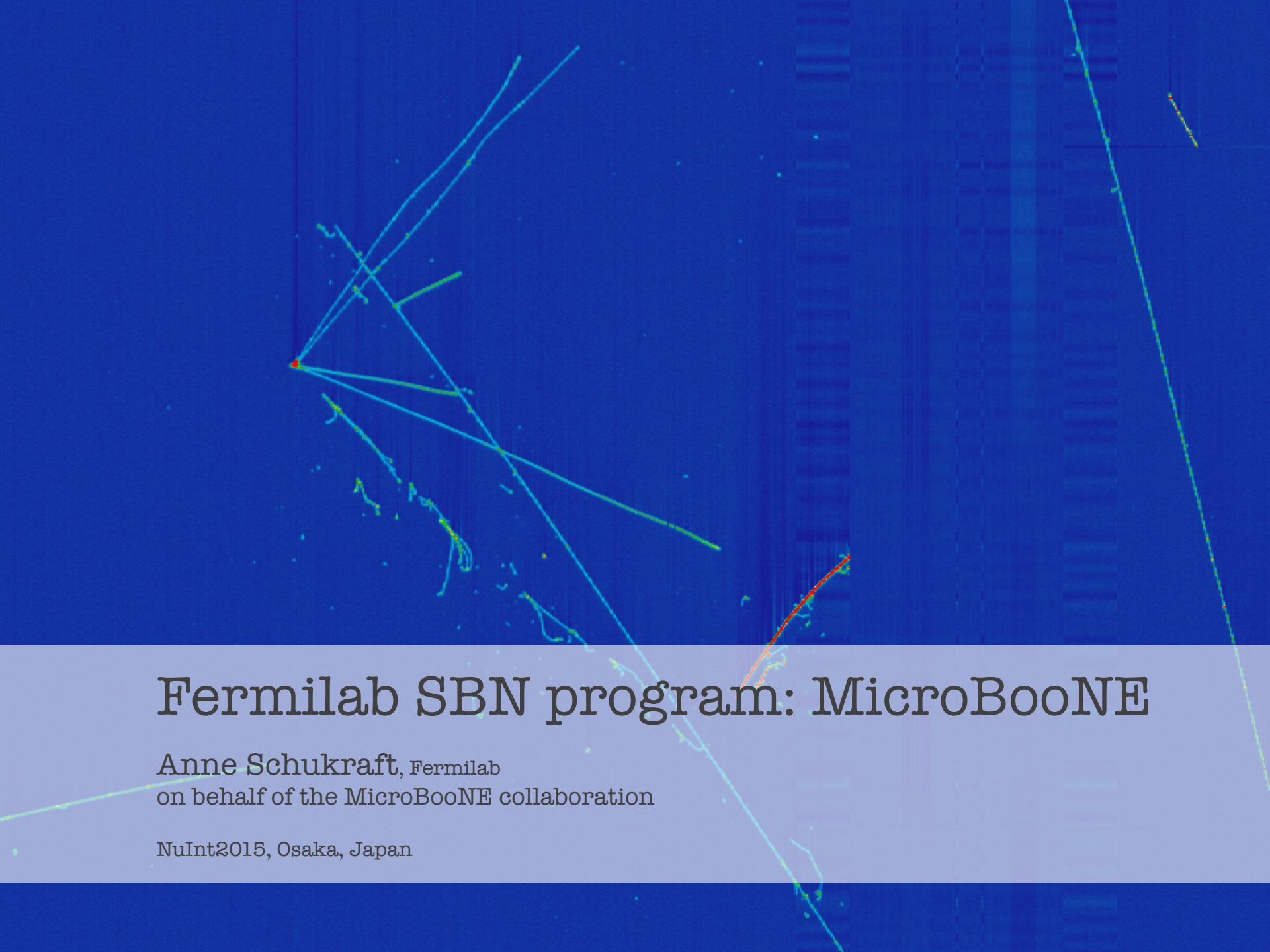
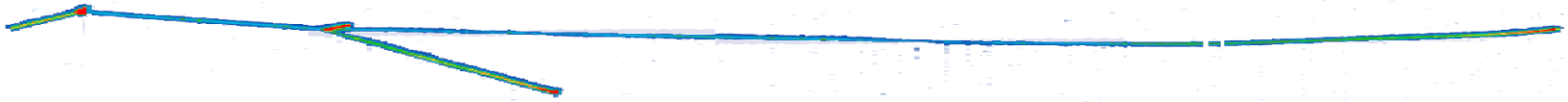


Fermilab SBN program: MicroBooNE

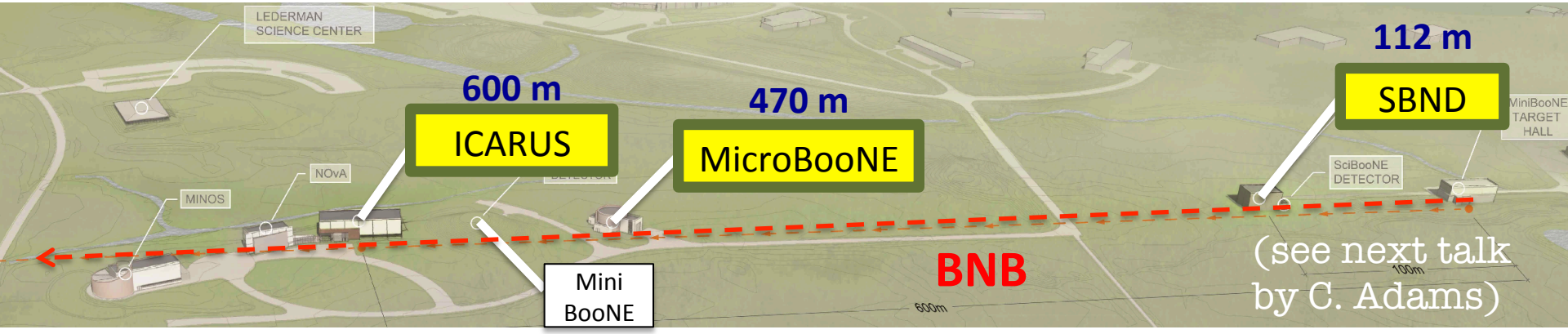
Anne Schukraft, Fermilab
on behalf of the MicroBooNE collaboration

NuInt2015, Osaka, Japan

MicroBooNE



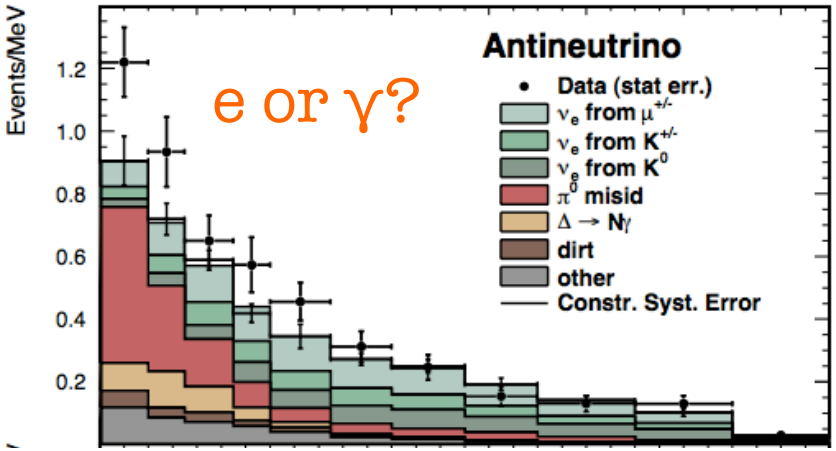
MicroBooNE: First LArTPC detector in the SBN program up and running!



(Booster Neutrino Beamline at Fermilab)

Primary physics goals:

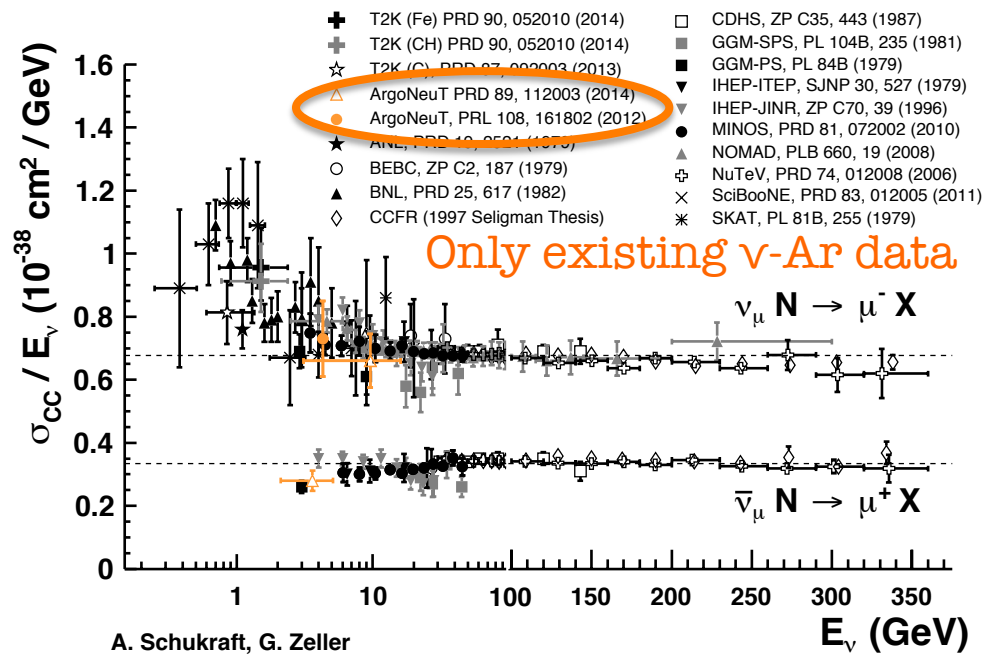
- Resolving the nature of the low-energy e-like event excess observed by MiniBooNE.
- Measuring neutrino-argon cross sections in the QE and RES range.



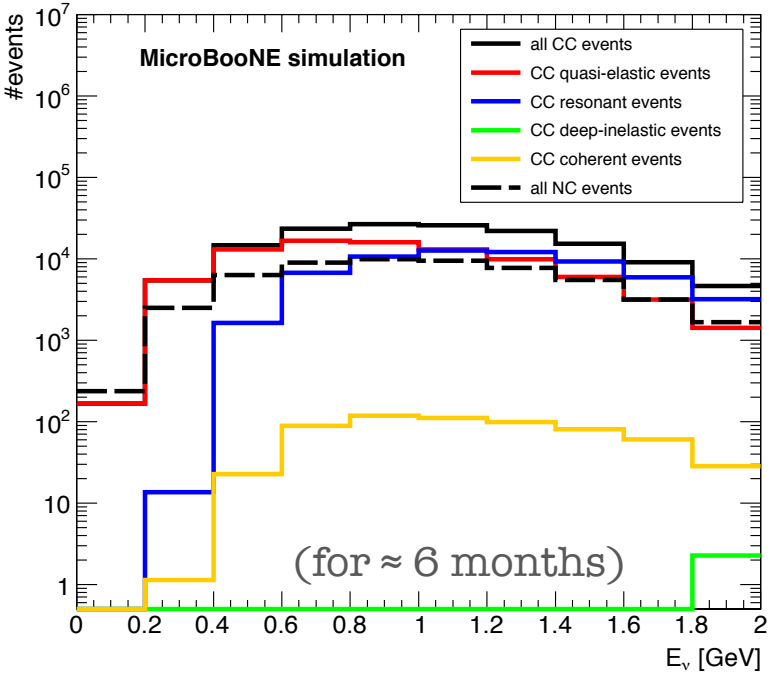
Cross section data on liquid-argon

Argon: target material for many future detectors

Need more experimental data to learn about nuclear effects and neutrino energy reconstruction



BNB ν_μ interactions in MicroBooNE



Energy range:
200 MeV – 2 GeV
(QE & RES)

First CC inclusive study in MicroBooNE

Practicing our first analyses on MC data
using fully-automated event reconstruction

MicroBooNE as-designed MC preliminary

Simulation for MicroBooNE as designed	MC events/ variable	Stat. unc.	Rel. stat. unc.	Sys. unc.	Rel. sys. unc.
Predicted no. of events	7968	89.3	1.1%	-	-
Cosmic only events	3401	-	-	58.3	1.7%
Cosmics in BNB events	261	-	-	130.5	50%
NC events	156	-	-	78	50%
ν_e and $\bar{\nu}_e$ events	22	-	-	22	100%
$\bar{\nu}_\mu$ events	12	-	-	2.4	20%
Total background	3852	-	-	164.3	4.3%
ν_μ CC events	4116	89.3	2.3%	164.3	4.0%
Φ_{ν_μ}	3.10×10^{10} cm^{-2}	-	-		12%
N_{target}	4.76×10^{31}	-	-		2%
ϵ	0.326	-	-		5%

(preliminary estimates)

(for ≈ 3 months)

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(preliminary estimates)

We are on the surface:
a lot of background from
cosmic muon tracks

(for ≈ 3 months)

First CC inclusive study in MicroBooNE

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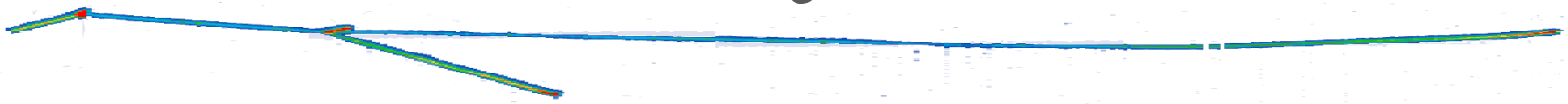
(preliminary estimates)

Efficiency * Acceptance:
Contained events only here

(for ≈ 3 months)

First CC inclusive study in MicroBooNE



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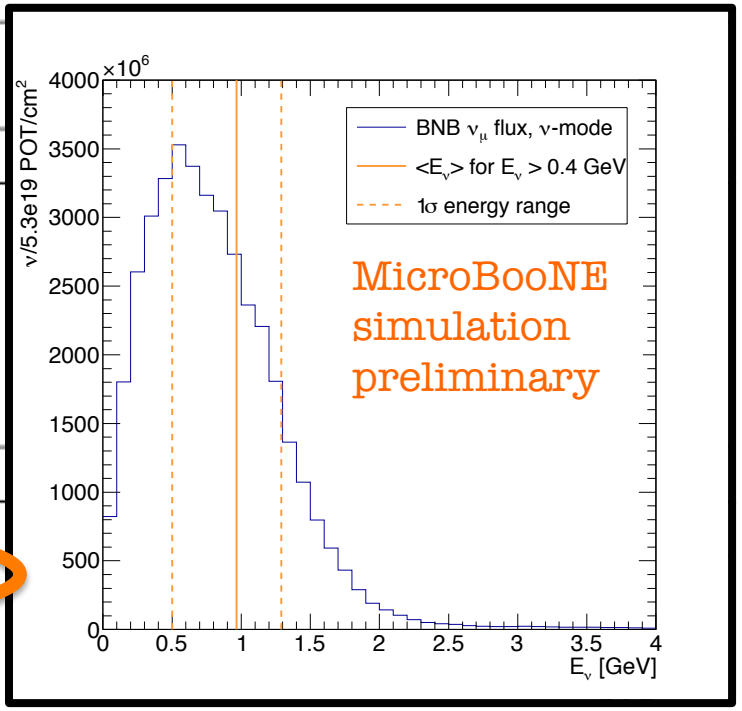


(for ≈ 3 months)

Average energy:

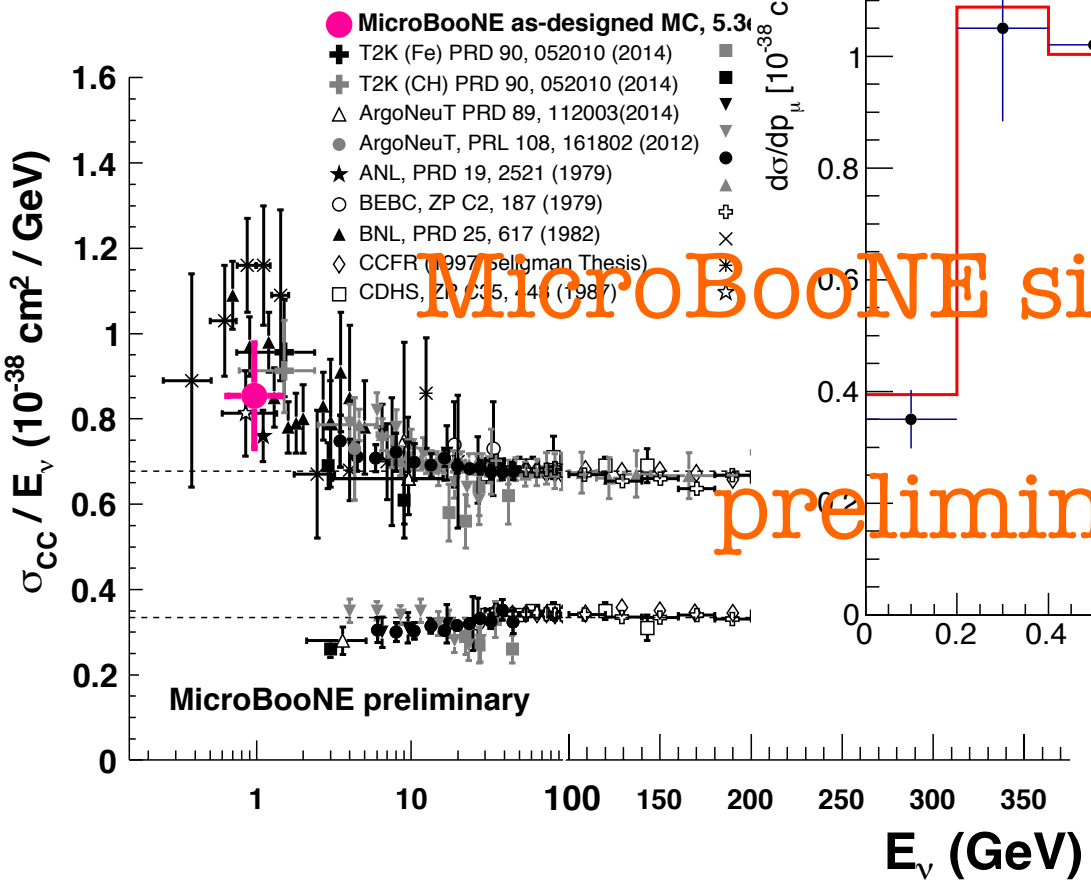
967^{+323}_{-467} MeV

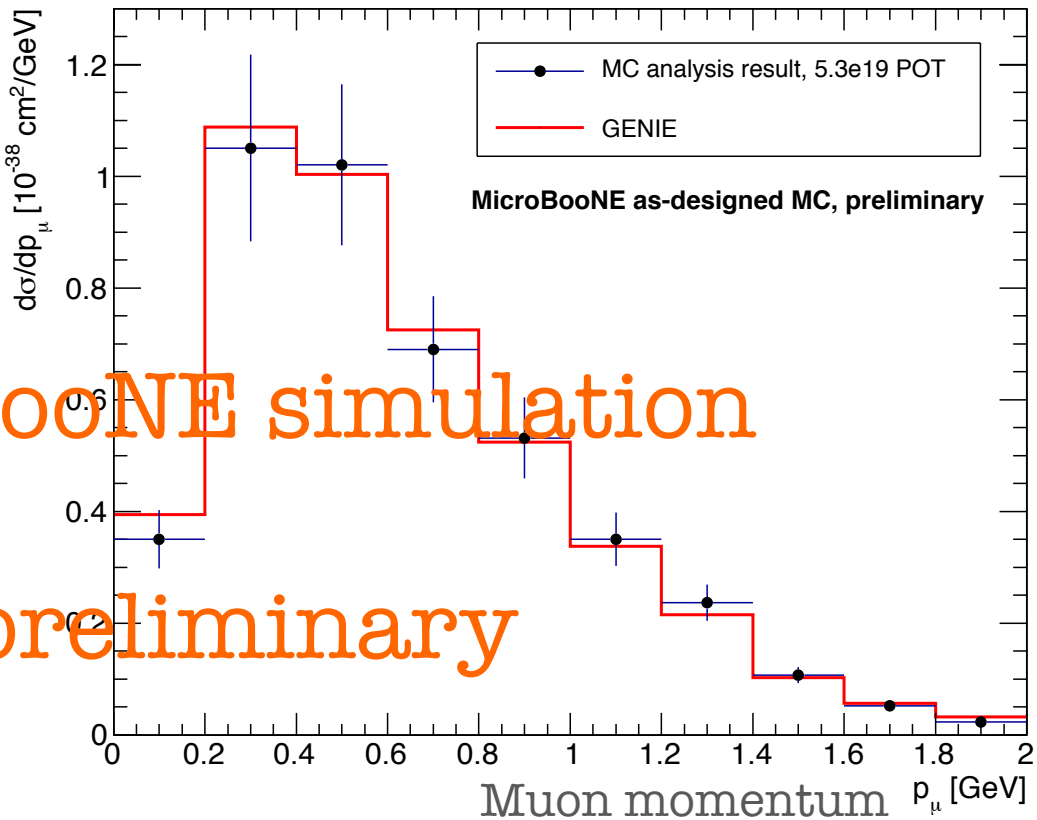
(for an analysis threshold of 400 MeV)

First CC inclusive study in MicroBooNE

Single-differential (for ≈ 3 months)

Flux-integrated

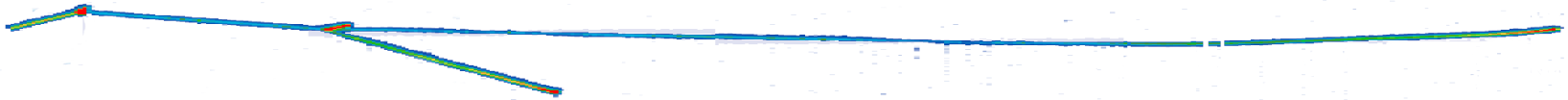




MicroBooNE simulation

preliminary

CC 0π in MicroBooNE

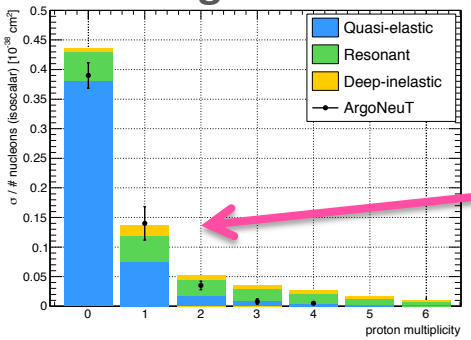


1e20 POT (6 months, 87 tons, no efficiencies)

First analyses	ν_μ		
CC inclusive	CC 0π	NC elastic	NC single π^0
26553	16997	2596	1719

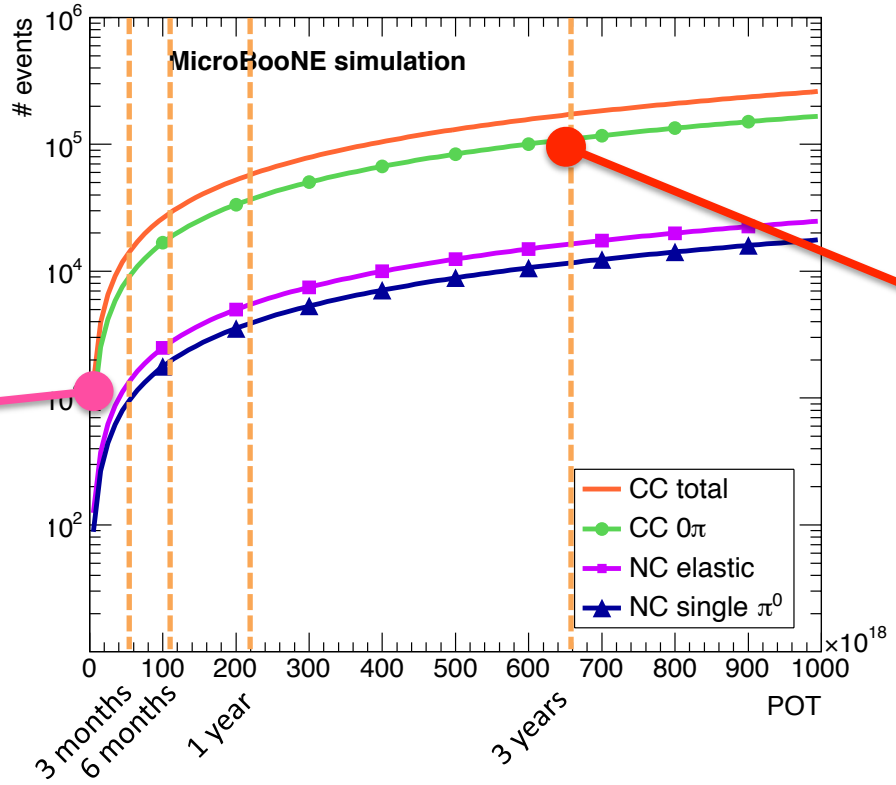
Reaching ArgoNeuT statistics:
< 1 months

ArgoNeuT



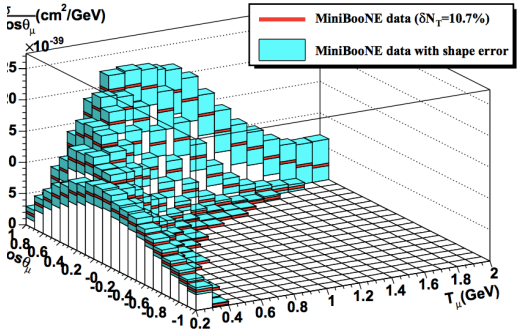
≈ 900 events

(see talk by O. Palamara)

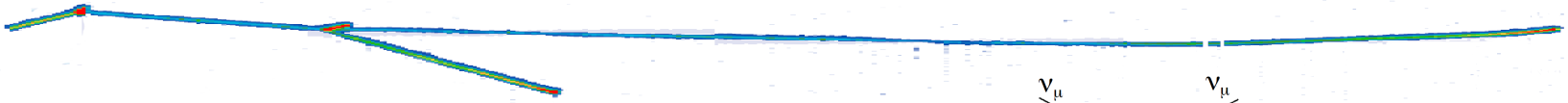


Ultimate goal: double-differential cross sections a la MiniBooNE
3 years

MiniBooNE

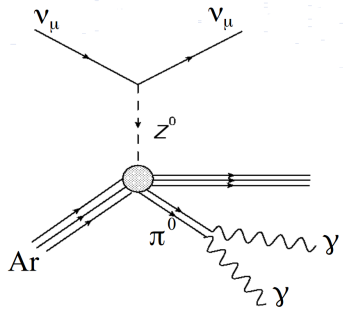


NC π^0 in MicroBooNE

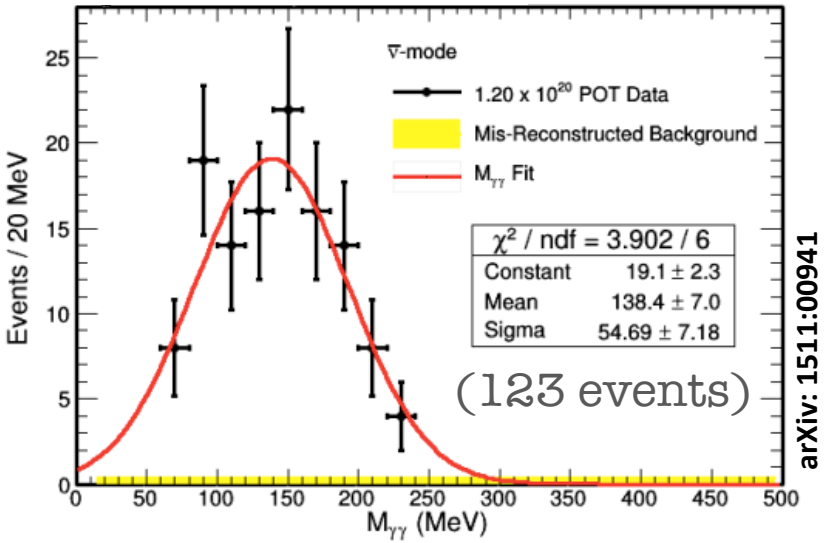


Why is this interesting?

- Background for ν_e appearance search
- Calibration with π^0 mass peak
- Very different pion absorption in Ar vs C – first chance to measure these effects!



ArgoNeuT

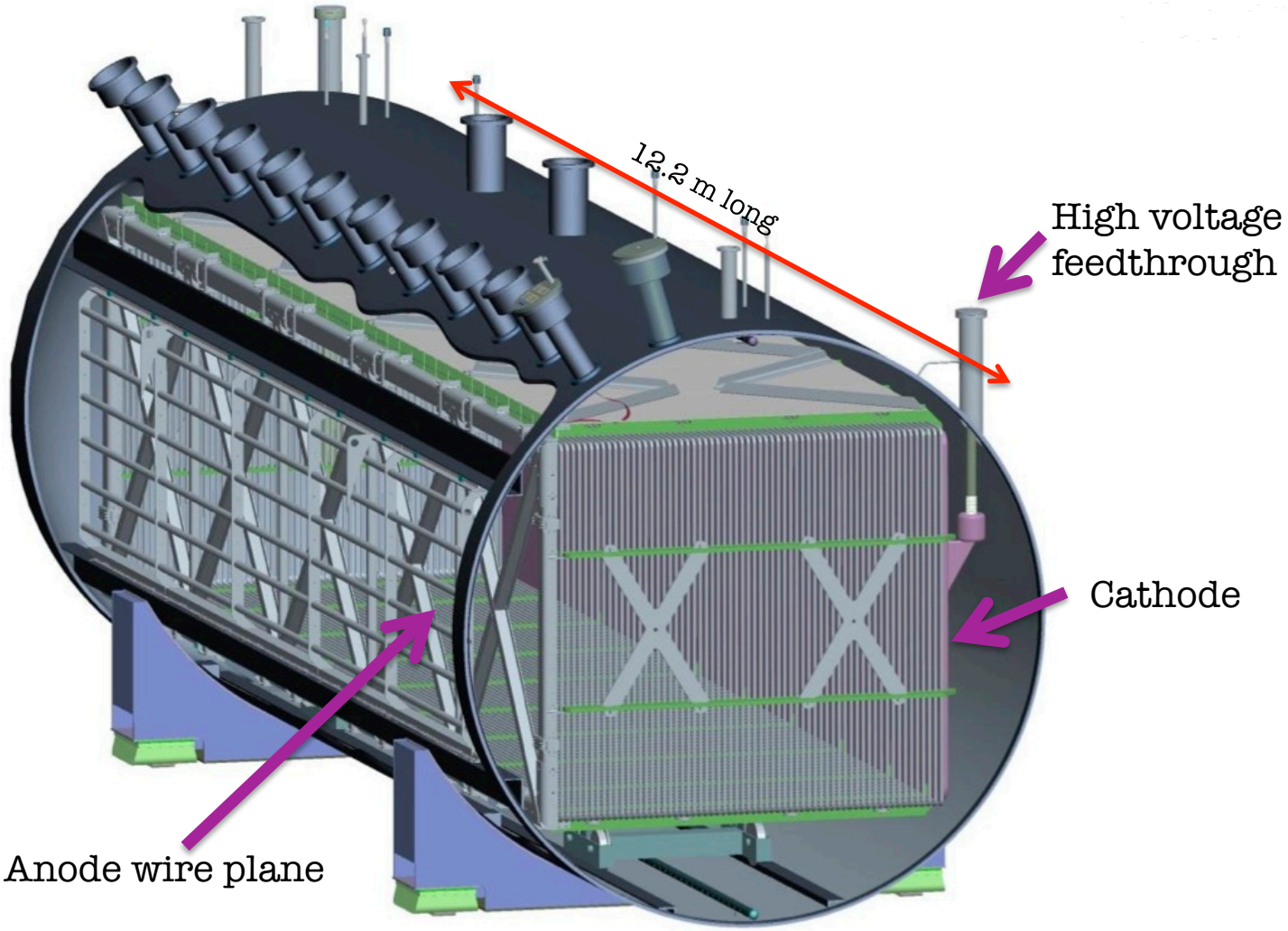


MicroBooNE

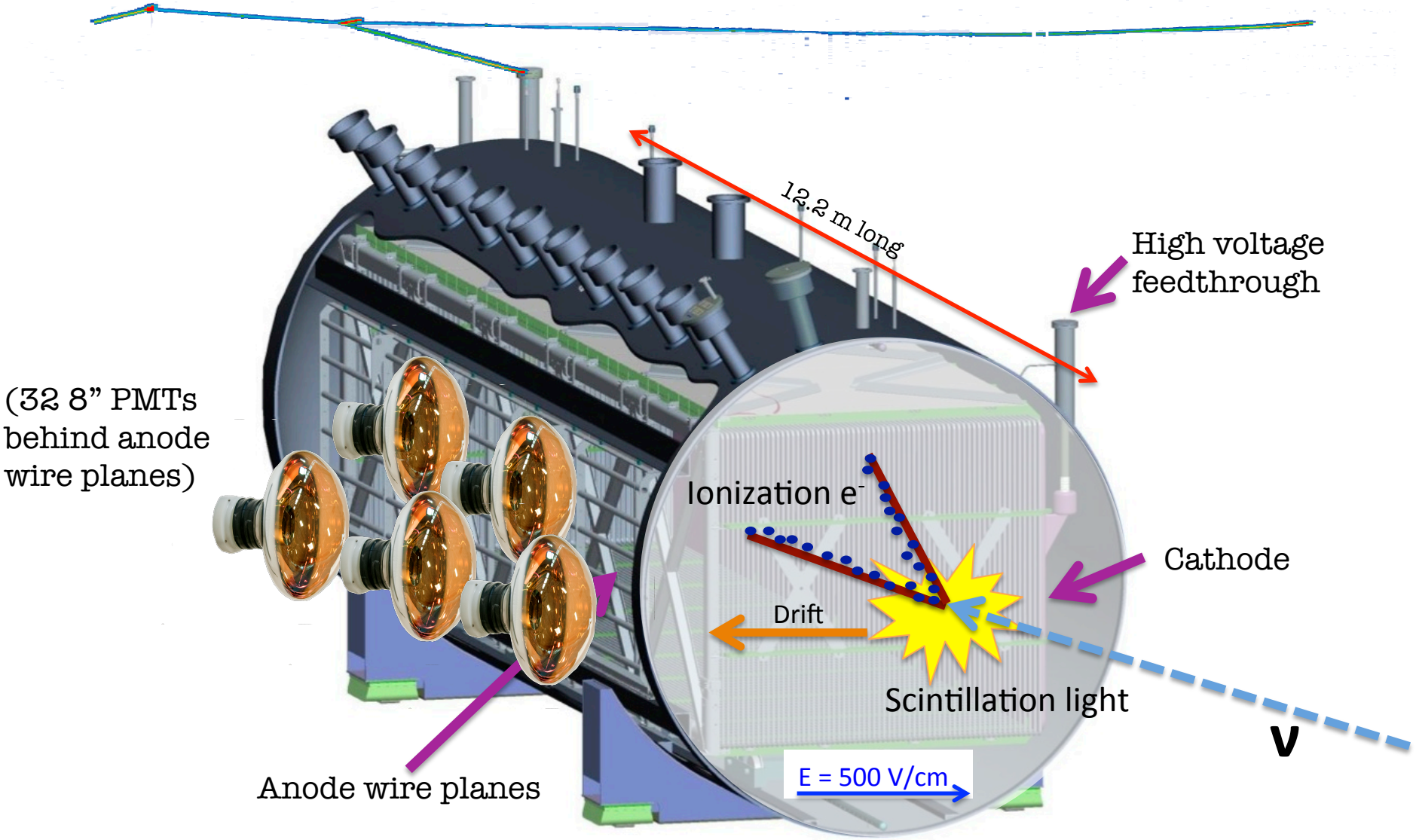
	NC single π^0		After Eff.
≈ 3 months	886	O(10%) eff.	89
≈ 6 months	1771	→	177
≈ 3 years	11688		1169

Expecting low efficiency:
The fraction of events with both photons from the π^0 decay contained in the fiducial volume and above detection threshold is rather low

The MicroBooNE detector



The MicroBooNE detector



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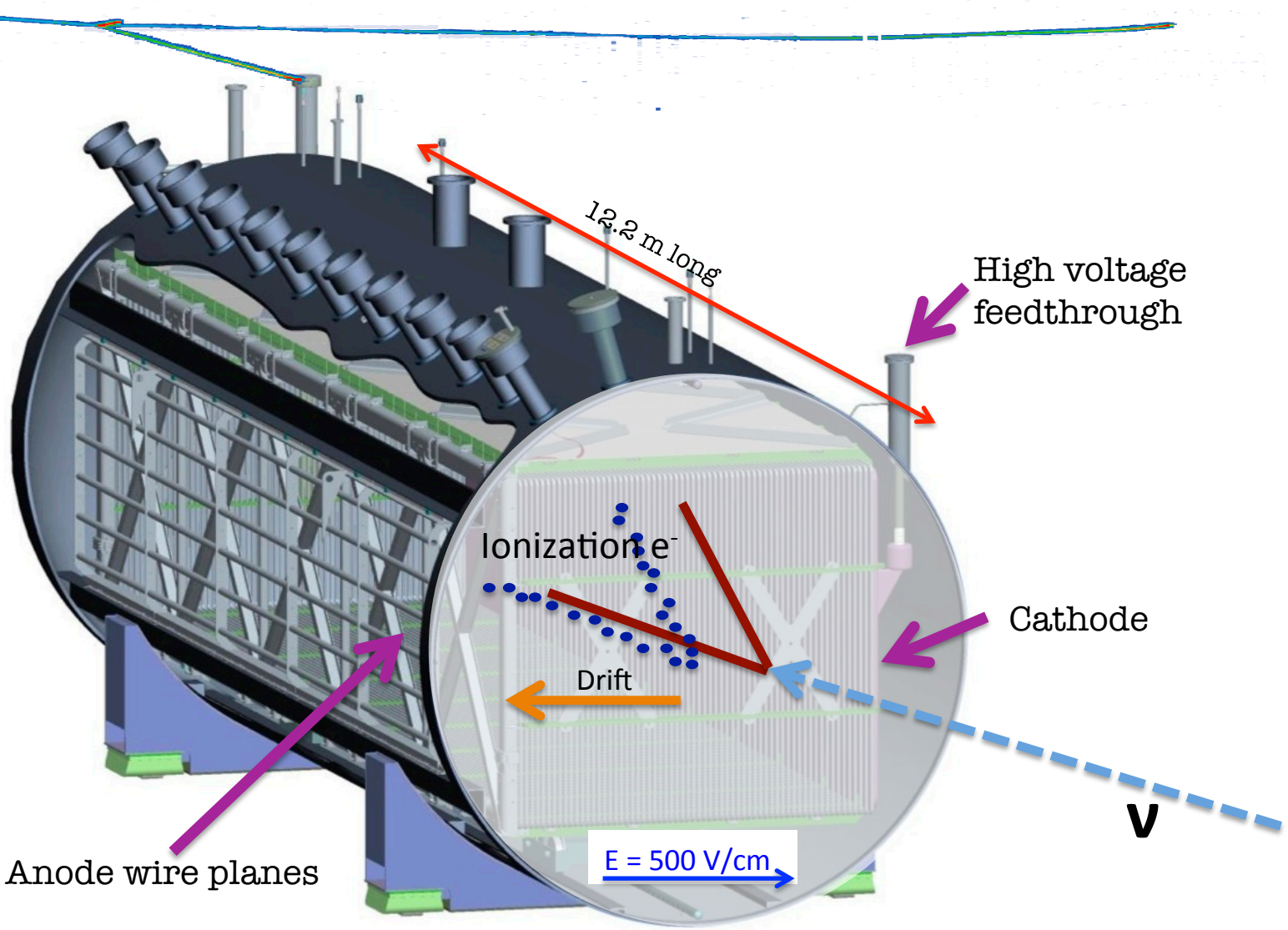

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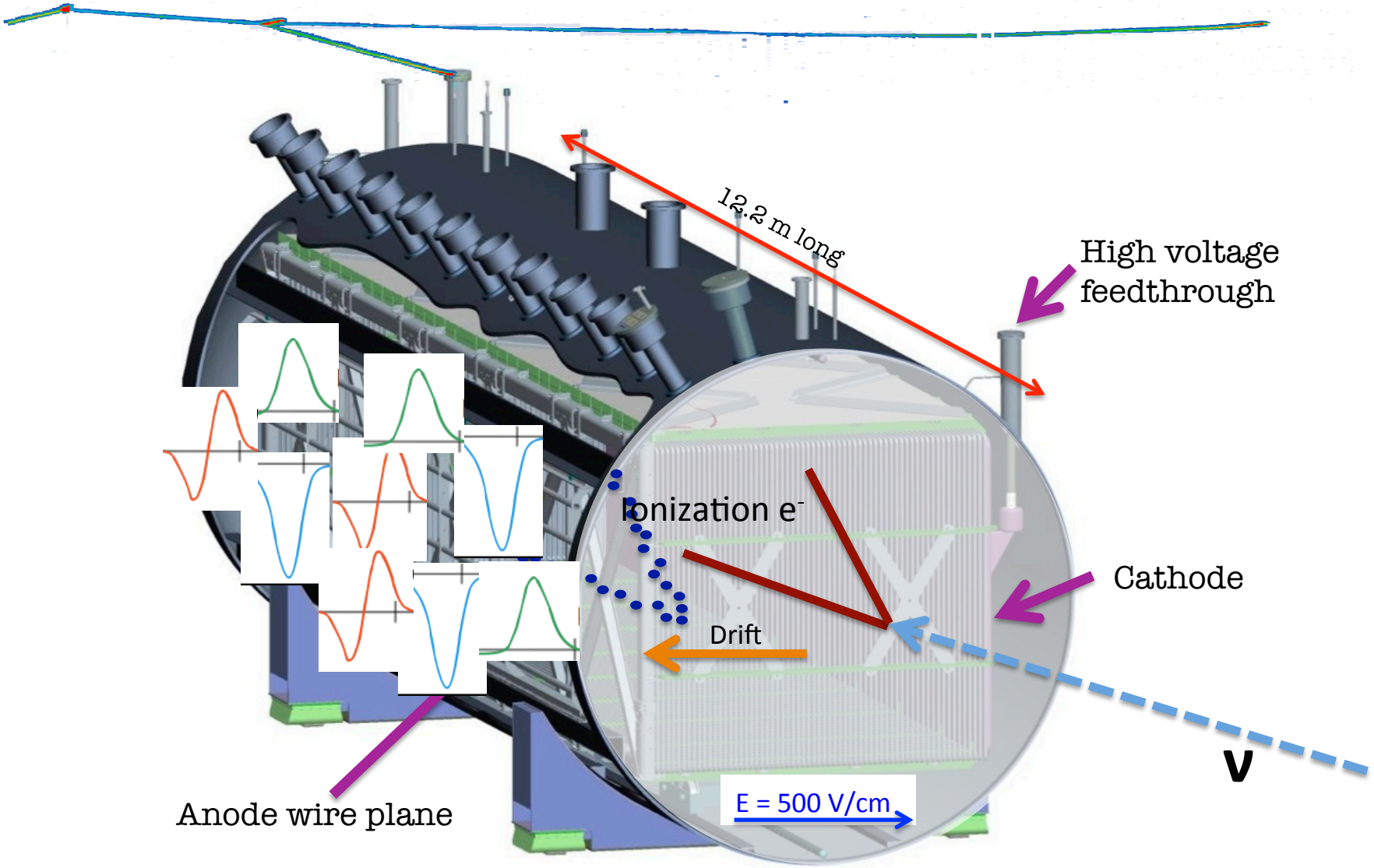
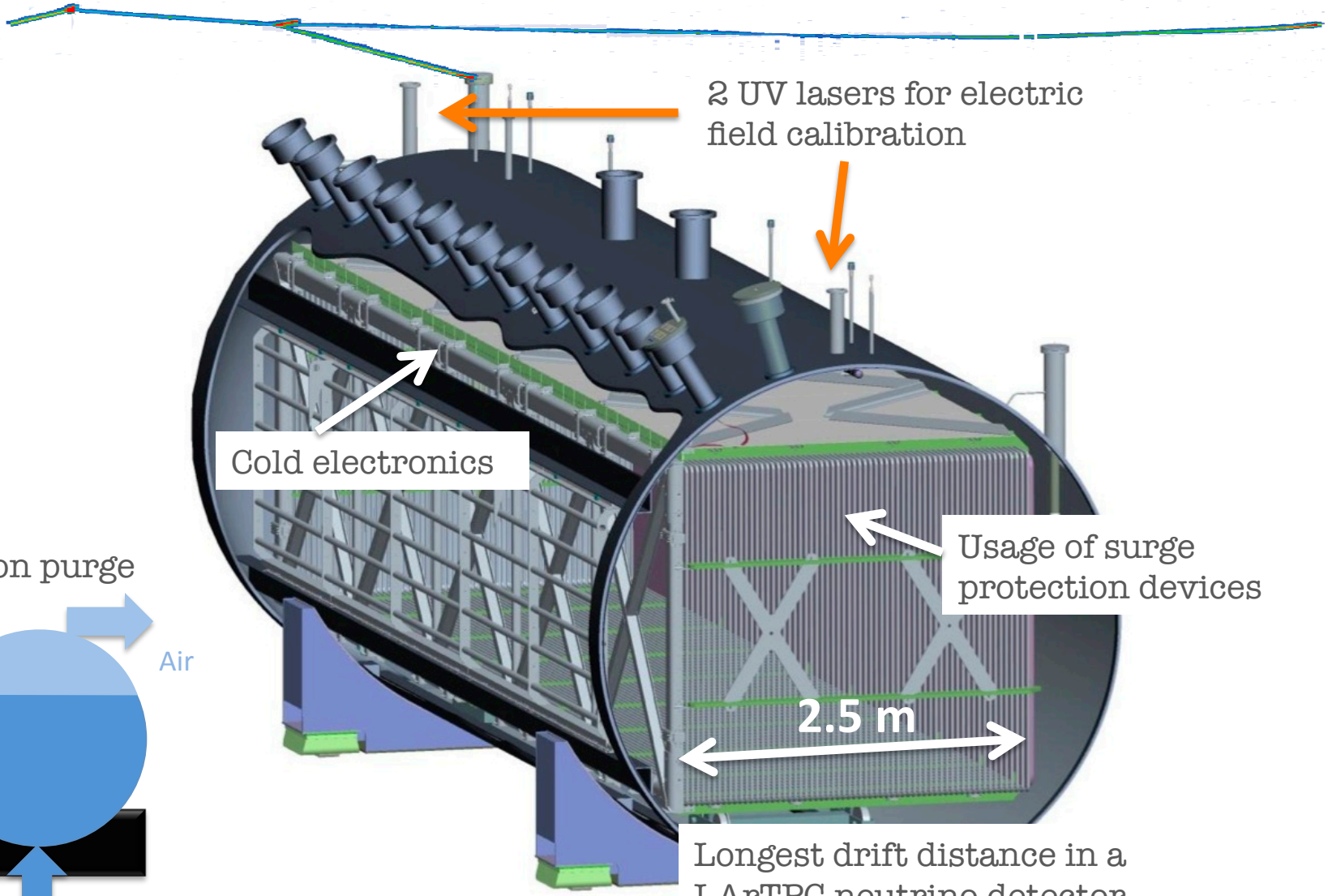
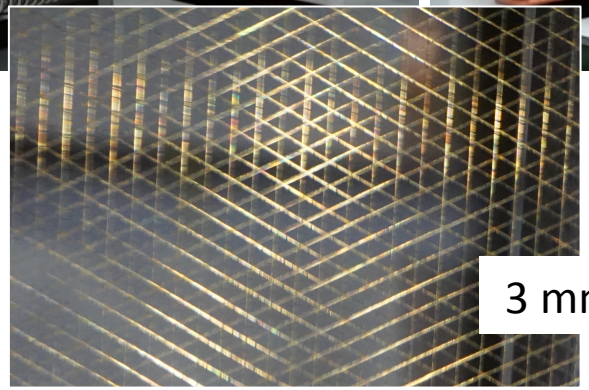


R&D in MicroBooNE



MicroBooNE construction

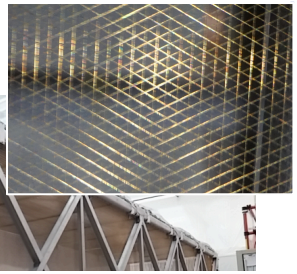
TPC construction: 2013



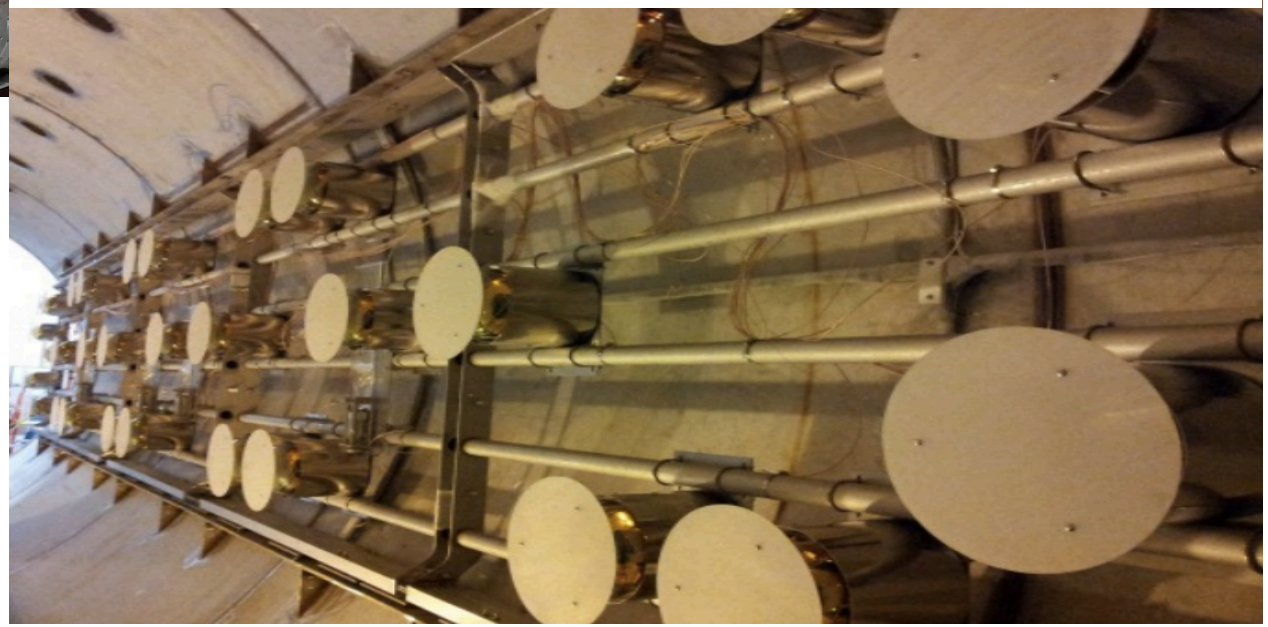
3 mm wire spacing

MicroBooNE construction

TPC construction: 2013



PMT system installation: Dec 2013



MicroBooNE construction

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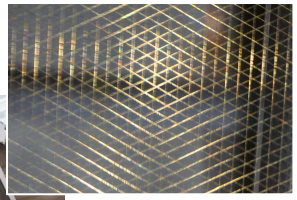
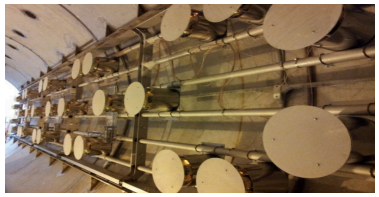
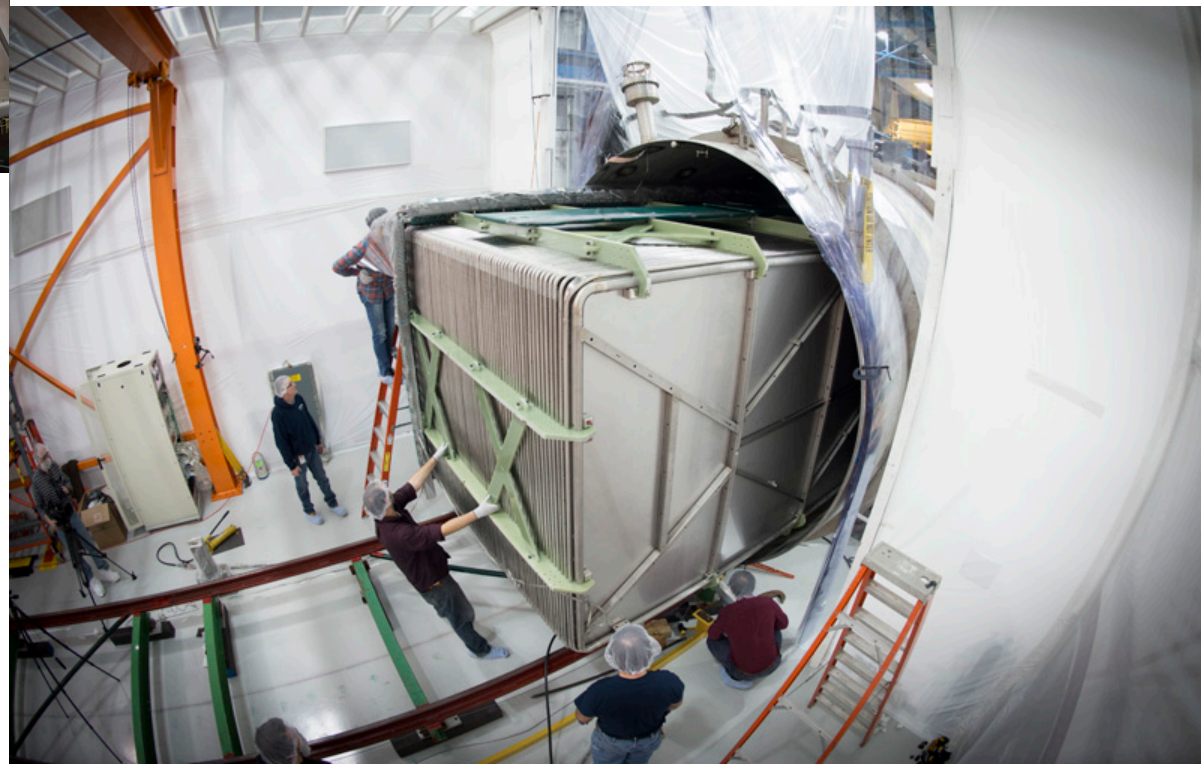




TPC construction: 2013

TPC insertion: Dec 23rd, 2013



MicroBooNE construction

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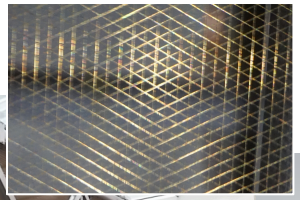
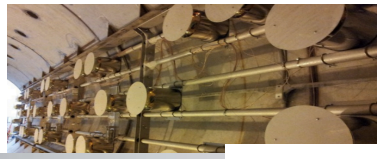




TPC construction: 2013

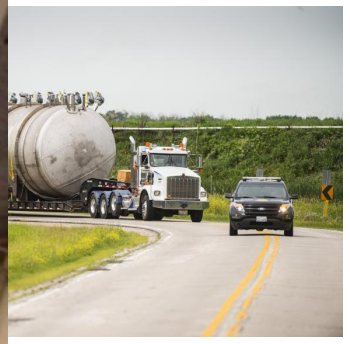
Moving day! June 23rd, 2014

MicroBooNE's home in the beam line: The LAr Test Facility

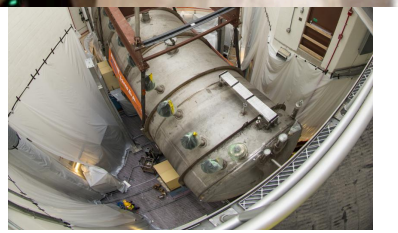
MicroBooNE construction

TPC constr

day! June 23rd, 2014



Foamed in! July 2014

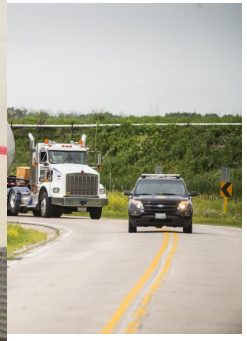


MicroBooNE's home in the beam line: The LAr Test Facility

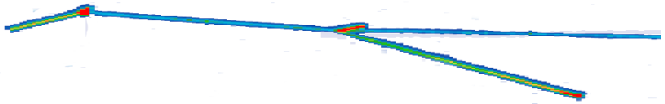
MicroBooNE construction

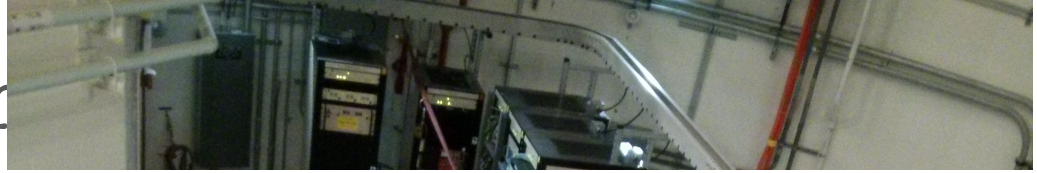
Cabled up! Sept. 2014

ne 23rd, 2014



MicroBooNE constr





All electronics in! Dec. 10, 2014

TPC construction: 2013

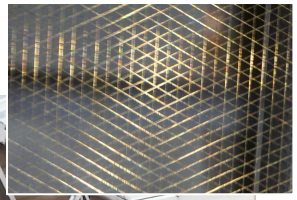
MicroBooNE's home in the beam line: The LAr Test Facility

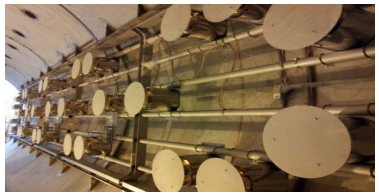
Cabled up! Sept. 2014

MicroBooNE construction

PMT system installation: Dec 2013

TPC construction: 2013





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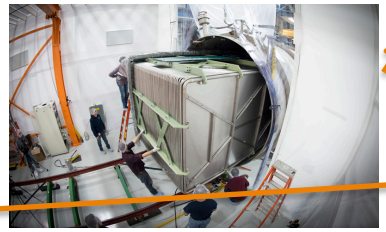
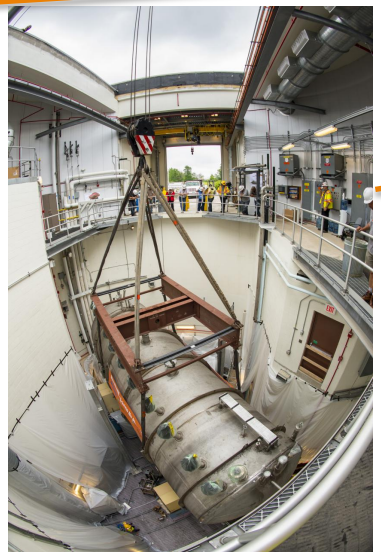




MicroBooNE's home in the beam line: The LAr Test Facility

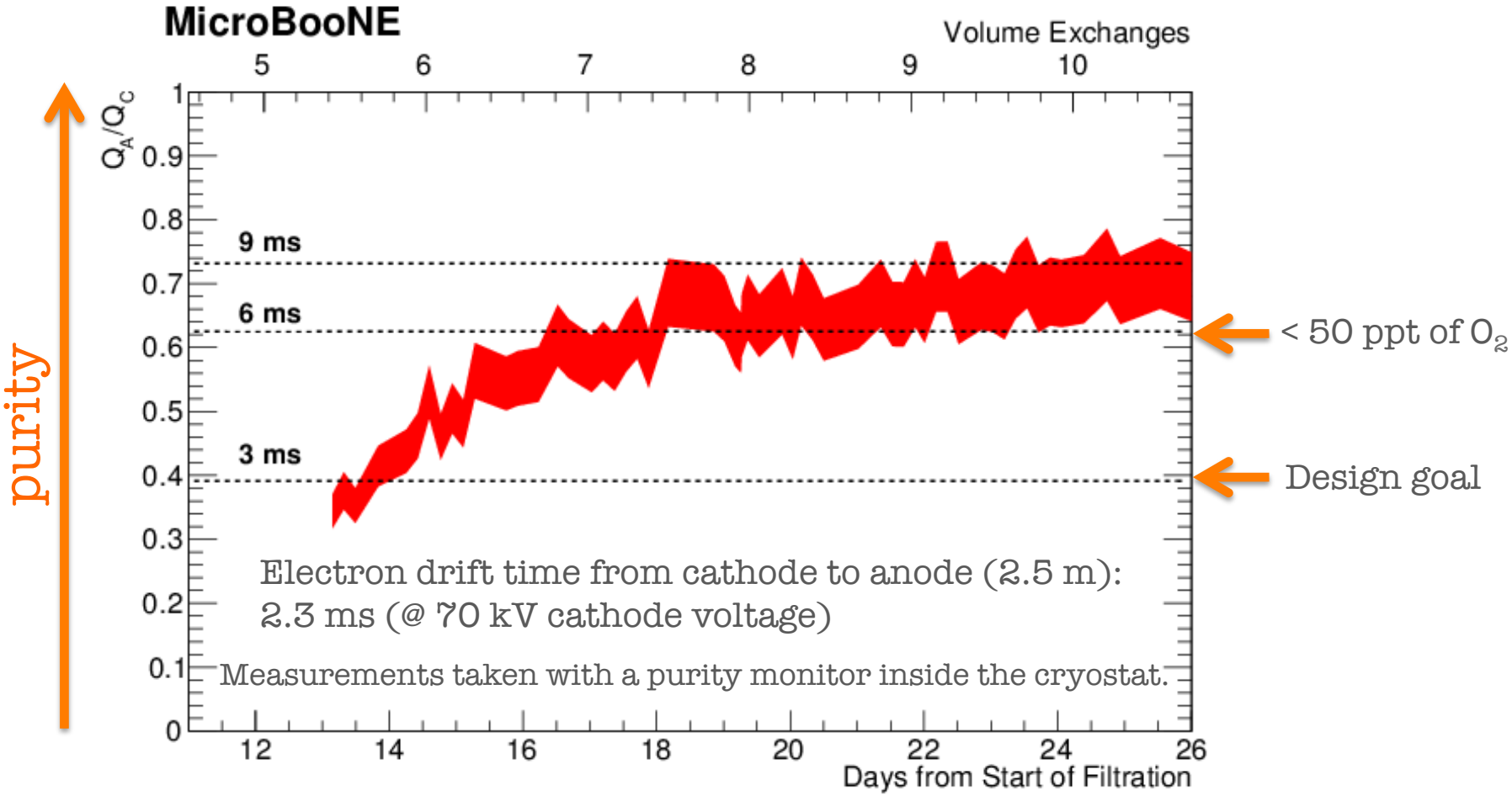
Foamed in! July 2014

Cabled up! Sept. 2014

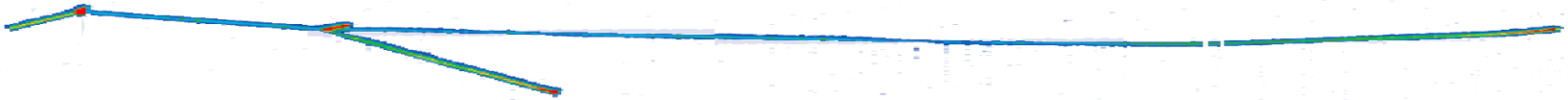
All electronics in! Dec. 10, 2014

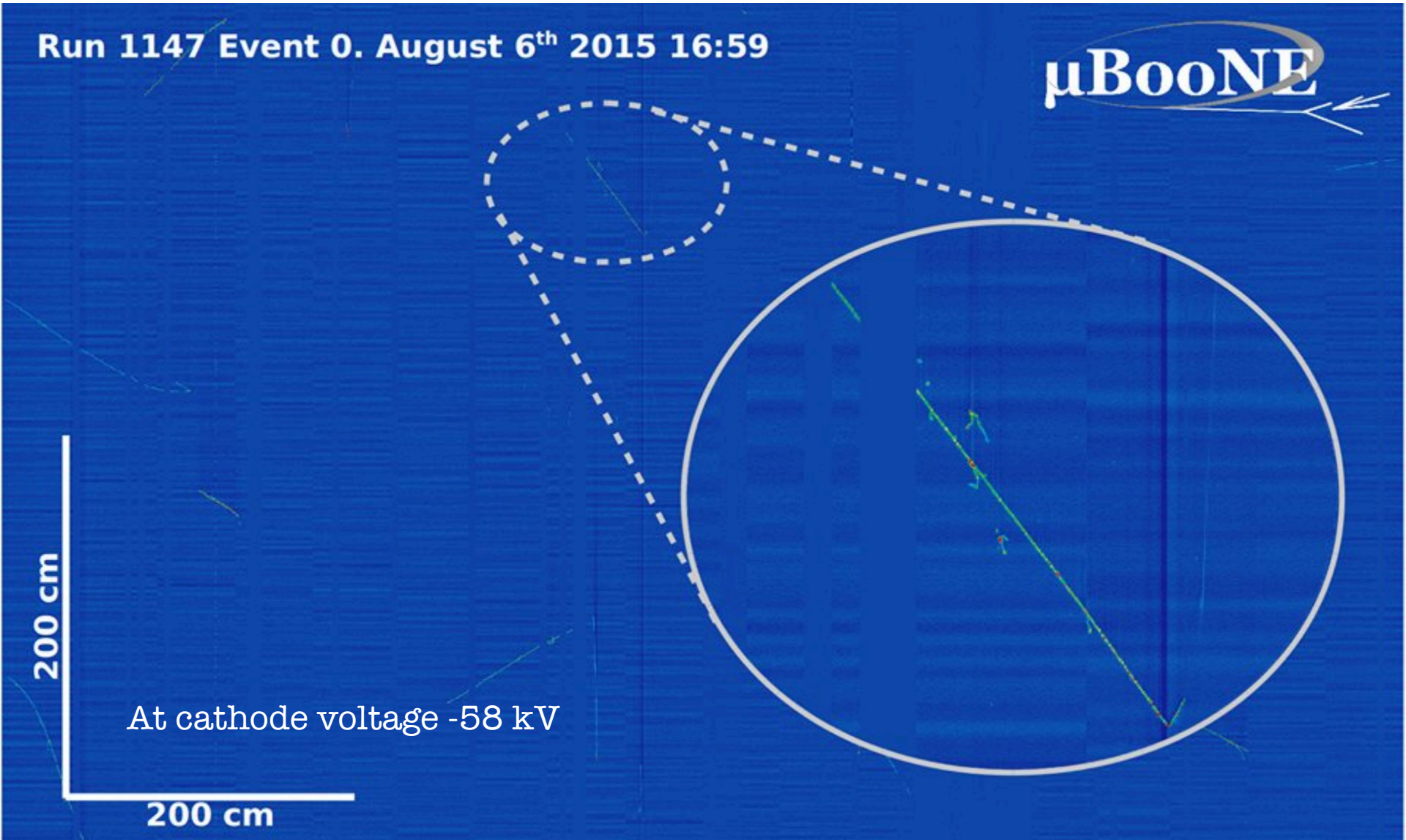
Argon purity

Liquid-argon drift electron lifetime after a two week filtration process.

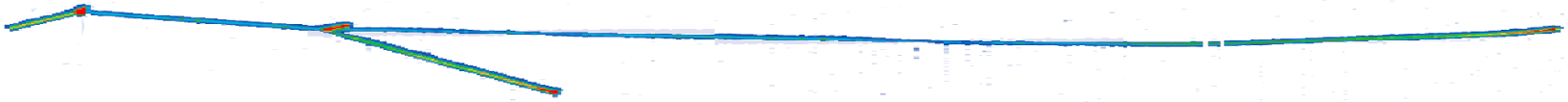


First cosmic tracks!

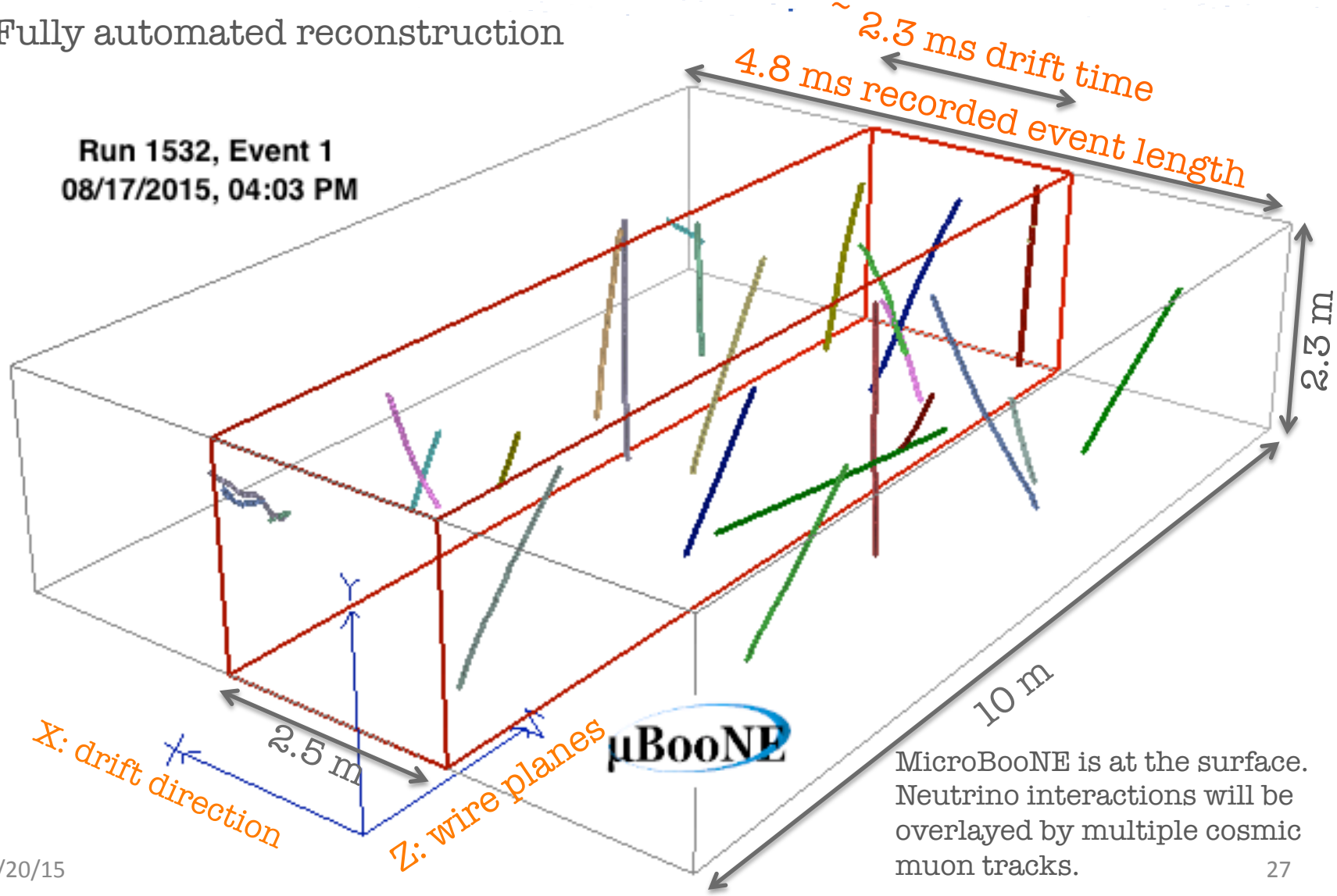




Cosmic muons in 3D

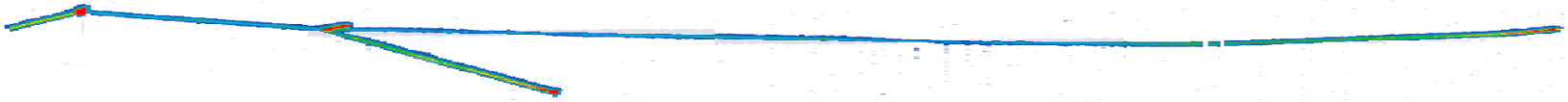


Fully automated reconstruction

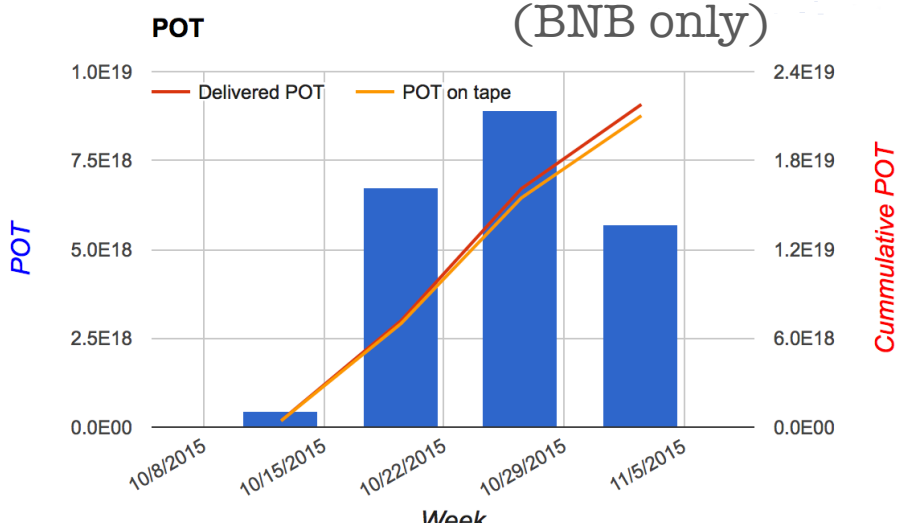


MicroBooNE is at the surface. Neutrino interactions will be overlayed by multiple cosmic muon tracks.

Beam on!

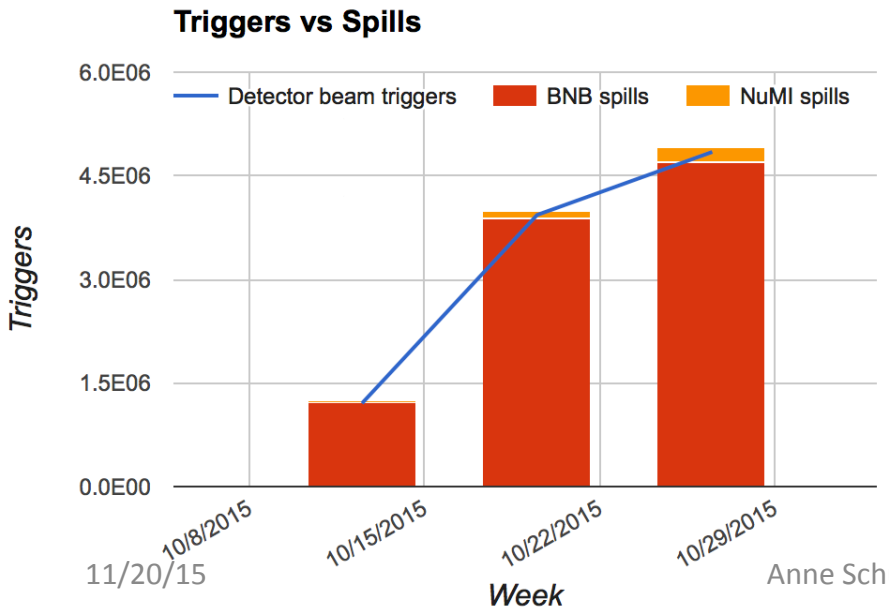


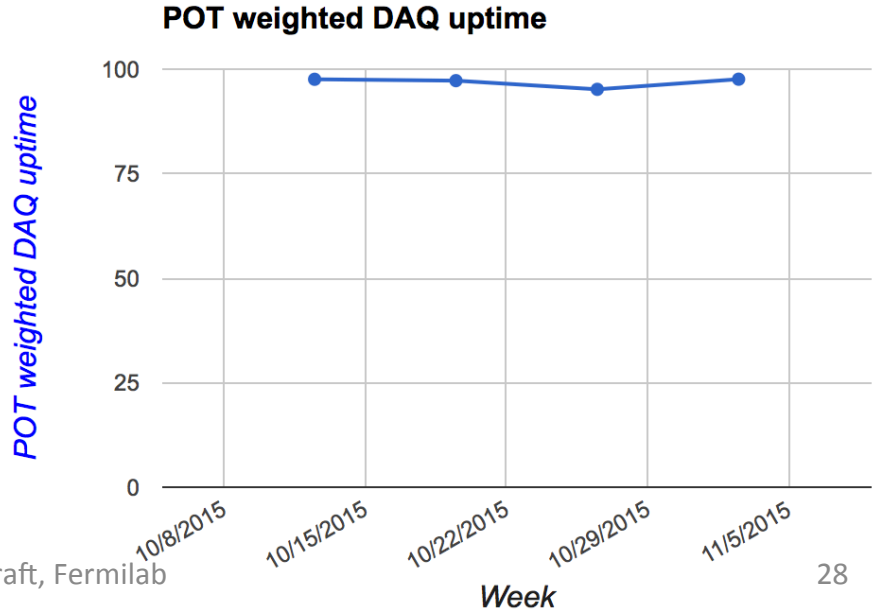
(BNB only)



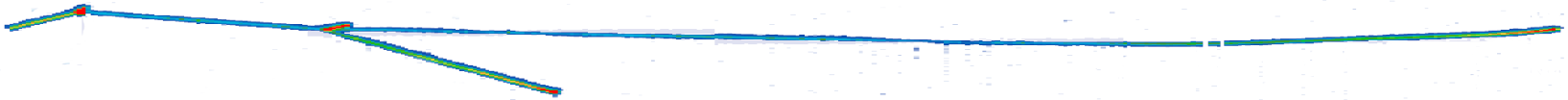
We are receiving Booster Neutrino Beam (BNB) since Oct 15, 2015!

Very stable data taking:





The neutrinos are coming



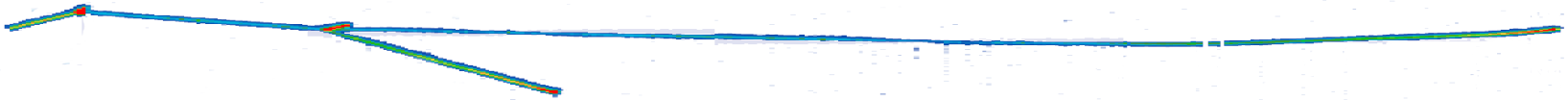
- Not every beam spill will produce a neutrino interaction in the detector. Most events contain only cosmic induced tracks.

- Cosmic muon tracks come randomly.
  Neutrinos come during the beam spill window.

Duration of a readout event: 4.8 ms

Duration of a beam spill: 1.6 μs

The neutrinos are coming



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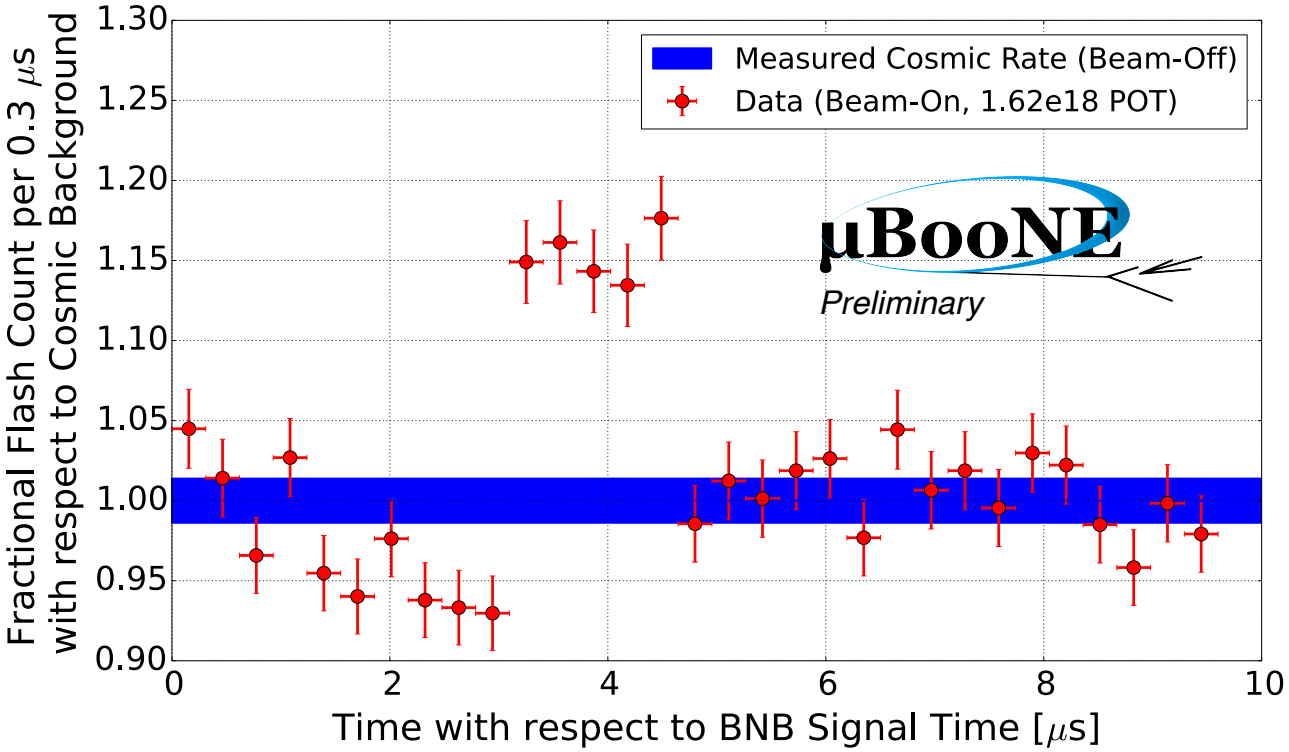
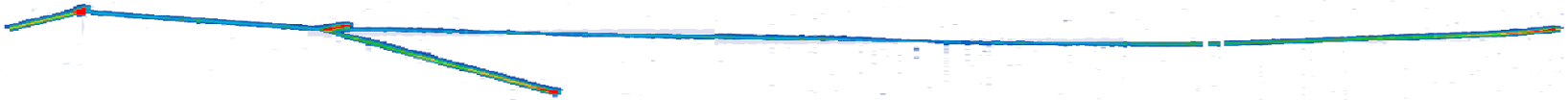


Timing of scintillation light signals detected with the PMT light system.

The neutrinos are coming



- Not every beam spill will produce a neutrino interaction in the detector. Most recorded events contain only cosmic muon tracks.

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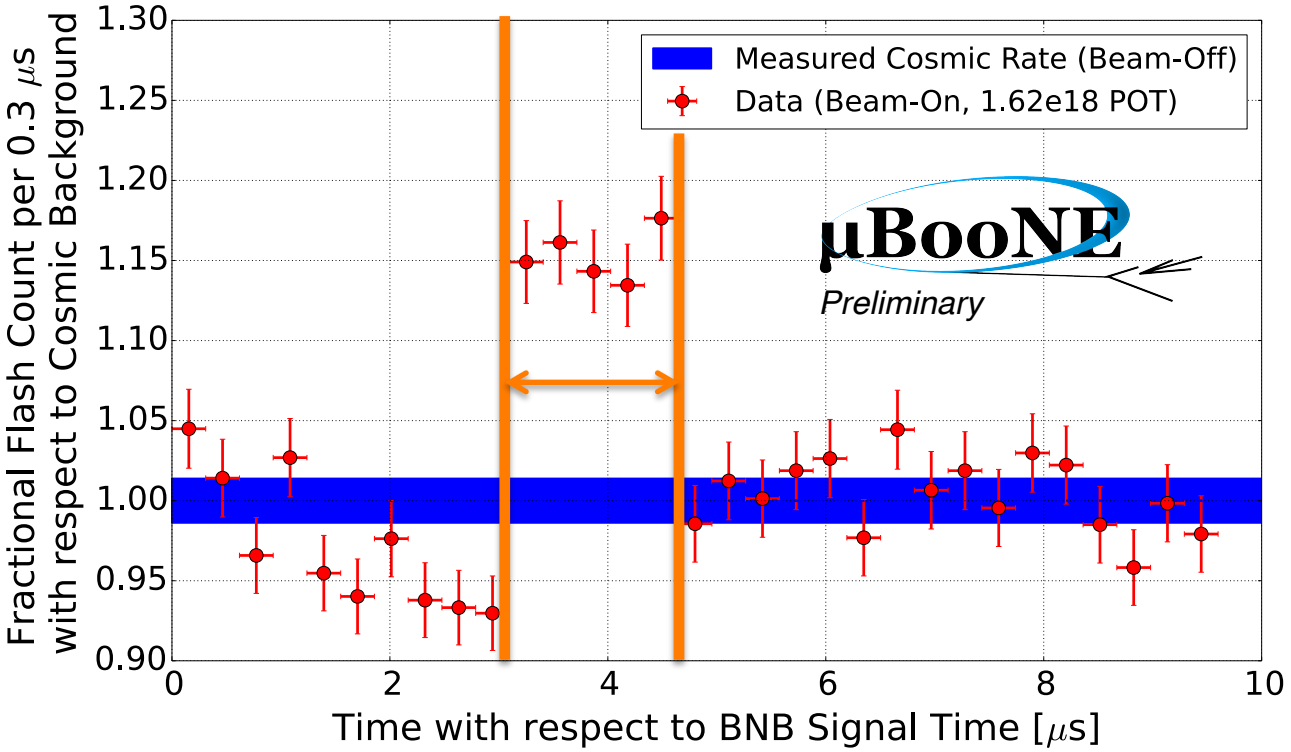
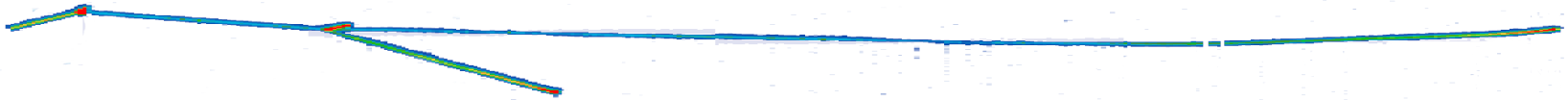
Duration of a beam spill: 1.6 µs



Timing of scintillation light signals detected with the PMT light system.

First fully automated reconstruction & selection



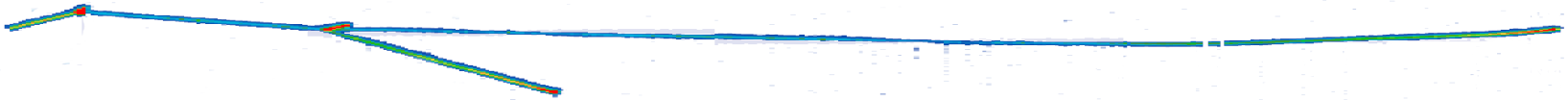
- Reconstruct events in 2D & 3D
- Select neutrino-like topology
- Aiming for: minimum reconstruction effort, and high purity, but not high efficiency

MicroBooNE preliminary
1.86e18 POT (BNB)

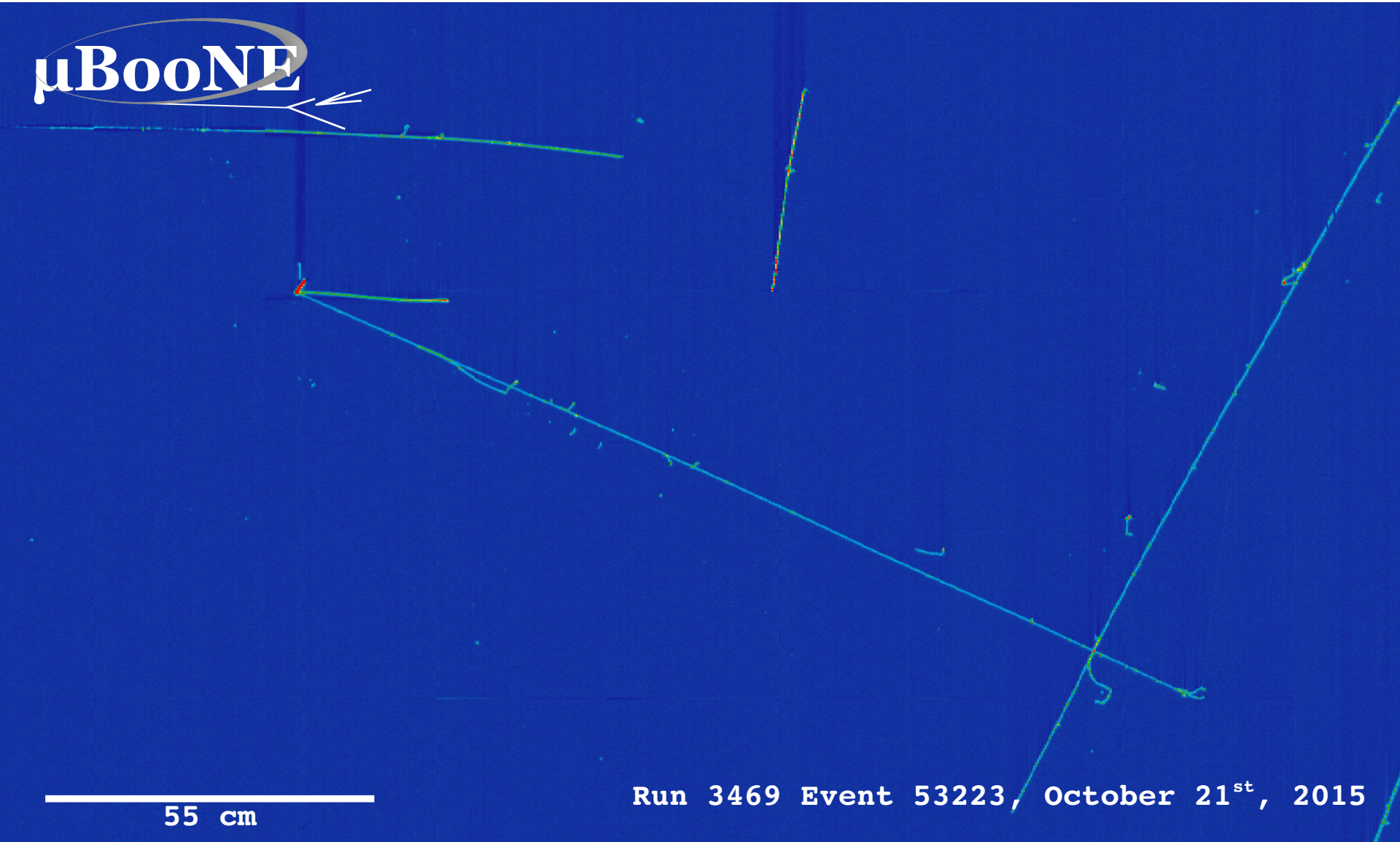
	Fully automated selection	
Number of events	Optical + 3D-based	Optical + 2D-based
Non-beam background (expected from off-beam measurements)	4.6 ± 2.6	385 ± 24
Total observed (during beam)	18	463

Clear excess of selected events over background.

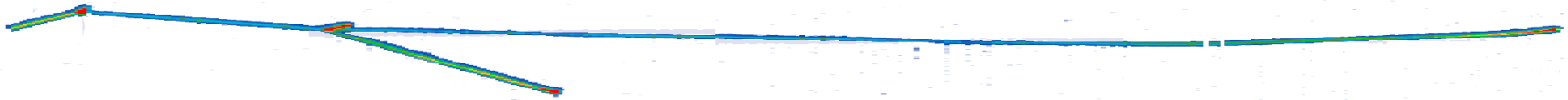
First neutrino events



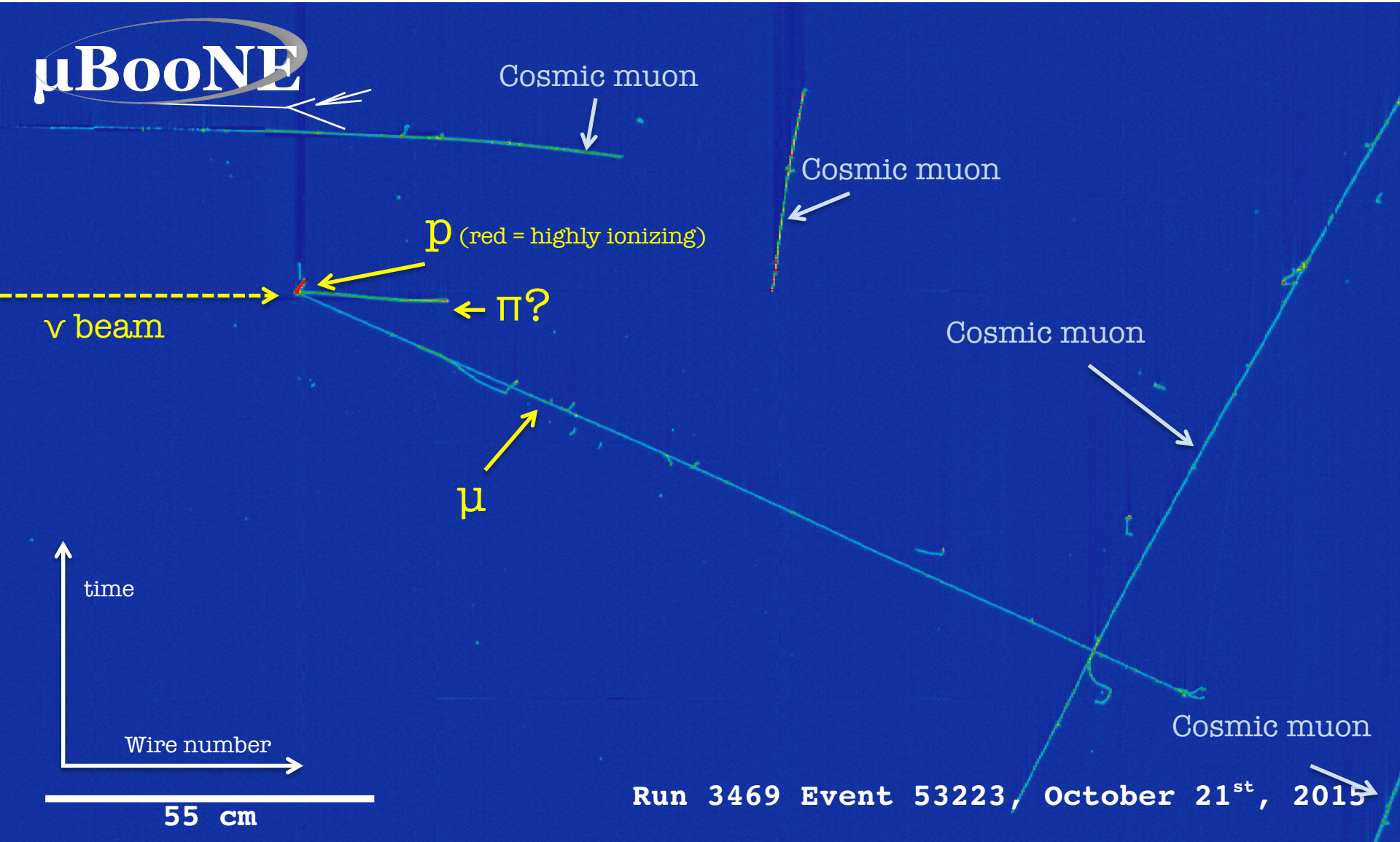
(collection plane view)



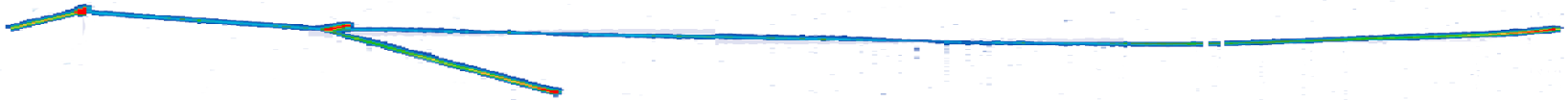
First neutrino events



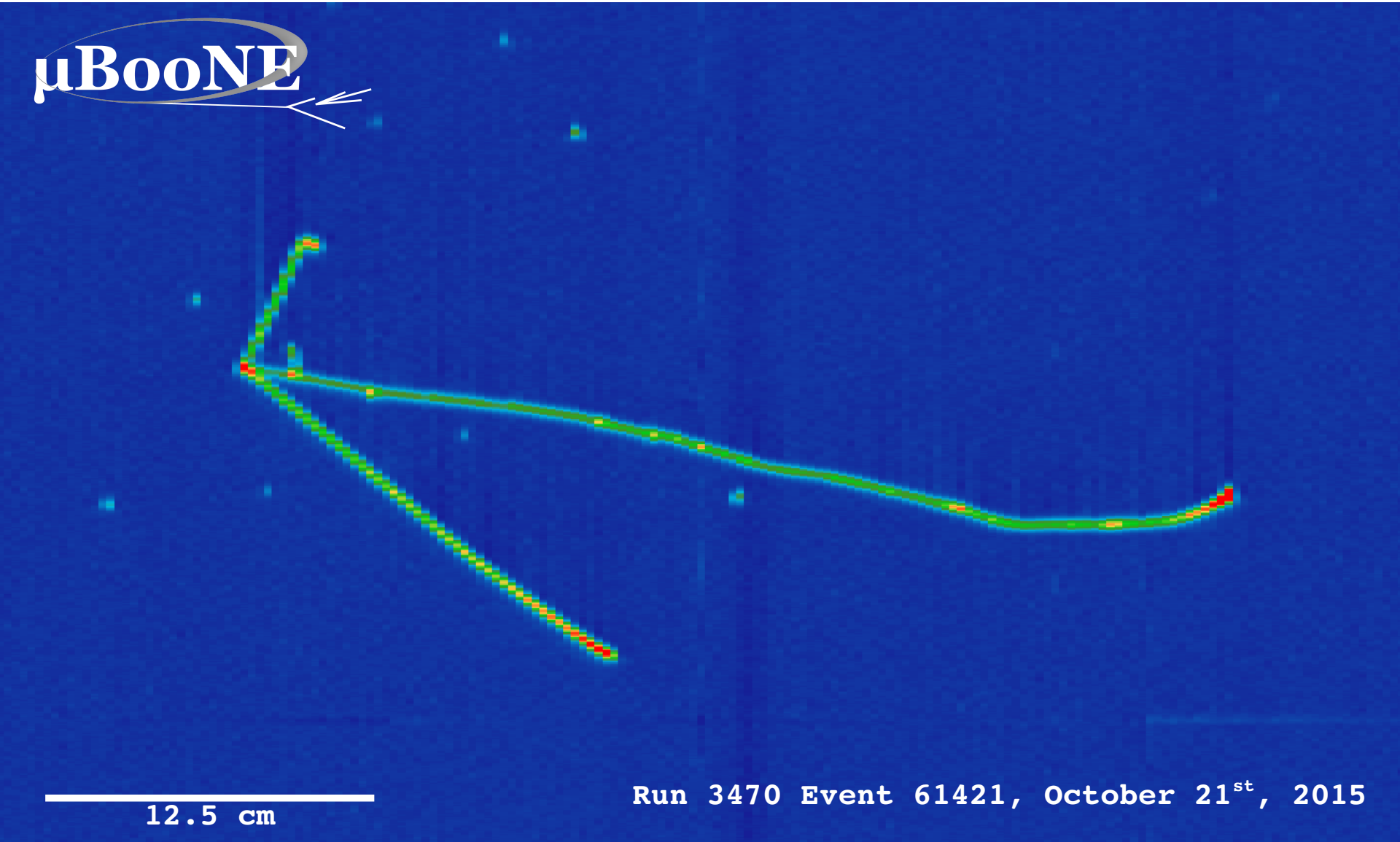
(collection plane view)



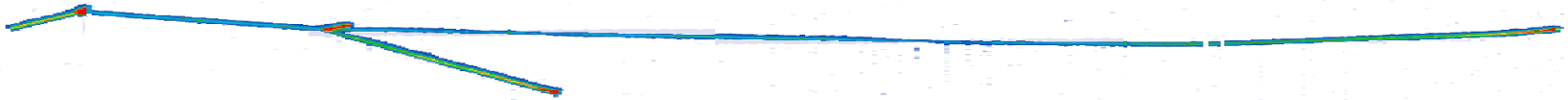
First neutrino events



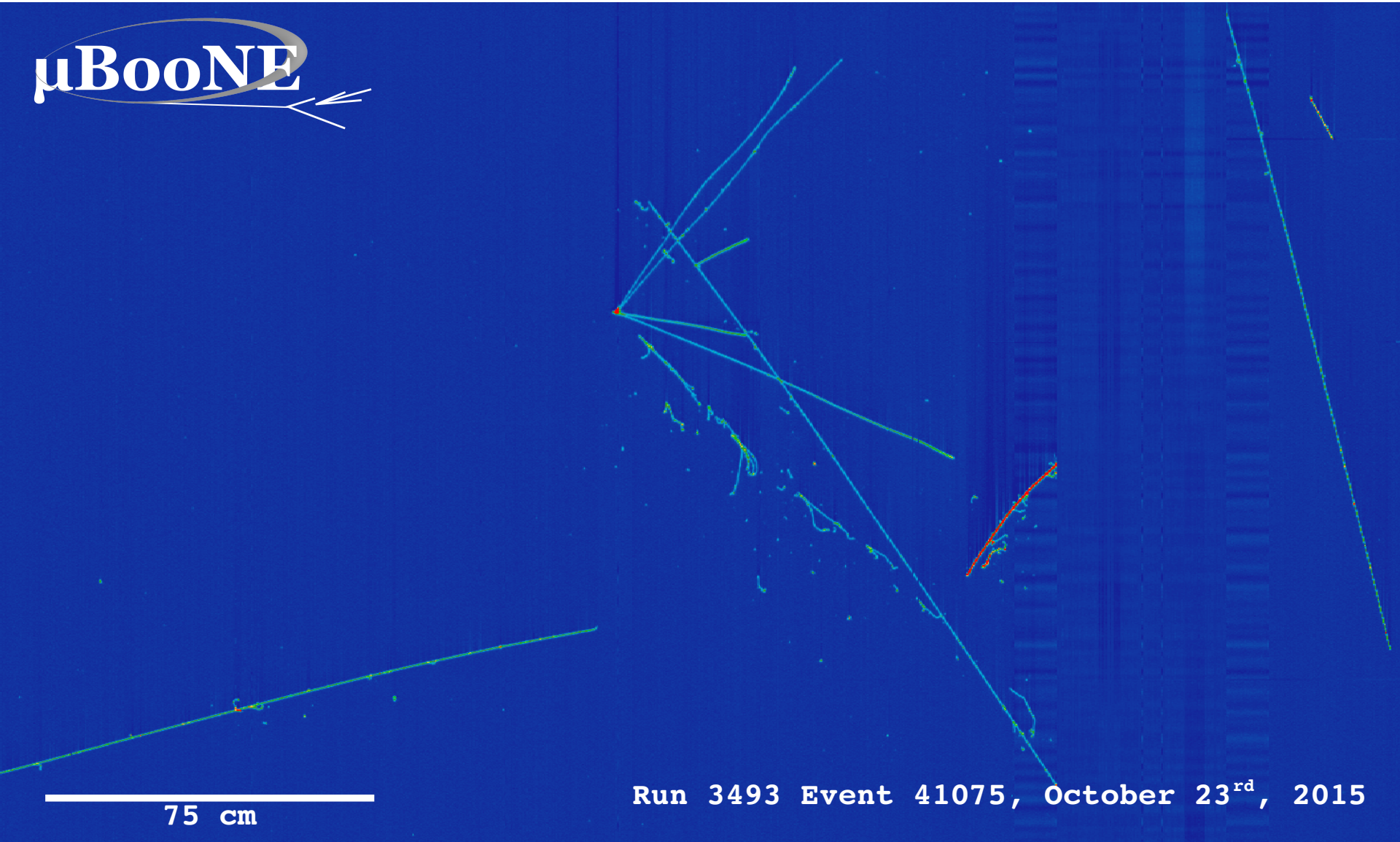
(collection plane view)



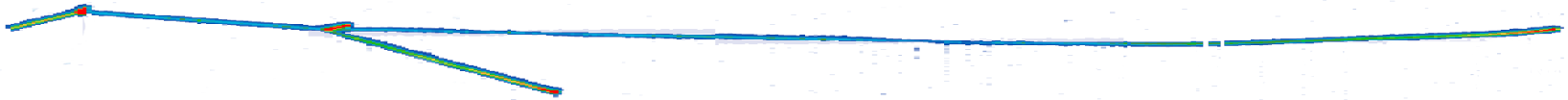
First neutrino events



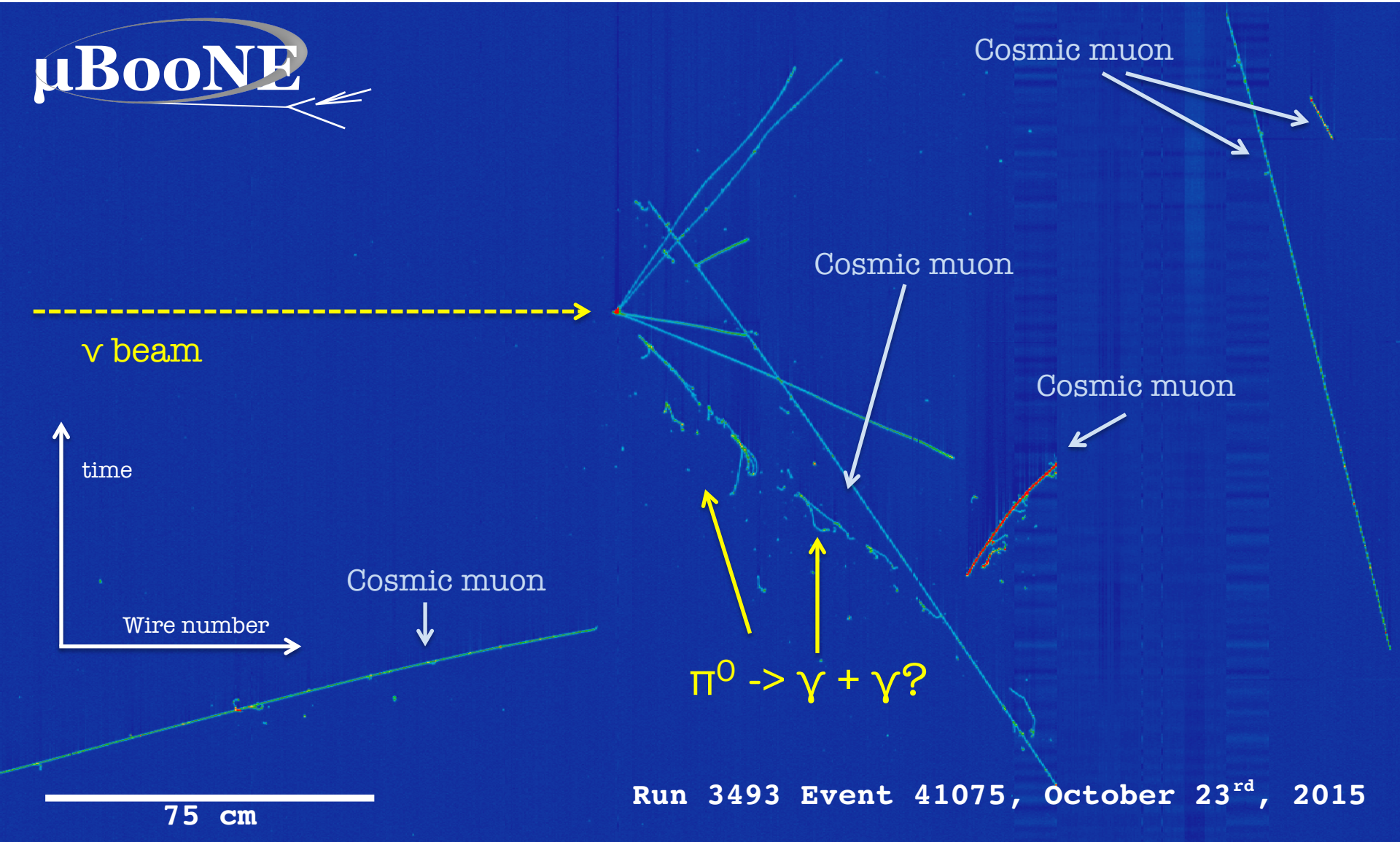
(collection plane view)



First neutrino events



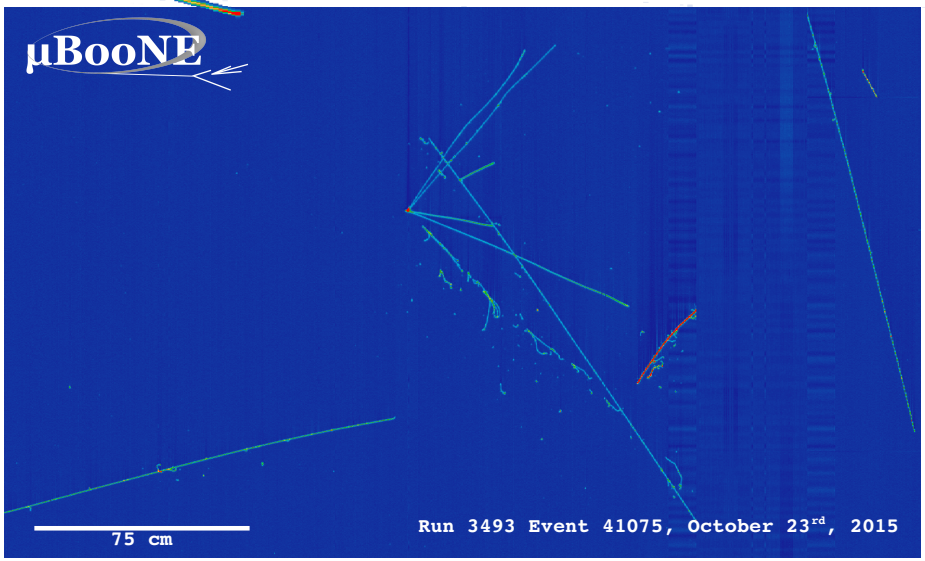
(collection plane view)

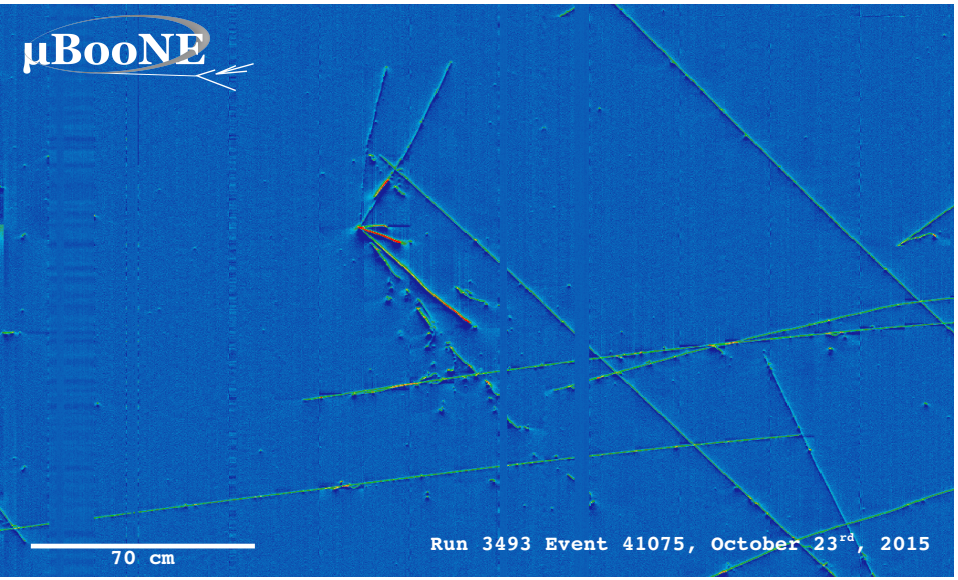


First neutrino events

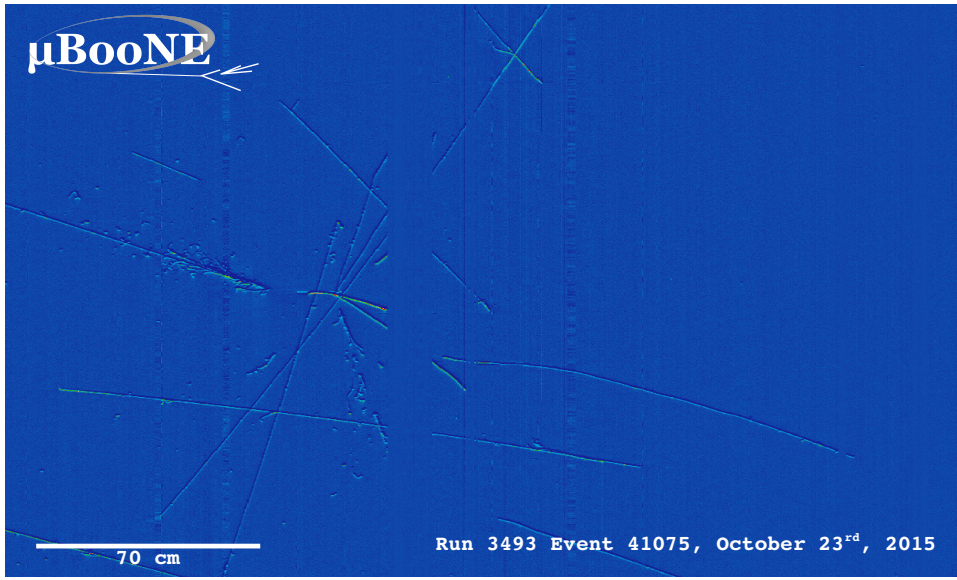
(collection plane view)

Same event in all three anode plane views.



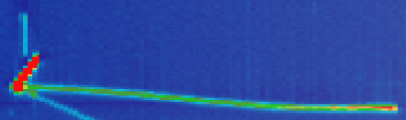


(induction plane view (V))



(induction plane view (U))

Summary



- MicroBooNE sucessfully started operation and is observing beautiful neutrino interactions.
- We have started work on several cross section channels and are getting prepared for our first data.
- We will be able to produce interesting physics results using the data accumulated during the first few months.