Long Term DCR measurement at MiB

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LT DCR measurements

On 30th Oct. 2020 in MiB we started a long-term test measurements on DCR with one Hamamatsu S13360-HQR, to be sure that **it do not increase with time**.

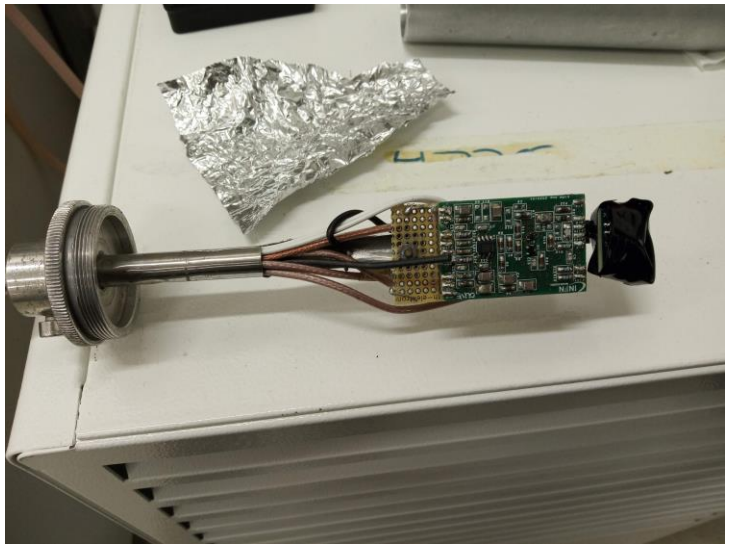
We performed this measurement in the **Bicocca Cryogenics Laboratory** :

- Clean environment for e.m. pickup
- Dark room and cryogenic infrastructures
- All instruments after an UPS+ e.m. filter

LT DCR measurements

To further remove ambient light, we wrapped the SiPM with an aluminum foil and a black insulating tape.

We leaved the SiPM in LN and power them to nominal OV (3V OV).



LT DCR measurements

We recorded DCR measurements, one per week, in order to test the stability of DCR.

Unluckily we had 2 black-outs in Mib (9^{th} Dec and 7^{th} Jen), so the SiPM went out.

The thermal condition did not change, since we did not remove the device from LN bath.

Time stability of DCR

(mHz/mm^2)	with bursts	without bursts
30/10/2020	40.76	5.06
03/11/2020	25.70	3.08
10/11/2020	28.14	3.34
13/11/2020	24.67	2.92
20/11/2020	30.77	3.55
25/11/2020	29.96	2.58
27/11/2020	28.18	2.75
04/12/2020	24.60	3.39
10/12/2020	54.11	4.33
18/12/2020	23.84	3.51
22/12/2020	42.53	3.13
30/12/2020	43.70	4.06
08/01/2021	26.83	4.03
15/01/2021	22.57	5.72
22/01/2021	31.15	3.05

No evidence of DCR increase with time.

Additional consideration

- At that time (2020), the full long-term test was expected to come from ProtoDUNE-HD, where we tested (in 2024):
  - Potential deterioration of the packaging
  - change of operating current in time
  - change of cross-talk and after-pulse in time
- As a consequence, we mostly focused on DCR, which is a more precise estimator of the potential increase of currents over time but does not test variation in time of gain
- Since a full ProtoDUNE-VD test will (likely) be available after the Production Readiness Review we suggest:
  - to use DCR as an estimator of the current change in time
  - to ignore packaging aging since the packaging is the same as FD1-HD and has already been tested (i.e. you can wrap the SiPMs as we did)
  - to perform periodic checks of the pulse amplitude at the oscilloscope to check for gain variations or, even better, measure I-V curves in reverse