Calibration of dE/dx in the SVX Detector

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Motivation

- Electrons provide a physics-based response to track the performance of the detector
- monitor gain vs. time to see the effects of radiation damage
- Particle identification in B physics
- To look for Charged Massive Particles (CHAMPs) with short lifetimes

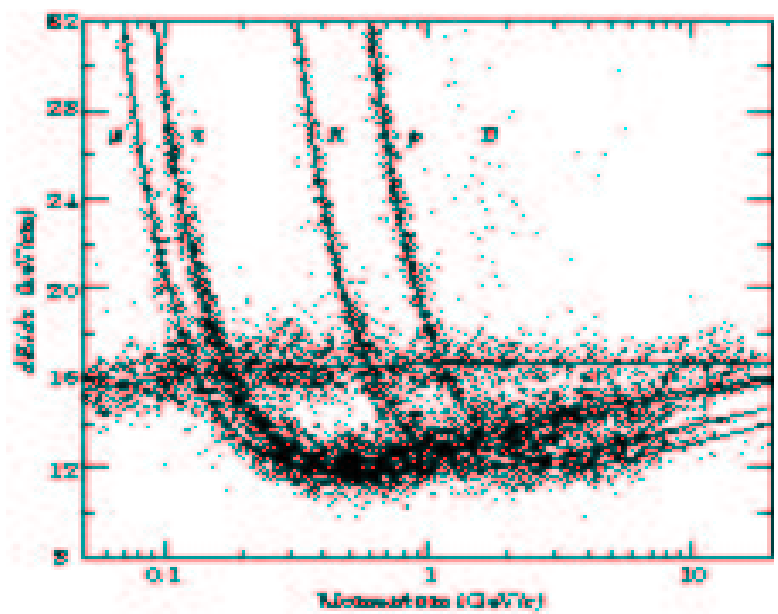
Electrons from Conversions

- Why Electrons?

-- Electrons have high βγ and those above 200 MeV have reached the Fermi plateau in their energy deposition

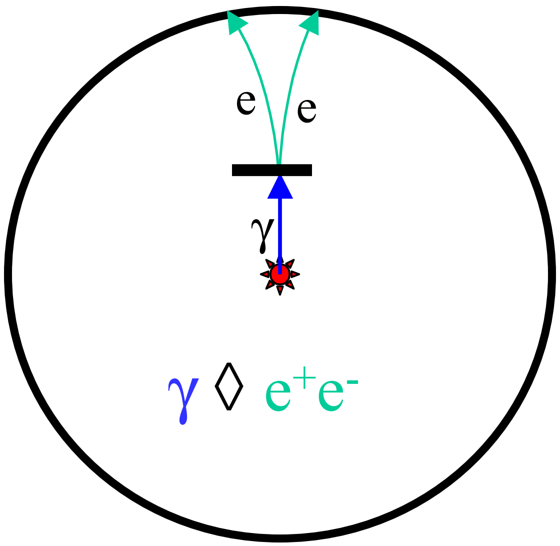
-- Electron ionizing deposition energy independent of their momentum

-- Use all electrons to calibrate response



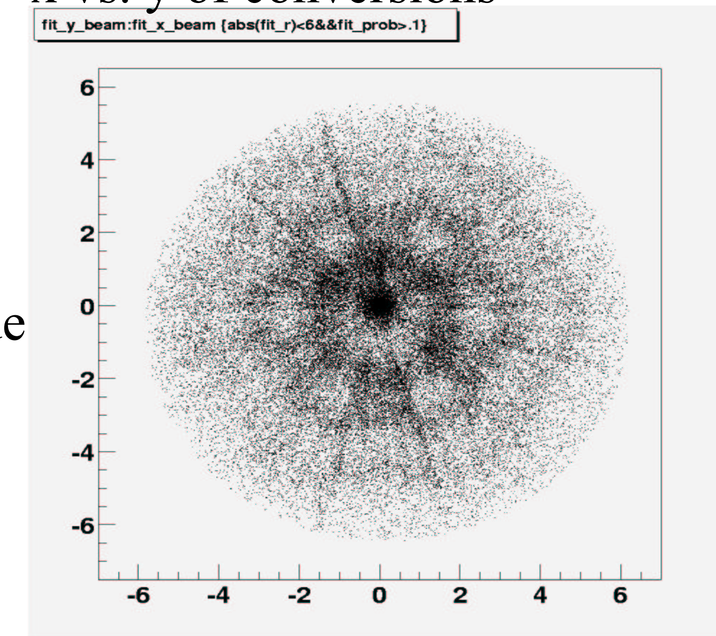
Taken from the PDG

Conversion Sample

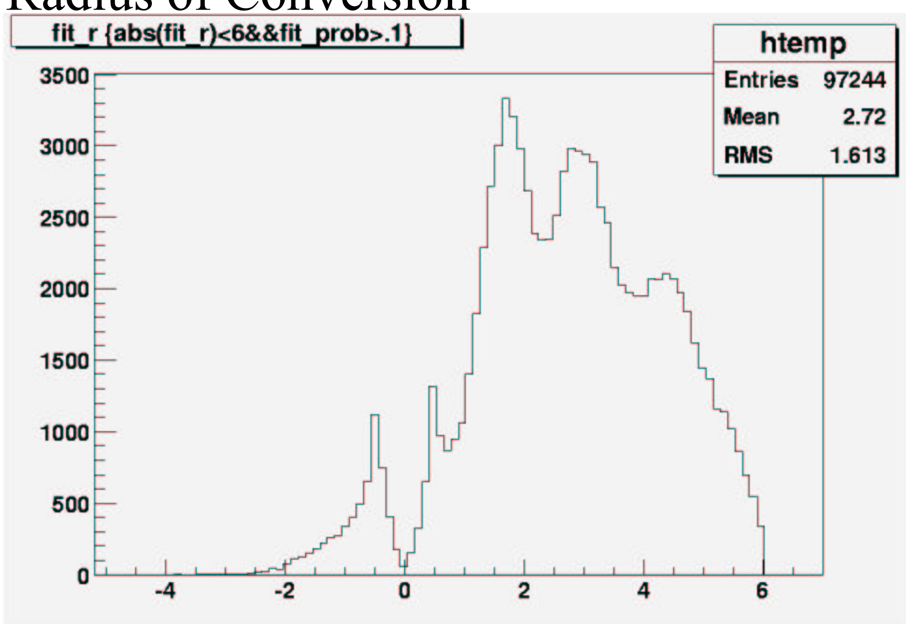


-- The electrons from conversions separate only in the r-ϕ plane due to the magnetic field.
-- Cut on separation where they are parallel and Δcot(θ).

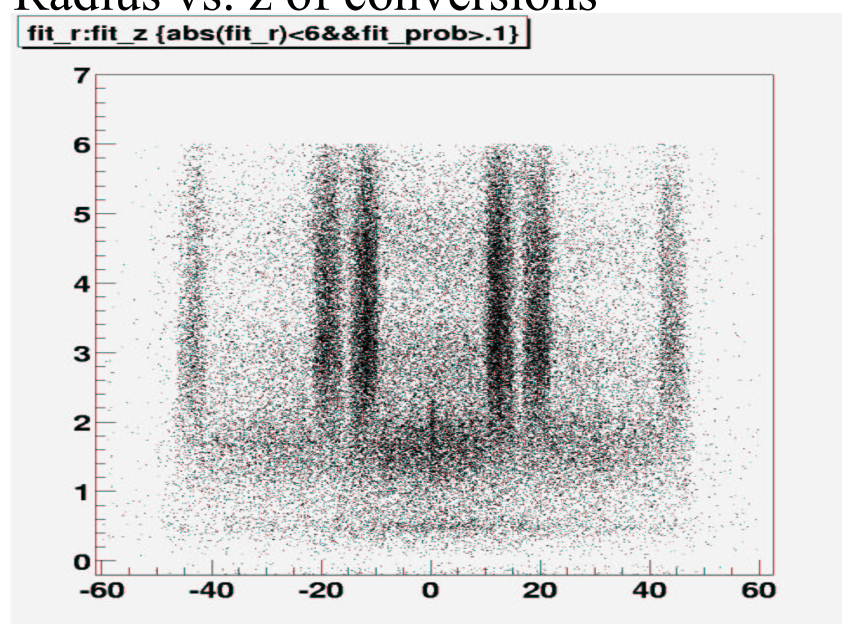
x vs. y of conversions



Radius of Conversion

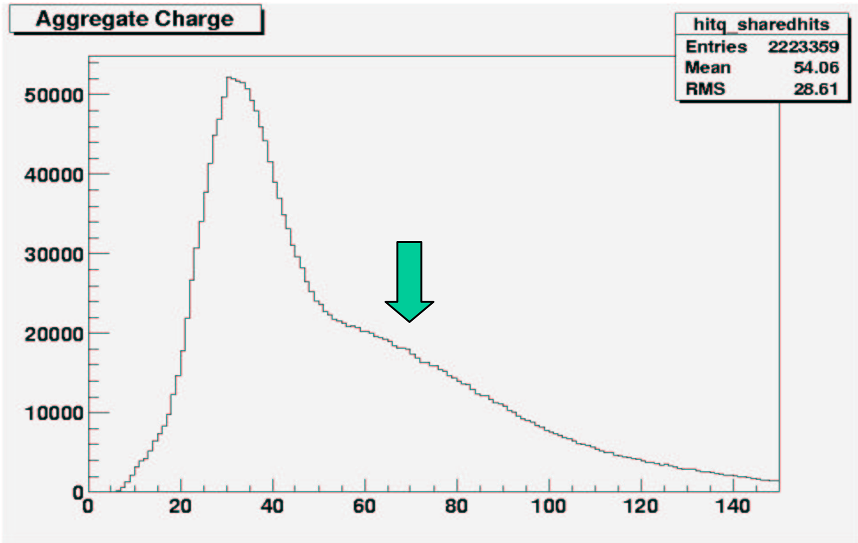


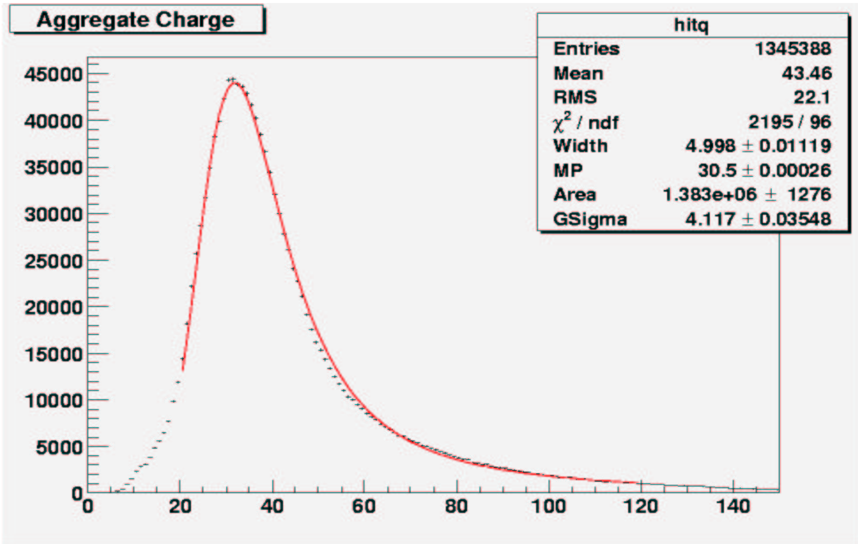
Radius vs. z of conversions



Shared Clusters

- Hits on Layers 0 – 4 (i.e. ***only SVX***)
- Fiducial cut- center of cluster is not within 3 strips of each end of a chip
- Correct for path-length through the chip
- The cluster is not shared by multiple tracks.
  - 90º z chips have the second peak even after this requirement.
  - Pattern recognition on SAS layers is more robust.





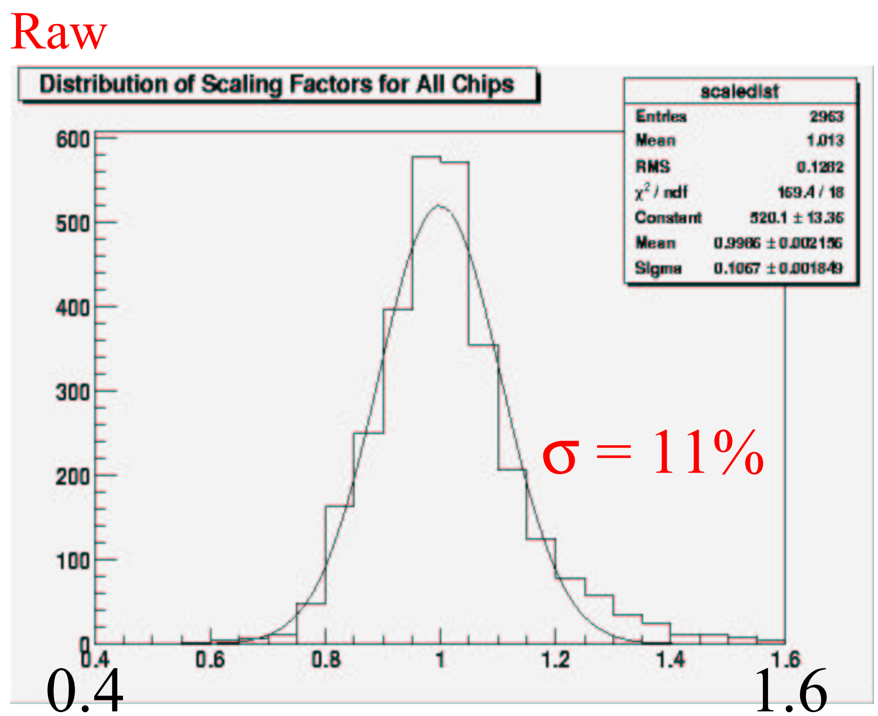
Calibration

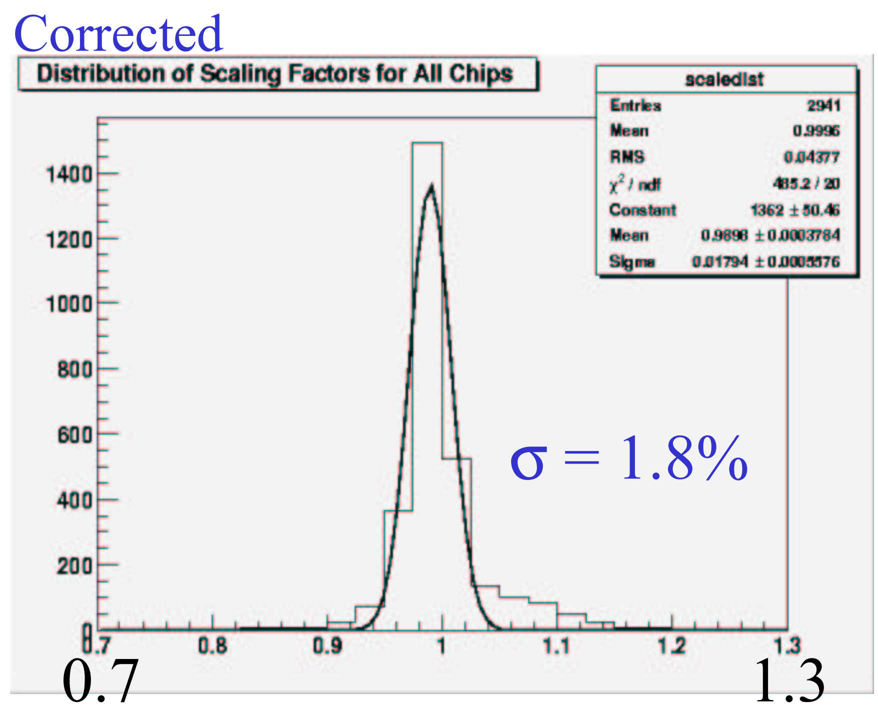
- Fit for gain of each chip

  -- require at least 30 tracks through each chip

  -- maximum likelihood fit with a Landau function, get most probable value (MPV)

- Line up all MPV's at mean MPV for all chips
- Uncertainty before correction ~ 11%
- Small (1.8%) residual non-uniformity after correction
  - Residual spread due to procedure for fit ranges
    - Understood, correctable in principle by one more iteration





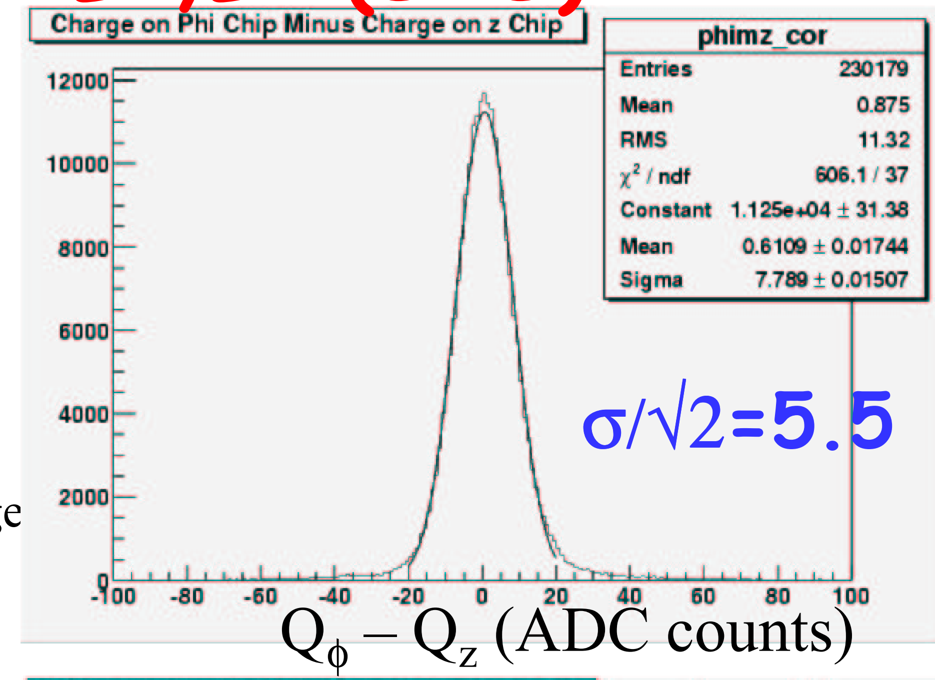
Note Scale

Charge Resolution

$Q_\phi - Q_z$

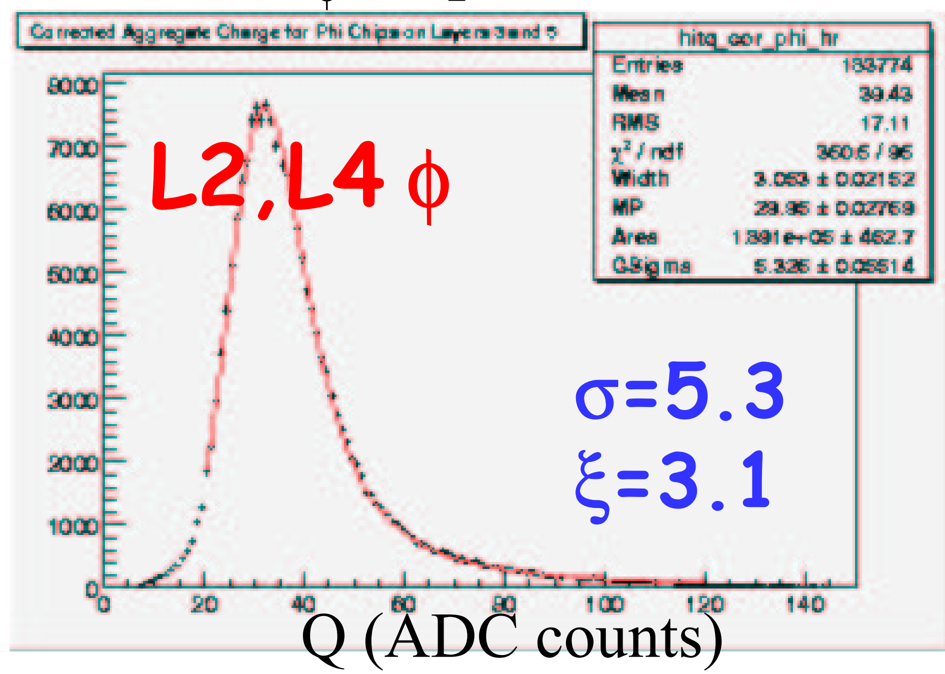
- Take a hit which is recorded on both the ϕ and the z side of the layer, after correction and only on small angle stereo layers (L2 and L4)
- *σ = 7.8± 0.02 ADC counts,*
  Uncertainty = 8.0/√(2) = 5.5 ADC counts
- This contributes to the distribution of charge measurement- we measure a *Landau convolved with a Gaussian.*

L2,L4 (SAS)



Charge Deposition

- Fit to a Landau ⊗ Gaussian
- Gaussian width *σ = 5.3± 0.02 ADC counts*

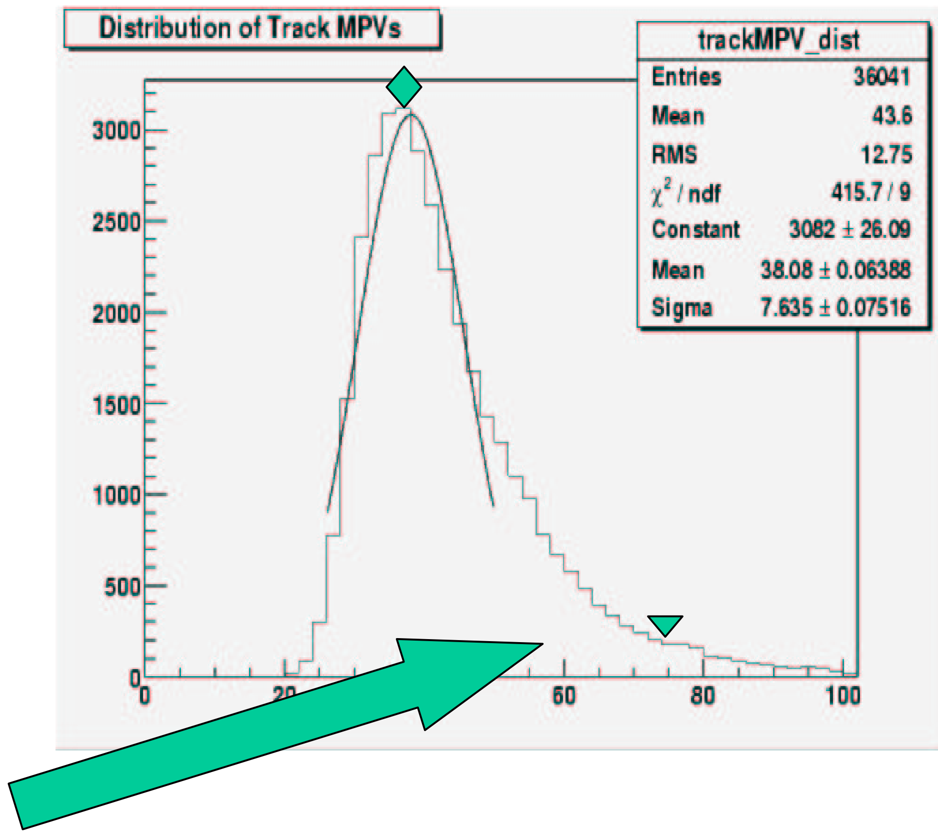


Overall

- Two methods are consistent
- Average charge resolution/cluster: 18%

Per-track dE/dx

- Simplest approach
  - Average the ϕ and z sides on a layer (since they see intrinsically the same deposition)
  - Form the average of all clusters on the track
- Assume that mean is proportional to track MPV
  - Problems
    - Poor resolution even in the core
    - This estimator has large high-side tails
    - T ≡ # at twice MP/# at MP

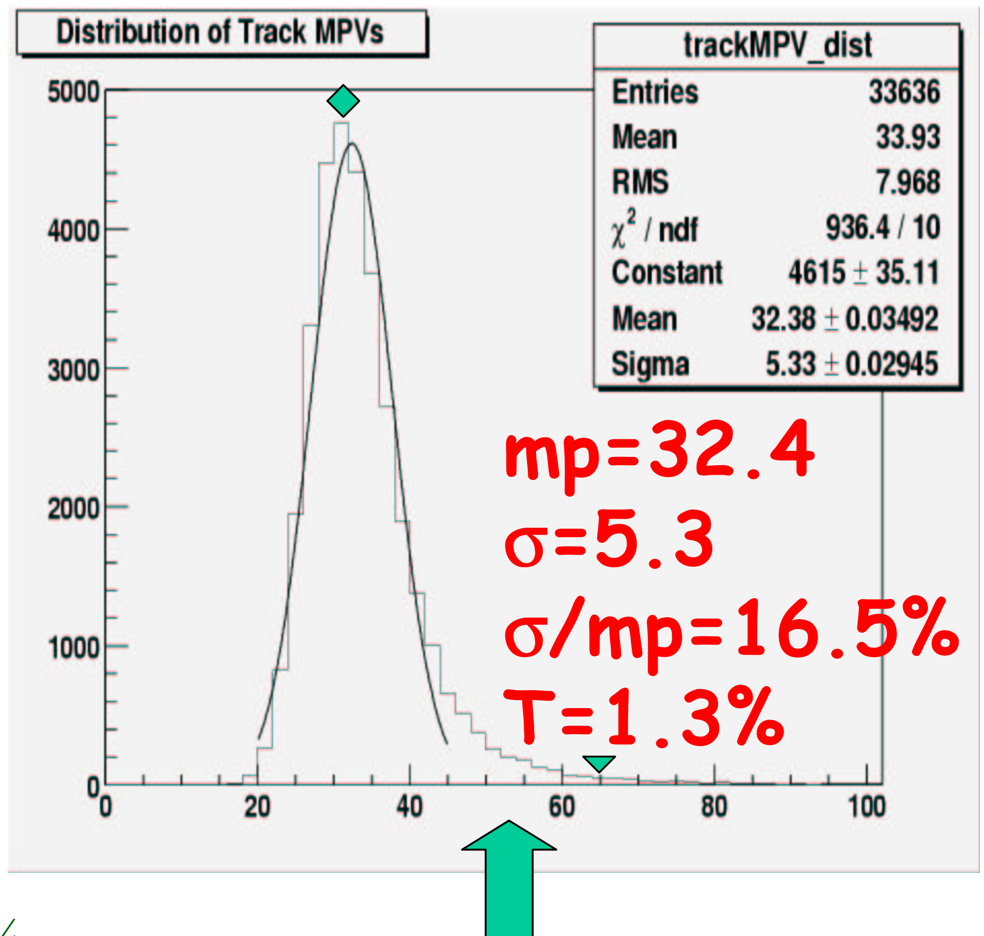


20% resolution

T≡L(2MP)/L(MP)=7%

Truncated Mean dE/dx

- Typical in wire chambers to use "X% truncated means"
  - X typically from 10 to 40%
  - Remove highest charge X fraction of hits
  - Form average from remaining
    - Formally defined for Landau distribution
- In SVX, can form the "n-1 truncated mean"
  - Remove highest-charge cluster
    - Similar to X~25%
  - Form average from remaining
    - On average, 3.0 layers used to form average
    - Resolution improves from 20% to 16.5%

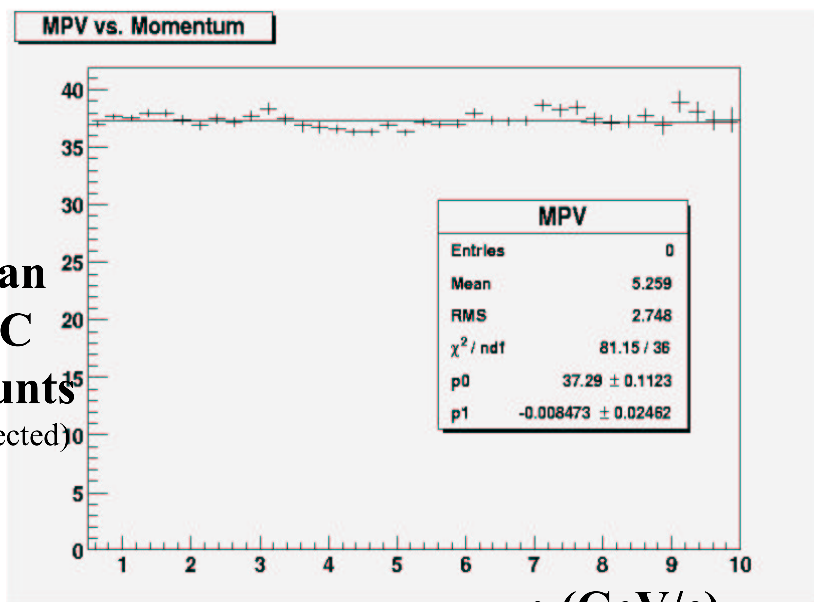


Tails, but better

Cross Checks

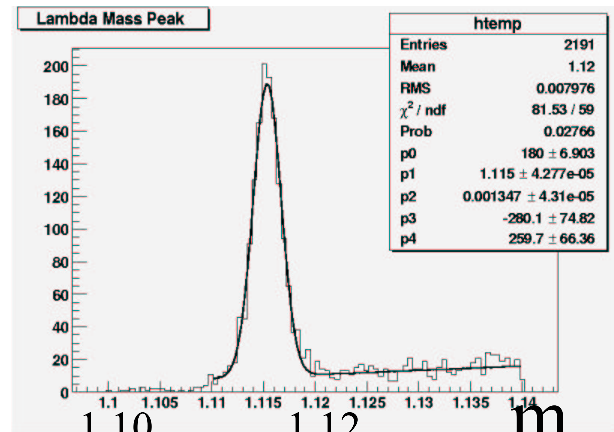
Flatness of Electron dE/dx

- Plot truncated mean vs. momentum
- Check to see if the flatness hypothesis is true for electrons
- Slope is -0.008±0.025, consistent with zero

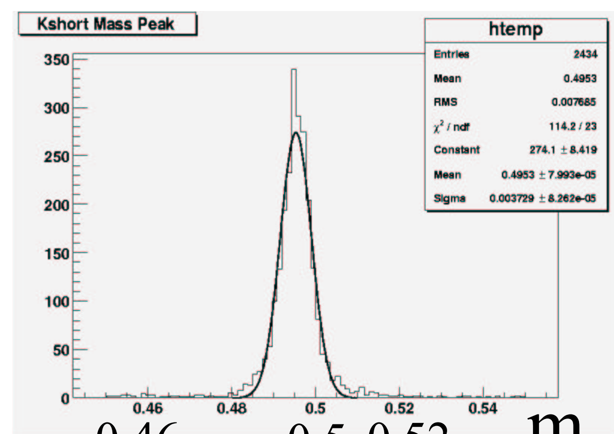


Other Samples

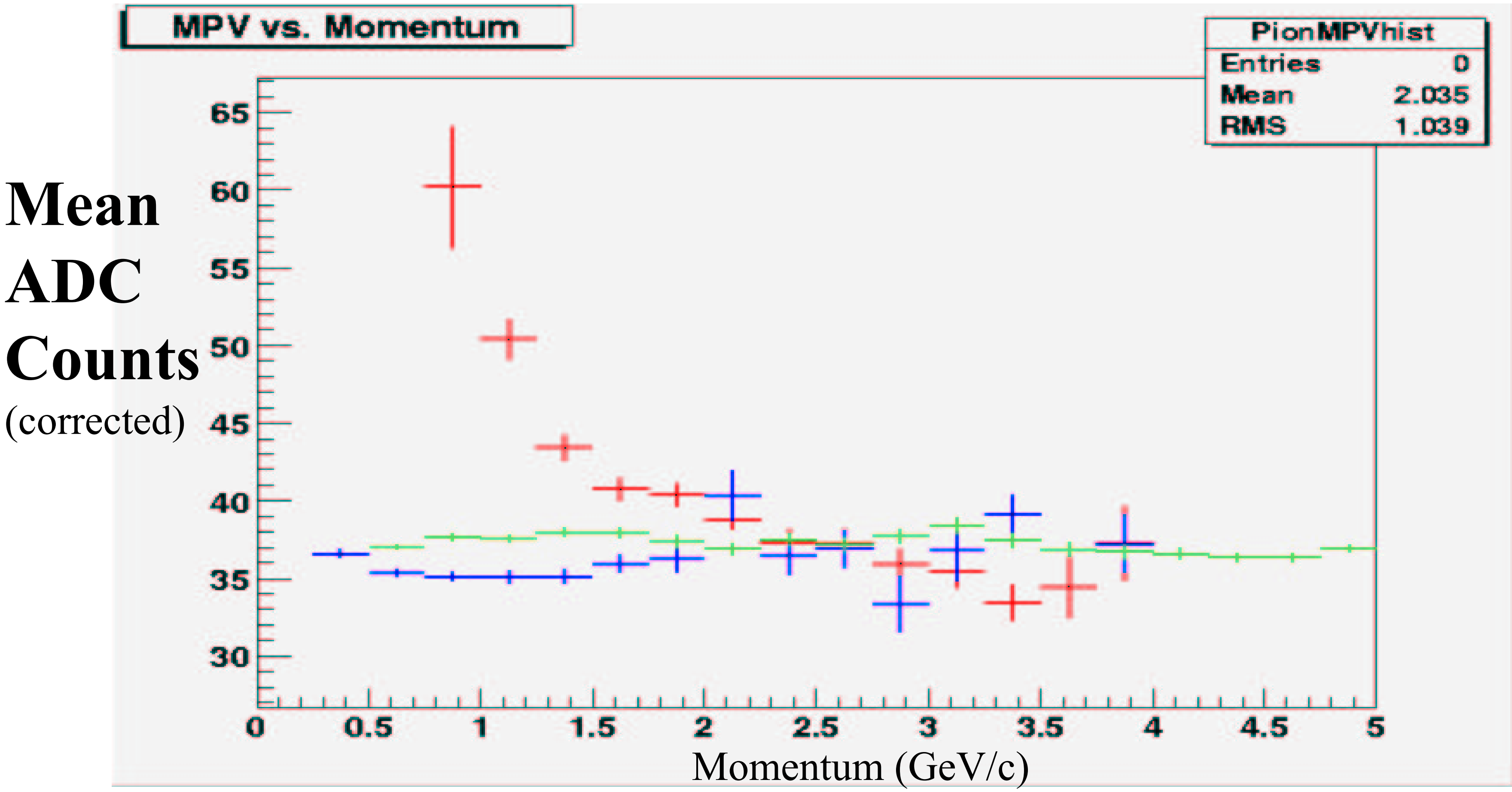
- Get protons from Λ decays - Λ ◊ $p\pi$, mass peak at 1.115, $\sigma = 0.002$



- Get pions from K_s decays - K_s ◊ $\pi\pi$, mass peak at 0.495, $\sigma = 0.004$



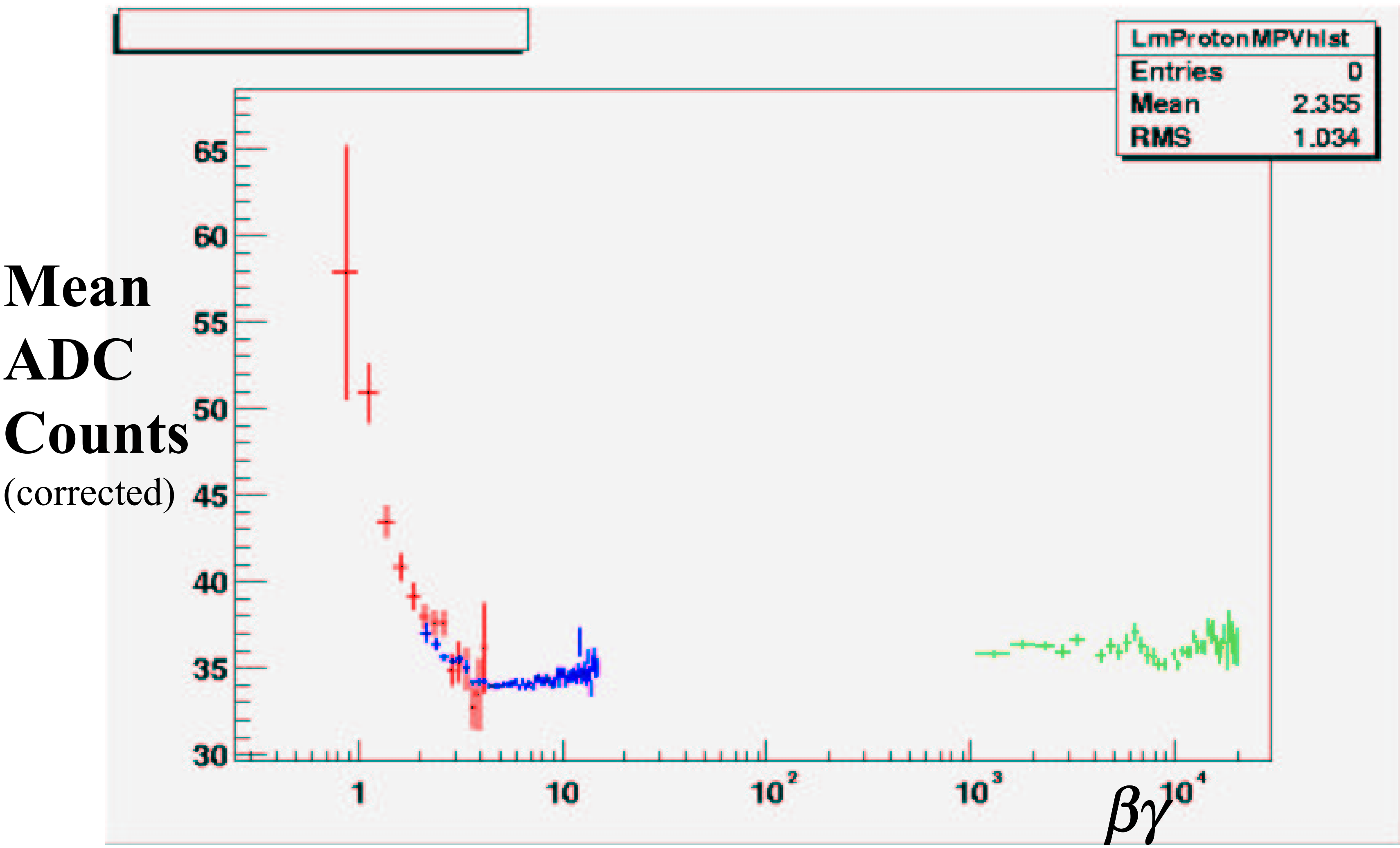
dE/dx vs. Momentum



Green – electrons (γ conversion), Red – Protons (Λ decay), Blue – pions (K_s decay)

(Ratio of Fermi plateau (e) to minimum ionizing (π) – 1.06)

Universal Curve



Green – electrons (γ conversion), Red – Protons (Λ decay), Blue – pions (K_s decay)

Correcting Charge Deposition

- The gains for each chip has been put into the SICHIPGAIN table in the Online Production and Online Development calibration databases (gains also propagate to the corresponding offline databases)
- Gains are given in kilo electrons/ADC count
  - corrections shown in this talk align the Landau peaks at 27.8 ADC counts for a minimum ionizing particle
  - a MIP should deposit 4fc which translates to 0.8982ke/ADC
    - SiHit (getQtotal) will give the charge in thousands of deposited electrons
- Jason Nielsen and I will modify SiClustering Module and DBCorrector to modify the deposition on each strip before clustering. User will be able to turn off this correction.
- Will periodically (~ every 6 months) update the gains because radiation damage will degrade the peak

Packaging dE/dx for CDF

- CDF note 6751 on gain calibration
- Gains are in the calibration database and will be updated periodically
- The user will be able to choose whether they want the corrected or the uncorrected charge deposition (to be implemented and documented)
- Plan to have an SVX dE/dx function that returns the dE/dx of a given track

  - initially will return a number in ADC counts

  - eventually will return a σ for deviation from the MPV assuming that the particle is x (x = e, μ, p, K, π) based on its momentum and energy deposition