Karlsruher Institut für Technologie

GenFit fitting performance study

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Track Fitting in the Reconstruction

- Fitting the tracks found by pattern recognition is one of the final stages of the whole track reconstruction
- The GenFit library is given the information which hits belong to a track and a fit to the track model using the Kalman method is performed
- GenFit provides two fitting modes which are relevant here:
  - **KalmanFitter**

    Performs a forward and backward fit with the Kalman method and computes a smoothed average for the final fit results
  - **Deterministic Annealing Filter**

    Applies the KalmanFitter multiple times and removes outlier hits after each KalmanFitter call
- Both methods are available in basf2 via the `KalmanRecoFitterModule` and `DAFRecoFitterModule` modules
- But: only the DAF-method is used in our reconstruction (and in the following studies)

Track Fitting in the Track Reconstruction II

The `TrackCreatorModule` performs the final track fit in basf2

Currently:

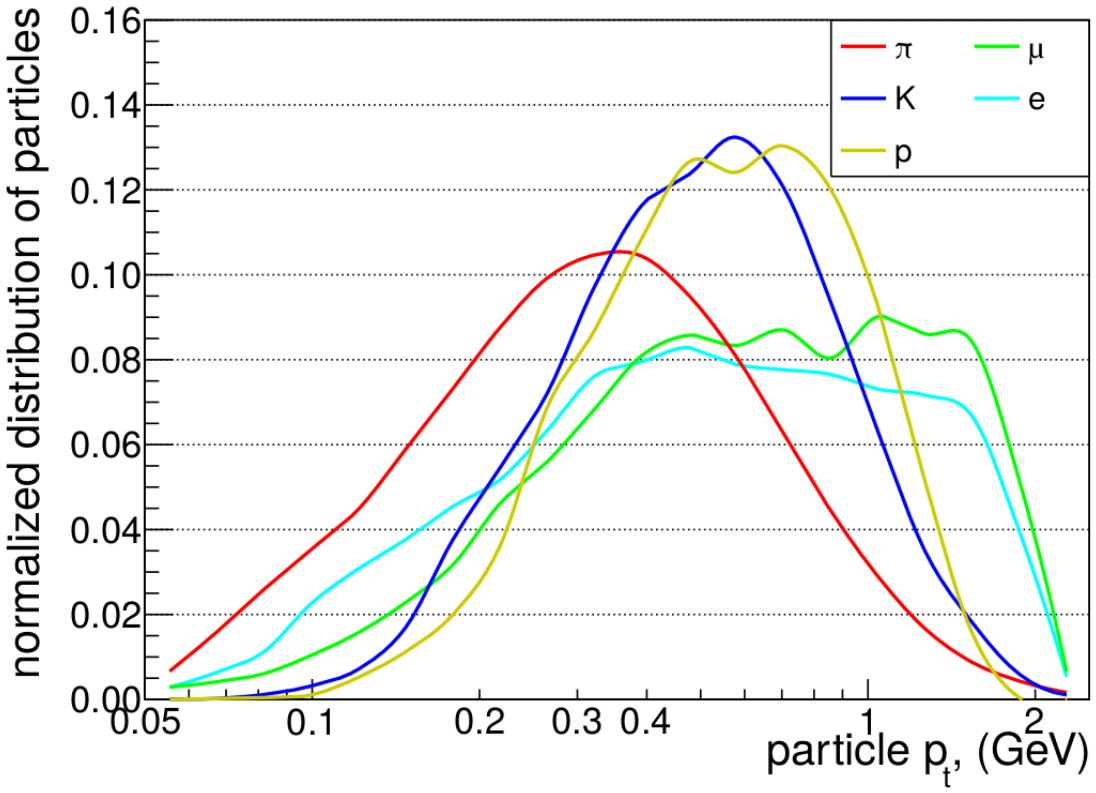
- Track is fitted with a pion hypothesis
- If fit is not successful
  - the track is dropped and not stored in output
- If fit successful
  - Additional particle hypothesis are fitted
  - All successful fit are extrapolated to the POCA with the beam line and stored: 1 Belle2::Track with Belle2::TrackFitResults for each succesful hypothesis

Coming Soon (https://agira.desy.de/browse/BII-2261)

- All hypothesis are fitted
- The successful ones are stored
- If at least one track fit was successful, a Belle2::Track is stored

Particles and Spectra @ Y4S

Particle type	Average fraction	PDG Id
$\pi^{\pm}$	72.8%	211
$K^{\pm}$	14.9%	321
$e^{\pm}$	5.8%	11
$\mu^{\pm}$	4.7%	11
$p^{\pm}$	1.8%	13
		2212



This Study

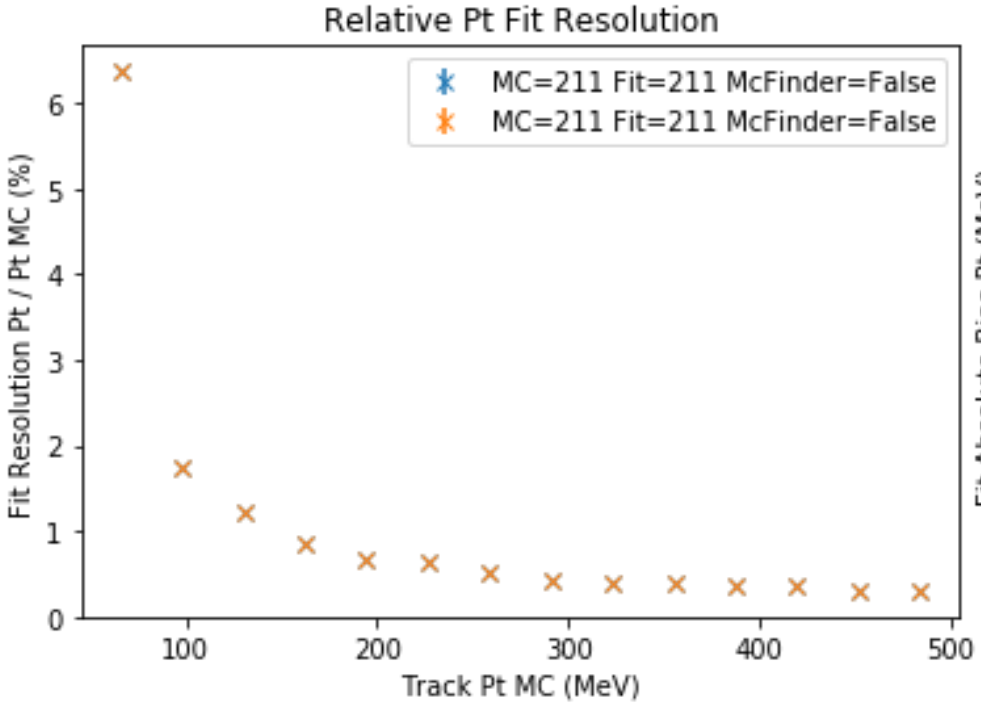
Goal

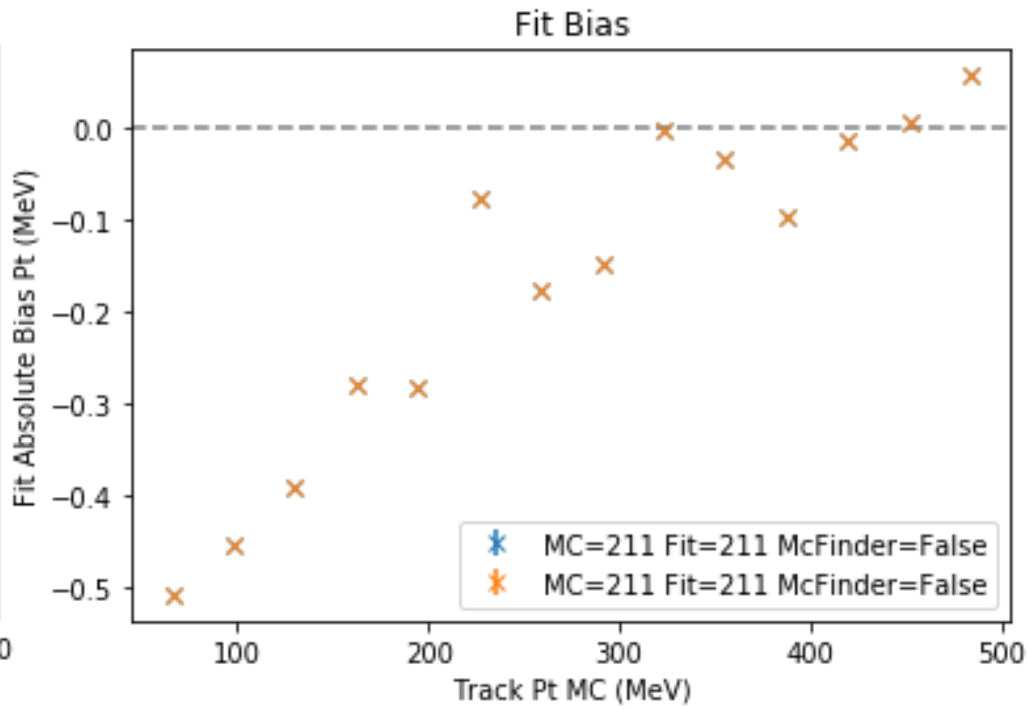
- Understand whether the correct fit hypothesis gives a better estimation of the track's transverse momentum measurement than the default pion hypothesis

Method

- Start with the most simplest setup imaginable
- ParticleGun with 1 particle of specific type/event covering the whole acceptance range and the Pt range 50 – 500 MeV
- Run only the track finding, all downstream modules disabled (esp. the `TrackCreatorModule`)
- Fit tracks with the `DAFRecoFitterModule` with default settings and only one specific hypothesis and check the outcome
- Look at the transverse momentum (pt) estimation of the fit: most direct impact of changed fit hypothesis (→ different energy loss)
  - Impact on other parameters like d0 is a second-order effect
- Fitted pt Residuum distribution with double gaussian function and extracted the mean and sigma of the gaussian fitted to the central part of the distribution

Pion



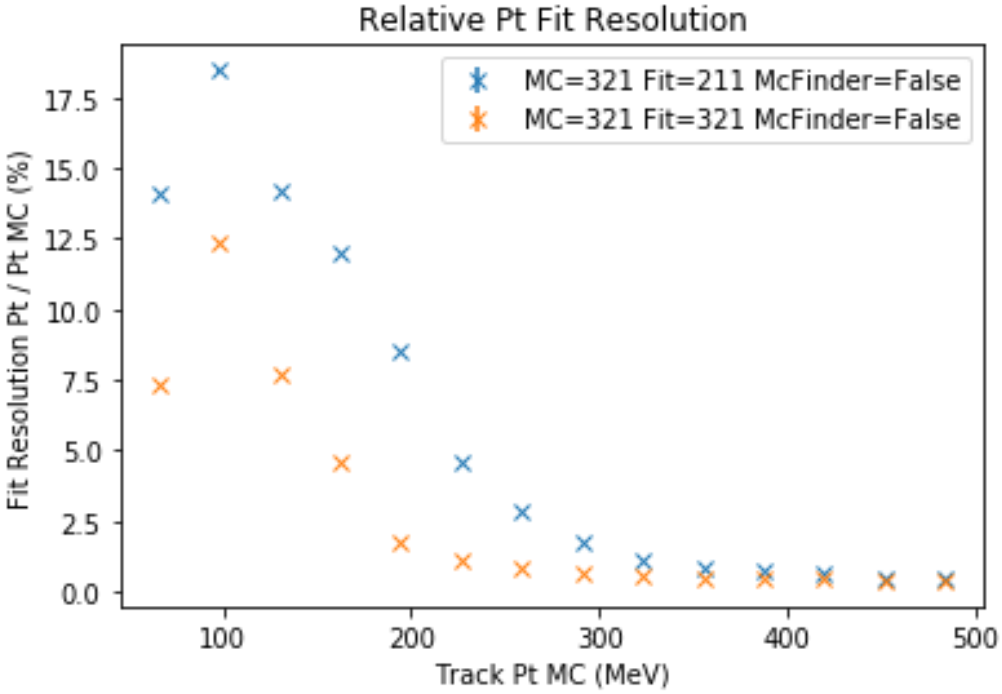


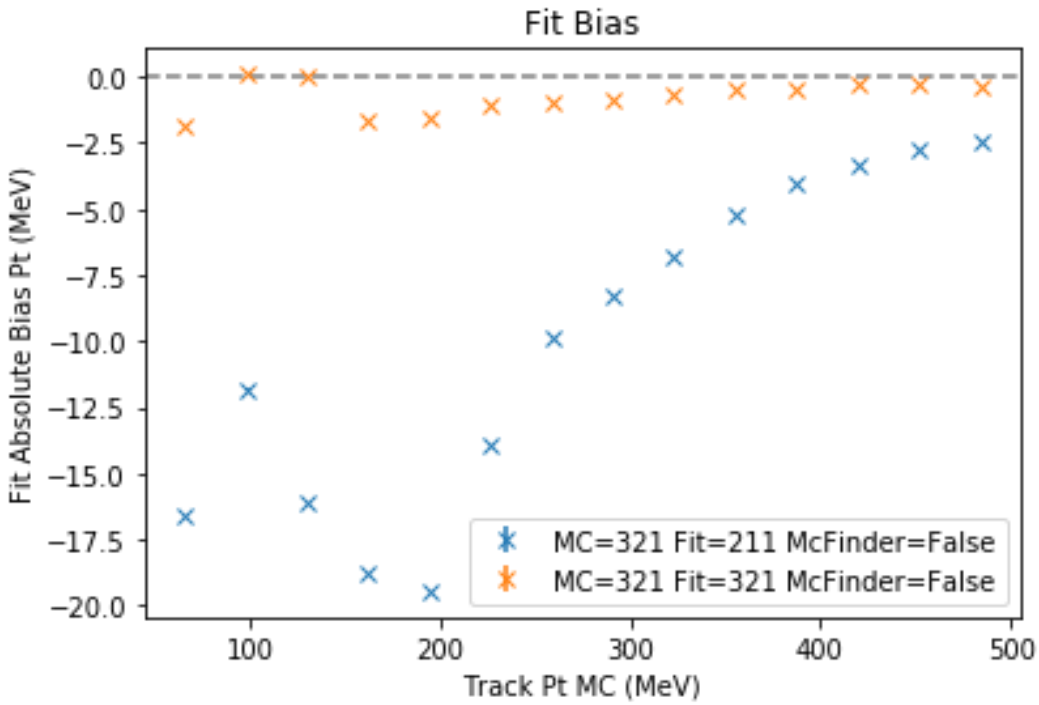
Pion Fit Hypothesis

Correct Fit Hypothesis

- **Just for cross-checking, no surprises here**
- **Systematic bias to lower pt in low-pt tracks**

Kaon



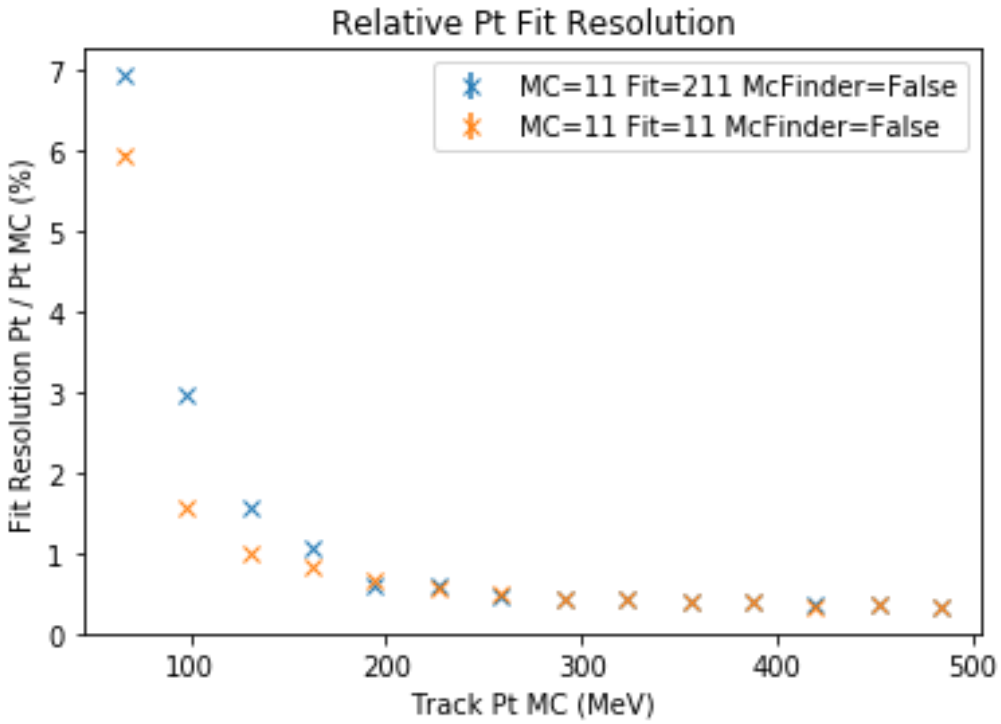


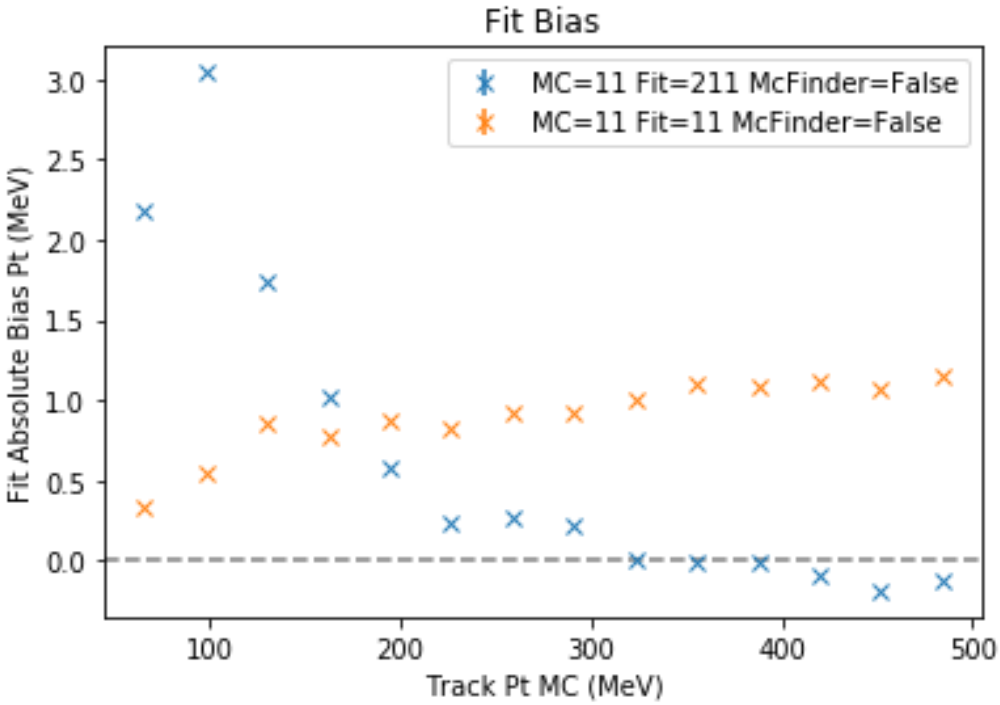
Pion Fit Hypothesis

Correct Fit Hypothesis

- **Fitting with correct Hypothesis improves the Fit Bias and the Resolution in all Pt ranges**

Electron Fit



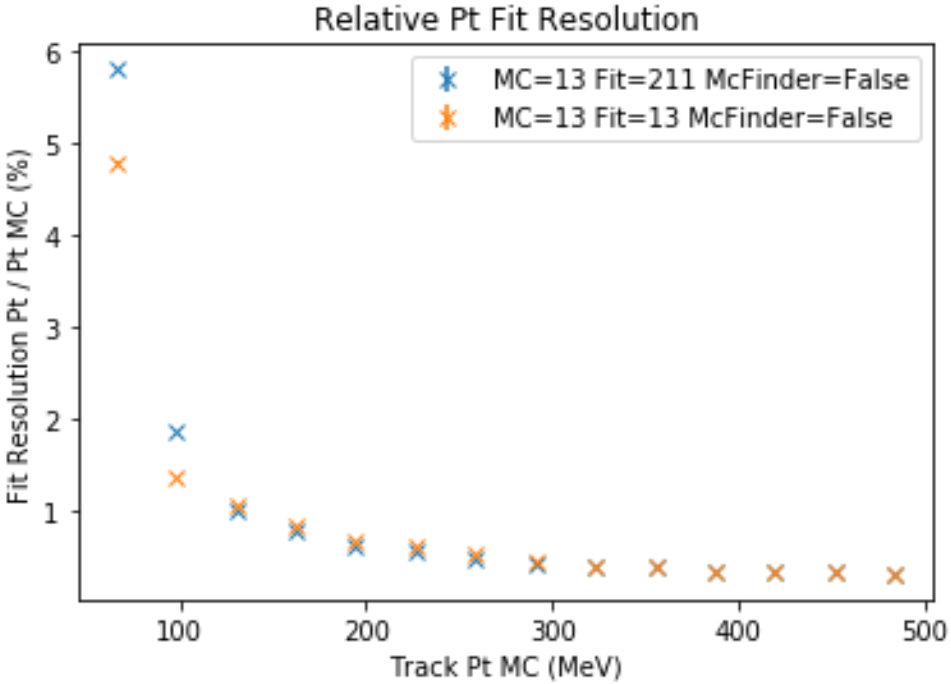


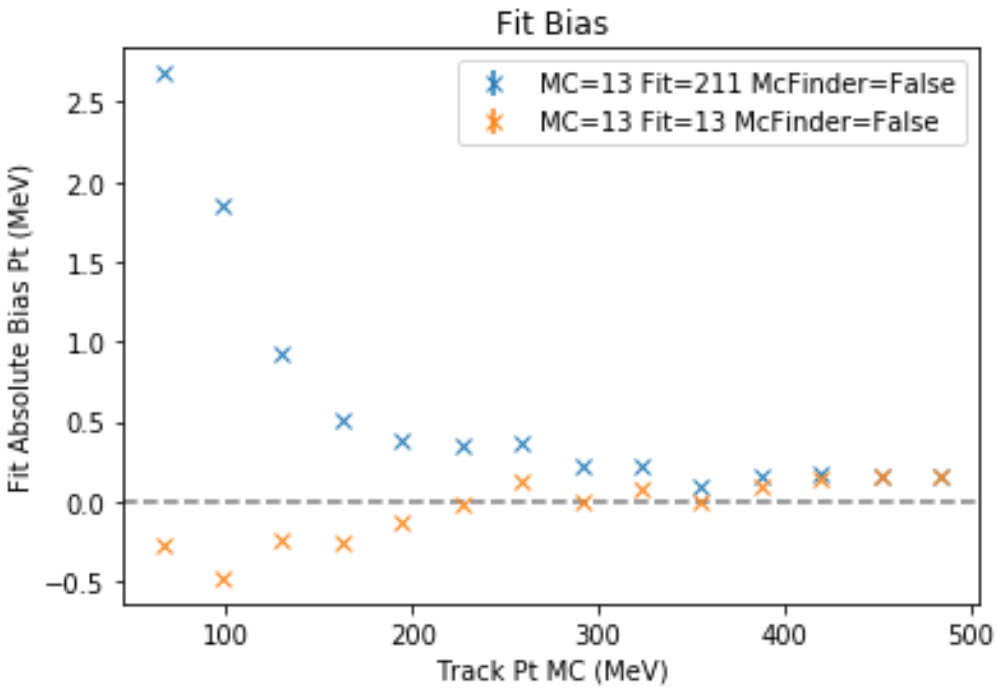
Pion Fit Hypothesis

Correct Fit Hypothesis

- **Fitting with correct Hypothesis improves the Resolution in lower Pt Range esp. in lower Pt range**
- **But: Systematic Bias for electron fit hypothesis**
  - **Problem with electron material effects model? Further investigation needed**

Muon Fit



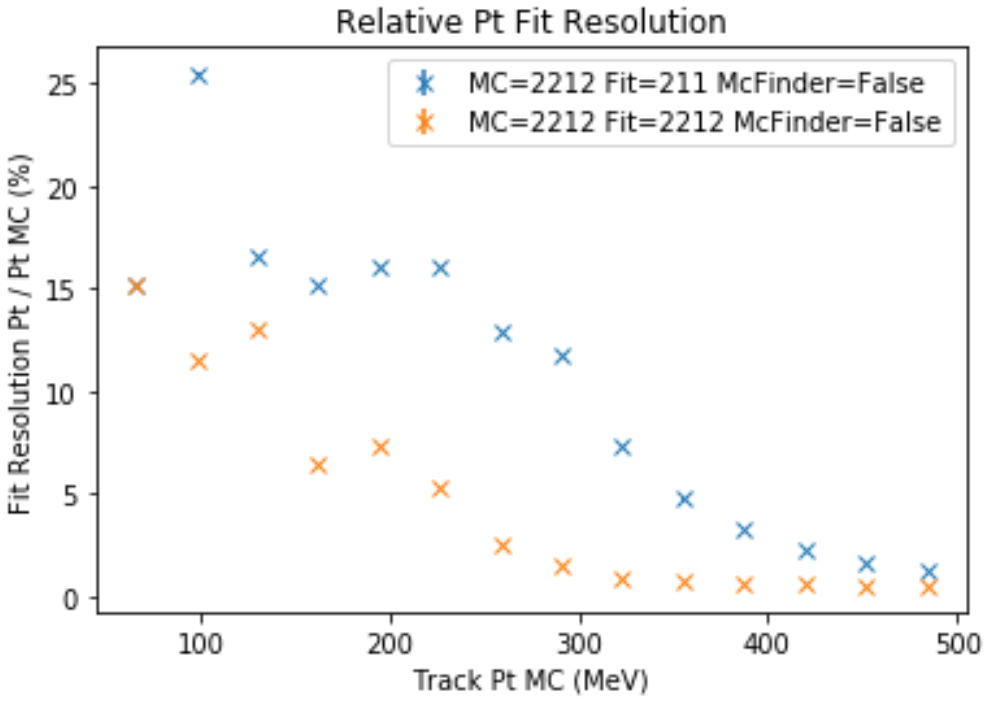


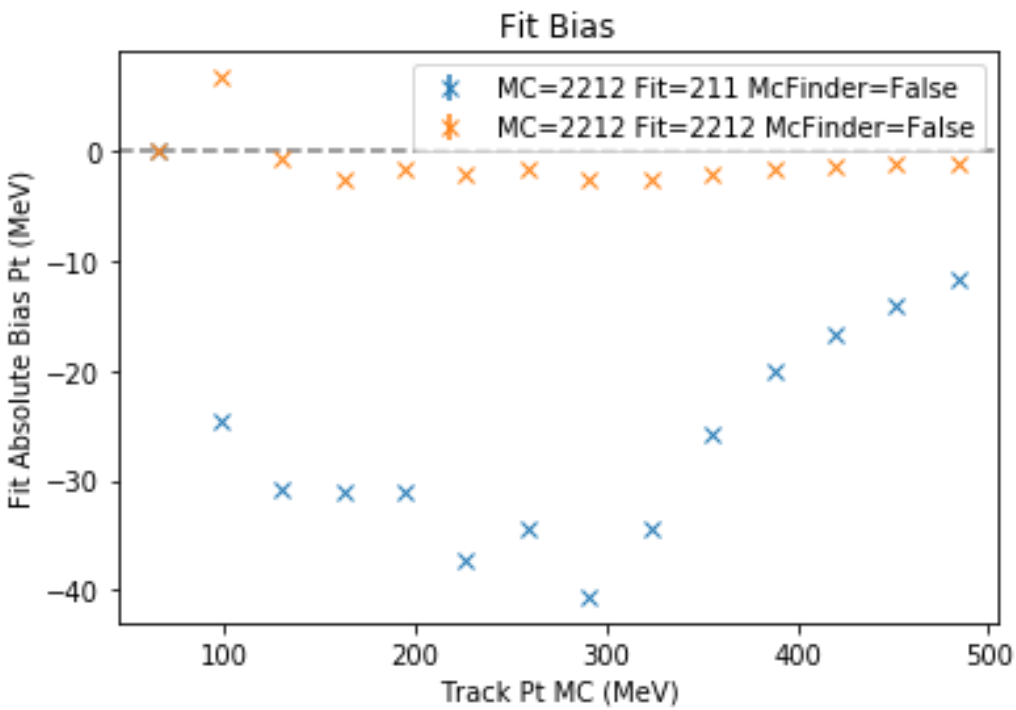
Pion Fit Hypothesis

Correct Fit Hypothesis

- **Fitting with correct Hypothesis improves the Fit Bias and the Resolution in all Pt ranges**

Proton Fit





Pion Fit Hypothesis

Correct Fit Hypothesis

- **Fitting with correct Hypothesis improves the Fit Bias and the Resolution in all Pt ranges**
- **Big improvement with Proton hypothesis as expected due to the large mass difference btw. Proton and Pion**

Summary

- Fit resolution and biases studied for all relevant particle types and fit hypothesis
- Using a specific hypothesis always improves the fit quality
  - Except for electron fits, which have a systematic bias for large pt values

Next Steps

Short-Term

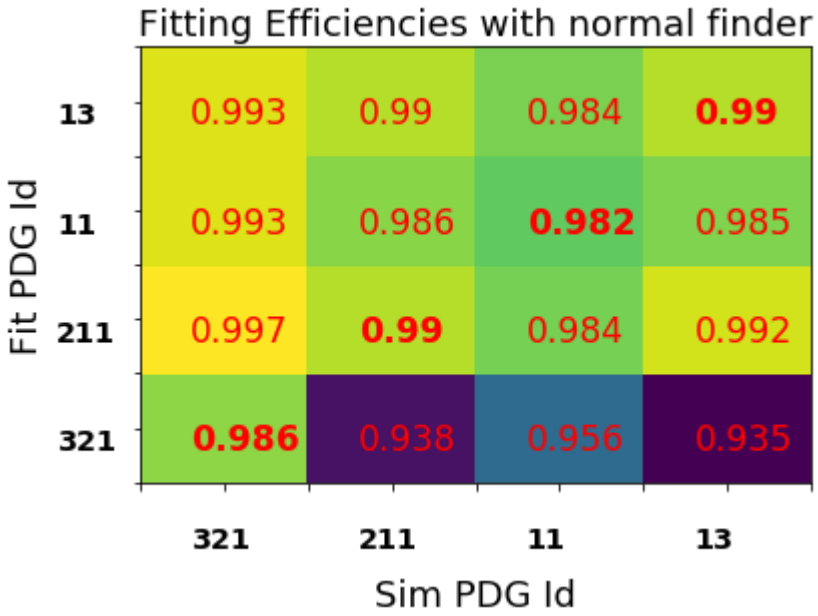
- Enable multi-hypothesis fitting for the next release
- Optimize fitting runtime by tuning the iterations of the DAF and using the eigen library

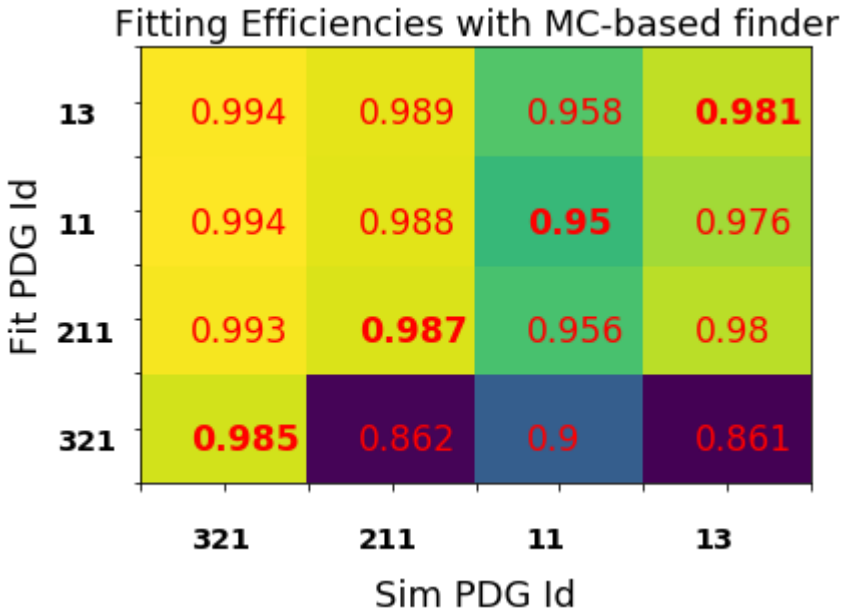
Mid-Term

- Revisit and fix the electron fitting model of GenFit

Backup

The Big Picture (from September Tracking Meeting)





- Fitting efficiencies with our normal finders (non-MC based) look very good
- Using the correct hypothesis gives the best result in all cases but in Kaon fit
  - Using Pion to fit Kaons gives better efficiency
- Fitting efficiency is worse by ~3% when using the MC-finder
  - Reason: loopers