MicroBooNE: Physics Overview and Detector Assembly

Ryan Grosso (University of Cincinnati)
ON BEHALF OF
The MicroBooNE Collaboration

UNIVERSITY OF Cincinnati

Outline

- MicroBooNE physics motivation
- MicroBooNE detector overview
- Status of detector construction

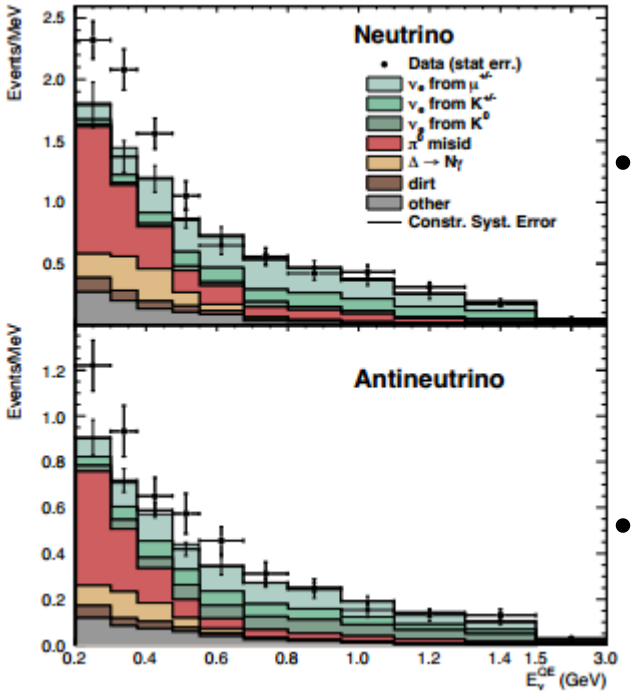
Collaboration

- **Brookhaven:** Hucheng Chen, Kai Chen, Susan Duffin, Jason Farell, Francesco Lanni, Yichen Li , David Lissauer, George Mahler, Don Makowiecki, Joseph Mead, Veljko Radeka, Sergio Rescia, Andres Ruga, Jack Sondericker, Craig Thorn , Bo Yu
- **University of Chicago:** Will Foreman, Johnny Ho , David Schmitz
- **University of Cincinnati:** Ryan Grosso, Jason St. John, Randy Johnson, Bryce Littlejohn
- **Columbia University:** Nancy Bishop, Leslie Camilleri, David Caratelli , Cheng-Yi Chi, Jennet Dickinson, Georgia Karagiorgi, David Kaleko, Bill Seligman, Mike Shaevitz , Bill Sippach, Kathleen Tatum, Kazuhiro Terao, Bill Willis
- **Fermilab:** Roberto Acciarri, Bruce Baller, Dixon Bogert, Ben Carls, Herb Greenlee, Cat James, Eric James, Hans Jostlein, Mike Kirby, Sarah Lockwitz, Byron Lundberg,Alberto Marchionni, Stephen Pordes, Jennifer Raaf, Gina Rameika, Brian Rebel, Rich Schmitt, Steve Wolbers, Dave Schmitz, Jin-Yuan Wu, Tingjun Yang, ***Sam Zeller****
- **Kansas State University:** Tim Bolton, Saima Farooq, Sowjanya Gollapinni, David McKee, Glenn Horton-Smith
- **Los Alamos National Lab:** Gerry Garvey, Jackie Gonzales, Wes Ketchum, Bill Louis, Geoff Mills, Zarko Pavlovic, Richard Van de Water
- **Massacusetts Institute of Technology:** William Barletta, Len Bugel, Janet M. Conrad, Christina Ignarra, Ben Jones, Teppei Katori, Tess Smidt, Arati Prakash
- **Michigan State University:** Carl Bromberg, Dan Edmunds
- **New Mexico State University:** Tia Miceli, Vassili Papavassiliou, Stephen Pate, Katherine Woodruff
- **Otterbein University:** Nathaniel Tagg
- **Princeton University:** Kirk McDonald, Bill Sands
- **Saint Mary's University of Minnesota:** Paul Nienaber
- **Syracuse University:** Jonathan Asaadi, Mitch Soderberg
- **University of Texas at Austi:** Son Cao, Junting Huang, Karol Lang, Rashid Mehdiyev
- **University of Bern, Switzerland:** Antonio Ereditato, Igor Kreslo, Michele Weber, Christoph Rudolf von Rohr, Thomas Strauss
- **Virginia Tech:** Mindy Jen, Leonidas Kalousis, Camillo Mariani
- **Yale University:** Corey Adams, Christina Brasco, Eric Church, ***Bonnie T. Fleming****, Ellen Klein, Ornella Palamara, Flavio Cavanna, Roxanne Guenette, Kinga Partyka, Andrzej Szelc

What are MicroBooNE's Goals?

Physics

- Investigate the MiniBooNE low energy excess
- Measurements of ν-Ar cross sections



Technology

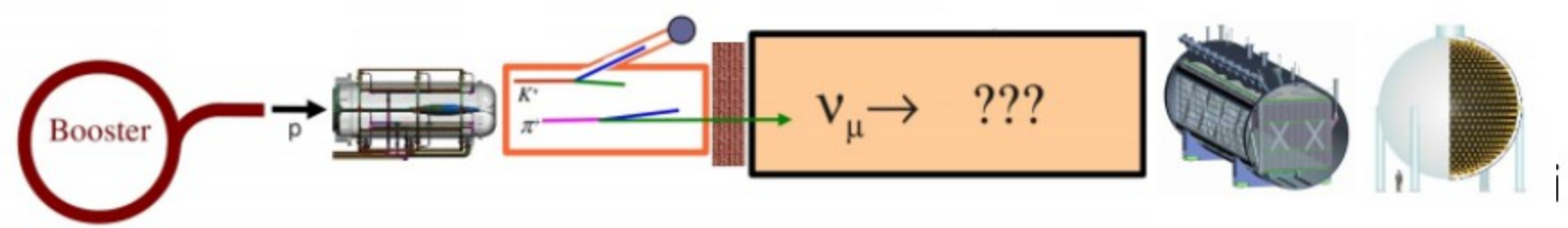
- Test cryostat and TPC design, light detection, experiment operations.
- Understanding the construction cost of such a large detector.

R&D

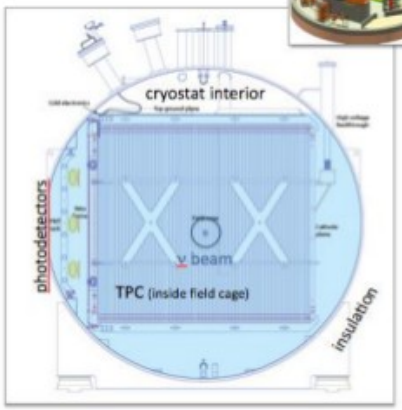
Long drift length (2.5m)
Surface Running
Nucleon Decay Backgrounds
UV Laser Calibration

Location

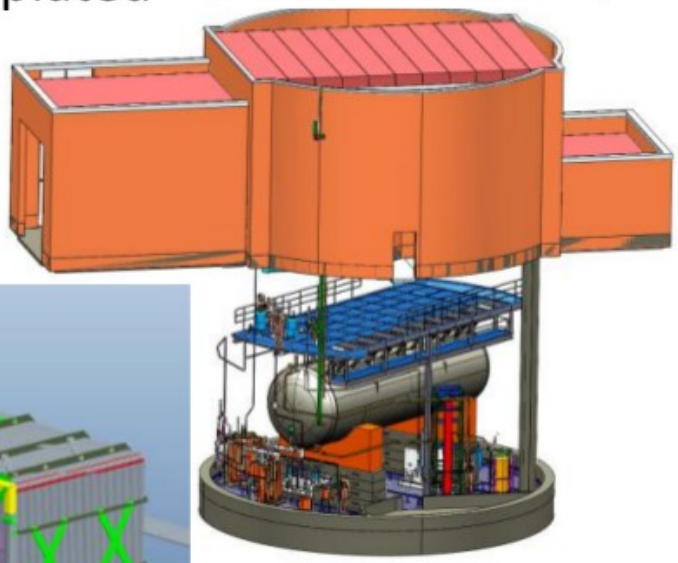
NuMI
BNB
MINOS
Miniboone
LArTF
Microboone

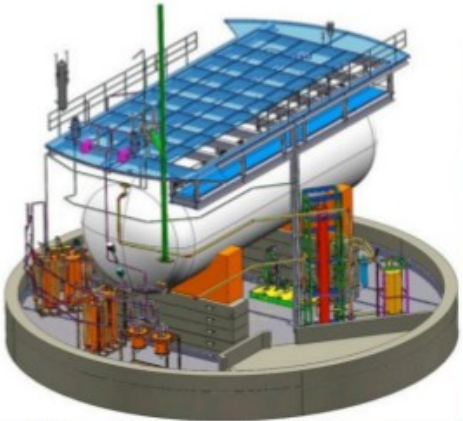

Booster
p
K+
π+
$\nu_\mu \rightarrow$???

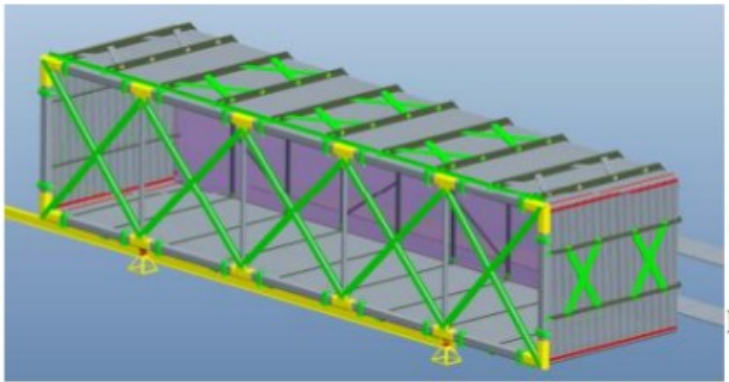
MicroBooNE Detector Overview



- LArTF will be L=470m from target
- Cryostat volume 170 tons
- ~70 tons **Fiducial Volume**
- Dimensions of TPC are 2.3m X 2.5m X 10.4m
- Wires are 150μm diameter SS Cu/Au plated
- 3 wire planes u,v,y (u,v ± 60°)
- Operate in the BNB in early 2014







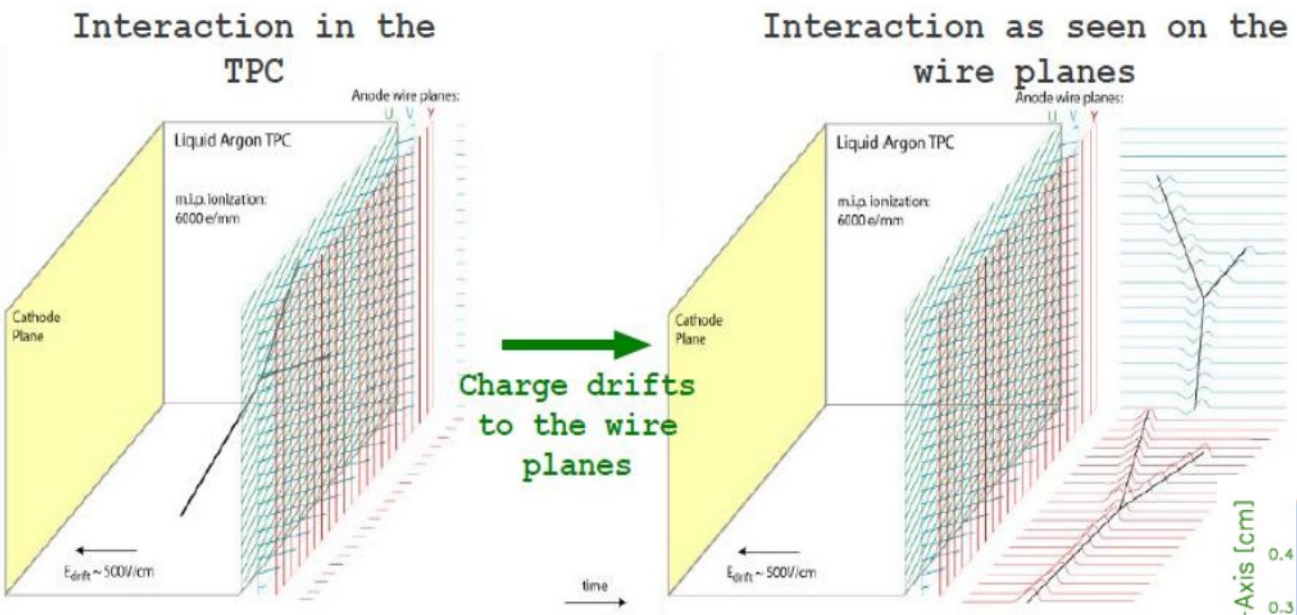
MicroBooNE Layout

Why LAr?

	He	Ne	Ar	Kr	Xe	Water
Boiling Point [K] @ 1atm	4.2	27.1	87.3	120.0	165.0	373
Density [g/cm³]	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	

- High Density (good target)
- Small radiation length (14.0 cm)
- Good dielectric properties (great for high voltages)
- Argon is relatively inexpensive **(1% of atmosphere)**
- Track ionization can drift over long distances if kept pure

How the Detector Works



*Max drift time 1.5ms * Max drift length 2.5m

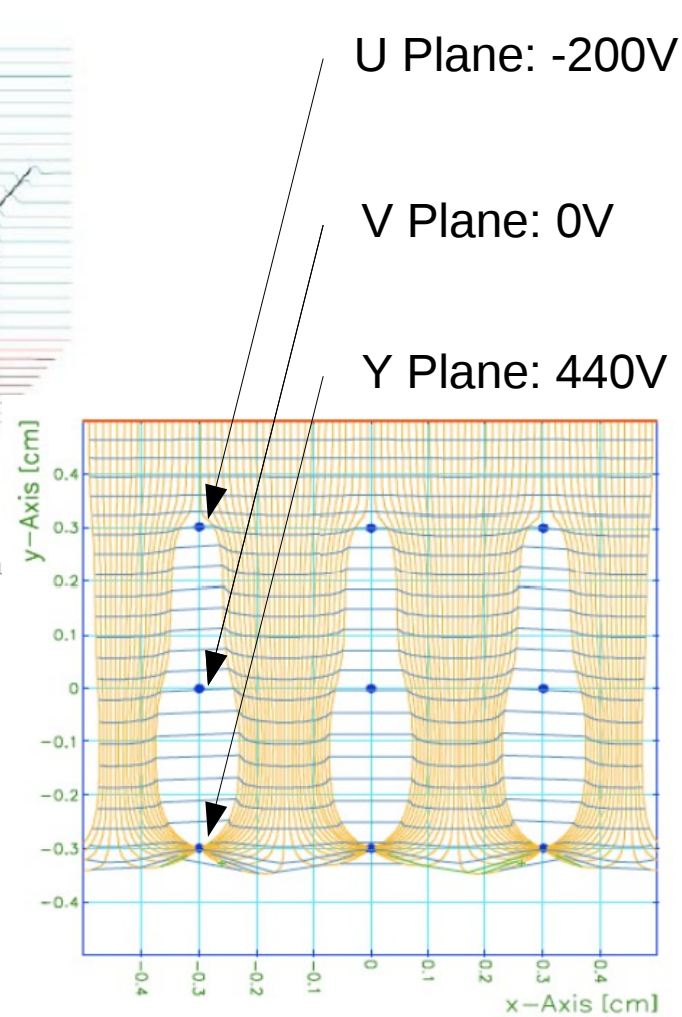
Transparency is a function of wire geometry and electric fields before/after each plane.

$$\frac{E_2}{E_1} \geq \frac{1+\rho}{1-\rho}$$

100% Transparency Condition

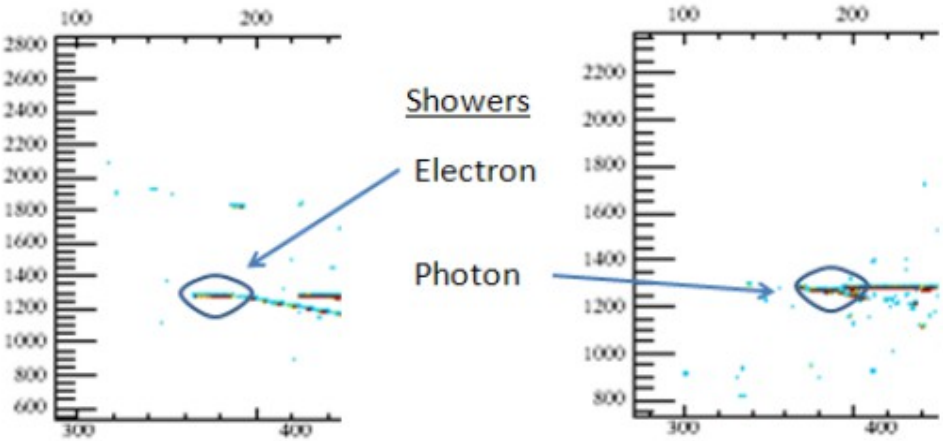
$$\rho = \frac{2\pi r}{d}$$

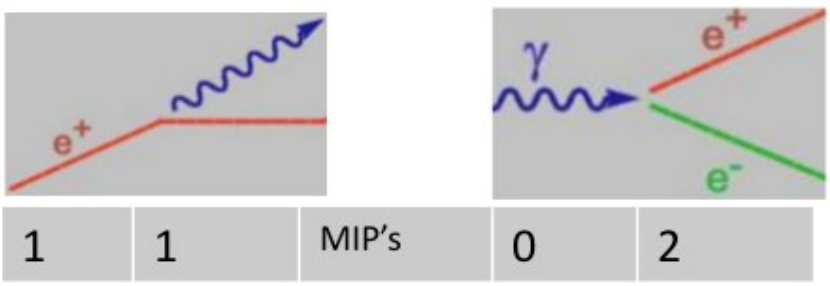
r = wire radius
d = wire pitch



e/γ Separation

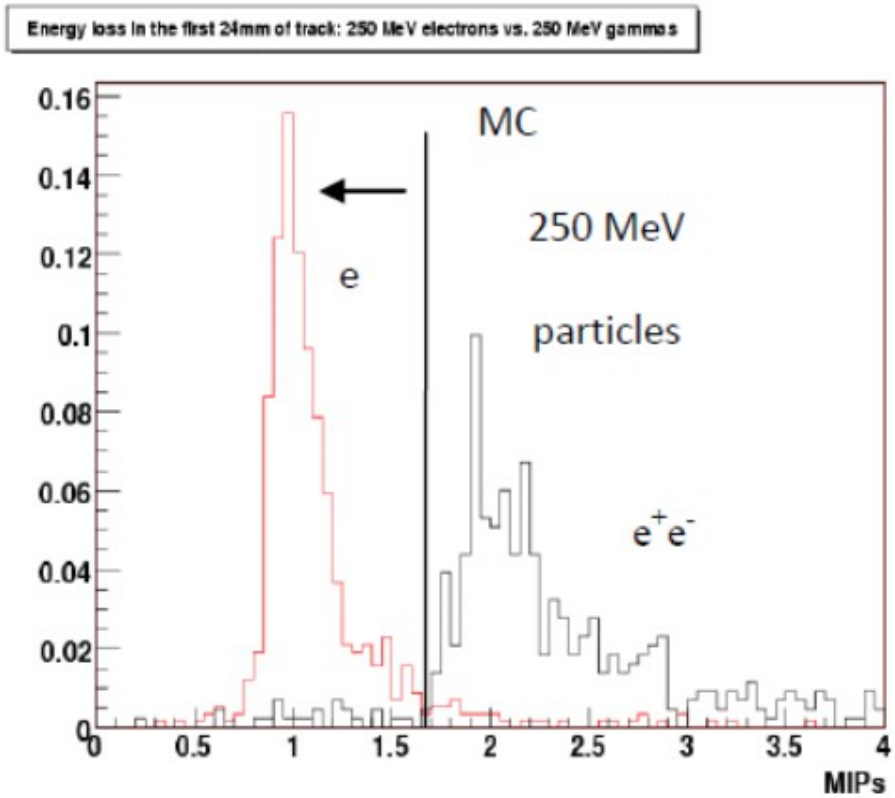
-Look at dE/dx of first part of the shower. Since the γ shower is formed by the electron position pair the loss of energy will be twice as large.





Bremsstrahlung

Pair production



TPC Construction

- TPC structure was completed in April
  - Many hours of work from undergraduates, grad-students, post-docs, scientists and

About Signal Wires

What's Important:

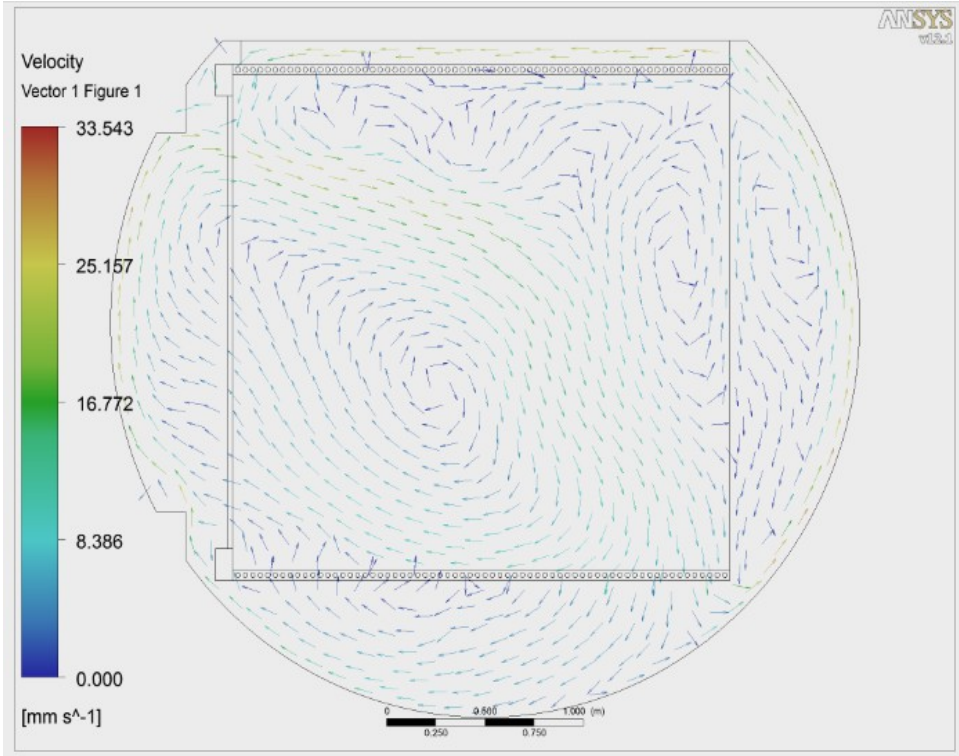
3mm spacing from wires:

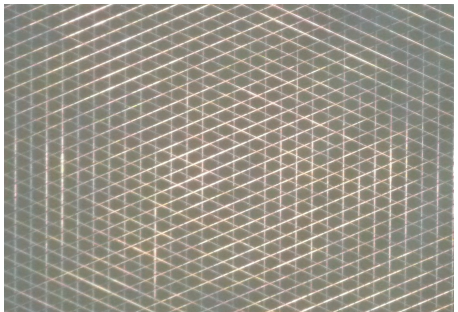
- Allows for fine grained tracking → e/γ separation

Wires at proper tension (0.7Kg)

Plane to plane 3mm spacing:

- Chance for shorting out other wires
  → Possible large dead regions
- Wires break load is 4.38kg





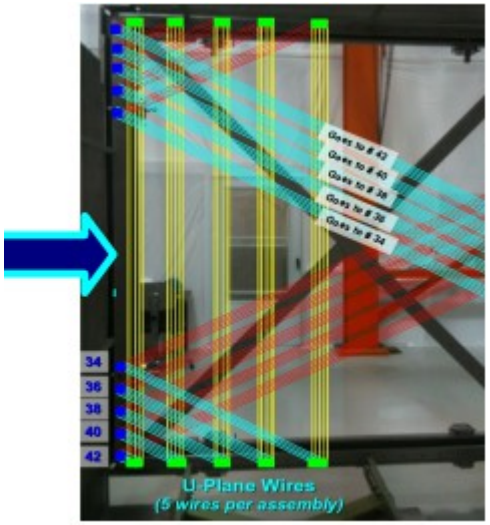
Mock Wire Installation

Propose:

- Develop a safe and proper method to install wires by using a small fraction of “mock” wires wound for this task

What was learned: (A LOT)

- Installation procedures
- Safe practices, keeping clean
- How to coarse tension and align



Preparing The Tent & TPC

- TPC Cleaned with Alcohol

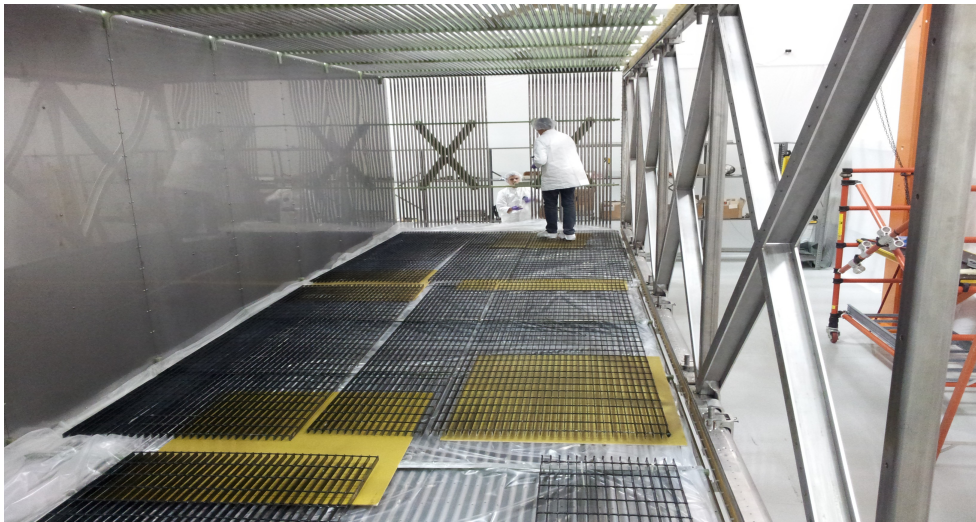
Power Washing Floor Grates

TPC Floor

Plastic over field cage tubes

Lay down floor grating

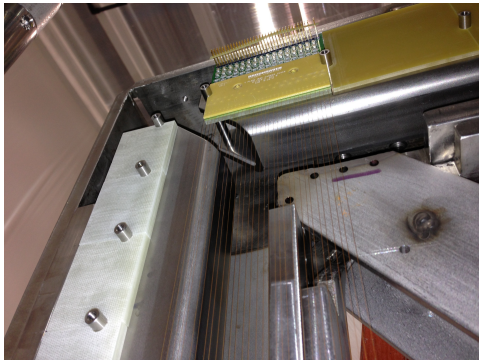
Secure flooring with Zip Ties



Installing Wires

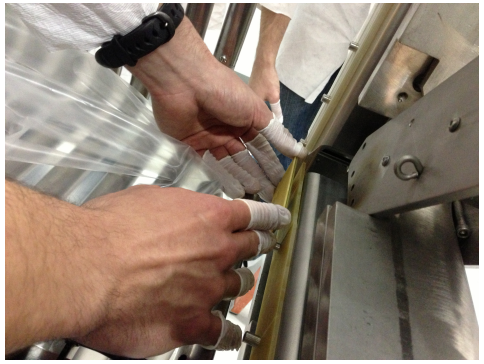
Delivered into TPC

Trade off boards

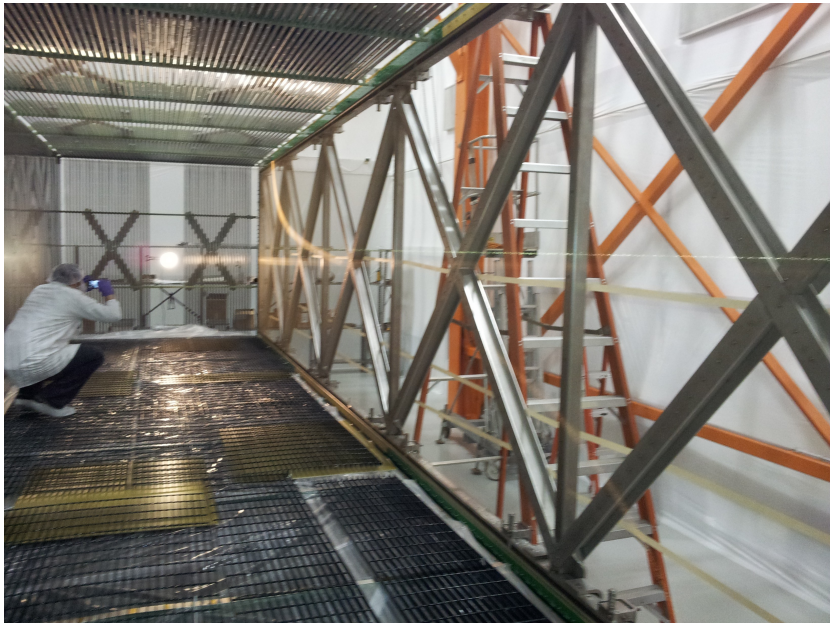


Install top horizontal

Install bottom horizontal



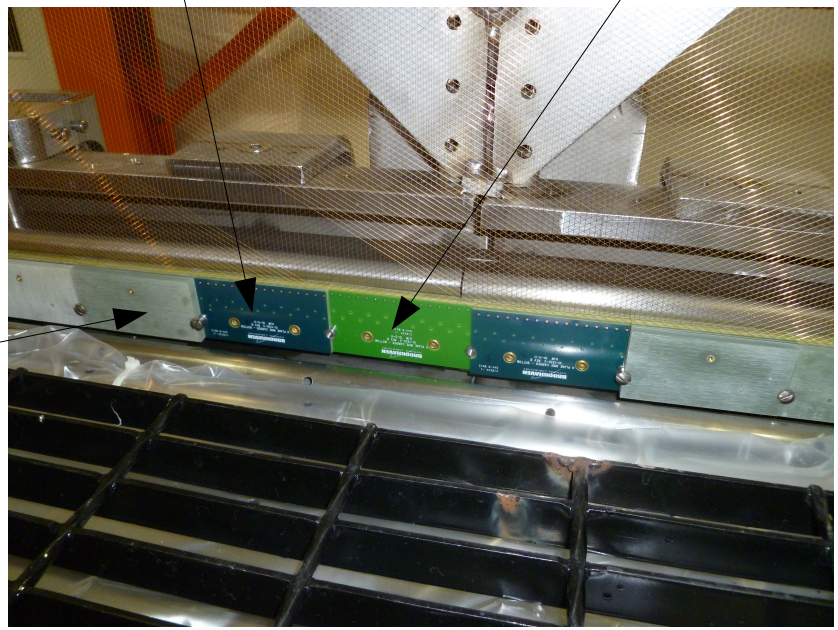
U & V Planes



Similar installation procedure

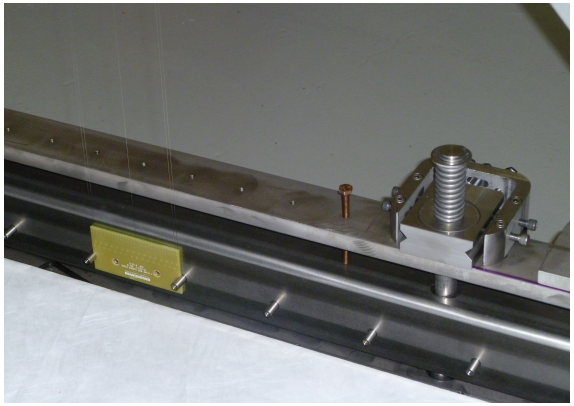
U plane

V plane

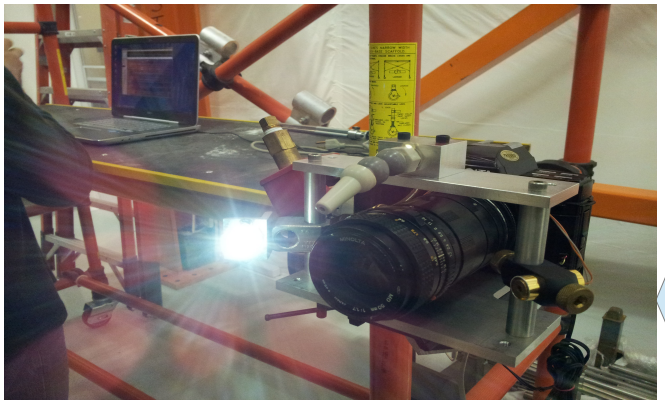


Cover Plates

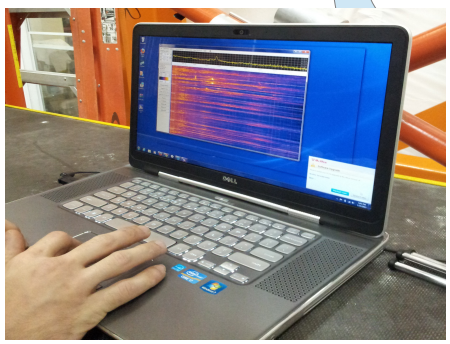
Tension & Alignment



Fine Adjustment



Tension Measurement



* 3mm plane to plane
* tension 0.7 kg

- Worked with FNAL Alignment

What's Next?

- Install Electronics and Readouts
  * David Kaleko
- Insert TPC & PMT systems in cryostat
- Transport sealed cryostat to LarTF
- Insulate & connect cryogenics
- Connect electronics
- Begin cooling & get ready for data!

Thanks for listening

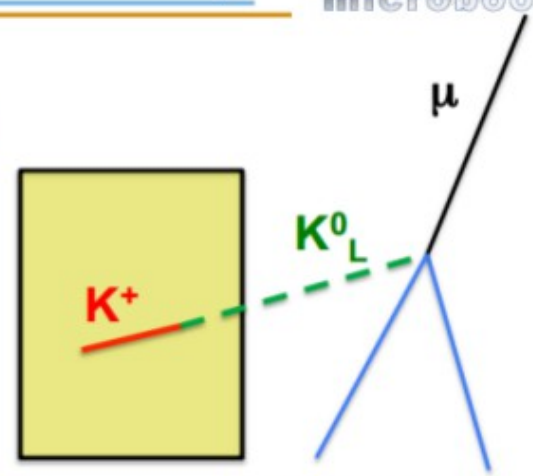
Backups

Proton decay search

A Measurement of Background to p→K decay mode

Cosmic ray:

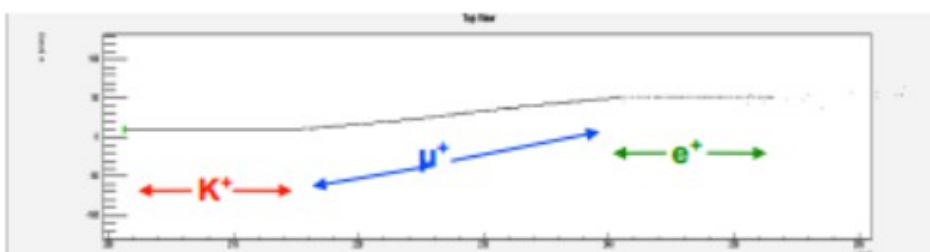
- μ interacting in the rock around the detector.
- Producing a K^0_L
- Enters the detector (No track) and charge exchanges $K^0_L p \rightarrow K^+ n$
- Looks like a K^+ from p decay.

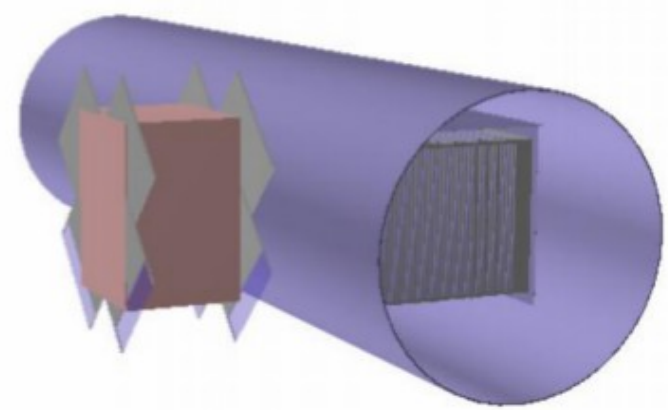


Argon n =1.23
Water n =1.33

Study:

- How many cannot be rejected on the basis of accompanying particles ?



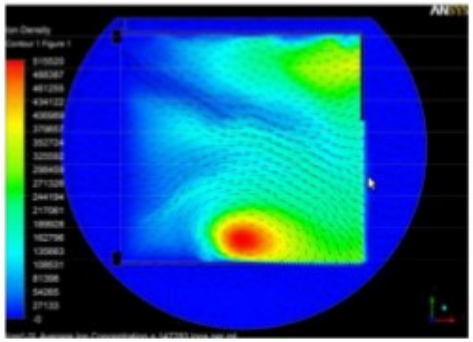


Laser calibration

Cosmics & interactions produce chraged Ar ions

Field distortions

Argon Flow ~ Drift electrons



Field distortions can be corrected by UV laser calibration.

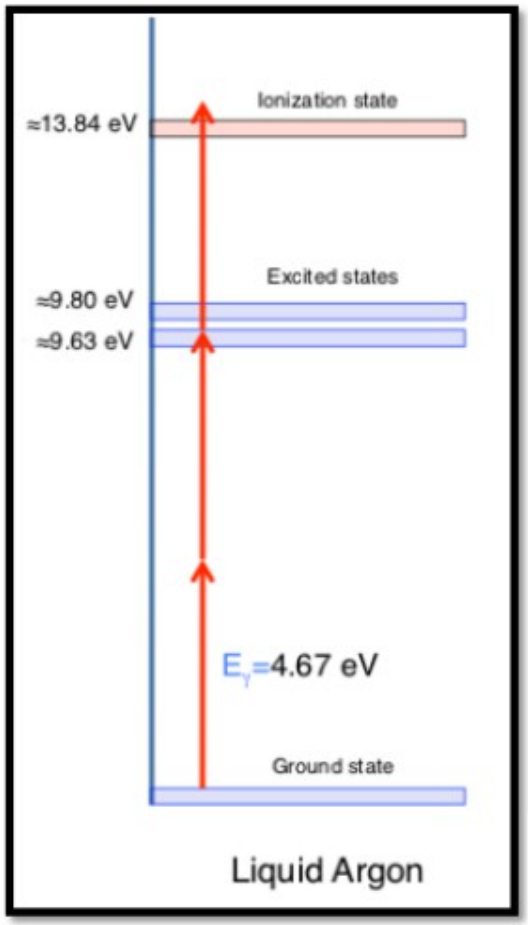
- Multiphoton ionization
- Non Resonant states, lifetime is

$$\tau_\gamma = \frac{\lambda}{2\pi c} = 1.4X10^{-16}s$$

- For quasi-resonant states

$$\tau_\gamma \propto \frac{1}{\Delta E} = \frac{1}{E_i - E_f}$$

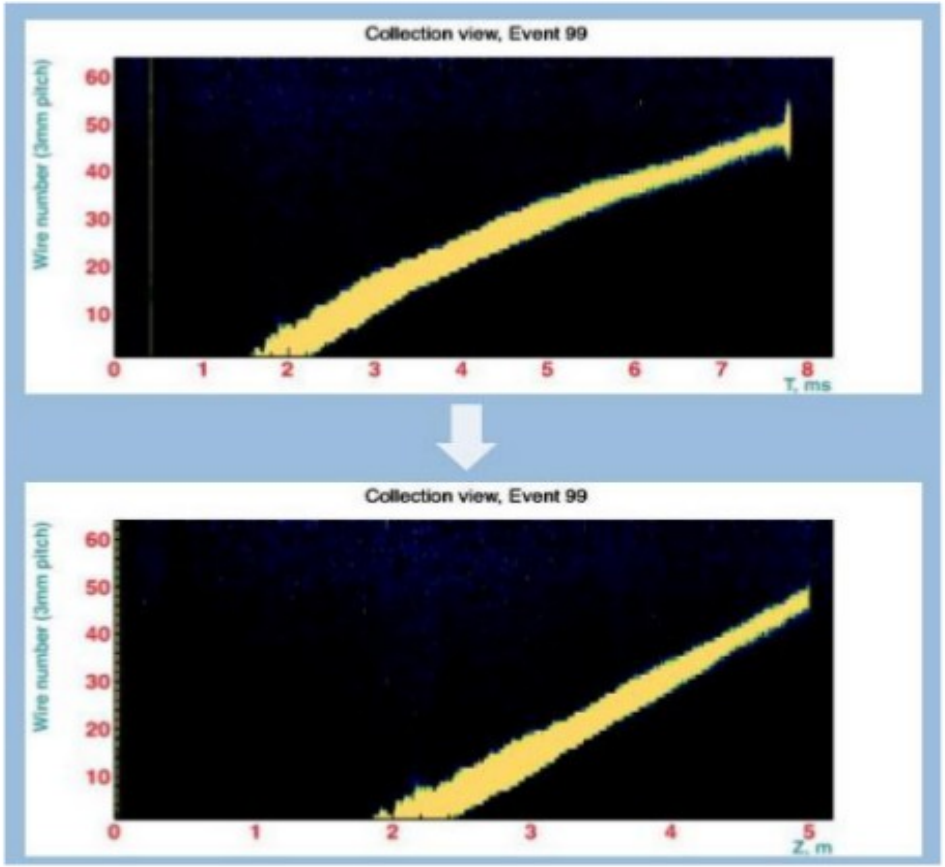
- Needs 3 photon ionization



Laser Corrections

Uncorrected

Electric field correction

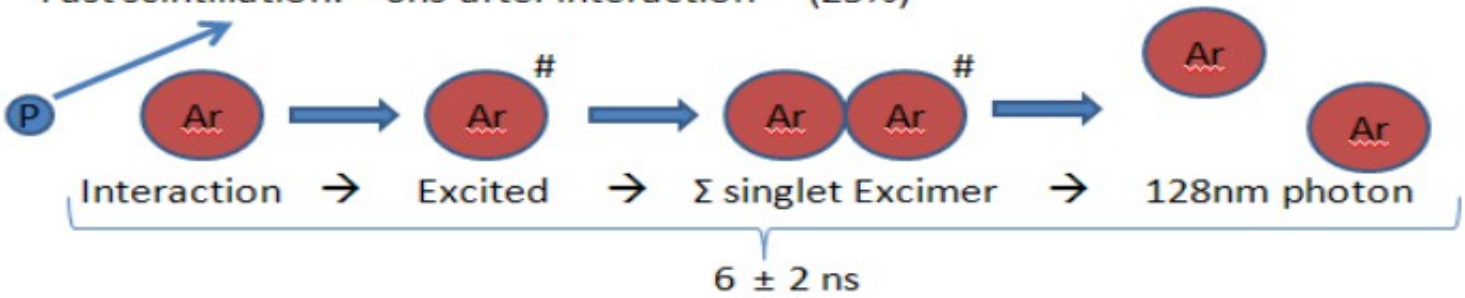


Light in LAr

- MicroBooNE optimized for scintillation light.
  - Trigger for events
  - Beam spills

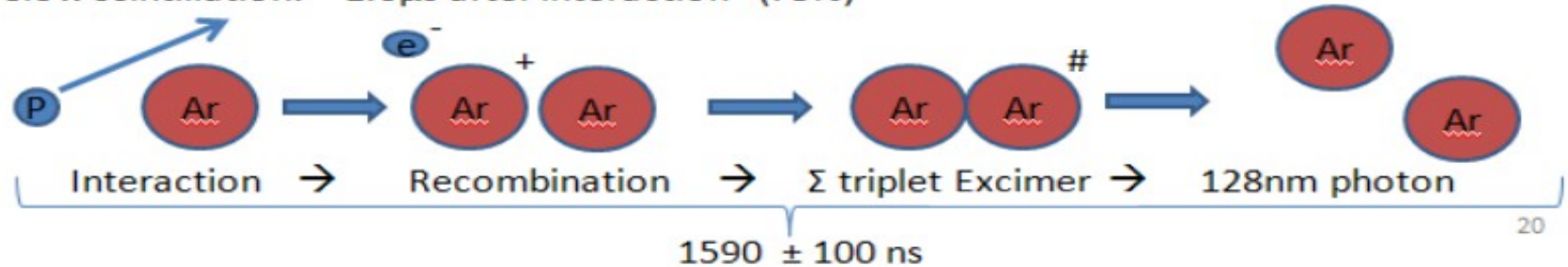
Two components to the light signal, slow and fast.

Fast scintillation: ~6ns after interaction (25%)

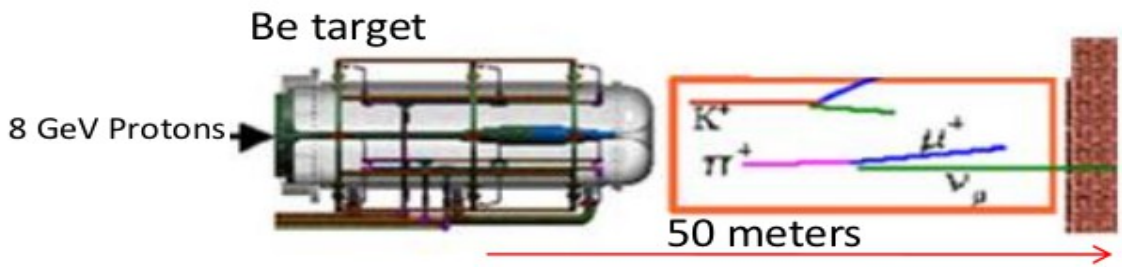


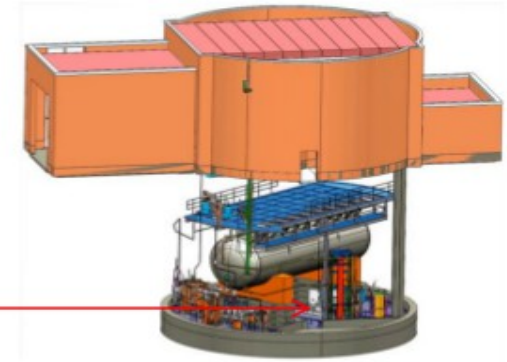
128nm can't penetrate glass → coated TPB WS

Slow scintillation: ~1.6μs after interaction (75%)

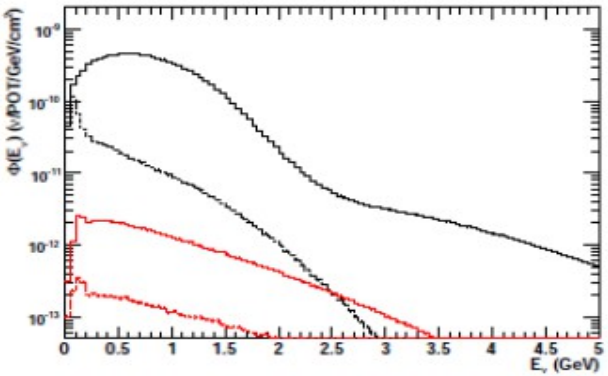


Neutrino Beams



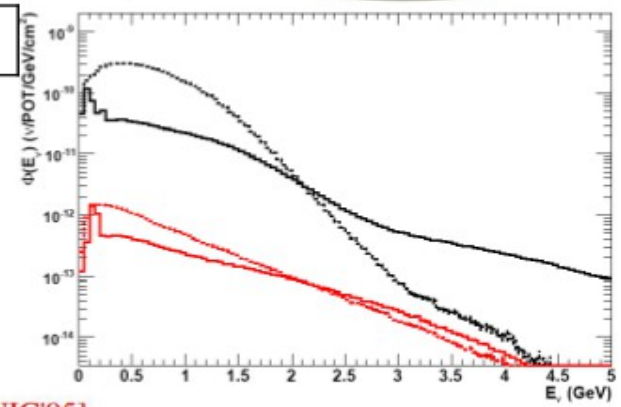


470 meters

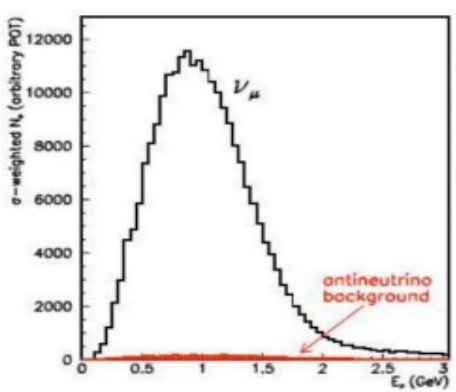


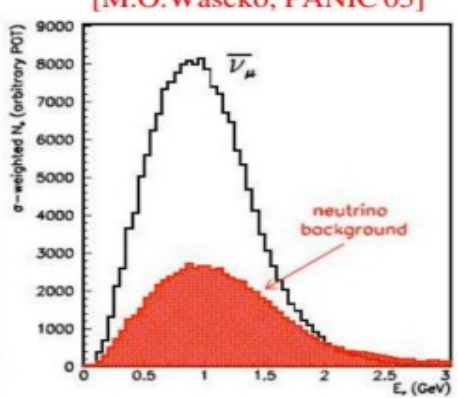
neutrino	Anti-neutrino

ν_e
$\bar{\nu}_e$
ν_μ
$\bar{\nu}_\mu$



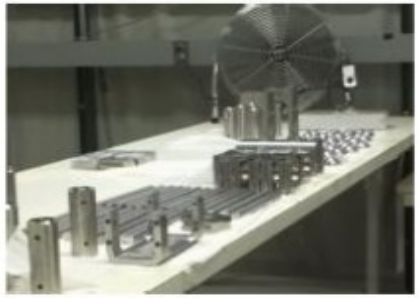
[M.O.Wascko, PANIC'05]





TPC Parts cleaning at Lab F

Lab F TPC parts prep area

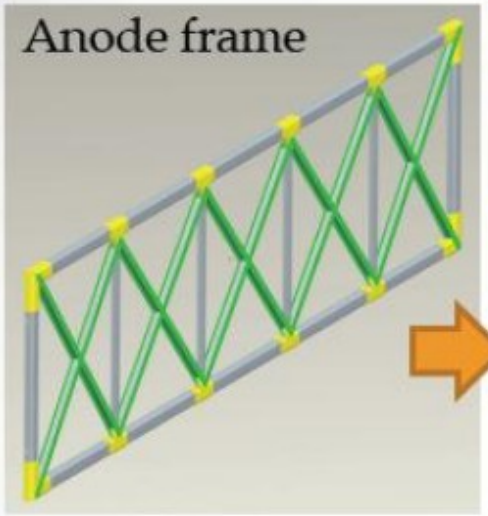


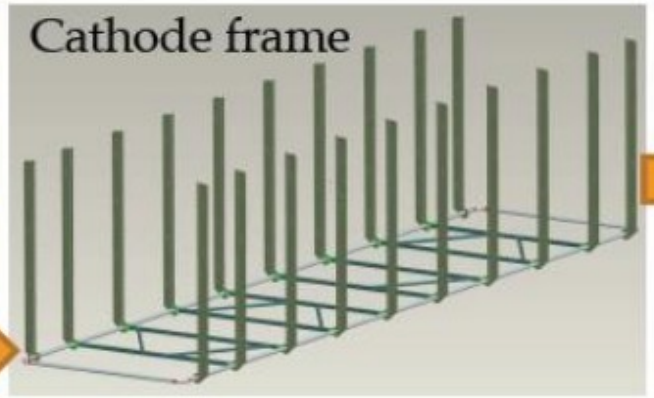
Small ultrasonic bath for cleaning hardware & small parts
(Thanks Pete Simon)

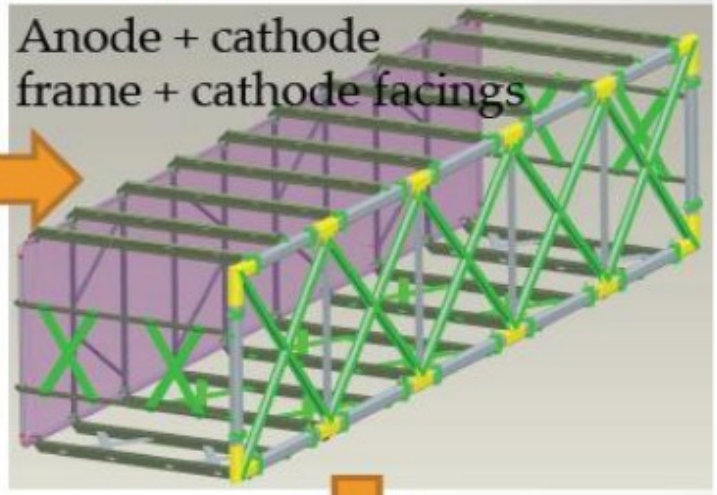
Large TPC parts being cleaned

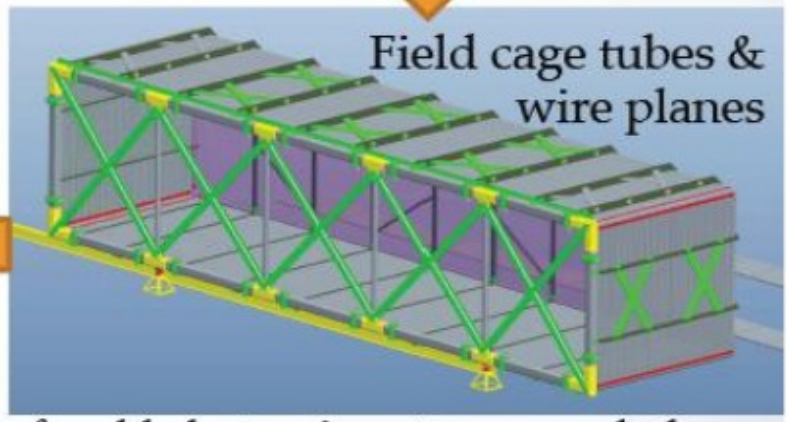
Cleaned TPC parts wrapped and ready for transport

TPC Assembly





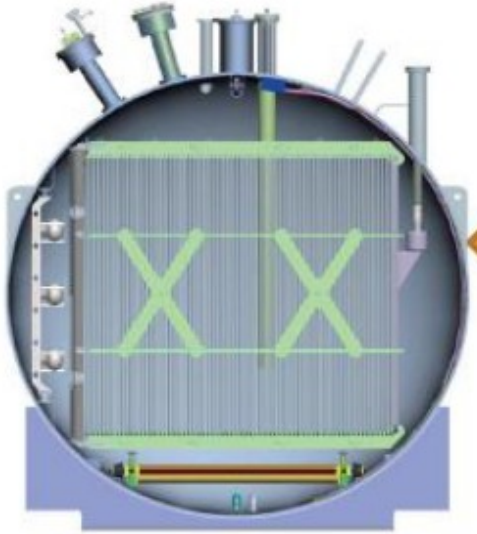




& cold electronics + top ground plane (not shown)

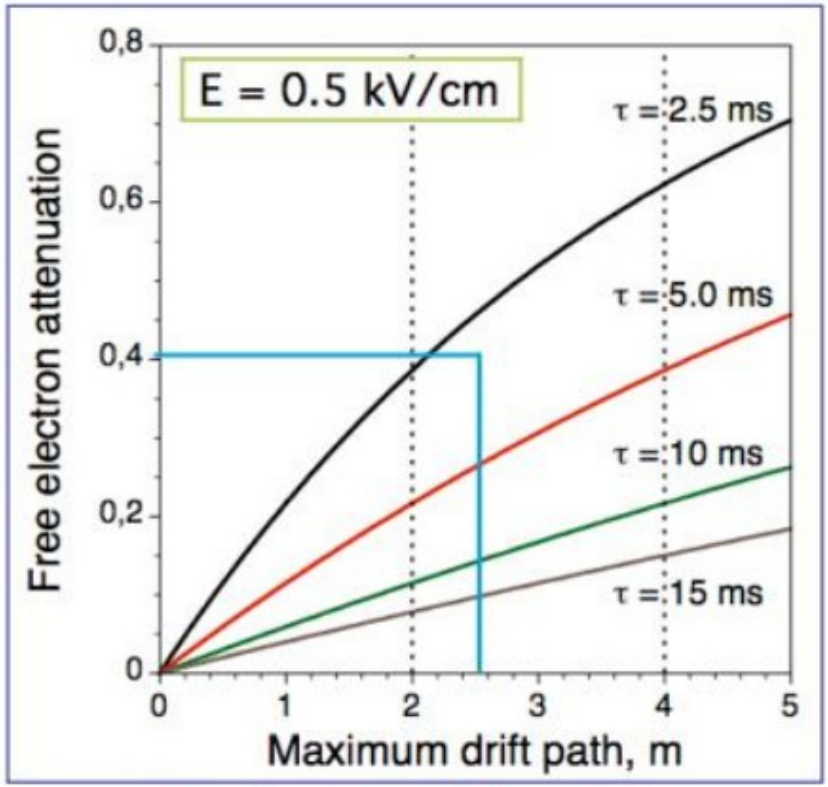
Insert TPC into cryostat

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



How Pure?

- Poor lifetime reduces the dynamic range and strains electronics
- 100 parts per trillion (ppt) O_2 equivalent corresponds to an electron lifetime of 3 ms
- The product of the contamination and the lifetime is a constant, so for a 10 ms lifetime you need 30 ppt O_2 equivalent
- In a field of 500 V/cm, the drift velocity is 1.6 mm/μs; the drift time for 2.5 m is then 1.56 ms
- Electron lifetime should be at least twice the maximum drift time to keep signal loss to < 40%



From C. Montanari, June 2007