The Detector System of the MICE Experiment

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Introduction

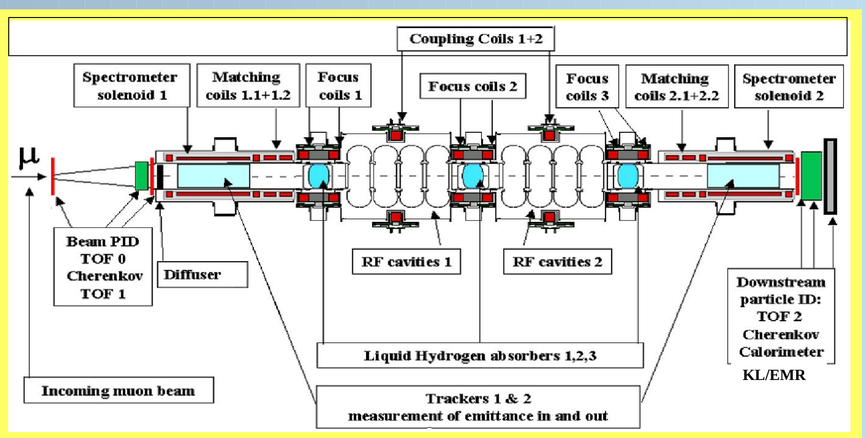
• **MICE** is a Muon Ionization Cooling Experiment running at the Rutherford-Appleton Laboratory, Chilton UK.

• Cooled muon beams will be a major technological step towards the development of a "neutrino factory" and "muon collider".

• A minimum ionizing muon beam will be transversely cooled by stages of -dE/dx in LH absorbers and longitudinal energy restoration in 201MHz RF cavities.

•The 6D emittance reduction is measured before and after the cooling stage by tracking individual muons through the system, using **two scintillating fiber detectors,** each inside a 4 T superconducting solenoid.

•Muon purity is assured by **threeTime-of-Flight** (TOF) measurements, **two threshold Cherenkovs** (μ/π), and **a low energy muon/electron ranger** KL/EMR (μ/e).

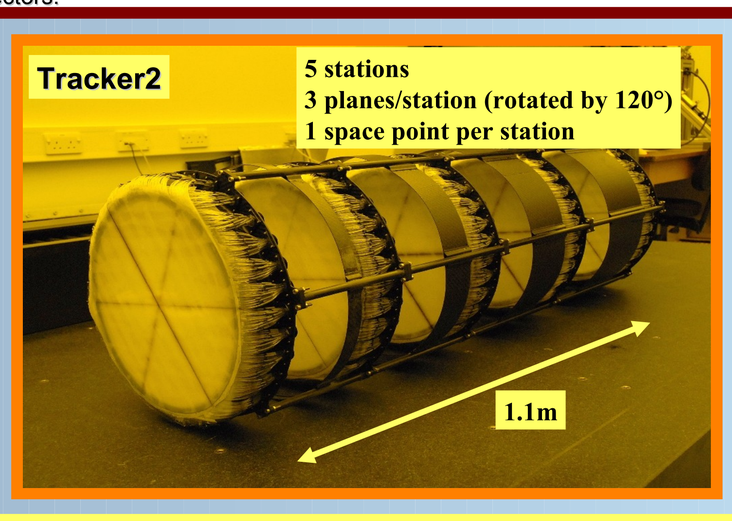


Tracker

Requirements:
- high rate capability – 600 muons/msec
- small amount of material – avoid beam heating
- operate in backgrounds from RF cavities
- high efficiency with low background
- passive detector – nothing to pick up RF noise

•Each tracker has 5 stations with three planes of 350 μm fiber doublets to give an accurate point in space.

•The incoming and outgoing 6D emittance is measured by determining x, x′,y, y′, and particle momentum with the tracker, and measuring t using time-of-flight detectors.

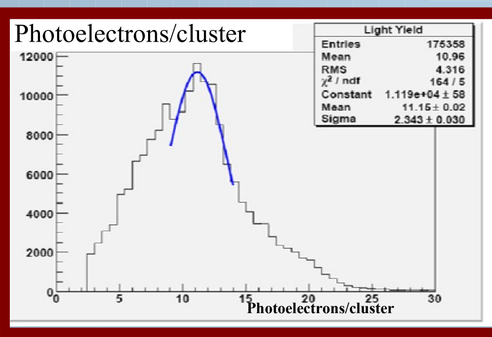


Scintillating fiber detector
- **30 cm active area**
- **mirrored fibers with 75% reflectivity**
- **7 neighboring fibers ganged together feed into a single 1 mm clear fiber for readout**

•VLPCs (Visible Photon Light Counters)convert the light to an electrical signal.

•VLPCs are solid state photodetection devices (operated at 9K) with high quantum efficiency and low noise with the ability to handle high rates.

Both MICE trackers have been built.
Tracker 1 tested successfully with cosmic rays.



Design goals met:
- **Light Yield Goal of 10.5 photoelectrons, measured 11**
- **Measured resolution consistent with goal of 430 μm**
- **Less than 1/1000 dead channels and nearly 100% efficiency**

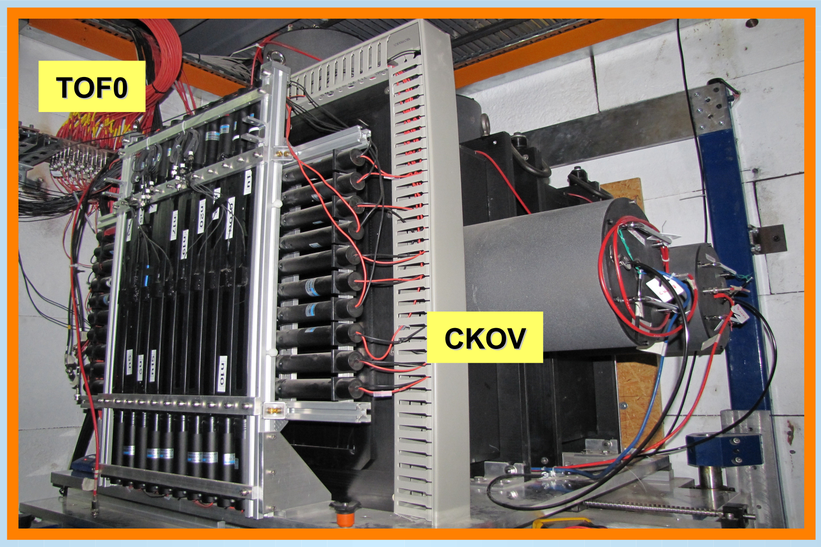
Time of Flight System

• **TOF0,1,2 -** Three time of flight stations (~40x40cm², 42x42cm², 60x60cm²) are positioned in the MICE channel at the start (TOF0), mid(TOF1), and rear(TOF2) positions.

• TOF0(1,2) station consists of a 10(7,10)X and 10(7,10)Y array constructed of BC404(420) scintillator bar assemblies with dual R4998 PMT readout with modified high rate active HV divider. Each assembly gives typically Δt_o=55ps timing resolution.

•The expected TOF resolution between 2 stations is

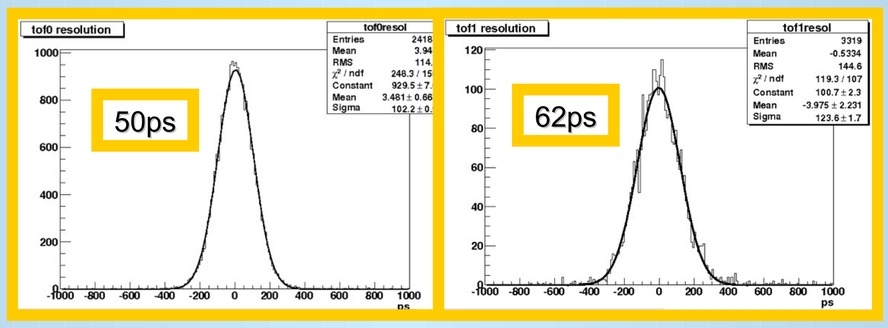
$$\Delta TOF^2 \sim 2\,\Delta t_o^2 + \sigma^2_{calib} \leq (75ps)^2$$



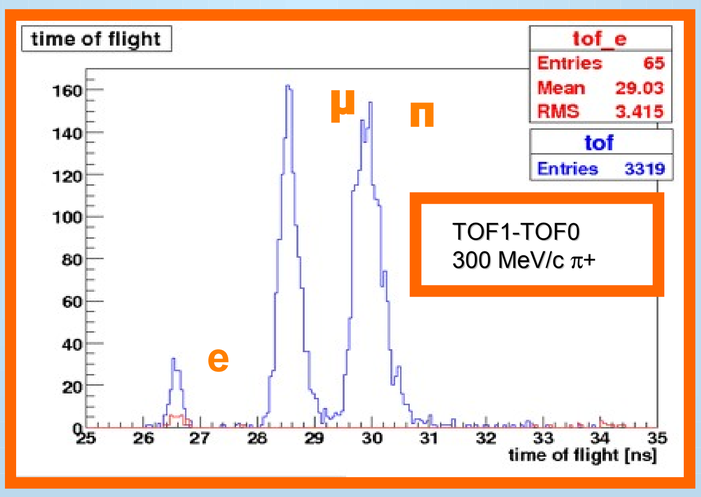
TOF Beam Measurements

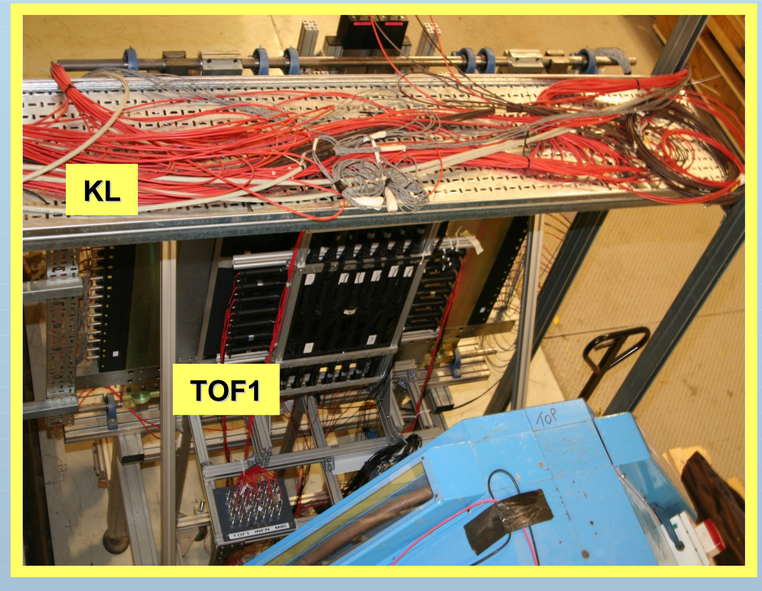
• TOFO and TOF1 assembly resolutions measured in 300 MeV/c MICE pion beam 2008. (Preliminary)

•Intrinsic time resolutions of 50 and 62 ps measured.



•TOF0-TOF1 μ/π separation in commissioning stage.
• Muon and electron peaks from in-flight π decays



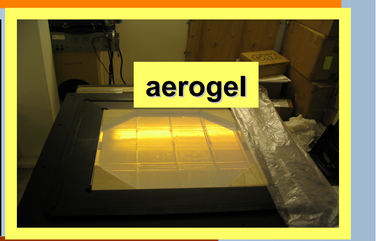


Cherenkov

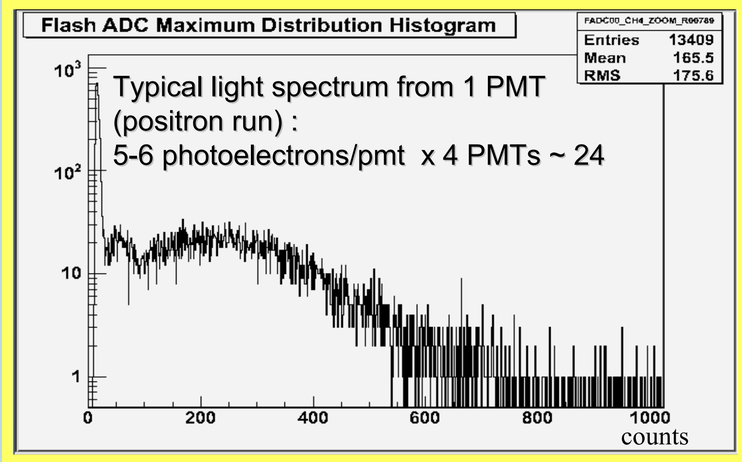
•Two threshold Cherenkov detectors positively identify muons from pions in the upstream MICE beamline.

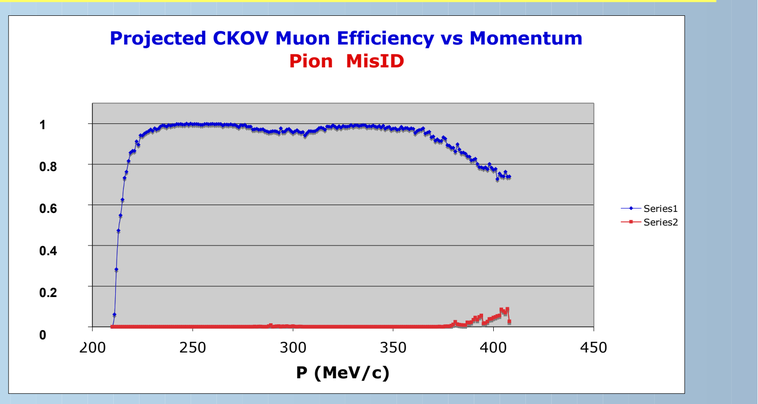
•High density aerogels of n=1.12 and n=1.07 were chosen with momentum thresholds for muon between 220-360 MeV/c.

	P^{th}_{μ} (MeV/c)	P^{th}_{π} (MeV/c)
Aerogel 1.12	220	280
Aerogel 1.07	280	360



CkOV Electron Response





KL/EMR

• **KL*/EMR** - electron preshower+electron-muon ranger. (*KLOE - Nucl.Instrum.Meth.A598:239-243,2009)

•**KL-** preshower constructed of 0.3mmPb+BF12 fiber (2.5 Xo, ΔE=7%/ √E, Δt~70ps / √E)

•**EMR-** 70cm active scintillator with WLS+multianode PMT readout (58bars x40 layers = 680mm, 2360 ch)