ν_μ disapperance analysis: preliminary results

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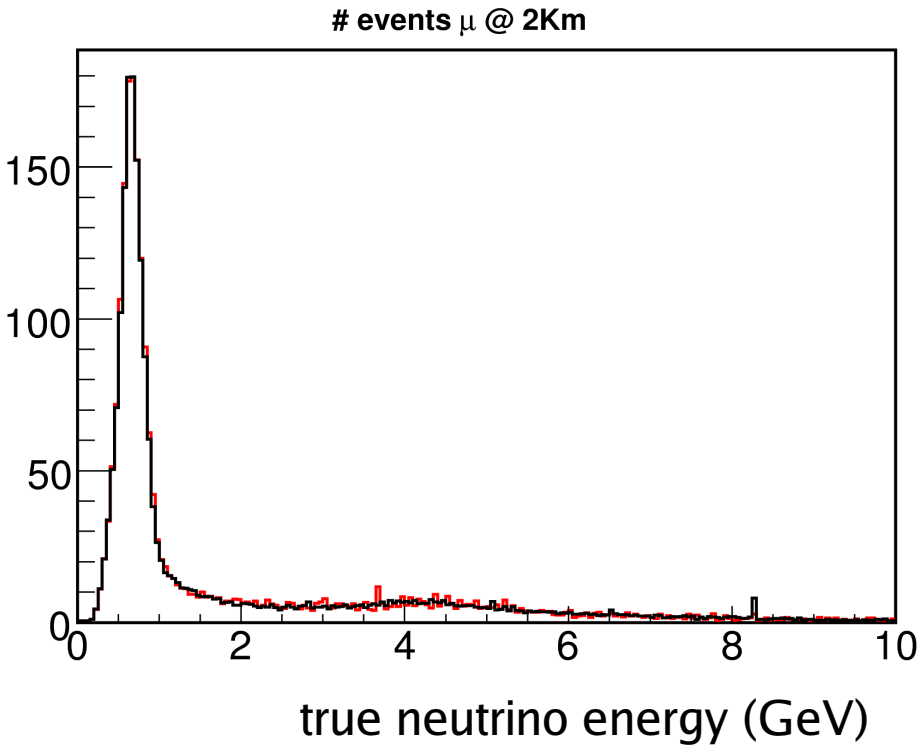
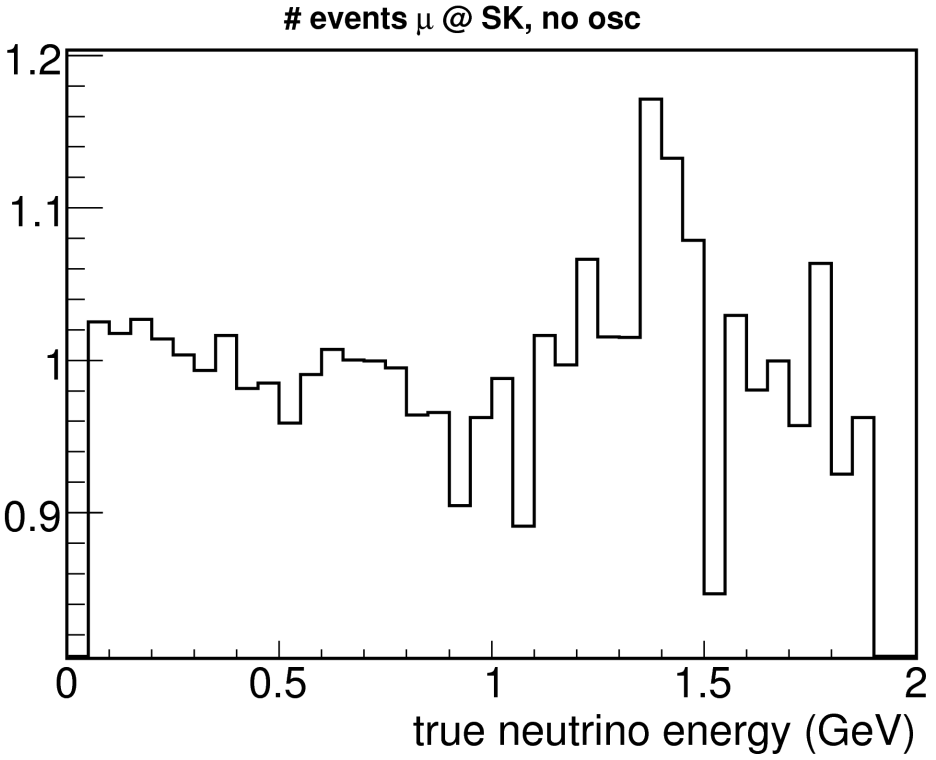
Goals

- Study ν_μ spectra at SK and 2KM
- Quantify the differences between unoscillated spectra
- Find the areas causing remaining differences
- In the rest of this talk all oscillations have been turned OFF.

Event rates at SK and 2KM





If true neutrino energy < 1 GeV, the differences are ~ +/- 5% until about 1 GeV

Analysis

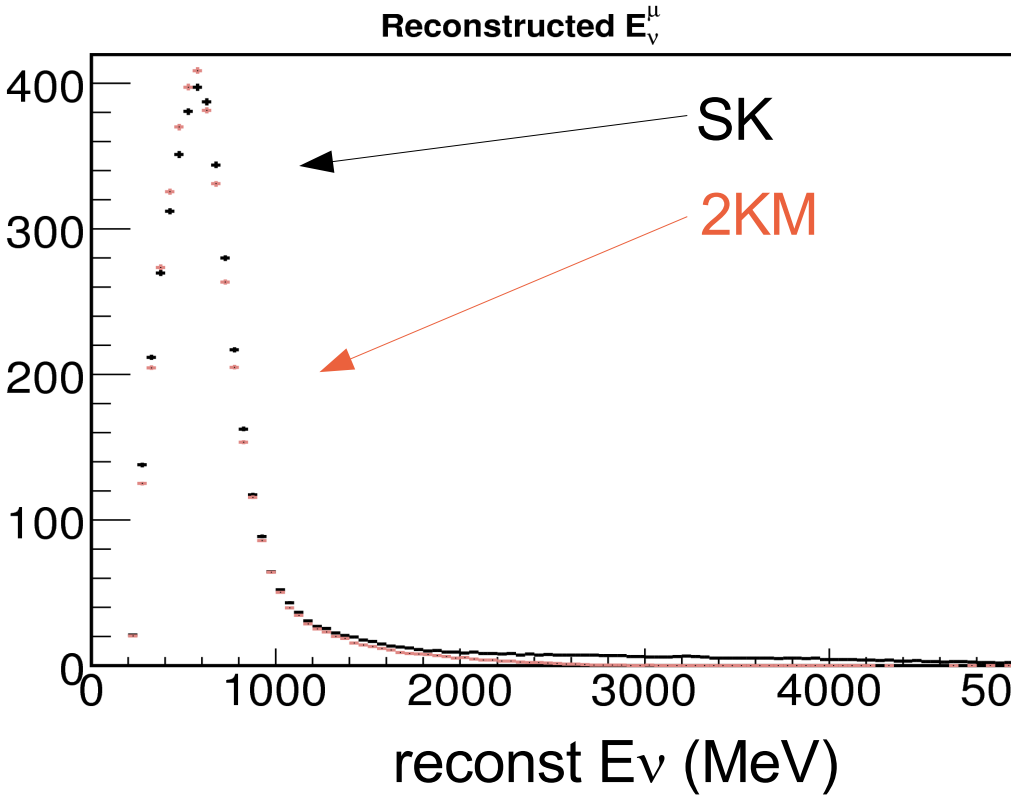
- Use a simple list of cuts :
  - “clean up” low energy events : Evis>30 MeV, muon momentum > 200 MeV
    total charge > 200 p.e. (SK)
  - Fiducial Volume (22.5kt SK, 100t or 56t at 2KM)
  - FC cut (#OD clusters <10 at SK, max individual charge<100 pe @ 2KM)

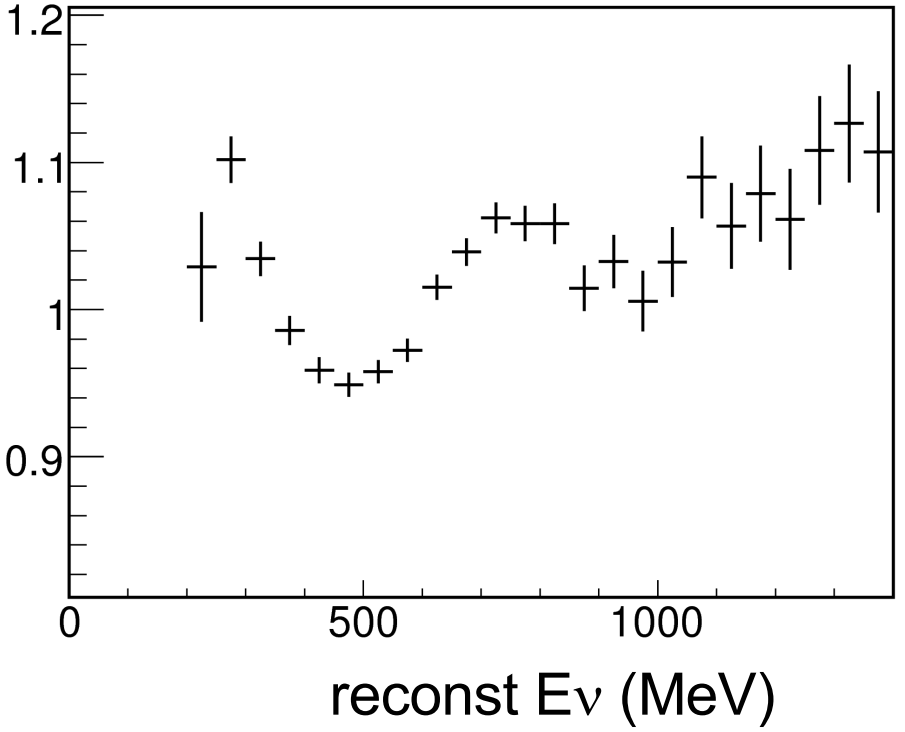
this cut has to be studied in details: there is a large difference in acceptance between the two detectors

  - 1 ring, mu-like events

- Compare $P\mu$ and $\theta\mu$, and also $E\nu$, without any F/N corrections (simple $1/L^2$ and fiducial mass scaling)

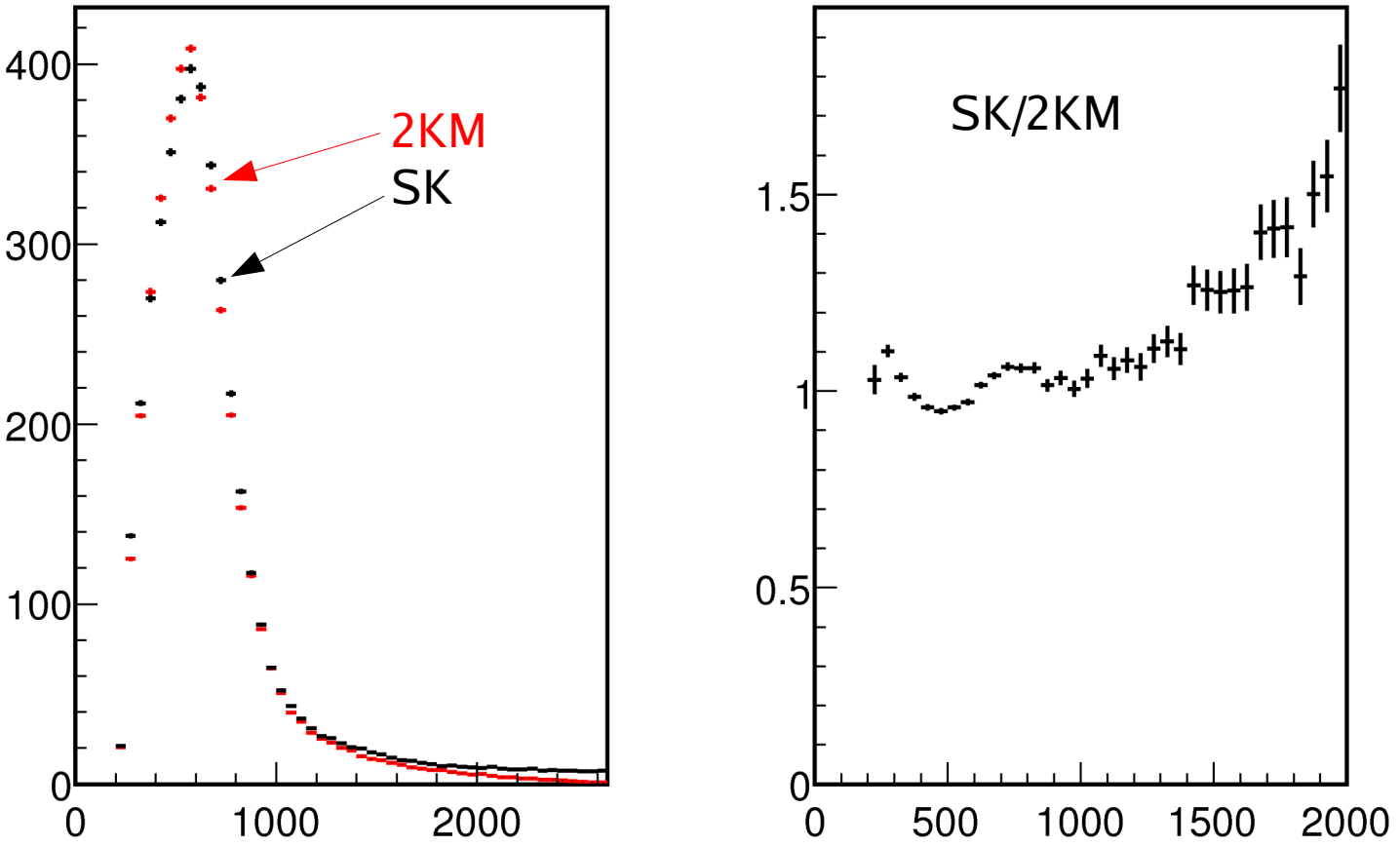
Results





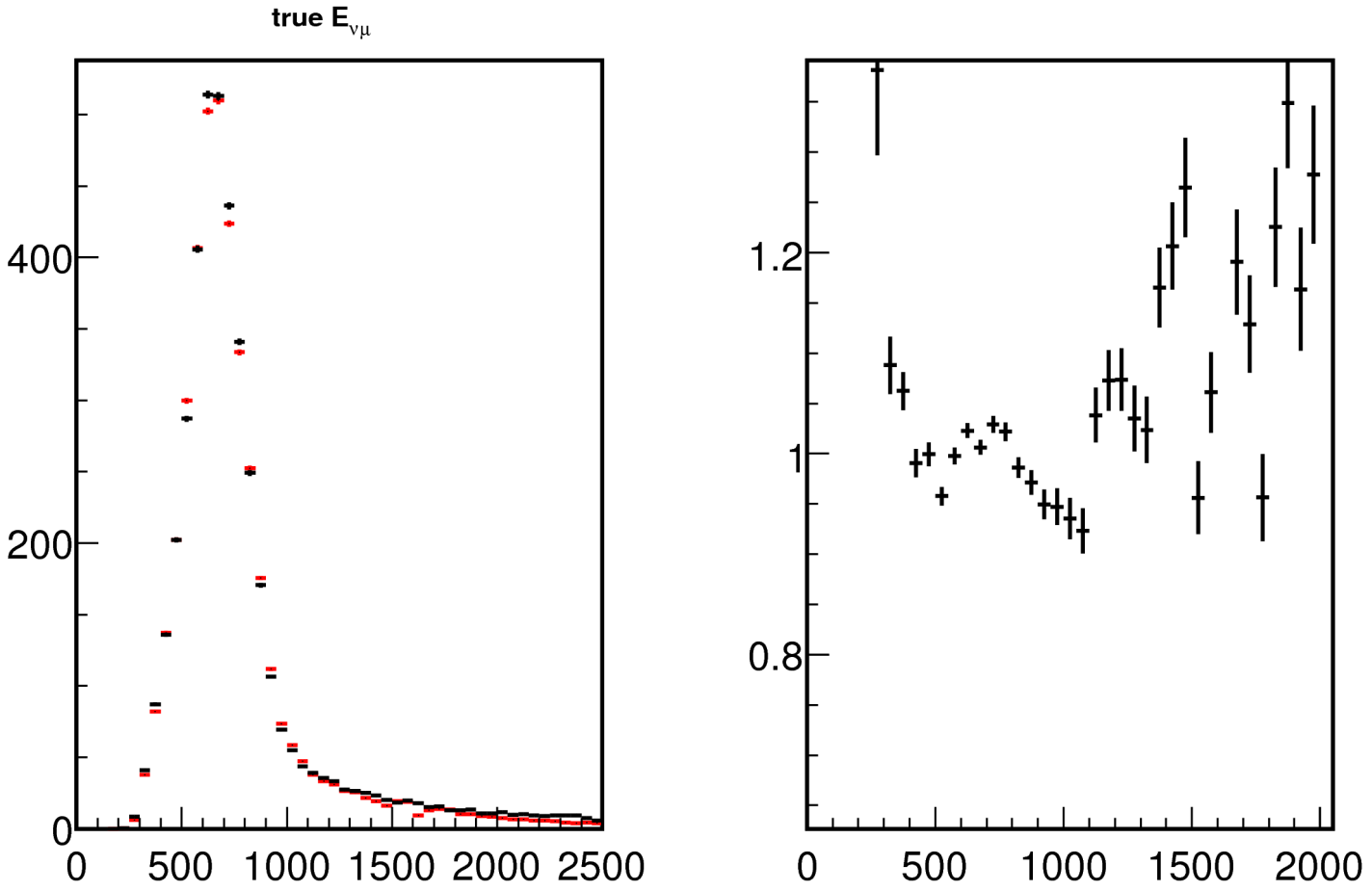
- Longer “tail” at SK because better FC acceptance
- structure in the peak area : the peak occurs at slightly lower values at 2KM & the spectrum is slightly narrower.
- Overall differences around peak on the order of +/-6%

CCQE spectra



reconstructed neutrino energy (MeV) for CCQE events only
after all selection cuts (FV,low energy cuts, FC, 1 ring mu-like)

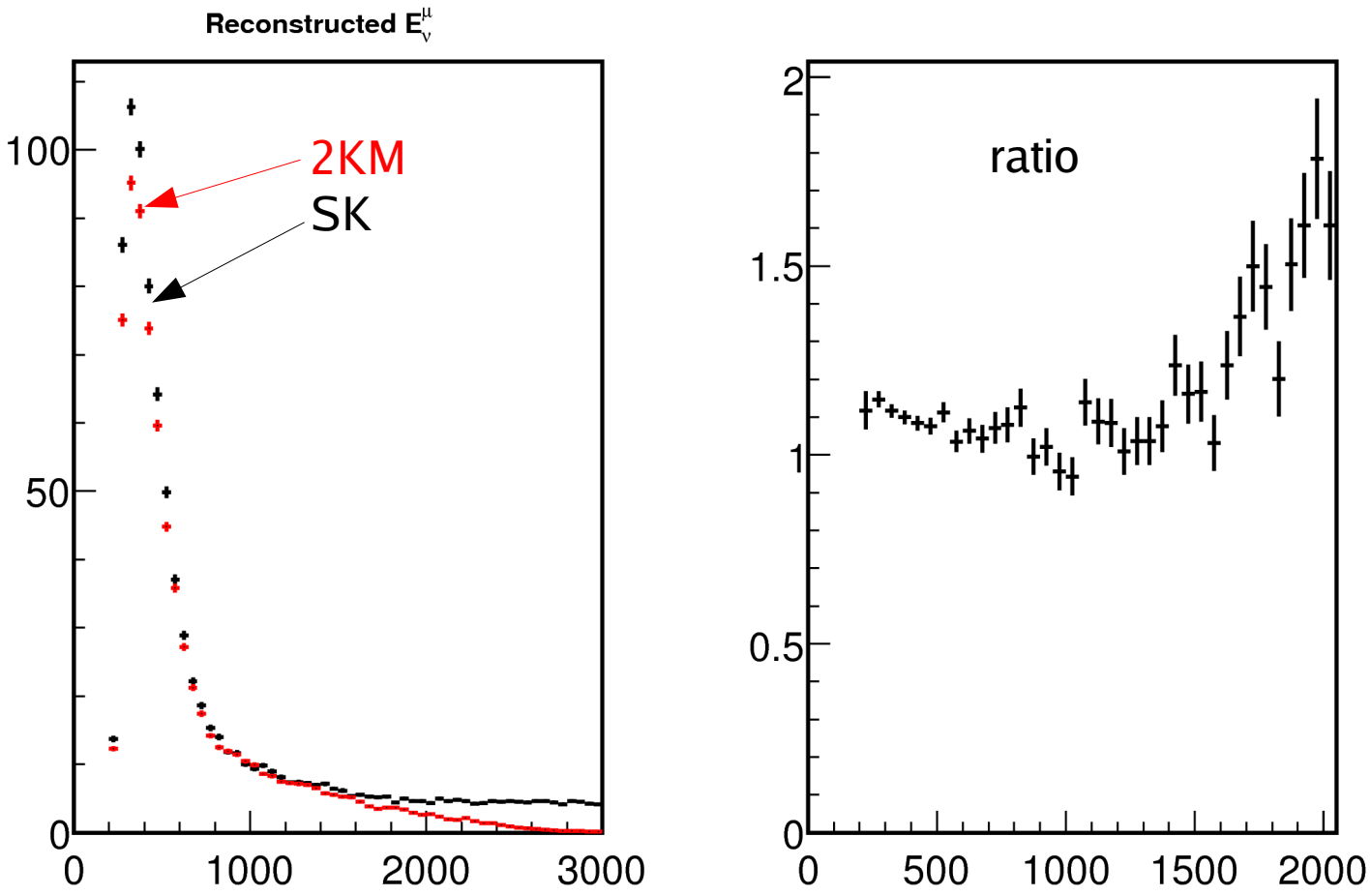
The structure is present in the pure CCQE sample



True energy, CCQE events after all cuts

Reconstruction effect ?

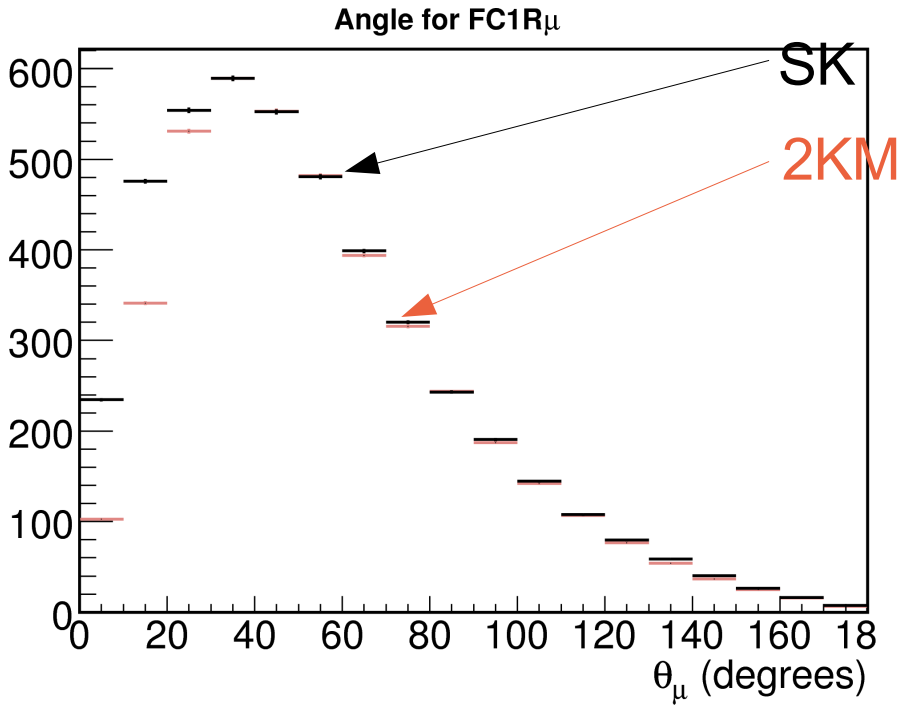
non QE spectra

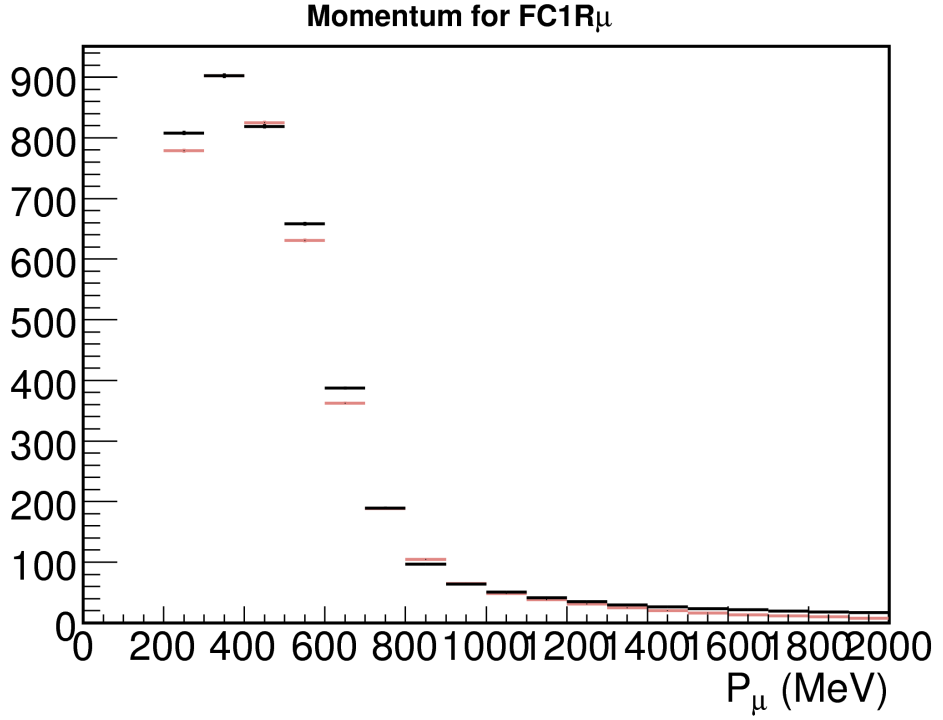


reconstructed neutrino energy (MeV), non-QE events after all cuts

Larger differences : the peak seems to be much “sharper” at SK

More results





- P_μ and θ_μ "make" the reconstructed energy distribution
- Momentum distributions have ~10% differences
- large difference (~50%) for low values of the angle : caused by acceptance.

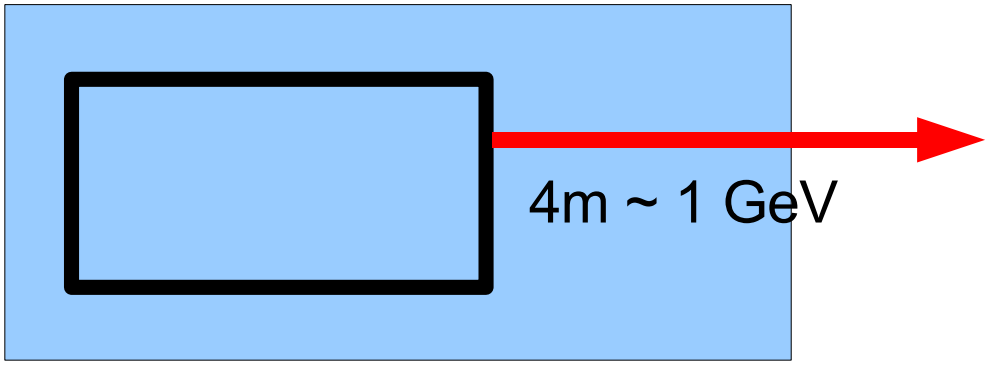
Efficiencies

Cuts	2KM	eff	cut eff	SK	eff	cut eff
FV, low E	924808	1.000		7574	1.000	
FC	742301	0.803	0.803	6935	0.916	0.916
1 ring	531015	0.574	0.715	4835	0.638	0.697
mu like	492165	0.532	0.927	4520	0.597	0.935

- "Efficiency" columns : the denominator is the "FV, low E" number
- "Cut efficiency" columns : the efficiency of each successive cut is computed
- Clearly the biggest difference is the FC/PC cut : SK has much larger acceptance than 2KM
- Ring counting and PID both seem to have small differences (~2%)

Acceptance correction

- The simplest way is to apply an extra cut on the visible energy and reduce the FV
- In the 2KM tank, muons on the downstream edge need to cross 4m of water to leave the tank -> ~ 1 GeV
- So if evis>~1 GeV more events are lost than at SK, but below 1 GeV it should be closer to SK
- Use a smaller FV (56t) instead of the regular 100t volume : vertices will be further away from the wall and more events will be contained

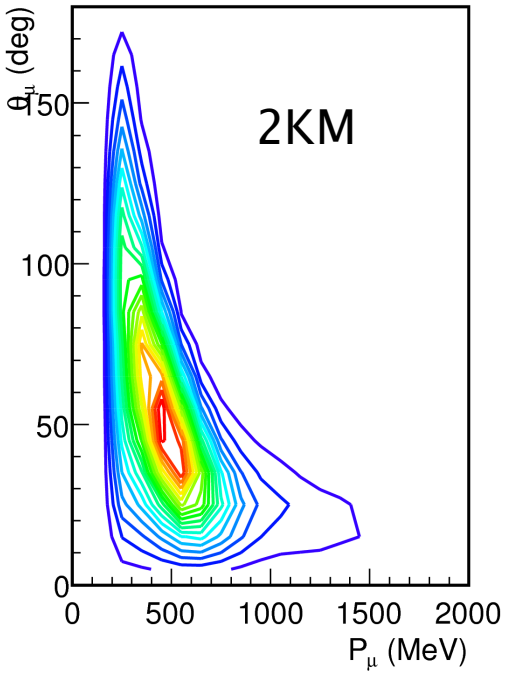


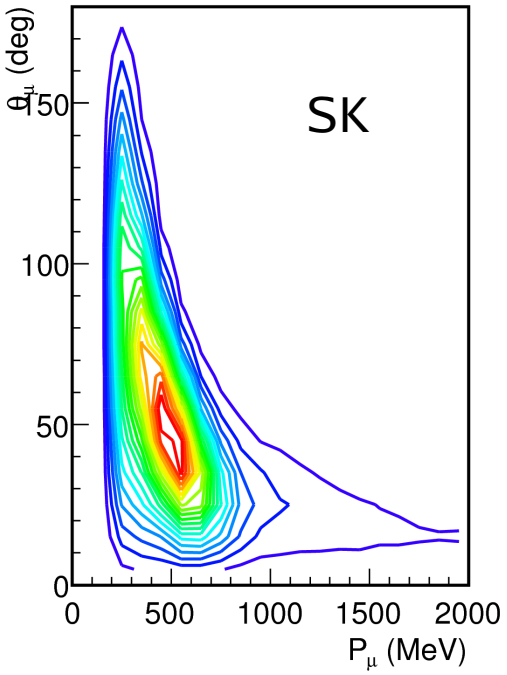
Efficiencies with new cuts

2KM : FV has 56 tonnes
2KM and SK : add “evis<1000 MeV” cut

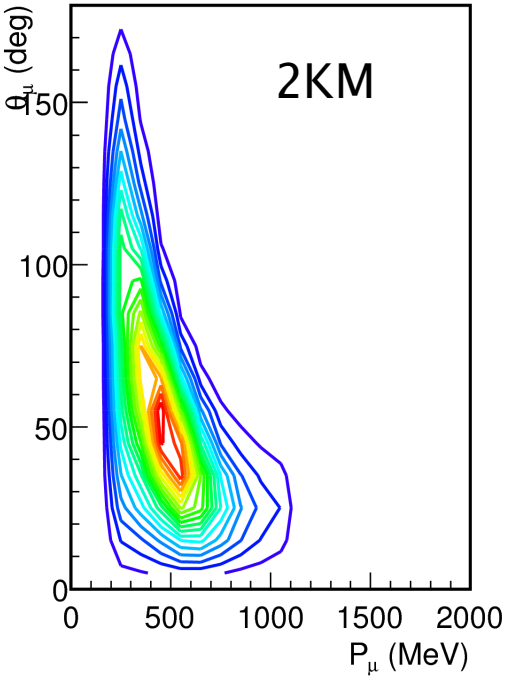
Cuts	2KM	eff	cut eff	SK	eff	cut eff
FV, low E	518660	1.000		7574	1.000	
FC	352104	0.679	0.679	5210	0.688	0.688
1 ring	278308	0.537	0.790	4210	0.556	0.808
mu like	263003	0.507	0.945	3966	0.524	0.942

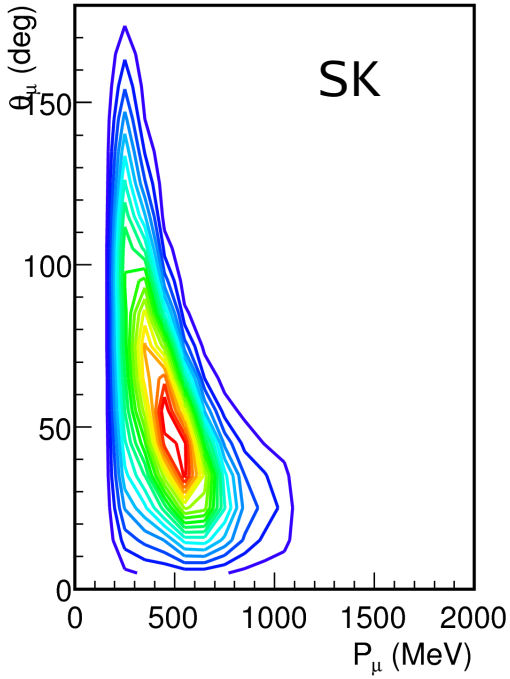
- Efficiency columns : the denominator is the “FV, low E” number
- Cut efficiency column : the efficiency of each successive cut is computed
- Much better, the acceptance cuts are now very close to each other
- Ring counting and PID still have small differences (~2%)
- This is crude. There are other methods (weighting) that could be used to compensate for the large differences in acceptance.





All cuts except Evis<1000 MeV

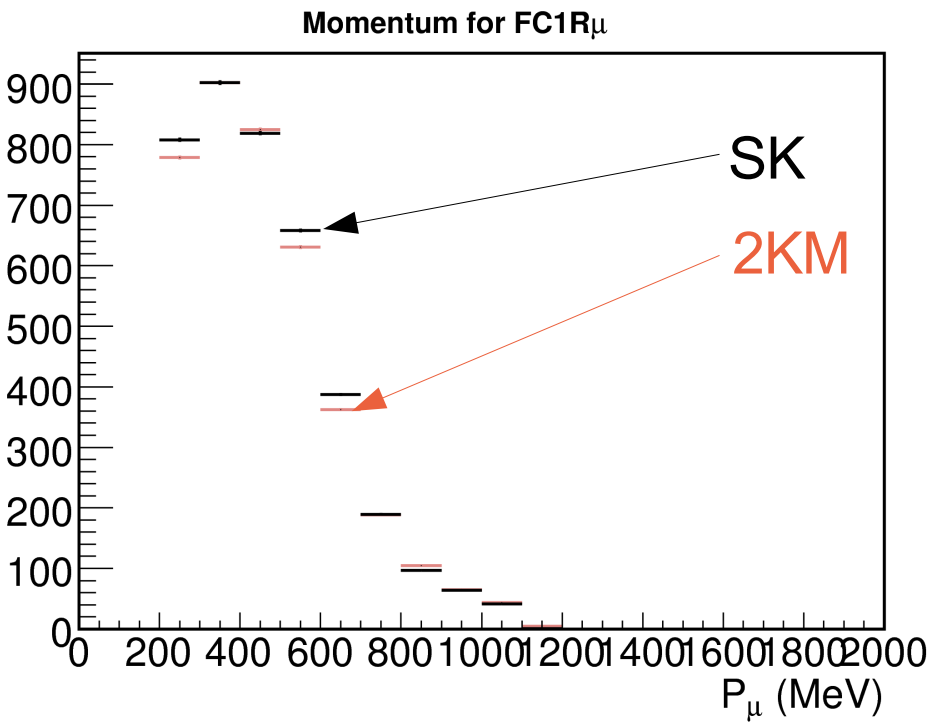


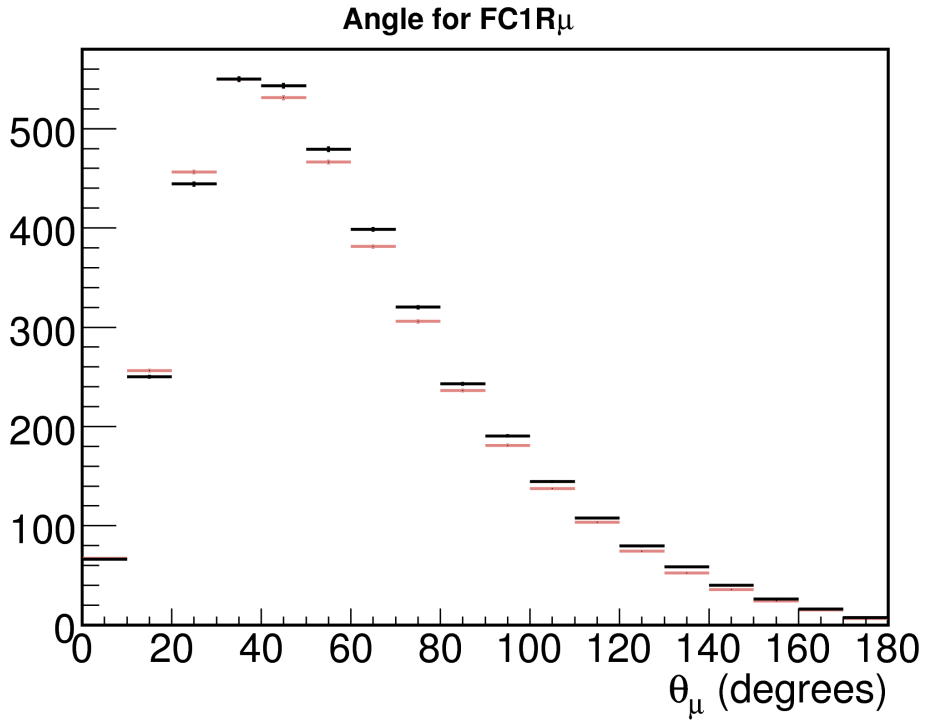


All cuts with :
- 56t FV @ 2KM
- Evis<1000 MeV at both positions

Better agreement

Results with tighter cuts

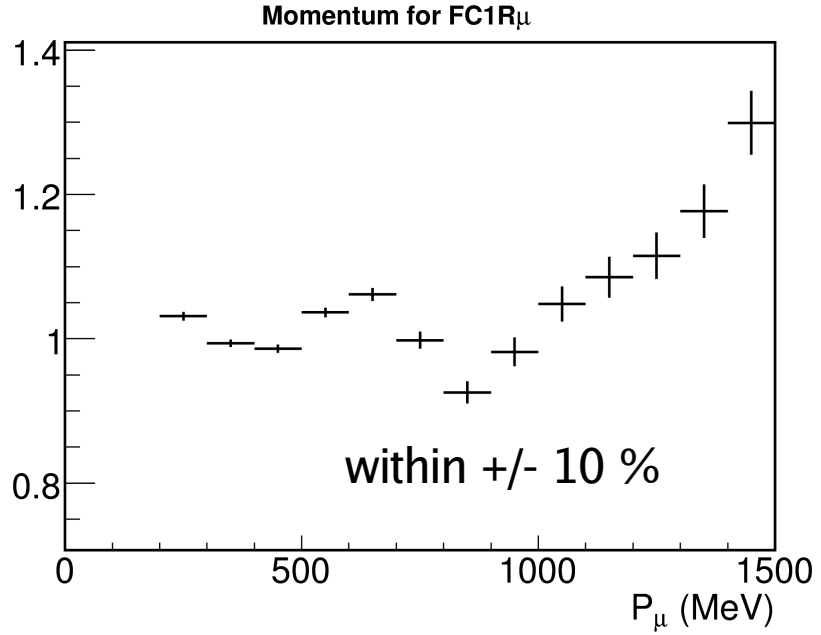


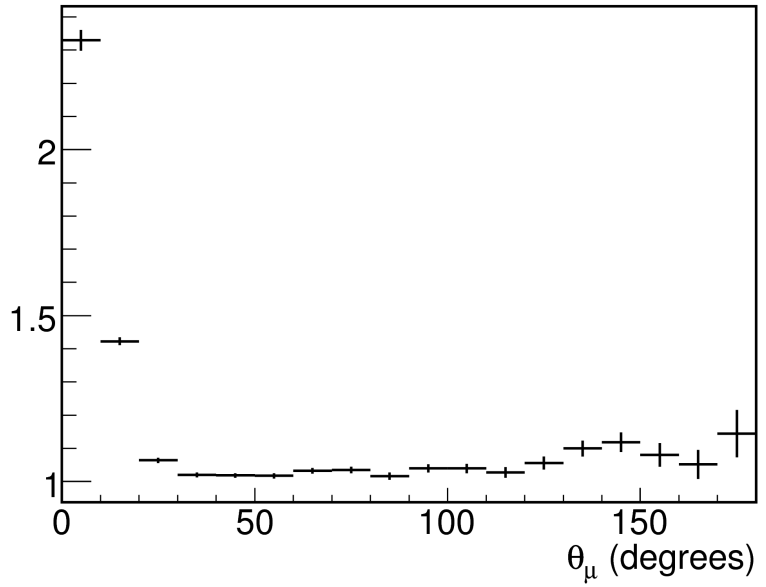


Removes the gap at low values of θ_μ

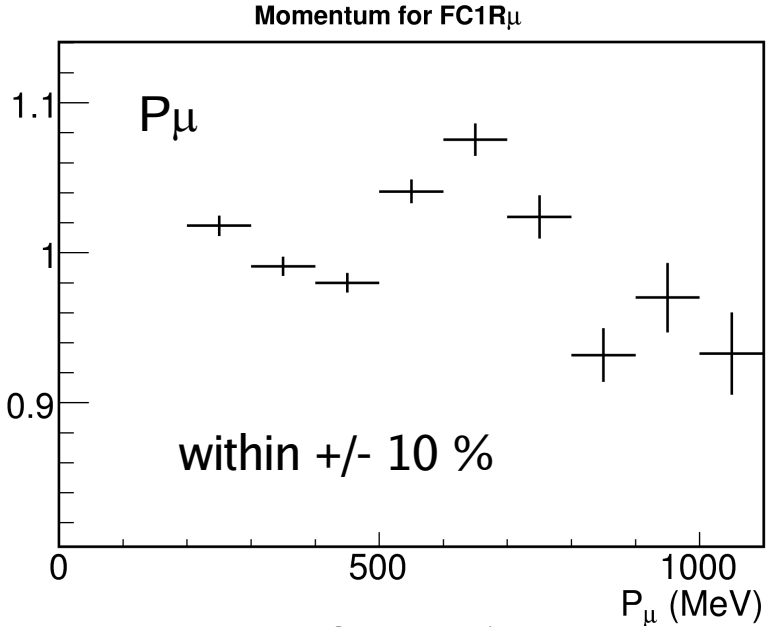
Ratios of momentum and angle distributions

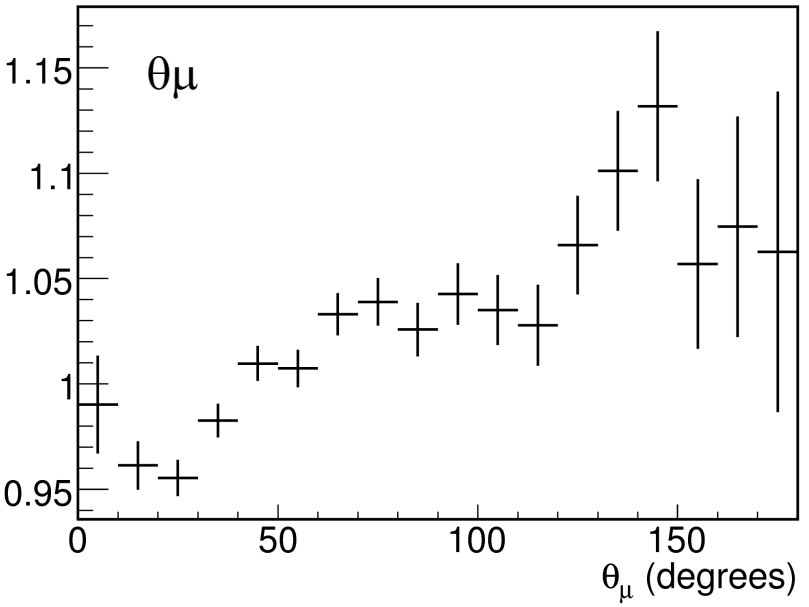
FV 100t @ 2KM
No Evis cut



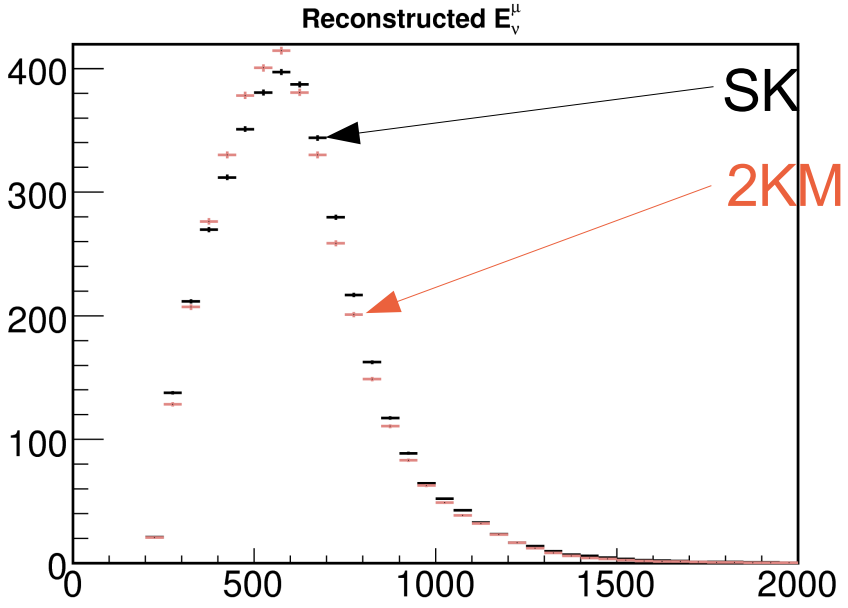


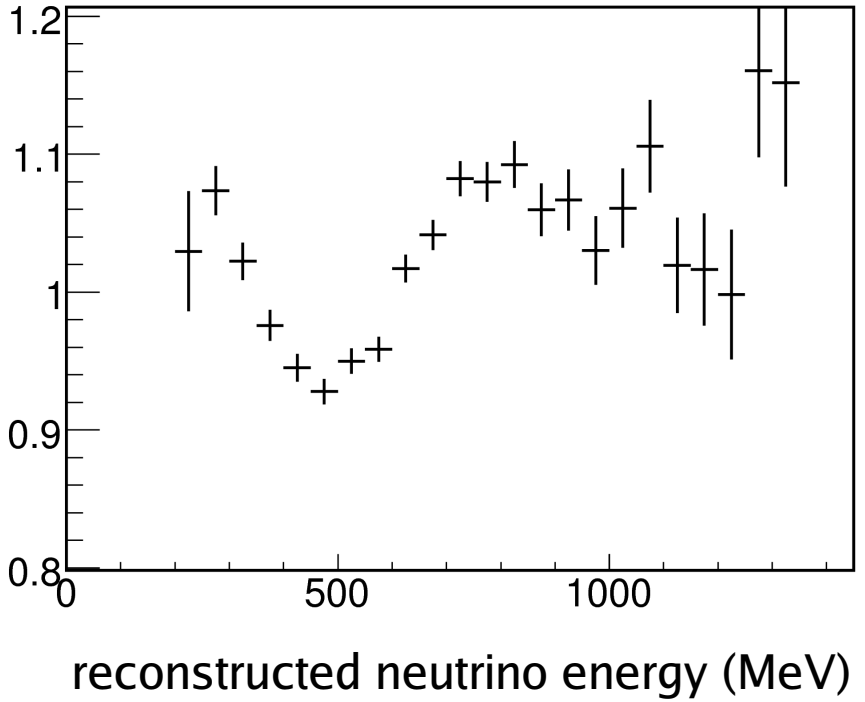
FV 56t
Evis < 1000 MeV @ SK & 2KM





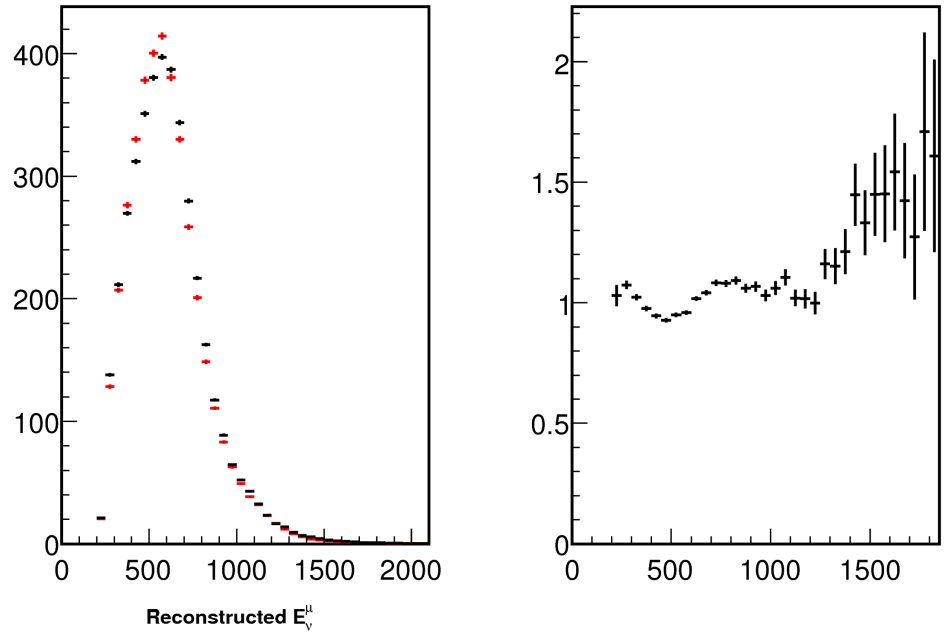
Spectra with tighter cuts





No improvement on the reconstructed spectrum with the Evis cut and the reduced fiducial volume

CCQE and nQE spectra



same structure

Conclusion

- At the “event rate” level, differences between SK & 2KM nm spectra are ~ +/- 5 %
- Using only simple scaling, after reconstruction, the differences are ~ +/- 6% (1 ring mu-like events)
- Efficiency studies show that the largest difference comes from FC/PC acceptance
- We can apply a tighter cut (FV 56t @ 2KM && evis <1000)
- This helps the efficiencies as well as the $P\mu$ and $\theta\mu$ distributions
- But the spectral differences are not improved : need more studies.

Supplemental slides

SK : overlayed QE/nQE spectra