University of Zurich[UZH]

MarmotX

Liquid Xenon Facility

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Photomultiplier tubes are commonly used today as photosensors in particle physics due to their fast response, low dark current and reliability. XENON1T, the world's most sensitive dark matter detector, uses specially designed Hamamatsu R11410-21 PMTs with a high quantum efficiency of ~35% for vacuum ultraviolet (178 nm) light, stable performance at −100 °C and ultra-low radioactivity for rare events searches.

MarmotX is a dedicated liquid-xenon PMT evaluation facility at UZH used to characterise the response and long-term stability of the photo-detectors used in the XENON projects

The MarmotX Facility

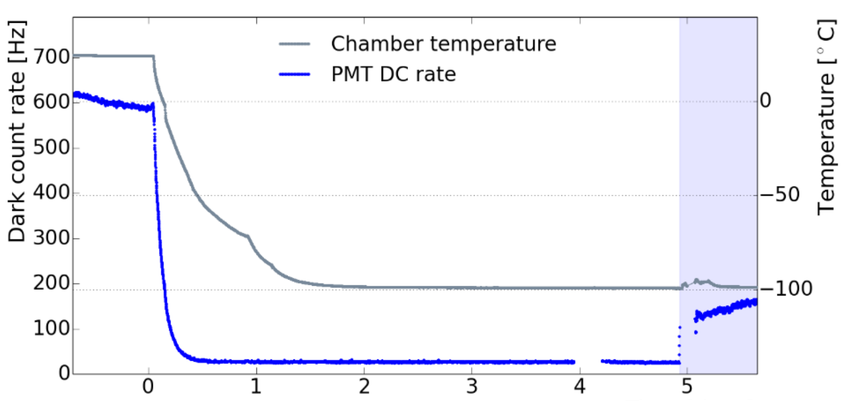
A gas or liquid xenon chamber, which can be used for detector evaluation as well as preparatory studies for larger liquid xenon experiments.

- 15 kg liquid xenon capacity with ten 3" PMTs
- Continuous xenon recirculation through a hot zirconium getter at 5 slpm to remove impurities

R11410-21 (left) and its dynodes (right)

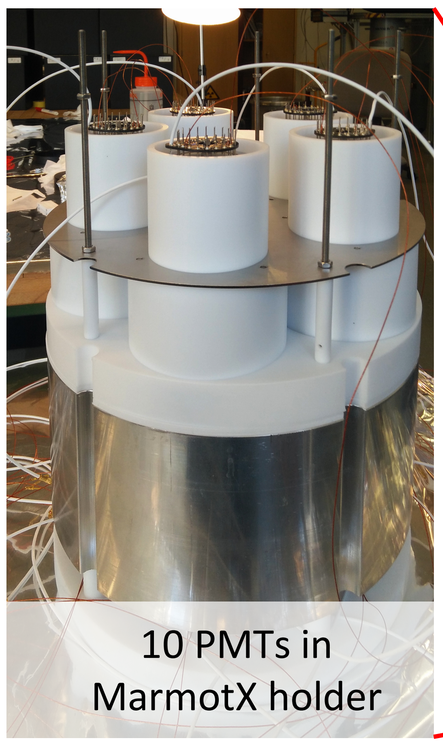
PMT Performance Measurements

The tests in liquid xenon focus on the long term stability of the PMTs. The dark count rate and gain can be monitored continuously for up to several months.

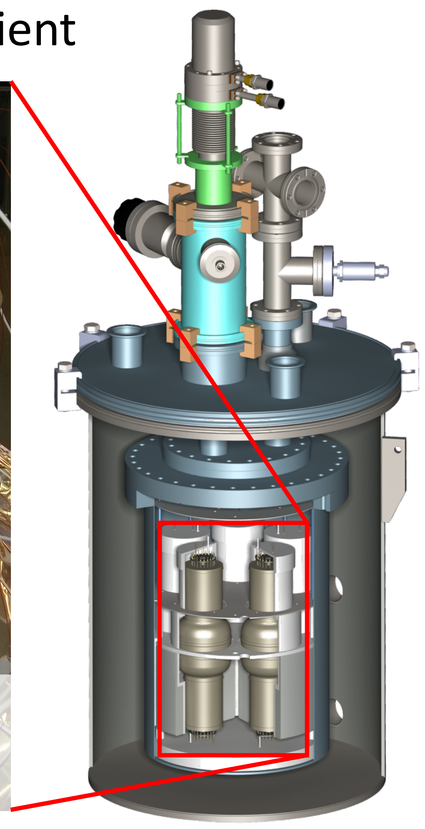


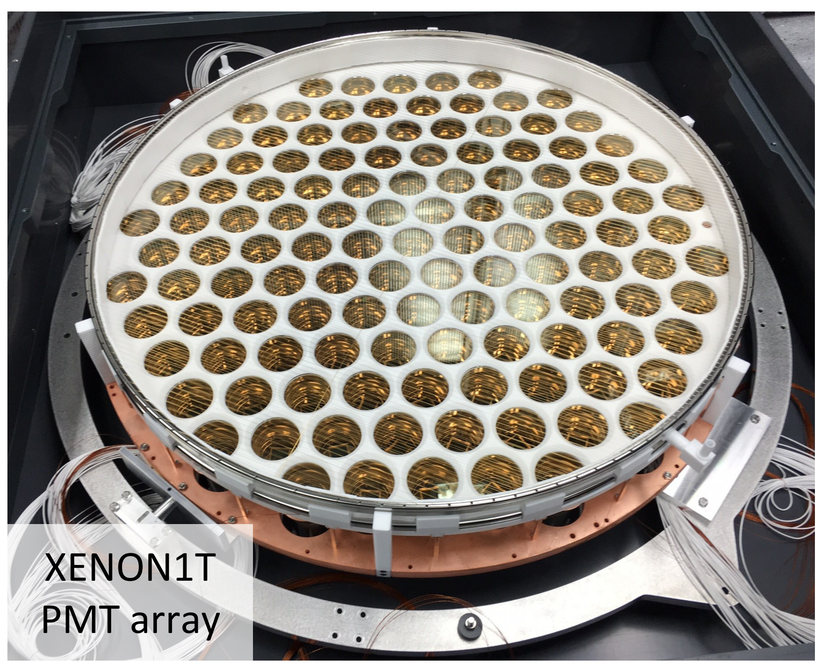
Stability of the Facility

- Cooling with pulse-tube refrigerator
- PID-controlled heater stabilises the temperature inside the chamber
- Temperature fluctuations ~0.2 °C
- 8 PT100 thermistor monitor the temperature gradient



10 PMTs in MarmotX holder

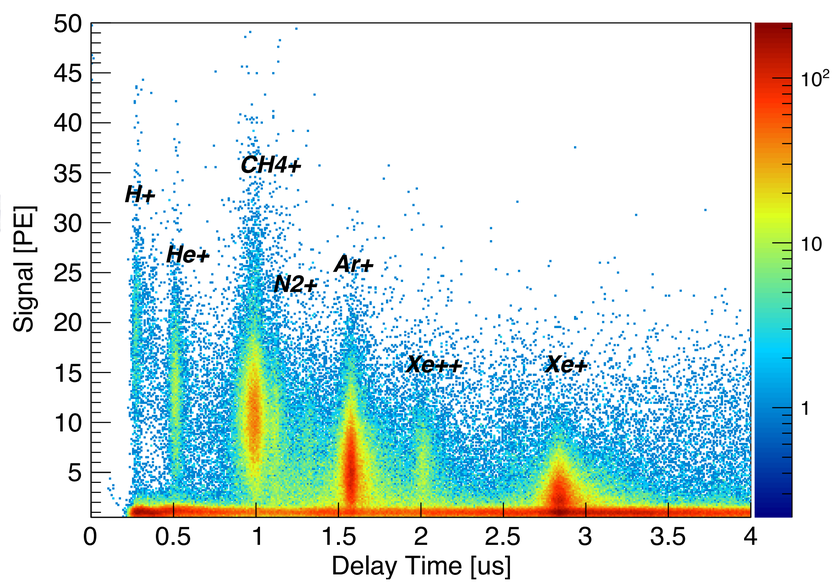




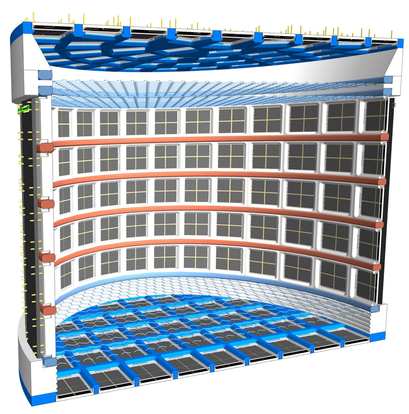
XENON1T PMT array

Afterpulse Measurements

Afterpulses are caused by positive ions generated by collisions with residual gas in the PMT's vacuum. The ion can be identified from the afterpulse delay. The appearance of xenon afterpulses during operation in MarmotX can indicate a small leak.

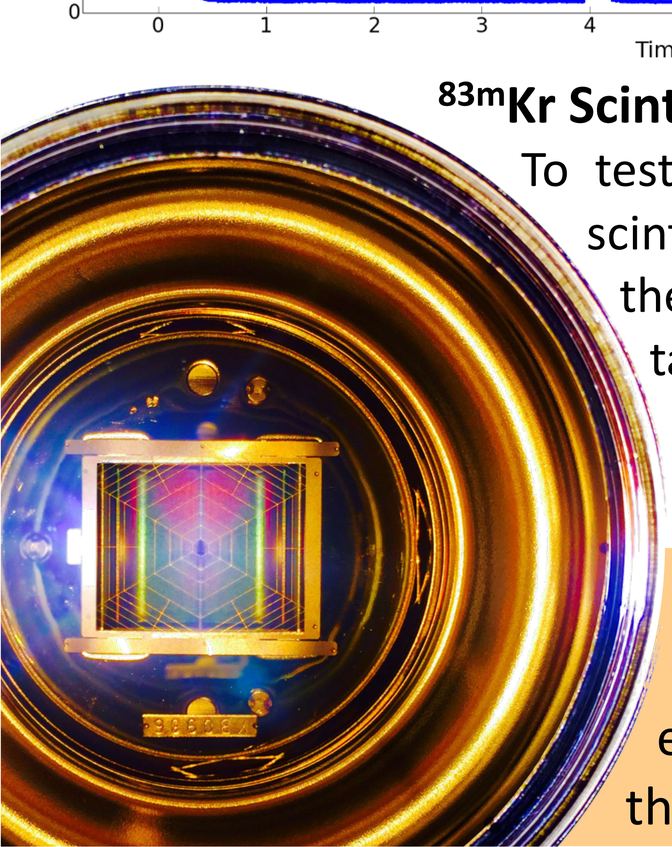


Future R&D plans for the facility

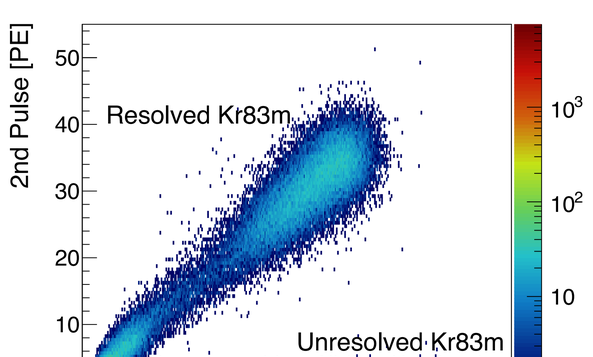


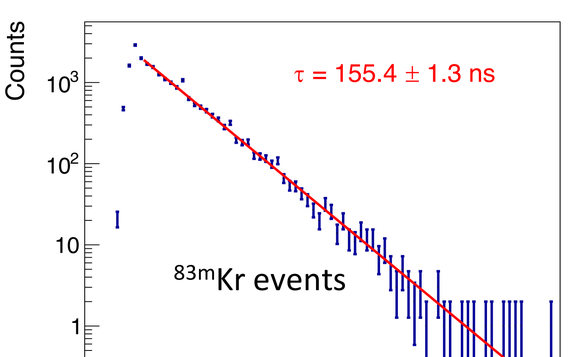
The next phase for MarmotX will be a dual-phase xenon TPC with four-pi coverage of SiPMs as an R&D phase for future large TPCs. This will significantly improve the light collection efficiency and sensitivity to low-energy dark matter events.

^{83m}Kr Scintillation Measurements



To test the detector response to LXe scintillation light we inject ^{83m}Kr into the liquid xenon. Events can be tagged due to its two-step decay (32.2 keV and 9.4 keV) with an intermediate decay time 157 ns.





MarmotX was used to evaluate photomultipliers that are currently taking dark matter data in XENON1T. As a result of the extensive testing campaign the experiment has been running stably for two years in liquid xenon. PMT tests for the next phase of the experiment, XENONnT, are underway.