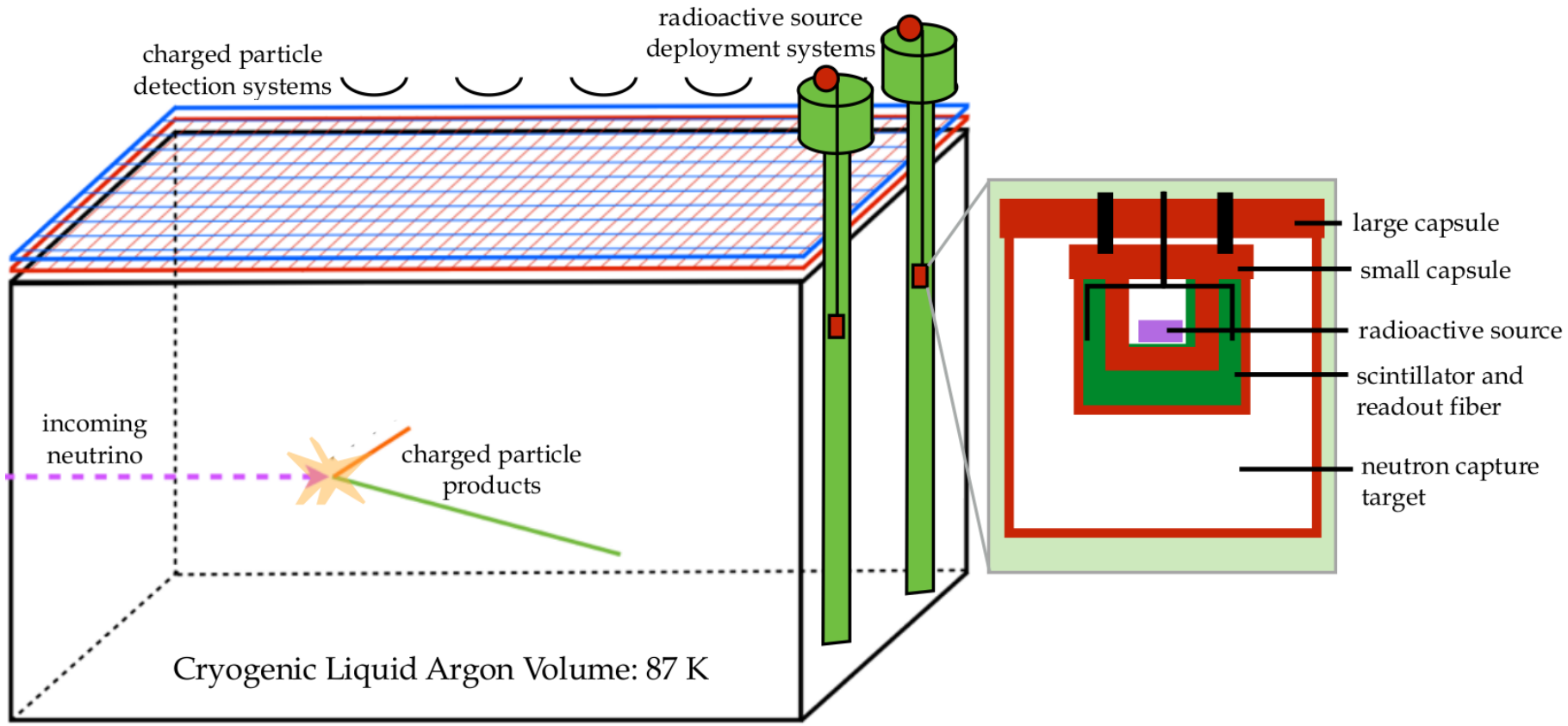
Radioactive Source Calibration



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University of Texas at Arlington

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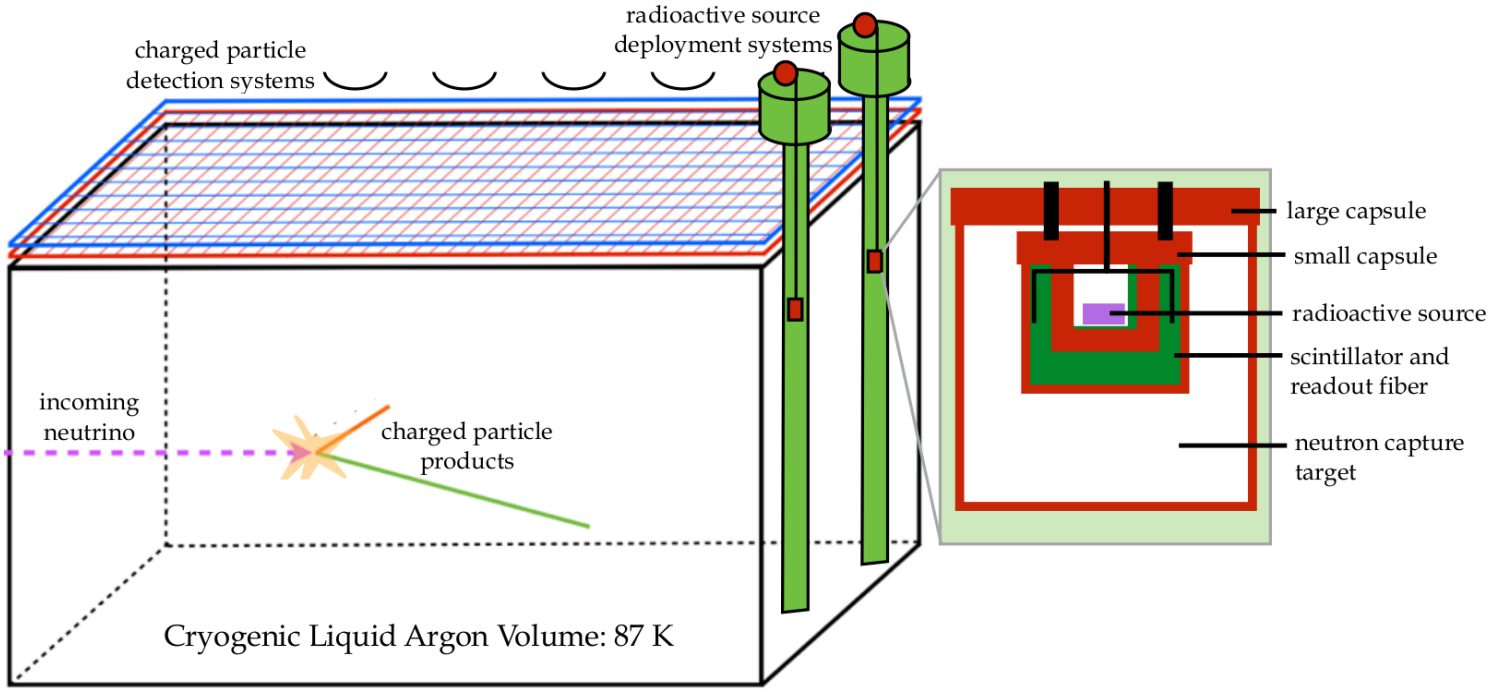
Illinois Institute of Technology

Radioactive Source Calibration

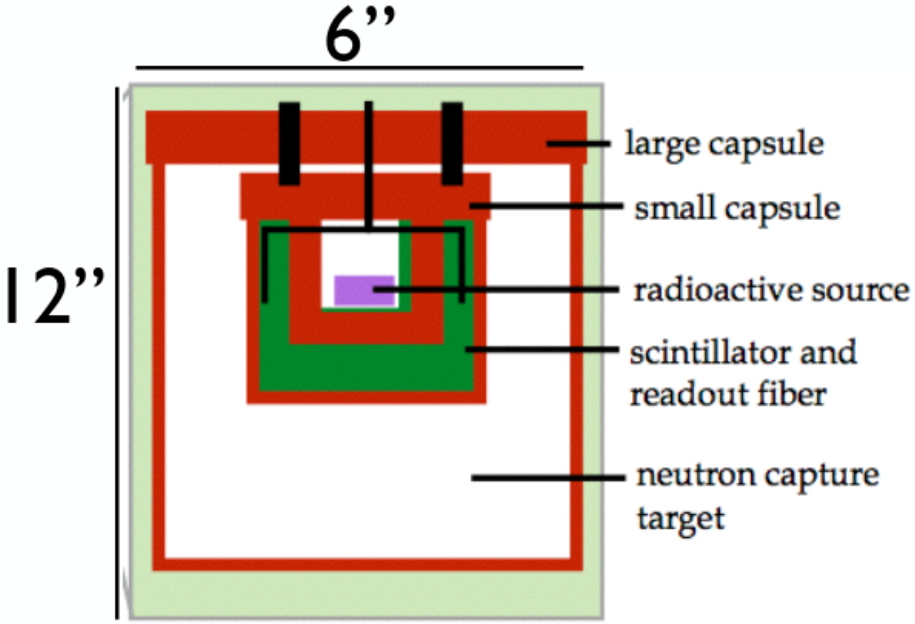
- **The original idea we were working on was a system which could**
  - Provide low energy calibration for both TPC and light collection system
  - Provide sample for matching between between TPC and light system
  - Demonstrate low energy reconstruction algorithms with a fixed source
  - plus many others……
- **We originally proposed this idea for SBND and would be happy to work with others to adapt this for DUNE**
  - I'll be showing some slides Bryce (IIT) and I (UTA) put together and work we've done recently on LArIAT

The idea for the system

- **“Dry” calibration axes positioned along side the TPC**
  - Allow for the deployment of different radioactive sources at various vertical distances
  - Multiple ports allow for different drift direction locations
  - Significant portion of the gammas from the radioactive sources deposit their full energy in the TPC
  - Minimal impact on TPC design



Calibration Peaks



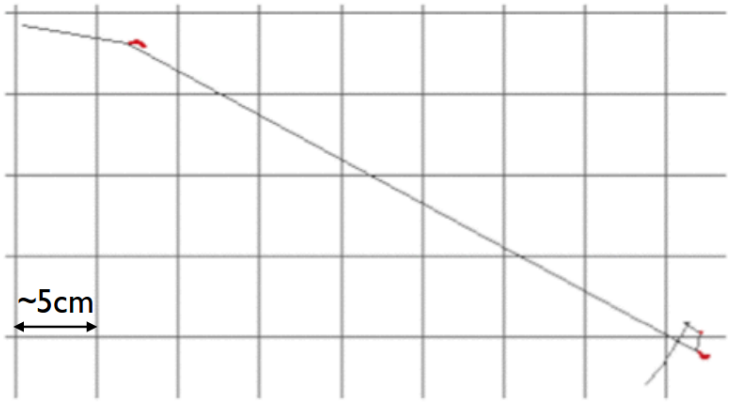
- **Neutrons from the source capture on target in the outer canister and produce gammas in the range of 1-10 MeV**
  - Can deploy a gamma source in a simplified canister in the same axis
- **Plastic scintillator around the source can provide a trigger for the readout system**

Some thoughts on sources and their corresponding signal

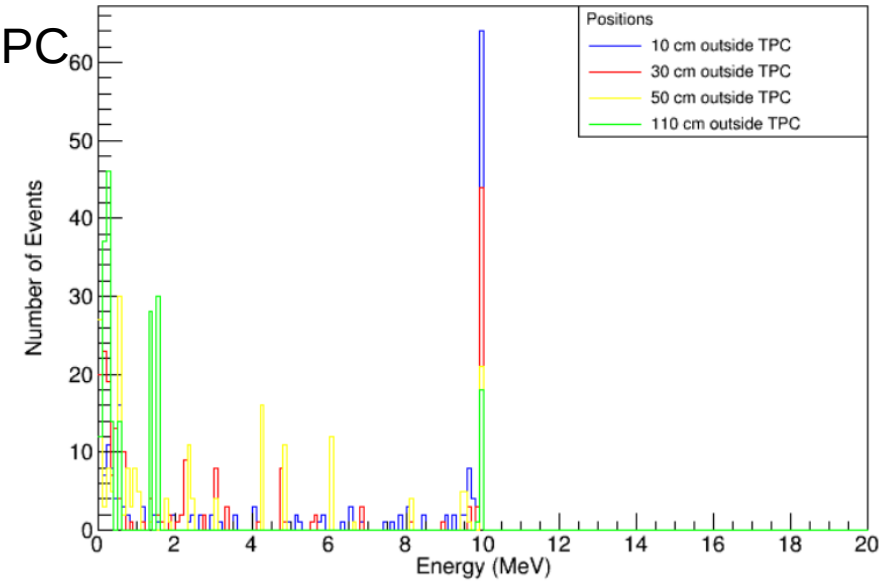
Gamma Energy (MeV)	Production Method	Producing Source
1.17, 1.33, in coincidence	β^- product de-excitation	^{60}Co gamma
4.4, monoenergetic	(n,C) inelastic scattering	AmC neutron
5.2, monoenergetic 10.8, monoenergetic	n-^{14}N capture	^{252}Cf and AmC neutron
6.1, monoenergetic	(α,n) product de-excitation	AmC neutron
6.1, cascade	n-^{40}Ar capture	^{252}Cf and AmC neutron
7.8, monoenergetic	n-^{60}Ni capture	^{252}Cf and AmC neutron
7.6, monoenergetic	n-^{56}Fe capture	^{252}Cf and AmC neutron
8.9, monoenergetic	n-^{58}Ni capture	^{252}Cf and AmC neutron
9.3, monoenergetic	n-^{54}Fe capture	^{252}Cf and AmC neutron

Signals

- **Did a quick study of what percentage of events leave their full energy inside the TPC**
  - 32% of 10 MeV gammas @ 10 cm outside the TPC
  - 22% of 10 MeV gammas @ 30 cm outside the TPC



A 10 MeV Gamma in SBND.



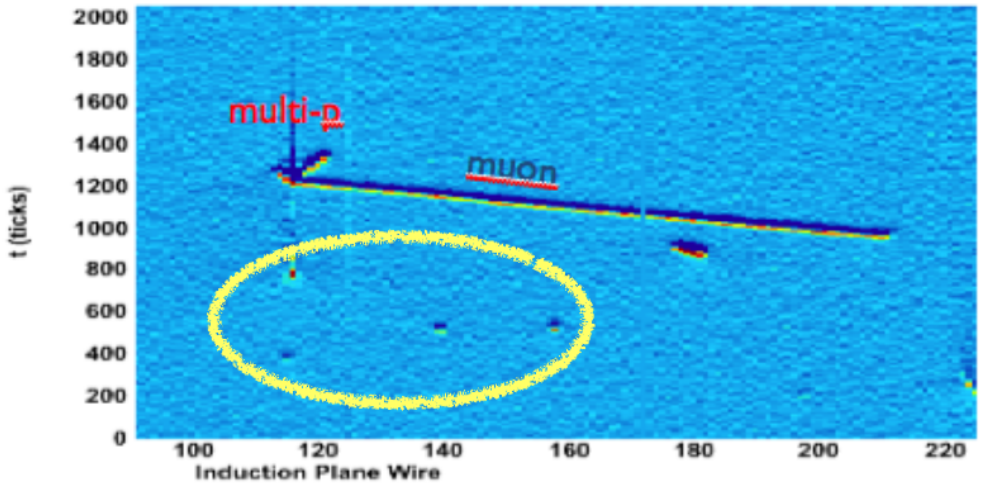
- **Did a similar study to see what percentage of neutrons capture on the intended target**

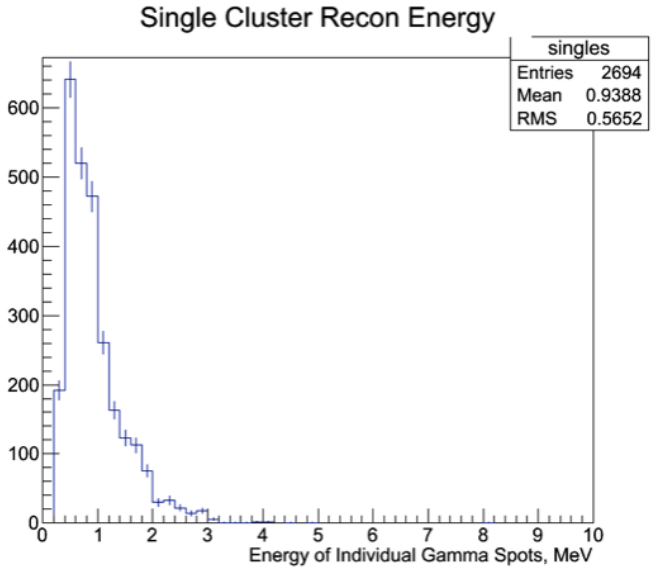
Neutron Energy	Size, Inner	Size, Outer	Inner/Outer Target	%Cap, Inner	%Cap, Outer
4.0	2”×4”	6”×12”	Argon/Argon	-	0.6%
0.1	2”×4”	6”×12”	Argon/Argon	-	30%
4.0	2”×4”	6”×12”	Acrylic/Steel	11%	30%
0.1	2”×4”	6”×12”	Acrylic/Steel	60%	38%
4.0	4”×4”	6”×12”	Acrylic/Steel	33%	21%
0.1	4”×4”	6”×12”	Acrylic/Steel	87%	11%
4.0	3”×4”	6”×12”	Acrylic/Nickel	33%	27%

Table V: Percentage of primary particles captured within cylinders.

What do these signals look like

- **Low energy gammas are a difficult signal to see in LArTPC**
  - IIT student is continuing a study using ArgoNeuT data looking at de-excitation gamma candidates to help develop these tools

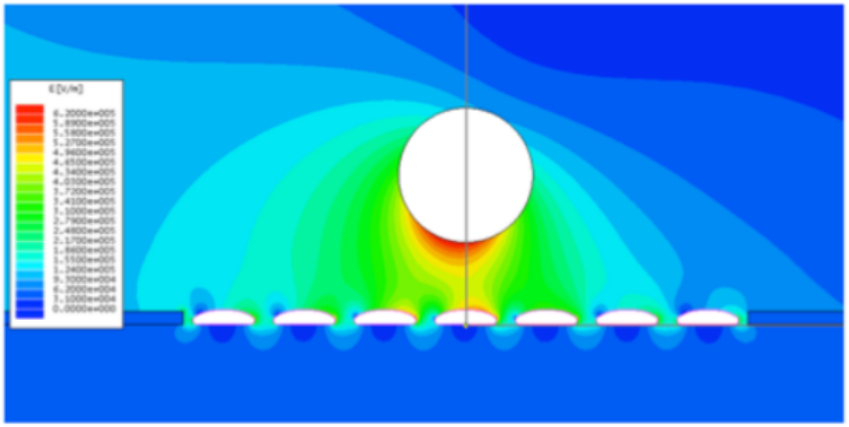




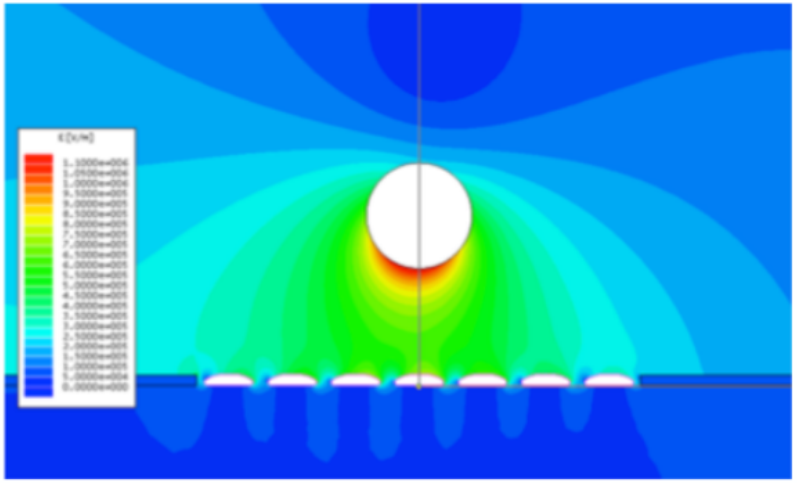
- **These small blips can be reconstructed and identified, but dedicated tools and running probably necessary**

Worrying about Electric Fields

- **Worked with Bo Yu (BNL) to determine the electric field for a 6” OD steel pipe at various locations along the SBND field cage**
  - Closest distance seems to be 10cm to keep things safe
  - Could go closer in regions closer to the anode



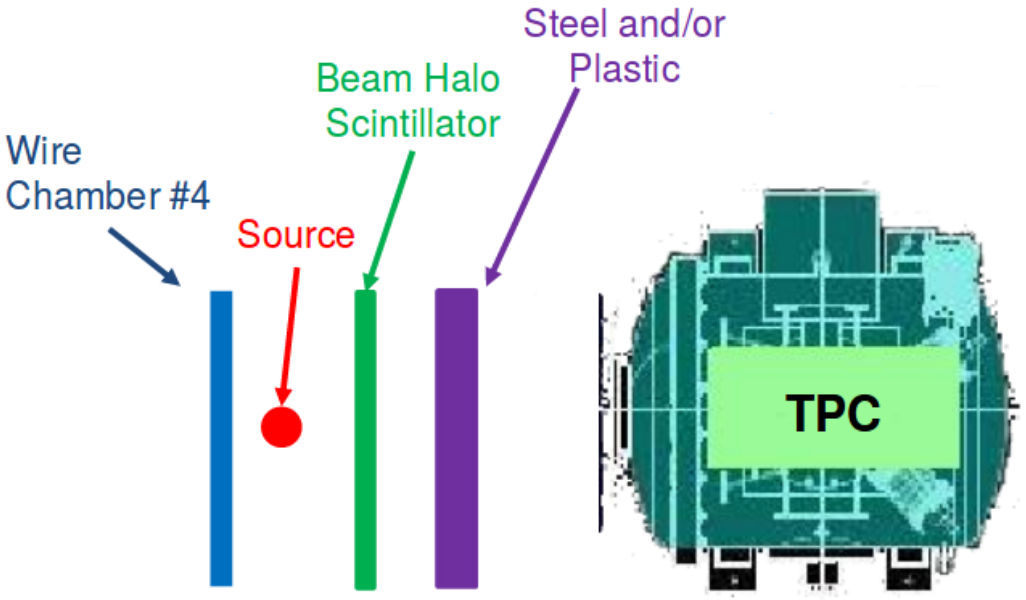
near-anode axis,
5 cm distance
6 kV/cm
maximum field

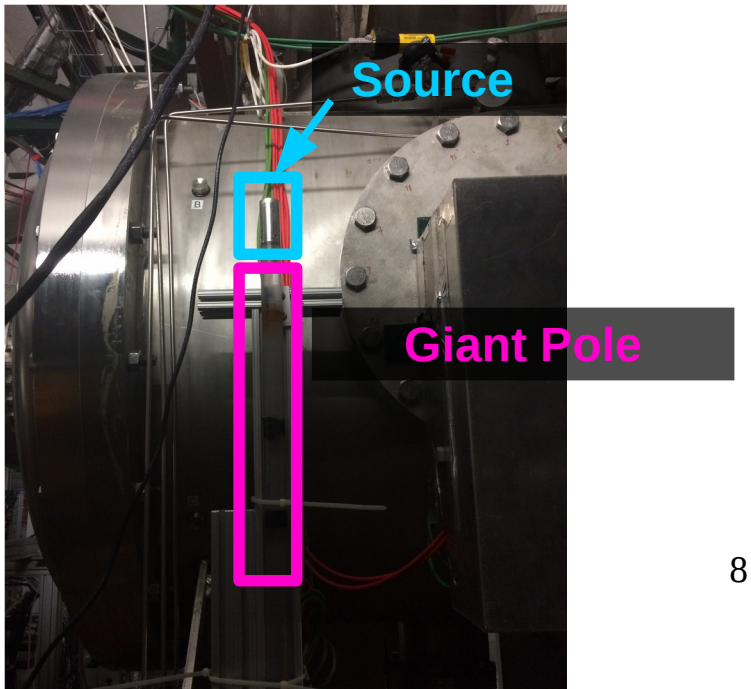


near-cathode axis,
10 cm distance
11 kV/cm
maximum field

Trying a simple deployment in LArIAT

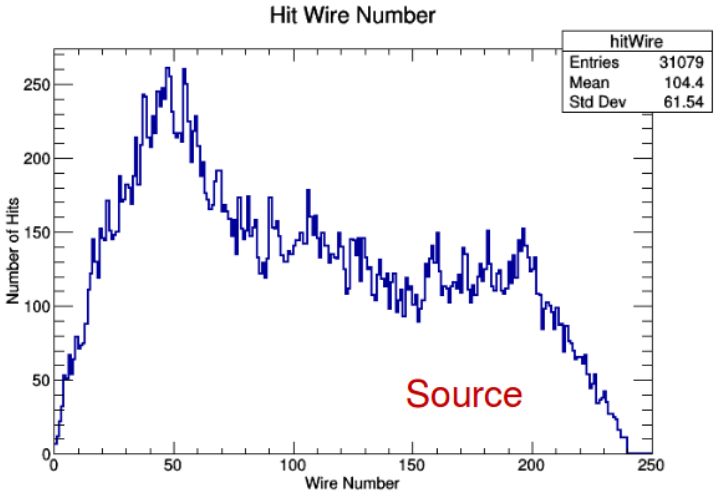
- **As a first test we wanted to see if these low energy events could be seen with the LArIAT detector**
  - Deployed a Cf 252 source at various points around the cryostat
    - Distances between the active volume and the source varied between 20 cm – 70 cm
  - Utilized various configurations of carbon steel and plastics to thermalize the neutrons
  - Ran with just a strobe trigger configuration
    - This was actually a problem due to the size and shape of the source used at FNAL where we couldn't use our canisters
    - Ultimately limited the useful data we could get from this study

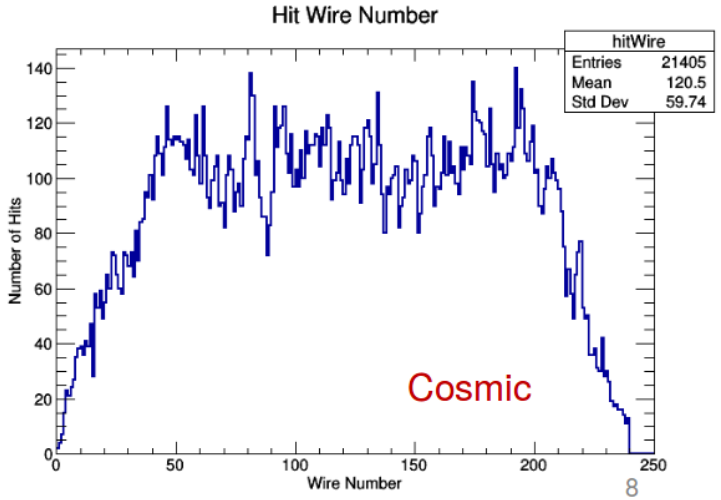




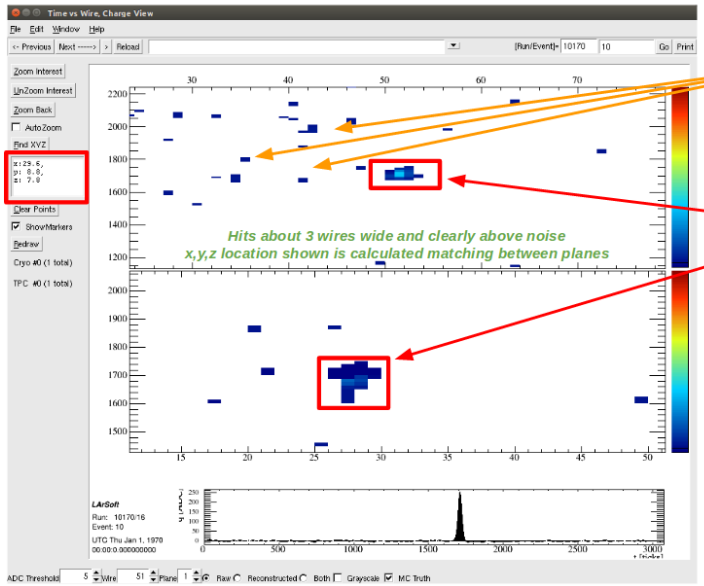
Some outcomes of the study

- **Could we see the activity from the source in the TPC?**
  - Yes!
    - Greater activity in the hits seen when source is present compared to cosmic background
    - Activity tracks the location of the source
    - Source related hits seem to be 3-5 wires long





Work done by IIT graduate student Ivan Lepetic

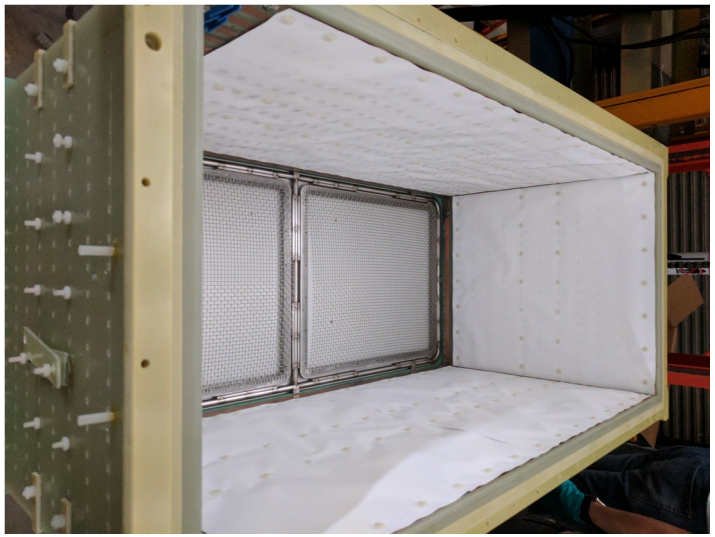


These tiny blips have ADC < 10 counts

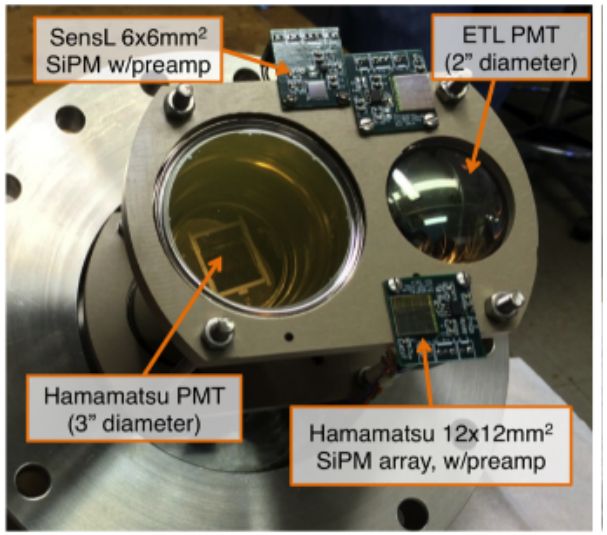
These hits are about 3 wires wide and the x,y,z location calculated seems reasonable

Some outcomes of the study

- **Did we see activity in the PMT's?**
  - No :-(
  - Because we weren't triggering based on the source, the timing of the LArIAT readout made it difficult to match PMT data to TPC data
    - This is something we could fix if/when we attempt this study again (we were doing this during the last days of running in 2016 and didn't have time to fix it

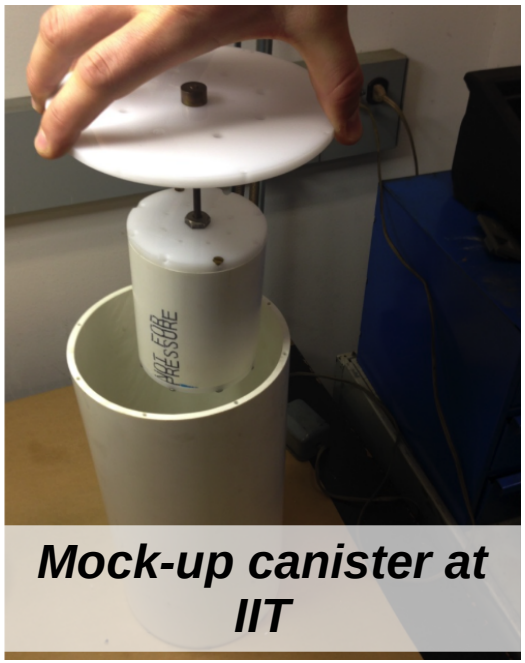


LArIAT TPC w/ WLS Foils



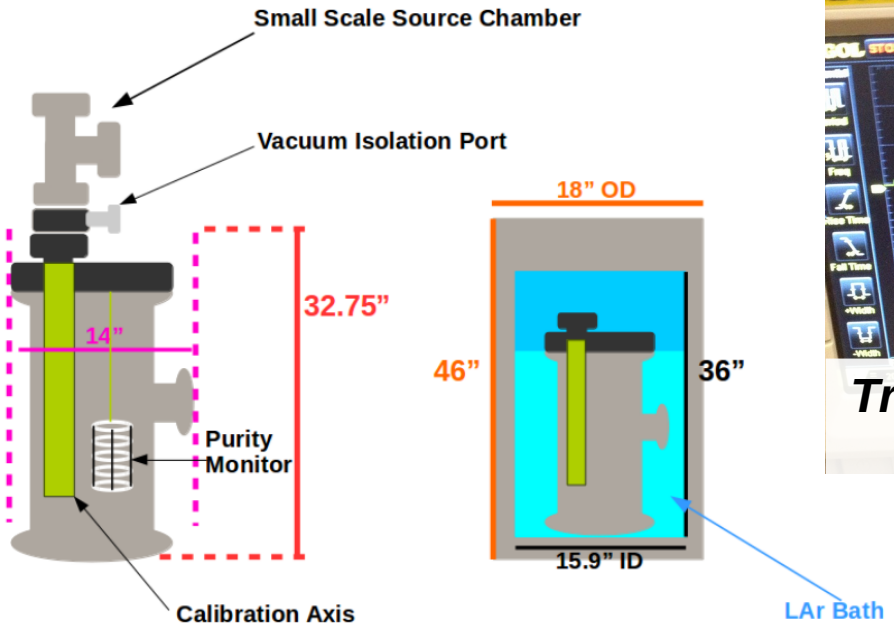
Ongoing R&D

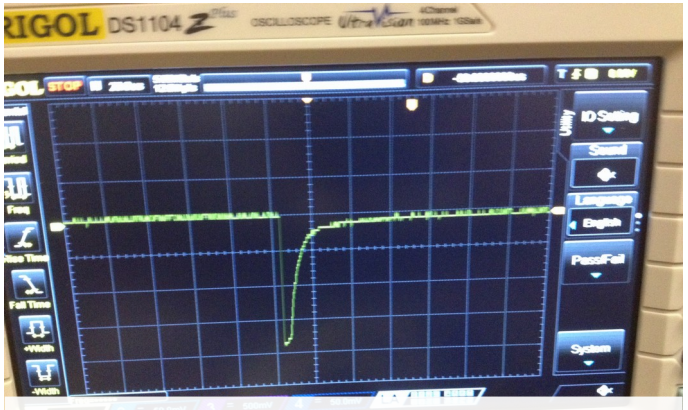
- **We've been working on mock-up, cryo-tests, and trigger work at IIT and UTA**
  - Things have been progressing (slowly) while we are working on many other things
- **If there are interests in pursuing these ideas further with tests in LArIAT / Test-stands / other detectors we are happy to continue and collaborate with others**



Mock-up canister at IIT

Diagram of UTA cryo test-stand





Triggered pulses seen from canister in cryostat

Thoughts / Questions / Comment

Thanks!