First look at left/right beam asymmetry: status report

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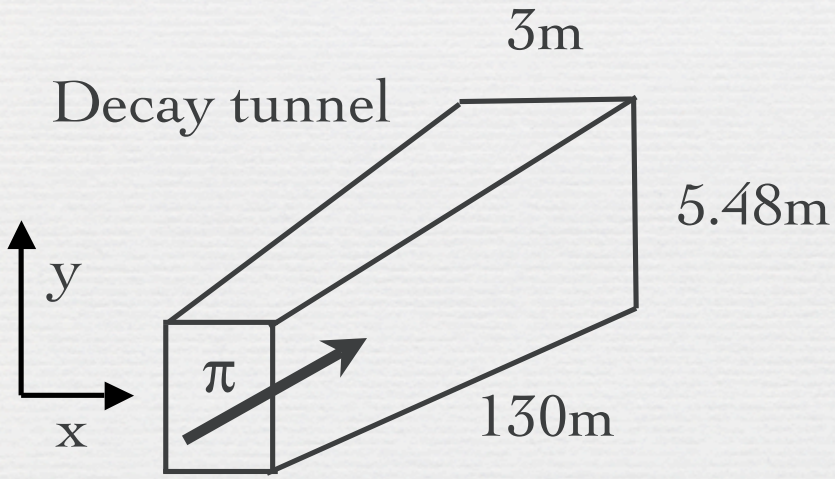
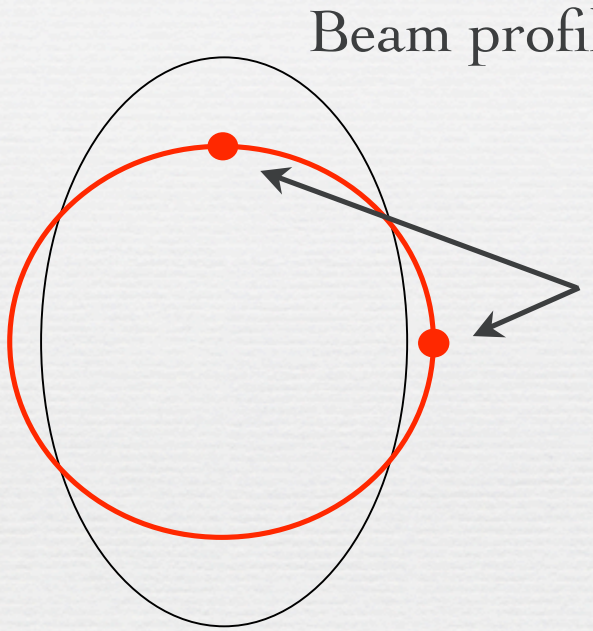
Decay tunnel

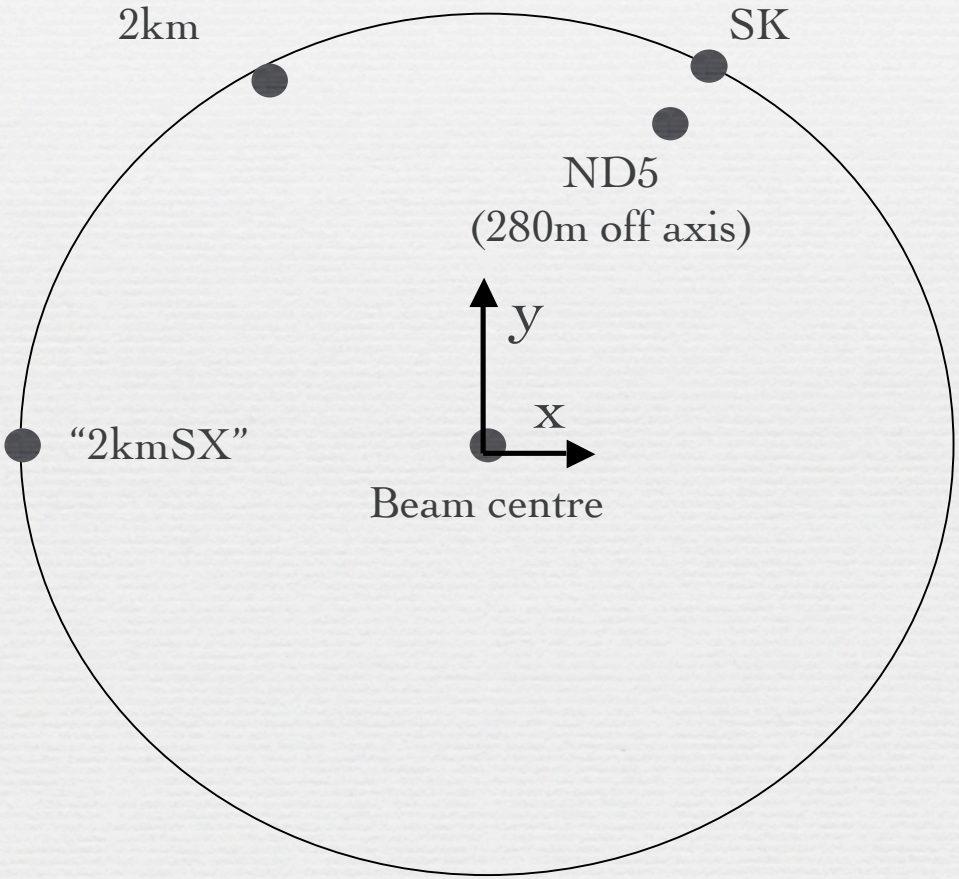




Positions with the same off axis angle but different flux.

- The shape of the decay tunnel is expected to break circular symmetry.
- The vertical opening angle is 2.41 degrees and the horizontal one is 1.32 degrees. These angles are not negligible compared to the off-axis angle of 2.5 degrees.(Important for high energy tail).

Detectors used

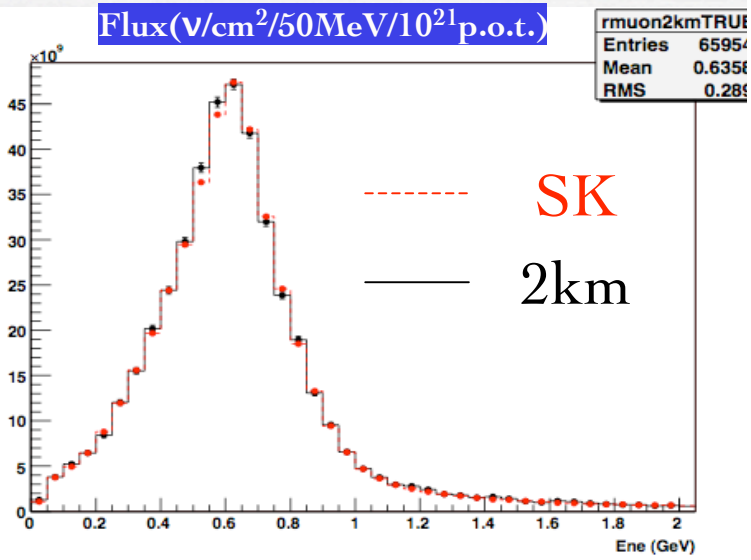


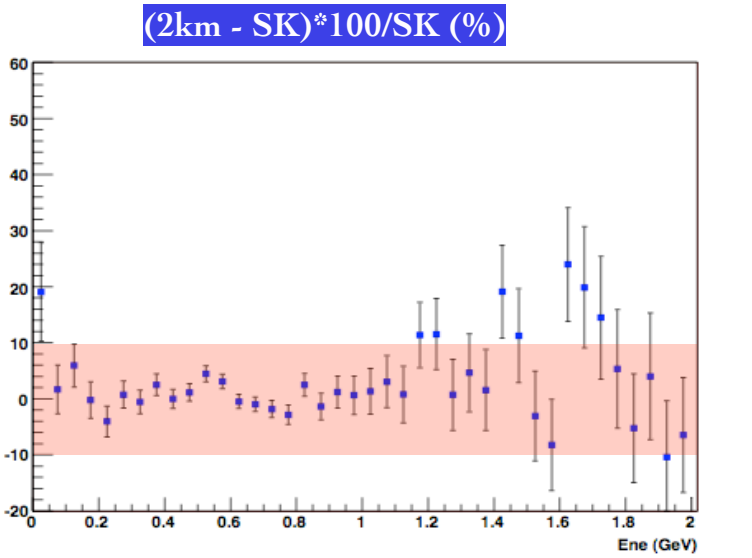
	Vertical angle	Horizontal angle	Total off-axis angle
Beam	3.637 deg	0	0
ND5	1.733 deg	0.624 deg	2.004 deg
SK	1.261 deg	0.783 deg	2.499 deg
2km	1.331 deg	-0.760 deg	2.428 deg
"2km SX"	3.637 deg	- 2.5 deg	2.5 deg

Beam profile

- The beam is left/right symmetric as it can be seen by the ratio between the fluxes at 2km detector and SK.
- This symmetry was expected since the decay tunnel is left/right symmetric.

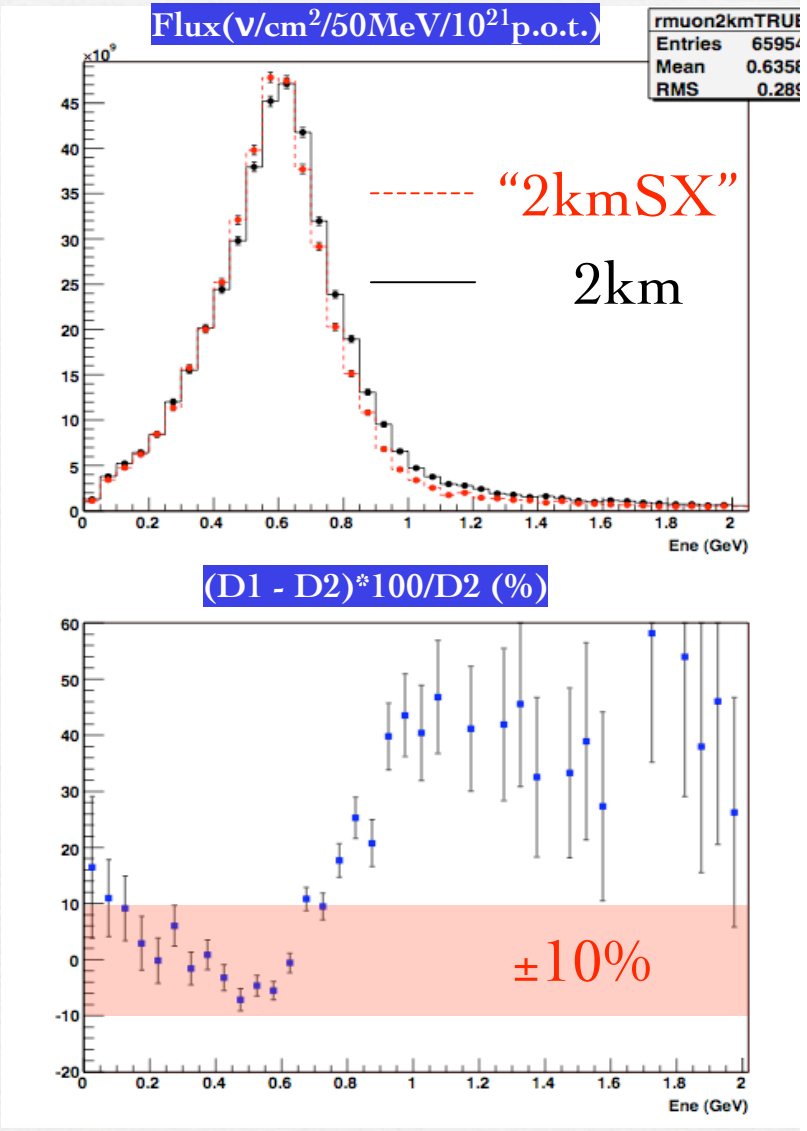
±10%





Beam profile (2)

- The evidence that the beam does not have a circular symmetry comes from the ratio between the flux seen at two detectors located at 2km (1839m), 2.5 degrees off-axis but at a different φ (not symmetric respect to the vertical axis).
- Detector 1(black) = 2km detector
- Detector 2 (red) = "2km SX"
- The problem is mainly related to high energy neutrinos (i.e. neutrinos above peak) coming from pions going "towards" the detector.
- The fact that the beam is not circularly symmetric represents a delicate aspect even when considering further detectors i.e. multi kton detectors in Korea.

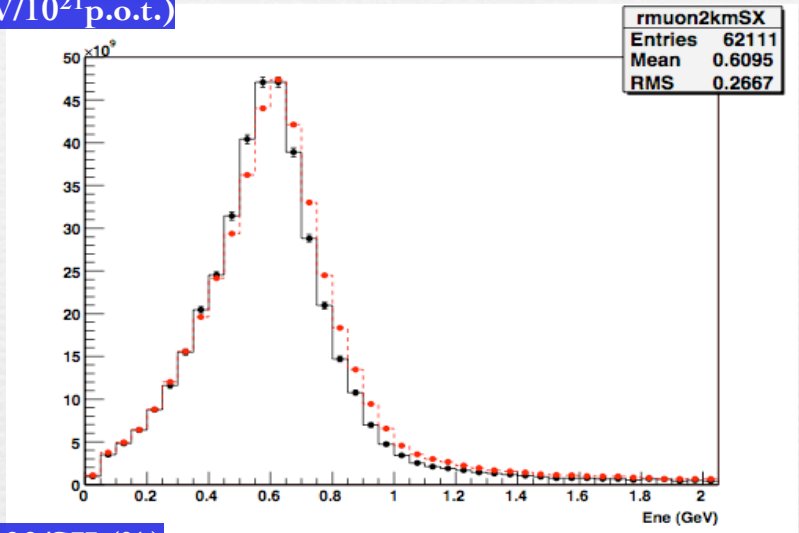


“2km SX”/SK

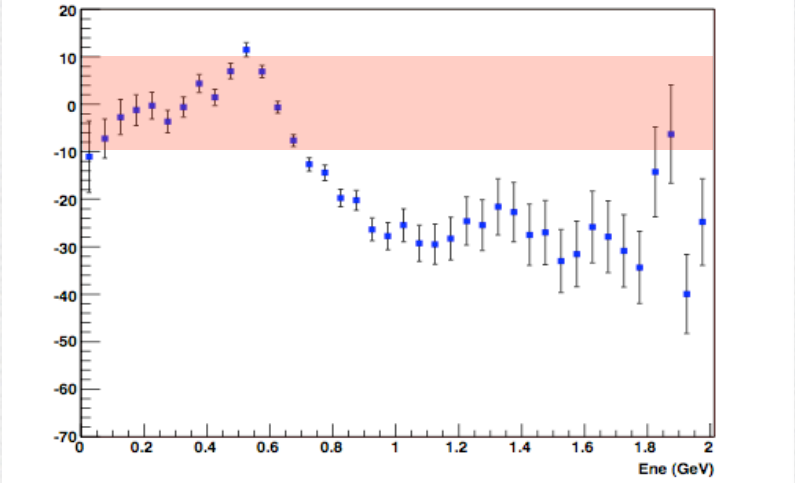
Beam centred: "2kmSX"/SK

"2kmSX" is a 2.5 degrees off axis detector at 2km. The area used to calculate the flux is 2m x 2m.

Flux(ν/cm^2/50MeV/10^{21}p.o.t.)



("2kmSX" - SK)*100/SK (%)



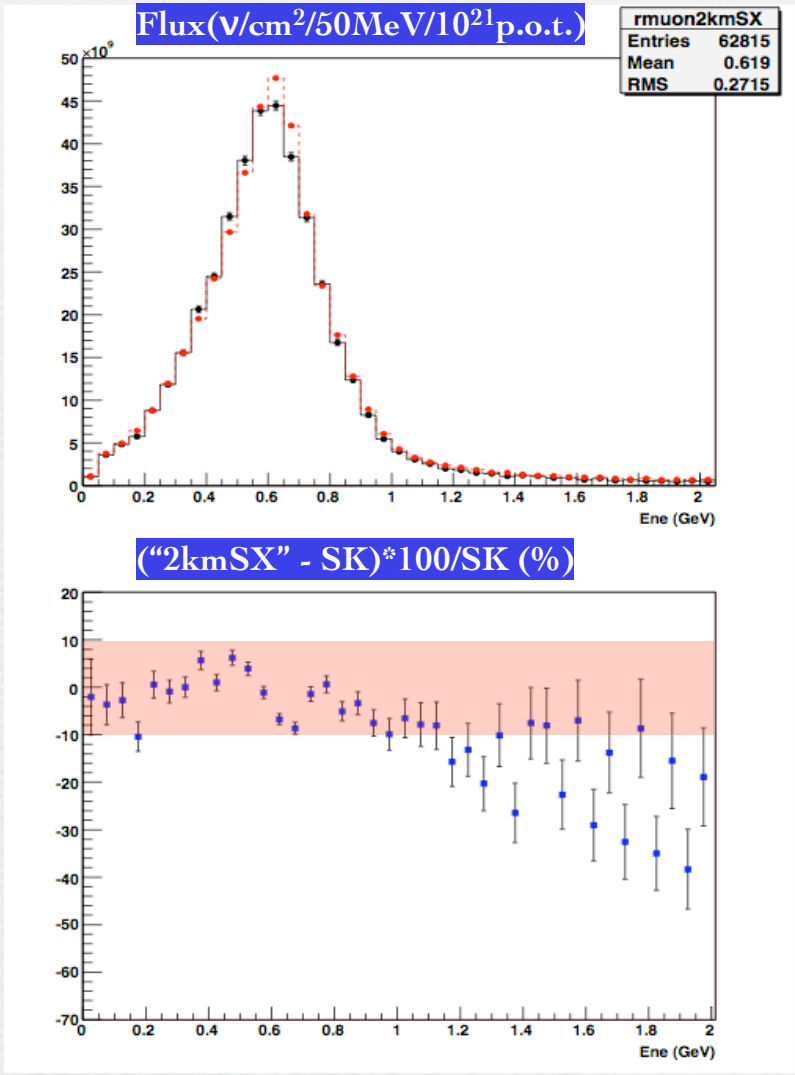
SK flux rescaled

SK

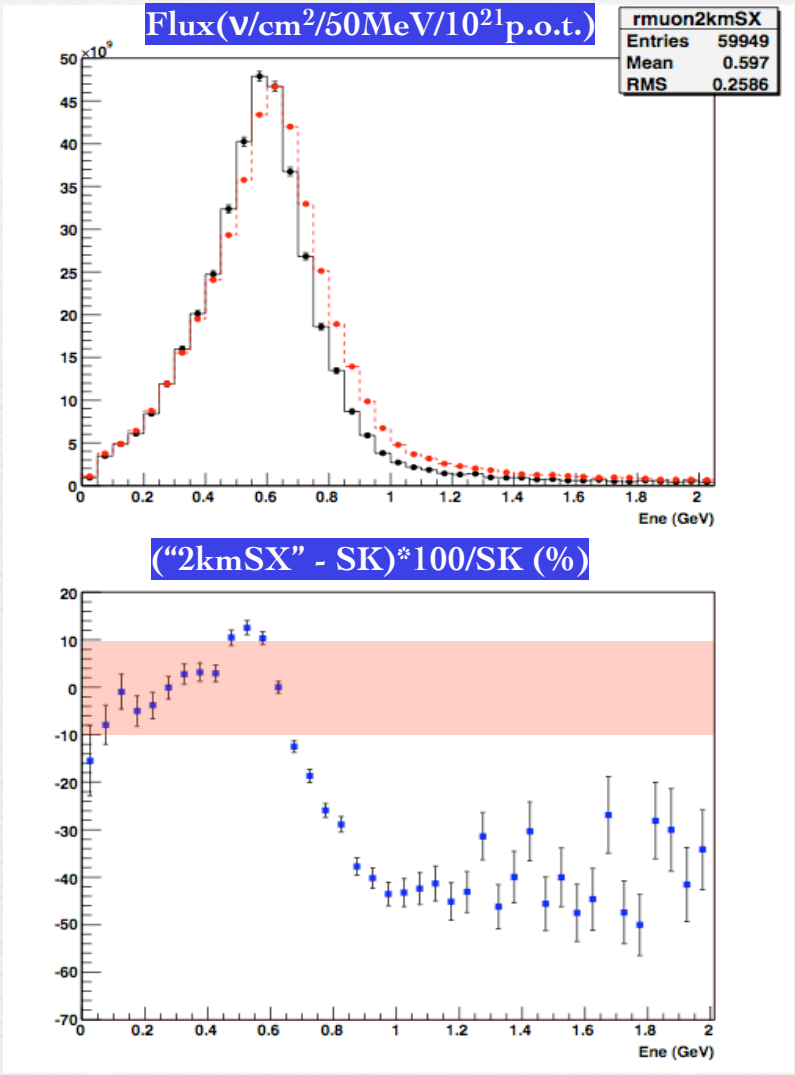
"2km SX"

±10%

Beam shifted X: “2kmSX”/SK



LEFT



RIGHT

SK flux rescaled

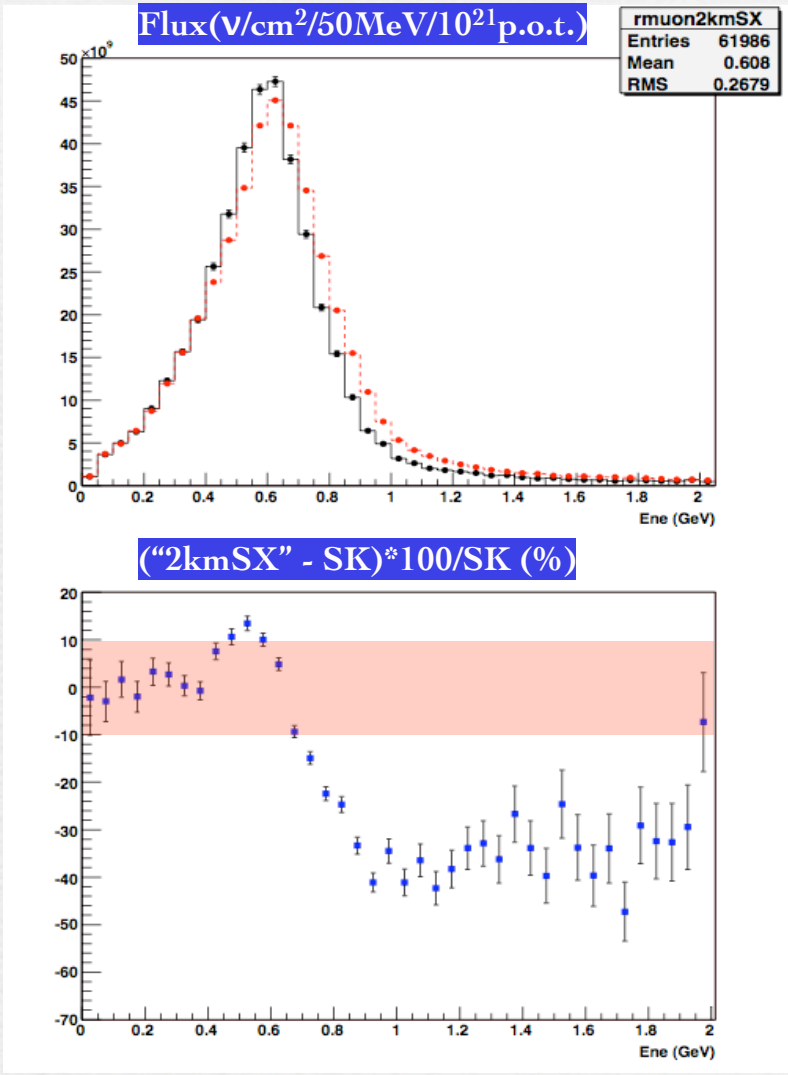
3mm protons shift

------- SK

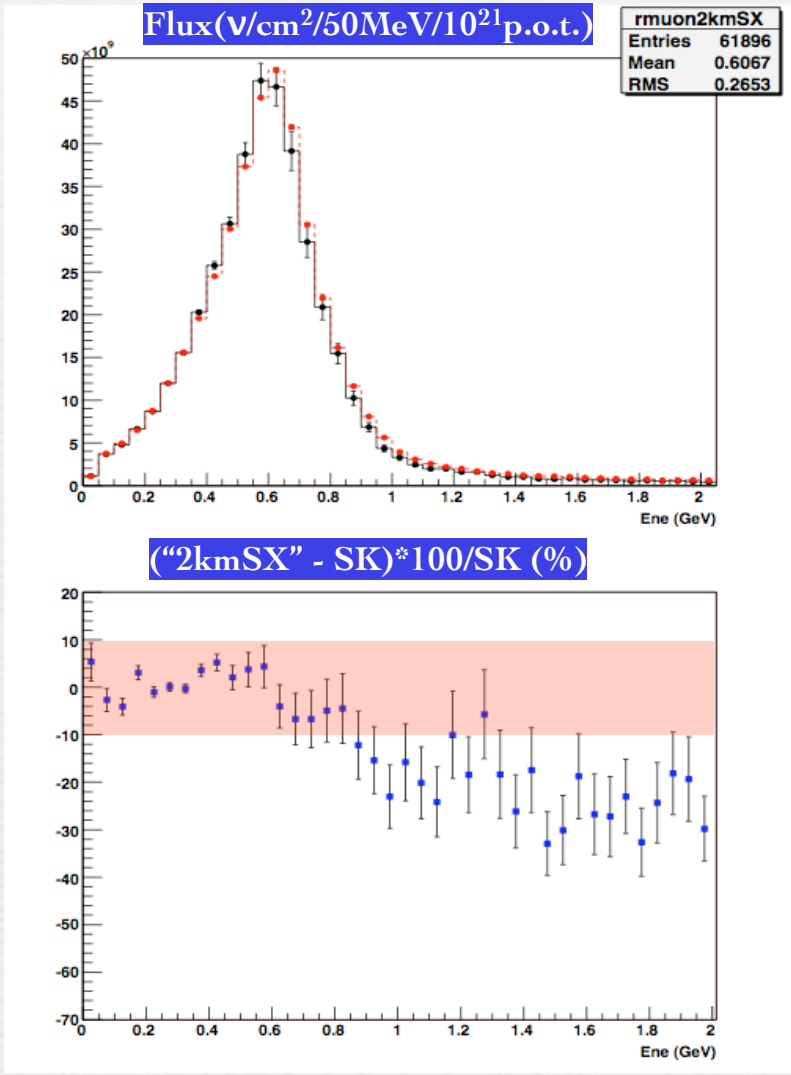
—— “2kmSX

±10%

Beam shifted Y: "2kmSX"/SK



UP



DOWN

SK flux rescaled

3mm protons shift

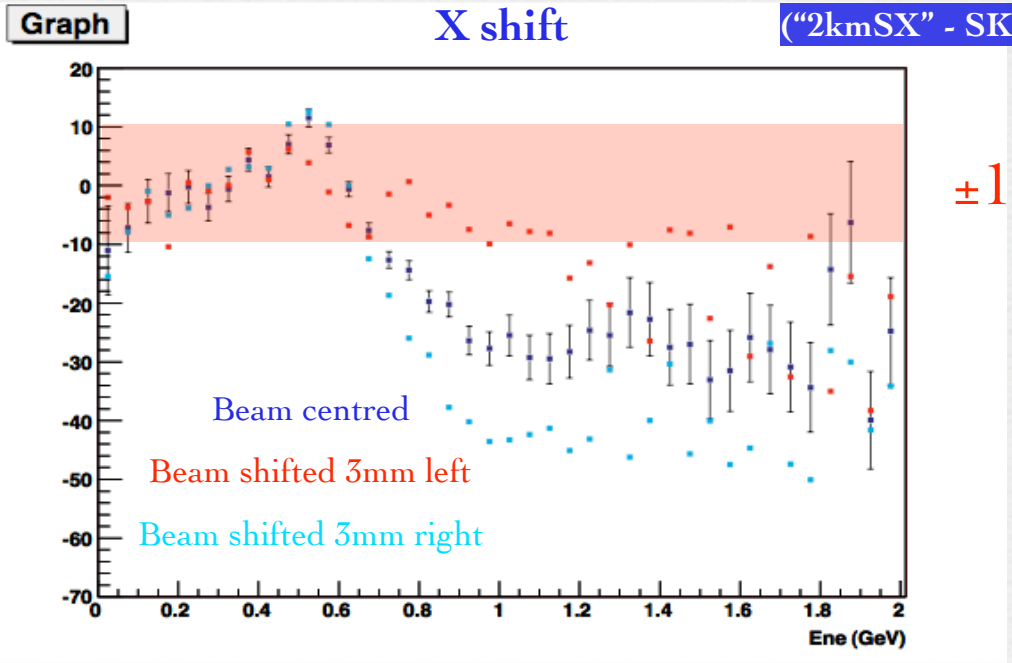
SK

"2kmSX

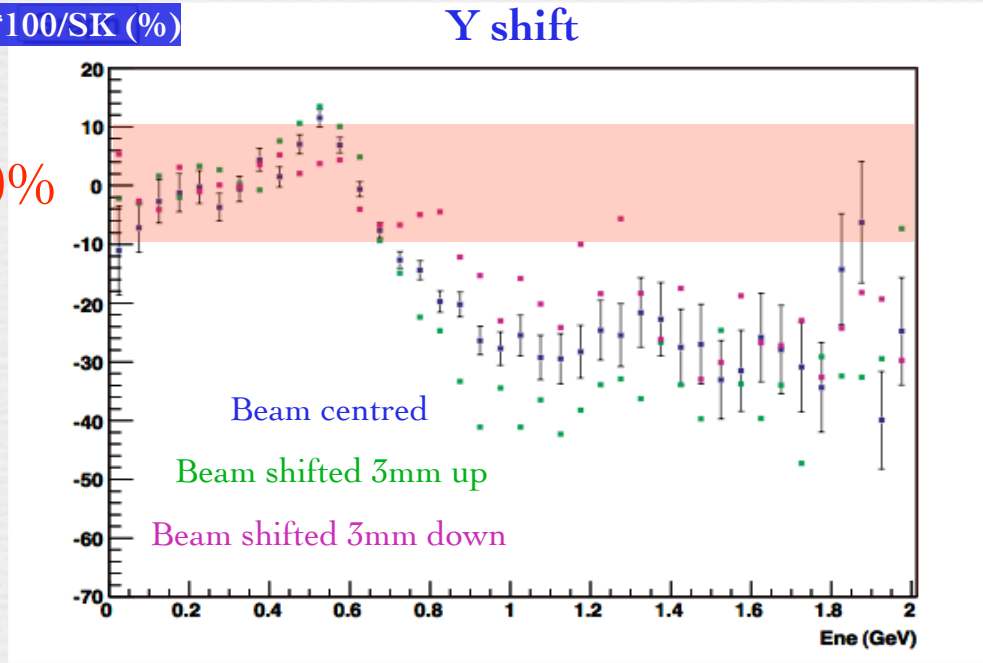
±10%

Comments

- The absolute changes in the ratio of the spectra "2kmSX"/SK obtained shifting the beam 3mm in the Y direction (green/purple) are about 10% between 0.6 GeV and 1 GeV. At peak the change is 4%.
- The absolute changes in the ratio of the spectra "2kmSX"/SK obtained shifting the beam 3mm in the X direction (red/cyan) are about 15% between 0.6 GeV and 1 GeV. At peak the change is 8%.
- The results obtained are conservative: with the 2km detector in the correct position the shift in Y should not change the ratio as much because of the left/right symmetry.



±10%

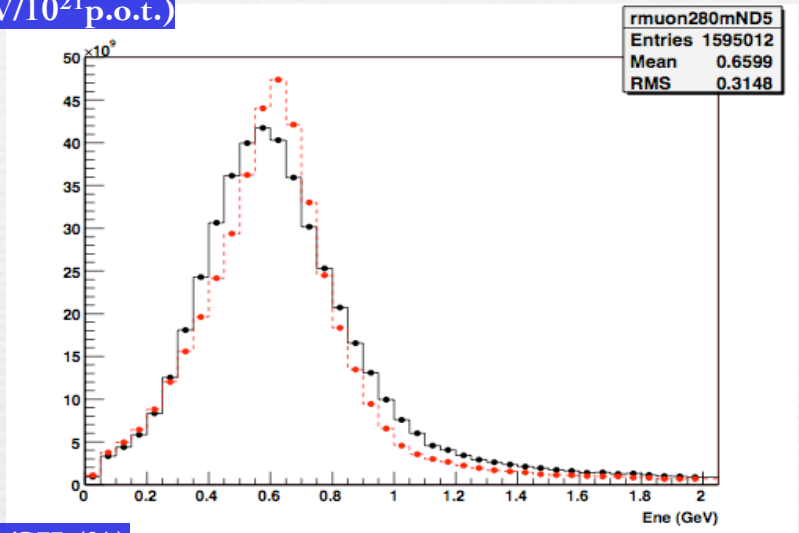


ND5/SK

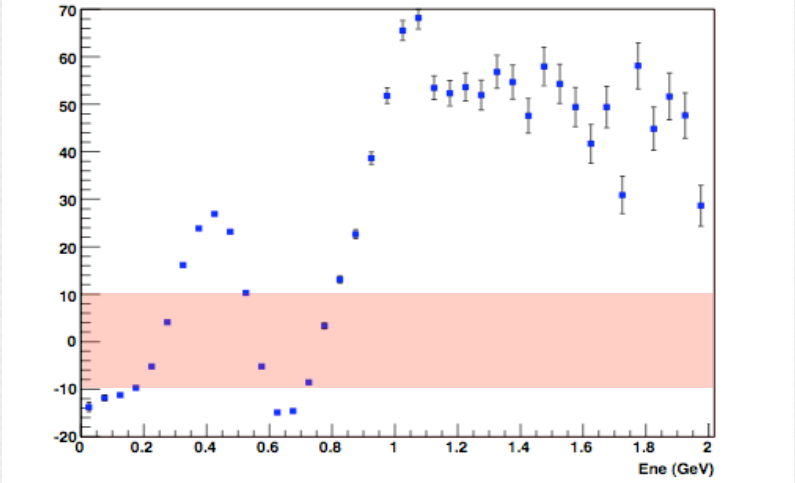
Beam centred: ND5/SK

ND5 is the 280m off axis detector. The area used to calculate the flux is 2m x 2m.

Flux(ν/cm^2/50MeV/10^{21}p.o.t.)



(ND5 - SK)*100/SK (%)



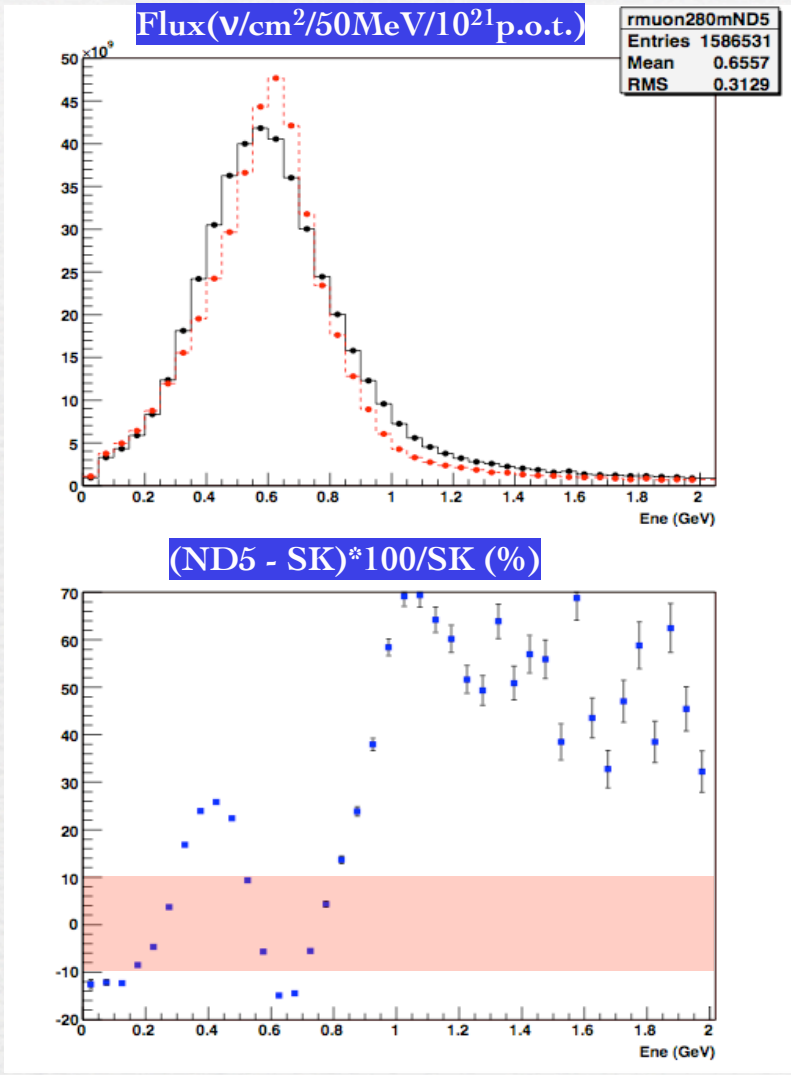
Fluxes rescaled according to distances.

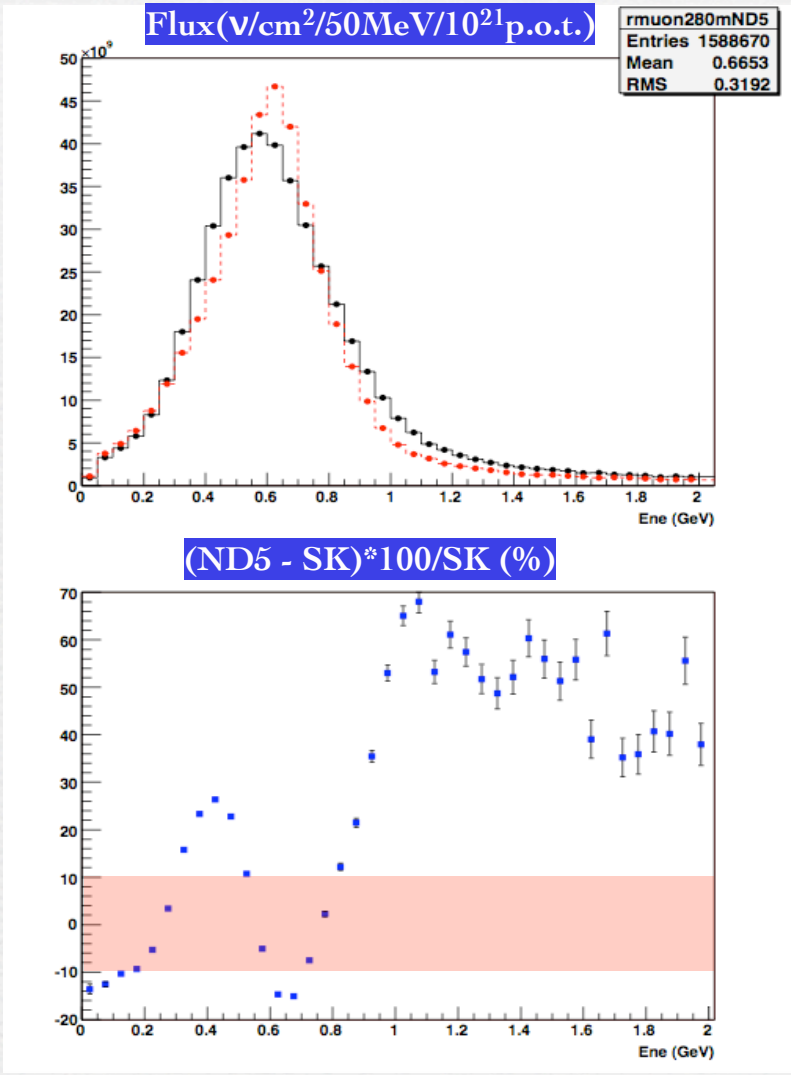
SK

ND5

±10%

Beam shifted X: ND5/SK





Fluxes rescaled according to distances.

3mm protons shift

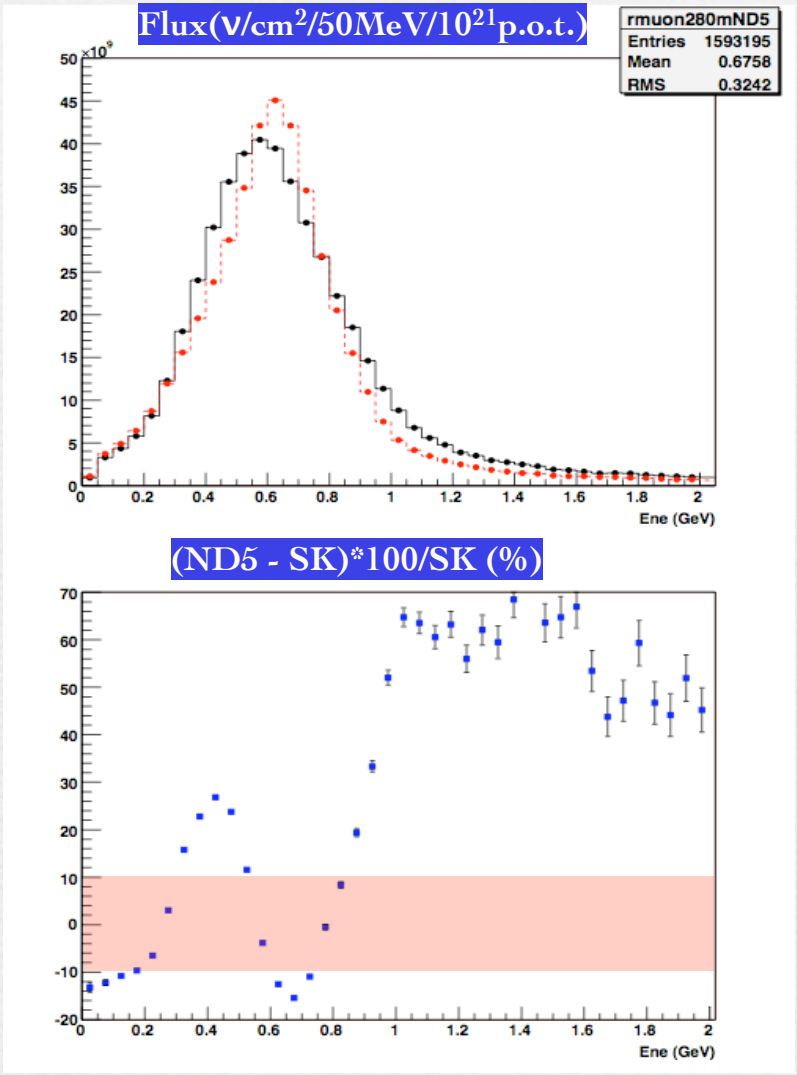
SK

ND5

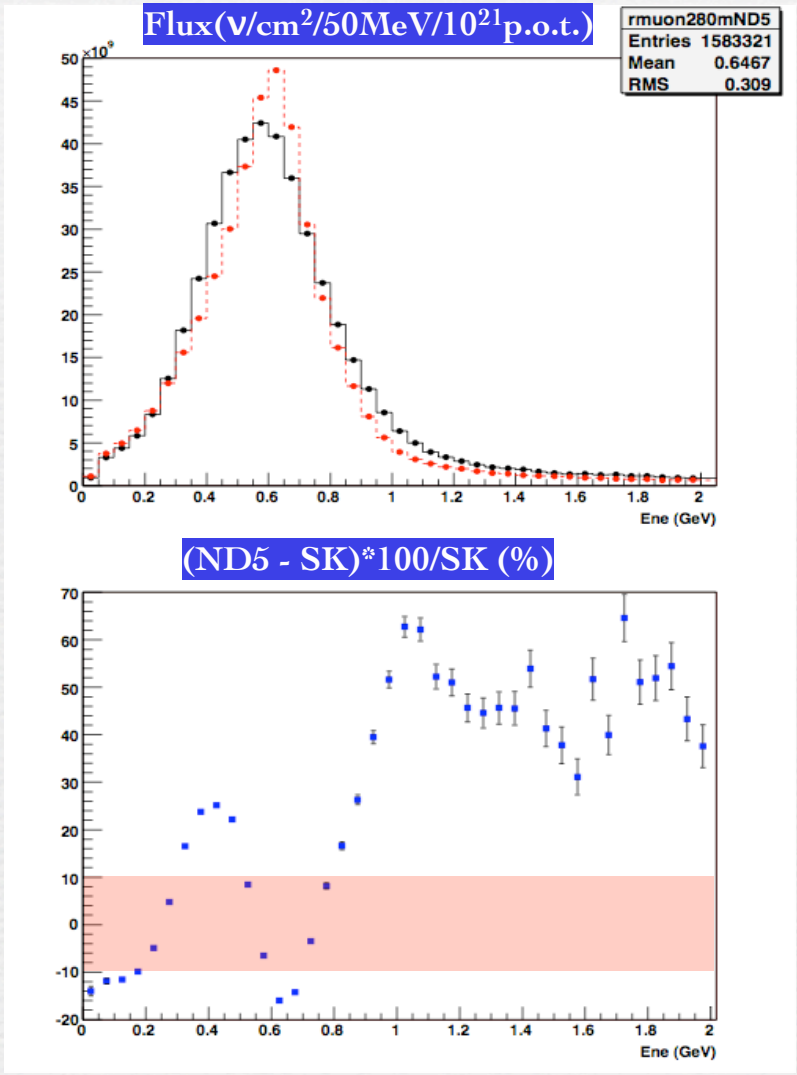
±10%

LEFT **RIGHT**

Beam shifted Y: ND5/SK



UP



DOWN

Fluxes rescaled according to distances.

3mm protons shift

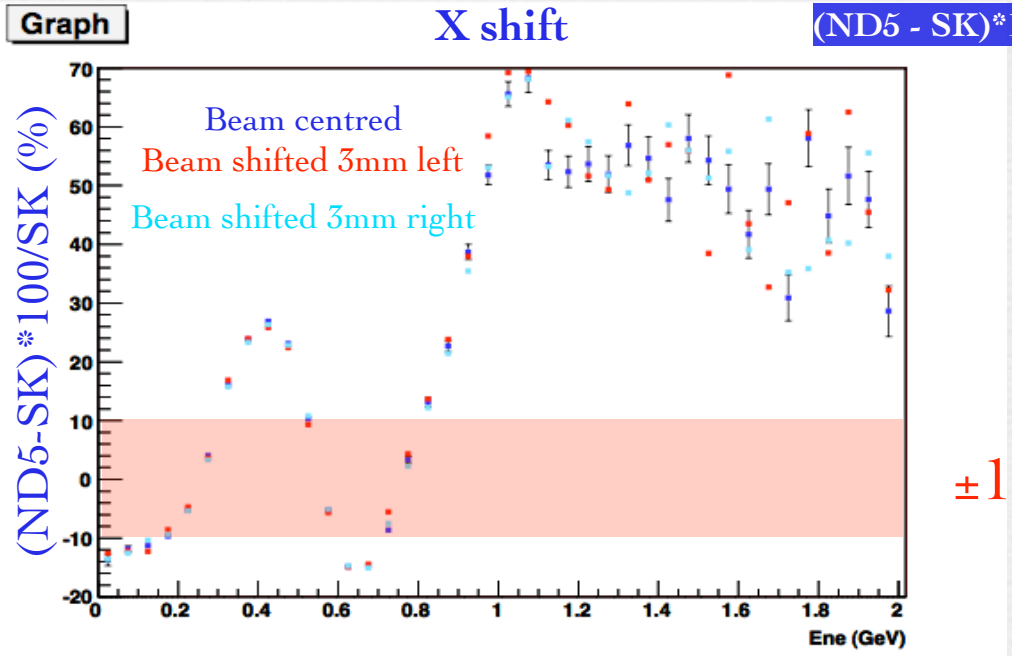
SK

ND5

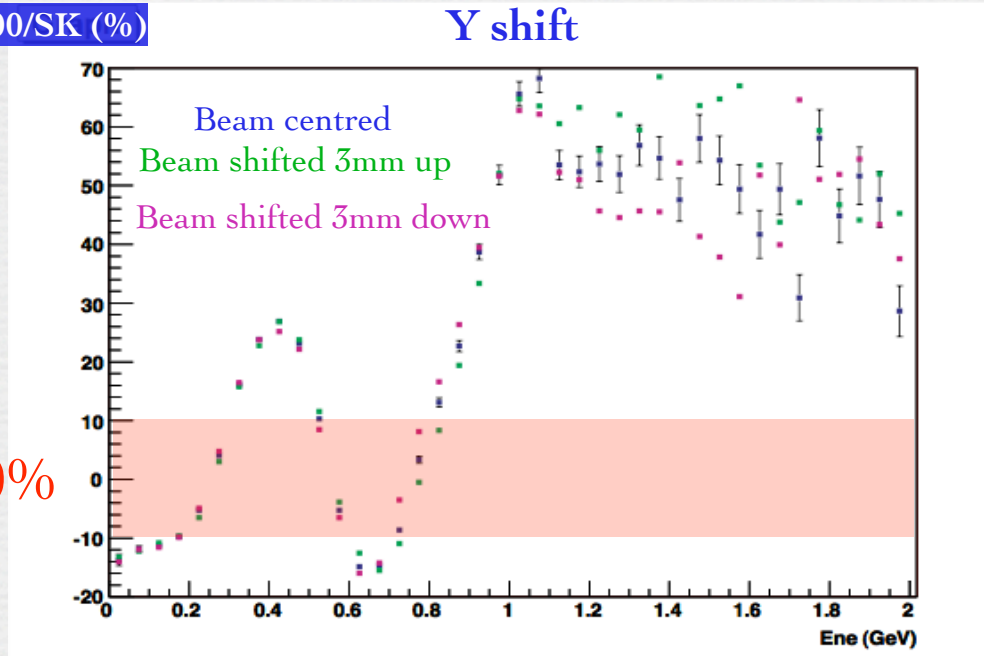
±10%

Comments

- The absolute changes in the ratio of the spectra ND5/SK obtained shifting the beam 3mm in the Y direction (green/purple) are about 5% up to 1 GeV. At peak the change is 3.5%.
- The absolute changes in the ratio of the spectra ND5/SK obtained shifting the beam 3mm in the X direction (red/cyan) are less than 5% up to 1 GeV. At peak the change is 2%



±10%



Conclusions

Conclusions/outlook

- Although the beam does not have a circular symmetry, it is left/right symmetric.
- Although ND5/SK ratio is far from being flat, it is not much sensitive to beam shifts because ND5 and SK have "almost" the same angular position (φ angle).
- Shifts of the beam are a delicate issue for the 2km/SK ratio because of the different angular position of the 2 detectors. In particular the ratio is sensitive to shifts along the X axis.
- If we assume that the flux changes linearly with the shift of the beam, we must reach a precision of about 1 mm in order to neglect the change of the flux at the 2km detector. (See Beam Position Monitor talk by N.Hastings at T2K collaboration meeting Jan. 2006)
- Studies with the "true" 2km detector must be carried out.