Development and Testing of LZ's High Voltage Grids

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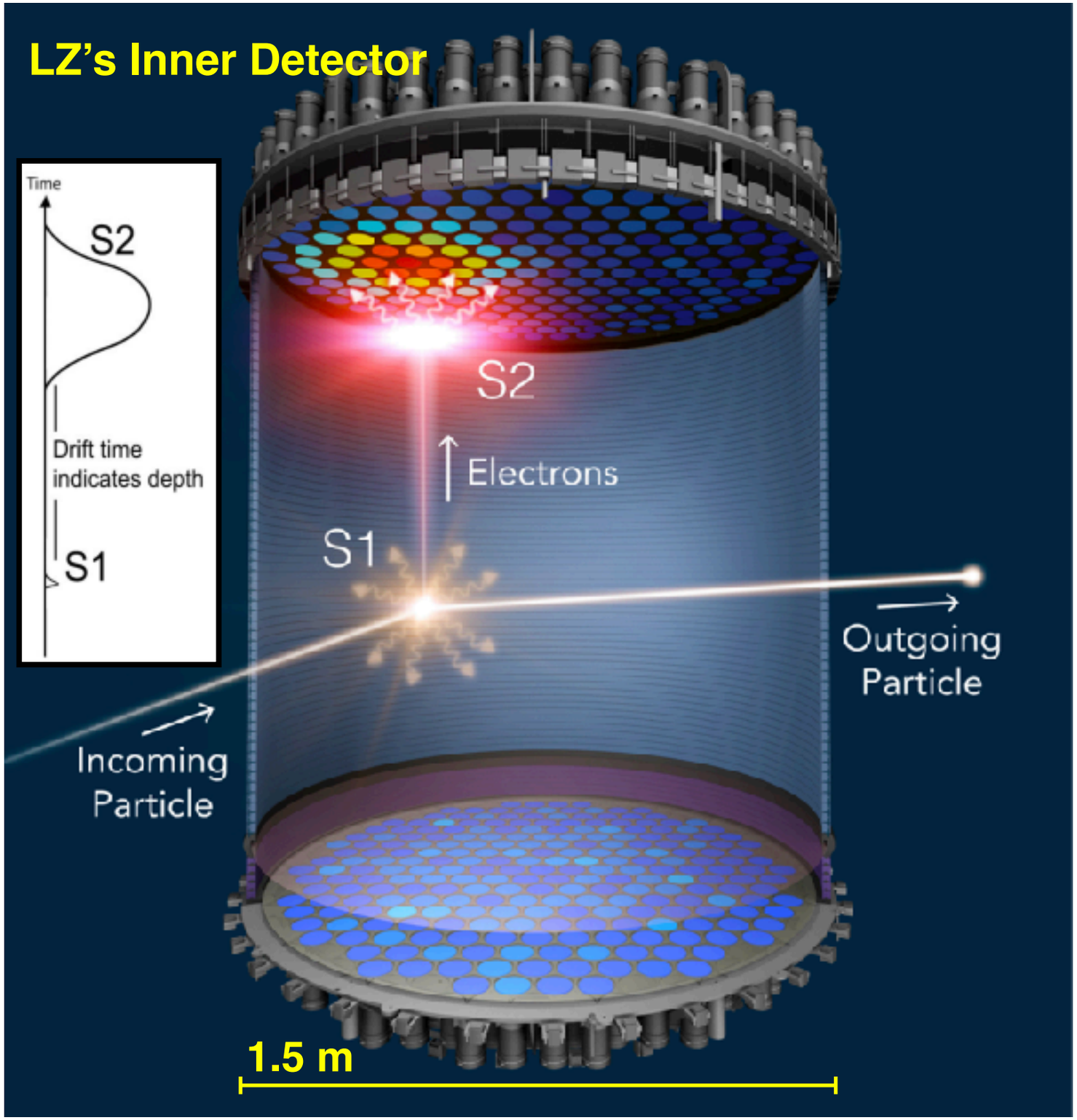
on behalf of the the LZ Collaboration

The LUX-ZEPLIN Experiment

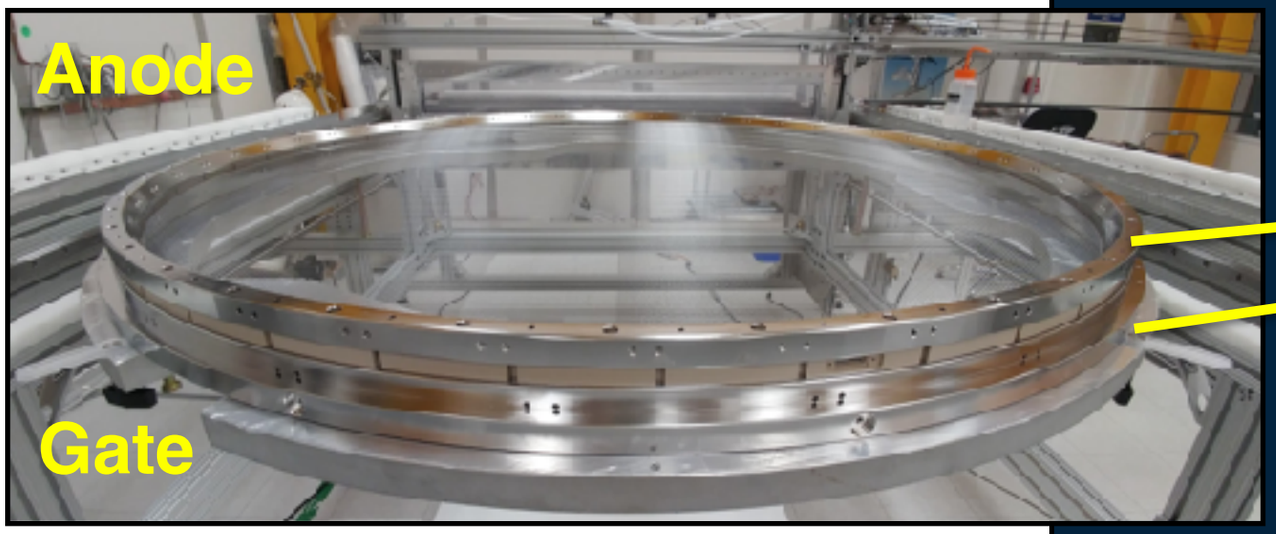
LZ: low-background WIMP search experiment.

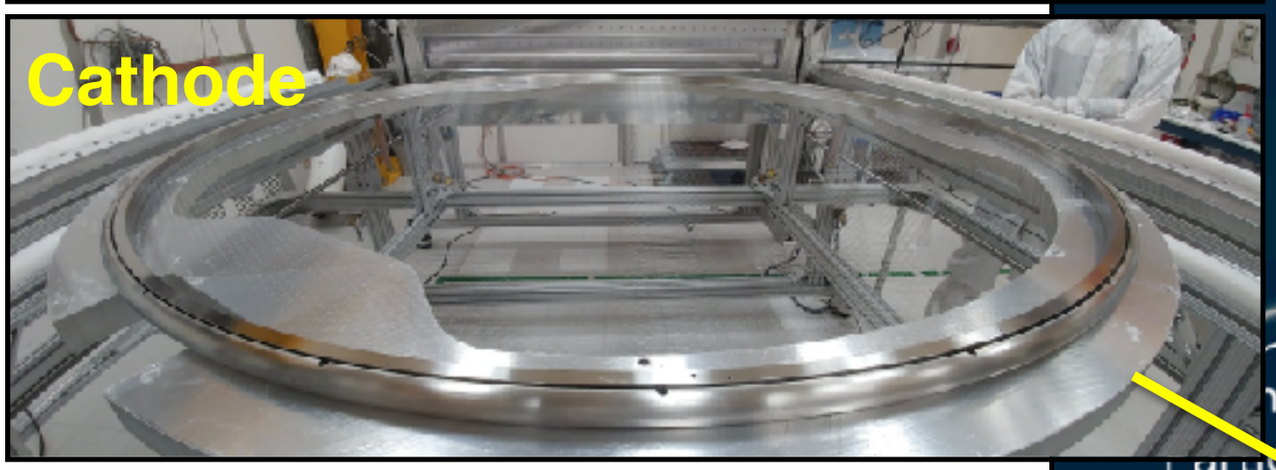
- Dual-phase liquid xenon time projection chamber (TPC)
- Sensitivity to single quanta of light and charge

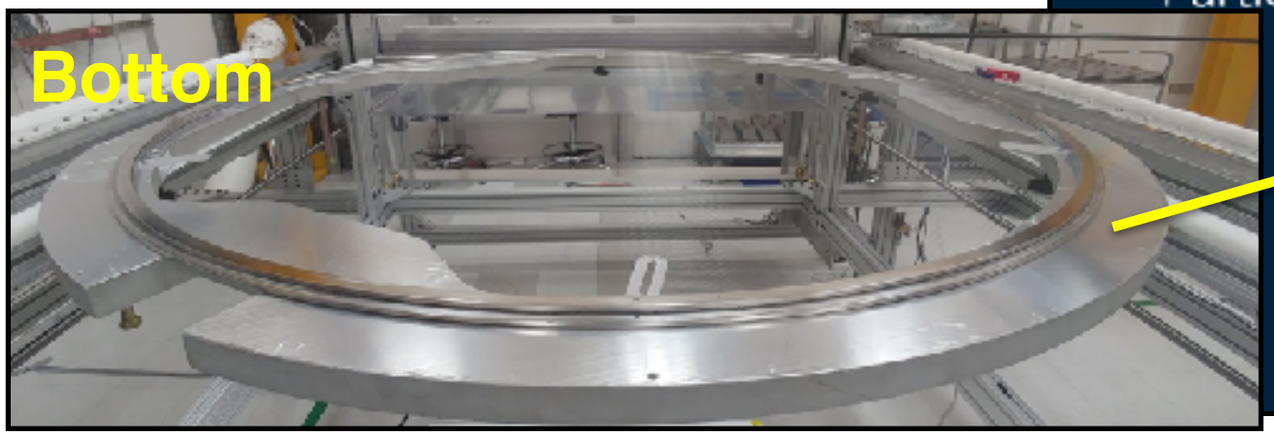


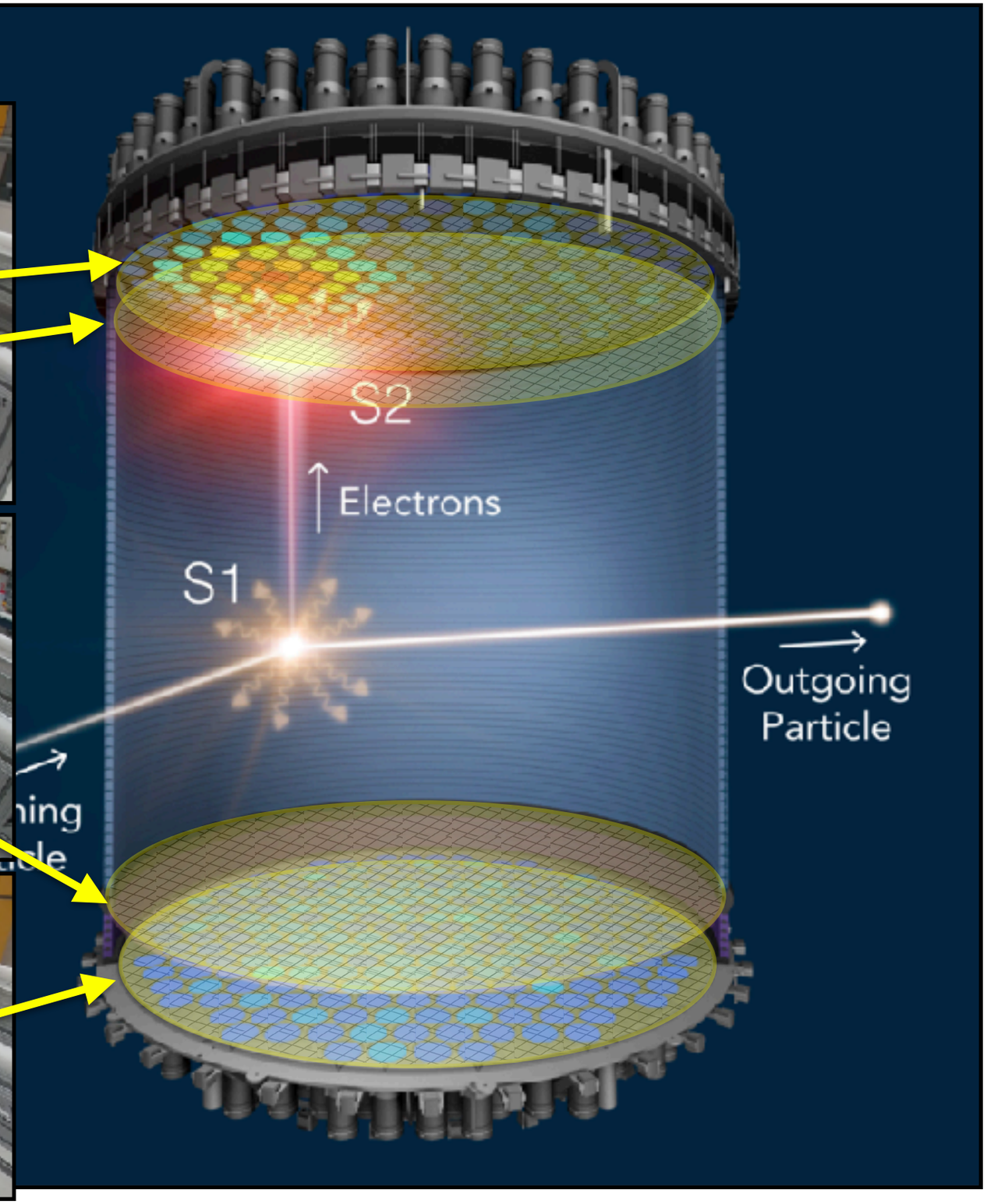
The LZ High Voltage Grids

Electric fields in LZ are set by four woven mesh wire grids.



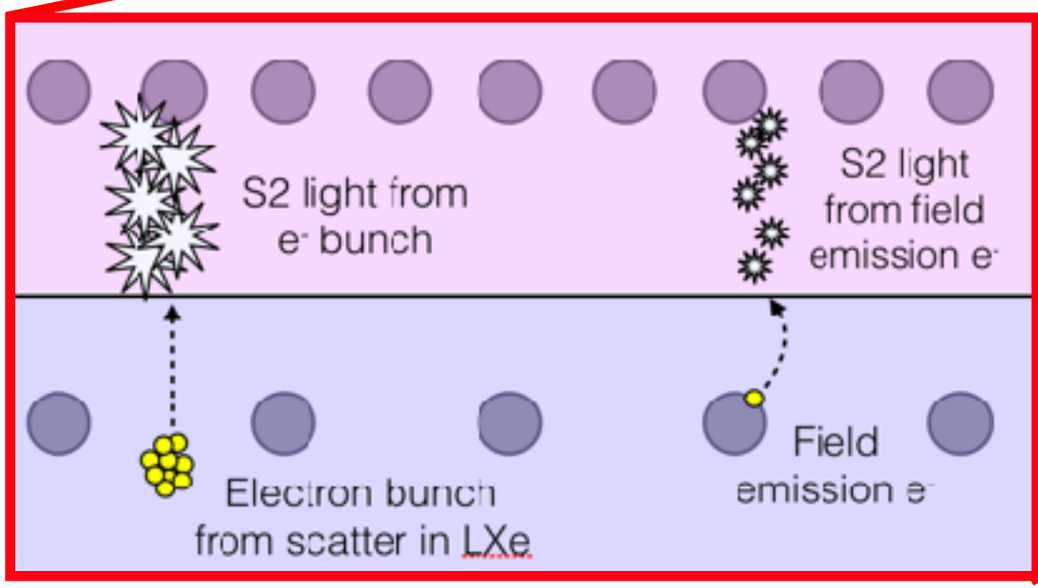


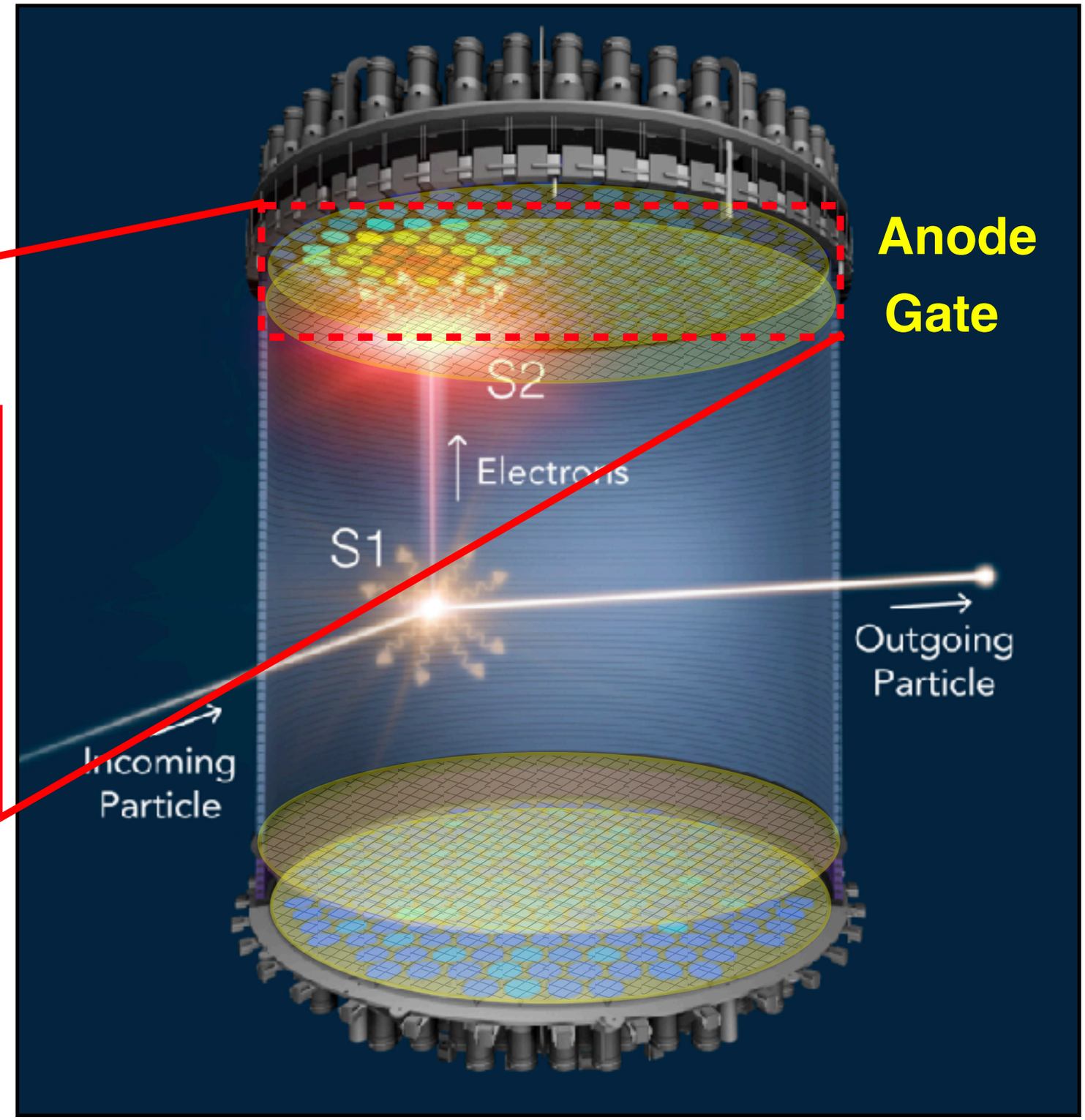




Electron Emission from the LZ Grids

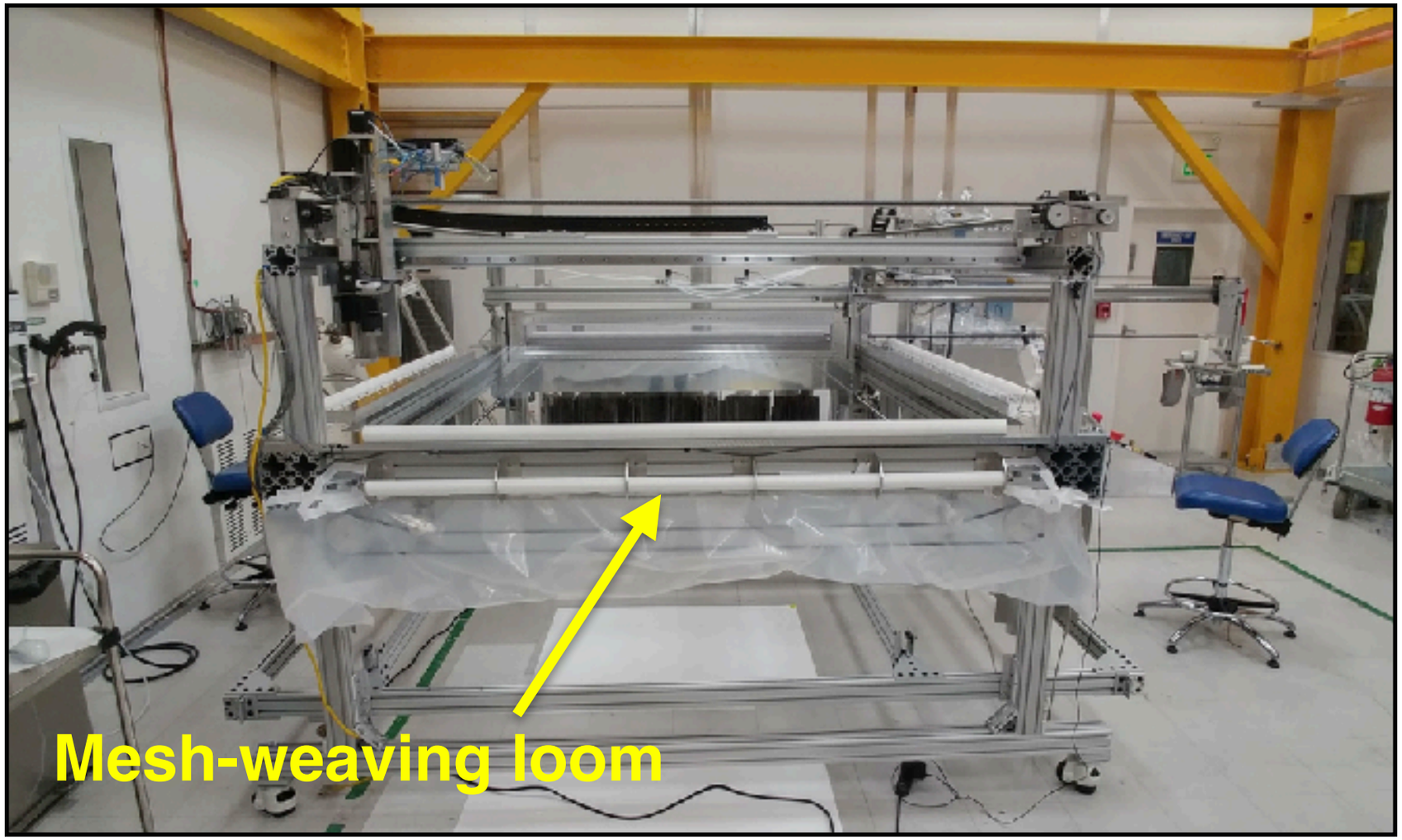
Grid-induced background: field electron emission

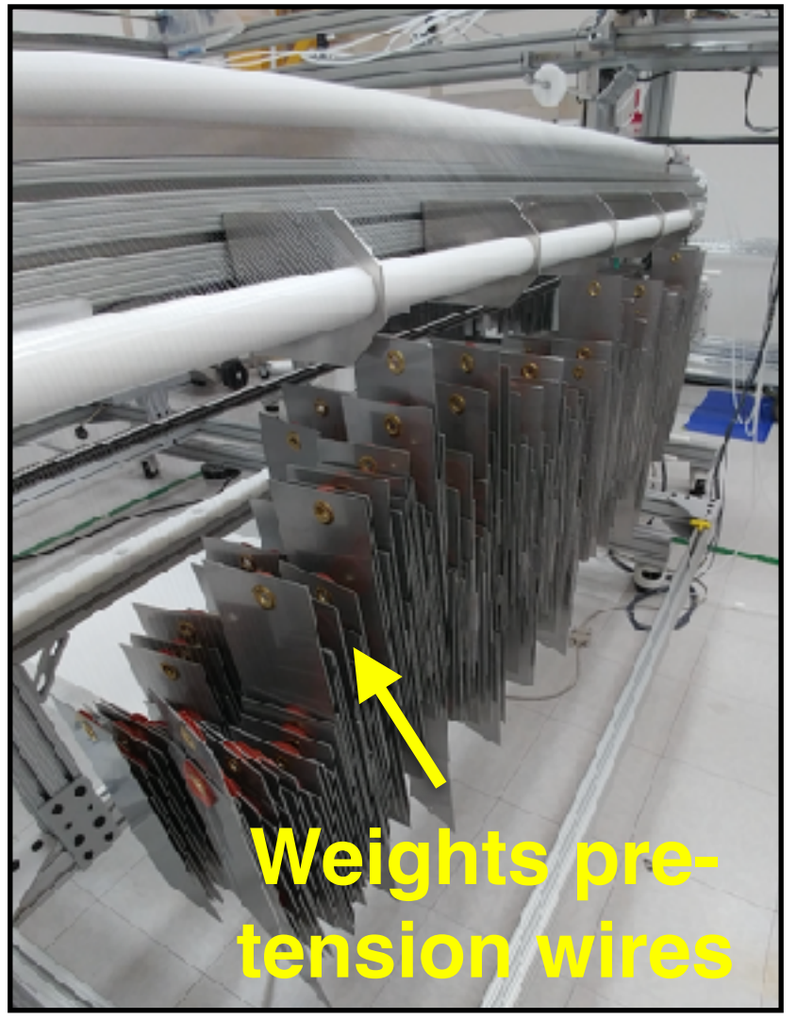




Understanding and limiting grid field emission is important.

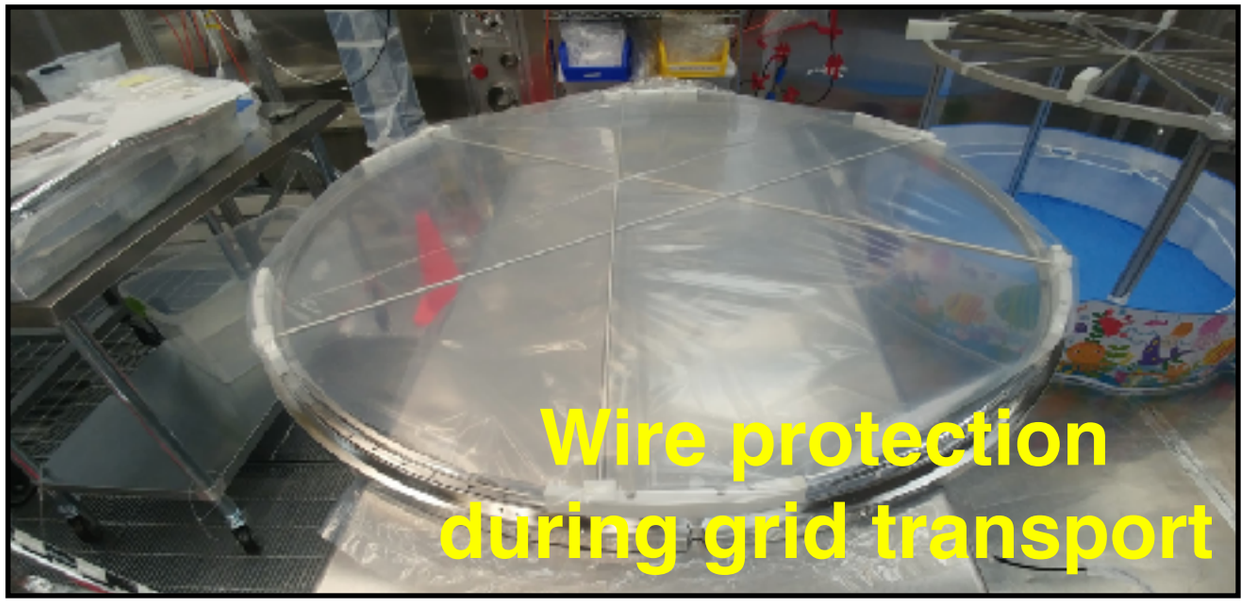
High Voltage Grid Production





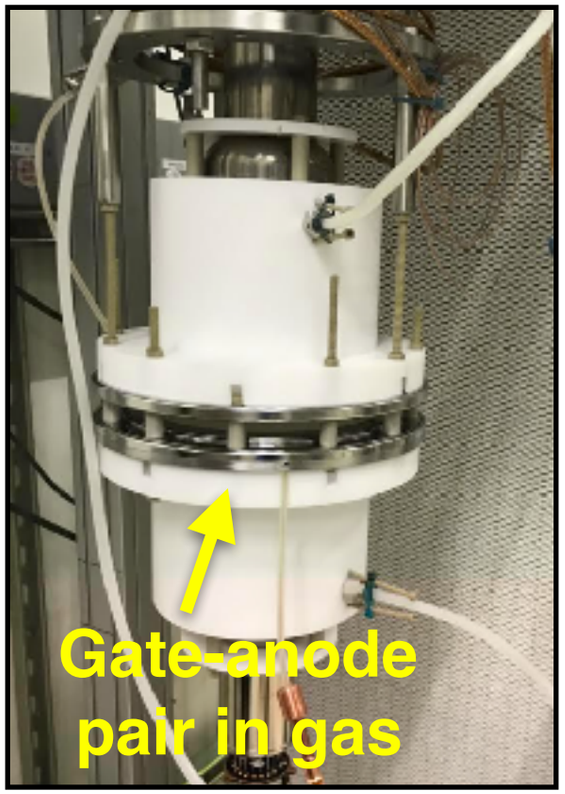
<u>Design and production tuned to limit risk of electron emission</u>

- Custom-built loom
- Pre-tensioned wires
- Class 100 cleanroom
- Bagging and transport protection

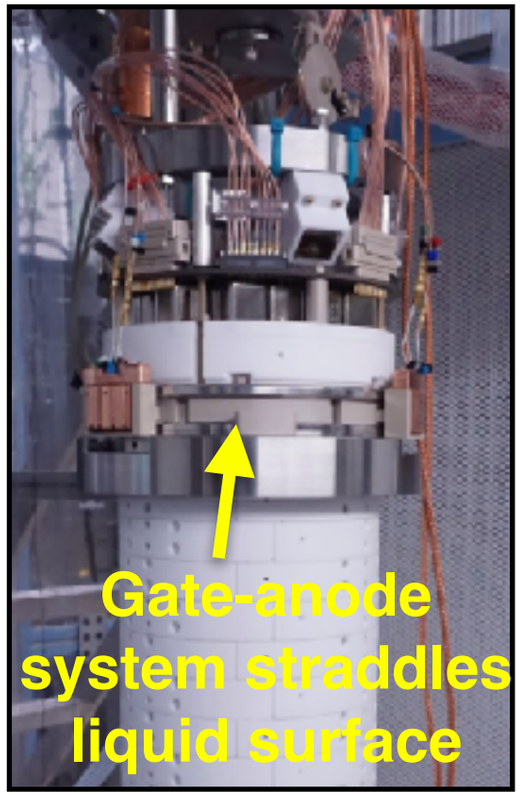


Measuring Electron Emission for Gate-Anode Pair

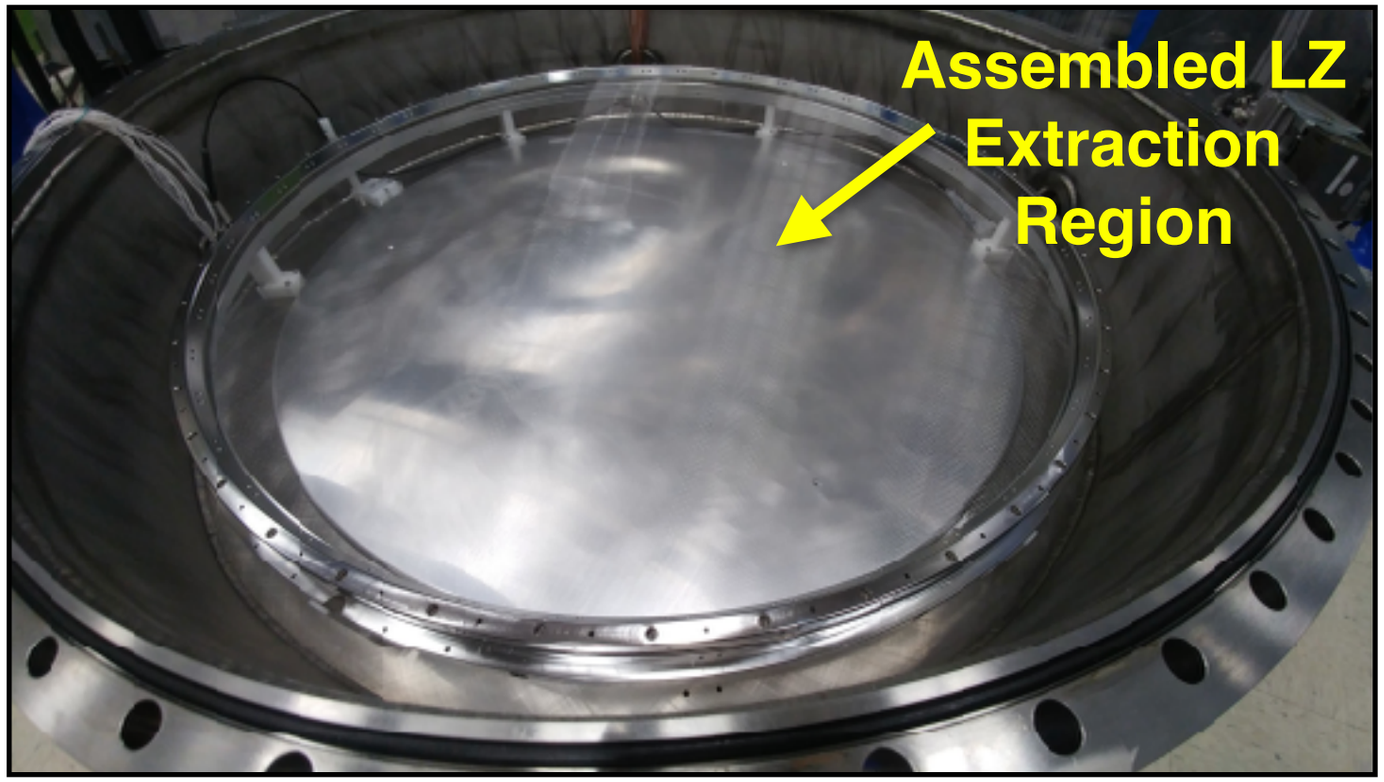
Goal: understand dominant contributors to electron emission from HV grids.



Small-scale GXe Chamber



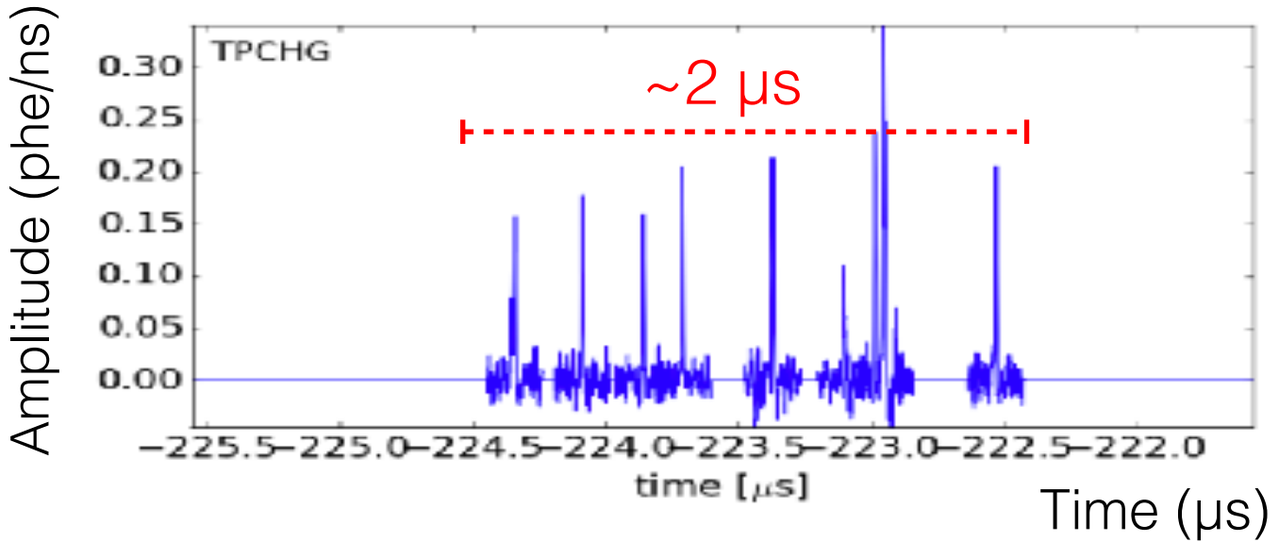
Small-scale Dual-Phase Xe TPC



LZ-scale GXe Chamber

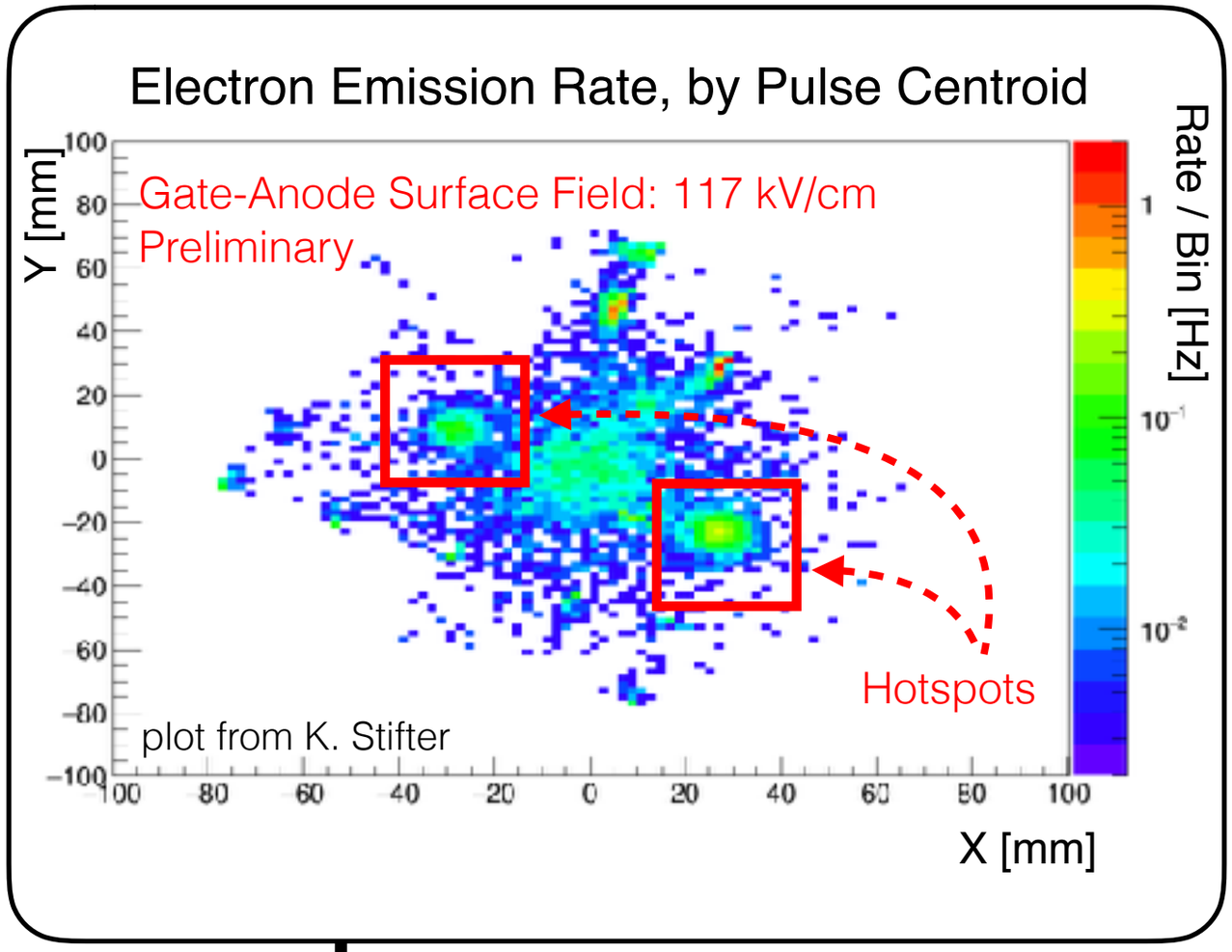
- PMT arrays detect electroluminescence light
- Isolate single electron emission pulses

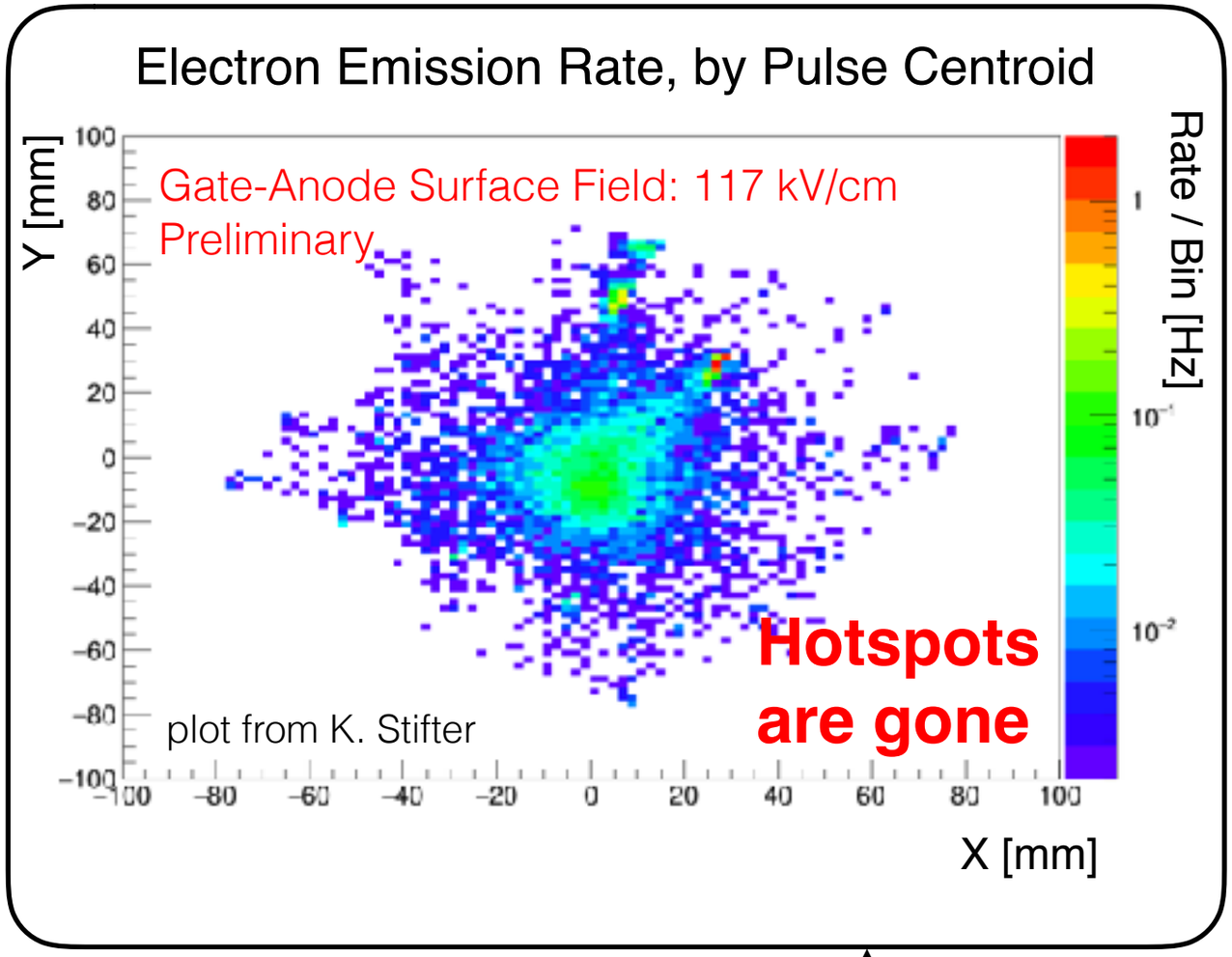
Field Emission Electron Candidate (Full-scale GXe)



Challenge: “Permanent” Grid Emission Sites

Tests in Small-Scale GXe Detector





Test 1

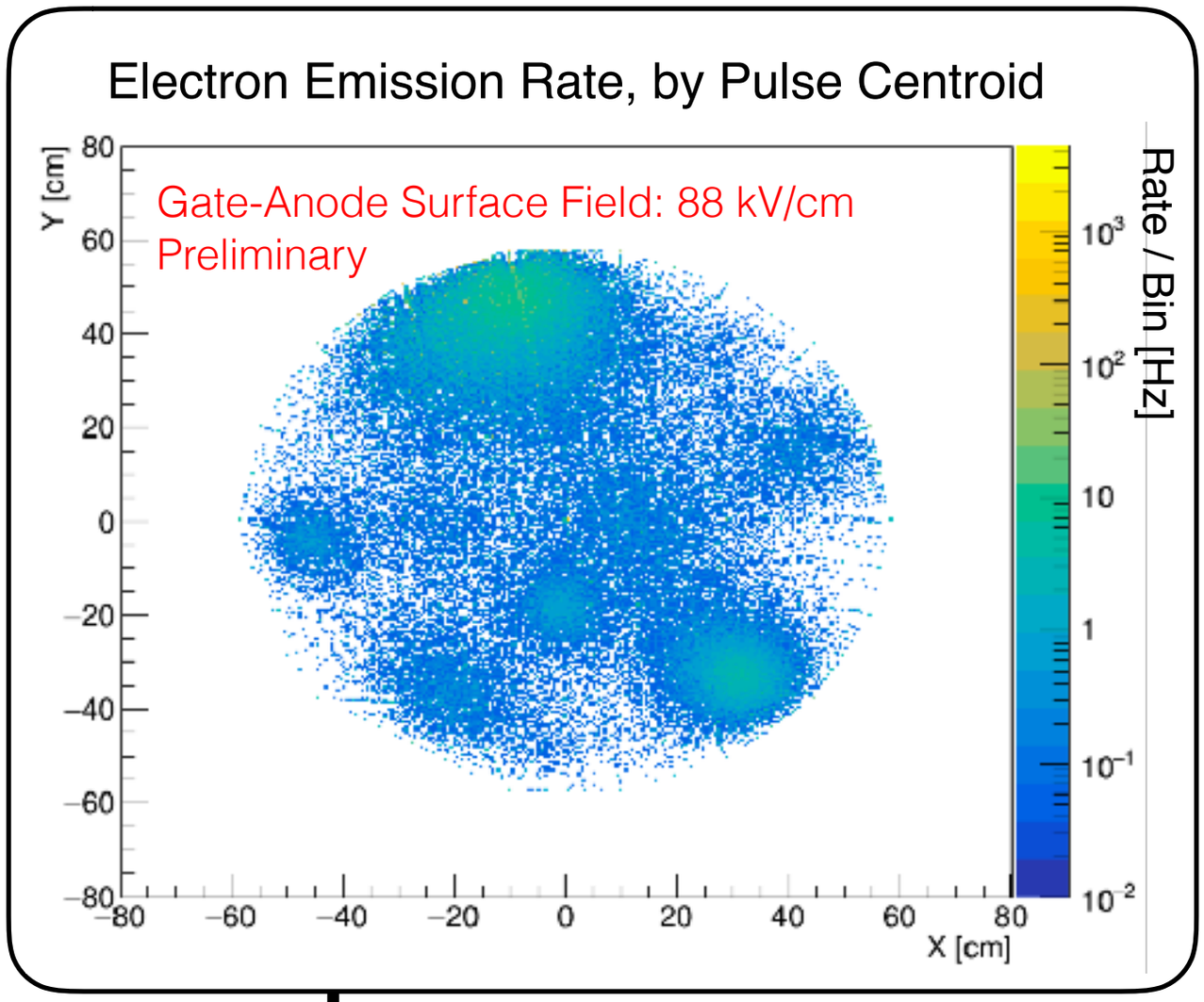
Test 2

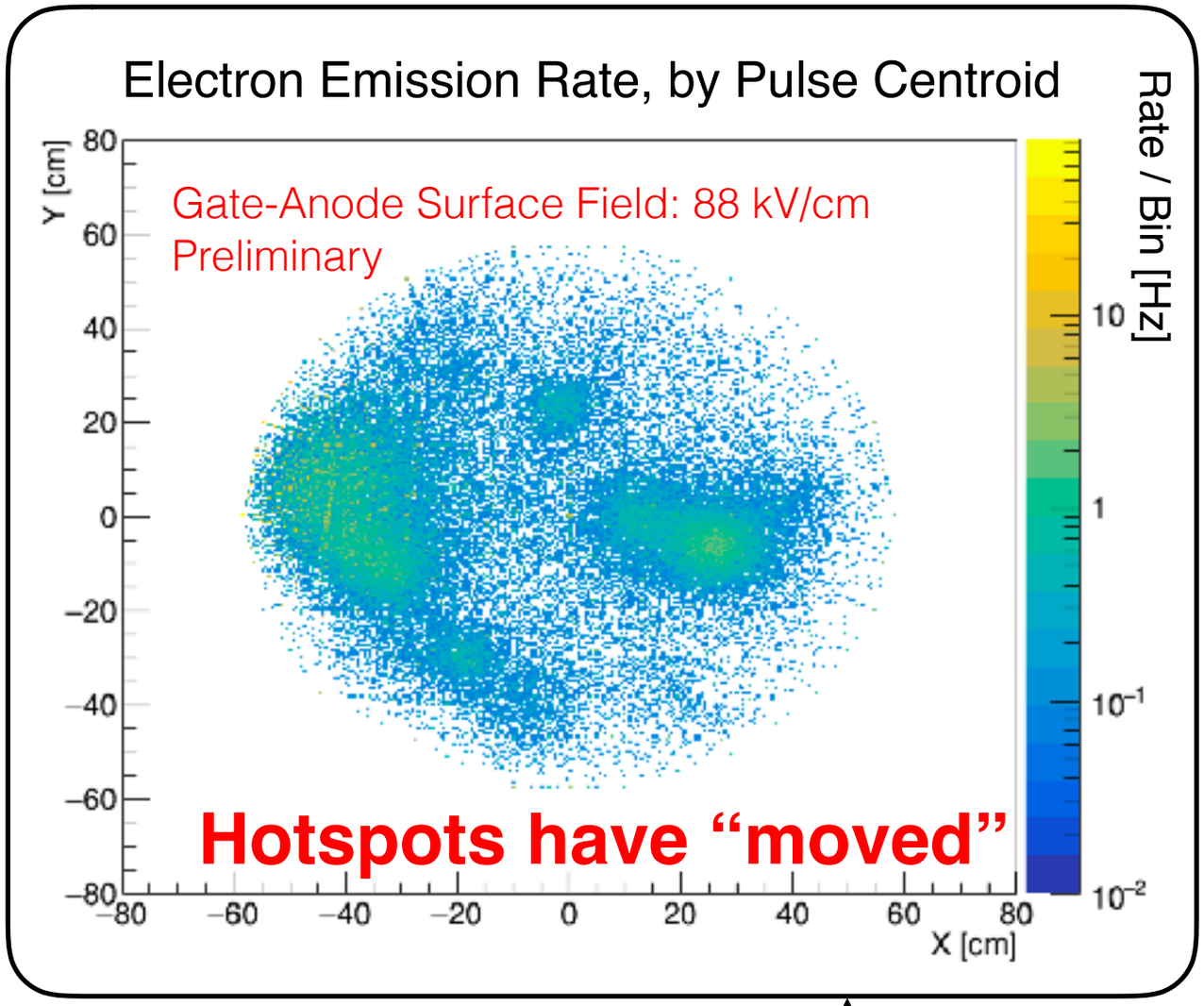
After Test 1: Grid passivated*

*Motivated by studies at Imperial College London (Tomás et al., arXiv:1801.07231v2)

Challenge: “Transient” Grid Emission Sites

Tests in LZ-Scale GXe Detector





Test 1

Test 2

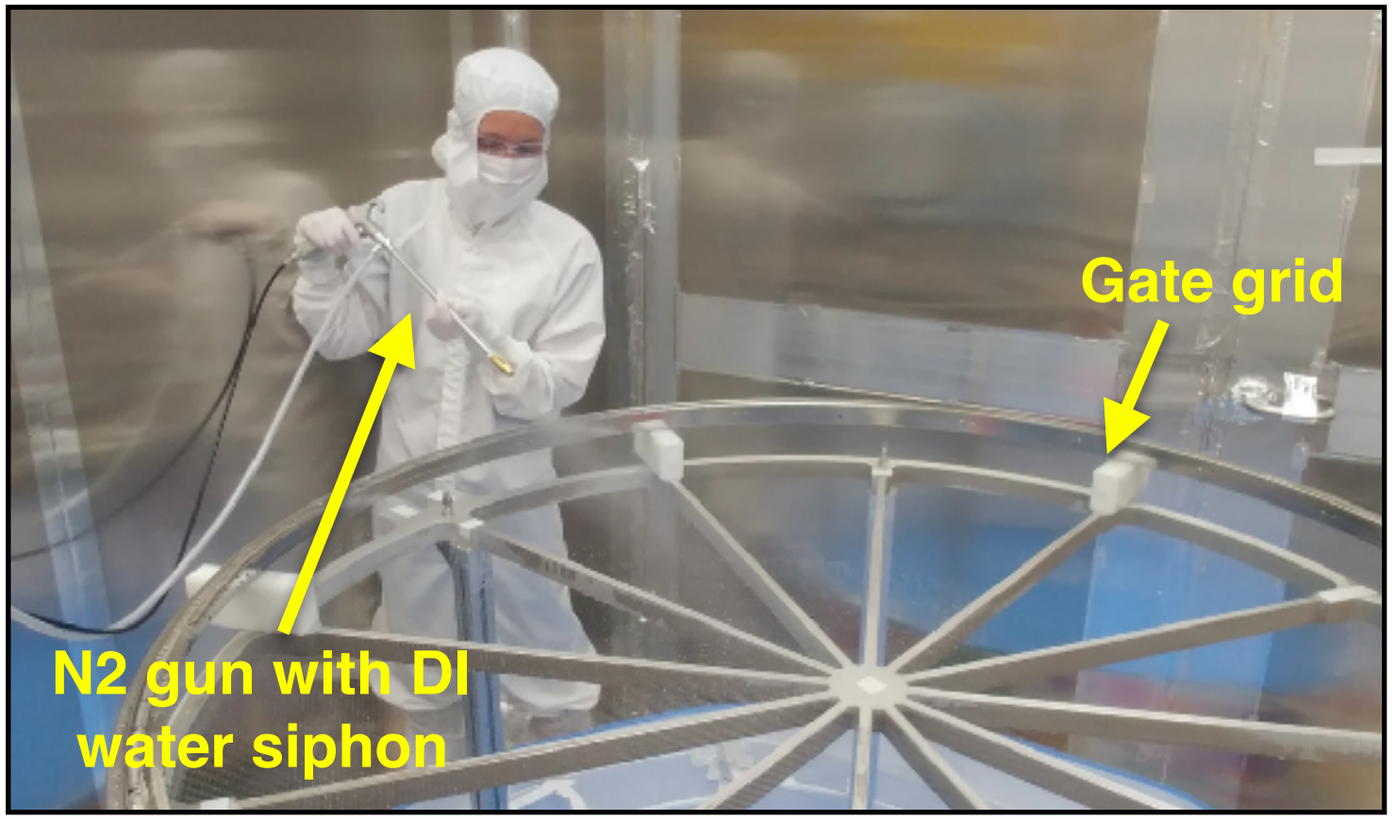
<u>After Test 1:</u>

1. Some dust/fibers added to grids during intermediate test
2. Some dust/fibers deliberately removed after intermediate test

Applying Electron Emission Reduction Strategies

<u>Passivation of the gate grid</u>
- Removes more “permanent” emission hotspots

<u>Pre-installation washing</u>
- Removes fibers and small dust particles
- Reduces debris-induced hotspots



Summary

1. Electron emission from high voltage wire grids will be a background in LZ.

2. At SLAC, the grids program is designed to minimize risk of this emission.
   1. Grid production is tuned to limit potential emission sites.
   2. A high voltage test platform was used to assess origins of emission.

3. We've successfully optimized grid performance by passivating and washing LZ grids before detector integration.

Thanks much to the SLAC Grids/System Test Teams (and many more):

- Dan Akerib
- Shaun Alsum
- Tyler Anderson
- Maris Arthurs**
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- Tomasz Biesiadzinski
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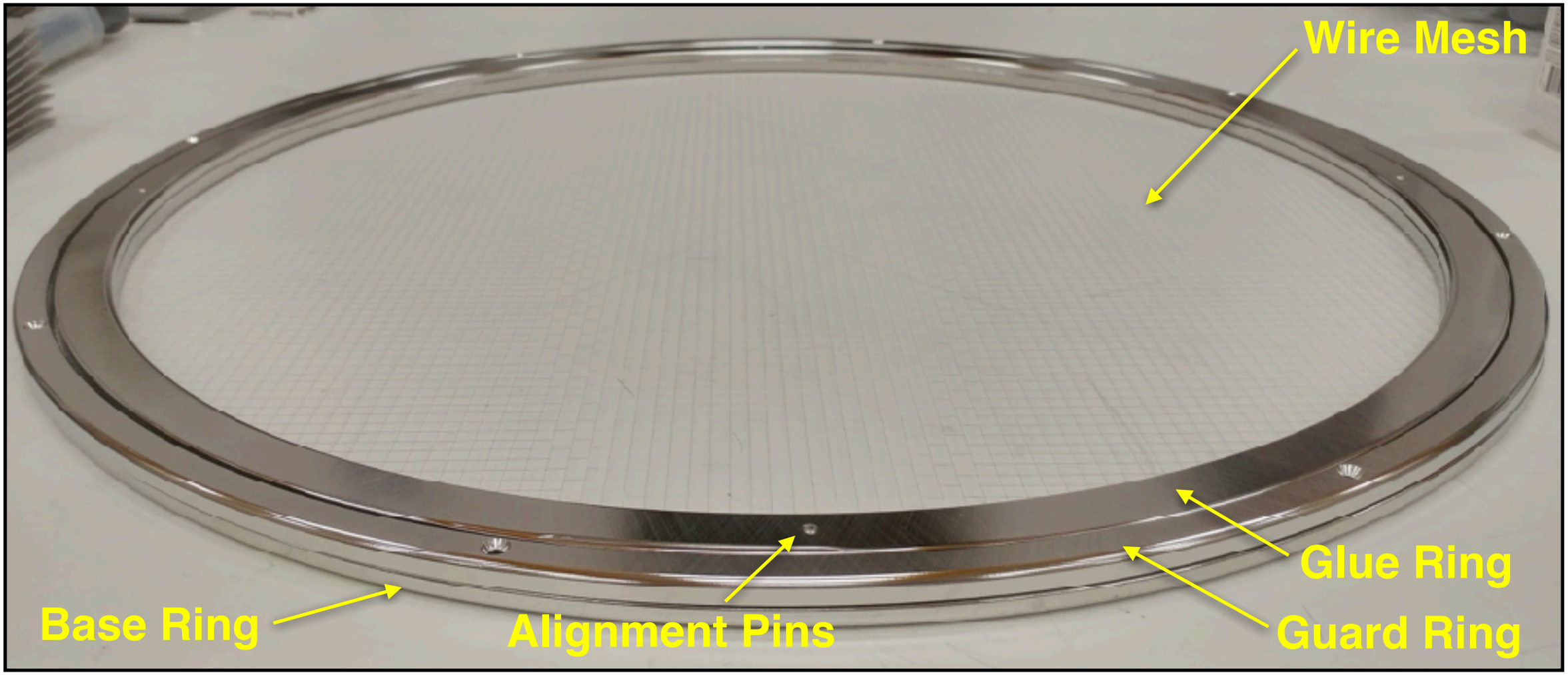
- Wei Ji
- Scott Kravitz***
- Nadine Kurita
- Wolfgang Lorenzen**
- Steffen Luitz
- Rachel Mannino*
- Maria Elena Monzani
- Eric Miller
- Kim Palladino*
- Tom Shutt
- Kelly Stifter
- Randy White
- TJ Whitis
- Ken Wilson***

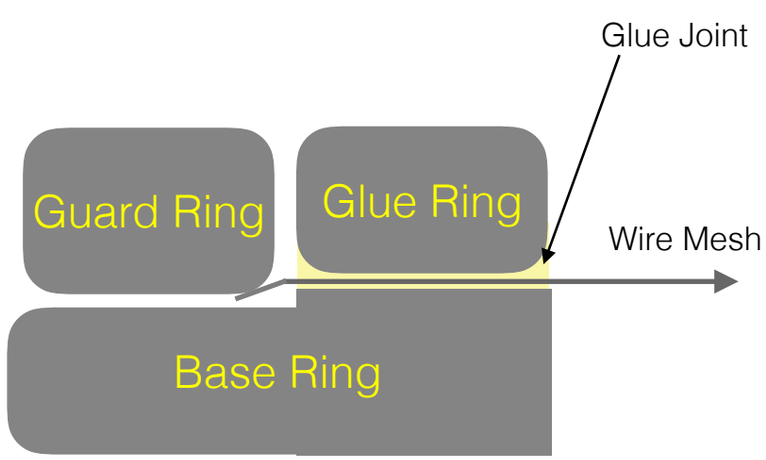
***Also associated with LBNL
**Also associated with University of Michigan
*Also associated with University of Wisconsin

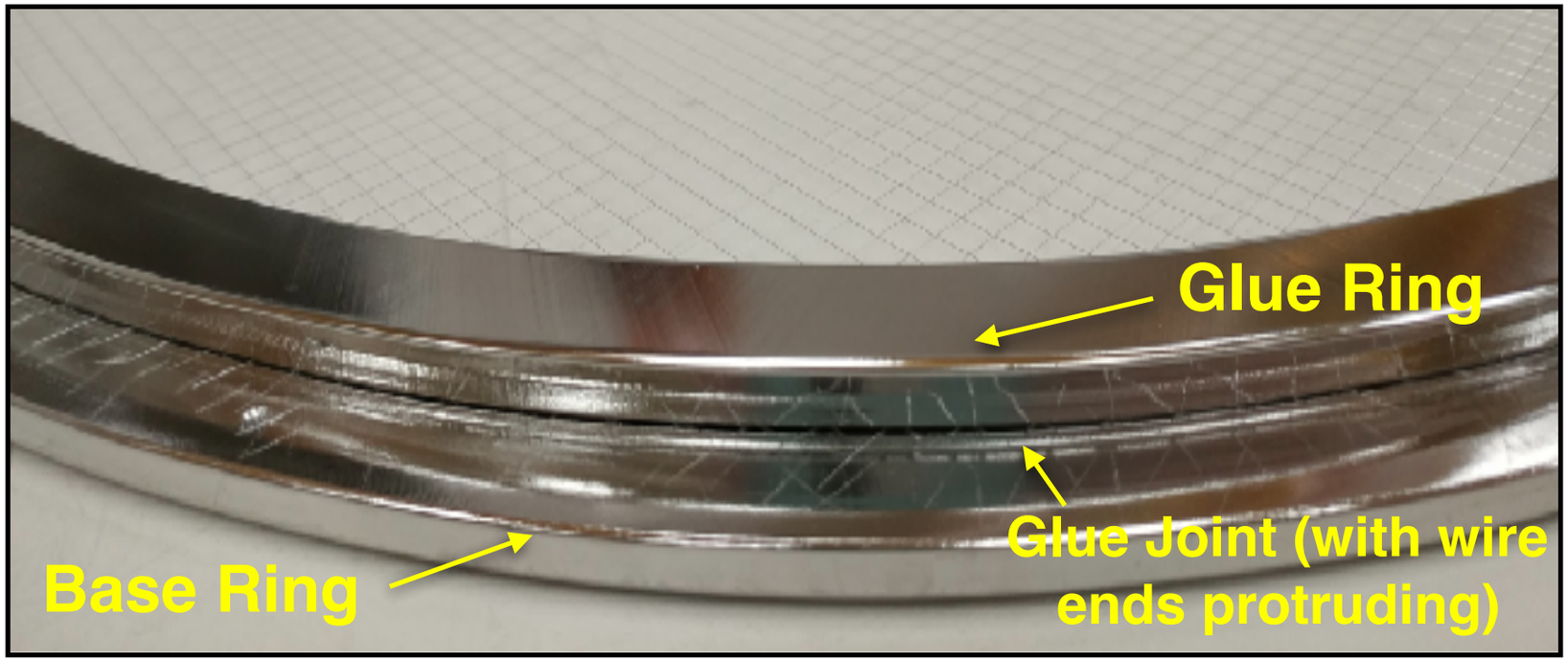
Backup Slides

Backup: Anatomy of a Grid

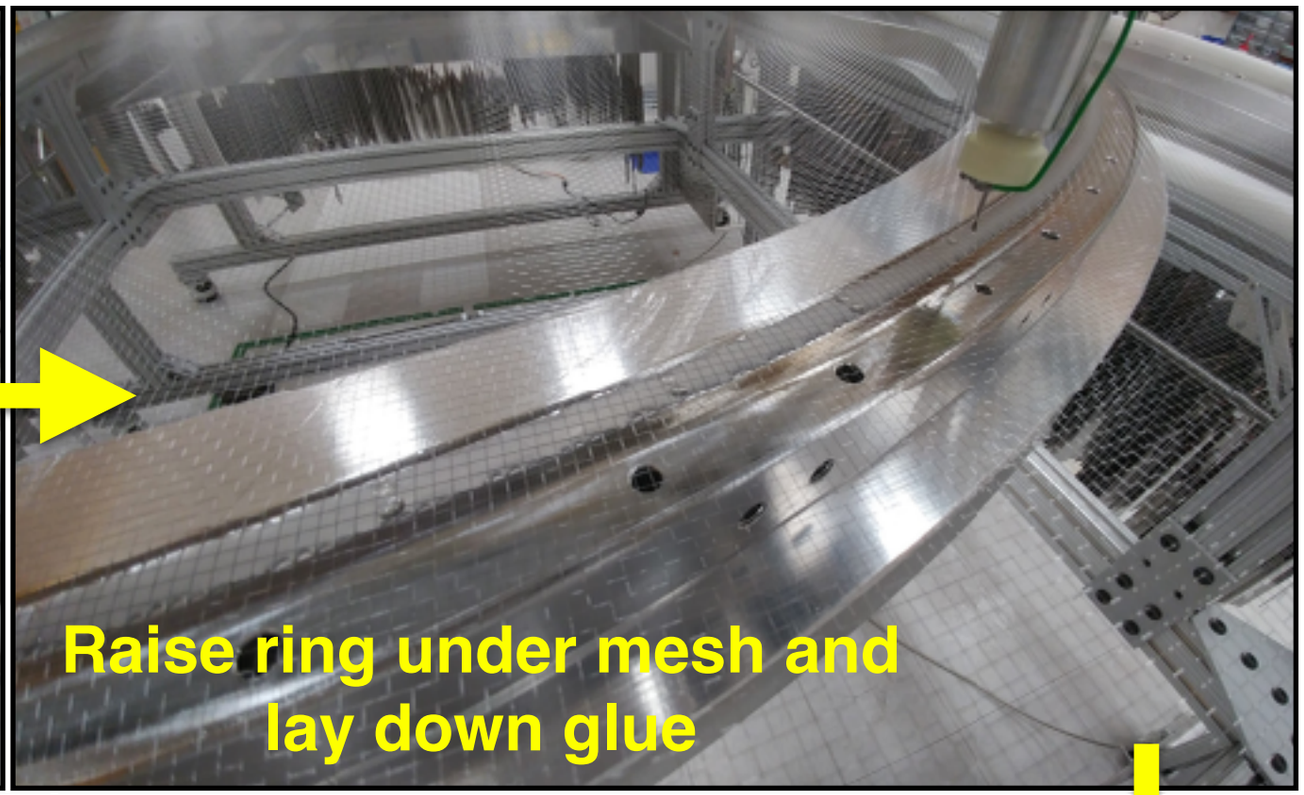


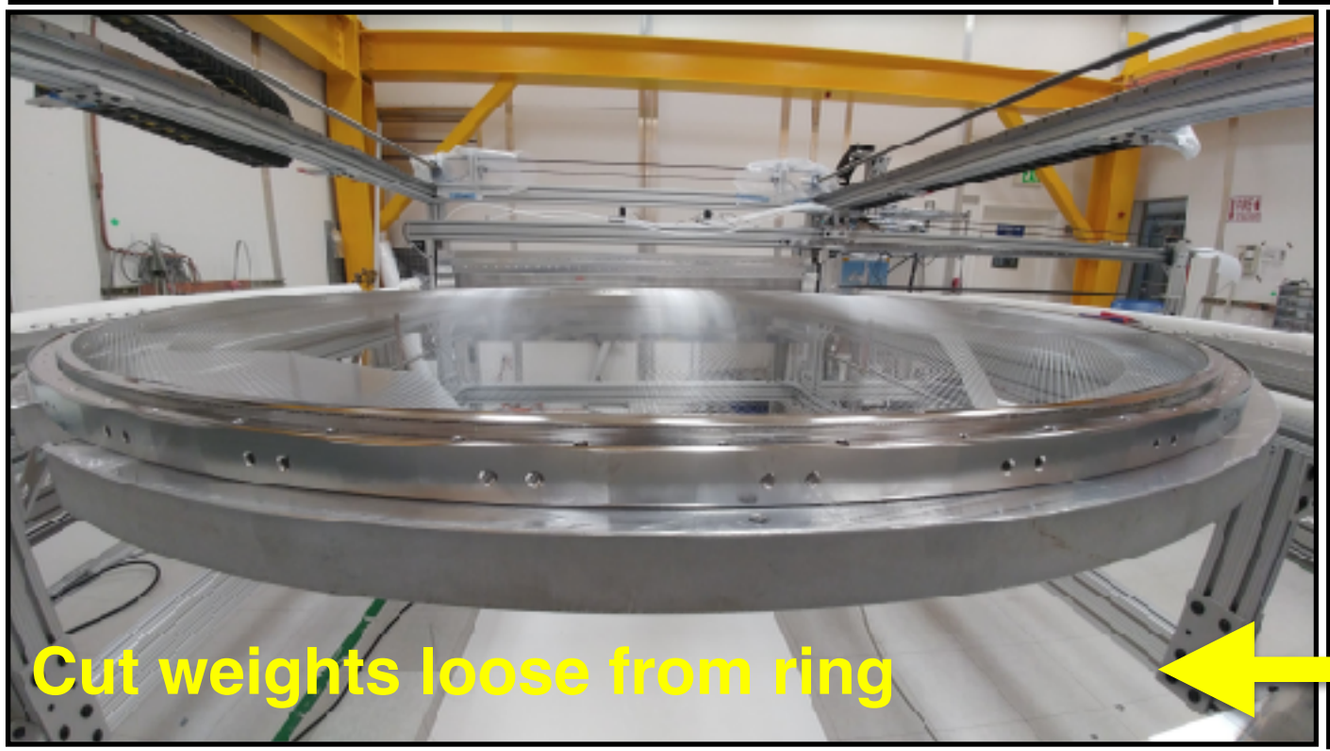
Grid Cross Section

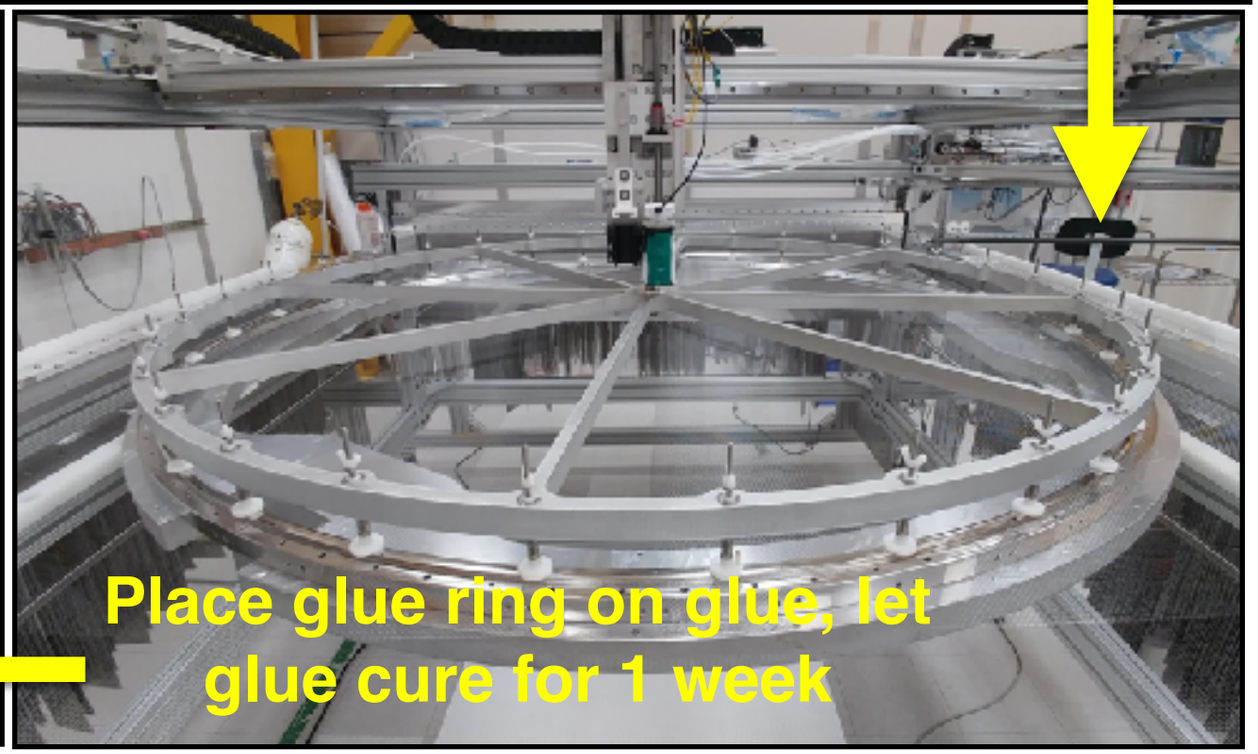




Backup: How a Grid is Made







Backup: Identifying the Electron Signal

Electrons drifting from grid to grid emit light in a pulse of a well-defined width.

- Drift time from grid to grid is well-defined.
- For ΔV = 10kV, duration is ~2.5 μs
- Select on a duration window to isolate electrons

Other cuts made for further isolation:

- Photon count: helps eliminate muons
- Anderson-Darling test statistic: helps eliminate pileup pulses

All Pulses from one run of LZ-Scale GXe Chamber