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TWO-PHASE FLOW MEASUREMENT
BY PULSED NEUTRON ACTIVATION TECHNIQUES

by

Paul Kehler

Components Technology Division

MASTER

for

Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

January, 1978

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TWO-PHASE FLOW MEASUREMENT
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ABSTRACT

The Pulsed Neutron Activation (PNA) technique for measuring the mass flow velocity and the average density of two-phase mixtures is described. PNA equipment can be easily installed at different loops, and PNA techniques are non-intrusive and independent of flow regimes. These features of the PNA technique make it suitable for in-situ measurement of two-phase flows, and for calibration of more conventional two-phase flow measurement devices.

Analytic relations governing the various PNA methods are derived. The equipment and procedures used in the first air-water flow measurement by PNA techniques are discussed, and recommendations are made for improvement of future tests.

In the present test, the mass flow velocity was determined with an accuracy of 2%, and average densities were measured down to 0.08 g/cm^3 with an accuracy of 0.04 g/cm^3 . Both the accuracy of the mass flow velocity measurement and the lower limit of the density measurement are functions of the injected activity and of the total number of counts. By using a stronger neutron source and a larger number of detectors, the measurable density can be decreased by a factor of 12 to 0.007 g/cm^3 for 12.5 cm pipes, and to even lower ranges for larger pipes.

1.0 INTRODUCTION

Nuclear safety test programs, such as the Loss of Fluid Test or the Upper Plenum Separate Effects (3-D) Test, are being conducted to collect experimental data required for the verification of computer codes assessing the safety of nuclear power plants. The measurement of mass flow rates and fluid properties is required to verify the accuracy with which the computer codes can model a loss of coolant accident and subsequent reflooding of the core by emergency cooling systems.

The measurement of transient mass flow rates of two-phase flow is performed with conventional equipment such as turbines, drag disks or pitot tubes, but is complicated by the need to identify the flow regime and to measure the average density over the cross section of the flow channel.

At the present time, the accuracy of conventional two-phase flowmeters is not considered to be adequate for reactor safety studies. Conventional instruments must be calibrated under controlled conditions and for different flow regimes. One way to calibrate two-phase flowmeters is by use of radioactive tracers^(1,6,7). Radioactive tracers can be produced in situ by neutron activation, and Pulsed Neutron Activation (PNA) techniques, which were used for the measurement of single phase flow velocities⁽⁹⁾ and for the calibration of liquid sodium flowmeters^(2,3,4,5), can also be used for the calibration of two-phase flowmeters.

The present report describes the analytic methods, experimental techniques, and results of the first two-phase flow measurement performed by the PNA technique.

2.0 ANALYTIC MODELING

In water flow measurements by the Pulsed Neutron Activation (PNA) technique, a D,T neutron source is used to activate oxygen by irradiating the water (and steam) with a short burst of 14 MeV neutrons. These neutrons produce a short-lived radioactive isotope of nitrogen by the reaction $O^{16}(n,p)N^{16}$. The half-life of N^{16} is 7.24 sec, and its emitted gamma ray has an energy of 6.1 MeV.

A NaI detector located downstream of the source (see Fig. 1) detects the induced activity as it flows past. After amplification and energy discrimination, the individual counts registered by the detector are stored in individual "time channels" Δt of a multichannel analyzer, operated in a multiscaler mode. The time channel in which the individual counts are stored indicates the "transit time" of the activities causing these counts. Figure 2

Fig. 1 Geometry, PNA Technique

Fig. 2 Example, Multiscaler Output

illustrates such a distribution of counts with time. Since some of the activity decays during transit between the source and the detector, the number of counts $c(t)$, as registered by the detector, must be corrected for this decay prior to any data processing, according to

$$C(t) = c(t) e^{\lambda t} \quad (1)$$

where

$$\begin{aligned} C(t) &= \text{decay corrected number of counts,} \\ \lambda &= \ln 2/T_{1/2} = \text{decay constant of } N^{16}, \text{ and} \\ t &= \text{time from activation to detection.} \end{aligned}$$

Whenever $C(t)$ is mentioned in the present report, the decay-corrected number of counts is to be understood.

Different methods can be used for the measurement of mass flow velocity and average density by PNA techniques. These methods are discussed, and the basic equations to be used for PNA data reductions are derived below.

2.1 Average Velocity by Transit-Time Method

When a slug of fluid is "tagged" at the source location in Fig. 1, and its transit time T between source and detector is known, then its velocity V is

$$V = Z_0 \frac{1}{T}, \quad (2)$$

where

$$Z_0 = \text{the distance between the source and the detector.}$$

Tagging of the fluid can be done by injection of salts with easily detectable properties (as was done as far back as in the early 1920's), by injection of radioactive tracers, or by neutron activation as in our PNA technique.

A large number of studies (including the classical work by Taylor) dealt with the dispersion of the injected tracers in time, and with numerical methods for the derivation of an "average transit-time" suitable for use in Eq. 2. These methods derive an average transit-time from the time distributed

number of counts $C(t)$, by using one of the following:
the mode t_0 , where

$$d C(t_0)/dt = 0 , \quad (3)$$

the median τ , where

$$\int_0^{\tau} C(t) dt = \int_{\tau}^{\infty} C(t) dt , \quad (4)$$

the mean $\bar{t}$, where

$$\bar{t} = \frac{\int_0^{\infty} t C(t) dt}{\int_0^{\infty} C(t) dt} , \quad (5)$$

or the reciprocal mean $\left(\frac{1}{t}\right)'$, where

$$\left(\frac{1}{t}\right)' = \frac{\int_0^{\infty} \left(\frac{1}{t}\right) C(t) dt}{\int_0^{\infty} C(t) dt} . \quad (6)$$

In our previous work, dealing with single phase flow measurement of liquid sodium, we have used the count distribution weighted reciprocal mean, Eq. 6.

None of these evaluation schemes was found to be sufficiently accurate for application to two-phase flow conditions, where the distribution of counts is, in most cases, significantly different from normal distributions. In annular flows, for example, the liquid ring close to the pipe wall flows much slower than the mass at the centerline of the pipe. In many situations, there is a distinct separation of the velocities of the two phases and the concept of "slip" can be used. For these complex two-phase flow conditions, a transit-time equation was derived directly from the definition for average mass flow, as shown below:

Let's assume that the neutron source activates uniformly the oxygen contained in a disk opposite the source. This oxygen may be contained in water in its liquid or gaseous phase. Furthermore, let's assume that all of the activated mass (liquid or gas) can be divided into small mass elements dm ,

where each element dm has an average axial velocity (averaged over z_0) of V . Then, the mass averaged velocity V_M of all the activated mass elements dm is

$$V_M = \frac{\int V \, dm}{\int dm} \quad (7)$$

It should be pointed out at this place that Eq. 7 is the definition of the mass averaged flow velocity and, as such, generally applies to all flow regimes. In particular, it also applies to annular flow regimes with distinctly separate phase velocities and very low flow velocities of the water film adhering to the pipe wall.

Integration of Eq. 7 can be done either in space or in time, as long as all mass elements dm are covered by the integral. In single phase flow situations, the velocity V of the individual mass elements is commonly assumed to be a function of the radius only, $V = V(r)$. In these cases, the mass elements can be assumed to be concentric rings, $dm = 2\pi r \, dr \, \Delta z \, \rho$, and Eq. 7 assumes the well known form for the mass averaged flow velocity for radial velocity distributions:

$$V_M = \frac{\int_0^r V(r) \, 2\pi r \, dr}{\int_0^r 2\pi r \, dr}, \quad \text{or} \quad (8)$$

$$V_M = \frac{1}{a} \int_0^r V(r) \, 2\pi r \, dr, \quad (9)$$

where

a = the cross sectional area of the pipe.

Although some two-phase velocity measuring systems are capable of measuring radial velocity distributions (e.g., "rakes" of pitot tubes, drag disks, or small turbines), the PNA technique can not do so. Equation 9, therefore, does not apply to the PNA technique. Instead, the transient time method of the PNA technique integrates Eq. 7 over time, by measuring the mass and velocity of each mass element dm as it passes the detector. The mass measurement is done through the measurement of the activity of the mass element dm , and the velocity measurement is done through the measurement of the transit time.

Assuming that the neutron fluence is constant over the diameter of the

pipe opposite the source, then the activity (in decays/sec) of each mass element dm will be proportional to its mass. In large-diameter pipes, uniformity of the neutron fluence can be improved by irradiating the flow with more than one neutron source from more than one direction. With proportionality between mass and activity of the individual mass elements, the mass flowing past the detector during the time interval dt will be

$$dm \propto A(t) dt, \quad (10)$$

where $A(t)$ = the activity "seen" by the detector at the time t .

For ease of understanding, let's assume that the "window" ΔZ of the detector is very small, and that the time of passage of the activity $A(t)$ past this window, Δt , is very short:

$$\Delta t = \frac{\Delta Z}{V} < dt. \quad (11)$$

Under this assumption, all counts $C(t)$ due to the activity $A(t)$ will be registered by the detector within the time interval dt , with

$$C(t) \approx A(t) \Delta t, \quad (12)$$

or

$$C(t) = \alpha \frac{A(t)}{V}, \quad (13)$$

where α is a constant.

The condition of Eq. 11 limits in no way the validity of the transit-time method of the PNA technique. It is only stated to simplify the assumptions for ease of understanding. Should, for example, for a given detector window ΔZ , dt be chosen to be shorter than Δt , or

$$\Delta t = n dt, \quad (14)$$

where $n \geq 1$,

then the total number of counts, $C(t)$ of Eq. 13, would simply be distributed over n time intervals dt instead of one time interval, and dm of Eq. 10 would

appear to be lower by a factor $\frac{1}{n}$ in each of the n time intervals dt . However, integration over the n time intervals would still result in the same value for $\int dm$. Also, the transit time, averaged over n time intervals, would be the same as the transit time for the case of only one time interval. Expressing $A(t)$ in Eq. 10 by Eq. 13 yields

$$dm = \frac{1}{a} V C(t) dt \quad (15)$$

which, when inserted into Eq. 7, gives the following definition of the mass averaged flow velocity:

$$V_M = \frac{\int V^2 C(t) dt}{\int V C(t) dt} \quad (16)$$

The transit time T of the mass elements "seen" by the detector at the time t is $T = t$, and their velocity is

$$V = \frac{Z_0}{t} \quad (17)$$

Substituting this value for V in Eq. 16 yields

$$V_M = Z_0 \frac{\int \frac{1}{t^2} C(t) dt}{\int \frac{1}{t} C(t) dt} \quad (18)$$

The integrals in this definition of the mass averaged flow velocity can be broken down into sums of integrals over small time periods Δt :

$$\int_0^{\infty} \frac{1}{t^2} C(t) dt = \sum_{i=1}^{\infty} \int_{(i-1)\Delta t}^{i\Delta t} \frac{1}{t^2} C(t) dt, \text{ and} \quad (19)$$

$$\int_0^{\infty} \frac{1}{t} C(t) dt = \sum_{i=1}^{\infty} \int_{(i-1)\Delta t}^{i\Delta t} \frac{1}{t} C(t) dt \quad (20)$$

Integration of counts over preset time increments Δt is performed by the PNA equipment, and the resulting total number of counts C_i is stored in channel i :

$$C_i = \int_{(i-1)\Delta t}^{i\Delta t} C(t) dt \quad (21)$$

Assuming an average time t_i for the time between $t = (i-1) \Delta t$ and $t = i\Delta t$

$$t_i = (i-1) \Delta t + \frac{1}{2} \Delta t, \quad (22)$$

and considering decay correction, Eq. 21 becomes

$$c_i e^{\lambda t_i} = \int_{(i-1)\Delta t}^{i\Delta t} C(t) dt \quad (23)$$

Insertion of Eqs. 22 and 23 into Eqs. 19 and 20 yields

$$\int_0^{\infty} \frac{1}{t^2} C(t) dt = \sum_{i=1}^{\infty} \frac{1}{t_i^2} c_i e^{\lambda t_i}, \text{ and} \quad (24)$$

$$\int_0^{\infty} \frac{1}{t} C(t) dt = \sum_{i=1}^{\infty} \frac{1}{t_i} c_i e^{\lambda t_i}, \quad (25)$$

and the definition of the mass averaged flow velocity, Eq. 18, reads in terms measurable by PNA equipment:

$$V_M = Z_0 \frac{\sum_{i=1}^{\infty} \frac{1}{t_i^2} c_i e^{\lambda t_i}}{\sum_{i=1}^{\infty} \frac{1}{t_i} c_i e^{\lambda t_i}} \quad (26)$$

Being the definition of the mass averaged flow velocity, Eq. 26 has no systematic error. The fundamental errors (due primarily to the finite collimation of the source and the detector), and the experimental errors (due to errors in measurement of times and distance, as well as to statistical errors),

however, do effect the accuracy of the flow velocity measurement by the transit time method of the PNA technique.

The physical meaning of Eq. 16 can be understood by inserting Eqs. 10, 15 and 17 into Eq. 18 which then reads:

$$V_M = Z_0 \frac{\int \frac{1}{t} A(t) dt}{\int A(t) dt} \quad (27)$$

The fraction by the two integrals in this equation is the definition of the activity averaged inverse of the transit time, $\left(\frac{1}{t}\right)$. Using this definition, Eq. 27 can be written

$$V_M = Z_0 \left(\frac{1}{t}\right) . \quad (28)$$

The equation used by us for the calibration of liquid sodium flowmeters^(2,3,4,5) was

$$\bar{V} = Z_0 \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} , \text{ or} \quad (29)$$

$$\bar{V} = Z_0 \frac{\int A(t) dt}{\int t A(t) dt} . \quad (30)$$

In this equation, the fraction by the two integrals defines the inverse of the activity averaged transit time $\frac{1}{t}$,

$$\frac{1}{t} = \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} , \quad (31)$$

and the average velocity of sodium was calculated by

$$\bar{V} = Z_0 \frac{1}{t} . \quad (32)$$

In the case of single-phase sodium flow, with almost normally distributed activities,

$$\left(\frac{\bar{I}}{t}\right) \approx \frac{1}{t} \quad , \quad (33)$$

and the error due to the incorrect data reduction technique was negligible. In two-phase flow situations, where the activities are not at all normally distributed, the activity-weighted average inverse transit-time can not be assumed to be approximately equal to the inverse of the activity-weighted average transit-time, and Eq. 26 must be used for data reduction.

2.2 Average Density by Transit-Time Method

The most promising potential of PNA techniques is the calibration of conventional two-phase flow measuring devices installed in calibration loops. In most calibration facilities, the mass flow of the gas and the liquid are measured separately and quite accurately prior to the mixing of the two phases. With the pipe diameter of the test loop known, the mass flows can be expressed in terms of superficial velocities, where superficial velocity is defined as the velocity that a phase would have in the pipe if the other phase were not present. When the superficial velocity of the gas is V_{GS} and the superficial velocity of the liquid is V_{LS} , then the superficial velocity of the total mass flow, V_{MS} , can be calculated to be

$$V_{MS} = V_{LS} + \frac{\rho_G}{\rho_L} V_{GS} \quad . \quad (34)$$

Since air is often used instead of steam in calibration loops, and since PNA techniques measure mass flow in terms of flow of oxygen atoms, this equation must be modified by inclusion of terms for the weight fraction of oxygen in the gas, F_G , and the weight fraction of oxygen in the liquid, F_L . The equation for the superficial velocity of oxygen flow (simulating water flow) then becomes

$$V_{MS} = V_{LS} + \frac{\rho_G}{\rho_L} \frac{F_G}{F_L} V_{GS} \quad , \quad (35)$$

where

$$\frac{F_G}{F_L} = 1 \text{ for steam-water mixtures, and}$$

$$\frac{F_G}{F_L} = .262 \text{ for air-water mixtures.}$$

Now, when all the mass flowing in the pipe is in liquid form, then $V_{MS} = V_M$, where V_M is determined by Eq. 26. On the other hand, when two-phase flow conditions prevail, and when the average density in the pipe, ρ_P , is not equal to the density of water, ρ_0 , then the following equation is true because of mass balance considerations:

$$\rho_P V_M = \rho_0 V_{MS} \quad , \quad (36)$$

and the average density ρ_P , averaged over the length of pipe between the source and the detector, can be determined as

$$\rho_P = \rho_0 \frac{V_{MS}}{V_M} \quad . \quad (37)$$

Supplemental mass flow data for the two-phases, generally supplied by the loop operator from readings of single-phase flow measuring equipment, are necessary for the determination of the average density by the transit-time method. An alternative method to determine density, based on the total activity method (Paragraph 2.3), depends on PNA supplied data only.

2.3 Density by Total-Activity Method

When, at a time t , an activity $A(t)$ moves past the detector window ΔZ with a velocity V , then the number of counts registered by the detector will be

$$c(t) = \beta A(t) \frac{\Delta Z}{V(t)} \quad (38)$$

where $\beta = \text{a constant.}$

After correction of the counts for decay (according to Eq. 1), this number of counts can be used as an indication for the amount of activity $A(t)$

passing the detector at any time t ,

$$A(t) = \frac{1}{\beta \Delta Z} C(t) V(t) , \quad (39)$$

and the total amount of activity passing the detector can be obtained by integration:

$$A = \int_0^{\infty} A(t) dt = \frac{1}{\beta \Delta Z} \int_0^{\infty} C(t) V(t) dt. \quad (40)$$

Since

$$V(t) = Z_0 \left(\frac{1}{t} \right) ,$$

$$A = \frac{Z_0}{\beta \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt. \quad (41)$$

Assuming a uniform distribution of neutron fluence over the diameter of the pipe opposite the source, the total activity introduced into the flowing medium is proportional to the average density ρ_S opposite the source:

$$A = A_0 \frac{\rho_S}{\rho_0} = \frac{Z_0}{\beta \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt , \quad (42)$$

where

ρ_0 = density of water, and

A_0 = the activity introduced in a water filled pipe.

Thus,

$$\rho_S = \frac{Z_0 \rho_0}{\beta A_0 \Delta Z} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt . \quad (43)$$

Introducing a constant k that describes the properties of the detector (sensitivity β and width of collimation angle, ΔZ),

$$\rho_S = k \frac{Z_0}{A_0} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt . \quad (44)$$

In any given series of experiments the source-detection spacing Z_0 is kept constant and the neutron output can be either kept constant or be normalized to yield a constant A_0 , and a new constant K can be defined

$$\frac{1}{K} = k \frac{Z_0}{A_0} , \quad (45)$$

with which Ec 44 takes the form:

$$K = \frac{1}{\rho_S} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt \quad (46)$$

The integral $\int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt$ can be obtained from PNA data. The constant K is determined by performing measurements with water filled pipes, where the density is known to be $\rho_S = \rho_0$. Once K is determined, Eq. 46 can be used for the measurement of the density for two-phase flow conditions.

2.4 Velocity By Total-Count Method

The total-count method for flow velocity measurement has been used frequently in the past (1,2,7,9). Its usefulness in measuring two-phase flow is discussed in this paragraph. The relation of A , the total induced activity, to the counts registered by the detector, was found to be (Eq. 40)

$$A = \frac{1}{\alpha} \int_0^{\infty} C(t) V(t) dt ,$$

where $\alpha = \beta \Delta Z = \text{a constant}$.

When an average velocity $\bar{V}$ is defined such that

$$A = \frac{1}{\alpha} \bar{V} \int_0^{\infty} C(t) dt , \quad (47)$$

then

$$A = \frac{1}{\alpha} \bar{V} C , \quad (48)$$

where

$$C = \int_0^{\infty} C(t) dt = \text{the total number of decay corrected counts.}$$

Combination of Eqs. 40 and 47 yields

$$\bar{V} = \frac{\int_0^{\infty} V(t) C(t) dt}{\int_0^{\infty} C(t) dt} \quad (49)$$

Since (Eq. 2)

$$V(t) = Z_0 \left(\frac{1}{t} \right) ,$$

$$\bar{V} = Z_0 \frac{\int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt}{\int_0^{\infty} C(t) dt} ,$$

This is the equation (Eq. 29) previously used in a single-phase situations, where the transit-time was determined by the count-weighted average of the inverse of the time^(2,3,4,5).

Application of the PNA technique to these single-phase flow situations has shown that in these cases, where the count distributions were found to be skewed but not too different from normal distributions, the count weighted inverse averaging technique yielded results that were accurate to within a few percent. This means that the total count method as expressed in Eq. 48 can be expected to be just as accurate as our early liquid sodium flow tests, and average flow velocities can be determined by

$$\bar{V} = \alpha \frac{A}{C} , \quad (50)$$

where

- α = a constant reflecting the sensitivity and geometry of the detector,
- A = the total activity injected into the system, and
- C = the total number of decay-corrected counts.

For two-phase flow velocity measurements by the total count method, it

must be considered that the induced activity A is proportional to the density (Eq. 42),

$$A = \frac{\rho}{\rho_0} A_0 ,$$

where

- ρ = average density of two-phase flow,
- ρ_0 = density of water, and
- A_0 = activity induced in water filled pipe.

Thus, Eq. 50 becomes for two-phase flow:

$$\bar{V} = \rho \frac{\alpha A_0}{\rho_0} \frac{1}{C} . \quad (51)$$

Introducing the same constant

$$K = \frac{\alpha A_0}{\rho_0 Z_0} \quad (52)$$

as in Paragraph 2.3, Eq. 51 becomes

$$\bar{V} = \rho Z_0 K \frac{1}{C} \quad (53)$$

or, with $\bar{V} = (1/\bar{t}) Z_0$,

$$K = \frac{1}{\bar{t}} \int_0^{\infty} C(t) dt$$

(54)

where (See Eq. 31)

$$\frac{1}{\bar{t}} = \frac{\int \frac{1}{t} C(t) dt}{\int C(t) dt} .$$

Comparison of Eq. 54 with Eq. 46 reveals their relation and illustrates their differences. As mentioned above, the total count method, Eq. 54, should only be applied to situations where the count distributions are not too different from normal. Applied to two-phase flow problems, this means that the total

count method should only be used in calibration runs with water-filled pipes, as a double-check on the transit-time method.

3.0 AIR-WATER LOOP TESTS

In August - September 1977, LOFT two-phase instrumentation systems were calibrated in the air-water loop located at the Semiscale facility of the Idaho National Engineering Laboratory. Subsequent to this calibration, the LOFT instrumentation was shipped to Karlsruhe, Germany, for calibration in a steam-water loop. The test plan for the Karlsruhe tests called for a comparison of the LOFT instrumentation systems with German equipment, and for a calibration of the LOFT equipment by radioactive tracer techniques.

The air-water loop at the Semiscale facility has a water flow capability of up to 25 l/sec and an air flow capability of up to 100 l/sec. PNA tests were not originally planned for the LOFT instrument test series. Thus, the PNA geometry could not be optimized. Instead of one optimum spacing between the source and the detector, two spacings of about 1m and 5m were used. In two-phase tests, the air and water were separated (in a separation tank) after passage through the test section. While the water was recirculated, the air was vented to the atmosphere. New air was injected at the mixing nozzle at a pressure of about 5.5 b (80 psi). The pressure at the LOFT instrumentation spool piece was maintained at 4 b (58 psi). Only this pressure at the spool piece was recorded and maintained by the loop operator. The inlet pressure and the back pressure in the separation tank were not recorded.

A first series of tests was performed in 7.5 cm pipes, and a second series of tests in 12.5 cm pipes. Prior to two-phase testing, the LOFT instruments were calibrated by pumping water only (and no air) through the loop.

The individual runs of these test series were identified by four-digit numbers XYZZ, where the first digit identified the nature of a run (X = 3 for two-phase test and X = 4 for an all-water calibration run), the second digit indicated the pipe diameter (Y = 0 for 7.5 cm pipes and Y = 5 for 12.5 cm pipes), and the last two digits (ZZ) were running numbers of the two series. This numbering system is kept throughout the present report.

The loop operator measured the flows of water and air by turbine meters. These data are the only ones used for support of the PNA data. Other data taken in these LOFT test series (three-beam densitometer, scanning

densitometer, flow momentum and flow velocity) were not available at the time of the writing of this report.

PNA derived values for the densities and mass flow velocities of the individual runs, tabulated in the Tables 19 and 20, can be used for comparison with the "conventional" flow data gathered at INEL and in Karlsruhe as soon as the latter data become available.

3.1 Test Setup

The geometries of the two test series are illustrated in Figs. 3 and 4. In these tests, the NaI detectors were shielded by 15 cm of lead. The neutron source was shielded by 10 cm of lead and 15 cm of borated polyethylene.

A block diagram of the equipment is shown in Fig. 5. Table 1 identifies the more important pieces of equipment.

3.2 Data Reduction Technique

PNA data are evaluated in terms of the sums $\sum \frac{1}{t^2} C$, $\sum \frac{1}{t} C$ and $\sum C$, where the C's are counts at the time t, corrected for background and for decay. Decay corrections were done according to Eq. 1, and the background was assumed to be

$$B = BZ + BE e^{-BLAM t} \quad (55)$$

where

BZ = the constant background,

BE = the short-lived background induced by the pulsed neutron source in the environment of the detector and in the detector itself, and

BLAM = the decay constant of the induced background.

BZ, BE and BLAM were calculated from the count distributions accumulated by the multichannel analyzer. Prior to the evaluation of the test data, printer plots were generated for the uncorrected count distributions, and limits L1 and L2 of the distributions were selected visually (see Fig. 6). Then, BZ was assumed to be equal to the number of counts at the end of the record (around channel 256), and BE and BLAM were calculated from the numbers of counts

Fig. 3 Test Setup, 7.5 cm Test

Fig. 4 Test Setup, 12.5 cm Test

Fig. 5 Block Diagram of Equipment

TABLE 1
LIST OF PNA EQUIPMENT

S : Pulsed neutron source on loan from SANDIA.
3 x 10⁹ neutron/pulse.
Repetition rate: 1 pulse/minute

D1 : 12.5 cm dia. x 7.5 cm NaI detector

D2 : 7.5 cm dia. x 7.5 cm NaI detector

A : Common amplifier

STAB1: Canberra Model 1720 Stabilizer

STAB2: Harshaw Model NA-23 Stabilizer

MCA : ND100, Four Input Multiscaler

TAPE : Pertec Model 7 x 40 recorder

PRINT: Centronics Model 306 Printer

TRIG : ANL built trigger circuit

DCV : Common DVM

MON : He³ detector (ionization chamber mode) in 15 cm
of wax.

INT : ANL built current integrator

Fig. 6 Background Model

around the channels L1 and L2, i.e., N1 and N2, according to:

$$BLAM = \frac{1}{GAIN (L1-L2)} \ln \left(\frac{N2 - BZ}{N1 - BZ} \right), \text{ and} \quad (56)$$

$$BE = \frac{N1 - BZ}{\exp. (BLAM \text{ GAIN } L1)} + BZ, \quad (57)$$

where

GAIN = the width of the channels L (Δt) .

L1, L2, BLAM, BZ, BE and GAIN are tabulated in Tables 2 and 3.

Net counts were obtained by subtracting the background from the gross counts N:

$$c = N - B \quad (58)$$

and were then corrected for decay according to Eq. 1, yielding background and decay corrected numbers of counts, C.

Other columns tabulated in Tables 2 and 3 are:

NEUT = The reading of the neutron monitor,

$$BKG = \sum_{L1}^{L2} B,$$

$$COUNTS = \sum_{L1}^{L2} N,$$

$$SUM Y/NEUT = \sum_{L1}^{L2} C/NEUT,$$

$$SUM (1/T) * Y/NEUT = \sum_{L1}^{L2} \left(\frac{1}{t} \right) C,$$

$$TINV = \frac{\sum_{L1}^{L2} \left(\frac{1}{t^2} \right) C}{\sum_{L1}^{L2} \left(\frac{1}{t} \right) C}$$

TABLE 2

COMPUTER PRINTOUT, 7.5 cm TEST

RUN	ARRAY	INVT	SUM (1/1717/NEUT)	SUM V/NEUT	COUNTS	MRG	BLAM	U2	ME	NEUT	L1	L2	GAIN
8001	1	0.16719E-01	0.20580E-04	0.12470E-05	18035	1499	0.77391E-01	0.00000E-01	0.45090E-02	0.21770E-01	0	05	0.2500
8002	203	0.32040E-01	0.41626E-03	0.12422E-05	1893	414	0.40130E-02	0.40000E-01	0.06042E-00	0.21770E-01	0	175	0.2500
8003	1	0.20800E-01	0.20000E-03	0.10034E-05	4868	432	0.55545E-01	0.31333E-01	0.13635E-02	0.22700E-00	0	50	0.2500
8004	203	0.4064E-01	0.43541E-03	0.10556E-05	819	89	0.0	0.43000E-01	0.0	0.22700E-00	0	70	0.2500
8005	1	0.38978E-01	0.20496E-03	0.54025E-04	2886	572	0.37150E-01	0.14000E-01	0.13333E-02	0.14000E-01	0	8	0.1000
8006	203	0.75471E-01	0.41626E-03	0.55522E-04	2886	120	0.0	0.15025E-01	0.0	0.14000E-01	0	100	0.1000
8007	1	0.86774E-01	0.23735E-03	0.24495E-05	1904	179	0.87142E-01	0.44000E-01	0.51120E-01	0.30520E-01	0	13	0.0500
8008	203	0.17298E-01	0.44015E-03	0.25540E-05	950	67	0.0	0.11675E-01	0.0	0.30520E-01	0	40	0.0500
8009	1	0.20212E-01	0.21106E-03	0.10557E-05	2140	1815	0.71594E-01	0.10133E-02	0.28049E-02	0.30000E-01	0	14	0.1300
8010	203	0.40175E-01	0.40537E-03	0.10149E-05	3251	406	0.0	0.46125E-01	0.0	0.30000E-01	0	145	0.1300
8011	1	0.41367E-01	0.14604E-03	0.49055E-05	12085	1024	0.11101E-00	0.65533E-01	0.15150E-02	0.20440E-01	0	15	0.0600
8012	203	0.81355E-01	0.41333E-03	0.21073E-05	4714	272	0.0	0.20125E-01	0.0	0.20440E-01	0	145	0.0600
8013	1	0.80189E-01	0.21750E-03	0.20004E-04	5828	591	0.23400E-00	0.46000E-01	0.53159E-01	0.22040E-01	0	15	0.0400
8014	203	0.80189E-01	0.21750E-03	0.20004E-04	5828	95	0.0	0.43750E-00	0.0	0.22040E-01	0	140	0.0400
8015	1	0.80189E-01	0.21750E-03	0.20004E-04	5828	400	0.28425E-01	0.46000E-01	0.20051E-01	0.00240E-01	0	20	0.0300
8016	203	0.80189E-01	0.21750E-03	0.20004E-04	5828	103	0.0	0.10625E-01	0.0	0.00240E-01	0	145	0.0300
8017	1	0.77331E-01	0.21055E-03	0.24173E-05	1917	307	0.0	0.72500E-01	0.0	0.54900E-01	0	17	0.0007
8018	203	0.77331E-01	0.21055E-03	0.24173E-05	1917	3734	0.0	0.21675E-01	0.0	0.54900E-01	0	150	0.0007
8019	1	0.39194E-01	0.22129E-03	0.54900E-05	3066	201	0.0	0.72500E-01	0.0	0.54900E-01	0	150	0.0007
8020	203	0.77331E-01	0.21055E-03	0.24173E-05	1917	2931	0.84225E-01	0.25000E-02	0.10000E-03	0.25000E-01	0	40	0.0000
8021	1	0.20001E-01	0.17111E-03	0.41073E-05	4907	0	0.0	0.0	0.0	0.25000E-01	0	32	0.0000
8022	203	0.0	0.0	0.0	0	2582	0.0	0.34438E-02	0.0	0.25000E-01	0	115	0.0000
8023	1	0.35048E-01	0.31190E-03	0.20434E-05	6281	0	0.0	0.0	0.0	0.25000E-01	0	22	0.0000
8024	203	0.0	0.0	0.0	0	676	0.78712E-01	0.12000E-01	0.29470E-02	0.70000E-00	0	0	0.5000
8025	1	0.46368E-01	0.46033E-03	0.20200E-05	2477	0	0.0	0.0	0.0	0.70000E-00	0	0	0.5000
8026	203	0.0	0.0	0.0	0	931	0.26199E-01	0.72600E-01	0.40494E-01	0.92440E-01	0	13	0.0500
8027	1	0.40217E-01	0.20342E-03	0.43049E-04	11679	303	0.0	0.37500E-01	0.0	0.92440E-01	0	145	0.0500
8028	203	0.40217E-01	0.20342E-03	0.43049E-04	11679	1131	0.40600E-00	0.12000E-02	0.48105E-01	0.45120E-01	0	10	0.0500
8029	1	0.10367E-01	0.40235E-03	0.11043E-04	5530	305	0.13452E-01	0.19000E-01	0.73472E-00	0.45120E-01	0	40	0.0500
8030	203	0.17119E-01	0.14020E-03	0.44671E-05	2504	1282	0.0	0.22500E-02	0.0	0.73472E-00	0	10	0.0500
8031	1	0.12047E-01	0.17007E-03	0.76971E-05	4937	395	0.0	0.25000E-02	0.0	0.73472E-00	0	95	0.0500
8032	203	0.21943E-01	0.11082E-03	0.47259E-05	2702	1534	0.55694E-00	0.25000E-02	0.52700E-01	0.73472E-00	0	75	0.0500
8033	1	0.14163E-01	0.54651E-03	0.33275E-05	2126	374	0.0	0.25750E-01	0.0	0.73472E-00	0	40	0.0500
8034	203	0.32651E-01	0.64610E-02	0.20200E-05	2494	302	0.0	0.50125E-01	0.0	0.73472E-00	0	150	0.0500
8035	1	0.16115E-01	0.20357E-03	0.12414E-04	4028	250	0.0	0.28125E-01	0.0	0.73472E-00	0	12	0.0500
8036	203	0.13145E-01	0.29415E-03	0.18075E-05	2047	429	0.0	0.78125E-01	0.0	0.73472E-00	0	140	0.0500
8037	1	0.17049E-01	0.17124E-03	0.10065E-04	4754	216	0.0	0.21250E-01	0.0	0.73472E-00	0	15	0.0500
8038	203	0.34795E-01	0.25384E-03	0.62610E-05	2403	981	0.23517E-00	0.12535E-02	0.38430E-01	0.62610E-01	0	15	0.0500
8039	1	0.22200E-01	0.13600E-03	0.65104E-05	5047	404	0.0	0.40675E-01	0.0	0.62610E-01	0	143	0.0500
8040	203	0.45162E-01	0.22971E-03	0.40621E-05	3076	1400	0.0	0.23125E-02	0.0	0.62610E-01	0	18	0.0500
8041	1	0.38659E-01	0.78150E-03	0.21434E-05	3841	0	0.0	0.0	0.0	0.62610E-01	0	0	0.0500
8042	203	0.0	0.0	0.0	0	482	0.22610E-01	0.76000E-01	0.53644E-01	0.50030E-01	0	12	0.0070
8043	1	0.39842E-01	0.19896E-03	0.51602E-05	3402	178	0.0	0.23125E-01	0.0	0.50030E-01	0	145	0.0070
8044	203	0.78011E-01	0.43535E-03	0.55170E-05	3011	499	0.11205E-01	0.09333E-01	0.23170E-01	0.50720E-01	0	15	0.0070
8045	1	0.40910E-01	0.13090E-03	0.47450E-05	3148	168	0.0	0.1375E-01	0.0	0.50720E-01	0	140	0.0070
8046	203	0.81567E-01	0.34600E-03	0.46149E-05	2616	611	0.85944E-01	0.12533E-02	0.43051E-01	0.72350E-01	0	15	0.0000
8047	1	0.46552E-01	0.19003E-03	0.37500E-05	3260	207	0.0	0.19375E-01	0.0	0.72350E-01	0	135	0.0000
8048	203	0.94108E-01	0.35167E-03	0.37877E-05	2679	843	0.43003E-01	0.13600E-02	0.64000E-01	0.89420E-01	0	17	0.0000
8049	1	0.70866E-01	0.12467E-03	0.16440E-05	2468	221	0.0	0.18125E-01	0.0	0.89420E-01	0	120	0.0000
8050	203	0.14884E-01	0.26569E-03	0.16440E-05	1736	3249	0.20095E-00	0.30607E-02	0.29420E-02	0.7566E-02	0	10	0.0300
8051	1	0.10526E-01	0.31102E-02	0.18000E-05	7159	816	0.0	0.57500E-01	0.0	0.7566E-02	0	100	0.0300
8052	203	0.20589E-01	0.31102E-02	0.18000E-05	2609	7311	0.17510E-00	0.55407E-02	0.54717E-02	0.15424E-02	0	10	0.0550
8053	1	0.58003E-01	0.62419E-03	0.12775E-05	3867	2147	0.0	0.14125E-01	0.0	0.15424E-02	0	90	0.0550
8054	203	0.11045E-01	0.06014E-02	0.91352E-05	7667	3343	0.24384E-00	0.37407E-02	0.17120E-02	0.11580E-02	0	9	0.0400
8055	1	0.60843E-01	0.16005E-03	0.27507E-05	6084	587	0.0	0.70250E-01	0.0	0.11580E-02	0	105	0.0400
8056	203	0.12332E-01	0.17455E-02	0.14411E-05	1144	485	0.13598E-00	0.46000E-02	0.5912E-02	0.11107E-02	0	23	0.0700
8057	1	0.31490E-01	0.27780E-02	0.25230E-05	7077	1281	0.0	0.11438E-02	0.0	0.11107E-02	0	120	0.0700
8058	203	0.15337E-01	0.76724E-01	0.10651E-05	1612	7793	0.14764E-00	0.42133E-02	0.40024E-02	0.79100E-01	0	32	0.1000
8059	1	0.11344E-01	0.34450E-03	0.32009E-04	17406	0	0.0	0.0	0.0	0.79100E-01	0	0	0.1000
8060	203	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.79100E-01	0	0	0.1000

TABLE 3
COMPUTER PRINTOUT, 12.5 cm TEST

RUN	ARRAY	TIME	SUM (1/17)X/NEUT	SUM Y/NEUT	COUNTS	BRG	BLAN	BZ	BE	NEUT	L1	L2	GAIN
4510	1	0.22093E	00 0.24450E	04 0.11031E	30321	2510	0.40055E-01	0.14400E	02 0.41424E	02 0.39240E	01 10	70	0.1300
4511	203	0.55131E	-01 0.44530E	03 0.48189E	6076	510	0.0	0.54375E	01 0.0	0.39240E	01 105	200	0.1300
4512	1	0.52140E	00 0.24407E	04 0.48189E	14030	1153	0.20204E	00 0.13500E	02 0.12304E	02 0.34170E	01 6	70	0.0650
4513	203	0.12408E	00 0.44450E	03 0.36100E	6007	350	0.0	0.43750E	01 0.0	0.34170E	01 6	100	0.0650
4514	1	0.56815E	00 0.26231E	04 0.31191E	8005	519	0.19041E	00 0.59333E	01 0.57703E	01 0.26910E	01 10	80	0.0300
4515	203	0.06815E	00 0.26231E	04 0.31191E	3987	222	0.0	0.25043E	01 0.0	0.26910E	01 120	215	0.0300
4516	1	0.50400E	00 0.47500E	03 0.72573E	5470	806	0.46459E	00 0.91333E	01 0.55525E	01 0.65270E	01 11	80	0.0070
4517	203	0.42500E	00 0.47500E	03 0.50457E	3510	208	0.94373E-01	0.73333E	00 0.15800E	01 0.65270E	01 110	215	0.0070
4518	1	0.20108E	00 0.23027E	04 0.12149E	4008	308	0.57805E	00 0.47333E	01 0.56430E	01 0.56270E	01 14	75	0.0140
4519	203	0.47572E	00 0.40025E	03 0.76087E	3107	87	0.0	0.10000E	01 0.0	0.56270E	01 115	210	0.0140
4520	1	0.19521E	00 0.26700E	03 0.50422E	10049	1950	0.61274E-01	0.13000E	02 0.23302E	02 0.27000E	01 11	85	0.1300
4521	203	0.54151E	-01 0.44400E	03 0.27755E	1718	434	0.13150E	00 0.44000E	01 0.55454E	01 0.27000E	01 4	105	0.1300
4522	1	0.33112E	00 0.69269E	03 0.25748E	12006	4159	0.10840E	00 0.19133E	02 0.53400E	02 0.49750E	01 35	195	0.1300
4523	203	0.79670E	-01 0.69320E	02 0.92755E	2242	924	0.90725E-01	0.60000E	01 0.18020E	01 0.47500E	01 35	195	0.1300
4524	1	0.33780E	00 0.17000E	04 0.55335E	41200	6527	0.47504E-01	0.54333E	02 0.34025E	02 0.87740E	01 6	95	0.0600
4525	203	0.77304E	-01 0.27133E	03 0.35433E	9695	820	0.0	0.47370E	01 0.0	0.67740E	01 110	230	0.0600
4526	1	0.11108E	00 0.32020E	03 0.30010E	2450	1908	0.53001E	00 0.22000E	02 0.10495E	02 0.75300E	01 4	70	0.0400
4527	203	0.67049E	00 0.74319E	02 0.94000E	3490	537	0.0	0.50875E	01 0.0	0.75300E	01 45	210	0.0400
4528	1	0.11840E	00 0.10112E	04 0.99130E	2653	227	0.0	0.12300E	01 0.0	0.50875E	01 155	250	0.0340
4529	203	0.16295E	00 0.19029E	03 0.12140E	3502	676	0.40738E	00 0.71335E	01 0.40101E	01 0.43700E	01 120	250	0.0250
4530	1	0.13922E	00 0.93971E	03 0.71683E	3001	289	0.0	0.23750E	01 0.0	0.43700E	01 8	80	0.0200
4531	203	0.22040E	00 0.21300E	03 0.95470E	2327	660	0.20734E	00 0.70000E	01 0.45934E	01 0.44020E	01 60	235	0.0200
4532	1	0.21210E	00 0.74851E	03 0.39621E	1627	257	0.0	0.17500E	01 0.0	0.44020E	01 11	100	0.0070
4533	203	0.35502E	00 0.14243E	03 0.41013E	1044	512	0.54600E	00 0.40000E	01 0.21401E	01 0.30900E	01 140	250	0.0070
4534	1	0.30442E	00 0.44731E	02 0.91407E	481	184	0.0	0.16125E	01 0.0	0.30900E	01 7	70	0.0170
4535	203	0.72037E	00 0.63701E	02 0.91407E	755	137	0.0	0.10000E	01 0.0	0.44300E	01 35	180	0.0170
4536	1	0.32515E	00 0.35035E	03 0.92035E	414	840	0.0	0.10500E	02 0.0	0.56300E	01 12	100	0.0070
4537	203	0.59723E	00 0.47049E	02 0.73321E	2721	321	0.0	0.30000E	01 0.0	0.56300E	01 135	250	0.0060
4538	1	0.37440E	00 0.12333E	04 0.54230E	2205	572	0.99005E	00 0.59667E	01 0.54052E	01 0.56000E	01 115	210	0.0060
4539	203	0.59132E	00 0.29002E	03 0.37970E	2174	753	0.0	0.24375E	01 0.0	0.56000E	01 110	230	0.0070
4540	1	0.39800E	00 0.11038E	04 0.29010E	1699	212	0.0	0.15093E	02 0.0	0.70420E	01 12	70	0.0070
4541	203	0.41013E	00 0.25421E	03 0.29570E	2002	753	0.0	0.25025E	01 0.0	0.70420E	01 110	230	0.0070
4542	1	0.49331E	00 0.64021E	03 0.18120E	1506	247	0.0	0.25025E	01 0.0	0.70420E	01 12	75	0.0075
4543	203	0.93317E	00 0.19014E	03 0.26695E	3418	1413	0.16788E	01 0.17807E	02 0.13504E	02 0.71300E	01 65	235	0.0075
4544	1	0.49747E	00 0.13417E	04 0.26700E	2605	559	0.0	0.59375E	01 0.0	0.71300E	01 17	75	0.0080
4545	203	0.93602E	00 0.29311E	03 0.31800E	3679	476	0.24400E	01 0.80000E	01 0.10021E	01 0.40920E	01 110	215	0.0080
4546	1	0.30162E	00 0.24020E	04 0.70205E	2392	133	0.0	0.12007E	01 0.10505E	00 0.40920E	01 145	250	0.0080
4547	203	0.86347E	00 0.30184E	03 0.53853E	4281	732	0.0	0.11438E	02 0.0	0.53800E	01 145	250	0.0080
4548	1	0.38000E	00 0.24400E	04 0.67715E	2535	200	0.0	0.20875E	01 0.0	0.53800E	01 21	90	0.0080
4549	203	0.90145E	00 0.42120E	03 0.47040E	3979	254	0.0	0.20220E	01 0.0	0.53800E	01 145	250	0.0080
4550	1	0.36015E	00 0.23022E	04 0.62802E	2435	120	0.0	0.20220E	01 0.0	0.53800E	01 145	250	0.0080
4551	203	0.90994E	00 0.40055E	03 0.44980E	7143	478	0.0	0.17000E	02 0.10020E	02 0.53420E	01 10	65	0.0340
4552	1	0.11314E	00 0.12175E	04 0.11241E	4238	478	0.0	0.40875E	01 0.0	0.57710E	01 140	250	0.0340
4553	203	0.15542E	00 0.12770E	03 0.12131E	6296	1419	0.35018E-01	0.21007E	02 0.81977E	01 0.79410E	01 105	240	0.0300
4554	1	0.13408E	00 0.43949E	03 0.60533E	5237	444	0.0	0.31675E	01 0.0	0.79410E	01 11	100	0.0150
4555	203	0.20249E	00 0.19725E	03 0.46803E	2705	936	0.68809E	00 0.54607E	01 0.40042E	01 0.60090E	01 120	250	0.0150
4556	1	0.22203E	00 0.63701E	03 0.31720E	2156	606	0.0	0.50250E	01 0.0	0.60090E	01 11	60	0.0120
4557	203	0.16209E	00 0.11497E	03 0.32100E	2436	1174	0.0	0.17230E	02 0.0	0.74010E	01 75	250	0.0120
4558	1	0.26008E	00 0.46005E	03 0.17531E	1605	427	0.0	0.25025E	01 0.0	0.74010E	01 10	100	0.0090
4559	203	0.56240E	00 0.10850E	03 0.20224E	1923	1401	0.0	0.18050E	02 0.0	0.75110E	01 60	250	0.0090
4560	1	0.47201E	00 0.25097E	03 0.60209E	947	451	0.0	0.25097E	01 0.0	0.75110E	01 60	250	0.0090
4561	203	0.81691E	00 0.57549E	02 0.74952E	947	451	0.0	0.25097E	01 0.0	0.75110E	01 60	250	0.0090

ARRAY 1 lists the data gathered by the detector at the short spacing. ARRAY 203 lists the sum of the data gathered by the two detectors (2 and 3) at the long spacing (see Figs. 3 and 4).

The raw data gathered by the multichannel analyzer (the counts N for the channel L) are listed in Appendix B. This Appendix also shows the background-corrected count distributions for all the runs tabulated in Tables 2 and 3.

The computer program used for the reduction of PNA data is listed in Appendix A.

3.3 Accuracy of the Test Data

The two basic equations used for the evaluation of the PNA data are the Eqs. 26 and 46. The validity of assumptions made in the derivation of these equations is discussed in Section 4. The uncertainty of the equation relating flow velocity and transit time (Eq. 28),

$$V_M = Z_0 \left(\frac{1}{t} \right),$$

was studied in detail for our past sodium flow measurements^(3,4).

Due to the small diameter of the pipes in the present test, the errors in velocity due to the mixing of the flow and to the non-uniformity of distribution of activity over the diameter of the pipe can be neglected. The statistical error due to the number of background counts can also be assumed to be negligibly small for most of the present runs. Thus, the error equation derived for PNA measurements^(3,4) is reduced to

$$\left[\frac{\epsilon(V_M)}{V_M} \right]^2 = \left[\frac{\epsilon(Z)}{Z_0} \right]^2 + \left[\frac{\sigma(Z)}{Z_0} \right]^4 + \frac{1}{N} \left[\frac{\sigma(1/t)}{1/t} \right]^2, \quad (59)$$

where

$\frac{\epsilon(V_M)}{V_M}$ = The uncertainty of the PNA derived average mass flow velocity,

$\epsilon(Z)$ = The uncertainty of the measurement of the source detector spacing Z_0 ,

$\sigma (Z)$ = The standard deviation of the distribution of the transit distance between the source and the detector, due to the finite collimation angles of the source and the detectors,

N = The total number of counts, and

$\sigma (1/t)$ = The standard deviation in the distribution of the inverse of the transit times, (or velocities).

In the present tests, the distances between the source and the detectors was measured within $\epsilon (Z) = 0.5$ cm.

Since $\sigma (Z)$ is dependent on both the source and the detector collimation, and since the pipe diameters in these tests were small, a good estimate for $\sigma (Z)$ is given by the square root of the square of the source diameter ΔZ_S and the detector diameter ΔZ_D :

$$\sigma (Z) = \sqrt{(\Delta Z_D)^2 + (\Delta Z_S)^2} \quad (60)$$

N , the total number of counts, is tabulated in Tables 2 and 3. In Table 4, average values for N are listed for the various conditions.

In two-phase flow situations, the velocities of the individual mass elements are not distributed normally. Therefore, an estimate for $\sigma (1/t)$ was derived from the distribution plots of Appendix B.

Table 4 lists the individual contributions to the uncertainty in the PNA measurement of the velocity, and the calculated uncertainty. According to this Table, the major contributions to the uncertainty are the size of the source and of the detectors. The overall uncertainty is about 4% for the short source-detection spacings, and about .5% for the long source-detection spacings.

According to Eq. 46, the density ρ_S at the source location can be derived by

$$\rho_S = \frac{1}{K} \int_0^{\infty} \left(\frac{1}{t} \right) C(t) dt \quad (61)$$

Since the error due to the uncertainty of $\left(\frac{1}{t} \right)$ is less than the error of the

TABLE 4

UNCERTAINTY OF PNA DERIVED VELOCITIES

ASSUMPTION	ϵ^2	7.5 cm Test		12.5 cm Test	
		$Z_0 = 1.190$	$Z_0 = 5.994$	$Z_0 = 1.081$	$Z_0 = 4.578$
$\epsilon(Z) = .005 \text{ m}$	$\left(\frac{\epsilon(Z)}{Z_0}\right)^2$	1.6×10^{-5}	7.0×10^{-7}	1.9×10^{-5}	1.2×10^{-6}
$\Delta Z_S = .18 \text{ m}$	$\left(\frac{\Delta Z_S}{Z_0}\right)^2$	2.3×10^{-2}	9.0×10^{-4}	2.8×10^{-2}	1.5×10^{-2}
$\Delta Z_D = .13 \text{ m}$	$\left(\frac{\Delta Z_D}{Z_0}\right)^2$	1.2×10^{-2}		1.4×10^{-2}	
$\Delta Z_D = .08 \text{ m}$	$\left(\frac{\Delta Z_D}{Z_0}\right)^2$		1.8×10^{-4}		3.1×10^{-4}
$\left[\left(\frac{\Delta Z_S}{Z_0}\right)^2 + \left(\frac{\Delta Z_D}{Z_0}\right)^2\right]^2$	$\left(\frac{\sigma(Z)}{Z_0}\right)^4$	1.2×10^{-3}	1.2×10^{-6}	1.8×10^{-3}	3.3×10^{-6}
Runs 4001-4009	N	8300	2500		
Runs 4510-4514	N			13000	4600
Appendix B	$\frac{\epsilon(T)}{T}$	.382	.155	.378	.170
	$\frac{1}{N} \left(\frac{\epsilon(T)}{T}\right)^2$	1.8×10^{-5}	9.6×10^{-6}	1.1×10^{-5}	6.3×10^{-6}
$\left(\frac{\epsilon(V_M)}{V_M}\right)^2 = \sum \epsilon^2$		1.2×10^{-3}	1.2×10^{-5}	1.8×10^{-3}	1.1×10^{-5}
$\epsilon(V), \%$		4	.5	4	.5

velocity reading, most of the uncertainty of the density reading is due to the statistical fluctuations of the total number of counts, C, used in Eq. 61:

$$\left(\frac{\epsilon(\rho_S)}{\rho_S} \right)^2 = \left(\frac{\epsilon(K)}{K} \right)^2 + \left(\frac{\epsilon(C)}{C} \right)^2 \quad (62)$$

$$\text{Since } C = N - B, \quad (63)$$

where

N = number of gross counts and
B = number of background counts ,

$$(\epsilon(C))^2 = (\epsilon(N))^2 + (\epsilon(B))^2 = N + B, \text{ and} \quad (64)$$

$$\left(\frac{\epsilon(C)}{C} \right)^2 = \frac{N + B}{(N - B)^2}, \quad (65)$$

and the overall uncertainty of the density reading is

$$\left(\frac{\epsilon(\rho_S)}{\rho_S} \right)^2 = \left(\frac{\epsilon(K)}{K} \right)^2 + \frac{N + B}{(N - B)^2} \quad (66)$$

Values for N and B are listed in Tables 2 and 3 (N = COUNTS , B = BKG). The constant K was determined experimentally (see Section 3.6) with an accuracy of about 3.5%.

3.4 Calibration of Water Flowmeters

Besides the PNA data, the only other information available for this report were the water-and air-flow rates, as measured by the loop operator with turbine meters. For calibration runs with water filled pipes (Run Nos. 4YZZ), the flow velocities measured by the loop's turbine meters and by the PNA transit time method can be compared directly.

Since data from the short-spaced detectors are expected to be less accurate than those from the long-spaced detectors (because of the large dimensions of the source and the detector and of their short spacings, see Table 4), the turbine meter readings were first compared with the PNA data

derived with long-spaced detectors:

Table 5 and Fig. 7 show the superficial water flow velocities as derived from the loop flow data, the mass flow velocities as derived by the PNA transit time method, and the difference between these sets of data. With the exception of two runs (Run Nos. 4511 and 4001), the agreement is quite good. The reason for the deviation of these two runs from proportionality must be an error by the loop operator, since the data derived by the PNA transit time method and the data derived independently by the PNA total count method agree quite well (see Fig. 9) and are, therefore, probably correct. The deviation of the turbine meter readings from the PNA derived mass flow velocities are plotted versus the mass flow rate in Fig. 8. This Figure does not include the Runs 4511 and 4001 and shows that, for all other runs, the deviation of the turbine meter readings is different for the two turbines used in the loop. Slow flow rates in the loop (up to 4 l/sec) were measured by a small turbine. Averaging the deviations shown in Fig. 8 shows that the small turbine deviates by $(+ 1.4 \pm 0.7)\%$ from the PNA data.

A large turbine is used in the loop to measure flow rates over 4 l/sec. Averaging the deviations of Fig. 8 indicates that the large turbine deviates by $(+ 5.2 \pm 0.8)\%$ from the PNA data. The accuracy of PNA transit time data is expected to be better than 1% (see Table 4). Therefore, the measured deviation of the turbine meters is believed to be realistic, and all turbine meter measured water flow data were corrected by a factor 0.986 for the small turbine and a factor of 0.948 for the large turbine.

Table 4 shows that, due to the large diameter of the source (.18 m), the large diameter of the detector (.13 m) and the relatively short source-detector spacing (~ 1 m), the accuracy of the short spaced transit time data can not be expected to be high. The accuracy of the two-phase data can be improved by derivation of an effective spacing between the source and the detection from the all-water calibration runs. In Table 6, an effective source-detector spacing of 1.190 m is derived for the 7.5 cm test and an effective source-detector spacing of 1.081 m for the 12.5 cm test. These effective spacings are by 6.1% shorter than the actually measured spacing in the 7.5 cm test (1.27 m) and by 5.4% shorter than the actually measured spacing in the 12.5 cm test (1.14 m).

As shown in Table 7, the mass flow velocities $V_M(S)$ calculated with these effective spacings deviate from the mass flow velocities calculated from the

TABLE 5

COMPARISON OF TURBINE METER READINGS TO PNA TECHNIQUE

RUN#	GPM	ℓ/sec	V _{LS} (m/s)	V _M (m/s)	Δ(%)
4001	1.424	.090	.026	.196	-86.8
4002	13.62	.859	.246	.243	+1.2
4003	25.52	1.610	.461	.452	+2.0
4004	600.	37.853	10.842	10.368	+4.9
4005	13.68	.863	.246	.241	+2.1
4006	27.52	1.735	.497	.488	+1.8
4007	54.43	3.434	.984	.962	+2.3
4008	551.	34.762	9.807	9.127	+7.5
4009	275.	17.349	4.969	4.662	+6.6
4510	33.07	2.086	.250	.253	-1.2
4511	63.6	4.012	.482	.568	-14.4
4512	131.8	8.315	.998	.960	+4.0
4513	528.8	33.361	4.005	3.858	+3.8
4514	301.1	18.996	2.280	2.178	+4.7

Notes:

GPM : Flow velocity measured by loop operator

V_{LS} : Superficial liquid flow velocity, from GPM and pipe diameterV_M : Mass flow velocity, (from Tables 11 and 13)

$$\Delta(\%) : \frac{V_{LS} - V_M}{V_M} \times 100$$

Fig. 7 Comparison of Turbine Meter Readings to PNA Data

Fig. 8 Deviation of Turbine Meter Readings from Mass Flow Velocities

TABLE 6

MASS FLOW VELOCITIES MEASURED BY SHORT-SPACED DETECTORS

RUN#	$v_{LS}^{(1)}$ (m/s)	$\left(\frac{1}{t}\right)^{(2)}$ (m/s)	z_{eff} (m)
4001	.026	.16719	-
4002	.243	.20800	1.168
4003	.455	.38978	1.167
4004	10.278	8.6774	1.184
4005	.243	.20212	1.202
4006	.490	.41367	1.185
4007	.970	.80189	1.210
4008	9.297	7.7331	1.202
4009	4.711	3.9194	1.202
Average, z_0			1.190
4510	.247	.22993	1.074
4511	.457	.52149	-
4512	.946	.86815	1.090
4513	3.797	3.5060	1.083
4514	2.161	2.0105	1.075
Average, z_0			1.081

(1) From Tables 8 and 9

(2) From Tables 2 and 3

TABLE 7

MASS FLOW VELOCITIES BY PNA TRANSIT-TIME METHOD IN WATER-FILLED PIPES

RUN#	(1) $v_M(S)$	(2) $v_M(L)$	$\frac{v_M(S) - v_M(L)}{v_M(L)}$	(3) v_{LS}	$\frac{v_{LS} - v_M(L)}{v_M(L)}$
	(m/s)	(m/s)		(m/s)	
4001	.199	.196	1.5%	.026	-
4002	.248	.243	2.1	.243	.0%
4003	.464	.452	2.7	.455	.7
4004	10.326	10.368	-.3	10.278	-.9
4005	.241	.241	.0	.243	.8
4006	.492	.488	.8	.490	.4
4007	.954	.962	-.8	.970	.8
4008	9.202	9.154	.5	9.297	1.6
4009	4.664	4.662	.0	4.711	1.1
4510	.249	.253	-1.6	.247	-2.4
4511	.564	.568	-.7	.457	-
4512	.938	.960	-2.3	.946	-1.5
4513	3.790	3.857	-1.7	3.797	-1.6
4514	2.173	2.178	-.2	2.161	-.8
Average			.0		-.2

(1) From Tables 10 and 12

(2) From Tables 11 and 13

(3) From Tables 8 and 9

long spacing data, $V_M(L)$, by less than 2.7% in all measured cases, and by 0.0% in the average. The (corrected) flow velocities measured by the turbine meter, V_{LS} , deviate from the long-spacing PNA data by less than 2.4%. Average deviation is 0.2%.

3.5 Two-Phase Measurements by the Transit-Time Method

Mass flow velocities can be calculated from the transit time and the distance between the source and the detector. Transit times $\left(\frac{1}{t}\right)$, calculated according to Eq. 26 by computer and tabulated in Tables 2 and 3, are also listed in the Tables 10 to 13 next to their corresponding mass flow velocities V_M . Average densities (averaged over the length of the pipe) were calculated from the mass flow velocities V_M and the superficial mass flow velocities V_{MS} , according to Eq. 37. The superficial mass flow velocities V_{MS} were calculated from loop operator supplied superficial water-and air-flow velocities, according to Eq. 35. These superficial flow velocities are listed in Tables 8 and 9.

3.6 Two-Phase Measurements by the Total-Activity Method

The relation between local density (at the source location) and the sum of the count distribution weighted transit-times is given in Eq. 46. The proportionality constant K in this equation can be read directly from the column $SUM (1/t) * \rho / NEUT$ of the Tables 2 and 3, for the water calibration runs that have a known density of $\rho = 1$.

Average values for K are derived in Table 14 for the four different test setups (two different pipe sizes and two different spacings). With K known, local densities were calculated for the individual test runs, as listed in the Tables 15 and 16. The accuracy of these local density values can be derived from the accuracy of K (listed in Table 14) and from the total number of counts, according to Eq. 66.

3.7 Measurements by the Total-Count Method

For activity distributions (at the PNA detector) that are not significantly different from normal distributions, there exists an inverse relation between the mass flow velocity and the total number of counts, as shown in Eq. 54. The proportionality constant K governing this relation is the same as the K derived for the calculation of the density from the total

TABLE 8
SUPERFICIAL FLOW VELOCITIES (in m/s)
7.5 cm TEST

RUN #	$V_{LS}^{(1)}$	$V_{LS}^{(2)}$	$V_{GS}^{(1)}$	V_{MS}
4001	.026	.026	0	.026
4002	.246	.243	0	.243
4003	.461	.455	0	.455
4004	10.800	10.238	0	10.238
4005	.246	.243	0	.243
4006	.497	.490	0	.490
4007	.984	.970	0	.970
4008	9.807	9.297	0	9.297
4009	4.969	4.711	0	4.711
<hr/>				
3001	.0222	.0219	.10	.0220
3002	.0250	.0247	.25	.0250
3003	.0249	.0246	.50	.0252
3020	.4970	.490	.10	.490
3022	.4995	.493	1.00	.494
3023	.4995	.493	2.60	.496
3024	.4995	.493	4.66	.499
3025	2.004	1.900	.10	1.900
3026	2.004	1.900	.24	1.900
3027	2.004	1.900	1.00	1.901
3028	2.004	1.900	4.86	1.906
3029	4.987	4.728	.10	4.728
3030	4.987	4.728	.21	4.728
3031	4.987	4.728	1.02	4.729
3032	5.011	4.750	5.11	4.756
3019	.2523	.249	5.11	.255
3018	.2523	.249	1.03	.250
3016	.0970	.0956	4.99	.1016
3006	.0248	.0245	5.01	.0306
3005	.0248	.0245	2.60	.0276

(1) Loop Instrumentation Data

(2) Data corrected according to Paragraph 3.4

TABLE 9
SUPERFICIAL FLOW VELOCITIES (in m/s)

12.5 cm TEST

RUN#	$V_{LS}^{(1)}$	$V_{LS}^{(2)}$	$V_{GS}^{(1)}$	V_{MS}
4510	.250	.247	0	.247
4511	.482	.457	0	.457
4512	.998	.946	0	.946
4513	4.005	3.797	0	3.797
4514	2.280	2.161	0	2.161
3514	.100	.099	.284	.099
3515	.101	.100	1.052	.101
3517	.250	.247	.260	.247
3518	.250	.247	.943	.248
3520	.489	.464	.081	.464
3521	.496	.470	.267	.470
3522	.503	.477	.976	.478
3523	.509	.483	2.515	.486
3524	.496	.470	5.152	.476
3525	2.003	1.899	.083	1.899
3526	1.997	1.893	.239	1.893
3527	1.983	1.880	.967	1.881
3528	1.997	1.893	1.481	1.895
3529	3.972	3.765	.102	3.765
3530	3.993	3.785	.256	3.785
3531	3.966	3.760	.389	3.760
3533	.489	.465	.086	.465
3534	.489	.464	.251	.464
3535	.523	.496	1.017	.497
3536	.498	.472	2.432	.475
3537	.496	.470	4.195	.475

(1) Loop Instrumentation Data

(2) Data corrected according to paragraph 3.4

TABLE 10
AVERAGE DENSITY BY TRANSIT-TIME METHOD,
7.5 cm TEST, SHORT SPACING

RUN#	$V_{MS}^{(1)}$ (m/s)	$\frac{1}{t}^{(2)}$ (s ⁻¹)	$V_M^{(3)}$ (m/s)	$\rho_P^{(4)}$ (g/cm ³)
4001	.026	.16719	.199	-
4002	.243	.20800	.248	.982
4003	.455	.38978	.464	.981
4004	10.238	8.6774	10.326	.991
4005	.243	.20212	.241	1.010
4006	.490	.41367	.492	.995
4007	.970	.80189	.954	1.017
4008	9.297	7.7331	9.202	1.010
4009	4.711	3.9194	4.664	1.010
3001	.0220	.020001	.024	.924
3002	.0250	.035048	.042	.599
3003	.0252	.046388	.055	.457
3020	.490	.46217	.550	.891
3022	.494	1.0289	1.224	.403
3023	.496	1.2097	1.440	.345
3024	.499	1.8163	2.161	.231
3025	1.900	1.6415	1.953	.973
3026	1.900	1.7049	2.029	.936
3027	1.901	2.2260	2.649	.718
3028	1.906	3.8658	4.600	.414
3029	4.728	3.9842	4.741	.997
3030	4.728	4.0910	4.868	.971
3031	4.729	4.6652	5.552	.852
3032	4.756	7.0686	8.412	.565
3019	.255	1.0526	1.253	.204
3018	.250	.56003	.666	.375
3016	.1016	.66483	.791	.128
3006	.0306	.33890	.403	.076
3005	.0276	.11344	.135	.204

(1) From Table 8

(2) From Table 2, Array 1

(3) $V_M = 1.190 \times (1/t)$

(4) According to Eq. 37

TABLE 11
AVERAGE DENSITY BY TRANSIT-TIME METHOD,

7.5 cm TEST, LONG SPACING

RUN #	$V_{MS}^{(1)}$ (m/s)	$\frac{1}{t}^{(2)}$ (s ⁻¹)	$V_M^{(3)}$ (m/s)	$\rho_P^{(4)}$ (g/cm ³)
4001	.026	.032640	.196	-
4002	.243	.040468	.243	1.002
4003	.455	.075471	.452	1.006
4004	10.238	1.7298	10.368	.987
4005	.243	.040175	.241	1.009
4006	.490	.081355	.488	1.005
4007	.970	.16045	.962	1.009
4008	9.297	1.5272	9.154	1.016
4009	4.711	.77786	4.662	1.010
3001	.0220	-	-	-
3002	.0250	-	-	-
3003	.0252	-	-	-
3020	.490	.093967	.563	.870
3022	.494	.17119	1.026	.481
3023	.496	.23983	1.438	.345
3024	.499	.32651	1.957	.255
3025	1.900	.33385	2.001	.949
3026	1.900	.34795	2.086	.911
3027	1.901	.45162	2.707	.702
3028	1.906	-	-	-
3029	4.728	.78911	4.730	1.000
3030	4.728	.81567	4.889	.967
3031	4.729	.94108	5.641	.838
3032	4.756	1.4884	8.921	.533
3019	.255	.20589	1.234	.207
3018	.250	.11048	.662	.378
3016	.1016	.12332	.739	.137
3006	.0306	.071537	.429	.071
3005	.0276	-	-	-

(1) From Table 8

(2) From Table 2, Array 203

(3) $V_M = 5.994 \times (1/t)$

(4) According to Eq. 37

TABLE 12AVERAGE DENSITY BY TRANSIT-TIME METHOD,12.5 cm TEST, SHORT SPACING

RUN 3	V_{MS} (1) (m/s)	$\frac{1}{t}$ (2) (s ⁻¹)	V_M (3) (m/s)	ρ_p (4) (g/cm ³)
4510	.247	.22993	.249	.994
4511	.457	.52149	.564	-
4512	.946	.86815	.938	1.008
4513	3.797	3.5060	3.790	1.002
4514	2.161	2.0105	2.173	.994
3514	.099	.19521	.211	.469
3515	.101	.33112	.358	.282
3517	.247	.33780	.365	.676
3518	.248	1.1108	1.201	.207
3520	.464	1.1848	1.281	.362
3521	.470	1.3922	1.505	.312
3522	.478	2.1216	2.293	.208
3523	.486	3.0942	3.345	.145
3524	.476	3.2515	3.515	.135
3525	1.899	3.7444	4.048	.469
3526	1.893	3.9804	4.303	.440
3527	1.881	4.9301	5.329	.353
3528	1.895	4.9747	5.378	.352
3529	3.765	3.6162	3.909	.963
3530	3.785	3.8080	4.116	.919
3531	3.760	3.8015	4.109	.915
3533	.465	1.1314	1.223	.380
3534	.464	1.3408	1.457	.318
3535	.497	2.2203	2.400	.207
3536	.475	2.8608	3.093	.154
3537	.475	4.7201	5.102	.093

(1) From Table 9

(2) From Table 3, Array 1

(3) $V_M = 1.081 \times (1/t)$

(4) According to Eq. 37

TABLE 13
AVERAGE DENSITY BY TRANSIT-TIME METHOD,
12.5 cm TEST, LONG SPACING

RUN#	$V_{MS}^{(1)}$ (m/s)	$\frac{1}{t}^{(2)}$ (s ⁻¹)	$V_M^{(3)}$ (m/s)	$\rho_p^{(4)}$ (g/cm ³)
4510	.247	.055331	.253	.975
4511	.457	.12409	.568	-
4512	.946	.20980	.960	.985
4513	3.797	.84254	3.857	.984
4514	2.161	.47572	2.178	.992
3514	.099	.054153	.248	.399
3515	.101	.079670	.365	.277
3517	.247	.077304	.354	.698
3518	.248	.16790	.769	.323
3520	.464	.16295	.746	.622
3521	.470	.22686	1.039	.453
3522	.478	.35802	1.639	.292
3523	.486	.72687	3.328	.146
3534	.476	.69725	3.192	.149
3525	1.899	.75912	3.475	.546
3526	1.893	.81613	3.736	.507
3527	1.881	.93317	4.272	.440
3528	1.895	.93662	4.288	.442
3529	3.765	.86397	3.955	.952
3530	3.785	.90149	4.172	.917
3531	3.760	.90994	4.166	.903
3533	.465	.15592	.714	.651
3534	.464	.20249	.927	.501
3535	.497	.36289	1.661	.299
3536	.475	.56246	2.257	.184
3537	.475	.83891	3.841	.124

(1) From Table 9

(2) From Table 3, Array 203

(3) $V_M = 4.578 \times (1/t)$

(4) According to Eq. 37

TABLE 14

THE CONSTANT K

RUN#	$Z_0 = 1.190 \text{ m}$	$Z_0 = 5.994 \text{ m}$
4001	2059	418.3
4002	2006	435.8
4003	2040	416.3
4004	2074	440.2
4005	2112	405.4
4006	1988	413.0
4007	2176	453.7
4008	2106	443.4
4009	2213	425.9
Average	$2086 \pm 74 \text{ } (+3.6\%)$	$428.0 \pm 16.1 \text{ } (+3.8\%)$
4510	2446	445.4
4511	2447	444.6
4512	2634	462.6
4513	2485	476.1
4514	2363	466.2
Average	$2475 \pm 99 \text{ } (+4.0\%)$	$459.0 \pm 13.7 \text{ } (+3.0\%)$

TABLE 15AVERAGE DENSITY BY TOTAL-ACTIVITY METHOD,7.5 cm TEST

RUN#	$Z_0 = 1.190$ $K = 2.086$		$Z_0 = 5.994$ $K = 428.0$	
	$\Sigma C/t$	ρ_D	$\Sigma C/t$	ρ_D
4001	2059	.99	418.2	.98
4002	2006	.96	435.8	1.02
4003	2040	.98	416.3	.97
4004	2074	.99	440.2	1.03
4005	2112	1.01	405.4	.95
4006	1988	.95	413.0	.96
4007	2176	1.04	453.7	1.06
4008	2106	1.01	443.4	1.03
4009	2213	1.06	425.9	1.00
3001	1701.1	.815	-	-
3002	912.0	.437	-	-
3003	802.3	.423	-	-
3020	2049.2	.982	410.2	.958
3022	882.4	.423	142.0	.332
3023	874.1	.419	110.8	.259
3024	538.6	.258	64.6	.151
3025	2035.7	.976	295.2	.690
3026	1772.4	.850	285.8	.668
3027	1386.6	.665	223.0	.521
3028	783.6	.376	-	-
3029	1998.9	.958	433.5	1.013
3030	1909.6	.915	394.6	.922
3031	1690.3	.810	353.9	.827
3032	1246.7	.598	265.7	.621
3019	272.4	.131	38.1	.089
3018	628.2	.301	98.6	.230
3016	164.0	.079	17.6	.041
3006	82.8	.040	7.67	.018
3005	344.6	.165	-	-

TABLE 16

AVERAGE DENSITY BY TOTAL-ACTIVITY METHOD,

12.5 cm TEST

RUN#	Z ₀ = 1.081 K = 2475		Z ₀ = 4.578 K = 459	
	$\Sigma C/t$	ρ_D	$\Sigma C/t$	ρ_D
4510	2446	.99	445.4	.97
4511	2447	.99	444.6	.97
4512	2634	1.06	462.6	1.01
4513	2485	1.00	476.1	1.04
4514	2363	.95	466.2	1.02
3514	926.8	.374	148.9	.324
3515	692.7	.280	69.3	.151
3517	1700.0	.687	271.4	.591
3518	320.2	.129	74.1	.161
3520	1011.5	.428	196.3	.409
3521	939.7	.388	213.7	.466
3522	748.5	.302	142.4	.310
3523	447.3	.181	65.9	.144
3524	130.4	.052	47.1	.103
3525	1233.5	.498	286.0	.623
3526	1108.8	.448	239.2	.521
3527	840.2	.339	190.1	.414
3528	1341.7	.542	293.1	.639
3529	2462.4	.995	461.8	1.006
3530	2488.9	1.006	421.3	.918
3531	2302.2	.930	406.5	.886
3533	1217.5	.492	187.8	.409
3534	839.5	.339	197.2	.430
3535	637.6	.258	115.0	.251
3536	466.5	.188	108.6	.237
3537	257.0	.104	57.5	.125

activity (Eq. 46).

Calibration runs with water filled pipes were found to have activity distributions close to normal (see Appendix B). Therefore, the total count method can be applied to these calibration runs. Using the K's derived in Table 14, and assuming a density of $\rho = 1$ for water filled pipes, the mass flow velocities V_{MC} is calculated by

$$V_{MC} = \frac{Z_o K}{C}, \quad (67)$$

and are listed in Table 17.

A comparison of these velocities derived by the total count method to the velocities derived by the transit time method, V_{MT} , is made in Table 18 and Fig. 9. These two sets of data, derived independently from the transit time and from the total number of counts, agree quite well. In particular, there is a good agreement of the data for the Runs 4001 and 4511, which leads to the conclusion that the PNA derived velocity data are accurate for these two runs. The difference between these PNA derived data and the velocity data recorded by the loop operator, shown in Fig. 7, must therefore be explained by an error in the reading of the loop instrumentation.

4.0 TEST RESULTS

As is common for new techniques, the application of PNA methods to the measurement of two-phase flow has solved some problems but has also revealed the existence of phenomena not previously considered. As anticipated, PNA techniques were found to be useful for the measurement of mass flow velocities and average densities. The major advantage of PNA techniques is that they are not intrusive and not dependent on flow regimes.

The capability of PNA methods to identify flow regimes has also been demonstrated. Figure 10 shows, for example, how more and more mass is being transferred from the liquid phase (moving at lower velocity) to the gas phase (moving at higher velocity), as the amount of air mixed with water is increased in a 7.5 cm pipe.

In Run 3020, the two-phase flow can be described as a homogeneous mixture (bubbly flow), flowing at a uniform velocity. As the amount of air is increased for Run 3021, a slight separation of the two-phase velocities becomes apparent. Run 3022 shows a very distinct slip of the two flow velocities.

TABLE 17

FLOW VELOCITY FROM TOTAL NUMBER OF COUNTS

RUN#	$C^{(1)}$ $Z_O = 1.190$ $K = 2086$	$V_{MC}^{(2)}$	$C^{(1)}$ $Z_O = 5.994$ $K = 428.0$	$V_{MC}^{(2)}$
4001	12870	.193	12922	.199
4002	10034	.247	10856	.236
4003	5402	.460	5552	.462
4004	245	10.132	256	10.021
4005	10857	.229	10149	.253
4006	4964	.500	5107	.502
4007	2800	.887	2845	.902
4008	279	8.897	292	8.786
4009	582	4.265	550	4.664
	$Z_O = 1.081$ $K = 2.475$		$Z_O = 4.578$ $K = 462.4$	
4510	11033	.242	8119	.261
4511	4882	.548	3611	.586
4512	3119	.858	2200	.962
4513	726	3.685	569	3.720
4514	1215	2.202	987	2.145

(1) SUM Y/NEUT., from Tables 2 and 3

(2) From Eq. 53, for $\rho = 1.0$

TABLE 18

COMPARISON OF TOTAL-COUNT VELOCITIES V_{MC} TO TRANSIT-TIME VELOCITIES V_{MT}

RUN #	$V_{MT}^{(1)}$	$V_{MC}^{(2)}$	$\Delta, \%$
4001	.198	.196	- 1.0
4002	.246	.242	- 1.6
4003	.458	.461	.7
4004	10.347	10.077	- 2.6
4005	.241	.241	.0
4006	.490	.501	2.2
4007	.958	.894	- 6.7
4008	9.178	8.842	- 3.7
4009	4.663	4.465	- 4.2
4510	.251	.252	.4
4511	.566	.567	.2
4512	.949	.910	- 4.1
4513	3.824	3.703	- 3.2
4514	2.176	2.173	- .1

AVERAGE DIFFERENCE

- 1.7

(1) Average values from Tables 10 to 13

(2) Average value from Table 17

Fig. 9 Comparison of Total-Count Velocities, V_{MC} , to Transit-Time Velocities, V_{MT}

Fig. 10 Slip of Phase Velocities

The flow regime of this run is probably slug flow with strong interaction of the liquid and the gas phase, and with a large number of water droplets entrained in the gas phase that moves at about three times the velocity of the liquid at the bottom of the pipe. In Run 3024, the flow is again homogenized, and the whole water mass is flowing as mist at a single velocity.

It should be very interesting to study such changes in flow regime in detail, by correlating PNA measured flow distributions with visual observations through transparent pipe sections. Neutron sources with higher output than the 3×10^9 neutrons/pulse available for the present tests should be used, and stronger collimation of the detector should be chosen to enhance the resolution of the measured flow profiles.

Figure 10 is redrawn from data listed in Appendix B. It is interesting to note that Run 3022 did not show phase separation at the long source-detector spacing (5.99 m). This change in flow regimes could be due to the homogenizing effect of the LOFT instrumentation package (see Fig. 3 for geometry), to a change in pressure along the test section, or to both. The implications of changing flow regimes on the PNA technique are discussed in Paragraph 4.2. The limitations of the PNA technique, using presently available equipment, are also discussed in that Paragraph, as well as in Paragraph 4.1.

4.1 Water Flow Measurements

Individual measurements of the flow velocity of water by the PNA transit time method, in pipes 7.5 cm and 12.5 cm in diameter, were found to be accurate to about 2%. Averaging of the velocity measurements performed at different flow velocities reduced this uncertainty to under 1%. Measurements performed on all water calibration runs were sufficiently accurate to calibrate the turbine meters used by the loop operator to measure water flow rates through the test section. The PNA data revealed that the small turbine, used to measure water flow rates up to 4 l/sec through the loop located at the Semiscale facility, reads $1.4\% \pm 0.7\%$ too high. The large turbine meter, used to read higher flowrates, reads $5.2\% \pm 0.8\%$ too high. Mass flow velocity readings taken with the total count method were compared to the readings taken with the transit-time method. The total count method is less accurate than the transit-time method. Its major merit lies in verifications of the transit-

time method in cases where there is a large disagreement between PNA data and velocity data taken by conventional instruments.

The average deviation of total count derived velocity data from transit-time derived data was found to be less than 4%, except in Run 4007 where the difference was 6.7%.

4.2 Two-Phase Flow Measurements

When the present test series was planned, little thought was given to the effects of changes of flow regime over the length of the test section. It was also assumed that, for the writing of this report, density and velocity data taken by the LOFT instrumentation being tested would be available, and that an assessment of the PNA technique, as well as a description of the flow conditions could be based on the LOFT instrumentation data. Unfortunately, to meet program schedules, this report had to be written prior to the availability of the LOFT instrument data (turbine, drag disk, three-beam densitometer). Thus, the only check on the accuracy and validity of the PNA data must be based on comparison of data derived independently by the transit-time method and the total-activity methods of the PNA technique.

The transit-time method measures the mass flow velocity V_P , averaged over the length of pipe between the source and the detector. The average density ρ_P can then be derived from

$$V_{MS} \rho_0 = V_P \rho_P \quad , \quad (68)$$

where

$$\begin{aligned} V_{MS} &= \text{the superficial mass flow velocity, and} \\ \rho_0 &= 1 \text{ g/cm}^3 = \text{density of water.} \end{aligned}$$

The subscript P in Eq. 68 stands for "averaged over length of Pipe". The total activity method measures ρ_D , the average density at the location of the detector, as shown in Section 5. The local mass flow velocity V_D can then be derived from

$$V_{MS} \rho_0 = V_D \rho_P \quad . \quad (69)$$

The subscript D in this equation stands for "averaged over the pipe cross section at the location of the Detector".

In compressible flow, or in two-phase flow with constant average density and uniform flow regime over the length of the test section, the two mass flow velocities derived by these two independent methods should be identical ($V_P = V_D$), as should the two densities ($\rho_P = \rho_D$). This was not found to be the case in the present test series.

The Figs. 11 to 14 are plots of ρ_D , the total-activity derived local densities, versus ρ_P , the transit-time derived pipe-averaged densities, for the two pipe sizes and the two source-detector spacings used in the present test series. These Figures indicate that the agreement between ρ_P and ρ_D is quite good for the short source detector spacings, but that a significant difference can be found at the long spacing. No explanation for the difference in local and average densities, at the long spacings, can be given at the present time. Several explanations are possible, however:

First of all, a change of densities over the length of the test section can be caused by a changing flow regime. In stratified flow, for example, the void fraction could easily change over a length of pipe of 6 m, even if the flow regime would be unchanged.

A second reason for density changes along the test section is found in pressure changes that are likely to exist in the Semiscale water loop. As mentioned in Section 3, air is injected into the mixing nozzle at a pressure of about 5.5 b. The loop terminates in a separation tank which is vented to the atmosphere. Although the pressure was maintained at about 4 b at the location of the LOFT instrument spool, the pressure gradient along the whole test section is not known. Also, the pressure drop across the LOFT instrument spool is not known.

Much time was spent in reviewing the experimental and analytical methods used for the present test series, to assess the possibility that the density difference shown in the Figs. 11 to 14 are not caused by flow conditions in the test section, but are due to incorrect PNA data gathering and/or data reduction methods. No experimental or analytical explanations were found, however, for the apparent density gradient. Among the error sources considered were the reading of the neutron monitor, and the possibility of loss of counts at the leading edge or at the trailing edge of the count distributions shown in Appendix B.

Fig. 11 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 12 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 13 Comparison of Local Density ρ_D to Average Density ρ_P

Fig. 14 Comparison of Local Density ρ_D to Average Density ρ_P

The neutron monitor, a He^3 detector surrounded by 15 cm of paraffin and operated as an ionization chamber, was sensitive to thermal neutrons. It was positioned about 1.5 m from the front of the neutron source. The test section was located between the source and the monitor, close to the source (see Fig. 5). The neutron source was surrounded on all sides (with the exception of the side facing the pipe) by 10 cm of lead and by 15 cm of borated polyethylene. 10 cm of polyethylene were placed between the source and the neutron monitor. It was assumed that this bulk of material surrounding the source would uniformly slow down and scatter the neutrons emitted by the source, independent of the void fraction of the flow in the pipe. Should there have been an effect of the void fraction in the pipe on the reading of the neutron monitor, then the neutron monitor would have read higher for higher void fractions, the normalized total number of counts would appear lower at higher void fractions, and a lower density could indeed have been indicated by the total activity method. If this had been the case, then the local densities read by the short spaced detector and by the long spaced detector should have been reduced by the same factor. However, according to the Figs. 11 to 14, the total activity derived densities are much lower at the long spacings than at the short spacings for both the 7.5 cm and the 12.5 cm tests. In addition, if the indicated density gradients were due to incorrect readings of the neutron monitor, then the error should be larger for the larger pipe (12.5 cm) than for the smaller pipe (7.5 cm). Figs. 11 to 14 show, however, that the opposite is true. Therefore, sensitivity of the neutron monitor to varying void fractions in the test section can be eliminated as cause for the apparent density gradient along the test section.

Exclusion of some fractions of activity from integration according to Eq. 46 could also lead to indicated densities that are lower than the true densities at the detector locations. Such exclusion of activities could be caused, for example, by improper selection of the summation limits L1 and L2 (see Tables 2 and 3). In the present tests, the PNA equipment had to be placed at available locations on the test section. Optimization of source-detector spacings was not possible. Therefore, instead of one optimum spacing, two alternate spacings were used for each test. In the 7.5 cm test, the ratio of the spacings was $5.99/1.99 = 5.0$, and in the 12.5 cm test the ratio of the spacings was $4.58/1.08 = 4.2$. These large ratios (especially the ratio of 5 for the 7.5 cm test) made it somewhat difficult to position

the two count distributions within the 256 channels of the analyzer memory. In many runs of the 7.5 cm test series the trailing edge of the count distributions of the long-spaced detectors was set (visually) quite close to channel 256, the end of the record (see Table 2, Array 203, L2). It is conceivable that in these cases some counts were not recorded by the analyzer and were lost for integration and evaluation.

In the second test series, with the 12.5 cm pipe, not only was the ratio of spacings smaller, but also a deliberate effort was made to place the whole count distribution from the long-spaced detector well within the recorded 256 channels. Doing this, the leading edge of the short-spaced distribution was pushed to rather low channel numbers (see Table 3, Array 1, L1), which could have conceivably resulted in the loss of some counts due to the particular background model used for the background correction of the gross counts, prior to integration (see Fig. 6).

Omission of counts from our data reduction routine does not only affect the total-activity derived densities, but also the transit-time derived velocities. Losses of counts at the trailing edge of the long-spacing distributions and/or losses of counts at the leading edge of the short-spacing distributions should cause an apparent increase of the mass flow velocities at the long spacing and/or an apparent decrease of the mass flow velocity at the short spacing. The ratio of the transit-time velocities measured at the short spacing to the transit-time velocities measured at the long spacing should be less than one. A comparison of the data in the Tables 10 to 14 shows, however, that the opposite is true. Therefore, incorrect selection of the summation boundaries, L1 and L2, can be excluded as a reason for the density gradient indicated in the Figs. 11 to 14.

It is conceivable that some counts could be lost to the data reduction routine employed for this test because of the flow characteristics of certain flow regimes. In annular flow, for example, where most of the mass is entrained in the gas phase, a thin water film could be moving along the wall of the pipe at extremely low velocities, and the short-lived activity ($T_{1/2} = 7$ sec) induced in the film due to neutron activation could have decayed by the time the activated region reached the detectors. This possibility still has to be studied analytically, but it is believed that whenever the water film is so thin as to adhere so tightly to the wall of the pipe, it will not carry a significant fraction of the total mass, and the

mass flow in this film, particularly when the film moves at extremely low velocities, is negligible when compared to the total mass flowing through the pipe. Furthermore, only the runs with the very lowest densities can be expected to have flow regimes that lie somewhere between wavy flow and dispersed annular flow. The intermediate density runs shown in the Figs. 11 to 14 can be best described as elongated-bubble or slug flows. Even if loss of counts due to the slow motion of the film of dispersed annular flow would explain some of the low local densities shown in the Figs. 11 to 14, an explanation for the apparent loss of density at the intermediate density ranges still would have to be found.

Whatever is the reason for the drop of the local densities at the long spacings (be it a drop of pressure or a loss of counts), data gathered by the long-spaced detectors should not be used for comparison with data obtained by the LOFT instrumentation. Only the data gathered by the short-spaced detectors should be used for this purpose. The Figs. 11 and 12 show that the two independent sets of data, evaluated by the transit-time method and the total activity method, are in reasonably good agreement for the short-spaced detectors. Therefore, they are quite likely to be accurate.

The Tables 19 and 20 list V_P , the average velocity derived by the transit-time method and ρ_D , the local density derived by the total activity method, from test data gathered by the short-spaced detectors. Since these two sets of data were derived independently from each other, the product of V_P and ρ_D is only approximately equal to the superficial mass flow velocity V_{MS} , as derived in the Tables 8 and 9:

$$V_{MS} \rho_0 \approx V_P \rho_D \quad (70)$$

where

$$\rho_0 = 1 \text{ g/cm}^3 = \text{density of water.}$$

If desired for comparison with the flow data measured by the LOFT instrumentation, the local velocity V_D and the pipe averaged density ρ_D can be obtained by Eqs. 68 and 69.

The uncertainty of the velocities listed in the Tables 19 and 20 is, according to Paragraph 3.3, a few percent. The uncertainty of the local density values, ρ_D , can be estimated from the spread of the data in the

TABLE 19
MASS FLOW VELOCITIES AND AVERAGE DENSITIES,

7.5 cm-TEST

RUN #	$V_{LS}^{(1)}$ (m/s)	$V_{GS}^{(2)}$ (m/s)	$V_{MS}^{(1)}$ (m/s)	$V_P^{(2)}$ (m/s)	$\rho_D^{(3)}$ (g/cm ³)
4001	.026	0	.026	.199	.99
4002	.243	0	.243	.248	.96
4003	.455	0	.455	.464	.98
4004	10.238	0	10.238	10.33	.99
4005	.243	0	.243	.241	1.01
4006	.490	0	.490	.492	.95
4007	.970	0	.970	.954	1.04
4008	9.297	0	9.297	9.20	1.01
4009	4.711	0	4.711	4.66	1.06
3001	.0219	.10	.0220	.024	.82
3002	.0247	.25	.0250	.042	.44
3003	.0246	.50	.0252	.055	.42
3020	.490	.10	.490	.550	.98
3022	.493	1.00	.494	1.22	.42
3023	.493	2.60	.496	1.44	.42
3024	.493	4.66	.499	2.16	.26
3025	1.900	.10	1.900	1.95	.98
3026	1.900	.24	1.900	2.03	.85
3027	1.900	1.00	1.901	2.65	.66
3028	1.900	4.86	1.906	4.60	.38
3029	4.728	.10	4.728	4.74	.96
3030	4.728	.21	4.728	4.87	.92
3031	4.728	1.02	4.729	5.55	.81
3032	4.750	5.11	4.756	8.41	.60
3019	.249	5.11	.255	1.25	.13
3018	.249	1.03	.250	.666	.30
3016	.0956	4.99	.1016	.791	.08
3006	.0245	5.01	.0306	.403	.04
3005	.0245	2.60	.0276	.135	.16

(1) From Table 8

(2) From Table 10

(3) From Table 15 ($Z_0 = 1.190$)

TABLE 20
MASS FLOW VELOCITIES AND AVERAGE DENSITIES,

12.5 cm TEST

RUN #	V_{LS} (1) (m/s)	V_{GS} (1) (m/s)	V_{MS} (1) (m/s)	V_P (2) (m/s)	ρ_D (3) (g/cm ³)
4510	.247	0	.247	.249	.99
4511	.457	0	.457	.564	.99
4512	.946	0	.946	.938	1.06
4513	3.797	0	3.797	3.79	1.00
4514	2.161	0	2.161	2.17	.95
3514	.099	.284	.099	.211	.37
3515	.100	1.052	.101	.358	.28
3517	.247	.260	.247	.365	.69
3518	.247	.943	.248	1.20	.13
3520	.464	.081	.464	1.28	.43
3521	.470	.267	.470	1.50	.39
3522	.477	.975	.478	2.29	.30
3523	.483	2.515	.486	3.34	.18
3524	.470	5.152	.476	3.52	.05
3525	1.899	.083	1.899	4.05	.50
3526	1.893	.239	1.893	4.30	.45
3527	1.880	.967	1.881	5.33	.34
3528	1.893	1.481	1.895	5.38	.54
3529	3.765	.102	3.765	3.91	1.00
3530	3.785	.256	3.785	4.12	1.01
3531	3.760	.389	3.760	4.11	.93
3533	.465	.086	.465	1.22	.49
3534	.464	.251	.464	1.46	.34
3535	.496	1.017	.497	2.40	.26
3536	.472	2.432	.475	3.09	.19
3537	.470	4.195	.475	5.12	.10

(1) From Table 9

(2) From Table 12

(3) From Table 16 ($Z_0 = 1.081$)

Figs. 11 and 12: For the 7.5 cm test series, the uncertainty is about 0.04 g/cm^3 , and for the 12.5 cm test series the uncertainty is about 0.06 g/cm^3 . These uncertainties are comparable to the uncertainties of three-beam densitometers⁽⁸⁾.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Feasibility of the PNA technique for the measurement of average mass flow velocities and average densities of two-phase flows was demonstrated by tests at an air-water loop with 7.5 cm and 12.5 cm pipes. The PNA measurements were made without interference with the major tests being run at the loop, and without penetration into the pipe.

Basic equations for the derivation of mass flow velocity and average density were derived. The limitations of the PNA technique with presently available equipment were established, and recommendations for improvement of future tests are made as follows:

Basic Equations

The two basic equations applicable to two-phase flow measurements are the transit-time equation (Eq. 18)

$$V_M = Z_o \frac{\int \frac{1}{t^2} C(t) dt}{\int \frac{1}{t} C(t) dt}$$

and the total-activity equation (Eq. 46)

$$K = \frac{1}{\rho_S} \int \frac{1}{t} C(t) dt .$$

These equations were derived from the definition of the average velocity (Eq. 16),

$$V_M = \frac{\int v^2 C(t) dt}{\int v C(t) dt}$$

and from the conservation of activity (Eq. 40):

$$A = \frac{1}{\alpha} \int v C(t) dt .$$

In the derivation of these equations it was assumed that the mass flow velocity V_M and the density ρ_S does not change over the source-detector distance. Under these assumptions, V_M in Eq. 16 is the average mass flow velocity, averaged over the whole length of pipe between the source and the detector ($V_M = V_P$), and ρ_S in Eq. 46 is the local density (averaged over the pipe cross section) at the source.

In situations where there is a change in mass flow velocity and/or density between the source and the detector locations, due to developing flow, the two basic equations have to be interpreted as describing

$$V_M = \frac{\int V_P V_D C(t) dt}{\int V_D C(t) dt} \quad \text{and} \quad (71)$$

$$K = \frac{\rho_D}{(\rho_S)^2} \int \frac{1}{t} C(t) dt, \quad (72)$$

where

V_P = average mass flow velocity, averaged over the length of the test section,

V_D = local mass flow velocity, at the detector location,

ρ_S = local average density, at the source location, and

ρ_D = local average density, at the detector location.

All two-phase PNA tests, particularly tests with steam-water phases (with phase change) must be designed to allow meaningful interpretation of test data in terms of the Eqs. 71 and 72.

Basic Experimental Studies

Controlled experiments should be performed to measure the density gradient along a test section, between the source and the detector. The average density at the detector location can be measured by multiple beam densitometers. The feasibility of determining the average density at the source, by measuring the attenuation of fast neutrons (from the source) in the flowing medium, should be studied.

Basic Analytic Studies

Two possible error sources still must be assessed analytically (or experimentally): First, the diffusion of radioactive N^{16} atoms from the liquid phase into the gas phase must be investigated. Secondly, the error in total mass flow due to the exclusion from measurement of the thin, slowly flowing water film of certain annular flow regimes must be assessed. It is not believed that the accuracy in total mass flow measurements is affected significantly by these two phenomena.

Range of Density Measurements

With the present neutron source, and using one detector, densities down to 0.08 g/cm^3 were measured with an accuracy of $\pm 0.04 \text{ g/cm}^3$. At these low densities, it was necessary to pulse the neutron source about a dozen times while flow conditions were kept constant. Overall time needed for velocity and density measurements at such low average densities is about 15 min. Development of a neutron source with higher output (than the presently available 3×10^9 neutrons/pulse) and with a higher repetition rate (than the presently available 1 pulse/min) will improve the accuracy and speed of low density measurements.

Development of a neutron source having an output of 10^{10} neutrons/pulse is feasible. Even if such sources should not become available in the immediate future, an increase in the neutron fluence could be obtained by increasing the number of sources with yields of 3×10^9 neutrons per pulse. For example, if three simultaneously triggered sources were clustered at the same axial location of a pipe, the measureable density range could be extended by a factor of 3. Another extension of the measureable range could be achieved by using a larger number of detectors and/or larger detectors. For example, if four 12.5 cm diameter detectors were used at the short spacing instead of the single detector in the present test, the measureable range of densities could be increased by another factor of 4. Thus, it should be possible to measure densities down to $0.08/12 = 0.007 \text{ g/cm}^3$ with presently available equipment.

In pipes larger than 12.5 cm, even more than four detectors could be used or, to simplify the problem of summing of counts, a ring-type detector could be designed that completely encircles the pipe. Such a ring detector could be built by using liquid scintillating material and two or more photomultipliers.

Neutron Monitor

A neutron monitor certain not to be affected by variation in void fraction should be used in future tests.

Data Gathering

In future tests, data from multiple detector locations should not be stored in multi-input multiscalers controlled by only one clock. Instead, a separate clock should be used for each detector spacing, and the peak of the count distributions should be placed around channel 80 of a 256 channel memory segment. Not all commercially available multichannel analyzers have the capability of separate timing of the separate inputs to separate multiscaler memory segments.

ACKNOWLEDGEMENTS

Many individuals, from several organizations, contributed to this work. Special thanks are due to L. C. Rutledge (ANL) who wrote the data reduction program listed in Appendix A and who furnished the finished data on which the report is based. Without the support and help of C. Solbrig, A. Baker and E. Feldman (EG&G, INEL) this PNA experiment could not have been performed. The SANDIA Laboratories have loaned us the neutron source used for these tests, and R. C. Dougherty and W. Newman from this organization were very helpful in providing advice in operation of the source.

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APPENDIX A

LISTING OF COMPUTER PROGRAM

This Appendix lists the computer program used for the reduction of test data and for the generation of the Tables 2 and 3 as well as for the background - corrected distribution plots of Appendix B.

COMPILER OPTIONS - NAME= MAIN,OPT=00,LINECNT=57,SIZE=0000K,
SOURCE,ENCUTC,NULIST,MUDECK,LOAD,MAP,NOEDIT,IO,NUNREF

C**

C** THIS PROGRAM IS WRITTEN TO READ RAW DATA TAPES PRODUCED BY THE

C** NO 100 PLUG-IN MAGNETIC TAPE SYSTEM (REF. P. KEHLER)

C** THE TAPE IS ASSUMED TO CONSIST OF SEVERAL FILES EACH FILE BEING

C** TERMINATED WITH A SINGLE END OF FILE MARK. EACH FILE IS ASSUMED

C** TO CONSIST OF SEVERAL RECORDS EACH HAVING A LENGTH OF

C** LESS THAN 800 BYTES. WITH 1 WORD = 3 BYTES, THE FIRST 256 WORDS

C** OF THE RECORD ARE CONSIDERED VALID.

C** THE FIRST RECORD IS ASSUMED TO HAVE A TAGWORD IN THE THIRD

C** WORD (CONTRARY TO THE DOCUMENTATION FOR THE SYSTEM WHICH SAYS THE TAG WORD

C** IS THE SECOND WORD). THE FORMAT OF THE TAG WORD IS HEXADECIMAL.

C** EACH SUBSEQUENT RECORD IS ASSUMED TO BE A SINGLE SPECTRUM

C** OF 256 CHANNELS, EACH CHANNEL TAKING ONE WORD.

C** THE HIGH ORDER BYTE OF EACH DATA POINT IS DISCARDED DUE TO ERRORS

C** ON THE TAPE.

C**

```

ISN 0002      LOG(CAL*1 INP(800),IUT(1024),BTAG(4))
ISN 0003      INTEGER*4 IDATA(256),IDAT1(256),IDAT2(256),IDAT23(256)
ISN 0004      INTEGER*4 ITAG
ISN 0005      EQUIVALENCE (IUT(1),IDATA(1)),(BTAG(1),ITAG)
ISN 0006      COMMON/IGWD/ITAG,NCTS,GAIN,IMDNG
ISN 0007      COMMON/LHTS/TA(6),XNEUT,IRUN
ISN 0008      COMMON/HUNG/ATITLE(12)
ISN 0009      IMDNG=0
ISN 0010      110 READ(5,900,END=800)NSKIP,NFILE
ISN 0011      900 FORMAT(2I5)
ISN 0012      IMUDE=0
ISN 0013      IF(NSKIP.NE.0)GO TO 115
ISN 0015      IF(NFILE.NE.0)GO TO 115
ISN 0017      IMUDE=1
ISN 0018      GO TO 300
ISN 0019      115 CONTINUE
ISN 0020      NEUF=0
ISN 0021      NREC=0
ISN 0022      200 IF(NEND.EQ.NSKIP)GO TO 300
ISN 0024      205 CALL BUFIN(INP)
ISN 0025      CALL CHRN(ICC,NBYTES)
ISN 0026      NREC=NREC+1
ISN 0027      IF(ICC)210,205,230
ISN 0028      210 NEUF=NEUF+1
ISN 0029      NREC=0
ISN 0030      GO TO 200
ISN 0031      230 WRITE(6,901)NEUF,NREC
ISN 0032      901 FORMAT(7H NEUF =,I5,7H NREC =,I5,13H PARITY ERROR)
ISN 0033      GO TO 205
ISN 0034      300 CONTINUE
ISN 0035      IF(NFILE.LE.0)NFILE=1
ISN 0037      IF(IMUDE.EQ.1)NFILE=1000
ISN 0039      C      IF(IMUDE.EQ.1)CALL STRPL
ISN 0040      DO 700 JFILE=1,NFILE
ISN 0040      IF(IMUDE.EQ.1)READ(5,910,END=800)JTAG,GAIN,IPRUC,
```

```

1 (ATITLE(1),I=1,12)
ISN 0042 910 FORMAT(2H,F12.0,15,51,12A4)
ISN 0043 IF (IMODE.EQ.2)IMODE=1
ISN 0045 CALL BUFIN(INP)
ISN 0046 CALL CHKIN(ICC,NBYTES)
ISN 0047 IF (ICC)405,410,415
C 405 WRITE(6,902)NSKIP,JFILE
ISN 0048 405 CONTINUE
ISN 0049 902 FORMAT(8H NSKIP =,15,8H JFILE =,15,12H END OF DATA)
ISN 0050 GO TO 800
C 415 WRITE(6,903)NSKIP,JFILE
ISN 0051 415 CONTINUE
ISN 0052 903 FORMAT(8H NSKIP =,15, 8H JFILE =,15,22H PARITY ERROR IN TAG )
ISN 0053 410 CONTINUE
ISN 0054 IF (NBYTES.GE.774)GO TO 420
C WRITE(6,903)NSKIP,JFILE,NBYTES
ISN 0056 904 FORMAT(8H NSKIP =,15,8H JFILE =,15,14H TAG HAS NBYTES =,15)
ISN 0057 IF (IMODE.EQ.1)IMODE=2
ISN 0059 GO TO 600
ISN 0060 420 CONTINUE
ISN 0061 BTAG(1)=0
ISN 0062 BTAG(2)=INP(7)
ISN 0063 BTAG(3)=INP(8)
ISN 0064 BTAG(4)=INP(9)
ISN 0065 NSPEC=0
ISN 0066 IF (IMODE.EQ.0)GO TO 446
ISN 0068 IF (11AB.NF,JTAG)IMODE=2
ISN 0070 IF (IMODE.EQ.2)GO TO 600
ISN 0072 446 CALL BUFIN(INP)
ISN 0073 CALL CHKIN(ICC,NBYTES)
ISN 0074 NSPEC=NSPEC+1
ISN 0075 IF (ICC)450,455,460
C 450 WRITE(6,906)NSKIP,JFILE,NSPEC
ISN 0076 450 CONTINUE
ISN 0077 906 FORMAT(8H NSKIP =,15,8H JFILE =,15,8H NSPEC =,15,4H EOF)
ISN 0078 GO TO 700
C 460 WRITE(6,909)NSKIP,JFILE,NSPEC
ISN 0079 460 CONTINUE
ISN 0080 909 FORMAT(8H NSKIP =,15,8H JFILE =,15,25H PARITY ERROR IN SPECTRUM,15
1 )
ISN 0081 455 NCTS=NBYTES/3
ISN 0082 NCTS=NCTS-2
ISN 0083 IF (NCTS.LT.250)GO TO 456
ISN 0085 NCTS=250
ISN 0086 456 CONTINUE
ISN 0087 IF (NSPEC.GT.3)GO TO 446
ISN 0089 DO 475 I=1,NCTS
ISN 0090 J=3*(I-1)+1
ISN 0091 K=4*(I-1)+1
ISN 0092 IOT(K)=0
ISN 0093 IOT(K+1)=0
ISN 0094 IOT(K+2)=INP(J+1)
ISN 0095 IOT(K+3)=INP(J+2)
ISN 0096 IF (NSPEC.EQ.1)IDAT1(1)=IDATA(1)
ISN 0098 IF (NSPEC.EQ.2)IDAT2(1)=IDATA(1)

```

```

ISN 0100      475 IF(NSPEC.EQ.1)IDAT3(1)=IDATA(1)
ISN 0102      IF(NSPEC.LI.3)GO TO 446
ISN 0104      DO 477 I=1,NCTS
ISN 0105      477 IDAT23(I)=IDAT2(I)+IDAT3(I)
ISN 0106      IF(IMODE.EQ.1)GO TO 447
ISN 0108      NO=1
ISN 0109      CALL PRINT1(IDAT1,NO)
ISN 0110      NO=2
ISN 0111      CALL PRINT1(IDAT2,NO)
ISN 0112      NO=3
ISN 0113      CALL PRINT1(IDAT3,NO)
ISN 0114      NO=203
ISN 0115      CALL PRINT1(IDAT23,NO)
ISN 0116      GO TO 446
ISN 0117      447 CONTINUE
ISN 0118      NO=1
ISN 0119      CALL PHPTS(IDAT1,NO)
ISN 0120      IF(IPROC.EQ.1)GO TO 448
ISN 0122      NO=203
ISN 0123      CALL PHPTS(IDAT23,NO)
ISN 0124      GO TO 446
ISN 0125      448 CONTINUE
ISN 0126      NO=2
ISN 0127      CALL PHPTS(IDAT2,NO)
ISN 0128      NO=3
ISN 0129      CALL PHPTS(IDAT3,NO)
ISN 0130      GO TO 446
ISN 0131      600 CONTINUE
ISN 0132      ICOUNT=1
ISN 0133      601 CALL HUFIN(INP)
ISN 0134      CALL CHKIN(ICC,NBYTES)
ISN 0135      ICOUNT=ICOUNT+1
ISN 0136      IF(ICC)700,601,602
C602      WRITE(6,1032)NSKIP,JFILE,ICOUNT
ISN 0137      602 CONTINUE
ISN 0138      1032 FORMAT(8H NSKIP =,I5,8H JFILE =,I5,9H ICOUNT =,I5,13H PARITY ERROR
      1)
ISN 0139      GO TO 601
ISN 0140      700 CONTINUE
ISN 0141      GO TO 110
ISN 0142      800 CONTINUE
C      IF(IMODE.EQ.1)CALL DUNEPL
ISN 0143      STOP
ISN 0144      END

```

LEVEL 21.7 (JAN 73)

US/360 FORTRAN H

DATE 78.004/10.56.15

COMPILER OPTIONS = NAMES MAIN,UP=00,LINECNT=57,SIZE=0000K,
SOURCE,EBCDIC,NOLIST,NONECK,LOAD,MAP,RUEDET,10,NURKEF

ISN 0002

SUBROUTINE PHINT(10DATA,NSPEC)

ISN 0003

INTEGER4 IJ(10),IDATA(256),ITAG

ISN 0004

COMMON/TCND/ITAG,NCIS

C ***

C ***

PHINT DATA

ISN 0005

WRITE(6,914)ITAG,NSPEC

ISN 0006

914 FORMAT(1H1,/,1H0,12H TAG WORD = ,28,7H ARRAY (5)

ISN 0007

LCHX=50

ISN 0008

LCI=0

ISN 0009

DO 477 I=1,10

ISN 0010

477 IJ(I)=1

ISN 0011

WRITE(6,912)IJ(I),I=1,10)

ISN 0012

912 FORMAT(1H0,11X,10(16,7X)/)

ISN 0013

KK=(NCIS-9)/10

ISN 0014

DO 476 I=1,KK

ISN 0015

J=1+(I-1)*10

ISN 0016

LEJ=1

ISN 0017

K=J+9

ISN 0018

IF (K.GT.NCIS)K=NCIS

ISN 0019

WRITE(6,911)JL,(IDATA(M),M=J,K)

ISN 0020

LCI=LCI+1

ISN 0021

IF (LCI.LI.LCHX)GO TO 476

ISN 0022

LCI=0

ISN 0023

WRITE(6,914)ITAG,NSPEC

ISN 0024

WRITE(6,912)IJ(I)(MM),MM=1,10)

ISN 0025

476 CONTINUE

ISN 0026

911 FORMAT(5X,15,10(2X,110))

ISN 0027

END

ISN 0028

END

ISN 0029

END

ISN 0030

END

LEVEL 21.7 (JAN 73) (S/300 FIMTAN H) DATE 70.000/10.50.10

COMPILER OPTIONS - NAME= MATN,OPT500,INCH=157,SIZE=0000K,
SOURCE,CHCUC,NULIST,MODECN,LOAD,MAP,NUEDIT,IP,NUMREF

ISN 0002 SUBROUTINE PRP(SIDATA,NSPEC)
ISN 0003 COMMON/LMTS/IA(6),XNEUT,GAIN,INDNG
ISN 0004 DIMENSION XK(256),IDATA(256),DATA(256),RNG(256)
ISN 0005 IF(NSPEC.EQ.1)HEAD(5,100)XNEUT,INDNG,IA(1),J=1,6)
ISN 0006 100 FURMAT(F10.0,7110)
ISN 0007 L1=0
ISN 0008 L2=0
ISN 0009 IF(NSPEC.EQ.1)J1=IA(1)
ISN 0010 IF(NSPEC.EQ.1)J2=IA(2)
ISN 0011 IF(NSPEC.EQ.2)J1=IA(3)
ISN 0012 IF(NSPEC.EQ.2)J2=IA(4)
ISN 0013 IF(NSPEC.EQ.2)J1=IA(5)
ISN 0014 IF(NSPEC.EQ.2)J2=IA(6)
ISN 0015 IF(NSPEC.EQ.3)J1=IA(7)
ISN 0016 IF(NSPEC.EQ.3)J2=IA(8)
ISN 0017 IF(NSPEC.EQ.3)J1=IA(9)
ISN 0018 IF(NSPEC.EQ.3)J2=IA(10)
ISN 0019 IF(NSPEC.EQ.3)J1=IA(11)
ISN 0020 IF(NSPEC.EQ.3)J2=IA(12)
ISN 0021 IF(NSPEC.EQ.3)J1=IA(13)
ISN 0022 IF(NSPEC.EQ.3)J2=IA(14)
ISN 0023 IF(NSPEC.EQ.3)J1=IA(15)
ISN 0024 IF(NSPEC.EQ.3)J2=IA(16)
ISN 0025 IL1=1-2
ISN 0026 IL2=1-2
ISN 0027 C ** CONVERT CHANNEL NUMBER TO INDEX
ISN 0028 IF(11.EQ.0)GO TO 850
ISN 0029 IL1=11+1
ISN 0030 IL2=11+2
ISN 0031 J1=J1+1
ISN 0032 J2=J2+1
ISN 0033 IF(11.LT.2)J1=1
ISN 0034 IF(11.LT.2)J2=1
ISN 0035 IF(11.LT.2)J1=1
ISN 0036 IF(11.LT.2)J2=1
ISN 0037 NCHAN1=J1-1
ISN 0038 NCHAN2=J2-1
ISN 0039 GO 200 I=1,NCHAN1
ISN 0040 K=11+1-1
ISN 0041 IRL=IRL+10*DATA(K)
ISN 0042 200 CONTINUE
ISN 0043 HL=IRL
ISN 0044 KCH=NCHAN1
ISN 0045 BL=HL/KCH
ISN 0046 IL2=IL2-5
ISN 0047 IL2=IL2+1
ISN 0048 IF(11.LT.2)J1=1
ISN 0049 IF(11.LT.2)J2=1
ISN 0050 IF(11.LT.2)J1=1
ISN 0051 IF(11.LT.2)J2=1
ISN 0052 IF(11.LT.2)J1=1
ISN 0053 IF(11.LT.2)J2=1
ISN 0054 IF(11.LT.2)J1=1
ISN 0055 IF(11.LT.2)J2=1
ISN 0056 IF(11.LT.2)J1=1
ISN 0057 IF(11.LT.2)J2=1
ISN 0058 IF(11.LT.2)J1=1
ISN 0059 IF(11.LT.2)J2=1
ISN 0060 IF(11.LT.2)J1=1
ISN 0061 IF(11.LT.2)J2=1
ISN 0062 IF(11.LT.2)J1=1
ISN 0063 IF(11.LT.2)J2=1
ISN 0064 IF(11.LT.2)J1=1
ISN 0065 IF(11.LT.2)J2=1
ISN 0066 IF(11.LT.2)J1=1
ISN 0067 IF(11.LT.2)J2=1
ISN 0068 IF(11.LT.2)J1=1
ISN 0069 IF(11.LT.2)J2=1

PAGE 002

```

ISN 0070      DO 400 (3),NCHAN3
ISN 0071      K=IL3+1
ISN 0072      IHZ=IRZ+IDATA(K)
ISN 0073      400 CONTINUE
ISN 0074      RZ=IRZ
ISN 0075      XCH=NCHAN3
ISN 0076      HZ=RZ/XCH
ISN 0077      GO TO 500
ISN 0078      450 CONTINUE
ISN 0079      RZ=RN
ISN 0080      500 CONTINUE
ISN 0081      IF(RZ.GT.HR)RZ=HR
ISN 0083      IF(RL.GE.PR)GO TO 600
ISN 0085      550 CONTINUE
ISN 0086      HE=0.
ISN 0087      BLAM=0.
ISN 0088      GZ=IGL+IGR
ISN 0089      XCH=NCHAN1+NCHAN2
ISN 0090      HZ=RZ/XCH
ISN 0091      GN TO 700
ISN 0092      600 CONTINUE
ISN 0093      RL=BL-RZ
ISN 0094      BIP=RP-RZ
ISN 0095      IF(RL.LE.0.001)GO TO 550
ISN 0097      HAT=BL/HIH
ISN 0098      RATN=ALOG(RAT)
ISN 0099      DEL=I2-L1
ISN 0100      DELI=DEL*GAIN
ISN 0101      BLAM=RATN/DELT
ISN 0102      XL1=LI
ISN 0103      XI=(XL1-0.5)*GAIN
ISN 0104      XLI=(111)*BLAM
ISN 0105      BE=RL/EXP(XLI)
ISN 0106      700 CONTINUE
ISN 0107      IPL=JLI+1
ISN 0108      IPR=IL2-1
ISN 0109      IHALF=7.24
ISN 0110      IKG=2.0
ISN 0111      DLAM=ALOG((140)/THALF)
ISN 0112      S1=0.
ISN 0113      S2=0.
ISN 0114      K=0
ISN 0115      S3=0.
ISN 0116      S4=0.
ISN 0117      S5=0.
ISN 0118      DO 600 I=IPL,IPR
ISN 0119      K=K+1
ISN 0120      TIMEST=1
ISN 0121      TIME=(TIME-0.5)*GAIN
ISN 0122      BI=EXP((-BLAM*TIME)
ISN 0123      RI=RC*(1+HZ
ISN 0124      SI=SI+HI
ISN 0125      XDAT=IDATA(1)
ISN 0126      S2=S2*XDAT
ISN 0127      WT=EXP(DLAM*TIME)*(XDAT-BI)

```

```

ISN 0128      DATA(K)=XDAT
ISN 0129      BKG(K)=61
ISN 0130      XY(K)=TIME
ISN 0131      S3 = S3 + (WT/TIME)
ISN 0132      S4 = S4 + (W1/(TIME+TIME))
ISN 0133      S5=S5*WT
ISN 0134      800 CONTINUE
ISN 0135      YIELD=S2-S1
ISN 0136      TINV=S4/S3
ISN 0137      PERNS=S3/XNEUT
ISN 0138      PERNS=S5/XNEUT
ISN 0139      NPTS=K
ISN 0140      C CALL PLNIC(DATA,BKG,XX,NSPEC,NPTS)
ISN 0141      GO TO 900
ISN 0142      850 CONTINUE
ISN 0143      YIELD=-0.0
ISN 0144      TINV=-0.0
ISN 0145      PERNS=-0.0
ISN 0146      S3=-0.0
ISN 0147      BLAM=-0.0
ISN 0148      BE=-0.0
ISN 0149      S1=-0.0
ISN 0150      S2=-0.0
ISN 0151      900 CONTINUE
ISN 0152      IF (INDNG.EQ.0)CALL XHONG
ISN 0153      IS1=S1
ISN 0154      IS2=S2+0.5
ISN 0155      WRITE(6,910)IRUN,NSPEC,TINV,PERNS,PERNS,
ISN 0156      1      I62,IS1,HLAM,BZ,BE,      KNEUT,
2      L1,L2,GAIN
ISN 0157      910 FORMAT(1X,2I5,3E12.5,2I4,4E12.5,      2I5,F8.4)
ISN 0158      RETURN
ISN 0159      END

```

LEVEL 21.7 (JAN 73)

US/560 FONTRAN M

DATE 78.004/16.56.18

COMPILER OPTIONS = NAME= MAIN,OPT=00,LINECT=57,SIZE=0000K,
SOURCE,EBODIC,NULIST,NUDECK,LOAD,MAP,NUEDIT,10,NUXREF

```

ISN 0002      SUBROUTINE XMDNG
ISN 0003      COMMON/IGWD/ITAG,NCTS,GAIN,INHNG
ISN 0004      INHNG=1
ISN 0005      WRITE(6,100)
ISN 0006      100 FORMAT(1H1,/,2X,'MON. AP. AY',3X,'TINV',7X,'SUM ',8X,'SUM ',
1              2'8KG',4X,'BLAH',4X,'33',2X,'HE',8X,'7X,'COUNTS',4X,
3X,'L2',3X,'GAIN')
ISN 0007      WRITE(6,200)
ISN 0008      200 FORMAT(23X,'(1/T)*Y/NEUT',4X,'Y/NEUT'/)
ISN 0009      RETURN
ISN 0010      END

```

COMPILER OPTIONS = NAME= MAIN,OPT=00,LINCCNT=57,SIZE=0000K,

SIURCL, EHCUC, NMLIST, NUDECK, LOAD, MAP, NUJEDIT, IO, NUJREF

```

ISN 0002      SUBROUTINE PLNIC(DATA,BKG,XX,NSPEC,NPTS)
ISN 0003      COMMON/ICMU/ITAG,NCIS,GAIN,HDNG
ISN 0004      COMMON/LHTS/IA(6),XHEUT,INUM
ISN 0005      COMMON/HDNG/ATITLE(12)
ISN 0006      DIMENSION XX(250),DATA(250),BKG(250)
ISN 0007      XMAX=0.0
ISN 0008      XMIN=10000.
ISN 0009      YMAX=0.0
ISN 0010      YMIN=0.0
ISN 0011      DO 100 I=1,NPTS
ISN 0012      IF (YMAX,LT,DATA(I)) YMAX=DATA(I)
ISN 0014      IF (XMAX,LT,XX(I)) XMAX=XX(I)
ISN 0016      IF (XMIN,GT,XX(I)) XMIN=XX(I)
ISN 0018      100 CONTINUE
ISN 0019      IBEGIN=-1
ISN 0020      CALL BGNPL (IBEGIN)
ISN 0021      CALL NUHWDN
ISN 0022      ITITLE='GR'
ISN 0023      IXNAME='100'
ISN 0024      IYNAME='100'
ISN 0025      XAXIS=0.0
ISN 0026      YAXIS=10.0
ISN 0027      CALL TITLE(ATITLE,ITITLE,'TIME (SEC)S',IXNAME,'COUNTS',
ISN 0028      I IYNAME,XAXIS,YAXIS)
ISN 0029      XORIGI=XMIN
ISN 0030      YORIGI=0.0
ISN 0031      XSIP=(XMAX-XMIN)/R.0
ISN 0032      YSIP=YMAX/10.0
ISN 0033      CALL GRAF(XORIGI,XSIP,XMAX,YORIGI,YSIP,YMAX)
ISN 0034      CALL NUDECK
ISN 0035      YPUS=10.1
ISN 0036      IMESS=100
ISN 0037      IMARK=-1
ISN 0038      GO TO 950
ISN 0039      CALL CURVE(XX,DATA,NPTS,IMARK)
ISN 0040      IMARK=0
ISN 0041      CALL CURVE(XX,BKG,NPTS,IMARK)
ISN 0042      XPOS=1.0
ISN 0043      CALL MESSAGE('RUN = 5',IMESS,XPOS,YPUS)
ISN 0044      XPOS=2.0
ISN 0045      CALL INTNO(INUM,XPOS,YPUS)
ISN 0046      XPOS=3.0
ISN 0047      CALL MESSAGE('ARRAY = 5',IMESS,XPOS,YPUS)
ISN 0048      XPOS=4.0
ISN 0049      CALL INTNO(NSPEC,XPOS,YPUS)
ISN 0050      IPLOT=0
ISN 0051      CALL FNAME
ISN 0052      CALL ENOPL(IPLOT)
ISN 0053      CALL BGNPL (IBEGIN)
ISN 0054      CALL NUHWDN
ISN 0055      CALL TITLE(ATITLE,ITITLE,'TIME (SEC)S',IXNAME,'COUNTS',
ISN 0056      I IYNAME,XAXIS,YAXIS)
ISN 0057      CALL GRAF(XORIGI,XSIP,XMAX,YORIGI,YSIP,YMAX)

```

```
ISN 0056      CALL NICHEN
ISN 0057      IMARK=-1
ISN 0058      950 CONTINUE
ISN 0059      DO 900 I=1,NPTS
ISN 0060      DATA(I)=DATA(I)-RNG(I)
ISN 0061      IF (DATA(I).LT.0.0) DATA(I)=0.0
ISN 0062      900 CONTINUE
ISN 0063      CALL CURVE(XX,DATA,NPTS,IMARK)
ISN 0064      XPOS=1.0
ISN 0065      CALL MESSAG('RUN = ',IMESS,XPOS,YPOS)
ISN 0066      XPOS=2.0
ISN 0067      CALL INTNO(INUN,XPOS,YPOS)
ISN 0068      XPOS=3.0
ISN 0069      CALL MESSAG('ARRAY = ',IMESS,XPOS,YPOS)
ISN 0070      XPOS=4.0
ISN 0071      CALL INTNO(NSPEC,XPOS,YPOS)
ISN 0072      CALL FRAME
ISN 0073      CALL ENDPL(IPLT)
ISN 0074      RETURN
ISN 0075      END
ISN 0076
```

APPENDIX B

TEST DATA

This Appendix contains tables and plots of the count distributions for the 7.5 cm test and the 12.5 cm test.

The tables are reproductions of the printout of the memory of the multichannel analyzer. The plots are background - corrected count distributions.

Identification of the data of the individual runs is consistent with the identification of runs in the main body of the report. The pages on which data for the individual runs can be found are listed in the Table of Contents of Appendix B.

TABLE OF CONTENTS OF APPENDIX B

Run Number	Array	Pages
4001	1,203	84,85
4002	1,203	86,87
4003	1,203	88,89
4004	1,203	90,91
4005	1,203	92,93
4006	1,203	94,95
4007	1,203	96,97
4008	1,203	98,99
4009	1,203	100,101
3001	1	102,103
3002	1	104,105
3003	1	106,107
3020	1,203	108,109
3022	1,203	110,111
3023	1,203	112,113
3024	1,203	114,115
3025	1,203	116,117
3026	1,203	118,119
3027	1,203	120,121
3028	1	122,123
3029	1,203	124,125
3030	1,203	126,127
3031	1,203	128,129
3032	1,203	130,131
3019	1,203	132,133
3018	1,203	134,135
3016	1,203	136,137
3006	1,203	138,139
3005	1	140,141

TABLE OF CONTENTS OF APPENDIX B (Continued)

Run Number	Array	Pages
4510	1,203	142,143
4511	1,203	144,145
4512	1,203	146,147
4513	1,203	148,149
4514	1,203	150,151
3514	1,203	152,153
3515	1,203	154,155
3517	1,203	156,157
3518	1,203	158,159
3520	1,203	160,161
3521	1,203	162,163
3522	1,203	164,165
3523	1,203	166,167
3524	1,203	168,169
3525	1,203	170,171
3526	1,203	172,173
3527	1,203	174,175
3528	1,203	176,177
3529	1,203	178,179
3530	1,203	180,181
3531	1,203	182,183
3533	1,203	184,185
3524	1,203	186,187
3535	1,203	188,189
3536	1,203	190,191
3537	1,203	192,193

578									
578	57	48	40	41	42	43	42	43	43
57	4	27	61	72	84	107	209	306	581
817	804	1070	1150	1229	1289	1178	1105	989	788
834	500	404	166	371	202	186	140	102	90
81	48	70	88	52	50	38	51	44	36
37	37	16	16	30	34	31	37	26	28
16	28	22	17	15	17	17	21	21	19
16	30	19	19	18	24	20	12	14	22
21	19	19	15	18	18	21	19	16	17
10	16	16	15	19	17	17	21	18	12
10100									
37	17	16	14	14	14	15	9	10	7
8	10	7	5	10	17	10	16	12	19
16	19	15	10	5	11	10	16	17	6
8	14	9	11	11	13	8	15	7	17
10	8	9	10	16	7	16	12	9	13
8	15	12	16	14	11	16	16	11	14
7	8	9	10	8	17	8	9	13	12
11	12	12	12	16	12	11	11	11	9
7	10	7	7	5	8	12	7	10	13
9	8	5	9	42	67	62	62	62	62
10000									
80	56	65	72	62	68	60	20	9	8
14	6	12	9	12	9	11	13	6	10
12	7	9	12	11	9	8	2	12	11
5	7	11	5	16	9	7	7	15	7
10	8	3	3	3	9	12	7	9	9
3	8	7	4	5	8				

4001 Array 1 $\Delta t = .25$

1787									
40000									
1787	4	5	6	6	2	4	5	4	7
5	5	5	5	6	4	2	4	4	7
4	5	6	5	4	7	4	6	3	7
6	7	7	4	2	4	2	5	5	4
5	5	6	2	4	4	4	8	2	4
5	5	5	9	4	7	5	5	2	5
2	8	5	5	6	2	2	6	1	4
3	5	2	3	4	2	5	3	5	5
4	5	3	6	6	5	6	1	4	3
4	5	11	6	9	2	4	3	3	6
06160									
5	4	19	11	17	27	17	25	21	36
37	31	58	59	61	48	74	70	52	59
48	77	62	56	63	45	52	45	48	40
43	45	29	32	41	30	21	25	13	19
11	18	18	15	10	5	15	12	7	7
7	11	4	4	3	4	10	8	6	5
6	5	5	4	2	6	5	3	10	7
5	6	4	2	2	6	4	3	3	7
10	6	3	9	7	1	6	4	8	2
11	7	7	25	3	1	6	1	2	4
40200									
3	1	5	2	4	8	2	20	60	56
5	11	3	4	2	6	5	5	8	9
2	4	6	7	4	2	1	5	8	4
2	6	4	2	7	2	10	3	5	4
6	2	5	4	6	4	0	2	5	2
4	3	8	2	8	4				

4001 Array 203 $\Delta t = .25$

10000	10	14	17	20	25	31	38	43	48
10000	11	14	16	18	21	24	28	32	36
10000	12	15	18	21	25	29	34	39	44
10000	13	16	20	24	29	34	40	46	52
10000	14	17	21	26	31	37	44	51	58
10000	15	18	22	27	33	40	48	56	64
10000	16	19	23	28	35	42	51	60	69
10000	17	20	24	30	37	45	54	64	74
10000	18	21	25	31	39	48	58	69	80
10000	19	22	26	32	41	50	61	72	84
10000	20	23	27	33	42	52	63	75	87
10000	21	24	28	34	43	54	66	78	91
10000	22	25	29	35	45	56	69	82	96
10000	23	26	30	36	47	59	72	86	100
10000	24	27	31	37	49	61	75	90	105
10000	25	28	32	38	51	64	79	94	110
10000	26	29	33	39	53	67	82	98	115
10000	27	30	34	40	55	70	86	102	120
10000	28	31	35	41	57	73	89	106	125
10000	29	32	36	42	59	76	92	109	130
10000	30	33	37	43	61	79	95	112	135
10000	31	34	38	44	63	82	98	115	140
10000	32	35	39	45	65	85	101	118	145
10000	33	36	40	46	67	88	104	121	150
10000	34	37	41	47	69	91	107	124	155
10000	35	38	42	48	71	94	110	127	160
10000	36	39	43	49	73	97	113	130	165
10000	37	40	44	50	75	100	116	133	170
10000	38	41	45	51	77	103	119	136	175
10000	39	42	46	52	79	106	122	139	180
10000	40	43	47	53	81	109	125	142	185
10000	41	44	48	54	83	112	128	145	190
10000	42	45	49	55	85	115	131	148	195
10000	43	46	50	56	87	118	134	151	200
10000	44	47	51	57	89	121	137	154	205
10000	45	48	52	58	91	124	140	157	210
10000	46	49	53	59	93	127	143	160	215
10000	47	50	54	60	95	130	146	163	220
10000	48	51	55	61	97	133	149	166	225
10000	49	52	56	62	99	136	152	169	230
10000	50	53	57	63	101	139	155	172	235
10000	51	54	58	64	103	142	158	175	240
10000	52	55	59	65	105	145	161	178	245
10000	53	56	60	66	107	148	164	181	250
10000	54	57	61	67	109	151	167	184	255
10000	55	58	62	68	111	154	170	187	260
10000	56	59	63	69	113	157	173	190	265
10000	57	60	64	70	115	160	176	193	270
10000	58	61	65	71	117	163	179	196	275
10000	59	62	66	72	119	166	182	199	280
10000	60	63	67	73	121	169	185	202	285
10000	61	64	68	74	123	172	188	205	290
10000	62	65	69	75	125	175	191	208	295
10000	63	66	70	76	127	178	194	211	300
10000	64	67	71	77	129	181	197	214	305
10000	65	68	72	78	131	184	200	217	310
10000	66	69	73	79	133	187	203	220	315
10000	67	70	74	80	135	190	206	223	320
10000	68	71	75	81	137	193	209	226	325
10000	69	72	76	82	139	196	212	229	330
10000	70	73	77	83	141	199	215	232	335
10000	71	74	78	84	143	202	218	235	340
10000	72	75	79	85	145	205	221	238	345
10000	73	76	80	86	147	208	224	241	350
10000	74	77	81	87	149	211	227	244	355
10000	75	78	82	88	151	214	230	247	360
10000	76	79	83	89	153	217	233	250	365
10000	77	80	84	90	155	220	236	253	370
10000	78	81	85	91	157	223	239	256	375
10000	79	82	86	92	159	226	242	259	380
10000	80	83	87	93	161	229	245	262	385
10000	81	84	88	94	163	232	248	265	390
10000	82	85	89	95	165	235	251	268	395
10000	83	86	90	96	167	238	254	271	400
10000	84	87	91	97	169	241	257	274	405
10000	85	88	92	98	171	244	260	277	410
10000	86	89	93	99	173	247	263	280	415
10000	87	90	94	100	175	250	266	283	420
10000	88	91	95	101	177	253	269	286	425
10000	89	92	96	102	179	256	272	289	430
10000	90	93	97	103	181	259	275	292	435
10000	91	94	98	104	183	262	278	295	440
10000	92	95	99	105	185	265	281	298	445
10000	93	96	100	106	187	268	284	301	450
10000	94	97	101	107	189	271	287	304	455
10000	95	98	102	108	191	274	290	307	460
10000	96	99	103	109	193	277	293	310	465
10000	97	100	104	110	195	280	296	313	470
10000	98	101	105	111	197	283	299	316	475
10000	99	102	106	112	199	286	302	319	480
10000	100	103	107	113	201	289	305	322	485
10000	101	104	108	114	203	292	308	325	490
10000	102	105	109	115	205	295	311	328	495
10000	103	106	110	116	207	298	314	331	500
10000	104	107	111	117	209	301	317	334	505
10000	105	108	112	118	211	304	320	337	510
10000	106	109	113	119	213	307	323	340	515
10000	107	110	114	120	215	310	326	343	520
10000	108	111	115	121	217	313	329	346	525
10000	109	112	116	122	219	316	332	349	530
10000	110	113	117	123	221	319	335	352	535
10000	111	114	118	124	223	322	338	355	540
10000	112	115	119	125	225	325	341	358	545
10000	113	116	120	126	227	328	344	361	550
10000	114	117	121	127	229	331	347	364	555
10000	115	118	122	128	231	334	350	367	560
10000	116	119	123	129	233	337	353	370	565
10000	117	120	124	130	235	340	356	373	570
10000	118	121	125	131	237	343	359	376	575
10000	119	122	126	132	239	346	362	379	580
10000	120	123	127	133	241	349	365	382	585
10000	121	124	128	134	243	352	368	385	590
10000	122	125	129	135	245	355	371	388	595
10000	123	126	130	136	247	358	374	391	600
10000	124	127	131	137	249	361	377	394	605
10000	125	128	132	138	251	364	380	397	610
10000	126	129	133	139	253	367	383	400	615
10000	127	130	134	140	255	370	386	403	620
10000	128	131	135	141	257	373	389	406	625
10000	129	132	136	142	259	376	392	409	630
10000	130	133	137	143	261	379	395	412	635
10000	131	134	138	144	263	382	398	415	640
10000	132	135	139	145	265	385	401	418	645
10000	133	136	140	146	267	388	404	421	650
10000	134	137	141	147	269	391	407	424	655
10000	135	138	142	148	271	394	410	427	660
10000	136	139	143	149	273	397	413	430	665
10000	137	140	144	150	275	400	416	433	670
10000	138	141	145	151	277	403	419	436	675
10000	139	142	146	152	279	406	422	439	680
10000	140	143	147	153	281	409	425	442	685
10000	141	144	148	154	283	412	428	445	690
10000	142	145	149	155	285	415	431	448	695
10000	143	146	150	156	287	418	434	451	700
10000	144	147	151	157	289	421	437	454	705
10000	145	148	152	158	291	424	440	457	710
10000	146	149	153	159	293	427	443	460	715
10000	147	150	154	160	295	430	446	463	720
10000	148	151	155	161	297	433	449	466	725
10000	149	152	156	162	299	436	452	469	730
10000	150	153	157	163	301	439	455	472	735
10000	151	154	158	164	303	442	458	475	740
10000	152	155	159	165	305	445	461	478	745
10000	153	156	160	166	307	448	464	481	750
10000	154	157	161	167	309	451	467	484	755
10000	155	158	162	168	311	454	470	487	760
10000	156	159	163	169	313	457	473	490

10000									
1786	268	206	351	121	77	48	33	24	12
12	0	12	10	5	8	10	26	15	34
60	72	107	98	97	94	82	66	62	54
30	31	17	20	23	12	7	8	7	3
17	6	0	8	12	5	4	7	9	5
4	6	5	4	4	4	6	3	5	8
7	4	5	8	8	9	2	3	2	10
0	4	6	10	9	17	4	3	4	8
0	4	6	6	1	14	4	5	4	4
0	9	9	4	6	6	5	4	8	6
10100									
0	2	8	8	2	5	7	1	2	9
0	0	0	0	6	1	8	2	5	4
0	0	0	0	0	0	6	0	9	9
0	0	0	0	0	0	4	10	6	10
0	0	0	0	1	0	8	9	6	5
0	4	4	0	7	7	10	4	6	4
0	10	6	5	11	8	6	5	6	4
0	0	0	10	9	8	9	4	11	1
0	0	0	1	4	5	6	2	13	7
11	6	9	0	10	4	7	6	4	11
10200									
0	6	10	2	7	6	4	3	1	6
0	9	0	6	6	7	8	9	4	8
0	9	4	6	7	6	7	2	4	7
0	0	0	4	8	5	4	7	4	10
0	4	9	1	6	4	5	3	3	3
0	7	5	1	3	2				

4004 Array 1 $\Delta t = .005$

158									
40000									
1178	1419	916	156	70	31	22	15	8	11
2	5	2	1	0	0	0	0	2	0
0	2	2	1	0	0	0	1	1	0
0	2	0	1	1	2	0	0	0	2
0	1	1	2	0	0	0	0	0	1
1	1	0	0	1	0	1	0	0	3
1	2	0	1	0	1	0	2	0	0
1	1	2	0	1	1	3	1	0	0
2	0	0	2	1	1	0	0	1	1
1	1	0	2	0	0	3	1	2	2
40100									
2	4	8	8	12	16	20	29	23	28
45	32	38	43	47	44	44	54	44	54
35	39	37	35	34	22	26	23	20	10
12	8	9	5	4	3	6	4	2	5
1	2	2	1	0	1	0	3	1	1
2	1	3	2	0	1	2	1	1	2
0	1	0	1	1	0	0	1	0	3
0	2	1	0	1	0	0	0	1	0
0	2	1	1	1	0	0	0	0	1
0	0	0	0	1	1	1	0	1	0
40200									
0	1	1	2	2	2	0	0	1	0
0	0	0	0	0	0	0	1	0	0
2	2	0	0	0	0	0	1	2	1
0	1	0	2	0	0	2	0	0	1
1	1	3	1	0	0	1	1	0	0
1	0	0	1	1	3				

4004 Array 203 $\Delta t = .005$

761									
10000									
767	101	41	57	17	23	10	36	31	46
49	59	77	17	27	34	47	43	39	34
30	51	51	69	78	103	125	187	260	326
427	1	696	785	945	1036	1079	1127	1115	1085
1107	989	979	929	979	800	694	574	532	468
422	347	110	376	274	185	178	164	144	92
98	78	77	69	56	61	59	43	60	43
49	41	56	45	32	26	28	30	24	36
25	21	19	27	23	26	24	30	21	16
37	20	17	1	29	19	17	23	21	18
10100									
31	29	20	12	14	17	14	27	18	21
26	17	19	9	17	11	17	11	23	15
46	14	15	19	15	18	14	20	23	22
12	12	18	15	14	13	13	13	15	13
19	11	12	16	14	12	17	14	13	17
17	27	11	16	15	11	9	18	11	16
13	18	13	10	13	13	4	11	15	13
16	10	8	20	16	6	11	15	11	9
6	4	9	11	9	6	11	16	11	13
8	12	14	11	17	18	15	9	9	14
10200									
12	7	9	8	10	9	9	15	15	14
12	12	14	5	14	8	12	10	8	15
10	19	16	9	15	8	11	10	14	17
9	9	11	13	11	7	10	11	15	13
11	11	13	8	9	12	11	15	8	6
13	12	6	12	9	7				

4005 Array 1 $\Delta t = .13$

761									
10000									
2761	46	2	1	5	5	1	1	6	4
4	1	4	7	3	3	5	4	3	5
3	2	0	1	2	3	1	5	2	2
3	3	1	2	6	3	2	1	5	2
3	1	2	7	5	6	4	3	3	2
6	7	3	4	4	5	2	4	1	2
0	4	2	3	2	4	2	3	2	3
3	4	5	7	6	1	4	4	1	4
3	2	5	5	4	6	3	6	0	6
6	3	1	4	4	3	6	7	3	3
40100									
5	1	2	3	6	3	2	3	2	2
1	1	4	3	2	4	4	2	2	1
2	2	3	4	3	5	6	6	1	3
0	2	6	2	5	3	2	3	1	5
1	3	2	5	1	3	5	1	1	3
2	2	1	6	2	4	5	5	6	6
9	12	13	16	16	10	18	29	36	37
34	35	51	55	42	73	52	60	55	61
63	77	77	59	101	87	85	72	94	72
92	83	68	70	92	81	66	74	62	55
40200									
53	59	61	43	56	51	35	44	33	30
34	29	25	33	24	29	20	23	23	13
19	27	13	10	13	10	16	14	9	10
14	6	8	9	5	4	5	17	3	4
9	7	3	4	7	6	11	6	4	5
4	4	8	2	7	5				

4005 Array 203 $\Delta t = .13$

10000									
250	80	37	16	19	21	17	10	16	18
17	12	16	15	16	17	24	31	19	21
22	23	18	34	46	45	75	101	123	188
257	382	367	457	548	544	632	680	662	612
686	594	542	571	478	459	468	349	295	262
226	207	174	144	113	96	82	76	61	57
53	66	76	32	40	32	24	19	17	18
27	19	19	14	12	19	24	15	12	21
20	13	13	20	8	6	10	18	17	16
22	11	11	14	13	13	11	15	16	12
10100									
9	13	9	14	16	15	11	9	15	13
10	16	11	14	12	10	8	15	12	8
15	21	16	14	15	11	7	7	12	15
19	17	15	18	6	8	10	16	8	10
12	17	21	16	12	9	16	7	4	11
8	7	8	9	10	10	13	6	9	14
8	15	12	9	11	9	13	8	4	10
9	6	12	11	16	5	5	8	9	14
12	8	16	10	10	7	12	8	11	13
10	7	6	16	11	6	13	7	15	8
10200									
8	9	6	10	12	12	7	8	7	5
7	15	9	9	10	16	4	6	8	7
8	10	12	10	14	8	10	7	8	4
8	6	9	4	9	5	10	12	12	15
11	5	3	15	9	7	5	4	8	7
4	7	10	11	1	8				

4006 Array 1 $\Delta t = .064$

380									
40000									
2580	19	3	2	0	4	2	4	0	2
2	0	0	0	3	2	5	2	3	1
1	0	2	4	1	2	1	3	1	2
1	1	4	3	1	1	1	4	2	1
2	3	3	2	2	1	0	2	2	1
2	2	2	2	2	2	0	1	1	4
2	1	2	2	2	2	4	1	2	1
3	0	2	2	1	0	1	2	2	4
4	2	1	2	4	1	2	3	5	2
9	1	0	2	1	2	2	2	0	4
40100									
3	2	0	2	1	2	1	1	0	1
2	3	1	0	1	2	2	2	0	0
5	0	1	2	1	3	3	3	0	3
0	1	2	0	3	1	3	1	2	2
1	2	2	0	0	1	5	0	2	0
3	0	3	5	10	3	6	9	1	5
9	6	12	12	18	11	30	22	34	39
42	47	40	60	64	61	74	79	88	87
107	111	115	92	101	109	127	116	108	125
114	119	120	108	121	118	103	103	117	119
40200									
84	74	89	109	82	99	74	82	68	82
68	53	49	34	40	38	32	35	28	31
23	27	19	25	14	18	22	16	12	19
13	9	12	12	3	7	6	10	5	4
7	7	2	6	5	6	2	6	2	5
2	4	0	4	3	5				

4006 Array 203 $\Delta t = .064$

10000	571	18	13	12	5	8	11	13	6
10	14	8	3	13	9	8	6	15	6
8	12	11	9	17	24	32	46	89	124
166	168	268	258	291	350	343	327	310	299
218	254	283	222	252	177	187	149	122	117
100	87	89	56	36	34	33	33	28	12
12	20	11	16	12	8	13	5	8	6
2	6	6	7	3	10	9	5	8	7
12	10	7	4	4	2	14	8	5	7
8	9	7	12	6	5	3	4	3	8
10100									
4	7	11	10	6	4	10	9	9	8
11	8	10	7	10	10	11	8	7	7
6	10	10	9	7	10	11	6	8	8
12	9	9	10	8	8	6	10	7	6
7	4	3	7	9	9	3	7	8	7
8	3	3	5	7	4	5	3	5	8
7	5	4	5	4	15	9	8	8	8
7	7	5	11	7	8	4	6	6	11
7	7	4	6	5	6	5	7	4	2
10200	5	6	10	4	3	8	5	9	7
7	5	1	3	7	5	9	3	5	10
2	3	10	2	3	4	4	8	5	14
6	7	4	3	4	7	6	1	5	2
8	5	7	4	11	1	7	5	6	6
4	9	4	6	3	2	4	8	6	1
5	5	6	4	7	4				

4007 Array 1 $\Delta t = .034$

214									
40000	779	11	2	1	2	0	2	2	0
1344	2	0	2	3	0	1	0	2	1
0	0	0	2	1	0	0	1	1	1
0	0	0	1	0	1	0	0	0	1
1	0	1	0	0	1	0	1	0	1
2	1	0	0	0	1	2	0	1	0
1	2	0	0	0	0	1	0	0	1
2	0	0	0	0	2	0	2	1	0
0	0	2	1	0	1	0	0	2	0
0	1	1	2	0	0	1	0	0	0
0	0	0	0	0	0	2	0	2	4
40100									
1	0	2	2	1	2	0	1	0	1
0	0	1	1	1	2	1	0	0	2
1	0	1	0	1	0	2	1	0	2
2	1	1	0	1	1	0	1	0	1
0	0	1	1	0	2	1	2	4	1
1	2	6	3	2	8	8	7	10	24
12	22	19	30	46	48	49	50	70	49
71	72	71	78	88	78	86	92	90	80
95	98	92	95	88	107	95	116	87	97
86	101	81	65	72	74	54	51	43	64
40200									
60	47	39	28	34	39	35	24	22	22
30	19	15	14	11	8	21	12	7	5
9	11	6	2	3	5	3	3	3	7
6	5	5	3	7	1	1	2	0	2
0	4	1	2	3	3	2	0	0	1
1	2	2	0	1	1				

4007 Array 203 $\Delta t = .034$

781	52	974	780	385	239	140	99	72	38
41	29	26	26	23	20	15	16	16	12
8	12	9	14	10	22	17	27	20	25
30	32	59	85	96	105	118	116	121	124
100	155	118	112	110	88	67	83	65	63
55	36	30	32	20	13	24	21	10	9
12	9	17	6	8	14	15	5	14	7
15	4	11	15	6	10	17	11	10	6
13	9	8	11	14	11	13	10	12	18
9	7	10	5	8	8	7	8	12	7
10100									
12	9	10	7	4	11	10	15	15	8
2	12	7	9	10	7	9	13	7	7
7	7	15	4	2	5	14	6	4	7
10	11	6	10	13	6	9	9	8	10
7	7	7	4	12	9	10	7	7	4
8	18	13	4	3	8	10	10	2	9
6	11	11	9	9	11	8	10	10	6
8	12	10	8	6	10	8	7	8	10
4	7	8	8	3	13	6	6	7	7
10	12	5	9	10	12	15	9	8	7
10200									
10	13	10	14	2	7	9	5	5	8
11	5	5	7	5	7	6	7	8	9
8	13	5	4	10	11	5	10	12	12
11	9	7	8	9	9	7	6	11	8
5	4	8	7	6	9	9	10	14	11
8	11	10	10	9	12				

4008 Array 1 $\Delta t = .0034$

1965									
40000									
1965	2355	897	416	227	122	88	44	35	8
14	7	4	5	8	9	4	6	1	1
4	0	4	1	1	1	4	1	0	2
1	0	1	1	0	1	1	1	1	2
0	0	2	0	0	4	0	2	0	0
2	2	0	2	0	0	0	2	1	3
2	1	2	0	0	0	2	3	0	1
2	4	0	0	0	0	0	1	2	1
2	1	2	1	2	1	1	1	2	0
1	0	0	4	1	1	0	2	1	3
40100									
0	1	1	2	0	1	0	1	1	0
0	0	1	1	1	2	0	0	0	1
0	2	2	1	0	1	1	1	2	1
1	0	0	2	1	0	3	1	2	1
1	0	2	0	0	1	0	0	1	1
2	2	3	2	2	1	0	1	0	2
0	3	1	4	1	7	6	3	7	11
11	8	12	12	14	22	24	27	23	30
38	32	48	39	32	51	53	49	51	55
58	50	43	54	64	59	74	47	59	42
40200									
45	38	42	52	37	37	35	34	39	27
24	22	20	10	20	21	16	15	14	13
13	7	9	3	4	4	5	5	1	1
4	4	3	2	7	4	0	2	2	2
0	7	2	1	4	0	0	3	2	1
0	2	4	2	1	1				

4008 Array 203 $\Delta t = .0034$

1000

100000

4000	1110	381	268	115	56	23	21	19	20
10	14	15	9	13	4	12	8	7	3
10	11	8	13	13	12	22	25	37	51
88	15	17	119	140	191	189	184	184	187
287	221	176	176	167	166	163	123	115	103
82	72	14	38	22	39	30	23	21	10
11	15	12	14	11	14	7	5	8	14
9	17	12	9	9	6	3	11	7	11
5	6	7	12	9	10	12	1	10	9
17	9	6	8	7	6	10	10	4	8
10000									
3	5	6	12	8	3	12	9	9	9
1	4	11	4	5	11	7	9	6	6
1	7	10	7	9	7	12	10	9	4
1	9	9	11	4	12	11	9	8	3
1	4	12	8	8	14	1	8	17	13
10	11	19	4	7	11	9	12	11	8
10	6	6	4	10	3	7	6	10	4
13	6	8	8	11	11	8	10	6	8
7	10	9	15	5	7	8	7	8	9
5	6	6	13	6	7	3	7	10	6
10000									
9	6	10	8	5	9	9	9	5	10
6	8	12	8	11	7	6	7	8	9
11	6	7	4	4	6	9	12	6	10
9	9	8	9	11	7	8	8	5	5
8	6	7	7	5	8	10	8	11	6
10	12	12	2	6	11				

4009 Array 1 $\Delta t = .0067$

.692

40000

2692	2162	450	142	55	24	7	9	6	7
3	2	3	3	1	3	3	1	3	3
0	0	1	1	2	2	2	1	0	1
2	0	0	2	2	2	0	1	0	1
1	2	2	2	1	0	2	0	0	2
0	0	1	1	2	1	4	0	0	0
0	0	0	0	1	0	1	0	2	0
1	0	1	0	0	1	2	0	1	3
1	1	1	0	1	0	0	0	0	0
0	1	1	1	0	1	0	2	3	2
40100									
2	2	2	1	2	0	1	1	4	0
3	3	0	0	2	1	2	1	5	1
0	0	2	0	0	0	1	0	1	1
1	0	1	3	1	1	1	1	0	0
1	2	1	0	1	1	0	1	1	1
1	1	1	1	2	1	0	4	2	4
1	2	4	4	8	7	8	6	11	14
19	26	31	27	41	35	41	39	47	46
53	53	70	68	68	84	81	95	93	74
96	83	83	97	89	82	77	95	79	90
40200									
85	73	82	72	53	56	64	53	46	54
41	36	26	36	18	27	22	11	15	14
18	10	10	13	4	8	7	4	5	5
3	8	5	4	3	5	7	4	1	1
3	4	1	1	5	2	0	2	3	5
2	5	3	1	2	5				

4009 Array 203 $\Delta t = .0067$

542									
10050									
542	172	149	120	120	124	126	124	115	93
100	104	104	94	79	108	79	77	92	78
86	67	81	65	64	72	64	61	52	44
52	59	68	53	53	62	51	69	63	58
71	59	57	49	61	74	56	52	44	61
54	51	61	69	165	94	73	73	65	68
99	90	161	117	95	90	79	77	71	95
91	96	75	77	97	72	77	78	80	51
54	59	49	56	53	48	53	52	45	42
55	46	42	39	42	38	39	39	33	34
10100									
42	30	27	34	34	39	36	41	43	36
39	29	21	24	21	21	17	35	21	29
33	35	25	41	25	36	38	34	23	32
19	35	28	27	23	32	20	38	40	24
21	24	27	21	24	27	36	29	34	34
28	24	21	26	26	23	37	16	26	38
22	24	17	34	34	31	29	24	20	27
25	20	38	30	24	24	23	38	29	33
36	36	28	33	31	24	35	30	21	29
27	30	23	32	31	23	24	24	26	38
10200									
34	36	22	36	36	18	22	36	36	31
40	34	16	21	21	26	18	32	34	31
37	36	35	20	22	34	35	28	26	28
27	28	12	10	10	28	26	25	40	25
31	27	32	22	10	24	34	31	19	27
31	16	19	23	23	28				

3001 Array 1 $\Delta t = .60$

178									
10000									
178	42	56	38	40	38	53	31	37	26
24	37	25	33	34	30	24	20	20	23
30	22	19	19	22	25	23	23	33	75
69	97	69	70	74	96	100	102	78	79
106	76	71	63	73	71	58	53	50	47
54	58	41	51	44	54	47	47	49	38
24	24	27	16	18	28	14	22	18	14
19	15	8	15	8	12	7	9	11	9
8	2	9	10	10	11	8	12	10	5
10	4	11	12	12	14	8	13	12	8
10100									
8	9	4	8	6	9	12	6	9	7
15	7	9	9	9	10	6	3	4	11
6	7	7	8	11	10	6	5	16	9
8	7	6	9	6	14	8	10	14	6
3	5	7	11	3	7	6	8	6	6
9	10	6	11	7	12	10	7	8	9
12	8	7	9	6	10	7	12	11	9
4	4	7	6	6	5	12	5	8	8
6	8	7	8	6	8	9	5	9	7
9	8	7	10	5	7	8	4	10	7
10200									
13	5	7	2	7	5	5	6	9	6
12	6	5	6	7	3	8	6	7	10
7	5	8	11	5	5	9	6	6	8
6	7	5	6	4	5	14	11	7	5
7	8	11	3	7	8	7	5	8	5
10	4	5	6	11	10

10000	177	171	166	25	32	16	17	11	20	18
177	17	16	11	12	25	14	12	11	25	19
17	16	11	12	25	14	12	11	25	19	130
177	171	166	25	32	16	17	11	20	18	612
177	171	166	25	32	16	17	11	20	18	311
177	171	166	25	32	16	17	11	20	18	46
177	171	166	25	32	16	17	11	20	18	22
177	171	166	25	32	16	17	11	20	18	13
177	171	166	25	32	16	17	11	20	18	13
177	171	166	25	32	16	17	11	20	18	10
10000	177	171	166	25	32	16	17	11	20	8
177	17	16	11	12	25	14	12	11	25	10
17	16	11	12	25	14	12	11	25	19	12
177	171	166	25	32	16	17	11	20	18	10
177	171	166	25	32	16	17	11	20	18	7
177	171	166	25	32	16	17	11	20	18	16
177	171	166	25	32	16	17	11	20	18	7
177	171	166	25	32	16	17	11	20	18	7
177	171	166	25	32	16	17	11	20	18	9
177	171	166	25	32	16	17	11	20	18	13
10000	177	171	166	25	32	16	17	11	20	6
177	17	16	11	12	25	14	12	11	25	8
17	16	11	12	25	14	12	11	25	19	11
177	171	166	25	32	16	17	11	20	18	7
177	171	166	25	32	16	17	11	20	18	10
177	171	166	25	32	16	17	11	20	18	8
177	171	166	25	32	16	17	11	20	18	11
177	171	166	25	32	16	17	11	20	18	7
177	171	166	25	32	16	17	11	20	18	10
177	171	166	25	32	16	17	11	20	18	14

3020 Array 1 $\Delta t = .056$

369	136	6	2	1	3	0	2	0	3
10000	1	1	1	1	1	0	1	3	4
2569	1	3	2	1	1	0	2	1	2
1	1	1	1	4	0	0	1	2	1
1	3	1	0	3	1	2	0	3	1
2	1	1	2	1	4	1	0	1	1
2	1	2	0	2	2	3	1	0	3
1	1	3	2	1	0	0	2	1	2
2	0	2	2	2	4	3	2	0	2
2	2	0	2	5	0	3	1	2	1
10000	2	0	1	3	0	1	1	0	2
2	0	2	3	0	2	1	0	0	0
1	1	2	1	4	2	2	4	1	1
0	2	3	1	0	2	5	4	1	2
2	3	2	4	0	1	2	5	0	1
0	2	5	5	5	2	3	4	8	7
12	16	16	17	28	29	41	38	37	48
68	73	67	76	84	103	111	105	104	123
100	107	127	133	132	143	131	117	134	100
107	102	99	95	97	100	90	85	90	80
10000	85	76	76	78	77	63	83	80	81
50	57	45	46	53	43	43	45	30	43
33	31	19	15	16	12	9	22	17	17
11	12	11	9	12	7	5	9	5	8
11	9	11	6	4	7	7	5	3	6
6	1	0	5	6	2				

3020 Array 203 $\Delta t = .056$

100									
10000									
900	720	12	25	19	16	17	21	20	22
19	19	22	16	23	30	54	58	75	102
146	195	177	210	197	194	174	166	162	158
144	169	186	96	93	100	83	95	82	92
90	95	94	79	74	70	60	83	69	65
76	80	103	96	109	113	132	90	101	87
76	49	51	52	42	51	35	38	28	19
36	21	25	26	12	25	17	17	7	24
11	24	13	13	15	5	16	11	23	16
17	24	16	12	14	8	20	17	10	14
10100									
16	11	12	11	15	13	14	13	18	8
19	10	9	8	12	12	13	7	8	15
9	16	10	16	15	10	15	19	11	13
17	17	17	10	12	10	8	9	15	15
3	12	3	16	4	11	15	16	11	10
14	17	15	16	10	17	8	16	11	12
12	8	12	15	15	11	18	15	13	12
8	9	10	6	11	13	12	8	13	8
8	12	10	5	8	15	16	14	15	9
17	11	10	12	11	10	14	9	3	9
10000									
10	11	14	9	17	11	8	12	13	13
0	9	14	4	10	16	15	9	8	14
9	5	12	9	11	10	10	7	12	12
9	12	9	8	12	9	5	11	9	11
10	12	13	5	15	12	10	14	11	15
6	17	16	8	14	11				

3022 Array 1 $\Delta t = .035$

3633									
40000									
3633	421	8	2	2	1	0	0	2	2
0	2	2	0	1	0	2	0	0	0
1	1	2	3	2	0	0	2	1	0
1	1	2	1	4	2	1	2	1	0
2	0	1	0	1	2	2	3	4	5
3	1	3	3	2	0	1	1	0	1
5	2	1	1	1	3	5	3	2	0
5	2	1	2	3	2	5	1	1	4
4	5	3	1	2	3	4	6	1	4
3	2	3	6	2	5	1	1	6	1
40100									
4	6	8	4	8	8	9	3	5	7
7	9	6	4	7	3	5	4	5	4
8	10	11	5	8	15	8	8	11	8
10	8	5	7	10	9	12	15	11	15
20	14	13	11	18	15	15	20	24	17
26	18	25	18	19	25	25	23	29	23
32	28	21	37	31	33	34	26	41	36
30	39	39	41	45	39	34	32	39	21
29	30	17	31	38	38	48	32	49	44
55	34	36	33	27	44	31	31	20	28
40200									
28	24	27	17	26	14	10	11	11	13
17	8	17	14	20	16	12	15	17	12
10	3	10	9	7	4	5	5	6	7
0	5	3	3	0	3	2	3	2	3
2	5	3	0	2	3	2	1	3	2
1	1	2	2	2	3				

3022 Array 203 $\Delta t = .035$

10000									
10000	1700	167	37	24	26	19	21	15	28
16	21	10	17	20	28	20	33	18	55
46	51	79	84	96	100	120	168	173	193
236	271	321	361	359	218	230	230	266	238
198	190	173	196	184	198	154	126	130	124
100	119	91	83	78	66	73	64	46	45
31	46	17	24	24	29	21	22	15	24
37	27	26	24	22	16	21	16	21	20
20	15	17	12	18	21	17	23	25	18
19	13	13	14	24	10	14	15	13	20
10100									
22	21	17	18	18	8	26	22	19	20
17	14	10	10	15	14	17	11	16	20
12	17	16	10	17	15	31	26	15	19
11	26	9	13	20	16	11	14	17	15
10	19	16	13	21	16	20	21	20	19
15	33	12	17	12	15	22	18	15	13
13	14	12	16	16	11	15	12	17	15
17	24	16	13	7	18	19	12	19	23
15	11	12	21	14	16	10	16	14	18
12	15	14	20	21	17	18	14	10	15
10200									
11	15	12	12	15	6	19	15	15	16
18	19	19	17	15	17	9	21	18	16
17	20	21	12	8	12	12	24	16	15
17	23	14	15	20	14	12	21	20	15
21	14	15	12	17	18	12	18	11	17
12	19	11	9	21	17				

3023 Array 1 $\Delta t = .025$

1786									
40000									
4786	1684	42	11	4	2	1	1	2	1
2	3	2	1	1	1	1	1	4	1
0	0	1	0	3	2	2	2	2	3
2	1	3	2	2	1	1	3	1	1
3	2	4	3	5	3	2	0	2	3
3	3	2	3	2	0	2	2	3	3
1	1	1	0	5	3	3	2	4	3
3	5	7	8	5	2	6	6	5	4
4	3	6	5	5	2	0	3	6	2
2	5	9	3	5	1	4	1	3	2
40100									
3	4	4	7	8	2	8	5	3	5
3	6	7	5	4	4	8	9	7	9
6	11	9	11	7	4	4	5	8	10
10	7	9	12	8	10	11	9	11	13
10	10	18	13	16	17	25	14	16	14
17	20	24	24	32	30	36	40	56	31
37	48	37	50	52	49	65	40	60	52
49	36	45	54	45	50	38	32	36	33
36	37	35	43	23	29	24	34	28	36
39	32	45	27	28	26	22	21	28	19
40200									
15	22	18	18	21	24	15	12	14	14
10	16	10	13	9	7	12	11	11	11
12	9	10	10	9	8	10	3	7	5
0	5	5	5	2	2	8	5	5	2
2	5	6	2	6	3	2	5	0	2
3	2	4	2	3	3				

3023 Array 203 $\Delta t = .025$

5757									
10000									
5757	20007	277	56	46	46	29	30	19	28
29	51	31	46	43	49	38	49	60	63
71	103	97	117	150	128	121	159	137	166
177	184	177	189	160	189	161	173	138	142
174	117	54	117	106	70	100	80	78	81
75	56	16	57	50	40	49	36	40	35
26	21	23	27	35	31	27	21	19	28
31	24	19	22	28	31	24	35	24	29
19	23	27	22	22	32	28	23	26	27
25	29	71	23	26	21	34	29	19	23
10100									
28	38	29	33	26	23	19	31	22	26
19	27	35	29	19	28	77	33	24	24
28	20	7	19	34	30	14	21	27	22
36	19	14	31	27	17	28	38	20	26
19	36	36	37	18	30	16	21	22	18
72	22	30	17	27	27	26	22	19	19
22	38	25	24	23	25	18	19	28	21
22	22	33	31	23	16	15	23	16	18
17	30	25	21	27	20	12	25	24	21
25	20	18	22	18	16	24	26	19	23
10200									
28	21	20	19	17	11	16	20	25	25
19	26	19	12	17	25	23	27	22	20
19	15	14	21	19	22	16	20	32	16
18	19	23	29	18	14	20	16	28	21
29	17	18	21	20	15	26	15	21	26
24	25	21	26	13	22				

3024 Array 1 $\Delta t = .020$

7770									
40000									
7770	2013	94	18	11	4	6	7	9	2
6	2	2	2	8	4	1	4	3	3
2	2	0	1	4	4	1	1	3	4
4	3	4	0	1	3	0	0	3	3
2	2	2	5	4	7	3	4	2	5
5	4	8	5	4	4	5	5	5	6
4	7	6	5	4	3	2	5	9	5
4	7	3	5	5	1	2	3	5	4
5	4	1	2	1	3	2	4	1	4
3	3	3	3	4	8	4	4	4	3
40100									
4	2	4	3	6	10	10	8	4	6
11	7	8	5	8	8	6	14	8	13
10	9	10	9	4	6	13	13	7	11
14	19	7	10	19	16	16	20	22	30
21	23	26	25	27	18	29	26	28	28
29	39	27	34	34	26	38	25	24	41
32	34	35	58	43	42	34	40	48	30
32	32	26	31	24	23	22	13	17	13
20	19	15	18	17	13	6	23	14	22
16	15	11	15	17	4	15	14	14	14
40200									
11	16	11	12	8	7	3	6	9	15
8	6	4	11	4	3	2	1	6	3
2	3	4	0	6	6	3	4	1	4
4	2	5	1	1	1	4	3	4	2
5	1	1	1	1	9	5	5	3	2
2	3	2	2	1	4				

3024 Array 203 $\Delta t = .020$

10000	270	110	10	20	11	12	5	11	6
8	10	5	4	7	7	7	7	12	6
10	5	11	15	10	20	20	40	54	67
110	170	160	191	200	204	204	200	200	267
270	100	107	105	160	170	120	125	100	76
70	10	10	10	10	10	10	27	10	11
10	11	11	11	12	13	0	5	0	5
10	10	10	7	6	9	9	11	12	7
10	10	10	4	10	6	7	10	6	11
10	0	0	10	0	0	6	6	0	0
10100	0	0	0	9	9	11	7	6	0
11	0	0	0	1	0	0	11	4	0
0	0	0	0	0	0	0	0	0	11
10	0	0	0	0	0	10	0	11	6
0	0	0	0	11	10	10	11	0	5
0	0	0	0	0	0	0	0	0	4
0	0	0	0	0	11	4	4	7	7
0	0	0	0	0	0	0	11	7	7
0	0	0	10	0	0	9	12	0	9
14	11	0	7	4	0	0	13	5	4
10000	0	0	0	7	0	9	9	10	0
10	4	0	0	0	0	9	0	5	10
10	14	0	0	0	7	4	0	5	7
0	0	0	0	0	0	5	0	6	7
0	0	0	0	0	0	0	4	7	0
0	4	4	7	9	5	0			

3026 Array 1 $\Delta t = .016$

3201	662	64	10	5	1	2	3	1	0
40000	2	1	1	2	0	1	2	1	2
3	1	0	2	0	0	0	1	0	1
0	1	0	0	0	2	0	3	0	0
0	1	0	2	0	2	1	0	0	0
1	2	2	2	0	2	2	1	1	2
0	1	2	2	1	1	0	0	0	3
2	0	0	2	1	0	1	1	2	1
1	1	0	0	0	0	0	0	0	1
1	0	1	1	0	1	0	0	0	0
40100	0	2	0	1	2	2	0	0	0
0	2	0	0	2	1	0	1	2	1
0	0	2	2	0	1	2	1	0	2
0	0	0	4	1	1	1	1	0	2
3	1	0	0	1	2	3	2	2	0
4	5	1	11	9	7	10	15	20	18
20	26	24	44	35	47	50	54	63	62
80	81	92	85	92	82	80	84	74	81
77	85	83	73	75	72	65	66	60	59
62	60	53	43	54	46	29	36	20	27
40200	22	20	23	24	15	12	12	14	10
4	18	16	8	10	7	7	5	9	5
6	0	2	7	5	2	9	5	5	2
5	4	2	5	2	3	0	5	2	5
2	5	4	2	1	3	1	3	4	1
2	4	3	3	3	1				

3026 Array 203 $\Delta t = .016$

100000									
995	1785	245	175	49	16	11	22	20	23
19	16	14	11	19	10	10	11	25	21
21	27	19	25	32	16	26	25	30	34
43	25	25	32	109	121	146	162	166	183
238	115	121	217	206	184	187	189	187	155
100	106	112	119	112	94	86	95	78	74
57	54	57	51	54	27	18	22	31	22
19	24	15	21	22	11	17	18	13	12
12	11	16	19	19	14	14	14	8	22
17	15	8	15	12	17	16	11	9	8
10100									
15	19	10	15	9	10	17	18	16	7
12	17	14	11	27	12	12	19	20	13
14	17	15	8	17	16	6	27	15	22
19	17	16	10	22	16	14	20	12	18
17	19	16	16	8	21	9	16	19	15
26	16	17	21	12	11	18	15	17	9
15	16	14	12	19	16	21	14	12	17
19	16	15	6	16	16	12	15	15	17
12	16	11	14	6	16	17	12	8	16
18	20	18	8	16	16	8	12	17	18
10200									
18	11	10	11	10	16	10	16	13	11
16	21	16	15	14	11	14	12	8	13
11	14	13	14	12	9	19	16	12	10
12	12	11	15	15	15	12	13	13	11
18	11	12	17	12	10	10	11	15	13
15	13	12	15	13	9				

3027 Array 1 $\Delta t = .011$

3275									
40000									
3275	2253	244	61	26	16	11	5	2	2
2	2	2	2	2	4	5	5	2	5
5	2	2	2	4	1	2	2	5	1
2	4	2	1	2	2	2	2	4	3
1	7	4	1	2	1	1	1	2	1
1	1	3	0	2	1	1	1	1	2
7	2	4	9	2	2	2	4	0	1
1	2	1	1	2	3	1	4	1	1
0	4	2	0	1	0	0	4	4	2
2	8	2	1	1	2	2	2	1	1
40100									
2	2	0	1	0	2	1	4	1	3
2	3	2	2	2	3	2	1	1	4
1	2	2	1	4	1	1	0	2	4
1	1	1	3	1	2	4	2	3	4
1	2	2	0	2	2	2	2	0	4
0	4	4	4	4	4	6	3	3	6
0	7	7	2	5	0	21	10	14	12
9	11	17	16	14	17	24	21	28	13
24	22	25	29	40	39	45	39	52	56
71	40	69	51	52	58	73	59	68	71
40200									
72	72	69	72	64	54	82	76	55	63
69	63	64	64	70	56	48	58	51	48
52	45	41	29	38	33	27	36	27	26
18	19	22	10	10	11	8	11	13	9
5	9	6	4	5	7	7	9	5	4
6	7	6	2	6	6				

3027 Array 203 $\Delta t = .011$

544									
10000									
544	1441	1866	691	336	156	96	57	56	38
41	28	29	24	23	31	24	20	18	26
24	21	20	21	32	30	35	29	34	40
46	49	59	45	62	75	83	78	105	93
17	100	91	104	119	112	130	99	94	100
112	101	95	89	92	92	84	75	75	72
67	53	48	57	47	48	66	42	42	27
36	30	32	43	23	28	29	25	33	29
38	27	28	23	19	26	29	27	25	18
14	29	19	22	16	22	26	21	25	27
10100									
20	38	28	18	17	18	20	27	24	25
20	22	23	32	25	31	26	20	26	28
27	19	23	23	22	14	13	21	26	32
12	16	21	27	19	19	20	25	24	12
21	24	20	10	15	22	23	36	24	24
13	32	19	22	24	21	25	21	29	29
14	28	26	32	18	29	25	22	25	20
28	21	21	32	26	21	25	19	23	19
17	21	16	18	18	26	18	30	18	22
22	11	16	21	23	14	12	13	16	30
10200									
24	24	15	27	19	18	26	20	14	22
28	19	26	19	16	22	18	18	18	27
28	20	22	23	23	20	20	29	19	29
24	23	20	17	15	21	20	14	23	17
14	16	26	19	32	26	20	32	21	23
18	17	11	16	18	27

700

10000

700	111.8	108	266	191	48	33	26	10	13
10000	11	9	11	9	11	9	8	10	9
10	18	21	16	17	22	35	30	36	61
87	167	156	166	199	211	183	208	266	177
182	191	190	117	136	114	90	77	61	50
46	32	27	23	23	17	18	12	15	15
12	18	10	7	6	10	8	15	10	5
2	5	12	18	7	5	11	15	5	7
14	12	11	7	8	15	6	9	10	11
5	9	12	7	10	12	4	8	8	14
10000									
7	10	15	7	6	8	9	12	5	10
11	7	12	12	16	10	8	11	20	8
4	6	11	5	8	11	4	8	8	10
17	16	7	5	9	7	12	10	5	11
5	6	9	6	16	10	12	10	11	5
12	8	7	8	5	6	6	10	6	14
5	16	9	12	9	7	7	6	14	9
10	2	7	12	13	14	10	8	13	8
6	7	2	8	8	6	7	8	8	11
8	8	13	5	11	13	10	12	11	9
10000									
8	11	9	8	7	12	13	8	7	14
5	10	9	9	8	9	11	6	10	7
9	15	14	8	15	4	9	8	4	5
4	12	4	8	12	11	6	10	8	12
10	4	9	2	10	6	11	7	9	9
4	8	9	6	13	10				

3029 Array 1 $\Delta t = .007$

2407

40000

2407	2267	438	125	54	20	8	7	4	3
2	1	3	3	1	5	0	3	1	3
2	2	1	0	1	2	0	2	2	1
0	2	0	2	0	1	1	2	0	1
5	2	4	3	0	4	2	0	2	2
1	1	3	2	2	2	0	0	1	3
1	0	1	1	1	3	1	0	1	3
3	0	0	2	0	1	1	0	1	0
2	0	1	3	1	0	3	1	1	0
1	1	1	1	0	0	1	0	1	5
40100									
2	2	1	0	2	1	3	0	0	0
3	1	3	0	2	1	1	1	2	0
1	1	1	3	4	5	1	2	1	1
0	2	2	1	0	2	3	2	0	0
1	2	3	1	0	2	2	2	4	2
1	2	8	5	5	7	7	11	10	11
11	21	21	17	34	38	38	39	49	64
61	53	73	83	76	87	92	88	113	94
106	91	93	104	105	80	91	84	82	86
85	62	60	62	51	62	47	47	34	35
40200									
30	35	24	32	15	21	23	22	15	11
10	8	11	7	10	7	5	10	2	7
4	1	3	5	1	5	5	1	6	4
2	1	0	2	3	1	3	7	0	1
2	2	0	2	0	2	1	1	1	3
0	1	5	1	2	1				

3029 Array 203 $\Delta t = .007$

100000	996	996	996	111	46	36	27	24	15
375	10	18	12	12	8	11	11	13	10
17	14	15	14	20	23	33	42	51	57
11	138	162	176	202	214	193	189	173	153
409	142	134	117	82	78	70	54	59	40
70	25	13	21	18	12	12	13	17	9
17	7	9	5	3	8	10	12	16	6
7	19	15	6	11	3	7	14	8	7
10	7	16	8	6	6	11	2	10	8
9	9	11	10	9	9	16	2	14	2
100000	6	8	12	7	7	10	9	11	9
9	11	11	6	6	9	5	7	6	8
17	15	13	3	9	7	8	9	14	6
9	9	17	16	6	14	13	11	8	7
9	14	14	10	7	9	9	9	6	2
9	9	6	9	7	11	6	10	5	8
5	12	11	12	15	7	11	10	6	6
9	11	2	9	3	5	9	7	9	9
10	8	7	11	14	5	5	11	13	6
8	10	14	2	12	5	10	5	10	7
100000	10	4	12	7	14	6	5	8	7
10	10	5	9	14	7	7	9	9	12
7	7	14	9	10	13	10	8	10	7
3	3	6	6	5	2	5	10	2	6
3	12	7	13	8	11	8	8	13	8
6	12	7	8	10	3				

3030 Array 1 $\Delta t = .007$

2006	2436	450	143	63	26	11	8	4	5
40000	4	3	2	1	2	2	2	1	1
2006	1	1	4	2	2	2	3	1	1
7	1	2	2	4	0	0	0	1	4
0	0	1	0	1	2	1	1	0	5
3	1	3	0	2	4	2	0	2	2
4	2	1	0	2	0	0	0	0	0
0	1	2	0	0	1	1	2	1	0
0	2	2	3	1	1	1	0	2	2
1	0	1	0	1	0	0	2	2	3
2	0	1	0	1	0	0	2	2	3
40100	1	0	1	2	1	0	0	3	1
3	1	3	0	2	1	5	3	0	0
1	1	2	0	1	3	2	0	3	0
0	4	0	0	0	1	2	0	2	1
2	3	1	2	4	1	1	3	4	2
1	7	8	17	8	18	25	20	33	45
8	34	39	55	62	69	65	63	66	65
37	76	75	74	79	78	89	71	75	68
71	67	67	70	66	60	64	50	58	50
69	48	37	28	38	28	26	19	13	15
47	40200	14	16	8	13	9	3	6	5
25	6	6	5	4	2	2	2	3	1
6	2	2	7	0	3	3	6	2	2
2	3	3	3	1	1	1	3	4	1
1	1	2	1	0	1	0	2	3	0
2	1	0	1	3	1				

3030 Array 203 $\Delta t = .007$

10000									
460	209	1701	478	210	95	63	33	23	31
27	18	17	14	17	12	12	17	11	20
14	18	22	11	27	32	36	39	69	68
90	107	119	152	170	177	186	166	166	159
148	160	121	122	110	98	80	76	63	45
55	41	42	35	39	36	22	17	18	25
18	12	19	17	12	12	8	14	14	11
9	9	19	19	17	13	13	11	16	11
12	14	13	10	13	13	10	10	9	16
16	15	10	12	14	14	11	14	15	12
10100									
10	14	14	7	7	16	14	18	9	9
10	11	22	17	16	12	11	11	16	11
10	12	12	10	17	16	4	12	13	11
13	11	15	11	17	14	7	22	18	11
10	12	14	17	11	16	14	17	8	14
17	14	10	11	12	12	13	14	10	20
9	13	12	13	11	8	12	8	11	10
6	12	10	15	13	5	8	17	14	12
11	6	12	16	12	7	13	21	11	14
9	5	10	14	10	13	7	12	9	16
10200									
17	10	16	8	12	16	17	11	15	9
12	9	13	10	12	10	11	16	13	18
19	12	16	13	9	15	10	10	11	17
15	11	8	12	11	12	8	12	13	10
12	6	10	13	7	10	15	13	15	16
6	11	4	11	16	19				

3031 Array 1 $\Delta t = .006$

2494									
40000									
2494	2002	696	220	99	50	27	18	6	6
10	3	2	6	5	3	6	6	2	2
3	3	0	1	2	2	2	5	2	3
4	1	0	2	2	0	1	1	1	1
3	1	3	3	2	3	4	2	2	4
0	1	0	4	1	3	2	4	0	1
2	5	1	4	2	0	2	1	2	2
0	0	0	0	1	1	0	1	1	5
0	2	3	2	2	1	0	0	0	6
1	1	0	2	0	2	1	0	2	0
40100									
0	2	1	2	0	1	1	0	2	2
1	1	1	3	3	1	1	1	2	1
2	3	0	1	1	0	1	3	2	2
1	1	1	0	1	2	0	0	4	1
3	1	3	2	0	4	6	5	4	7
5	12	13	22	16	13	22	25	23	26
36	44	35	36	60	47	59	62	64	75
46	58	72	70	53	62	73	75	66	77
68	72	71	63	58	53	73	49	53	48
37	31	37	35	39	37	26	36	27	16
40200									
20	20	14	22	18	15	17	15	18	10
11	13	5	10	9	11	13	5	8	8
6	4	7	3	7	6	6	5	3	6
4	2	4	3	2	5	7	3	3	4
3	0	2	1	5	2	3	4	3	2
3	1	3	3	3	1				

3031 Array 203 $\Delta t = .006$

10000									
20	10	10	10	10	10	10	10	10	10
25	10	10	10	10	10	10	10	10	10
30	10	10	10	10	10	10	10	10	10
35	10	10	10	10	10	10	10	10	10
40	10	10	10	10	10	10	10	10	10
45	10	10	10	10	10	10	10	10	10
50	10	10	10	10	10	10	10	10	10
55	10	10	10	10	10	10	10	10	10
60	10	10	10	10	10	10	10	10	10
65	10	10	10	10	10	10	10	10	10
70	10	10	10	10	10	10	10	10	10
75	10	10	10	10	10	10	10	10	10
80	10	10	10	10	10	10	10	10	10
85	10	10	10	10	10	10	10	10	10
90	10	10	10	10	10	10	10	10	10
95	10	10	10	10	10	10	10	10	10
100	10	10	10	10	10	10	10	10	10
105	10	10	10	10	10	10	10	10	10
110	10	10	10	10	10	10	10	10	10
115	10	10	10	10	10	10	10	10	10
120	10	10	10	10	10	10	10	10	10
125	10	10	10	10	10	10	10	10	10
130	10	10	10	10	10	10	10	10	10
135	10	10	10	10	10	10	10	10	10
140	10	10	10	10	10	10	10	10	10
145	10	10	10	10	10	10	10	10	10
150	10	10	10	10	10	10	10	10	10
155	10	10	10	10	10	10	10	10	10
160	10	10	10	10	10	10	10	10	10
165	10	10	10	10	10	10	10	10	10
170	10	10	10	10	10	10	10	10	10
175	10	10	10	10	10	10	10	10	10
180	10	10	10	10	10	10	10	10	10
185	10	10	10	10	10	10	10	10	10
190	10	10	10	10	10	10	10	10	10
195	10	10	10	10	10	10	10	10	10
200	10	10	10	10	10	10	10	10	10
205	10	10	10	10	10	10	10	10	10
210	10	10	10	10	10	10	10	10	10
215	10	10	10	10	10	10	10	10	10
220	10	10	10	10	10	10	10	10	10
225	10	10	10	10	10	10	10	10	10
230	10	10	10	10	10	10	10	10	10
235	10	10	10	10	10	10	10	10	10
240	10	10	10	10	10	10	10	10	10
245	10	10	10	10	10	10	10	10	10
250	10	10	10	10	10	10	10	10	10
255	10	10	10	10	10	10	10	10	10
260	10	10	10	10	10	10	10	10	10
265	10	10	10	10	10	10	10	10	10
270	10	10	10	10	10	10	10	10	10
275	10	10	10	10	10	10	10	10	10
280	10	10	10	10	10	10	10	10	10
285	10	10	10	10	10	10	10	10	10
290	10	10	10	10	10	10	10	10	10
295	10	10	10	10	10	10	10	10	10
300	10	10	10	10	10	10	10	10	10
305	10	10	10	10	10	10	10	10	10
310	10	10	10	10	10	10	10	10	10
315	10	10	10	10	10	10	10	10	10
320	10	10	10	10	10	10	10	10	10
325	10	10	10	10	10	10	10	10	10
330	10	10	10	10	10	10	10	10	10
335	10	10	10	10	10	10	10	10	10
340	10	10	10	10	10	10	10	10	10
345	10	10	10	10	10	10	10	10	10
350	10	10	10	10	10	10	10	10	10
355	10	10	10	10	10	10	10	10	10
360	10	10	10	10	10	10	10	10	10
365	10	10	10	10	10	10	10	10	10
370	10	10	10	10	10	10	10	10	10
375	10	10	10	10	10	10	10	10	10
380	10	10	10	10	10	10	10	10	10
385	10	10	10	10	10	10	10	10	10
390	10	10	10	10	10	10	10	10	10
395	10	10	10	10	10	10	10	10	10
400	10	10	10	10	10	10	10	10	10
405	10	10	10	10	10	10	10	10	10
410	10	10	10	10	10	10	10	10	10
415	10	10	10	10	10	10	10	10	10
420	10	10	10	10	10	10	10	10	10
425	10	10	10	10	10	10	10	10	10
430	10	10	10	10	10	10	10	10	10
435	10	10	10	10	10	10	10	10	10
440	10	10	10	10	10	10	10	10	10
445	10	10	10	10	10	10	10	10	10
450	10	10	10	10	10	10	10	10	10
455	10	10	10	10	10	10	10	10	10
460	10	10	10	10	10	10	10	10	10
465	10	10	10	10	10	10	10	10	10
470	10	10	10	10	10	10	10	10	10
475	10	10	10	10	10	10	10	10	10
480	10	10	10	10	10	10	10	10	10
485	10	10	10	10	10	10	10	10	10
490	10	10	10	10	10	10	10	10	10
495	10	10	10	10	10	10	10	10	10
500	10	10	10	10	10	10	10	10	10

3032 Array 1 $\Delta t = .004$

2748									
48000									
2748	1236	1080	504	224	116	81	42	22	19
12	12	6	8	3	4	1	3	2	4
0	6	3	3	3	0	3	1	4	0
5	1	2	1	4	2	4	5	0	1
2	1	2	4	3	2	1	1	0	2
0	0	3	1	0	4	4	0	3	1
1	0	4	2	1	3	0	2	3	4
0	5	3	2	0	2	0	0	6	0
1	2	0	0	1	1	1	3	1	0
2	3	2	1	3	5	5	4	2	3
40100									
2	2	0	2	3	0	2	5	2	4
2	1	0	3	2	6	1	1	2	0
2	1	0	3	3	2	2	5	4	4
1	3	3	6	6	8	10	3	8	7
0	10	10	12	14	12	15	17	16	16
23	23	20	24	34	27	31	32	34	28
26	16	29	35	38	32	39	32	35	30
27	22	40	18	25	25	39	35	37	19
25	28	22	20	24	27	20	18	13	27
16	13	21	16	20	14	13	9	9	12
40200									
15	10	11	11	16	9	5	7	6	5
8	15	11	5	6	5	4	5	4	3
2	10	1	4	6	2	7	4	6	4
3	5	2	5	4	5	3	3	3	2
2	6	1	2	2	4	1	1	1	4
3	2	1	4	2	1				

3032 Array 203 $\Delta t = .004$

10000									
877	2019	188	78	61	58	67	61	61	69
97	7	63	67	79	70	78	61	73	72
80	100	121	125	145	147	153	165	142	164
197	168	267	207	256	218	255	232	254	259
274	260	221	195	197	143	172	142	118	129
113	100	64	67	66	71	60	62	67	62
69	45	62	66	45	52	61	49	47	50
46	55	47	71	47	52	55	54	43	54
57	50	53	58	47	49	51	45	50	59
45	6	19	66	40	36	44	33	48	55
10100									
57	57	42	54	62	40	41	42	41	47
55	49	46	47	43	49	50	51	41	40
46	35	49	45	46	32	54	42	39	58
48	22	24	43	47	46	46	49	39	44
54	28	50	48	49	45	40	42	40	32
45	44	46	54	46	43	76	49	54	57
44	43	36	39	38	50	32	41	52	51
55	55	48	34	45	23	51	44	39	44
34	39	41	33	50	42	57	34	38	40
44	50	43	32	38	43	35	33	43	44
10200									
48	41	31	35	39	43	48	37	43	39
52	40	42	35	40	46	36	32	49	33
36	42	42	42	33	21	43	41	38	31
42	40	43	36	39	42	38	32	30	41
33	28	42	32	44	43	30	32	29	45
43	25	31	40	47	30				

3019 Array 1 $\Delta t = .03$

11904									
40000									
11904	1277	54	19	10	8	6	3	9	3
10	4	5	6	4	9	6	6	5	5
4	5	2	9	3	2	5	10	4	7
6	11	4	10	4	8	8	6	12	11
9	9	8	7	10	7	5	9	6	9
5	7	5	11	6	8	6	6	8	8
7	9	7	11	5	6	8	9	1	2
9	7	5	4	3	4	7	9	13	10
8	4	14	5	7	5	9	6	6	8
7	1	6	6	6	8	7	7	7	3
40100									
6	8	8	7	11	5	6	9	9	6
8	6	8	8	9	9	9	6	14	8
8	12	13	9	12	8	9	10	10	10
18	6	10	10	8	14	21	14	24	18
20	16	22	23	25	26	17	27	35	37
24	32	41	42	32	30	32	27	31	29
33	34	35	33	38	35	26	25	40	31
50	41	48	52	35	43	61	49	34	40
30	36	28	23	27	34	27	22	26	18
28	29	24	20	17	15	19	17	23	10
40200									
15	17	14	10	9	8	14	9	7	8
11	11	12	12	6	8	8	14	13	13
8	9	4	2	7	9	5	5	9	6
6	13	5	3	11	7	9	4	6	7
8	5	7	5	8	8	2	3	6	11
7	6	2	5	3	7				

3019 Array 203 $\Delta t = .03$

10000									
877	1000	117	120	104	114	113	117	108	96
90	110	110	111	116	118	107	116	109	273
105	161	101	107	101	107	124	101	118	119
470	118	100	100	100	104	117	100	110	113
501	118	100	100	100	100	115	100	118	120
179	111	102	107	105	107	109	100	109	170
119	101	100	114	116	120	114	101	108	143
108	110	110	120	104	110	90	90	120	82
109	97	111	90	100	86	116	95	74	77
10	10	9	9	10	11	17	80	68	90
10100									
80	10	50	17	82	75	69	66	71	72
11	10	60	80	81	10	10	71	77	78
10	10	10	91	64	81	50	80	101	78
17	10	80	60	60	69	60	81	71	56
10	10	60	74	66	68	84	76	75	74
96	70	74	68	61	56	73	67	67	47
47	67	69	72	60	81	74	62	70	61
67	69	67	74	54	59	69	72	59	53
65	70	74	56	65	56	47	64	70	58
61	59	80	54	58	49	83	65	57	62
10200									
51	71	77	79	60	66	43	57	46	57
61	80	62	70	67	92	53	70	71	50
70	92	51	56	57	61	55	60	56	69
50	60	62	68	66	59	53	63	60	74
57	67	50	65	51	59	56	44	78	53
52	59	49	45	51	48				

3018 Array 1 $\Delta t = .055$

12080									
40000									
12085	1110	20	10	10	13	12	12	12	13
8	14	13	9	8	16	11	14	17	12
12	6	9	12	13	9	10	12	10	17
9	11	9	16	9	14	8	20	10	15
8	8	10	10	9	6	9	7	10	15
16	12	7	11	12	11	6	7	12	16
14	17	6	14	20	15	14	16	18	13
16	17	14	16	14	12	15	11	11	9
9	22	14	17	18	16	14	10	16	15
13	14	14	16	17	15	17	22	12	12
40100									
12	12	22	12	17	18	21	12	17	20
18	14	22	15	20	26	21	19	24	24
29	24	23	31	29	34	43	38	32	32
50	40	41	34	58	62	51	47	63	72
62	62	107	86	76	72	72	83	76	89
73	70	86	105	89	113	108	104	107	98
103	107	102	99	103	102	108	102	99	96
93	91	94	87	97	98	94	74	95	85
90	72	106	78	83	83	97	87	78	83
73	72	72	89	79	59	56	51	52	57
40200									
57	60	40	54	58	54	55	46	46	38
49	48	47	40	51	31	33	27	25	28
33	31	33	28	21	35	20	29	20	17
16	14	14	16	24	19	11	20	17	13
12	11	19	11	15	15	16	14	15	13
12	9	15	12	19	14				

3018 Array 203 $\Delta t = .055$

7857									
40000									
7857	1612	159	83	67	73	72	55	55	52
58	56	67	56	53	69	52	60	55	61
58	66	56	57	55	66	68	63	65	73
56	78	80	87	108	115	112	132	124	137
164	164	164	162	162	153	154	180	146	140
140	145	119	149	108	120	110	111	95	92
74	63	58	77	62	63	60	58	66	58
45	49	37	54	40	46	51	53	67	46
41	47	48	56	47	41	49	50	39	47
49	54	50	55	44	56	48	52	47	50
16100									
46	39	37	37	52	55	51	39	44	42
46	52	47	39	38	46	38	45	35	43
44	27	51	42	44	41	50	52	31	34
37	36	39	50	41	45	48	39	51	51
44	36	53	46	41	45	47	32	33	47
39	36	47	32	39	45	47	37	29	26
38	49	59	54	52	52	46	41	39	28
41	43	40	46	26	40	34	39	29	37
45	36	36	32	34	28	43	49	50	39
48	40	38	36	34	39	42	52	45	39
10200									
38	47	48	38	36	33	31	37	41	32
45	32	31	50	37	44	32	40	39	38
37	38	15	37	28	26	38	34	39	38
48	30	38	33	38	40	33	32	39	33
34	44	32	45	40	41	41	31	41	23
45	35	33	30	45	35				

3016 Array 1 $\Delta t = .040$

7857									
40000									
7857	1842	24	21	8	8	8	4	3	9
9	8	8	7	4	8	5	4	9	10
3	5	4	4	2	4	7	8	11	7
6	5	8	7	8	4	7	8	6	7
7	9	11	8	4	5	8	5	6	5
7	6	13	9	8	6	8	10	1	6
3	4	7	2	6	2	7	6	5	5
7	8	9	2	3	6	2	7	10	5
7	6	4	8	5	11	9	3	11	10
9	7	9	9	8	2	7	7	7	5
40100									
5	4	8	2	2	5	7	7	7	8
7	4	8	6	5	9	5	7	5	6
10	10	6	8	2	7	7	11	6	3
2	7	8	10	4	11	1	14	9	8
5	9	9	8	5	3	3	5	10	12
2	5	10	11	9	6	6	7	5	11
9	13	10	4	6	5	3	12	8	13
8	12	7	6	8	15	13	10	8	12
13	11	15	18	17	16	17	25	20	15
26	21	18	19	33	30	28	24	13	21
40200									
28	31	24	31	24	27	34	24	31	23
25	24	23	18	21	28	36	32	14	20
13	15	20	24	20	24	17	13	9	13
8	12	13	13	11	15	5	9	14	6
3	8	6	8	11	10	9	12	9	10
10	8	6	7	5	6				

3016 Array 203 $\Delta t = .040$

3006									
100000									
599	99	100	117	98	89	98	80	98	110
91	100	100	109	92	97	114	118	95	109
112	99	98	96	97	105	118	94	114	88
102	120	10	117	100	105	106	107	172	196
207	163	100	200	205	188	202	185	175	181
165	106	1	101	101	120	120	99	99	97
97	99	91	95	84	79	89	89	79	77
97	87	91	96	74	75	74	81	83	91
76	73	72	68	74	75	79	51	75	77
90	91	9	75	77	71	67	67	75	68
10000									
81	64	61	75	85	65	71	60	76	76
65	71	70	65	71	57	76	70	71	71
69	70	66	61	74	58	67	71	80	63
78	60	60	69	59	61	60	61	67	67
72	60	60	75	65	72	65	64	69	64
77	61	62	61	59	60	67	64	63	53
65	61	60	61	57	61	64	64	67	66
60	61	62	57	61	66	67	63	69	51
69	61	60	55	59	60	57	55	60	60
66	60	63	51	69	55	56	62	69	54
100000									
84	50	67	61	47	45	55	60	56	48
61	57	56	55	58	53	44	59	51	53
56	57	56	58	48	50	39	50	41	54
48	62	58	46	50	48	34	62	46	47
54	48	49	52	47	56	47	52	49	37
47	46	55	47	46	50				

3006 Array 1 $\Delta t = .070$

99977									
100000									
99977	99977	16	16	18	19	17	20	13	19
22	10	9	16	9	11	10	9	7	14
44	9	13	10	13	7	17	15	12	10
42	9	10	10	21	19	13	10	13	7
17	10	13	13	10	10	9	7	9	10
11	12	11	12	10	12	8	9	10	7
7	9	1	10	12	7	7	11	11	17
12	7	7	11	10	11	10	9	11	17
11	10	10	7	11	17	15	4	7	14
12	10	14	10	13	11	6	12	14	10
100000									
15	6	14	9	9	14	5	6	14	11
9	15	12	13	7	11	12	9	12	9
7	9	9	8	9	10	10	8	10	7
9	12	2	7	15	12	15	15	7	16
10	11	16	11	10	13	11	9	11	20
15	9	9	15	11	12	11	11	10	19
10	14	11	8	18	15	11	9	15	11
16	9	14	20	17	16	11	8	17	17
12	16	24	20	14	18	19	16	14	14
15	14	24	27	29	23	29	16	25	23
100000									
25	16	33	20	20	26	13	14	14	17
20	17	13	14	10	18	21	11	17	20
15	15	17	15	10	7	14	11	9	10
12	10	12	11	9	16	11	11	17	17
13	13	10	4	12	13	18	17	13	11
10	8	9	8	13	12				

3006 Array 203 $\Delta t = .070$

460									
10000									
460	118	101	112	98	103	90	105	95	89
100	94	99	108	94	108	98	92	102	83
99	98	89	92	103	89	90	85	82	91
77	73	64	71	73	93	70	84	87	85
82	81	82	79	84	65	82	97	82	81
87	63	89	82	88	109	91	97	98	92
100	122	109	126	137	135	132	145	145	159
164	165	163	185	158	177	164	174	172	196
184	178	181	191	206	222	196	218	216	222
246	252	259	249	259	246	240	240	232	242
10100									
282	292	282	267	267	241	234	237	223	213
195	204	178	185	175	171	174	147	144	145
108	174	102	109	112	111	87	94	83	110
89	75	74	77	65	94	84	63	75	60
66	81	81	54	65	69	67	69	53	55
56	61	60	60	51	69	55	47	54	59
58	63	50	59	58	46	41	47	64	52
50	57	45	56	58	35	46	42	56	49
49	51	48	37	51	47	40	35	61	44
42	42	42	42	52	33	41	52	50	43
10200									
38	47	55	56	46	47	51	46	46	43
34	42	39	51	54	44	47	32	44	48
35	44	46	40	39	40	44	43	47	56
47	45	48	32	37	45	39	52	38	34
36	48	34	29	56	43	42	49	29	41
49	39	37	33	40	46

10000									
1000	121	54	58	54	60	98	52	61	55
97	58	53	62	53	55	59	60	67	89
97	119	104	229	104	424	962	729	985	1146
1000	1592	1557	1792	1608	1955	1794	1666	1501	1374
1007	1687	205	742	667	571	496	394	354	284
277	207	166	165	142	119	107	84	81	77
89	52	55	47	56	56	48	46	50	33
49	47	29	40	44	32	36	52	40	46
39	34	25	40	35	32	27	40	29	32
27	25	17	20	19	28	21	31	22	44
10100									
18	24	25	25	24	24	29	29	21	30
21	20	17	24	18	25	26	21	26	23
26	20	24	17	27	20	23	22	26	24
25	20	19	24	24	19	25	25	25	15
28	17	16	28	20	22	29	18	22	23
20	17	20	28	21	15	21	16	15	24
19	15	20	19	15	22	14	21	26	17
17	25	21	14	20	15	18	15	32	15
24	19	19	20	16	20	20	21	17	15
18	15	26	16	19	20	22	20	16	15
10200									
14	16	24	16	13	21	19	14	16	15
15	17	21	13	16	19	20	14	19	9
22	17	13	14	18	27	14	19	15	11
20	23	20	22	15	18	11	11	17	18
18	15	10	11	17	18	10	16	20	13
16	13	15	15	11	16				

4510 Array 1 $\Delta t = .13$

3718									
40000									
3718	72	7	7	5	7	7	4	6	4
3	3	2	4	10	6	3	10	8	2
5	7	8	2	8	6	3	9	4	8
1	2	8	5	4	5	3	8	6	6
5	6	7	3	6	7	7	4	6	6
4	4	12	7	5	2	2	4	2	5
3	4	4	3	4	7	7	6	8	4
4	6	8	5	5	6	8	6	7	5
5	4	4	5	3	10	6	8	3	6
1	9	5	8	8	8	7	8	5	4
40100									
11	4	10	7	4	3	6	4	5	6
1	7	10	13	19	22	31	28	42	50
65	69	84	106	108	115	125	153	141	177
180	164	178	180	170	190	217	166	194	166
171	175	162	175	137	169	139	125	118	104
106	91	91	92	77	53	80	72	58	48
44	51	44	42	32	27	22	21	40	31
17	24	20	25	10	15	23	17	12	12
12	14	11	11	7	10	7	5	7	5
7	4	9	6	7	8	9	7	7	4
40200									
8	7	5	6	7	3	5	7	4	5
9	3	10	10	6	3	8	10	6	3
9	7	4	6	6	6	8	1	9	10
2	5	4	11	5	10	12	10	1	7
2	10	8	7	3	5	6	3	4	8
8	8	3	5	9	7				

4510 Array 203 $\Delta t = .13$

10000									
348	348	10	12	20	25	31	26	16	22
39	39	21	11	25	35	43	45	64	77
92	141	260	287	342	504	619	816	918	951
1000	1001	962	964	894	757	625	569	464	359
348	347	266	175	179	117	91	88	60	50
30	30	39	42	38	35	37	33	33	30
33	38	39	35	30	19	27	11	16	16
36	34	29	17	16	21	20	20	18	21
19	18	11	17	20	12	17	16	22	21
21	15	15	20	22	26	18	11	20	10
10100									
17	22	22	7	14	15	15	19	19	21
29	29	27	25	29	31	19	9	9	16
18	17	27	19	27	26	21	12	18	11
17	17	11	15	17	15	21	12	17	14
17	32	13	11	17	14	16	16	15	21
15	16	15	18	12	17	12	12	20	19
17	24	9	20	13	18	16	7	11	14
17	10	15	10	6	13	11	20	19	15
23	12	12	15	19	12	17	11	14	11
15	19	7	9	13	10	13	9	16	14
10200									
15	16	15	12	8	15	14	12	10	15
12	12	13	13	10	12	12	9	11	10
13	9	14	11	19	10	9	17	9	8
8	12	14	14	10	13	7	18	9	10
8	15	16	11	8	17	17	12	7	16
19	20	8	14	11	13				

4511 Array 1 $\Delta t = .065$

3101									
40000									
3101	319	7	5	1	3	3	6	3	5
1	3	6	1	2	2	2	4	1	4
4	4	0	3	5	2	2	4	2	3
2	2	4	8	4	1	6	2	3	4
0	3	4	5	2	5	2	1	3	2
3	5	3	4	1	5	3	5	2	5
2	4	2	5	2	7	1	2	2	3
1	4	3	5	5	0	4	4	3	1
1	2	3	4	3	3	4	2	3	7
2	0	5	2	2	3	5	6	3	5
40100									
3	7	9	15	20	27	49	59	68	62
90	107	120	139	158	179	187	205	200	196
212	226	216	226	234	191	208	198	198	169
157	158	131	146	125	120	107	106	94	71
76	74	70	37	44	58	30	22	32	28
16	32	22	21	22	22	15	17	18	12
16	15	11	11	2	7	2	7	3	6
10	8	5	10	5	7	6	3	3	6
5	3	6	6	3	5	3	7	4	6
4	3	4	6	2	4	3	3	6	2
40200									
5	3	2	2	1	5	7	3	1	3
3	1	4	6	3	4	3	5	5	5
2	2	2	5	5	0	2	7	8	1
2	3	2	3	3	2	4	1	5	2
3	7	4	3	4	2	2	3	3	2
3	3	4	5	1	3				

4511 Array 203 $\Delta t = .065$

175									
10000									
475	1562	902	217	94	67	21	26	13	22
13	12	10	19	14	8	12	8	18	17
14	21	18	29	30	44	51	55	69	111
118	153	187	205	249	306	314	299	318	285
286	362	241	236	176	169	165	129	110	92
76	51	34	45	43	25	23	30	22	22
18	12	18	14	20	17	16	10	9	13
10	10	12	12	12	14	11	20	10	13
9	16	12	20	15	8	19	8	4	10
17	16	17	12	15	12	16	8	7	13
10100									
8	9	8	8	9	11	7	7	8	12
10	8	10	9	10	10	8	8	6	11
11	9	10	6	10	9	11	9	13	13
19	9	5	10	12	9	9	12	11	11
17	21	9	12	11	17	12	12	14	6
10	5	5	7	8	11	10	5	12	19
12	8	14	12	9	14	8	8	10	18
10	5	12	13	7	9	15	7	9	8
6	9	12	11	13	12	10	14	7	10
13	11	11	10	17	10	16	9	12	8
10200									
10	11	12	10	11	12	7	10	13	8
15	21	12	16	10	10	13	20	14	10
15	16	6	9	7	11	9	13	12	18
17	9	10	15	8	9	16	9	9	9
15	10	12	9	12	9	9	13	9	6
7	11	7	5	17	10				

4513 Array 1 $\Delta t = .0078$

3600									
40000									
3600	3223	479	148	46	14	7	3	5	5
8	2	2	0	1	4	5	1	2	1
2	0	0	1	0	5	1	0	2	5
1	2	4	2	0	1	1	1	2	1
2	1	2	0	2	0	1	1	2	1
0	1	0	2	0	2	2	1	2	2
2	1	5	4	2	2	2	3	2	3
1	1	1	0	2	3	2	2	2	0
2	0	4	3	3	1	0	1	0	0
0	0	2	3	1	1	0	2	2	0
40100									
1	1	2	1	1	1	2	2	0	2
4	2	2	2	2	0	4	2	5	1
0	3	3	2	4	1	5	5	7	4
11	26	11	25	26	42	44	41	52	67
61	85	68	97	96	107	82	108	109	110
115	108	112	111	118	97	105	115	97	86
92	80	76	72	61	73	48	48	56	56
37	39	33	31	28	28	27	23	27	15
20	19	15	14	7	8	5	10	6	8
5	5	5	5	3	3	4	4	5	4
40200									
3	5	6	1	1	2	1	4	3	3
2	1	1	2	1	7	3	1	0	3
2	0	1	2	0	1	3	2	2	0
0	2	2	1	3	0	1	3	0	0
4	1	1	1	1	2	1	1	0	0
0	0	1	0	1	1				

4513 Array 203 $\Delta t = .0078$

3000									
100000									
2500	370	110	27	17	14	10	9	11	9
7	17	11	0	5	8	8	7	6	15
13	16	14	24	30	31	43	60	82	103
120	165	183	220	247	266	311	290	291	285
254	245	220	186	172	131	118	101	93	65
50	58	42	30	24	20	23	15	17	13
17	9	5	0	10	7	10	0	6	4
5	9	5	7	4	9	8	7	7	6
5	7	3	14	2	5	5	0	9	6
7	9	0	0	0	4	9	4	9	5
10100									
2	0	0	0	9	4	4	5	5	7
4	0	0	0	4	2	7	7	0	0
5	0	10	7	0	10	9	5	6	6
5	0	7	7	0	0	3	5	9	0
5	0	7	0	7	0	1	7	6	0
4	0	7	0	5	5	5	0	6	9
5	0	4	4	4	4	5	5	1	6
5	0	4	7	4	7	1	0	0	0
10	0	4	7	7	5	0	5	0	11
5	5	0	0	0	6	13	5	4	5
10200									
4		7	0	7	6	5	6	5	5
5	10	0	0	7	4	6	4	7	11
5	5	11	0	3	3	10	4	4	3
5	7	0	0	0	7	2	7	2	5
5	7	0	0	9	4	6	3	3	6
5	0	0	0	0	4				

4514 Array 1 $\Delta t = .014$

3000									
40000									
3000	686	50	9	7	1	3	2	1	1
1	0	1	2	2	1	2	1	0	1
0	1	0	2	1	3	0	1	1	1
1	0	0	1	0	1	1	1	0	2
0	0	2	1	1	0	0	3	0	0
3	0	0	0	0	0	1	0	0	1
1	0	0	1	1	2	0	1	1	2
0	0	0	0	1	0	0	0	1	1
1	0	0	1	1	0	1	1	0	0
1	1	0	0	1	0	1	2	1	1
40100									
1	0	3	1	3	0	3	3	0	1
0	1	2	0	0	1	0	0	3	1
0	1	2	0	5	1	8	4	10	12
15	30	21	36	30	62	56	64	64	71
90	81	67	85	114	85	90	103	79	119
98	100	105	85	95	95	92	80	95	74
56	70	56	60	50	53	39	39	30	32
36	24	34	20	25	13	17	18	14	0
9	0	10	15	14	6	0	7	0	7
4	6	6	4	3	4	1	2	1	3
40200									
5	1	2	2	2	0	2	3	0	0
0	2	1	1	3	3	0	3	0	3
1	0	0	1	1	0	0	1	1	5
1	2	0	0	4	1	0	0	1	0
1	1	6	0	1	0	0	0	1	1
0	6	0	0	1	0				

4514 Array 203 $\Delta t = .014$

10000									
187	51	7	42	44	33	39	47	32	38
77	25	24	14	35	35	47	47	49	44
51	57	56	18	76	71	70	99	96	121
127	174	171	160	200	254	102	377	491	543
516	507	411	780	790	319	317	267	231	239
186	183	174	237	163	168	163	120	102	117
105	97	64	94	86	86	61	59	49	55
48	37	31	52	25	39	26	31	22	29
71	20	27	24	27	23	23	35	20	21
25	24	20	20	25	21	20	24	34	44
10100									
26	26	19	25	22	13	16	28	17	24
19	22	21	20	21	18	16	26	13	13
15	17	17	19	17	14	14	19	15	18
16	14	20	21	26	17	15	22	13	19
19	8	15	20	17	17	27	23	8	18
17	24	19	23	17	22	13	4	18	16
26	18	10	24	21	19	14	15	19	17
17	10	12	23	17	12	12	17	17	16
9	19	15	8	24	11	11	10	14	15
15	16	18	13	20	21	18	19	14	11
10200									
11	10	11	17	17	15	12	16	14	11
18	16	15	9	19	13	10	14	14	17
13	16	13	10	9	11	13	9	7	10
10	13	11	17	16	14	18	11	14	10
11	13	16	14	9	14	12	13	17	12
14	11	12	19	11	8				

3514 Array 1 $\Delta t = .130$

2587									
40000									
2587	12	2	5	5	8	4	2	7	7
4	14	3	7	5	6	8	6	8	4
1	9	5	2	5	2	6	6	3	4
2	5	8	2	1	4	2	1	7	4
2	4	6	5	4	5	7	6	9	1
3	5	2	2	2	4	4	4	6	8
2	6	5	7	6	5	1	5	3	8
6	5	8	4	4	3	7	2	7	0
5	5	5	2	7	4	5	6	7	4
7	6	7	2	10	8	3	3	7	4
40100									
2	3	8	4	6	9	8	5	8	7
11	10	9	11	10	14	12	13	16	16
15	12	13	18	18	17	17	22	22	20
39	31	43	27	35	39	37	49	37	36
38	47	22	25	28	43	46	41	37	36
26	41	39	31	29	33	24	38	24	24
29	23	16	25	18	16	15	11	10	8
12	9	9	13	9	4	4	5	11	2
4	2	4	6	8	2	5	3	6	6
5	7	10	1	3	10	6	4	7	4
40200									
5	4	7	5	3	0	5	8	4	4
5	6	4	7	6	2	3	3	8	2
7	4	2	4	4	12	2	3	4	4
4	7	7	3	3	2	4	0	3	1
9	7	7	7	3	8	2	1	3	2
2	3	5	6	5	5				

3514 Array 203 $\Delta t = .130$

10000									
10000	174	68	74	60	78	72	66	83	89
99	91	109	105	188	265	216	242	354	365
257	248	345	311	317	242	276	262	231	229
266	279	262	267	233	257	239	188	200	202
195	207	124	179	159	177	175	165	158	143
115	125	119	136	134	130	151	179	149	137
163	126	86	79	59	56	55	52	56	49
42	43	39	31	49	50	34	31	32	49
71	43	13	32	40	34	40	29	42	37
76	21	12	38	30	30	28	42	36	36
10100									
12	12	26	37	26	30	25	30	24	26
25	25	16	15	25	31	20	24	29	37
26	6	29	42	35	29	28	34	33	31
23	11	34	31	33	26	33	32	27	29
19	24	28	29	23	34	22	30	28	24
19	20	29	29	24	24	27	23	23	30
31	27	23	14	21	22	22	24	22	16
26	22	15	31	24	31	29	19	23	29
23	29	18	29	22	20	16	16	23	23
25	21	27	16	22	25	14	16	15	21
10200									
30	24	24	27	17	25	11	20	19	31
25	18	18	21	20	20	14	20	23	8
14	17	20	30	14	30	22	16	17	16
14	17	15	16	16	21	19	20	20	14
17	28	25	24	16	19	18	17	16	16
16	27	17	13	17	18				

3515 Array 1 $\Delta t = .130$

4427									
40000									
4427	48	4	6	3	13	8	6	5	4
11	4	5	8	8	9	6	8	11	6
5	14	8	9	9	12	12	7	7	7
3	8	7	15	5	6	4	6	10	1
11	12	11	11	8	12	14	6	11	5
4	10	8	5	9	9	7	6	8	10
8	8	8	7	10	11	16	18	20	18
15	25	20	14	14	23	11	26	16	24
13	17	14	19	18	19	16	13	24	18
14	13	18	13	25	32	43	62	61	70
40100									
52	42	34	36	34	34	23	26	29	18
22	23	22	12	16	10	20	15	23	22
31	34	20	19	13	21	23	17	14	19
17	9	16	10	11	20	18	10	9	4
7	8	8	9	8	9	12	15	6	3
12	8	9	2	7	6	4	11	10	5
4	4	7	6	12	5	6	5	6	9
5	5	11	6	7	3	15	9	6	11
8	9	10	7	4	8	7	8	4	6
5	4	3	7	11	4	10	7	6	4
40200									
7	6	15	6	1	8	4	7	6	7
4	6	10	4	11	3	3	5	1	11
5	1	8	7	5	8	1	7	5	8
4	10	7	7	3	6	7	4	5	9
8	6	10	8	6	1	1	8	10	3
3	8	5	10	3	8				

3515 Array 203 $\Delta t = .130$

1000									
10000									
1000	415	94	116	87	93	78	96	80	96
97	91	90	99	97	116	107	142	134	139
174	212	289	357	440	578	717	829	845	951
908	994	970	990	999	964	960	912	910	906
917	1009	1018	1048	1075	1069	1074	1016	1079	1070
1059	1104	1164	1109	1082	1049	893	915	704	667
507	462	444	480	425	474	297	240	206	176
176	135	176	128	101	106	101	105	110	98
86	78	78	86	96	75	82	91	68	67
87	86	70	79	68	79	75	78	91	77
10100									
67	70	64	75	79	76	81	59	70	67
71	81	77	70	66	61	61	75	71	66
67	71	70	67	64	74	47	69	64	58
63	74	67	51	81	61	63	70	79	64
59	60	61	71	72	66	69	57	60	64
45	76	67	66	66	71	75	79	79	86
74	74	74	78	73	85	75	79	73	85
36	74	80	73	74	91	69	61	66	60
60	76	66	62	53	63	61	60	61	55
52	67	53	59	53	56	52	49	64	65
10200									
60	53	54	58	64	54	54	51	62	52
60	49	49	61	55	59	59	54	54	62
40	57	56	49	53	58	54	63	62	79
62	50	59	51	60	46	60	51	45	48
56	56	58	59	51	53	53	55	56	58
52	52	49	52	54	57				

3517 Array 1 $\Delta t = .080$

7534									
40000									
7534	179	8	10	10	10	14	9	7	9
9	12	11	8	8	7	12	9	11	12
9	6	6	11	7	10	3	8	8	5
4	11	7	9	6	9	8	9	9	5
10	11	6	8	8	4	11	3	3	4
2	7	12	8	7	12	13	9	6	11
11	13	14	4	15	12	9	14	7	8
5	9	8	5	10	7	10	3	4	10
10	8	5	13	8	7	8	11	11	8
9	13	13	8	13	11	7	9	8	16
40100									
10	10	8	8	7	14	5	17	8	10
7	9	8	7	13	5	4	6	6	9
7	8	13	17	16	19	9	19	28	24
32	29	46	31	33	36	51	50	75	66
63	74	81	109	117	133	139	160	147	161
171	210	228	218	246	238	227	242	254	257
255	254	259	258	249	235	222	230	251	208
192	168	157	163	120	143	146	132	131	140
116	115	104	99	94	69	80	73	72	61
52	37	60	43	44	24	33	25	31	32
40200									
24	21	23	18	27	22	16	9	13	8
20	21	15	15	18	9	8	15	9	8
12	9	13	9	10	5	9	8	5	7
7	6	12	6	7	4	9	11	11	11
8	8	9	9	5	6	6	7	7	11
10	8	8	5	6	8				

3517 Array 203 $\Delta t = .080$

777									
10000									
777	827	54	46	25	11	16	27	42	42
39	39	49	76	59	74	90	85	114	142
171	150	172	154	155	157	155	121	129	130
107	117	110	98	77	71	37	62	65	51
54	47	41	43	31	40	37	39	32	34
27	34	32	27	29	26	34	27	30	25
18	19	32	31	28	33	40	33	26	28
39	19	32	34	22	26	29	29	29	24
36	21	26	29	25	22	18	21	23	35
39	29	31	30	26	19	39	20	19	26
10100									
32	32	33	29	26	35	17	16	18	35
17	39	32	34	31	16	27	26	28	19
39	32	37	33	19	32	27	27	20	26
16	34	36	33	28	19	30	34	27	29
33	30	32	39	39	34	21	20	21	22
33	34	28	30	31	22	21	27	22	32
22	26	26	20	26	14	22	24	31	22
35	24	19	28	21	27	24	21	26	26
16	27	21	21	25	24	19	19	20	22
22	26	19	26	35	23	19	35	24	24
10200									
23	14	19	20	21	18	21	20	27	26
26	20	22	19	12	13	23	22	23	17
21	25	33	23	16	31	19	17	14	20
20	18	18	23	20	21	18	22	16	22
25	34	17	25	13	28	24	25	26	21
21	19	26	16	27	17				

3518 Array 1 $\Delta t = .040$

5754									
40000									
5754	511	13	9	5	1	4	5	6	4
6	3	6	7	5	5	4	5	6	4
3	3	6	6	6	2	4	7	6	5
3	2	5	5	6	4	2	4	4	2
5	1	5	4	4	5	2	5	5	2
6	3	4	1	2	7	5	3	4	4
4	7	5	2	5	3	2	5	5	2
2	6	3	7	1	4	5	6	10	1
4	1	1	3	4	2	7	10	6	5
4	9	9	6	5	2	6	1	6	2
40100									
6	6	5	5	7	5	6	5	7	8
2	6	9	4	10	13	9	8	10	11
14	13	18	12	18	14	25	26	19	24
17	26	39	32	27	18	46	31	32	38
34	41	42	47	35	56	44	62	50	68
50	63	63	54	57	51	43	37	43	45
44	56	42	57	38	35	45	38	23	27
30	21	21	19	23	20	18	25	15	15
11	20	10	17	14	8	9	10	12	15
4	8	5	7	4	6	4	9	6	5
40200									
3	6	5	10	4	9	8	8	9	5
3	5	6	4	7	7	6	9	3	4
4	3	7	3	9	5	12	4	8	3
5	2	2	5	5	5	3	2	2	3
2	1	5	4	4	4	3	6	4	10
2	9	4	3	2	7				

3518 Array 203 $\Delta t = .040$

10000									
172	172	172	172	172	172	172	172	172	172
19	19	19	19	19	19	19	19	19	19
98	126	173	191	217	265	252	262	249	191
187	189	189	111	100	91	82	93	47	39
94	20	20	20	23	18	9	15	11	15
19	11	11	19	14	10	11	11	12	12
19	12	12	7	9	13	13	13	8	15
11	11	8	14	16	9	14	14	14	14
13	8	7	15	14	14	12	14	16	14
16	14	14	1	11	12	10	18	15	8
10100									
19	12	15	22	9	15	10	12	13	11
17	1	1	11	11	7	16	16	17	18
11	10	9	1	10	13	11	13	11	10
9	15	11	12	17	9	15	7	11	5
10	14	7	6	8	13	12	9	9	11
16	18	4	11	13	10	14	11	11	12
12	13	13	9	9	7	8	9	8	8
14	13	11	10	8	13	10	5	15	9
7	12	9	13	6	15	7	14	12	10
11	9	13	6	11	6	10	8	10	6
10000									
11	11	4	5	6	9	17	12	5	11
8	11	12	6	11	12	12	9	16	9
12	8	6	5	10	6	7	12	5	16
9	8	11	16	16	11	6	12	13	4
7	12	9	8	9	9	9	5	7	7
8	11	11	4	4	9				

3520 Array 1 $\Delta t = .034$

3072									
40000									
3072	101	5	5	1	3	1	3	1	2
2	2	2	1	6	0	1	2	0	0
1	3	3	1	2	1	0	0	1	2
2	1	2	0	2	2	1	6	2	2
2	2	0	2	1	2	0	1	3	2
4	1	2	4	4	0	4	1	0	2
1	1	1	1	3	3	1	1	2	1
0	0	2	3	4	3	2	3	0	2
0	2	5	2	1	2	1	3	3	2
5	2	2	3	2	0	3	2	6	3
40100									
1	0	3	2	2	2	2	1	1	1
2	2	1	1	4	4	4	2	1	4
1	0	1	6	1	0	2	1	1	1
1	1	1	3	2	0	3	4	3	3
2	5	1	5	3	3	5	4	6	2
9	5	9	10	8	11	16	23	29	19
28	39	31	39	39	39	47	46	46	63
54	63	77	61	61	49	74	62	65	61
63	45	55	63	63	57	48	54	50	53
49	44	47	40	37	43	32	37	33	34
40200									
31	20	29	19	32	22	22	28	13	15
19	26	12	17	14	13	9	10	9	7
2	7	7	10	12	4	7	4	5	3
7	6	3	6	4	1	5	5	4	6
3	3	3	4	3	2	3	1	1	1
2	1	4	0	5	2				

3520 Array 203 $\Delta t = .034$

100000									
219	210	50	25	25	15	20	4	12	16
16	15	8	12	17	23	18	19	32	31
49	50	56	101	98	130	159	105	187	152
191	189	181	170	157	145	127	102	89	77
82	79	67	59	51	49	49	44	40	31
77	66	54	48	19	14	19	17	9	15
50	56	10	50	11	12	11	14	10	11
12	10	12	10	10	11	16	14	10	4
11	15	12	6	11	8	8	8	16	7
10	12	12	12	10	15	17	9	7	8
10100									
18	7	11	16	12	8	10	6	16	15
7	10	9	5	12	12	10	8	9	8
12	9	10	15	12	7	14	9	12	12
14	7	11	12	13	10	16	12	14	7
13	13	21	9	12	9	7	9	14	10
15	7	10	15	9	11	17	16	6	12
7	5	9	7	11	10	10	12	7	9
14	6	9	12	11	12	7	5	5	11
7	14	10	14	5	9	12	6	10	16
15	12	10	13	6	8	9	12	5	8
10200									
13	12	10	10	11	4	8	17	14	15
11	5	12	7	10	0	7	10	6	7
17	12	7	11	13	10	9	12	7	6
5	8	12	11	7	12	7	12	12	11
11	10	11	5	8	12	9	8	11	10
11	9	6	8	10	9				

3521 Array 1 $\Delta t = .025$

2438									
40000									
2438	293	16	1	6	4	2	1	1	1
2	1	1	3	2	2	3	2	0	1
1	2	1	1	1	2	0	0	0	0
3	3	0	2	1	1	0	1	2	4
0	0	1	1	0	0	0	0	2	1
4	0	1	2	0	2	0	0	1	1
1	0	1	4	4	2	1	0	1	2
1	4	1	0	2	1	0	2	1	2
2	7	3	1	2	1	1	0	0	2
1	1	1	1	1	4	2	4	2	1
00100									
4	0	2	0	2	0	0	0	2	2
0	1	1	4	1	0	0	1	0	1
0	1	0	1	0	1	0	0	3	1
1	4	0	4	7	10	5	7	4	10
4	11	13	16	19	21	19	23	15	22
27	12	33	25	31	38	32	24	46	44
42	48	38	42	39	40	39	42	52	48
70	47	50	41	42	51	44	38	61	55
58	46	56	55	49	65	47	44	51	41
62	49	44	45	42	36	30	32	32	33
00200									
25	29	24	33	21	36	22	17	23	21
15	22	31	24	15	18	5	14	17	10
12	12	4	14	6	12	2	14	10	10
5	11	5	8	7	4	10	3	4	6
6	5	2	3	4	6	5	3	4	3
1	3	2	3	1	1				

3521 Array 203 $\Delta t = .025$

16456	276	262	250	125	56	30	18	19	10	10
5	5	4	11	4	9	5	2	8	6	
4	6	8	6	7	8	12	6	13	13	
11	14	13	25	17	27	22	14	20	20	
17	26	23	19	19	19	19	25	20	15	
26	27	21	22	22	21	13	20	12	15	
14	14	10	5	16	8	10	13	12	11	
10	6	10	12	1	15	7	6	8	13	
10	16	16	11	10	9	11	9	7	7	
7	7	5	7	9	6	6	8	6	4	
16456										
5	5	6	7	6	6	6	5	9	5	
5	5	4	7	5	5	4	9	9	5	
5	6	6	5	4	6	8	10	10	10	
5	11	6	7	5	6	6	9	9	10	
5	6	8	7	5	6	11	5	8	13	
9	11	6	6	5	6	5	6	7	4	
4	6	4	6	6	6	7	6	6	5	
9	5	6	4	4	4	6	9	6	11	
4	6	2	5	6	5	4	6	4	5	
6	4	8	9	6	5	9	5	10	6	
16456										
2	4	6	5	3	5	10	7	7	5	
4	5	4	5	6	5	2	6	4	5	
4	1	11	4	7	5	5	6	4	4	
2	4	1	5	2	2	5	6	4	4	
5	2	7	5	6	5	6	10	5	9	
4	4	2	4	5	5					

3523 Array 1 $\Delta t = .007$

1717	1717	1161	214	60	22	12	6	5	5	1
40000										
1717	2	1	2	2	0	0	1	1	3	0
2	0	0	0	0	0	1	5	1	4	0
2	2	1	2	0	0	2	1	0	1	1
2	3	2	2	0	0	1	1	2	2	2
1	1	0	0	0	3	1	2	2	0	0
1	2	0	2	2	2	2	1	0	2	1
3	1	0	4	2	2	1	2	0	0	3
0	2	2	2	2	1	2	2	2	1	2
2	2	2	1	1	1	0	1	0	2	0
40100										
1	1	2	1	0	0	2	3	1	1	0
0	0	0	0	0	0	1	1	0	1	0
2	0	1	0	0	1	1	0	1	0	2
1	2	1	2	0	0	2	0	1	0	1
1	1	0	1	1	0	0	4	2	2	3
1	0	1	2	4	4	3	0	4	4	3
5	2	4	4	4	7	4	1	5	2	2
5	3	5	5	5	3	5	4	4	5	5
2	2	7	5	5	1	7	7	6	0	5
7	5	7	7	7	4	9	9	8	0	6
40200										
7	5	10	4	3	5	5	5	6	2	6
7	4	4	7	0	6	5	5	9	0	7
7	7	3	6	7	7	16	9	3	4	1
4	3	3	6	7	7	5	5	3	7	10
1	4	1	2	1	1	4	7	1	1	0
2	2	4	1	2	2	2				

3523 Array 203 $\Delta t = .007$

Output

138	137	137	138	139	14	11	11	10	13
14	14	14	14	14	14	14	14	12	20
22	13	22	17	17	15	14	23	13	23
15	20	19	15	22	15	20	16	11	14
13	19	11	5	9	12	8	10	9	10
10	0	8	8	8	11	8	7	8	8
9	8	10	10	0	11	7	16	13	3
8	10	8	5	7	14	8	9	8	8
10	0	8	5	9	6	10	7	13	10
10	10	0	6	8	8	9	10	10	7
10100									
0	11	8	10	10	10	0	0	8	8
8	10	8	10	8	7	0	0	7	9
11	9	8	11	9	9	4	4	7	11
10	0	0	0	10	4	0	0	9	7
10	0	0	0	10	10	0	0	7	12
10	0	0	0	9	8	8	7	9	8
10	9	9	7	11	11	7	4	10	10
0	10	8	4	12	3	10	4	4	8
0	1	8	0	10	10	7	10	0	6
0	8	7	12	12	10	0	8	10	7
10000									
0	7	4	0	9	0	7	10	11	6
0	8	8	4	0	13	9	12	10	8
0	8	0	0	0	6	4	1	11	8
0	10	8	8	8	9	4	7	8	13
0	0	0	0	9	4	8	8	11	10
0	0	0	0	10	10				

3524 Array 1 $\Delta t = .017$

2000

40000	761	50	13	5	1	1	2	3	5
2000									
2	1	1	0	0	1	0	1	0	1
0	0	0	0	0	1	1	1	0	3
4	1	0	0	1	1	1	0	2	0
0	0	0	0	0	2	0	0	1	0
0	0	0	4	0	4	3	4	4	7
0	0	6	0	5	5	0	0	6	5
0	10	1	4	0	6	4	0	4	1
0	0	0	4	0	1	0	0	0	0
0	0	1	0	7	0	4	0	7	0
40100									
0	0	5	4	0	2	4	6	6	3
0	0	0	4	0	2	0	1	7	0
0	1	2	10	0	7	0	0	0	0
0	4	5	0	3	4	0	0	0	0
0	1	4	1	3	1	0	1	3	0
0	1	1	2	1	1	1	1	1	2
0	1	2	0	0	0	0	0	0	4
0	2	2	0	1	2	0	2	0	2
1	0	3	0	1	1	1	1	2	1
40200									
2	1	0	1	1	2	1	1	1	1
1	0	1	2	0	2	1	1	1	2
0	1	2	3	1	2	2	1	1	2
1	0	1	2	1	2	0	2	1	1
0	2	1	1	0	0	2	3	1	0
1	1	1	0	0	3				

3524 Array 203 $\Delta t = .017$

100000

274	10	217	220	24	40	23	27	24	18
10	10	1	14	10	13	9	5	13	9
10	10	19	7	17	16	27	24	29	41
40	11	5	62	36	91	98	100	125	124
119	27	40	109	88	74	75	65	68	72
57	19	19	18	44	44	26	15	27	18
21	19	14	15	19	17	14	7	9	11
11	10	10	14	12	11	11	11	12	6
8	5	10	4	4	11	7	11	15	18
10	10	9	10	8	8	10	11	8	7
10000									
9	7	11	11	4	15	9	8	8	12
1	1	1	1	8	11	1	7	7	13
9	10	10	10	10	10	11	10	10	12
10	7	19	14	14	10	9	8	8	7
9	1	10	6	17	7	7	8	10	11
9	1	9	6	7	5	6	9	12	8
17	8	11	7	5	11	16	11	12	13
12	3	9	8	13	4	6	10	9	7
16	10	7	13	8	5	9	10	11	9
5	9	13	11	9	9	5	5	14	8
10000									
6	7	7	17	5	5	11	8	10	10
9	7	9	14	11	8	11	10	5	8
9	8	6	8	8	9	5	9	15	13
14	10	8	16	11	5	10	11	9	6
6	12	8	9	10	5	8	8	5	10
11	13	7	6	17	10				

3525 Array 1 $\Delta t = .007$

2202

40000

2202	2125	197	101	51	21	15	13	7	5
1	2	2	2	5	2	5	5	5	4
3	1	1	3	1	3	0	1	4	4
1	2	3	1	2	0	1	3	1	2
1	1	1	1	2	2	1	0	2	1
1	1	2	2	1	3	1	1	2	2
2	9	1	2	1	2	2	2	2	2
1	0	0	0	0	3	5	1	2	2
1	2	2	1	2	1	2	2	4	0
3	2	2	1	1	0	1	0	1	1
40100									
1	2	1	0	2	2	1	2	5	1
0	1	1	2	0	3	0	0	0	2
2	2	1	2	1	2	5	0	1	1
3	0	1	1	1	2	0	0	3	0
1	0	5	2	0	0	2	0	5	2
1	6	2	5	0	6	5	11	7	13
16	15	6	22	21	24	14	15	16	28
38	15	38	49	31	47	34	38	45	40
40	53	42	45	49	42	46	31	38	51
37	33	46	42	40	36	35	40	40	34
40200									
30	36	16	30	27	27	34	29	20	33
26	29	24	24	17	21	22	13	20	15
12	18	13	12	16	14	8	13	6	15
9	7	4	7	12	2	5	6	4	7
2	6	11	2	8	2	5	3	3	1
5	1	4	5	8	6				

3525 Array 203 $\Delta t = .007$

10000									
298	1000	100	100	68	59	50	18	13	17
13	1	1	4	19	19	12	11	17	16
15	23	17	23	12	47	33	35	73	37
107	116	101	107	116	107	101	85	83	67
87	58	45	57	11	34	24	77	18	26
20	17	21	25	10	13	13	17	18	20
19	11	15	14	14	6	8	11	15	11
11	9	10	8	12	12	11	13	9	13
17	12	16	12	13	8	15	12	12	13
11	7	11	5	16	11	7	9	13	12
10000									
11	19	15	1	14	10	10	11	10	11
17	11	7	11	9	11	8	14	8	20
19	11	11	8	1	17	15	16	11	7
4	10	7	12	10	5	10	16	9	7
7	8	11	17	10	17	7	15	13	9
12	16	8	12	11	7	11	4	10	9
11	11	9	10	11	11	10	7	11	10
9	12	13	11	15	15	10	15	9	11
10	8	11	7	9	11	14	12	14	9
12	12	6	12	7	6	10	10	14	7
10000									
17	21	14	14	11	10	17	16	6	19
17	8	11	10	8	9	12	11	11	11
9	7	12	5	18	8	17	13	13	8
8	16	12	13	10	6	9	8	16	7
9	8	8	10	6	6	15	12	12	8
9	11	17	8	7	9				

3526 Array 1 $\Delta t = .008$

3173									
40000									
3173	1080	268	59	25	13	8	6	7	3
3	4	2	0	4	3	1	3	1	3
3	1	3	1	3	7	3	1	5	1
3	2	0	0	2	1	1	0	2	0
2	1	1	2	1	1	3	1	2	1
4	1	2	4	1	2	2	1	3	1
1	1	3	2	2	1	0	0	1	2
2	0	0	4	0	4	1	3	2	5
0	0	3	2	0	0	1	1	1	3
2	2	0	1	0	0	5	2	2	1
40000									
2	0	1	1	1	0	1	2	1	1
2	2	1	0	1	1	2	4	3	1
2	2	3	1	2	6	3	7	7	7
7	16	9	19	19	19	21	24	28	28
29	47	31	36	42	41	42	44	46	39
44	38	45	52	43	40	43	20	29	42
27	35	36	38	38	47	23	33	18	20
13	14	24	26	15	21	12	13	17	14
18	13	13	11	12	9	9	6	3	10
11	8	5	5	8	2	4	5	5	6
40000									
7	2	4	6	5	4	5	3	1	2
3	4	3	4	0	2	0	3	4	4
1	6	3	5	3	2	1	1	2	6
2	1	1	2	1	1	2	1	1	1
4	4	2	2	4	1	1	3	0	2
1	2	1	2	1	1				

3526 Array 203 $\Delta t = .008$

10000									
288	1	1000	378	107	77	14	16	30	21
29	26	2	17	10	16	71	21	20	21
21	47	69	26	47	81	81	78	71	79
26	100	18	88	18	86	57	77	66	51
26	69	74	69	78	74	56	27	26	26
21	29	25	20	18	7	14	17	15	18
27	12	16	18	16	16	18	16	20	13
17	12	17	14	17	12	17	14	15	12
12	12	14	26	11	14	9	21	11	23
16	17	17	10	16	16	9	11	17	14
10000									
11	12	16	16	11	14	8	21	8	11
12	17	17	17	17	17	17	17	12	10
17	17	17	16	11	16	16	16	16	8
16	17	17	17	17	17	17	17	15	11
17	17	17	17	17	17	17	17	16	11
17	17	17	17	17	17	17	17	12	7
14	17	17	14	14	14	14	21	8	9
14	11	11	9	11	16	16	7	17	15
16	7	16	16	16	16	16	14	12	6
17	7	17	14	8	16	16	16	14	13
10000									
14	9	9	9	9	17	5	10	13	9
17	9	9	17	13	9	9	9	8	11
17	19	14	10	12	17	9	10	11	13
17	12	15	12	12	8	10	1	1	17
17	16	15	9	12	8	11	11	5	9
12	14	7	12	12	11				

3527 Array 1 $\Delta t = .007$

2174									
40000									
2174	3527	562	113	26	23	13	11	5	10
2	6	3	4	1	6	4	5	6	4
2	2	2	4	1	1	2	1	2	2
2	1	2	1	2	0	0	1	1	5
2	2	2	2	1	1	2	4	1	2
1	2	1	4	3	2	2	2	1	4
1	1	1	5	1	2	1	2	1	2
5	2	1	5	1	1	2	6	2	5
6	2	2	3	1	2	4	6	3	0
1	2	1	1	1	5	6	2	1	3
40000									
2	2	2	4	2	3	1	2	2	2
6	2	6	1	2	6	2	5	3	8
4	9	7	2	10	10	5	7	10	8
26	16	20	22	12	18	26	23	24	31
27	25	21	24	23	39	36	34	25	38
26	21	14	24	26	27	19	29	25	24
24	26	16	17	20	25	24	16	23	21
12	21	17	10	12	22	17	15	12	13
11	12	8	12	13	14	12	12	7	7
9	7	11	6	11	3	4	9	12	12
40000									
4	8	7	9	10	3	3	5	2	4
5	3	5	5	5	6	4	7	4	6
5	2	5	2	5	6	2	2	6	3
2	5	4	2	3	5	1	5	5	5
3	6	2	6	3	4	2	5	4	3
1	1	4	2	3	2				

3527 Array 203 $\Delta t = .007$

10000									
257	1	1	107	67	70	78	19	19	16
0	0	0	1	7	7	11	6	10	18
11	16	10	10	12	24	10	67	76	98
197	186	180	201	182	201	237	201	140	199
177	180	180	180	180	87	77	55	56	45
48	27	26	21	27	15	18	19	7	11
11	17	19	6	7	9	12	7	6	9
7	11	0	7	10	4	12	8	11	6
13	7	11	8	10	12	7	6	8	11
11	0	0	11	6	6	9	7	6	9
10100									
7	10	10	6	5	12	11	6	8	18
0	11	10	11	10	8	5	11	7	12
3	7	10	0	6	8	7	0	11	6
13	6	6	10	0	9	9	8	8	9
0	0	6	6	6	11	6	9	11	9
7	0	0	0	10	11	0	10	9	13
9	9	9	6	7	10	7	5	14	10
7	11	8	7	8	4	4	8	7	12
10	6	0	4	0	9	9	5	13	9
11	0	0	9	11	6	8	8	7	5
10700									
10	8	6	10	11	4	12	7	16	3
11	6	10	4	10	9	11	5	11	10
11	10	10	8	0	8	9	11	8	14
12	11	7	8	8	6	11	9	10	9
16	9	10	10	12	9	6	7	8	13
6	9	0	15	3	8				

3529 Array 1 $\Delta t = .008$

2817									
40000									
2817	1001	250	75	19	17	7	1	4	1
1	0	1	0	1	1	1	2	1	0
2	0	2	0	2	1	2	0	1	2
2	0	1	1	3	2	2	0	0	0
1	0	0	2	1	0	0	0	2	0
0	0	0	1	1	2	1	0	2	0
0	0	1	0	0	0	1	2	2	1
1	1	2	0	0	1	4	0	1	2
0	1	0	0	2	0	3	1	4	0
1	1	2	0	1	1	0	0	1	3
40100									
0	0	0	2	2	3	0	0	0	2
0	0	1	2	1	3	1	1	2	2
0	0	0	4	7	15	21	17	27	39
24	41	24	57	68	64	59	62	75	78
70	80	70	77	66	75	85	72	79	65
71	49	77	48	63	46	42	40	42	39
30	26	31	27	21	22	20	18	17	14
12	12	18	15	12	13	12	5	6	4
7	6	4	5	1	5	3	3	7	6
4	1	2	3	3	1	2	2	2	1
40200									
4	2	3	5	2	4	0	0	1	2
4	2	1	2	0	1	2	0	1	1
1	2	1	1	2	1	0	2	1	1
5	0	0	1	1	1	3	0	1	0
1	2	2	0	1	2	1	1	2	2
2	1	0	1	0	1				

3529 Array 203 $\Delta t = .008$

100000									
2771			29	4	7	10	18	18	25
1			4	4	4	11	11	11	125
102	188	200	208	209	203	202	208	206	211
207			20	26	18	15	17	122	105
28	21		21	22	20	28	20	21	28
12	2		21	28	15	24	20	24	22
21			20	20	17	18	18	22	10
24	24	2	1	15	21	15	21	25	17
12	12	12	18	20	20	28	17	18	19
1			18	18	17	17	17	26	20
10100									
2			21	26	17	20	20	22	17
1			2	2	1	14	1	21	23
21	1	1	1	1	1	18	18	24	31
18	18		27	15	21	29	11	28	12
11	1	1	12	14	14	18	11	12	11
22			15	15	11	21	19	14	10
18	18	14	20	28	18	22	19	17	21
21	21	17	27	17	27	24	21	14	18
22	22	1	29	11	21	12	10	21	17
27	27	1	19	15	19	15	21	23	20
10200									
17	28	15	26	19	18	9	17	15	15
13	18	22	20	21	17	17	21	10	21
20	12	19	22	17	17	15	17	12	20
17	17	12	25	11	18	15	17	21	20
26	10	18	22	18	19	17	15	19	17
17	25	18	20	18	11				

3533 Array 1 $\Delta t = .034$

4500									
40000									
4502	478	10	4	0	2	4	3	4	8
4	0	4	0	0	2	4	0	0	4
2	0	0	4	0	0	0	0	0	4
1	1	0	1	0	0	0	0	0	2
4	4	1	1	0	0	4	0	0	0
0	2	4	2	0	0	0	0	0	4
1	1	3	0	0	1	4	4	0	1
1	7	2	0	2	4	7	7	1	5
2	1	0	1	1	1	7	0	0	4
4	0	0	0	0	2	0	0	7	5
40100									
6	1	2	4	5	1	0	4	2	2
4	2	0	0	0	0	0	0	6	1
4	7	4	3	4	0	4	0	1	5
4	1	2	8	4	0	1	0	0	1
7	2	6	1	1	0	4	6	11	4
4	5	5	5	2	10	13	5	6	13
12	21	18	29	21	38	44	38	49	58
68	60	68	70	72	72	97	79	72	98
85	100	98	92	90	99	95	90	77	106
102	119	75	87	75	77	61	65	74	73
40200									
72	68	81	60	44	56	41	47	42	37
41	24	52	44	45	36	35	42	41	24
27	29	32	19	25	19	12	21	8	17
15	15	7	22	11	9	9	9	9	14
8	11	3	4	5	5	9	1	6	4
7	12	3	4	2	3				

3533 Array 203 $\Delta t = .034$

0.00									
10000									
440	1700	81	51	24	46	25	29	27	26
24	70	17	71	52	42	70	76	98	139
165	210	280	128	316	308	309	347	312	292
375	363	271	197	321	186	155	137	123	109
111	76	80	61	35	37	32	34	31	37
41	25	16	17	14	15	44	11	27	24
77	26	16	22	29	26	27	32	32	35
20	27	22	27	31	29	30	28	23	25
25	23	19	12	37	32	29	24	29	19
26	22	25	21	18	25	17	24	21	33
10100									
27	26	17	22	28	24	24	24	22	28
70	76	14	26	24	19	10	20	22	19
26	21	24	22	24	19	17	21	34	26
28	27	27	16	19	34	22	17	16	16
47	21	21	22	24	25	22	30	32	19
14	21	24	24	22	23	17	19	25	23
20	21	25	21	16	22	25	29	32	10
19	20	27	24	21	17	22	23	31	18
18	22	26	28	21	26	18	30	29	23
21	19	19	21	20	14	28	15	22	15
10200									
18	20	19	26	29	15	20	30	26	18
16	17	20	17	24	21	17	22	29	25
19	27	22	24	19	15	23	20	24	27
20	22	15	24	22	22	26	19	21	35
26	20	26	22	18	27	26	26	19	21
18	18	24	17	23	11				

3534 Array 1 $\Delta t = .030$

5347									
40000									
5347	1682	28	10	7	5	5	3	6	5
3	3	5	3	2	3	5	3	4	8
9	4	3	8	3	3	2	2	4	3
2	6	7	4	6	0	3	4	4	2
2	3	5	4	1	1	0	6	4	1
0	1	2	5	4	5	10	2	5	1
5	2	3	4	3	3	3	4	3	5
4	2	2	5	5	4	5	4	8	6
2	2	3	1	5	5	5	3	4	5
2	5	2	4	7	3	3	4	1	5
40100									
8	4	1	2	3	1	2	4	3	1
4	3	3	3	3	3	7	2	7	7
5	6	5	11	14	10	6	16	16	10
17	18	24	26	30	33	33	31	41	34
45	40	48	51	47	58	61	60	70	66
72	85	28	82	67	76	69	91	76	92
93	86	92	98	94	93	81	97	101	108
106	108	103	100	107	117	94	82	92	87
79	80	69	74	78	70	60	57	39	52
51	48	49	41	51	44	46	40	45	31
40200									
24	31	25	22	26	25	18	25	17	20
16	10	7	11	12	9	13	9	6	10
8	6	12	6	5	9	2	3	5	4
5	6	6	8	6	2	6	2	1	5
3	5	5	3	2	5	3	4	6	3
7	5	7	6	1	6				

3534 Array 203 $\Delta t = .030$

700									
10000									
700	1672	291	68	38	20	13	12	15	18
17	6	13	14	15	16	13	16	12	30
37	43	56	66	87	79	78	100	66	64
60	56	64	70	60	75	48	61	77	56
53	72	58	60	53	48	44	47	50	39
40	54	28	19	38	16	30	23	26	29
21	22	20	24	23	18	18	16	18	10
12	11	9	14	12	21	12	14	12	13
8	8	9	6	12	12	10	7	8	7
19	9	11	10	7	16	7	10	10	15
10100									
10	8	16	8	8	8	10	13	14	7
15	14	14	9	12	22	11	8	10	12
17	11	12	9	10	9	11	16	9	8
9	5	9	2	11	12	16	10	11	7
5	8	11	8	9	11	9	11	11	13
7	17	10	8	14	7	9	7	9	11
14	11	10	6	16	13	8	9	10	7
12	5	14	9	10	10	7	15	6	11
15	12	7	12	4	10	14	9	17	8
13	14	13	11	12	10	13	8	11	10
10200									
10	7	10	10	9	13	16	10	6	9
5	12	11	4	8	10	11	11	11	10
7	5	8	5	6	14	6	9	7	8
14	8	9	12	10	10	12	8	8	12
10	11	7	14	10	12	7	11	10	8
10	9	12	10	5	6				

3535 Array 1 $\Delta t = .015$

2050									
40000									
2050	2271	121	15	5	9	1	1	2	6
1	0	3	0	0	1	1	0	1	0
3	1	0	0	2	2	1	2	2	3
3	3	1	0	3	0	3	0	4	2
1	1	1	2	3	0	3	1	1	1
1	6	2	4	1	2	3	0	1	0
0	4	0	1	1	4	4	3	1	3
1	3	1	1	2	3	2	0	5	3
1	1	0	0	1	4	1	0	2	1
0	2	1	0	1	1	2	0	2	2
40100									
0	1	6	5	1	0	0	0	1	1
1	1	0	1	1	2	1	3	6	2
2	0	2	1	2	0	3	1	4	3
2	2	4	3	4	6	1	3	4	12
8	9	12	13	14	20	16	26	10	16
13	19	8	15	19	31	25	17	14	25
37	23	19	26	24	21	23	30	25	23
17	34	27	31	28	32	39	23	19	30
28	23	33	24	27	31	26	24	22	30
27	26	25	22	32	30	34	27	23	24
40200									
19	16	26	24	20	15	25	20	20	14
18	16	24	10	28	21	13	24	15	13
16	13	15	21	16	10	7	15	15	15
18	14	17	14	5	6	9	11	13	13
8	13	13	14	12	10	3	8	8	8
6	8	8	8	6	5				

3535 Array 202 $\Delta t = .015$

794									
10000									
794	1680	372	116	47	35	30	29	28	13
96	14	18	17	27	22	13	25	20	26
32	49	45	48	65	67	58	78	92	86
91	93	78	76	61	73	67	56	59	55
40	37	32	43	38	49	39	41	41	34
25	27	31	21	24	27	17	31	25	26
28	32	16	24	16	17	18	22	25	27
18	22	20	13	17	15	20	18	17	19
27	21	23	23	20	23	24	10	10	18
19	28	17	18	19	11	27	19	21	26
10100									
76	22	14	18	18	25	16	23	22	20
24	25	24	18	18	14	24	19	28	19
20	21	14	23	19	23	19	11	28	19
17	24	16	30	20	18	21	22	21	18
12	12	21	16	18	20	17	19	21	13
26	14	14	26	21	26	27	20	22	19
27	25	16	19	25	18	23	7	25	18
22	21	13	16	20	20	20	25	10	20
8	15	21	19	11	18	11	13	19	21
18	21	22	14	27	17	18	14	26	10
10200									
16	14	19	20	23	16	10	17	18	15
25	21	14	10	30	6	30	21	11	10
20	23	15	14	17	18	20	22	21	19
19	15	16	21	14	11	16	16	19	27
14	24	17	8	22	20	13	18	16	21
16	20	17	25	16	18				

3536 Array 1 $\Delta t = .012$

4328									
40000									
4328	1896	154	46	18	6	8	3	2	1
3	2	2	2	3	0	7	4	1	4
5	3	0	1	3	5	6	1	5	5
2	2	3	5	4	6	2	2	1	3
4	5	3	4	3	4	2	2	1	0
2	3	6	2	4	1	2	1	2	1
3	2	6	2	2	2	4	3	4	2
4	3	1	1	5	1	4	3	6	1
1	2	4	2	4	2	6	4	2	5
3	0	3	0	4	5	9	4	5	4
40100									
8	6	7	4	7	7	8	7	5	8
9	7	3	6	8	10	8	8	8	11
4	5	8	6	7	2	6	12	10	15
6	11	14	15	17	17	14	17	18	22
21	21	24	14	16	16	19	26	18	14
25	19	27	23	17	25	31	23	17	21
18	17	12	17	11	16	12	19	17	20
18	7	15	10	10	9	12	18	12	12
7	12	9	16	10	13	15	7	14	14
12	12	14	9	11	9	18	10	18	12
40200									
12	12	13	9	11	2	10	10	8	6
12	5	7	5	5	4	7	5	5	4
5	4	7	16	7	3	6	4	8	6
7	4	5	1	5	4	7	4	4	3
4	5	6	6	0	1	2	2	2	0
6	2	6	3	2	1				

3536 Array 203 $\Delta t = .012$

3537									
100000									
278	1759	701	214	79	41	24	14	30	30
23	24	24	26	29	21	10	35	17	36
23	29	26	27	32	37	47	41	31	49
33	30	28	36	33	36	33	38	30	33
34	33	33	21	32	38	37	25	18	25
22	12	32	37	18	19	15	18	20	26
17	24	19	13	16	21	21	21	12	22
13	21	14	22	17	12	14	22	12	18
19	13	12	25	15	15	14	18	17	13
17	15	10	16	20	12	15	7	16	15
100000									
15	8	18	18	21	13	19	18	18	12
8	15	11	11	10	25	15	27	24	19
29	10	16	11	14	20	13	8	20	14
27	11	17	14	15	13	18	23	25	18
29	10	17	10	15	21	13	17	17	19
15	21	14	17	20	13	12	20	21	11
22	14	20	16	23	19	16	15	21	16
15	17	21	17	9	18	16	15	14	19
16	12	18	20	13	15	18	19	24	13
14	16	10	17	16	22	16	16	17	11
100000									
14	16	10	18	31	18	20	10	13	13
18	24	19	15	6	13	13	16	10	19
21	17	15	18	20	21	16	14	20	13
19	21	19	19	15	19	8	17	13	14
19	16	18	16	6	18	24	16	24	16
24	12	19	17	14	17				

3537 Array 1 At = .009

2619									
400000									
2619	1319	349	82	20	11	7	4	1	5
3	4	8	0	2	2	9	1	4	2
3	7	2	4	2	2	4	4	3	3
3	0	1	1	2	2	4	2	1	4
3	2	2	1	1	3	1	3	0	5
3	1	2	5	2	5	1	2	1	4
1	1	3	0	2	1	4	1	4	4
3	3	1	2	2	2	4	3	0	6
3	6	1	6	7	5	6	4	3	7
3	5	6	4	7	6	7	6	7	5
400000									
4	5	5	5	5	4	5	5	5	6
3	6	0	3	3	3	2	6	6	4
3	1	3	3	0	3	6	6	4	9
4	7	4	0	10	7	6	6	6	4
4	6	15	13	6	3	10	6	6	6
4	5	7	6	3	3	6	7	2	11
10	5	0	7	1	4	7	4	4	6
5	4	3	6	3	3	5	5	3	0
2	6	7	7	0	7	6	6	0	0
9	6	7	5	0	7	6	9	5	2
400000									
4	5	8	6	9	8	10	3	5	2
4	0	7	1	3	6	2	4	5	4
7	5	4	7	4	3	5	5	5	6
6	6	2	5	5	3	2	2	2	2
2	5	6	1	3	3	2	4	2	4
3	2	2	1	2	5				

3537 Array 203 At = .009