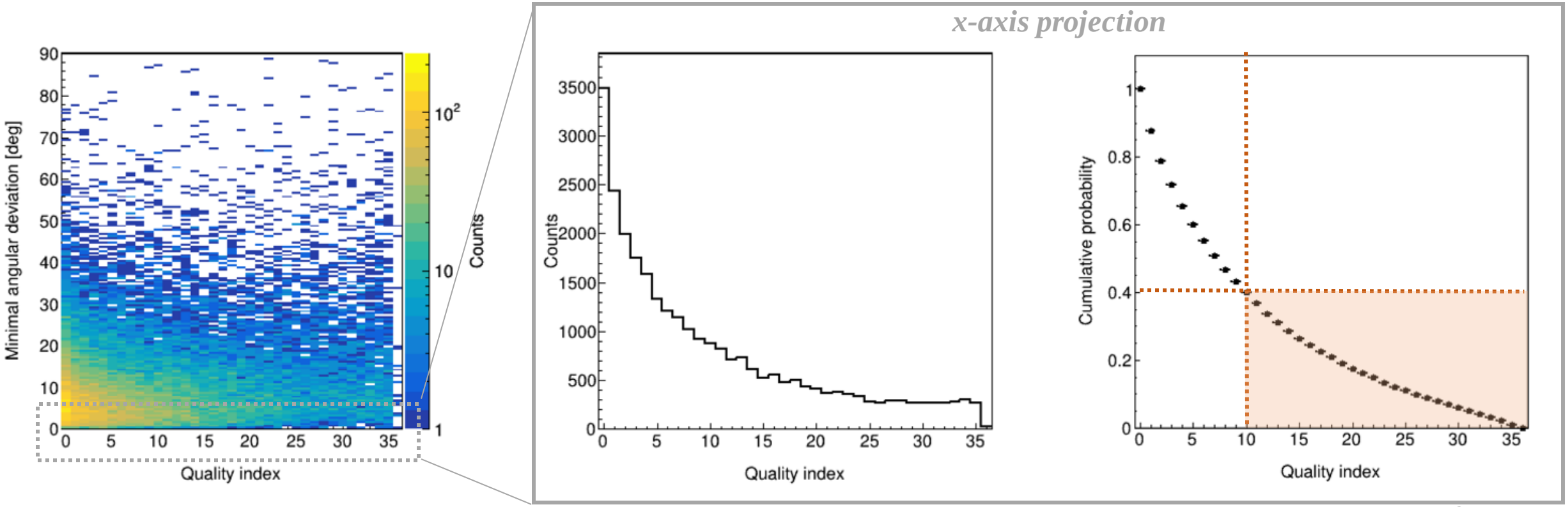
Categorizing misreconstructed fits for low-energy tracks

Recap

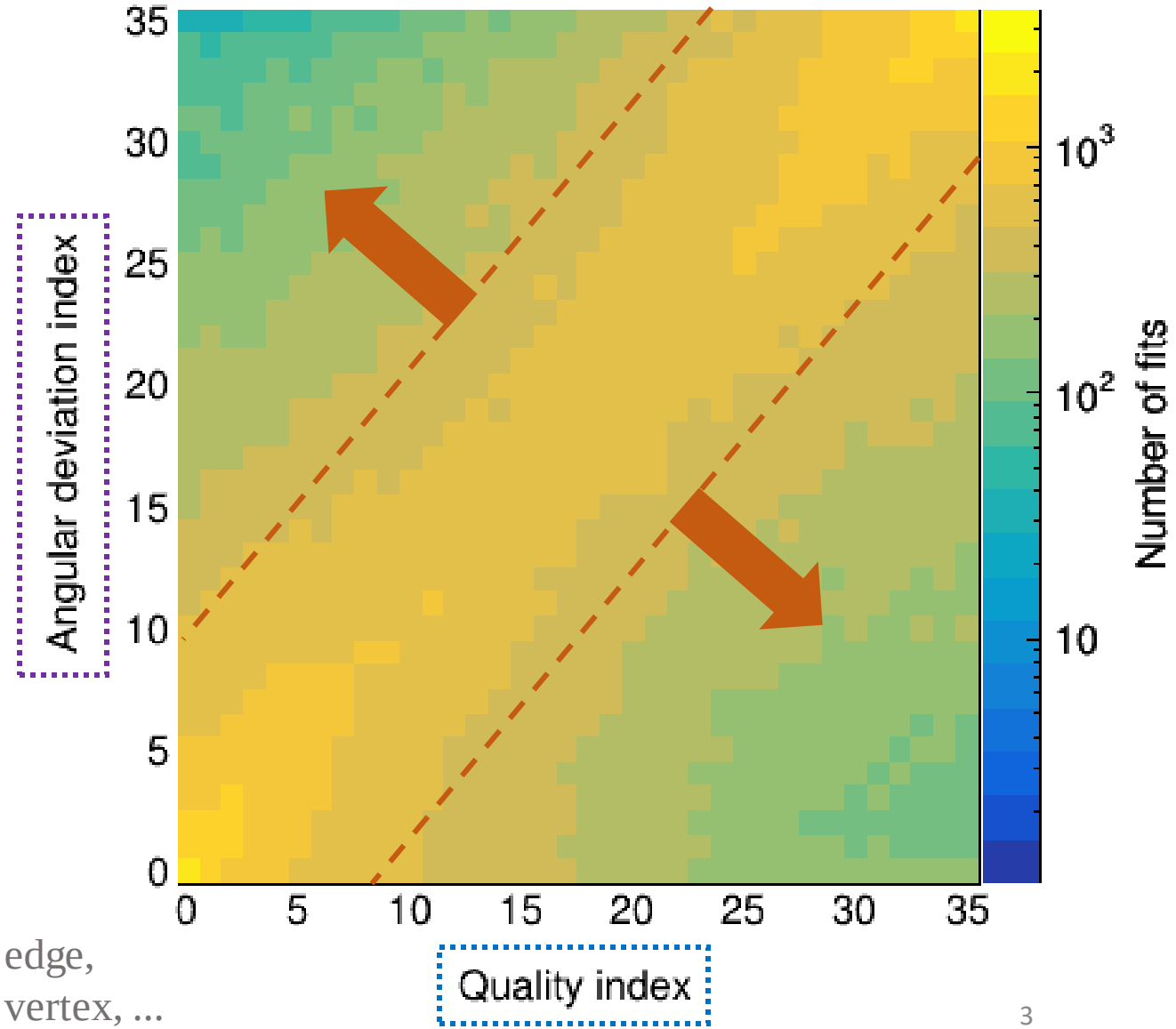
- Investigating the merit of exploiting Poissonian (no-)hit information in direction reconstruction
  - Low-energy (1-10 GeV) muon-neutrino MC-files; O(1e4) events
- Showed that there is a large tail of fits close to MC-truth, but with bad quality



Angular deviation versus quality

- Directional fit hypotheses can be ordered according to:
  - **Decreasing quality**
  - **Increasing angular deviation w.r.t. MC-truth**
- Large population of fits expected at:
  - High quality and small angular deviation
  - Low quality and high angular deviation
- But also see significant populations of fits in **other regions**
  - What fit directions have high angular deviation but yield good quality?
  - What fit directions have small angular deviation but yield bad quality ?

Low energy/short track, vertex close to detector edge, badly reconstructed energy, badly reconstructed vertex, ...



Categorization

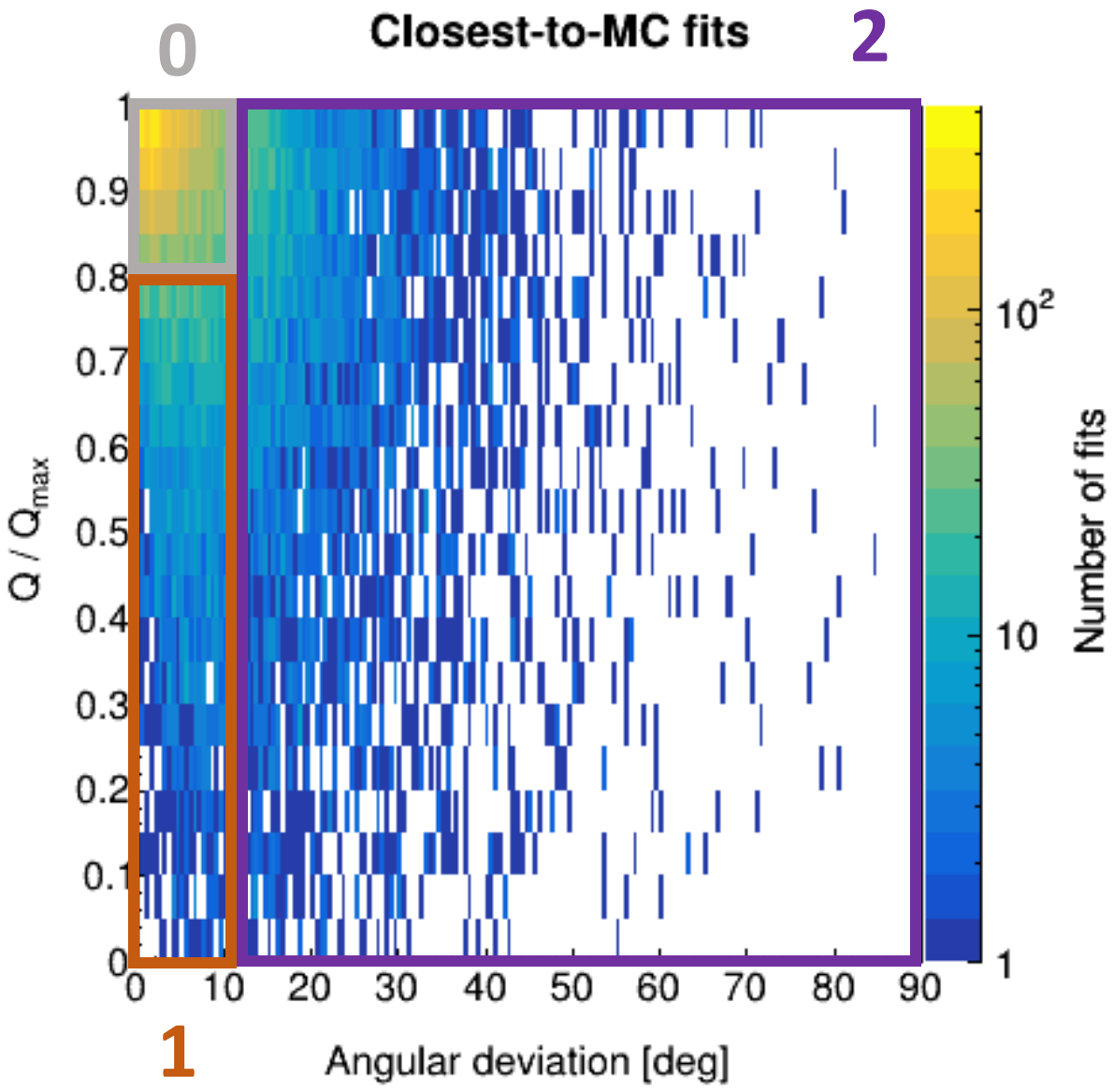
- For each recontructed event, select fits whose directions lie closest to the MC-truth (i.e. best fits)

- Show how much the quality of these fits compares to the fit with maximal quality (y-axis), as function of the angular deviation (x-axis)

  - Some best fits have **bad relative quality**, despite being **well-reconstructed directionally**

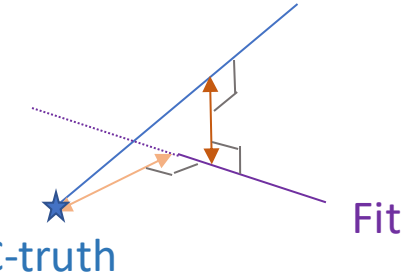
  - There are also events where **best fit lies far from MC-truth**

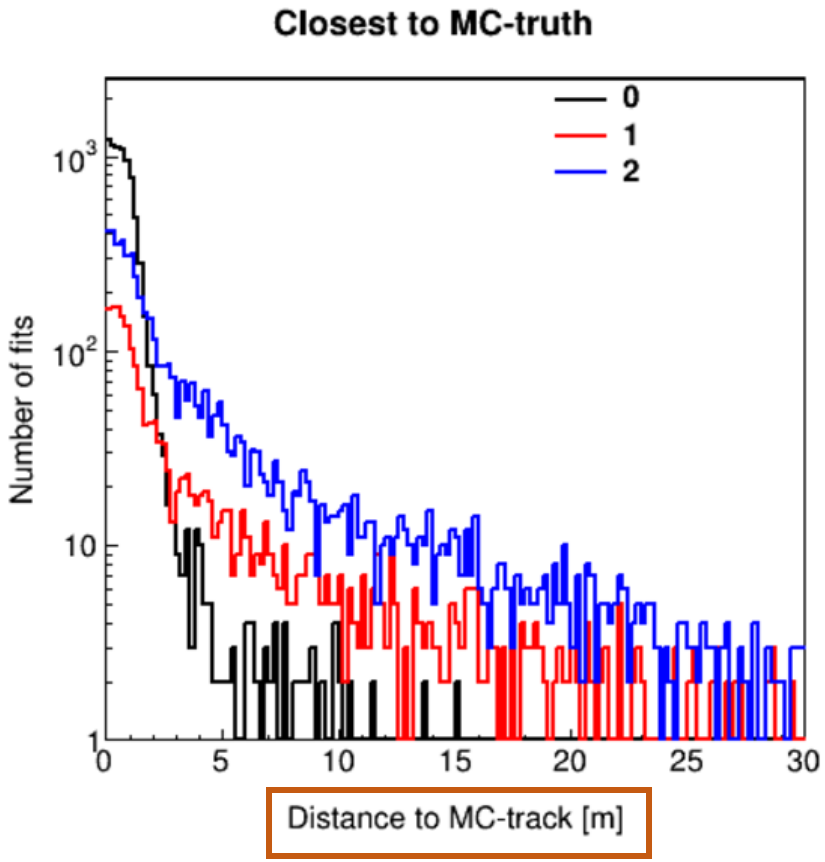
  - Large population with **excellent quality and well-reconstructed direction**

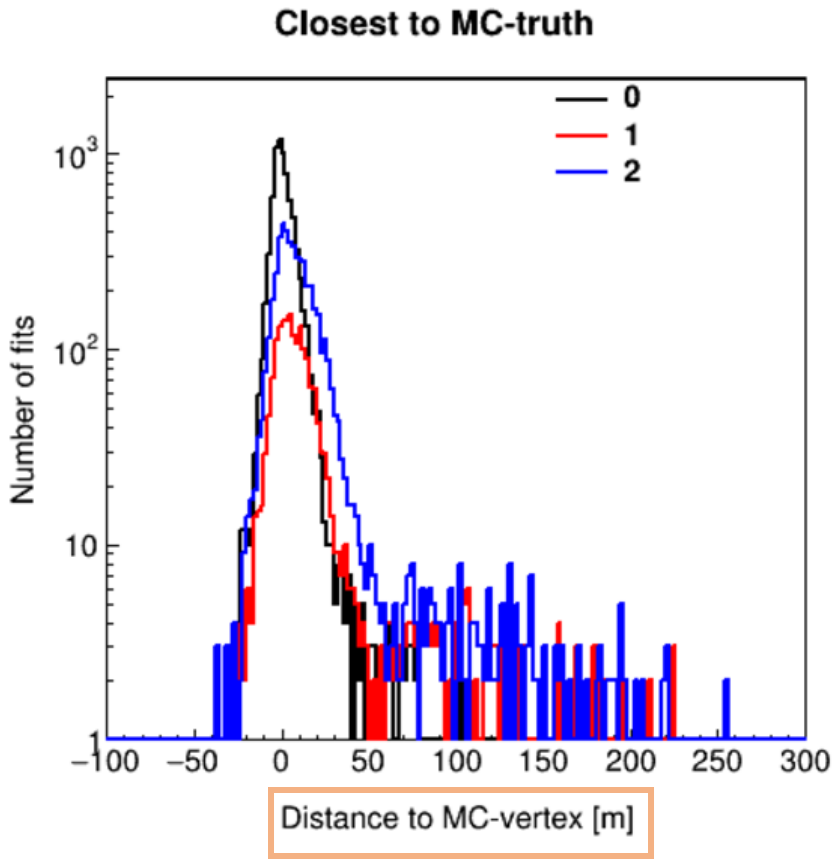


Event geometry

- Categories 1 and 2 (misreconstructed) tend to be more populated by fits with:
  - Greater minimal distance to MC-track
  - Greater minimal distance to MC-vertex



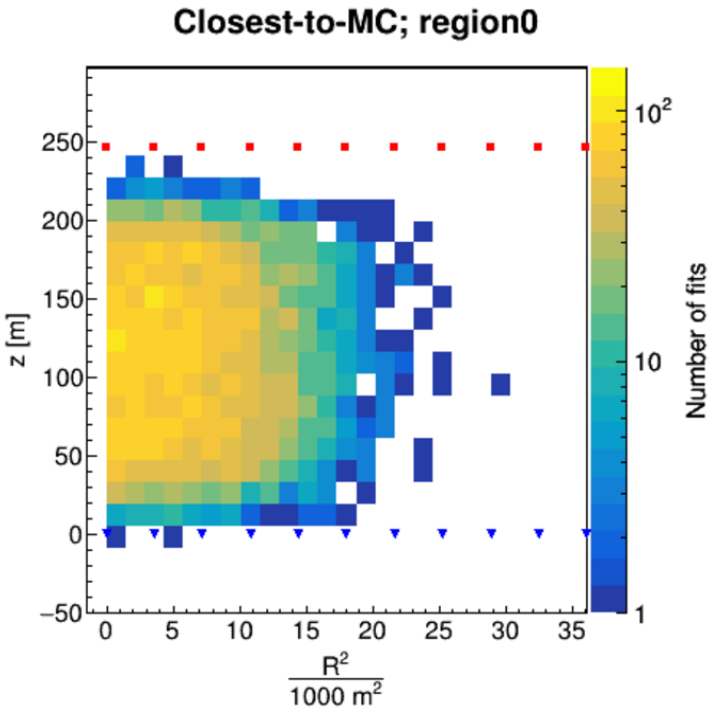


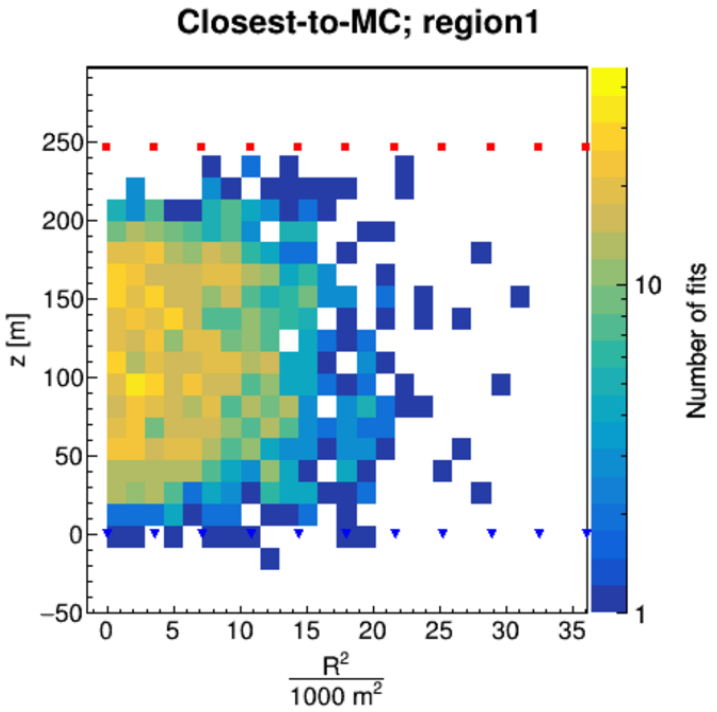


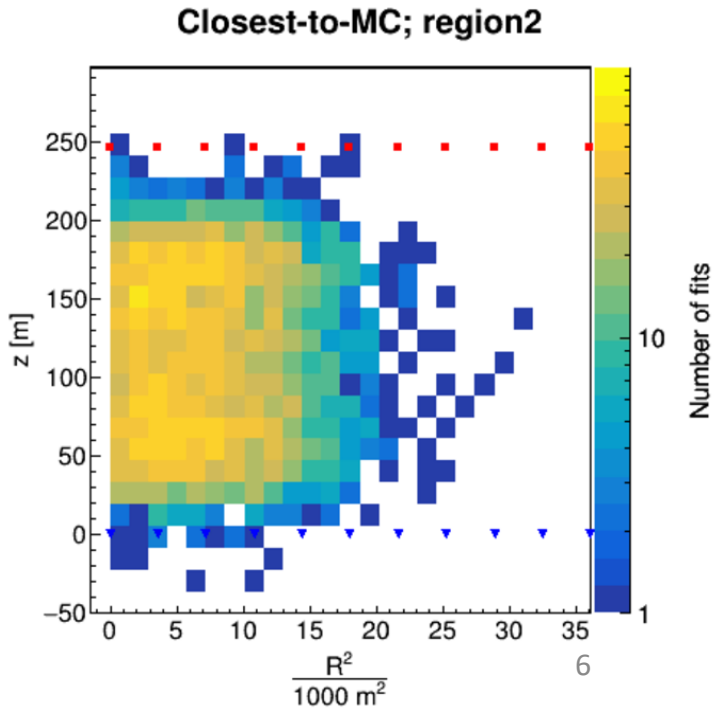
Event geometry

- Event vertices may lie at or beyond the detector boundary, more than average in the 2 problematic regions
  - But no significant increase apparent in plots below

ORCA full detector ~120 m radius,
Corresponds to ~15 in the plots below

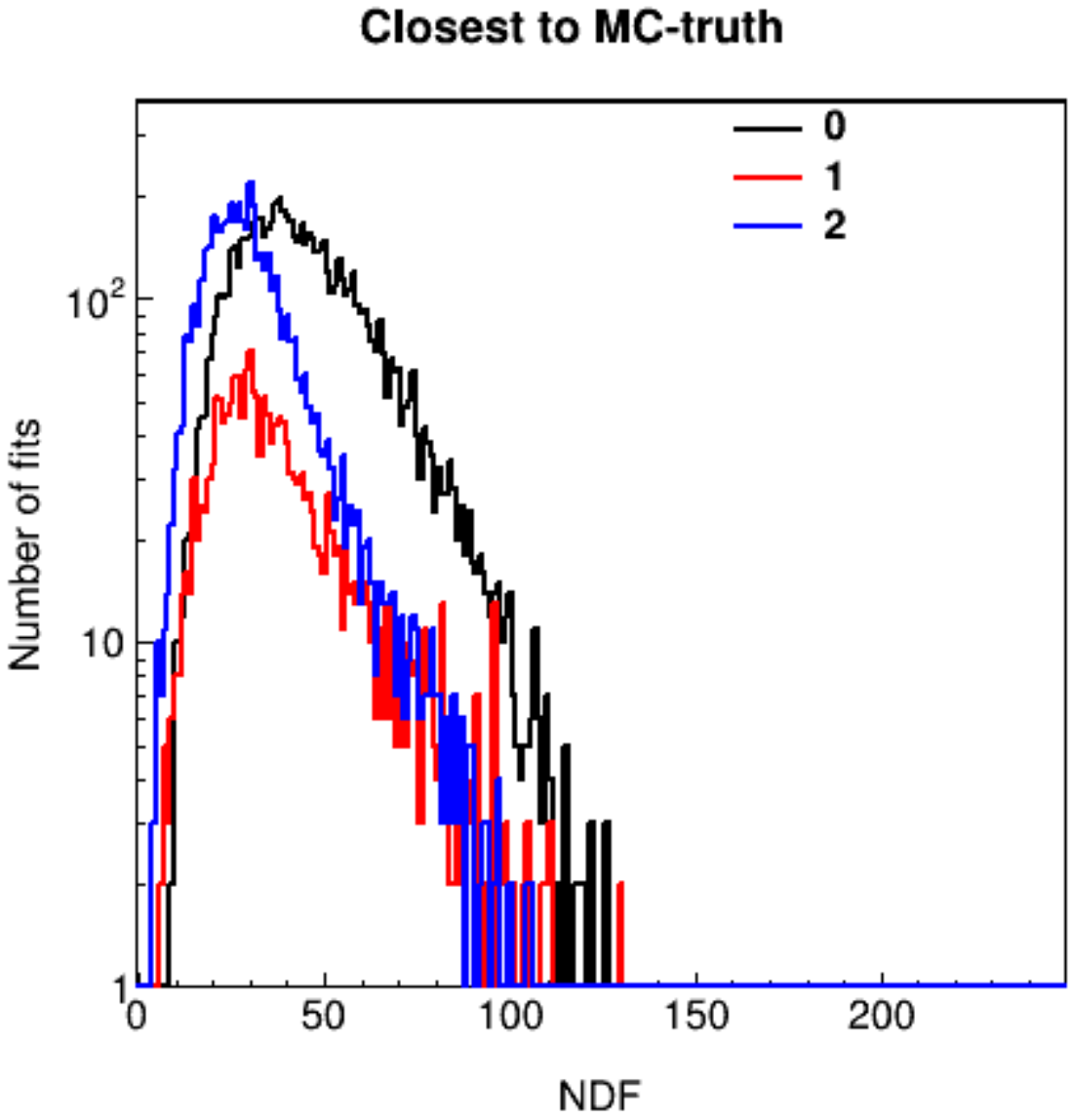






Hit statistics

- Misreconstruction may also be related to low hit statistics
  - I.e. low 'NDF' = # hits - # fit parameters
  - Indeed lower hit statistics for both regions of misreconstruction
- Should also be visible in event energies
  - Low energy <--> low hit statistics



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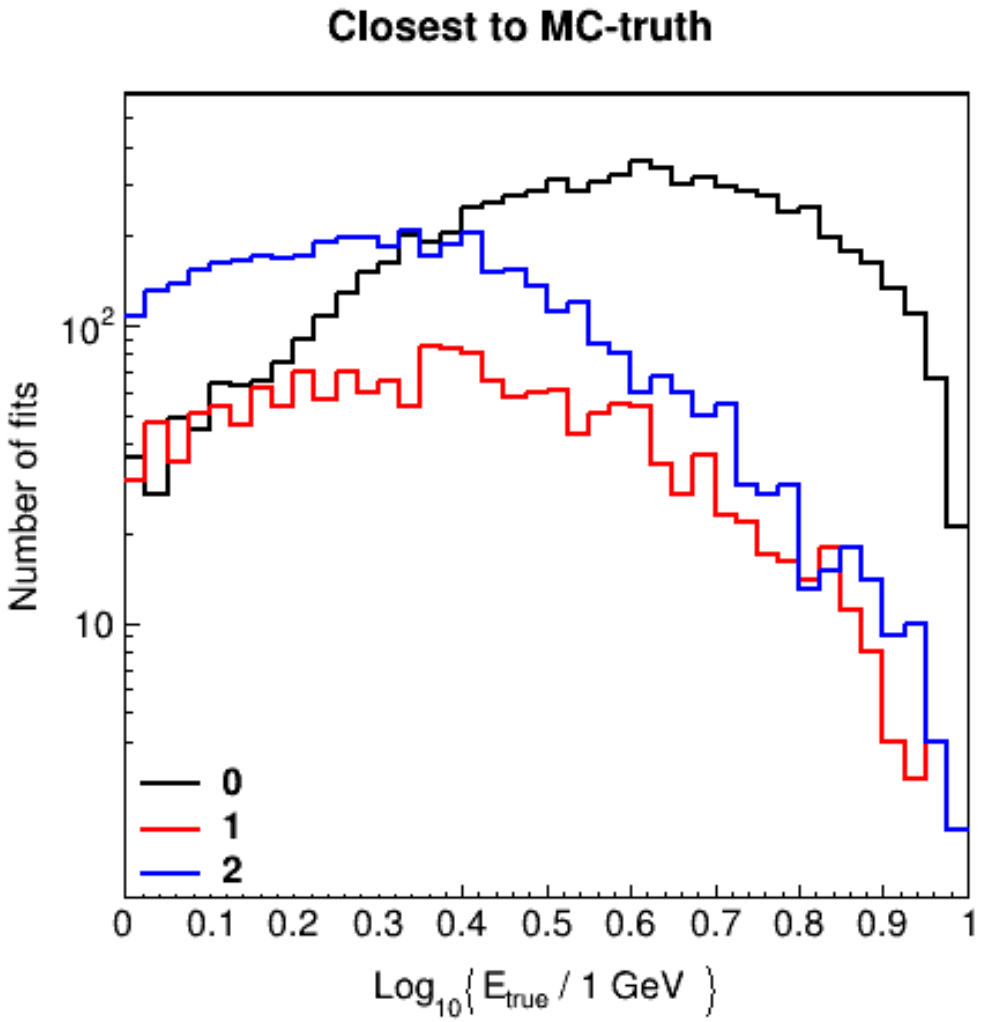


Conclusions

- Best quality != best reconstructed direction

- Based on fractional quality and angular deviation w.r.t. MC-truth,
  3 categories have been made:

  i. Small angular deviation (**good**) with small fractional quality (**bad**)
  ii. High angular deviation (**bad**) with high fractional quality (**good**)
  } **Misreconstructed**

  iii. Small angular deviation (**good**) with high fractional quality (**good**) **Okay**

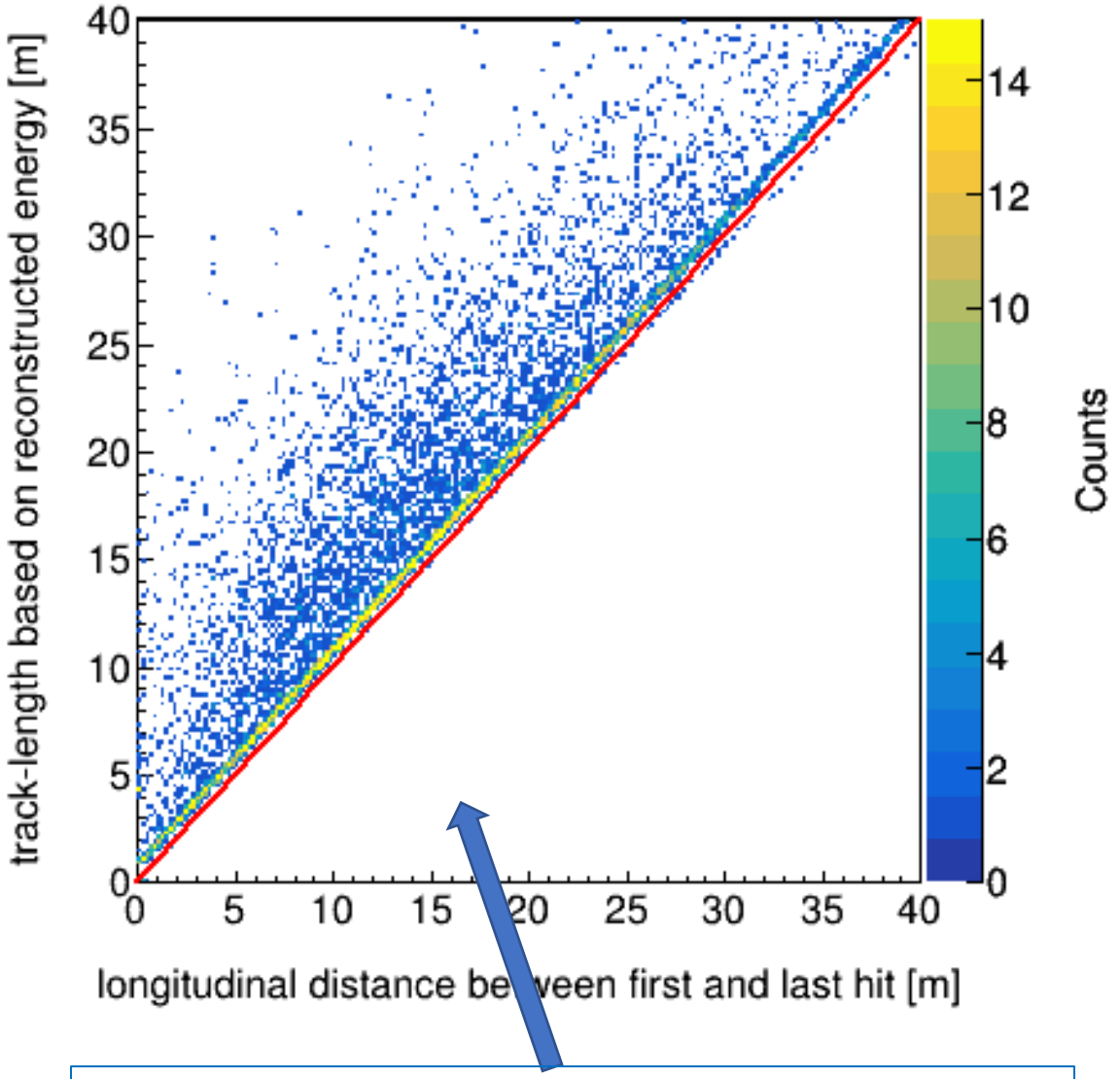
- Underlying reasons for misreconstruction in i. and ii. have been scrutinized:

  - Low(er) hit statistics seems to be a prime cause
  - This invites us to think about incorporating hit information
    as a cross-check for the arrival-time based likelihoods

EXTRA

Track length cross-check

- JStart and JEnergy provide mutual cross-check
- JStart:
  - Projects PMT hits back on track hypothesis under Cherenkov angle
  - Longitudinal distance between first projected hit (H_i) and last projected hit (H_f) approximates track length
- JEnergy:
  - Muon energy MLE based on number of hits and no-hits in cylindrical subdetector starting at H_i
  - Reconstructed energy can be converted into track length, based on muon energy loss



No upper limit on subdetector length,
--> JEnergy's track length estimate greater than JStart's