Mass tests facility Status Report

DUNE PRR: FD1 PDS SiPMs

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on behalf of Photosensor WG

Contents

- Mass tests purposes & protocol;
- CACTUS system apparatus;
- Future steps;
- Measurements and results;
- Conclusions

SiPM massive tests

Purposes:

- Check SiPM working parameters;
- Failure/mortality rate;
- Quality assurance;

Measurements & parameters:

- IV@roomT→(FW) R_q^{RT} + (REV) V_{bd}^{RT} ;
- IV@LN2T→(FW) $R_q^{LN2T\_pre}$ + (REV) $V_{bd}^{LN2T\_pre}$;
- Thermal cycles;
- IV@LN2T→(FW) $R_q^{LN2T\_post}$ +(REV) $V_{bd}^{LN2T\_post}$;
- Extended IV@LN2T → dark current
- DCR@LN2 T→global-DCR total dark signals, AP, CT + bursts

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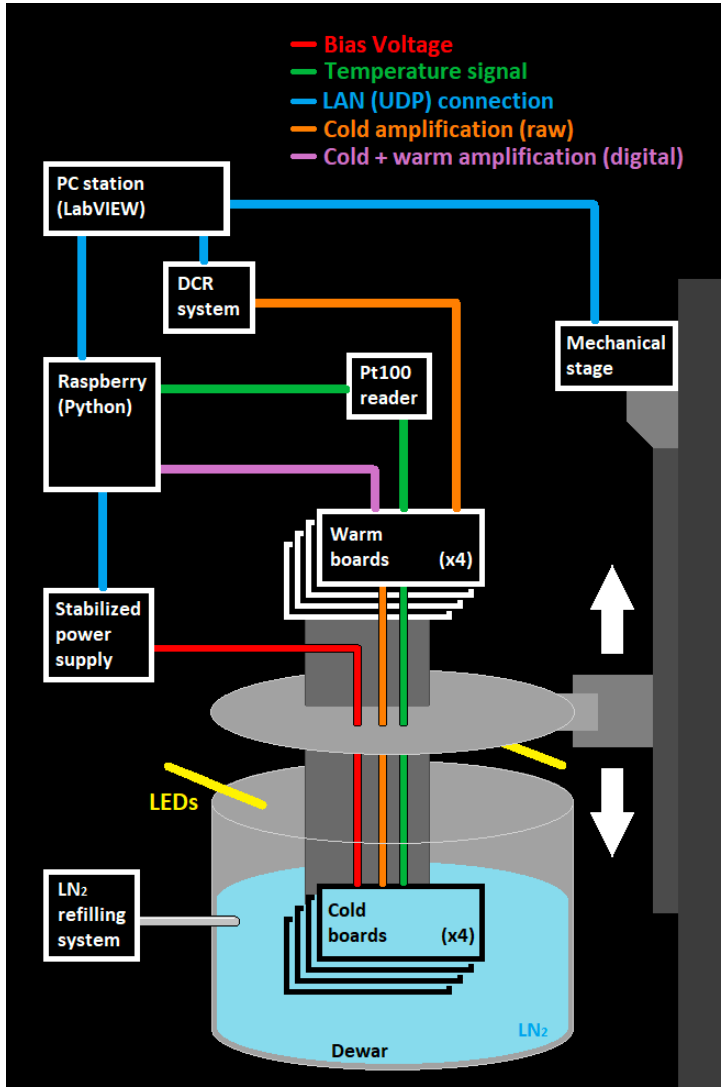
The mass test set-up

Cryogenic Apparatus for Continuous Tests Upon SiPM

- Custom setup developed by INFN and Universities of Ferrara and Bologna;
- Massive tests on the entire SiPMs production to perform the quality assurance of all the sensors;

Features: modularity / automatic /easy replication



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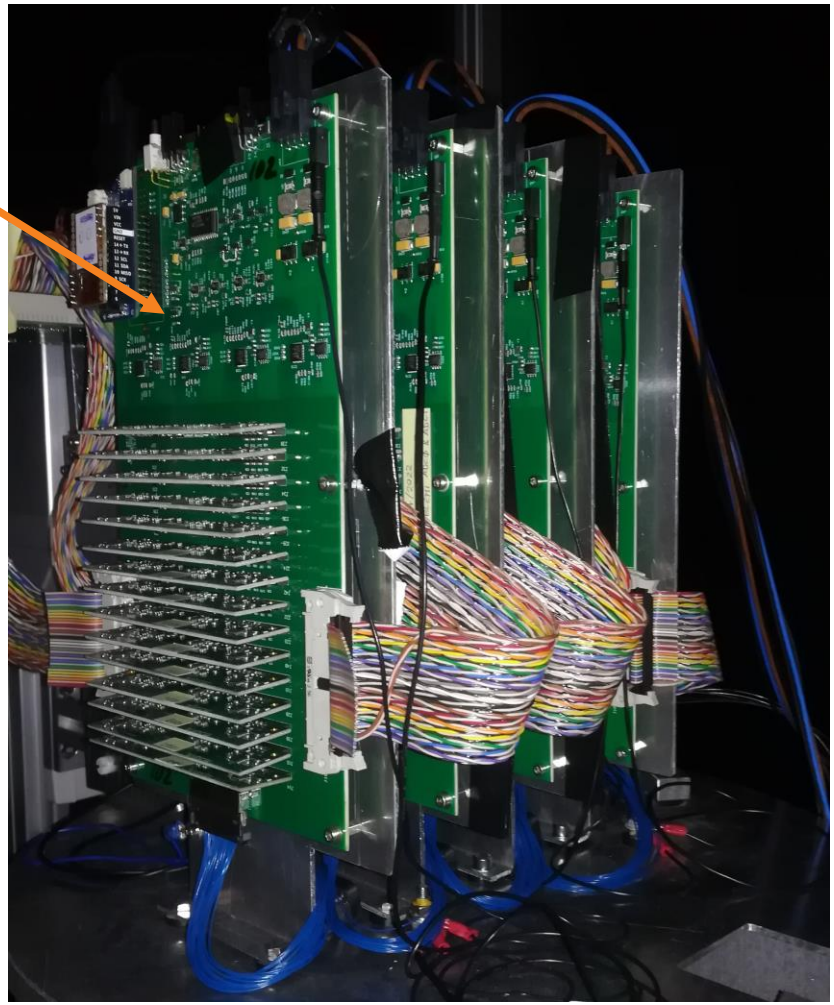
The mass test set-up

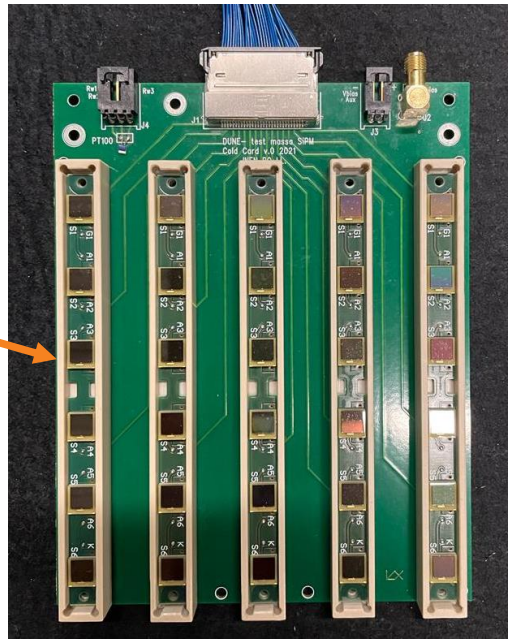
Motherboards + front-end cards:

- 4 motherboards/system;
- 15 front-end cards/motherboard;
- 120 independent channels;
- Current measure/digitalization;
- Signals acquisition;
- Supply power.

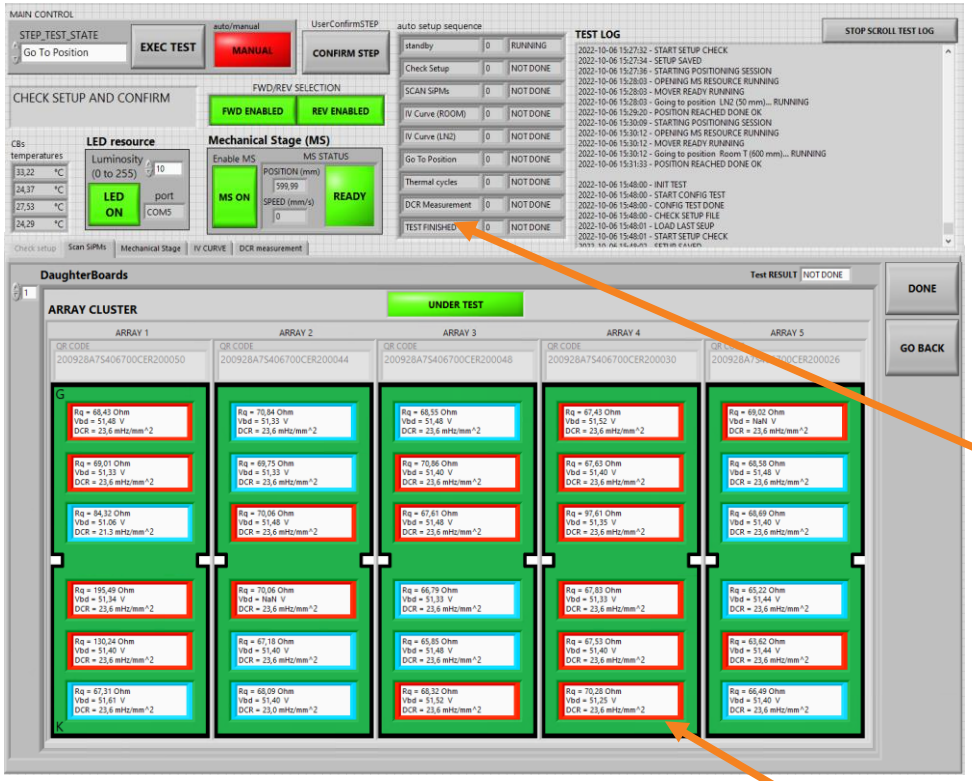


Cold boards:

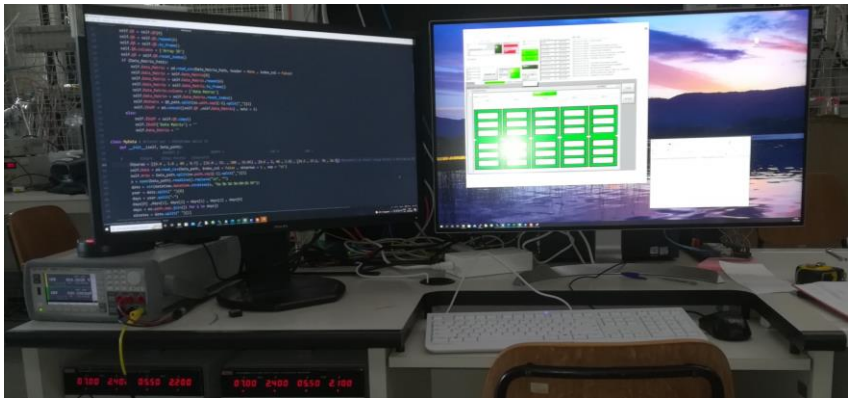
- 4 boards/system;
- 5 arrays/board;
- 120 SiPM;
- Temperature monitor;
- Bias voltage.



Control panel



Labview interface



A unique Labview interface allows to perform each step of the quality assurance tests

At the end, a panel shows the final report and if the SiPMs are in specs.

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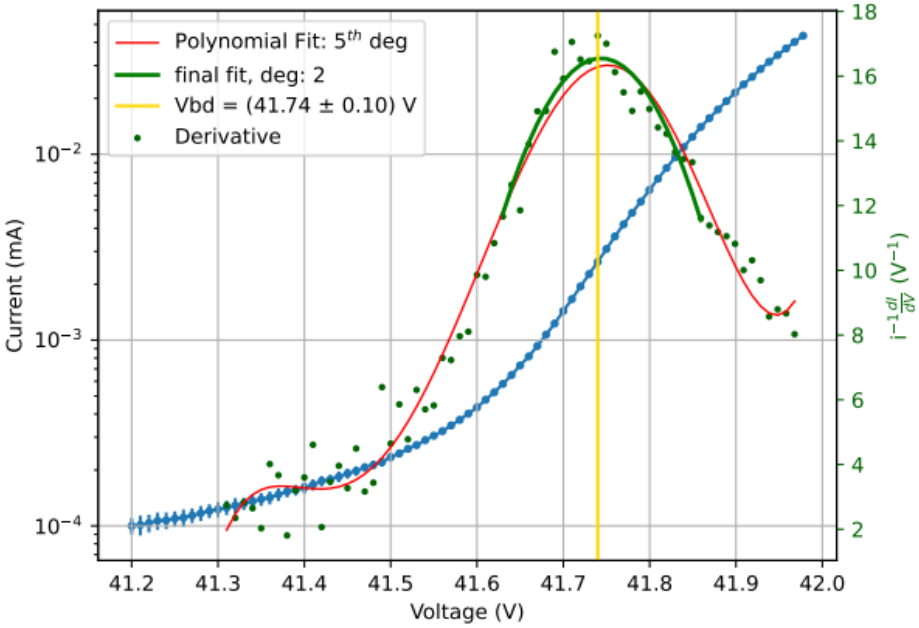
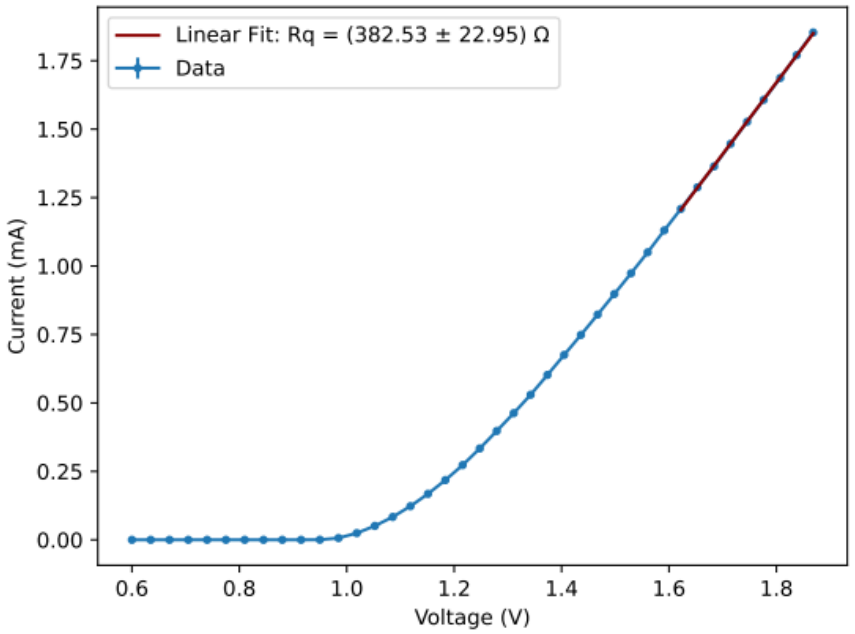
Acquisition example

IV curve:

- The system sets the voltage and measures the current flowing through each SiPM simultaneously (different parameters can be set);
- R_q and V_{bd} estimations from online fits of the data;





Global DCR:

- The system sets the over-voltage and measures the total counts above 0.5 p.e. in a defined time window.

Performance

Features:

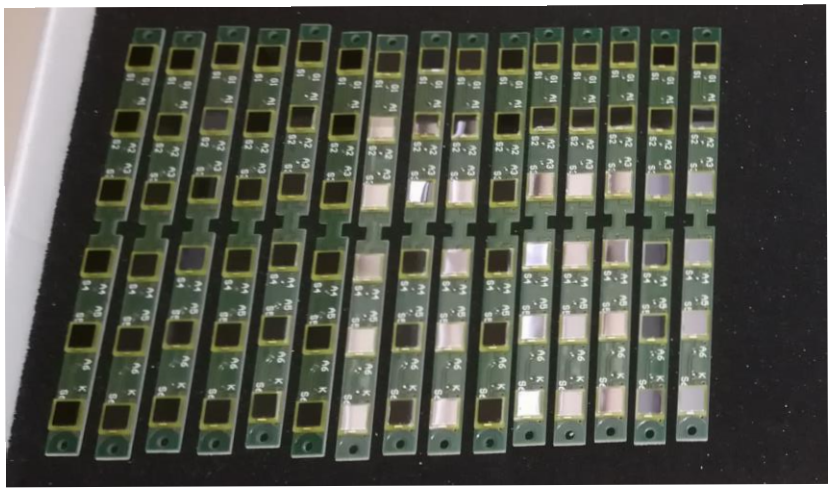
- 55 liters liquid Nitrogen auto refilling system;
- 120 parallel channels;
- Voltage precision 10mV;
- DC acquisition mode;
- Measured current range from 10nA to 3mA;
- AC acquisition mode;
- Programmable threshold DCR;
- 60cm translator stage.

Complete quality assurance tests for 120 SiPM in parallel!

Measurements and commissioning phase

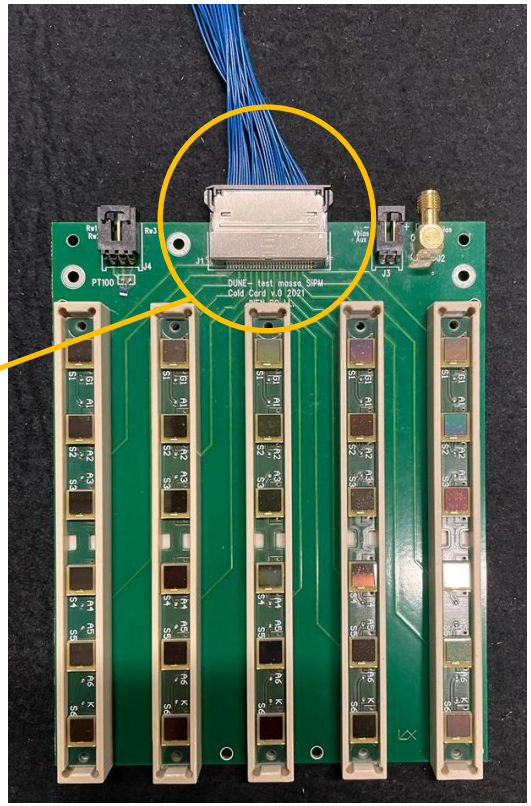
During April and May 2022 Bologna and Ferrara groups received and performed the complete characterization of:

- ~4200 HPK sensors;
- ~3200 FBK sensors;



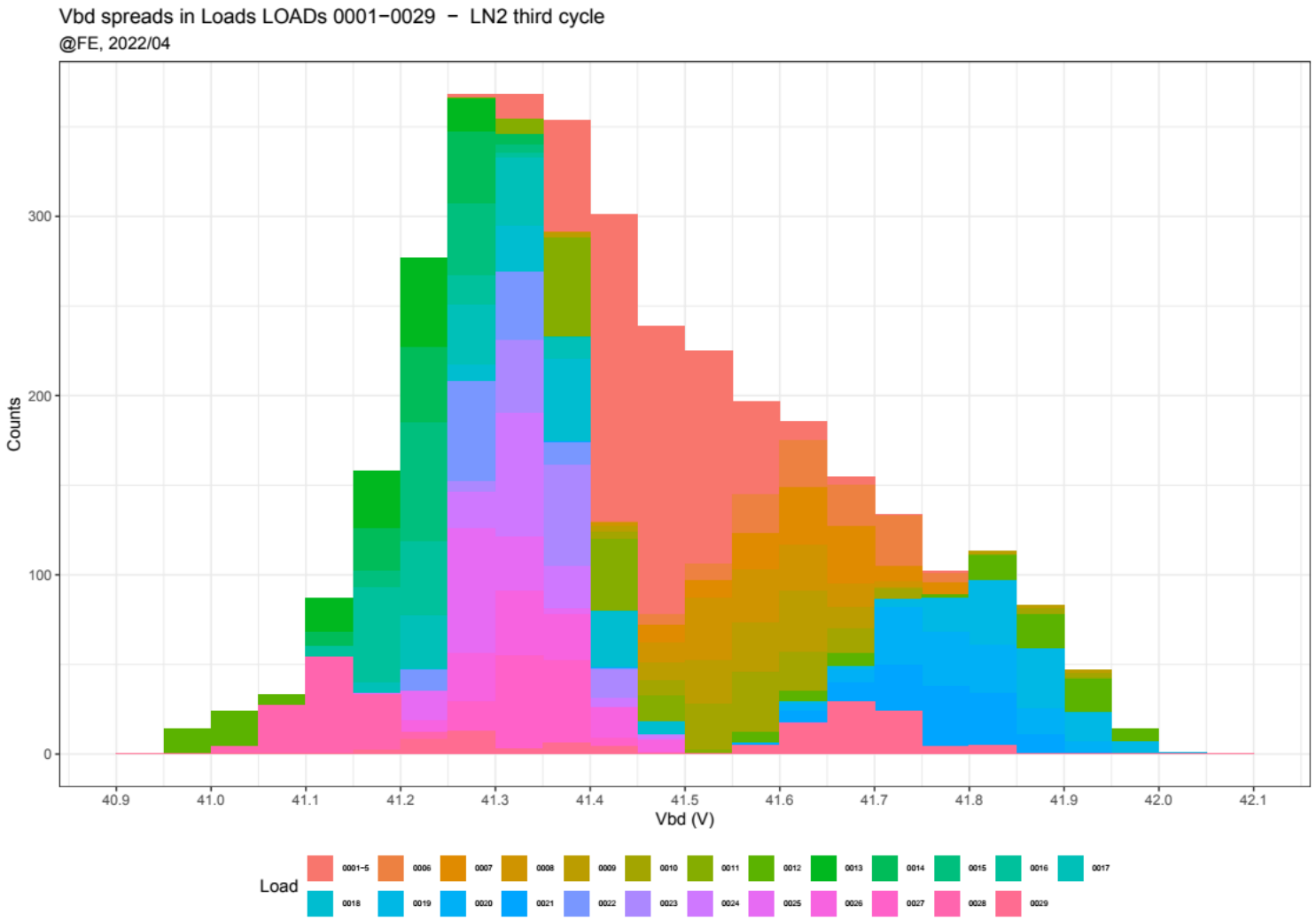
Measurements and commissioning phase

During the thermal cycles in LN2 the humidity freezes inside the connector of the cold boards
→in this case it is impossible to measure R_q and V_{bd}



A new connector has been identified suitable for the application (**EQCD-020-23.62-SBR-SBR-1-B**)
better “protection” from humidity without loss of electrical connection

HPK loads V_{bd} @ LN2



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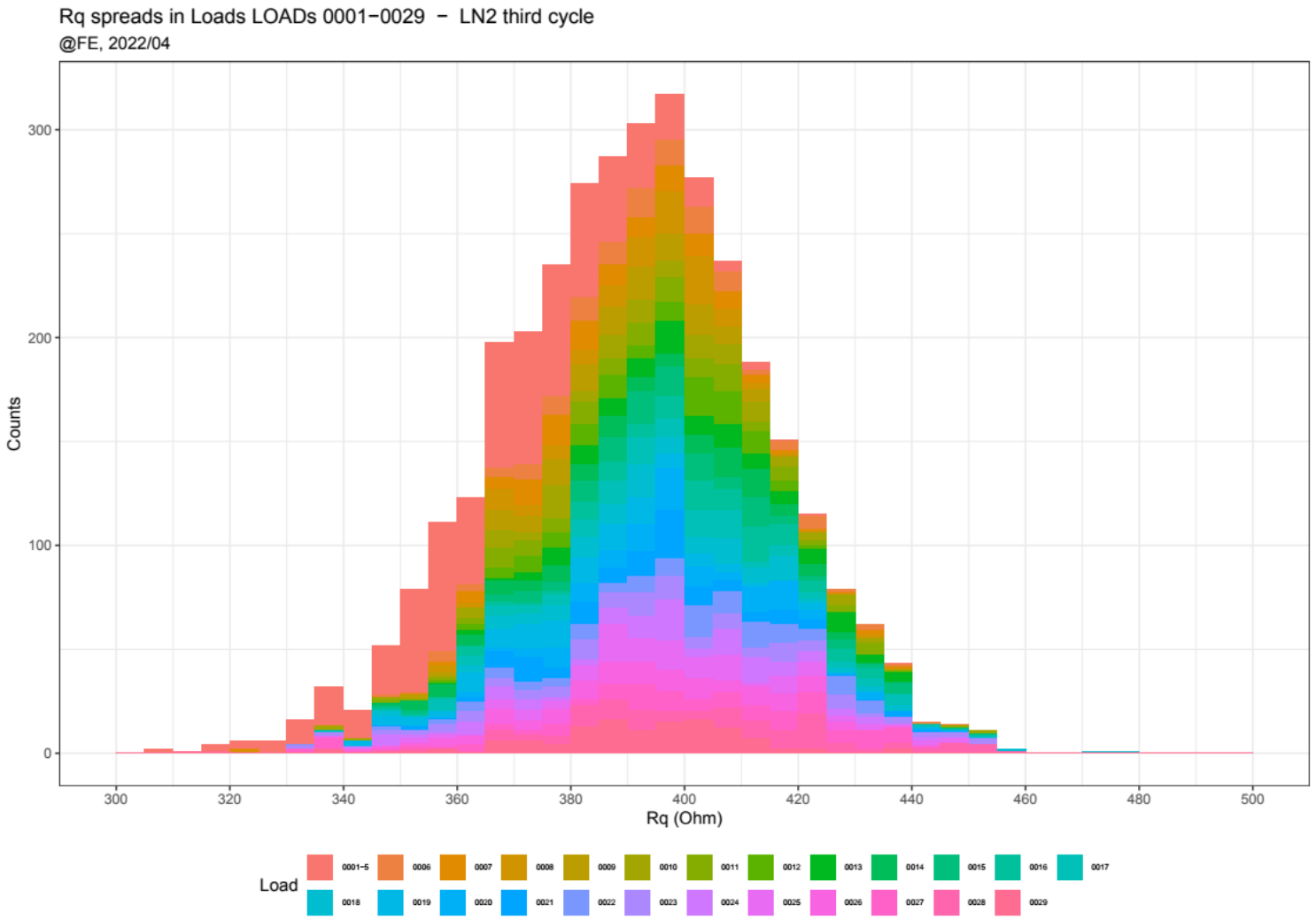
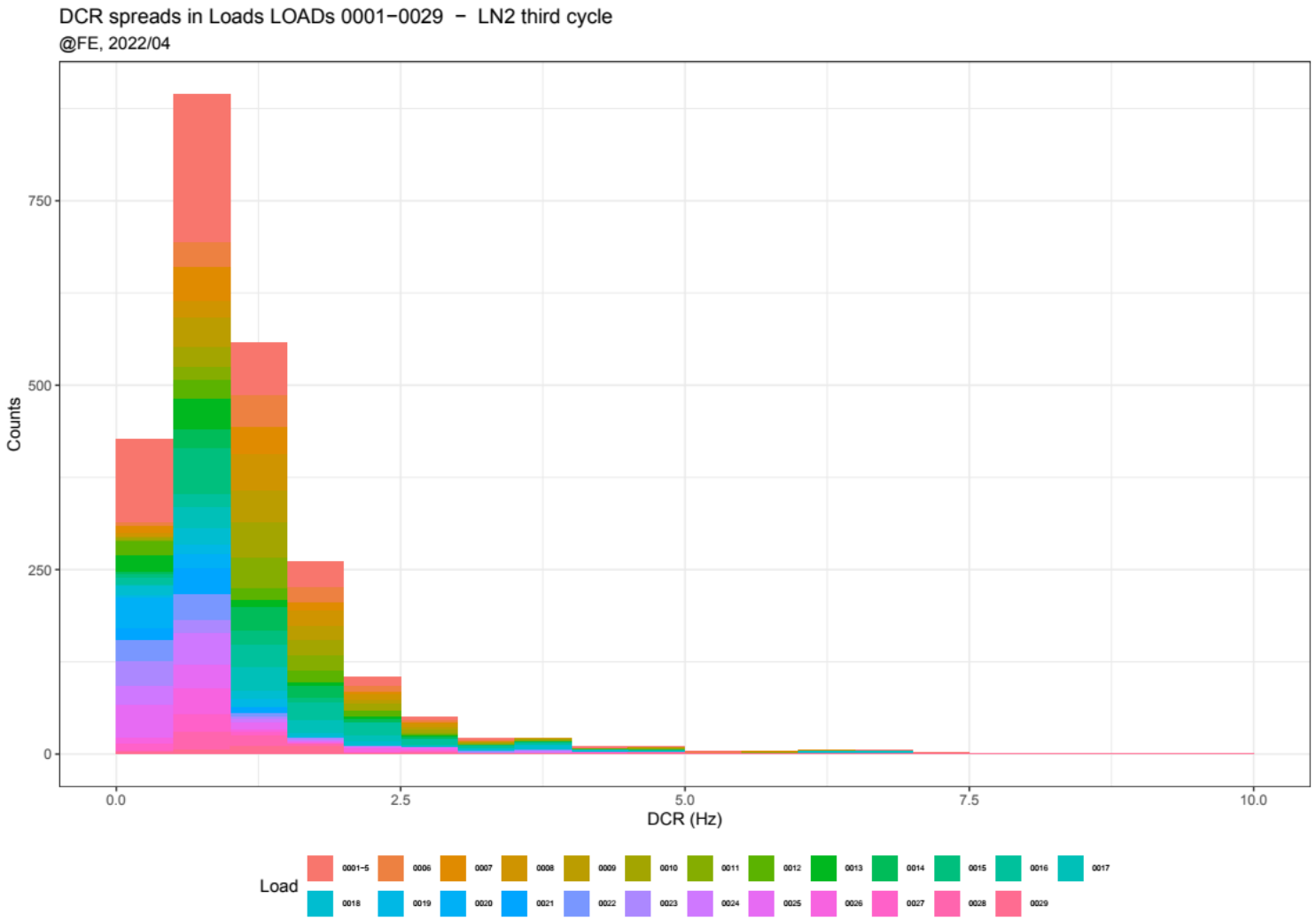
HPK loads R_q @ LN2



HPK loads DCR @ LN2



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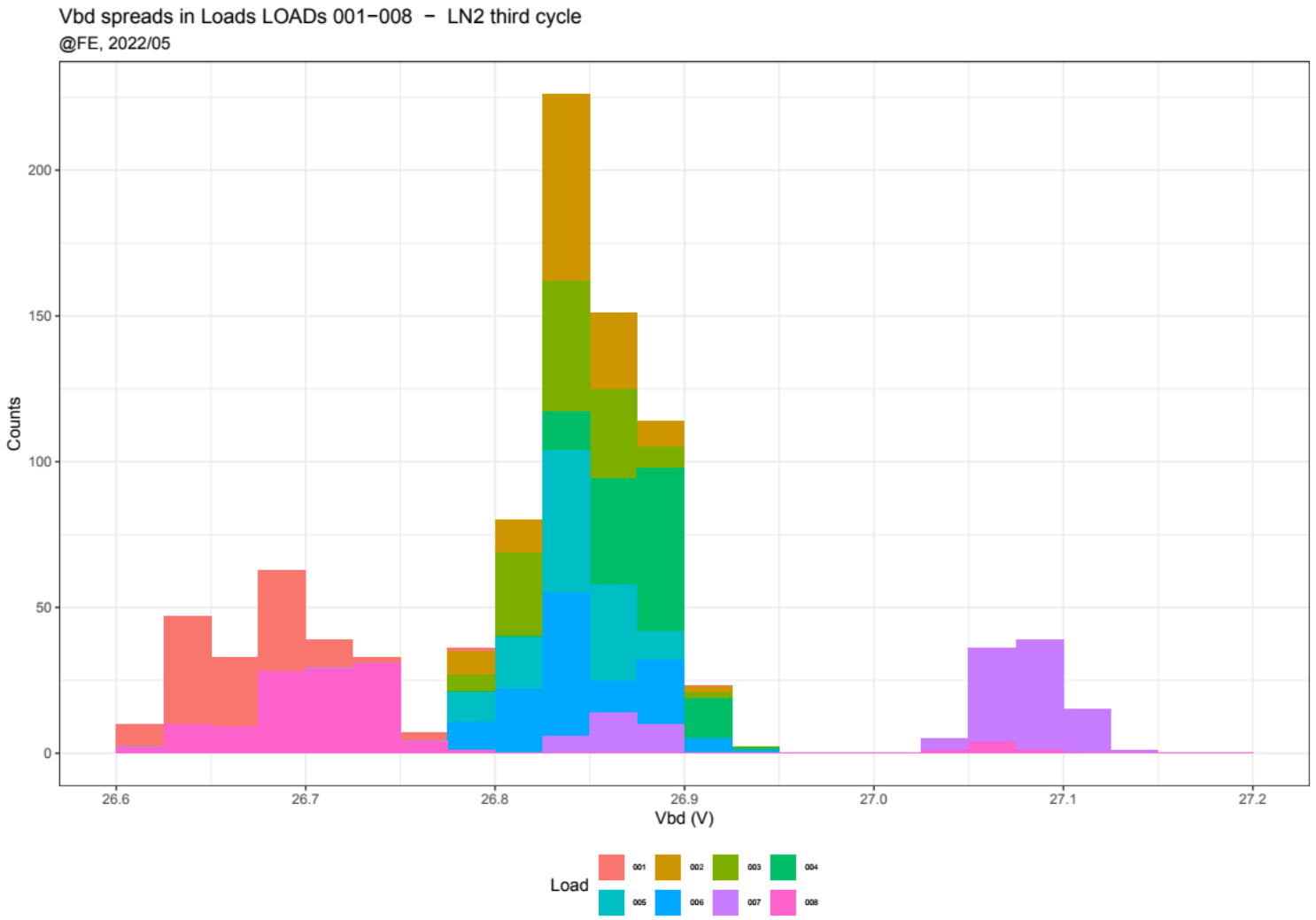
FBK loads V_{bd} @ LN2



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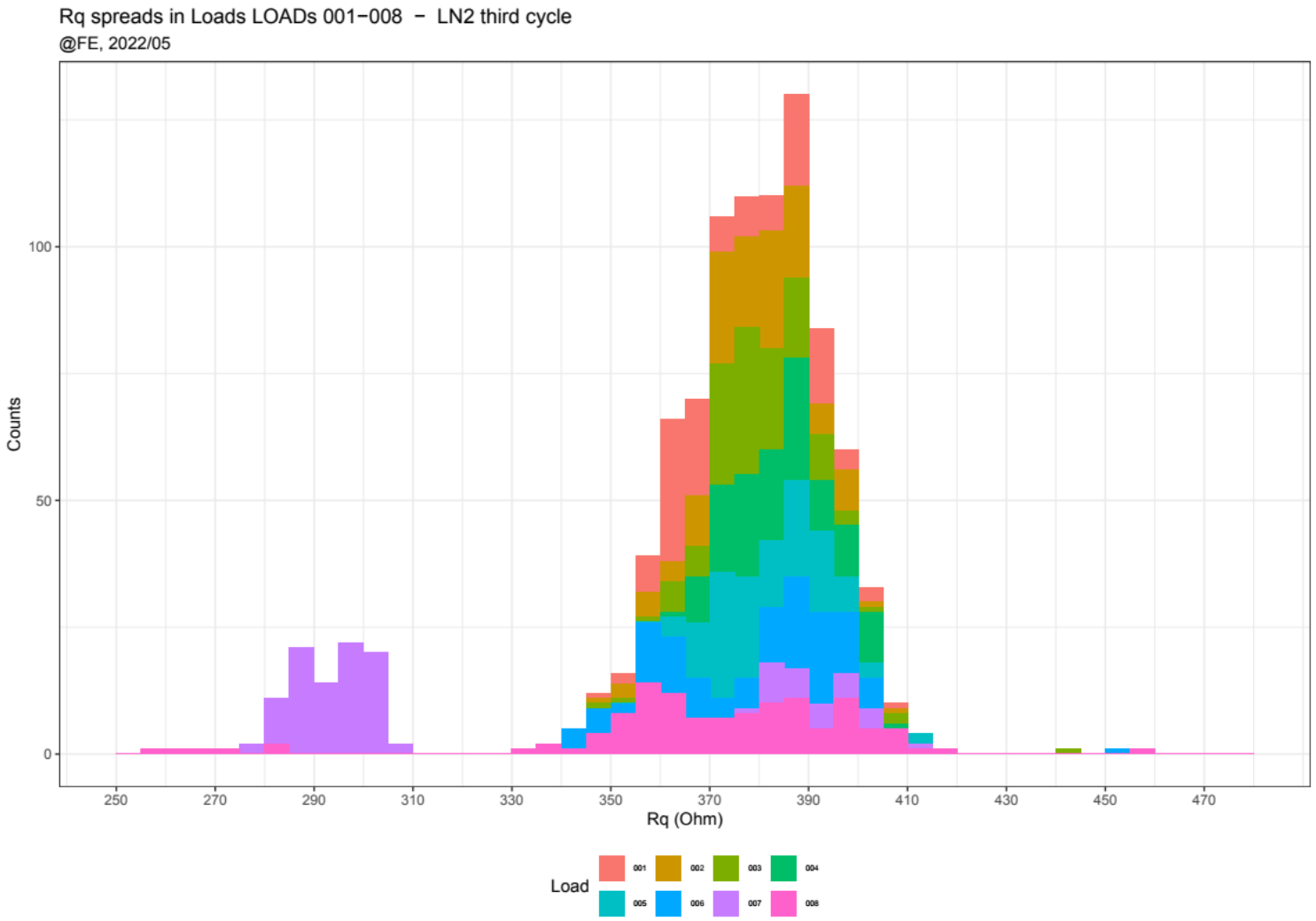
FBK loads R_q @ LN2



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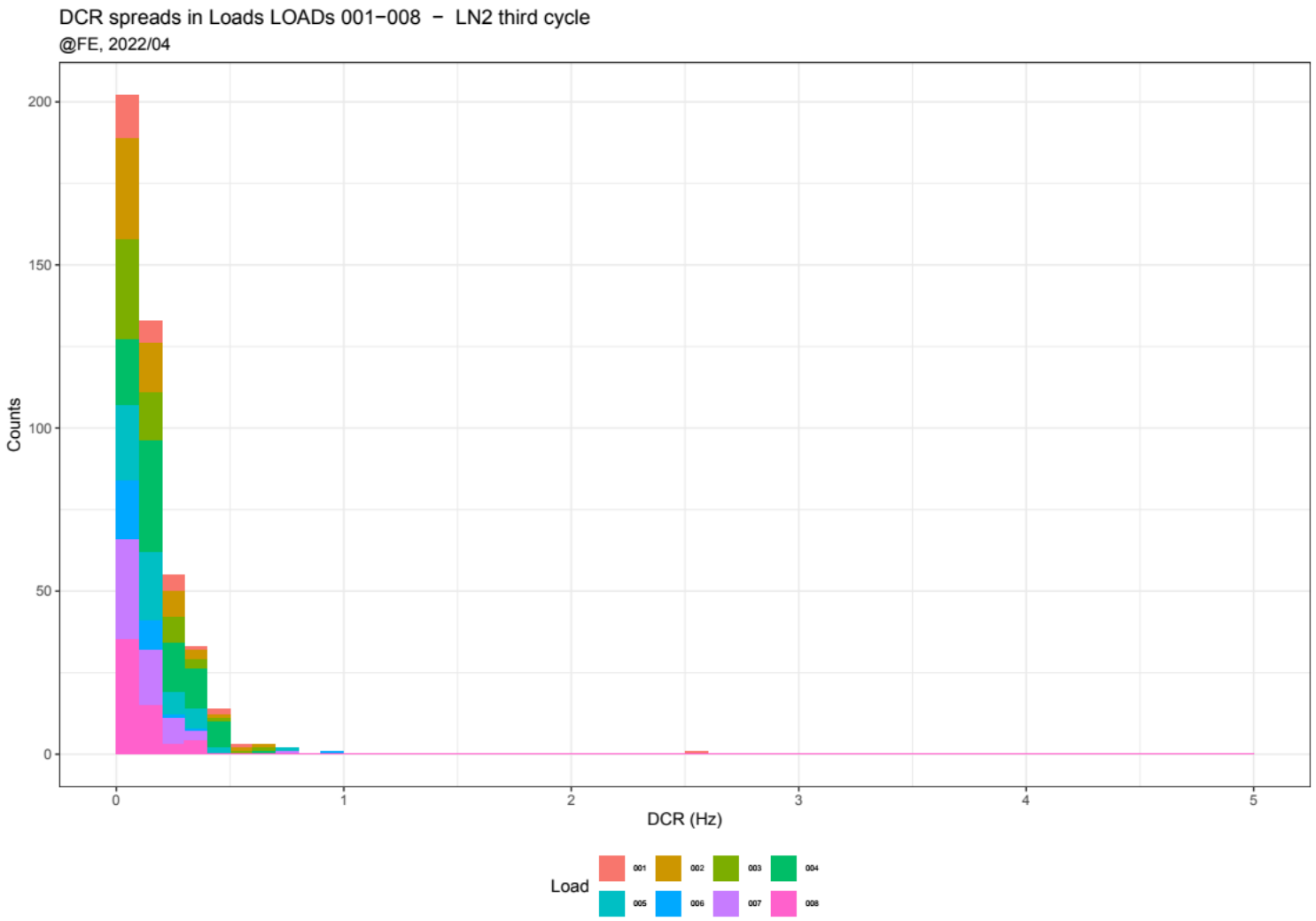
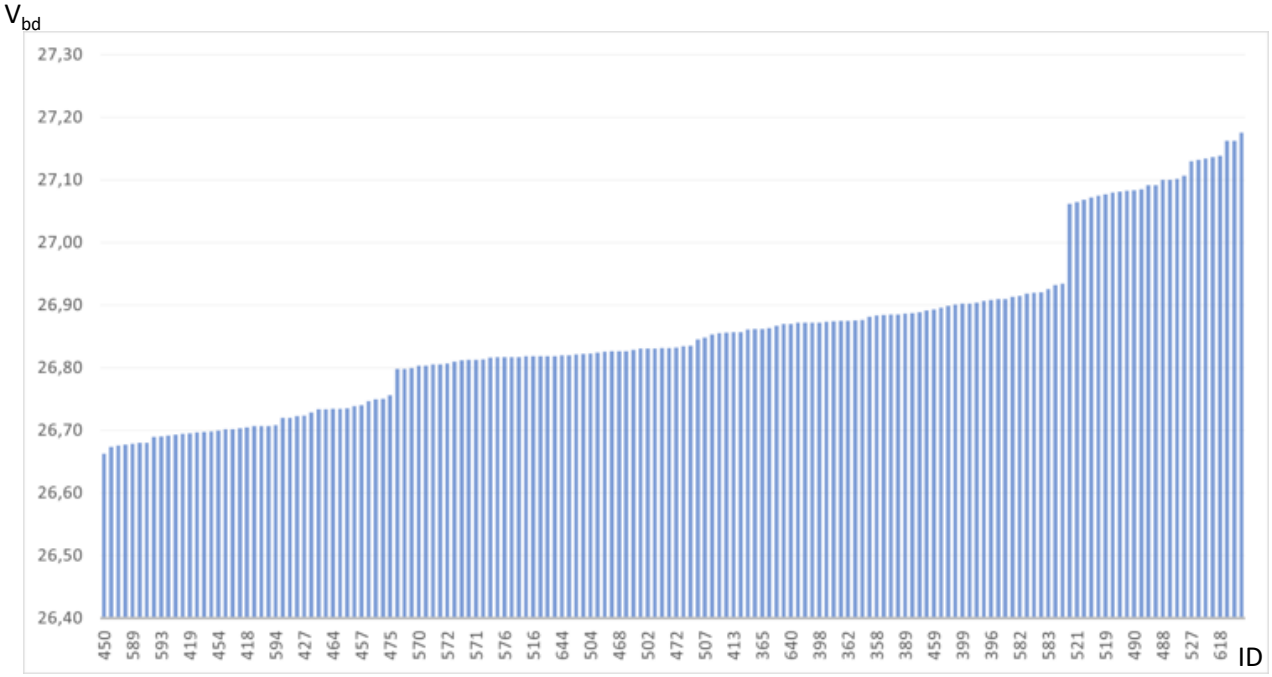
FBK loads DCR @ LN2



Sorted V_{bd} on FBK sample LN_2



Replication of the mass test facility

- **Warm electronics** → provided by Fe-Bo
- **Cold electronics** → provided by Fe-Bo
- **Mechanics** (flange, cold boards support) → provided by Fe-Bo
- **Step motor** → in charge of the hosting labs
- **Dewar 55 lt (**with automated refill system) → in charge of the hosting labs
- **Black box** for housing of the apparatus → in charge of the hosting labs
- **Power supply** (V_{bias}Source measure Unit) → in charge of the hosting labs
- **Power supply** (step motor, warm electronics, DCR system) → in charge of the hosting labs

Conclusions

- Bologna and Ferrara sites: SiPM massive test system CACTUS;
- CACTUS can measure IV-curve (R_q and V_{bd}) and global-DCR for 120 SiPMs in parallel;
- CACTUS can perform a variable number of thermal cycles following programmable profiles;
- Till now we tested ~4200HPK and ~3200FBK SiPMs;
- Cold Bord for replicas already produced;
- New groups involved in SiPM characterization (Milano, Prague, Granada).