Extending pandaroot to run Kalman Filter with all Hypotheses

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on behalf of the $\overline{\text{P}}$ANDA collaboration

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Kalman filter current design

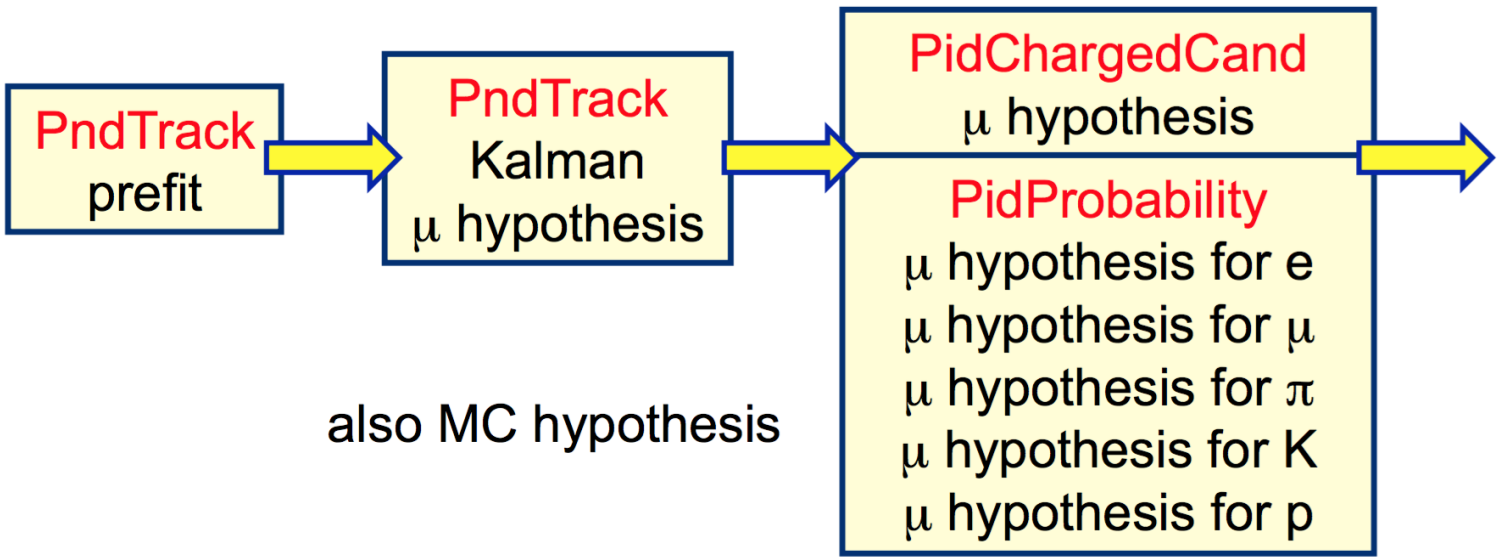


Figure from PANDA Computing Workshop 2017

Kalman filter current design

Following tasks are run during the reco- and PID stages:

- RecoKalmanTask: Perform track fitting (Kalman Filter) with μ hypothesis
- PidCorrelator: Extrapolate tracks to EMC with π hypothesis to distinguish neutrals
  Cut is made on EMCquality variable
  (done by user at analysis level instead?)
- PidAlgo: Run all PID algorithms from each subdetector
- McCloner: Filter out MC tracks that are not related to (for 500 $\overline{\Lambda}\Lambda$, 20.000 $\rightarrow$ 2000 tracks)

Pull Distributions (Stretch Functions)

The pull distribution z for an observation i, also known as stretch function, is defined as (calling it MC pull distribution)

$$z_i = \frac{y_{MC,i} - \eta_i}{\sigma(\eta_i)}$$

- Pull distribution used to study performance of kinematic fits
- MC pull used to see performance of Kalman filter

All tests in this presentation on $\overline{p}p \to \overline{\Lambda}\Lambda \to \overline{p}p\pi^+\pi^-$ @ 1.642 GeV/c

Performance of Kalman Filter

In an ideal fit:

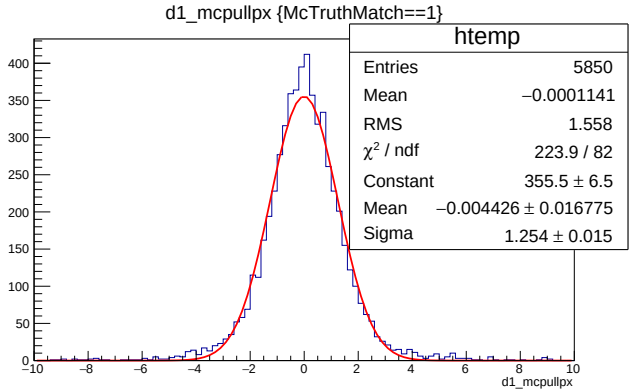
- Pull distributions should be normal distributed

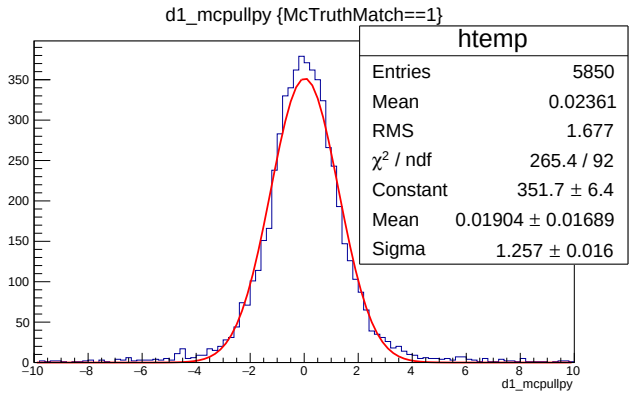
There are issues with the fit if:

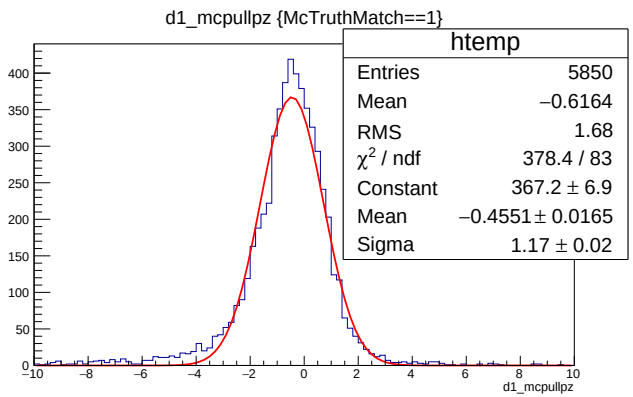
- Skews in pull distributions $\Longrightarrow$ bias in measurements
- Narrower (broader) normal distributions $\Longrightarrow$ errors over(under)estimated
- Background contamination can also alter pull distributions $\Longrightarrow$ remove with MC truth info

MC pull distribution, (no Ideal Hypothesis)

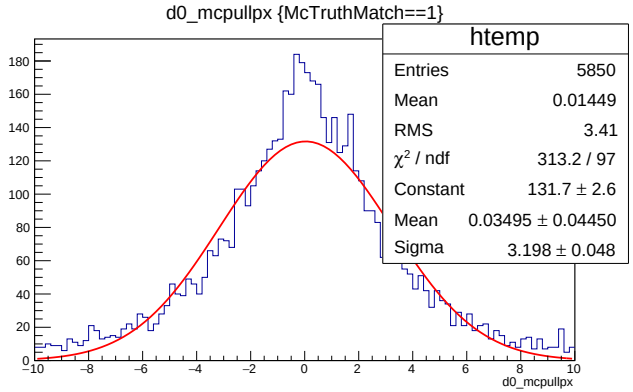
PiMinus

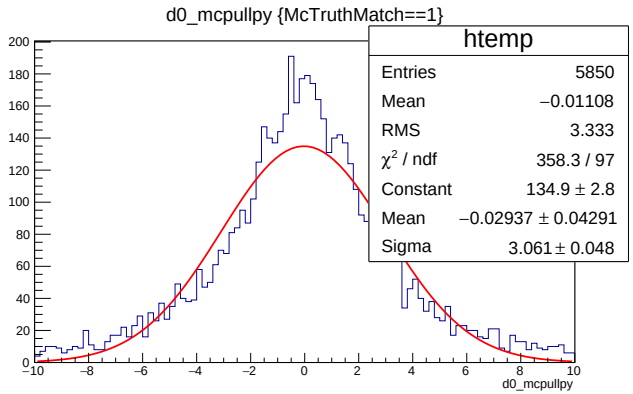


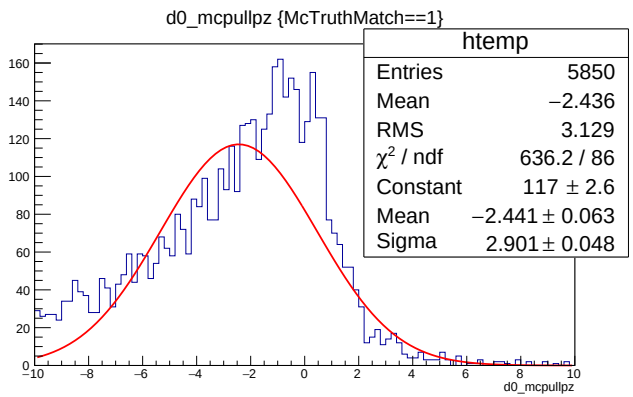




Proton

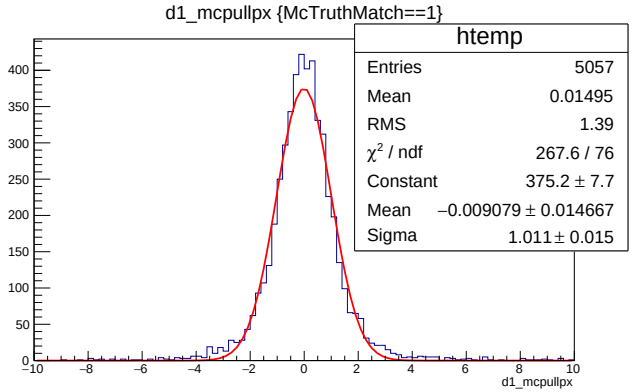


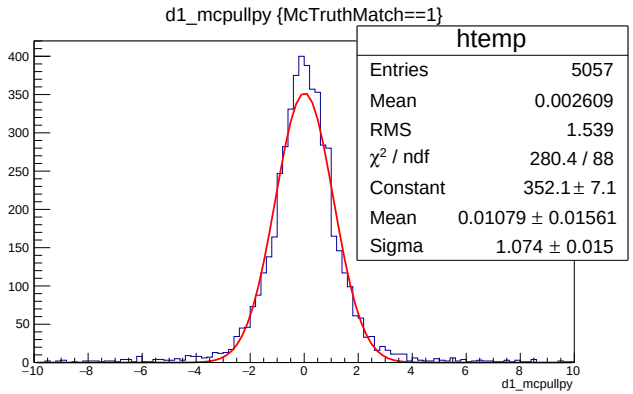


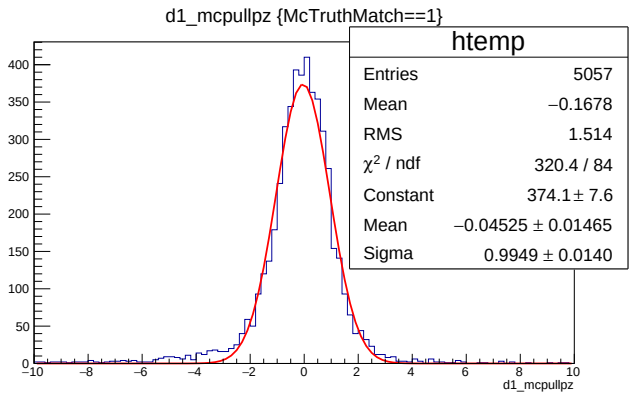


MC pull distribution (with Ideal Hypothesis)

PiMinus







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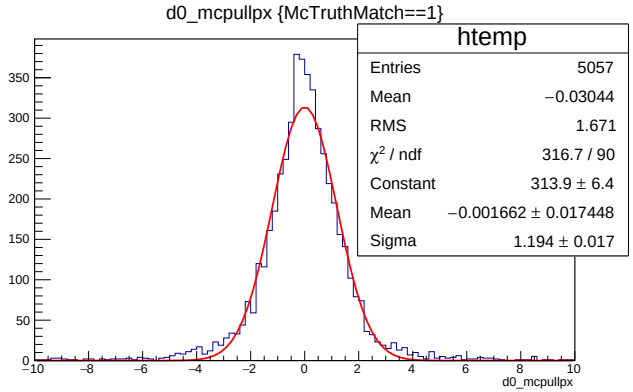
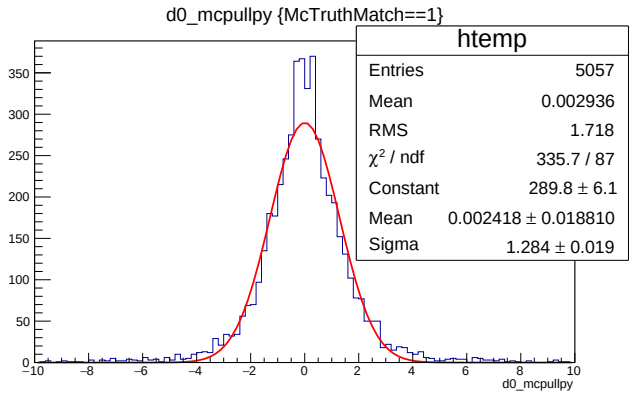
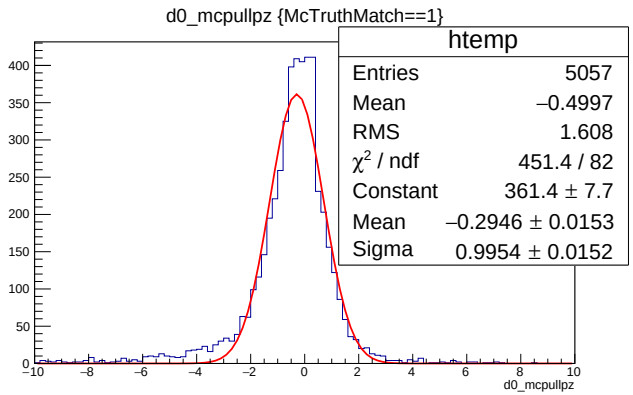






Kalman filter new design

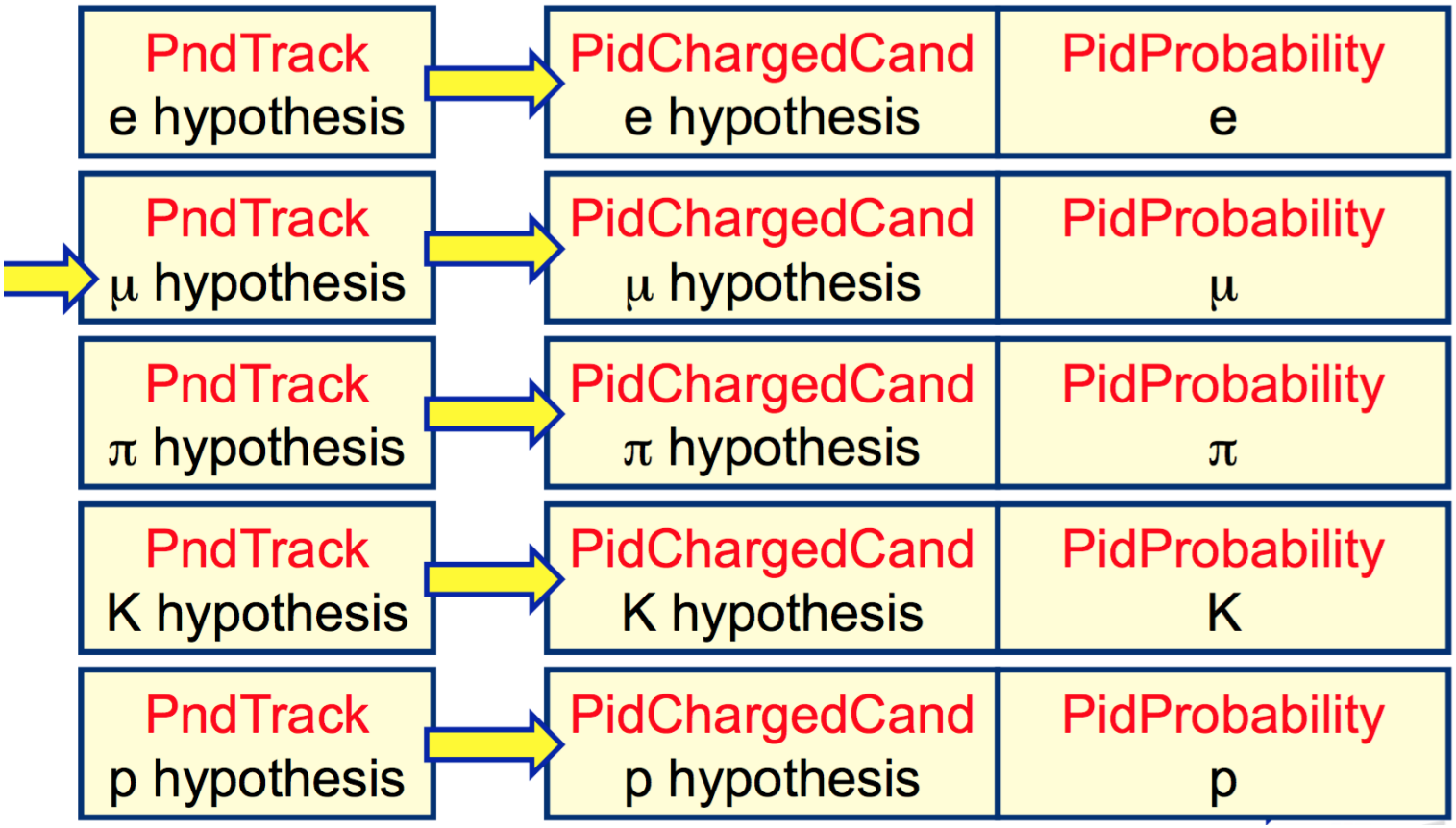


Figure from PANDA Computing Workshop 2017

Reconstruction Stage

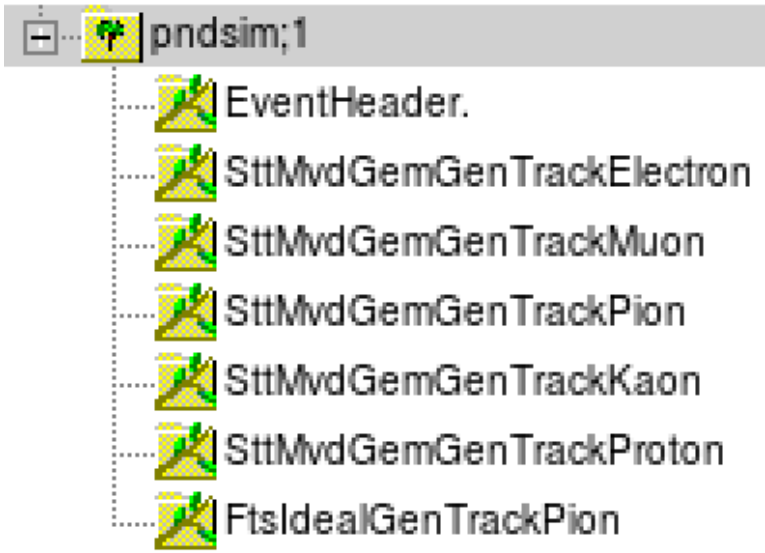
- In reco macro, pass option "multikalman", and Kalman filter will run 5 times with all hypotheses
- If *e.g.* only pions and protons are interesting, pass them in option string

```
  // -----   Initial Settings   ---------------------------------------------
  PndMasterRunAna *fRun= new PndMasterRunAna();
  fRun->SetInput(input);
  fRun->SetOutput(output);
  fRun->SetFriend1(friend1);
  fRun->SetFriend2(friend2);
  fRun->SetFriend3(friend3);
  fRun->SetFriend4(friend4);
  fRun->SetParamAsciiFile(parAsciiFile);
  fRun->Setup(prefix);

  // -----   Add tasks   ----------------------------------------------------
//  fRun->SetOptions("multikalman;pion;proton");
  fRun->SetOptions("multikalman");
  fRun->AddRecoTasks();
```

Reconstruction Stage

PndMultiKalmanTask properties:

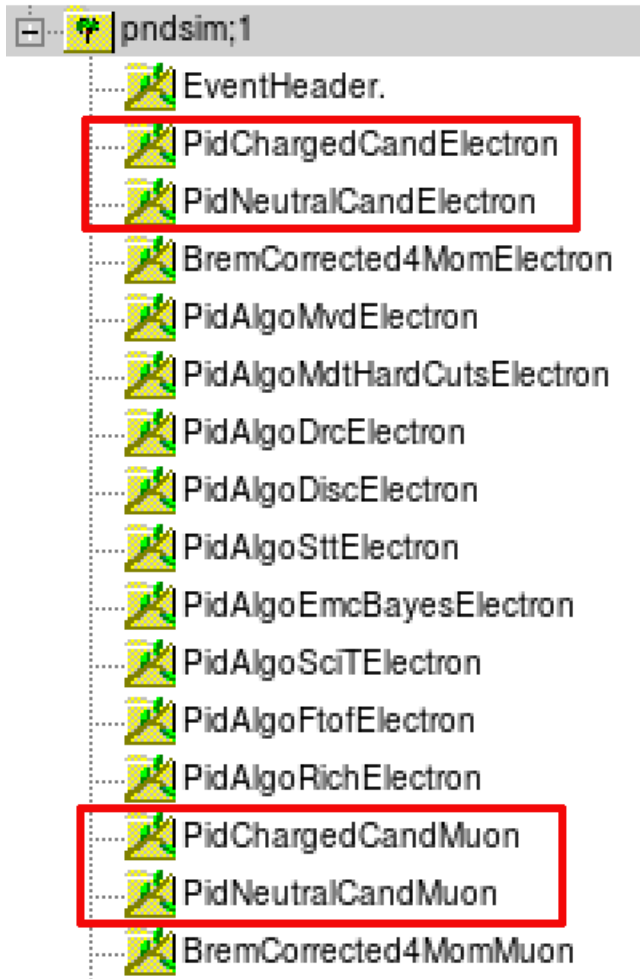
- Possible to run with standard pattern recognition as well as ideal PR
- If no hypotheses are specified in the options, all five hypotheses are used
- Currently, PndMultiKalmanTask does not run with FTS PR output...
  $\Longrightarrow$ only running pion hypothesis for now



PID Stage: PndCorrelator

PndCorrelator - first task PID stage

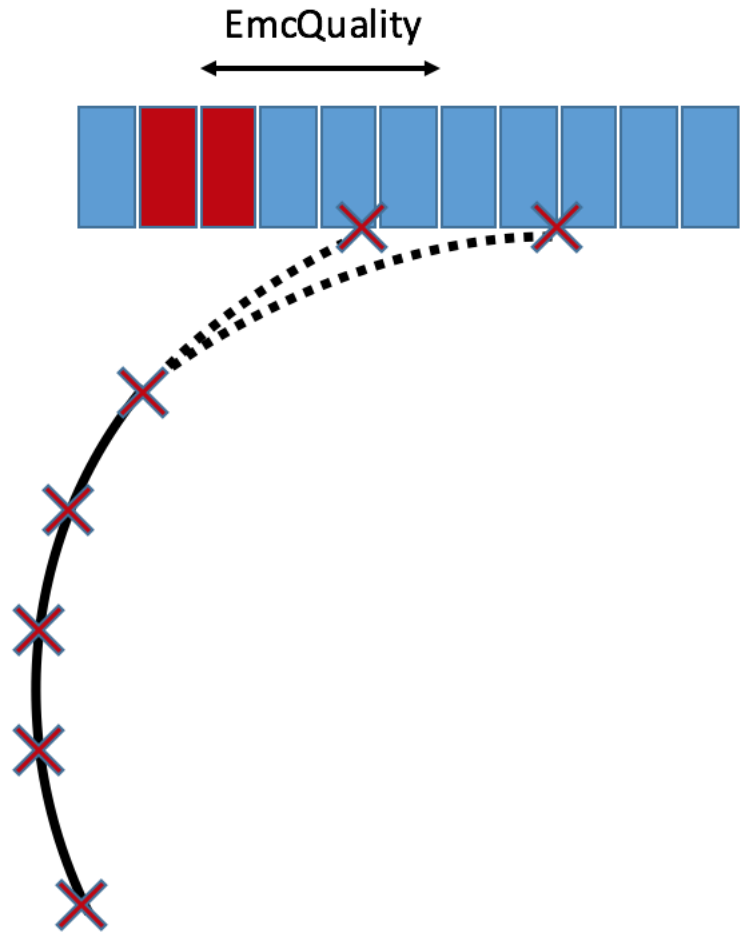
- Produces PndPidCanididates for
  - Track candidates
    - charged
  - EMC bumps
    - neutral
- PndCorrelator run for each track fit hypothesis



PID Stage: PndCorrelator

Why 5 sets of neutral PndPidCandidates?

- A given track can have successful fit with one hypothesis but failed with another
- Neutrals produced if EmcBump distance to track larger than EmcQuality
- Extrapolating track to EMC dependent on particle hypothesis
- Five sets of neutrals produced by extrapolating with different hypothesis



PID Stage: PndPidAlgos, PndMcCloner

Significant changes:

- PndAlgos and PndBremCorrector running for each hypothesis
- New PndMcCloner2 class:
  - Checks if a MC track is related to a track that was successfully fitted with any hypothesis
    (Again, Kalman fit can converge for *e.g.* pion hypothesis but fail for proton hypothesis).
  - Save MCtrack if that is the case.
- Everything handled in new PndMasterMultiPidTask class
- If no hypotheses specified in options, all five hypotheses are used

```
    // -----   Add tasks   ------------------------------------------------
    fRun->SetOptions("multikalman;pion;proton");
//  fRun->SetOptions("multikalman");
    fRun->AddPidTasks();
```

Analysis Stage

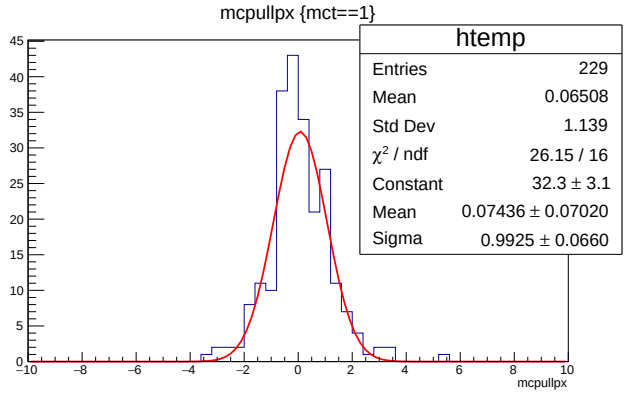
PndAnalysis - main analysis object taking care of file read/write

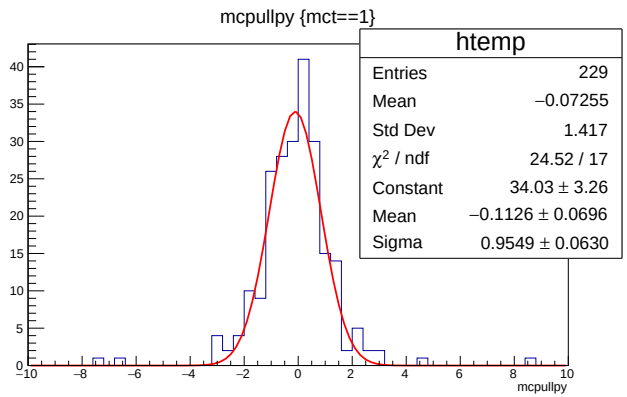
- Now reads up to five sets of TClonesArrays, one set for each hypothesis
- When filling RhoCandLists, following is specified
  - Particle hypothesis + PID criteria + Charge
  - Name of branch containing subdetector PID info
- Usage same as before

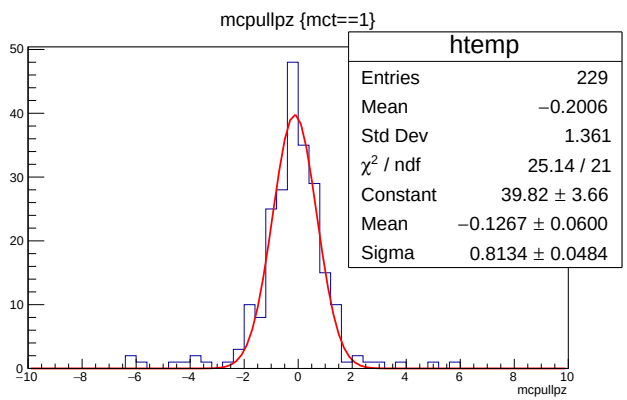
```
//      theAnalysis->FillList(piplus,  "PionAllPlus");
//      theAnalysis->FillList(piminus, "PionAllMinus");
//      theAnalysis->FillList(protonplus,  "ProtonAllPlus");
//      theAnalysis->FillList(protonminus, "ProtonAllMinus");

        theAnalysis->FillList(piplus,  "PionAllPlus", "PidAlgoIdealCharged");
        theAnalysis->FillList(piminus, "PionAllMinus", "PidAlgoIdealCharged");
        theAnalysis->FillList(protonplus,  "ProtonAllPlus", "PidAlgoIdealCharged");
        theAnalysis->FillList(protonminus, "ProtonAllMinus", "PidAlgoIdealCharged");

//      theAnalysis->FillList(piplus,  "PionTightPlus","PidAlgoStt;PidAlgoMvd;PidAlgoEmc
//      theAnalysis->FillList(piminus, "PionTightMinus","PidAlgoStt;PidAlgoMvd;PidAlgoEm
//      theAnalysis->FillList(protonplus,  "ProtonTightPlus","PidAlgoStt;PidAlgoMvd;PidA
//      theAnalysis->FillList(protonminus, "ProtonTightMinus","PidAlgoStt;PidAlgoMvd;Pid
```

MC pull distribution (Multikalman, with tight pid cut)

PiMinus







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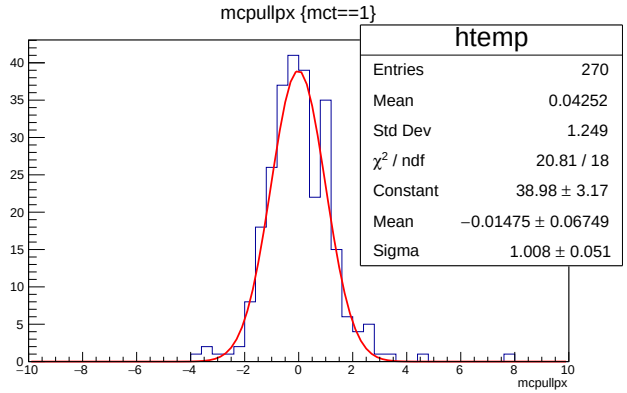

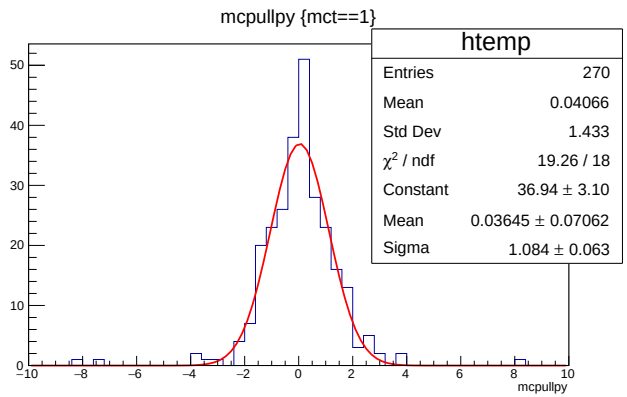

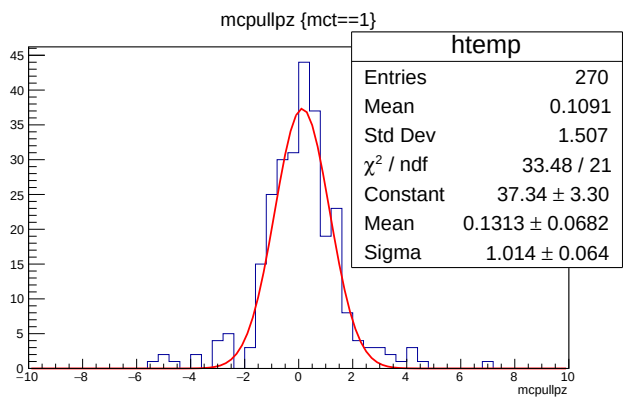

Summary

- Pandaroot simulation and analysis chain modified to run MultiKalman filter
- Preliminary tests shows significant improvements for protons in $\overline{p}p \rightarrow \overline{\Lambda}\Lambda$ @ 1.642 GeV/c
- Feature will be pushed to dev branch soon...

Summary

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- Feature will be pushed to dev branch soon...

Thank you for your attention!

Backup