Current Operations: Neutrino Detectors/Computing (MiniBooNE, MINOS, MINERνA)

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Fermilab
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U.S. DEPARTMENT OF ENERGY

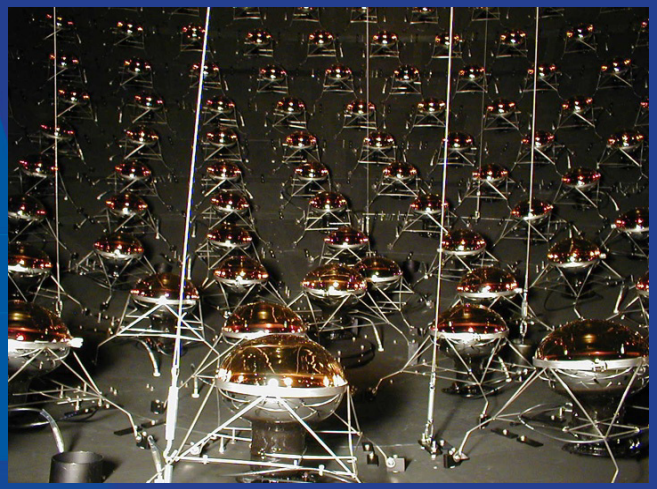
Fermilab

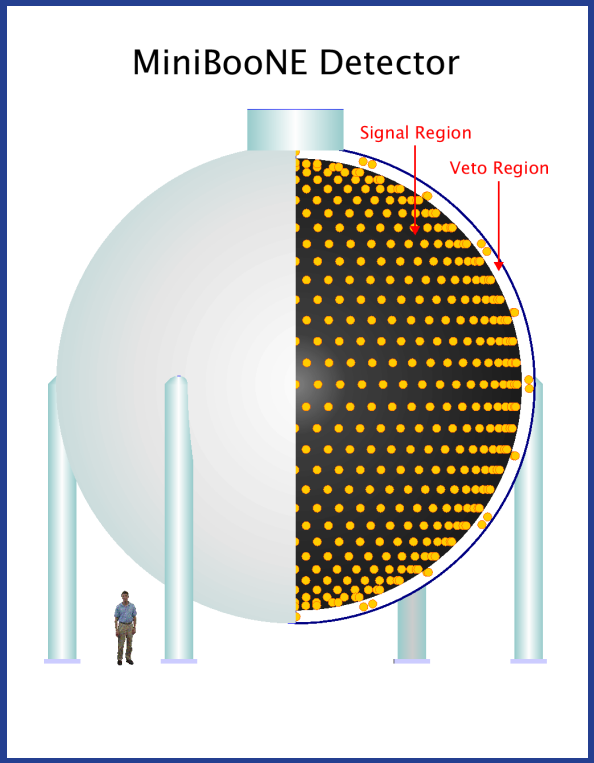
Outline:

- Introduction to the detectors and how they run
  - MiniBooNE (since September 2002)
  - MINOS (since March 2005)
  - MINERvA (since March 23, 2010)
- General Issues for Neutrino Beam Operations
  - Spare Beamline Components
  - MINOS Near Detector DAQ Operations
  - Cooling in NuMI Near Detector Hall
  - Neutrino versus Anti-Neutrino Running at NuMI
- Computing Resources for Operating Neutrino Experiments
  - Personnel Support
  - Disk and Tape Storage Space
  - Computing Nodes (grid and interactive both)

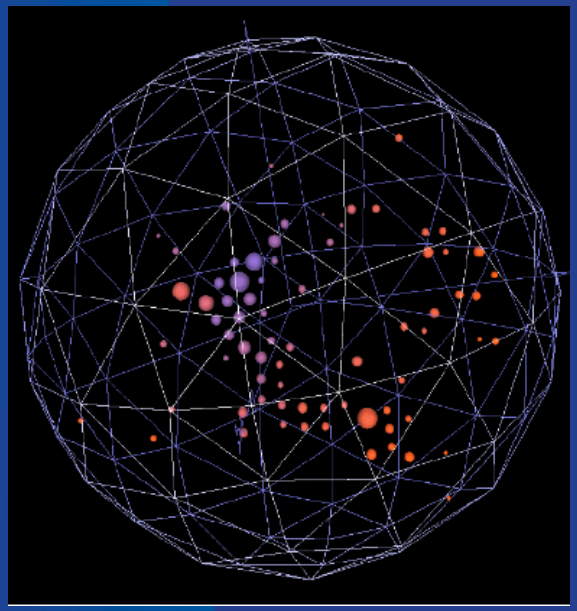
MiniBooNE Detector

- Pure mineral oil
  - Cherenkov:Scint ~ 3:1
  - Total volume: 800 tons (6 m radius)
  - Fiducial volume: 500 tons (5m radius)
- 1280 8” PMT’s at 5.5 m radius
  - 10% photcathode coverage
- 240 veto PMTs (outer optical barrier).



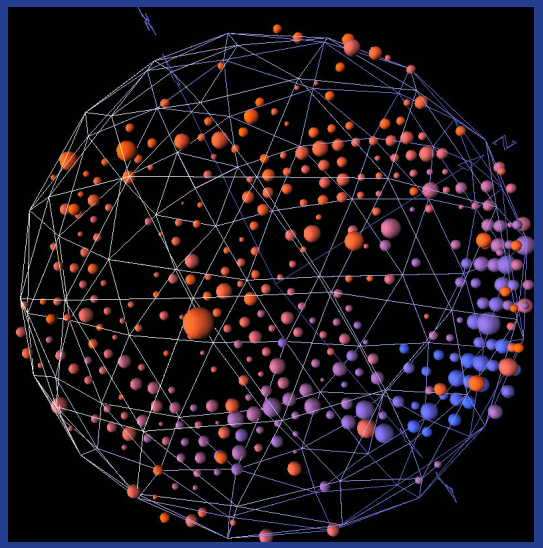


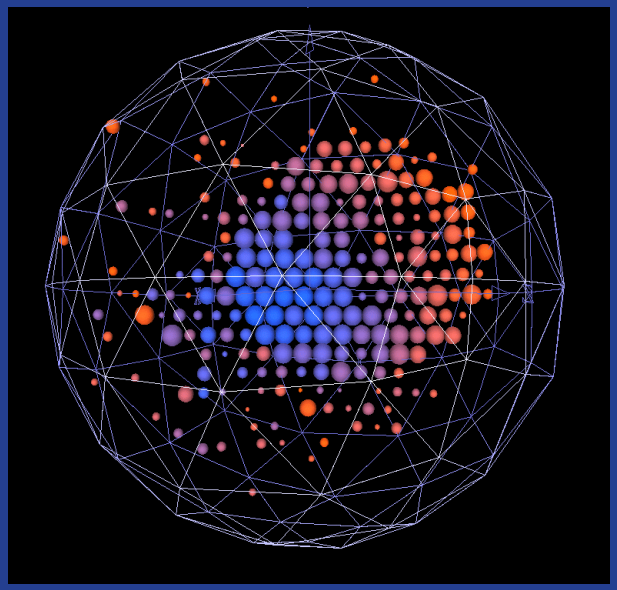
MiniBooNE Event Displays (Data)



e candidate

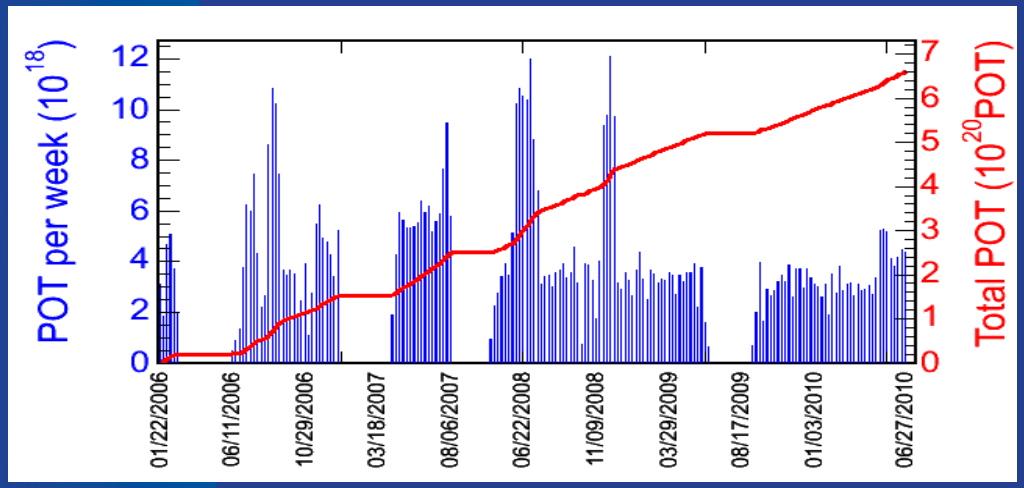
π^0 candidate





μ candidate

MiniBooNE Detector Operations



Total Antinu data:

6.6E20 POT

Since Sept 09 Shutdown:

Antinu data: 1.4E20 POT

Beam uptime: 90%

Detector uptime: 99%

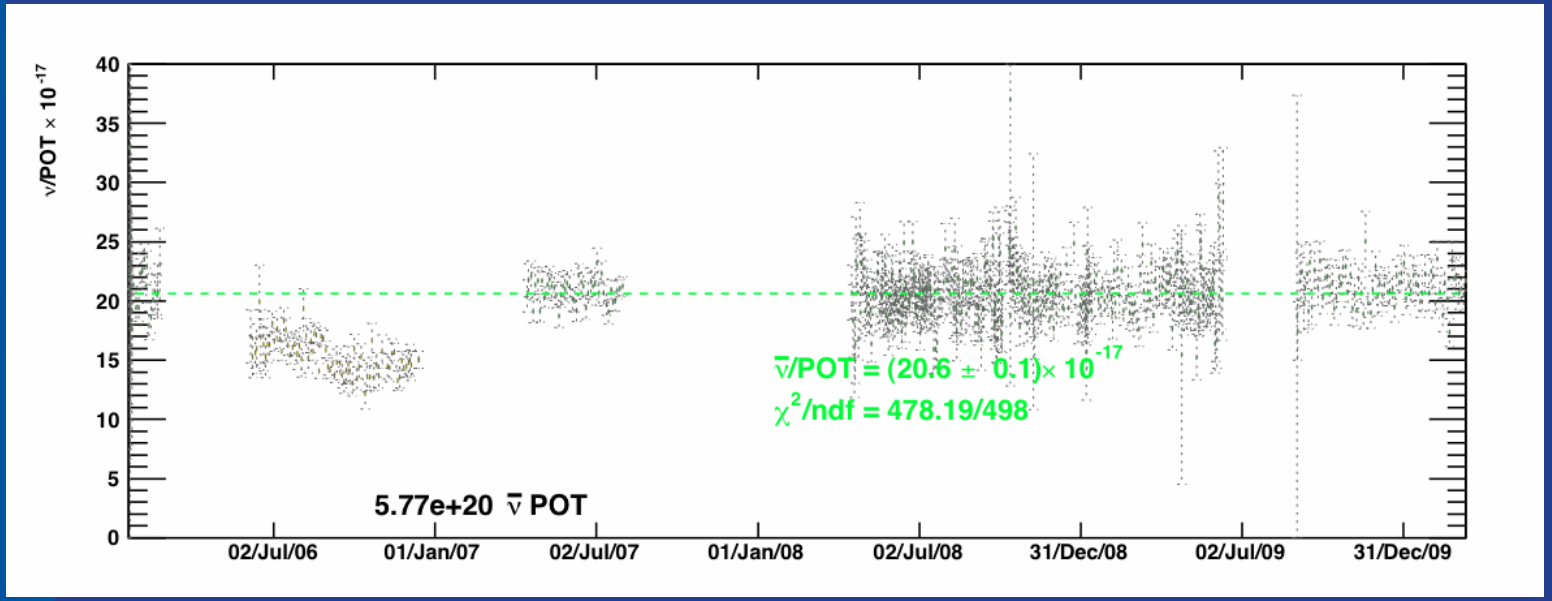
98% of the channels are working. About 1 channel a year is failing (non repairable)

Limited supply of trigger cards & crate CPU's.

Trigger card failure rates: once every 2-3 years

Have a few spares of these, enough for 2 years,

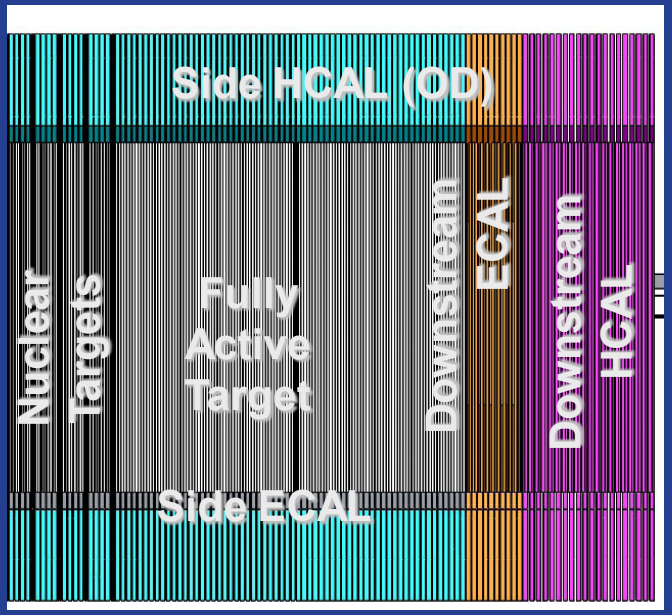
MiniBooNE Events per Proton on Target



Neutrinos/POT since absorber problem period has been stable,

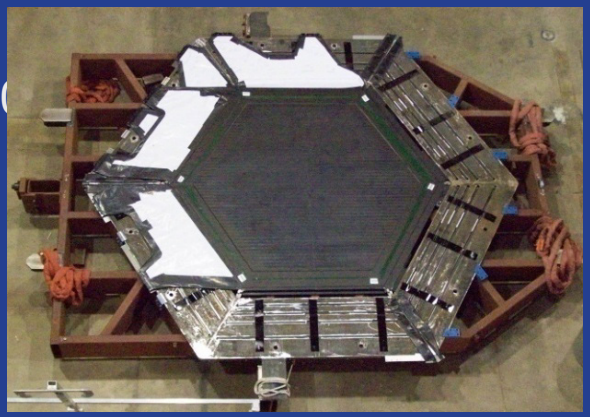
i.e. both beam and detector response are stable!

MINERνA

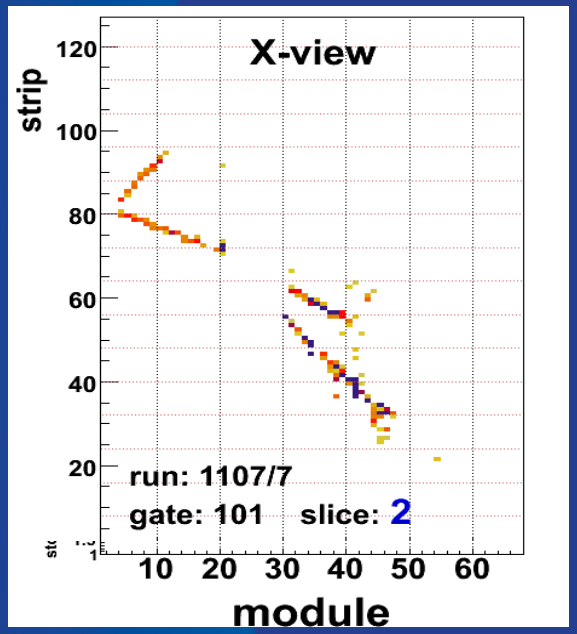


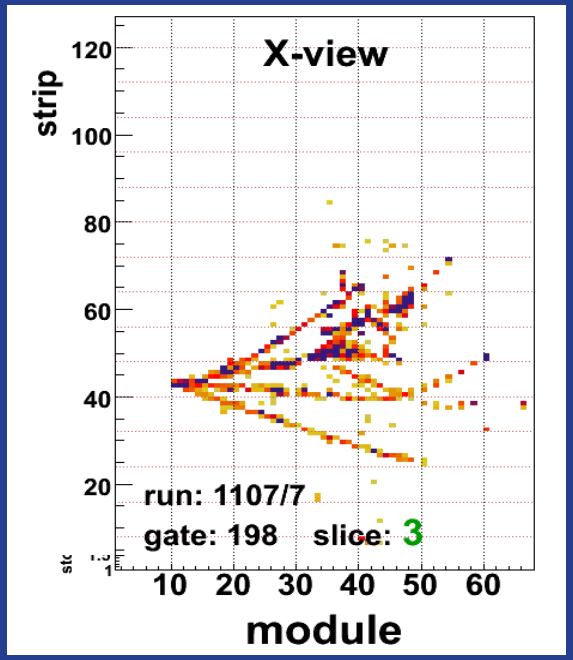
- First year MINERνA is included in "Operations" talk!
  - CD-4 in June
  - 3 months early
  - 9% under budget

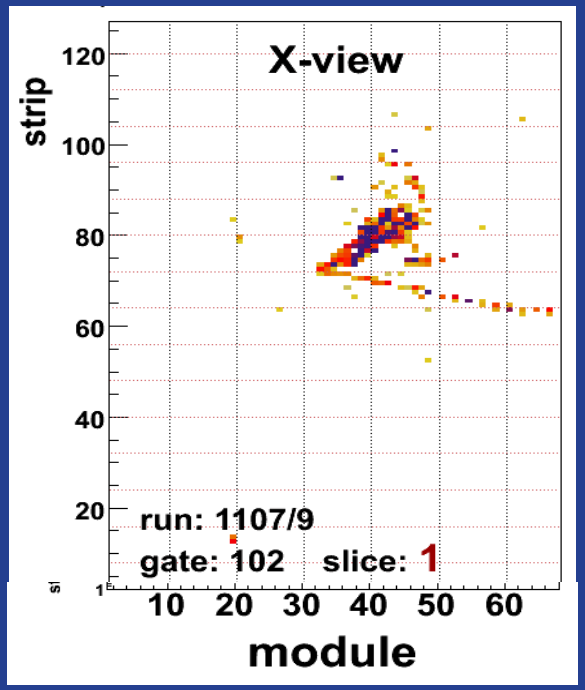
- 120 modules
  - Finely segmented scintillator planes read out by WLS fibers
  - Side calorimetry
  - Targets of C, Fe, Pb, CH, H_2O, He (late 201
- 491 64-anode PMT's
- Front End Electronics using Trip-t chips (D0)
- MINOS Detector gives muon momentum and charge



MINERνA Event Displays (Data)





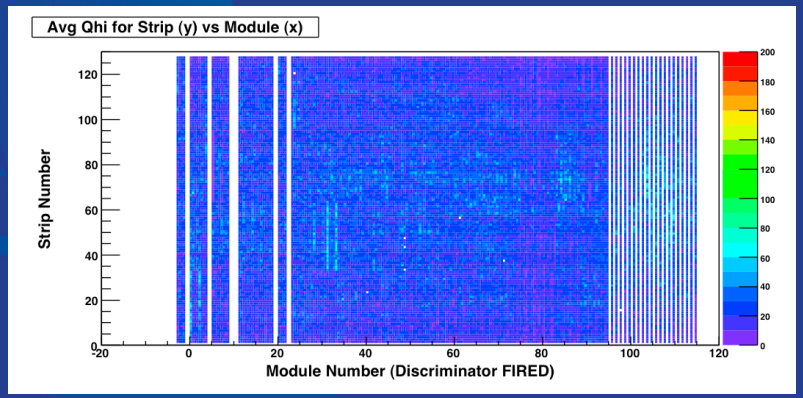


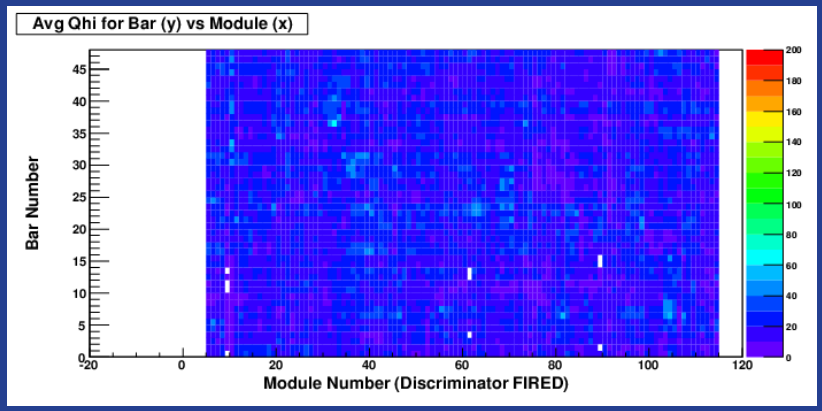
One view, three different events during antineutrino running

See detached Vertices, multi-particle final states, electromagnetic showers

MINERνA Operations

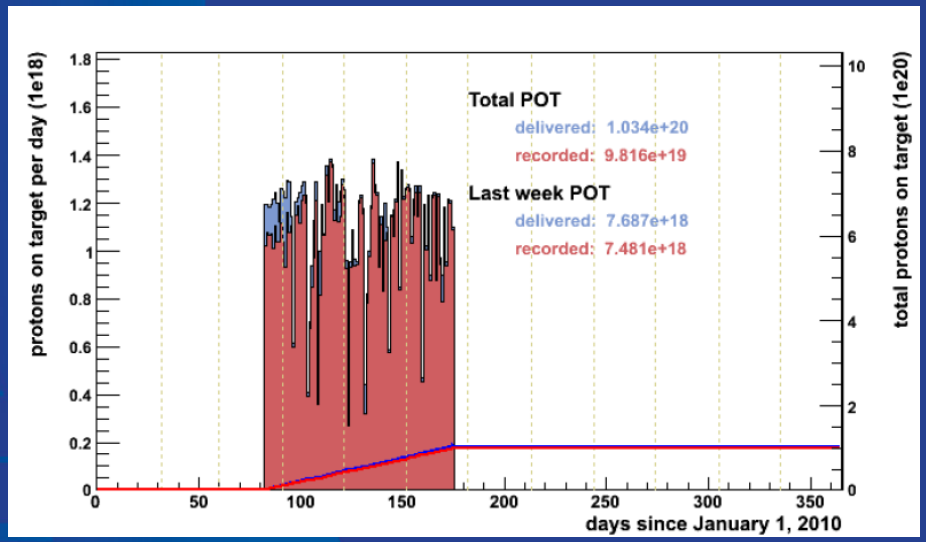
- Start of Full Detector run: March 23, 2010
- Fewer than 20 dead channels out of 32,000
- PMT Box replacements: ~3 in 3.5 months
  - Replacements due to noisy or dead channels
  - All reparable (so far)
- Front End Board replacements: ~9 in 3.5 months





MINERνA Protons on Target and Operations

- Currently running >95% live
- Have 1×10^{20} protons on target in Low Energy running out of $(4+0.9 \text{ in special})\times10^{20}$ of total



Spare components:

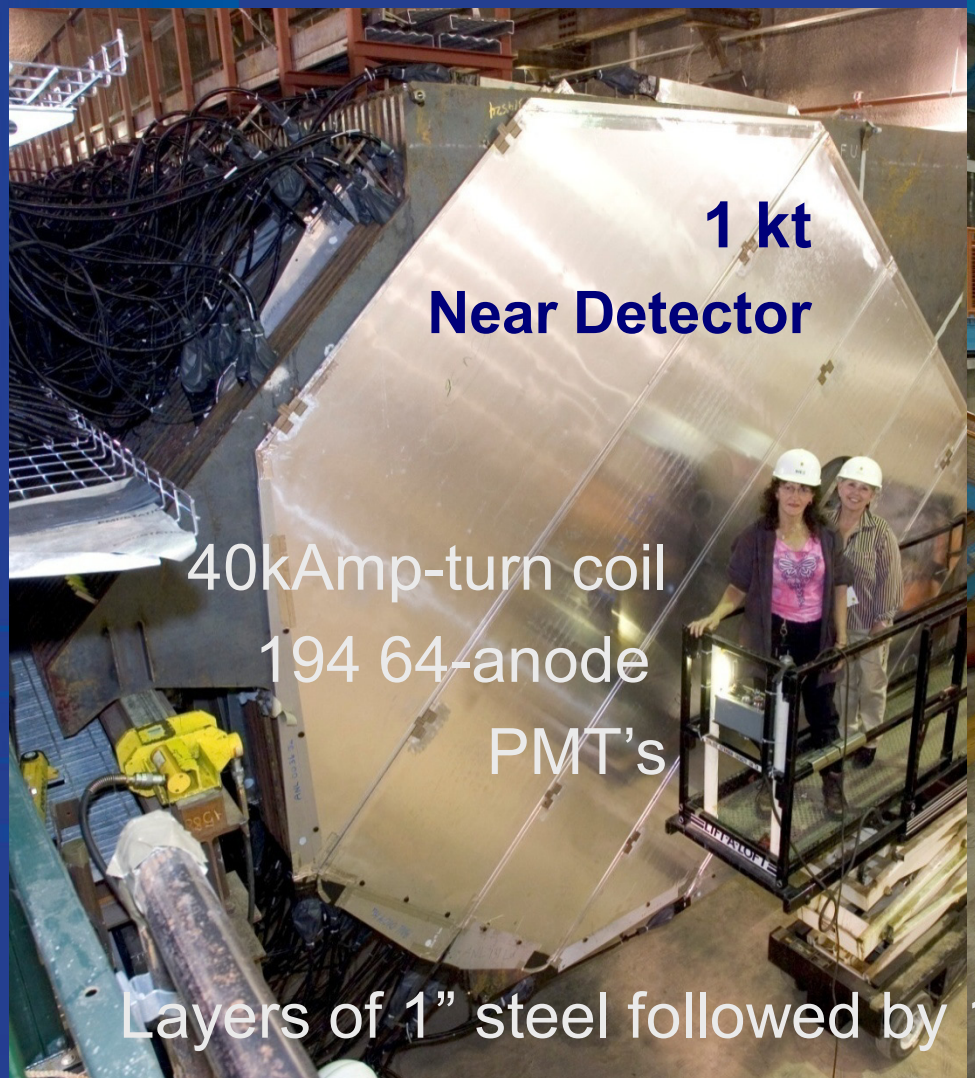
Hot spare DAQ machine to be installed this shutdown

25 spare PMT's and PMT boxes

100 spare Front End Boards

Operations Need: Technician for PMT box replacements and repair

MINOS



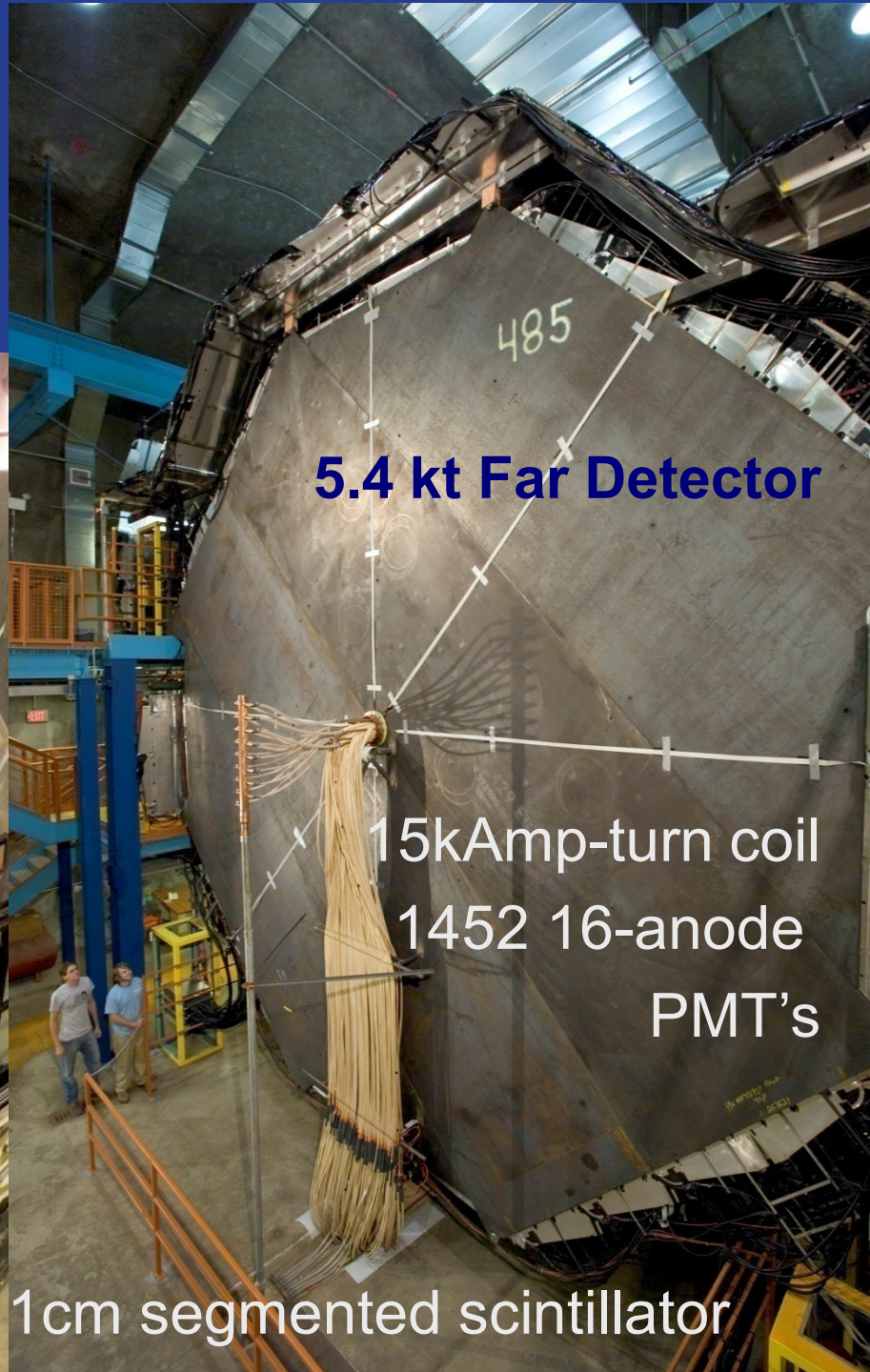
1 kt

Near Detector

40kAmp-turn coil

194 64-anode

PMT's



5.4 kt Far Detector

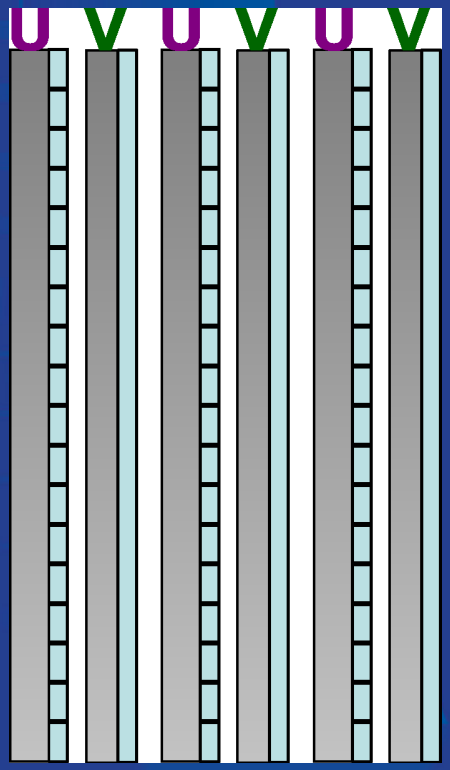
15kAmp-turn coil

1452 16-anode

PMT's

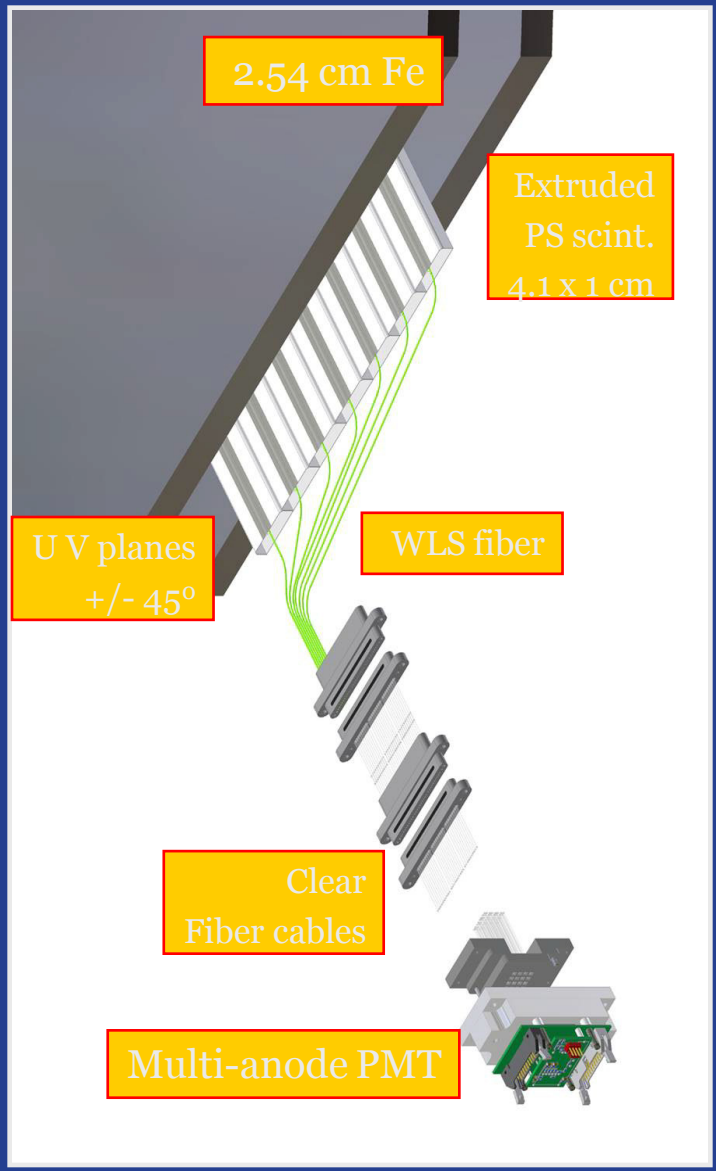
Layers of 1" steel followed by 1cm segmented scintillator

MINOS

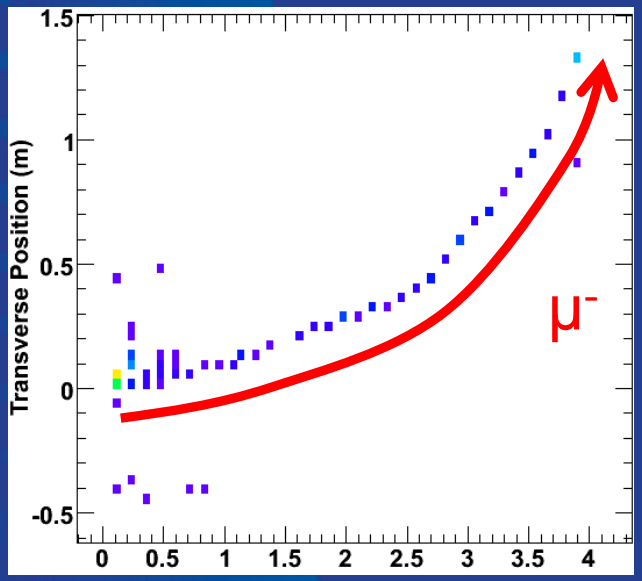


Near and Far Detectors are functionally identical:

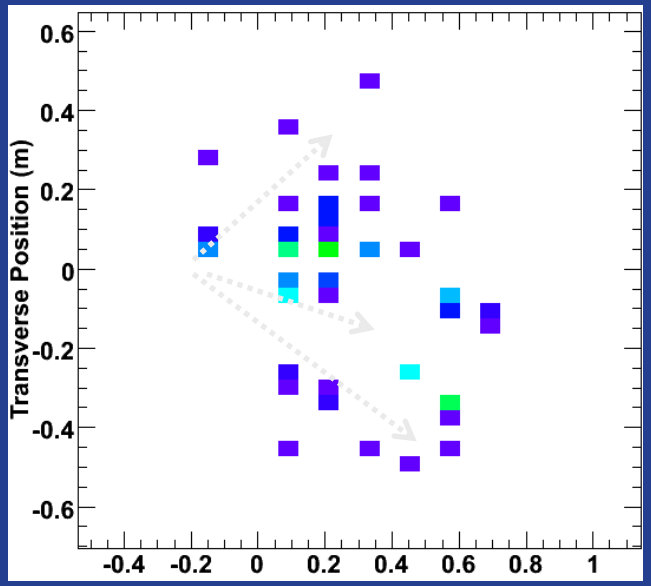
- 2.54cm thick magnetised steel plates
- co-extruded scintillator strips
- orthogonal orientation on alternate planes – U,V
- optical fibre readout to multi-anode PMTs



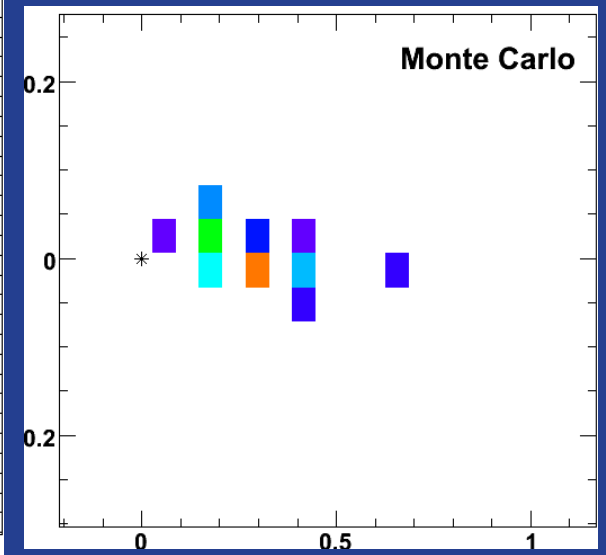
MINOS Event Displays



Charged Current ν_μ Event

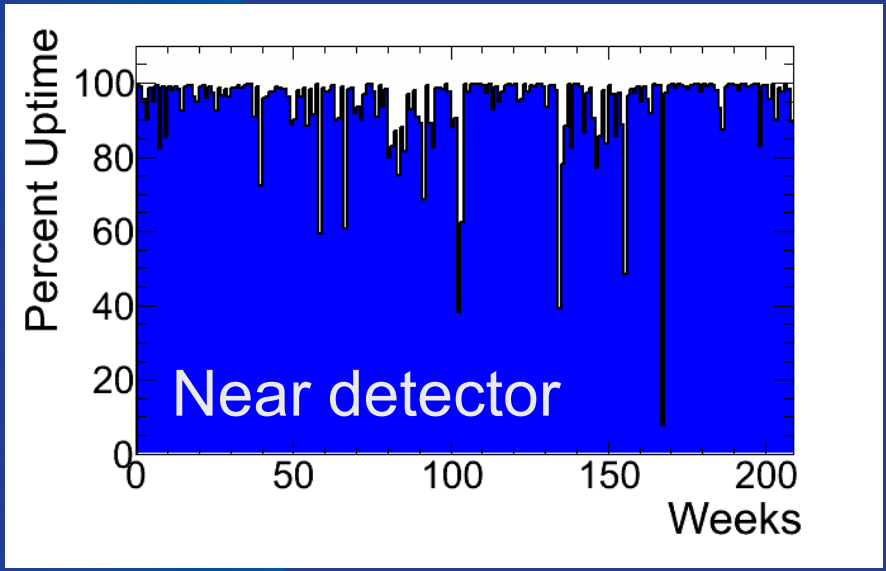


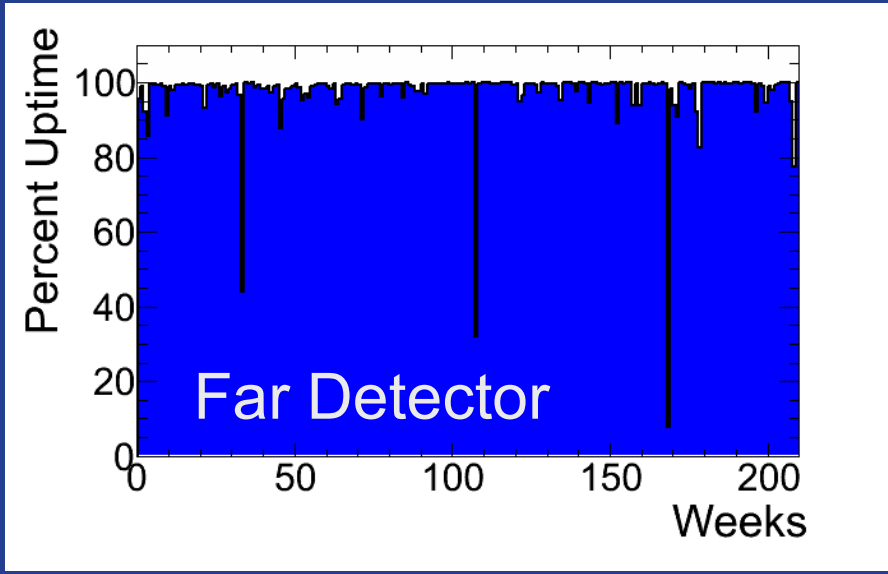
Neutral Current Event



Charged Current ν_e Event

MINOS Operations





Component Swap	Frequency of swap
Minder	20 per year (near)
Fan Pack, power supply	Every few months
PMT's (swap per year)	Near: 3 Far: 1
Other components	Rare

MINOS Far Operations Need:

Mine Crew support:
Currently 40 hrs/week,
important for
Far Detector swaps

ISSUES OF OVERLAP

MINOS Electronics Spares

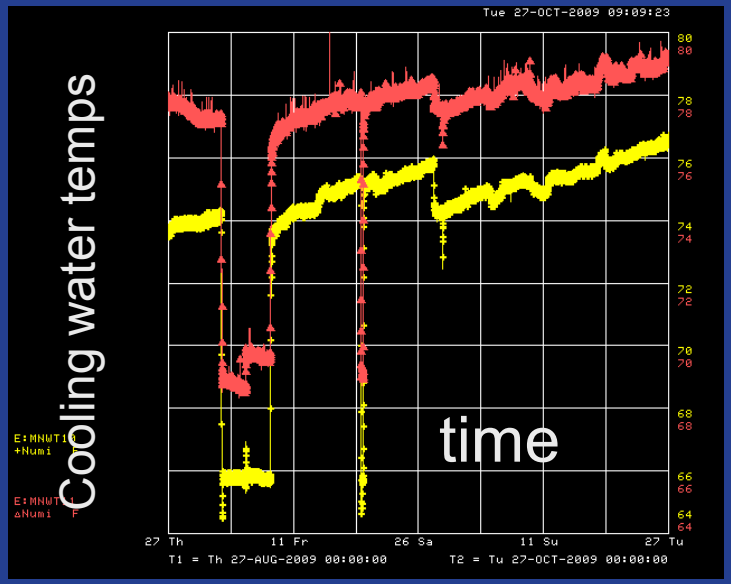
- 3 spare ROP's each for Near and Far detector
- ~10 spare far detector PMT's
- >10 spare Near Detector PMT's
- 2 hot spare Near Detector DAQ PC's
- 3 spare timing modules (TRC's) for Far Detector
- ROP's have been repaired by company in Switzerland
- Near Detector PMT Boxes have been repaired by Argonne, agreement is to continue this through MINERvA era

MINOS Data Acquisition Operations

- MINOS Near Detector (and its magnetic field) necessary for most MINERνA analyses
- UK support for DAQ operations discontinued
- Fermilab has provided a new person to support this at ¼ FTE: Donatella Torretta
- MINERvA has also provided new collaborators to work on this (post-docs from Rutgers and W&M)
- Training session at RAL this past Spring

NuMI Near Detector Hall Cooling Upgrade

- Current ambient hall temperature: 77°F, used to be 68°F
- Scintillator light yield decreases with increasing temperature: additional exponential increase of 0.2% for every °C above 68°F
- Scintillator aging also increases with increased temperature
- Higher temperature also causes more electronics errors
- Current Hall cooling system was only designed to cool MINOS and MINERvA
  - assuming incoming groundwater level of 300gpm
  - Current groundwater inflow: 130gpm
- New closed loop system designed, implementation started



NuMI Spares

- Targets:
  - Target #3: Installed during 2009 Shutdown
  - Target #4: To be installed during 2010 Shutdown
  - Target #5: In production, to be ready in October 2010
  - Target #6: Production started, ~ready in Summer 2011
- Horns:
  - First 2 horns went 28M or more pulses each, 10M spec
  - Horn1 #2: In use since July 2008, has had ~20M pulses
  - Horn1 #3: Ready
  - Horn1 #4: to be ready mid-2011, will work in NOνA era
  - Horn2 #2: In use since December 2008, has ~15M pulses
  - Horn2 #3: Ready
  - Horn2 #4: to be ready mid-2011, will work in NOνA era

Booster Neutrino Beam Spares

- 1st Horn died after 95M pulses.
- Currently running second horn, with over 260M pulses (world record!), showing no ill signs.
- Have complete third horn and target ready.

NuMI Neutrino and Anti-Neutrino Running

- As of March 23, 2010:
  - MINERvA started its run, MINOS has 1.74E20 in anti-neutrinos
- Run times requested in Low energy:
  - MINERvA: 4+0.9E20 in neutrino
  - MINOS: an additional 2.5E20 in anti-neutrino
- 650 calendar days between 3/23/10 until 2/29/12
  - less known shutdowns (summer 2010, another target swap)
- An average ”good day” over the past year is 1.1E18
- The product of those two is 7.1E20, short of 7.4E20, even assuming no downtimes at all
- PAC recommendation: “split the pain equally”

Contingency Plans for NuMI

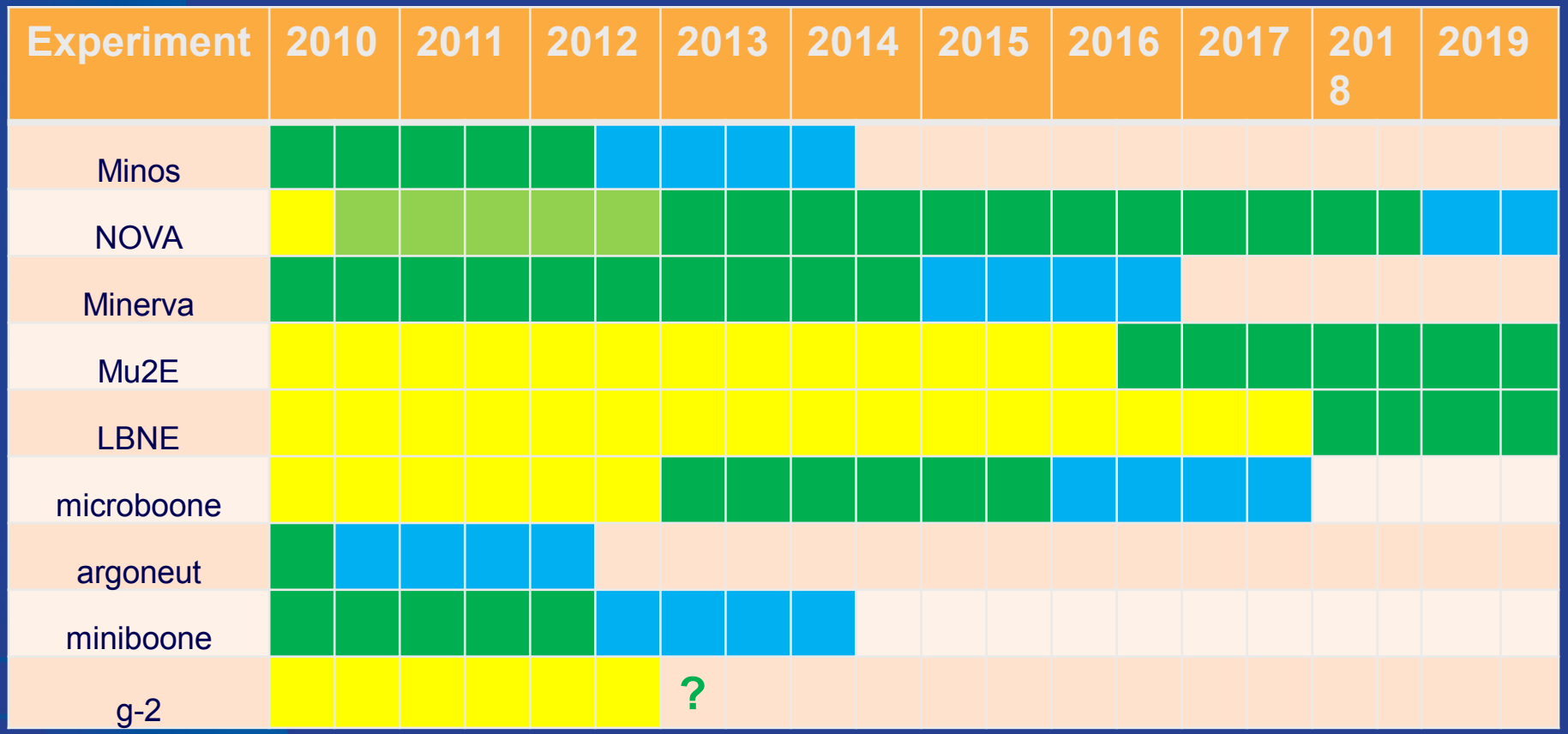
- How to implement PAC recommendation is under discussion
  - Splitting the risk to the experiments
  - Plan for contingency
- Contingency is needed because:
  - Complex may not provide 1.1e18/day for 650 days
  - MINOS may continue to see neutrino vs anti-neutrino discrepancy
- Options for getting more Low Energy running:
  - Delay 2012 shutdown and continue LE running
  - Come up after 2012 shutdown in Low Energy mode until NOvA's far detector is complete

Computing for MiniBooNE, MINOS, MINERνA

3 experiments, 3 models of Computing

- MiniBooNE:
  - most computing done on site
  - Computing support done through servicedesk tickets
  - Opportunistic grid submissions
- MINOS:
  - Significant data computing done on site
  - 2 People in MINOS collaboration also in CD
  - Vast majority of monte carlo generation off-site
- MINERνA
  - So far, most computing done on site
  - Substantial computing and DAQ support through post-docs
  - Computing support done through servicedesk tickets
  - Lee Lueking serves as Liaison between CD and IF, (as of 1/09) following slides come from Lee

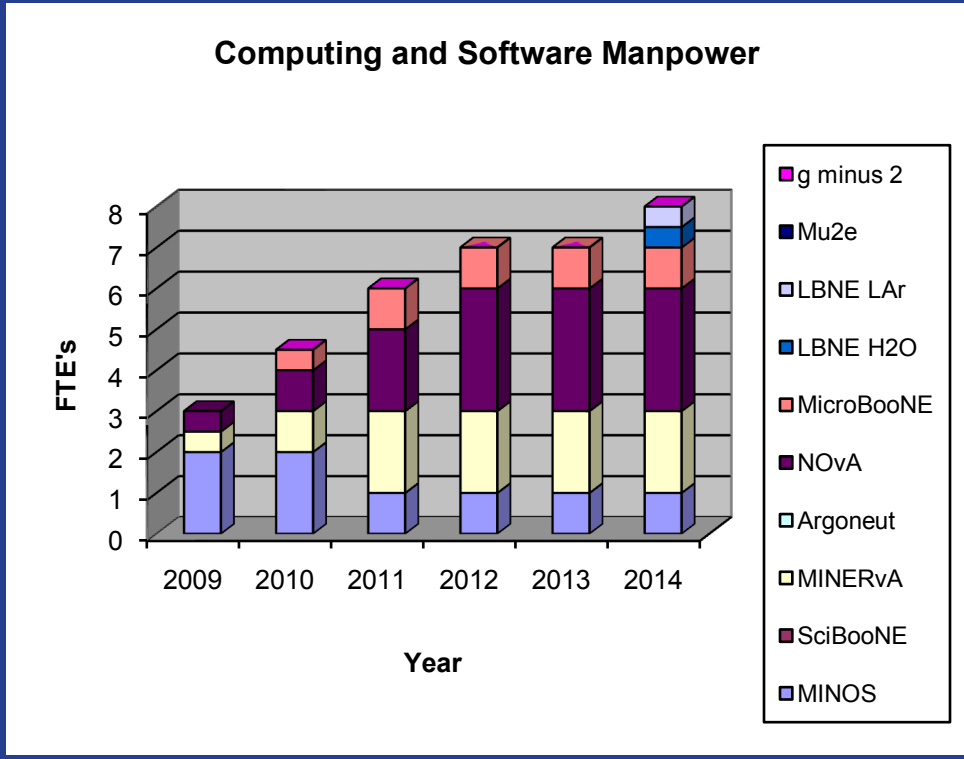
New Plan:
9 experiments, one computing model



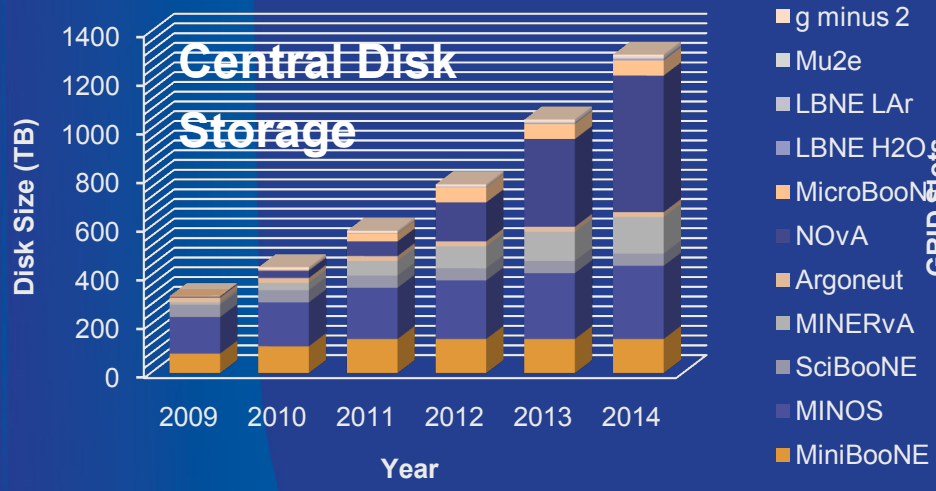
Intensity Frontier Personnel Needs

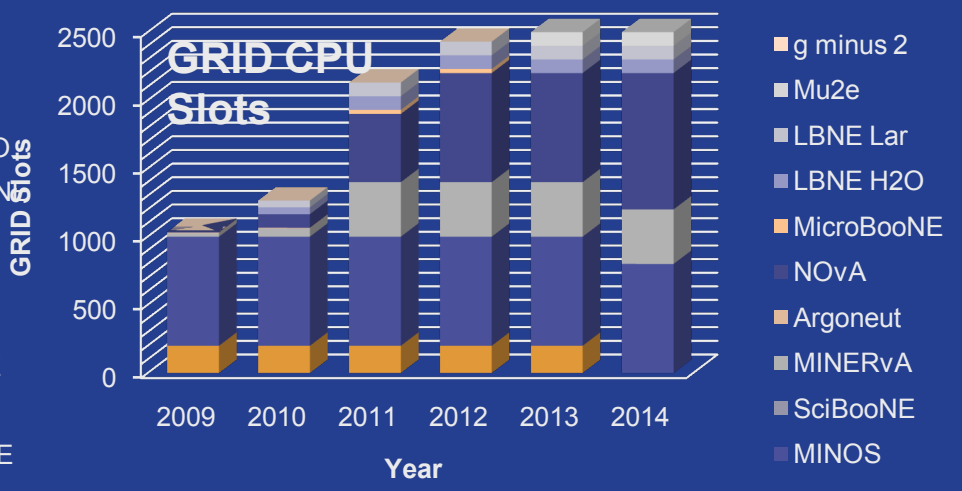
- CD provides manpower to the Intensity Frontier
  - Infrastructure procurement, commissioning and operations
  - Software development, maintenance, and consulting
  - Support for experiment computing set up and data operations.
- What is and isn't provided
  - Infrastructure operations is provided for all (not shown at left)
  - Dedicated Data Operations personnel have not been yet been provided for any IF experiments except MINOS
  - MINOS needs will decrease with time, Lee Lueking has joined NOvA, CD still needs to identify the remaining personnel requested

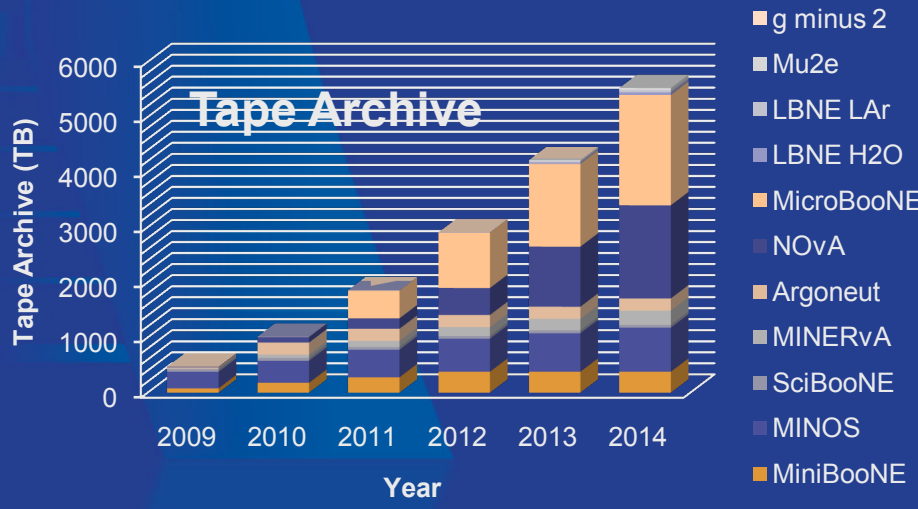
CD Manpower requested by Experiments

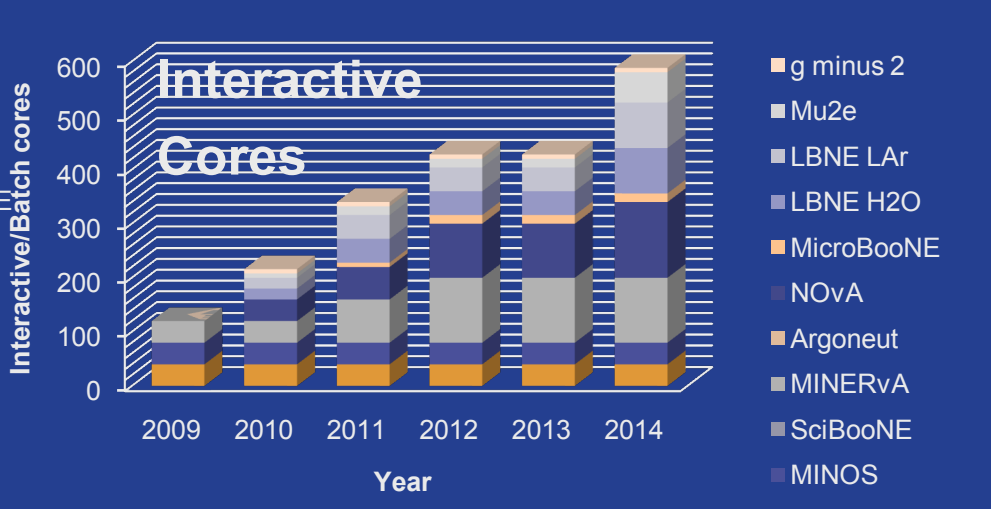


Intensity Frontier Computing Needs









Experiments Needs for Computing Hardware

- This is a list that has input from the experiments themselves, (includes all IF experiments)

Experiment	Disk (TB)	Tape (TB)	Int. (cores)	GRID (cores)	Servers
MINOS	30+60=90	100	0	0	3
NOvA	30	90	20	400	0
MINERvA	40	100	40	400	3
Mu2e	2	10	6	10	0
LBNE	20	5	48	100	0
MicroBooNE	5	1	8	50	0
ArgoNeuT	0	0	8	30	1
MiniBooNE	25+13=38	30	0	0	0
Muon g - 2	20	0	8	0	0
(replacements)				340	
TOTAL	245	336	138	1330	7
TOTAL Cost	$245k	$15k	$78k	$516k	$32k

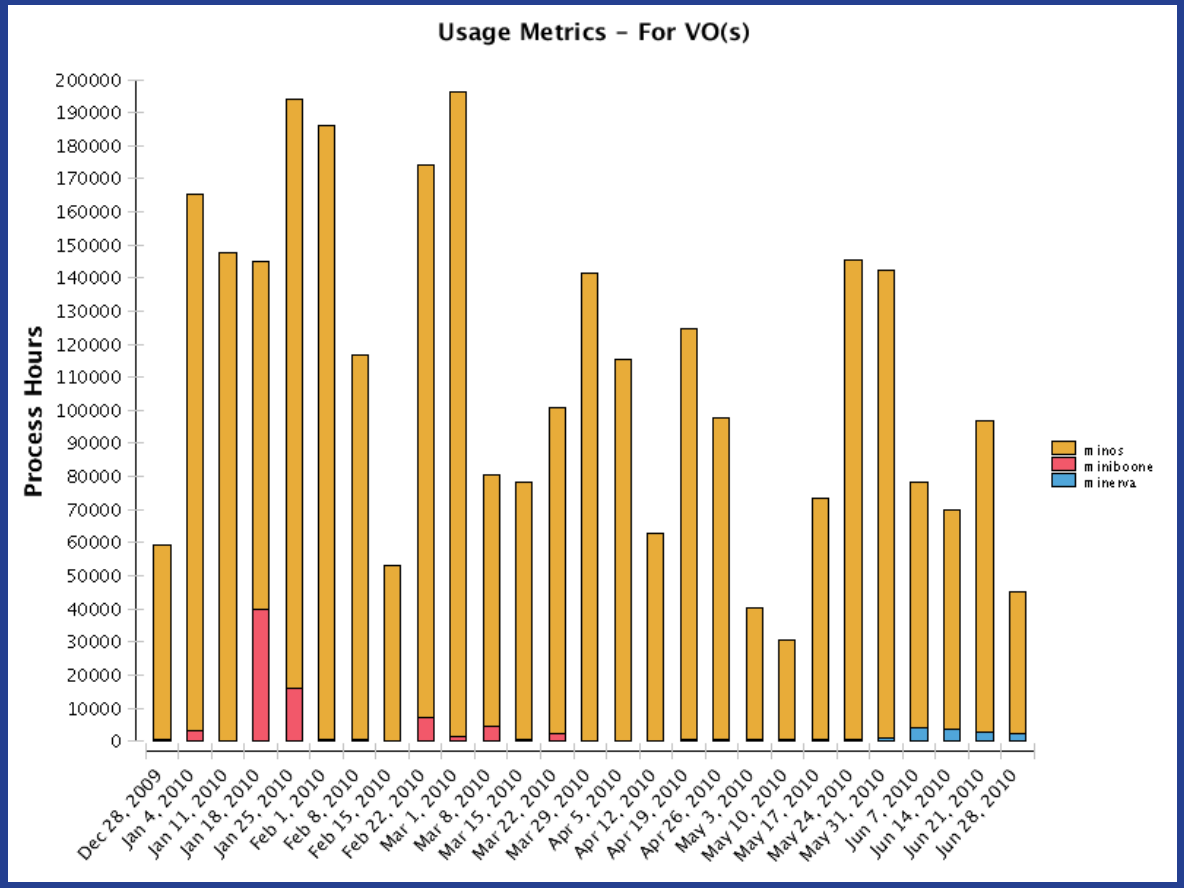
Intensity Frontier Budget Reductions

- Central Disk (request cut by 50%)
  - Reduction will infringe on ability to do efficient analysis work on multiple data streams simultaneously
  - Additional manpower needed to find less expensive storage options, and provide on-demand caching solutions.
  - Additional loads on tape facilities
  - Forces support for older beyond end-of-life hardware.
  - Example: MINERνA could only produce monte carlo for 1.5 times the data statistics
- GRID CPU (request cut by 75%)
  - Will have serious impact on ability to do physics processing and analysis, especially during peak periods.
  - Additional effort needed to enable additional opportunistic resources outside of Fermilab.
  - Forces support for older beyond end-of-life hardware.

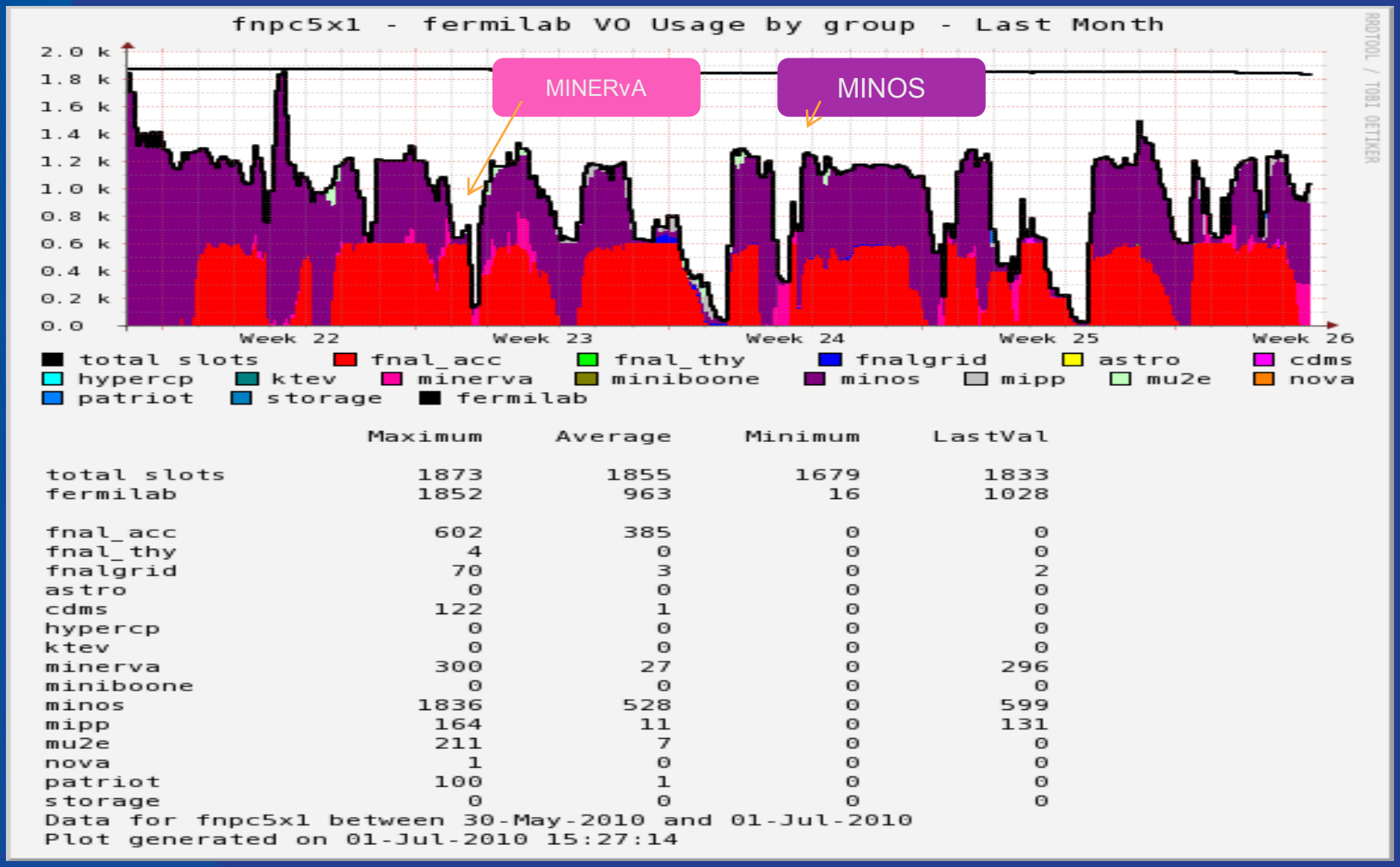
Intensity Frontier Budget Reductions

- Interactive CPU (request cut by 50%)
  - Significantly constrains users developing code and doing analysis.
  - Will force users to use desktops and other alternatives requiring additional support.
  - MINERνA can't run reconstruction code as fast as the data is coming in while rest of nodes are in normal use
- Miscellaneous (cut by 50% books, training, computing, etc.)
  - Reduces effectiveness of Fermilab CD contribution to experimental program.
  - Stymies ability of CD/REX I-Front team to respond to urgent needs.
- Possible Mitigation: buy ahead (CPU/DISK) in FY10 if funds are available at end of FY.

FermiGrid Usage by MINOS, MiniBooNE & MINERvA for last 6 Months



FermiGrid Usage for June 2010



	Maximum	Average	Minimum	LastVal
total slots	1873	1855	1679	1833
fermilab	1852	963	16	1028
fnal_acc	602	385	0	0
fnal_thy	4	0	0	0
fnalgrid	70	3	0	2
astro	0	0	0	0
cdms	122	1	0	0
hypercp	0	0	0	0
ktev	0	0	0	0
minerva	300	27	0	296
miniboone	0	0	0	0
minos	1836	528	0	599
mipp	164	11	0	131
mu2e	211	7	0	0
nova	1	0	0	0
patriot	100	1	0	0
storage	0	0	0	0

Data for fnpc5x1 between 30-May-2010 and 01-Jul-2010
Plot generated on 01-Jul-2010 15:27:14

Computing Resources Outside Fermilab

Experiment	Anticipated External Resources
MINOS	Wm & Mary, RAL, CalTech, Tufts, UTA. MC all done off site.
MiniBooNE	No Computing resources outside the lab are used (aside from remote operations terminals)
MINERνA	Until now experiment wiki resided at Rochester, moving to FNAL. Plan to do MC generation offsite as well

Experiment	GRID Resources External to Fermilab
MINOS	Wm & Mary, RAL, CalTech, Tufts, UTA. MC all done off site.
MINERνA	Hampton University. Wm & Mary, others likely

Conclusions

- Three successful operating neutrino experiments
  - All with detector uptimes >95%
  - Beamline performances have been record-breaking
  - All with current spares in place for upcoming 2 years
  - All providing unique measurements in neutrino sector
- Planning underway for addressing computing needs of intensity frontier in a more integrated fashion
  - More personnel from CD being directed to Intensity Frontier efforts
  - More consistent treatment can allow better optimization of limited resources

Future: General Purpose Computing Facility

- Goal
  - Build a general purpose interactive login cluster for Intensity Frontier
  - Include a local batch facility for developing, debugging, and running small jobs.
- Status
  - Phase 1 (now) in place as login clusters for each experiment.
  - Phase 2 (4QFY11) to be implemented with Virtual Machines (VM's) and separate local batch machines
  - 2011 (and beyond) continue to increase resources to meet the needs of the experiments.

	Phase 1 (cores)	Phase 2 (cores)	2011 (cores)
MINERvA	32	40	80
MiniBooNE	x	x	x
MINOS	40	40	40
NOvA	40	40	60