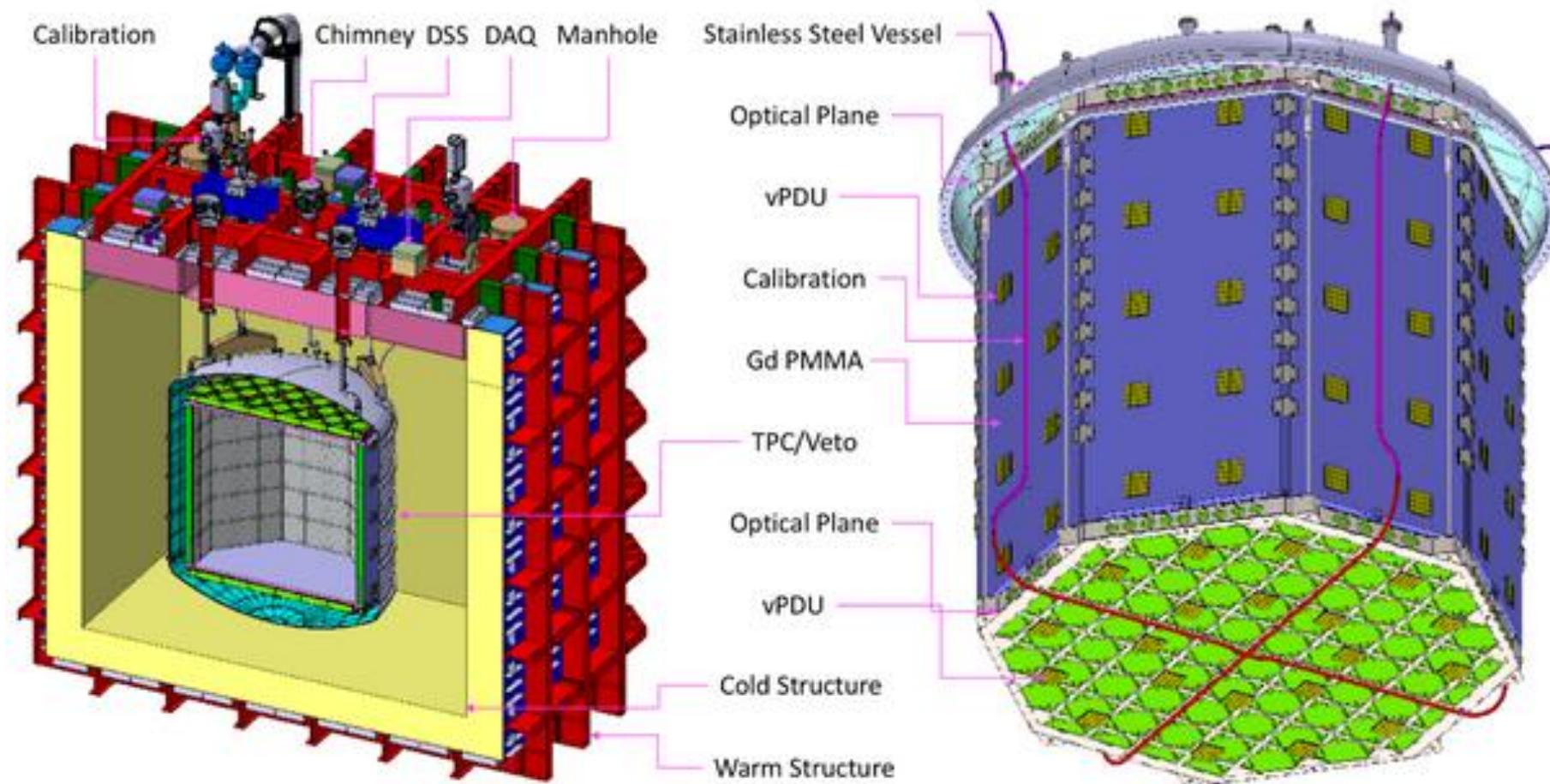


Testing photodetectors for the Darkside-20k inner veto

Emma Ellingwood

Feb 4, 2026

Darkside-20k



Distribution of DarkSide-20k UK sites

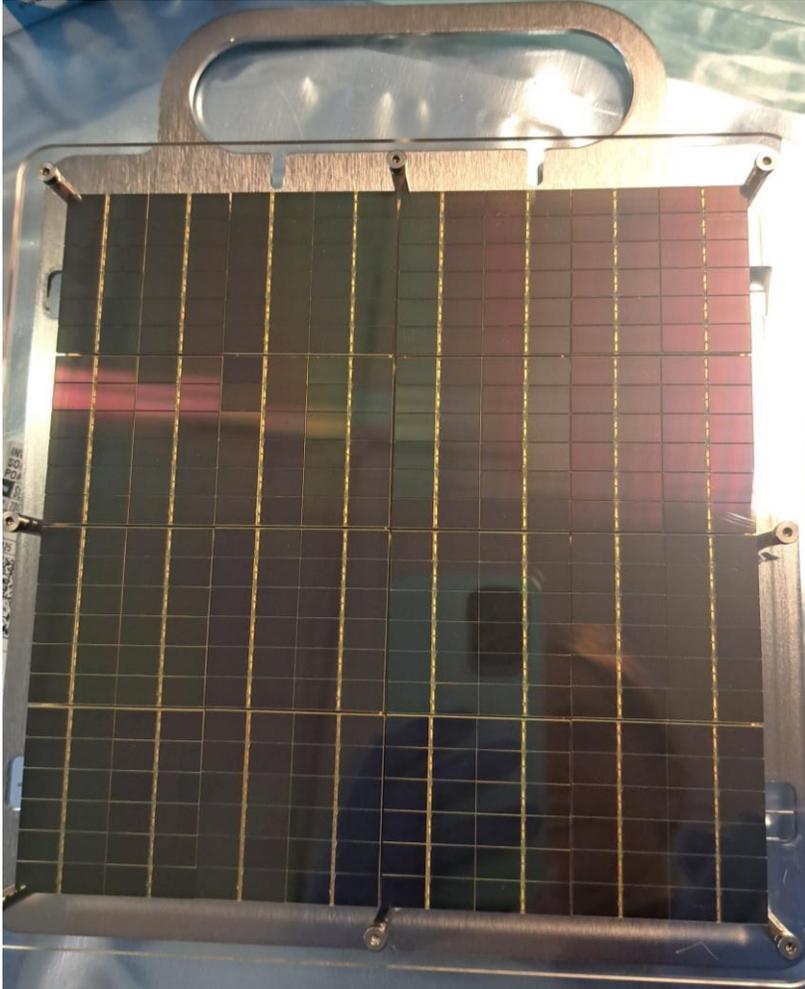
P vPDU cold test
+ @ AstroCeNT
Warsaw, Poland

Key

- Q QR code etching
- P PCB population
- S SiPM die attach + wire bonding
- T vTile cold test
- I Integration (vPDU) and warm test
- P vPDU cold test



Darkside-20k vPDUs



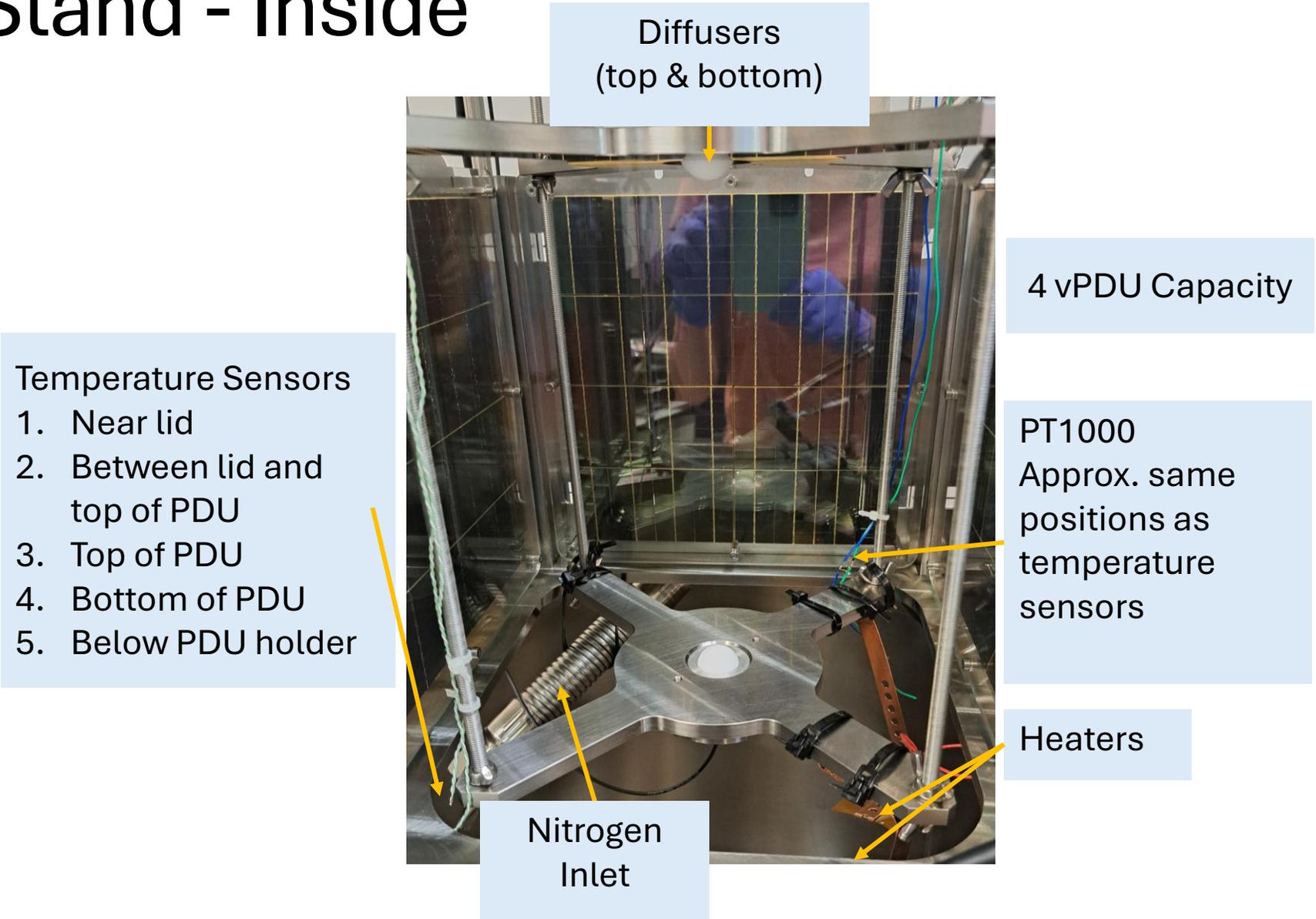
- 20x20cm photodetection units comprising of 384 SiPMs
 - 1 vTile = 24 SiPMs mounted on a front-end board
 - 1 vPDU = 16 vTiles mounted on a custom motherboard
- 120 vPDUs needed for Darkside
 - 35 of these were cold tested in Edinburgh

Test Stand - Outside



- Commercial Cryofab 150L dewar
- Multiple feedthroughs for power supply, output signals and monitoring equipment
- Lid also had nitrogen inlet, pressure monitor, burst disk and manual pressure relief valve
- 3D printed covers to reduce light leaks
- System covered in two layers of black material
- Internal structure mounted to lid holds vPDUs
- For cold tests the dewar is filled with <100 L of LN₂

Test Stand - Inside



Diffusers
(top & bottom)

4 vPDU Capacity

- Temperature Sensors
1. Near lid
 2. Between lid and top of PDU
 3. Top of PDU
 4. Bottom of PDU
 5. Below PDU holder

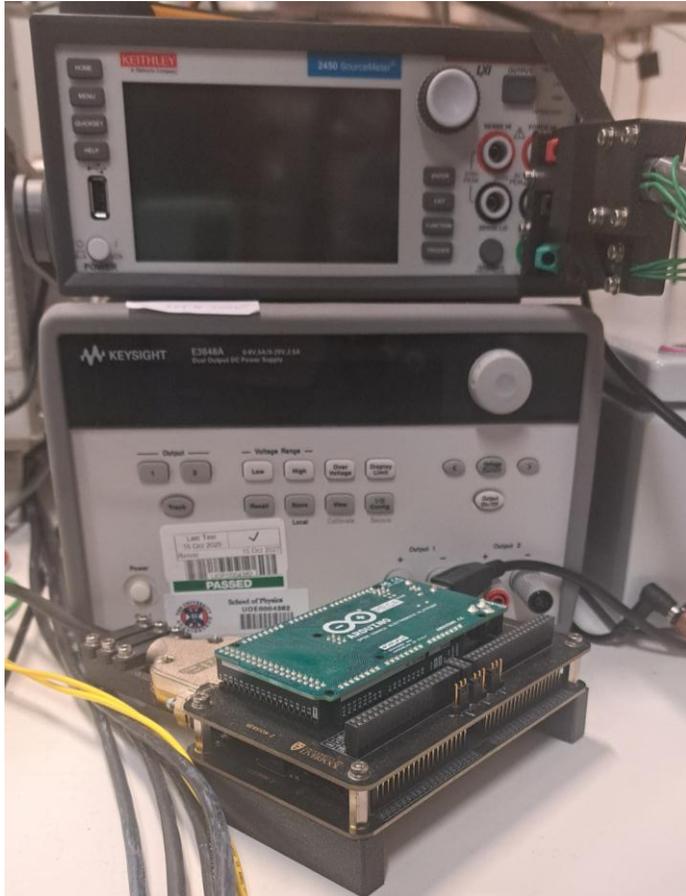
PT1000
Approx. same positions as temperature sensors

Nitrogen Inlet

Heaters

vPDU Electronics

vPDU Control



Keithley 2450 power supply

Keysight E3642 power supply

Custom Arduino-based steering module

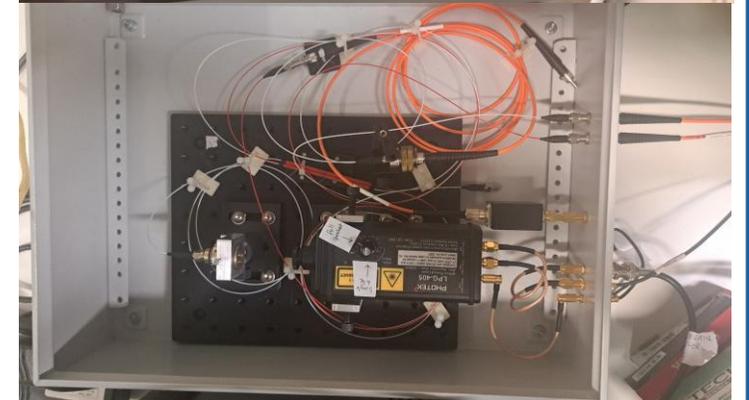
CAEN V2740 Digitiser



Laser setup

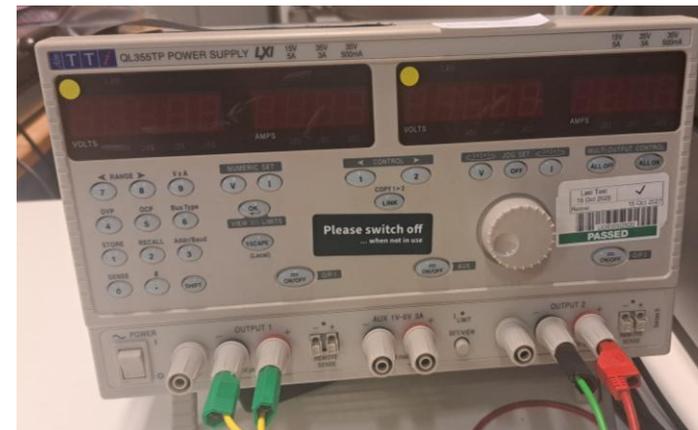
VM2786B pulse generator

Photek LPG-405 setup



Monitoring Electronics

- Pfeiffer vacuum MaxGauge pressure monitor
- BTM-4208SD temperature recorder – 5 sensors, read out separately
- PT1000 level sensors – 5 sensors, single current reading out
- QL 355TP power supply – for heater and PT1000 sensors

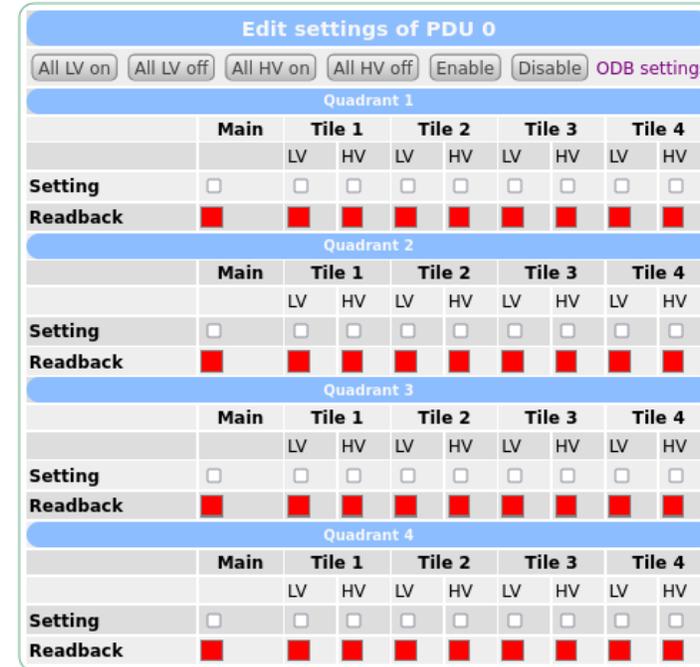
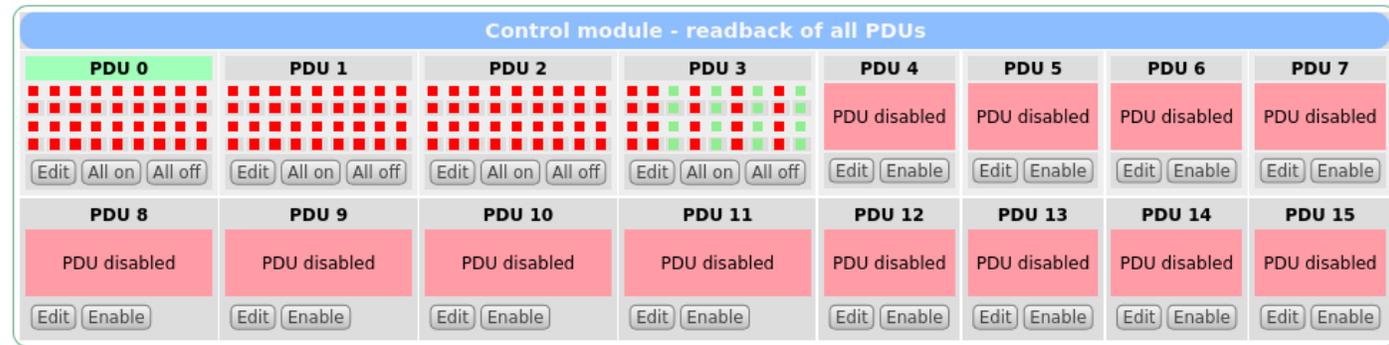


Measurements

- Each run takes ~1 week
- Warm tests
 - Low-voltage power check
 - IV curves for each tile and quadrant
 - Noise spectra for each tile and quadrant
- Cold tests
 - Low-voltage power check
 - IV curves
 - Noise spectra
 - Laser SPE tests
- Temperature monitors and PT1000 sensors kept monitored throughout testing

Software

- All DAQ electronics are controlled remotely using MIDAS software
 - CAEN DAQ
 - Keithley
 - Keysight
 - Control Module
- All monitoring equipment related programs are written in python
 - Control of monitoring equipment power supply control
 - Temperature and PT1000 live plotting
 - Equipment status updates to mattermost



Analysis Framework

- A 'veto passport' analysis framework made at Oxford to standardize analysis procedures for all institutions doing these tests. ROOT/python based.
- Determines the dark count rate, gain, SPE, RMS, etc.
- vPDUs that fail tests can either be retested or reworked and then retested.
- vPDUs that pass all tests are repacked awaiting shipment

Results

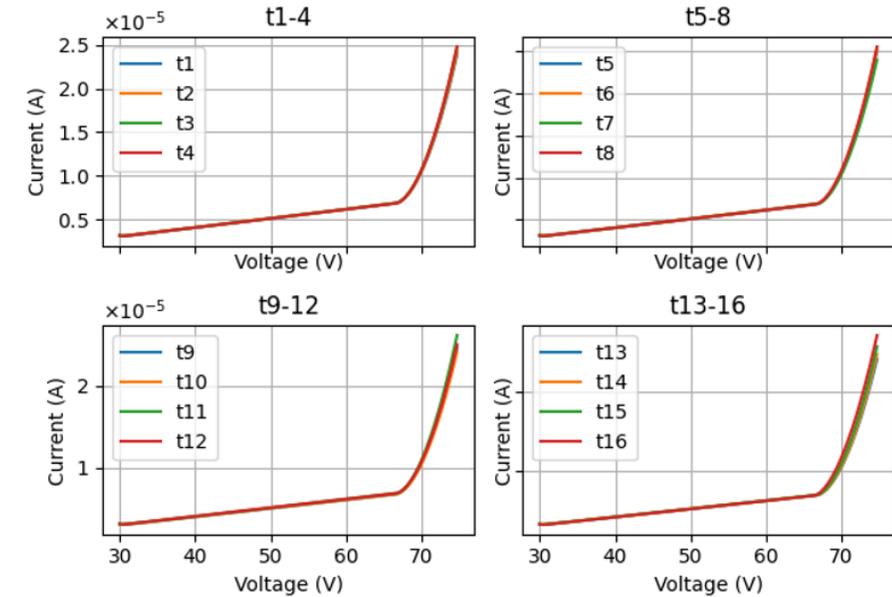
vPDUs are graded based on parameters like:

- Dark count rate
- SNR
- Gain
- RMS
- LV draw check
- IV breakdown voltage

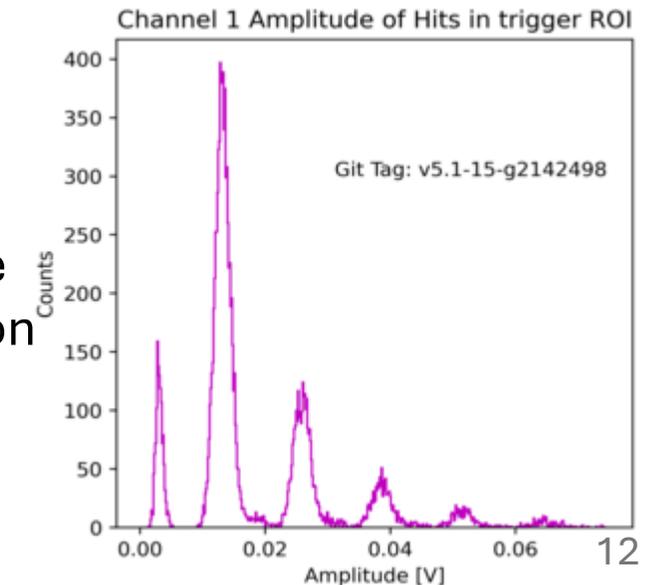
Sample low-voltage check

Cold				
Test Start :	2025-06-10 19:25			
4PDUs connected, signal cables connected				
All measurements in mA				
All off	22	23	23	23
	vPDU40 Ch0	vPDU99 Ch1	vPDU115 Ch2	vPDU118 Ch3
Q1 MB	63	64	65	65
Q1 T1	88	88	89	89
Q1 T2	88	89	88	89
Q1 T3	88	88	88	88
Q1 T4	88	88	88	89
Q1 All tiles	160	158	159	160
Q2 MB	63	65	65	65
Q2 T1	88	88	89	90
Q2 T2	88	89	89	90
Q2 T3	87	89	89	90
Q2 T4	87	89	89	89
Q2 All tiles	160	160	162	162
Q3 MB	64	65	64	65
Q3 T1	89	89	88	88
Q3 T2	88	82	89	89
Q3 T3	88	89	88	89
Q3 T4	88	89	88	89
Q3 All tiles	161	155	160	161
Q4 MB	64	63	65	64
Q4 T1	87	87	88	88
Q4 T2	87	88	88	88
Q4 T3	88	87	89	89
Q4 T4	88	87	89	89
Q4 All tiles	158	159	159	160
Full PDU	571	564	571	576

Example of warm tile IV curves for a vPDU



Laser test amplitude distribution



Packing and Shipping

- Each vPDU is triple bagged – one anti-static bag, 2 layers of radon-free vacuum bags with desiccant and humidity monitors
- Large peli cases with customised inner box to limit shock to vPDUs
- Shockwatches and VB300 vibration loggers on the interior box



Other lab equipment



Pfeiffer ASM 340
helium leak checker.



Evaporator

For applying coatings,
like WLS to other
materials.

We also have (but I have
no image)

- Cryocooler
- High-voltage power
supply