Latest experiences and first test beam results using VMM3a/SRS

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CERN, University of Bonn

RD51 Collaboration Meeting

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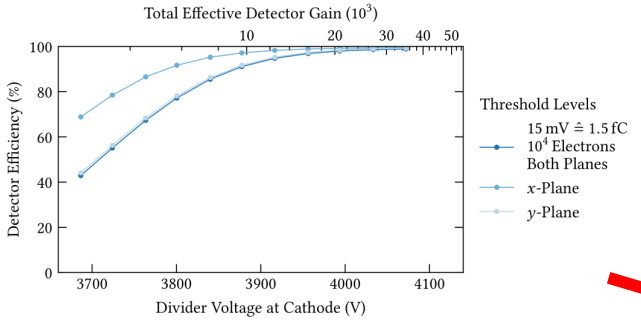
Outline

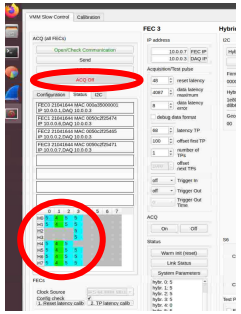
Objectives and experimental set-up

Past issues and found solutions

First preliminary results



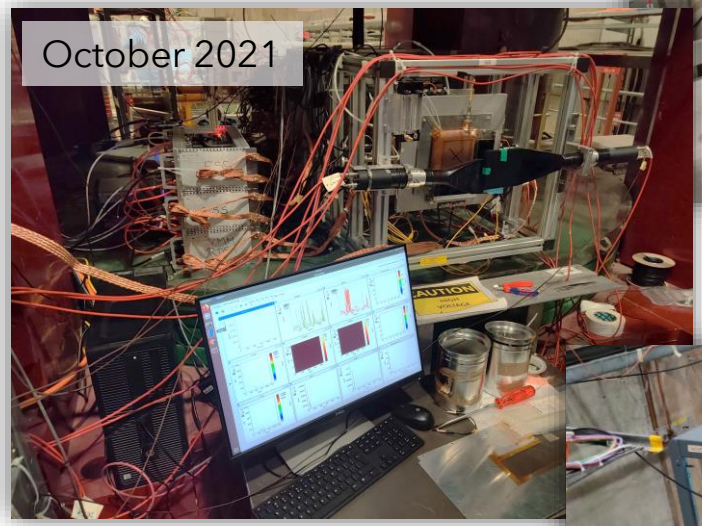
Issues to be still solved

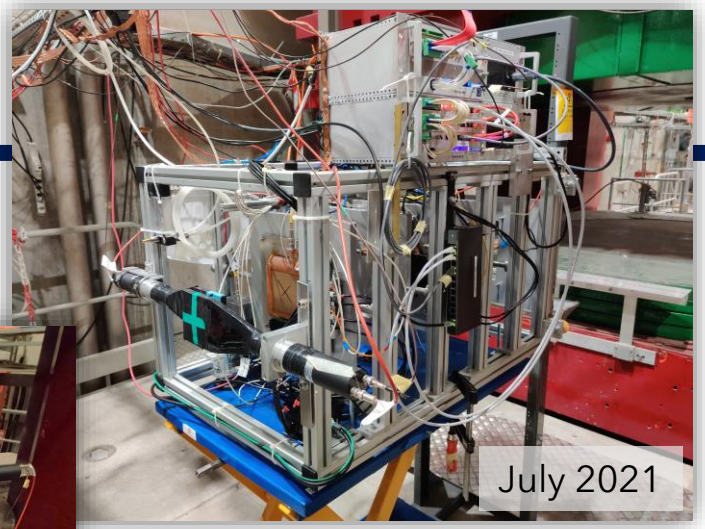


Main objectives

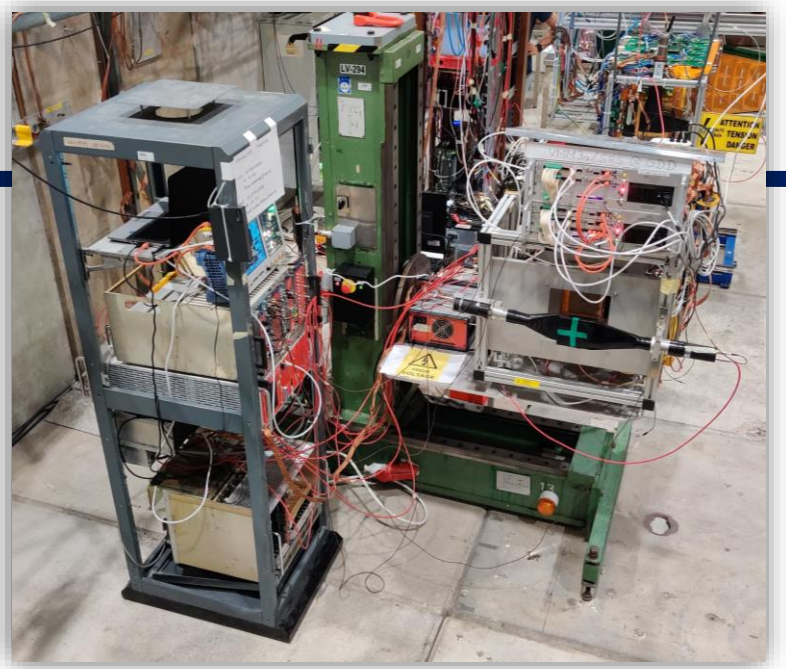
- Optimisation of VMM3a/SRS for larger-scale (multi-detector/multi-FEC) systems by using it in the RD51 GEM beam telescope
- Three test beam campaigns so far

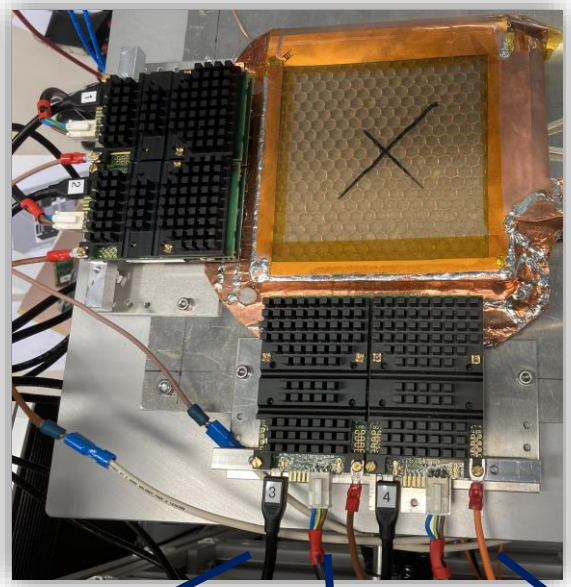
- Validate improvements implemented since the previous test beam
- Find parts that still require improvement
- At the same time: profit from VMM3a/SRS capabilities
  - Detector tests
  - Beam monitoring/beam quality

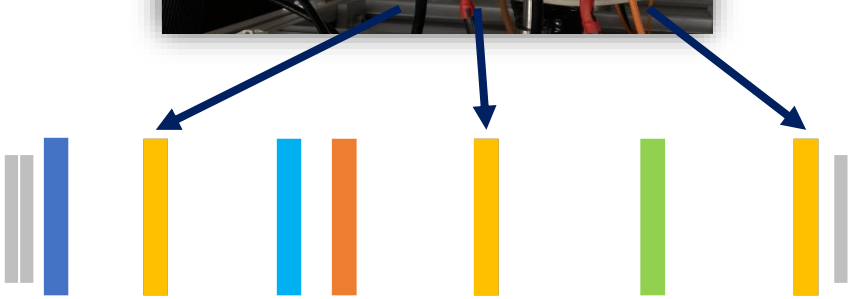




Experimental set-up (May 2022)







Beam telescope **(1536 + 128 channels)**:

- 3 COMPASS-like triple-GEM detectors (10 x 10 cm²)
- x-y-strip read-out (256 + 256 strips)
- 1 scintillator adapter

Detectors under test **(1536 channels)**:

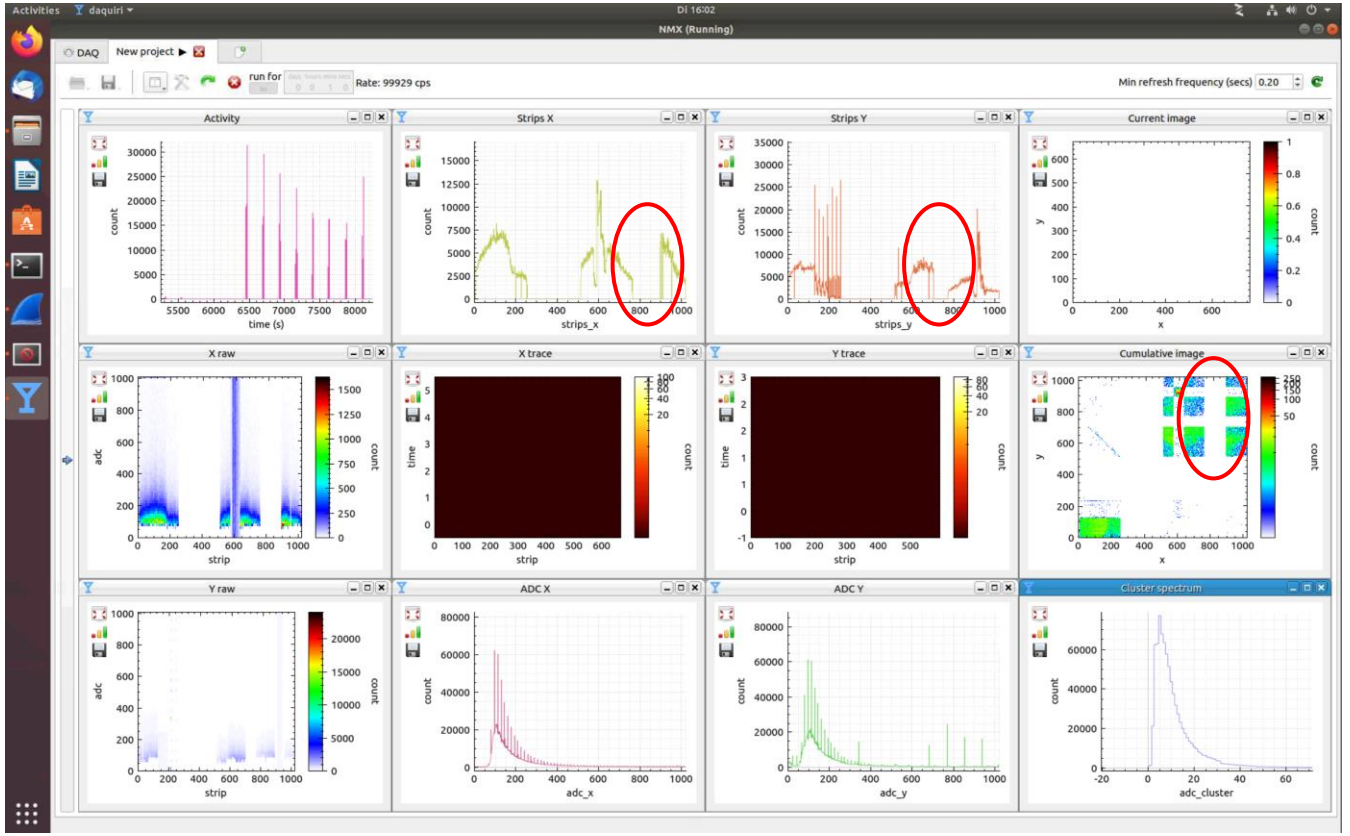
- 1 COMPASS-like triple-GEM detector (reference)
- 1 small-pitch triple-GEM detector
- 1 resistive thin-mesh MicroMegas
- 1 XYU triple-GEM detector (in exchange for small-pitch and MM)

VMM3a/SRS:

- 25 hybrids
- 4 FECs + DVMMs
- 1 CTF
- 2 PowerCrate 2k
- **3200 channels**

Validation of improvement 1:
Synchronisation and instable "ACQ on"

- After acquisition start, some hybrids are not sending data
- Restart acquisition
  - Some other hybrid is not sending any data
  - Random swapping
- **Appears only in multi-FEC systems, only when CTF is used and FECs have to be synchronised**
- Suspicion: CTF clock quality



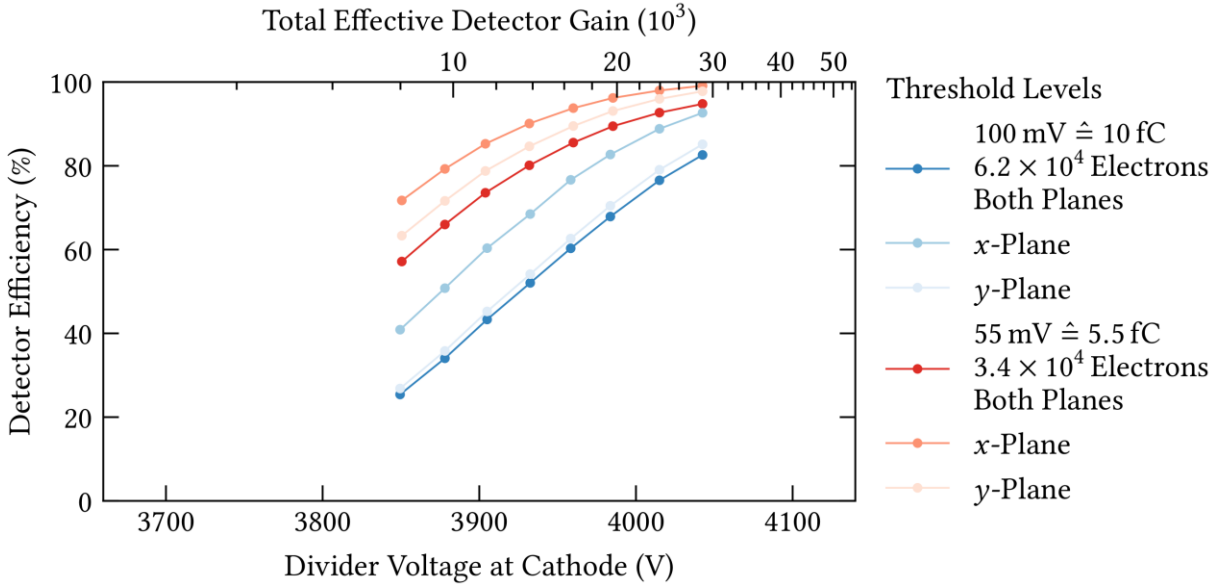
Solution: different firmware commit

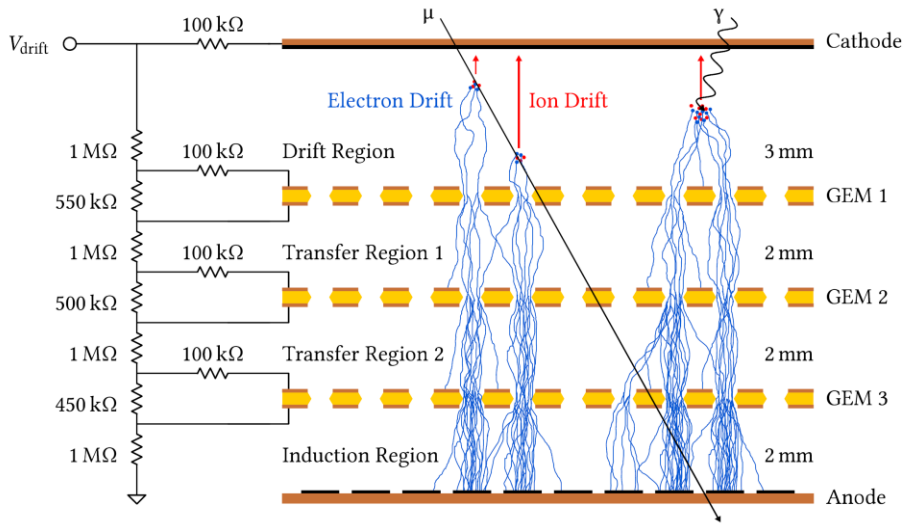
⇒ A single commit of the ESS firmware for the SRS works. Once this commit is modified, the system becomes again more unstable.

⇒ No idea how the solution works (what is different in this commit), but it works…

Validation of improvement 2:
Noise, high threshold and inefficiencies

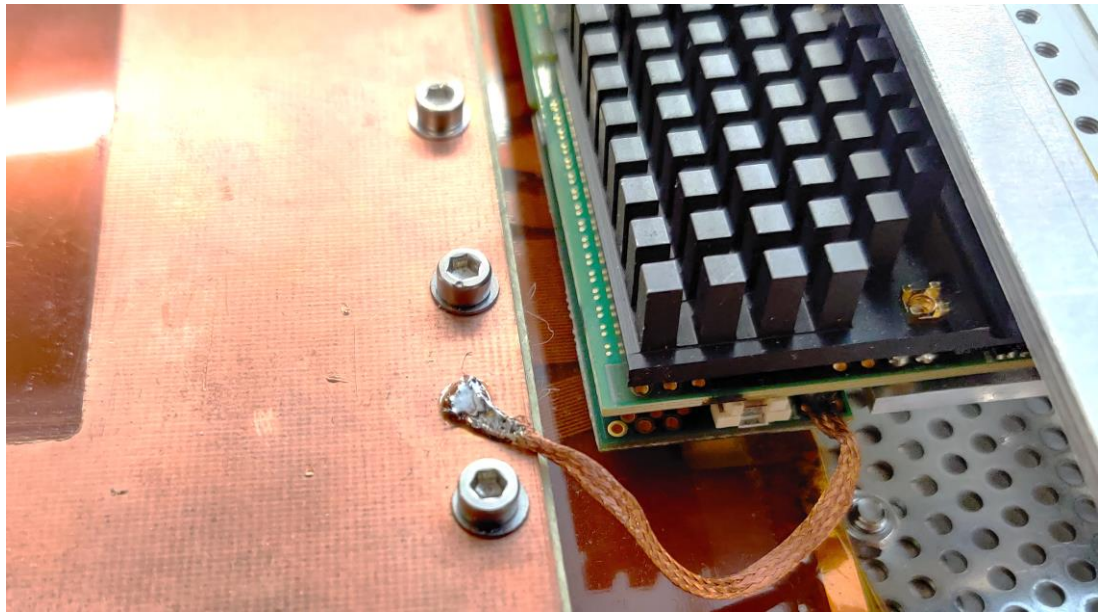
- VMM3a/SRS: self-triggered read-out with trigger @ threshold level
  - Everything that goes above THL will be processed by the VMMs' channels
  - If the THL is too low, noise will dominate the data processing
- During October 2021 beam:
  - THL of ~55 mV above baseline (~5.5 fC or 34 000 electrons per channel)
- Inefficient even at high detector gains

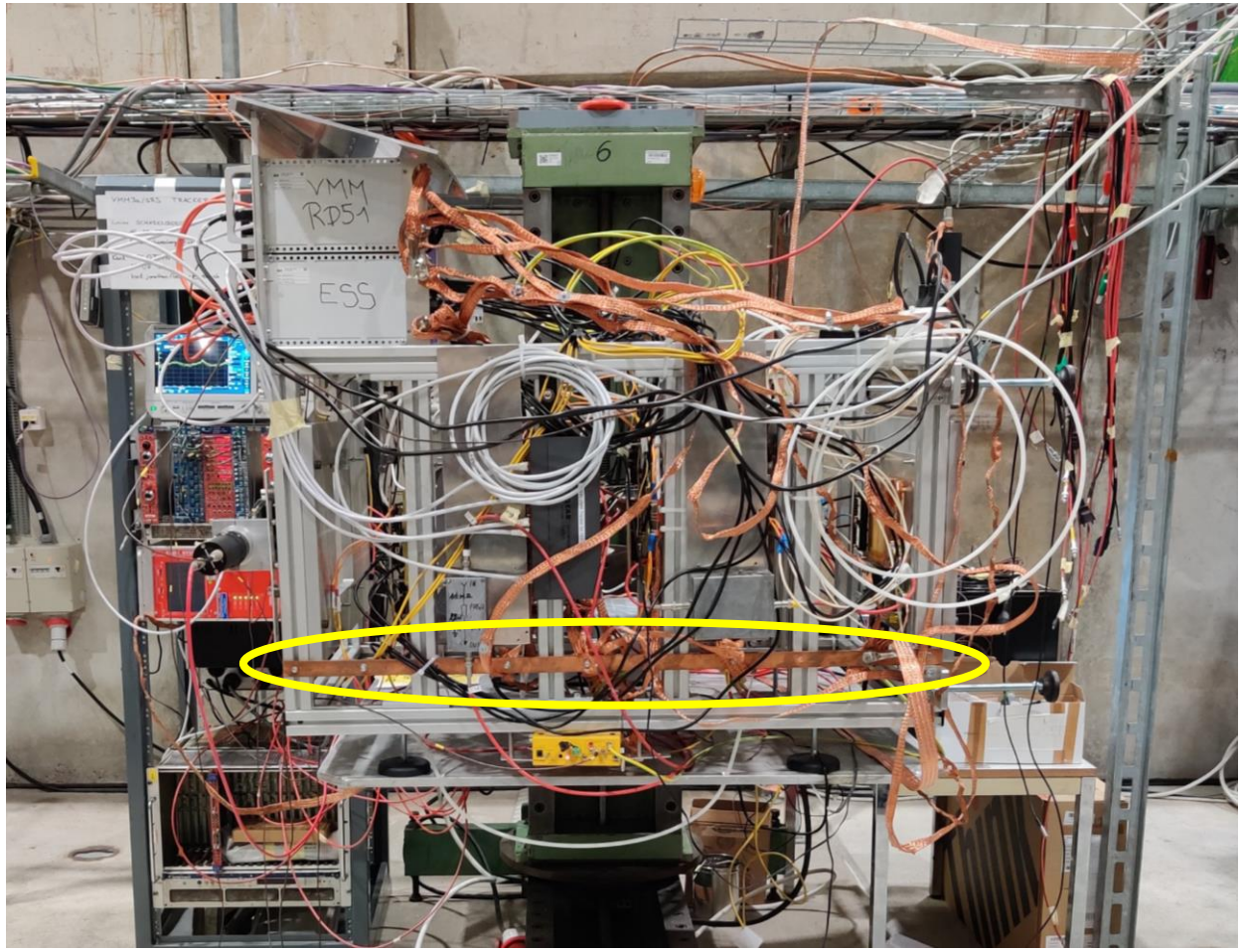




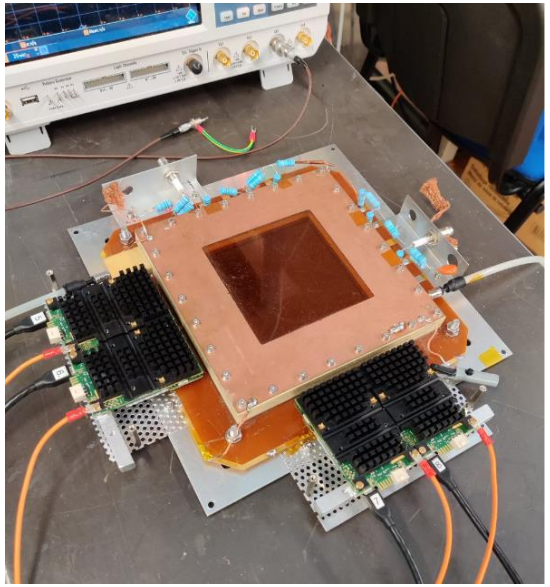
Validation of improvement 2:
Noise, high threshold and inefficiencies

- Improved the common ground
- Improved the analogue and detector ground => Panasonic to Hirose adapter introduces lots of noise if not grounded

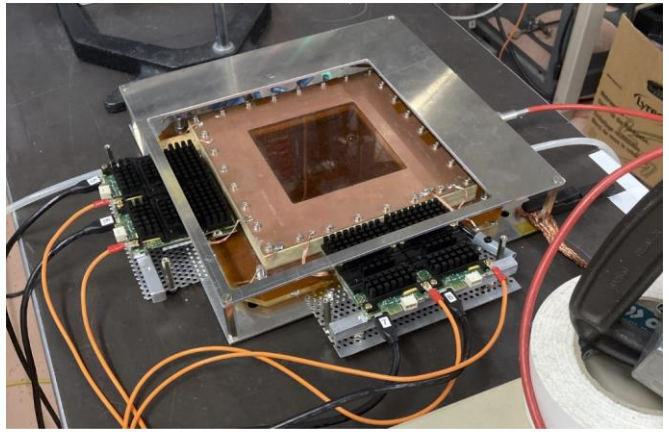


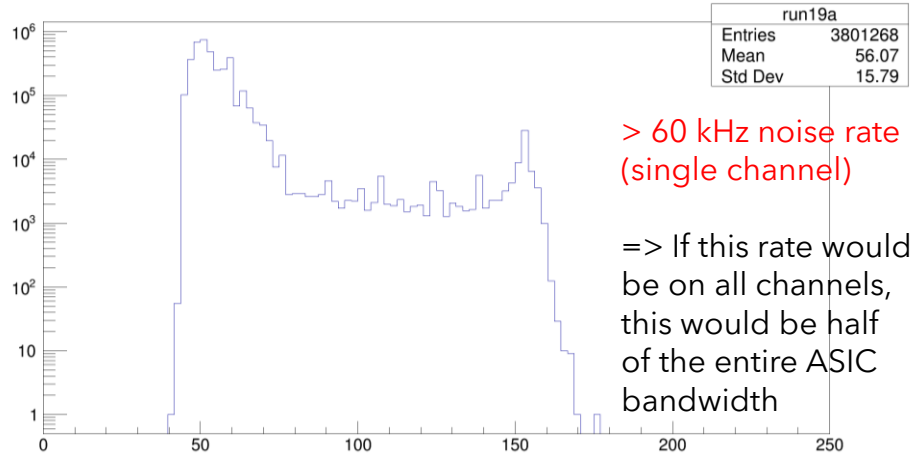


Validation of improvement 2:
Noise, high threshold and inefficiencies



Common ground
Without HV
No adapter ground

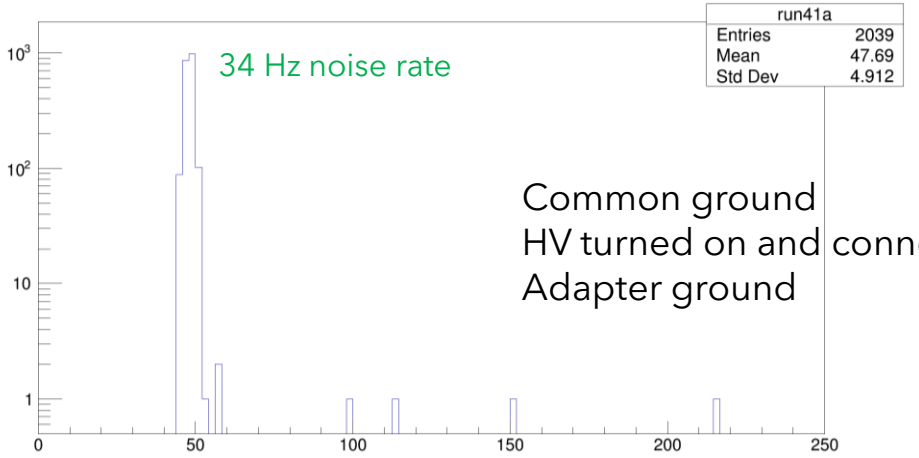




> 60 kHz noise rate (single channel)

=> If this rate would be on all channels, this would be half of the entire ASIC bandwidth

5 mV THL
60 s of acquisition
Single channel

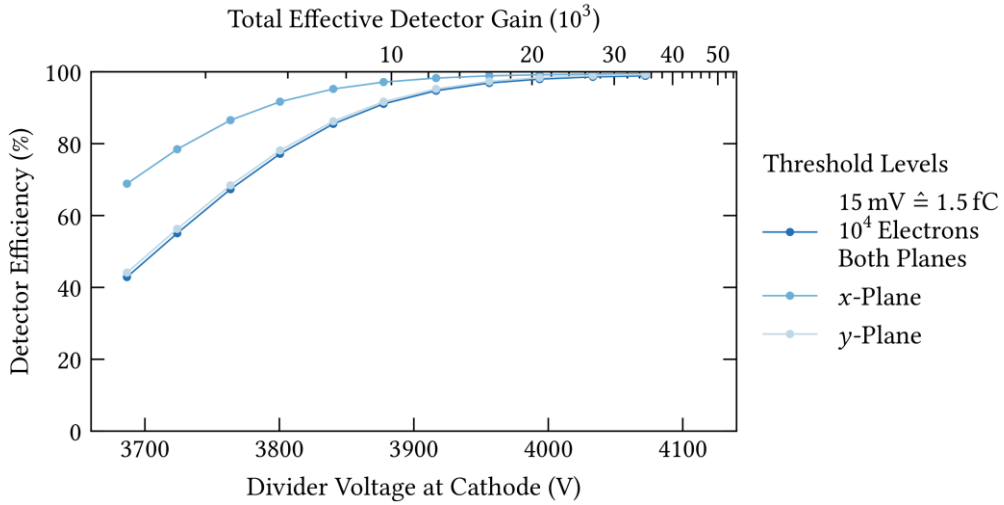


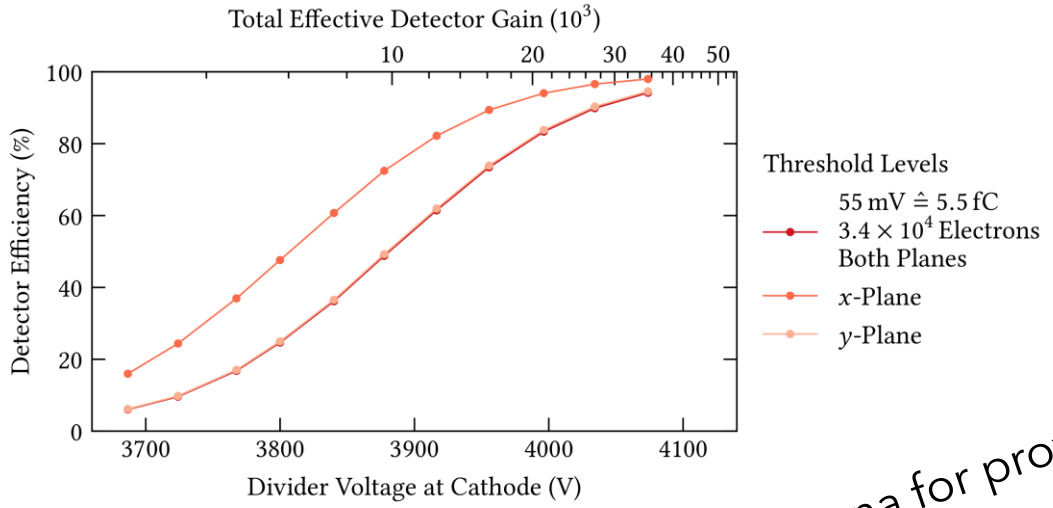
Common ground
HV turned on and connected
Adapter ground

Validation of improvement 2:
Noise, high threshold and inefficiencies

PRELIMINARY

- Significant increased efficiency
  > 95% for x-plane @ gain of 10000
- Same detector



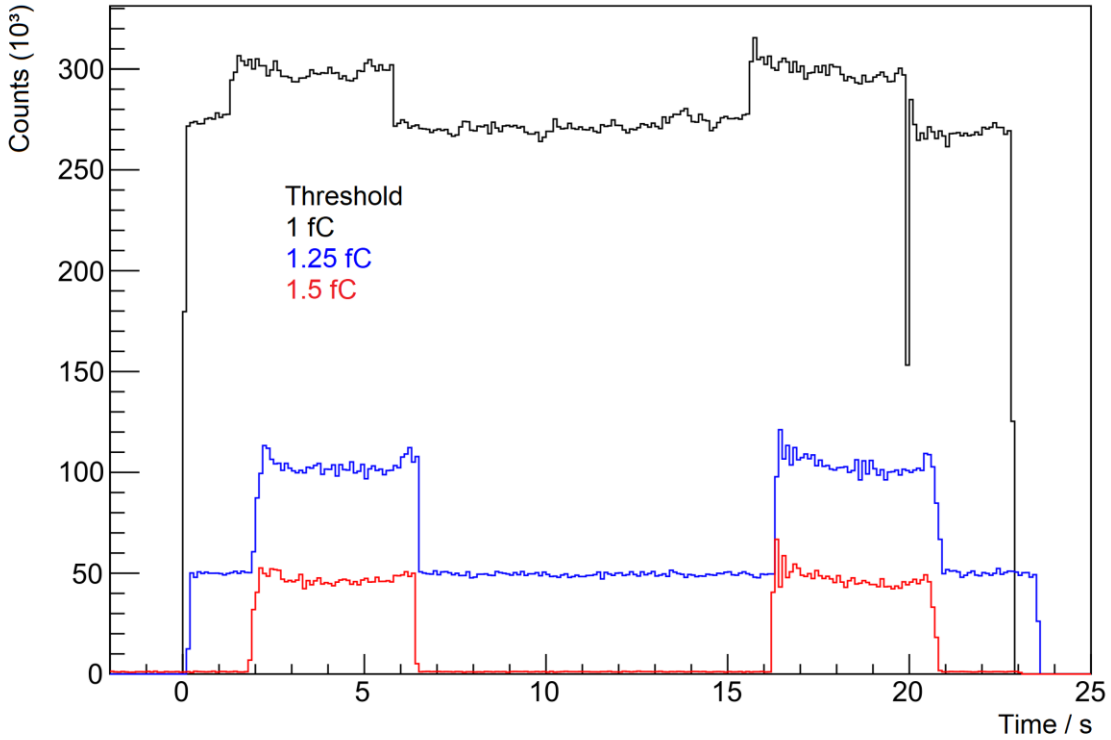


- Operation at ~1.5 fC threshold possible
- Requires special “tuning”
  => MM that was tested contains metal backplane
  => Much noisier; difficult to go down to such low thresholds

Thanks to Jona for providing the tracking software and the assistance in using it

Problem of too low thresholds

- 2 SPS spills (~20 s of data taking)
- Operated here at 12 mV/fC electronics gain
  - 1.5 fC THL (everywhere)
    - 4.4 million hits recorded with DUT
    - ~90 MB raw data (1 DUT + 3 trackers)
  - 1.25 fC THL (DUT), 1.5 fC THL (trackers)
    - 16.4 million hits recorded with DUT
    - ~200 MB raw data
  - 1.0 fC THL (DUT), 1.5 fC THL (trackers)
    - 64.3 million hits recorded with DUT
    - ~1 GB raw data
    - Too much noise; clustering software does not find any clusters for DUT. To be further investigated.

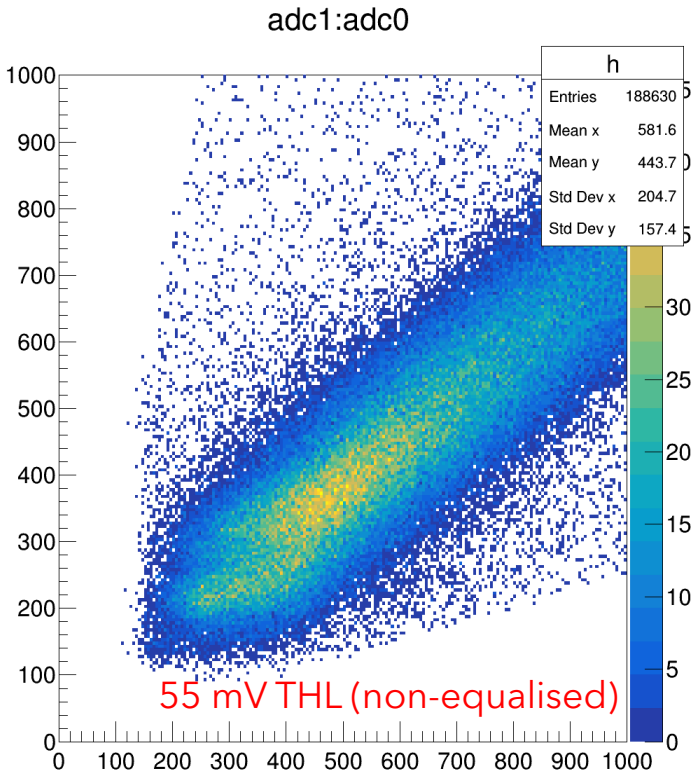


3000 electrons lower THL only in DUT (trackers not changed) => 10 times more raw 'data' (90 % is noise)

Validation of improvement 3:
Threshold equalisation

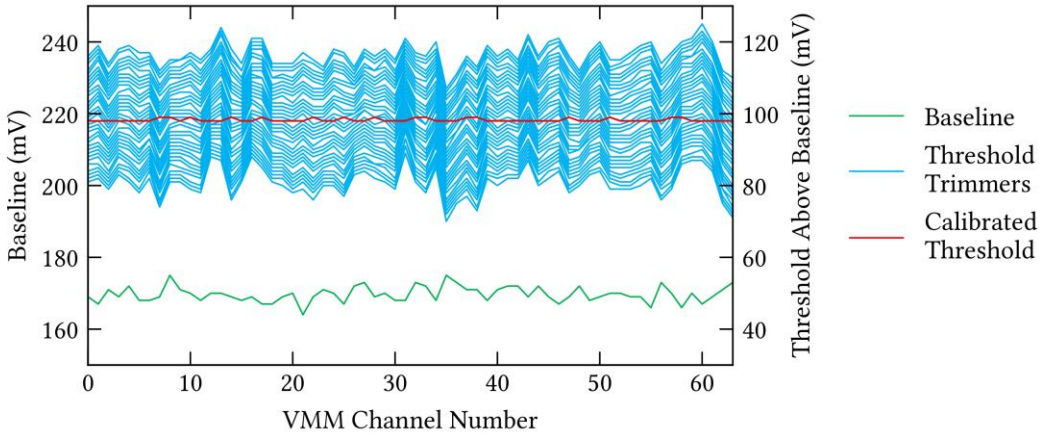
PRELIMINARY

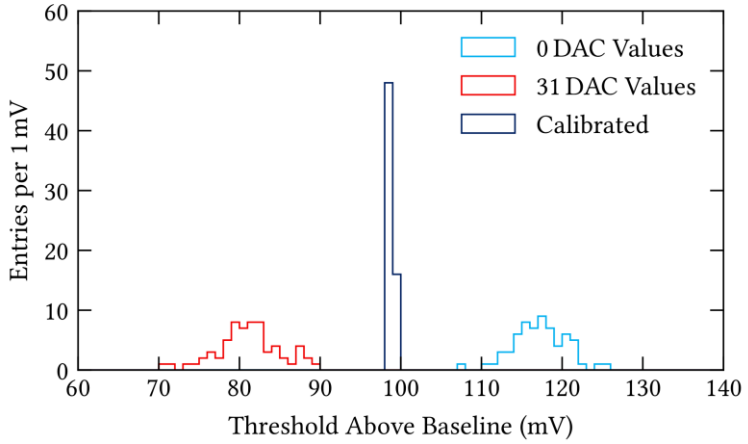
October 2021:
splitting in charge correlation plot



Suspicion: non-equalised threshold levels

Adjusted threshold equalisation procedure in THL
(thanks to George for the explanation)





Validation of improvement 3:
Threshold equalisation

PRELIMINARY

October 2021:
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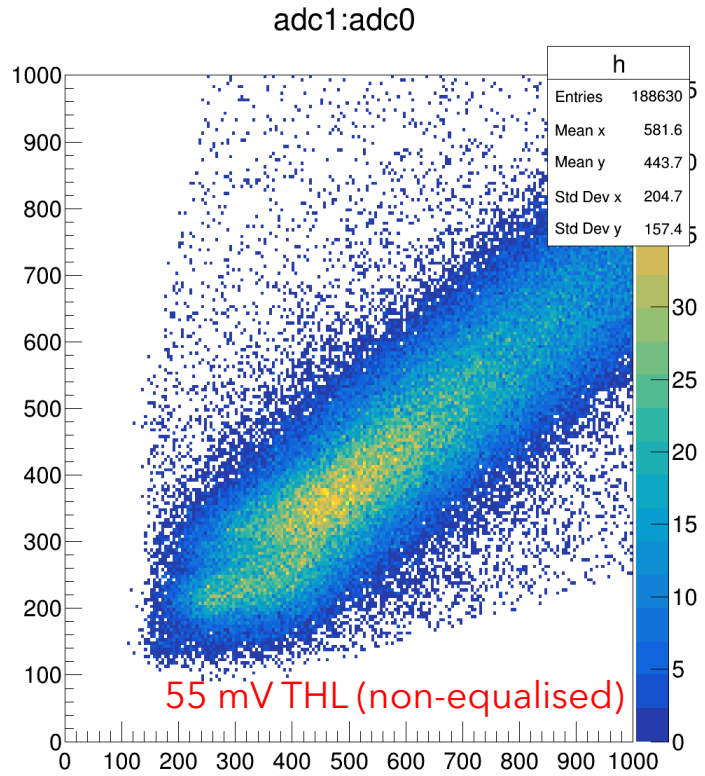
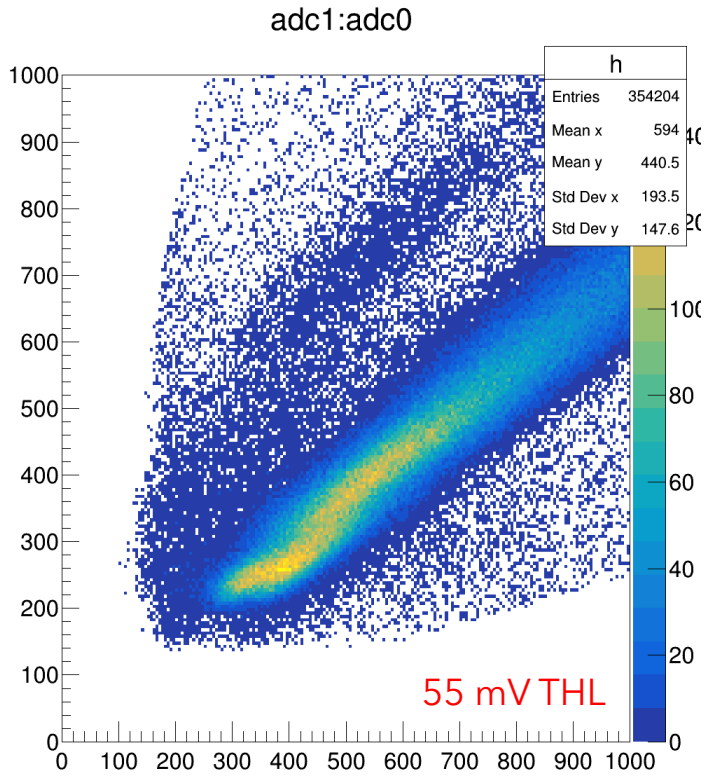
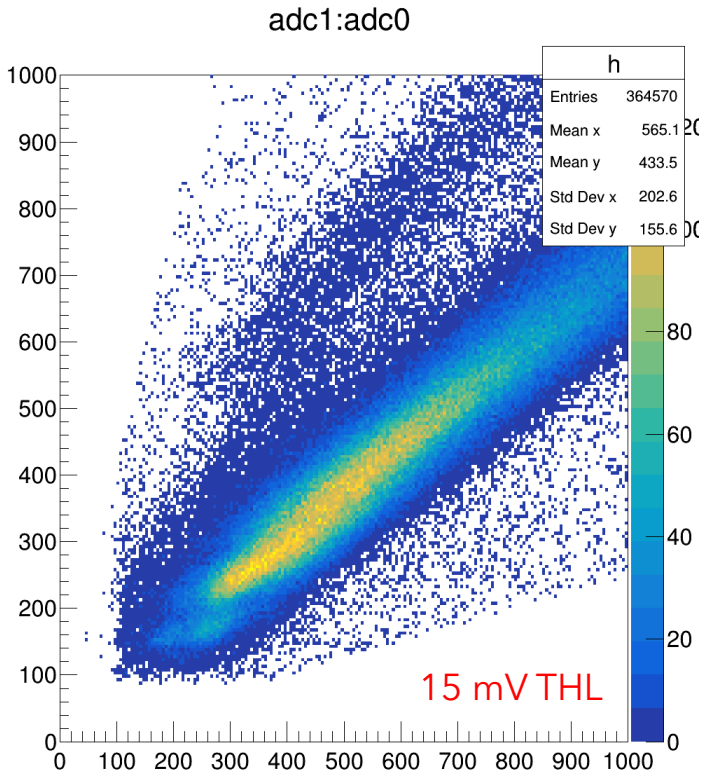


With equalised THL



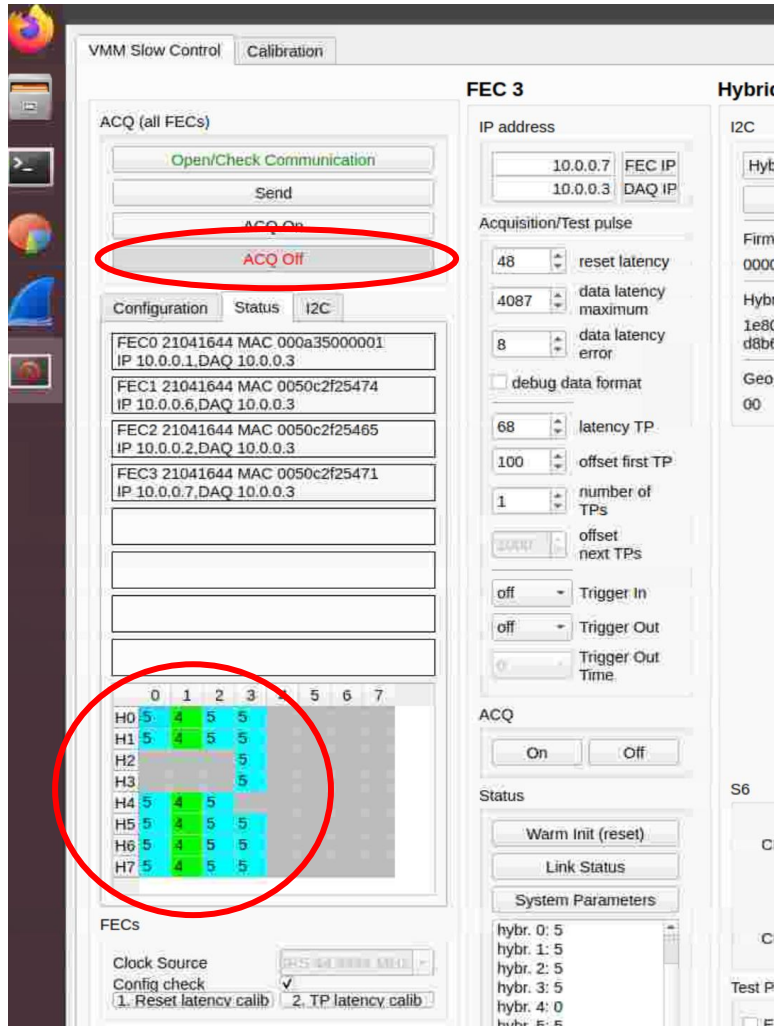
+ lower THL



Threshold equalisation is implemented and works
Does not solve conclusively the issue with the splitting => further investigation required

Yet unsolved issues

- Despite 'magic firmware' and CTF:
  - Sometimes problems with synchronisation
  - 1 FEC might not be synchronous with all the others
  - ACQ on/off 'solves' the problem
- FEC not sending data, but hybrids stuck in ACQ mode
  - ACQ on => FEC sends no data
  - ACQ off => hybrids in link status 5 (data taking mode)
  - Workaround (usually several attempts required)
    - Warm Init (reset)
    - Open Communication
    - ACQ on
    - Powercycle if problem still occurs
  - Surprisingly frequent (~once a day) during May 2022 beam
- So far: no able to stably operate a multi-FEC system, where 8 hybrids have to be read out on at least one FEC/DVMM (if at least on FEC/DVMM is fully equipped => less stable operation)
  - To be investigated e.g. with different powering schemes
  - With (asynchronous) operation and PMX, 8 hybrids per DVMM could be read out
  - To be checked, if cooling of DVMM is required



Summary

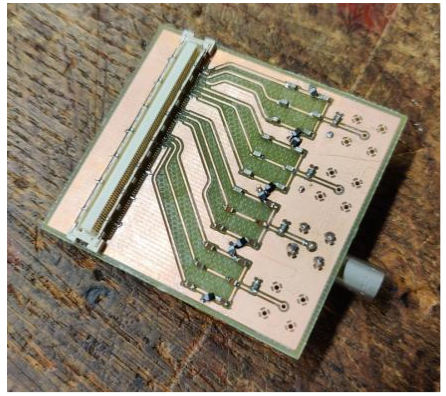
- Significant improvements on larger-scale VMM3a/SRS since July 2021
  - From unstable towards reasonable stability to perform detector studies
- 'Magic' firmware for multi-FEC systems increased stability (all hybrids sending data)
- Every time working with VMM3a/SRS
  - Grounding is extremely important
  - Optimised grounding allowed us to reach 1.5 fC as THL and hence > 95% efficiency at detector gains of 10^4
- Efforts on operating the detectors at lower gain
  - Triggered read out could help
- Still some issues to be understood and solved, especially for set-ups with higher hybrid load per FEC (e.g. data rate and power)

Outlook
Self-triggered in an triggered experiment

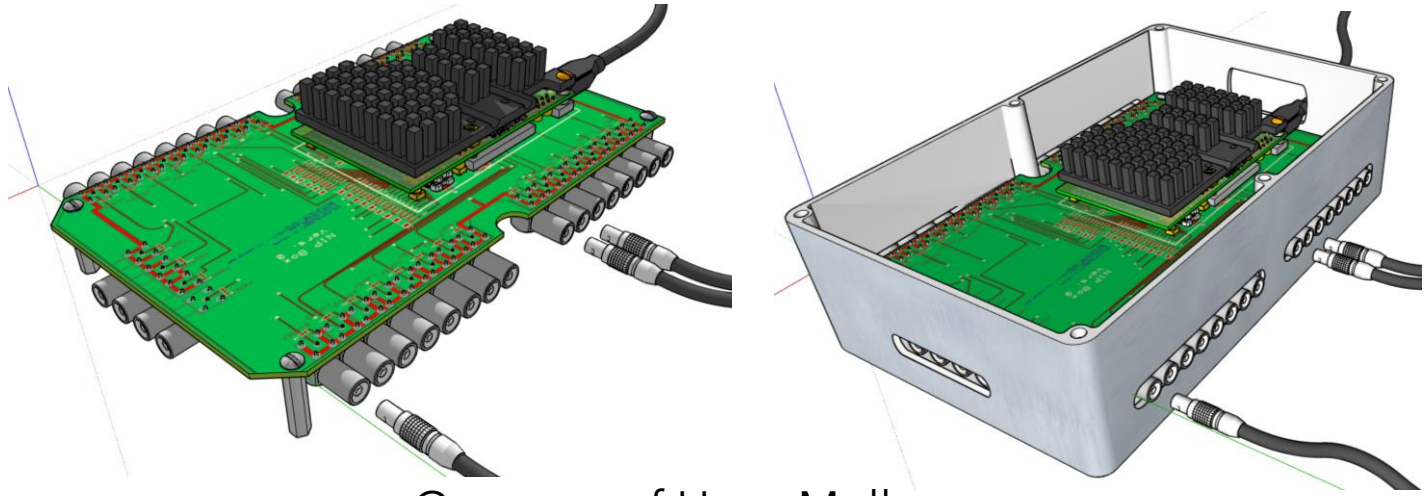
PRELIMINARY

- NA61/SHINE asked, if they could borrow the RD51 GEM beam telescope with VMM3a/SRS readout
- Alternative to their tracking system in front of the experiment's target

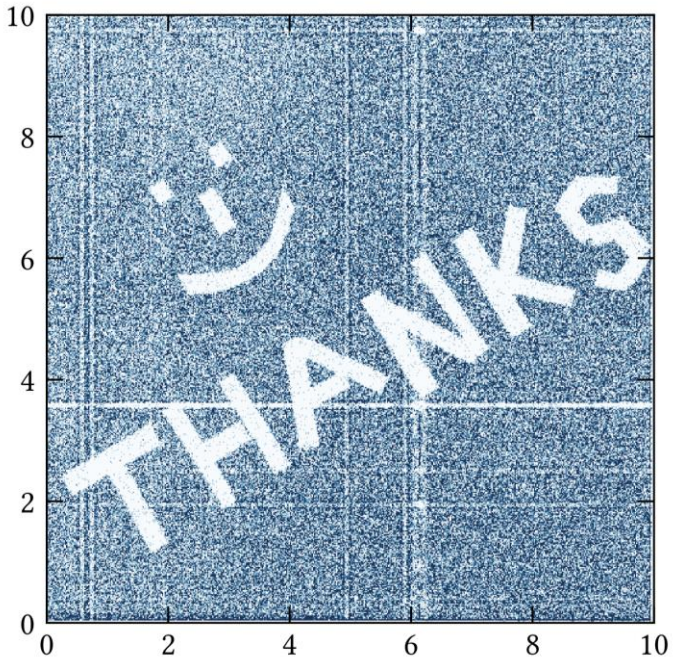
- How to integrate a self-triggered readout system into a triggered experiment? => event counter adapter
- Development of trigger adapter, which can read bit-wise an event counter
- Based on the idea from Mainz: LEMO inputs to VMM hybrid
- Split each event-counter bit into one LEMO input => 32-bit event counter = 32 LEMO connector (+4 spares)
- To be tested from next week onwards



Thanks to Pepe for the adapter



Courtesy of Hans Muller



for your attention!