

Neutrino Group Overview

Zelimir Djurcic
(for ANL neutrino group)

Outline

- Neutrino Group Context
- Group Projects
 - MINOS
 - Double Chooz
 - NOvA
 - LBNE
 - Other ν
- Plans



Overview of the Neutrino Group



ANL Neutrino Group within HEP

-ANL neutrino program aligned with HEP mission,
i.e Intensity Frontier:

“The Intensity Frontier, where intense particle beams and highly sensitive detectors are used to pursue alternate pathways to investigate fundamental forces and particle interactions by studying events that occur rarely in nature.”

-Answer fundamental unanswered questions in neutrino physics, in particular:

- 1) What is the value of the third neutrino mixing angle, θ_{13} ?
- 2) Do neutrinos violate CP symmetry and if so by how much?
- 3) What is the hierarchy of neutrino masses?



ANL Neutrino Group Context

We are making significant contributions to **FOUR** neutrino projects

- Double Chooz
- MINOS
- NOvA
- LBNE
- and
- Detector R&D

Plus...

- ✿ Particle Data Group
- ✿ Neutrino Security/Non-proliferation
- ✿ Neutrino Oscillation Industry Web Site
<http://www.neutrinooscillation.org/>
- ✿ Soudan 2, HUSEP, UNO
- ✿ OMNIS/ADONIS & COGENT
- ✿ MIPP
- ✿ MiniBooNE
- ✿ Participation in reviews, referees...
- ✿ Monthly Neutrino Newsletters sent to > 1600.
- ✿ Neutrino Outreach
- ✿ Sponsor and co-organize many neutrino meetings
- ✿ Offers for more than our share of speakers at International Meetings

Members of the Group

» ANL Full time staff

- Maury Goodman (Group Leader)
- Richard Talaga
- Steve Magill
- Zelimir Djurcic
- Jonathan Paley

» Postdocs

- Xiaobo Huang
- Sarah Budd
- Michelangelo D'Agostino
- Matt Wetstein (partial)

» Others

- Mayly Sanchez Joint Appointment, Iowa State
- Phil Schreiner Faculty appointment from Benedictine
- Tom Fields Emeritus
- Paul Bloom Faculty appointment from North Central College
- David Ayres Emeritus
- Students IMSA & Vijay Jampani

» Plus

- Mechanical Group: V. Guarino, K.Wood, et al.
- Electronics Group: G. Drake, et al.



Experiments/Projects

- LBNE
- Double Chooz
- MINOS
- NOvA
- Other ν

Neutrino Breakout Session Plan (Wednesday, 5/25/11)

2:20	Neutrino Overview (Maury Goodman, 10+5)
2:30	Double Chooz Calibration (Michelangelo D'Agostino, 10+5)
2:45	Double Chooz Analysis (Zelimir Djurcic, 10+5)
3:00	MINOS (Xiaobo Huang, 10+5)
3:15	Break
3:35	NOvA DAQ (Steve Magill, 10+5)
3:50	NOvA Operations (Jon Paley, 10+5)
4:05	NOvA PVC & Assembly (Richard Talaga, 10+5)
4:20	NOvA Analysis (Sarah Budd, 10+5)

Detector R&D Breakout Session Plan (Wednesday, 5/25/11)

13:20	Wireless readout of neutrino detectors (15') Zelimir Djurcic
13:35	Neutrino detectors with LAPD (15') Mayly Sanchez
13:50	Dual Readout Calorimetry (10') Steve Magill





MINOS

(Main Injector Neutrino Oscillation Search)



MINOS Timeline

- 1987 – First Calculations of neutrinos from Fermilab to Soudan at ANL
- 1990 – Letter of Intent
- 1991 – ANL ran “Long-Baseline Neutrino Oscillation” workshop at Fermilab
- 1992 – 822 proposal, ANL spokesperson
- 1994 – MINOS collaboration forms
- 1995 – MINOS approved, HEPAP subpanel on long-baseline oscillations
- 2003 – MINOS Far detector completed
- 2005 – First Far detector event in neutrino beam
- 2011 – (Probable) end of data taking
- 2012+ -- MINOS+, (ANL not participating), will continue to maintain ND electronics

- **Recent papers (15 since 2009):** Δm^2_{32} , search for ν_e appearance, search for sterile neutrino component, atmospheric μ^+/μ^- , lorentz invariance, measurements with antineutrinos, seasonal variations, atmospheric K/π ,
- **Analyses in progress:** atmospheric ν , lorentz invariance, ν_e appearance,



MINOS Current Involvement

- Phil Schreiner, convenor of “Universal Physics Analysis Group”
 - Atmospheric neutrinos, cosmic rays, K^+/K^- , p/K
- Sarah Budd, convenor of the “Calibration Group”
- Maury Goodman, chairman of the Institutional Board, executive committee
 - Atmospheric neutrinos, cosmic rays
- Xiaobo Huang, calibration, ν_e
- Mayly Sanchez, ν_e
- Tom Fields, analysis of muon production
- Dave Ayres, maintains author lists & other collaboration lists
- Richard Talaga, shifts only
- Jon Paley, database

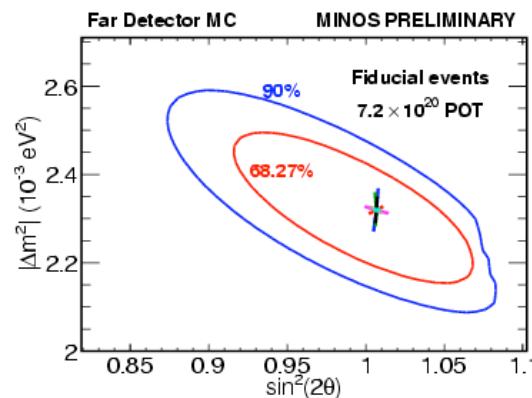




Argonne
NATIONAL LABORATORY

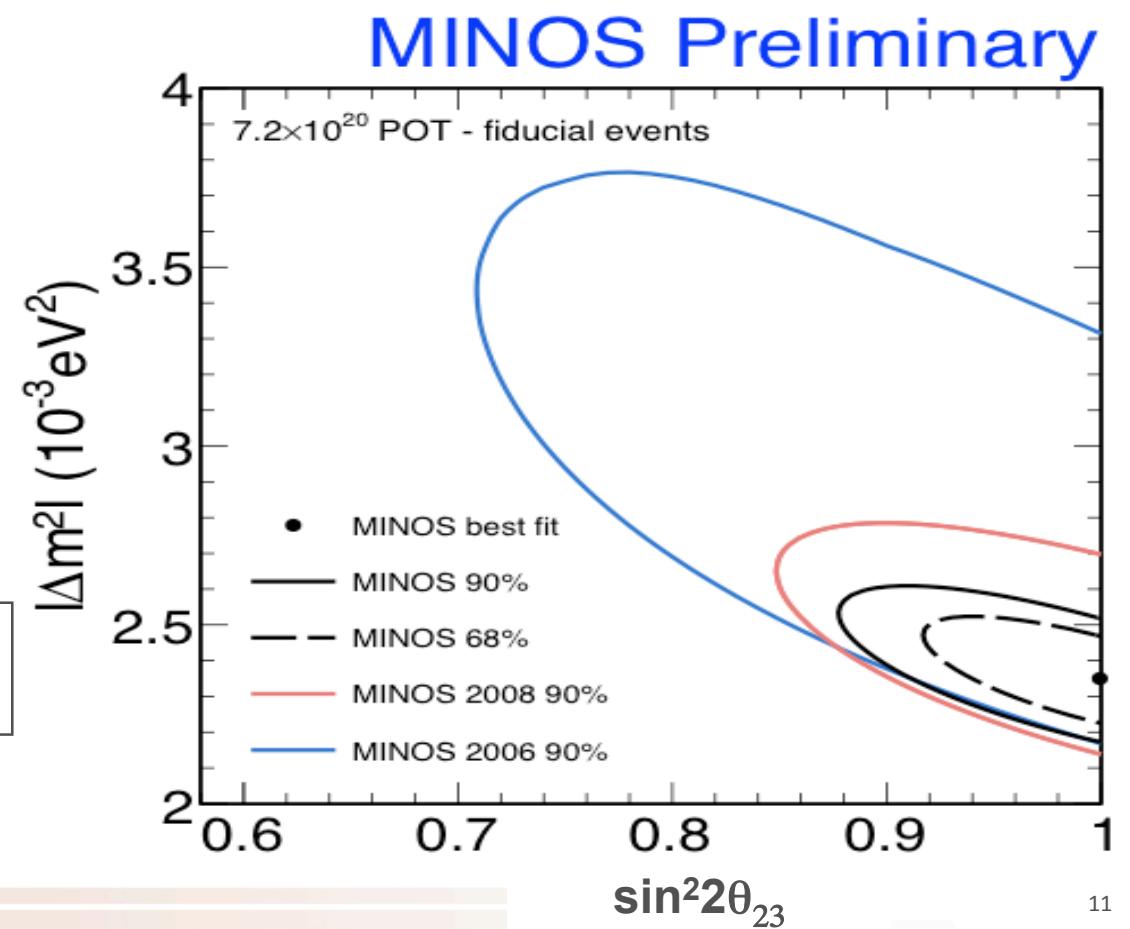
World's best measurement of Δm^2_{32}

Presented at Neutrino 2010 in Athens



$$|\Delta m^2| = 2.35^{+0.11}_{-0.08} \times 10^{-3} \text{ eV}^2$$

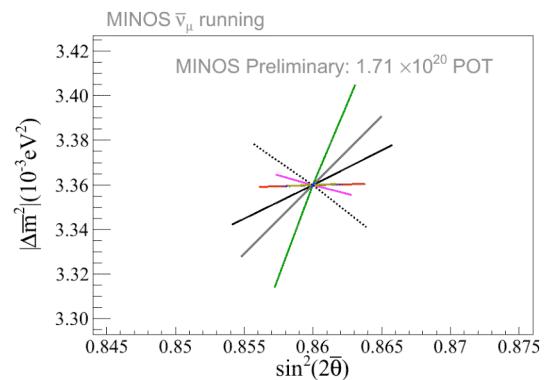
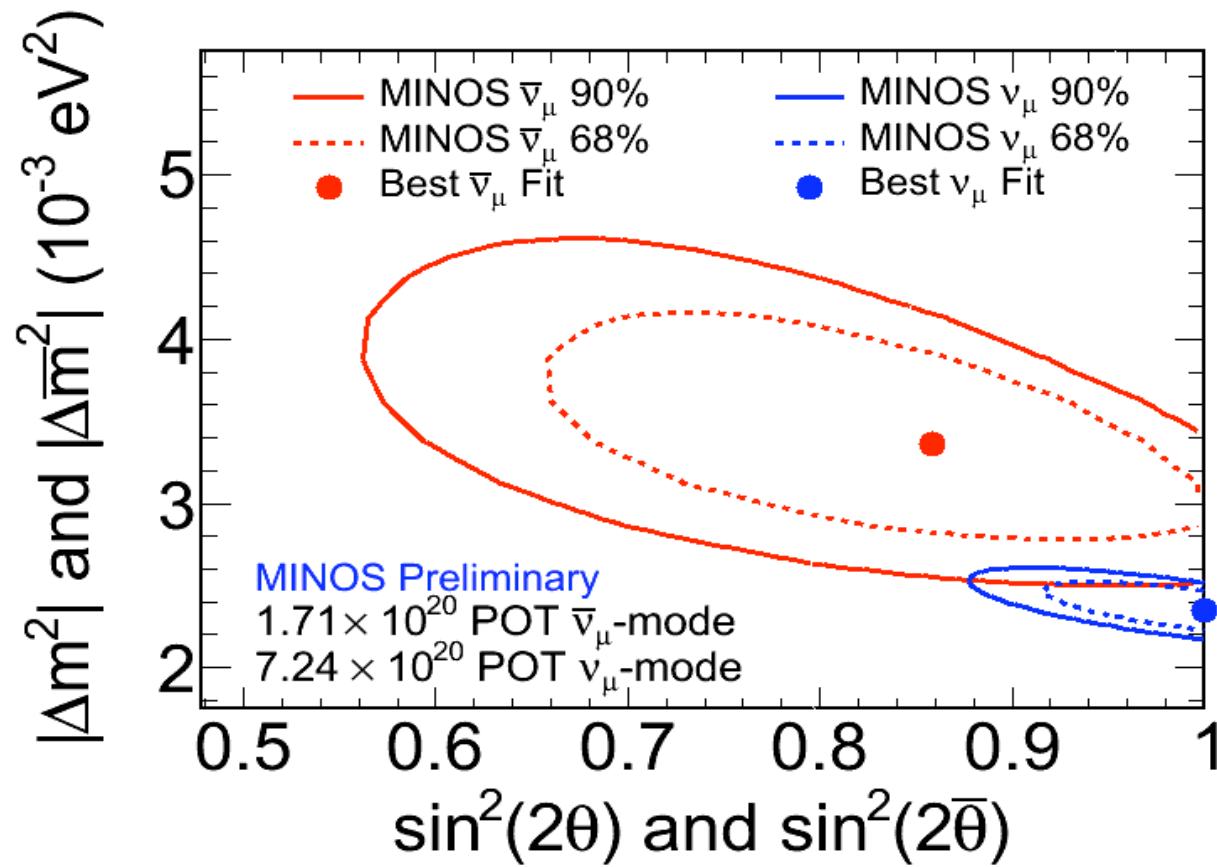
0.19 uncertainty; was 0.26



MINOS Antineutrinos



Is there a difference between ν and anti- ν ?



Double Chooz (Reactor Anti-neutrino Experiment)



Double Chooz Current Involvement

- Michelangelo D'Agostino
 - leadership in calibration Z-axis system development/deployment
 - simulation and analysis of ${}^9\text{Li}$ and Michel electrons from stopping muons
 - analysis software improvement
- Zelimir Djurcic
 - co-convenor of “Calibration Group”
 - simulation and analysis of spallation neutrons
 - reactor flux calculations and systematics
- Maury Goodman
 - executive committee
 - oversee articulated arm system and funding
 - θ_{13} sensitivity studies

Everyone is participating in:

- data analysis at collaboration level
- data analysis within US cluster
- work with summer intern students (V.Jampani(current), A.Rizvi, J.Adams(last year))
- preparation for the radioactive source deployment
- preparation for the data analysis of deployed radioactive sources
- detector shifts



Double Chooz Schedule

Far Detector:

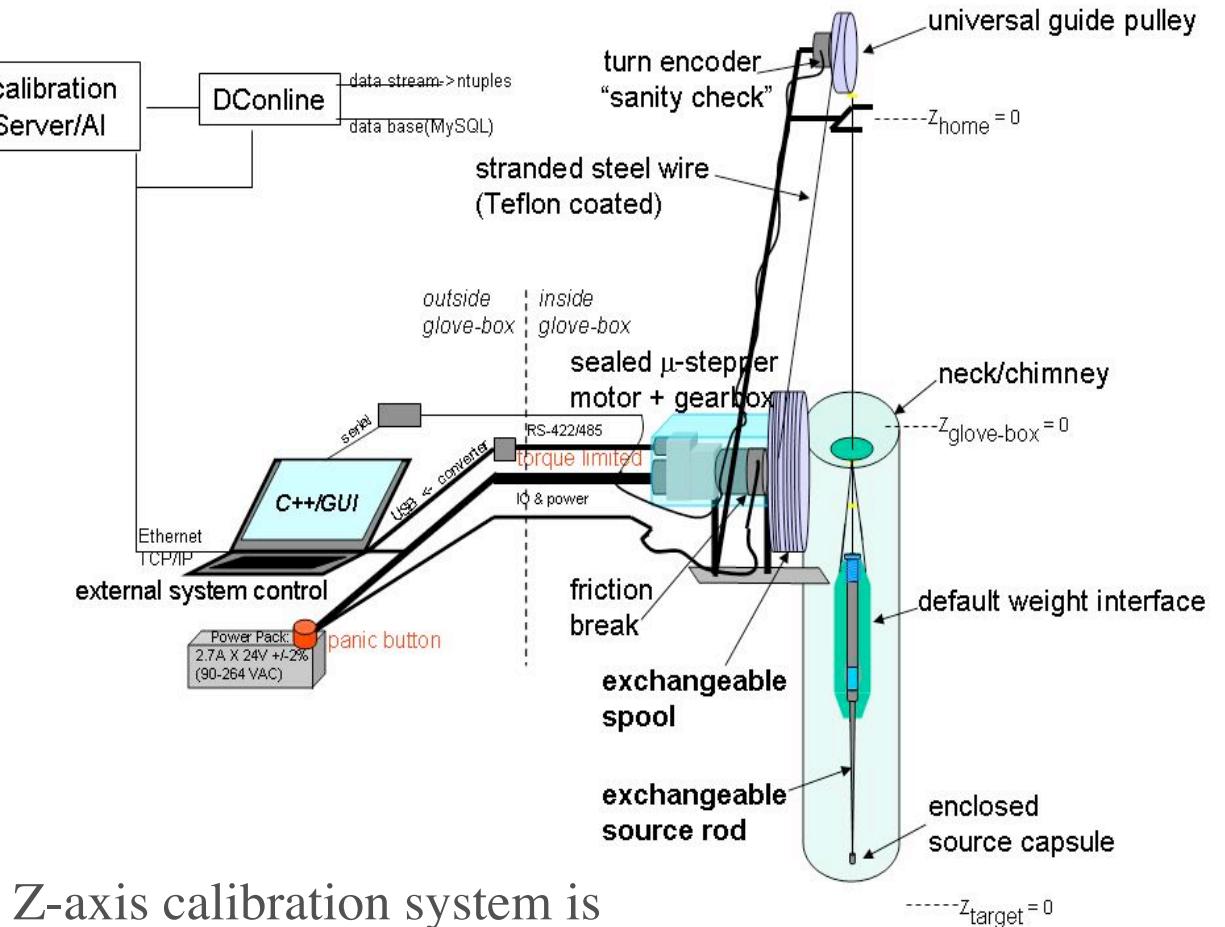
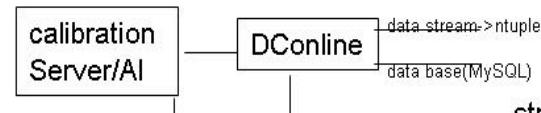
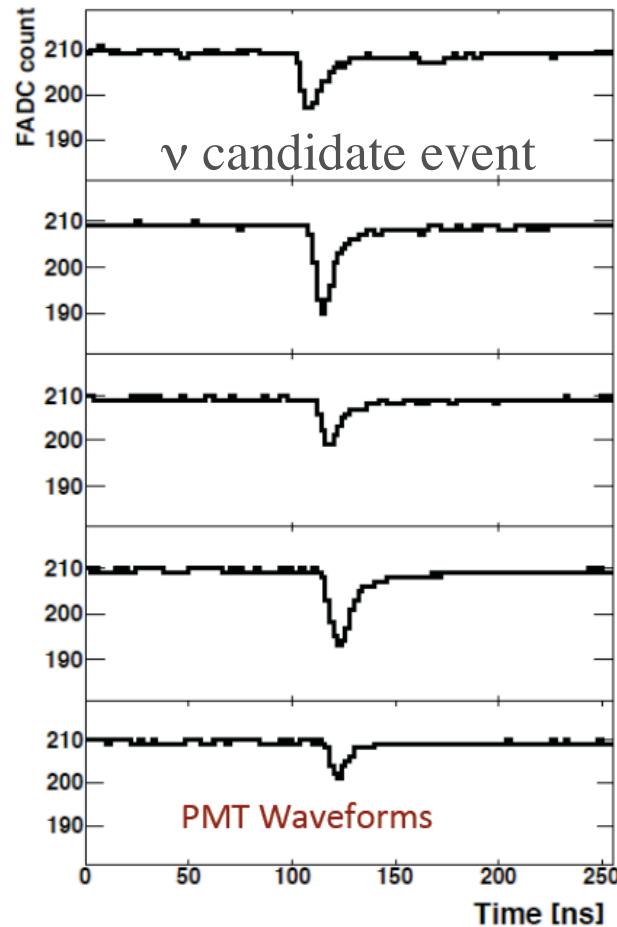
- Far Detector commissioned and taking physics data from April 13, 2011.
- Remaining tasks:
 - The lower Outer Veto (OV) installation is under way → date June 10.
 - The deck installation after the lower OV system is in place → end June 24.
 - The glove box installation → end date July 1.
 - The clean tent installation → end date July 8.
 - The Z-axis deployment system installation and commissioning, radioactive source deployments in the target by mid-July.
 - The upper OV is installed after the first calibration deployments (FD complete).
- First Results on θ_{13} :
 - Expect Far Detector only result this summer when sensitivity to θ_{13} better than original CHOOZ sensitivity (~3 months of data at full reactor power).
 - Interpretation may be complicated by the reactor neutrino anomaly

Near Detector:

- Near Detector Lab Construction started 29th April 2011.
- The lab will be delivered in March-April 2012 ready for physics.



Double Chooz Current Status :

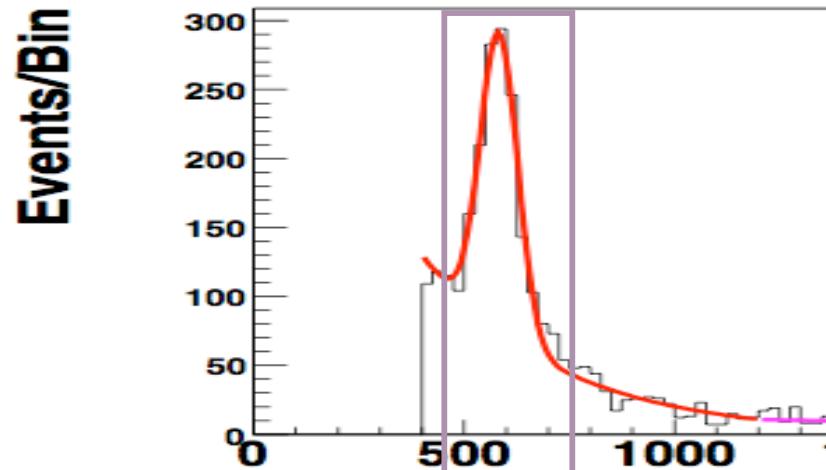


Z-axis calibration system is under readiness review

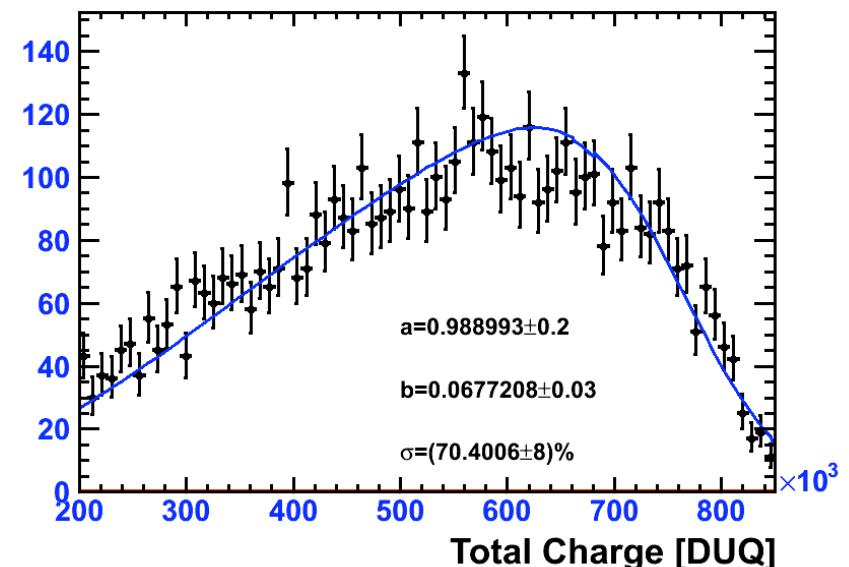


ANL Analysis Examples

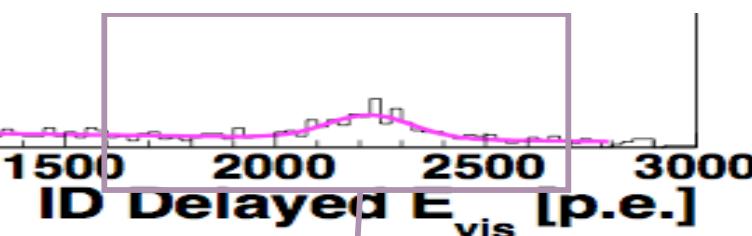
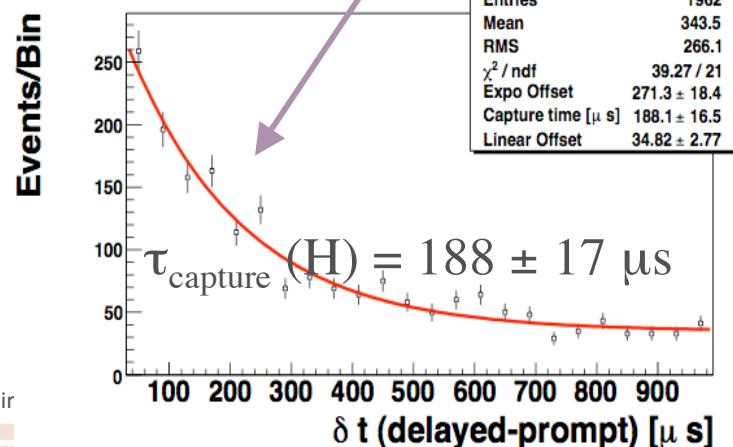
- spallation neutrons
- Michel electrons



Michel Electron Spectrum From 1 Day of Data



H/Gd n captures:





NO ν A

(NuMI Off-Axis ν_e Appearance Experiment)

NOvA Current Involvement

- Sarah Budd

- module construction

- Quality Control of detector components

- mechanical hardware database

- multiple analysis tasks

- Zelimir Djurcic

- Developing leak checking system for Near and Far Detectors

- Booster Beam Simulation

- Maury Goodman

- Speakers Committee chair

- Vic Guarino

- Engineering Team

- Xiaobo Huang

- Developing calibration techniques with stopping muons

- Preparing for analysis of cosmic ray induced backgrounds

• NOvA Detector Overview

- Steve Magill

- Developed data-logger for DAQ.

- Developing "cheater" for algorithm optimization.

- Optimization of the Near Detector

- e/π^0 selection algorithm

- Jon Paley

- NOvA Run coordinator

- database coordinator

- developer of DAQ Run Control and Resource Manager

- IB member

- Mayly Sanchez

- Offline Coodinator

- Rich Talaga

- Level 2 manager for PVC

- EC member

- realized large powder & extrusion contracts for Far Detector



NOvA Schedule

- Prototype Near Detector (NDOS) - operational, taking data.
-Regular shifts started.
- Start Far Detector construction at Ash River – Fall 2011
- Accelerator shutdown starts for NOvA - March 2012
- Beam returns at 700 kW, with ~2/3 of Far Detector ready – Feb. 2013
- Expect Far Detector complete by Fall 2013



Module Stacks & Leak Test Station



Placing Module in NDOS Block

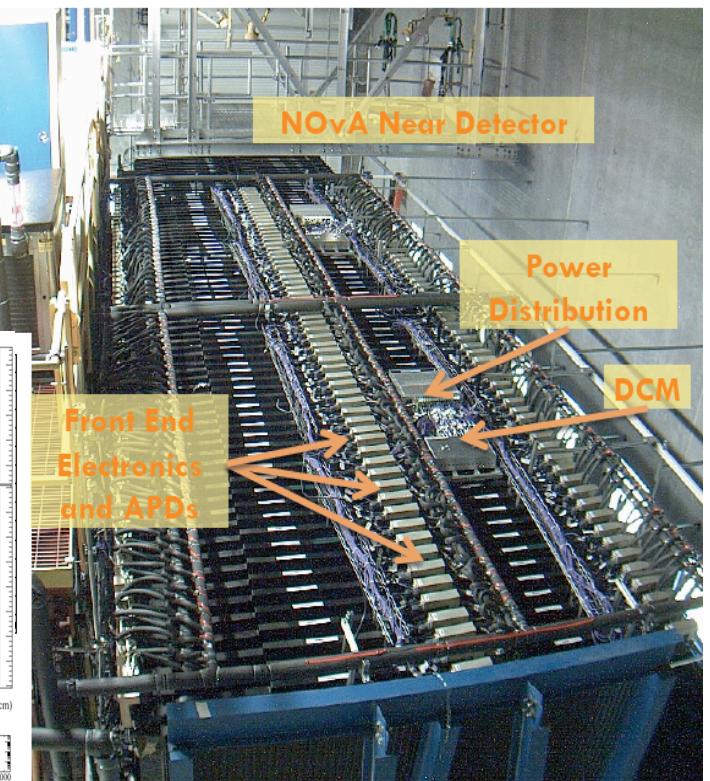
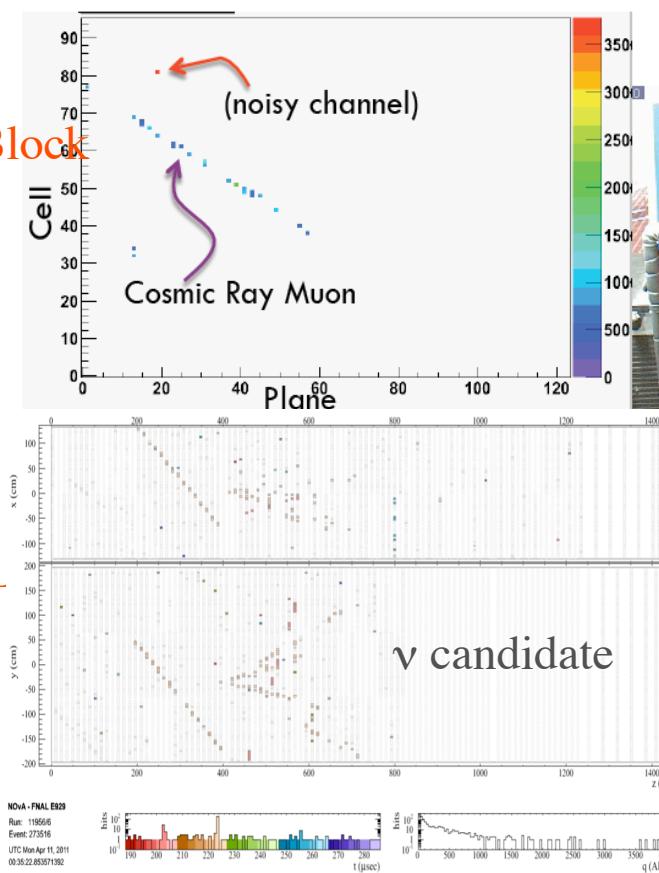


NDOS Block Shipped to FNAL



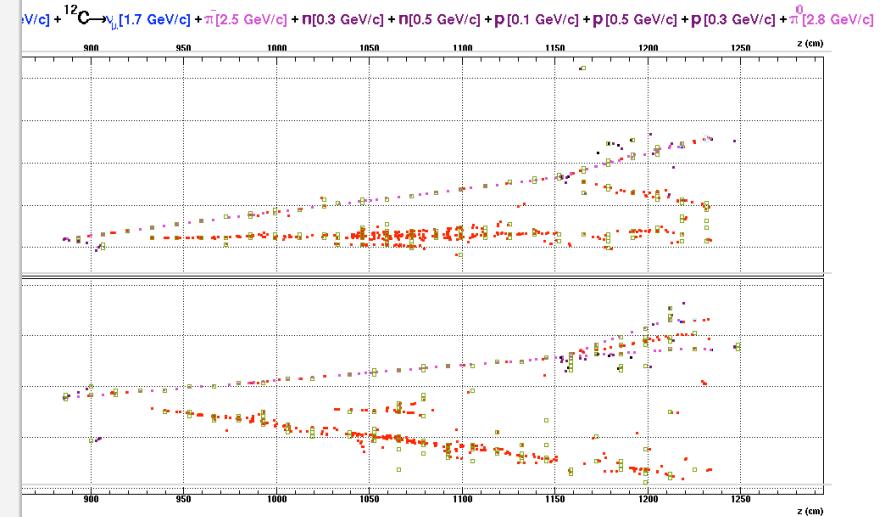
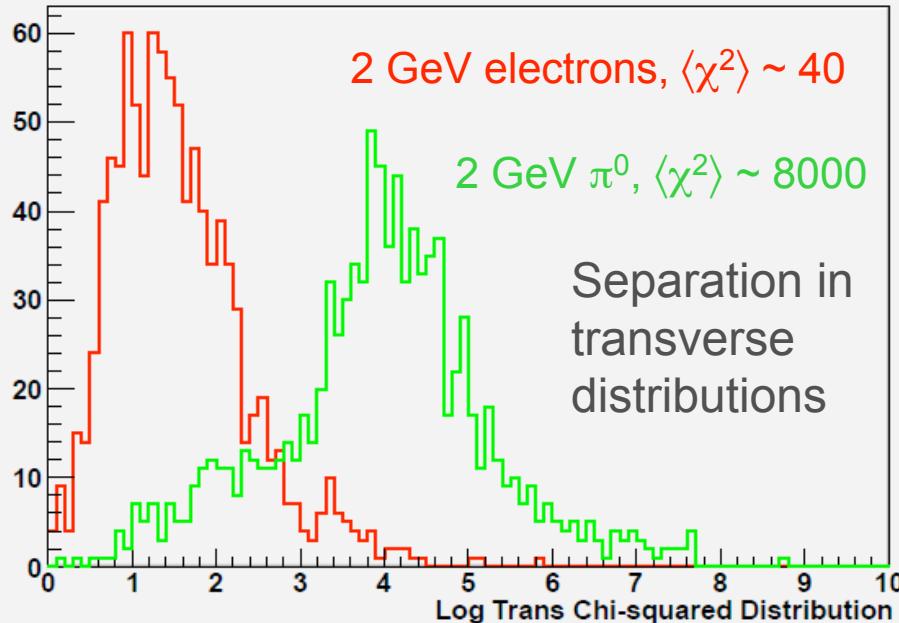
Block Overview

NOvA NDOS Construction

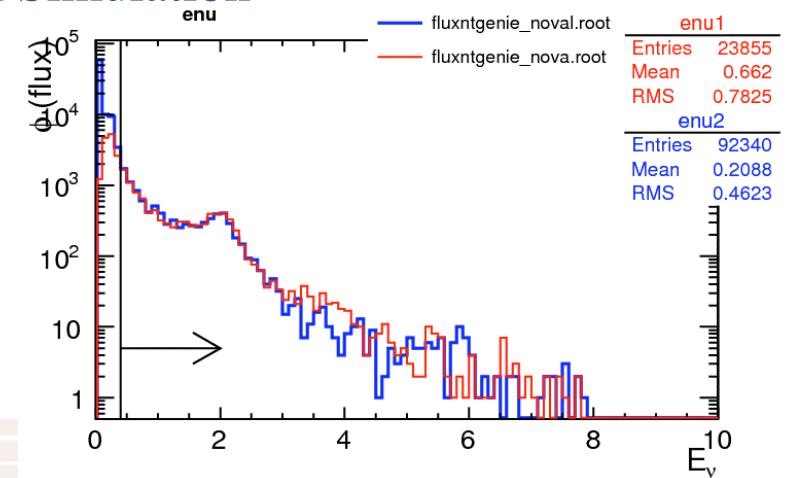
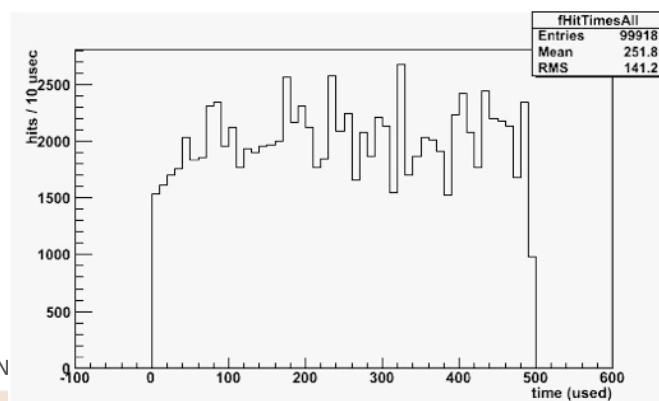


ANL Analysis Examples

e, π^0 rejection with transverse H-Matrix



Cosmic and beam Simulation





LBNE

(Long-baseline Neutrino Experiment)



Long-Baseline Neutrino Experiment Collaboration

Alabama: J. Goon, I Stancu

Argonne: M. D'Agostino, G. Drake, Z. Djurcic, M. Goodman, X. Huang, V. Guarino, J. Paley, R. Talaga, M. Wetstein

Boston: E. Hazen, E. Kearns, S. Linden, J. Stone

Brookhaven: M. Bishai, R. Brown, H. Chen, M. Diwan, J. Dolph, G. Geronimo, R. Gill, R. Hackenberg, R. Hahn, S. Hans, D. Jaffe, S. Junnarkar, J.S. Kettell, F. Lanni, L. Littenberg, J. Ling, D. Makowiecki, W. Marciano, W. Morse, Z. Parsa, C. Pearson, V. Radeka, S. Rescia, T. Russo, N. Samios, R. Sharma, N. Simos, J. Sondericker, J. Stewart, H. Tanaka, C. Thorn, B. Viren, Z. Wang, S. White, L. Whitehead, M. Yeh, B. Yu

Caltech: R. McKeown, X. Qian, C. Zhang

Cambridge: A. Blake, M. Thomson

Catania/INFN: V. Bellini, G. Garilli, R. Potenza, M. Trovato

Chicago: E. Blucher

Colorado: S. Coleman, R. Johnson, A. Marino, M. Tzanov, E. Zimmerman

Colorado State: M. Bass, B. Berger, J. Brack, N. Buchanan, J. Harton, V. Kravtsov, W. Toki, D. Warner, R. Wilson

Columbia: R. Carr, L. Camillieri, C.Y. Chi, G. Karagiorgi, C. Mariani, M. Shaevitz, W. Sippach, W. Willis

Crookston: D. Demuth

Dakota State: B. Szcerbinska

Davis: M. Bergevin, R. Breedon, J. Felde, P. Gupta, M. Tripanthi, R. Svoboda

Drexel: C. Lane, J. Maricic, R. Milincic, K. Zbiri

Duke: T. Akiri, J. Fowler, K. Scholberg, C. Walter, R. Wendell

Duluth: R. Gran, A. Habig

Fermilab: D. Allspach, M. Andrews, B. Baller, E. Berman, D. Boehnlein, M. Campbell, A. Chen, S. Childress, B. DeMaat, A. Drozhdin, T. Dykhuis, C. Escobar, A. Hahn, S. Hays, A. Heavey, J. Howell, P. Huhr, J. Hylen, C. James, M. Johnson, J. Johnstone, T. Junk, B. Kayser, G. Koizumi, T. Lackowski, P. Lucas, B. Lundberg, T. Lundin, P. Mantsch, E. McCluskey, N. Mokhov, C. Moore, J. Morfin, B. Norris, V. Papadimitriou, R. Plunkett, C. Polly, S. Pordes, O. Prokofiev, J. Raaf, G. Rameika, B. Rebel, D. Reitzner, K. Riesselman, R. Rucinski, R. Schmidt, D. Schmitz, P. Shanahan, M. Stancari, J. Strait, S. Striganov, K. Vaziri, G. Velev, G. Zeller, R. Zwaska

Hawaii: S. Dye, J. Kumar, J. Learned, S. Matsuno, S. Pakvasa, M. Rosen, G. Varner

Indian Universities: V. Singh (BHU); B. Choudhary, S. Mandal (DU); B. Bhuyan [IIT(G)]; V. Bhatnagar, A. Kumar, S. Sahijpal(PU)

Indiana: W. Fox, C. Johnson, M. Messier, S. Mufson, J. Musser, R. Tayloe, J. Urheim

Iowa State: M. Sanchez

IPMU/Tokyo: M. Vagins

Irvine: G. Carminati, W. Kropp, M. Smy, H. Sobel

Kansas State: T. Bolton, G. Horton-Smith

LBL: R. Kadel, B. Fujikawa, D. Taylor

Livermore: A. Bernstein, R. Bionta, S. Dazeley, S. Ouedraogo

London-UCL: J. Thomas

Los Alamos: S. Elliott, A. Friedland, V. Gehman, G. Garvey, T. Haines, D. Lee, W. Louis, C. Mauger, G. Mills, A. Norrick, Z. Pavlovic, G. Sinnis, W. Sondheim, R. Van de Water, H. White

Louisiana State: W. Coleman, T. Kutter, W. Metcalf, M. Tzanov

Maryland: E. Blaufuss, R. Hellauer, T. Straszheim, G. Sullivan

Michigan State: E. Arrieta-Diaz, C. Bromberg, D. Edmunds, J. Huston, B. Page

Minnesota: M. Marshak, W. Miller

MIT: W. Barletta, J. Conrad, T. Katori, R. Lanza, L. Winslow

NGA: S. Malys, S. Usman

New Mexico: B. Becker, J. Mathews

Notre Dame: J. Losecco

Oxford: G. Barr, J. DeJong, A. Weber

Pennsylvania: J. Klein, K. Lande, A. Mann, M. Newcomer, S. Seibert, R. vanBerg

Pittsburgh: D. Naples, V. Paolone

Princeton: Q. He, K. McDonald

Rensselaer: D. Kaminski, J. Napolitano, S. Salon, P. Stoler

Rochester: R. Bradford, K. McFarland

SDMST: X. Bai, R. Corey

SMU: T. Liu, J. Ye

South Carolina: H. Duyang, S. Mishra, R. Petti, C. Rosenfeld

South Dakota State: B. Bleakley, K. McTaggart

Syracuse: M. Artuso, S. Blusk, T. Skwarnicki, M. Soderberg, S. Stone

Texas: S. Kopp, K. Lang, R. Mehdiyev

Tufts: H. Gallagher, T. Kafka, W. Mann, J. Schnepps

UCLA: K. Arisaka, D. Cline, K. Lee, Y. Meng, F. Sergiampietri, H. Wang

Virginia Tech: E. Guarnaccia, J. Link, D. Mohapatra, R. Raghavan

Washington: H. Berns, S. Enomoto, J. Kaspar, N. Tolich, H.K. Tseung

Wisconsin: B. Balantekin, F. Feyzi, K. Heeger, A. Karle, R. Maruyama, D. Webber, C. Wendt

Yale: E. Church, B. Fleming, R. Guenette, K. Partyka, J. Spitz, A. Szelc

LBNE: Argonne Role

Inside the box

- Veto detector for Liquid Argon option
 - Jon Paley, L3 manager
- Collaboration management
 - Maury Goodman, Deputy Spokesperson
- Calibration
 - Mayly Sanchez, Calibration coodinator
- Water Cerenkov testing
 - Thinking about a large water test facility at ANL for mounting, pressure, vibrations, water transparency, etc.

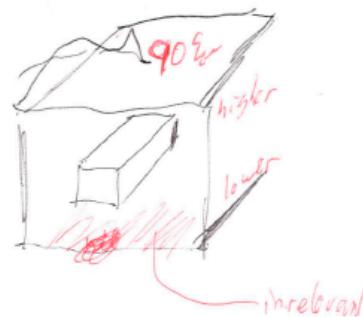
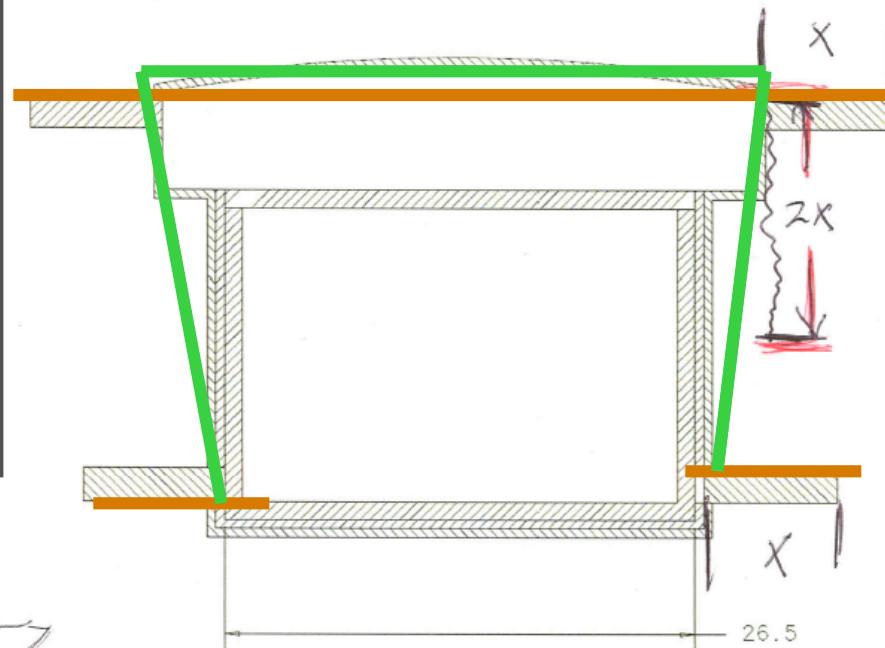
Outside the box

- LAPPD
 - Simulations by Mayly Sanchez & Matt Wetstein
- Wireless electronics & HV
 - LDRD by Zelimir Djurcic
 - Related work of David Underwood
- Water based scintillators
 - Following work at BNL
- Other New Ideas
 - DEAdALUS idea



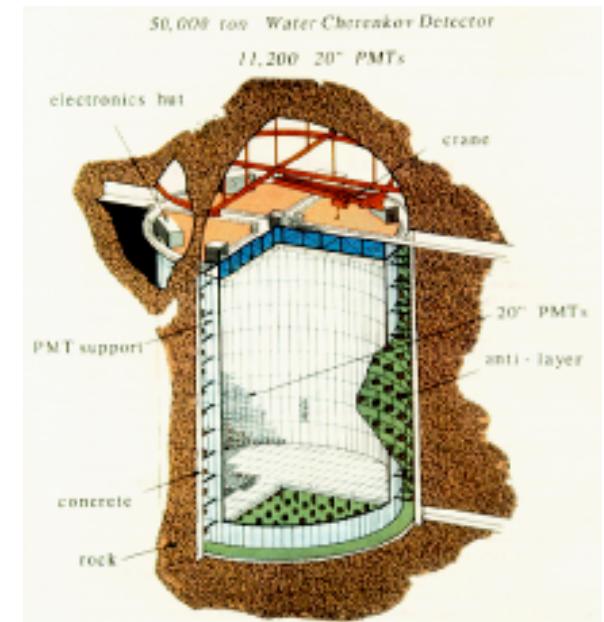
Liquid Argon Veto

- Veto at top & bottom or walls?
- Purpose is to identify muons which might lead to a K_L , which could cause background for proton decay ($p \rightarrow \nu K^+$)
 - Alternative schemes to study:



Possible Water Tank at ANL

- New idea for large water tank (~1000 tons of water) for:
 - Testing mounting prototypes
 - Testing pressure
 - Testing vibrations
 - Testing wireless electronics
 - Testing wired electronics
 - Testing battery sources of power in water
 - Testing water transparency
 - Testing water based liquid scintillator
 - Testing LAPPD compatibility with water
- To be developed and presented at Water Cherenkov workshop in July 2011



Plans



Short Term

- MINOS, Double Chooz and NOvA can keep us quite busy in next 5 years:
 - MINOS: analysis, expect reducing activity in next year.
 - Double Chooz: taking data, expect peak in 2-3 two years.
 - NOvA: very active, will be peaking right after Double Chooz
- LBNE: expect to steadily grow our involvement over a long period (>5 year).
 - Will learn on the size of θ_{13} from current involvement:
 - If θ_{13} is large enough, an ambitious long-baseline program of some is in our future.
 - If θ_{13} is smaller, a slower program to continue pushing the sensitivity will be a top priority.



Longer Term Opportunities

We expect to shape the field and follow new developments to the far future:

- possible evolution of neutrino goals
 - short baseline neutrino workshop discussed follow up on anomalies (LSND, MiniBooNE, MINOS, reactor anomaly)
- possible new techniques
 - LAPPD detector
 - wireless readout
 - LAr development

