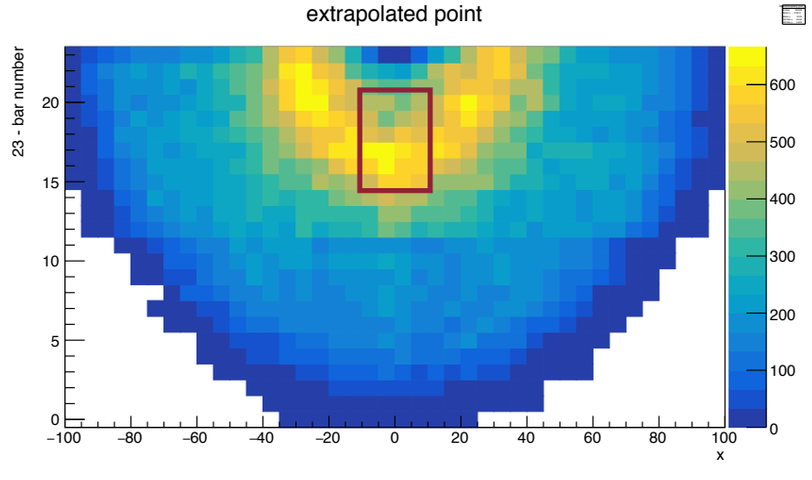
FastDIRC update

Yunjie Yang
7/23/2019

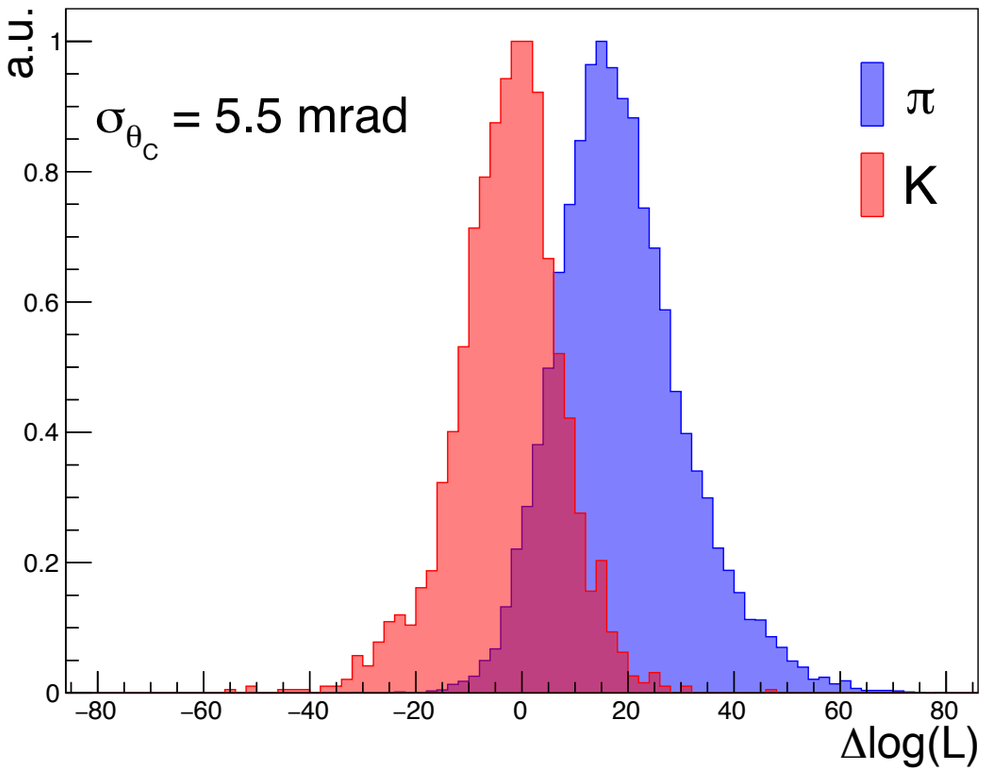
Datasets and Selection

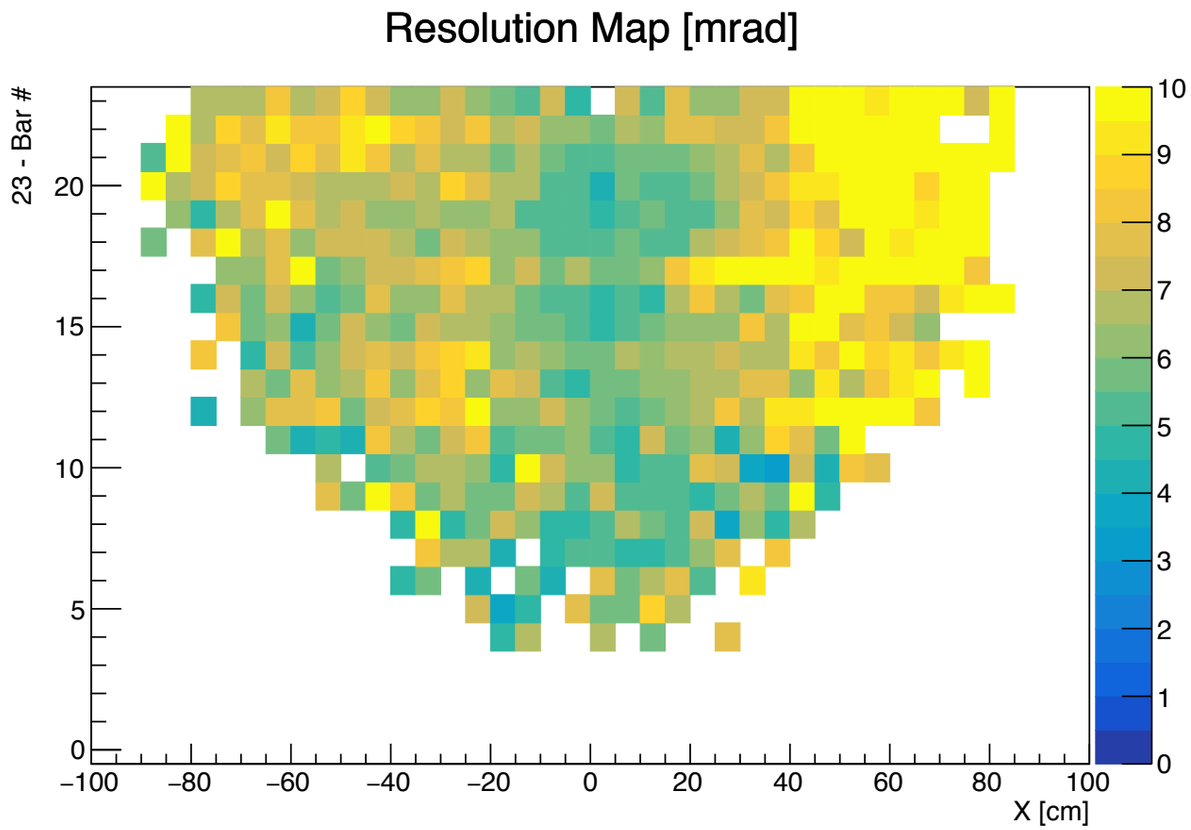
- Dataset: REST_ver08, pass09; all runs
- Selection:
  - ρ,ϕ events
  - event level: ρ,ϕ inv. mass; missing mass; event χ^2
  - track quality: min. dist. to TOF hit; TOF deltaT; # of drift chamber hits
- Momentum ranges: [2.5, 3.5] and [2.8, 3.2] GeV
- “selected region”: bar [#3, #8], x: [-10, 10] cm



where things were:

in selected region





- Observe separation, but…
- Problem: “pions look like pions, but kaons don’t look like anything” (i.e. pion DLL mean > 0, kaon DLL mean ~0)
- (Probably) something in the reconstruction itself, not so much about overall effects like tracking, alignment etc.

P: [2.5, 3.5]

Note: at 3 GeV, for n=1.47, $\Delta\theta_C$ ~11.5 mrad

Reminder: KDE-based Reconstruction

Track (momentum, position, angle)

FastDIRC's novel fast ray-tracing technique
(given geometry)

Generate O(100k) hits (i.e. *support points*)
under each particle hypothesis

Loop over observed hits, calculate a probability against every (close-by) support points using a chosen *kernel* (Gaussian kernel in use)

Obtain a log-likelihood (LL) for this track
under each hypothesis

Distance measure and “near” hits

- Define a distance measure:

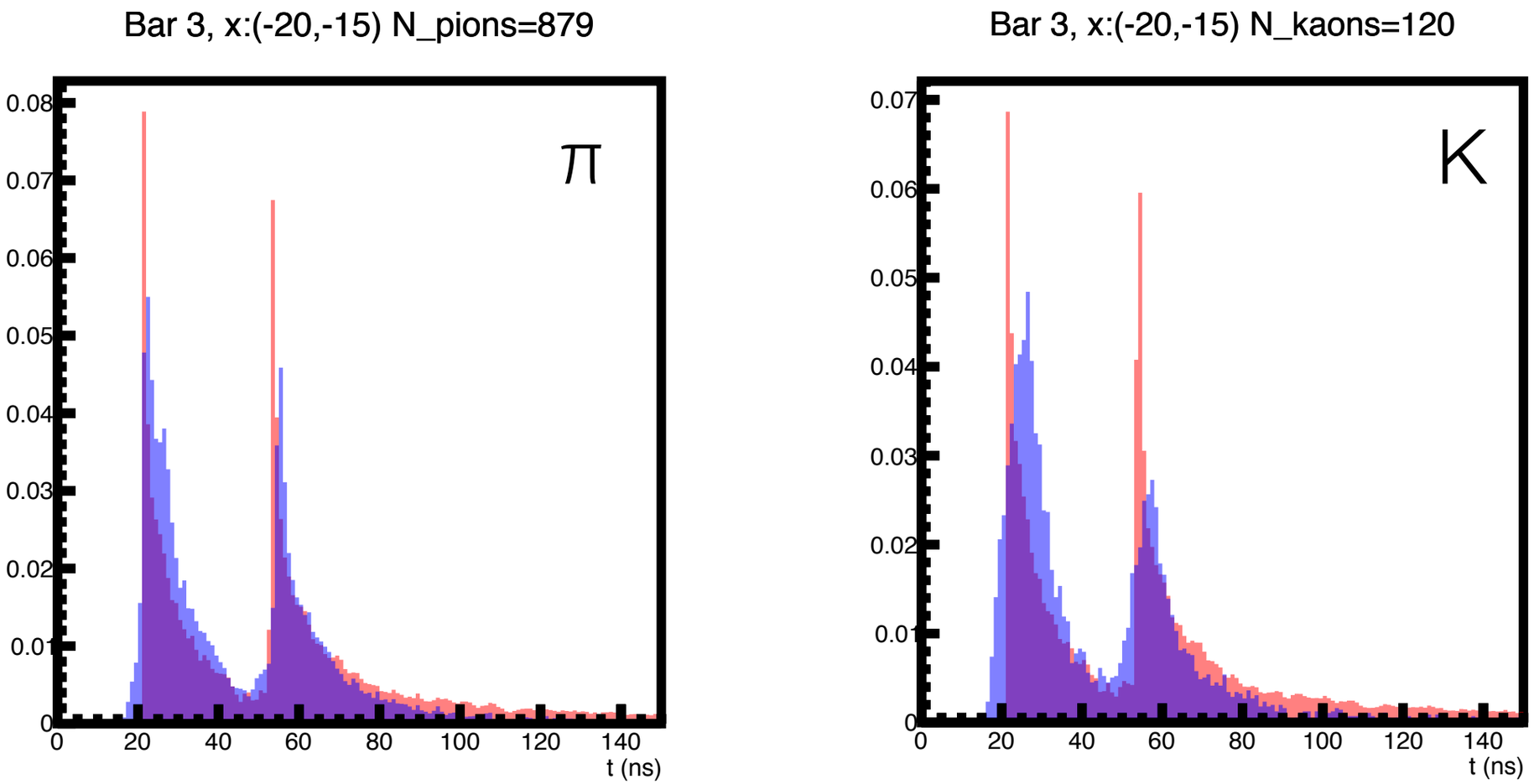
$$r^2 = \frac{(x_{O,i} - x_{S,j})^2}{\sigma_x^2} + \frac{(y_{O,i} - y_{S,j})^2}{\sigma_y^2} + \frac{(t_{O,i} - t_{S,j})^2}{\sigma_t^2}$$

- “O” for observed hits, “S” for generated support/PDF hits

- Parameters in use: $\sigma_x=\sigma_y=6$ (mm), $\sigma_t=1$ (ns)

- A hit (index i) is called a “near” hit if it is within 5 unit from any support point j

Hit timing distribution: generated support hits vs. data near hits



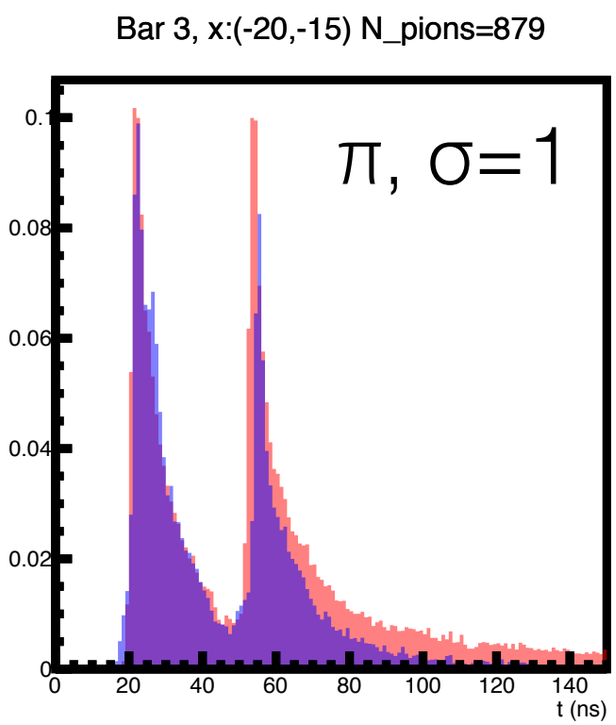
Red: generated support/PDF hits

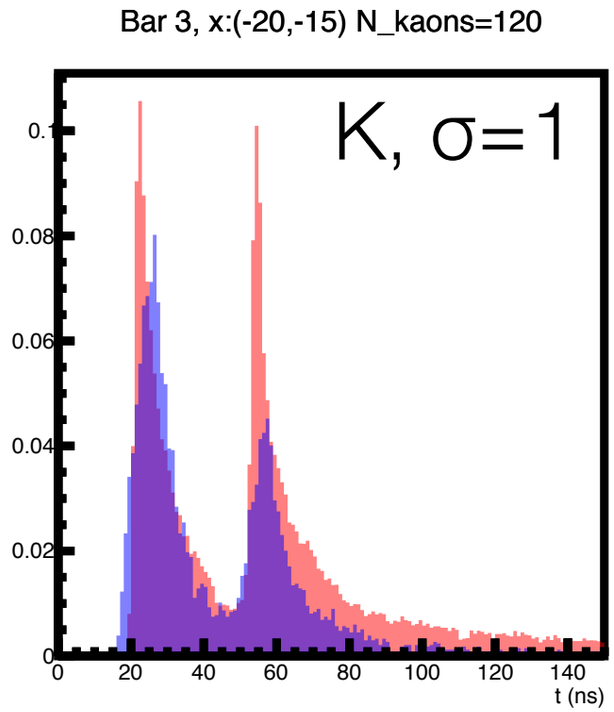
Blue: data “near” hits

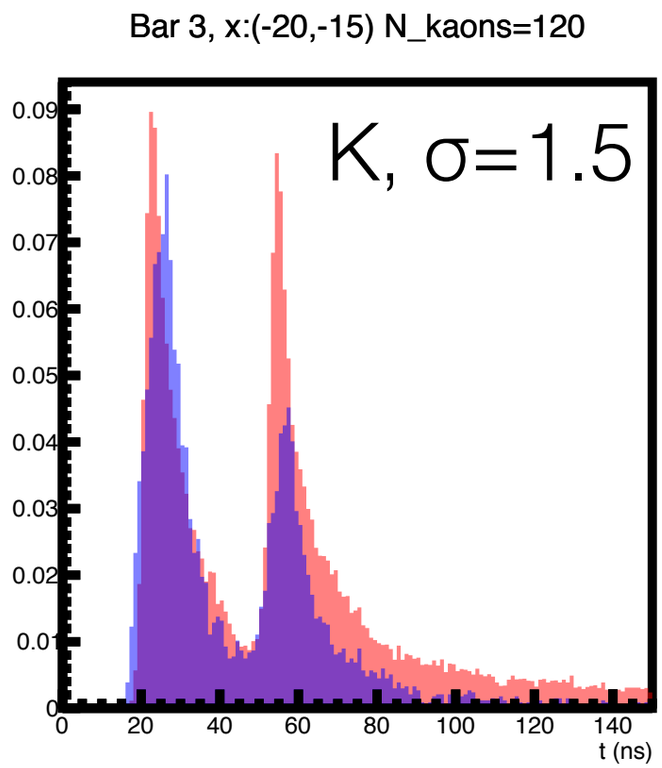
Blue looks like a smeared version of red, but it seems to affect kaons more than pions (what might be the cause?)

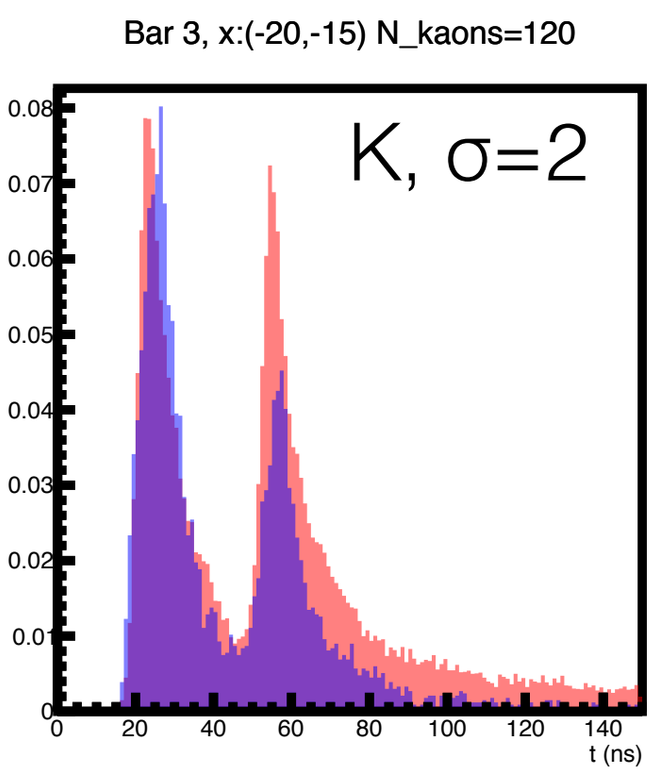
P: [2.5, 3.5]

Smearing the red: add to each support hit's time a value drawn from a Gaussian of mean 0, and some width σ









P: [2.5, 3.5]

Ways to account for this effect

1. Smear the support/PDF hits:
   - for each support hit, add an additional smearing value to the generated time
   - use different widths in the Gaussian draw for pions vs. kaons
2. Use different bandwidth parameters σ_b for pions vs. kaons PDFs
   - Cannot do it naively; need to be careful with normalization
   - Cannot choose a σ_b that's too large otherwise DLL distributions become too wide

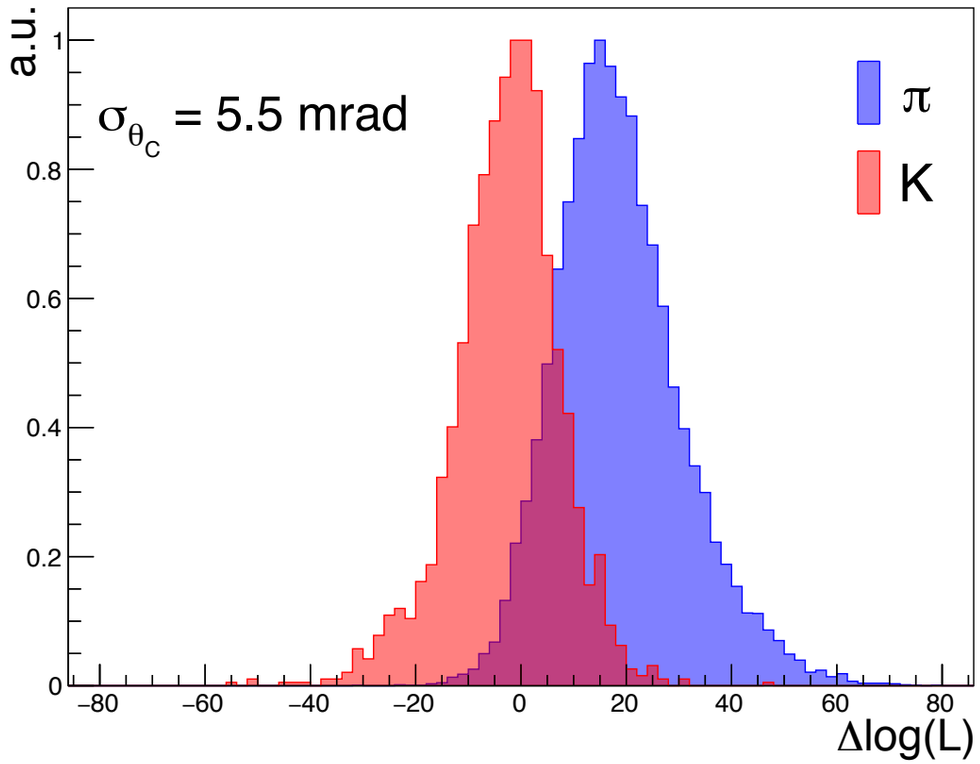
$$\text{prob.} \propto \exp\left(-\frac{r_{i,j}^2}{\sigma_b^2}\right)$$

Tried method #1 with additional smearing widths σ=1 for pions and σ=1.5 for kaons

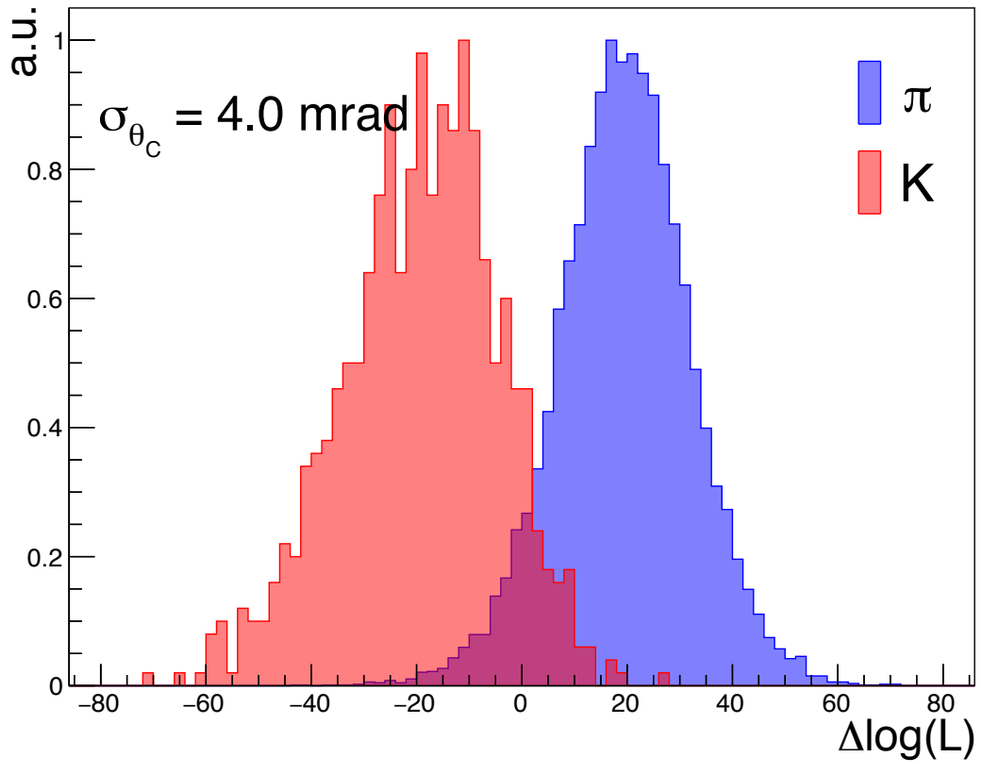
Effects of smearing on recon.

in selected region

P: [2.5, 3.5]



P: [2.8, 3.2]

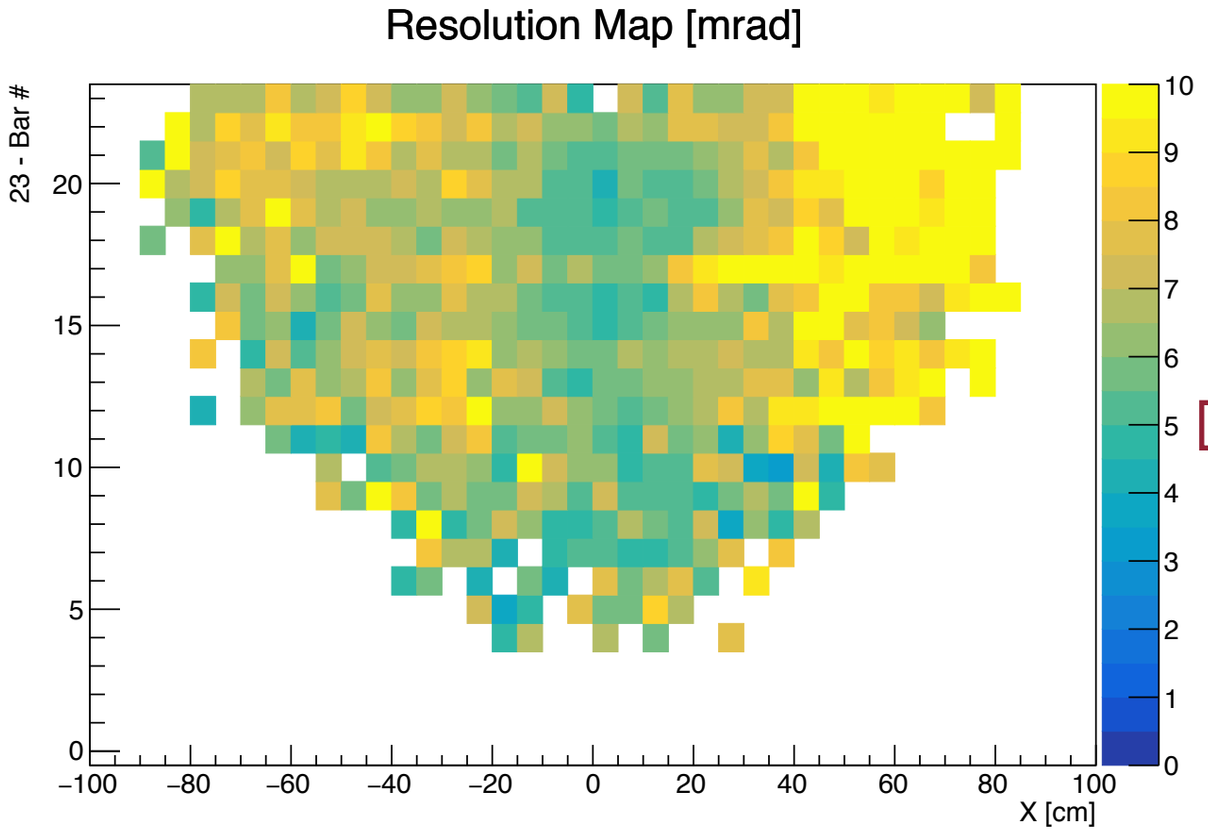


- Good news: “kaons now look like kaons”
- Bad news: wider distributions due to added smearing
- Overall: ~30% increase in performance; ~3σ at 3 GeV

Note: at 3 GeV, for n=1.47, $\Delta\theta_C$ ~11.5 mrad

Effects of smearing on recon. : resolution maps

P: [2.5, 3.5]



P: [2.8, 3.2]

Note: at 3 GeV, for n=1.47, $\Delta\theta_C \sim 11.5$ mrad

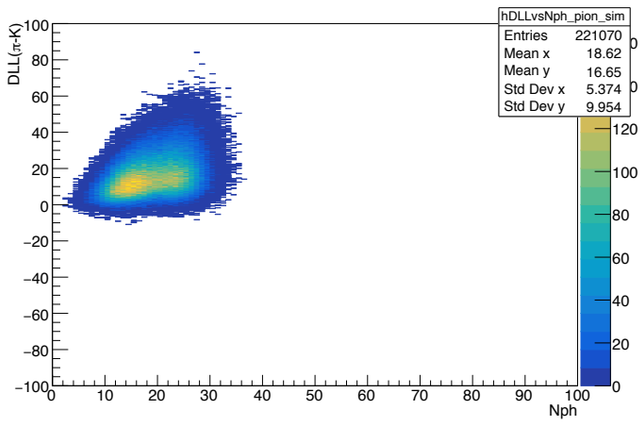
back up

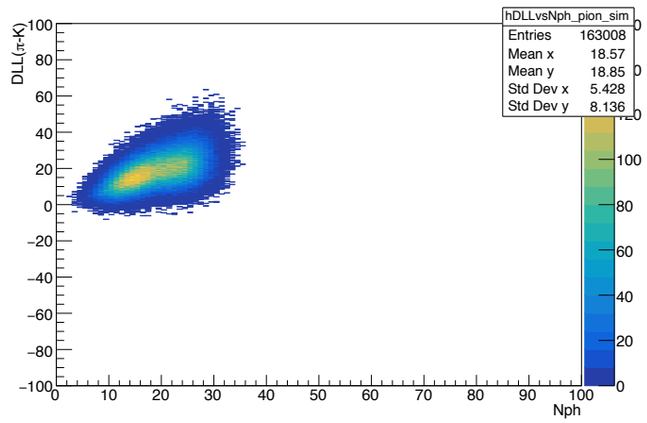
DLL vs. Nph (near)

P: [2.5,3.5], no smearing

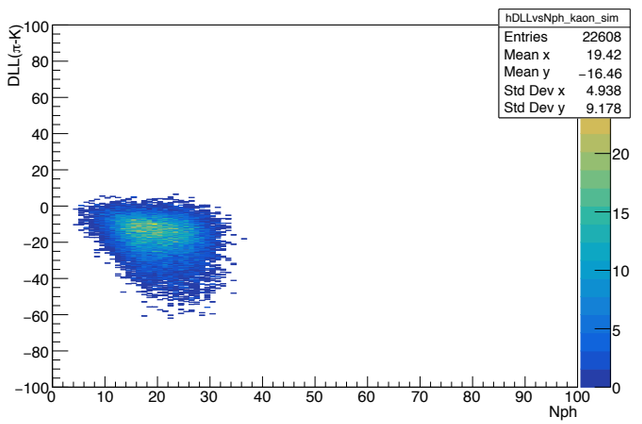
P: [2.8,3.2], with (1,1.5) smearing

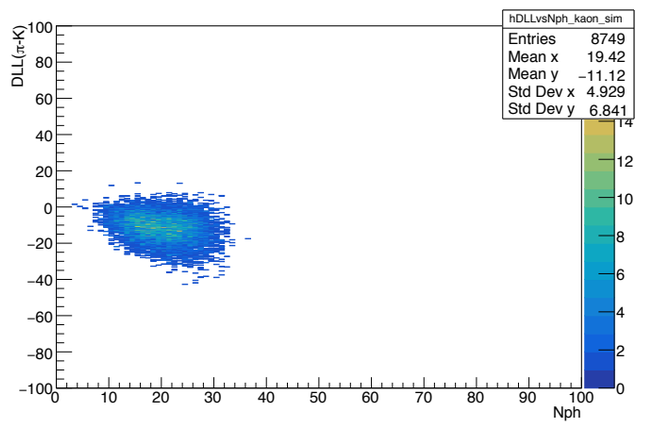
sim. pion hits:



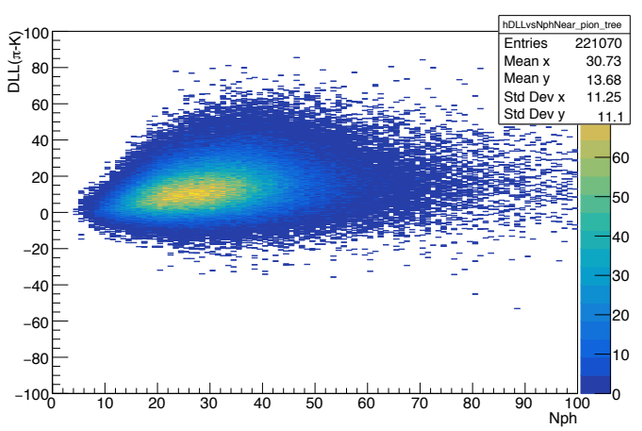


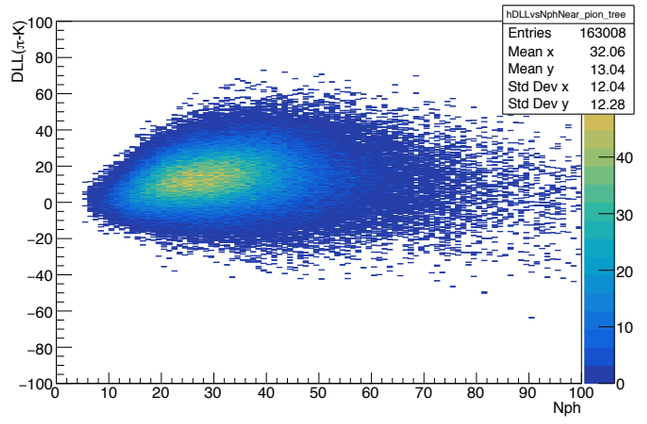
sim. kaon hits:



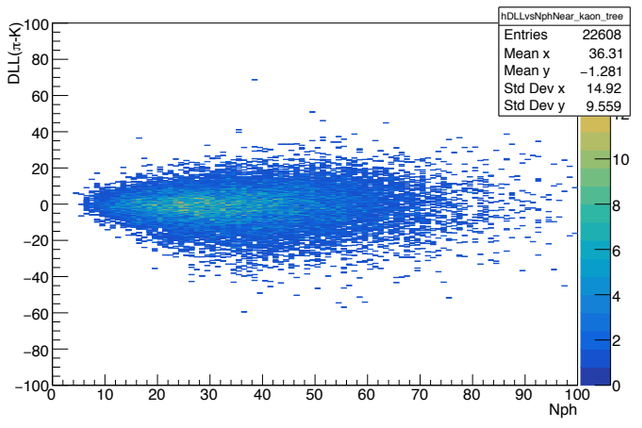


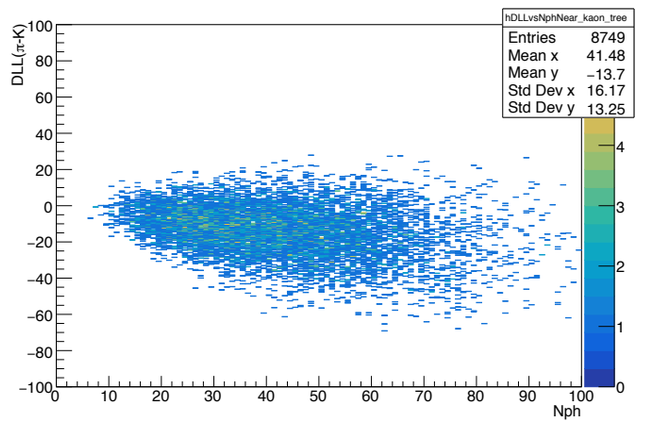
data pion hits:





data kaon hits:





Datasets and Selection Details

- dataset: /lustre/expphy/volatile/halld/home/jrsteven/RunPeriod-2019-01/dirc_monitoring/analysis_REST/ver08_pass09/merged
- event level:
  - inv. mass: ρ: [0.66, 0.84], ϕ: [1.012, 1.028]
  - missing mass squared: ρ: [-0.004, 0.003], ϕ: [-0.003,0.002]
  - event χ^2: ρ: <10, ϕ: < 15
- track quality:
  - min. dist. to TOF hit: < 4 cm
  - TOF deltaT: [-0.5, 0.5] ns
  - # drift chamber hits: > 30