Time Imaging Reconstruction

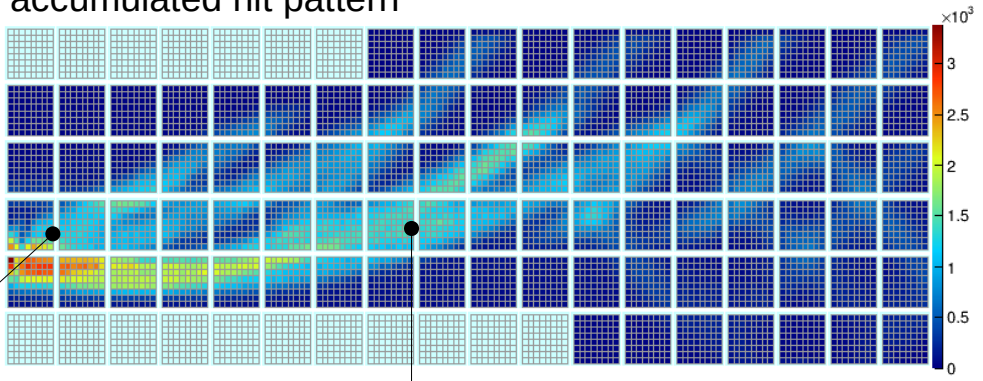
Roman Dzhygadlo

10 Dec 2021,
GlueX DIRC Meeting

Time Imaging

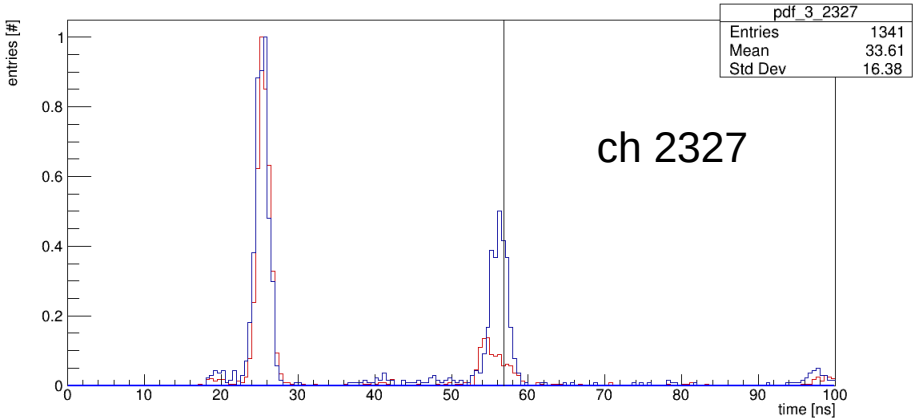
$$\log\mathcal{L}_h = \sum_{i=1}^{N} \log(S_h(c_i,t_i) + B_h(c_i,t_i)) + \log P_h(N)$$

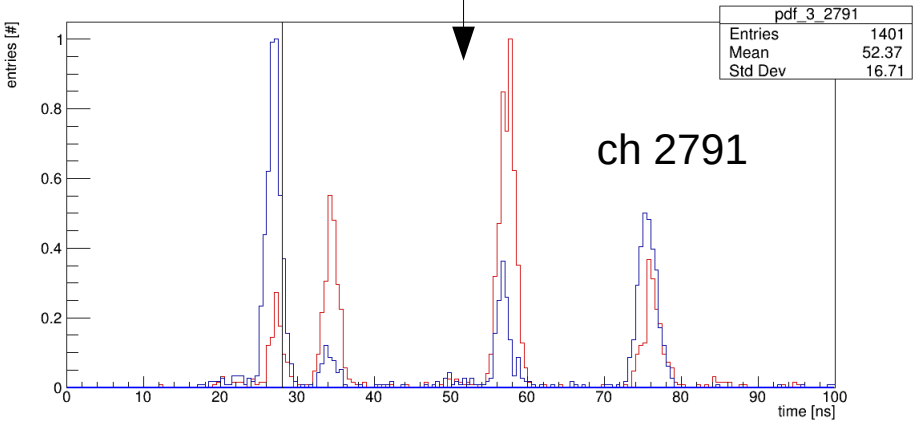
accumulated hit pattern



hdgeant4 for pi/K at 4 GeV/c

propagation time of Cherenkov photons:

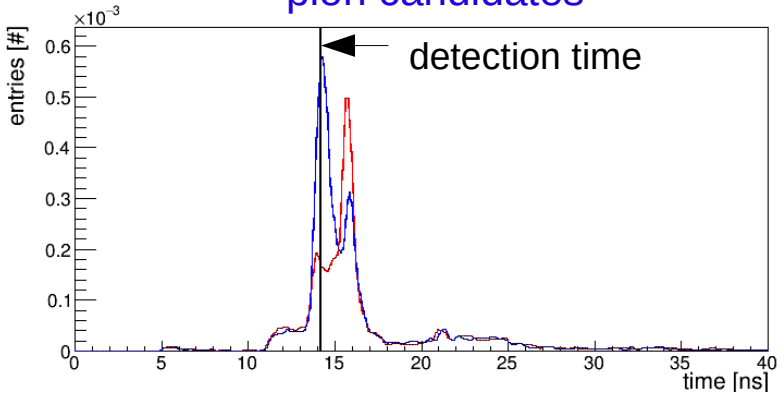




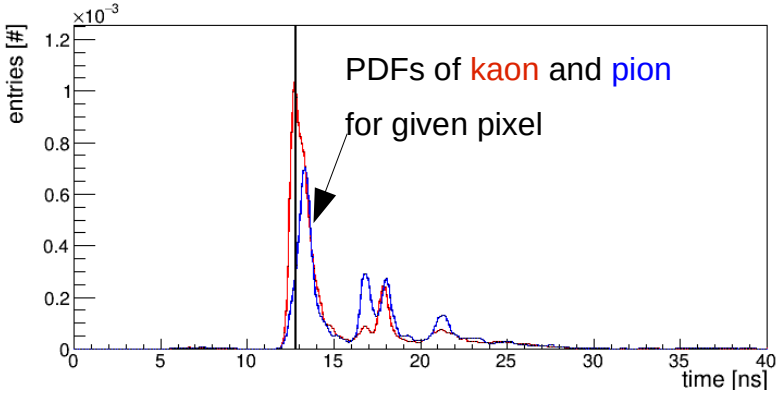
Time Imaging

$$\log\mathcal{L}_h = \sum_{i=1}^{N} \log(S_h(c_i, t_i) + B_h(c_i, t_i)) + \log P_h(N)$$

pion candidates



kaon candidates



Probability Density Functions

- From data
  - best PID (does not need calibration)
  - requires a large amount of data in whole angular and momentum acceptance
- Simulated
  - full Geant4 simulation of every possible particle type direction and momentum
  - needs extensive offline simulations
- Analytical
  - no prerequisites
  - initially developed for Belle II TOP (M. Staric, et al., Nucl. Inst. and Meth. A 595 (2008) 252)
  - modified for PANDA Barrel DIRC to account for spherical lens focusing (PDFs using LUT)
    (R. Dzhygadlo et al. 2020 JINST 15 C09050, arXiv:2009.09927)

Analytical PDF using LUT

$$\log\mathcal{L}_h = \sum_{i=1}^{N} \log(S_h(c_i,t_i) + B_h(c_i,t_i)) + \log P_h(N)$$

$$\sum_{k=1}^{m_j} n_{kj}\, g(t_{kj}, \sigma_{kj})$$ = sum of Gaussians

n_{kj} ~ effective pixel size

σ_{kj} ~ chromatic dispersion, optical aberrations

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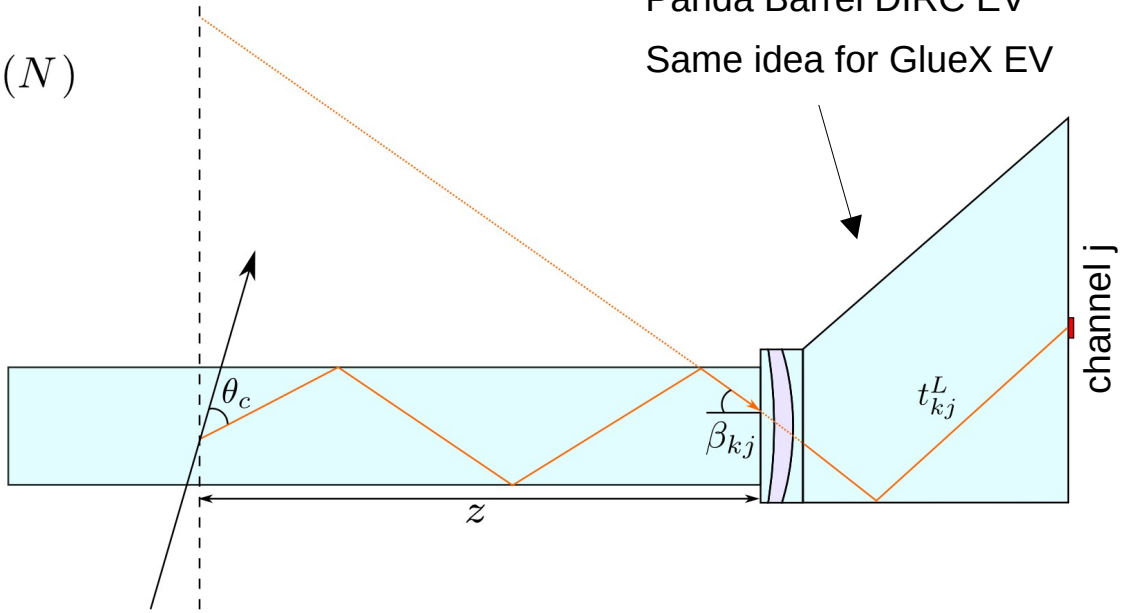
Panda Barrel DIRC EV

Same idea for GlueX EV



$$t_{ki} = \frac{z}{\cos\beta_{ki}} \frac{n_g}{c_0} + t^L_{ki}$$

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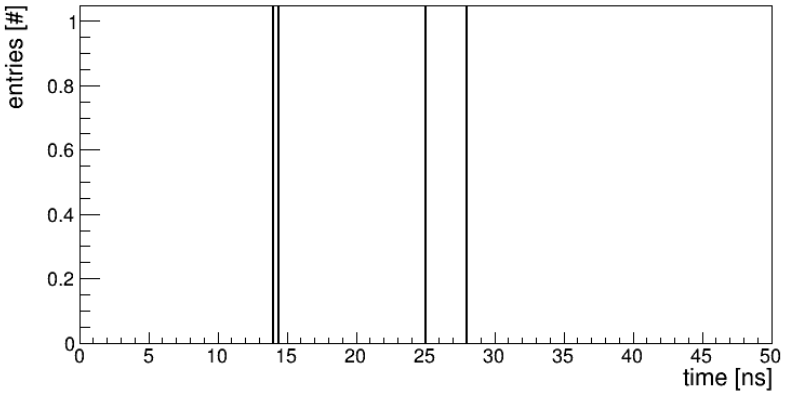

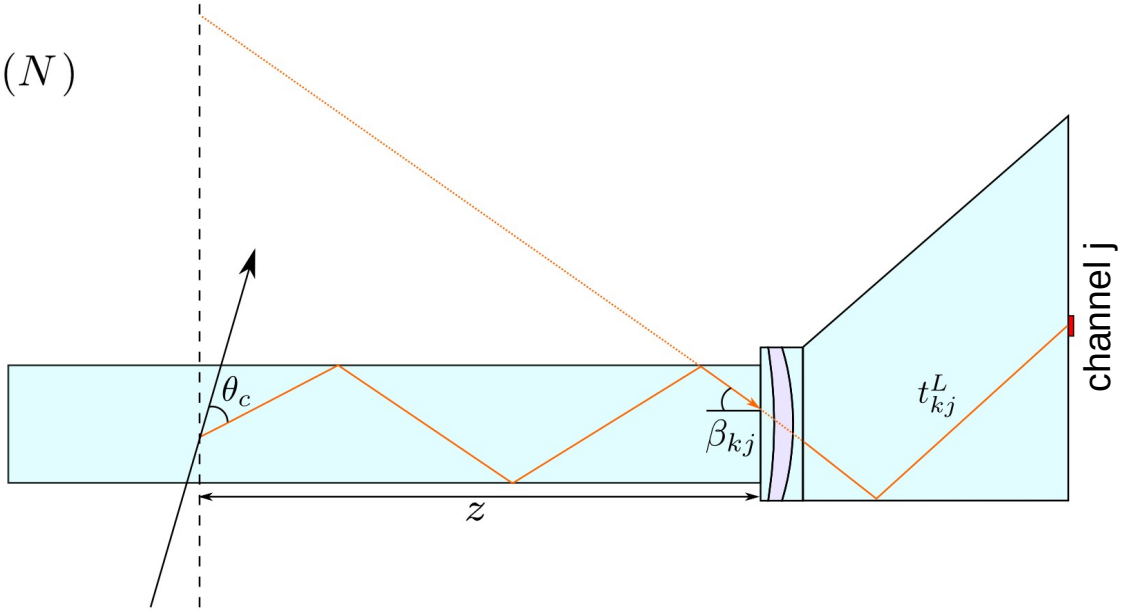

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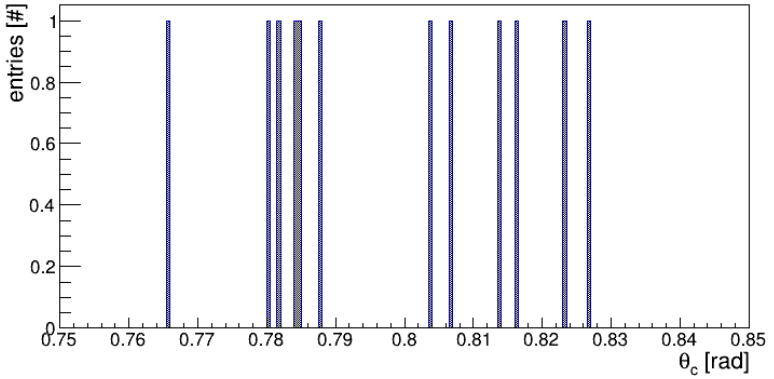
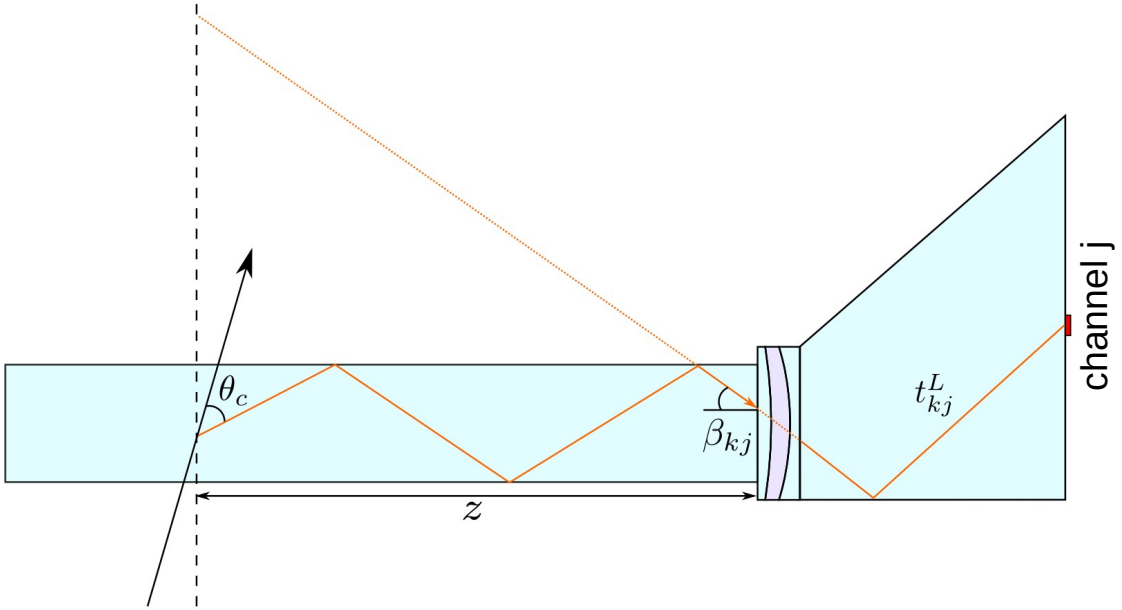
Analytical PDF using LUT

Cherenkov angle distribution





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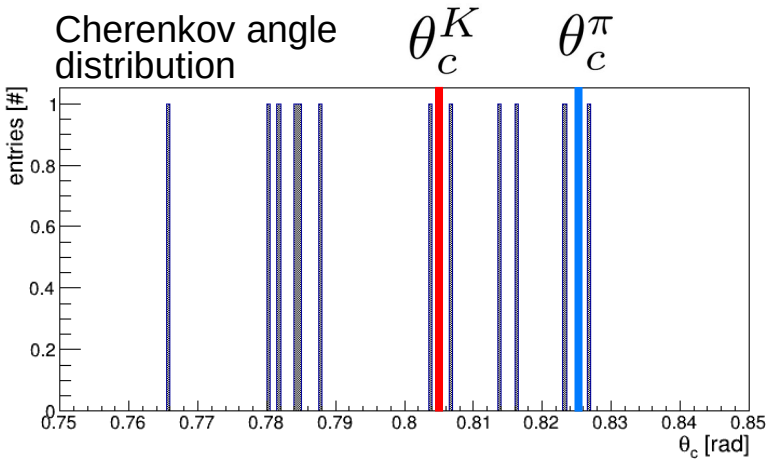
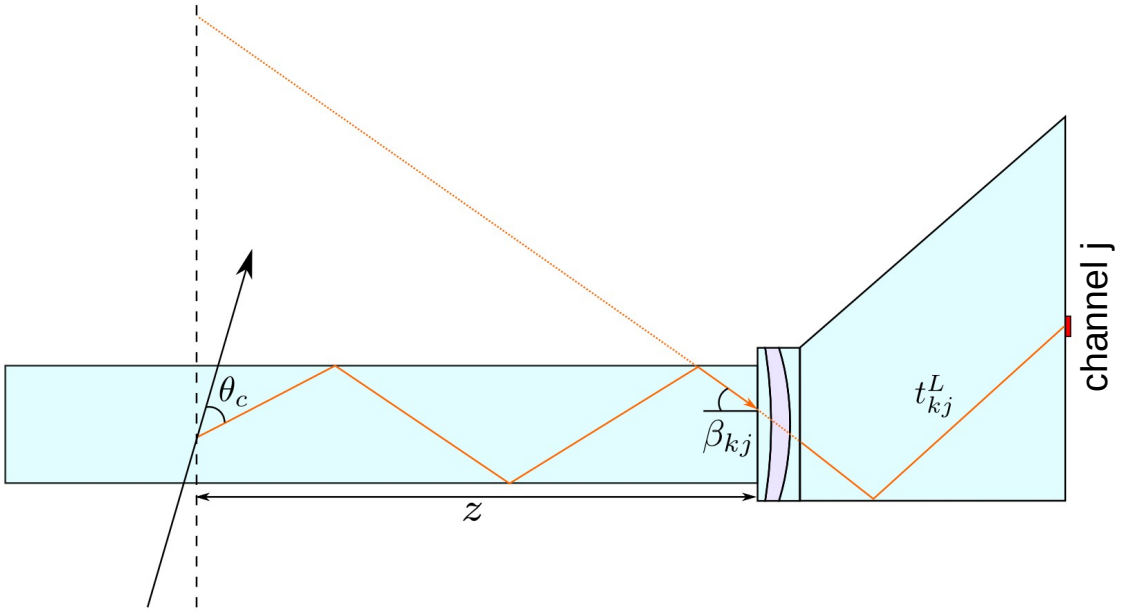
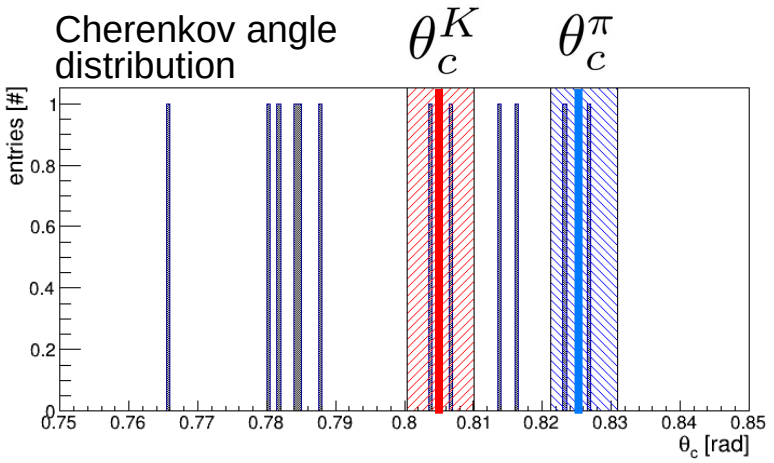
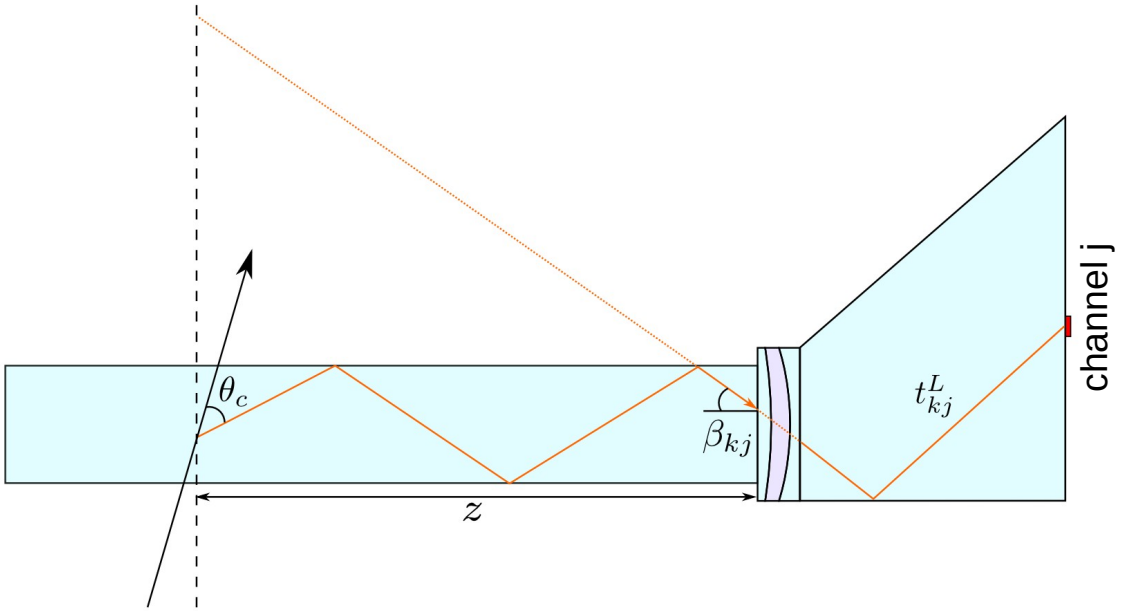




$$t_{ki} = \frac{z}{\cos\beta_{ki}}\frac{n_g}{c_0} + t_{ki}^L$$

Analytical PDF using LUT





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Analytical PDF using LUT

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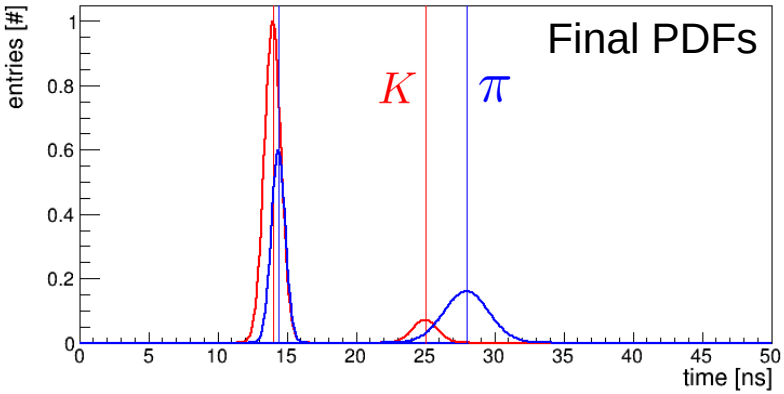

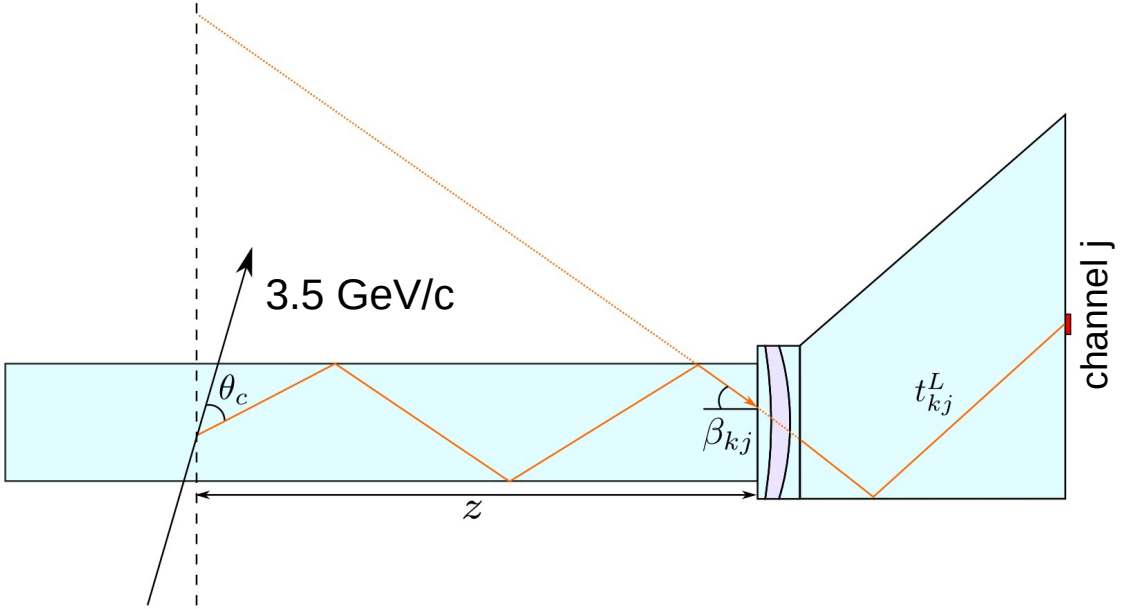

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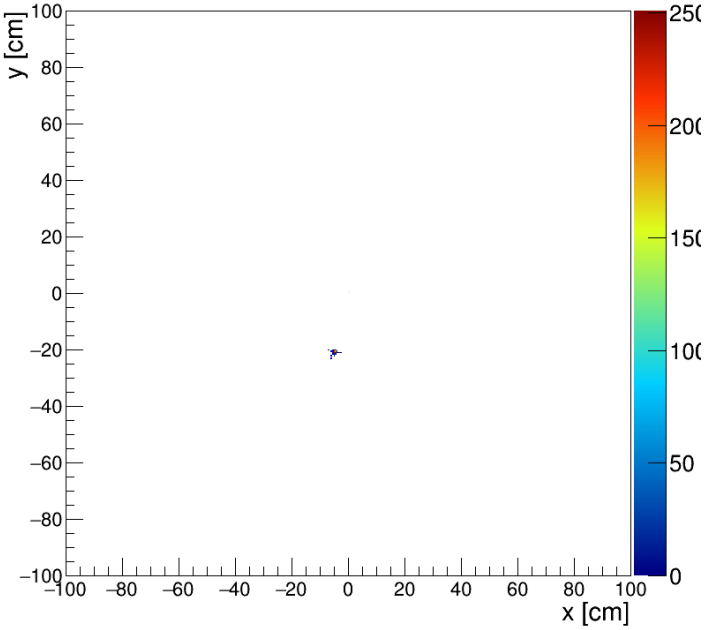
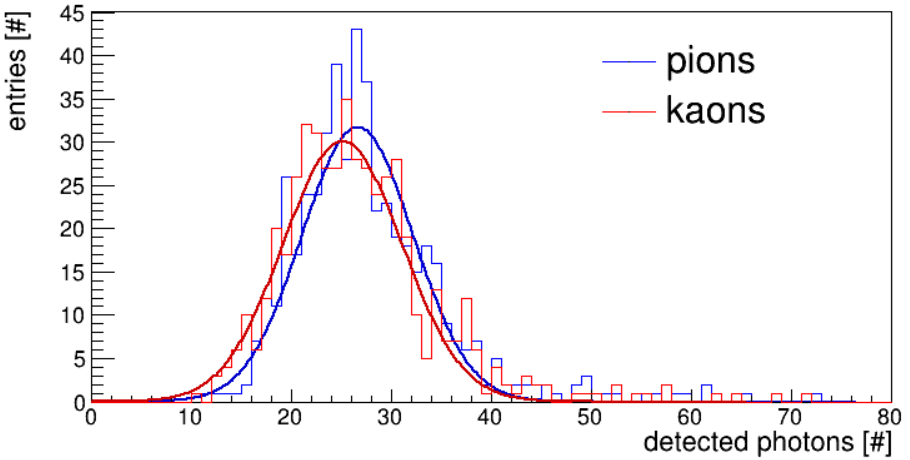
pi/K @ 4 GeV/c hdgeant4 simulation

bar #3, phi = -90 degree



Detected photon yield (adjusted to the beam data)

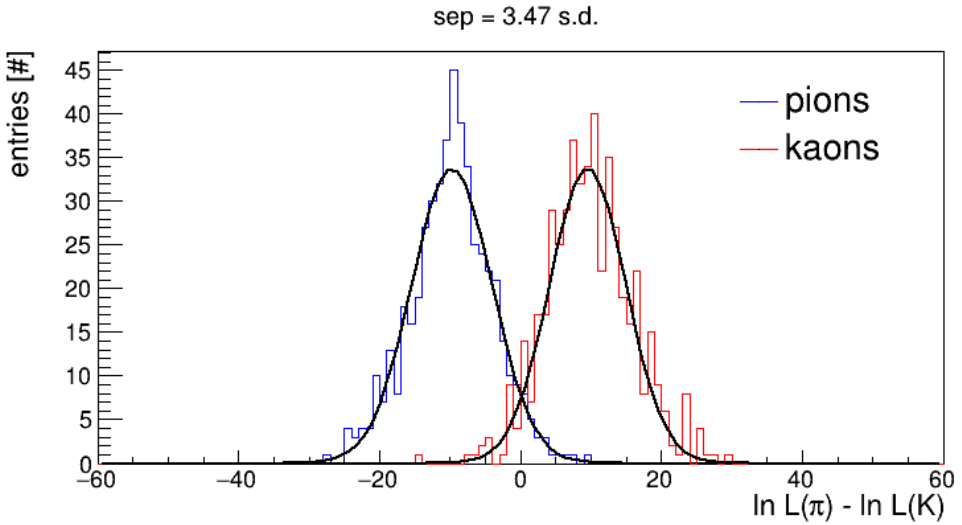


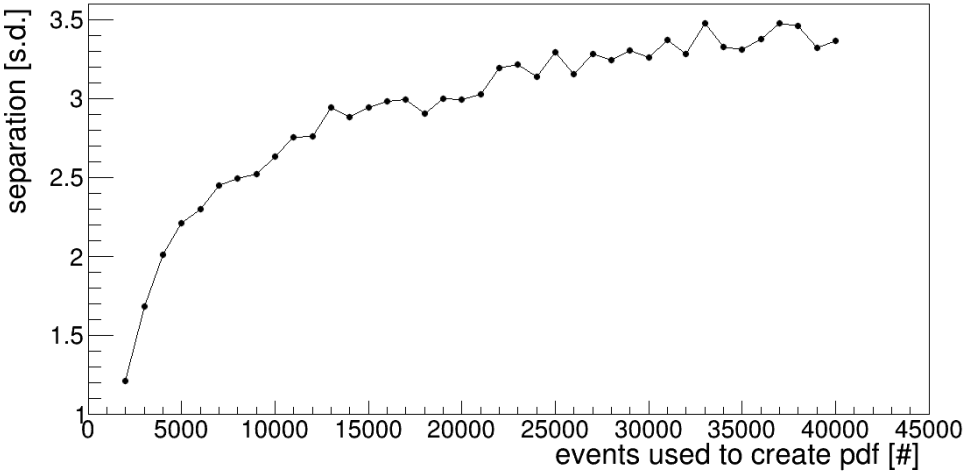
Time smeared with 0.8 ns

Performance with Simulated PDF

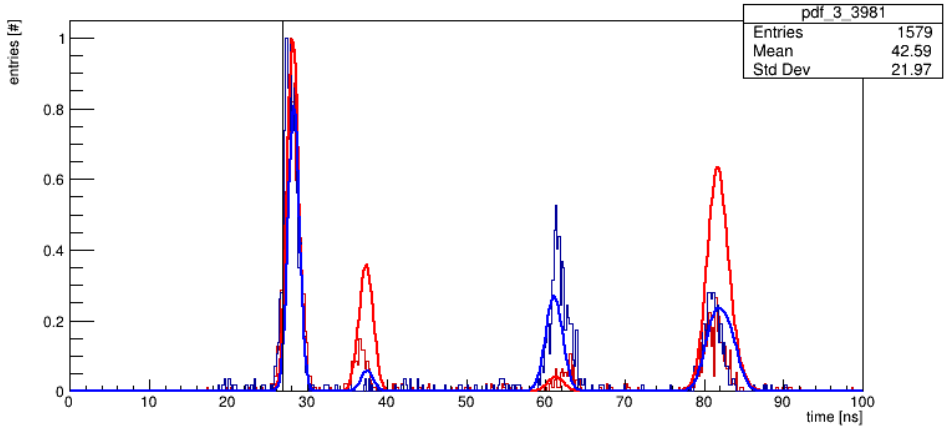
Simulation

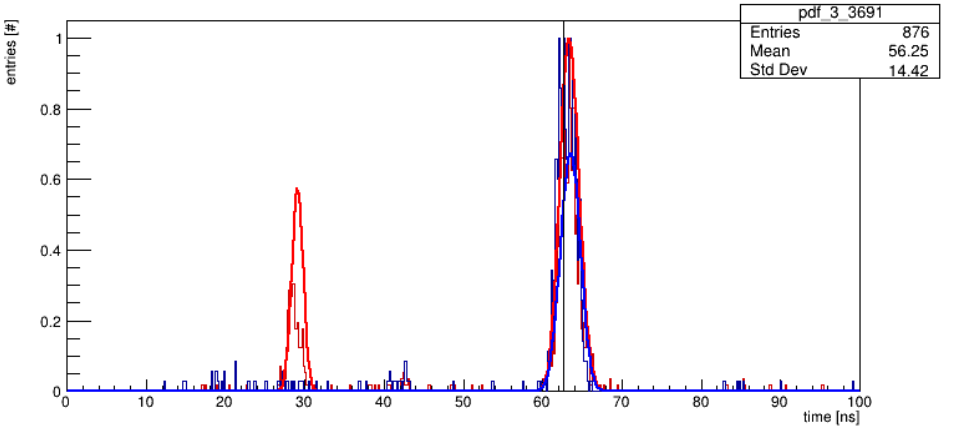
pi/K @ 4 GeV/c

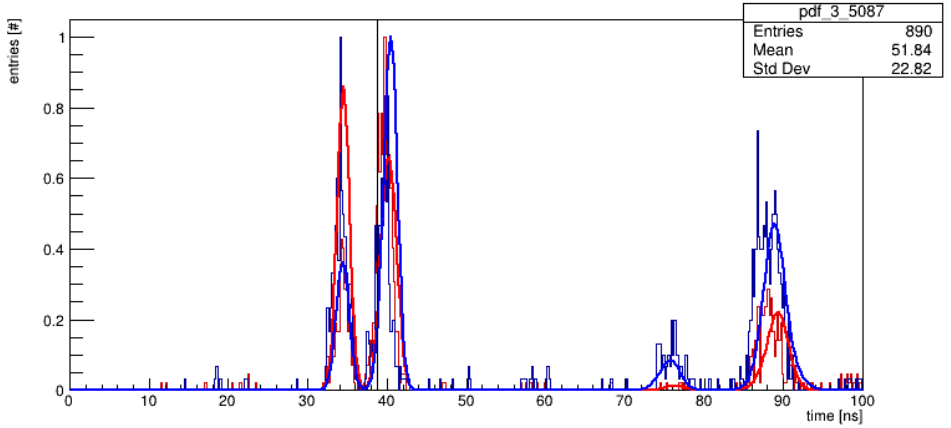


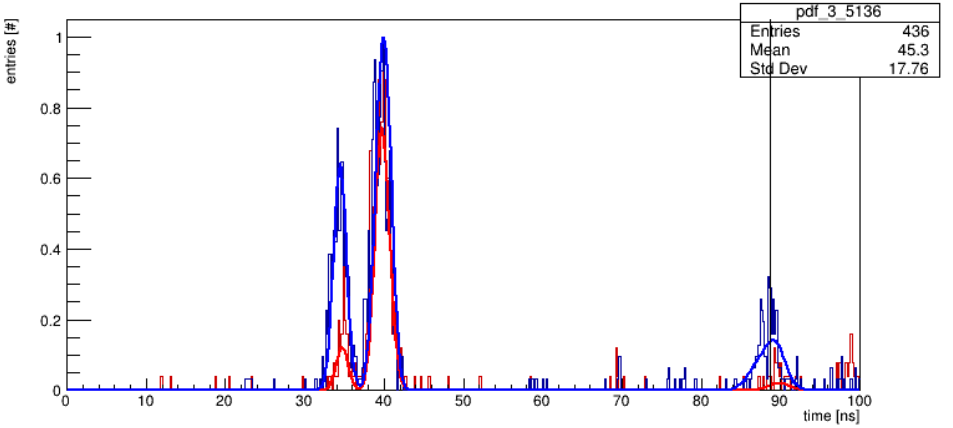


PDF Examples. Analytical vs Simulated









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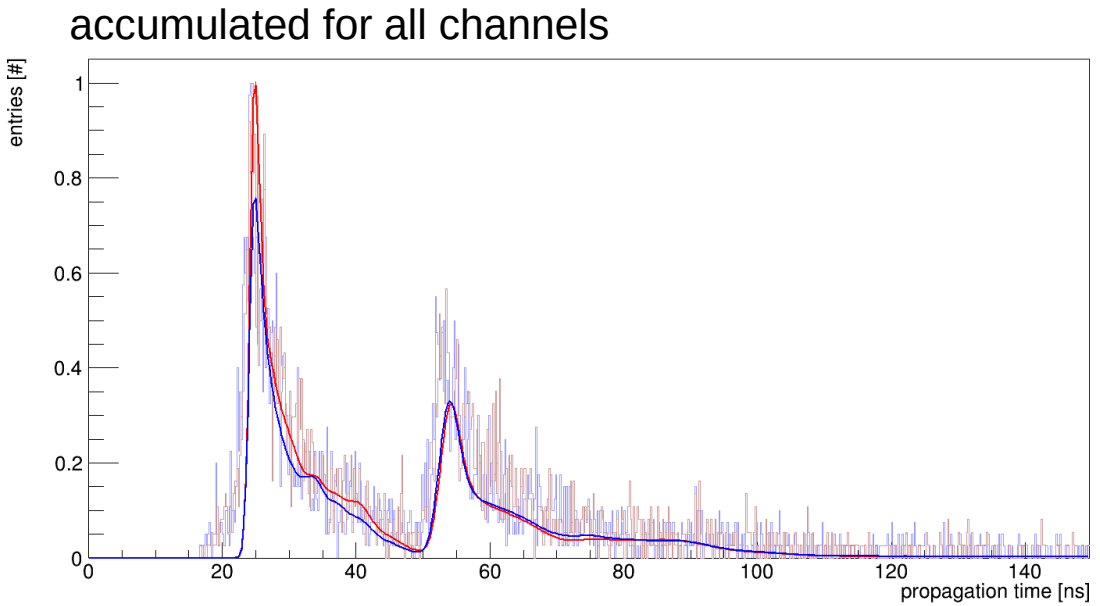

Performance with Analytical PDF

Simulation

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