Experiment Readiness Review For MINERvA

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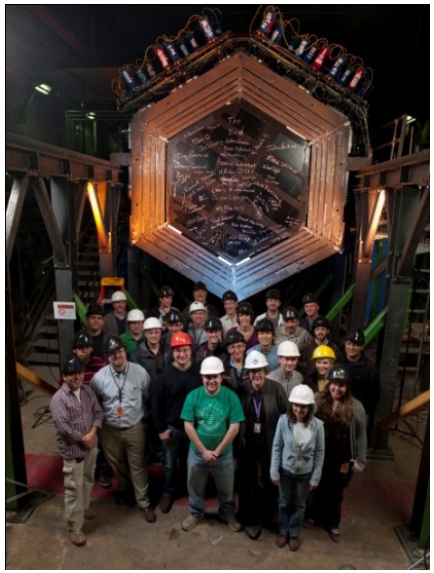
Physics Overview

- MINERvA is studying neutrino interactions in unprecedented detail on a variety of different nuclei – He, C, CH_2, H_20,Fe,Pb
- Low Energy (LE) Beam Goals:
  - Study both signal and background reactions relevant to oscillation experiments (current and future)
  - Measure nuclear effects on exclusive final states
    - As function of a measured neutrino energy
    - Study differences between neutrinos and anti-neutrinos
  - Measure exclusive channel cross sections and dynamics
- Medium Energy (ME) Beam (NOvA) Goals:
  - Structure Functions on various nuclei
  - Study high energy feed-down backgrounds to oscillation experiments



Scientific Goals for FY13

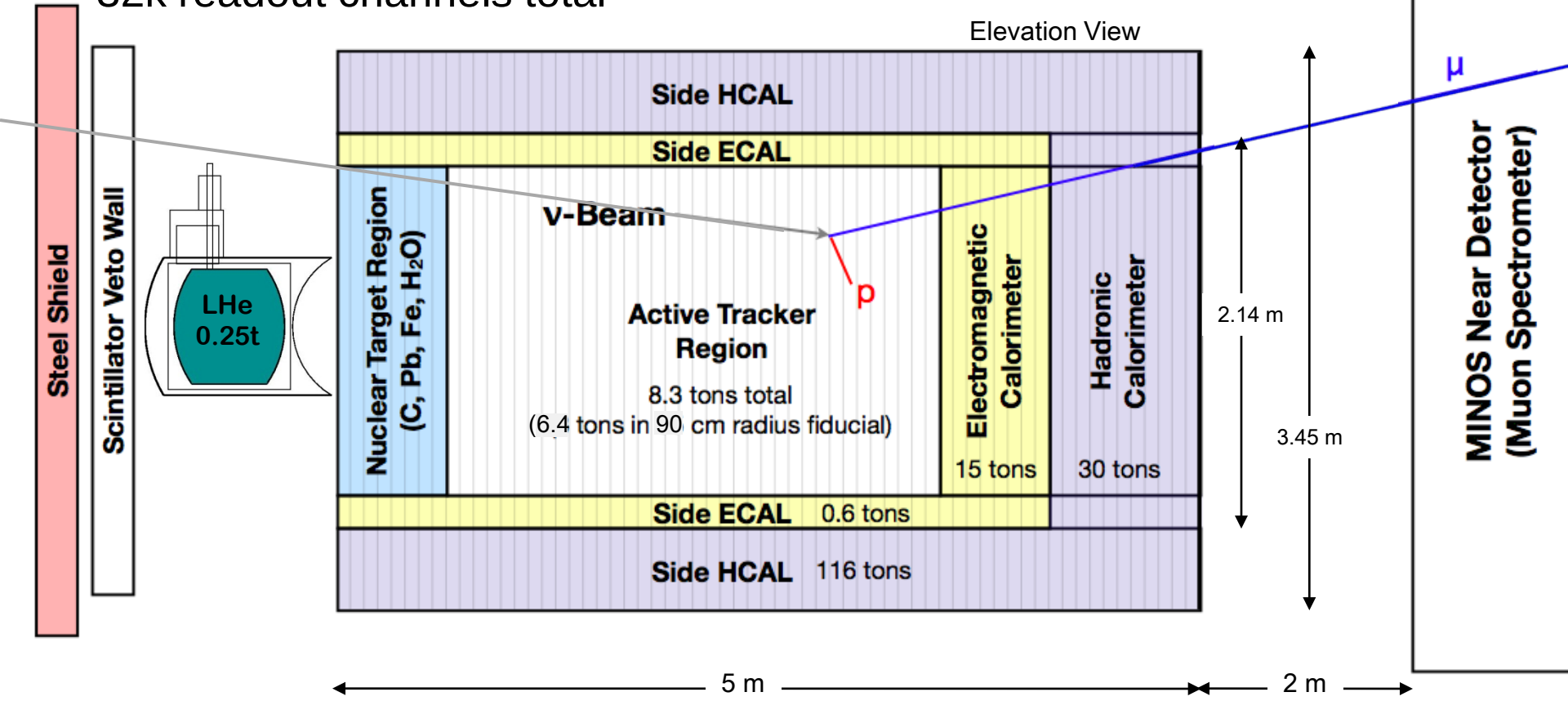
- Publish first results on the Low Energy Data set
- Get ready for beam
  - New Chain Read Out Controller (CROC) for faster cycle time
  - Cryogenic Detector
  - Rest of the detector similar to LE run
- Take ME data with high livetimes
  - Look at the data at a high level as we are taking it
- Over-arching Issue:
  - We are a small experiment with a VERY small number of RA's, and a VERY small Fermilab group (4 people, <4FTE's)

Outline

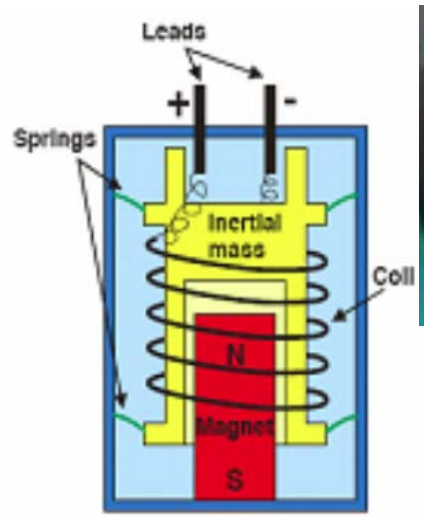
- Things we need to start taking data
  - MINERvA Detector
  - MINERvA DAQ Upgrade
  - Water Target
  - Helium Target
  - Muon Monitors for Alcove 4 (need to be installed)
  - MINERvA Roof Repair
- Things we need to keep live time high during ME run
  - Replace old control room and DAQ computers
  - Training new Detector Experts including Run Control Expert
  - Testing and Repairing PMT Boxes
  - Testbeam
- Things we need to publish Physics expeditiously
  - Prioritized list from Computing Infrastructure Review
  - Scientific Personnel

MINERvA Detector

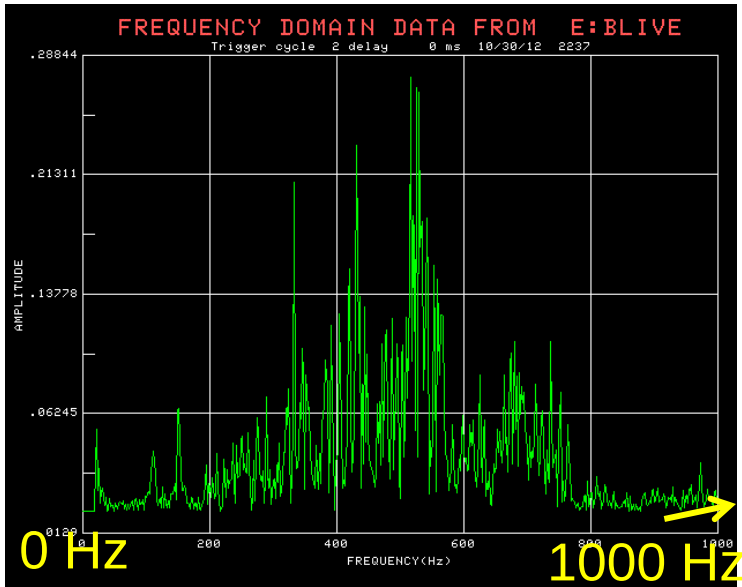
- Detector comprised of 120 “modules” stacked along the beam direction
- Central region is finely segmented scintillator tracker
- ~32k readout channels total



NOvA Excavation



GS-11D Geophone



- Hamamatsu gave some indication that vibrations 500-1500 Hz at about 1 g could damage the PMTs if they were on HV.
- During NOvA NDH Construction Impact Review on 11/7/11, we were told to expect vibrations 10-50 Hz with velocity ~ 0.07 mm/sec at our detector
- We put geophones on the MINERvA PMT to measure the vibrations
  - Thanks to Todd Johnson (AD) & Linda Bagby (PPD EE Dept)
- Measured
  - max velocity=0.33 mm/sec
  - FFT done by MCR gives 400–500 Hz,
  - At 500 Hz this is about 1g
- Vibration levels that could damage PMTs

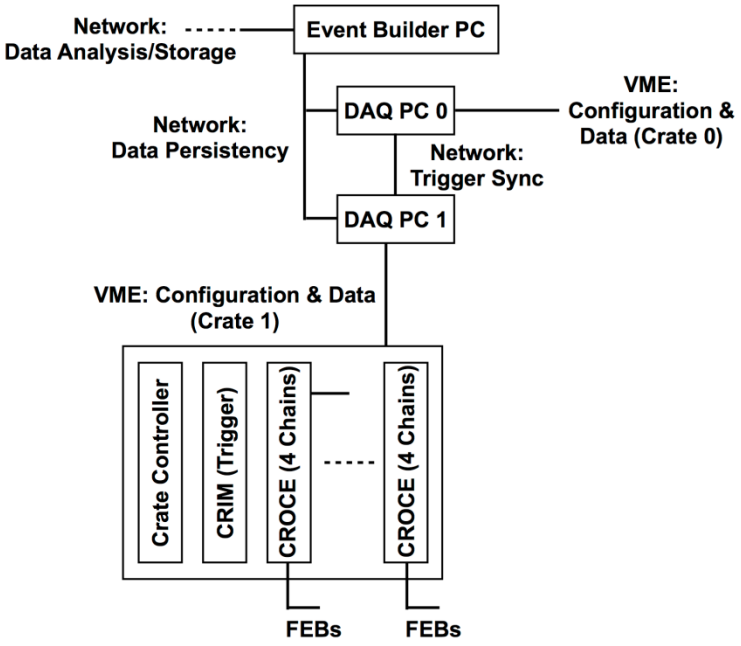
MINERvA Excavation Shifts

- HV was left off during the excavation
- Ran shifts starting 5:30PM weekdays for about 1½ hours
  - Ran PEDs and light Injection to determine if there has been any change in the detector.
    - All PMTs operating
    - There appears to be no change in the detector or PMT gains
    - No detector problem created by the excavation
  - Shifter posts plots of vibration sensors
- We are still leaving HV off except for shifts
- Recently, started running DAQ over longer periods
  - We have the CROC board throwing a hardware error after several hours of running, causes the run to stop.
    - Almost certainly due to a FEB board (front end board on PMT box)
  - Software reset of VME crate fixes it
- Live time integrated over entire LE run >97%

CROC-E Upgrade

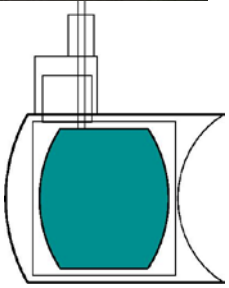
- Presented by Carrie McGivern in Feb 4 AEM meeting
- This upgrade is need for running in the ME Run.
- Present readout time for a beam event and a calibration event takes 1.4 sec & depends on activity in spill
  - Time between beam spills
    - LE Run 2.2 sec
    - ME Run 1.33 sec
  - Readout is too slow
- New CROC-E boards replace CROC boards (CROC talks to FEB, front end board)
  - Reduces readout time to 1.2 sec for 1 beam & 5 calibration events
  - Boris Baldin & Cristian Gingu, PPD EE Dept
- Modify DAQ software
  - Gabe Perdue (Rochester) , Geoff Savage (PPD) & Carrie McGivern (U. of Pitt.)

CROC-E Upgrade

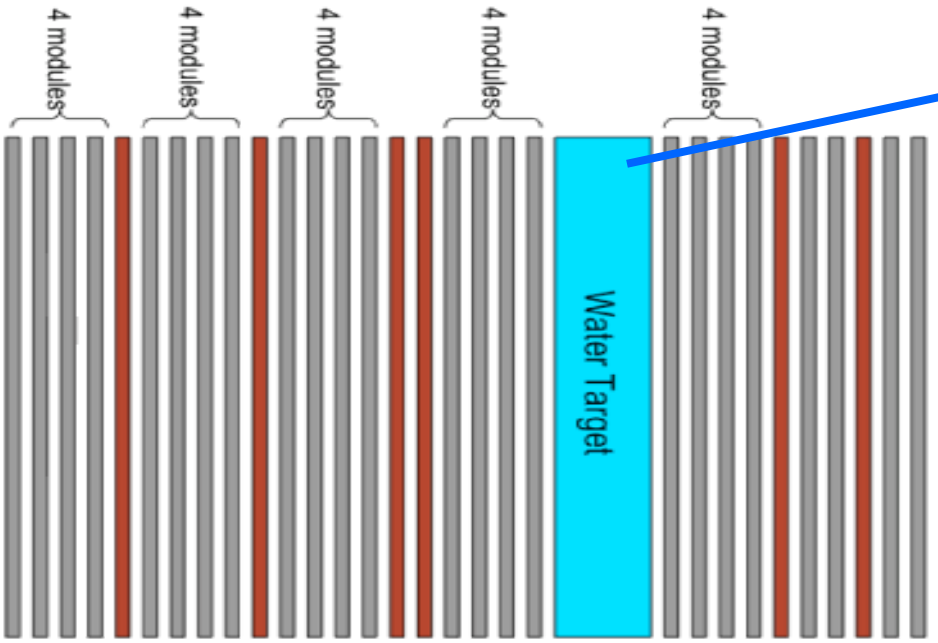


- The readout is made more parallel. Instead of looping over FEBs, it loops over channels in the CROCs.
  - Decreases readout time by factor of 10
- 2 Prototype boards completed
- Jan 7 - OK given to fabricate the rest
- Mar 15 - Fabricate rest of boards
- Mar 22 – Test boards on test stand
  - DAQ software for CROC-E ready
- Apr 1 – Install boards in MINOS Hall
- Apr 15 – DAQ testing and certification with new CROC-E boards
- The plan has only about 1 month of contingency

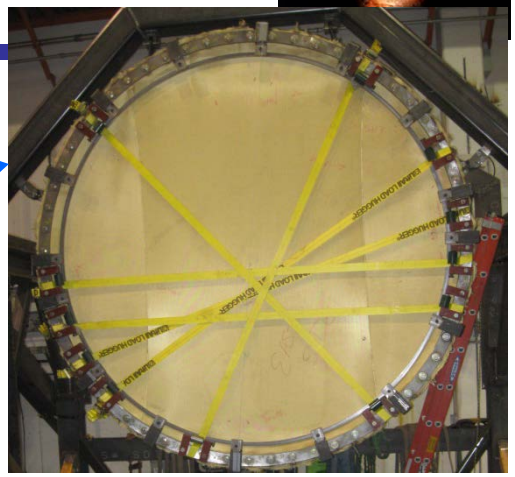
Nuclear Target Region
He & Water Targets

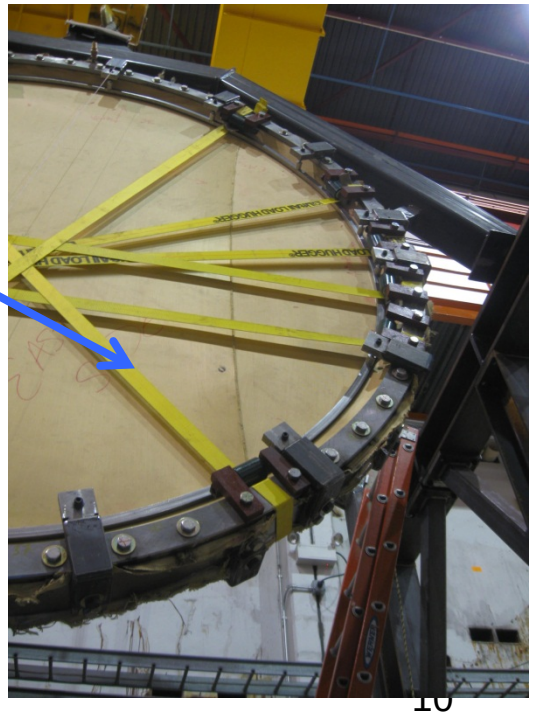


He Target



Water Target





- Water target is made of Kevlar which stretches from the water pressure
  - The straps constrain the expansion of the target
- If the Kevlar expands enough to push on the adjacent planes of scintillator, there might be damage to the plane

Water target

- During Feb we will decide a plan for the water target. The options are:
  - Pull the target out
    - Just before we drained the target it was almost touching the upstream scintillator
    - Takes 1 day, 4 people do pull the target out
    - Possibly rebuild it since the Kevlar is stretching
    - The thought was it would have to be rebuilt as the Kevlar would stretch
  - Filling the target
    - Takes ½ day, we filled it while taking beam data
  - Leave it in and not fill it

Helium target Filling

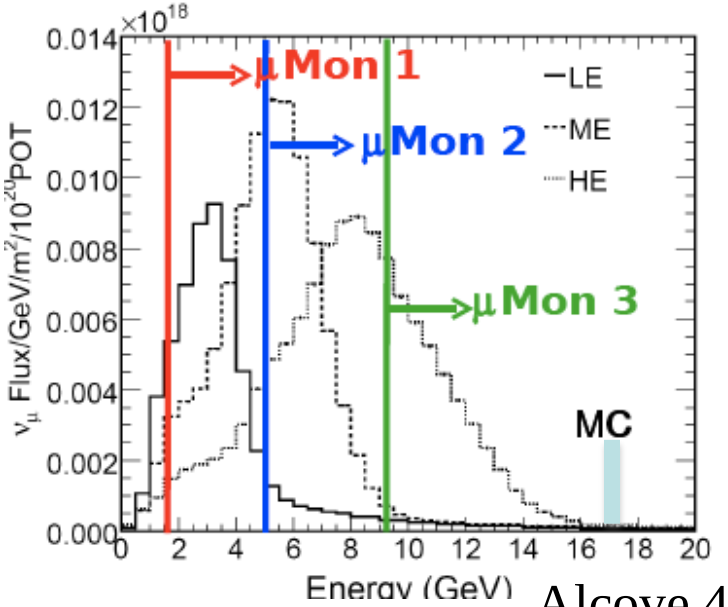
- The helium target refrigerator needs to be refurbished in order to stay within manufacturer's recommendations for the next run
  - Done by outside contractor
  - Have asked the manufacture for a quote and schedule
- Need to investigate the operation of the helium level gage
  - In LE run the devices which measure the He didn't work quite right, so they need to be addressed
- Expect to have the job done by March 15
- Should start filling target 2 months before start of good beam
  - Need to have time for a false start recovery and have the target run stable for at least a week before it's needed.
  - Last time it took couple of months, but some mistakes were made it this long
- People – Bob Sanders, Dan Markley & tech, with some help of Jim Kilmer , John Voirin's techs help with handling dewars
- Monitoring done by Bob Sanders & Dan Markley, that needs to continue

Helium Target

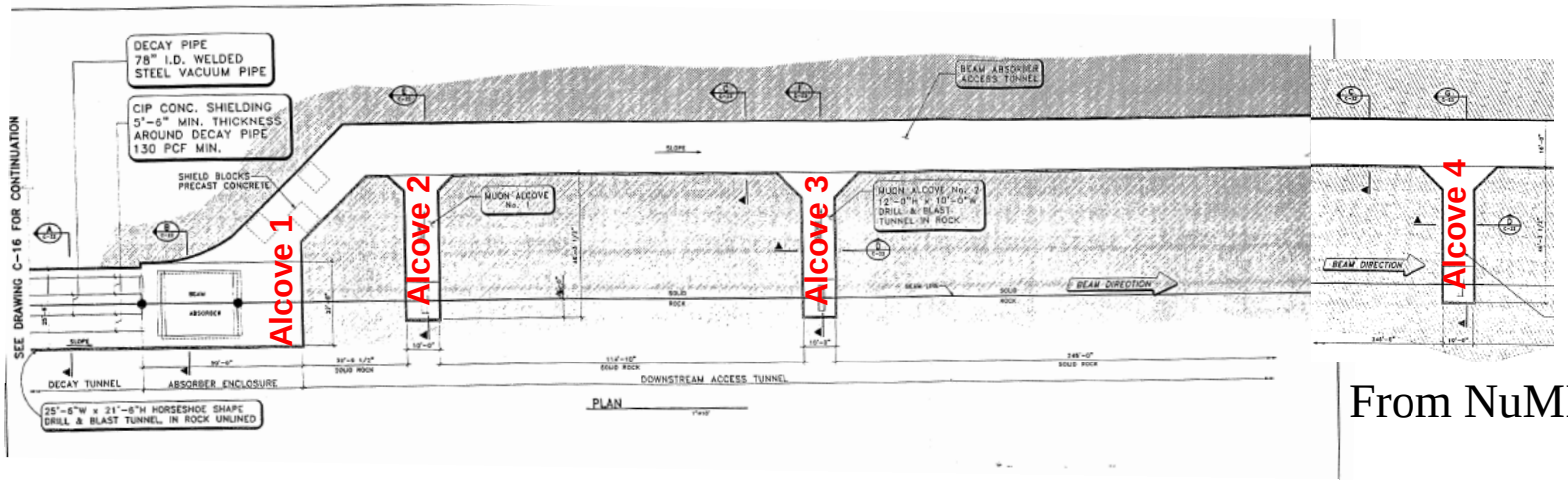
- Filling the helium target costs about $20,000
- We need about 20% empty target running
- We may elect to start the run with the target empty, but if there is a long period of neutrino running we may start with the target full
- In order to know whether to fill the target at the start of the run or not we need to know NOvA's run plan for the beam.

4th Muon Monitor for NuMI

- Current instrumentation:
  - 3 alcoves, each with higher muon energy threshold
  - 2 alcoves see “focusing peak”, last alcove only sees high energy tail
  - Last alcove important baseline for comparisons
- Going from LE to ME configuration:
  - Alcove 3 no longer sees only the high energy tail
  - Need instrumentation in 4th alcove for the best information from the system
- This helps the monitoring & hadron production



Alcove 4



From NuMI TDR

Muon Monitor 4 installation

- The hardware is scheduled to arrive middle of March
  - Stand and gas manifold are already in place
  - Need to lower and mount 9 tubes and hook up to the gas line in the alcove
  - Work for two techs for two days for the installation
- Linda Bagby is in overseeing the electronics and getting the ORC
  - Collecting drawings and information necessary for ORC
  - Use same electronics as muon monitor 1,2,3
  - Setup electronics rack Feb – March
  - Rack ready with ORC – beginning of April
- MM 4 needed to be operational for horn current scan.
- Need person to be in charge of MM 4 and get it running (2 months?)
- Need 2 people to be in charge of MM 1,2,3 to insure they are working, would make sense for one to be same person for MM 4

Muon Monitor

- The muon monitors are needed by all the experiments and there should be a plan to support them
- Of the 2 people one should be FNAL person and other an experiment person

Roof repair

Easter 2011 water storm

- The major source of MINERvA downtime during LE Run was due to debris & water falling from ceiling on the detector
  - Debris is on the covers over FEBs
- Roof was installed during NOvA shutdown, but needs to be improved
- The present roof is made of Herculite & retains water on it during heavy water leaks and leaks it onto the detector

Roof Repair

- Fix is to install metal roof panels over the existing roof where the water can flow off
- Work on the roof installation to start next week
- The installation should take two techs about one week
- The roof has to be removable as we will not be able to access most PMTs or FEBs with the roof on.

Running MINERvA

- We are running shifts right now
  - We have runs over very short period time to be sure the detector is OK, but runs over longer period of times, ~ 6 hours, get CROC errors , probably from FEB errors
    - This will have to be fixed
- We do not have a cosmic ray trigger so that we have to wait for beam to look at tracks.
- In the LE Run, we had a collaborators called “Expert Shifters” who were the 1st person the shifter called if there was a problem
  - For the LE run these were people who got the detector operational.
  - MINERvA will be training collaborators to be “Expert Shifters”.
  - Some of this training will to happen after beam starts.

Running MINERvA

- Shift documentation exists for the LE run
  - We will make shift document can be made easier for the shifter.
- We will start with the previous online monitoring which works
  - We will need to check that the CROC-E replacement works so we will need to check event displays and be sure tracking works.
  - Quickly run data through high level reconstruction to ensure the data is OK

Things we need to ensure high live-time

Control Room Computers

- Control Room machines being taken over by FEF in CD
- 4 Control room machines with their warranty having expired or just about to expire. (in PPD FY13 budget)
- FEF have ordered 4 machines with 4 year warranty and we expect them to arrive in about 2 weeks
- FEF will install them along with direction from MINERvA
- Run Control will need to be installed on these machines.
- Expect installation to be finished by Mar 15

DAQ Computers

- 3 DAQ computers, one of them is an event builder
  - The DAQ will still work with these computers
- Computers are ~ 3 ½ years old and have been in a very dirty & an hot environment
- They should be replaced
- We expect to be ordering new DAQ computers soon
  - Install operating system and MINERvA software
  - Test them above ground
  - Some reconfiguration of the MINERvA racks might be necessary
  - Install the computers
- Time scale for finishing is ~ Mid June
- The person in charge of this is Geoff Savage, (PPD)

Detector Experts

- Experts have left and remaining experts have done their detector responsibilities
- We will need people to fill their shoes
- There are tasks to do during shutdown and its best if the “experts” work on these tasks to become trained on what the issues are for certain tasks
  - The previous tasks can be tackled by the new experts
- Note, for LE Run, the detector was reliable and many of the software problems have been worked out.
- During shutdown we are updating and creating documentation for detector tasks.

DAQ Experts

- The present DAQ Expert is Gabe Perdue
  - He is a senior RA applying for jobs, so we cannot count on him long term
- We will need new DAQ experts
  - One of the 2 new RA's based at FNAL, Carrie McGivern is becoming a DAQ expert
    - Working on CROC-E upgrade
  - We will need more 2 more DAQ experts
  - The CROC-E upgrade gives a person an opportunity to learn the DAQ

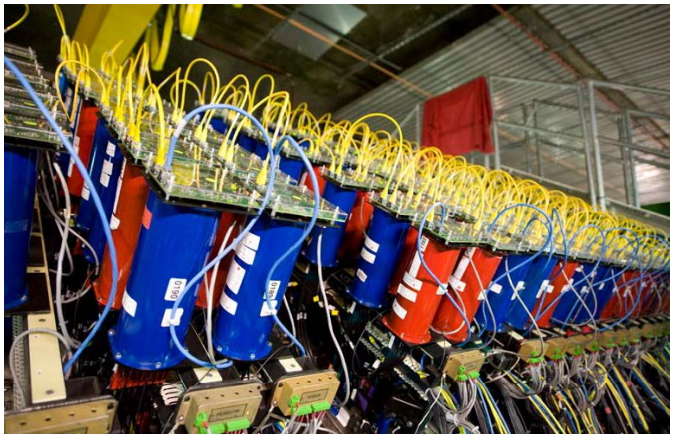
Run Control (RC) Expert

- MINERvA RC software program that coordinates various pieces of the DAQ system, Some of its tasks:
  - Coordinates various DAQ tasks between different computers
  - Provides interface between DAQ and online monitoring
  - Supplies DAQ interface to the user
  - Enables the exchange of control from one user/site to another
- Written in Python, on top of the graphics library WxPython
- Written and maintained by a senior grad student at Rochester, Jeremy Wolcott, who is working on his thesis
- We need at least one person to take over RC to understand and maintain this program.
  - Geoff Savage has express interest in being both a DAQ & RC expert
  - Installing RC on the new control room PC for a new person helps to become involved in RC

DAQ people needed for Hardware Repairs

- Need collaborators trained to run the DAQ to go down with the people who are replacing hardware.
  - Hardware includes PMTs, FEB, Power components …
  - This people do not have to be trained to replace the this hardware.
  - We will train some Expert Shifters to do this
    - Note these do not have to be DAQ experts
  - Procedures for this are in progress

Detector Experts, PMT box Replacements



- PMT box replacement – Dan Ruggiero only expert
- Dan has been doing this since the assembly of the detector
  - Dan knows how to replace a tube depending on its location.
- 2 person job, 2d person helps out person replacing the PMT box
- Dan is training Steve Chappa, Kevin Kuk , Roberto Davila from PPD EE Dept.
  - In Lab G, Dan built simulated replacement setup.
  - The optical cables and light injector fibers are plugged in blind
  - After much practice, we may have them do some tubes on the detector
  - Difficult job especially for PMTs in certain places. Sometimes to replace a PMT box you have to remove 2 PMTs.

Detector Experts

- FEB replacement – most often replacement
  - Much easier than PMT replacements.
  - To replace a PMT you must remove the FEB so FEB replacement is a subset of PMT replacements
  - Can be done by people trained to replace PMTs
- UROC – computer station which are used for the remote shifts.
  - Jeremy Wolcott, UR grad student, set this up and is in charge of UROC
  - UROC operating system will need to upgraded and the plan is to have this done by April
  - We will need to have a collaborator to take over from Jeremy.

Detector Experts

- VME crate & modules in the crate
  - The RA who work on the CROC-E upgrade will be an expert
  - Need someone else
  - In LE run we did not have a failure in this system
- Control Room Computers & Online Monitoring
  - Run Control has online monitoring components
    - New Run Control expert will play a role in this.
  - Jeremy Wolcott, Arturo Fiorentini – senior grad students are current experts
  - A RA who has left was also an expert
  - We will need to replace these people with at least 2 new collaborators
  - CD/FEF are the system administrators and service the control room machines

Detector Experts

- Veto in front of He target
  - Joel Mousseau, senior grad student
- Muon Monitors
  - Previously discussed

Detector experts
PPD EE Hardware

- Fire safety system needed for MINERvA roof
  - Roof is between the detector & sprinkler system
  - Set up by Linda Bagby, Steve Hahn has agreed to be an expert too
- RPS – rack protection system
  - Expert Jamieson Olsen & Linda Bagby, PPD EE Dept
- Power Distribution
  - Experts – Jamieson Olsen & Linda Bagby, PPD EE Dept
  - UPS – Replaced during shutdown & created a detailed procedure
  - Documentation for about ½ of the tasks exists – Parts:
    - FEB power supply, called FESB
    - UPS
    - AC Distribution Box
    - DC Bulk Supply
    - Fuse Chassis
- Steve Chappa & Roberto Davila will supply technical assistance
  - They will need to be trained

Run Coordinator

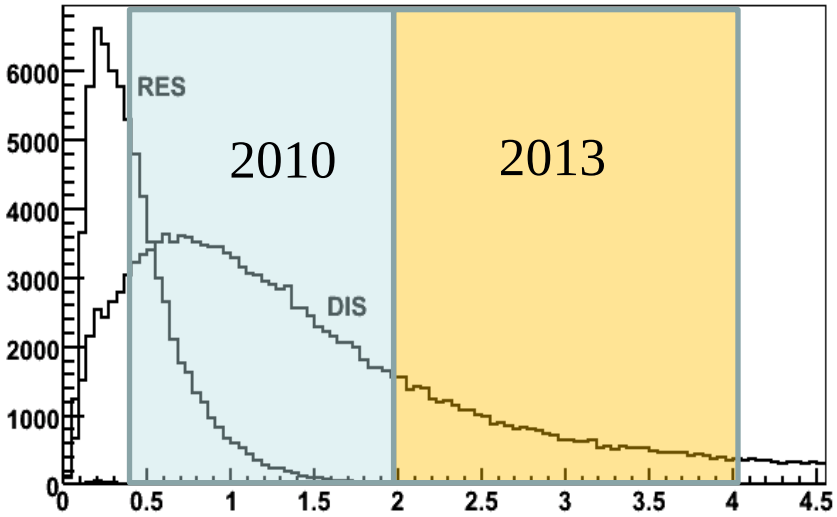
- Need to replace Ex Run Coordinator: Cesar Castromonte who was a CBPF RA
  - He covered many parts of the detector and is a big factor in expert knowledge.

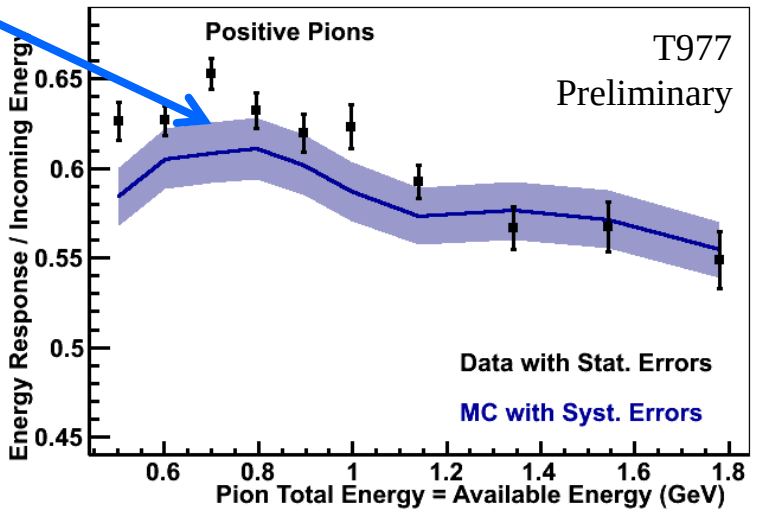
Testing PMT Boxes

- We have 14 certified good PMT Boxes in the good PMT cabinet
  - ~ 10 need repair
  - ~ 20 more need to be tested
- Dan Ruggiero understands the repair of the PMTs Boxes
- The PMT test stand worked at the end of the LE Run but we have not tried it since.
  - The 2 people who tested the PMTs have left
  - We will need to resurrect the old analysis program
- After the test stand is resurrected with the analysis program , we will need to have a tech to test these PMT boxes and repair the PMT boxes that can be repaired.

MINERvA 2013 Test Beam Run

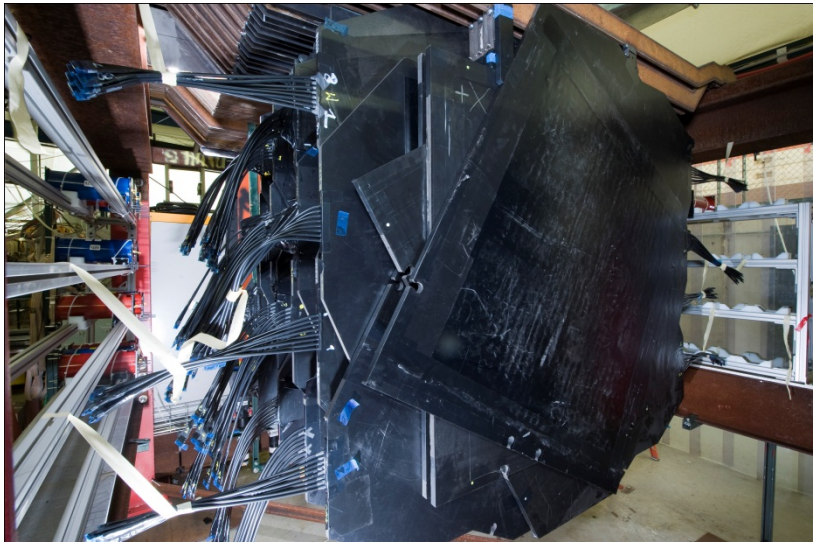
- Our 2010 test beam run was optimized for Low Energy beam physics:
  - Exclusive final states (RES)
  - Single particle detector responses at low energies
  - Used Tertiary beamline, acceptance tuned to <2GeV
- 2010 run successful, already setting hadron energy scale at MINERvA and constraining systematics
- 2013 test beam run goals focused on Medium Energy beam physics
  - Deep Inelastic Scattering
  - Would need a differently tuned beam from 2010 run





MINERvA 2013
Test Beam Run (cont'd)

- Detector was partly disassembled after 2010 run, and will need to be reassembled and refurbished
  - Absorber-plane stack
  - Plug planes into photosensors
  - 3 FTE months of mech. techs. & 10K M&S
- Photosensors for 2010 run were "borrowed" from the main detector, and are not available
  - Need 40 PMTs; have ~15 spares
  - Options:
    - Take from the detector (1.5 FTE-months of mechanical techs to remove-replace)
      - Can't analyze cryotarget during this time; would want to do early in run.
      - However, since we don't have support for refurbishing the detector, we have not moved forward with that plan.
    - Order new Hamamatsu PMTs to put into existing boxes
    - Deploy SiPM drop in replacement if successful
  - Both of the last two require significant new funds, order $50K.
- Funds to support any of these solutions have been requested, but aren't in our PPD budget



Expert Technical Support Needed

- Dan Ruggiero was part of the crew that built the MINERvA detector
- He is the only person left who is has an overall knowledge of the detector
  - As a result he is the only one who is qualified to replace PMTs
    - He is training 3 PPD people supplied by the lab
  - When the water target was being installed, during the installation he stopped the installation so that it could proceed in a way that better protected the detector.
    - Some damage took place on the detector and he was instrumental in getting most of the damage fixed.
  - Should we need to reposition the nuclear targets for physics reasons, Dan's knowledge would be instrumental in this
  - He worked on the 2010 test beam and his knowledge would be instrumental if we setup the test beam again.

Expert Technical Support Needed

- Major change is being suggested in technical support
- The old model is that PPD paid for a Rochester tech
- New model involves a crew of people & Dan may be hired by FNAL to be on that crew.

Offline: getting to Publications

- New (continued) effort needed from Computing Division, review mid-Jan 2013 of Experiment Goals and Computing Needs
- Highest Priority action item from that review: Encourage more cache/tape usage -- and rely less on disk being addressed by moving experiments to SAM-LITE
  - MINERvA is severely hampered by lack of disk space and the fact that there's no caching system in place that we can use
  - Medium Energy demands on disk space and computing will be even higher than Low Energy demands
    - Many more neutrinos per POT (ME is better focused beam)
    - Many more interactions per neutrino, because energy is higher
    - Protons per pulse also expected to be higher
    - Total estimate is a fact of 6 more disk space needed per year
  - Need to go all the way through our processing as we take data
    - LE Run we could not do that because of disk space constraints
    - Competition for resources will be even tougher because we have many low energy analyses preparing for publications as we ramp up in the ME Run.

MINERvA Census

- MINERvA is a small collaboration: 65 active shifters as of today
  - 6 active FTE RA's now (7 people)
    - 4 RA's have been on the experiment >2 years, incl. 1 FNAL RA
    - 1.5 FTE new RA's focused on ME Run
  - Total of 18 RA's on the LE Run over past 5 years
    - Most of the original RA's who built the experiment are gone
  - 21 Graduate Students on the LE Run
    - Strong Guest and Visitor Program means many of these are from Latin American Institutions
  - 12 active students ME Run
    - These are the students who are junior enough to do service work today
    - ½ of these students are based at FNAL
  - This is small pool of people to service the detector and ensure good data taking run during the ME Run

Fermilab Post-doc Census

- 43 Fermilab RA's: 1 on MINERvA
  - 34 on Intensity+Energy Frontier
    - CMS: 15 post-docs
    - CDF: 2 post-docs
    - D0: 5 post-docs
    - Intensity Frontier: 12, including 3 who are splitting their time between IF and TeVatron experiments
  - 19 in Theory plus Particle Astrophysics
- MINERvA will be one of 3 running FNAL experiments this summer, and one of 2 running experiments with physics-quality data NOW
- A dedicated hire of a RA for MINERvA should be a high priority

Summary

- Having experts for the lifetime of the experiment to service the detector
  - DAQ & DAQ hardware – need 2 more new people
  - Run Control – need person
  - Online Monitoring – need 2 MINERvA people & Run Control person has online monitoring responsibilities
  - Muon Monitors need Lab person & experiment person, experiment person does not have be a MINERvA person
  - PMTs & FEB, power distribution – PPD EE is supplying support
  - General knowledge of the detector – Dan Ruggiero
  - Need tech to test and repair PMT boxes
  - Need 2d Run Coordinator

Summary

- Almost all of the original people that built and got the experiment working have moved on to other jobs or are searching for jobs
- CROC-E Upgrade necessary for taking data during the ME Run
  - Small contingency for this upgrade
- Control Room Computers – replacements schedule looks OK
- DAQ computer replacement – No contingency
- Need to test and repair non-working PMT boxes.
- He Target
  - Very little contingency on having target filled for start of run
  - Need to understand NOvA's run plan to decide whether to fill it at beginning of run
- We are planning a testbeam run, but at this point lack photodetectors.

Back-up Slides

Backup: Other Computing Division Support Efforts

- 2nd Highest Priority: Migration help off Gaudi—at least off Pool data format into Root
  - This is more MINERvA-specific, we chose Gaudi long ago after not getting guidance from CD about which framework to use
- 3rd highest: Provide help in optimizing GEANT4 as experiments push downward in thresholds
- 4th highest: tie that helps many experiments
  - Investigate alternative computing strategies for analyses that are I/O limited (this helps many experiments)
  - Help/impetus in moving MC simulation off FNAL machines to other GRID sites
- 5th priority: Need a way to understand/manage/quota's for bluearc disk usage to facilitate removal of unnecessary files

HV varying problem

- While I have been RC, the problem which occurred most frequently the HV varying problem.
  - Since being RC probably 10 PMTs have had this problem, probably 10 before.
  - Periodically the HV of a PMT will vary 5-10-20 volts 1-2 times a week for about 1-2 hours maybe more.
  - Sometimes replacing the FEB fixes the problem, sometimes we need to replace the PMT, so origin is confusing
- We replace the hardware when beam is down
  - We have not been replacing PMTs, but we replace the 3 ones doing this after the run was over
- Repairing the PMTs which this problem and determining that the problem is mixed would help understand the problem.