Study of SiPMs for the JUNO-TAO detector

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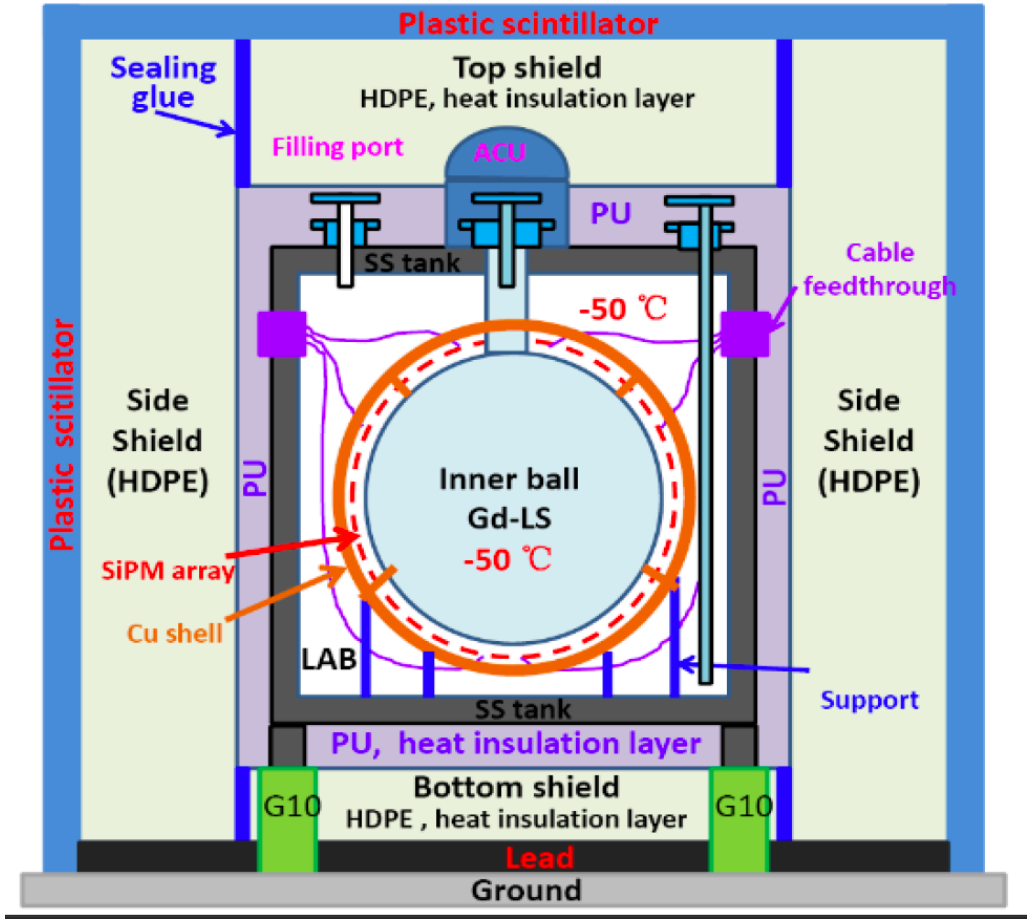
JUNO-TAO detector



Taishan Antineutrino Observatory (TAO), a satellite experiment of Jiangmen Underground Neutrino Observatory (JUNO).

It is proposed to measure reactor neutrino spectrum with an energy resolution at level of $1\%/\sqrt{E[MeV]}$

It will be placed at 30-35 m from one of reactor cores at Taishan nuclear power plant (4.6 GWth)

- 1 ton fiducial of Gd-LS;
- - 50 °C operating temperature;
- ~10 m^2 Silicon Photomultipliers (SiPM arrays) with a coverage of 94%.

Abusleme, Angel, et al. "TAO Conceptual Design Report: A Precision Measurement of the Reactor Antineutrino Spectrum with Sub-percent Energy Resolution." arXiv preprint arXiv:2005.08745 (2020).

Our requirements on SIPMs

- 4100 SiPMs tiles with 94% coverage;
- Tiles (8 x 8), ≥ (6 x 6) mm^2 ;
- PDE ≥ 50% at 400 nm;
- DCR ≤ 100 Hz/mm^2 at – 50 °C (operating temperature for JUNO-TAO detector);
- Probability of correlated noise ≤ 10% including cross talk and afterpulsing;
- Uniformity of V_{bd} ≤ 10%;
- The radioactivity of the SiPM tiles should be less than 100 Hz.

R&D on SiPMs is still in progress with several prototypes from Hamamatsu, SensL and FBK manufactures.
The search for a tile with the required radiopurity is one of the main task at the moment.

Massive Characterization

Two phases for the massive characterization

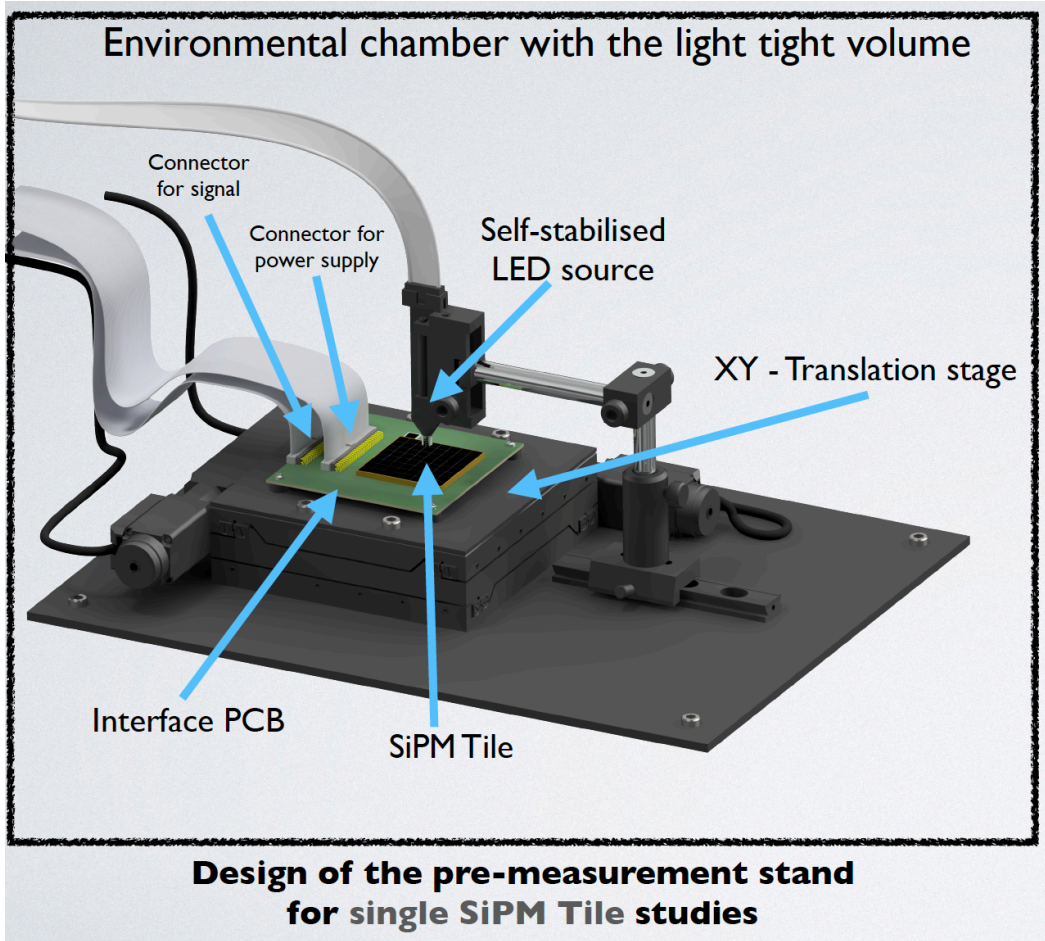
1. Visual inspection (scratches, bubbles…):
   - clean room;
   - microscope.
2. Properties measurements at two temperatures: 20 °C and -50 °C.

   a) At – 50°C:
   - Dark Current Rate (DCR);
   - Gain;
   - PDE, cross talk and after pulse will also be measured;
   - I-V curve.

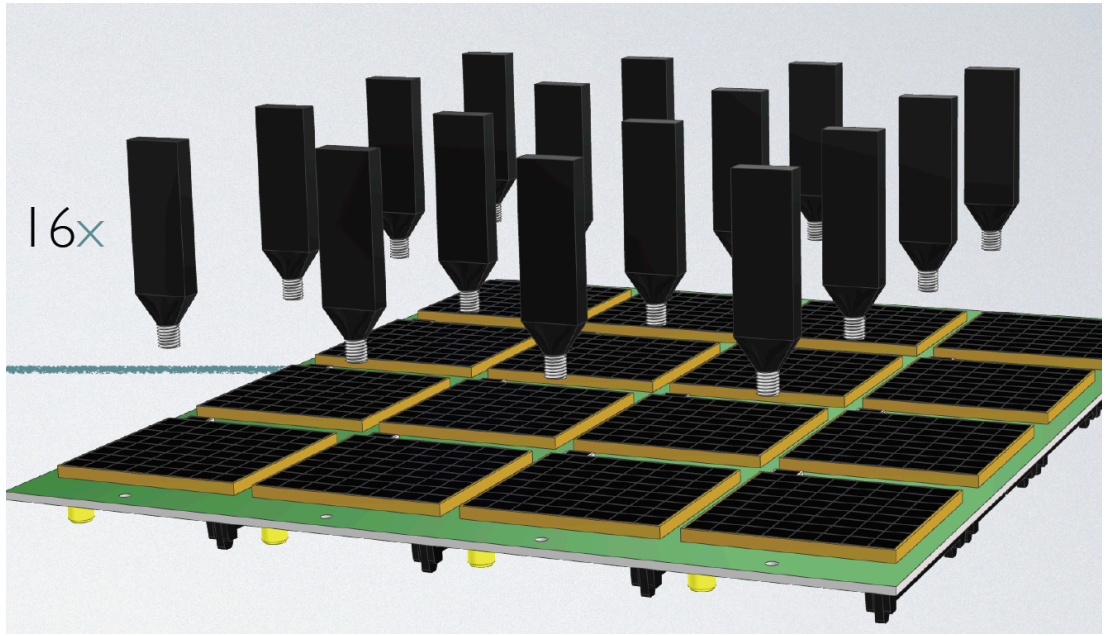
   b) At 20 °C
   - I-V curve.

Set-up for massive characterization

Set-up and procedure are being developed by JINR



Courtesy of A. Rybnikov

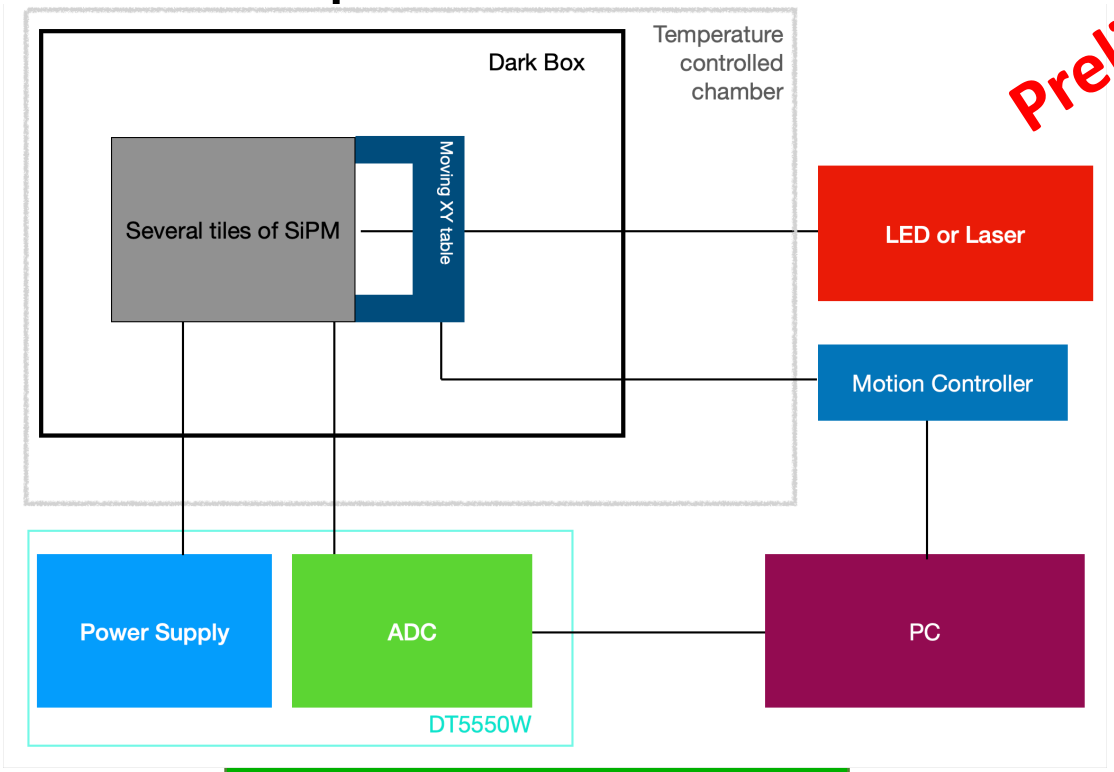


16 tiles will be mounted on PCB (design in progress) with 16 light points

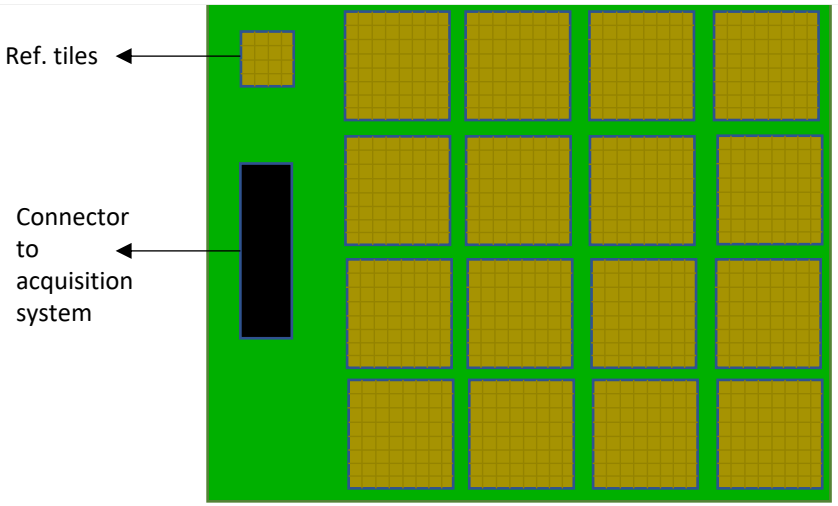
- Hot scan -> 20 °C
- Cooling down from 20°C to -50 °C
- Cold scan -> -50 °C

Our set-up for the massive tests

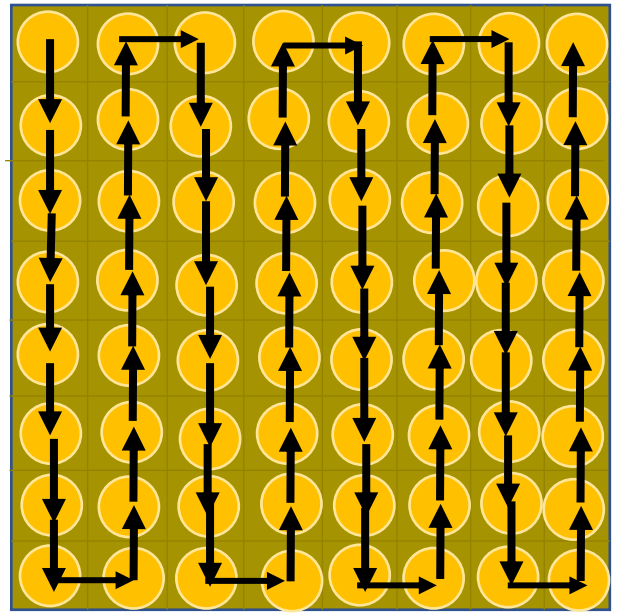
Preliminary



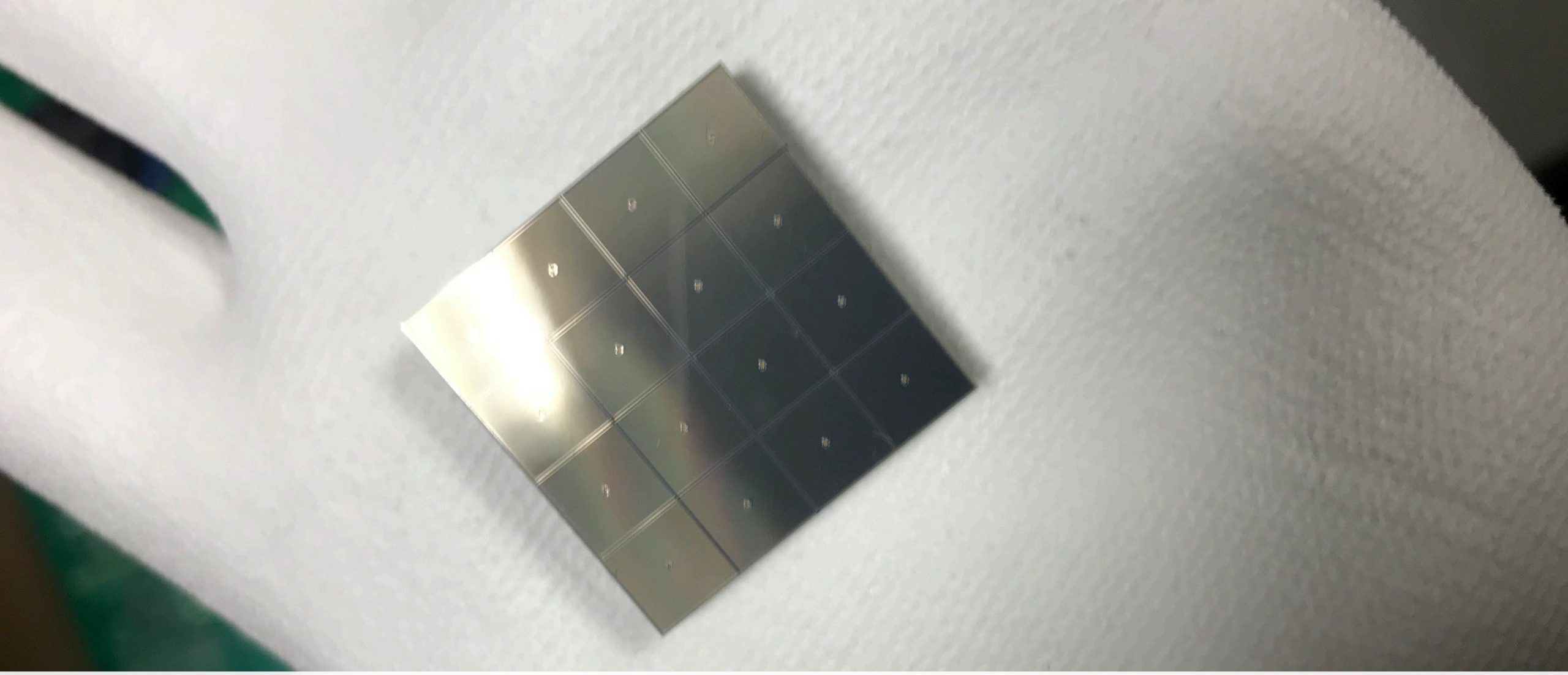
- CAEN DT5550W with 2 Citiroc1A:
  - 64 ch;
  - SiPMs Bias (20-85 V);
  - 80 MS/s, 14bit ADC.
- climatic chamber;
- motorized table;
- PicoQuant PDL 800-D with head at 402 nm (LASER)



The PCB with (4x4) tiles to parallel measurement



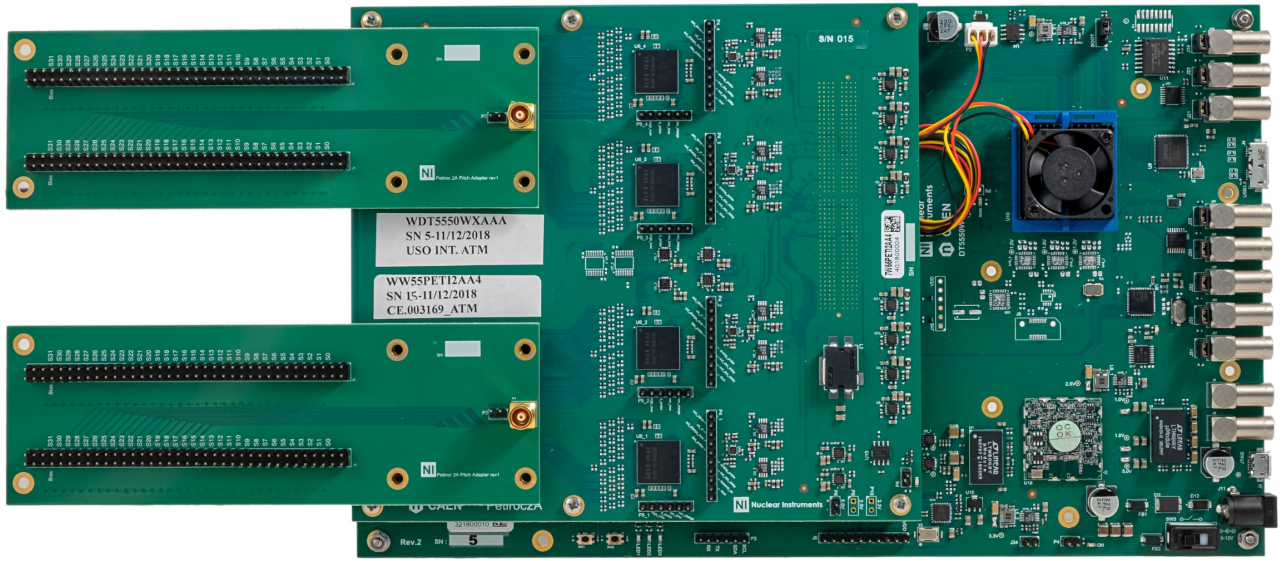
Scanning step to measure the PDE of each SiPM on the tile

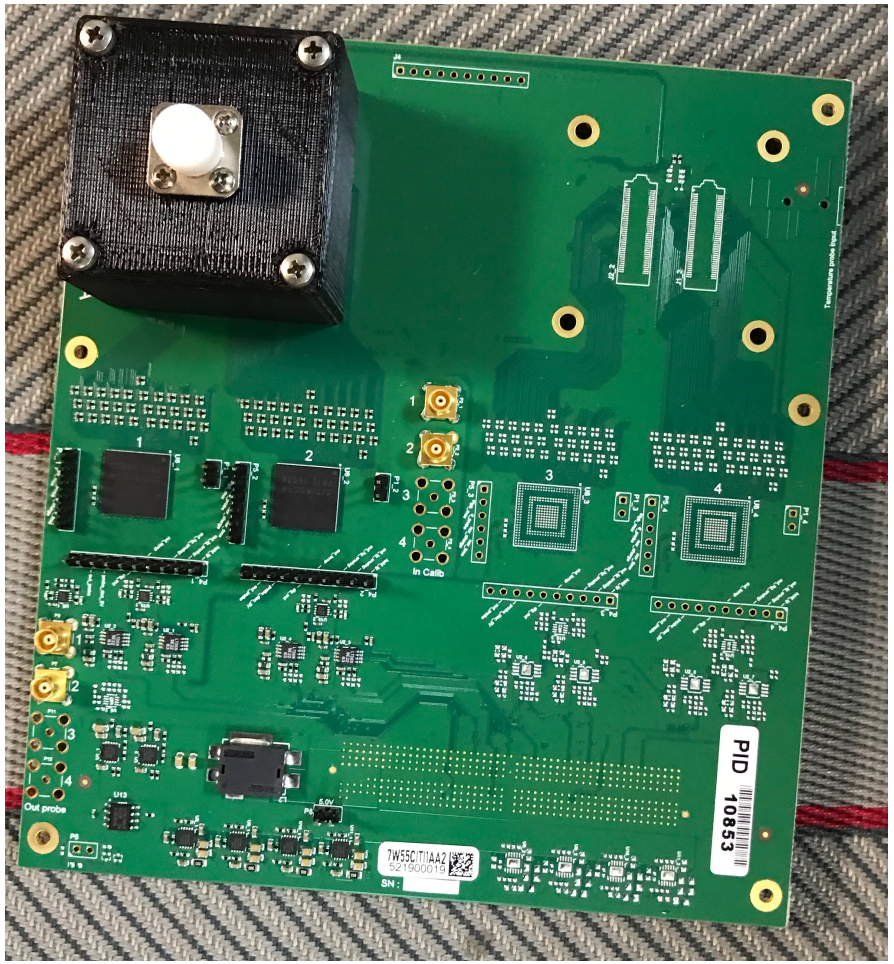


Thank you!

Backup

Our setup: DT5550W



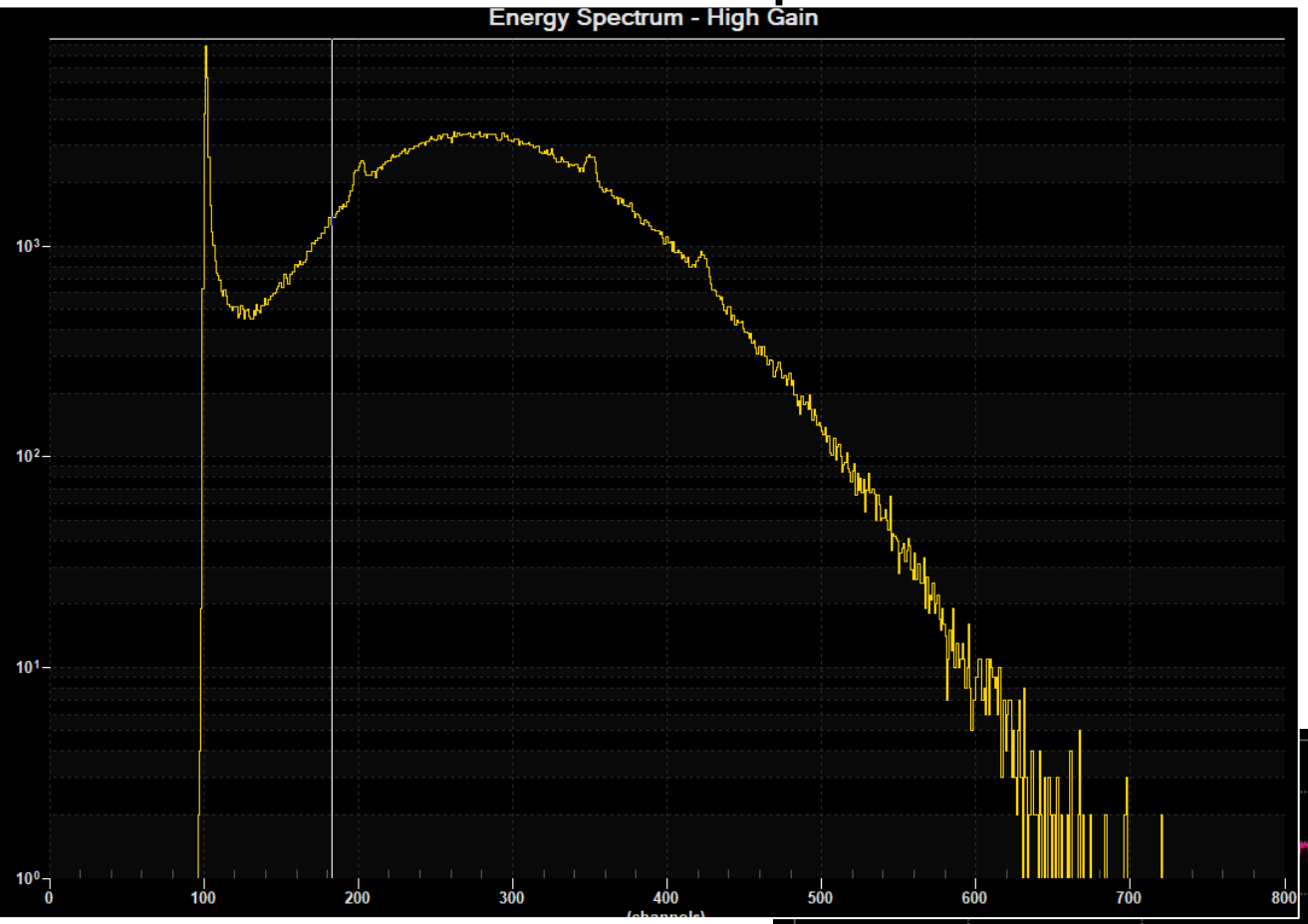


Our setup: Laser and LED

CAEN SP5601 (400 nm)

Picoquant PDL 800-D with LDH P-C 405B head (402 nm)

Noise and first spectrum



Noise comparable with low intensity signal (1 and 2 p.e.)