PID Analysis in the MICE 2015/01 Data

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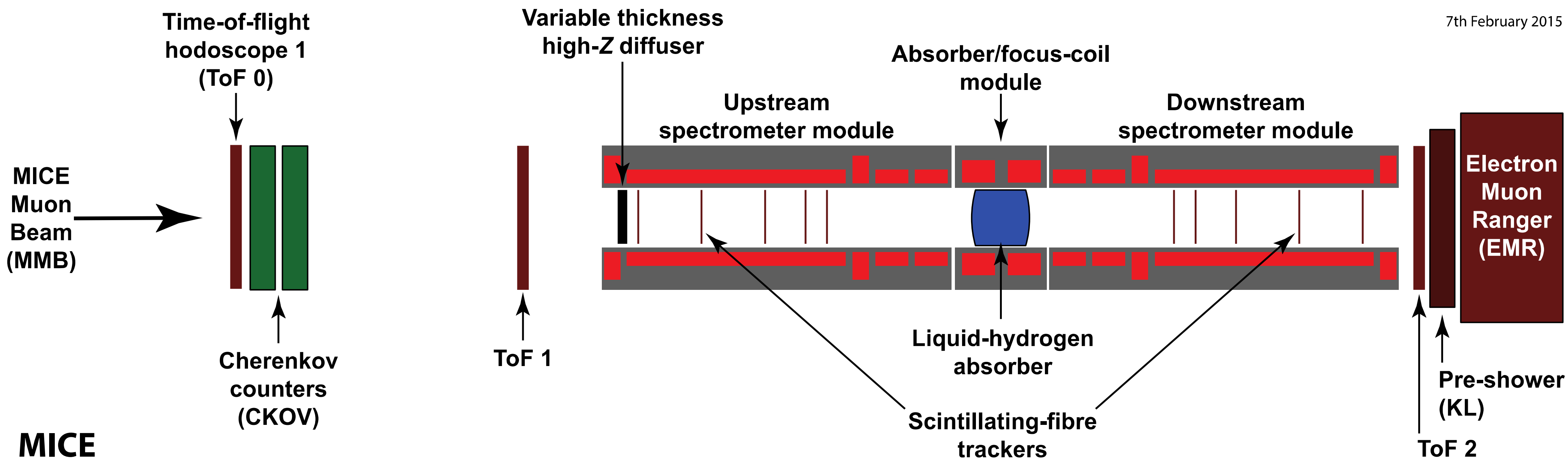
Objectives

- Need high purity muon beam for demonstrating muon ionization cooling.
- Recognize and reject pions and electrons in the MICE beam.
- Evaluate the performance of the PID detectors.

MICE PID Detectors



- Upstream detectors for separation of muons and the left-over pions in MICE beam,

i. Time-of-flight, TOF0 and TOF1

ii. Cherenkov counters, CkovA, and CkovB

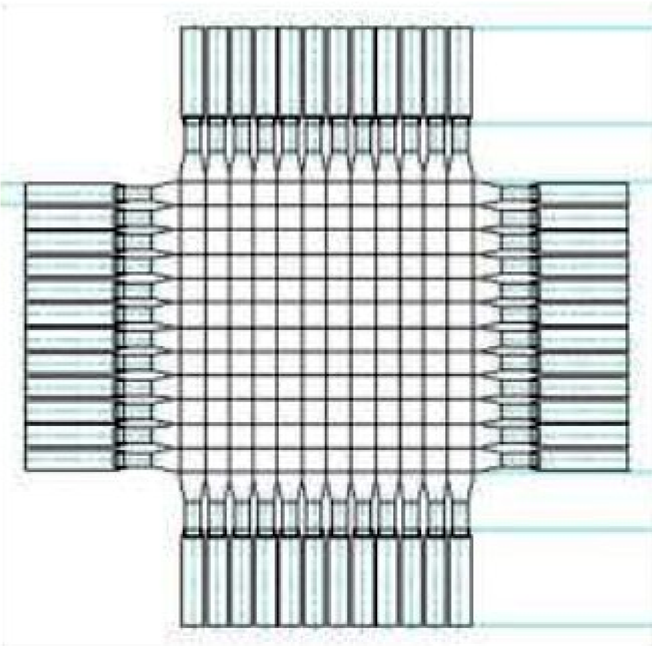
- Downstream detectors for separation of muons and electrons in MICE beam,

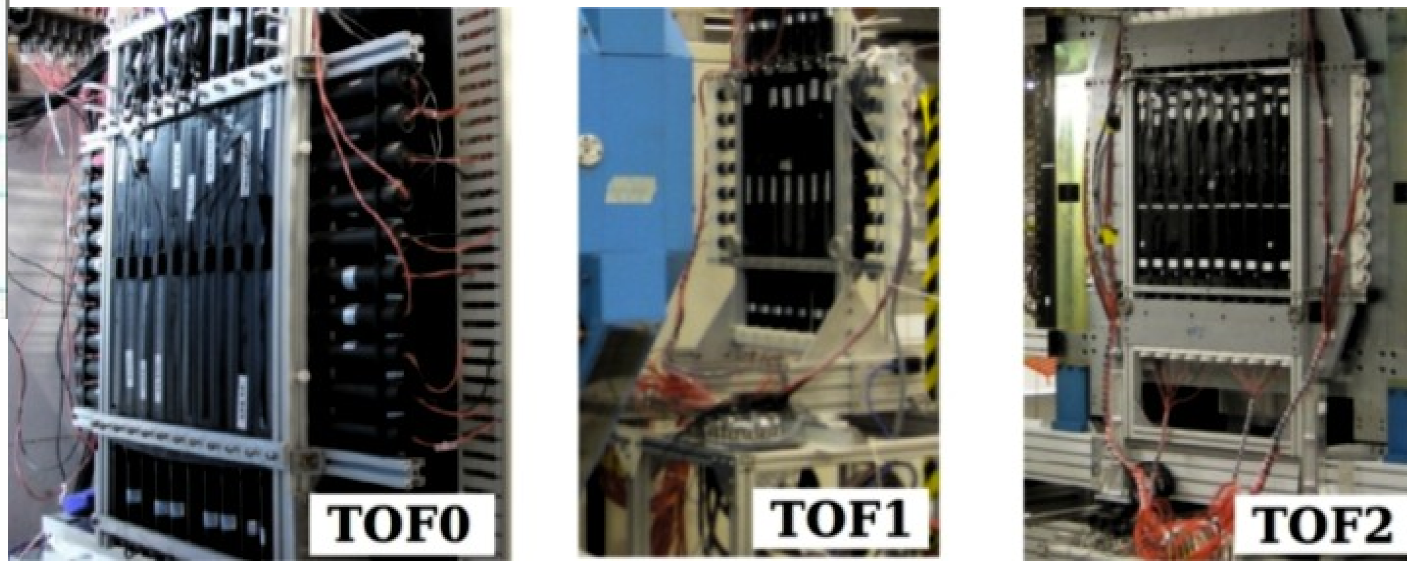
i. TOF2

ii. KLOE-light, KL

iii. Electron Muon Ranger, EMR

TOF Detectors

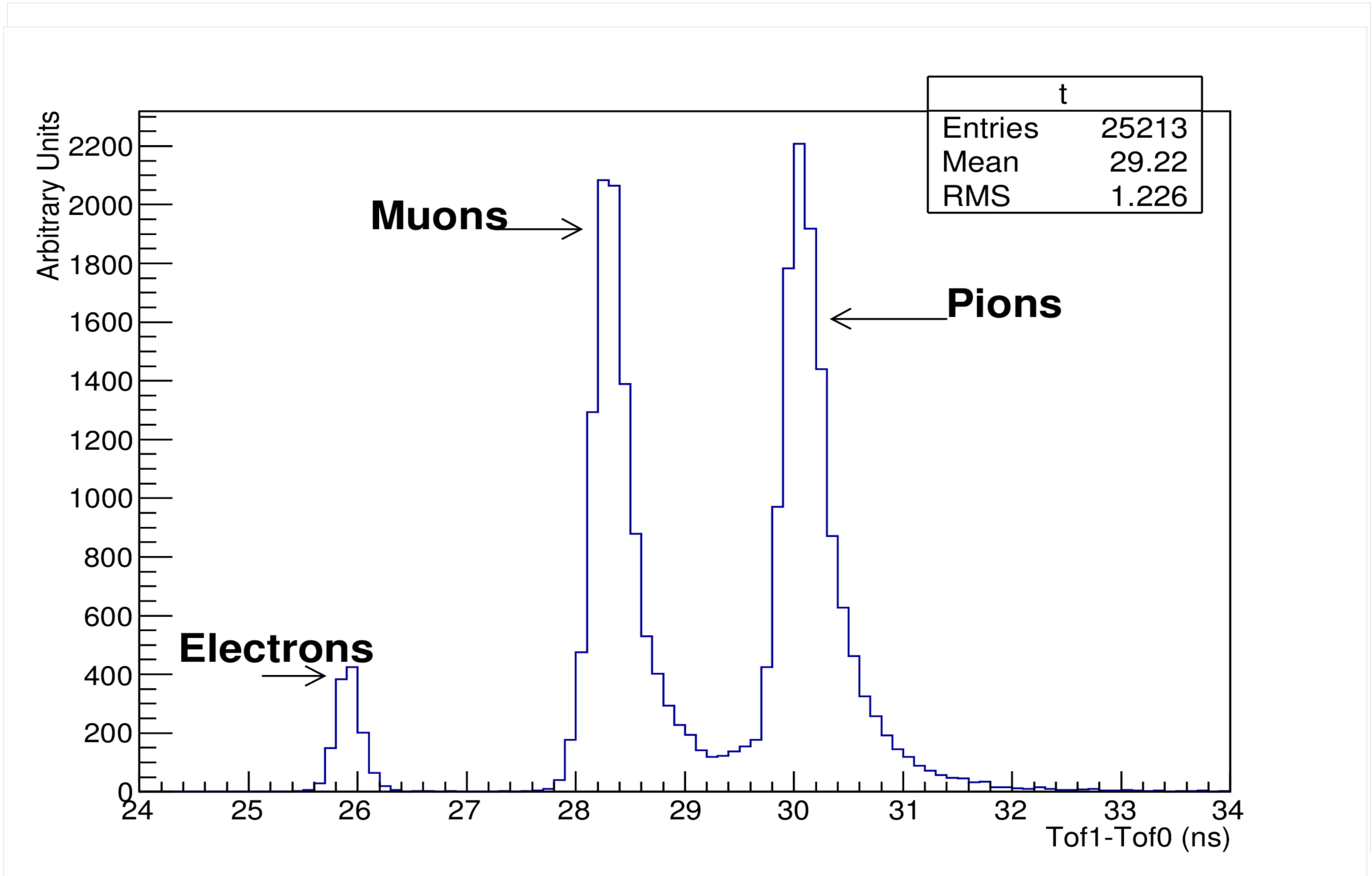




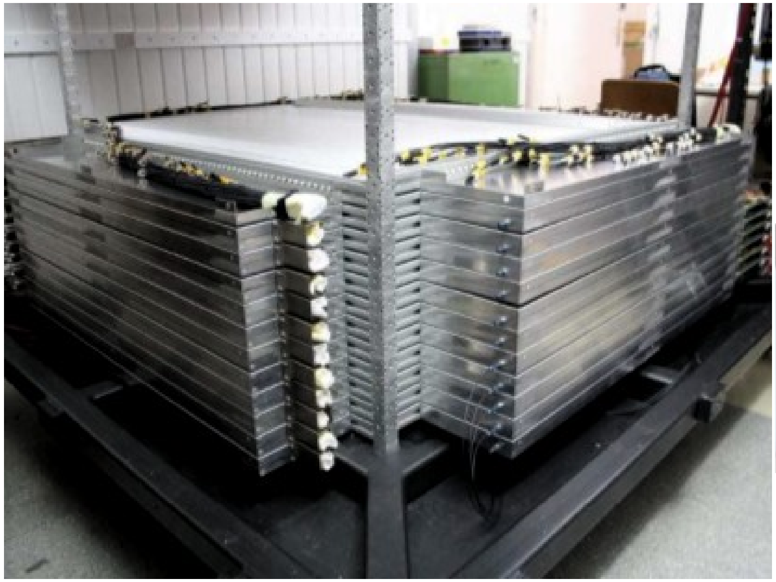
Images from D. Rajaram's Map Meeting Talk

- Two planes with vertical and horizontal scintillating slabs.
- Provide upstream and downstream PID.
- Precise timing measurement with respect to the RF.
- Used for experimental trigger.

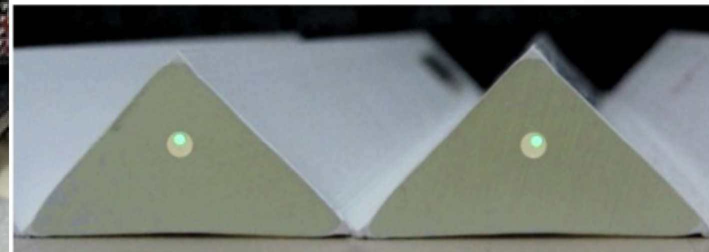
TOF0 → TOF1

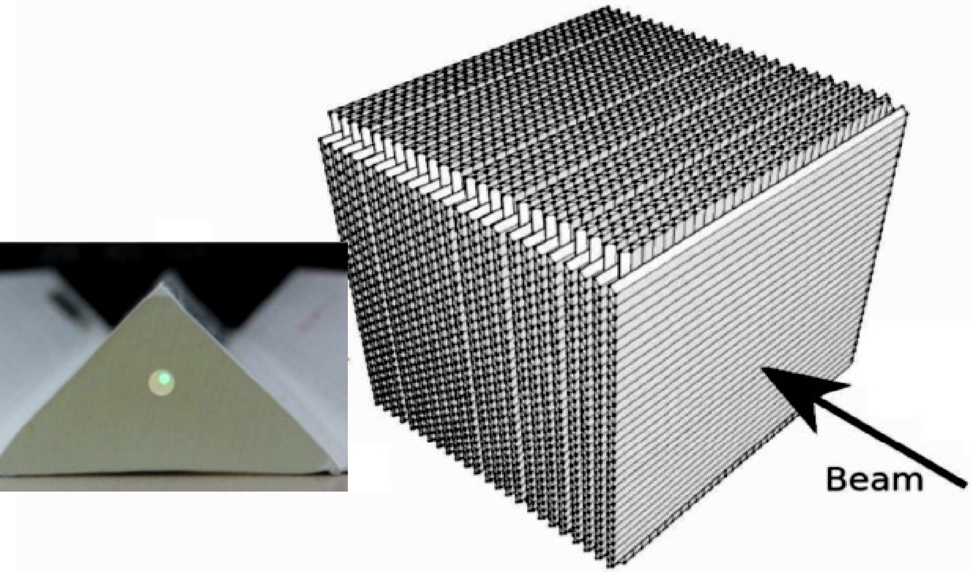


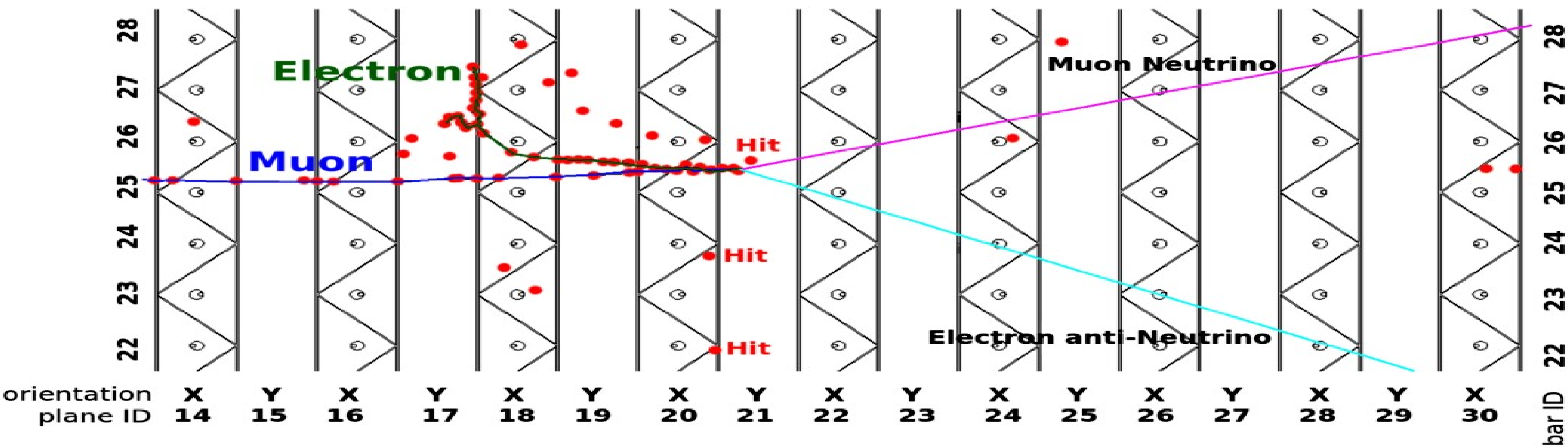
- Run # 7236 → 300 MeV/c positive reference pions with TOF1 trigger and no SSD and SSU.
- Distinct electron, muon and pion peaks. Time of flight of electrons ~26ns, of muons ~ 29ns and of pions ~30ns.
- Time of flight information used as reference for PID variables in other detectors.



EMR



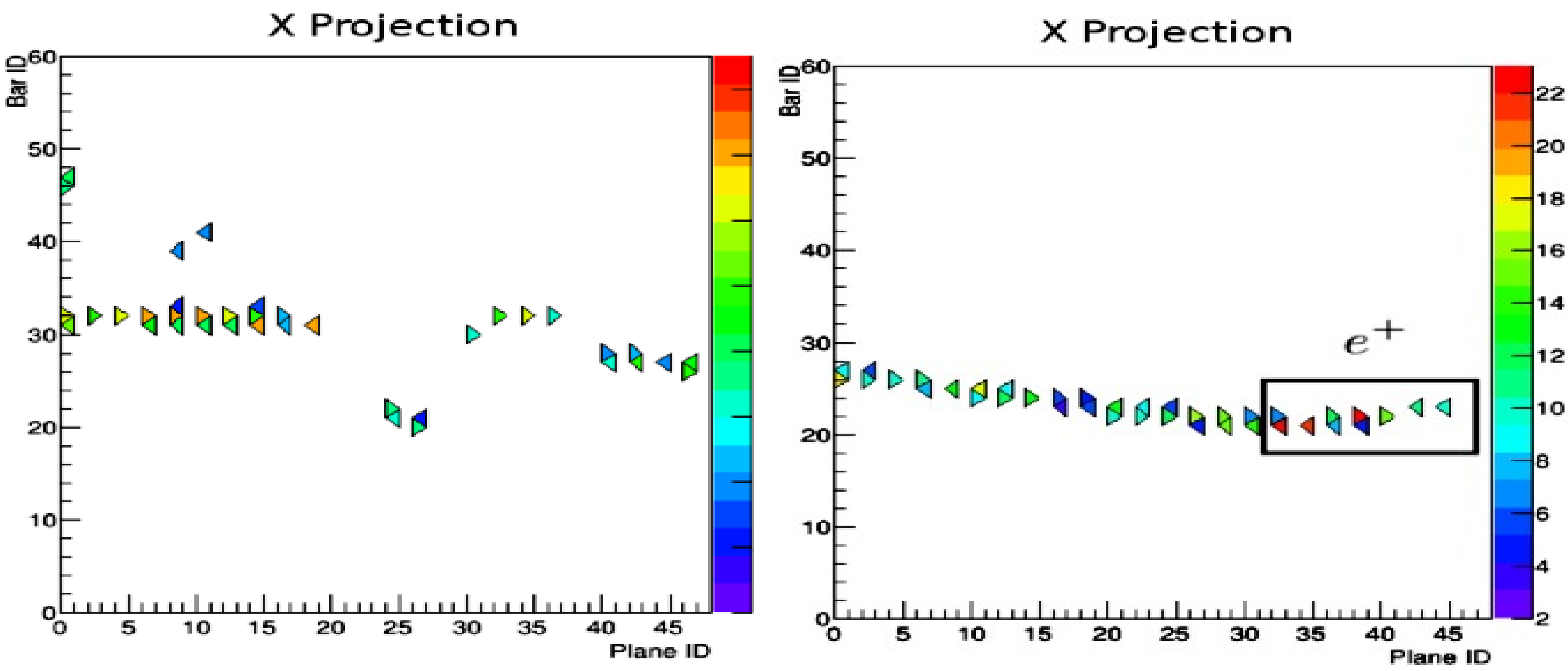




Images from Ruslan Asfandiyarov's CERN Thesis

- Important for distinction between electrons and muons in the MICE beam.
- 48 planes. 59 triangular scintillator bars per plane glued with wavelength shifting fiber.
- Bottom image → the cartoon of a typical event display in the EMR

Plots of Typical Event Displays in EMR



Plots from EMR paper by F. Drielsma et.al

- On the left, EMR electron shower event display in terms of the energy deposited.
- On the right, we have EMR muon track decaying into electron in term of energy deposition is displayed.

EMR PID Variables

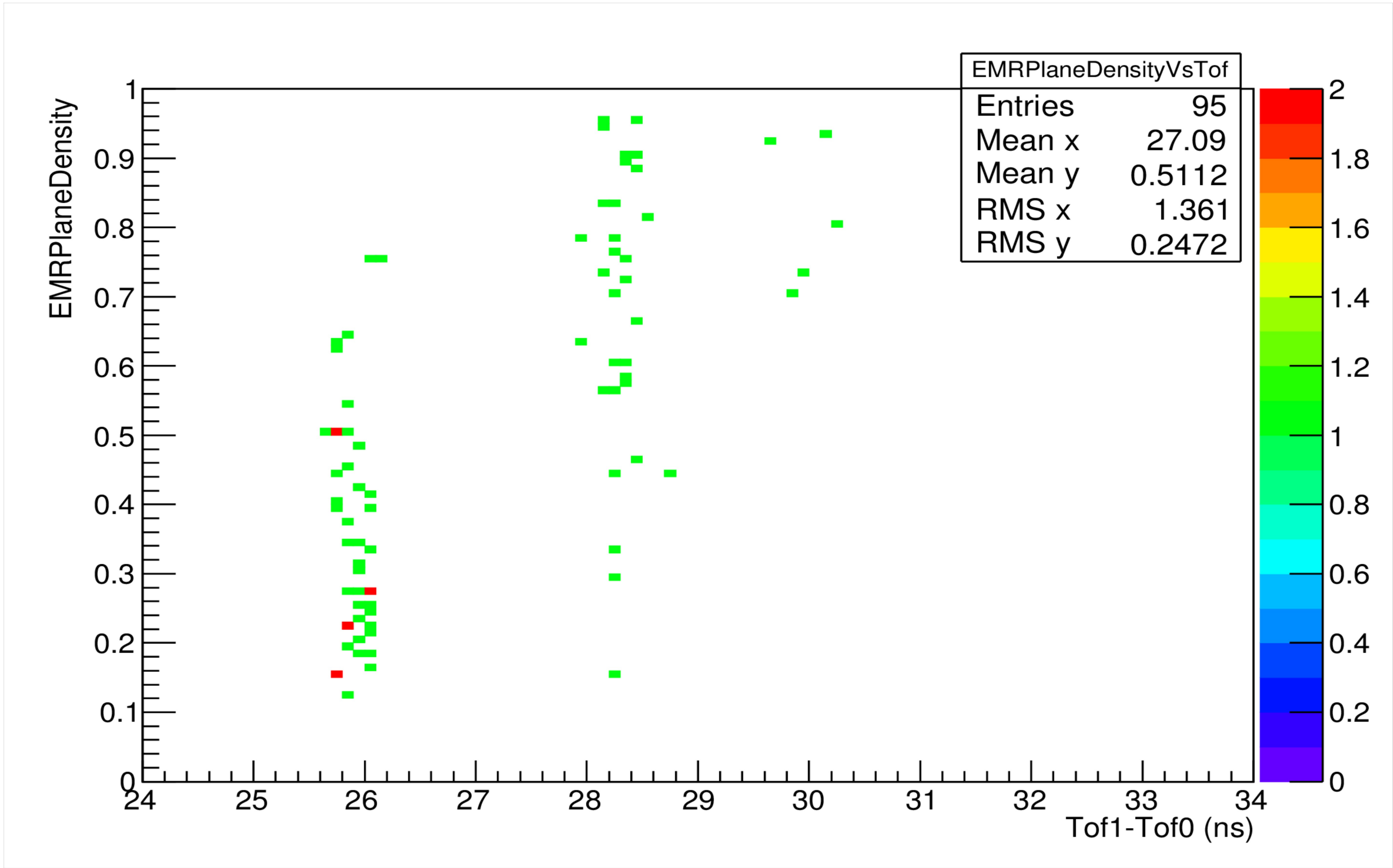
- **Plane Density:**
- Electron showers and muon tracks have different track topologies → electrons have multiple and disconnected tracks, and muons deposit consistent hits in planes along their path.
- N_x and N_y, number of plane hits in the x and y projections, and Z_x and Z_y, the most downstream plane hits in the x and y projections.

$$\rho = \frac{N_x + N_y}{Z_x + Z_y}$$

- **Primary range:**
- The track length of the incoming muons and electrons in the MICE beam
- Good PID variable for the straight muon tracks. Less precise for electron showers.
- Calculated by looking at the last plane hit in the EMR.
- **Chi2**:
- Sum of the Chi2 of the linear least square fit in the x and y plane projections.
- Small Chi2 for muons, and large Chi2 for electrons.

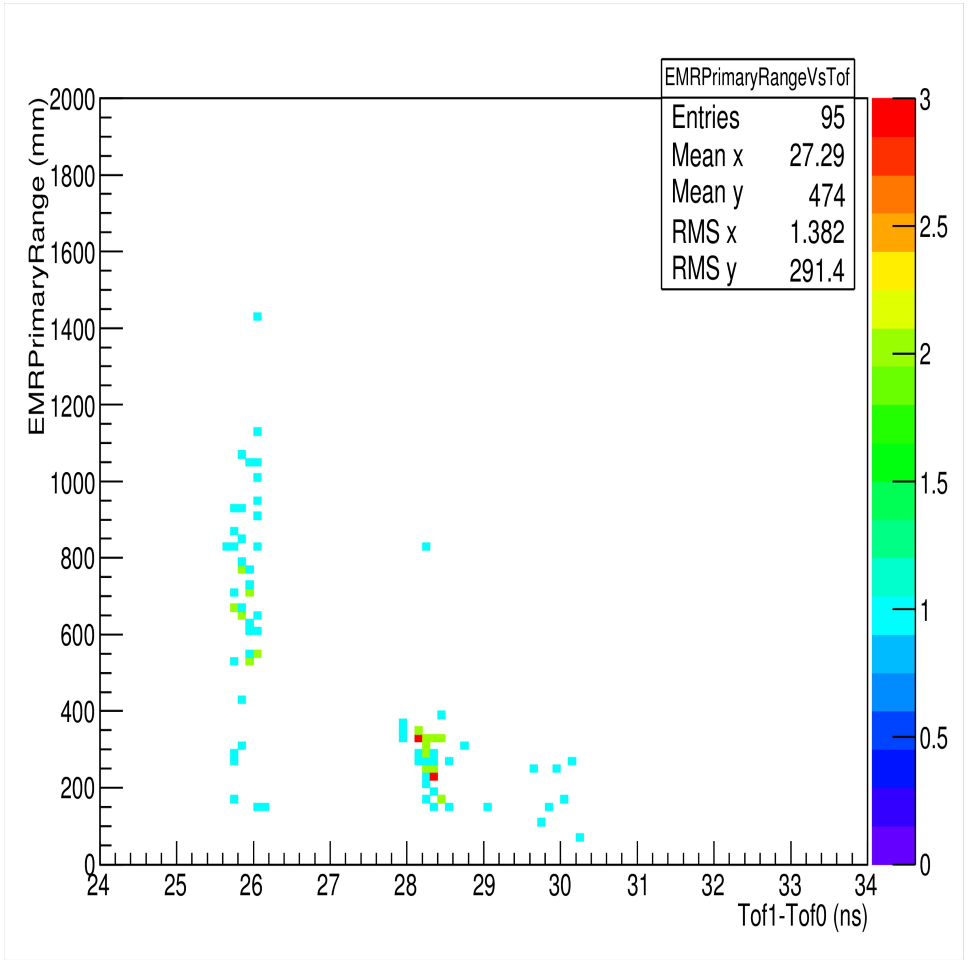
$$\frac{\chi^2}{N} = \sigma_y^2 \left(1 - \frac{Cov(x,y)}{\sigma_x \sigma_y}\right)$$

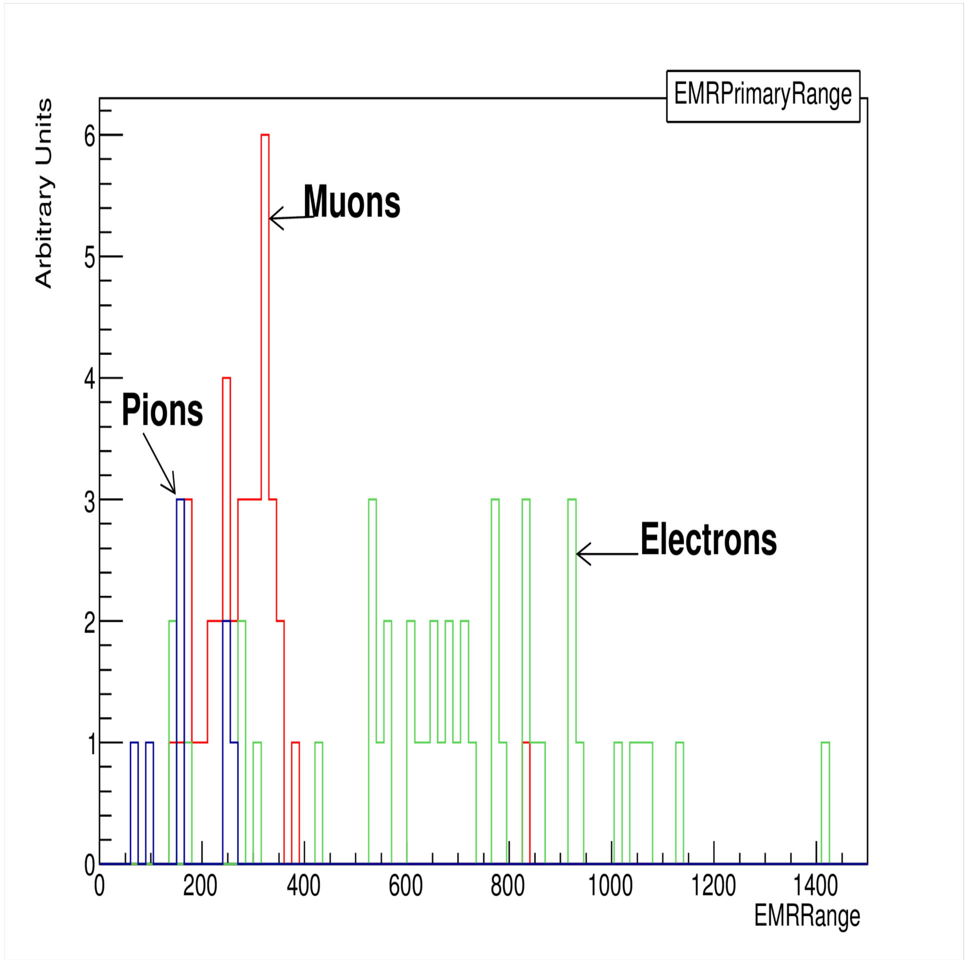
EMR Plane Density Vs. TOF



- Muon show plane density values closer to 1.
- Electrons are more densely populated at smaller plane density values.

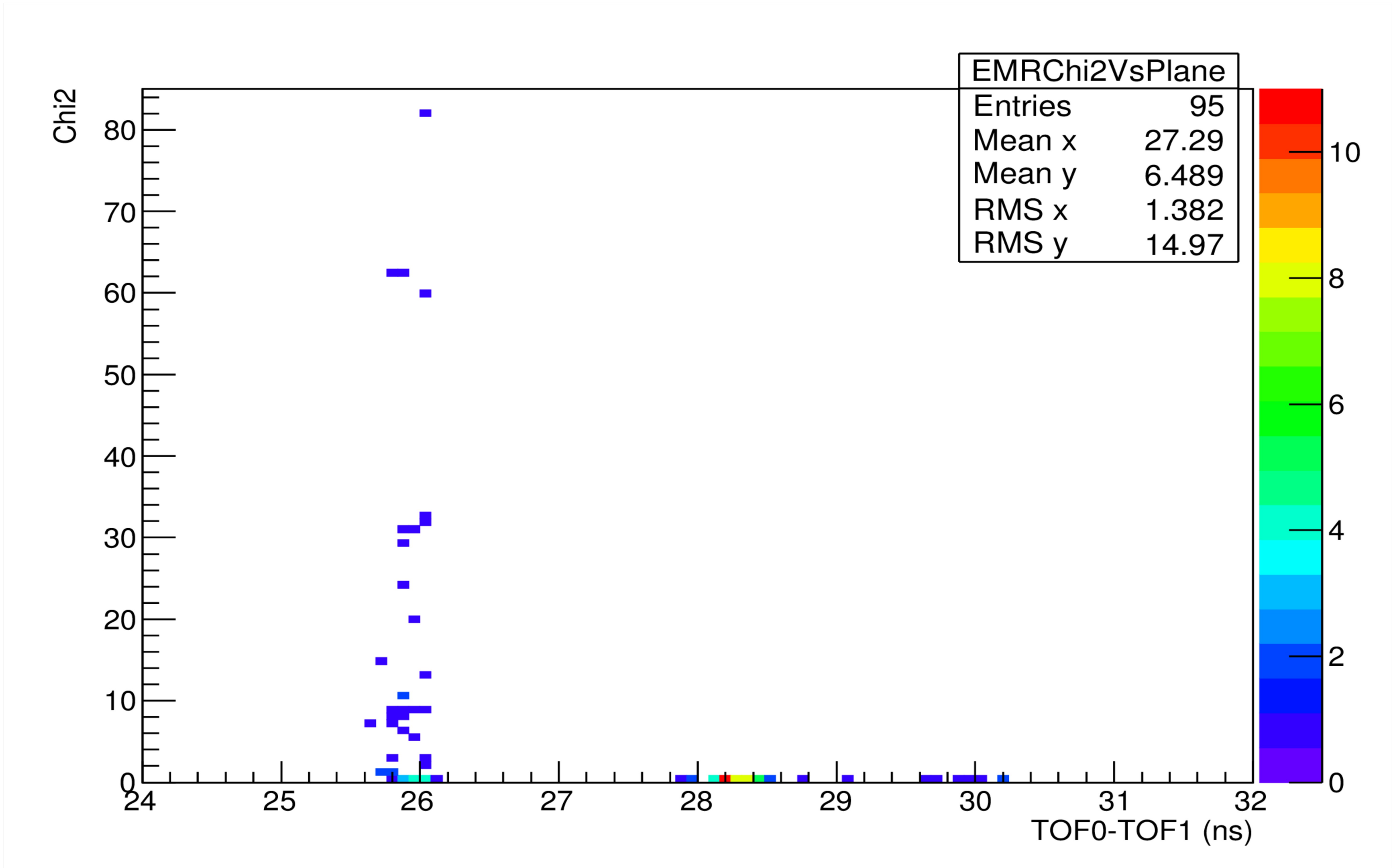
EMR Primary Range Plots





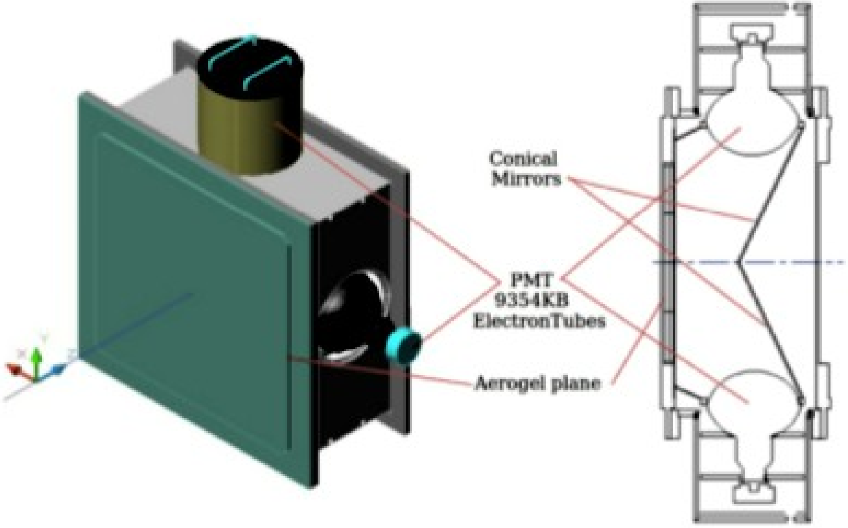
- Muons have a more well-defined range.
- Electrons have a more spread-out range.

Chi2 Vs TOF



- Muon sample has small Chi2, populated close to 0.
- Electrons have large Chi2 distributions.

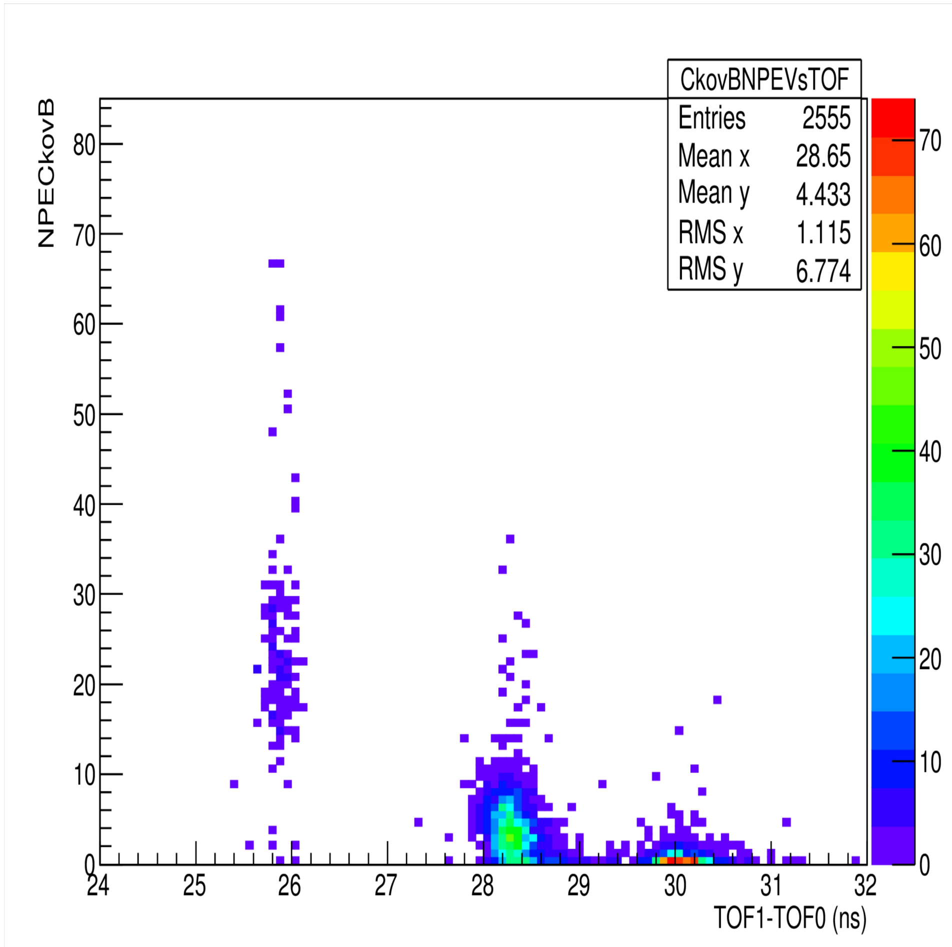
CkovA and CkovB

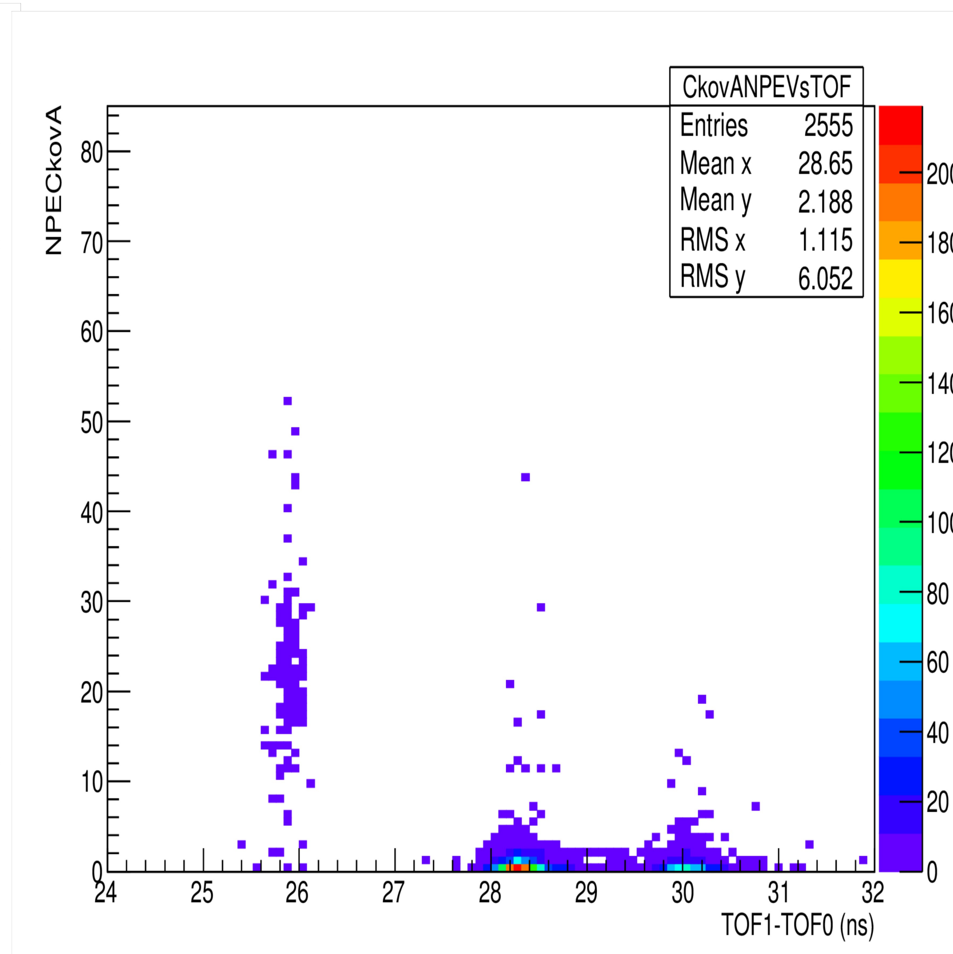


Images from D. Rajaram Winter MAP meeting

- Produces Cerenkov light in thick layer of Aerogel. PMTs connected at both ends.
- Muon and pion energy threshold CkovA and CkovB.

CkovA and CkovB NPE vs TOF





- Pions below threshold in both Ckovs.
- More muon-related NPEs in CkovB.
- Electrons give light in both counters. Electrons due to delta rays.

Looking Ahead

- Similar PID analysis with helical track data.
- Incorporate momentum information for the different particle species in MICE beam.
- Make use of other Cerenkov variables to do further PID analysis with Cerenkov detectors.
- PID analysis using the KL detector.