

# R&D on High Voltage in Liquid Argon

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Sarah Lockwitz, *FNAL*

October 29, 2014

# Recent Interest in LAr High Voltage (HV)

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<b>Experiment</b>
ICARUS
Darkside 50
MicroBooNE
CAPTAIN
LBNE
GLACIER
ArDM

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- Noble liquid detectors often require HV
  - New proposals may push the limits of HV stability for a given design

<b>Experiment</b>	<b>Voltage</b>
ICARUS	75 kV
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MicroBooNE	128 kV
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LBNE	170 kV
GLACIER	1-2 MV
ArDM	100 kV

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- Noble liquids are a popular detector medium
- Noble liquid detectors often require HV
  - New proposals may push the limits of HV stability for a given design
- While experiments have successfully operated with HV in LAr
  - it would be useful to understand the parameters that affect HV stability in LAr when designing future experiments

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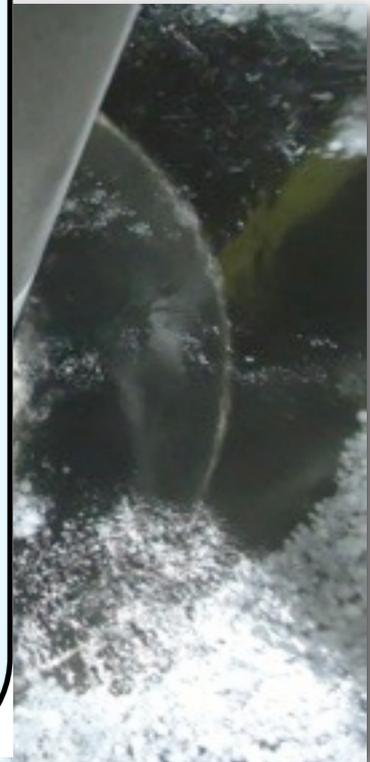
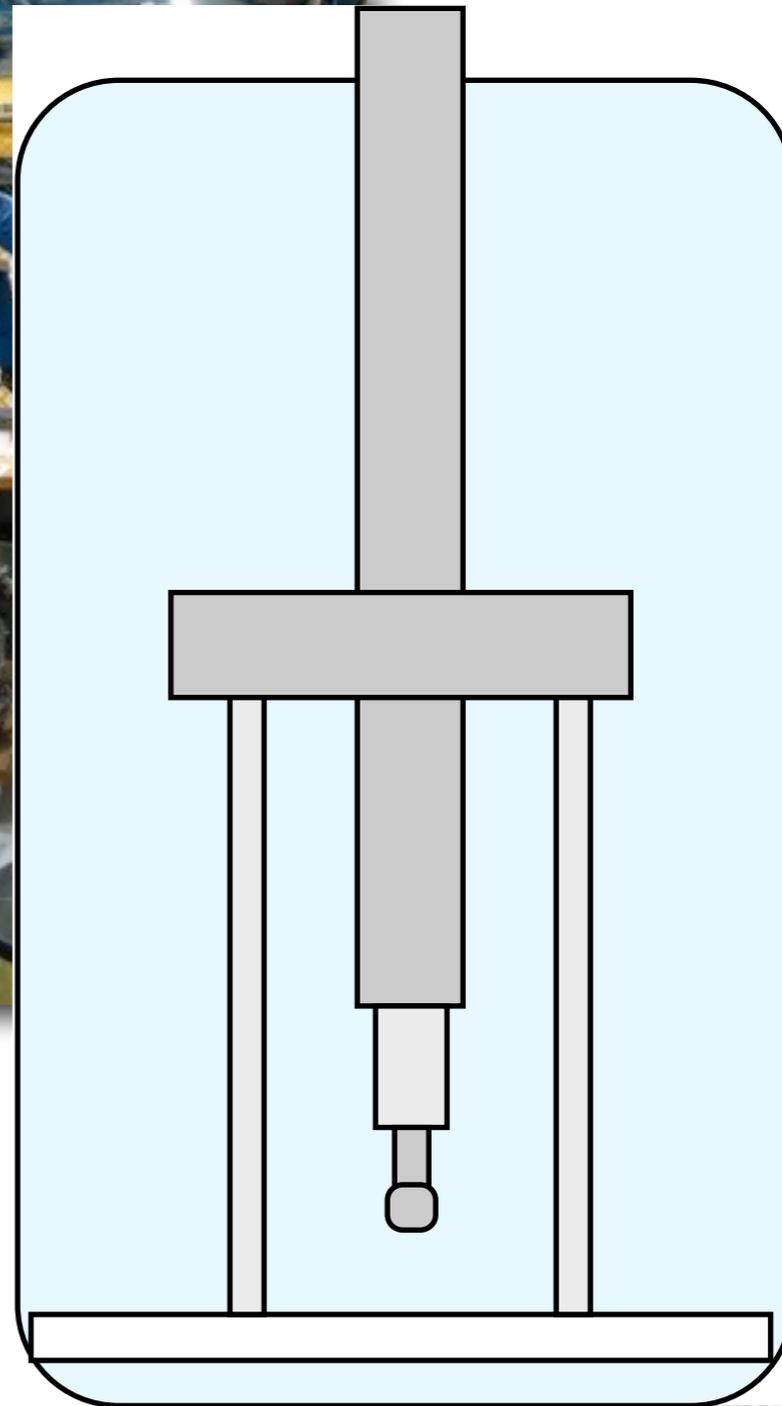
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- Trips/sparks were not an infrequent phenomenon for us



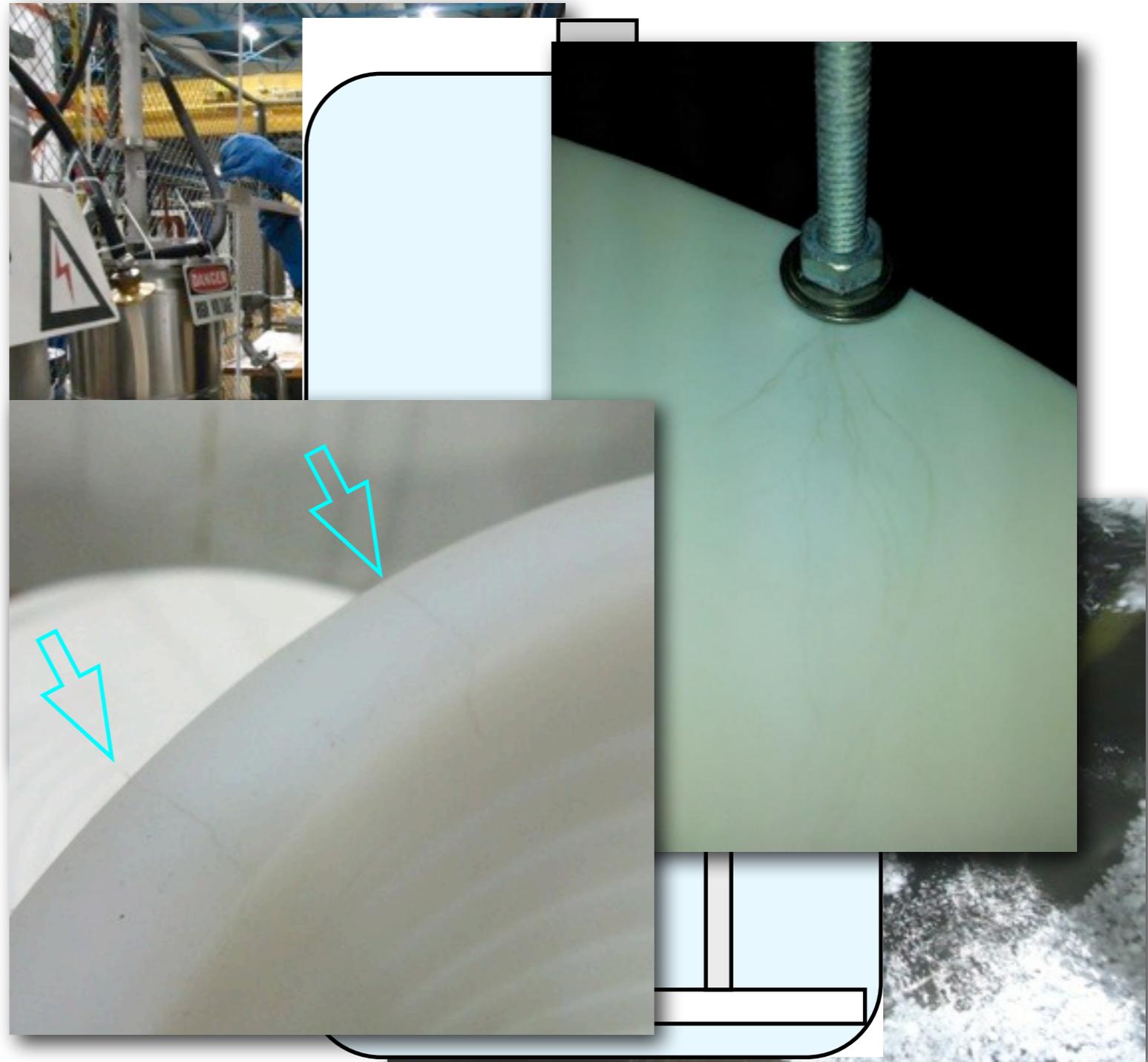
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- For me, the beginning of this work involved testing a prototype feedthrough in an open LAr dewar
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  - Until we saw them *through* the argon!



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TABLE 6.2  
*Electric strengths of liquefied gases*

Liquid	Strength (MV cm <sup>-1</sup> )
Nitrogen	1.6–1.88
Oxygen	2.38
Argon	1.10–1.42
Hydrogen	> 1.0
Helium I, II	0.7

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- This caught our eye because the common thought was that the electric strength of LAr was  $\sim 1.4$  MV/cm
- Upon closer inspection, this value seems to come from a measurement at very small distances using small (5 mm) spheres

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planation of the effect. The nonlinear plot for argon and stainless steel suggests that the strength of argon for really large spacings ( $> 100 \mu$ ) would be much less than that quoted in Table II, and any increase for smaller spacings may be due to

Swan, 1960

lower end of the cell. Gap adjustment between the 0.5-cm diameter spherical electrodes can be made to within  $\pm 1 \mu$ , i.e., with  $\pm 2\%$  error for a 50- $\mu$  gap,

ELECTRODE SPACING

Table II. Mean strengths for liquified gases (mv/cm)

	Platinum electrodes		Stainless steel electrodes	
	from Fig. 2	from ref. (2)	from Fig. 3	from ref. (2)
Argon	1.10	0.86	1.42	1.00
Oxygen	2.00	0.93	2.38	1.04
Nitrogen	2.26	0.93	1.88	1.00

# Our Experience: LAr Electric Strength

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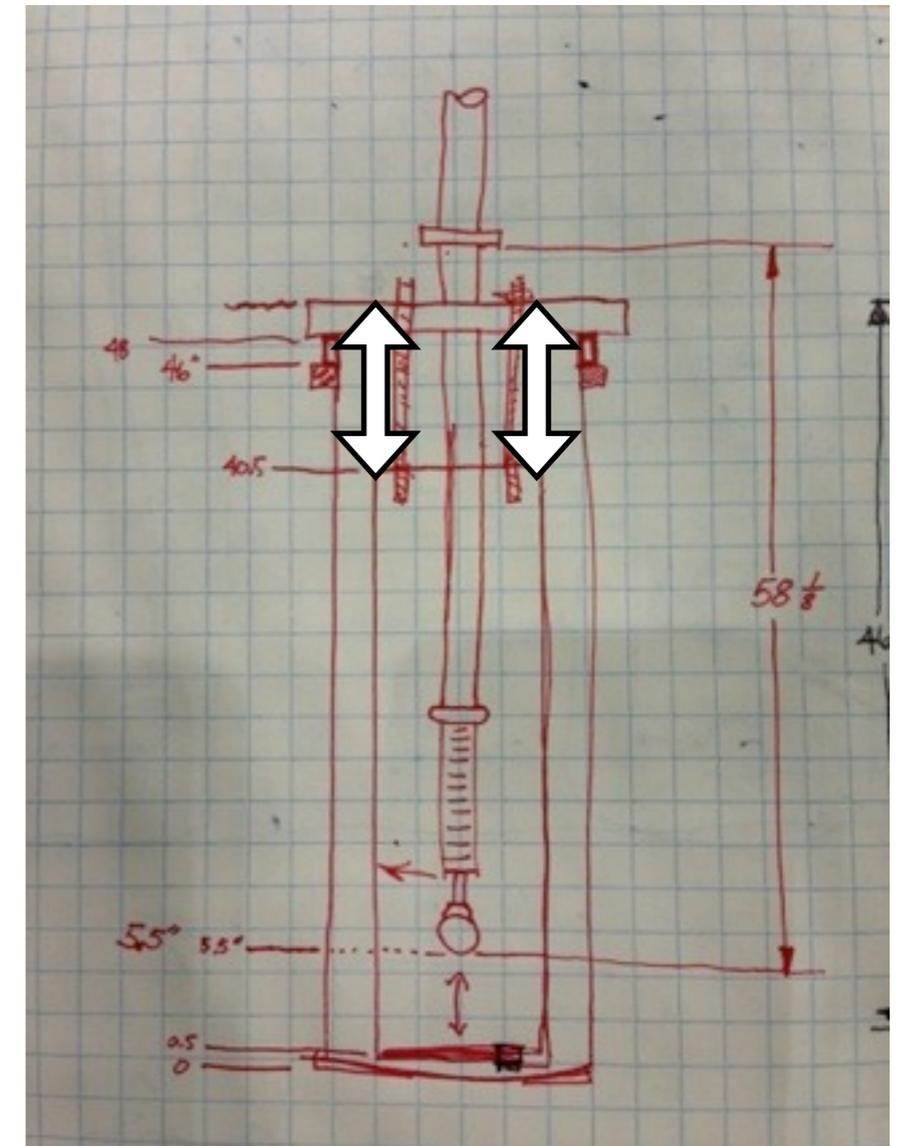
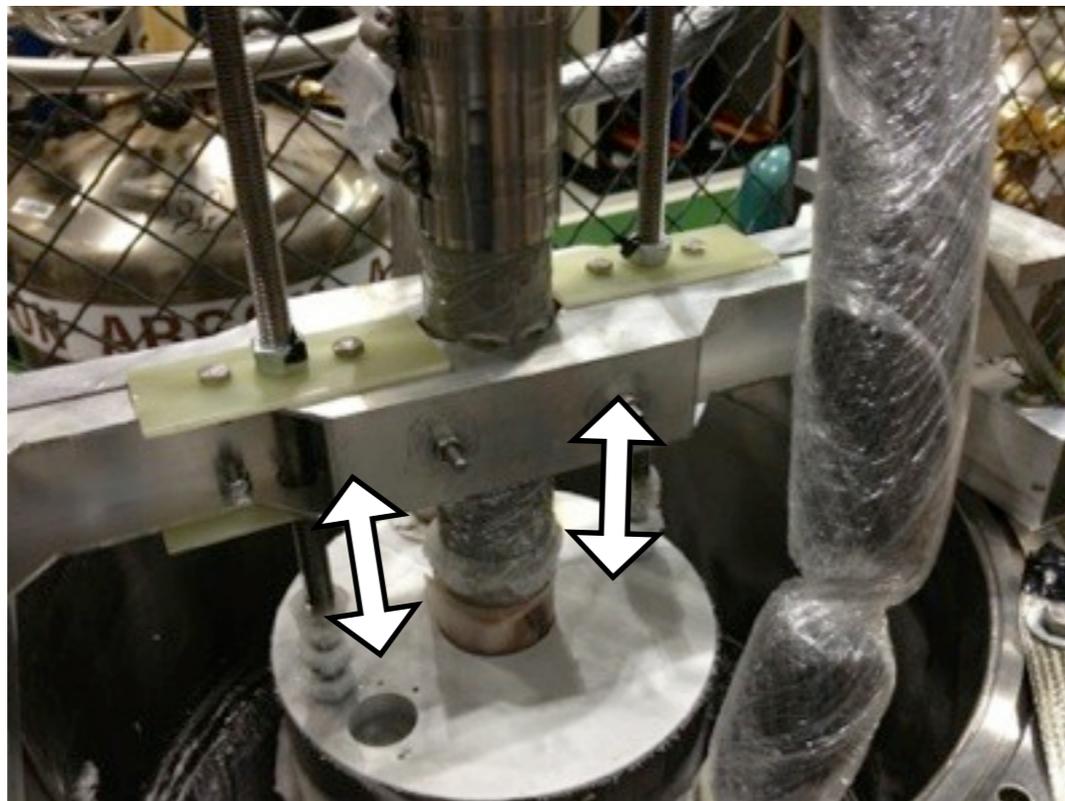
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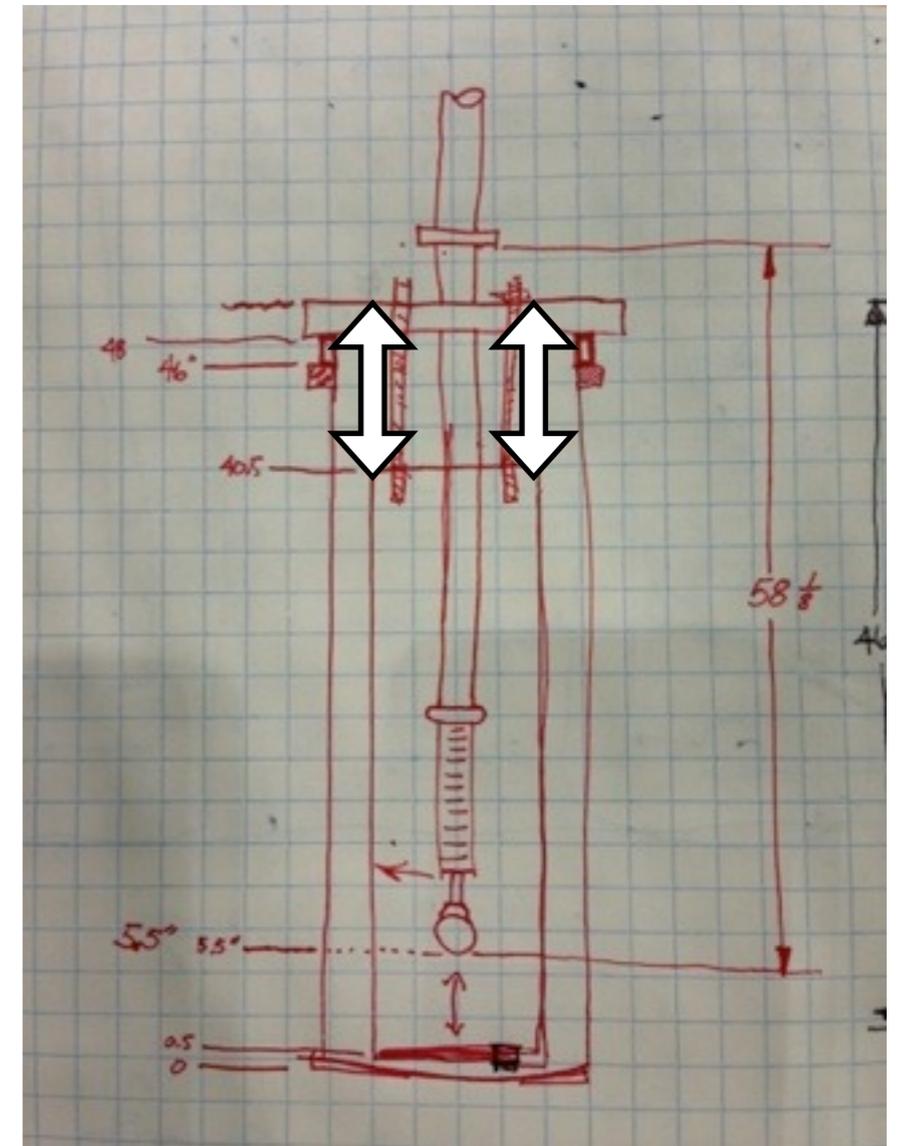
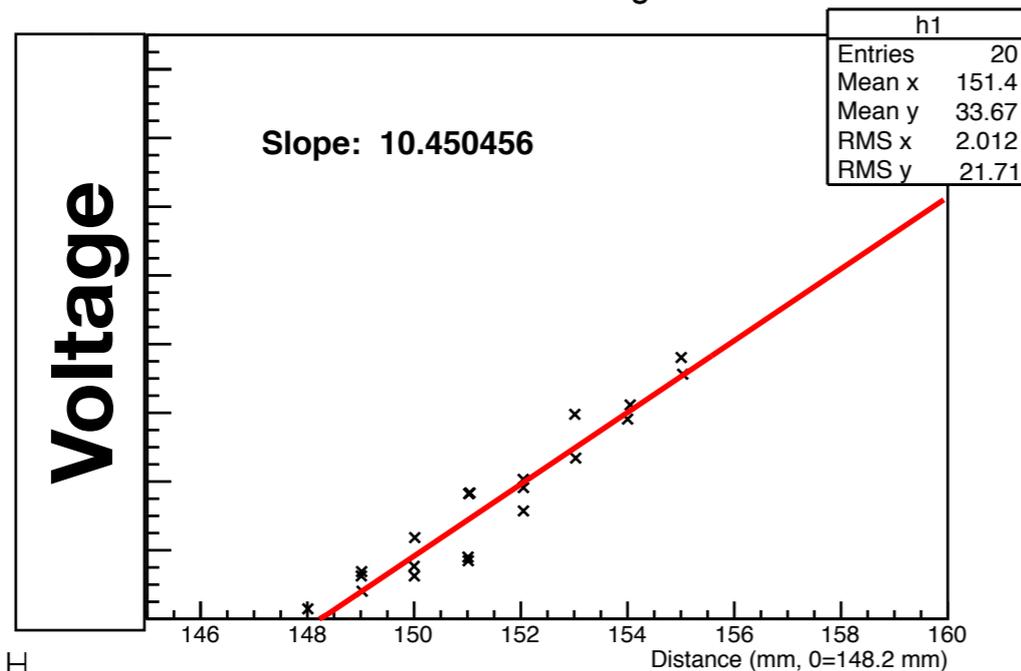
- This led to us to measure the electric strength of LAr
  - First, in an open cryostat (summer 2013 -- *caveat: impurities*)
  - Sphere-plate geometry with an adjustable gap spacing



# Our Experience: LAr Electric Strength

- This led to us to measure the electric strength of LAr
  - First, in an open cryostat (summer 2013 -- *caveat*: impurities)
  - Sphere-plate geometry with an adjustable gap spacing
- The breakdown voltage is indeed varying with distance
  - → **The breakdown is occurring through the LAr**

06/20/13 Breakdown Voltage vs. Distance



# Our Experience: LAr Electric Strength

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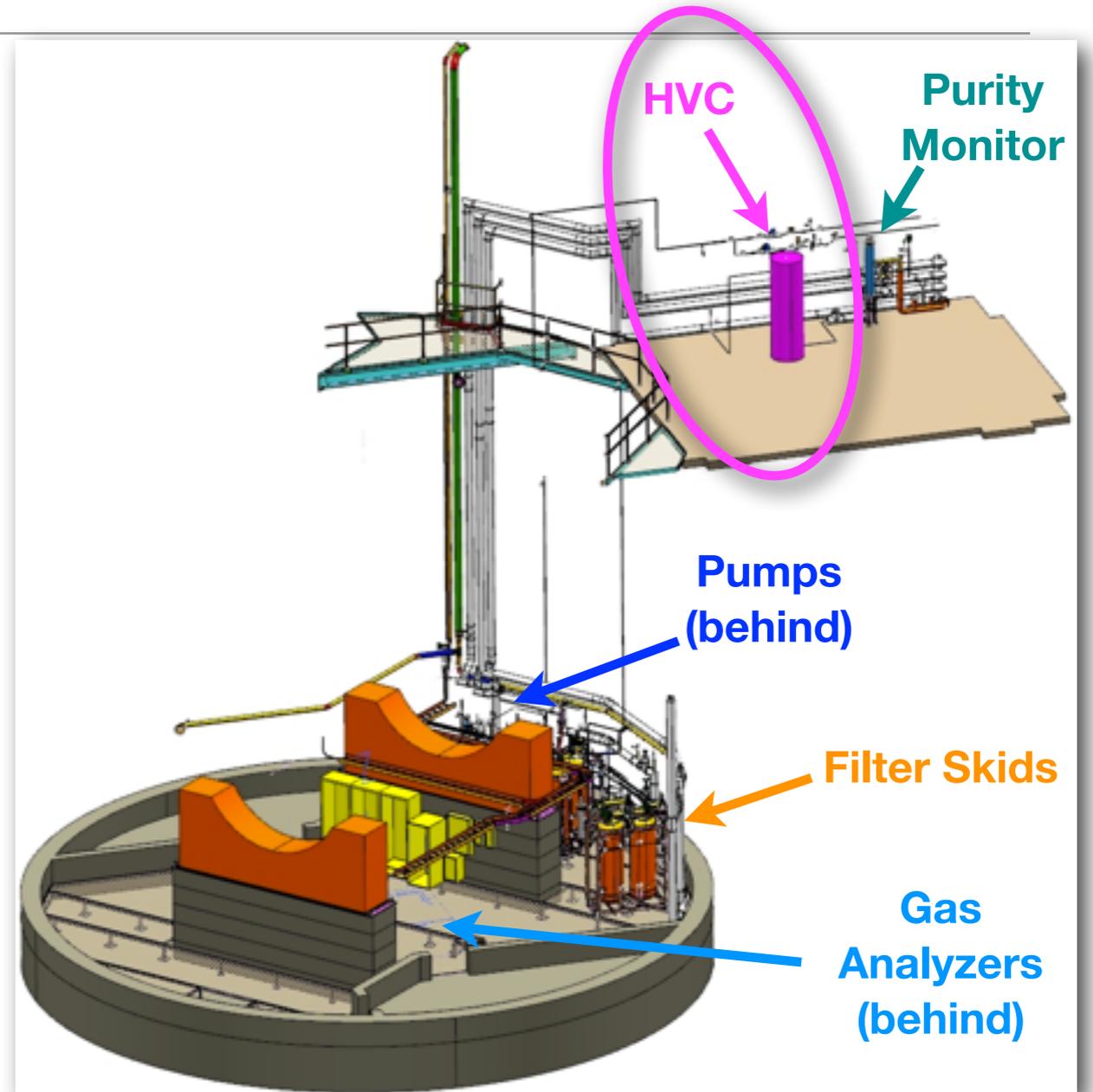
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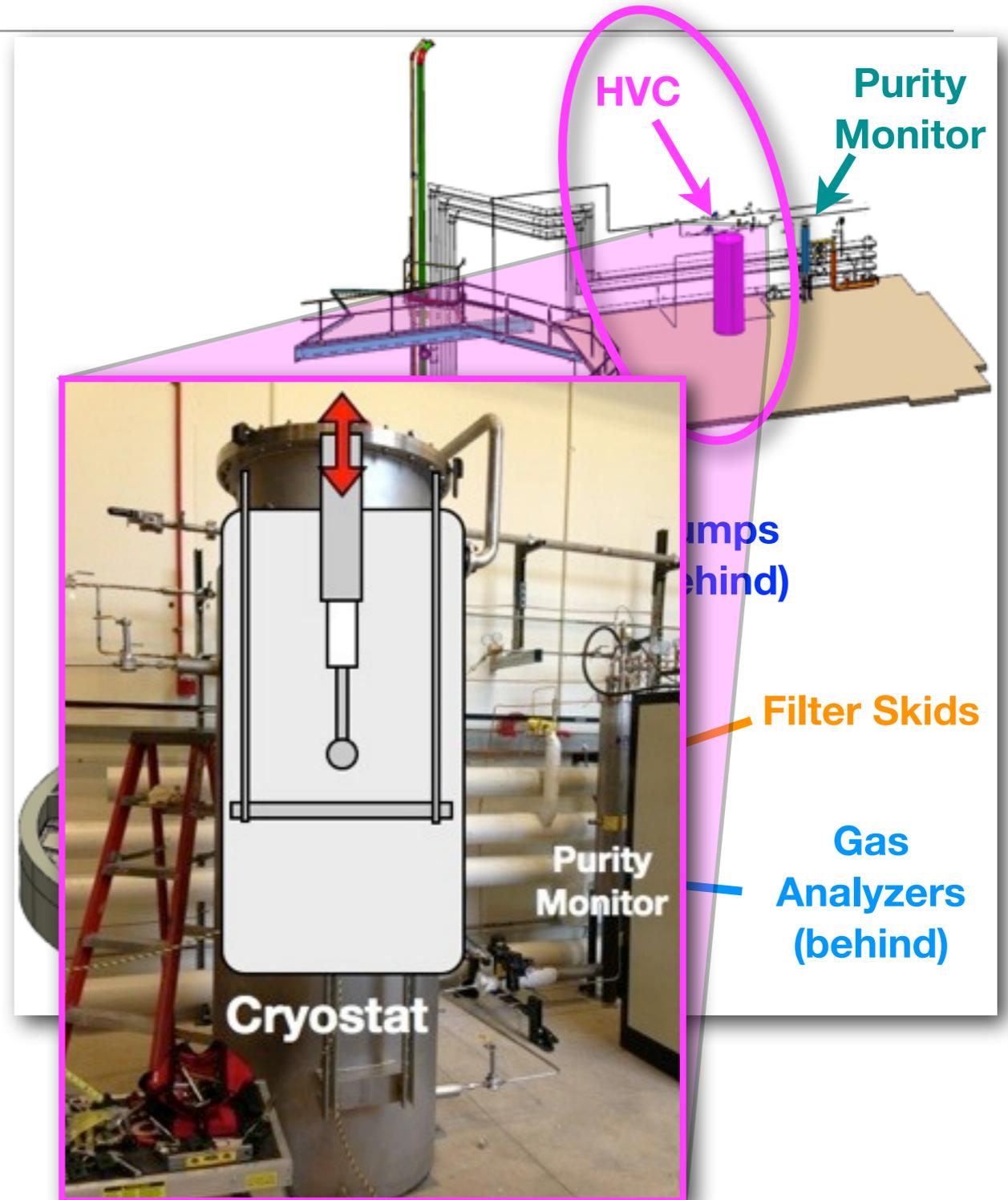
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- Earlier this year, MicroBooNE wanted measurements in a more controlled environment
- A test cryostat was plumbed into their phase 1 cryosystem
- A sphere-plate geometry was used testing 3 sphere sizes at varying purities and explored distances up to 25 mm



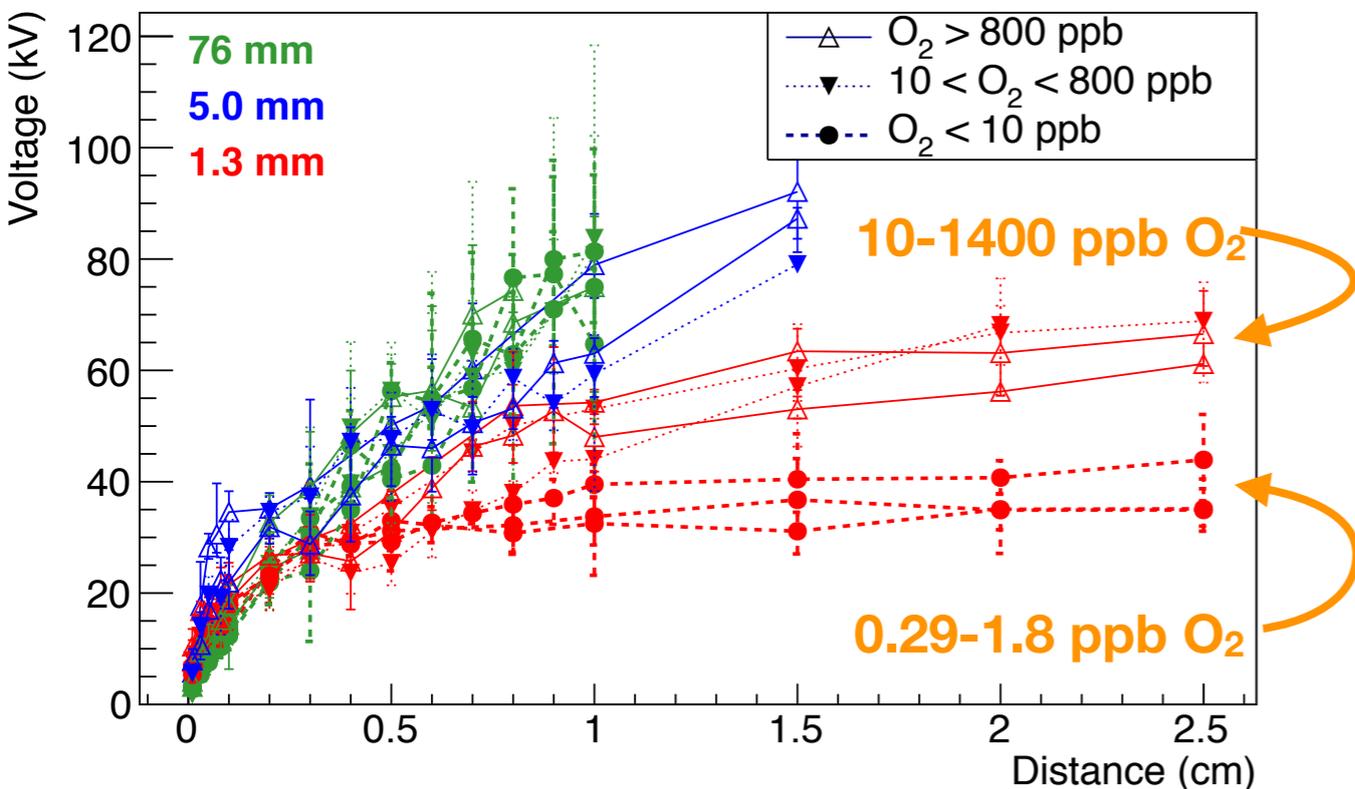
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- We found (see <http://arxiv.org/abs/1408.0264>)
  - Indications of a purity effect with the 1.3 mm sphere for gap spacings above 0.6 mm (no indications for the larger spheres)

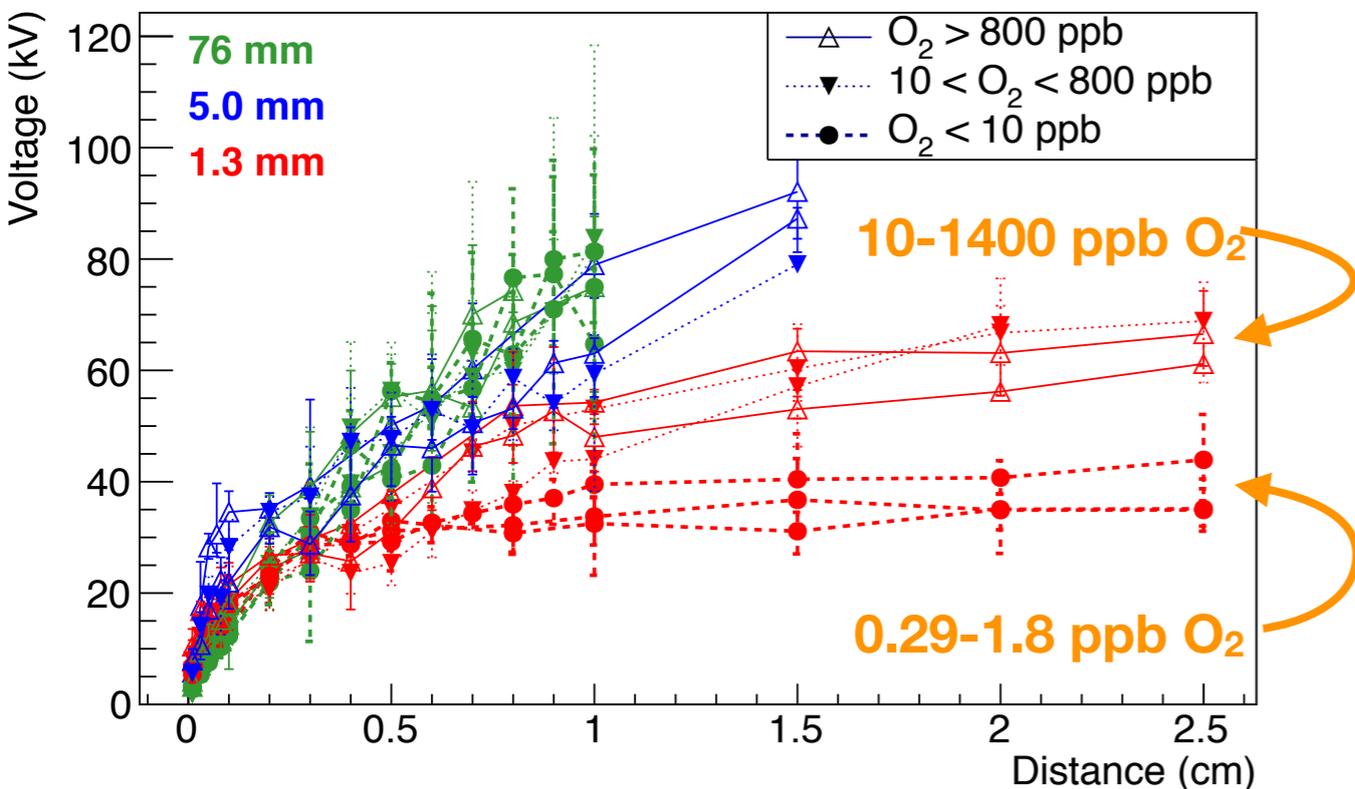
Average Breakdown Voltage vs. Distance



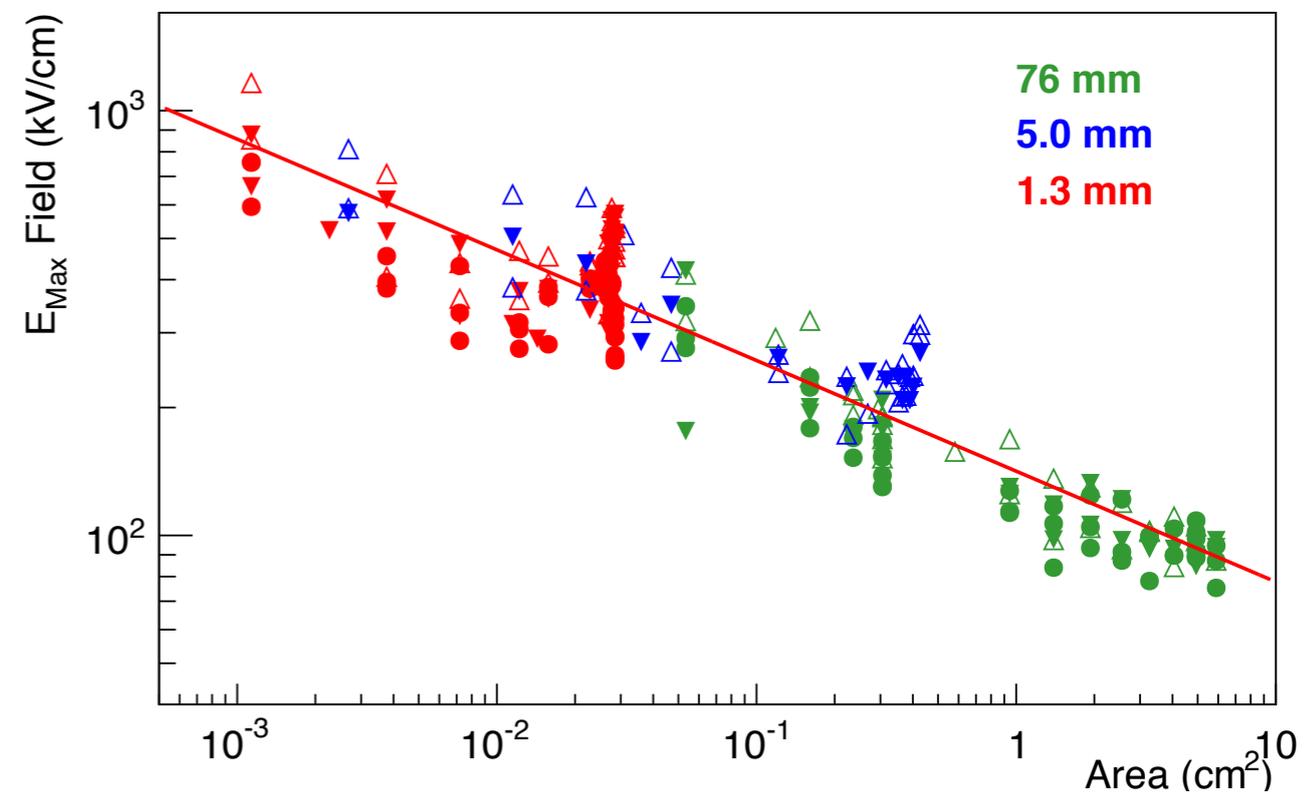
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- We found (see <http://arxiv.org/abs/1408.0264>)
  - Indications of a purity effect with the 1.3 mm sphere for gap spacings above 0.6 mm (no indications for the larger spheres)
  - Stressed area seemed to be a unifying parameter of interest between the sphere sizes and gap spacings

Average Breakdown Voltage vs. Distance



Maximum E Field vs Stressed Area ( $E > 0.8 \cdot E_{MAX}$ )



# Plan for the coming year

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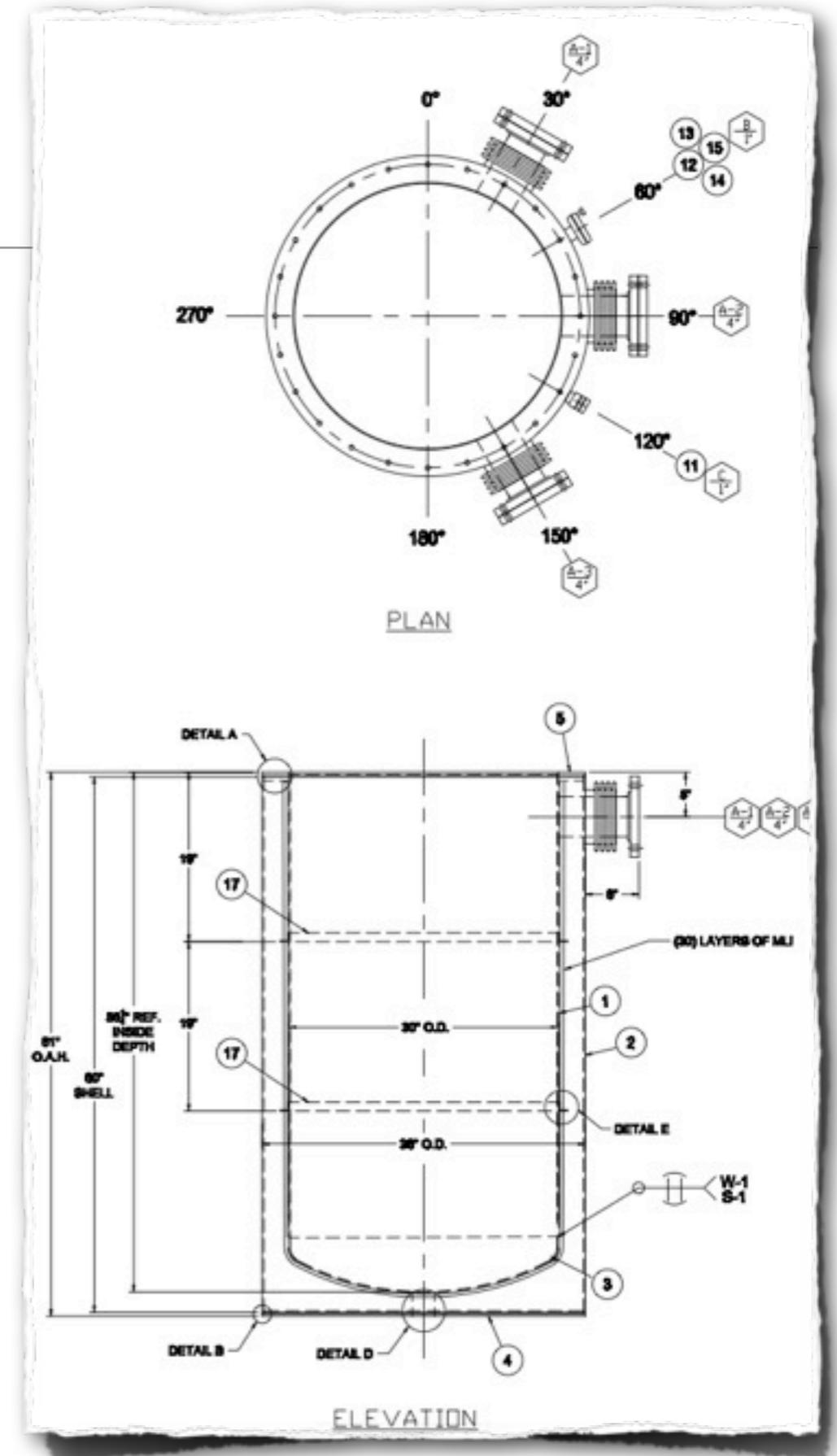
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- We are having a new cryostat plumbed into the PAB

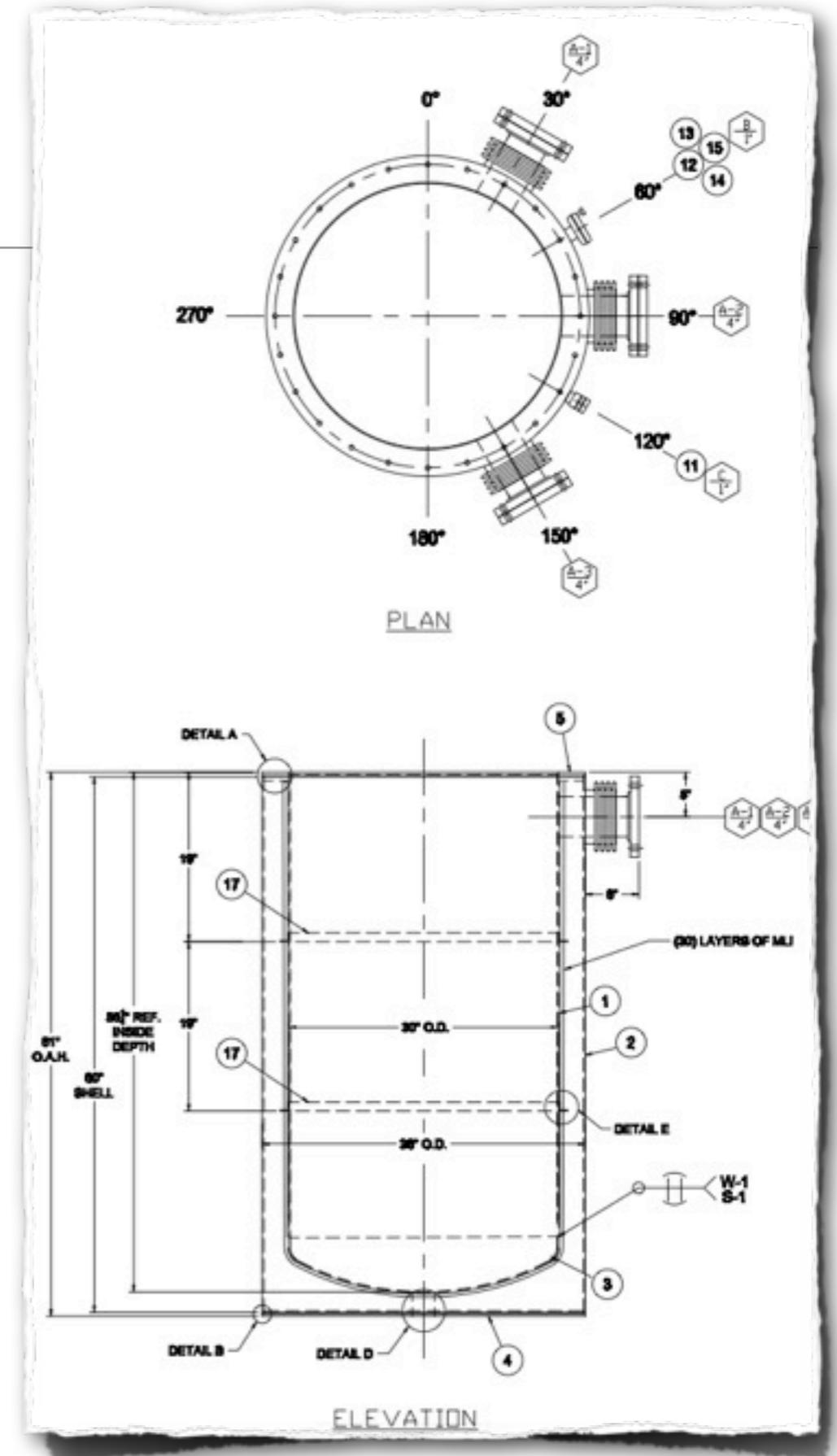
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  - Breakdown (or big) Liquid ArgoN  
Cryostat for High-voltage  
Experimentation (BLANCHE)



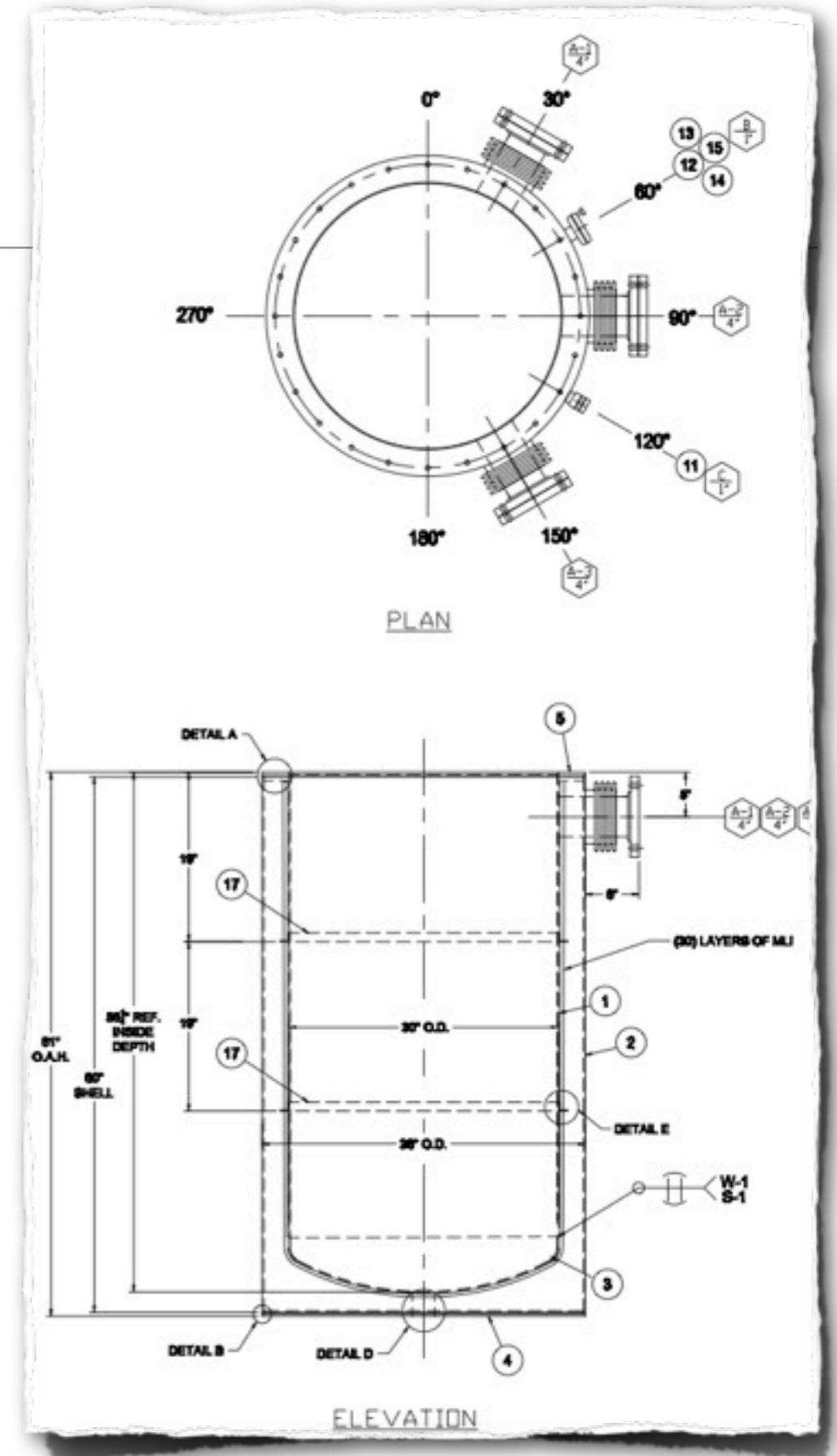
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  - Will use existing expertise & infrastructure
- We plan to begin using Blanche after the New Year
  - We will do preliminary tests in an open cryostat



# Continuing the research

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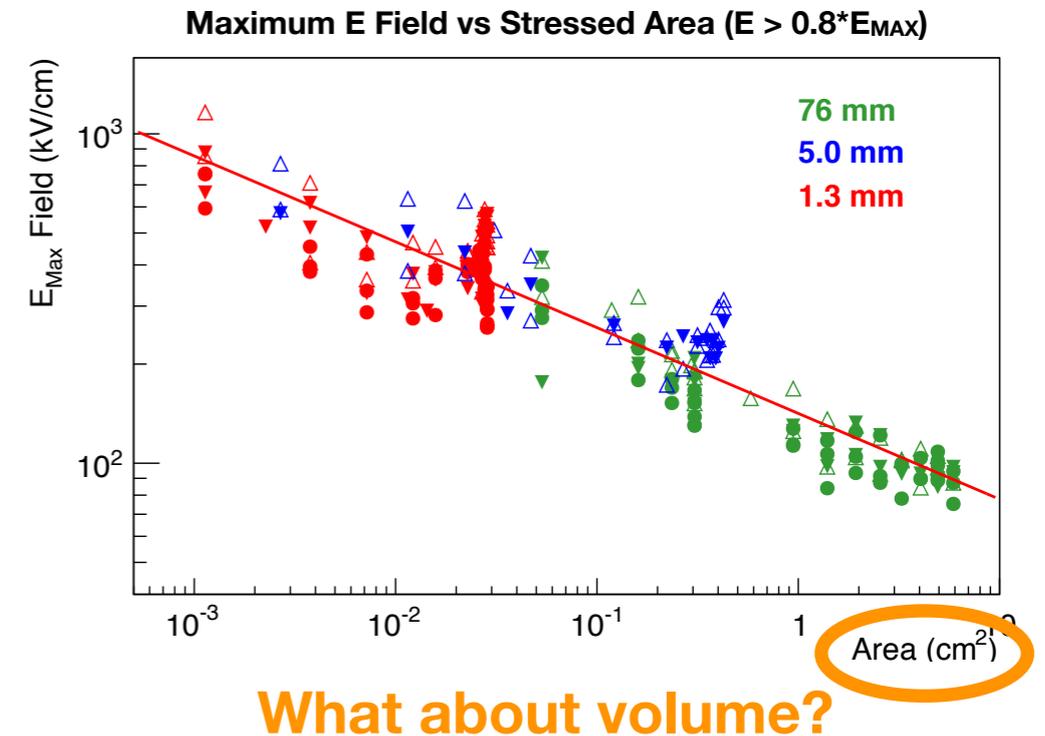
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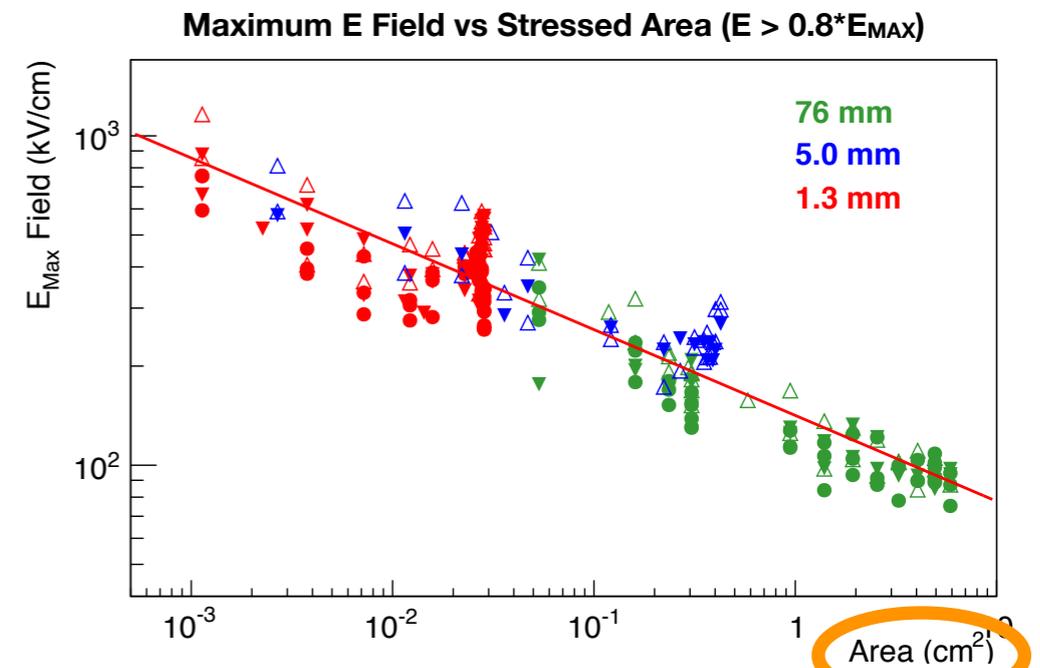


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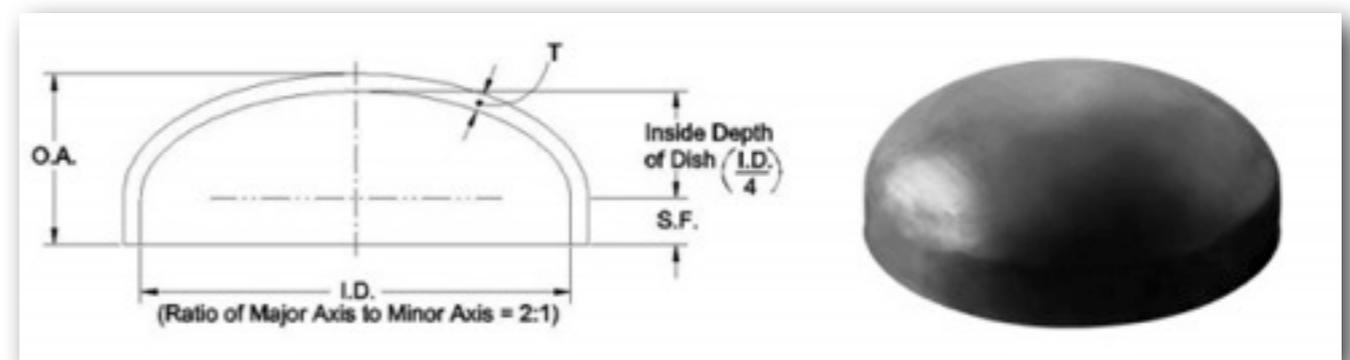
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- Instead of a sphere-plate geometry, we plan to test elliptical tank ends



What about volume?



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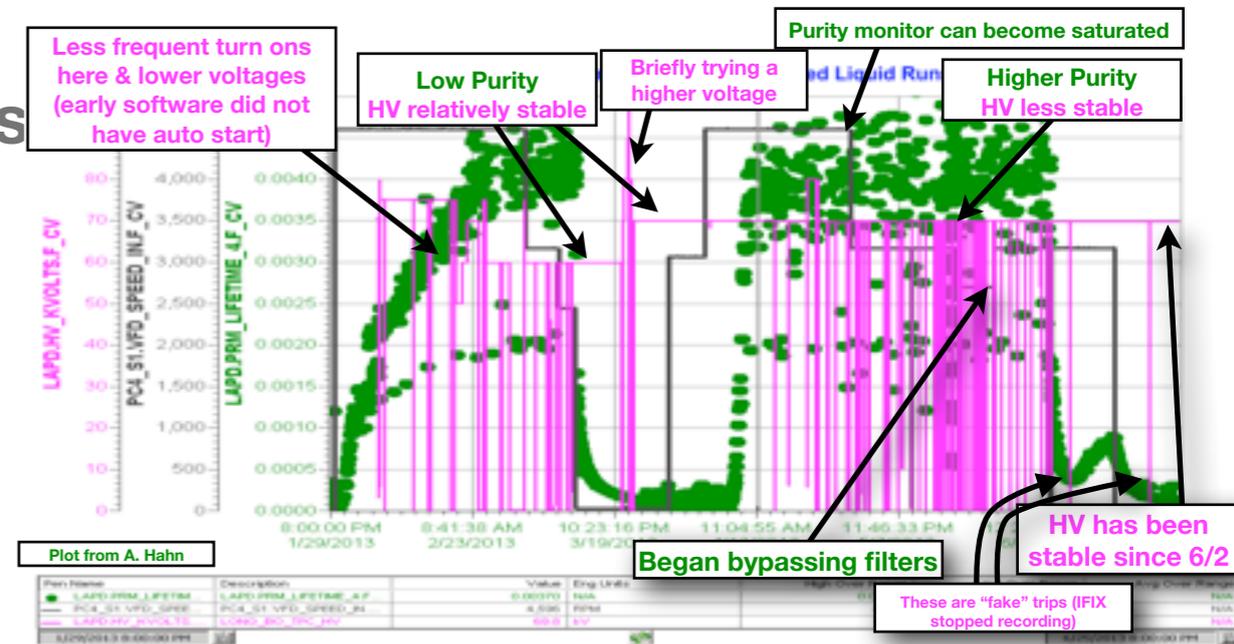
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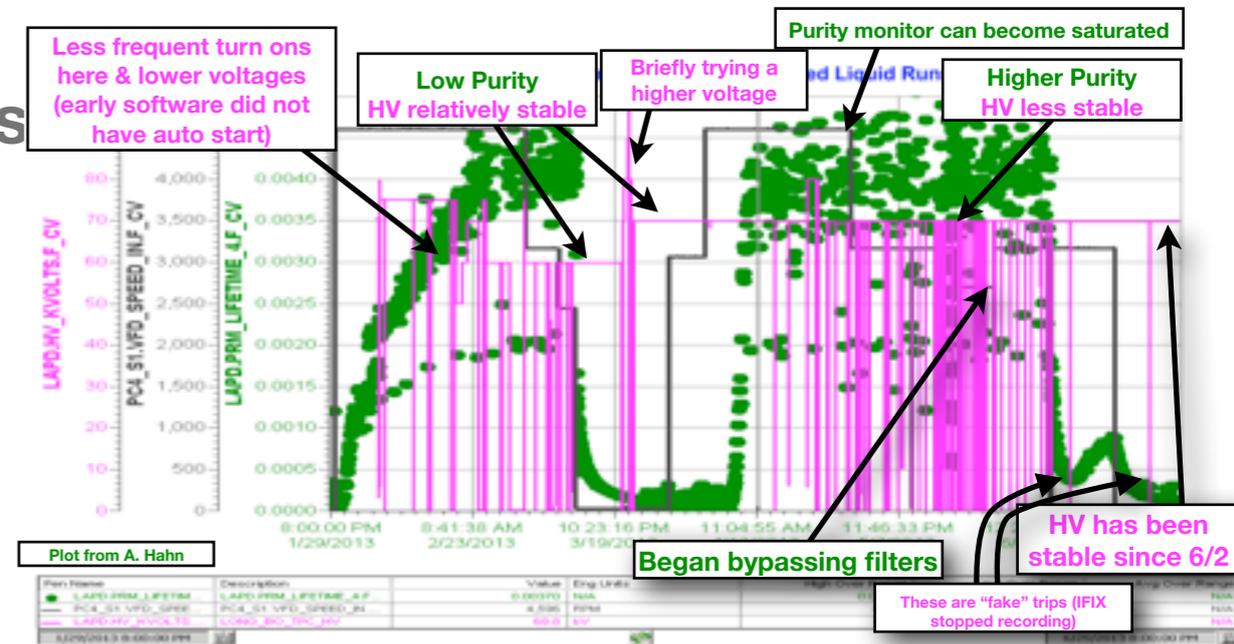


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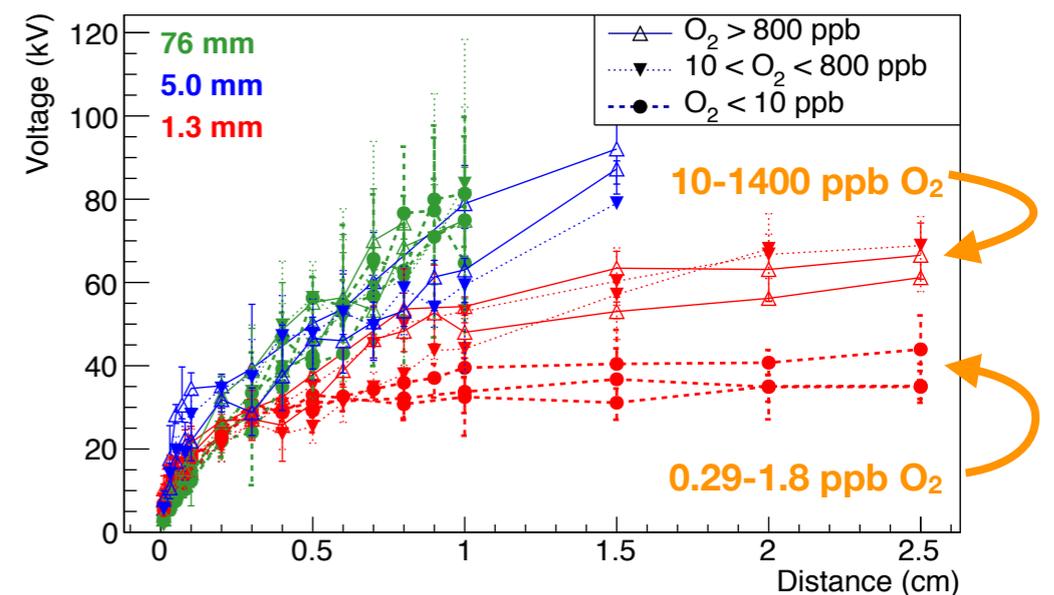
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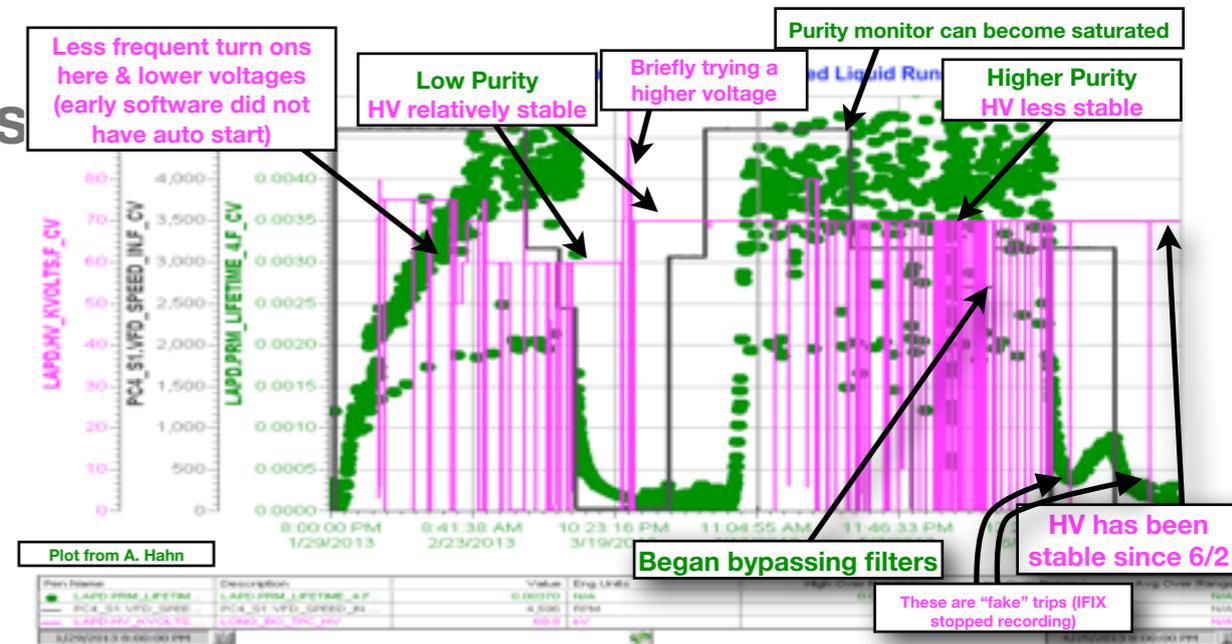


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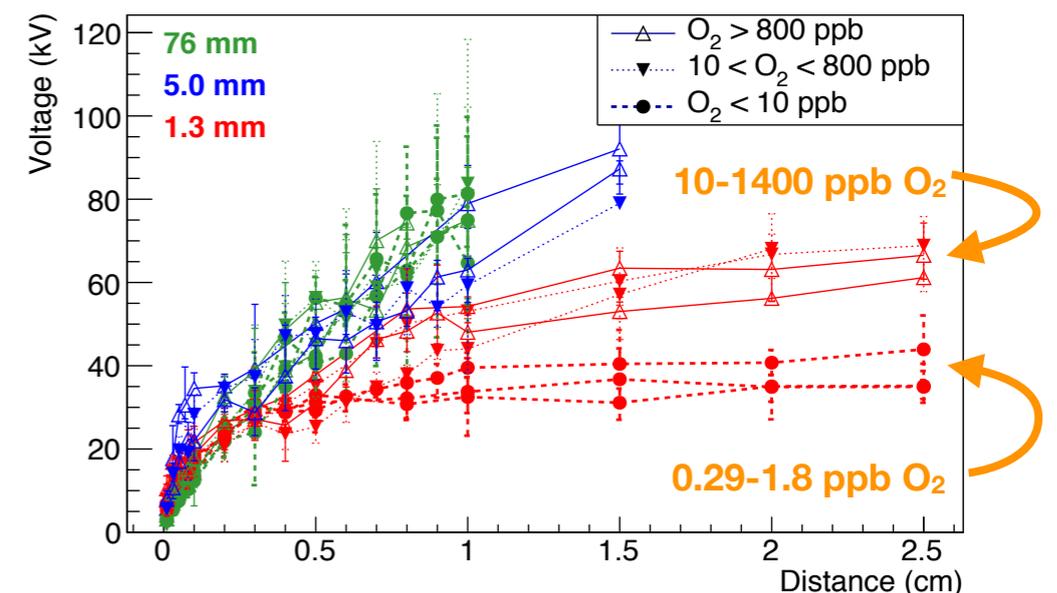
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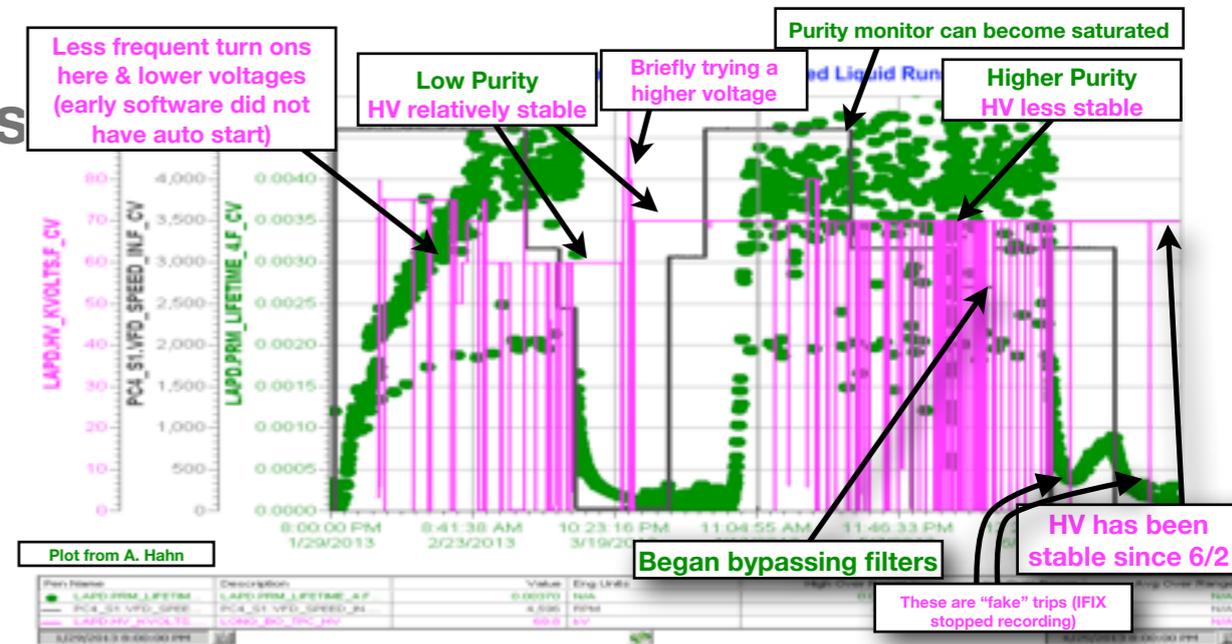


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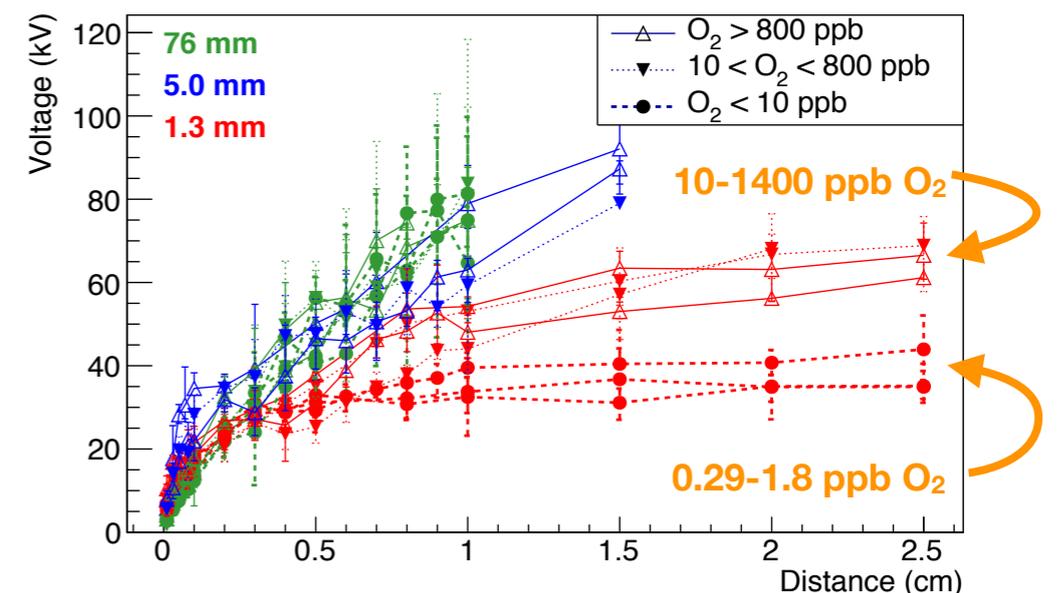
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  - We want to better understand the conditions where purity affects HV performance
  - And light as it relates to breakdown



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## 2. The performance of electrical insulators in liquid argon

- Insulators are often under electrical stress in parts of LArTPCs (and their feedthroughs)
- We plan to study insulator performance in a high voltage feedthrough-like geometry in the coming months

