TOF for PID

A first look

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ILD Meeting, Ichinoseki, Feb 22, 2018

Outline

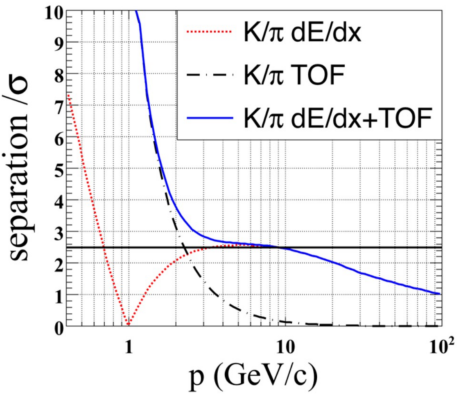
- Introduction
- Time information in *CalorimeterHits*
- Time distribution in showers
- Correcting for *Time of Flight*
- First Results
- Summary and Outlook

report on work done by N.Weinhold during internship at DESY, 2017

Introduction

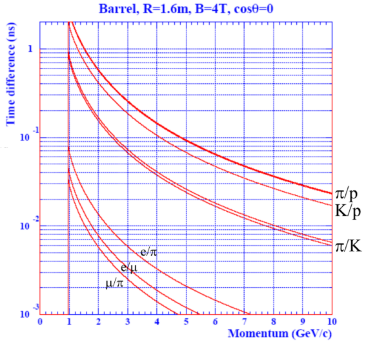
- investigate the use of the calorimeter hit time in order to measure the *time of flight* to improve *PID*
- idea: add TOF estimators to *PFOObjects* on DST files
- start with looking at calorimeter hit times for single particles w/ fixed (P, θ)

  `CalorimeterHit::getTime() : time of first Geant4 step`
- then see what can be done on the cluster level



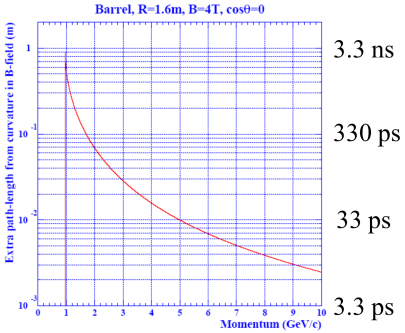
M.Ruan @ LCWS2017

TOF - not only for PID ?



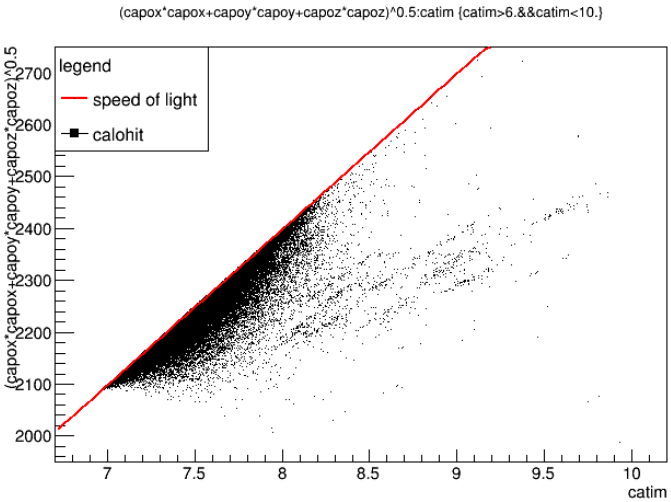
prepared by G.Wilson for LDC

depending on how good the time resolution will be, it might also help to improve the PFA by disentangling calorimeter hits from neutral and charged particles - or even from charged particles of different momenta

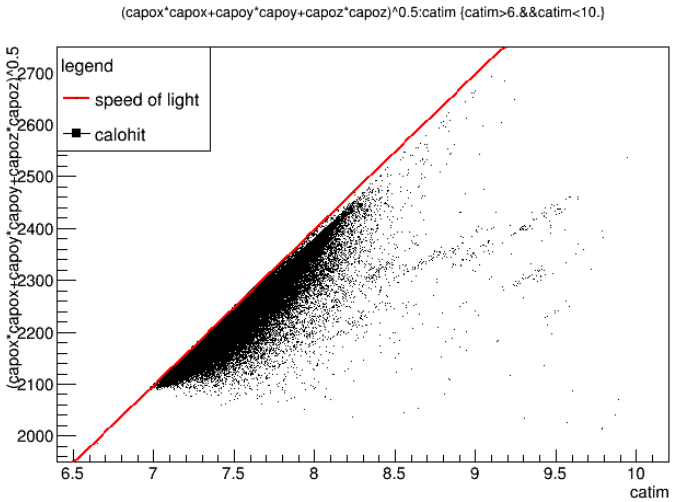


prepared by G.Wilson for LDC

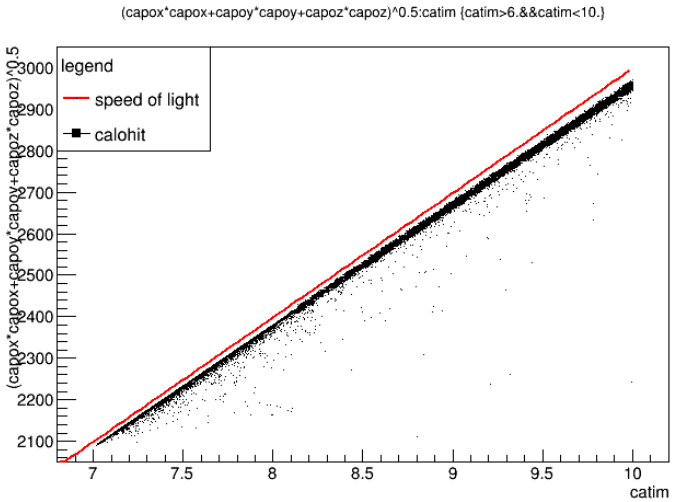
Hit distance vs time for γ - 5Gev - 60 deg



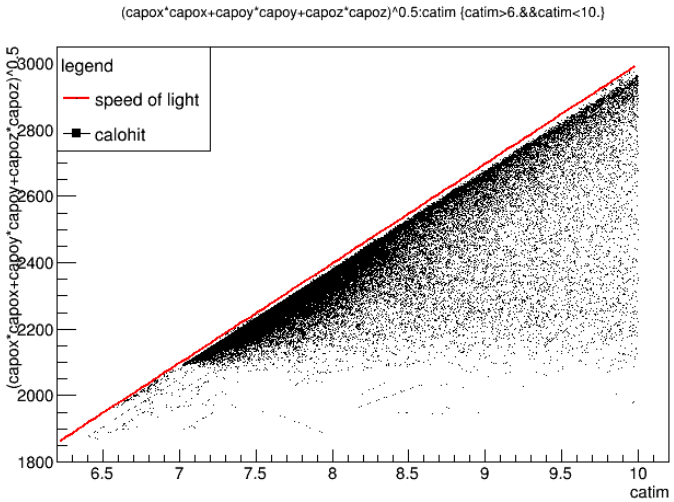
Hit distance vs time for e^- - 5Gev - 60 deg



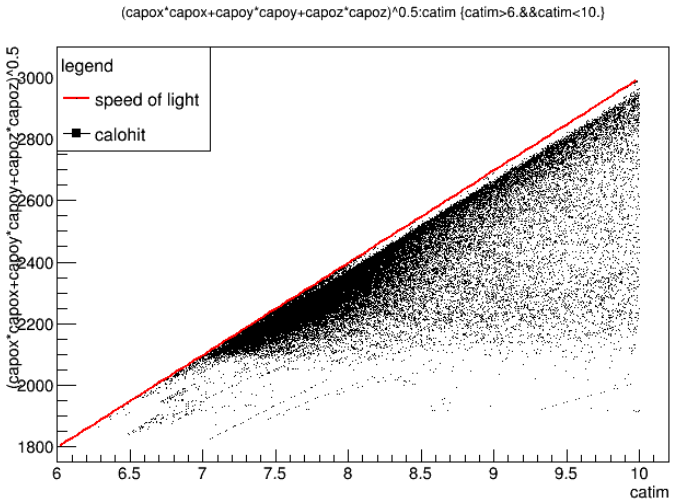
Hit distance vs time for μ^- - 5Gev - 60 deg



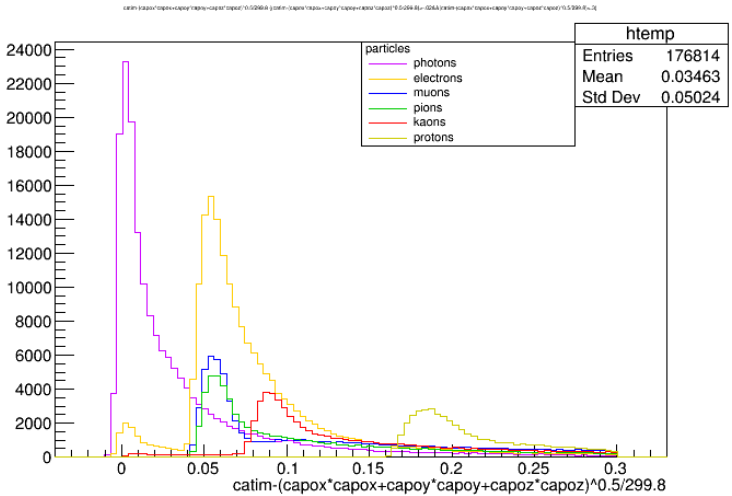
Hit distance vs time for π^- - 5Gev - 60 deg



Hit distance vs time for K_L^0 - 5Gev - 60 deg



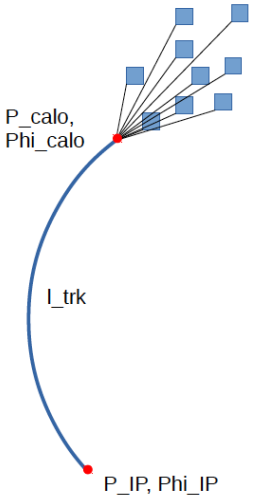
Compare hit time to particle that travels @ speed of light



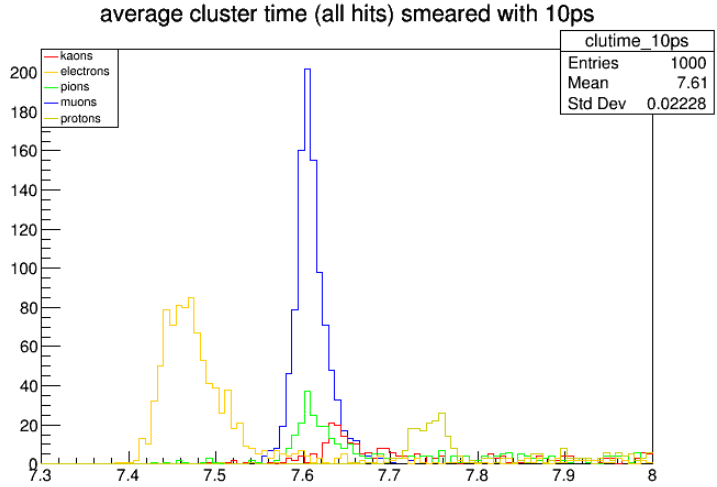
now look at cluster level . . .

Time of flight correction for hits

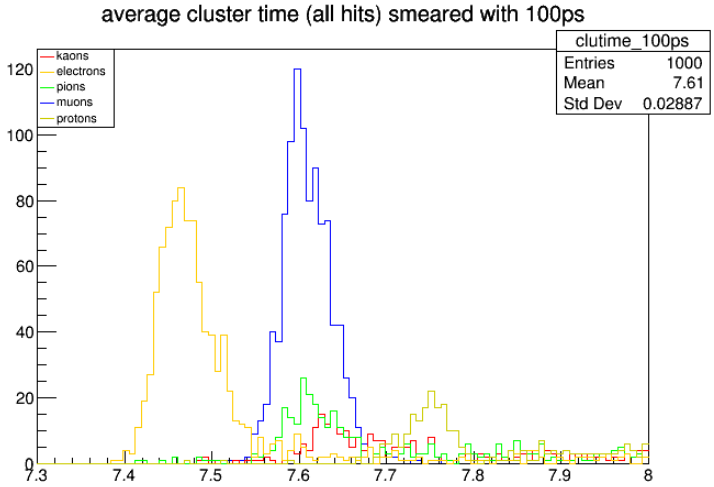
- correct hit time wrt. entry point into calorimeter
  $t_{cor} = t_{hit} - dist(P_{calo}, P_{hit})/c$
- compute mean value for (parts of the cluster)
  $t_{clu} = \sum_{i=0}^{N} t_{cor,i}$
- compute the track length
  $l_{trk} = |\phi_{IP} - \phi_{calo}|/\omega)\sqrt{(1 + tan^2(\lambda))}$
- compute estimator for velocity
  $\beta = l_{trk}/t_{clu}/c$



Example: average cluster time for 10 ps resolution

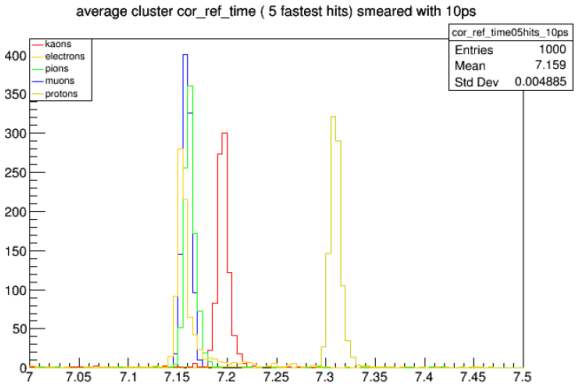


Example: average cluster time for 100 ps resolution



Other estimators for Cluster time

- looked at various estimators for the *cluster time*
- take corrected hit time t_{cor} for
  - 5, 10, 20 fastest hits
  - 5%, 10%, 20% fastest hits
- observe best results for 5 fastest hits
- *example:* particles with $p = 5\,GeV$ at 60 deg, fixed azimuth angle



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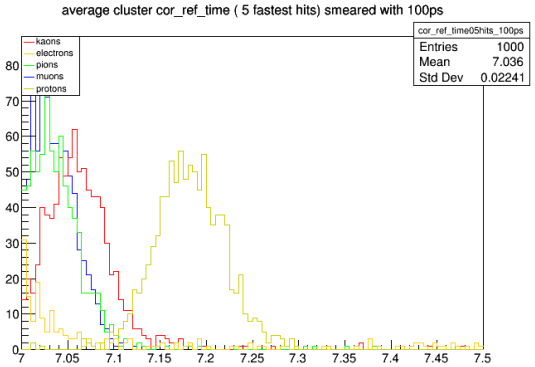
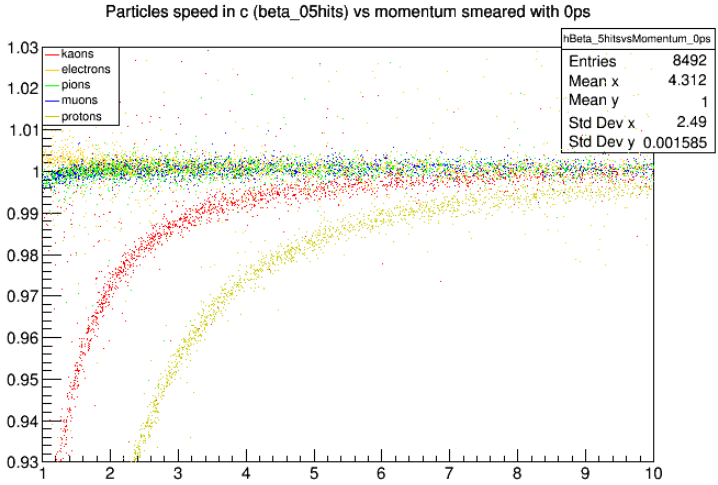
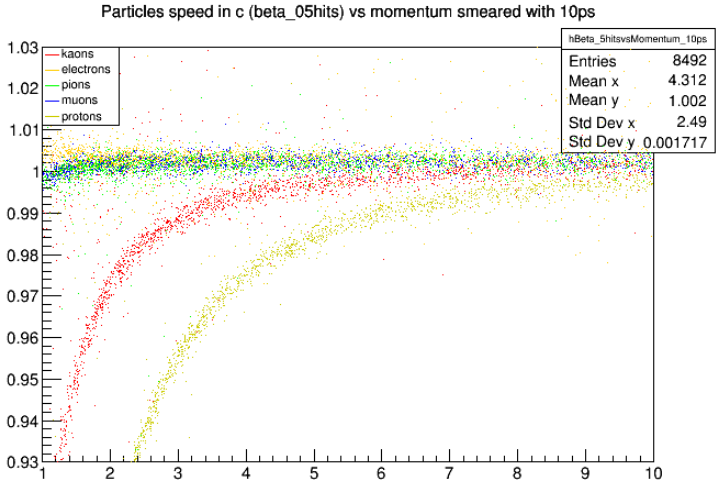


Next: look at β for single particles with random momenta and directions

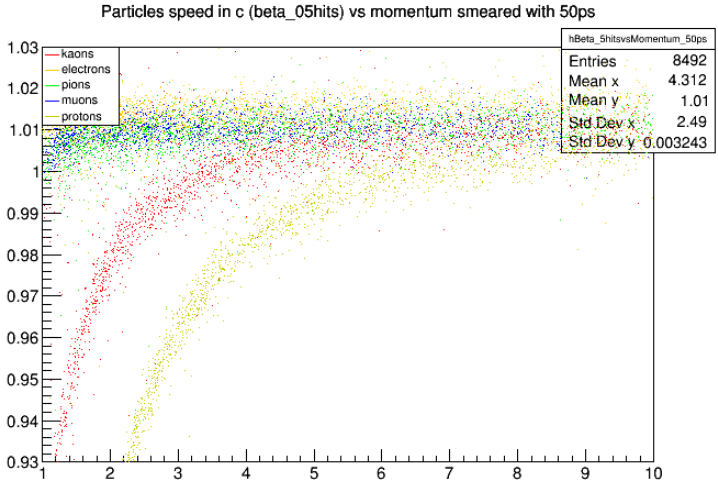
Estimate of beta vs momentum (0ps resolution)



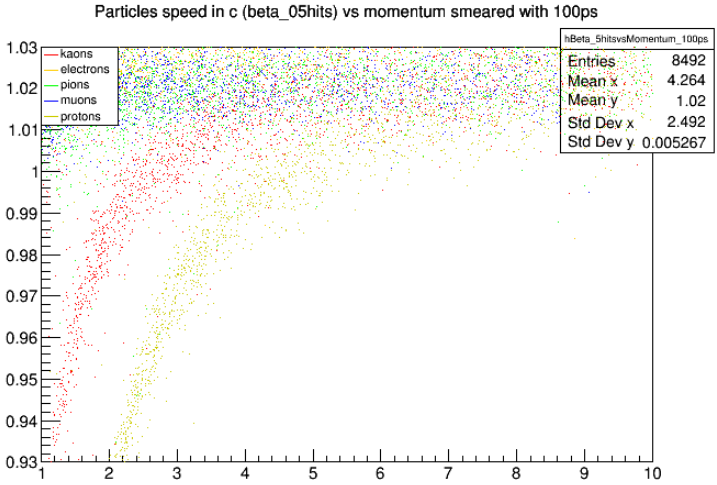
Estimate of beta vs momentum (10ps resolution)



Estimate of beta vs momentum (50ps resolution)



Estimate of beta vs momentum (100ps resolution)



Summary and Outlook

- first look at usage of caloritmeter hit time measurements for PID
- goal: add some TOF estimators to the DST files
- with different assumptions on the achievable time resolution
  - e.g. 10 ps, 50 ps, 100 ps
- which estimators ? all ?
- β estimators are **not un-biased** !

Next Steps

- investigate other estimators, e.g. based on *most energetic hits*
- need to understand on how to include TOF for PID
- write code to extract and add parameters to PFO objects
- agree on a *realistic* assumption for time resolution that can be used in analyses: 100 ps ?