OAK RIDGE NATIONAL LABORATORY

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ORNL**FOREIGN TRIP REPORT**

ORNL/FTR-3804

DATE: 23 October 1990

SUBJECT: Report of Foreign Travel of William M. Bugg, Head
Department of Physics, University of Tennessee, Knoxville

TO: Dr. Alvin W. Trivelpiece, Director

FROM: Dr. William M. Bugg

PURPOSE: The purposes of this trip were to visit the L3 experiment at CERN and explore the potential future collaborations on the design and construction of the proposed L* detector for the Superconducting Super Collider

SITE VISITED: 10/09-12/89 CERN Geneva, Switzerland Prof. Sam Ting

ABSTRACT: Dr. William M. Bugg and a group from ORNL had very productive meetings with Professor Sam Ting and other members of the L3 collaboration. The L3 detector system, subsystems, and the associated support facilities were examined in some detail. Discussions were held with scientists involved in planning for the L* detector systems and members of the L3 staff interested in positions at ORNL/UTK.

The trip was very successful. A collaborative arrangement was established for UTK and ORNL to become involved in the future design and construction of the L* detector. These include hosting the main meeting of the L* collaboration at ORNL to complete the Expression-of-Interest (EOI) proposal. Several prospective candidates were interviewed and collaborative interactions were started on some detector subsystems for L*.

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1990

REPORT OF FOREIGN TRAVEL

CERN, Geneva, Switzerland
October 9-12, 1989

1. Introduction

ORNL plans to play a major role in Superconducting Super Collider (SSC)-related R&D. Universities in the South and Southeast have formed the Southern Association for High Energy Physics (SAHEP) and have asked ORNL to collaborate with them in a proposal to design and construct detector systems for the SSC. We have also had previous discussions with Professor Ting concerning ORNL involvement in a similar capacity in the L* detector proposal. In response, a Center for Advanced Detector Systems has been established at ORNL to act as an interface group for SAHEP and other collaborating members, and we plan to strengthen the high energy research group in the Physics Division through several joint appointments with The University of Tennessee, Knoxville (UTK) under the Science Alliance Program.

The travelers were invited by Professor Ting to visit the L3 experiment and to hold discussions on ORNL/UTK participation in the future SSC L* experiment. The purpose of this trip was to establish a working collaborative arrangement with Professor Ting on L* and begin to interview members of the L3 group interested in joining the ORNL/UTK high energy program. The members of the team were Professor Bill Bugg from UTK and those at ORNL intimately involved in this endeavor. During the ORNL visit to the L3 collaboration, the first physics paper of the collaboration was finalized. The travelers were given copies of the final draft.

The trip was scheduled to coincide with a shut-down period of the Large Electron-Positron collider accelerator to allow the travelers to tour and examine the L3 experimental apparatus, and to have detailed discussions with the L3 participants. While the parameters of the L3 detector are well known, it is very impressive to actually see the device. At the time of the visit, the endcap hadronic calorimeters were in the process of being installed. The institution primarily responsible for this subsystem is the University of Aachen. The endcap calorimeters were ready at the time that L3 first obtained beam. However, since access to the vertex chambers had to be maintained in the initial phases, the calorimeter end caps could not be installed earlier. At this point, the only L3 subsystem

not in place is the endcap BGO (bismuth germanate) detectors. Components are currently being manufactured in Shanghai.

2. Discussion of L3 and L* Subsystems

2.1. Computing

Discussions were held with Dr. R. Mount of the California Institute of Technology, who is in charge of L3 off-line computing. Off-line data processing is a high priority of the collaboration. Data are accumulated on magnetic cartridges and hand-carried from the detector site to the central computing facility at CERN, where L3 owns its own IBM-based computing facility. The data are accessed and manipulated by means of a large number of Apollo work stations, located in the central L3 office complex. Impressive three-dimensional color graphics were demonstrated. It was pointed out that the central IBM facility is not adequate to handle the L3 load and that DOE is being asked to double L3's computing capability.

An optical fiber link between the experimental site and the central computer (10 km in length) is in place and has been tested. At the time of our visit, however, this link was not in use. When fully operational, the link will eliminate the need for the transportation of magnetic cartridges between the experimental area and the computing center.

2.2. Hadronic Calorimeters

Discussions were held with Professor Yuri Galaktionov of the Institute of Theoretical and Experimental Physics (ITEP) of Moscow and with members of his staff. These discussions centered entirely around L* issues. It had been made clear earlier by deputy spokesman of L3, H. Hofer, that L* calorimetry was to be the domain of ITEP. However, in the discussions with Galaktionov, the travelers got the impression that the Soviet team was anxious to collaborate. They clearly stated that collaborative efforts were indicated in all phases, from the choice of appropriate technology to the ultimate fabrication and assembly, which will clearly have to take place somewhere in the U.S. - preferably at ORNL. The travelers reaffirmed their interest in calorimetry in general and indicated their willingness to collaborate with ITEP and with other members of the L* collaboration interested in calorimetry.

Presentations were made by ITEP staff members. They feel that the technologies that need to be considered seriously are TMS (tetramethyl silicon), silicon, liquid scintillators, and gas detectors. In particular, two L* projects have already been initiated by ITEP and they were described in some detail. Copies of transparencies were obtained. The first of these projects is the TMS study. The work is being carried out in collaboration with Karlsruhe. A TMS chamber has been constructed at ITEP and has been in operation for more than six months. The chamber was used in a so-called

single chamber scan. The tests consisted of making measurements with the chamber located at various positions within a modular stack. The stack configuration consisted of several combinations of uranium plates, occasionally interleaved with plastic scintillators. Test results were shown. It was concluded that any desired degree of compensation can be achieved, including overcompensation ($\pi^+/e^- \approx 1.3$). The tests were carried out with 5-GeV electrons and pions.

The second ITEP R&D project consists of a parallel plate chamber (PPC) study. The advantage of PPCs is that they are very fast and can handle high rates ($>10^7 \text{ s}^{-1} \text{ cm}^{-2}$). In addition, they are resistant to radiation damage. The difficulties involved include extremely tight mechanical tolerances to avoid discharges at operating voltages ($\text{HV} > 5550 \text{ v}$). The gap of the prototype chamber is 0.94 mm, and it is filled with pure isobutane at normal pressure. The gain achieved is 5×10^4 , and the efficiency for minimum-ionizing particles was found to be 98%. The data rate capability was demonstrated to be $10^5 \text{ s}^{-1} \text{ mm}^{-2}$. The response to cosmic rays, as well as to radioactive sources (^{239}Pu), has been studied. The dimensions of the constituent unit of the PPC is 103 mm by 107 mm, and it is divided into four quadrants. Single scans, similar to those carried out with the TMS chamber, have yet to be performed. Design studies of possible mosaics consisting of a large number of standard constituent units have been carried out.

2.3. L* Magnet and Site Requirements

Discussions were held with engineers and with magnet experts, notably Paul Herve, who has made major contributions to the L3 magnet design, as well as to the design of several other detector magnets. The L* specifications are for a relatively low-field (0.75 tesla) solenoid. If the magnet were to operate at room temperature, 20 MW of power would be required. This consumption is about 10% of the total estimated SSC power consumption. Outside dimensions of the octagonal magnet are estimated to be 27 m side-to-side, with a cavity measuring 19 m side-to-side. The 6000-ton L3 conventional magnet would be scaled up to 49,000 tons. Eight hundred m^3 per hour of cooling water would be required. In spite of the colossal nature of the contemplated magnet and in spite of the associated requirements, the CERN design group is of the opinion that the conventional magnet design is the only practical approach and that the difficulties associated with a superconducting magnet design are insurmountable. Nevertheless, the Khurchatov Institute in Moscow is pursuing the superconducting option, and a choice between the two technologies may be made in early 1990. The travelers were shown drawings of the proposed shaft and of associated access and support facilities proposed for the SSC site. Discussions with SSC personnel have taken place over the last five months, and boundary conditions have been agreed upon. A system for the installation (in

segments) of the huge magnet coil has been designed. The requirements for surface support buildings have been studied.

2.4. Muon Chambers

The muon chamber assembly area (located near the North Area of the Super Proton Synchrotron) was visited. A spare central-region muon chamber was being assembled, and the assembly procedure was observed. The travelers were impressed with the complexity and the precision of the muon chamber design. The assembly of the chambers is extremely labor intensive, and highly skilled (up to Ph.D.-level) personnel are required. It was clear to the travelers that the muon chambers of L* could not be designed on the basis of a scale-up of the L3 design. A totally new semi-automated approach is required. This situation presents both an opportunity and a challenge for the ORNL engineering organization. One remarkable feature of the L3 muon chambers is that final alignment of a given chamber is a function of the actual location inside the L3 detector. For example, muon chambers deployed vertically are not interchangeable with those deployed in a horizontal orientation. A large rotating jig has been built to make the required adjustments possible.

3. Interviews with Potential Employment Candidates

The following candidates were interviewed for possible positions in the ORNL/UTK high energy group.

Dikran Antreasyan	INFN, Italy
Michael H. Capell	Michigan
Patricia McBride	Harvard
David Strickland	Princeton
Wolfgang Wallraff	Aachen

In addition to these candidates, Dr. Marion White and Dr. Jeff Mills of the L3 group have visited ORNL and UTK and discussed possible employment in the high energy effort.

4. BGO Detectors

The L3 BGO detectors were discussed with several collaboration members. The WA80 experiment needs to obtain as many BGO and lead-glass detectors as possible for a heavy-ion run scheduled for next summer. The L3 collaboration has a test array of 100 BGO crystals that may be available. The geometry of the crystals is not optimum for WA80 purposes, but they are still likely to be useful; discussions centered on the possibility of borrowing them for the duration of the WA80 run. In subsequent conversations with H. Hofer and S. Ting, it was agreed that a formal request by letter will be made, should WA80 decide to make use of the test detectors. An interesting point brought out during a discussion with David Stikiand was that, while the painting of crystal surfaces may be the

best treatment for tapered units, rectangular detectors should not be painted. Wrapping the units is probably the most appropriate surface treatment for the proposed WA80 units.

5. Accomplishments and Conclusions

The visit to CERN was very useful for the travelers. High energy physics efforts such as these are very complex technically and organizationally. If L* is funded, it will involve hundreds of scientists and engineers from 10-20 different countries. A successful project means that all the scientists and engineers must somehow work in concert to blend the many individual subsystems built by various groups into one grand detector system. Before a detector system can be proposed to the DOE and SSC Project for support, it must be designed, at least conceptually. This presents yet another level of complexity to design a sophisticated detector system that is not yet funded for a project that is at least ten years from completion.

We held several meetings with Professor Ting and his group to establish a suitable arrangement for ORNL to become productively involved in L*. Several important points were considered during two final meetings with Professor Ting. First, Ting wanted to make sure that the proposed L* venture, as well as the new high energy positions, were subscribed jointly by ORNL and by the University of Tennessee. Professor Bugg of UTK was able to reassure him on this point. Next, Ting solicited ORNL help in the evaluation of L* magnet options (conventional versus superconducting). He pointed out that Khurchatov scientists and engineers intend to come to CERN during November to work with appropriate L3 personnel. It was suggested that ORNL magnet experts join the activities at that time in order to make their own evaluation regarding the two options and in order to evaluate the Khurchatov superconducting design. ORNL is planning to send Dr. Marty Lubell and/or Dr. Jim Luton who have extensive experience in both conventional and superconducting magnet systems.

We also discussed plans for the L* Expression of Interest letter due in May 1990. This document will define the participants and the scope of the L* project for the DOE and SSC Project. Ting indicated that two meetings are planned in early 1990 to finalize the above document. The first meeting is to be held in Moscow in February 1990. He requested ORNL to supply the names of those who will attend this meeting from ORNL. He also suggested that ORNL L* members plan to visit CERN prior to the Moscow meeting to coordinate the various collaborative efforts and consolidate opinions. Ting suggested that the second and final (prior to the filing of the expression of intent) L* collaboration meeting be held in Oak Ridge in March 1990. The travelers agreed to host this meeting at which about 100 participants are expected from 13 different countries.

During the final meeting with Ting, Professor Galaktionov was called in. Discussions centered, once again, on the possibility of calorimeter collaboration between ITEP and ORNL. The issue of possible

appointments of Soviet scientists to ORNL positions was also raised. It was also suggested that ITEP scientists visit ORNL for about one week prior to the collaboration meeting proposed for March to accelerate design plans for the calorimeter.

The collaboration on L* and similar involvements of ORNL with SAHEP members who become involved in L* or other SSC detector systems constitute a significant change in direction and a major future commitment for the Laboratory. The SSC is scheduled to begin operation around 1998 and it will take that long to build the major detectors needed for experiments on SSC. Thus we will need to establish an infrastructure for collaborative R&D for a ten-year period. It is not possible to interact effectively with L* or SAHEP to build a detector system, or to reap the scientific benefits of having done so, without adding high energy physicists to our staff at ORNL. We plan to do this through joint appointments with UTK to leverage our resources, but it will nevertheless require increasing our funding base in high energy physics at ORNL.

It now appears that ORNL will serve as a major U.S. base for much of the design and construction work associated with the L* detector. This will mean that scientists from all over the world, many from sensitive countries, will be required to work for extended periods with ORNL scientists and engineers, and that the construction may utilize many ORNL facilities. Consequently, we need to work with ORO and DOE Headquarters to streamline our accessibility for these projects.

Literature Received

1. "A Determination of the Properties of the Neutral Intermediate Vector Boson $Z^0 \rightarrow \beta^+ \beta^-$," preprint of the L3 collaboration.
2. "A Barium-Fluoride Crystal Calorimeter Prototype and a Precision Calibration System for the SSC," G. Grath et al., preprint.
3. "L* Hadron Calorimeter Gas PPC Project," copies of ITEP transparencies.
4. "L* Hadron Calorimeter TMS Project," copies of ITEP/Karlsruhe transparencies.

APPENDIX

Itinerary

10/08/89	Depart for Geneva, Switzerland
10/09/89	Arrive Geneva
10/10-17/89	CERN, Geneva
10/13/89	Return to Oak Ridge of all travelers (except F. Plasil)
10/18/89	Return of F. Plasil to Oak Ridge

END

DATE FILMED

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