

ICECUBE

Direct reconstruction for IceCube: DirectFit (ppc) and DirectReco (clsim)

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Photon propagator workshop
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Direct reconstruction as a concept

- Photon tables have inherent limitations and challenges
- Instead, use a photon propagator to generate charge expectations for event hypotheses

Benefits: use latest ice models, no interpolation artifacts, precision

Costs: computationally slow, subject to MC statistical fluctuations

DirectFit

Capable of reconstructing data with direct photon simulation with ppc

Fit routine proceeds through several iterations of a localized random search where many position and direction are tested and the best fit energies at those steps are calculated.

Following fit, approximate Bayesian computation (ABC) method applied based on fit results to estimate posterior. Delta-llh cut and proposal function derived from localized-random search steps. No prior.

Ref. arXiv:1309.7010

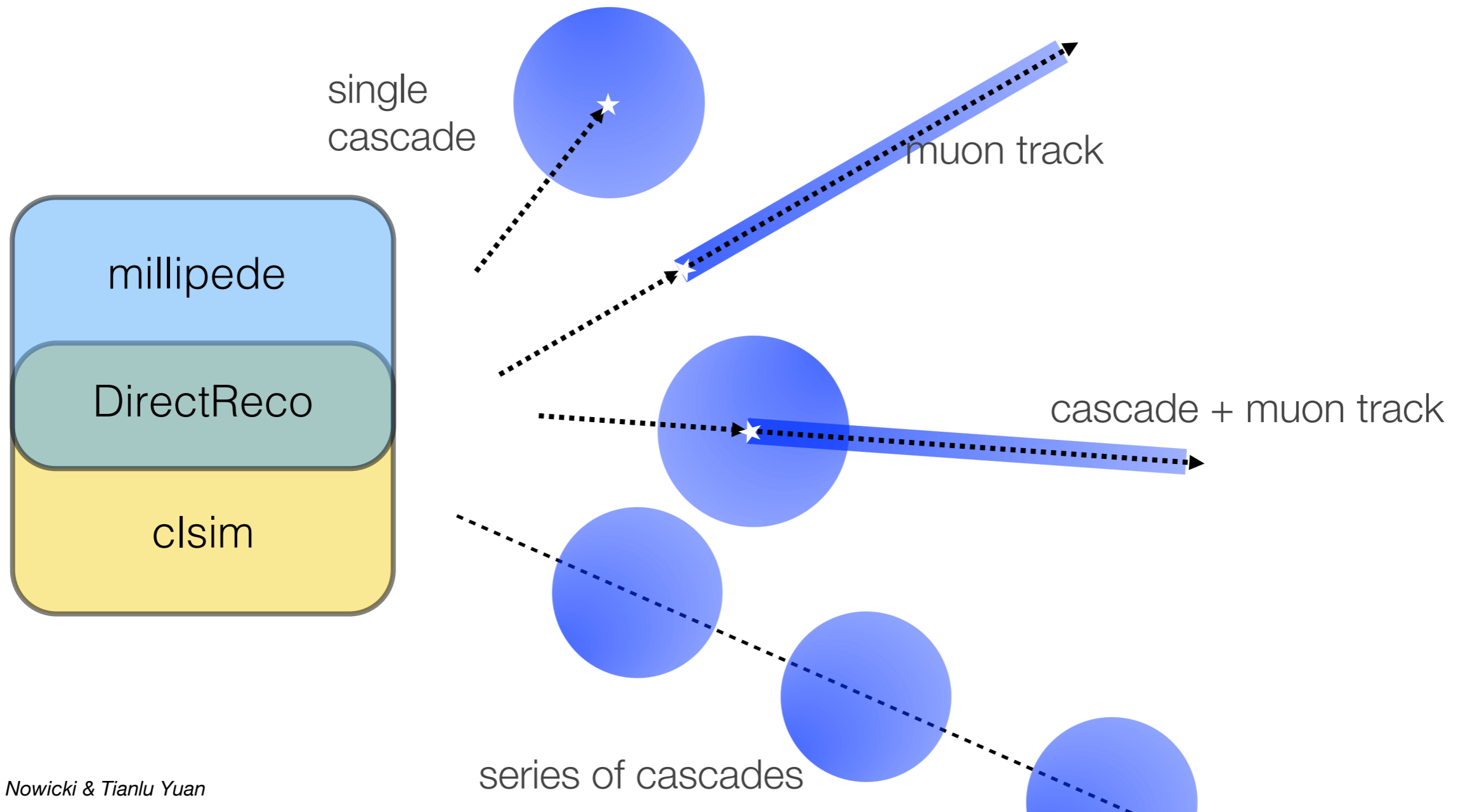
Documentation:

<https://docs.icecube.aq/icetray/main/projects/ppc/index.html>

https://docs.icecube.aq/icetray/main/projects/ppc/llh_manual_2013.html

DirectReco

- Uses existing **millipede** reco framework but with charge expectations provided by **clsim** photon propagation for arbitrary choice of ice model (no photon tables)
- Retains flexibility in choice of hypothesis, parameters, minimization, ...

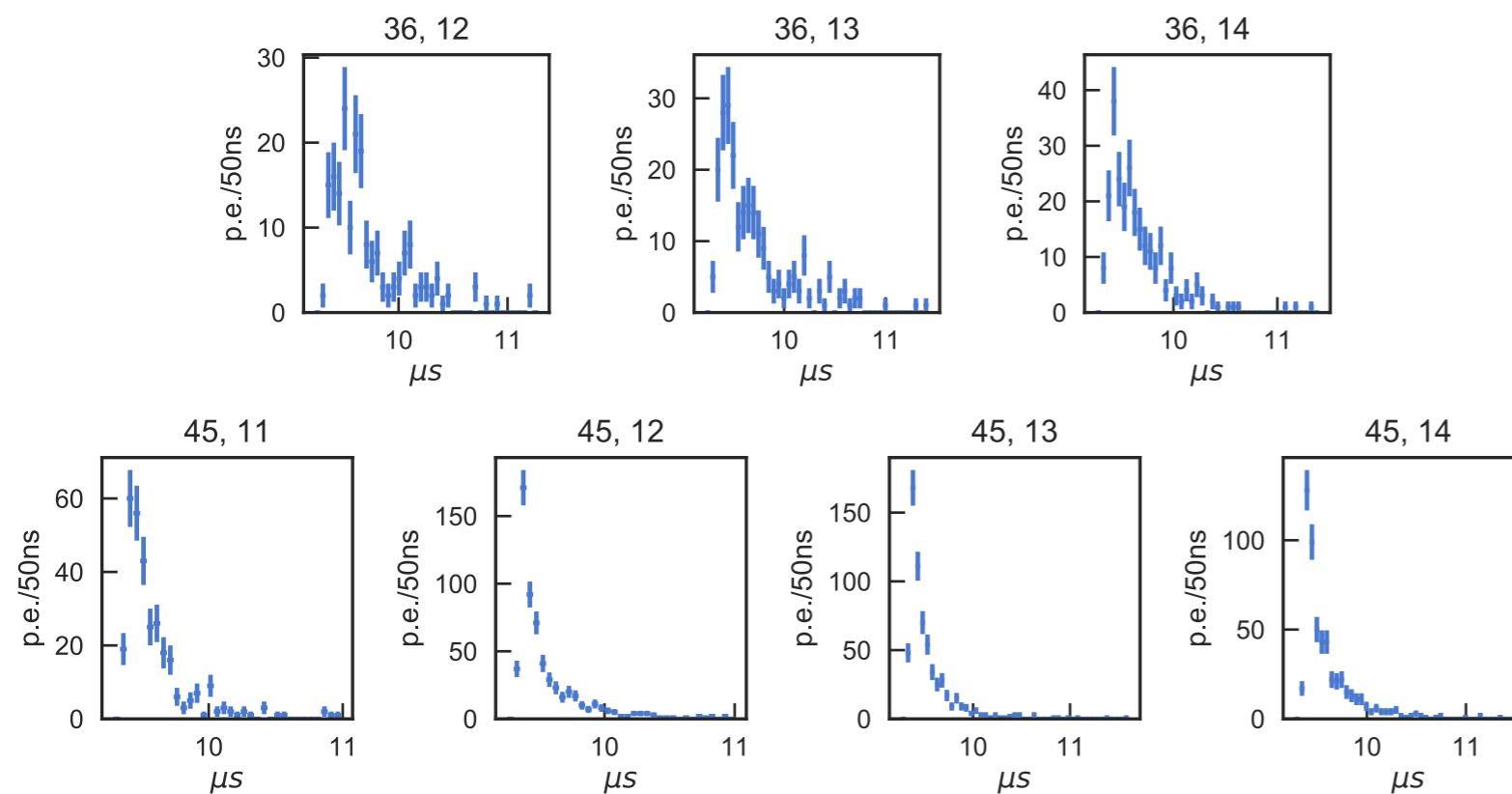


Comparing the methods

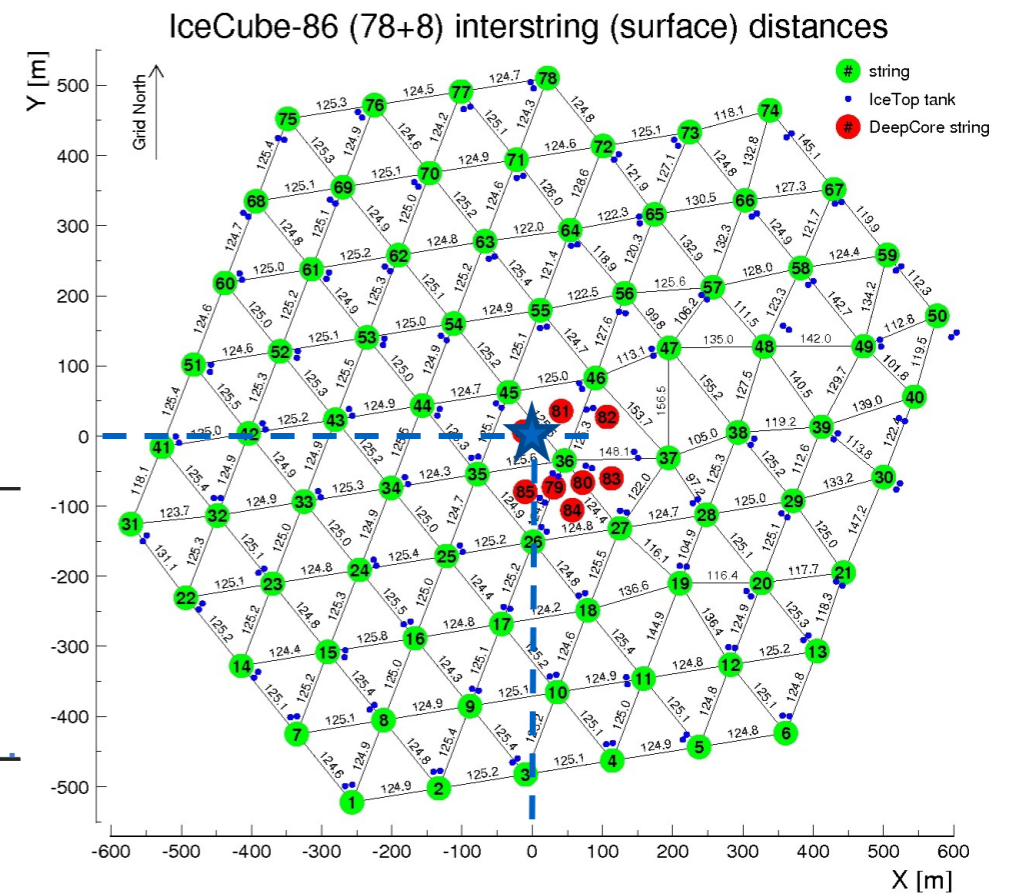
	DirectFit	DirectReco
photon propagator	ppc	clsim
modules	ppc, llh	clsim, millipede, photonics_service
integrated into IceCube software	no, run standalone	yes (lives in a branch of combo)
minimizer	Localized random-search + ABC	choose from those integrated with millipede
likelihood	dima	dima
event hypothesis	cascade or track	those existing or can be implemented in millipede

DirectFit example: step 1 simulation

I. $E=100$ TeV, ice=spice-3.2, $r=(0, 0, 300)$, $\theta=(90z, 0a)$

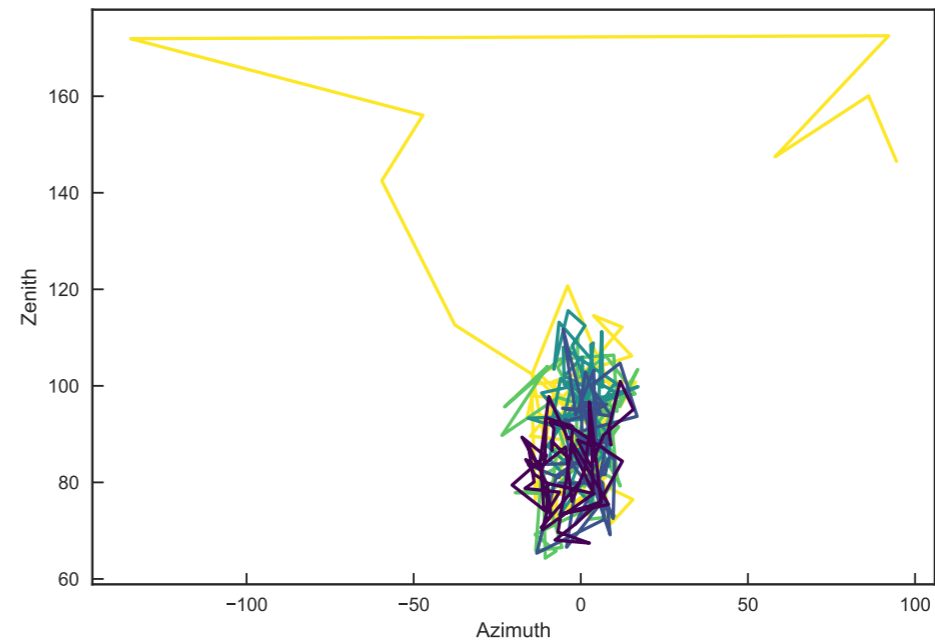
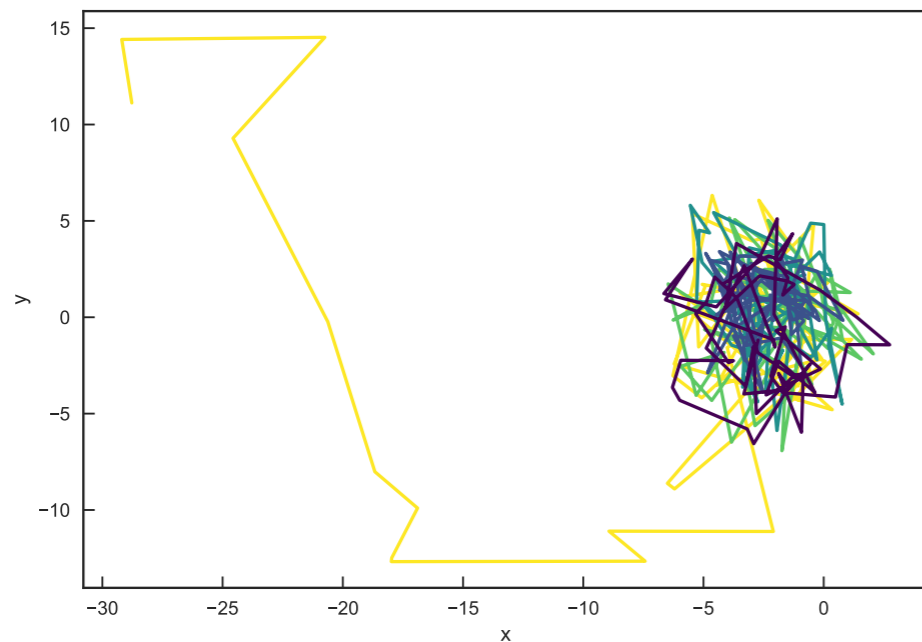


Hits from ppc



DirectFit example: step 2 reconstruction

1. $E=100$ TeV, $\text{ice}=\text{spice-3.2}$, $r=(0, 0, 300)$, $\theta=(90z, 0a)$
2. Localized random search to find minimum

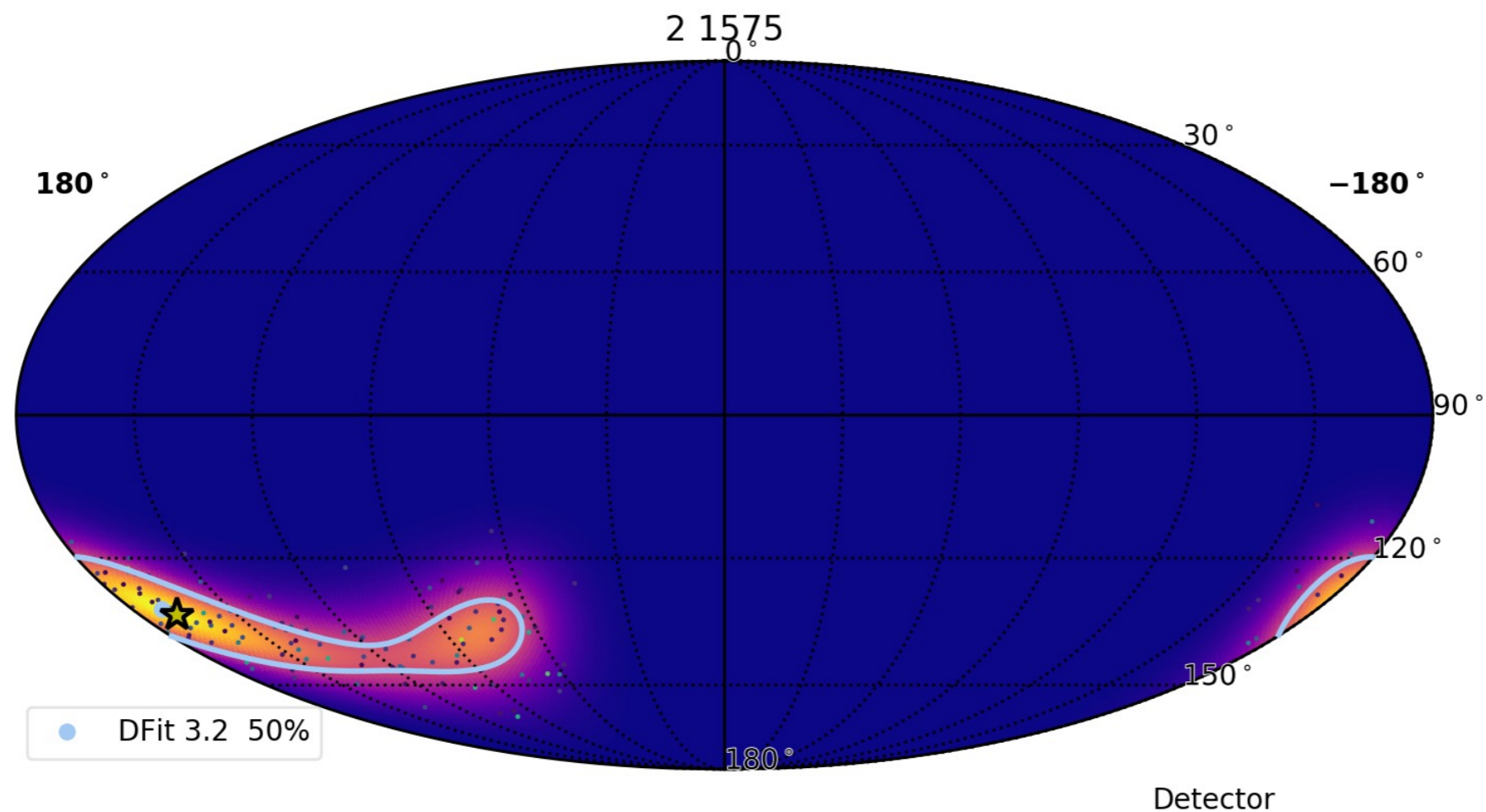


start

Spread and mean of last
5% of steps used to
initialize step 3

DirectFit example: step 3 error calculation

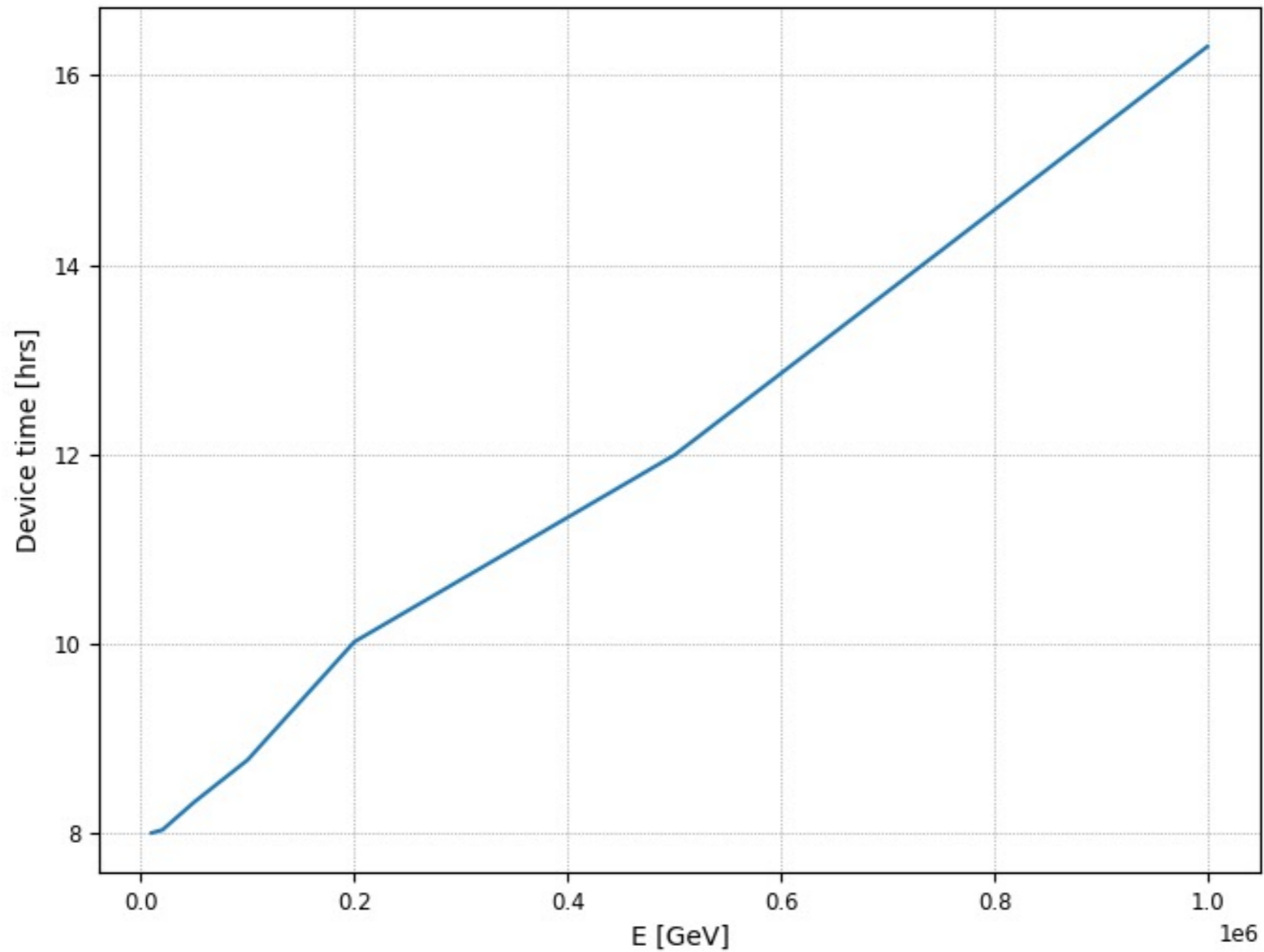
1. $E=100$ TeV, $\text{ice}=\text{spice}-3.2$, $r=(0, 0, 300)$, $\theta=(90z, 0a)$
2. Localized random search to find minimum
3. Generate probabilities across the parameter space



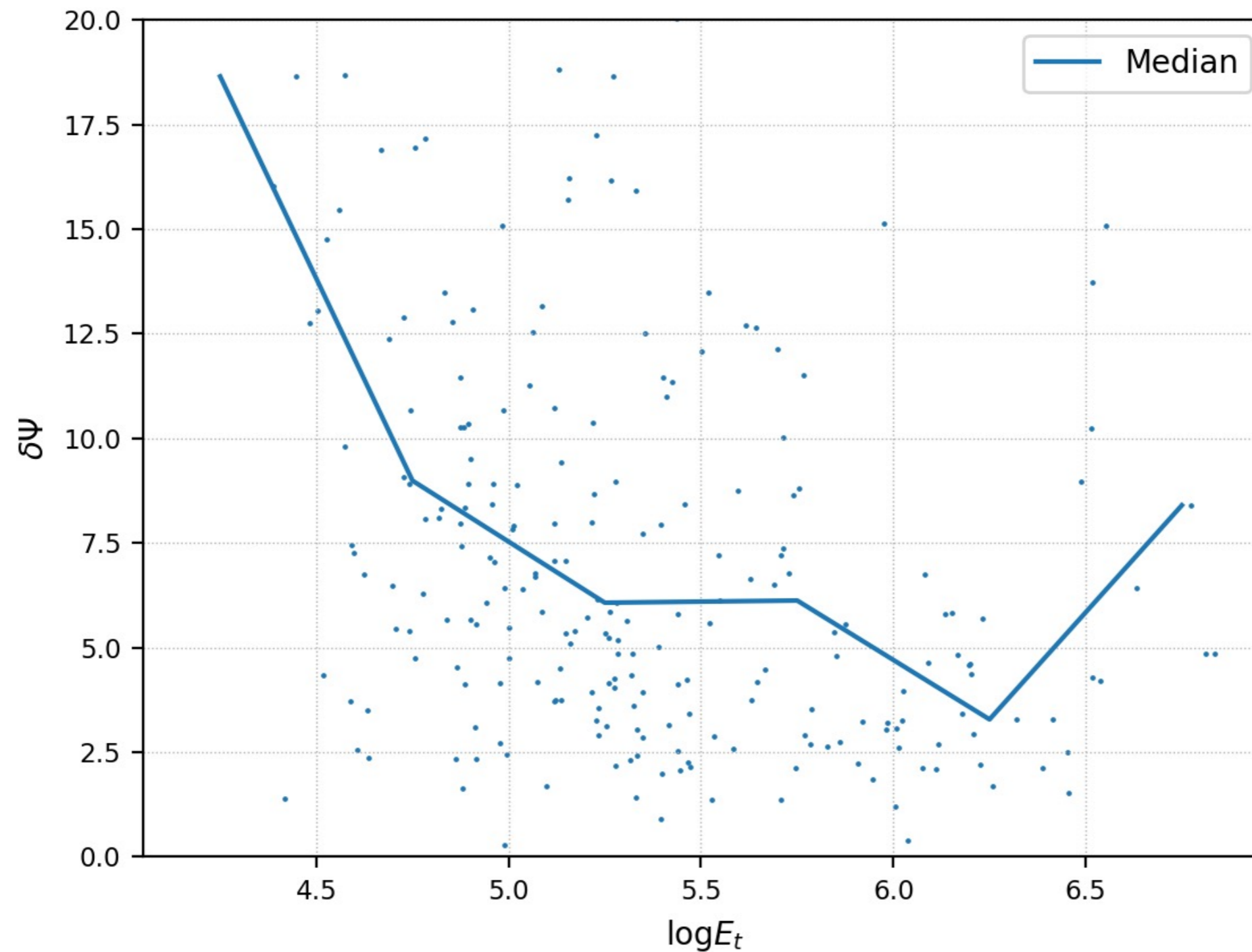
ABC outputs set of points
Fitted to FB8 distribution

Runtime scales with energy

Device time for localized search and ABC roughly equal



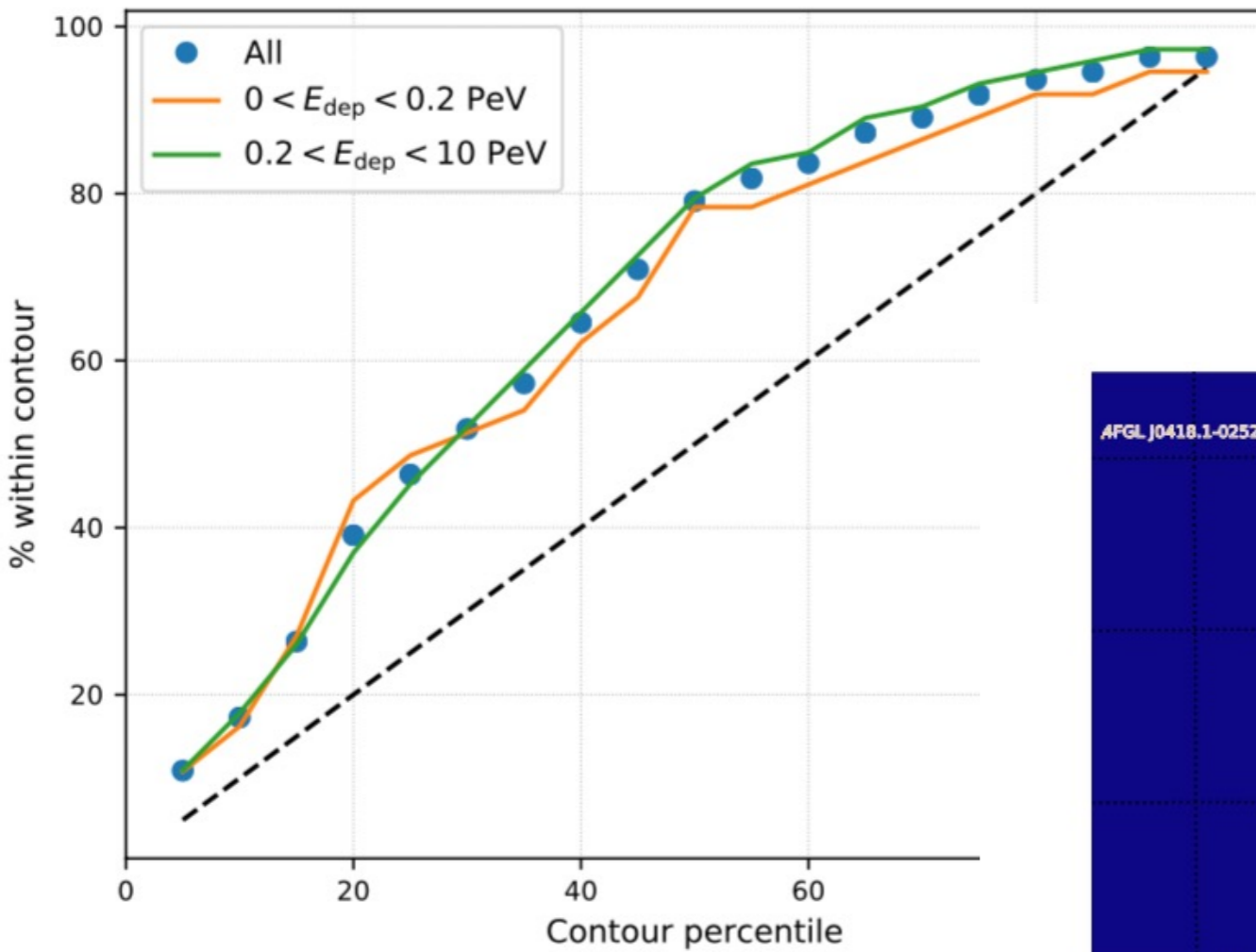
Degrees between true direction and best-fit from FB8



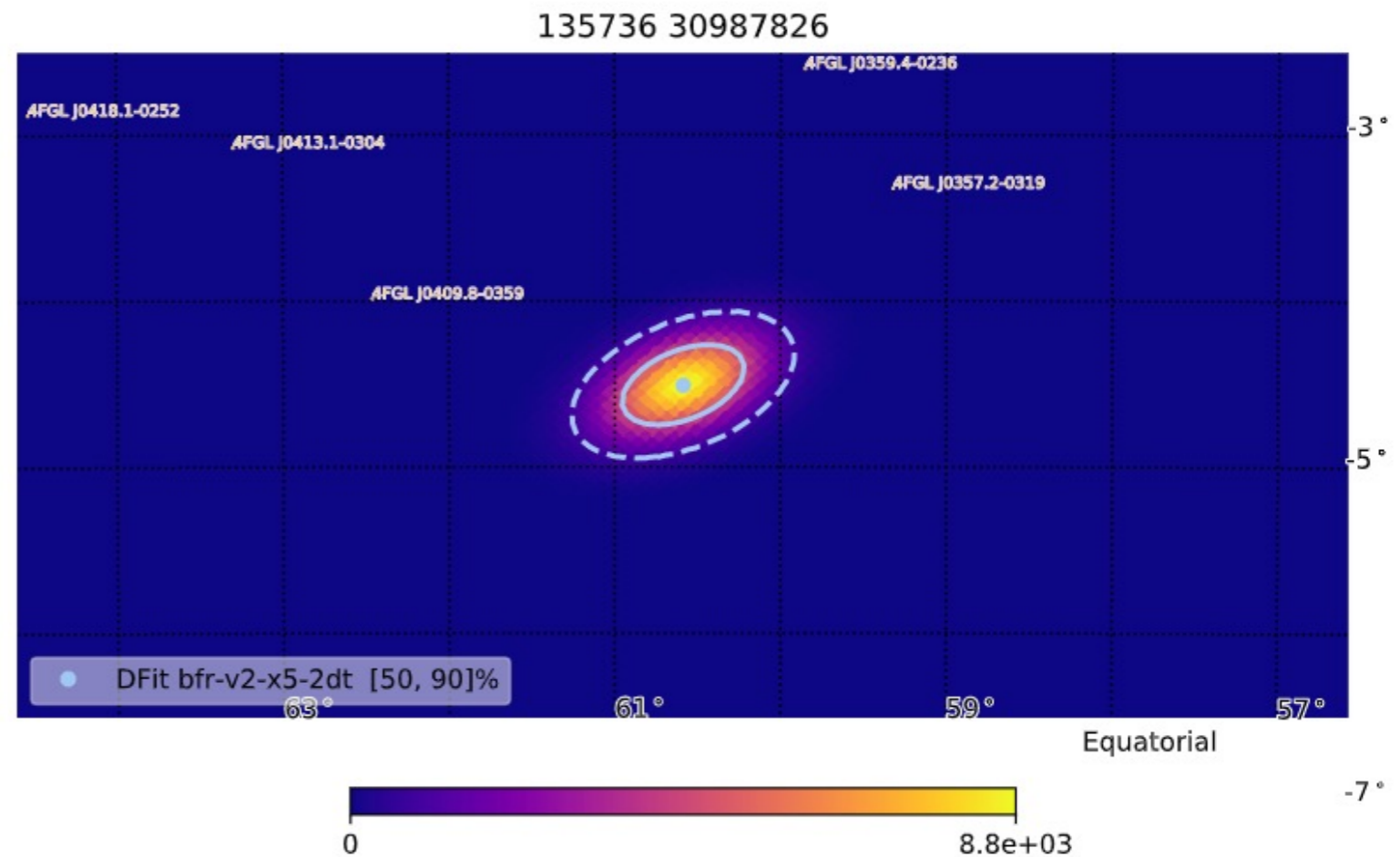
Track reco

Millipede-like multiple-cascade hypothesis ($\sim 7m$ separation)

Set with env var `MLPD=1`



Output from
Realtime bot



Some good-to-know items for DirectFit

Env vars

- MLPD: 0=cascade, 1=track
- SREP: Sets the simulation statistics [units relative to data]
- QSAT: Sets the charge threshold for bright DOMs, which are excluded from llh
- LSIG: Sets model error term to allow for systematic error in llh

A few more examples

