MiniBooNE Results / MicroBooNE Status

Eric Church, Yale University
LLWI, 22-Feb-2014

G'aaah! The US–Canada game is on!

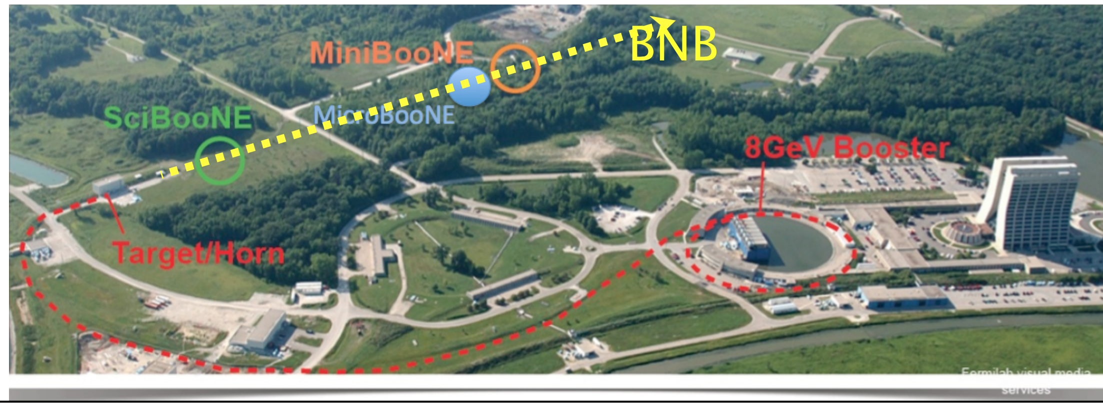
microboone

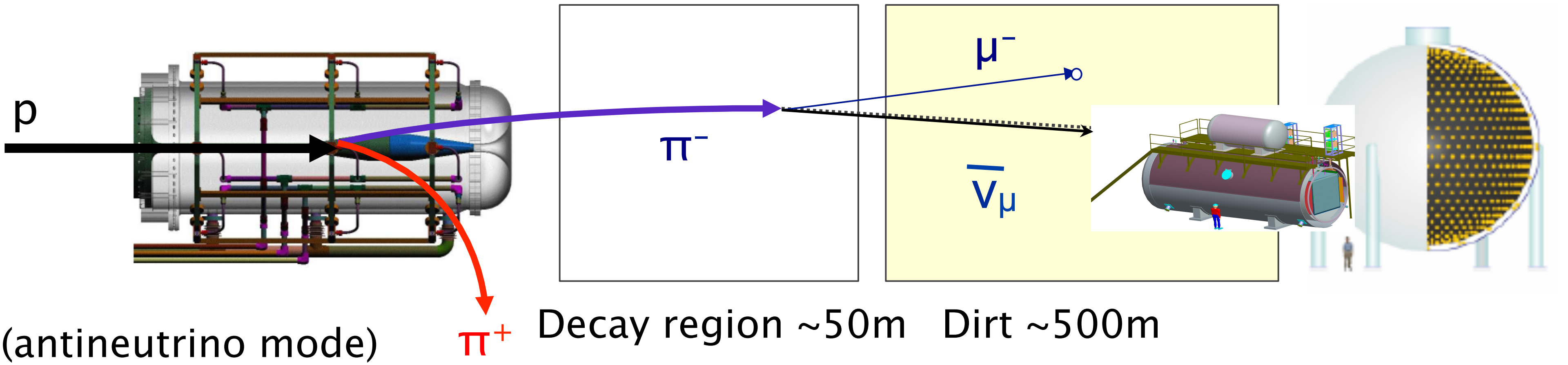
right now!
(what are we
doing at this talk?)

Outline

- MiniBooNE
  - past results
  - future
- MicroBooNE
  - physics motivation
  - R&D motivation
  - status: (running is imminent!)

The Booster Neutrino Beam

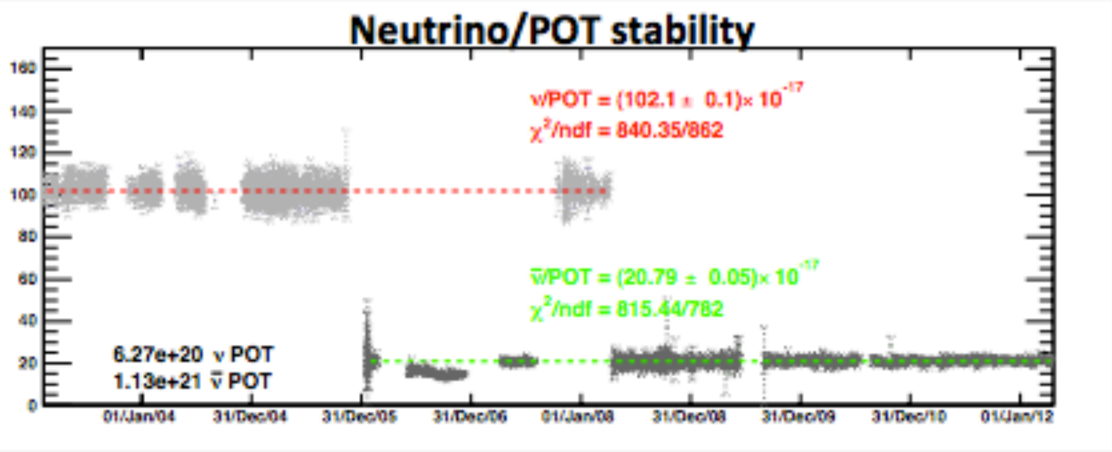




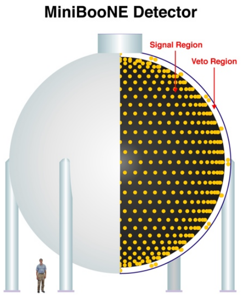
Horn polarity flip allows nu or anu modes.

MiniBooNE history

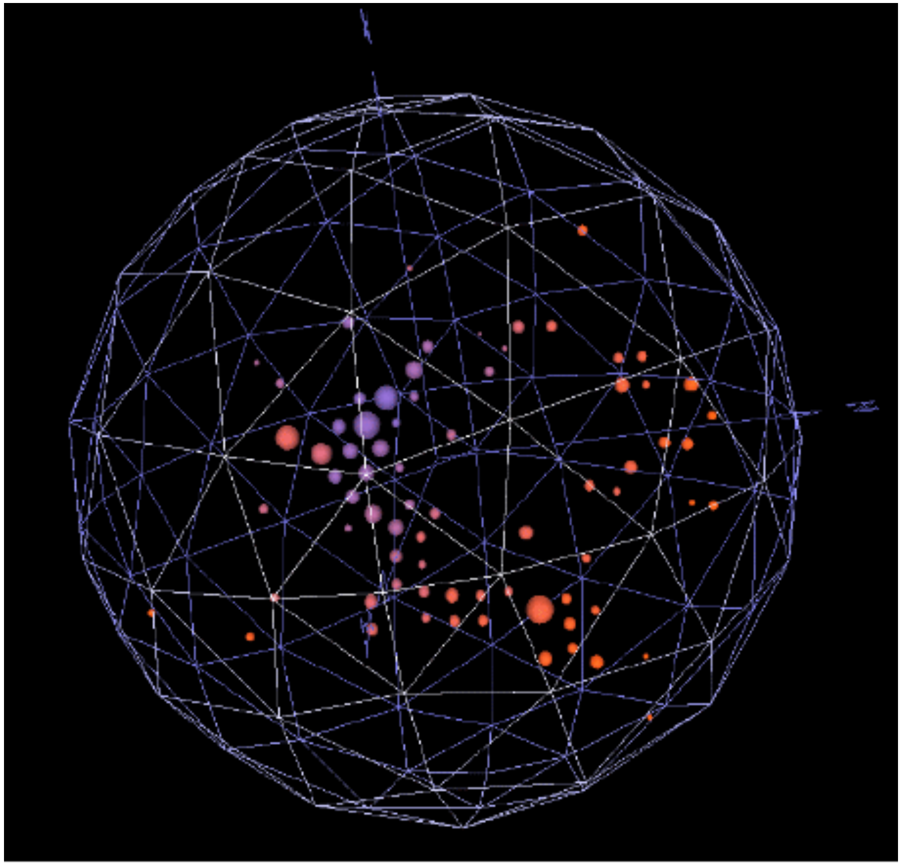
MB running has been stable for 10 years:

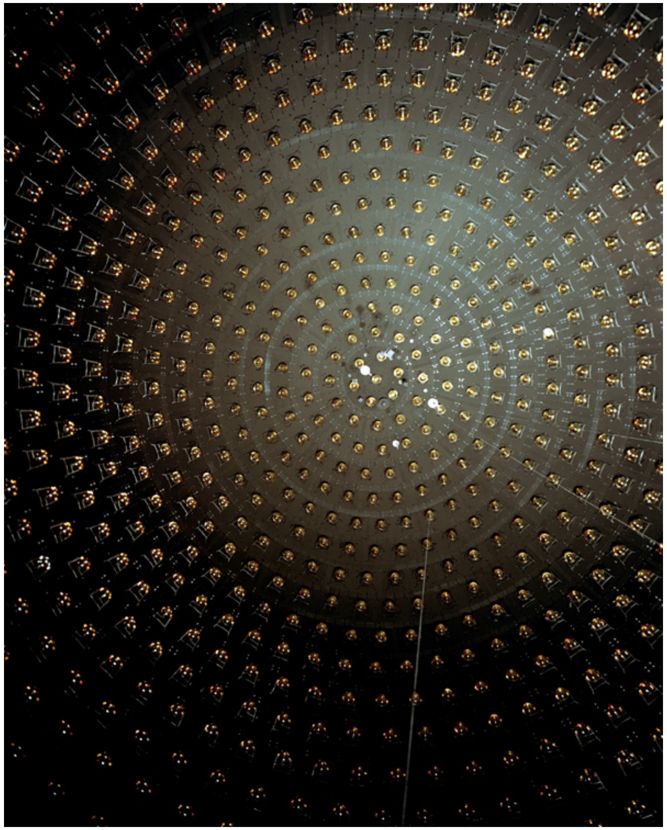


MiniBooNE



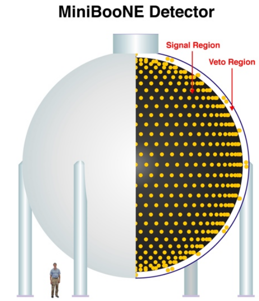
- 800 tons of Mineral Oil
- 10% photocathode coverage





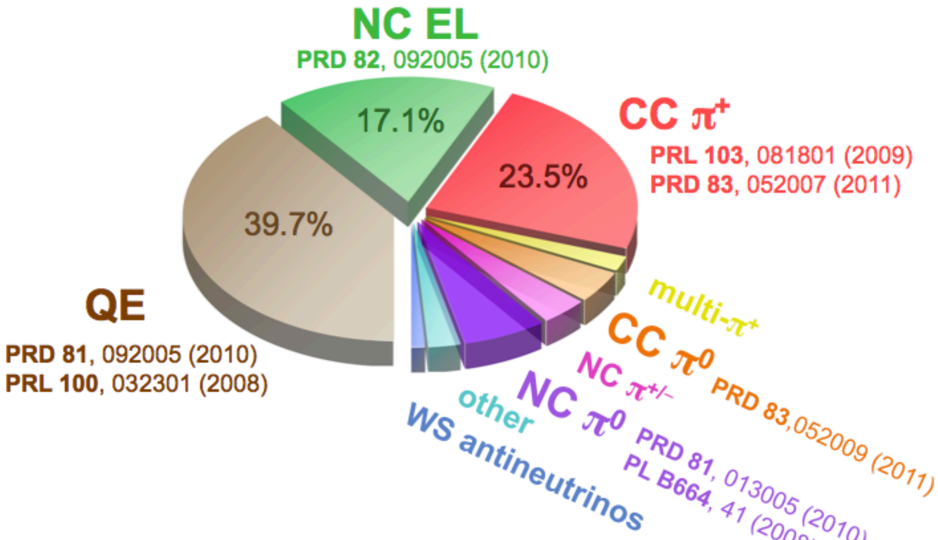
candidate $\nu_\mu \rightarrow \nu_e$ Charged Current (CC) event

MiniBooNE cross-sections



Neutrino Cross Sections

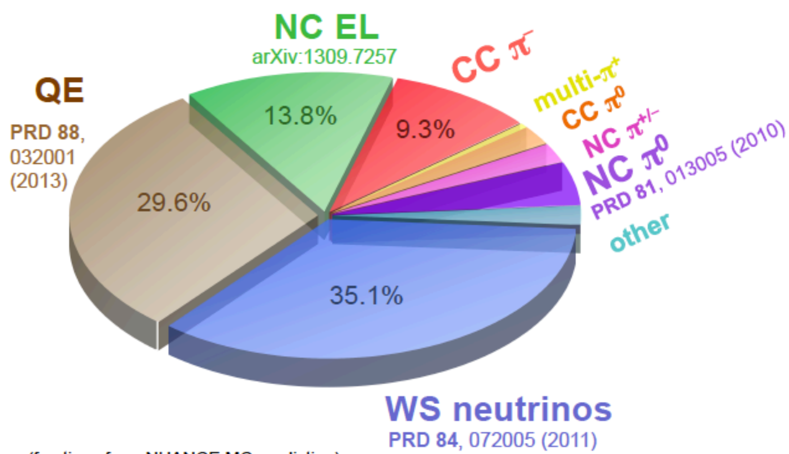
- 8 neutrino mode cross section publications



(fractions from NUANCE MC prediction)

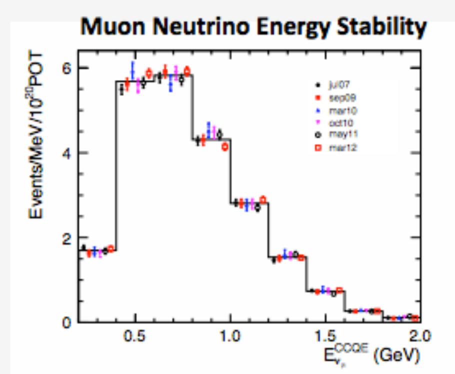
Antineutrino Cross Sections

- 4 anti-ν mode cross section publications



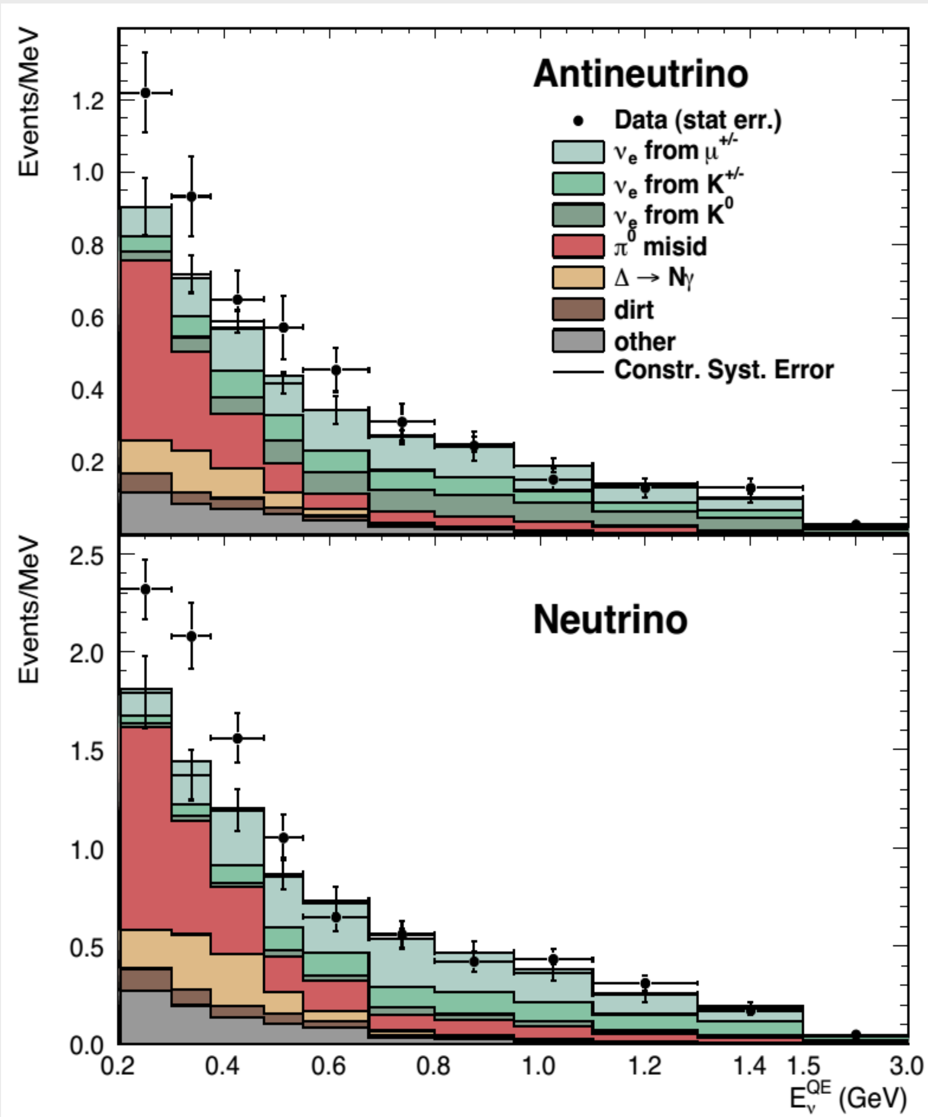
(fractions from NUANCE MC prediction)

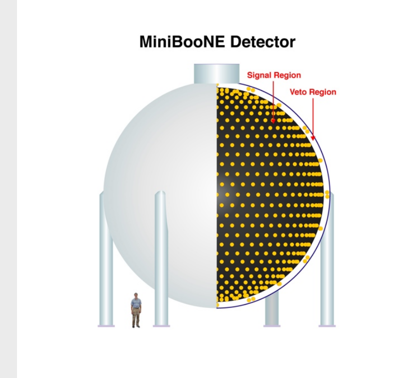
Detector is well understood in both BNB horn modes.



MiniBooNE oscillation analysis:

oscillation sample E_ν distributions



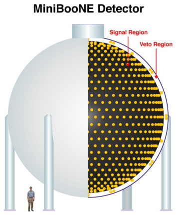


Phys. Rev. Lett. 110, 161801 (2013)

Combined analysis:
240.3 +/- 62.9 3.8σ

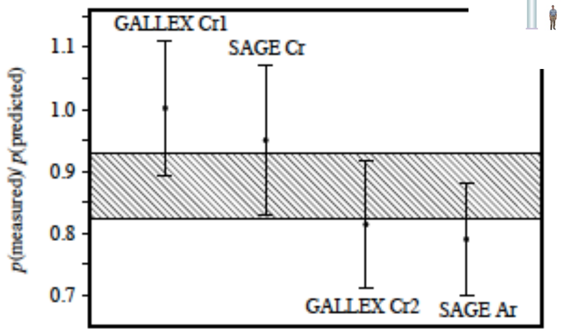
-Requires multiple sterile ν for satisfactory fit.
-Excess at low-energy where NCγ and NCπ^0 dominate, should examine these carefully!

Short-Baseline Neutrino Anomalies



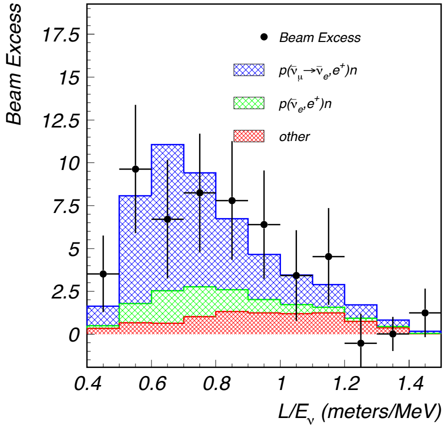
Gallium anomaly

SAGE, Phys. Rev. C 73 (2006) 045805



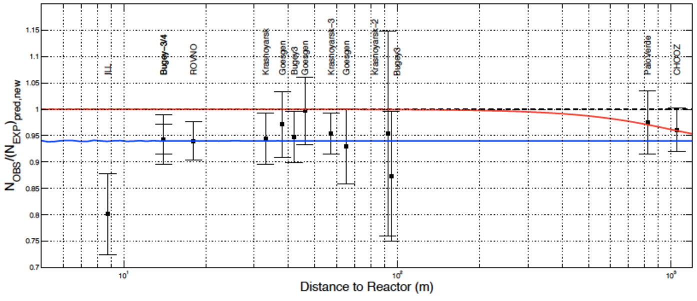
LSND

A. Aguilar et al., Phys. Rev. D 64, 112007, (2001)

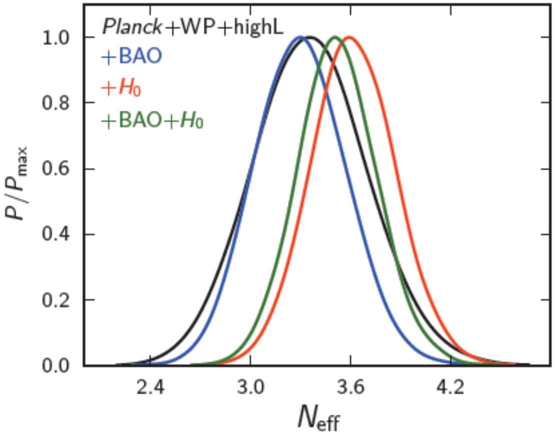


G. Mention et al., Phys.Rev.D83:073006,2011

Reactor anomaly

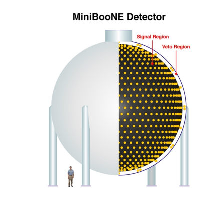


Cosmology

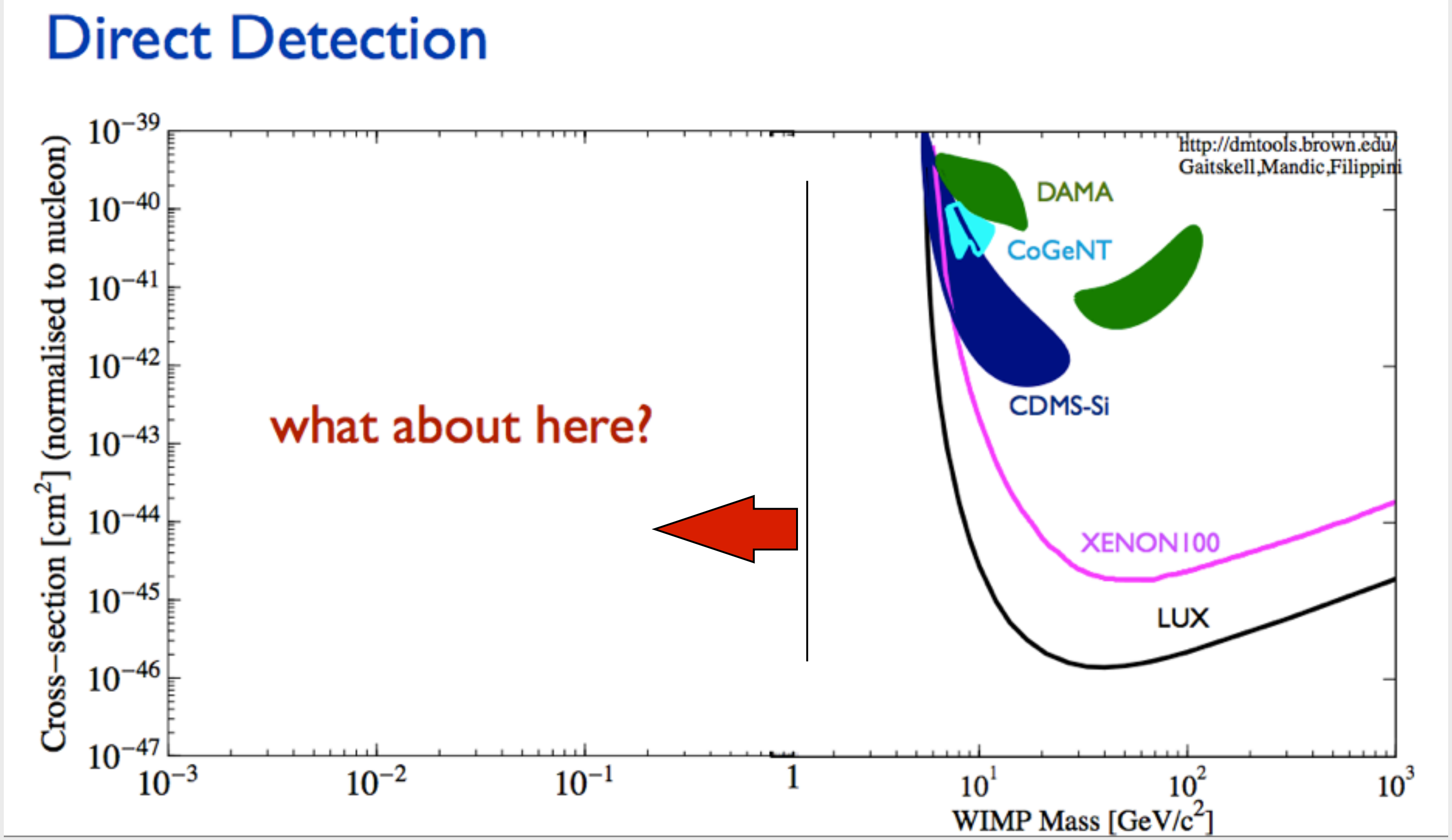


arXiv:1212.6267 & arXiv:1303.5076 & arXiv:1304.5981

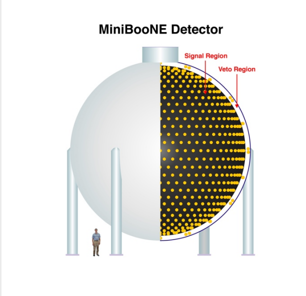
MiniBooNE in the Dark Matter Business



ala arXiv:1307.6554

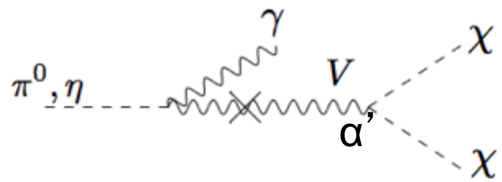


MiniBooNE as DM detector



$\kappa F_{\mu\nu} V^{\mu\nu}$

Decays of mesons:

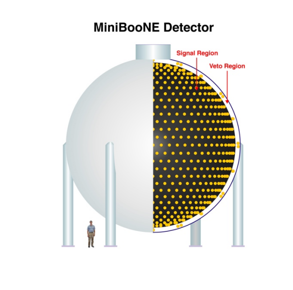


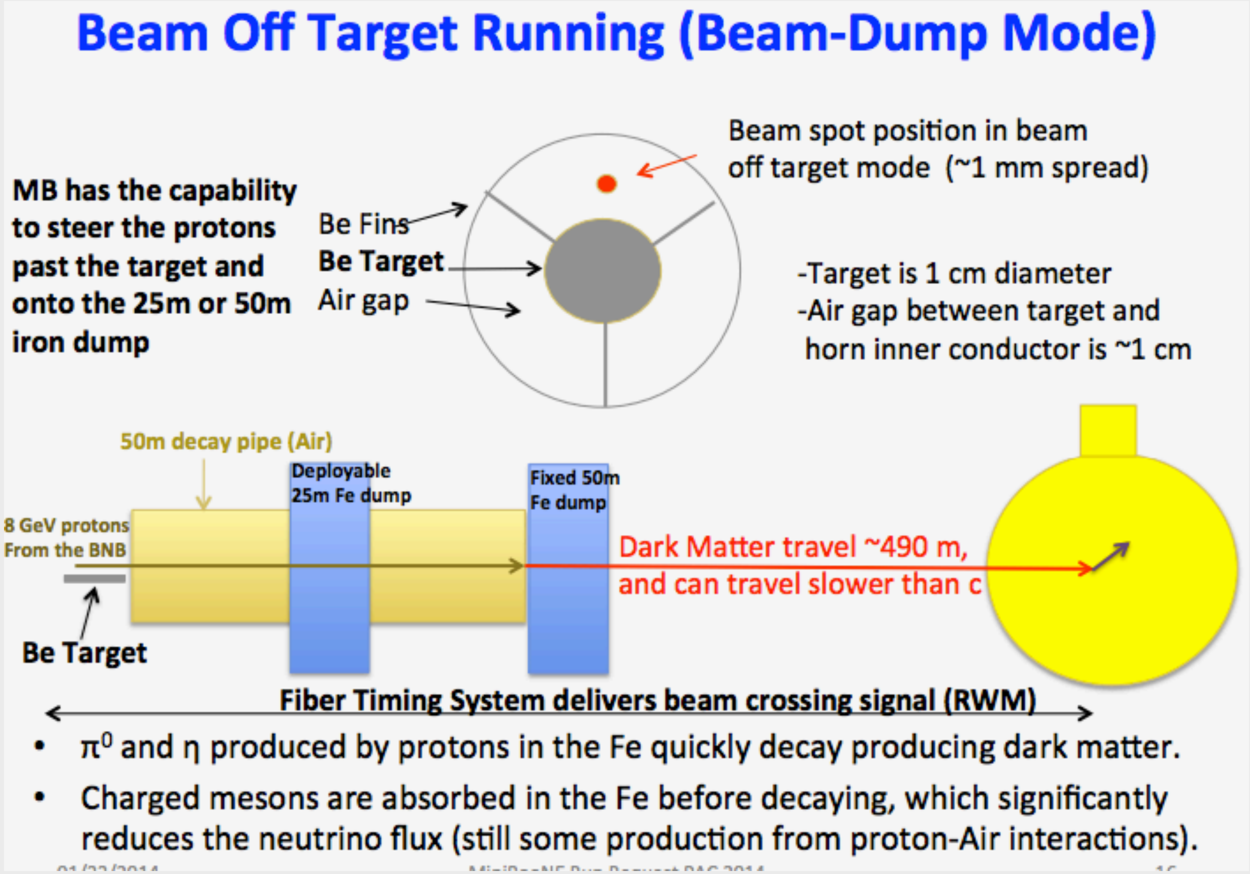
Dark Matter detection via scattering

$\chi-$nucleon elastic

$\chi-e^-$ elastic

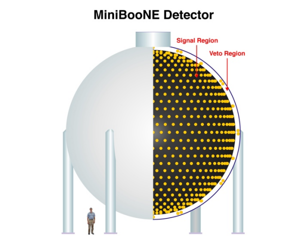
MiniBooNE as DM detector



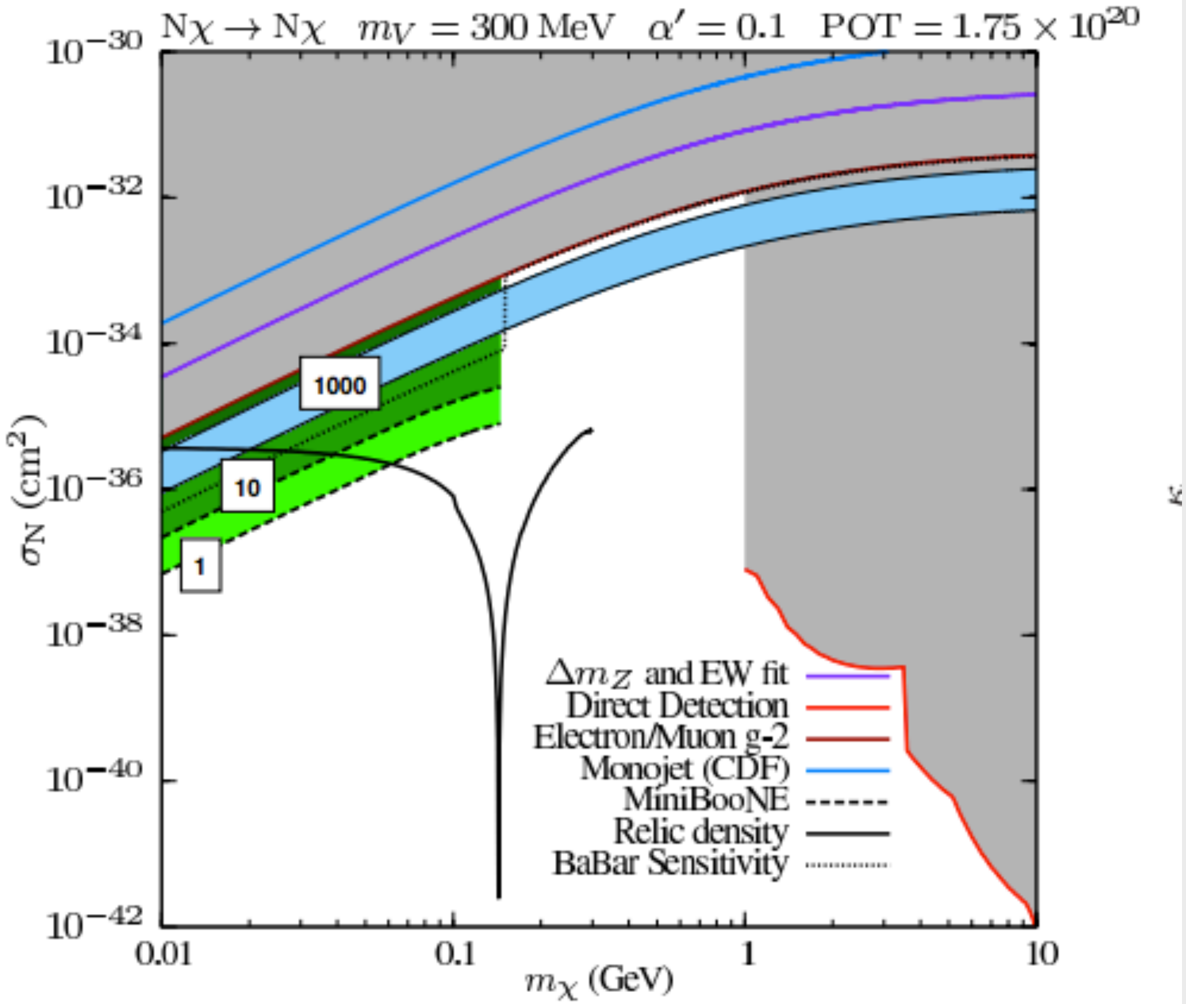


Need, ironically, to remove neutrino background!

MiniBooNE as DM detector

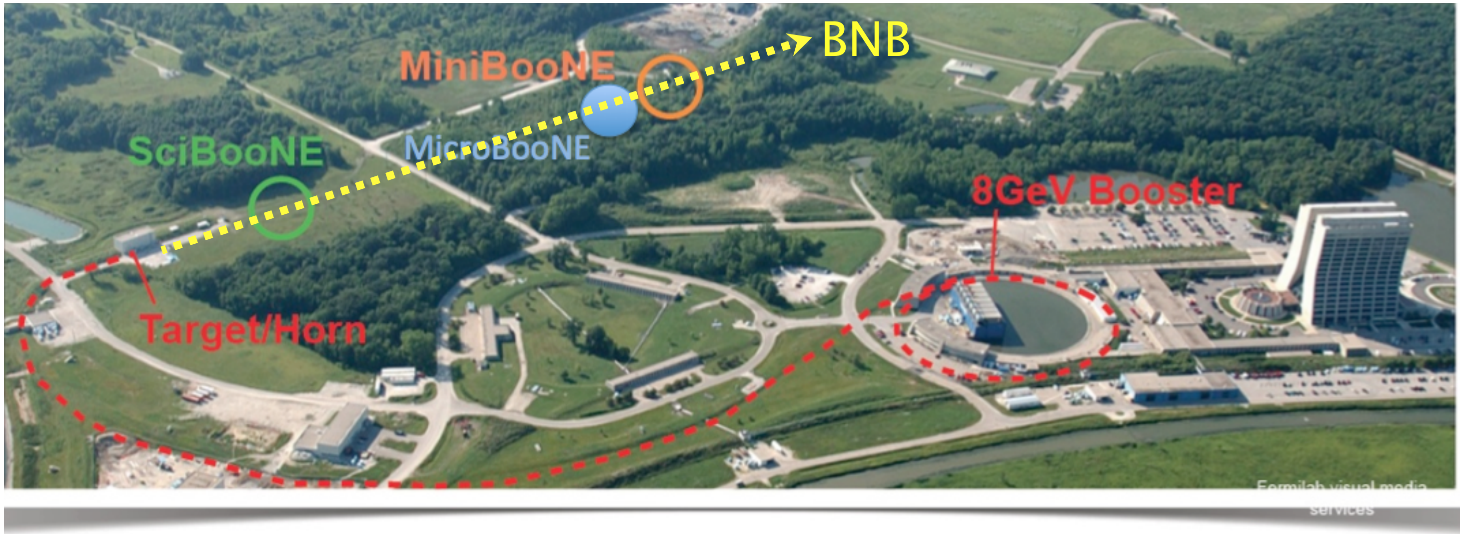


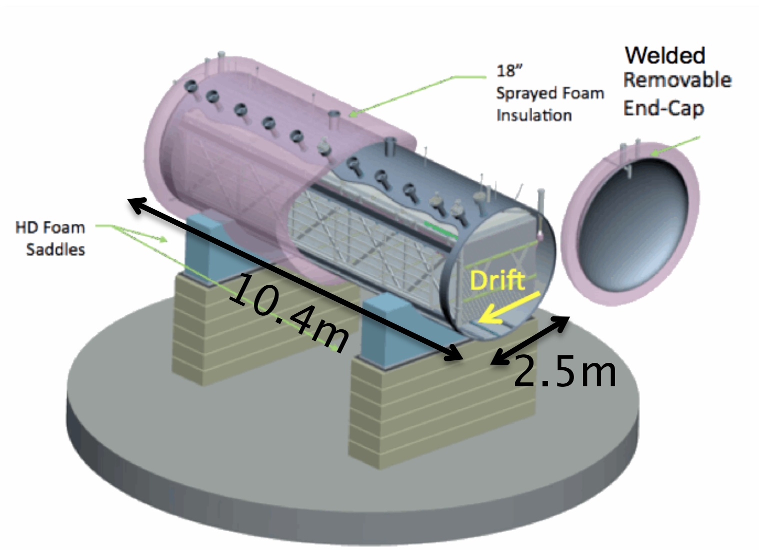
Dark Matter signal rates



9-Feb-2014: FNAL PAC recommends MiniBooNE search for DM go forward!

MicroBooNE





- goals:
  - MiniBooNE excess events
  - σ_ν measurements in argon
  - R&D for future LAr TPCs

Motivation

Spring-Summer, 2014!

- Physics
  - MiniBooNE low energy excess
  - Cross Sections
  - Burst Supernova neutrinos -- we are a SNEWs consumer
- R&D
  - Long drift length (2.5m)
  - DAQ: Cold front-end electronics (up through shaper)
  - DAQ: Continuous readout with offline SN trigger
  - Reconstruction/pID: LArSoft
  - LAr fill w.o. evacuation
  - Surface Running
  - UV Laser Calibration System

MicroBooNE Collaboration

Brookhaven: M. Bishai, H. Chen, K. Chen, S. Duffin, J. Farrell, F. Lanni, Y. Li, D. Lissauer, G. Mahler, D. Makowiecki, X. Qian, J. Mead, V. Radeka, S. Rescia, A. Ruga, J. Sondericker, C. Thorn, K-C. Wu, B. Yu

University of Cambridge: A. Blake, J. Marshall, M. Thomson

University of Chicago: W. Foreman, Johnny Ho, D. Schmitz, J. Zennamo

University of Cincinnati: R. Grosso, J. St. John, R. Johnson, B. Littlejohn

Columbia University: N. Bishop, D. Caratelli, L. Camilleri, C. Chi, J. Dickinson, D.Garisto, D. Kaleko, G. Karagiorgi, B. Seligman, M. Shaevitz, B. Sippach, K. Tatem, K. Terao, B. Willis

Fermilab: R. Acciarri, B. Baller, D. Bogert, B. Carls, M. Cooke, H. Greenlee, C. James, E. James, H. Jostlein, M. Kirby, S. Lockwitz, B. Lundberg, A. Marchionni, S. Pordes, J. Raaf, G. Rameika, B. Rebel, A. Schukraft, S. Wolbers, T. Yang, G.P. Zeller*

Kansas State University: T. Bolton, S. Farooq, S. Gollapinni, G. Horton-Smith, D. McKee

Los Alamos: G. Garvey, J. Gonzales, W. Ketchum, B. Louis, G. Mills, Z. Pavlovic, R. Van de Water

MIT: W. Barletta, L. Bugel, G. Collin, J. Conrad, C. Ignarra, B. Jones, T. Katori, M. Toups

Michigan State University: C. Bromberg, D. Edmunds

New Mexico State University: A.McLean, T. Miceli, V. Papavassiliou, S. Pate, K. Woodruff

Otterbein University: N. Tagg

University of Oxford: G. Barr, R. Guenette

University of Pittsburgh: S. Dytman, D. Naples, V. Paolone

Princeton University: R. Klemmer, M. Komor, K. McDonald, W. Sands

Saint Mary's University of Minnesota: P. Nienaber

SLAC: M. Convery, M. Graham, D. Mueller

Syracuse University: J. Asaadi, J. Esquivel, M. Soderberg

University of Texas at Austin: S. Cao, J. Huang, K. Lang, R. Mehdiyev

University of Bern, Switzerland: A. Ereditato, I. Kreslo, C. Rudolf von Rohr, T. Strauss, M. Weber

INFN, Italy: F. Cavanna, O. Palamara *(currently at Yale)*

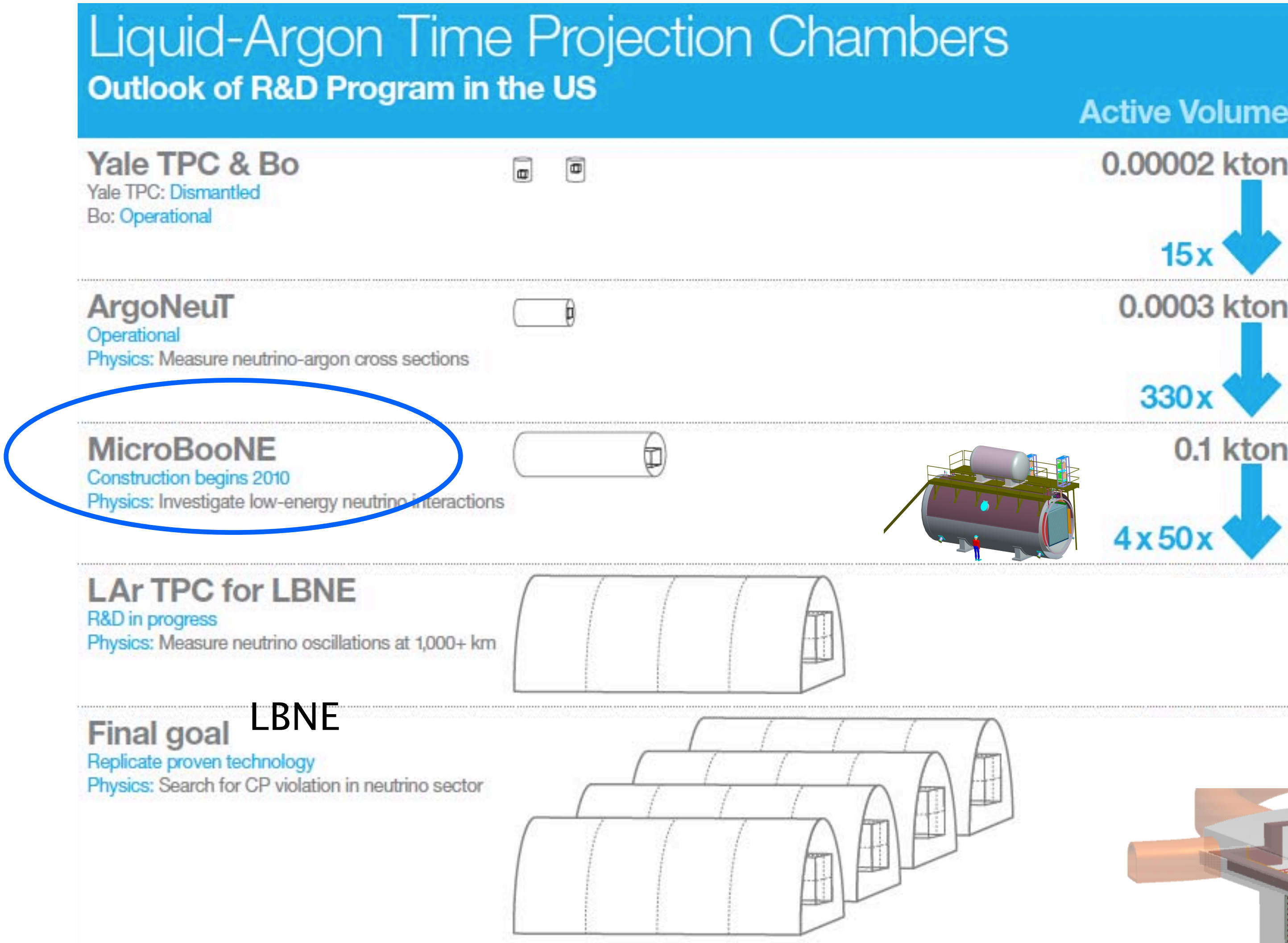
Virginia Tech: M. Jen, L. Kalousis, C. Mariani

Yale University: C. Adams, E. Church, B. Fleming*, A. Hackenberg, K. Partyka, A. Szelc

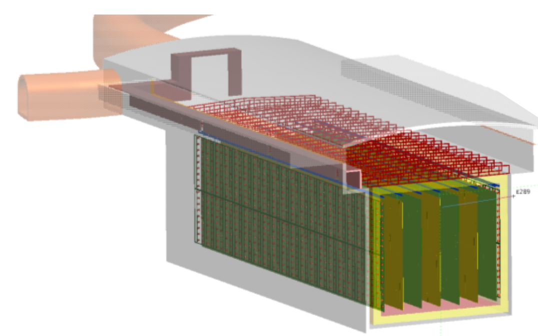
120 collaborators from 21 institutions, 24 postdocs, 15 grad students

* spokespeople

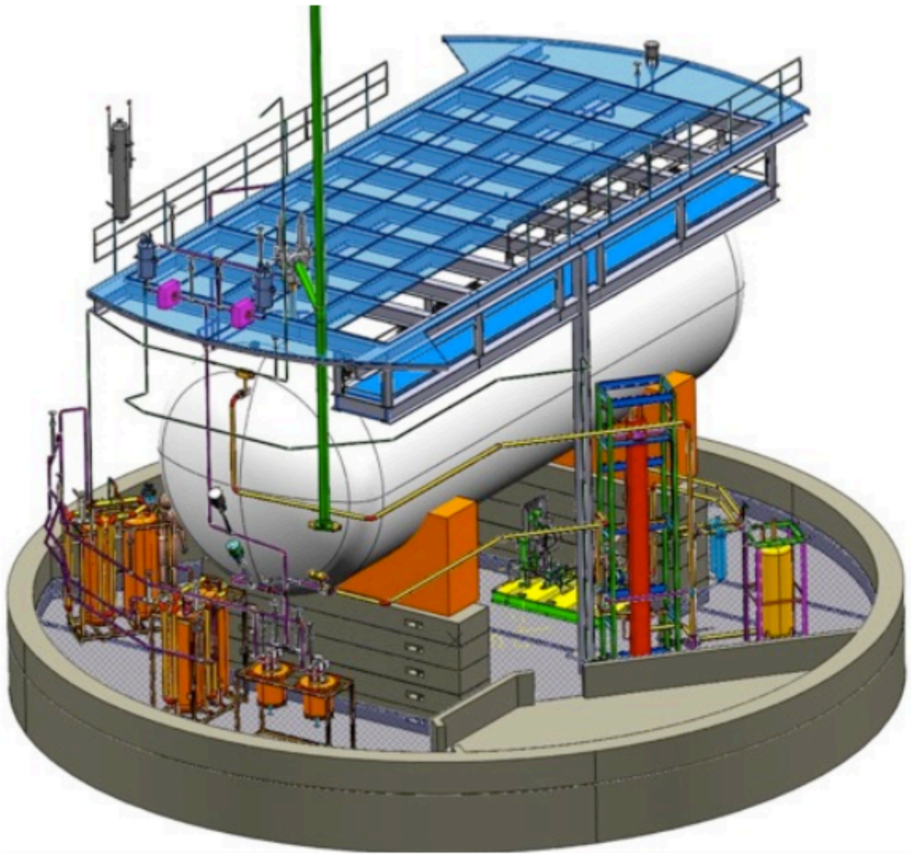
The US Integrated Plan for LAr

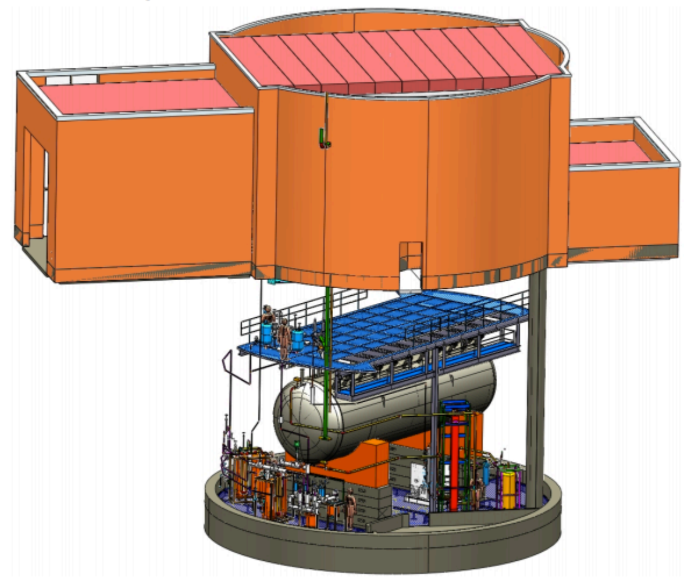


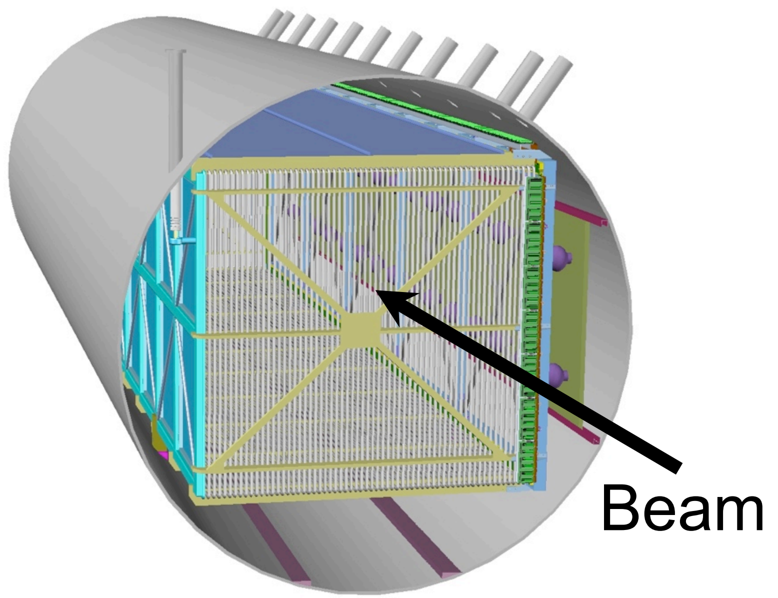
34 kton



The Design

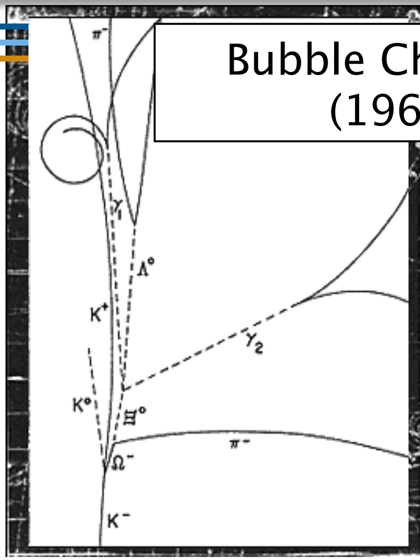






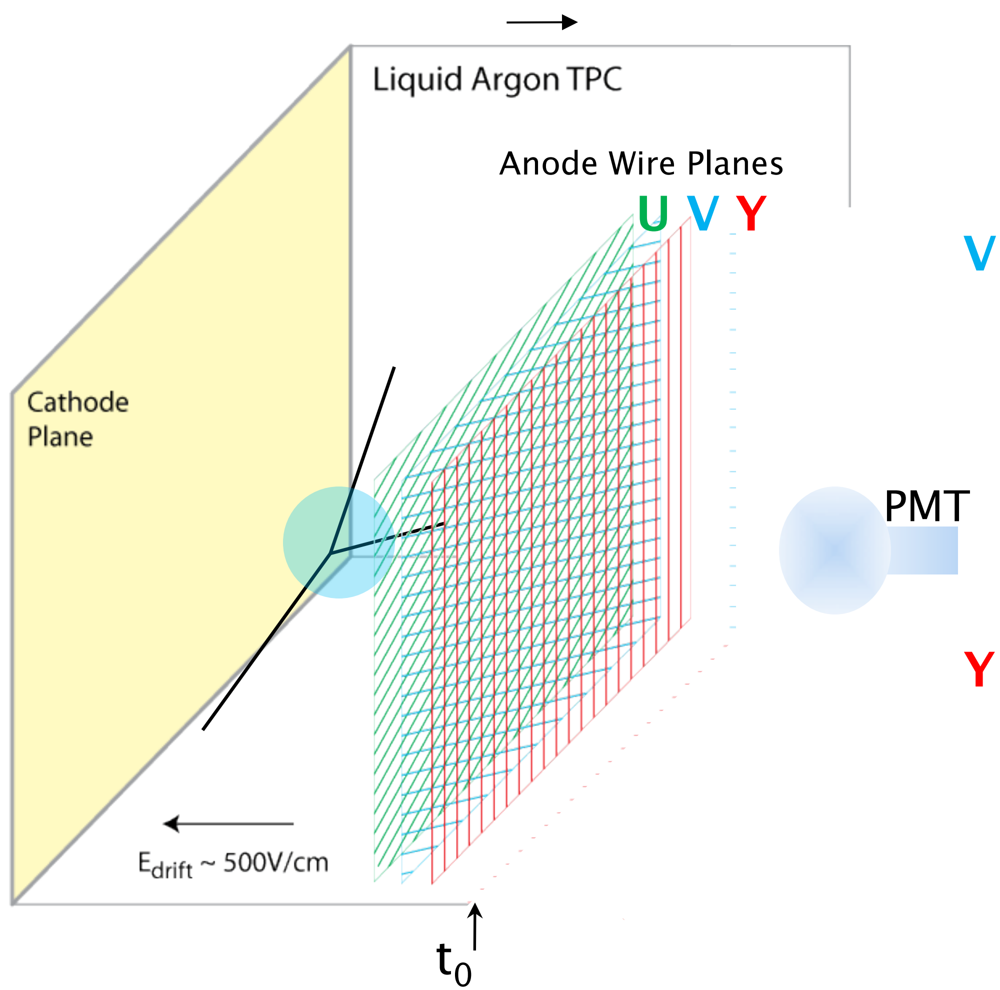
2.5x2.4x10.4 m^3

How Does a LArTPC Work?

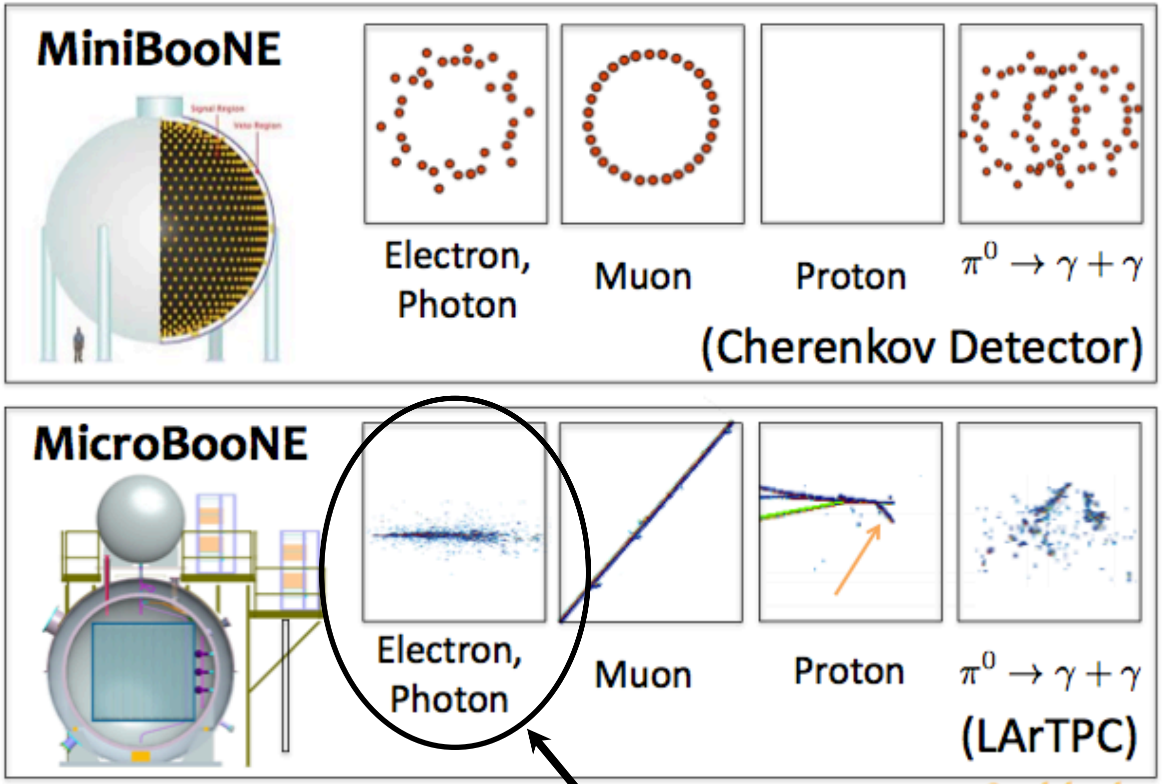


Bubble Chamber (1964)

1. Energy loss by charged



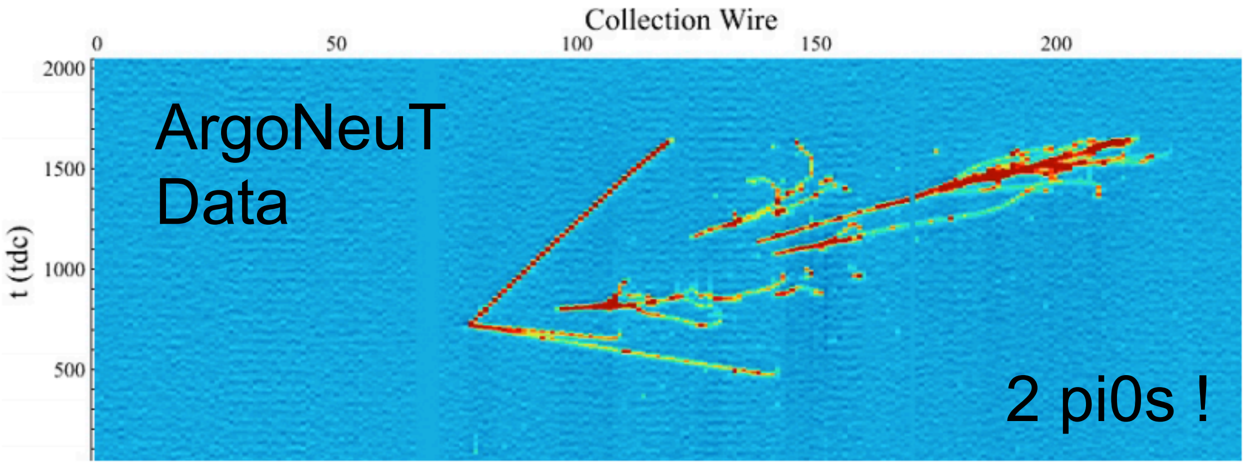
signals in the detectors



electrons, photons are distinguishable from their early ionization signature

signals in the detectors: pi0s

LArTPCs give an unprecedented level of detail into neutrino interactions.

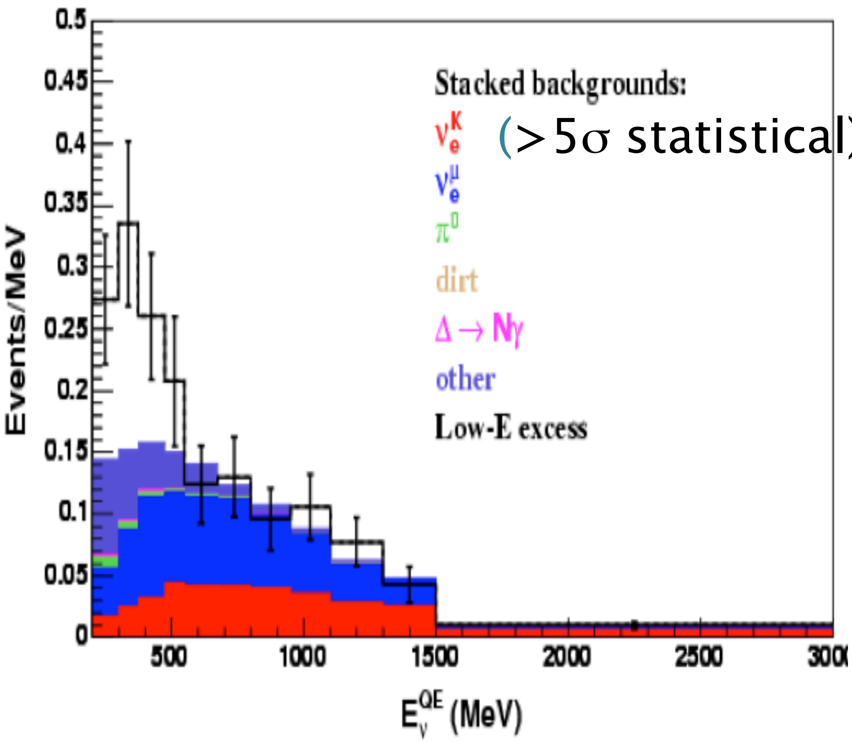


Note the high (x2) ionization early in each gamma

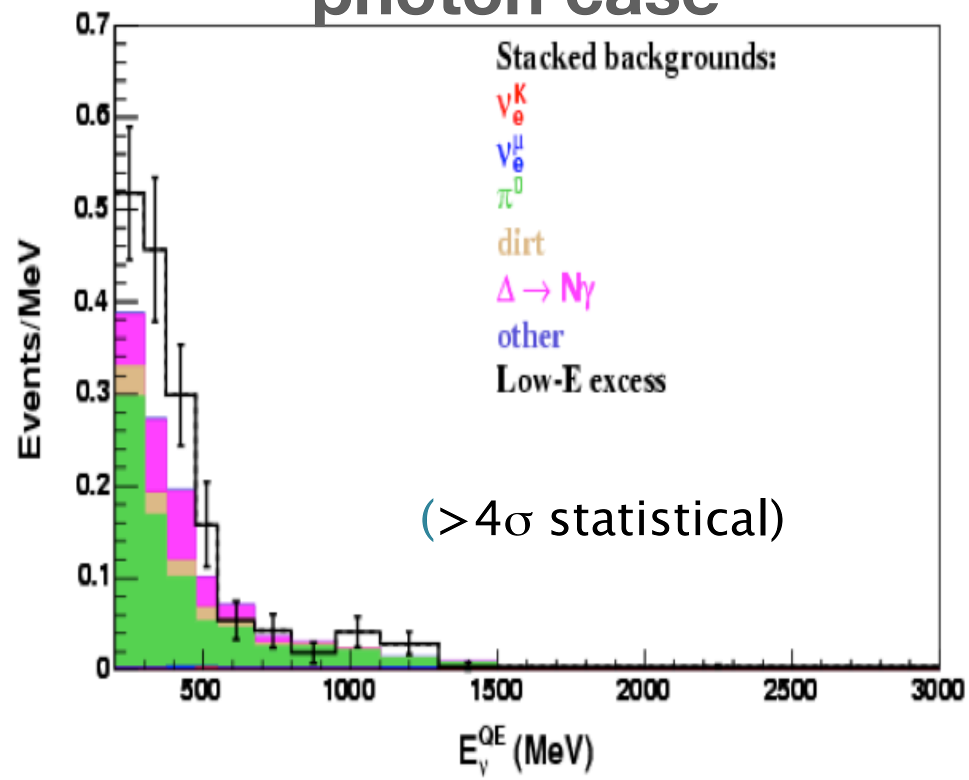
electrons or gammas?

Expected MiniBooNE Excess in MicroBooNE

electron case



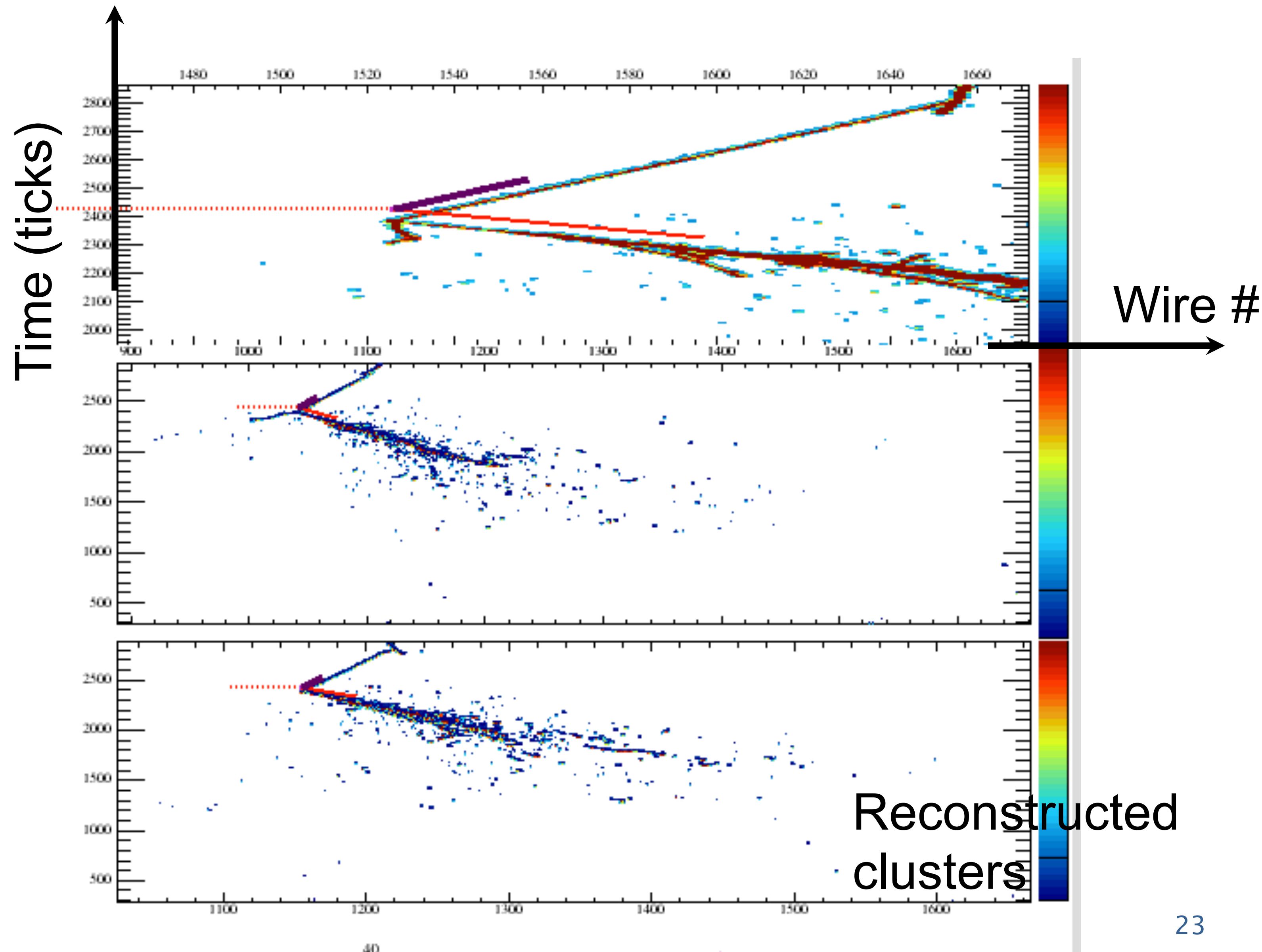
photon case



6.6×10^{20} POT

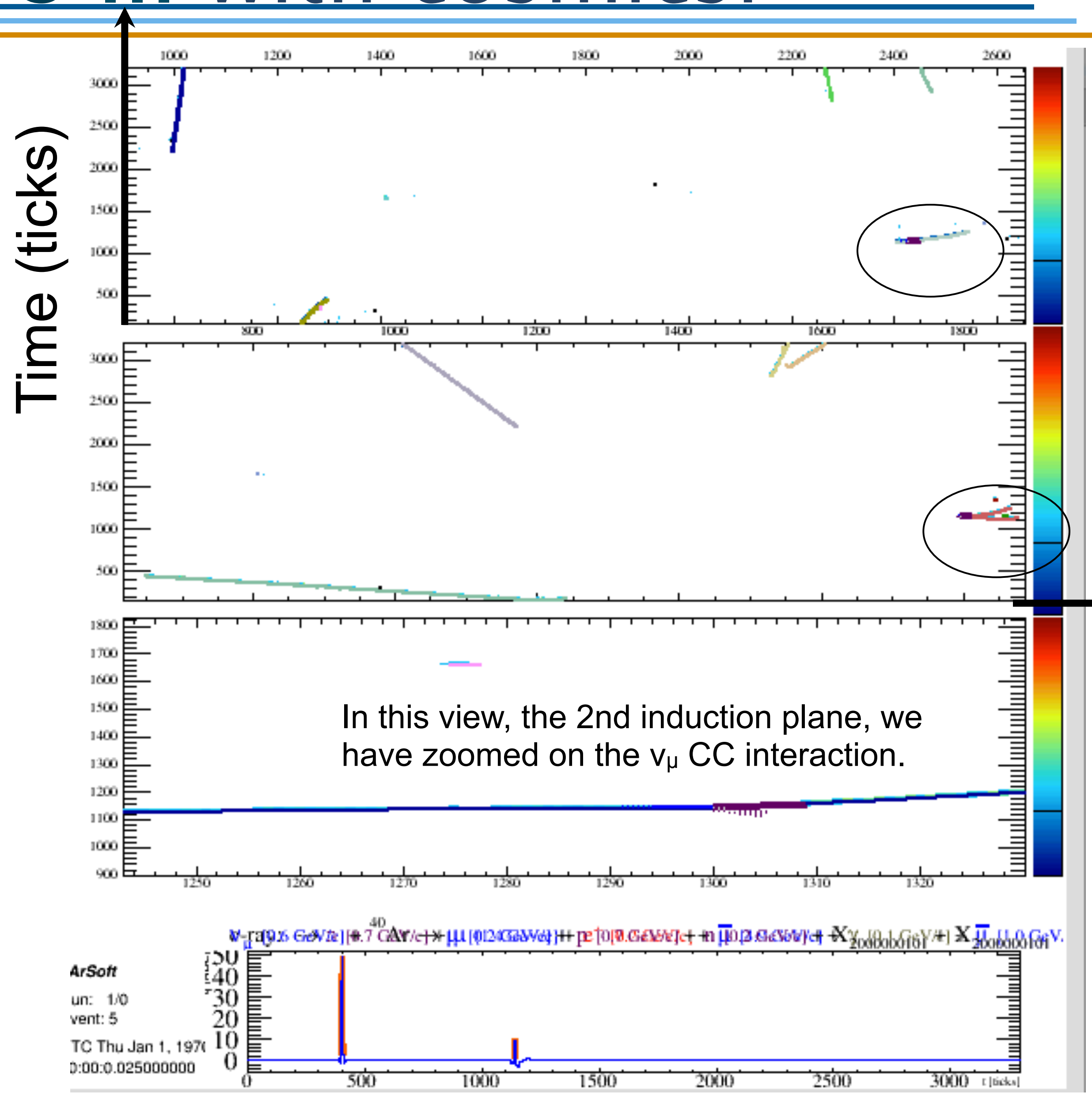
Monte Carlo

ν_e Charged Current (CC) in MicroBooNE



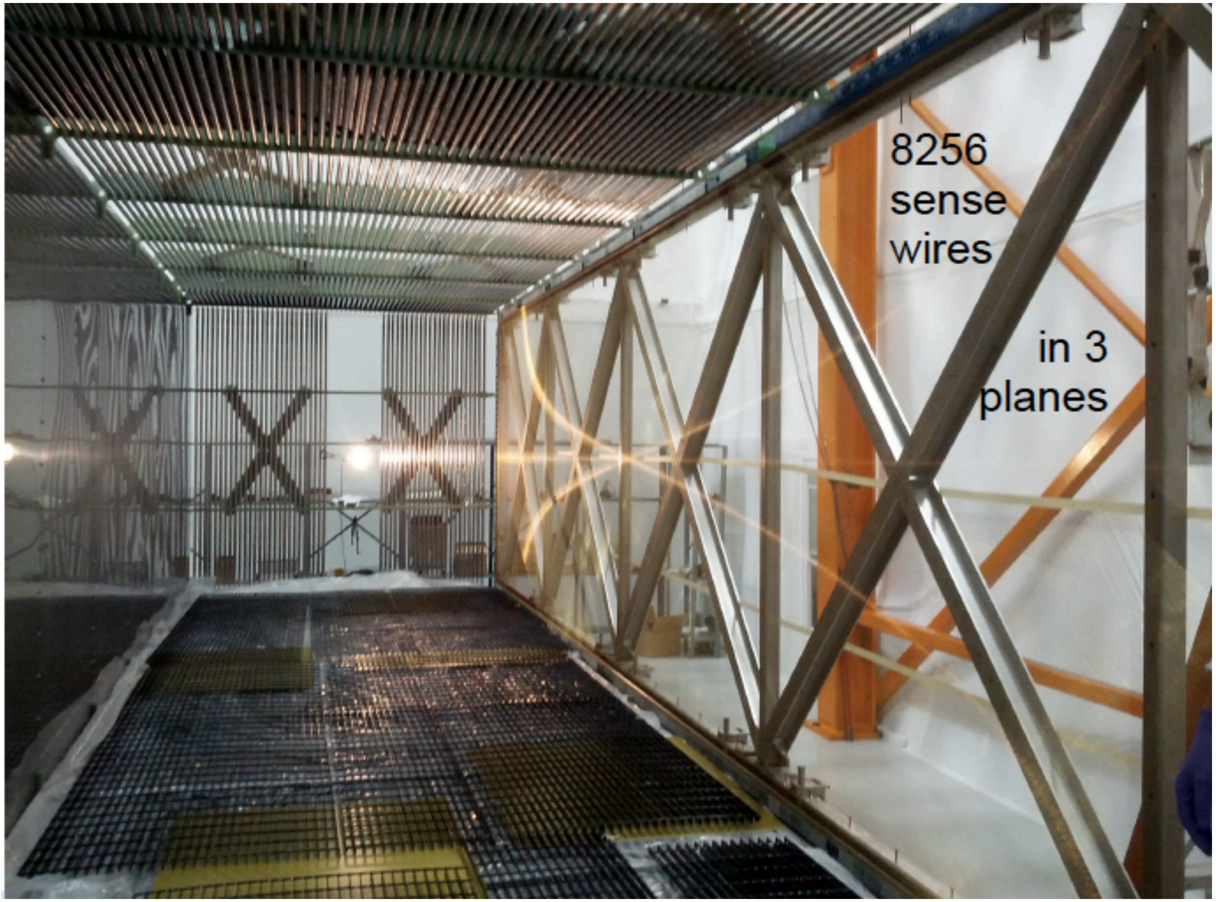
Monte Carlo

ν_μ CC … with cosmics!



The neutrino interaction is circled.

Detector Construction

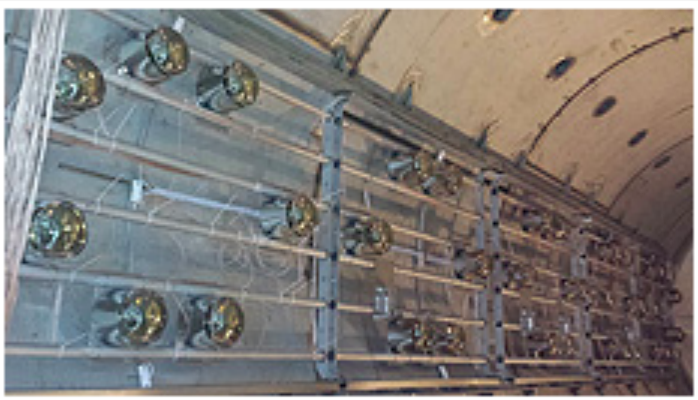


TPC strung
May, 2013

PMT final assembly

Construction Update

Optical system installed in MicroBooNE detector



MicroBooNE's optical system, which captures and measures light resulting from particle interactions, was recently installed in the experiment's detector. *Photo: Matt Toups, MIT*

Fermilab Today

Final Assembly of PMT array and Installation in the detector
September 2013

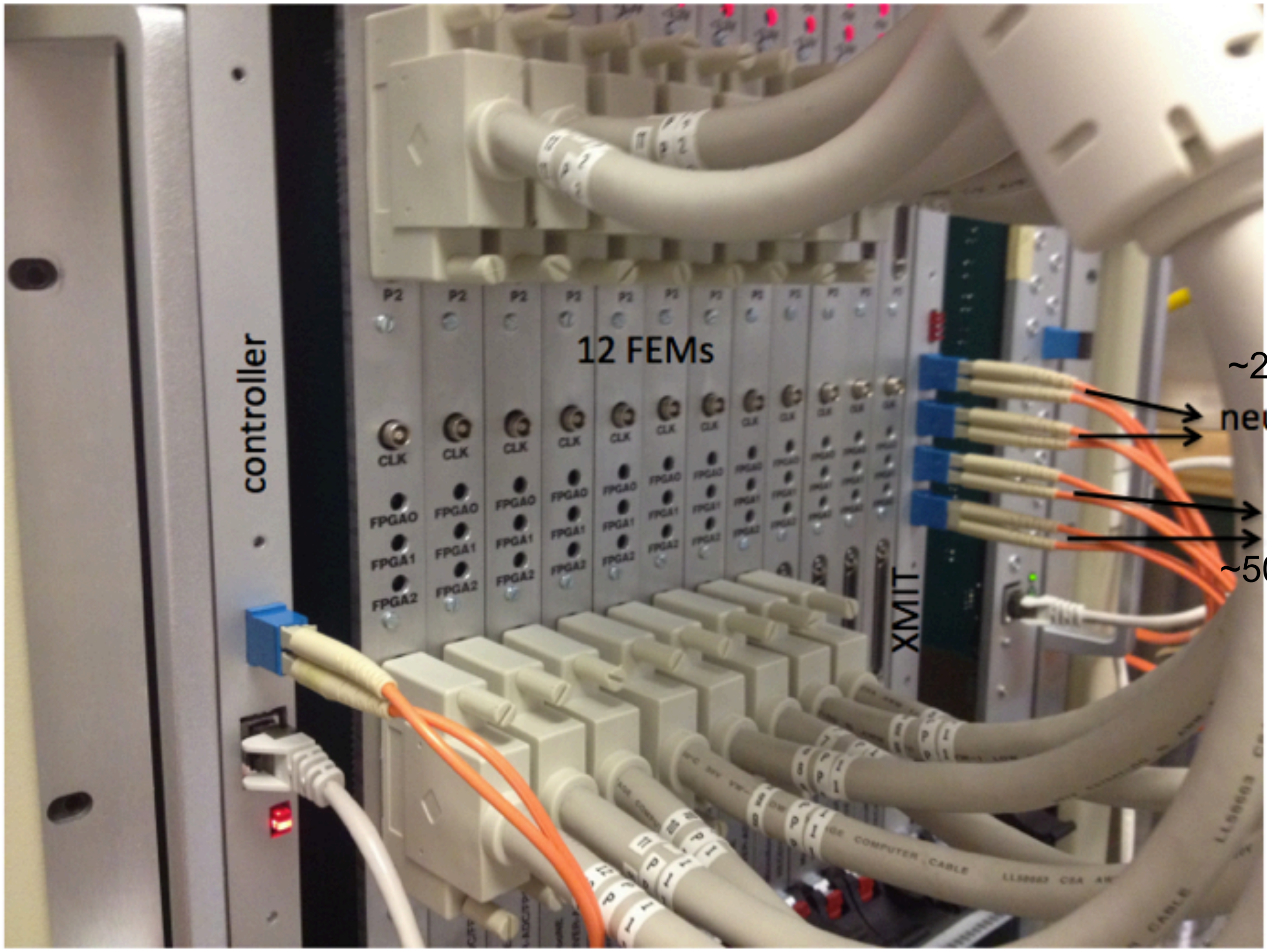
TPC installation into the Cryostat

December 20
2013

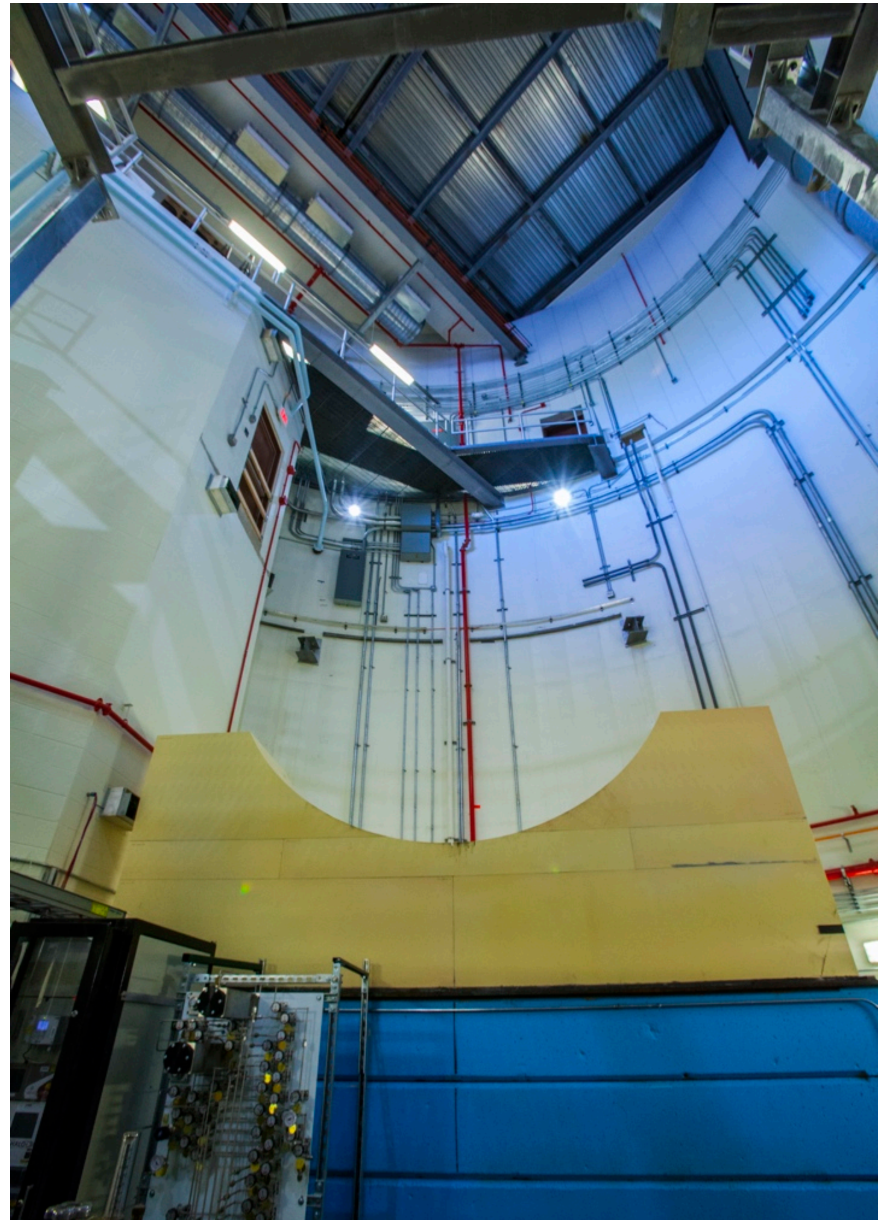
DAQ TPC crate – 9 total

Wires tested/read-out
in situ with vertical slice DAQ.

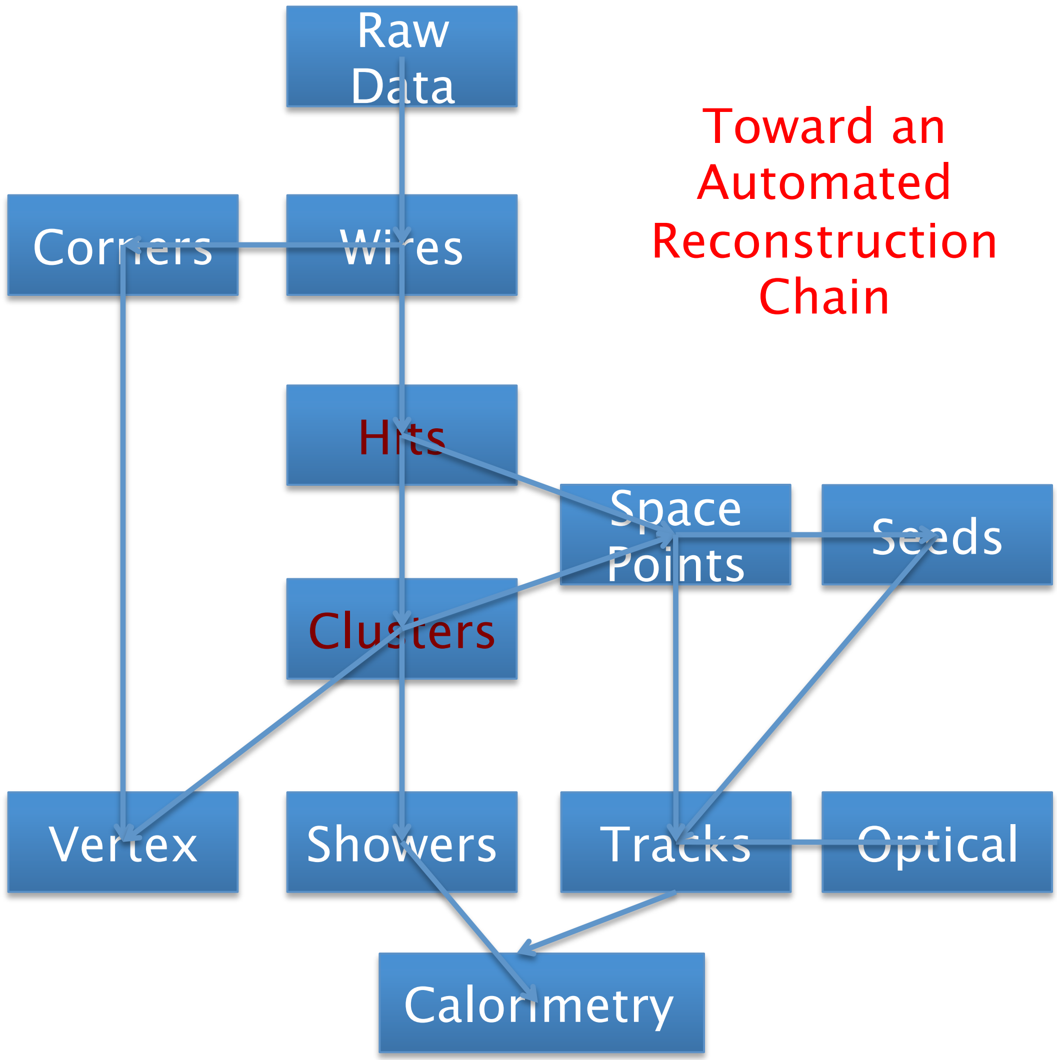
PMTs readout in situ
with full DAQ.



LArTF: MicroBooNE building



LAr Reconstruction Development

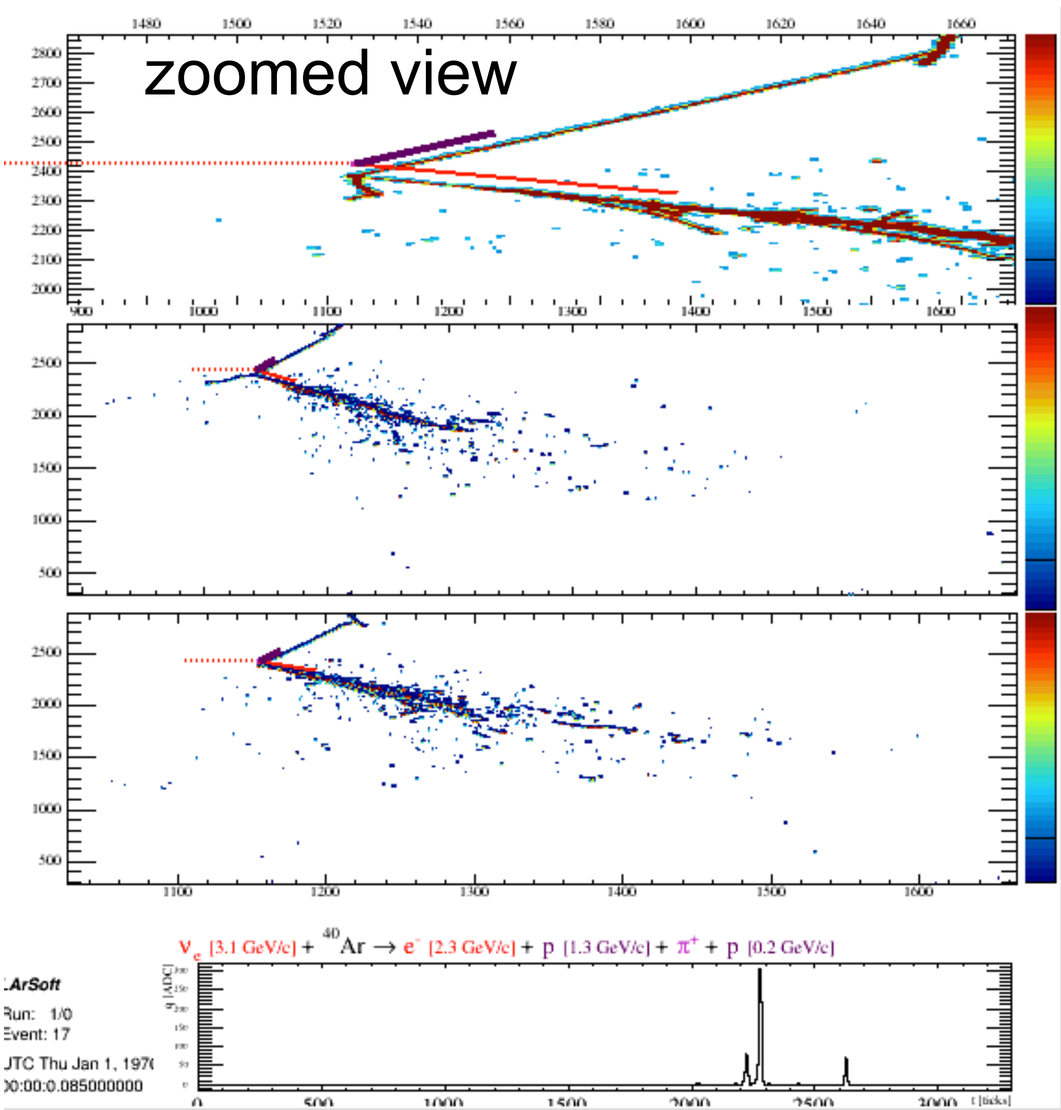


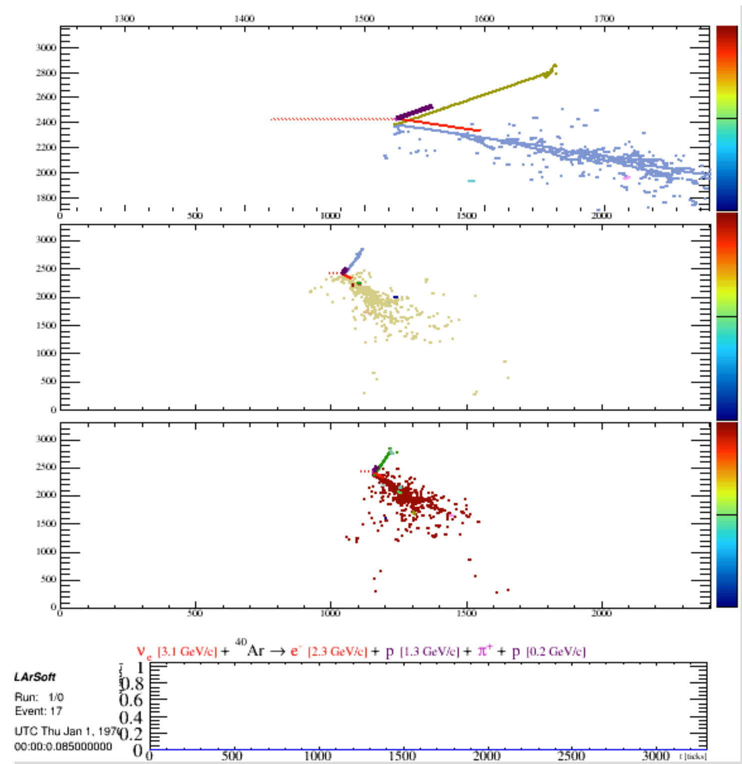
Toward an Automated Reconstruction Chain

Simplified version

Monte Carlo

ν_e CC in MicroBooNE





Reconstructed clusters

Conclusions

- MiniBooNE has one final chapter ahead: Dark Matter search and BNB monitor!

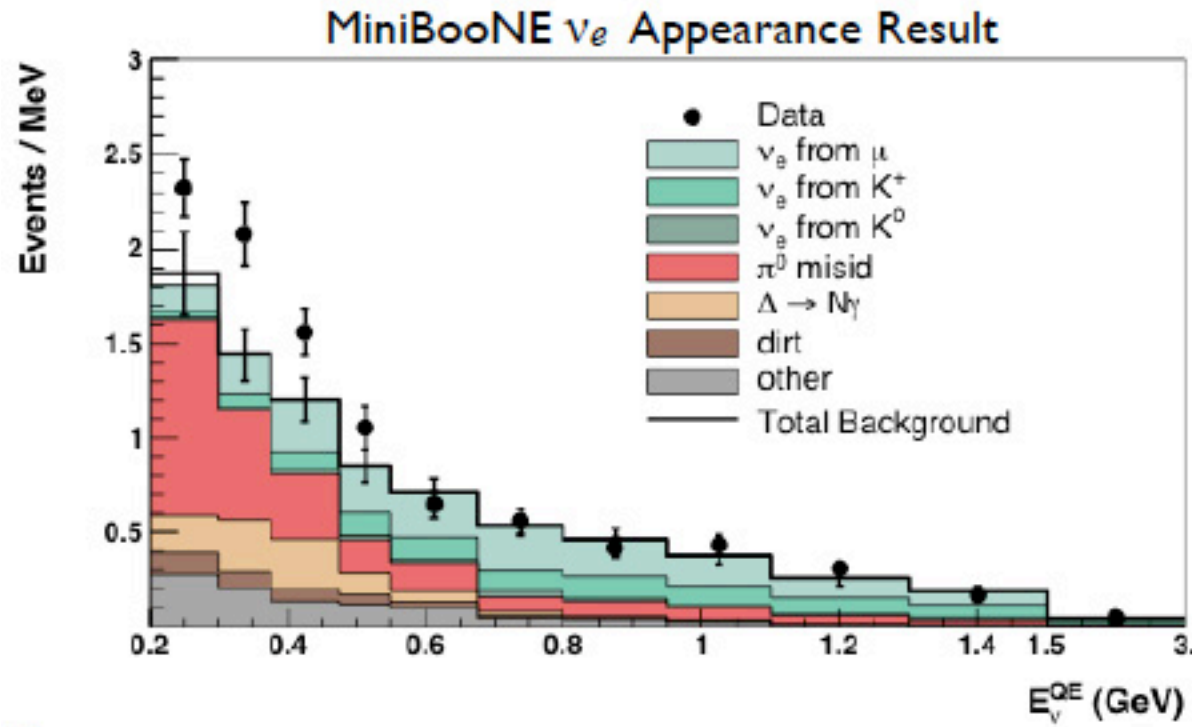
- MicroBooNE's final pre-commissioning work is underway

- MicroBooNE will move to LArTF and take data in Summer, 2014

- Thereby, the US experimental neutrino program enters a crucially important phase

Back-up Slides

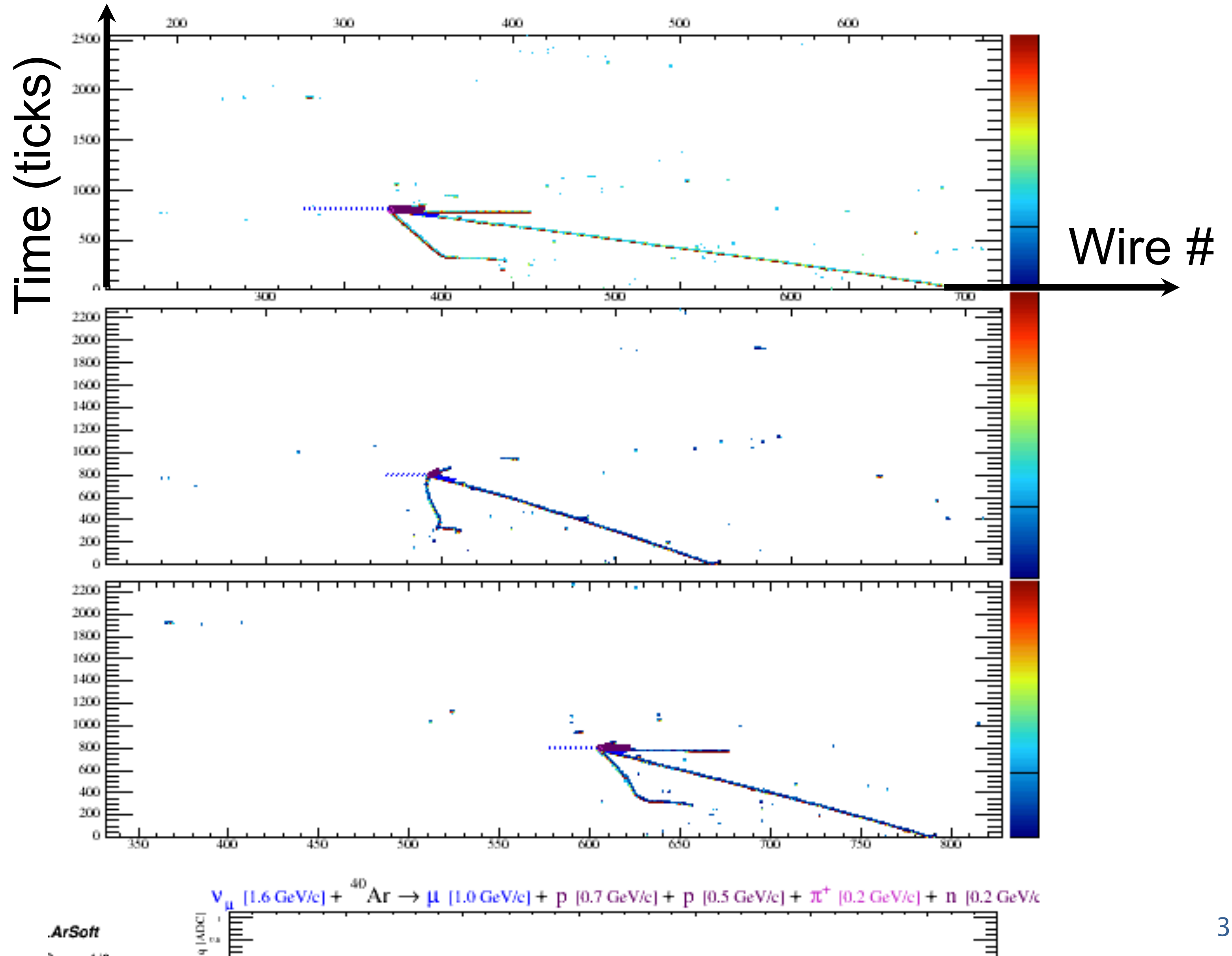
low Energy MiniBooNE excess



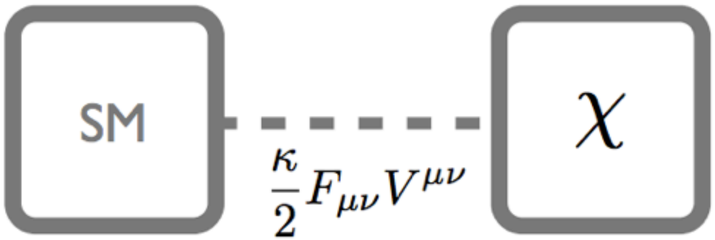
electrons
or gammas?

128.8 ± 43.4 events
0.200<E<0.475 GeV

Monte Carlo ν_μ Charged Current (CC) event

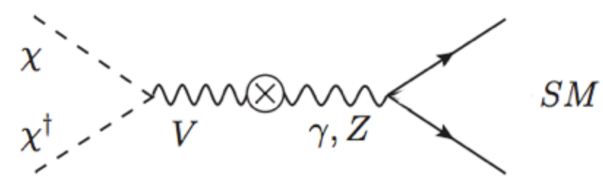


Benchmark vector portal model of light dark matter



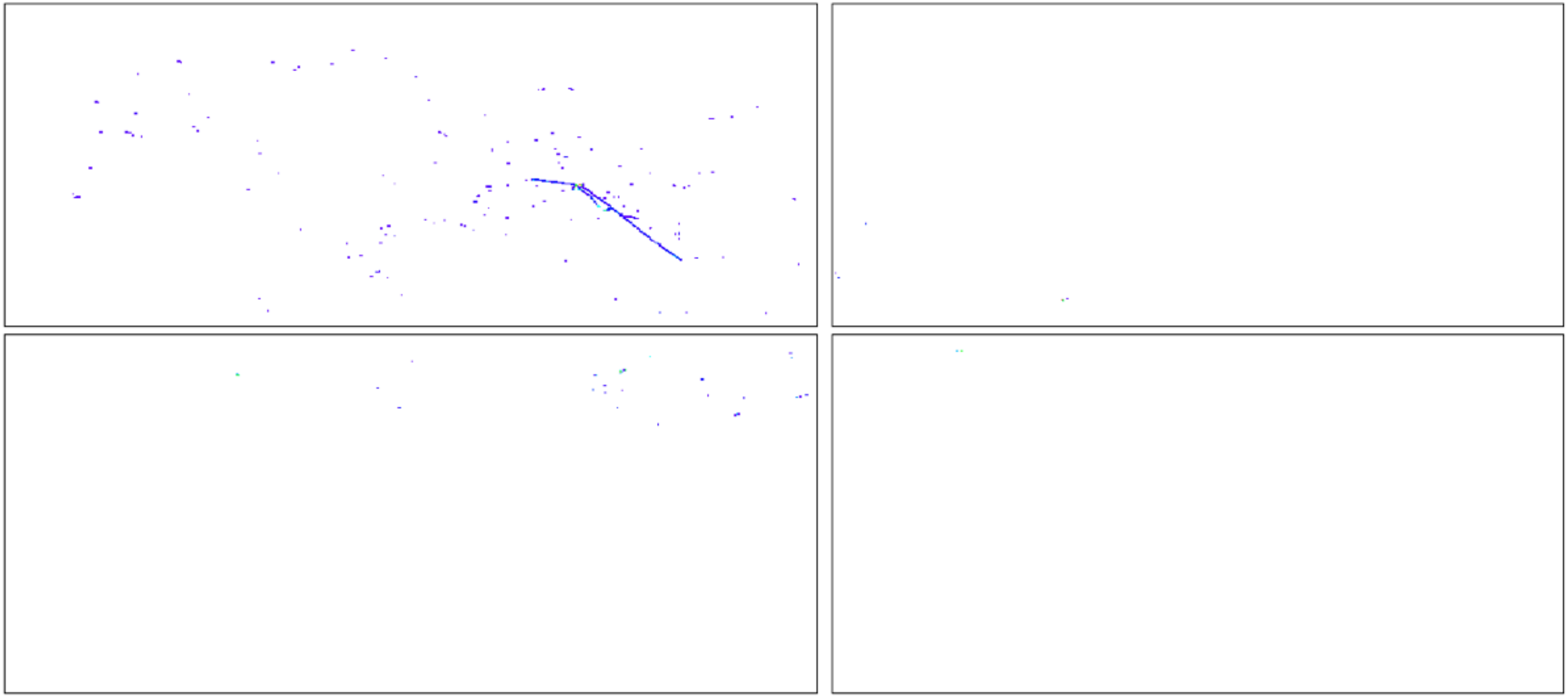
[Holdom]
[Pospelov, Ritz, Voloshin,
[Hooper, Zurek]
[Arkani-Hamed, et al]
... and many others

- Dark photon mediates interaction between DM and SM
- 4 new parameters: $m_\chi, m_V, \kappa, \alpha'$
- Can obtain correct relic abundance



LBNE modular TPCs

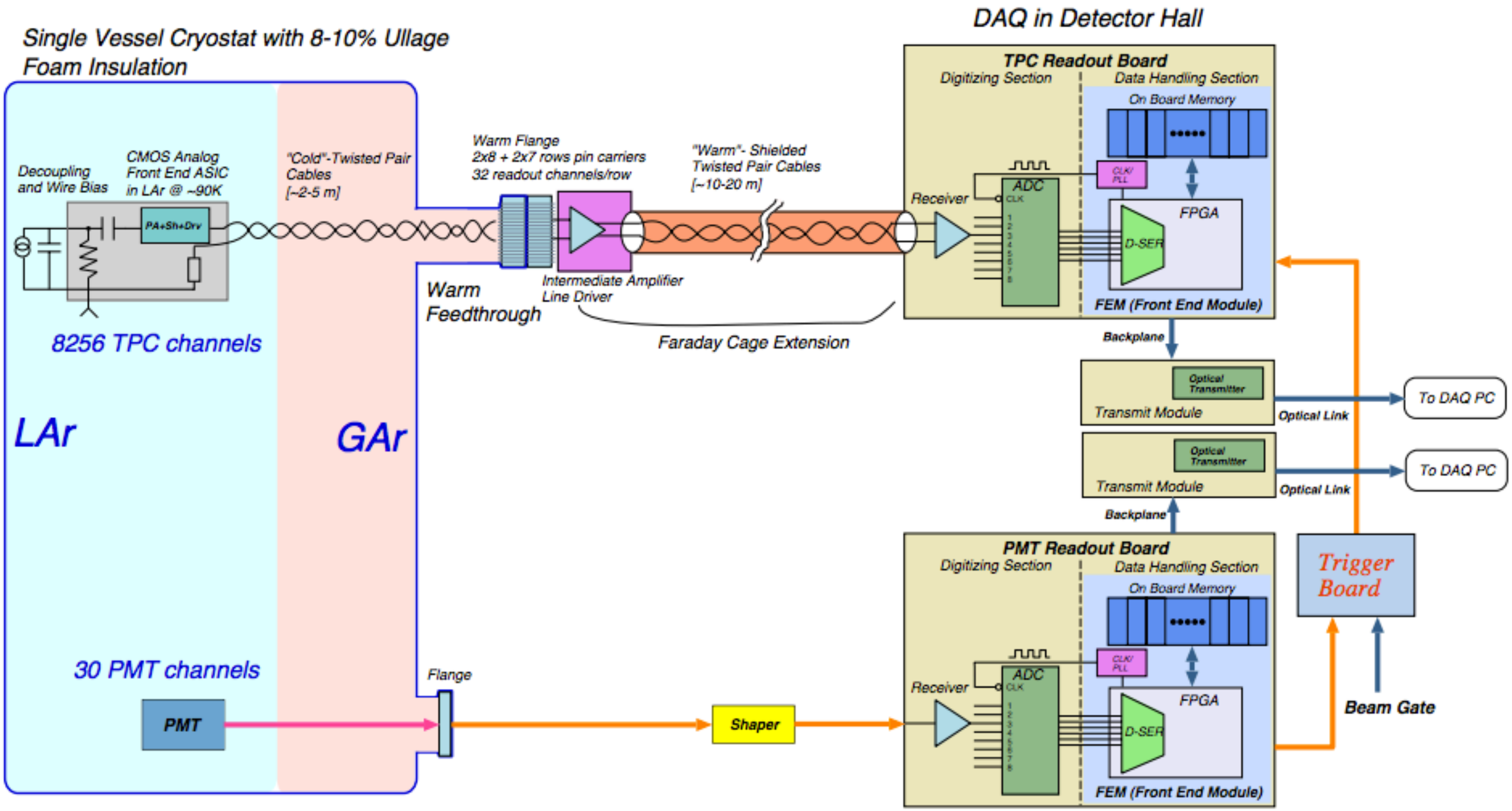
- z view only of atmospheric neutrino



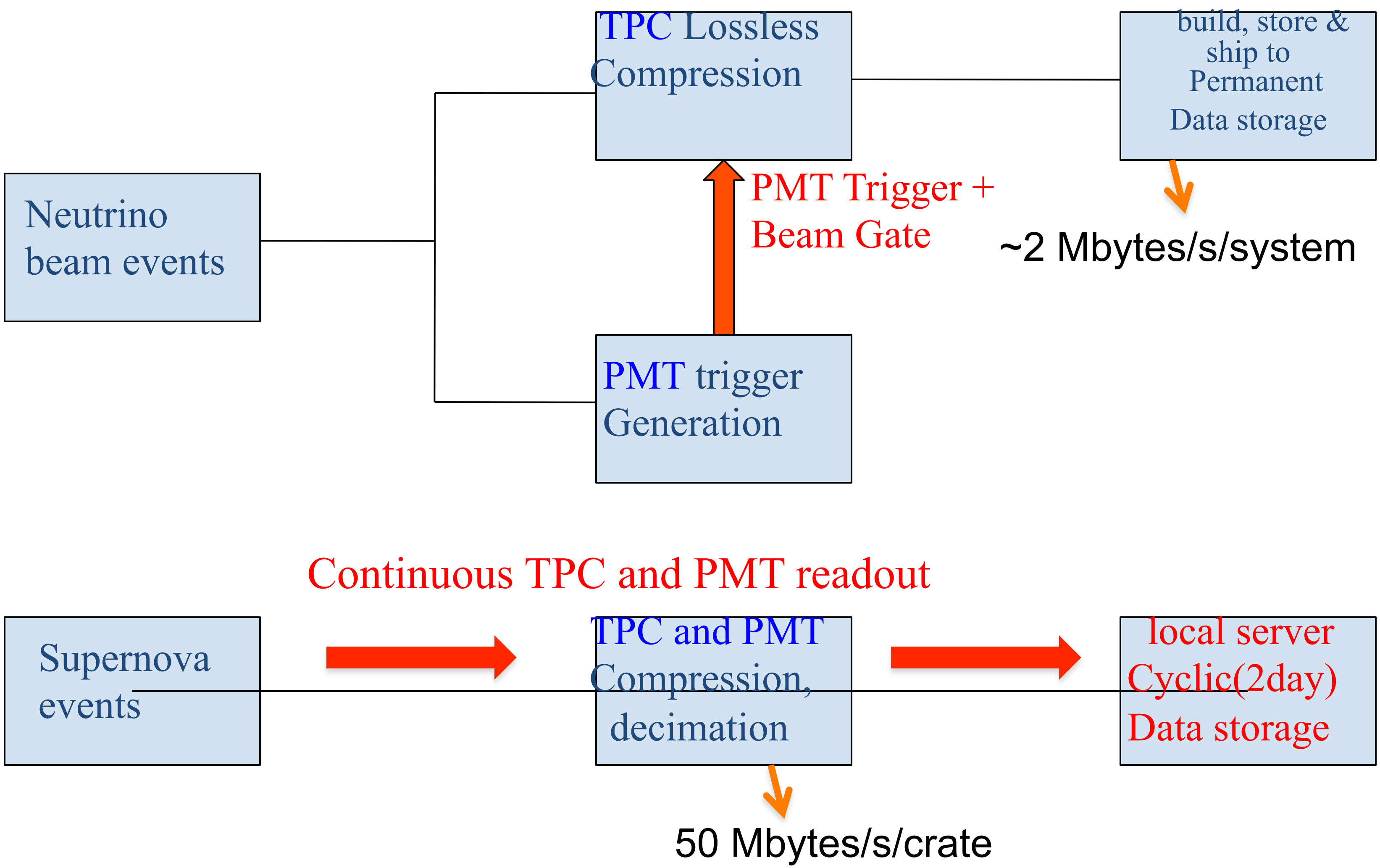
Specs

Cryostat Volume	150 Tons
TPC Volume (l x w x h)	89 Tons (10.4m x 2.5m x 2.3m)
# Electronic Channels	8256
Electronics Style (Temp.)	CMOS (87 K)
Wire Pitch (Plane Separation)	3 mm (3mm)
Max. Drift Length (Time)	2.5m (1.5ms)
Wire Properties	0.15mm diameter SS, Cu/Au plated
Light Collection	~30 8" Hamamatsu PMTs

MicroBooNE DAQ



Digitizing Boards: Current MicroBooNE design



Use the SN data stream to select and study K background events