Upgrade of the Xurich-II TPC with SiPM arrays

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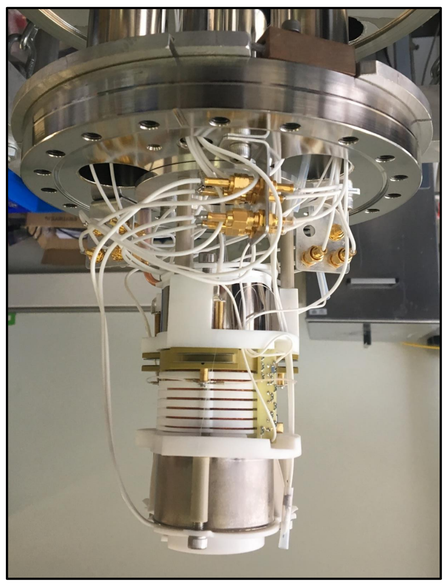
The Xurich-II TPC

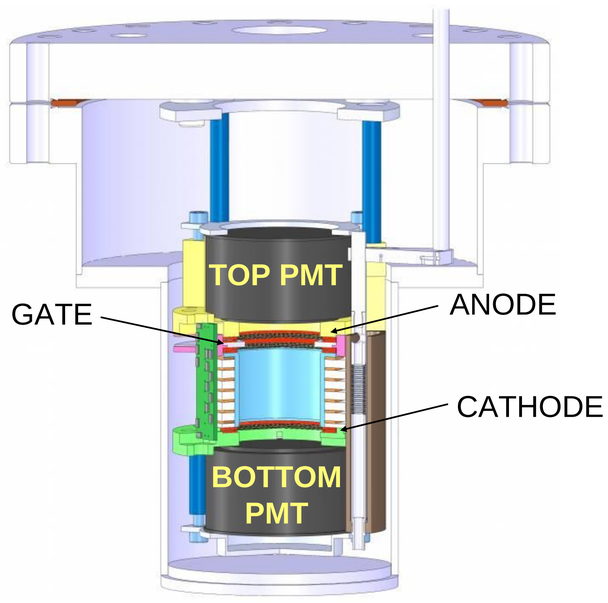
Xurich-II is a small scale, two phase xenon Time-Projection Chamber (TPC) operated at the University of Zürich.

This detector was built to study particle interactions in Liquid xenon (LXe) at very low energies (50 keV).

In the context of Xenoscope, [2] an ERC funded project, Xurich-II was upgraded to test novel photosensors, Silicon Photo-Multipliers.

This is the first two-phase TPC to be operated with SiPM arrays.





Original configuration with two 2-inch PMTs, top and bottom

Silicon Photo-Multipliers

SiPMs are solid-state, single-photon sensitive devices operated in Geiger mode. These devices are made of multiple Single Photon Avalanche diodes (SPAD) produced on a common Silicon substrate. The cells are coupled to one another by individual quenching resistors.

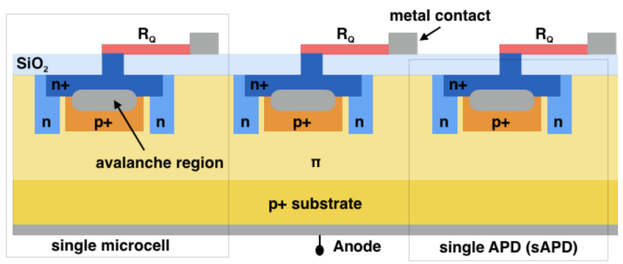
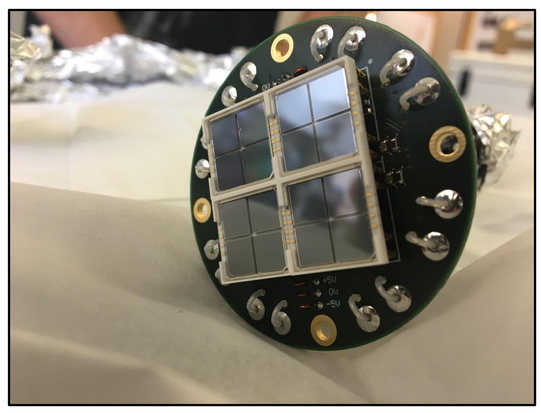


Diagram of three SiPM cells

VUV-sensitive SiPM

- Hamamatsu S13371 12×12 mm^2
- 50×50 μm^2 cell size
- Custom-made pre-amplified base
- Dark Count Rate: 0.8 Hz/mm^2 at 172 K [3]



SiPM arrays of Xurich-II with custom-made pre-amplified base

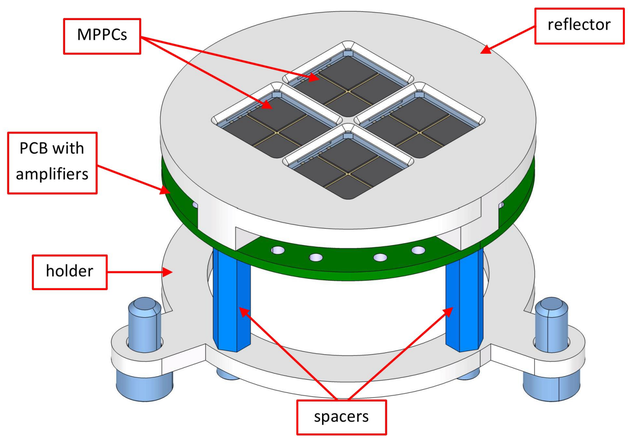
Upgrade of Xurich II with SiPMs

Current Configuration of Xurich II

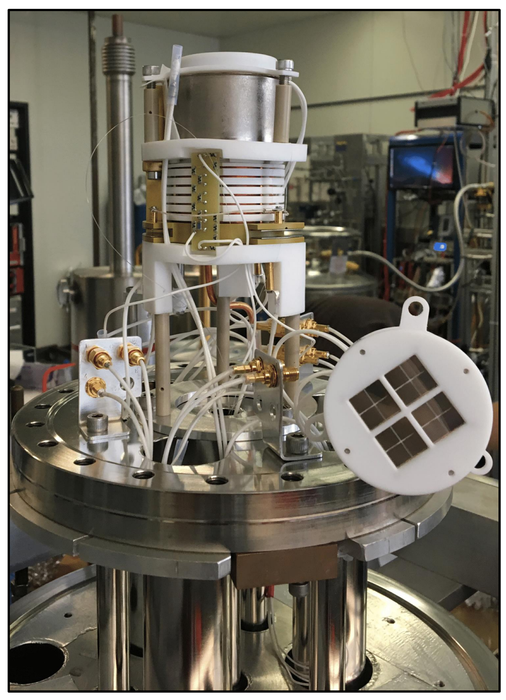
Xurich II offers an optimal environment to test alternatives to PMTs:

Array of SiPMs

- Rapid implementation
- High gain
- Lower radioactivity
- Good SPE resolution
- Position reconstruction capability



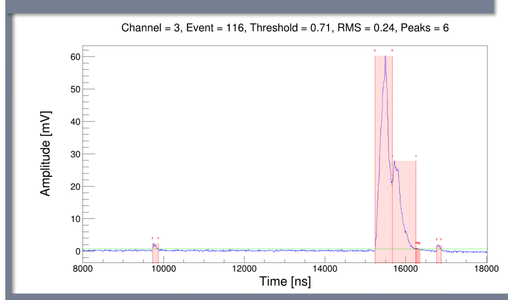
Schematic view of the SiPM array



PHASE I Array of **SiPMs** in the **top** and **PMT** in the **bottom**

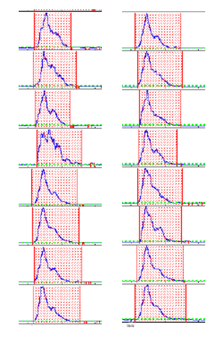
PHASE II Array of **SiPMs** in the **top** and in the **bottom**

SiPM waveforms



Left: Full ^{83m}Kr event waveform

Right: All 16 SiPM channels of Xurich-II

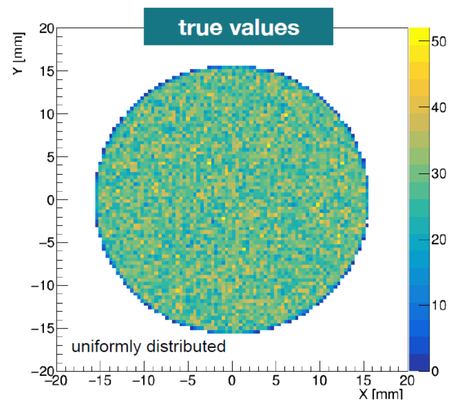


Position reconstruction

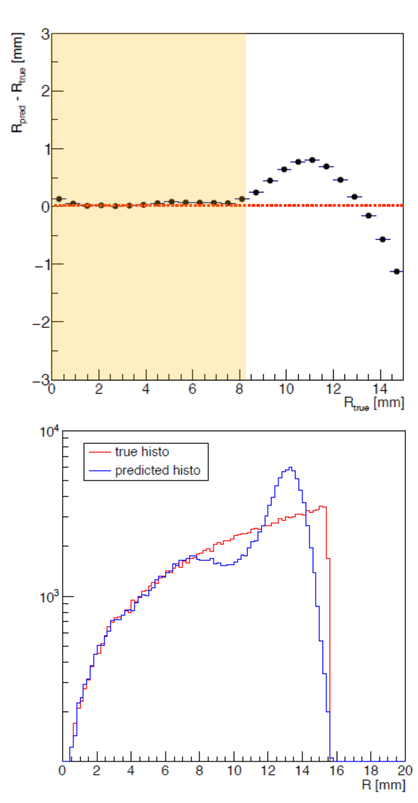
The implementation of small SiPM arrays in Xurich-II allows, for the first time, to perform position reconstruction in the TPC.

The position reconstruction is performed with the *Toolkit for Multivariate Data Analysis* (TMVA) neural network.

The reconstruction is good in the central regions, but biased at the perimeter.



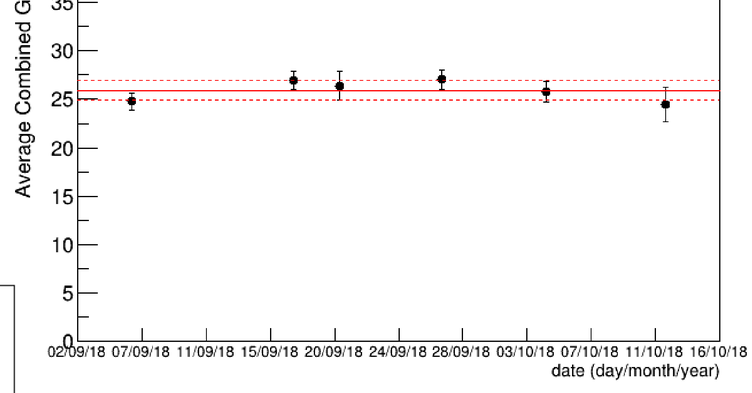
Position reconstruction in the X-Y plane



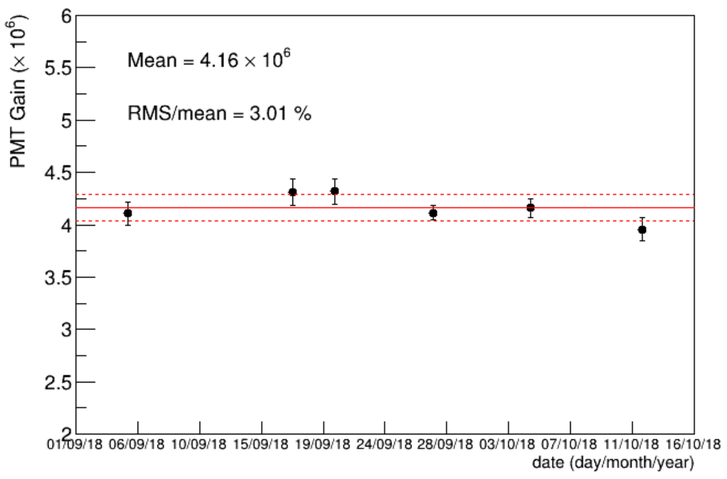
Position reconstruction as a function of radius

Gain stability

The gain stability of both the SiPM arrays and the bottom PMT are checked regularly to confirm the good operating performance of the photo-sensors.



Average Gain of the SiPM arrays over time



Gain of the bottom PMT over time

Outlook

Xurich-II will be used to test position reconstruction of the SiPM arrays, and investigate low energy interactions from ^{83m}Kr and ^{37}Ar calibrations.

References:
[1] Baudis, L. et al. Eur. Phys. J. C (2018) 78: 351
[2] http://www.physik.uzh.ch/en/groups/baudis/Research/Xenoscope.html
[3] Baudis, L. et al., arXiv:1808.06827

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