Status of dE/dx in ILCSoft v02-00

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Asian Linear Collider Workshop Fukuoka
31.05.2018

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DESY

dE/dx - Compute_dEdxProcessor

- Part of MarlinReco::Analysis::PIDTools

  ~ somewhat parameterised implementation of TPC testbeam results and MarlinTPC simulation for the full ILD simulation
- Runs in TrackingReco after full tracking
- Calculates a dE/dx value for each reconstructed track and attaches it to the track object
  - dE is the deposited energy of each hit
  - dx is the travel distance of the particle for each hit
  - To compensate for Landau tail the highest and lowest dE/dx values are truncated before calculating the mean for one track
  - Mean per track is optionally smeared to recreate test beam resolution
- dE/dx is then used as input for PID tools

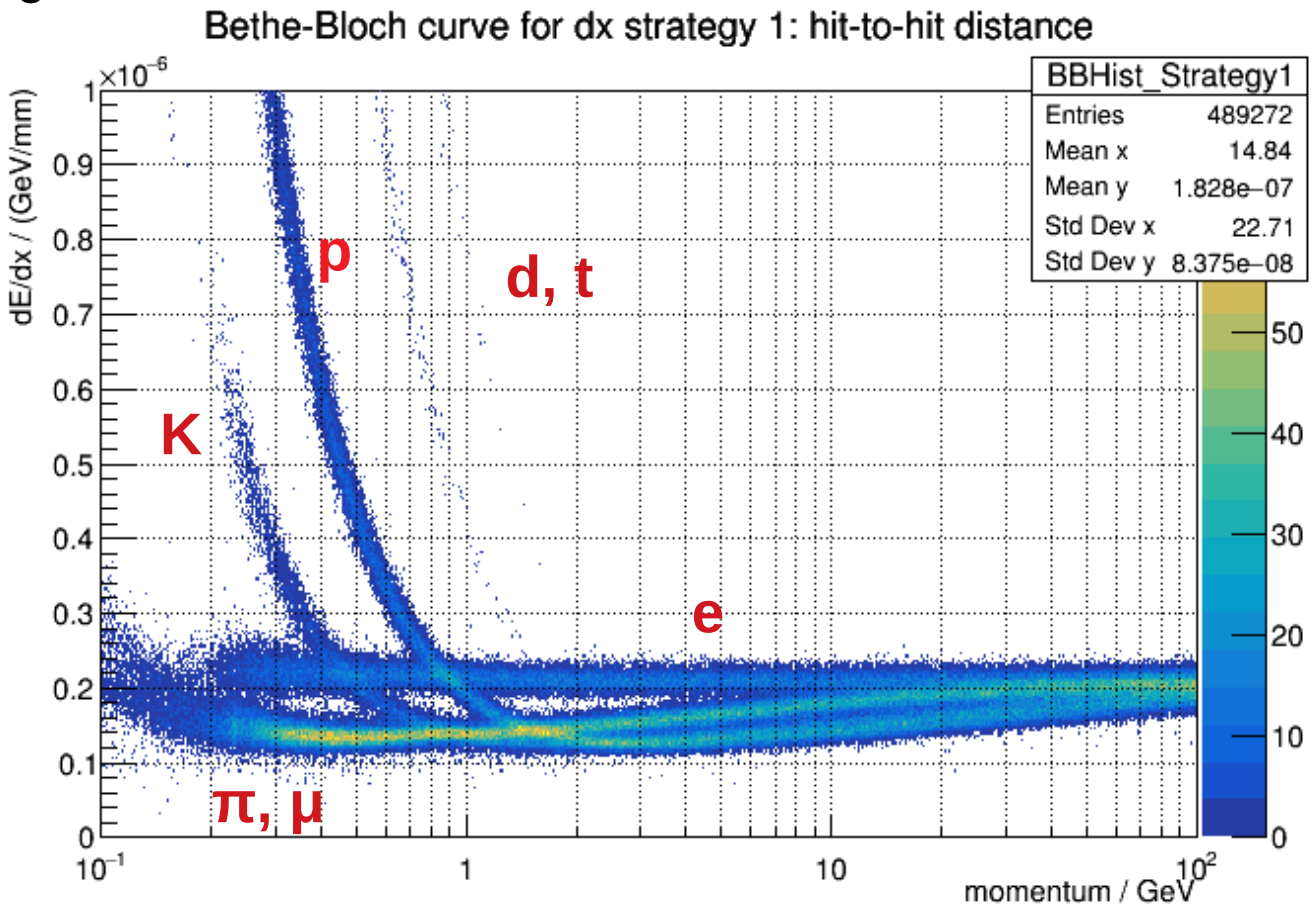
dE/dx - Compute_dEdxProcessor

- dx calculation strategy implemented
- New processor options:
  - Change truncation values (8%, 30%)
  - Select strategy for dx calculation
  - Generate dE/dx plots for all strategies
  - Turn off assigning dE/dx to track to only generate plots
- General fixing, polishing & documentation

- Part of v02-00, used for current IDR MC production
- Few issues remaining

dE/dx – Plots

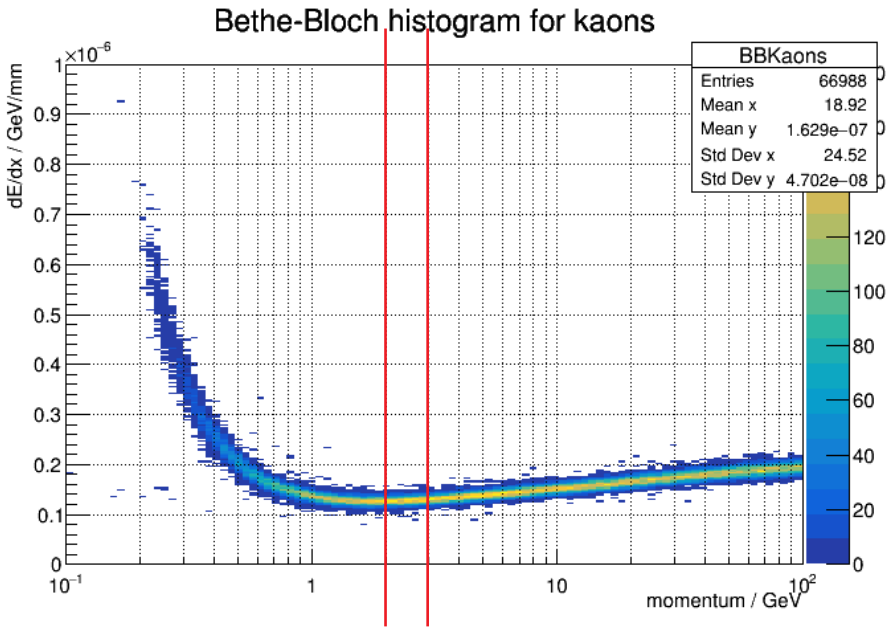
- If strategy comparison is switched on, Bethe-Bloch plots for each strategy are produced – will be changed to a generic switch independent of strategies



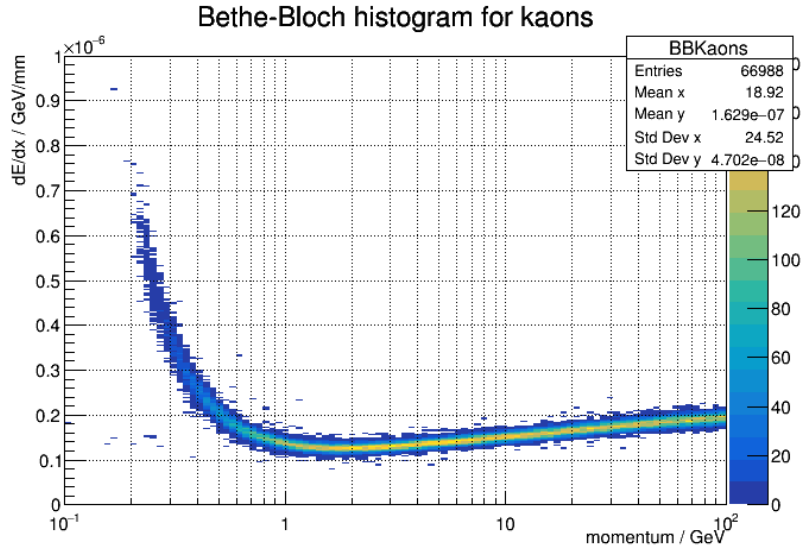
Analysis of one BB-curve

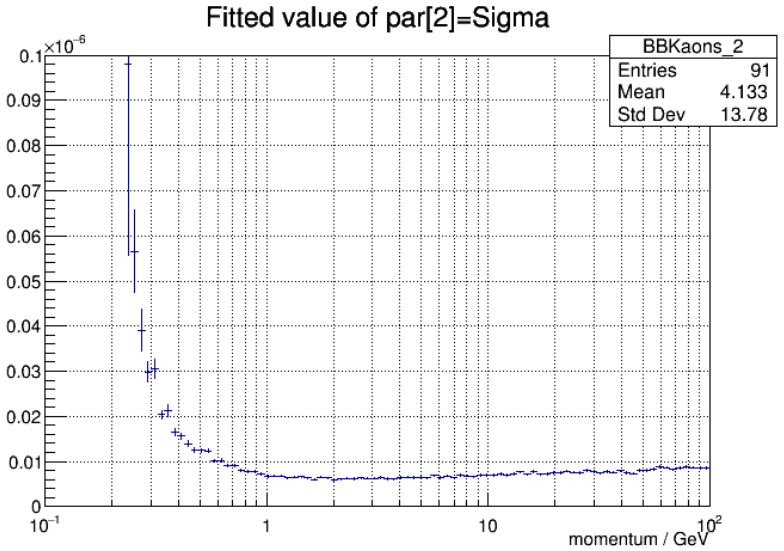
- Use TH2::FitSlicesY
- Goes through every bin in x (momentum) and fits a Gaussian to the distribution in y (dE/dx)
- Reduced (logarithmic) momentum bin number to 100
- Used all single particles files (100k per species)

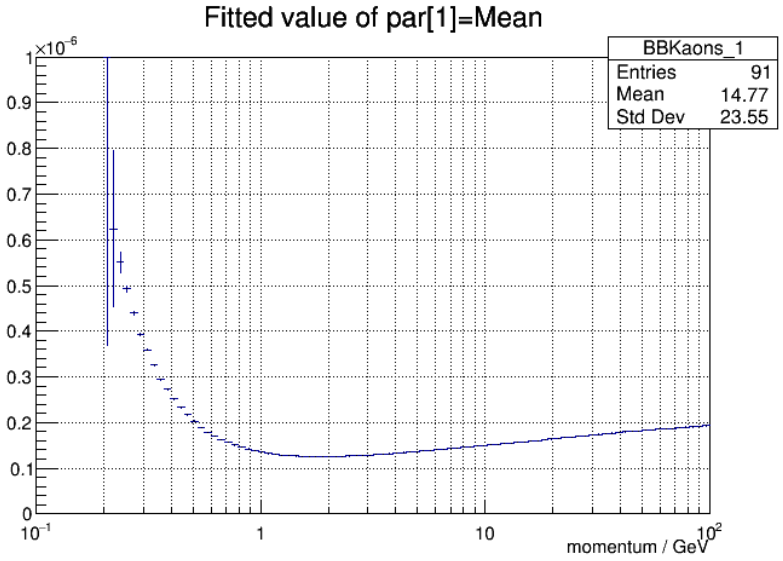
→ got sufficient statistics to have good overall fit results

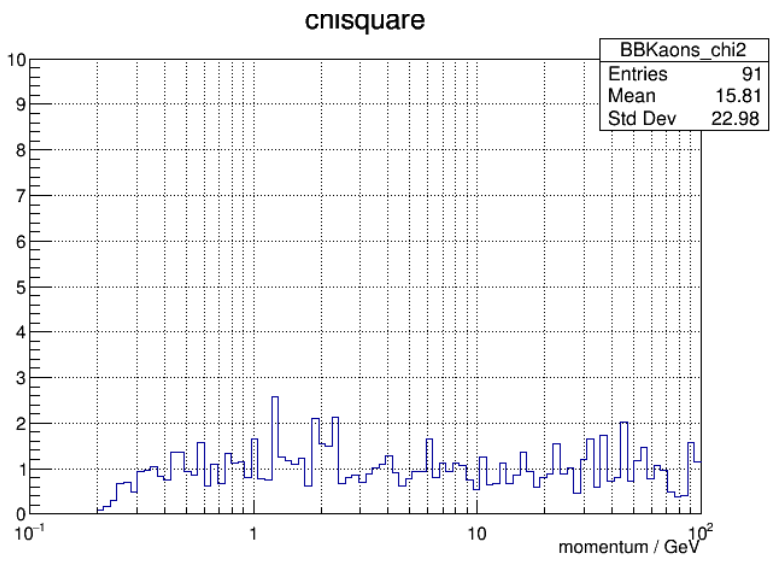


Separation Power – fit results example









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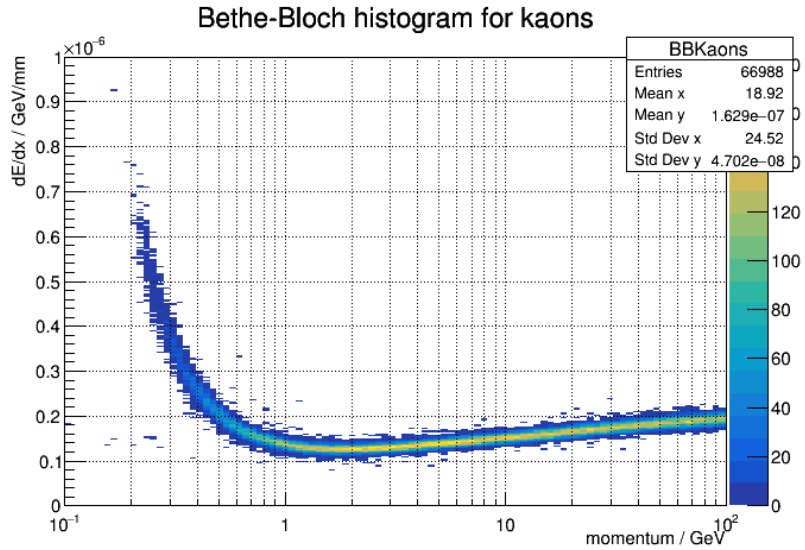
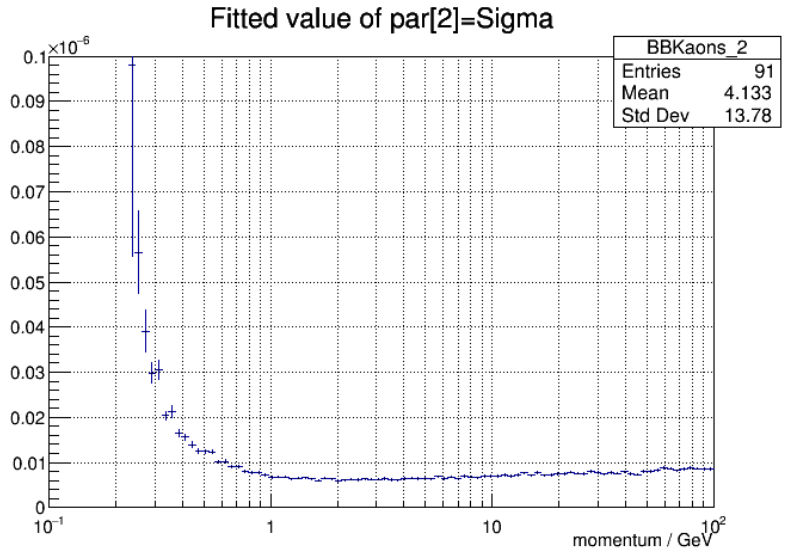
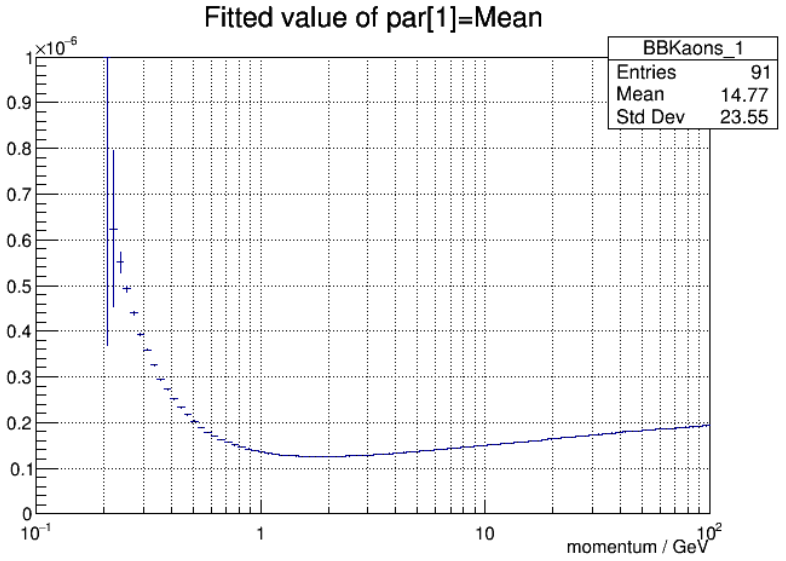
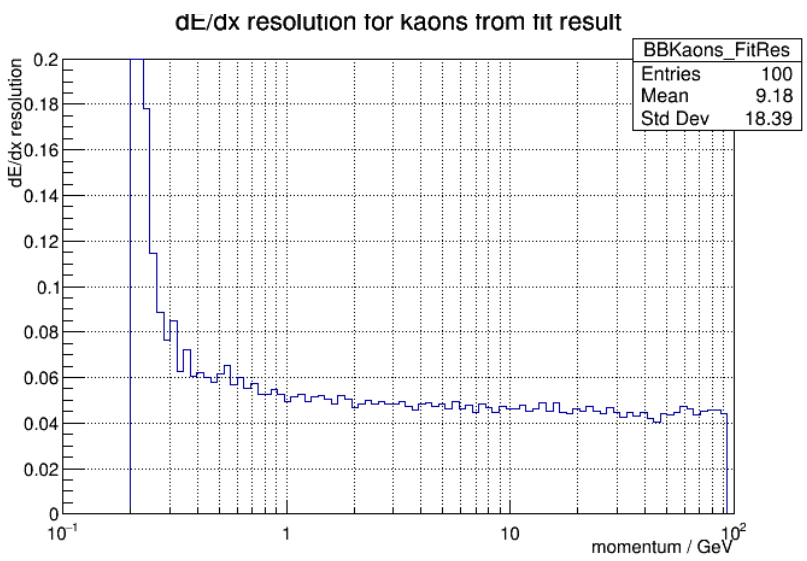


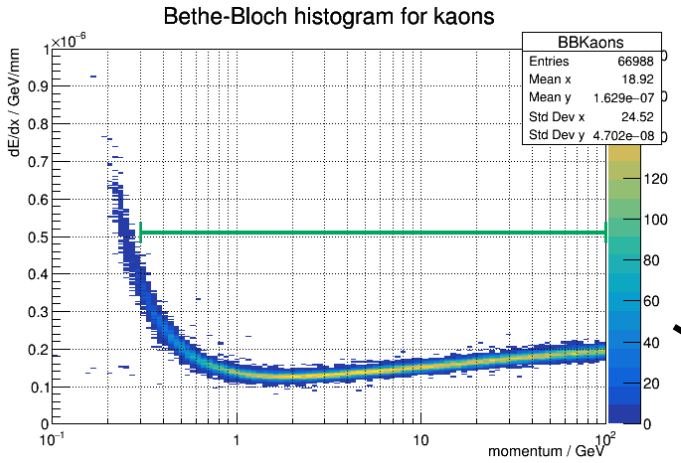


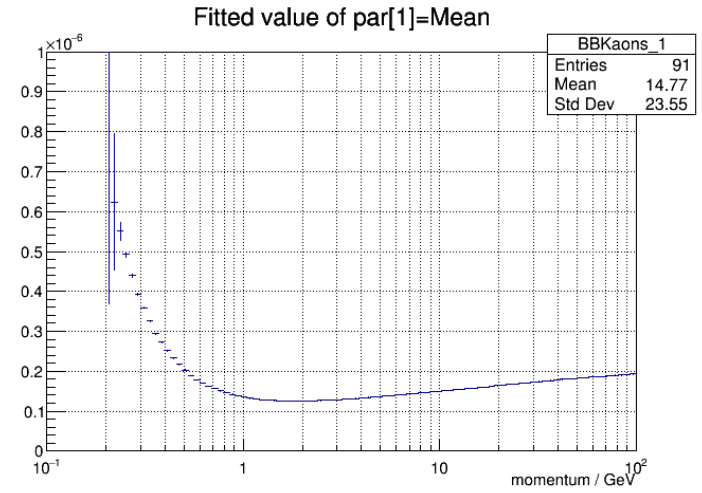


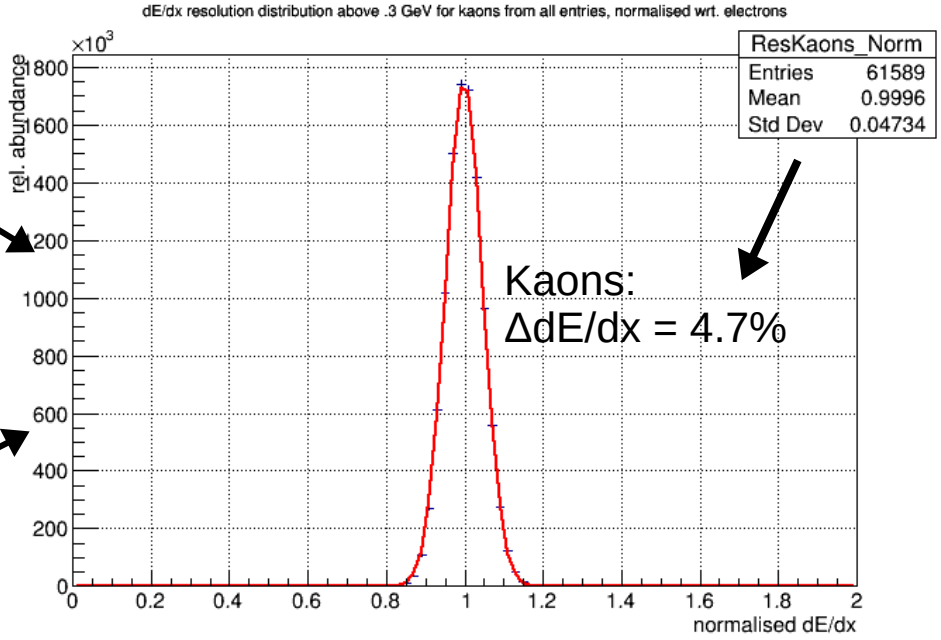


Resolution – other particles: correct for Bethe-Bloch curve

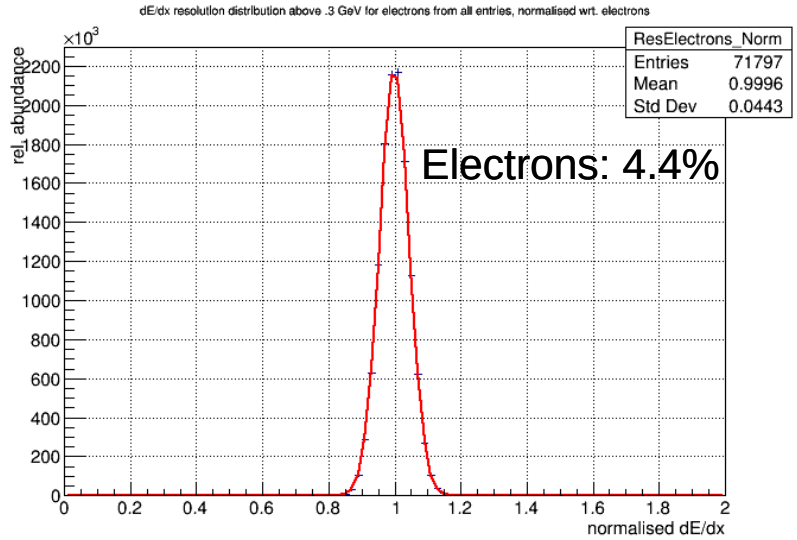
- Normalise each track entry by the fit mean value of the corresponding bin

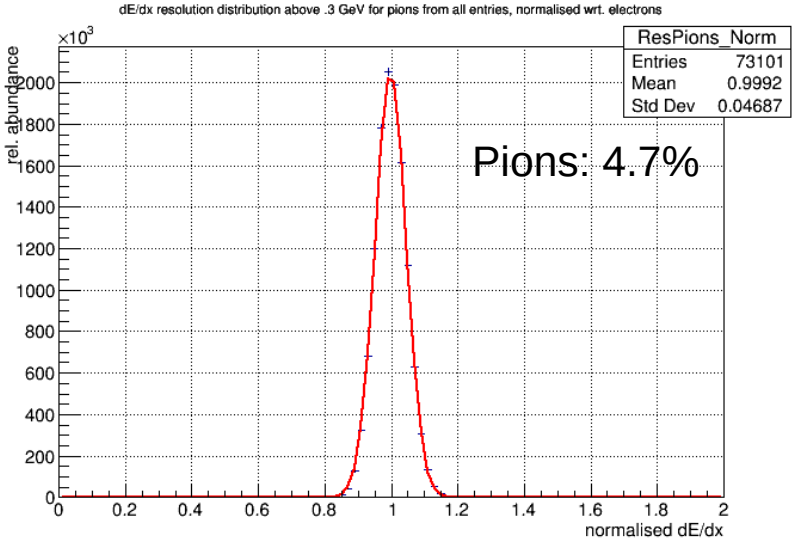


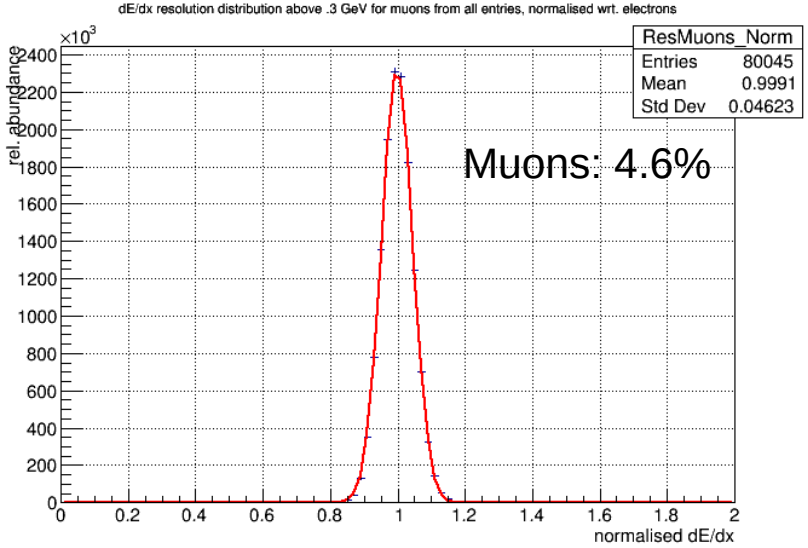


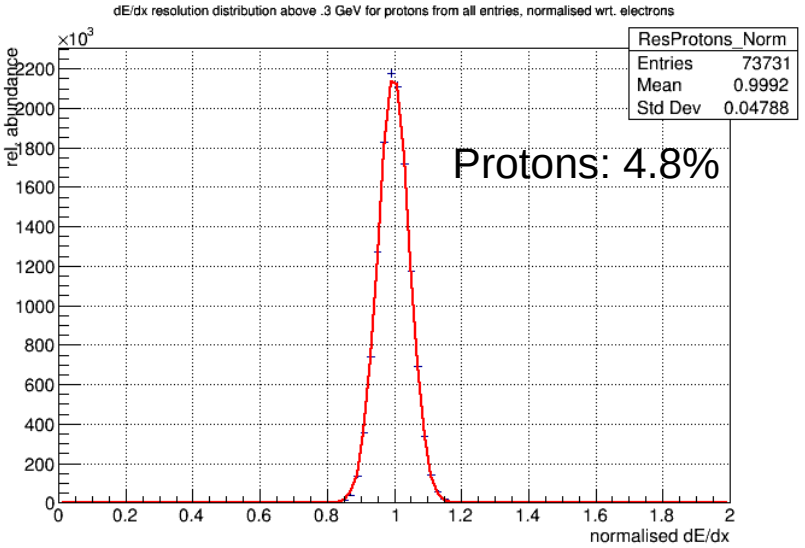


Resolution: ~ 4.5% above 1 GeV

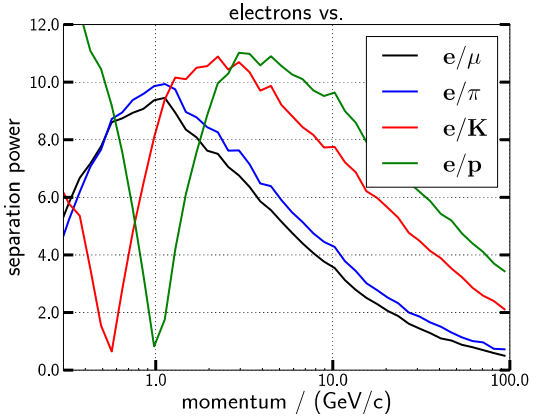


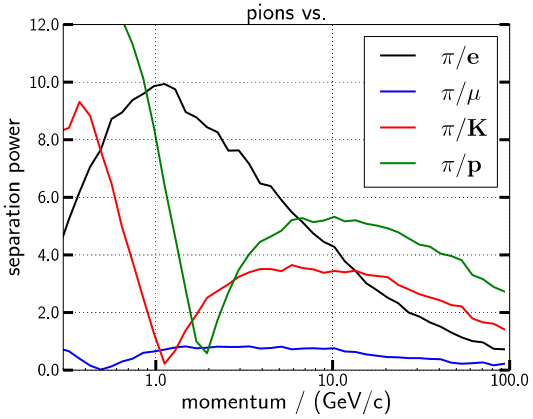


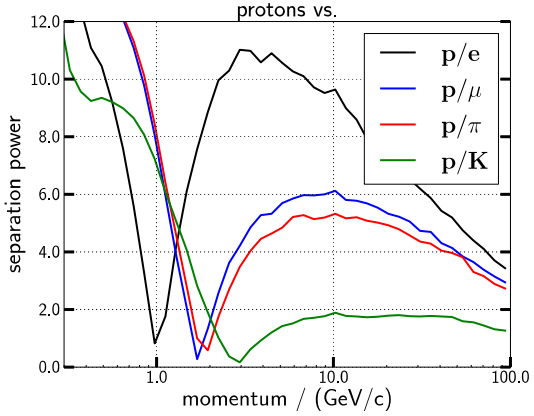


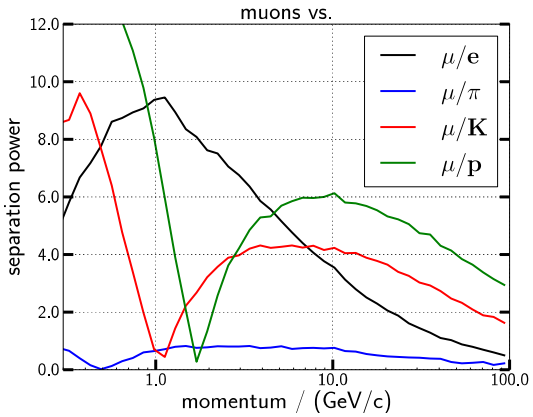


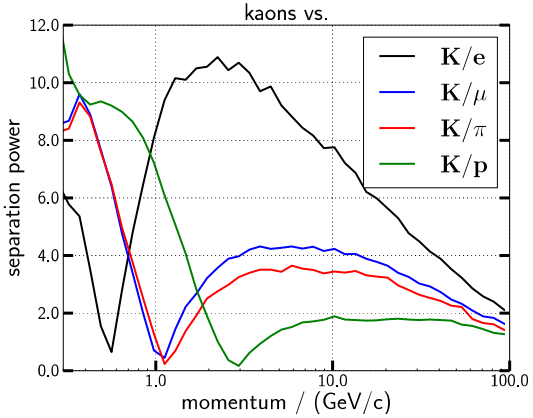
Separation Power – Combined Plots









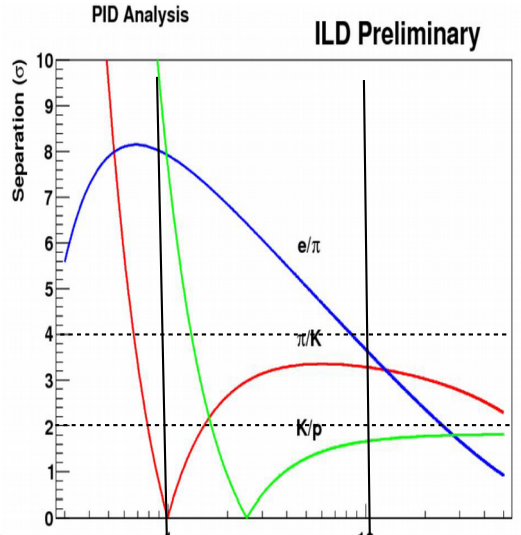


Separation Power:

$$S = \frac{|\mu_1 - \mu_2|}{\sqrt{\frac{1}{2}(\sigma_1^2 + \sigma_2^2)}}$$

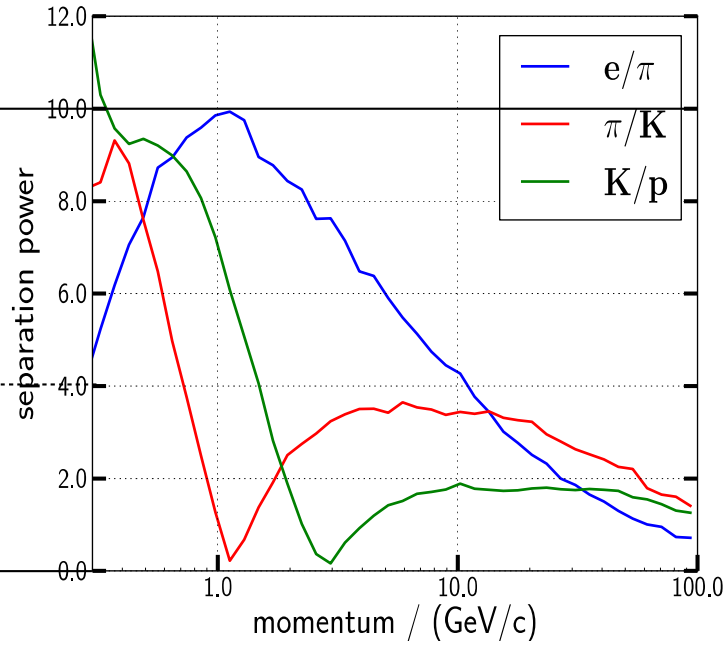
Separation Power - Comparison

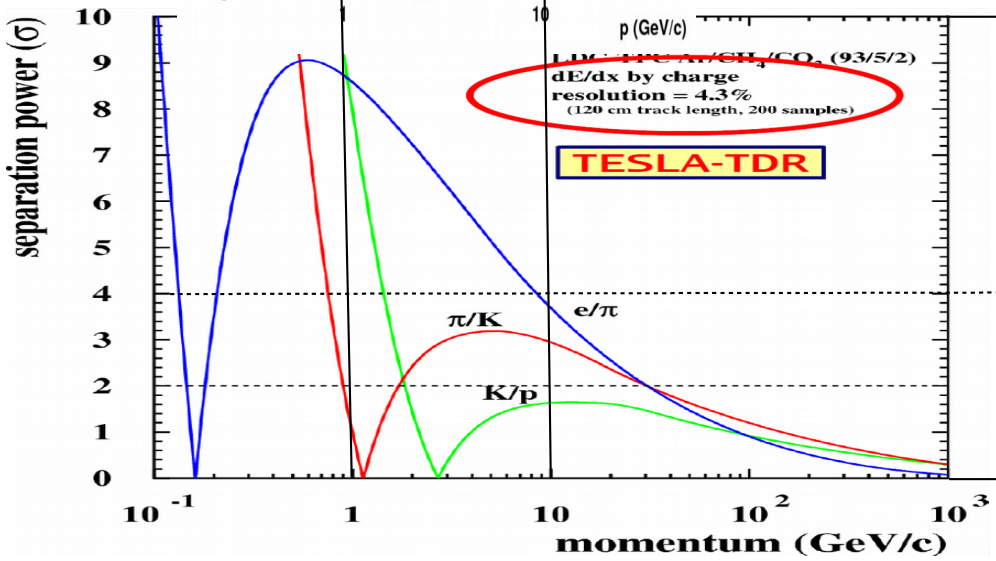
Kurata: Particle ID in ILD, talk at Calorimeter Workshop 19.01.2018



Plots aligned for matching axes

this work

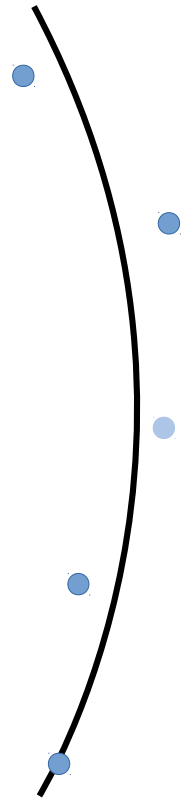




Hauschildt: Gaseous Tracking and dE/dx at Future Colliders, talk at CERN particle physics seminar, 05.07.2007

dE/dx – dx calculation strategies

- 1 (so far): use real distance between track hit centers
- 2: use helix path length of projected hits (points on the helix closest to the hit position)
  - Gets rid of hit-to-hit position fluctuation
  - Can be acquired from class MarlinUtil::SimpleHelix
  - Performs worse than strategy 1
- 3: use helix path length over the row height of the hit row
  - Gets rid of missing-hits problem, uses all hits
  - Calculate crossing point of helix with cylinder at upper and lower row edge (hit radius +/- half pad height)
  - Get helix path length between those crossing points
  - Performs similar to strategy 1



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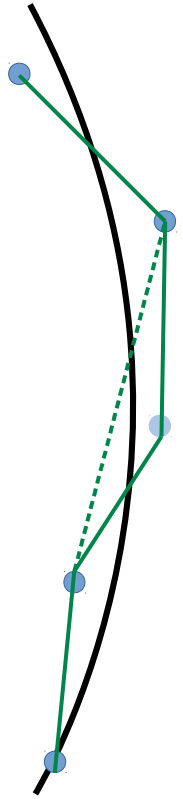

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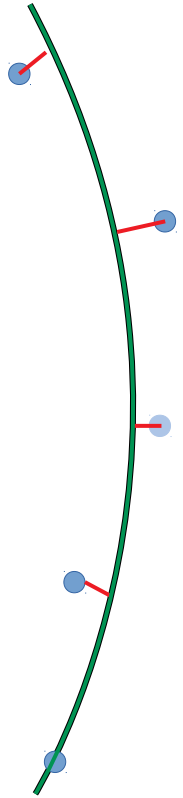

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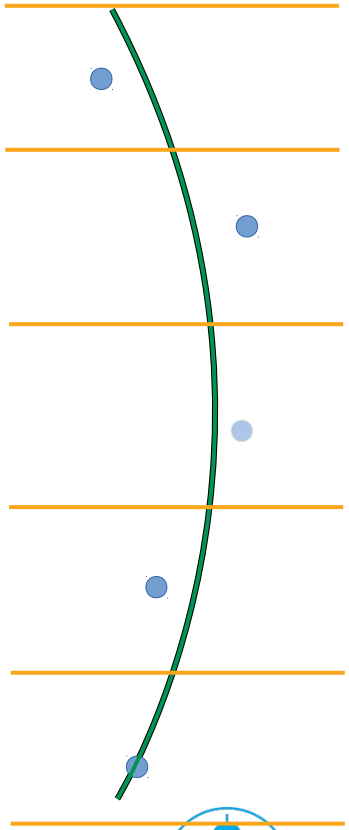
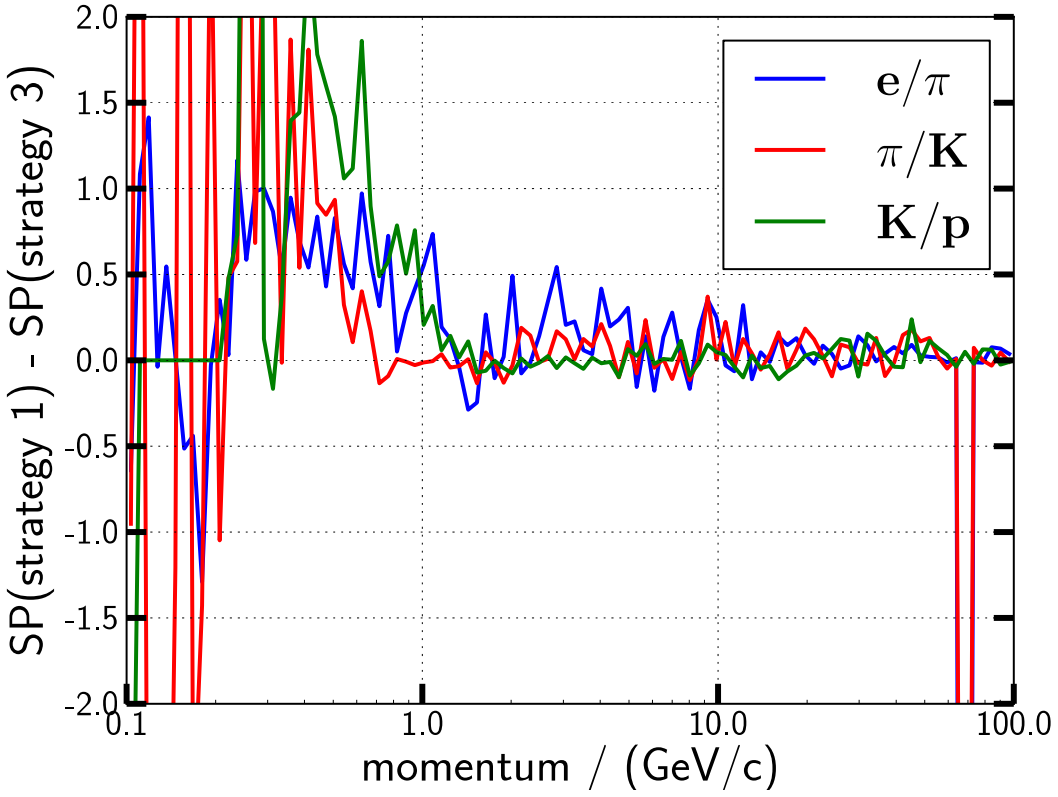


dx Strategy Comparison

- Strategy 1 is very similar to, maybe slightly better than strategy 3
- Difference plot:



Open issue: dE/dx error formula

- Current formula: $$\Delta\frac{dE}{dx}=\frac{dE}{dx}\cdot 4.7\,\%\cdot\left(\frac{L}{1\,m}\right)^{-0.34}\cdot N_{trunc}^{-0.45}$$

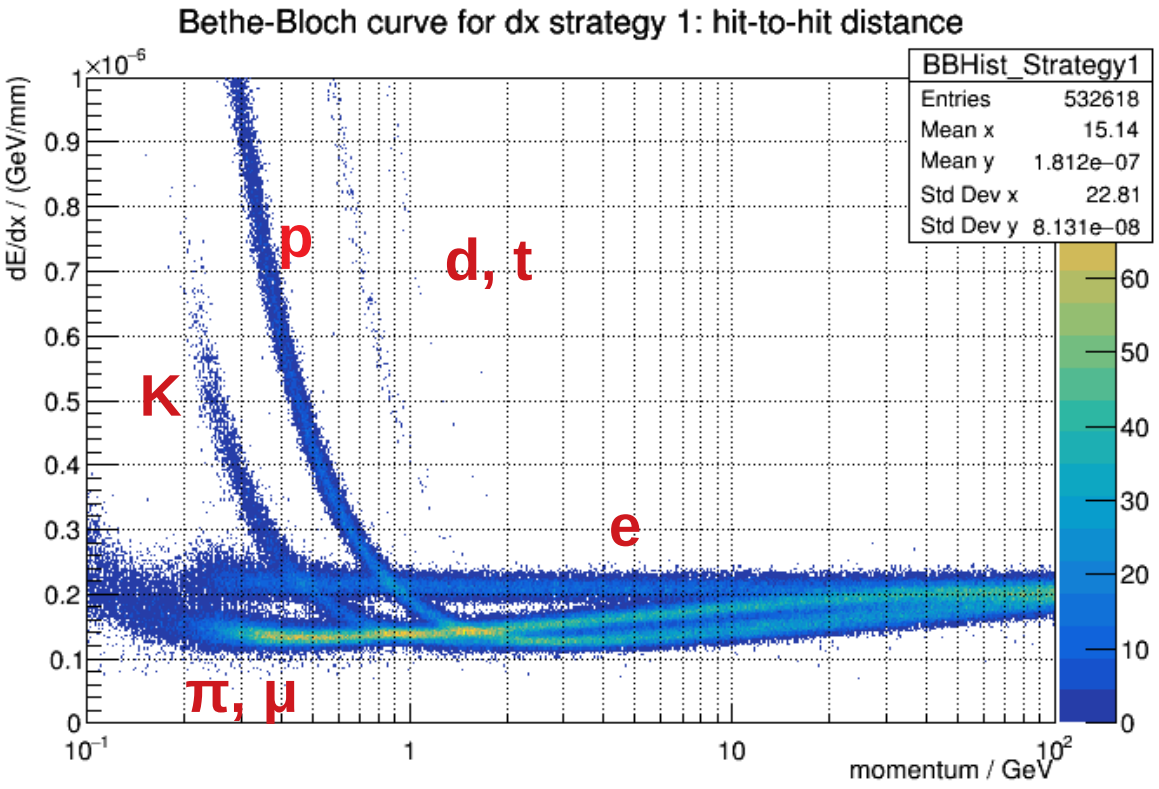
- Proposed formula: $$\Delta\frac{dE}{dx}=\frac{dE}{dx}\cdot 4.7\,\%\cdot\left(\frac{L}{N_{Hit}\cdot 6\,mm}\right)^{-0.34}\cdot\left(\frac{N_{Hit}}{220}\right)^{-0.45}$$

  equivalent: $$\Delta\frac{dE}{dx}=\frac{dE}{dx}\cdot 4.7\,\%\cdot\left(\frac{L}{1.32\,m}\right)^{-0.45}\cdot\left(\frac{N_{Hit}\cdot 6\,mm}{L}\right)^{-0.11}$$

- *L*: track length, N_{Hit}: total number of hits, N_{trunc}: after truncation
- The observed dependence on track length and/or granularity is weaker, and fits neither the current nor the proposed formulae.

To Do

- Error formula
- Various small things & checks → work in progress!
- Add analysis code to github
- Comparisons based on separation power:
  - dx strategies
  - Detector models and technologies
  - Improved dE/dx resolution (high granularity TPC)
  - Added weighting or other refined algorithms
- Interesting: Combine with potential TOF


Bethe-Bloch curve for dx strategy 1: hit-to-hit distance
BBHist_Strategy1
Entries 532618
Mean x 15.14
Mean y 1.812e−07
Std Dev x 22.81
Std Dev y 8.131e−08
×10⁻⁶
dE/dx / (GeV/mm)
momentum / GeV
p
d, t
K
e
π, μ

Thanks!

Backup