Development and Testing of LZ’s High Voltage Grids

Ryan Linehan
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.
Design and production tuned to limit risk of electron emission
- 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.

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

Gate-anode pair in gas

Gate-anode system straddles liquid surface

Assembled LZ Extraction Region

Small-scale GXe Chamber

Small-scale Dual-Phase Xe TPC

LZ-scale GXe Chamber

Field Emission Electron Candidate (Full-scale GXe)

~2 µs
Challenge: “Permanent” Grid Emission Sites

Tests in Small-Scale GXe Detector

Electron Emission Rate, by Pulse Centroid

Gate-Anode Surface Field: 117 kV/cm
Preliminary

plot from K. Stifter

Hotspots

Rate / Bin [Hz]

X [mm]

Y [mm]

Test 1

Electron Emission Rate, by Pulse Centroid

Gate-Anode Surface Field: 117 kV/cm
Preliminary

plot from K. Stifter

Hotspots are gone

Rate / Bin [Hz]

X [mm]

Y [mm]

Test 2

After Test 1: Grid passivated*

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

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Challenge: “Transient” Grid Emission Sites

Tests in LZ-Scale GXe Detector

Electron Emission Rate, by Pulse Centroid

Test 1

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

Test 2

Hotspots have “moved”
Applying Electron Emission Reduction Strategies

Passivation of the gate grid
- Removes more “permanent” emission hotspots

Pre-installation washing
- 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.

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Backup Slides
Backup: Anatomy of a Grid

- Wire Mesh
- Glue Ring
- Guard Ring
- Base Ring
- Alignment Pins
- Glue Joint (with wire ends protruding)

Grid Cross Section

- Guard Ring
- Glue Ring
- Wire Mesh
- Glue Joint

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Backup: How a Grid is Made

1. Weave Mesh on Loom
2. Raise ring under mesh and lay down glue
3. Place glue ring on glue, let glue cure for 1 week
4. Cut weights loose from ring
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 $\Delta V = 10kV$, duration is $\sim 2.5 \mu s$
- 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