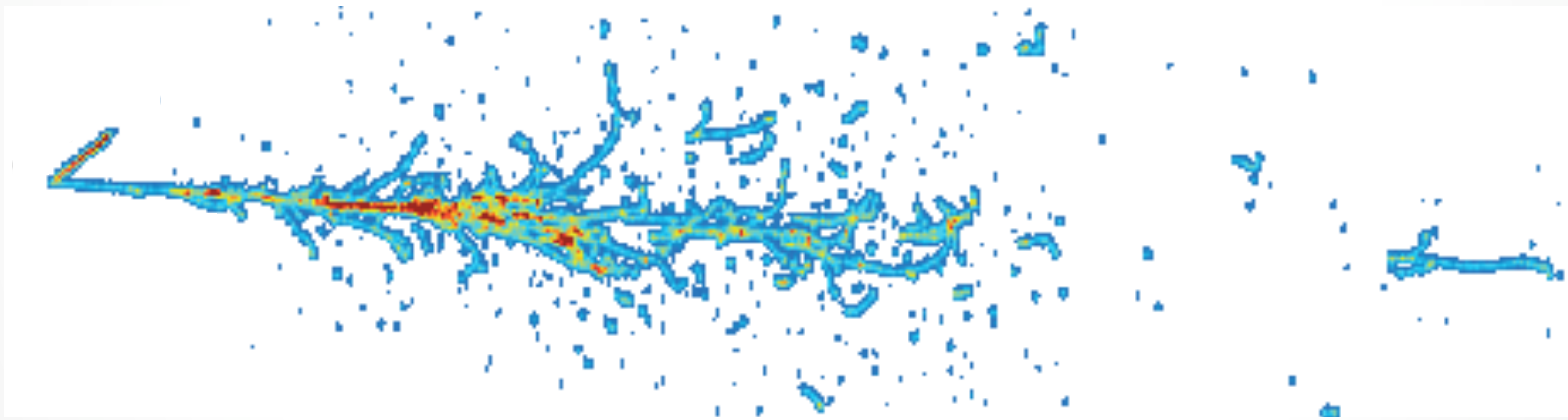
MicroBooNE Status



Jen Raaf

Fermilab Users' Meeting

June 12-13, 2012

MicroBooNE (E-974)

- Liquid Argon Time Projection Chamber (LAr TPC)
  - 170 tons LAr (~84t active)
  - Located on Booster Neutrino Beamline
- Major advance in neutrino detector technology
  - Purity without evacuation
    - Initial demo by LAPD
  - Foam insulation
  - Cold electronics
  - 2.5 m drift distance

See poster #16 (E. Klein)

MicroBooNE Goals

Technology

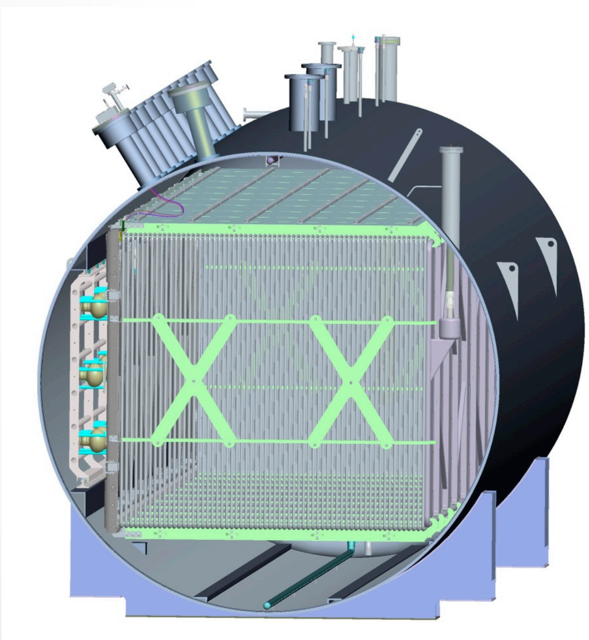
- MicroBooNE will fully test LAr TPC technology at a scope and scale that will help inform the design and operation of much larger LAr TPC detectors for next-generation neutrino oscillation experiments
- Make a major contribution to the development of full reconstruction of neutrino interactions in LAr TPCs

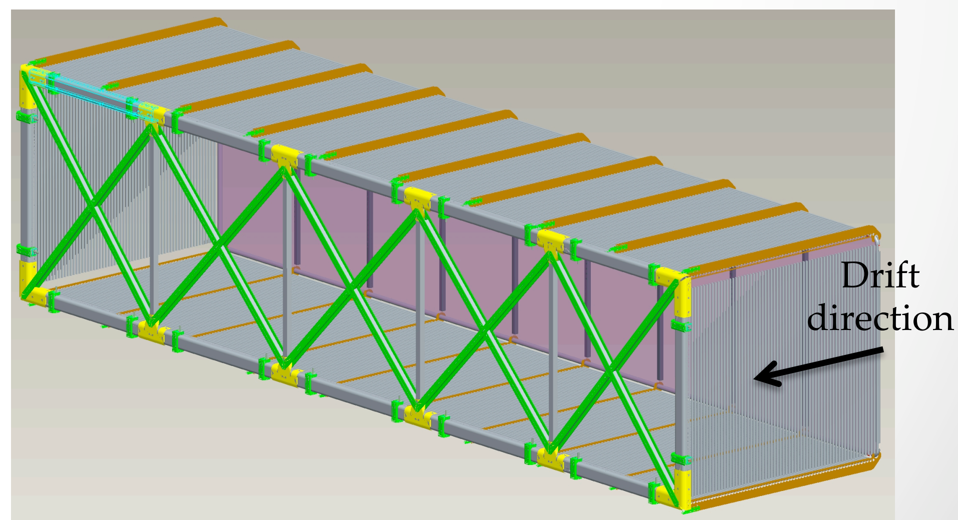
Physics

- Investigate the source of the low energy excess seen by MiniBooNE by using the unique electron/photon discrimination power offered by LAr TPCs
- Make the first high-statistics measurements of neutrino interactions in argon

MicroBooNE Detector

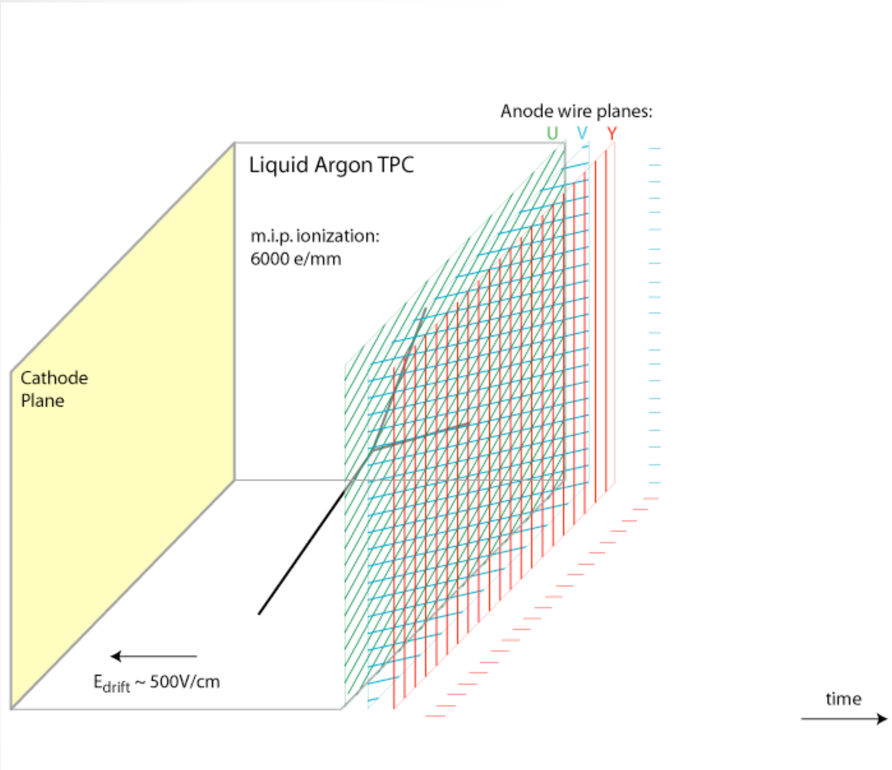
- TPC active volume
  - Length: 10.37 m
  - Height: 2.33 m
  - Width: 2.56 m (drift length)
  - 3 wire planes
    - 2 induction planes
    - 1 collection plane
- Scintillation light detection by PMTs viewing LAr volume through wire planes


TPC in cryostat

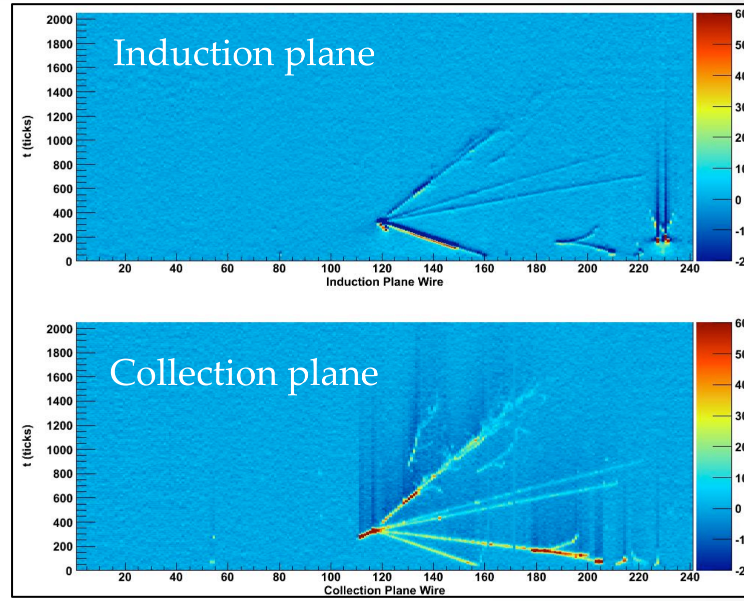


TPC field cage, cathode, & anode planes

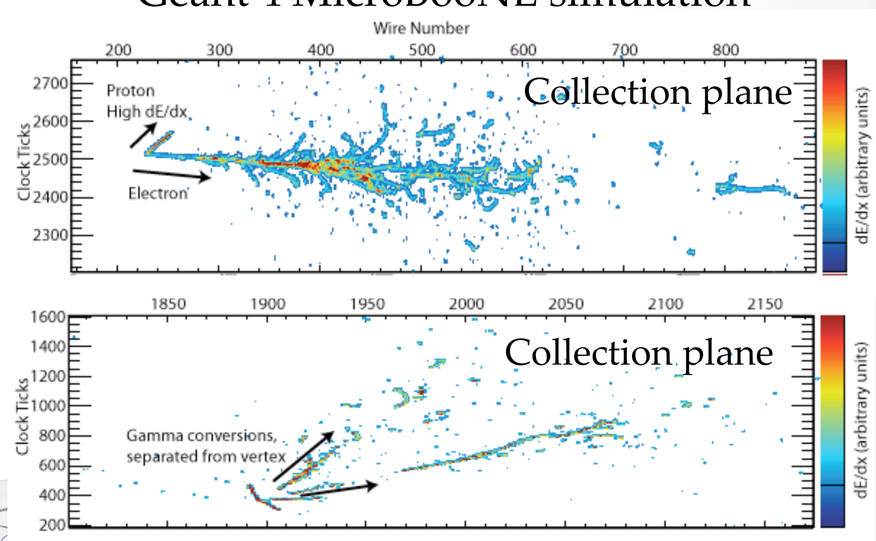
LAr TPC Operation



ArgoNeuT neutrino candiate

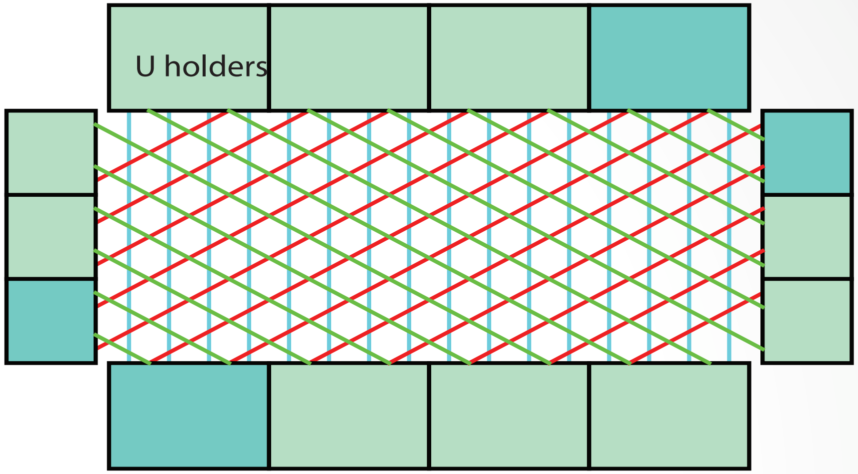


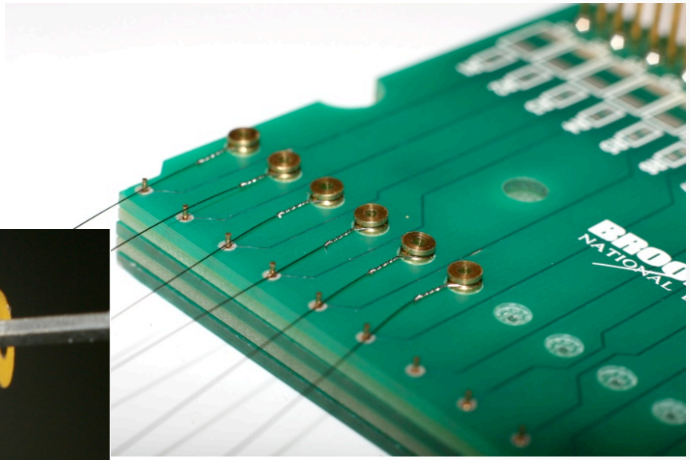
Geant 4 MicroBooNE simulation

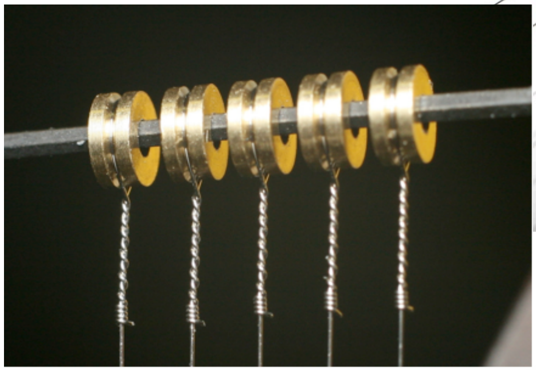


Anode Wire Planes

- 3 wire planes (U,V,Y)
  - Y (3456 wires): vertical
  - U (2400 wires): +60°
  - V (2400 wires): -60°
- 3 mm wire pitch
- Fully automated wire-winding machines @ Yale & Syracuse

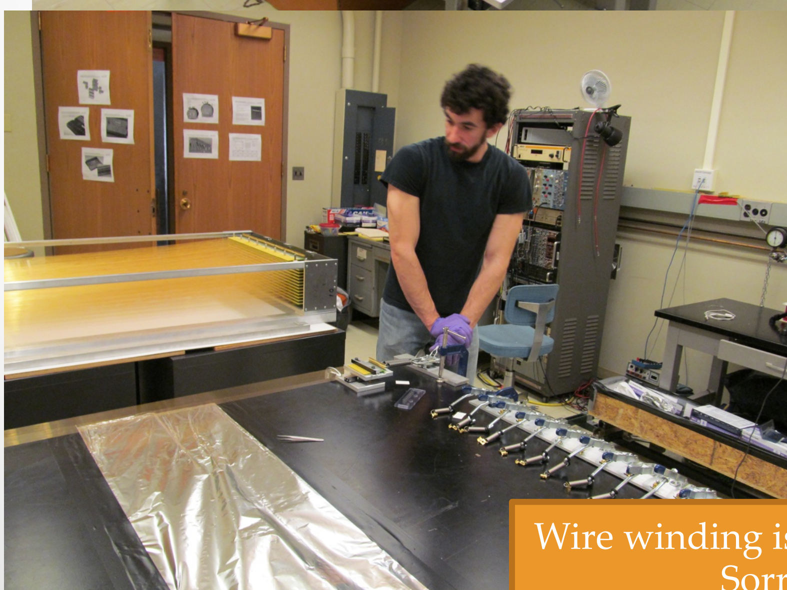






Wire Winding

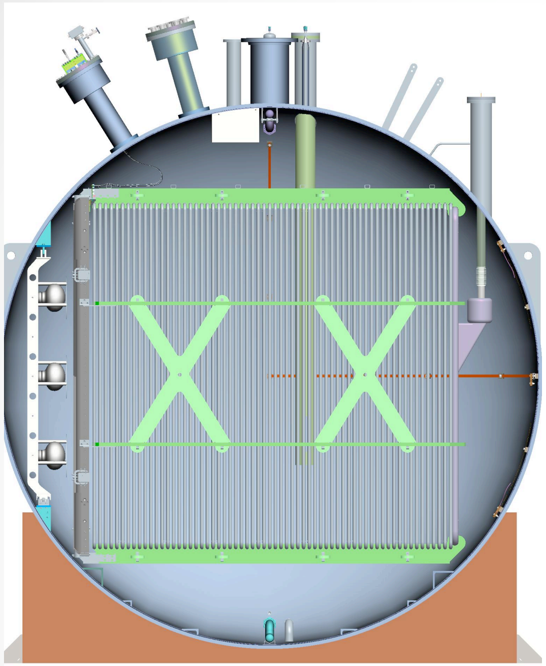
At Syracuse

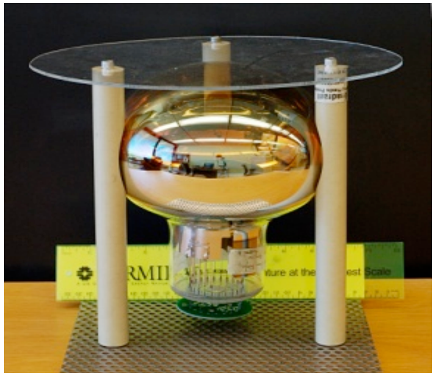


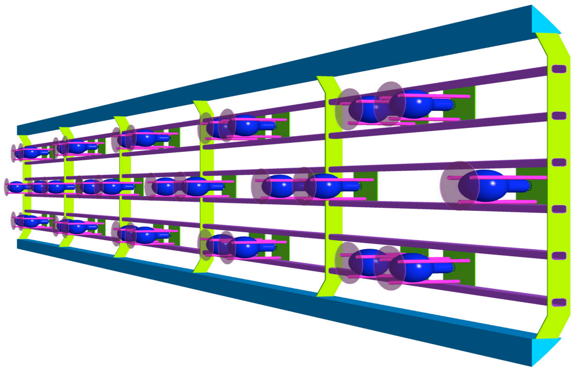
Arrival at FNAL

Wire winding is also ongoing at Yale
Sorry, no pics!

PMT System





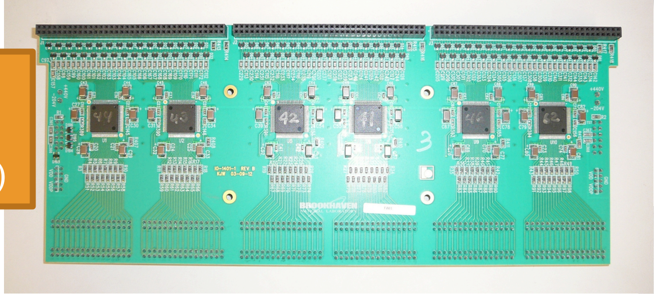


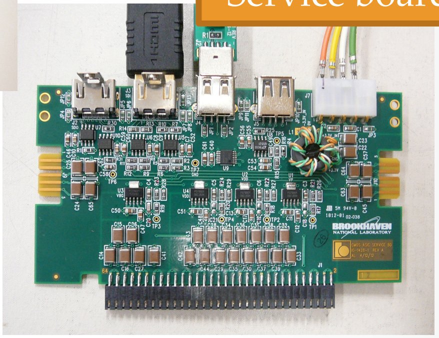
PMT test stand at PAB

- 30 PMTs mounted on a support rack outside the region of the E-field will detect scintillation light
- Ongoing tests by MIT and St. Mary's University of Minn. to study properties of wavelength shifter plates and PMTs

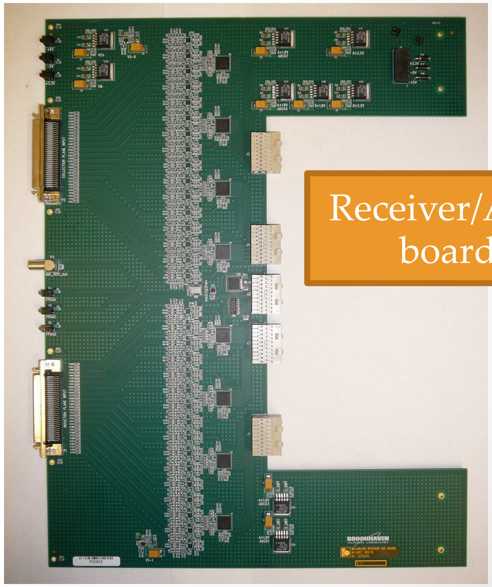
See poster #7 (C. Chiu)

Front End Electronics Testing at BNL

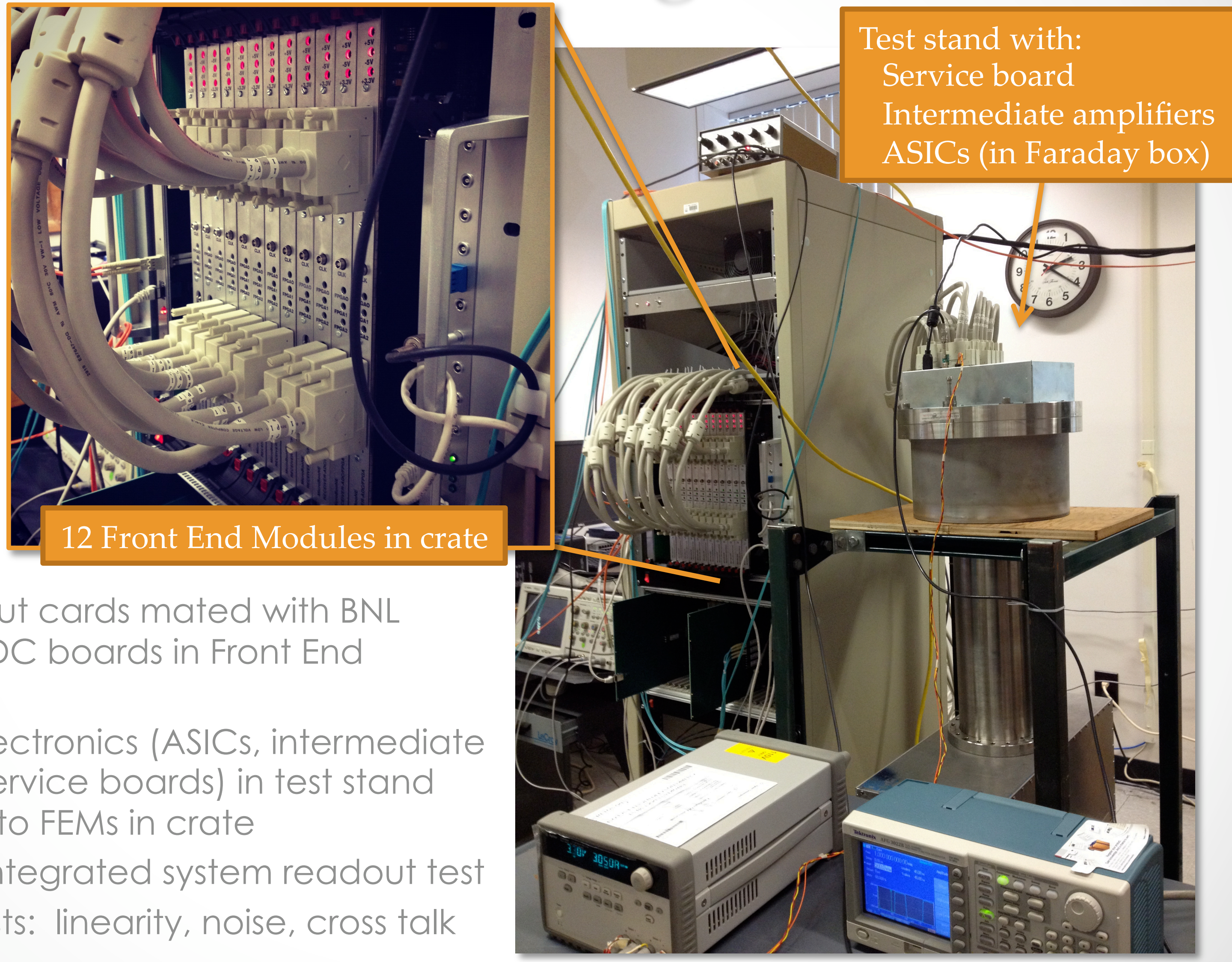




- Cold electronics
  - Room temperature & cold testing of version 3 prototype CMOS ASICs & cold motherboards
- Warm interface electronics
  - Intermediate amplifiers: evaluation test with pre-production boards
  - Service board: under testing now
  - ASIC configuration board: 1st prototype works well, new design
- Digitizing electronics
  - Receiver and ADC board: 10 pre-production version 1 pieces being assembled now



BNL/Nevis Joint Integration Test



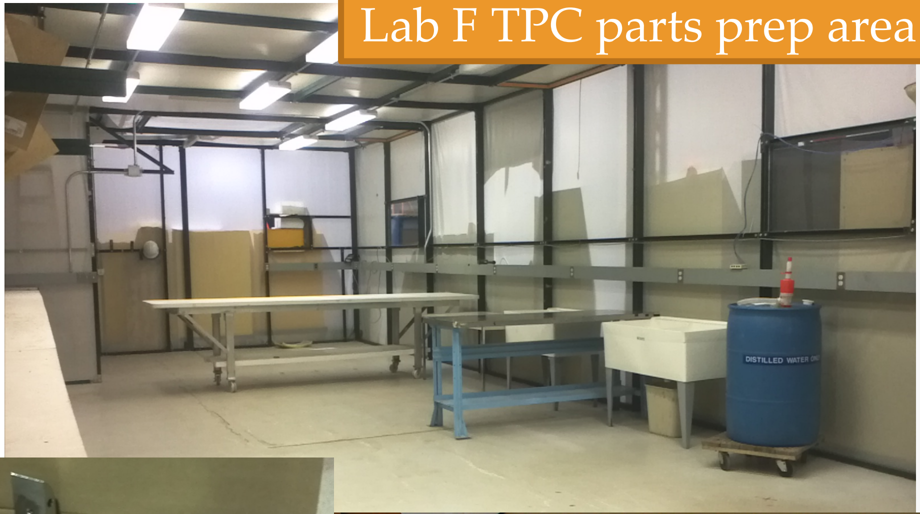
- Nevis readout cards mated with BNL Receiver/ADC boards in Front End Modules
- Front End Electronics (ASICs, intermediate amplifiers, service boards) in test stand connected to FEMs in crate
- Successful integrated system readout test
- Ongoing tests: linearity, noise, cross talk

Detector Assembly Area at DØ

Thanks to DØ for their hospitality

Preparation of TPC Parts

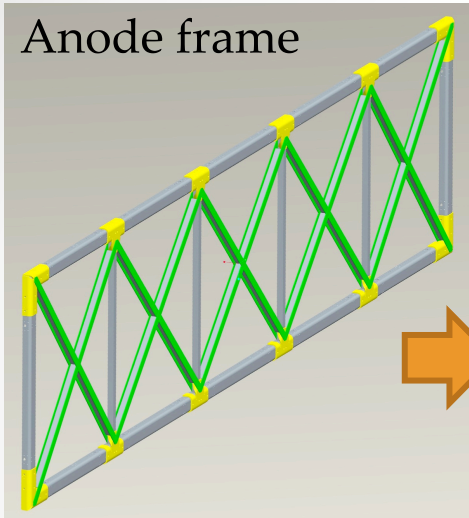
- TPC parts cleaning/ preparation at Lab F
- ~50% of anode frame parts have arrived; assembly this summer

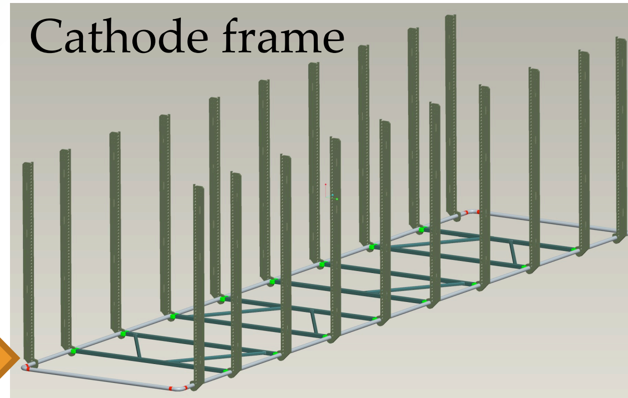


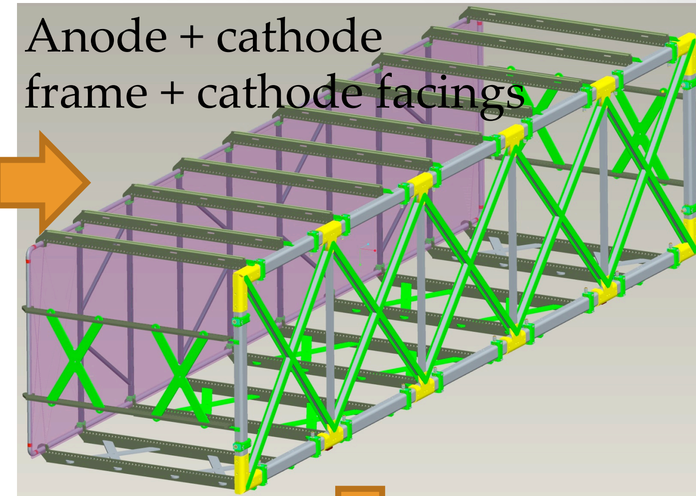
Lab F TPC parts prep area

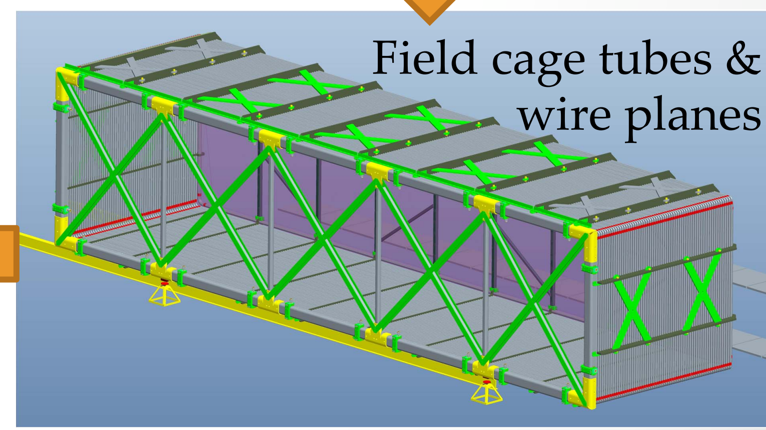
Various TPC parts ready to be cleaned

TPC Assembly





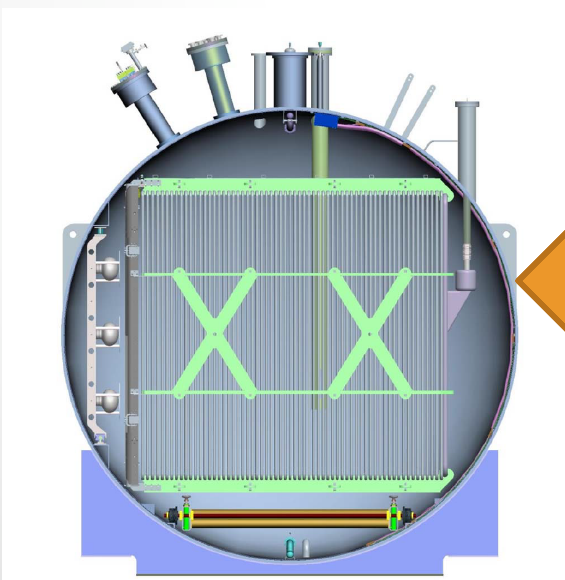




& cold electronics + top ground plane (not shown)

Insert TPC into cryostat

Install PMTs + support rack. Test, test, test.
Seal endcap.
Drive to LArTF!



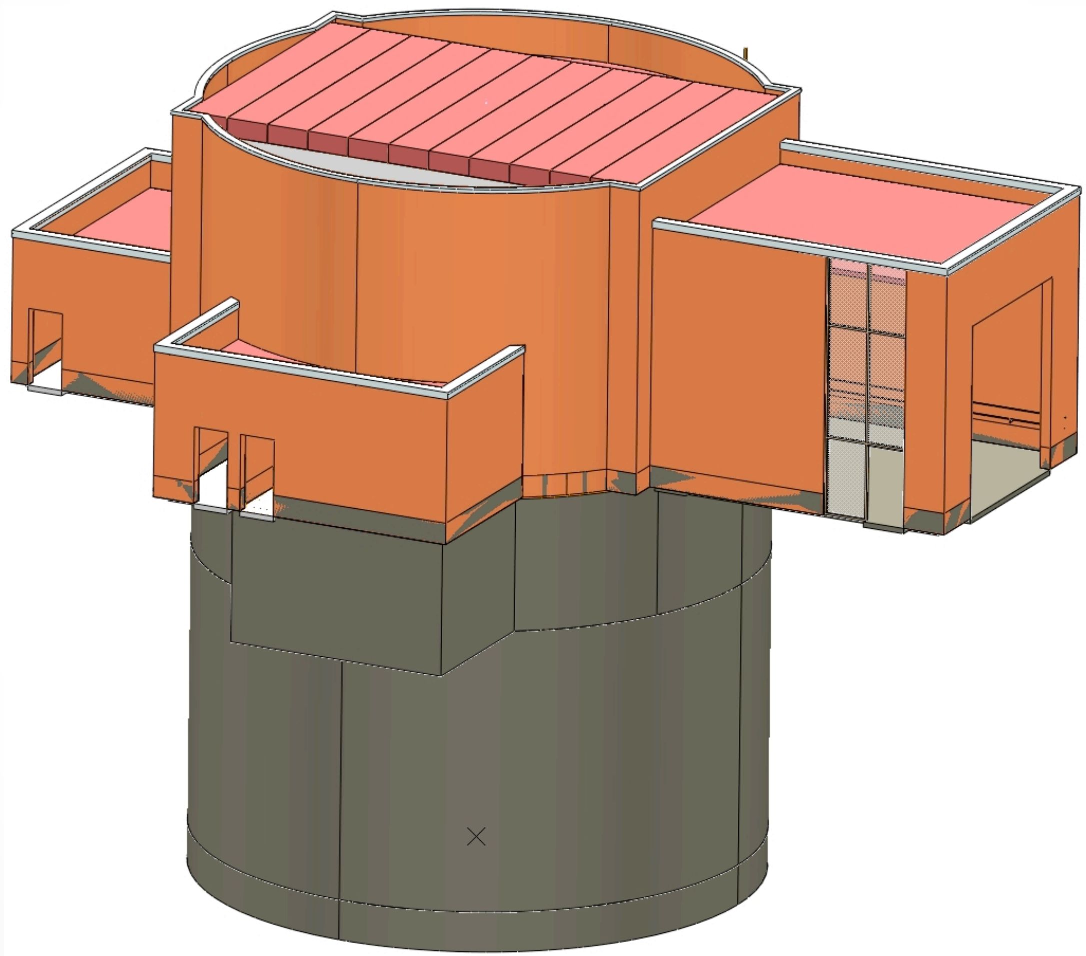
LAr Test Facility Construction

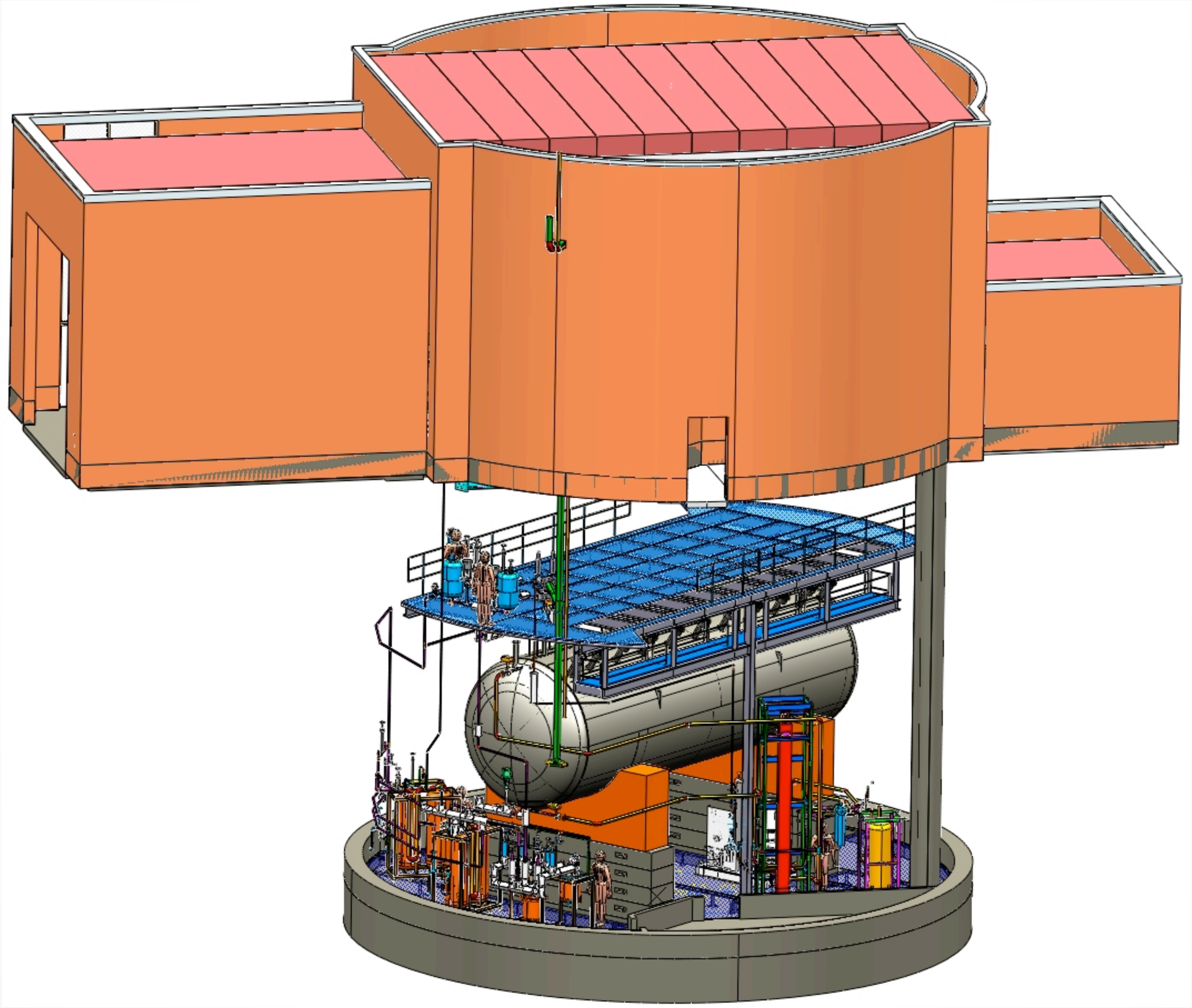
February, 2012

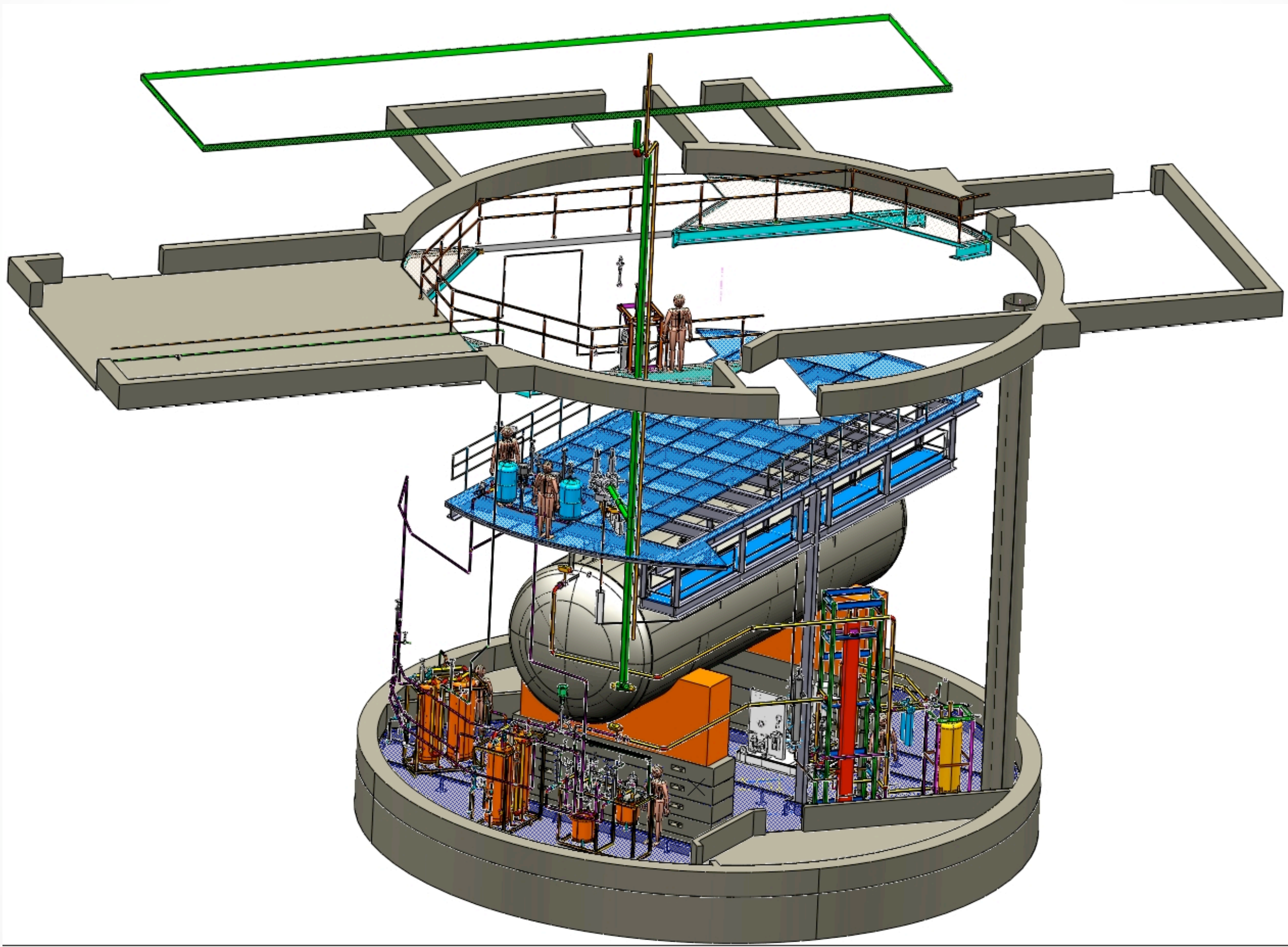
April, 2012

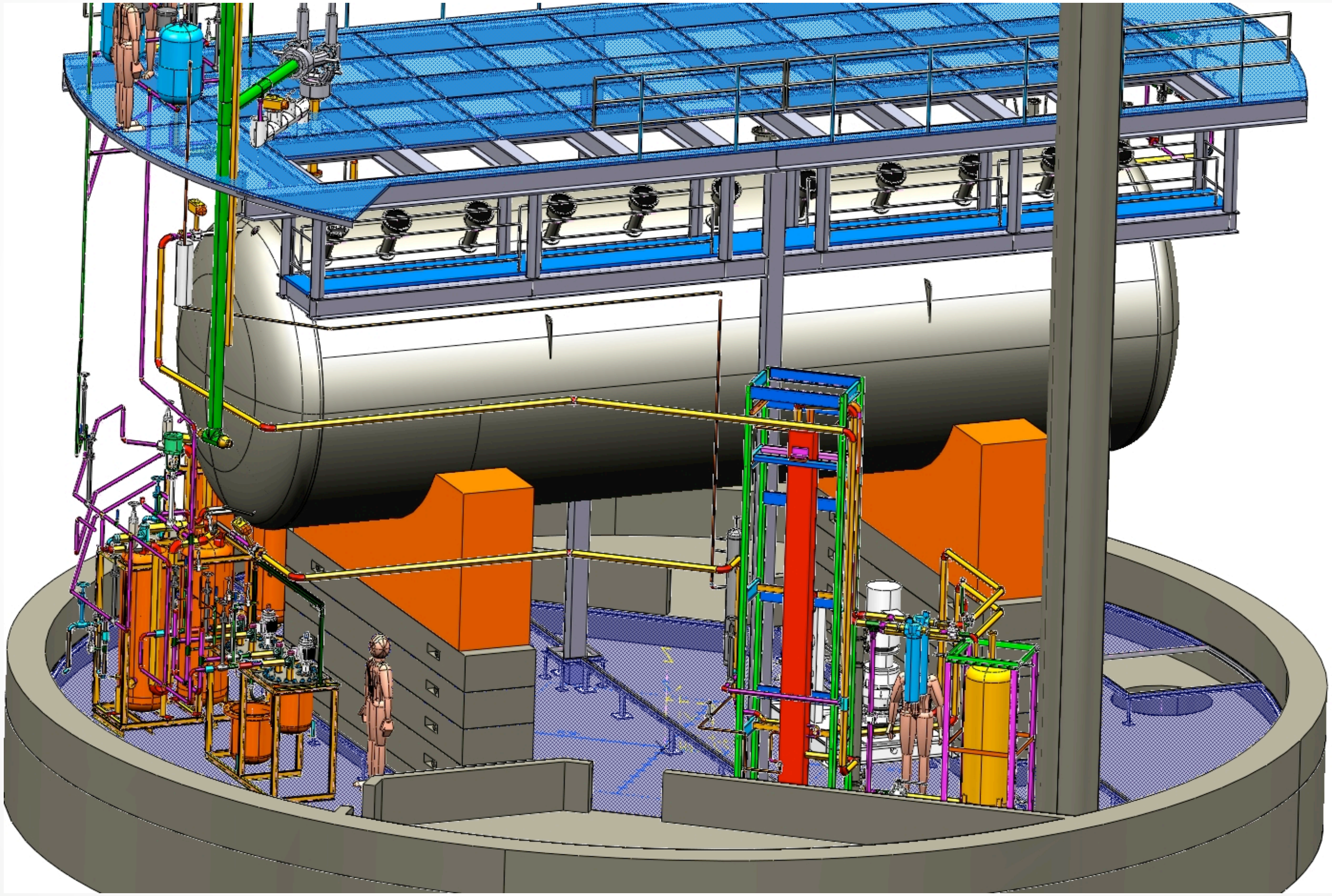
June, 2012

- Ground-breaking January, 2012
- Steady progress through winter and spring
- Contracted beneficial occupancy: March 15, 2013
- Currently ahead of schedule

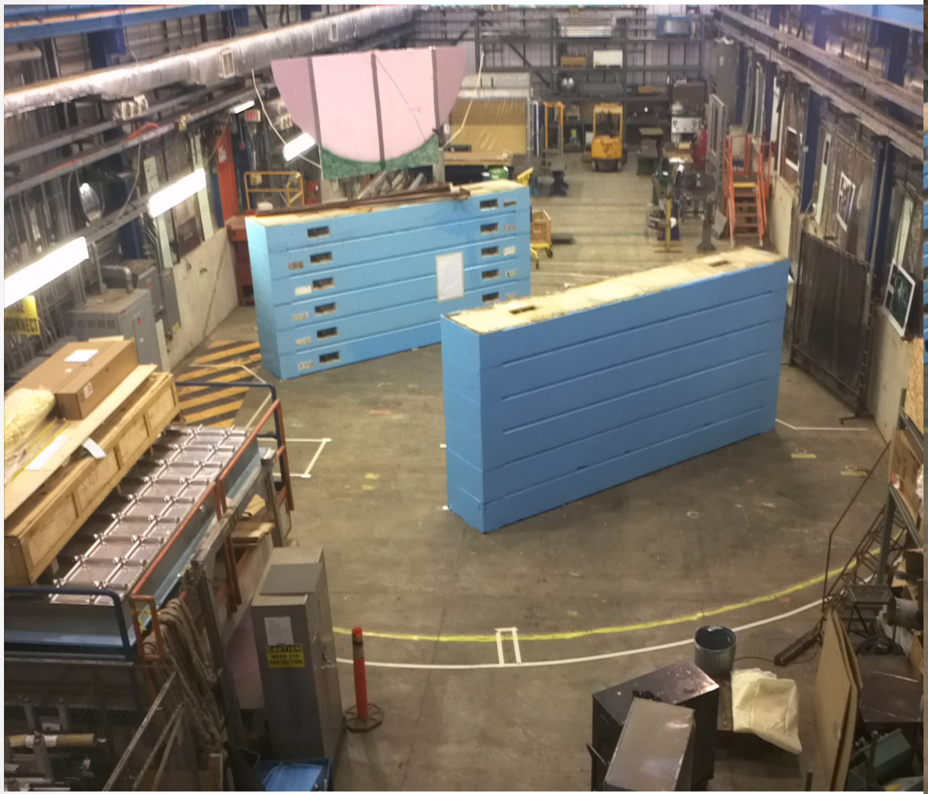


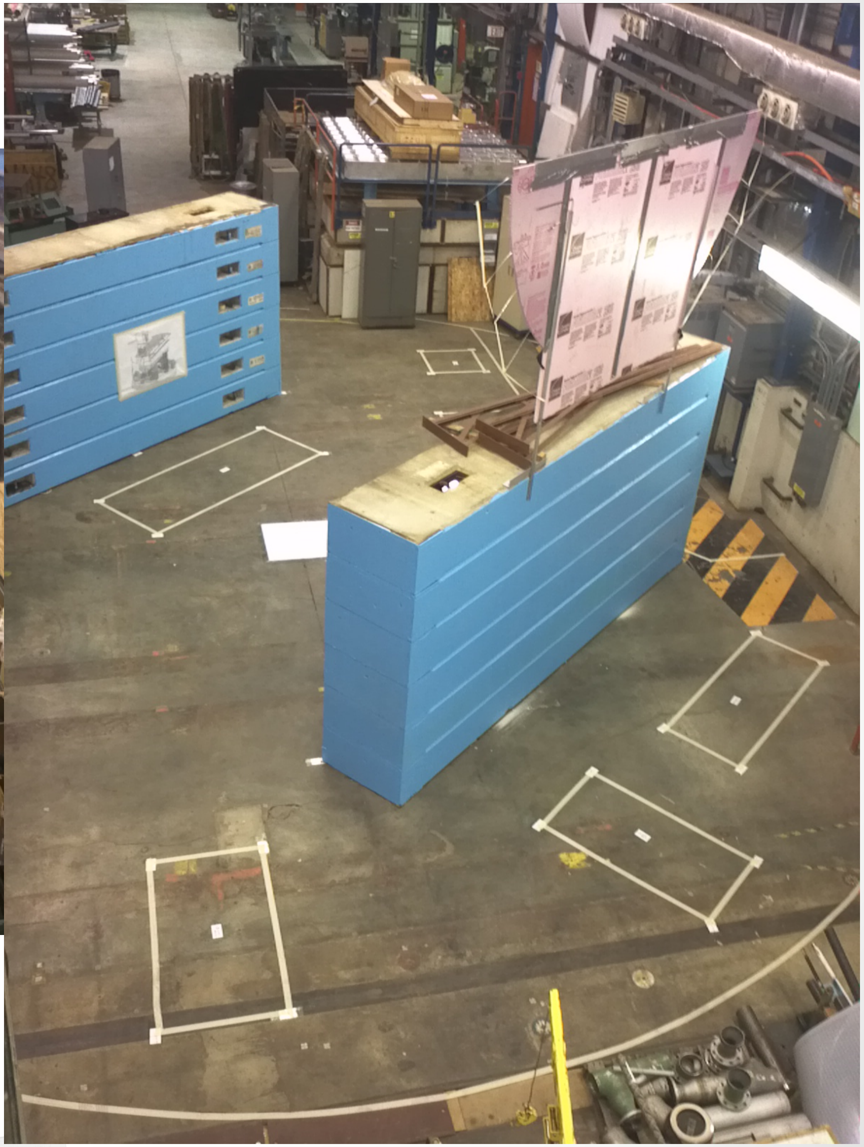






LArTF Mock-up at Lab F





Assembly Schedule

- Machined TPC parts shipped to FNAL (Spring-Summer 2012)
- TPC frame assembly (Summer-Fall 2012)
  - Lots of activity this summer! Come watch our progress at the DØ Assembly Building.
- Cryostat delivery (Winter 2012/13)
- Cold electronics delivery/installation (Winter-Spring 2013)
- TPC installation in cryostat (Spring 2013)
- Instrumented cryostat installed in LAr Test Facility (Spring-Summer 2013)
- Ready to fill with LAr (Late 2013)

Summary

- Ongoing testing of systems
  - PMTs & wavelength shifter plates
  - Cold electronics and intermediate electronics
  - Front end module readout
- LAr Test Facility building
  - Steady progress so far; ahead of schedule
  - Mockup of building layout at Lab F
- Ramping up activities in preparation for full assembly
  - Fun and exciting work this summer!

Thank you!

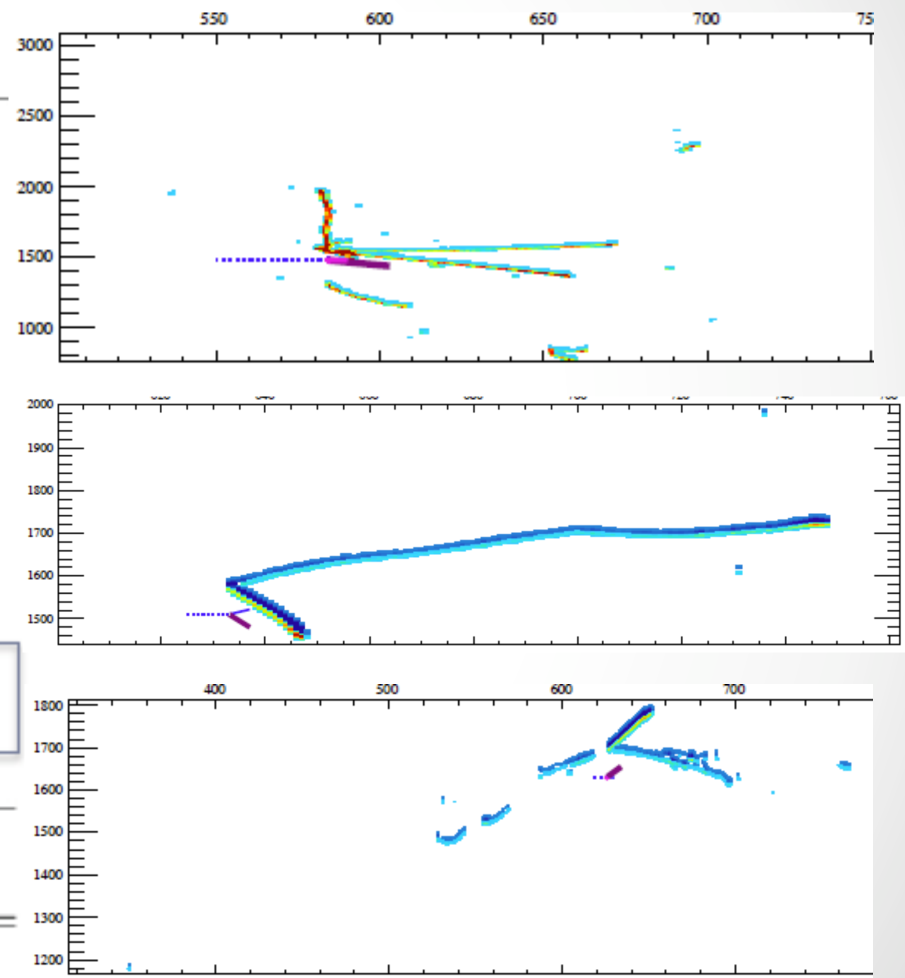
MicroBooNE Collaboration (16 institutions)

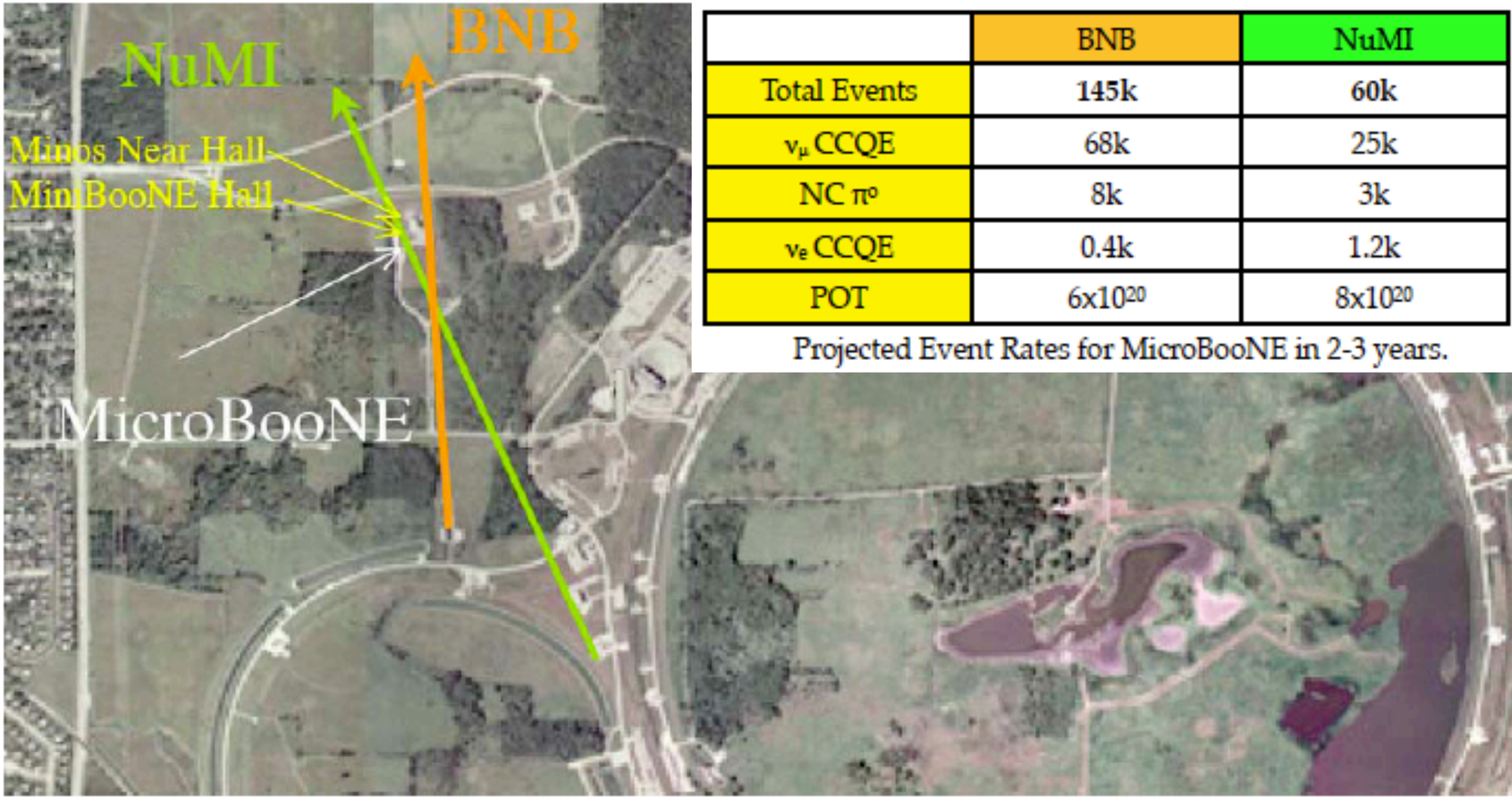
- Brookhaven Lab H. Chen, S. Duffin, J. Farrell, F. Lanni, Y. Li, D. Lissauer, G. Mahler, D. Makowieki, J. Mead, V. Radeka, S. Rescia, J. Sondericker, C. Thorn, K. Wu, B. Yu
- Columbia University L. Camilleri, R. Carr, G. Cheng, C. Chi, G. Karagiorgi, C. Mariani, B. Seligman, M. Shaevitz, B. Sippach, B. Willis
- Fermilab B. Baller, D. Bogert, B. Carls, H. Greenlee, C. James, H. Jostlein, M. Kirby, S. Lockwitz, B. Lundberg, S. Pordes, J. Raaf, G. Rameika, B. Rebel, R. Schmitt, D. Schmitz, J. Wu, T. Yang, S. Zeller
- Instituto Nazionale di Fisica Nucleare, Italy F. Cavanna, O. Palamara
- Kansas State University T. Bolton, D. McKee, G. Horton-Smith
- Laboratory for High Energy Physics, University of Bern, Switzerland A. Ereditato, I. Kreslo, T. Strauss, C. von Rohr, M. Weber
- Los Alamos Lab G. Garvey, J. Gonzales, B. Louis, C. Mauger, G. Mills, Z. Pavlovic, R. Van de Water, H. White
- Massachusetts Institute of Technology W. Barletta, L. Bugel, J. Conrad, C. Ignarra, B. Jones, T. Katori, A. Prakash, T. Smidt
- Michigan State University C. Bromberg, D. Edmunds
- New Mexico State University V. Papavassiliou
- Princeton University Q. He, C. Lu, K. McDonald
- St. Mary's University P. Nienaber
- Syracuse University M. Asaadi, M. Soderberg
- University of Cincinnati R. Grosso, R. Johnson, B. Littlejohn
- University of Texas at Austin S. Kopp, K. Lang, R. Mehdiyev
- Yale University C. Brasco, E. Church, B. Fleming, R. Guenette, E. Klein, A. Szelc

Event Rates

Expected event rates for 6.6×10^{20} POT

production mode	# events
CC QE ($\nu_\mu\, n \to \mu^-\, p$)	60,161
NC elastic ($\nu_\mu\, N \to \nu_\mu\, N$)	19,409
CC resonant π^+ ($\nu_\mu\, N \to \mu^-\, N\, \pi^+$)	25,149
CC resonant π^0 ($\nu_\mu\, n \to \mu^-\, p\, \pi^0$)	6,994
NC resonant π^0 ($\nu_\mu\, N \to \nu_\mu\, N\, \pi^0$)	7,388
NC resonant $\pi^\pm$ ($\nu_\mu\, N \to \nu_\mu\, N'\, \pi^\pm$)	4,796
CC DIS ($\nu_\mu\, N \to \mu^-\, X$, $W > 2$ GeV)	1,229
NC DIS ($\nu_\mu\, N \to \nu_\mu\, X$, $W > 2$ GeV)	456
NC coherent π^0 ($\nu_\mu\, A \to \nu_\mu\, A\, \pi^0$)	1,694
CC coherent π^+ ($\nu_\mu\, A \to \mu^-\, A\, \pi^+$)	2,626
NC kaon ($\nu_\mu\, N \to \nu_\mu\, K\, X$)	39
CC kaon ($\nu_\mu\, N \to \mu^-\, K\, X$)	117
other ν_μ	3,678
total ν_μ CC	98,849
total ν_μ NC+CC	133,580
ν_e QE	326
ν_e CC	657

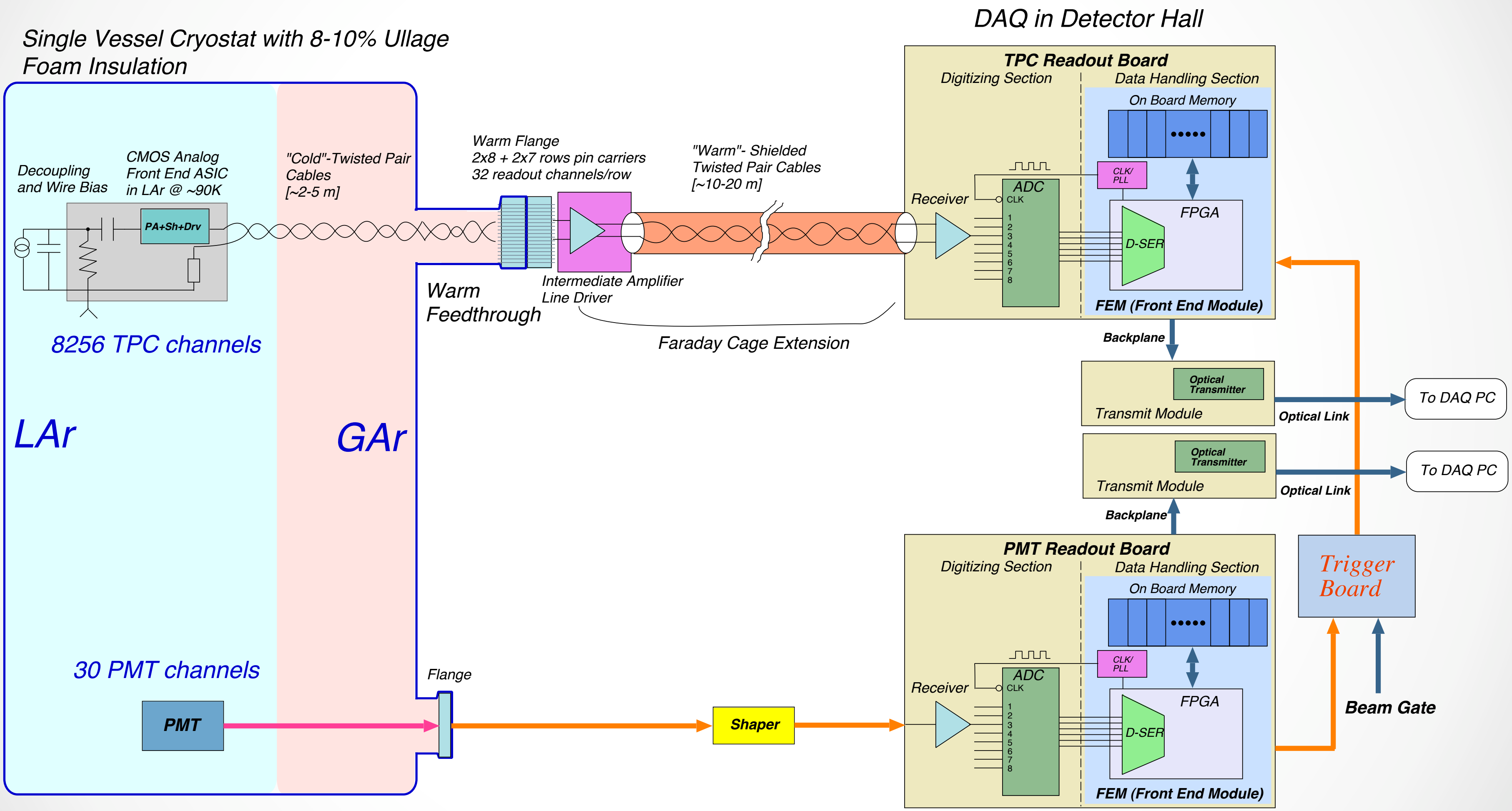




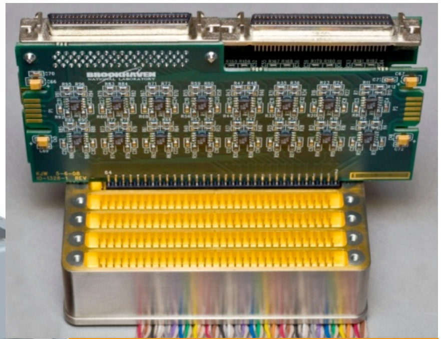
	BNB	NuMI
Total Events	**145k**	**60k**
ν_μ CCQE	68k	25k
NC π^0	8k	3k
ν_e CCQE	0.4k	1.2k
POT	6×10^{20}	8×10^{20}

Projected Event Rates for MicroBooNE in 2-3 years.

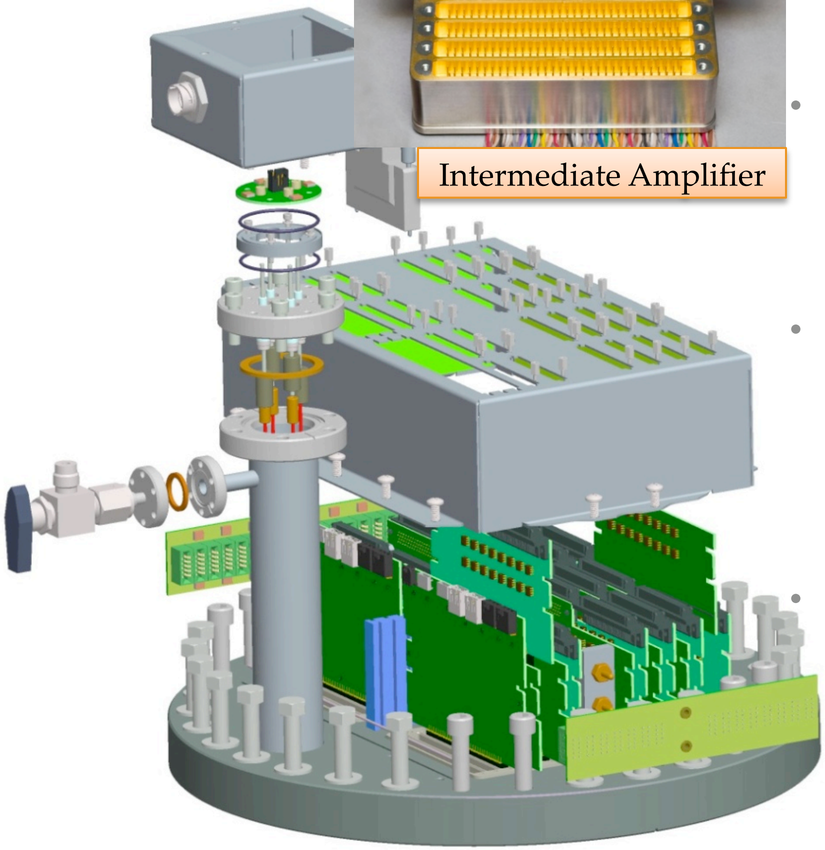
Electronics System



"Warm" Electronics



Intermediate Amplifier



Full signal feed-through assembly drawing

- Signal Feed-through
  - ATLAS LAr Calorimeter style feed-through, technology exists: high signal density (1920 pins)
  - Pin carriers welded on flange: 100% hermetical
  - Faraday box is built and mounted on feed-through
  - Bias voltage feed-through to provide bias voltage filtering and reliable ground connection
- Cable Assemblies
  - Cold cable: Teflon FEP insulation, 100 Ω +- 10%, AWG 26 solid core sliver plated
  - Warm cable assembly is commercial off-the-shelf SCSI-3 Ultra LVD/SE MD68M/M cable
- Intermediate Amplifier
  - 32 channels per board
  - Differential driver to improve noise immunity
  - Provide an appropriate gain (~12 dB) to detector signals to make it suitable for long distance (10 – 20 m) transmission
- Service Board
  - Provide +1.8 V control and monitoring to front end ASIC, +3.3 V, -3.3 V filtering and distribution to intermediate amplifier
  - Provide calibration pulse driver to front ASIC which has built in switch to turn on/off pulse injection to individual channels
- ASIC Configuration Board
  - Provide ASIC configuration signals interface between ASICs and PC

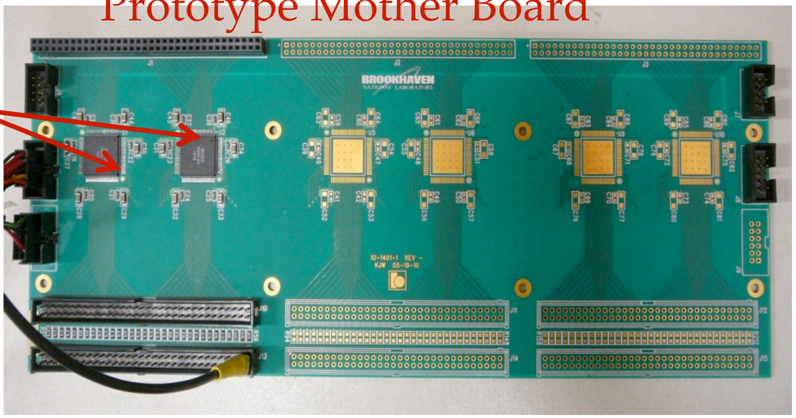
CMOS Analog Front End ASIC

- 16 channels per chip
- Charge amplifier, high-order filter
- Adjustable gain: 4.7, 7.8, 14, 25 mV/fC (55, 100, 18
- Adjustable filter time constant (peaking time): 0.5
- Selectable dc/ac (100 μs) coupling
- 136 registers with digital interface
- 5.5 mW/channel (input MOSFET 3.6 mW)
- Designed for long cryo-lifetime

- Circuit performance is almost identical at 300K and 77K, except noise is ~2x lower
- Calibration capacitor on ASIC changes by ~0.5% from 300K to 77K

- **Prototype #1: Works, tested, fully characterized**
- **Prototype #2: minor fixes successful, tested, evaluated**
- **Prototype #3: addresses additional problems , in evaluation**

Prototype Mother Board



Cold motherboard with 4 ASIC chips (64 channels) populated

ASIC die & package