

The MICE Particle Identification System

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Introduction

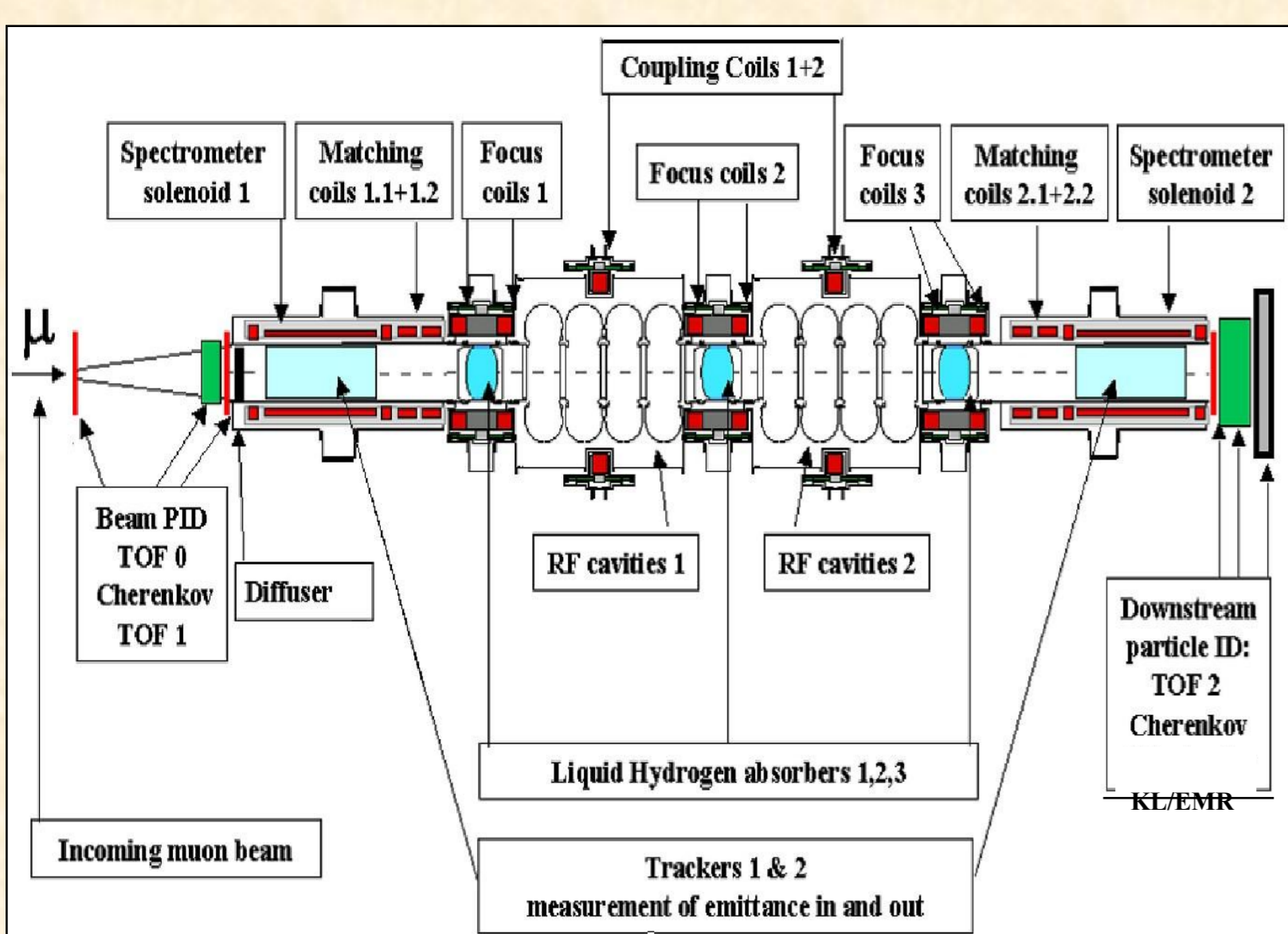
MICE is a Muon Ionization Cooling Experiment running at the Rutherford-Appleton Laboratory, Chilton UK.

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

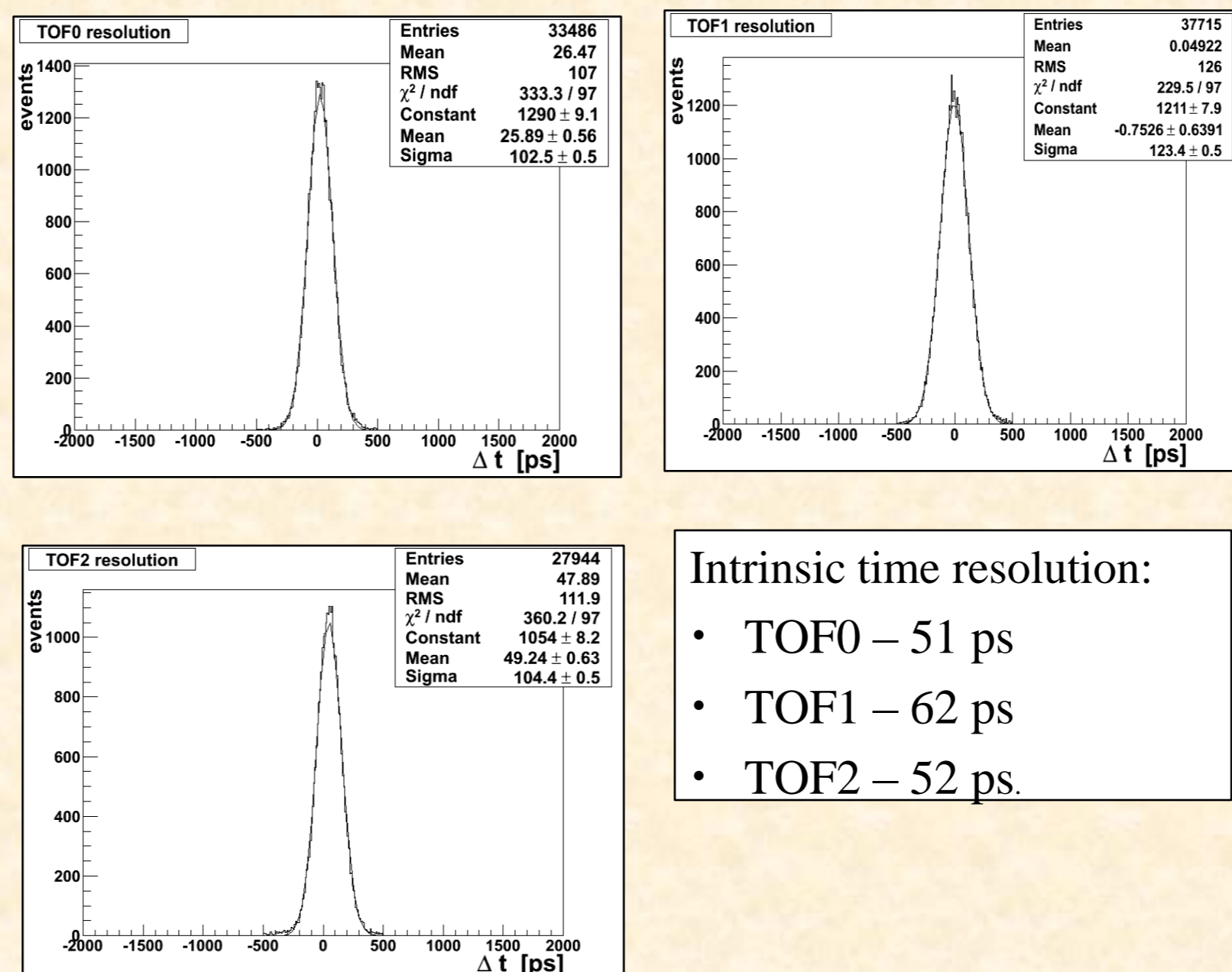
A minimum ionizing muon beam will be transversely cooled by stages of $-dE/dx$ in LH absorbers and longitudinal energy restoration in 201MHz RF cavities.

The 6D emittance reduction is measured before and after the cooling stage by tracking individual muons through the system.

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



TOF0, TOF1 and TOF2 assembly resolutions measured in MICE pion and electron beams spring 2010. (Preliminary)



Intrinsic time resolution:
 • TOF0 – 51 ps
 • TOF1 – 62 ps
 • TOF2 – 52 ps.

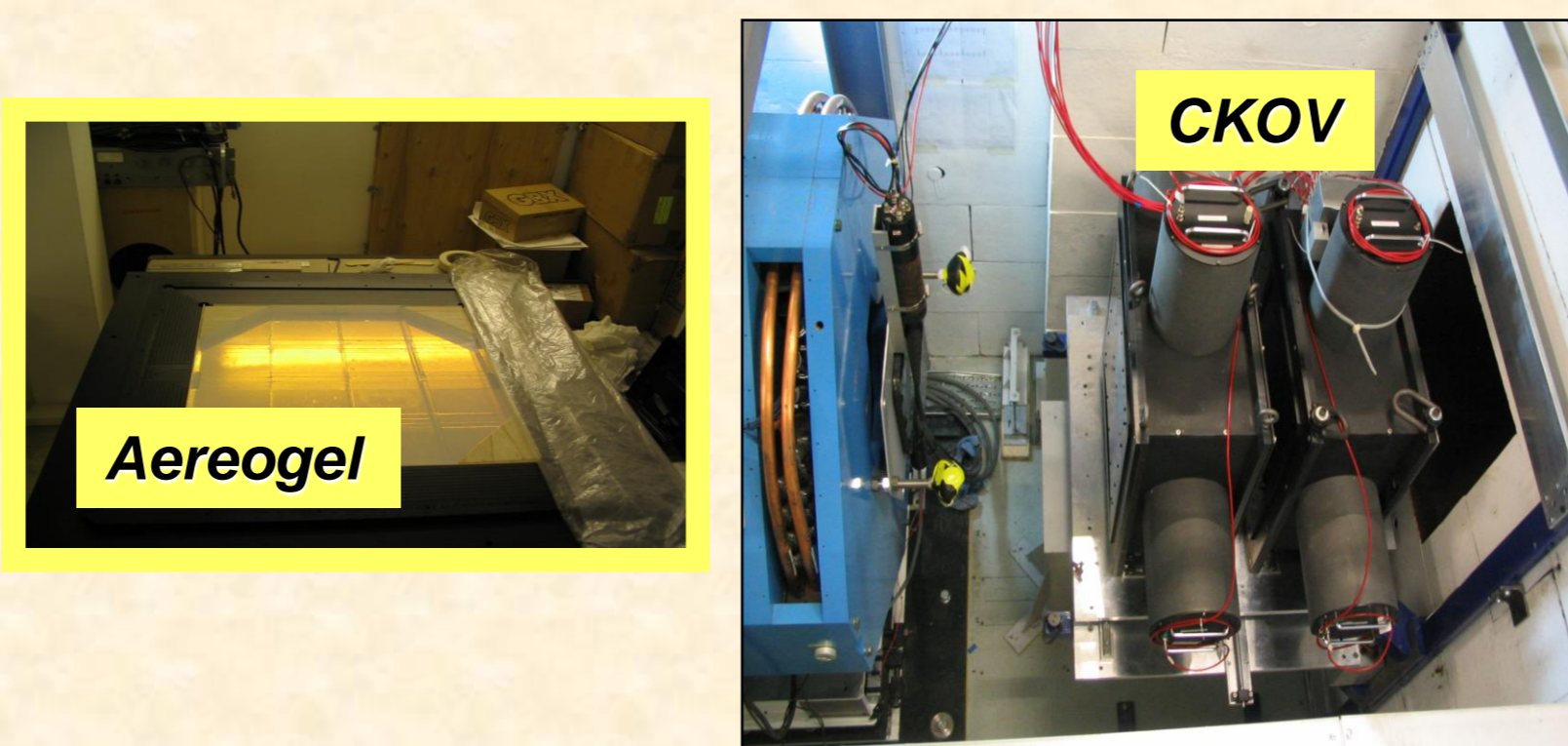
TOF0-TOF1 and TOF1-TOF2 μ/π separation in commissioning stage.
 • Muon and electron peaks from in-flight π decays

Cherenkov Particle Identification

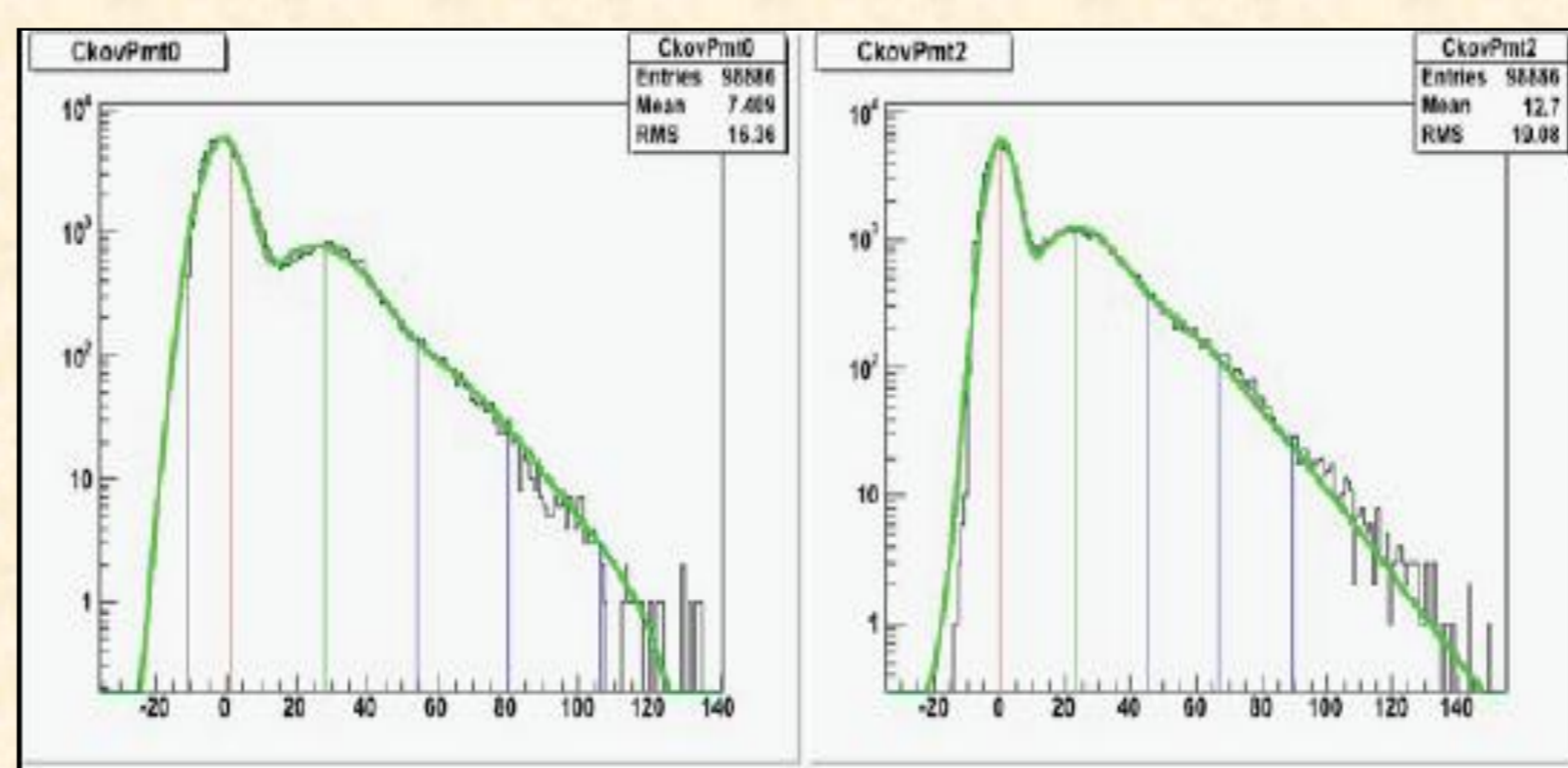
CKOVab- Two threshold Cherenkov detectors positively identify muons from pions in the upstream MICE beamline.

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

	$P^{th}_{\mu}(MeV/c)$	$P^{th}_{\pi}(MeV/c)$
Aerogel 1.12	220	280
Aerogel 1.07	280	360



Cherenkov Electron Response



• red vertical line – pedestal peak
 • green vertical line – single photoelectron peak
 • blue vertical lines – 2, 3 and 4 photoelectron peaks

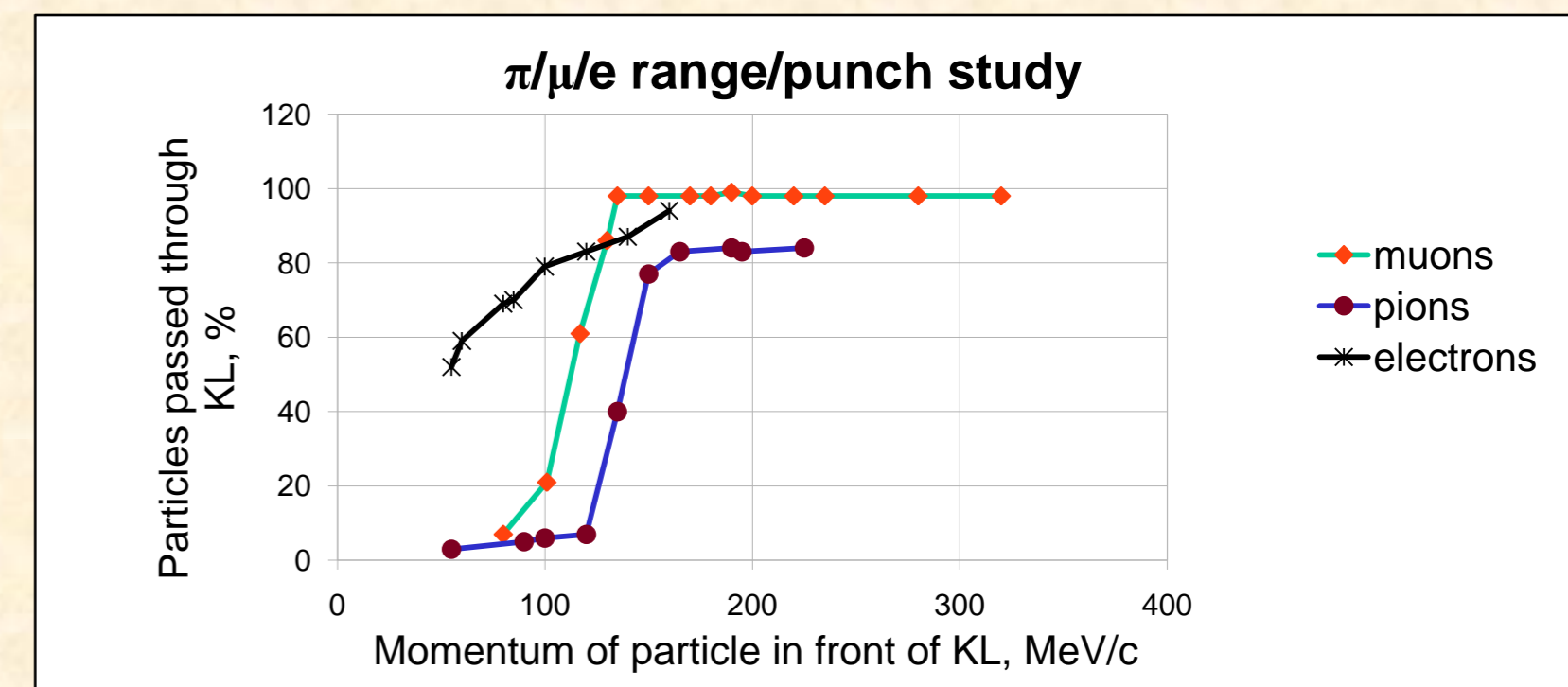
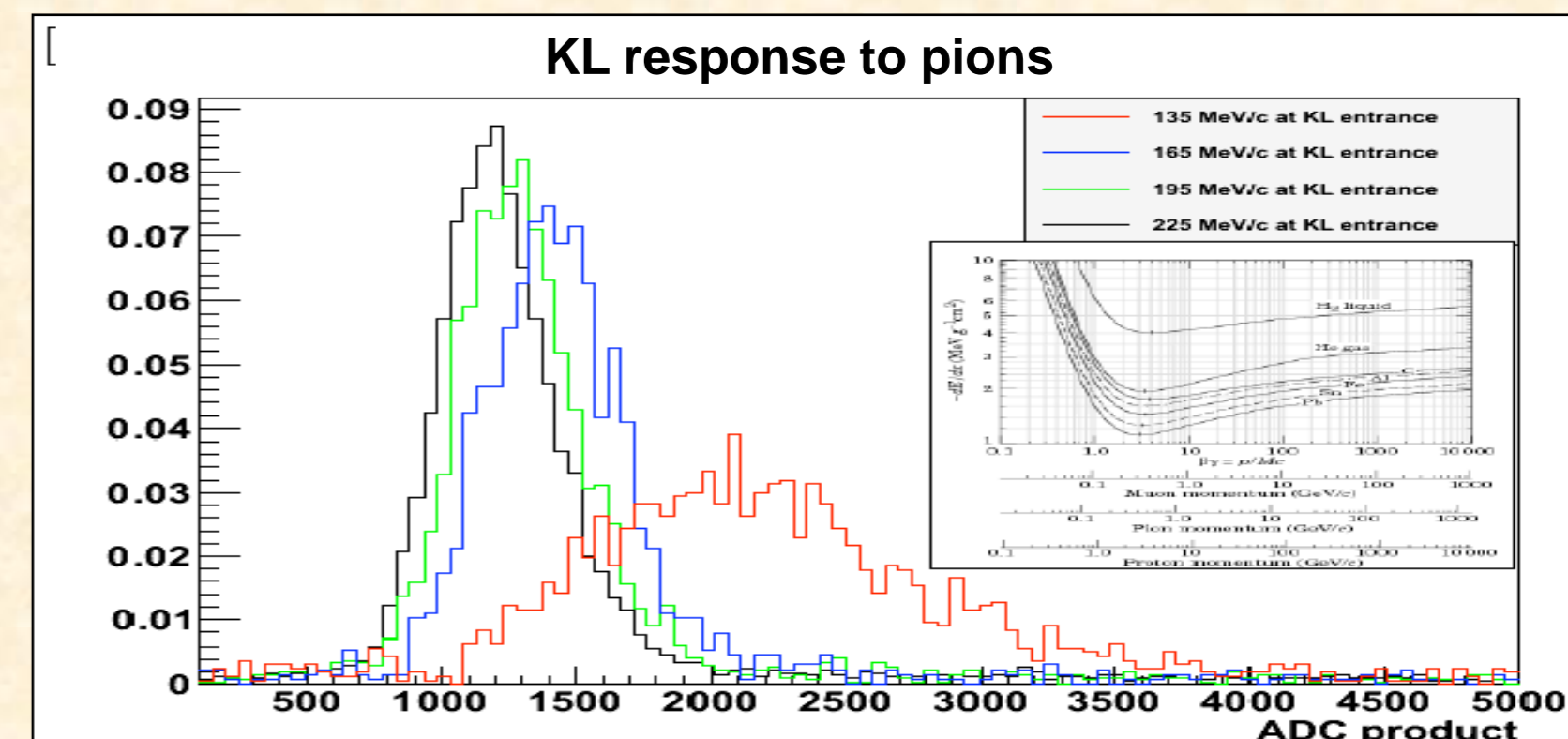
Downstream PID Assembly

0.5% of μ s decay in flight:
 • need electron rejection at 10^{-3} to avoid bias on emittance reduction measurement
 • TOF2 X/Y hodoscope,
 • EMC Calorimeter for MIP vs E.M. Shower : KL (built) + EMR (in construction)

KL

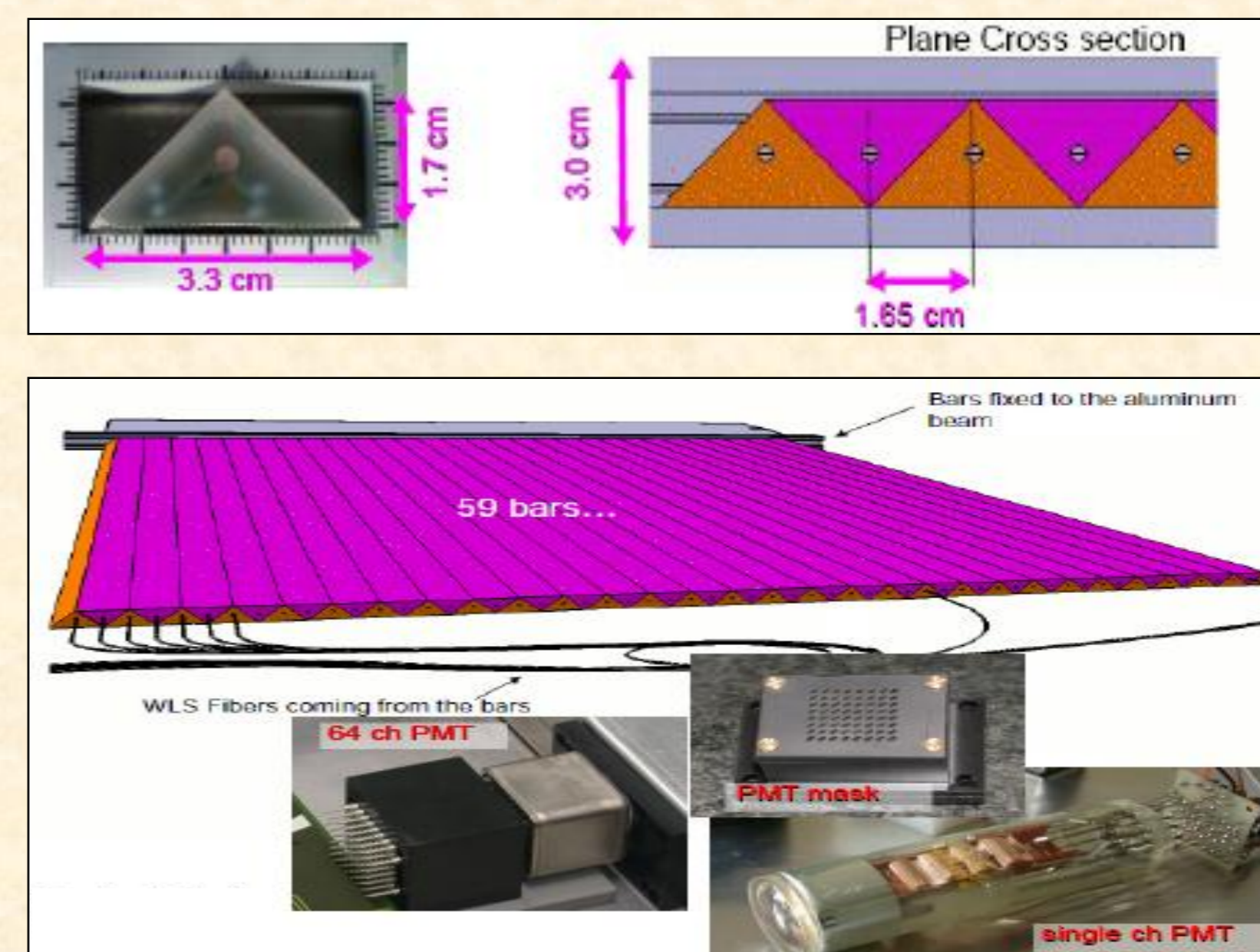
KL – KLOE* Light electron preshower. Constructed of 0.3mm Pb + BF12 fiber (2.5 Xo, $\Delta E=7\%/\sqrt{E}$, $\Delta t \sim 70ps/\sqrt{E}$)

(*KLOE - Nucl.Instrum.Meth.A598:239-243,2009)

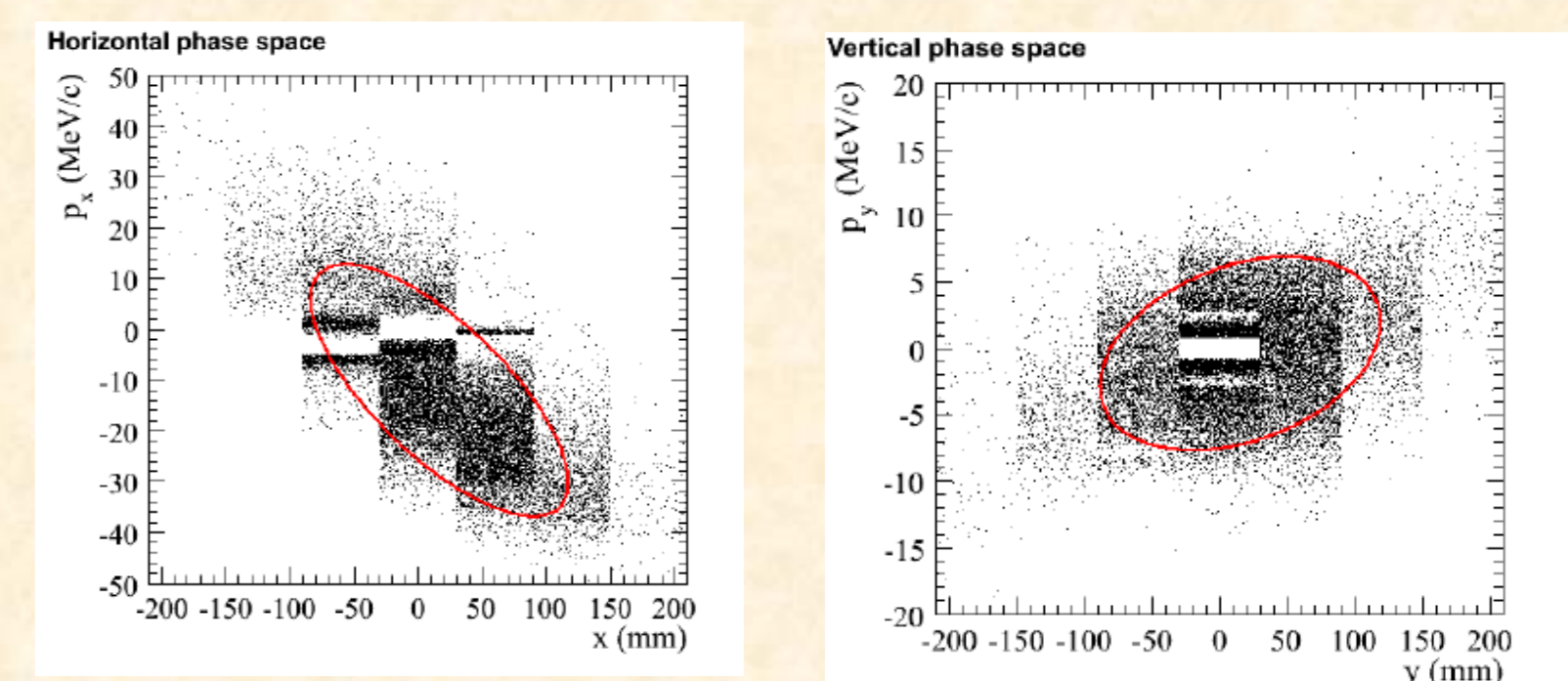
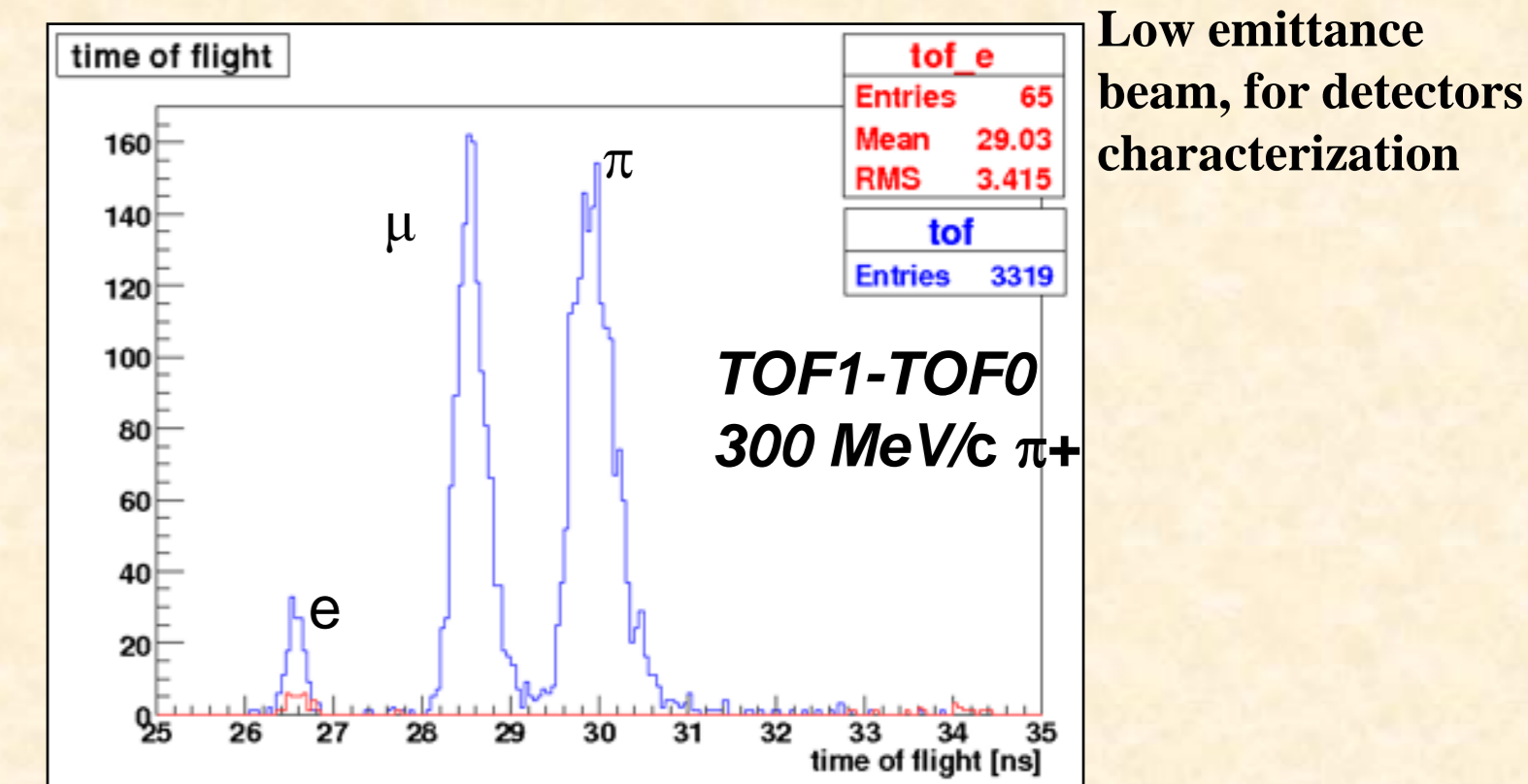
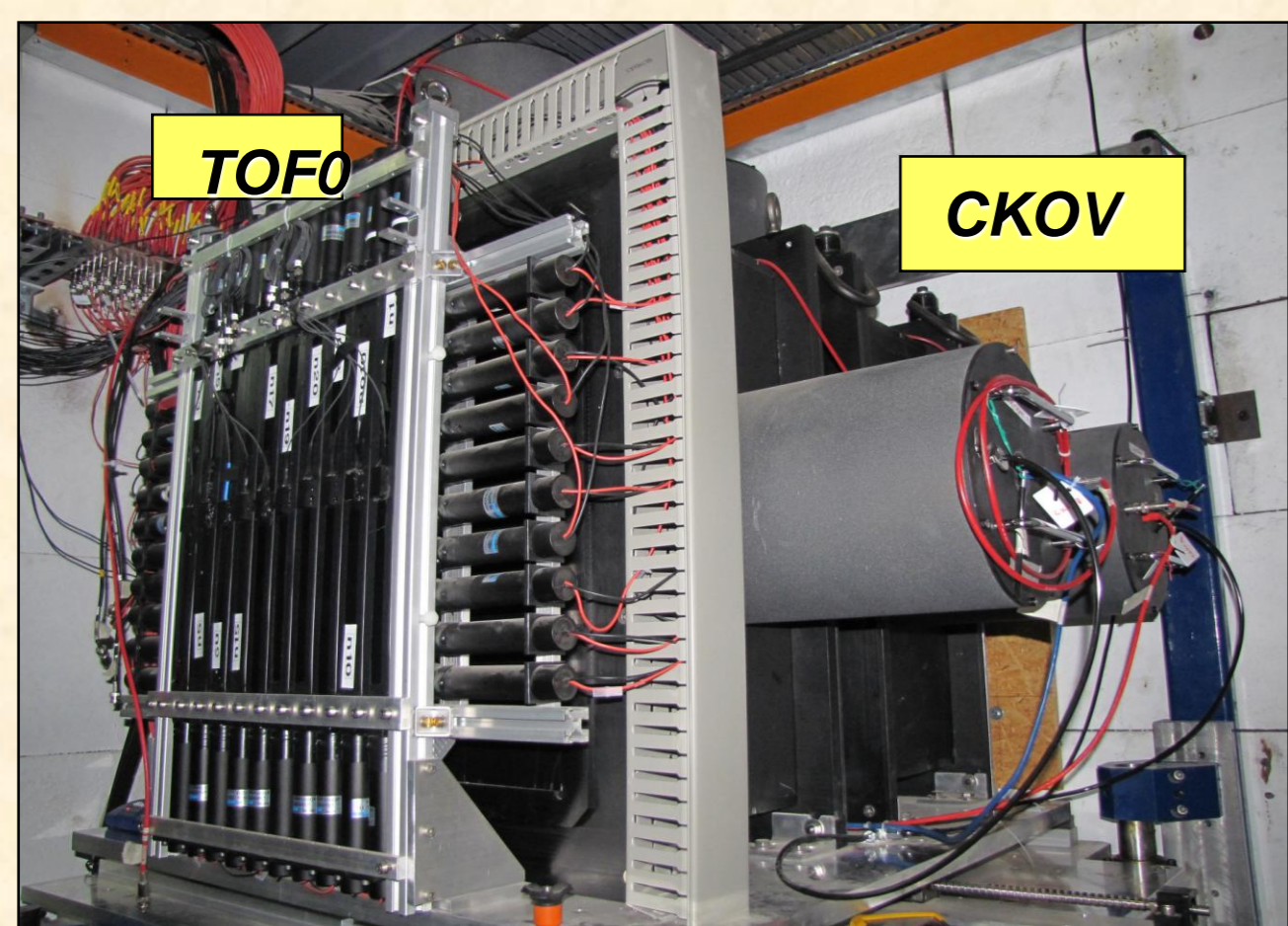


EMR

EMR – Electron-Muon Ranger (under construction and tests)
 • 50 layers of fully active scintillator bars organized in x-y way
 • 59 triangular shape 1.1 m long bars in each plane - 1m2 active region
 • Light carried out by a single 1.2 mm diameter WLS fiber
 • Fiber connected on one side to a single channel photomultiplier
 • On the other side to a 64 channel multianode photomultiplier



MICE beamline characterization with PID detectors



Reconstruction of 4D emittance using only TOF0 and TOF1 (x, p_x, y, p_y). Values are reconstructed within 10 %

Time of Flight System

TOF0,1,2 - Three time of flight stations ($\sim 40 \times 40 \text{cm}^2$, $42 \times 42 \text{cm}^2$, $60 \times 60 \text{cm}^2$) are positioned in the MICE channel at the start (TOF0), mid (TOF1), and rear (TOF2) positions.

TOF0(1,2) station consists of a $10(7,10) \times 10(7,10)$ array constructed of BC404(420) scintillator bar assemblies with dual R4998 PMT readout with modified high rate active HV divider. Each assembly gives typically $\Delta t_0 = 55 \text{ps}$ timing resolution.

The expected TOF resolution between 2 stations is

$$\Delta \text{TOF}^2 \sim 2 \Delta t_0^2 + \sigma_{\text{calib}}^2 \leq (75 \text{ps})^2$$



MICE HALL:
 TOF2/KL
 TOF1