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COVER SHEET
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Which Trip Report Being Submitted: Geneva, Switzerland; June 5–15, 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-3649

Date: June 26, 1990

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

To: Alvin W. Trivelpiece

From: Glenn R. Young

PURPOSE

Reconstruction of the trigger electronics for the ongoing WA80 experiment.

SITES VISITED

6/5–15/1990	CERN, Geneva, Switzerland	H.-A. Gustafsson H. H. Gutbrod

ABSTRACT

The traveler spent two weeks at CERN working with H.-A. Gustafsson of Lund University on a complete redesign of the trigger electronics used by the WA80 experiment at the CERN SPS. This "new trigger" incorporates much more programmable logic than previously and includes new monitoring electronics and digital oscilloscopes interfaced to the main on-line computer. This new trigger will see its first on-line use during the heavy-ion run scheduled for August 2 through September 2, 1990, at the SPS. Tests of the new layout using the existing laser systems as signal sources will be performed in July 1990. Conversations were had with other members of WA80 present about the experimental setup for the August 1990 heavy-ion run at CERN. 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 current plans for dimuon experiments at RHIC and commented on perceived difficulties for such a program at the LHC.

REPORT OF FOREIGN TRAVEL

CERN, Geneva, Switzerland
June 5–15, 1990

The traveler spent two weeks at CERN collaborating with H.-A. Gustafsson on a reconstruction of the trigger electronics for the ongoing WA80 experiment. The same two persons had rebuilt the earlier WA80 trigger from scratch in November, 1989, following the installation of new water-cooled racks for the WA80 readout electronics during the summer of 1989. It had been felt that these racks were essential to solve persistent cooling problems in the electronics area during earlier runs. The decision had been made in the fall of 1989 to defer installation of the upgraded trigger until late spring of 1990, since it required the use of equipment not all of which had arrived at CERN by late 1989. In fact, not all of it had even been procured or constructed. H.-A. Gustafsson had participated in the calibration runs which had taken place in December 1989 and March–May, 1990, and had remarked upon the difficulties experienced during that period with expanding the old trigger in piecemeal fashion to accommodate the new detectors now a part of WA80, particularly the two new towers of lead-glass from the Kurchatov Institute, the high-resolution BGO photon detector that is under development, and the new position-sensitive multistep avalanche counters that will be tested in the 1990 run and installed in the 1991 run.

Initial discussions were had with other WA80 members present, particularly H. Gutbrod, T. Awes, R. Schmidt, and I. Lund, about which triggers to include for this year's run and what would constitute our minimum-bias trigger for the run. The streamer-tube multiplicity arrays, which were formerly a part of the minimum-bias trigger, have been moved to just in front of the lead-glass arrays and rearranged into a U-shaped array to provide charged-particle rejection for the glass. Since these arrays are no longer phi-symmetric and now cover a restricted range of pseudorapidity, it was not desired to use them as part of a minimum-bias trigger. The Midrapidity Calorimeter (MIRAC) has been moved to cover rapidities from midrapidity and forward (and all azimuthal angles). It was realized that the transverse energy signal from this detector could be used for defining a minimum-bias trigger if two discriminator levels were set for it: one at very low values to select minimum-bias collisions and the other at reasonably high levels (with exact setting depending on the target) to select central collisions. Due to known low-level noise on this signal, some care must be taken with the lower setting. As agreed earlier, the Zero-Degree Calorimeter (ZDC) will be retained for fast triggering and event classification.

Two days were spent reviewing the upgraded trigger layout planned last July, 1989. Some changes were made to that, based upon availability of modules, because funds had not been available from the various groups in WA80 to purchase all the new programmable modules desired. Some judicious rerouting of signals and reassignment of positions on bus cables allowed us to account for existing plus all new detectors for the 1990 run. Provisions were made for the new ^{241}Am stabilized

PIN diode monitors for the laser systems. However, when the expanded calibration system is prepared for the BGO detector for the 1991 run, additional programmable logic must be procured.

The traveler and Dr. Gustafsson then spent a week "with the raised flooring up" pulling out old cables, installing all the new input patch panels and delay loops, moving the NIM and CAMAC crates, and redistributing cooling and power loads. Considerable emphasis was given to routing input and delay lines to try to avoid the usual cabling confusion that plagues most triggers. Some success along these lines was achieved. The electronics were installed and partially debugged before the traveler had to depart for the U.S. Modifications to the layout were recorded and will be used to update the trigger layout as stored on the computer database.

The use of programmable logic wherever possible required an expansion of the VAX-based programs used by WA80 to handle such logic. Programs to handle programmable logic matrices and the new computer-controlled constant fractions were prepared by Burkhard Kolb of GSI and discussed with the traveler. It was possible to exercise that for the discriminators and establish that it handled the basic functions properly. Programs still need to be prepared to handle the programmable gate generators. This is straightforward.

The new layout also includes a number of monitoring functions not included in earlier trigger layouts. These include monitoring of gate widths to the charge-integrating ADCs, as well as monitoring of inputs and outputs from the logic matrices and other programmable logic units using a new digital oscilloscope supplied by the University of Münster. Other members of the trigger group are charged with preparing those programs.

The traveler also attended a 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. The NA38 group is well known for their studies of J/ψ and Drell-Yan production in heavy-ion collisions, and has presented evidence of a decrease in the J/ψ yield, relative to that for Drell-Yan pairs, in central collisions of heavy ions at SPS energies. This so-called J/ψ suppression has been advanced by some as a signal of quark deconfinement. The traveler has been encouraging the members of NA38, in particular Dr. Sonderegger, to participate in the upcoming RHIC workshops. Attendance at the above CERN workshop was an outgrowth of those discussions.

Evidently this working group is a part of a much larger effort convened under the auspices of the International Committee on Future Accelerators (and prodded strongly by the present CERN Director General) to examine the physics possibilities for a hadron–hadron collider that could be built in the existing LEP tunnel at CERN using beyond-state-of-the-art magnets of 10-tesla peak field. (CERN potentates will tell you that 10-tesla magnets exist with adequate field quality — this is true, but these are 1-meter-long test magnets. Full-length magnets do not exist. Students of the recent history of high-energy accelerator building will recall that the early short prototypes for both ISABELLE and the SSC met field quality and training specifications, but that full-length usable magnets proved much harder to come by. Thus, one must adopt a wait-and-see attitude towards the present CERN claims.) The LHC would collide beams of 8 TeV + 8 TeV protons in two rings of magnets — in essence, a 40% scale model of the SSC. Heavy ions of any masses could also be collided due to the existence at CERN of heavy-ion injectors. Lead–lead collisions at 3 TeV/nucleon + 3 TeV/nucleon could be produced. Full reports of all working groups will be presented at a general meeting scheduled for October at Aachen, F.R.G., concerning the LHC.

The meeting the traveler attended was the second in a series and, as such, devoted much of the time to a reporting of the results of various homework assignments handed out at the earlier meeting. Of considerable interest to the planning for RHIC experiments were calculations made by V. Ruuskanen, S. Gupta, and B. Kampfer concerning the relative production cross sections of thermal lepton pairs and direct photons arising from either a quark-gluon plasma or a hot pionic gas. The latter case would correspond to the case in which no deconfinement transition is reached, either because it does not exist or because conditions for traversing it are not attained. All theorists pointed out that due to the quite high beam energies of lead ions in the LHC (3 TeV/nucleon per beam), greatly overheated pionic gasses result if there is no phase transition. The thermal lepton pair and direct photon emission from such an extremely hot (650 MeV temperature!!) pionic gas could easily exceed that from a system in which a quark-gluon plasma was created. This could occur because **any** charged objects colliding will result in lepton pair and photon emission: the cross section and spectral shape of the pairs and photons measure the temperature and collision frequency of electrically charged objects, but cannot tell what the charges of the objects are, i.e., whether they are integrally charged, as are pions and protons, or whether they are fractionally charged, as are quarks. The fact then that the pionic gas does not invest any of its total energy in the latent heat of the phase transition to a plasma works out numerically to a larger production of lepton pairs and photons by the pionic gas than by the plasma in top-energy Pb+Pb collisions in the LHC. Almost the exact opposite situation is expected to be obtained at RHIC, where the pion gas would not be nearly so overheated and would thus have a SMALLER total yield of lepton pairs and photons.

The traveler presented a sketch of the presently envisaged dimuon detector for RHIC and 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. Later discussions with Sonderegger reached the conclusion that he has come to much the same ideas as have we concerning a split hadron filter and the need for intermediate and initial-stage tracking in such a detector. The traveler invited interested parties to be sure to attend the RHIC workshop to be held on July 2–7, 1990, at BNL.

The latter part of the meeting dealt with initial studies of such collisions using existing Monte Carlo event generators on the market. There is a need to upgrade the codes on the market for operation on faster computers and to increase their storage requirements in order to handle the vast final-state multiplicities. For example, only mass 90+90 collisions could be handled by several codes. An interesting result seen in most models is an expected rise in the mean transverse momentum, in particular, of pions emitted, from values of 350–450 MeV/c at the SPS and even the Tevatron, to 700–800 MeV/c. This most likely arises from the great increase in the importance of the gluon distributions in nuclei in particle production once center-of-mass energies of a few TeV/nucleon are surpassed. This arises simply because at x values of 0.01 and center-of-mass energies of 100 GeV/nucleon, the momenta of the participant partons are of the order of 1 GeV/c, which are the momenta of interest and dominate much of the collision dynamics. For such x values, gluons are already more numerous than quarks but do not completely dominate the picture. However, for energies of 1–10 TeV/nucleon, partons with x values of 0.001 and 0.0001 come into play and have center-of-mass momenta of 1 GeV/c. These partons are almost entirely gluons and have a quite large number density.

This point was discussed from a purely QCD standpoint in the morning part of the session. To illustrate this point, S. Gupta showed a comparison of jet cross sections at RHIC and LHC energies. The yield of jets at LHC is dominated, by a factor of 20–50, by those arising from collisions of two gluons at x values less than 0.001. Having such a preponderance of gluons "in play" means that second and higher order corrections to all QCD diagrams become extremely important, due to the importance of initial and final-state scatterings of the incident partons off the gluons in addition to the main hard scattering of interest. This would greatly complicate the behavior of cross sections with transverse momentum at the LHC as compared to RHIC. It is expected that the exact shape of the gluon momentum distributions will have major implications for particle and soft jet production at the LHC and SSC.

It is possible to get a direct handle on these distributions in electron-proton collisions at center-of-mass energies of 100–200 GeV, such as will be studied at the HERA collider in Hamburg, F.R.G., starting in 1991. Results from HERA will, therefore, bear close watching. These results will also be important for RHIC, due to the possible modification of gluon structure functions in nuclei and the large number of gluon–gluon collisions which will occur in heavy-ion collisions there.

The traveler arranged to obtain copies of the minutes of this meeting, the previous one and the ensuing one, set for July 24, when they become available.

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