Fermilab U.S. DEPARTMENT OF ENERGY | Office of Science

Measurement of the gas gain and understanding the gas flow in the Mu2e Tracker

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Supervisor: Vadim Rusu

Midterm presentaiton

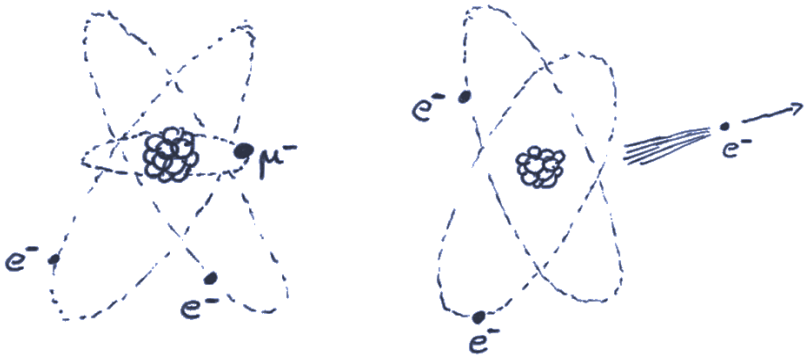
29 August 2022

Overview

- Mu2e experiment and tracker
- Tracker's Panel
- Experimental setup
- Results: old and new data from panel MN084
- Conclusion and Perspectives

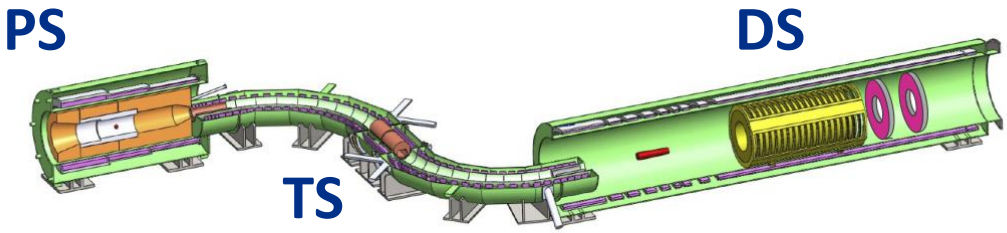
Mu2e Experiment

Neutrino-less conversion of muons into electrons in the Coulomb field of an Al nucleus



$$\mu^- N \rightarrow e^- N$$

$$\mathrm{E_e} = \mathrm{m}_\mu - \mathrm{B}_\mu - \mathrm{E_{rec}} = 104.97\,\mathrm{MeV}$$



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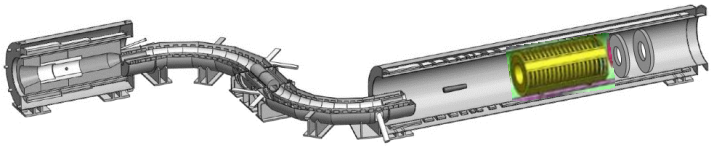
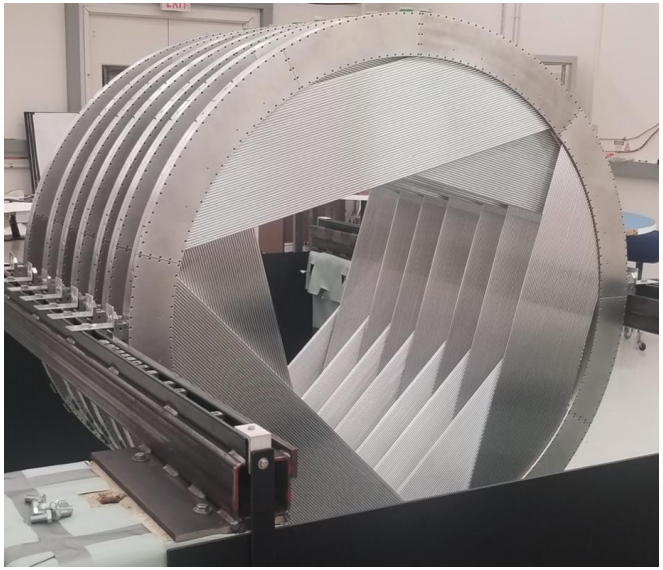
Mu2e Tracker

- **Low mass** straw tube detector

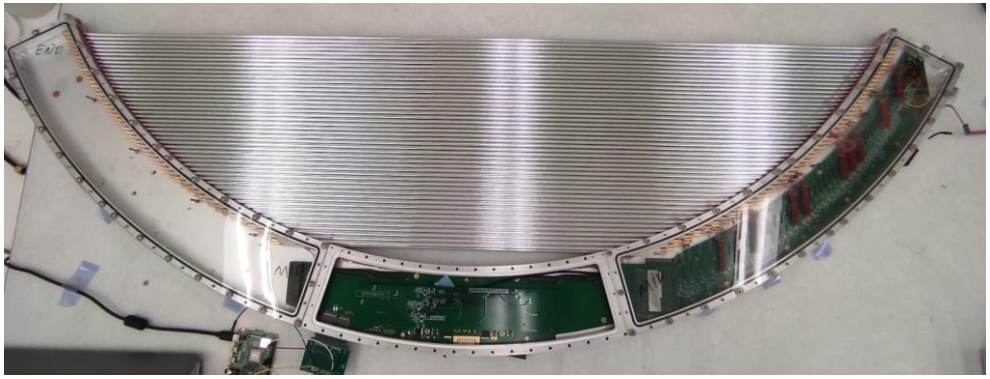


- Position and the momentum of the electron
- Still under construction

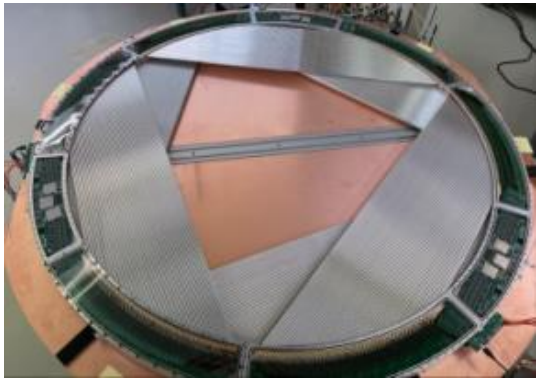


Mu2e Tracker's panel

- 96 Mylar straws
- 5 mm diameter and 15 µm walls
- 25µm gold plated tungsten sense wire



Panel MN084



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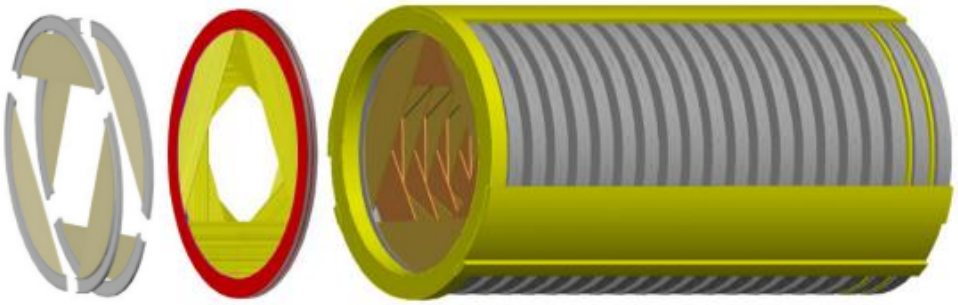
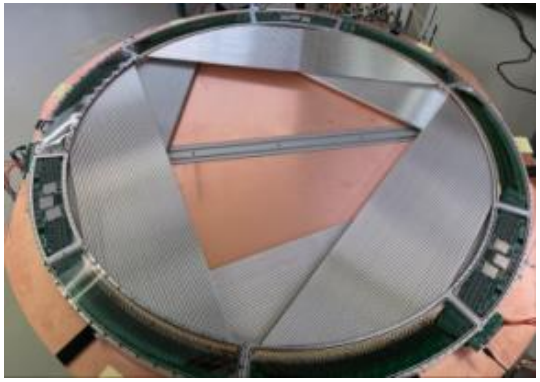
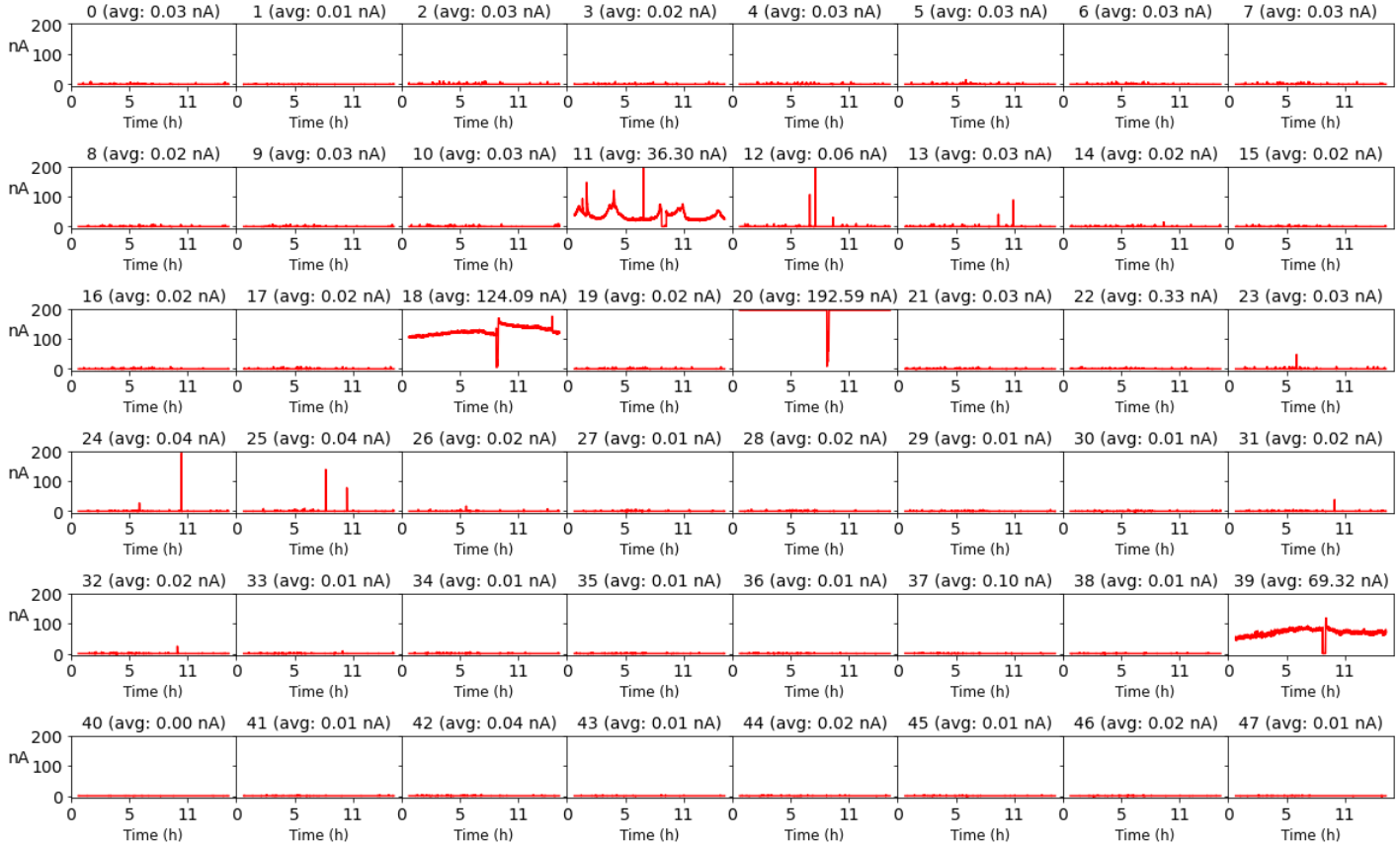




What's the problem?

Higher Voltage ⇒ Higher gain

Measurement with no sources ⇒ No ionization products ⇒ Small current



Fermilab

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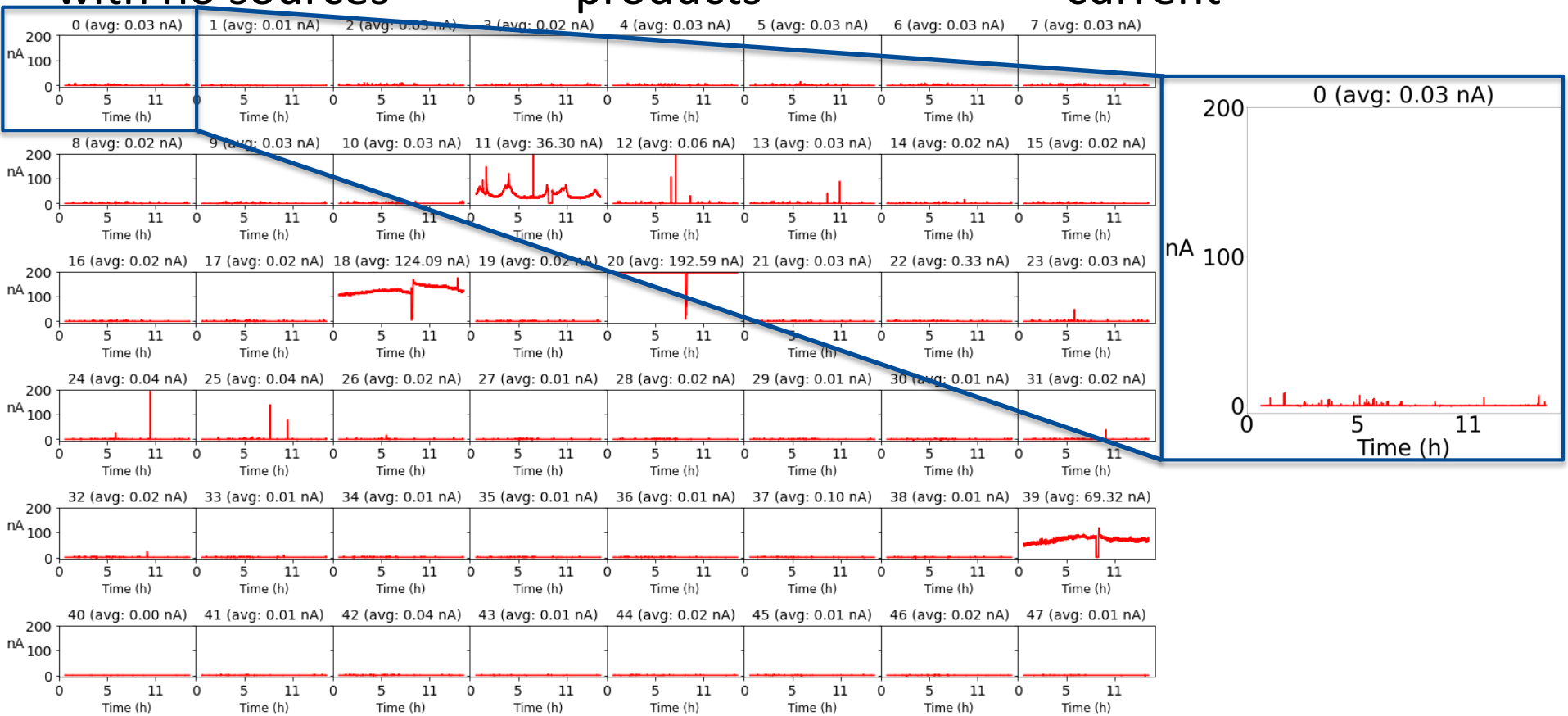

Fermilab

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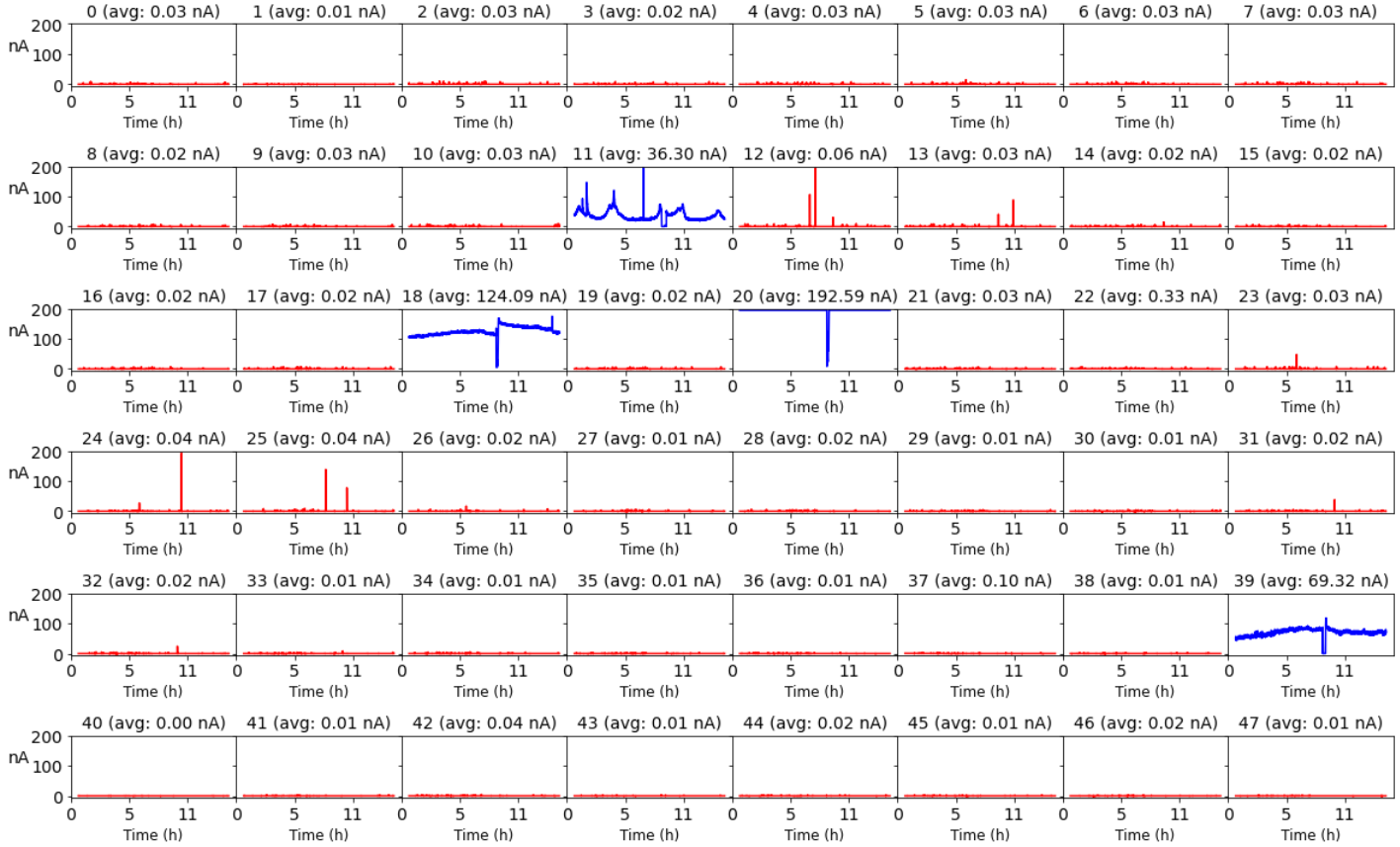

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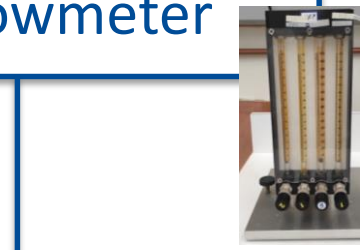
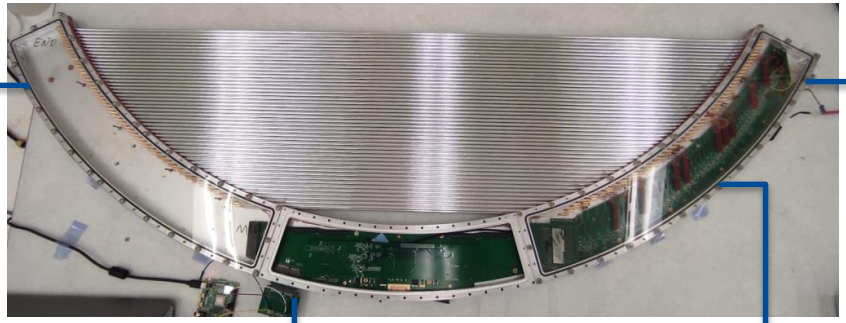
The experimental setup

- Gas flowmeter
- Panel MN084
- Droege HV supplier
- Slow amplifiers
- Raspberry PI

- V = 1450 V
- Pedestal measurement





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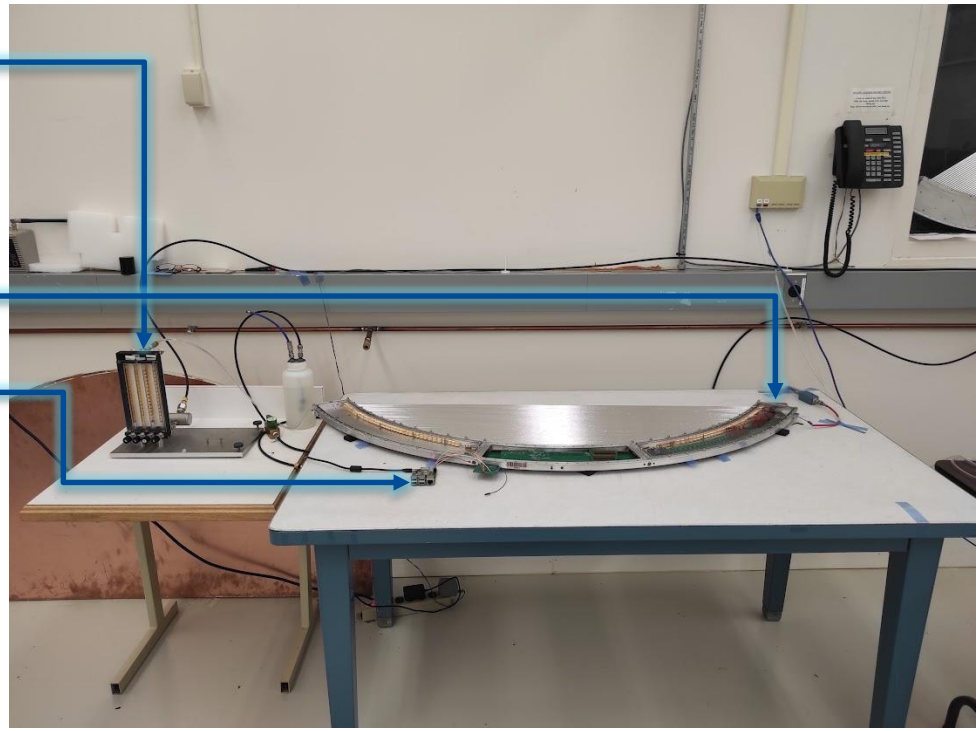
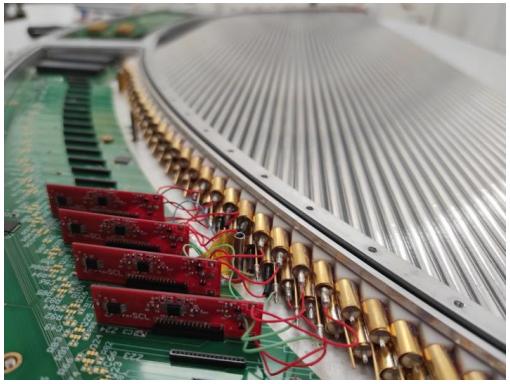
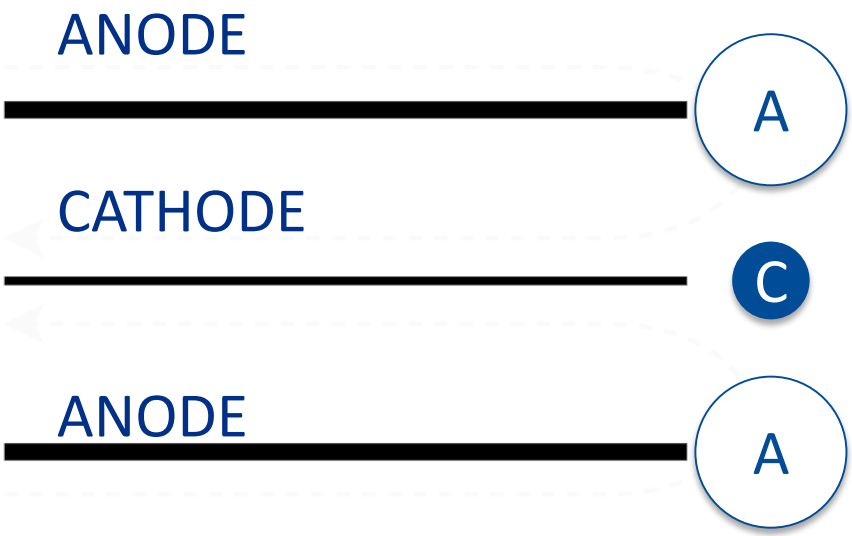


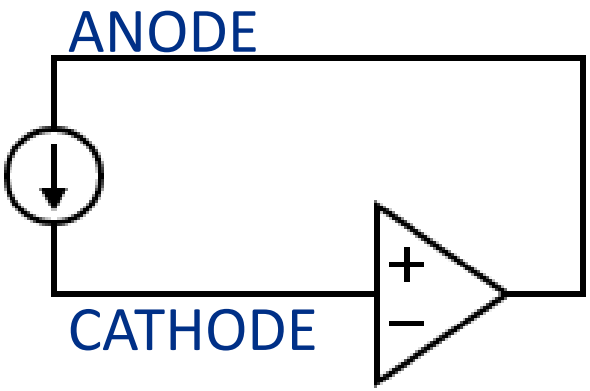
- V = 1450 V
- Pedestal measurement

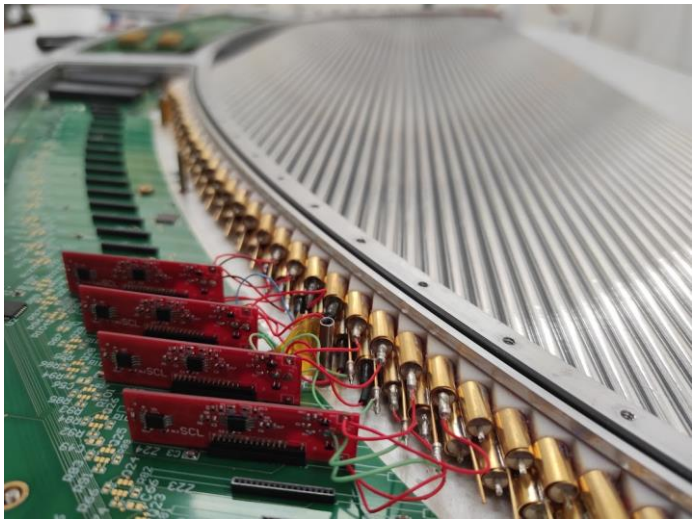


Measuring the current



- Two rows of straws
- Measurement is performed on the cathode at low potential





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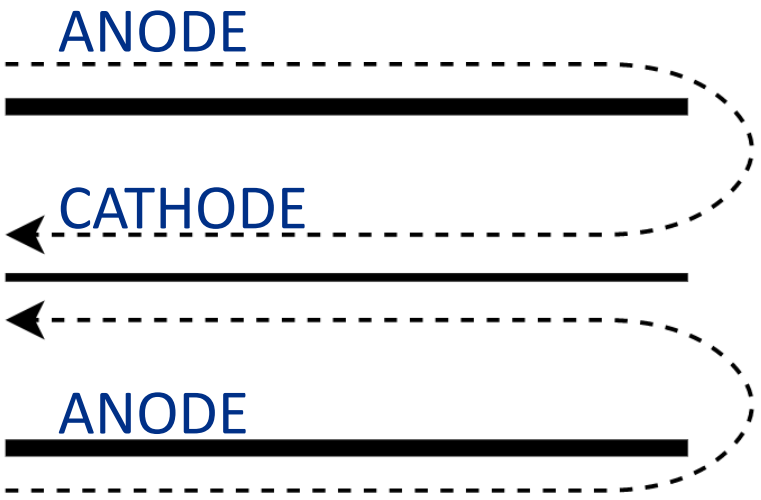

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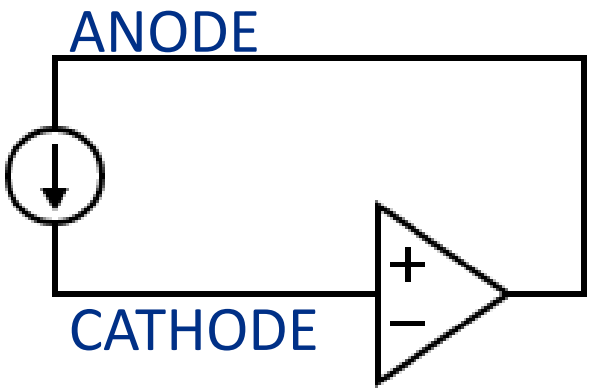
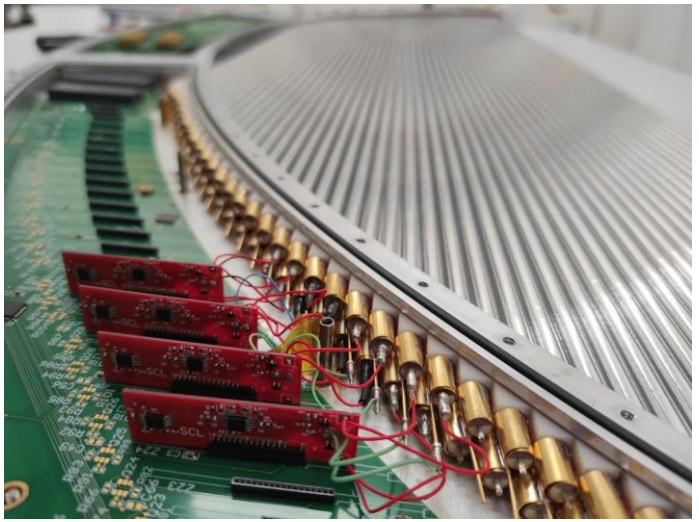
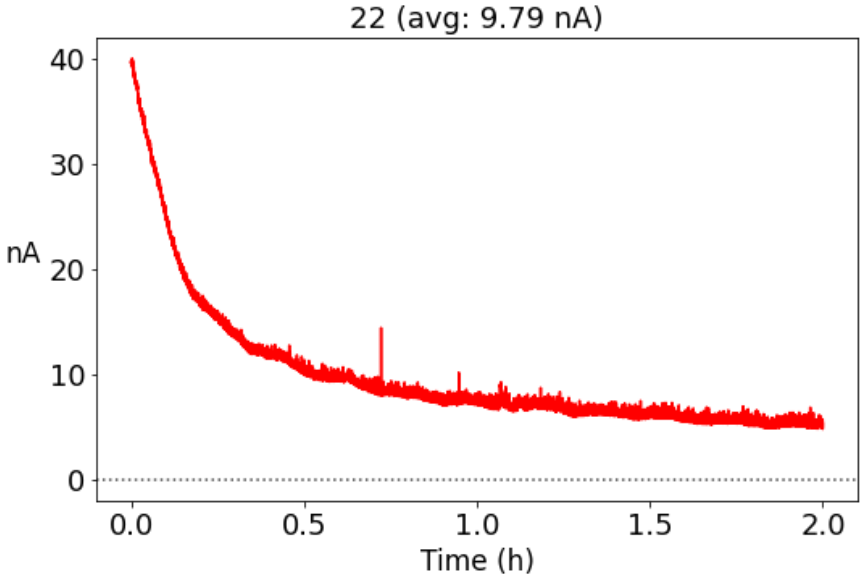
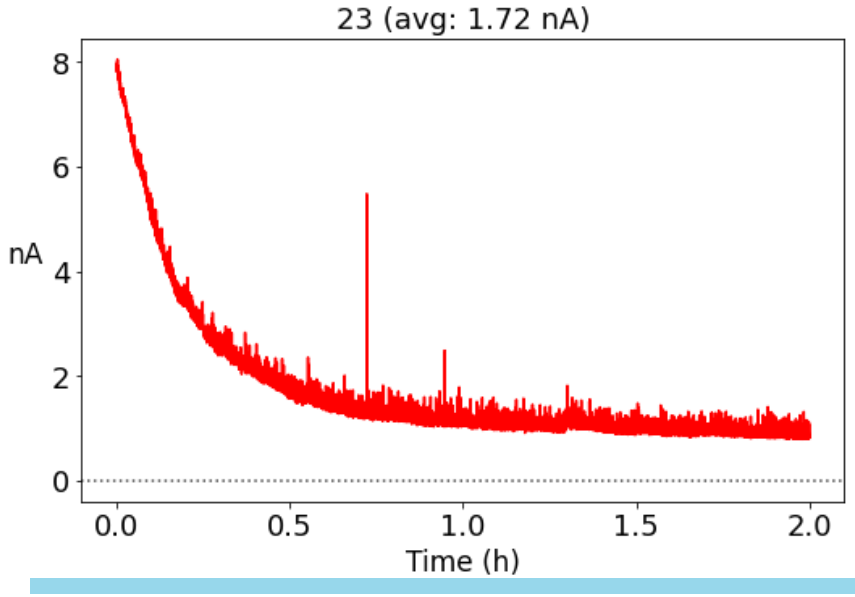




New data



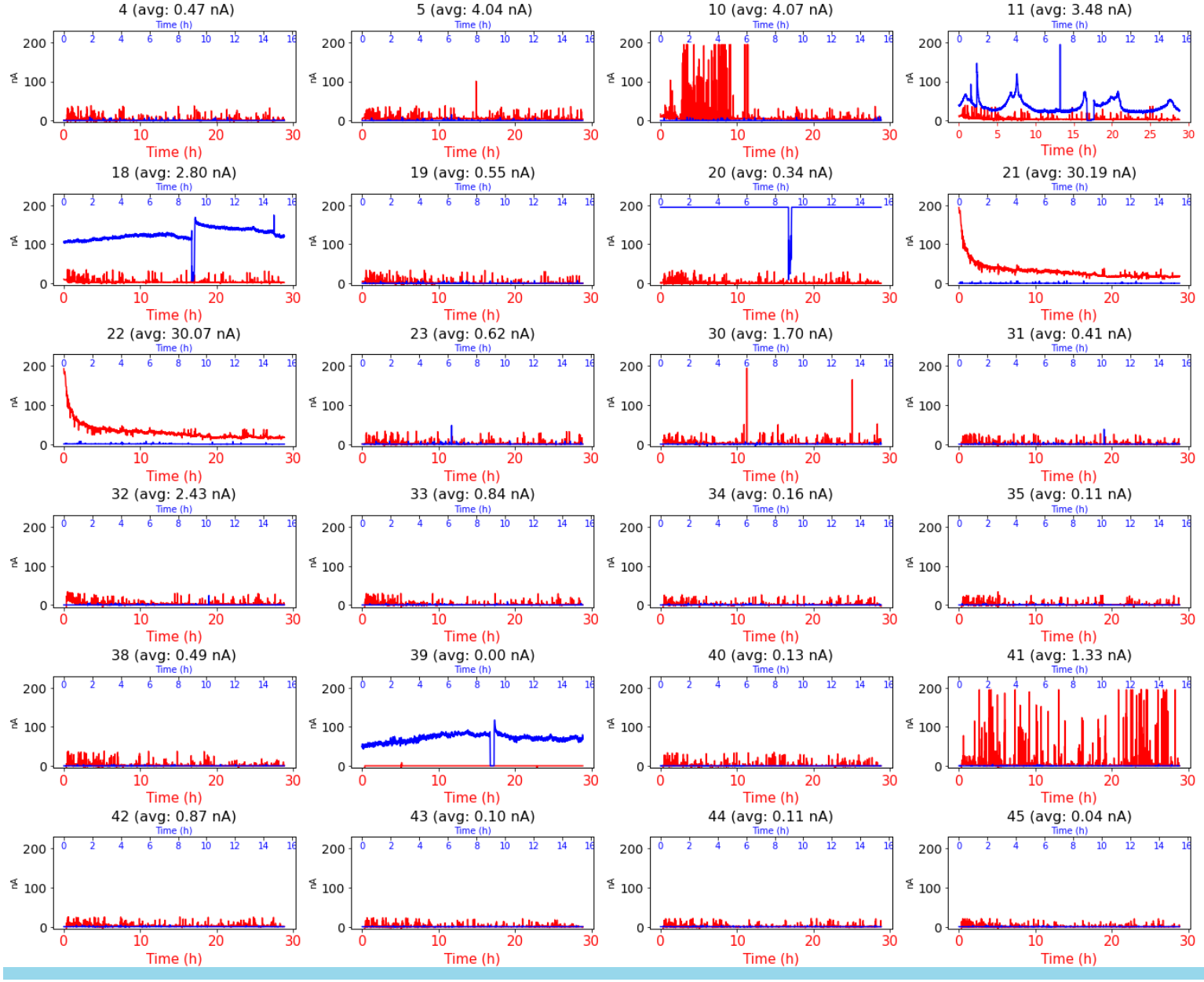


Effect of **conditioning**

The first time HV is applied high currents are measured

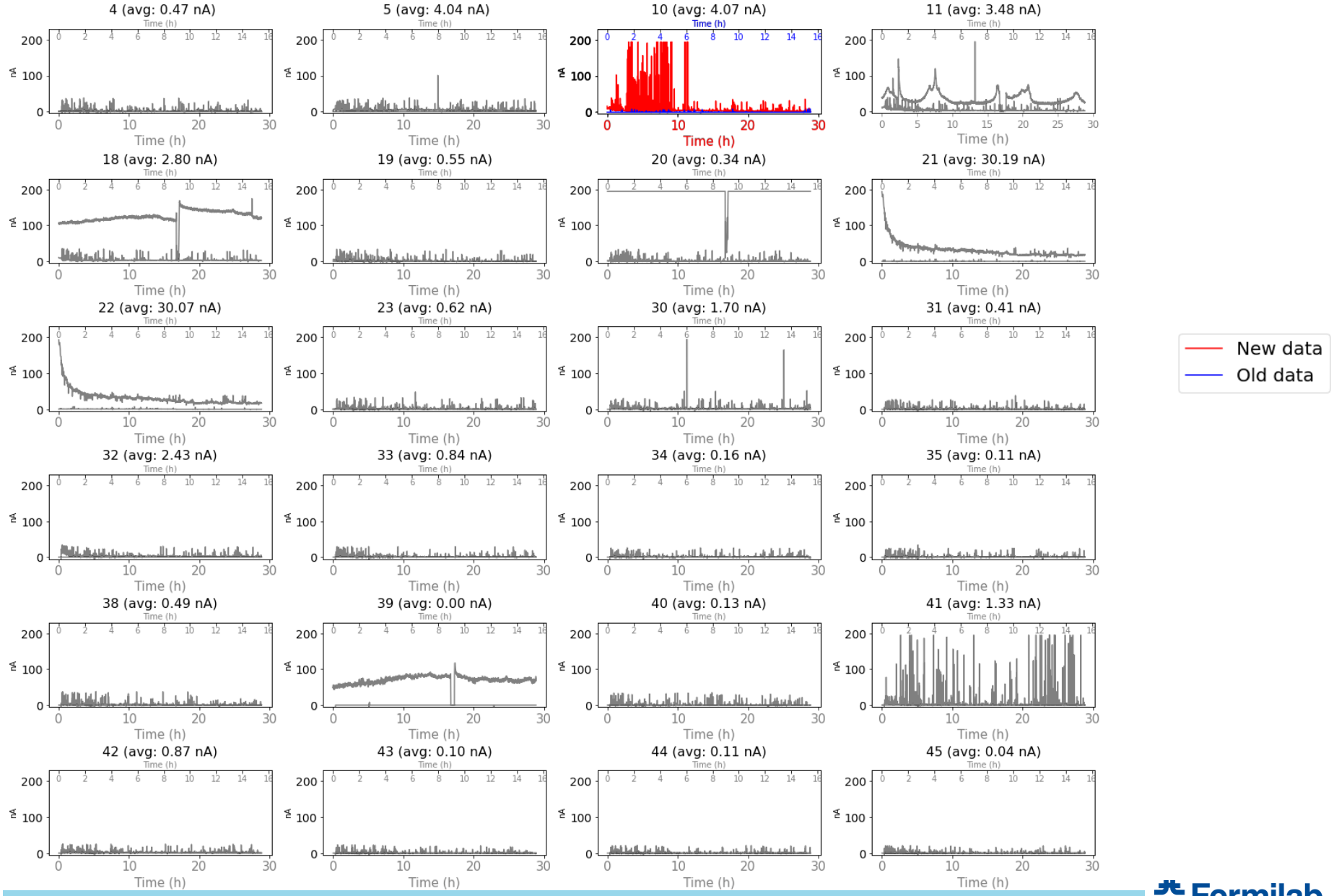
Fermilab

Comparison with old data



Fermilab

Comparison with old data



Fermilab

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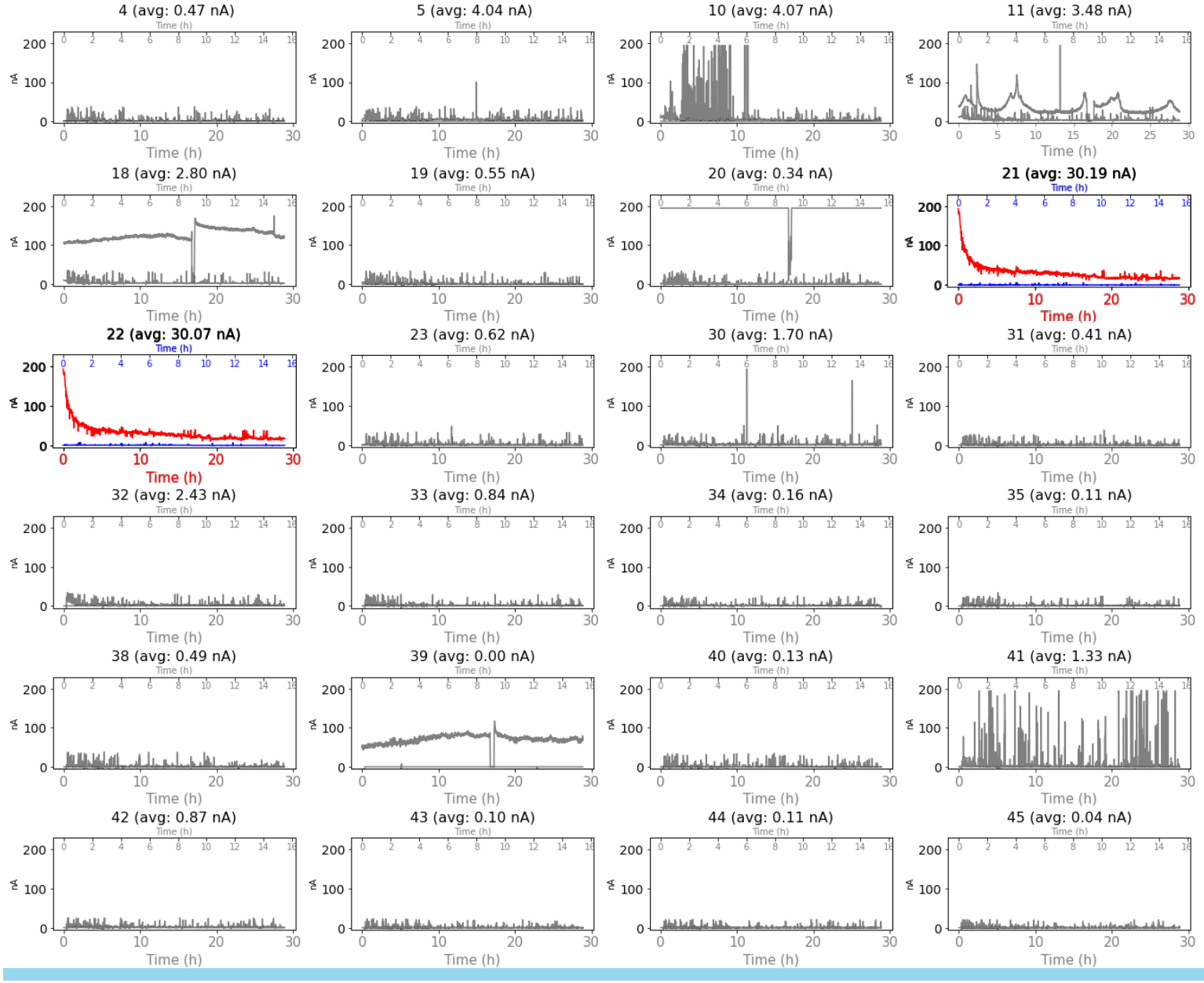
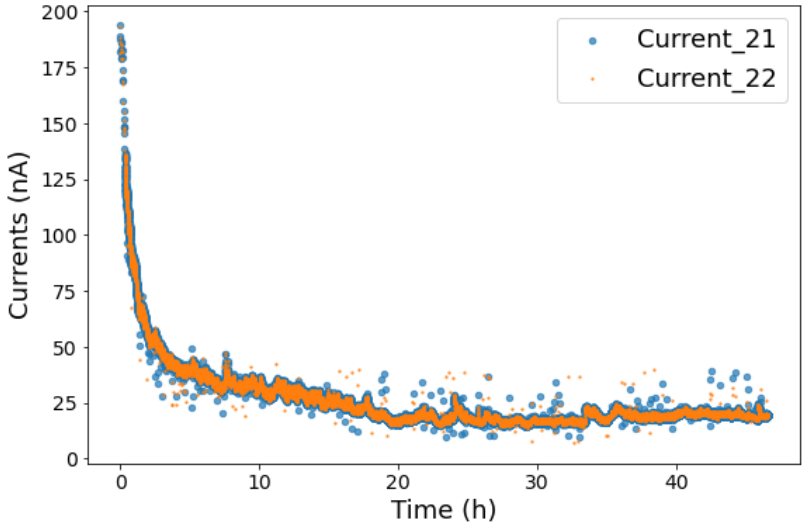
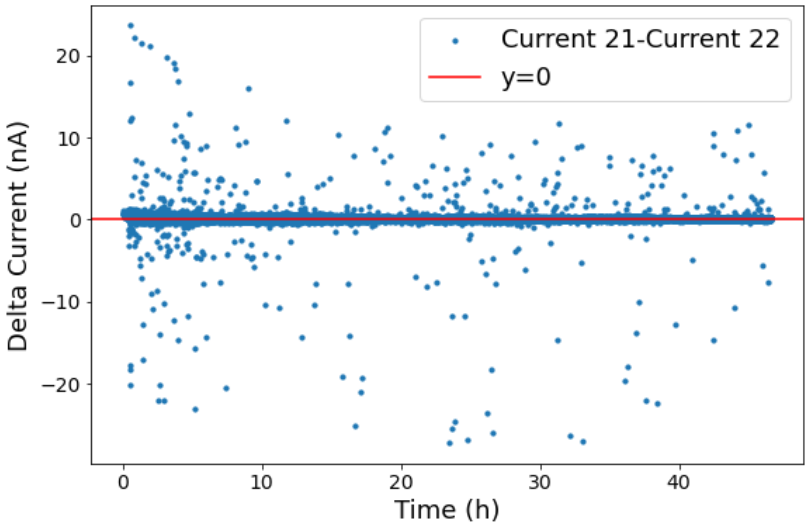


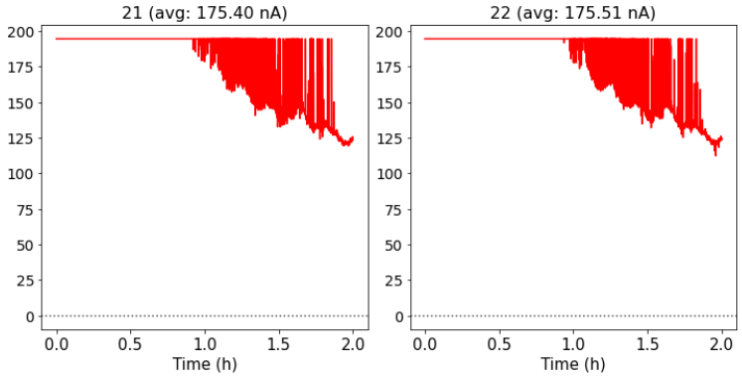
Fermilab

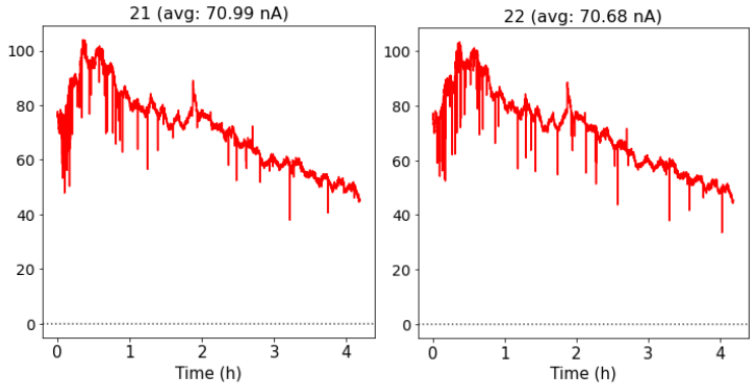
High and identical currents



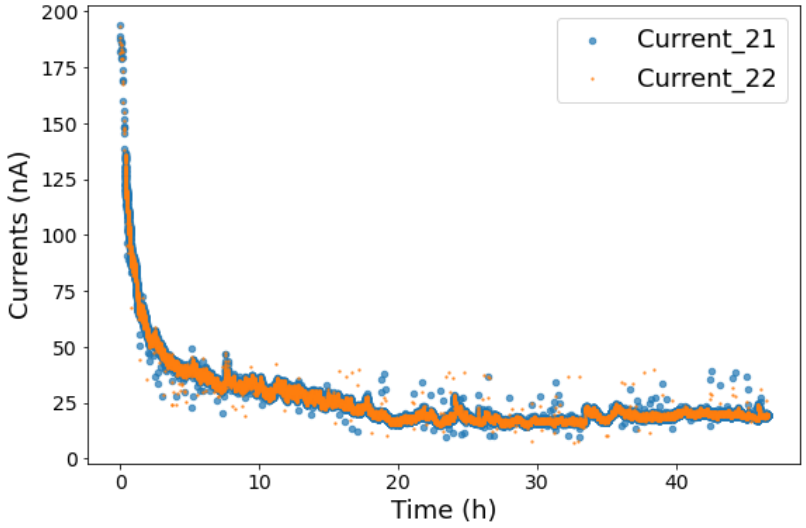


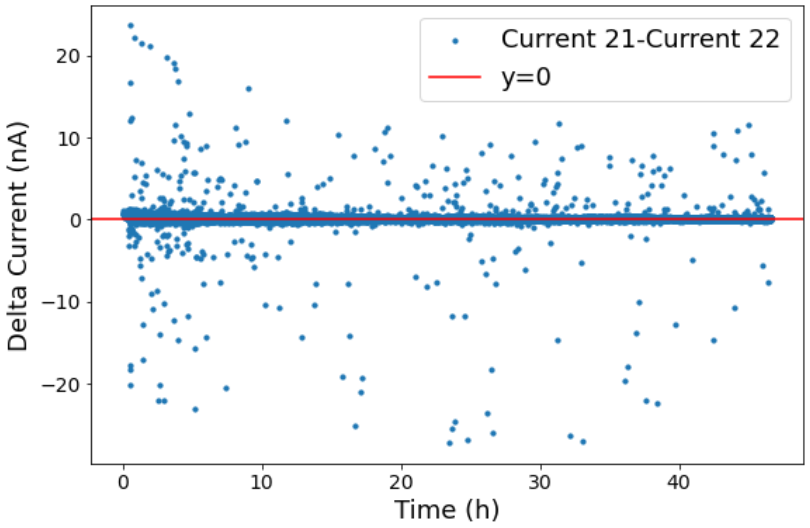
Also in the past measurement





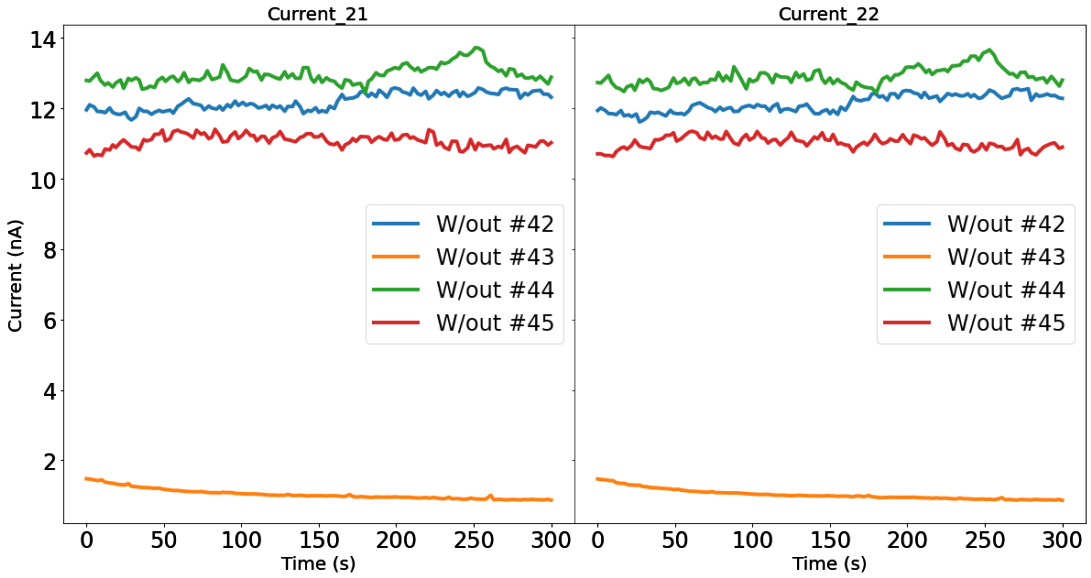
High and identical currents





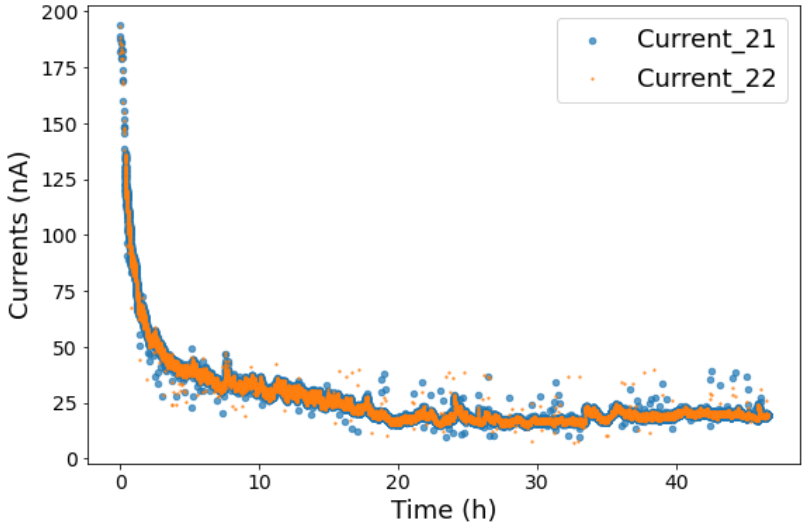
Disconnecting #42, #43, #44, #45 one by one

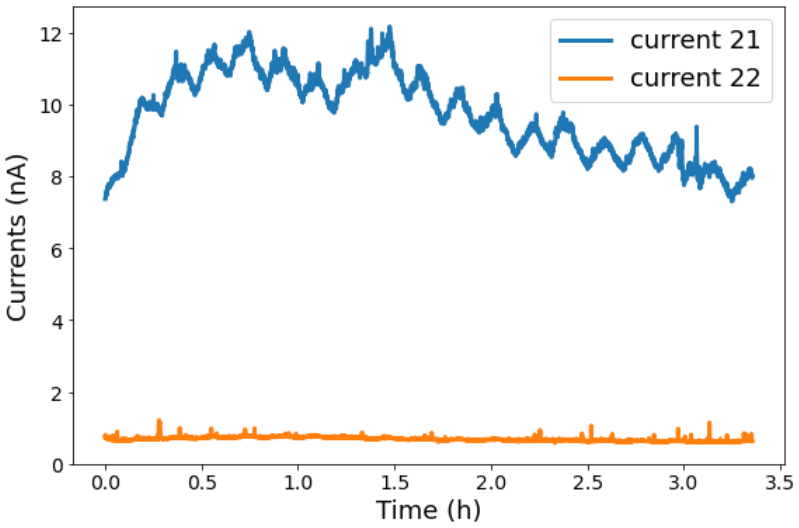
Straw **#43** draw **high current**

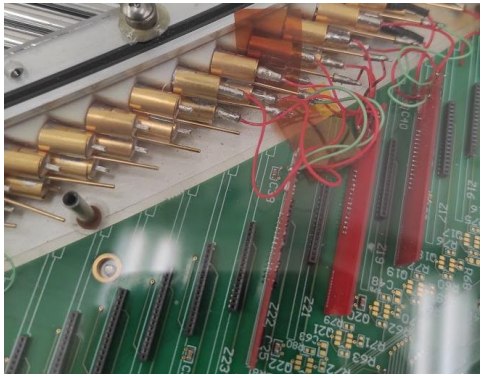


Fermilab

High and identical currents







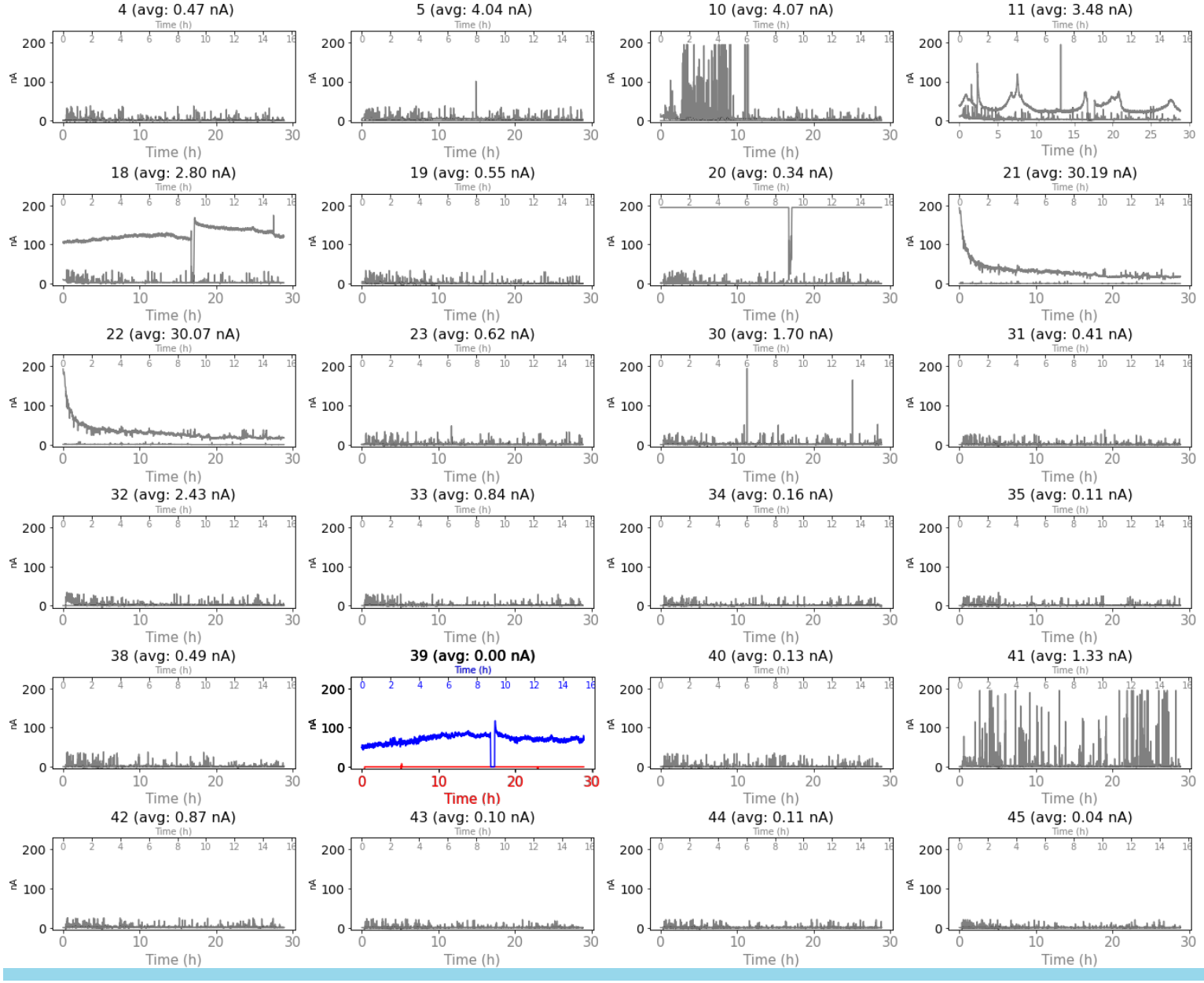
Short and **high current**

Perspectives

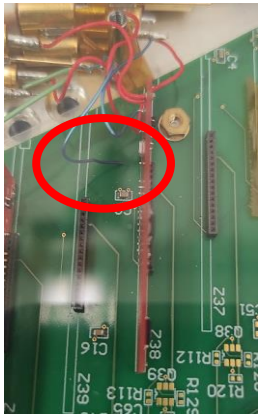
- What happens when air is in the panel? Do we need to wait for a reconditioning time before taking data? How long?
- What happens when HV is shut off? This must be taken into account as well. Again, do we need to wait before taking new data?
- What's the reason of the high current? Can it be reduced? What's the compromise between reducing the high current and preserving high gain?

Thank you for your attention

Comparison with old data



New data
Old data

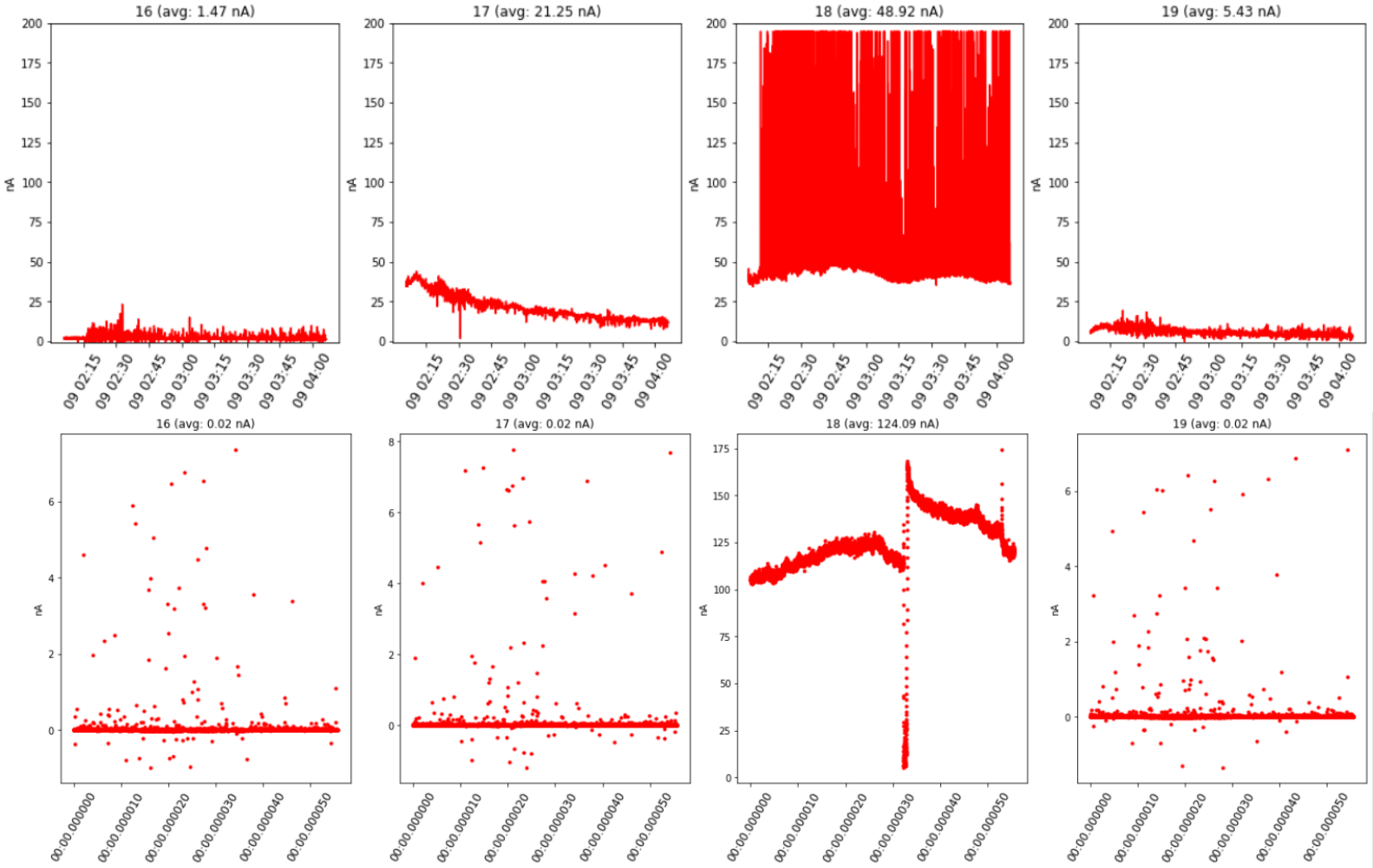


Fermilab

08/15 More measurements

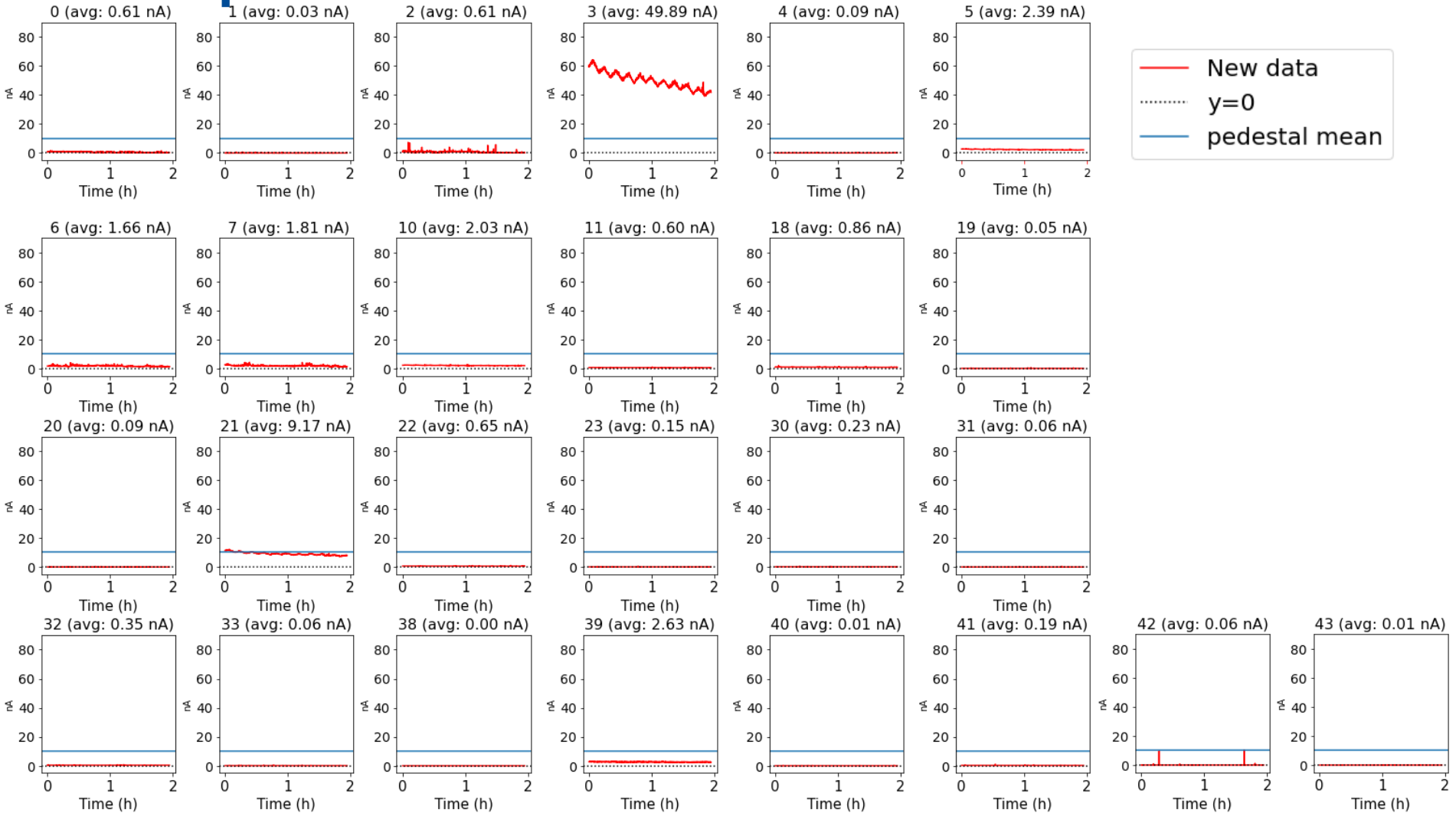
2 cramps Z16, Z18

New data:
2 hours

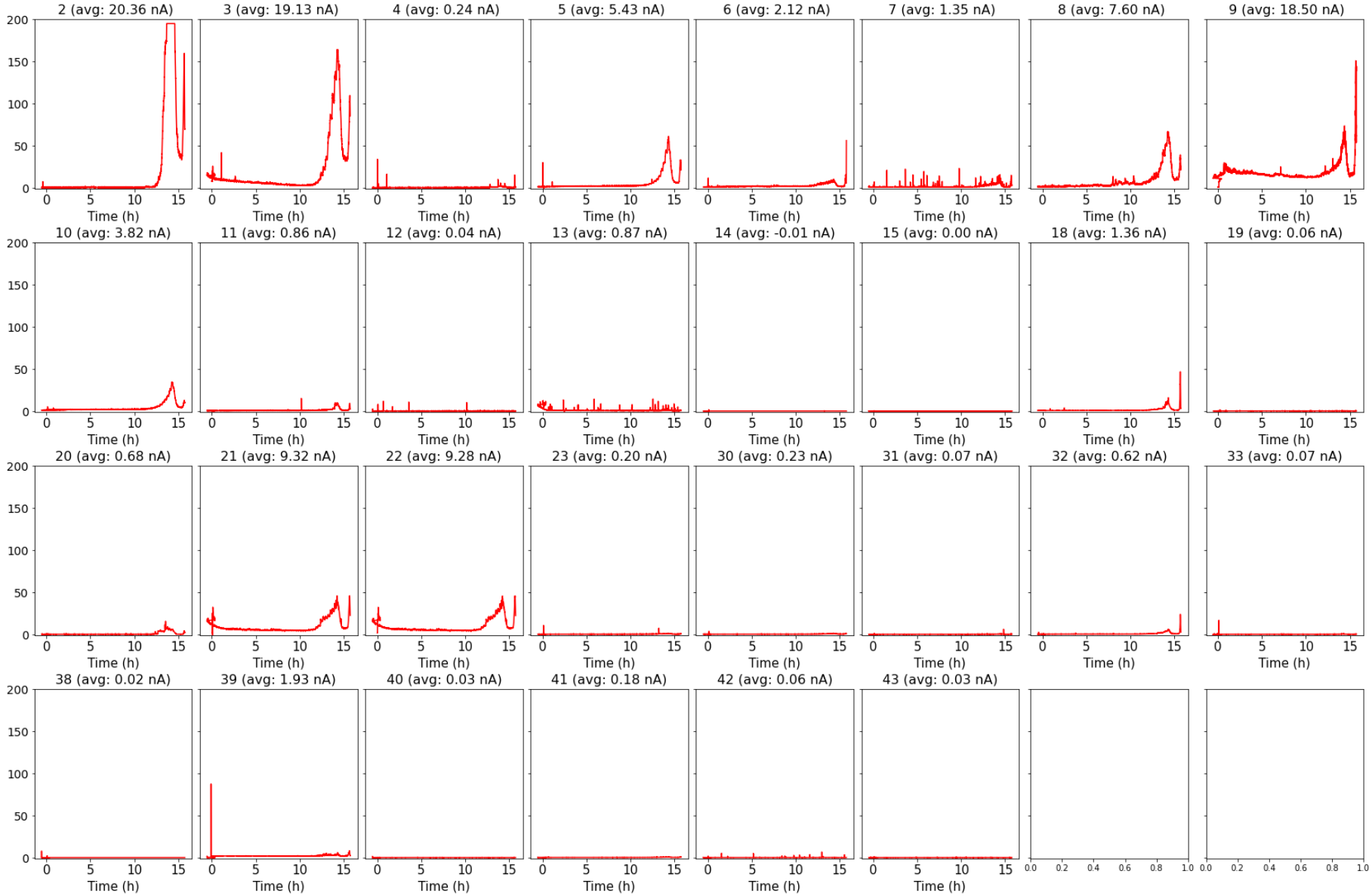


Old data:
24 hours

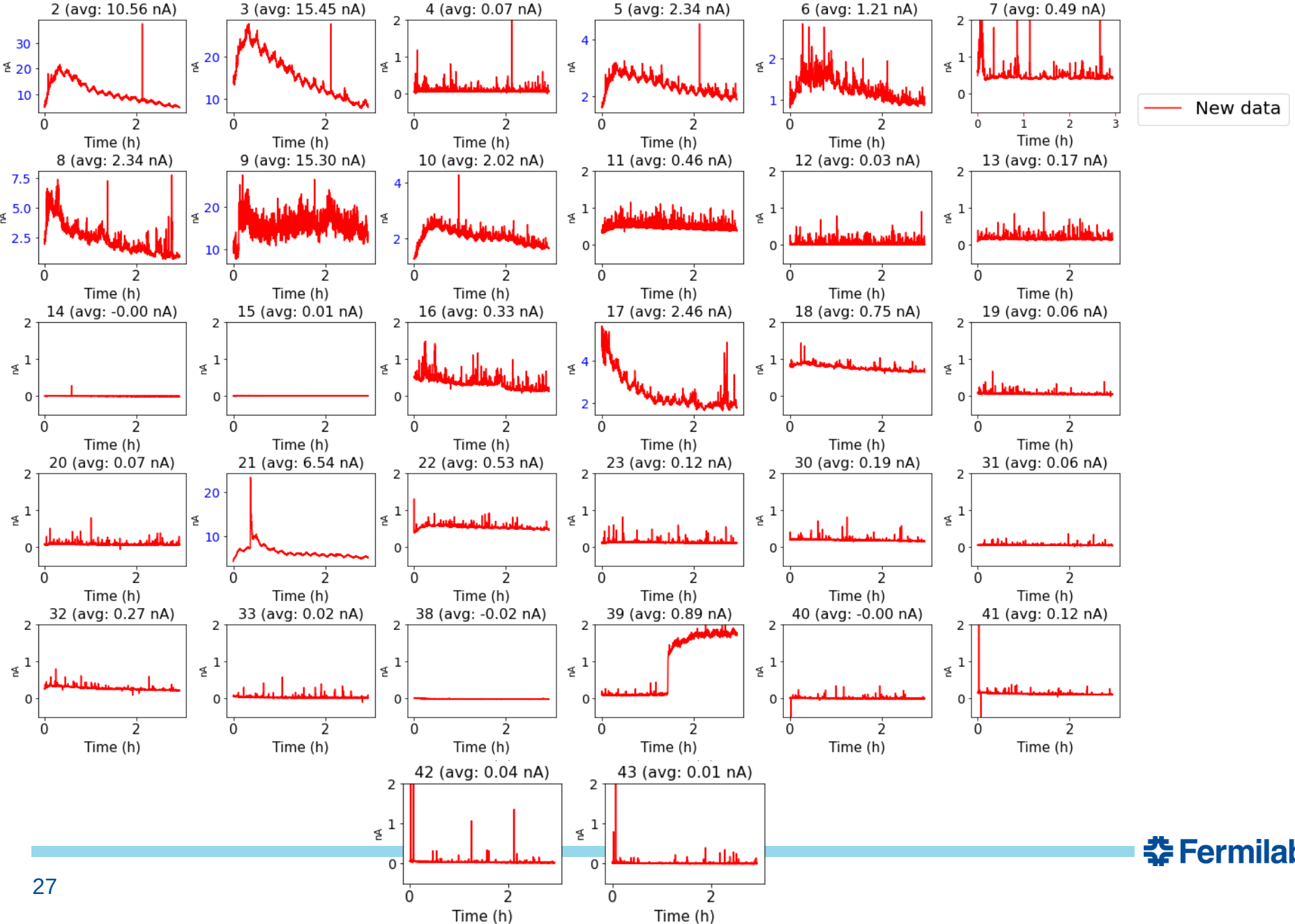
08/23 update


0 (avg: 0.61 nA)
1 (avg: 0.03 nA)
2 (avg: 0.61 nA)
3 (avg: 49.89 nA)
4 (avg: 0.09 nA)
5 (avg: 2.39 nA)
6 (avg: 1.66 nA)
7 (avg: 1.81 nA)
10 (avg: 2.03 nA)
11 (avg: 0.60 nA)
18 (avg: 0.86 nA)
19 (avg: 0.05 nA)
20 (avg: 0.09 nA)
21 (avg: 9.17 nA)
22 (avg: 0.65 nA)
23 (avg: 0.15 nA)
30 (avg: 0.23 nA)
31 (avg: 0.06 nA)
32 (avg: 0.35 nA)
33 (avg: 0.06 nA)
38 (avg: 0.00 nA)
39 (avg: 2.63 nA)
40 (avg: 0.01 nA)
41 (avg: 0.19 nA)
42 (avg: 0.06 nA)
43 (avg: 0.01 nA)
nA
Time (h)
New data
y=0
pedestal mean

08/24 update: run out of gas

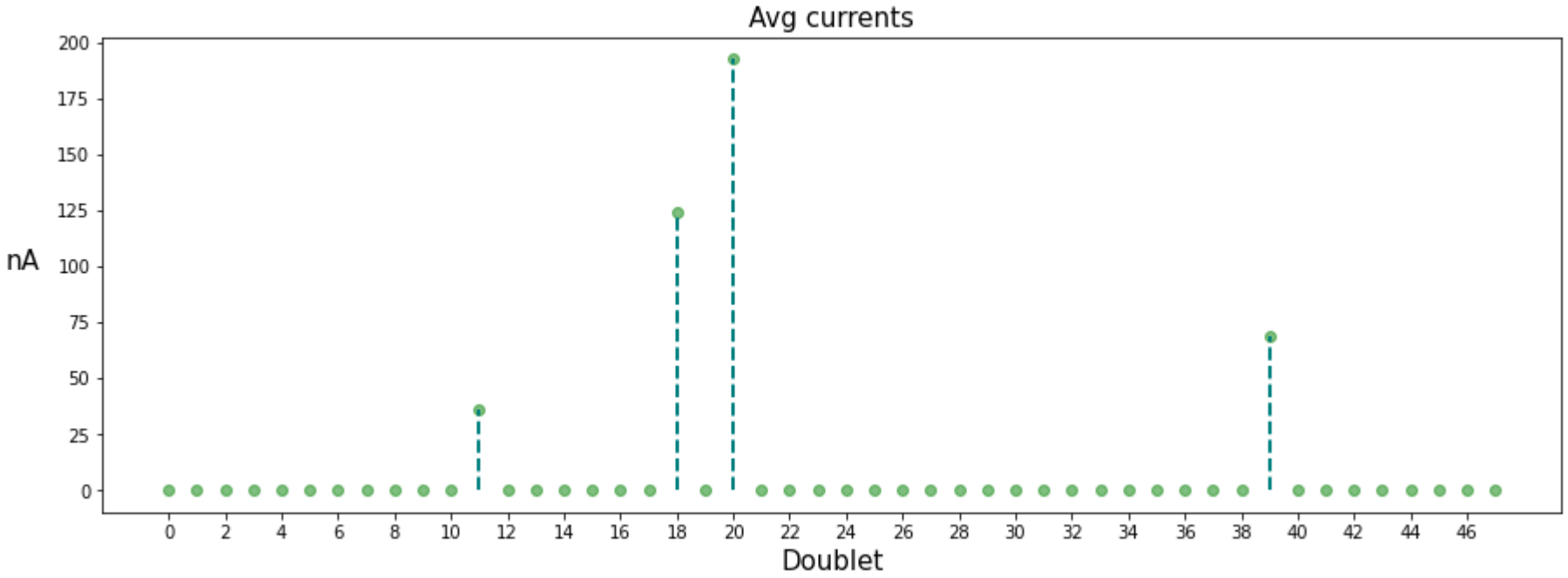


Gas refilled



Fermilab

Full dataset of panel MN084

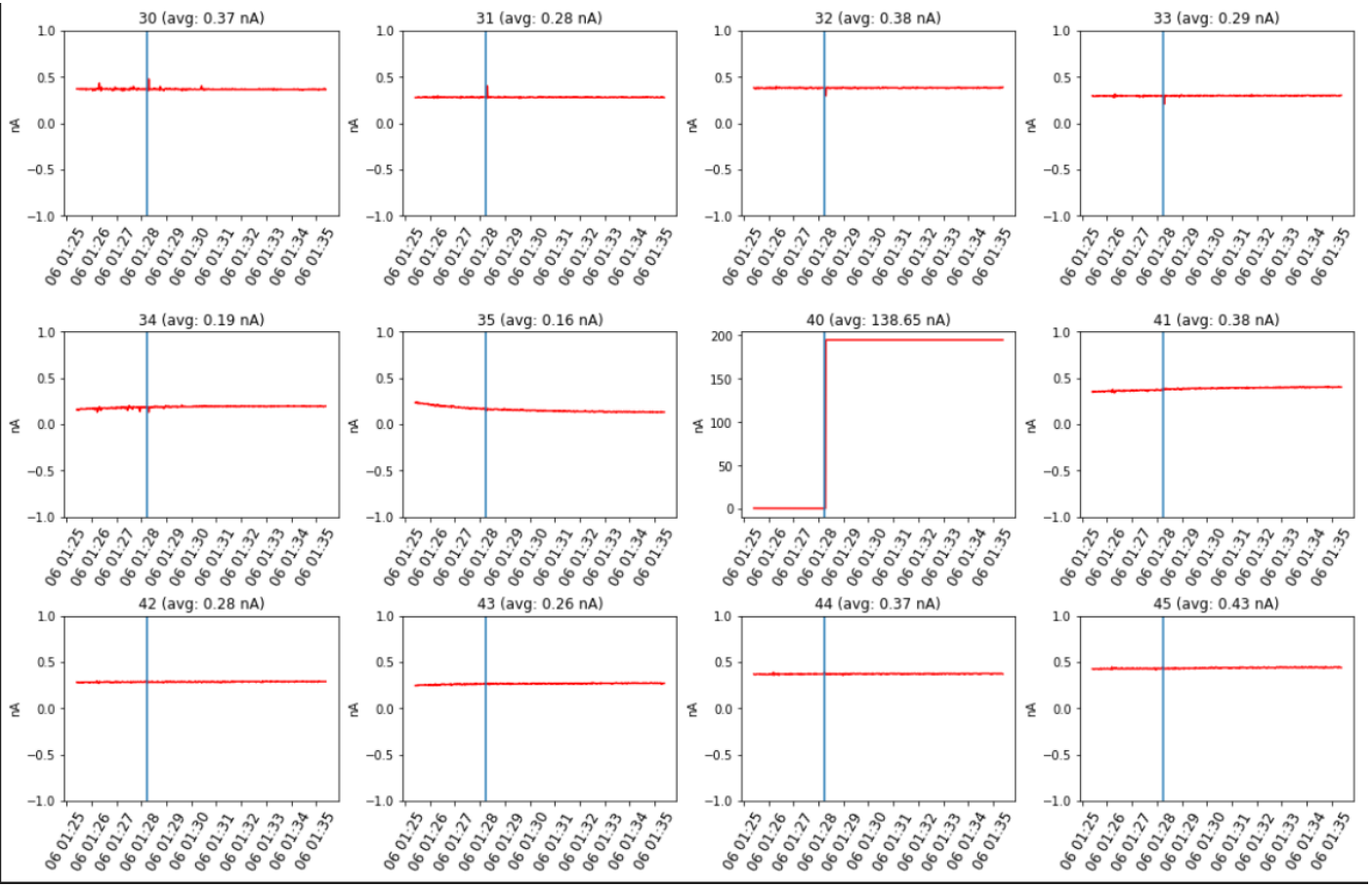


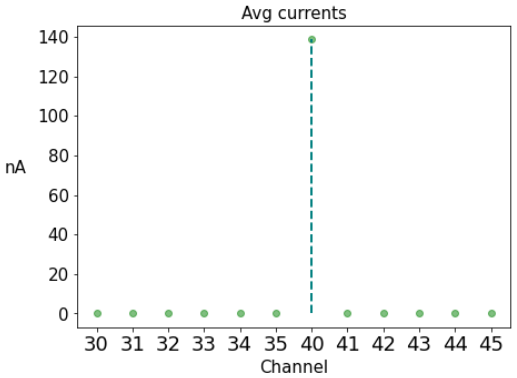
08/12 Pedestal measurement

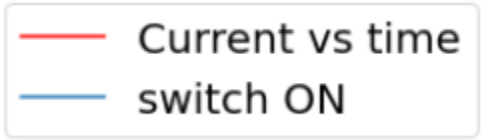
6 S.A. connected Z30, Z32, Z34, Z40, Z42, Z44

Panel MN084 **Nominal Voltage=5 V**

- 3 min of measurements with the switch off (few mV)
- 7min of measurements with the switch ON but the voltage set to the minimum (5 Volts)







08/12 Pedestal measurement

- The problem is not in the slow amplifier. Moving the same slow amplifier to another slot it works. Using different slow amplifiers in Z40 they have the same issue.

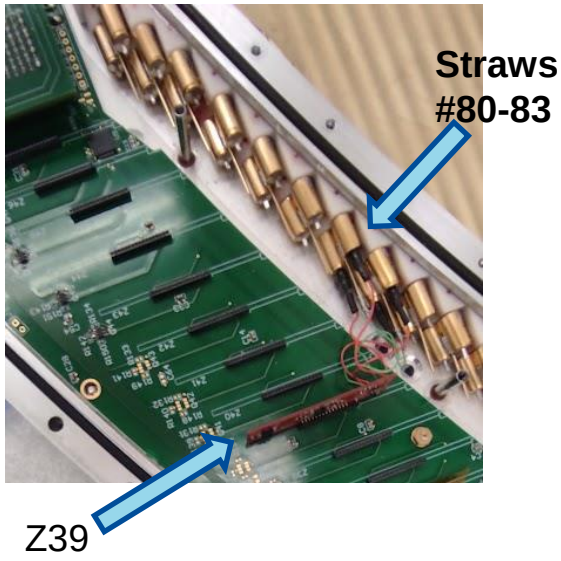
```
---z32 (61)---
current 1 (nA) = 10.306
current 2 (nA) = 10.350

---z34 (61)---
current 1 (nA) = 10.156
current 2 (nA) = 10.200

---z40 (61)---
current 1 (nA) = 204.794
current 2 (nA) = 10.281

---z42 (61)---
current 1 (nA) = 10.181
current 2 (nA) = 10.169

---z44 (61)---
current 1 (nA) = 10.363
current 2 (nA) = 10.425
```

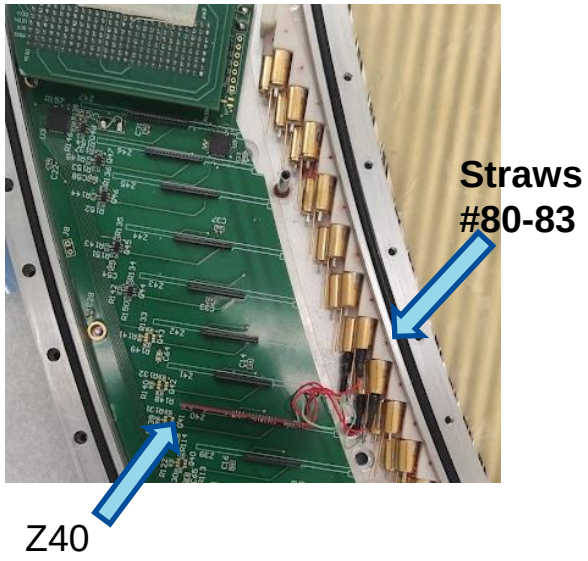
```
---z30 (72)---
current 1 (nA) = 10.438
current 2 (nA) = 10.269

---z32 (72)---
current 1 (nA) = 10.331
current 2 (nA) = 10.344

---z34 (72)---
current 1 (nA) = 10.069
current 2 (nA) = 10.350

---z42 (72)---
current 1 (nA) = 10.188
current 2 (nA) = 10.181

---z44 (72)---
current 1 (nA) = 10.375
current 2 (nA) = 10.419
```

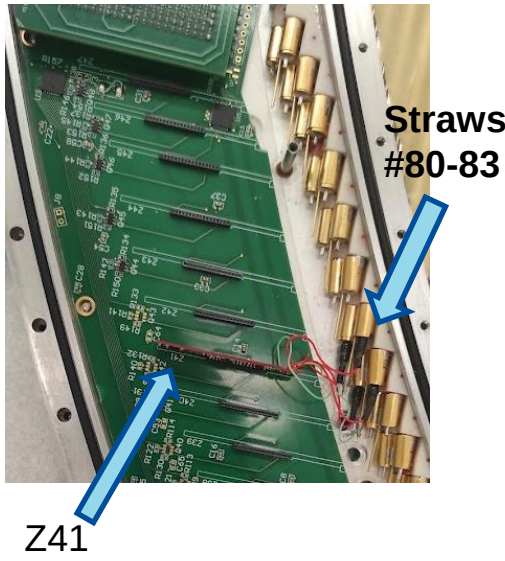
08/12 Pedestal measurement

- The problem is not in the slow amplifier. Moving the same slow amplifier to another slot it works. Using different slow amplifiers in Z40 they have the same issue.

- Placing the same cramp on Z39, Z40, Z41 connected to the same **straws #80-83** saturates in current







08/12 Pedestal measurement

- The problem is not in the slow amplifier. Moving the same slow amplifier to another slot it works. Using different slow amplifiers in Z40 they have the same issue.

- Placing the same S.A. on Z39, Z40, Z41 connected to the same **straw #80** saturates in current

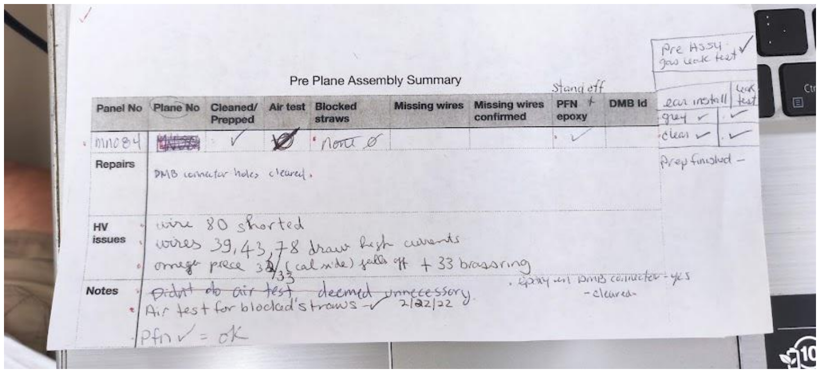
- The problem is not in Z40, it seems to be in the straw

- We checked **connectivity** in the straw with the multimeter and that was good (same values of all the other straws)

- We checked **contact** between the anode and the ground and the same behaviour was found in the other straws

08/15 Short in straw 80 of panel MN084

- Pigtail caused the **short** on wire **#80** in panel MN084



Pre Plane Assembly Summary

Panel No	Plane No	Cleaned/ Prepped	Air test	Blocked straws	Missing wires	Missing wires confirmed	Stand off + PFN epoxy	DMB Id
MN084	[illegible]	✓	∅	None ∅			✓	

Repairs: DMB connector holes cleared.

HV issues:
- wire 80 shorted
- wires 39, 43, 78 draw high currents
- omega piece 33/33 (cal side) falls off + 33 brassring

Notes:
- ~~Didn't do air test~~ deemed unnecessary
- Air test for blocked straws ✓ 2/22/22
- Pfn ✓ = ok
- epoxy on DMB connector - yes - cleared

Pre Assy gas leak test ✓

ear install	leak test
grey ✓	✓
clear ✓	✓

Prep finished –