Disappearance Group Report

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for the Disappearance Group
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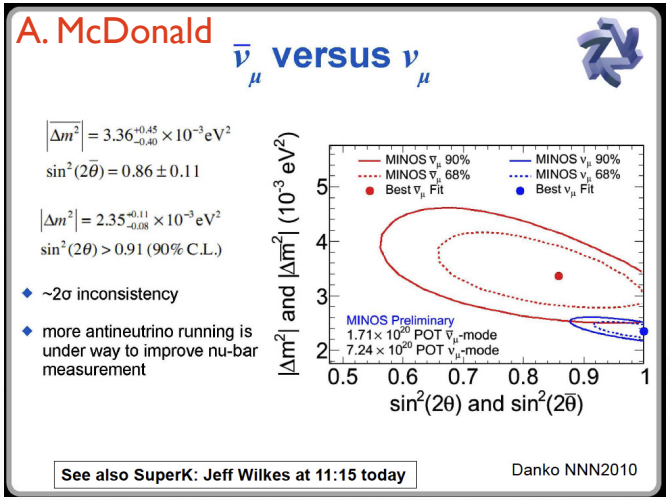
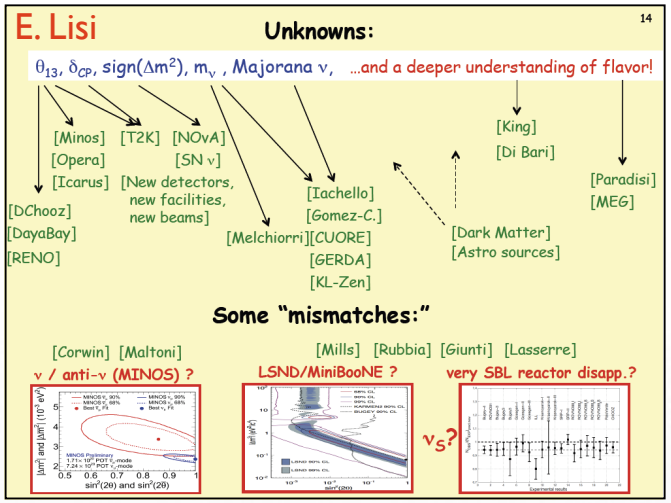
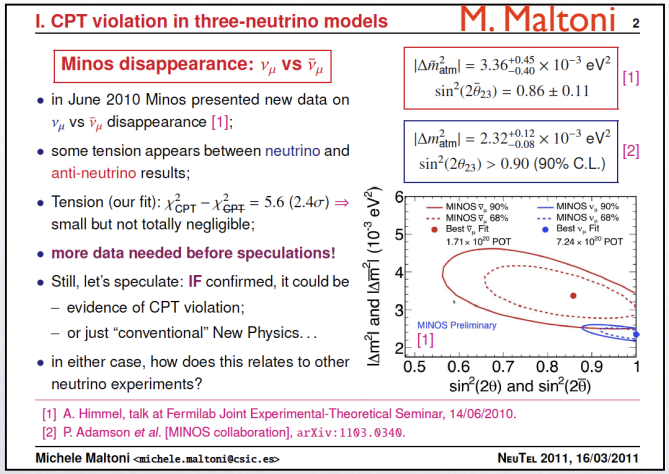
MINOS Collaboration Meeting@Fermilab
04/03/2011

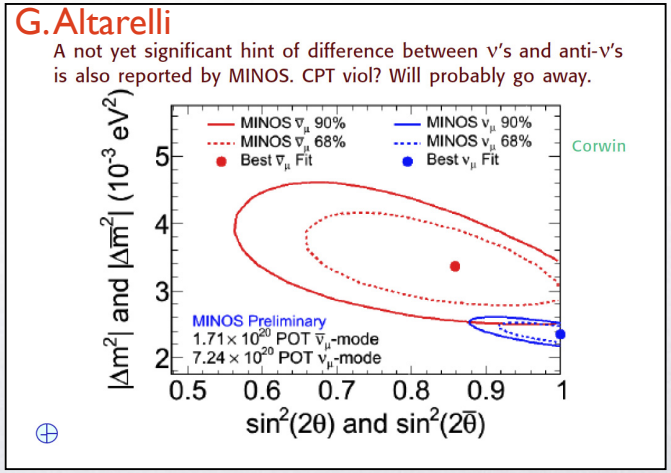
Introduction

- MINOS 1.7x10^{20} POT RHC results continue to generate much interest
  - Neutrino vs. anti-neutrino osc. parameters plot shown in 8 talks at Neutrino Telescopes in Venice!









1.7×10^{20} POT RHC Paper Submitted!

- RHC paper in arXiv and submitted to PRL yesterday. Use new blessed plots! - DocDB-7929

- Highlights:

97 CC $\bar{\nu}_\mu$ events observed

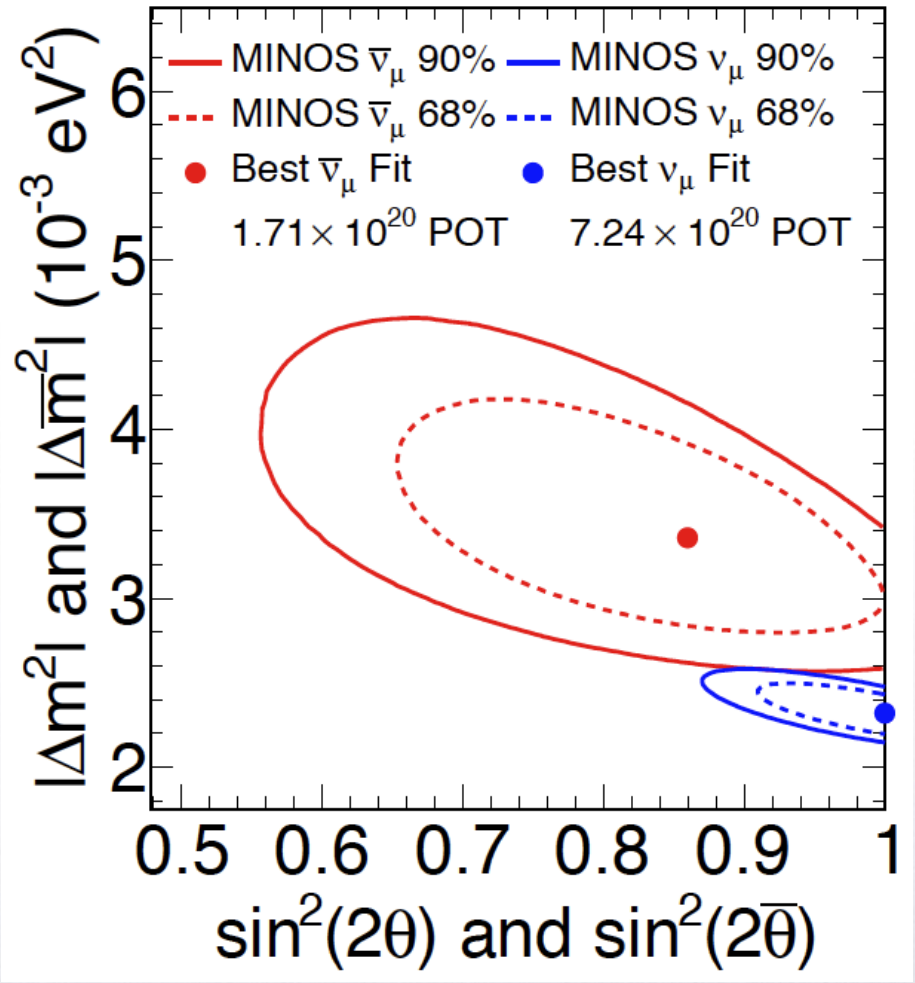
156 events no-osc. prediction

6.3σ exclusion of no-osc. hypothesis

$$|\Delta\overline{m}^2| = 3.36^{+0.46}_{-0.40} \times 10^{-3}\mathrm{eV}^2$$

$$\sin^2(2\bar{\theta}) = 0.86^{+0.11}_{-0.12}$$

Probability that ν_μ and $\bar{\nu}_\mu$ osc. parameters are identical is 2.0%



Analysis Strategy

- How will we analyze the new RHC data being taken since November 2010?

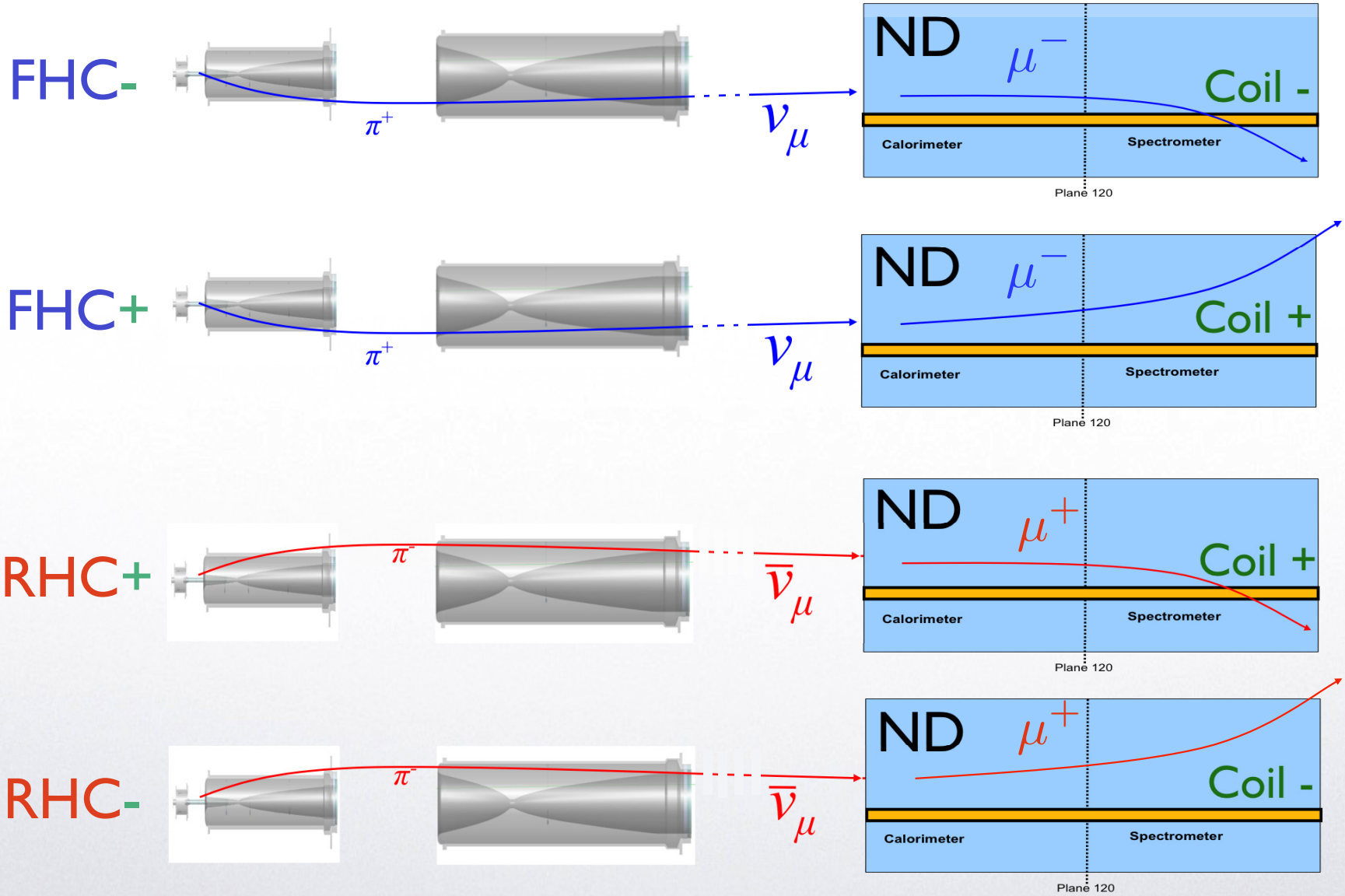
- Keep it simple
  - Same selector (kNN) as 1.7×10^{20} POT analysis
  - Same extrapolation (Beam Matrix)
  - Same fitting procedures

- Analysis Improvements
  - Reconstruction upgrades/bug fixes
  - Use kNN shower energy as in the 7.1×10^{20} POT CC analysis
  - Cross-check systematics used in previous analysis and look into new ones
  - Use rolling calibrations to expedite results turnaround

Analysis Work

- Thoroughly understand Data/MC distributions in detectors
  - FHC-/FHC+ comparisons to understand detector acceptance effects
  - Special RHC- ND running requested to enable RHC+/RHC- comparisons
  - FD comparisons with open set and with blinded y axis for closed set
- Look for potential changes in beam flux (new target used in Run Period 7)
  - Monitor stability of energy spectrum between data taken in Run Periods 4 and 7 and within Run Period 7
- Validate newly generated analysis DSTs by using them to reproduce previous analysis

FHC+/FHC-, RHC+/RHC-



FHC+/FHC- Studies (Joe Walding)

Regions defined by track end location

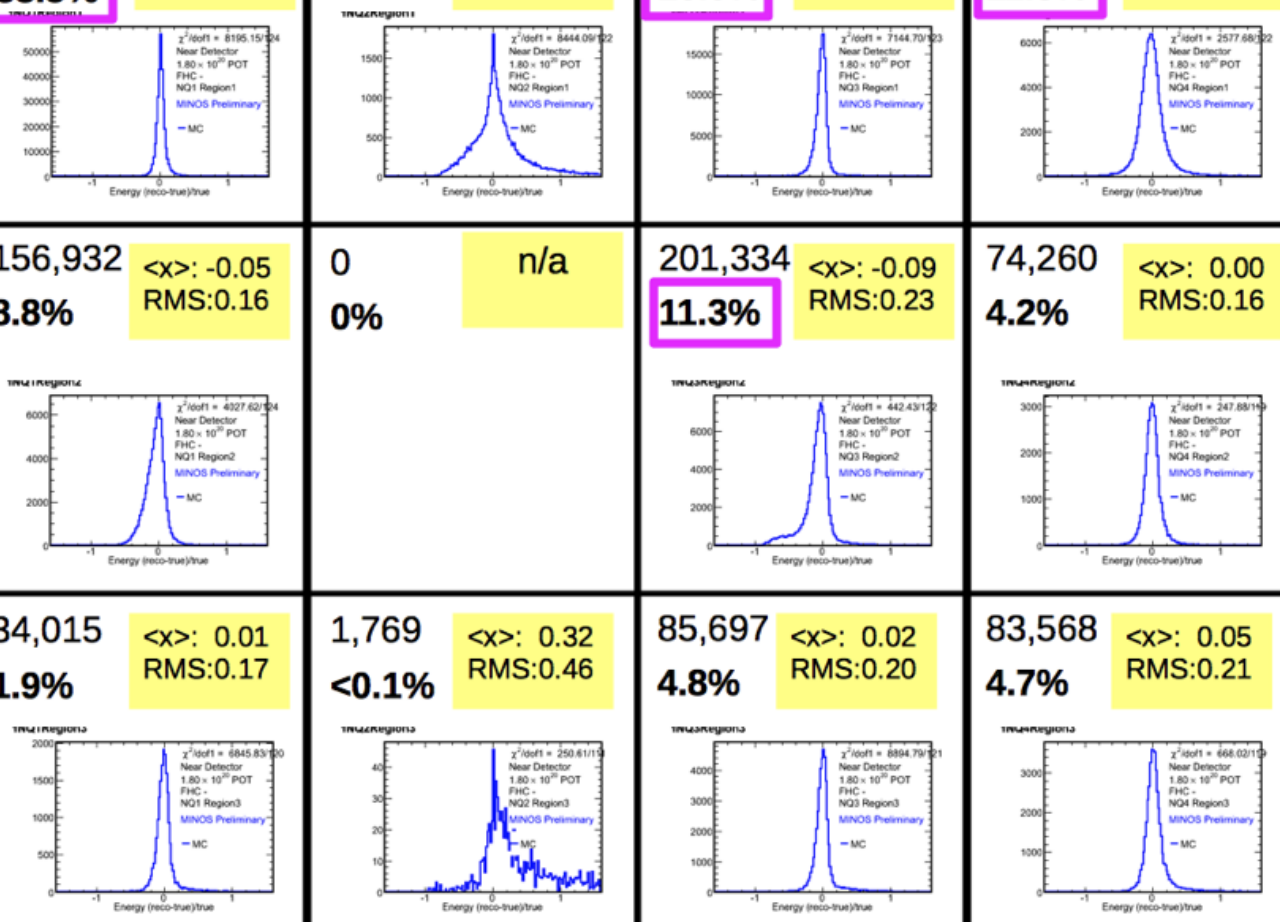
Negative charge events

FHC- with TR	44.2% Z1	3.6% Z2	32.1% Z3	20.2% Z4
64.4% XY1	599,702 **33.5%** D/MC: 1.01	63,705 **3.6%** D/MC: 0.92	285,835 **16.0%** D/MC: 1.04	203,061 **11.3%** D/MC: 0.97
24.3% XY2	156,932 **8.8%** D/MC: 0.96	0 **0%** D/MC: n/a	201,334 **11.3%** D/MC: 1.02	74,260 **4.2%** D/MC: 1.09
11.4% XY3	34,015 **1.9%** D/MC: 0.98	1,769 **<0.1%** D/MC: 0.94	85,697 **4.8%** D/MC: 1.03	83,568 **4.7%** D/MC: 1.02

FHC+/FHC- Studies (Joe Walding)

Regions defined by track end location

FHC- with TR	44.2% Z1	3.6% Z2	32.1% Z3	20.2% Z4
64.4% XY1	599,702 33.5% <x>: 0.02 RMS:0.13	63,705 3.6% <x>: 0.08 RMS:0.40	285,835 16.0% <x>: -0.02 RMS:0.17	203,061 11.3% <x>: 0.00 RMS:0.23
24.3% XY2	156,932 8.8% <x>: -0.05 RMS:0.16	0 0% n/a	201,334 11.3% <x>: -0.09 RMS:0.23	74,260 4.2% <x>: 0.00 RMS:0.16
11.4% XY3	34,015 1.9% <x>: 0.01 RMS:0.17	1,769 <0.1% <x>: 0.32 RMS:0.46	85,697 4.8% <x>: 0.02 RMS:0.20	83,568 4.7% <x>: 0.05 RMS:0.21



Negative charge events

FHC+/FHC- Studies (Joe Walding)

Regions defined by track end location

Negative charge events

FHC+ with TR	27.7% Z1	25.0% Z2	7.2% Z3	40.0% Z4
98.1% XY1	183,993 **27.0%** D/MC: 1.02	170,701 **25.0%** D/MC: 0.99	43,797 **6.4%** D/MC: 1.07	270,509 **39.7%** D/MC: 1.01
0.9% XY2	2,354 **0.4%** D/MC: 0.94	0 **0%** D/MC: n/a	3,172 **0.5%** D/MC: 1.30	476 **<0.1%** D/MC: 1.35
0.9% XY3	2,081 **0.3%** D/MC: 0.91	612 **<0.1%** D/MC: 0.87	2,236 **0.3%** D/MC: 1.05	2,326 **0.3%** D/MC: 0.97

FHC+/FHC- Studies (Joe Walding)

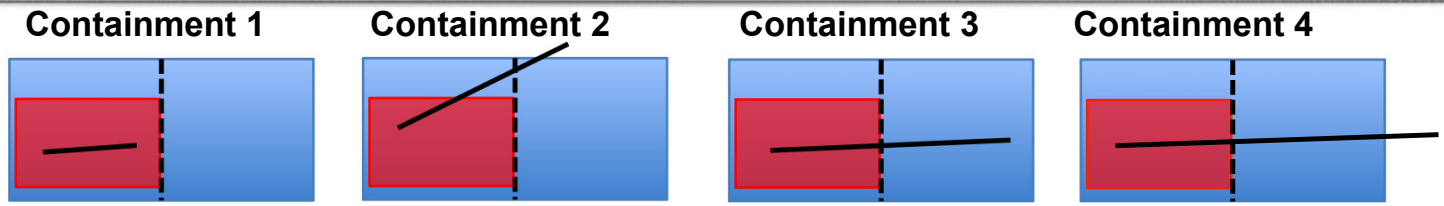
Regions defined by track end location

FHC+ with TR	27.7% Z1	25.0% Z2	7.2% Z3	40.0% Z4
98.1% XY1	183,993 27.0% <x>: 0.01 RMS:0.14	170,701 25.0% <x>: 0.06 RMS:0.30	43,797 6.4% <x>: -0.07 RMS:0.18	270,509 39.7% <x>: 0.03 RMS:0.24
0.9% XY2	2,354 0.4% <x>: 0.03 RMS:0.29	0 0% n/a	3,172 0.5% <x>: -0.06 RMS:0.23	476 <0.1% <x>: -0.03 RMS:0.17
0.9% XY3	2,081 0.3% <x>: -0.13 RMS:0.21	612 <0.1% <x>: 0.13 RMS:0.35	2,236 0.3% <x>: -0.14 RMS:0.25	2,326 0.3% <x>: 0.08 RMS:0.30

Negative charge events

RHC+/RHC- Studies (Benton Pahlka)

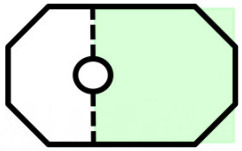
RHC+ without TR



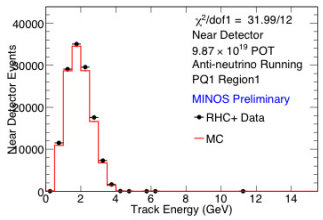
(all regions correspond to the location of the track end)

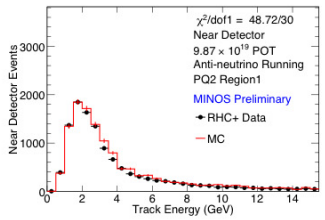
Positive charge events

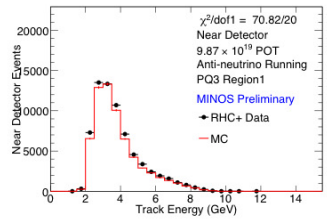
Region 1

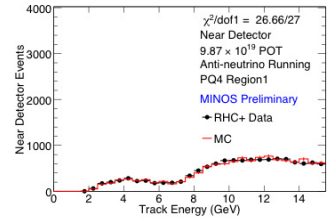


Containment 1	Containment 2	Containment 3	Containment 4
131744 37%	13019 4%	68738 19%	24073 7%

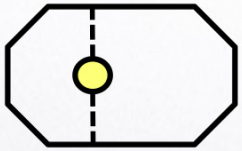




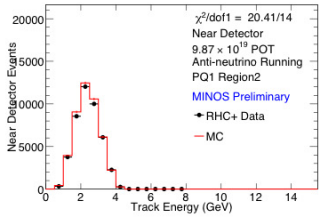


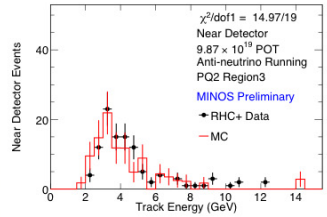


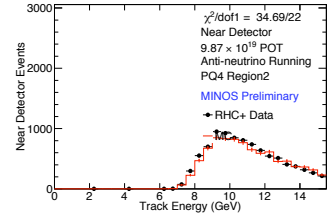
Region 2



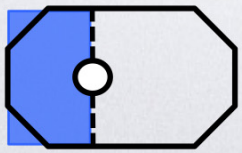
Containment 1	Containment 2	Containment 3	Containment 4
43326 12%	0 0%	38419 11%	11142 3%



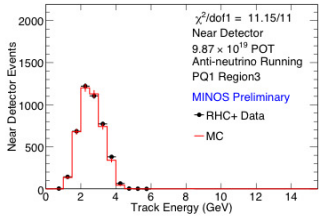


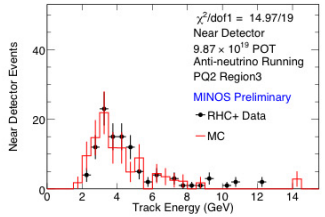


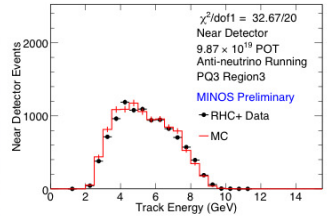
Region 3

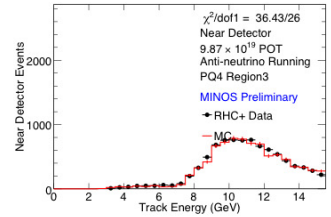


Containment 1	Containment 2	Containment 3	Containment 4
4385 1%	112 <1%	10096 3%	10247 3%



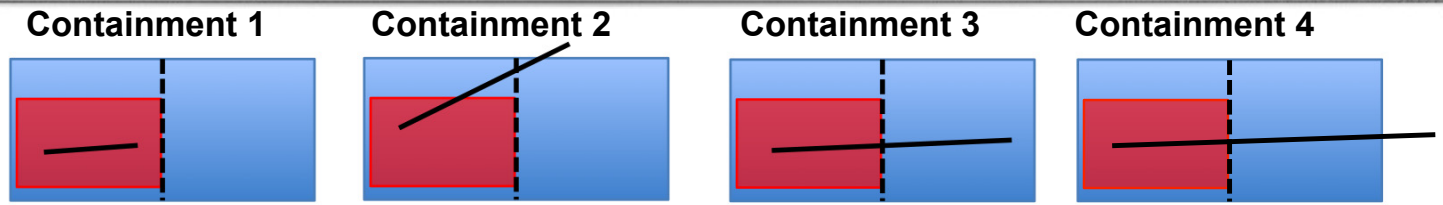






RHC+/RHC- Studies (Benton Pahlka)

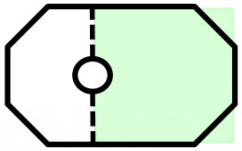
RHC- without TR



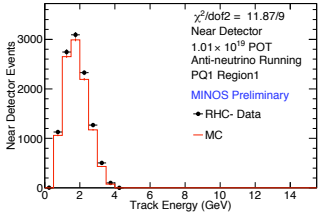
(all regions correspond to the location of the track end)

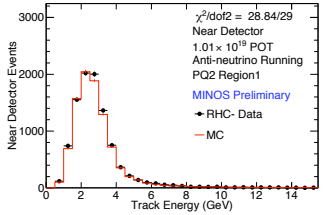
Positive charge events

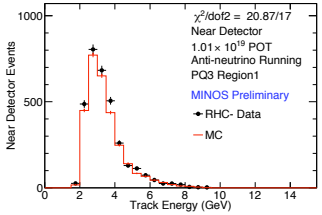
Region 1

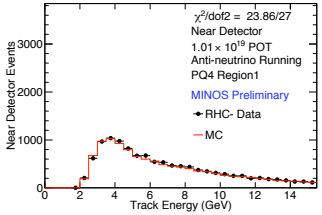


Containment 1	Containment 2	Containment 3	Containment 4
11169 30%	9809 26%	3211 9%	13118 35%

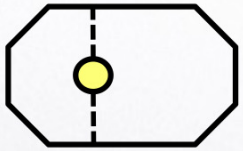




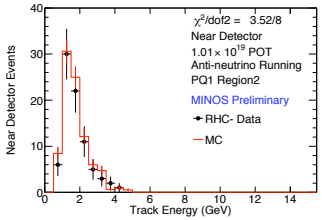


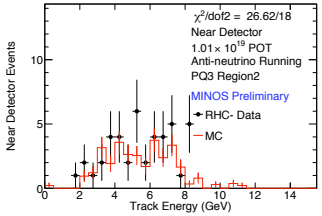


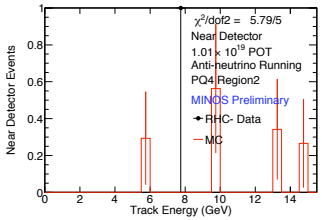
Region 2



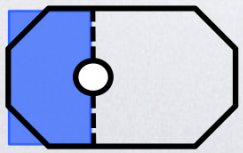
Containment 1	Containment 2	Containment 3	Containment 4
80 <1%	0 0%	43 <1%	8 <1%



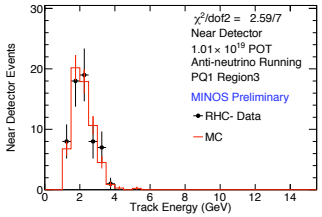


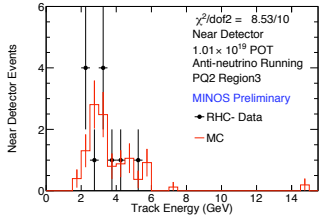


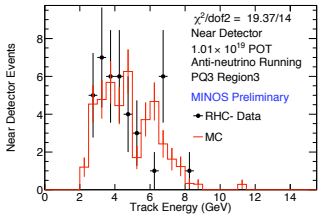
Region 3

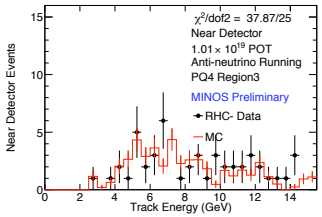


Containment 1	Containment 2	Containment 3	Containment 4
61 <1%	13 <1%	39 <1%	75 <1%

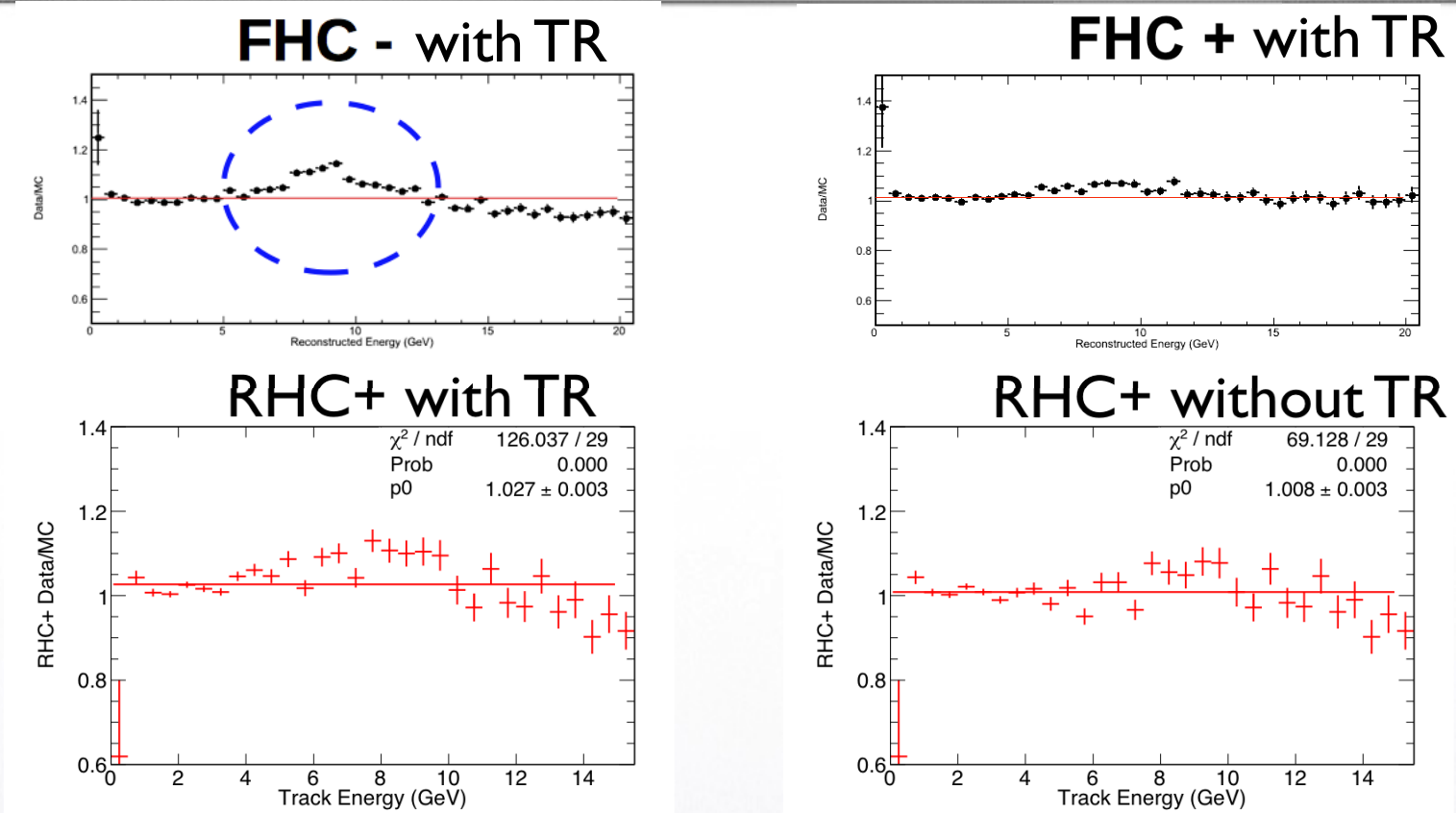








Data/MC Diffs (Joe, Benton)

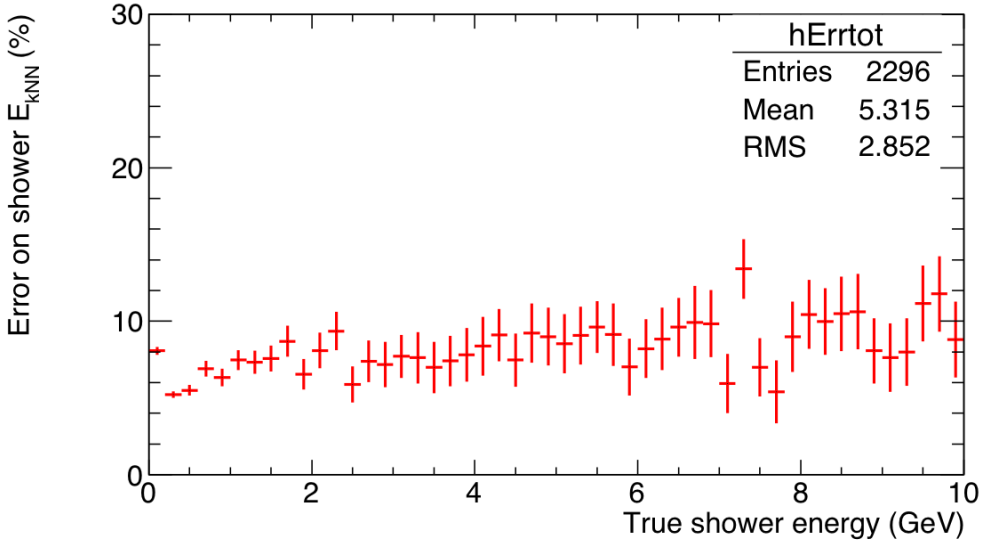


- 7-10 GeV discrepancy seen in FHC- sample also seen in RHC+
- Goes away in RHC+ (but not in FHC-) if track reclamation not applied - discussing whether to continue using track reclamation
- FHC- discrepancy mitigated by using energy from curvature instead of range for events stopping in spectrometer
- Investigating other containment regions

kNN Shower Energy (Son Cao)

- Recalculate systematics due to using kNN shower energy correction with RHC
  - new dedicated daikon_08 RHC samples generated - Thanks to MC, Batch

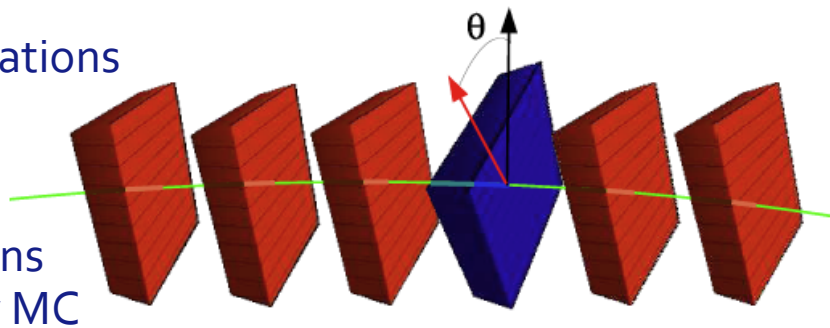
1. Pion/nucleon absorption
2. Baryon x_F selection
3. Formation Zone
4. INTRANUKE assumption-absorption
5. deBroglie ring
6. Charged/neutral particle correlation
7. Neutral pion probability
8. Two-body decays

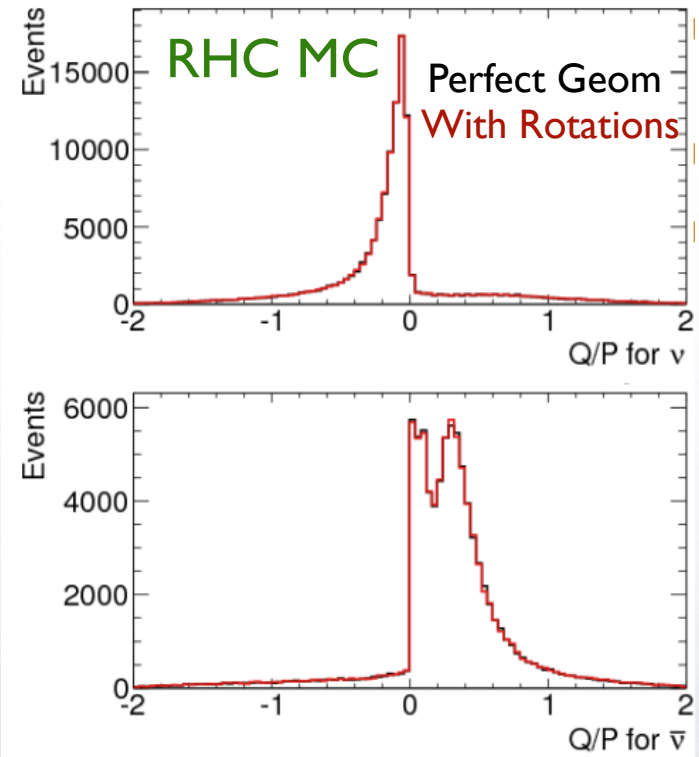


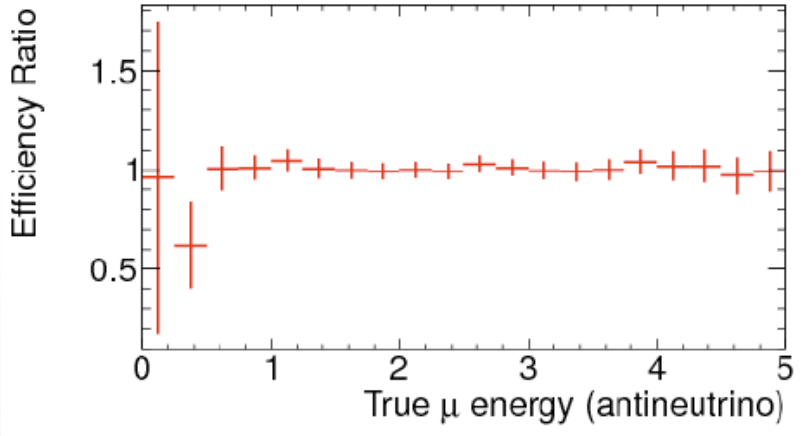
- Error on kNN shower energy for RHC estimated at ~8%
  - Set at ~6% for FHC analysis
  - Work in progress. Need to reproduce FHC estimates
- Also working on evaluation of kNN correction in FD prediction
  - Looking at possible improvements from developing RHC-specific correction

Rotation Alignment (Jasmine R.)

- Evaluate systematic error from plane-to-plane rotations
- Use muon track residuals to probe rotations
- Special MC generated with data measured rotations (thanks Robert!) compared with perfect geometry MC







- Above plot shows ratio of μ^+ selection efficiencies of rotated to perfect geometry MC
- Very small effect as expected
- Suggested re-evaluation for systematic rotations affecting multiple planes

Original Schedule

- Nominal box opening - May 1st (~4×10^{20} POT of RHC data)
  - Results to be shared only with lab management
  - Go public at Summer conference

- Release blessing package April 1st
  - Close out ND data set on Feb 1st
  - Close out FD data set (kept blind) by March 1st
  - Top-off FD data around box opening date (~May 1st)

- Schedule affected by understanding apparent changes in the ND spectrum indicated by Data Quality/Stability Monitoring plots
- Target failure and FD downtime mean 4×10^{20} POT might only be achievable by June or later

Analysis Timeline

READY DATE	MILESTONE	TASK (belongs to)
Feb. 24, 2011	**NT-05 Target Failure**	Run Period 7 ended - 1.24×10^{20} POT of good FD data (target being fixed by **Beams Div.**)
April 1, 2011	**Data Quality**	Update of data quality DB tables (**DQ group - Andy**)
April 1, 2011	**Cal. constants**	Production of calibration constants for Feb. 2011 (**Calibration group**)
April 7, 2011	**Data Processing**	Dogwood5 processing of Run Period 7, Nov. 2010 - Feb. 2011 (**Batch group**)
April 14, 2011?	**Data Quality/Stability Monitoring understood**	Identify source of ND spectral differences in Run Period 7 (**DQM group - Nate, Peter + Anna, Rashid, Alex S.**)
April 21, 2011	**All NuDST code modifications done**	Complete containment studies (**Joe, Benton**) and finalize kNN E_{shw} correction (**Son**)
April 28, 2011	**NuDST Code validated**	Regenerate Run Period 4 NuDSTs with R2.5, check against previous analysis (**Joe, Justin**)
May 1, 2011	**New NuDSTs generated**	Generate Run Period 7 NuDSTs with R2.5 (**Joe**)
May 8, 2011	**Data/MC studies**	Look at ND, FD Open Set, blinded Y-axis FD (**Benton, Joe, Alex R., Richa, Anna**)
May 11, 2011	**Helper files generated**	Generation of beam matrix helper files (**Mark M.**)
May 11, 2011	**Systematic uncertainties**	Absolute, Relative had. energy, MEU check, kNN Energy, rotation alignment, acceptance, normalization check (**Calibration, Son, Jasmine, Joe, Benton, Scanning Team**)
May 18, 2011	**Systematic errors for analysis**	Calculate from systematically shifted MC samples (**Alex R.**)
May 25, 2011	**Earliest date for blessing package**	Produce blessing package + supporting documentation (**Disappearance group**)
?	**Results shown to Collaboration**	Fits to Data + Feldman-Cousins surface (**Mark M., Zeynep**)

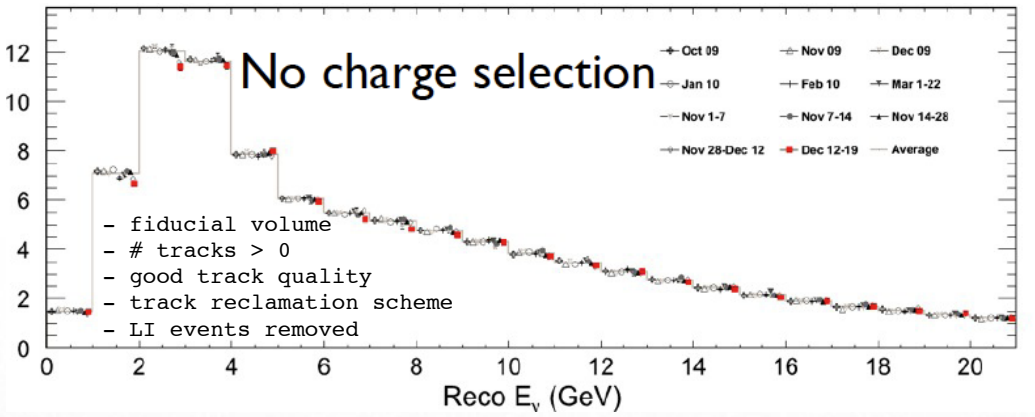
Top-up

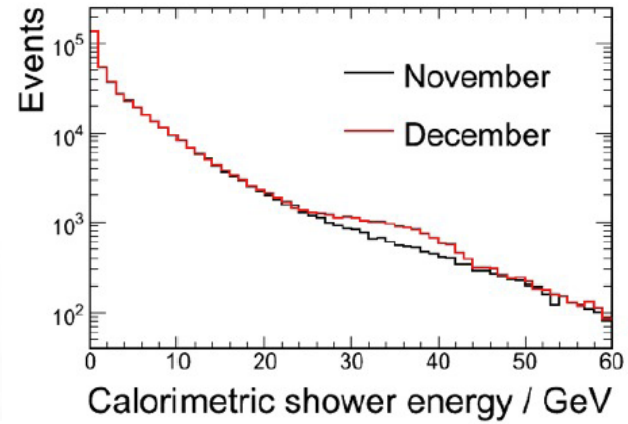
- Run Period 8 will start when NuMI beam is back up

- Run Period 8(?) top-up
  - Work on understanding how new data compares with Run Period 7 while data is collected
  - When we decide to close the Run Period 8 data set, expect ~4 weeks for Calibration, Batch Processing, NuDST processing, and fits before updated results are presented

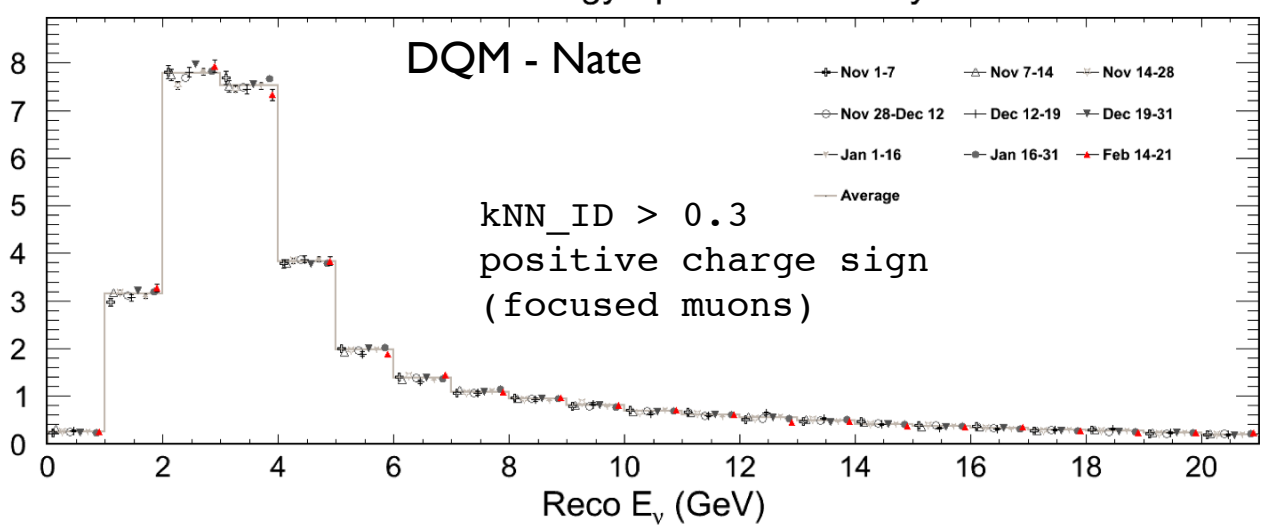
Data Stability

- At Oxford, much time was spent understanding differences in ND neutrino spectrum seen in Data Quality Monitoring (DQM) plots
  - Tracked down by Justin and Ryan N. to a hot strip that contributed 28 GeV showers intermittently between Dec. 6, 2010 and Jan. 20,2011



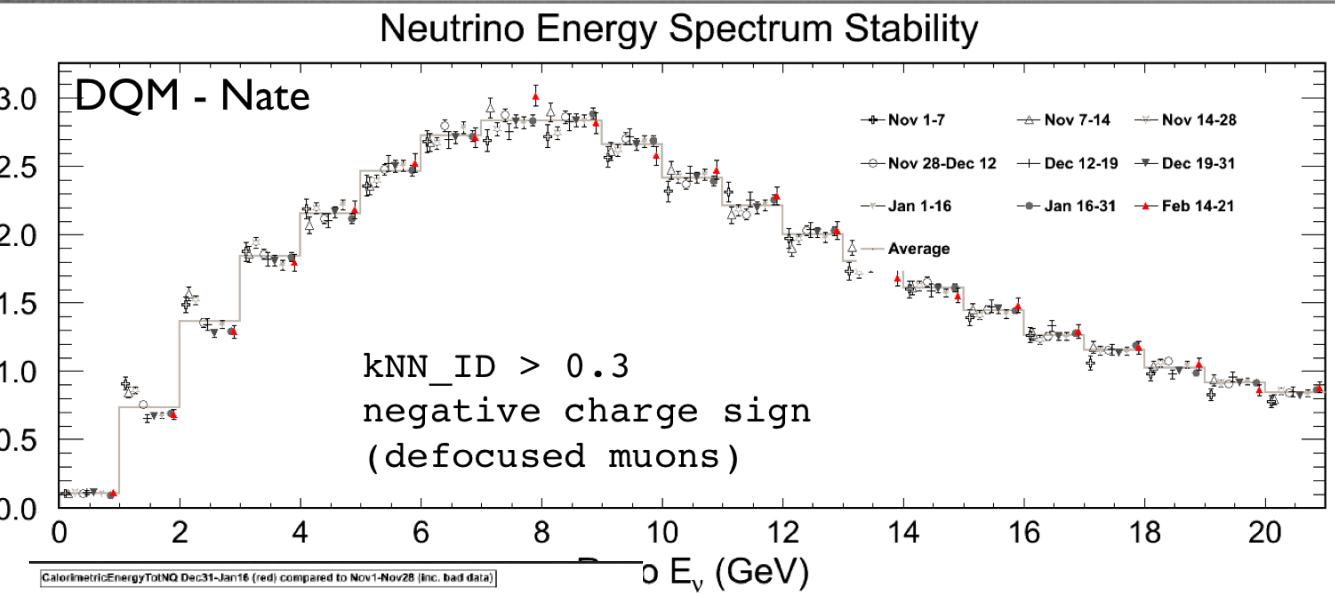


Neutrino Energy Spectrum Stability

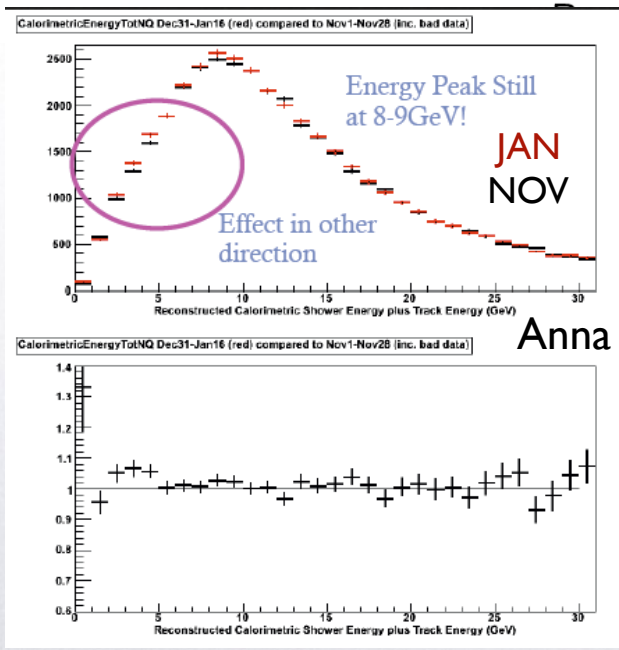


- After reprocessing with hot strip masked, positive charge sample looks okay

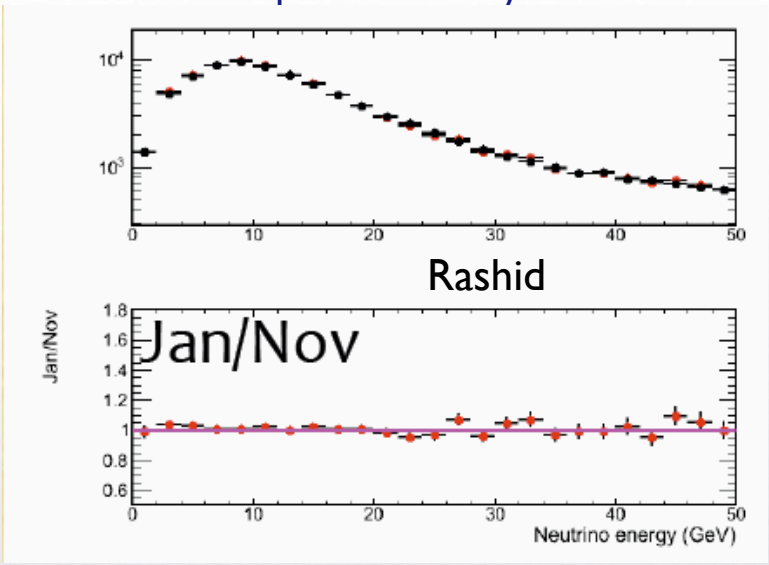
Data Stability



- However, discrepancy between November and after first week of December remained



- This is not reproduced by Anna nor Rashid using NuDSTs

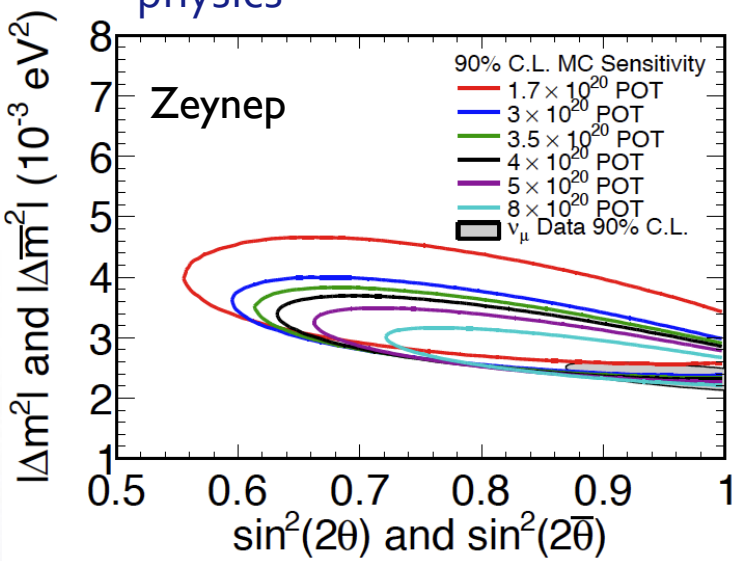


Data Stability

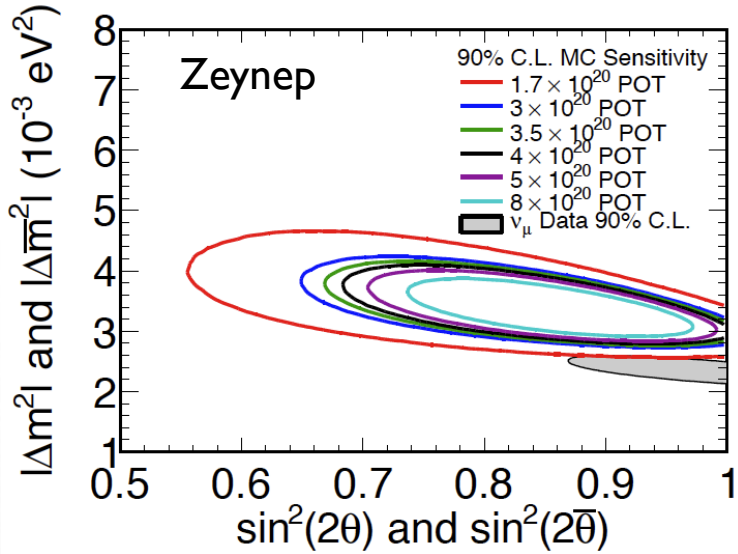
- DataQualityMonitoring package has not been updated since November 2008 (R1.30 Minossoft)
  - Inputs are "antps" generated using R2.0 version of AnalysisNtuples (circa 2009)
  - Code depends on R1.30 (tagged August 2008) version of NCUtils code
- Andy noted that antp's did not have correct data quality information, which is currently read out from database tables
- Created a hybrid R2.5 test release with code from R1.30 AnalysisNtuples to generate files DQM can process, but with the correct data quality info
  - January 2011 processed, November 2010 half-way done
- However, it is unlikely data quality will fully explain the effect
- Anna is working on event-by-event comparisons of antp info vs NuDST info for DQM selected events. Expect news by phone meeting Thursday

Conclusions

- Next MINOS RHC result will be a very exciting result!
  - Deliver most precise $\Delta\overline{m}^2$ measurement and test the possibility of new beyond SM physics



POT($\times 10^{20}$)	$\Delta\overline{m}^2(\times 10^{-3}\text{eV}^2)$	$\sin^2 2\overline{\theta}$	% Likelihood
1.71	3.38	0.858	2.293
3.0	2.98	0.863	6.600
3.5	2.93	0.863	8.706
4.0	2.88	0.868	11.099
5.0	2.77	0.883	16.004
8.0	2.62	0.907	29.651



POT($\times 10^{20}$)	$\Delta\overline{m}^2(\times 10^{-3}\text{eV}^2)$	$\sin^2 2\overline{\theta}$	% Likelihood
1.71	3.38	0.858	2.293
3.0	3.38	0.858	0.223
3.5	3.38	0.858	0.100
4.0	3.38	0.858	0.043
5.0	3.38	0.858	0.010
8.0	3.38	0.858	$0.000^{+2.3\times 10^{-5}}$

- Estimate ~2 months of hard work to get analysis ready
- Looking forward to more RHC data!

Details of Track Reclamation

Original motivation: Improve agreement between data and MC

<u>If we use track reclamation:</u>

- Keep_If (IsGoodTrackFitPassReclamation)
  - keep if trkfitpass = 1
  - if trkfitpass = 0 but it is a “good track”, keep
  - “good track” defined as
    - | planeTrkVtxu – planeTrkVtxv | ≤ 5
    - | planeTrkEndu – planeTrkEndv | ≤ 40
    - planeTrkEndu/v < 270

<u>If we DO NOT use track reclamation:</u>

- keep if trkfitpass = 1