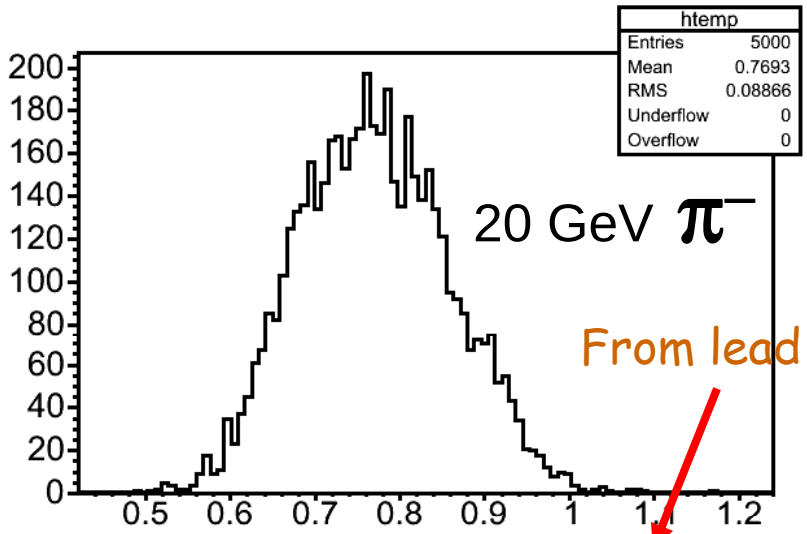
# *Response and Resolution of Cerenkov Dual-Readout Calorimeter (Simulation Only)*

**Shin-Shan Yu, Adam Para, Hans Wenzel**

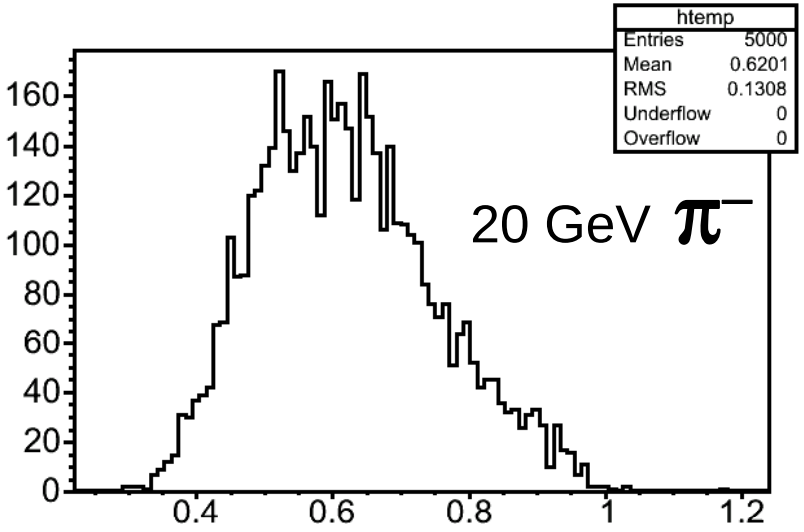
**Fermi National Accelerator Laboratory**

**September 20th, 2006**

# *Why?*




Normalized pion response : ioniziation




Normalized pion response : Cerenkov

- Goal
  - Improve resolution of the measured hadronic energy
  - ($\sigma_E$/E)  sqrt(E) a constant and small (30%)
  - Normalized response ~ 1
- Dual-readout use information both from Cerenkov and ionization signals to obtain the Em fraction ($f_{em}$) in the jet for each event

# Response of A Pion in the Detector

$$R_\pi = f_{em} + (\frac{h}{e})(1 - f_{em}),$$

$$R_\pi^{Cerenkov} = f_{em} + (\frac{h}{e})^{Cerenkov}(1 - f_{em}),$$

$$R_\pi^{ionization} = f_{em} + (\frac{h}{e})^{ionization}(1 - f_{em}),$$

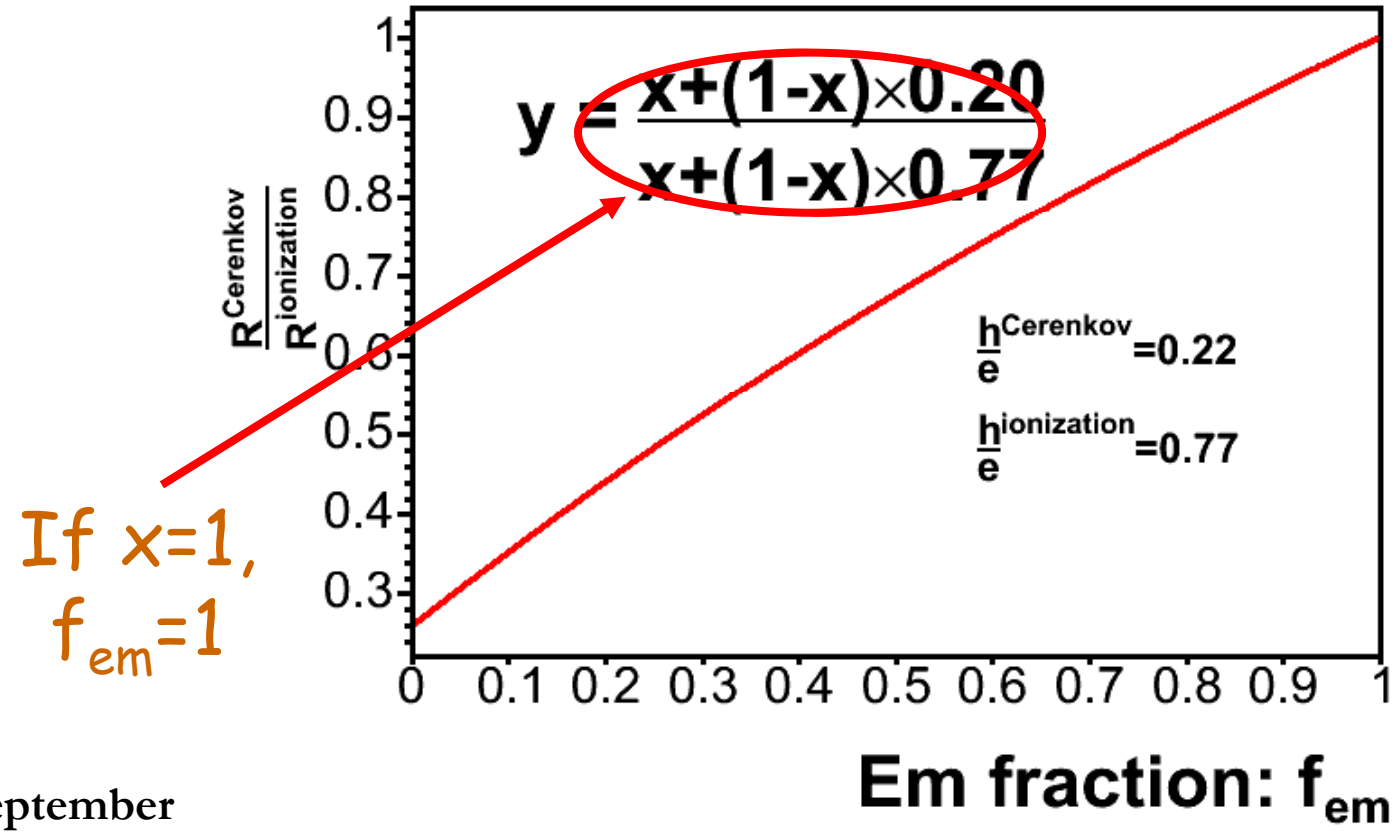
Or use "x" to represent $f_{em}$?

Solve $f_{em}$?

$$x = \frac{R_\pi^{Cerenkov}}{R_\pi^{ionization}} = \frac{f_{em} + (\frac{h}{e})^{Cerenkov}(1 - f_{em})}{f_{em} + (\frac{h}{e})^{ionization}(1 - f_{em})}$$

# *X vs. $f_{em}$*

- x and $f_{em}$ have a one-to-one relation
- We use x to find out the correction formula for pion of each energy



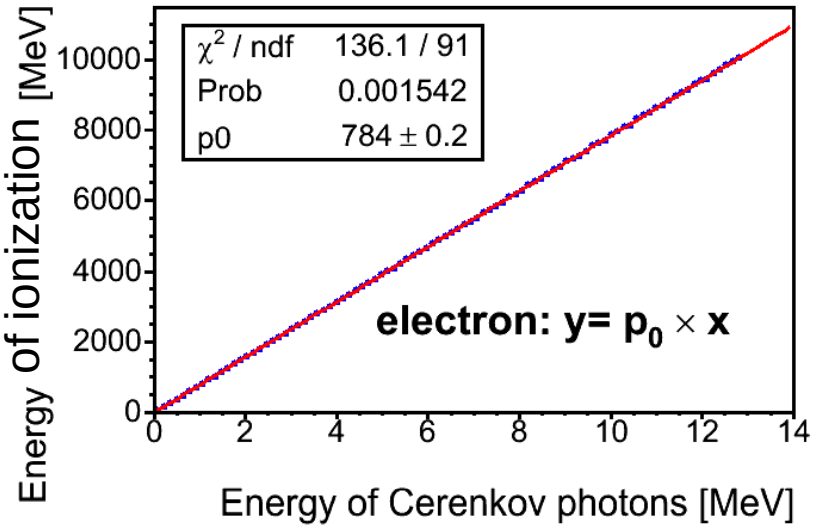
# How? Part I

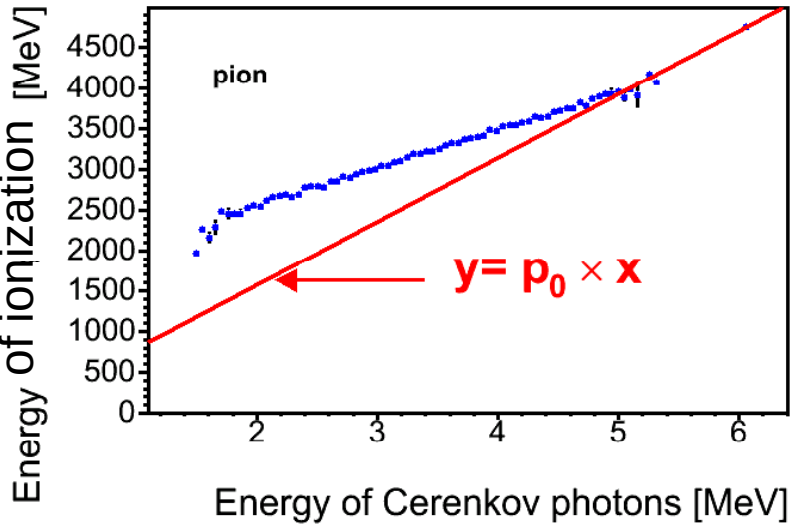
- dualRCalor package
- Generate 5000 events with a single pion or electron shooting at the calorimeter (fixed incident point)
  - Study response and resolution
    - One big block of lead glass, 100 m depth
    - 1500 layers of 20 mm lead glass, 5 mm scintillator
    - Kinetic energy of pion: 1, 5, 10, 20 and 50 GeV
  - Study sampling fraction
    - Fix active layer depth (5 mm) and pion kinetic energy at 20 GeV
    - Use lead glass in the active layer
    - Cerenkov layer depth: 10, 20, 50, 75 mm
    - Use scintillator in the active layer

# How? Part II

- Store information
  - Total ionization energy deposited in the Cerenkov and active layers ($E_{ion}$)
  - Total energy of Cerenkov photons ($E_{pho}$)
  - Total energy of the incident particle (kinetic energy + mass) ($E_{gun}$)
  - **$X = E_{pho}/E_{ion}$**
- Normalize pion response to that of electron
  - check **$E_{ion}$ vs. $E_{pho}$** of electron
- Derive correction formula
  - Fit **$E_{ion} / E_{gun}$** as a function of **$(1 - E_{pho}/E_{ion}$ X slope)**
- Make the correction
  - Divide **$E_{ion} / E_{gun}$** by

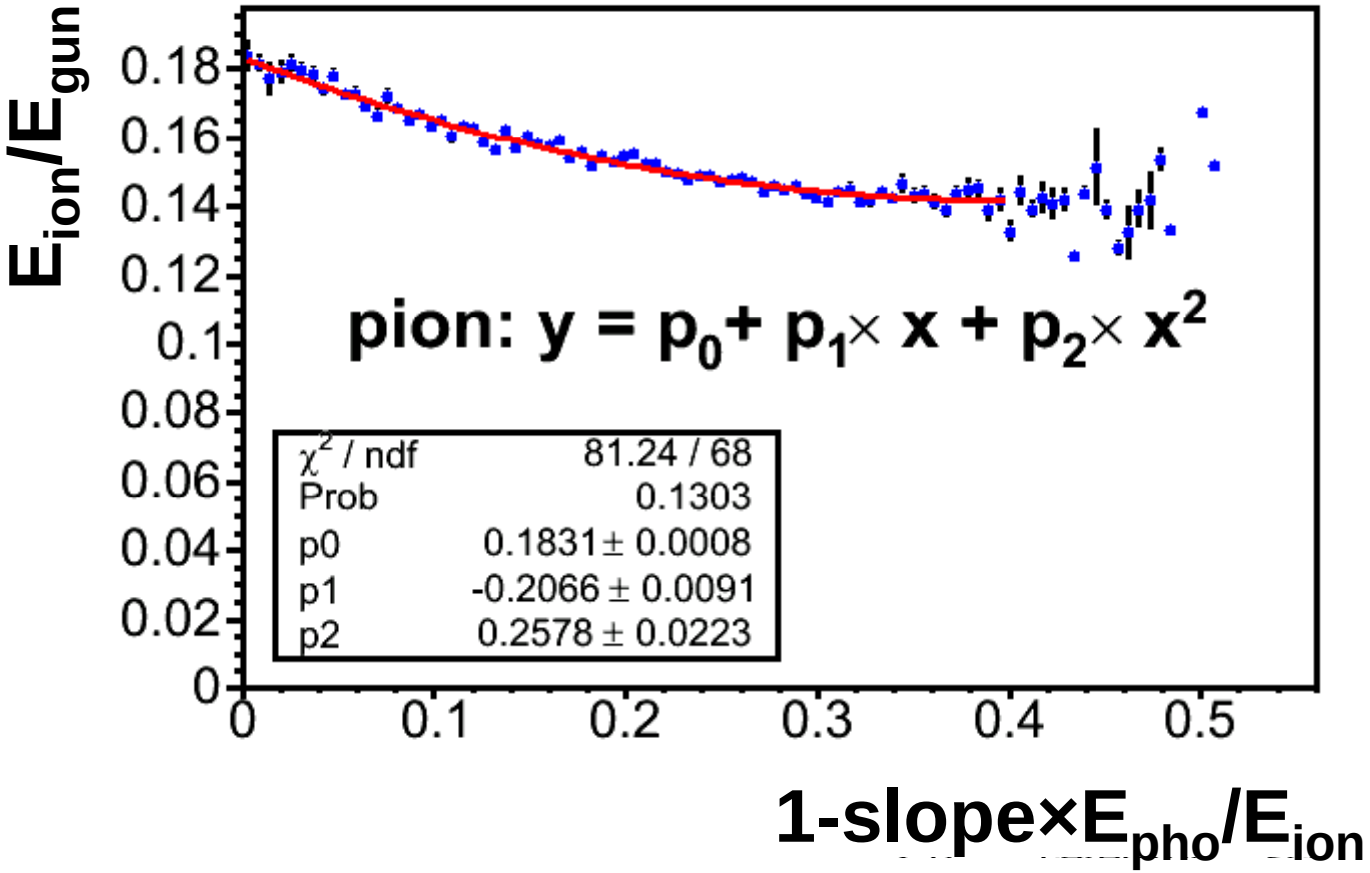
**the correction formula above**



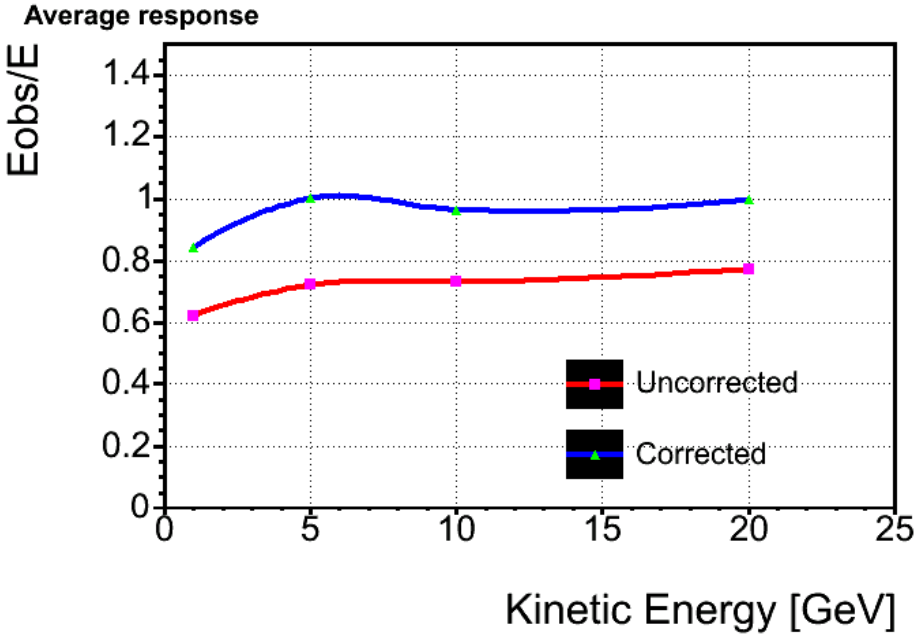



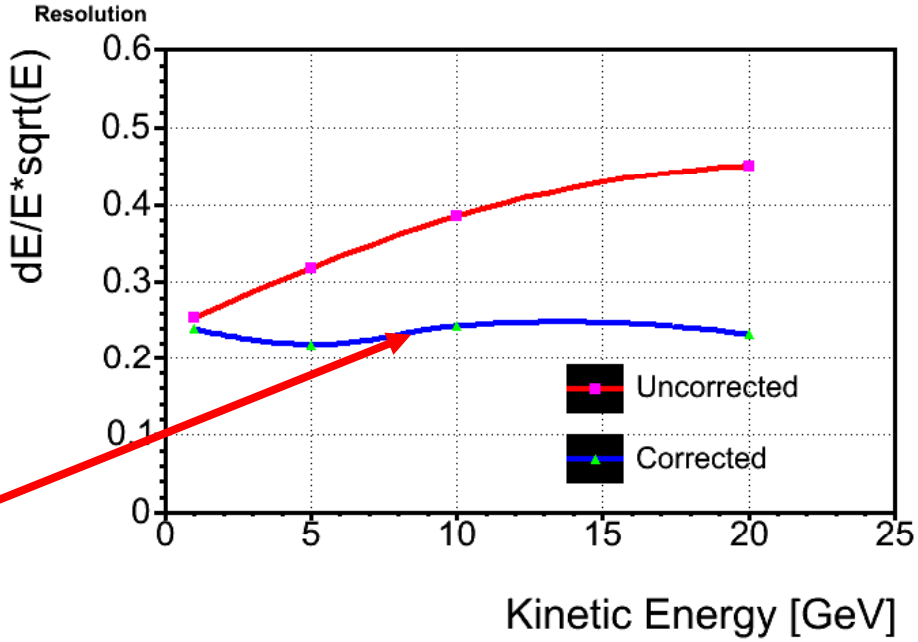
# *Deriving the Correction Formula*

20 GeV pion, Cerenkov layer depth: 20 mm
Active layer depth: 5 mm (lead glass)



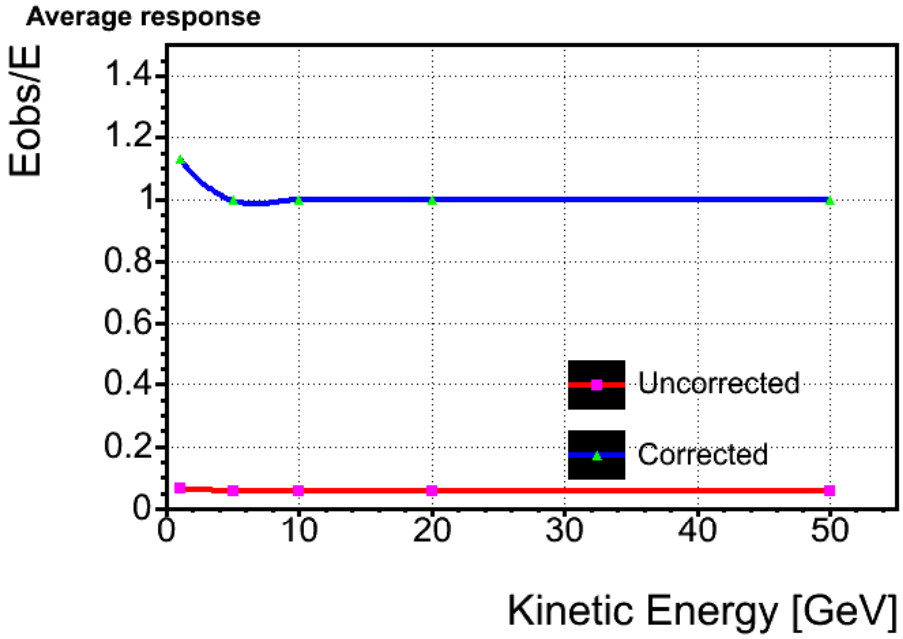
# *One Big Block of Lead Glass (100 m)*

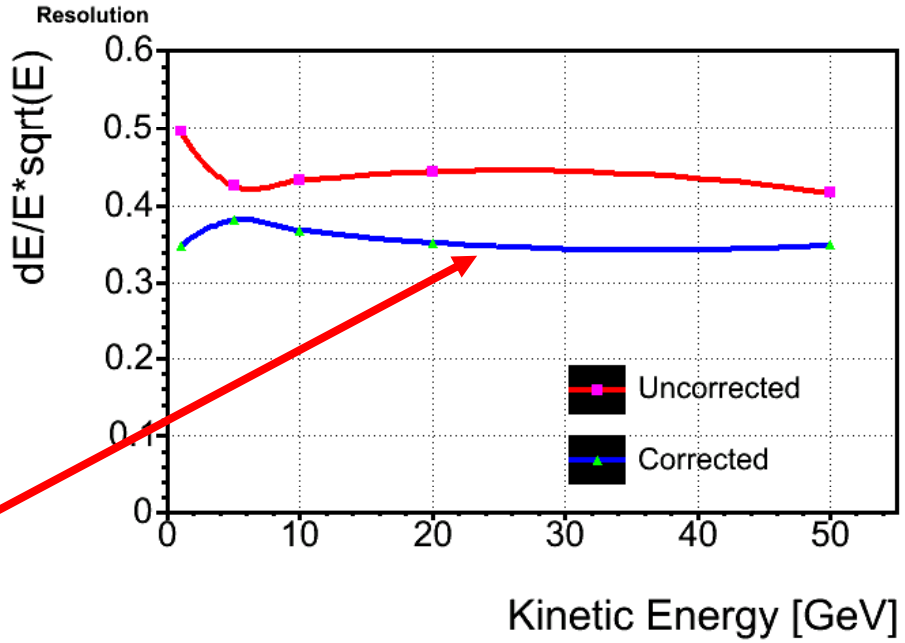



25%

# *1500 Layers of 20 mm Lead Glass and 5 mm Scintillator*

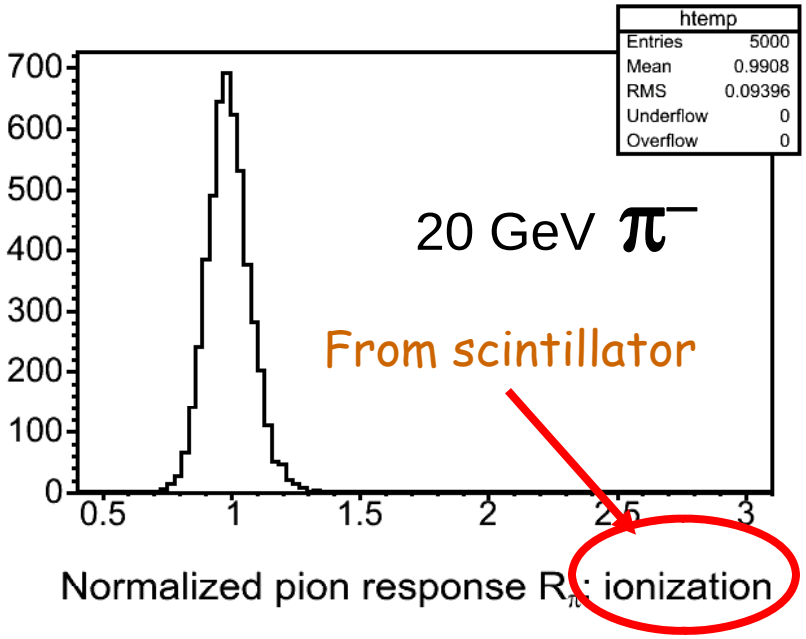


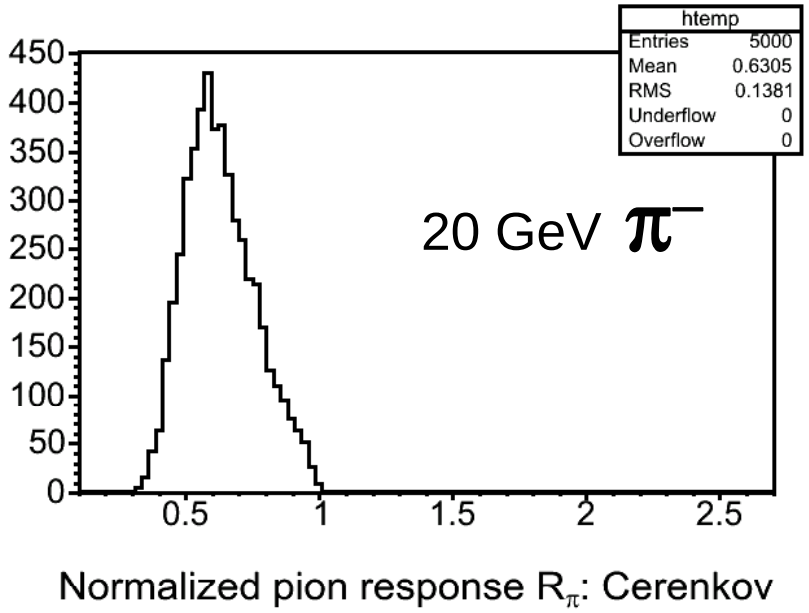




35%

# *The Scintillator Is Different from the Lead Glass*

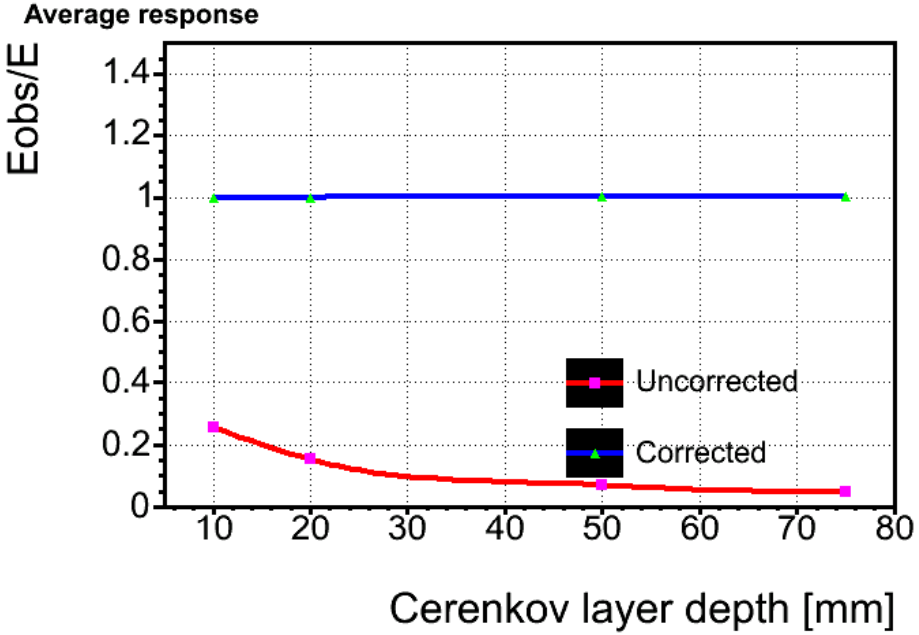
20 GeV pion, Cerenkov layer depth: 20 mm, Active layer depth: 5 mm

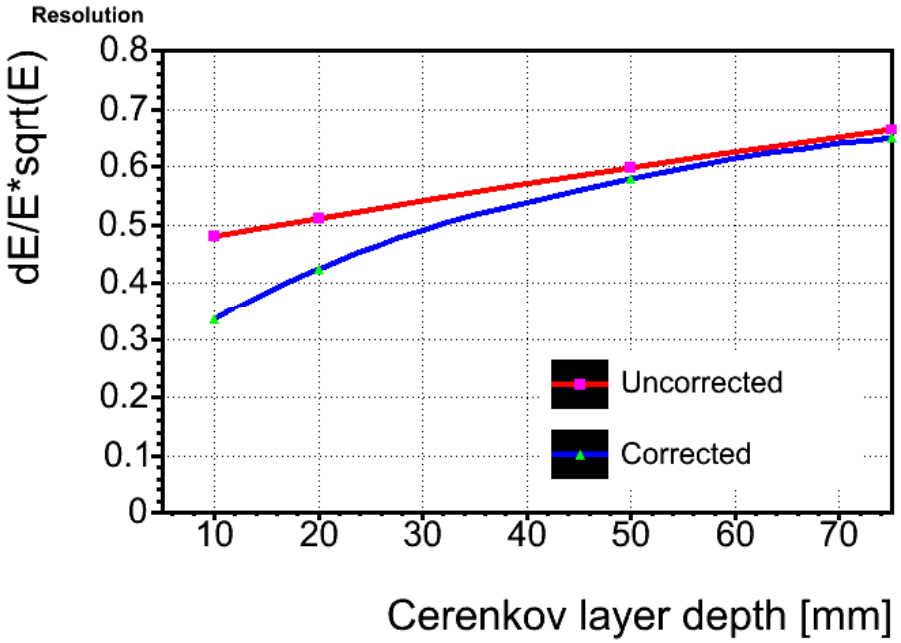


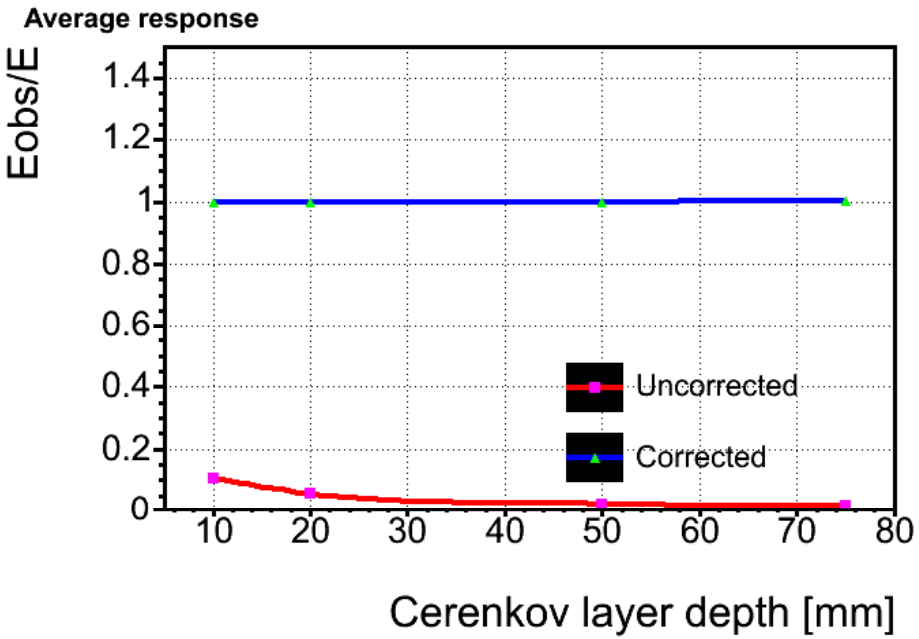

- The hydrogen in scintillator traps neutron
- Now scintillator acts like a compensating material
- In order to separate the sampling fraction effect from the compensation, try using lead glass as the active material

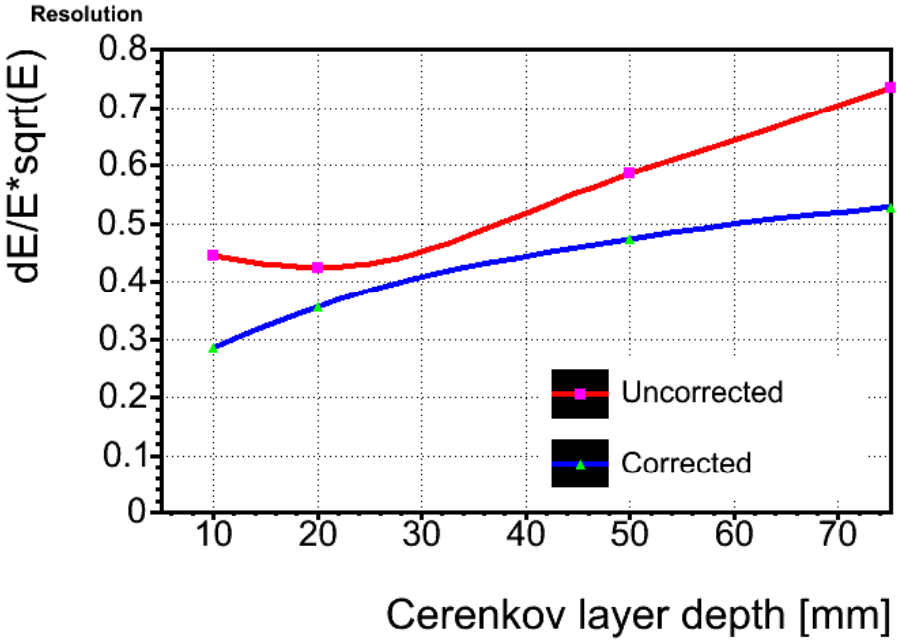
# *Active Layer: Lead Glass*



# *Active Layer: Scintillator*



# *Conclusion & To-do*

- For Cerenkov layer depth < 50 mm, the resolution of the scintillator active layer is better than that of the lead glass active layer
- But why is the improvement still not significant?

  *Any suggestions? Ideas?*
- Fix the Cerenkov layer depth and vary the active layer depth