ORNL/FTR--3743

DE91 000386

COVER SHEET

FOR TRIP REPORTS SUBMITTED TO THE

OFFICE OF ENERGY RESEARCH

Destination(s) and Dates for
Which Trip Report Being Submitted: Geneva, Switzerland; 7/26–9/4/1990

Name of Traveler: Glenn R. Young

Joint Trip Report Yes

X No

If so, name of other traveler(s): ____________________

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ORNL FOREIGN TRIP REPORT

ORNL/FTR-3743

Date: September 18, 1990

Subject: Report of Foreign Travel of Glenn R. Young, Group Leader, Physics Division

To: Alvin W. Trivelpiece

From: Glenn R. Young

PURPOSE

To participate in the 1990 run of the WA80 experiment.

SITES VISITED

7/26–9/4/90	CERN, Geneva, Switzerland	H.-A. Gustafsson H. H. Gutbrod

ABSTRACT

The traveler spent six weeks at CERN participating in the 1990 run of the WA80 experiment. The traveler concentrated on trigger electronics for the first two weeks and on operation of the experiment for much of the next four. New electronics designed at ORNL for reading out the new BGO spectrometer were tested with the BGO in beam. Improvements were made, in collaboration with the ORNL engineers who designed the electronics. Plans were made for constructing the electronics in large quantities. Conversations were had with other members of WA80 about the analysis of results from this year's run and our plans for the 1991/1992 runs proposed for CERN. Lengthy conversations were had about the draft of a first paper concerning limits on direct photon production. Finally, the traveler attended an all-day session of the dilepton working group chartered to consider dilepton and photon experiments using heavy-ion beams in CERN's to-be-proposed Large Hadron Collider (LHC). At this meeting the traveler presented recent results from the group working on such a proposal for RHIC and updated his earliei presentation of June 1990 to this working group.

UCN-2383A
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REPORT OF FOREIGN TRAVEL

CERN, Geneva, Switzerland
July 26–September 4, 1990

The WA80 experiment has been thoroughly reconfigured for running in 1990. The original arrangement emphasized a large geometrical coverage and collection of data concerning global features of nucleus–nucleus reactions at energies of $E/A = 60$ and 200 GeV. A part of the experiment was dedicated to observing photons emitted in such reactions. This was done by using the SAPHIR (Single **A**rm **P**hoton detector for **H**eavy **I**on **R**eactions) array of 1278 lead-glass modules, which was constructed and cared for by collaborators from the University of Münster, F.R.G. After the initial runs of WA80 in 1986–1988, it was decided that sufficient information was in hand concerning global features and that a reconfiguration to concentrate on photons, searching for directly emitted photons, was in order. Consequently, the **MI**d-**RA**pidity **C**alorimeter (MIRAC), designed and partly built by ORNL, was moved to angles forward of 90 degrees in the center of mass; the GSI/LBL Plastic Ball detector around the target was removed; the streamer-tube multiplicity arrays were reconfigured as photon vetoes; and emphasis was given to installing much more lead glass to improve our photon detection coverage. This greatly improved our efficiency for detecting neutral mesons decaying by photon emission, such as π^0's and η's. The principal new detectors are two 1500-element arrays of lead glass from the Kurchatov Institute, U.S.S.R. These were provided by the group of Professor Vladislav Manko of Kurchatov. New collaborators from Brookhaven National Laboratory participated with Kurchatov personnel and those from all other WA80 groups in preparing and installing these new lead-glass towers over the spring and summer. They were placed on the sides of the existing SAPHIR array. The resulting coverage in ϕ increased from 80 degrees to more than 200 degrees. This resulted in more than an order of magnitude increase in our acceptance for η mesons at transverse momenta below 1 GeV/c. The photon detectors were also located further from the target than in previous years in order to improve our ability to handle the high multiplicities of produced particles in an event. The inner edge of the detectors was placed close to 90 degrees in the center-of-mass system, well forward of SAPHIR's previous location. This presumably gives us an improved handle on the photon distributions in nucleus–nucleus reactions. The projectile this year was $E/A = 200$-GeV ^{32}S. We used targets of sulfur and gold in order to study a symmetric system (S+S) as well as a light plus heavy system (S+Au), wherein we expect to achieve the highest energy densities.

The traveler spent his first two weeks at CERN collaborating with H.-A. Gustafsson of Lund, Hans-Georg Ritter and M. Bloomer of LBL, M. Purschke of Münster, and H.R. Schmidt of GSI on bringing into operation the new trigger of WA80, installed by the traveler and H.-A. Gustafsson in June 1990. This required careful collaboration with B. Kolb of GSI, who was in charge of the new VME-based on-line system used this year. This system, after tune-up, proved capable of decreasing our dead time per event by a factor of two relative to the case for earlier

WA80 runs, in spite of an increase in the total number of parameters to be read out. This improvement, taken together with a longer spill flattop from the SPS accelerator, meant that we were able to increase our number of events per spill to tape by a factor of 3 compared to earlier years.

The initial tune up of the experiment was badly hampered by erratic performance of the SPS accelerator. The SPS has not accelerated heavy ions since 1987. Many components needed for LEP operation have been added to the PS and SPS accelerators since that time. LEP operated in parallel with ion acceleration, increasing demands on the CERN operations staff. It became clear after several days of no beam or poor performance that several important diagnostic devices had been allowed to fall into disrepair in the past three years. It also became apparent after we did obtain beam that the maintenance program for our beam line had been greatly curtailed compared to previous CERN practice. We experienced repeated problems with radiation alarm faults and magnet power-supply drifts and faults. We were also badly hampered on evening and night shifts by the decision by SPS management to base all maintenance personnel in the North Area after normal working hours. This was done simply because of the loss of personnel to the LEP project and the desire to keep remaining crews at a minimum size. The consequence for us was a 1- to 2-hour wait for any fault outside of normal hours (which is more than half the clock time in a given week) in order for the needed person to drive over from the North Area (in France) to the West Area (in Switzerland), where we operate.

The decision was made to operate the experiment using a less restrictive minimum-bias trigger than in previous years. Earlier we insisted that the Zero-Degree Calorimeter detect a pulse-height less than 90% of that of the projectile. This corresponds to more than 4σ below the beam energy. This was necessary because the target is only 1/1000 of an interaction length thick, which means that the reaction products only appear out from under the beam peak's tail at energies of 90% of the beam or less. Based on analysis we have done over the past years, a better minimum-bias trigger consisting of a low (circa 1 GeV) threshold on transverse energy and a requirement that no fragment of $Z \geq 16$ appear within 0.3 degrees of the beam was implemented. Using this, we were able to see the rise in the cross section at very low (< 10 GeV) values of transverse energy, as expected for quite peripheral events.

After considerable discussion, we decided NOT to implement the large-transverse-momentum trigger for the photon detectors. Instead, we chose a high transverse energy trigger (above 90 GeV for gold targets) and a "peripheral" trigger which insisted that the minimum-bias trigger fire but that the zero-degree counter still see an energy deposit within 20% of the beam energy. This latter requirement could have been made more restrictive but for degraded performance of the ZDC, compared to earlier years, because of continued slow damage to its scintillator elements by beta and gamma radiation from the uranium sheets in the ZDC.

Data-taking was started around August 8; routine data-taking commenced a few days later after final problems with the accelerators were resolved. The most troublesome of these was an unexplained blowup of the beam emittance between the PS and the SPS. Several sources of this were identified, including quadrupole magnets in the transfer lines that were wired backwards. We were able to collect more than 12 million events on the gold target, 2 million on the sulfur target, and several runs of minimum-bias data. Estimates made before the beam time indicate that the statistics on the gold target should allow a final analysis of the direct-photon yield that can identify any such yield at the 5% level, an improvement of a factor of 3 over present limits.

During the week of August 20–24, two electronic engineers from ORNL, Charles Britton and Alan Wintenberg, visited CERN and participated in the on-line tests of the custom electronics that they and their group had designed for our BGO detectors. These electronics follow standard nuclear-pulse-shaping design practice, but have a novel auto-ranging gain section that allows them to sample a wide dynamic range. An effective resolution of greater than 20 bits is obtained with the use of conventional 12-bit ADCs. Dr. T. Awes of our group had investigated the performance of the electronics prior to the arrival of Drs. Britton and Wintenberg and had identified some possible areas for improvement related to low-level thresholds, overall gain settings, and coincidence requirements and timings. Certain on-the-spot changes were made to the circuits to improve these matters. In particular, it was possible to lower the low-level threshold to a value of circa 10 MeV, while maintaining a noise σ of 1 MeV and a full-scale range of 80 GeV or more. In line with this work, a visit was paid to Dr. Peter Denes of Princeton and the L3 experiment. He contributed significantly to the readout electronics for the L3 BGO detector. A useful comparison of techniques and design choices ensued. In particular, we learned that L3 went to considerable effort to build low-noise bulk power supplies for their BGO electronics in order to obtain sufficient common-mode rejection. Dr. Britton had developed a novel way of balancing the preamplifier front end that avoids this problem altogether in the WA80 electronics.

The traveler and Drs. Britton and Wintenberg visited Dr. P. Jarron of CERN in order to discuss monolithic circuits built by Dr. Jarron for use in silicon-strip detector readout in the UA2, ALEPH, and DELPHI experiments at CERN. Similar work is underway at ORNL to design circuits for use at FNAL in the proposed BCD experiment. This is headed by Dr. Britton. A discussion of possible methods to handle large dynamic range and integration of electronics onto the detector proper's substrate ensued. This is of particular interest for designing vertex detectors for RHIC, where the high charged-particle multiplicities compel use of highly integrated electronics to control costs and cable-plant space.

Plans were made for analysis of this year's data. The large increase in number of lead-glass modules and size of the data set have led other members of the collaboration to propose that a variety of computing resources be brought to bear on the analysis task. In particular, several members of WA80 have purchased RISC-based workstations and desire to contribute this expanded computing power to the task of producing data summary tapes (DSTs). The photon detectors require the largest data bases and largest amount of numerical fitting of data of all detectors in WA80. The decision was taken to convert our off-line programs to machine-independent format to facilitate using several different computers. ORNL is expected to convert the software for calorimeters and is requested to help convert part of the core routines plus the (separate) data base program. We are also expected to carry out the usual calibration tasks for the calorimeters and help operate DST production.

A draft of a paper summarizing current limits on direct photon production in relativistic heavy-ion collisions at CERN energies, based on our E/A = 200-GeV ^{16}O and proton runs, was circulated during the run. This addresses one of the main measurement goals of WA80. Measurements of direct photon production and thermal lepton-pair production represent the only direct probes of the early time behavior of relativistic heavy-ion collisions being pursued at CERN. The paper was discussed at length. Detailed discussions of analyses leading to photon reconstruction efficiency values and quoted error bars were had; this efficiency gives the dominant uncertainty in our results, outside of statistical effects. ORNL will investigate alternative methods of determining the photon reconstruction efficiency this fall as one of our new jobs related to the photon analysis.

The traveler also attended a second meeting of a working group concerned with possible future measurements of lepton pairs and direct photons emitted in collisions of very heavy ions in the to-be-proposed CERN Large Hadron Collider (LHC). This working group was chaired by Dr. Peter Sonderegger, who is a member of the CERN scientific staff and also of the heavy-ion experiment NA38, which has measured muon pair emission in heavy-ion collisions using beams from the CERN SPS. Further details of the *raison d'etre* of this working group are given in the traveler's previous trip report (ORNL/FTR-3649) from June 1990. Nearly all of the meeting was given over to a presentation by the traveler of the plans for a dimuon experiment at RHIC, plus a short description of the physics motivation and detector ideas of other RHIC working groups.

The traveler presented an update of the presently envisaged dimuon detector for RHIC, taking into account the work done for the RHIC Summer Workshop in July at BNL. He explained the dynamic range and background issues leading to its design. This was discussed for a period, and the group discussed some adaptations for use at the LHC. It became clear to the traveler that much of the discussion was driven more by considerations of where a heavy-ion group might be allowed to operate at the LHC, possibly as an adjunct to a large particle-physics experiment, as opposed to how a heavy-ion group might design a best detector for their own physics interests. It also became clear that the working group had done little work on the realities of any of their proposed detector schemes. The traveler again pointed out that RHIC at BNL will be a dedicated machine for this physics. The traveler arranged to obtain copies of the minutes of this and ensuing meetings.

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