Photo by Linda Kirby

Status of MicroBooNE

Michael Kirby, Fermilab

XVI International Workshop on Neutrino Telescopes

Venice, Italy March 4, 2015

Status of MicroBooNE

- motivation for MicroBooNE at Fermilab
- physics goals of MicroBooNE
- detector design and performance goals
- where the experiment currently stands

Motivation for MicroBooNE

- understand MiniBooNE excess in ν_e-candidates
  - started from the LSND excess
  - short baseline neutrino physics is extremely interesting right now
- measurements of ν-Ar cross sections
  - improved understanding of neutrino-nucleus interactions
- Liquid Argon detector research and development for future experiments
- Supernova neutrinos and proton decay bkg

Photo by Reidar Hahn

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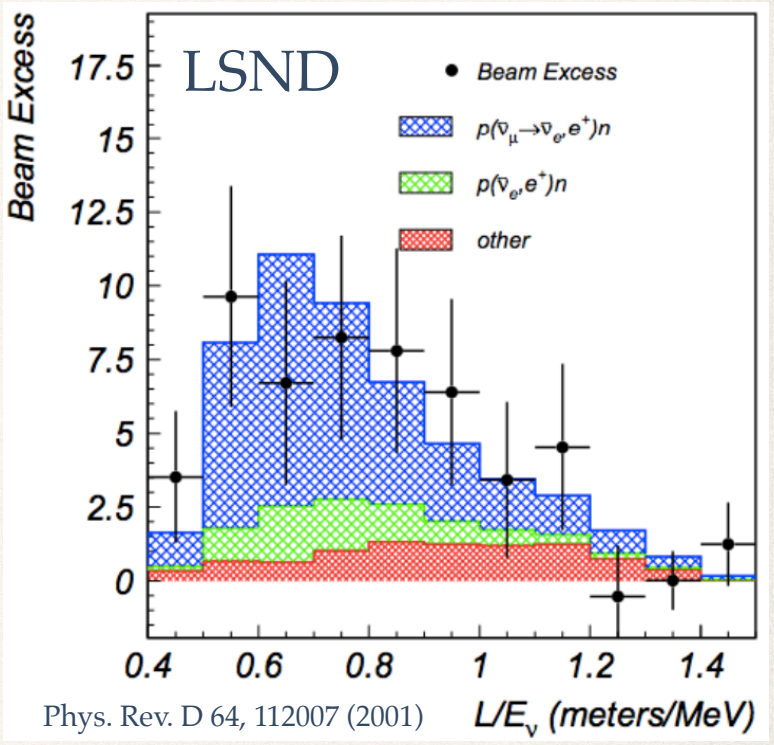

Phys. Rev. D 64, 112007 (2001)

two-flavor oscillation best fit

$\Delta m^2 = 1.2\ eV^2$

$\sin^2 \theta = 0.003$

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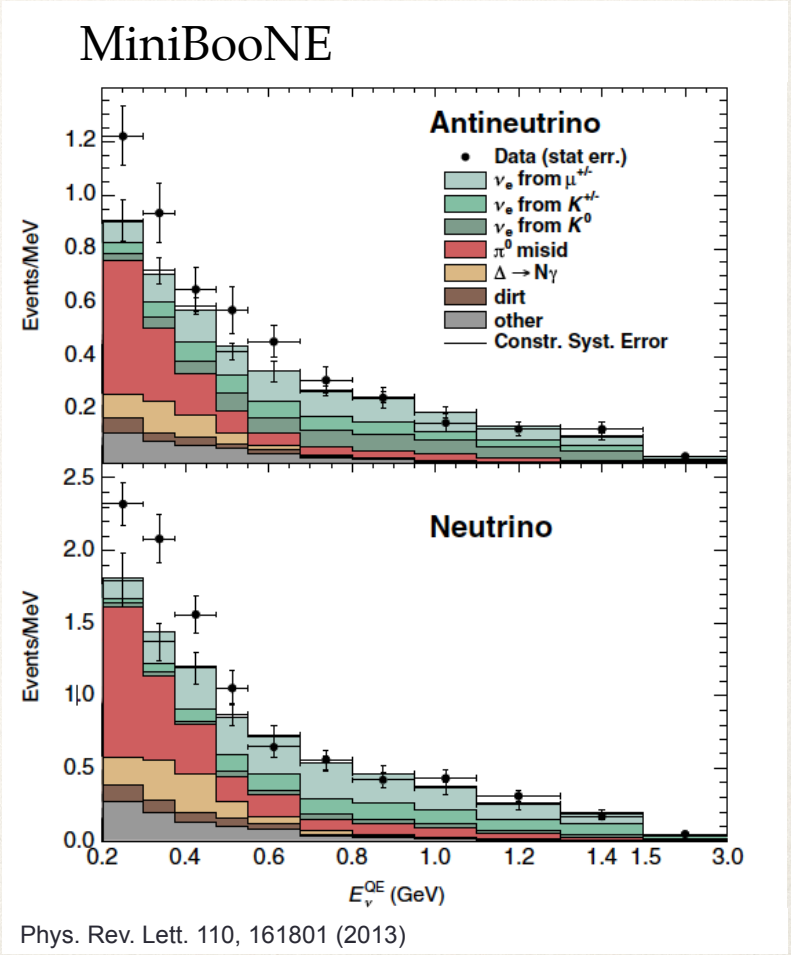

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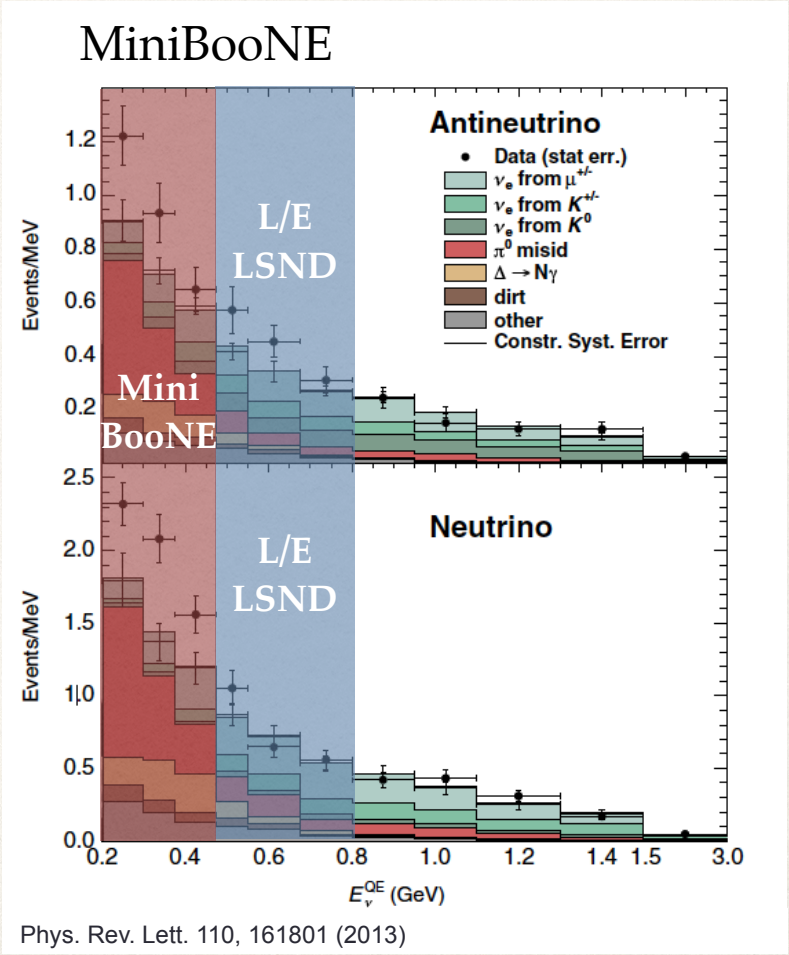

Phys. Rev. Lett. 110, 161801 (2013)

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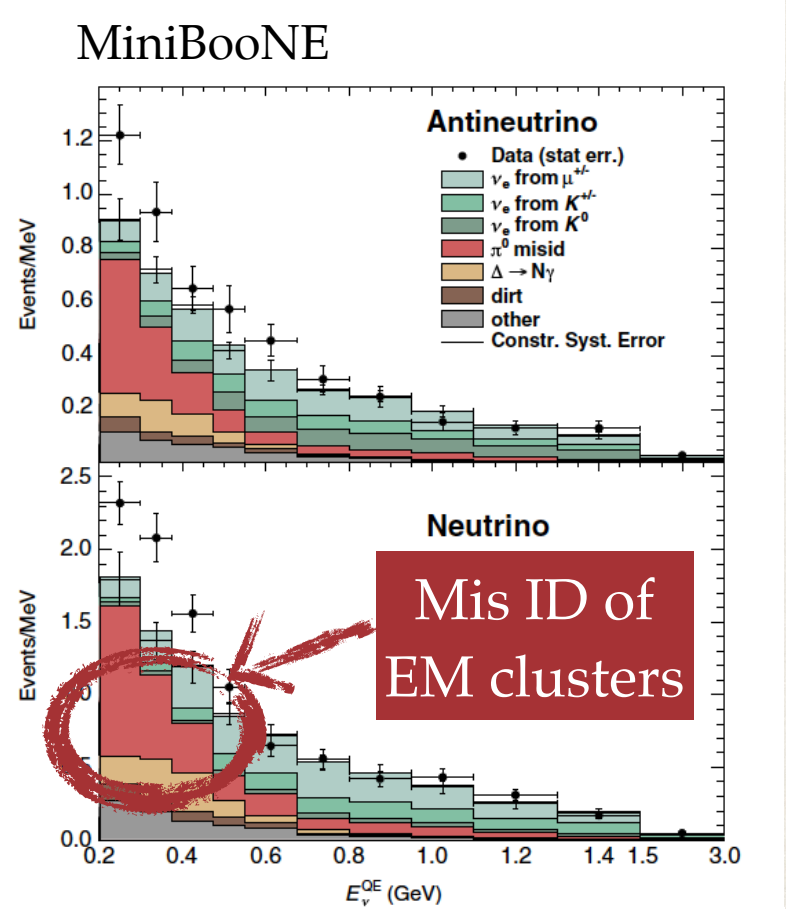

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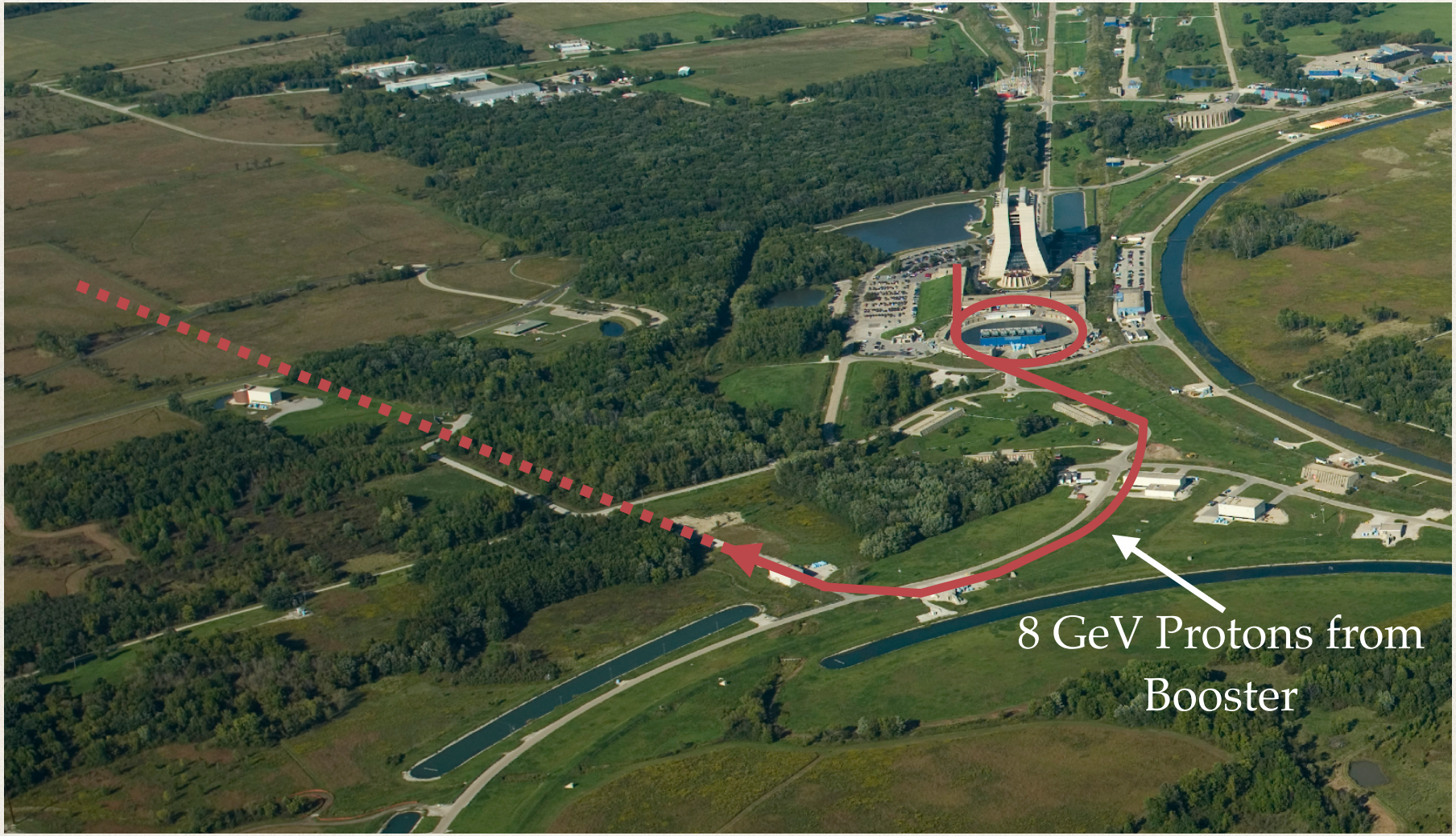
Booster Neutrino Beam at Fermilab



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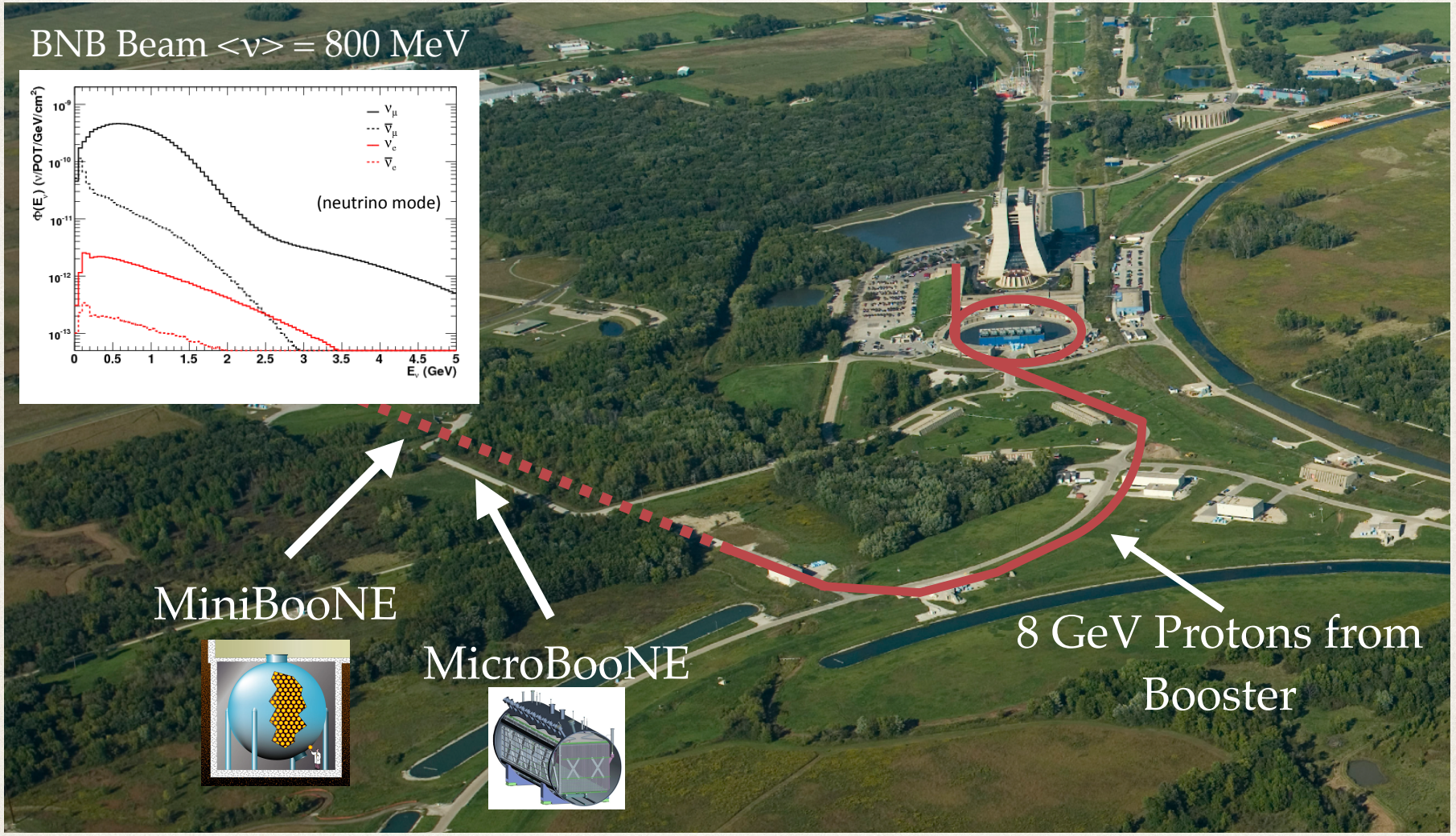

Utilize the same beam line for MicroBooNE, 470m baseline

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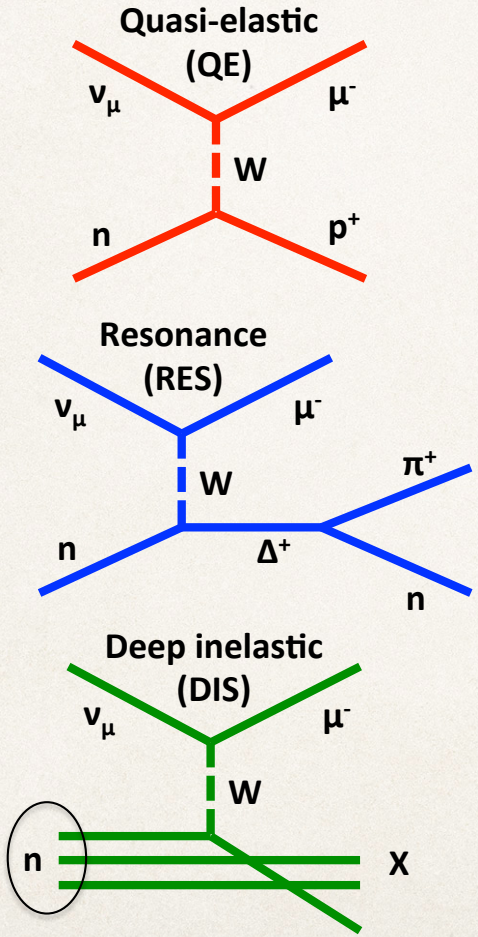
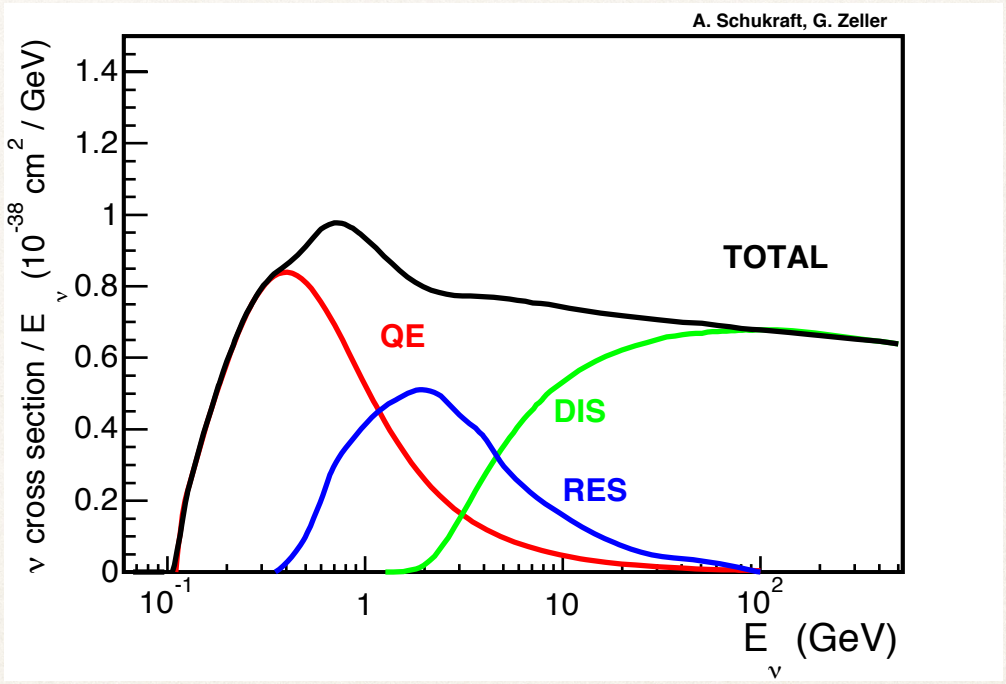
neutrino interacting with nucleons

Slide courtesy of Anne Schukraft





(also neutral current diagrams)

neutrino interacting with nucleons

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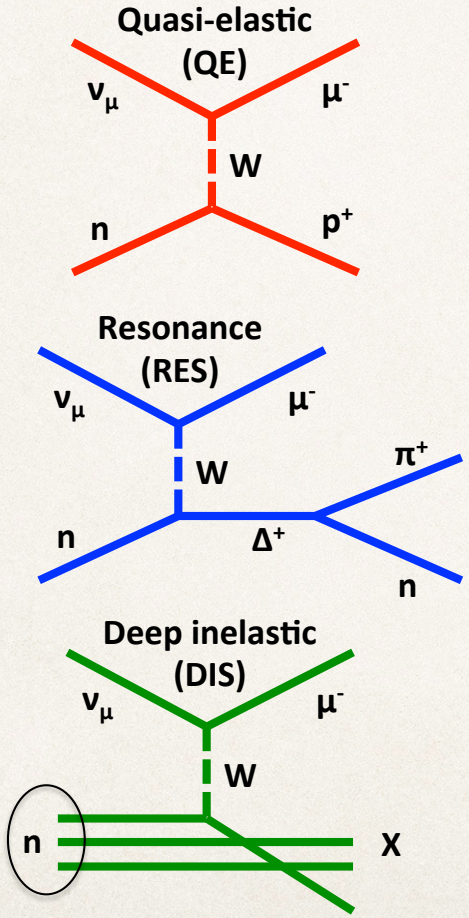
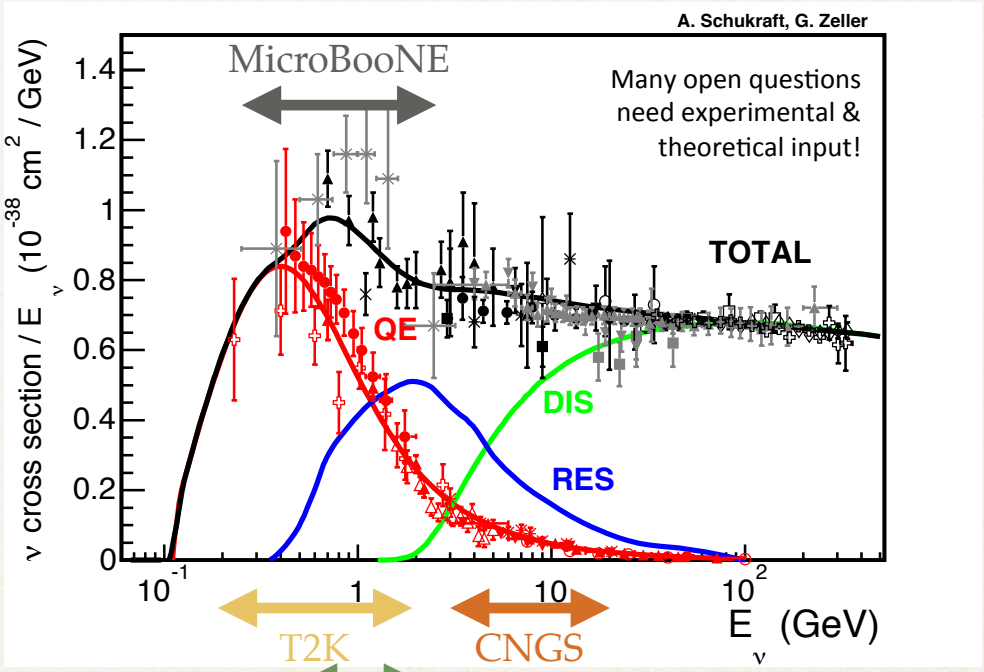


Lots of interesting (nuclear) physics over all energy ranges.



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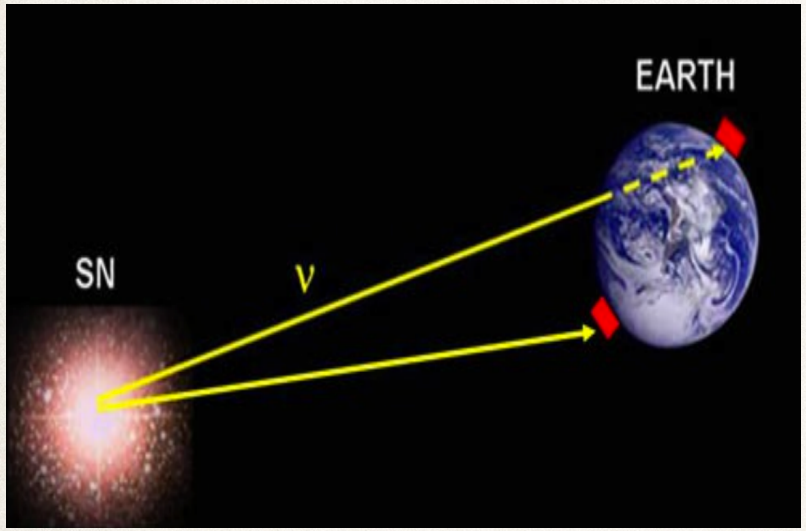
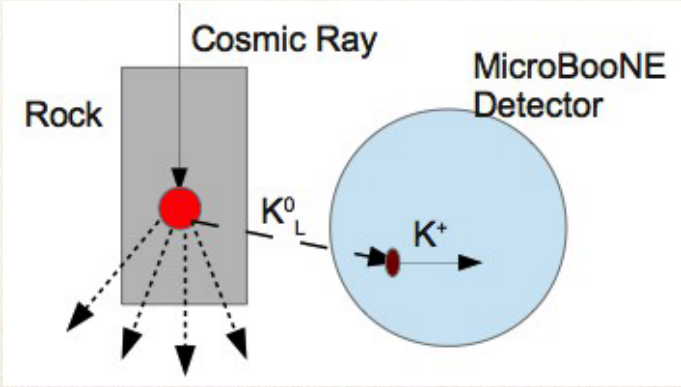
Supernova neutrinos and proton decay at MicroBooNE



- MicroBooNE is also prepared to be part of the SNEWS response network
- Special data streams are utilized to cache unbiased, continuous readout
- expect 10-20 low-energy electron-ν for supernova collapse at 10 kPc
- LAr TPC detectors sensitive to electron-ν
  - water and liquid scintillator detectors sensitive to electron anti-ν

- Many GUT scale theories predict baryon number violation
- MicroBooNE detector is too small to be sensitive to proton decay
- can make important measurements of proton decay backgrounds
- neutral Kaon production in rock can charge exchange and mimic proton decay - important for future large LAr detectors



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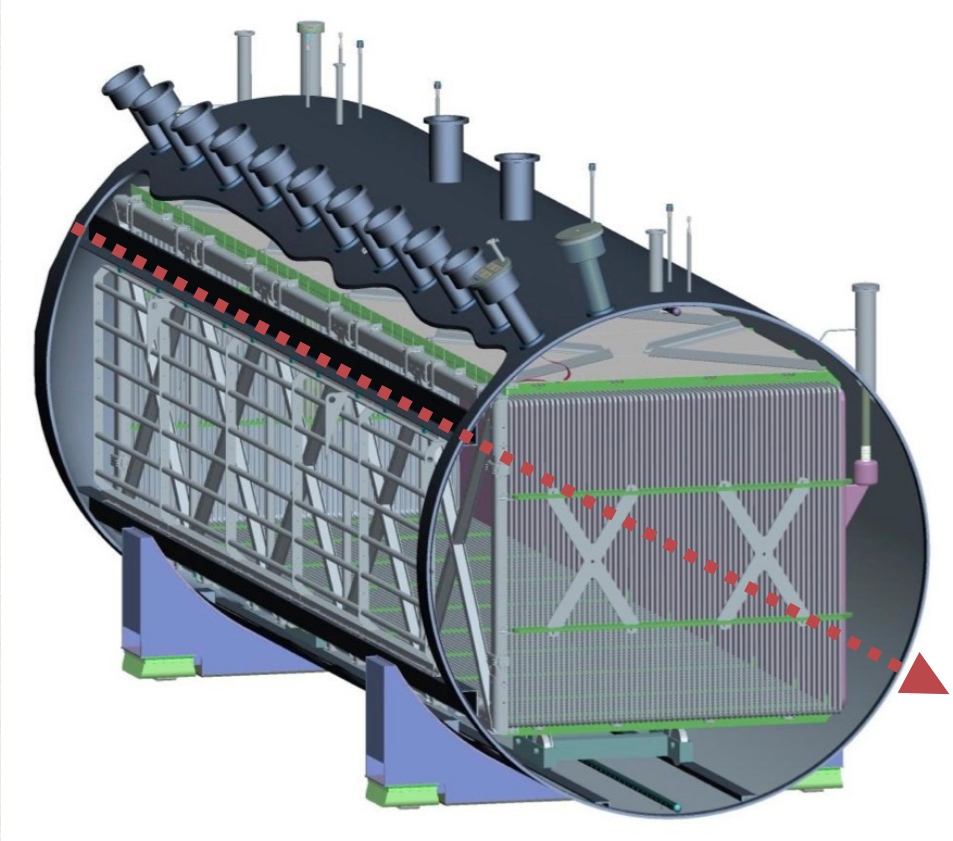
MicroBooNE Detector Design



- 170 ton Liquid Argon TPC
  - building on ICARUS technology
- 89 ton active volume
- 8256 readout wires in 3 anode planes
- 128 kV HV across 2.56 m drift distance
- 32 PMTs
- 2 UV lasers for calibration

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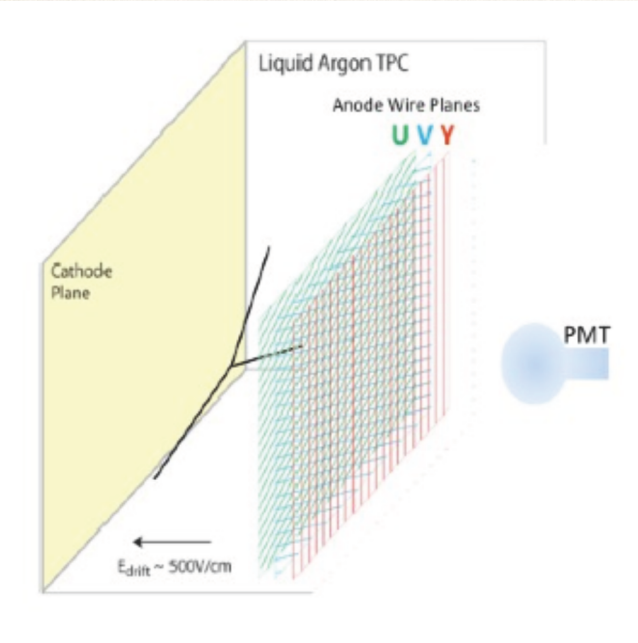

Like a ship that speeds past instantaneously,
you see the flash of the bow light,
and eventually the waves on the shore

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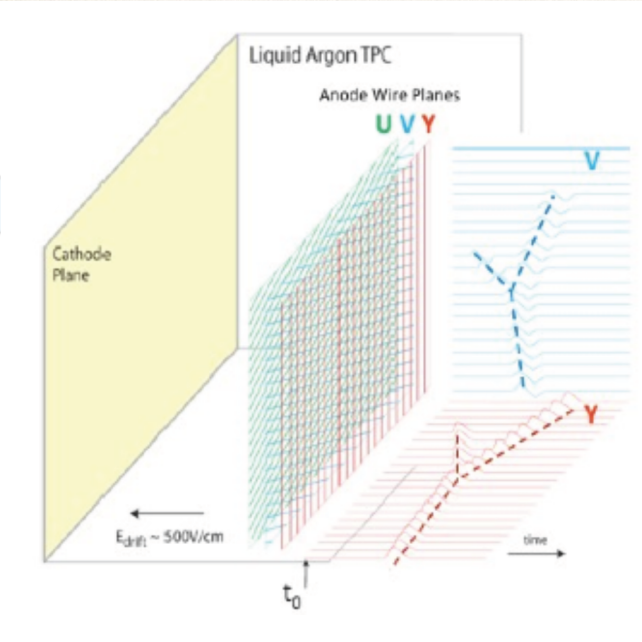

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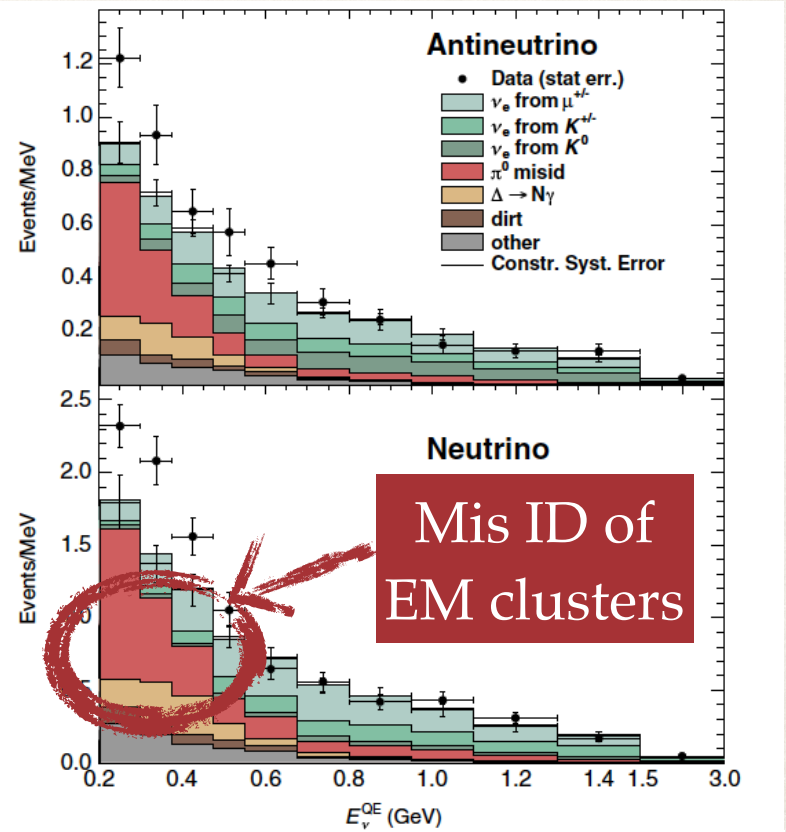

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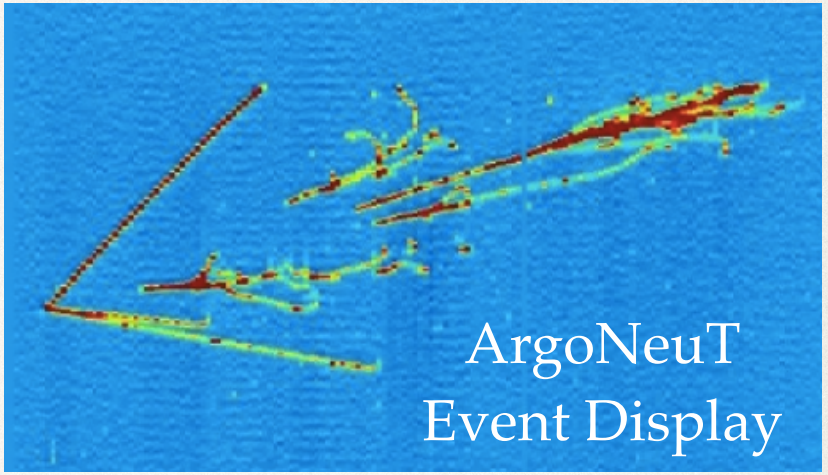

- topological cuts
  - gap between vertex and EM shower
  - electron-position shower pair
- dE/dX at start of shower

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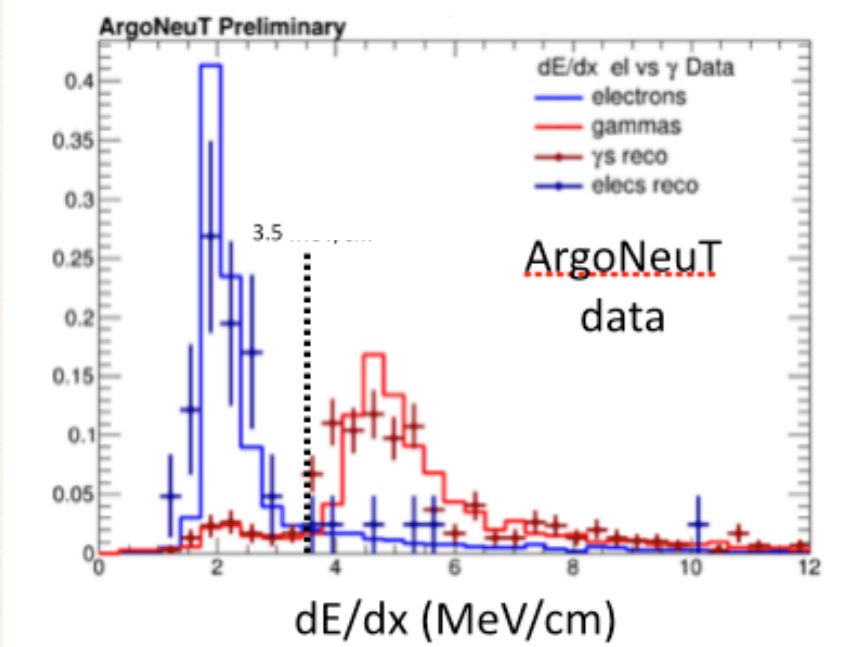

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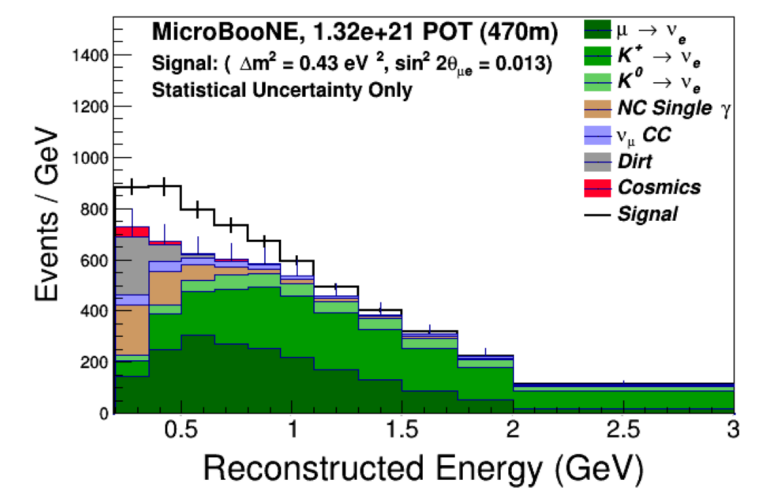

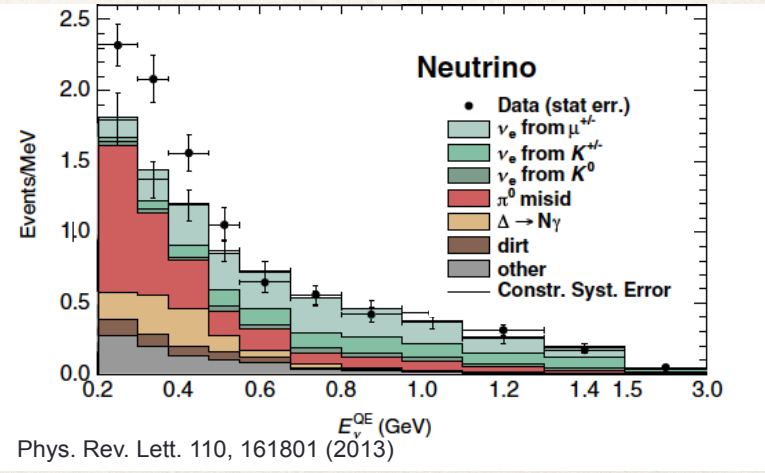

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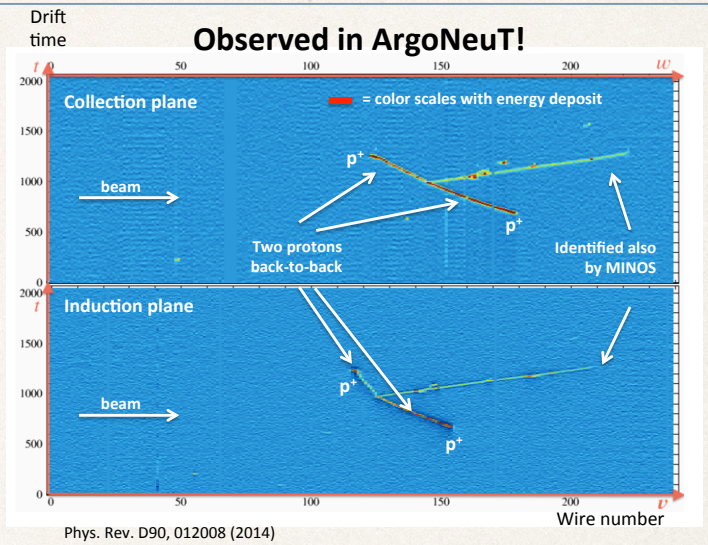

Phys. Rev. D90, 012008 (2014)

- improved identification of final state particles
  - multi-proton events identified in ArgoNeuT data
  - important for CC QE and FSI tuning
- increased statistics with 6.6E20 POT requested

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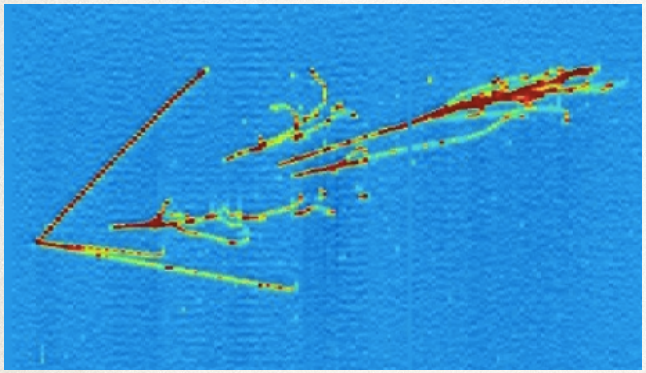
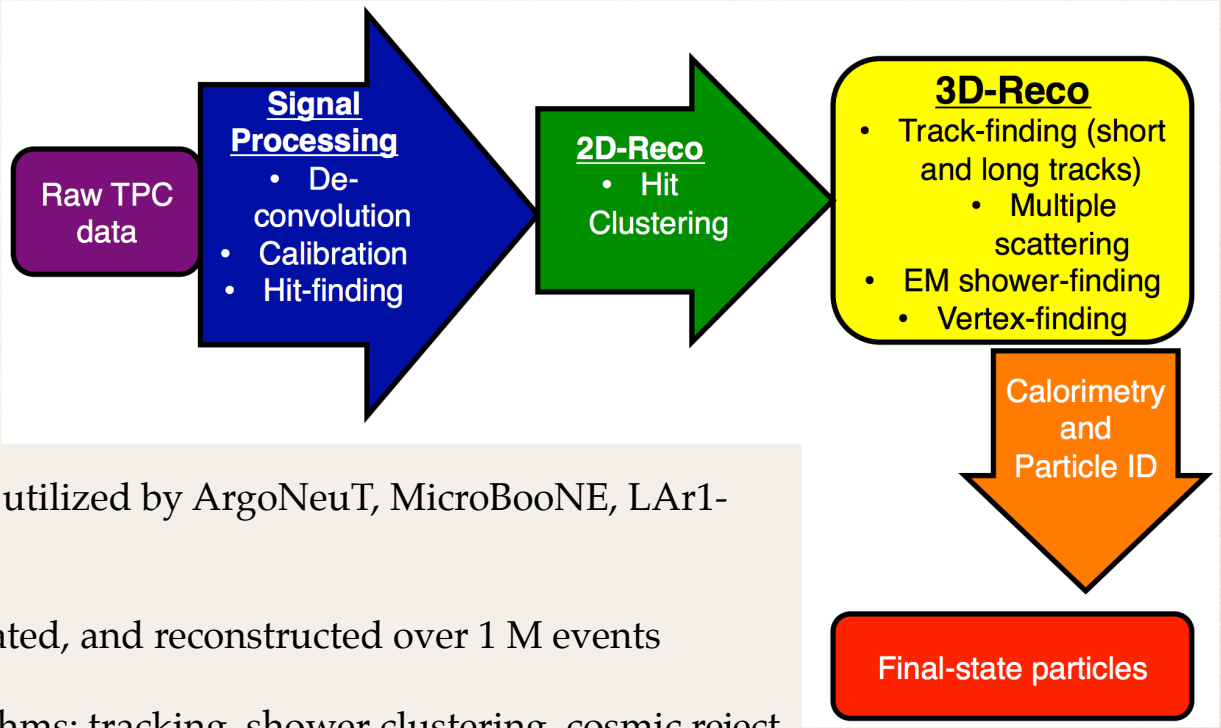
Technological advancements in LAr TPC

- argon fill without evacuation (proven with LAPD)
- cold front-end electronics
- long drift (2.5 m)
- automated reconstruction
- laser calibration

LArSoft automated reconstruction





- LArSoft reconstruction framework utilized by ArgoNeuT, MicroBooNE, LAr1-ND, and other collaborations
- MicroBooNE has generated, simulated, and reconstructed over 1 M events
- working on extensive list of algorithms: tracking, shower clustering, cosmic reject, muon MCS, etc
- ArgoNeuT utilized earlier version of LArSoft for several publications of neutrino interaction cross sections

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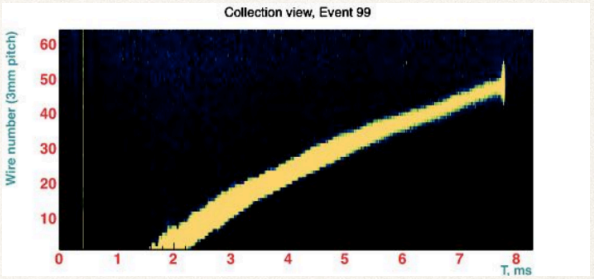
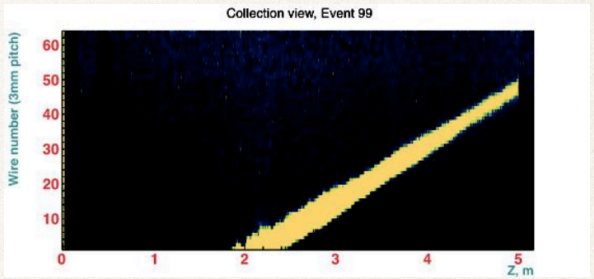
UV Laser Calibration

before



after



- >10 peer reviewed papers published on detector technology
- purity, HV, PMTs, laser calibration, surge protection

Current status of MicroBooNE

- TPC installed in cryostat in Dec 2013
- TPC/Cryostat was installed in June 2014
- Insulation complete, cryogenic preparation begun, and anticipate delivery of argon soon
  - argon fill without evacuation (demonstrated with LAPD)
- FrontEnd DAQ and Cabling is complete
- full scale DAQ readout has begun

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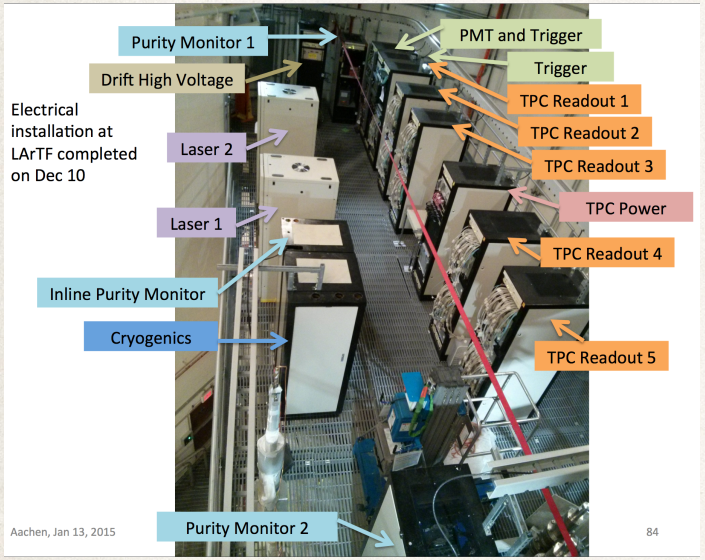

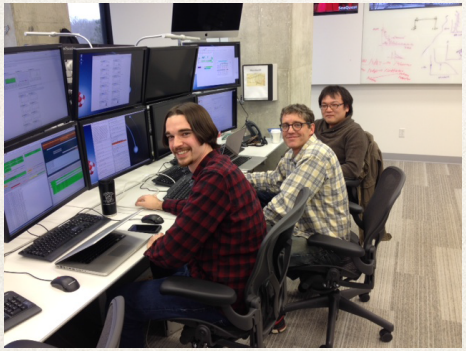

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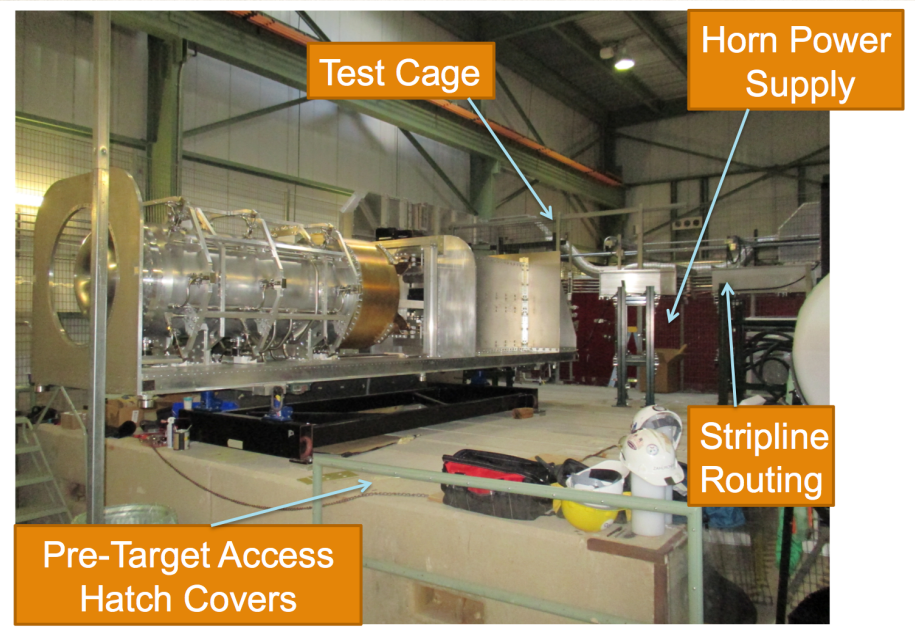

- BNB Horn-2 in service since Oct 2004 - pulsed > 400 M times
  - Nov 2014, 2 of 4 functioning cooling headers became clogged
- BNB Horn-2 is being replaced with updated design Horn-3
- anticipate first POTs before July shutdown
- possibly as early as first week of May
- Fermilab has approved MicroBooNE for 6.6 E 20 P.O.T

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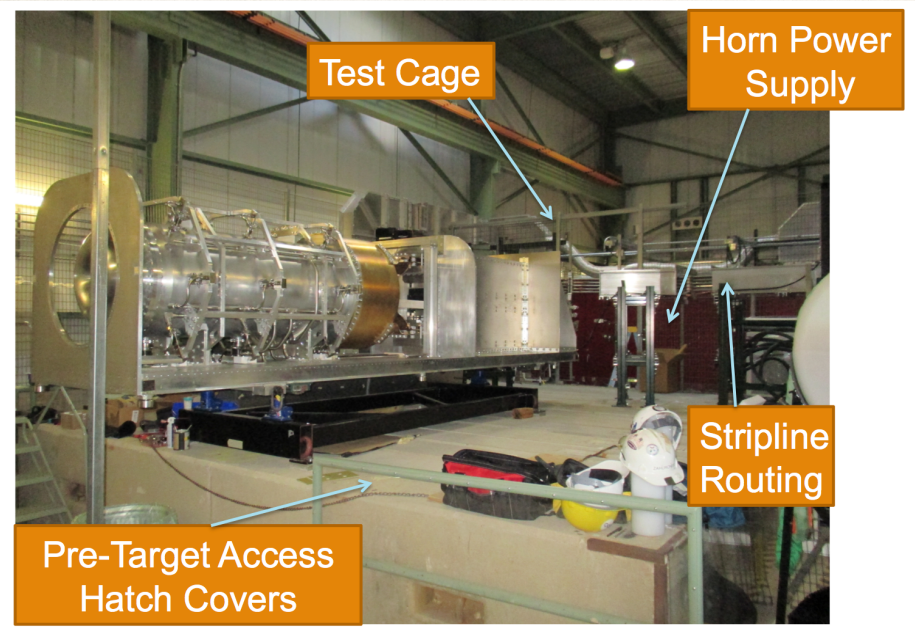

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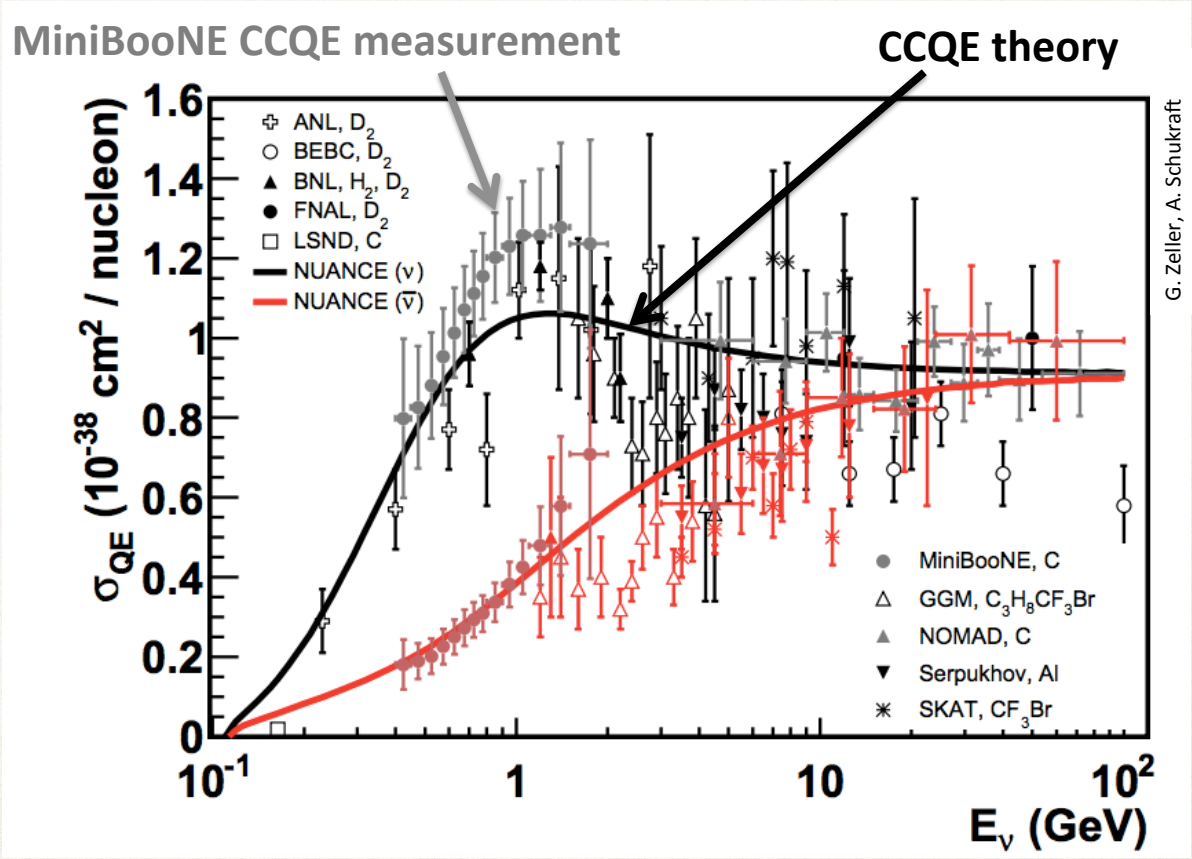
MicroBooNE rapidly preparing for first beam operation!

MicroBooNE is excited for start of physics and first beam

Backup Slides

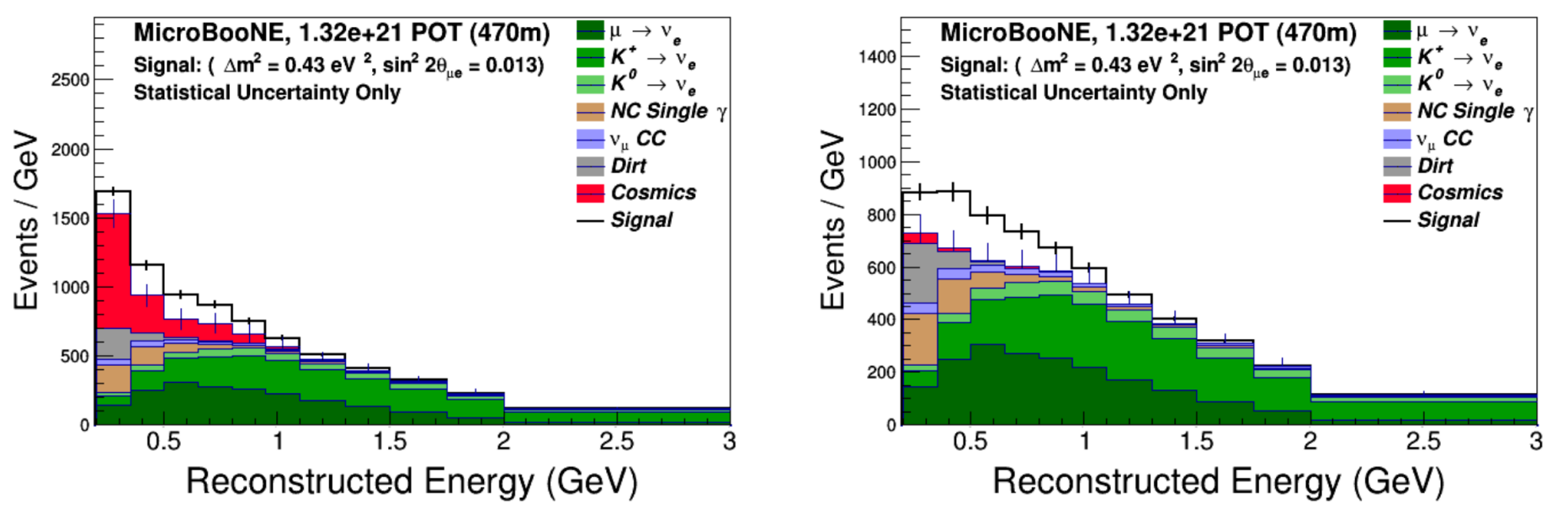
Comparison of data with CCQE theory - high statistic sample μBooNE

- CCQE theory important to Long Baseline Osc experiments
- Short range nucleon-nucleon correlations
- Meson exchange that mimics CCQE
- Final state interactions ejecting additional nucleons



Slide courtesy of Anne Schukraft

MicroBooNE cosmic background rejection in appearance analysis



- only muon proximity and dE/dX rejection
- rejection with internal light collection and external cosmic taggers

LAr Purity for MicroBooNE

Purity requirements

Electronegative impurities (O_2 and H_2O) absorb the drift electrons

$$N_e(t_{drift}) = N_e(t_0) \times \exp(-t_{drift} / \tau)$$

A calculation for MicroBooNE:

Electrical field: 500 V/cm
-> Drift velocity: 1.6 mm/us

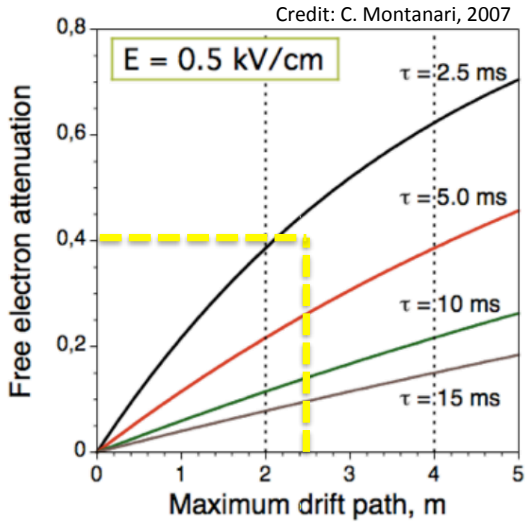
Maximum drift distance: 2.5 m
-> Maximum drift time: 1.56 ms

Want to lose at most 40% signal
-> need an electron lifetime of 3 ms

-> Corresponds to **100 ppt O_2**

In addition:
Need to avoid quenching and absorption of scintillation light by N_2
-> require < 2 ppm N_2

Credit: C. Montanari, 2007



Aachen, Jan 13, 2015 Anne Schukraft, Fermilab 86