NAMES AND DESCRIPTIONS OF
CHEMICAL TECHNOLOGY LABORATORY
DETECTOR SYSTEMS

March 1975

W. H. Zimmer

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DETECTOR SYSTEMS

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March 1975

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FIGURE 1 TYPES OF SEMI-CONDUCTOR DETECTORS

FIGURE 1

STANDARD SEMICONDUCTOR DETECTOR CONFIGURATIONS

The n (negative) layer is highly exaggerated for clarity. It consists of a lithium doped or diffused layer which seldom exceeds half a millimeter in thickness. The n and p regions both act as non-detector sorption volumes.

NAMES AND DESCRIPTIONS
OF CHEMICAL TECHNOLOGY LABORATORY
DETECTOR SYSTEMS

INTRODUCTION

Gamma and X-ray detector systems providing spectral information for analysis in the Gamma, X-ray Data Reductions (GXDR) system are identified by an alphabetic name. Rather than provide a full page description of a detector system every time one is mentioned, this document is presented for reference. One page detector descriptions will be provided as the detector systems are placed in service.

In the succeeding pages each type of detector system will be pictured, followed by a one page description of the system and of its applications.

All of these detectors are semiconductor detector which must be cooled to the boiling of liquid nitrogen and evacuated to a maximum pressure of 10^{-5} Torr in order to operate. The detector housing is known as the cryostat and the liquid nitrogen reservoir is known as the dewar.

FIGURE 2

SIDELOOKING DETECTOR SYSTEMS

Midactivity range, Ge(Li) gamma detector systems.

DETECTOR SYSTEM: ADescription

This type of detector system is designed to analyze the middle range of gamma activities, from 0.1 microcurie to a millicurie. The detector is a lithium drifted germanium [Ge(LI) (jelly)] semiconductor. As is general for this type of detector, it projects into a radiation shield. The detector is trapezoidal with its axis parallel to the floor and aligned with the sample positions. The number 1 sample position is always in contact with the detector face. Detector system "A" has six geometry positions. The shield is ten centimeters lead, graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to cut down the re-emission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield. The shield cross section is 61 centimeters by 61 centimeters.

The detector signal is preamplified with a room temperature TC 135 preamplifier and amplified with a 1.6 μ sec shaping time constant using a TC 202 amplifier. The signal is restored to baseline with a TC 611 baseline restorer and digitized in a 50 MHz_z NS-911 Analog-to-Digital Converter (ADC) pulse height analyzer. The energy calibration is 500 eV per channel in a 1024 channel analyzer.

Sample Mounts

1/4" flat mounts
1" flat mounts
T1 mounts (1 ml liquid)
T2 mounts (2 ml liquid or solid)
25 cc mounts

Limitations

Sources are administratively limited to fifteen percent deadtime (c.a. 7000 c/s). If the source exceeds this it is moved to a higher numbered geometry, at a greater distance from the detector. Because the detector is not physically anchored to the shield, daily recovery factors using a known source of ^{133}Ba must be determined at positions one and two. The bulk sample mounts can only be analyzed in positions 2 through 6.

Detector System A

Specifications

Location: Room 234-5 Building 200 W Area (CTL)

Manufacturer: Nuclear Diodes Inc.

Date: 7/69

Model No.: LGC 4.7XX

Bias: -1550 V

Serial No.: L-433

Capacitance of Detector and Cryostat: 28.5 picofarads

Resolution:	2.4 keV (FWHM) @	1332 keV
	4.8 keV (FWTM) @	1332 keV
	keV (FWHM) @	keV

Peak to Compton ratio: 16:1 @ 1332 keV

Relative efficiency: 4.7% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	10.8 cm ²
	Length	36 mm
	Drift depth	mm
	Drift configuration	five side
	Active volume	cm ³
	Distance from window	9 mm

Cryostat Type: Right Angle-chicken feeder

DETECTOR SYSTEM: C₄ - F - WDescription

This type of detector system is designed to analyze the middle range of gamma activities, from 0.1 microcuries to a millicurie. The detector is a lithium drifted germanium [Ge(Li)] semiconductor. As is general for this type of detector, it projects into a radiation shield. The detector is a closed-end, coaxially drifted cylinder with its axis parallel to the floor and aligned with the sample positions. The number 1 sample position is always in contact with the detector face. Detector system "C₄" has six geometry positions. The shield is ten centimeters lead, graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to cut down the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield. The shield cross section is 61 centimeters by 61 centimeters.

The detector signal is preamplified with a room temperature Princeton Gamma Tech RG-11 preamplifier and amplified and baseline restored with a 4.0 μ sec shaping time constant using a Canberra 1413 amplifier. The signal is routed to a 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 4096 channel analyzer. The energy calibration is 500 eV per channel.

Sample Mounts

- 1/4" flat mounts
- 1" flat mounts
- T1 mounts (1 ml liquid)
- T2 mounts (2 ml liquid or solids)
- 25 cc mounts
- 25 cc rotational mounts

Limitations

Sources are administratively limited to fifteen percent deadtime (c.a. 10,000 c/s). If the source exceeds this it is moved to a higher numbered geometry, at a greater distance from the detector. Bulk sample mounts can only be analyzed in positions 2 through 6. If any of the bulk samples cannot achieve five percent deadtime at position 2 they are analyzed on R(3) or S(3) systems. If any sample mount cannot achieve less than fifteen percent deadtime at position 6, they are analyzed on the E detector system. Because the detector is not physically anchored to the shield, daily recovery factors using a known source of ^{137}Cs must be determined at positions 1 and 2. Resolution and peak-to-Compton checks using ^{60}Co are determined weekly. Samples which cannot achieve five percent deadtime at position 1 must be remounted with either a large sample size or a sample configuration compatible with more sensitive detector systems; S(3), R(3), Y or Z.

Detector System C₄Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech

Date: 9/74

(the 4th crystal)

Model No.:

Bias: + 3000 V

Serial No.: 1031

Capacitance of Detector and Cryostat: 20 picofarads

Resolution:	1.90 keV (FWHM) @	1332 keV
	3.65 keV (FWTM) @	1332 keV
	0.99 keV (FWHM) @	121.9 keV

Peak to Compton ratio: 35.66:1 @ 1332 keV

Relative efficiency: 9.0 % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension:	Diameter	41.0 mm
	Length	40.0 mm
	Drift depth	15.25 mm
	Drift configuration:	Closed end coaxial
	Active volume	45 cm ³

Cryostat Type: Right Angle - common vacuum (HT)

Detector System F

Specifications

Location: Room B-1-A 222-S Building 200 W Area (PCL)

Manufacturer: Princeton Gamma Tech

Date:

Model No.:

Bias: + 3000 V

Serial No.: 849

Capacitance of Detector and Cryostat: 16 picofarads

Resolution: 1.77 keV (FWHM) @ 1332 keV
3.44 keV (FWTM) @ 1332 keV
0.71 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 35.9:1 @ 1332 keV

Relative efficiency: 8.6 % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension: Diameter 40.5 mm
Length 39.0 mm
Drift depth 15.25 mm
Drift configuration: Closed end coaxial
Active volume 46 cm³

Cryostat Type: Right Angle - common vacuum (HT)

Detector System W

Specifications

Location: Room B-1-A 222-S Building 200 W Area (PCL)

Manufacturer: Princeton Gamma Tech

Date: 8/71
repaired 3/75

Model No.:

Bias: + 3000 V

Serial No.: 692

Capacitance of Detector and Cryostat: 22 picofarads

Resolution:	2.33 keV (FWHM) @	1332	keV
	4.59 keV (FWTM) @	1332	keV
	keV (FWHM) @		keV

Peak to Compton ratio: 31.2:1 @ 1332 keV

Relative efficiency: 11.3% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	43.5	mm
	Length	42.3	mm
	Drift depth	17.0	mm
	Drift configuration:	Closed end coaxial	
	Active volume	60	cm ³

Cryostat Type: Right Angle - common vacuum (ET)
(10 liter dewar and 12 inch dewar extension)

Detector D

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech Date: 3/73
(last repair)

Model No.: Duode Bias: + 2500 V

Serial No.: 803

Capacitance of Detector and Cryostat:

Resolution:	2.2	keV (FWHM)	@	1332	keV
	4.19	keV (FWTM)	@	1332	keV
		keV (FWHM)	@		keV

Peak to Compton ratio: @ keV

Relative efficiency: 10.7% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	40.8	mm
	Length	55.5	mm
	Drift depth	16.0	mm
	Drift configuration:	Closed end coaxial	
	Active volume	cm ³	

Cryostat Type: HT-8 inch end cap

FIGURE 3

WELL SONDE DETECTORS

The detector on the left has been broken down to the detector-dewar section and a larger capacity liquid nitrogen dewar for storage has been added. The detector on the right is ready to lower into a well. The hose on the left is a 30 meter breather tube. The cable on the right lifts the sonde and transmits the signal through its 150 meter length.

DETECTOR SYSTEM: BDescription

This detector system was designed to analyze gamma energy emissions from inside a well or underwater, up to thirty meters underwater. The support cable is 150 meters in length and transmits the preamplified signal. The detector system may be operated in any attitude up to 60 degrees from vertical. The detector is a planar Intrinsic Germanium (IG) semiconductor mounted so that it faces the side of the well. It is readily collimated and has low sensitivity, therefore its primary use is the directional location of the source of high levels of radiation underground or underwater.

The detector sonde contains the detector, a cooled first stage FET, RG-11 preamplifier modified to run on ± 12 VDC, preamplifier power supply, bias supply (both rechargeable), the battery charger and a 24 hour supply of liquid nitrogen. The preamplified signal is transmitted through the 150 meter lifting cable where it is amplified and baseline restored with a 6.0 μ sec shaping time constant using a Canberra 1413 amplifier. The signal is routed to a 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 4096 channel analyzer. The energy calibration is 500 eV per channel.

Limitations

Only the activity received at the detector can be analyzed. Source-detector distance and geometry can only be approximated.

The detector can be used outside a well only with the same 24 hour liquid nitrogen restriction as in the well. At this time there is no intention of modifying the power connectors to enable operation with the auxiliary dewar.

Detector System B

Specifications

Location: Mobile Dev-Van-II or storage in 222-S/200 W Area (PLS)

Manufacturer: Princeton Gamma Tech

Date: 2/75

Model No.: Special IG 205

Bias: - 1500 V

Serial No.: 190

Capacitance of Detector and Cryostat:

Resolution:	.591 keV (FWHM) @	122	keV
	2.57 keV (FWTM) @	662	keV
	1.334 keV (FWHM) @	662	keV

Peak to Compton ratio: 6.67:1 @ 1332 keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	200	mm ²
	Length		mm
	Drift depth	5	mm
	Drift configuration:	intrinsic Ge planar	
	Active volume	1	cm ³

Cryostat Type: Sonde

The detector working face is on the cylindrical axis of the sonde/cryostat and pointed at the X on the outside surface.

DETECTOR SYSTEM: LDescription

This detector system was designed to analyze gamma energy emissions from inside a well or underwater, up to 30 meters underwater. The support cable is 150 meters in length and transmits the preamplified signal. The detector system may be operated in any attitude up to 60 degrees from vertical. The detector is a high sensitivity, closed-end, coaxial, lithium drifted germanium [Ge(Li)] semiconductor. It is intended to analyze radially around a well at maximum sensitivity.

The detector sonde contains the detector, a cooled first stage FET, RG-11 preamplifier modified to run on ± 12 VDC, preamplifier power supply, bias supply (both rechargeable), the battery charger and a 24 hour supply of liquid nitrogen. The preamplified signal is transmitted through the 150 meter lifting cable where it is amplified and baseline restored with a 4.0 μ sec shaping time constant using a Canberra 1413 amplifier. The signal is routed to a 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 4096 channel analyzer. The energy calibration is 500 eV per channel.

Limitations

The activity received at the detector is presumed to be evenly distributed radially around the well hole. Attenuation corrections are based on an infinitely thick sorber.

The detector can be used outside a well only with the same 24 hour liquid nitrogen restriction as in the well. At this time there is no intention of modifying the power connectors to enable operation with the auxiliary dewar.

Detection limits are calculated directly from the sample spectrum and the counting parameters by the GXDR system.

Detector System L

Specifications

Location: Dev-Van-II or storage in 222-S/200 W Area (PLS)

Manufacturer: Princeton Gamma Tech

Date: 2/75

Model No.:

Bias: - 1600 V

Serial No.: 908

Capacitance of Detector and Cryostat:

Resolution:	1.98	keV (FWHM)	@	1332	keV
	3.91	keV (FWTM)	@	1332	keV
	0.775	keV (FWHM)	@	121.9	keV

Peak to Compton ratio: 30.7:1 @ 1332 keV

Relative efficiency: 13.8% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	49.0	mm
	Length	37.0	mm
	Drift depth	18.0	mm
	Drift configuration:	Closed end coaxial	
	Active volume	70	cm ³

Cryostat Type: Sonde

FIGURE 4

THREE DETECTOR SYSTEMS

Designed for high efficiency, gamma energy analysis of bulk samples.

DETECTOR SYSTEM: S (3)Description

The three detector systems are designed to analyze bulk samples in the low activity range, microcurie to nanocurie per liter levels. Each of the three detectors is a lithium drifted germanium [Ge(Li)] detector in a closed end coaxial configuration with nominally ten percent relative efficiency. The detectors are arranged to form three sides of a square box to present the maximum detector surface area to the sample. There is only one counting position, at the focus of the three detectors, and only bulk samples are analyzed.

The shield is ten centimeters lead, graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to cut down the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield. The shield for this system stands between the detector and the dewars thus reducing the level of background radiation from the molecular sieve material in the dewar walls.

The detector signals are preamplified with room temperature Princeton Gamma Tech RG-11 preamplifiers that have been pole zero matched. This signal is mixed in a PGT model 308 preamplifier mixer module then amplified and baseline restored in a Canberra 1413 amplifier using four micro-second shaping time constant. The signal is routed to a 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 4096 channel analyzer. The energy calibration is 500 eV per channel.

Sample Mounts

T1 mounts (1 ml liquid)
T2 mounts (2 ml liquid or solids)
25 cc mounts
65 cc mounts
L/2 (half liter) mounts

Limitations

Sources are administratively limited to 15 percent deadtime (c.a. 10,000 c/s). If the source exceeds this value the mount (except 65 cc) is analyzed on a single mid activity range detector system. The 65 cc mounts are analyzed on very low activity detector systems (Z or Y) if they cannot achieve five percent deadtime. Detection limits are calculated directly from the sample spectrum and the counting parameters by the GXDR system. Net weights must be known to apply sorption corrections.

Detector S₁ of S₍₃₎ system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech

Date: 6/25/75

Model No.:

Bias: + 2300 V

Serial No.: 1155

Capacitance of Detector and Cryostat: 17.5 picofarads

Resolution: 1.98 keV (FWHM) @ 1332 keV
3.75 keV (FWTM) @ 1332 keV
0.814 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 33.7:1 @ 1332 keV

Relative efficiency: 10.5% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 44.5 mm
Length 43.8 mm
Drift depth 16.25 mm
Drift configuration: Closed end coaxial
Active volume 55 cm³
Distance from window <5 mm

Cryostat Type: HT

06/30/75

Detector S₂ of S₍₃₎ system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech

Date: 6/25/75

Model No.:

Bias: + 2600 V

Serial No.: 1153

Capacitance of Detector and Cryostat: 18 picofarads

Resolution: 1.95 keV (FWHM) @ 1332 keV
3.72 keV (FWTM) @ 1332 keV
0.794 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 35.8:1 @ 1332 keV

Relative efficiency: 12.3% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 45.5 mm
Length 45.5 mm
Drift depth 16.75 mm
Drift configuration: Closed end coaxial
Active volume 60 cm³
Distance from window <5 mm

Cryostat Type: HT

06/30/75

Detector S₃ of S₍₃₎ system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech

Date: 6/25/75

Model No.:

Bias: + 2200 V

Serial No.: 1174

Capacitance of Detector and Cryostat: 17 picofarads

Resolution: 1.70 keV (FWHM) @ 1332 keV
3.14 keV (FWTM) @ 1332 keV
0.753 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 35.9:1 @ 1332 keV

Relative efficiency: 10.7% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 46.0 mm
Length 33.0 mm
Drift depth 17.5 mm
Drift configuration: Closed end coaxial
Active volume 55 cm³

Cryostat Type: HT

06/30/75

DETECTOR SYSTEM: R(3) [Formerly RIS]Description

The three detector systems are designed to analyze bulk samples in the low activity range, microcurie to nanocurie per liter levels. Each of the three detectors is a lithium drifted germanium [Ge(Li)] detector in a closed end coaxial configuration with nominally ten percent relative efficiency. The detectors are arranged to form three sides of a square box to present the maximum detector surface area to the sample. There is only one counting position, at the focus of the three detectors, and only bulk samples are analyzed.

This particular set of detectors can be rearranged so that the detectors are vertically aligned for box and drum gamma energy analysis.

The shield is ten centimeters lead, graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to cut down the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield.

The detector signals are preamplified with room temperature Princeton Gamma Tech RG-11 preamplifiers that have been pole zero matched. This signal is mixed in a prototype PGT module then amplified in a Tennelec TC 202 amplifier using two microsecond shaping time constant and baseline restored in a TC 611 baseline restorer. The signal is routed to a 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 4096 channel analyzer. The energy calibration is 500 eV per channel.

Sample Mounts

T1 mounts (1 ml liquid)
T2 mounts (2 ml liquid or solids)
25 cc mounts
65 cc mounts
L/2 (half liter) mounts

Limitations

Sources are administratively limited to 15 percent deadtime (c.a. 10,000 c/s). If the source exceeds this value the mount (except 65 cc) is analyzed on a single mid activity range detector system. The 65 cc mounts are analyzed on very low activity detector systems (Z or Y) if they cannot achieve five percent deadtime. Detection limits are calculated directly from the sample spectrum and the counting parameters by the GXDR system. Net weights must be known to apply sorption corrections.

Detector R₁ of R (3) system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Ortec (Redrifting by PGT) Date: 6/75
(last repair)

Model No.: Bias: + 1800 V

Serial No.: OR-938

Capacitance of Detector and Cryostat: 18 picofarads

Resolution: 1.70 keV (FWHM) @ 1332 keV
3.29 keV (FWTM) @ 1332 keV
keV (FWHM) @ keV

Peak to Compton ratio: 35.9:1 @ 1332 keV

Relative efficiency: 10.4% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 43.0 mm
Length 40.0 mm
Drift depth 17.0 mm
Drift configuration: Closed end coaxial
Active volume 54 cm³
Distance from window <5 mm

Cryostat Type: HT, Right angle left

06/30/75

Detector R₂ of R (3) system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Ortec (Redrifting by PGT) Date: 5/23/75
(last repair)

Model No.: Bias: + 3000 V

Serial No.: OR-947

Capacitance of Detector and Cryostat: 28 picofarads

Resolution: 2.09 keV (FWHM) @ 1332 keV
4.15 keV (FWTM) @ 1332 keV
0.854 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 31.3:1 @ 1332 keV

Relative efficiency: 10.5% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter mm
Length mm
Drift depth mm
Drift configuration: Closed end coaxial
Active volume 55 cm³
Distance from window <5 mm

Cryostat Type: HT (301)

06/30/75

Detector R₃ of R (3) system

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Manufacturer: Ortec (Redrifting by PGT) Date: 4/74
(last repair)

Model No.: Bias: + 1800 V

Serial No.: OR-912

Capacitance of Detector and Cryostat: 20 picofarads

Resolution: 2.05 keV (FWHM) @ 1332 keV
4.00 keV (FWTM) @ 1332 keV
keV (FWHM) @ keV

Peak to Compton ratio: 35:1 @ 1332 keV

Relative efficiency: 11.1% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 41.0 mm
Length 46.2 mm
Drift depth 17.0 mm
Drift configuration: Closed end coaxial
Active volume 60 cm³

Cryostat Type: HT, right angle right

FIGURE 5

E DETECTOR SYSTEM FOR HIGH ACTIVITY
RANGE GAMMA ENERGY ANALYSIS

- A Primary Ge(Li) detector
- B Guard NaI(Tl) detector in anticoincidence to primary
- D Liquid nitrogen dewar (primary)
- J Collimator
- P Multiplier phototubes (guard)
- Pb Lead shielding

DETECTOR SYSTEM: E [Formerly Hi-Ac]Description

The E detector system is designed to analyze samples with activities from microcuries to curies or to analyze very low levels of isotopic activity in the presence of very high levels of peaked interference. It is an Anti-Compton system (hence Hi-Ac) to suppress interference from both Compton continuum and background radiation.

The primary detector is a very high quality, closed end coaxial, lithium drifted germanium [Ge(Li)] detector mounted in a vertically down configuration. Gamma radiation reaches the primary detector through a collimator which extends through a five centimeter shield wall and another five centimeters of guard detector. The guard detector is two half cylinders of thallium activated sodium iodide [NaI(Tl)] scintillator joined on the collimator/primary well axis. Its dimensions are 28.5 cm diameter by 25.4 cm deep. The well which receives the primary detector is off-center so that gamma photons scattered through the angles zero to 180 degrees have a probability of interaction with the scintillator of greater than 90 percent for photon up to 2 MeV in energy. Any such photon pulse received in the guard detector in coincidence with a pulse in the primary detector ($\leq 1 \mu\text{sec}$) will cause the cancellation of the primary signal; they will not be recorded in the pulse height analyzer.

Compton events are photons which partly transmit their energy to the primary detector and the remainder of it outside the primary so that they do not record a full energy event in the pulse height analyzer. Instead they record as a continuum of lower energy events which act as interference to lower, full energy emissions. Background is the full spectrum of gamma photons received from sources other than the sample, hence interference. The guard NaI(Tl) detector system in anti-coincidence to the primary Ge(Li) detector is directed at both of these events and reduces their impact by an approximate factor of ten. This detector system is particularly useful in analyzing very low level activities in the presence of high level interferences.

Detector system E receives gamma photons through a graded lead collimator from any of four positions within the sample shield or through a second collimator from any of three calibrated sample cart positions outside the shield.

The furthest calibrated source-detector position is 8.53 meters and can accommodate samples with surface readings in excess of 1000 R. All interior shield, collimator and sample cart surfaces are graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to reduce the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in lead.

The primary, Ge(Li) detector signal is preamplified with a cooled first stage FET, Princeton Gamma Tech RG-11C preamplifier. The signal is amplified with a 4 μ sec shaping time constant and baseline restored with a Canberra 1413 amplifier. This signal is analyzed in a 100 MHz ADC unless a coincident blocking pulse is received via the guard detector and coincidence circuitry below.

The energy calibration is 500 eV per channel in 4096 channels.

Sample Mounts

All standard mounts except 65 cc mount.

Limitations

Sources are administratively limited to 15 percent deadtime (c.a. 10,000 c/s). If the mount exceeds this value it is moved to a more distant geometry. If five percent deadtime cannot be attained, the source is moved to a closer geometry or to a midrange detector system. Random summing correction must be performed using the pulser mode. That is a pulser count is recorded simultaneously with the energy analysis and the loss in recorded pulser count rate is used to correct the entire spectrum for random summing losses.

Detector System E

Specifications

Location: Room B-1-A 222-S Building 200 W Area (CTL)

Primary Manufacturer: Princeton Gamma Tech Date: 8/74

Model No.: Bias: + 2400 V

Serial No.: 840

Capacitance of Detector and Cryostat: 30 picofarads

Resolution: 1.92 keV (FWHM) @ 1332 keV
3.70 keV (FWTM) @ 1332 keV
0.70 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 44.8:1 @ 1332 keV
420:1 (AC) @ 1332 keV
655:1 (AC) @ 622 keV

Relative efficiency: 17.2% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension: Diameter 49.5 mm
Length 54.0 mm
Drift depth 17.0 mm
Drift configuration: Closed end coaxial
Active volume 80 cm³

Cryostat Type: DT

Guard Manufacture: Harshaw Chemical Date: 9/74

Model No.: 45M4BW540/3 B-X Bias: + 1100 V

Serial No.: GG792 Multiplier Photo Tube type 4524 4 ea

Capitance of Detector and Cryostat:

Resolution: 12.3% (FWHM) @ 662 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension: Diameter 285 mm
Length 254 mm
Drift depth mm
Drift configuration
Active volume 15,400 cm³

FIGURE 6

VERTICAL, DIPSTICK CONFIGURATION

This configuration is used for all types of detectors in mid to low range gamma and X-ray analysis and in isotopic excitation X-ray fluorescence.

DETECTOR SYSTEM: G_xDescription

This detector system is designed with minimal sorption between the radiation source and the detector but with good radiation stopping power. Therefore, it is useful in low energy gamma analysis and full range (4 to 140 keV) X-ray and X-ray fluorescence analysis. Its primary areas of application are plutonium isotopic analysis in which gamma emissions from 100 keV to 420 keV are analyzed with exceptional resolution and K X-ray analysis of the rare earths through the transuranics on the periodic chart of elements.

The detector is an intrinsic germanium planar detector with the operating face behind a one mil (0.0254 mm) beryllium window. For plutonium isotopic analysis an 0.56 mm cadmium sorber is usually interposed between the source and the detector to reduce the contribution of 59.6 keV ²⁴¹Am emission relative to the useful range of emissions. Only relative counts are taken. For gamma and X-ray energy analysis, standard geometrics are precalibrated and all positions are referenced to the working face of the detector. For X-ray fluorescence analysis this detector system utilizes isotopic sources to excite the orbital electrons of the sample material to higher levels and the detector analyzes the characteristic "fluorescence" X-rays emitted when the electrons return to base energies. Annular isotopic excitation sources are available which fit over the detector head and provide a c.a. 180° excitation-emission path. Also available are disc sources in a selectable "wheel" with the samples in a sample changer wheel which provide a c.a. 90° excitation-emission path. Both alternatives are provided with chambers which can be operated in a vacuum or with a helium atmosphere to reduce air path sorption.

The detector signal is preamplified with a pulsed optical feed back, Princeton Gamma Tech PO-12B preamplifier, amplified and baseline restored with 10 μsec shaping time constant using a modified Canberra 1413 amplifier. A PGT model 343 pulse pile up rejector is used to eliminate distorted pulses. The signal is then routed to either a 50 or 100 MHz Analog-to-Digital Converter (ADC) for analysis in a 1024, 2048 or 4096 channel pulse height analyzer. The energy calibration is variable with the intended application. For plutonium isotopic analysis 100 eV per channel with a zero intercept at 126 keV is standard.

Sample Mounts

Plutonium isotopic: Any configuration

Gamma, X-ray and

X-ray fluorescence: Spectrocup, 2 x 2 slide mount or
end cap mounts

Limitations

Lithium drifted Silicon [Si(Li)] detector systems are more efficient for K X-ray emission analysis for elements with energies lower than the rare earths (c.a. 30 keV) and are preferentially used in that range. Since this Ge detector type is usually very thin, five to seven millimeters, they are not used for higher energy photon analysis unless exceptional resolution is required and high activity samples and/or long counting times can be tolerated.

Detector System Gx

Specifications

Location: Mobil in 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech Date: 2/75

Model No.: Bias: - 1700 V

Serial No.: 171

Capacitance of Detector and Cryostat:

Resolution:	0.175 keV (FWHM) @	5.9 keV
	keV (FWTM) @	keV
	0.496 keV (FWHM) @	121.9 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	100	mm ²
	Length		mm
	Thickness	7	mm
	Drift configuration:	intrinsic germanium planar	
	Active volume	0.7	cm ³
	Distance from window	2.54	mm

Cryostat Type: SD

DETECTOR SYSTEM: HDescription

The "H" detector system was designed to perform the same tasks as "G_x" system. It differs only in age and performance.

The detector is a LEPS (Ortec trade name which stands for Low Energy Photon Spectrometer) detector, a lithium drifted planar detector with the working surface treated to be nearly windowless to low energy radiation. The detector is behind a 10 mil (0.254 mm) beryllium window. For X-ray fluorescence the "H" detector only works with annular isotopic excitation sources.

The detector signal is preamplified with an Ortec 116 pre-amplifier, amplified by a Tennelec TC 202 amplifier with 1.6 μ sec shaping time constant and baseline restored with a TC 611. At this time the detector is not in routine use.

Sample Mounts

Plutonium isotopic: Any configuration

Gamma, X-ray and

X-ray fluorescence: Spectrocup, 2 x 2 slide mount or end cap mounts

Limitations

Lithium drifted Silicon [Si(Li)] detector systems are more efficient for K X-ray emission analysis for elements with energies lower than the rare earths (c.a. 30 keV) and are preferentially used in that range. Since this Ge detector type is usually very thin, five to seven millimeters, they are not used for higher energy photon analysis unless exceptional resolution is required and high activity samples and/or long counting times can be tolerated.

Detector System H

Specifications

Location: Room 234-5 Building 200 W Area (PCL-NDA)

Manufacturer: Ortec Inc.

Date: 6/69
(last repair)

Model No.: 8013-08

Bias: - 900 V

Serial No.: GS 270

Capacitance of Detector and Cryostat:

Resolution:	0.336 keV (FWHM) @	6.4 keV
	0.369 keV (FWTM) @	14.4 keV
	0.671 keV (FWHM) @	121.9 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	50	mm ²
	Length		mm
	Drift depth	5	mm
	Drift configuration:	LEPS [Ge(Li)] planar	
	Active volume	0.25	cm ³

Cryostat Type: 80 Vertical

DETECTOR SYSTEM: JDescription

This type of detector is designed to analyze the middle range of gamma activities, from 0.1 microcuries to tens of microcuries. The detector is a lithium drifted germanium [Ge(Li)] semiconductor. The detector configuration is vertical, dipstick as in Figure 6. The entire detector system is enclosed in radiation shielding. The detector is a true coaxial cylinder with its axis vertical and aligned with the center of the sample holder. The sample holder attaches to the cryostat end cap and contains three positions; number one is closest to the detector.

The shield is ten centimeters lead graded with 0.56 millimeters of cadmium and 0.25 millimeters of copper to cut down the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield. The shield cross section is 61 centimeters by 61 centimeters.

The detector signal is preamplified with a room temperature Tennelec TC 135 preamplifier, amplified with a Tennelec TC 202 with 2.4 microsecond shaping time constant and baseline restored with a Tennelec TC 611. The signal is routed to a 100 MHz ADC for analysis in a 4096 channel pulse height analyzer. The energy calibration is 500 eV per channel.

Sample Mounts

1" flat mounts
Tl mounts (1 ml liquid)

Limitations

Sources are administratively limited to 15 percent deadtime (c.a. 10,000 c/s). If the source exceeds this it is moved to a higher numbered geometry or to a detector system with less sensitivity; C₄, F, W, or E. Samples which cannot achieve five percent deadtime at position one must be remounted with either a larger sample size or a sample configuration compatible with more sensitive detector systems; S₍₃₎, R₍₃₎, Y, or Z.

Detector System J

Specifications

Location: Room B-1-A 222-S Building 200 W Area (PCL)

Manufacturer: Nuclear Diodes Inc.

Date:

Model No.: LGCC 12.0-2.6

Bias: + 3000 V

Serial No.: L-724

Capacitance of Detector and Cryostat: 23 picofarads

Resolution: 2.57 keV (FWHM) @ 1332 keV
keV (FWTM) @ keV
1.50 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 27.5:1 @ 1332 keV

Relative efficiency: 12.0% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension: Diameter 42 mm
Length 53 mm
Drift depth 16.6 mm
Drift configuration: coaxial₃
Active volume cm³
Distance from window 3 mm
Window 0.5 mm Al

Cryostat Type: Vertical dipstick

DETECTOR SYSTEMS: K and NDescription

These detector systems are designed with minimal sorption between the radiation source and the detector and with optimum efficiency in the 3 to 30 keV range. They are therefore most useful for calcium to cesium K X-ray fluorescence analysis or, to a lesser extent, L X-ray fluorescence analysis of the high Z elements in the periodic chart. The detector configuration is vertical dipstick as in Figure 6.

These detectors are planar lithium drifted Silicon [Si(Li)] detectors operating behind their beryllium windows. Annular isotopic sources are used to excite the orbital electrons of the sample material to higher levels and the detector analyzes the characteristic "fluorescence" X-rays emitted when the electrons return to base energies. This mode of excitation provides an approximately 180° excitation-emission path. A chamber is available to provide either vacuum or helium atmosphere for this path to reduce air path sorption and interference.

The K detector signal is preamplified with a Kevex 2002 pulsed optical feedback preamplifier and amplified with 8 μ sec shaping time constant using a Kevex 4500P. A Kevex model 4590 is used for pulse pile up rejection. Signals are pulse height analyzed in whatever is available; NS-720, NS-750, NS-880, NS-911, or ND 50/50. All have equal to or greater than 50 MHz ADC's.

The N detector is a mobile, van operated system used semi-quantitatively for trace metal in rock analysis. A Nuclear Semiconductor Inc. NSI 502A preamplifier, Tennelec TC 202 amplifier with 8 μ sec shaping time constant and TC 611 baseline restorer prepare the detector signal for input to a Packard 200 channel/800 channel range pulse height analyzer.

Sample Mounts

For K:	Spectrocup, 2 x 2 slide mount or end cap mount
For N:	Any freshly fractured or sawn rock face that is reasonably flat.

Limitations

Lithium drifted Silicon [Si(Li)] detector systems are more efficient for emissions in the range 3 to 30 keV than other detector systems and are preferentially used in that range only.

Detector System K

Specifications

Location: Mobil in 222-S Building 200 W Area (CTL)

Manufacturer: Kevex

Date: 1/75
(last repair)

Model No.: 3000

Bias: + 1000 V

Serial No.: 1426

Capacitance of Detector and Cryostat:

Resolution:	0.160 keV (FWHM) @	5.898 keV
	0.378 keV (FWTM) @	14.4 keV
	0.2217 keV (FWHM) @	14.4 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension:	Area	30	mm ²
	Length		mm
	Drift depth	3(?)	mm
	Drift configuration:	planar	Si(Li)
	Active volume		cm ³
	Distance from window	6	mm
	Window	0.025 mm	Be

Cryostat Type: Vertical dipstick

Detector System N

Specifications

Location: Mobile - unlimited

Manufacturer: Nuclear Semiconductor

Date: 6/71

Model No.:

Bias: - 400 V

Serial No.: QA17-1

Capacitance of Detector and Cryostat:

Resolution:	0.198 keV (FWHM) @	6.4 keV
	0.449 keV (FWTM) @	14.4 keV
	0.238 keV (FWHM) @	14.4 keV

Peak to Compton ratio:	@	keV
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Relative efficiency:	% [to 3 x 3 inch NaI(Tl) @ 25 cm source (⁶⁰ Co) detector distance]
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Crystal Dimension:	Area	30	mm ²
	Length		mm
	Drift depth	3	mm
	Drift configuration:	planar Si(Li)	
	Active volume	0.090	cm ³
	Window	0.025	mm Be

Cryostat Type: Vertical dipstick

FIGURE 7

IN SITU DETECTOR SYSTEM

Designed to analyze the surface and near-surface gamma emitters in the tenth square meter defined by the conical collimator.

DETECTOR SYSTEMS: I (In Situ)Description

The "I" or In Situ detector system was designed for the single purpose of analyzing the gamma and bremsstrahlung radiation from a defined tenth square meter of surface, any surface. In soils the vertical profile of isotopic distribution is determined from cored samples and the photon attenuation applied accordingly. This detector system will provide fine structure to the aerial radiation surveys performed by EGG and will provide an accounting for clean-up efforts for any present or future uncontrolled radiation releases.

The detector is a Lithium drifted Germanium [Ge(Li)] closed end coaxial in a vertically down configuration. It is intended to operate inside a conical shield which supports the detector system and defines one tenth square meter of surface (Figure 7). The shield consists of 6.35 millimeters of aluminum, 6.35 millimeters of lead, 0.56 millimeters of cadmium and 0.25 millimeters of copper. The cadmium and copper "grading" cut down the reemission of lead K fluorescence X-rays which result from sample emitted gamma photons absorbed in the shield.

The detector bias and preamplifier power are both supplied from battery boxes (Figure 7). The detector signal is preamplified with a room temperature Canberra 970 preamplifier, amplified and baseline restored with a two microsecond shaping time constant using a Canberra 1413 amplifier. The signal is transmitted through a 150 meter cable to an NS 911 1024 channel pulse height analyzer with a 50 MHz ADC. Energy calibration is 1 keV per channel.

Sample Mounts

None.

Limitations

Analysis with this system is limited to one tenth square meters of solid surface. For accurate results the vertical isotopic distribution must have previously been determined from core samples. For density and water content correction, a small plug sample must be taken from the sample area and sealed immediately.

Detector System I

Specifications

Location: Mobile Dev-Van-I or Storage in 222-S/200 W Area (PLS)

Manufacturer: Canberra Industries

Date: 7/73
(last repair)

Model No.: 7229

Bias: + 3000 V

Serial No.: 467/R

Capacitance of Detector and Cryostat: 16 picofarads

Resolution:	2.11 keV (FWHM) @	1332 keV
	4.01 keV (FWTM) @	1332 keV
	1.10 keV (FWHM) @	121.9 keV

Peak to Compton ratio: 30:1 @ 1332 keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	43.5 mm
	Length	38.5 mm
	Drift depth	15.75 mm
	Drift configuration:	Closed end coaxial
	Active volume	cm^3
	Distance from window	10 mm

Cryostat Type: 7906-10, common vacuum-vertically down

FIGURE 8

PQ DETECTOR SYSTEM

Designed for collimated well core gamma energy analysis

DETECTOR SYSTEM: PQDescription

The PQ detector system was designed to analyze well cores through collimated slits. Analysis is to be performed at the well head in Dev-Van-II, the core storage location or in the laboratory.

These detectors are Lithium drifted Germanium [Ge(Li)] semi-planars or low energy coaxials. That is the cylindrical ingot is so short relative to the diameter that after closed end coaxial drifting the detector looks like and has the energy response characteristics of a planar detector (Figure 1). The lithium doped sorption layer exists on the working face of the detector so it has very poor efficiency for energies lower than 50 keV as is true for coaxial detectors. The response is good to excellent in both efficiency and resolution across most of the energy range for fission products, 60 keV to 1400 keV and the investment is relatively small. Hence the application.

The detector signals are preamplified using a Canberra 970 preamplifier, amplified and baseline restored with 4 μ sec shaping time constant using a Canberra 1413 and mixed in a Tracor Northern NS 459 mixer. The intent is to analyze one signal from the mixer in the NS720 4096 channel analyzer that looks like it came from one detector. The NS 720 contains a 100 MHz ADC. Energy calibration is 500 eV per channel.

Sample Mount

Well cores in liners with outside diameters from 5 centimeters to 20 centimeters.

Limitations

None until the count rate becomes so high no signal is received.

Detector P of PQ System

Specifications

Location: Dev-Van-II or storage in 222-S/200 W Area (PLS)

Manufacturer: Canberra Industries

Date: 2/74

Model No.: 7227

Bias: + 2500 V

Serial No.: 534

Capacitance of Detector and Cryostat:

Resolution:	1.95 keV (FWHM) @	1332 keV
	3.98 keV (FWTM) @	1332 keV
	0.670 keV (FWHM) @	121.9 keV

Peak to Compton ratio: 17:1 @ 1332 keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	15.5 cm ²
	Length	mm
	Drift depth	19.0 mm
	Drift configuration:	Closed end coaxial
	Active volume	30 cm ³
	Distance from window	5 mm

Cryostat Type: 7905-10Sp (Common vacuum-side looking)

Detector Q of PQ System

Specifications

Location: Dev-Van-II or storage in 222-S/200 W Area (PLS)

Manufacturer: Canberra Industries

Date: 3/74

Model No.: 7226

Bias: + 1800 V

Serial No.: 538

Capacitance of Detector and Cryostat:

Resolution:	1.97 keV (FWHM) @	1332 keV
	3.99 keV (FWTM) @	1332 keV
	0.774 keV (FWHM) @	121.9 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Area	15 cm ²
	Length	mm
	Drift depth	19 mm
	Drift configuration:	Closed end coaxial
	Active volume	28.5 cm ³
	Distance from window	5 mm

Cryostat Type: 7905-10Sp (Common vacuum-side looking)

FIGURE 9

Si(Li) "X" DETECTOR SYSTEM

Above: Two Si(Li) detector cryostat dewars designed for use in the Spectrace 440 X-ray fluorescence and sample changer.

Below: Spectrace 440 with X-ray tube (upper left) excitation.

DETECTOR SYSTEM: X_sDescription

This detector system is designed to operate in a sample changer chamber in either direct or indirect excitation modes using transmission target, X-ray generating tubes. Both the detector and the excitation tubes operate with maximum efficiency in the three to 30 keV range. They are therefore most useful for calcium to cesium K X-ray fluorescence analysis or to a lesser extent L X-ray fluorescence analysis of the middle to high Z elements in the periodic chart.

The detector configuration shown in Figure 9 is intended to form a 90 degree angle to the direct mode excitation source with the sample at the apex of the angle. Direct mode excitation means an X-ray beam originates in the lower excitation tube through the built in transmission target which determines the excitation energies through a filter (in a secondary filter/target wheel not visible in Figure 9b) which sorbs all but the desired X-ray and finally to the sample. The sample sorbs the incident X-rays and reemits X-rays characteristic of its composition which are visible to the detector. However the reemitted X-rays cannot have higher energies than the incident X-rays and the efficiency of reemission falls rapidly for reemitted X-rays much lower in energy than the incident X-rays. Indirect mode excitation originates in the upper transmission target, excitation tube in Figure 9b. The emitted X-ray beam is directed at an elemental target which sorbs the X-rays and reemits lower energy X-rays characteristic of that target. From there the X-rays are directed to the sample as in direct mode excitation. Indirect mode excitation is a means of filling the gaps of maximum fluorescence efficiency available through the use of direct mode excitation sources.

The sample chamber provides the means of programing the analysis of up to twenty 1.25 inch diameter samples. Vacuum or helium atmosphere can be provided to reduce the air path sorption and interferences from air components such as krypton, xenon and radon.

The detector is a planar, Lithium drifted Silicon [Si(Li)] semiconductor operating behind a thin beryllium window. The signal is preamplified with a Nuclear Semiconductor Inc. (NSI) 504, pulsed optical feedback preamplifier and amplified with 8 microsecond shaping time constant using an NSI 513 amplifier pulse pileup rejector. The signal is then routed to a 100 MHz ADC in either a satellite pulse height

analyzer for later transmission to an NS 880 via cassette magnetic tape or directly to the NS 880. The NS 880 is the GXDR system which performs data reduction.

The X detector system is mobile within the 222-S Building.

Sample Mounts

Spectrocup, 2 x 2 slide mount or end cap mount.

Limitations

Si(Li) detector systems are more efficient for emissions in the range 3 to 30 keV than other detector systems and are preferentially used in that range only. Direct access to X detector is difficult so only tube excitation, fluorescence analysis is performed with it.

Detector System X_SSpecifications

Location: Mobile in 222-S Building 200 W Area (CTL)

Manufacturer: Nuclear Semiconductor Inc. Date: 5/8/75
(last repaired)

Model No.: 10902/504-LN30-3 Bias: 600 V

Serial No.: 1777-QA57-5

Capacitance of Detector and Cryostat:

Resolution:	170	keV (FWHM) @	6.40 keV
	321	keV (FWTM) @	keV
	149	keV (FWHM) @	5.90 keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension:	Area	30	mm ²
	Length		mm
	Drift depth	3	mm
	Drift configuration:	planar Si(Li)	
	Active volume	0.090	cm ³
	Window	0.025	mm Be

Cryostat Type: SD165G

FIGURE 10

DETECTOR SYSTEM "Y"

Designed for ultra low activity gamma energy analysis using Compton and background suppression. The Anti-coincident guard detector has been lowered from around the primary Ge(Li) detector.

DETECTOR SYSTEM: Y (Formerly: Environmental Level)

Description

The Y detector system was designed to analyze samples at ultra low levels of activity with individual isotopic components at the picocurie level and the total sample at the sub-microcurie level. The system may be used in either an anti-Compton mode to suppress interference from both Compton continuum and background radiation or in a nonanti-Compton mode in which the sample, contained in a Marinelli beaker, surrounds the primary detector for maximum counting efficiency.

The primary detector was a top quality, closed end coaxial Lithium drifted Germanium [Ge(Li)] detector in 1969. When operated by itself 700 milliliters of sample are contained between plastic bags, which are in turn between molded polystyrene "boxes" forming a Marinelli beaker. The net effect is to surround the detector on all its closed coaxial surfaces to a uniform thickness for maximum efficiency. When operated in the anti-Compton mode, samples are contained in a 65 cubic centimeter molded polystyrene box and it is positioned in contact with the cryostat end cap of the primary detector. The guard NaI(Tl) annulus and plug are raised around the sample until contact is made.

Any photon pulse received in the guard detector in coincidence with a pulse in the primary detectors (≤ 1 μ sec) will cause the cancellation of the primary signal; they will not be recorded in the pulse height analyzer. Compton events are photons which partly transmit their energy to the primary detectors and the remainder of it outside the primary so that they cannot record a full energy event in the pulse height analyzer. Instead they record as a continuum of lower energy events which act as interference to the lower, full-energy emissions. Background is the full spectrum of gamma photons received from sources other than the sample, hence interference. The guard NaI(Tl) detector system in anti-coincidence to the primary Ge(Li) detector is directed at both of these events and reduces their impact by an approximate factor of ten. This detector system is particularly useful in analyzing ultra low levels of activity in the presence of as much as five orders of magnitude interference. Since the sample in the anti-Compton mode of analysis is inside the guard detector a large proportion of the photon events received by the guard detector do nothing but enter pulses which are spurious

to the system logic and which may cause random coincidence events with the primary detector reducing its efficiency for non-coincident events. This is the limiting factor for total sample activity in the system.

Also, gamma photons which result from coincident, cascade decay of isotopes such as ^{60}Co , ^{106}Rh , ^{46}Sc , etc. usually emit their photons at an angle of 180° to each other. This means a photon which enters and records in the primary has a very high probability of also recording in the guard detector thus cancelling the primary signal. The effect is dependent on relative energies and sample bulk but generally with the bulk of sample in a 65 cc source there is still a net gain in signal to noise ratio.

The circuit diagram of Y system is on page 78, Figure 10a.

Sample Mounts

700 cc gel mounts
65 cc mounts of all types
(including flat mounts)

Limitations

Sources are administratively limited to less than two percent deadtime in contact with a 2 x 2 inch NaI(Tl) detector attached to a 2 MHz ADC. If the mount exceeds this value it must either be remounted using a smaller active aliquot or the mount must be analyzed on a less sensitive detector system such as the three detector $R_{(3)}$ or $S_{(3)}$ combinations. Both Y and Z detector systems are in a laminar flow clean room to maintain a low background. The sample must be non-smearable and non-linting before entry.

Random summing corrections must be performed by recording a pulser count simultaneously with the energy analysis. Loss in recorded pulser count rate is used to correct the entire spectrum for random summing loss.

Detector System Y (primary)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Nuclear Diodes Inc.

Date: 9/69

Model No.: LGC-9.5-4.0

Bias: - 1750 V

Serial No.: L-577

Capacitance of Detector and Cryostat: 48 picofarads

Resolution: 2.58 keV (FWHM) @ 1332 keV
4.82 keV (FWTM) @ 1332 keV
2.29 keV (FWHM) @ 661.6 keV

Peak to Compton ratio: 236.5:1 (AC) @ 661.6 (point source)

Relative efficiency: 10.2% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension: Diameter 41 mm
Length 71 mm
Drift depth 15 mm
Drift configuration: Closed end coaxial
Active volume 88 cm³
Distance from window 5 mm
Window 0.5 mm Al

Cryostat Type: Vertically down, chicken feeder

FIGURE 10A

Y DETECTOR SYSTEM CIRCUIT DIAGRAM

BLR: Base Line Restorer
 TSCA: Timing Single Channel Analyzer
 DA: Delay Amplifier
 ADC: Analog to Digital Convertor

Detector System Y (annulus)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Harshaw Chemical Co.

Date: 10/69

Model No.: 37.5M6BW48/2B-X

Bias: + 1545

Serial No.:

Capacitance of Detector and Cryostat:

Resolution:	90	keV (FWHM) @	662	keV
		keV (FWTM) @		keV
		keV (FWHM) @		keV

Peak to Compton ratio:	@	keV
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Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	238	mm
	Length	305	mm
	Annulus inside	92	mm
	Configuration:	Right cylinder ₃	Annulus NaI(Tl)
	Active volume		cm ³
	Distance from window		mm
	Window		

Cryostat Type:

Detector System Y (plug)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Harshaw Chemical Co.

Date: 12/69

Model No.:

Bias: + 1243

Serial No.:

Capacitance of Detector and Cryostat:

Resolution:	50	keV (FWHM) @	662	keV
		keV (FWTM) @		keV
		keV (FWHM) @		keV

Peak to Compton ratio:		@		keV
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Relative efficiency:	% [to 3 x 3 inch NaI(Tl) @ 25 cm source (⁶⁰ Co) detector distance]
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Crystal Dimension:	Diameter	90.5 mm
	Length	76.2 mm
	Drift depth	mm
	Configuration:	Right cylinder NaI(Tl)
	Active volume	cm ³
	Distance from window	mm

Cryostat Type:

FIGURE 11

Z PRIMARY, Ge(Li) DETECTORS

Above: Upper primary detector

Below: Lower primary detector

FIGURE 12

DETECTOR SYSTEM Z

The dewar for the lower primary detector is to the right. Samples are inserted into the anticoincident guard, annulus detector and the annulus is completed with a 3" x 3" NaI(Tl) "plug". The shield door is couterbalanced.

FIGURE 13

DETECTOR SYSTEM Z

Designed for ultra low activity gamma energy analysis. A sample is shown between the upper and lower primary Ge(Li) detectors. The "plug" detector is laying in front of the sample access opening.

DETECTOR SYSTEM: Z [Formerly AC, Dual Ge(Li)]

Description

The Z detector system was designed to update the capabilities of Y detector system. It is designed to analyze samples at ultra low levels of activity with individual isotopic components at the picocurie level and the total sample at the sub-microcurie level. The detector system is intended to be used only in the Compton suppression mode.

There are two primary detectors, a matched pair of very large, high performance, closed end, coaxial Ge(Li) detectors. At the time of purchase in 1974 these detectors represented the best available in size combined with peak-to-Compton performance. The primary signals are mixed so that their combined signals are treated as coming from a single large detector. As seen in Figure 13, the sample is inserted between the upper and lower primary detectors and enclosed in a guard detector annulus with plug. Samples are contained in a 65 cubic centimeter molded polystyrene box which is slipped into a graded shield ring. The entire assembly is placed in a plastic bag before being introduced into the detector system. The bag is to control contamination of the detectors. The shield ring limits the useless and interfering radiation that could go directly into the guard detector. It consists of 1.59 millimeters of lead graded with 0.56 millimeters cadmium and 0.25 millimeters of copper. Point sources are mounted between 13 micron, polypropylene films in a spector cup assembly which is inserted in turn into a 65 cubic centimeter container with the ends milled out and the diameter filled with lead.

Any photon pulse received in the guard detector in coincidence with a pulse in the primary detectors ($\leq 1 \mu\text{sec}$) will cause the cancellation of the primary signal; they will not be recorded in the pulse height analyzer. Compton events are photons which partly transmit their energy to the primary detectors and the remainder of it outside the primary so that they cannot record a full energy event in the pulse height analyzer. Instead they record as a continuum of lower energy events which act as interference to the lower, full-energy emissions. Background is the full spectrum of gamma photons received from sources other than the sample, hence interference. The guard NaI(Tl) detector system in anti-coincidence to the primary Ge(Li) detector is directed at both of these events and reduces their impact by an approximate factor of ten. This detector system is particularly useful in analyzing ultra low levels of activity in the presence of as much as five orders of magnitude interference. Since the sample in

the anti-Compton mode of analysis is inside the guard detector a large proportion of the photon events received by the guard detector do nothing but enter pulses which are spurious to the system logic and which may cause random coincidence events with the primary detector reducing its efficiency for non-coincident events. This is the limiting factor for total sample activity in the system. It is also the reason for the internal shield ring.

Also, gamma photons which result from coincident, cascade decay of isotopes such as ^{60}Co , ^{106}Rh , ^{46}Sc , etc. usually emit their photons at an angle of 180° to each other. This means a photon which enters and records in the primary has a very high probability of also recording in the guard detector thus cancelling the primary signal. The effect is dependent on relative energies and sample bulk but generally with the bulk of sample in a 65 cc source there is still a net gain in signal to noise ratio.

The circuit diagram of Z system is on page 87, Figure 13a.

Sample Mounts

65 cc mounts of all types (including flat mounts)

Limitations

Sources are administratively limited to less than two percent deadtime in contact with a 2 x 2 inch NaI(Tl) detector attached to a 2 MHz ADC. If the mount exceeds this value it must either be remounted using a smaller active aliquot or the mount must be analyzed on a less sensitive detector system such as the three detector $R_{(3)}$ or $S_{(3)}$ combinations. Both Y and Z detector systems are in a laminar flow clean room to maintain a low background. The sample must be non-smearable and non-linting before entry.

Random summing corrections must be performed by recording a pulser count simultaneously with the energy analysis. Loss in recorded pulser count rate is used to correct the entire spectrum for random summing loss.

EZS : EXTRAPOLA

DDL : DOUBLE DE

LS+D : LOGIC SHA

TSCA : TIMING SIN

DWG NO.

REV NO.

DRAWING TITLE OR INDEX NO.

REFERENCE DRAWINGS

U.S. ATOMIC ENERGY COMMISSION
RICHLAND OPERATIONS OFFICE

Atlantic Richfield Hanford Company
Richland, Washington 99352

Z DETECTOR SYSTEM
CIRCUIT DIAGRAM

DWG NO.

FIGURE 13A

SHEET NO.

SHEETS

Detector System Z_u (upper primary)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech.

Date: 6/74

Model No.:

Bias: + 3000 V

Serial No.: 875

Capacitance of Detector and Cryostat: 28 picofarads

Resolution: 1.81 keV (FWHM) @ 1332 keV
3.34 keV (FWTM) @ 1332 keV
0.80 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 50:1 @ 1332 keV

Relative efficiency: 20.85% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 52 m
Length 52 mm
Drift depth 19 mm
Drift configuration: Closed end coaxial
Active volume 105 cm³
Distance from window mm

Cryostat Type: DT

Detector System Z₁ (lower primary)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Princeton Gamma Tech

Date: 5/28/75
(last repair)

Model No.:

Bias: + 3000 V

Serial No.: 966

Capacitance of Detector and Cryostat: 21 picofarads

Resolution: 1.77 keV (FWHM) @ 1332 keV
3.34 keV (FWTM) @ 1332 keV
0.70 keV (FWHM) @ 121.9 keV

Peak to Compton ratio: 43.8:1 @ 1332 keV

Relative efficiency: 19.66% [to 3 x 3 inch NaI(Tl) @ 25 cm
source (⁶⁰Co) detector distance]

Crystal Dimension: Diameter 52.0 mm
Length 46.5 mm
Drift depth 19 mm
Drift configuration: Closed end coaxial
Active volume 100 cm³
Distance from window <5 mm

Cryostat Type: NPR

06/30/75

Detector System Z (annulus)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Harshaw Chemical Co.

Date: 12/74

Model No.: 37.5M4BW48/3A-X

Bias: + 1100 V

Serial No.: GG 765

Capacitance of Detector and Cryostat:

Resolution:	105	keV (FWHM) @	662	keV
		keV (FWTM) @		keV
		keV (FWHM) @		keV

Peak to Compton ratio: @ keV

Relative efficiency: % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	257	mm
	Length	305	mm
	Annulus inside dia.	76.2	mm
	Configuration;	Right cylindrical annulus NaI(Tl)	
	Active volume		cm ³
	Distance from window		mm

Cryostat Type:

Detector System Z (plug)

Specifications

Location: Room B-1-B 222-S Building 200 W Area (CTL)

Manufacturer: Harshaw Chemical Co.

Date: 6/74

Model No.: 12S12/3F-X

Bias: + 900 V

Serial No.: GG 76Y

Capacitance of Detector and Cryostat:

Resolution:	50 keV (FWHM) @	662 keV
	keV (FWTM) @	keV
	keV (FWHM) @	keV

Peak to Compton ratio:	@	keV
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Relative efficiency: 100 % [to 3 x 3 inch NaI(Tl) @ 25 cm
source (^{60}Co) detector distance]

Crystal Dimension:	Diameter	76	cm
	Length	76	mm
	Drift depth		mm
	Configuration:	Right cylinder	NaI(Tl)
	Active volume		cm ³
	Distance from window		mm

Cryostat Type:

FIGURE 14

GAMMA, X-RAY DATA REDUCTION (GXDR) SYSTEM

In the background, at either end are NS-660 systems dedicated to gamma energy analysis. The system in the center is an NS-880 dedicated to X-ray analyses of all types. In the foreground are two TI-733 ASR terminals which service all three systems.

GAMMA, X-RAY DATA REDUCTION (GXDR) SYSTEM

The current Gamma, X-ray Data Reduction (GXDR) system consists of two NS 660's devoted to gamma data reduction and one NS 880 devoted to all other radiation emission analysis (Figure 14). All spectral data from the data acquisition systems enters the system through read only magnetic tape cassette units. Calibration data tables in and reports out for the NS 660 systems are via TI733 ASR terminals and their magnetic tape cassette decks. A 4096 channel spectral input takes 90 seconds per spectrum, 60 seconds for calibration read-in per sample type (c.a. 12 spectra), ten second terminal keyboard entry, and 20 second report read-out.

Plan for GXDR Update (Figure 15)

Phase 1 will establish a PDP8L/Nova 1220 hard wired link between the four 4096 channel pulse height analyzers in the ND 50/50 and one of the NS 660 GXDR computers. The primary purpose is to put four idle analyzers back into service. Transfer of spectral data will be on demand. That is, when a spectrum is ready to come over to the NS 660 everything else will have to be shut down while that spectrum is first transferred and then data reduced. Timing is approximately the same as before except every spectrum received will represent a different sample type and the 60 second calibration read-in will be performed each time. A secondary application is the entry of cassette spectral data from the NS 660 to the ND 50/50 for qualitative analysis, point plotting and interactive data reduction.

Phase 2 will establish communication between the GXDR Nova 1220 and the CAMAC Nova 840 computer/discs and through them the incoming data via the laser link with 234-5 Building. The communications link consists of a Multiprocessor Communications Adapter (MCA) board in each computer and a hard wire linkage between them. Phase 2 will permit entry of 234-5 Building spectral data to one NS 660 only, it will permit expanded use of both computer facilities, and it will permit programming for phase 3 to be initiated.

Phase 3 consists of the installation of a Diablo moving head disc on the Nova 1220 together with a 16,000 word memory board to facilitate its use and an MCA link with the other NS 660. A CAMAC crate will be purchased for phase 4 application. These additions will permit off-line storage of spectral data on disc thus eliminating 90

FIGURE 15

PLAN FOR GXDR UPDATE

seconds of operator time per entry and the demand mode entry from the ND 50/50 pulse height analyzers. They will also permit storage, search and access to the calibration tables and report output on disc instead of on TI733 ASR cassette thus eliminating 20 to 80 seconds per data reduction. These savings apply to both NS 660's and are estimated to increase their efficiency ten-fold.

Phase 4 consists of a second NS 880 with terminal and the CAMAC modules to interface the Digital Equipment Corporation PDP-11 computer in the NS 880 to the Nova 1220 computer with disc in the NS 660 and from thence to the CAMAC computer and the laser link with 234-5 Building. The second NS 880 will provide backup and additional capacity to the original. It will have an interface to accept spectral data from an existing NS 111A or from disc. Since the original NS 880 has the same PDP-11 computer it will automatically be capable of connection to the CAMAC interface but will not normally be so employed. The interface will provide the only means of transmitting and receiving spectral data from 234-5 Building to a NS 880 aside from a messenger carrying a cassette.