Electron-Muon Ranger (EMR)

Status of the EMR Project

R.Asfandiyarov[1], P.Béné[1], R.Bloch[1], A.Blondel[1], D.Bolognini[3], F.Cadoux[1], S.Débieux[1], J-S.Graulich[1], C.Husi[1], Y.Karadzhov[1], F.Masciocchi[1], L.Nicola[1], M.Prest[3], K.Rothenfusser[1], E.Vallazza[2], V.Verguilov[1]

[1]DPNC, Université de Genève, Switzerland

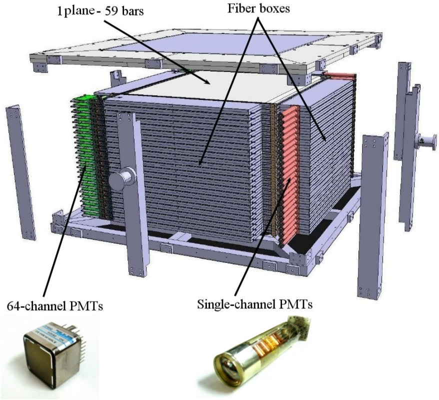
[2]INFN, Sezione di Trieste, Italy

[3]Università degli Studi dell'Insubria and INFN, Sezione di Milano Bicocca, Italy

MICE Collaboration Meeting 31, October 30, 2011

Table of Contents

EMR Overview



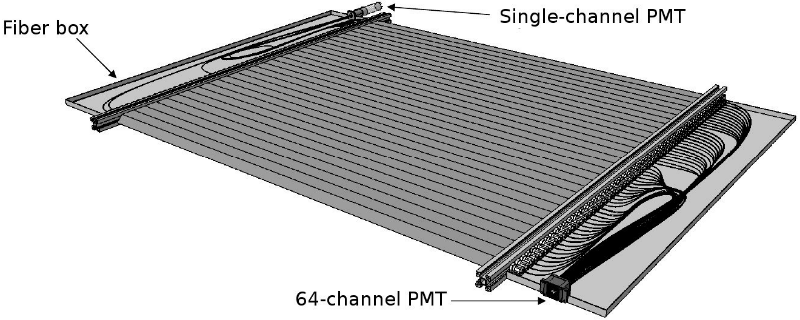
- EMR detector is designed to fully stop muons from the MICE cooling channel and provide distinct signatures for muons and electrons.

Characteristics

- 24 modules (X-Y planes)
- 59 triangular scintillator bars per plane $\rightarrow$ 2832 bars
- each bar is read out by WLS fiber
- total energy per plane is detected by single-channel PMT (PHILIPS)
- energy in every bar is detected by 64-channel PMT (HAMAMATSU)
- custom made electronics based on MAROC/FPGA ISICs and integrated with CAEN boards

- Broken readout of even a small amount of channels would pose a significant complication for the off-line analysis

Design of the EMR Plane



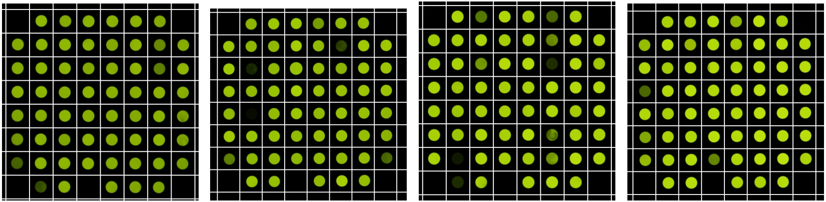
In the original design of the detector a 3 meter wavelength shifting fiber collects and transfers light to PMTs on both sides of a plane.

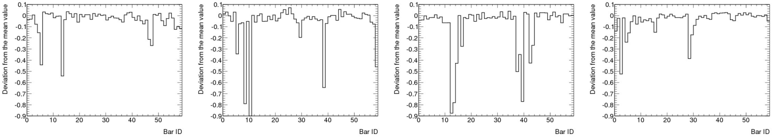
Caution

Since the fibers have the same length and the connector is located on the side of the fiber box, it is always necessary to bend the fibers to pack them into the fiber box.

Several planes of this design have been assembled and tested.

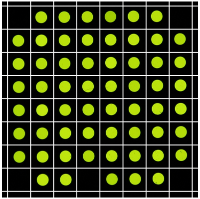
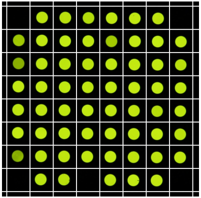
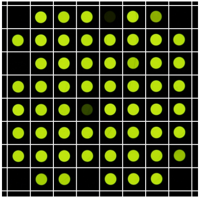
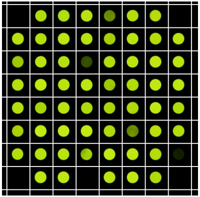
Optical Tests: Plane 1-4

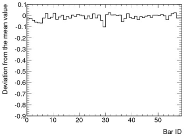


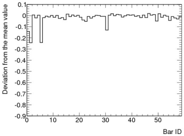


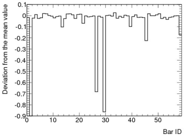
The plots show the deviation of the average luminosity of every channel from the mean value of luminosity calculated from 20 the most brightest channels. Downward spikes represents broken channels and the depth indicates the level of damage.

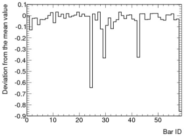
Optical Tests: Plane 5-8









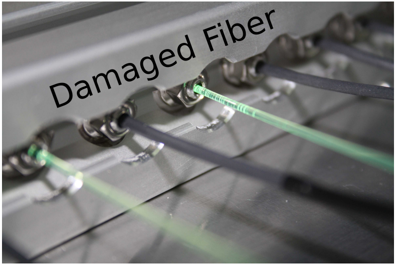
Caution

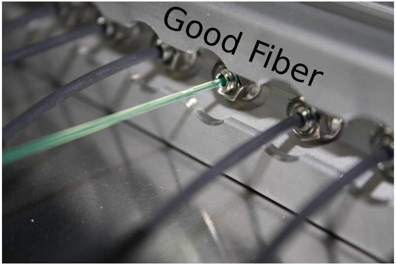
10% of the fibers are damaged

Visual Inspection of Broken Fibers

Problem

It was found that the fiber of previously identified broken channel has many white scratches just after a small aluminum tube.

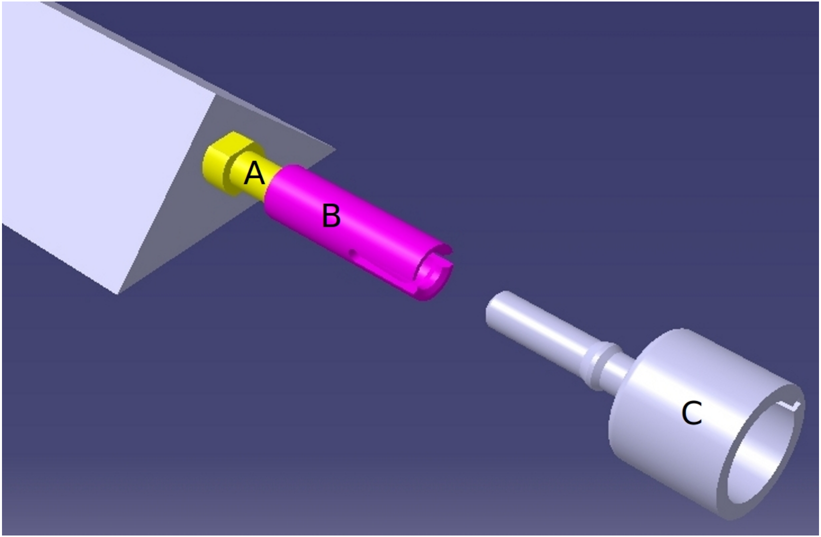




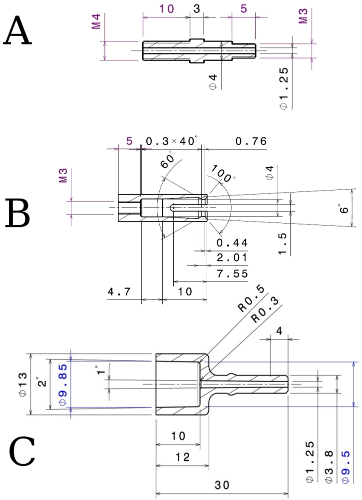
Solution

It was proposed to decouple PMT connectors and WLS fibers by introducing a special connector at both ends of the scintillator bar and a clear fiber to transfer light from the bars to PMTs.

New Fiber Connectors



Dimensions of the New Connectors



The part A (aluminium) is attached to the scintillator bar on both ends after the WLS fiber is inserted into the hole inside the bar and glued. After the glue is fixed, the end face of the part A is polished. The adapter B (plastic) is screwed onto part A and the connector C (plastic) is clipped into adapter B. The end face of connector C should be also polished. *The enlargement in connector C will be explained later.*

Caution

One of the important tests is the measurement of light loss in the connector and the comparison of this loss with the gain due to the change to the clear fiber. Since the light attenuation in WLS fiber is higher than in clear fiber, the gain is estimated to be about 15%.

WLS Fiber and Index Matching Grease (IMG)

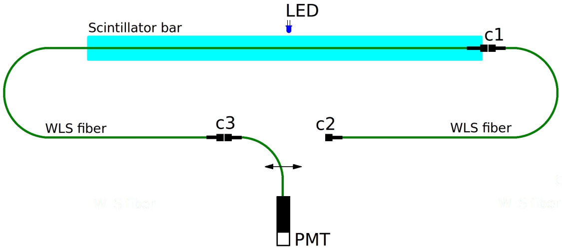
WLS Fiber

Manufacture reference	BCF-92
Physical property	Fast blue to green shifter
Diameter	1.2 mm
Core material	Polystyrene
Core refractive index	1.6
Density	1.05
Trapping efficiency	5.6% minimum
Decay time	2.7 ns

Index Matching Grease (IMG)

Refractive Index	1.61
Composition	Siloxane and Proprietary Polyether
Index Change Rate	No index change
Viscosity	444 cSt (water at 20 ℃ 1 cSt)
Compatible	Polypropylene

Test of the New Connectors

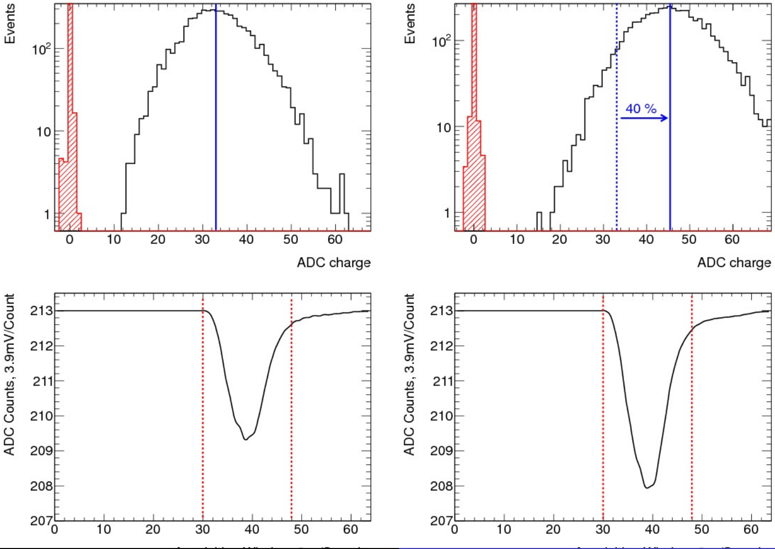


#	Measurement	w/o IMG	with IMG	Improvement due to IMG
1	c3	13.4 ± 0.3	19.6 ± 0.3	46%
2	c2 + c1(w/o IMG)	8.6 ± 0.2	13.5 ± 0.4	57%
3	c2(with IMG) + c1	13.5 ± 0.4	19.4 ± 0.6	44%
loss c1 w/o IMG		35%	31%	-
loss c2/c1 with IMG		0%	0%	-

Index Matching Grease (IMG)

The IMG drastically improves light transmission through the fiber optical contact. A special test bench was set up to check a long term stability of the IMG.

Improvement due to the Index Matching Grease



EMR Production and Assembly Procedure

The production is spit into three parts. The first two are independent and performed in parallel:

1. Production of Bars

60 bars are assembled at a time in stead of 20 since there is no need to stretch 3 m WLS fiber, only 1.2 m will be used. A storage of completed bars is much easier. Every bar is tested before module assembly.

2. Production of PMT Connectors

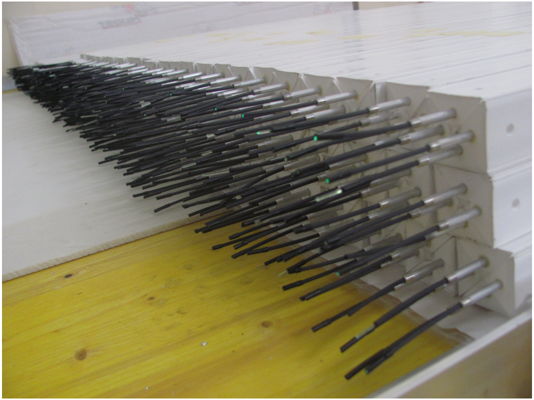
Single and 64-channel PMT connectors can be produced and tested independently from the production of bars.

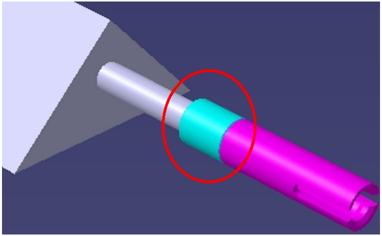
3. Module Assembly

X and Y planes are assembled with tested bars and connectors and put into EMR box to the final position.

Re-use of Already Produced Bars

More that 1000 bars have been produced following the old design. These bars are re-used. The WLS fibers are cut





and an additional adapter (aluminium) is used to align the fiber and attach the new connectors.

Possible Use of the New Connectors with SiPM

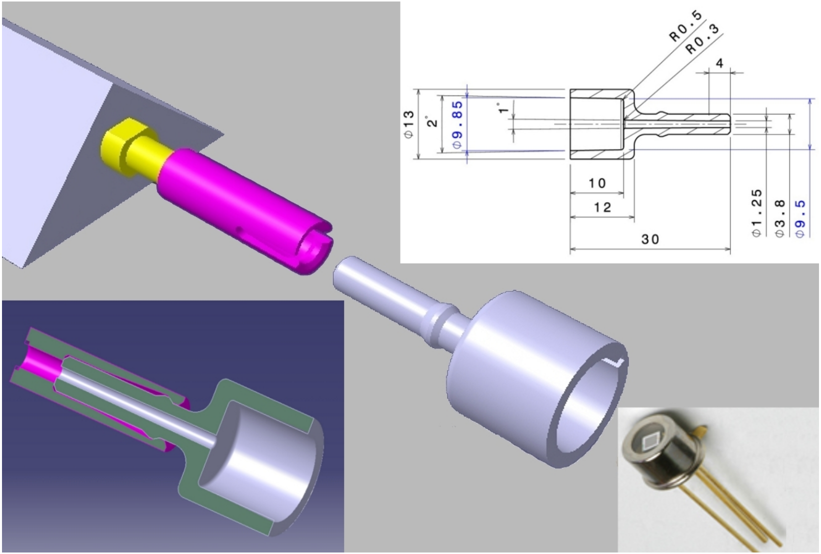
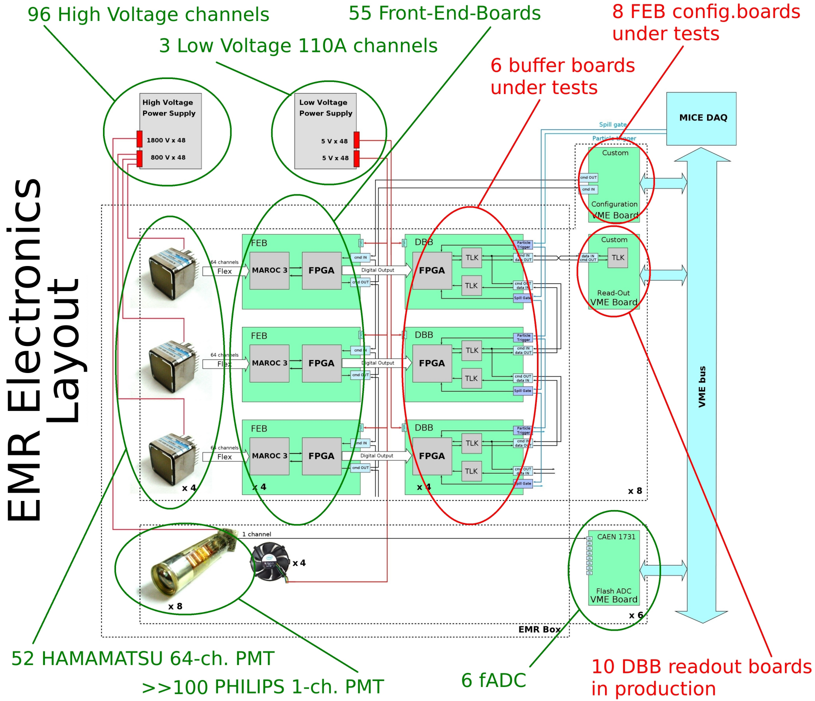
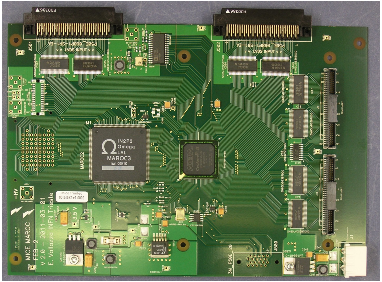


Table of Contents


EMR Electronics Layout
96 High Voltage channels
55 Front-End-Boards
8 FEB config.boards under tests
3 Low Voltage 110A channels
6 buffer boards under tests
High Voltage Power Supply
1800 V x 48
800 V x 48
Low Voltage Power Supply
5 V x 48
5 V x 48
MICE DAQ
Spill gate
Particle trigger
Custom
Configuration VME Board
cmd OUT
cmd IN
Custom
Read-Out VME Board
TLK
data IN
cmd OUT
FEB
MAROC 3
FPGA
64 channels
Flex
Digital Output
cmd IN
cmd OUT
DBB
TLK
Particle Trigger
cmd IN data OUT
cmd OUT data IN
Spill Gate
x 4
x 8
VME bus
1 channel
CAEN 1731
Flash ADC VME Board
x 6
EMR Box
52 HAMAMATSU 64-ch. PMT
>>100 PHILIPS 1-ch. PMT
6 fADC
10 DBB readout boards in production

Front-End-Boards

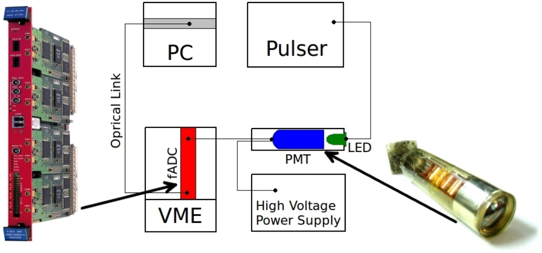
- 55 Front-End-Boards have been produced
- delivered to UNIGE a week ago
- will be tested next month

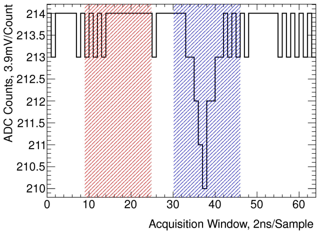


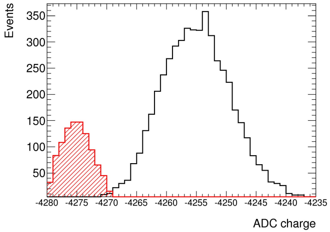
- MAROC-3 ASIC: 64 amplifiers, shapers and discriminators
- ALTERA Cyclone-II FPGA: board logic

Flash ADC Test Bench

CAEN V1731 - 500MS/s, 8 channels



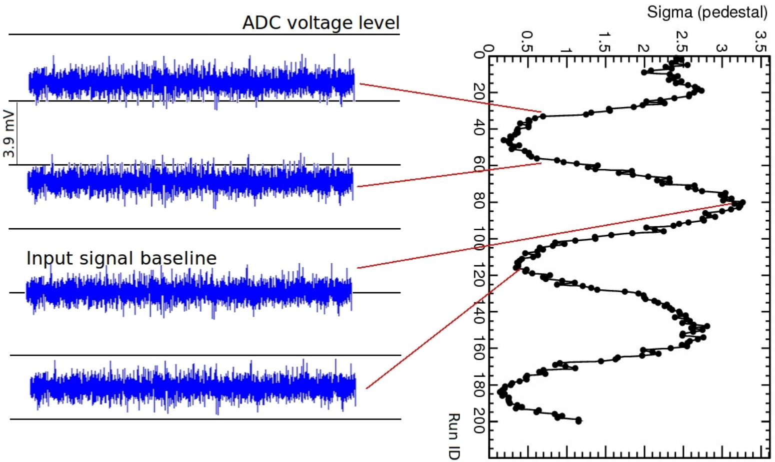




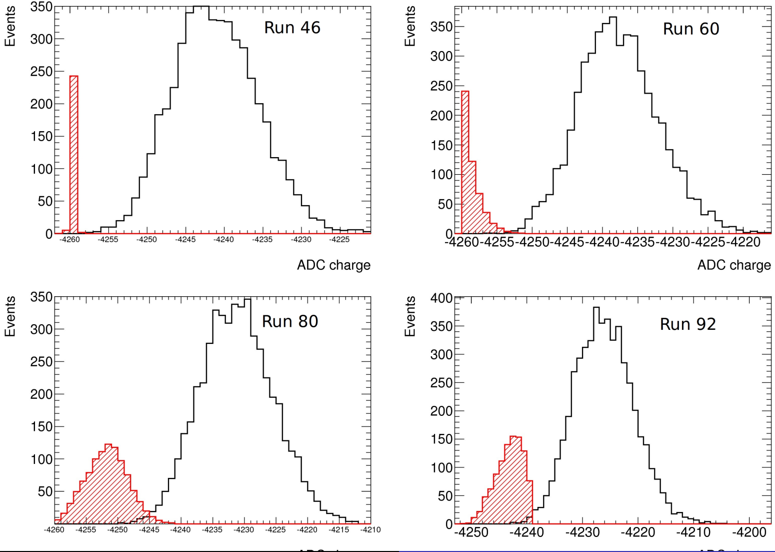
- a test bench is set up to study fADC behaviour
- light pulses are created by LED and similar to those generated by MIP particle in triangular scintillator bars
- this setup is identical to the final readout of the PHILIPS 1-ch. PMT in EMR
- it is also used to test/select the PMTs

Signal Baseline VS ADC level

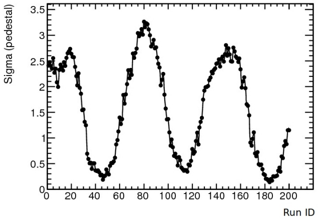
The width of the pedestal distribution (and consequently the signal value) is greatly affected by the position of a signal baseline relative to the ADC voltage level.

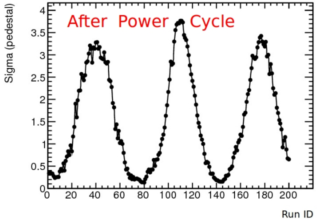


Signal Baseline VS ADC level



Signal Baseline VS ADC level





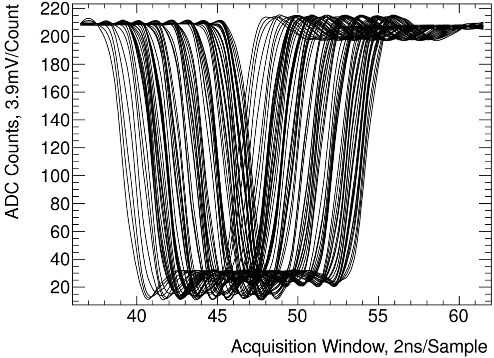
- A position of the input signal baseline relative to the ADC voltage level (DC_OFFSET parameter) changes randomly after a power cycle of the board, consequently the signal value** changes as well
- In order to make consistent measurements it is necessary to select DC_OFFSET corresponding to the minimum of pedestal sigma distribution - calibration of the board

	Before power cycle	After power cycle
minimum*	45 / 113	76 / 142
signal value**	18.35 / 18.18	18.62 / 17.93

* run ID corresponding to the minimum of pedestal sigma distribution (smallest possible noise level)
** the integral of a signal distribution minus pedestal value

Trigger Uncertainty and Delay

A standard NIM signal was spit using a fan-out board and those two were used as a trigger and input signal



- Since the trigger sampling clock is 1/8 of the ADC sampling clock, 8 samples uncertainty on the signal occurs over the acquisition window
- Also there is a constant delay of the trigger signal of 64 ns due to the trigger processing logic circuits in FPGA

Updated Schedule

Taking into account all the mentioned above (modifications in design etc.) we suggest the following new schedule:

- Construction:
  - Finish the scintillator modules (4-5 months $\rightarrow$ March)
- Tests and analysis are performed **in parallel**:
  - Test the FEBs (1 month $\rightarrow$ November)
  - Finish and test the VME boards (2 months $\rightarrow$ December)
  - Setup all the hardware in DATE (2 months $\rightarrow$ January)
  - Cosmic tests of assembled modules (3 months $\rightarrow$ April)
  - Analysis software (4 months $\rightarrow$ May)
- Cosmic test of the full detector (2 weeks $\rightarrow$ April)
- Packing, shipment, installation at RAL (1 month $\rightarrow$ May)

New Dates

Therefore we can conclude that the EMR will not be ready by January 2012.
It is more realistic to aim for the run in May-June 2012.

Table of Contents

Plots for Online Monitoring

Particle Range

- Total charge per plane VS the plane ID (1 plot)

Tracking

- Transverse beam profile: X VS Y per module (24 plots)
- Longitudinal beam profile: X VS module ID (1 plots)
- Longitudinal beam profile: Y VS module ID (1 plots)

General Monitoring Plots

- Distribution of the total charge per plane (48 plots)
- Distribution of the time over threshold per bar (48x59 plots)

EMR Operation and Monitoring

Power/Current Consumption

- High voltage PSU
  - 96 channels (CAEN SY527/SY4527)
    - 1800 V @ 670 μA - 48 channels
    - 800 V @ 340 μA - 48 channels
  - voltage and current should be monitored
- Low voltage PSU
  - 3 channels (CAEN SY8800)
    - 5 V @ 110A(max)
    - 2 lines for FEB, 1 line for DBB
    - cooling fans
  - voltage and current should be monitored

Temperature

Each front-end-board has a temperature sensor which is read out by the DAQ

Table of Contents

Summary

- Some modifications to the EMR design have been introduced to exclude broken channels and to facilitate the production
- The production is ongoing and estimated to be finished by March 2012 (*the original schedule has to be shifted*)
- All Front-End-Boards have been produced and will be tested soon
- VME electronics are under production and tests
- **EMR is progressing steadily**