SNRI2020 Lab Proposal

CMOS Cryogenic Readout Electronics

Scuola Nazionale dei Rivelatori Innovativi 2020

Kick-off Meeting

Torino

2019-11-22

Istituto Nazionale di Fisica Nucleare

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Why?

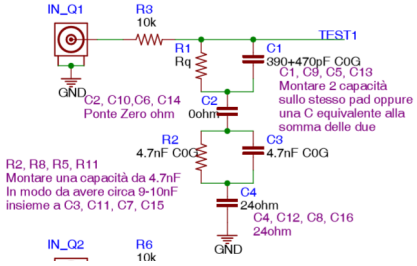
- Cryogenic operation of CMOS is a rapidly growing field of interest
- Quantum computing (control and periphery electronics at 4K)
- Dark matter and neutrino experiments with LAr, LXe
  - Darkside, ARGO (global DM dual-phase TPC 300-ton, >2027)
  - DUNE, proto-DUNE
  - nEXO
  - ...

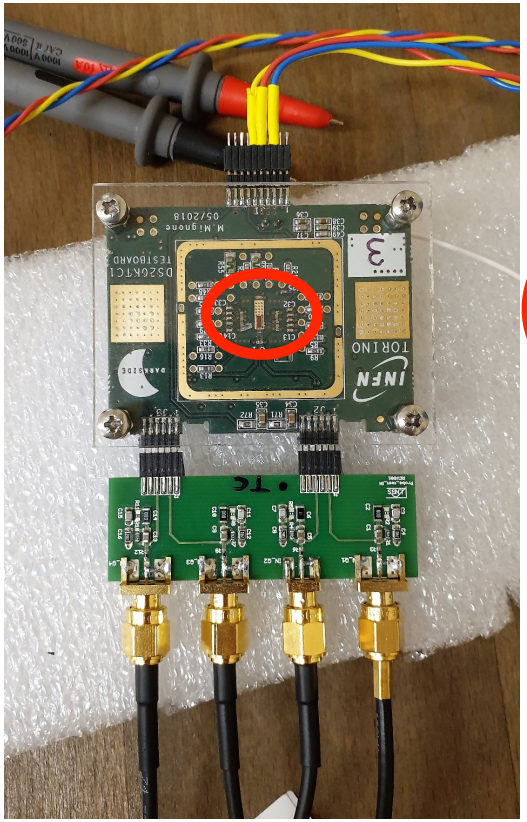
Context of the ongoing activity

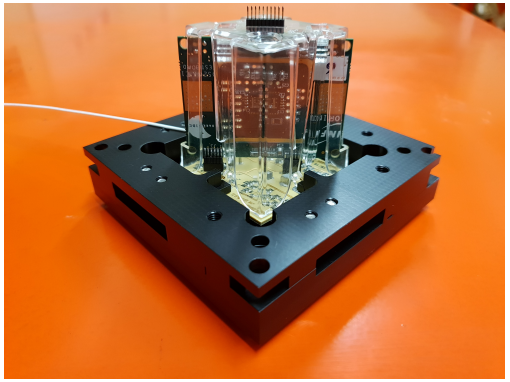
- Activity at INFN-TO in the framework of Darkside
- CMOS microelectronics development for cryogenic operation
- Readout of large area SiPM tiles (24 cm^2)
- Developed 2 prototypes of front-end amplifier for operation at 87K
- Laboratory proposal using ICs and associated FEBs, and SiPMs

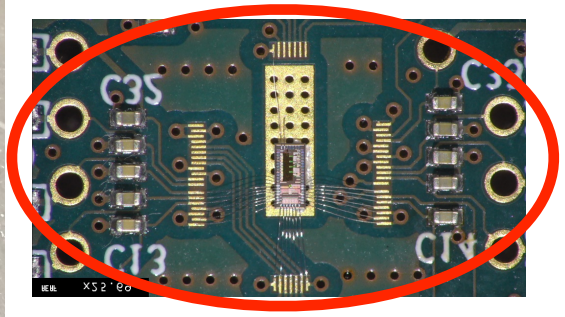
Materials and Lab setup

- LN2
- dewar
- oscilloscope
- test boards and load cards
- SiPM tiles
- laser and cryo fibre



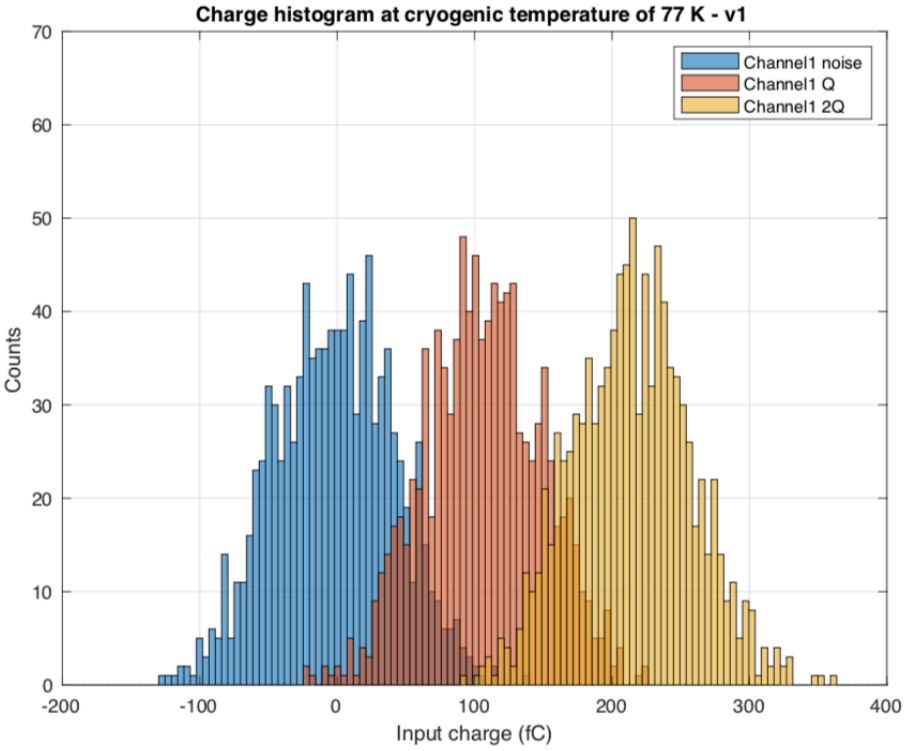


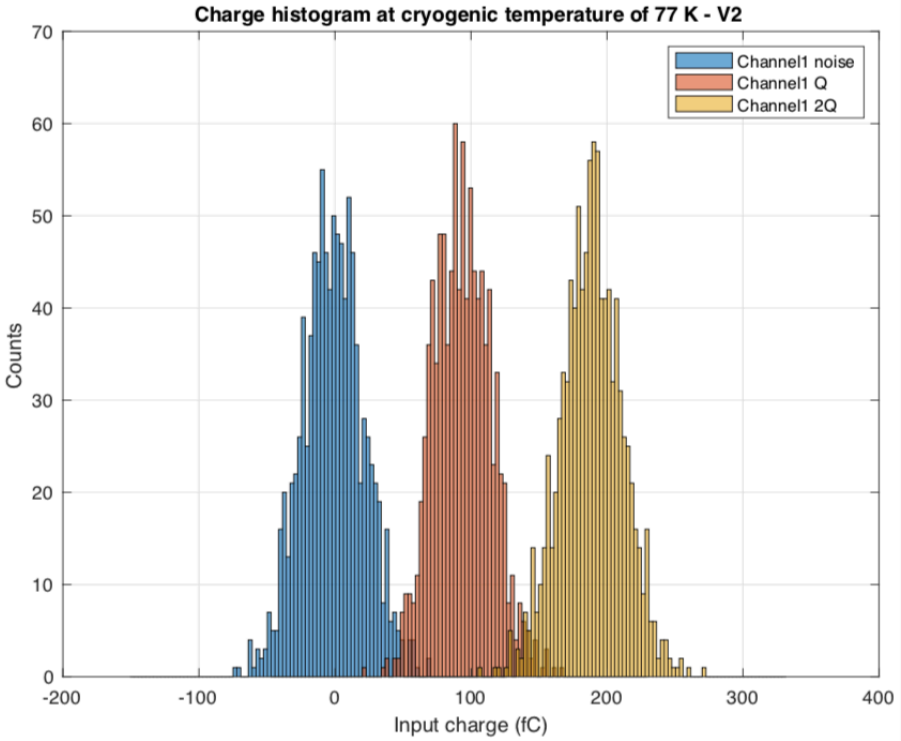




Proposed activity: electrical tests

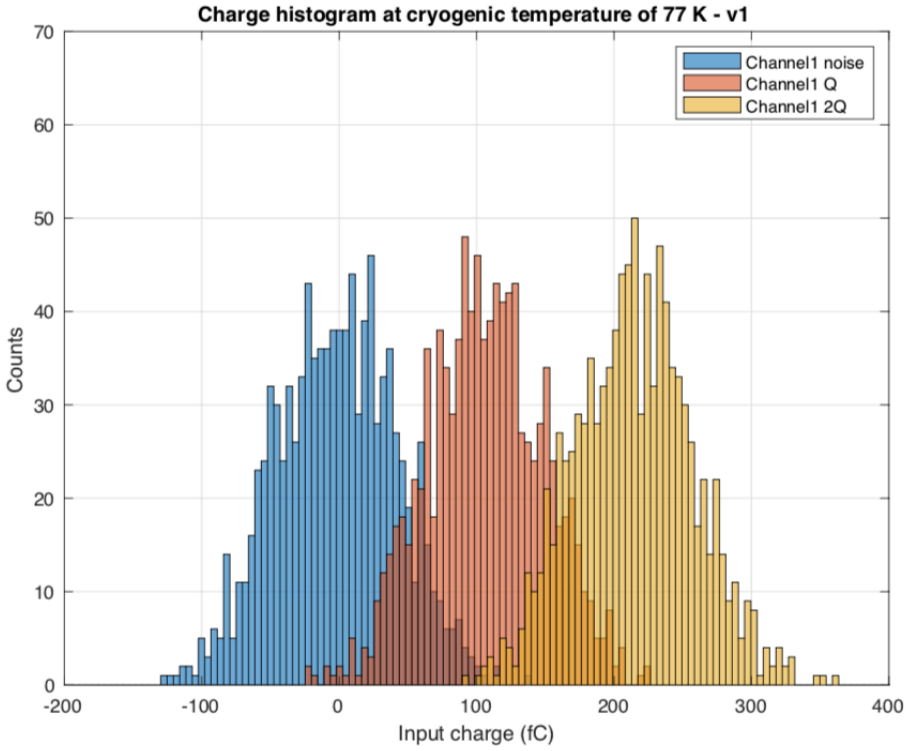
- Spectra of integrated output current signal of different amplifier designs, on a single channel, for a single p.e. Q=95 fC (charge injection board and programmable pulse generator)
- Obtain the resulting charge histogram of channel 1 DS20K v1 (left) and DS20K v2 (right),

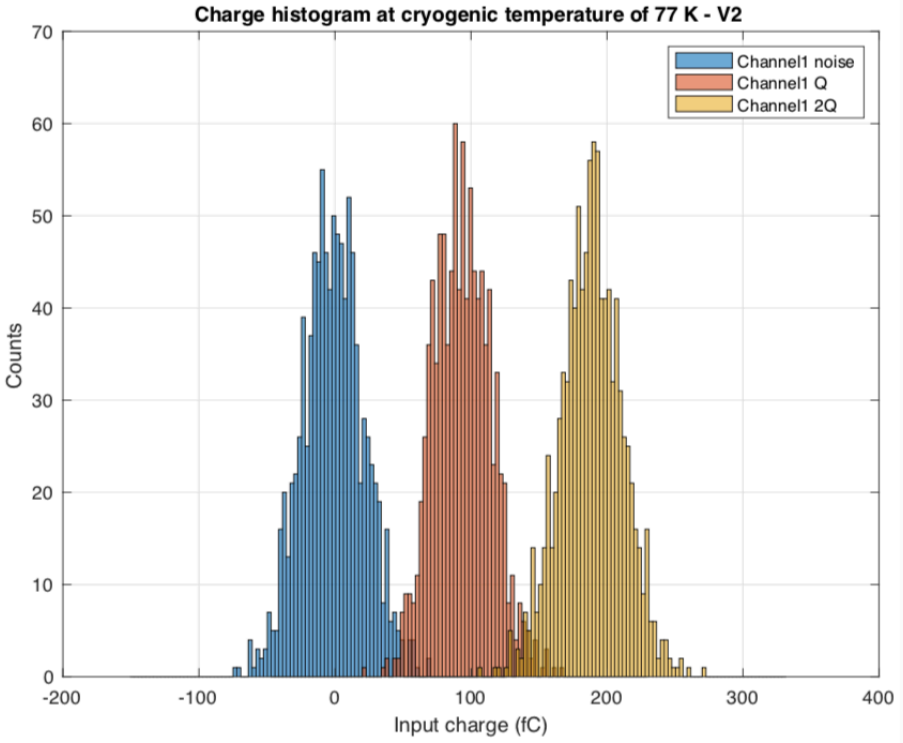




Proposed activity: electrical tests

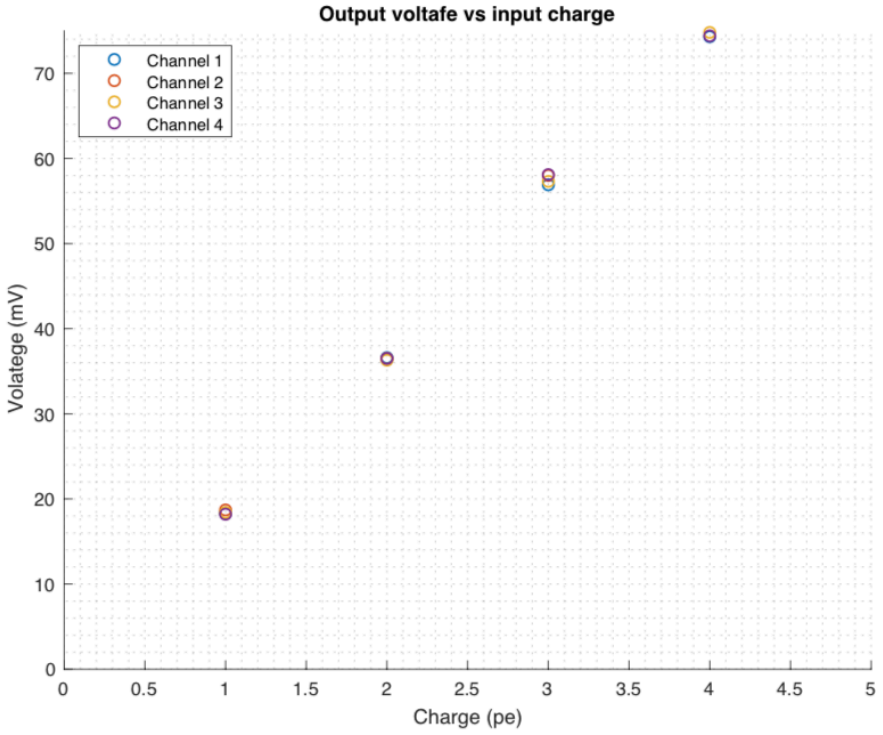
- Obtain spectra of output charge of different amplifiers using all channels at Q=95fC
- Charge histogram of all channels V1 (left) and V2 (right), N=3000 samples.

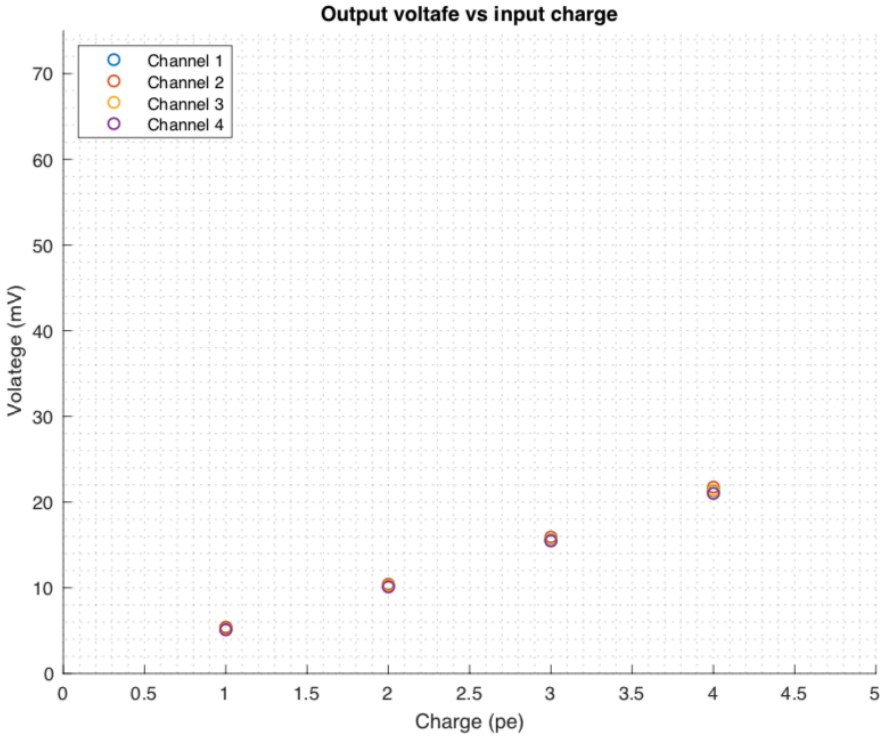




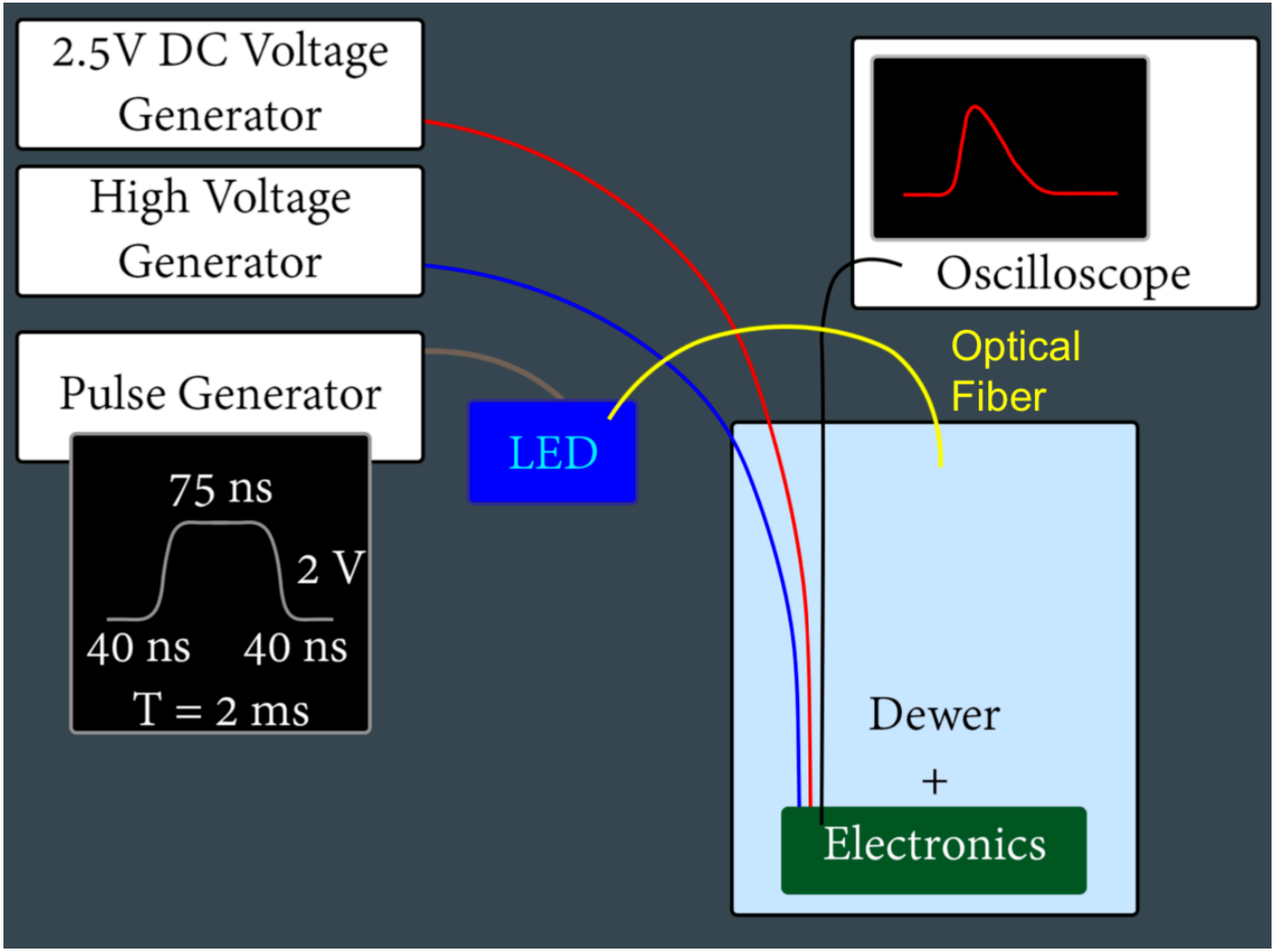
Proposed activity: electrical tests

- Calculate the gain (measuring pulse height for 1-2-3-4 p.e.) at LN (77K) with a charge injection circuit and a test-pulse generator, comparison between different amplifiers



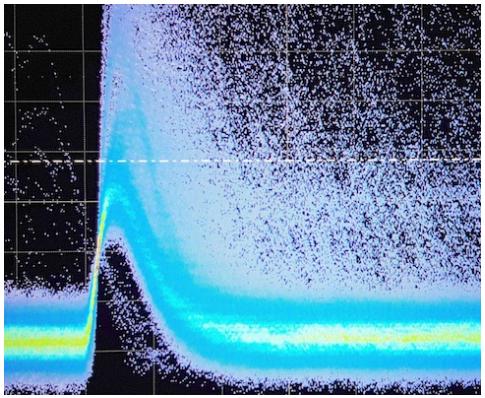


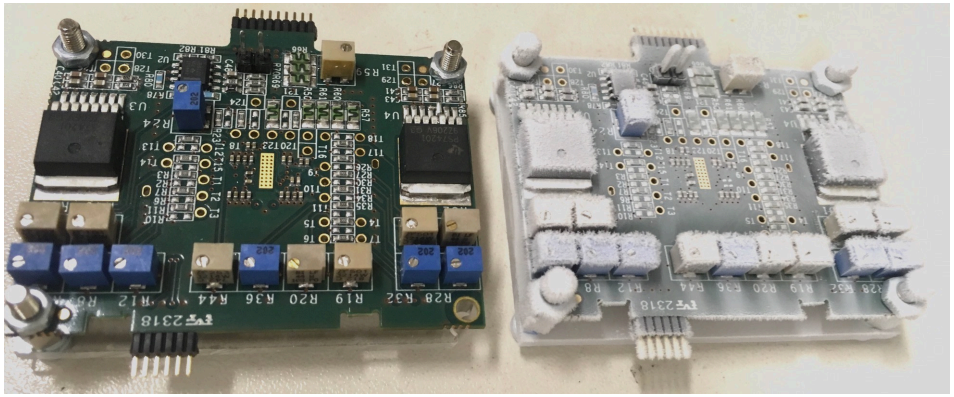
Proposed activity - tests with SiPMs



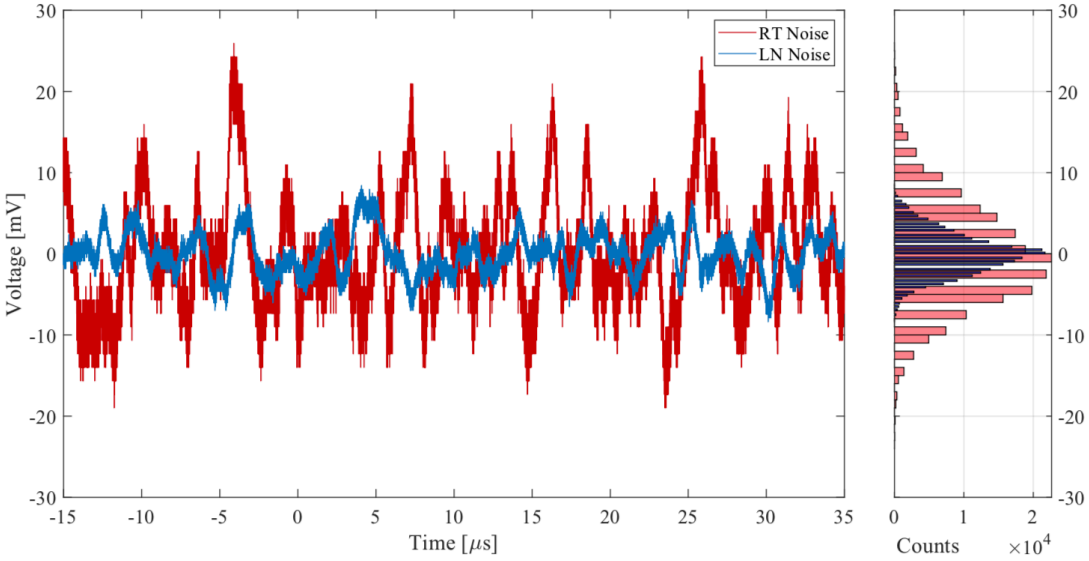
Proposed activity: basic tests with SiPMs

- Trigger on single-photon and measure r.m.s. at RT and LN





Noise V_{RT} = 6.4 mV, V_{LN} = 2.3 mV

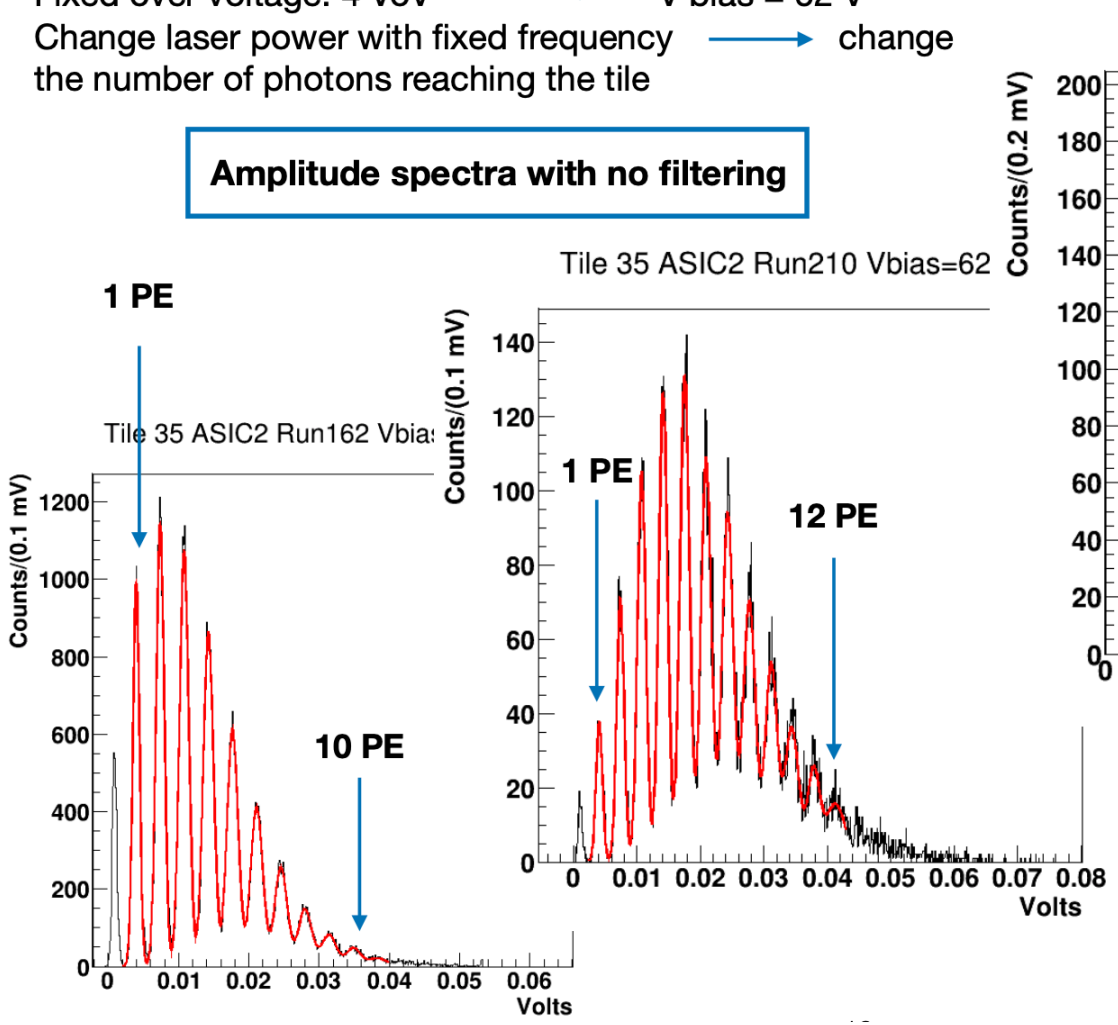


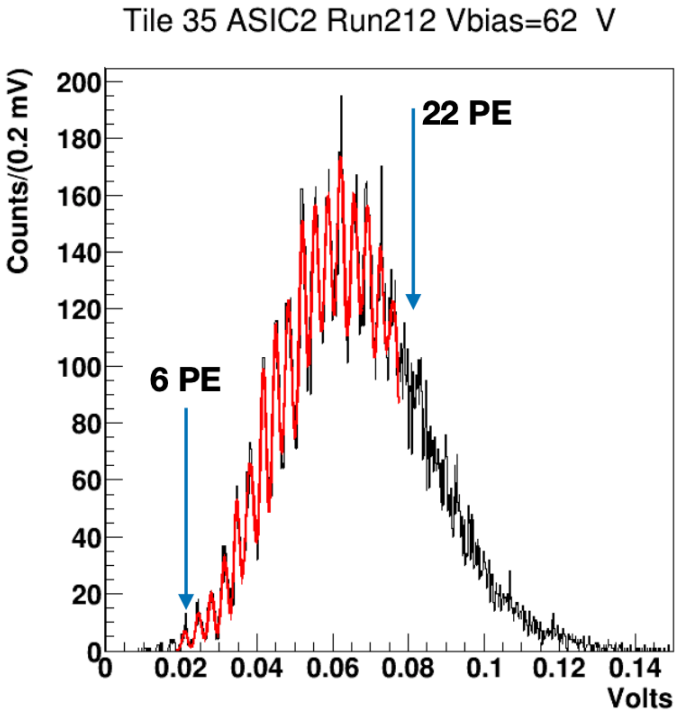
Proposed activity: SiPMs and laser tests

- multi-photon histograms (below, activity at INFN-GE - B. Bottino)

Fixed over voltage: 4 VoV → V bias = 62 V
Change laser power with fixed frequency → change the number of photons reaching the tile

Amplitude spectra with no filtering





Multi Gauss fit:
- Free amplitude
- Free mean
- Free RMS

Proposed activity: SiPMs and laser tests

- evaluate SNR as a function of OV (below, activity at INFN-GE - B. Bottino)

Bias Voltage	Over Voltage	1 PE peak	1 PE sigma	Noise RMS	SNR
62 V	4 V	3.43 mV	0.46 mV	0.46 mV	7.5
64 V	5 V	4.36 mV	0.50 mV	0.48 mV	8.7
66 V	6 V	5.30 mV	0.55 mV	0.48 mV	9.6
68 V	7 V	6.22 mV	0.60 mV	0.49 mV	10.4
70 V	8 V	7.06 mV	0.71 mV	0.54 mV	9.9

Logistics and security

- *safe handling of LN:*
  - *important to clarify an appropriate concept of "hands-on approach"...*
- *security and training of attendees*
- *protection (gloves, goggles)*
- *LN transportation and storage*