MICE PID

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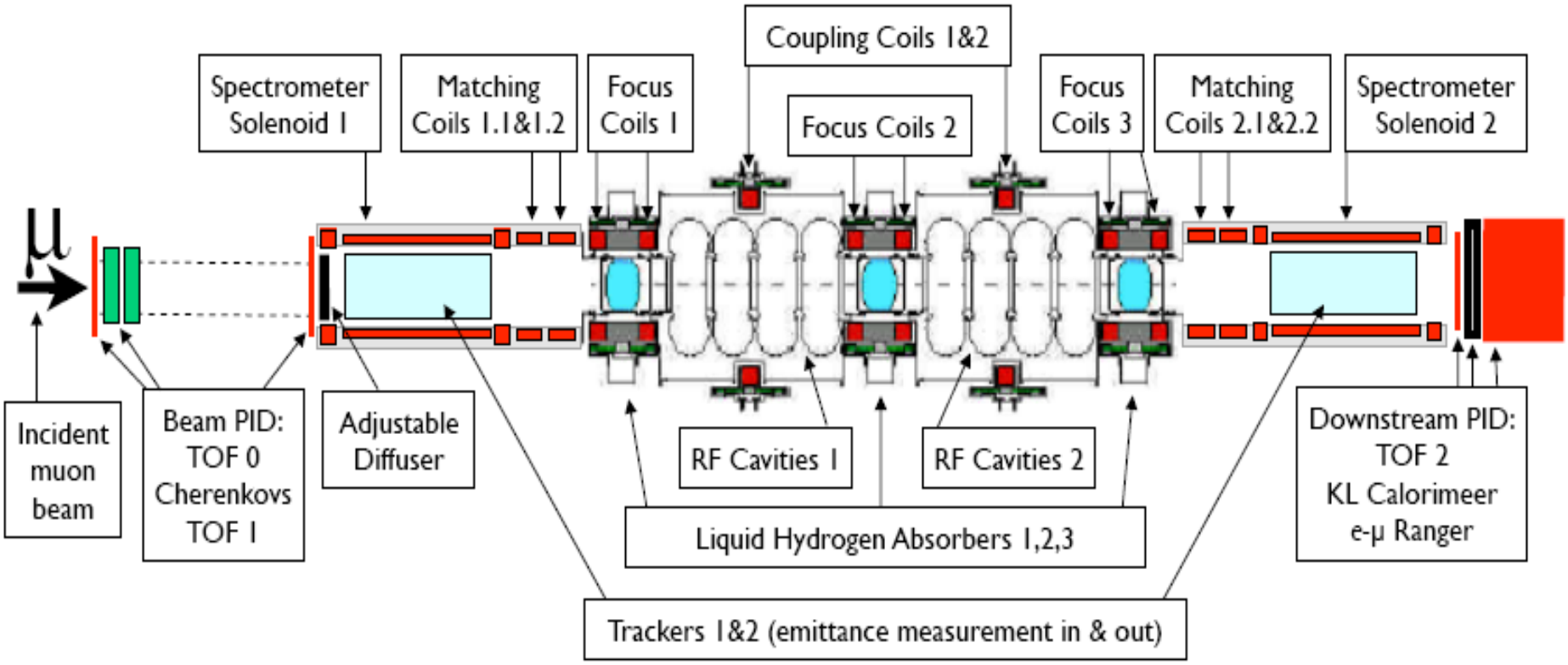
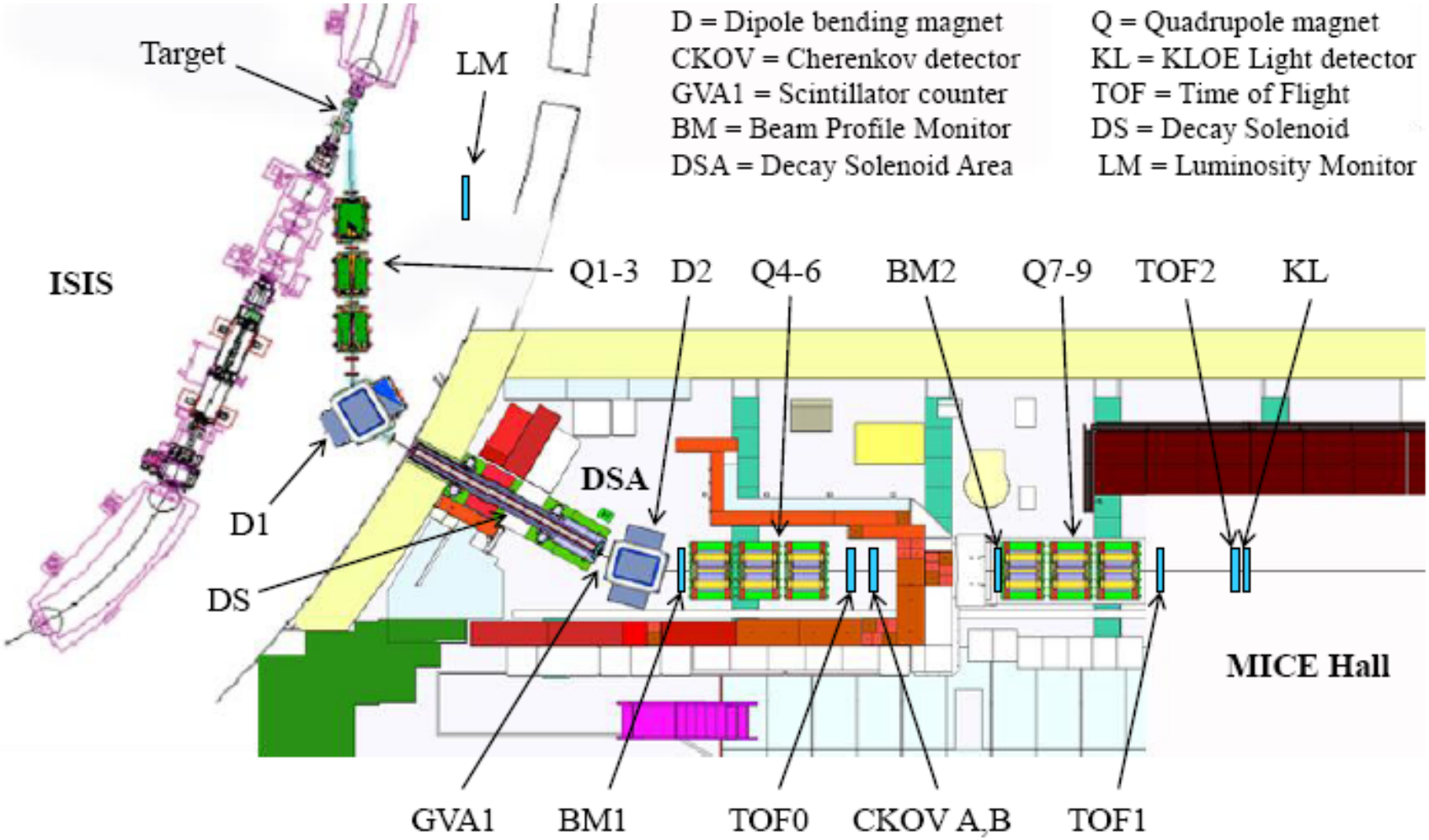
MICE PID Overview

- Being a muon cooling measurement, Particle ID is important to ensure high muon purity
  - Reject undecayed pions & electrons from decay
- Upstream of the cooling channel:
  - π/μ separation
  - 2 Time of Flight Detectors (TOF0, TOF1)
  - 2 Aerogel threshold Cherenkovs (CKOVa,CKOVb)
- Downstream:
  - μ/e separation
  - TOF2
  - EM Calorimeter (EMC)
    - "KLOE-light" (KL)
    - Electron-Muon Ranger (EMR, in construction)

MICE Layout

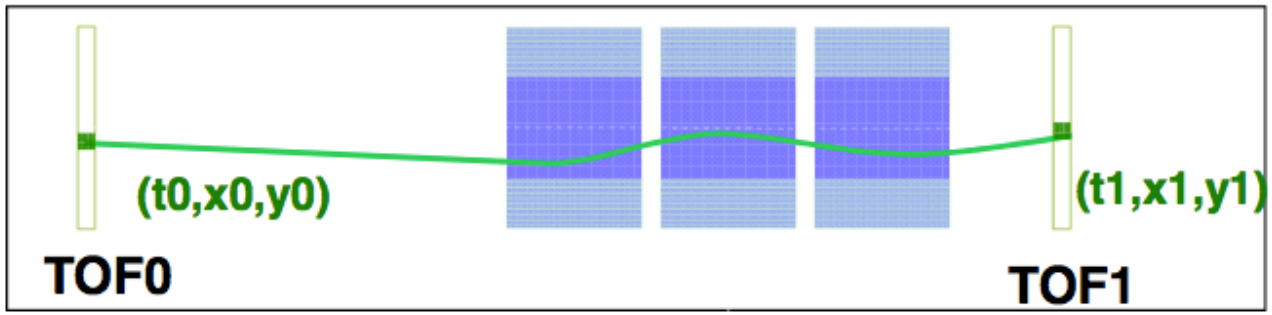

Coupling Coils 1&2
Spectrometer Solenoid 1
Matching Coils 1.1&1.2
Focus Coils 1
Focus Coils 2
Focus Coils 3
Matching Coils 2.1&2.2
Spectrometer Solenoid 2
μ
Incident muon beam
Beam PID: TOF 0 Cherenkovs TOF 1
Adjustable Diffuser
RF Cavities 1
RF Cavities 2
Downstream PID: TOF 2 KL Calorimeer e-μ Ranger
Liquid Hydrogen Absorbers 1,2,3
Trackers 1&2 (emittance measurement in & out)

MICE Layout (current, STEP I)



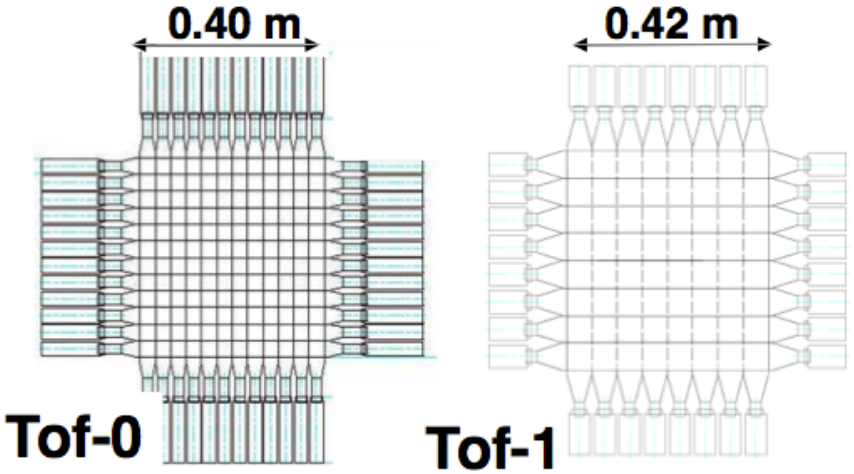
- TOF0 → TOF1: ~ 8 m
- TOF1 → TOF2: ~ 2.5 m

TOF

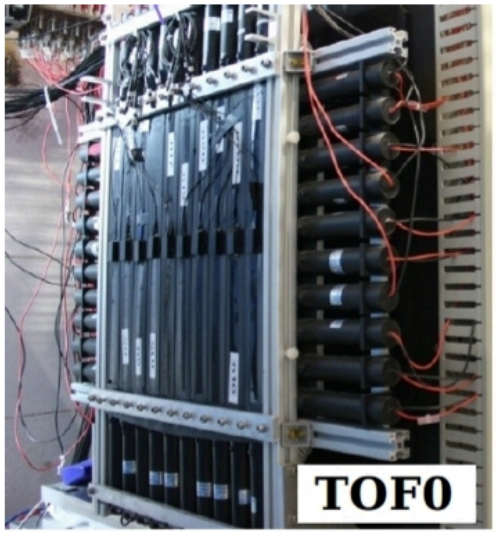


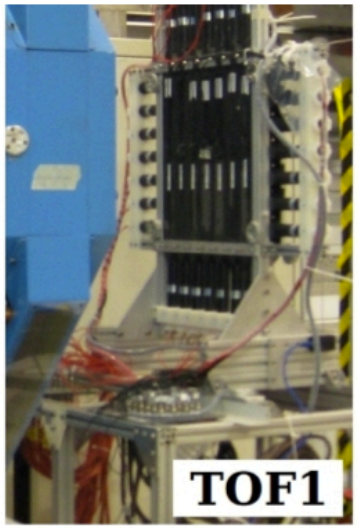
- Detector requirements:
  - Upstream & Downstream PID
  - Provide experimental trigger
  - Precise timing wrt RF
- Design:
  - 1” thick scintillator slabs in *x* & *y* planes
  - read out at both ends
  - PMT choice motivated by high rates (> 1 MHz @ TOF0), high fringe fields
  - Readout: multi-hit TDC, 14-bit ADC

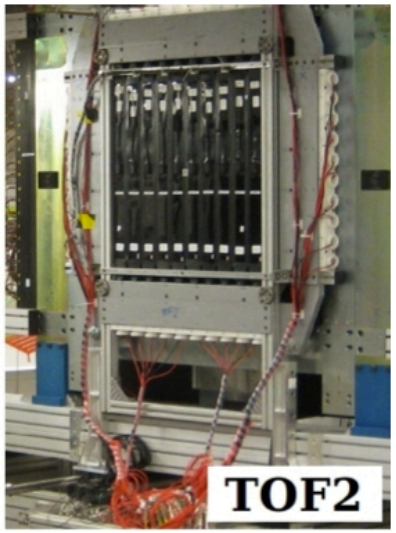
TOF

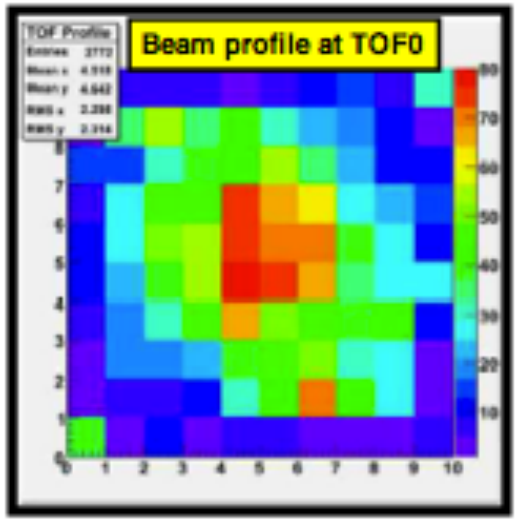


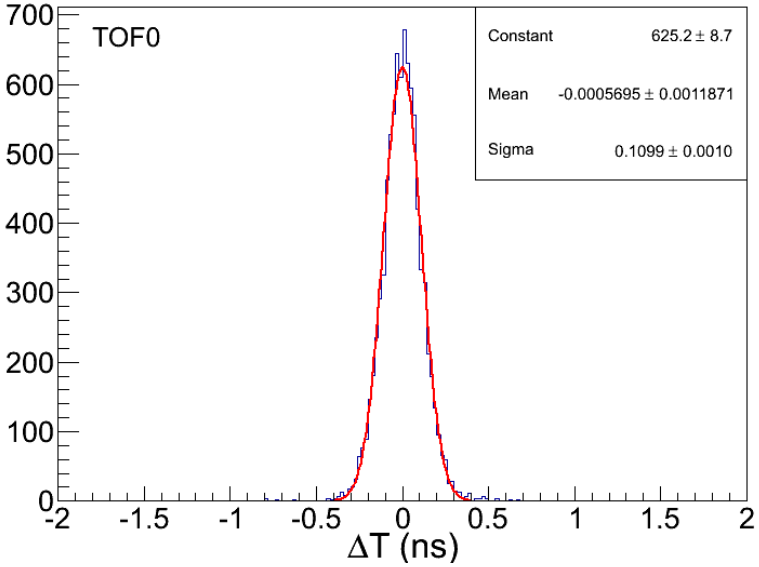
- TOF0: 10 x 4cm bars
- TOF1: 7 x 6 cm bars
- TOF2: 10 x 6 cm bars

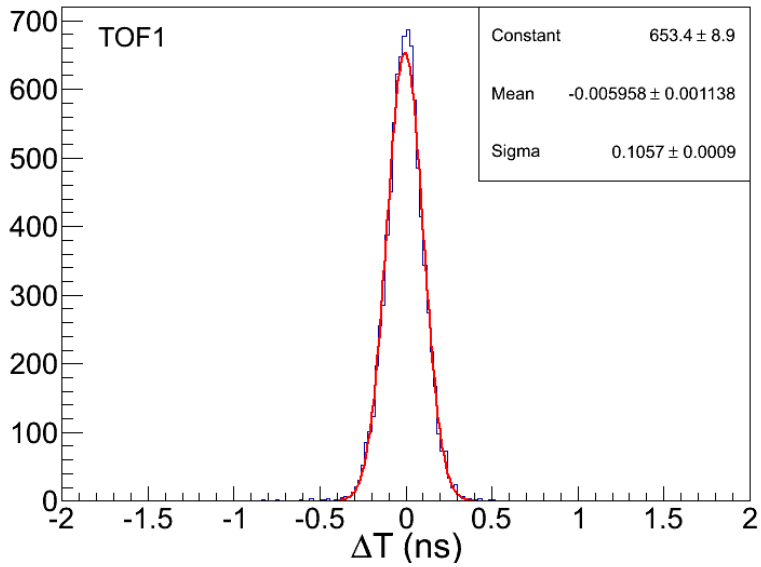


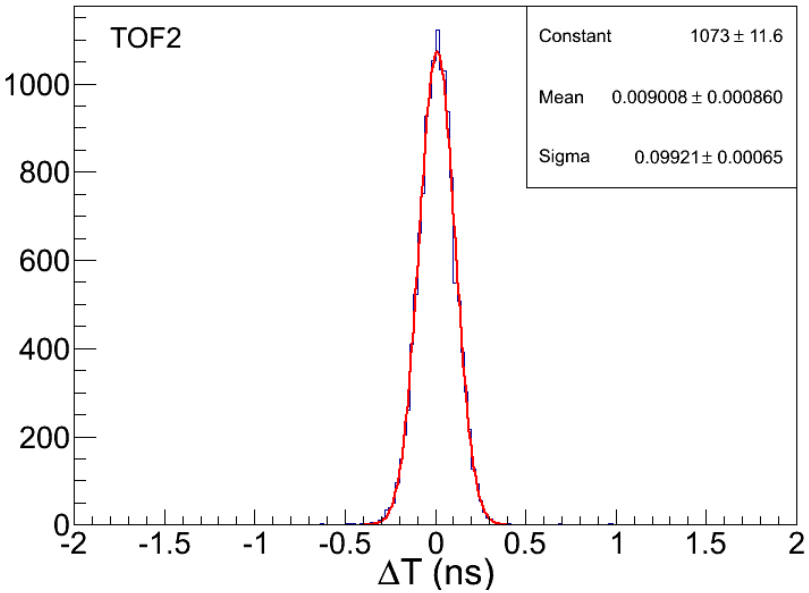








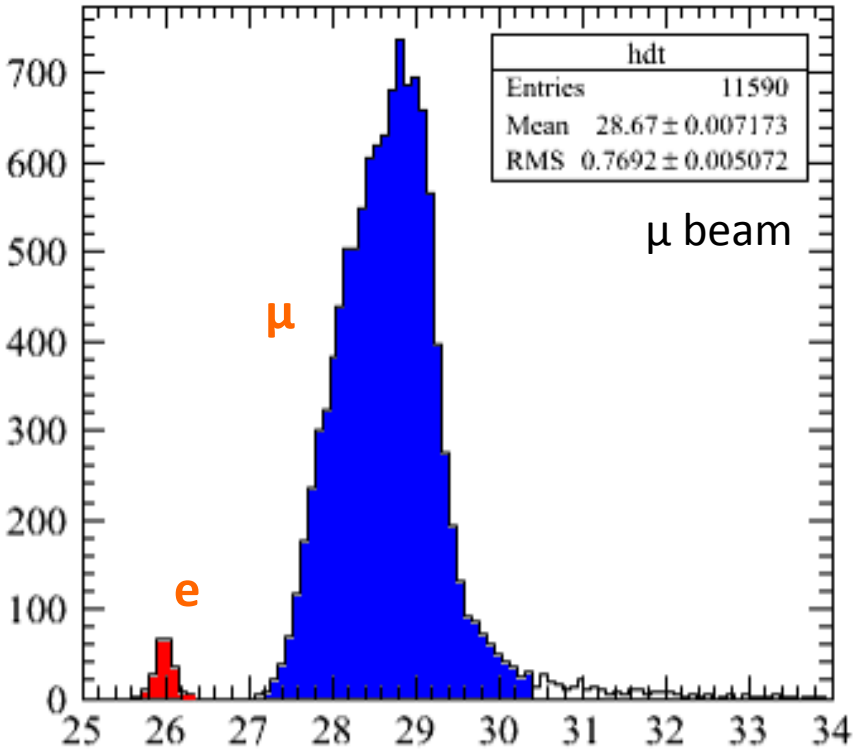


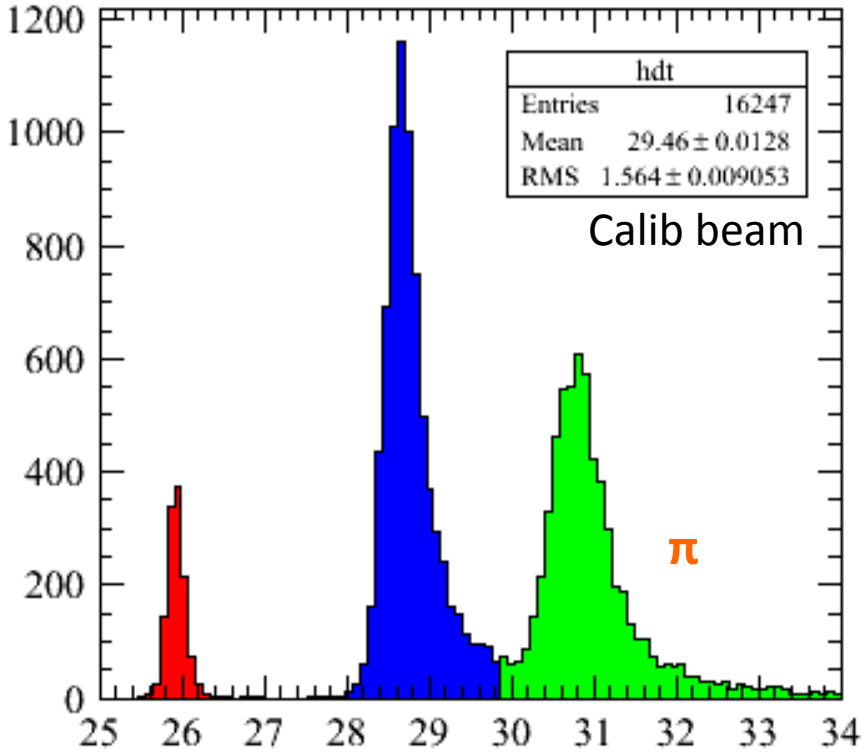


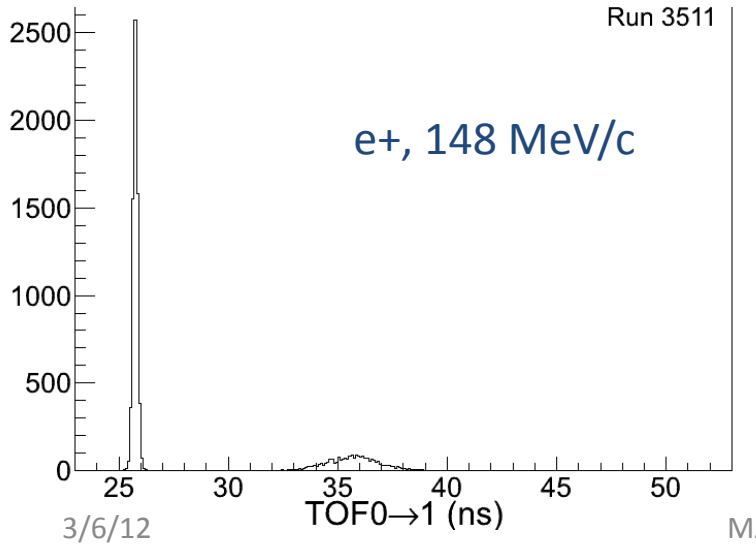
- Fully calibrated with Dec'11 data
  - corrected for slew, cable delay, trigger

<u>Time Resolutions:</u>

- TOF0: 55 ps
- TOF1: 53 ps
  - *was* 64 ps -- improved due to refurbished/replaced PMTs
- TOF2: 50 ps

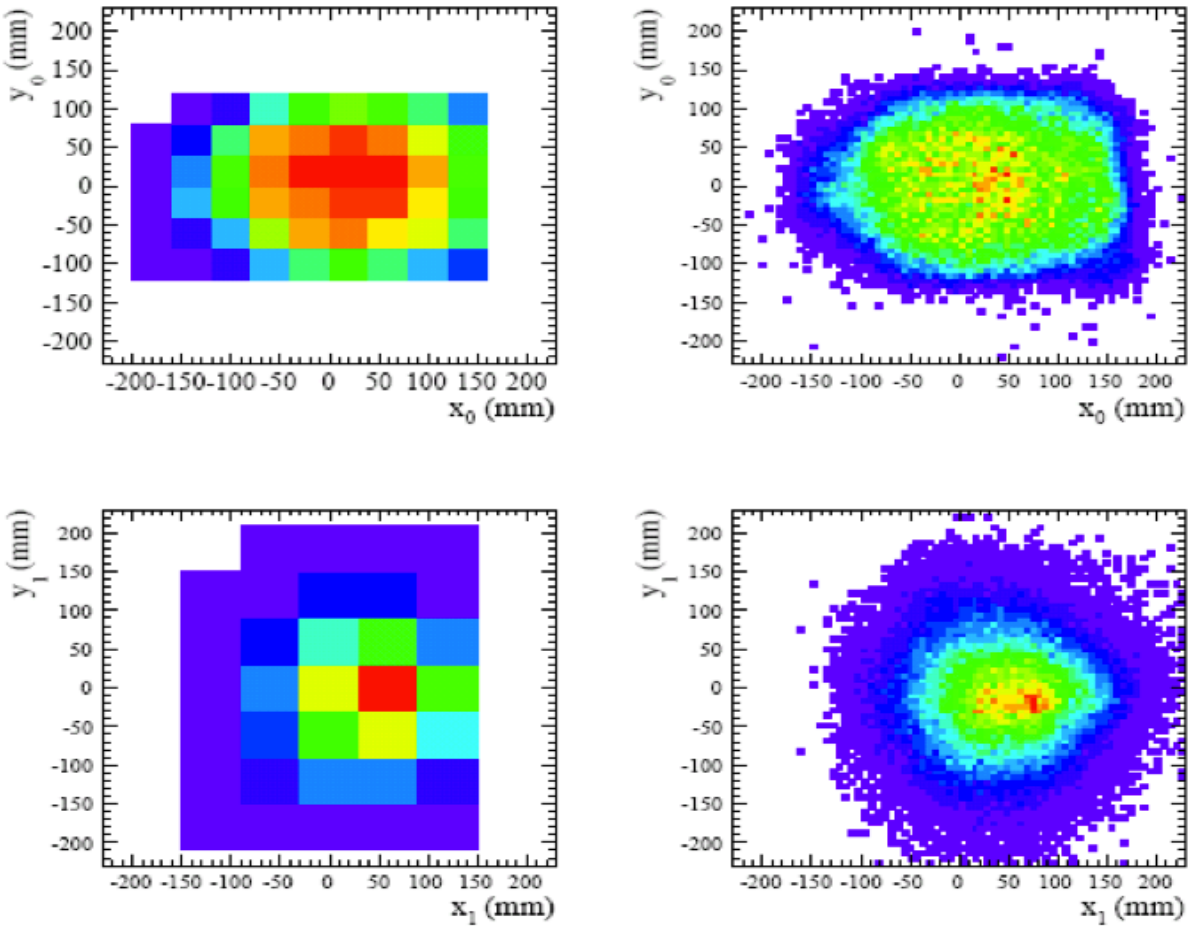






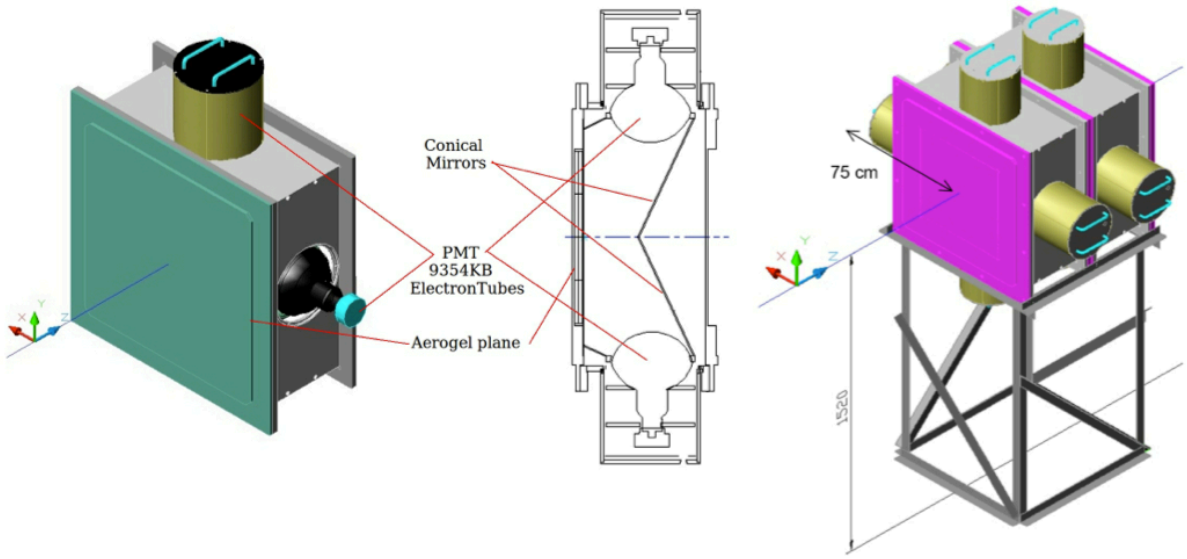
- Excellent separation using TOF
- Further rejection of pion contamination will be done using the CKOVs

TOF Reconstruction



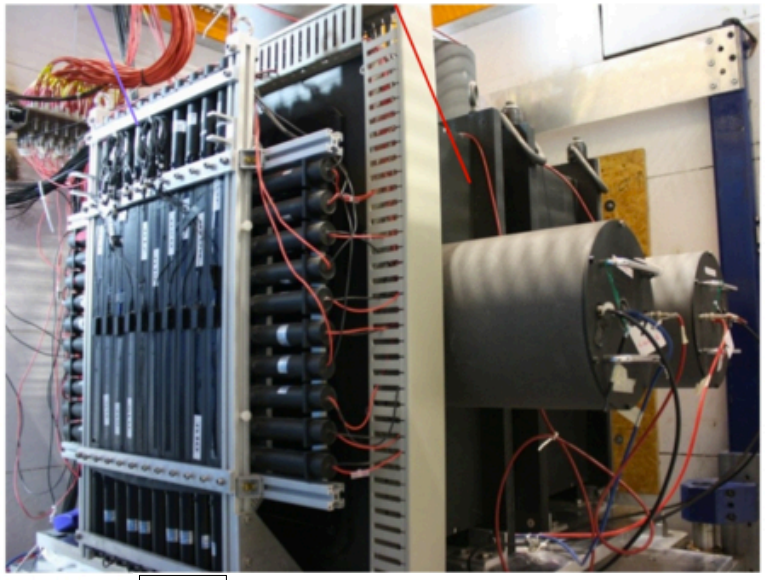
- In addition to PID, TOF also provides spatial information
  - Left: Incident particles' position as given by the slab number hit
  - Right: Position reconstructed using time difference between PMTs at either end

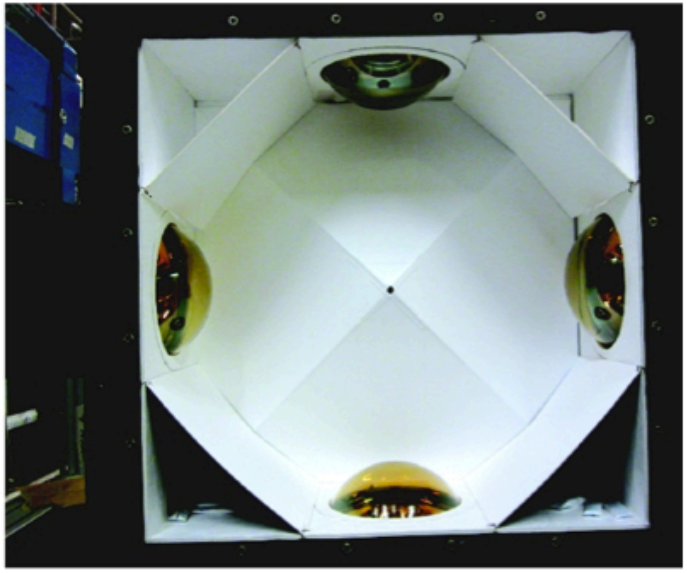
CKOV

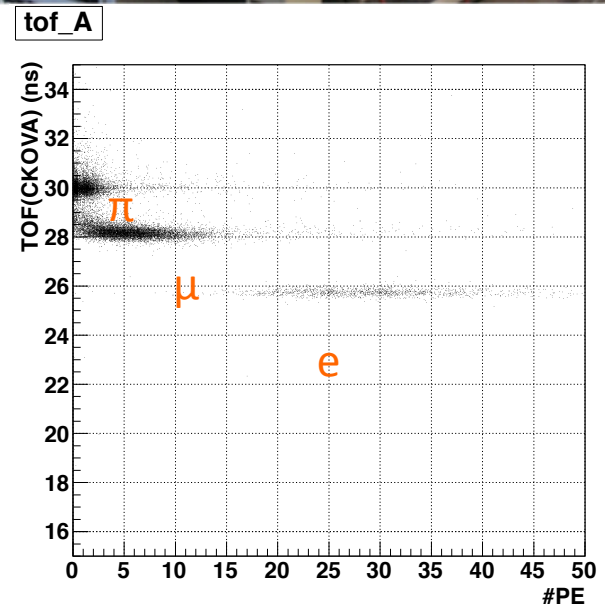


- Cherenkov light produced in a 2.3 cm thick layer of aerogel
  → reflected by 4 intersecting conical mirrors → four 8" PMTs
- Aerogel layers: 46 x 46 cm^2, n=1.07, 1.12
- Thresholds:
  - μ: 278 MeV in CKOVa, 210 MeV in CKOVb
  - π: 367 MeV in CKOVa, 277 MeV in CKOVb
  - e.g. @ 240 MeV: *e* trigger both counters, *μ* trigger B, pions none

CKOV

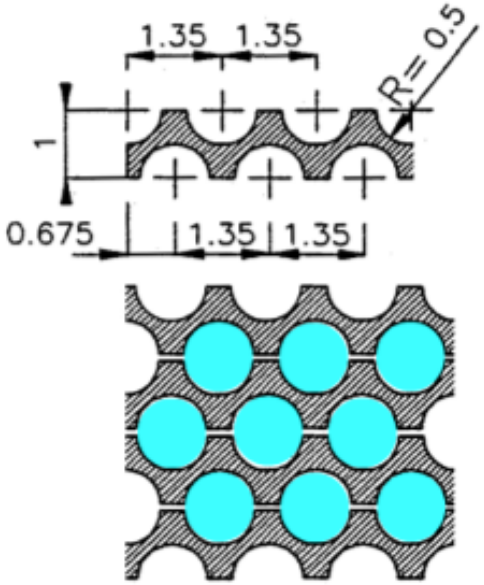


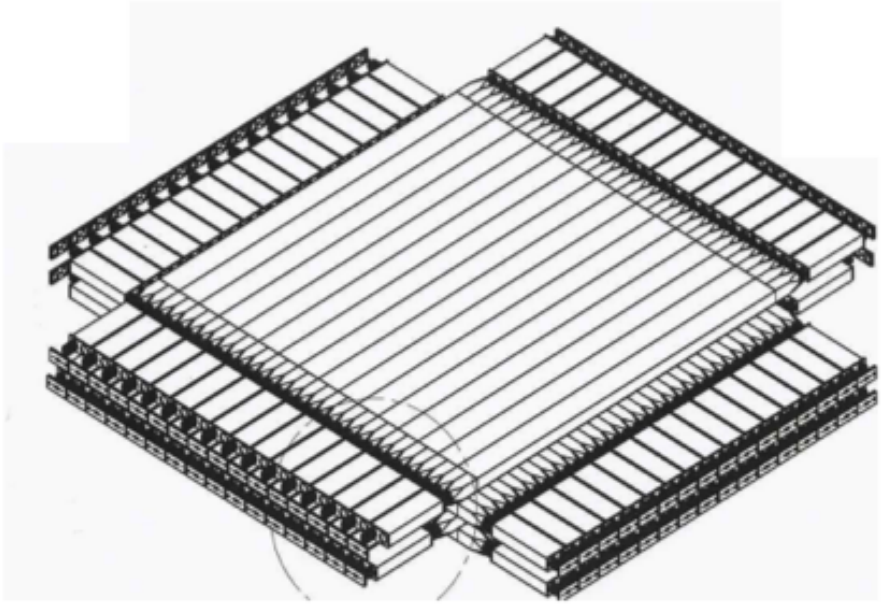




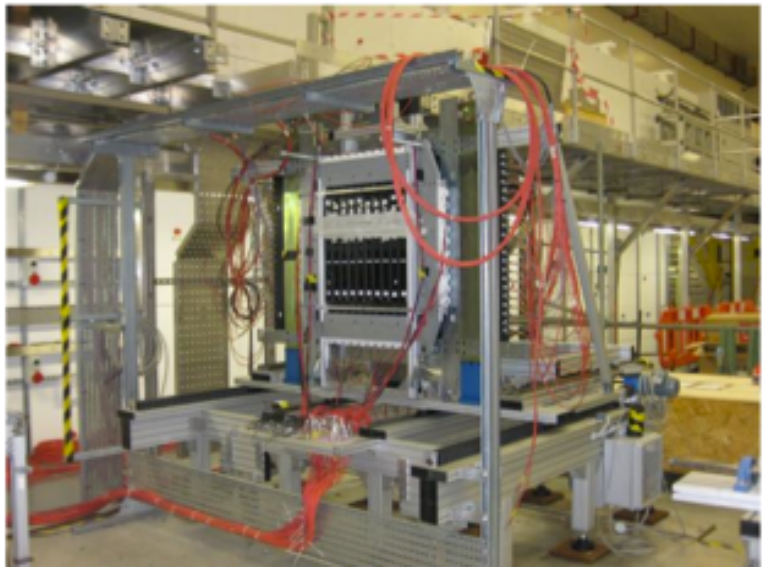
- Calibration: completed
- Analysis of 2011 data in progress:
  - Estimate background light after window replacement
  - Extract PID using information from both counters

KL



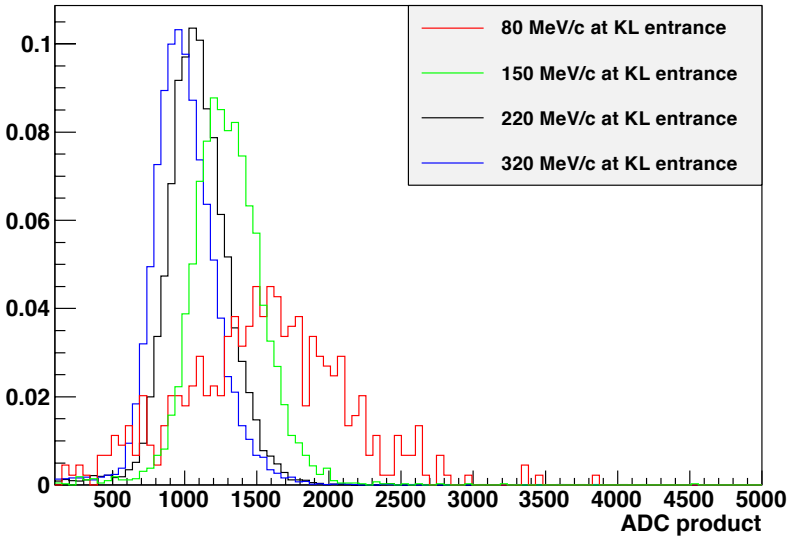


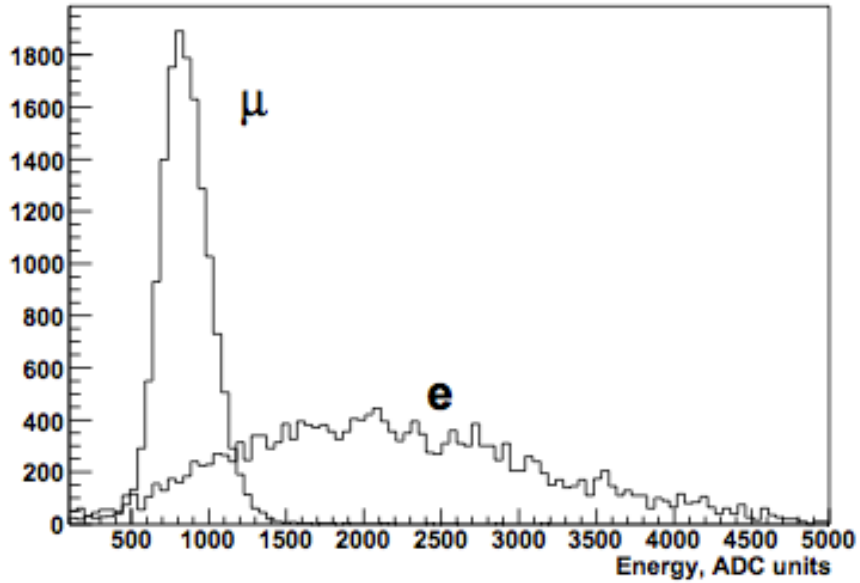
- Sampling calorimeter: Grooved Pb foils + 1mm fibers
- 93 x 93 x 4 cm^3 active volume. ~ $2.5X_0$, ~ 0.15λ
- Acts as a pre-shower in front of the EMR
- installed in the MICE Hall in June 2008



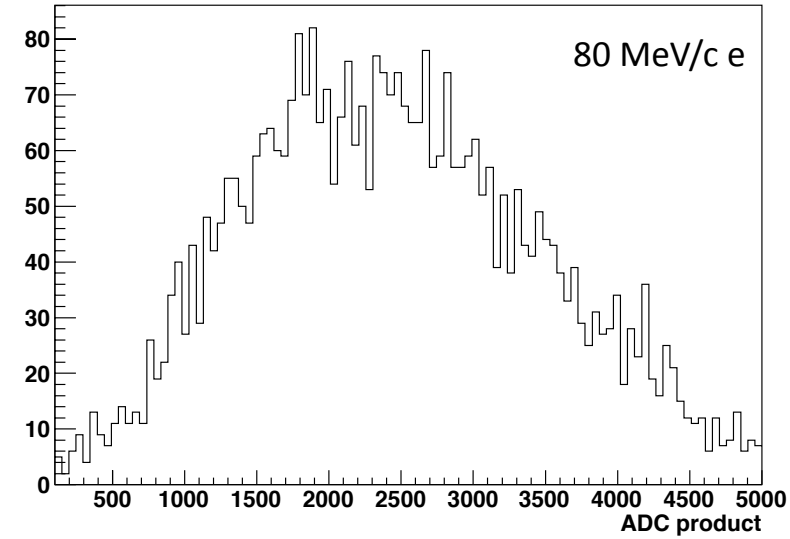
KL Performance

Muons

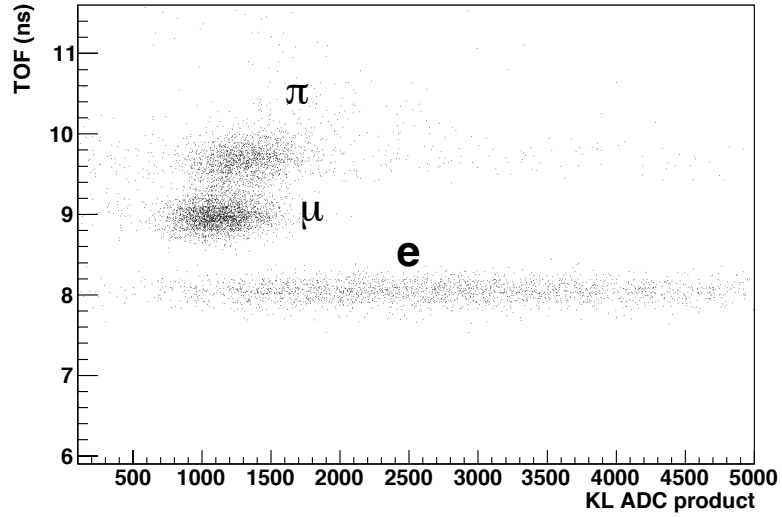




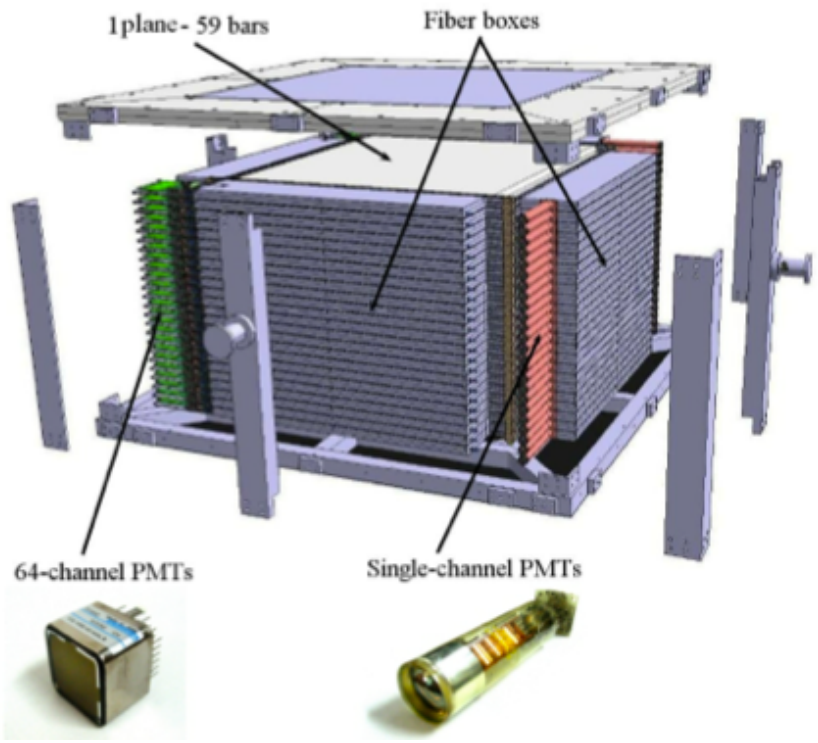
Electrons



KL ADC vs. TOF

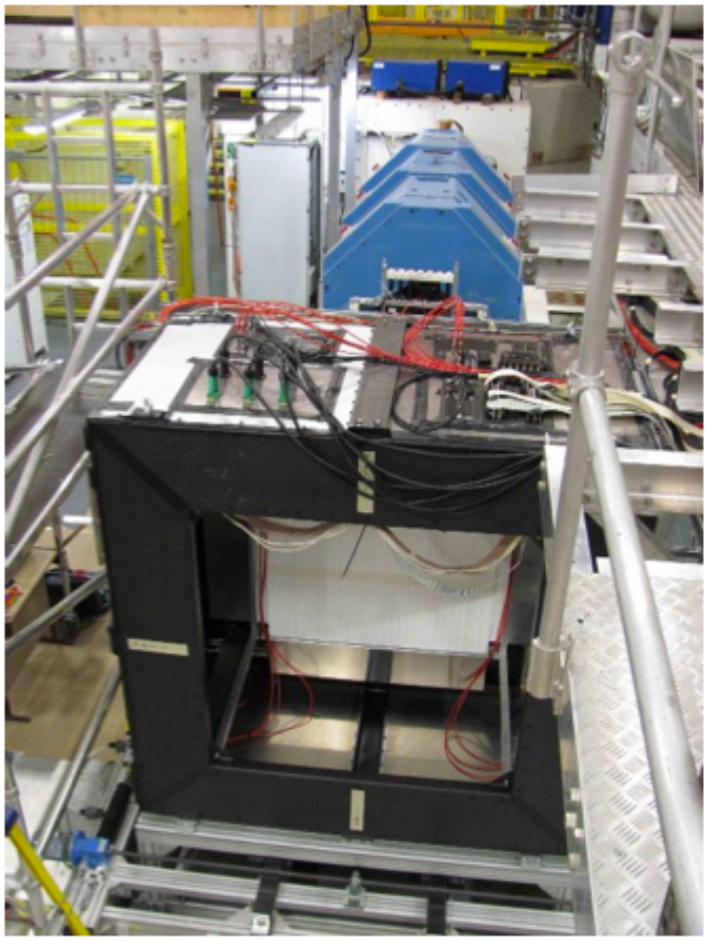


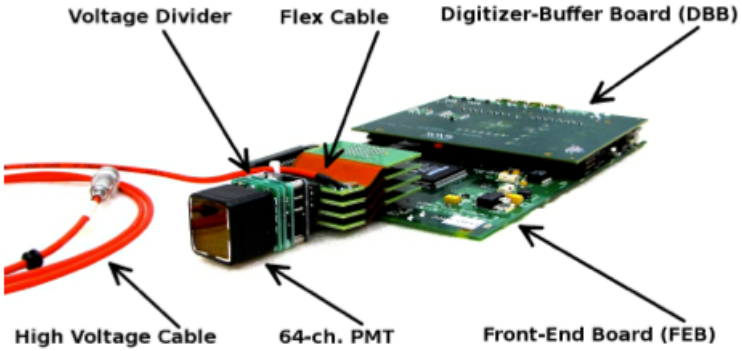
EMR



- Fully active scintillator detector. Will stop all particles, measure range, identify μ/e
- μ:
  - show tracks
  - Energy deposition flat
- e:
  - will shower
  - Energy loss decreases along z
- 1 m^3 of active volume
- 48 planes: 59 triangular scintillator bars in with glued 1.2 mm WLS fibers
- light collected by single-anode PMT on one side & by 64-channel PMT on the other:
- the granularity of the detector will allow it to reconstruct individual tracks and measure energy deposition in every bar

EMR Status & Plans





- EMR box with 3 X-Y modules (6 planes) was installed in the MICE hall in June for preliminary tests
- electronics and DAQ have been successfully tested
- installation & commisioning this summer

Conclusions

- MICE PID detectors (TOF, CKOV, KL) installed and working well
- Detectors calibrated & resolutions meet design requirements
- Able to achieve purity ~ 99%
- Further analyses using information from all PID detectors have started
- Final PID detector – EMR – will be installed and commissioned this summer