Developments on VMM3a/SRS for the RD51 beam telescope

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RD51 Collaboration Meeting

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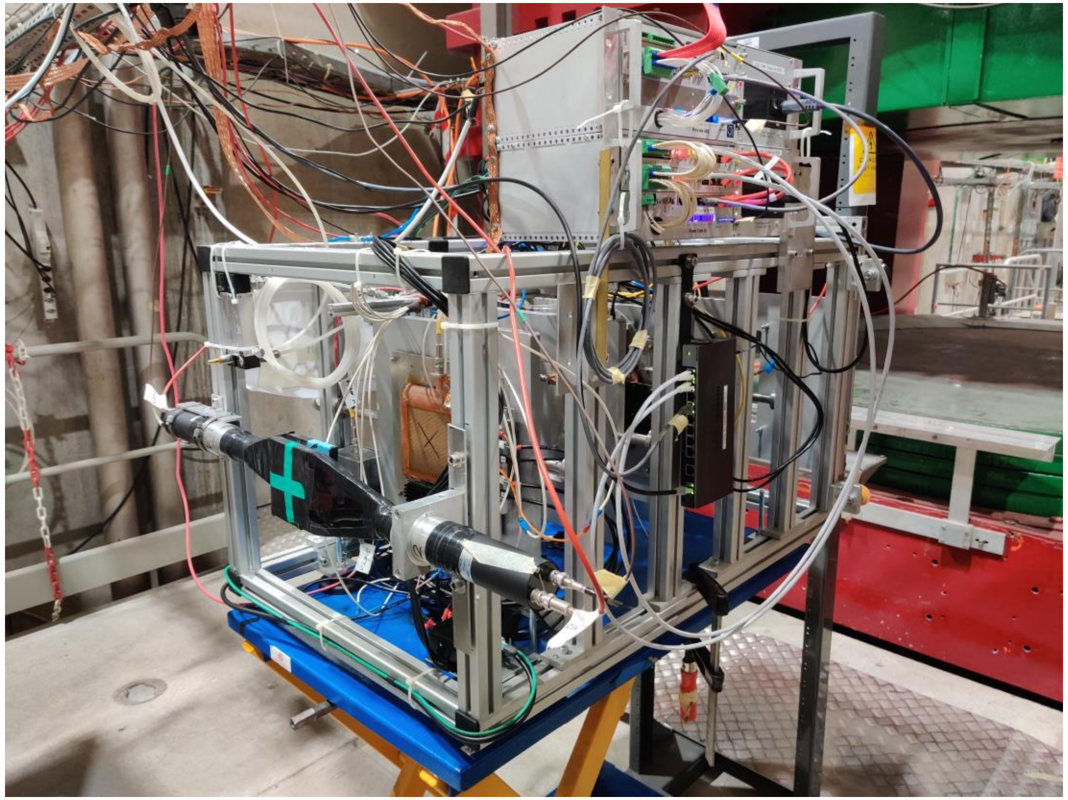
Outline

1. Experimental set-ups
2. Electronics and available hardware
3. Technical scope
4. Physics scope

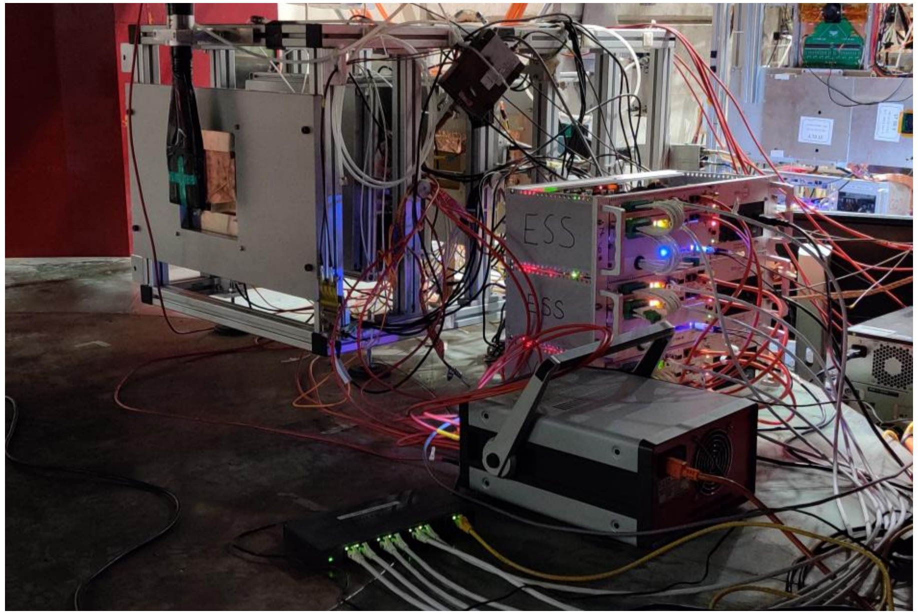
Experimental set-up (July 2021)

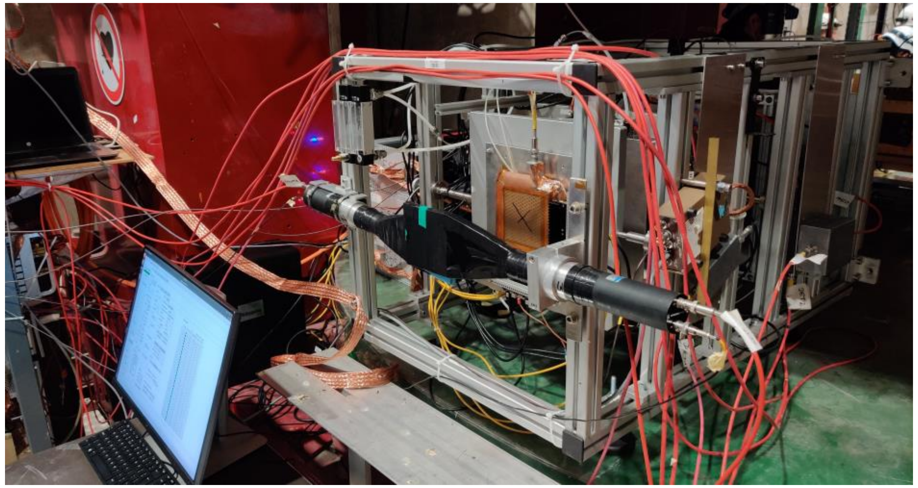


- 3 COMPASS-like triple-GEM trackers
- 1 COMPASS-like DUT

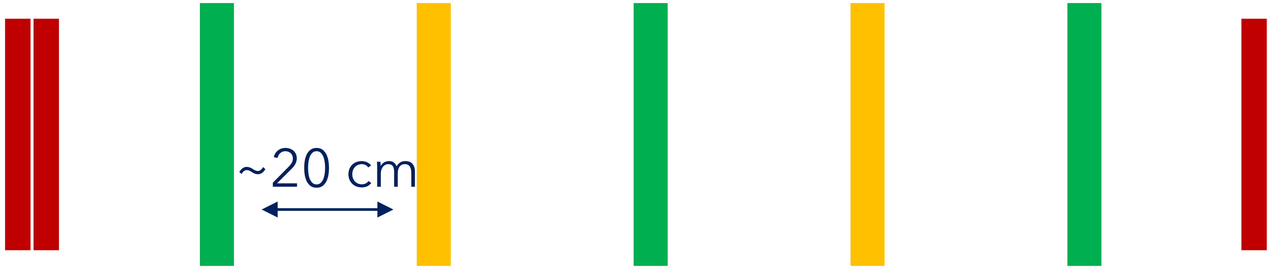
- 10 x 10 cm² active area
- x-y-strip readout (256 + 256 strips with 400 μm pitch)
- 3 scintillator/PMTs to a NIM logic

Experimental set-up (October 2021)





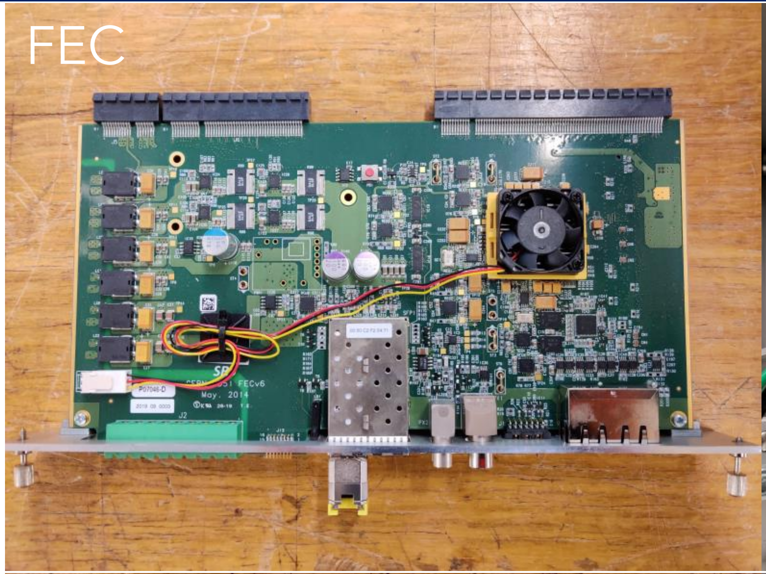
- 3 COMPASS-like triple-GEM trackers
- 2 COMPASS-like DUTs

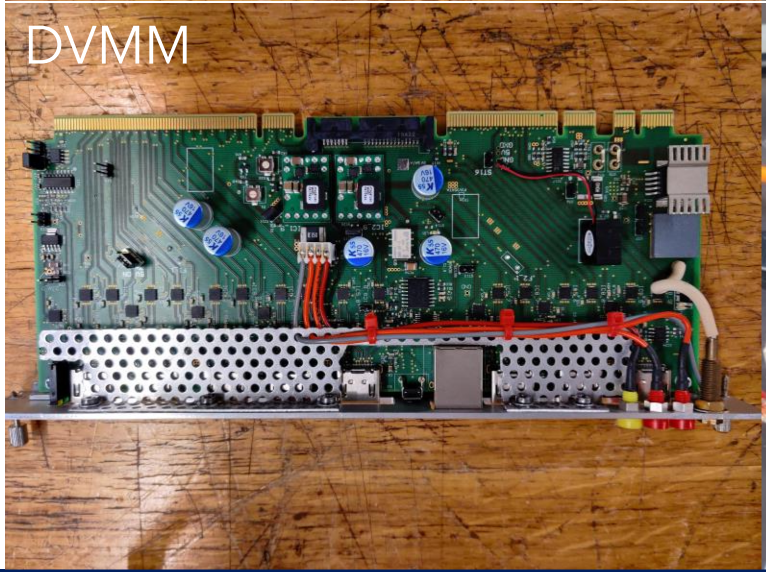


- 10 x 10 cm² active area
- x-y-strip readout (256 + 256 strips with 400 μm pitch)
- 3 scintillators/PMTs to a NIM logic

Electronics

- July 2021: largest minimal system (only for the 4 GEM detectors)
    - 1 Powercrate 2k
    - 2 FEC+DVMM
    - 16 RD51 VMM hybrids (2048 channels)
    - 2 PMX
- October 2021: rate-optimised system (for the 5 GEM detectors)
    - 3 Powercrate 2k
    - 5 FEC+DVMM (one detector per FEC)
    - 20 RD51 VMM hybrids (2560 channels)
    - All power over HDMI





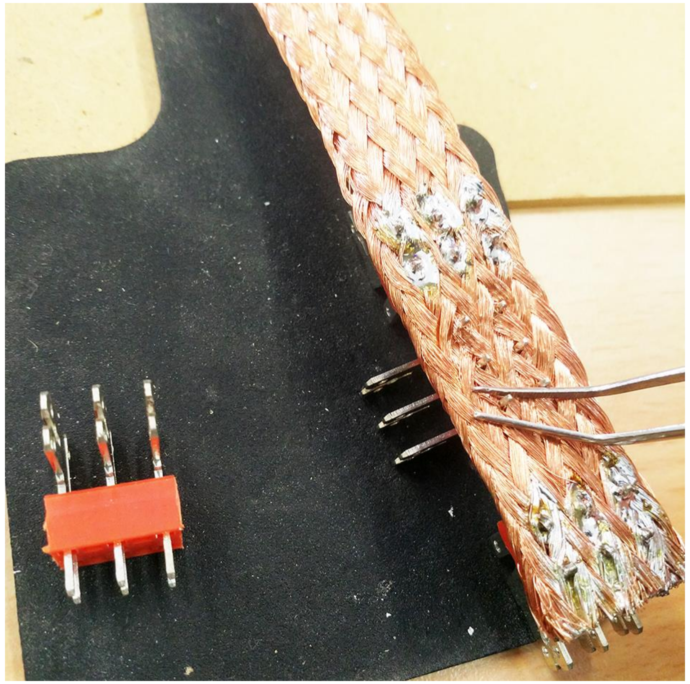
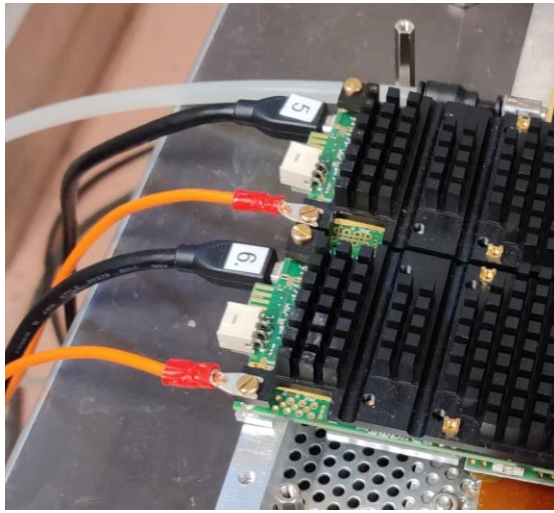
Available hardware

- Detectors
  - 3 triple-GEM detectors for tracking
  - 1 triple-GEM DUT as reference
  - Up to 3 other DUTs; *depends however on the DUT's size and if enough electronics is available*
- Electronics (only from RD51; at the moment distributed between various institutes)
  - During October 2021: lots of hardware from ESS was used by RD51
  - 4 to 5 FECs
  - 3 DVMMs (2 with PMX/power-over-HDMI support, 1 prototype for external power)
  - up to 24 hybrids (some of which are only partially working)

Technical scope
Powering and grounding

- More hybrids = more power consumption
- **Power distribution from the SRS crate** -> PMX from Hans Muller
- Ground return towards the SRS crate -> grounding brade fanout from Hans Muller



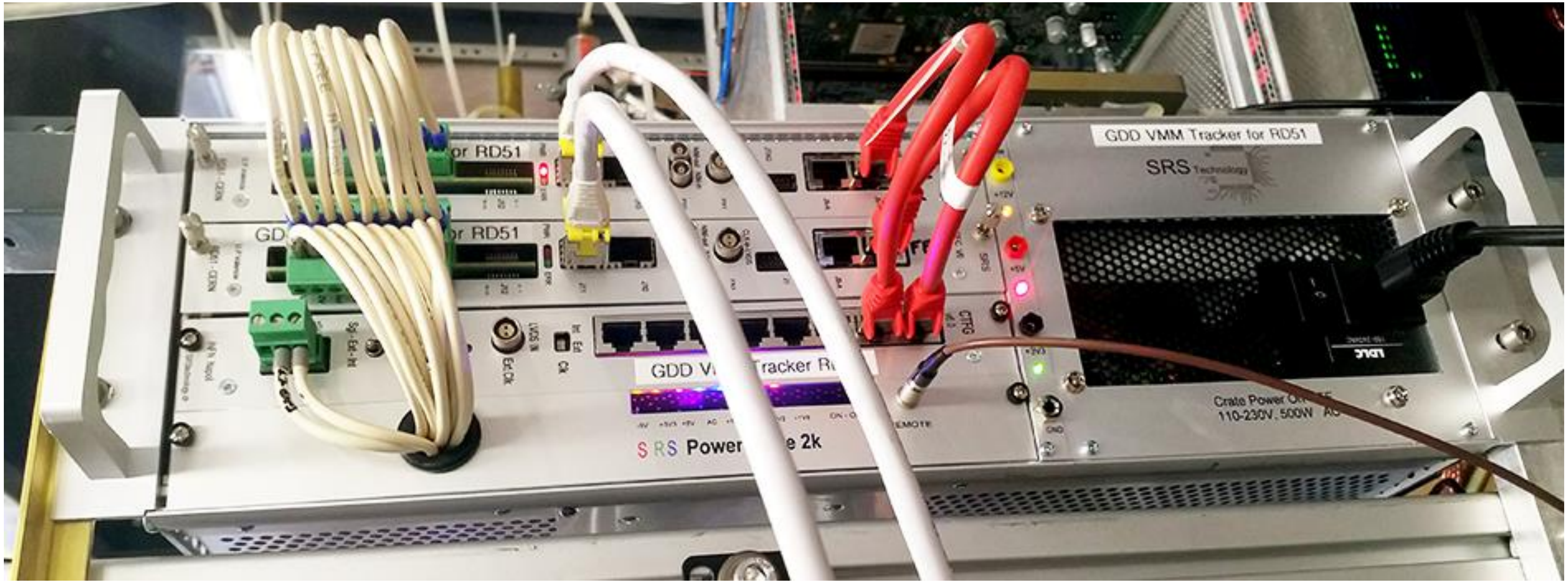



https://indico.cern.ch/event/1071632/contributions/4616924/

Technical scope

System stability and clock distribution

- Multi-FEC system => common clock to all FECs via CTF card



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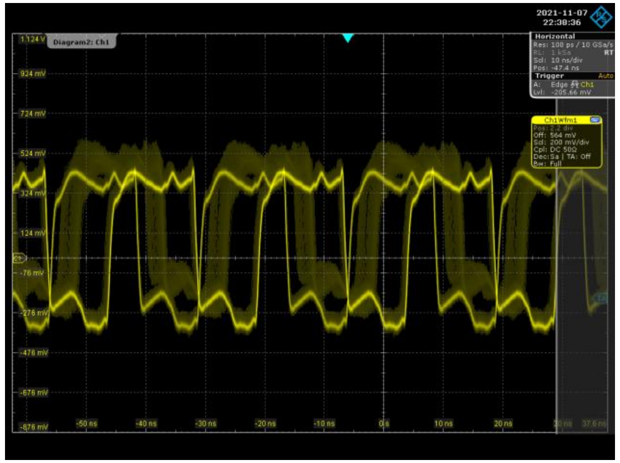
Technical scope

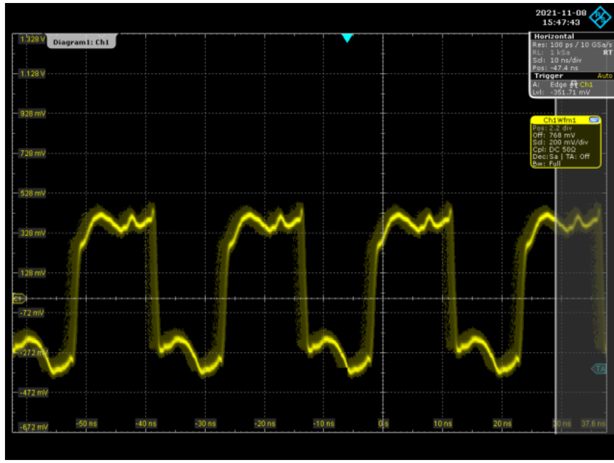
System stability and clock distribution

- Multi-FEC system => common clock to all FECs via CTF card
- Observation during July beam: instable ACQ start
  - => All hybrids can be configured an receive a clock
  - => Not all hybrids send data once the ACQ is turned on
  - => Random, which hybrid does send data and which one does not
  - => The ones that send data are stable
- Possible solution found during October beam:
  - Jitter on CTF clock
  - Add PLL jitter cleaner to CTF

Clock without PLL



Clock with PLL



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Technical scope

Plans for the future

System stability (can/should be done before the next beam in the lab)

- Validation of PLL jitter cleaner in the lab
- Test also the AIDA TLU (Timing/Trigger Logic Unit) as clock distribution
- New firmware under development, which allows to powercycle specific hybrids instead of physically rebooting the entire system

Hybrid cooling

- During beam some hybrids reached temperatures of 60 °C
- In the lab: 50 to 55 °C
- With active cooling: ~35 °C
- Investigate the noise on the signal

Technical scope

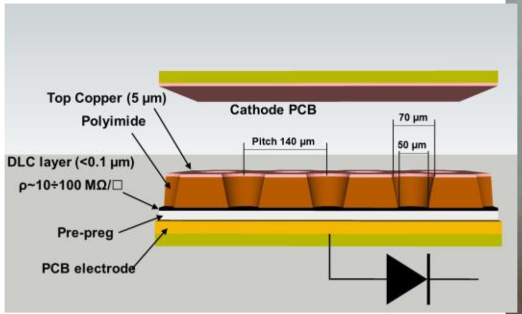
Software

- Cluster reconstruction, also for multiple detectors available
- VMM is self-triggered => new event-building needed => written by Jona Bortfeldt
- These events can be processed by the same tracking software as the one used by Picosec
- Analysis and optimisation of tracking software for VMM3a data still ongoing

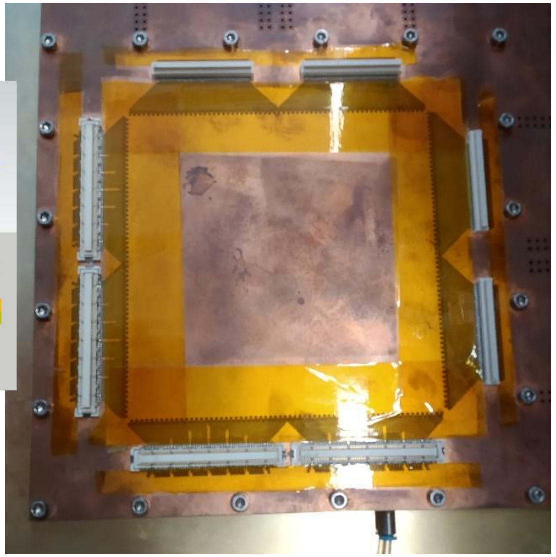
- More tools for 'on-the-fly' analysis during beam needed
- See discussion at the end of this session

New technologies: µRWELL prototype

- Goal of the next test beam campaigns: test µRWELL prototype for the beam telescope
- For previous results with APV25/SRS see: https://indico.cern.ch/event/1040996/contributions/4404219/
- Lab, modelling, beam activities: study prototype, get insight on the final design for the beam telescope
  - Rate-capability
  - 2D readout and charge sharing => dynamic range/adjustable electronics gain of the VMM is useful for non-equal charge sharing



https://doi.org/10.1088/1748-0221/14/05/P05014

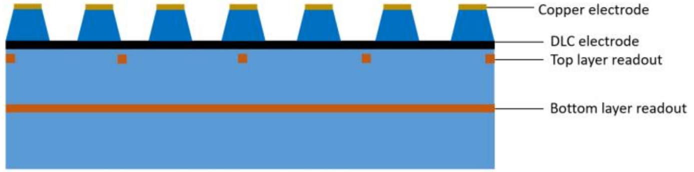


Yi Zhou, Xu Wang et al. (USTC)
Eraldo Oliveri

A 2-D µRWELL PCB with 15cm×15cm a-C DLC was designed and fabricated. The DLC was made in China

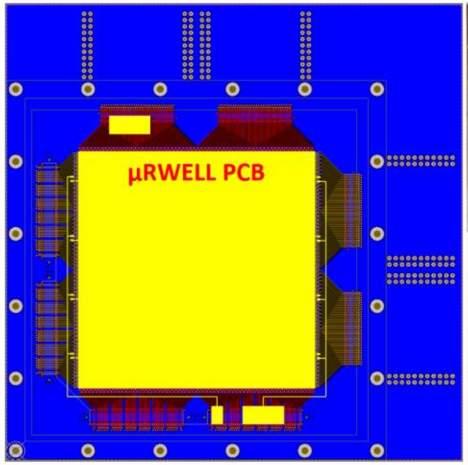
µRWELL PCB
- Sensitive area: 10cm×10cm divided into 4 sectors
- Well pitch: 140 µm
- Pre_preg (50 µm) isolate the DLC electrode from readout strip

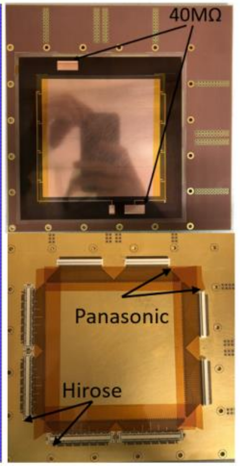
2-D readout strip
- Pitch: 400 µm
- Top layer: 80 µm
- Bottom layer: 350 µm
- Insulate thickness: 50 µm
- Readout strip channel: 1024



Schematic of µRWELL PCB

All the readout strips are connected to 4 HIROSE (for laboratory test) / PANASONIC (for beam test) connectors.



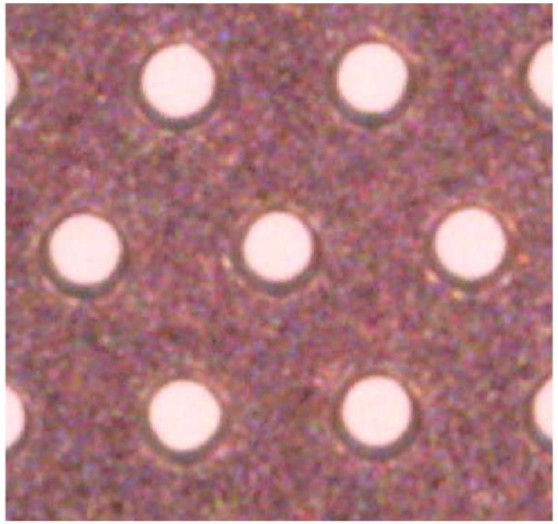


Yi Zhou, Xu Wang et al. (USTC)
Djunes Janssens

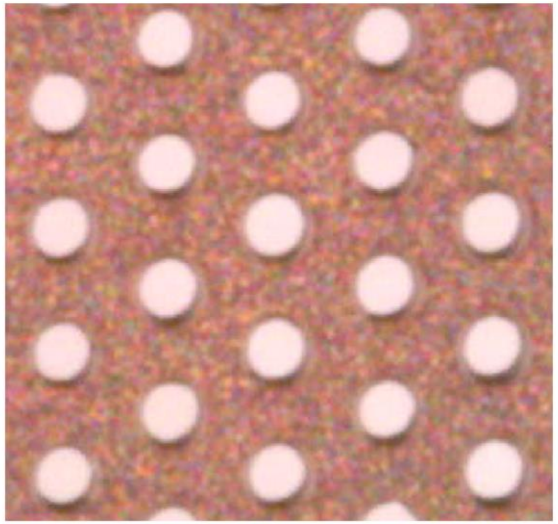
New technologies: small pitch GEM

- Use small-pitch GEMs to improve the spatial resolution of a triple-GEM detector

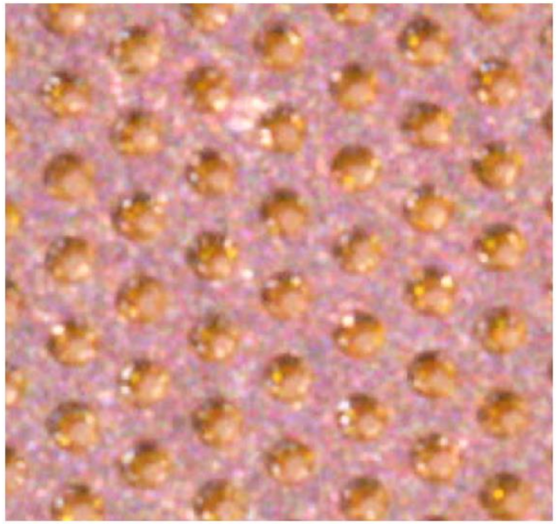
Standard 140μm pitch
50μm Kapton
70μm holes



90μm pitch
50μm Kapton
60μm holes



60μm pitch
25μm Kapton

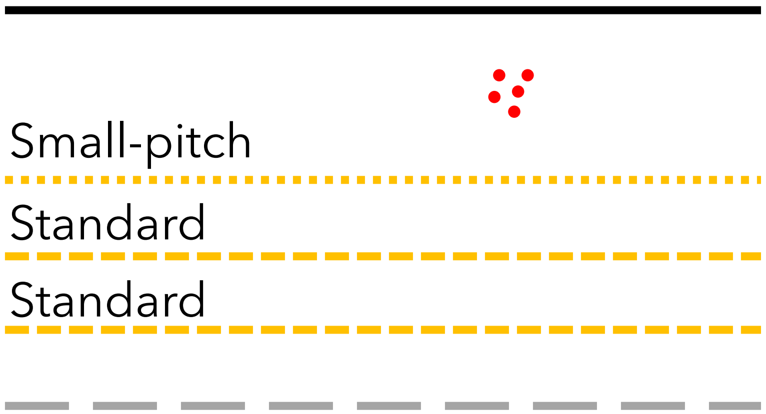


Florian Brunbauer

New technologies: small pitch GEM

- Use small-pitch GEMs to improve the spatial resolution of a triple-GEM detector
- Better sampling/charge collection of primary charge
- Two types of small pitch GEMs:
  - 90 µm hole pitch, 50 µm polyimide, 5 µm copper
  - 60 µm hole pitch, 25 µm polyimide, 5 µm copper
- Three configurations during the October beam

Configuration	GEM1	GEM2	GEM3
A	90/50 µm	140/50 µm	140/50 µm
B	60/25 µm	140/50 µm	140/50 µm
C	90/50 µm	90/50 µm	90/50 µm



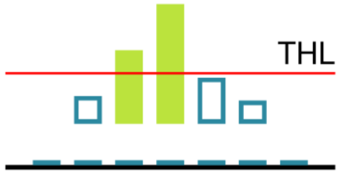
Physics scope

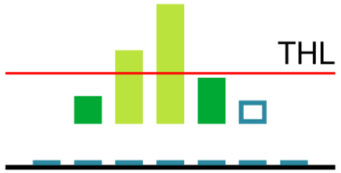
Spatial resolution: past and future beams + ongoing data analysis

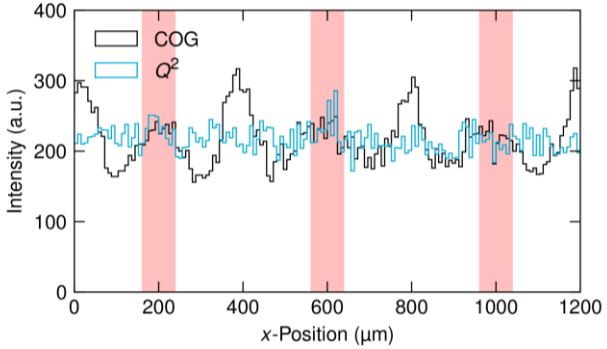
- Investigate the effect of the small pitch GEM
- Study the effect of the VMM's neighbouring-logic

  => recover charge below threshold in a self-triggered readout system

  => more charge information should improve the position reconstruction
- Study alternative position reconstruction methods (instead of centre-of-gravity)







Physics scope

Spatial resolution: past and future beams + ongoing data analysis

- Dependence on the threshold level, detector gain
    - COMPASS-GEM divider currents: (660) 700 to 735 μA
    - Gain range: 1.5 to 30.0 x 10^3
    - Threshold levels: 40 to 100 mV above the baseline
    - Threshold in electrons: 27 to 69 x 10^3 electrons (at 9 mV/fC electronics gain)

    => Improve S/N and signal/threshold for the next beam

- With small-pitch GEM detector: CAEN HiVolta (DT1415ET) power supply
    - Dependence on the different fields (drift, transfer, induction)
    - Drift scan from 60 to 5600 V/cm
    - Induction/transfer scans from 250 to 5000 V/cm
    - Gain scans for each GEM individually
    - Settings optimised for electron transparency with lower total divider voltage (https://hdl.handle.net/20.500.11811/8516)

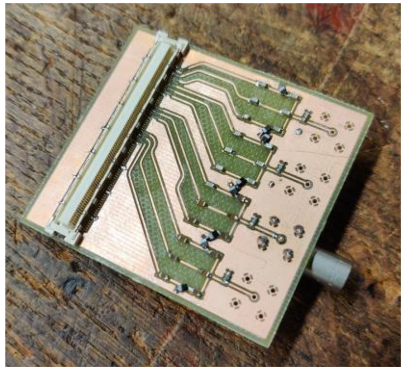
Settings	Induction	GEM3	Transfer2	GEM2	Transfer1	GEM1	Drift
COMPASS	730 V 3650 V/cm	328.5 V	730 V 3650 V/cm	365 V	730 V 3650 V/cm	401.5 V	730 V 2433 V/cm
Optimised	730 V 3650 V/cm	313.7 V	308.8 V 1544 V/cm	358.6 V	343 V 1715 V/cm	396.8 V	730 V 2433 V/cm

Physics scope

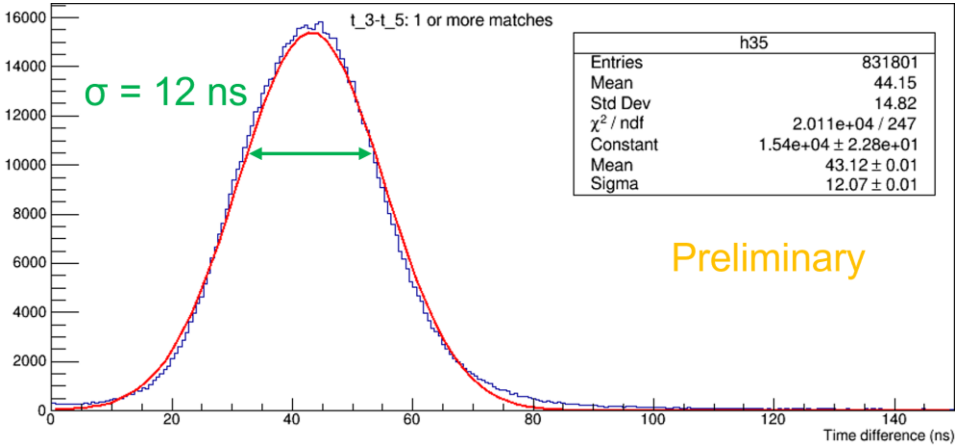
Time resolution

PRELIMINARY

- Time resolution of the electronics: 1-2 ns
  if correctly calibrated
- All detectors can be kept in the same readout scheme
- Other detector types can be added
  - Scintillators + PMTs
  - NIM coincidence unit
- Time resolution of scintillator system (*non-calibrated electronics*) **~ 4 ns**
- Scintillator + triple-GEM: **~ 12 ns**
- Triple-GEM: **~ 11 ns**
  - Ar/CO2 (70/30 %)
  - 3 mm drift + 2 mm induction gap
  - Same as in doi:10.1016/j.nima.2004.07.146 for COMPASS GEMs



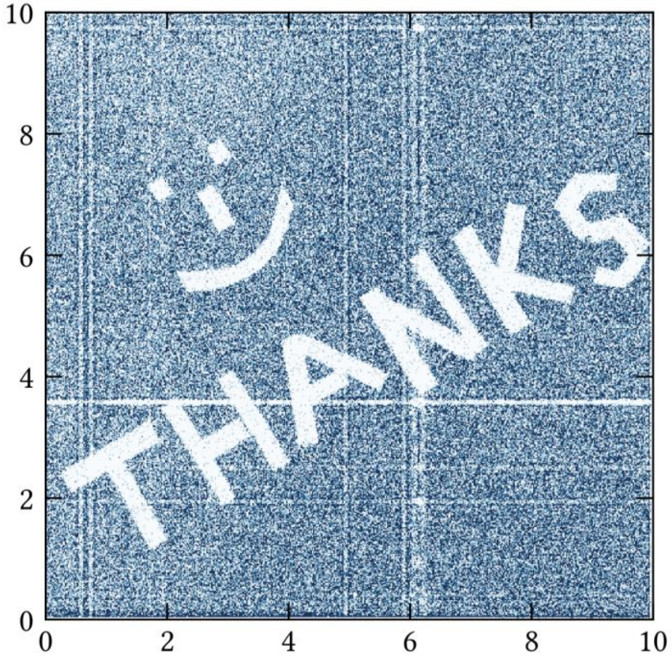
NIM-logic to VMM adapter



Analysis done by our summer student Daniel Sorvisto

Summary

- Last year: commissioned the electronics for the new RD51 telescope
  - New powering scheme (HDMI and/or PMX)
  - Improved grounding
  - Improved clock distribution and thus system stability
- Started with physics measurements
  - Improving spatial resolution with electronics features (neighbouring-logic) and position reconstruction algorithm
  - Testing small pitch GEM for improved spatial resolution
  - Measure the time resolution of the DUTs
- This year:
  - Continue with the physics scope from last year
  - Validate the improvements from last year
  - Test the μRWELL
  - Get the new beam telescope ready for everybody



for your attention!