PAH 1

What do Oscillation measurements [redacted] want from a near detector?

I. ν_μ CC Disappearance
Δm^2 precision
$\sin^2 2\theta$ precision } separately

A. "ν Energy" Response of an ideal Calorimeter (plot)

- changes predictions of

$$\frac{\Phi \cdot \sigma \text{ (far)}}{\Phi \cdot \sigma \text{ (near)}} \text{ vs } \Delta m^2 \text{!}$$ (plot)

This affects:

1. Δm^2 systematic error (~5 - 10% ?)

2. whether or not an experiment (MINOS) can see

OSCILLATION as opposed to just

DISAPPEARANCE

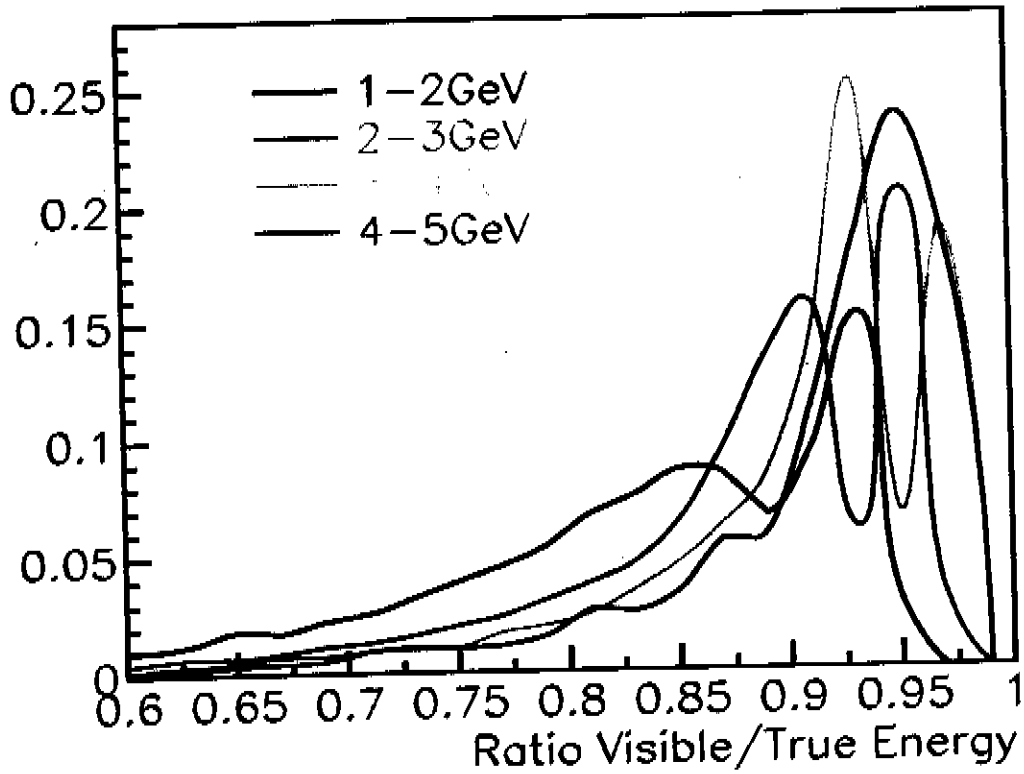
DAH2

Neutrino Energy Resolution

Visible Energy in a Calorimeter is NOT equal to the True Neutrino Energy

- Kinetic Energy $\neq$ Total Energy
- Nuclear Effects cause some π to be reabsorbed
- Detector Resolution (not considered here)

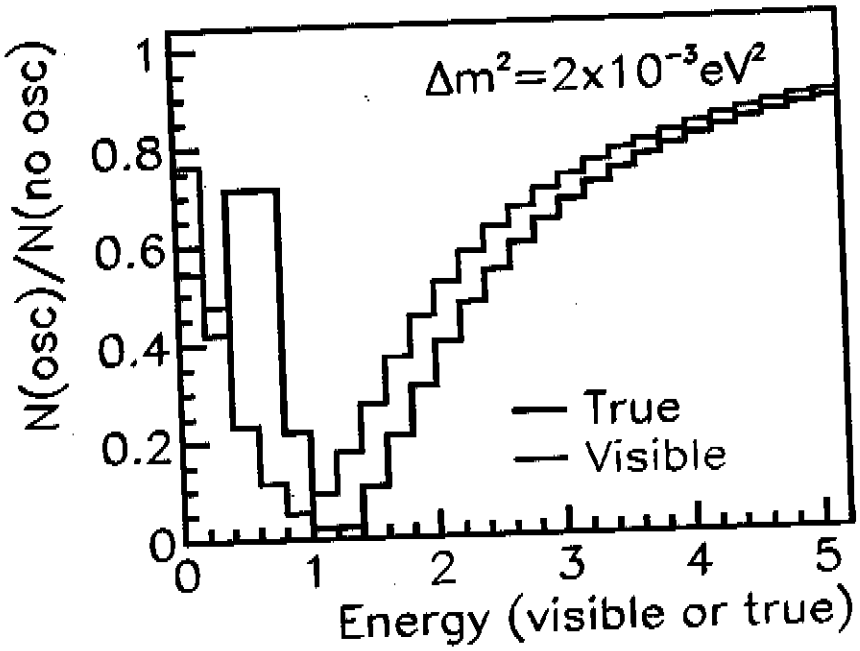
Neugen Predicts: (thanks to H. Gallagher)

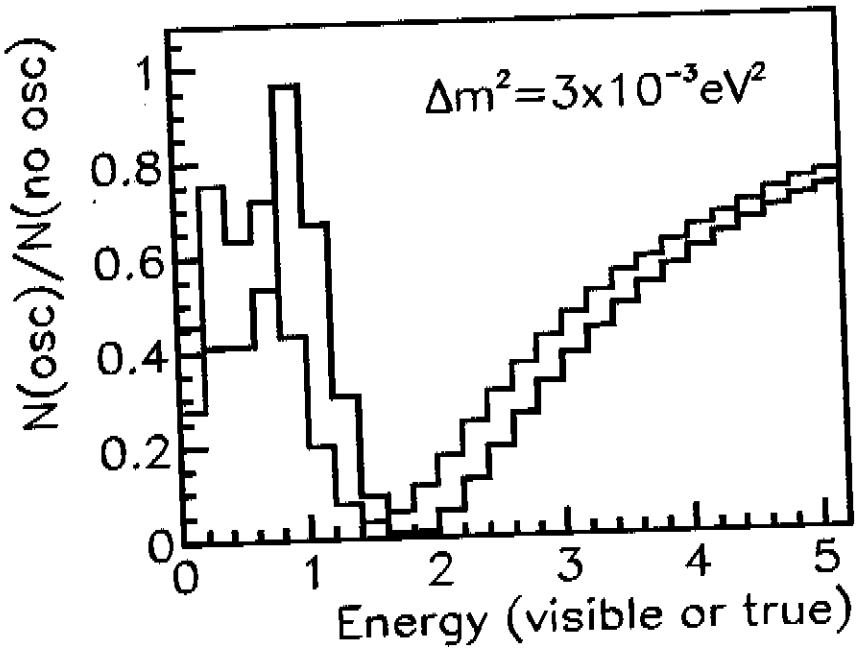


As Energy gets higher, function gets narrower

PAH3

Effects of Neutrino Energy Smearing





How big an effect smearing will play depends on Δm^2!

B. ν_μ Disappearance - Signal acceptance

"Longest track length" cut will be made to distinguish CC/NC (plot)

C. NC Background Rejection

NC Background - overall level
- visible energy (y) distribution
- most energetic $\pi^\pm$ "energy spectrum"

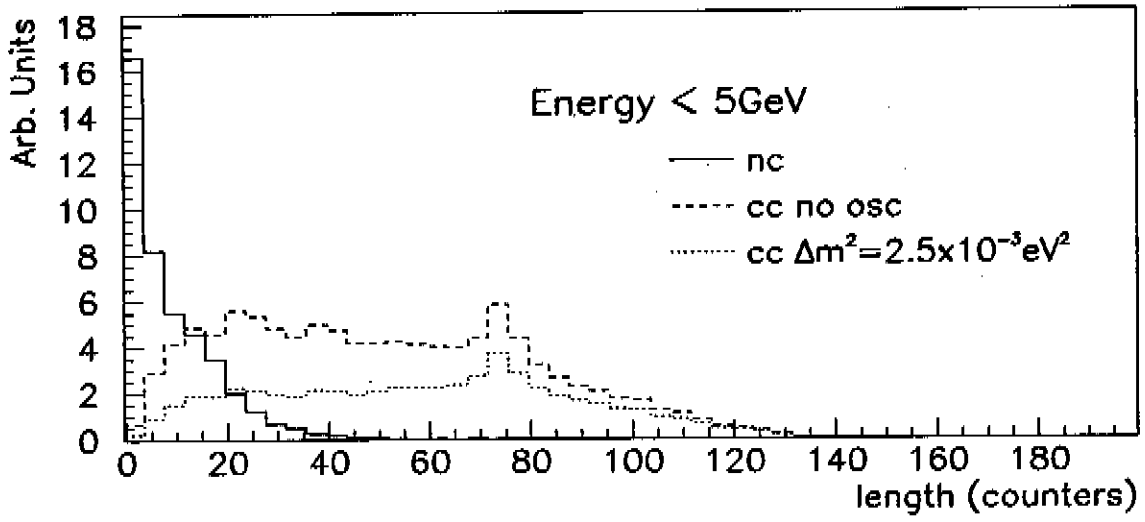
@NUMI, some NC bkgd from "HE tail", some from peak

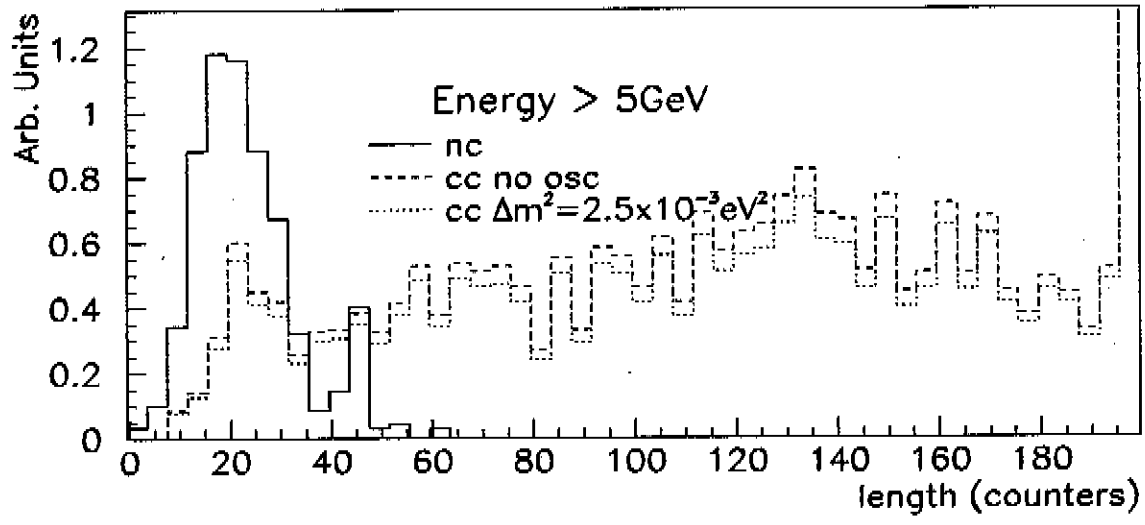
D. σ_{DIS} / σ_{RES} / σ_{QE} mixture vs E_ν

Again, affects acceptance, esp. since far Det Φ may be <u>very</u> different from ND Φ $\left(\frac{L(near)}{L(far)}\right)^2$

DAHS

Length Distributions





DAHG

II. NC/CC Measurements

- confirm osc. framework
- search for sterile components

- sterile fraction already limited to $\lesssim .18$ or so...

	Near (evts/t·yr) E<5 + E>5	Far (evts/kt·yr) E<5 + E>5
ν_μ CC no osc.	127K	189
ν_μ CC $\Delta m^2 = 2.5\times10^{-3}$ eV^2	——	136
ν_μ NC events	39K	56 $\left(\frac{1}{\sqrt{560}} \simeq \sim 4\%\right)$

Understanding diff. fractions means understanding σ(NC) vs E_ν. Not only for E_ν <5GeV

again, y distributions important too

DRAFT

III. $\nu_\mu \to \nu_e$ Search (MINOS / NUMIOA)

- dominated in MINOS by NC background

1. $\frac{d\sigma}{dE_\nu}(\nu N \to \nu \pi^0 X)$

2. Ideally, would like π^0 energy dist. vs E_ν.

3. $\frac{d^2\sigma}{\partial E_\nu \partial E_\nu}(\nu N \to \nu \pi^0 X)$

because cuts will be made on

$$\frac{E(\text{electromagnetic})}{E(\text{total})}$$

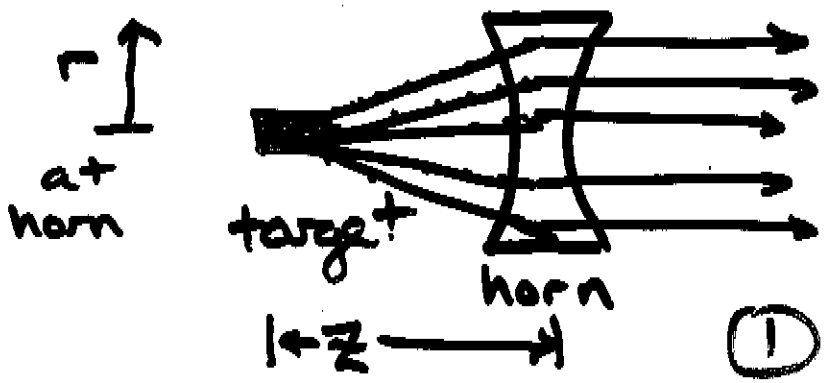
p.s. don't forget high y CC background for this too, and NC/CC analysis.

Question: How do JLAB π^0 energy distributions + σ's for various targets relate to what we need?

is it straightforward to go from A to B?

DAHS

Games we can Play with NuMI Beamline



$\Delta p_t = Ar$

$p_{perfect\ focus} =$ [redacted] $z \cdot A$

① move target back - raise p_{pf}

② lower horn current. lower p_{pf}

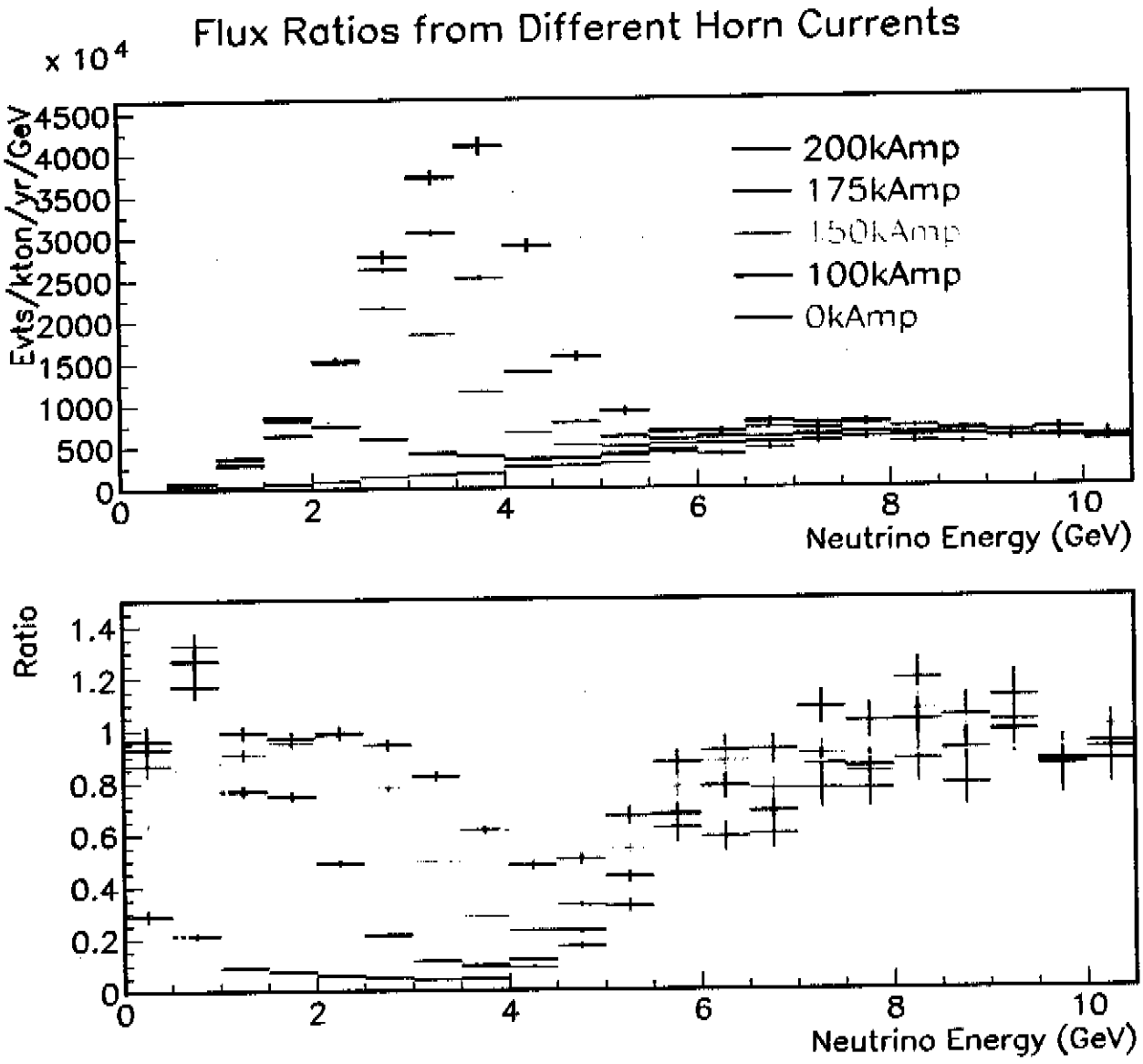
- But remember, there is a hole in the middle of the horn....
- particle production uncertainties higher, the higher the fraction of particles go through horn.

③ change from $\nu \rightarrow \bar{\nu}$ (takes ~1 week)

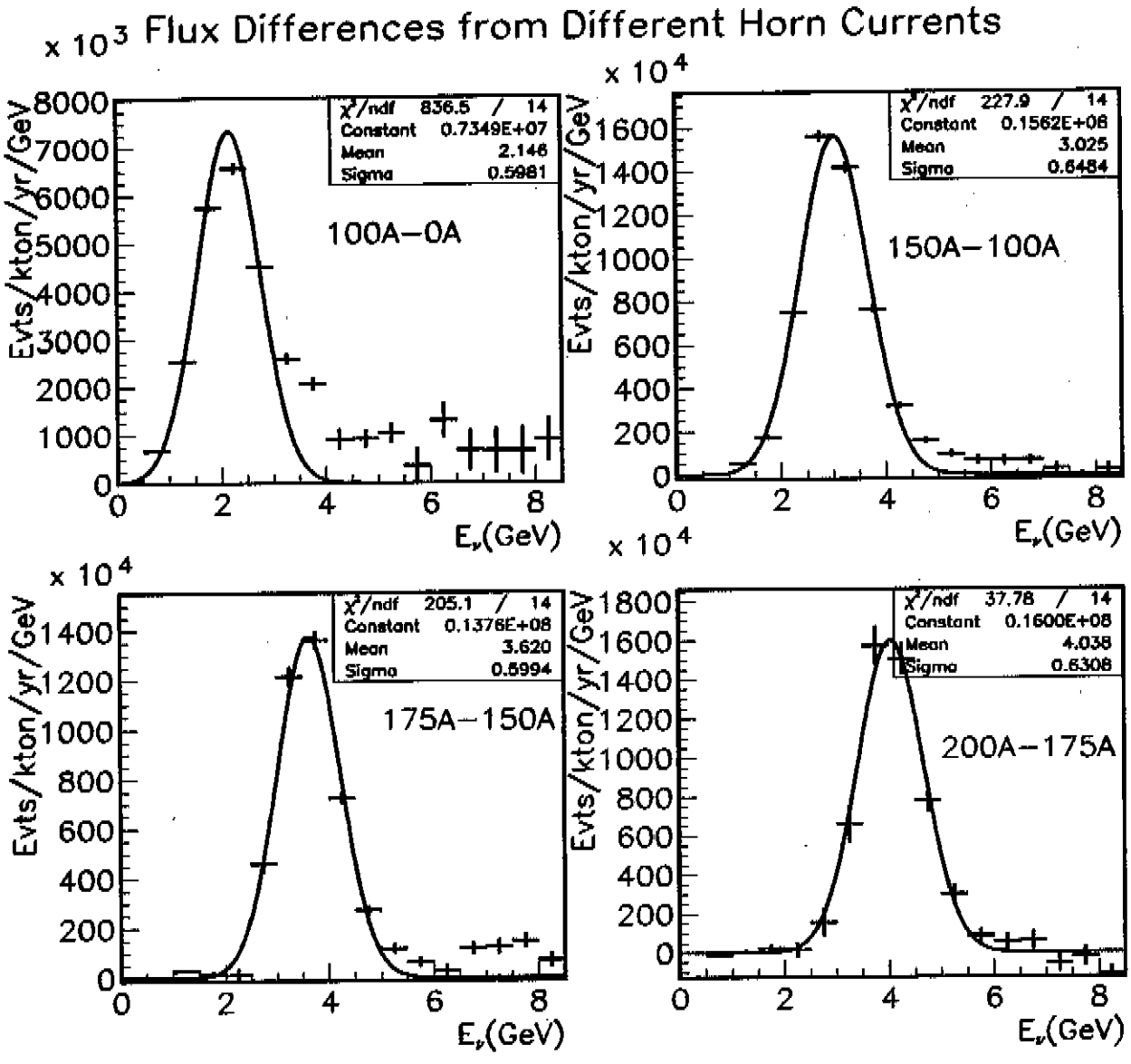
These changes can probably be much more powerful when combined with better detector!

DAH 9

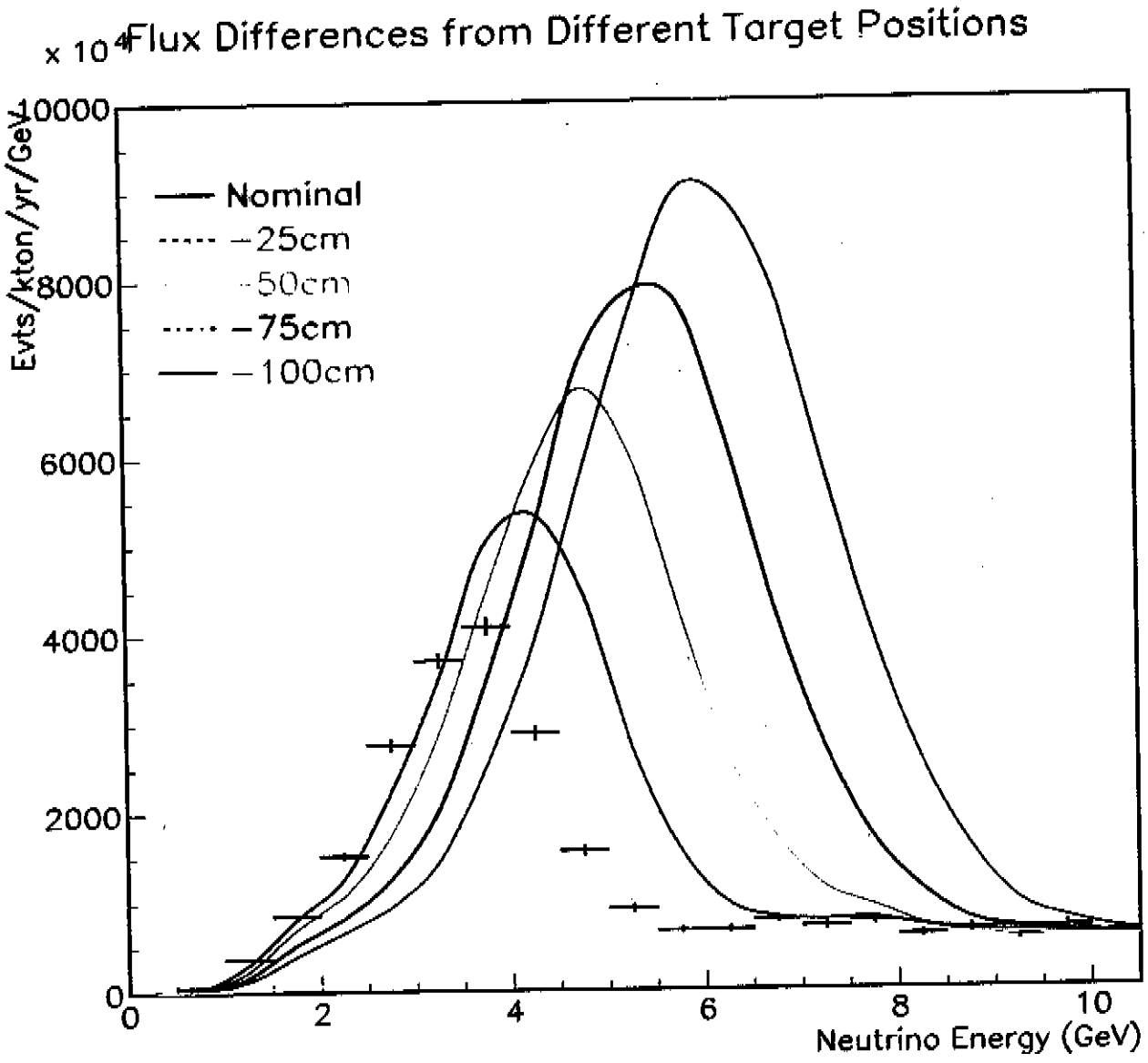
Effects of Horn Current Changes



Effects of Horn Current Changes



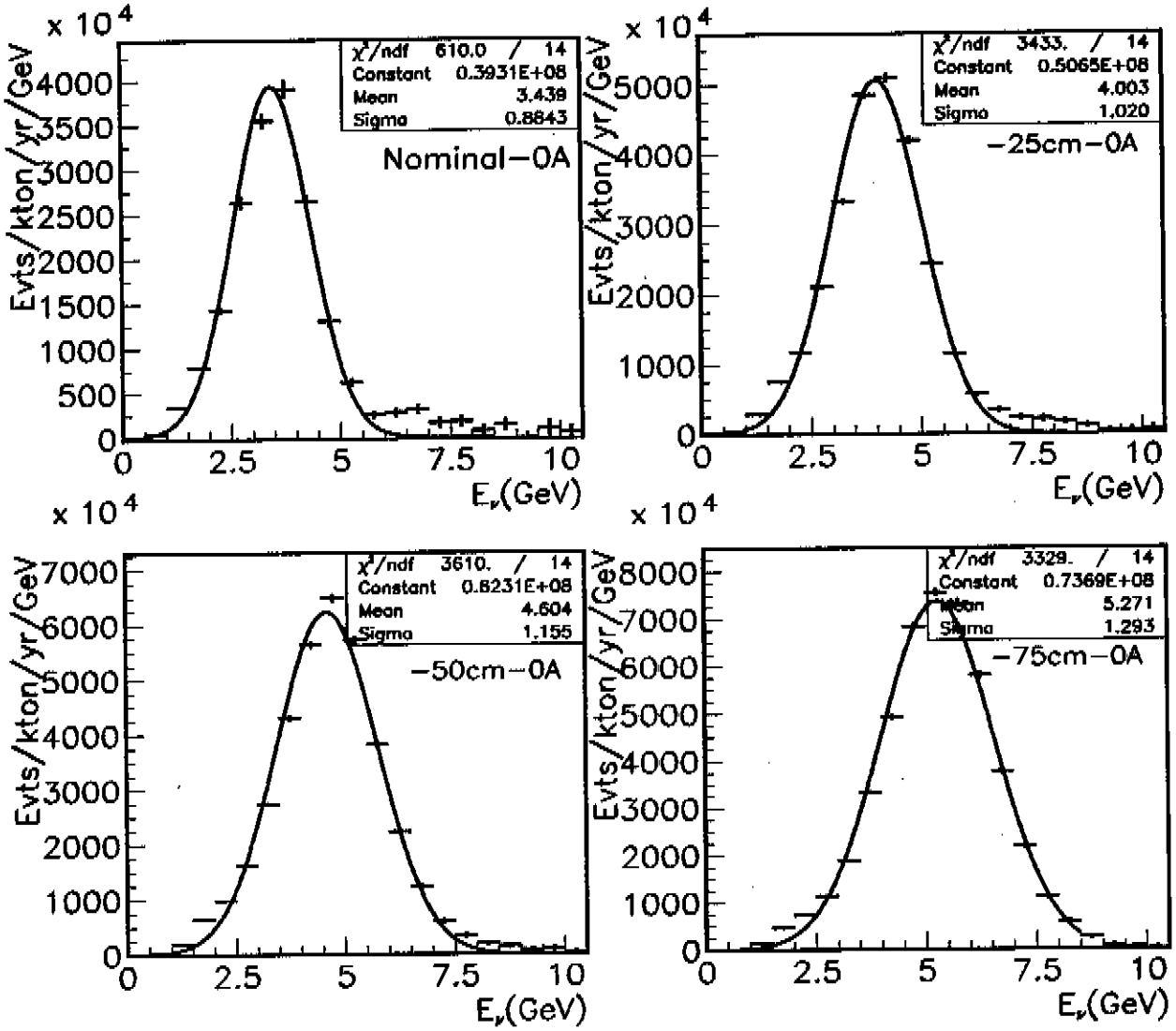
Effects of Target position Changes



DAH 12

Effects of Target position Changes

Flux Differences from Different Target Positions



DAH 13

Event rates and energy distributions

Run Condition	Mean Energy (GeV)	Width (GeV)	Evts /15ton/week
100Amp-0Amp	2.1	0.6	1.3K
150A-100A	3.0	0.65	3.0K
175A-150A	3.6	0.6	2.5K
200A-175A	4.0	0.6	2.9K
200A-0A	3.4	0.9	11K
-25cm-0A	4.0	1.0	15K
-50cm-0A	4.6	1.2	22K
-75cm-0A	5.2	1.3	29K

DAH 4

Measurement	MINOS	New NID	JLAB
$\frac{\partial\sigma_{TOT}}{\partial E}(\nu_\mu N \to \mu^- X)$	✓	✓	
DIS/RES/QE	—	✓	
"Energy Smearing"	barest of constraints?	✓	✓
$\partial^2\sigma/\partial E\partial y\ (\nu_\mu N \to \mu^- X)$	~~above~~ Some ycut, maybe	✓	
$\frac{\partial\sigma}{\partial E}(\nu_\mu N \to \nu_\mu X)$	maybe a rough constraint	✓ (OA)	
$\frac{\partial^2\sigma}{\partial E\partial y}(\nu_\mu N \to \nu_\mu X)$	—	OA	
$\frac{\partial\sigma}{\partial E}(\nu_\mu N \to \nu_\mu \pi^0 X)$	—		
NC $\pi^\pm$ energy dist	—	OA (?)	✓
NC π^0 energy dist	—	OA (?)	✓
⋮			
$\frac{\sigma^{\bar\nu}}{\sigma^{\nu}}(E_\nu)$ way important			