PMT Tests for the XENON1T Dark Matter Experiment.

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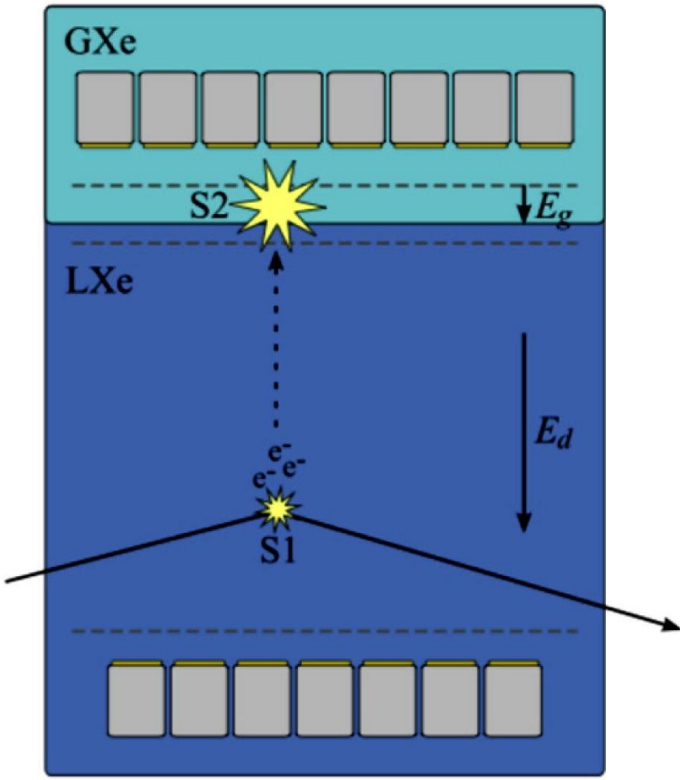
The XENON1T Dark Matter Experiment

XENON1T is designed to **search for WIMPs** by measuring simultaneously the scintillation (**S1**) and ionization signals (**S2**) from a WIMP interaction within a **TPC filled with liquid xenon** (LXe).

Detection principle

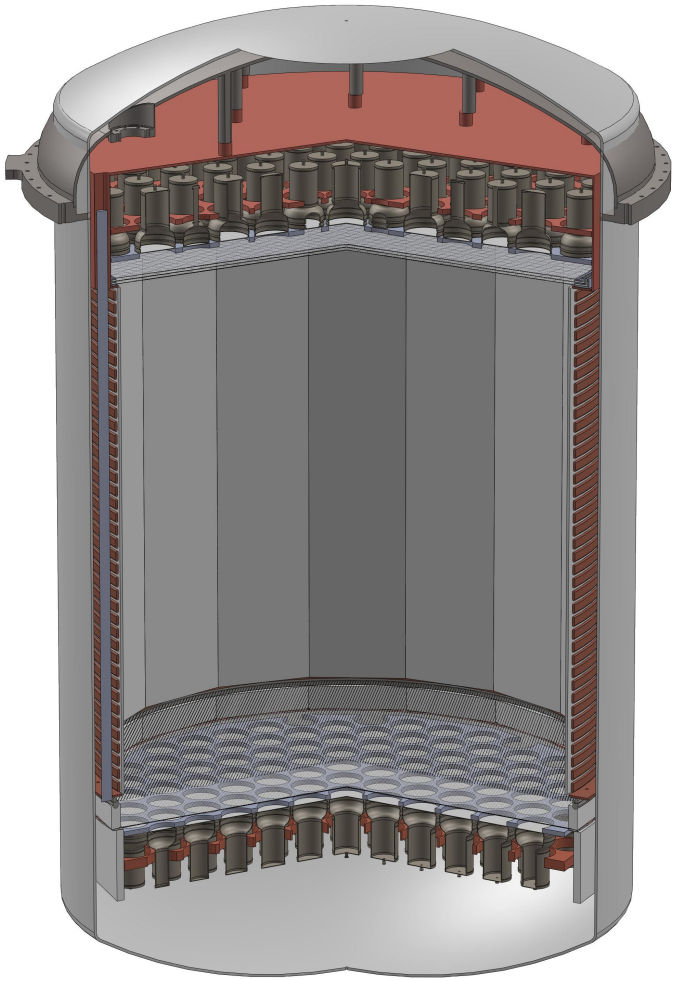


Top array → **127 PMTs**

TPC volume →

WIMP

Bottom array → **121 PMTs**

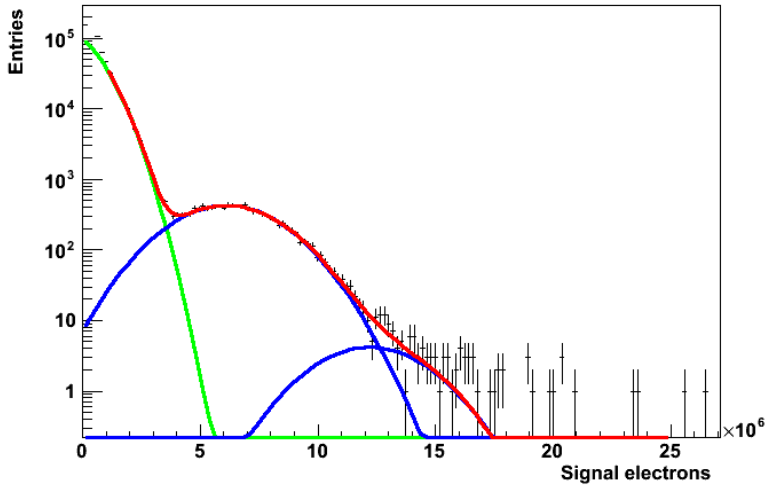


PMT tests at UZH

The Hamamatsu R11410 PMT

- 3 inch low-radioactivity PMT with a special bialkali photocathode and 12 dynode stages.

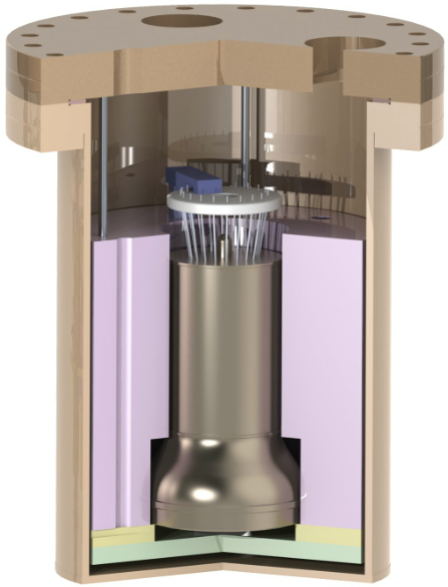
Example calibration spectrum:



The left-most peak (green) is noise and the main peak is from single photo-electrons (solid blue) with a smaller contribution from double photo-electron signals.

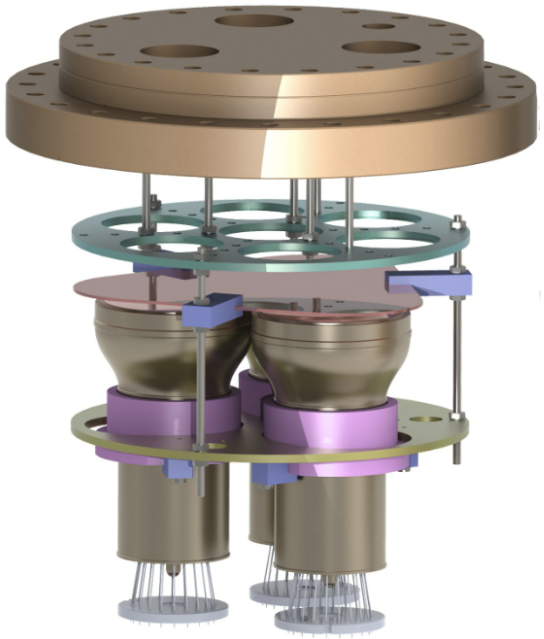
Experimental setups

MarmotXS



- One PMT at a time.
- Long-term stability measurements in LXe and
- Thermal-cycling tests.

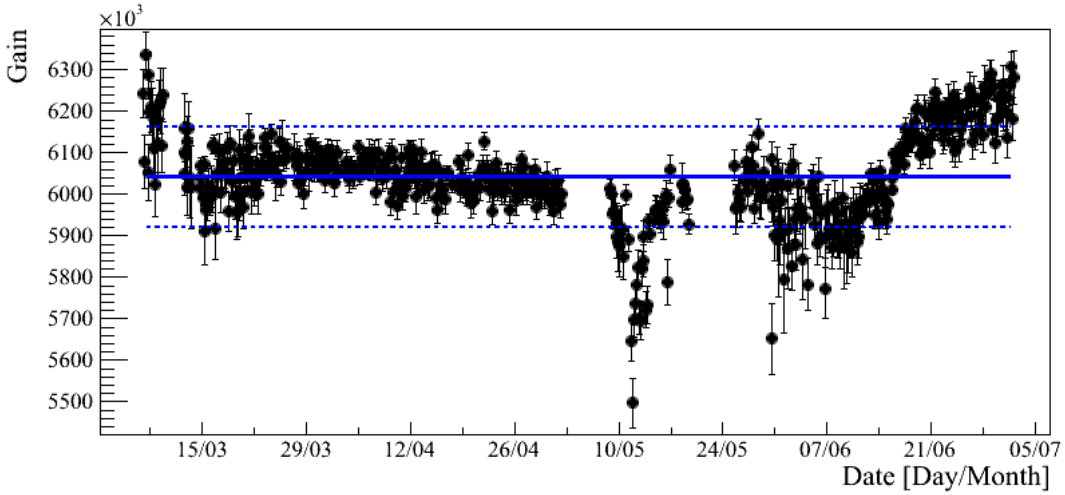
MarmotXL



- Used to test realistic arrangements in gaseous Xe under various electric fields.
- Is being conditioned to host PMTs in LXe and will be built into a TPC.

Long term stability tests and thermal cycling

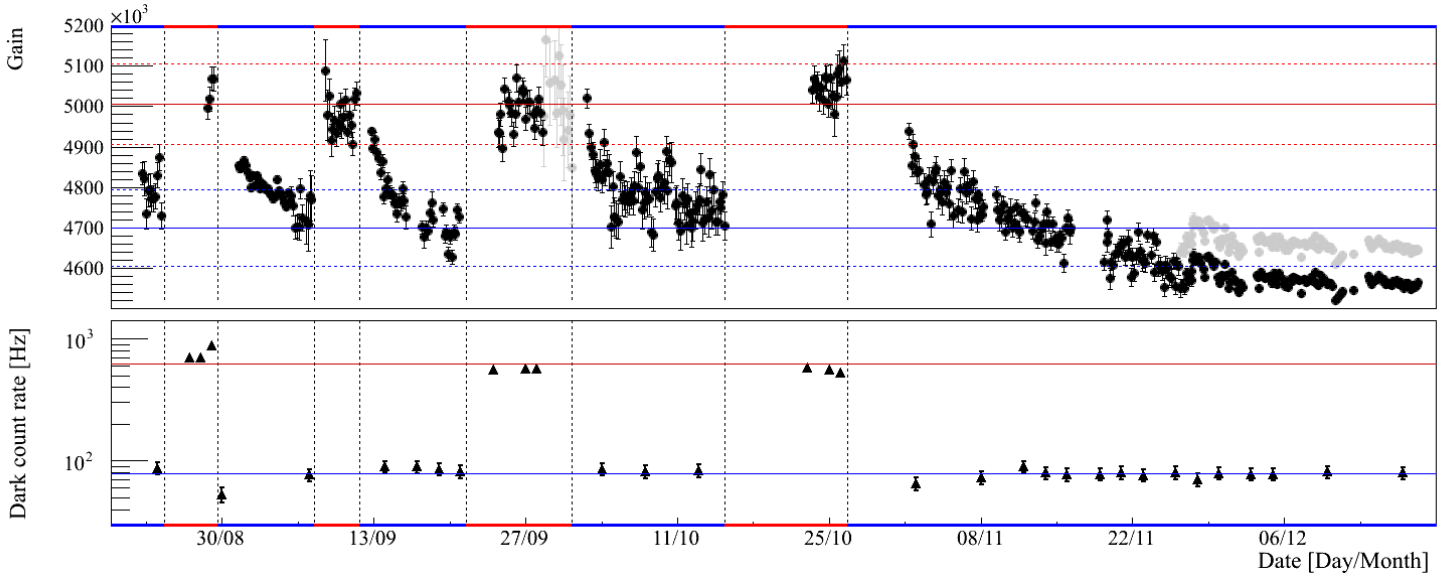
5 month gain stability test in LXe.



← Final increase in gain is due to a change in detector temperature and pressure.

Below: Red sectors are at room temperature and blue sectors are at -100°C (LXe).

Thermal cycling gain and dark count rate test.

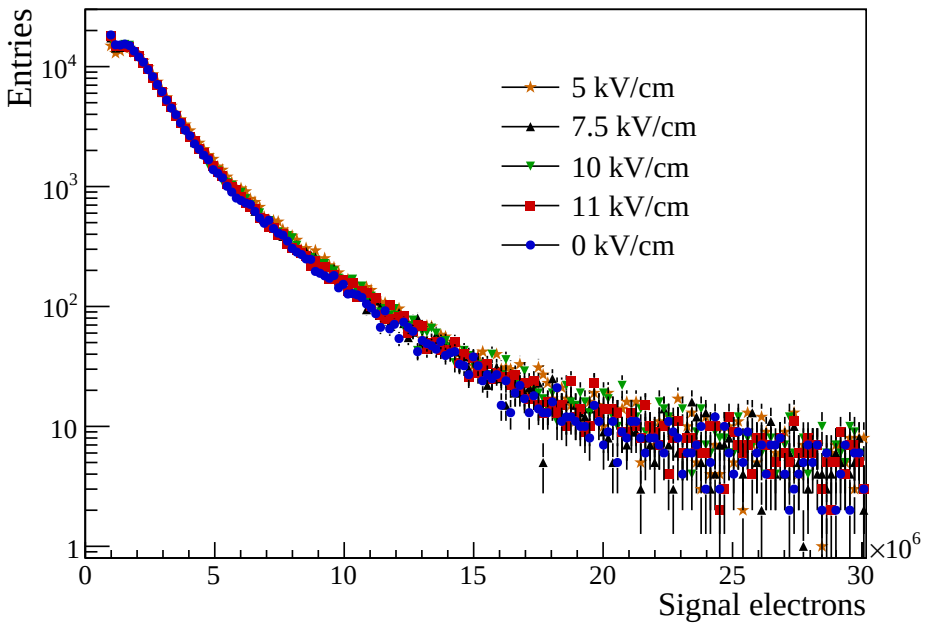


HV tests in gaseous Xe

Inter-PMT distance test in HV configurations in order to test the desired PMT arrangement in the TPC array.

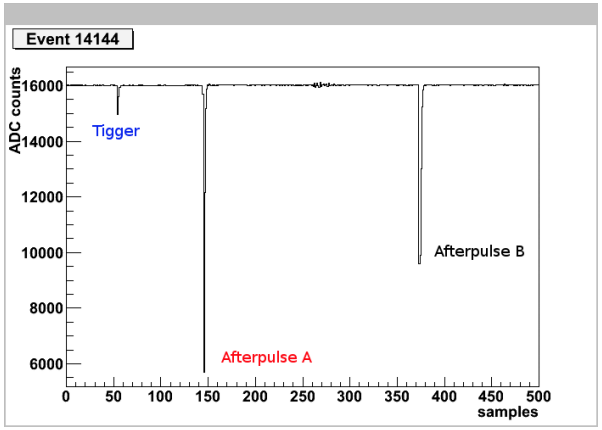
- ✓ Center to center: 80mm.
- ✓ Gap between PMTs: 2mm.

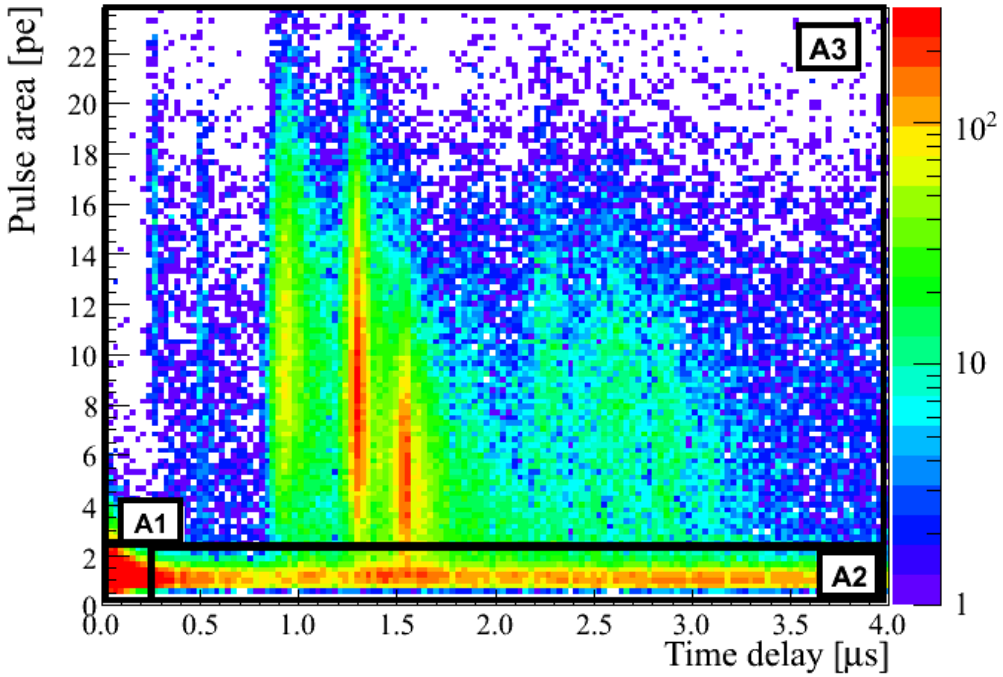
Many tests with electric fields up to 11 kV/cm have been made.



No voltage breakdown in any HV configuration.
No significant field dependence is detected, the PMT response is unaffected by the field above its photocathode.

Study of Afterpulses





Afterpulse groups:

- **A1:** Delay of several tens of nanoseconds, mean of about 1PE.
- **A2:** 1PE afterpulses measured continuously through the whole time interval.
- **A3:** Residual gas molecules generate afterpulses of more than 2PE at specific times.

Afterpulse rates:

PMT	Total %	A1	A2	A3
ZK5626	9.95	3.53	2.47	3.95
ZK5629	2.23	0.45	1.48	0.30
KA0068	5.18	2.59	1.02	1.57
KA0070	1.08	0.30	0.55	0.23

Hamamatsu specifications: $< 10\%$