Electron-Muon Ranger: Totally Active Scintillator Detector for MICE

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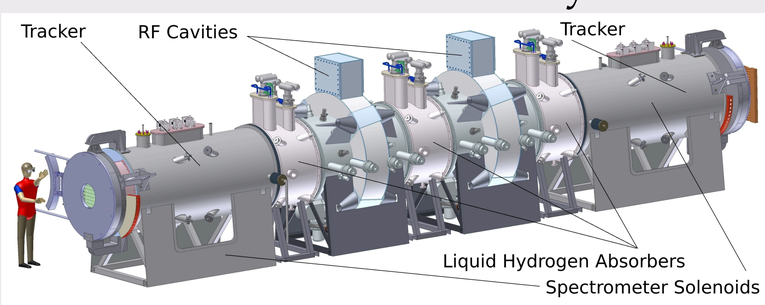
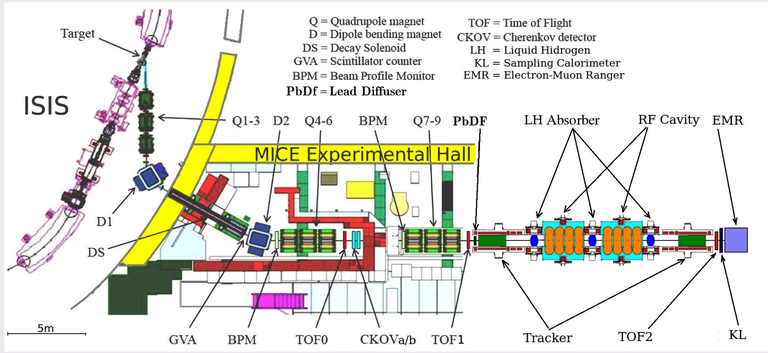
Introduction

The Electron-Muon Ranger (EMR) is a totally active scintillator detector (TASD) to be installed in the muon beam of the Muon Ionization Cooling Experiment (MICE) - an R&D project for the future neutrino factory.



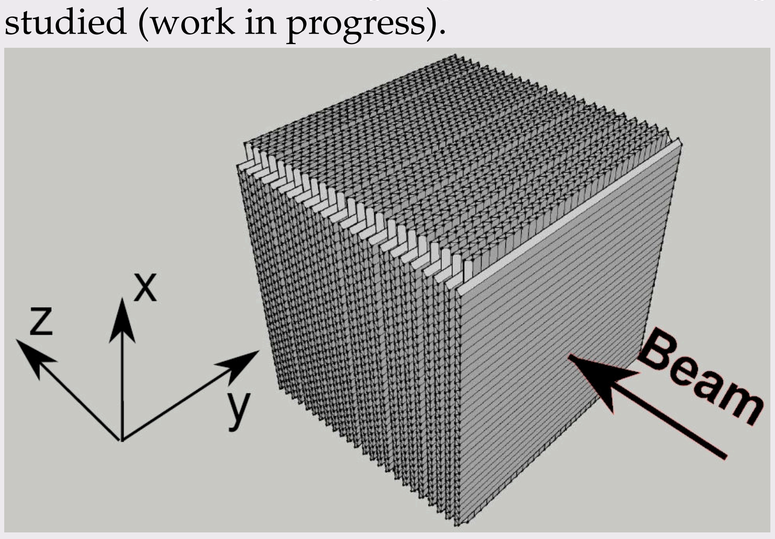
The ISIS synchrotron at RAL (UK) accelerates high intensity protons up to 800 MeV, 217 μA at 50 Hz, that hit an internal target that provides a source of pions for a pion to muon decay channel, and thereby muons for MICE. The momentum of muons is around 200 MeV/c.



The EMR will be installed at the very end of the MICE downstream detection system and will stop and measure properties of all outgoing particles and will help to reject decay electrons.

EMR Simulation and Physics

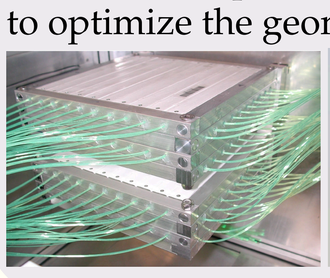
The EMR is simulated in Geant4. Particle identification and tracking capabilities are being studied (work in progress).

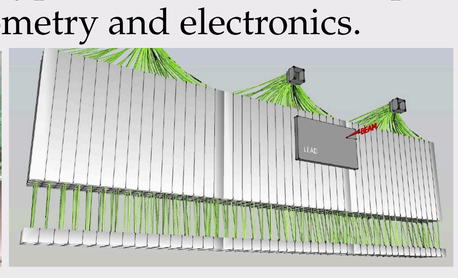


Due to the high granularity of the detector it is possible to identify each particle and measure its range and shower shape.

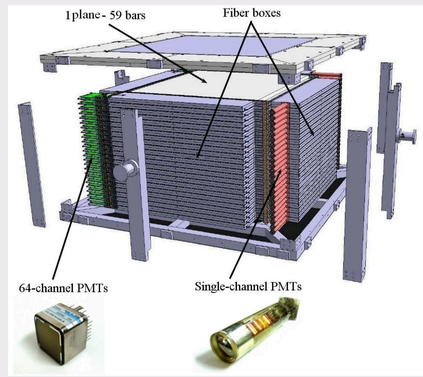
EMR Prototypes

A number of prototypes have been developed to optimize the geometry and electronics.

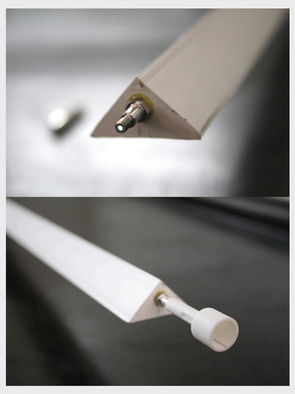




EMR Design



- 2880 channels
- 24 X-Y modules
- 59 scintillator bars per plane
- WLS fiber glued inside each bar
- WLS fiber coupled to light guide
- Total energy per plane detected by single-channel PMT (PHILIPS)
- Energy in every bar detected by 64-channel PMT (HAMAMATSU)



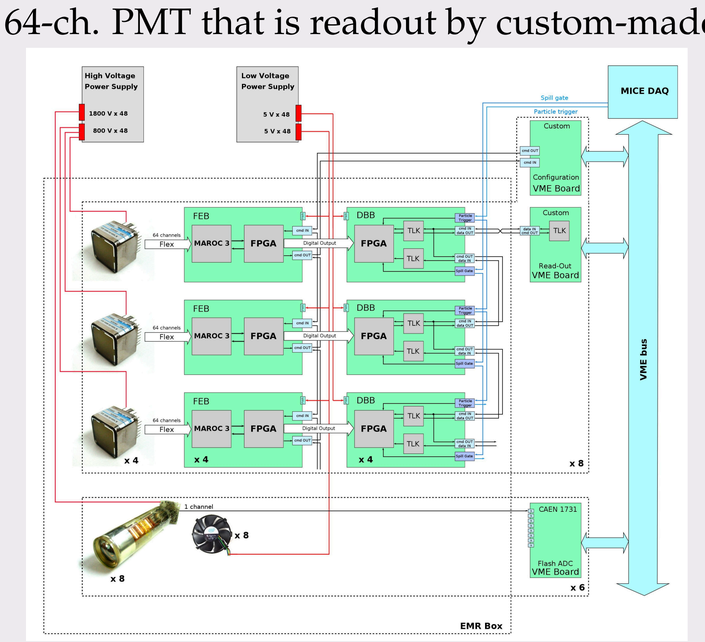
Special connectors have been designed to couple WLS fiber to light guides.

Wavelength shifting Fiber:
- Manufacturer: Saint-Gobain Crystals
- Diameter: 1.2mm
- Double cladding: 4% of diameter
- Core material: polystyrene
- Numerical aperture: 0.74
- Trapping efficiency: minimum 5.6%
- Total length: 3.5km

Light Guide:
- Manufacturer: Kuraray
- Diameter: 1.5mm
- Double cladding: 6% of diameter
- Core material: polystyrene
- Numerical aperture: 0.74
- Bending radius: 15cm
- Total length: 7km

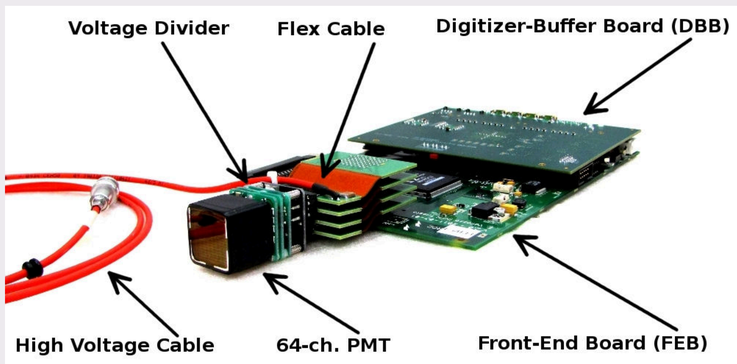
EMR Electronics

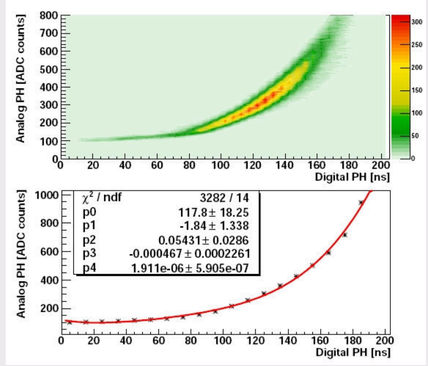
The EMR has dual readout. Fibers from one side of a plane are bunched together and directed to a 1-ch. PMT that gives the total energy in the plane. Eight 1-ch. PMTs are readout by one flash ADC (CAEN V1731), there are 6 fADCs in total. Fibers from the other side of a plane are coupled to a 64-ch. PMT that is readout by custom-made electronics as described below...



Front-End Board (FEB) is designed to readout the 64-ch. PMT. It hosts a MAROC ASIC that amplifies, discriminates and shapes all input signals. Pulse height information can be extracted at low rate (during calibration with cosmics). Time over threshold information is directed to a piggy-back buffer board.

Digitizer-Buffer Board (DBB) receives signals from FEB and stores them in buffer memory. MICE beam is made of ~1ms spills every second. Every spill is composed of hundreds of particles. All interactions of these particles are stored in DBB and transfered to PC at the end of a spill.

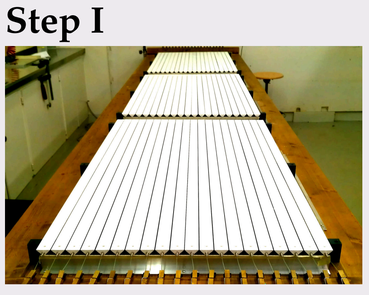




Pulse height from a slow shaper is proportional to the time over threshold of the fast shaper, i.e. it is possible to retrieve the pulse height at high rate.

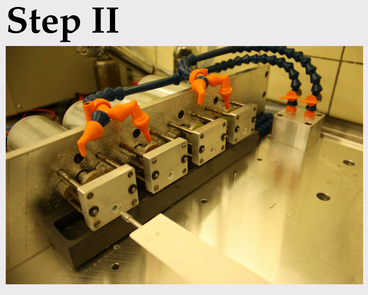
EMR Construction

Step I



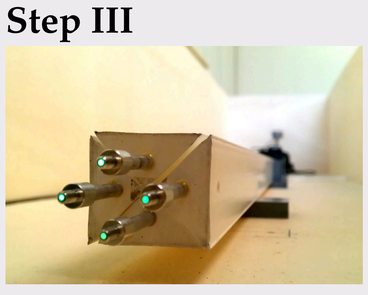
WLS fibers are inserted in triangular scintillator bars and glued with epoxy. 60 bars at a time.

Step II



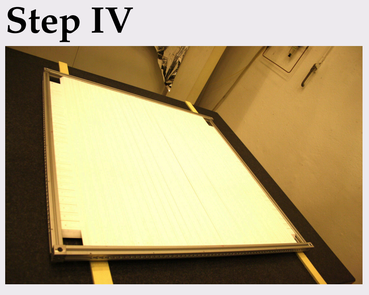
Both faces of bar fiber connectors are polished with a special machine. The last polishing paper is 1μm grade.

Step III



Each bar is tested with an LED and a digital camera. Bars with light output more than 15% below than average are rejected.

Step IV



Only tested bars are used for module assembly (2 planes, 118 bars).

Reference

M. Bogomilov *et al.* [MICE Collaboration], arXiv:1203.4089 [physics.acc-ph]

Summary

Currently the EMR is being built at the University of Geneva and it is planned to install it in MICE by the end of 2012.