PID detectors summary

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Summary

- TOF/KL performances in 2010 run
- EMR status
- BPM/CKOV updates
- Integration in MICE Hall of PID detectors
- 2011 run and conclusions

TOF/KL performances in 2010

- Smooth performances in 2010 run
- No major hardware problems
- Refurbishment of TOF0,TOF1 PMTs
- All described in the forthcoming MICE note – 367

MICE Collaboration MICE-NOTE-DET-XXX

9 February 2011

Analysis of PID detectors (TOF and KL) performances in the MICE 2010 run

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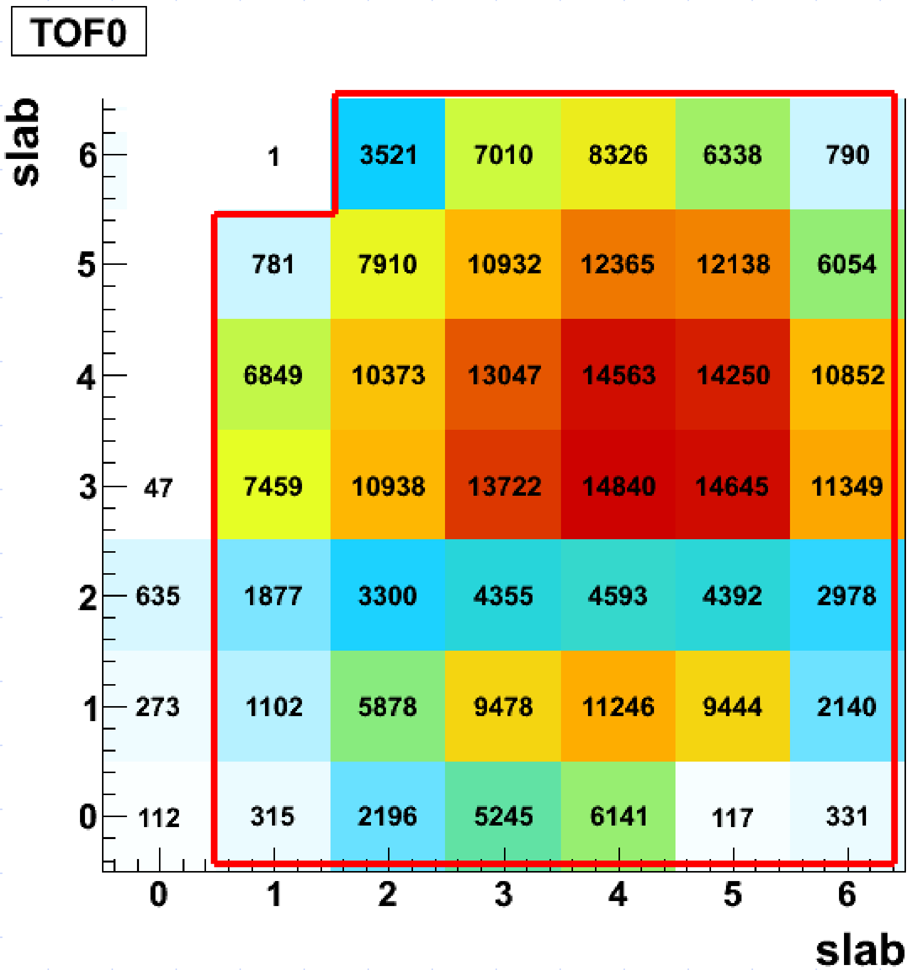
[d] *Department of Atomic Physics, St. Kliment Ohridski University, Sofia, Bulgaria*

The performances in the 2010 run of the main installed PID detectors of MICE: the time-of-flight system and the KL downstream calorimeter are reported in this paper. All detectors have shown a stable behaviour during all the run, with minor hardware problems, and performances compatible with the expectations.

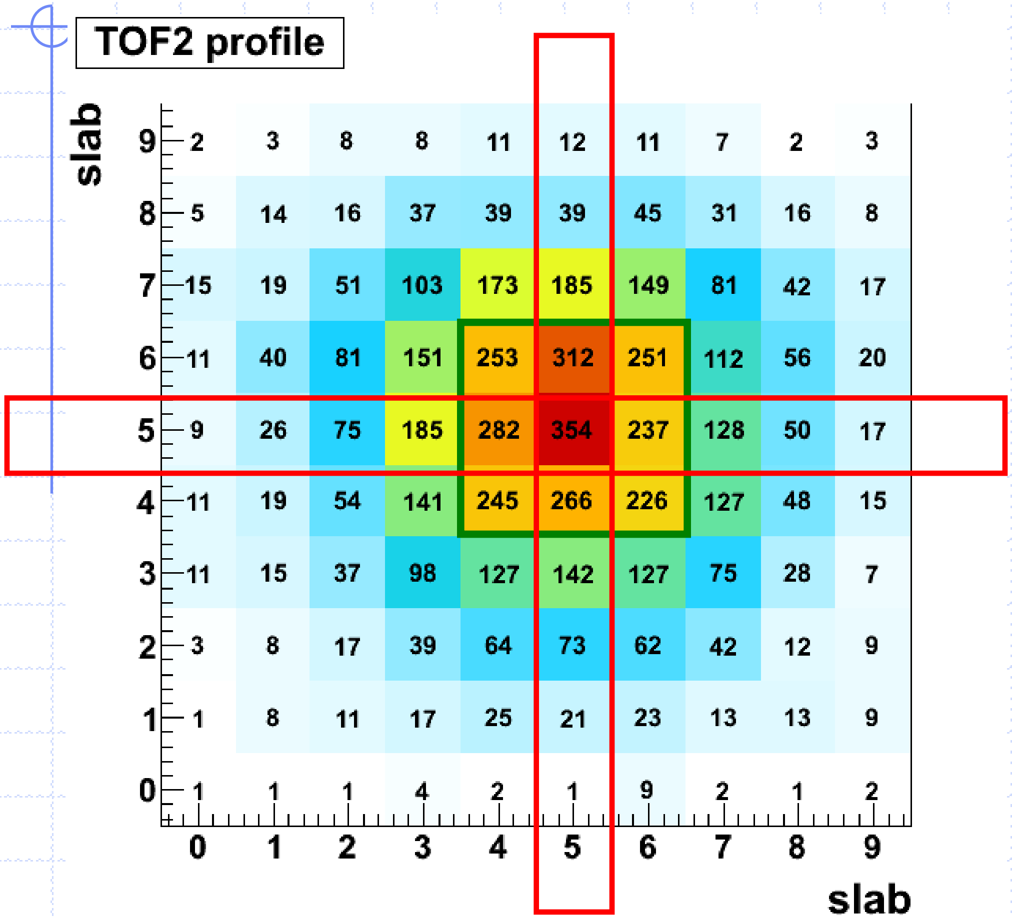
[1] Now at Sofia University St. Kliment Ohridski
[2] Partially supported by INFN, sezione Milano Bicocca

Requirements for calibration of the trigger station



- Any kind of beam settings are OK.
- We need >100 events in each pixel.
- For this particular example we will be able to calculate the relative trigger delays only in the pixels inside the red area.

Requirements for calibration of the other stations



- We need electrons. => We need electron beam.
- The important is the number of hits in the central pixel of each slab. We need >200-300 events in these pixels.
- For the example here we will be able to have a calibration only in the green area in the centre.

TOF performances in 2010 run

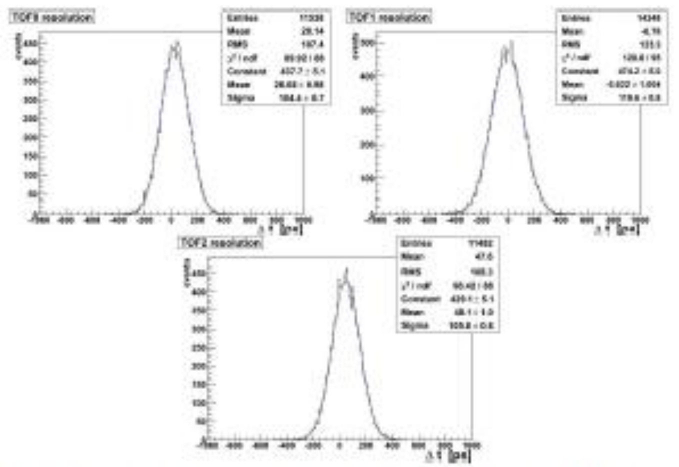


Fig. 9. Time difference Δt_{XY} between vertical and horizontal slabs in TOF0, TOF1 and TOF2. Trigger is on TOF1.

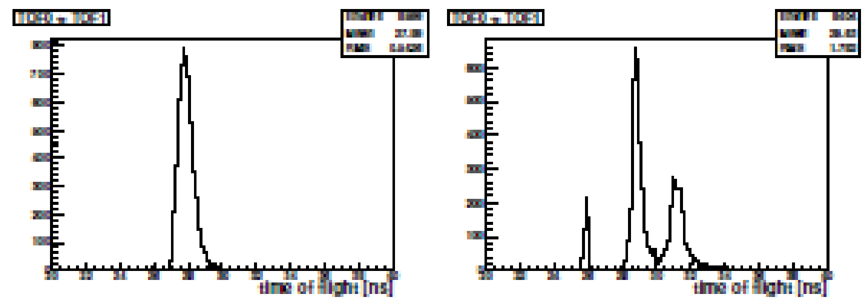


Fig. 10. Time of flight between TOF0 and TOF2 for muon (left) and electron (right) beam.

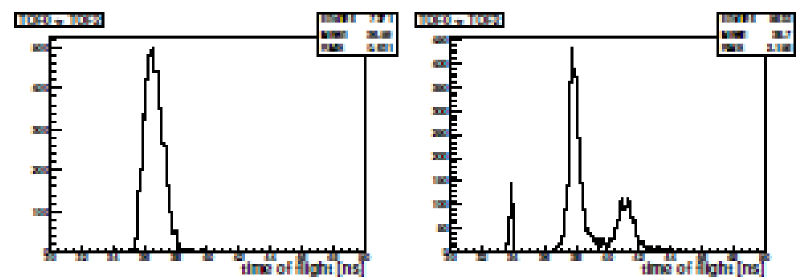


Fig. 11. Time of flight between TOF0 and TOF2 for muon (left) and electron (right) beam.

- Time resolution after calibration:
- TOF0 – 51ps;
- TOF1 – 58ps;
- TOF2 – 52ps.

TOF stability during 2010 run

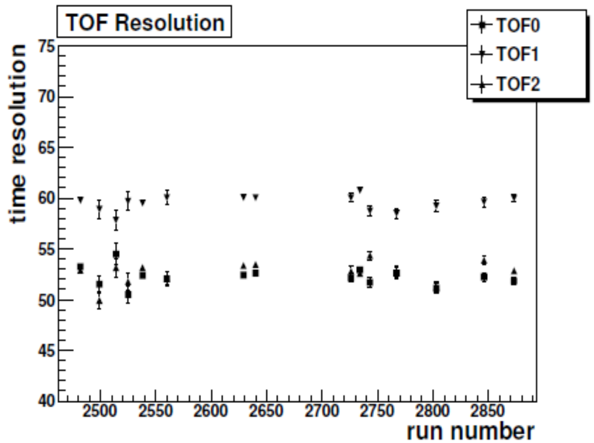


Fig. 12. Stability of the time resolution of the TOF stations versus running time. Nomi
muon beam data with trigger from TOF1.

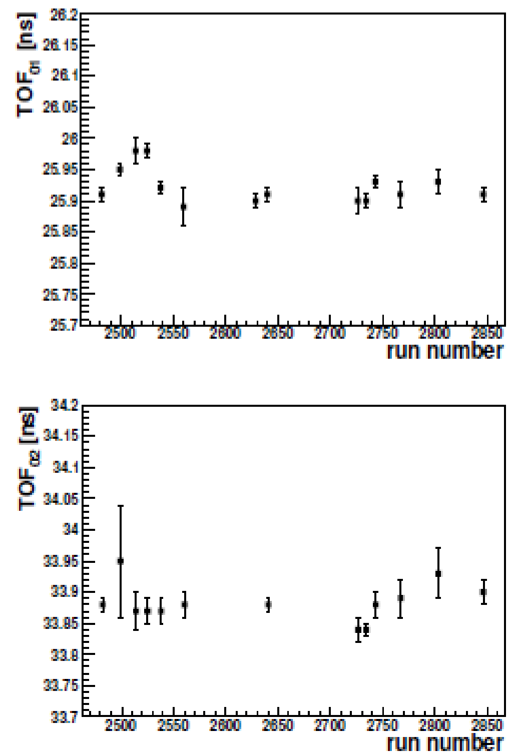


Fig. 13. Stability of the time-of-flight of electrons between TOF0 and TOF1 (top) and TOF0 and TOF2 (bottom) versus run number. Nominal muon beam data with trigger from TOF1.

KL response to μ - π - e

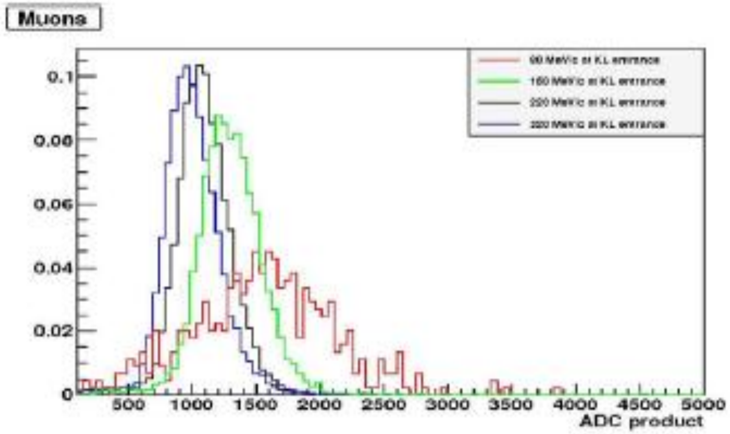


Fig. 23. KL response (normalized) to muons with different momenta.

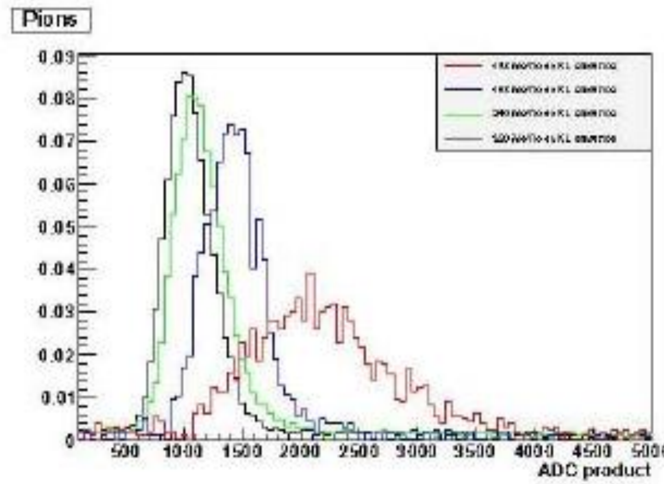


Fig. 26. KL response (normalized) to pions for different incident momenta.

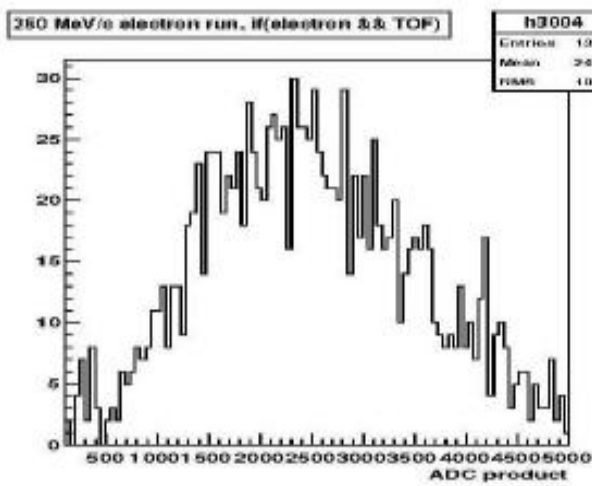


Fig. 24. KL response to 80 MeV/c electrons.

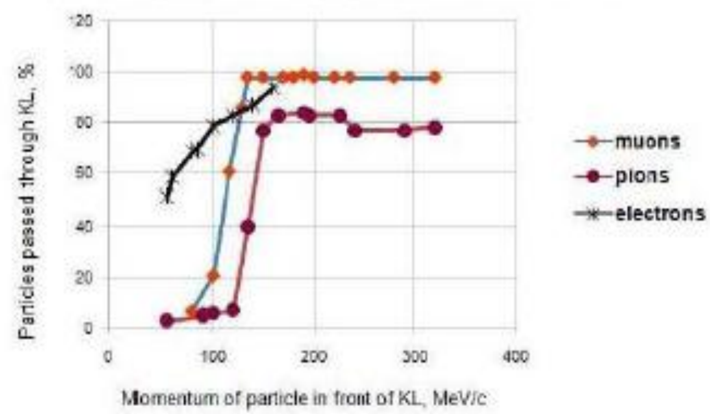


Fig. 27. The fraction of electrons, muons and pions passing through KL and reaching the TAG counters.

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KL stability

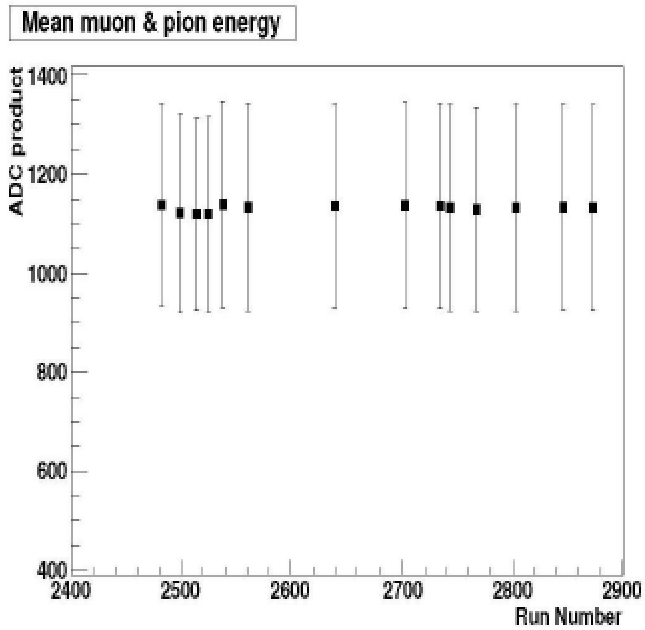


Fig. 21. Stability of KL response to muons and pions for nominal muon beam runs. The run number is on the abscissa, while on the Y-axis there is the ADC product. The error bars are the σ's of the Gaussian fit.

The study of KL stability during 2010 data taking has shown:

- No dead or noisy channels
- Pedestal stable with rms ~ 2.5 ADC counts
- Response to "MIP" (μ & π) stable in time

TOF0+TOF1 refurbishing

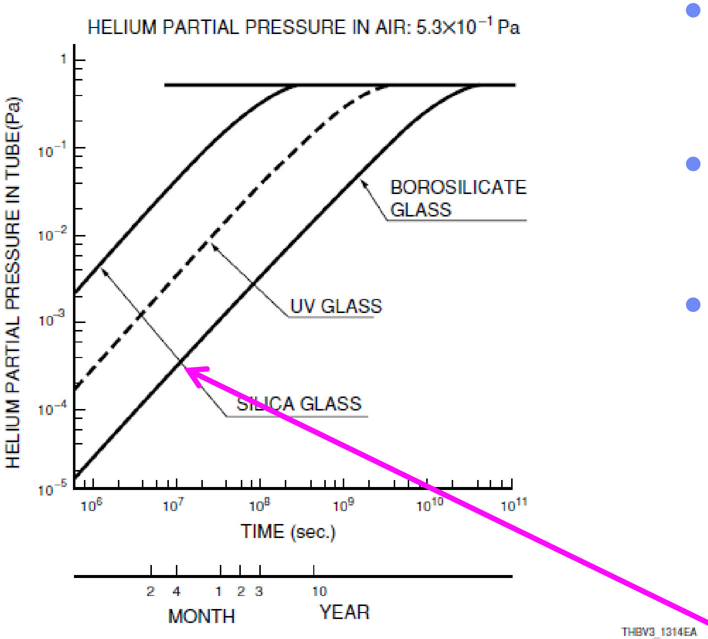
- many PMTs of TOF0 are very old (bought in 2006 by Alain and others in 2007) and have an old design of the active divider and the valve insulation from mu metal, giving a lot of problems (spikes …)
- Hamamatsu Japan kindly agreed to refurbish them (kapton insulation/new active divider) if back to firm before 31/12/2010: after it they say it would be OUR problem
- So in early September we dismounted the first PMTs to be sent back to Japan (MB,GC,RB) and the operation was redone in December (MB,AB,RB) during the Heathrow blockade. In total ~ 50 PMTs were sent back: clearly the operation was not done in a single shot.

- TOF0 has been refurbished and put back in DSA with newer PMTs (about 20 out of 40) , TOF1 is in Milano under refurbishing

TOF0/TOF1 maintenance operations at RAL

TOF0 refurbished

He poisoning of R4998 PMTs



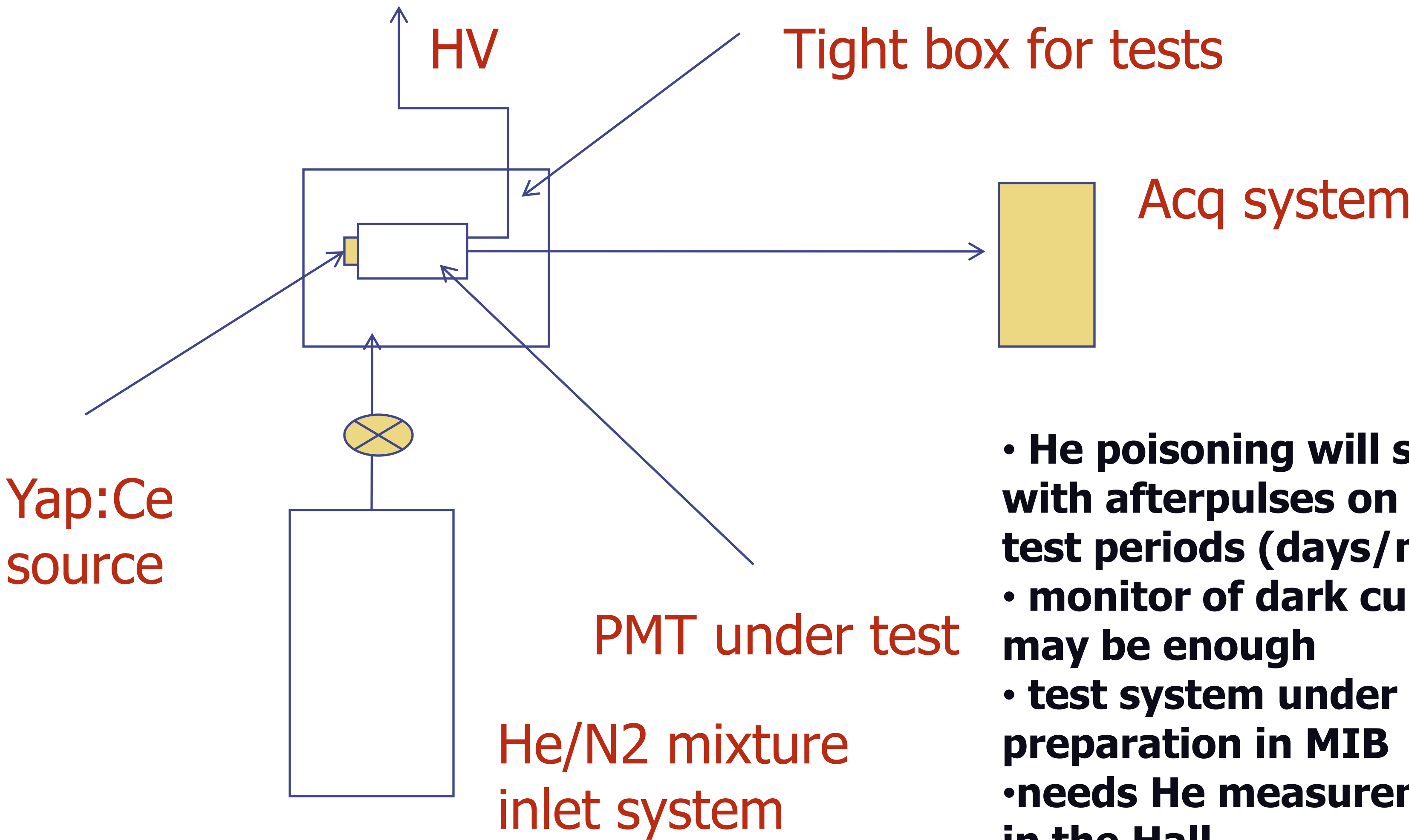
3-14: Bulb materials and variations in helium partial-pressure inside a tube

- We need some input for the possible releases of He in the Hall
- Up to now some preliminary discussions with M. Courthall, Andy, …
- The idea is to test a R4998 PMT with a mixture of 3%He+97%N2 to see at what level problems begin to show up (measure τ)

R4998 window

Helium gas exists on the earth at a partial pressure of about 0.5 Pa. As stated above, the permeability of helium through silica glass is extremely high, as much as 10^{-19} cm^2/s (at a pressure difference of 1.013×10^5 Pa) at room temperatures. Because of this, the helium pressure inside the photomultiplier tube gradually increases and finally reaches a level close to the helium partial-pressure in the atmosphere. The time needed to reach that level depends on the surface area and thickness of the silica glass. For instance, if a 1-1/8 inch (28 mm) diameter side-on photomultiplier tube with a silica bulb is left in the atmosphere, the helium partial-pressure inside the tube will increase to 9×10^{-2} Pa after one year. (Refer to Figure 13-14.)

Test system layout



- **He poisoning will show up with afterpulses on long test periods (days/months)**
- **monitor of dark currents may be enough**
- **test system under preparation in MIB**
- **needs He measurements in the Hall**

Cerenkov

Run Plan Session - Cherenkov

- Inspections in fall 2010 show hardware in stable/ready condition.
- Online monitoring software should be updated.
  - V1734(100 MHz fadc) -> V1731(500 MHz fadc) transition issues.
  - Peter Sonnek at UM looking at Online and Reco Code.
- Ckov may require special led pulser and cosmic run during beam off periods.
  - Sonnek, Cremaldi will schedule time to visit RAL in Mar /Apr.
- Would like access to Run Control Software to review V1731 DAQ setup.
  - Programmable DC Offsets, LVDS setup, Event size pre-post trigger adj, etc.
- Fast Access to Data for Offline monitoring.

L. Cremaldi, CM29, Feb 15, 2011.

V1731

4/8 Ch. 8 bit 1000/500 MS/s Digitizer

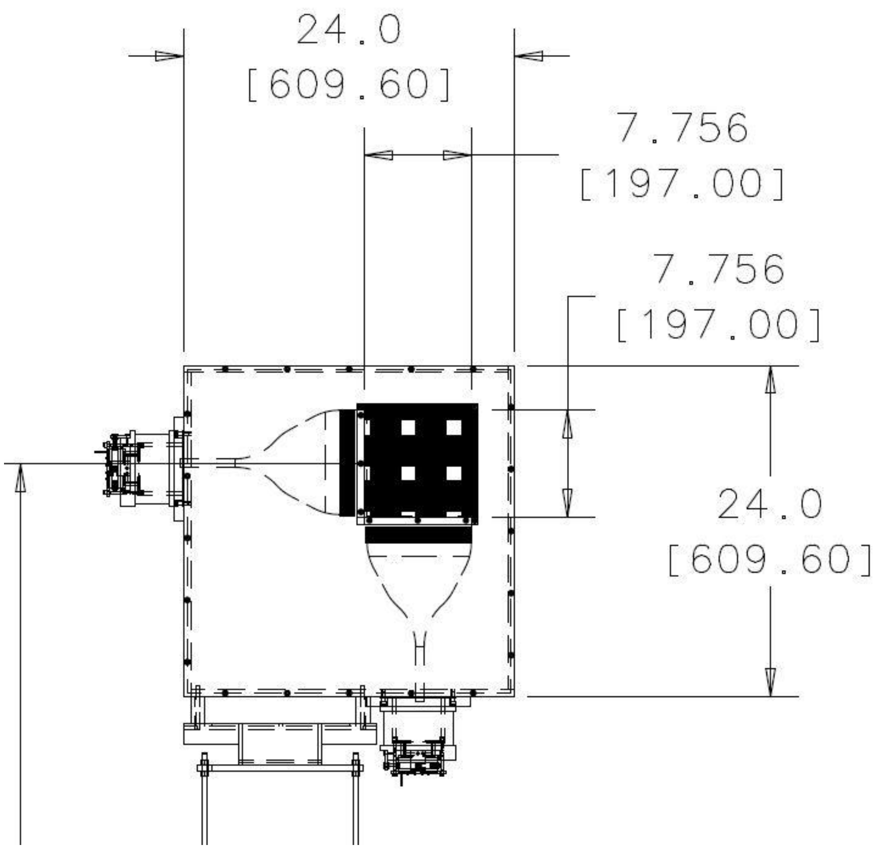
+Image

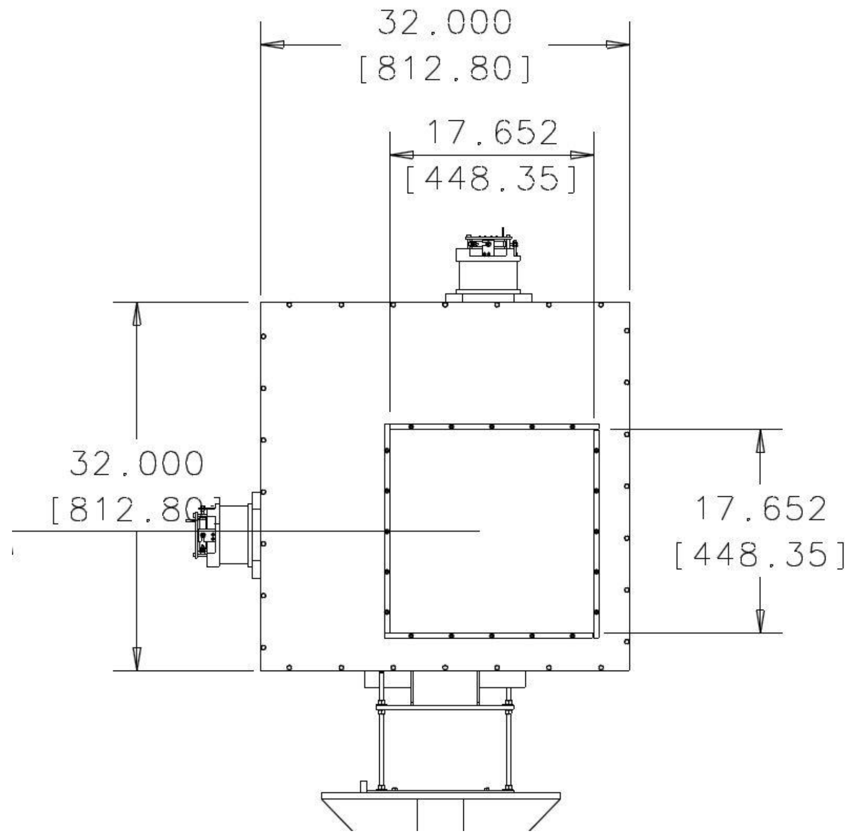
- 8/4 channel
- 8 bit 500 MS/s - 1 GS/s (interleaved) ADC
- 1 Vpp Input dynamics (single ended or differential).
- 16-bit programmable DC offset adjustment (±0.5V)
- External ADC clock input or PLL synthesis from internal/external reference
- Front panel clock In/Out available for multiboard synchronisation (direct feed through or PLL based synthesis)
- 16 programmable LVDS I/Os
- Trigger Time stamps
- Memory buffer: up to 4 MSample/ch
- FPGA for real-time data processing
- Zero Suppression and Data Reduction algorithms
- Programmable event size and pre-post trigger adjustment
- VME64X compliant interface
- Optical Link interface
- A2818 PCI controller available for handling up to 8 Modules daisy chained via Optical Link
- Firmware upgradeable via VME/Optical Link
- Libraries, Demos (C and Labview) and Software tools

Fermilab

Beam Profile Monitors

- Small (20 X 20 cm)
- Large (45 X 45 cm)



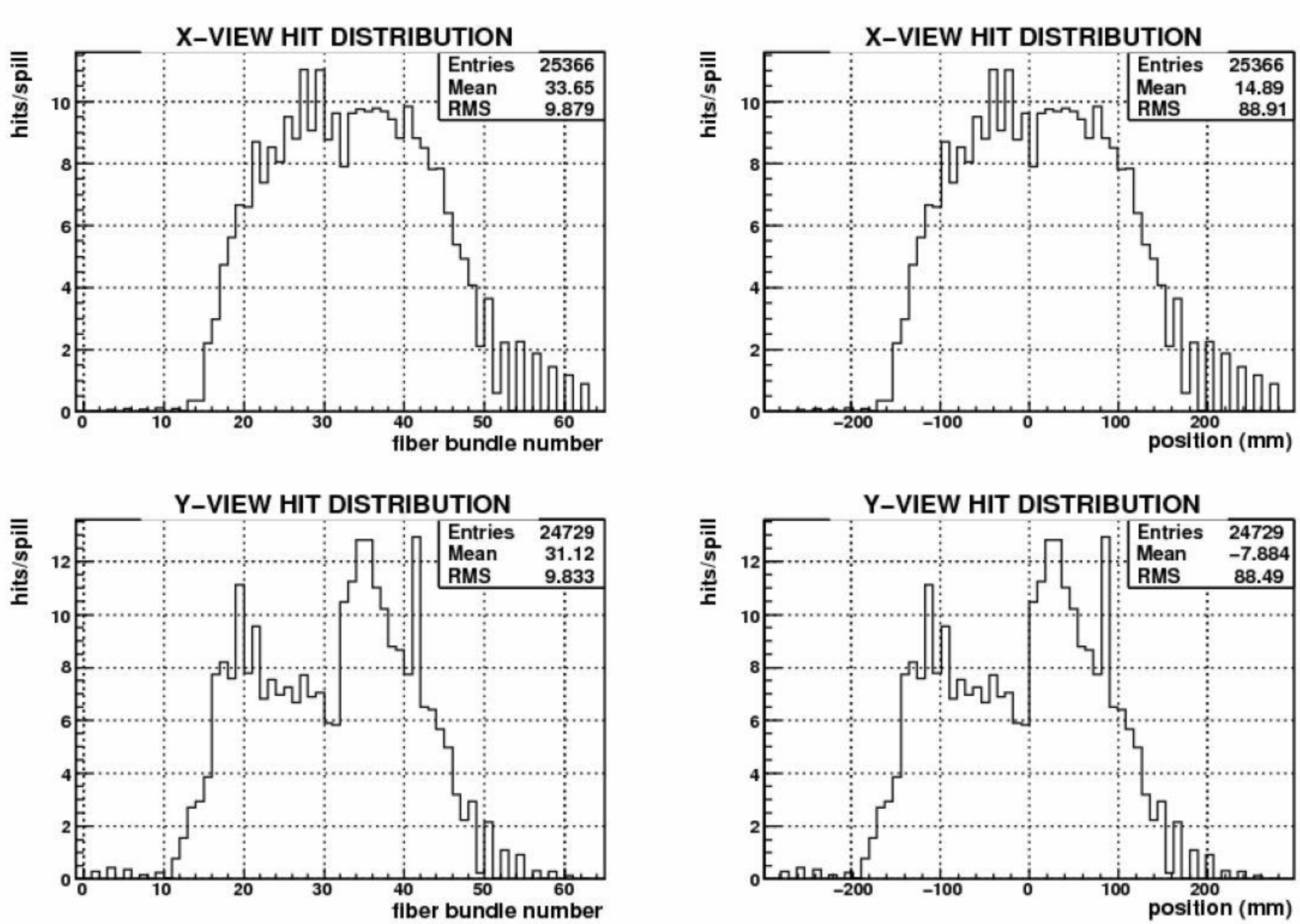


Status

- The Electronic Noise that was seen has been completely removed
  - Shielding
- Both BPMs have been calibrated to some extent with a ^{60}Co source
  - However the activity was so low that we had some difficulty
- As a rate monitor the Global "Or" output from the X or Y views (or both) and X•Y gives an instantaneous beam rate measurement and should be linear up to ½ a GHz or so (we wish)
  - Signals are routed to MLCR
  - Only issue has been overheating. This was solved with the addition of an external fan on the cans that contain the MAPMT and electronics
- We did get some beam data with the small BPM

Small BPM Beam Data II

Normalised hits distribution (beam data)



Upgrade

- The Burle MAPMTs have large non-uniformity and gain variation
- A number of systems at Fermilab use them
- Replace MAPMTs with SiPMs
- For us this would be easy if 1 to 1 SiPM to fiber
  - But then many channels!
- Use Winston Cone
  - Pin for Pin replacement of readout module

EMR

Application

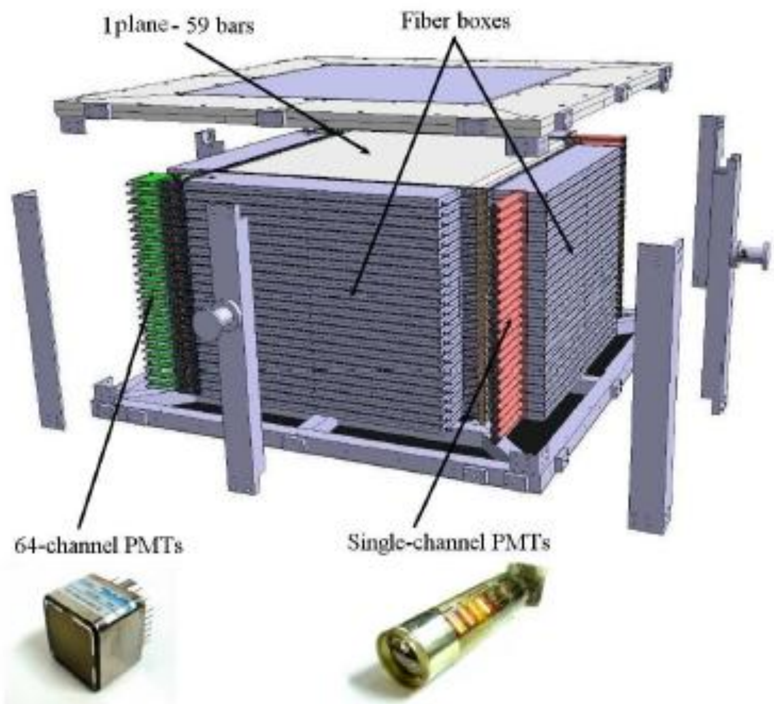
Physics Goals

- 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.

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

R.Asfandiyarov (U.Genève), Status of EMR Project | MICE Collaboration Meeting 29, February 15-18, 2011 2/27

EMR Production

- **Detector Hardware**
  - Conservative estimation: one layer per working week
  - 18 scintillator layers already pre-assembled
  - 48 layers by the end of September
- **Electronics**
  - Front-End Board (FEB)
    - Analog amplification and discrimination)
    - Developed by Trieste/Como
    - Prototype is validated; first production batch launched
  - Digitization and Buffer Board
    - Developed in Geneva
    - Prototype in production
  - If the prototype works, we can equip 3 modules in June

Production Status. Bars

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).

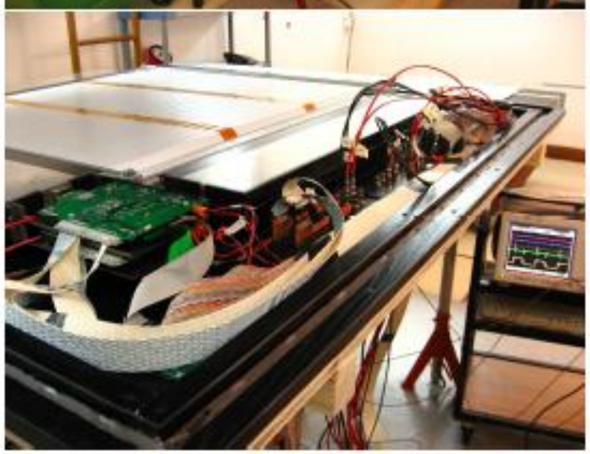
In order to speed up gluing of WLS fibers into scintillator bars a special device is being employed.

Production Status. Fiber connectors

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.

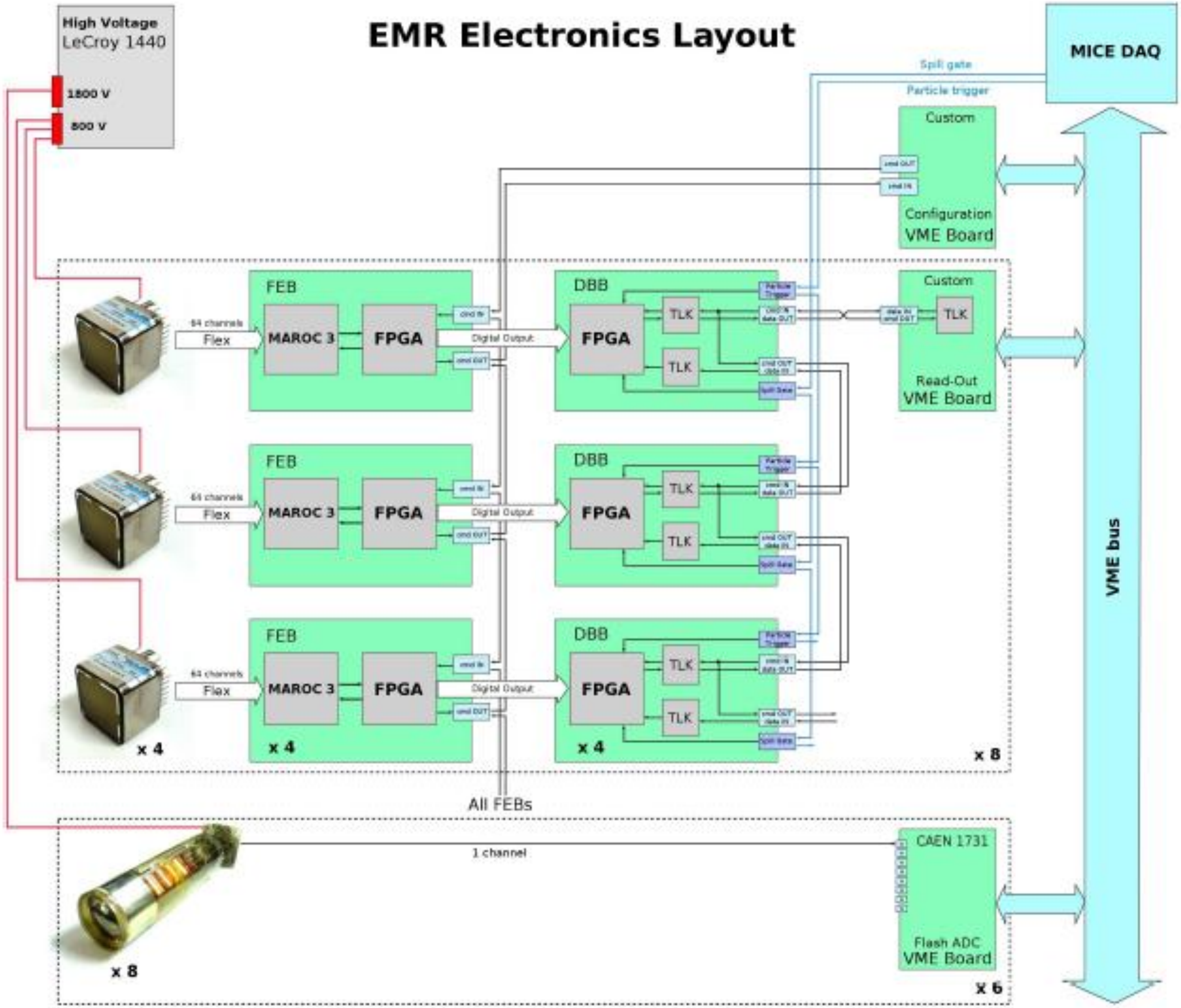
A dedicated polishing machine is being used.

EMR Test Setup



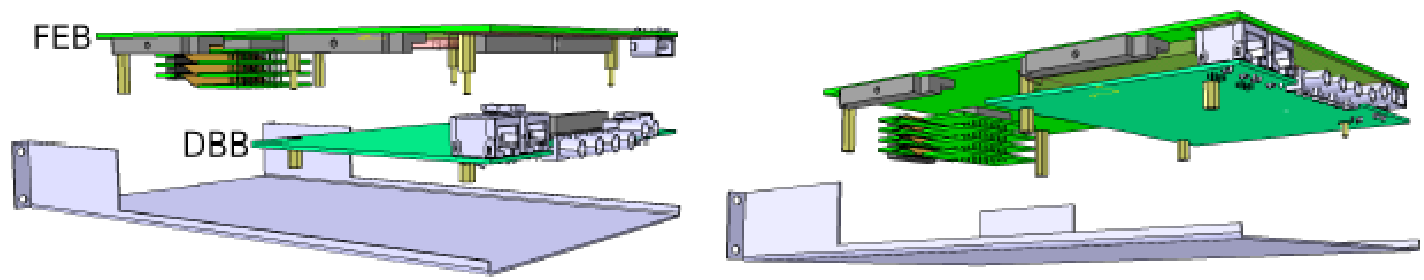
- all set up to perform tests with cosmics
- 2 CPUs, VME (read-out boards) and NIM (coincidence unit) crates
- LeCroy-1440 high voltage power supply for single- and 64-ch. PMTs
- scintillator triggers and silicon micro-strip detectors for track reconstruction and efficiency measurements (silicon detector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

EMR Electronics Layout

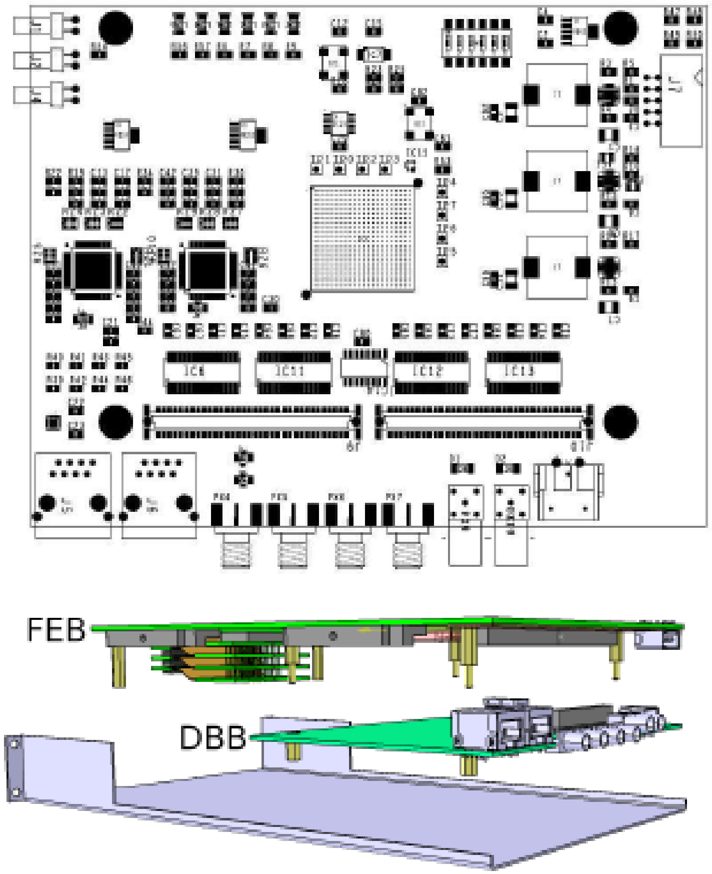


New Electronic Boards for 64-channel PMT

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.



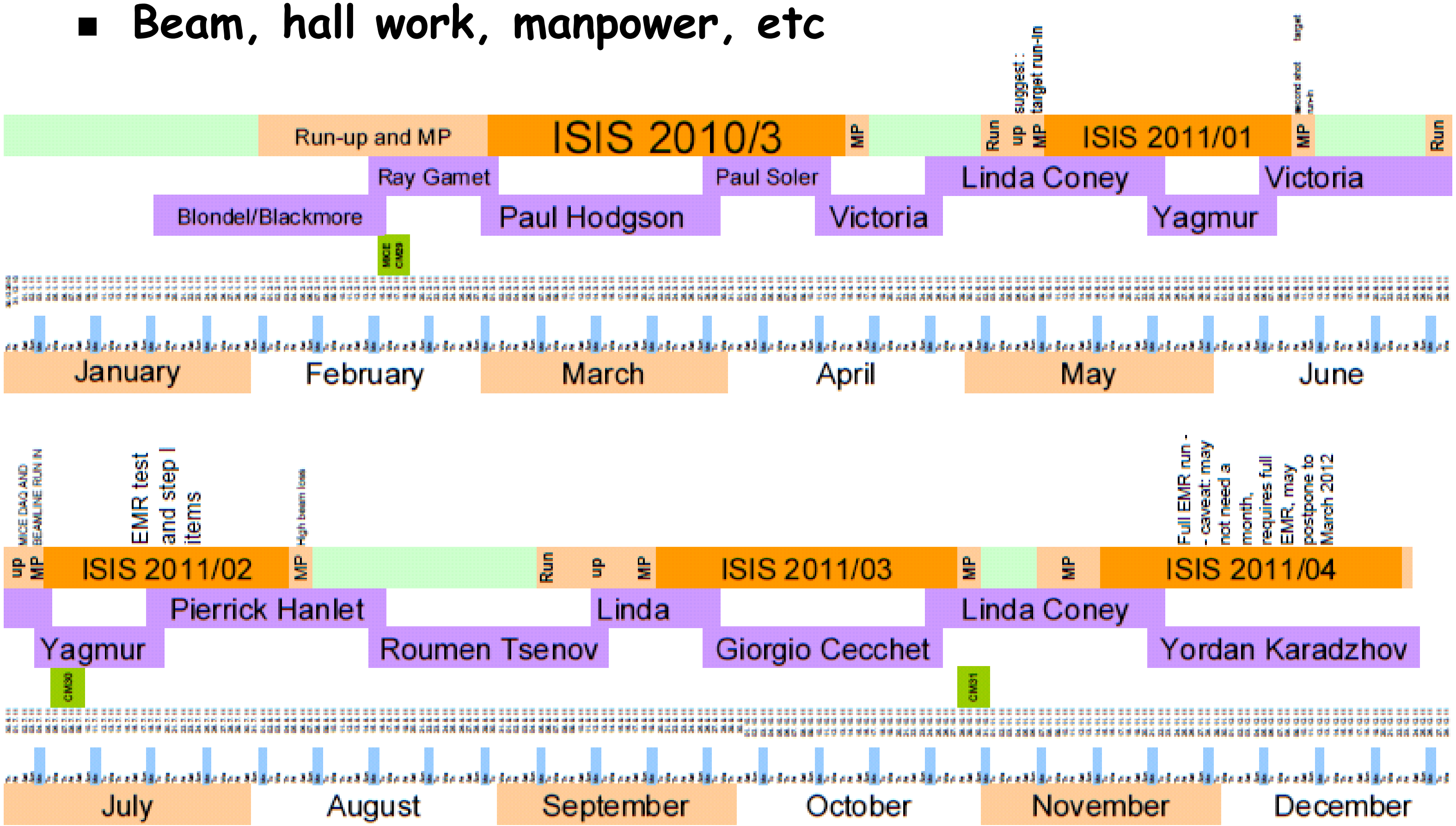
Digitizer-Buffer-Board



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.

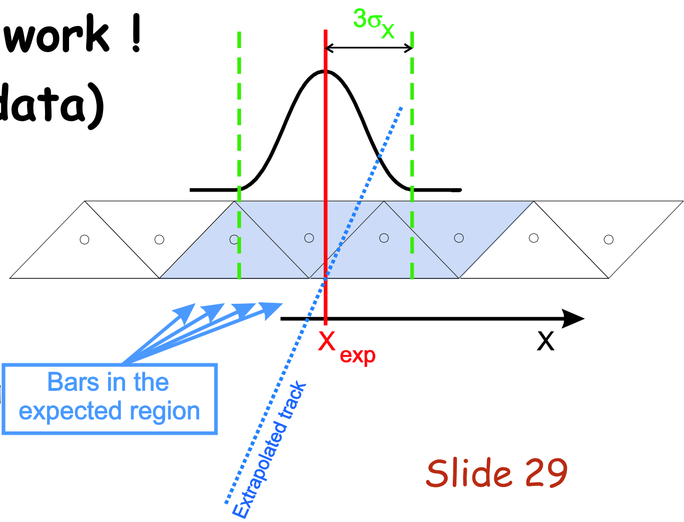
Installation

- Many constraints
  - Beam, hall work, manpower, etc



Data Taking plan

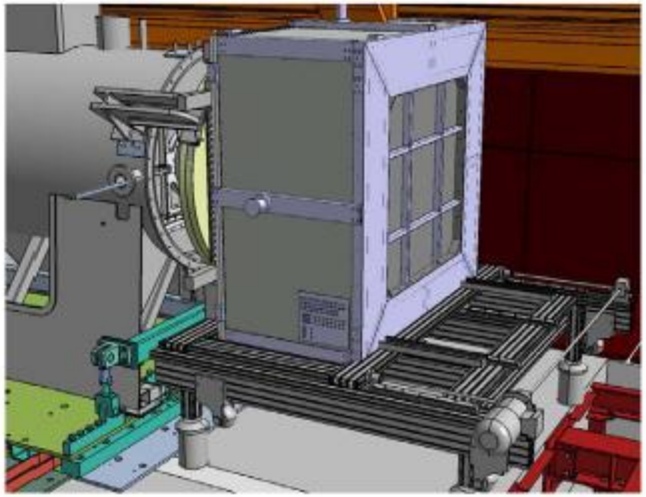
- **Scan momentum (140-280 MeV/c)**
  - "Pion" beam
    - PID using TOF
  - Q7-Q9 Off
    - *Straight tracks*
  - Measure Muon range
  - Test PID
- **Gain equalization (channel by channel)**
  - Needed to sum single energy loss
  - 6 * 59 = 354 channels -> A lot of work !
  - Need single bar hits (only 10% of data)
  - Will take a lot of time…
- **More detailed plan to be drawn**
  - Yordan will be the champion !



EMR Integration

Andy Nichols – Sofia MICE CM28)

- *It's now big and heavy….*
- *2.5 tonnes*
- *Will have to adapt KL trolley for clearance*
- *And make new independent frame for EMR, mounted to floor, with adjustments in X&Y*
- *But there's a solution*
- *Useful discussions this week*
- *INFN staff will also visit Uni Geneva*
- *This is one ingredient in re-defining the 2011-2012 plan*



Meeting MiB, Rm3, UniGe in November 2010

Science & Technology Facilities Council

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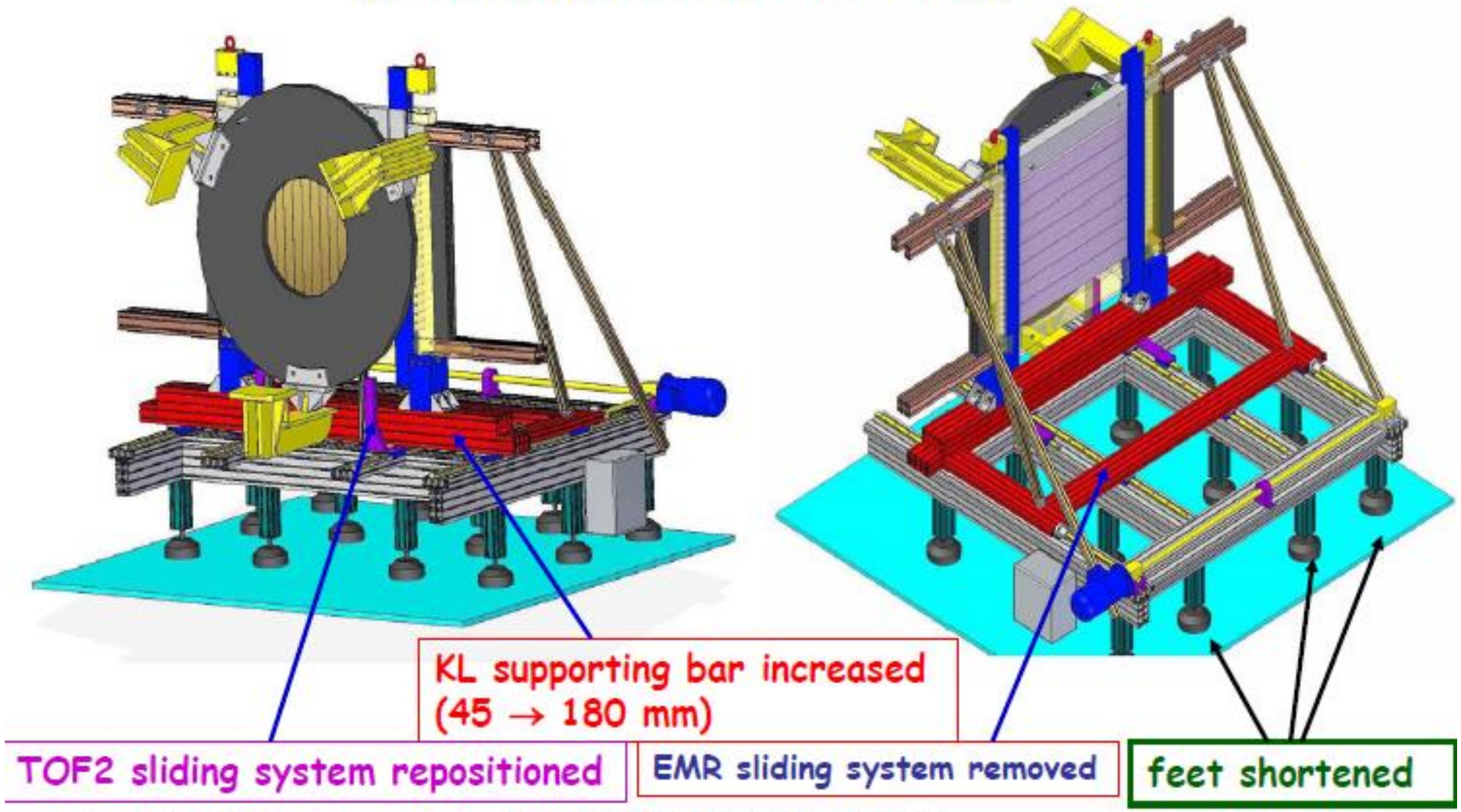
Downstream PID trolley - Update

(partially done in november 2010)



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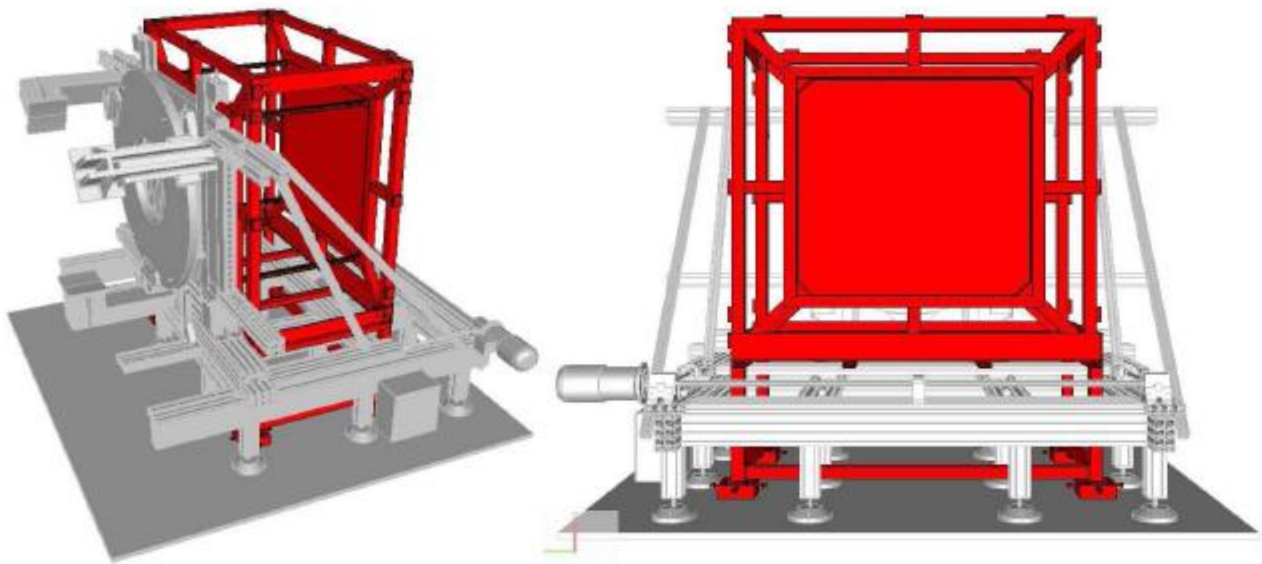
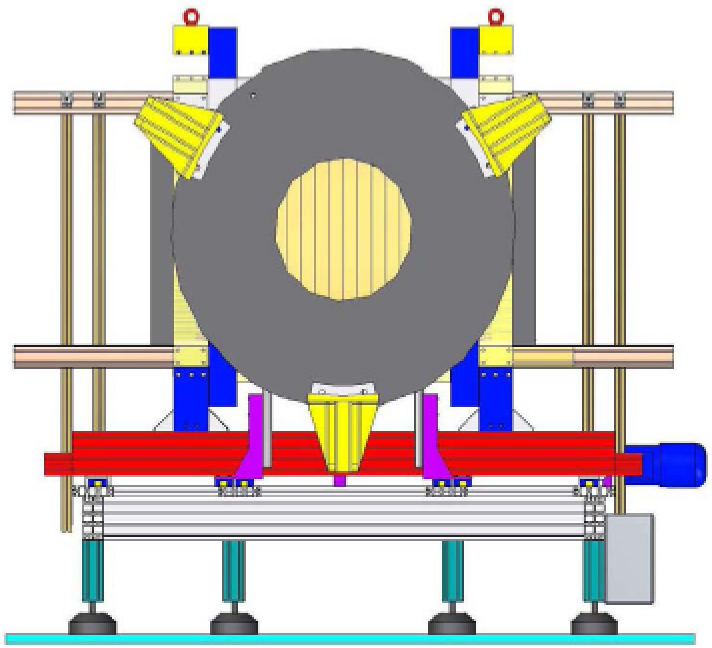
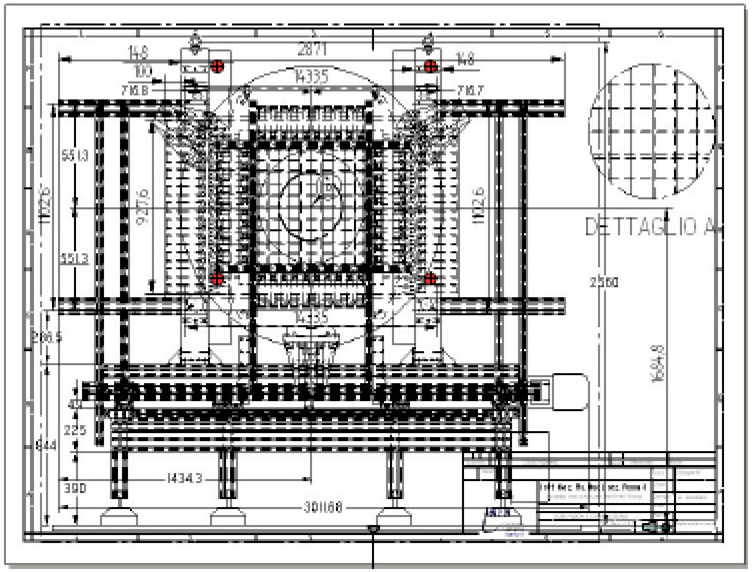
EMR at RAL

Integration with KL and Supporting Frame



Trolley – front view for detector survey





(definite reference points)

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Conclusions

- Good performances of installed PID detectors (TOF,KL, CKOV) in 2010 run
- need final agreement on platform mods from F. Cadoux to schedule operations for EMR integration
- we eagerly wait for EMR data in July
- needs some data for TOF/KL recalibration