STAR NOTE 274

Preliminary Results of Optimization Tile/Fiber Read-out System

O.Grachov*
Wayne State University
Department of physics and astronomy,
666 W.Hancock, Detroit, MI 48201

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Abstract

In this paper we are discussed the results of optimization of tile/fiber read-out system. We have used Bicron materials for tile/fiber assemblies and α-groove for Wave-Length Shifting fiber (WLS) read-out pattern. The results indicate that such tile/fiber read-out system meets the design criteria for the Barrel EMC of STAR.

*Visitor from Institute for High Energy Physics, Protvino, Russia.

1. Introduction.

The materials used in the Barrel EMC optical system must have various properties. They must have good long-term stability, be non-demanding in handling, and easy for machining. Materials be able to survive the expected radiation doses without necessity of replacement.
Our baseline choice of materials are Bicron BC404A scintillator plastic with emission peak 408 nm; green Bicron BCF91A WLS fiber, peaking at 494 nm and Bicron BCF-98 clear fiber.
These materials have been studied by SDC and CDF groups and satisfies these requirements[1, 2, 3, 4].
The total optical system must produce enough light for easily identification of the minimum-ionizing particles penetrating the calorimeter and must have good transverse uniformity of the response.
In this note we present results of the measurements of tile/fiber assemblies built to the specification of the Barrel EMC. To realize the tile/fiber technology, several developments were required. These developments, largely due to the CDF and SDC groups, include fiber splicing, megatile production, and fundamental measurements of the tile-fiber optical system.

2. Tile/fiber optical system.

We chose the α-groove of WLS fiber layout in tile. The light yield of the tile with α-groove is 1.43 times higher than the light yield of the tile with σ-groove[5]. In order to limit the number of individual elements in each sampling layer, the 40 tiles of each layer of the module of calorimeter are grouped into a single mechanical unit called megatile. Megatile production procedure is similar CDF megatile production. The light cross-talk between neighboring tiles is less than 2% per edge of the tile. The light from each tile of megatile is collected by a Wave-Length Shifting fiber that is placed in a machined groove in the scintillator. Both ends of the WLS fiber are spliced to 3m long clear fibers[6] that transport the light to the box with PMT located outside the magnet. Each tile of the megatile and lead absorber plate have narrow notch (about 70mm X 3.5mm) for mechanical protection of 42 optical fibers which go through the notches outside the calorimeter. Dimensions and position of notches will be optimized for fiber routing and for decreasing of phi-crack between calorimeter modules. This design of read-out pattern is similar to the SDC design[7].

3. Photodetector.

The STAR EMC requires the purchase of approximately 10000 photomultiplier tubes. The significant requirements for the phototube are:
- low cost;
- the photocathode active diameter greater than 20 mm to contain 168 fibers and total dimensions in oder to fit within the limited space;
- uniformity of photocathode;
- green-extended photocathode, high quantum efficiency at 494nm;

- linearity in the region up to 80 mA peak current;
- high gain(10^6) and low dark current(50 nA);
- long-term stability.

Many types of photmultipliers for calorimetry in collider setup have been studied by SDC , CDF, DO and PHENIX groups. Many phototubes appeared to meet most of these requirements. We concentrated on studying the FEU115M[8, 9, 10]. These phototubes are more closely matched our needs. We have compared FEU115M and R580-17(Hamamatsu). Some results will be discussed below.

4. Light yield and uniformity measurements.

We fabricated scintillating tiles at a Wayne State University. In this fabrication, we cut a scintillating plate and then we performed grooving. We have used 5 mm thick scintillator material. Dimensions of tile are 125 mm x 132 mm. The light from the tile was collected by a 1 mm diameter WLS fiber. The tile had a α-groove, with the distance between the tile edges and the fiber groove equal to 1.5 mm. The depth of the groove was equal to 2 mm, the width - 1.25 mm. The tile were wrapped with white paper. Dimensions of notch are 70 mm x 3.5 mm . The Fig.1 shows s schematic drawing of geometry of read-out pattern.

The scintillating tile is excited by a Ru^{106} 3 MeV β-ray source. A trigger counter is placed over the tile. Light from a tile/fiber is converted to electric signal a PMT. The signal from a PMT is digitized by a LeCroy 2249A CAMAC module. The trigger counter consists of a 2 mm^2 trigger scintillating fiber (BCF-12) and PMT (Hamamatsu RC4044). The trigger signal with a gate width of 40 nsec is put into a gate line of the ADC module. The detailed description of the experimental setup can be found in note[11].

We have compared the light yield of tile/fiber read-out system using PMT R580-17(Hamamatsu) and FEU115M(Russia). Typical single photoelectron peaks for FEU115M and R580-17 are shown on Fig.2a and 2b. They have been obtained by using a tile/fiber arrangements similar to that which will be used in the calorimeter. We estimate the light yield from a tile/fiber system in terms of an average number of photoelectrons produced by photoelectric effect on the PMT photocathode as follows:

$$N_{p.e.} = \frac{X_{ave} - X_{ped}}{X_{spp}}$$

, where X_{ave} is a weighted mean of ADC counts of the distribution of the sample, X_{ped} is a pedestal counts estimated from a pre-measurement of the single photoelectron peak, and X_{spp} is a single photoelectron peak counts[12, 13].

We find that the light yield which was measured with FEU115M is about 25% greater than for PMT R580-17. Pulse height spectrum are shown on Fig.3a) and 3b). For these measurements we have used 50 cm length WLS fiber without splicing to 3m length clear fibers.

Absolute light yield have been measured with 3m long clear fibers spliced to green fibers . The light yield is 2.5 p.e. for R580 and 3 p.e - for FEU 115M. In addition we studied the tile with 6.5 m length WLS fiber without splicing. Fig.4 shows the ADC pulse hight spectrum for tile/fiber read-out using 6.5 m green WLS fiber. The light yield of the optical system with FEU115M

was 1.6 p.e.
The uniformity response of tile/fiber assemblies have been measured using the collimated Ru^{106} source. Fig.5 shows the plot of transverse scan of the tile. The uniformity of the response is better than 4%.
We have also studied the light output dependence on tile wrapping. The light yield from tile wrapped with white paper is about 3.5% larger than for the tile with the edges painted with white reflective paint BC-620 from Bicron.
For all measurements, except the absolute light measurements, we have used the same tile and the same WLS fiber. During about one month measurement, the tile/fiber system have not shown any signs of mechanical instability.

Acknowledgments

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References

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Figure Captions

Fig.1 The schematic drawing of geometry of read-out pattern.

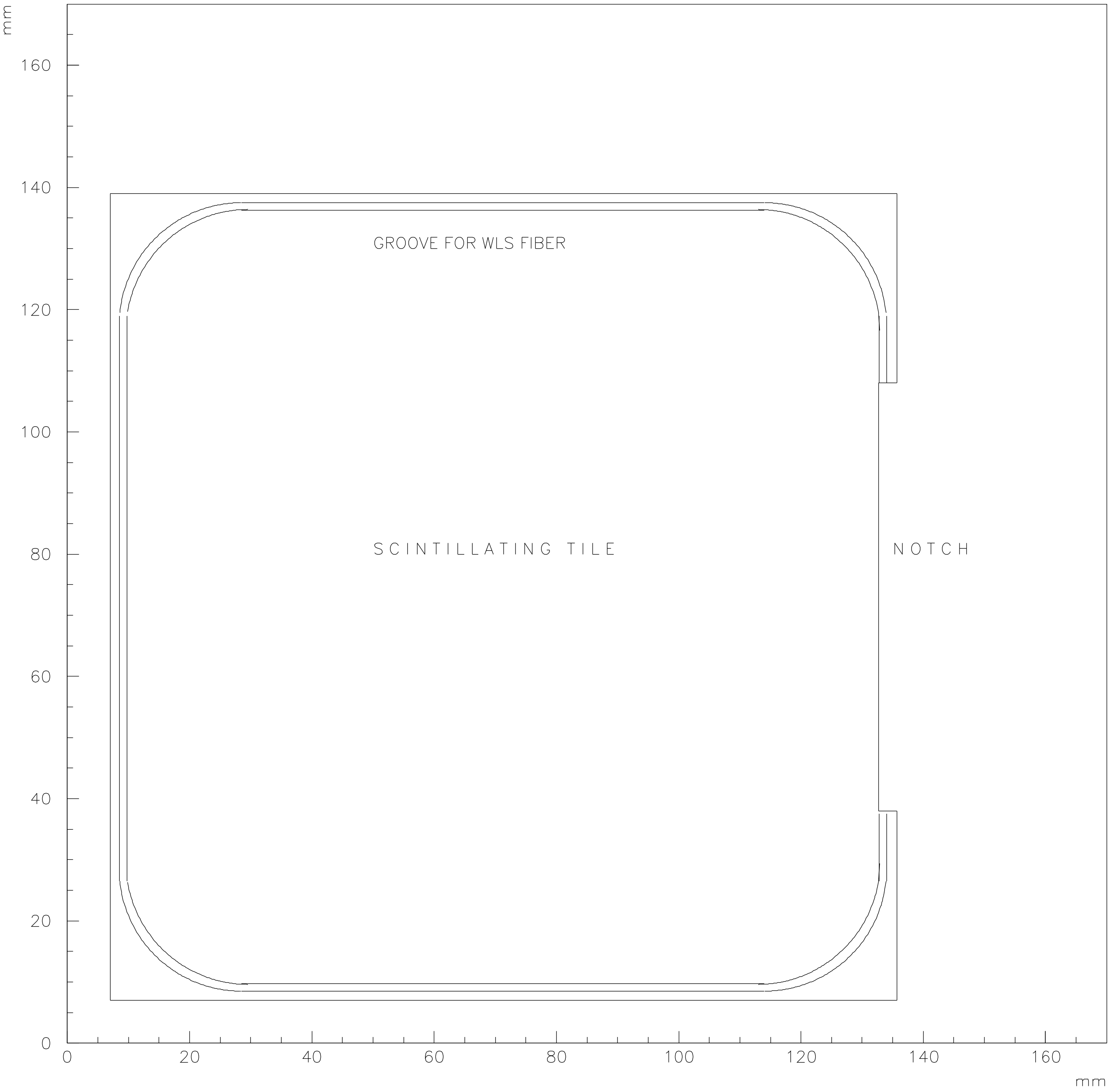
Fig.2. Single photoelectron distribution.
a). FEU 115M;
b). PMT R580-17;

Fig.3. ADC pulse height spectrum.
a). FEU 115M; The light yield is 10.5 p.e.
b). PMT R580-17; The light yield is 8 p.e.

Fig.4. ADC pulse height spectrum for tile/fiber read-out system using 6.5 m green Bicron BCF91A WLS fiber.(The light yield is 1.6 p.e.)

Fig.5. The transverse scan of tile using collimated β source. The uniformity of the response is better than 4%.

Fig 1.


GROOVE FOR WLS FIBER
SCINTILLATING TILE
NOTCH
mm
mm
0
20
40
60
80
100
120
140
160

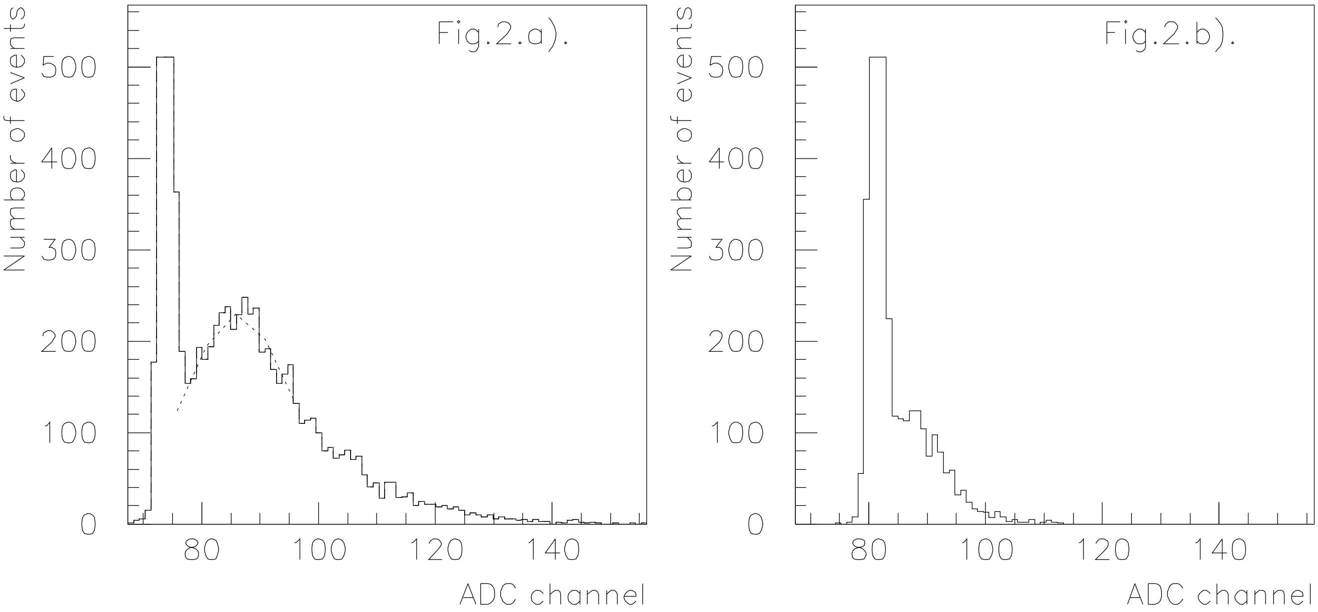


Fig.2.a).
Fig.2.b).
Number of events
0
100
200
300
400
500
80
100
120
140
ADC channel

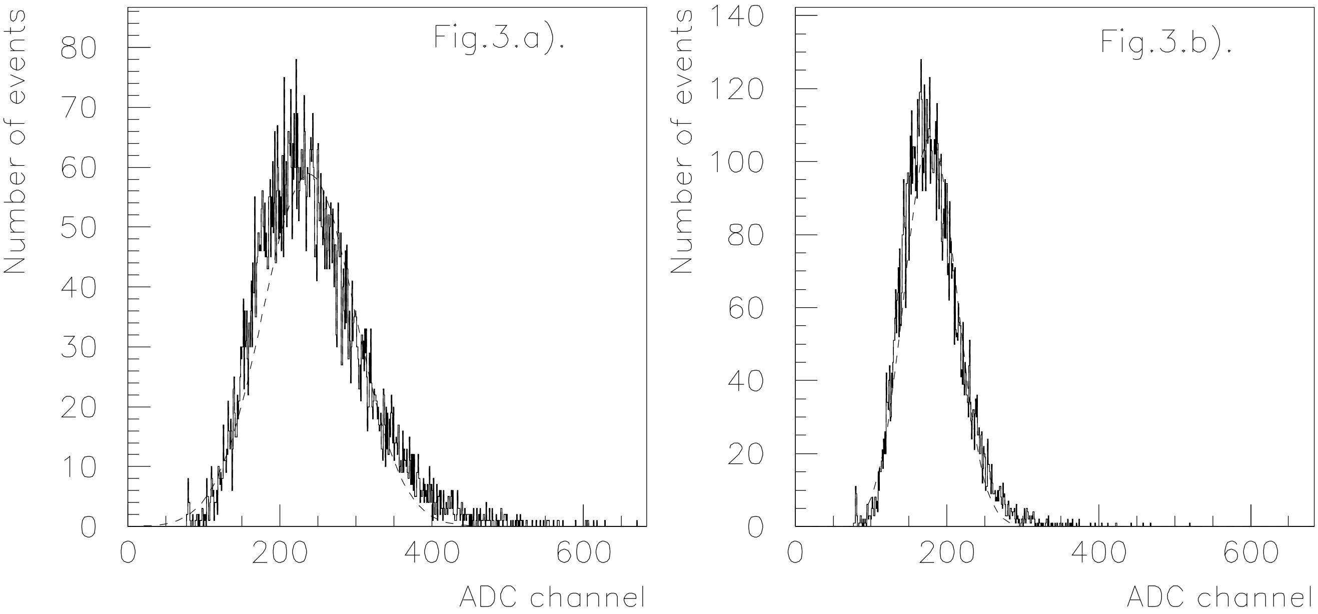


Fig.3.a).
Fig.3.b).
Number of events
0
10
20
30
40
50
60
70
80
100
120
140
0
200
400
600
ADC channel

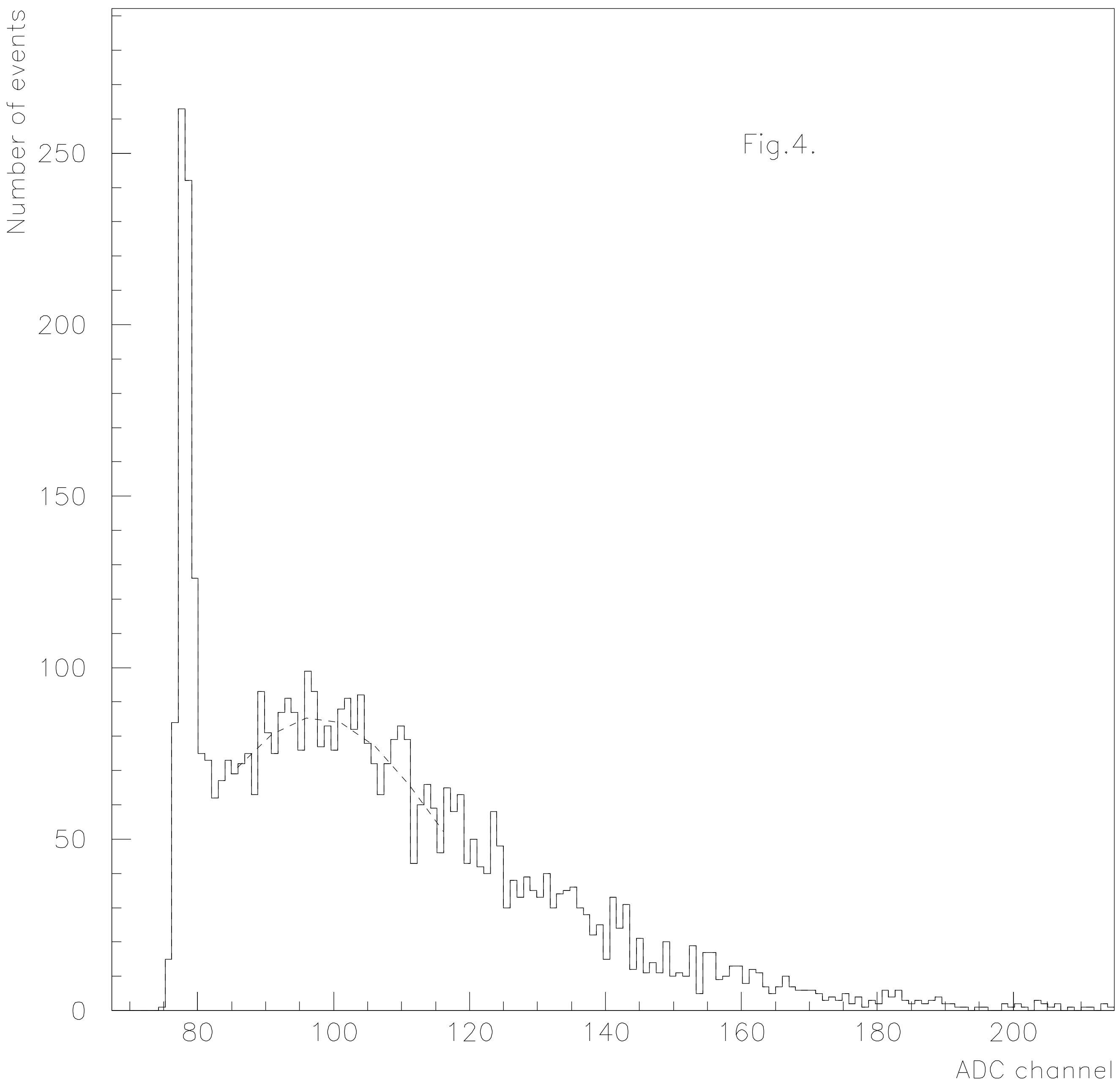


Fig.4.
Number of events
0
50
100
150
200
250
80
100
120
140
160
180
200
ADC channel

Fig.5. The transverse scan of tile using collimated source.