Construction and Calibration of the PHENIX PbSc Electromagnetic Calorimeter

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SUMMARY

The electromagnetic calorimeter for the PHENIX experiment at RHIC is now being assembled and tested at Brookhaven National Lab. When completed, the calorimeter will cover a rapidity range of +-0.35 units and an azimuthal angle of 180 degrees. At a distance of 5 meters from the interaction region, it will have a total active area of close to $64m^2$, subdivided into 8 equal sectors of approximately $2 \times 4\ m^2$ each. Six sectors will be lead-scintillator shashlik type sampling calorimeters designed and built specifically for use in PHENIX, and will contain 15552 individual towers, each read out with its own photomultiplier tube. The remaining two sectors will incorporate approximately 10,000 Pb Glass Cherenkov calorimeter modules from the WA98 experiment at CERN.

The production of all six Pb-scintillator sectors was recently completed and approximately one half of the all modules have been tested. The calorimeter design features a single 4 tower module which is repeated throughout, all of which were industrially produced with a number of quality control steps to insure uniformity and consistency, as well as high light yield, for each tower. Results will be presented on the uniformity of the calorimeter and the accuracy of a cosmic ray based pre-calibration scheme. Experience with pre-matching modules with PMT's in order to reduce the number of independent high voltage channels will also be described.

The design of the calorimeter module is given in Fig. 1. Four optically independent towers (60 sampling layers of 1.5mm Pb & 4 mm Sc ganged together by penetrating wavelength shifting fibers used for light collection) are mechanically grouped together into a single module. This grouping forms the basic building block with a minimum of supporting components that can be readily mass produced. The manufacturing process can be broken down into individual simple steps, and each module can be easily manipulated during the assembly procedure. The calorimeter modules were built to industrial standards of quality control, and the usual control of mechanical tolerances was supplemented by scintillator light yield measurements using radioactive sources on about 2% of all tiles. Acceptance tests were made on every module, including excitation of the individual tiles in each tower by UV light from a laser. The tower response was also measured with calibrated photomultipliers tubes. The consistency of the quality control procedure was verified by comparing relative variations in the light yield measured at the production site to those measured by exposing the towers to cosmic ray muons. An example of these results is shown in Fig. 2, which includes data from modules built using different quality fibers, thus tending to increase the observed spread in light yield between modules.

All modules are grouped together into 6×6 arrays called supermodules. These supermodules, which weigh about 700 kg each, are supported on a rigid backbone and held together by welded stainless skins. Each supermodule is assembled and tested by physicists who install the photomultiplier tubes, connect the laser monitoring system and calibrate each module either in a particle beam or using cosmic muons. As part of the calibration, the absolute light yield per calorimeter tower is measured in terms of the number of photons produced per unit of electromagnetic energy deposited. Figure 3 gives a summary of the present data available on the light yield for all supermodules tested so far and shows a nearly Gaussian distribution with a $\sigma \sim 13$ %, thus providing an assessment of our ability to maintain the uniformity over the entire calorimeter. Additional details regarding the precalibration of each supermodule and our ability to establish initial running conditions at RHIC will be given in the submitted paper.

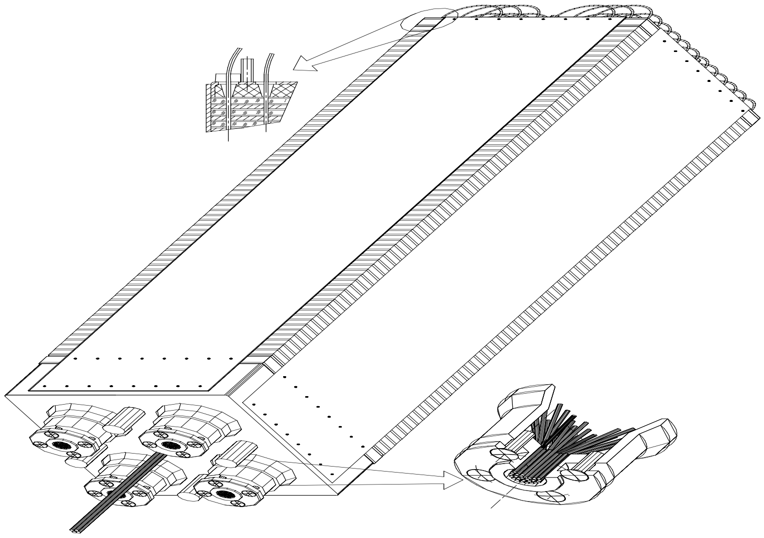

Figure 1: PHENIX EMCal Quad-Tower Module

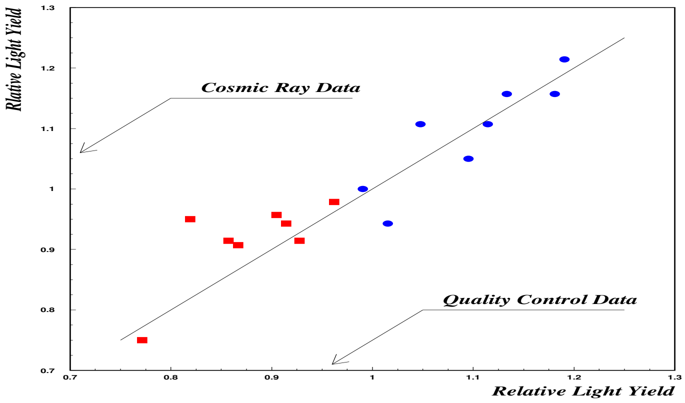

Figure 2: Correlations between Light Yield Measurements

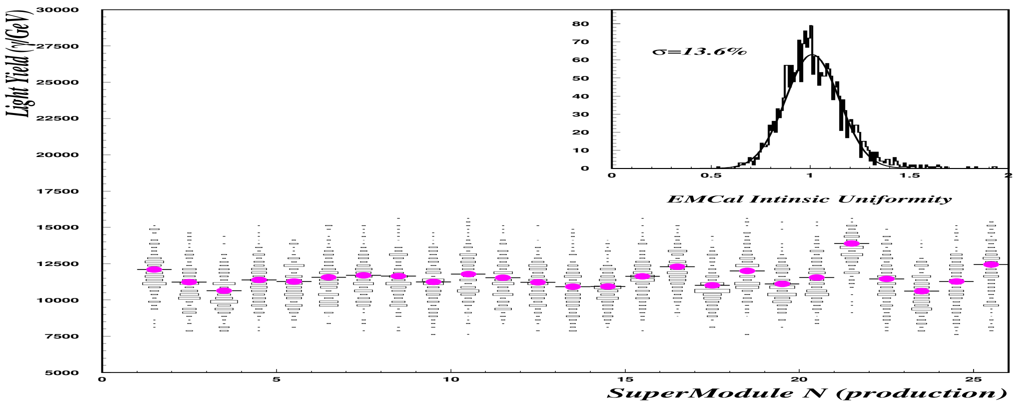

Figure 3: PHENIX EMCal Light Yield