

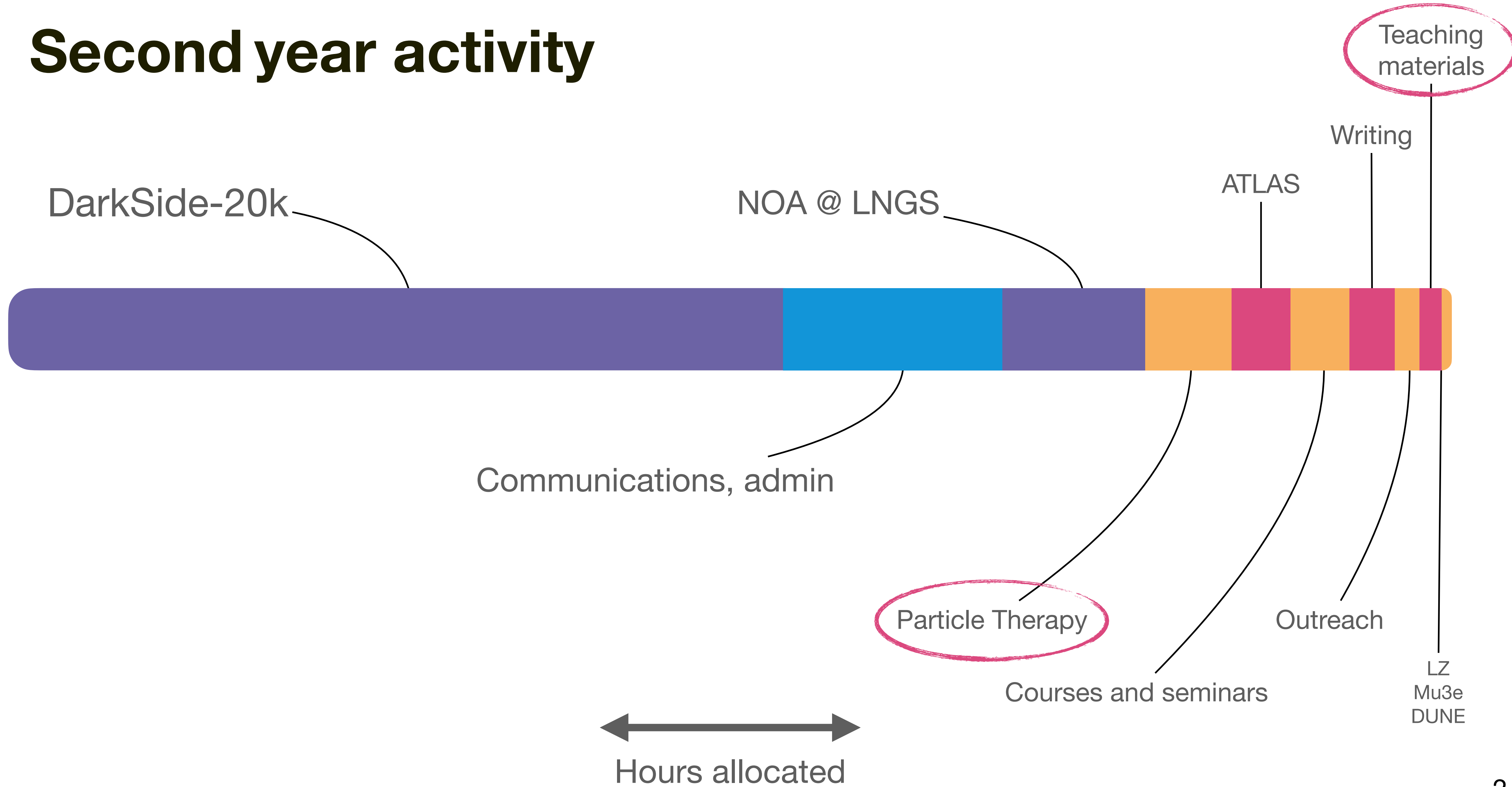
# DarkSide-20k production

Particle Physics Annual Meeting  
Thursday 18th May 2023

L. Boynton, D. Hollywood, T. Jones<sup>1</sup>, T. Lee, M. Lockwood,  
P. Sinclair, A. Taylor, J. Taylor<sup>1</sup>, P. Timko, J. Vossebeld<sup>1</sup>, M. Whitley

<sup>1</sup> Supervisory team

# Second year activity



# Outline

## 1. DarkSide-20k:

- Experiment overview
- The University of Liverpool's contributions

## 2. Specific contributions made to the project

# Experiment

- **Dark Matter (DM) direct detection experiment @ LNGS [1]**
- **Liquid argon, 20 tonne fiducial volume**
- **Near-UV SiPMs with wavelength shifter: 128 nm to 420 nm**
  
- **Primary DM candidate:**
  - **Cold dark matter: Weakly Interacting Massive Particle (WIMP)**
  - **sensitivity  $1.2 \times 10^{-47} \text{ cm}^2$  for WIMP mass of  $\sim 1 \text{ TeV}/c^2$**
  
- **Liverpool's contribution**
  - **Production of 50% of the veto detector tiles (vTiles),  $n=1250$**
  - **Cold testing of motherboard assemblies (with 16x vTile)**

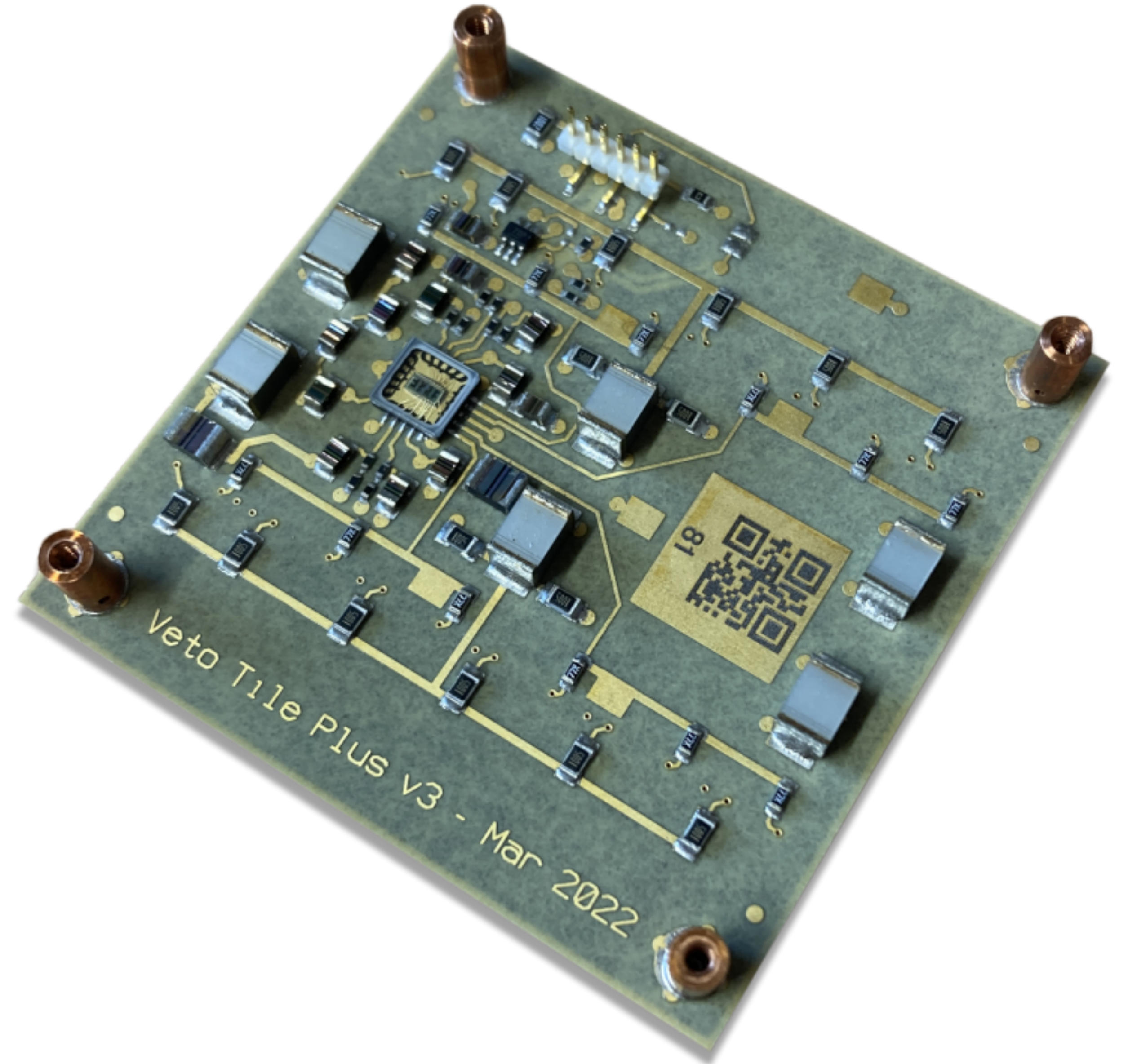
# **Refinements to pre-production processes**

- **Final Design Review and Production Readiness Review**
  - **Processes and procedures defined**
  - **Recommendations from the review panel implemented**
- **Production expected to commence in Q3 2023**



# vTile PCB

- PCBs received with back-side already populated



# Two-stage assembly

**Indium Corp.**  
**52In48Sn, 118°C**

2

**130°C for 5 min**  
**140°C for 10 sec**



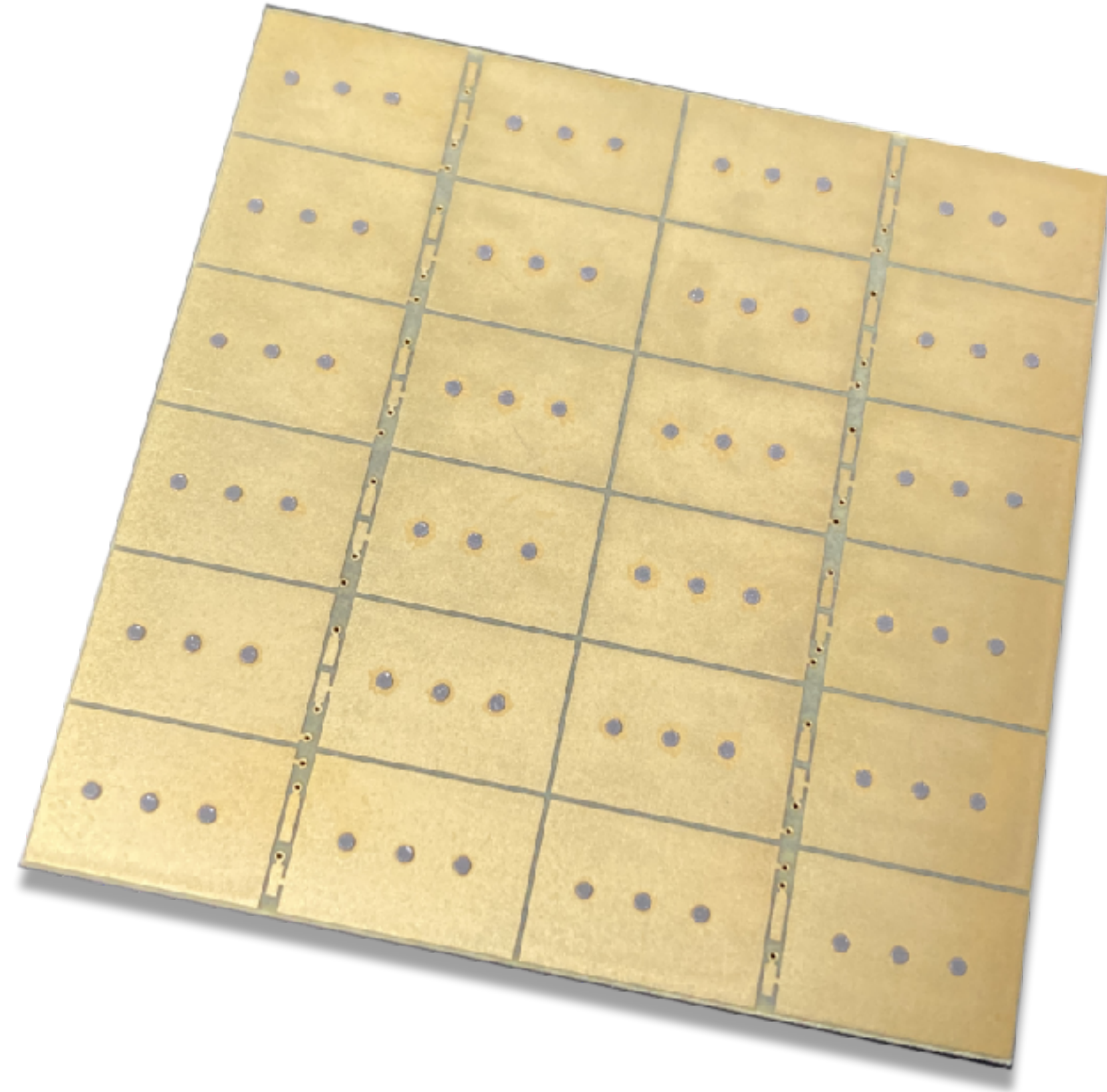
**CHIPQUIK**  
**42Sn57.6Bi0.4Ag, 138°C**

1

**150°C for 5 min**  
**200°C for 1 min**



# Manual precision placement



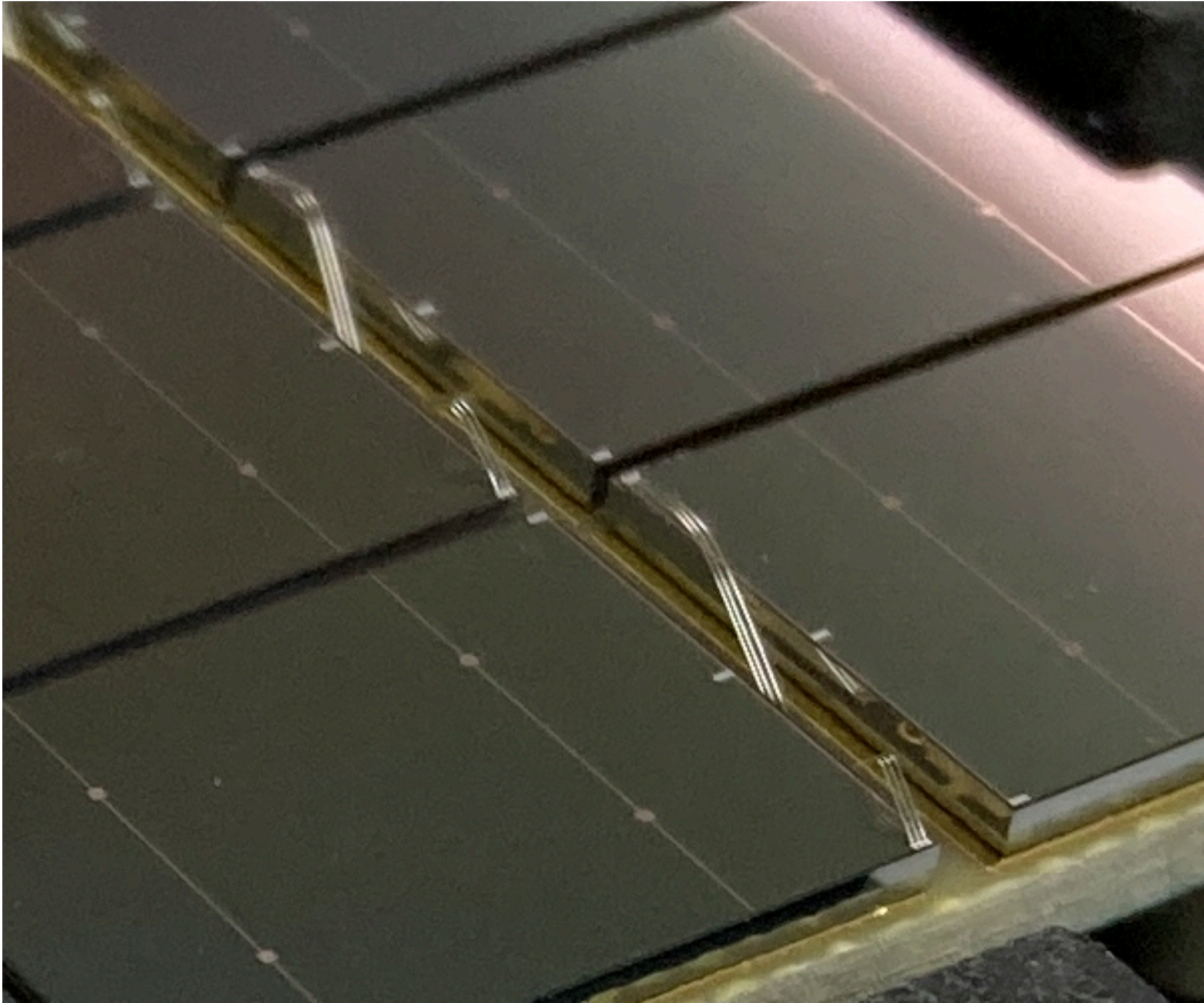
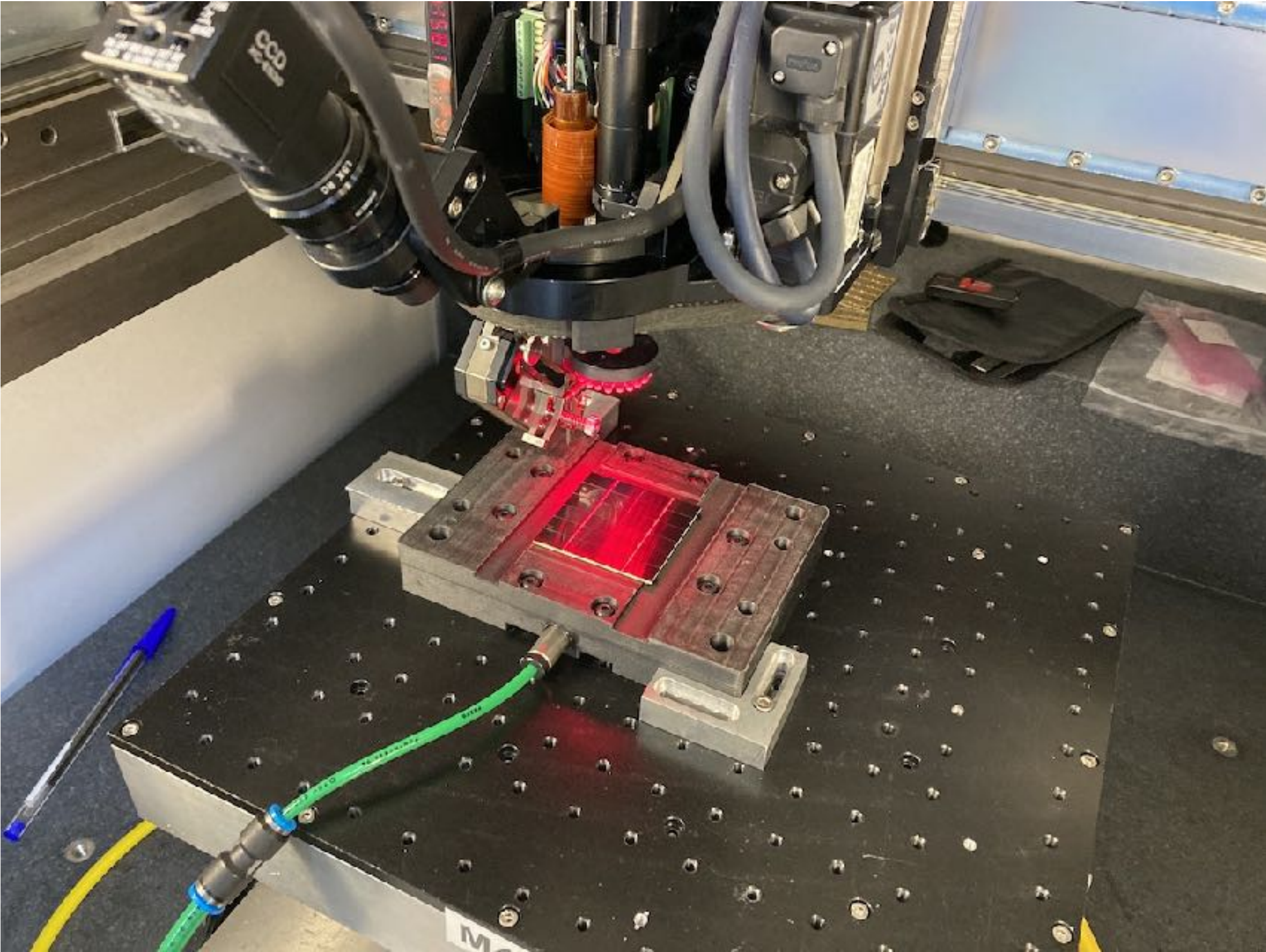
**Indium solder paste deposition  
(front-side)**



**SiPM alignment stencil  
(chemically etched)**



# Wirebonding





# Health and safety

- **Use of indium solder paste**
  - **RA/COSHH/Occupational health requirements**
  - **Adequate ventilation, measures to prevent ingestion**
- **Health screenings**
  - **before commencement**
  - **12 weeks after commencement**
  - **1 year after commencement**

# Software contributions

- **Python interface to the PostgreSQL production database [1, 2]**
  - **Used by all UK consortium members**
  - **Cross-platform (Win/Mac/Linux)**
  - **Can be used interactively**
  
  - **Authentication**
  - **GET/POST operations**
  - **Compound operations that require multiple lookups**

[1] [https://gitlab.in2p3.fr/darkside/productiondb\\_software/](https://gitlab.in2p3.fr/darkside/productiondb_software/) (requires registration)

[2] <https://test.pypi.org/project/ds20kdb-avt/>



# NOA @ LNGS, ISO-6 cleanroom





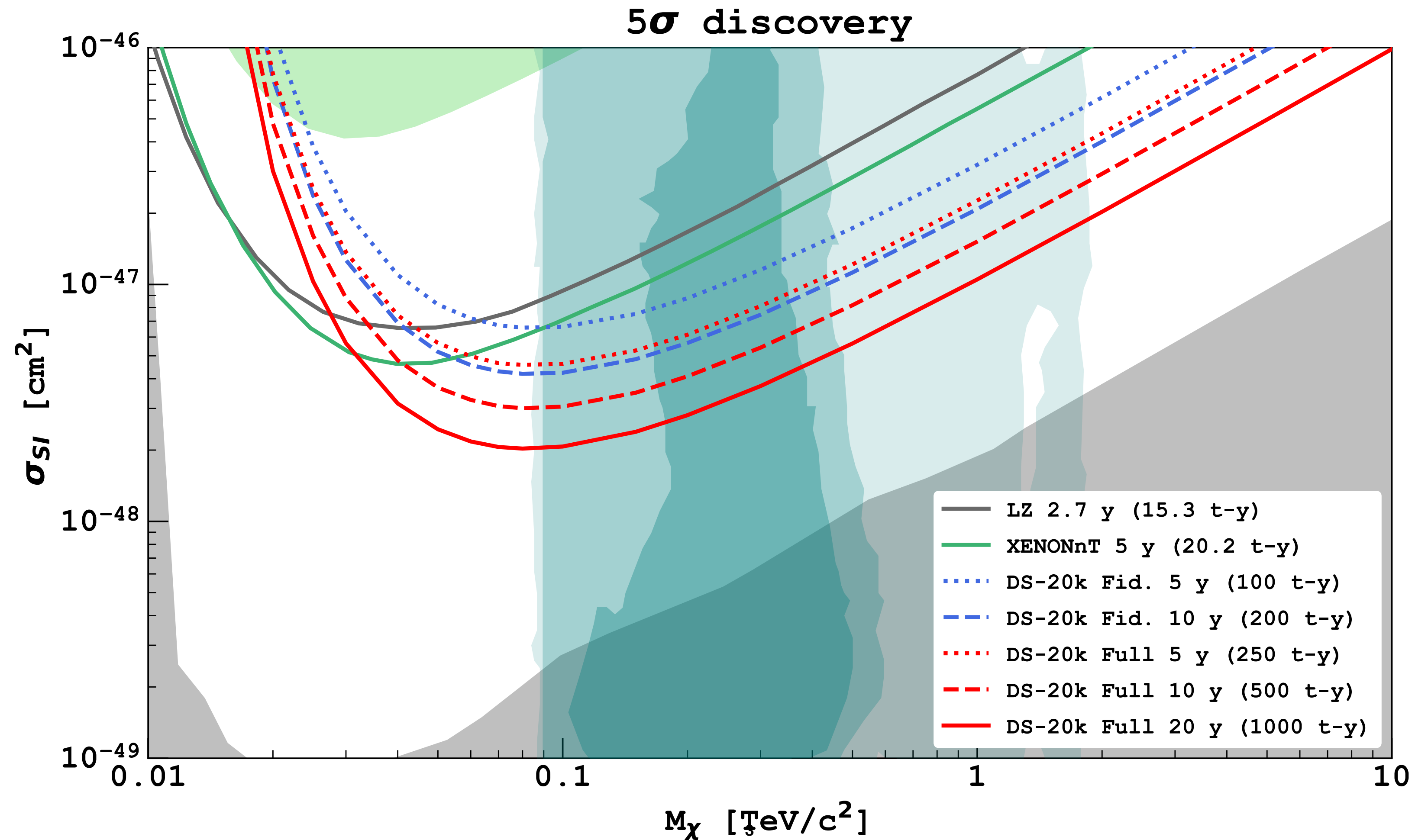
# Future work

- **Nordson PRO4 3-Axis Automated Dispensing System**
  - **DarkSide-20k partial automation**
- **SemiProbe SA8 probestation**
  - **Comparison against cryo-probing results from LNCS**
- **Performance comparison of low cost sensor arrays against discrete desktop instrumentation**
- **Analysis of motherboard cold testing results**



# Backup slides

# DarkSide-20k sensitivity [1]



[1] Cristiano Galbiati. Overview of DS-20K: High level overview of DS-20K structure: technical, budget, schedule, management. Darkside TDR Re- view: Forti Committee Meeting. June 27, 2022. url: <https://agenda.infn.it/event/31679/contributions/173234/attachments/92596/126642/Galbiati%20LNGS%20Forti%20Committee%20Meeting%20Jun%2026%202022.pdf> (requires login)



# Design and testing

- **Design before implementation**
- **Documentation**
  
- **Cross-platform testing**
- **Reliable software distribution & dependency management**
  
- **Good language practice -> easier correctness verification**
- **Unit tests [1]**
- **Fuzzing [2, 3]**
- **Profiling [4, 5]**
- **Memory usage analysis [6]**

[1] <https://docs.pytest.org/en/7.3.x/>

[2] <https://github.com/google/atheris>

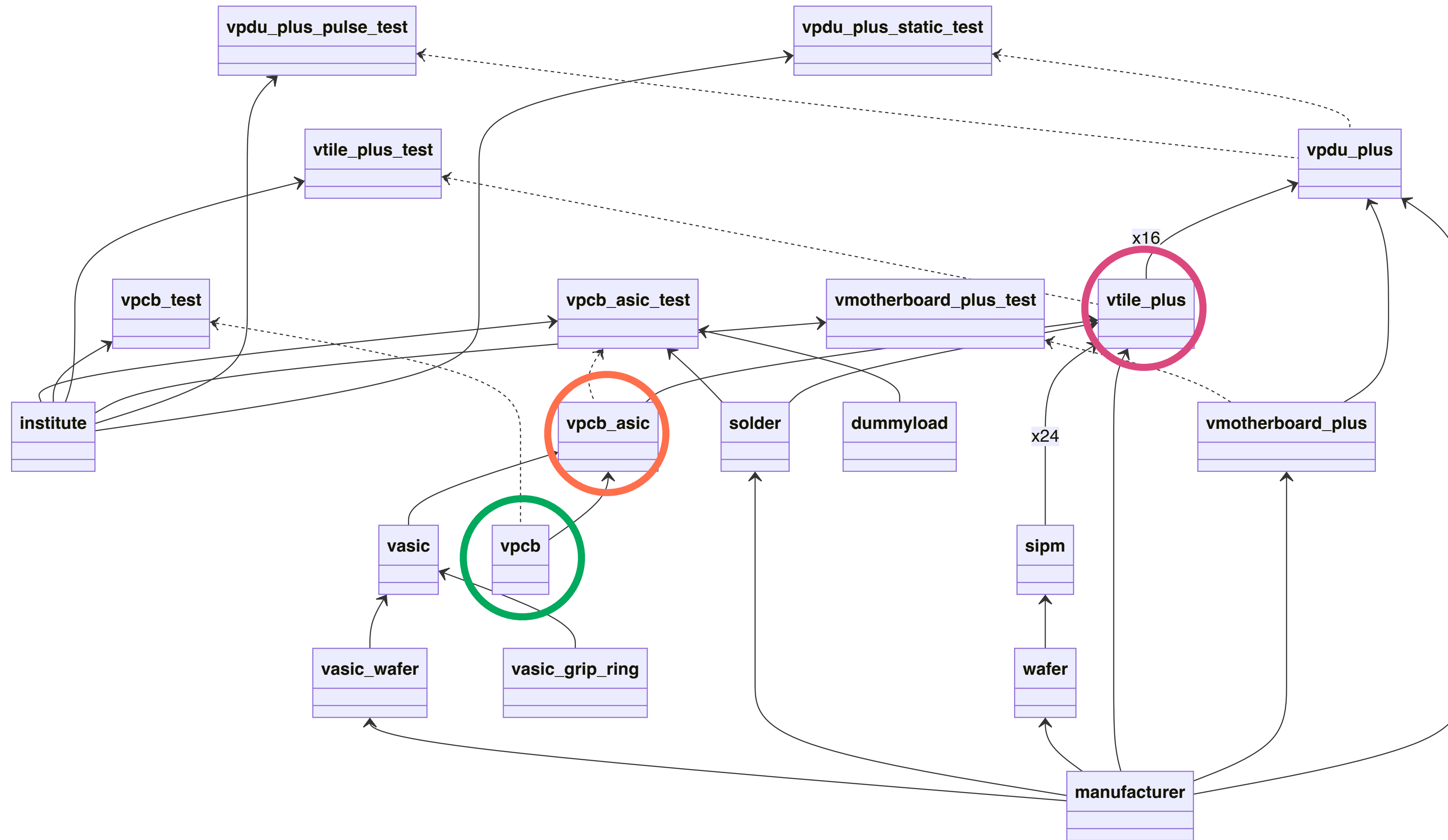
[3] <https://llvm.org/docs/LibFuzzer.html>

[4] <https://docs.python.org/3/library/profile.html#module-cProfile>

[5] <http://jiffyclub.github.io/snakeviz/>

[6] <https://docs.python.org/3/library/tracemalloc.html>

# Software contributions - compound db lookups

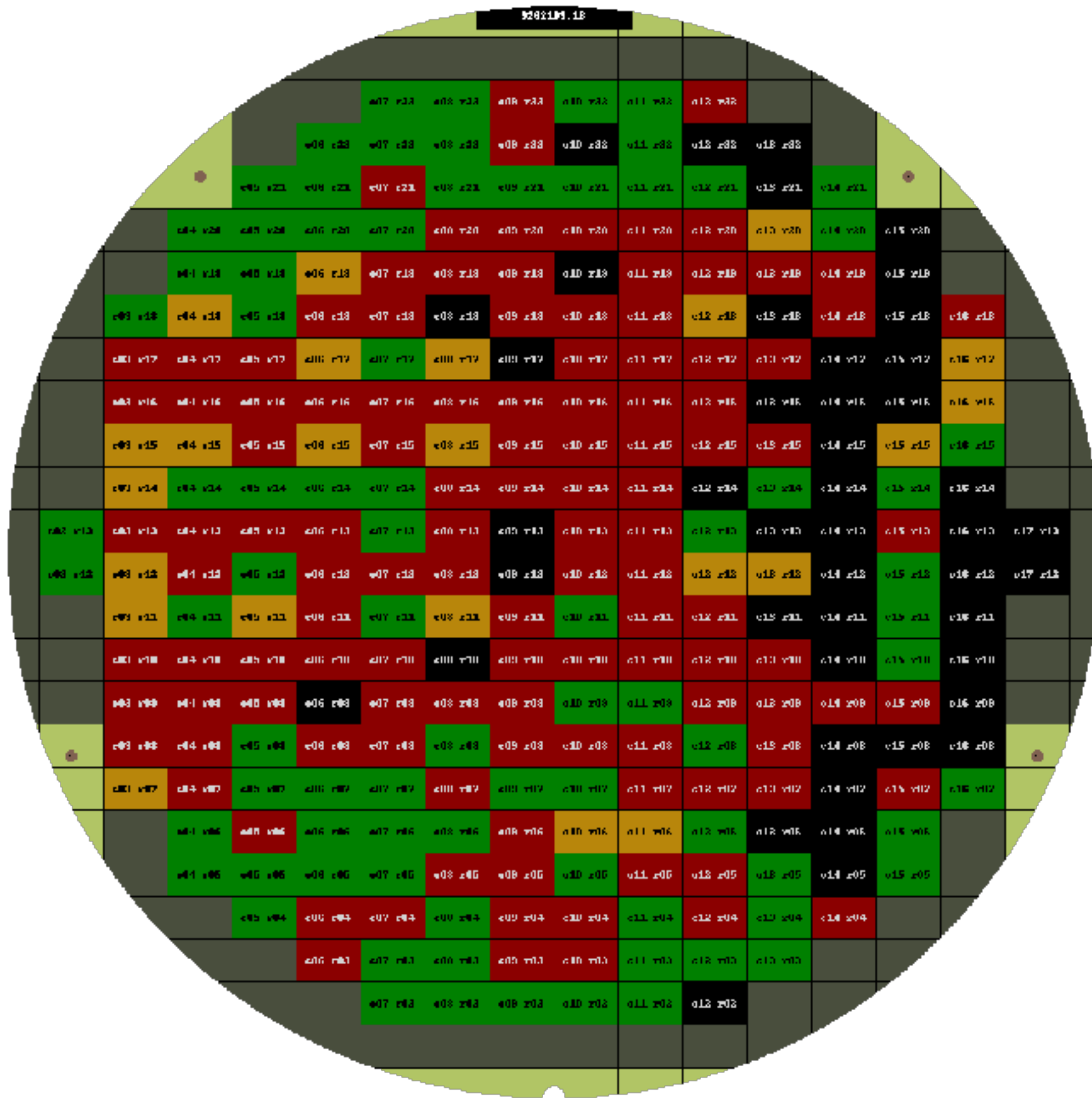


# Software contributions

- **Python interface to the PostgreSQL production database**
  - **Wafer map visualisation**
    - **Tolerable performance for www use (< 150ms)**
    - **A faster version in Rust [1] will be available shortly**
  - **GUI application for submitting vTiles to the database (STFC)**

[1] <https://www.rust-lang.org/>

# Software contributions



POST vTile

File Tools Help

-SIPMs

SIPM 19	SIPM 13	SIPM 7	SIPM 1
lot wafer col row 9262109 15 9 2	lot wafer col row 9262109 15 10 3	lot wafer col row 9262109 15 11 4	lot wafer col row 9262109 15 11 4
SIPM 20	SIPM 14	SIPM 8	SIPM 2
lot wafer col row 9262109 15 10 2	lot wafer col row 9262109 15 11 3	lot wafer col row 9262109 15 13 4	lot wafer col row 9262109 15 13 4
SIPM 21	SIPM 15	SIPM 9	SIPM 3
lot wafer col row 9262109 15 12 2	lot wafer col row 9262109 15 12 3	lot wafer col row 9262109 15 6 3	lot wafer col row 9262109 15 6 3
SIPM 22	SIPM 16	SIPM 10	SIPM 4
lot wafer col row 9262109 15 13 3	lot wafer col row 9262109 15 13 3	lot wafer col row 9262109 15 7 3	lot wafer col row 9262109 15 7 3
SIPM 23	SIPM 17	SIPM 11	SIPM 5
lot wafer col row 9262109 15 7 2	lot wafer col row 9262109 15 7 2	lot wafer col row 9262109 15 8 3	lot wafer col row 9262109 15 8 3
SIPM 24	SIPM 18	SIPM 12	SIPM 6
lot wafer col row 9262109 15 8 2	lot wafer col row 9262109 15 8 2	lot wafer col row 9262109 15 9 3	lot wafer col row 9262109 15 9 3

-Supplemental details

Manufacturing institute  
University of Liverpool

PID of solder syringe  
17

QR-code  
23020703000097001

Production run number  
3

-Production date/time (timezone: UTC)

Year	Month	Day	Hour	Minutes
2023	5	4	9	30

Actions  
check submit

Console  
Loaded file /Users/avt/.ds20kdb\_defaults  
Check start: 2023-05-15 15:17:04  
SiPM 19: missing field(s)  
SiPM 20: missing field(s)  
SiPM 21: missing field(s)  
SiPM 22: missing field(s)



# Environmental monitoring

- **Software originally design for the ATLAS, re-used for DarkSide-20k [1, 2]**
  - **OO Python API, Raspberry Pi based**
  - **Supports:**
    - **ATLAS common hybrid NTC, thermocouples**
    - **ADCs, strain gauges**
    - **SMC vacuum and flow rate sensors**
    - **Peltier devices, switchable polarity via relay arrays**
    - **Generic temp/humidity/barometric pressure**
    - **ULT-80 Chiller**
    - **Keithley DMM6500 Digital multimeter**

[1] <https://gitlab.ph.liv.ac.uk/avt/atlas-itk-pmmcb>

[2] <https://pypi.org/project/mmc-b-avt/>



# Laboratori Nazionali del Gran Sasso

## Gran Sasso d'Italia

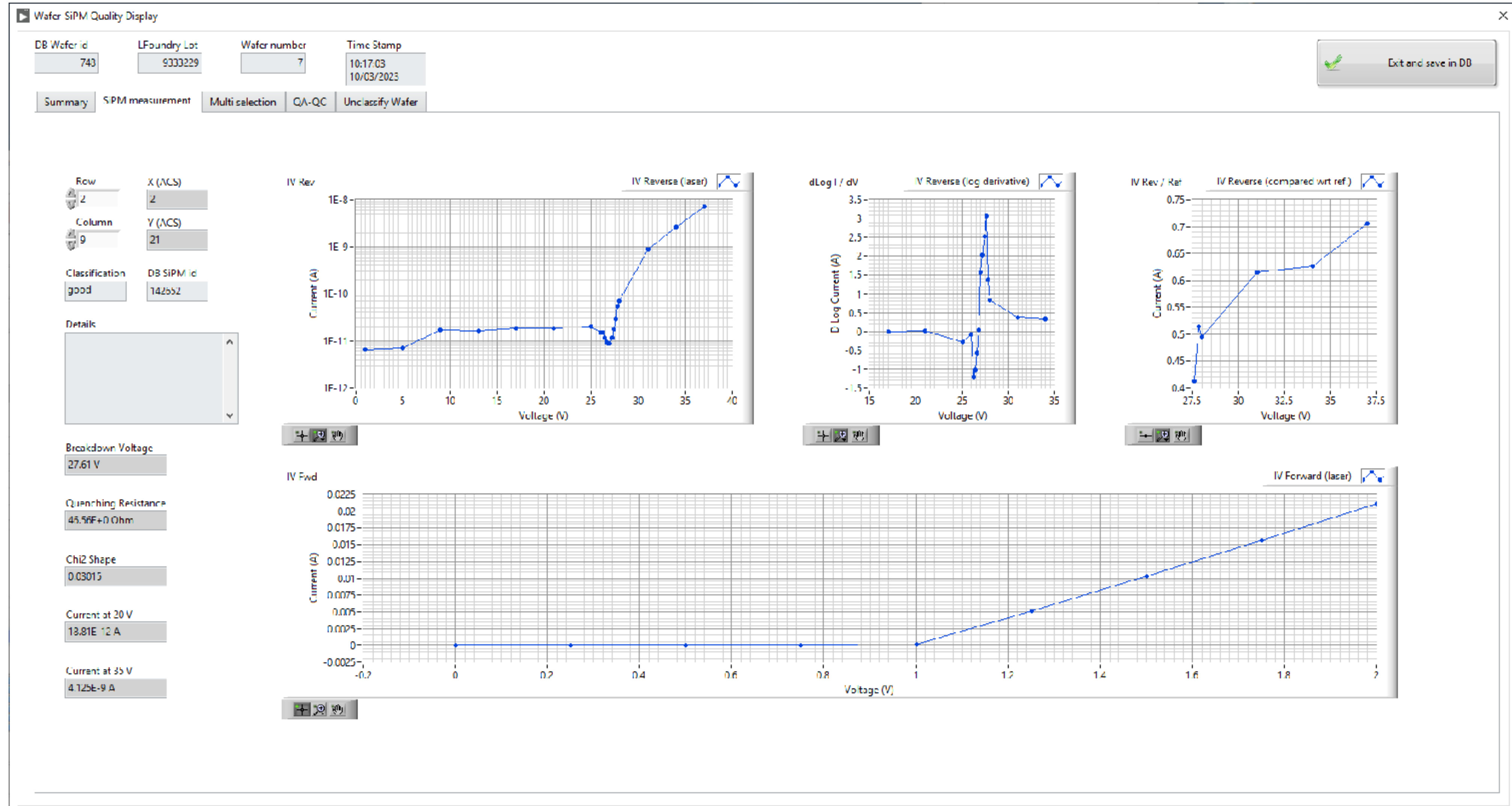




# LNGS, wafer 9365590.19

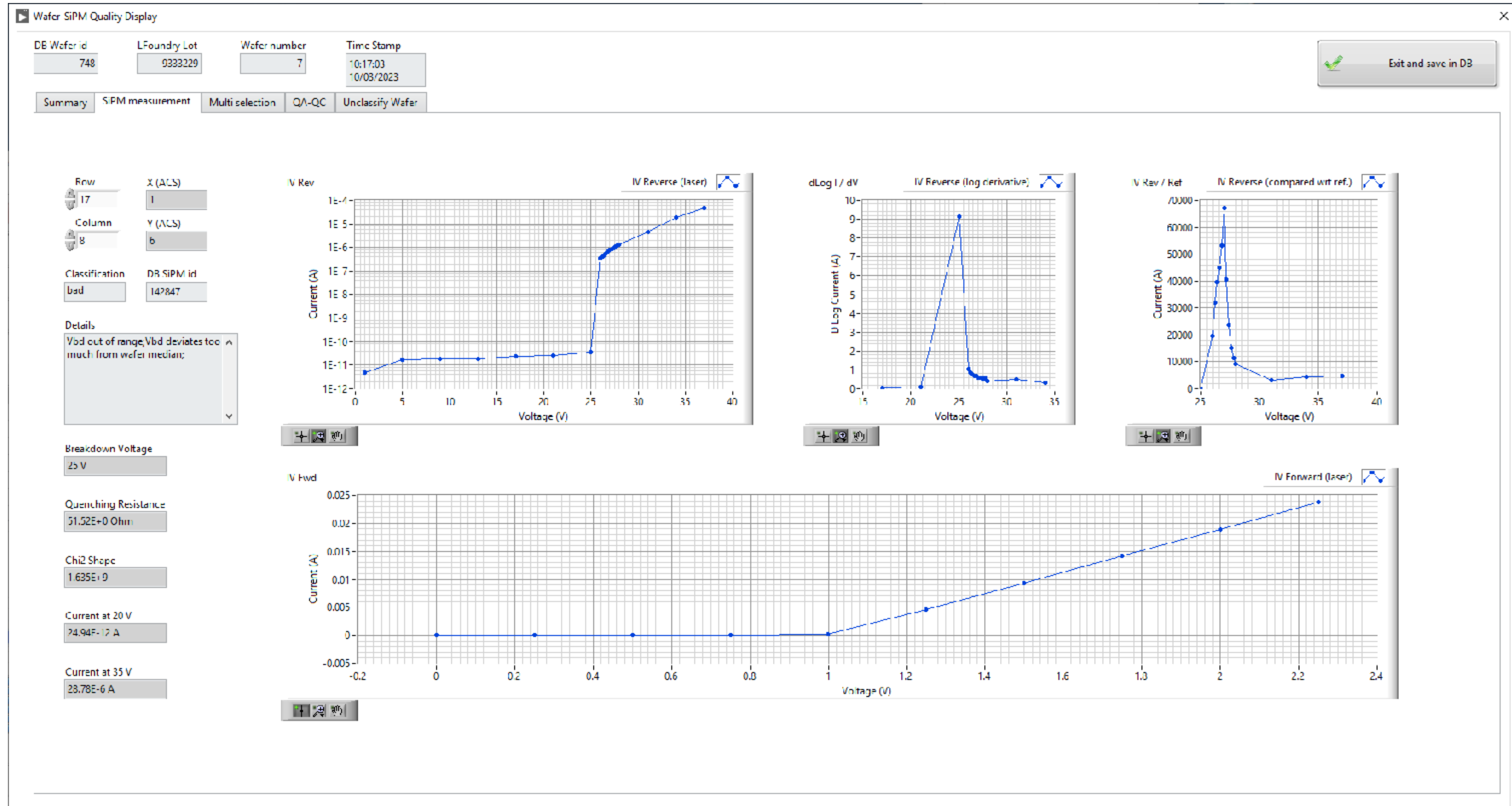


# LNGS, good SiPM

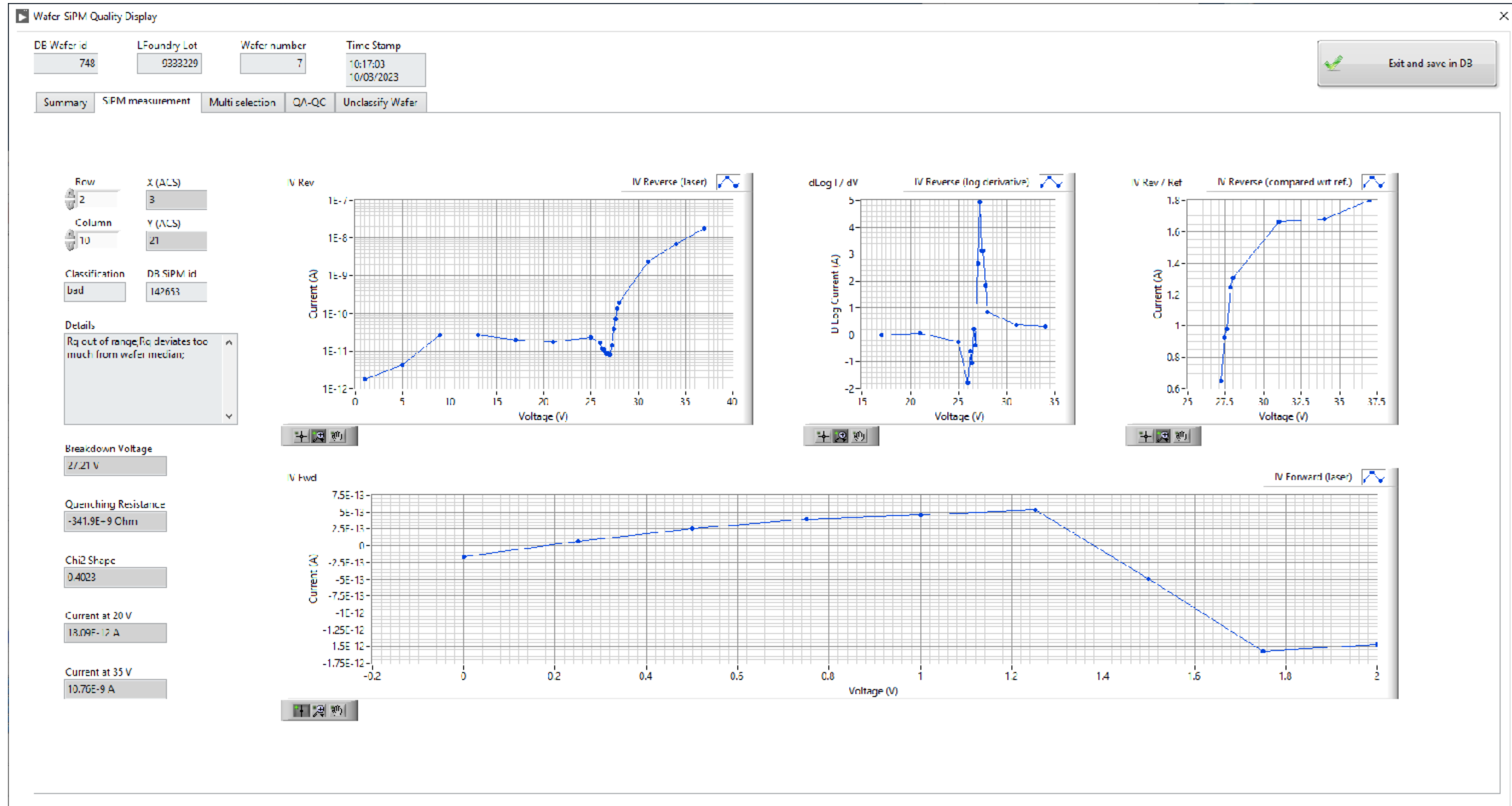




# LNGS, bad SiPM 1



# LNGS, bad SiPM 2

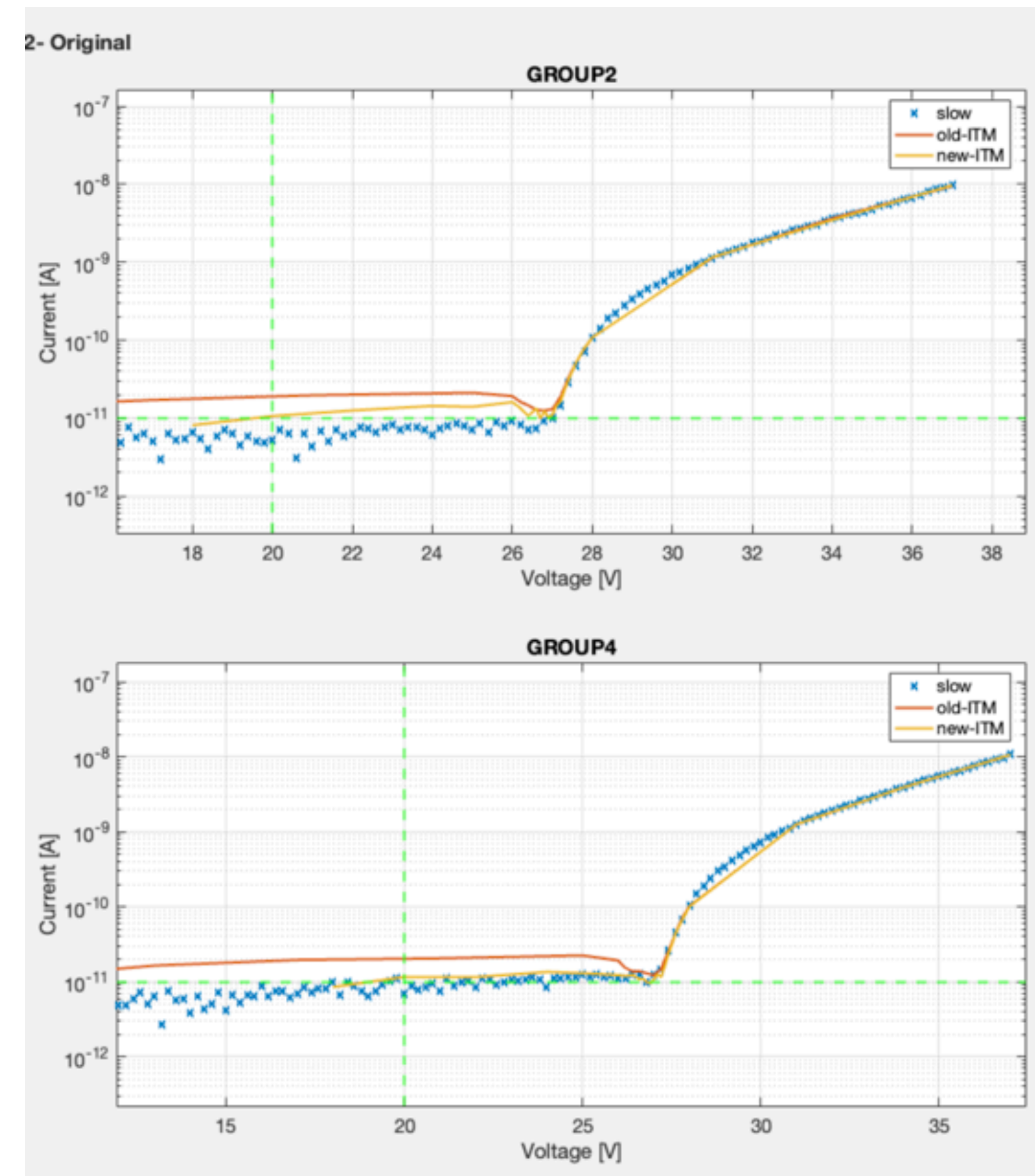


# LNGS, reverse IV

## Reverse IV curves settings

Keithley ACS uses measurements ITM (i.e. settings)

- IV curves at 77K have a slow settling time in the pre-breakdown region
- The “new-ITM” accounts for it introducing a significant delay before to start the voltage sweep
- After breakdown measurement are unchanged
- Step close to  $V_{bd}$  was reduce to 0.1 V
- Statistics per point improved in the new ITM (10 current points)



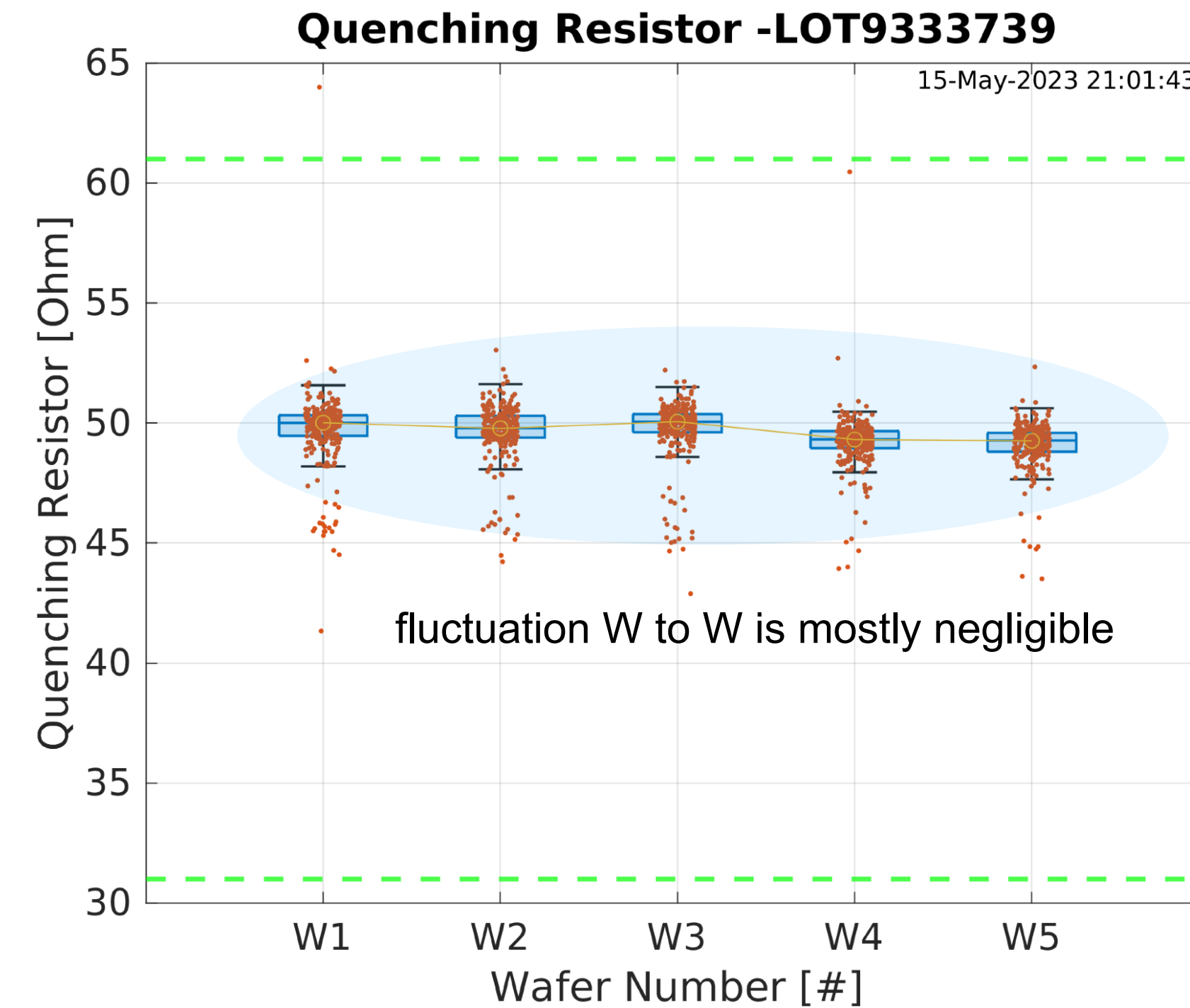
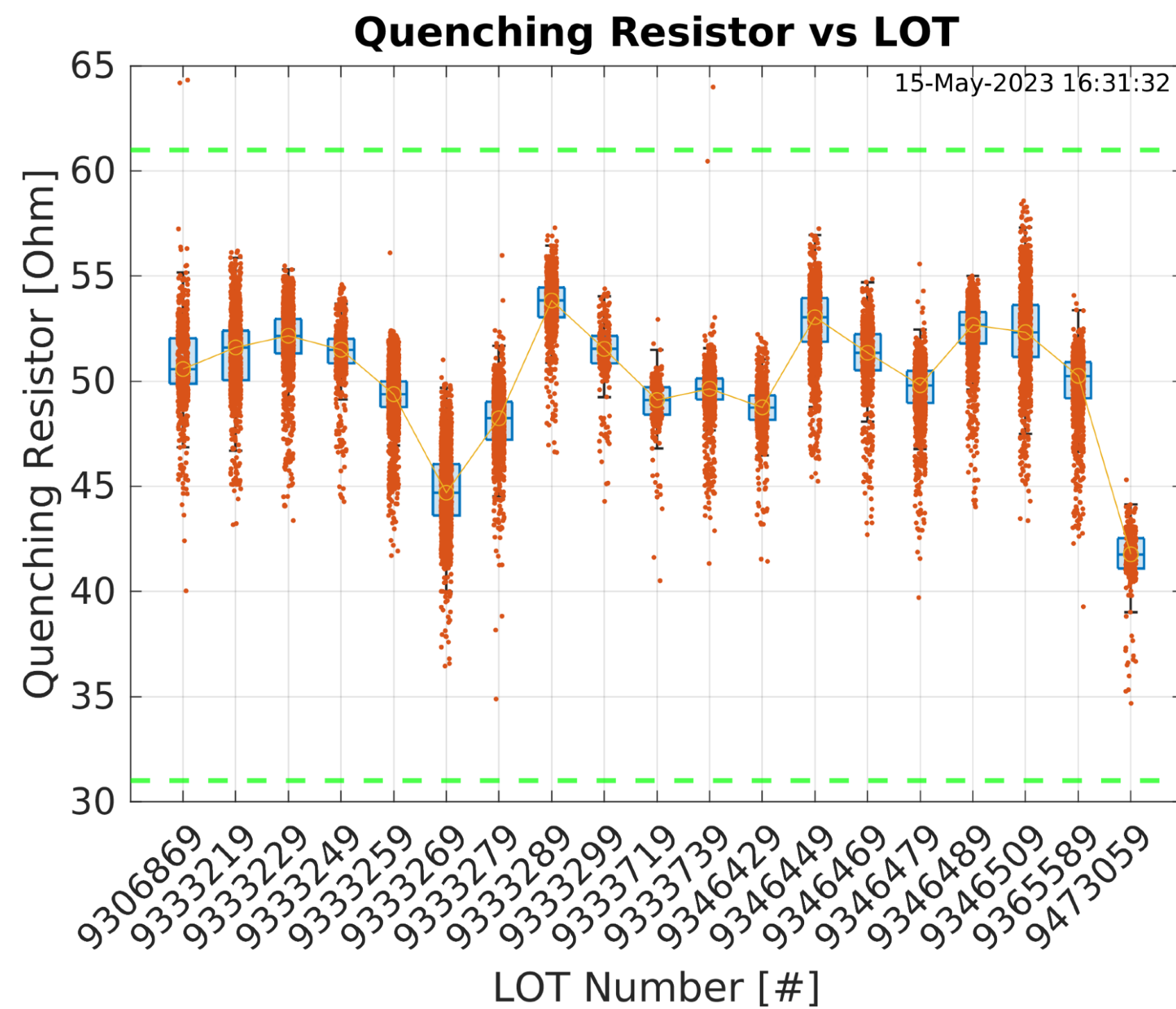
11

# LNGS, quenching resistor

## Quenching Resistor

- Quenching resistor is found by fitting the forward IV curve at large bias voltage

16

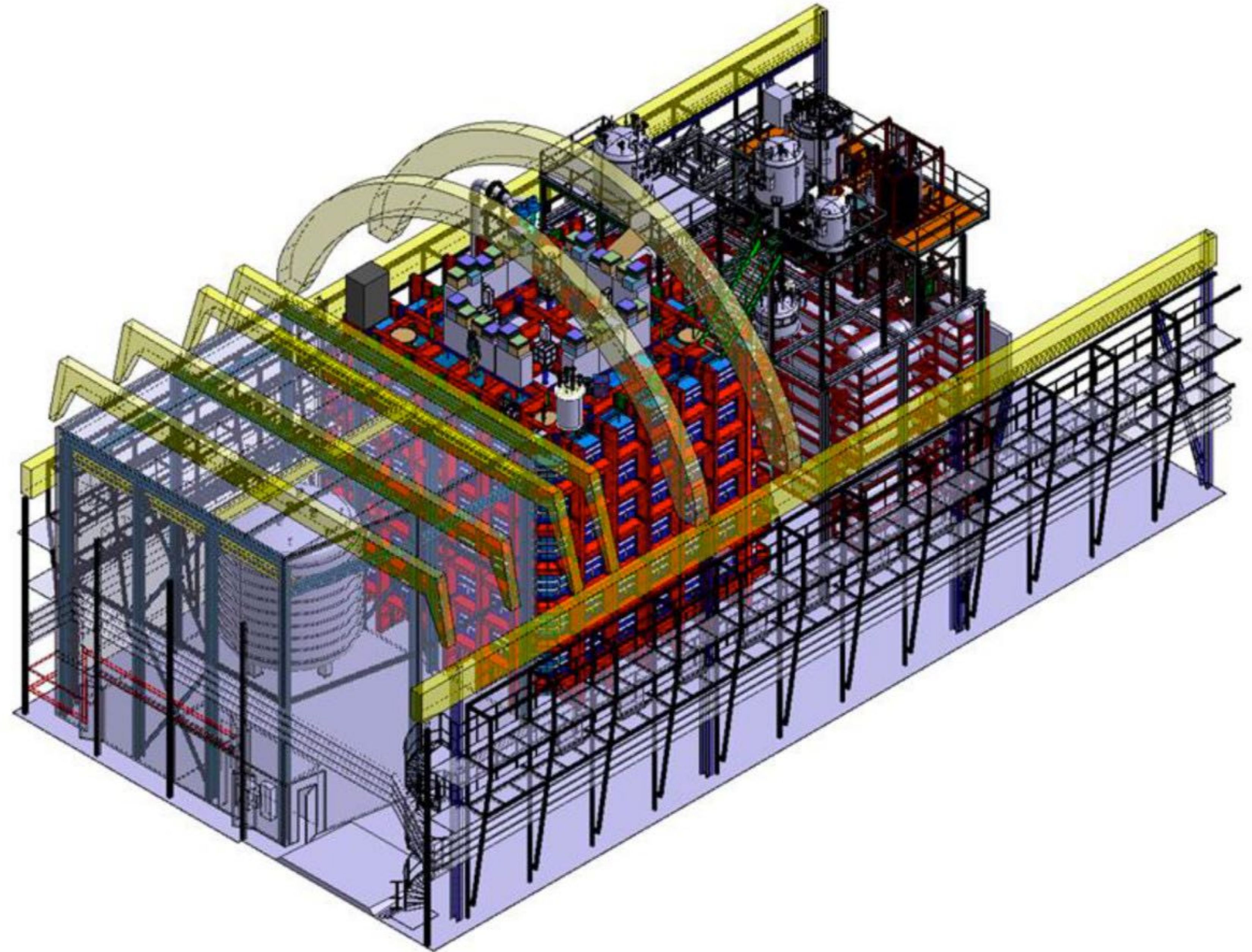


**Proposed requirement 46 +/- 15 Ohm**

(Requirement from "Bando" 37 +/- 16 Ohm)



# LNGS Hall C





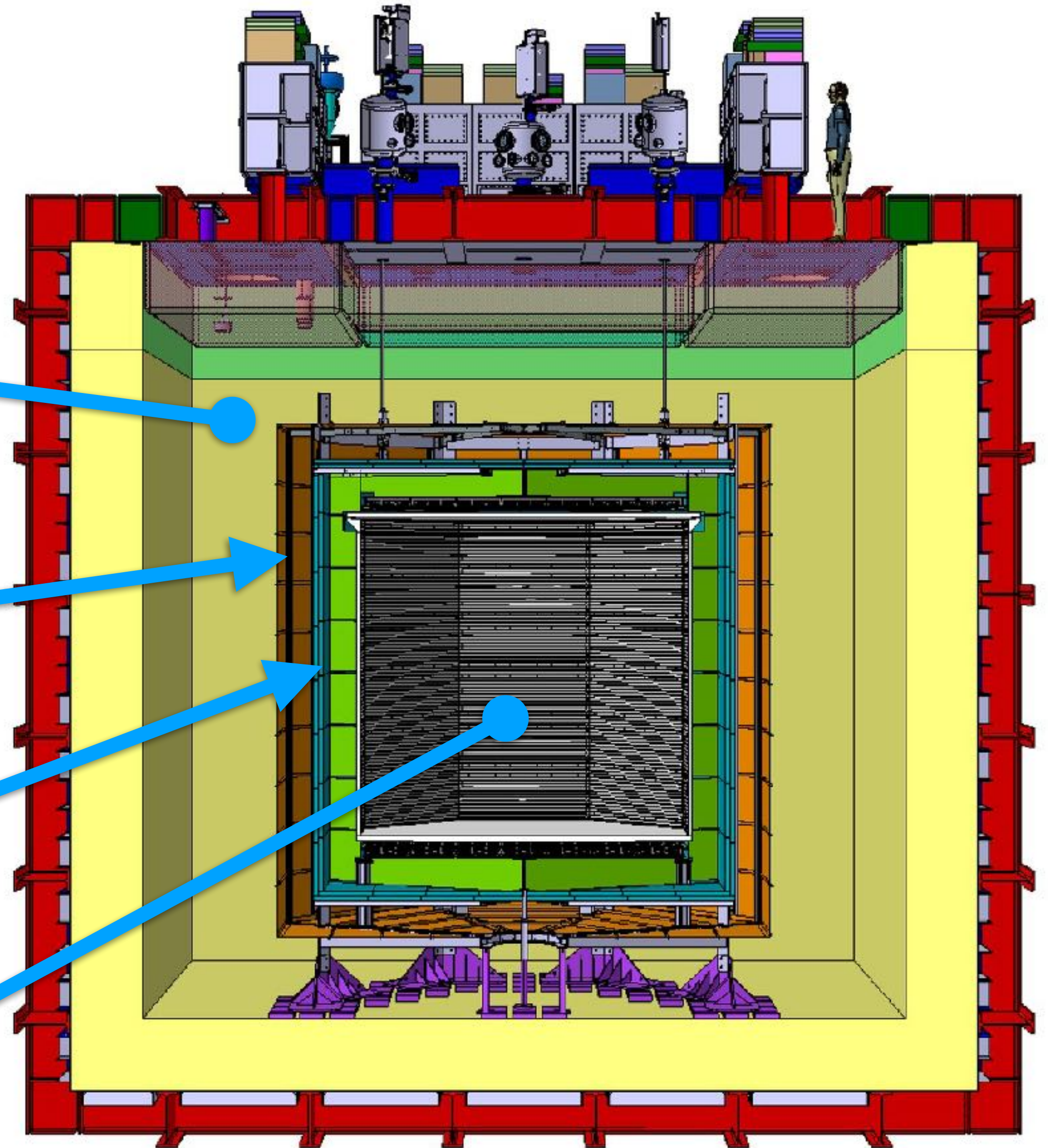
# Cryostat

passive shielding, LAr (700t)

copper Faraday cage

veto structure

TPC LAr (50t), fiducial volume 20t



# Veto schematic

