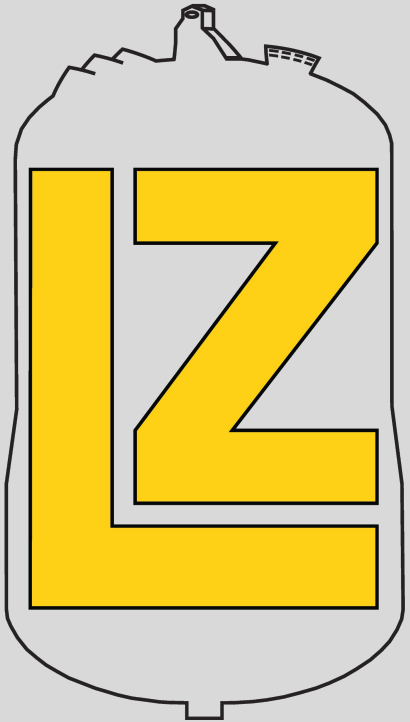
Metallic wire grid behavior and testing in low pressure gaseous noble elements detector

Wei JI

CPAD 2017 Oct 12, 2017



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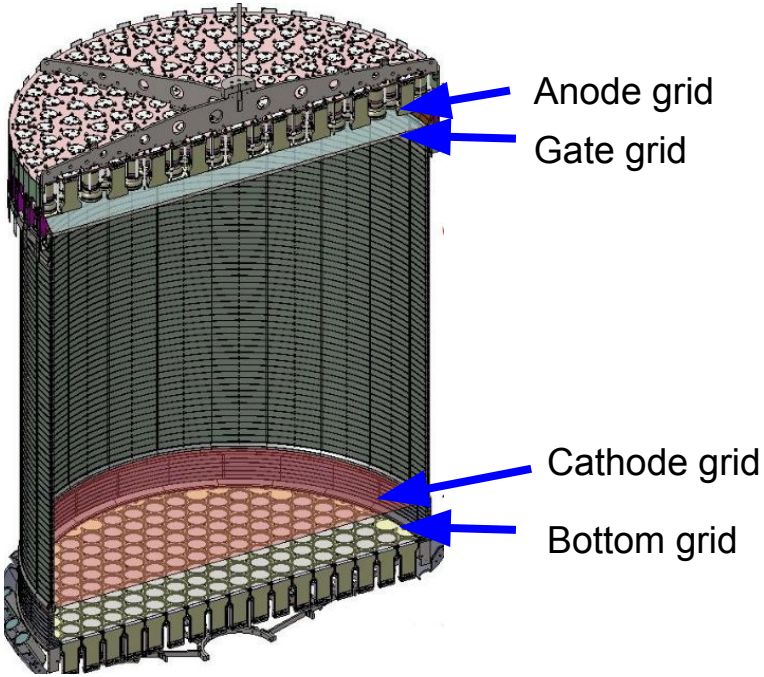
KIPAC

Overview

- Motivation
- LZ Grids test in xenon gas and liquid.
- Results and discussion.

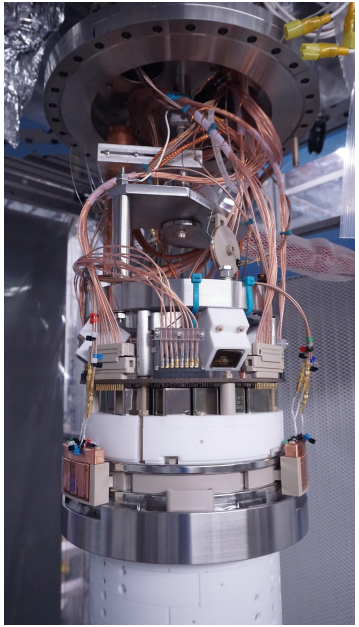
Motivation

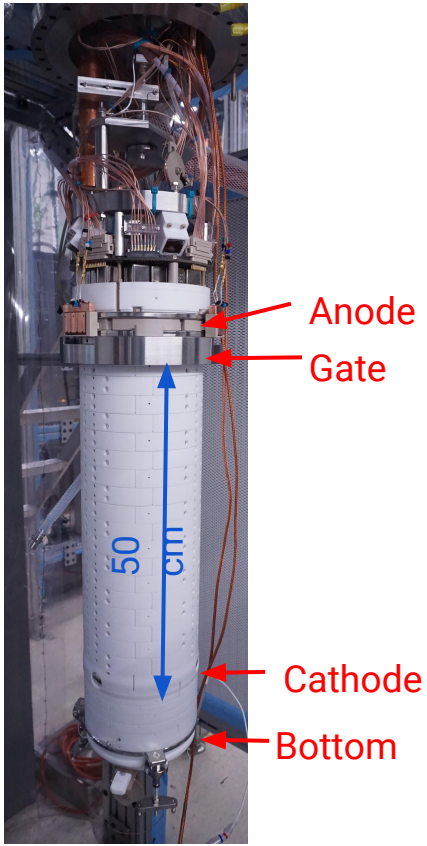


Cross section of LZ TPC

1. LZ TPC has grids.
2. Grids are troublesome.
3. Grids need to be transparent, mechanically rigid, which makes them worse.
4. We are testing LZ grids.
5. Our Approach:
    a. **Phase I:** Small scale grids in dual phase. (see A. Fan's talk)
    b. **Phase II:** Full scale grids in gas phase.
    c. **Gas Test:** Small scale gas tests that bridge the two.

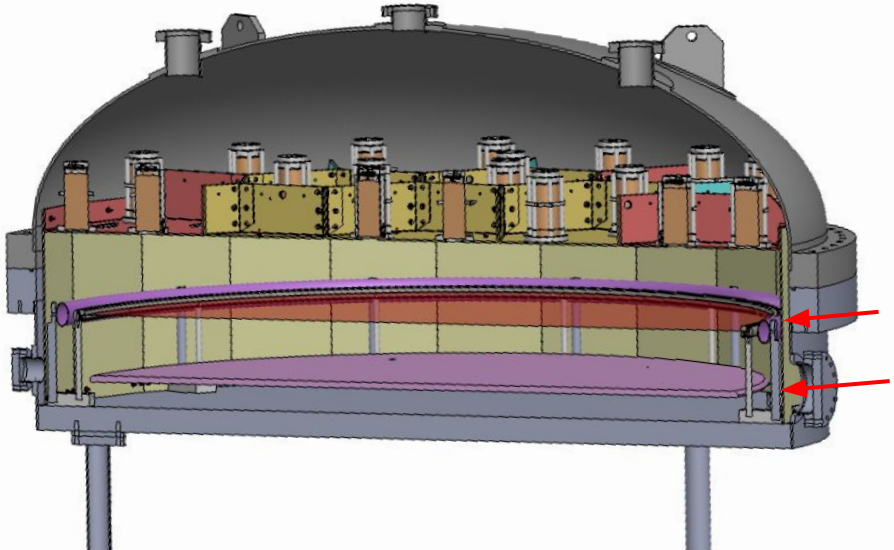
Phase I





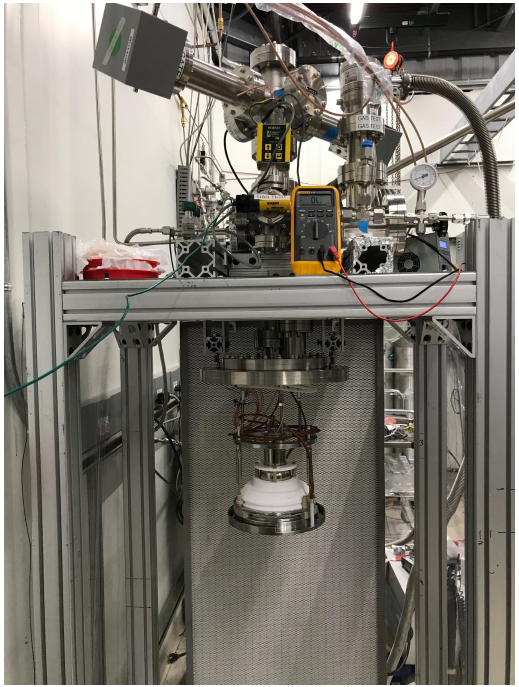
- Designed for broad set of tests.
- Well suited to study modest size grids in liquid xenon.
- 0.15 meter diameter
- 32 PMT coarse array.
- Liquid operations are time consuming.

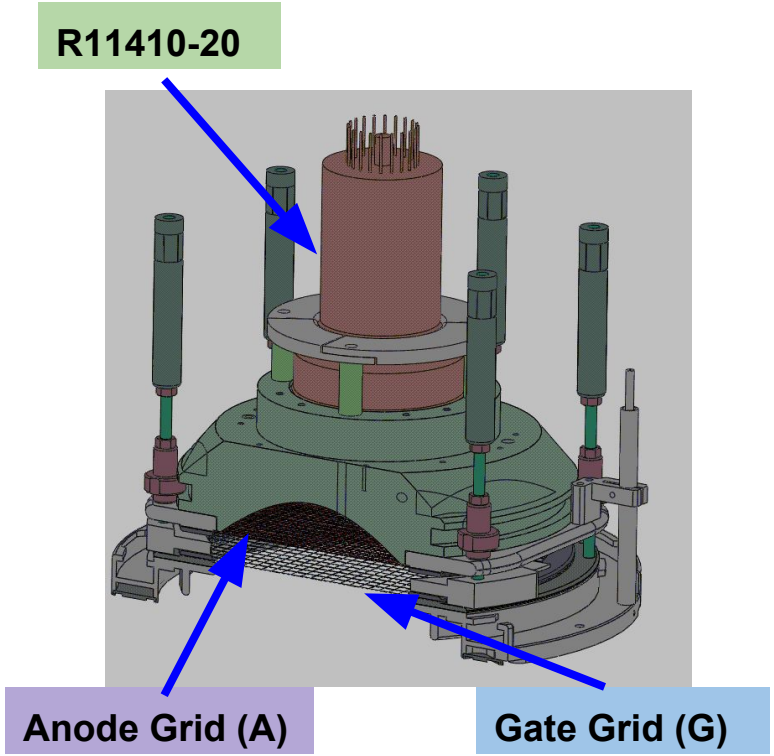
Phase II



- Focusing on LZ grids tests.
- 1.5 meter diameter
- 32 PMT sparse array.
- MgF2 coated ground plane for increasing light collection.
- Handling large grid is cumbersome.

Gas test



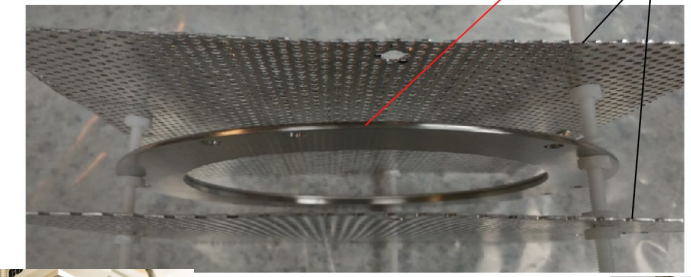


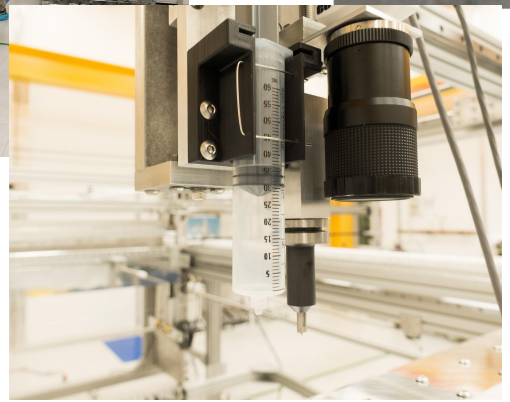
- PMT readout.
- 0.15 meter diameter.
- Electron extraction region: gate and anode grids.
- Light collection efficiency: 2-5%.
- Single electron sensitivity.
- Operating voltage: -8 → +8 kV.
- Operating pressure: 0→3.5 bara.

LZ Gas system test grids

weaving

Electro-polishing and passivating

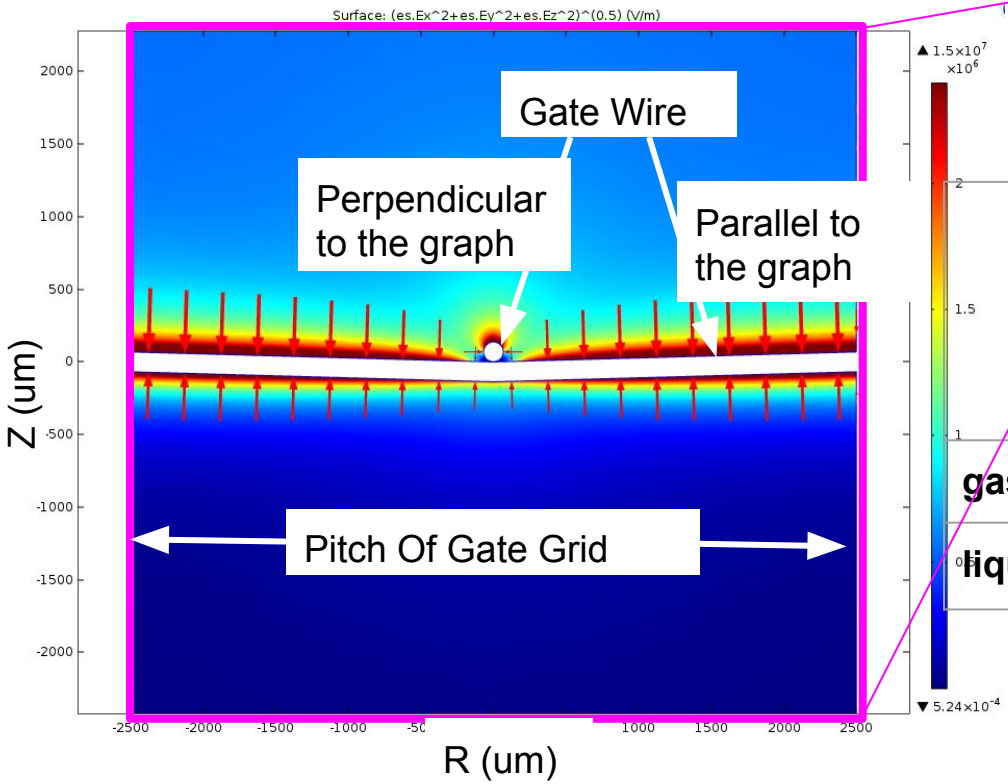


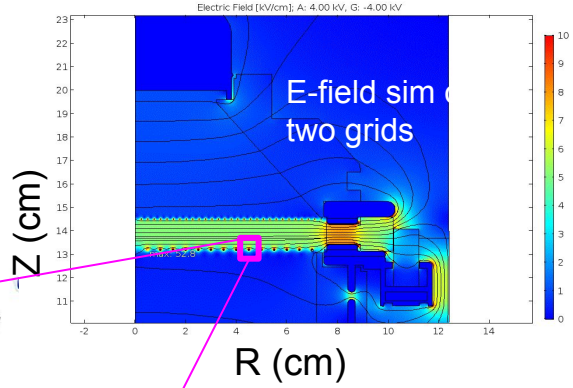


gluing

Assembling for test

Fields





GAP: 1.3 cm, Liquid level: 0.5 cm above gate grid.

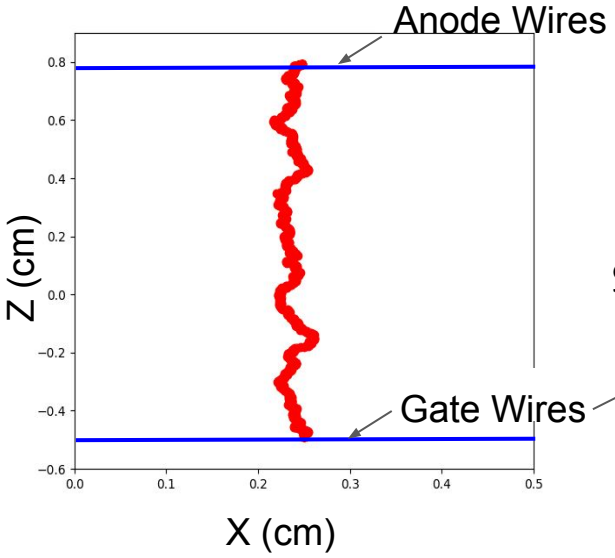
	Anode Voltage (kV)	Gate Voltage (kV)	Drift Field (kV/cm)	Electric Field On Gate Wire (kV/cm)
gas	**4**	**-4**	**-5.479**	**64.9**
liquid(LZ)	**5.75**	**-5.75**	**-5.057**	**54.7**

Considering work function of metal is different between liquid and gas xenon. Field emission should be similar in the two cases.

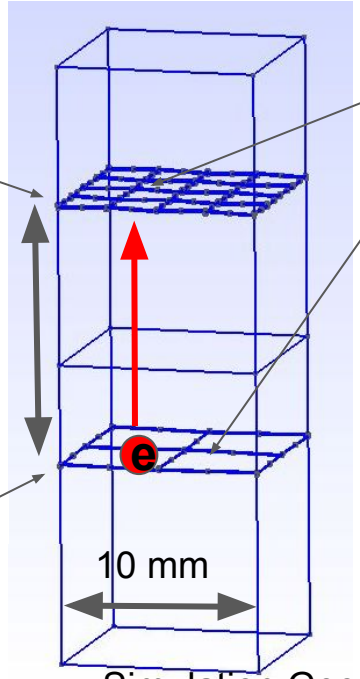
Pulse Simulations with Garfield++

$$dL_s/dx = a\,E_s/N + b$$

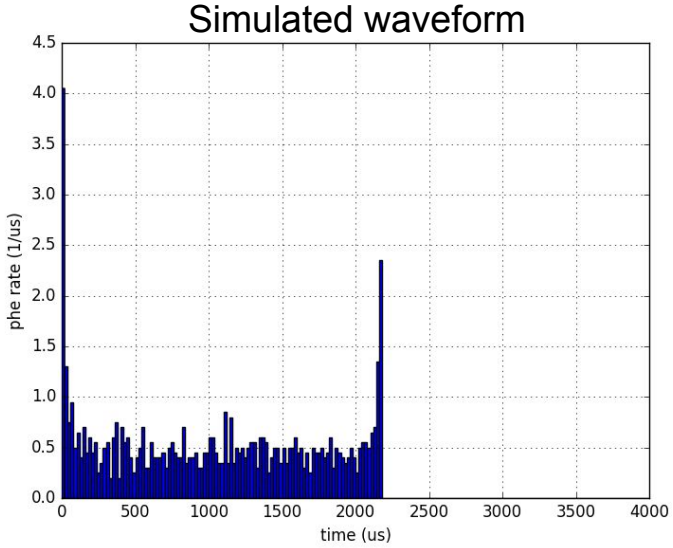
L_s: Secondary scintillation photons.
E_s: Electric field of scintillation region.
N: number density of noble gas.



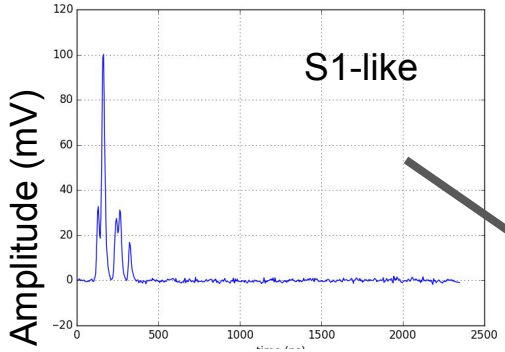
Electron track

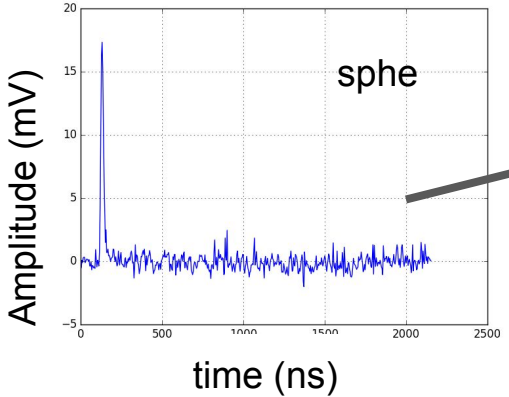


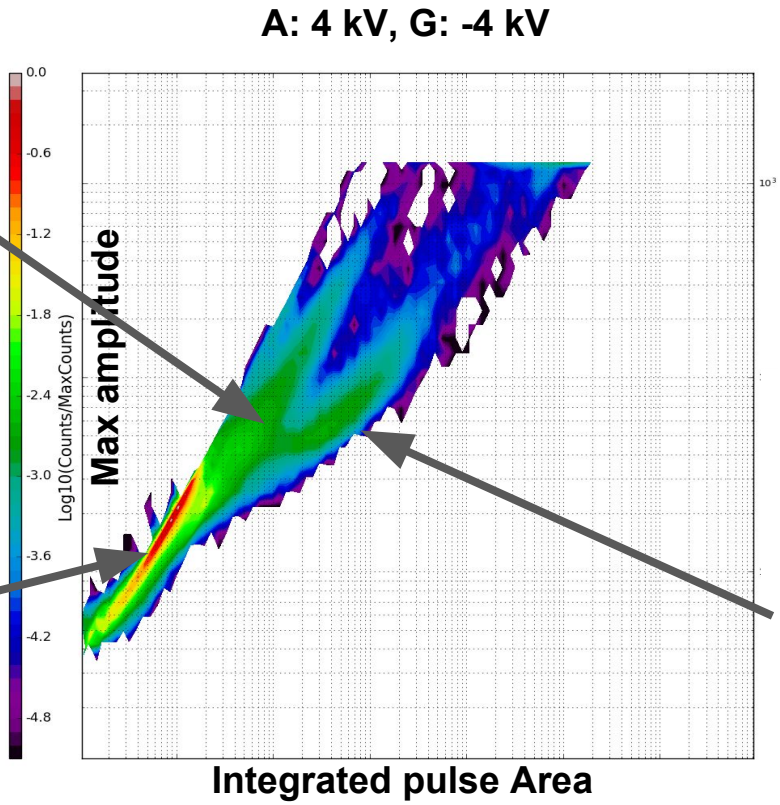
Simulation Geometry

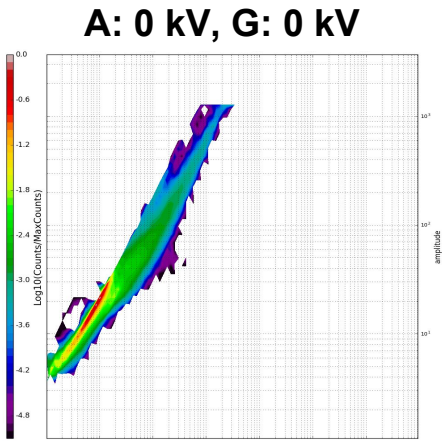


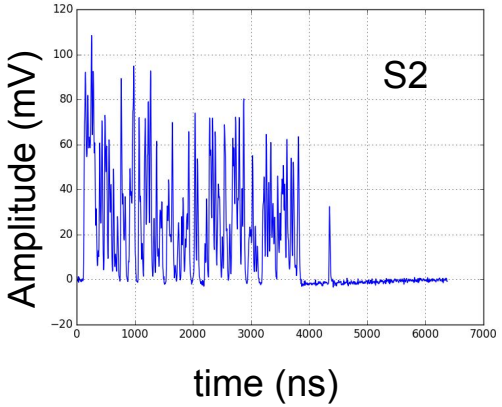
Pulse classification





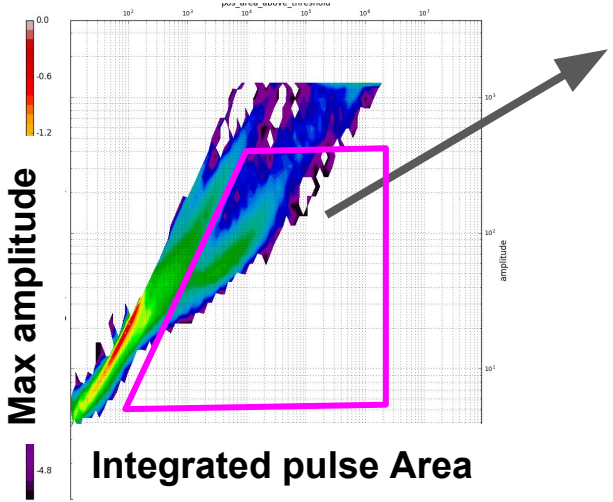


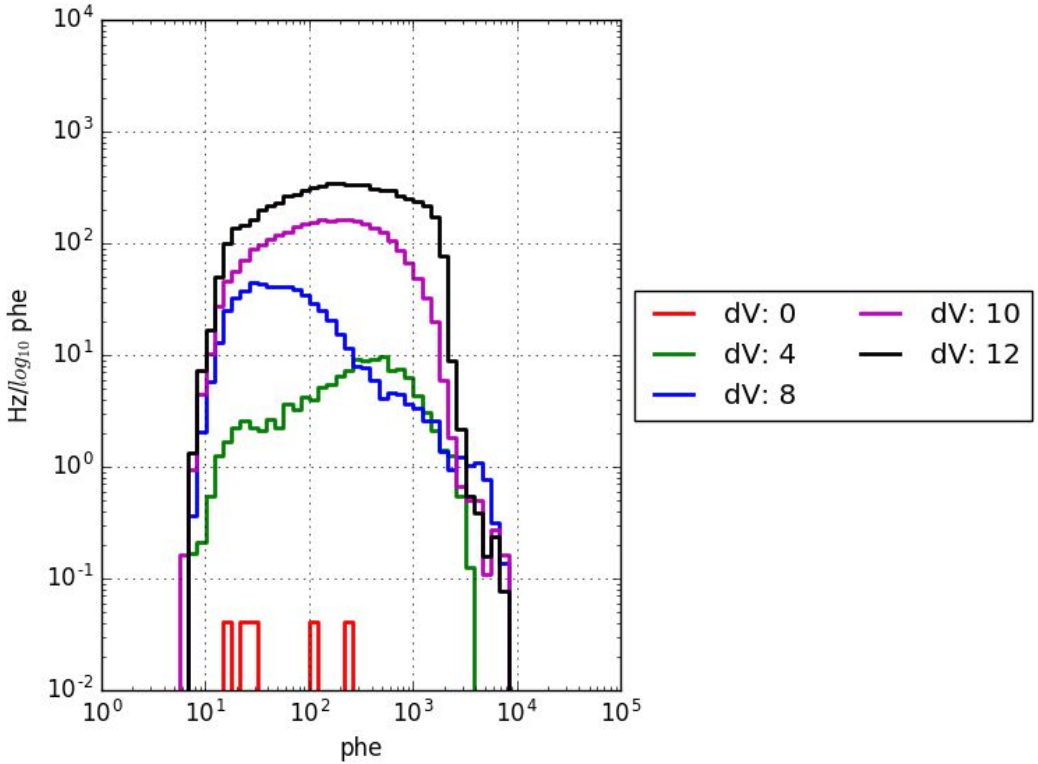




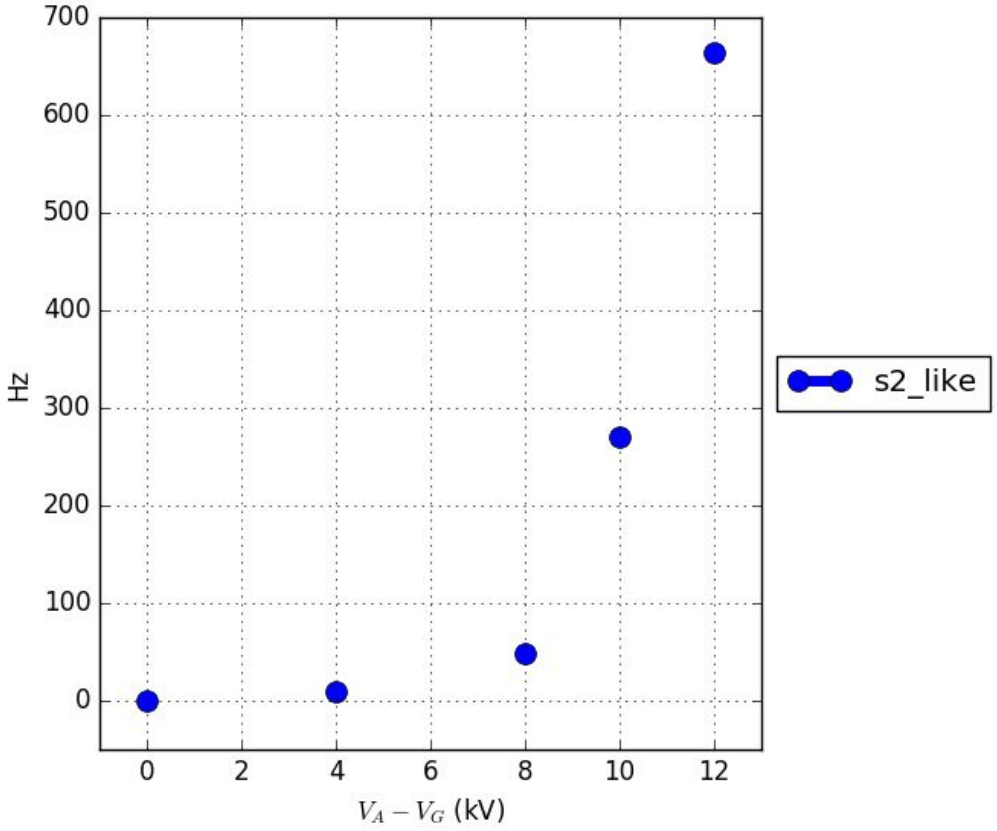
Emission rate and pulse size scale with voltage

A: 4 kV, G: -4 kV





First look at electron emission



Conclusion

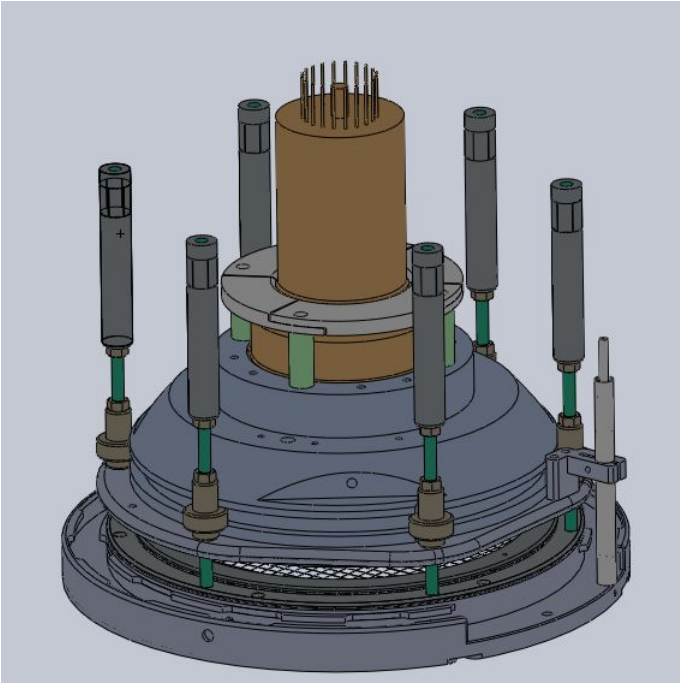
- Initial measurements appear sensitive to electron emission from grid wires.
- Electron emission turn on near the equivalent gate grid surface field as LZ.
- Next steps:
  - More detailed studies with 2 PMTs.
  - Correlate gas and liquid grid behaviour.
  - Full size grid tests in gas.

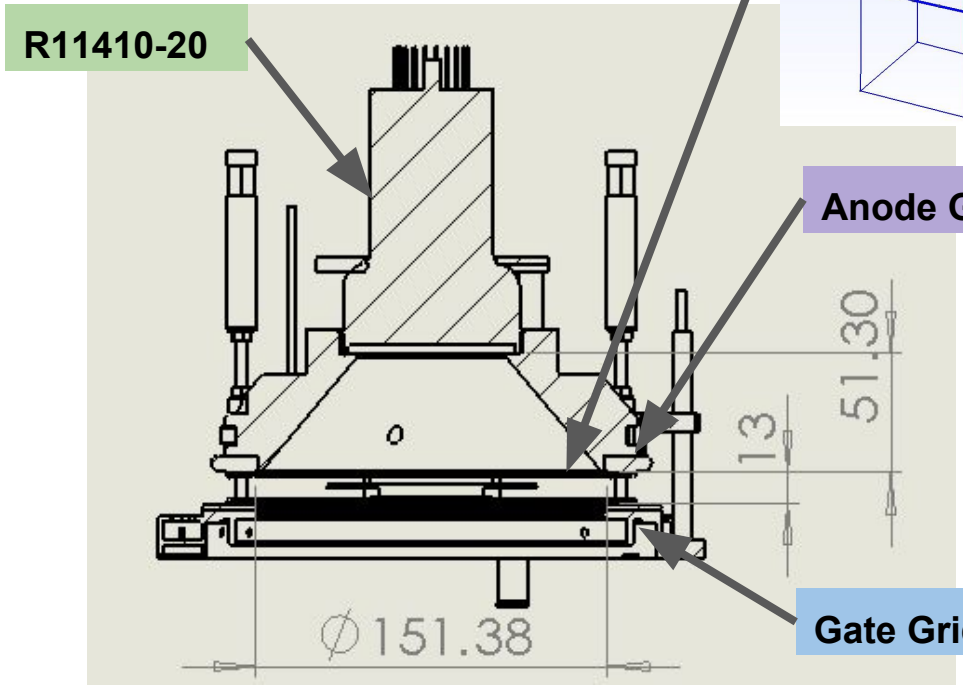
Acknowledgements:

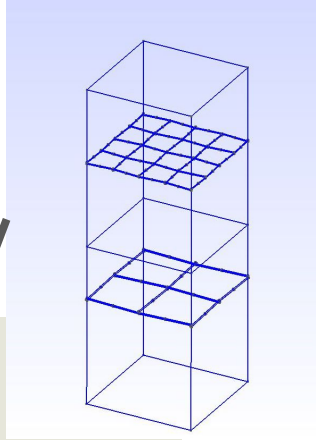
Thank you!

BACKUP

LZ Gas system test grids

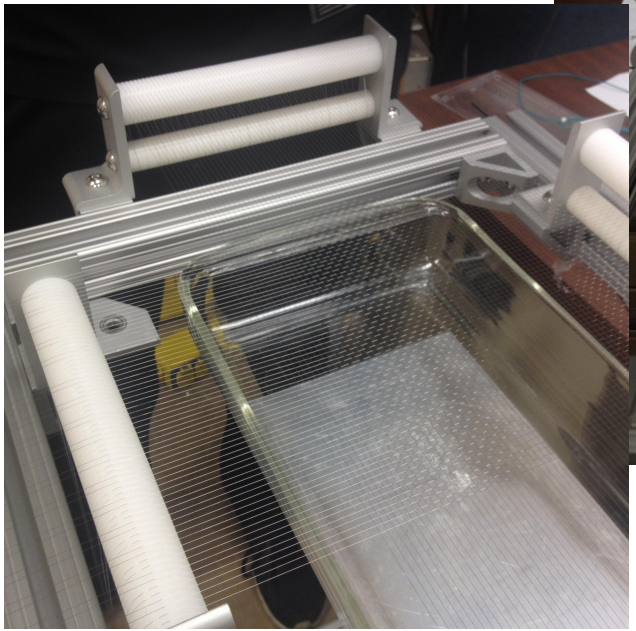


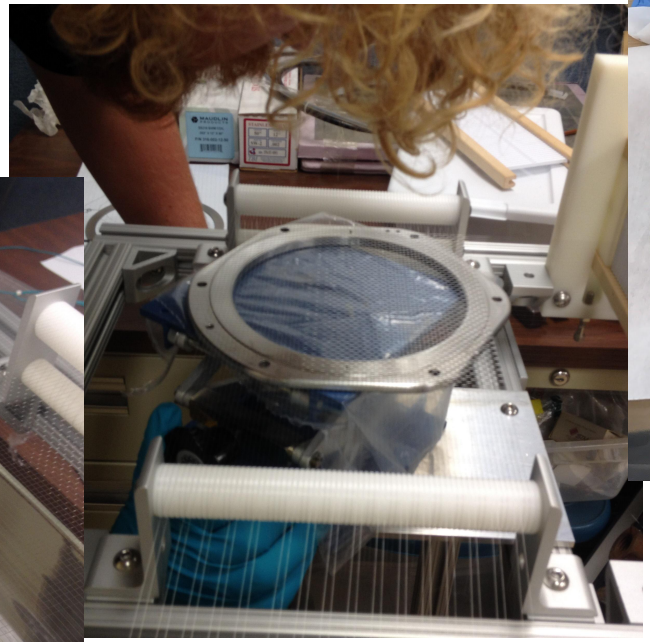




LZ Gas system test grids

weaving

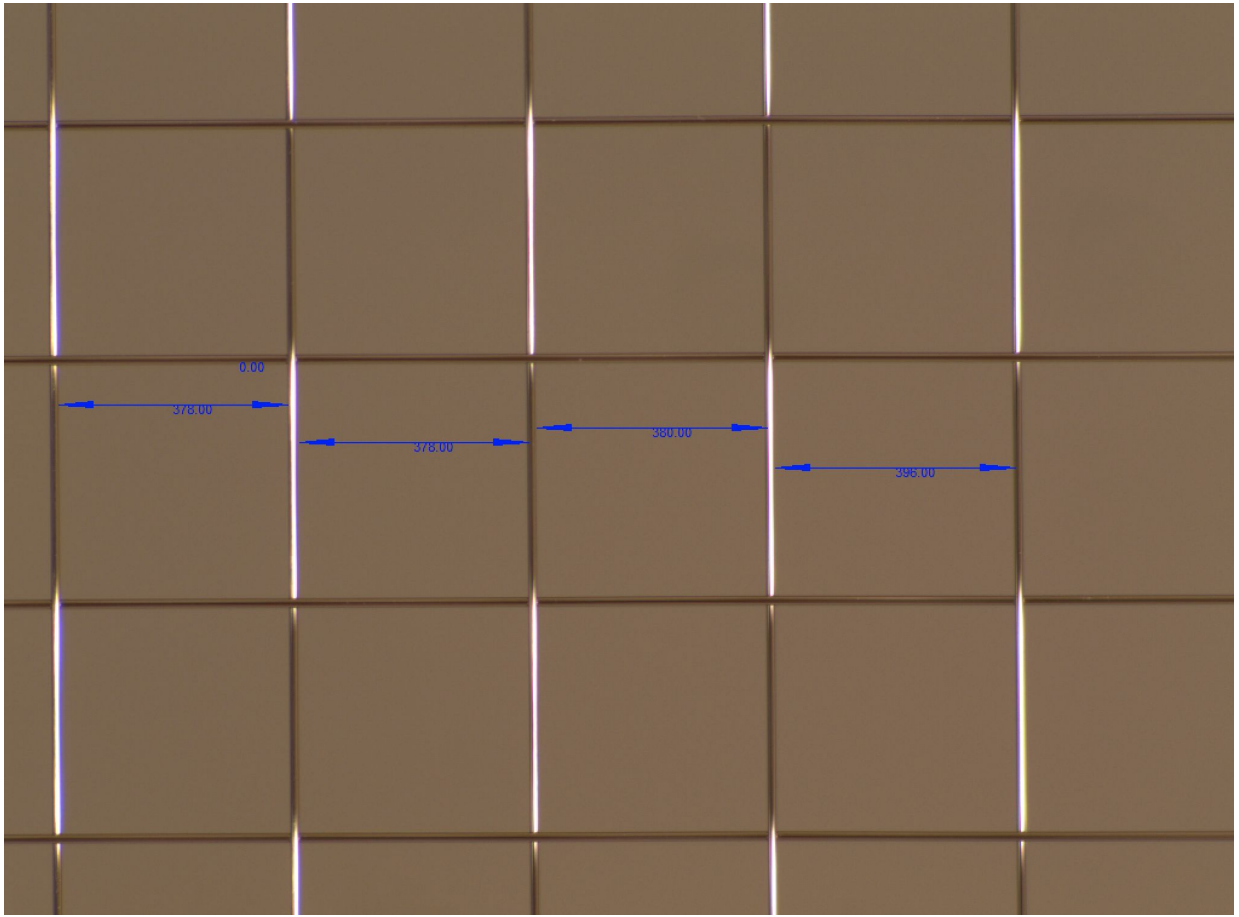




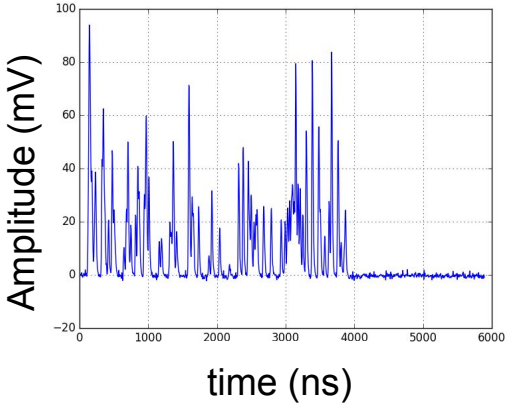
gluing

assembling

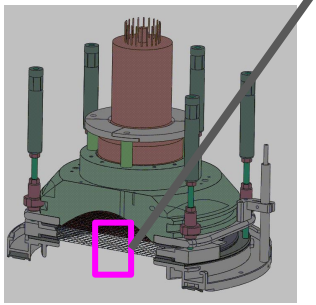
Grid

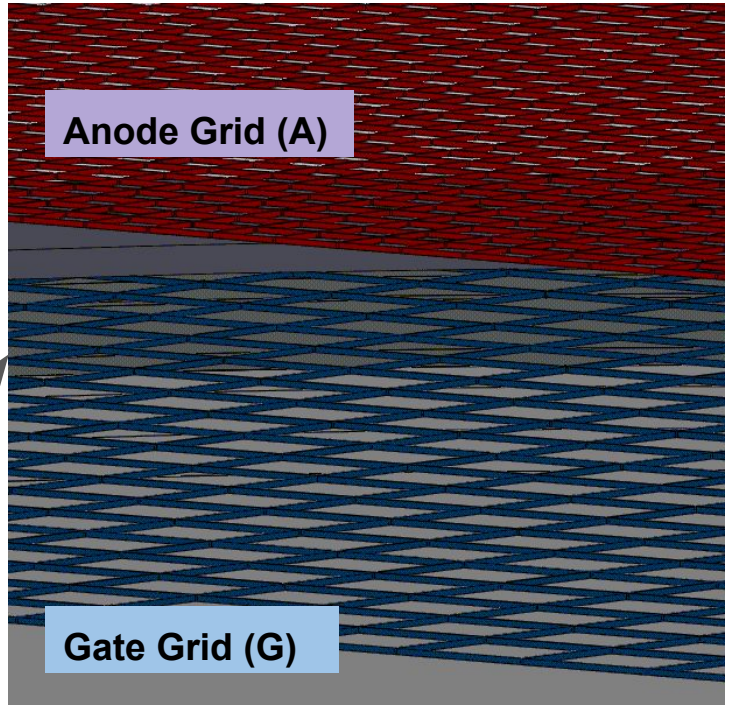


Signal



Typical waveform





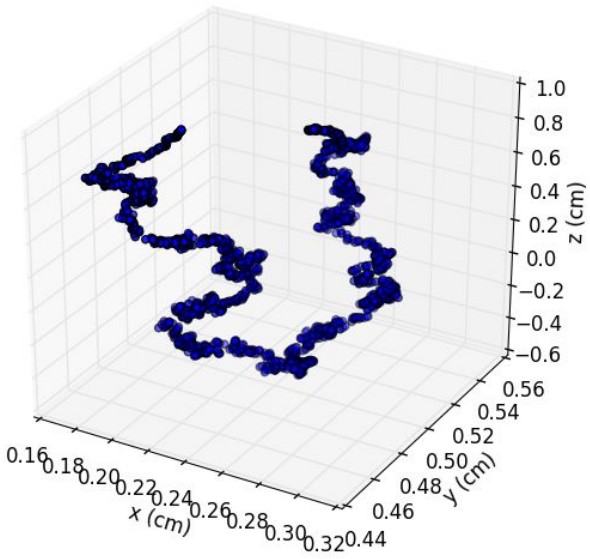
Landing on anode wire

Creating Scintillation light (S2)

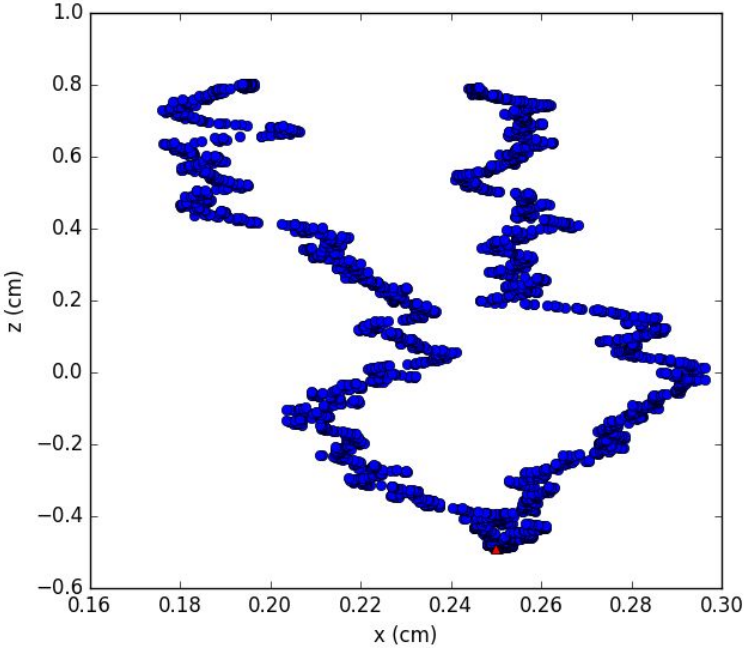
Multiplication around gate grid

Electron emission from gate grid

Electron Track (with multiplication)

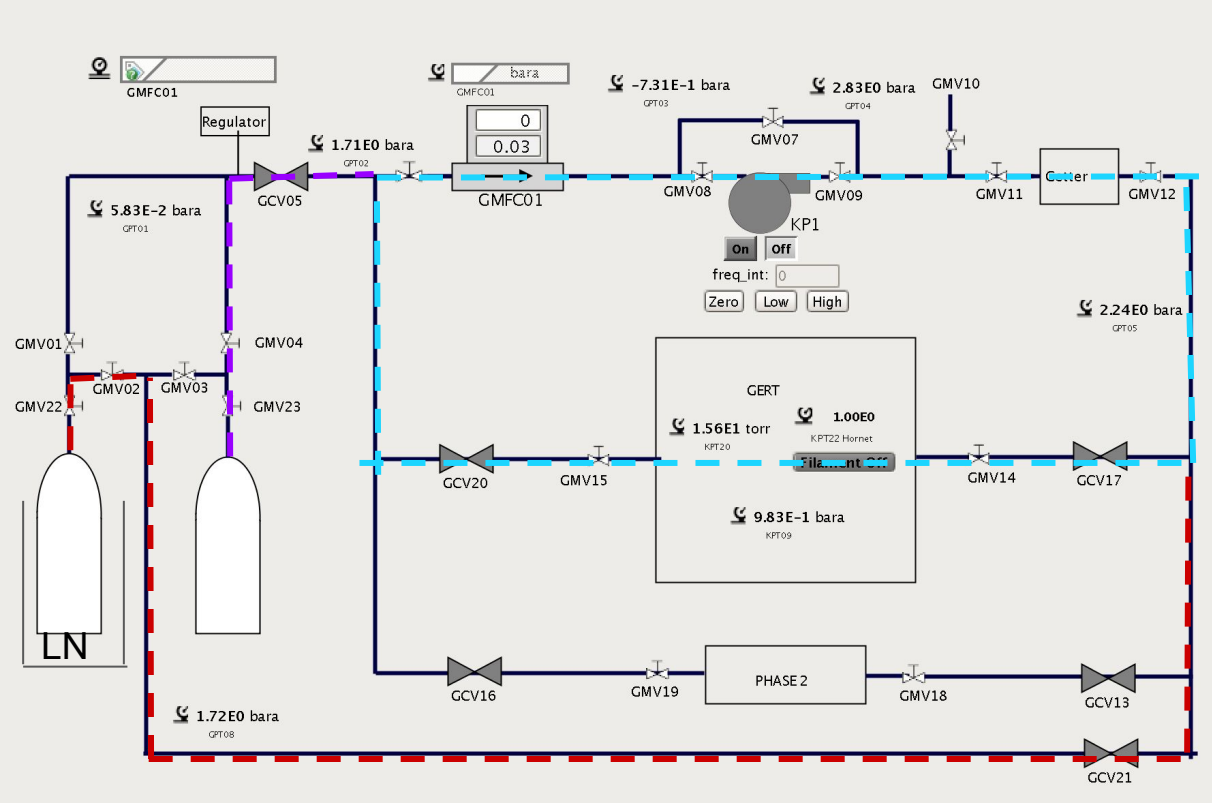


Electron track



Electron track(xz projection)

Xenon circulation system



Circulation

Add xenon

Remove xenon

Grid parameters

Grid Name:	Anode Grid (**A**)
Grid Diameter:	151.38 mm
Wire Diameter(original):	0.1 mm
Wire Diameter(treated):	Not measured
Wire Pitch:	2.5 mm
Wire Surface:	4211.5 mm^2
Area ratio scale to LZ:	**1.006%**

Grid Name:	Gate Grid (**G**)
Grid Diameter:	151.38 mm
Wire Diameter(original):	0.075 mm
Wire Diameter(treated):	0.068 mm
Wire Pitch:	5 mm
Wire Surface:	1579.1 mm^2
Area ratio scale to LZ:	**1.006%**

previous work[1]: 1.e-4 → This work: 1.e-2 → future work: 1

[1] Adam Bailey Thesis