On Axis Monitors for Off-Axis Beam

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6. How is this related to ν_μ, ν_e off-axis fluxes?
7. What Monitoring can and can't tell you

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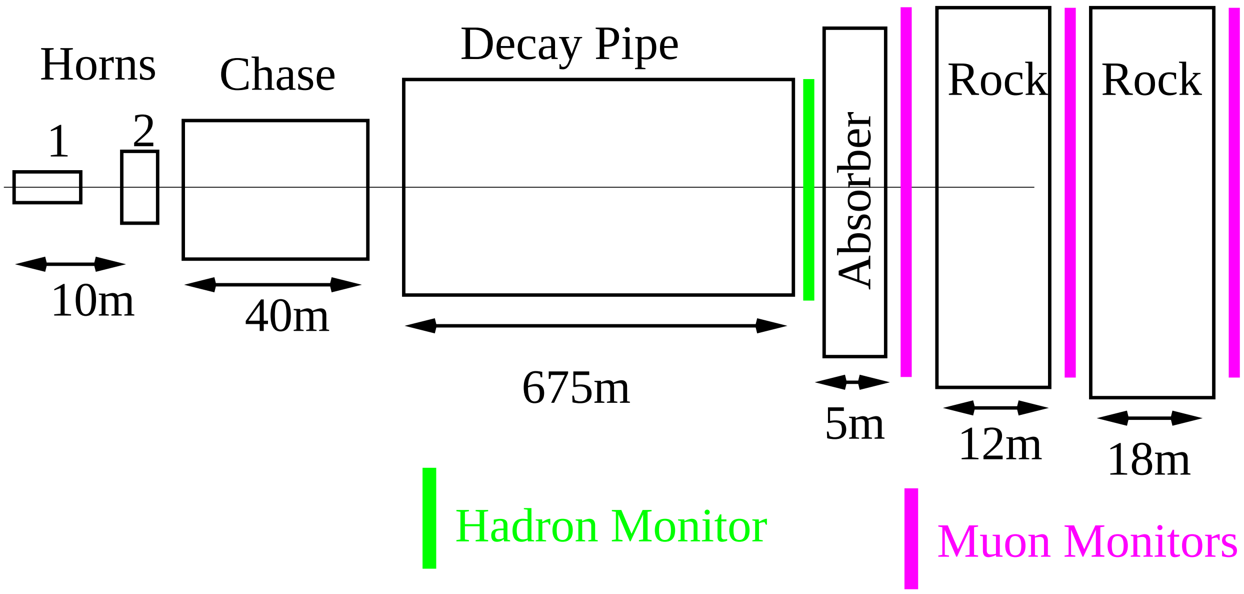
Fermilab
May 3, 2002
New Initiatives for the NuMI-Off-Axis Beam

Role of Beamline Monitors



Role of Monitors

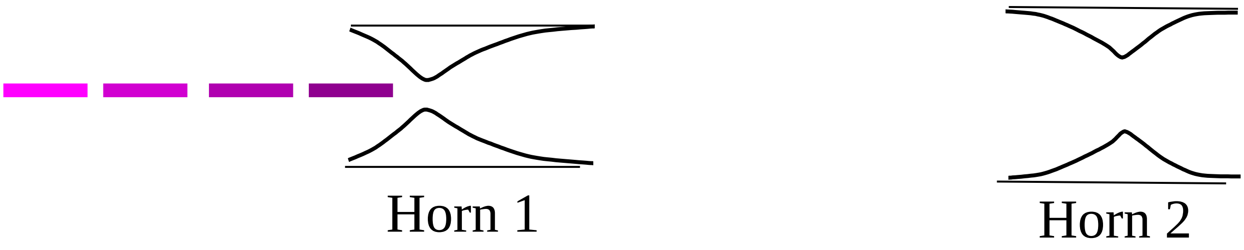
- Commissioning–check of alignment
- Normal Running –make sure optimal beam is being created
- Re-commissioning–any time beamline element is moved
  - Primary beam instrumentation needs replacement
  - Horns get moved/replaced

Operating Conditions

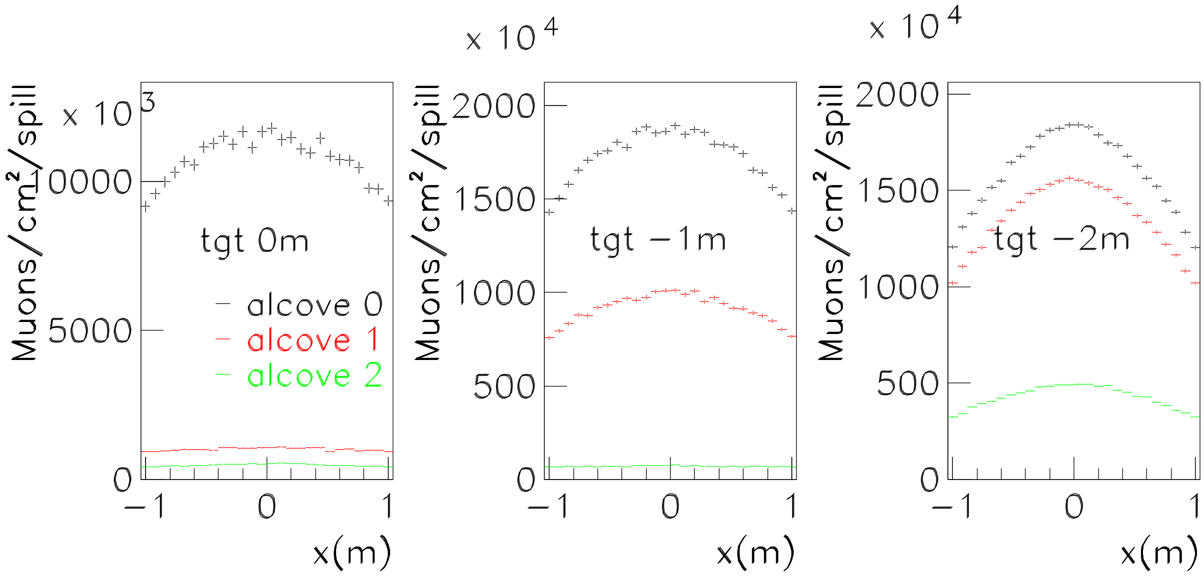
- Radiation Levels Ref: N.Grossman
  - Alcove 0: 6.6 MRad/year (mostly muons)
  - Alcove 1: 0.7 MRad/year (mostly muons)
  - Alcove 2: 0.15 MRad/year (mostly muons)
  - DHM: 15 Grad/year (60% neutrons)
- Temperature Ref: D.Pushka
  - Muon Alcoves: $60° - 80°$ F
  - First Muon Alcove: 4° F higher
  - DHM: 95°F to 105°F
    with spatial variation!
- Humidity Ref: D.Pushka
  - Muon Alcoves: very humid, temperature maintained just above dew point
  - DHM: relative humidity less than 60%
- Pressure –track atmospheric pressure
  3% level expected (ref: Airport readings)

Role of Variable Energy Beam

Variable Energy Beam Concept



As target goes farther upstream, higher energy pions get focused–more collimated neutrino and muon beam...

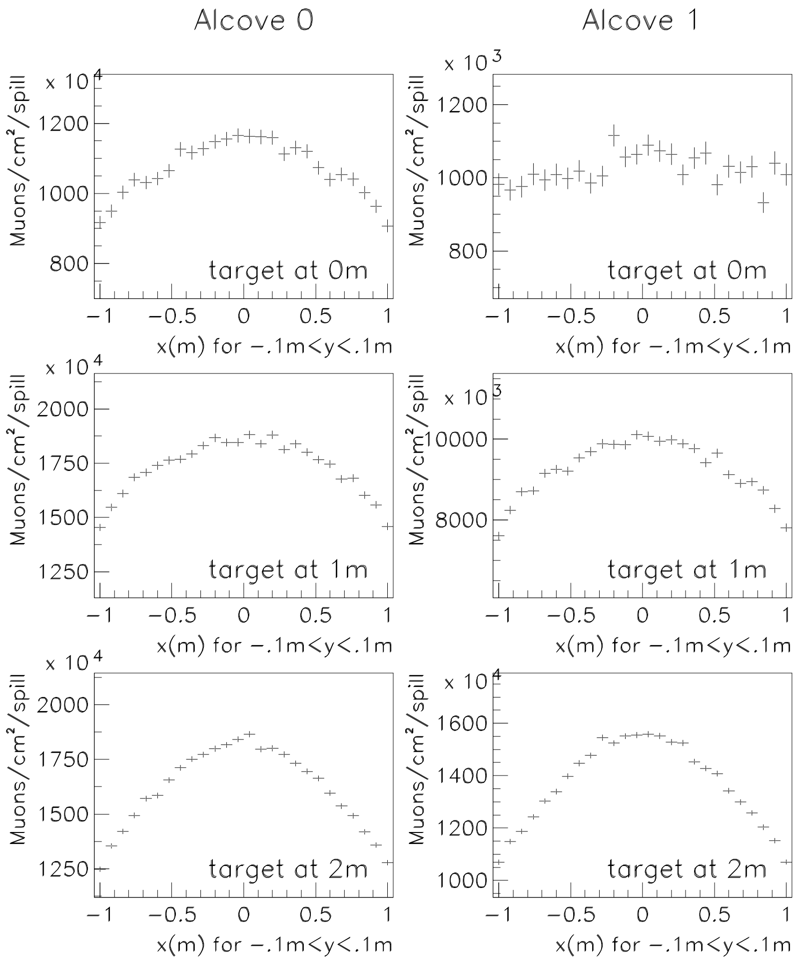


(pbeam muon simulation, no aluminum core in absorber)

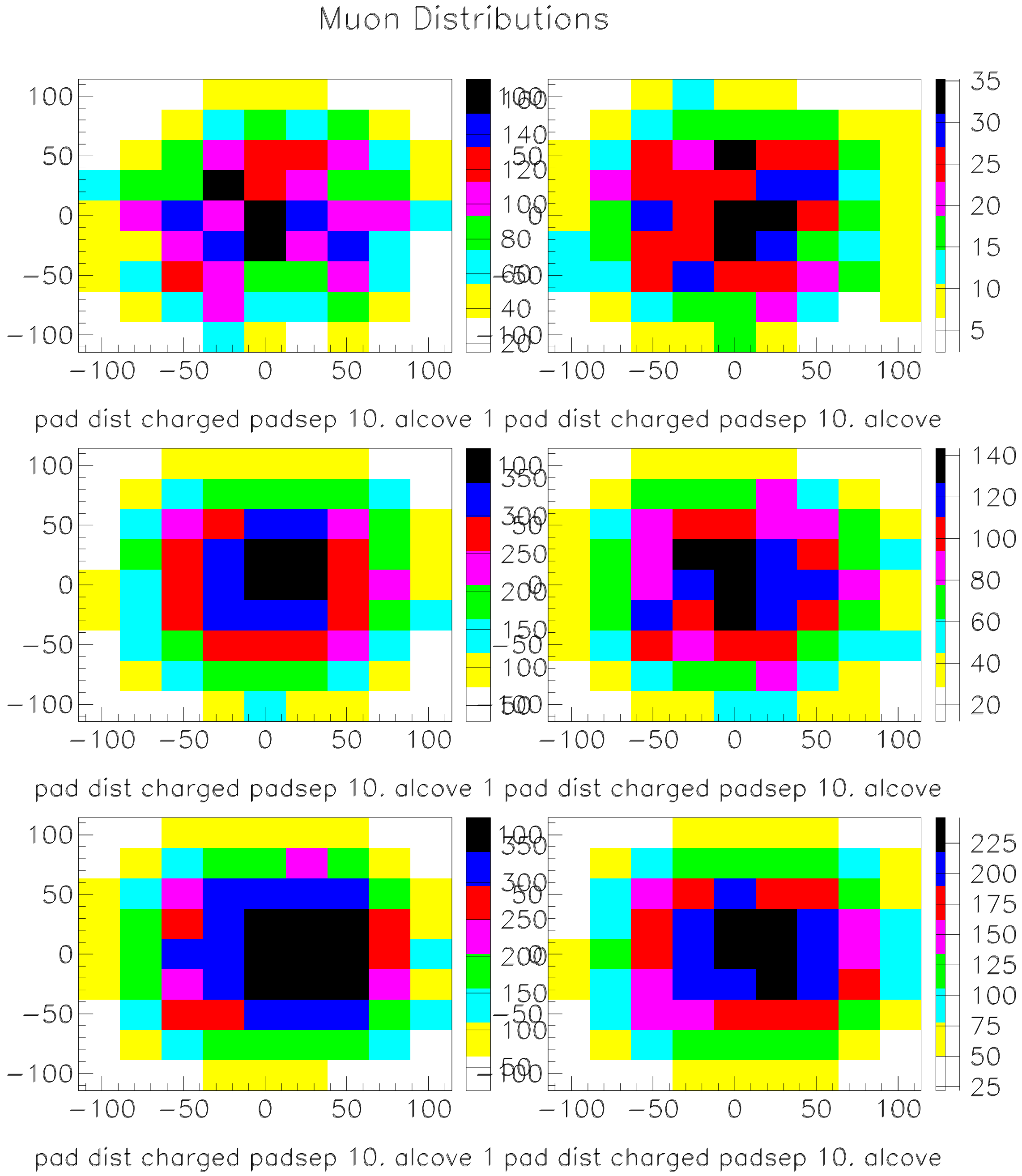
Alignment of Neutrino Beam – Muons

Survey Accuracy of alcoves	2cm
Lever Arm	739m, 751m, 769m
$\Delta(\mu\ events)$ @0.5m	4 to 10%
Error on Mean	to few cm per spill
Resulting Pointing Accuracy	better than 100μrad

This is the only fast measurement we have of the neutrino beam direction...



Including Information about Absorber



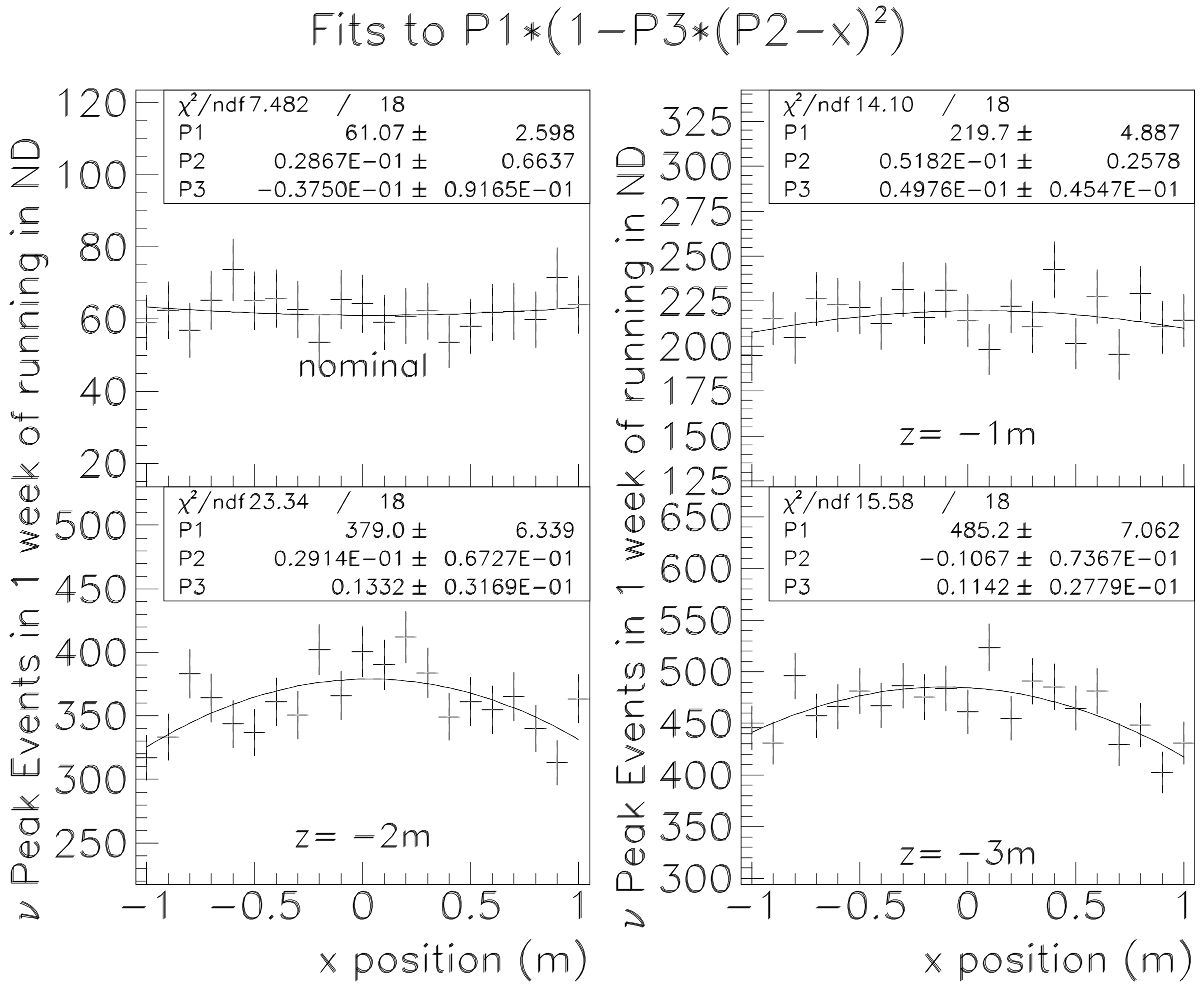
Left to Right: Alcove 0 to Alcove 1

Top to Bottom: Nominal, Target back 1m, 2m

Alignment of Neutrino Beam – Neutrinos

Survey Accuracy of ND	2cm
Lever Arm	1040m
$\Delta(\nu\ events)$ @1m	0 to 10%
Error on Mean	to 10cm per week
Pointing Accuracy	up to 10μrad

To do this measurement the target must be back a few meters from nominal...

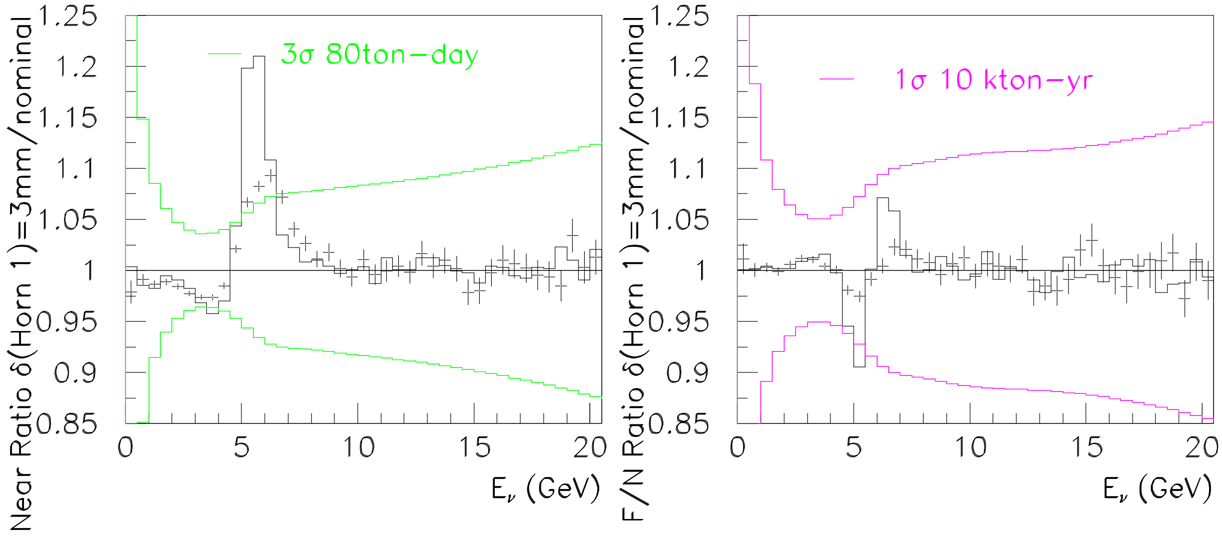


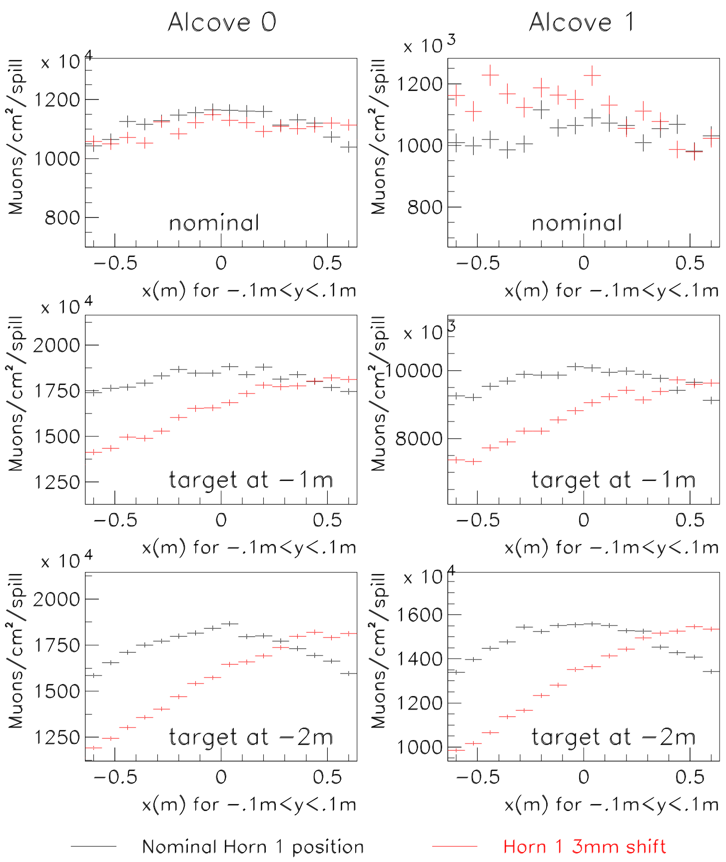
Spill to Spill Monitoring

- If spot size at DHM changes and primary proton beam doesn't, then it's a target problem. (could also show up as muon monitor problem)
- If Rates in Muon Monitors change, and DHM doesn't change, then it's problem with the horns.
- If Primary beam monitoring devices ever need replacing, their subsequent alignment will be checked by DHM.

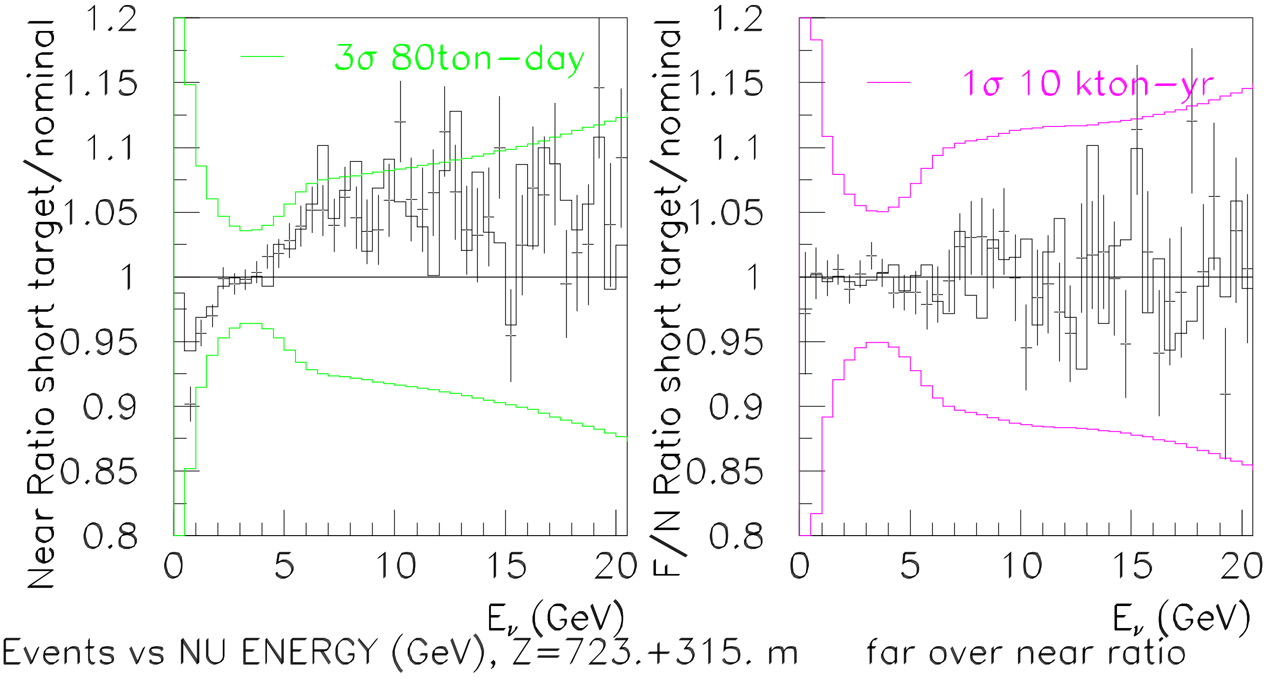
Example of Periodic Semi-Medium Monitoring

Effect of 3mm shift in Horn 1:

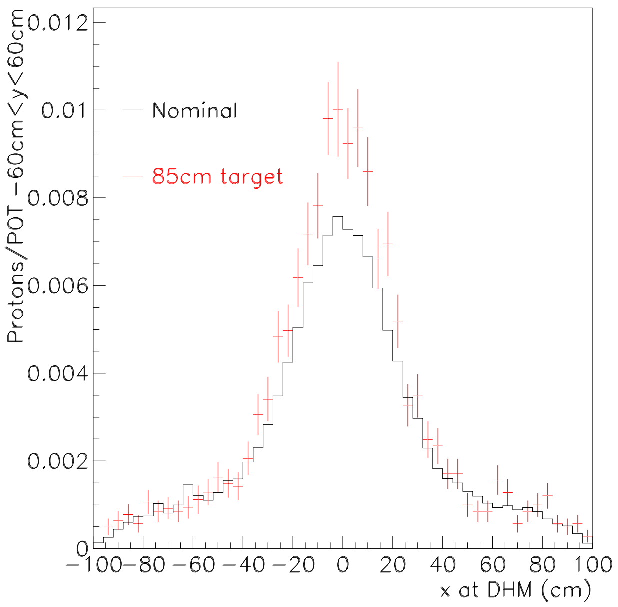




Target Integrity During Run



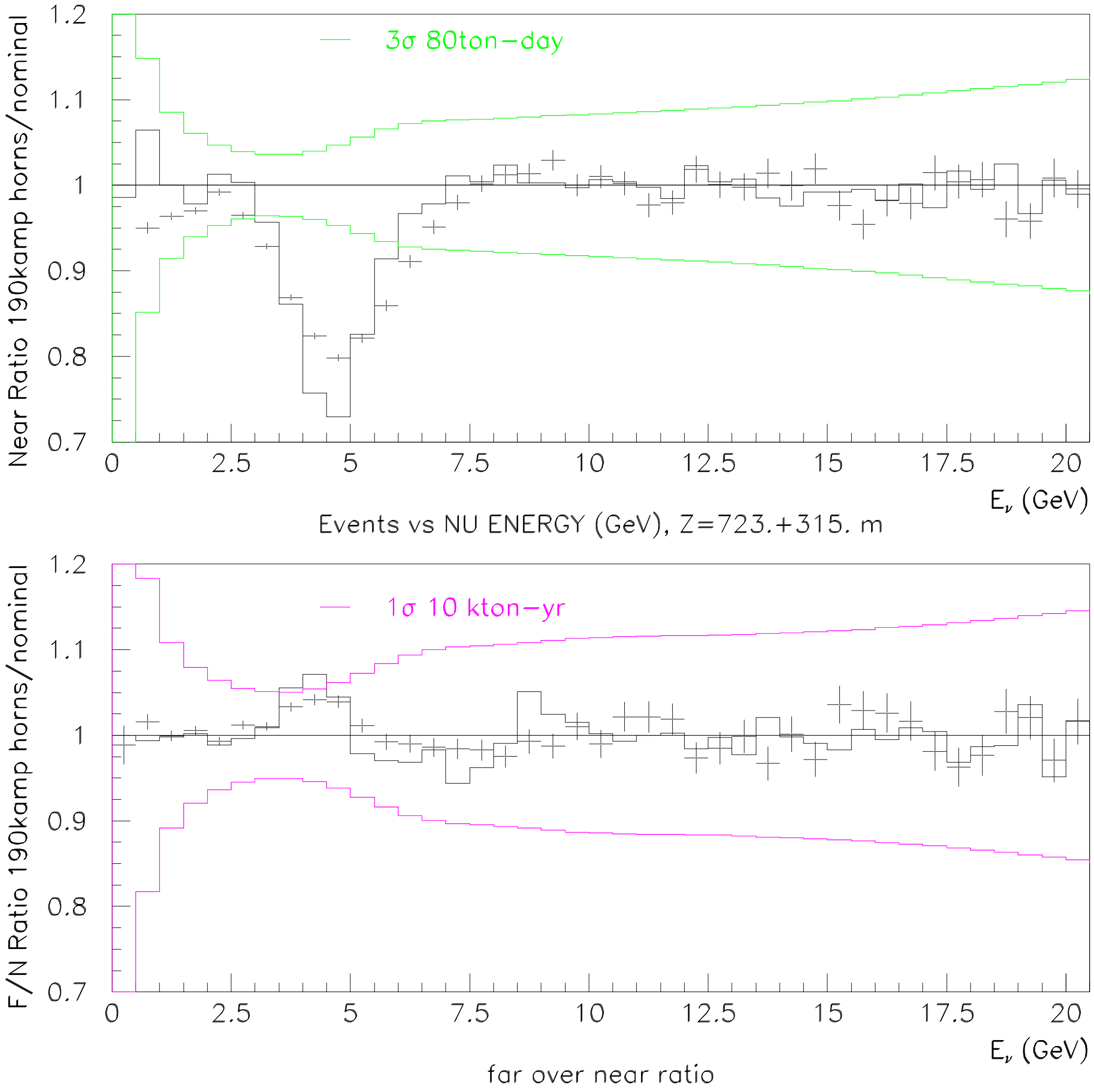
DHM Change



Flux Loss in Muon Alcoves:

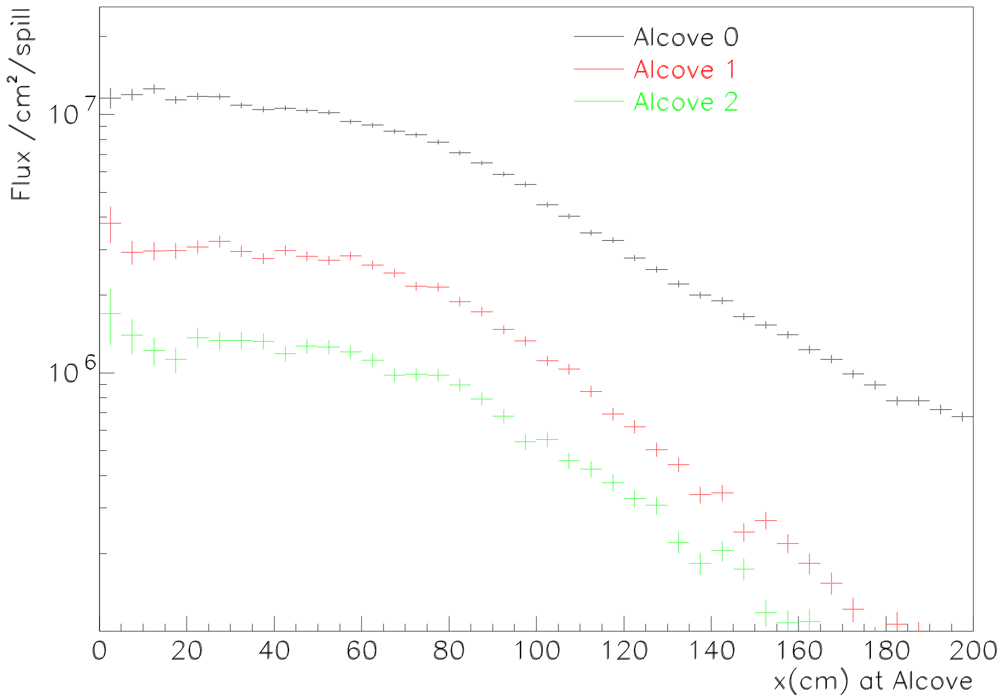
Alcove	Rate/Nominal
0	$0.996 \pm .02$
1	1.04 ± 0.026
2	1.10 ± 0.024

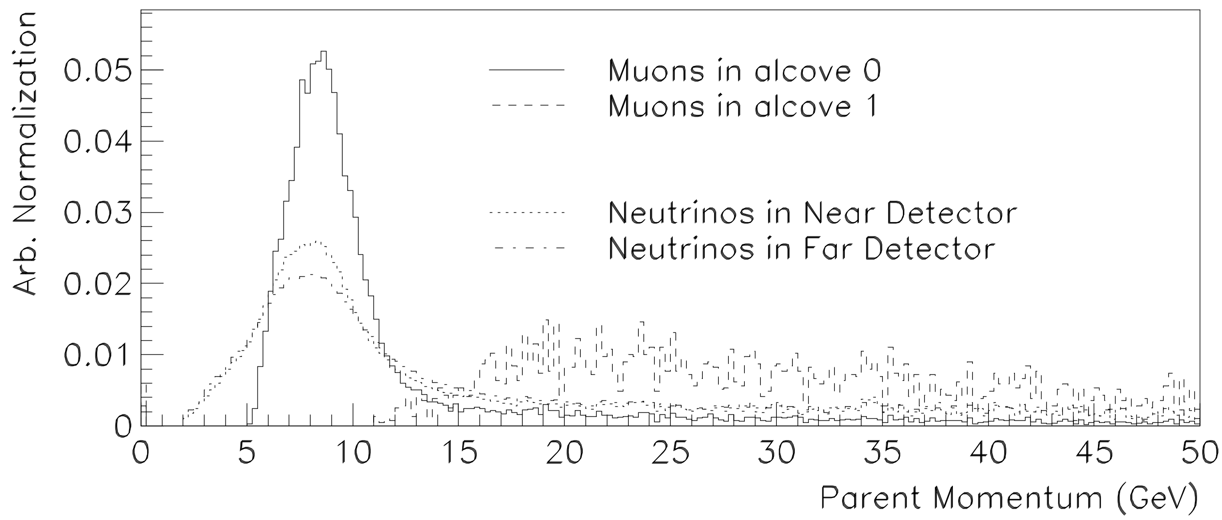
Horn Current Loss During Run



Alcove	Rate/Nominal
0	$0.92 \pm .02$
1	0.89 ± 0.01
2	0.98 ± 0.01

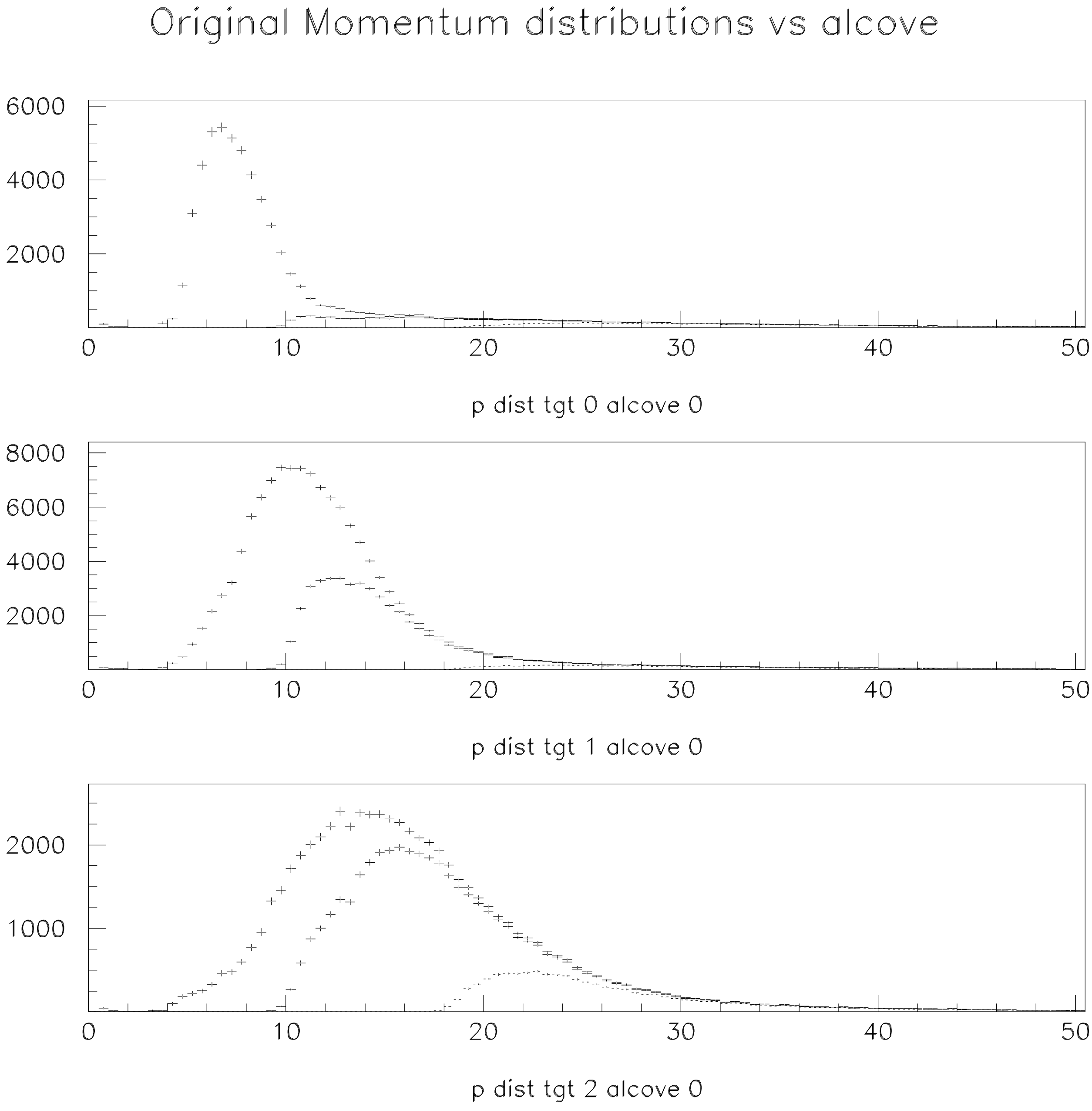
Fluxes and Composition
Muon Monitors



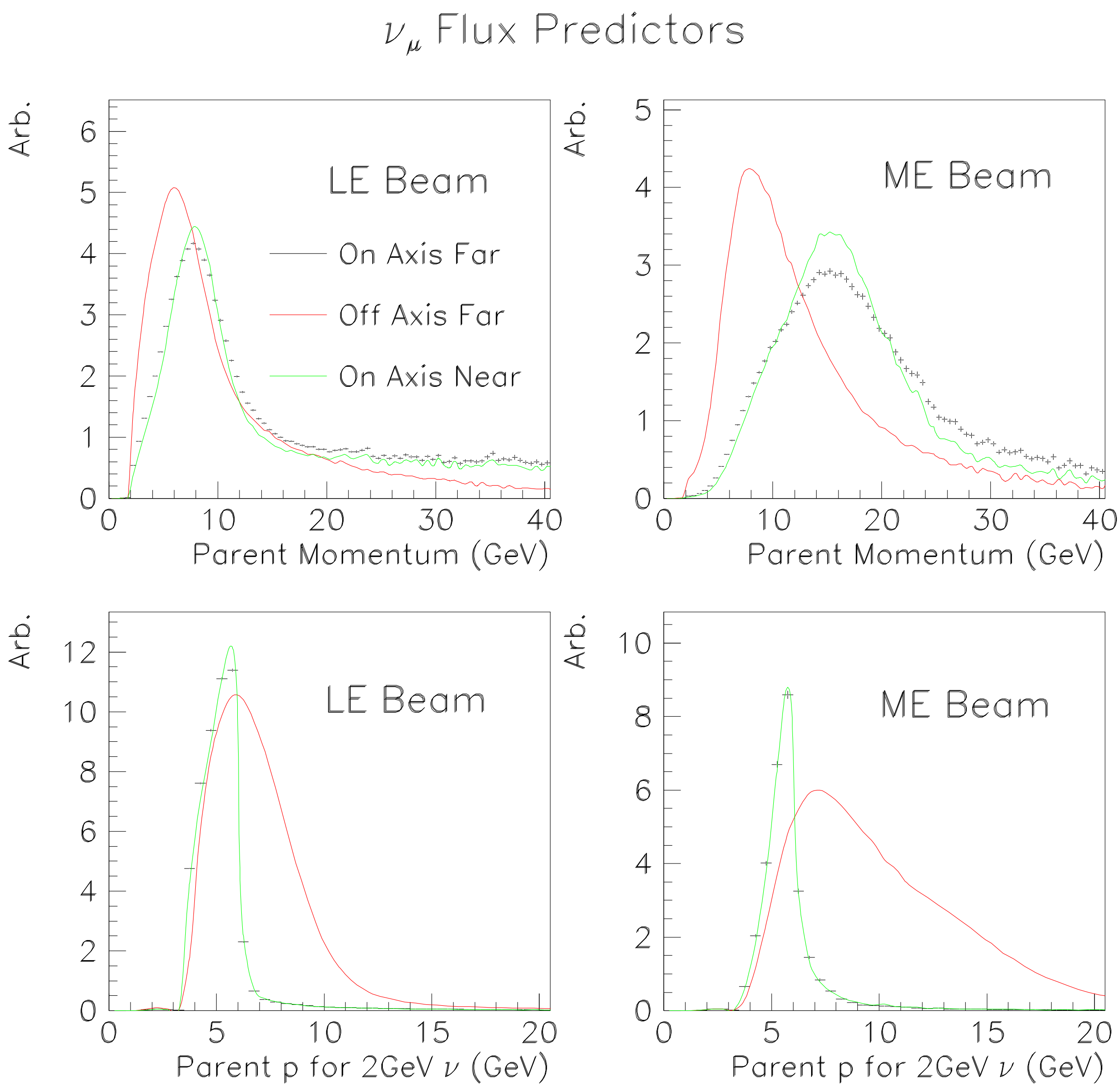


When target moves upstream, alcove 1 starts seeing muons from horn-focused pions as well.

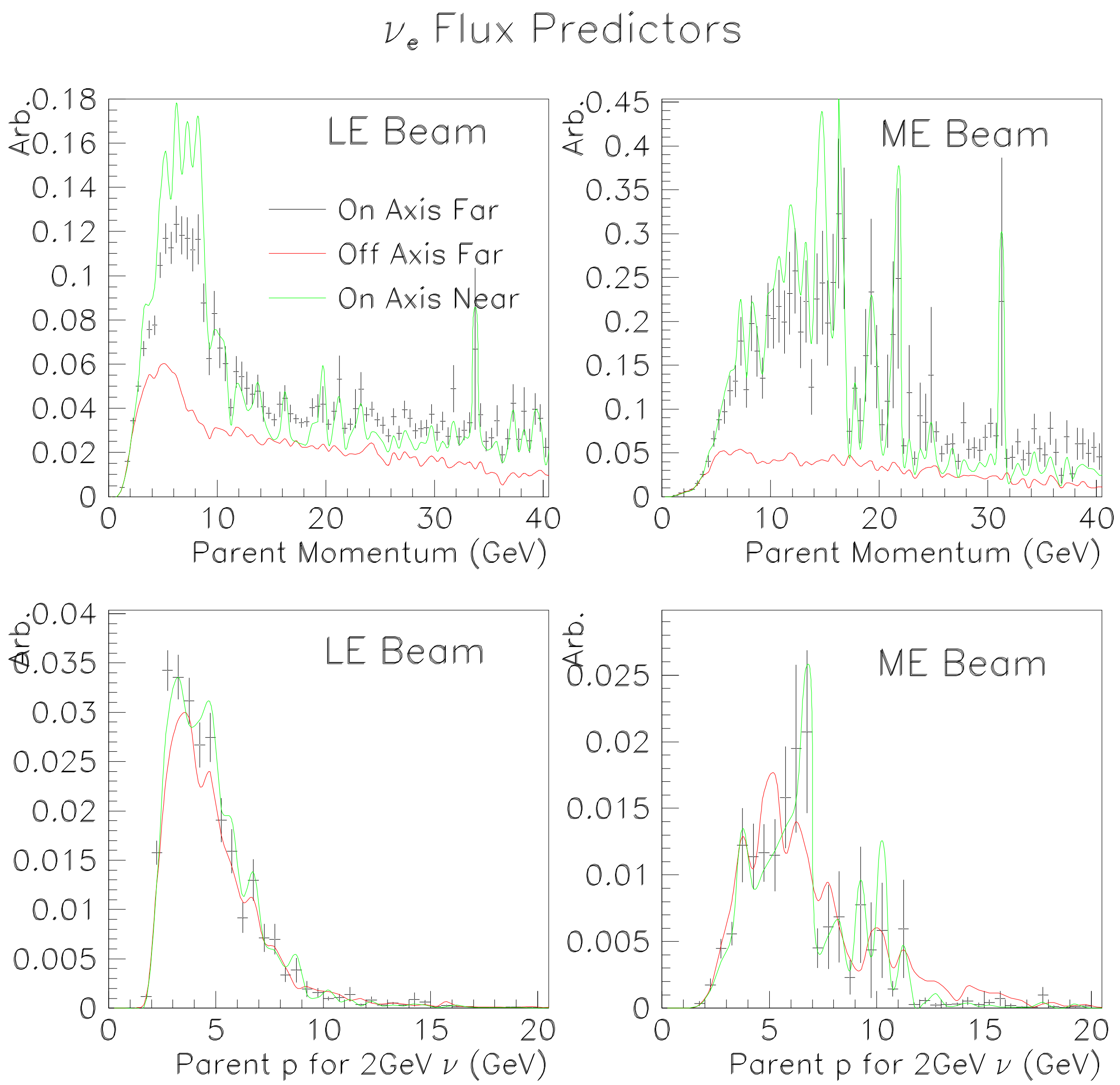
Parent Momentum Distributions for different target locations (GNUMI)



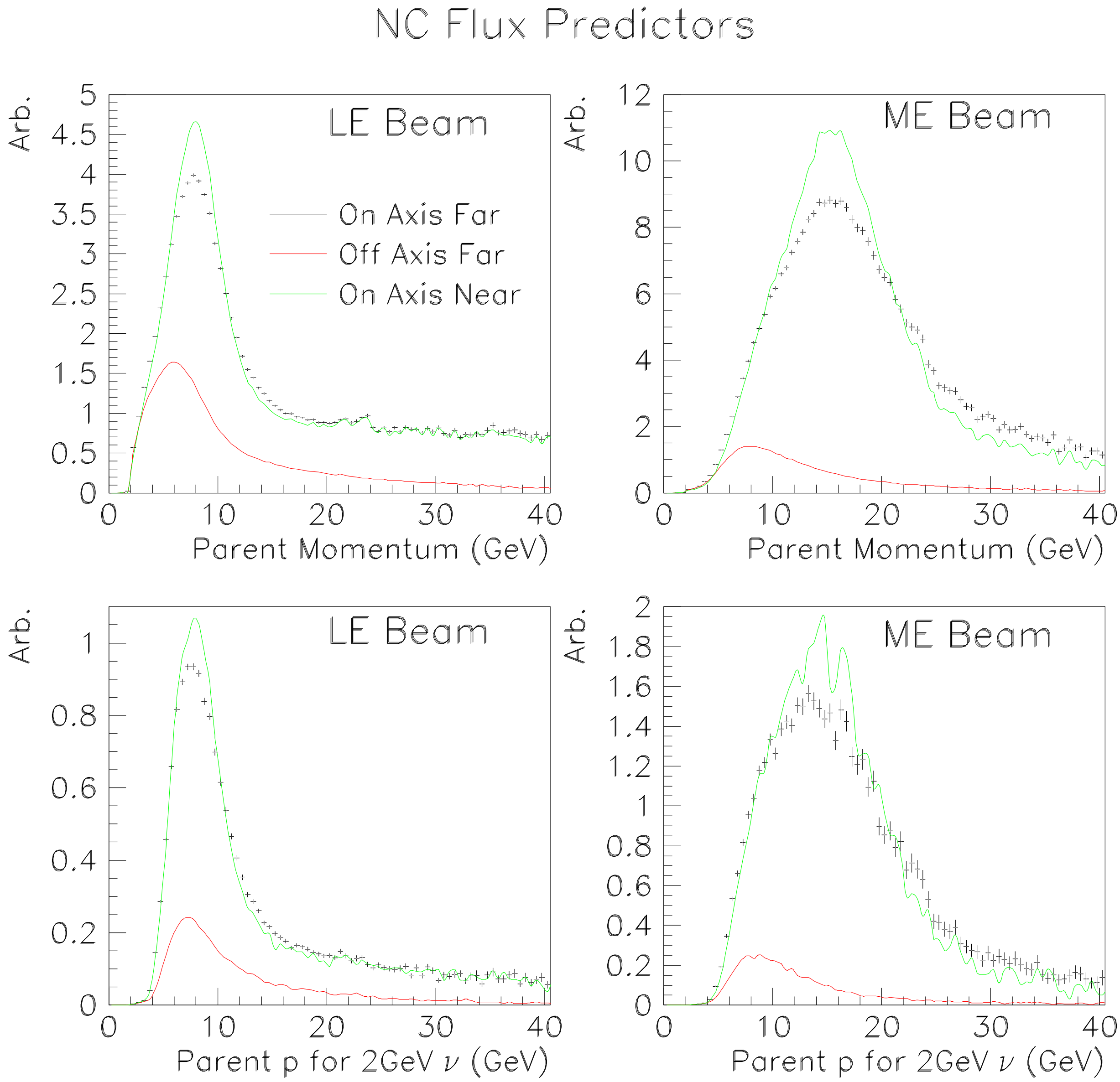
Parent Momentum Distributions
Off Axis and On Axis



Can Monitors Track ν_e Rates?



Can Monitors Track NC Rates?



Conclusions

- Hadron Monitor will verify initial proton beam direction, and during the run verify target integrity
- Muon Monitoring system will be able to do absolute pointing of the neutrino beam when the target is moved back 1 or 2 meters from nominal position.
- Given information in Near Detector and Monitors, there are additional handles in the muon and hadron monitors which can record the stability of the off-axis beam
- momentum distribution of muons in monitors is most well-matched to momentum distribution of particles that feed down into signal region from NC background
- Due to uncertainties in delta-ray production, these Monitors cannot be used for absolute rate predictions of off-axis fluxes!