Karlsruher Institut für Technologie

Belle II

GenFit fitting efficiency 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:

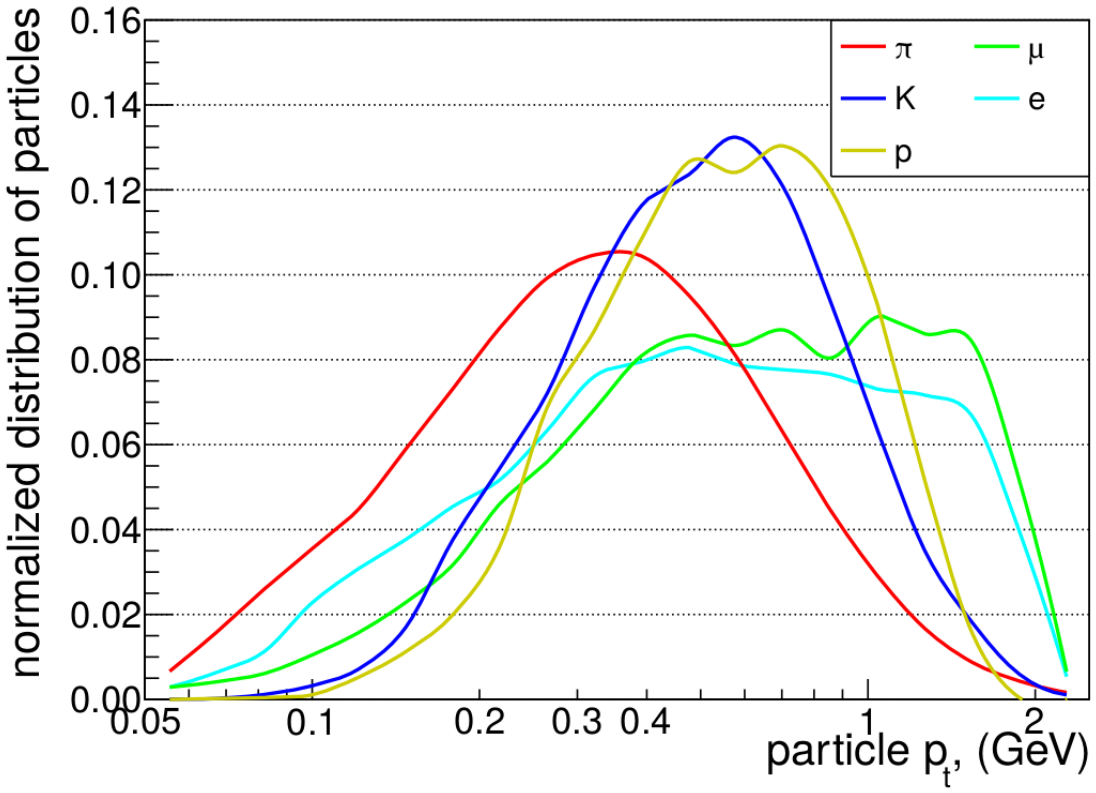
- Track is fitted with a pion hypothesis
- If fit is not successful
  - the track is dropped and not stored in output
- If fit successful
  - Additional particle hypothesis are fitted
  - All successful fit are extrapolated to the POCA with the beam line and stored: 1 Belle2::Track with Belle2::TrackFitResults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



This Study

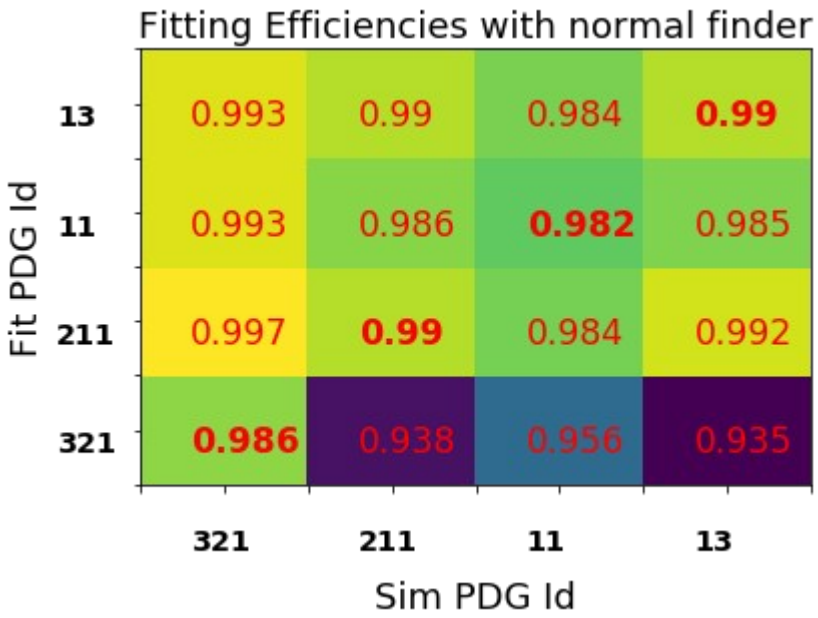
Goal

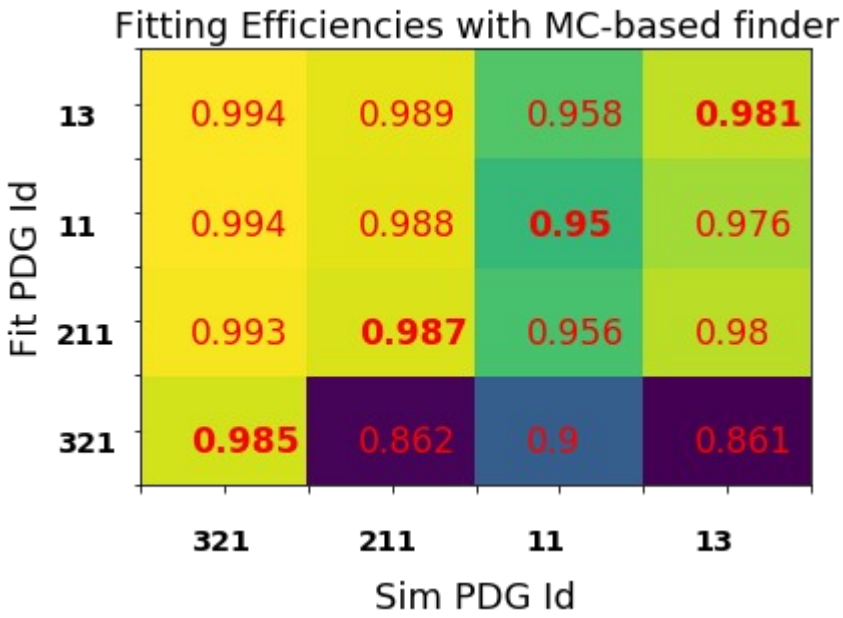
- Quantitative numbers on how many found tracks cannot be fitted with GenFit > lost to analysis
- Is there a specific pattern in tracks we cannot fit ?

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 (MC truth and normal reco), all downstream modules disabled (esp. the `TrackCreatorModule`)
  - Tracks not fittable by `TrackCreatorModule` are discarded and don't show up in the final selection
  - Not easy to disentagle if track finding or fitting failed
- Fit tracks with the `DAFRecoFitterModule` with default settings and only one specific hypothesis and check the outcome
- Fit successful is determined via the `RecoTrack::wasFitSuccessful(..)` method which checks if the fit fully converged (means all hits were used and none were skipped due to failing extrapolation for example)
  - Same method is used to determine the tracks which are stored by `TrackCreatorModule`

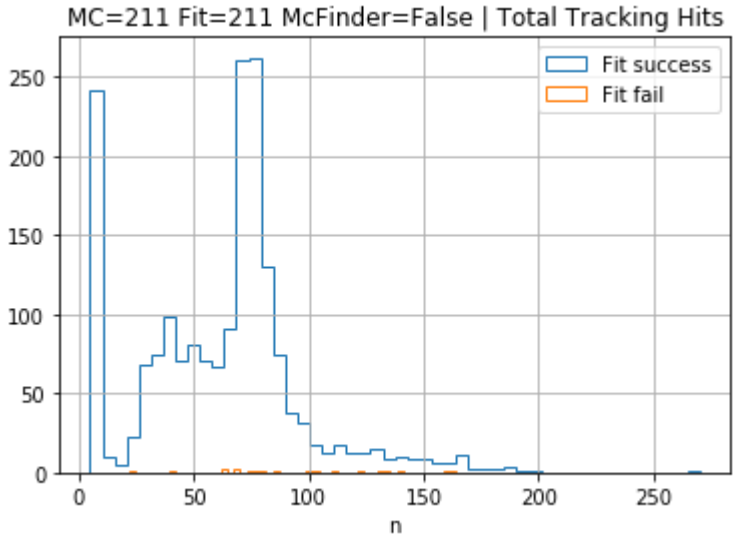
The Big Picture

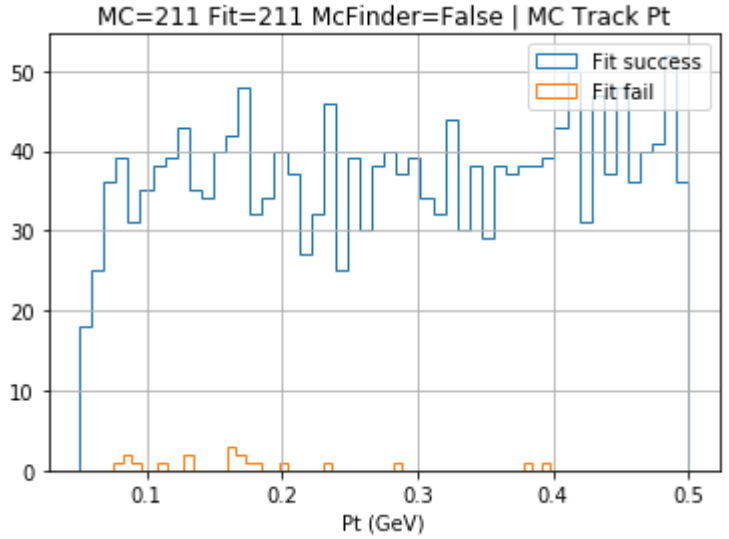


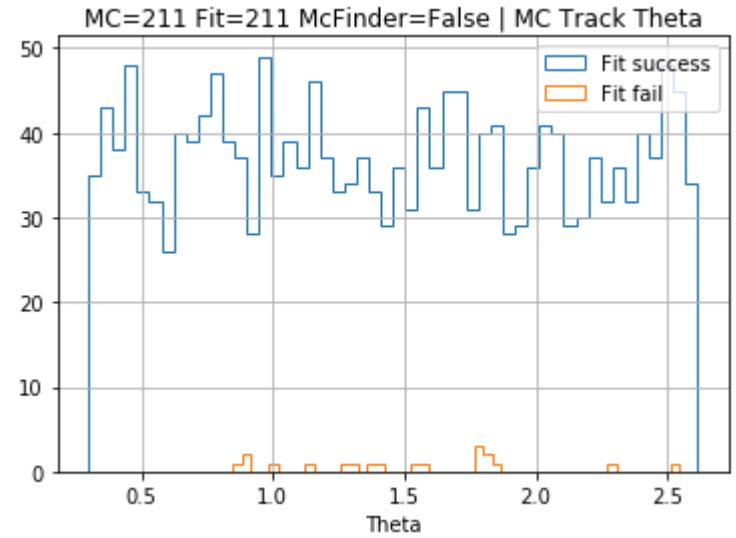


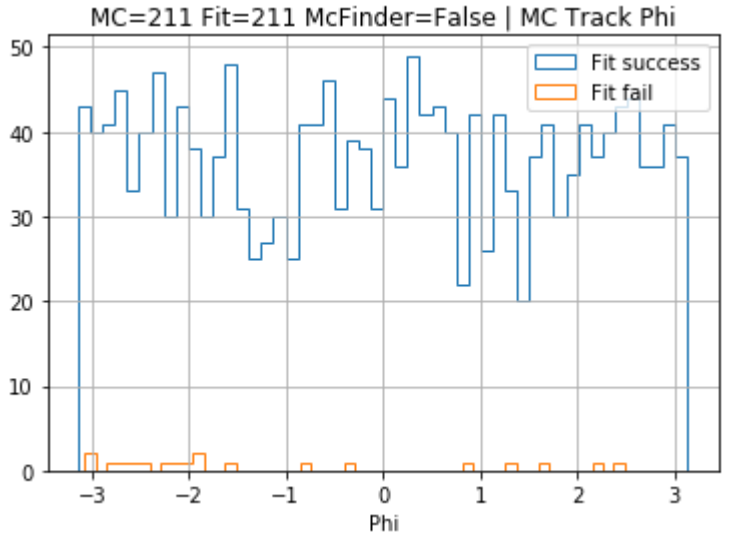
- Fitting efficiencies with our normal finders (non-MC based) look very good
- Using the correct hypothesis gives the best result in all cases but in Kaon fit
  - Using Pion to fit Kaons gives better efficiency
- Fitting efficiency is worse by ~3% when using the MC-finder
  - More on that later. Hint: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

Pion Hypothesis Fit, normal Reco



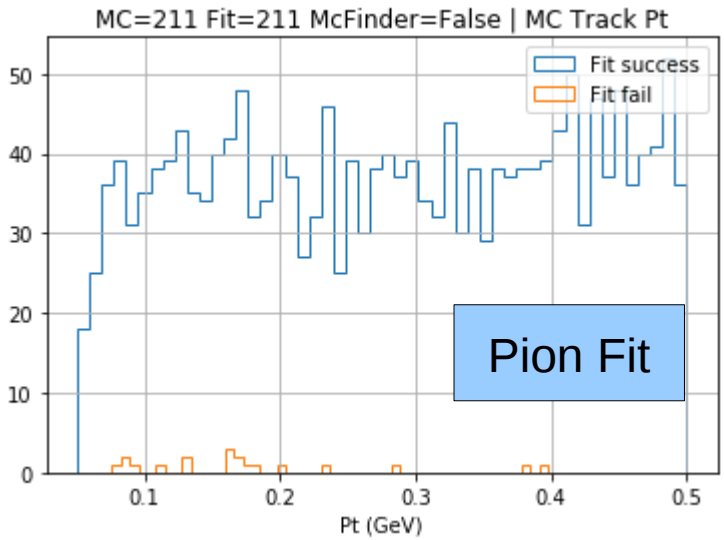


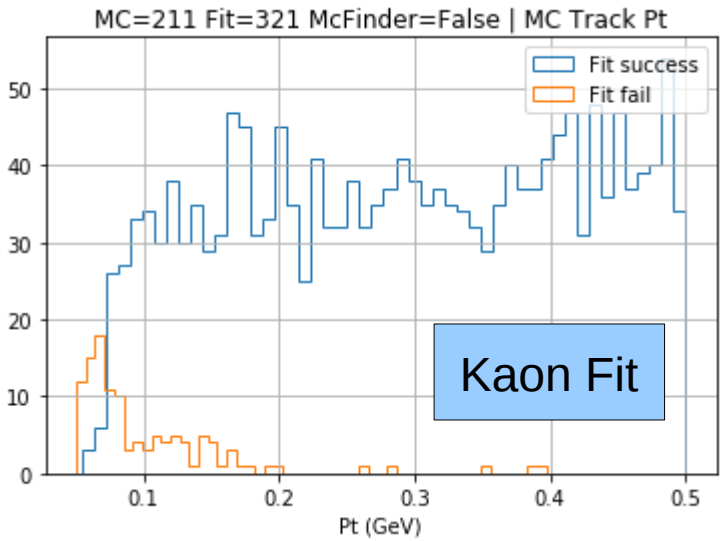




- No correlation found btw. failing fits and the usual track parameters
- Most failed fits in the region 100 to 200 MeV (material eff. have the most impact)

Fitting Pions with Kaon hypothesis ?



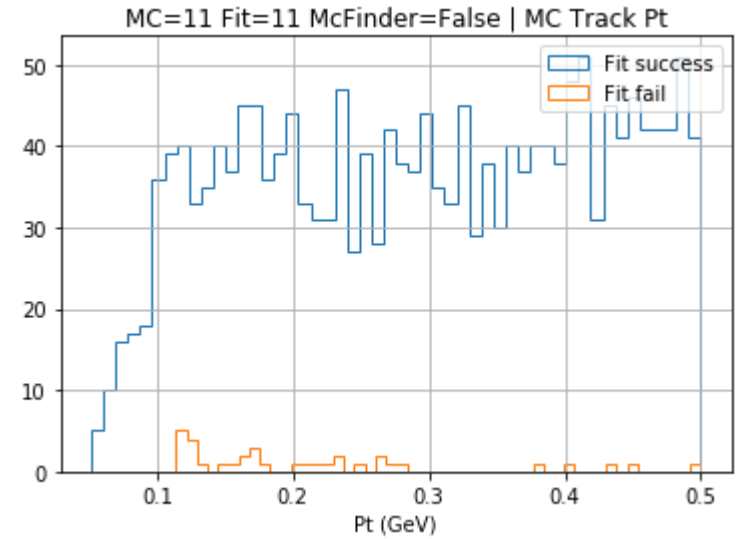


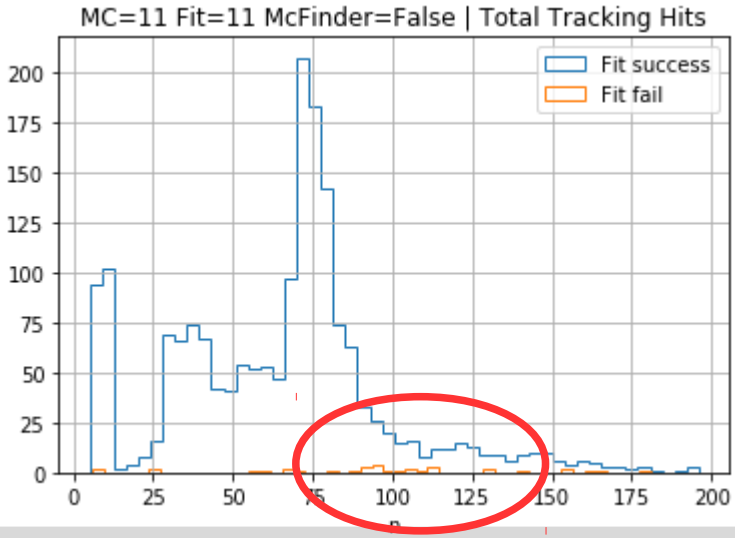
- As expected: fits with the wrong mass hypothesis fail mostly in the low-pt region where material effects have the biggest impact

Electron Fitting

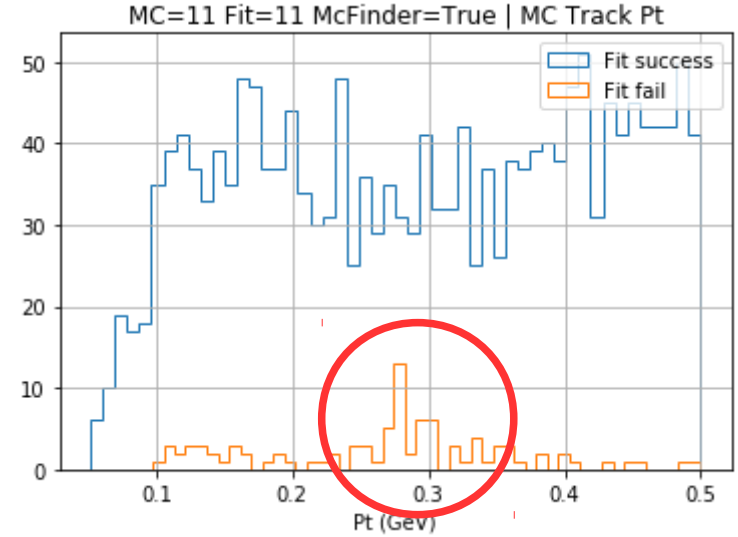
- Most failed electron tracks have > 80 hit points
  - Fits more likely to fail for long tracks and difficult material effects with electrons?
- Problem with MC-Finder visible here: looping tracks (esp. at ~280) have many hits and can’t be fitted

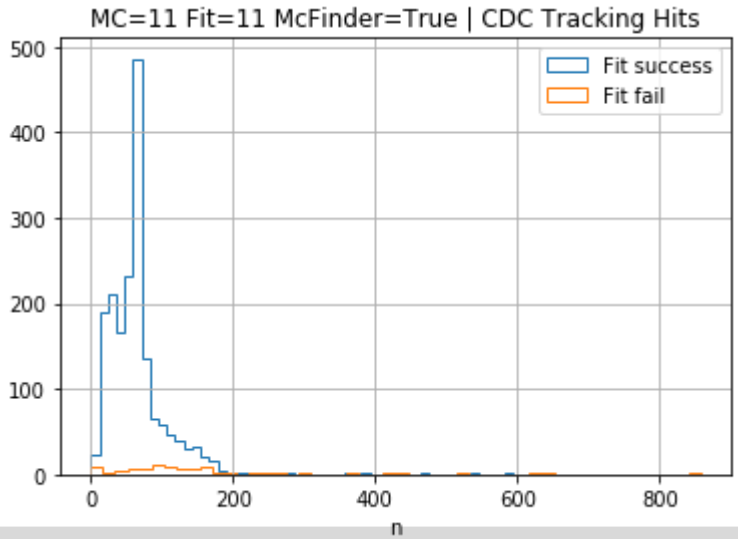
NORMAL RECO



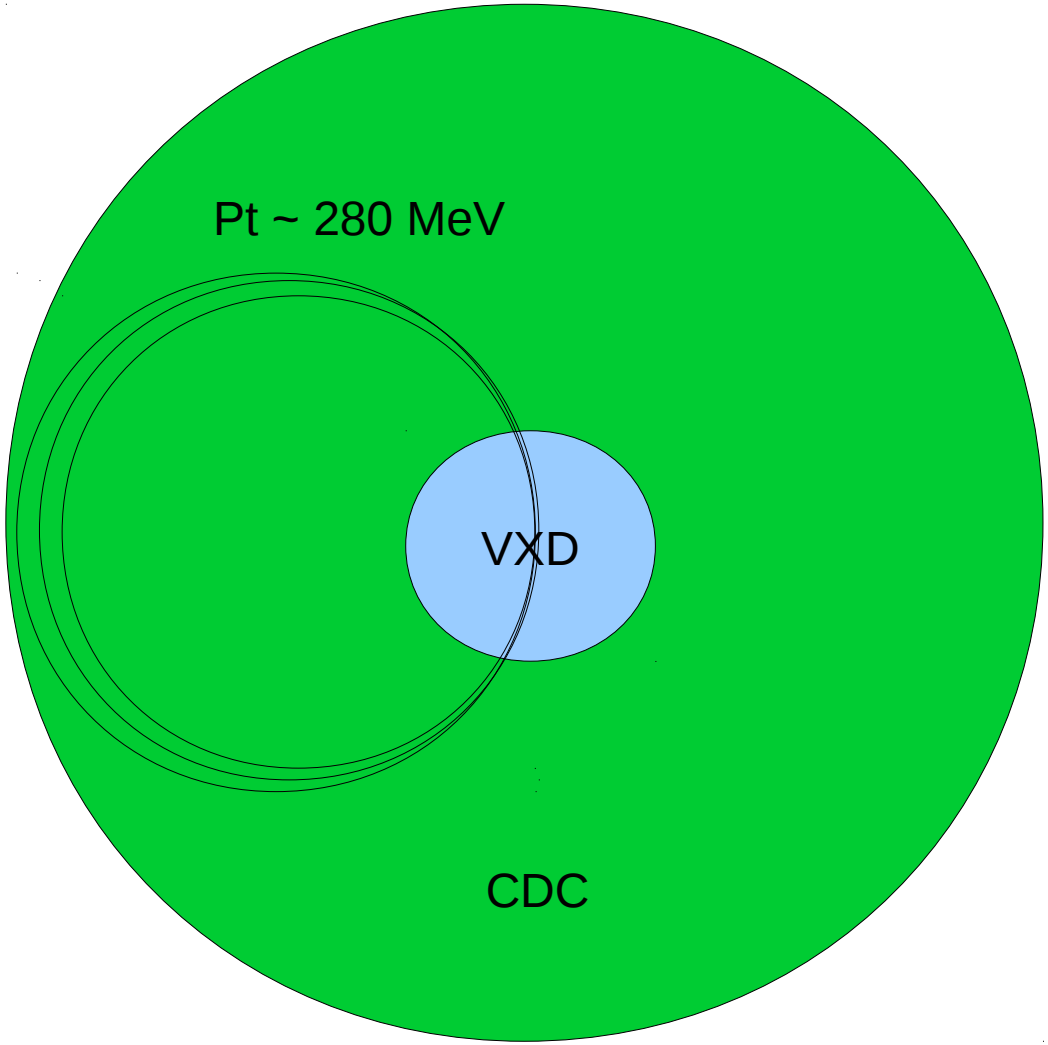


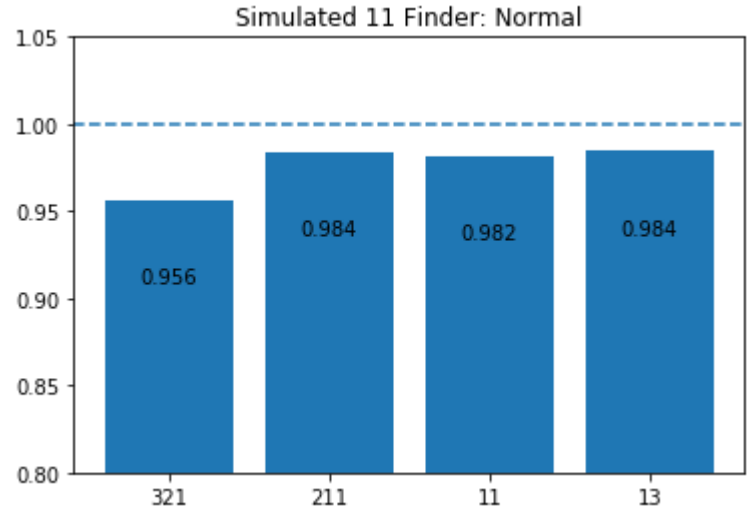
MC-BASED FINDER

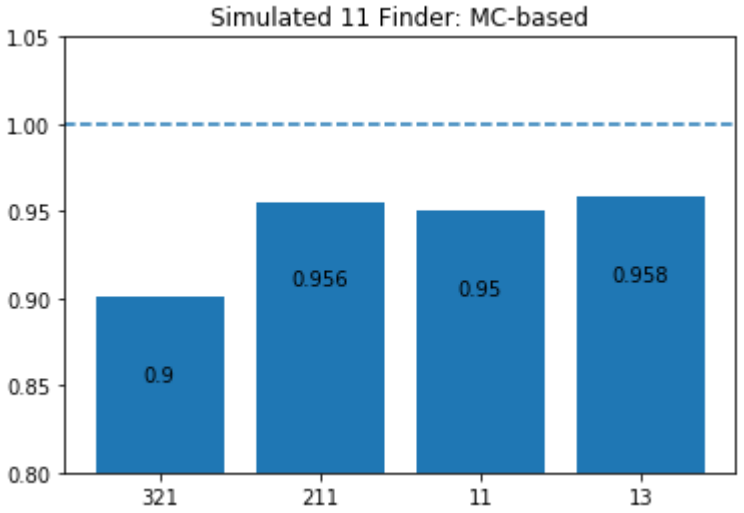




Electron Fitting: MC-based vs Normal Reco



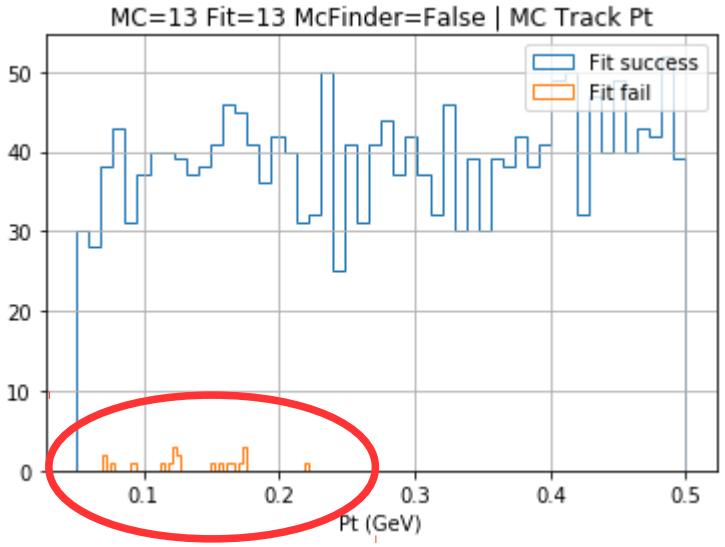


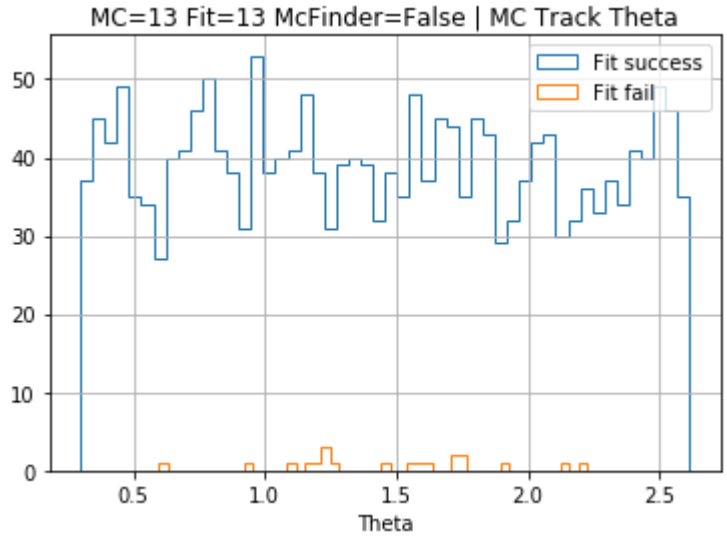


Muon Fitting

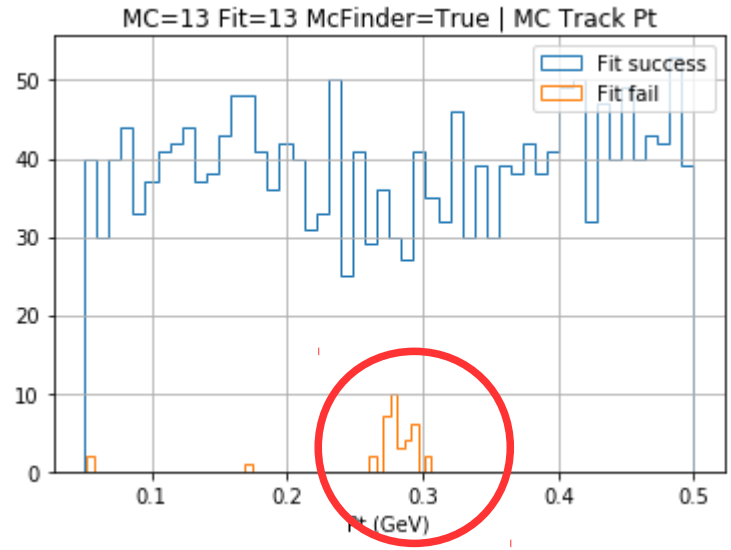
- Fitting MC-Finder Muons: same problem with loopers
- Interesting feature: there is a category of tracks (50 to 180 MeV) which fail in normal finder but work with MC-finder, not clear why

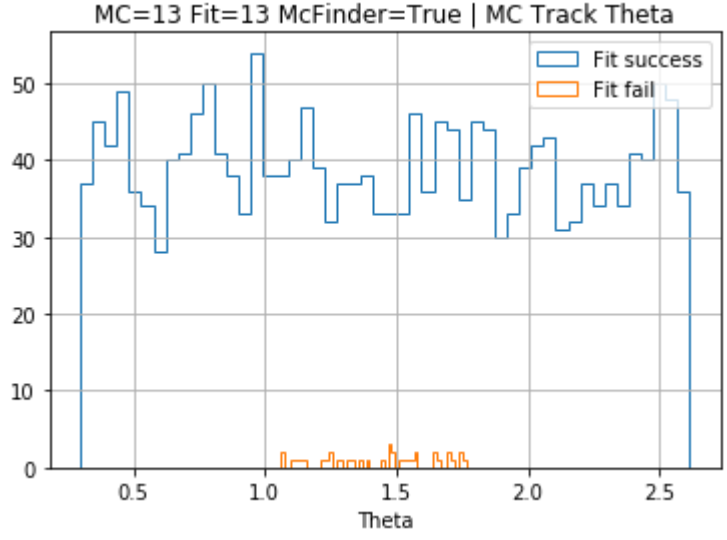
NORMAL RECO





MC-BASED FINDER



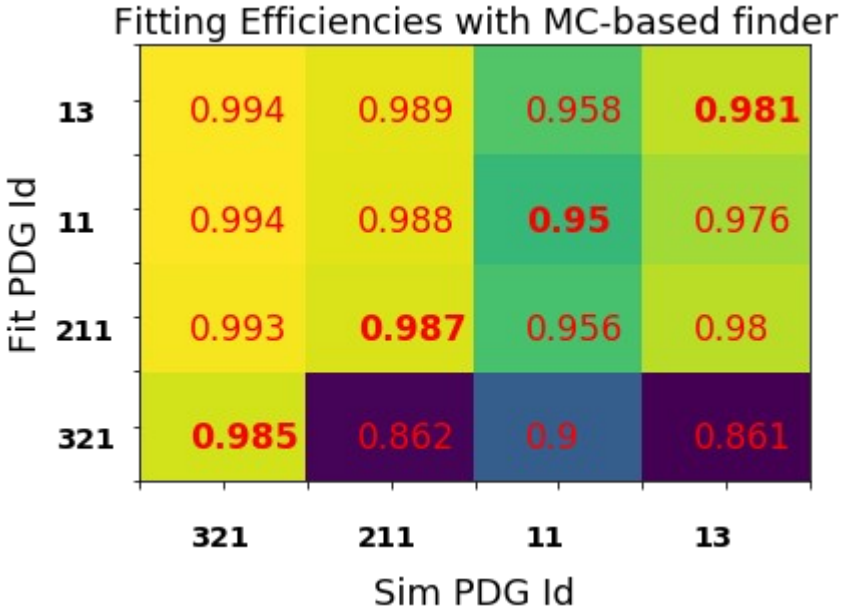


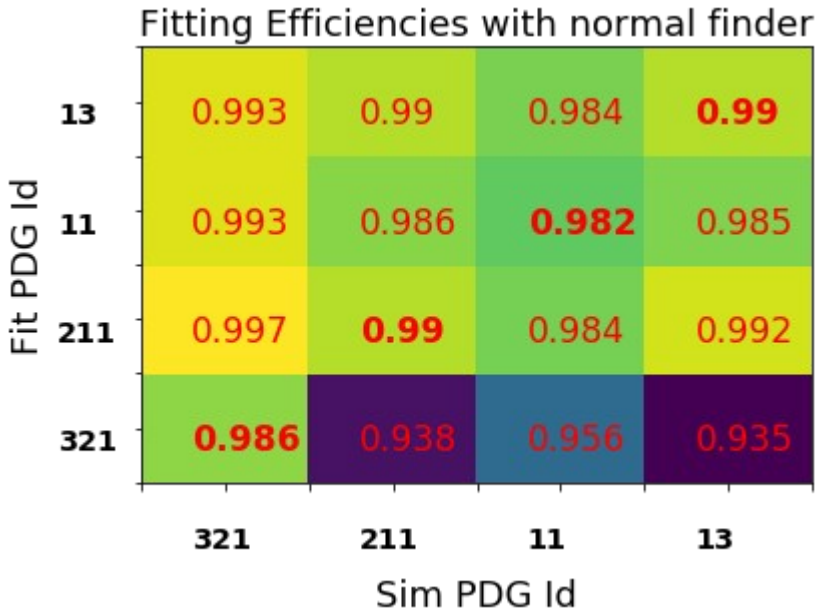
Discussion Points

- Should we change MCTrackFinder to fit only the first loop of tracks ?
  - The TrackFinderMCTruth can already mark hits of downstream loops as auxiliary
  - Who might be the actual users of MC-Finder based track fits?
- Should we invest further work to understand and improve some “features” esp. the failed muon fits in the region

  Pt < 180 MeV?
- We also have the `KalmanRecoFitterModule` which only performs the Kalman fit w/o the DAF procedure on top:
  - This module has quite bad performance (~ 80% efficiency)
  - Should we mark this module as obsolete or with a B2FATAL so no one uses it by accident ?

Summary





- **Positive Finding**: Fitting of these isolated tracks works very well and for all hypothesis
  - But remember: this study did not look at any fitted parameters and their distributions
- **Next step**: apply the same procedure with background to understand the impact of wrongly assigned hits on the DAF's performance