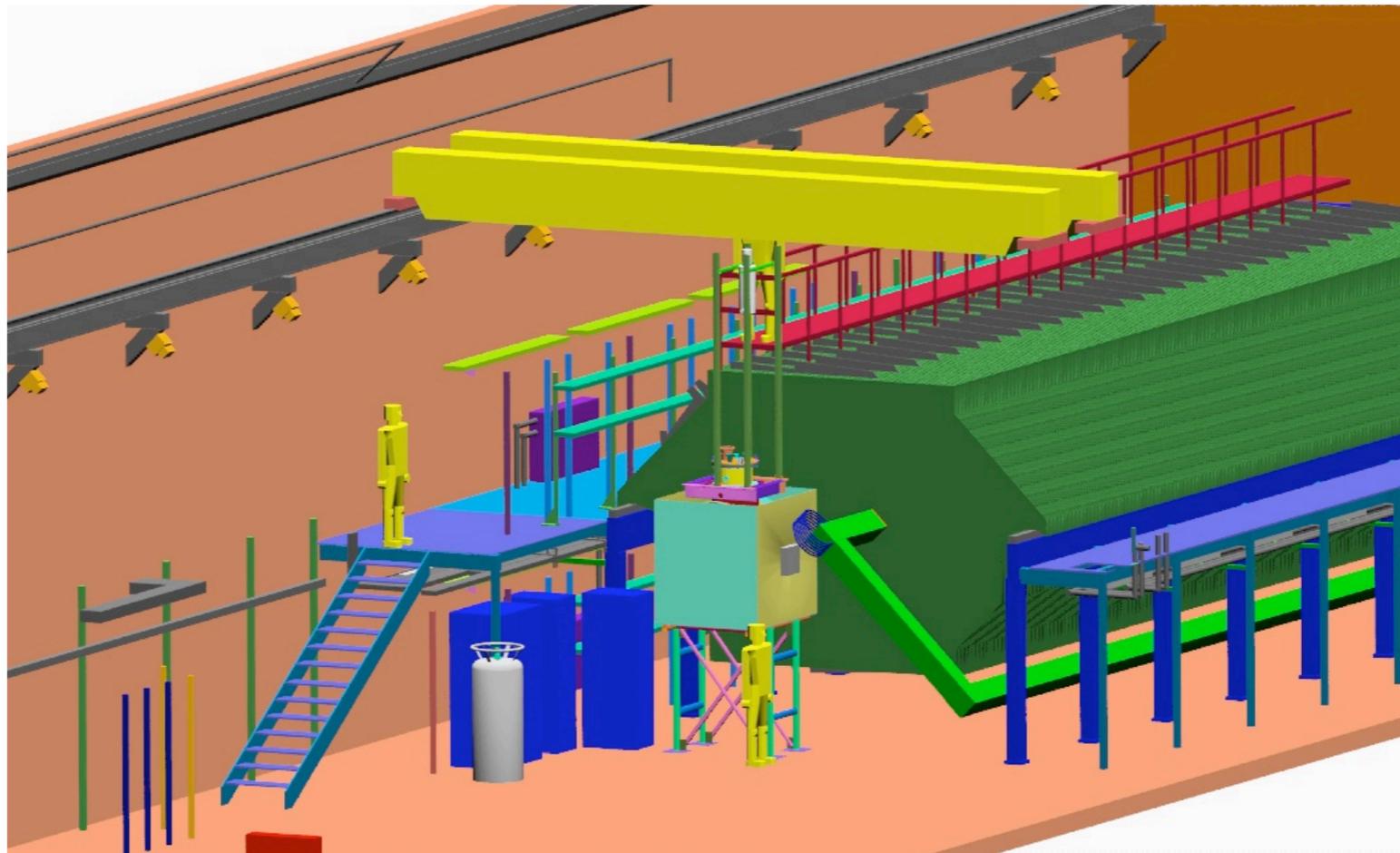




All Experimenter's Meeting
Mitch Soderberg
Yale University
6/1/2009

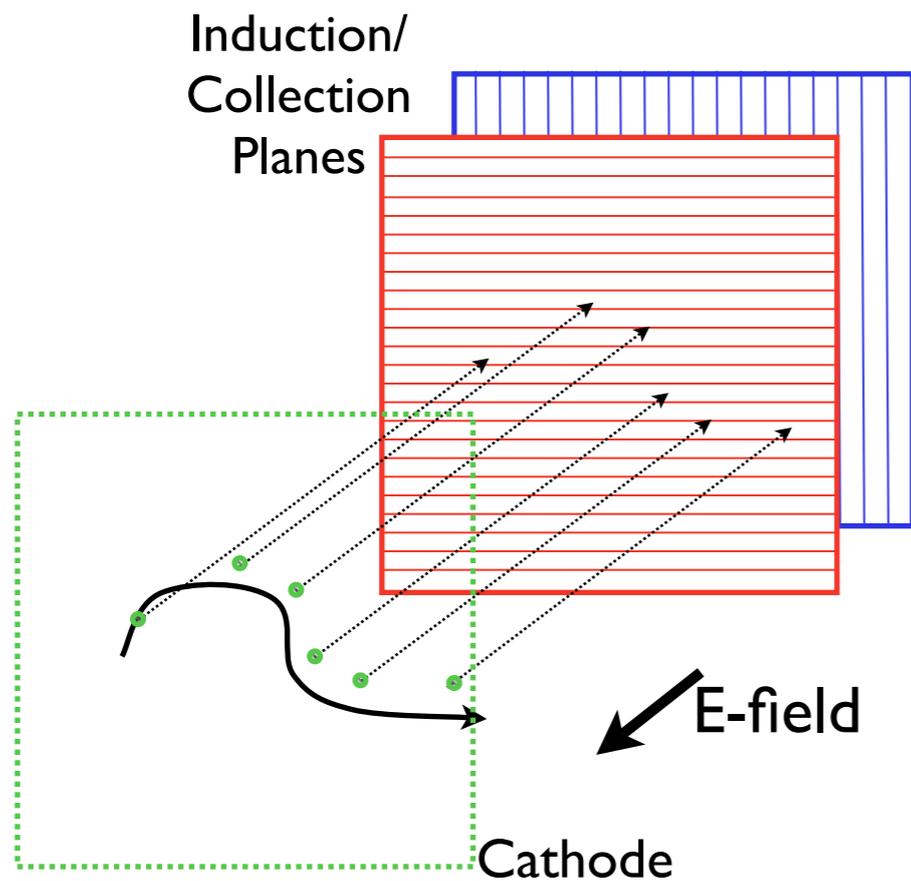
Introduction

- ArgoNeuT (a.k.a. - test experiment T962) is a ~175 liter Liquid Argon Time Projection Chamber
- Sits in front of MINOS near detector in NuMI beamline. Use MINOS as a muon range stack.
- Goals:
 - ▶ Gain experience building/running LArTPCs.
 - ▶ Accumulate a sample of neutrino events.
 - ▶ Confront some aspects of underground running and safety.
 - ▶ Develop simulation of LArTPCs and compare with data.

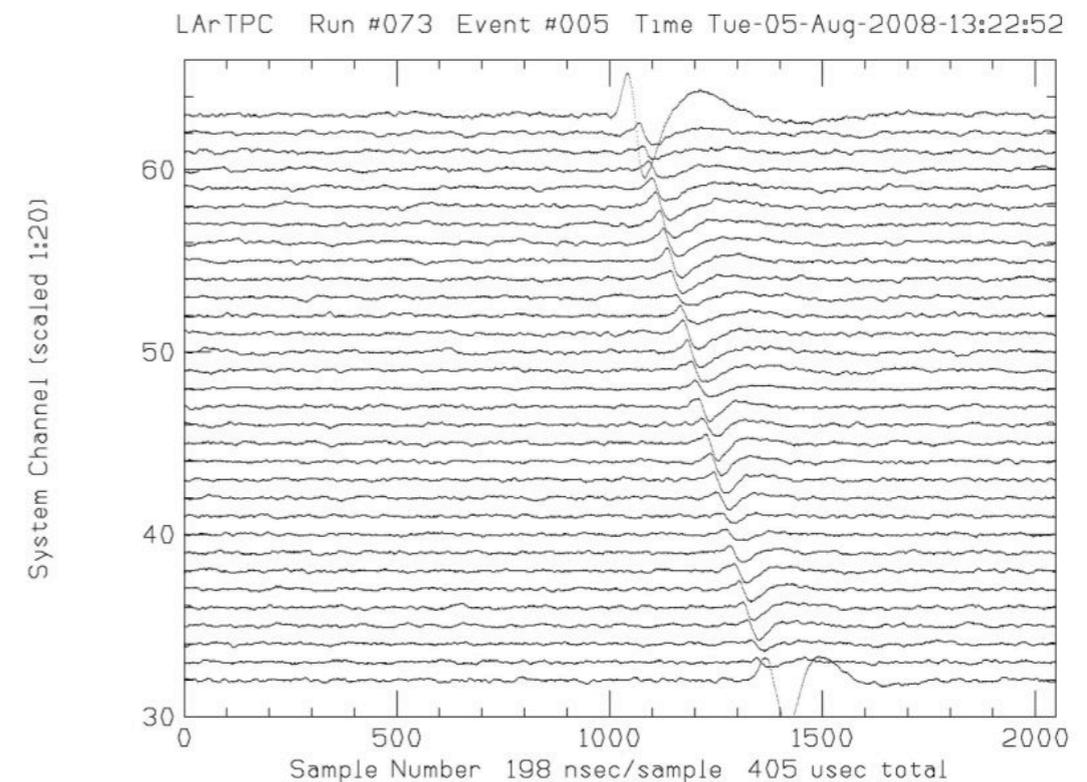


Liquid Argon TPC: Basic Idea

- Interactions inside TPC produce ionization particles that drift along electric field lines to readout planes.
- Scintillation light also present, can be collected by PMTs and triggered on.
- Knowledge of drift speed, T_0 of events, and physical location of wires, can be used to reconstruct interaction.
- Argon is an excellent medium for this technique due to its inert properties.
- Argon must be very clean (ppt) to allow drift over several meters without large attenuation.
- Excellent particle ID capability using dE/dx tag.

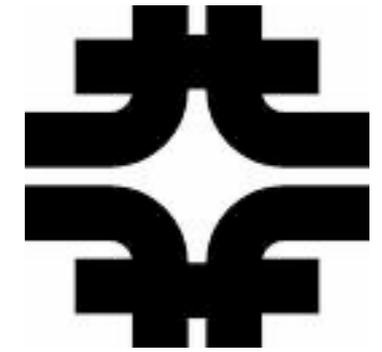


Train of pulses, with time offsets due to different drift lengths.



Event taken with "Bo" detector at PAB.

Collaboration



F. Cavanna
University of L'Aquila

B. Baller, C. James, G. Rameika, B. Rebel
Fermi National Accelerator Laboratory

M. Antonello, R. Dimaggio, O. Palamara
Gran Sasso National Laboratory

C. Bromberg, D. Edmunds, P. Laurens, B. Page
Michigan State University

S. Kopp, K. Lang
The University of Texas at Austin

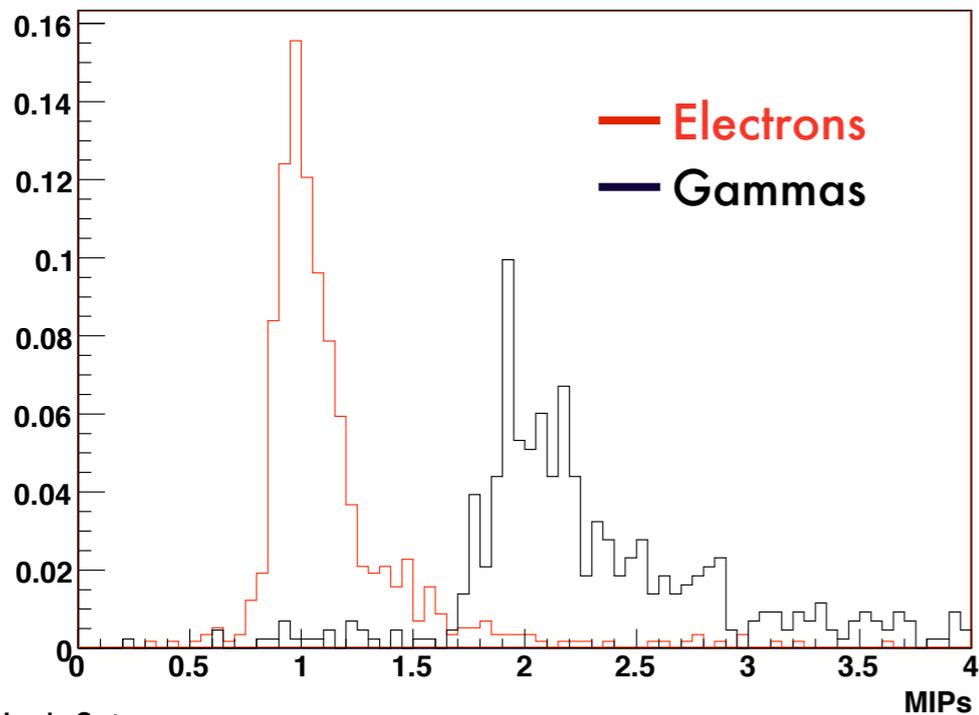
C. Anderson, B. Fleming*, S. Linden, M. Soderberg, J. Spitz
Yale University

Physics Goals

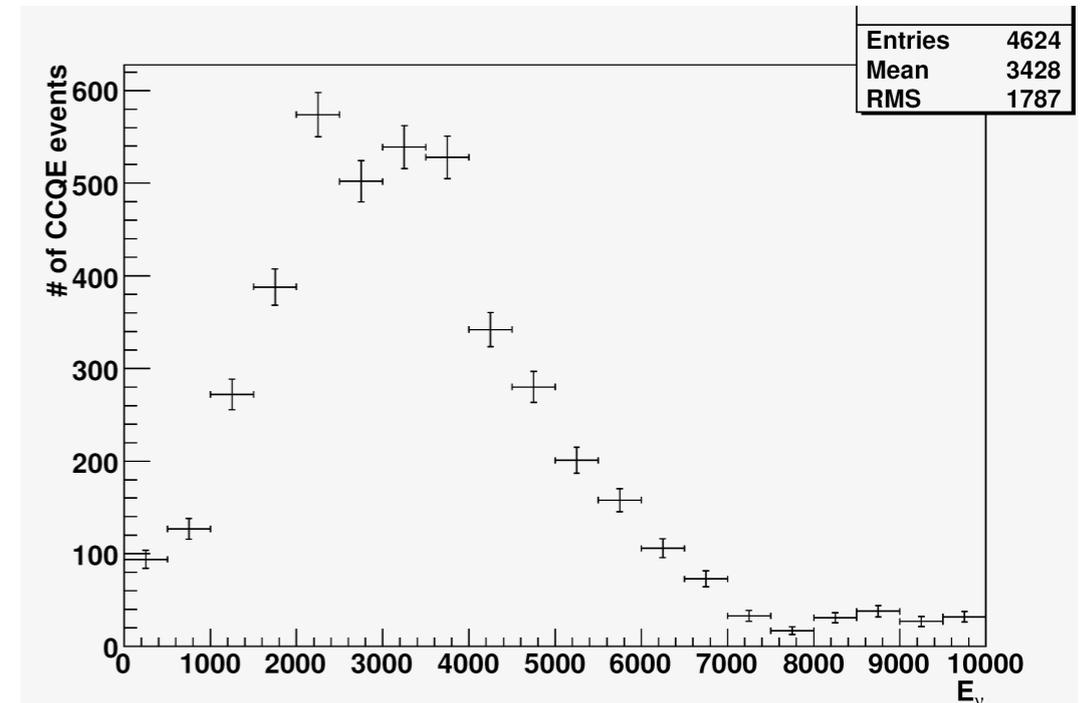
Event Type	# in ArgoNeuT/day (0.8×10^{17})
ν_μ CC	160
$\bar{\nu}_\mu$ CC	14
ν_e CC	3
NC	54
Total	231

Expected event rate

Energy loss in the first 24mm of track: 250 MeV electrons vs. 250 MeV gammas



Josh Spitz

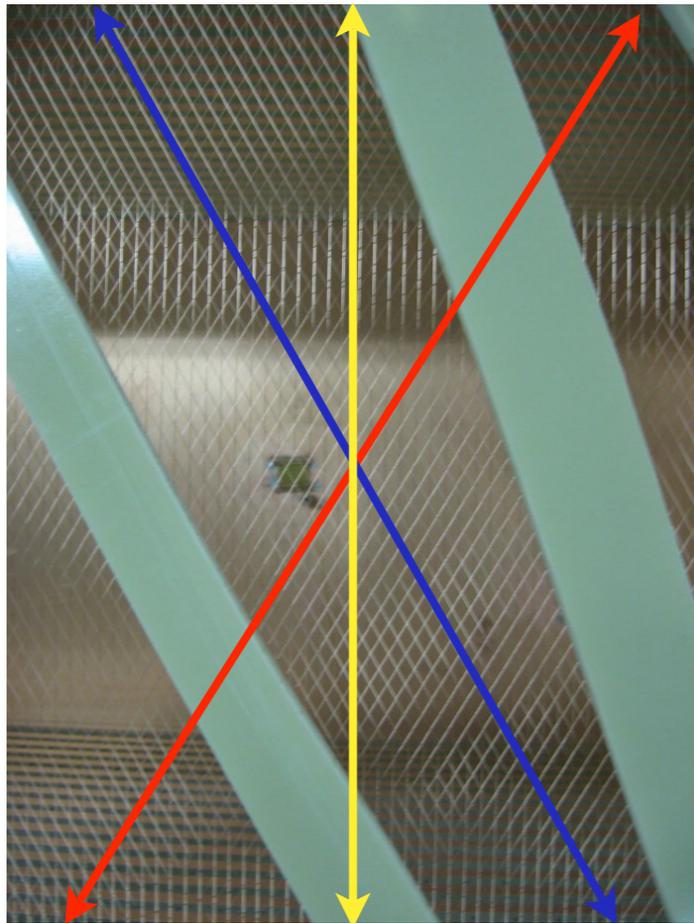


Josh Spitz

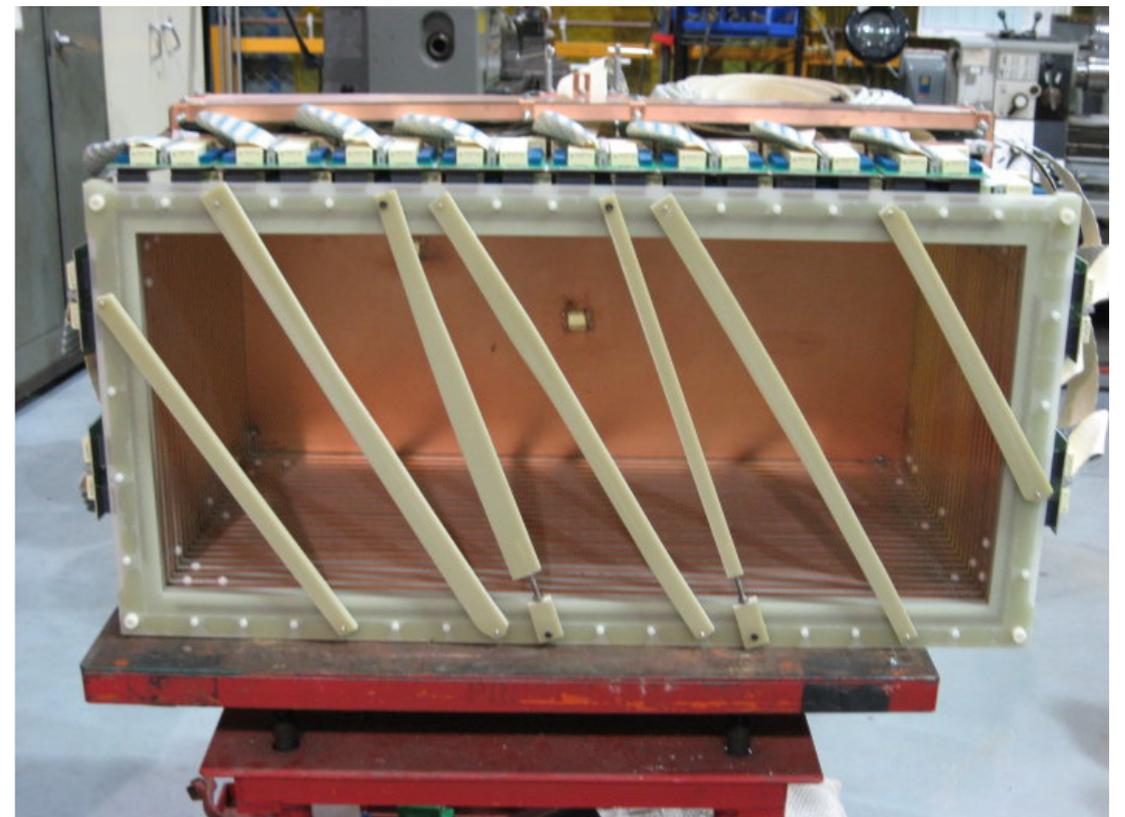
- Electron/gamma separation - Study capability of LArTPCs using dE/dx tag.
- Collect large sample of CCQE events, measure cross-section
- Develop realistic simulation of LArTPCs
- Develop reconstruction algorithms.

ArgoNeuT Detector

- 175 liter active volume in TPC
- 480 channels of electronic readout built by MSU.
- Collection, Induction2, Induction1 planes. Wires at $\pm 60^\circ$
- 4mm wire pitch, 4mm plane spacing.
- 500V/cm electric field, Max. drift of ~ 50 cm.
- Purity monitor for measuring impurities in liquid argon.



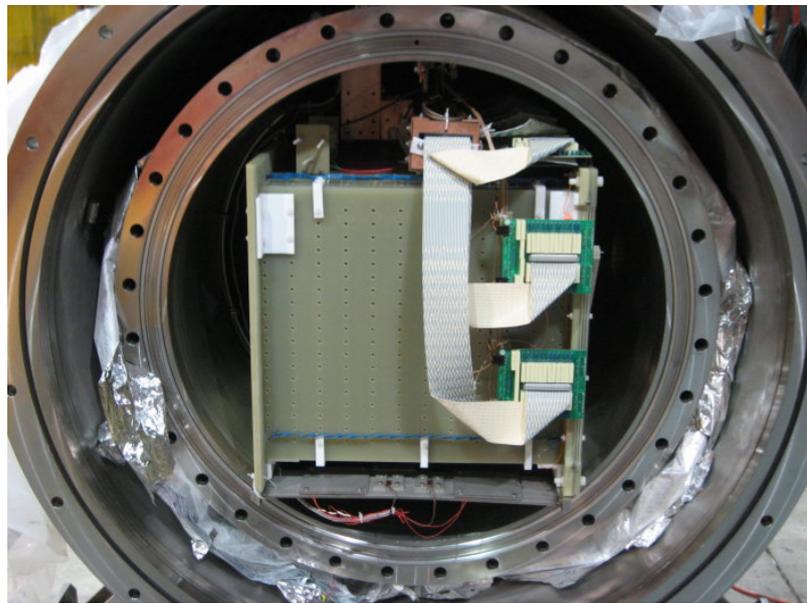
Wire Orientations



TPC with readout cables

ArgoNeuT Detector

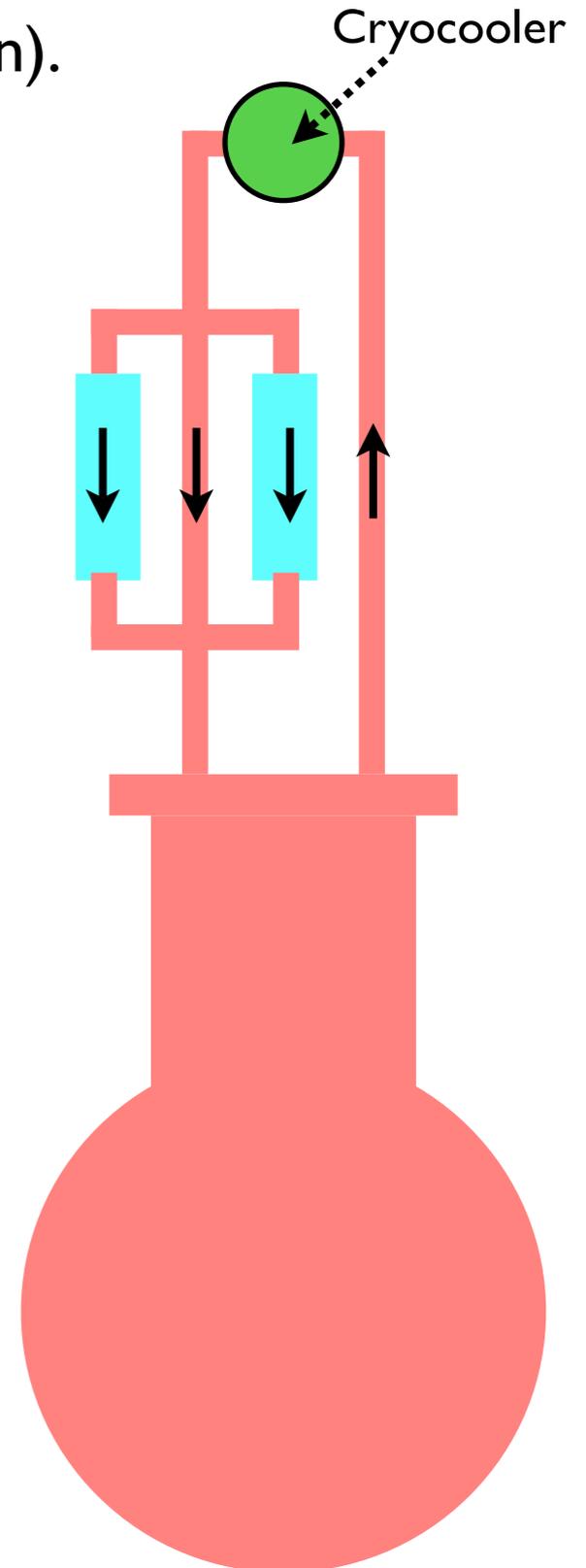
- Self-contained cryogenic system (*i.e.* - maintain constant Argon supply).
- Recirculate argon through filters to remove impurities (e.g. - Oxygen).
- Cryocooler used to condense boil-off gas.
- Vacuum-jacketed cryostats/pipes for insulation.
- Multiple relief paths to achieve safe running.



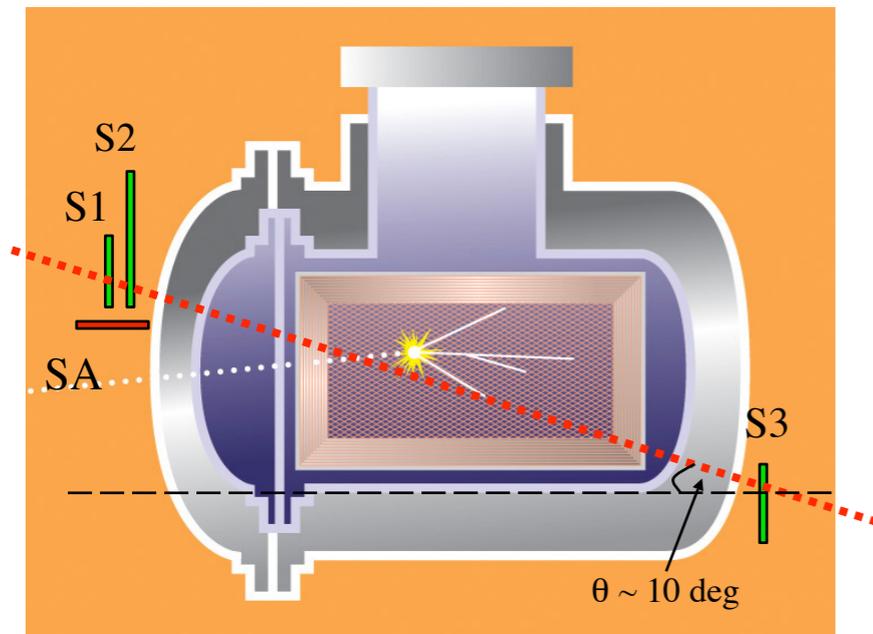
Vacuum-insulated vessel.



ArgoNeuT at PAB.

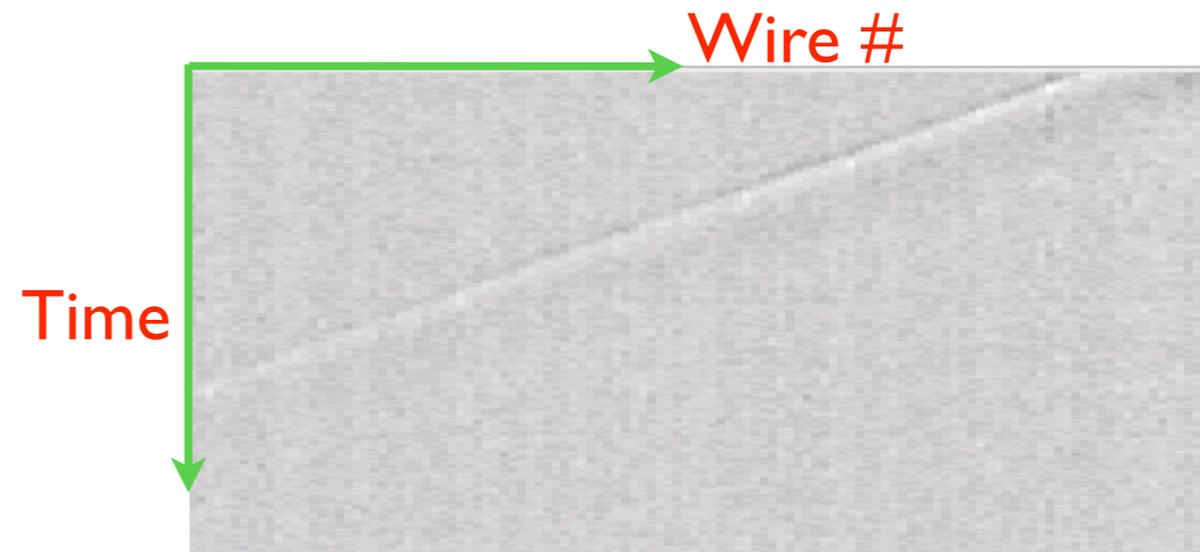


Commissioning: Aug.5-Sep.18, 2008

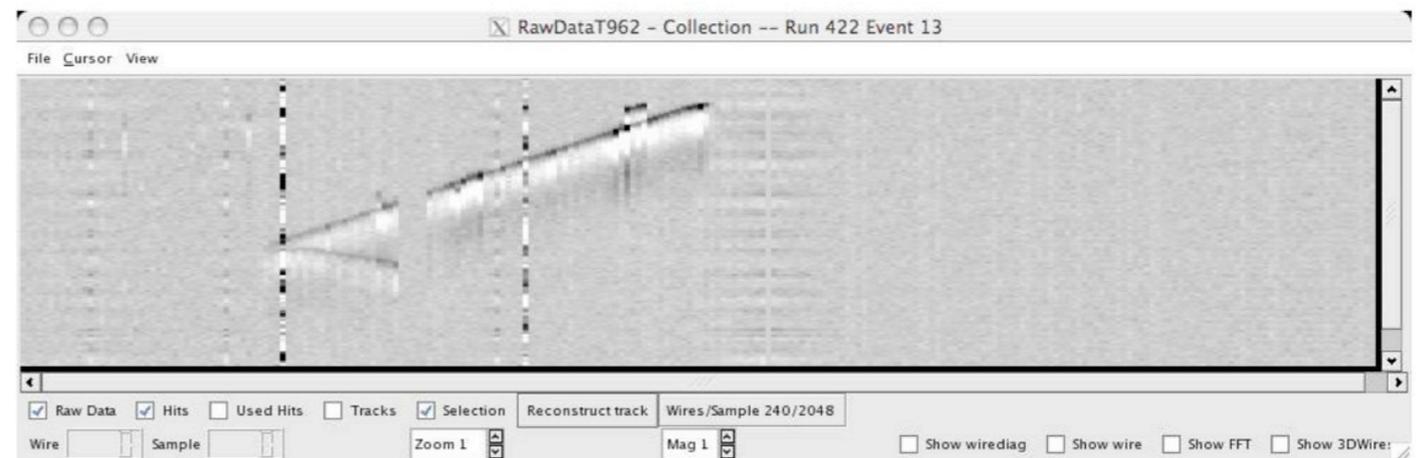
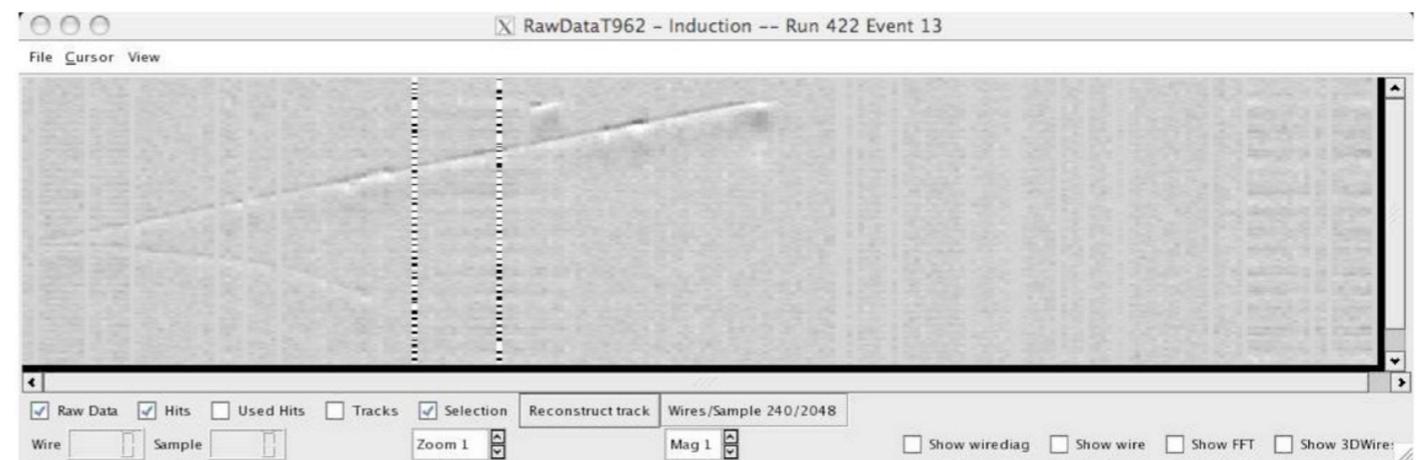


Cosmic Trigger for Commissioning

Noisy channels due to readout cables getting damaged during commissioning install. All cables have since been replaced.



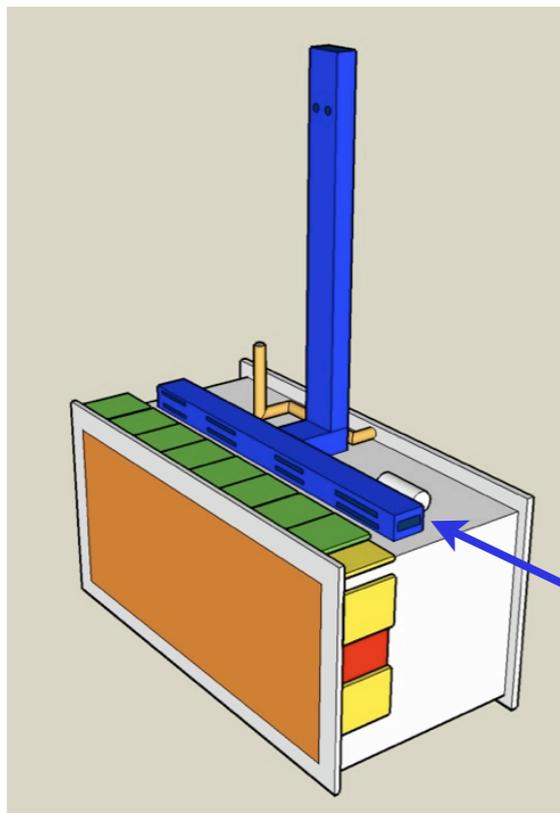
Induction View of Cosmic muon event



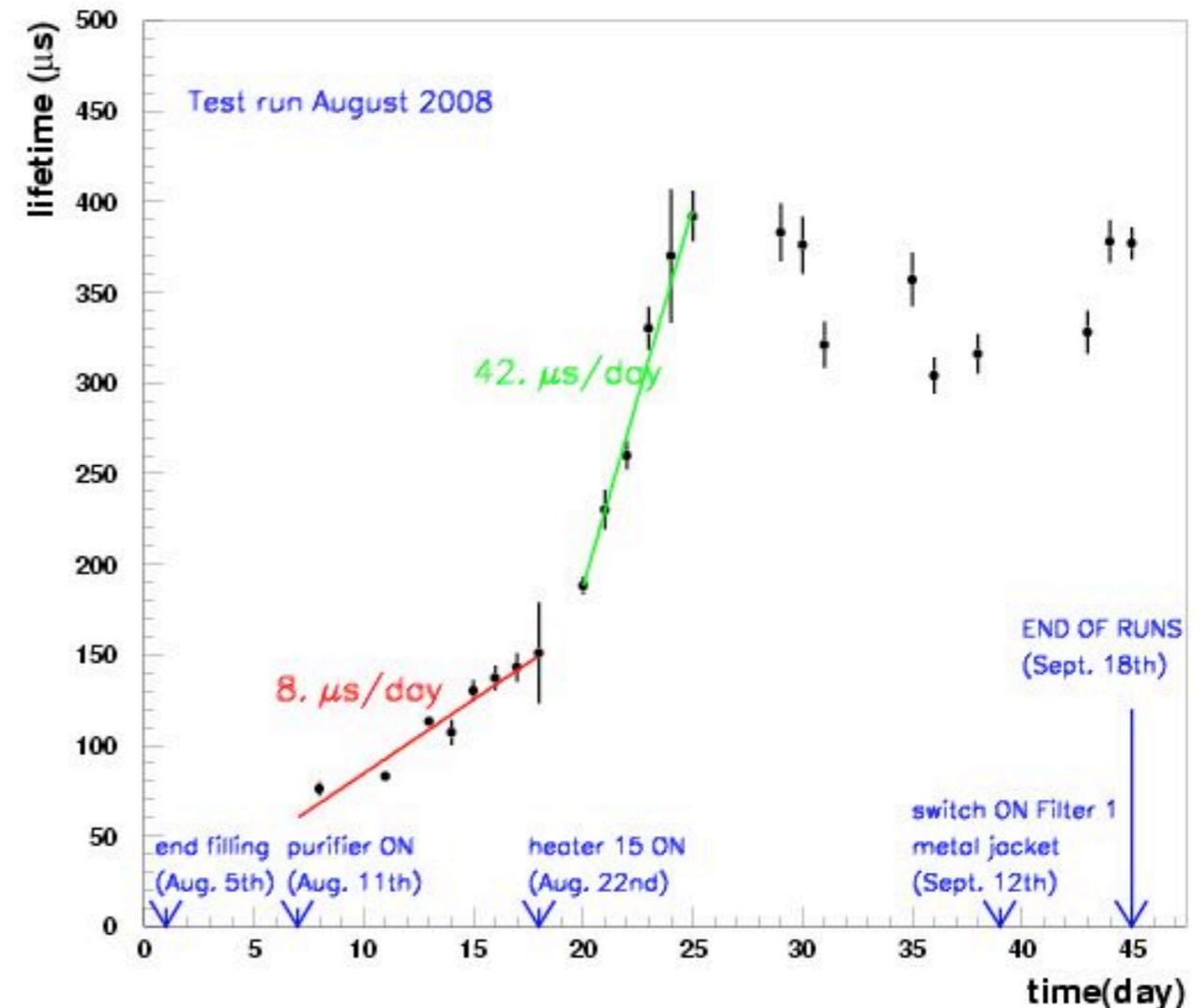
Collection/Induction views of Commissioning Event

Commissioning: Lessons

Problem	Solution
Can't ramp HV above 5kV	Built New HV Feedthrough
Bad Channels	Replaced Cables, Added Cable-Tray
No Signal on Purity Monitor	Built new fiber-optic feedthrough
Low Purity	Rerouted Internal Plumbing; Added Sieve
Inaccurate Temp. readings	Added new / calibrated thermocouples



Added cable-tray to protect/control cables



Initial purity in the cryostat was low, but adjusting settings of cryo. system showed ability to clean it.

Underground Operation

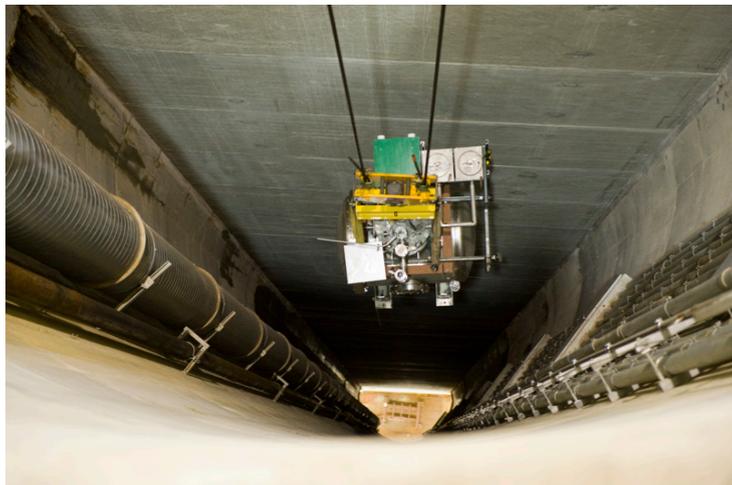
Many safety issues addressed to prepare for underground operation that maintains ODH-0 rating of tunnel:

- ArgoNeuT sits in a mixing bathtub, which acts as tertiary containment in case both cryostats fail.
- Relief piping is routed to vent line (runs up and out shaft), to ensure no argon released in tunnel.
- All possible trapped volume spaces routed to vent line.
- 2 ODH monitors to alarm if leak is detected.
- Slow control system in tunnel, and online, to alert of any ODH hazards.



Status

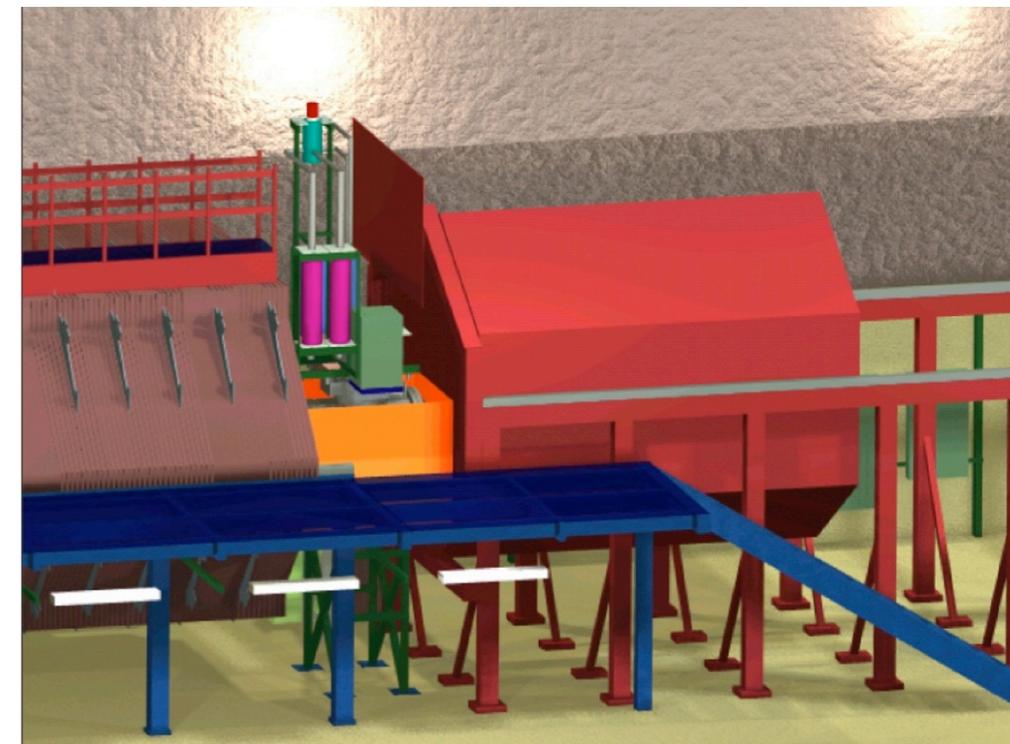
- Modifications based on commissioning run, and reassembly underground took several months.
- Lots of effort went into getting approved for operation underground...many Fermilab people helped out in this process.
- Filled the cryostat underground Friday, May 8.
- Solved many problems since commissioning run (HV, cabling, purity monitor, etc...).
- Initial argon purity low....currently recirculating to clean things up. Based on our experience at PAB, and the improvement we already see, we have confidence this will work.
- Shutdown is in 2 weeks....will try to collect as many events as we can.
- Plan is to run through end of 2009, into 2010.



Moving underground



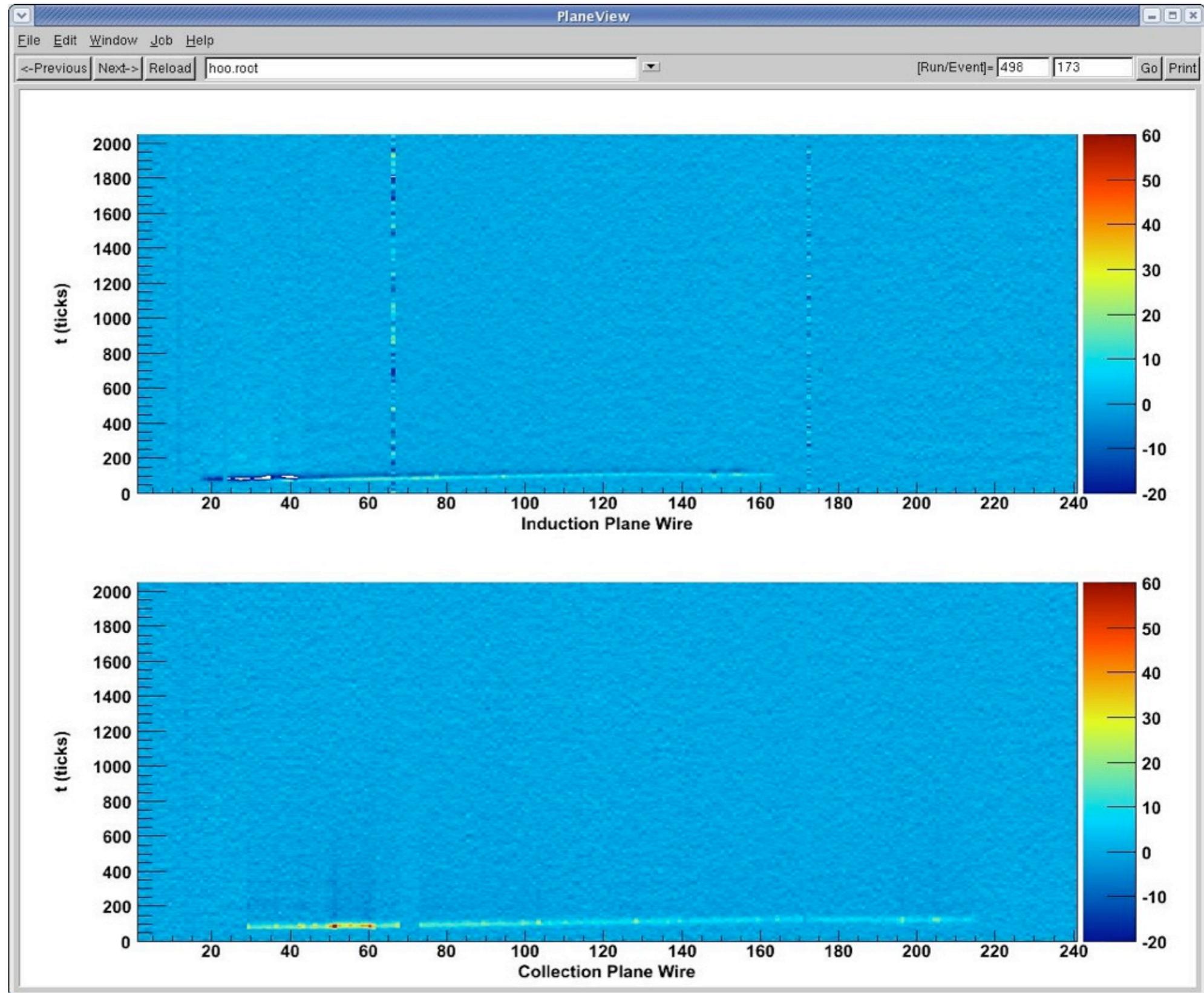
Looking through Minerva frame.



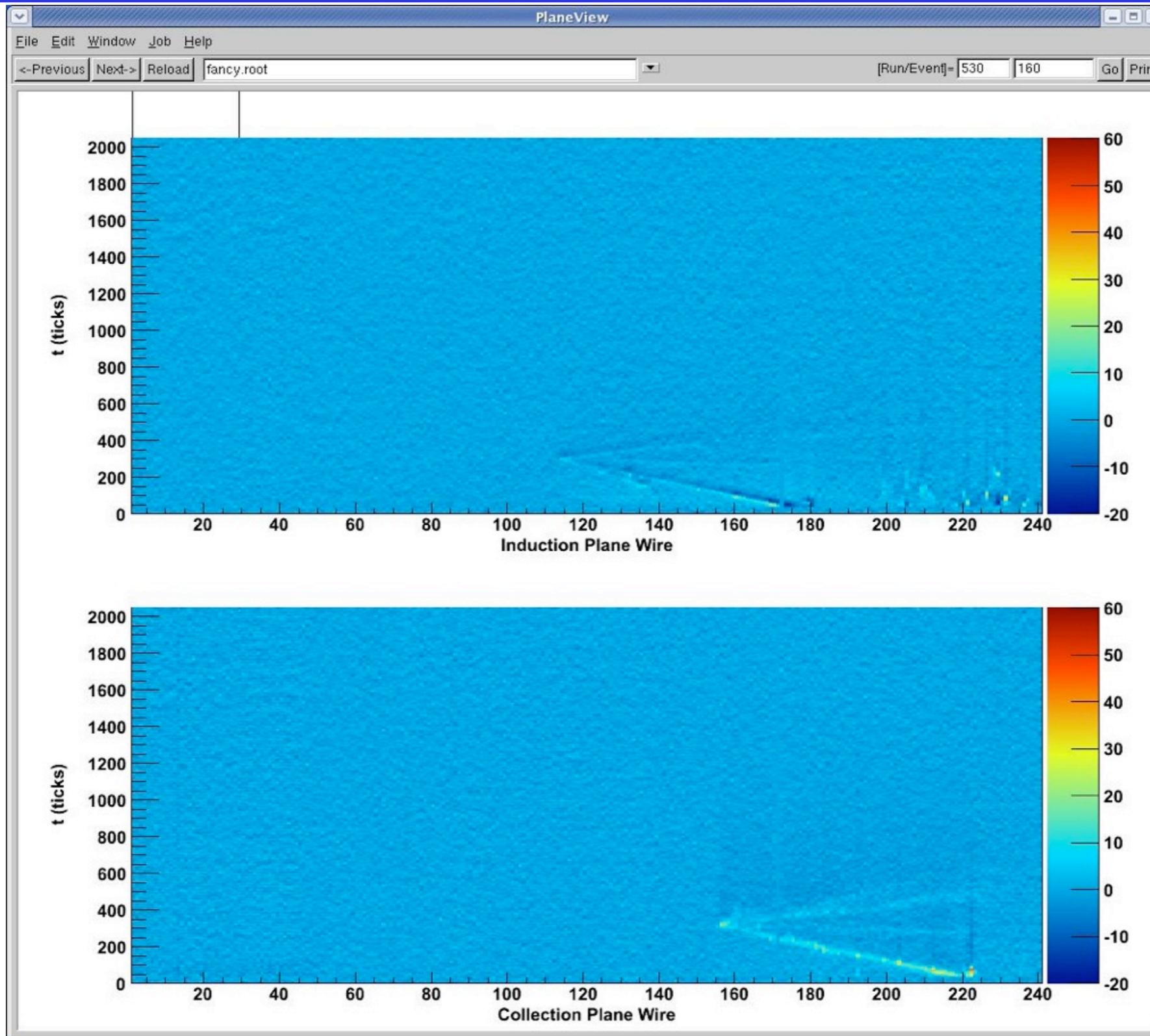
Schematic of NuMI experiments

Events

May 15, 2009
One of our first events...
a muon close to the
wireplane

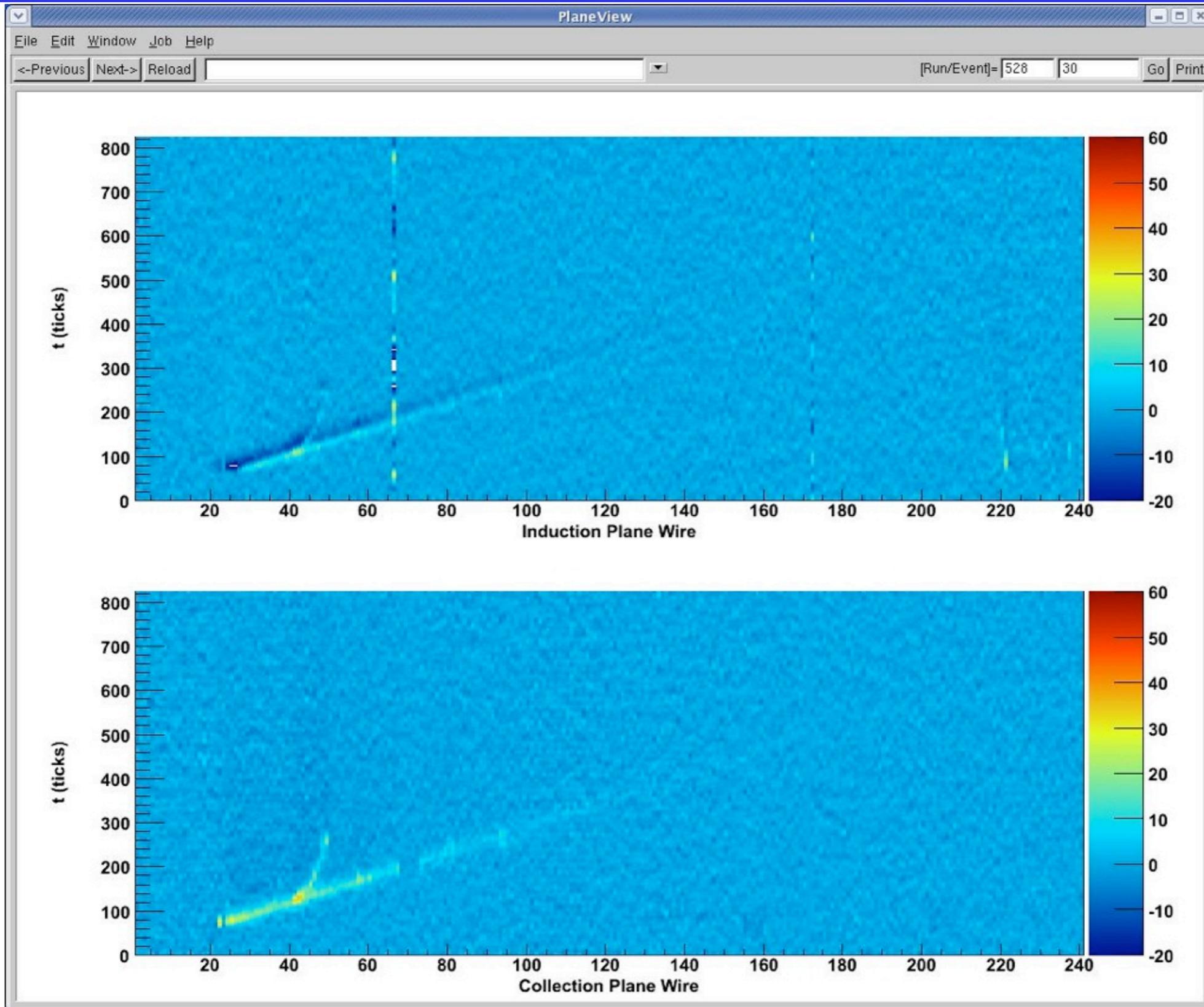


Events



Neutrino candidate (May 27, 2009)

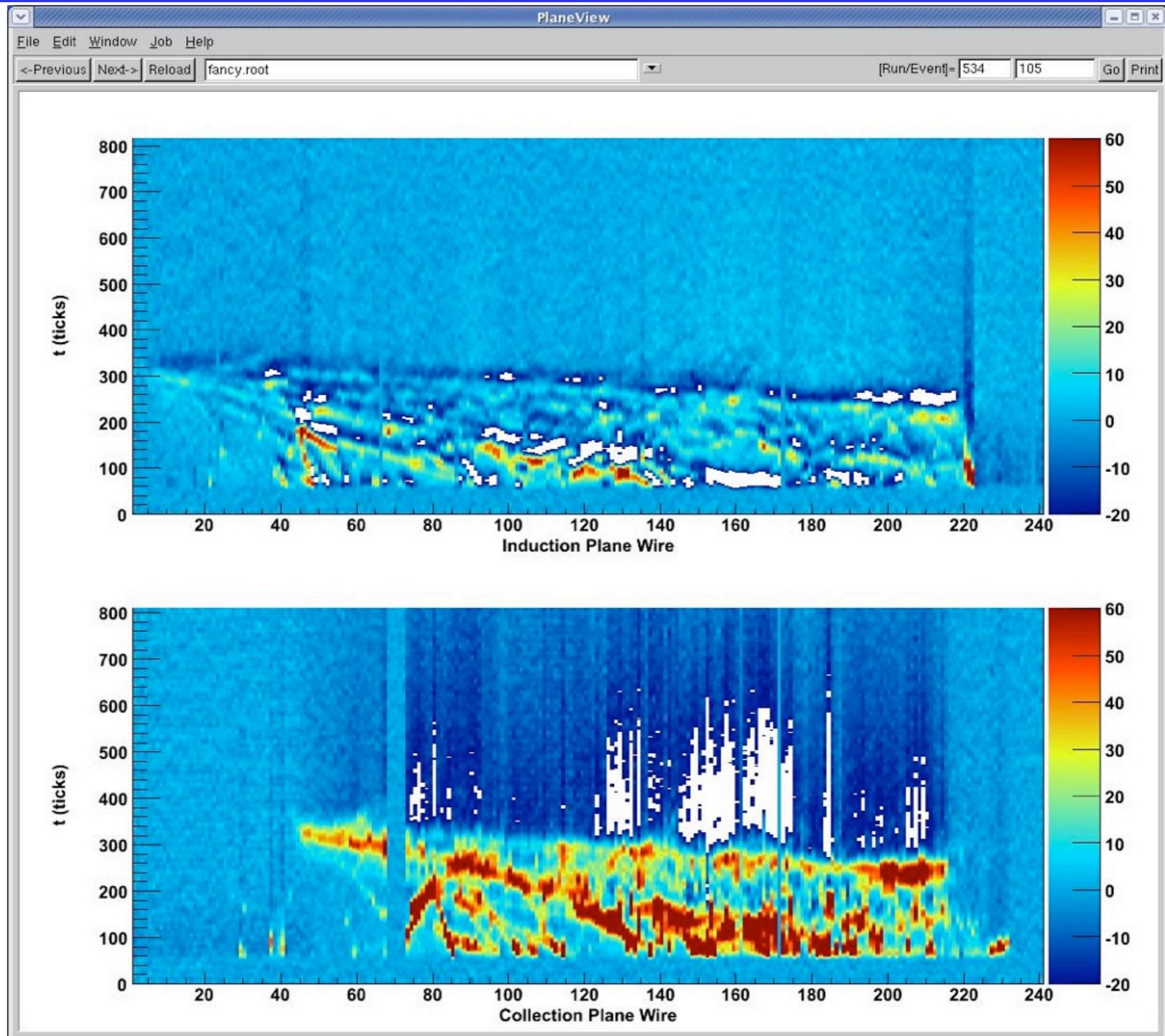
Events



Muon with delta-ray (May 26, 2009)

Events

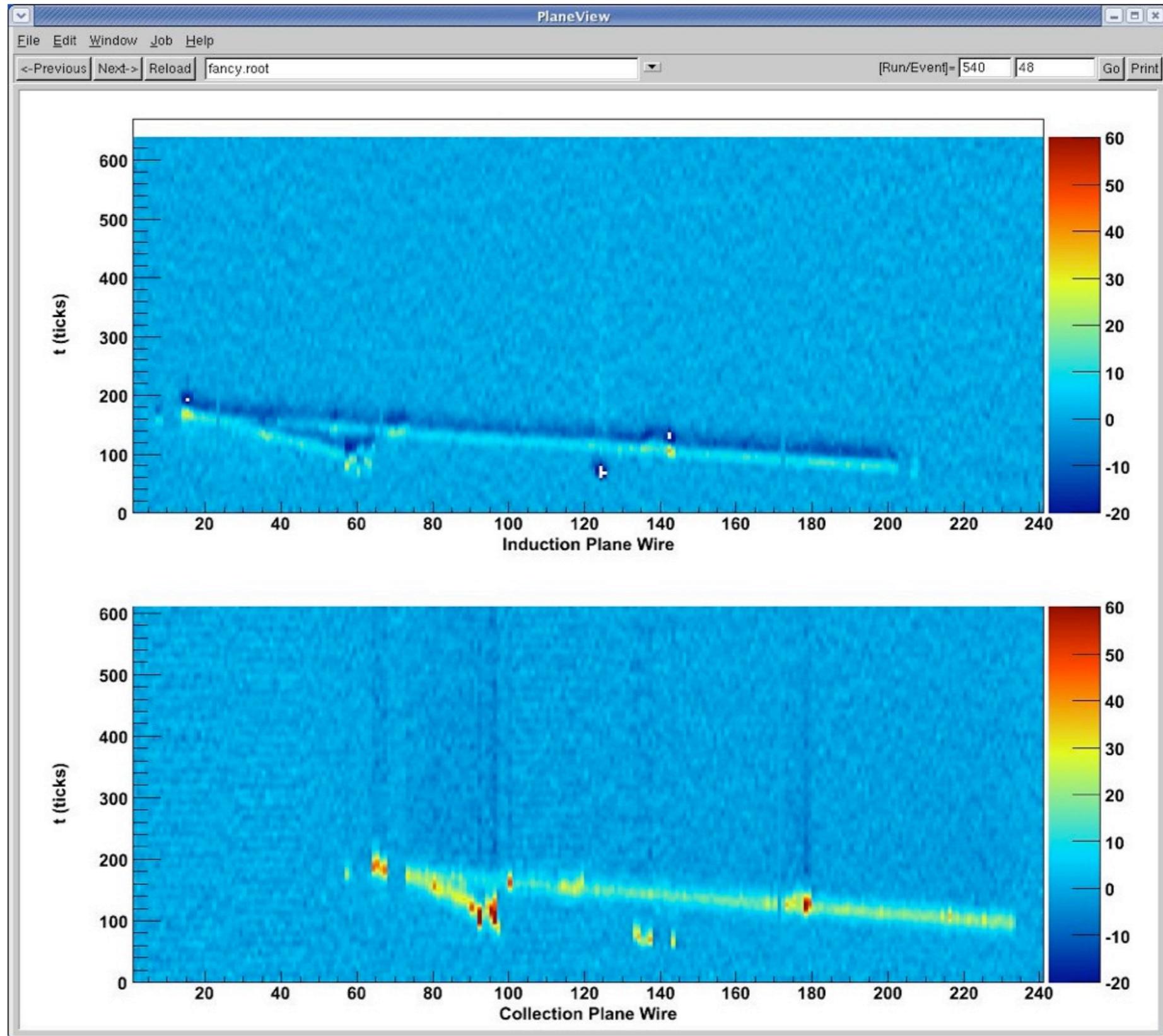
Possible neutrino event...lots of energy deposited. (May 28, 2009)



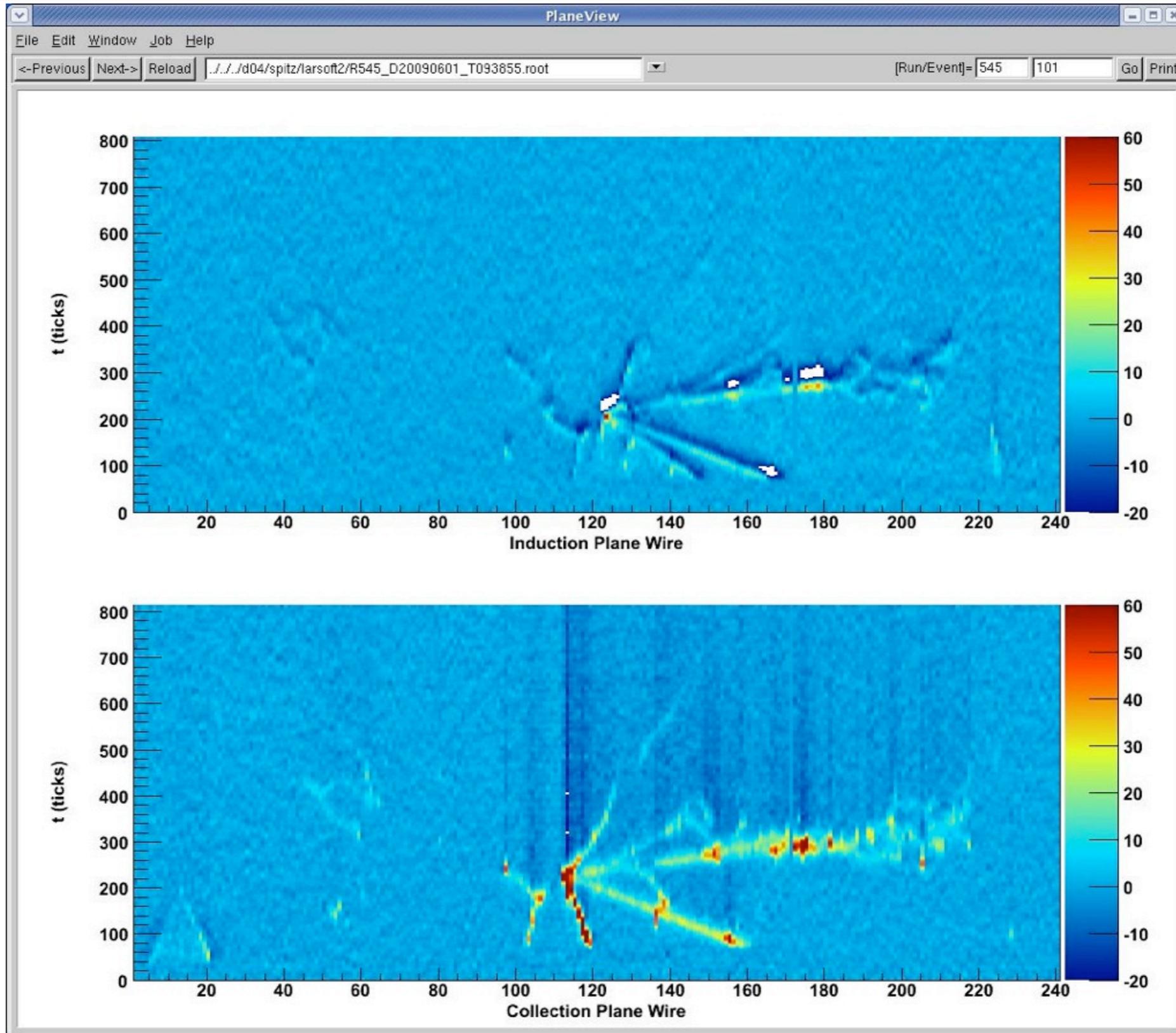
(White bins are off-scale...need to work on event display to fix this.)

Events

Possible neutrino event...quasi-elastic?
(May 29, 2009)

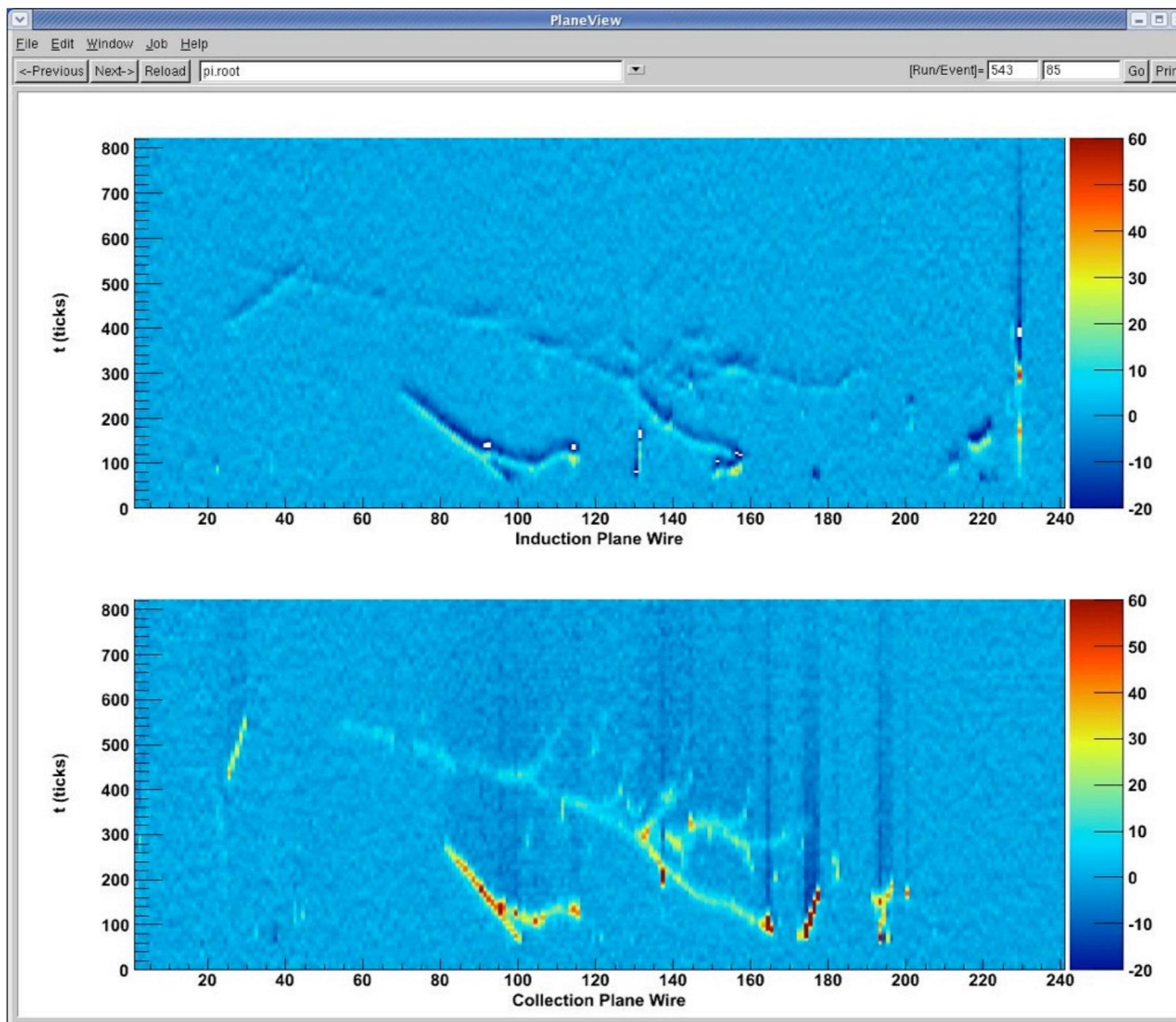


Events



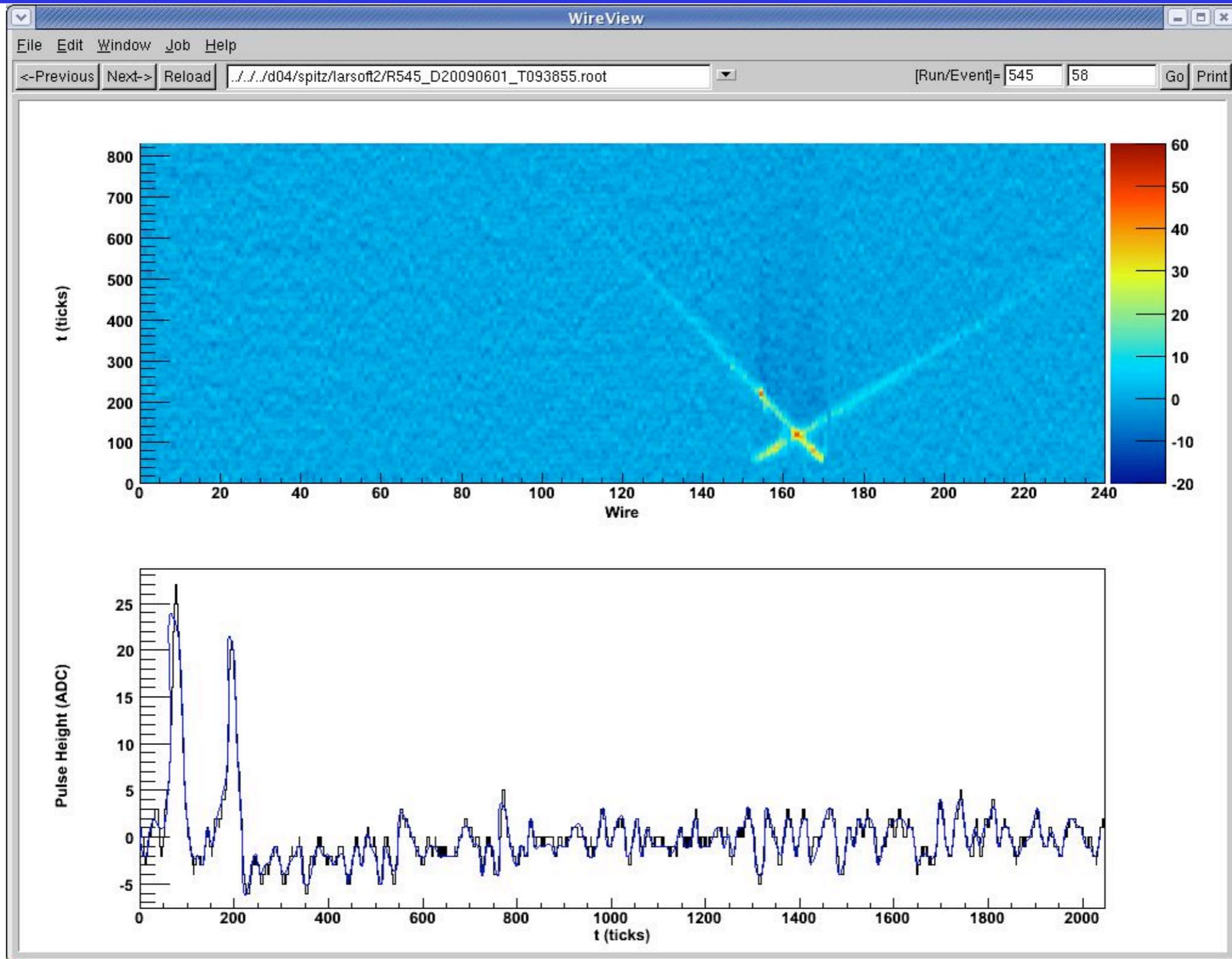
Neutrino Candidate (from this morning)

Events



Pion Candidate? (from this morning)

Events



Muons (from this morning)

Thanks!

- Thanks to the accelerator division for all those neutrinos ;-)
- We've tapped into **lots** of Fermilab talent to get to where we're at.
- Here is a (probably incomplete) list of Fermilab employees who have contributed to ArgoNeuT.

- ★Otto Alvarez
- ★Mike Andrews
- ★Scott Carlson
- ★John Cornele
- ★Curtis Danner
- ★Dave Erickson
- ★Bryan Falconer
- ★Dwight Featherston
- ★Kelly Hardin
- ★Walt Jaskierny
- ★Hans Jostlein
- ★Cary Kendziora
- ★Andrew Lathrop
- ★Dan Markley
- ★Tim Martin

- ★Eric McHugh
- ★Chuck McNeal
- ★Bill Miner
- ★Wanda Newby
- ★Tom Olszanowski
- ★Jason Ormes
- ★Vince Pavlicek
- ★Mark Ruschman
- ★Jim Schellpfeffer
- ★Rich Schmitt
- ★Bob Sanders
- ★Mark Shoun
- ★Terry Tope
- ★Jim Tweed
- ★John Voirin

Conclusion

- ArgoNeuT will give us a sample of neutrino events in an LArTPC, for the 1st time in the U.S., and the first time ever in a low-Energy beam.
- Real data/experience is invaluable in improving LArTPC technique.
- We have just started running in the tunnel. Already discussing ways to improve initial argon purity for next fill...want to be ready and waiting with clean argon before beam is turned backed on this Fall.

BACK-UP SLIDES

Noble Liquids: Properties

- Ionization and scintillation light used for detection (transparency to own scintillation).
- Ionization electrons can be drifted over long distances in these liquids.
- Excellent dielectric properties allow these liquids to accommodate very high-voltages.
- Argon is relatively cheap and easy to obtain (1% of atmosphere).



	He	Ne	Ar	Kr	Xe	Water
Boiling Point [K] @ 1 atm	4.2	27.1	87.3	120.0	165.0	373
Density [g/cm ³]	0.125	1.2	1.4	2.4	3.0	1
Radiation Length [cm]	755.2	24.0	14.0	4.9	2.8	36.1
dE/dx [MeV/cm]	0.24	1.4	2.1	3.0	3.8	1.9
Scintillation [γ /MeV]	19,000	30,000	40,000	25,000	42,000	
Scintillation λ [nm]	80	78	128	150	175	