TOF Reco & Lookup Tables

Oskar Hartbrich

TOF Reconstruction Recap I

- ePIC tracking measures **momentum** and **track length**
  - Enables calculation of expected mean hit times of various particle species
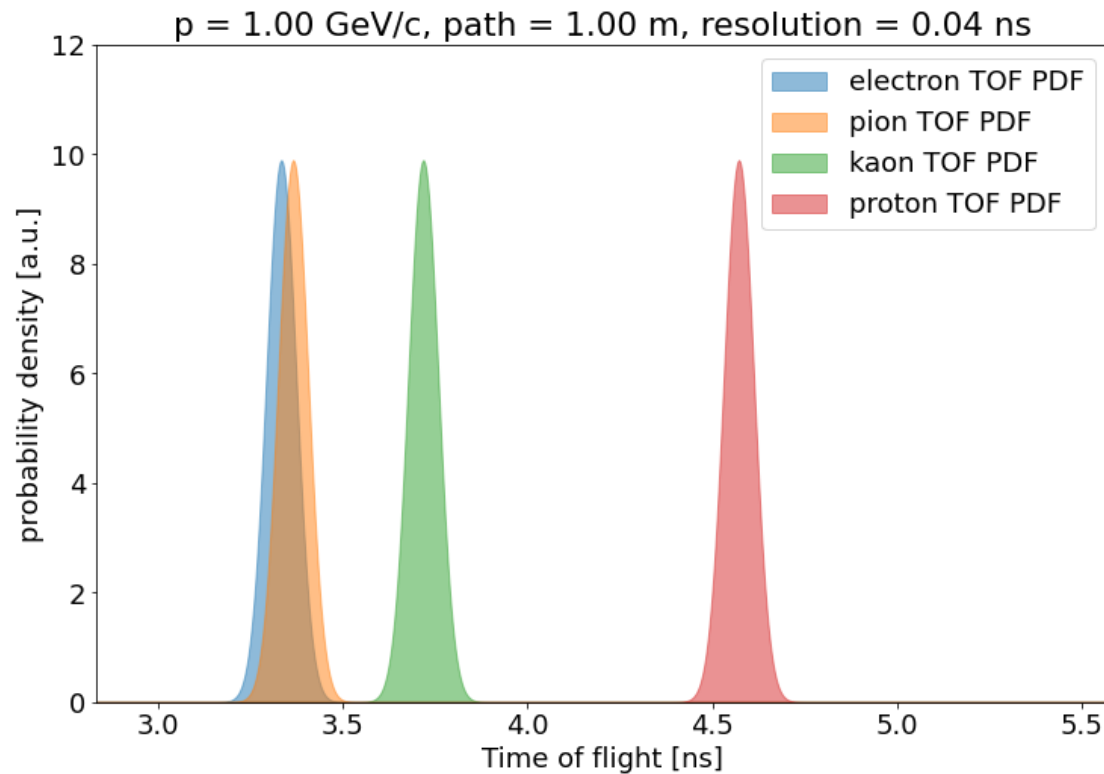
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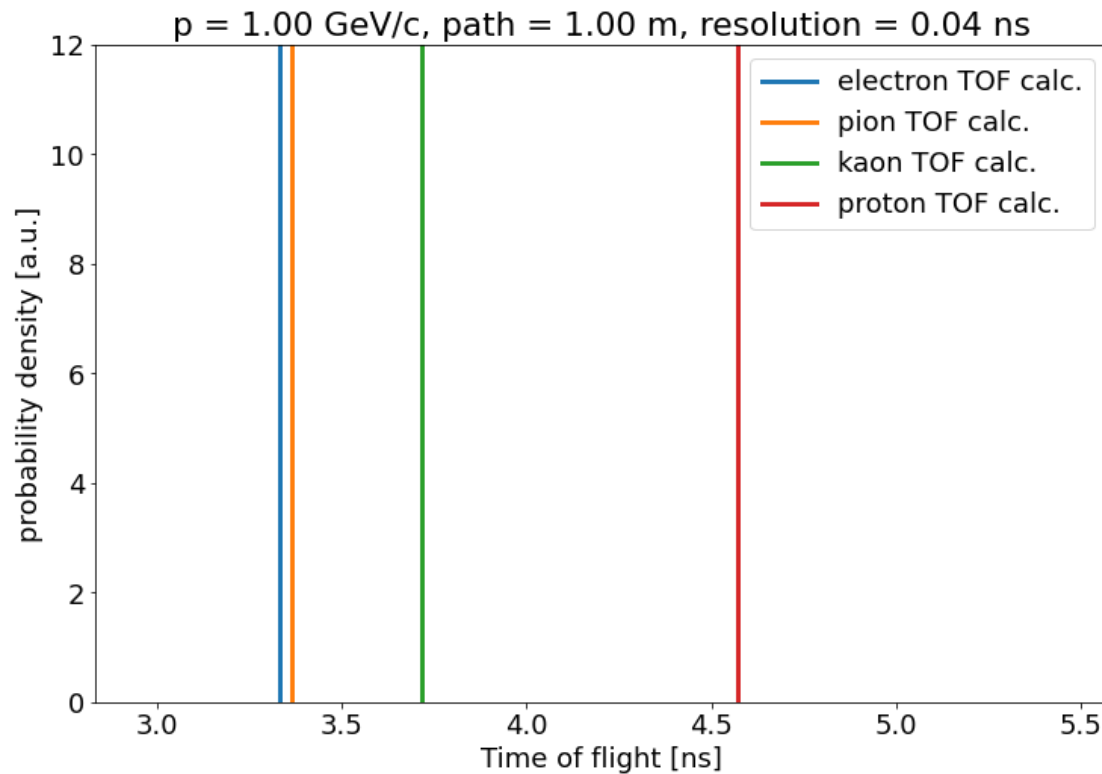
TOF Reconstruction Recap II

- ePIC tracking measures **momentum** and **track length**
  - Enables calculation of expected mean hit times of various particle species
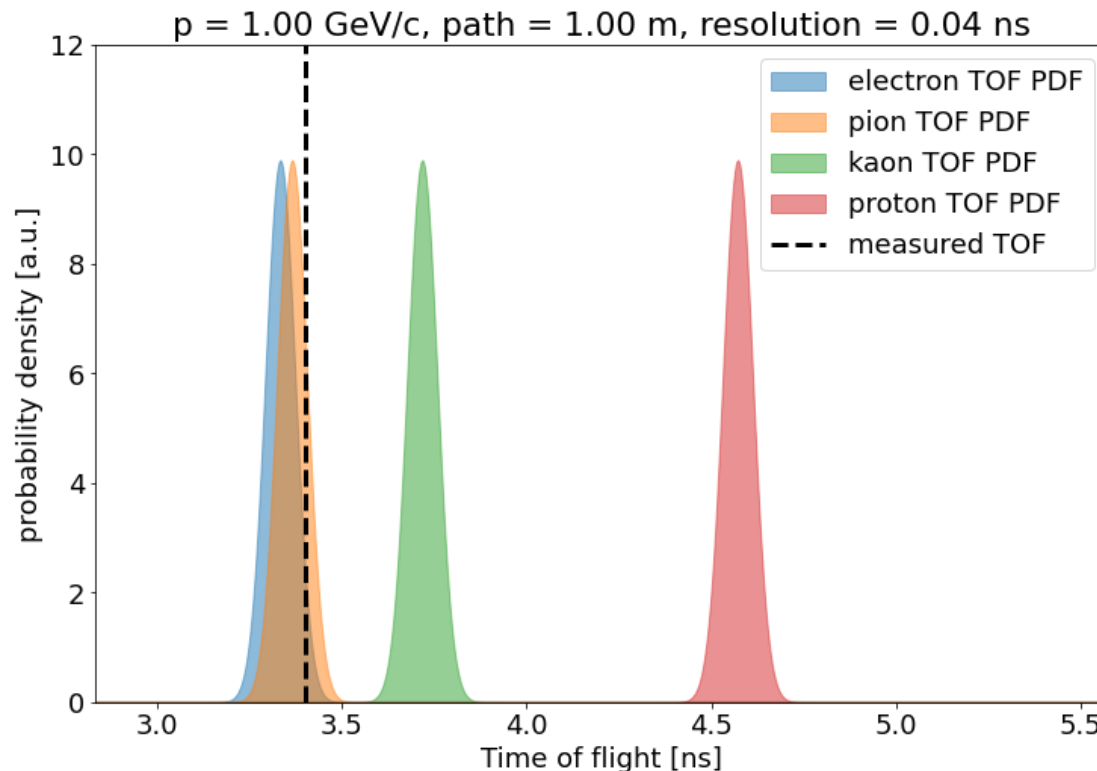 - Apply expected distribution based on resolutions: yields PDF for each species

TOF Reconstruction Recap III

- ePIC tracking measures **momentum** and **track length**
  - Enables calculation of expected mean hit times of various particle species
  - Apply expected distribution based on resolutions: yields PDF for each species

- TOF system measures **hit time**
  - Comparison with PDFs yields likelihood and thus reconstruction probability

p = 1.00 GeV/c, path = 1.00 m, resolution = 0.04 ns

- L(e): 2.52
  - LL(e): 0.92

- L(pi): 6.88
  - LL(pi): 1.93

- L(K): 0.00
  - LL(K): -28.7

- L(p): 0.00
  - LL(p): -419

- **Prob(pi)** = L(pi)/ (sum(L)) = **72.3%**

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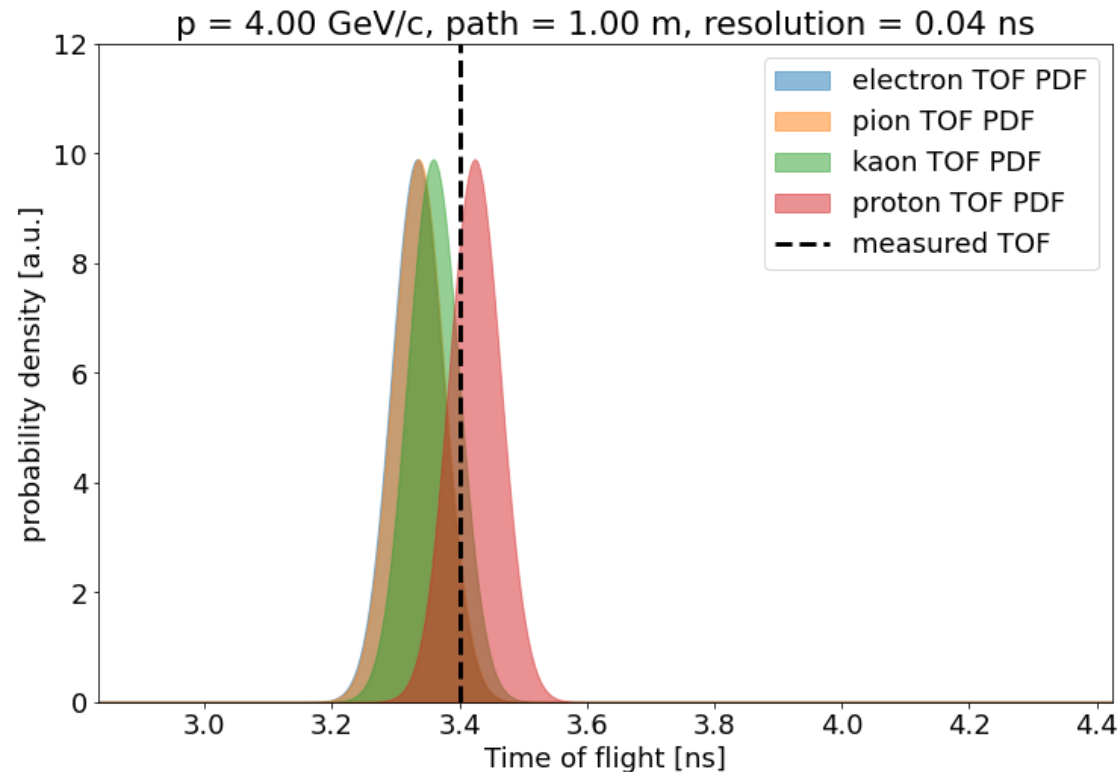
TOF Reconstruction Recap IV

- ePIC tracking measures **momentum** and **track length**
  - Enables calculation of expected mean hit times of various particle species
  - Apply expected distribution based on resolutions: yields PDF for each species

- TOF system measures **hit time**
 - Comparison with PDFs yields likelihood and thus reconstruction probability

- L(e): 2.52
  - LL(e): 0.92

- L(pi): 2.74
  - LL(pi): 1.01

- L(K): 5.84
  - LL(K): 1.77

- L(p): 8.31
  - LL(p): 2.12

- **Prob(pi)** = L(pi)/ (sum(L)) = **14.1%**

Lookup Tables for ePIC PID

- Temporary standin for ePIC physics studies.

- Each PID system provides particle ID probabilities p(e), p(pi), p(K), p(p) in tables, binned in:
  - Truth PID, q, p, phi, theta. Bins in p, phi, theta chosen by subsystem.
  - Straightforward to extract from MC: Throw known truth particles, count reconstruction probabilities in given bin.

- "Reconstructed PID" here means "most likely hypothesis"
  - This is **a** valid choice of working point, but not necessarily the **best** or **only** possibility
  - Some surprising consequences arise...

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TOF Lookup Table Binning

- Existing MC sample for TOF performance study is finite

- TOF is symmetric (enough) in theta, q

- 17 bins in phi
  - Nicely covers gap between forward and barrel with single "empty" bin
  - Expect more structure in barrel than in endcap

- 20 bins in p: [0, 6] GeV/c
 - Covers most structure, good enough.
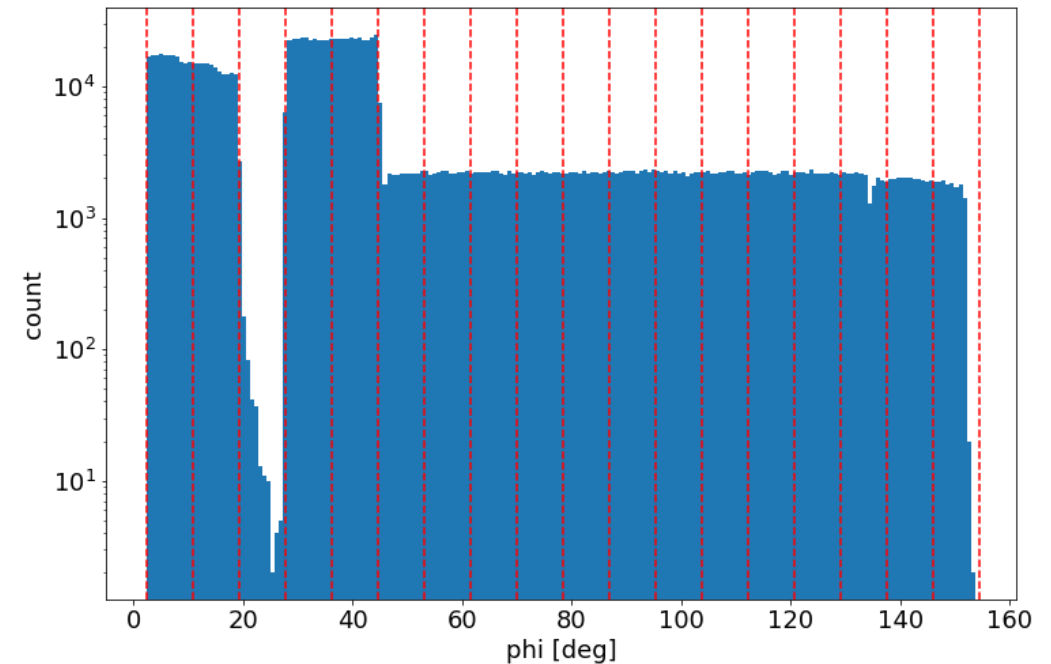
TOF Lookup Table

- Reasonable representation overall

- Submitted to Markus Diefenthaler et al, included in April production.

- Known Caveats:
  - Limited binning does not properly represent low momentum cutoff curve
  - MC sample TOF geometry likely not on very latest version, but good enough within constraints of phi binning
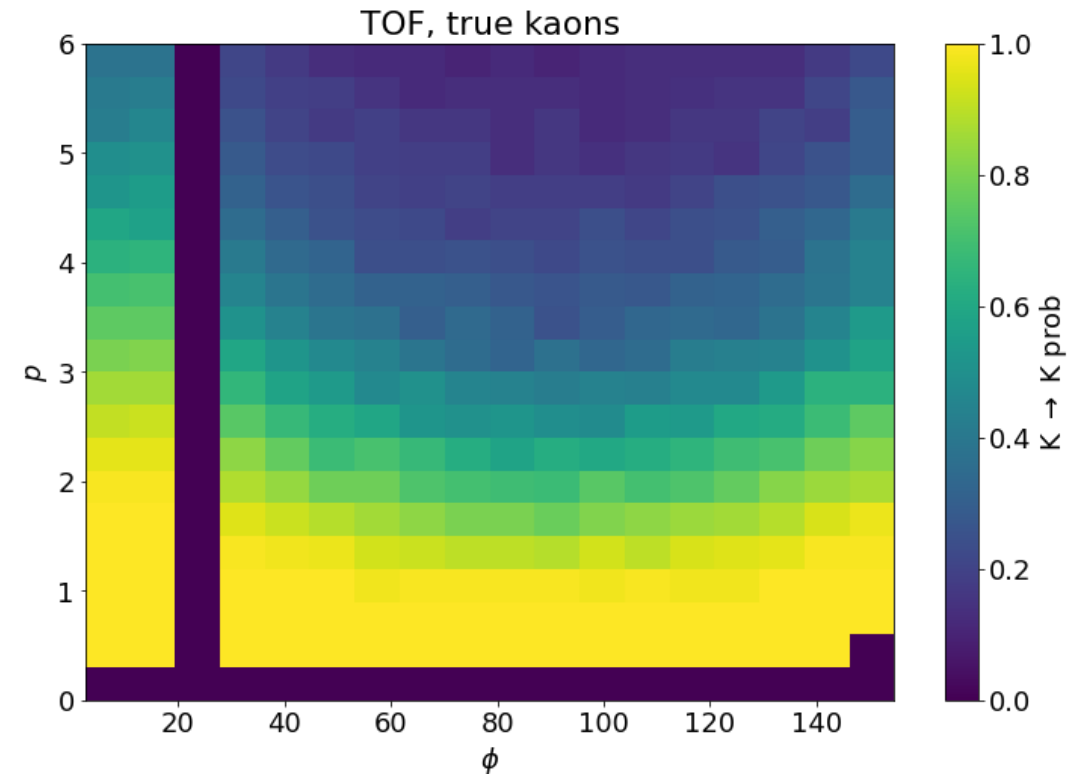
TOF, true kaons

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TOF Reco etc.

TOF Lookup Table – Surprising Consequences

- Towards insensitive momentum regions, reconstruction probabilities become bimodal between lowest and highest mass hypothesis

- This is a consequence of a "reversed" conditional probability
  - Correct application would require input of prior abundances

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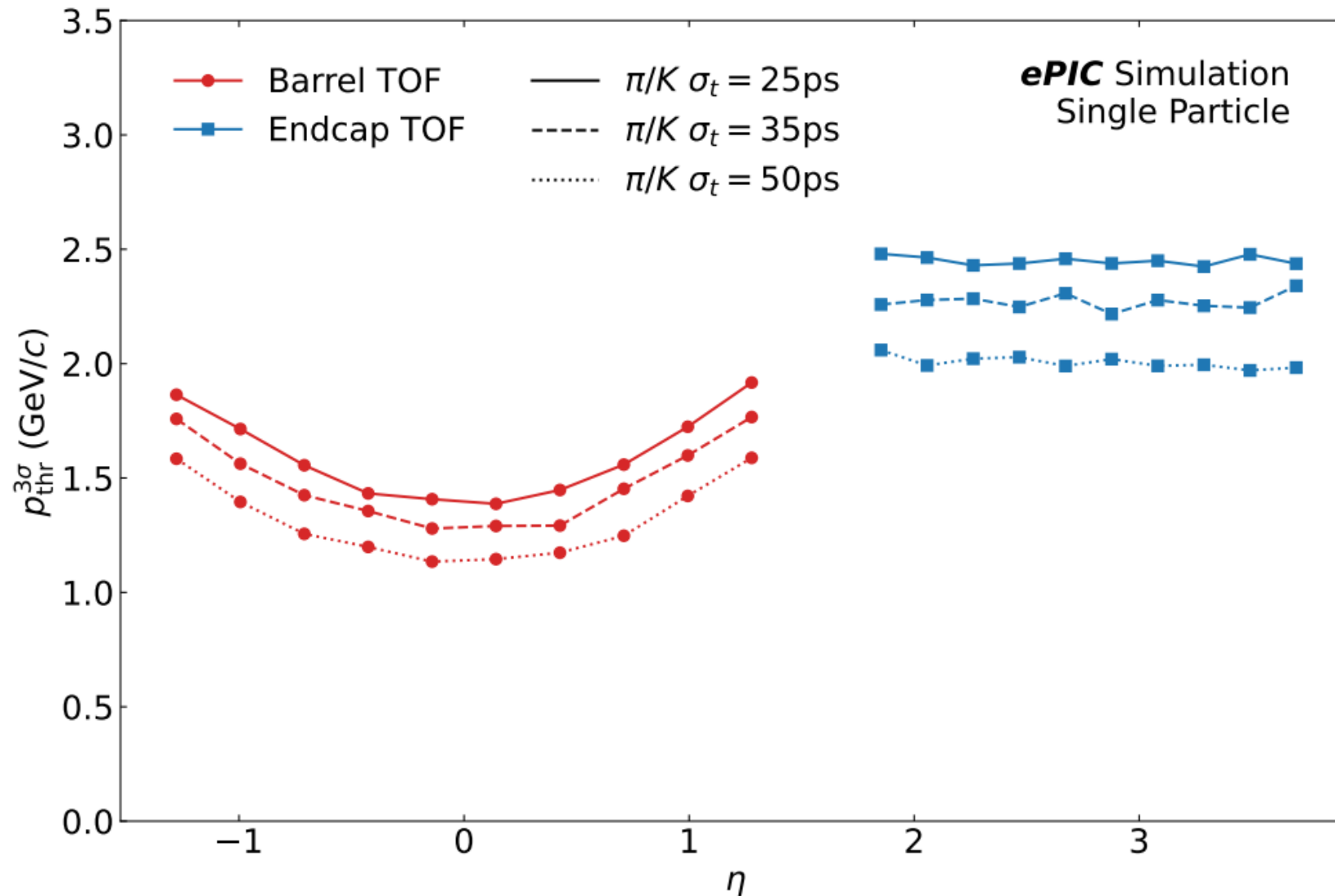TOF Reco etc.
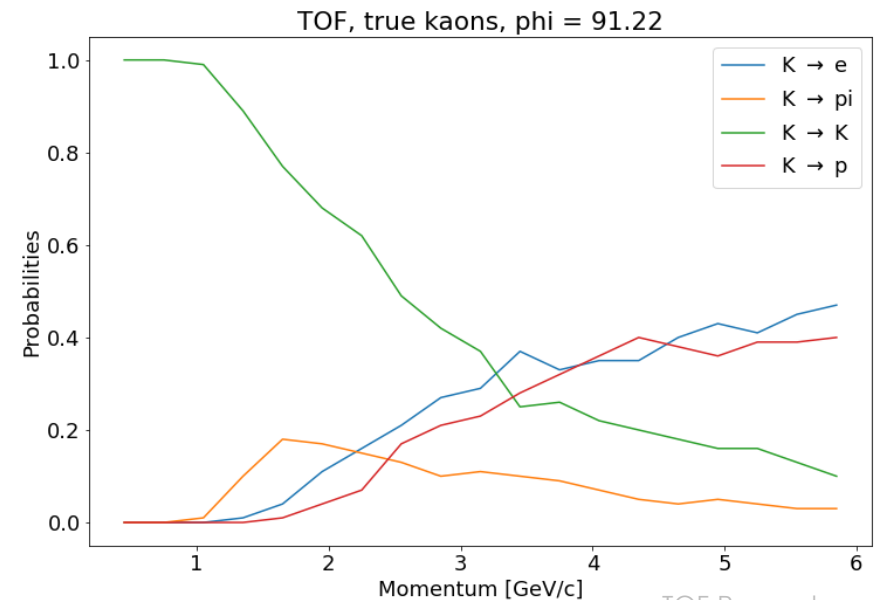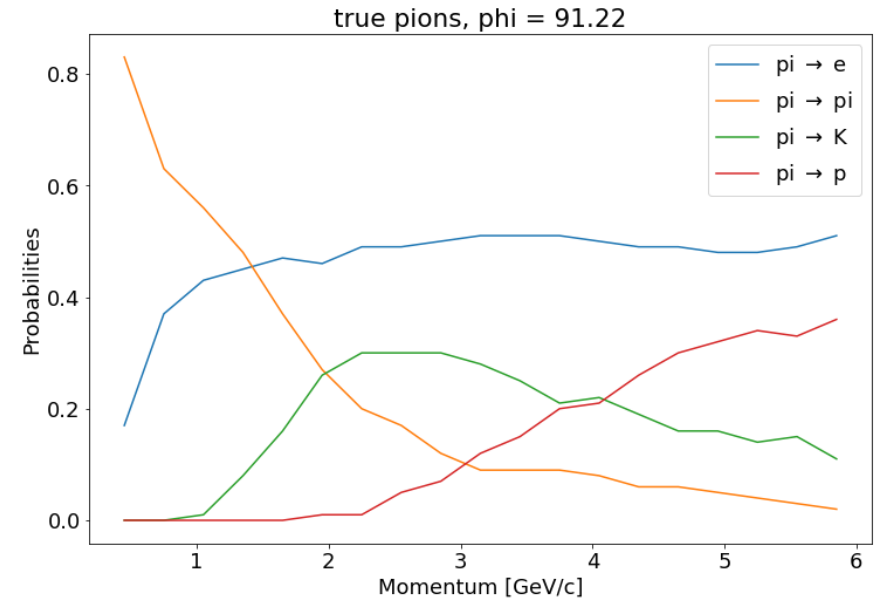
TOF Lookup Table – Surprising Consequences

- Towards insensitive momentum regions, reconstruction probabilities become bimodal between lowest and highest mass hypothesis

- This is a consequence of a "reversed" conditional probability
  - Correct application would require input of prior abundances

- Not a TOF issue, but universal:

pfRICH, true kaons, eta = 2.7975
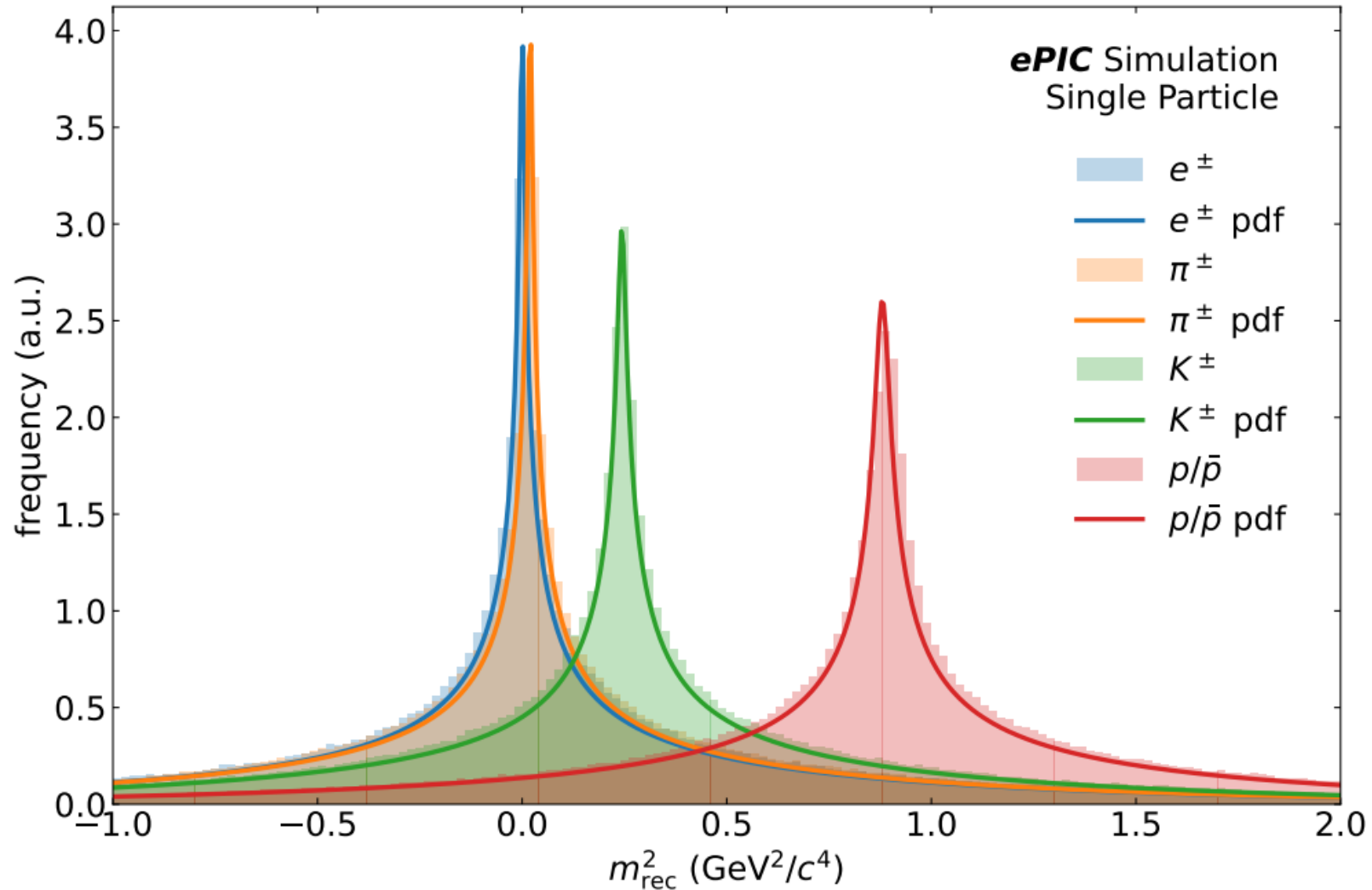
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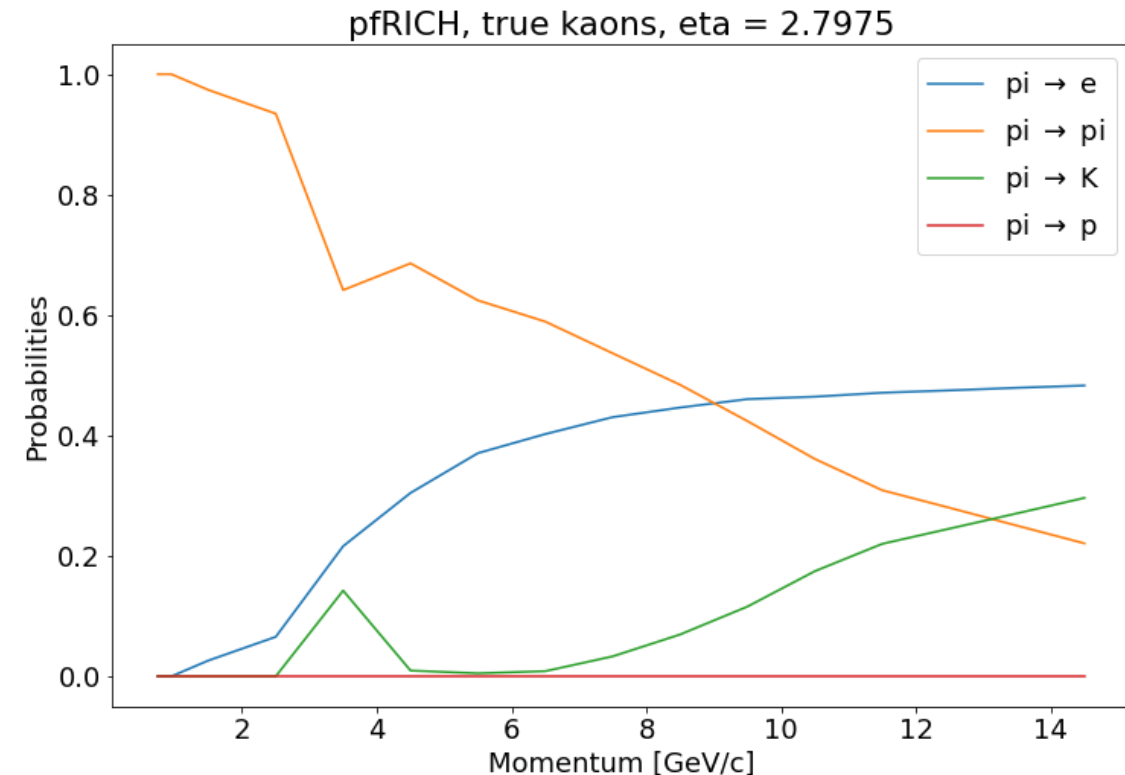
Summary

- ePIC TOF PID LUT ready for use in April production campaign
  - Total size ~56kB ASCII

- Other PID system LUTs ready as well

- First analysis ready outputs expected soon
  - Let's see how physics analysis WGs will make use of the information…

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TOF Reconstruction Status

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TOF Reco etc.

TOF Reconstruction Status

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TOF Reco etc.

TOF Reconstruction Status

TOF pion efficiency/mis-iD at $p_\pi > 0.5$

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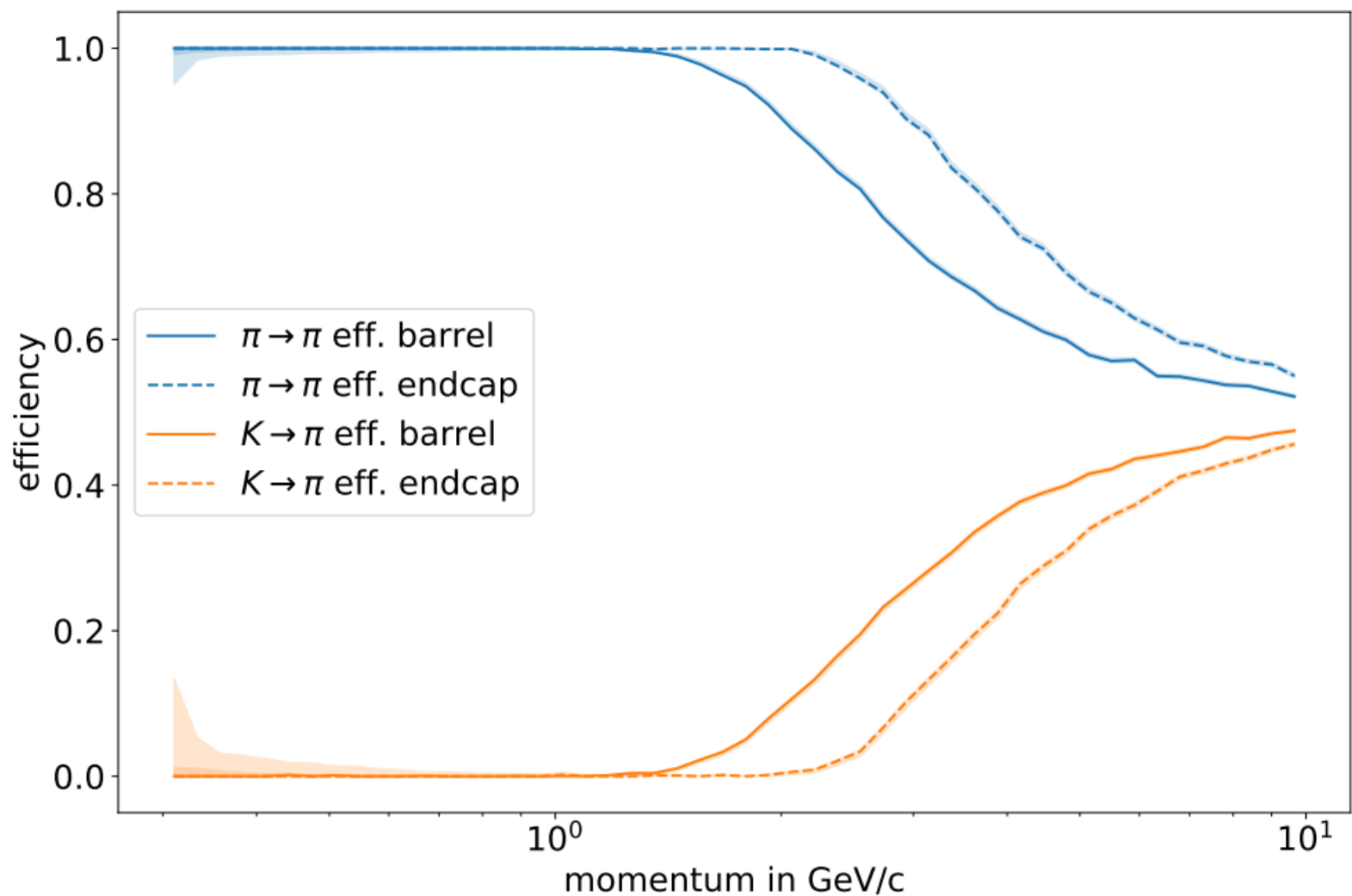
TOF Reconstruction Structure

- None of this semi-standalone python code is useful for combined studies
  - Or for real events for that matter.

- We know how we want to implement this into eicsoft

- Based on Chris' Dilks dRICH reco structure
  - Good to agree on general approach to unify architectures

- Can use simplest possible implementations for start, then add as much as we want over time...

- N.b.: Glaring omission: event T0 iteratively depends on TOF reco...
  - Iterative T0 reco exists in ECCE code base, anyone interested?

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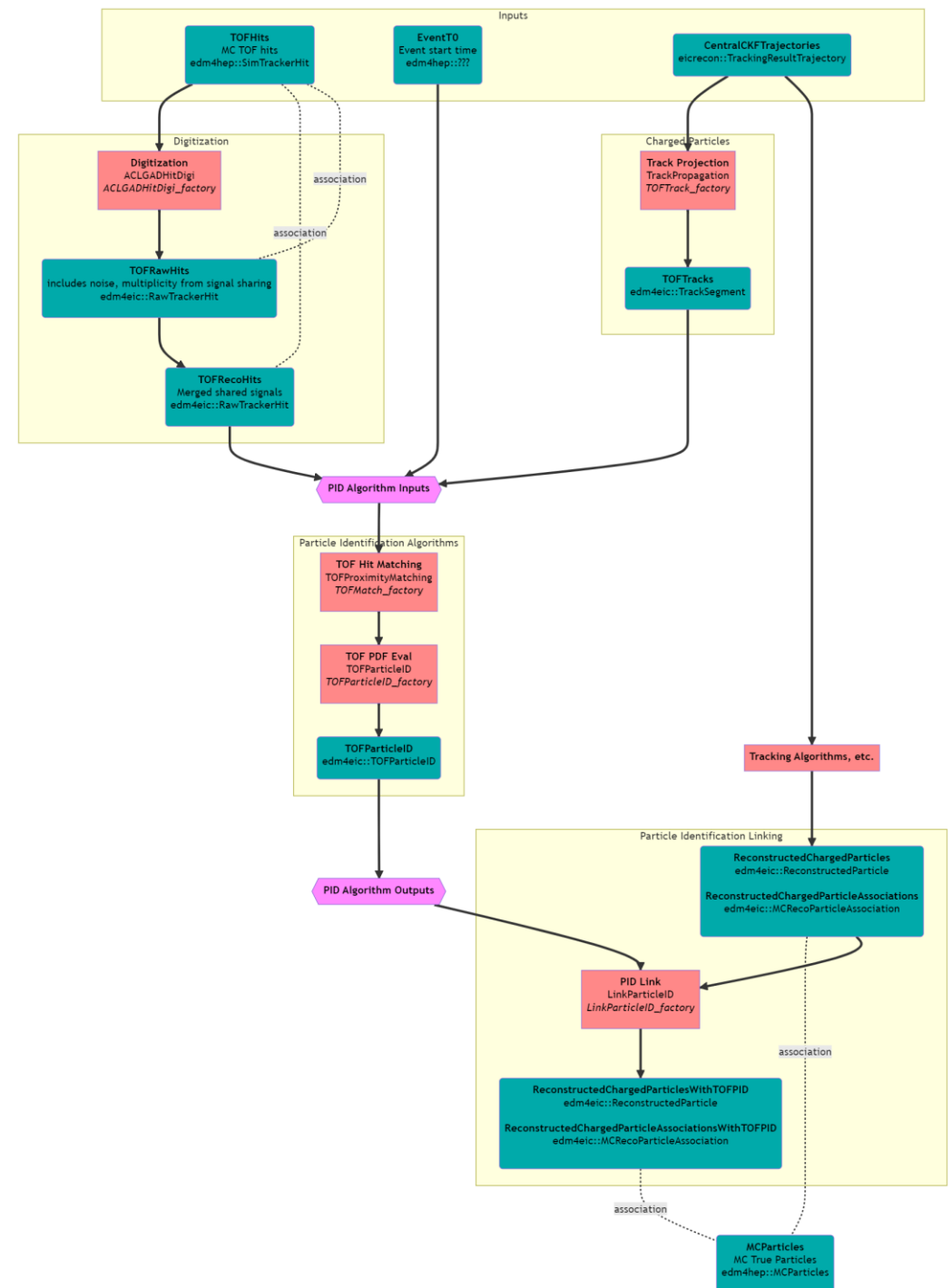
But… why is it not yet implemented?

- Because **I failed to do it**.
  - Wei Li (Rice) has a new postdoc interested in TOF simulation and reconstruction, will try again with their help…
  - Yano-san et al. at Hiroshima have started TOF tracking simulation studies as well and might be interested?
  - I will be happy to help with concepts and debugging.

- Ultimately need fully integrated PID reconstruction codes for all systems in eicsoft to really go forward with individual and combined studies for the TDR

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Executive Summary

- We know **what** to do
- We have shown that **it** works
- We have not **done** it

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TOF Reco etc.

Towards Combined PID Performance Plot for TDR

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TOF Reco etc.