An Agressive Scenario for NuMI Upgrades

Fritz DeJongh

Fermilab

March 11, 2002

NuMI off-axis detector:

- Physics with no new investment in NuMI.
- However, competition from JHF-Kamioka proposal.

A more aggressive proposal?

- Consider beamline upgrades and larger detectors.
- It will cost more.
- Can it be compelling and cost-effective?

Comparison of NuMI off-axis and JHF-Kamioka Phase 1

- $\sin^2(2\theta_{13}) = 0.1$
- $+\ \Delta M^2$
- leading terms only

NuMI Off-axis	JHF-Super-K
0.4 MW	0.75 MW
40 kton-years	112 kton-years
20% efficiency	40% efficiency
$\Rightarrow$ 24 events	$\Rightarrow$ 123 events
(Barenboim, de Gouvea, Velasco)	

The NuMI proposal:

1. Cannot compete directly with JHF-Super-K.
2. Has marginal sensitivity to the sign of ΔM^2 even for the largest allowed values of $\sin^2(2\theta_{13})$.

Prospects for Beamline Upgrades

New proton driver:
$\Rightarrow$ up to 2 MW from Main Injector.

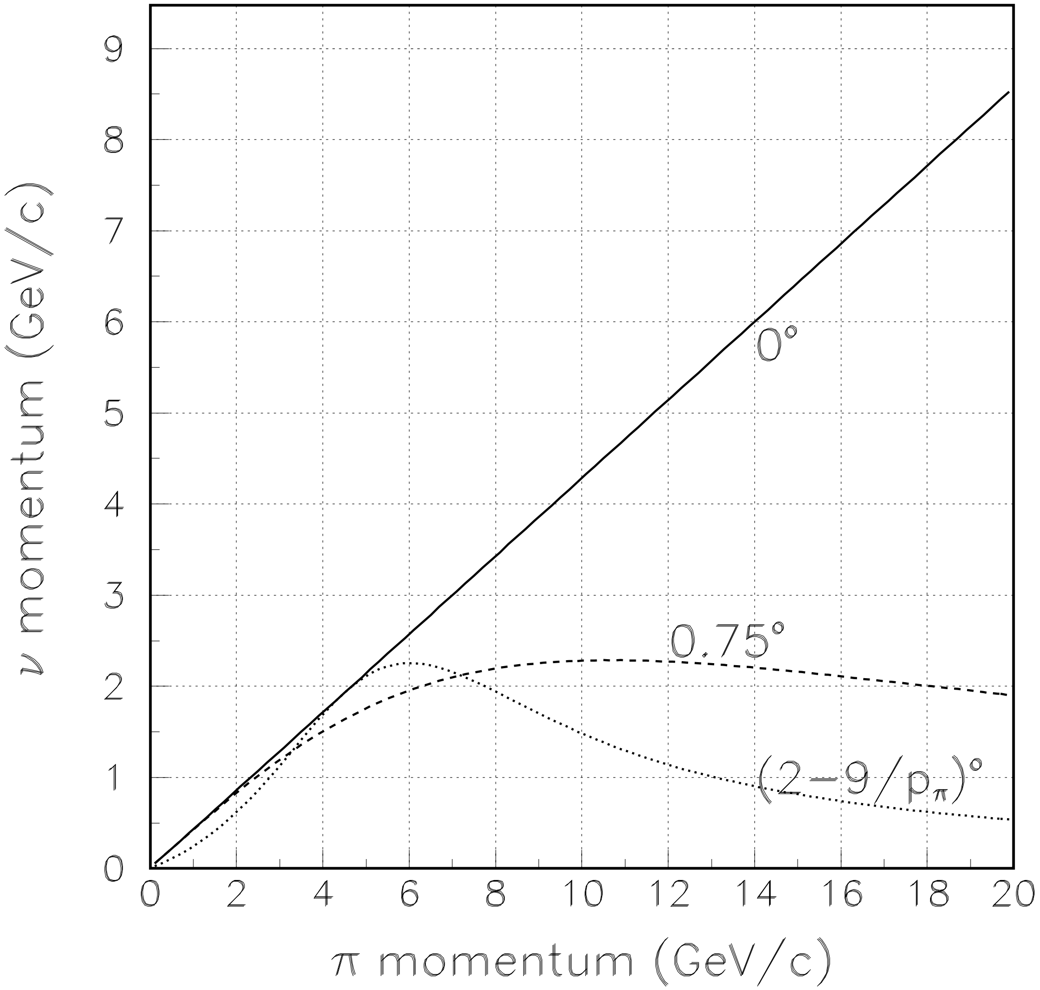
Linac option:
$\Rightarrow$ Get 2 MW at any energy $\leq$ 120 GeV.
Proton beam might have less halo.

How can NuMI handle 2 MW?

Upgrade target area for 2 GeV neutrinos:
Narrow-band beam
Suppressed high-energy tail
Proton and pion absorbers before decay tunnel

$\Rightarrow$ A restricted fraction of pion energy enters decay tunnel.

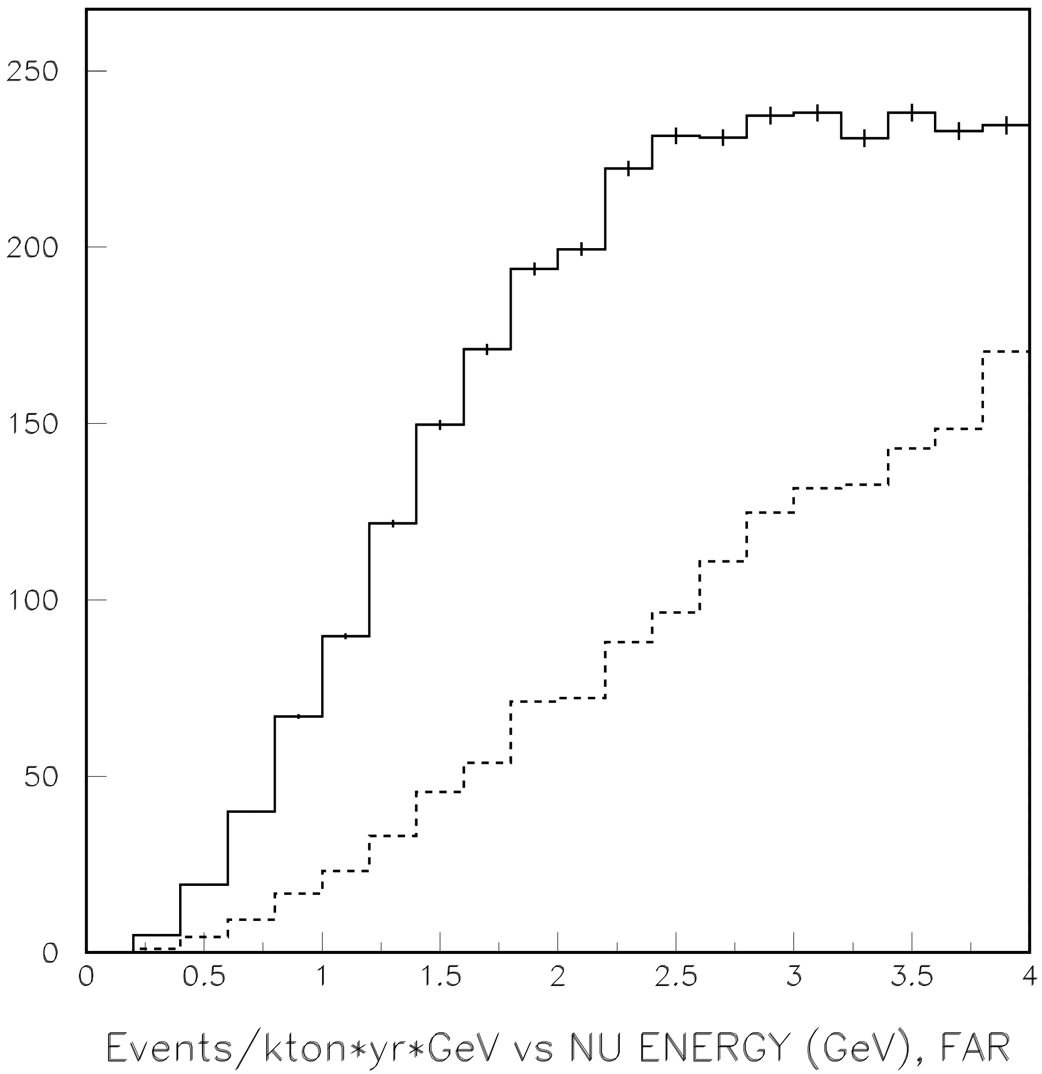
Two ways to generate 2 GeV neutrino beams



1. Beam 0.75° off-axis.
   2 GeV neutrinos come from wide range of pion momenta

2. Beam with 2° dipole bend for 4.5 GeV pions.
   2 GeV neutrinos come from pions near 6 GeV.

Neutrino spectrum for perfect focusing (on axis)

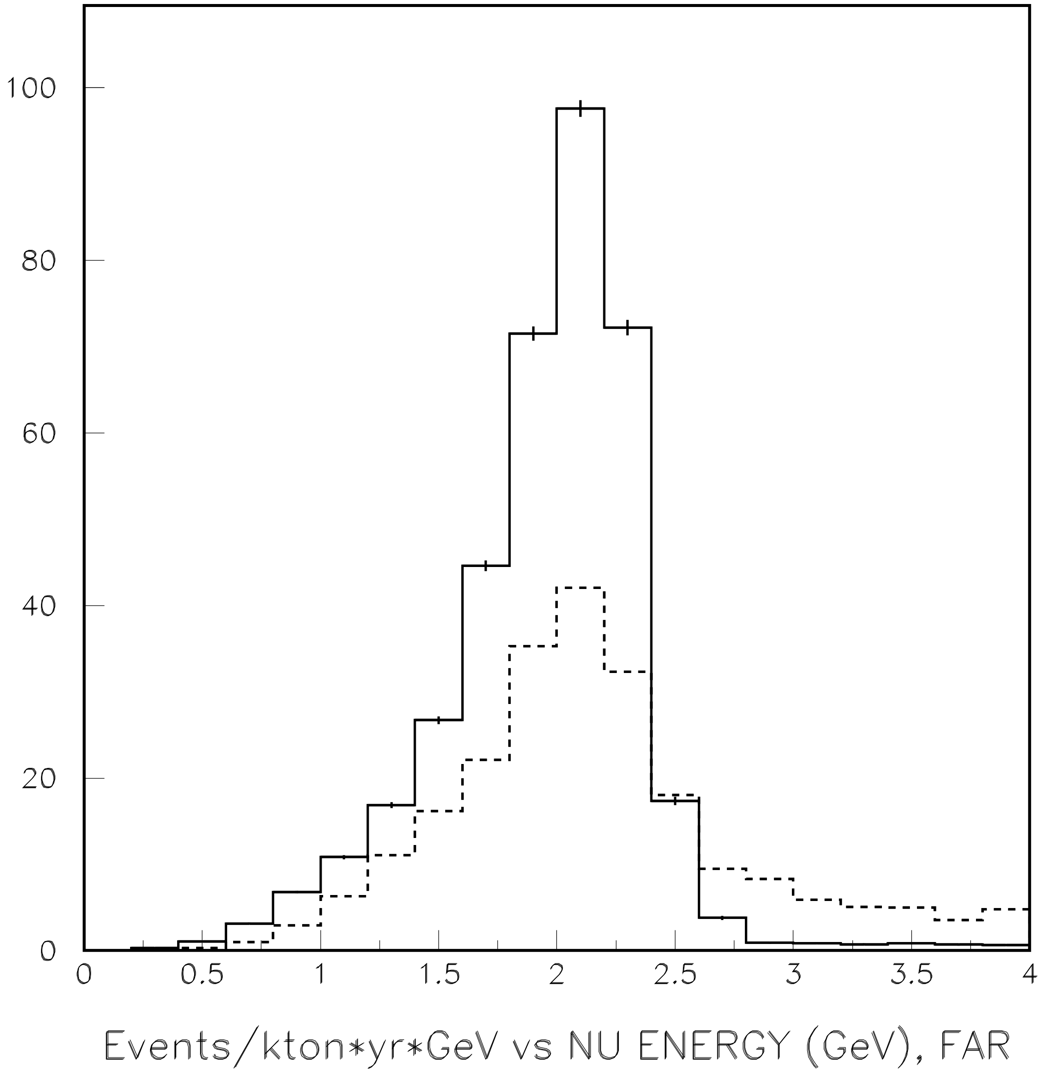


Compare for equal power at different proton energies:

1. Solid line: 30 GeV protons
2. Dashed line: 120 GeV protons

30 GeV protons are inherently better for 2 GeV neutrinos.

Comparison of off-axis and dipole beams at equal power



Caution: pbeam hack!
π absorption not included

- Solid line: Dipole beam with 30 GeV protons
- Dashed line: Off-axis beam with 120 GeV protons

$\Rightarrow$ Linac proton driver and dipole upgrade could yield:

- 10$\times$ the flux
- Better spectrum shape

compared to “current” off-axis beam.

Detector considerations

Dipole beam would be on-axis: Minos would benefit.

New detectors:

Variations on NuMI

Reduce cost/kton (*Adam Para*)
low-Z absorber
$\Rightarrow \times 3$ target mass/X_0
Cheaper tracker?
50 kton feasible?

Water Cerenkov

Use one Hyper-K module?
70 kton fiducial
When done, use materials for US contribution to Hyper-K.

$\times 5$ improvement in kton-years possible?

Conclusions

Simply placing a new detector off-axis the current NuMI beamline does not appear to be an appealing proposal.

However, given the NuMI beamline and a linac proton driver, there may be a cost-effective way to go $\times 10$ beyond JHF-Super-K:

- Find a way to upgrade the target area to handle 2 MW of 30 GeV protons and produce a narrow band beam.
- Find a way to build a large detector near Minos.

Perhaps components can be recycled into the JHF/FNAL - Hyper-K program (or whatever).