WCSim → fitqun
Event Reconstruction and Interface to WCSim Update

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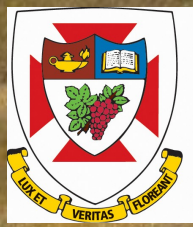


THE UNIVERSITY OF WINNIPEG

for team fitqun

Hyper-Kamiokande Open Workshop #4
Jan. 28, 2014

fiTQun Review

- Reminder: fiTQun is a maximum likelihood fitter
  - Likelihood function defined with PMT charge and time:

$$L(\mathbf{x}) = \prod_{i}^{\text{unhit}} P(i\text{unhit}|\mathbf{x}) \prod_{i}^{\text{hit}} P(i\text{hit}|\mathbf{x}) f_q(q_i|\mathbf{x}) f_t(t_i|\mathbf{x})$$

Unhit probability Hit probability Charge likelihood Time likelihood

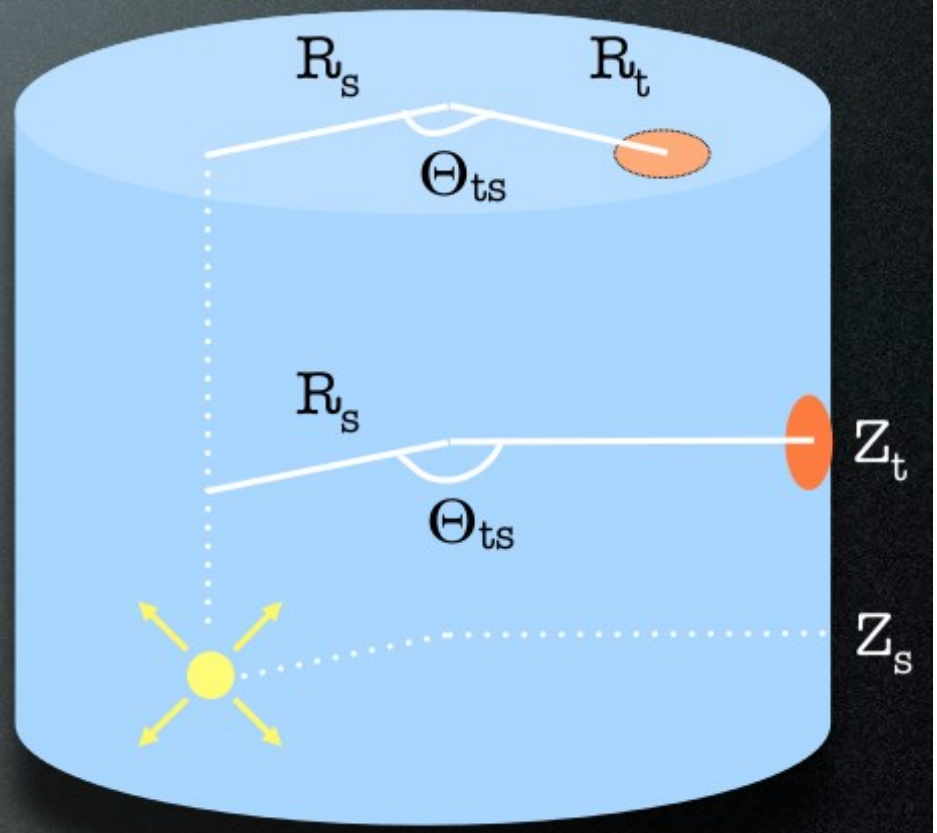
  - Track parameters ($\mathbf{x}$) varied simultaneously to maximize the likelihood

- Please refer to previous workshops for more details on the algorithm and progress:

1. http://indico.ipmu.jp/indico/getFile.py/access?contribId=35&sessionId=9&resId=0&materialId=slides&confId=7
2. http://indico.ipmu.jp/indico/getFile.py/access?contribId=20&sessionId=10&resId=0&materialId=slides&confId=10
3. http://indico.ipmu.jp/indico/materialDisplay.py?contribId=16&sessionId=9&materialId=slides&confId=23

fiTQun Scattering Tables

- Take advantage of **cylindrical geometry**
- A_{scat} will depend on
  - Source direction (θ_s, ϕ_s)
  - Source position (Θ_{ts}, R_s, Z_s)
  - Z_t for PMTs on the sides
    - $A_{side}(\theta_s, \phi_s, \Theta_{ts}, R_s, Z_s, Z_t)$
  - R_t for PMTs on the ends
    - $A_{end}(\theta_s, \phi_s, \Theta_{ts}, R_s, Z_s, R_t)$
- Must tabulate 6-dimensional scattering tables using the detector MC



Status of Interface

- Head v. of fitqun is now working with WCSim input
  - Compiles with no dependence on SK libraries or CERNLIB
  - Geometry read from WCSim file
  - Fills hit and time structures accounting for WCSim sub-event times
  - Requires libWCSimRoot.so to read WCSim events
  - Some truth information now passed along (Ryan Terri)

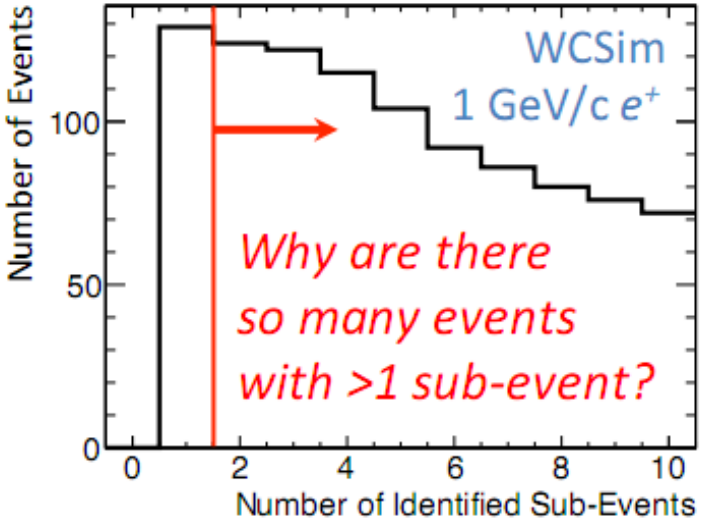
- Tests with latest version of WCSim, using both SK and HK presented here

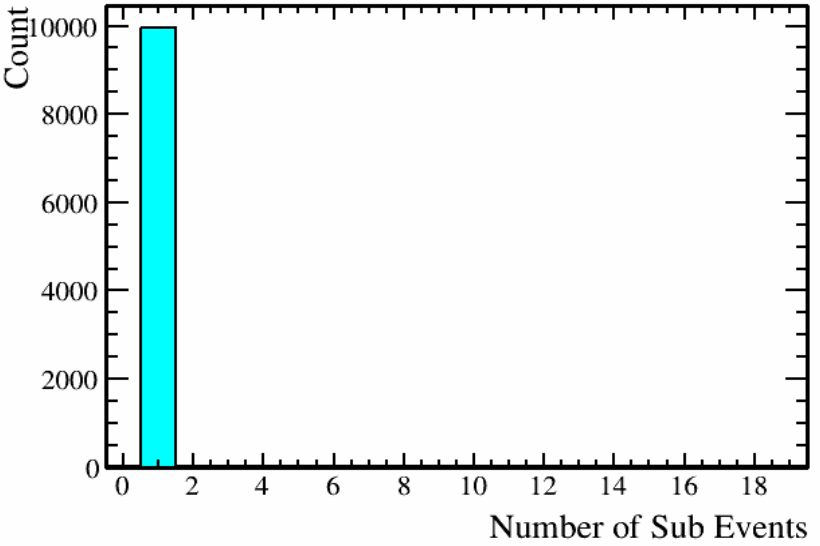
Where to get the code

- Instructions on how to get the code, and how to compile it is available on the hk wiki page:
  - https://wiki.hyperk.org/Software/Release
- Code used for these tests will be put into the git repository described there in the coming week
- Most development work on fiTQun is being done for Super-Kamiokande, whose source code is stored in T2K protected cvs
  - Every so often the code will be copied over to the Hyper-K git repositories
  - Any new developments in git repository will have some code shear that will need to merge updates from T2K

Sub Event Problem in previous version of interface fixed

- Found that fiTQun arrays were not being properly cleared between events (top)
  - Caused by fact that clearing was done in no longer included library
- Now fixed by explicitly zeroing arrays between events (bottom)



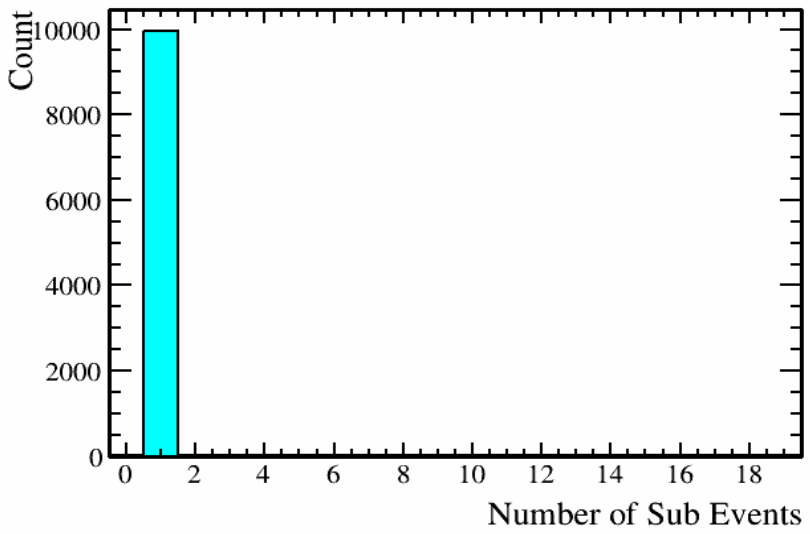


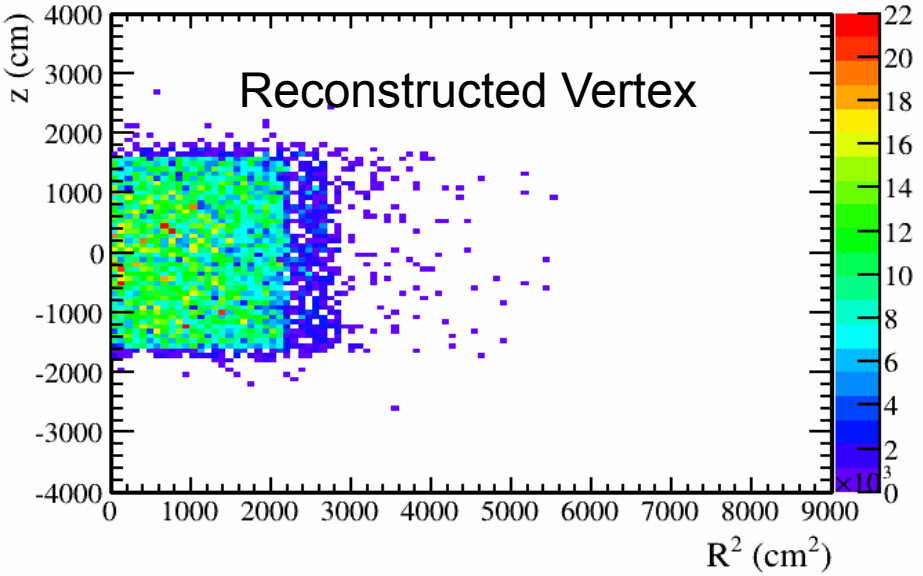
WCSim samples generated

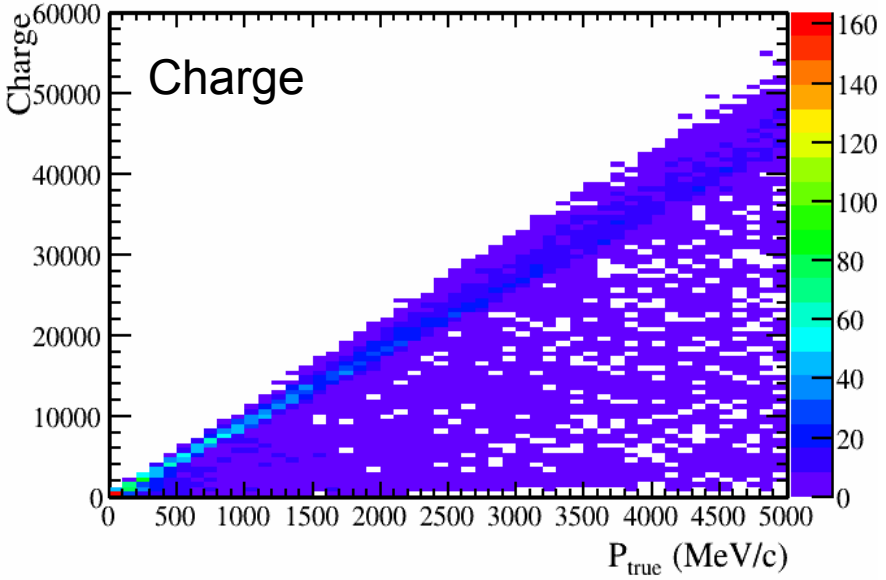
- Using rev. 1762 of WCSim
- Using SK geometry, or HK geometry
- Starting vertices random positions more than 2m from wall
- Random starting direction
- Four different samples (10k events each):
  - SK geometry
    - e- uniform (0 - 5000 MeV)
    - mu- uniform (0 – 5000 MeV)
  - HK geometry
    - e- uniform (0 – 1000 MeV)
    - mu- uniform (0 – 1000 MeV)
- Distributions visually checked with histograms

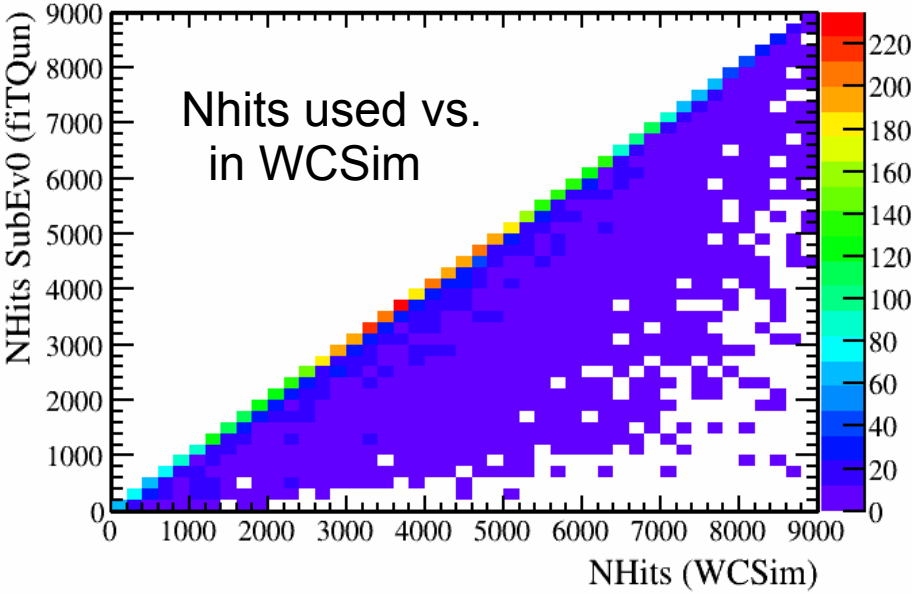
A few sample distributions

SK 0 to 5GeV electrons

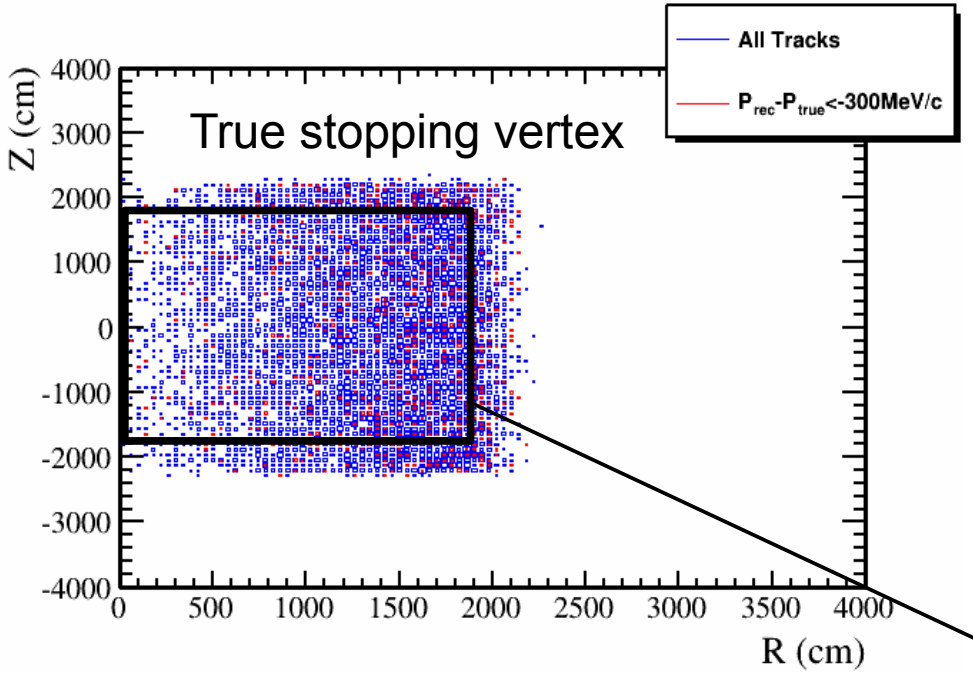


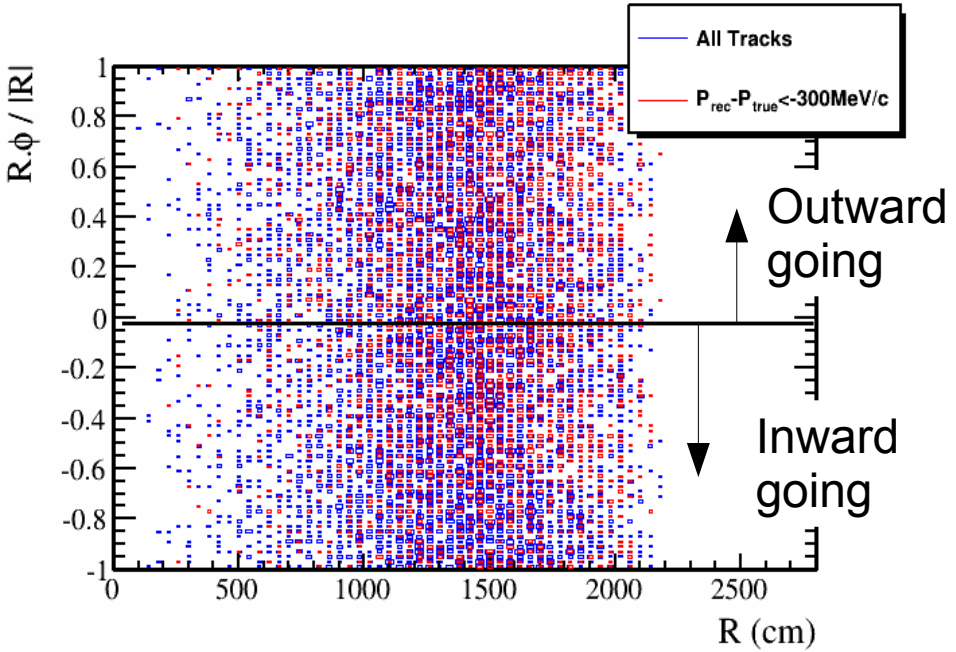


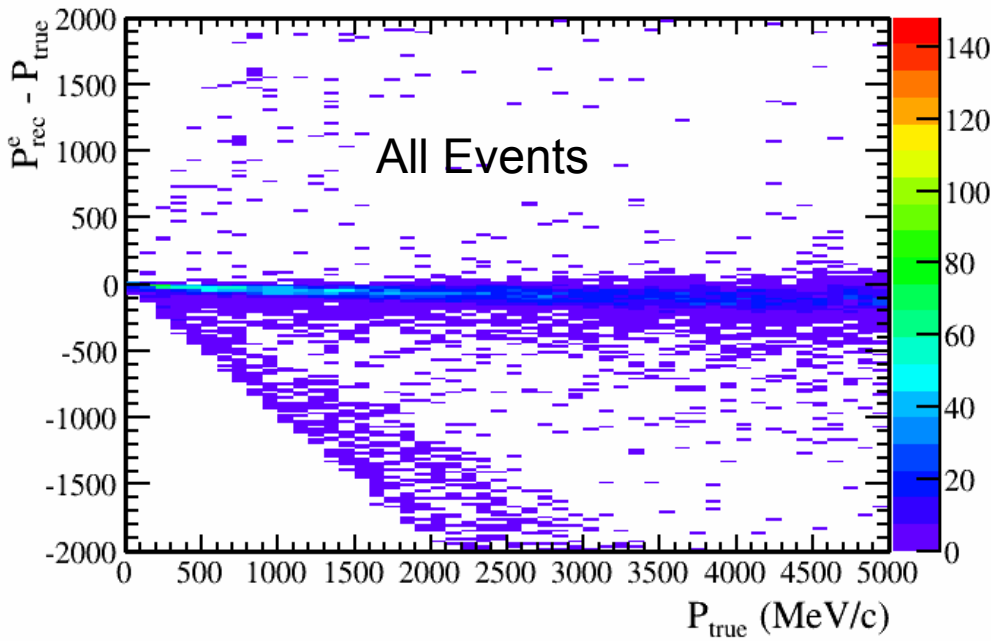


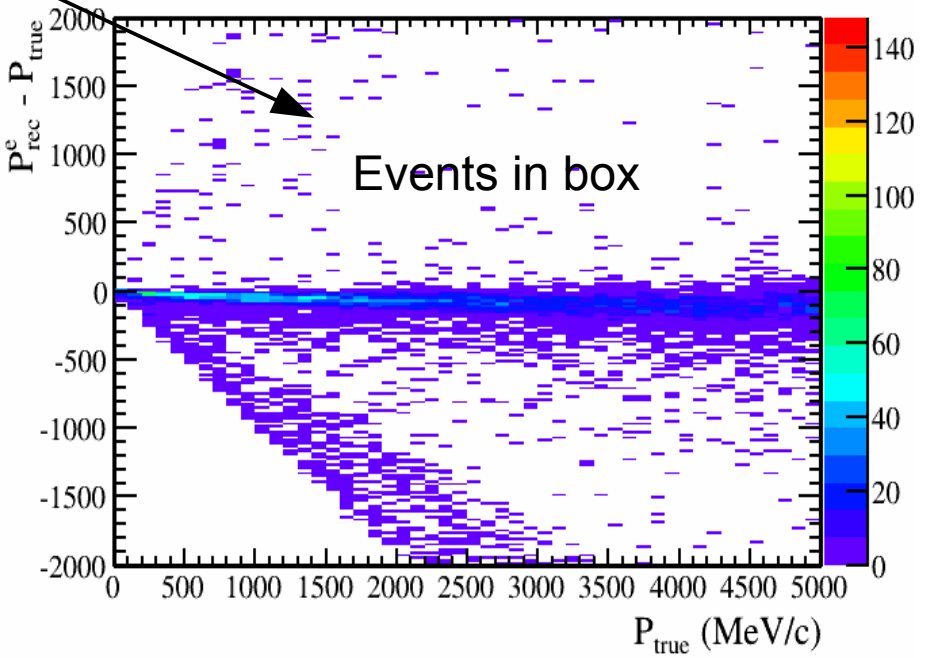


SK 0 to 5GeV electrons

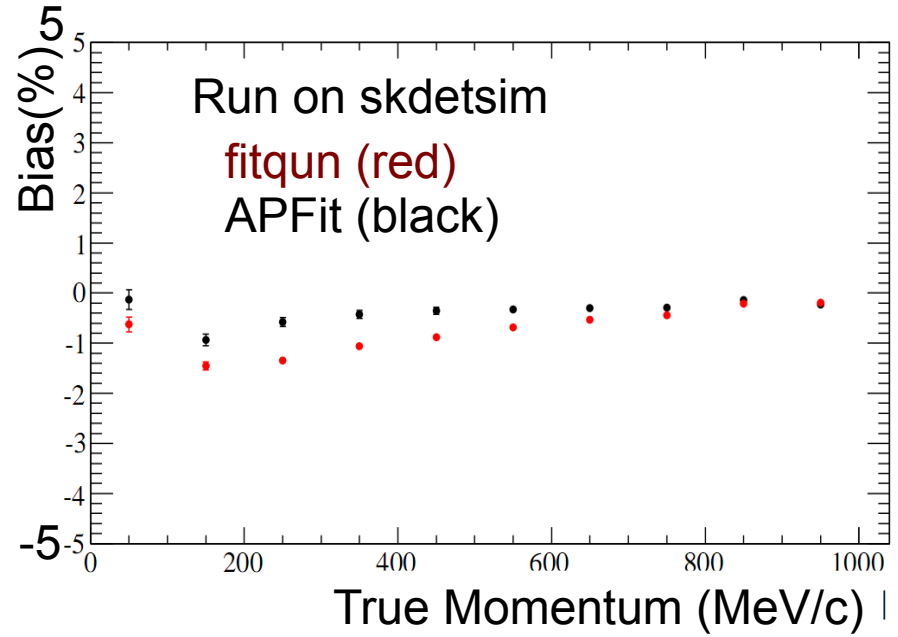


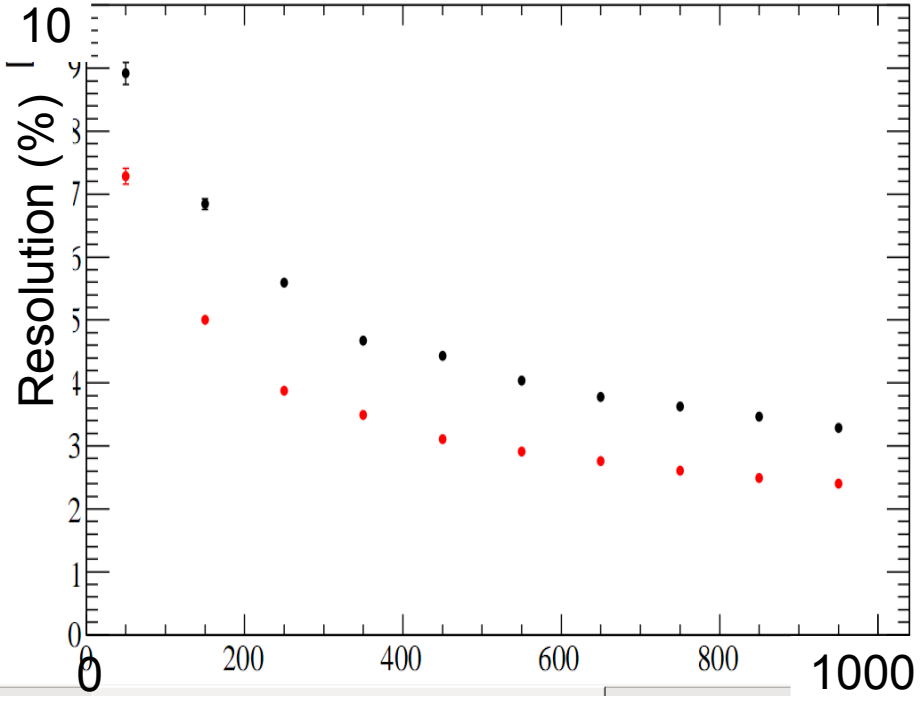




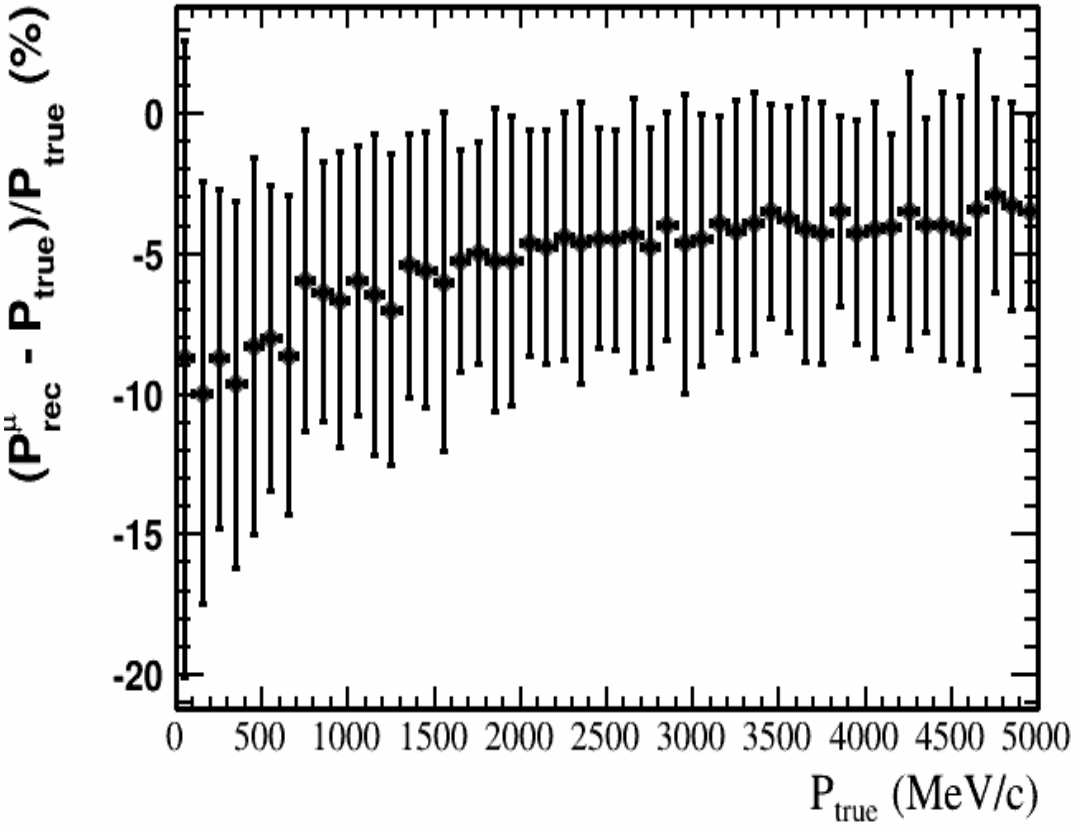


SK, electron resolution and bias





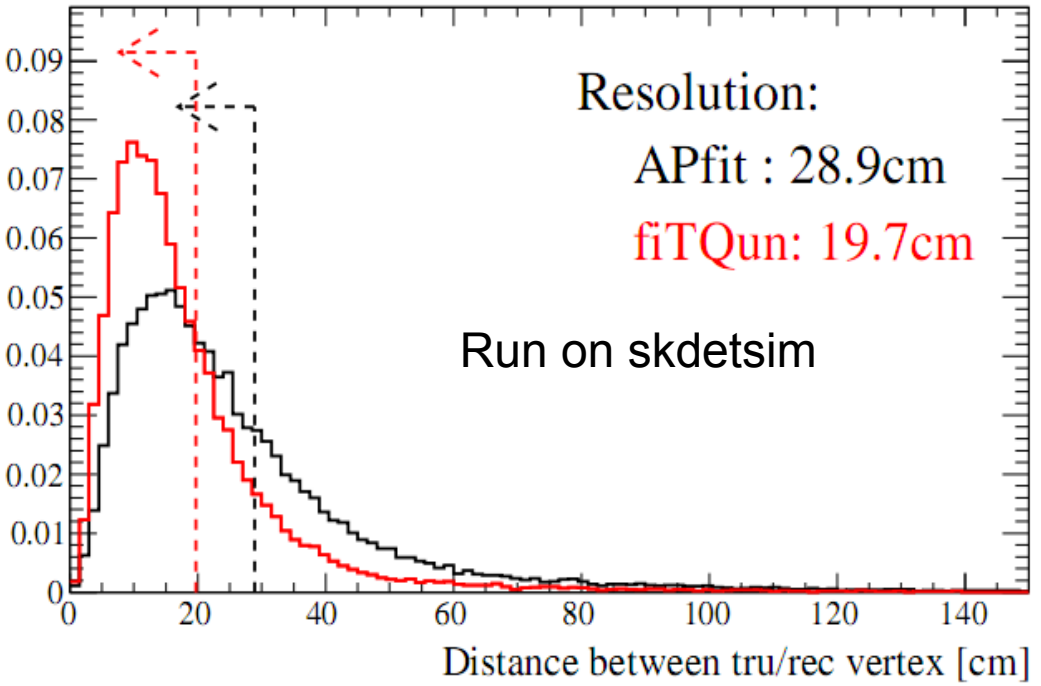
fitqun Run on WCSim
Error bar is resolution

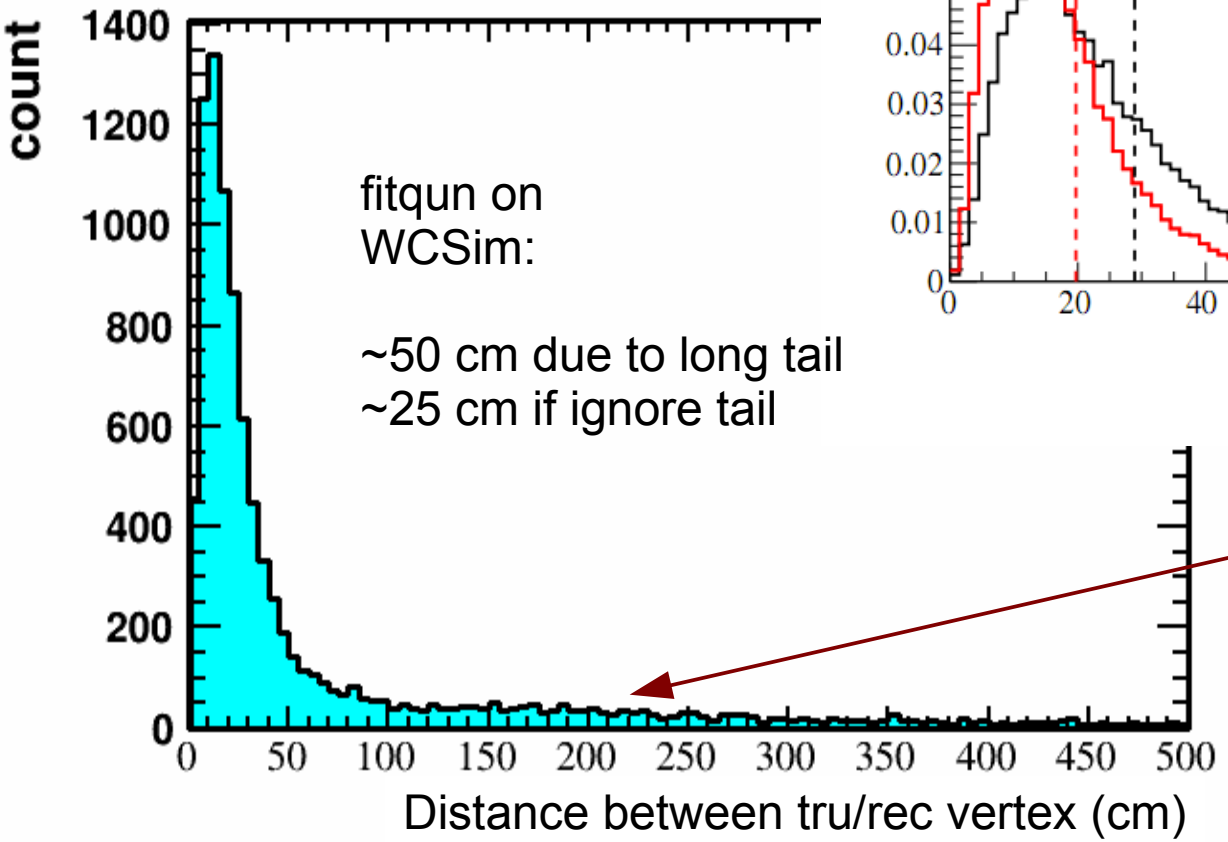


5-10% bias on electron momentum
Resolution 3.5% at 5 GeV/c, 8% at 100MeV/c

SK, electron vertex resolution

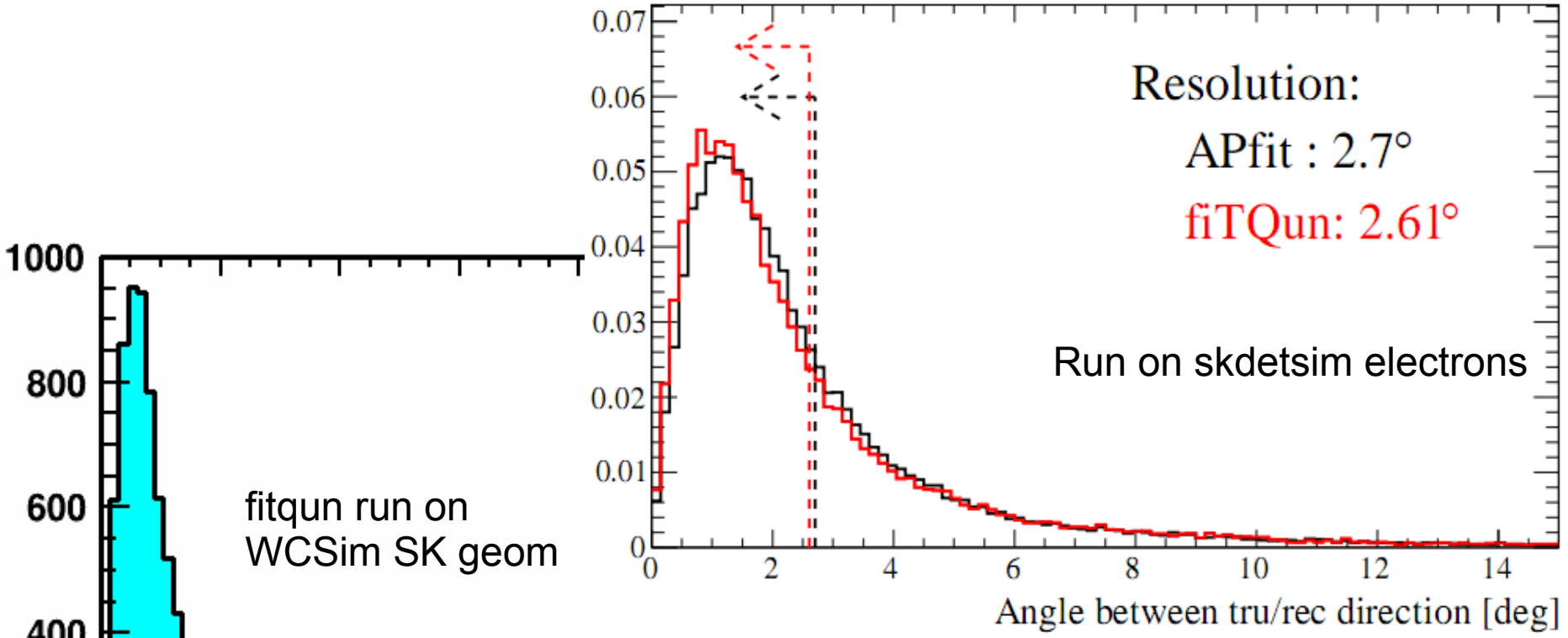
Resolution defined as distance inside of which 68.3% of Events fall

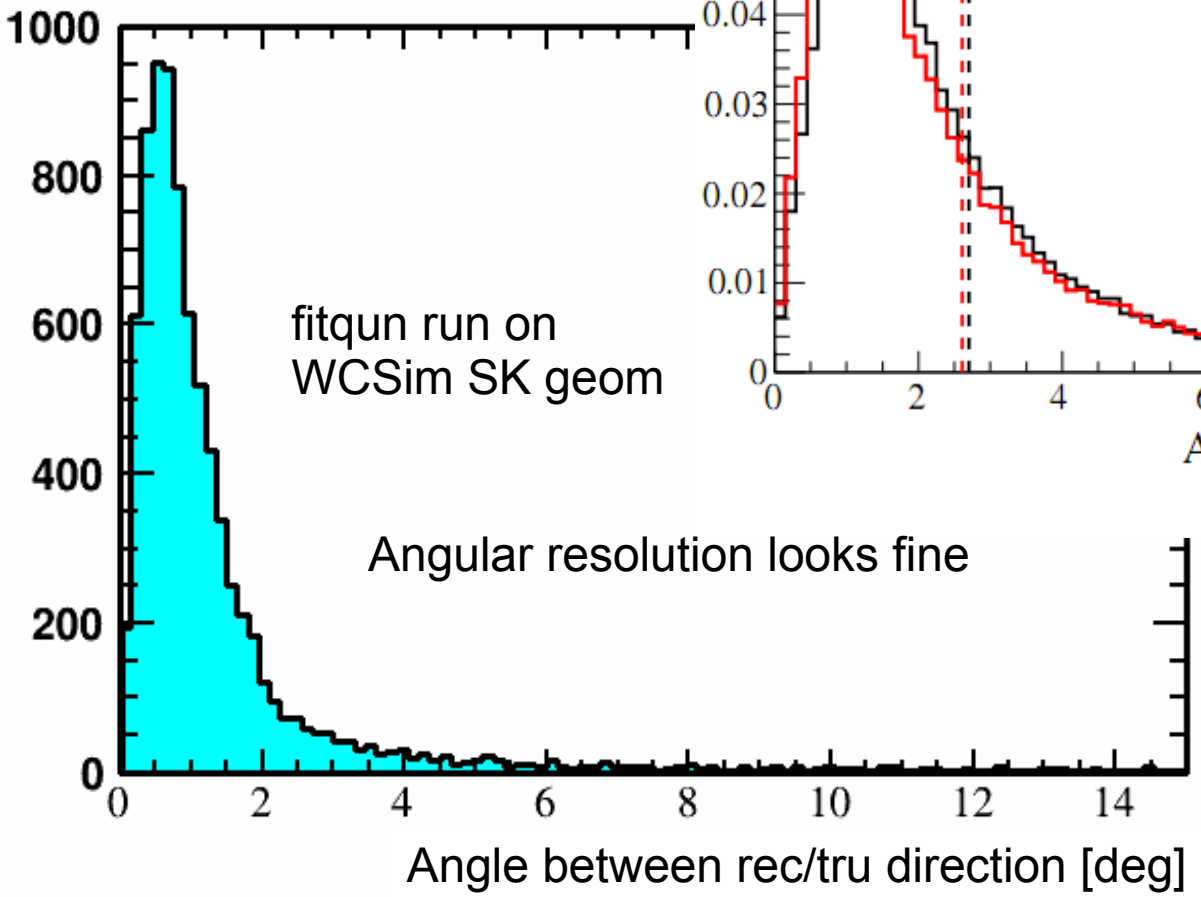




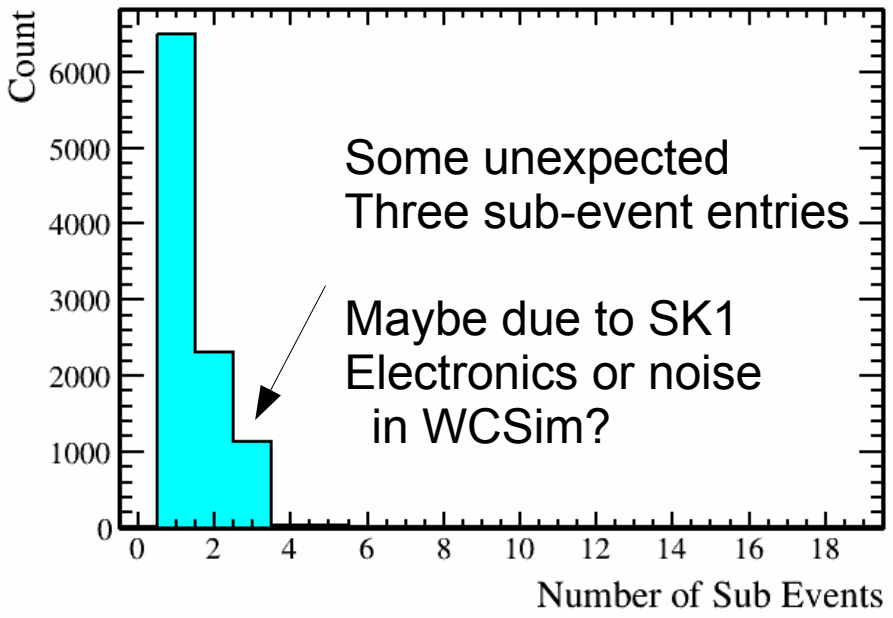
Still a long tail
Possibly not selecting clean enough set of events.

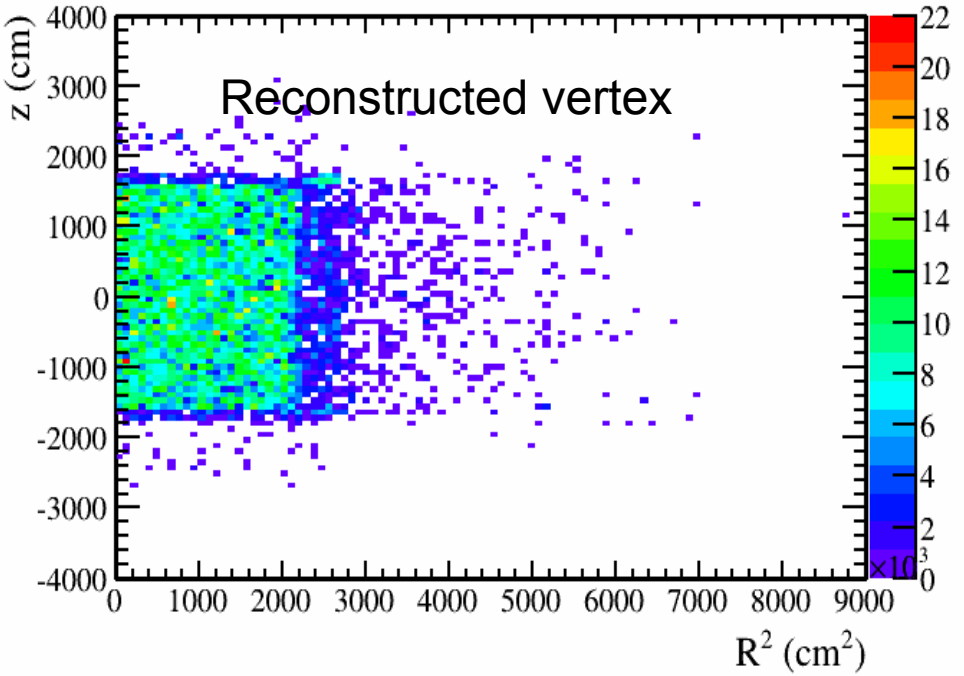
SK, electron angular resolution

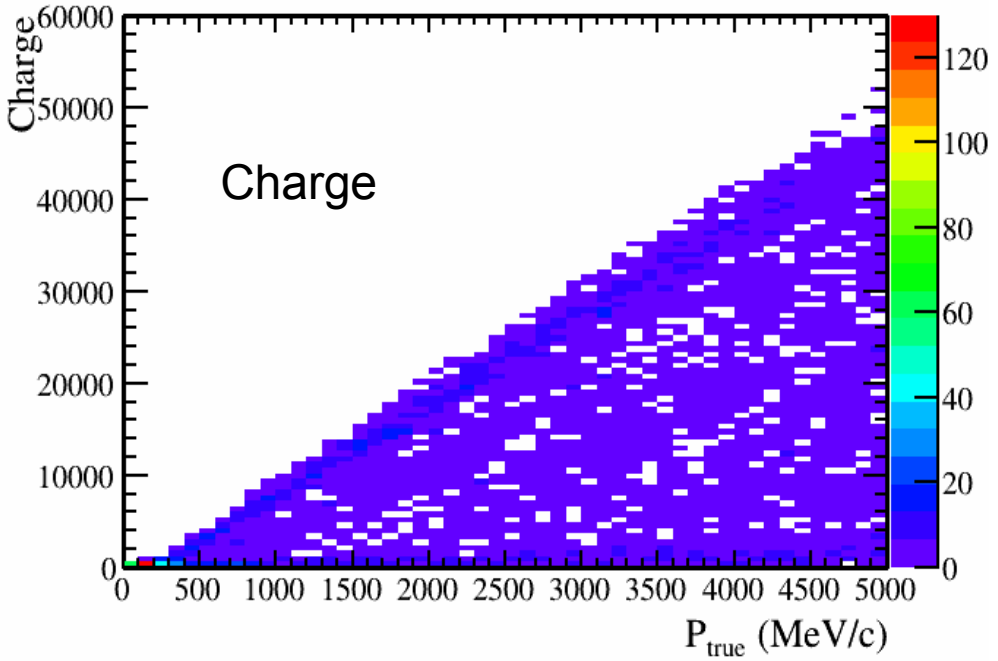


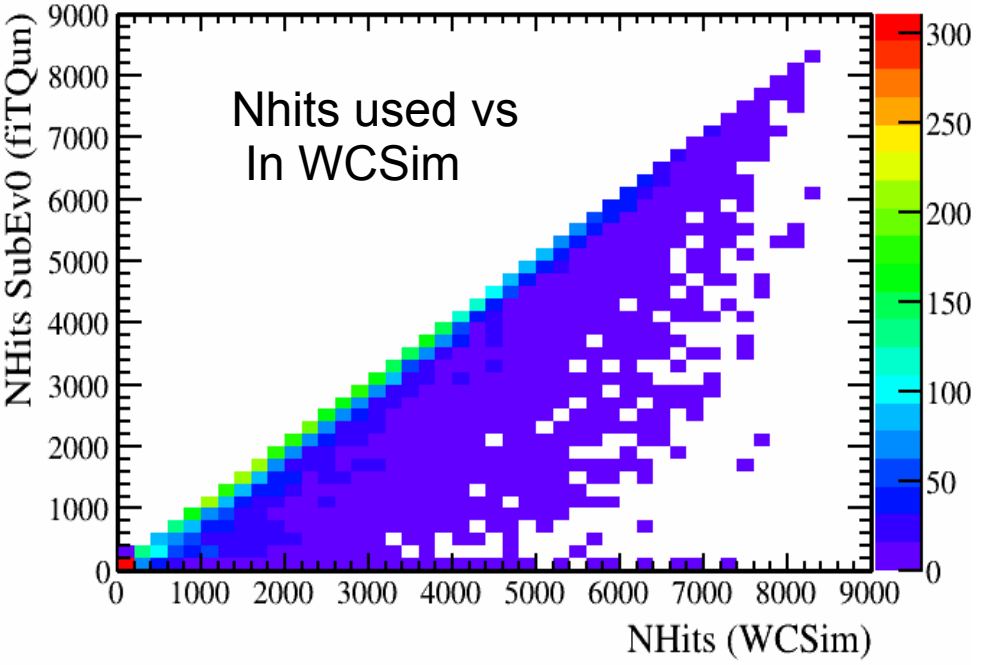


SK 0 to 5GeV muons

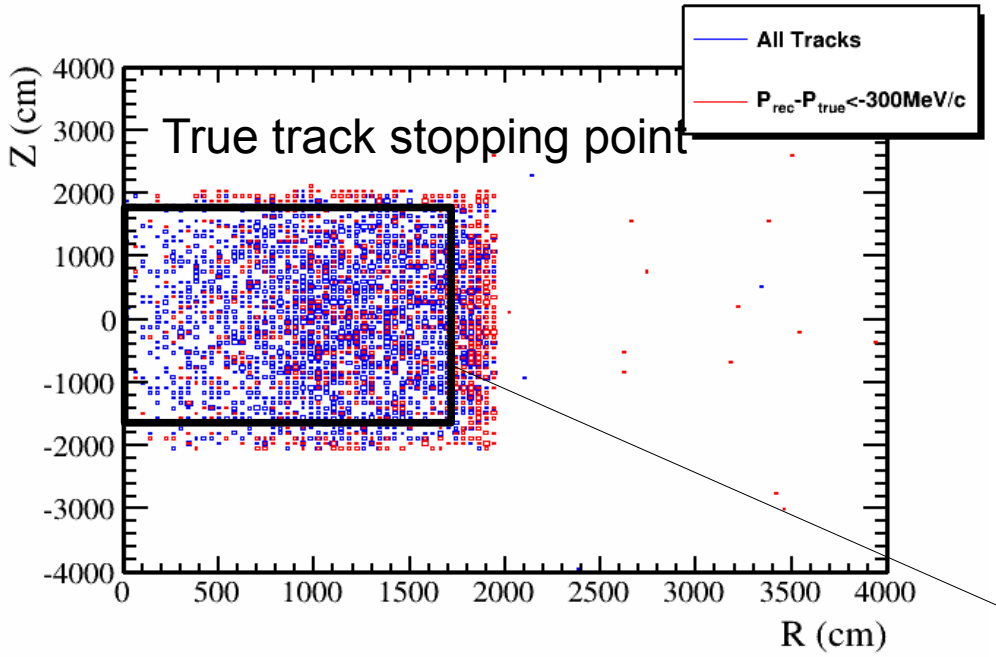


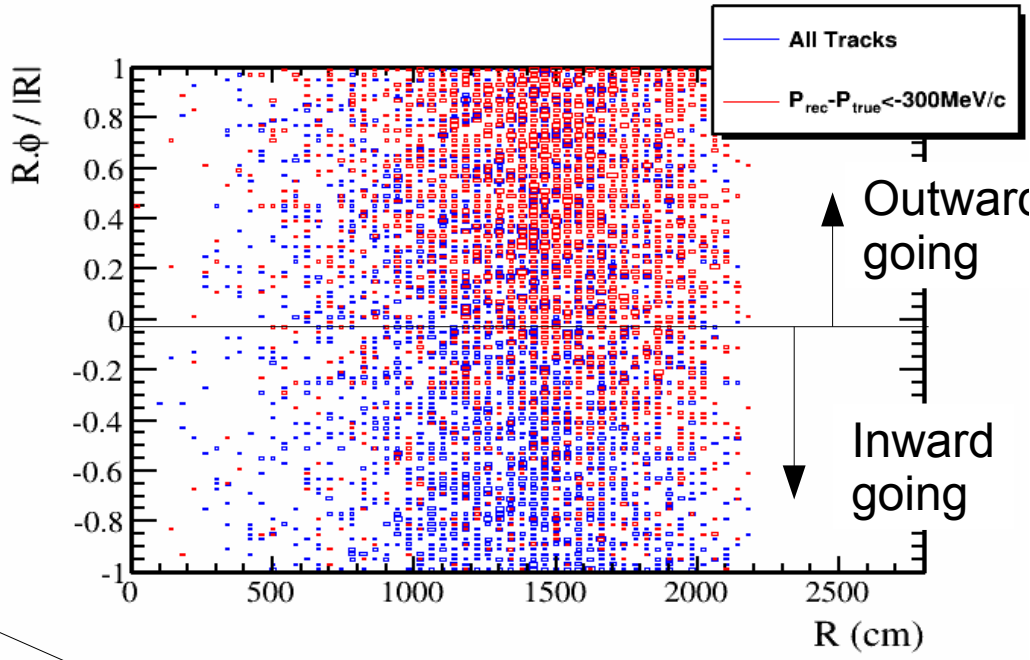


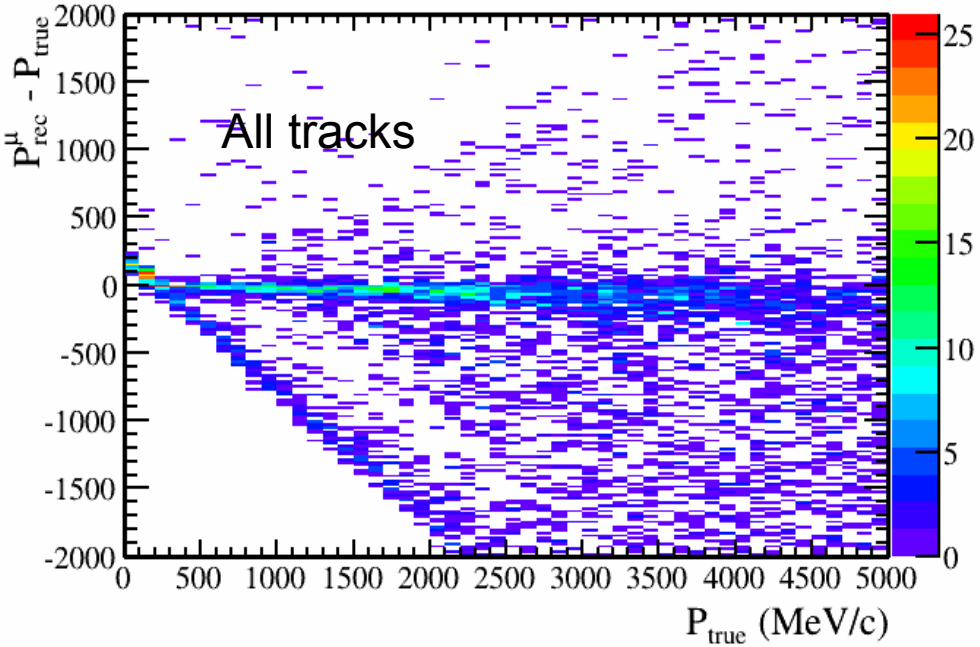


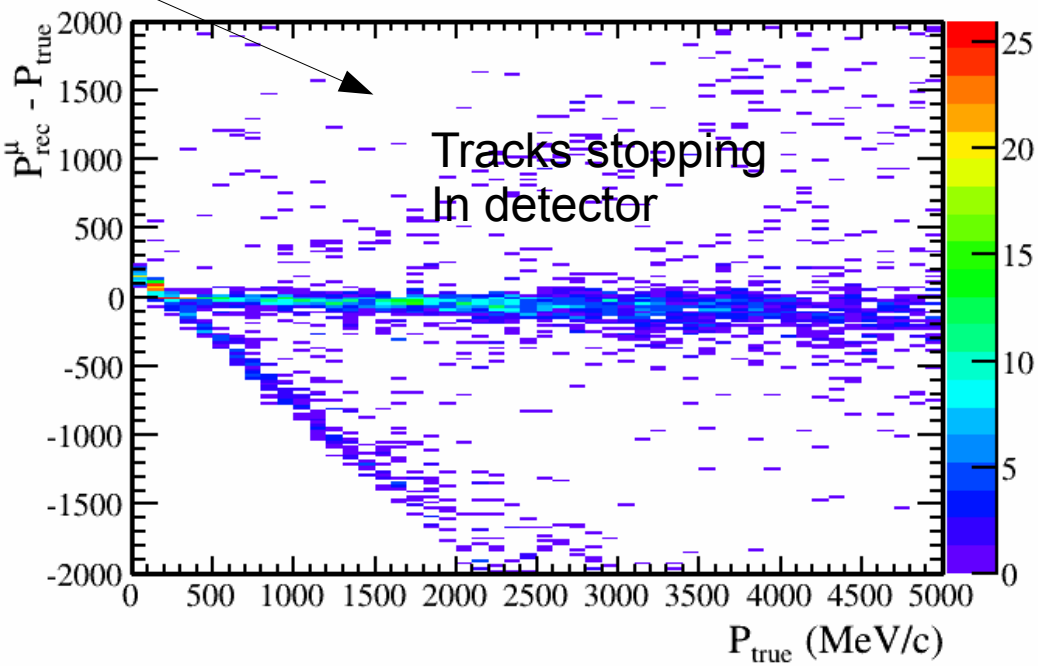


SK 0 to 5 GeV muons

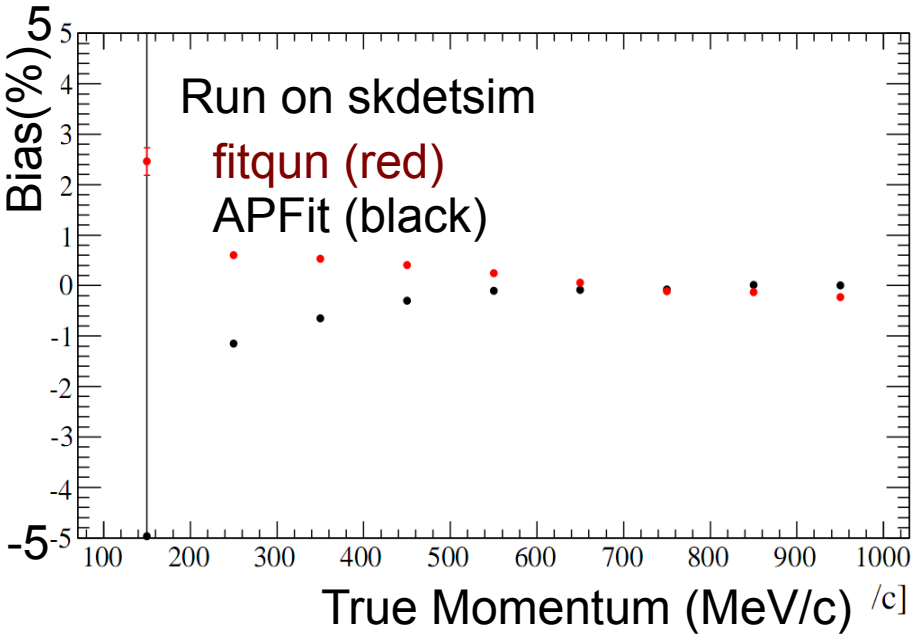


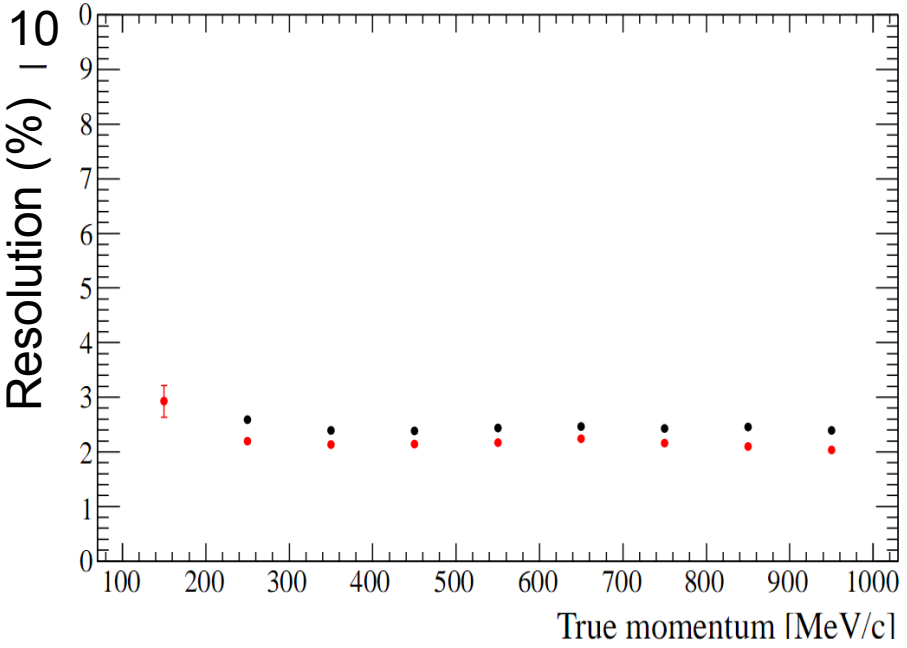






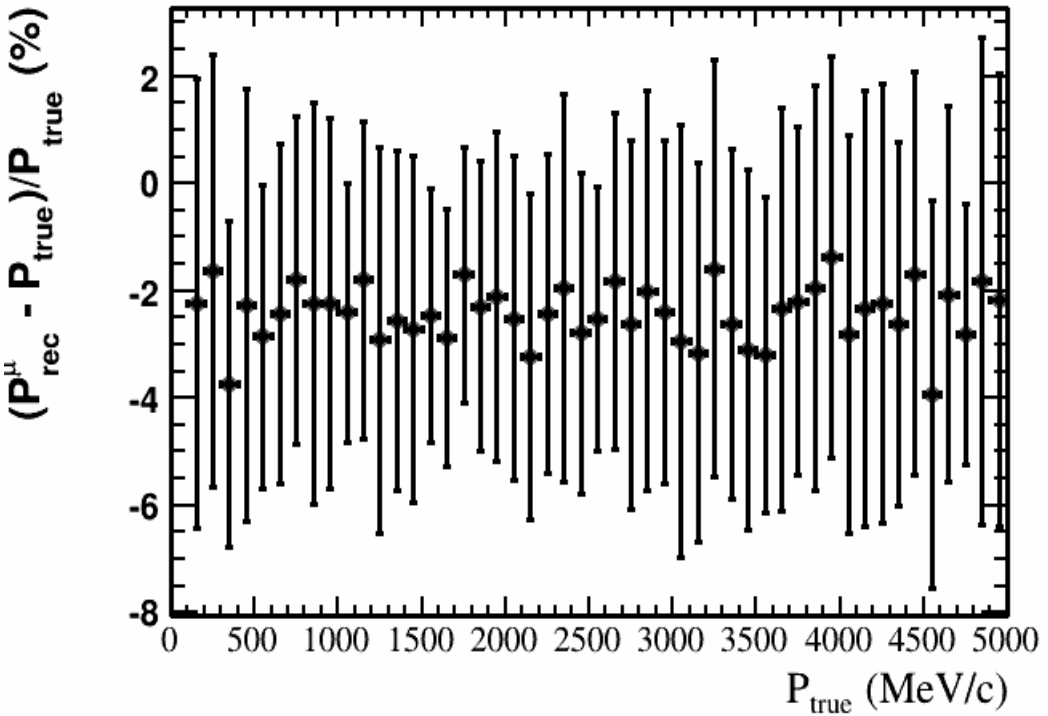
SK, muon resolution and bias





0 1000

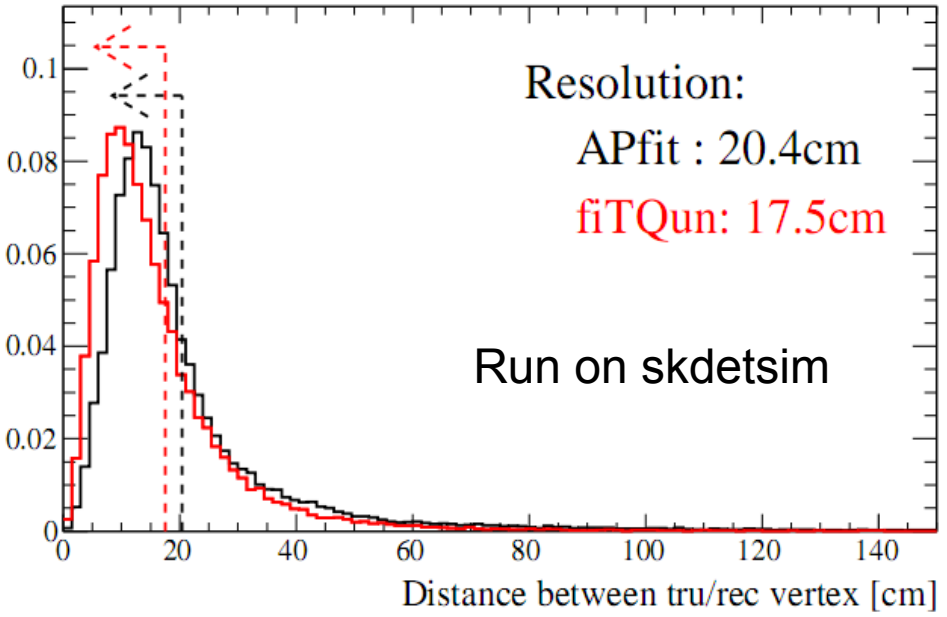
fitqun Run on WCSim
Error bar is resolution

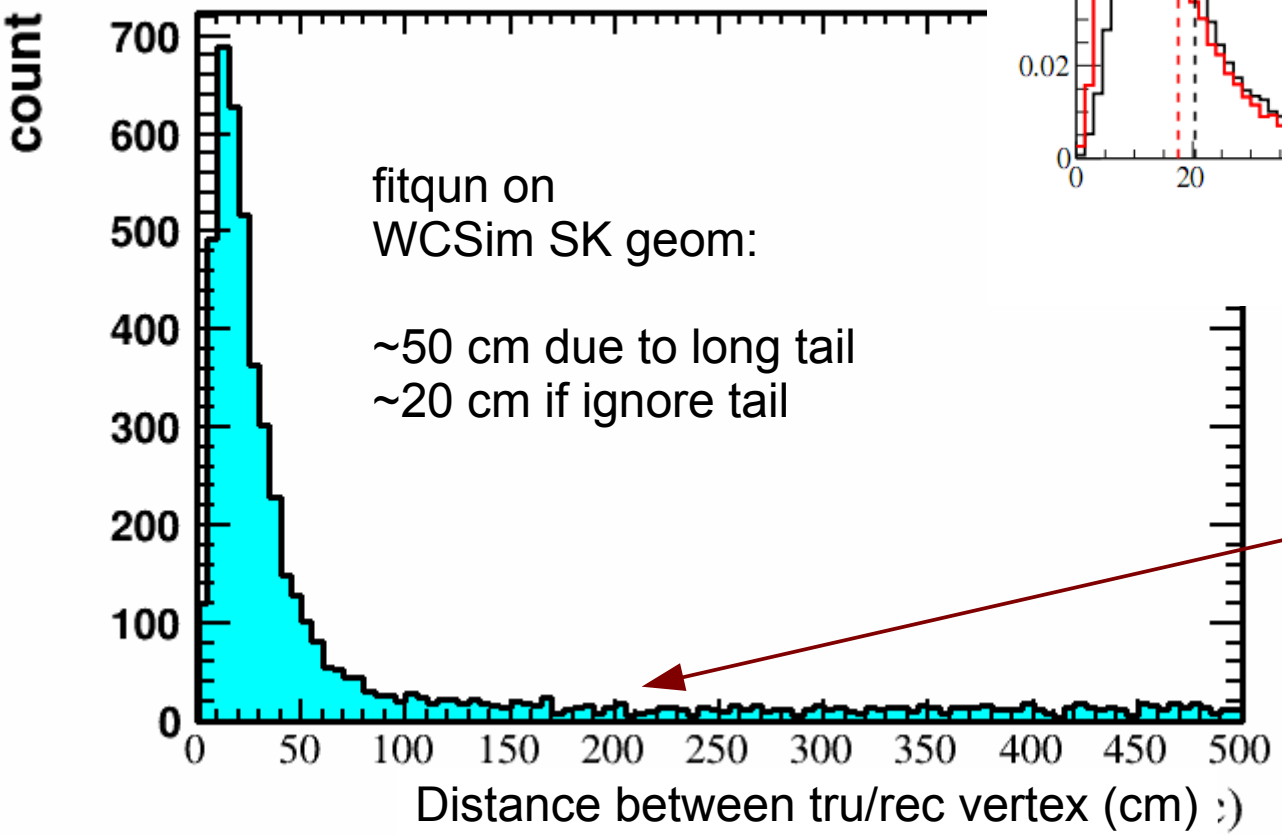


~2% bias on muon momentum
Resolution ~3.5% at 5 GeV/c,
~2.5% at 500MeV/c

SK, muon vertex resolution

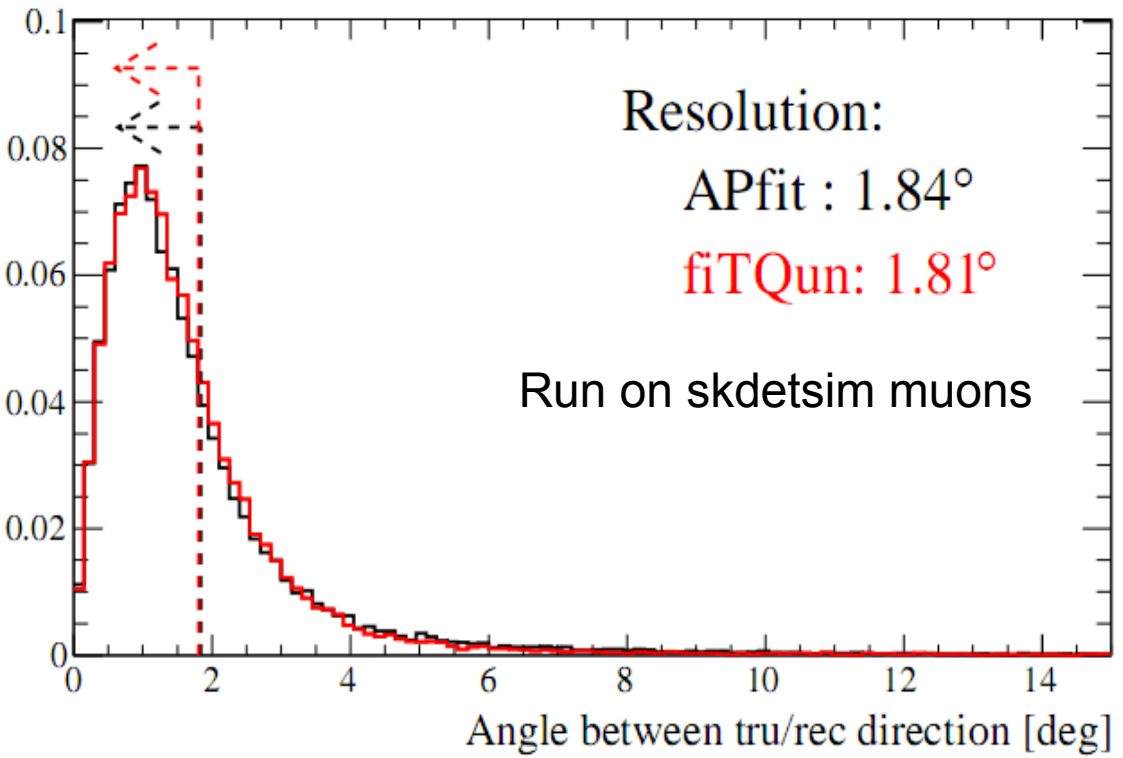
Resolution defined as distance inside of which 68.3% of Events fall

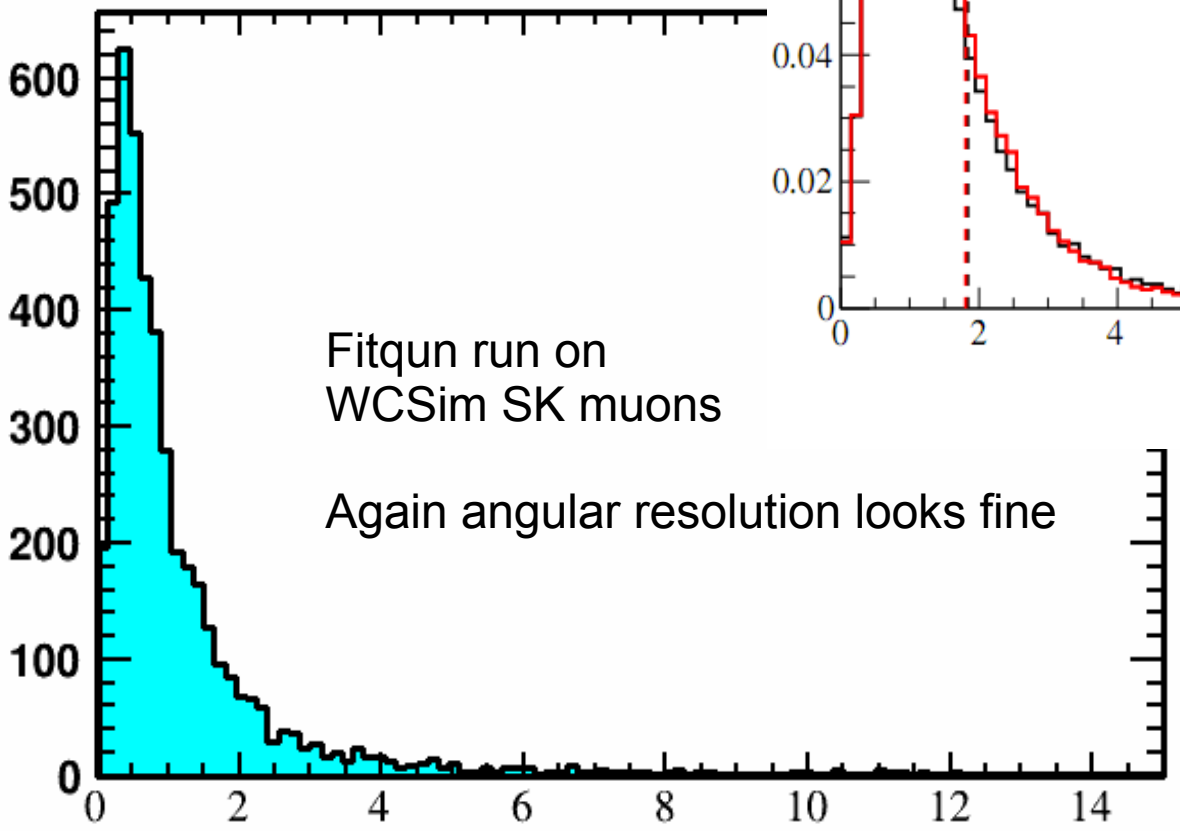




Still a long tail
Possibly not selecting clean enough set of events.

SK, muon angular resolution

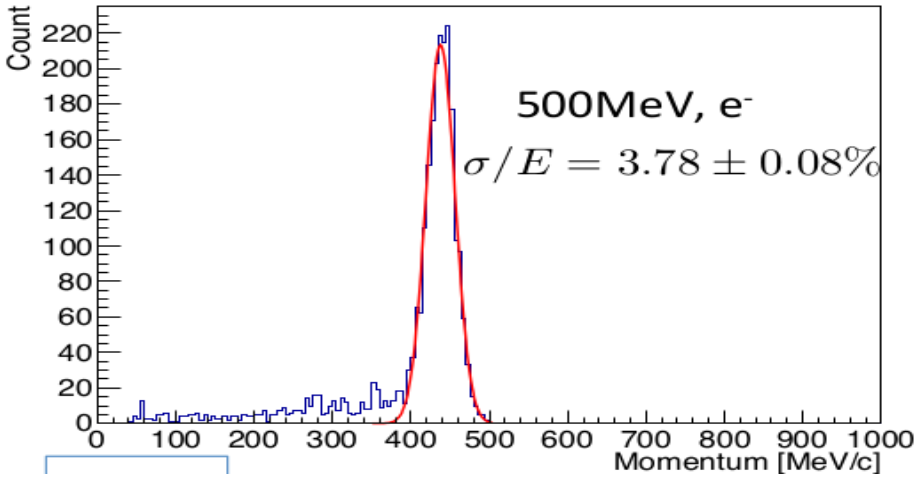


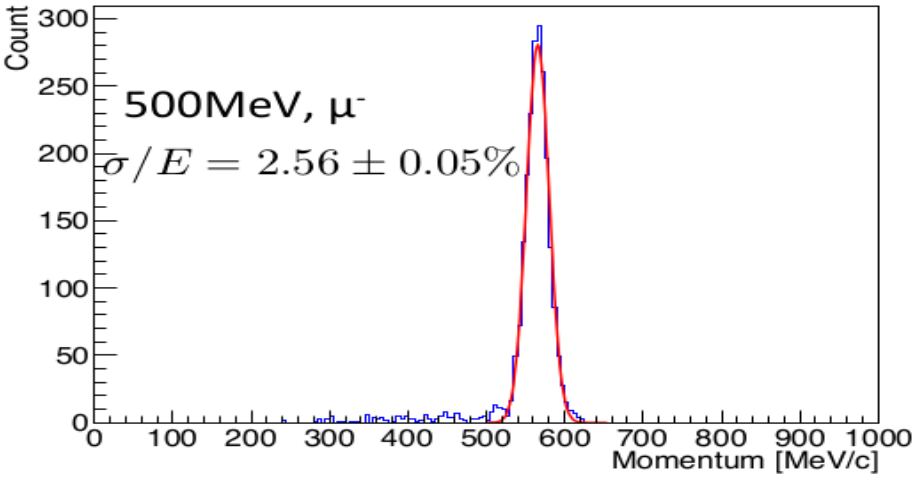


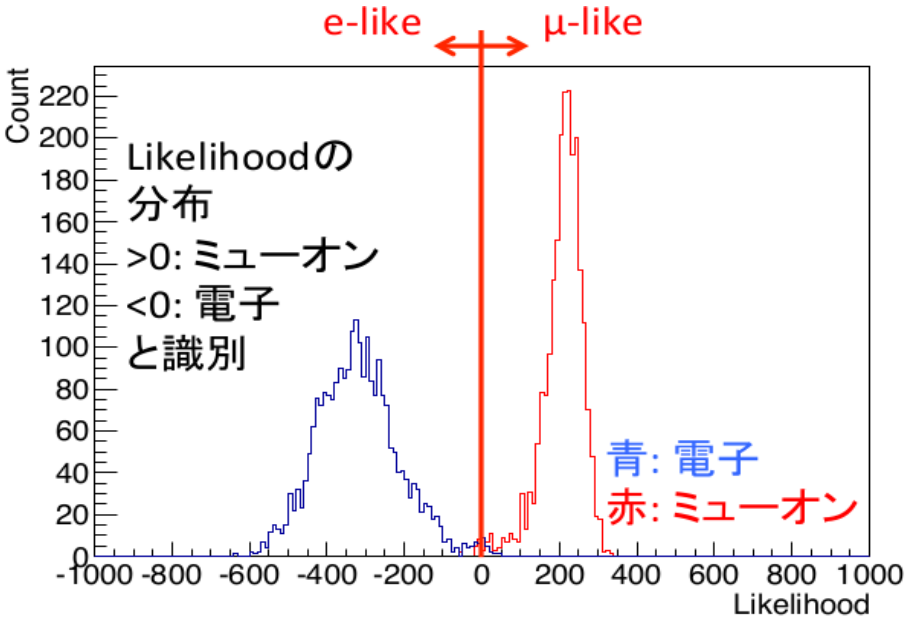
Fitqun runs on HK geometry

- These are the first tests of this sort, that uses fitqun developed for SK geometry
  - Recall the light scattering tables assume the SK cylindrical geometry, and dimensions
  - Direct light predictions were only designed to wrk up to 50 m (for SK), and the larger volume of HK could cause some problems
    - We plan to test this in the coming weeks.
  - This should cause significant errors in the resulting distributions
  - A fix for this geometry dependence is being developed now

Initial tests with HK geometry of Okajima

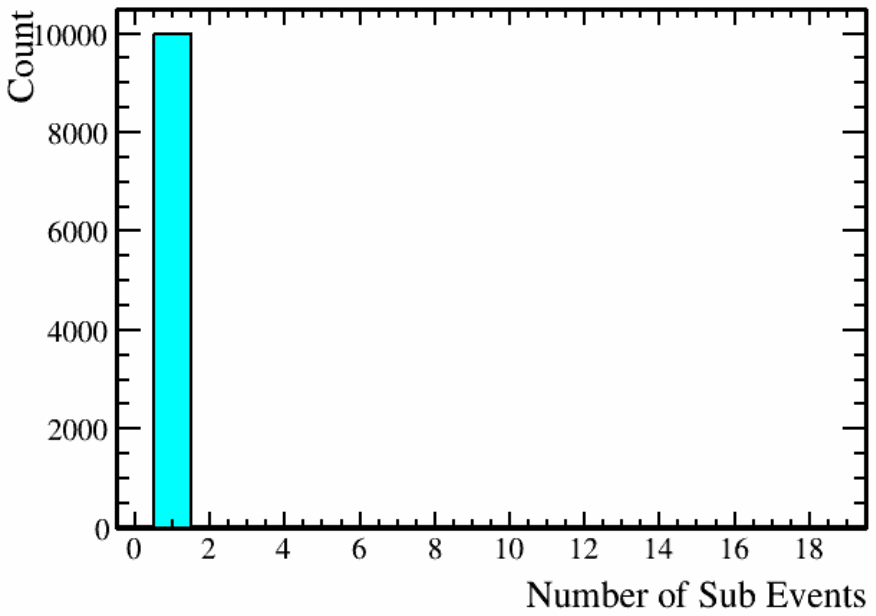


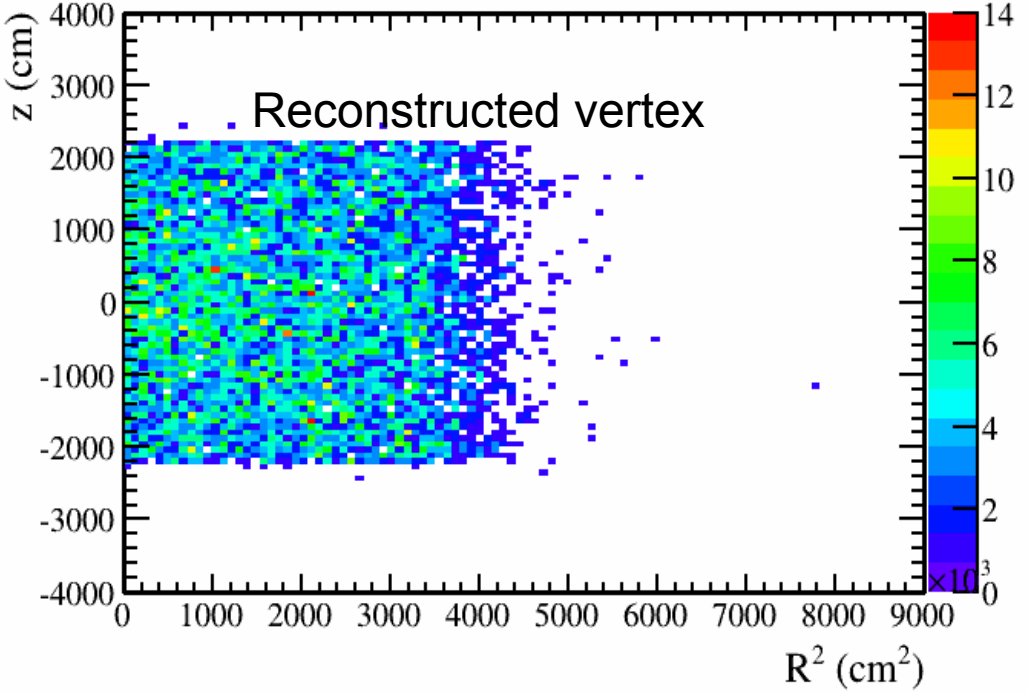


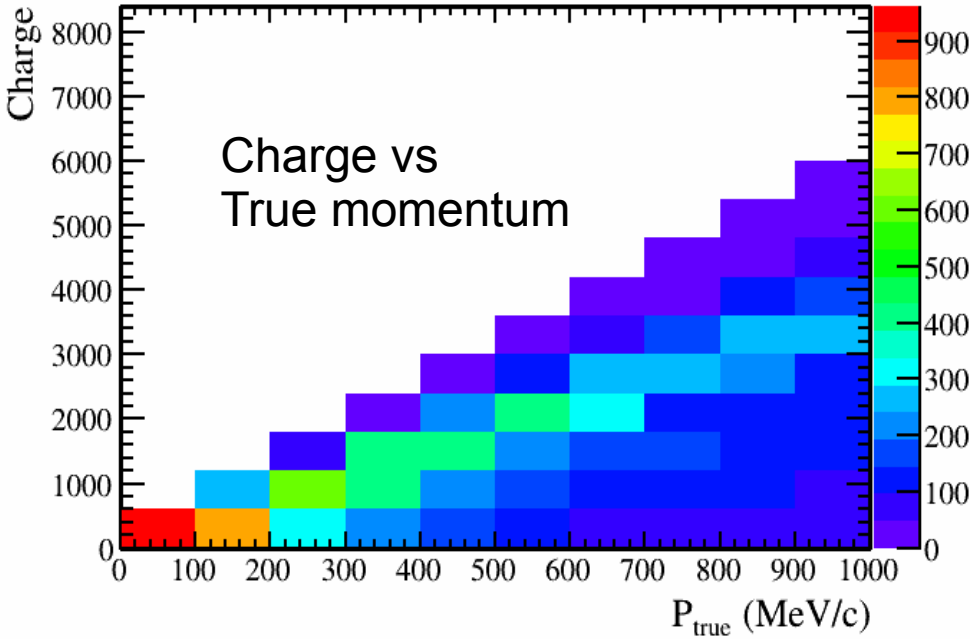


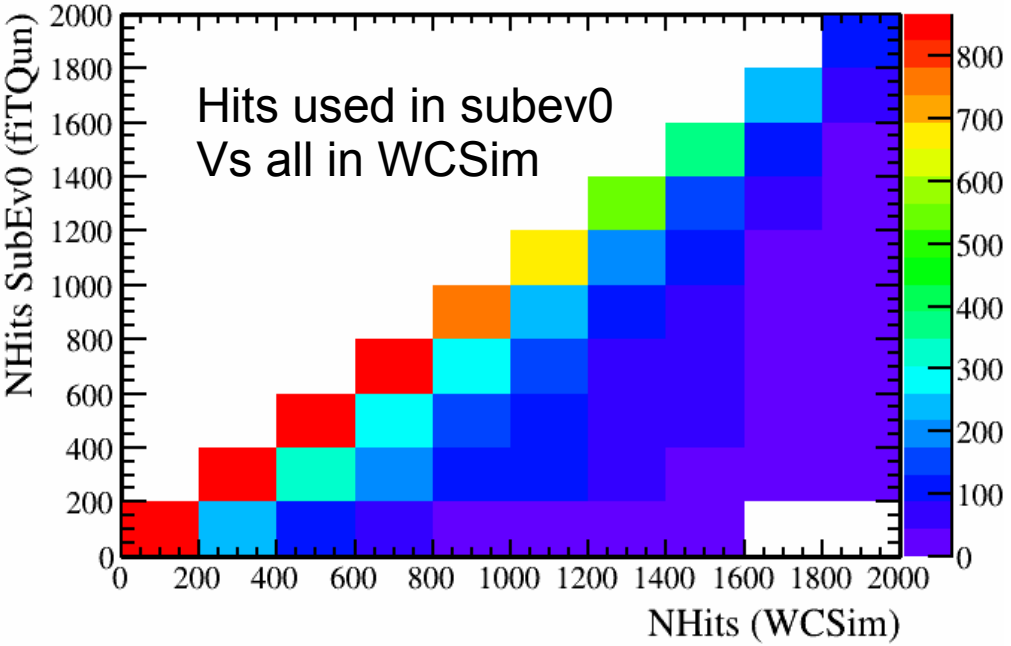
Initial resolution results, and Particle ID tests look reasonable.

HK 0 to 1 GeV electrons





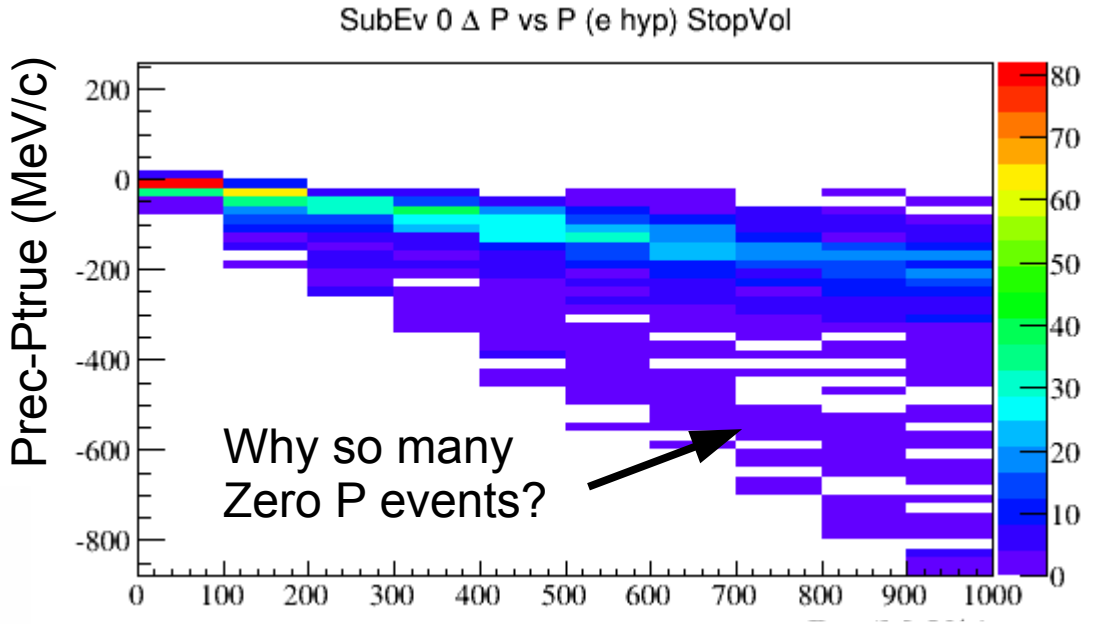


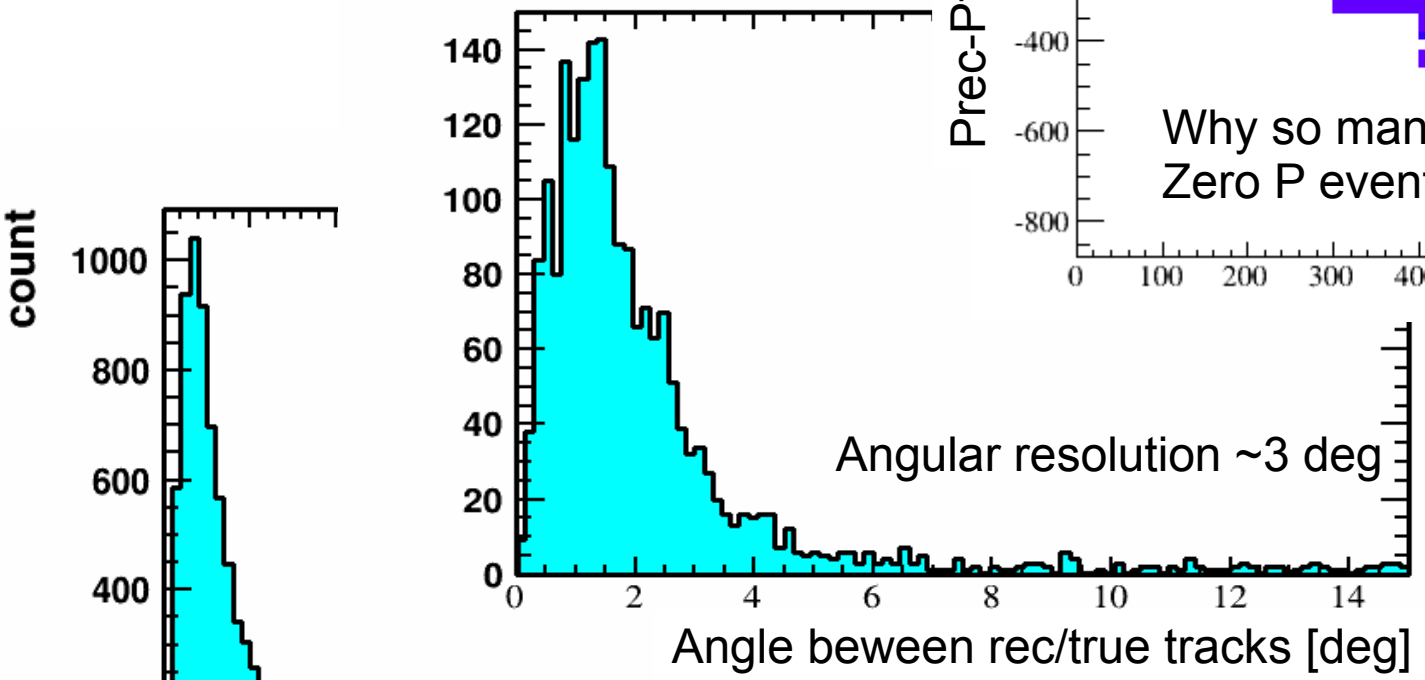


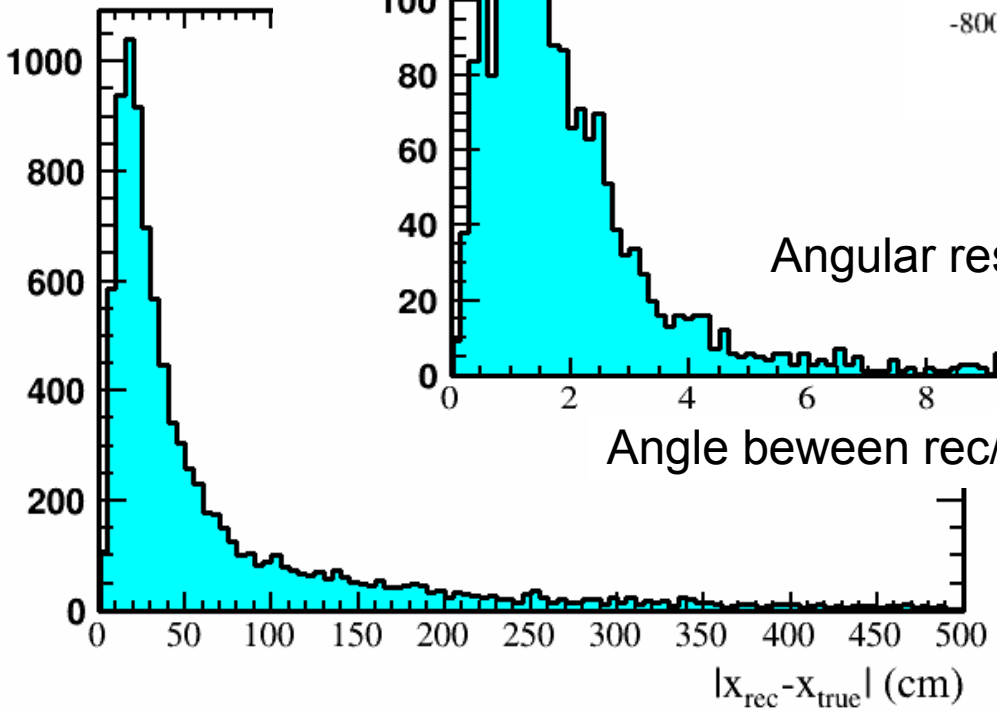
Fitqun run on WCSim HK Geometry (0 to 1 GeV electrons)

Very large momentum bias needs
Further investigation

Momentum still has large tail on it
Making resolution ~10%
→ needs ir

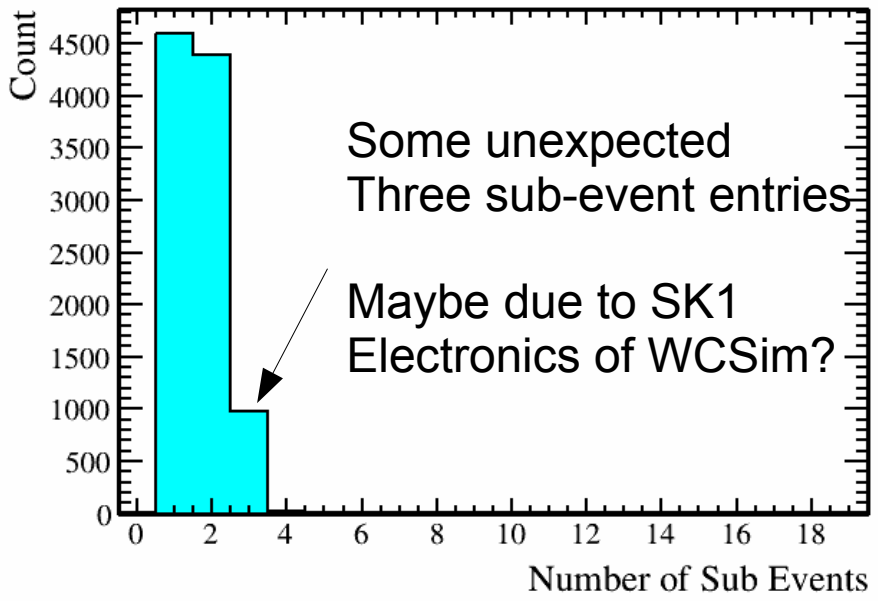


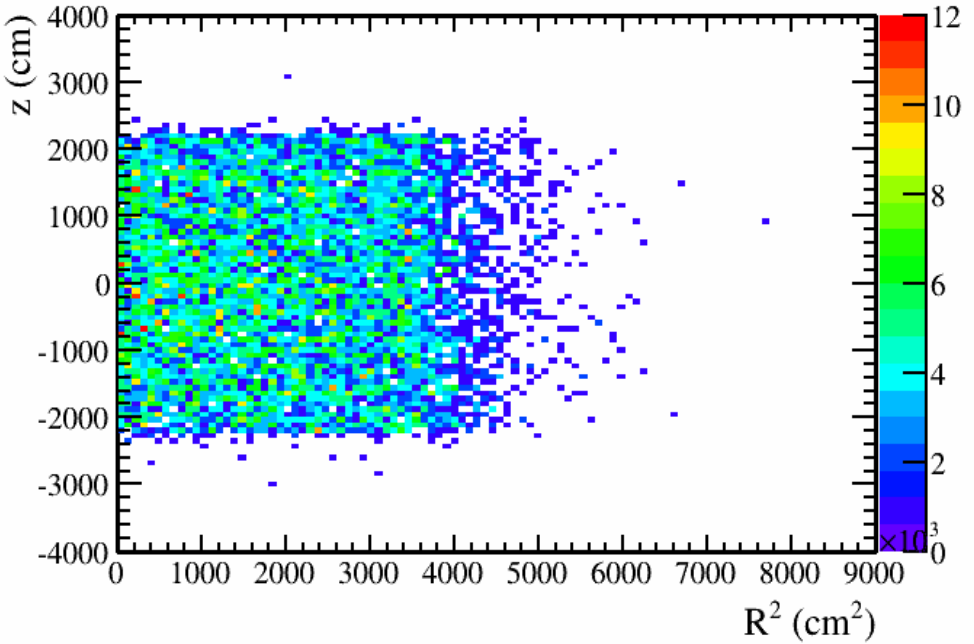


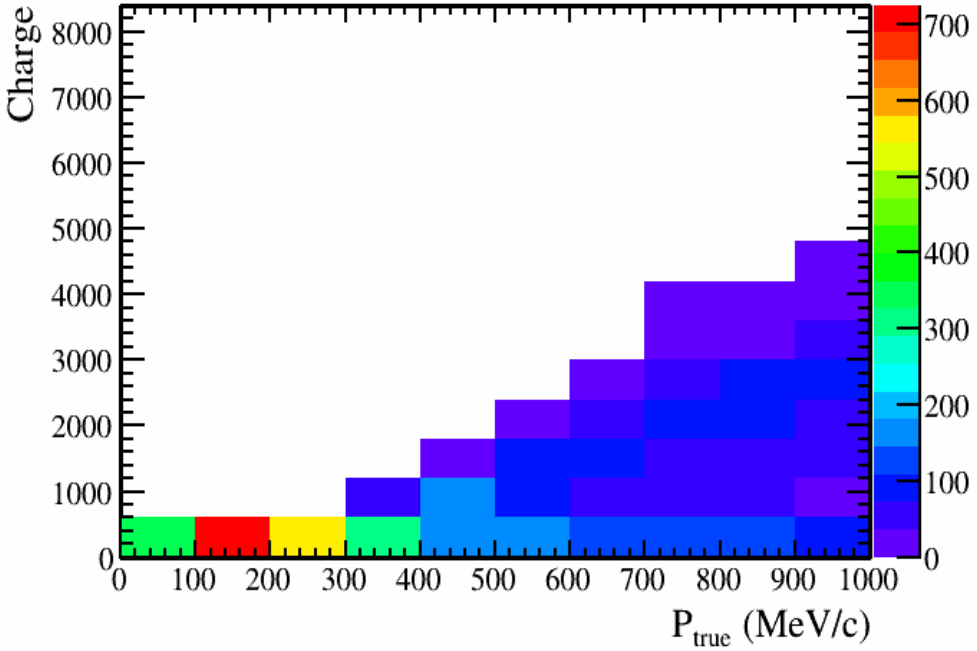


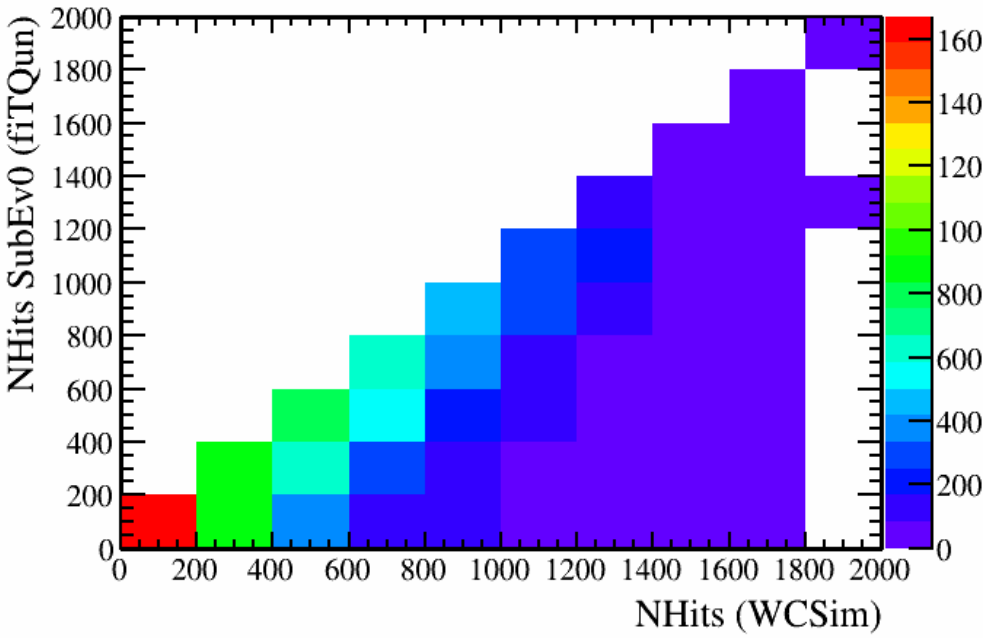
Vertex resolution peaks
At about 25 cm, but has a
Large tail, similar to SK case

HK 0 to 1 GeV muons





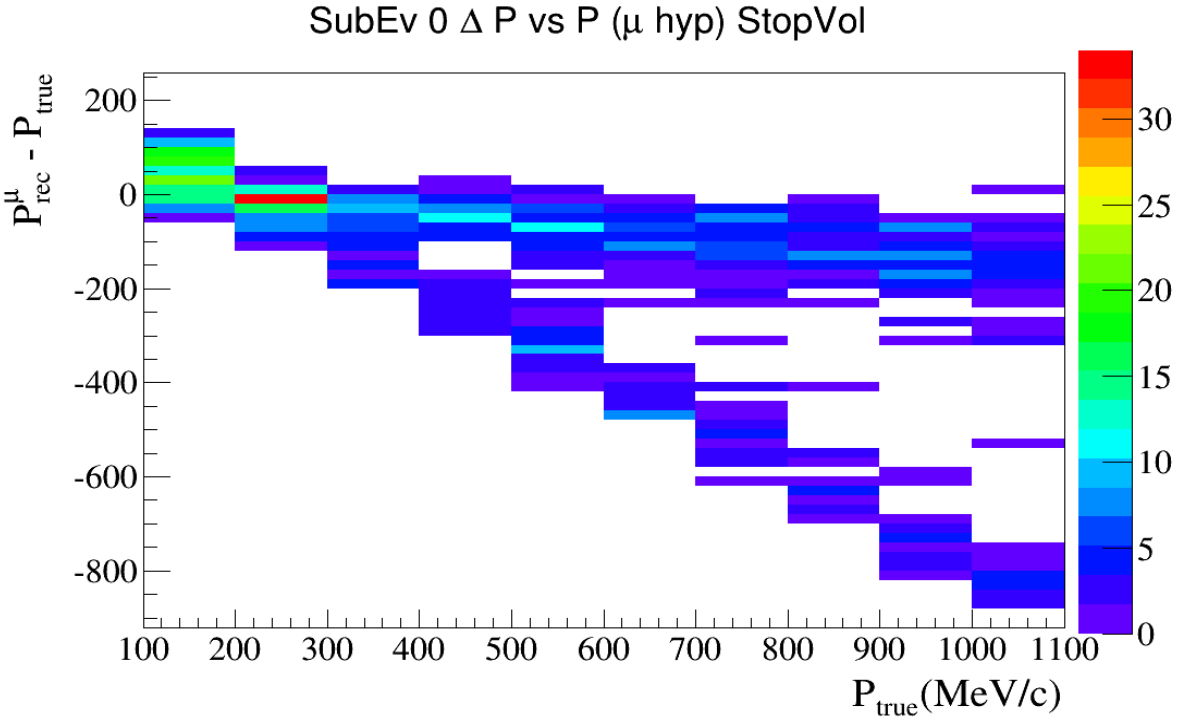


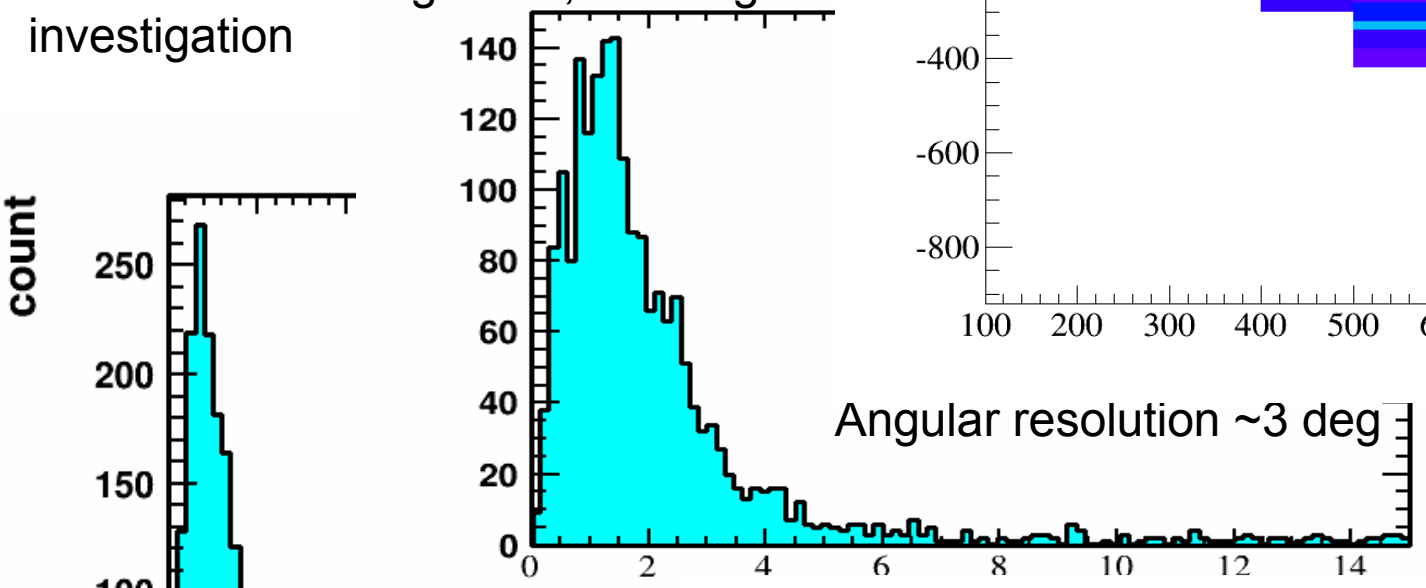


Fitqun run on WCSim HK Geometry (0 to 1 GeV muons)

WCSim HK geometry muons
Reconstructed in fitqun also
Have large bias

Resolution has large tails, needing investigation





Angular resolution ~3 deg

Position resolution peaks around 30cm
But again have long tails

The road ahead

- Update light scattering table for HK
  - Code to generate new light tables using WCSim is being developed
- Updates to root tree output
  - Existing tree is mainly for debugging
  - More truth information needs to be added instead of having to correlate events with MC file
- Updates to compiling to not require full WCSim libraries
- Looking into momentum bias and tails seen with HK geometry
  - Maybe related to using wrong light tables, or another more subtle bug