Electron-Muon Ranger (EMR)

Construction and Tests

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], D.Lietti[3], F.Masciocchi[1], L.Nicola[1], M.Prest[3], K.Rothenfusser[1], E.Vallazza[2], V.Verguilov[1]

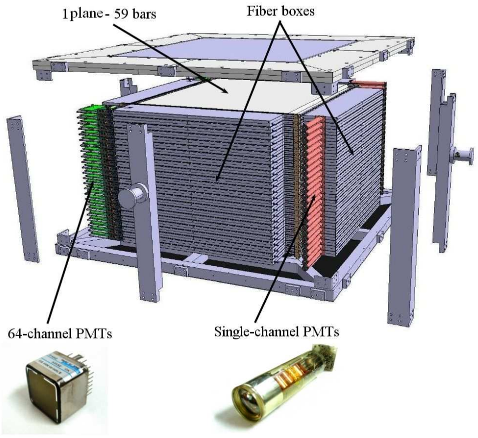
[1]DPNC, Université de Genève, Switzerland

[2]INFN, Sezione di Trieste, Italy

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

MICE Collaboration Meeting 29, February 15-18, 2011

Characteristics
Horizontal View



Characteristics

- 24 modules (X-Y planes)
- 48 planes
- 59 bars per plane
- 2832 bars
- 3m WLS fibers per bar
- 8.5 km WLS fibers
- single and 64-channel PMTs per plane
- 3072 + 48 channels

Application

Physics Goals

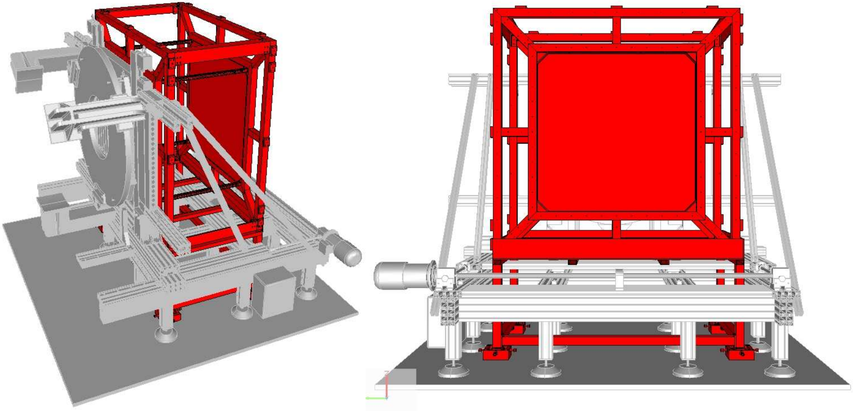
- Almost 1m^3 of active volume allows to stop electrons and muons with momentum up to 280 MeV/c.
- Different behavior of muons and electrons gives very distinct identification signatures.
- Granularity of the detector allows to reconstruct individual tracks and measure energy deposition in every bar.

Future Applications

Because of the modularity and relatively low cost, this detector can be extended to cover big area and be used in large scale neutrino experiments.

EMR at RAL

Integration with KL and Supporting Frame



The bottom chassis and related x-y-z system (x4) to tune the EMR position with respect to KL are under development.

Production Status

All supporting metal bars manufactured, all fiber boxes produced, more than 1000 bars glued with fibers, 18 planes assembled, 2 modules (4 planes) are fully equipped with fiber boxes and PMT connectors (see EMR Test Setup).

In order to speed up gluing of WLS fibers into scintillator bars a special device is being employed.

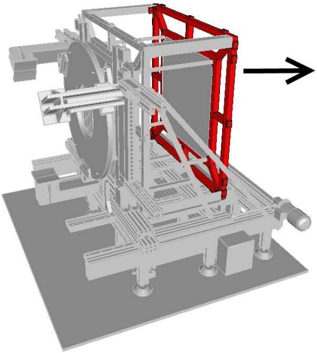
Production Status

It is crucial to have very good optical contact between fibers and PMTs window in order to reduce light loss. After fibers are glued into connectors they are polished.

A dedicated polishing machine is being used.

Outer Box

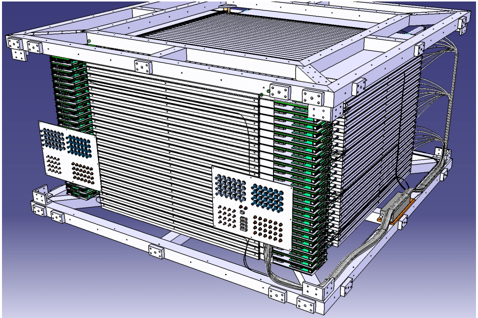
The Outer box will house the EMR planes and patch panels and will be used for transportation.

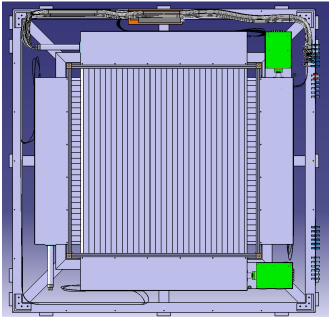


One of theframes has been manufactured and will be used to store completed modules.

Patch Panels

work in progress





- there will be 4 patch panels located on the sidewall of the outer box (more than 200 connections)
- cables tightly attached to supporting frames and walls
- all patch panels will be detachable for easy access
- protection will be put on low voltage power cables

Issues

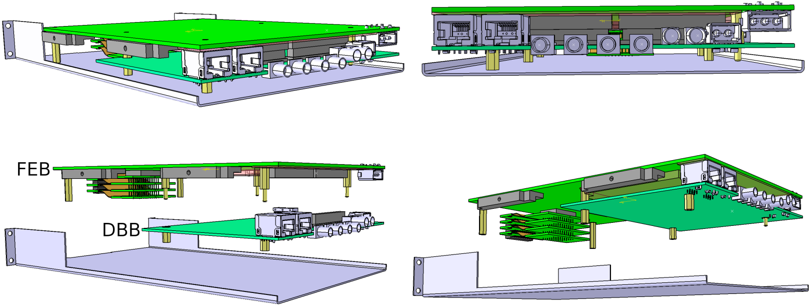
- 1-2 scintillator bars are usually replaced during assembly due to broken fibers (we keep the bars for future use)
- 16 low voltage power supplies should be ordered:
  - each should provide 5V and 15A
  - will power 48 DBBs and 48 FEBs
  - separate digital and analog lines

Production Schedule

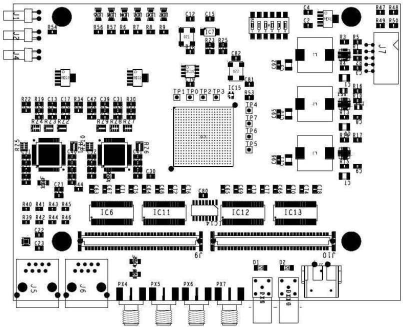
- 1 module (2 planes) can be completed within a week (if 118 bars were glued with fibers and assembled earlier)
- production of all the modules will be finished in September-October this year (see EMR Schedule)
- the outer box will be produced by May to be used for transportation and tests in June

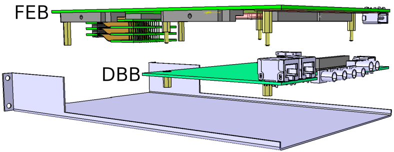
New Electronic Boards for 64-channel PMT

A new Front-End-Board (FEB) and Digitizer-Buffer-Board (DBB) were developed in order to read 64-channel PMT and store data during the MICE spill and subsequently transfer it to a dedicated VME board.



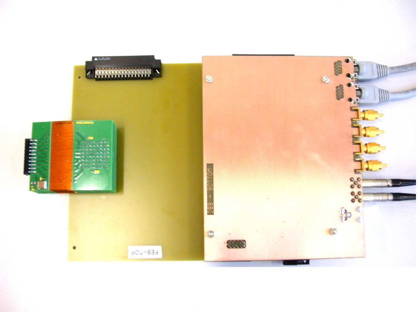
Digitizer-Buffer-Board

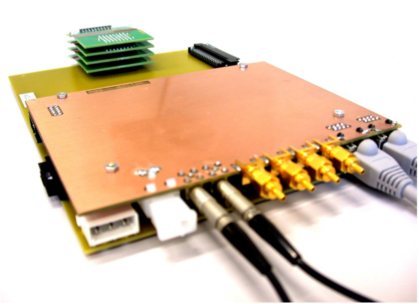


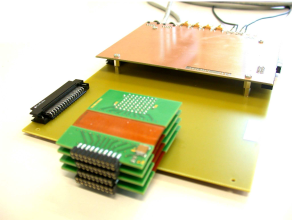


The DBB samples the 64 channels coming from FEB and transmits the event data upon request of the acquisition system. FPGA performs the sampling, data buffering, and data-flow control functions of the board. Internal memory of the FPGA is used to store data which is a collection of rising/falling edge timestamps which occurred on each channel during a spill. Six DBB are daisy-chained together with upstream and downstream links. The first DBB in each group is directly connected to the acquisition system.

Mechanical Model of DBB and FEB



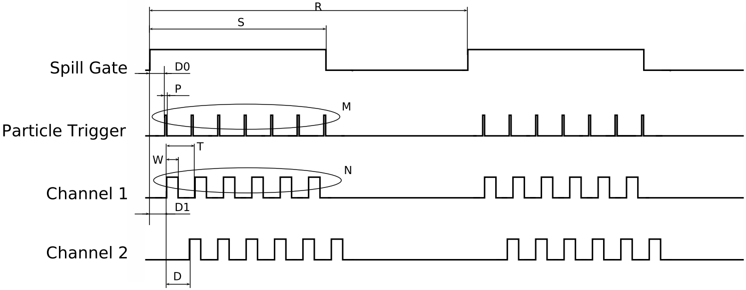




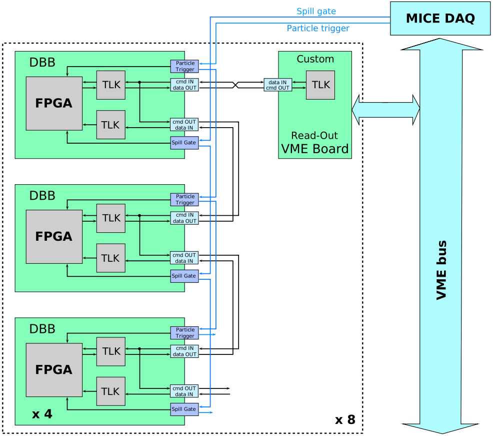
A full mechanical model of DBB and FEB was produced in order to test the assembly and accessibility of different connectors.

Test Signal Generator for DBB

- In order to check the functionality of the DBB independently from the FEB (since DBB might be produced earlier), a special Test Signal Generator (TSG) has been proposed.
- The TSG should be able to generate a limited set of well defined signal patterns that could be used to check that the DBB is doing what it is supposed to do.



Communication of DBB with VME Board



1. at the end of MICE spill a command is sent to 8 VME read-out boards to start reading data simultaneously
2. the VME boards send commands to six DBB requesting data in sequential order
3. MICE DAQ waits until all VME boards finish receiving data from DBB and then reads the data from VME boards in sequential order

EMR Data Format

work in progress

Data format

Header

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Header type				0	0	0	0	0	0	Board ID						Spill Number															
0	0	0	0	0	0	Trigger count										0	0	0	Hit count												

Data Word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Data type				Channel ID						Hit time																					

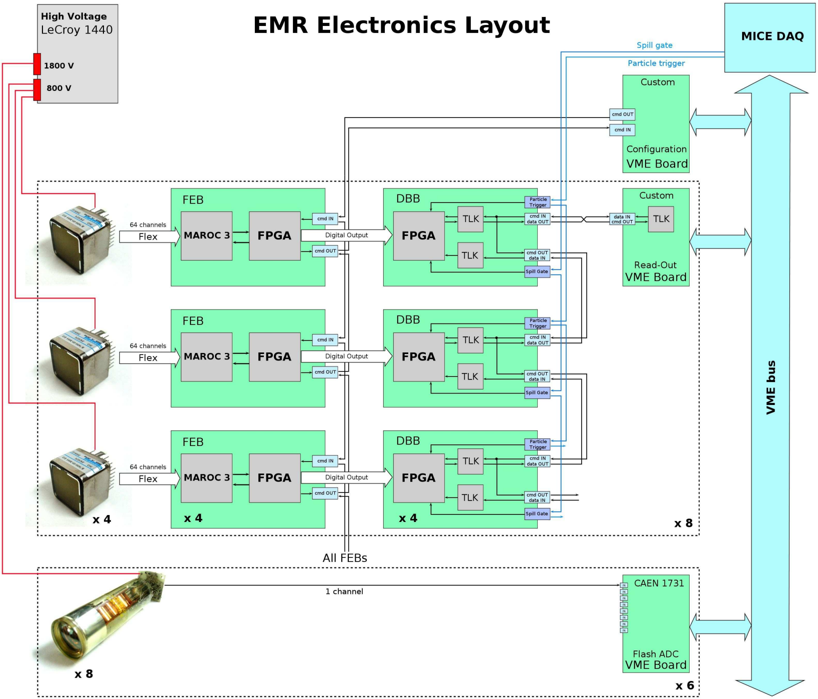
Trailer

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Trailer type				Status						Board ID						Spill Number															

Format of control commands

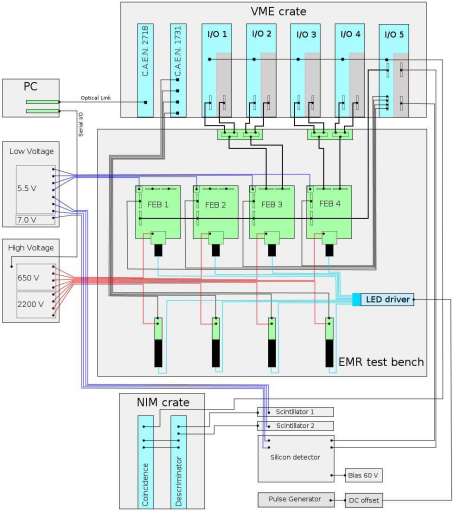
Command

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Cmd type				Command						Board ID						Arguments															



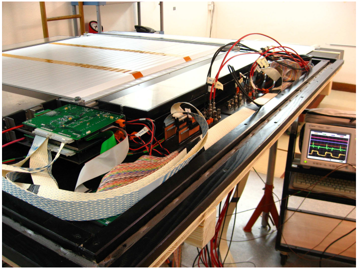
EMR Electronics Layout
High Voltage
LeCroy 1440
1800 V
800 V
MICE DAQ
Spill gate
Particle trigger
Custom
cmd OUT
cmd IN
Configuration
VME Board
FEB
64 channels
Flex
MAROC 3
FPGA
cmd IN
cmd OUT
Digital Output
DBB
FPGA
TLK
Particle Trigger
cmd IN data OUT
cmd OUT data IN
Spill Gate
Custom
data IN cmd OUT
TLK
Read-Out
VME Board
x 4
x 8
All FEBs
1 channel
CAEN 1731
IN
Flash ADC
VME Board
x 6
VME bus

Block Diagram of the Test Setup at UNIGE



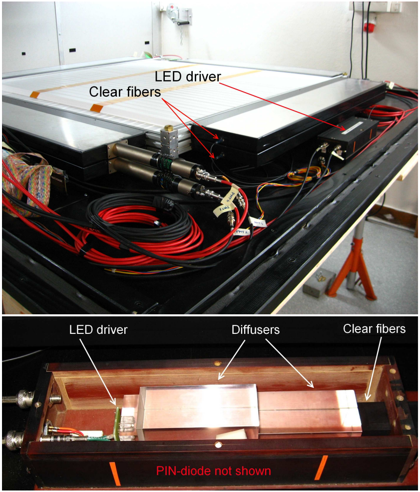
- the test setup is used to setup DAQ system and test modules before transportation to RAL
- 2 modules are installed inside light tight box
- lower module is kept as a reference, upper one is exchanged
- analog signal from 64-ch. PMT is read from all boards, digital - only from the upper two

EMR Test Setup



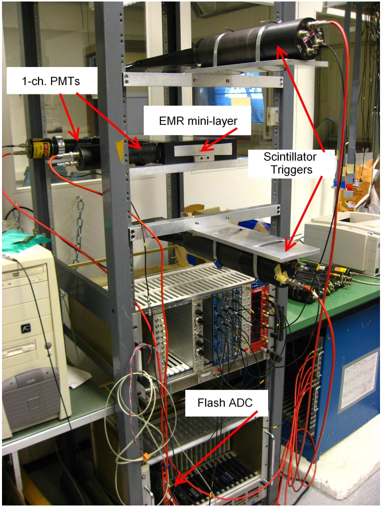
- all set up to perform tests with cosmics
- 2 CPUs, VME (read-out boards) and NIM (coincidence unit) crates
- LeCroy-1440 high voltage power supply for single- and 64-ch. PMTs
- scintillator triggers and silicon micro-strip detectors for track reconstruction and efficiency measurements
- LED pulser system for PMTs

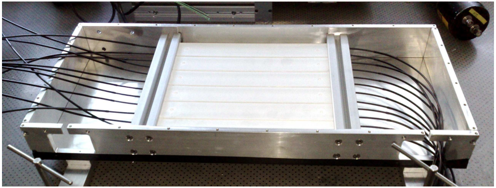
LED Pulser System for PMTs



- the LED Pulser system (provided by P.Hanlet) is used to monitor the performance of PMTs
- short pulses are fed into LED driver attached to light diffusers
- light is distributed through clear fibers directly to all PMTs
- PIN-diode is used in order to monitor light intensity
- similar system but with 98 fibers will be used in the final setup

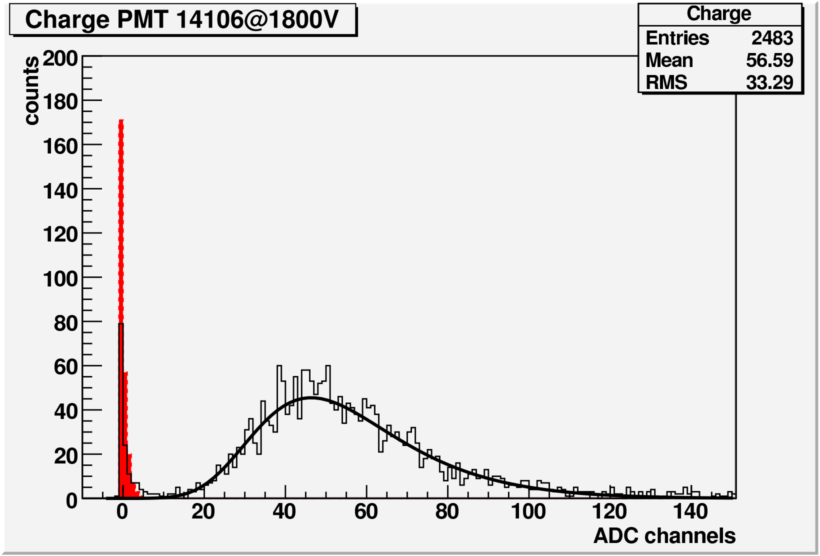
EMR mini-layer for testing single anode PMTs



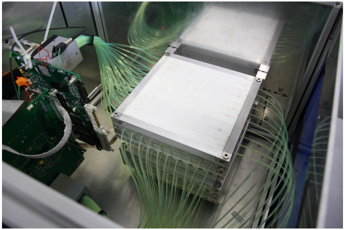


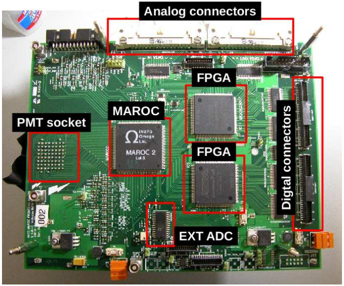
- EMR mini-layer: short EMR scintillator bars with fibers fed into two single anode PMTs, the same as for the experiment
- purpose: to test single anode PMTs and study their performance
- cosmic muons are used for calibration
- signals from PMTs are analyzed by flash ADC (C.A.E.N. v1731)

Cosmics Spectrum at 1800 V



Small EMR Prototype at Trieste

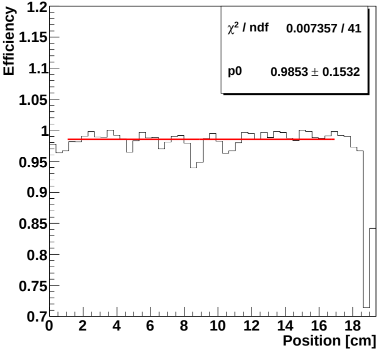


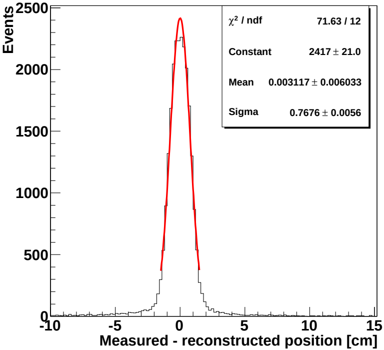


- it was used in order to test prototypes of front-end board (FEB)
- it consists of 8 planes of plastic scintillator bars arranged in two blocks and in a x-y geometry
- the FEB is based on the 64 channel MAROC ASIC which can provide one multiplexed analog output and 64 parallel digital ones. Because of the experimental duty cycle, the analog readout is used just for tests and for the commissioning. The Time-Over-Threshold architecture is implemented in the digital output: this allows to compare the analog and the digital readouts.

Small EMR Prototype at Trieste

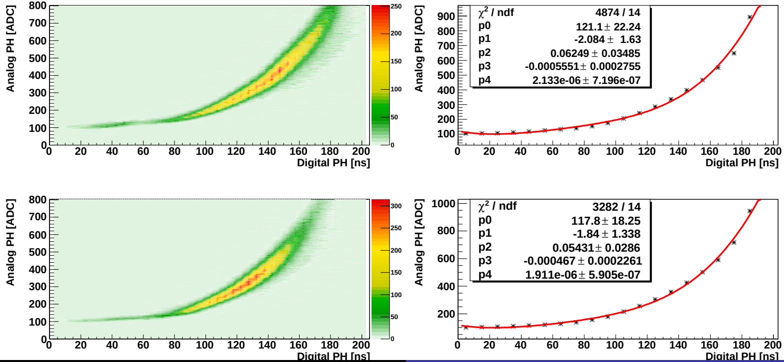
- spatial resolution is around 7mm for all bars
- efficiency has a value of the order of 99%





Small EMR Prototype at Trieste

There is a clear correlation between analog and digital signals. Analog pulse hight versus time over threshold is shown. This can be fitted by 4^{th} order polynomial. **Digital signal can be used in order to estimate energy deposited in each single bar.**



Summary

- Construction and assembly of EMR modules has resumed and should be completed by September/October 2011.
- Newly constructed modules will be tested with cosmic test setup at UNIGE before final assembly.
- New electronics boards (FEB and DBB) for 64-ch. PMTs are in production. Firmware needs to be written. Testing should be done in May. If everything works, 3 fully equipped modules and outer box will be delivered to RAL in June.

EMR Schedule

	2011										
	February	March	April	May	June	July	August	September	October	November	December
EMR construction and assembly	8 modules		16 modules + Outer box for transportation		24 modules			Complete EMR assembly			
Electronics	Production of 6 FEB+DBB And 1 VME board			DBB+VME Tests	Production of 48 FEB+DBB and 8 VME boards			Further tests of electronics			
Tests	Tests	Cosmic tests and calibration 8 modules	Cosmic tests and calibration 16 modules					Cosmic tests and calibration 24 modules			
Transportation					Delivery and installation of 3 modules at RAL					Delivery and installation of full EMR at RAL	
At RAL	CM 29					Test run at RAL 5 July – 5 August				Physics run at RAL 15 November – 23 December	