Beam Spec Advisory Group Report

Adam Para
Fermilab

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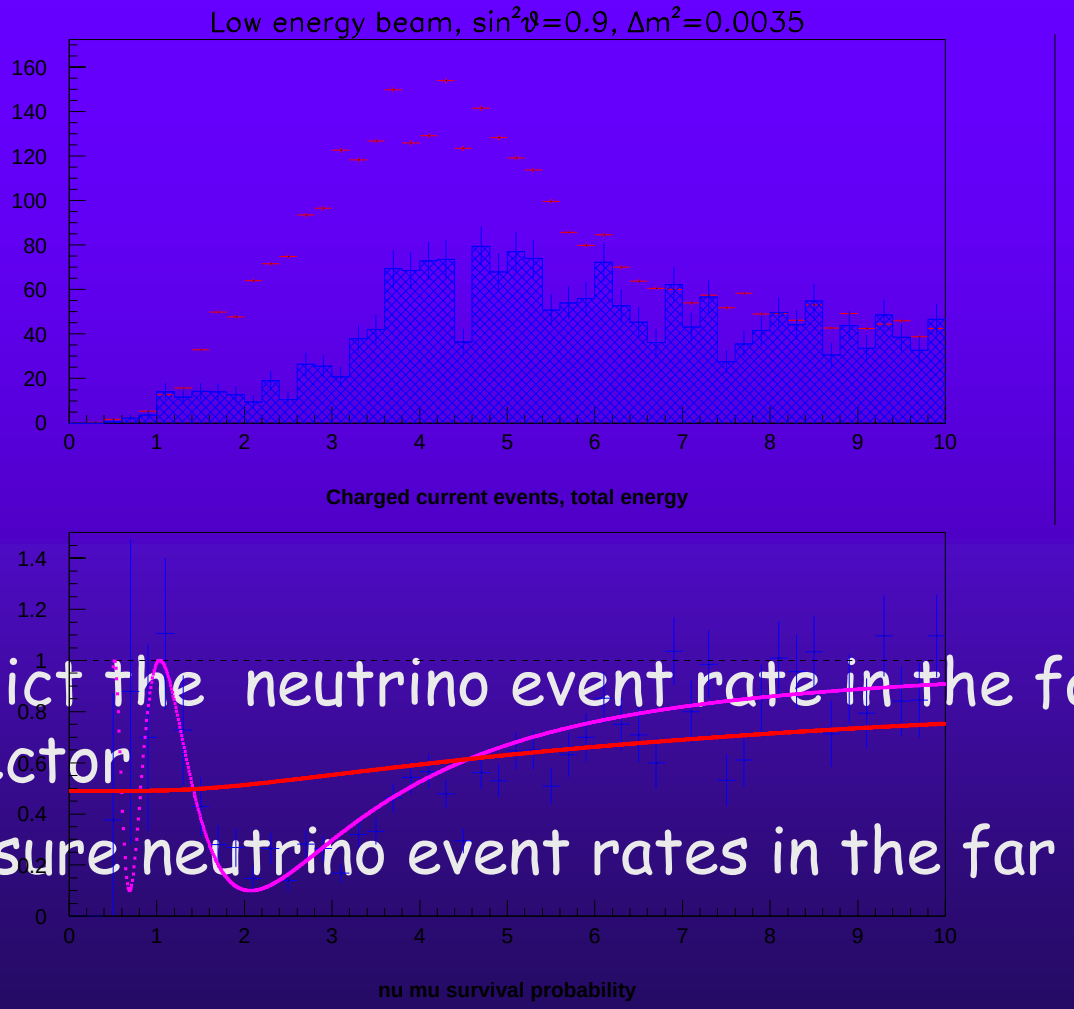
BSpAG report

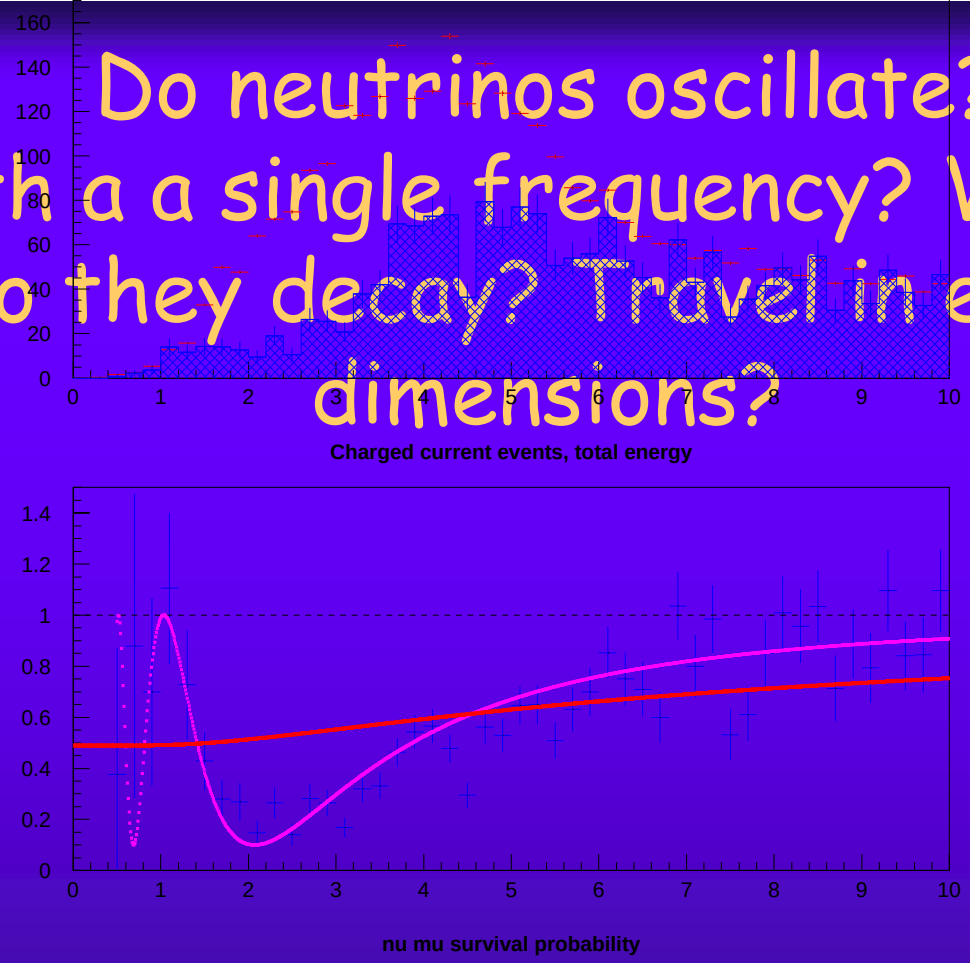
- Motivation
- Baffle recommendation
- Horn positioning system recommendation
- Neutrino flux battles (Sacha Kopp,next talk)
- Variable energy beam issues

Do neutrinos disappear?



- Predict the neutrino event rate in the far detector
- Measure neutrino event rates in the far detector

Do neutrinos oscillate? With a a single frequency? Which? Do they decay? Travel in extra dimensions?

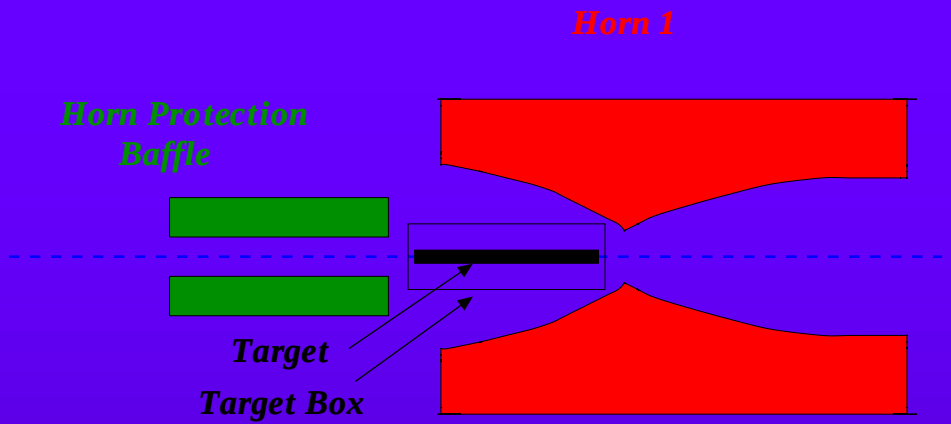


- Predict the neutrino CC events total energy spectrum in the far detector
- Measure neutrino CC events total energy spectrum in the far detector
- Their ratio yields the neutrino survival probability

Understanding of the expected far detector neutrino flux is a key to the experiment

- You will be giving (some day) a MINOS talk and presenting the results. Are you confident that:
  - we have all necessary information that you will need to defend the understanding of the neutrino flux?
  - we have adequate redundancy/reliability?
- A number of people working on the beam issues is very small (but slowly growing)
- Given the status of the project it will be soon (it is now?) counterproductive to think about significant (any?) modifications
- The train is leaving. Are you comfortable with the directions it is taking?

Horn Protection Baffle



Baffle:

Protect the inner conductor of the horn, cooling lines of the target (decay pipe window ??)

Baffle issues (Brajesh):

- Proton beam scraping/interacting with the baffle produces high(er) energy beam component which induces systematic error on the far detector flux prediction
- Size of the effect can reduced by a factor of two if baffle is moved further upstream

- Make the baffle opening as large as it is consistent with its protective functions (recommended)
- Baffle position/mounting (under discussion)

Beyond the baseline: horn fiducials

Motivation:

Horns (especially horn 1) position is a very important factor determining the neutrino beam

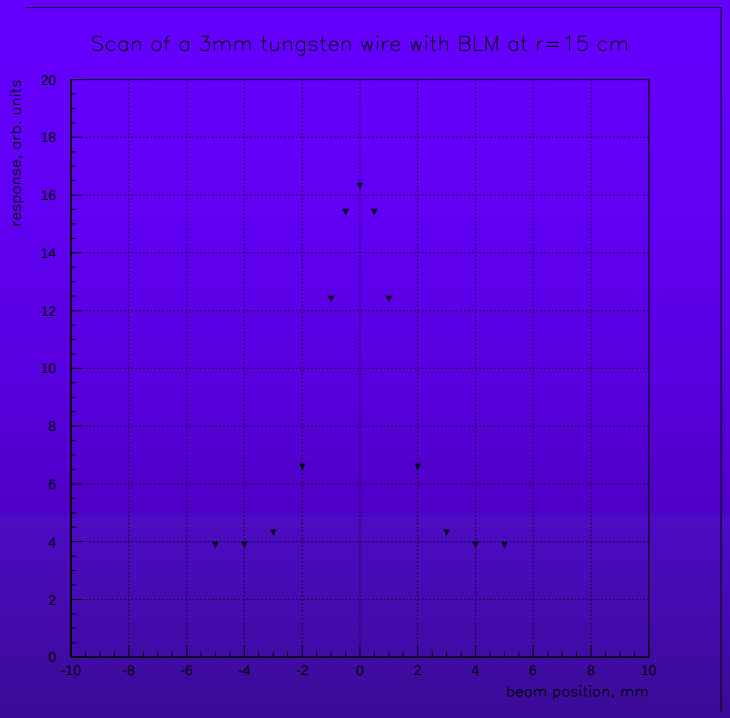
Provide a method of verifying the horn alignment with respect of the proton beam:

- At the beam commissioning phase – cross check of the survey
- During the data taking – diagnostics in case beam conditions change
- After a possible horn replacement

Method:

- A pair of (tungsten?) wires attached to the end of the horn
- Beam Loss Monitor located ~ 1 m behind the horn
- Move the proton beam across the wires and measure the signal of the BLM
- Extra bonus: can locate the neck of the horn with low intensity proton beam

Locating the horn(s) position



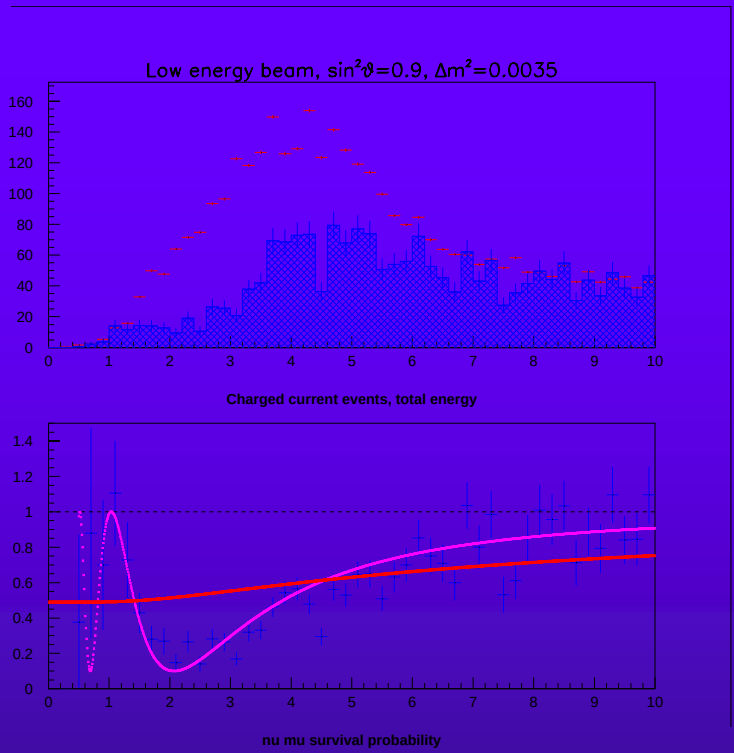
- Comfortable signal/noise ratio expected
- Expected precision of 100-200 microns possible (limited by the knowledge of the position of the wires with respect to the horn
- Can be done at full or reduced proton intensity

Recommendation: include in the scope of the project

Measure the disappearance curve: over what energy range?

Observed energy distribution of ν_μ CC interactions provides a measure of the ν_μ survival probability, at the distance L, as a function of E_ν

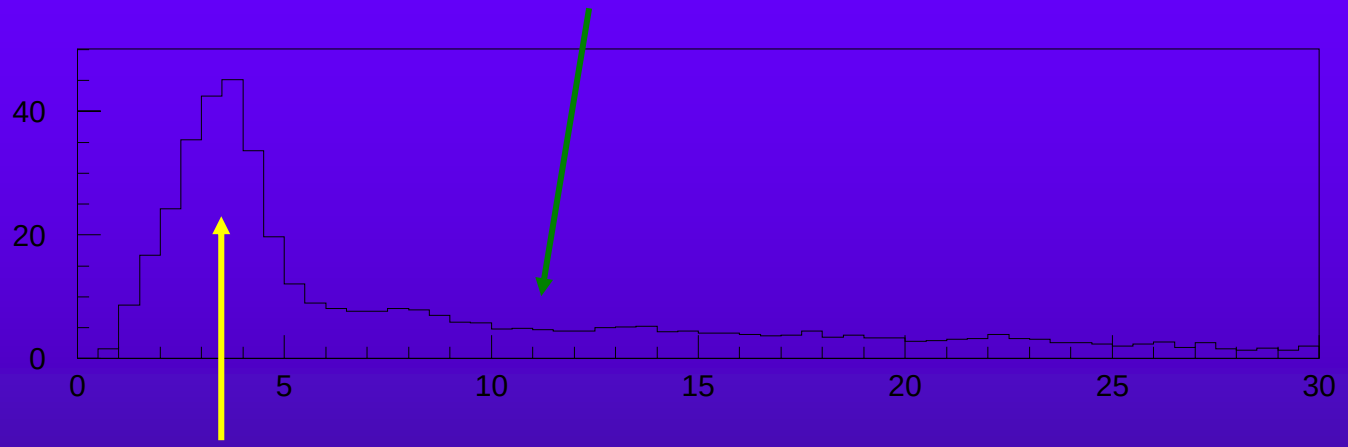
- Shape of the disappearance curve provides information on Δm^2 and $\sin^2 2\theta$



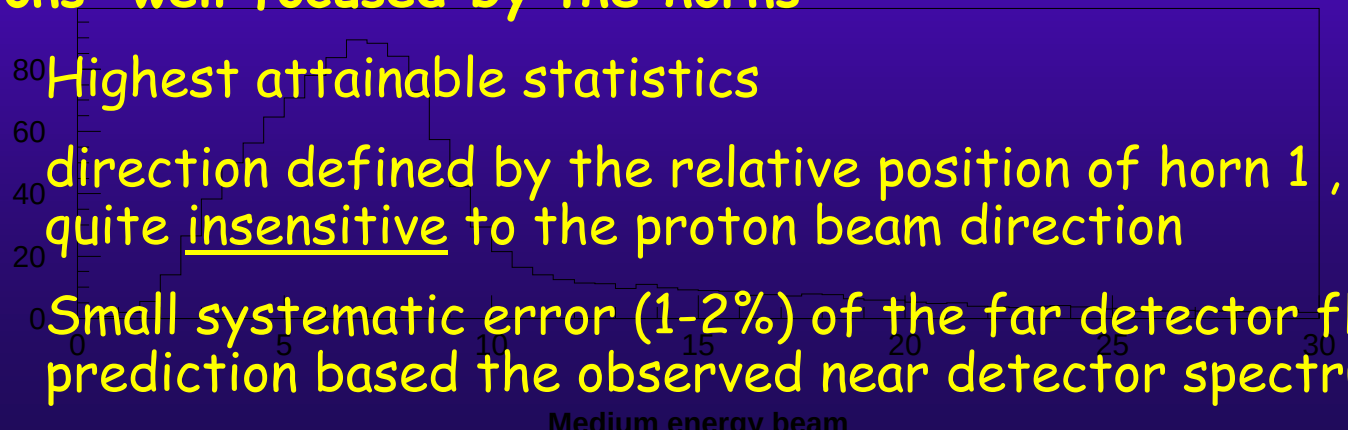
- Confidence level of the results depends on the systematic error on the flux prediction
- Low Δm^2 reach limited by the low energy neutrino flux
- Upper limit of energy of interest depends on physics (10? 15? 20? GeV)

Components of the Neutrino Beam

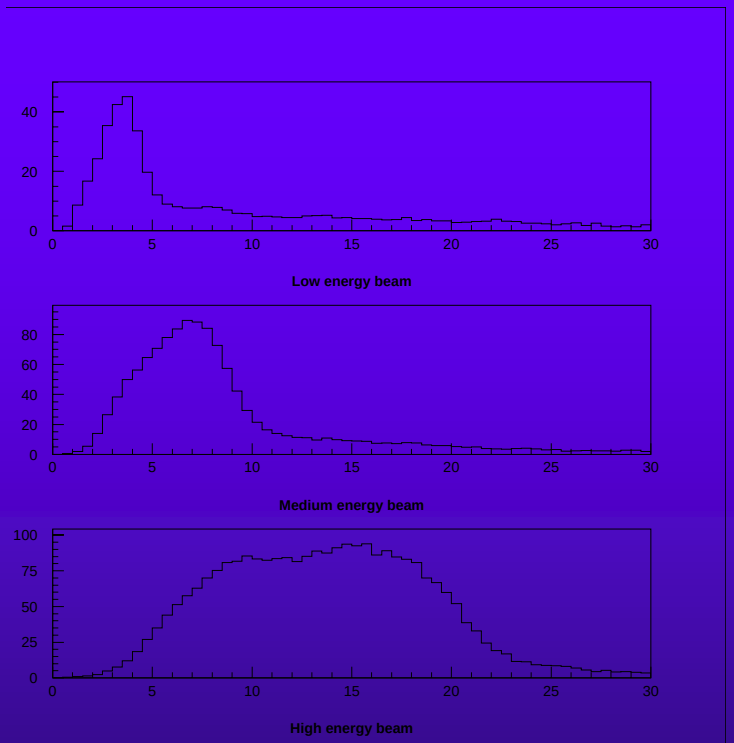
- Pions going through the neck of horn 1, bare target beam:
  - direction defined by the proton beam direction
  - Flux error dominated by pion production uncertainty



- **Pions well focused by the horns**
  - Highest attainable statistics
  - direction defined by the relative position of horn 1 , quite <u>insensitive</u> to the proton beam direction
  - Small systematic error (1-2%) of the far detector flux prediction based the observed near detector spectrum



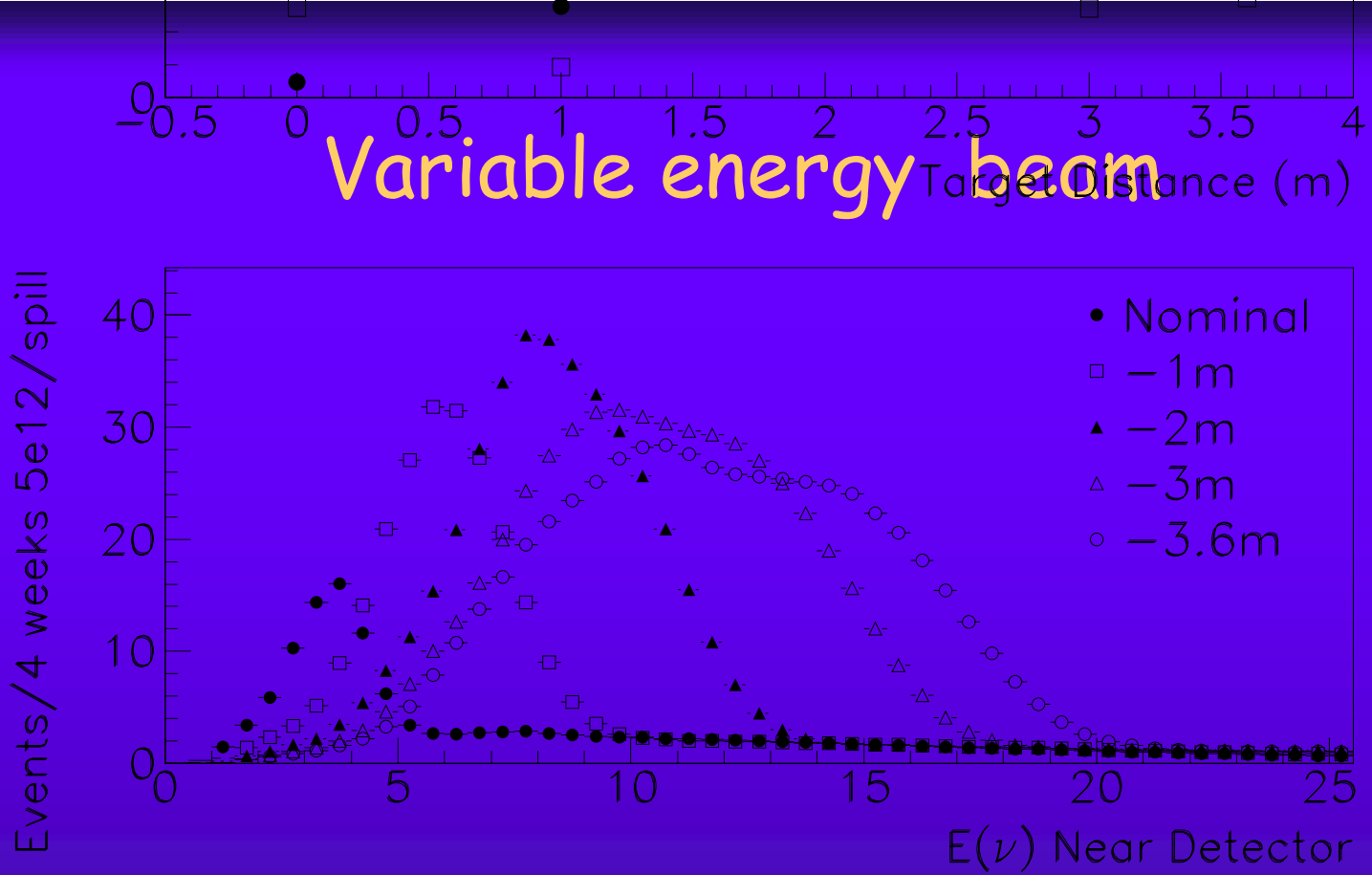
NuMI Neutrino Beams



Three proposed beam configurations cover the energy range 2-20 GeV, but

- Beam elements reconfiguration required
- Loss of running time
- need to re-commission and re-establish the beam line
- commission low energy beam (baseline!) - problematic
- high threshold proposition

Variable energy beam

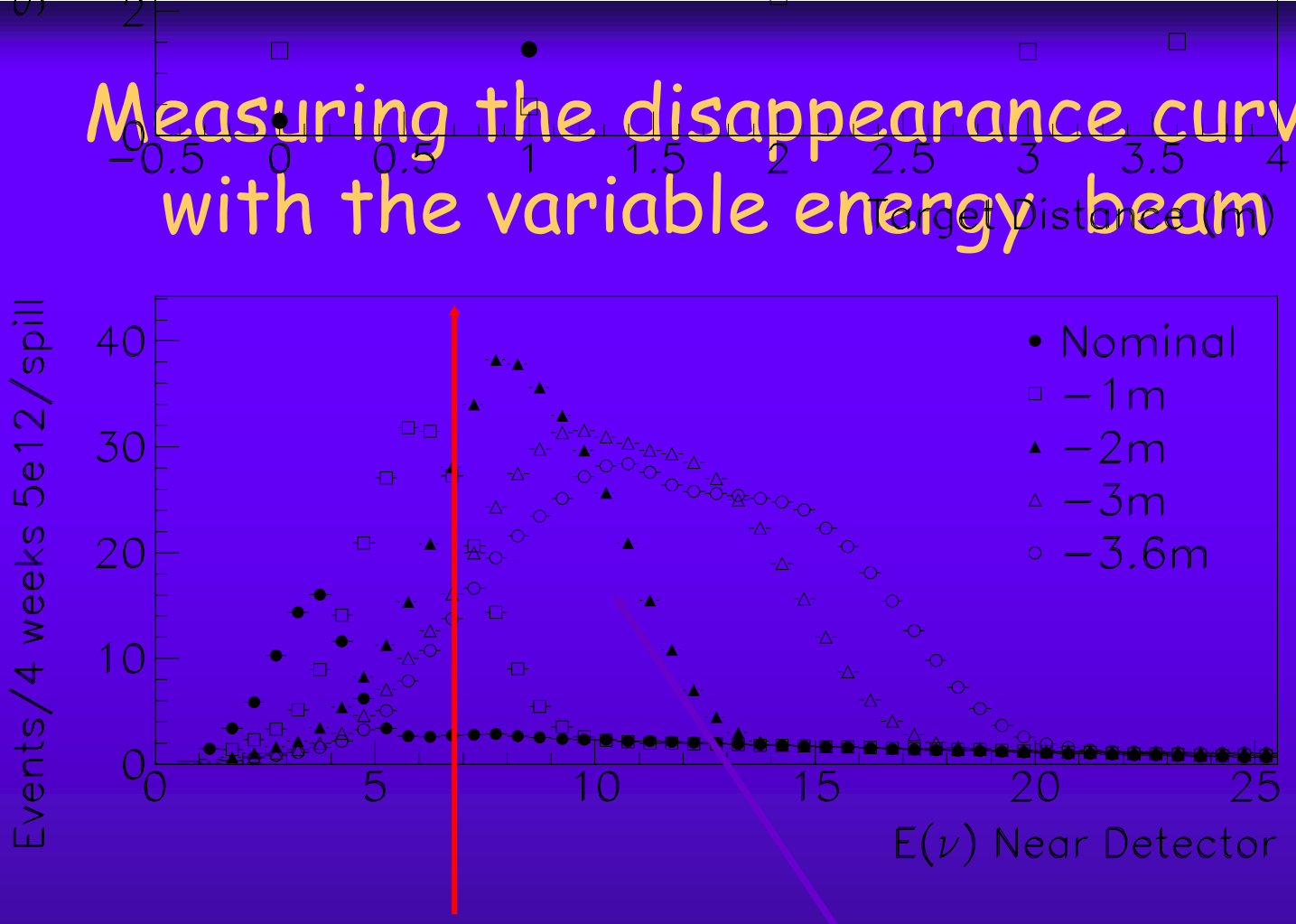


- Horn 1 and 2 at the nominal (Low Energy) positions
- Target retracted by x meters from the nominal position

- Peak energy (low systematic error) moves to higher energies with increasing Δz
- Event rate in the near/far detectors grows

?? What is a desired? sufficient? range of energies

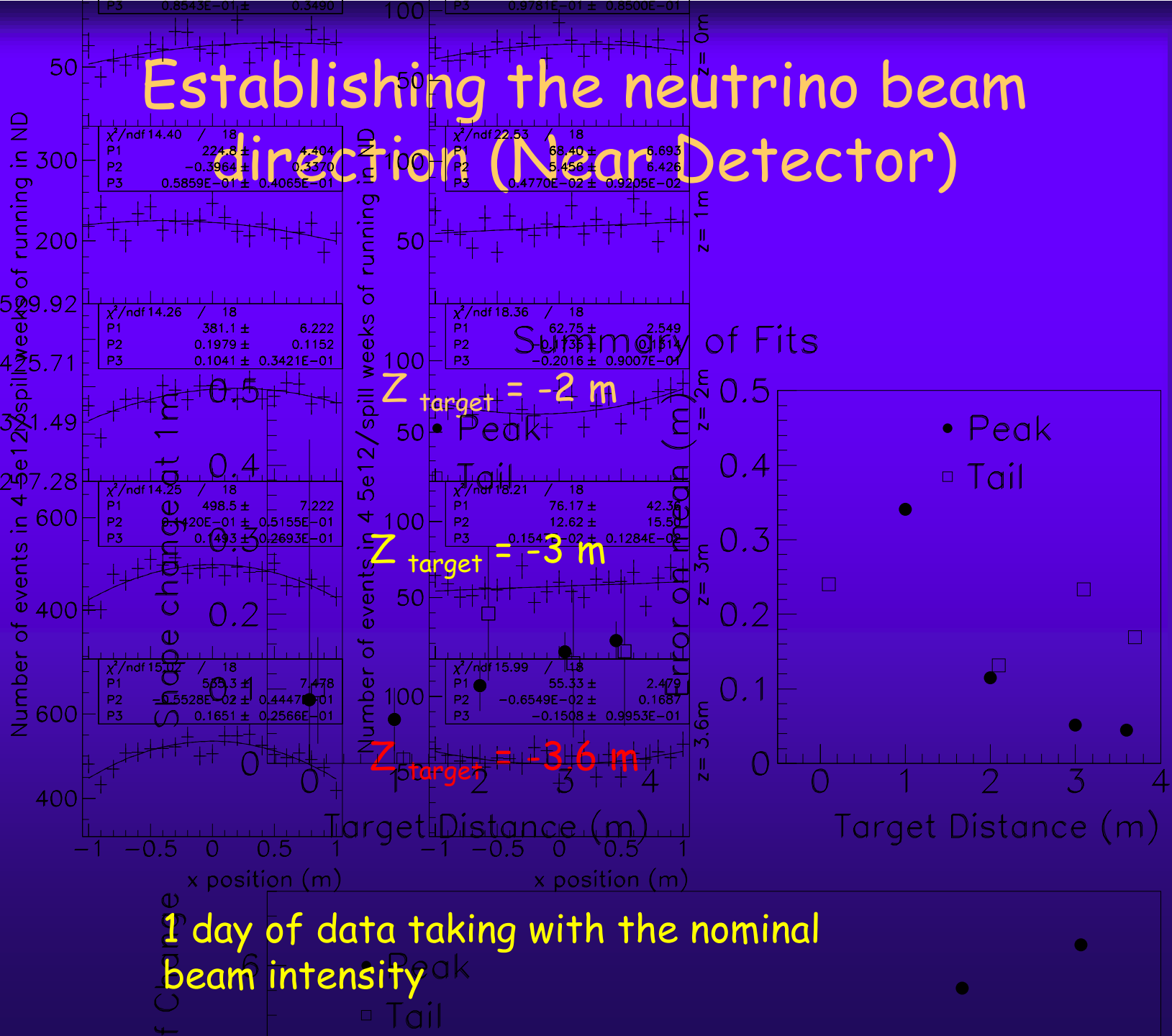
Measuring the disappearance curve with the variable energy beam



Measure the disappearance probability at the same energy with different systematics (rising edge/peak/falling edge/tail of the spectrum)

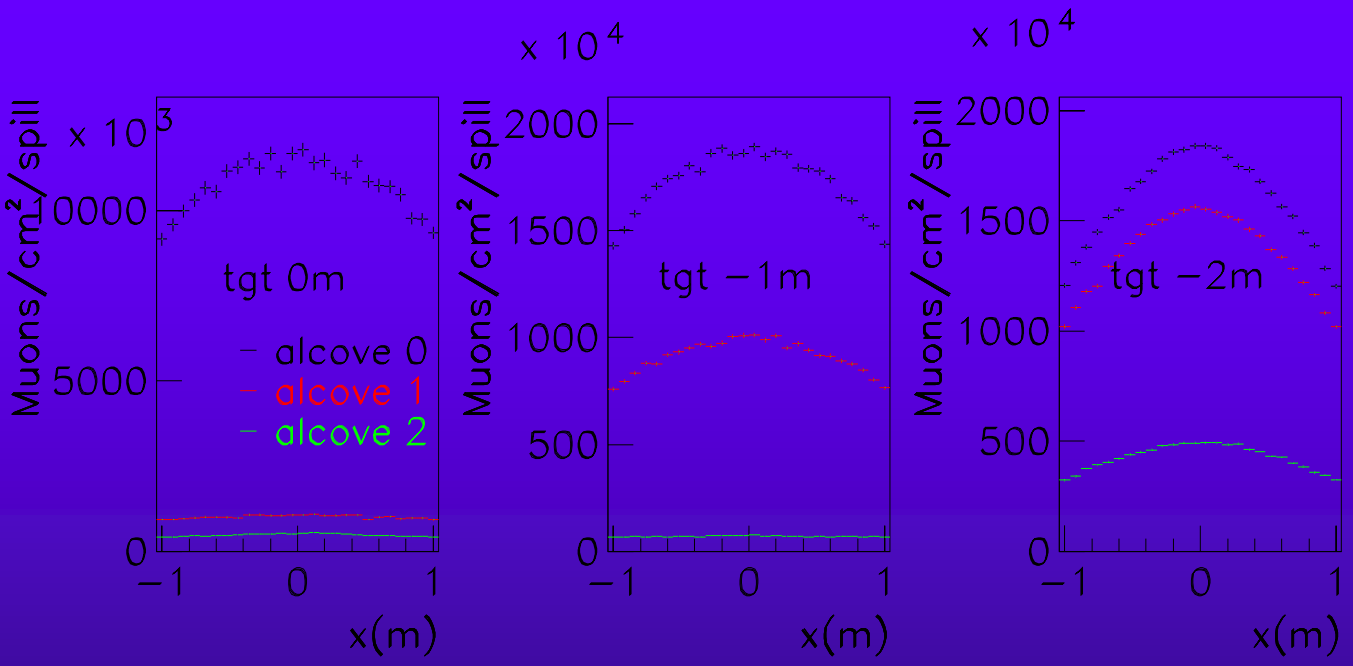
Reduce statistical error

Establishing the neutrino beam direction (Near Detector)



1 day of data taking with the nominal beam intensity

Establishing the neutrino beam direction: muon monitors



- Very fast measurement (duration determined by the target moving time)
- Added bonus: muon momentum distribution?

Other possible benefits of the variable energy beam

- Collect auxiliary data sets with non-standard target positions (Δz,Δr) – understanding of the beam line properties (focusing, production spectra)
- Tool to understand sources of a potential malfunction of the neutrino beam line (if detected by muon monitors and/or change of the observed rates/spectra at the Near Detector)
- Periodic check of the alignment of the beam line

To do or not to do? What range of distances/energies?

Discussion/decision at the next Collaboration Meeting. In the meantime:

- Collect/understand arguments (desired range)
- Cost/benefit analysis
- Risk analysis
- Scope, implications, technical issues
- Your input is important. Speak up. Join the effort.
- Execution (if at all) likely to be physicists manpower limited – you can make a big difference