Beam Performance and Systematic Studies

ν_e *Meeting 07/26/05*

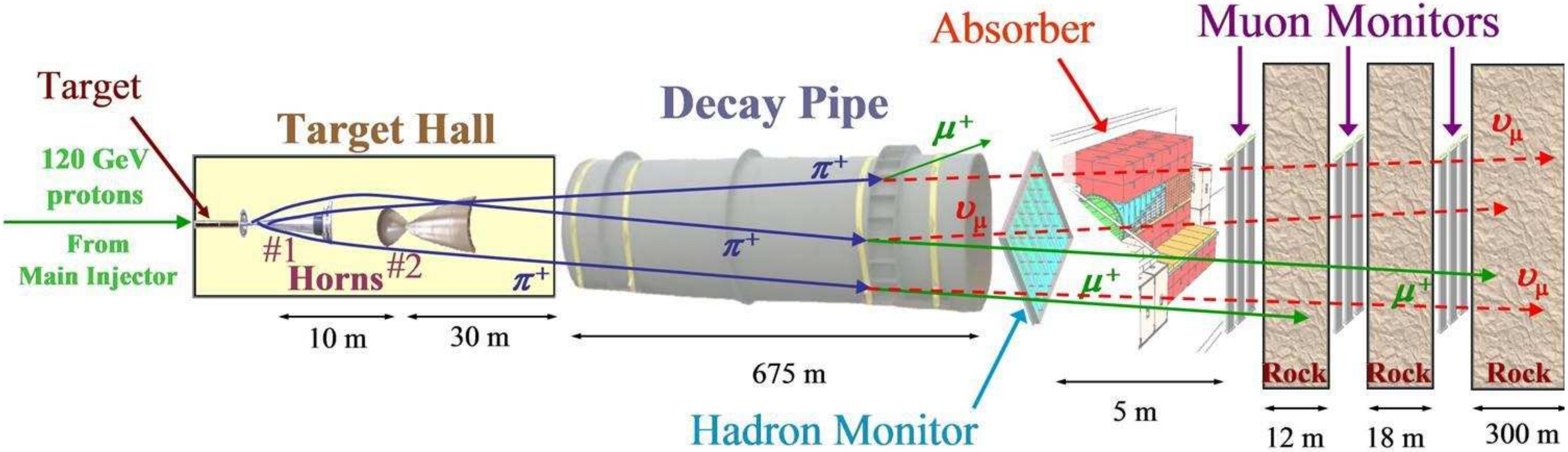
Mary Bishai (for the beam monitoring group)

Introduction

GOAL: Determine and quantify sources of systematic uncertainties on MINOS measurements originating from non-ideal beam conditions. Sources of uncertainties we know so far are:

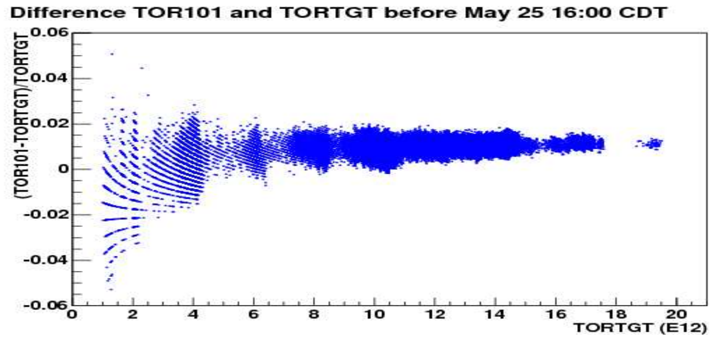
1. Absolute calibration and uncertainty on beam intensity measurements.
2. Beam width variation at the target.
3. Batch-batch variation in beam position at the target
4. Beam scraping the baffle
5. Target/Baffle/Horn alignments
6. Horn current stability/calibration
7. Skin depth effect

PRIMARY BEAM PERFORMANCE

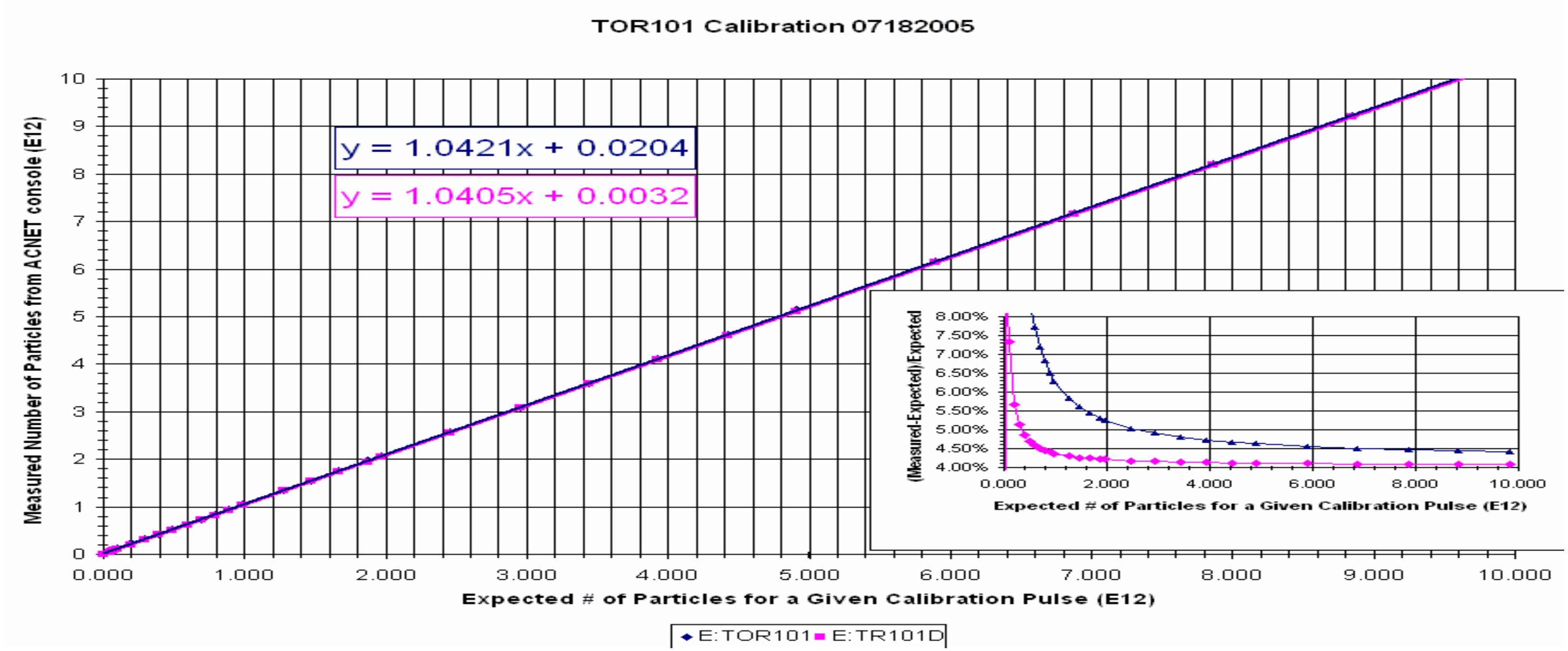


Systematics - POT Calibration

Difference between TOR101 and TORTGT prior to May 25 16:00 is within 1% at $>$ 5E12 .

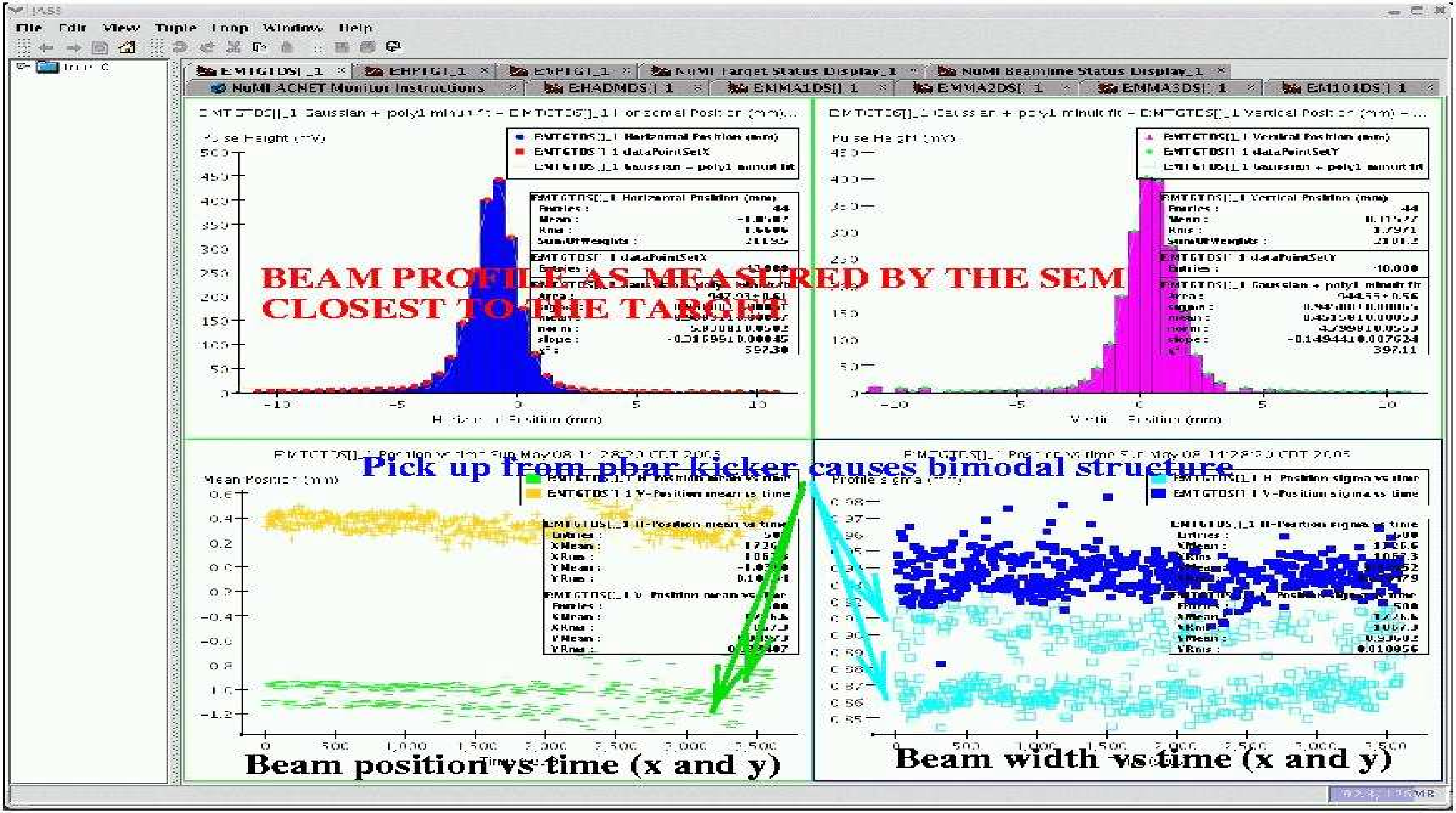


Absolute toroid calibrations using a current source- Doug Jensen:



Toroid is +4.2% off. Stability better than 1%.

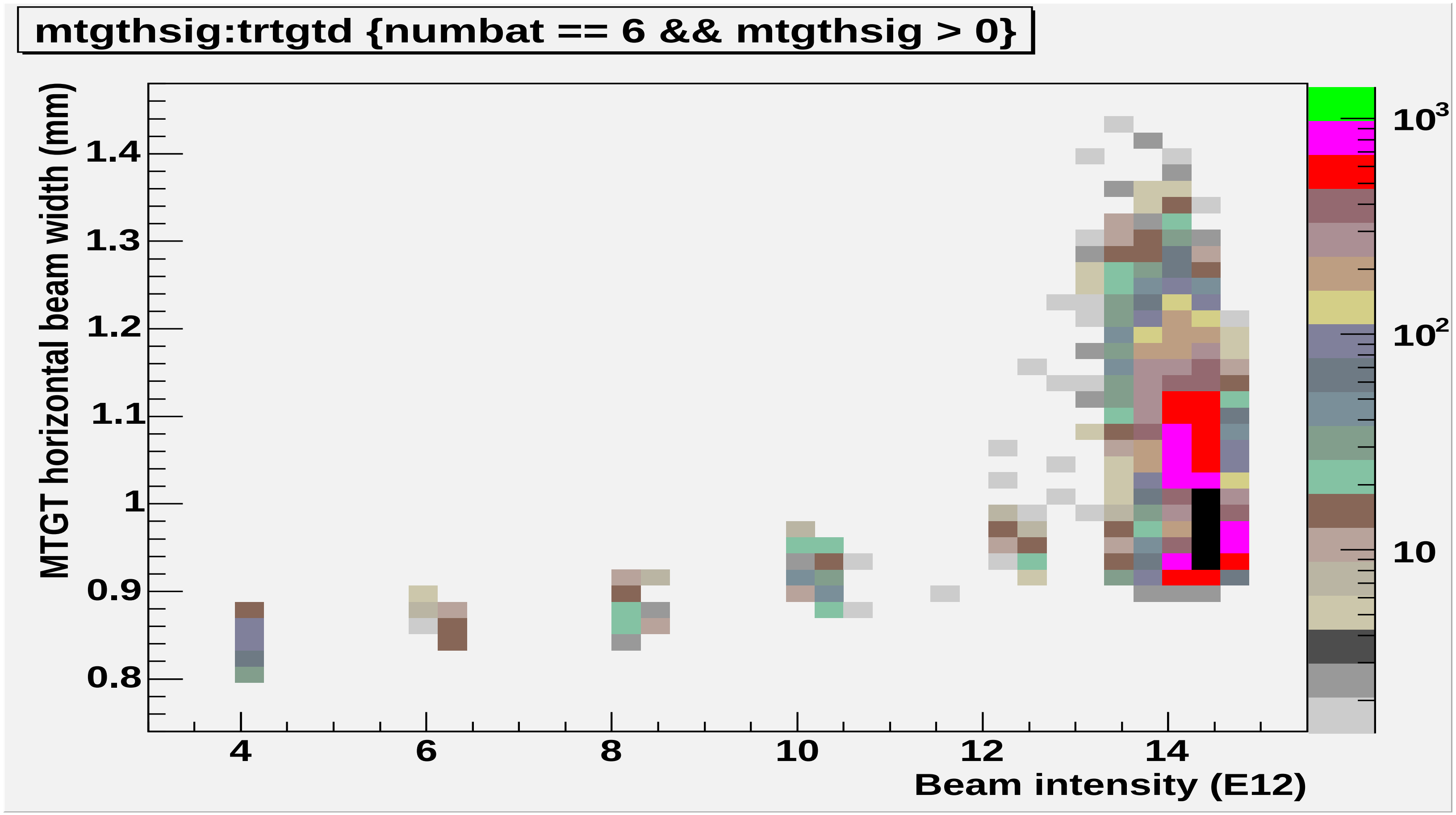
Beam width at the target-Typical



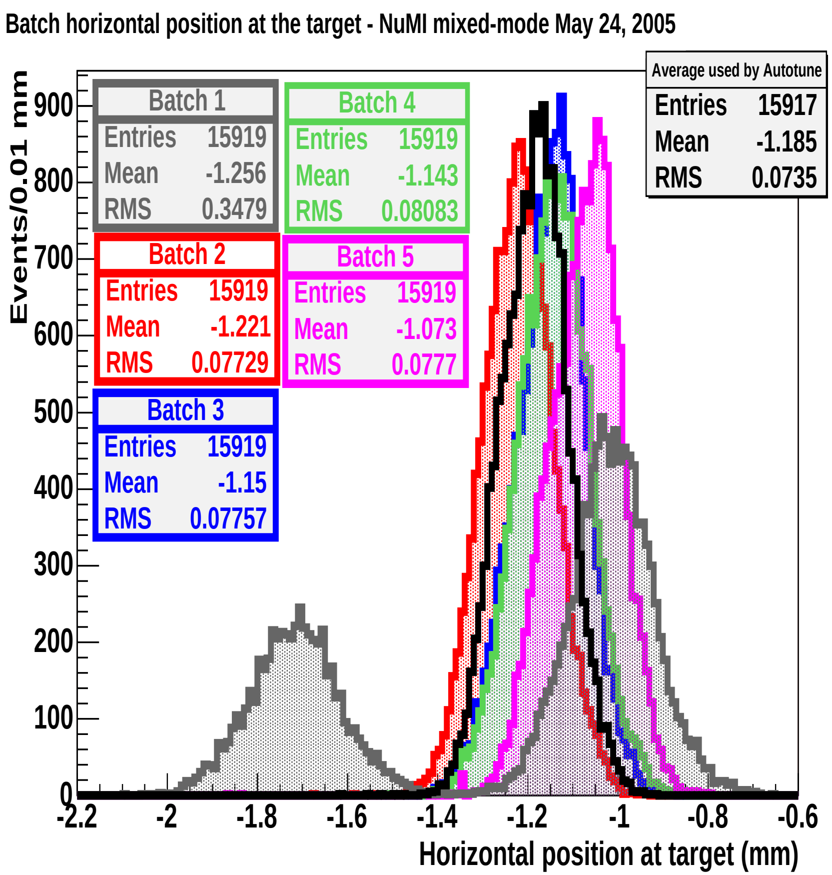
Beam has non-Gaussian components

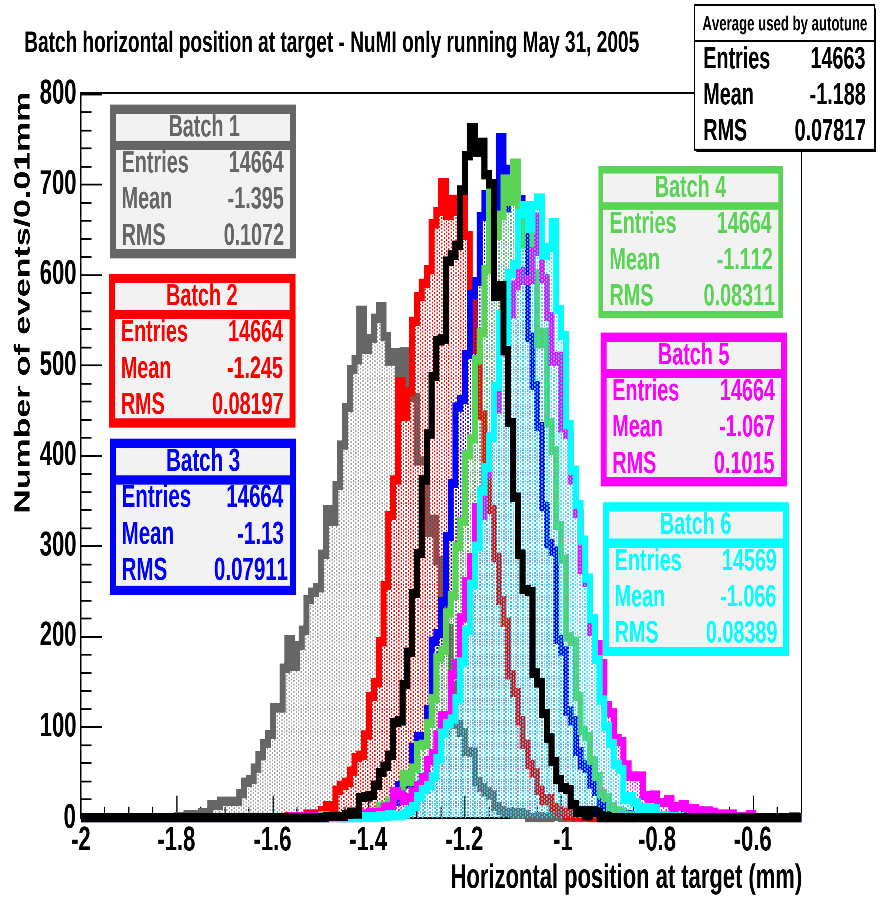
Beam width vs intensity

NB: Independant of Booster problems beam width will change with intensity/batch. Width vs intensity when we have 5 batches observed on May 23rd:



Batch-batch beam positions

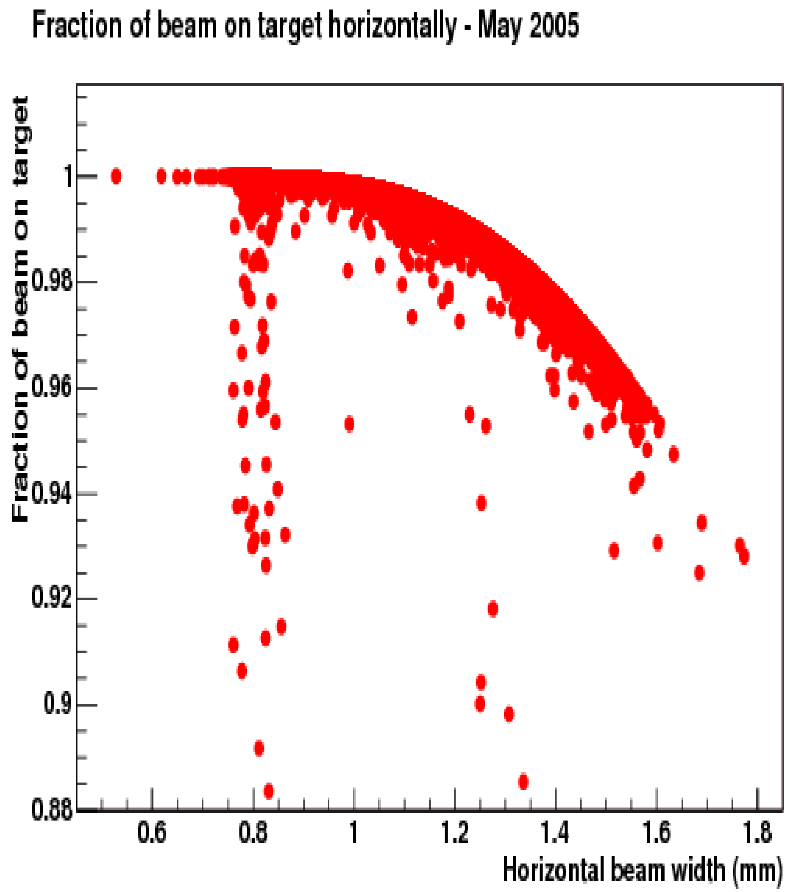


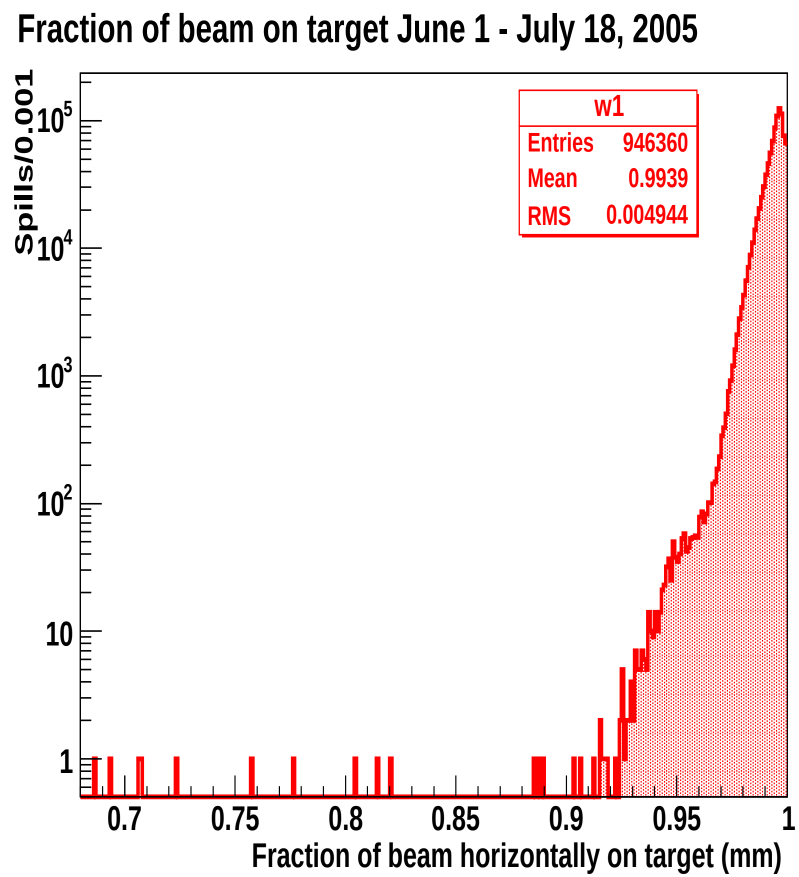


Mixed-mode **NuMI only**

Variation in proton position at target is $<$ 1mm.

Systematics: Beam on target



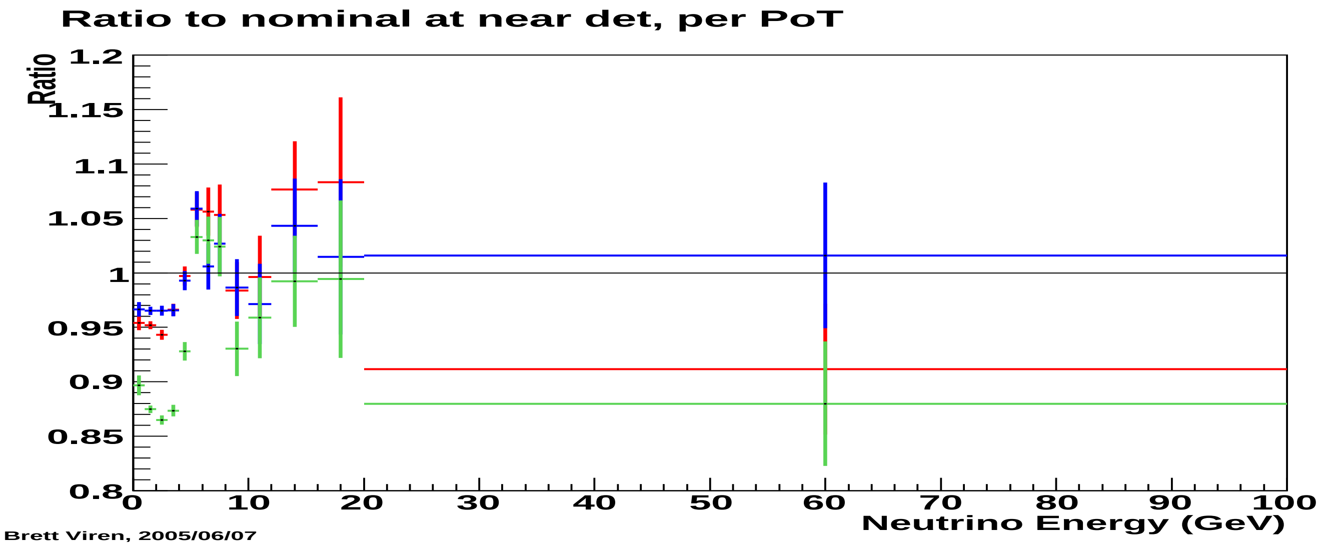


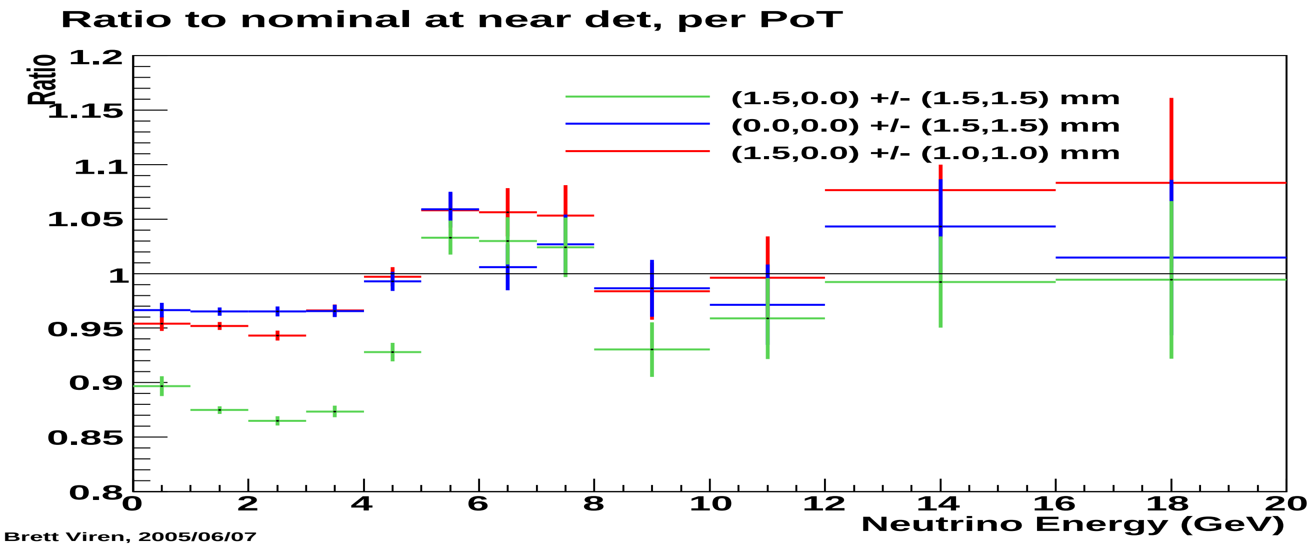
June 1 - July 18 0.66% POT off target (Gaussian assumption.)

Beam width/position: ND spectrum

Using G3NUMI

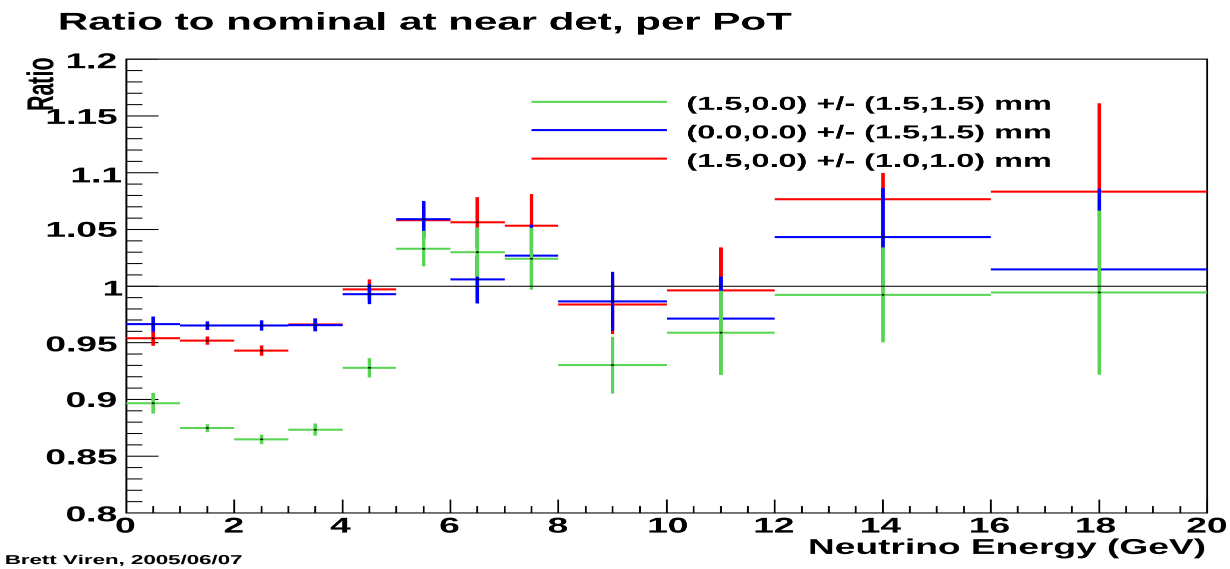
Brett Viren



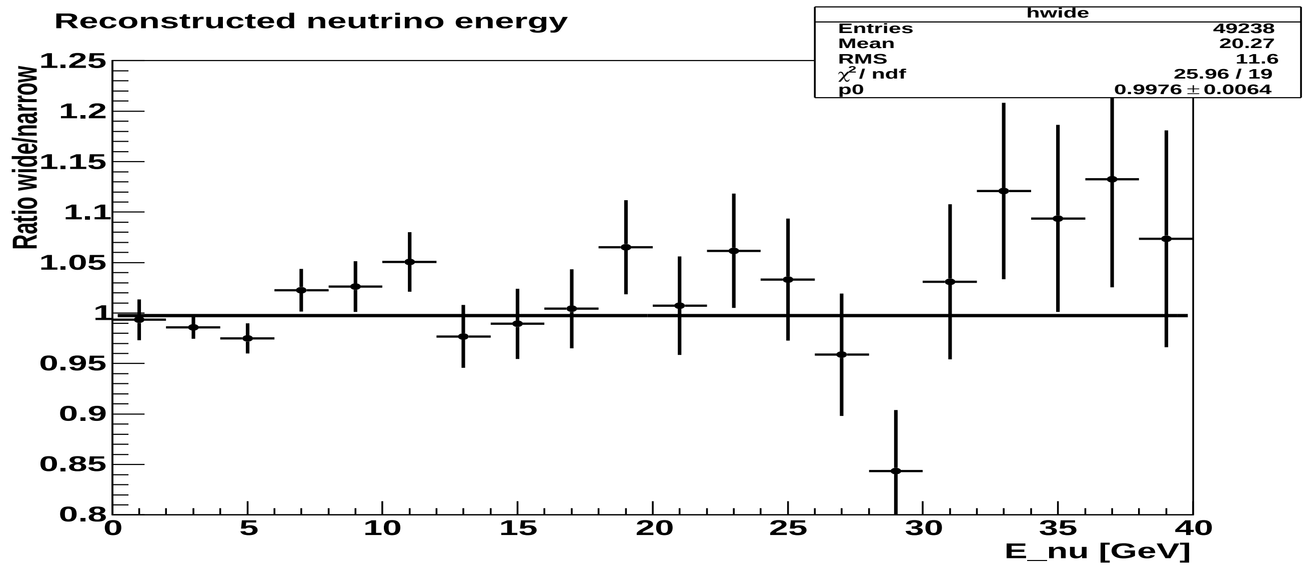


Beam width/position: DATA

Mark Dierckxsens



$\Leftarrow$ **GNUMI v17**

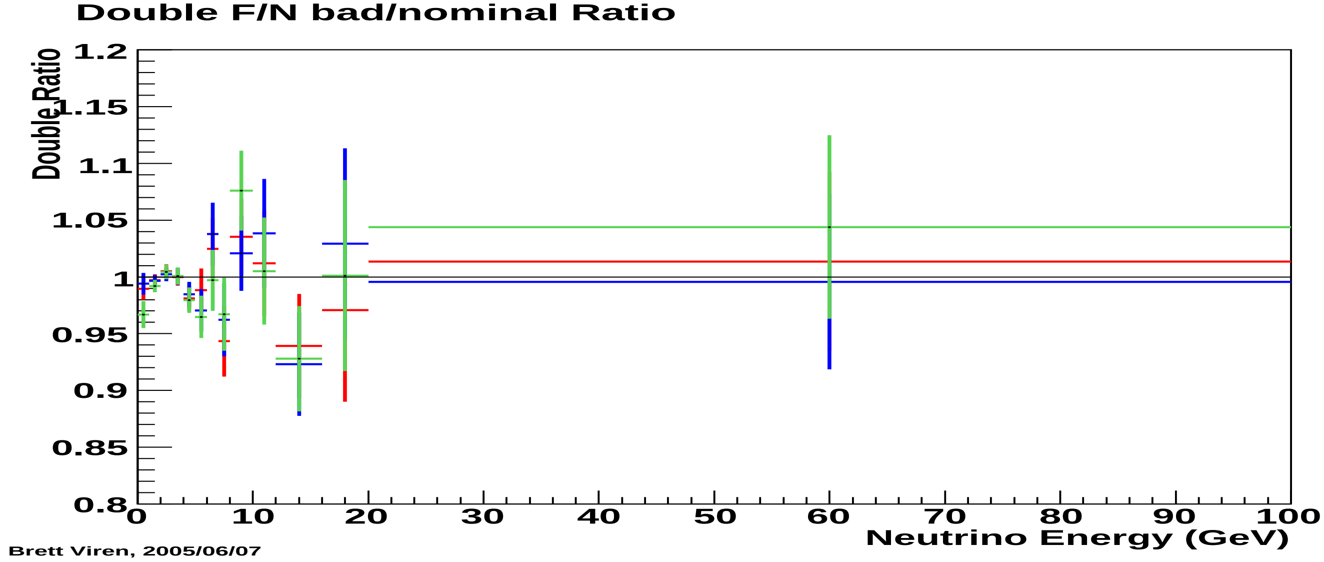


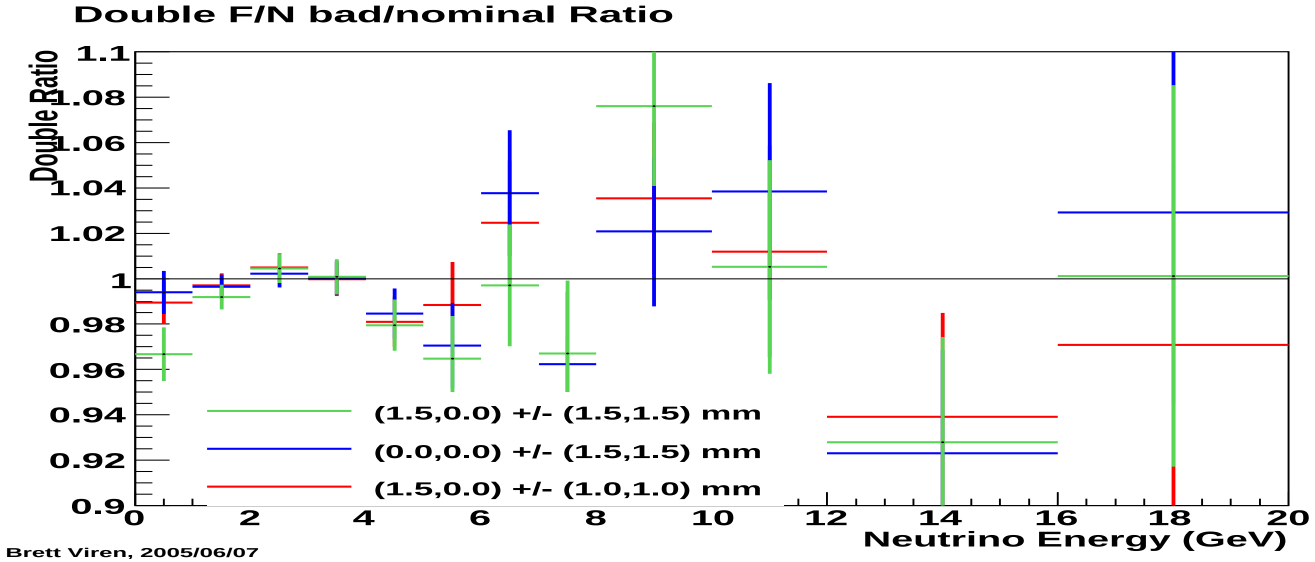
$\Leftarrow$ **May pLE data**

Systematics ND/FD ratio

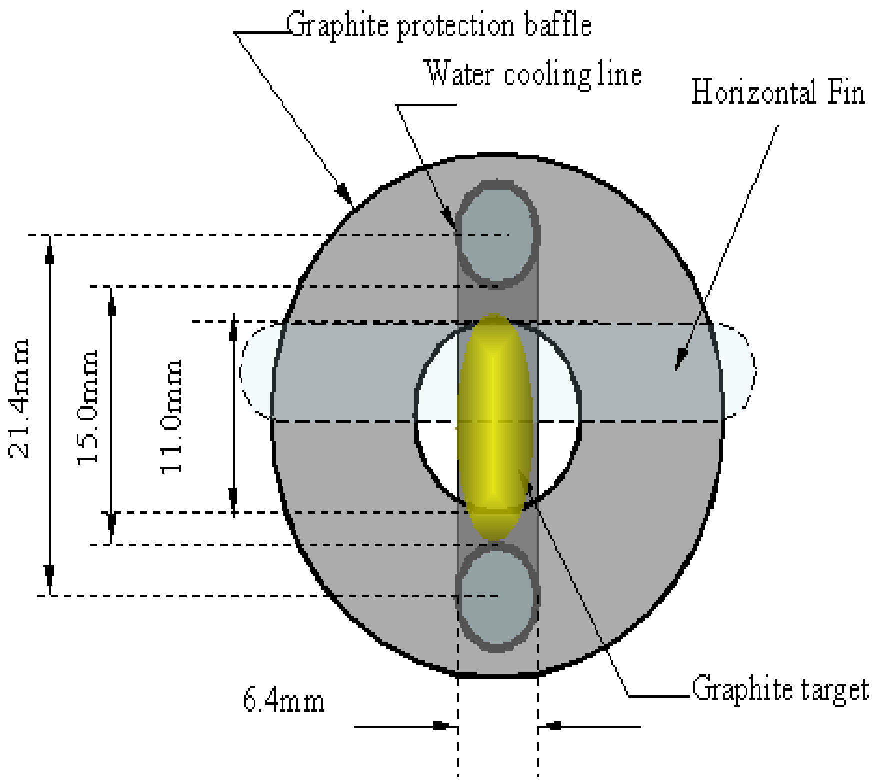
Using G3NUMI

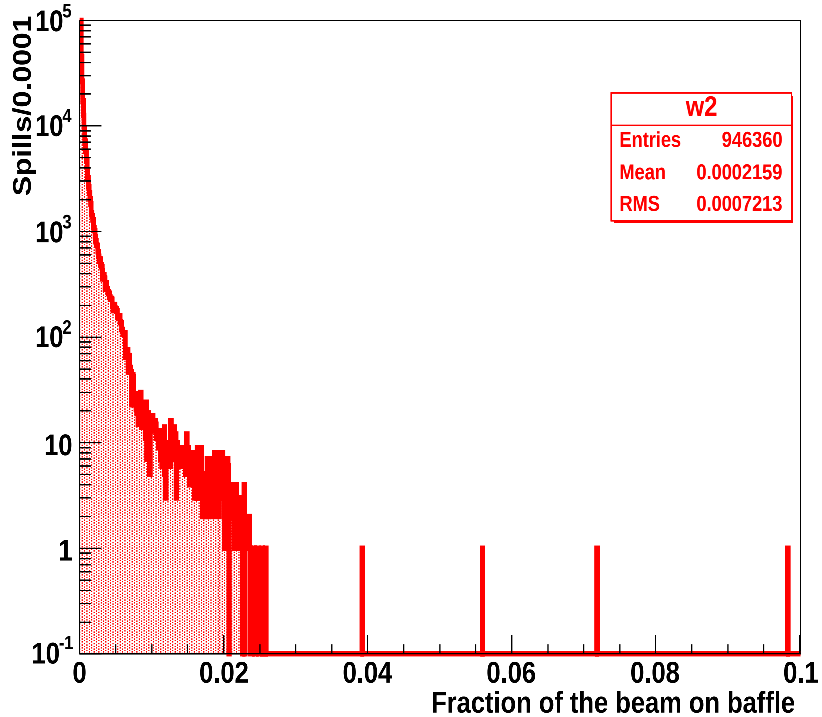
Brett Viren





Fraction of Beam on Baffle

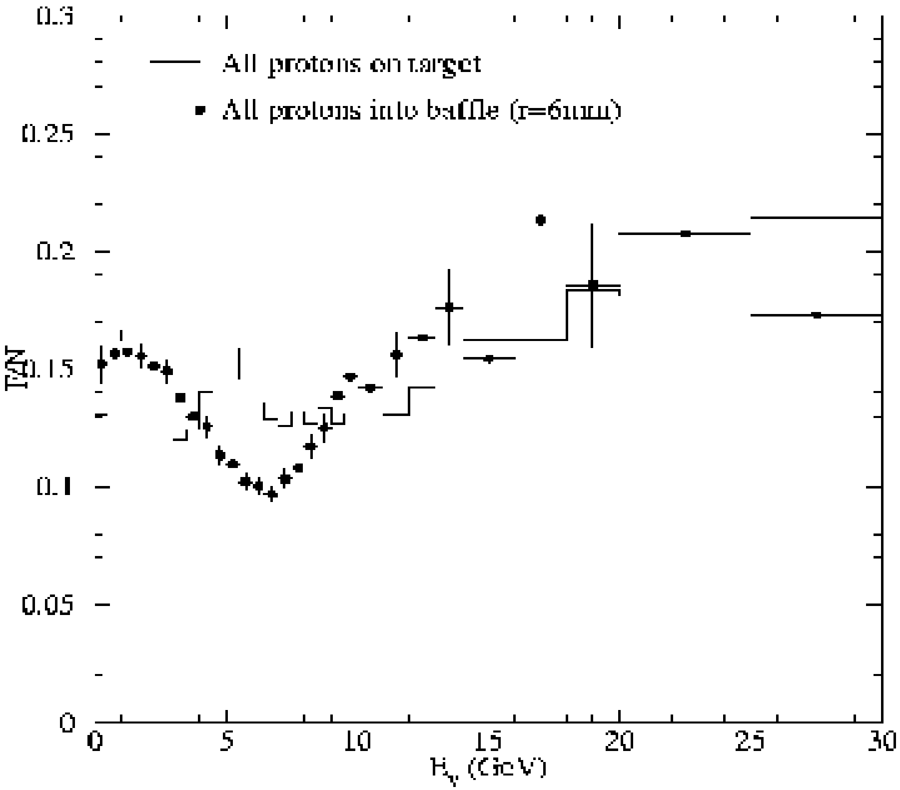


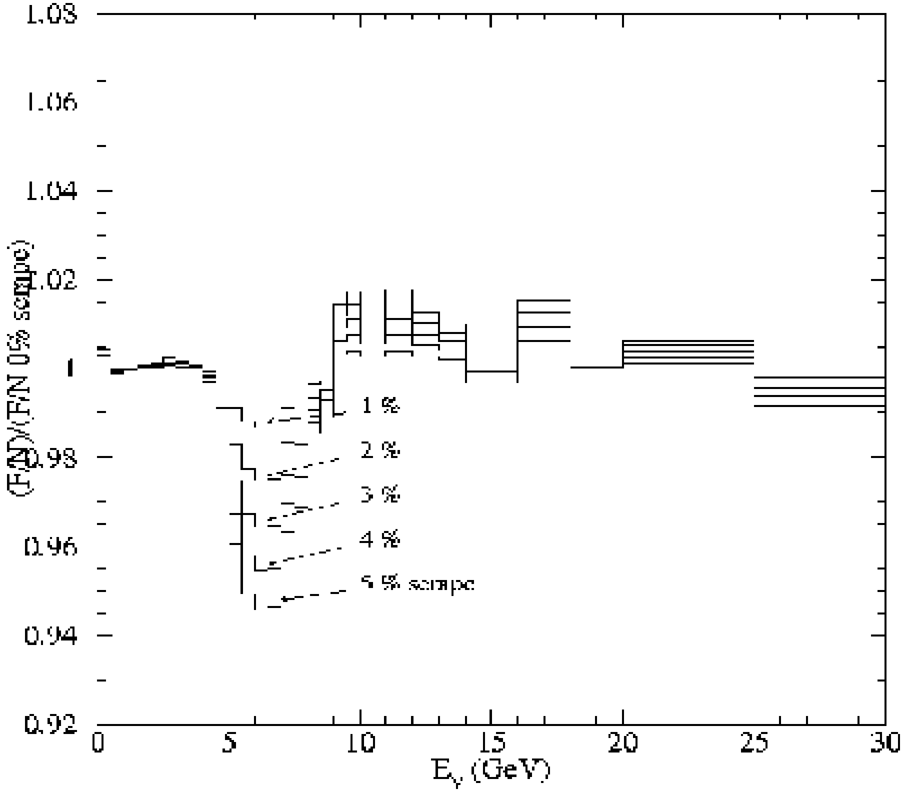


June 1- July 18 : only 0.02% beam on baffle

Systematics: Beam on Baffle

Using G3NUMI **Zarko Pavlovich**





June 1- July 18 : only 0.02% beam on baffle

Target Hall Alignments

Alignment using p-beam

Using proton beam scanning **Bob Zwaska**

Summary of Measurements

- Components are consistently to the left , and usually down
  - ➢ Exception is that baffle is about 1 mm high w.r.t. target – maybe consistent with direct observations in target hall

		Profile Monitor		BPM	
		Offset (mm)	Angle (mrad)	Offset (mm)	Angle (mrad)
Horizontal	Baffle	-0.75		-1.21	
	Target	-0.95		-1.41	
	Horn 1	-0.65	-0.18	-1.24	-0.18
	Horn 2	-1.01	-0.11	-1.82	-0.18
Vertical	Baffle	+0.14		+1.12	
	Target	-0.90		+0.13	
	Horn 1	-0.33	+0.20	+0.81	+0.26
	Horn 2	-1.61	-0.42	+0.08	-0.43

Alignment Survey

Virgil Bocean

Preliminary Estimation based on Stability Analysis Results

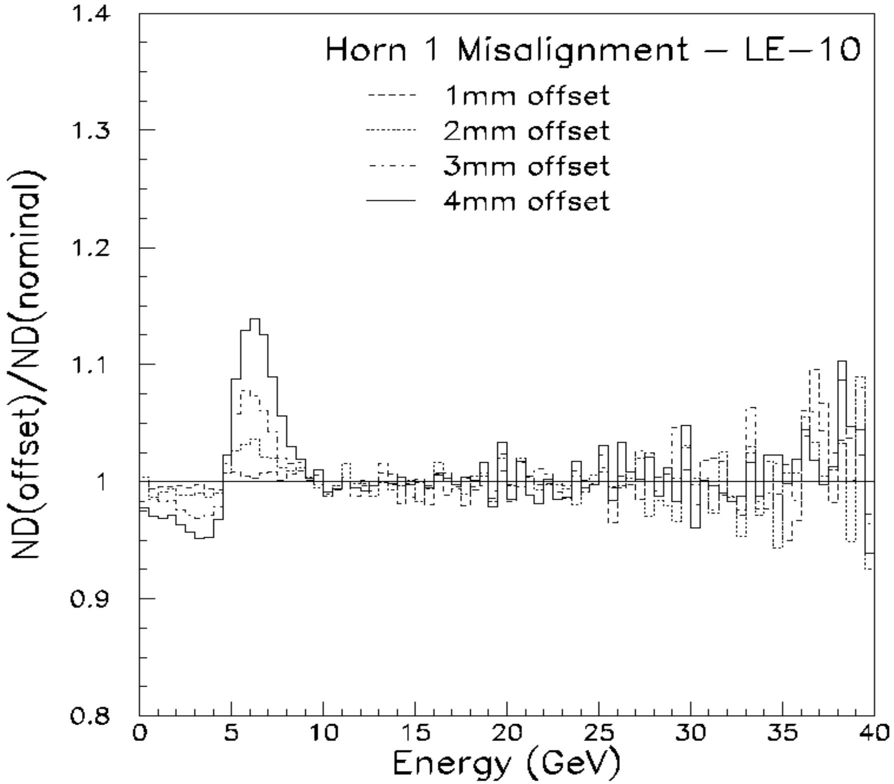
- **Horizontal beam on Target**
  - Aisles (horizontal) deformation due to load = - 0.9 mm
  - Displacement due to thermal expansion ($\Delta T = 4^oC$) = -0.1 mm
  - Target misalignment = 0.1 mm
  - **Total Horizontal estimated displacement = -1.1 mm**
- **Vertical beam on Target**
  - Aisles (vertical) deformation due to load = - 0.5 mm
  - Displacement due to thermal expansion (DT = 4^oC) = -0.1 mm
  - Target misalignment = -0.1 mm
  - **Total Vertical estimated displacement = -0.7 mm**
- Currently we are running beam at -1.1 mm horizontal and +0.5 mm vertical from the nominal trajectory to be centered on Target

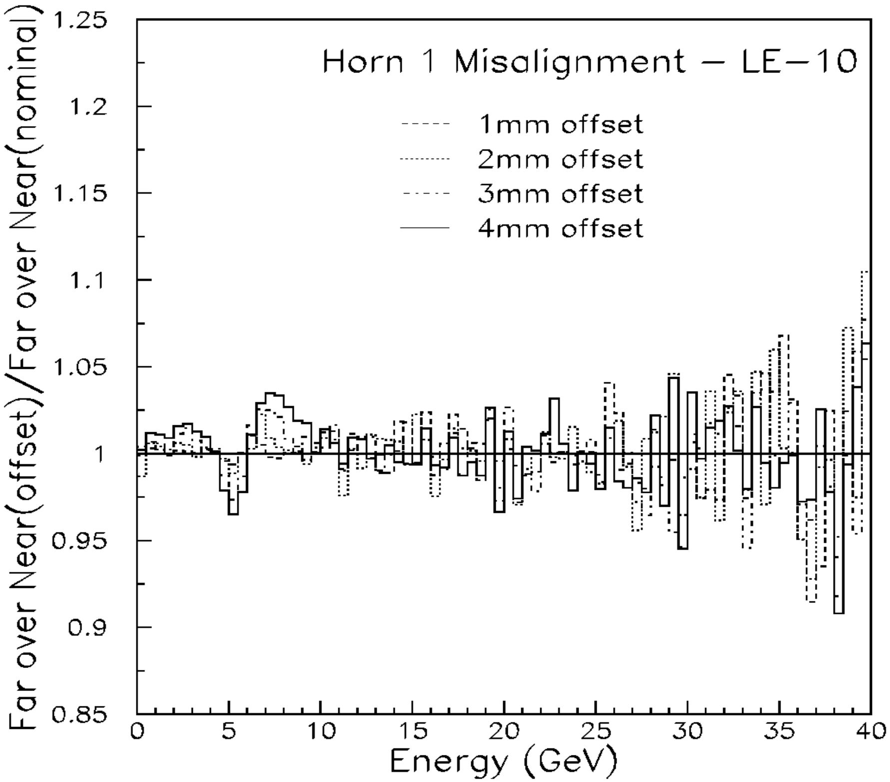
Beam is aimed at x=-1.1mm and y=+0.5mm

Systematics: Horn Alignment

Using *smeared* PBEAM

Zarko Pavlovich



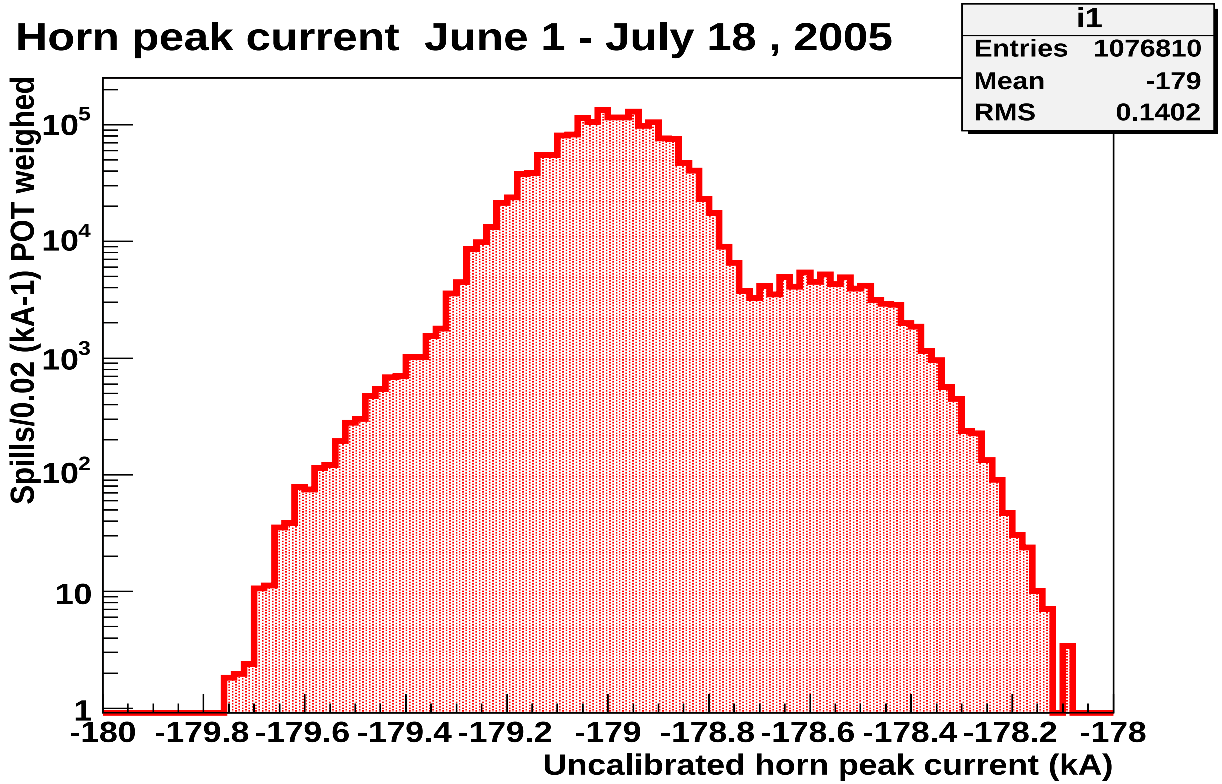


Repeat using unsmeared PBEAM

Horn currents

Horn current stability

In LE-10, calibrated horn current should be -185kA



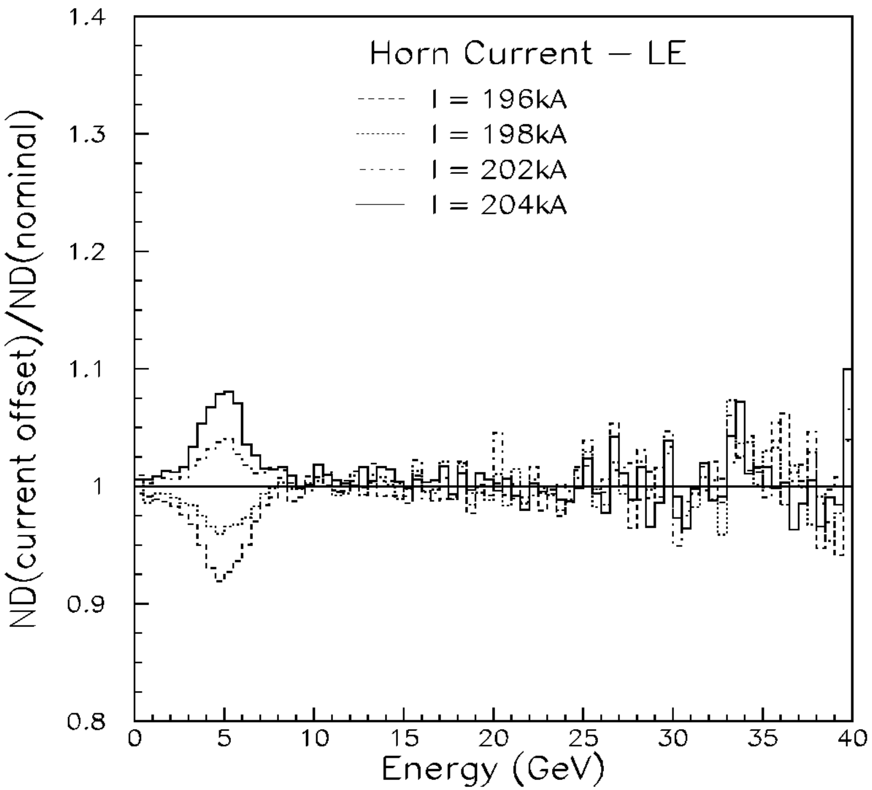
Horn current calibration is off by 0.988 ± 0.005- Jim Hylen

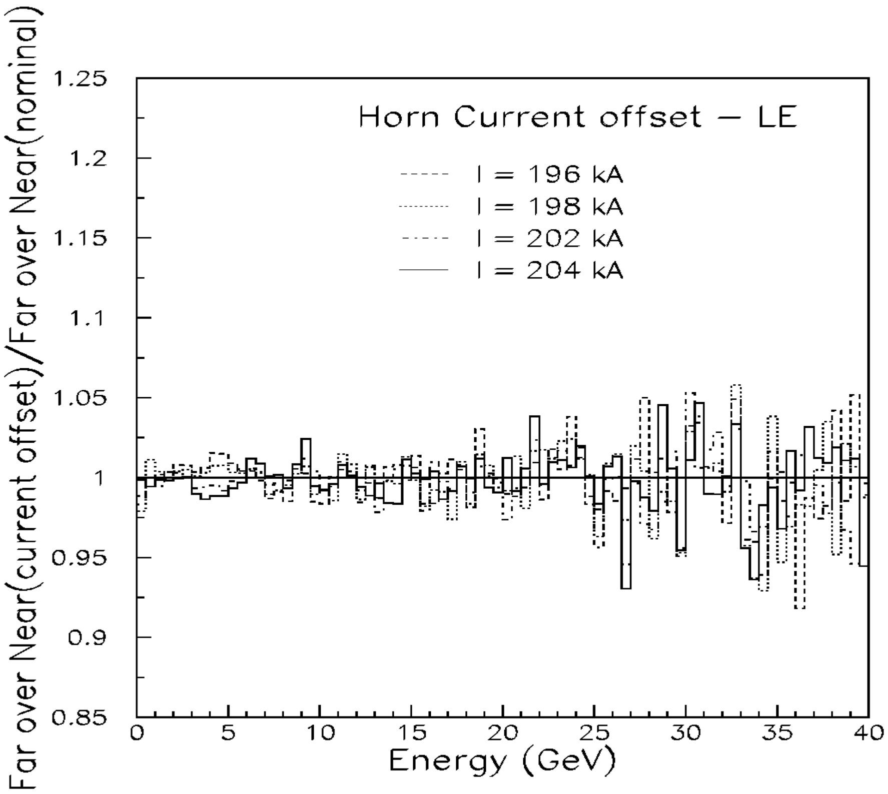
Horn current stability $<$ 0.5%

Systematics: Horn Current

Using *smeared* PBEAM

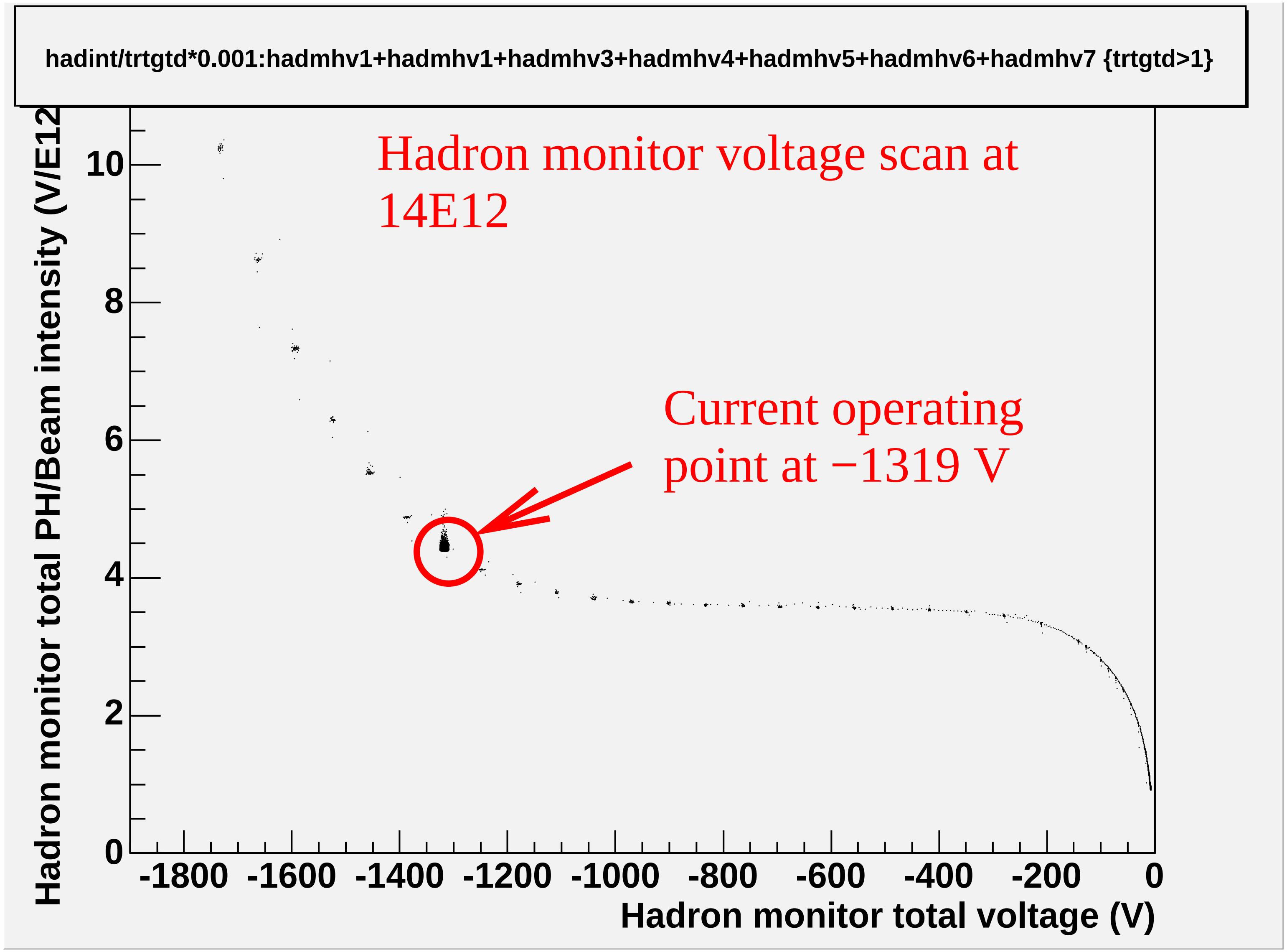
Zarko Pavlovich





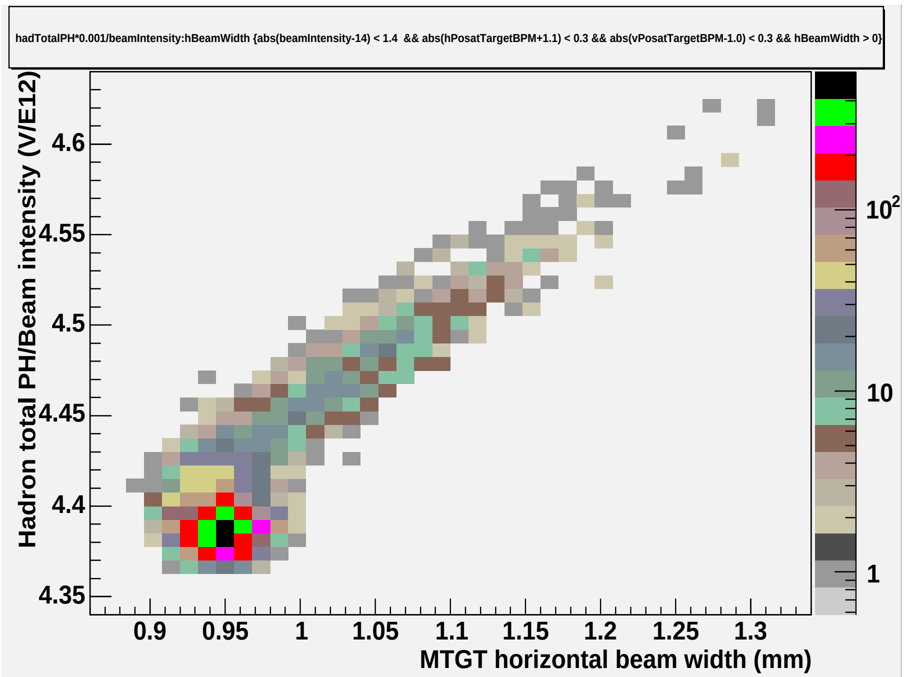
Using the secondary Beam Monitors

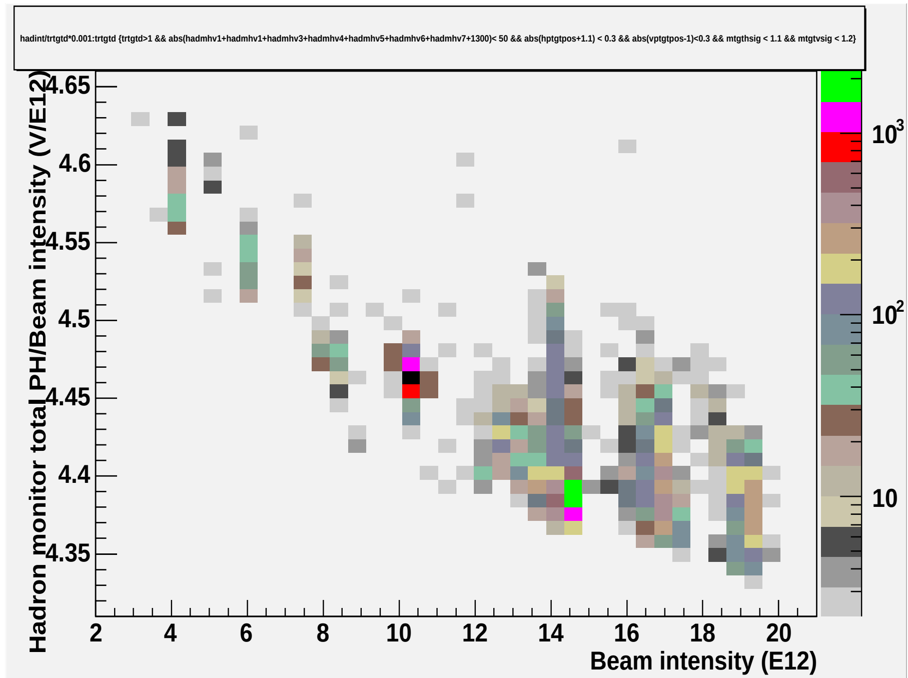
Hadron monitor response



Hadron monitor stability

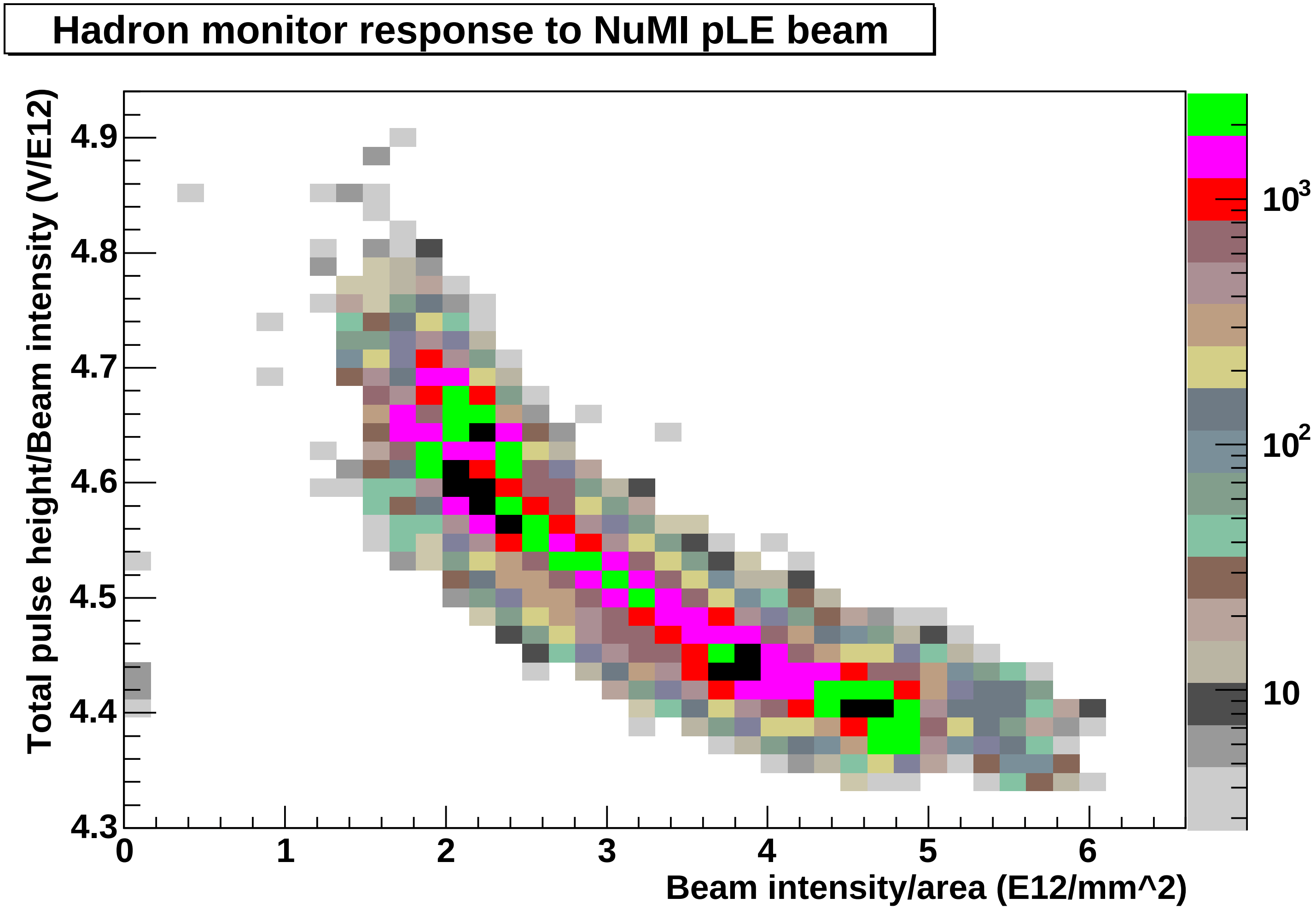
For beam centered on the target within ± 0.3 mm, we observe a depenance of the hadron monitor signal on width and intensity:





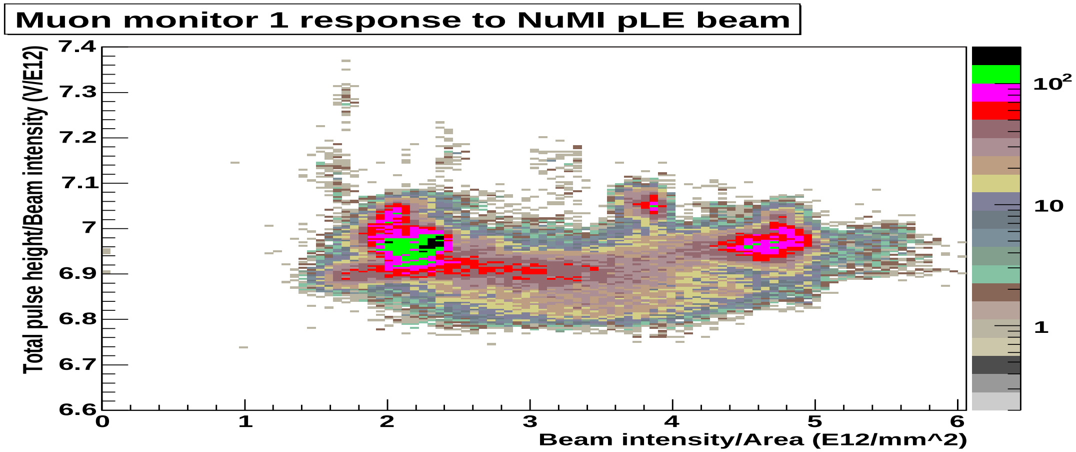
$$POT = 14 \pm 1.4 \qquad \sigma_H < 1.1, \sigma_V < 1.2$$

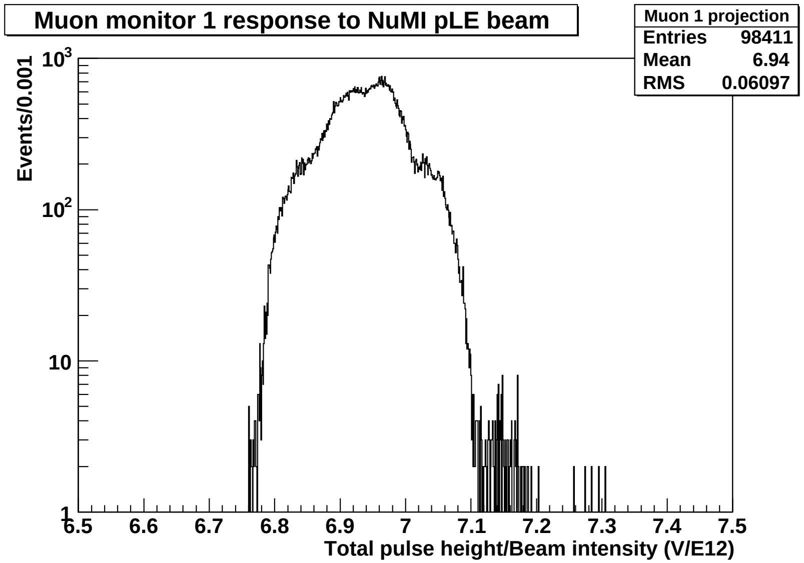
Hadron monitor stability

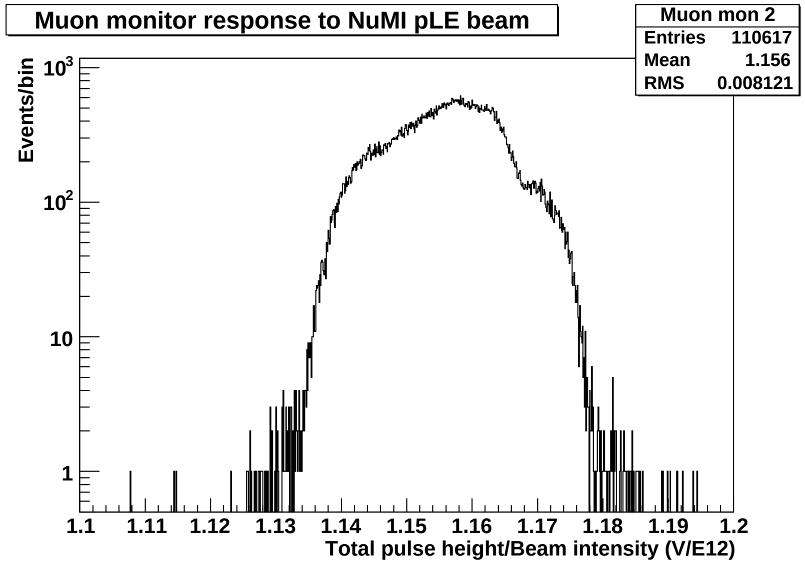


ACTION ITEM: Improve hadron mon response by changing voltage settings?

Muon monitor stability





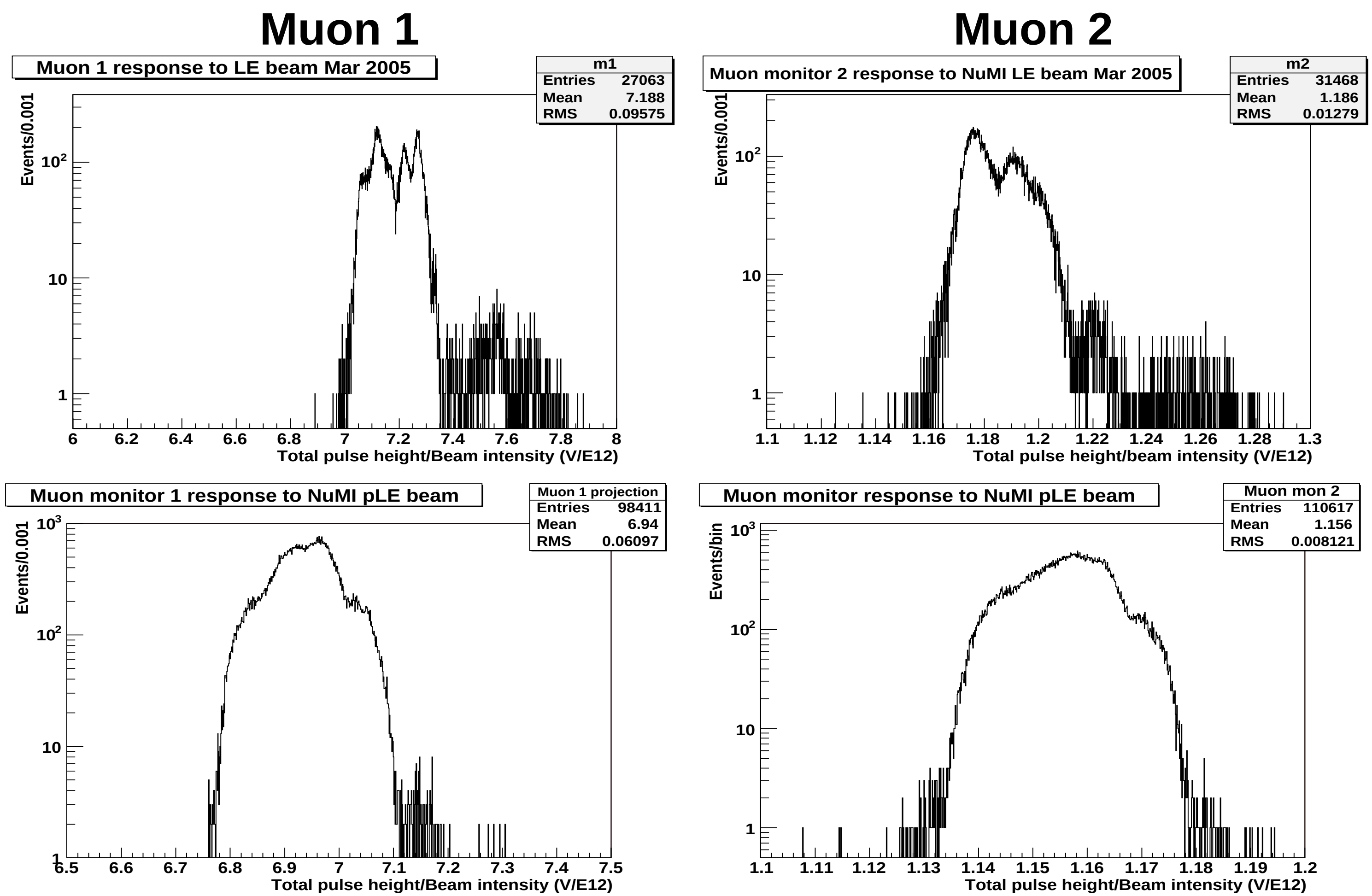


Muon monitor 1 & 2 are stable at the 1% level.

Using μ monitors to track beam

May, pLE $d_T = 10$cm, $I_H = -185$kA. Mar, LE $d_T = 2$cm, $I_H = -200$kA.

	Muon 1	Muon 2
LE 3/05		
pLE 5/05		



LE 3/05

pLE 5/05

3.5% reduction 1.5% reduction

ACTION ITEM: seems larger than expected 2% reduction in ν peak

Action items

- Incorporate beam width and position variation distributions in G3NUMI
- Run unsmeared PBEAM to get ratios of change - then use that to weigh full reconstructed simulation to get systematics.
- Generate more MC statistics for the HE tail.
- ND data-data comparisons wherever possible with the most statistics.
- Quantify hadron and muon monitor beam response and compare to simulation.