High Voltage Tests for MicroBooNE

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Fermilab

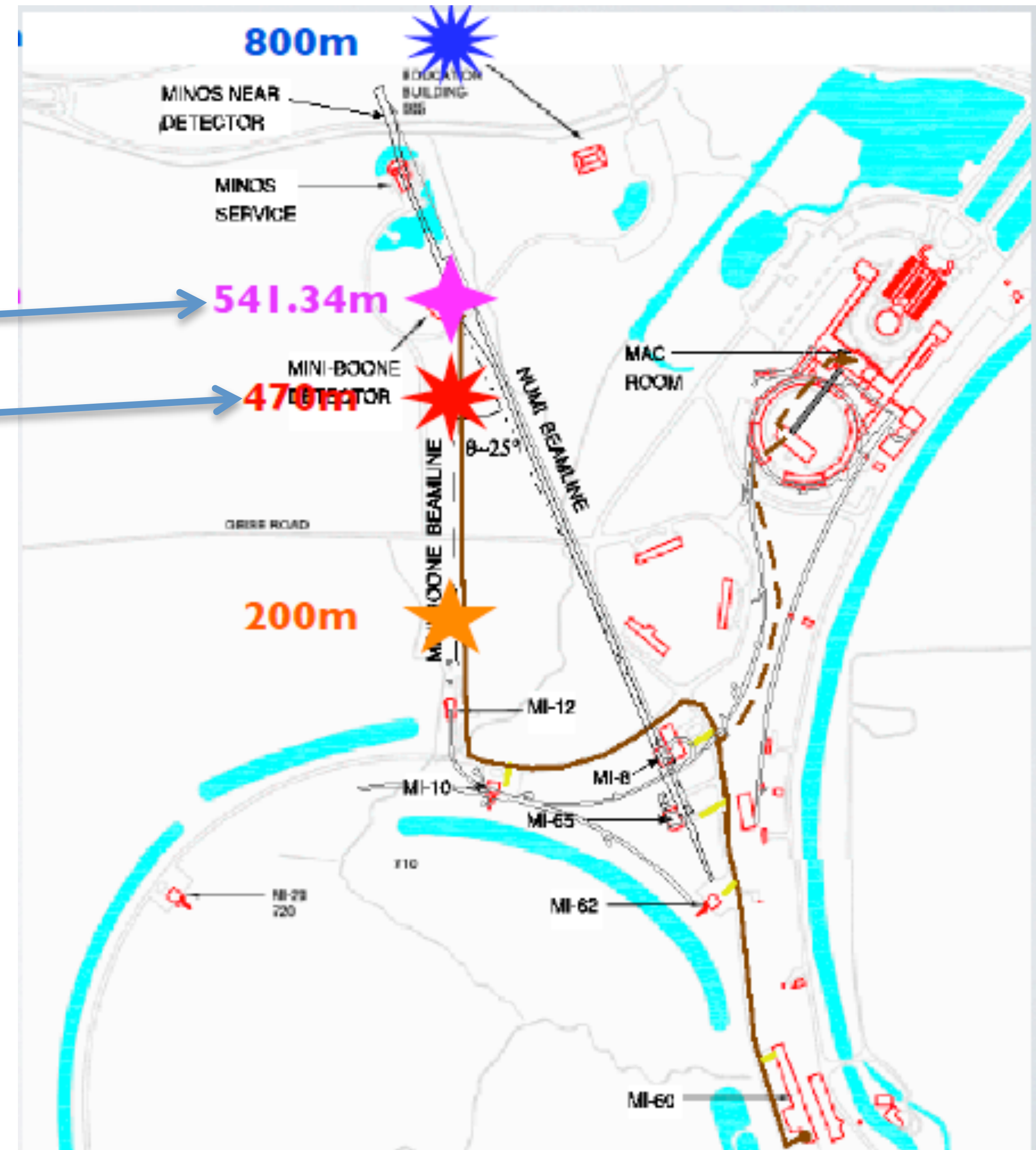
presenting for the Collaboration &
Task Force 4

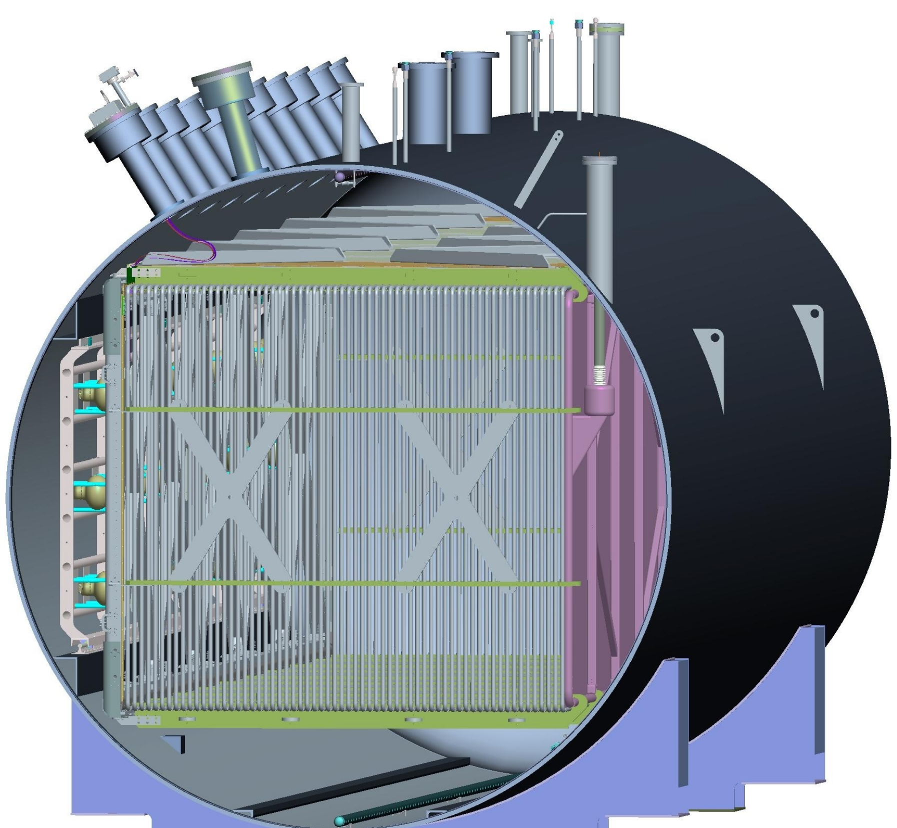
8 Nov 2013

MicroBooNE Experiment

- A liquid argon time projection chamber (LAr TPC) containing 170 tons of liquid argon, and located on the Booster Neutrino Beamline.
  - MiniBooNE
  - MicroBooNE

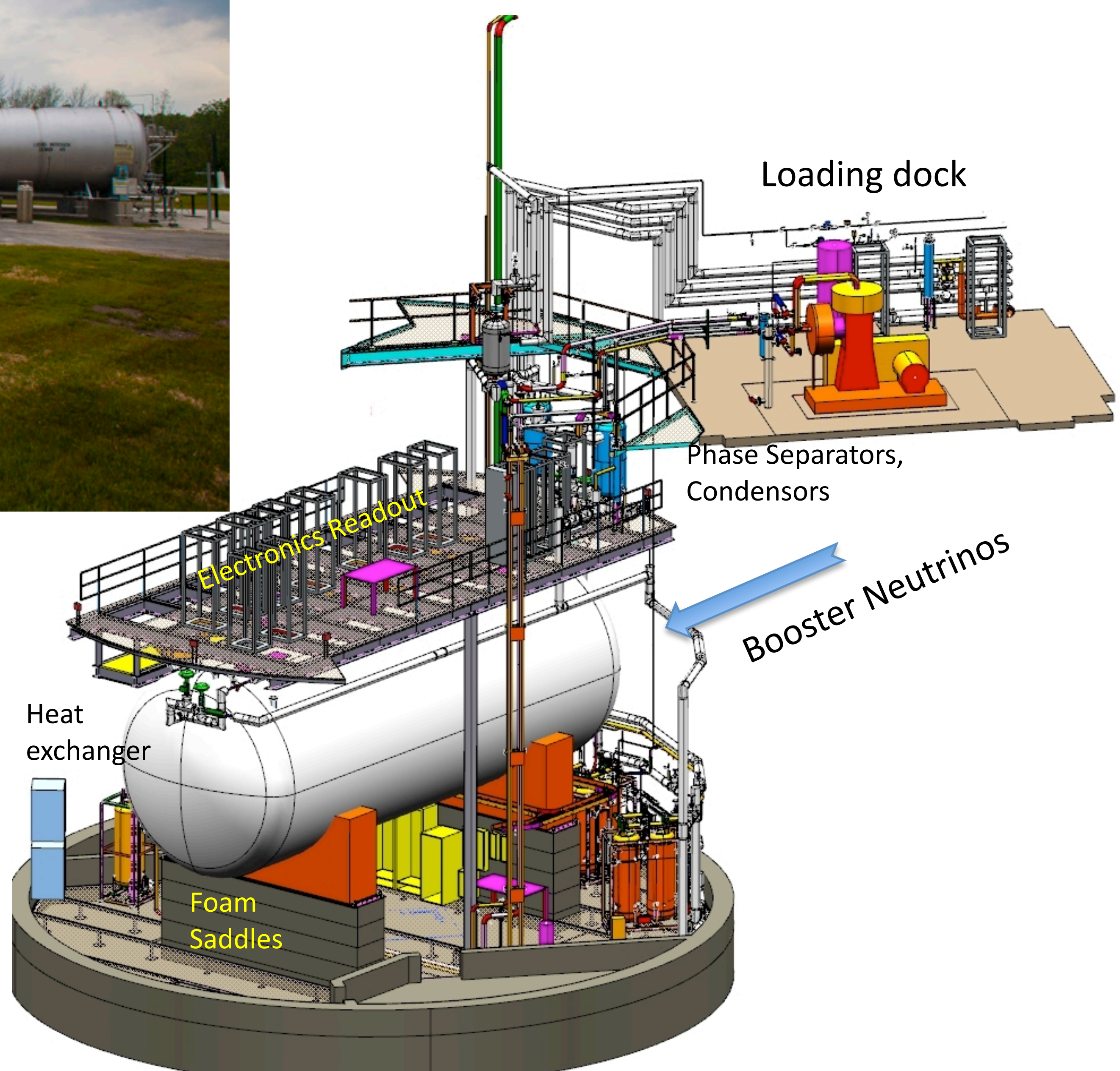
@LArTF





8, 256 wires; U,V,Y planes; 3 mm spacing
32 PMTs for fast light collections

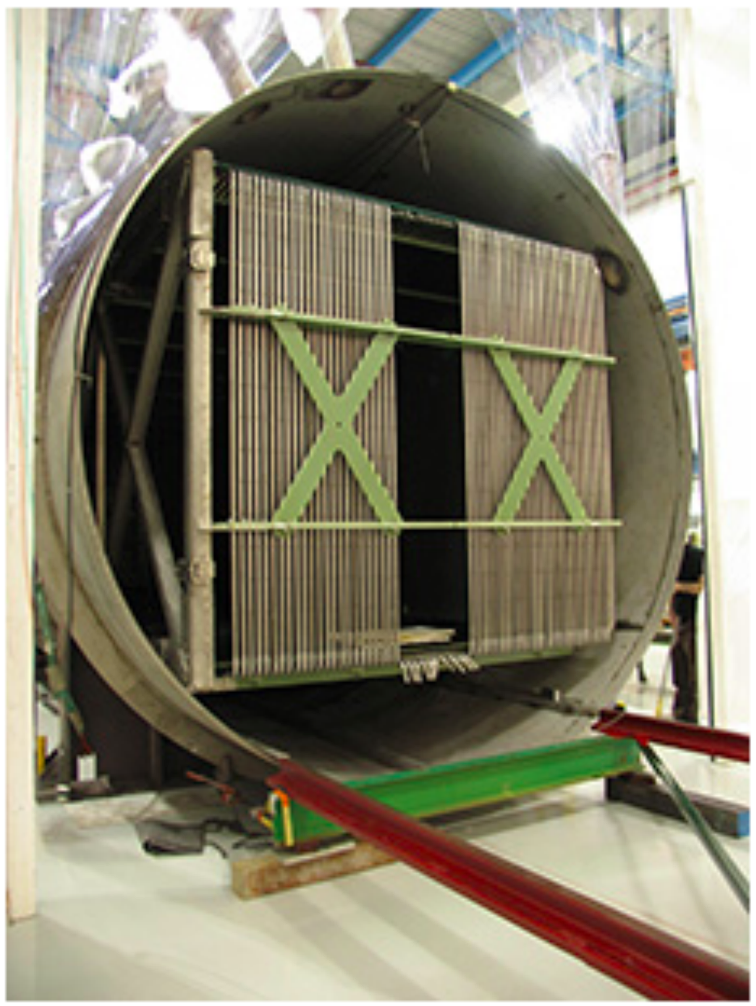
MicroBooNE @ LArTF



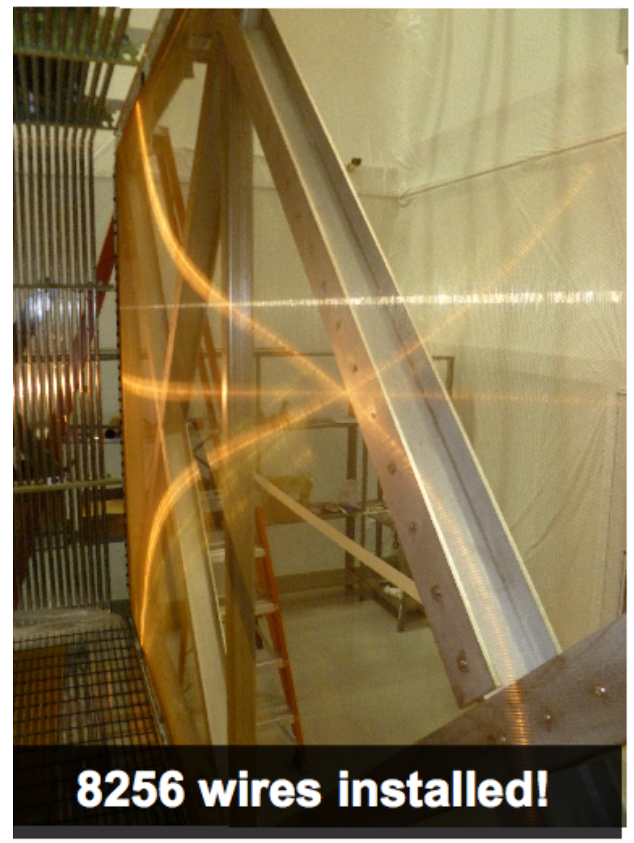
Detector Construction

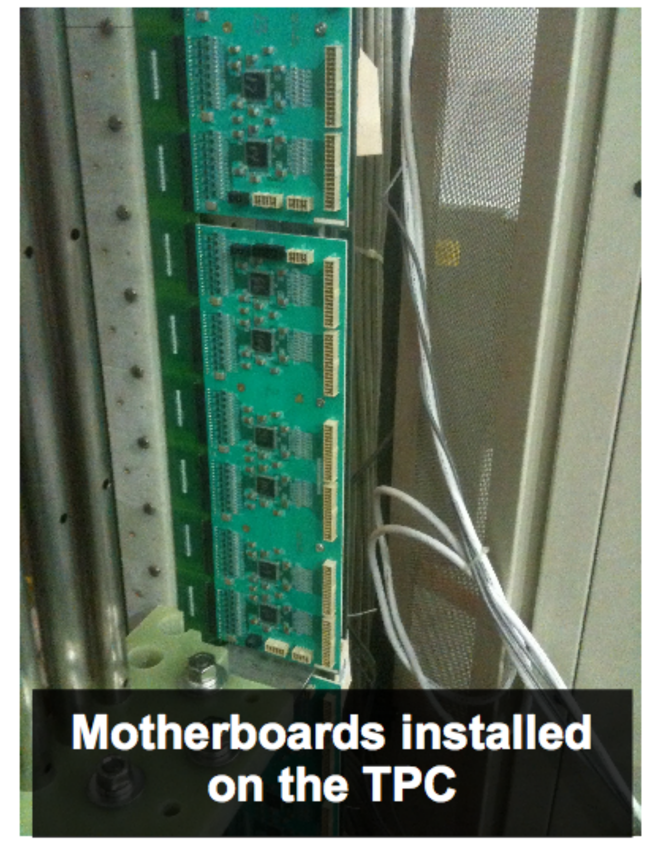
Feature

Liquid-argon time projection chamber gets a test fit



A 6-ton time projection chamber now sits inside the MicroBooNE cryostat. *Photo: Sarah Khan*





Detector Overview

- MicroBooNE : 170 t (~70 t fid.) liquid argon TPC
- TPC dimensions : 10.3m × 2.3m × 2.5m

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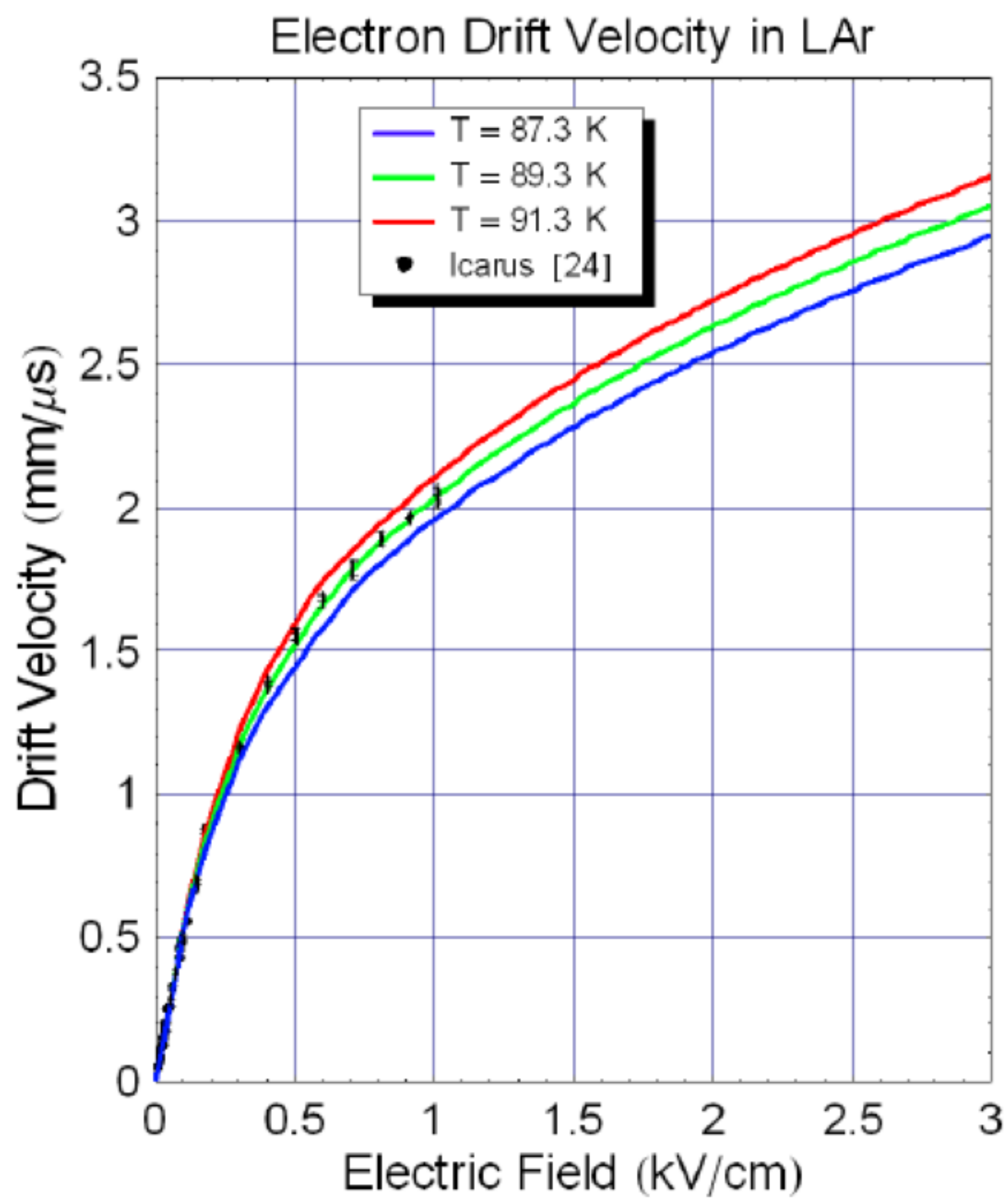
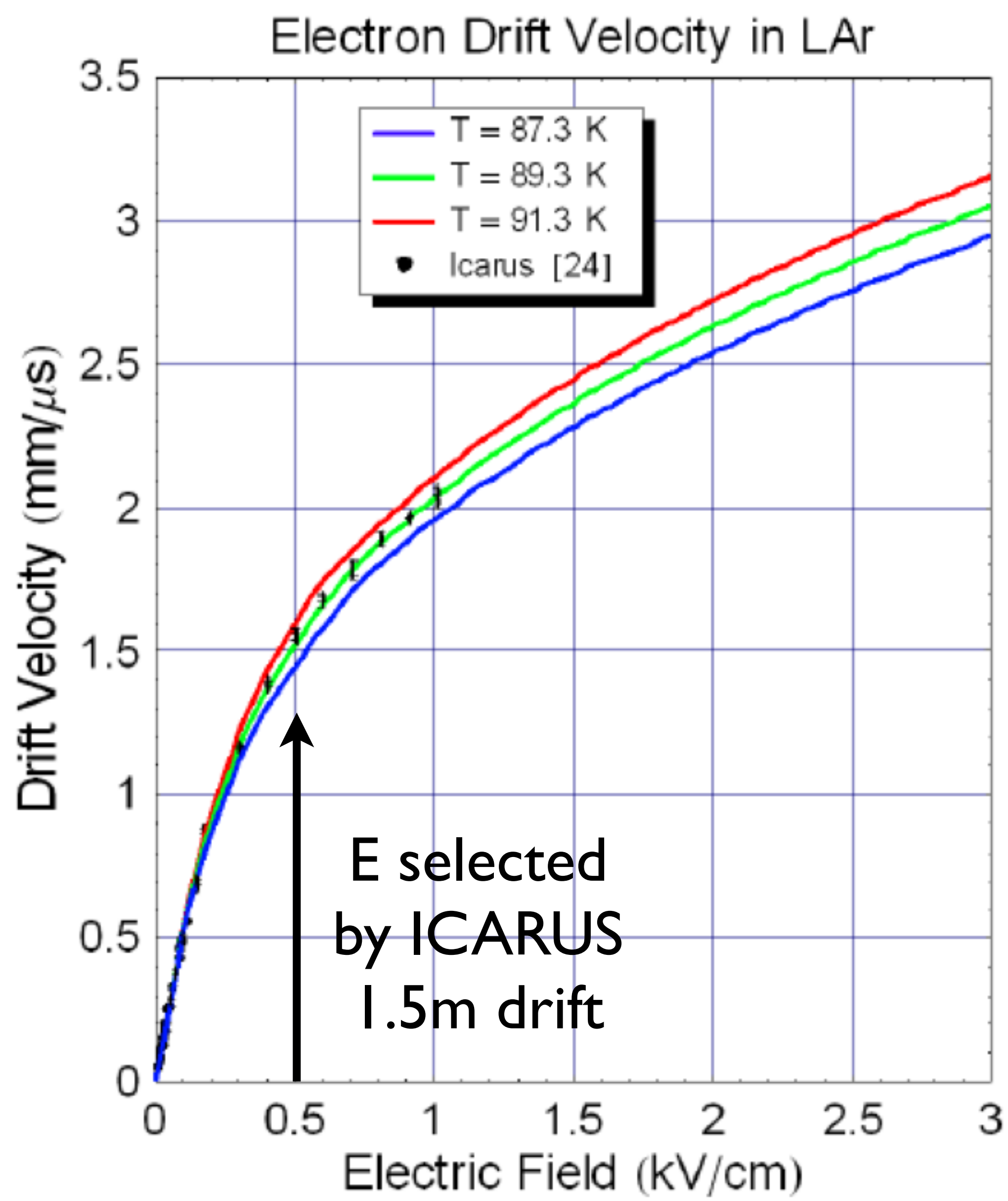
- 8256 channels (*vert.&±60^{0}*)
- 32 PMT
- UV laser → calibration tracks

Drift velocity vs *E* field



Drift velocity vs *E* field

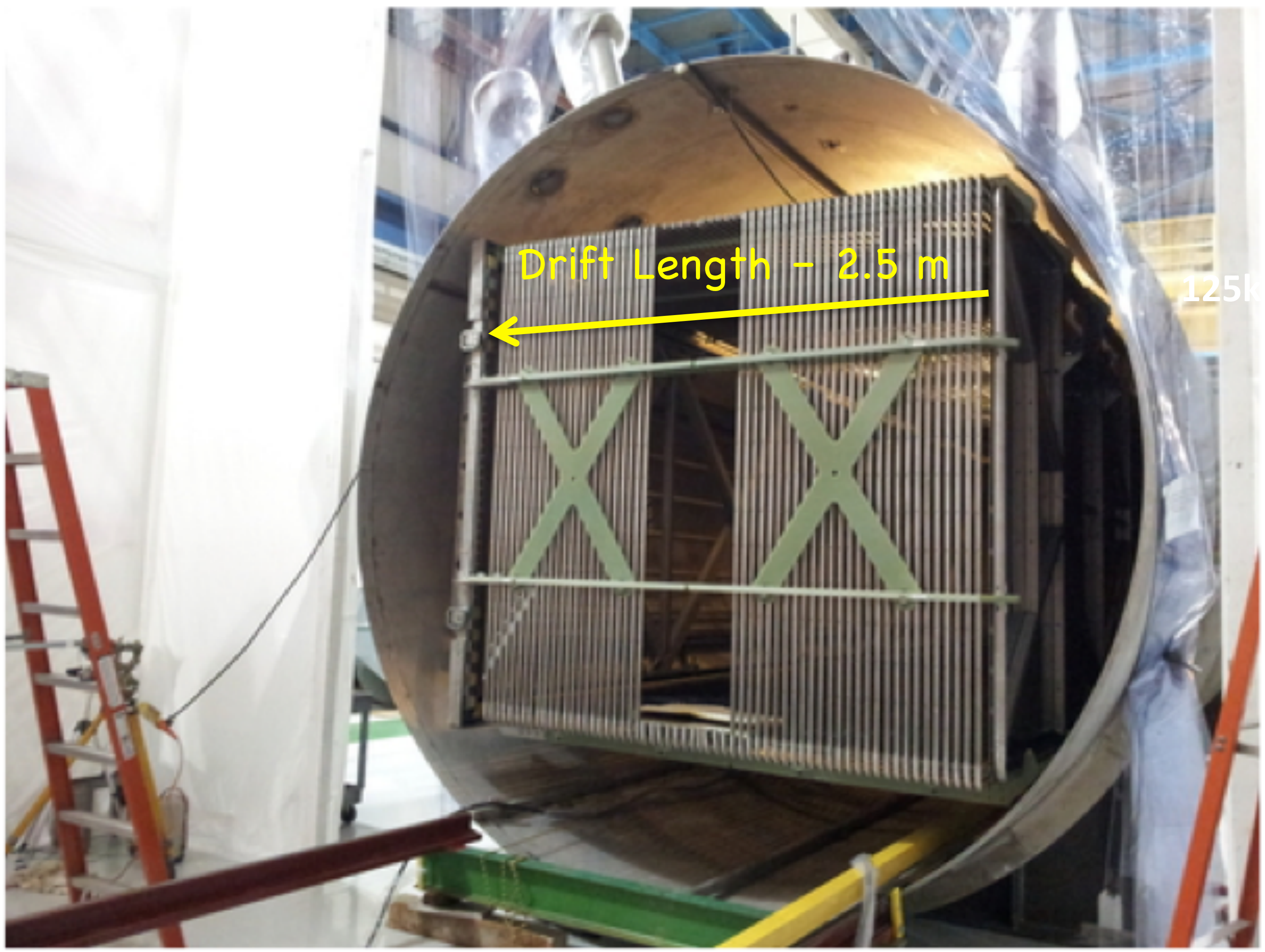


⇒ ~125kV for 2.5m drift

Focus of this Talk

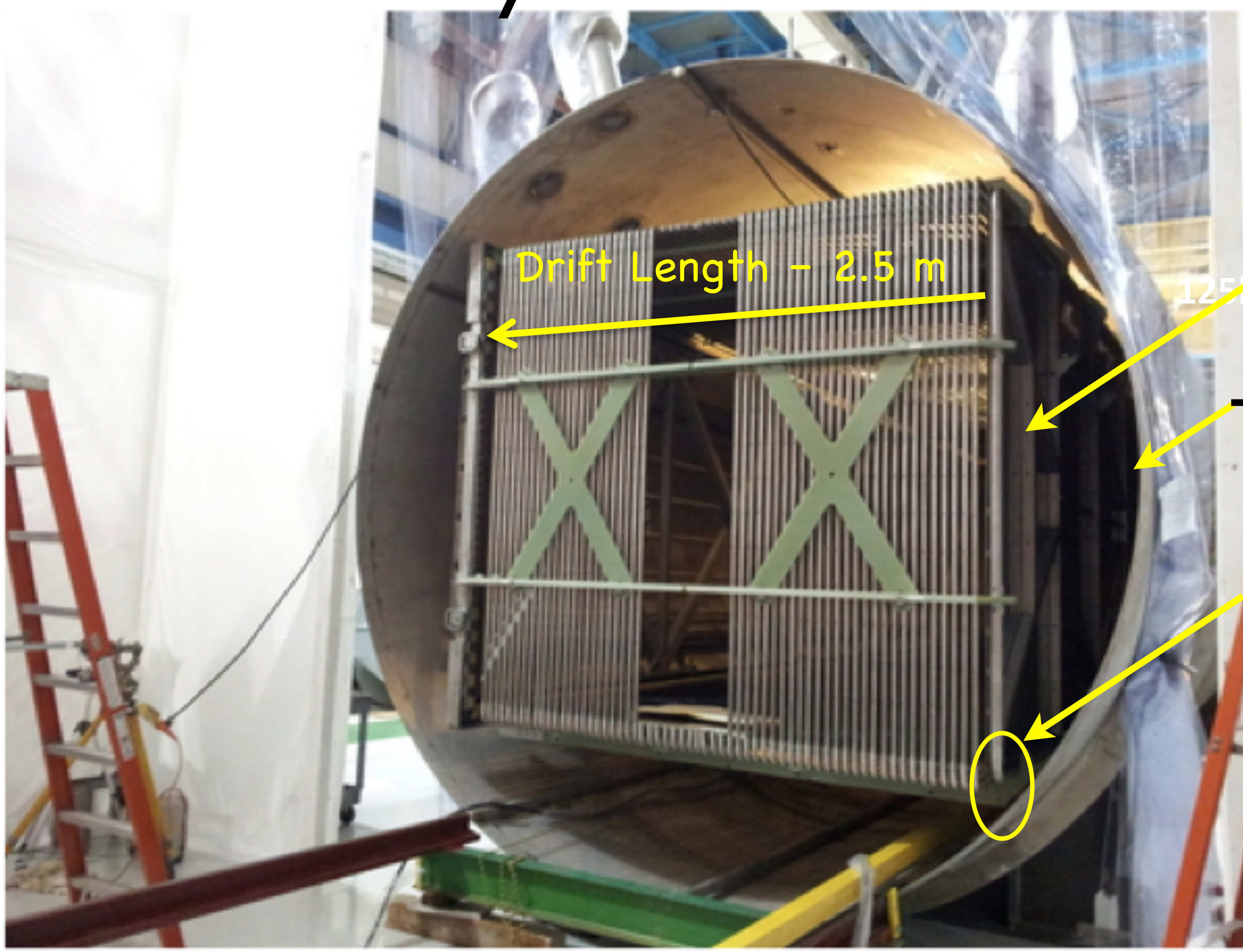
- MicroBooNE has started a set of initiatives prior to installing detector
- One of these, an auxiliary, or "test" cryostat with instrumentation is the subject of this talk
- Will conduct a suite of measurements re: HV properties of LAr (generic and specific)
- No data yet ...

Cryostat / TPC



Cryostat Vessel

Proximity of HV to vessel wall



HV

~10 cm

Motivations for Test

Table 3.3 *Maximum breakdown strengths of some liquids*

Liquid	*Maximum breakdown strength (MV/cm)*
Hexane	1.1–1.3
Benzene	1.1
Transformer oil	1.0
Silicone	1.0–1.2
Liquid Oxygen	2.4
Liquid Nitrogen	1.6–1.9
Liquid Hydrogen	1.0
Liquid Helium	0.7
Liquid Argon	1.10–1.42

"High Voltage Engineering"
C.L. Wadhwa

Example from literature #1: breakdown field strength

Maybe so...

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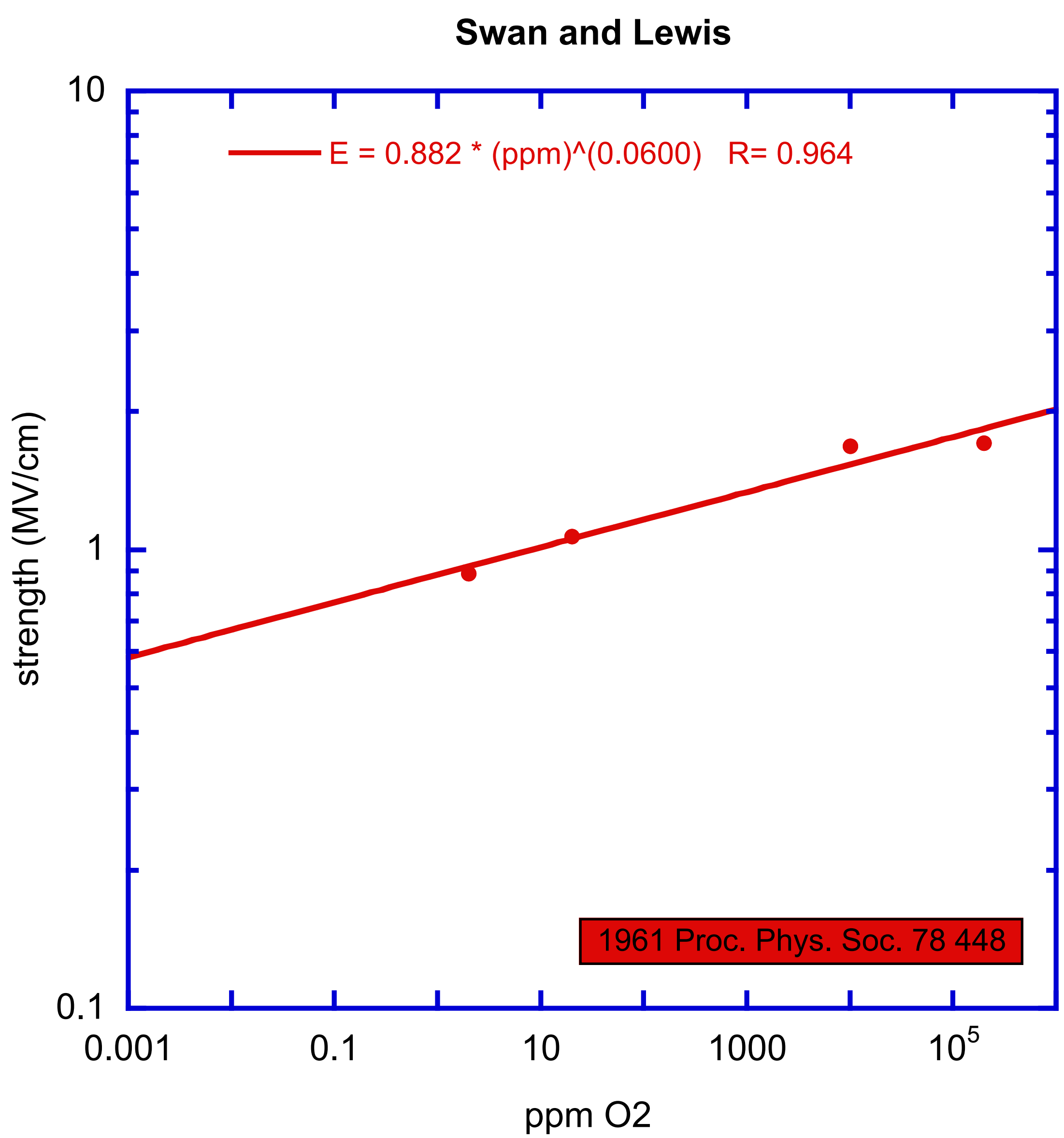
<u>Example from literature #1:</u> breakdown field strength

Maybe so...
but under what conditions?
<u>perhaps not ours!</u>

Motivations for Test

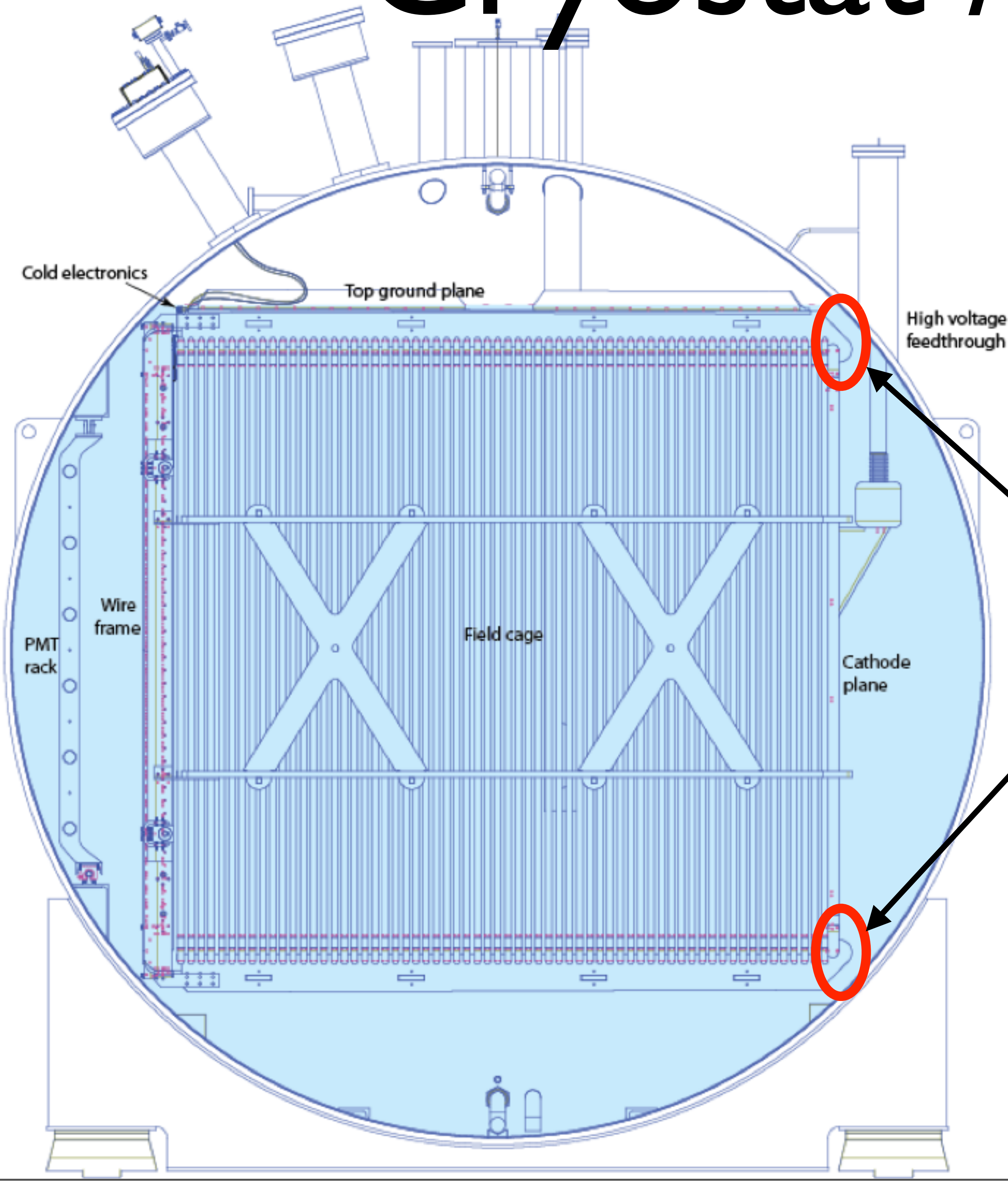


Example from literature #2:

breakdown field vs purity

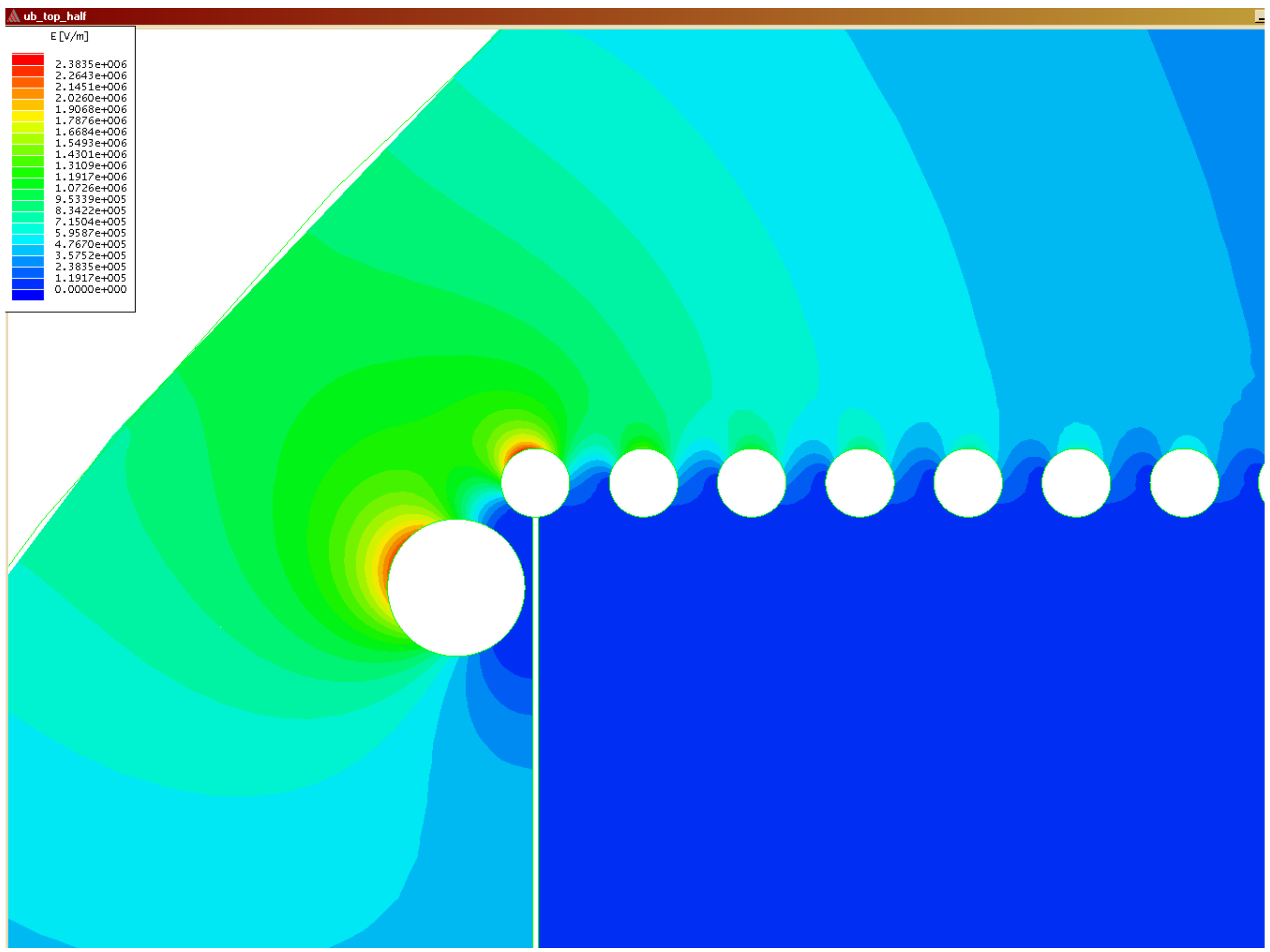
"extrapolation anxiety"

Cryostat / TPC



"regions of concern"

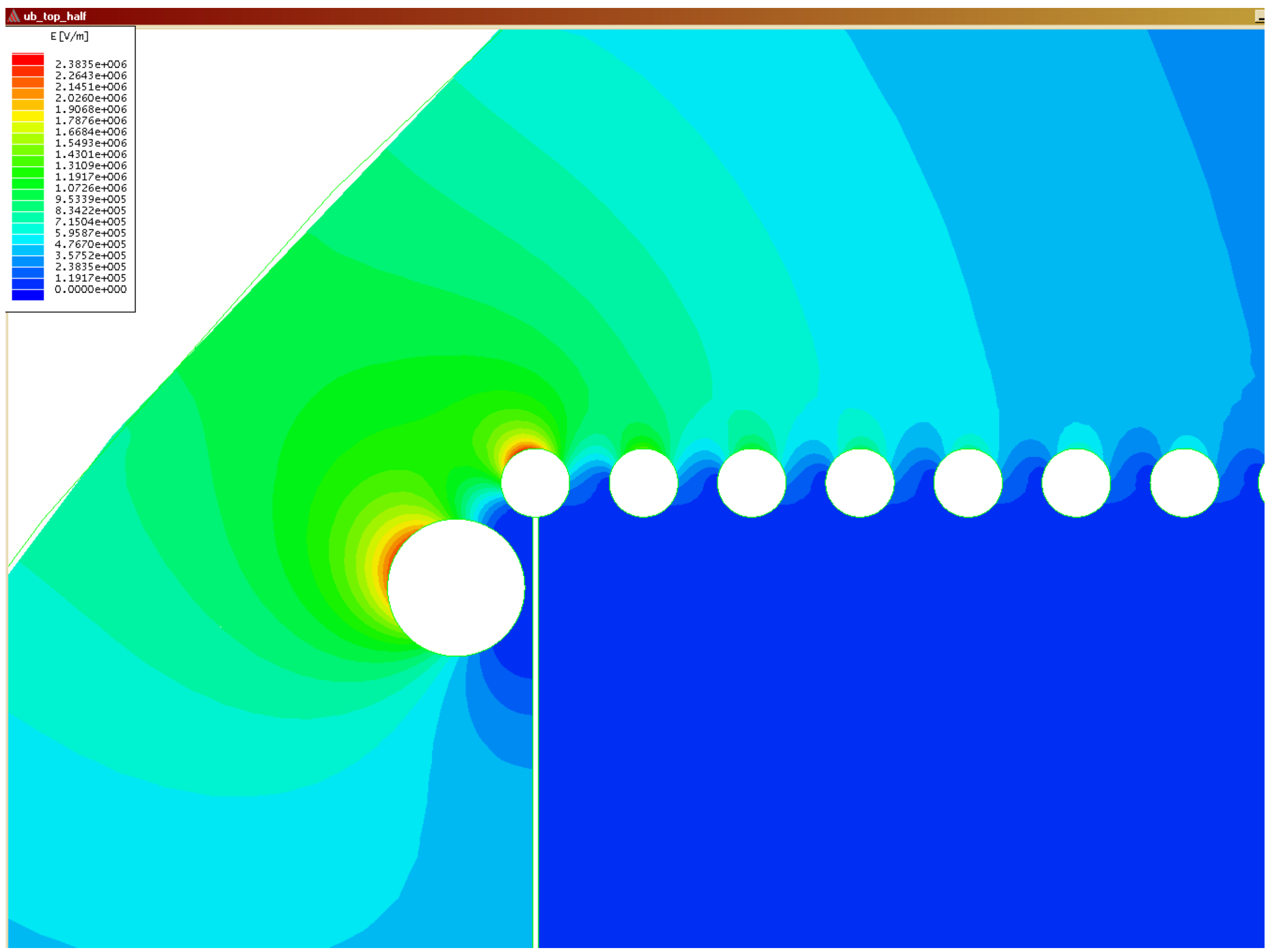
Simulations & Design Criteria



Simulation near point(s) of closest approach

max E → 24 kV/cm @ HV=125kV

Simulations & Design Criteria



Simulation near point(s) of closest approach

max E → 24 kV/cm @ HV=125kV

current rule-of-thumb:

maintain maximum field less than ~10 X breakdown voltage

begs the following --- what E_{max} is appropriate?

Motivations for Test

Specific

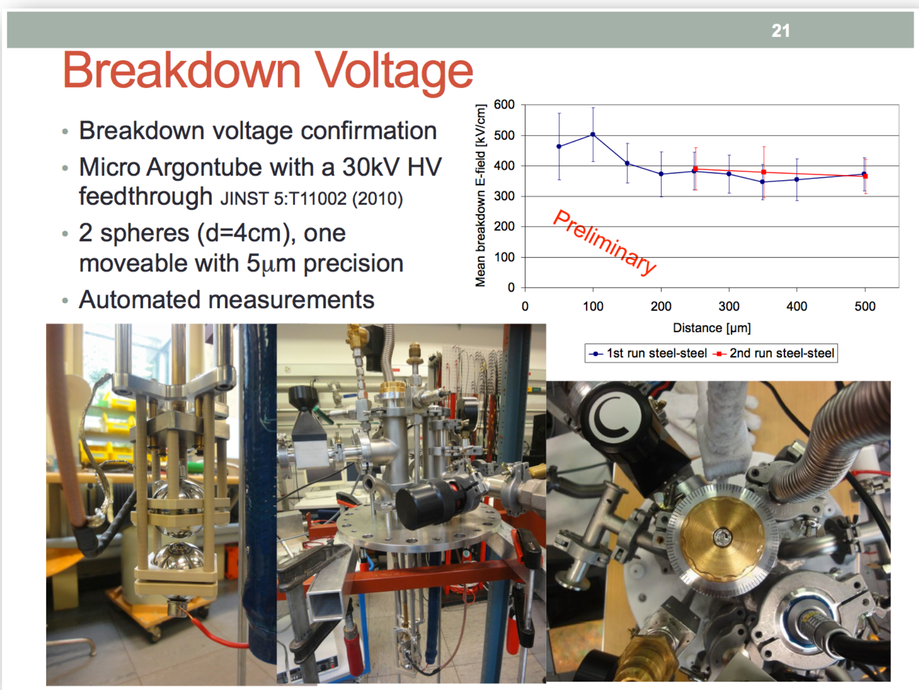
- We want to operate at ~500 V/cm
- 250cm cathode to wire ⇒ 125 kV
  - verify feedthrough performance
  - "optimum" purity (lifetime)
  - PMT considerations
  - operation at surface

Motivations for Test

Generic

- Explore LAr dielectric properties wrt:
  - Applied voltage
  - LAr purity
  - Conductor geometry
- Breakdown / Corona / ε
- Careful control / monitoring of conditions

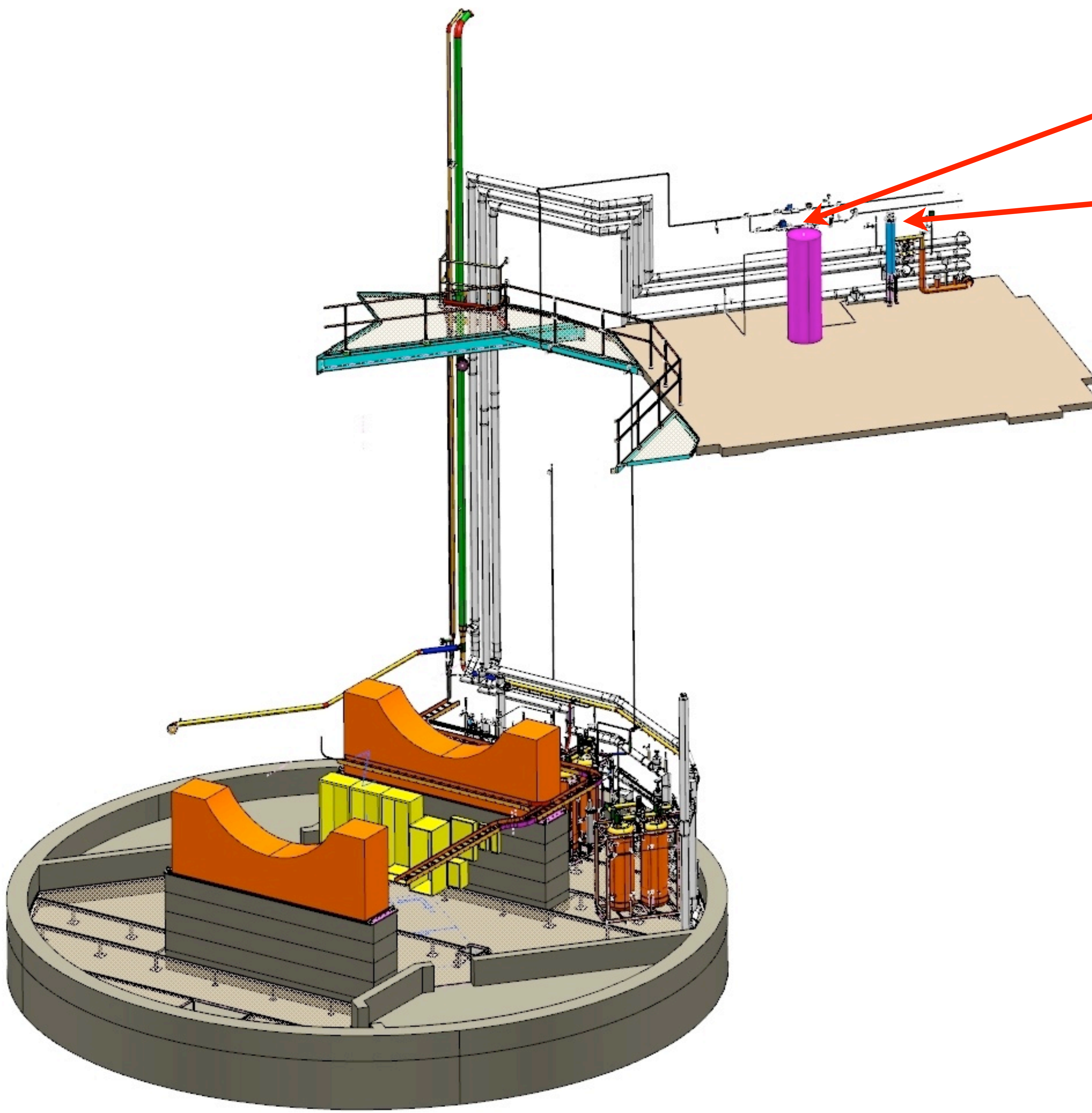
Recent Data



Recent breakdown field measurements at Bern

Stay seated for Thomas' presentation to follow

The Setup

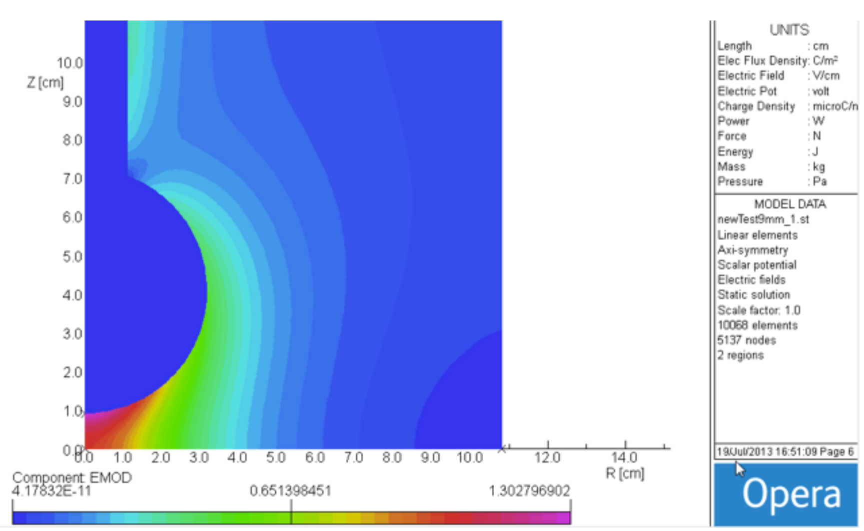


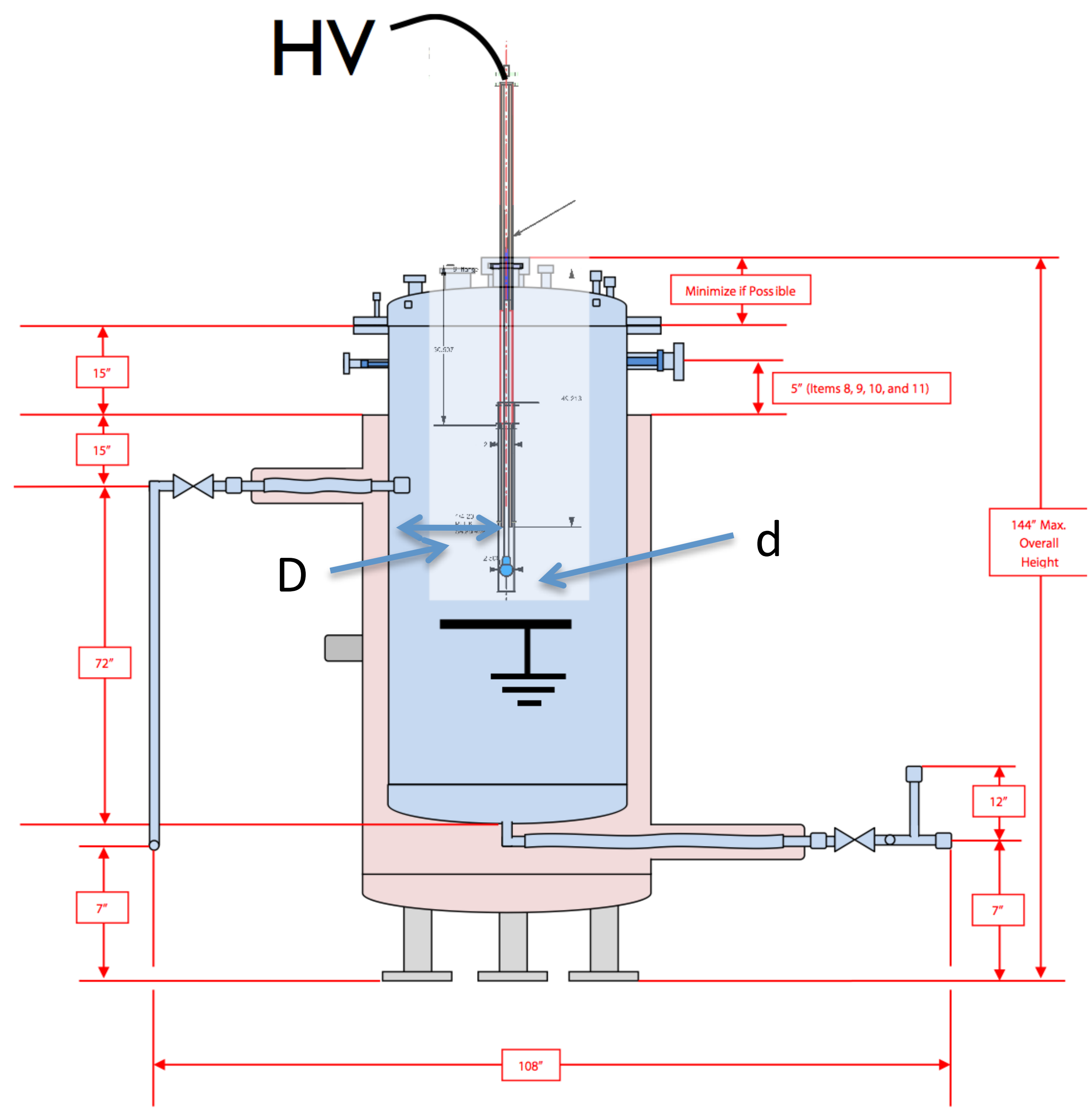
The Setup

- 800 liter cryostat at LArTF (expt. bldg.)
- plumbed to MicroBooNE cryo system
- in-line purity monitor (column lifetime vessel)
- fixed flat electrode (0V) and HV electrode on FT
  - changeable FT electrodes (1.3mm to 57mm dia.)
  - HV up to 150 kV
  - FT electrode movable from 0 to 100mm

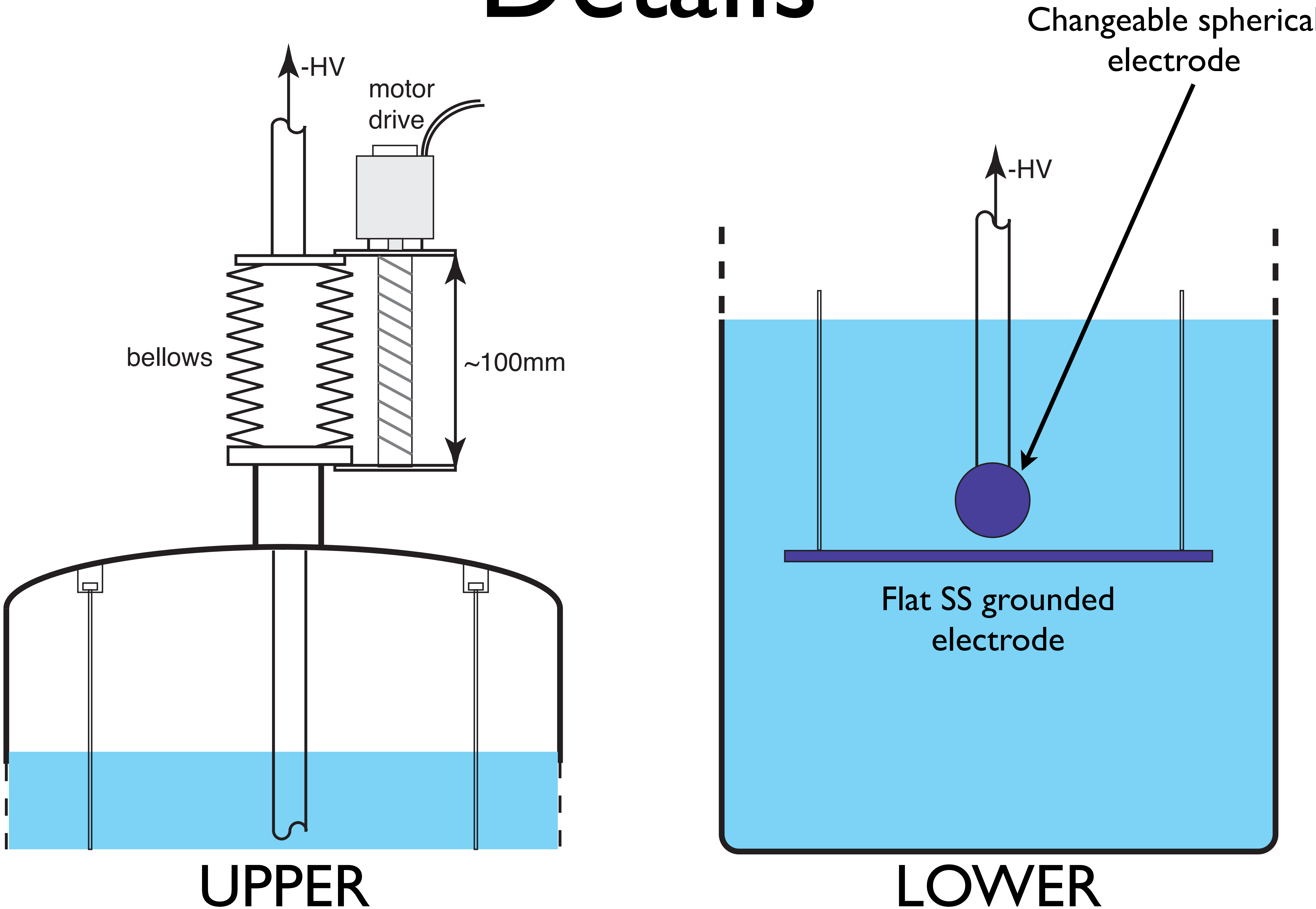
The Setup

- D >> d
- 0 cm < d < 10 cm
- Shape and quality of the electrodes
- Ability to model the set-up





Details


-HV
motor drive
bellows
~100mm
UPPER
-HV
Changeable spherical electrode
Flat SS grounded electrode
LOWER

Test Schedule

- ~~Cryostat just arrived ✓~~ ready for shipping
- Parts assembled ~22 Nov
- Cryostat filled early December
- First measurement series before Xmas
- Qualify production FT over holidays+

Test cryostat removed when large cryostat set in place

Measurements

- Breakdown characterization (V, dist., purity)
- Test HV production feedthrough
- Corona ignition(?)
- Dielectric constant ε
- Positive HV
- LAr additives (quenching agents CH_4 CF_4)

A Test Sequence

Measurements example - breakdown:

- 57mm spherical electrode
- scan voltage and distance @ purity level 0
- ~1 day repeat scan @ purity level 1

Anticipate significant lifetime changes ~ day

Estimate electrode changeout ~2 days

Test results may answer...

- Can we diagnose/understand breakdown quantitatively?
- What are the optimum operating parameters?
- Are there additives to improve / stabilize performance?

- Looking forward to discussions ...

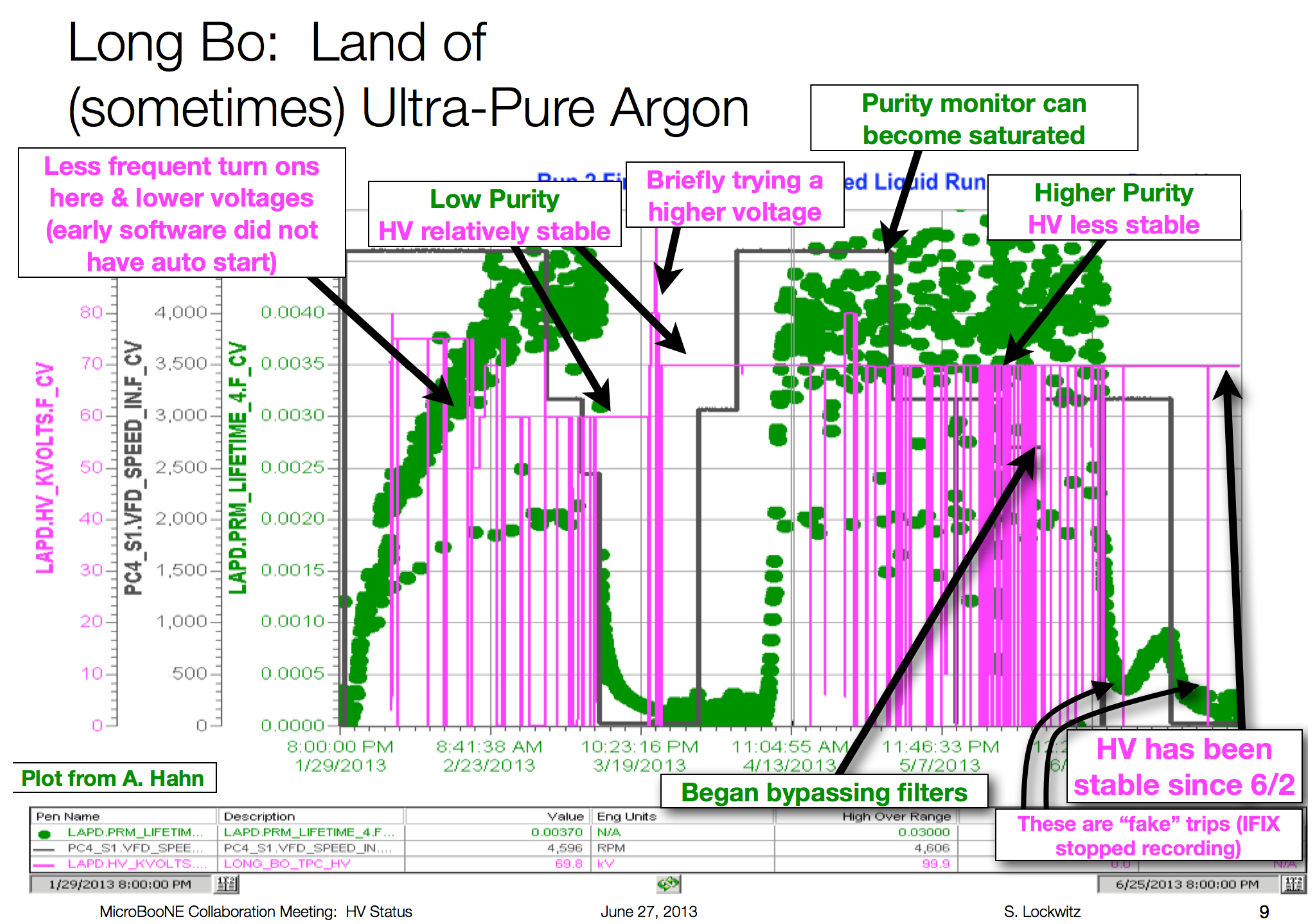
MicroBooNE Schedule

- Load large cryostat with TPC in December
- Install cryostat / TPC at LArTF by next March
- First data by summer 2014

Backup

Breakdown vs Purity

- Many factors can affect the performance of a HV system
  - Properties of the FT itself
  - Environment
- Simultaneous with our uB FT studies, data was being taken with the "Long-Bo" TPC in LAPD
  - A variety of different HV affects were observed
  - Breakdown was correlated with the purity



This plot is confusing, and should not be used to draw quantitative conclusions.
It's just meant to remind us that the HV-LAr purity connection is real