The DARWIN experiment

Development of assay techniques for large electrodes

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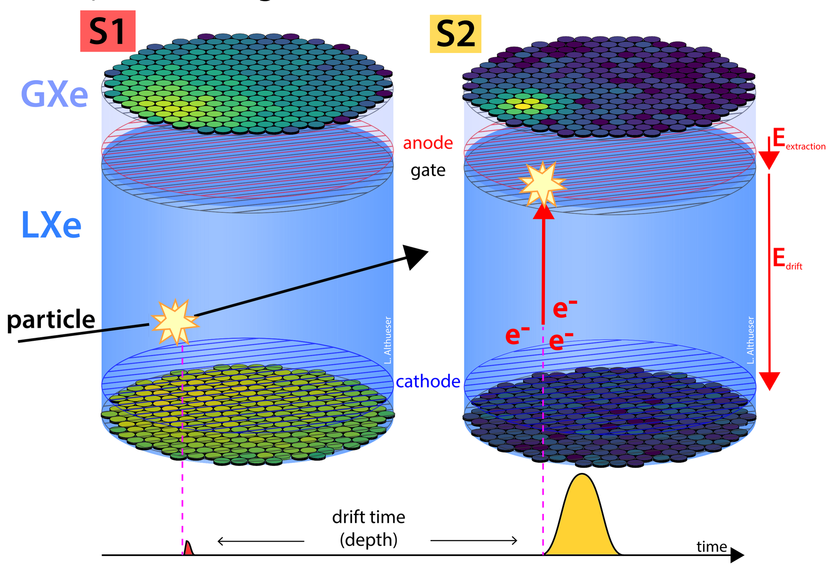
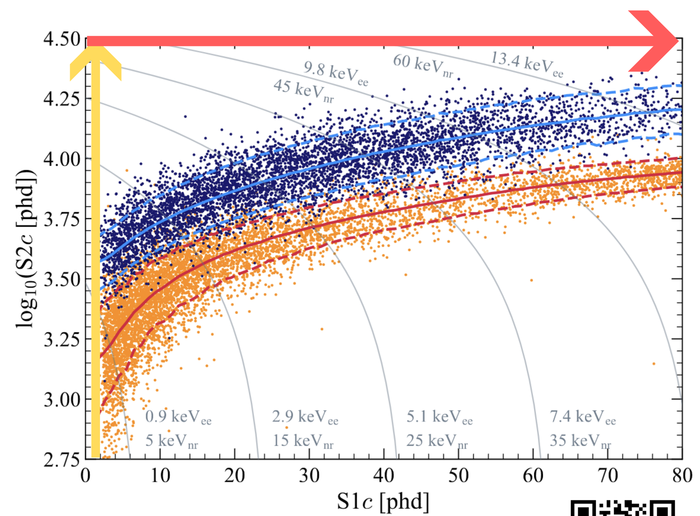
Dual-phase TPCs

Dual-phase time projection chambers (TPCs) filled with liquid xenon (LXe) and a vapour phase of gaseous xenon (GXe) on top are leading the field in searching for weakly interacting massive particles (WIMPs), a kind of dark matter (DM). Darwin or XLZD will be a future detector with a TPC at its heart, containing ~60 t xenon.

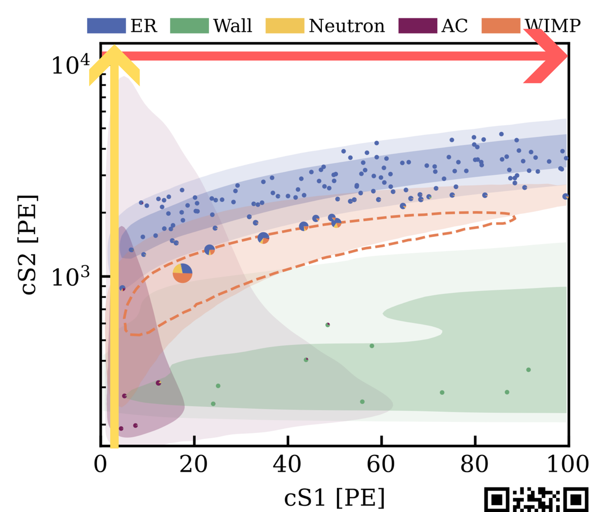


S1 & S2

Dark matter will interact through a **nuclear recoil** with the xenon inside of the TPC; background events such as gamma rays interact with the electron shell (**electronic recoil**). Looking at the amount of **S1** and **S2** light in every event allows the discrimination between the two cases.

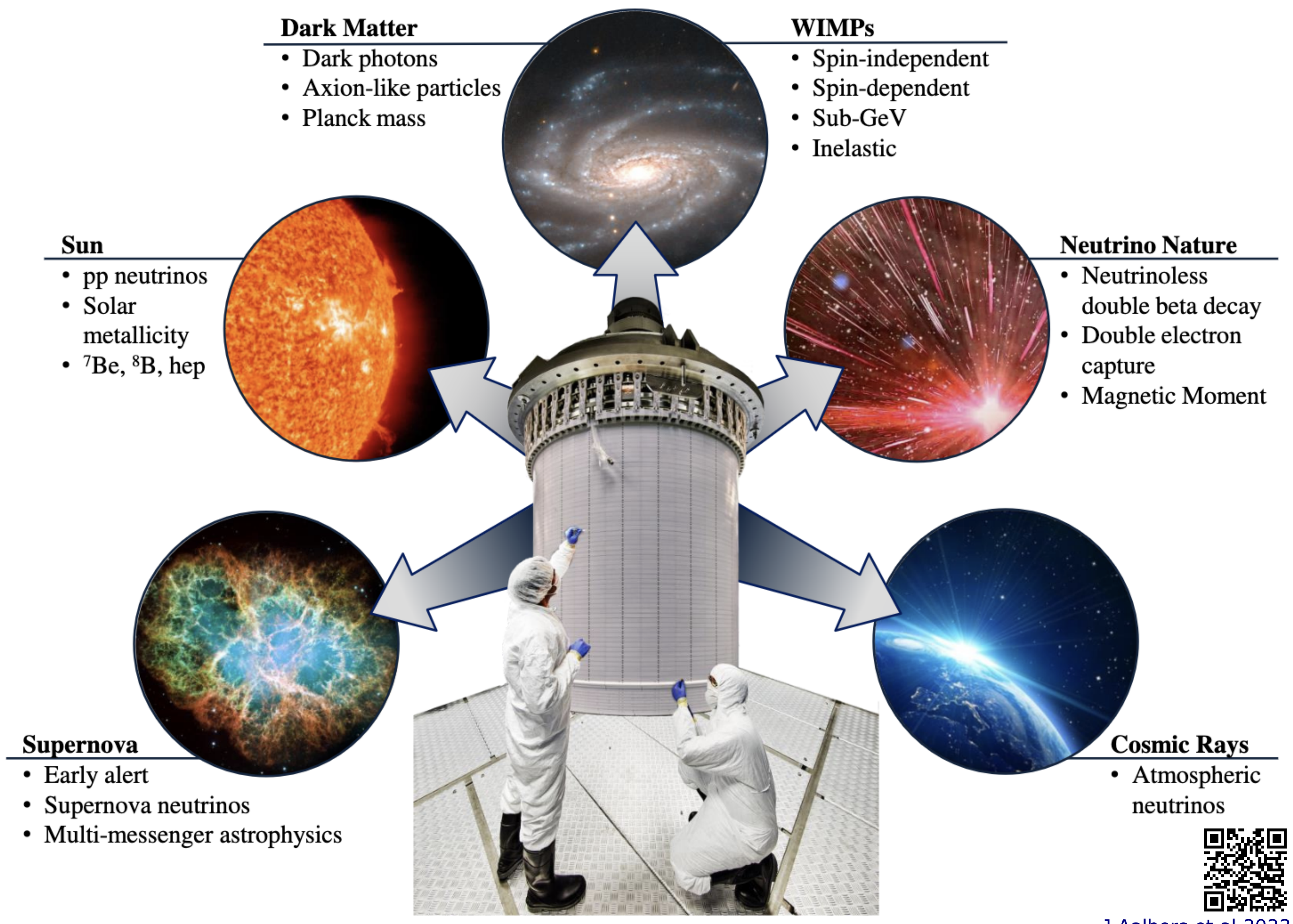


Calibration data of LZ
Phys. Rev. Lett. 131, 041002



XENONnT WIMP search
Phys. Rev. Lett. 131, 041003

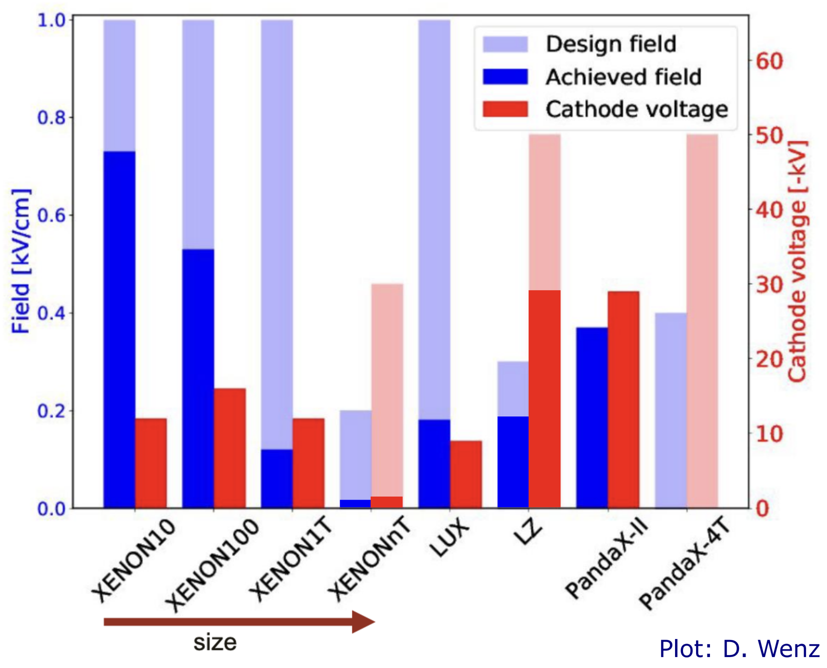
DARWIN/XLZD: The ultimate dark matter detector



J Aalbers et al 2023
J. Phys. G: Nucl. Part. Phys. 50 013001

Building a 60 t TPC

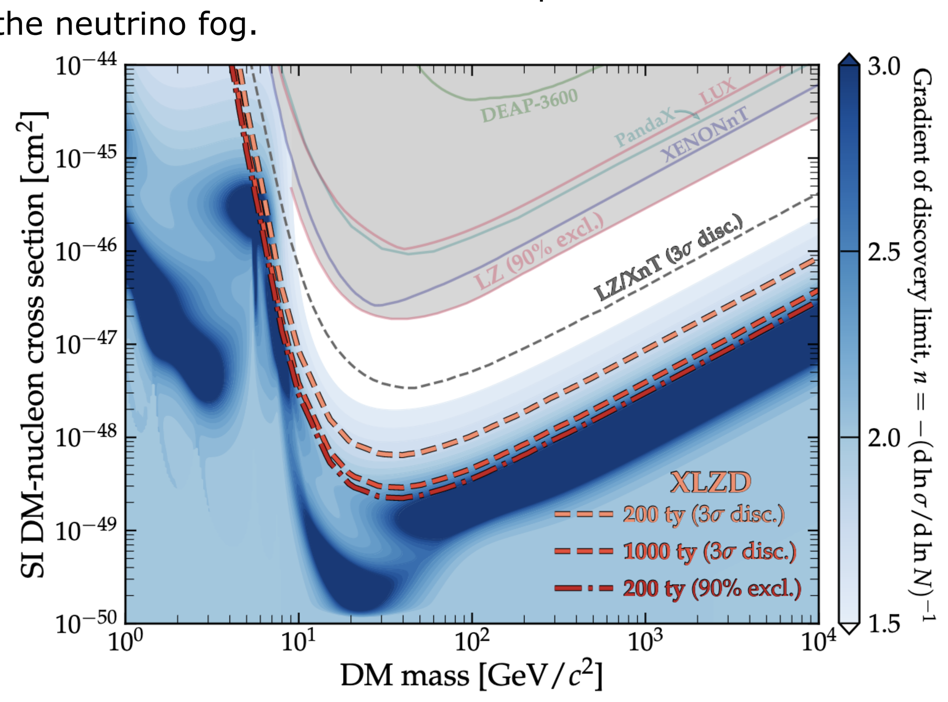
The XENONnT and LZ TPCs each have a diameter and height of about 1.5 m. DARWIN would have a 2.6 m diameter, and XLZD 3 m. This scaling up entails many challanges; for the purpose of this work we focus on the construction of the electrodes for such a future detector. One issue encountered during the evolution of xenon filled TPCs worldwide is that they often did not reach their design fields and voltages.
XENONnT uses wire grids as electrodes (with 200 m to 300 m of wire each) while LZ uses woven meshes.



Plot: D. Wenz

DARWIN/XLZD: Towards the neutrino fog

The plot shows DARWIN/XLZD's target for the WIMP discovery sensitivity vs the systematic limit due to coherent elastic neutrino nucleus scatters from solar and atmospheric neutrinos. At a given contour n, the exposure needs to be increased by at least a factor of 10^n in order to probe a 10 times lower cross section. This limit is the neutrino fog.



XLZD, target sensitivity
arXiv:2404.19524

XENON LZ Darwin = XLZD consortium

https://xlzd.org/

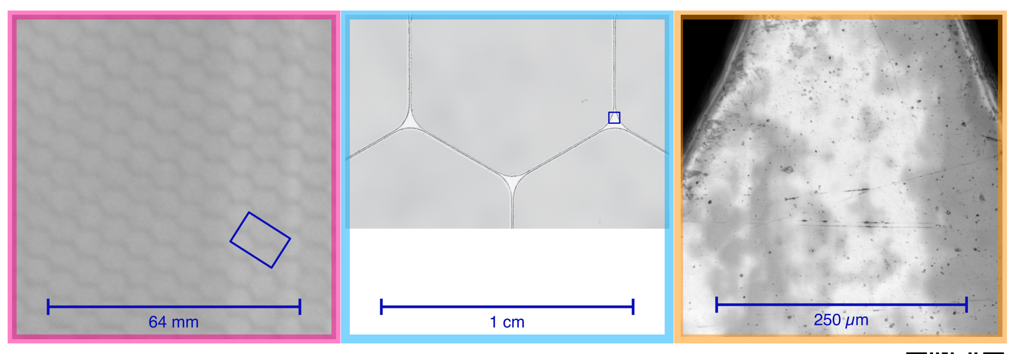
PRISMA$^+$ laboratory electrode scanning set-up

Goal: **Establish methods to assay the suitability of electrodes for a future xenon filled dual-phase TPC, before employing them inside of a detector.**

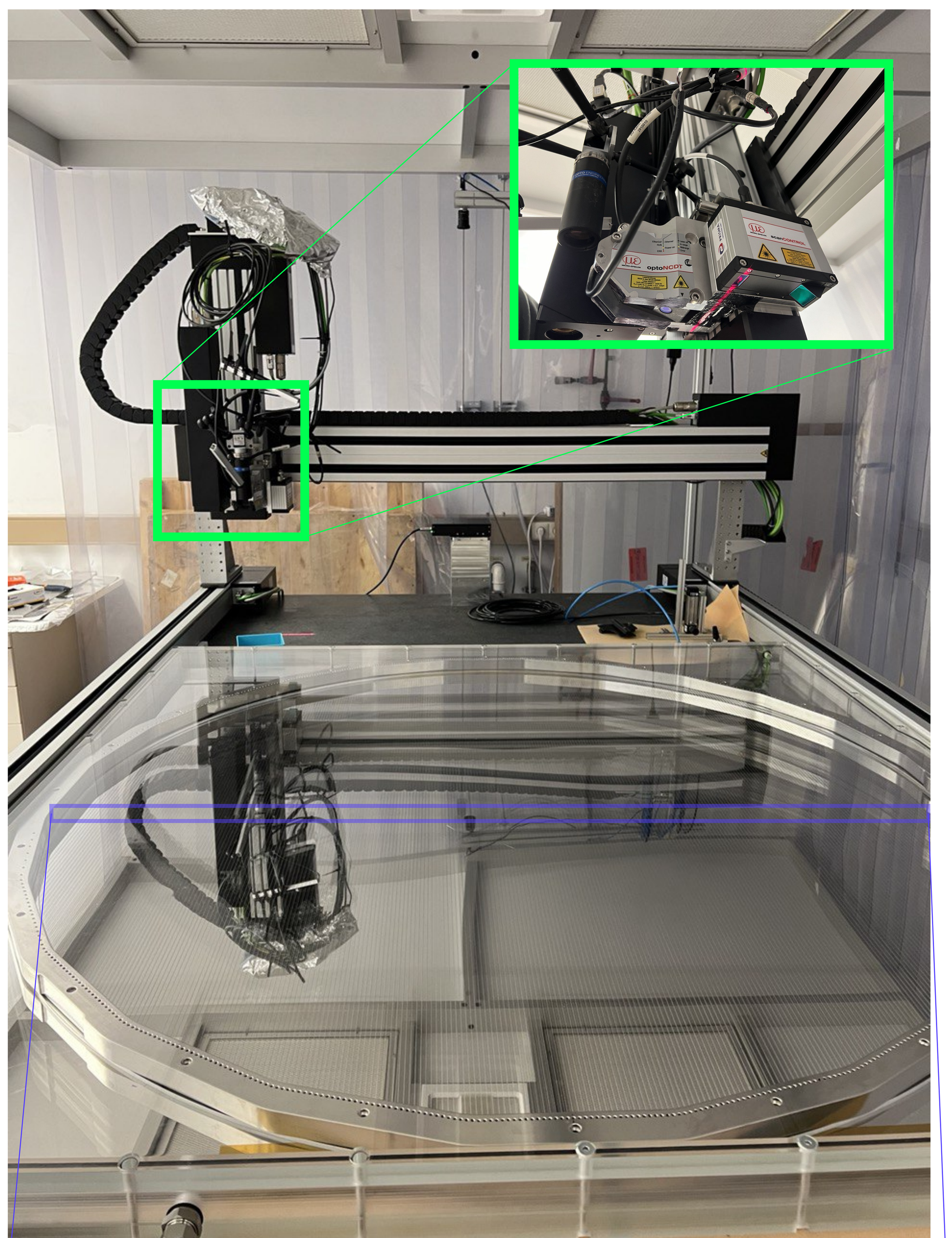
The set-up features a moveable gantry with an active region of 196 cm by 126 cm, with the following components:
- a point-laser based distance measurement system
- a line-laser based distance measurement system
- a high resolution camera: Field of view 12.3 x 8.7 mm^2, 5.3 μm x 5.3 μm resolution
- a confocal microscope with x10, x20, and x50 magnification, max. resolution (x50) 0.3 μm

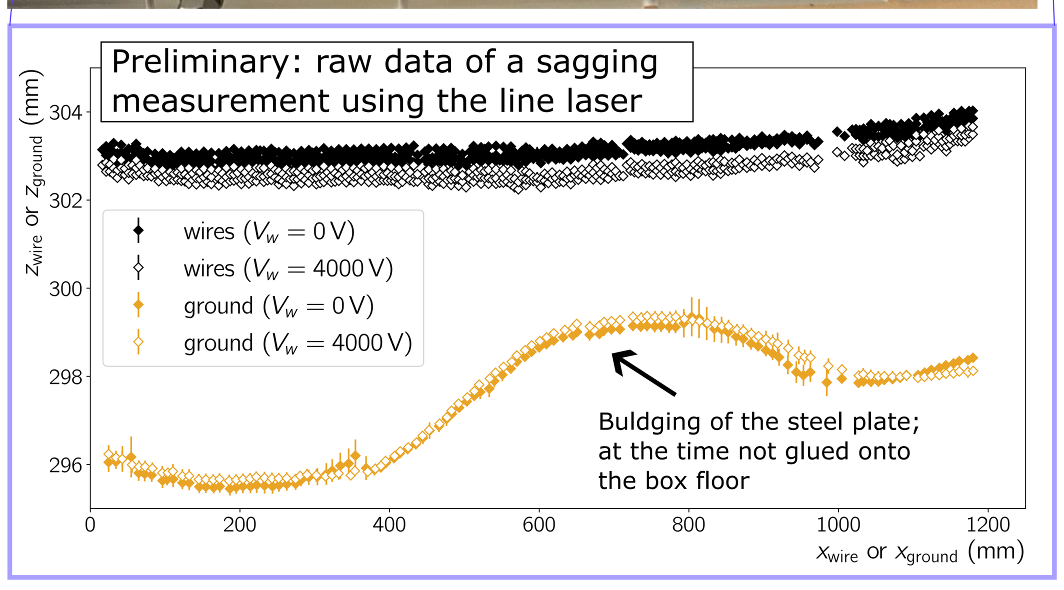
A PNMA box with a plane electrode at the bottom allows to test electrodes with up to 140 cm diameter and 3 cm height under high voltage and in a different atmosphere than air.

There is an overview camera with 1.5 m x 1.5 m field of view.



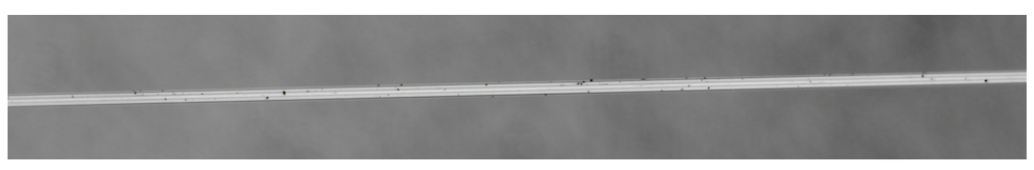
A. Deisting
XeSat2023





Capabilities:
- Electrode sagging measurements with and without high voltage using the laser distance measurement systems
- High resolution imaging of wires and meshes
- Discharge and corona discharge measurements using the cameras and the high voltage power supply current monitoring

Spots in high resolution images



Many spots can be identified in high resolution images of wires, even using thoroughly cleaned wires.

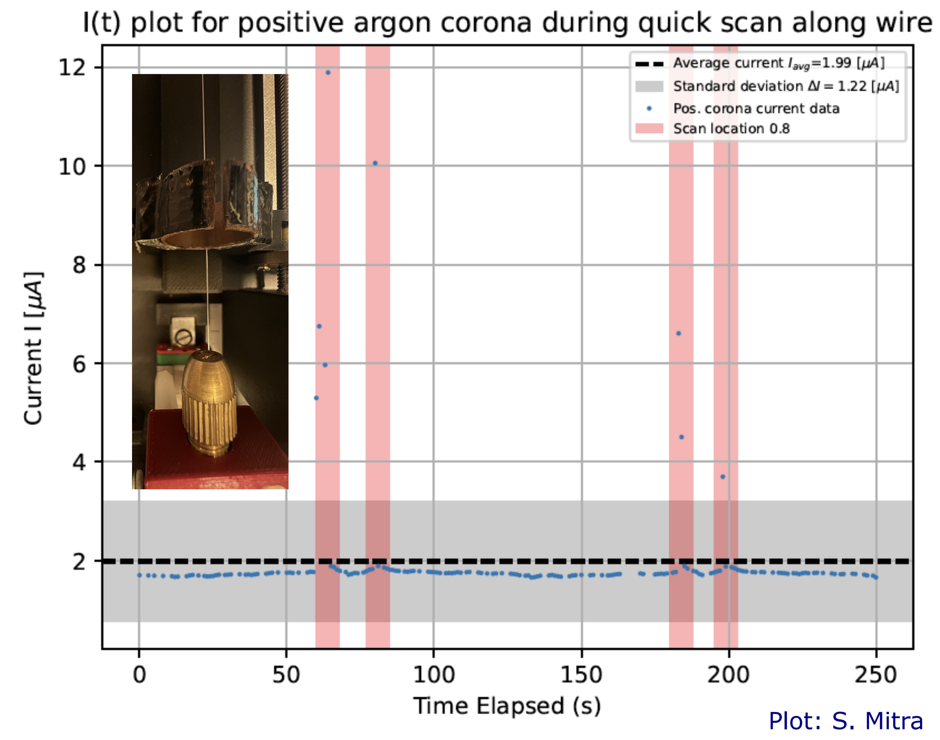
Question: **Are these spots indicative of defects and should one exclude the wire from being used in a future dual-phase TPC?**

Field enhancing asperities on wires could lead to field emission, which would create background S2 signals or, in the worst case, breakdown between electrodes.

For this reason, Corona discharges have been studied and their location was checked for correlation with spot locations. No strong indication for correlation has been observed in tests with 20 cm long wire samples.

Monitoring the dark current, when moving a ring electrode along a wire, is sensitive to ~10 μm large asperities.

I(t) plot for positive argon corona during quick scan along wire



Plot: S. Mitra