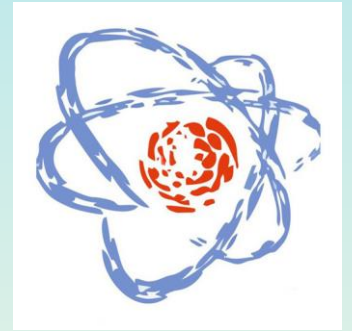




The 25th conference of AYSS



Development of methods for SiPM mass testing.

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DLNP, JINR

Supported by



Under grant #21-42-00023

Almaty, 2021



JUNO

(The Jiangmen Underground Neutrino Observatory)

Goals:

- Neutrino mass hierarchy Measurements
- Oscillation parameters measurements
- Astrophysics and rare processes

Location:

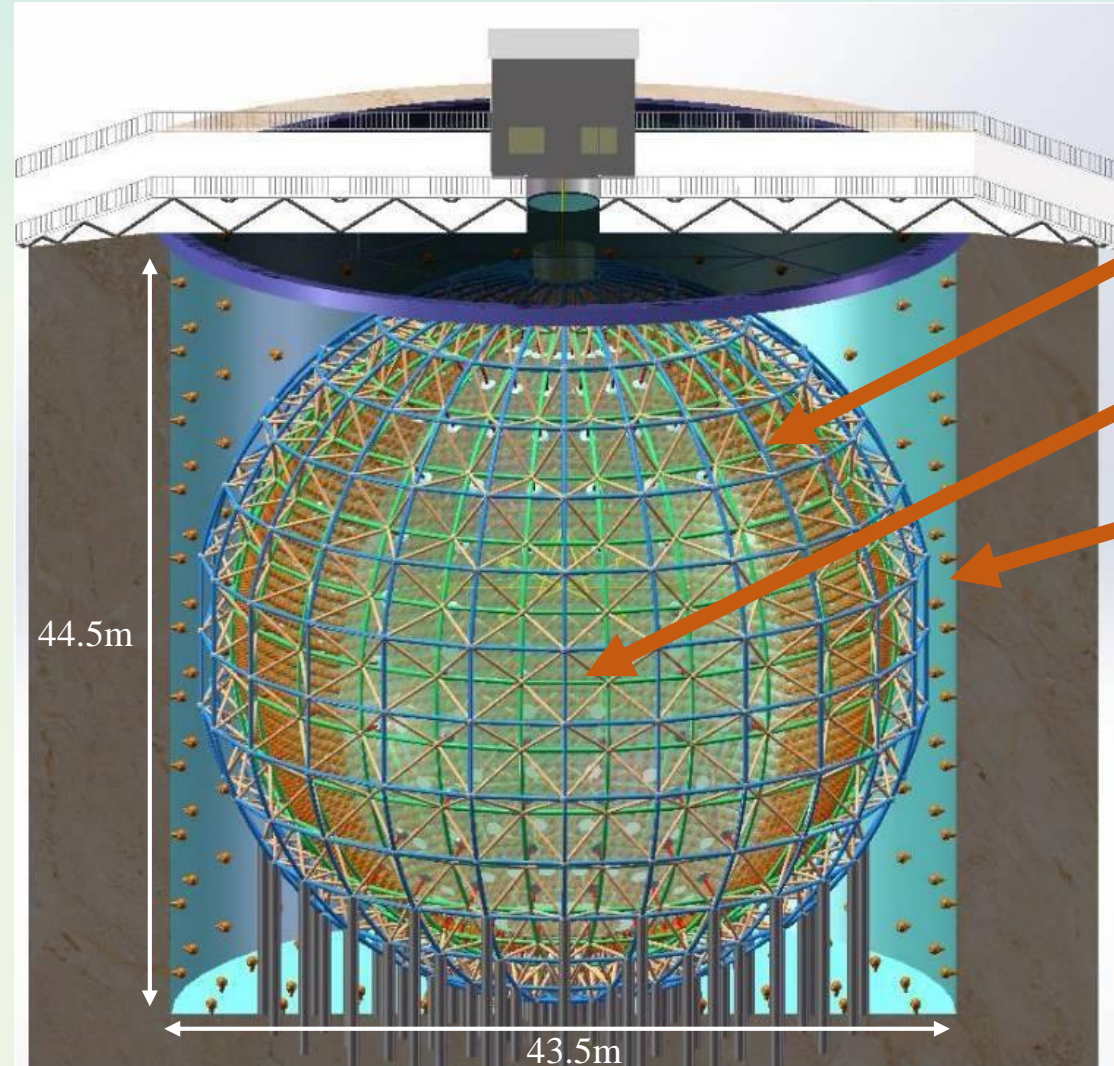


Powerful source:

Yangjiang and Taishan power plants
26.6 GWth in 2020, later 35.7 GWth

Ideal baseline:

53 km



- Acrylic Sphere 35.4m diameter

- 20 kton LAB based liquid scintillator

- Water Cherenkov Veto 20kt ultrapure water
and 2000 20" PMTs

- About 20,000 large
20" photomultiplier tubes (PMTs)

- 25000 3" small PMTs

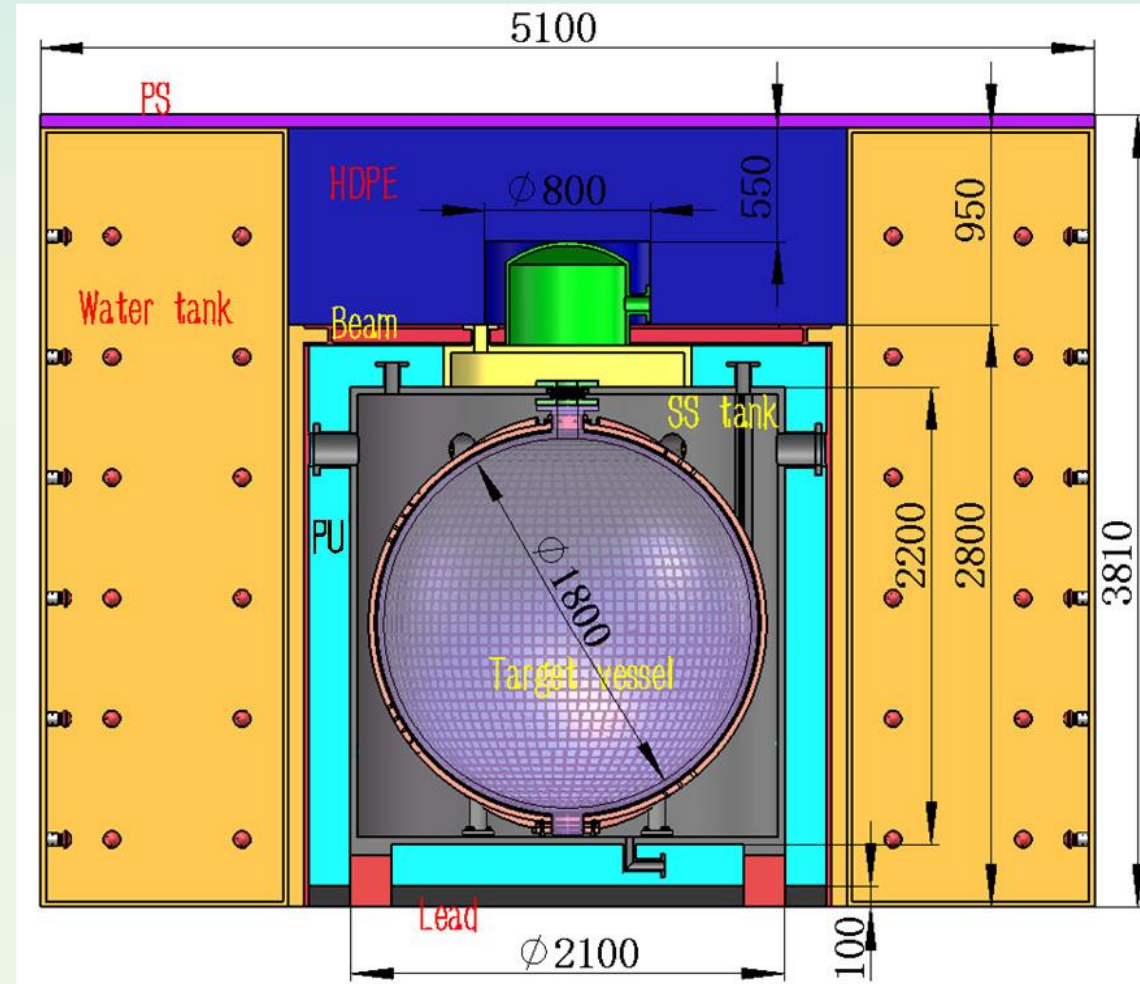
- 700 m underground

TAO

The Taishan Antineutrino Observatory (satellite experiment)

The main purposes of the TAO experiment are:

- 1) to provide a reference spectrum for JUNO.
- 2) to provide a benchmark measurement to test nuclear databases.
- 3) to provide increased reliability in measured isotopic antineutrino yields.
- 4) to provide an opportunity to improve nuclear physics knowledge of neutron-rich isotopes.
- 5) to search for light sterile neutrinos with a mass scale around 1 eV;
- 6) to provide increased reliability and verification of the technology for reactor monitoring and safeguard.



Schematic view of the TAO detector.

- TAO will be placed at ~ 30 m from a core of the Taishan Nuclear Power Plant.

- A spherical acrylic vessel will contain ~ 2.8 ton gadoliniumdoped liquid scintillator.

- TAO will be operates at -50C celsius

- Sphere will be covered by ~10 m2 Silicon Photomultipliers (SiPMs)

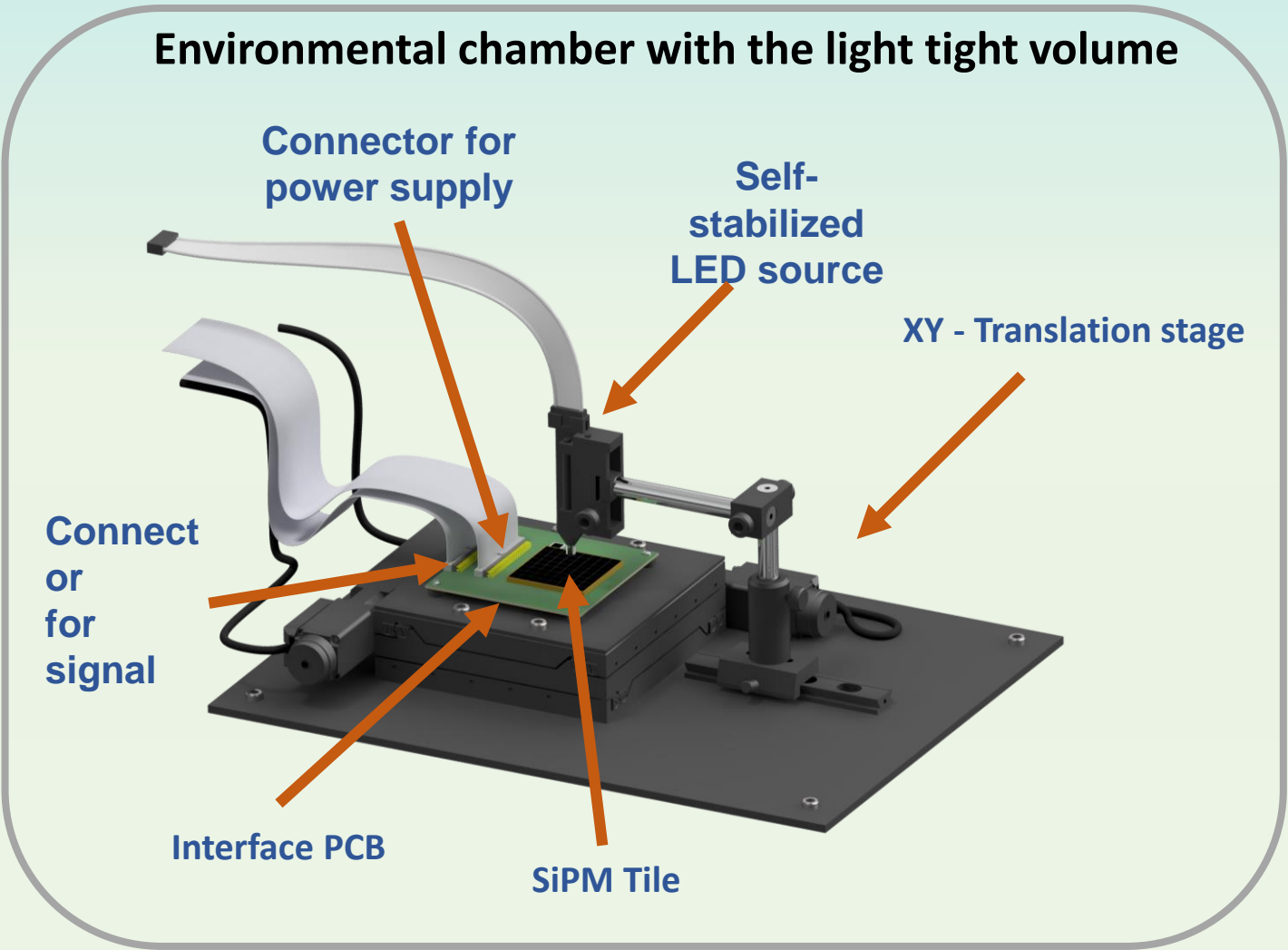
- total number of tiles ~ 4000 pcs

- all tiles need to be characterized

SiPM parameters Requirements

Parameters	Specification	Comments
PDE	$\geq 50\%$	at 420 nm, not including correlated noise
Dark count rate	$\leq 100 \text{ Hz/mm}^2$	at -50°C
Probability of correlated noise	$\leq 10\%$	including cross talk and afterpulsing
Uniformity of Vbd	$\leq 10\%$	to avoid bias voltage tuning
Size of the SiPM device	$\geq 6 \times 6 \text{ mm}^2$	for easy handling
SiPM coverage within tiles	$\leq 94\%$	not included in SiPM's PDE

Measurement stand concept



Measurement procedure:

1	SiPM Tile installation	~5 min	
2	Hot scan	~45 min	+20°C, 5mm/s 1kHz
3	Cooling down	~30 min	~3 °C/min
4	Cold scan	~45 min	-50°C, 5mm/s
5	Heating	~15 min	5 °C/min
Total time:		2h20min	

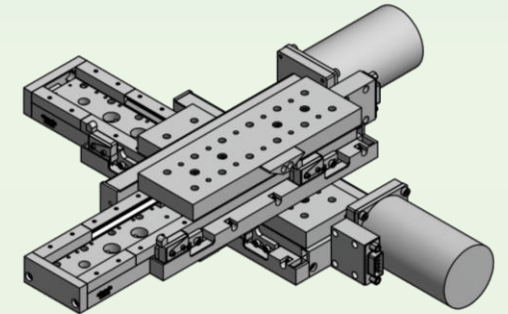
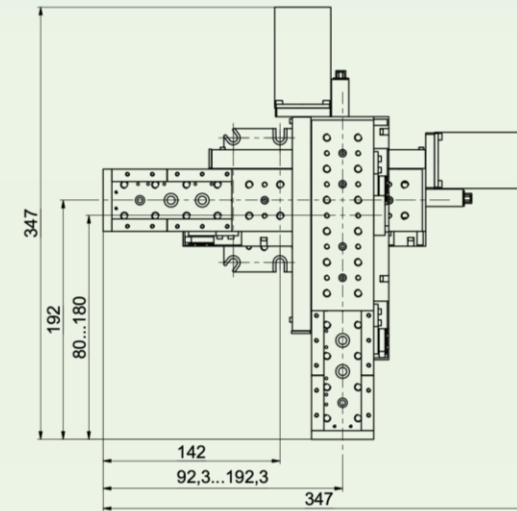
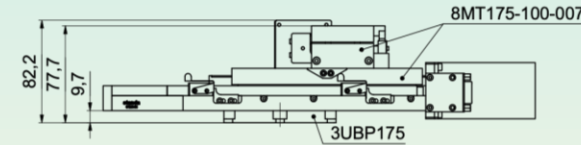
Design of the pre-measurement stand for single SiPM Tile studies

Translation stage issue

Power supplies



Motors controllers

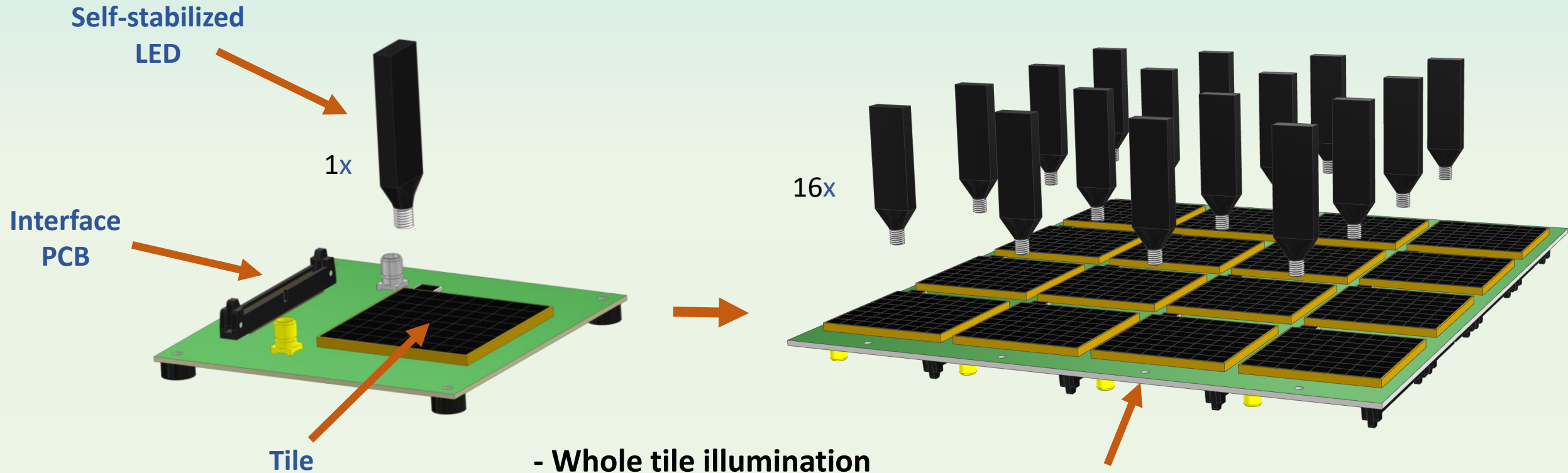


Parameters:

- Number of axes: 2 axes
- Travel range: 60-150mm (both axes)
- Speed: over 5 mm/s
- Positioning accuracy: better than 100 μ m
- Dimensions: less than 40x40x10 cm

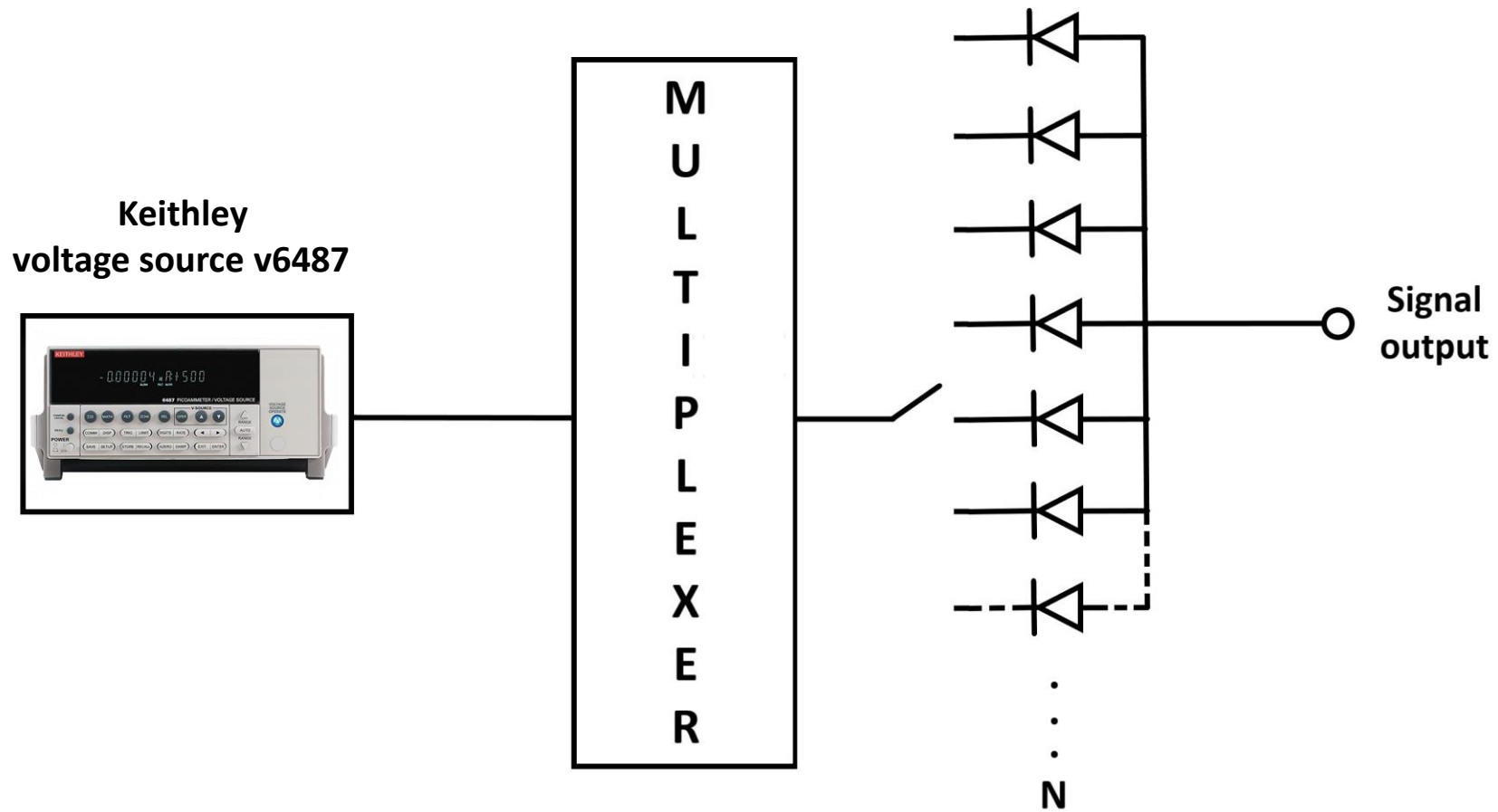
The stage doesn't operate at -50°C

New testing approach



- Whole tile illumination
- No translation stage
- Power each SiPM individually

Multiplexer power supply concept:



128 channel power supply



Power unit (128 channels)

- **4x DACs AD5535B**
 - 32 channels
 - 0-200V range [adjustable by reference]
 - 550 uA/channel
 - 14 bits/selected voltage range
 - Temperature sensor
- **1x Microcontroller STM32F373 + additional multiplexers**
 - 3 x24 bit ADC on chip
 - 7 channel multiplexers
 - 132 channels in total [128 voltage + 4 temperature]
- **4x integrated circuit (IC) of reference sources** (selectable by jumper junction)
- **current limiter IC**
- **2x 68pin IDC connectors**
- **1 HV connector** for an external clean power supply
- **VME 6U standard**

JINR



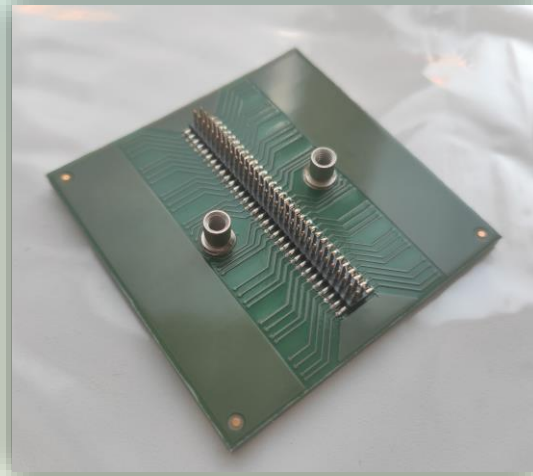
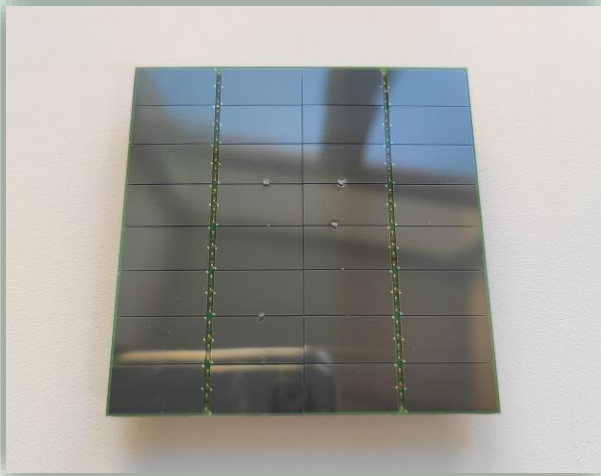
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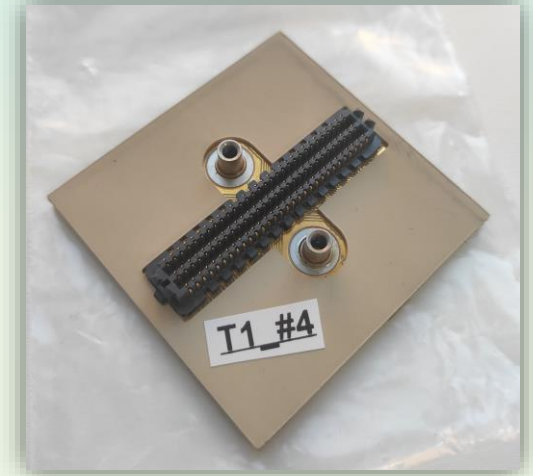
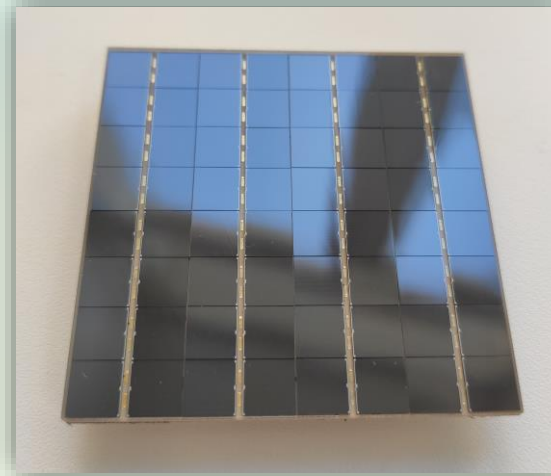
Marathon
company

Tiles examples

4 x 8 array



8 x 8 array

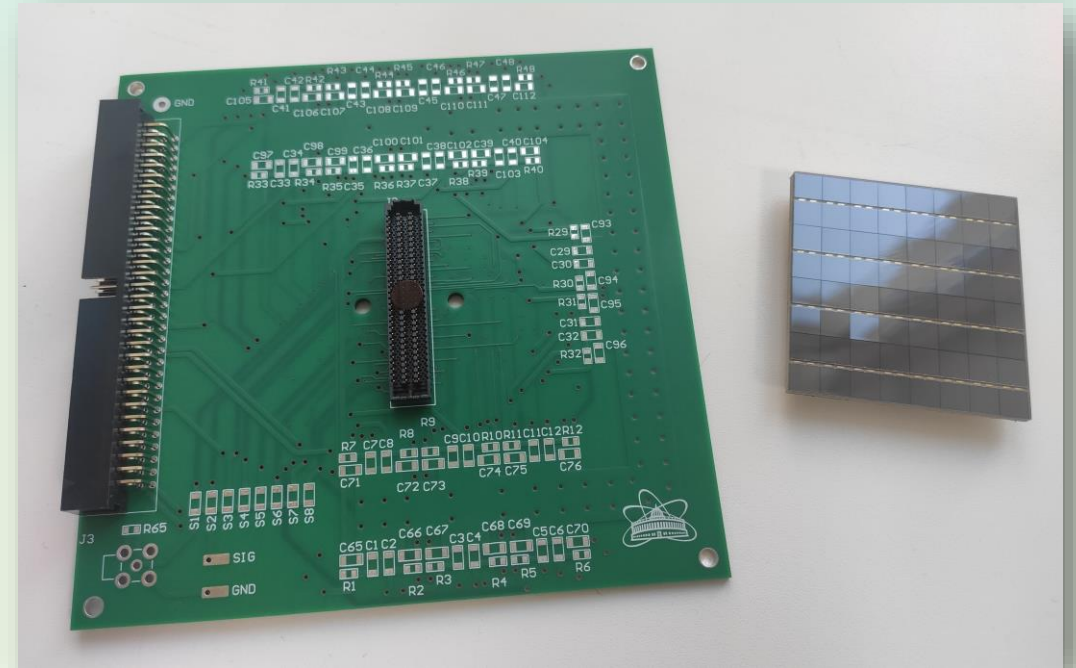


- Tiles dimensions: 50 x 50 mm
- Typical operation voltage: $\sim 50\text{V}$
- Dark current at V_{op} : $\sim 3\mu\text{A}$

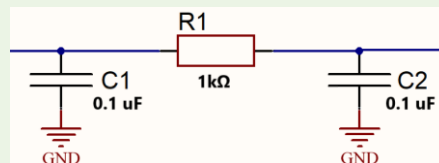
Interface PCBs



32-channel PCB for 4x8 tile prototype

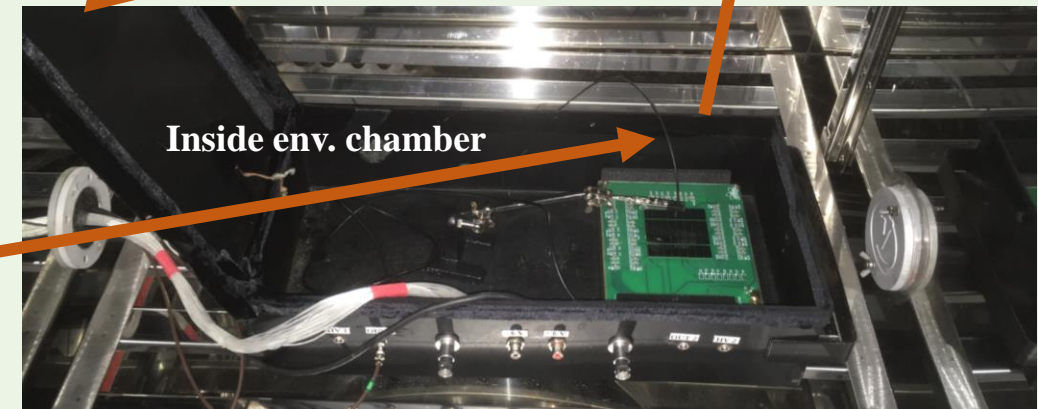
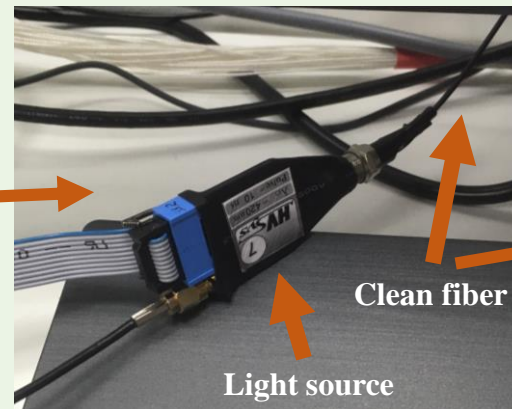
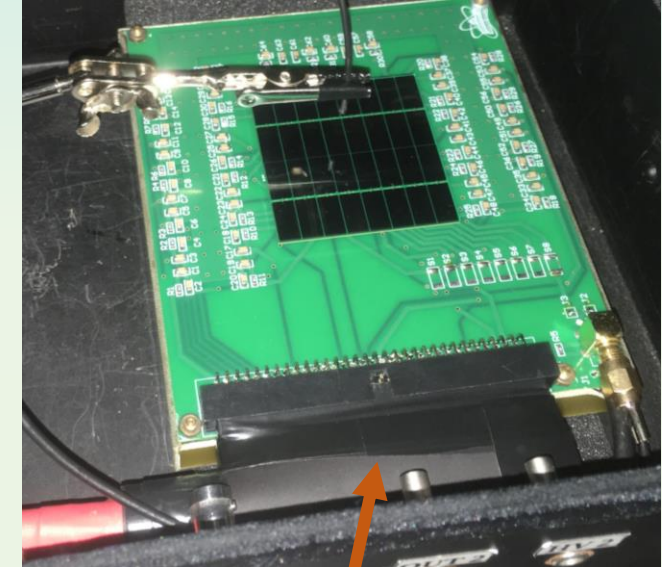
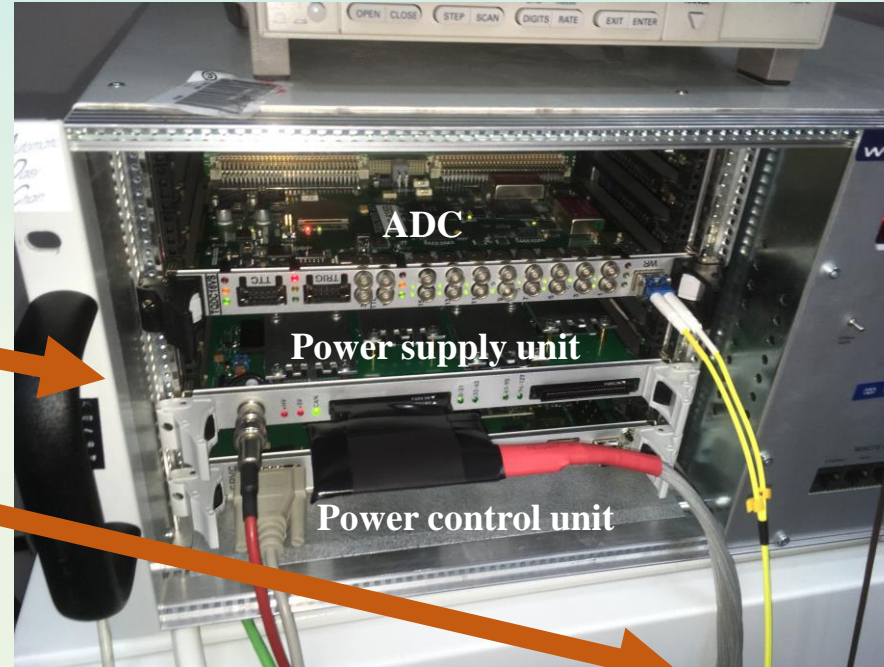
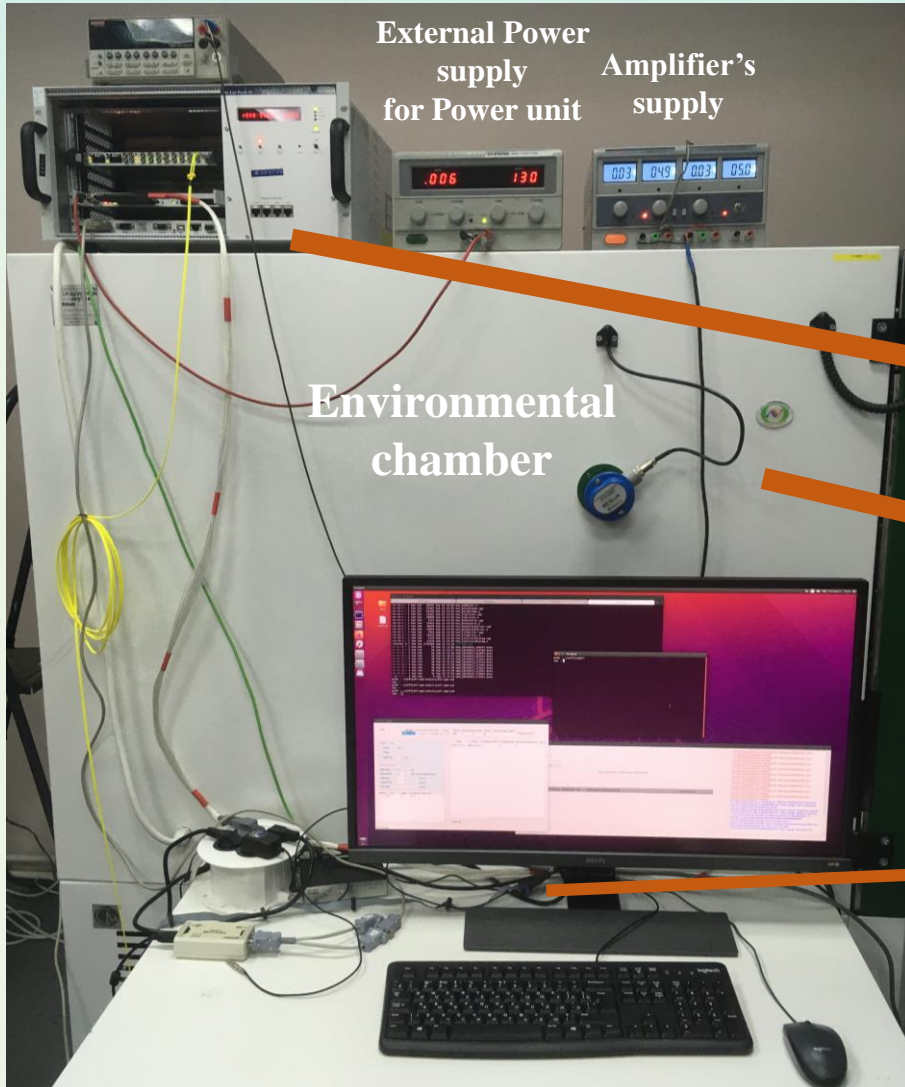


64-channel PCB for 8x8 tile prototype



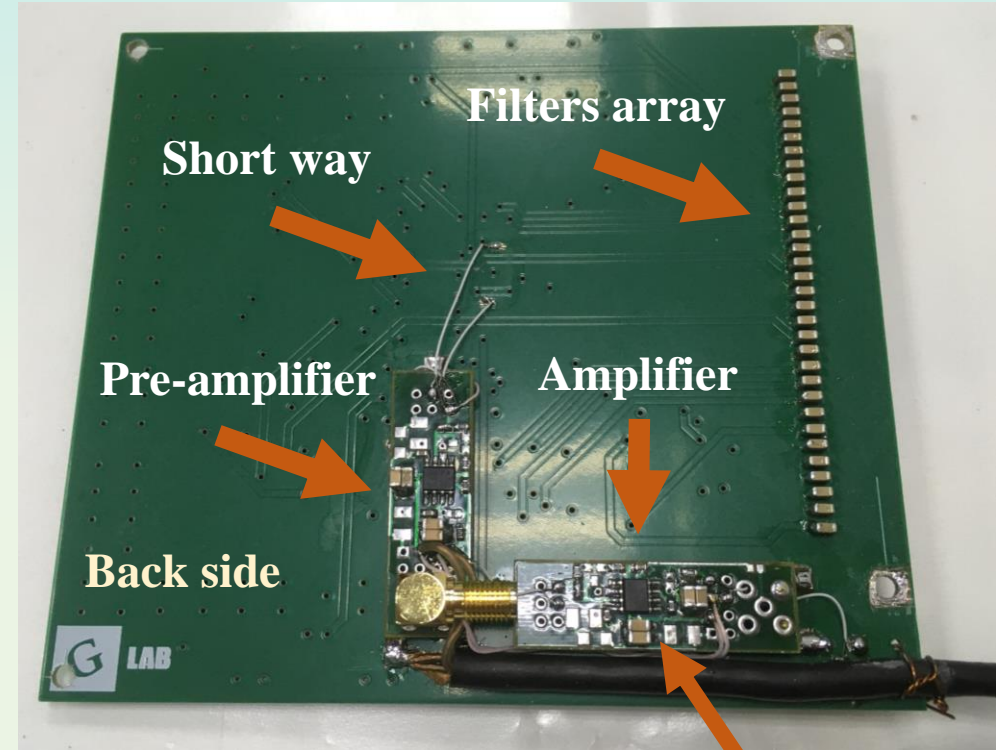
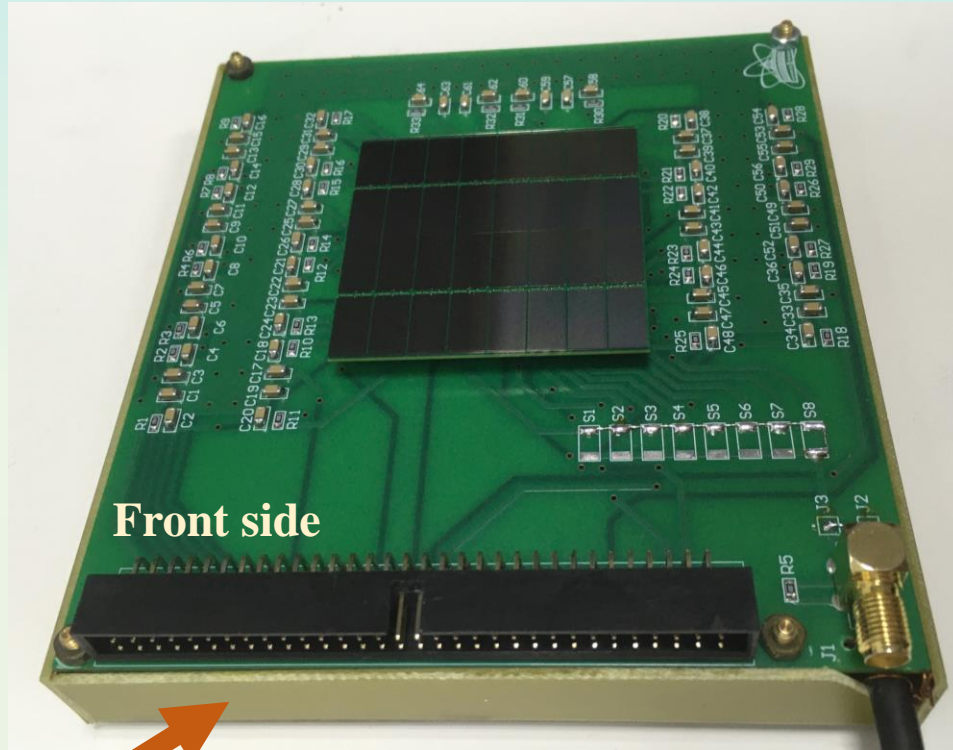
Equipment setup

Keithley Multimeter
for temp. monitoring



Noise issue

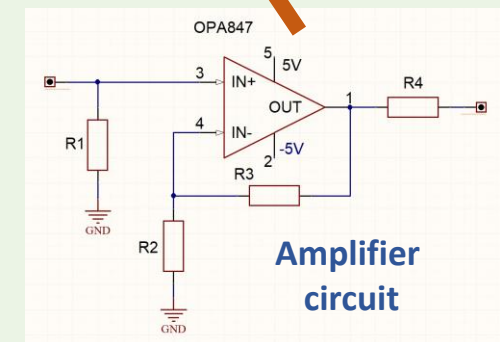
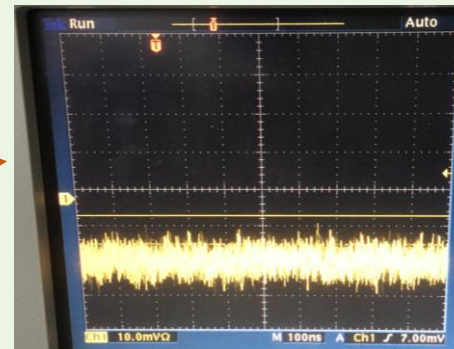
First tile prototype
interface PCB board



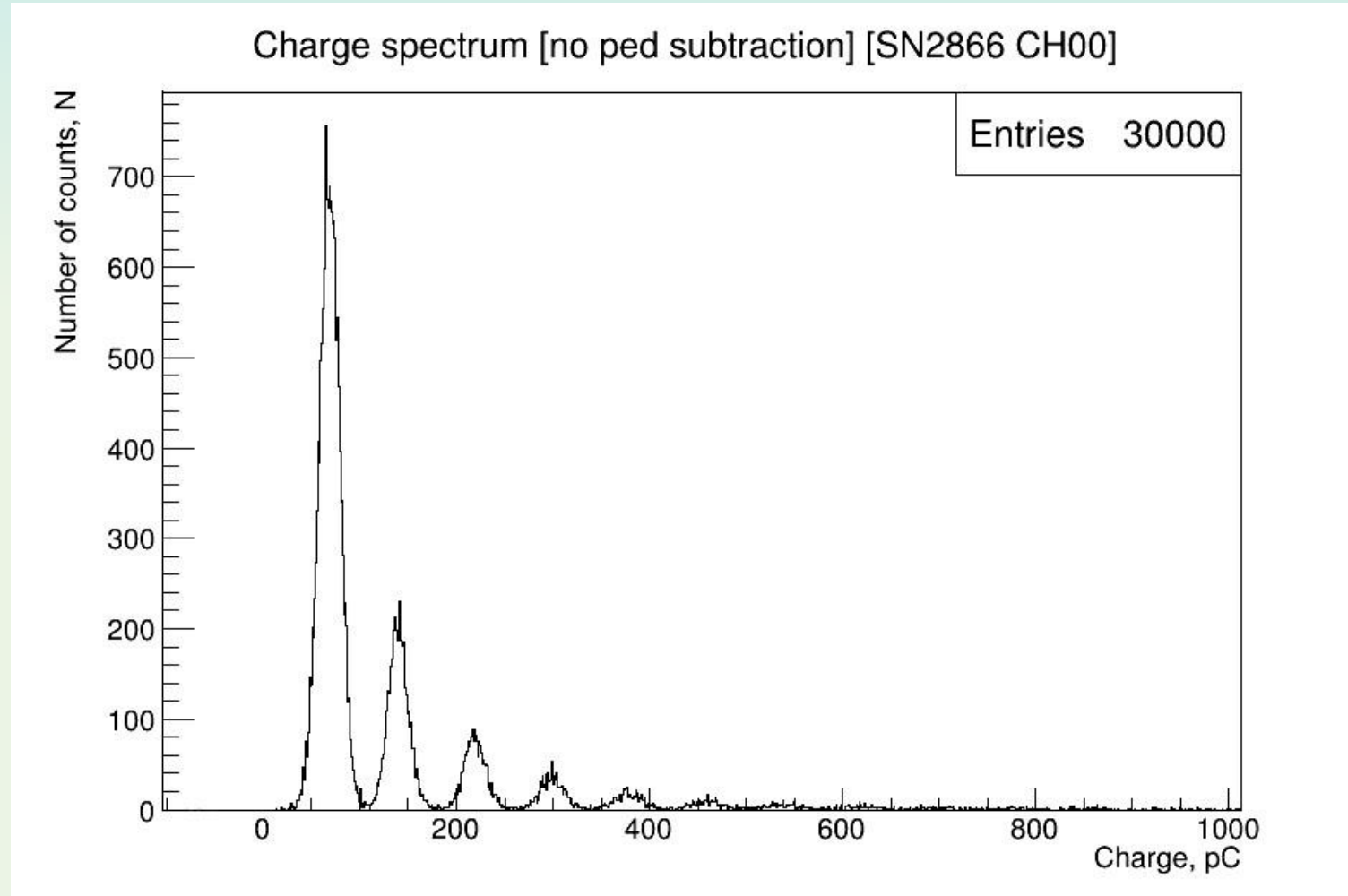
initial noise level $\pm 150\text{mV}$

final noise level $\sim \pm 5\text{mV}$

charge per photoelectron $\sim 8\text{mV}$

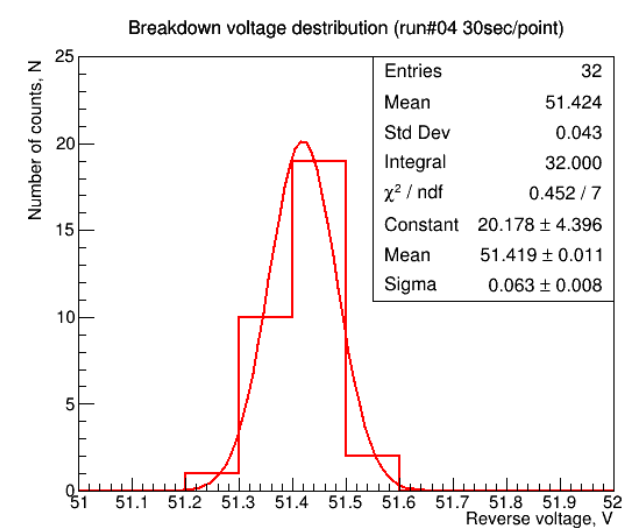
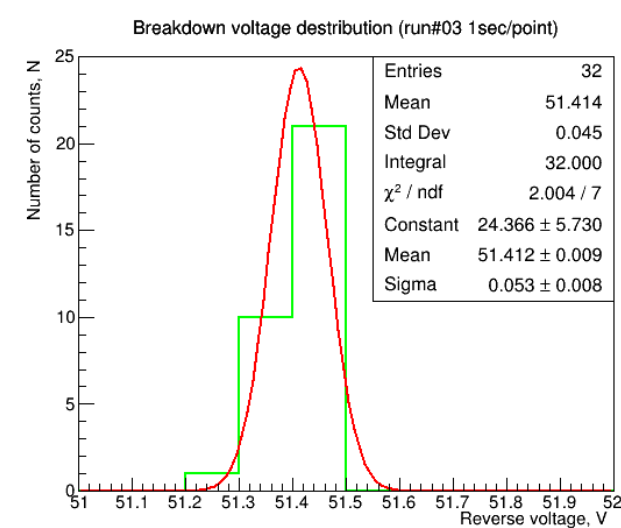
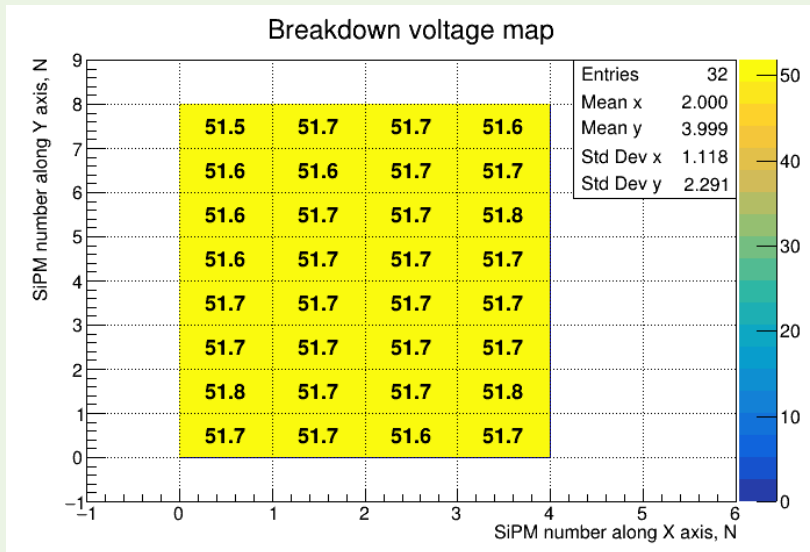
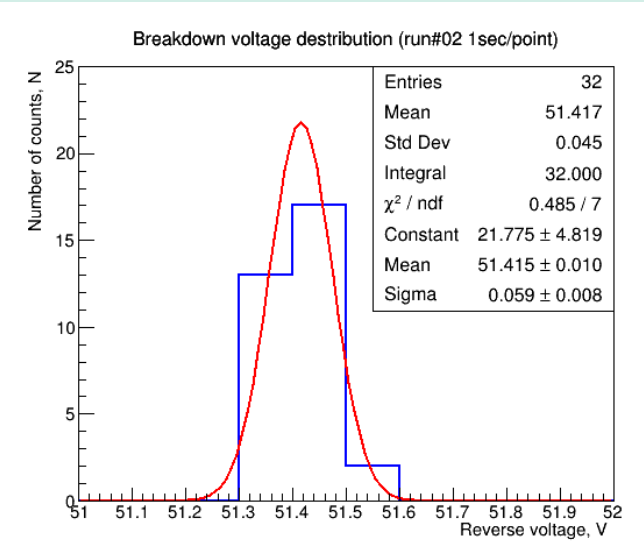
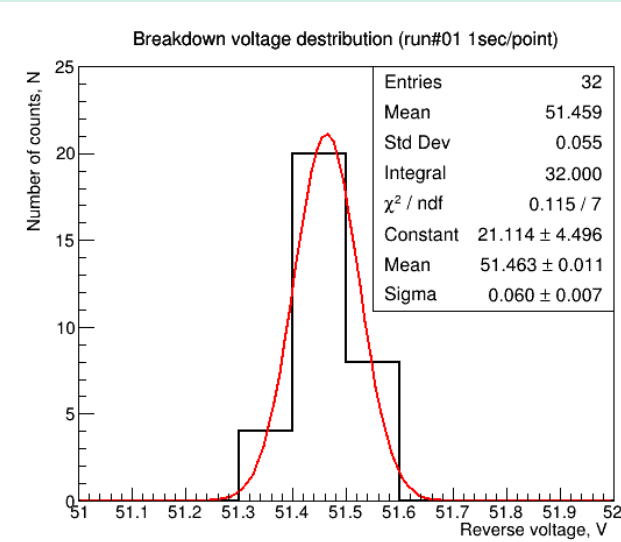
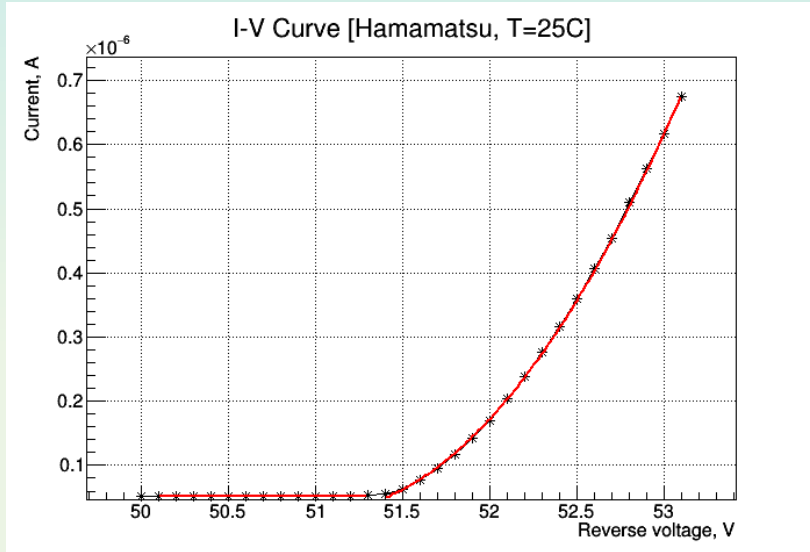


First results



We can see the noise charge spectrum!

Breakdown voltage measurements



Summary

- The measurement setup is developed and assembled
- The testing procedure is developed and checked
- The first tile prototype is tested



- Different prototypes testing
 - Mass testing scaling

Thank you for attention!

Questions?