Options for a Detector at the Second Oscillation Maximum in the NuMI Beam

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Introduction

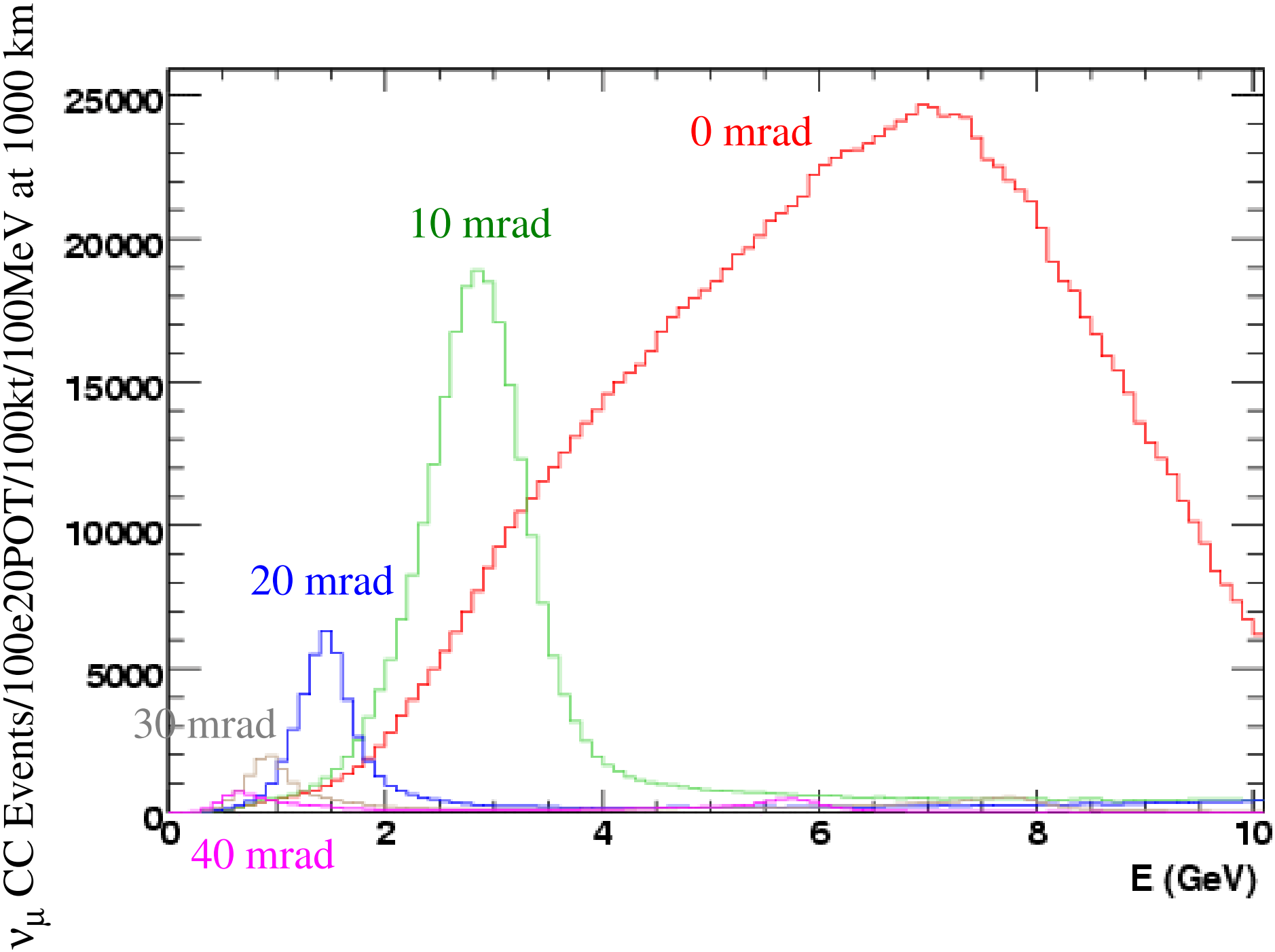
- This represents my first week of thinking carefully about a detector at the 2nd oscillation maximum. Apologies in advance to those who have thought about it more.
- I first wanted to answer two questions:

[1] Is LE or ME better for running the "NOVA-I" and "NOVA-II" detectors simultaneously?

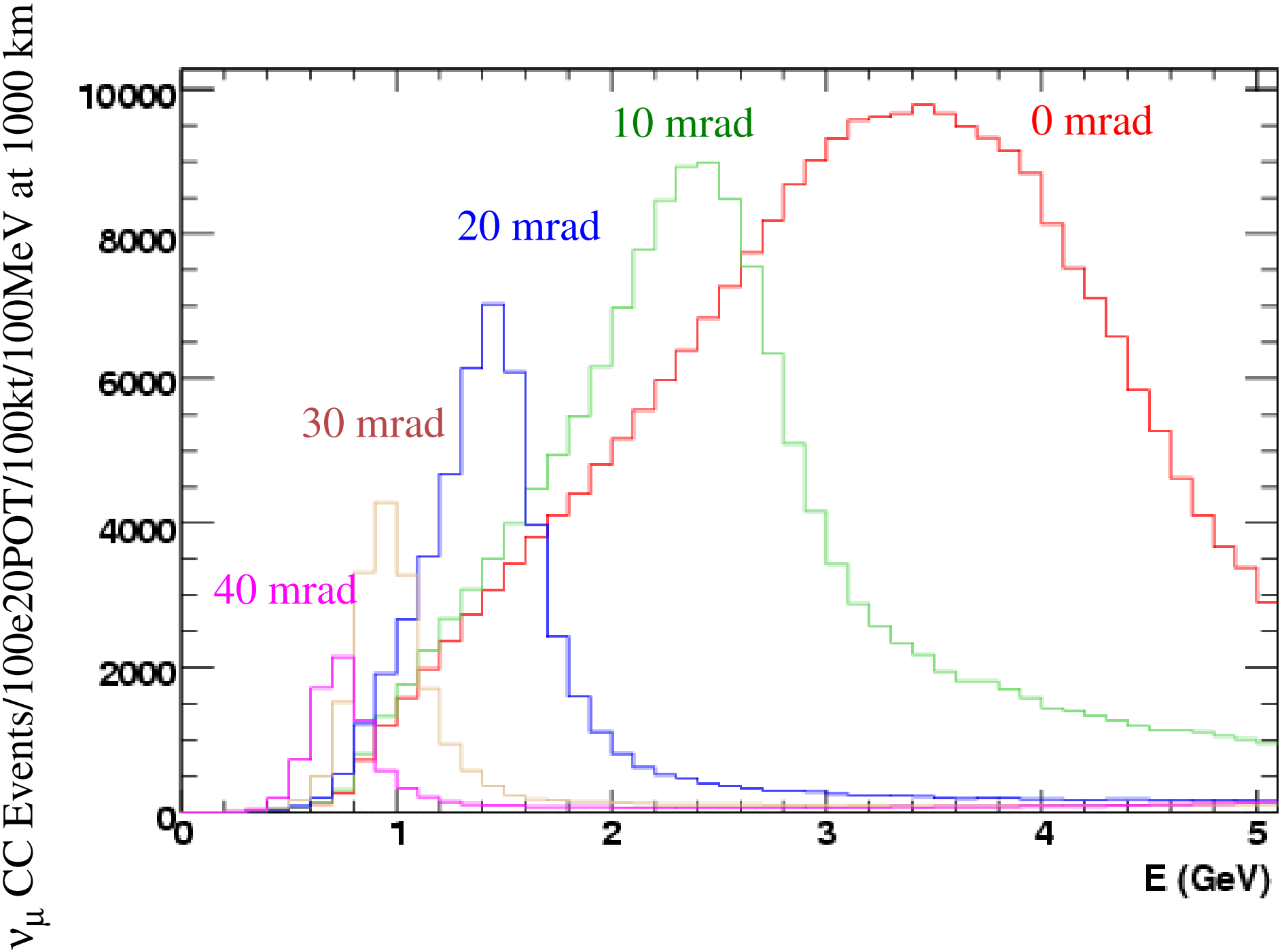
[2] What is the best L for the NOVA-II detector?

- Fluxes are based on my tables of fluxes as function of angle which can be downloaded from: http://enrico1.physics.indiana.edu/messier/off-axis/spectra/. These allow a rapid exploration of various beam options (low and medium energy NuMI tunes in both neutrino and anti-neutrino mode). Code provided to interpolate fluxes to any detector location.
- Fluxes are based on a FLUKA target model which matches MINOS ND much better than GEANT-FLUKA. I strongly advise against using GEANT-FLUKA.

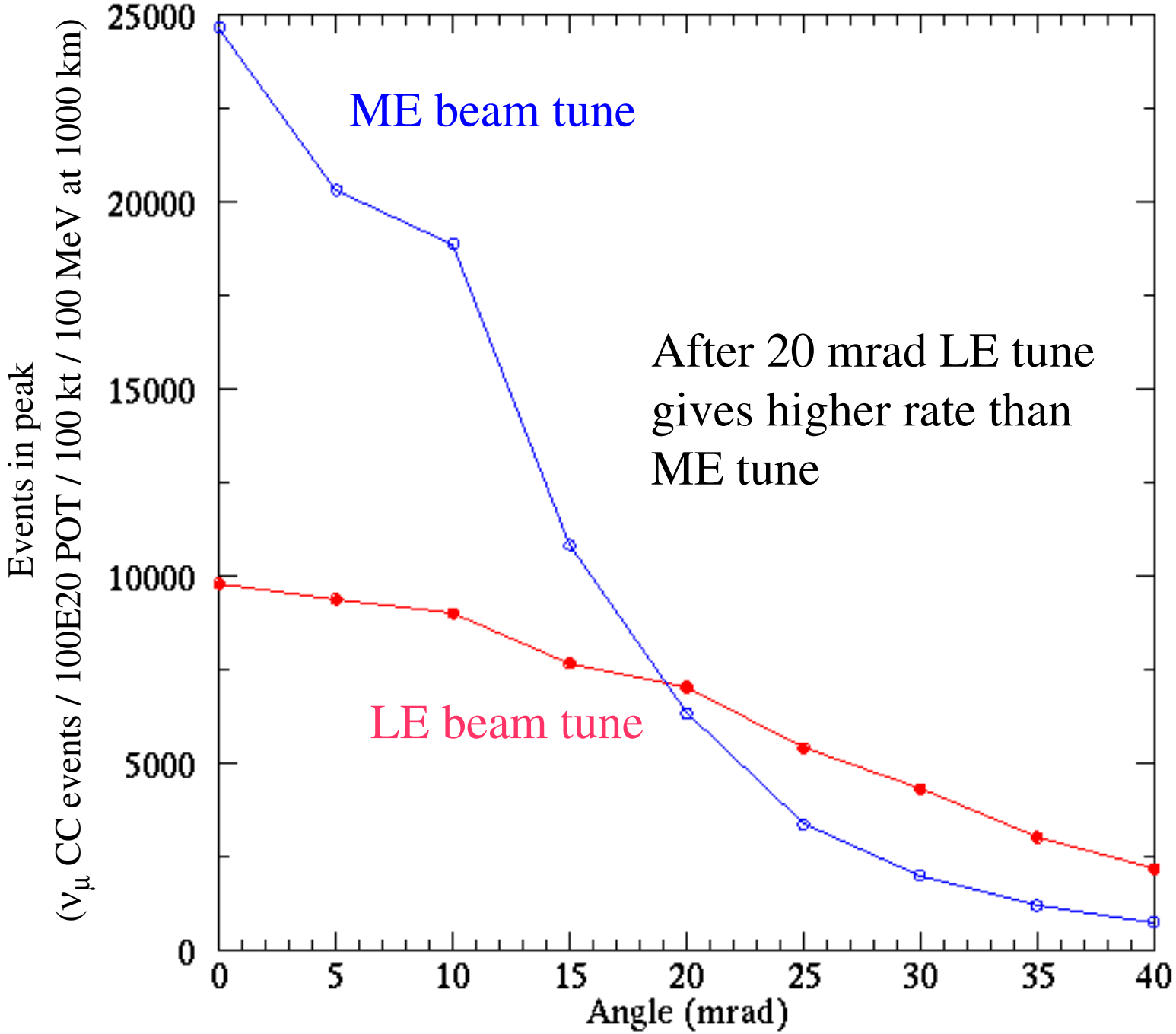
Scan detector position in NuMI medium energy tune



Scan detector position in NuMI low energy tune

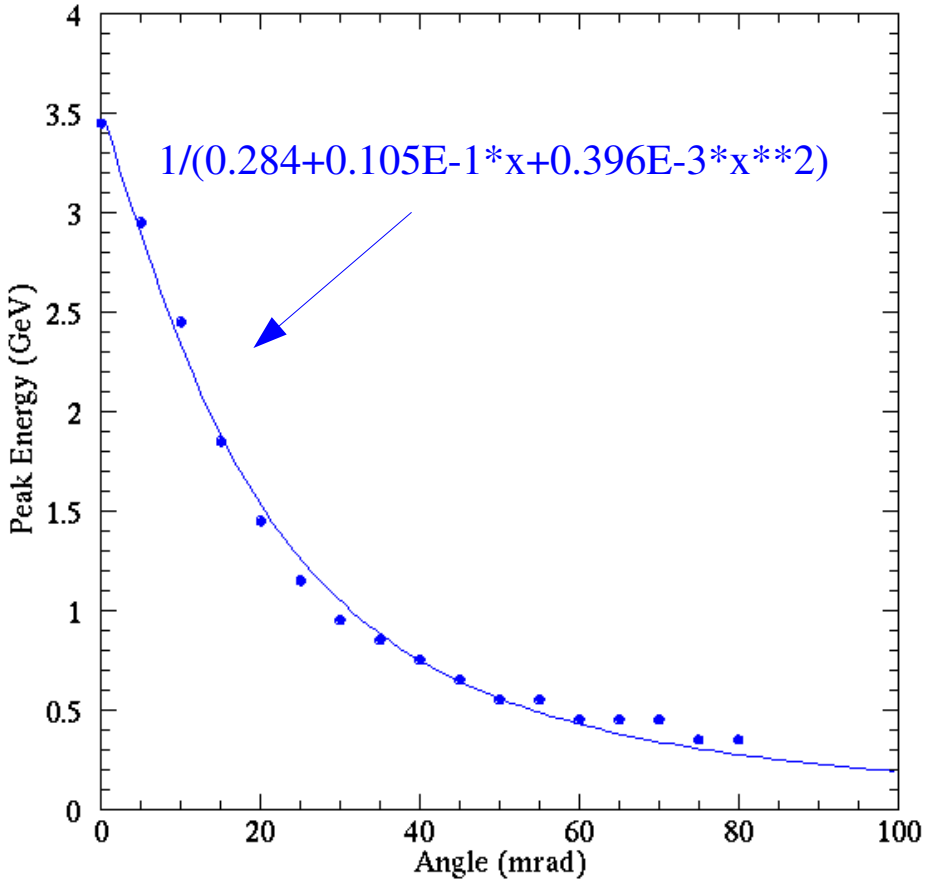


Comparing event rates as function of off-axis position

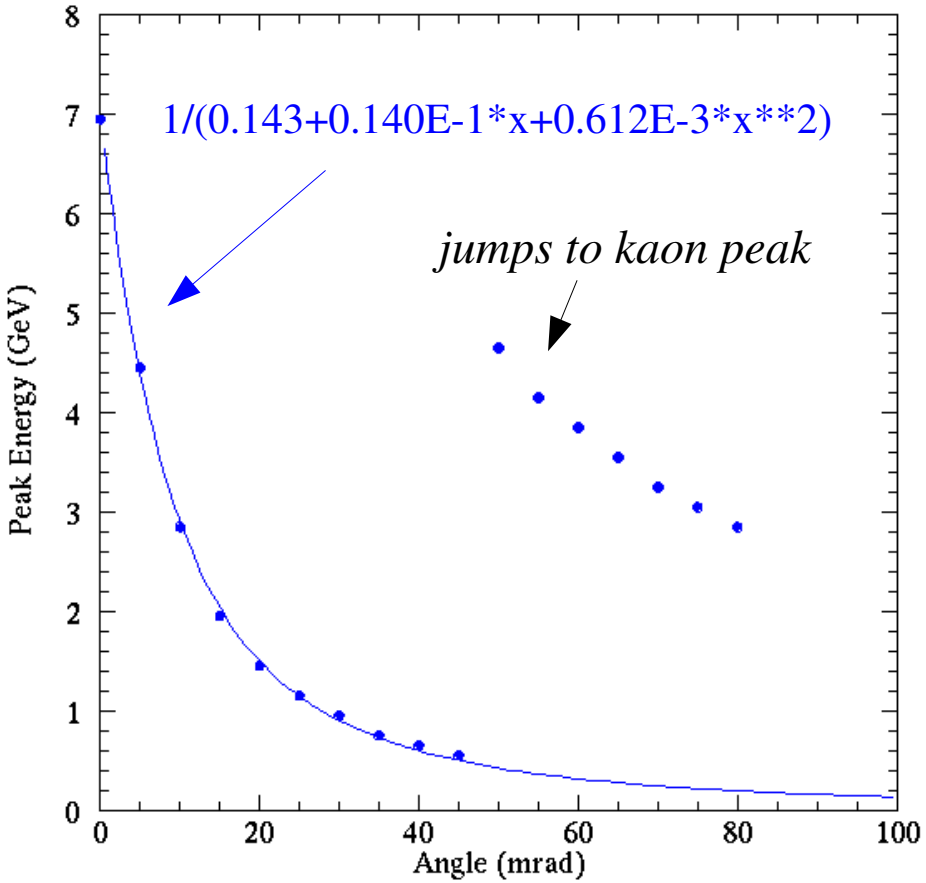


Positions of peaks: LE and ME beam

Low Energy NuMI Tune



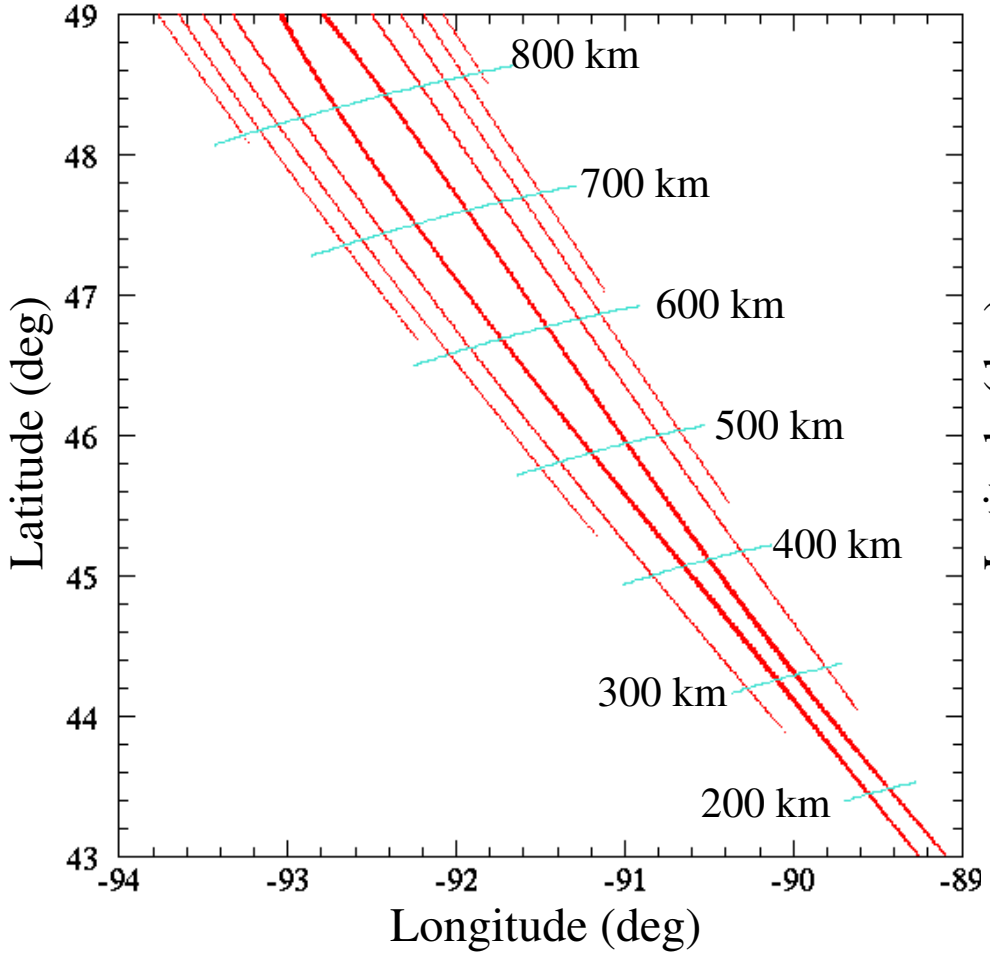
Medium Energy NuMI Tune



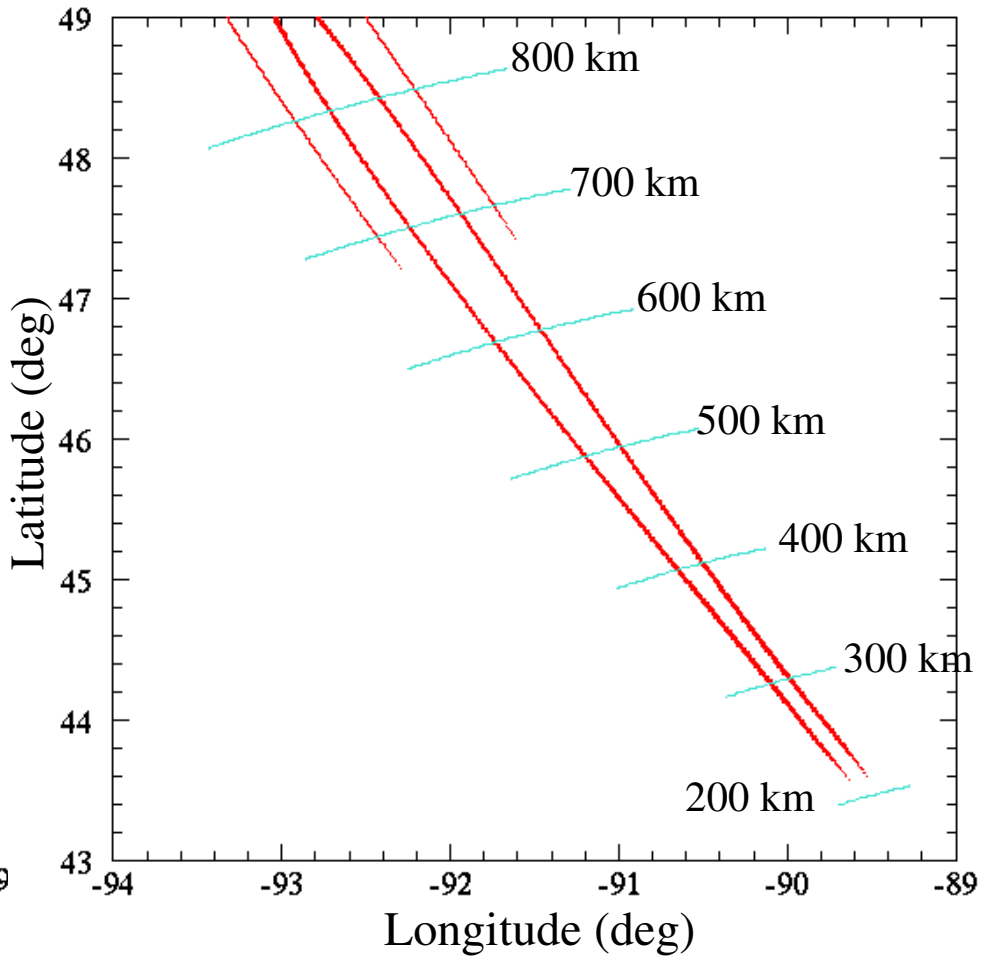
- Trace out peak of ν_μ energy spectrum as function of off-axis angle
- Well described by 1/polynominal
- Pion peak always larger than kaon peak in LE beam

Shopping for detector sites

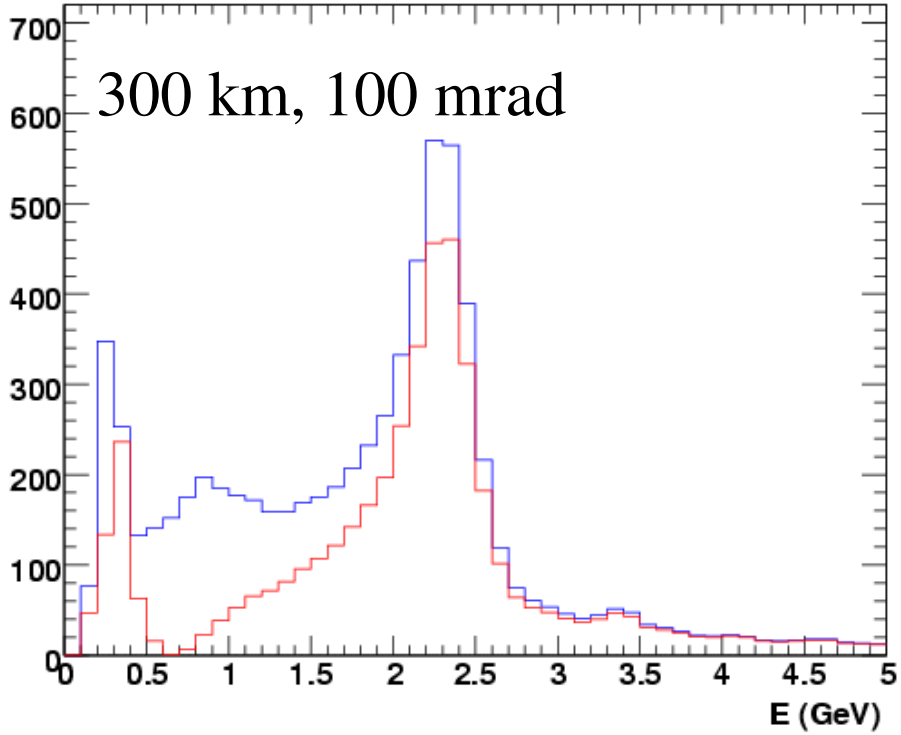
Low energy tune

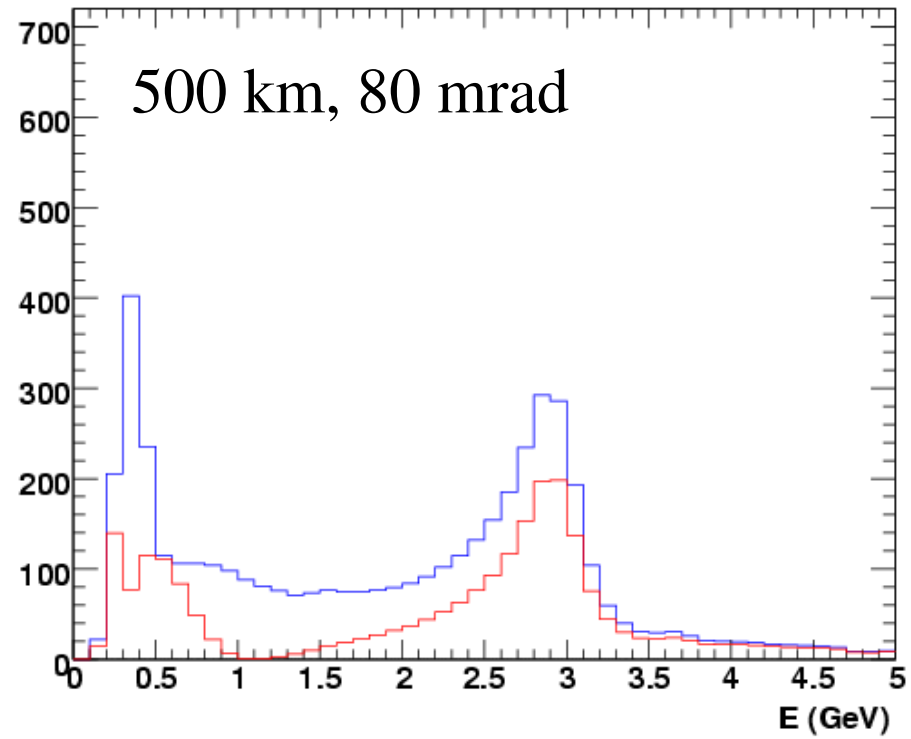


Medium energy tune



- Red bands highlight regions where oscillation maxima occur at beam peak energy
- Many more options for 2nd maximum locations in LE tune

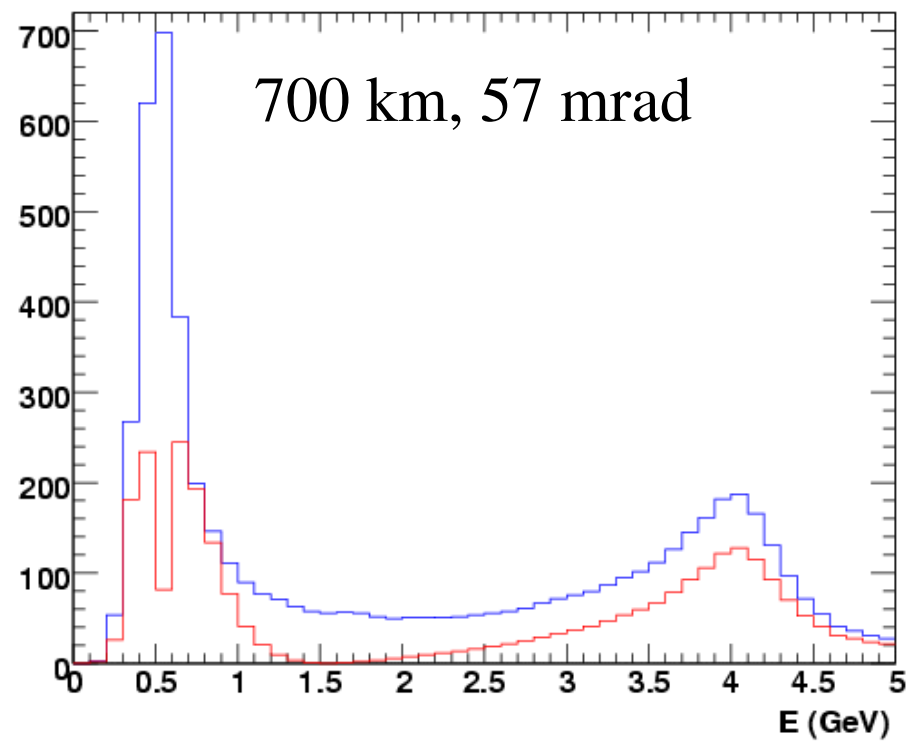


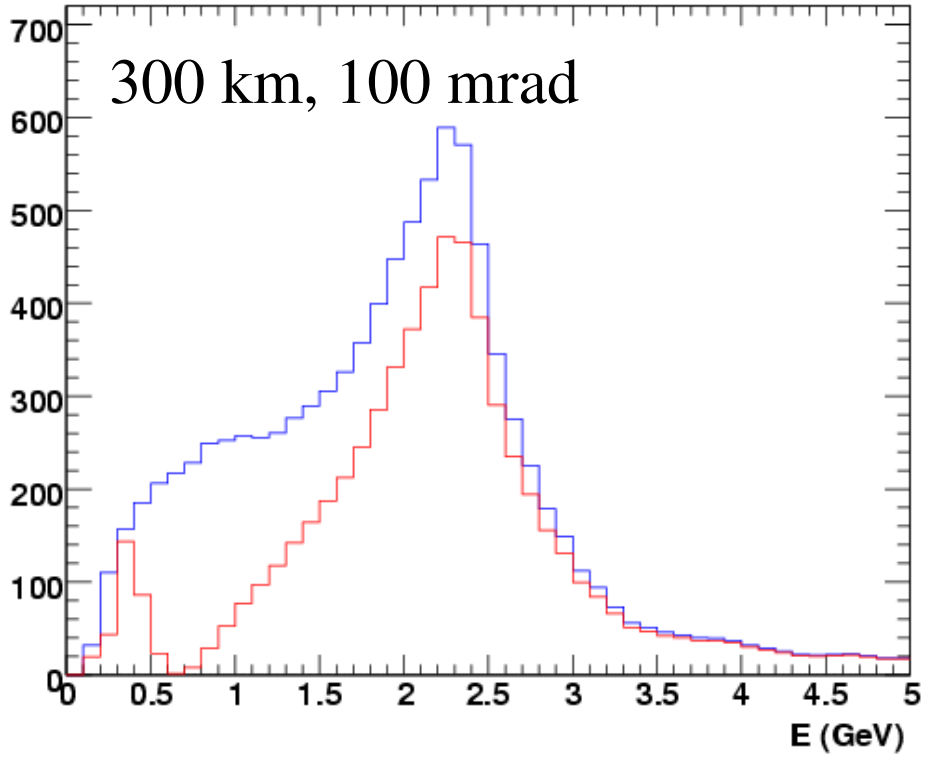


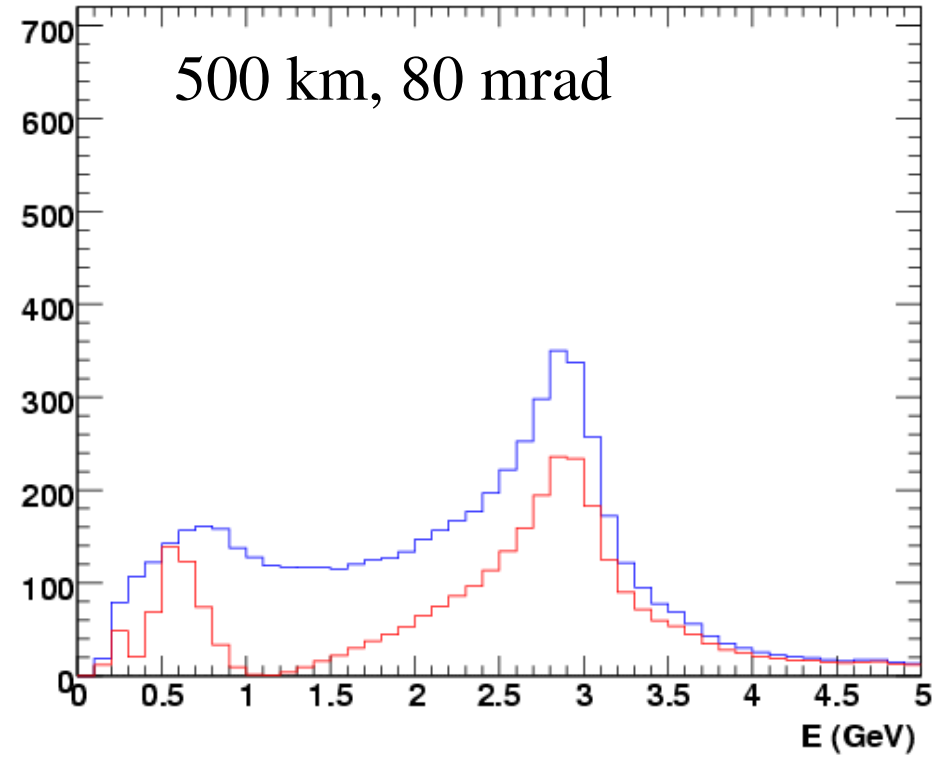
LE Tunes at different 2nd max sites

Same vertical scale on all plots

Vertical axis is is units of νμ CC events/100 kt/60e20 POT/100 MeV



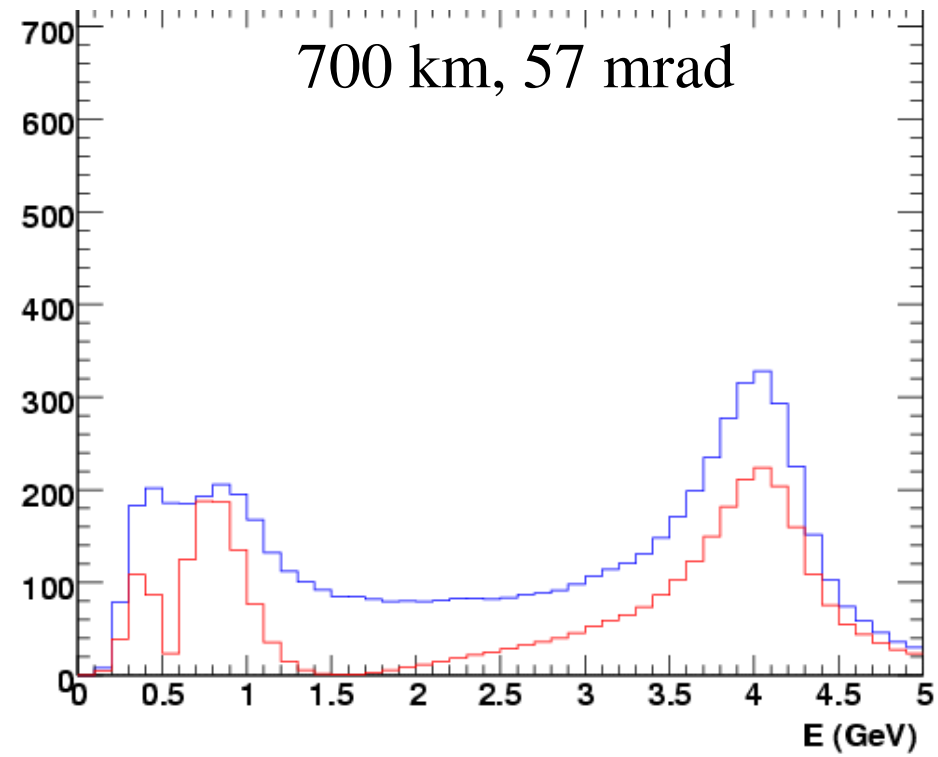




ME Tunes at those same sites (could do a little better moving transversely)

Same vertical scale on all plots. Same as previous slide.

Vertical axis is is units of νμ CC events/100 kt/60e20 POT/100 MeV



Electron neutrino rates

Signal rates calculated at:

$\theta_{12} = 35^o$

$\theta_{23} = 45^o$

$\theta_{13} = 10^o$

$\delta = 0$

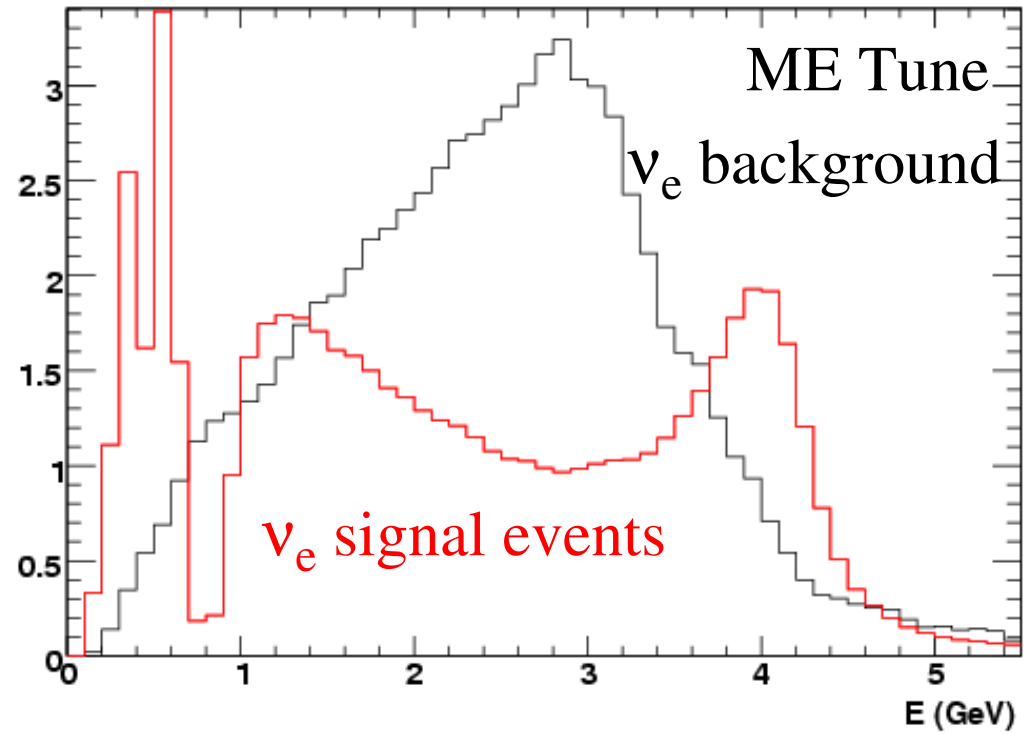
$\Delta m^2_{21} = +8x10^{-4}\ eV^2$

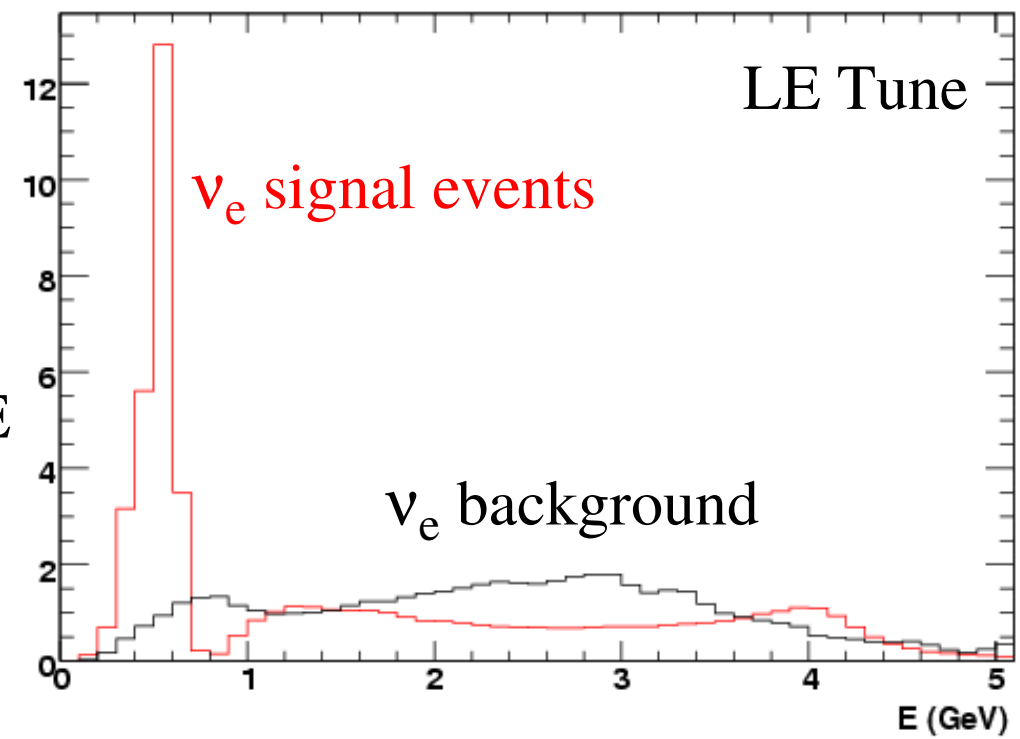
$\Delta m^2_{32} = +2.7x10^{-3}\ eV^2$

50 kt detector

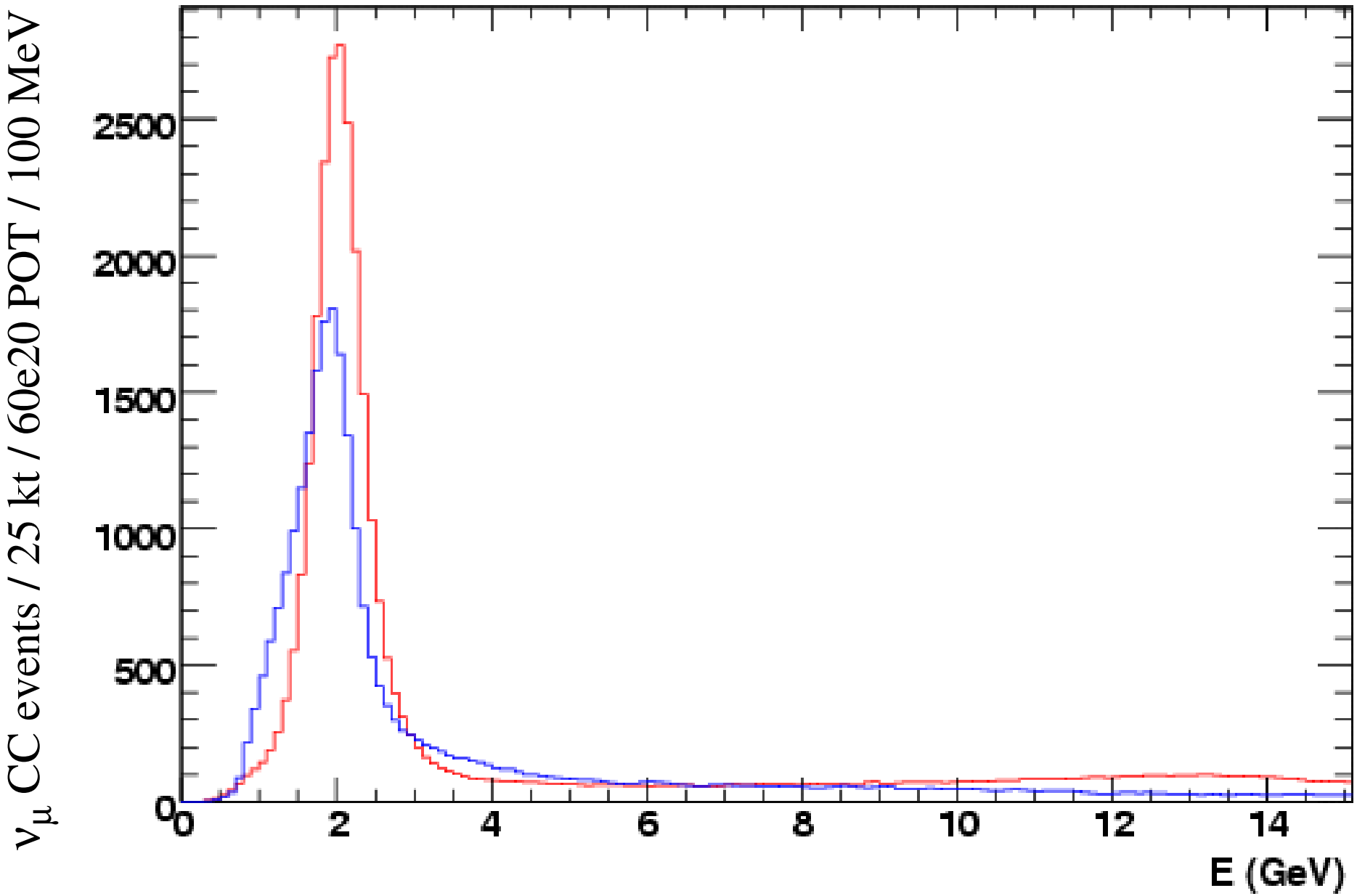
30E20 POT

Again, LE looks much better than ME





Comparison of LE and ME tunes for "NOVA-I" (L=810, 14 mrad)



Summary

- Just getting started on a serious look at the options for a NOVA detector located at second maximum
- LE significantly better for 2nd maximum
- LE not too bad at 1st maximum
- Trade off between energy of second maximum and angle required to achieve that energy seems to favor longer baselines
- All 2nd maximum locations have significant amount of data at 1st maximum also
- My guess is that LE beam will be (much) preferable when running the two detectors simultaneously