

Neutrino Operations

Sam Zeller
Fermilab Institutional Review
June 6-9, 2011

with help from:

A. Blake, D. Harris, J. Hylen,
A. Kreymer, L. Lueking, M. Marshak,
K. McFarland, R. Plunkett, C. Polly,
R. VandeWater, and J. Walding

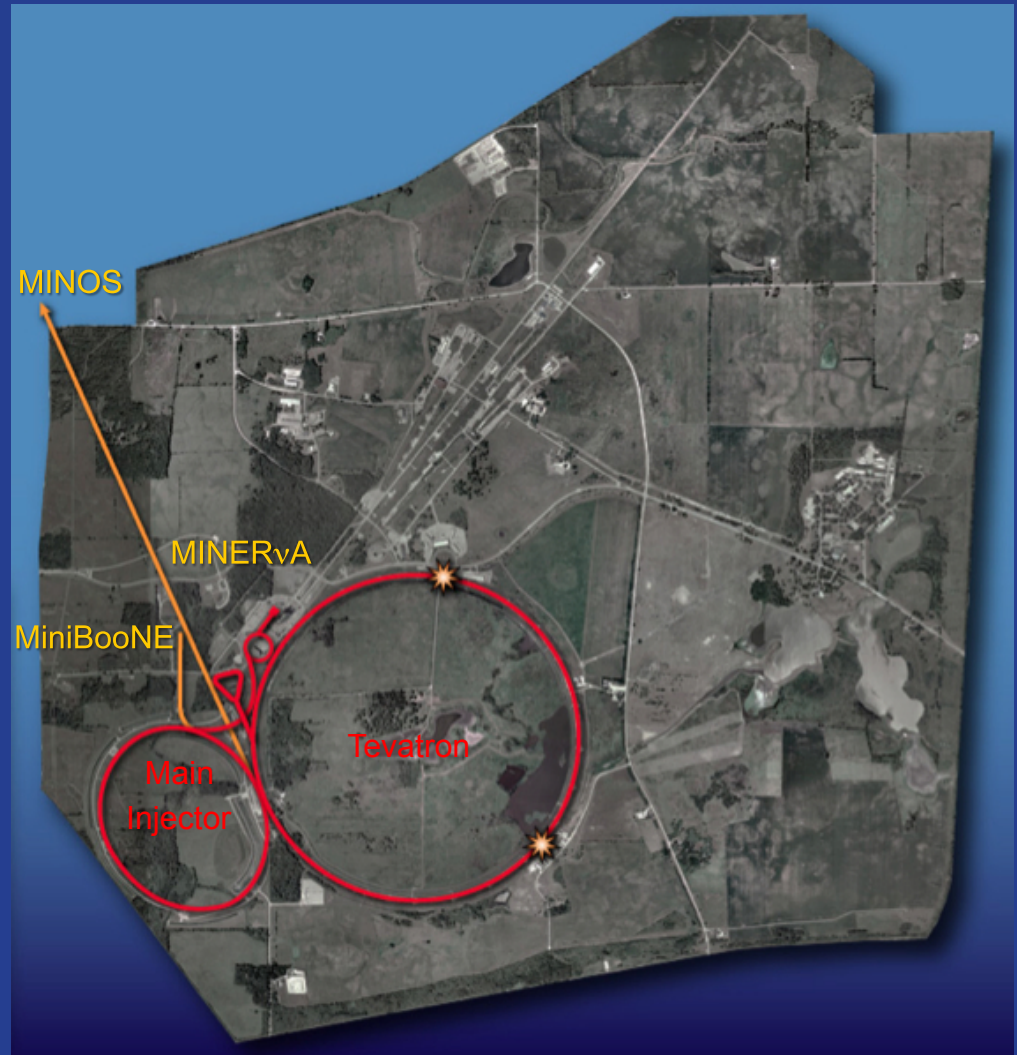


Outline

- introduction to current neutrino program
 - MiniBooNE
 - MINOS
 - MINER ν A
- brief overview of detectors and beams associated with these three operating neutrino experiments
- review the performance and operation of these detectors and beams over the past year
- projections for data collection up until the 2012 shutdown

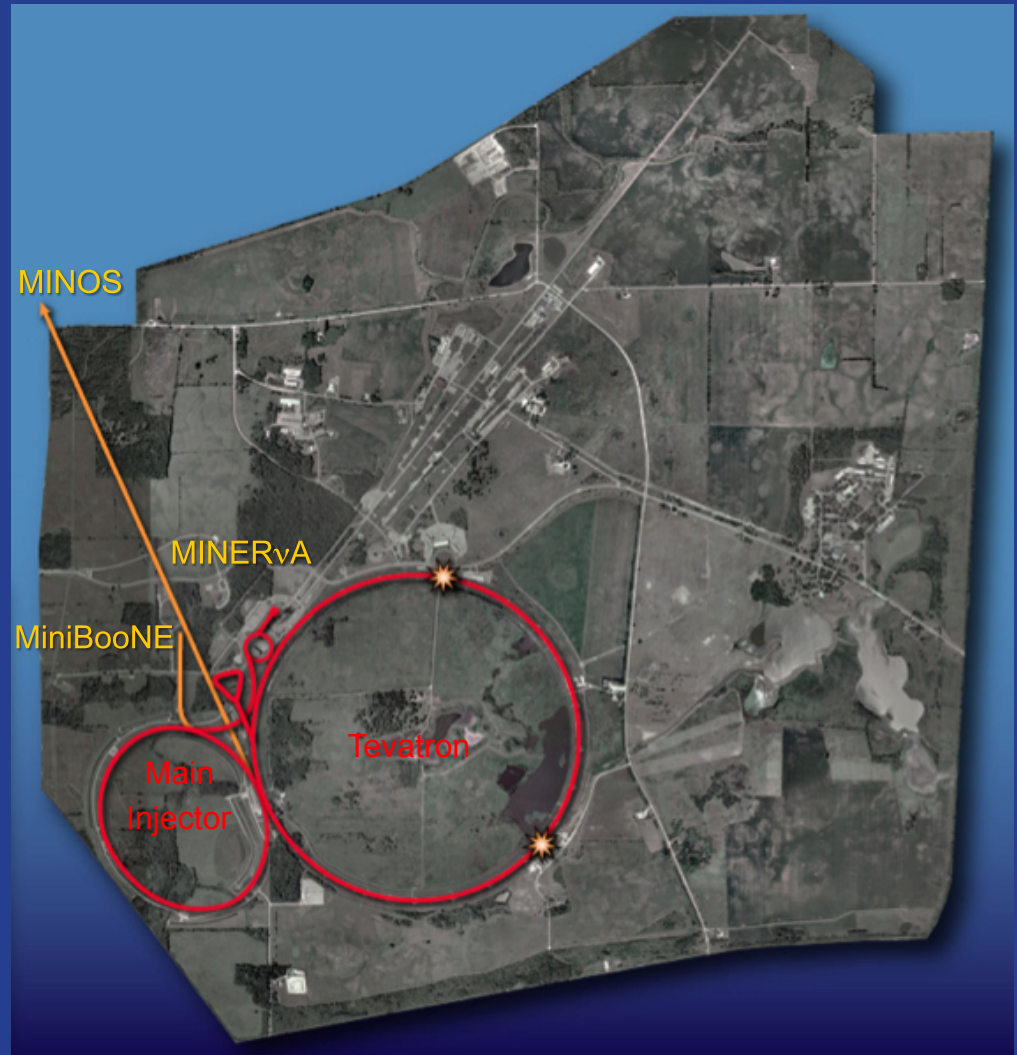
Current Neutrino Program

- FNAL has a very active ν program with 3 running experiments operating 4 detectors in 2 beamlines and at 2 sites
- Booster (8 GeV protons)
 - MiniBooNE
- NuMI (120 GeV protons)
 - MINOS
 - MINERvA



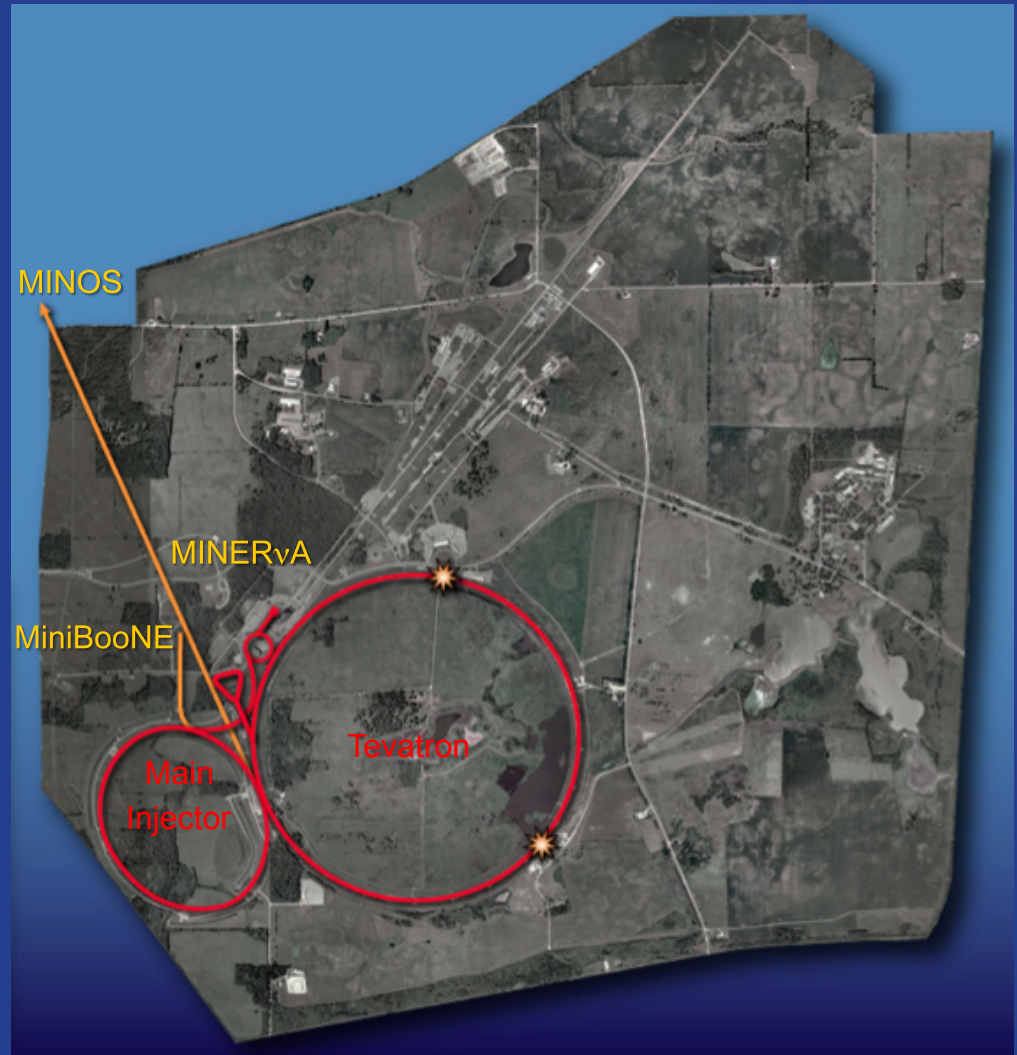
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 - MicroBooNE
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 - MINOS
 - MINERvA
 - ArgoNeuT
 - NOvA



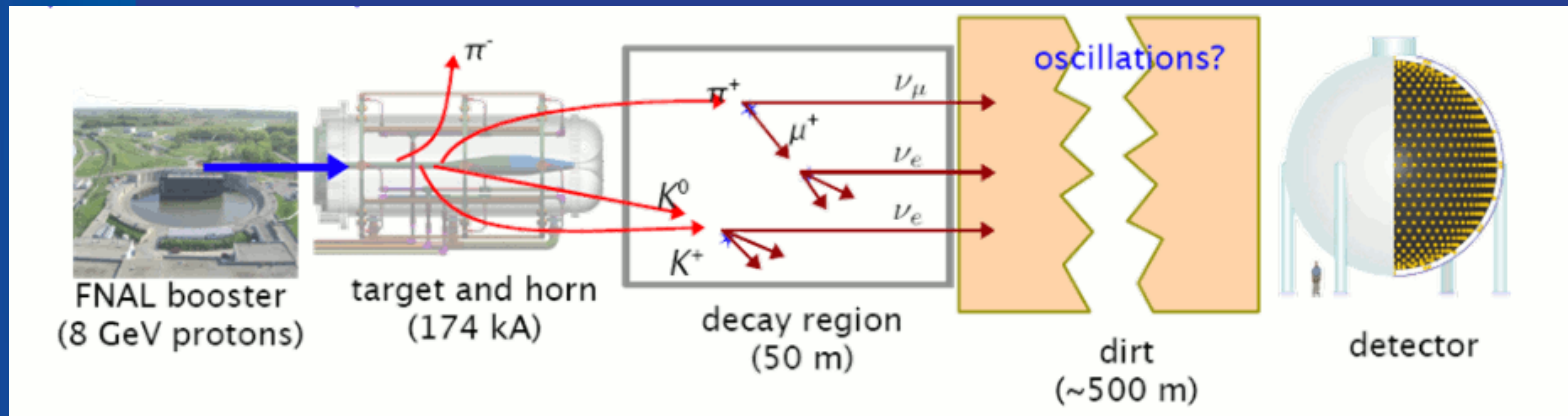
MiniBooNE

operating since Aug 2002

- single detector, short baseline ν experiment
- studies both ν oscillations and ν interactions

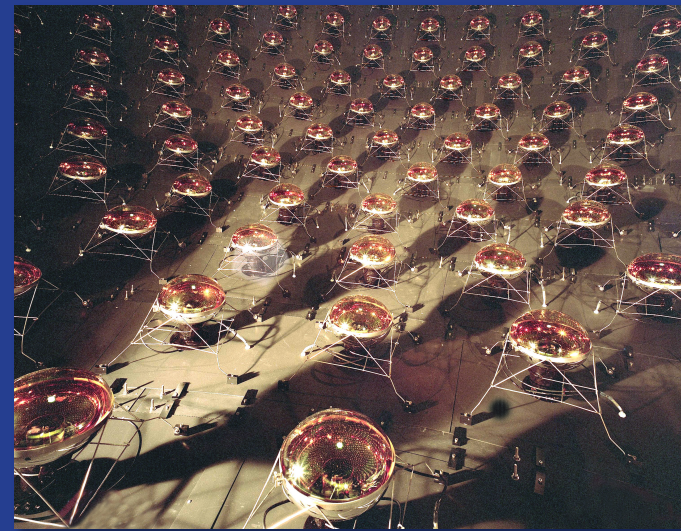


MiniBooNE Setup



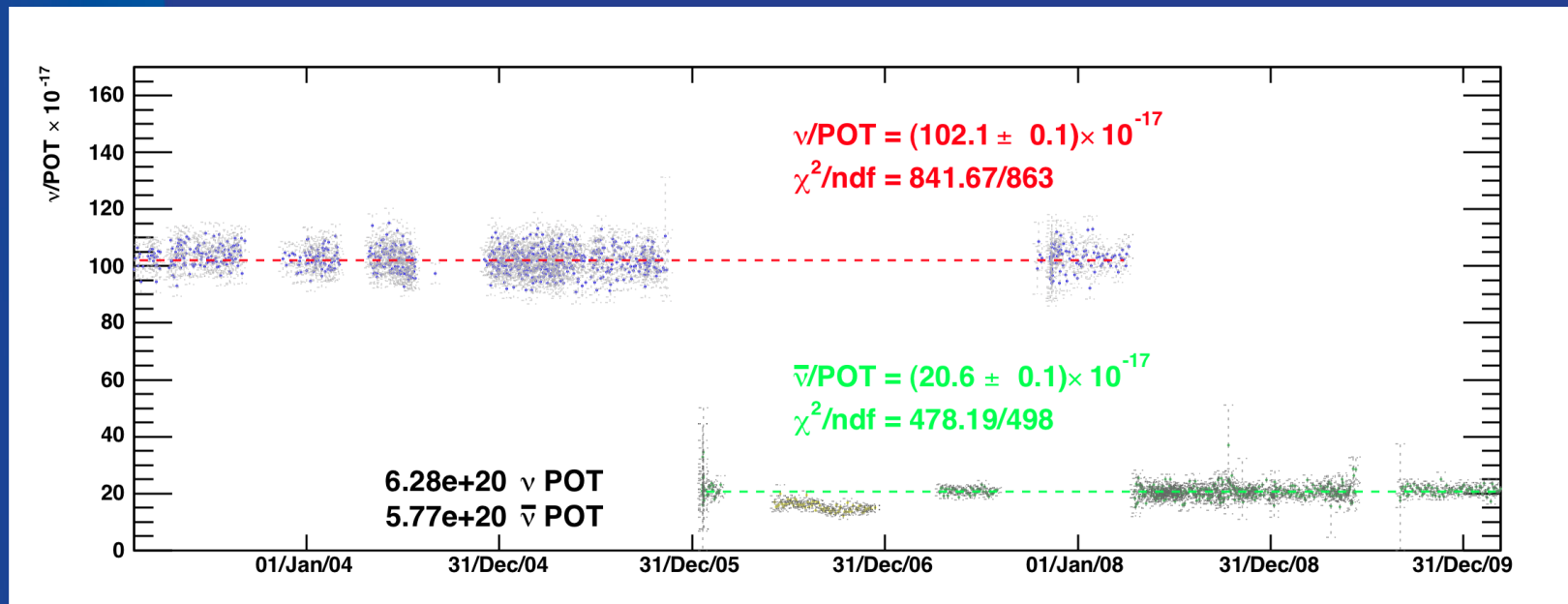
← 541m →

- 8 GeV protons, air-cooled Be target, single magnetic focusing horn, ν and anti- ν
- Cerenkov detector filled with 800 tons CH_2 , 1200+ PMTs



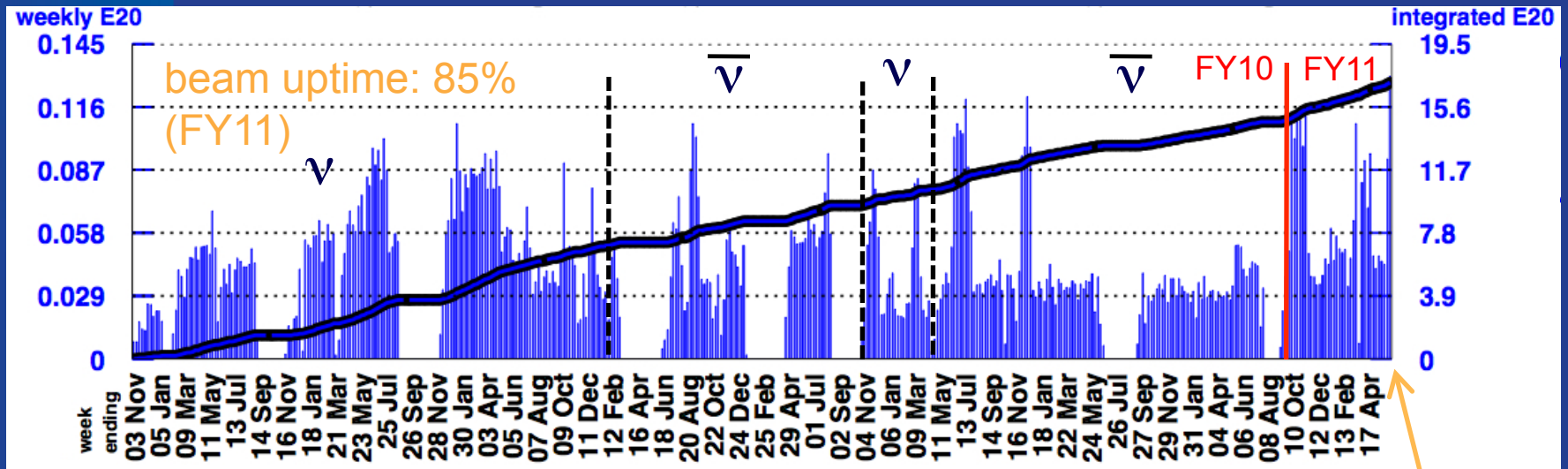
MiniBooNE Detector

- MB detector has been operating for almost 9 years now



- detector has been stable throughout run (stable to ~1%) and very reliable (>99% detector uptime)

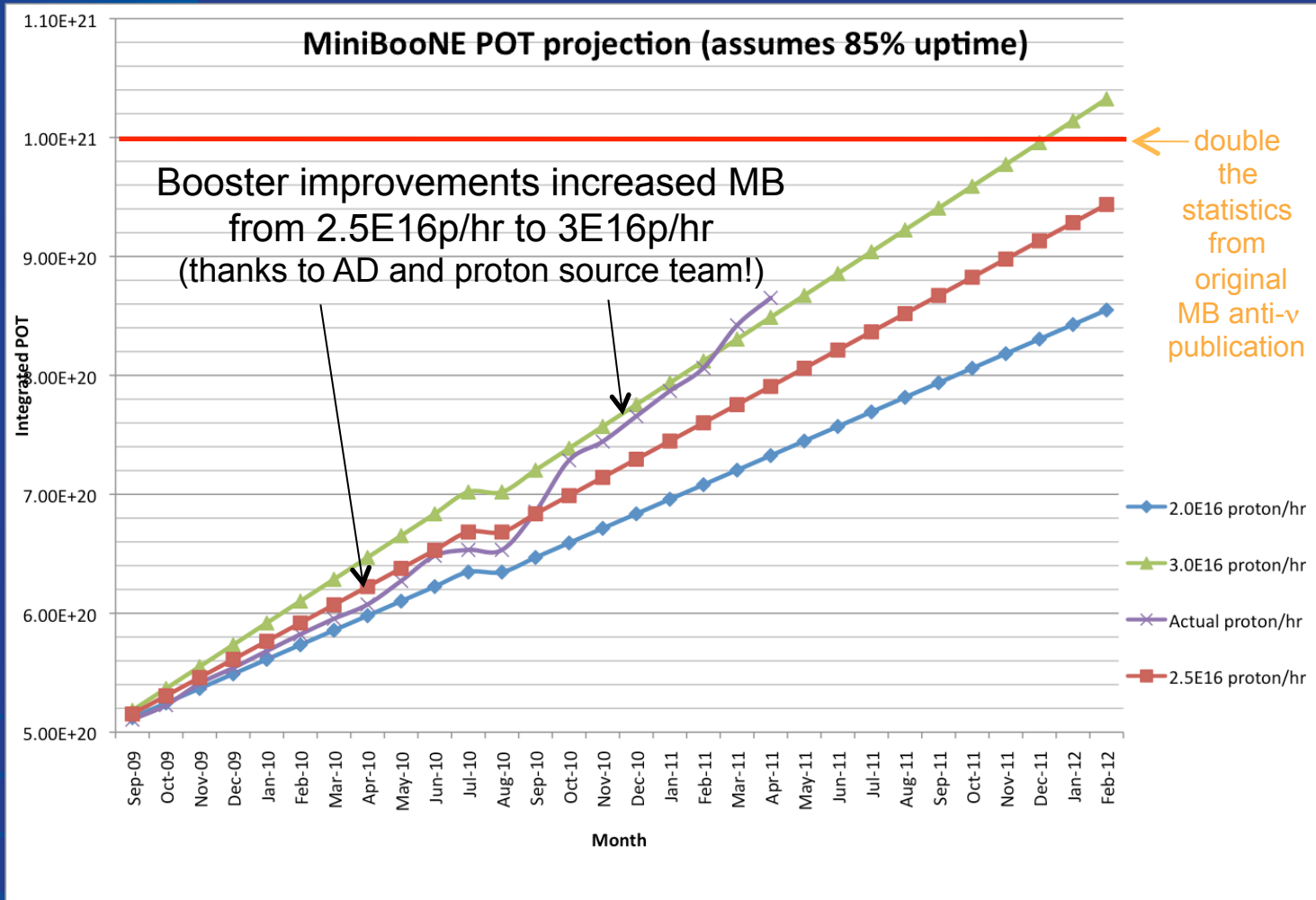
Proton Delivery to MiniBooNE



- total anti- ν data collected = 8.65×10^{20} POT
 - 5.66×10^{20} POT analyzed and published, plan to go public this summer with anti- ν data collected up to May 23, 2011
- MiniBooNE has benefitted from NuMI downtime and from Booster improvements ...

record week!
 0.13×10^{20} POT
 97% beam uptime

MiniBooNE Outlook

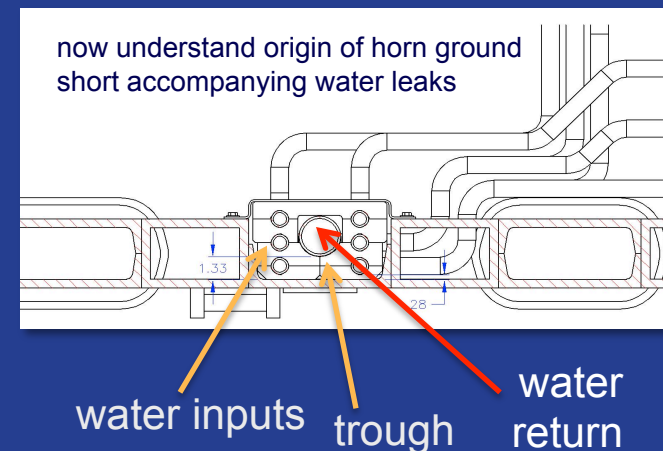


- plan is to continue running anti- ν 's until the 2012 shutdown

- current projection: MB on the path to collect $>1 \times 10^{21}$ POT by March 2012

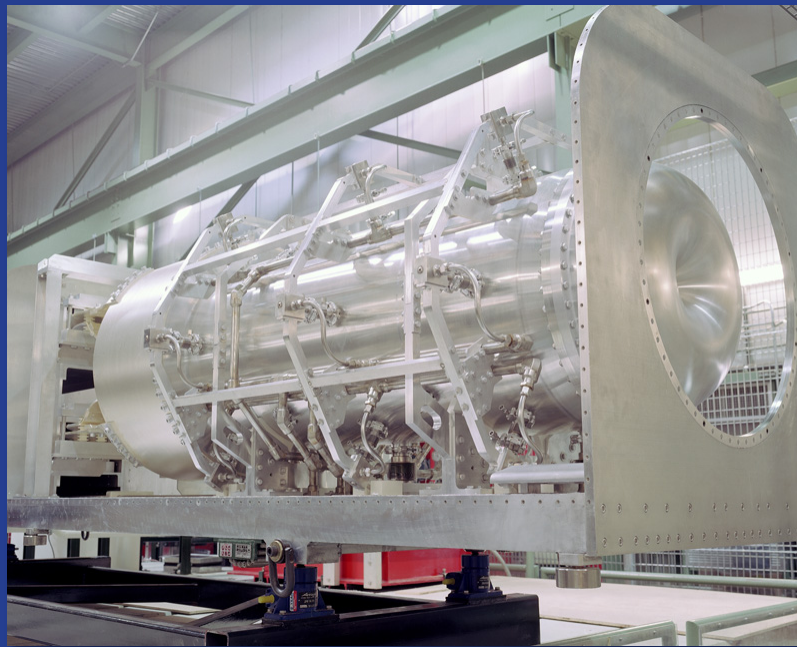
MiniBooNE Horn Recovery

- 1st horn died after 95M pulses (July 2004)
- problems with 2nd horn in Sept 2010 (water leak, ground short)
 - 2 problems – unsure how related looked alot like 1st horn failure
 - installed de-humidifier after 1st horn failure bought time to diagnose, keep running
 - closed 2 of 6 water lines to stop leak
 - investigation by FNAL/LANL team: determined that ground shorts related to water accumulating in drain pan shorting horn return line
 - with water leak stopped, short completely cleared up ... horn recovered!
- 2nd (current) horn and target have since run successfully; overall have accumulated >320M pulses (world record!)



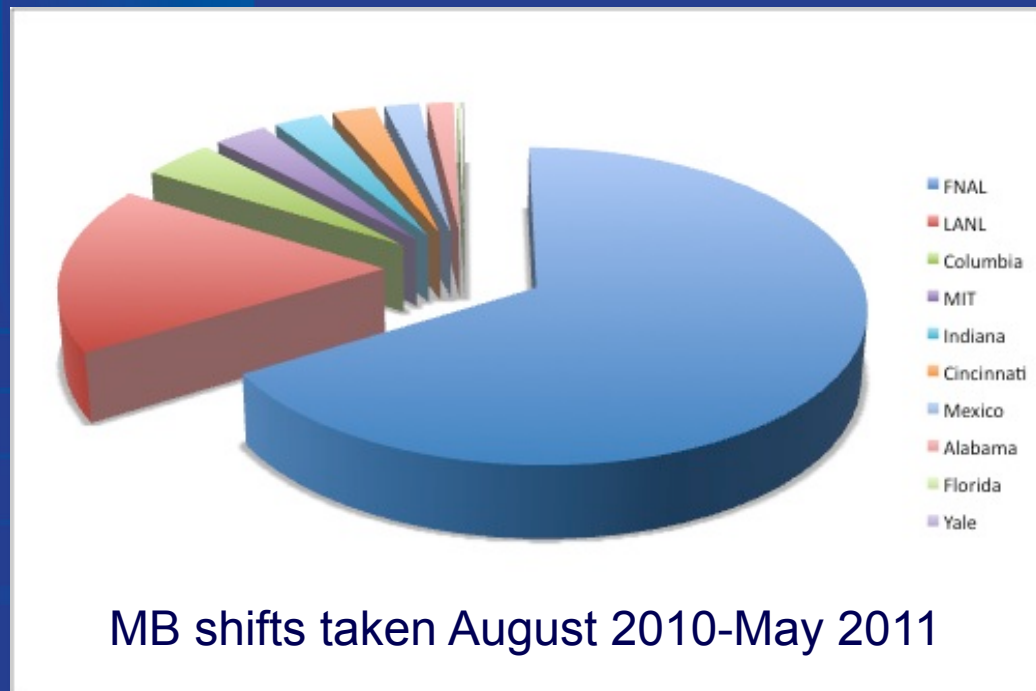
MiniBooNE Horn and Target Spares

- complete 3rd horn and target ready for installation
- also have a 4th target and some horn parts
 - *could build a 4th horn, but would require \$ investment*



MiniBooNE Remote Shifts

- remote shifts have been part of the key to continued running
- maintain beam and detector monitoring from remote control rooms at 9 different institutions



- in past year, ~40% of MB shifts were remote
 - *significantly reduced travel costs and time*
 - *continues to go well*
- MINERvA now also set-up for remote shifts (MINOS currently seeking approval)

MINOS

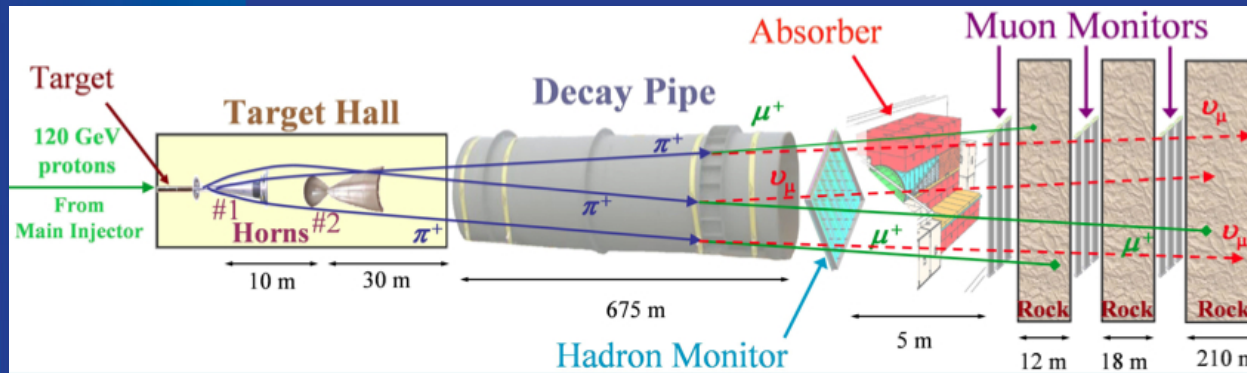
operating since Mar 2005

- two detector, long-baseline ν oscillation experiment
- also broad range of physics analyses beyond oscillations

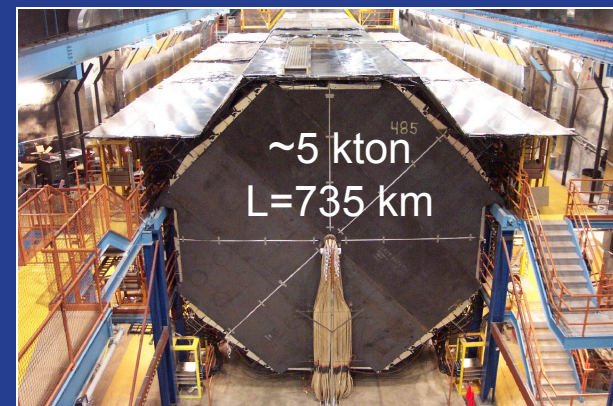
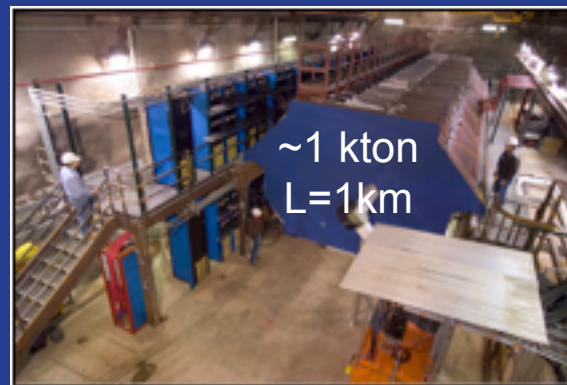


MINOS Setup

- 120 GeV protons, movable graphite target, two horn focusing system, ν and anti- ν

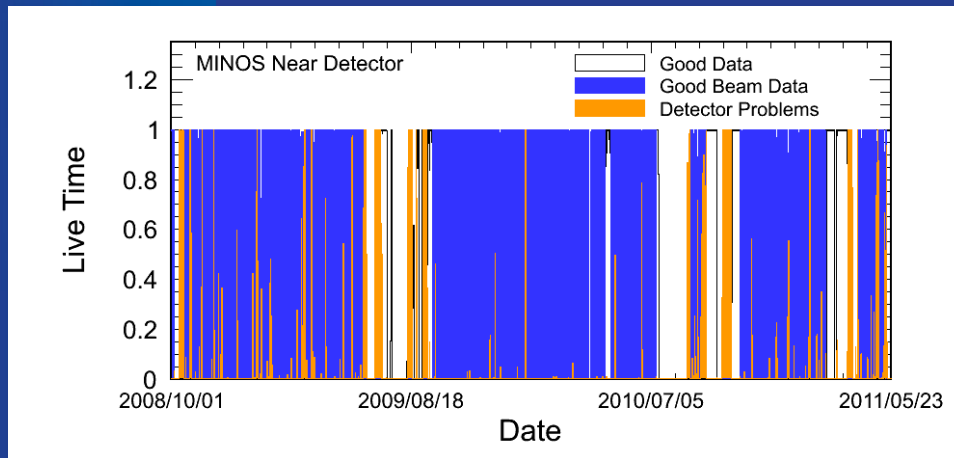


- two detectors to mitigate systematics
- magnetized steel/scintillator tracking calorimeters



MINOS Detector Performance

- both near and far detectors operate with minimal downtime

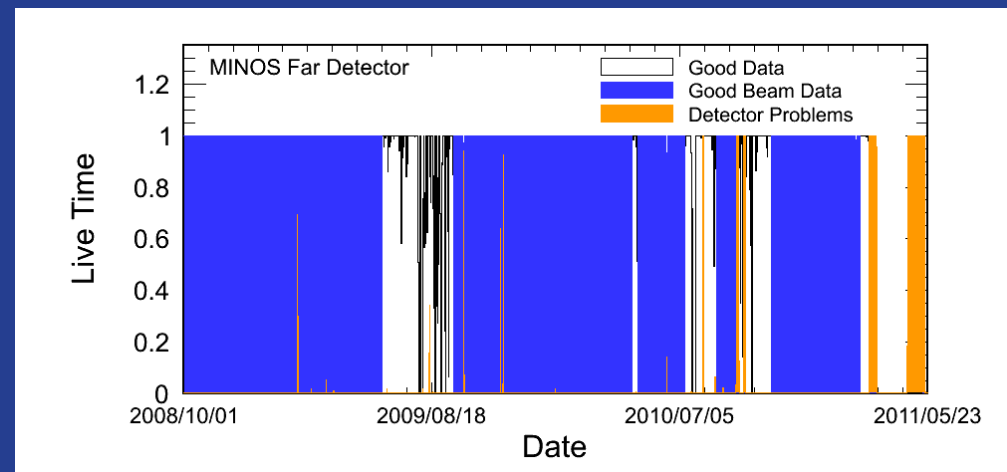


← **ND uptime: 93%**
*(beam-weighted, past year;
was 92% for past 3 years)*

FD uptime: 85% →

*(beam-weighted, past year;
was 94% for past 3 years)*

- recent downtime due to incident in Soudan mine



Incident in Soudan Mine

- fire started in Soudan mine shaft at 9pm March 17th, 2011
 - *caused by regular maintenance performed by DNR state park staff (owns Soudan mine)*
- DNR & lab staff reacted quickly
- Minnesota Interagency Fire Center (MIFC) installed an emergency response team which worked to extinguish the fire
- extraordinary team effort
 - *FNAL fire dept sent equipment, provided advice in dealing with fire*
 - *everyone working together has restored ability for special staff to enter mine*
- no one was in mine at the time; no injuries or detector damage



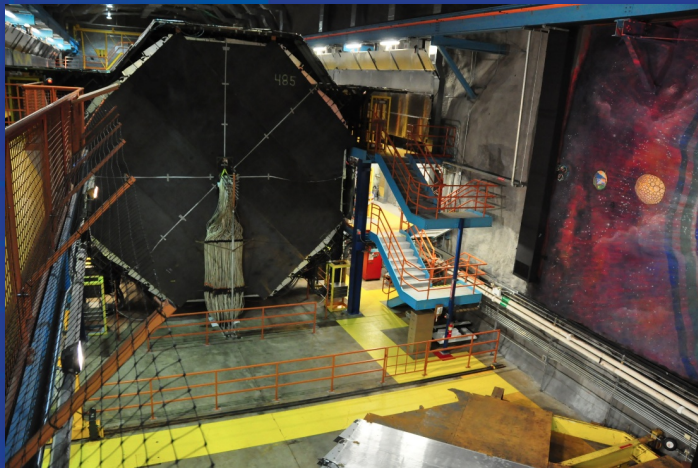
Duluth News Tribune

Clean-Up

- large amount of foam was pumped in from the top of mine
 - foam pushed open fire doors, swept in debris
 - also, lowest part of magnet coil partially immersed in water



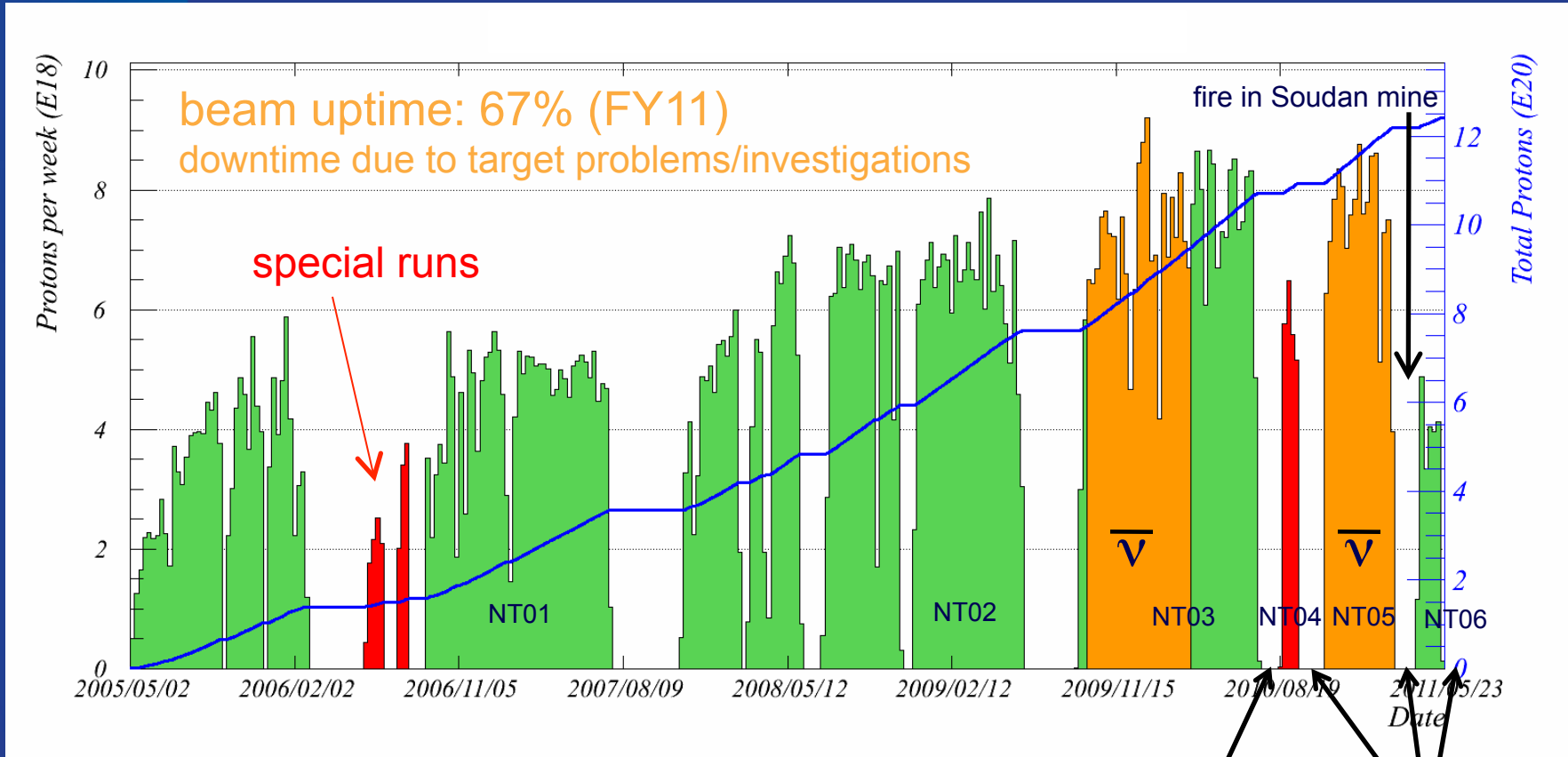
- lab occupancy has been re-established
ES&H participated in inspection of lab



- clean-up of laboratory is complete
- electronics powered-up normally
- magnet coil slowly ramped up to dry it out (FNAL provided advice)
- shaft repairs are underway

May 19: MINOS FD fully operational and running at full field, ready for beam

MINOS Proton Delivery



- total anti- ν data: 3.2×10^{20} POT
(out of 4.2×10^{20} POT request)

- plan to release this summer (~x2 more data)

summer
shutdown

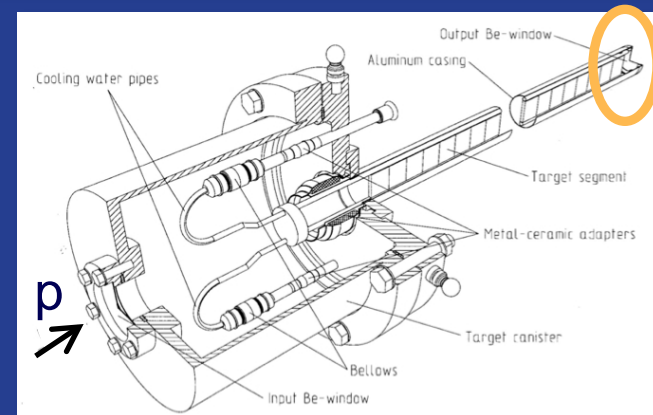
downtime
due to
target problems

Recent NuMI Target History

- after 6 years of good performance with NuMI LE targets, the last ½ year has been a challenge; decent longevity with 3 targets, then 3 quick failures

target design	maximum beam power	integrated POT	lifetime (design=12months)	target failure mode
NT01	270 kW	1.6×10^{20} POT	16 months	frozen drive shaft
NT02	340 kW	6.1×10^{20} POT	33 months	graphite core deteriorated
NT03	375 kW	3.1×10^{20} POT	10 months	water leak
NT04	375 kW	0.2×10^{20} POT	<1 month	water leak
NT05	337 kW	1.3×10^{20} POT	4 months	water leak, weak laser weld
NT06	305 kW	0.2×10^{20} POT	6 weeks	water leak

- downstream water turn-around modified for NT06 after NT05 autopsy

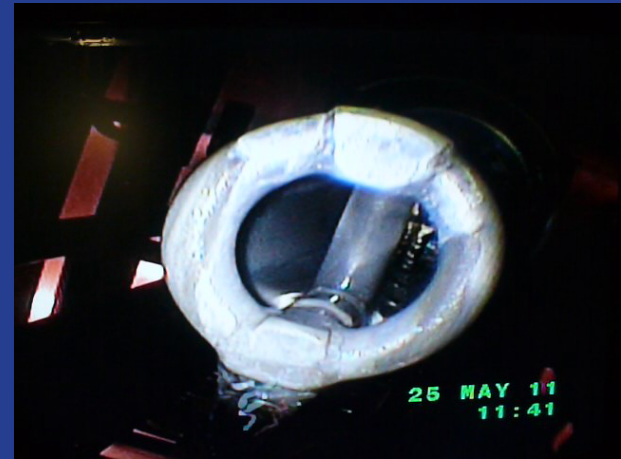


Investigations

- series of tests conducted on both horn & targets (radioactive environment, so diagnostics are challenging)

- horn
- scan of relative horn/target position ✓ok
 - in-situ magnetic field test & field modeling ✓
 - horn on/off running ✓ok
 - boroscope

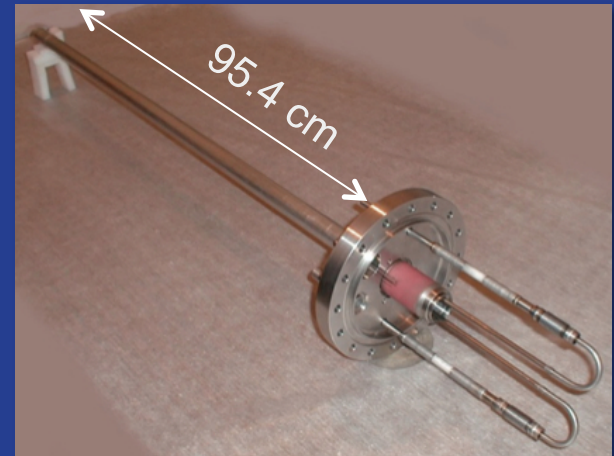
- target
- visual autopsy of NT06 ✓*
 - autopsy of NT04



- * NT06 autopsy revealed water leak in upstream end of target; no problem with downstream turn-around

NuMI Plans & Spares

- currently, no new targets
 - *2 new targets in construction (NT07,08 from IHEP)*
- collaborating with RAL on target failure analysis and potential add'l resources
- this week: plan is to resume operations with refurbished NT01
 - *NT01 ready to install, will likely run at low intensity*
- NT07 should be done early/mid August (IHEP)
 - *2 week shutdown to install*
 - *nominally 1 year of operation with this style target*



MINER ν A

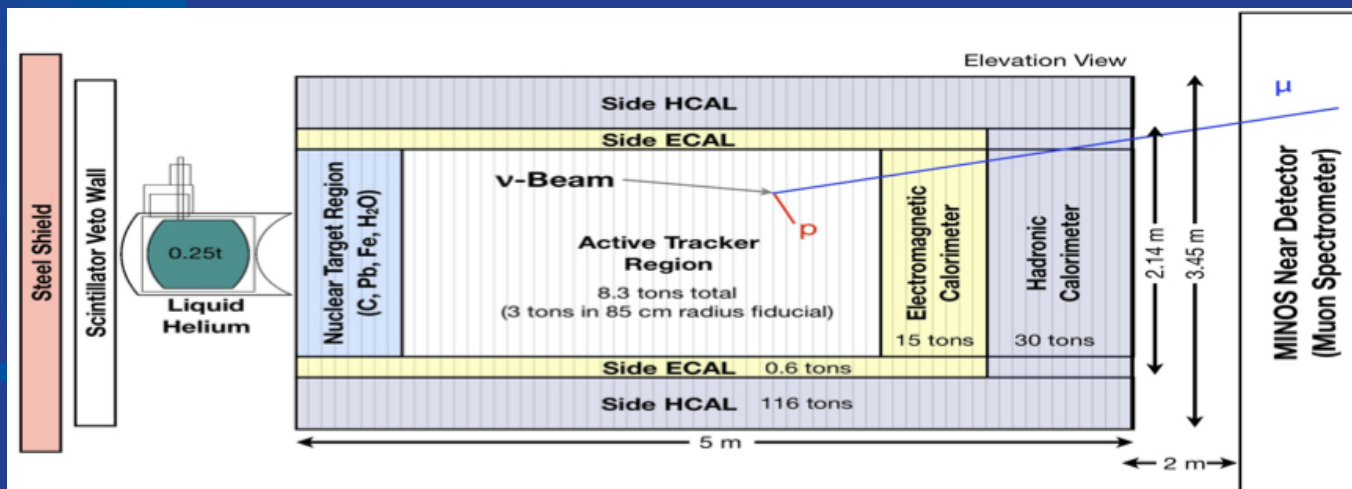
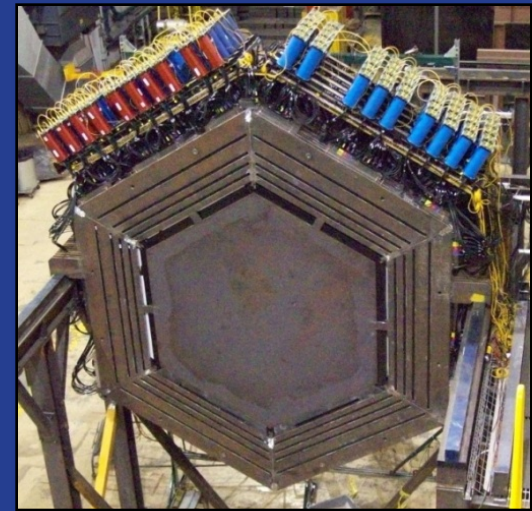
operating since Mar 2010

- is a relative newcomer
- precision ν cross section measurements on a variety of nuclear targets over a broad energy range



MINER ν A Setup

- NuMI beam (same as MINOS)
- shares NuMI near detector hall, L=1 km
- fully active, finely segmented scintillator tracker surrounded by calorimeters + additional targets upstream of active region



← MINOS ND acts as a muon spectrometer

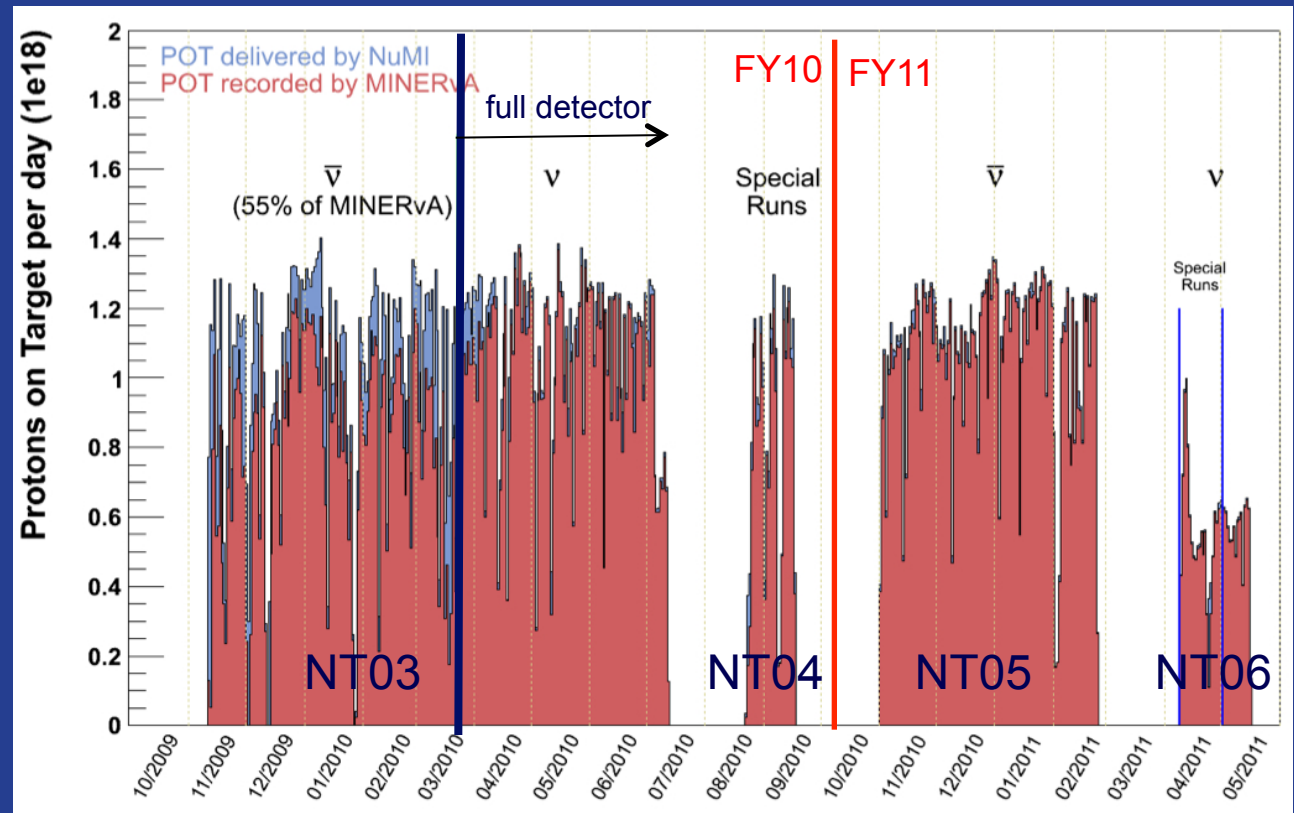
MINER ν A Highlights Over Past Year

- tremendous progress over past year – completed full detector installation (March 2010) and is successfully taking data
- 03/11: MINER ν A project received 2011 DOE Secretary's Award of Achievement
- 03/11: 1st preliminary physics results presented at NuInt11 (J. Raaf's talk)
- 04/11: cryogenic target installed to run with He in LE beam
(currently undergoing safety review, estimate 1st data with filled target in July)



MINERvA Proton Delivery

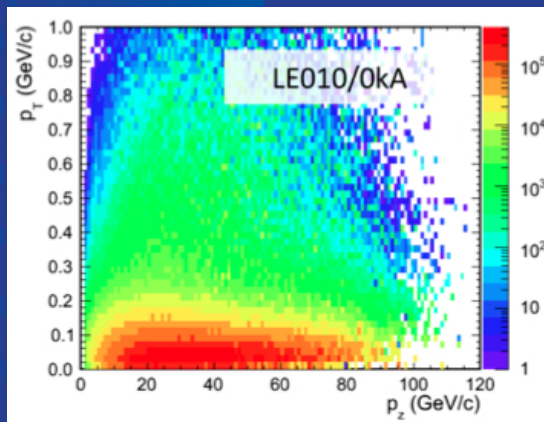
- quickly rose to high detector live-time after a few weeks of running with full detector
- running >97% since May 2010 (96% live since start)



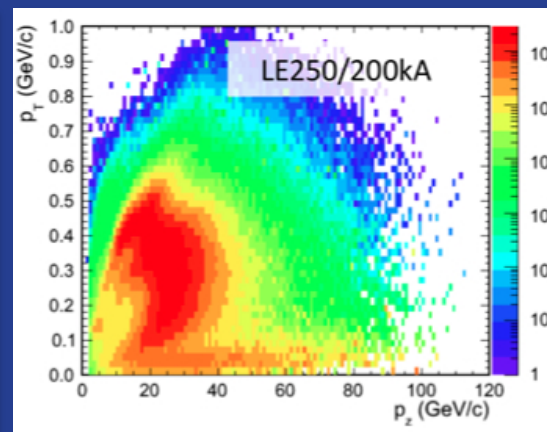
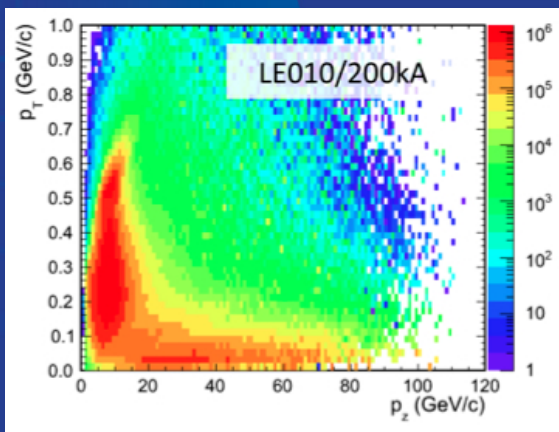
- collected total of:
 - 1.53×10^{20} POT ν (out of $4 + 0.9 \times 10^{20}$ request)
 - 1.30×10^{20} POT anti- ν

Special Target Runs

- one of key features of the beamline is ability to change target position and horn current



- with suitable choice, can vary in fine detail the T and L momentum of particles emanating from the target



- allows you to map out the kinematic dist of parent particles
- important for understanding the incoming ν flux & reducing flux uncertainties

Status of MINER ν A Special Target Runs

- MINER ν A plans a series of six LE ν mode special runs:

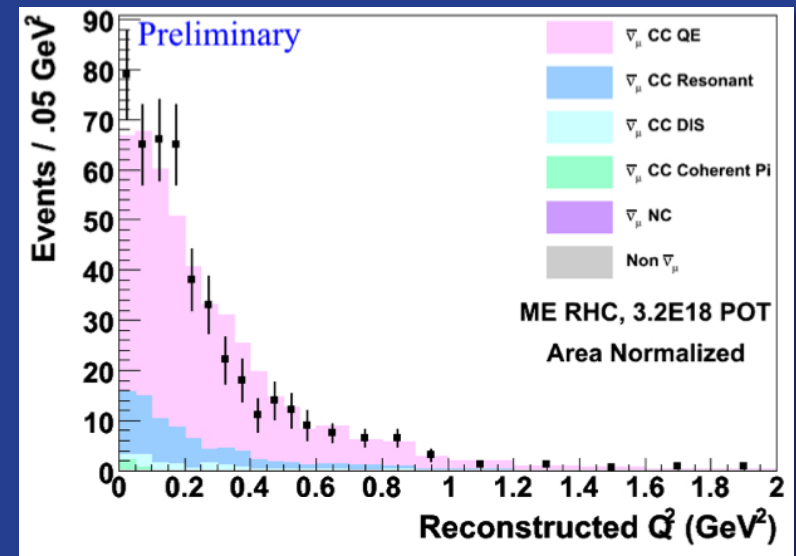
Target Position	Horn Current	POT Requested	POT on Tape
LE10cm	150kA	0.15e20	-
LE10cm	200kA	0.15e20	-
LE10cm	0kA	0.15e20	0.07
LE100cm	200kA	0.15e20	-
LE150cm(ME)	200kA	0.15e20	0.07
LE250cm(HE)	200kA	0.15e20	0.07

0.2x10²⁰ POT
(out of 0.9x10²⁰ initial request)

- also data in one anti- ν special run:

Target Position	Horn Current	POT Requested	POT on Tape
LE150cm(ME)	-200kA	0.15	0.07

- started in August 2010
- unable to complete due to NuMI target failures
- plan is to come back to these (cannot do in NO ν A-era)

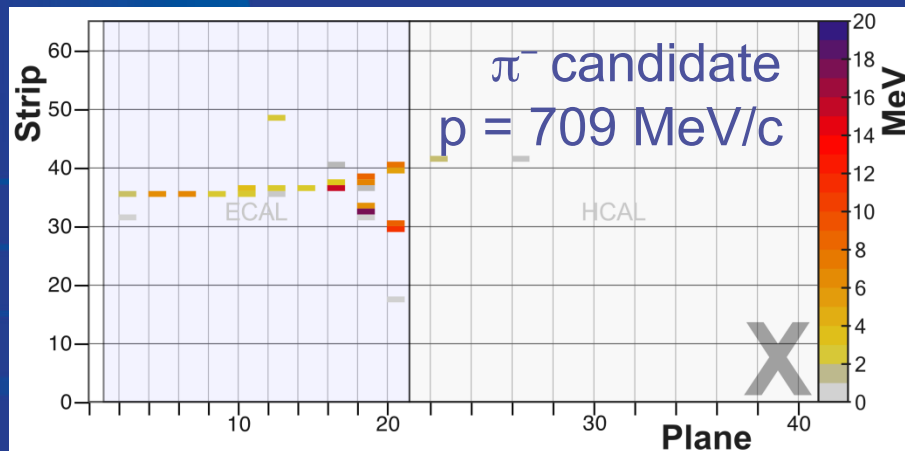
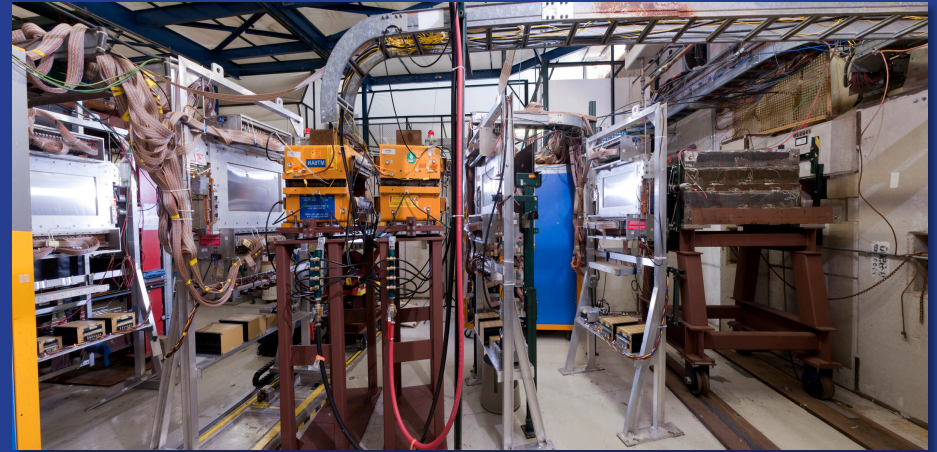


MINER ν A Testbeam Activities

- June-July 2010, exposed a replica of MINER ν A detector to a dedicated, LE tertiary pion beam at FTBF

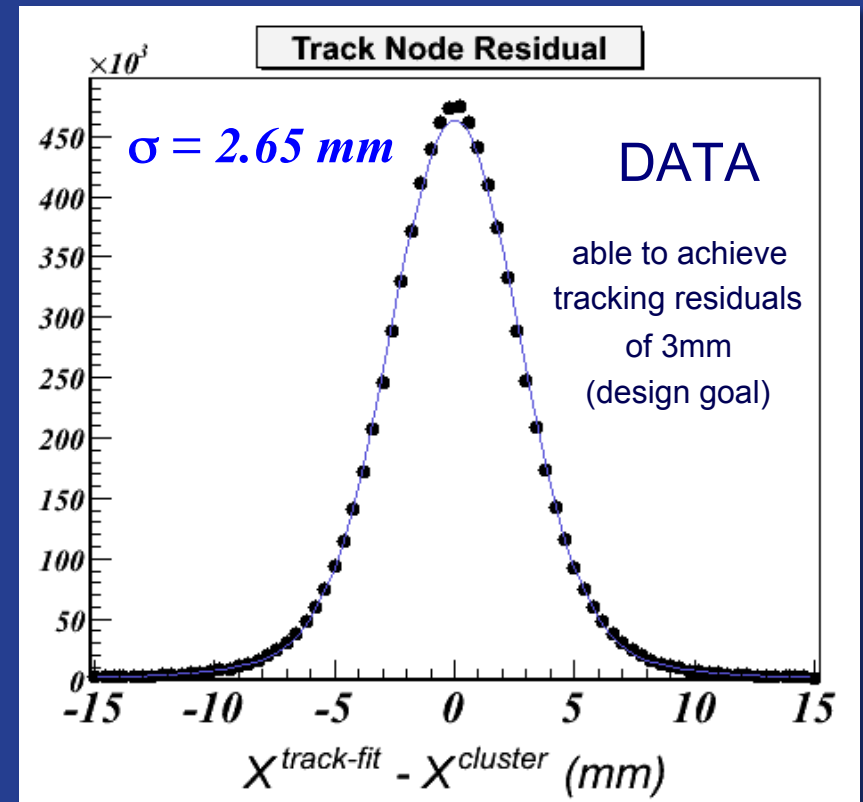
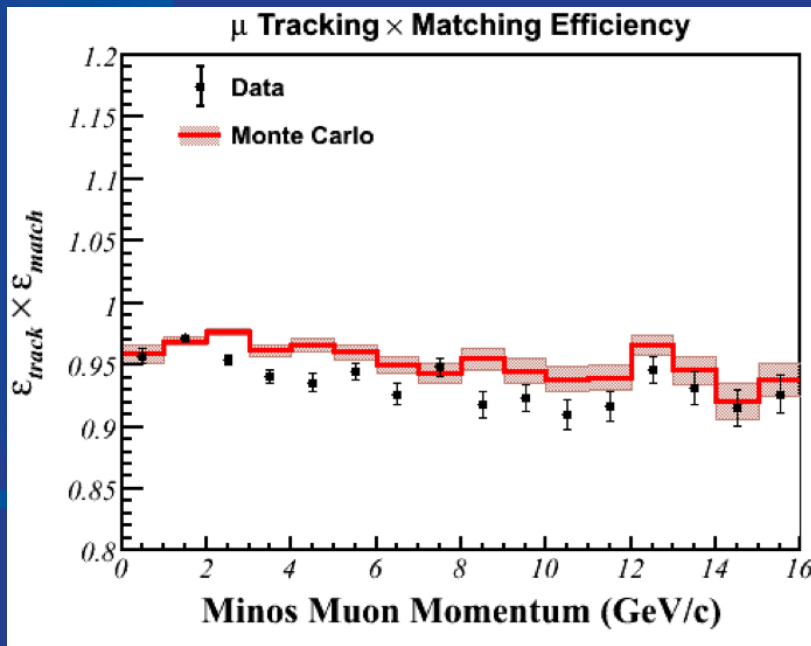
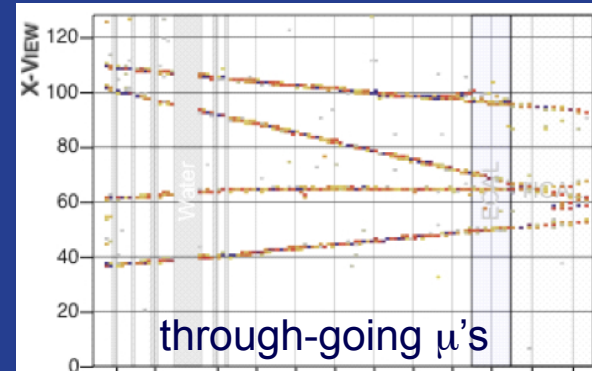
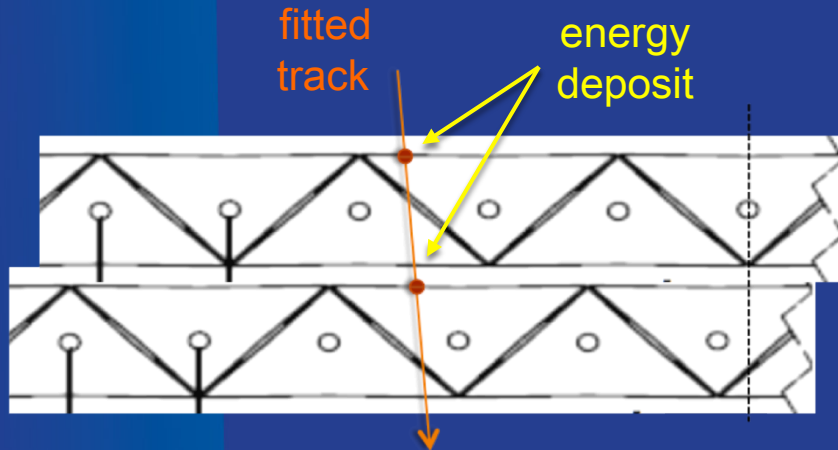
- 400-1200 MeV π 's

(beamline is now a permanent part of FTBF!)



- important to calibrate the absolute energy response of MINER ν A detector (measure E scale to $\sim 2\%$)
- analysis is going well

Reconstruction Status



important steps on the path to physics!

Making Plans for the Future

- MINER ν A depends on MINOS ND for μ reconstruction
- after March 2012 shutdown, MINER ν A personnel will be needed to operate MINOS ND; *already getting a head start!*
- Oct 2010: a task force was appointed to plan for this transition
- MINER ν A collaborators now full partners in monitoring MINOS ND and replacing electronics
 - FNAL has provided a new person to support this transition ($\frac{1}{2}$ FTE)
 - MINER ν A has also provided new collaborators to work on this (post-docs/scientists from Rochester, W&M)



NuMI Outlook

- as of today:

- *MINOS has collected 3.2×10^{20} POT anti- ν*
- *MINER ν A has collected 1.5×10^{20} POT ν*

- run times requested in LE mode:

- *MINOS: 4.2×10^{20} POT anti- $\nu = (1.7 + \text{additional } 2.5) \times 10^{20}$*
- *MINER ν A: 4.9×10^{20} POT $\nu = (4.0 \text{ LE} + 0.9 \text{ special runs}) \times 10^{20}$*

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The Committee recommends sharing the short-fall of POT such that MINOS receives ~90% of the total requested POT for antineutrino running and MINER ν A receives ~90% of the total requested POT for neutrino running - assuming the current operation capabilities of the NuMI beamline.

(PAC, June 2010)

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- *MINER ν A has 31% of full request*

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- current projection for remaining protons for NuMI between now and March 2012 shutdown: **2.2×10^{20} POT**

- in this optimistic model and if remainder of run is ν mode, then both experiments would get to **~3/4 of their requests**

- *Directorate is considering strategies for extra running*

Computing in Past Year



MINER_vA

- data-taking, data-processing & storage

MINOS

- optimization, maintenance, and operation of existing computing tools

MiniBooNE

- economical computing solutions to combat aging infrastructure

- in assuring that data-taking and operations continue smoothly, have had to respond to differing needs and computing models
- going forward, FNAL strategy for targeting common solutions for IF experiments (even before they start operations) will be beneficial

Conclusions

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 - *MINOS has world's largest sample of long-baseline anti- ν 's*
 - *MINER ν A's goal is to collect more LE ν data; important to do before NO ν A turns on!*
- both legs of the FNAL neutrino program preparing new physics results to be released this summer!