

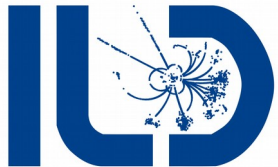
# PID with $dE/dx$ and TOF at ILD

But can we do *more* abbreviations?

Uli Einhaus

LCTPC Collaboration Meeting

10.01.2019



**HELMHOLTZ**  
RESEARCH FOR GRAND CHALLENGES



# What is done in MarlinReco?

- MarlinStdReco:
  - TrackingDigi
  - TrackingReco → Compute\_dEdxProcessor
  - [Calo]Digi
  - ParticleFlow
  - HighLevelReco → LikelihoodPIDProcessor  
→ TOFEstimators



# What is done in MarlinReco?

- Compute\_dEdxProcessor
  - Takes  $dE/dx$  of hits, combines it for a track, smears it to match expectation (test beam result), adds it to tracks (tracks are later attached to PFOs)
- LikelihoodPIDProcessor
  - Takes observables like  $dE/dx$  or shower shape, calculates distance from expected values as well as likelihood for different hypotheses, adds them to PFOs
- TOFEstimators
  - Calculates time-of-flight measurements based on Ecal hits, adds them to PFOs



# What is shown in this talk?

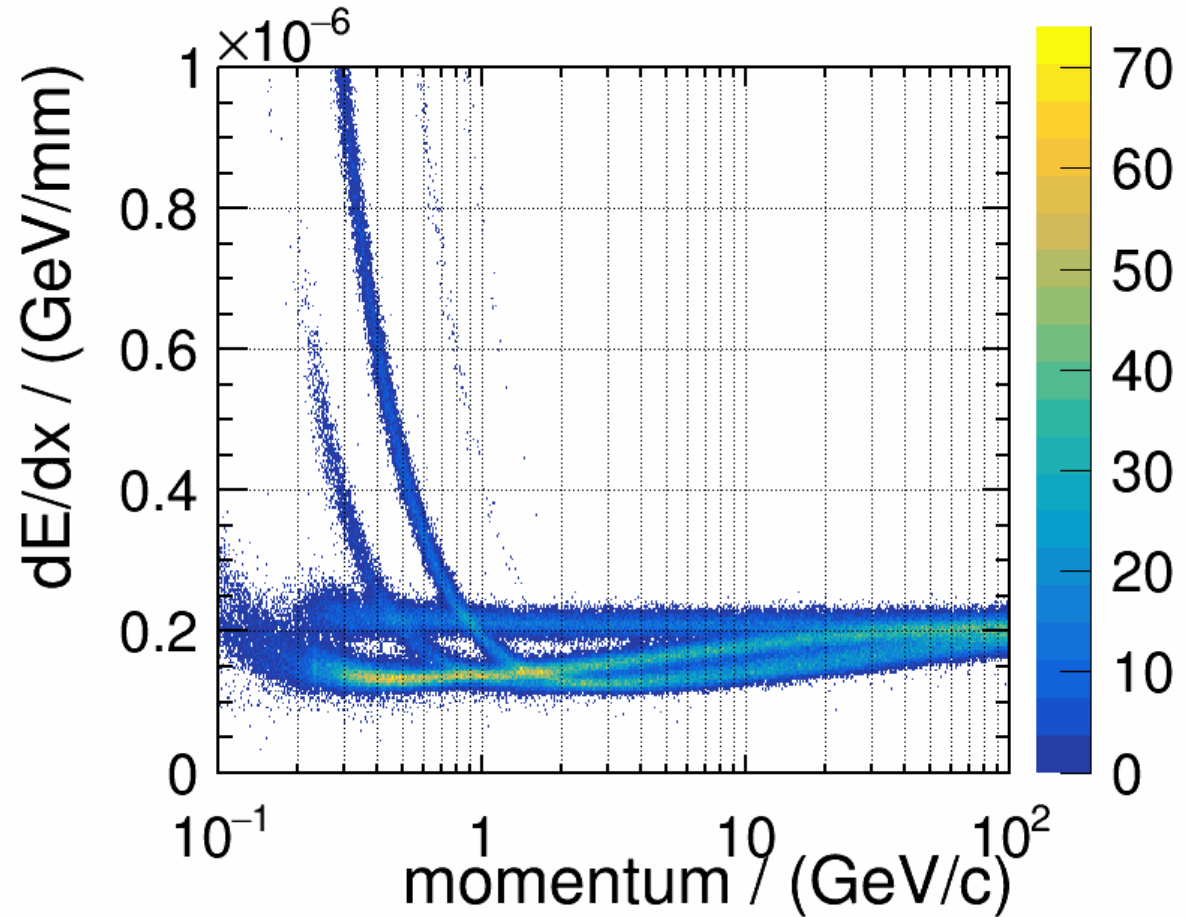
- Plots of  $dE/dx$  and TOF values and separation powers based on that
- $dE/dx$ : ILCSoft v02-00-01, mc-opt-3
- TOF: ILCSoft v02-00-00, mc-opt-2
- $dE/dx$  for single particle calibration files as well as for 6-fermion- $t\bar{t}$  events to check behaviour in 'busy' topologies



# dE/dx: The Bethe-Bloch Curve

- Particles used:  
  
electrons,  
muons,  
pions,  
kaons,  
protons

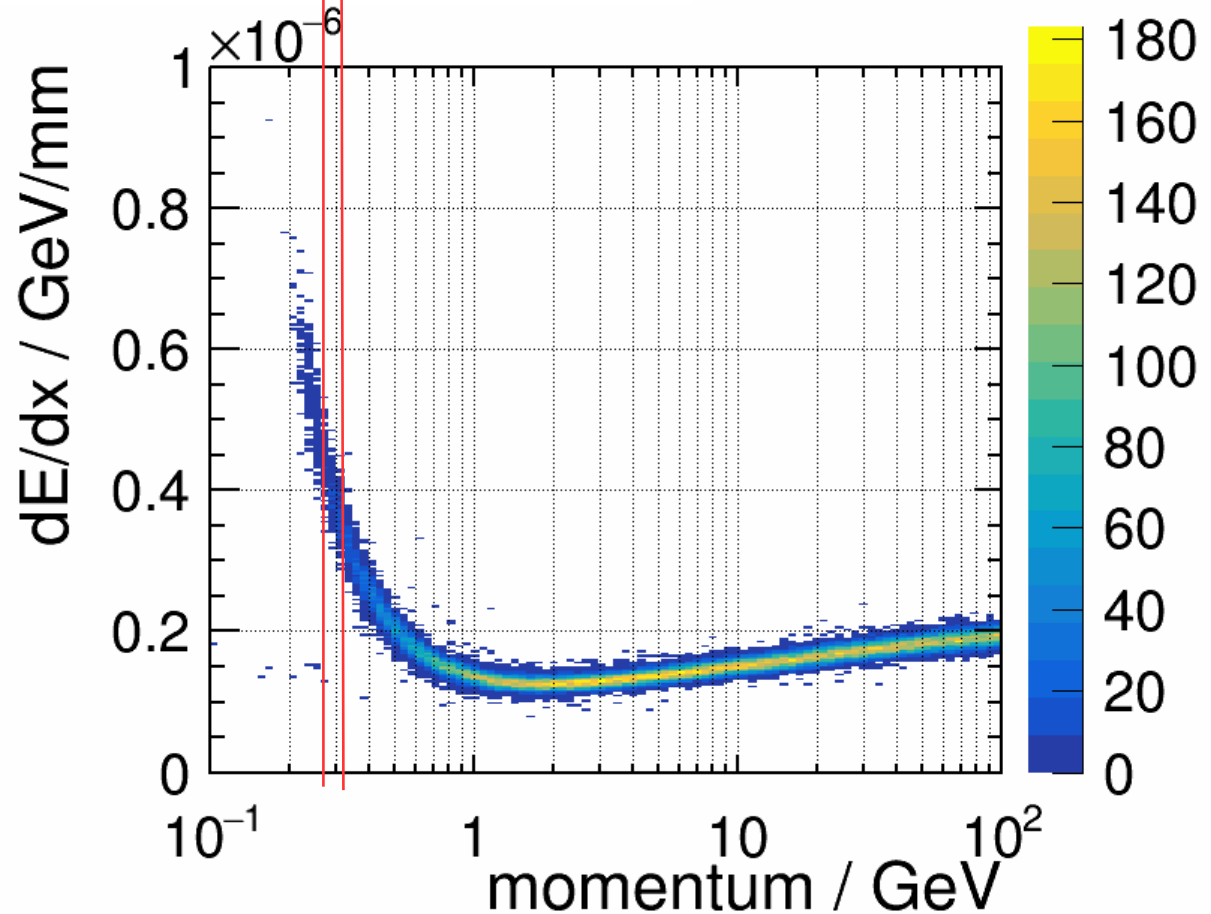
Bethe-Bloch curve for dx strategy 1: hit-to-hit distance



# dE/dx: The Bethe-Bloch Curve

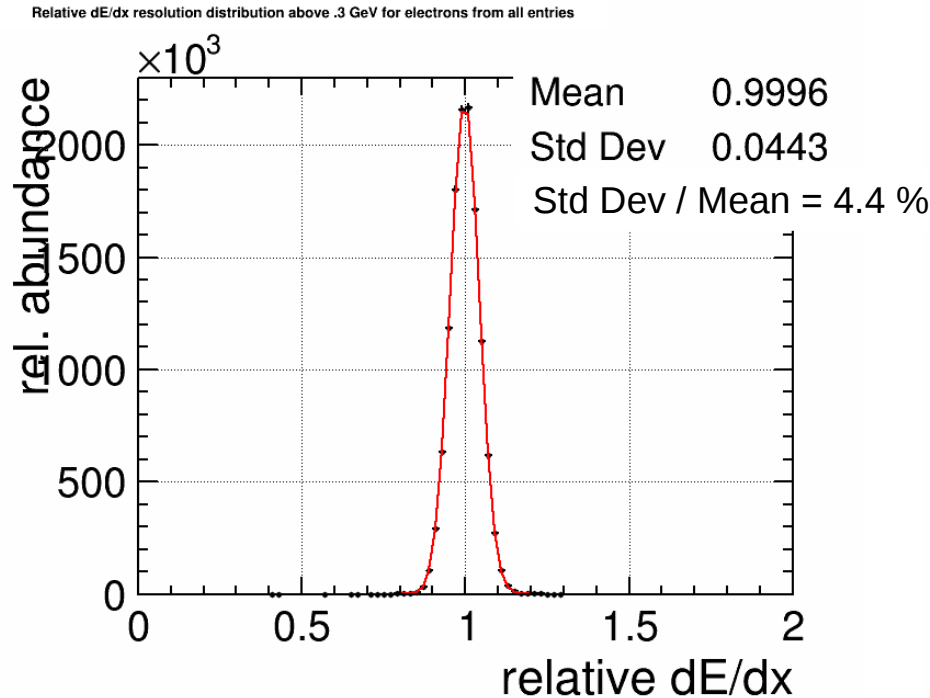
- Take a slice of the Bethe-Bloch curve, make a Gaussian fit
- Sigma / mean gives the resolution of that bin
- After correction for the momentum dependence, extracted as mean, all data points can be used for a global resolution fit

Bethe-Bloch histogram for kaons

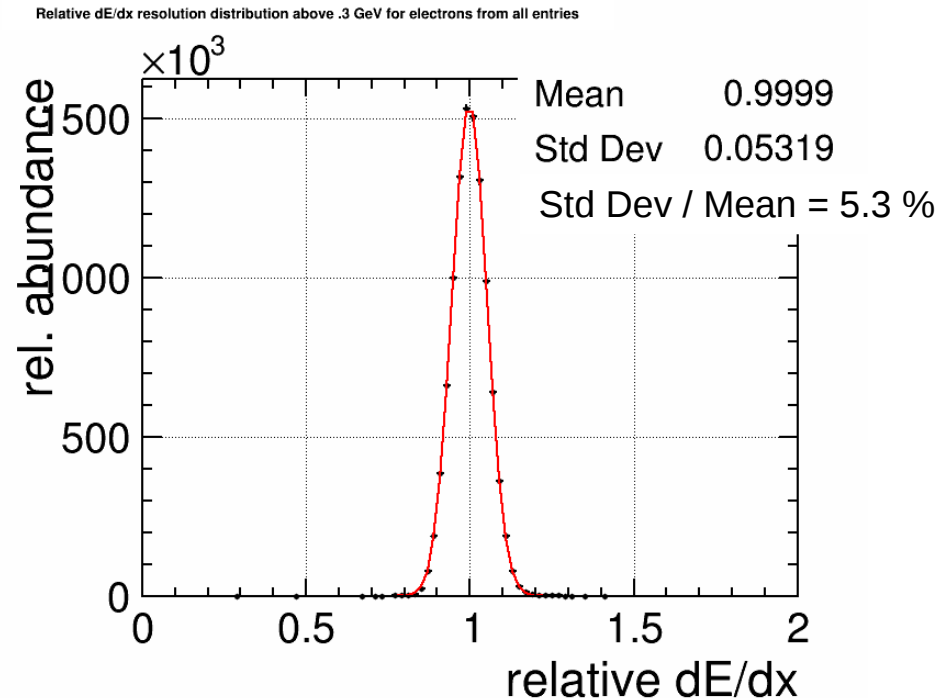


# dE/dx: Resolution

## Large ILD



## Small ILD



Testbeam results, extrapolation to ILD:  
4.2 % large, 4.8 % small (GridGEM)  
4.7 % large, 5.4 % small (AsianGEM)

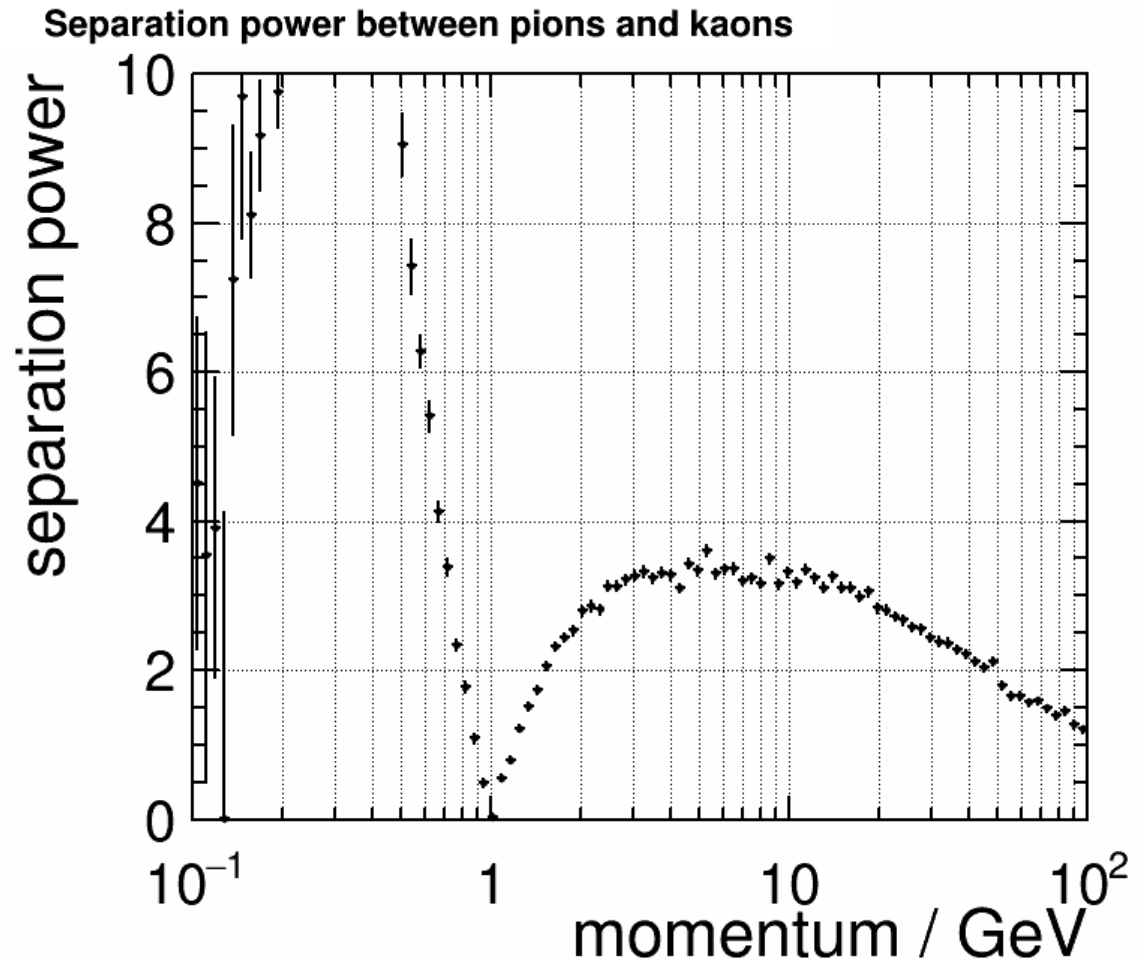


# dE/dx: Separation Power

- With the sigma and mean from above one can get the separation power:

$$S = \frac{|\mu_{\pi} - \mu_K|}{\sqrt{\frac{1}{2}(\sigma_{\pi}^2 + \sigma_K^2)}}$$

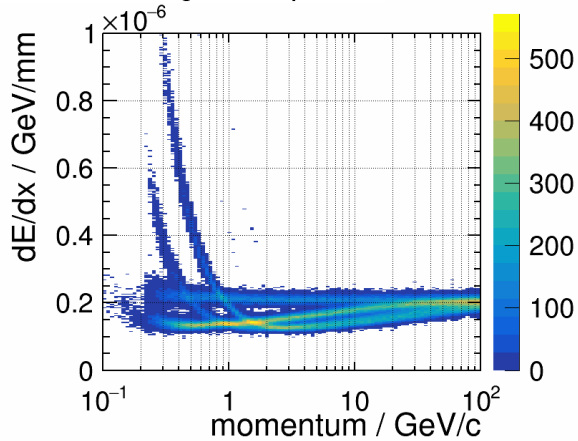
- Calculated for each combination of particles



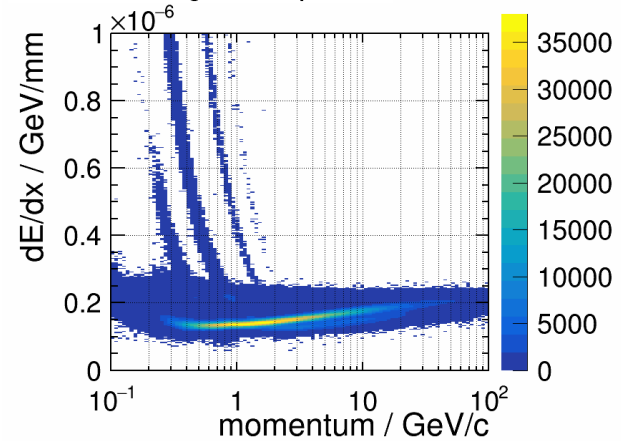


# Comparison: dE/dx for single particles vs. 6f-tt events

Bethe-Bloch histogram for all particles

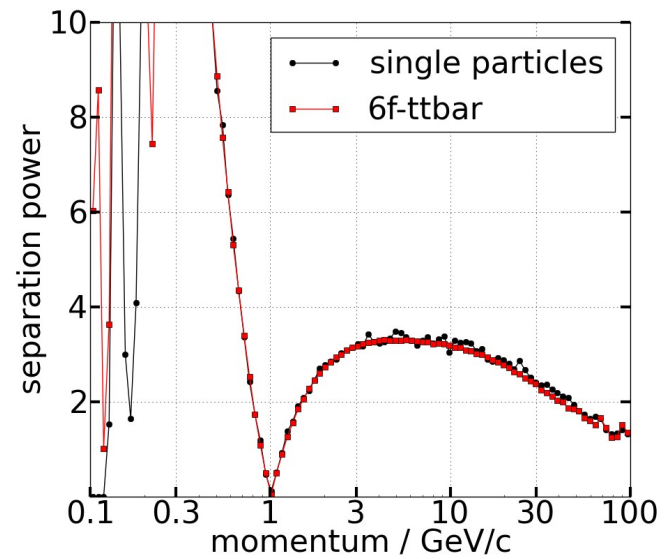
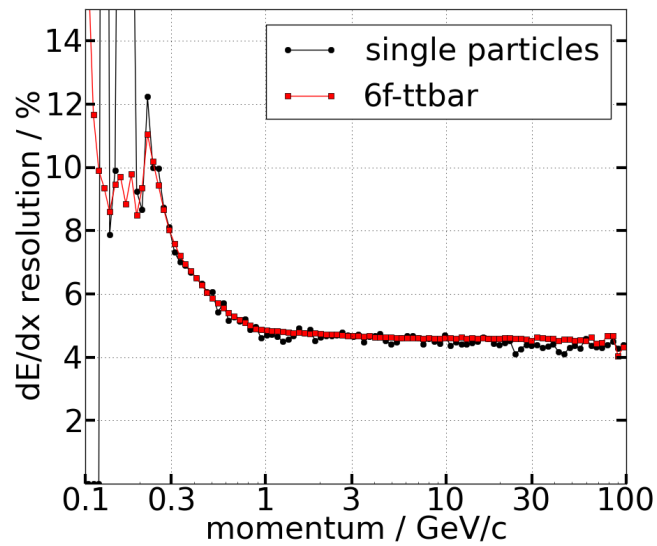


Bethe-Bloch histogram for all particles



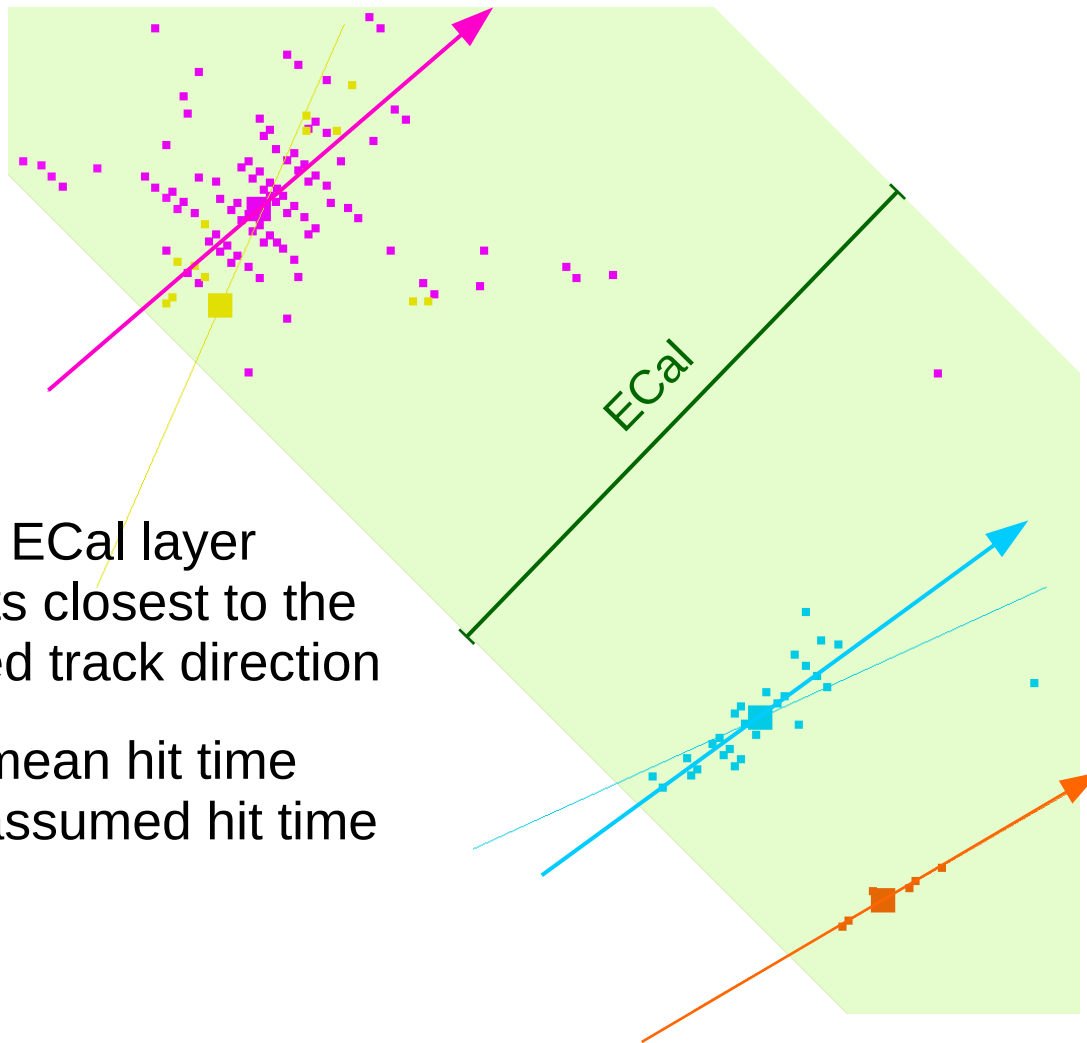
	l5 single	l5 6f-tt	s5 single	s5 6f-tt
electrons	4.3 %	4.5 %	5.3 %	5.4 %
muons	4.5 %	4.8 %	5.4 %	5.7 %
pions	4.5 %	4.6 %	5.5 %	5.6 %
kaons	4.6 %	4.7 %	5.5 %	5.7 %
protons	4.6 %	4.7 %	5.5 %	5.7 %

# Resolution & $\pi/K$ -separation in single comp. to $t\bar{t}$



# Time-Of-Flight: Measurement

Image from  
CED viewer



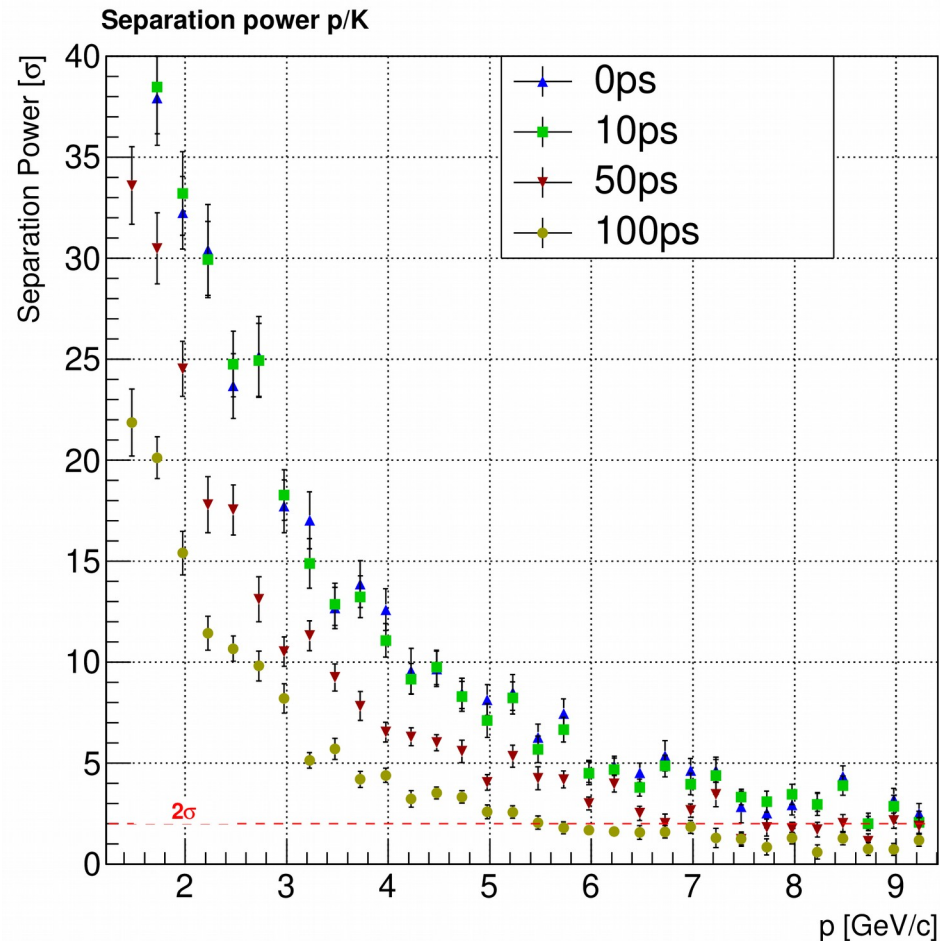
- From each ECal layer take the hits closest to the extrapolated track direction
- Calculate mean hit time based on assumed hit time resolution

# Separation Power

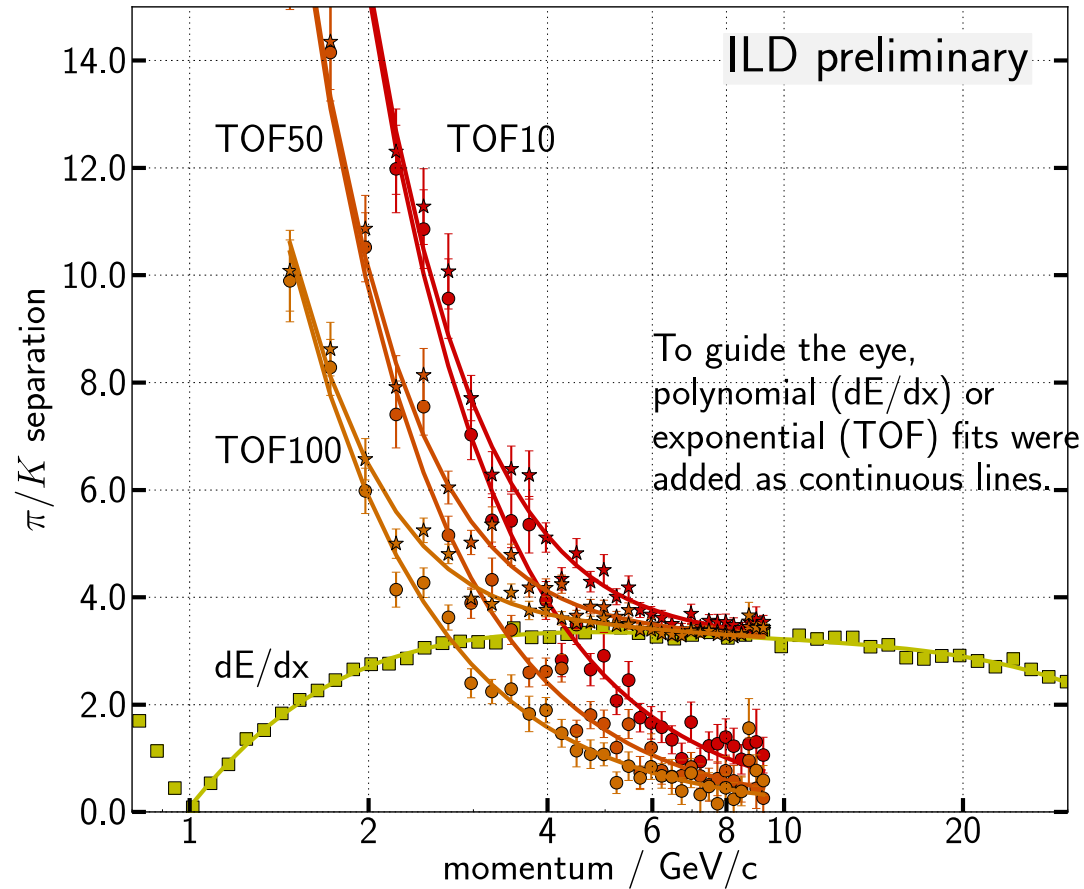
- By Sukeerthi Sundaresan:

[<https://agenda.linearcollider.org/event/7972/contributions/41753/attachments/33290/50855/ParticleID-TOF.pdf>]

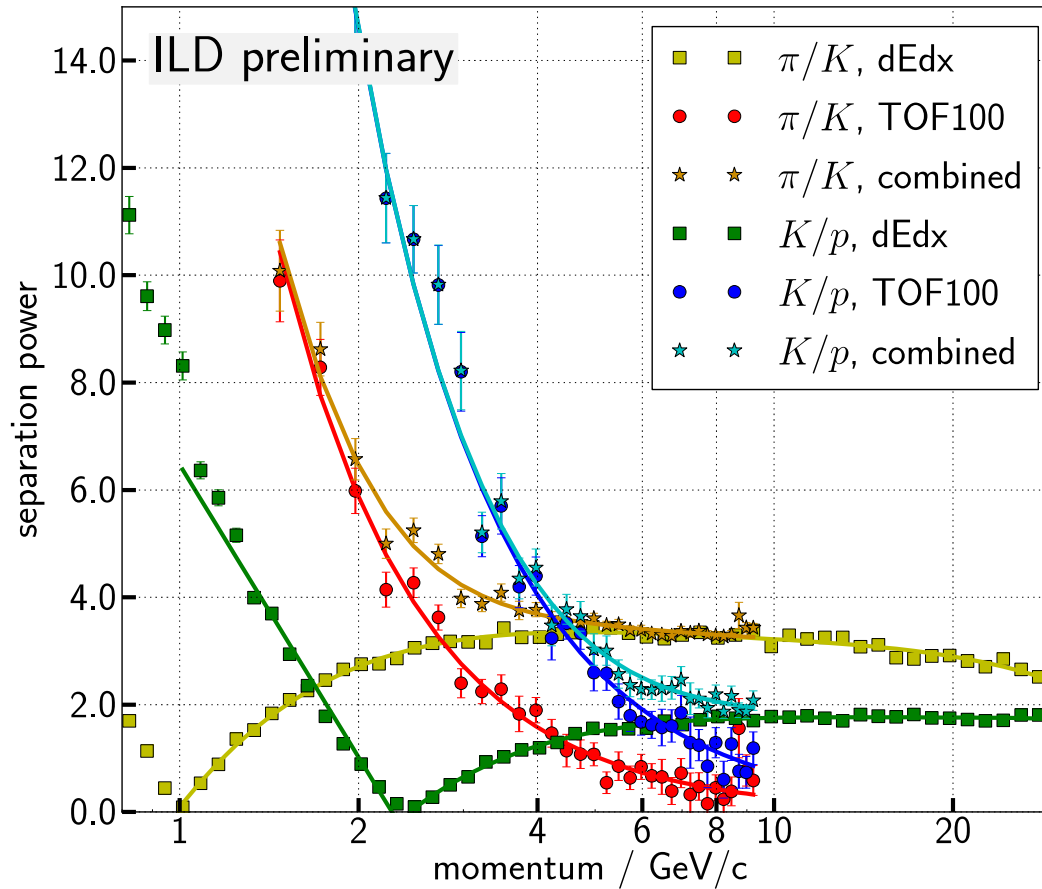
- Pion/kaon and kaon/proton separation
- Only barrel considered
- More comprehensive analysis ongoing by Jakob Beyer



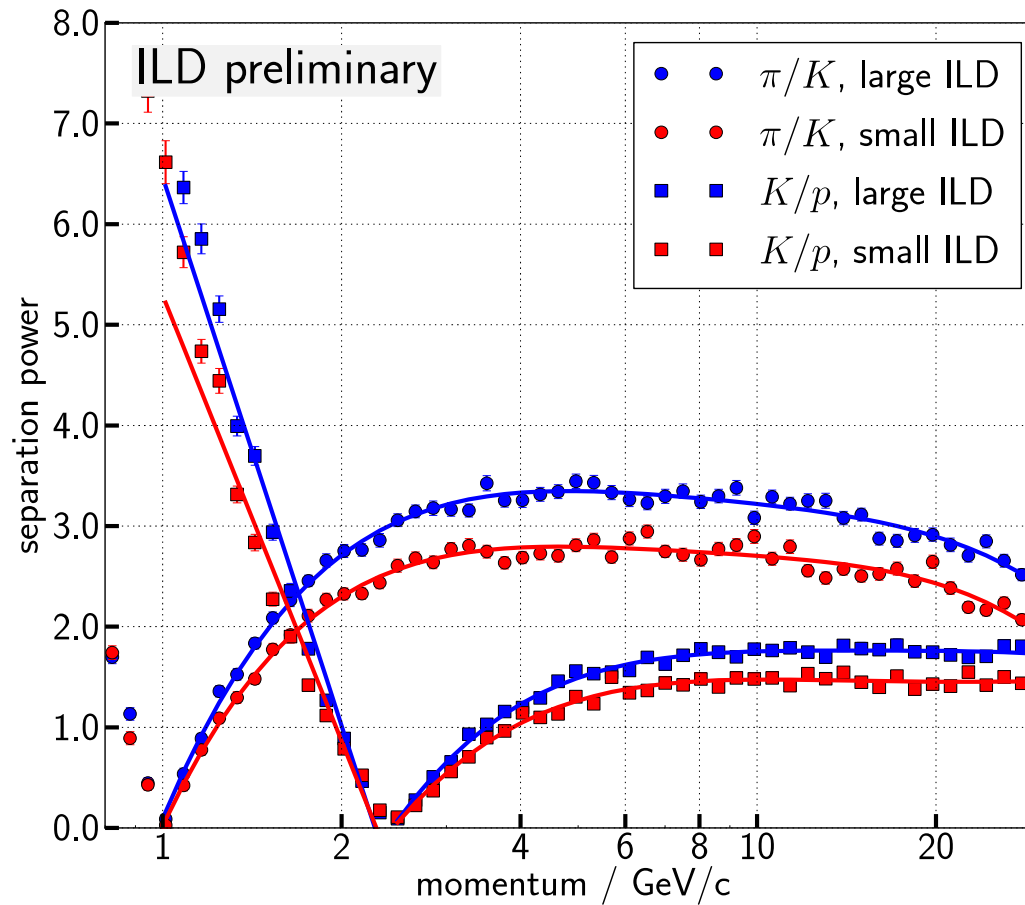
# Combined Plots: pion/kaon



# Combined Plots (TOF100)



# Combined Plots: dE/dx in Large vs. Small ILD



# PID with $dE/dx$ and TOF at ILD

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Thank you!  
-  
Questions?  
-  
Backup



