SoLID EC

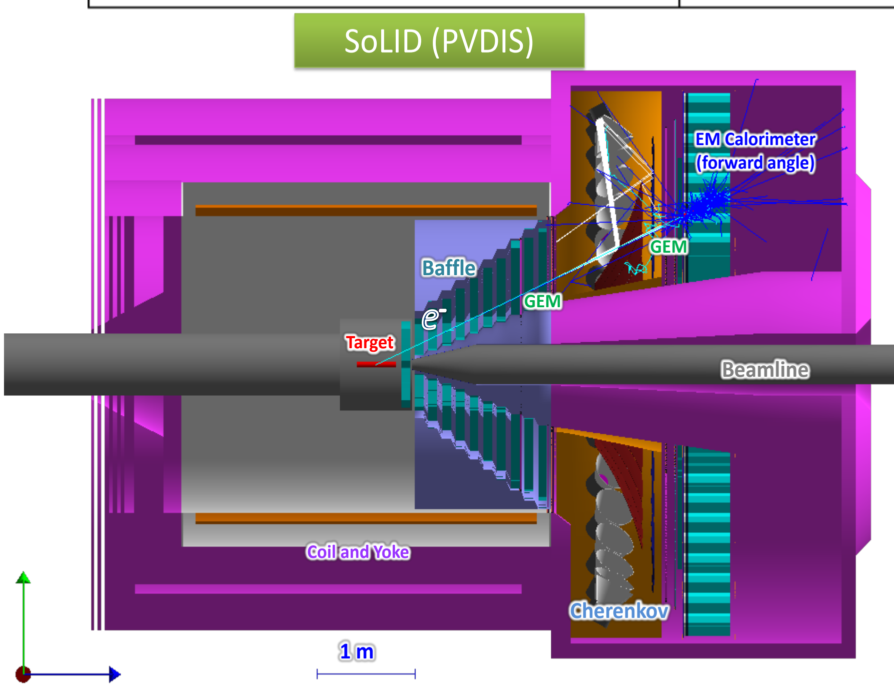
11/30/2021

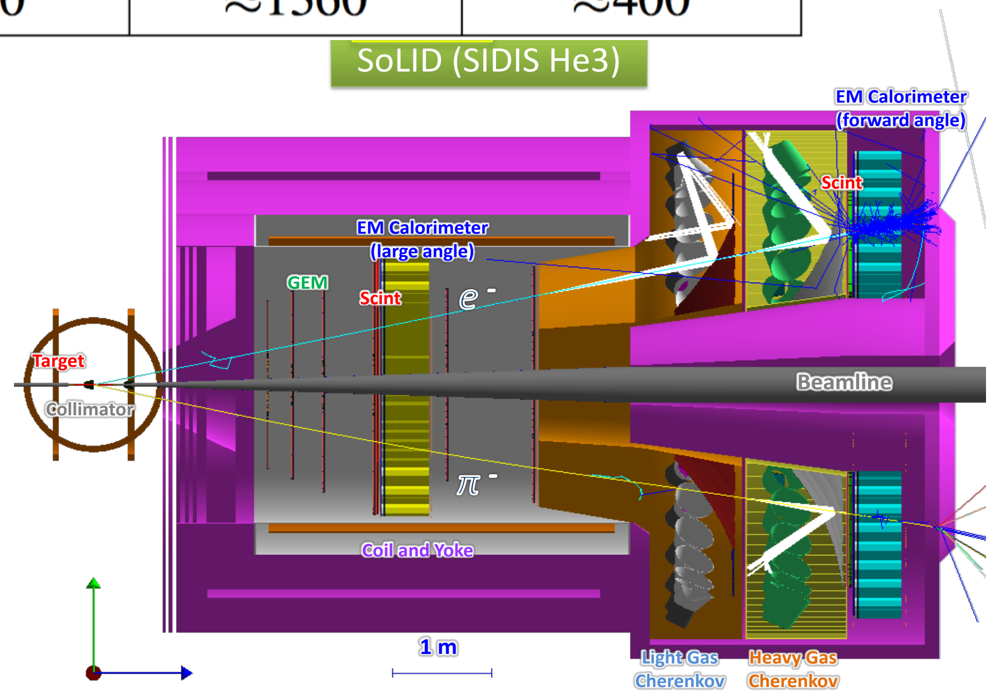
- Separate electron from pions and other hadrons
- Trigger capability
- Shower position measurement

EM Calorimeter Overview

- EM Calorimeter is used for PID, triggering, and background suppression.
- It is divided into large- and forward-angles in SIDIS configuration.

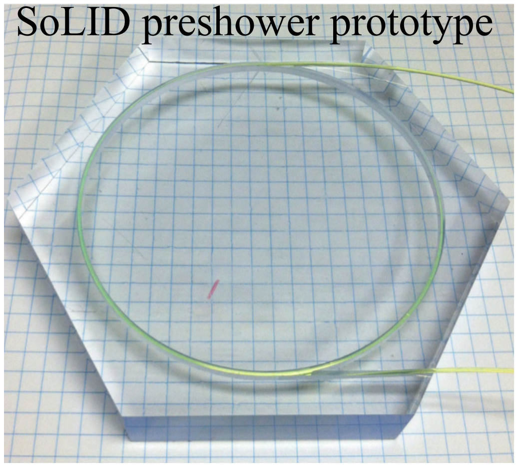
	PVDIS FAEC	SIDIS FAEC	SIDIS LAEC
z (cm)	(320, 380)	(415, 475)	(-65, -5)
Polar angle (degrees)	(22,35)	(8,15)	(16.3, 24)
Azimuthal angle	Full coverage		
Radius (cm)	(110, 265)	(98, 230)	(83, 140)
Coverage area (m^2)	18.3	13.6	4.0
Total number of channels	≈1830	≈1360	≈400

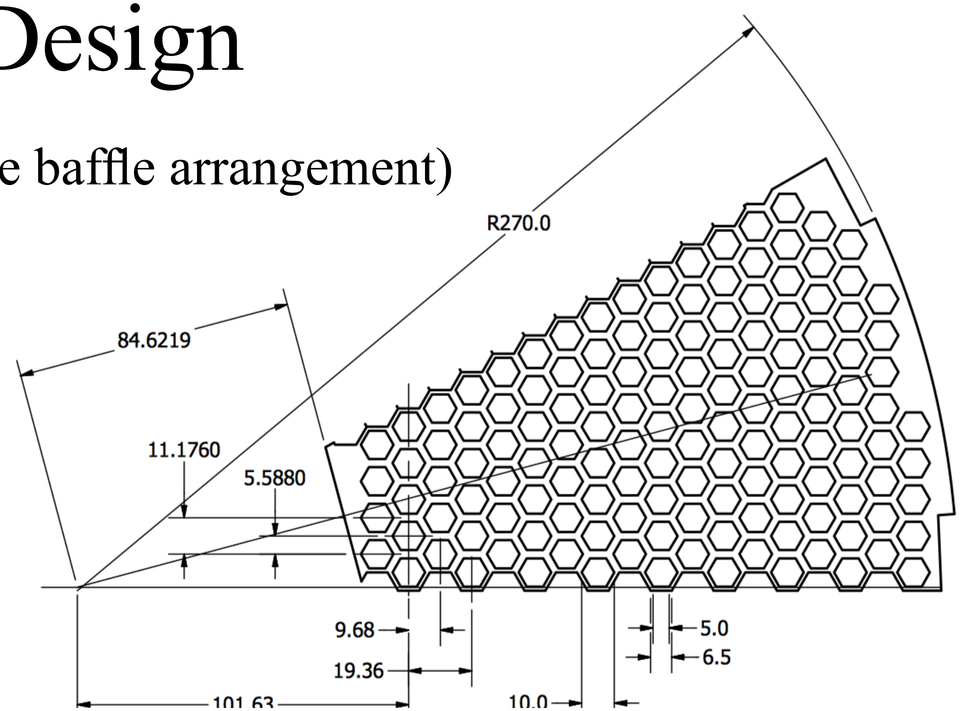


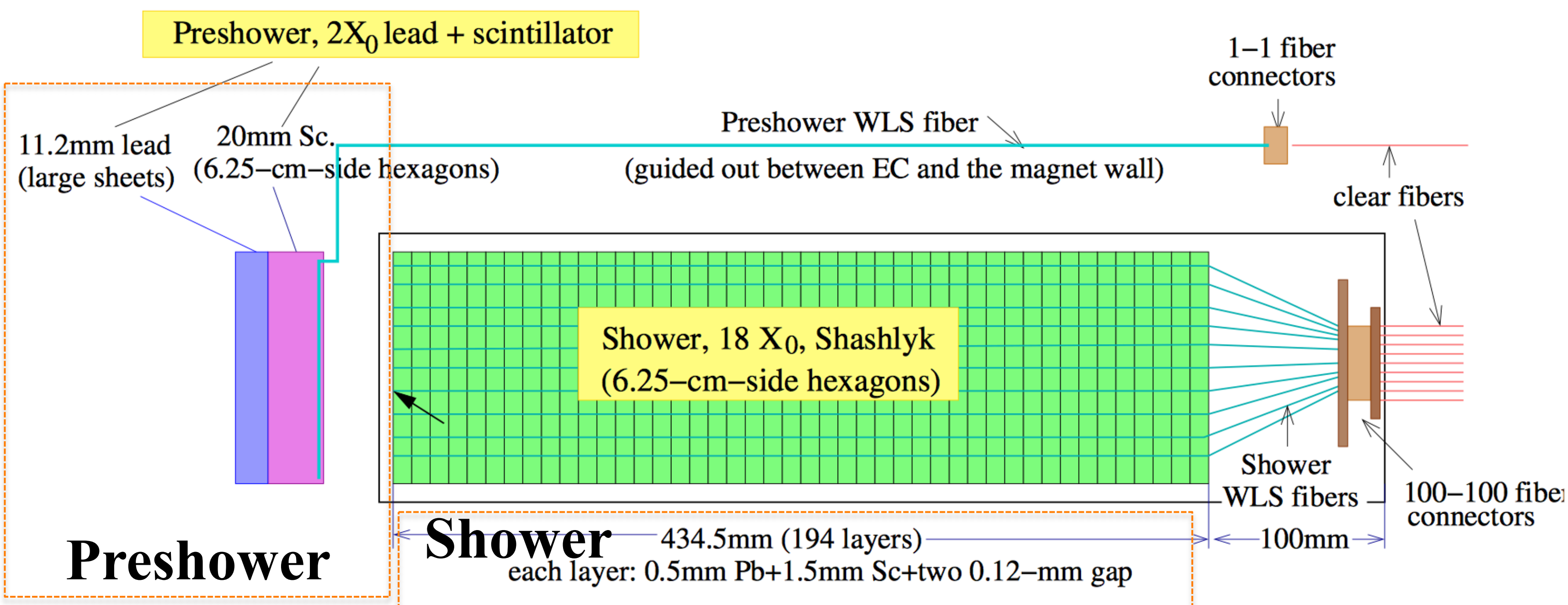


EC Design

- PVDIS 30 sectors (corresponding to the baffle arrangement)

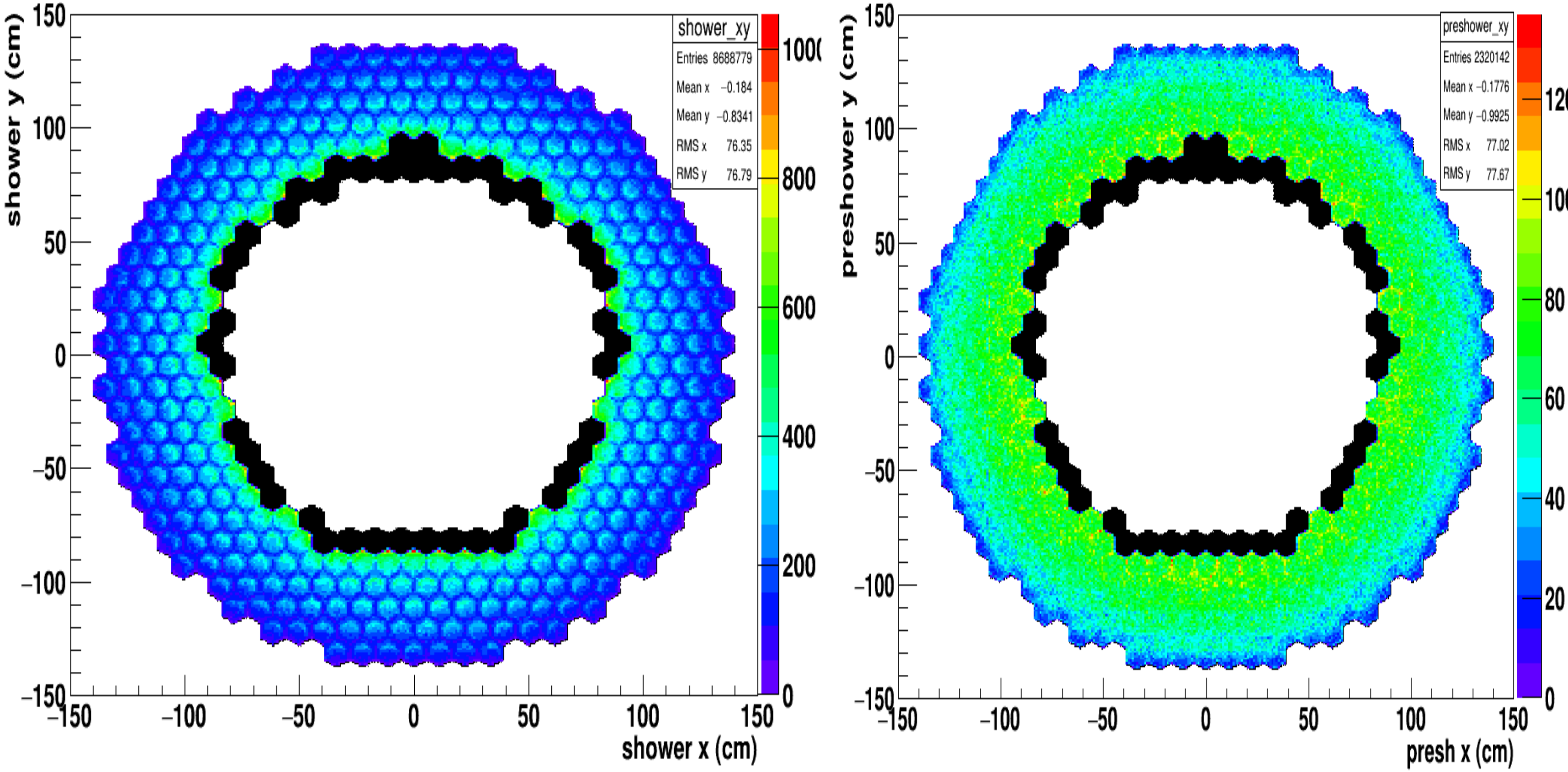






Simulation

GEMC---geant4



SIDIS: EC FA+LA only

EC Energy Calibration

$$\frac{E}{p} = \frac{E_{shower}^{total} + E_{preshower}^{total}}{P_{flux}}$$

$$= \frac{aE_{shower}^{scin} + bE_{preshower}^{scin}}{p_{flux}} \simeq 1$$

$$p_i = \boxed{a}X_i + \boxed{b}Y_i + \boxed{\varepsilon_i}$$

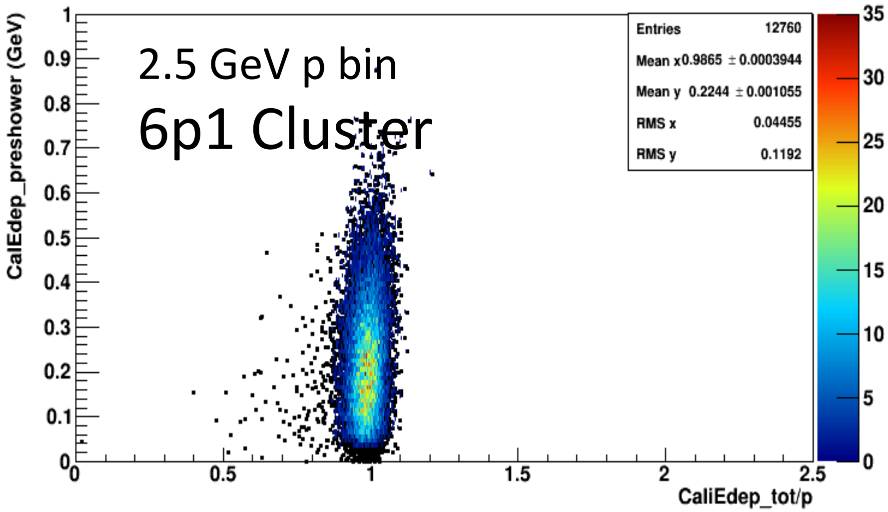
Calibration paramters

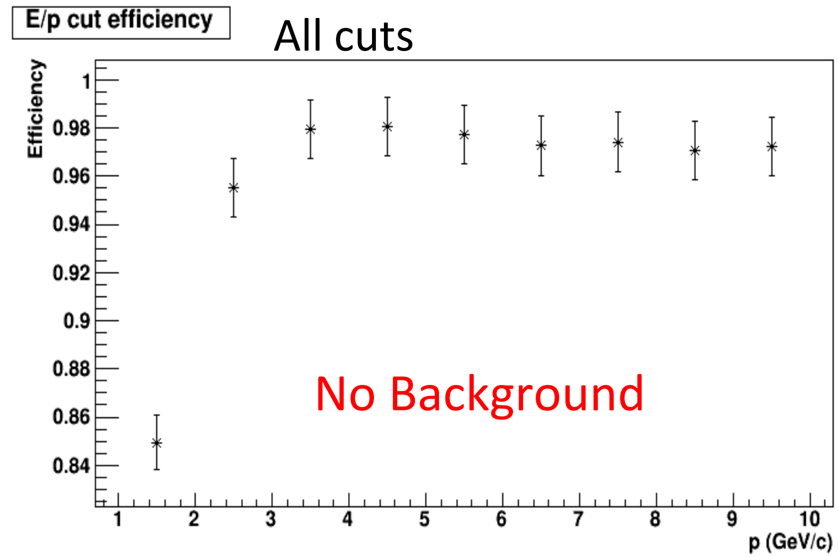
$$\text{f} = \sum_{i=1}^{N} \varepsilon_i^2 = \sum_{i=1}^{N} (p_i - aX_i - bY_i)^2$$

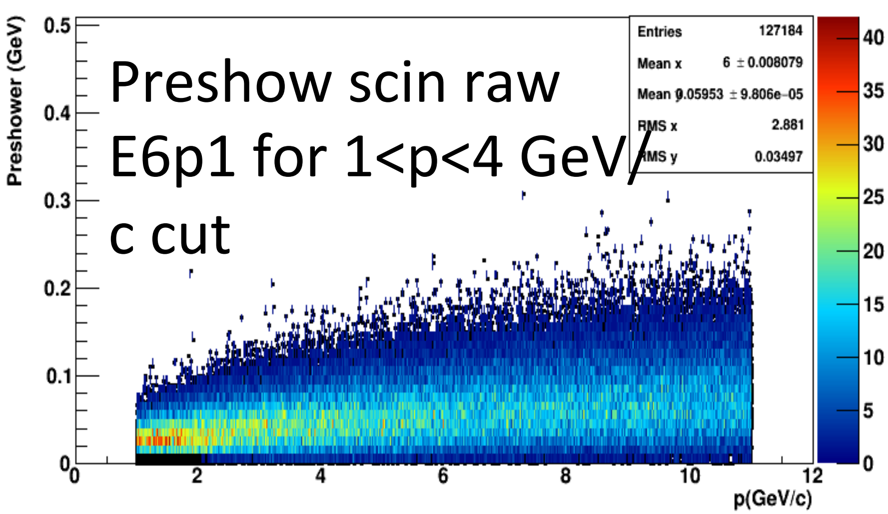
$$\frac{\partial f}{\partial a} = 0 \qquad \frac{\partial f}{\partial b} = 0$$

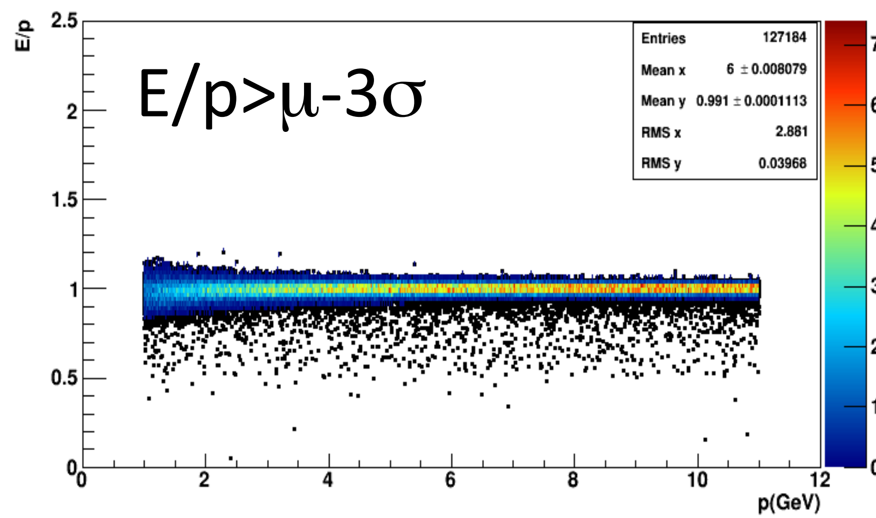
0-11 GeV e- beam, θ_e [7.5°,14.85°] SIDIS FAEC Configuration

Prelead: $2.0X_0$

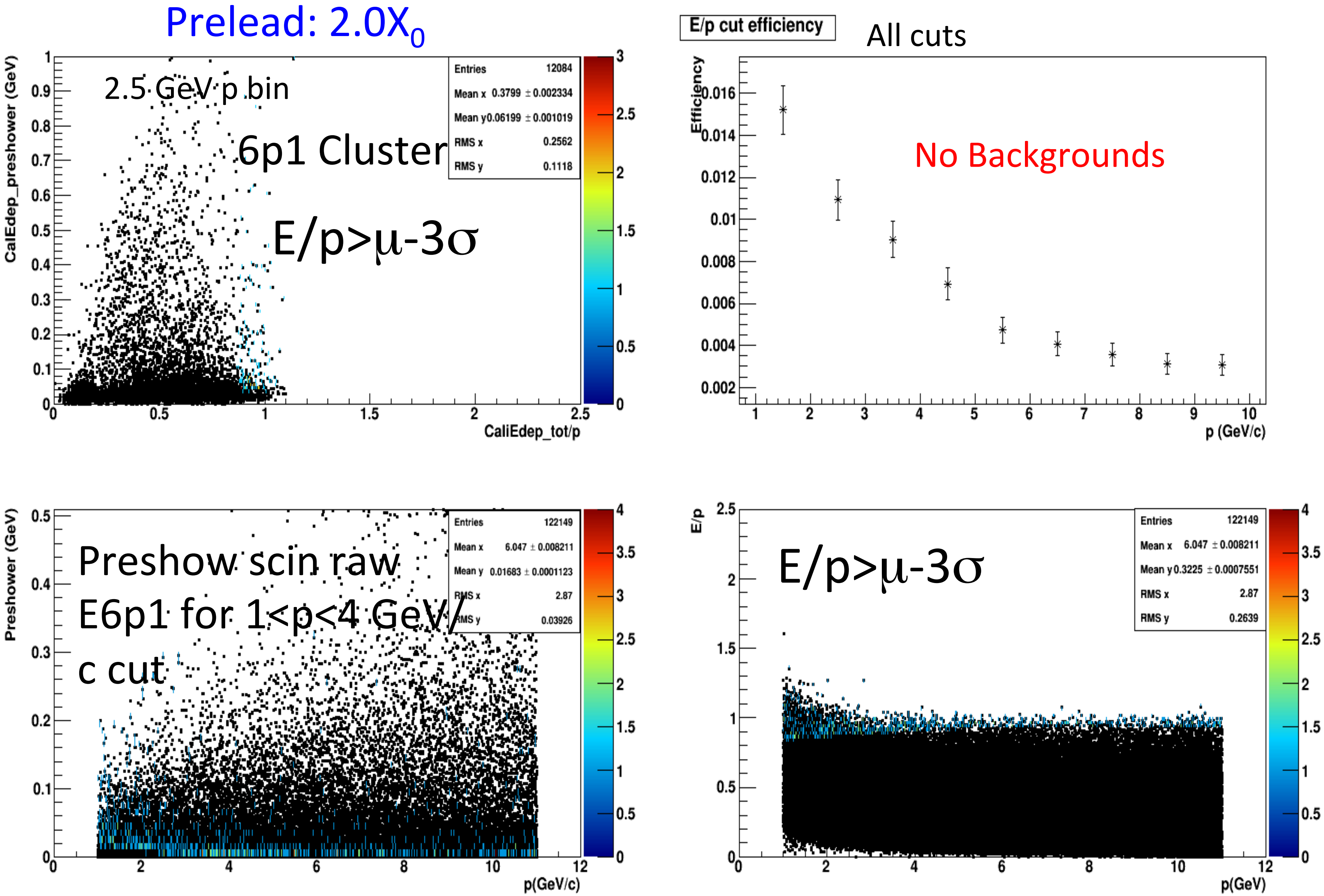








0-11 GeV π- beam, θ [7.5°,14.85°] SIDIS FAEC configuration



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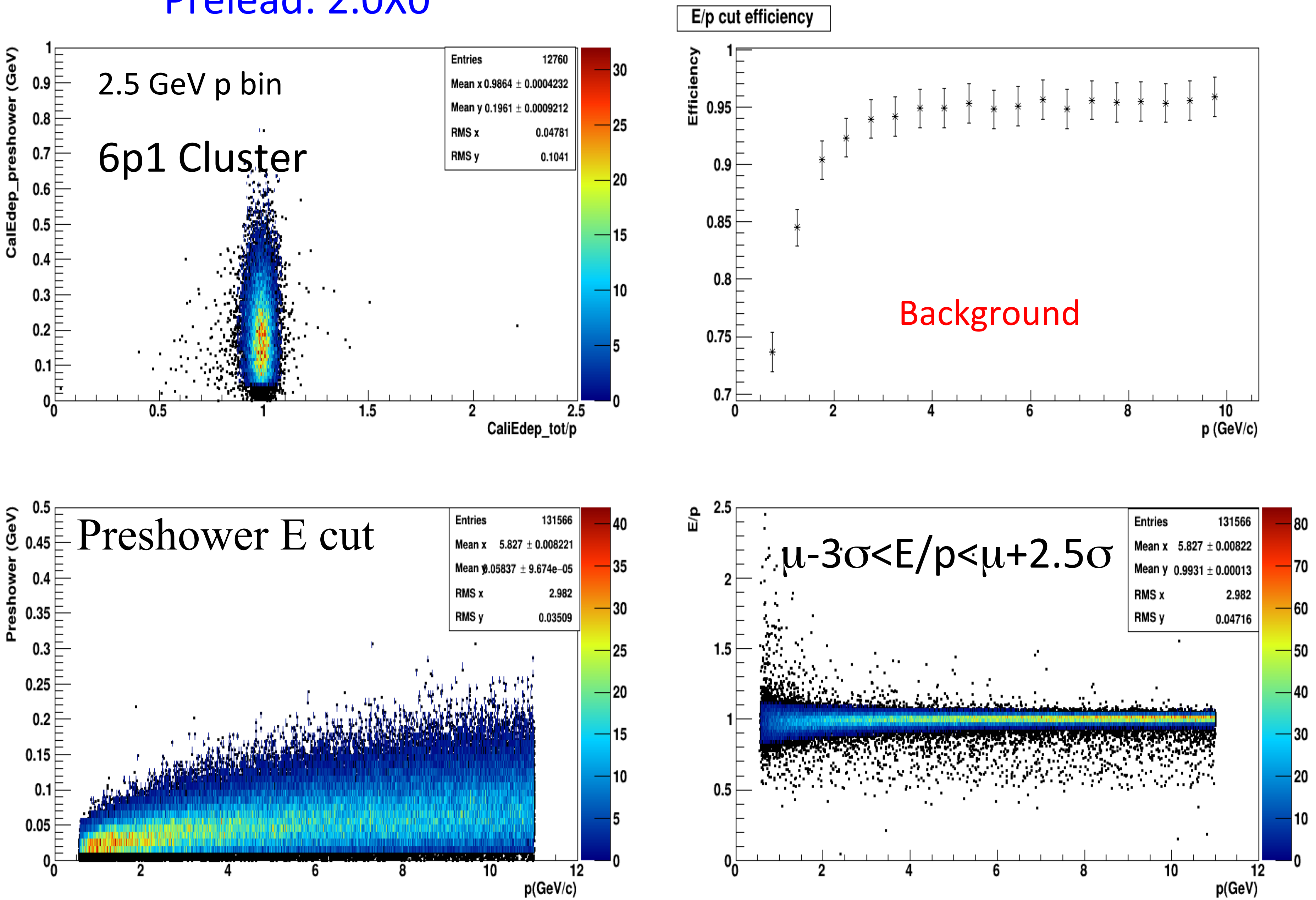

0-11 GeV π- beam, θ [7.5°,14.85°] SIDIS FAEC configuration

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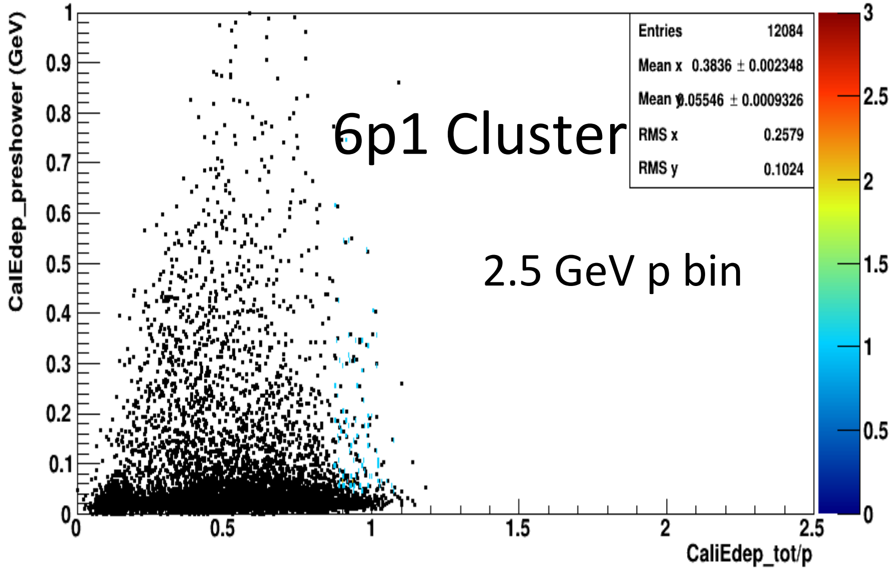
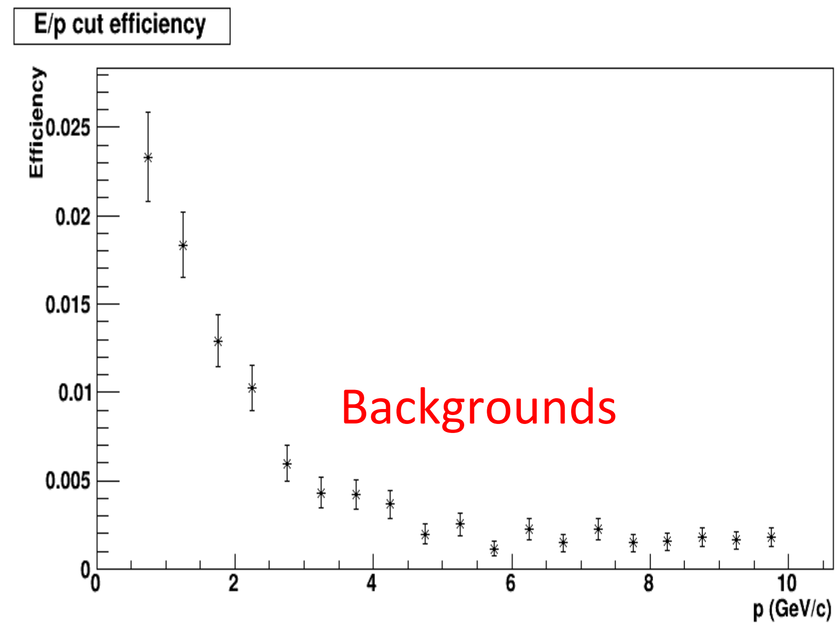
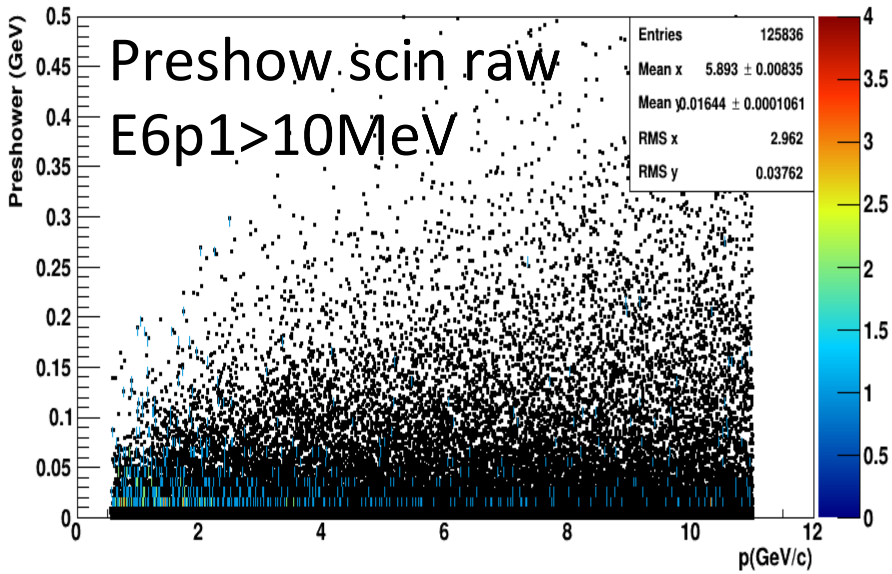
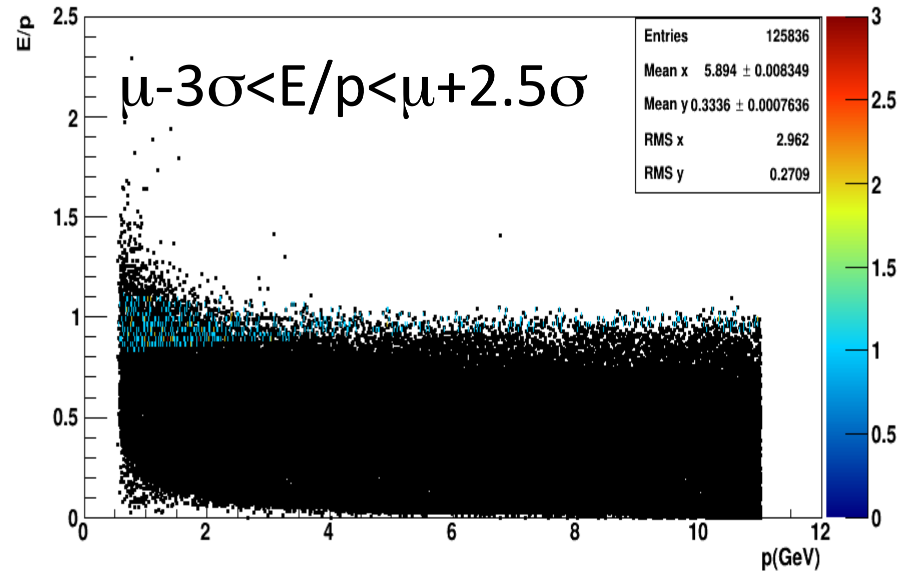


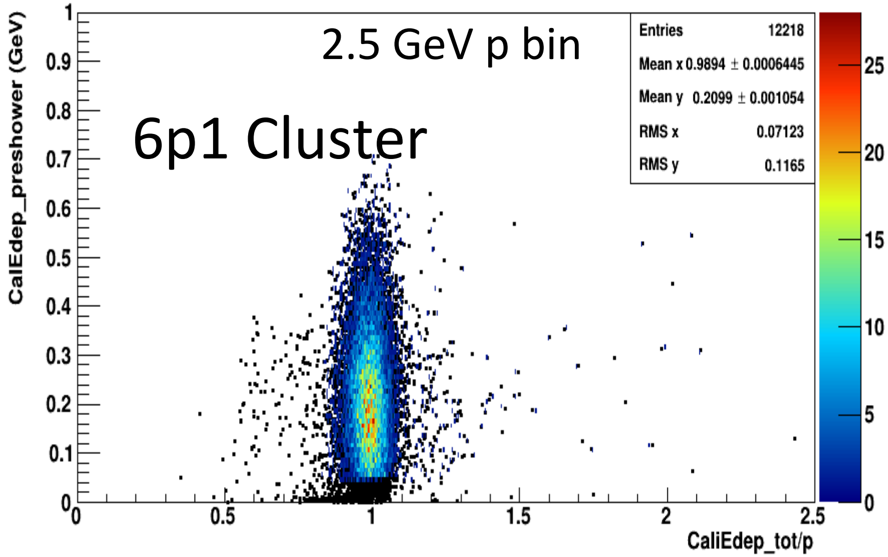


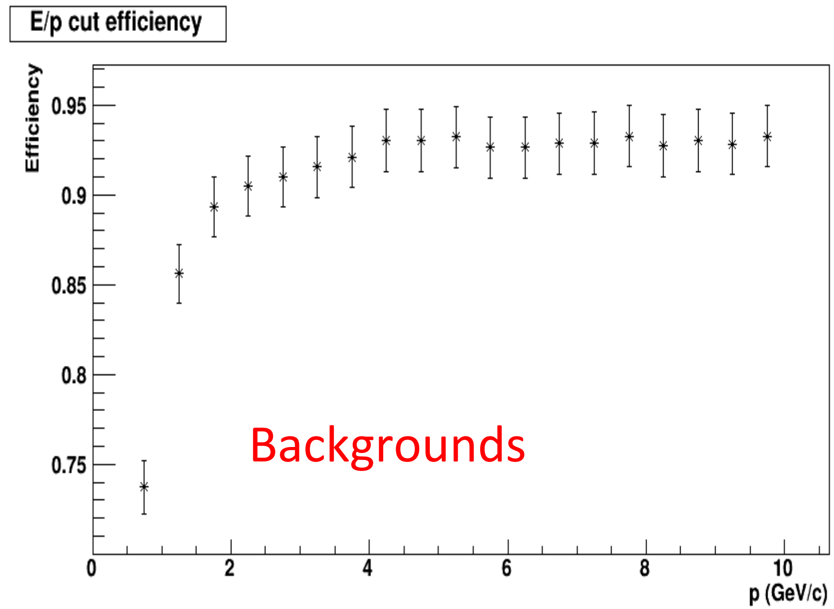


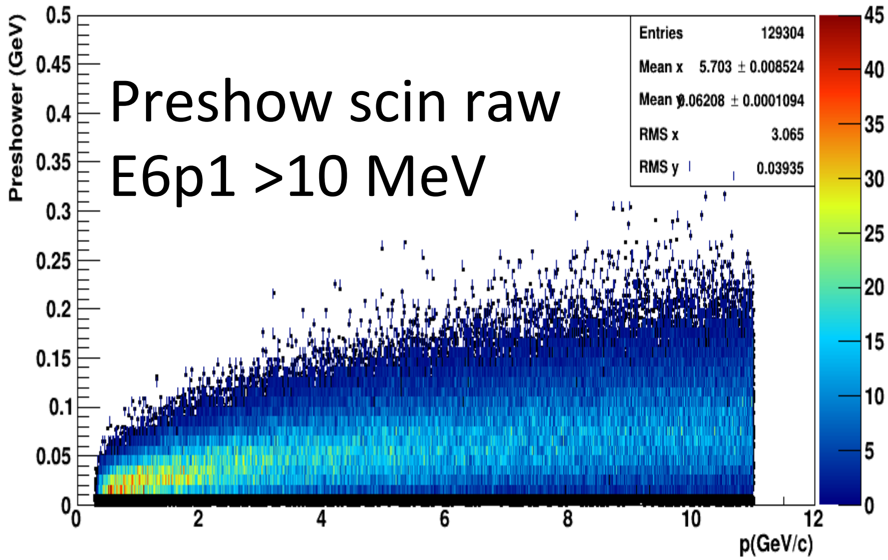


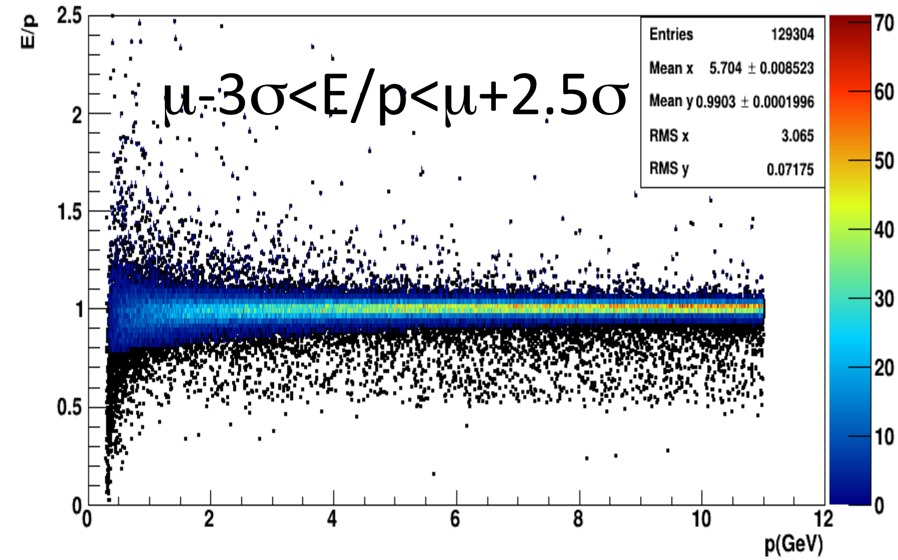
0-11 GeV e- beam, θe [18°, 22°] SIDIS LAEC Configuration

Prelead: 2.0X0



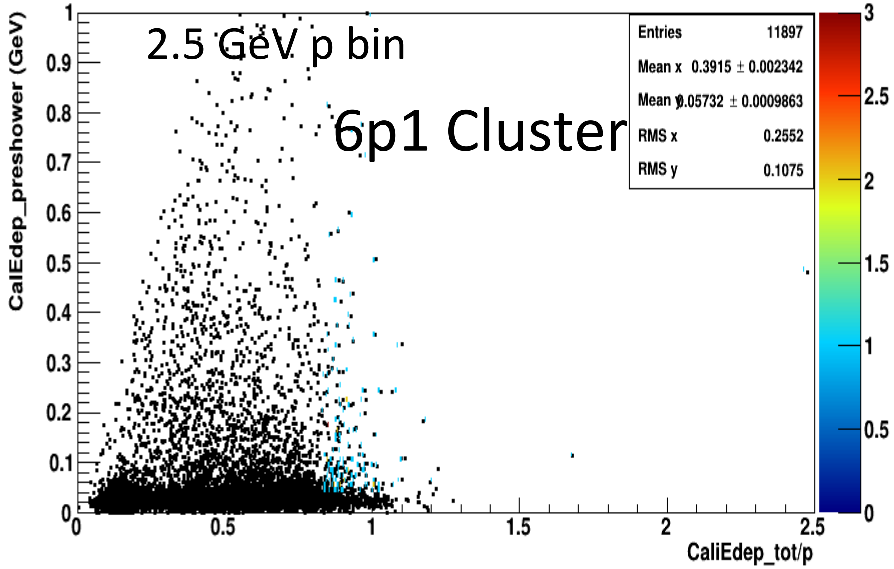


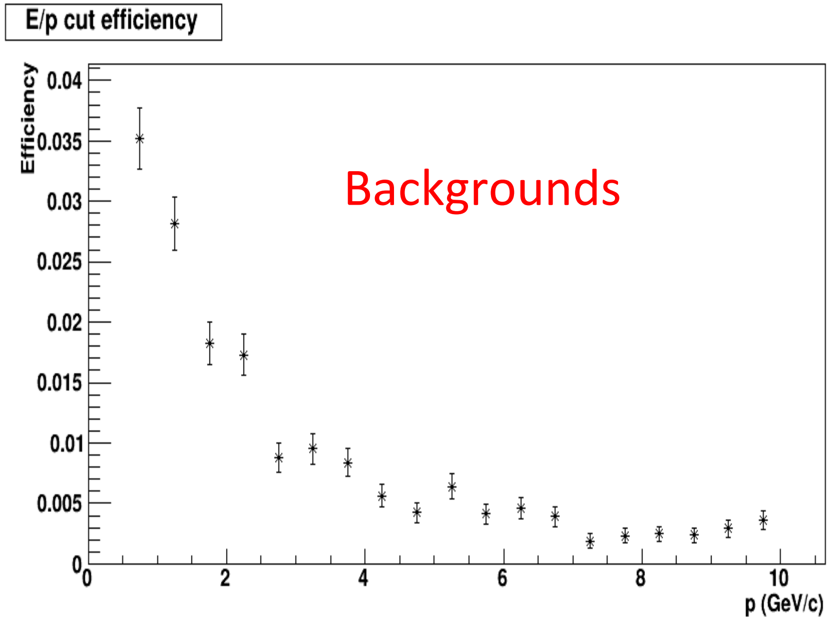


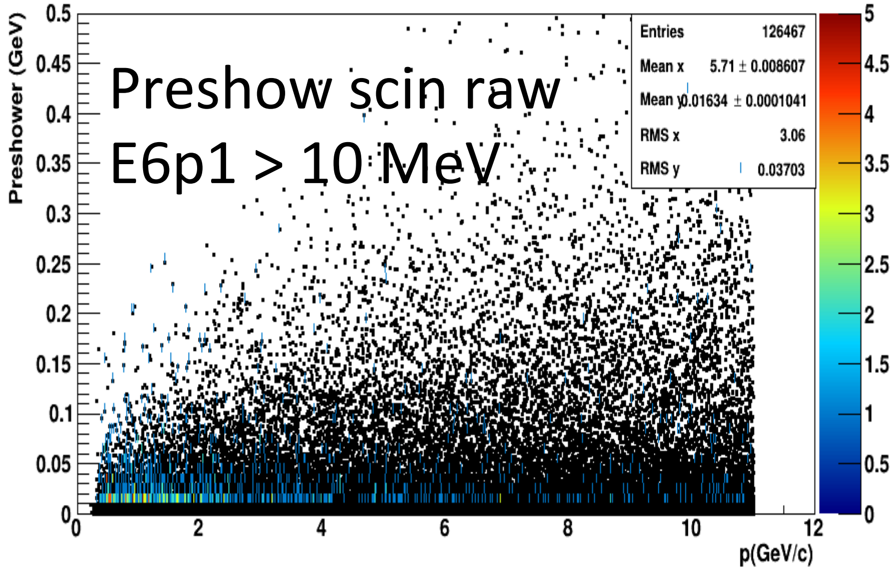


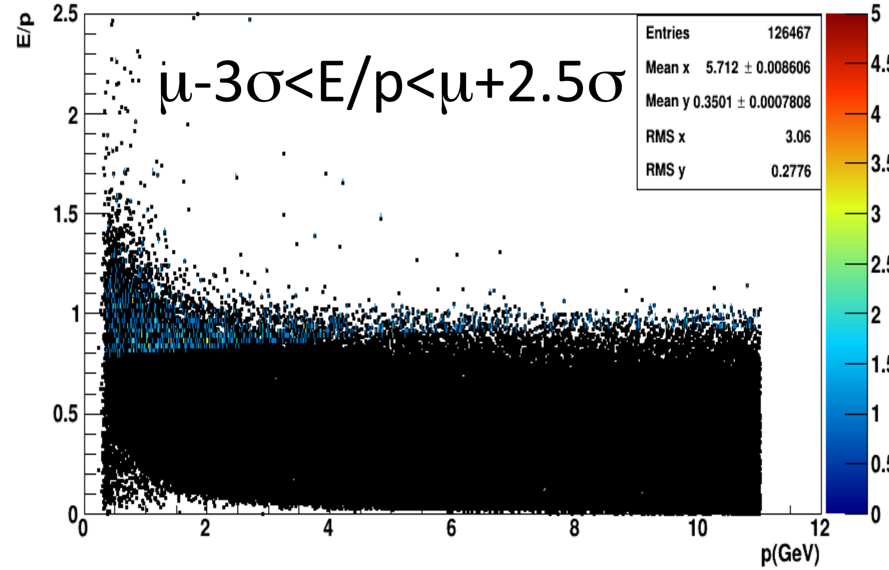
0-11 GeV π- beam, θ [18°,22°] SIDIS LAEC configuration

Prelead: 2.0X0









PID Performance Summary

	Desired performance
π^- rejection	$\gtrsim$[50:1]
e^- efficiency	$\gtrsim$90%
Energy resolution	$< 10\%/\sqrt{E}$
Radiation resistance	$\gtrsim$400 kRad
Position resolution	$\lesssim$1 cm

- With background contribution, PID performance from both FAEC and LAEC are:
  >50:1 π- rejection at 95% e efficiency for p>2GeV/C (FAEC)
  47:1 π- rejection at 85% e efficiency for 1<p<2 GeV/C (FAEC)
  >50:1 π- rejection at 95% e efficiency for p>4GeV/C and 85%-90% for 2GeV<p<4GeV (LAEC θ[18°,22°])

- By including the edge effect, the PID performance will be 10%-15% worse than that without the edge effect.

ECAL Trigger Capability

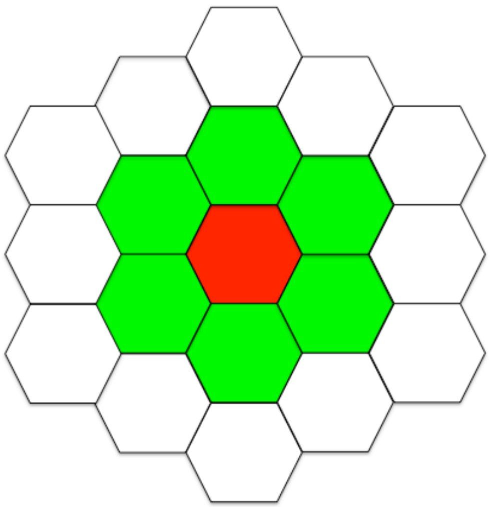
- **PVDIS (FAEC): 15kHz/sector, each with a separate trigger:** for each sector, the trigger will be a coincidence between the gas Cherenkov and electromagnetic calorimeter.

✓ electron trigger

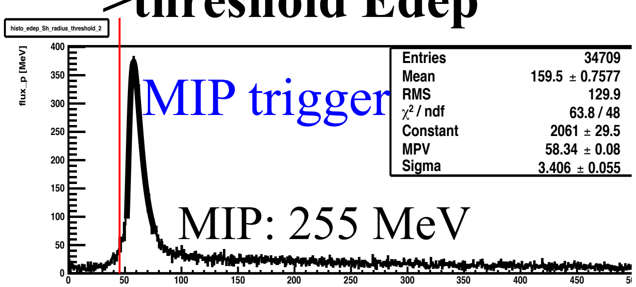
- **SIDIS (FAEC+LAEC): 100kHz:** FAEC: a coincidence of the gas Cherenkov detector, the E&M calorimeter, the scintillator paddle detector (SPD). LAEC: ECAL+SPD

✓ Electron trigger

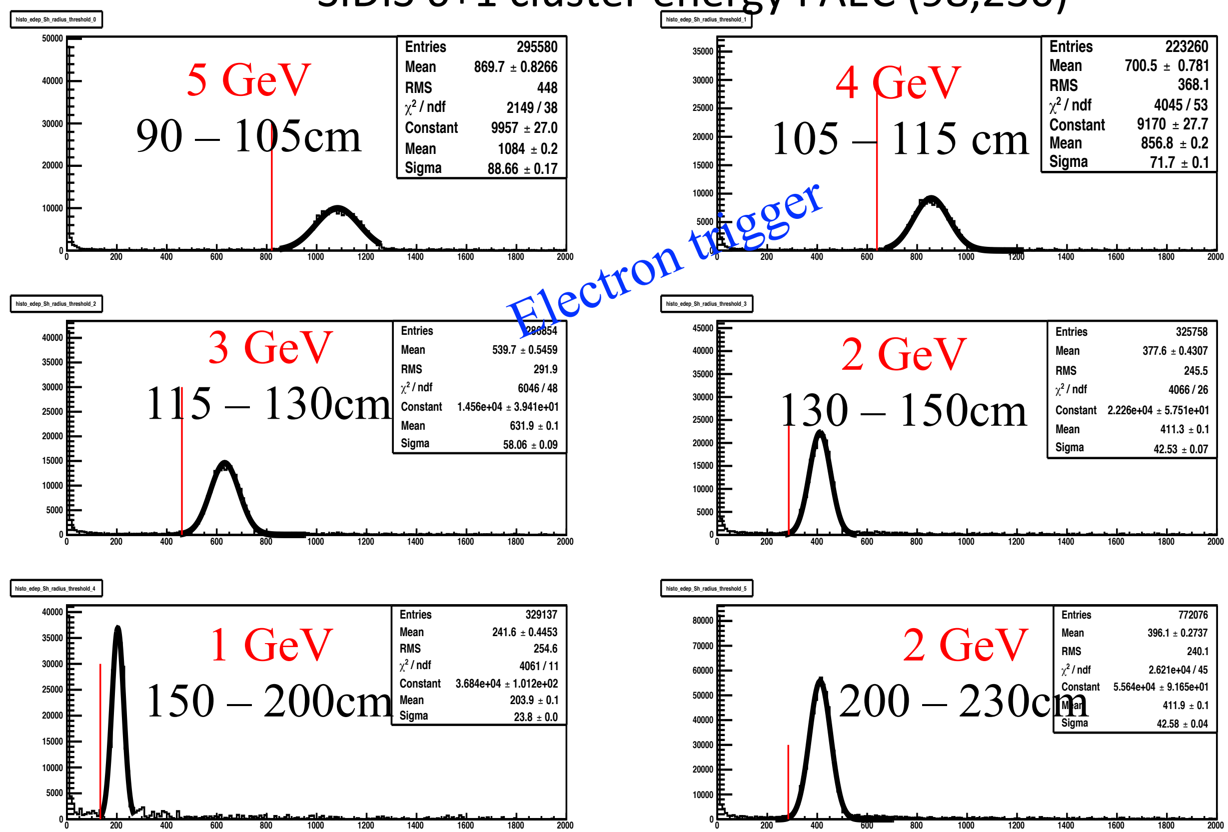
✓ MIP trigger



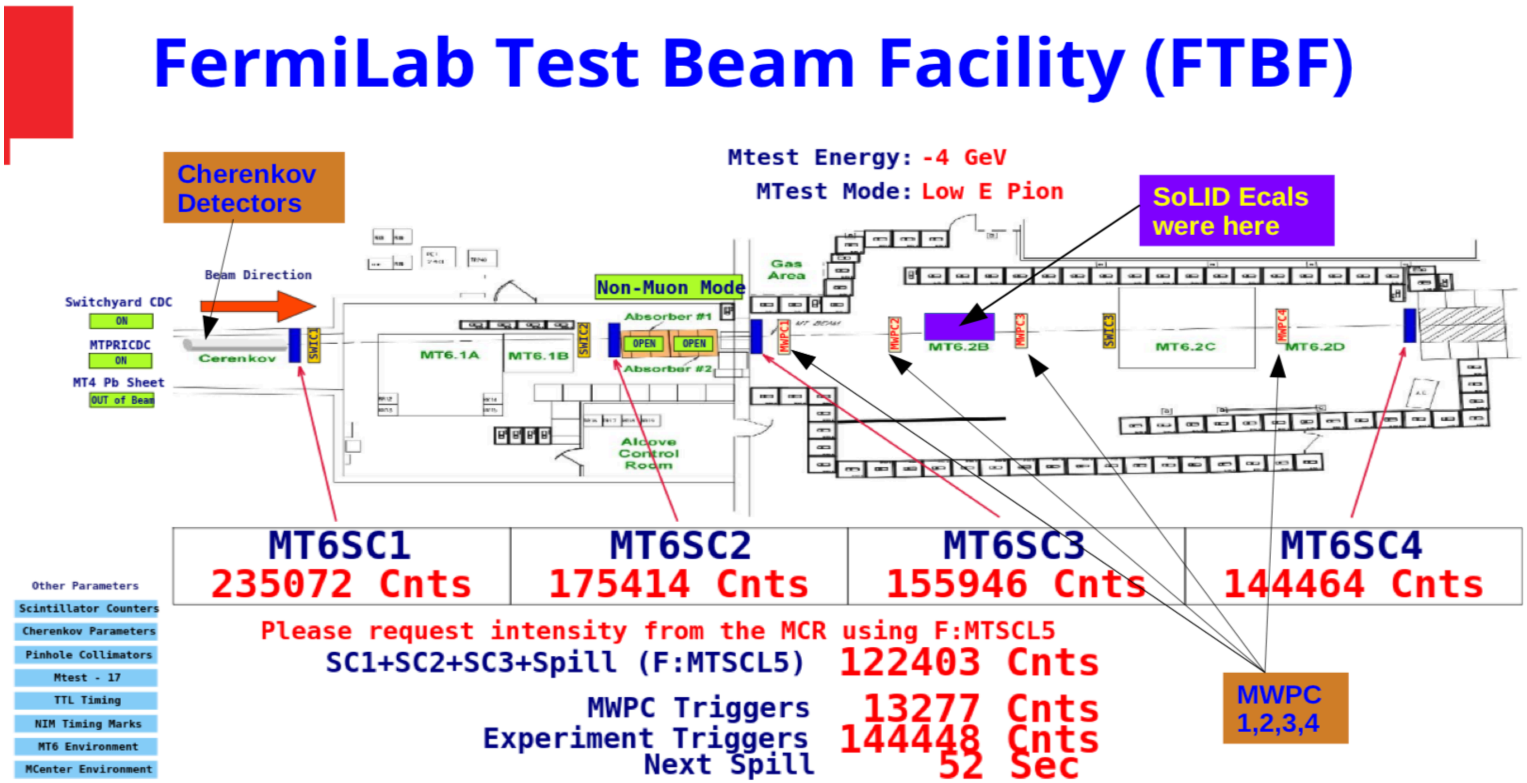
Local Maximum E6p1 >threshold Edep



SIDIS 6+1 cluster energy FAEC (98,230)



EC beam test status



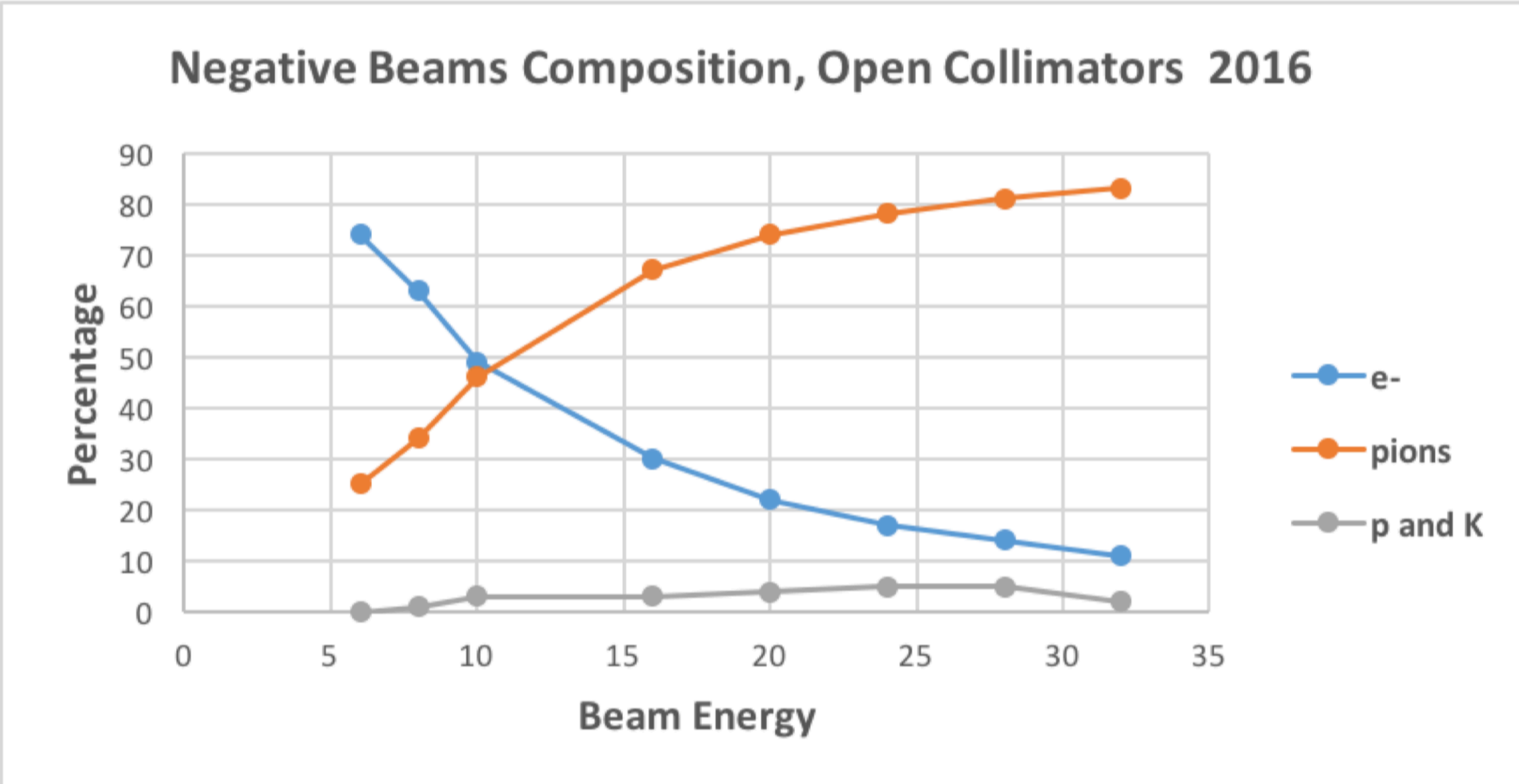
- Low rate beam test -----beginning of 2021 at Fermi lab
  (data is available---three modules)
- High rate beam test-----beginning of 2022 at Jlab

ML for EC ?

- **Particle Identification** (Autoencoder Neural Networks (GlueX))
  - ✓ Signal+background
  - ✓ $E/p \approx 1$
  - ✓ Preshower cut
- **Trigger cluster**
  - ✓ 6p1 sum E
- **Shower Position Measurement**
  - ✓ The average shower depth is a monotonic function of E, and a deeper shower induce a shift of the shower center in the radial direction.
  - ✓ The correction can be done by applying shift in radial and azimuthal position as a function of $(E, \sin(\theta))$.

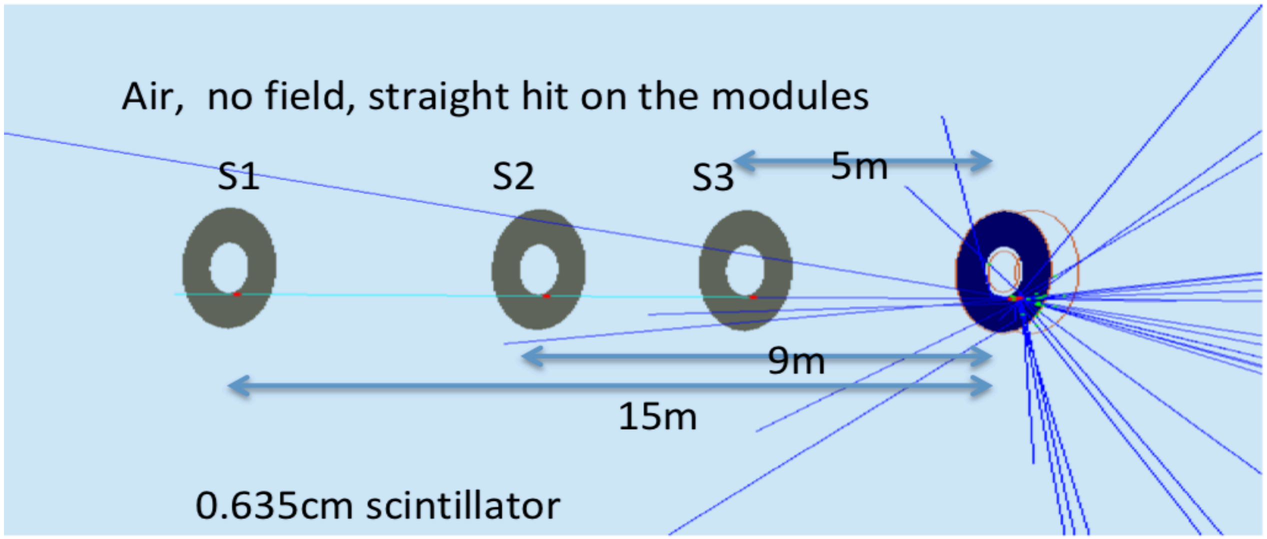
Back up

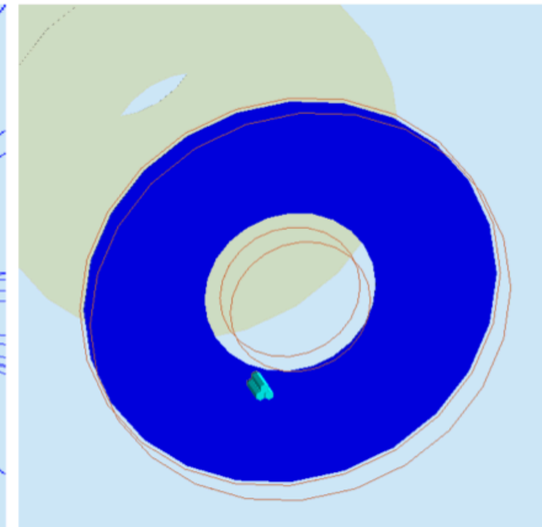
Particle Composition in MTest



Scale factors:

- 6 GeV e-/π=75/25=3
- 2 GeV e-/π=95/5=19

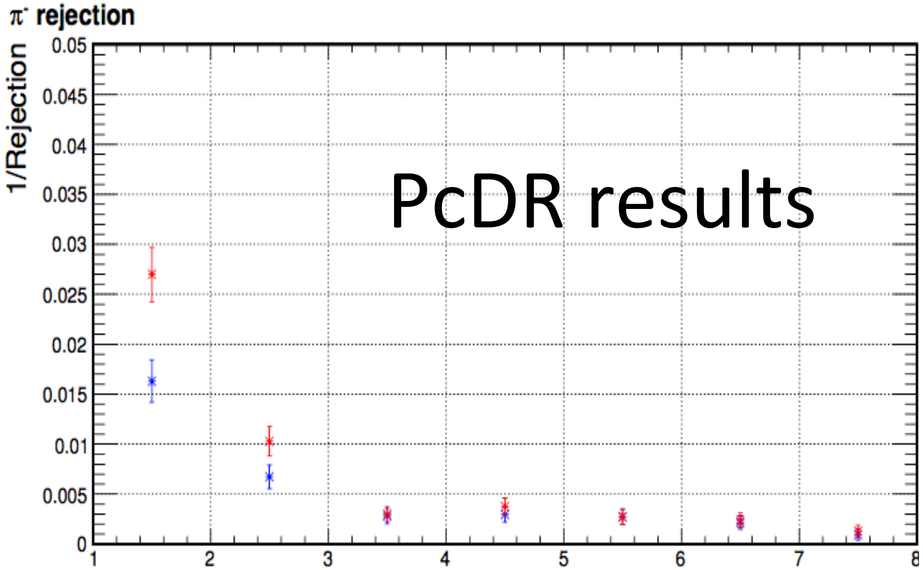


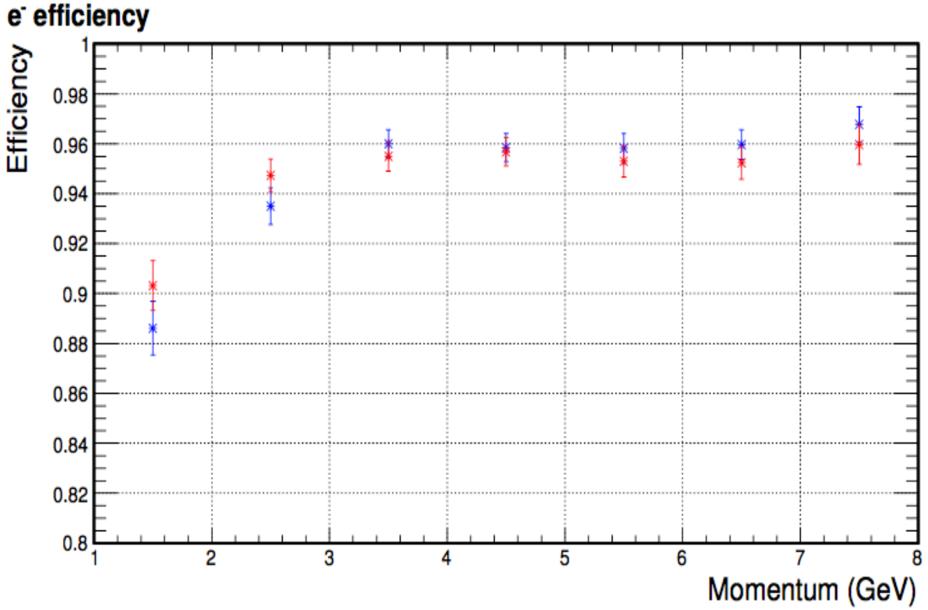


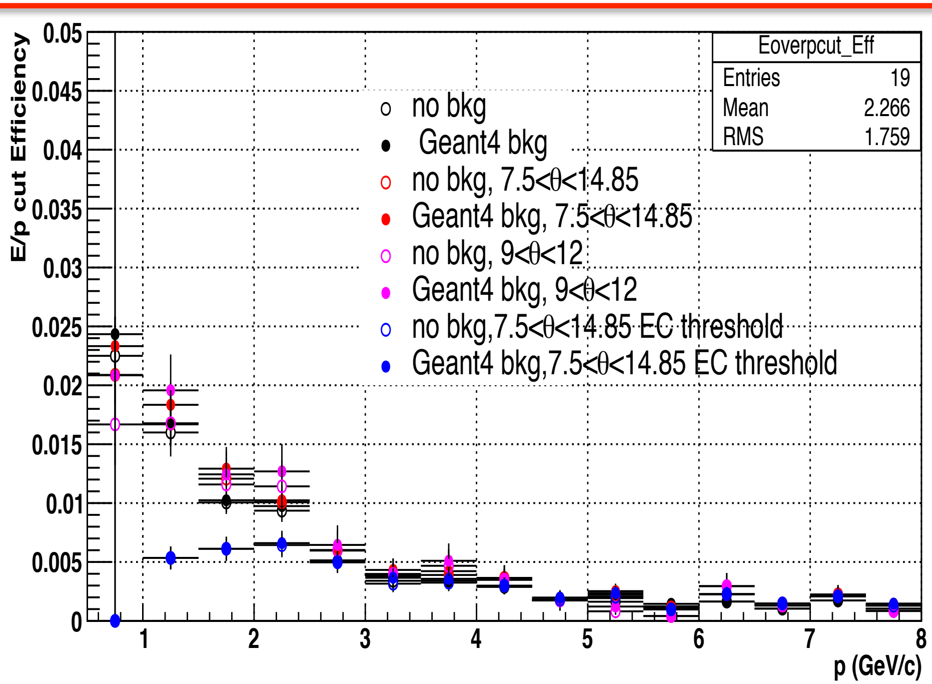
ECAL beam test module's configurations:

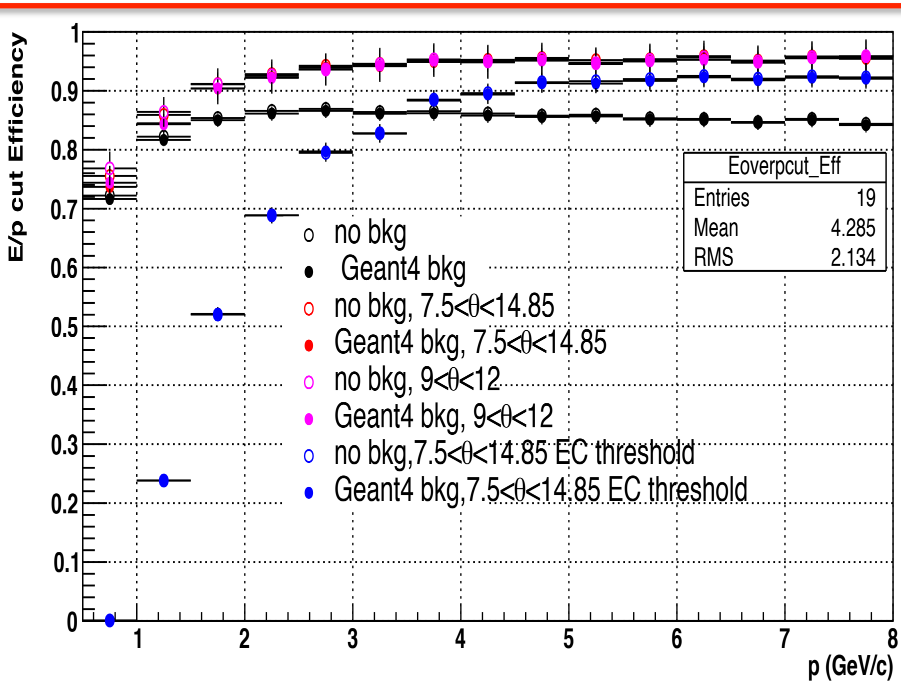
- 1.12cm pre-lead
- 2cm pre-scintillator
- 2cm (1.9cm for beam test) Al support structure
- Shower scintillator/lead 0.15cm/0.05cm (194 layers)
- 6mm Al at front of the shower
- Replace 0.12mm Mylar to 0.07mm TIO_2 painting.

FAEC PID Cuts Efficiency









LAEC PID Cuts Efficiency