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ORNL FOREIGN TRIP REPORT

ORNL/FTR-3327

Date: July 17, 1989

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

To: Alvin W. Trivelpiece

From: G. R. Young

ORNL/FTR--3327

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PURPOSE

To participate in a meeting of senior members of the NA35 and WA80 collaborations and to help write a joint letter of intent proposing a joint experiment to be performed when lead beams become available at CERN.

SITES VISITED

June 28–30, 1989	Frankfurt University, F.R.G.	R. Stock, H. Gutbrod
July 1–7, 1989	CERN, Geneva, Switzerland	H.-A. Gustafsson

ABSTRACT

The traveler participated in a meeting between the NA35 and WA80 collaborations for the purpose of completing a letter of intent to the CERN SPS Committee, setting out our plans for a joint proposal to use the lead beams that may be available in 1993 from the CERN SPS. The main thrusts of the joint proposal are large acceptance and particle identification for all charged particles in the forward hemisphere and precision detection of photons over a restricted range of rapidity. The principal elements of the experiment are a set of 5 TPCs and 4 RICH counters to accomplish the first objective and an array of 3000 BGO crystals to accomplish the second.

The traveler then spent one week at CERN working with H.-A. Gustafsson of Lund University on a redesign and upgrading of the trigger for the WA80 experiment. The major changes proposed are full programmability of the trigger and installation of a trigger supervision system, including a digital oscilloscope and a high-bandwidth logic analyzer, to set up and monitor the WA80 trigger.

REPORT OF FOREIGN TRAVEL

Joint NA35 and WA80 Collaboration Meeting
Frankfurt, F.R.G., June 28–30, 1989

The traveler attended the joint NA35/WA80 meeting held at Frankfurt, F.R.G., on June 28–30, 1989. This meeting was the culmination of a series of joint meetings that have been held over the past 18 months. Their purpose has been to agree on the physics goals of a joint proposal to CERN to use the E/A = 160-GeV beams of lead nuclei that would become available at the CERN SPS in 1993–1994, assuming CERN agrees to pursue the lead-beams project. An essential piece of the discussion has been the layout of the experiment, which has taken quite some negotiation, because the detector requirements for the various physics goals lead to conflicting demands on angular region covered. The present meeting finally carried a sense of urgency, since it was held only days before letters of intent had to be delivered to the SPS Committee (SPSC). This deadline helped resolve issues that had been discussed without conclusion for several months.

There are two major measurement thrusts espoused by various members of the collaborations. One is detection of all charged particles emitted at rapidities, Y, forward of $Y_{c.m.} = 0$ in the center-of-mass system of two colliding lead nuclei. The desire is to measure the three-momentum of these particles and also to identify their type. With this information, one can determine where half the baryons go in a collision. (This should suffice, on average, since lead–lead collisions are necessarily symmetric about $Y_{c.m.} = 0$, though not in detail for a single event.) This is information that is central to learning about stopping of nuclei and creation of large energy densities. The information also is sufficient to extract HBT correlations on an event-by-event basis for π^+ and for π^- mesons. A similar analysis can be done for charged kaons, which are of additional interest because they carry strangeness. Obviously, spectral information and relative abundance ratios can be determined on an event-by-event basis, further characterizing the hadronic content of the event.

The other main thrust is detection of so-called "direct" photons emitted from the reaction. These should carry information about conditions prior to hadronization, when any deconfined phase of strongly interacting matter would exist. It is thought that this information would not be confused by final-state interactions during the hadronization step, meaning that the spectral shape and number of direct photons could be used to study the dense phase we seek to create in these collisions. Unfortunately, these direct photons are masked by more numerous decay photons, primarily from decays of π^0 and η mesons. Thus, a detector has to be used which can reconstruct these mesons and allow for their accurate subtraction from the total observed yield.

A study of the kinematics of charged particles emitted has shown that particle identification and momentum measurement can be accomplished by using a series of TPCs as tracking detectors, coupled with RICH counters at the larger angles. If the TPCs are deep enough (roughly 5 meters at 1 atmosphere), then they provide a sufficiently accurate measurement of specific ionization to separate pions, kaons, and protons of energies above 5 GeV, assuming an accurate momentum measurement. The kinematics of E/A = 160-GeV collisions then show that RICH counters (or some other device with similar capability) are required to handle pions and kaons near $Y_{c.m.} = 0$ for transverse momenta below about 0.5 GeV/c. The needed momentum dispersion must be provided by a large magnet. Thus, it was proposed to use the existing NA35 vertex magnet to provide momentum dispersion for the first 3 meters downstream of the target and to locate a set of 5 TPCs and 4 RICHes symmetrically about the beam axis to detect positively and negatively charged particles. The TPC at zero degrees would be placed at 12 meters from the target. This arrangement was shown to have good acceptance and to be able to identify pions, kaons, and protons over most of its acceptance.

The photon detector needs to view the same region in angle as that for the charged particles. This resulted in much juggling of the above design during the earlier period when it was thought that the photon detectors would be lead glass, as presently used in WA80. Recent combinatorial studies at Oak Ridge have shown that a photon detector of 6 to 10 times better energy resolution than lead glass will be required in order to measure the π^0 and η meson cross sections in the presence of the large combinatorial backgrounds present in lead–lead collisions. This prompted us to consider the use of inorganic crystals to obtain the needed energy resolution. An evaluation of the existing types resulted in the conclusion that BGO would be the best choice. This has the advantage that it is also the most compact high-resolution photon detector available, which eased considerably the job of fitting it into the magnet + TPC + RICH scheme outlined above. We found that it could be placed just downstream of the central TPC, if the photon detector is to be located forward of $Y_{c.m.} = 0$, or just above and below the forward TPC, if the photon detector is to be located behind $Y_{c.m.} = 0$. Both locations take advantage of the sweeping action on charged particles afforded by the vertex magnet to ease the number of pixels required for the photon detector.

The traveler presented the results of simulations carried out at ORNL and at Münster in preparation for this merger meeting. The central item was a set of combinatorial studies performed by Terry Awes of ORNL, showing that the use of BGO made a photon experiment feasible for low-p_T photons, even in lead–lead collisions. The photon detector proposed would cost an estimated $6M and consist of 3000 pieces of BGO, each $2.5 \times 2.5 \times 25$ cm^3 in size. It would be placed 13 meters from the target and subtend 120° in ϕ and roughly half a unit in rapidity.

A lengthy presentation of the requirements of the TPC and RICH setup was made by Howell Pugh of LBL, with a discussion of the various requirements for momentum resolution, vertex location, particle identification, and two-track separation (crucial for the HBT studies). This talk included discussion of detailed simulations of dE/dx spectra, using the event generator FRITIOF and the Monte Carlo code GEANT, carried out by John Harris of LBL. These distributions are central to assessing whether the proposed devices can, indeed, identify particles.

These talks took the better part of the first two days of the meeting. A fairly intense discussion continued throughout these presentations on the merits and problems of the proposed detectors. After some enumeration of physics goals, particularly those involving the photon measurements, it was decided to pursue a layout as described above, with the photon detectors located just behind $Y_{c.m.} = 0$ (i.e., just outside 6° in the laboratory frame).

The one large uncertainty in the agreed-upon layout was whether a large dipole magnet should be placed around the downstream TPC which surrounds the beam pipe. (This might actually be two TPCs in a final design.) Hans Gutbrod presented a design based on the L3-magnet philosophy (conventional aluminum coils, not superconducting; very large coil cross section to reduce power consumption; use of inexpensive slabs of steel wherever possible in the yoke). This would utilize large amounts of steel offered by Indian and Czechoslovakian collaborators and a coil fabricated at CERN. The magnet would be very large (10 meters tall for a 4-meter gap at 0.5 Tesla), yet would consume only 3 MW of power.

There is one particularly attractive advantage in having this magnet, in that a momentum analysis can then be done for particles traversing the TPC inside it without having to assume anything about the origin of the particles. (The scheme described above with a vertex magnet and TPCs in a field-free region requires assuming that the particles originate from the target in order to determine their momentum.) One can then use this information, together with the entrance position and angle of a particle, to see if it originated from a decay vertex downstream of the target. This would greatly increase the acceptance of the experiment for Λ's, particularly because the design covers forward rapidities, where the Λ's get a goodly kinematical boost and, therefore, a sizable lifetime dilation. In addition, if such Λ's can be spotted with good acceptance, then a forward-rapidity location of the photon detectors would give us the possibility to look for higher-mass hyperons which decay by photon or π^0 emission. This would make possible the study of hyperons which can be seen no other way because they have a π^0 or photon among their daughters. Example modes include $\Sigma^+ \rightarrow p + \pi^0$ (51.6%), $\Sigma^0 \rightarrow \Lambda + \pi^0$ (100%), $\Omega^- \rightarrow$ Cascade 0 $+\pi^-$ (23.6%), and $\Omega^- \rightarrow$ Cascade $-$ $+\pi^0$ (8.6%).

The difficulties in utilizing such a magnet were enumerated by H. Pugh. In particular, the readout of the TPC becomes much more costly (more readout pads); the gas pressure must increase; and the track reconstruction in the TPC becomes more difficult because the tracks are now curved. It was not possible to settle these issues clearly during the short meeting; thus, this proposal for an additional large dipole was written into the letter of intent as a possibility requiring further investigation.

The remainder of the meeting was spent preparing individual sections of the write-up, debating the physics topics to be enumerated in the letter, and arranging details of figure production and final polishing. The agreement was reached that R. Stock and H. Gutbrod would remain at Frankfurt the next week and complete the letter, which would then be hand-delivered by Gutbrod to CERN on July 10. The traveler spent the rest of his time conferring with K.-H. Kampert, H.-A. Gustafsson, and F. Plasil about details of the write-up dealing with the photon detectors and the triggering scheme.

Visit to CERN
Geneva, Switzerland, July 1–7, 1989

The traveler spent the next week at CERN collaborating with H.-A. Gustafsson on a redesign of the trigger for the ongoing WA80 experiment. The present electronics shack has been cleared temporarily in order to install new water-cooled racks for the WA80 readout electronics. We decided to seize this opportunity to prepare a thorough overhaul of the WA80 trigger electronics, which has grown into a complex thicket over the past 3 years of running. Our guiding philosophy was to design a new layout where as much of the circuitry as possible was under CAMAC control and, therefore, programmable. We also wanted to have a trigger supervision system capable of viewing several signals simultaneously (of the order of 10 to 16). This affords us the ability to view the full input conditions for the trigger logic matrices and to diagnose the trigger electronics without having to disassemble it bit by bit as is now required to be able to probe various signals. This also allows us to simulate various trigger conditions using pattern generators under computer control. This gives us a new ability that we have not had before to diagnose the trigger.

Two days were spent reviewing the present trigger layout and discussing the various decisions taken in its construction. The remainder of the time was spent laying out the new trigger, documenting it, investigating costs of various elements of it, and preparing a preliminary design of the trigger supervision system. A report was prepared to the collaboration detailing the proposed new scheme and discussing the financial investment required to realize it. We remark here that the typical investment required for such a trigger, which comprises two levels plus supervision, totals in excess of $500K. Much of what is needed in our case is already available within WA80; however, the additional investment needed will probably exceed $150K.

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