LArTPC DUNE Near Detector

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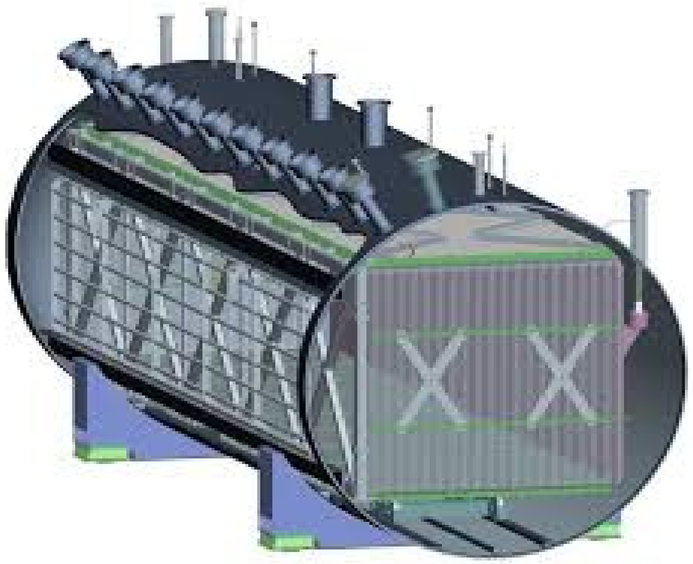
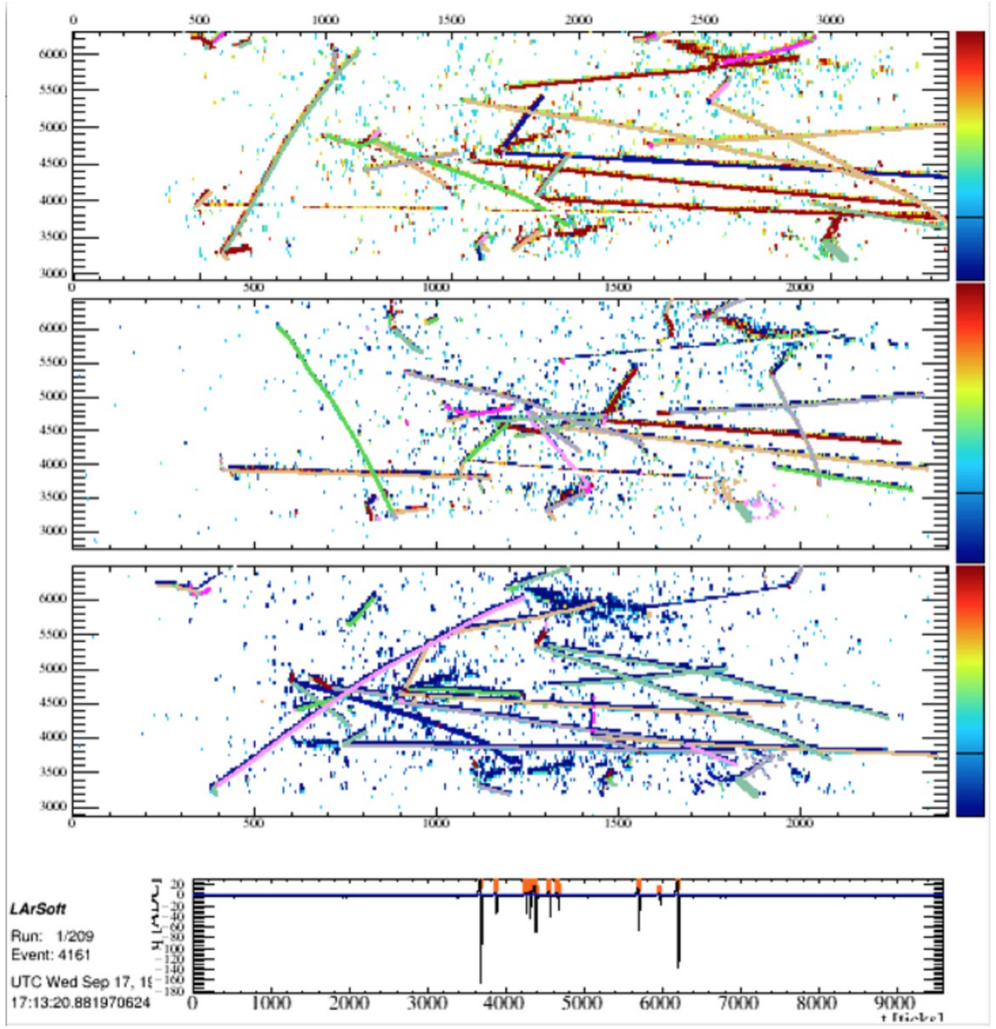
What Has Gone Before

Begin with the MicroBooNE geometry

2.56 m drift x 2.3 m height x 10.36 m length

Used MicroBooNE detector simulation
(simulate wire signals and optical flashes)



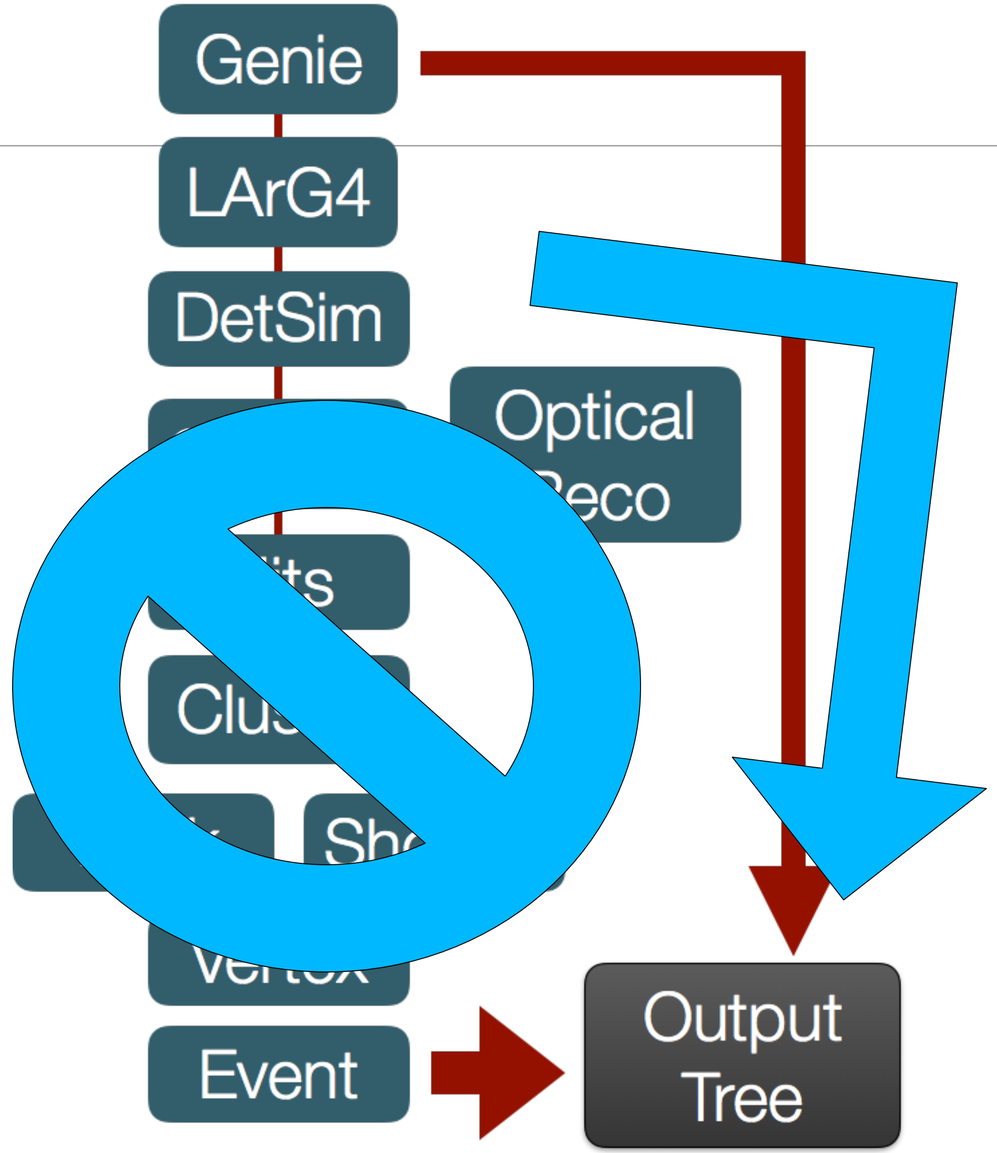


Transitioning out of MicroBooNE

We plan to still use LArSoft (and NuTools), but will likely not use the full reconstruction chain

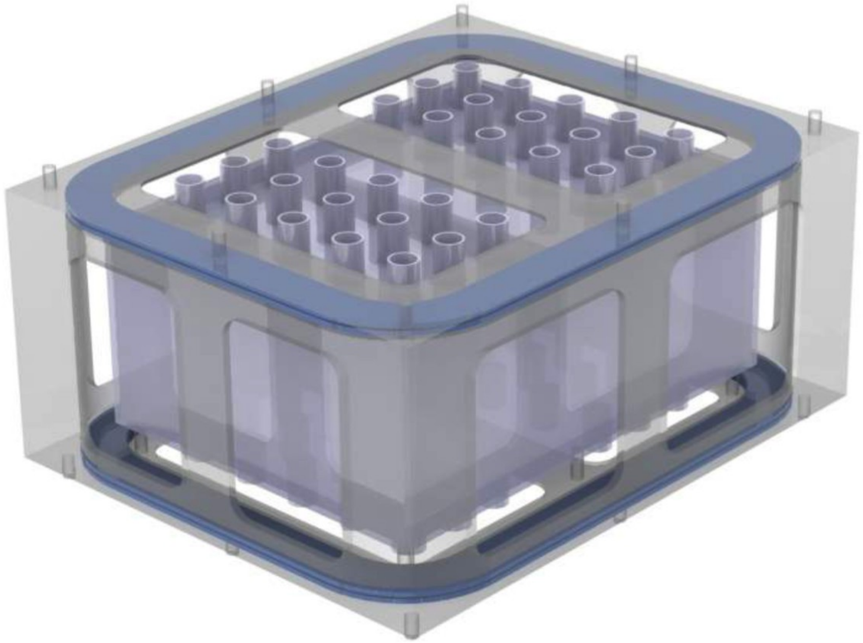
We're in discussion with the other groups to define the extent of reconstruction needed and uncertainties for the final study

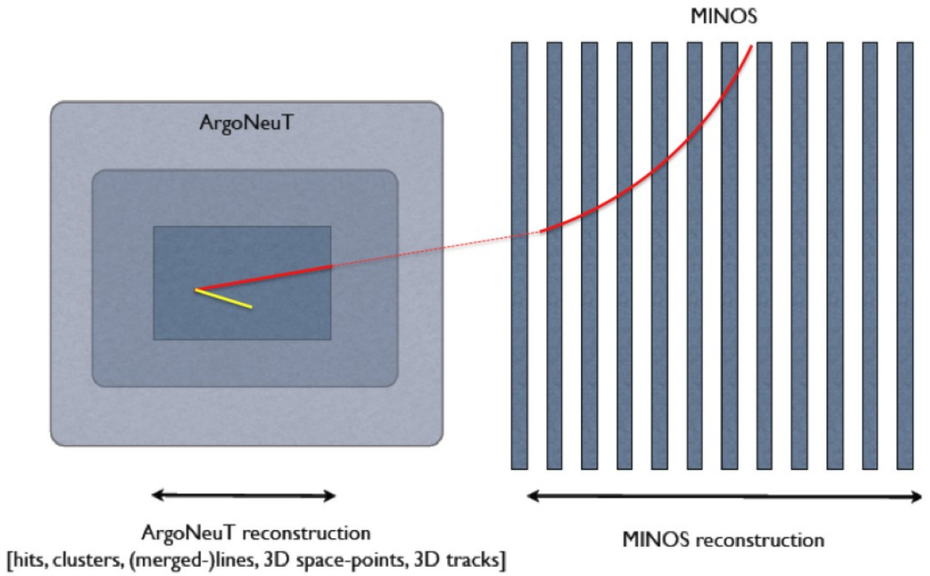
We're moving away from the MicroBooNE geometry and moving to a new readout



LArTPC Design Concepts

Option A:
Modular LArTPC
Within superconducting Helmholtz coil



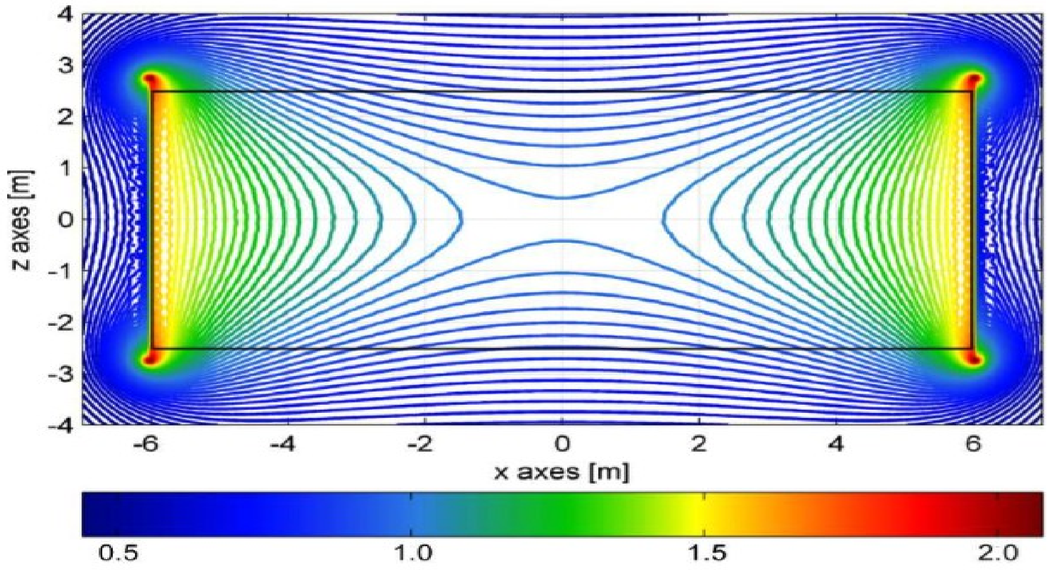


Option B:
Hybrid detector
Non-Magnetized Modular LArTPC
In front of spectrometer

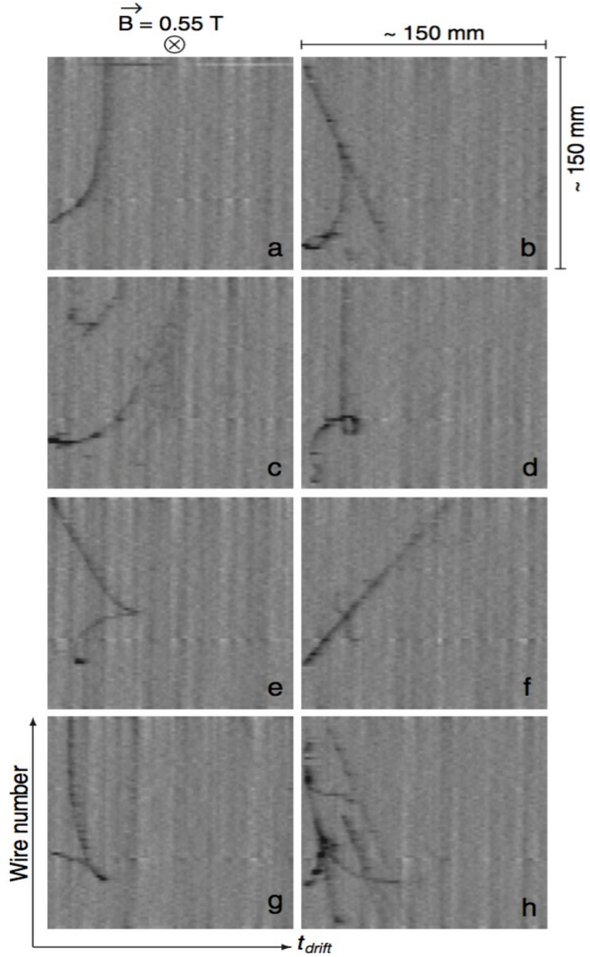
Magnetized TPCs aren't so crazy

Recent engineering studies for 150 t LArTPC at 1 T.

Demonstrated operation, successful PID



B-field [T] in the xz-plane of the solenoid model. Detector volume indicated with black rectangle. L.Y. van Dijk 2014



Real events collected with the LAr TPC in a B-field of 0.55 T. A. Badertscher, et al. 2005

Recommended Reading

L.Y. van Dijk - “*Design Optimization of a new Superconducting Magnet System for a LAr Neutrino Detector*”. CERN 2014

D. B. Cline & K. Lee -“*Possible Study of Rare Decays of Muons and Kaons and a Neutrino Near Detector with a Liquid Argon “ICARUS”-like Detector*”. UCLA 2011

A. Badertscher, et al. - “*Test of a Liquid Argon TPC in a magnetic field and investigation of high temperature superconductors in liquid argon and nitrogen*”. ETH 2010

A. Badertscher, et al. - “*First operation of a liquid-argon TPC embedded in a magnetic field*”. ETH 2005

Modular Magnetized TPC - Why?

Neutrino/antineutrino analysis – ID e+/- & μ+/-

Momentum measurement less dependent on containment

Shorter drift-times - Less stringent purity, less pileup & lower voltage

Light contained - Less optical pileup, accurate trigger & veto

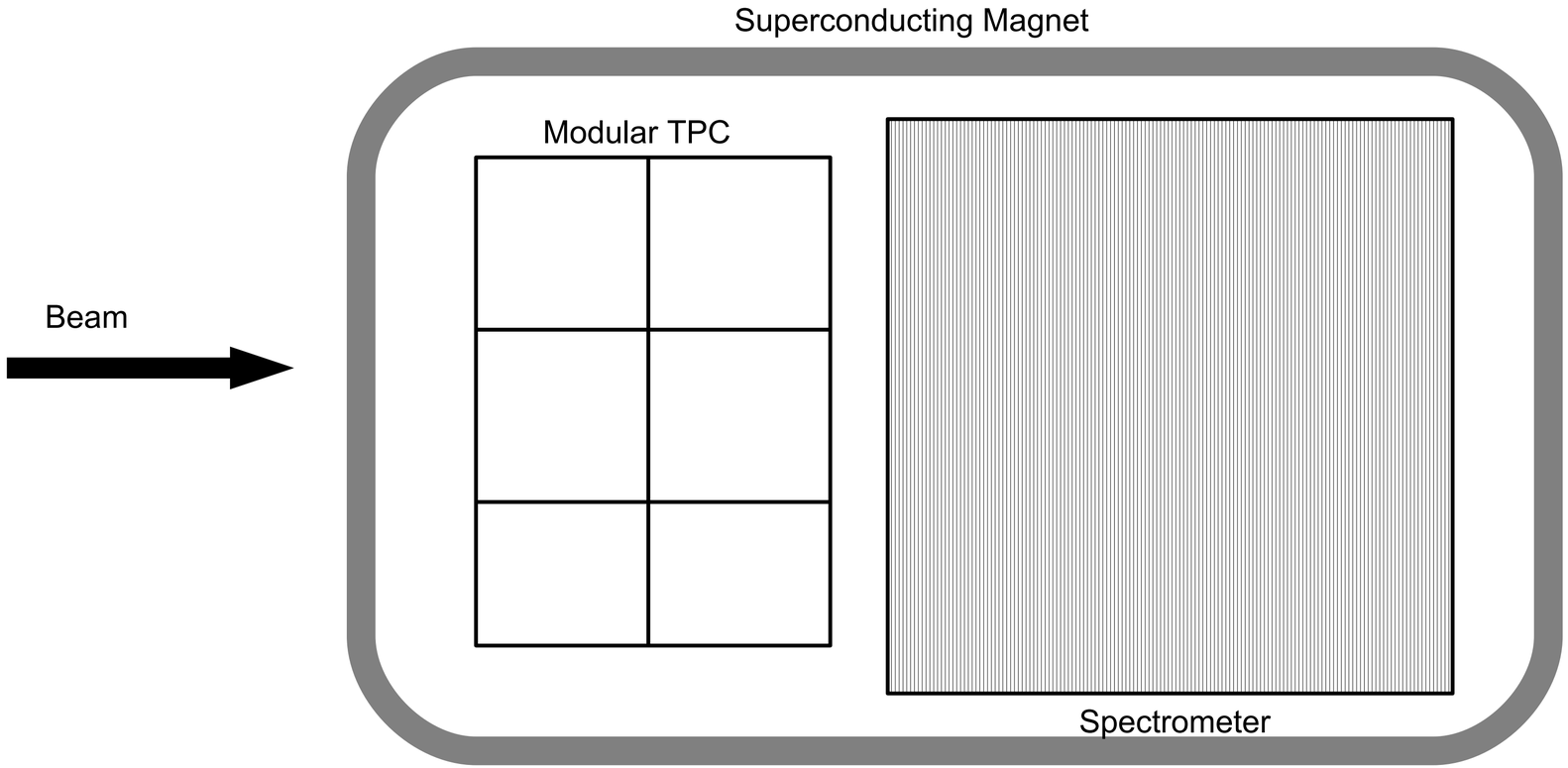
Run constantly - No need for low rate & upgrade sans down-time

Pixel readout - Live 3D reconstruction with reduced reconstruction ambiguity

Magnetized Modular LArTPC

LArTPC does not need the entire volume.

Spectrometer could share magnet.



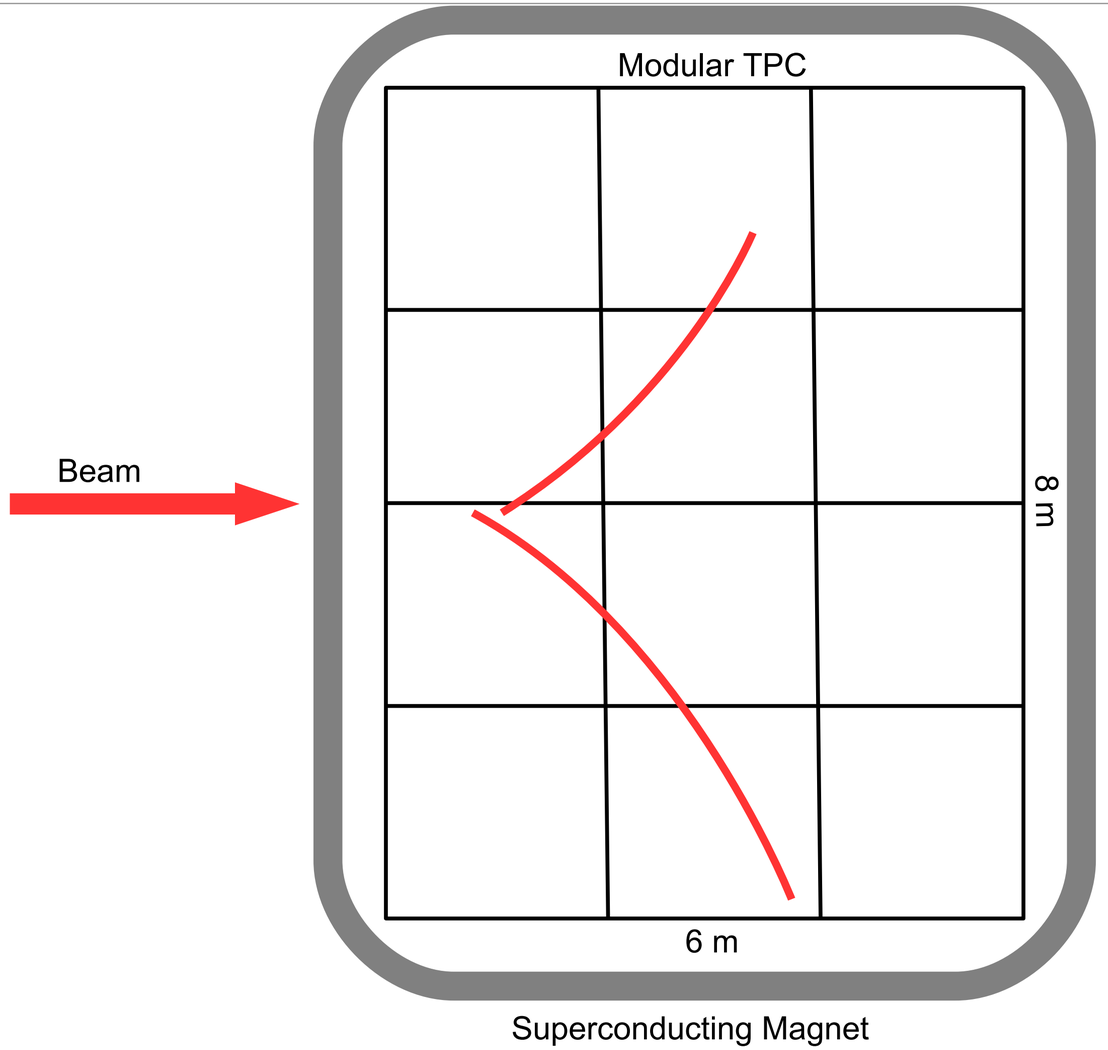
Magnetized Modular LArTPC

Optimized for LArTPC.

B-field at ~1T.

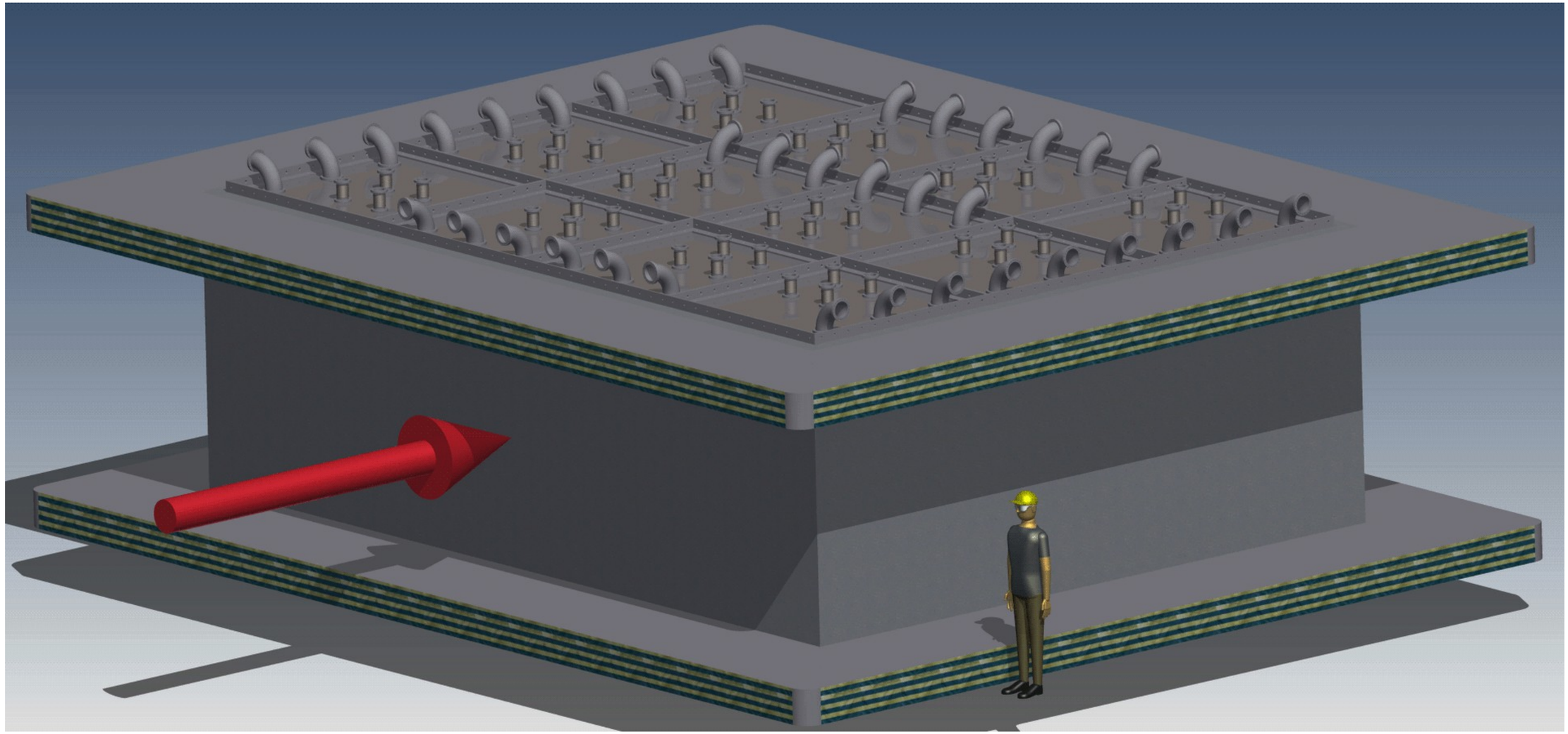
Modular TPC total 6 m x 8 m x 3 m
- ~ 200 t.

Module 2 m x 2 m x 3 m.
- 1 m drift length



* Proposed ND hall 30 m x 16m

Magnetized Modular LArTPC

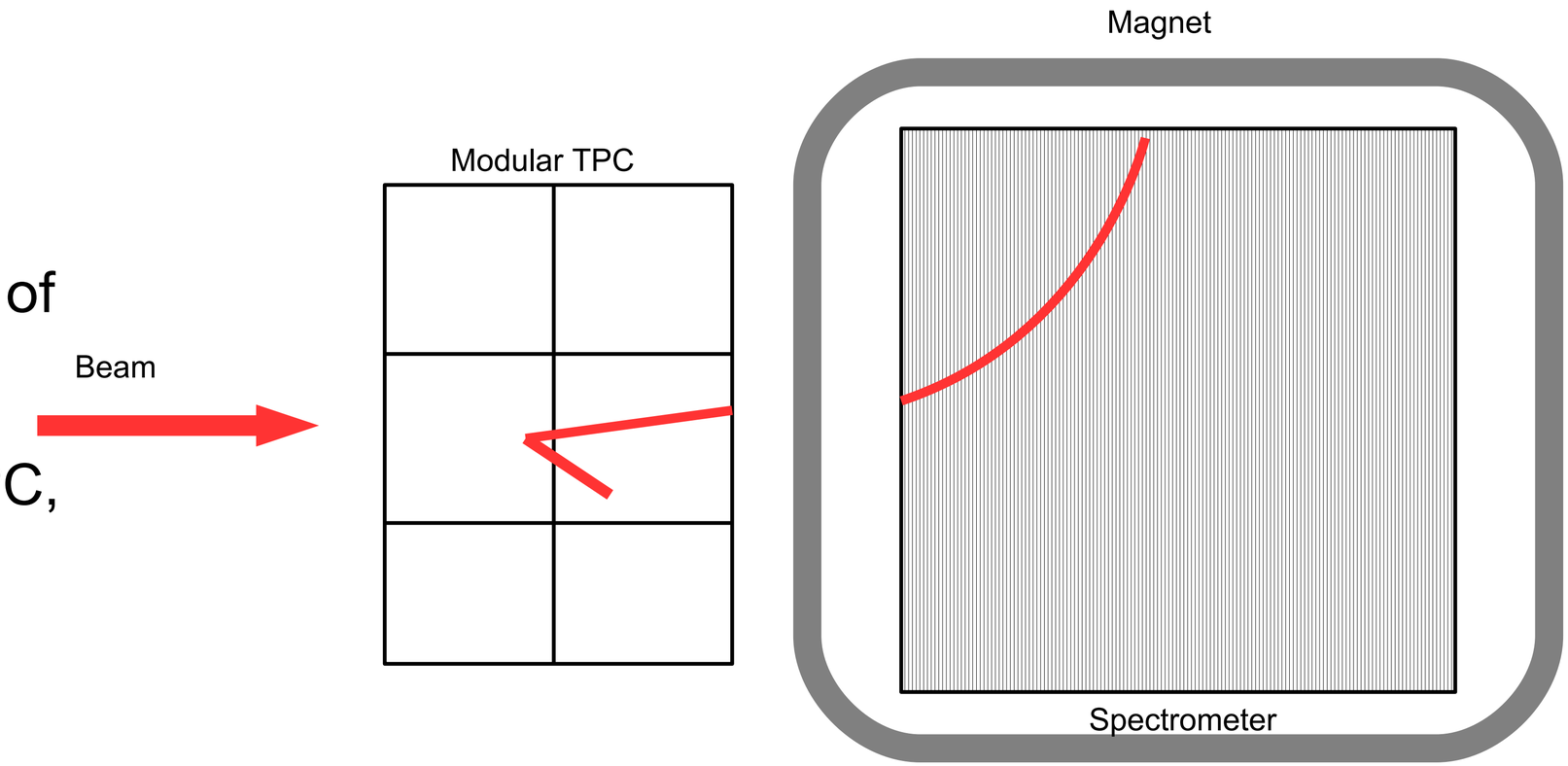


Non-Magnetized LArTPC

Hybrid detector.

Modular LArTPC upstream of spectrometer.

With only a 4 m long LArTPC, ~100t is achievable



Simulation Tasks

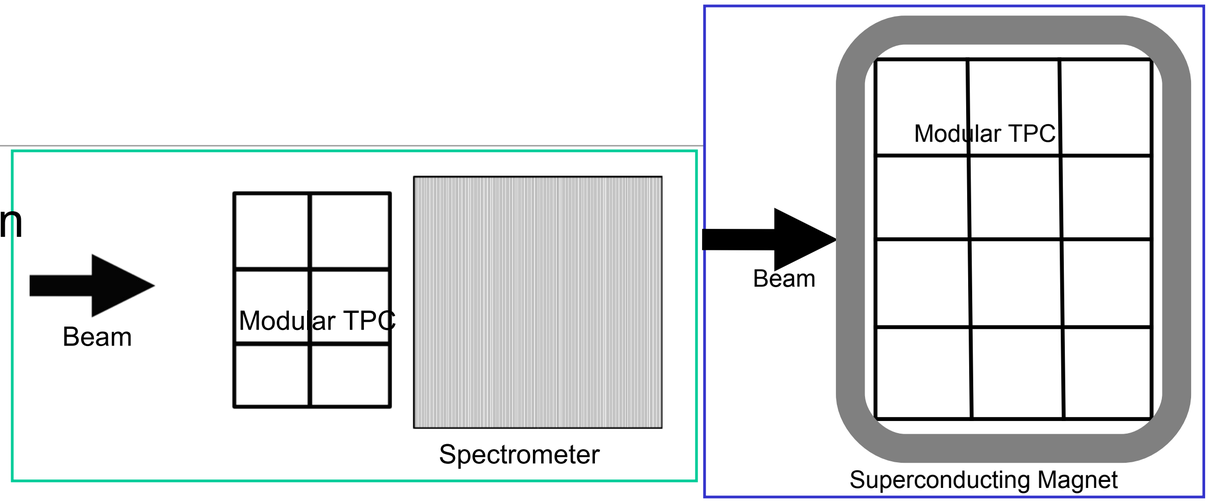
Define new volume
- Containment study – study & optimize
- How the modular design helps with pile up (acceptance & rate)

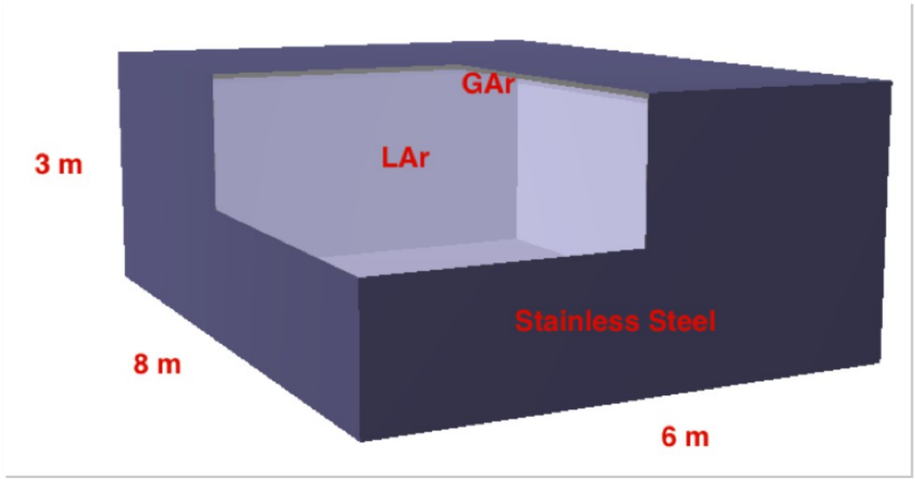
Apply magnetic field
- Compare MagFields (0, 0.25, 0.5, 0.75, 1, 1.5 T)
- Can we separate e+- showers?
- To what extent does multiple scattering affect momentum resolution?
- Is a magnet necessary?

Resolution of pixel readout
- Determine expected performance, for more accurate reconstruction

Detailed Simulation Tasks

- Need a magnet geometry within a month for simulation of background events
- Before the May collaboration meeting:
  - Define a new volume
    - Make both 3x2 and 4x3 geometries
    - Incorporate it into LArSoft
    - Apply a magnetic field
      - Study containment (what fraction of showers are contained vs. energy?)
      - As a first step, can e+/- showers visually be differentiated
      - Can temporarily leave wires in to run existing reconstruction
        - Evaluate effect of multiple scattering on momentum resolution of short tracks
        - Energy & angular resolution studies with particle gun





Detailed Simulation Tasks

- Need to maintain one version for a large submission job and output trees
  - Right now, this is the uB model
  - Will update in large steps
- Longer term: incorporate the argon cube modules (detailed gdml) and evaluate the effect of the gaps and module boundaries

- Some Thoughts on Readout:
  - Pixels result in less ambiguity than wires in reconstruction
    - But the existing reconstruction framework uses wires
  - It is desirable to leverage the existing reconstruction, but it may be beyond the scope of this TF to work pixel readout into the reconstruction chain.
  - A well modeled pixel readout would be useful for the future of ArgonCube, but we need to consider our available effort.
  - We are currently in discussion with the other groups on what is needed/desired for the Task Force study
  - Real resolution of readout will be measured in the upcoming hardware test at LHEP Bern. (May/June*)

Hardware Tasks

Modular TPC needs to be demonstrated in particle beam.

Magnetized TPC with superconducting Helmholtz coil.

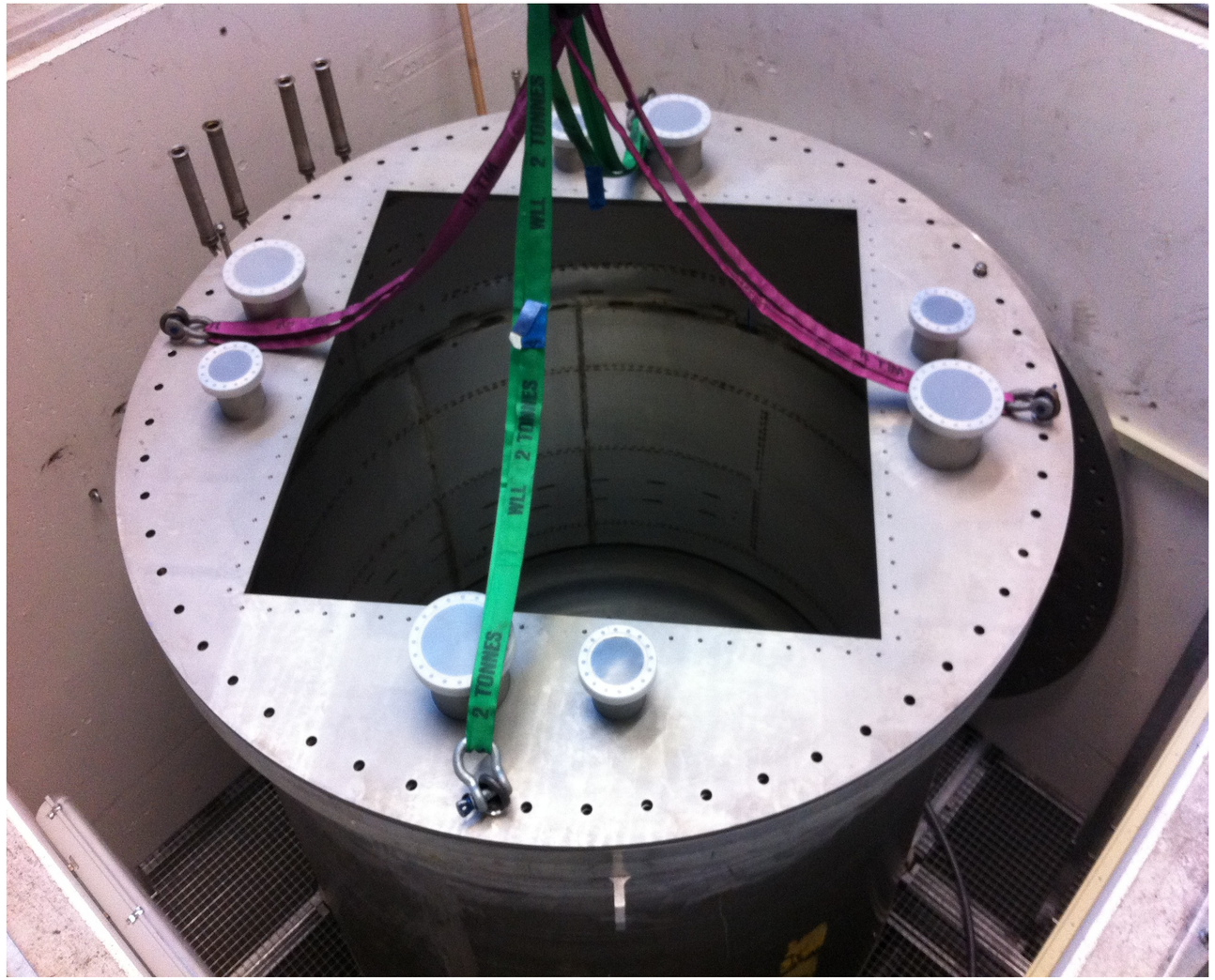
To determine expected resolution, pixels readout needs testing in LAr with comparable drift length to ND.

Modular Prototype

Modular prototype (ArgonCube) under construction.

TPC tests summer 2016.

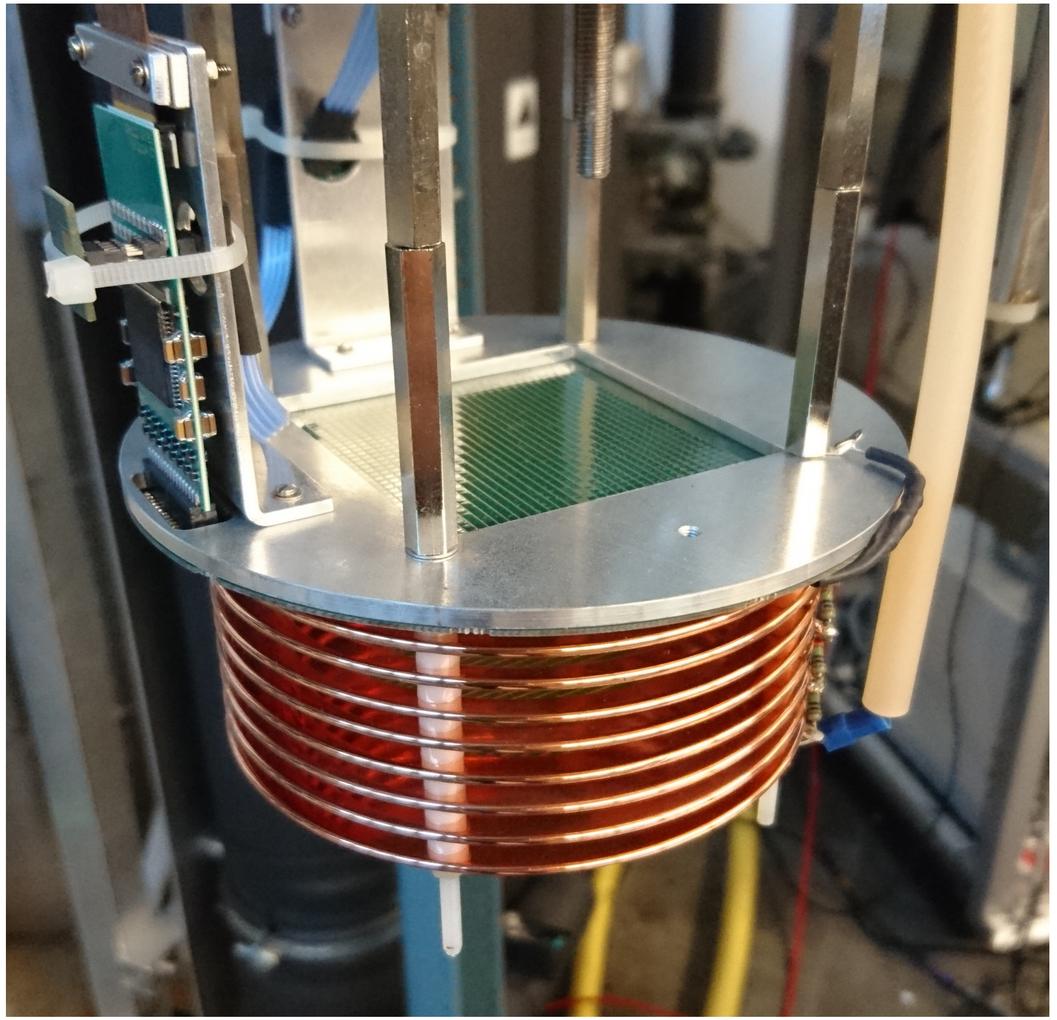
*Not initially magnetized.



Magnetized Prototype

Modify existing TPC, adding superconducting Helmholtz coils.

TPC tests summer 2016.

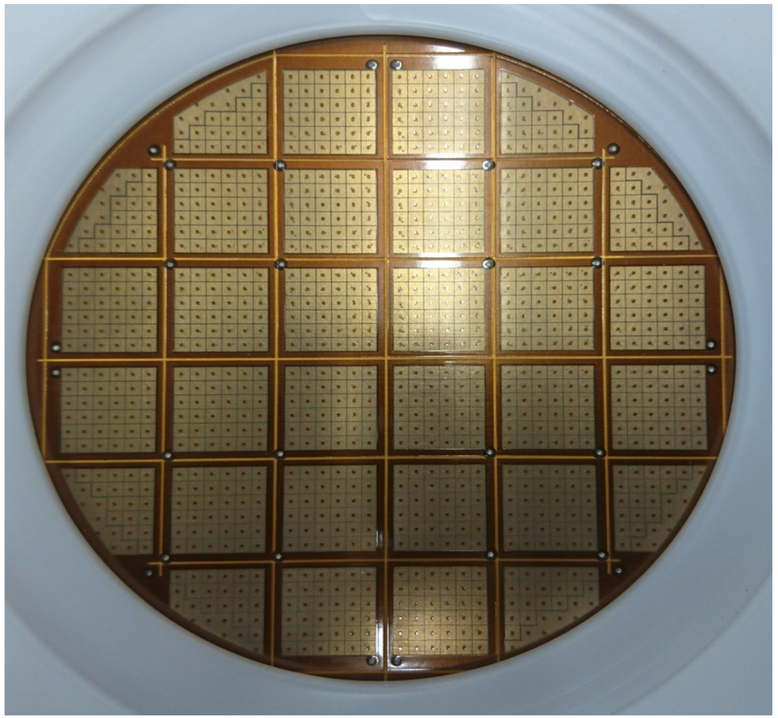


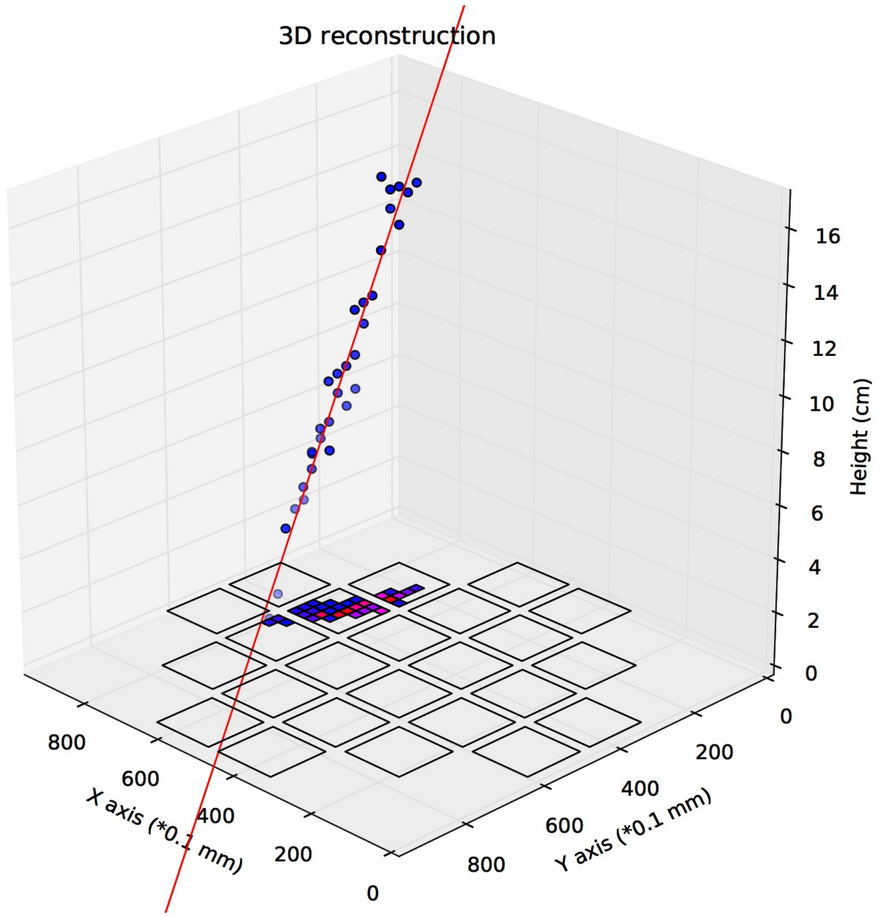
*Kapton readout plane

Pixel Readout

1 m drift TPC tests summer 2016.

*Not initially magnetized.





M. Auger, Bern

Summary

We are moving from the MicroBooNE geo, to ArgonCube's modular technology to the DUNE near detector.

This allows simulation workload to be shared across collaborations.

Simulation is proceeding within the framework of ArgonCube, working in parallel with R&D for optimal design.

Two options are considered: Option A, a magnetized LArTPC of order 200 t. Option B, a standalone LArTPC of order 100 t. Both potentially complementary to other technologies.

Modular Detector

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