UNIVERSITY OF TORONTO

ν_e CCQE/CC1π^+ Selection Studies

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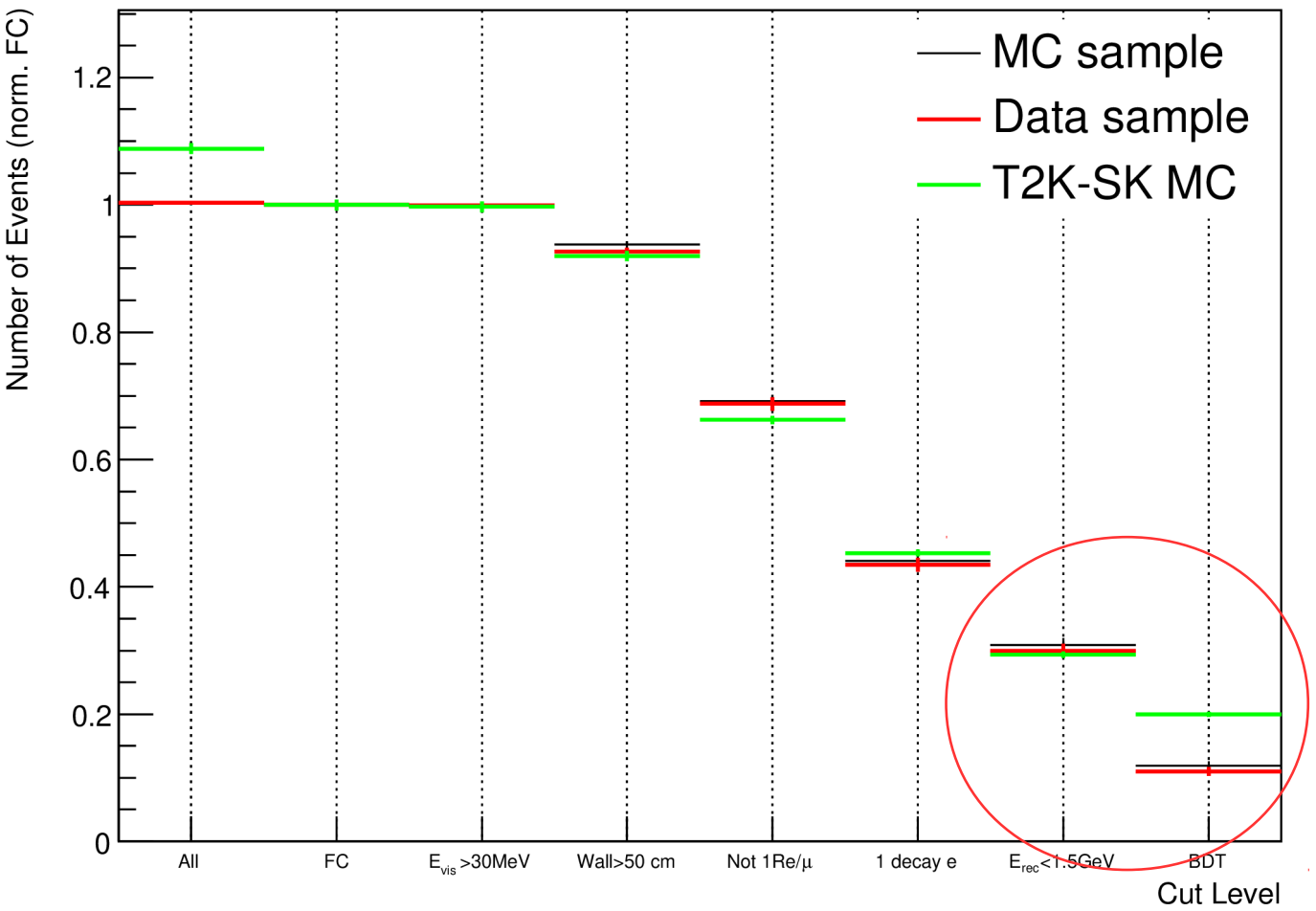
ν_e CCQE/CC1π^+ Meeting

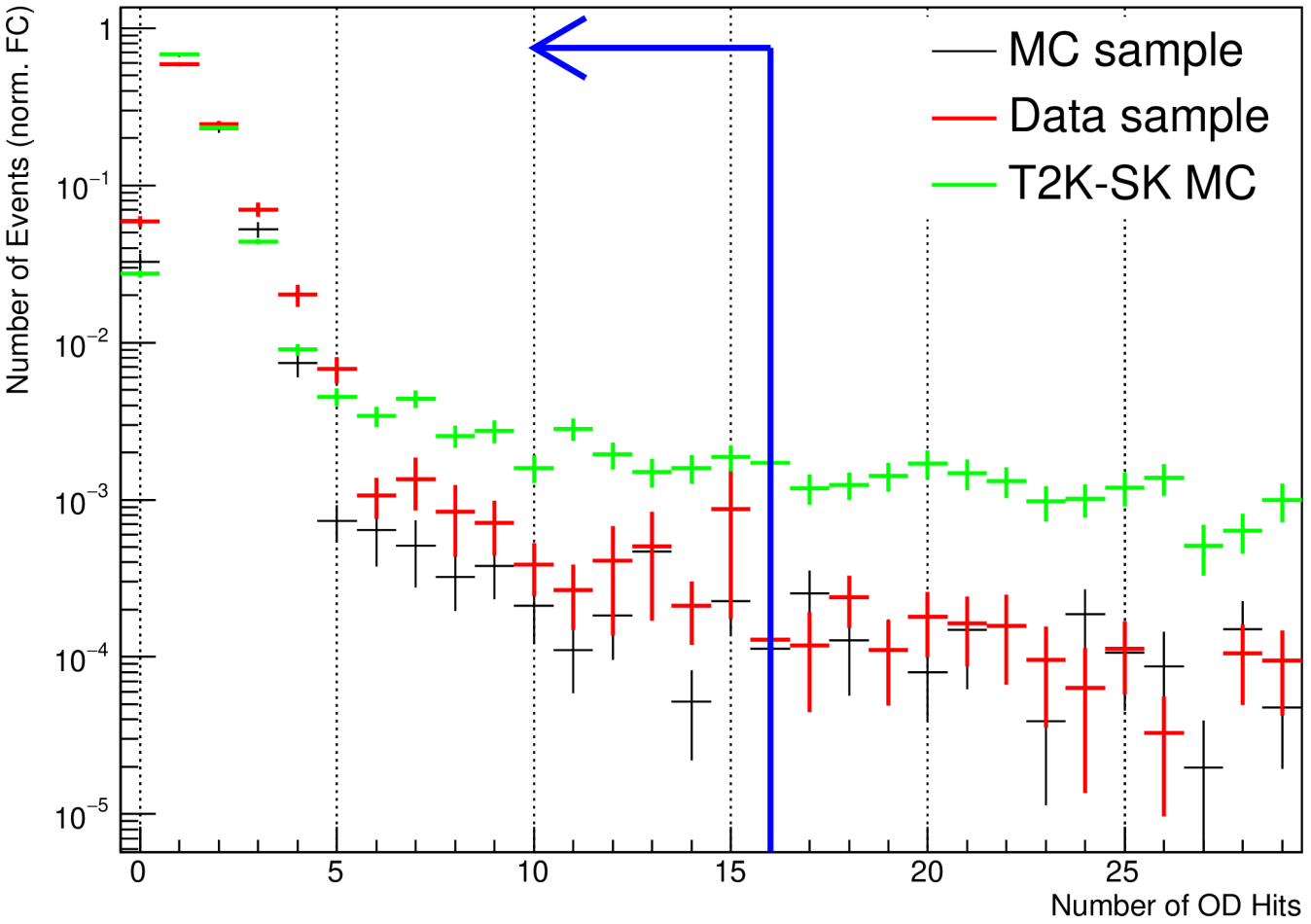
July 30, 2019

Hybrid Sample BDT Cut Discrepancy

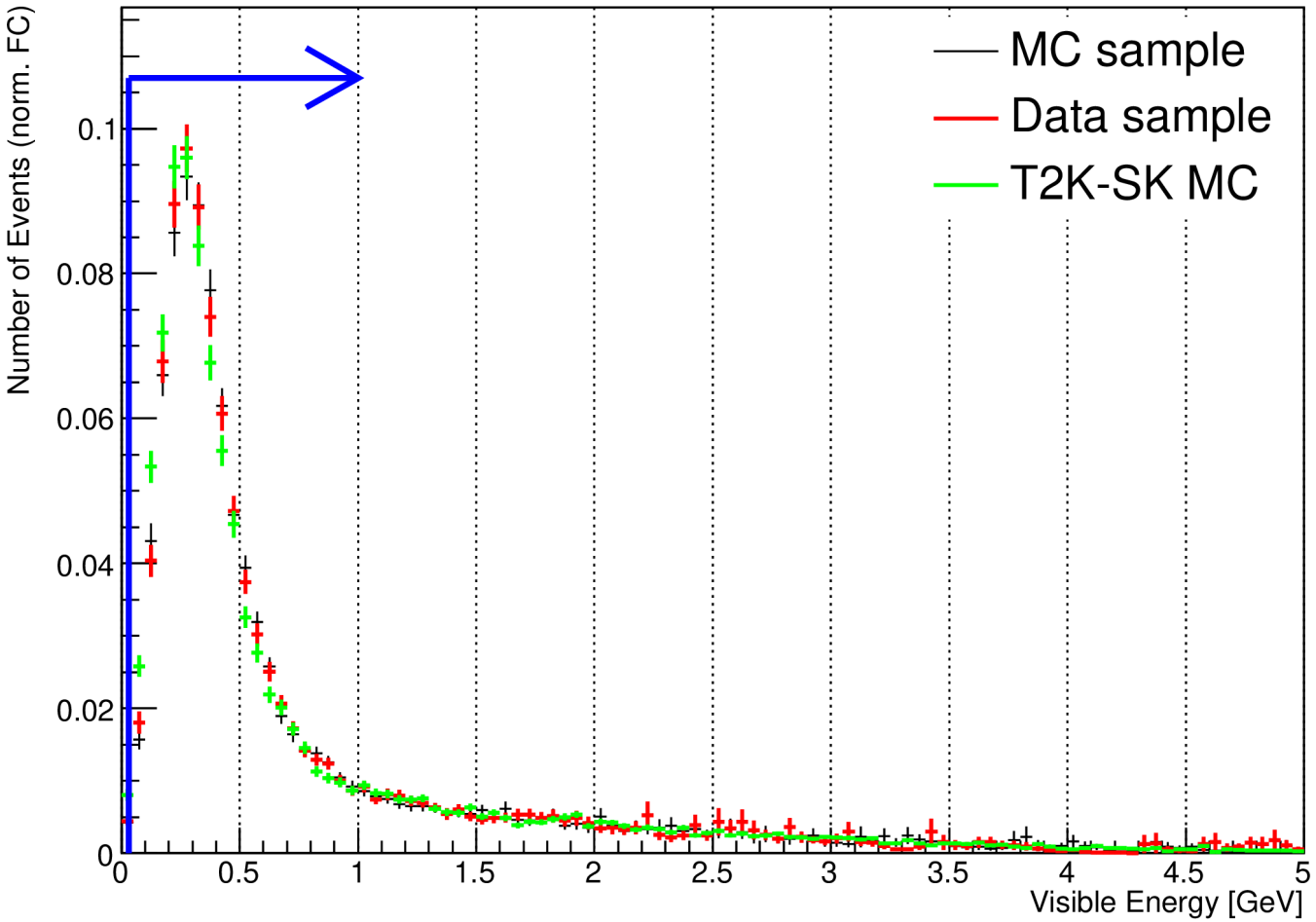


- Now oscillating hybrid sample and T2K-SK MC
- T2K-SK events shown here are $1e1\pi^+$
  - Same final state definition used when constructing hybrid sample
- Events normalised to FC events
- Still see efficiency discrepancy at BDT cut

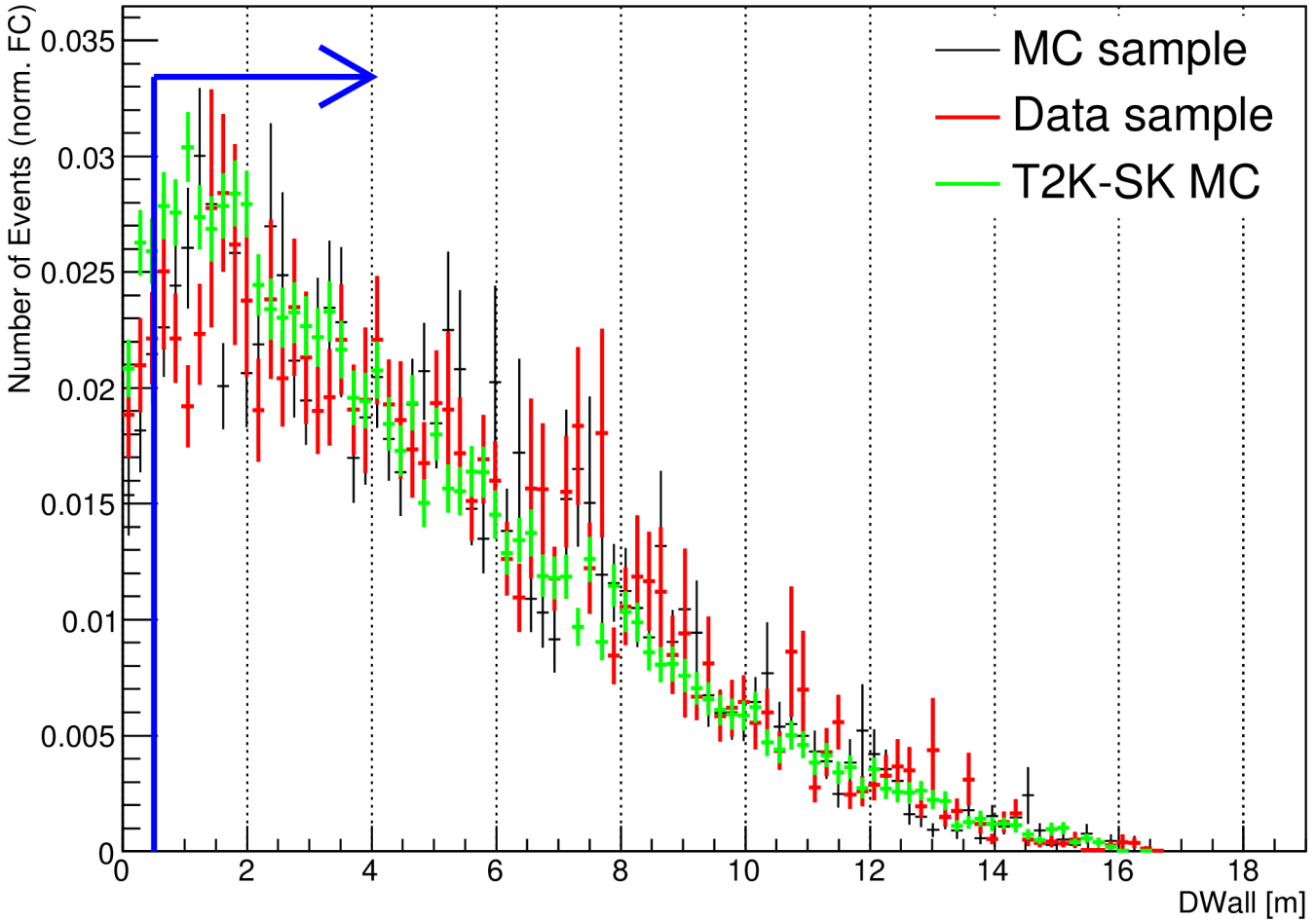
nhitac < 16


Number of Events (norm. FC)
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
5
10
15
20
25
Number of OD Hits
MC sample
Data sample
T2K-SK MC

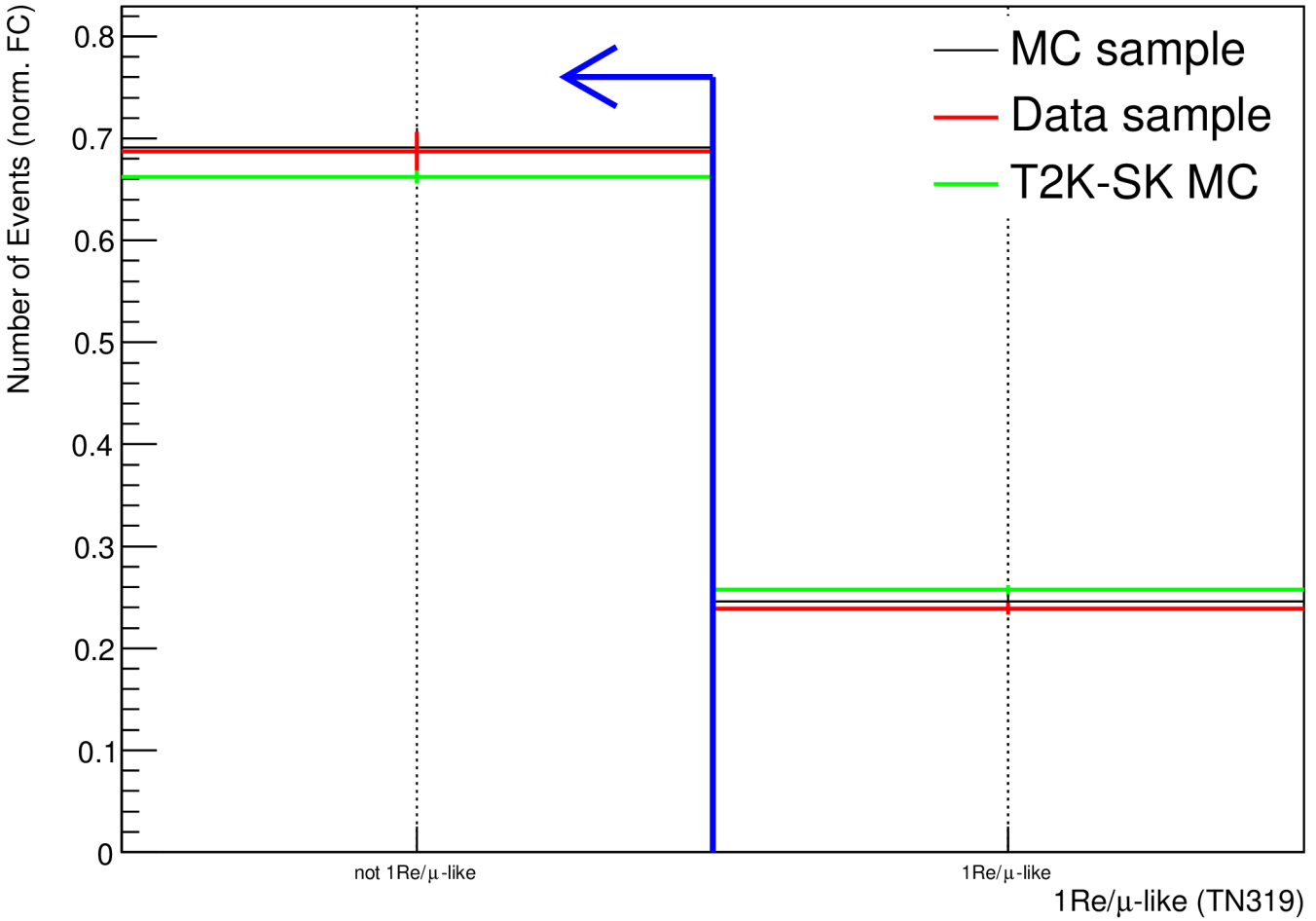
E_{vis} > 30 MeV


MC sample
Data sample
T2K-SK MC
Number of Events (norm. FC)
Visible Energy [GeV]
0
0.02
0.04
0.06
0.08
0.1
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

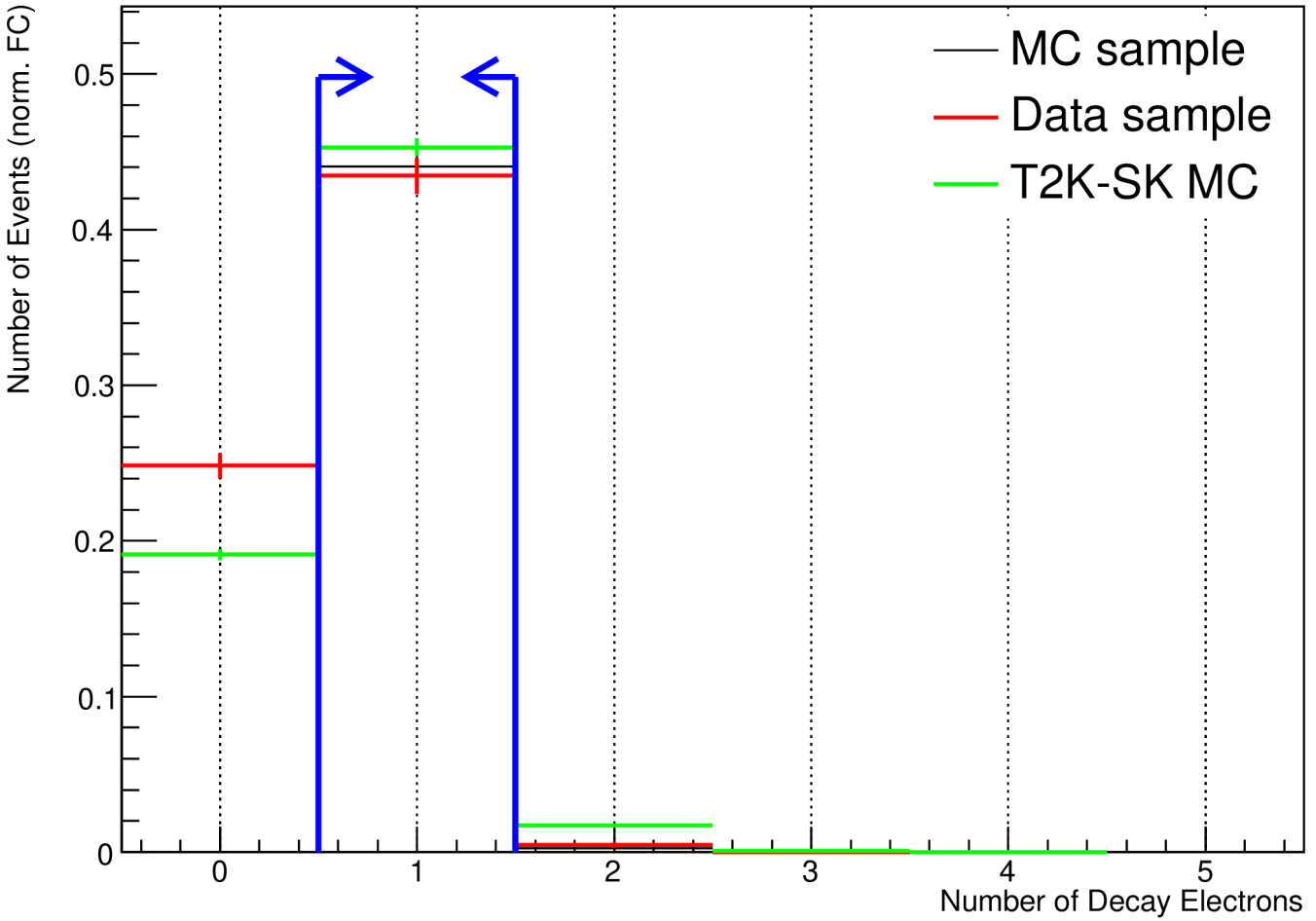
Wall > 50 cm


Number of Events (norm. FC)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
2
4
6
8
10
12
14
16
18
DWall [m]
MC sample
Data sample
T2K-SK MC

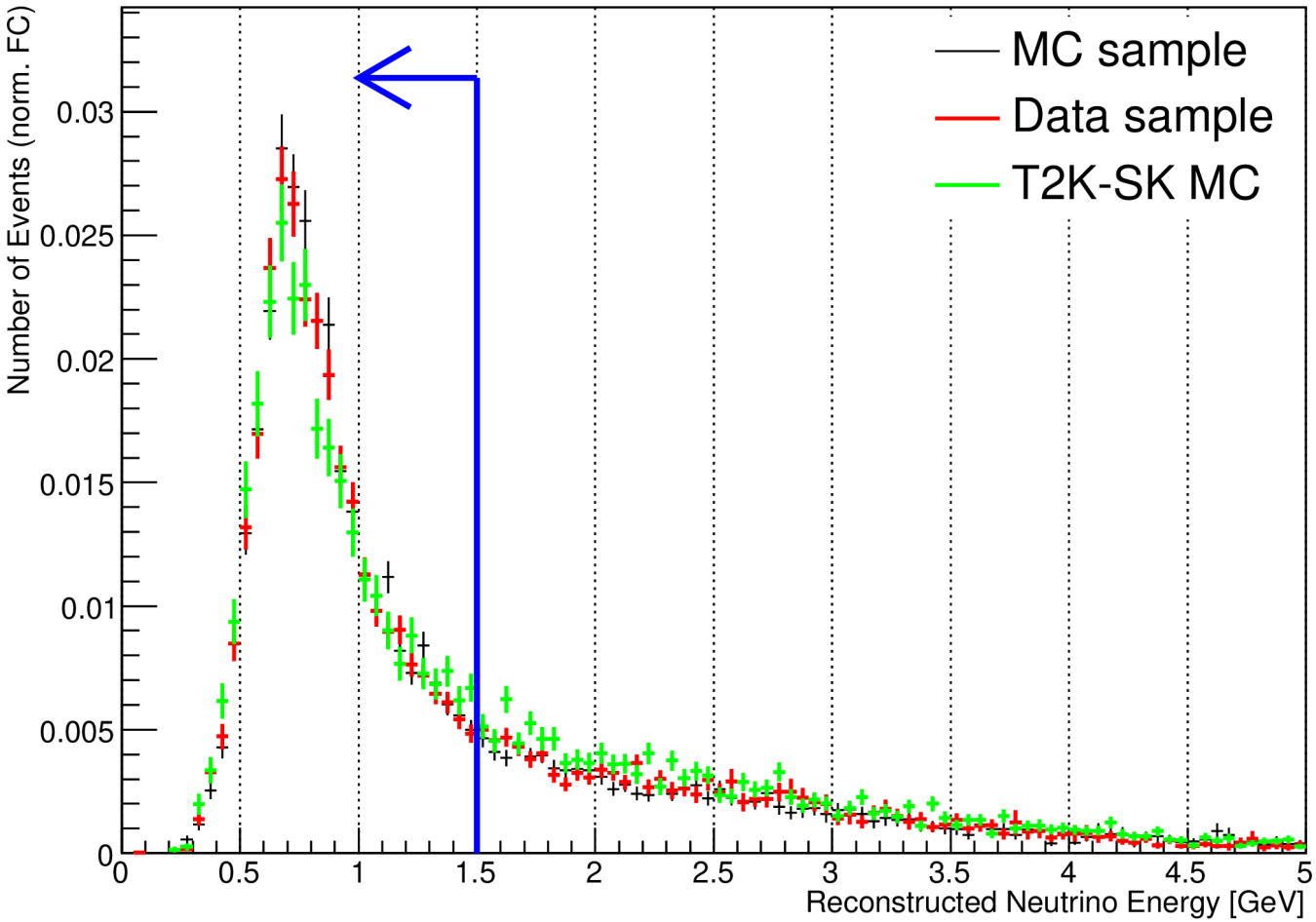
Not 1Re-like (TN319)



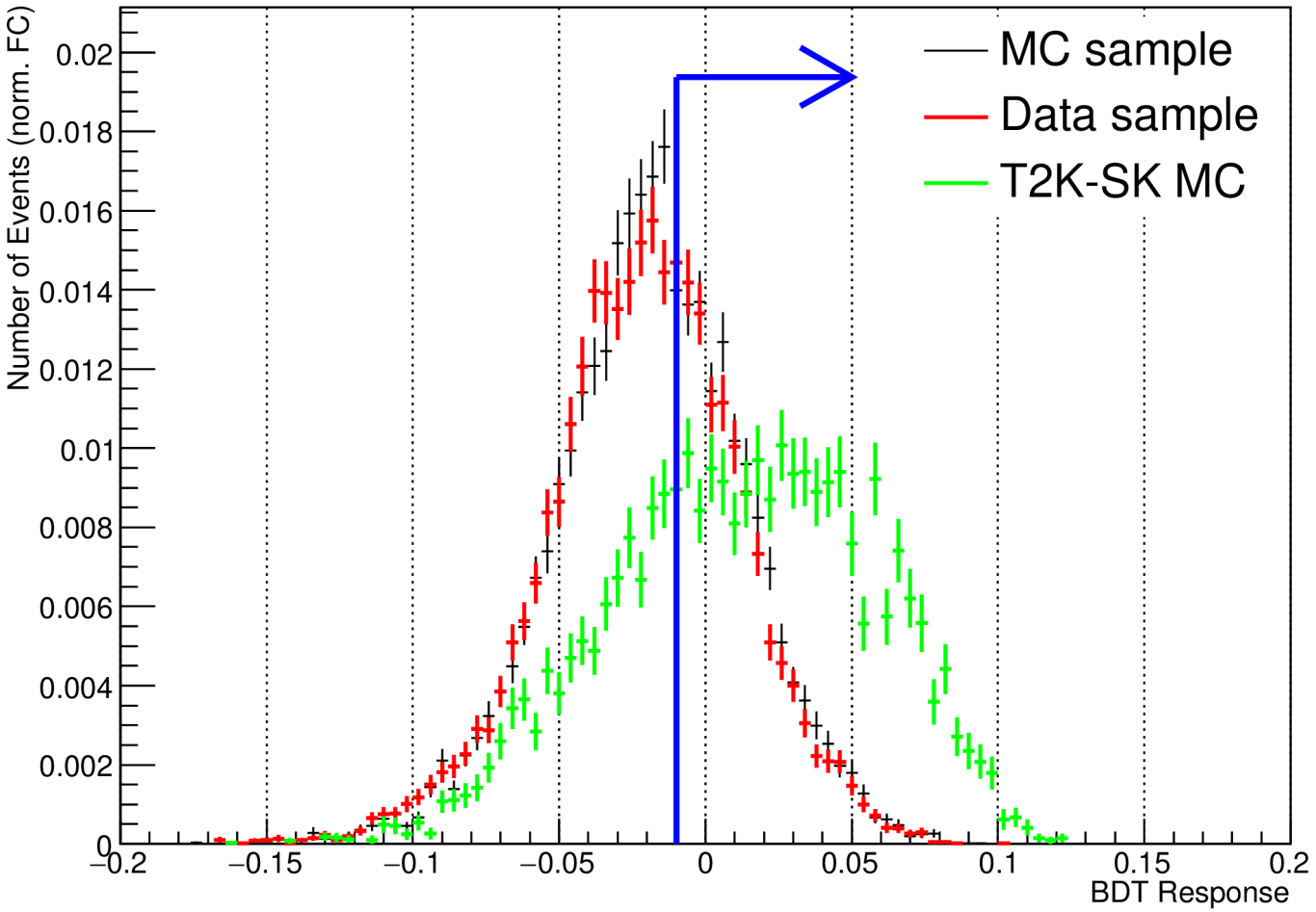
1 Decay Electron



E_{rec} < 1.5 GeV


MC sample
Data sample
T2K-SK MC
Number of Events (norm. FC)
0
0.005
0.01
0.015
0.02
0.025
0.03
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Reconstructed Neutrino Energy [GeV]

BDT Response > -0.0100



Thoughts on BDT Cut Discrepancy

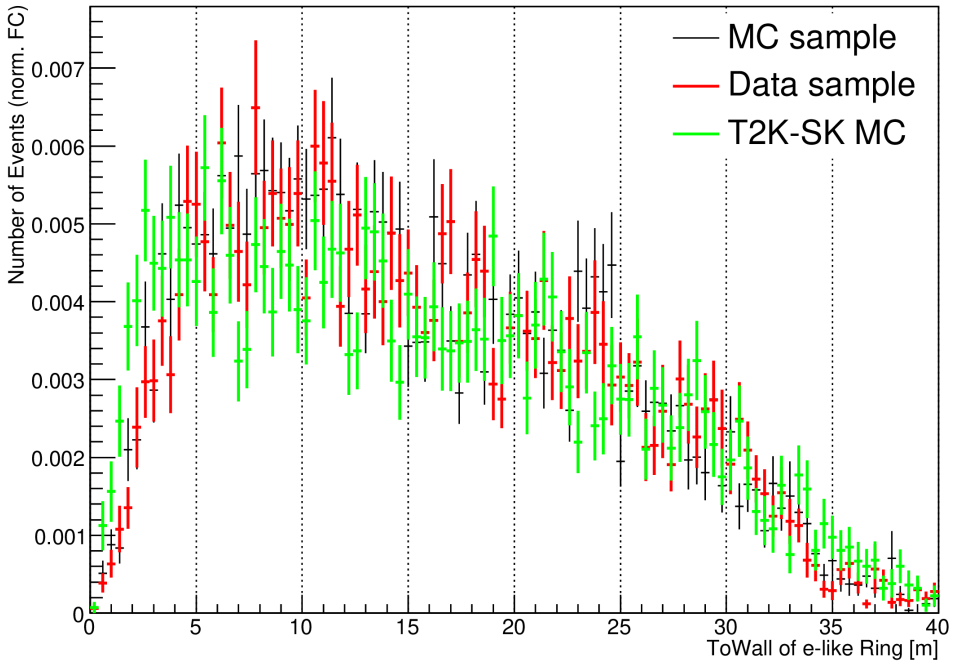
- Main difference between events in hybrid samples vs T2K-SK MC is the direction of the neutrino
  - It could be that the BDT is using this directionality in its event selection
    - For example, **ToWall distributions** might depend on directionality of incident neutrinos
- Or, there could be **differences between fiTQun v4 and fiTQun v5**
  - T2K-SK MC is reconstructed with SK14c libraries (fiTQun v4)
  - Hybrid samples are reconstructed with SK16c libraries (fiTQun v5)

2Reπ 1de BDT variables
likelihood ratios (up to 3 rings)
1-ring and 2-ring fit momenta
E_{rec} ($CC1\pi^{+}$)
Wall
ToWall e and π (2Reπ reconstruction)
distance between sub-events
$\cos(\theta_{e\pi})$ (2Reπ reconstruction)
p_{low} (2Reπ reconstruction)
reconstructed $m_{\pi 0}$

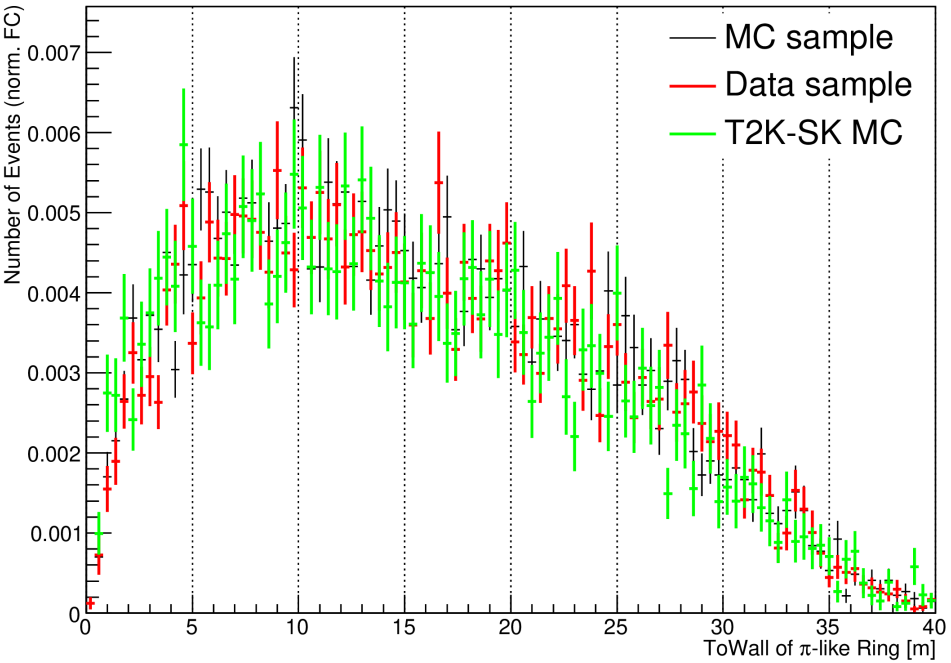
ToWall of e and π^+

after E_{rec} cut, before BDT cut

ToWall of e-like Ring



ToWall of π-like Ring

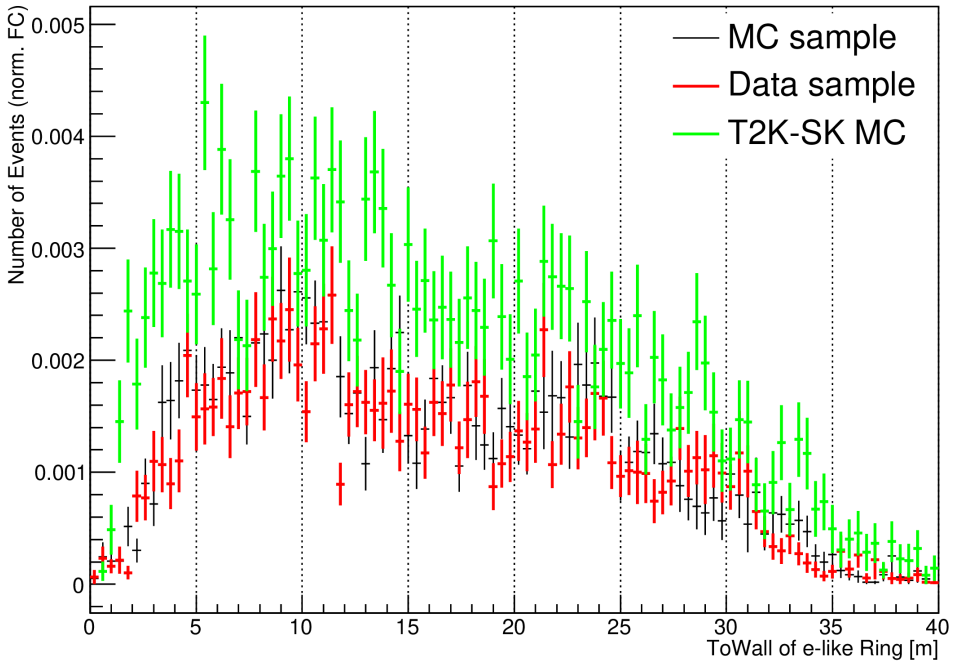


No significant discrepancy in ToWall distributions

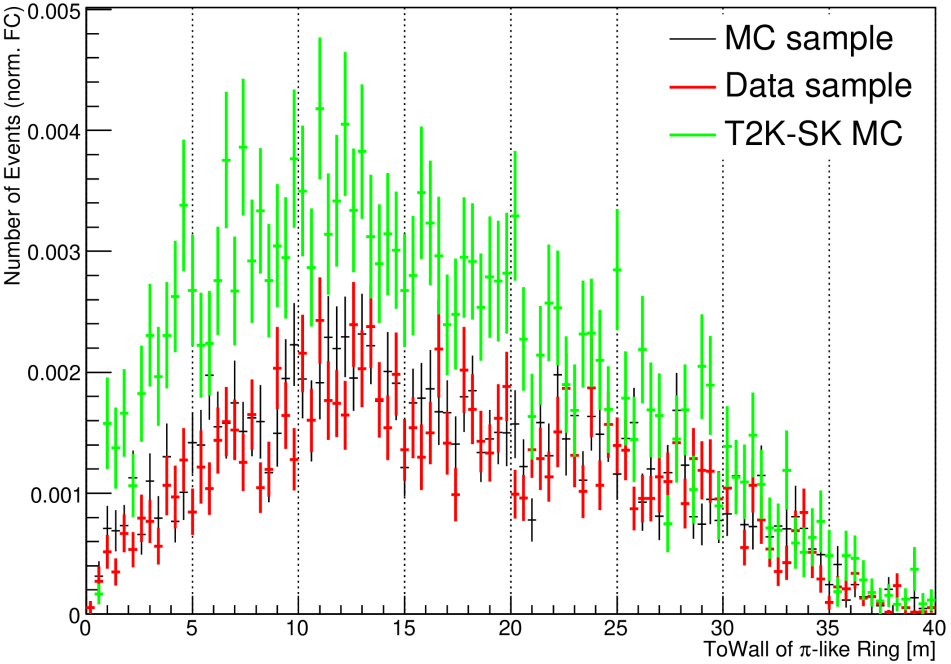
ToWall of e and π^+

Final Sample – after BDT cut

ToWall of e-like Ring



ToWall of π-like Ring



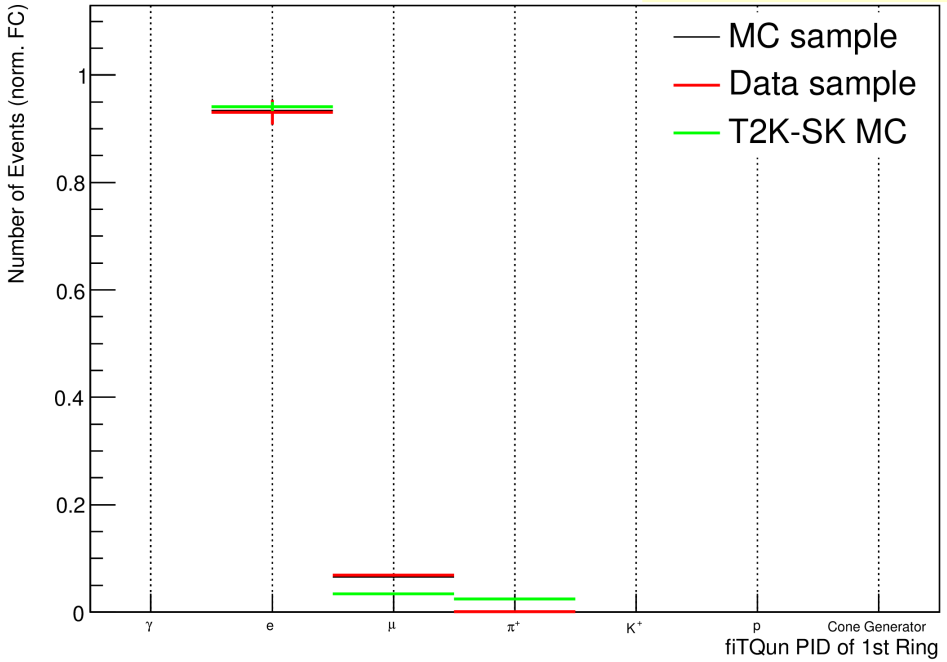
No significant discrepancy in ToWall distributions
(apart from normalisation)

fiTQun PID of 1st and 2nd ring

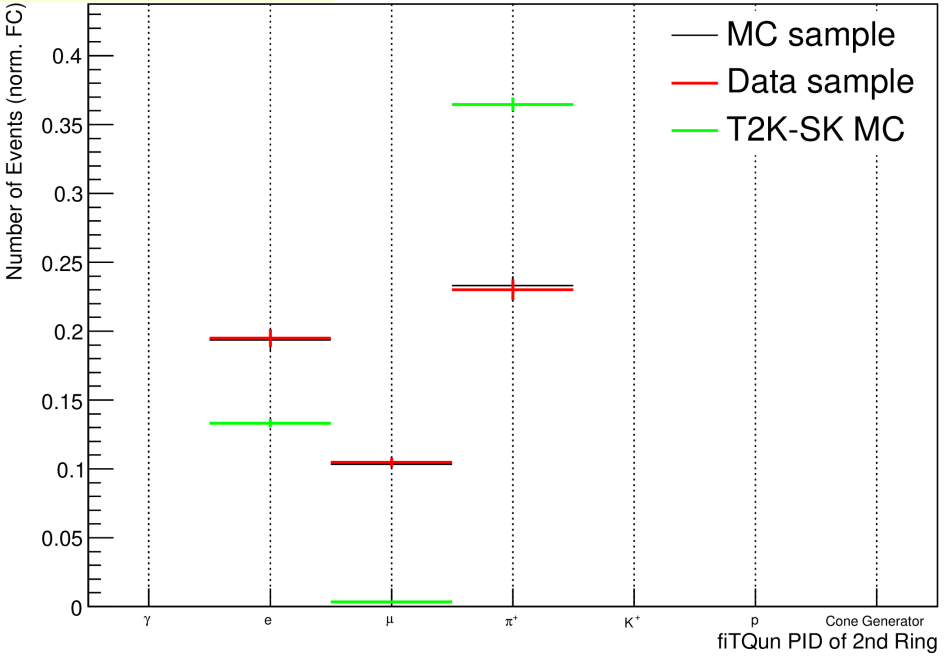
Fully Contained: after nhitac cut, before E_{vis} cut

Large discrepancy between hybrid sample and T2K-SK MC!

fiTQun PID 1st Ring



fiTQun PID 2nd Ring



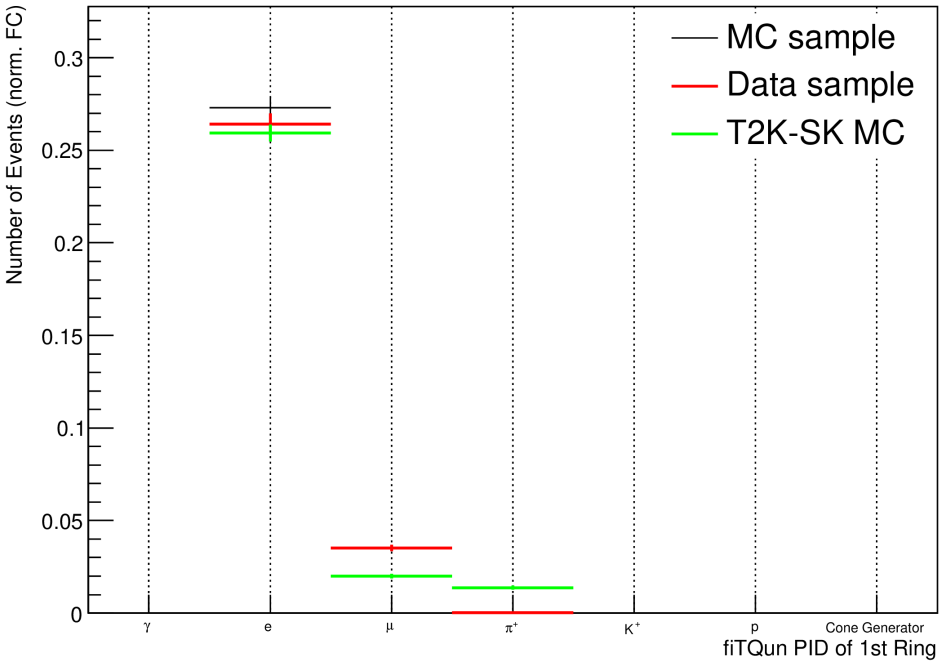
- fiTQun PID of 1st ring
  - fqmrpid[0][0]
- This variable is plotted for all events
  - since all events have at least 1 ring in favoured fiTQun reconstruction

- fiTQun PID of 2nd ring
  - fqmrpid[0][1]
- This variable is plotted for events with fqmrnring[0]>1

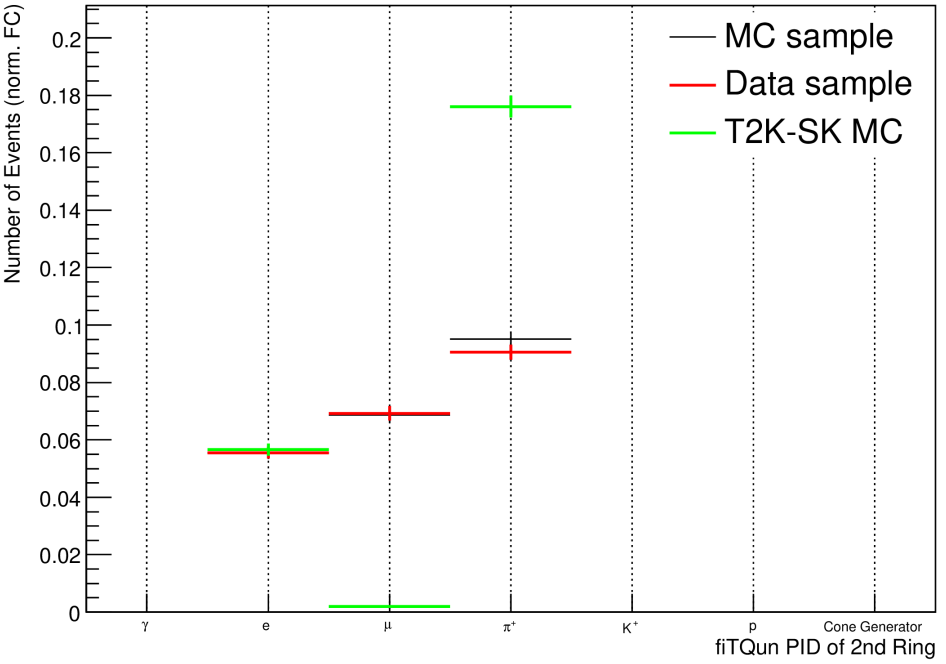
fiTQun PID of 1st and 2nd ring

after E_{rec} cut, before BDT cut

fiTQun PID 1st Ring



fiTQun PID 2nd Ring

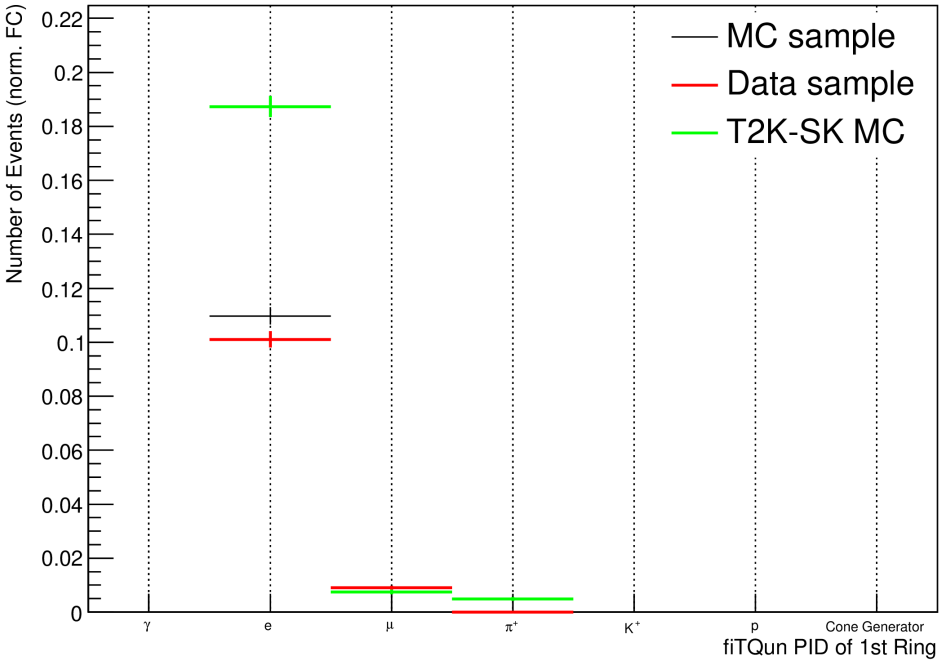


- Cris Vilela checked the PID distributions for the atmospheric SK MC, comparing fiTQun v4 and fiTQun v5
  - found similar discrepancy
- Therefore, the issue is likely not with my hybrid sample or BDT, but rather with fiTQun itself

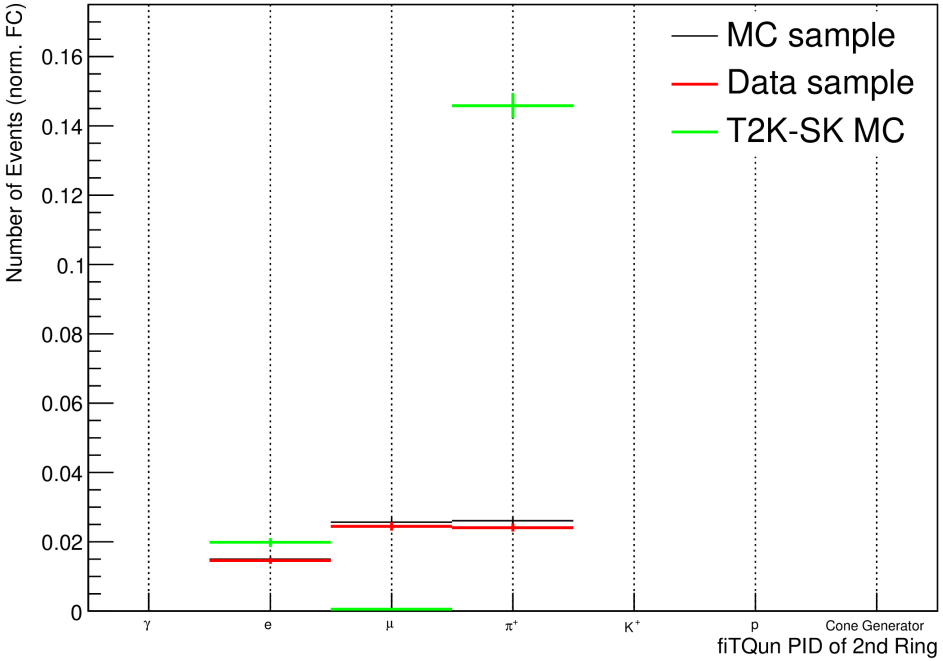
fiTQun PID of 1st and 2nd ring

Final Sample – after BDT cut

fiTQun PID 1st Ring



fiTQun PID 2nd Ring



Plan Moving Forward

- Cris is looking into the fiTQun v4 and fiTQun v5 discrepancy
- In the meantime, I plan to reconstruct the hybrid sample with fiTQun v4
  - Will probably wait until the weekend to submit jobs
    - Kamioka computer maintenance this week

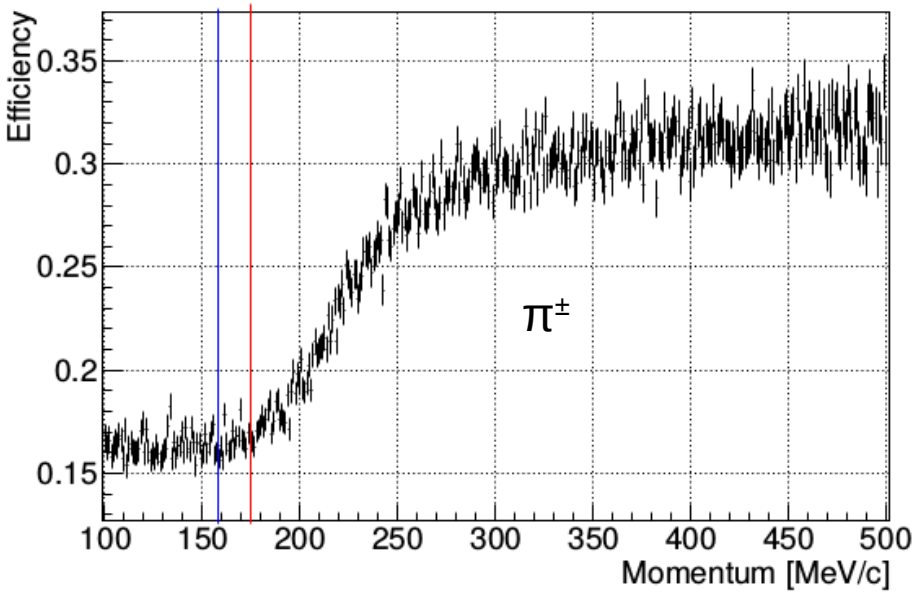
Backup

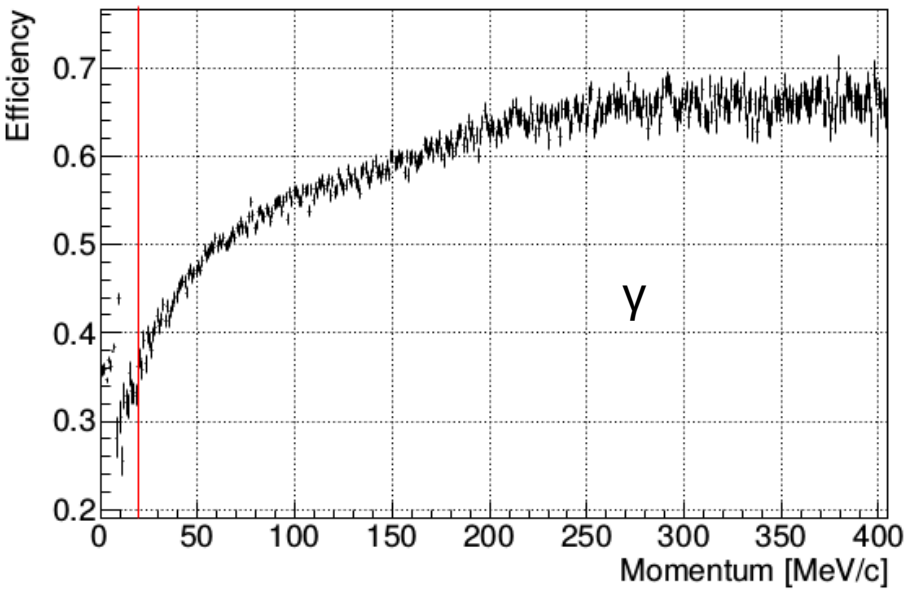
Final State Definition: Particle Thresholds

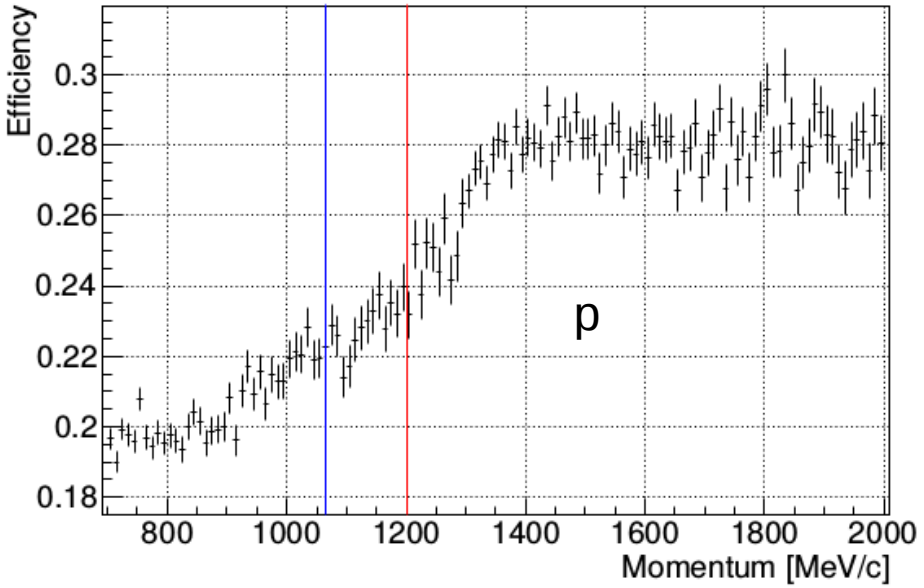
- Yoshida-san determined her thresholds by looking at fiTQun's ring detection efficiency (see next slide)
  - I changed my thresholds to be consistent with hers
- Table below shows the momentum thresholds used in my studies, as well as those used when selecting for $1e1\pi^+$ events for the hybrid sample

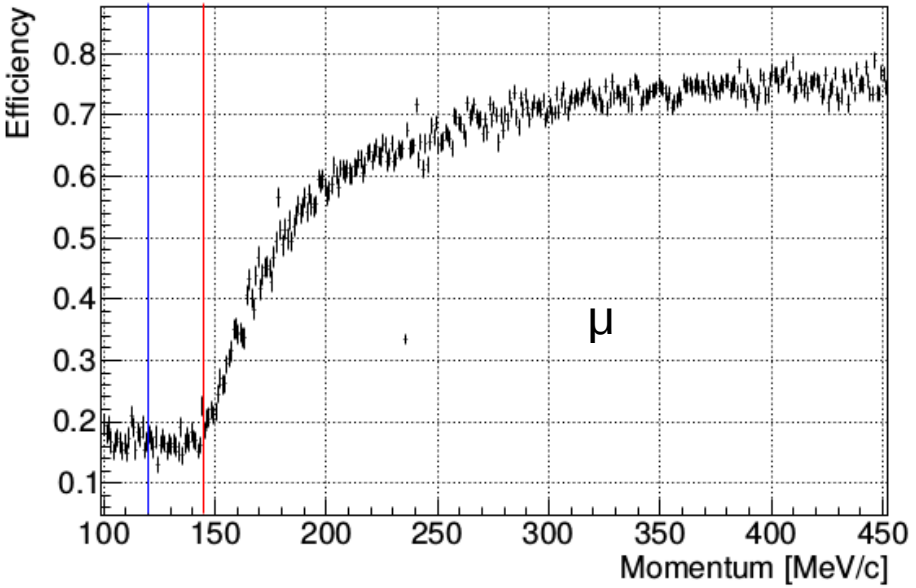
Particle	Final State Momentum Threshold	Hybrid Sample Construction Threshold
γ	20 MeV/c	20 MeV/c
e	10 MeV/c	30 MeV/c
μ	145 MeV/c	145 MeV/c
$\pi^{\pm}$	175 MeV/c	175 MeV/c
p	1200 MeV/c	1200 MeV/c
other	p/E > 0.75188	p/E > 0.75188

To be consistent with E_{vis} > 30 MeV cut applied when selecting for atmospheric e-like events









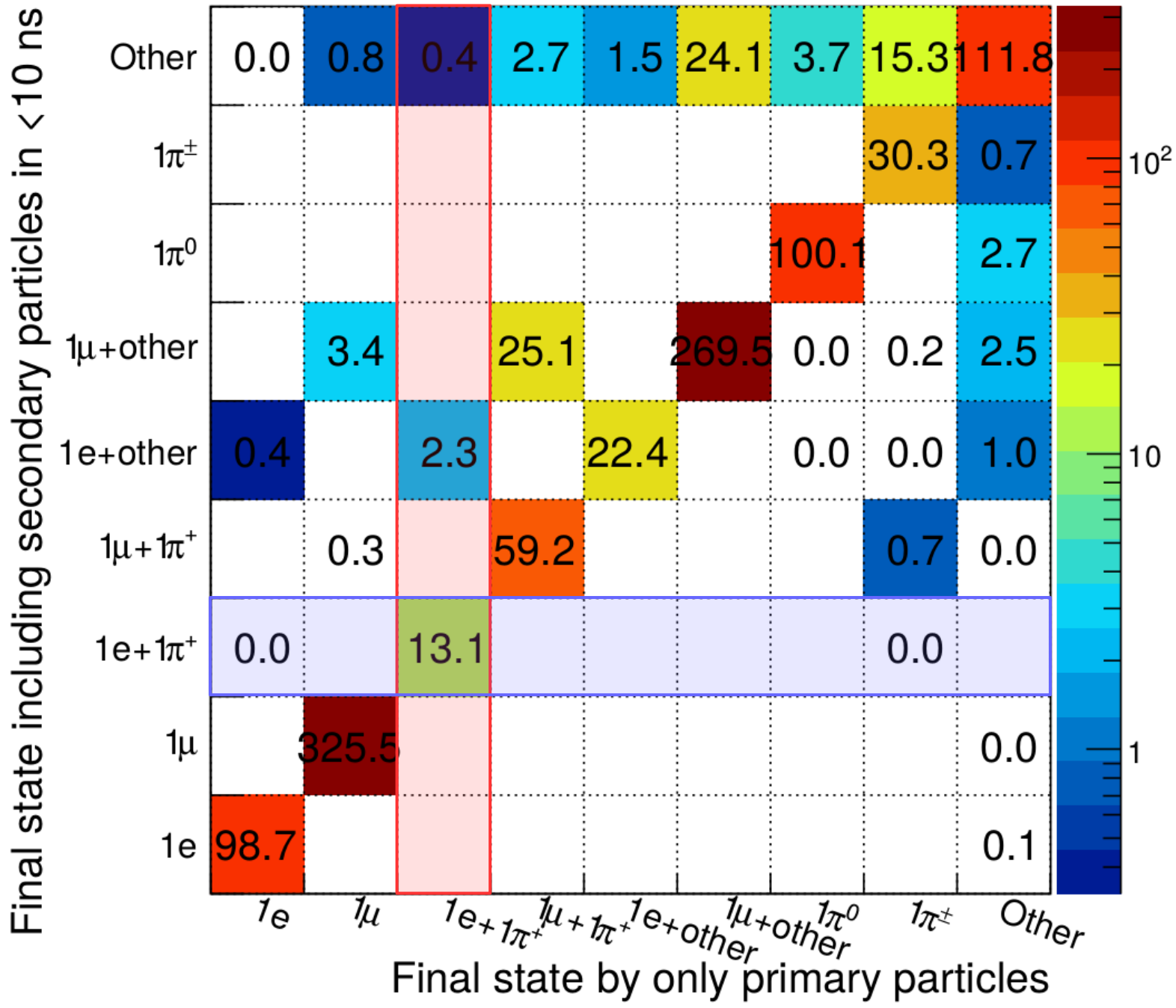
Note: the threshold for electrons (10 MeV/c) comes from the minimum momentum considered when tuning fiTQun likelihood functions

Primary and Secondary Banks

- Both primary and secondary particle banks are looked through when selecting for final state particles
  - This comes from Xiaoyue's final state definitions used in her atmospheric fit

Primary Stack (VCWORK)	Secondary Stack (CONVVECT)

• Requires Ichvc[i]==1 (i.e. flagged "to chase")
• Ignore nucleus
• Ignore neutrons
	• Ignore particles produced with GEANT interaction code corresponding to:
	  • pair production
	  • Compton scattering
	  • photo-electric
	  • Bremsstrahlung
	  • below tracking threshold
	• Ignore nucleus
	• Ignore neutrons
	• Ignore events with generated time > 10 ns
	• Ignore particles with same ID as parent (i.e. scattered particles)
	• Ignore gammas with π^0 parent particle


Final state including secondary particles in <10 ns
Other
1π±
1π0
1μ+other
1e+other
1μ+1π+
1e+1π+
1μ
1e
0.0 0.8 0.4 2.7 1.5 24.1 3.7 15.3 111.8
30.3 0.7
100.1 2.7
3.4 25.1 269.5 0.0 0.2 2.5
0.4 2.3 22.4 0.0 0.0 1.0
0.3 59.2 0.7 0.0
0.0 13.1 0.0
325.5 0.0
98.7 0.1
1e 1μ 1e+1π+ 1μ+1π+ 1e+other 1μ+other 1π0 1π± Other
Final state by only primary particles
10²
10
1