CALORIMETRY

(Convener's report)

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The calorimetry sessions put an emphasis on ATLAS and CMS experiments which are the two major general purpose experiments exploring new physics frontiers through the study of head-on collisions of protons accelerated each to 7 TeV at an expected peak luminosity of 1.0×10^{34} cm^{-2} s^{-1} at the Large Hadron Collider (LHC). Major progresses have been reported for both experiments. A large part of ATLAS calorimetry is using liquid argon as active medium.

Robert Orr gave an overview of the ATLAS liquid argon system. These liquid argon calorimeters have the capability to achieve the measurement, with sufficient resolution, of the energy and direction of jets, electrons and photons, and E_T^{miss} over a wide pseudorapidity interval. Particle identification is provided , particularly γ/π^0 and e/π separation. Robert Orr discussed the structure of the various liquid argon calorimeters regarding energy and angular resolutions to be achieved. The accordion structure has been adopted for the barrel electromagnetic calorimeter. The "spanish fan" configuration has been selected for the electromagnetic endcap calorimeter to maintain a spatially constant sampling fraction avoiding the accordion structure difficult to realize in the region covered by this detector. Large irradiation levels will be encountered at LHC. In particular, the hadronic endcap calorimeter (HEC) and the forward calorimeter (FCAL) will be exposed to high fluences of particules and their design takes this constraint into account. The HEC is based on a conventional plate design, compact and radiation hard. The FCAL, covering the pseudorapidity range $3\leq |\eta| \leq 5$, is the most exposed to radiation (10^{16} neutrons cm^{-2} year^{-1}). It consists of three sections: FCAL1, FCAL2, FCAL3. The structure of FCAL2 and FCAL3 consists of a paraxial arrangment of tungsten rods inside copper tubes. The liquid argon gap between the rod and tube provides the ionization region. FCAL1 is very similar with the exception that the matrix and electrode rods are made of copper. FCAL construction is well on schedule and will be ready for the start of the ATLAS data taking campaigns.

The FCAL having received a particular attention in Robert Orr's presen-

tation, the other parts of the ATLAS liquid argon calorimetry system were also covered in details by several speakers. We heard a presentation of Fares Djama reporting on test results of ATLAS barrel and end-cap prototype modules tested with electron beams at CERN. The energy resolution measured for the two prototypes are fulfilling the physics requirements. Module stacking and cabling are well underway with 25% of the modules completed by the time of the conference. The module production will continue towards commissioning in 2004.

The HEC was presented by Jim Pinfold who gave a detailed report on its construction. The talk he gave presented the plans for assembly of the HEC and its insertion into the endcap cryostat. The results of test beam studies were reported. The response of the module to electrons, muons and pions were measured with electron and pion energy resolutions following the design and physics requirements. Jim Pinfold also described further tests to be performed and involving ATLAS electromagnetic and forward calorimeter modules. Finally, the schedule of assembly of the HEC was exposed.

Stefan Simion provided a status report of the readout of the ATLAS liquid argon calorimeter. The readout system has been redesigned to improve its radiation hardness and therefore to comply with radiation tolerance requirements. In particular, six radiation hard ASICs have been developed and are being operated, after undergoing successful functional and radiation tests, on a new prototype of front-end electronic board. He noted also that DSM technology has been retained for the switched capacitor array (SCA) controller, the gain selector and for clock distribution circuitry. The front-end board serial configuration protocol and the optical output link both use DMILL technology. The only commercial ICs still used on the front-end board are the ADCs, the differential drivers for the SCA address bus and the G-link serializer for the optical output link.

To conclude the series of presentations on ATLAS calorimetry, Larry Price presented the hadron ATLAS tile calorimeter which is a sampling device made out of steel as absorber and scintillating tiles as active material. It realizes a simple and very well proven idea of calorimetry. Wavelength shifting fibers collect the scintillation light from the tile at both of their open - azimuthal-edges and bring it to photomultipliers at the periphery of the calorimeter. The full tile calorimeter consists of a barrel cylinder at the collision point which is 564 cm long and extended barrel cylinder 292 cm long at each end of the barrel and separated by a gap for detector services. Photomultiplier tubes and front-end electronics are packaged in drawers which are inserted into the girders at the outer radius of each module.

Several talks presented the current developments and status of CMS. He-

len Heath presented the status of the CMS precision electromagnetic calorimeter (ECAL) made of lead tungstate ($PbWO_4$) crystals. The use of $PbWO_4$ material allows calorimeter compactness due to its short radiation length and small Molière radius. It has good radiation hardness properties and its fast scintillator and peak emission frequency is well adapted to the short LHC interbunch crossing time (25 ns). After a successful R&D phase, the ECAL project is now moving to a construction phase.

Pablo Sempere Roldan presented a review of the construction of the first large size ECAL barrel unit. This unit was comprising 400 $PbWO_4$ crystals. Various aspects of the construction sequence were discussed such as uniformization of light collection, gluing the crystals to photodetectors, assembly process, module thermal regulation.

The status of the CMS hadron calorimeter was reported by Vasken Hagopian. This calorimeter includes a central barrel and two endcaps, made of brass and scintillators. Two forward calorimeters extend the pseudorapidity coverage up to large pseudorapidity ($|\eta| \leq 5$). Energy leakage from the central barrel are measured with scintillators located outside the magnet coil, within the muon system. After several design changes to simplify the calorimeter and reduce the cost, the construction of the calorimeter is about 50% complete. Then, it is expected to have a working CMS hadron calorimeter at the start of the data taking.

We had also a report from calorimetry activities in DESY/HERA. Andy Ziegler gave a talk on the new ZEUS tungsten/scintillating fiber spaghetti electromagnetic calorimeter for the luminosity monitoring system after the upgrade of the HERA luminosity. The detector was successfully tested and achieved an energy resolution of $17.0\%/\sqrt{E}$+15.7%/E and a position reconstruction resolution of 0.93×0.51 mm^2.

Finally, Franz Steinbuegl presented a new concept of an active element for the large cosmic ray calorimeter ANI located on the Mount Aragatz, Armenia. A new concept for active medium has been translated into a prototype which has undergone a first set of tests. The basic element is a long tube filled with water (10-40 m long and 30×30 cm^2 cross section) and read out by two photomultipliers at both ends. The significant fraction (about 50%) of the Cerenkov light produced by the passage of a charged particle through water is absorbed by a dissolved wavelength shifter dye and re-emitted around 420-550 nm. A new type of reflector material has been used to optimize light transportation over long distances.