Power consumption and thermal dissipation of veto FEE electronics

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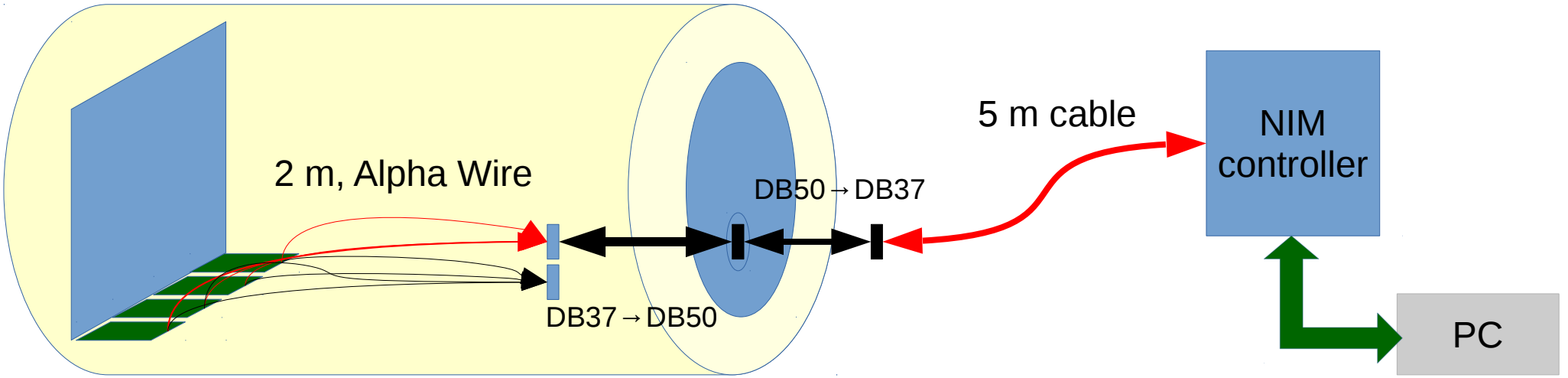
Will the FEE burn in vacuum?

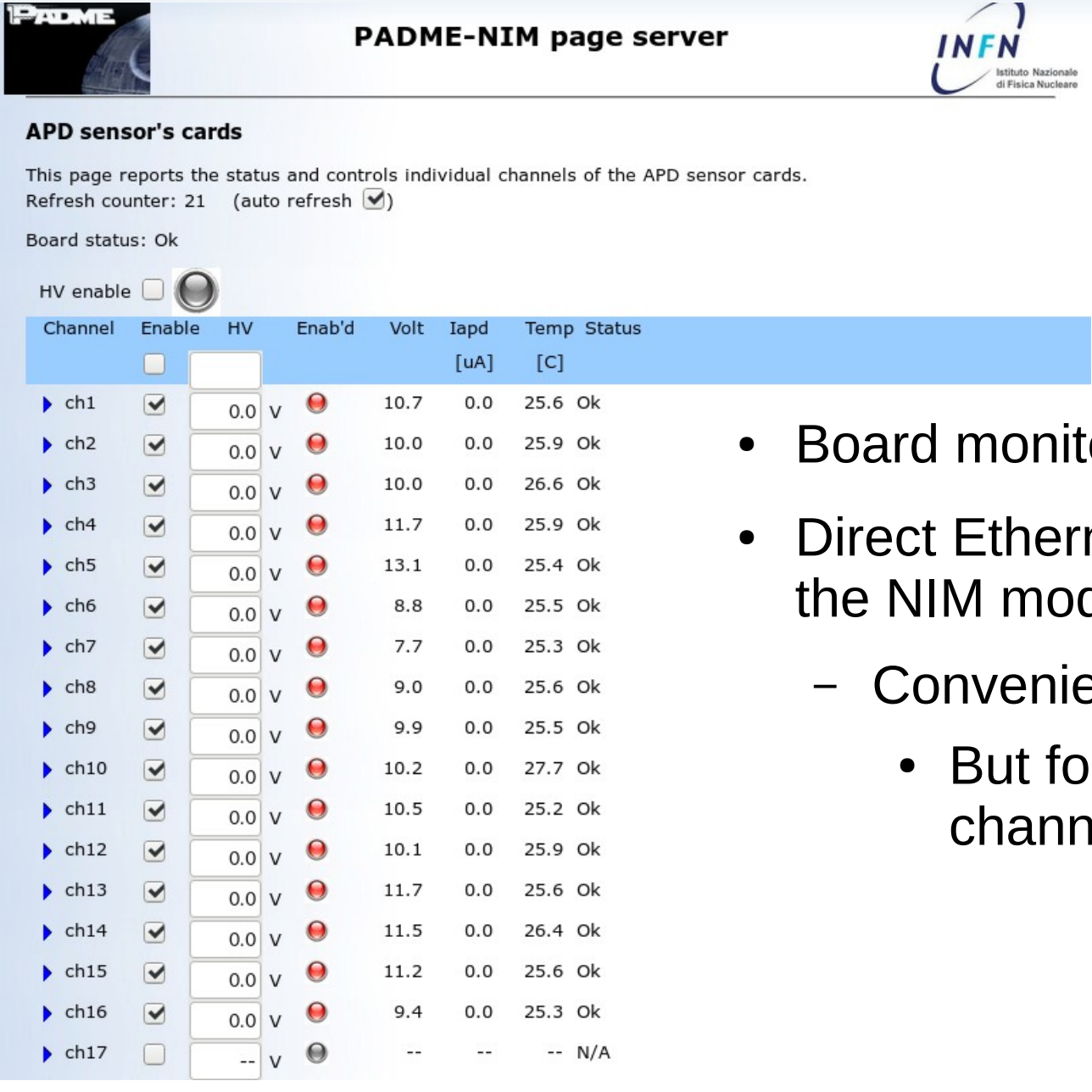
- Goal: test the thermal dissipation strategy
- Steps:
  - Electrical setup preparation
  - Temperature monitoring
  - Mechanical preparation
  - Outcome
  - Power balance

Electrical setup



- DB37M→ DB50F and DB37F → DB50F prepared, each 50 cm long
  - Pinning on the DB50 side chosen according to „common sense“
  - Using flat cable with 10 twisted pairs (4 x SDA, 4xSCL, 1 HV, 1 LV)
  - Cable tested and verified
- Additional extension cable – controller→ DB37→DB50 patch
  - 5m, flat cable, tested and verified
  - Verification = possibility to control and monitor the FEEs and SiPMs

Temperature monitoring



PADME-NIM page server

INFN Istituto Nazionale di Fisica Nucleare

APD sensor's cards

This page reports the status and controls individual channels of the APD sensor cards.
Refresh counter: 21 (auto refresh ☑)

Board status: Ok

HV enable ☐

Channel	Enable	HV		Enab'd	Volt	Iapd [uA]	Temp [C]	Status
ch1	☑	0.0	V		10.7	0.0	25.6	Ok
ch2	☑	0.0	V		10.0	0.0	25.9	Ok
ch3	☑	0.0	V		10.0	0.0	26.6	Ok
ch4	☑	0.0	V		11.7	0.0	25.9	Ok
ch5	☑	0.0	V		13.1	0.0	25.4	Ok
ch6	☑	0.0	V		8.8	0.0	25.5	Ok
ch7	☑	0.0	V		7.7	0.0	25.3	Ok
ch8	☑	0.0	V		9.0	0.0	25.6	Ok
ch9	☑	0.0	V		9.9	0.0	25.5	Ok
ch10	☑	0.0	V		10.2	0.0	27.7	Ok
ch11	☑	0.0	V		10.5	0.0	25.2	Ok
ch12	☑	0.0	V		10.1	0.0	25.9	Ok
ch13	☑	0.0	V		11.7	0.0	25.6	Ok
ch14	☑	0.0	V		11.5	0.0	26.4	Ok
ch15	☑	0.0	V		11.2	0.0	25.6	Ok
ch16	☑	0.0	V		9.4	0.0	25.3	Ok
ch17	☐	--	V		--	--	--	N/A

- Board monitoring web interface exists
- Direct Ethernet communication with the NIM module
  - Convenient and transparent
    - But for few channels, for more channels it becomes a burden

Following the links in the HTML...

ad.htm

```
<head>
        <meta content="text/html; charset=utf-8" http-equiv="Content-Type">
        <title>PADME control page</title>
        <link href="ad.css" media="screen, projection" rel="stylesheet" type="text/css">
        <script src="json2.js" type="text/javascript"></script>
        <script src="jsUtil.js" type="text/javascript"></script>
        <script src="ad.js" type="text/javascript"></script>
        <script type="text/javascript">onload=function(){panelLoad();}</script>
</head>
<body>
```

ad.js

```
var formUpdate  = new periodicObj("brdusr.cgx", 2000, brdusr_htm_update);
```

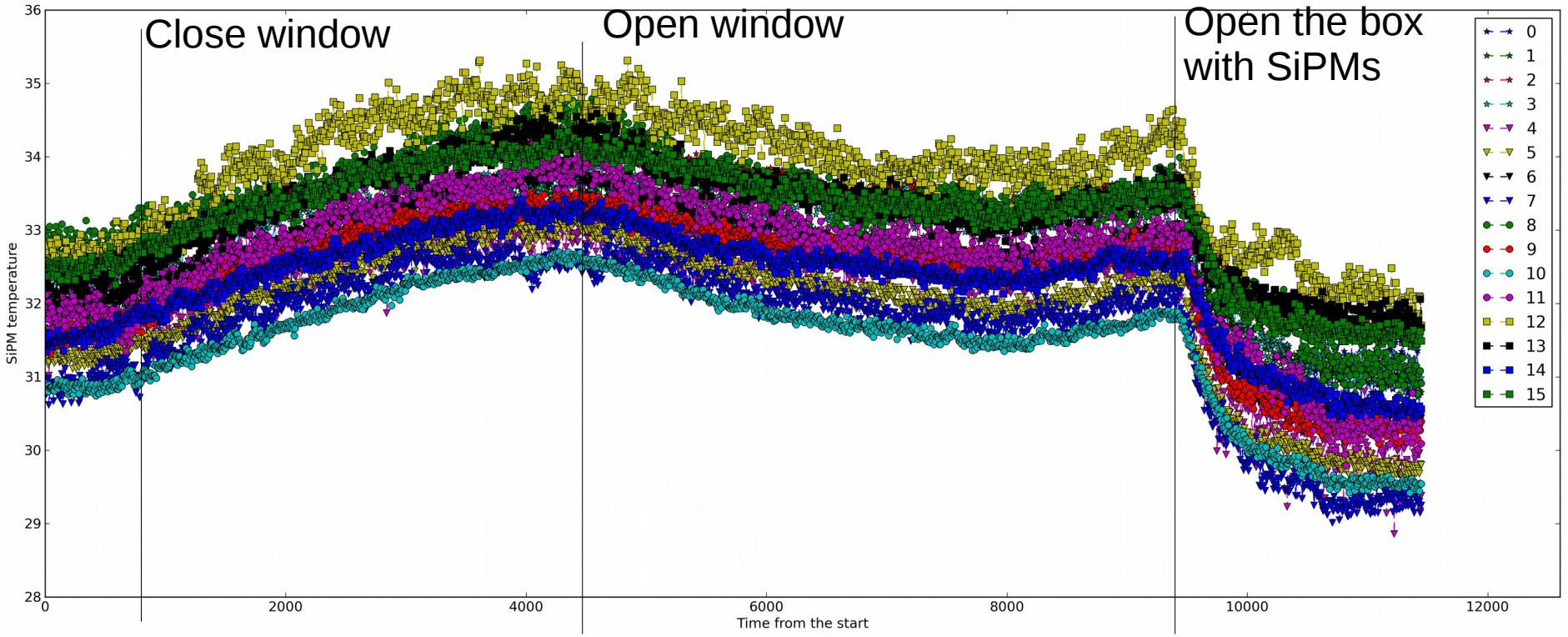
brdusr.cgx


```
[{"id":"","ch":1,"cardSts":1,"hvReq":55.0,"hvLvl":54.7,"cardTemp":33.08,"apdCurrent":0,"apdTemp":31.0,"cardSsupplyV":4975.2,"er
rSts":0,"errCnt":0,"lastErr":"Ok"},{"id":"","ch":2,"cardSts":1,"hvReq":55.0,"hvLvl":55.0,"cardTemp":31.86,"apdCurrent":0,"apdTe
mp":31.0,"cardSsupplyV":4973.2,"errSts":0,"errCnt":0,"lastErr":"Ok"},{"id":"","ch":3,"cardSts":1,"hvReq":55.0,"hvLvl":55.0,"car
dTemp":31.14,"apdCurrent":0,"apdTemp":31.5,"cardSsupplyV":4973.1,"errSts":0,"errCnt":0,"lastErr":"Ok"},{"id":"","ch":4,"cardSts
":1,"hvReq":55.0,"hvLvl":55.0,"cardTemp":31.85,"apdCurrent":0,"apdTemp":31.6,"cardSsupplyV":4974.7,"errSts":0,"errCnt":0,"lastE
```


- The CPU on the board runs an html and a JavaScript servers
  - The update on the displayed form is through JS functions
- The data is taken and parsed from three files: brdcfg.cgx brddat.cgx brdusr.cgx
  - All they are respecting the JSON format!

Simple monitor

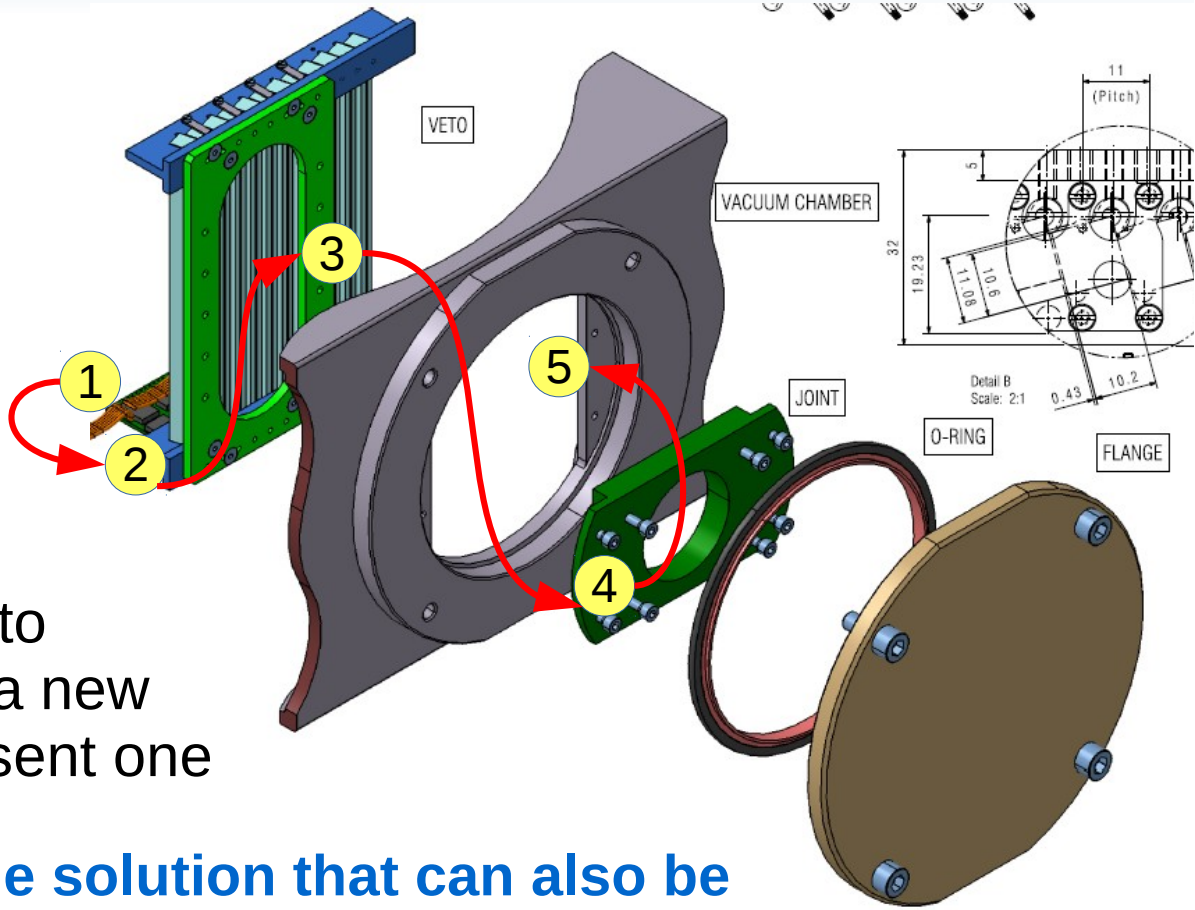
- A python script with JSON parser, container and a exploiting basic plotting
- Tested for long term in office environment



- The temperature measurement seem to follow the natural expectations
  - So it seems a reliable indication for the Tcard

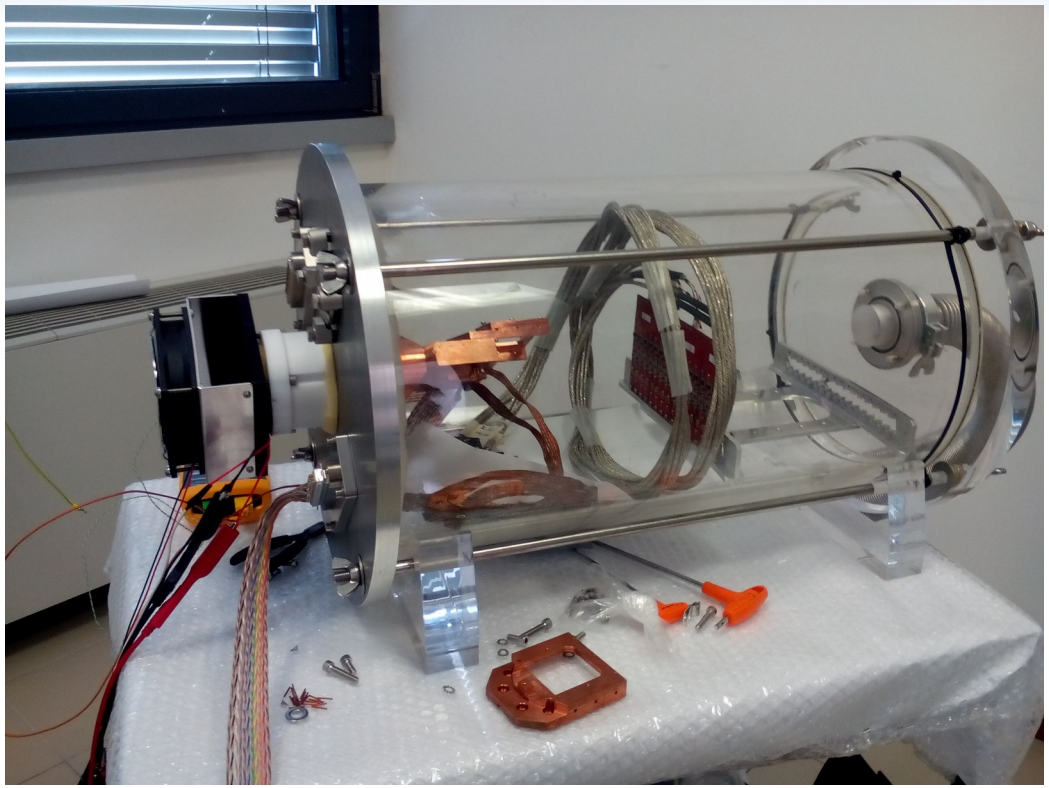
Installation

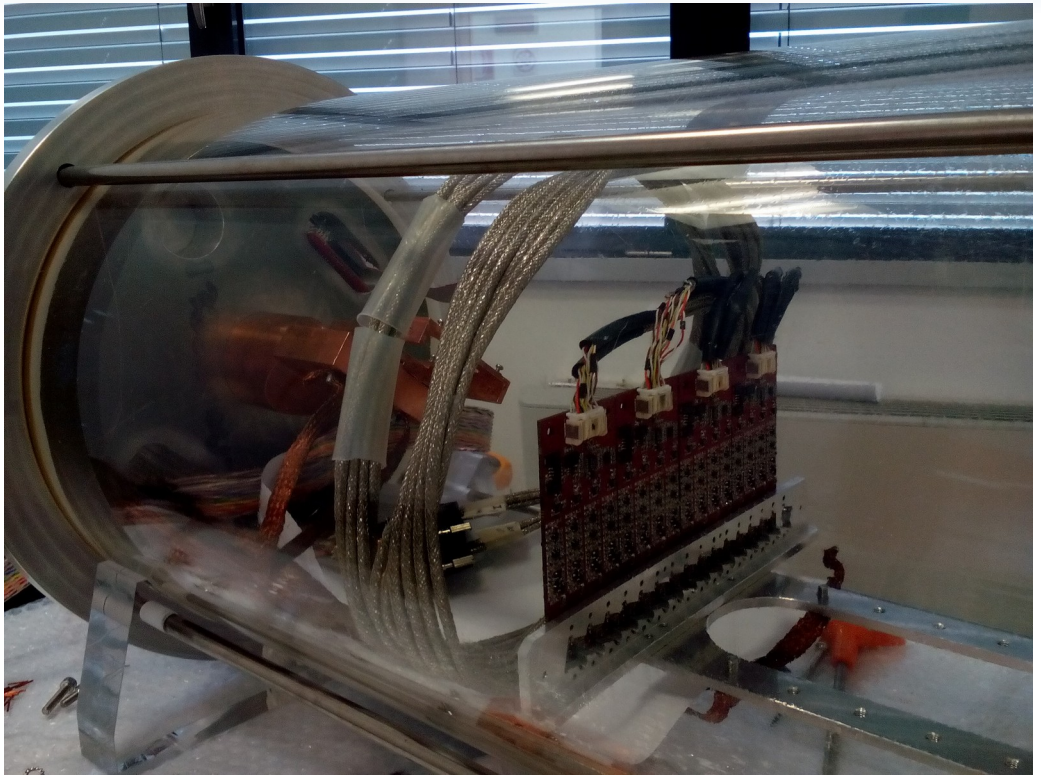
- Base heat transfer solution
  1. FEE cards →
  2. aluminium frame →
  3. enclosing back panel →
  4. supporting panel →
  5. vacuum chamber



- A realistic test should assume to include all components … i.e. a new flange or machining of the present one
- **Can we make another possible solution that can also be realized in test environment?**
  - Use only braided copper cable for heat transfer from 3 directly to 5
  - Can be implemented both at the experiment and at a test setup – and can also be the worst case scenario test

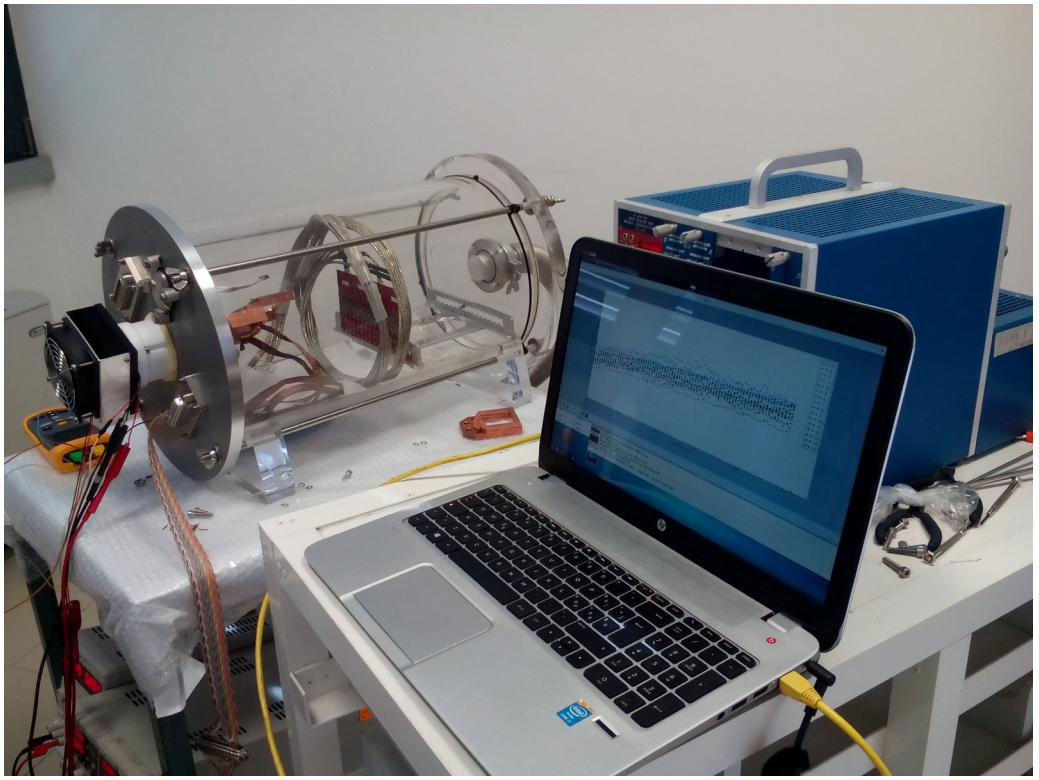
Installation

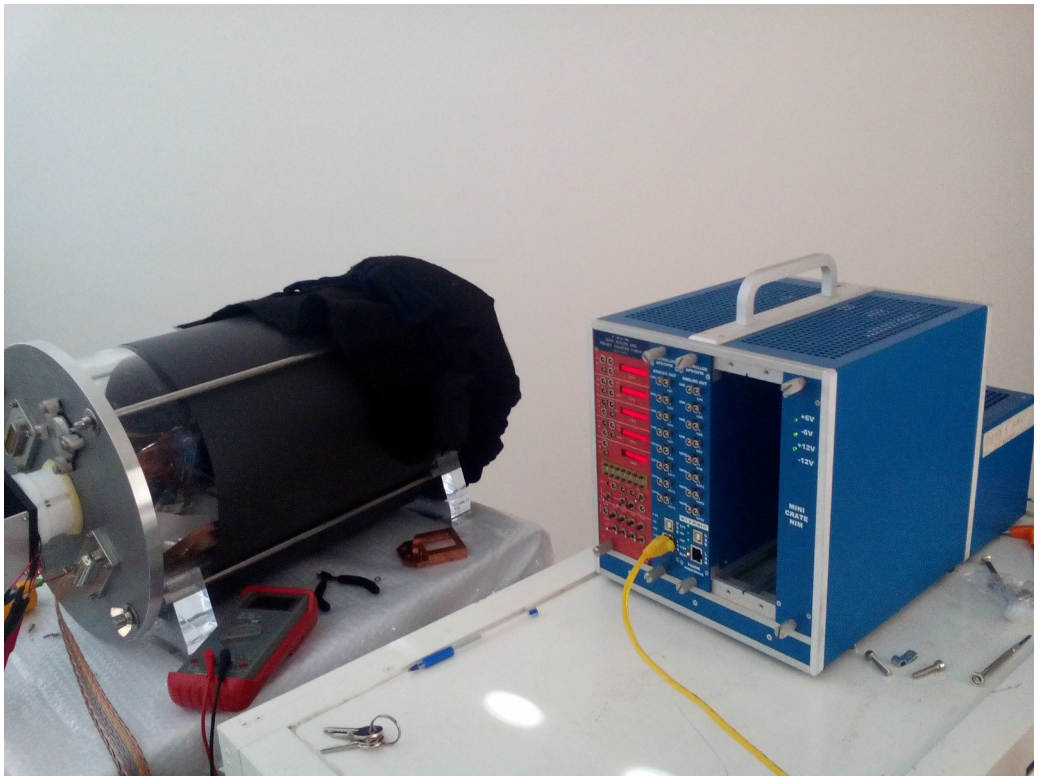




- Two braided copper wires, ~1 cm wide, attached to the Mimosa copper support
- Signal/control cables not touching the cards
- The only additional heat transfer is through the wires and the plastic chamber itself
  - The contact between the frame and the chamber is negligible
  - The fan was used occasionally, the Peltier - never

Setup

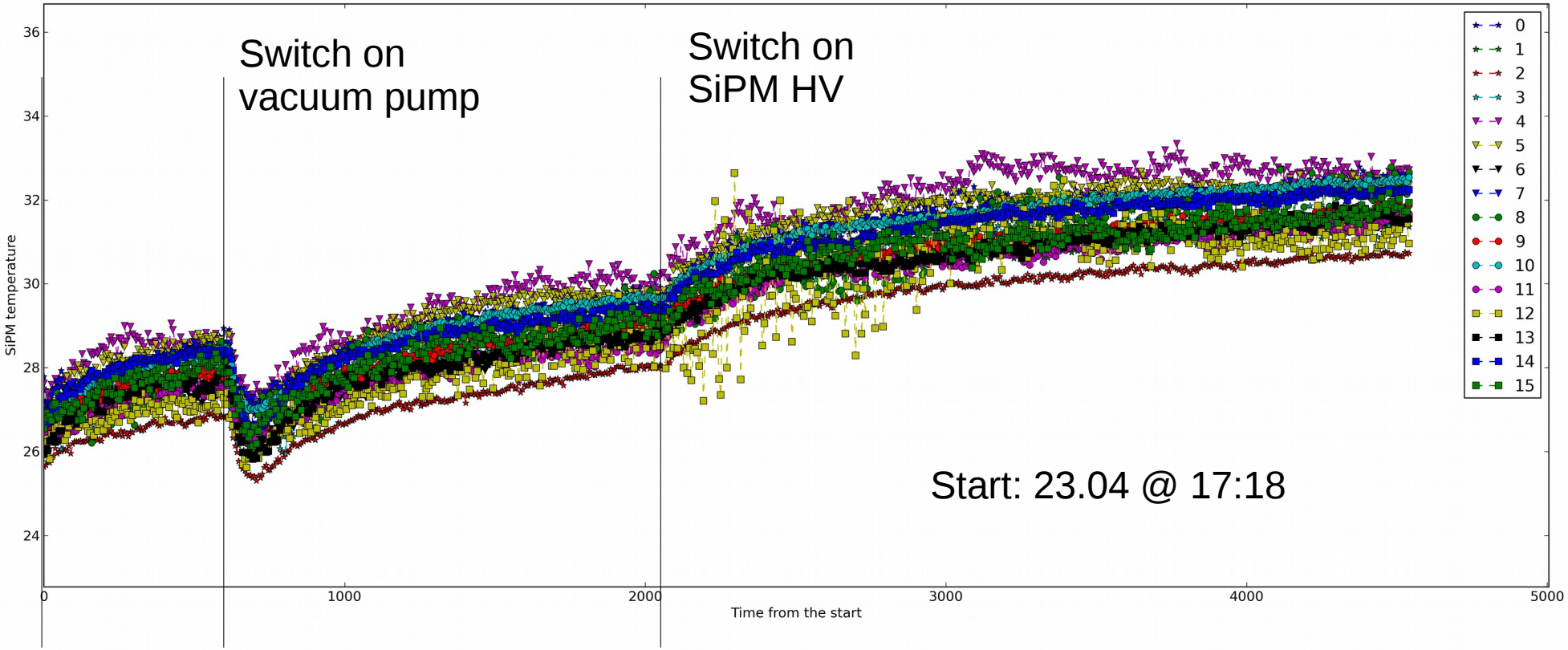




- The chamber got covered by Tedlar and black cloth to decrease the light on the SiPM
  - However no special attention was made to keep them in full darkness
  - A lower HV (close but below the breakdown voltage) leads to sizeable signal amplitudes and a load to the amplifiers

Temperature trend

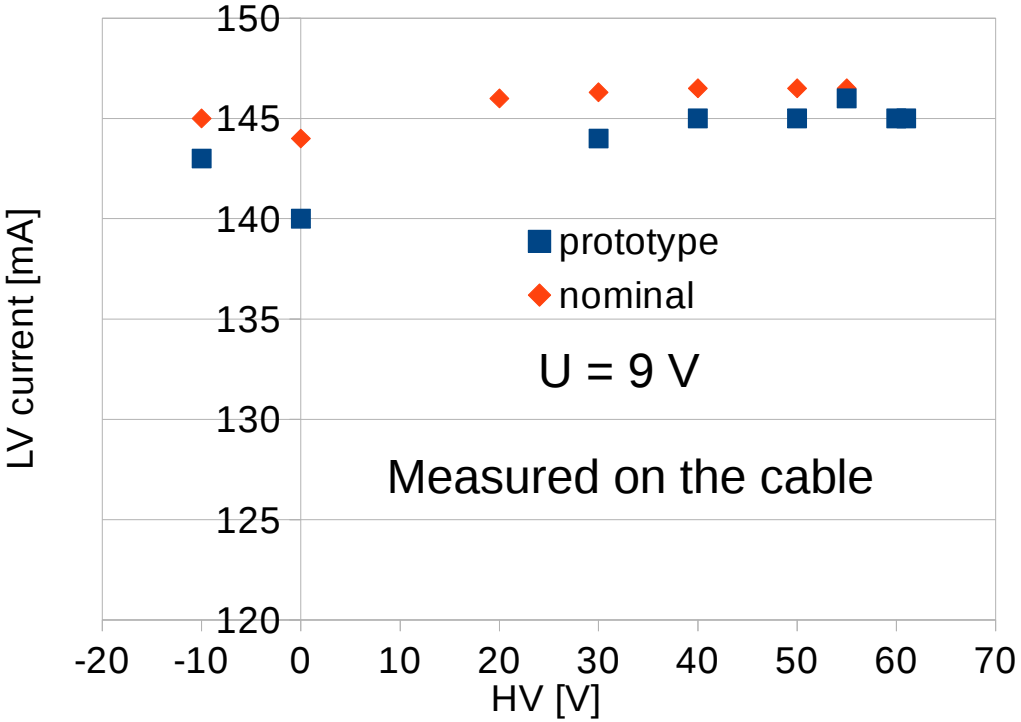
Controller ON



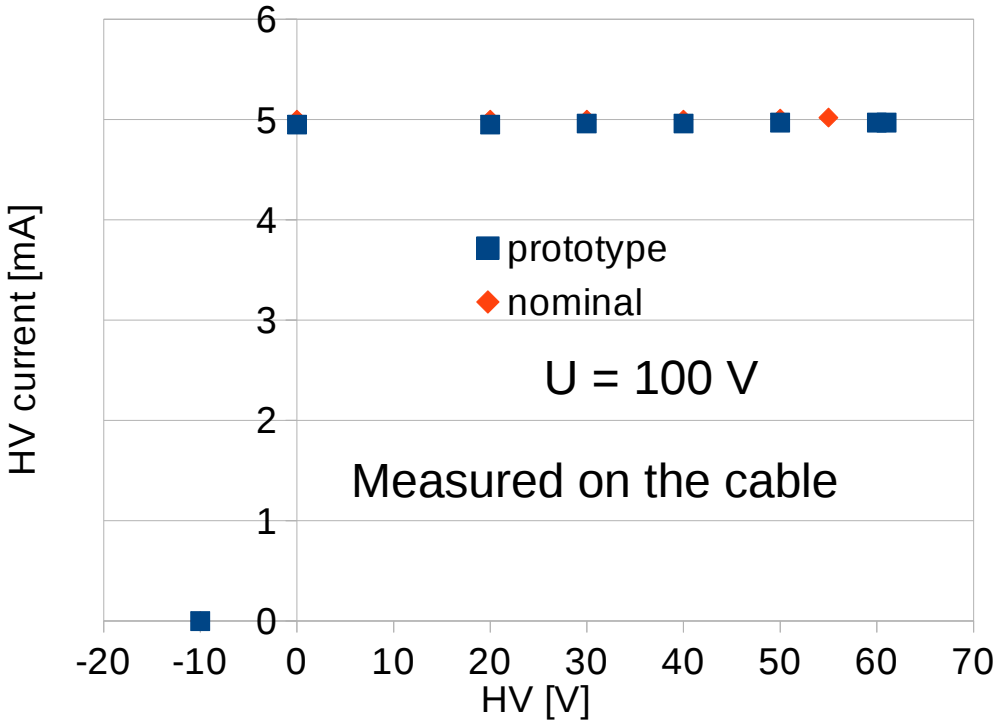
- The system operated for > 1 h without any intervention necessary
- The temperature seem to stabilize after initial increase
  - Heating and dissipation tend to equalize
  - The maximal temperature was about 32 – 33 C

FEE power characteristics

- Controller ON:
  - 9V – OK (measured 9.0 V),
  - HV – 0 V (measured ~5-6 V)

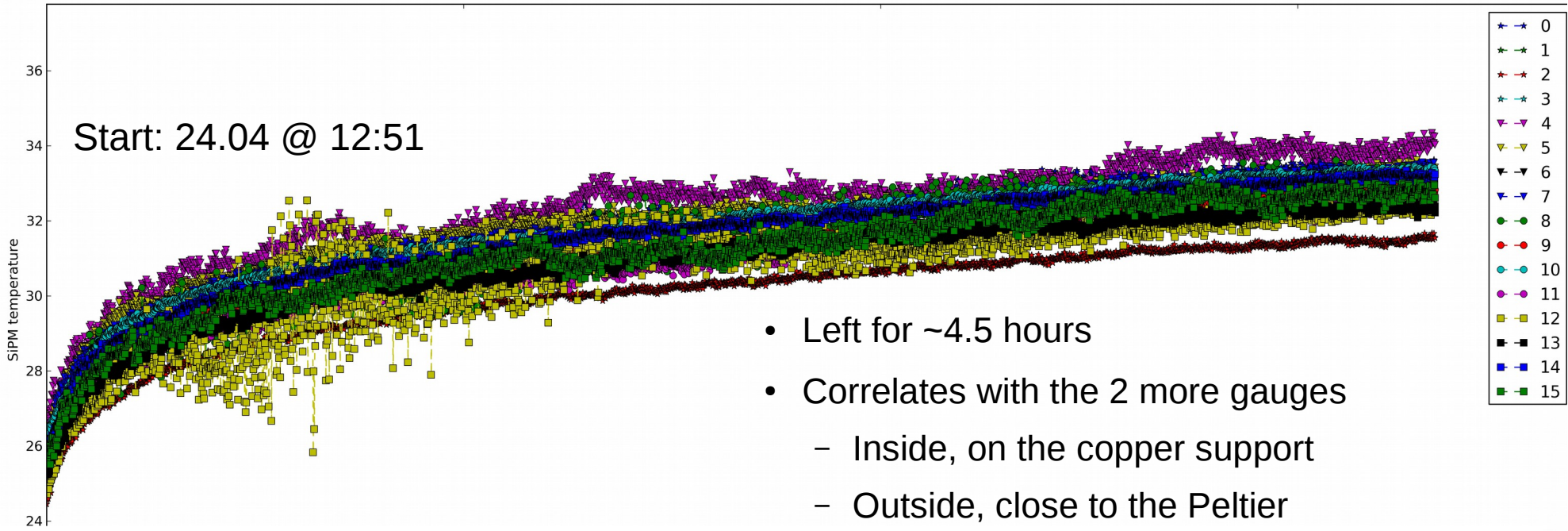


- HV ON:
  - 9 V – OK
  - 100 V – OK (measured 99.7 V)

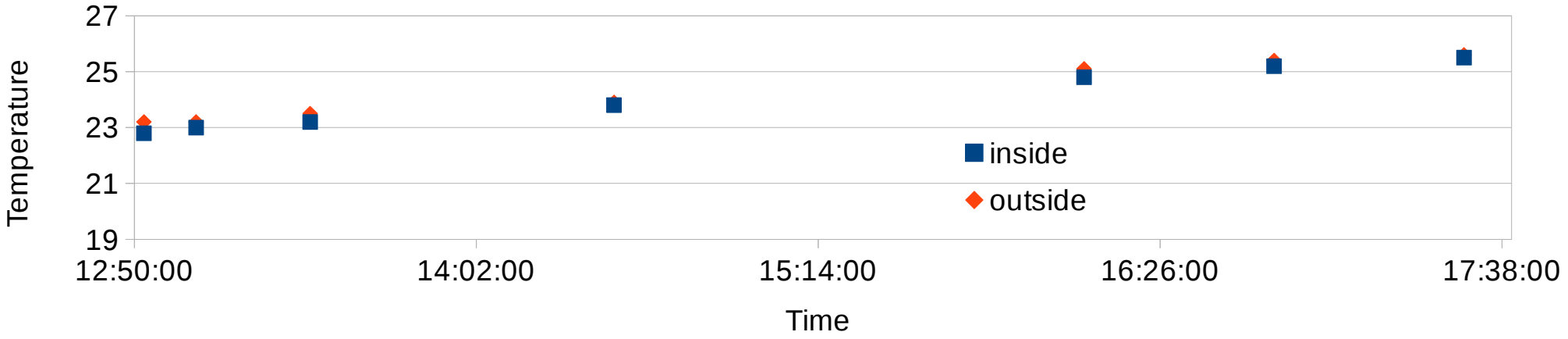


- The LV current is stable and does not exceed 150 mA @ 9 V **(< 10 mA/channel !!!)**
  - Slight increase with the increase of the HV, amplifiers consume more current due to increase of rate
- Current on the HV line (when HV is ON) is fixed to ~312 mA/channel (300 mA by specification)
- Power consumption: ~1.3 W (LV) + 0.5 W (HV) ~ **1.8 W for 16 channels**

Educated thermal test



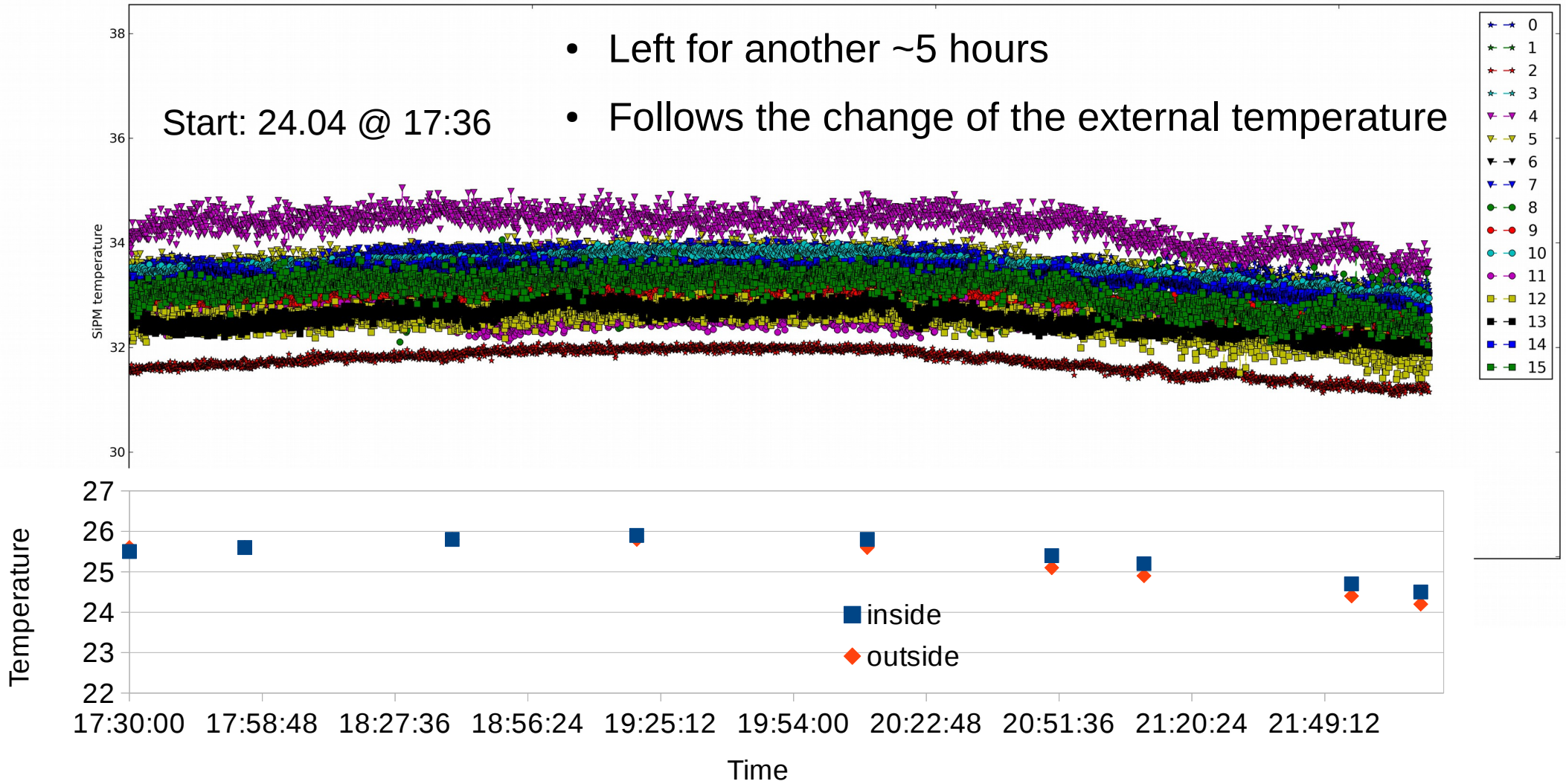
- Left for ~4.5 hours
- Correlates with the 2 more gauges
  - Inside, on the copper support
  - Outside, close to the Peltier



Educated thermal test

- Left for another ~5 hours
- Follows the change of the external temperature

Start: 24.04 @ 17:36



Vetoes DCS

Pure „C“ module developed to handle the NIM controller values

From brdusr.cgx
js length = 2584
# of TOKENS = 382
# of channels = 16

id	chan	status	hvset	hvlvl	cardT	sipmI	sipmT	errSt	errcnt	lasterr
0	1	1	62.00	61.60	33.58	0.00	31.20	0	0	0
1	2	1	62.00	62.10	32.34	0.00	31.40	0	0	0
2	3	1	62.00	62.00	31.47	0.00	31.90	0	0	0
3	4	1	62.00	61.90	32.86	0.00	31.90	0	0	0
4	5	1	61.20	61.00	33.70	0.00	31.10	0	0	0
5	6	1	62.00	62.10	33.31	0.00	31.90	0	0	0
6	7	1	62.00	62.00	32.32	0.00	31.90	0	0	0
7	8	1	62.00	61.60	33.35	0.00	32.00	0	0	0
8	9	1	62.00	62.80	33.05	0.00	30.70	0	0	0
9	10	1	62.00	61.90	32.64	0.00	31.70	0	0	0
10	11	1	62.00	61.90	33.22	0.00	31.50	0	0	0
11	12	1	62.00	62.30	32.19	0.00	31.80	0	0	0
12	13	1	62.00	62.20	32.20	0.00	31.50	0	0	0
13	14	1	62.00	62.20	32.33	0.00	31.10	0	0	0
14	15	1	62.00	62.50	33.02	0.00	31.50	0	0	0
15	16	1	62.00	62.10	32.86	0.00	31.50	0	0	0

Put into operation readout from cgx of NIM module for DCS with C module

using proper variables to be put into mySQL DB

For the moment testing on raspberry connected to NIM module, then to DCS

Final version: directly from DCS main

NOTE: this is just to read, not yet to set the values

Work in progress...

Conclusion

- The total power to be dissipated is about **12 W per a whole veto station**
- The power dissipation for the HEPveto is ~ 2 W
- An effective thermal dissipation mechanism can be realized just with 2 braided copper wires
  - 6 wires per veto, exploiting also the free backplanes, screw threads already there
- The cards temperature is ~ 8 degrees higher than the outside temperature
  - Expecting < 30°C if the chamber is @ 20°C
- A python monitoring script to follow the FEE status
- Dedicated DCS module developed in C