VMM3a/SRS front-end electronics for DRD1 beam telescopes

AIDAinnova Task 3.5.2 on Common DAQ Developments

Lucian Scharenberg *on behalf of the CERN EP-DT GDD team*

3rd DRD1 Collaboration Meeting, 11 December 2024

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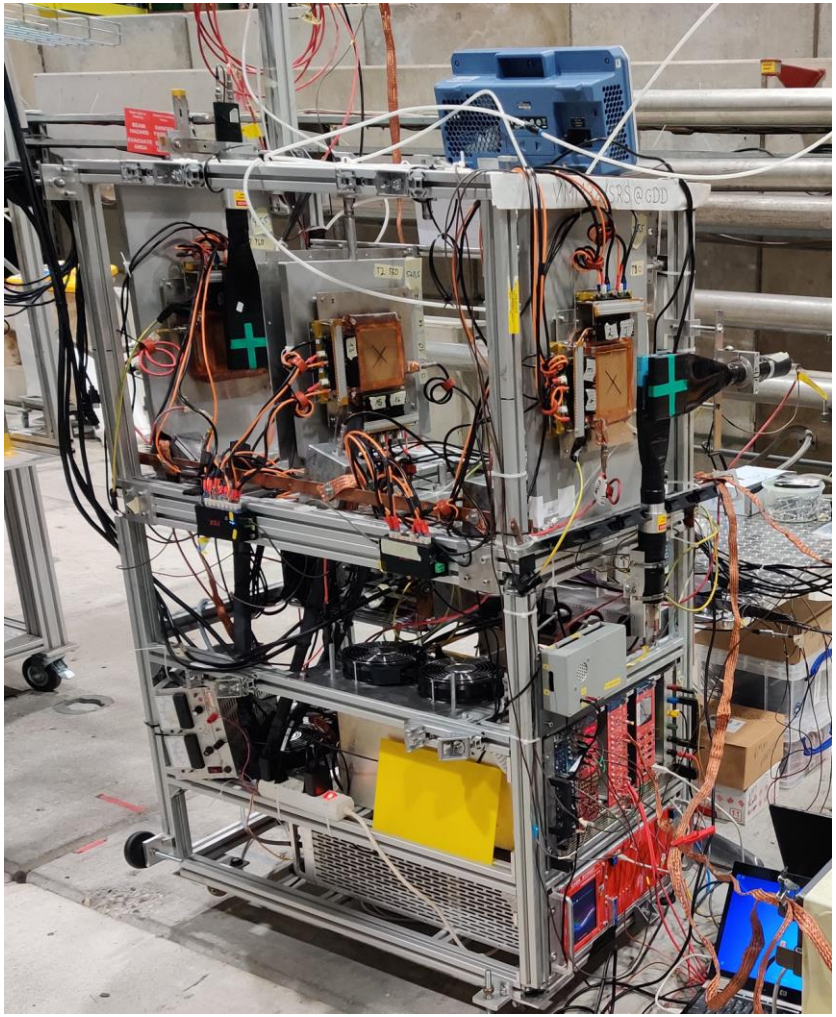
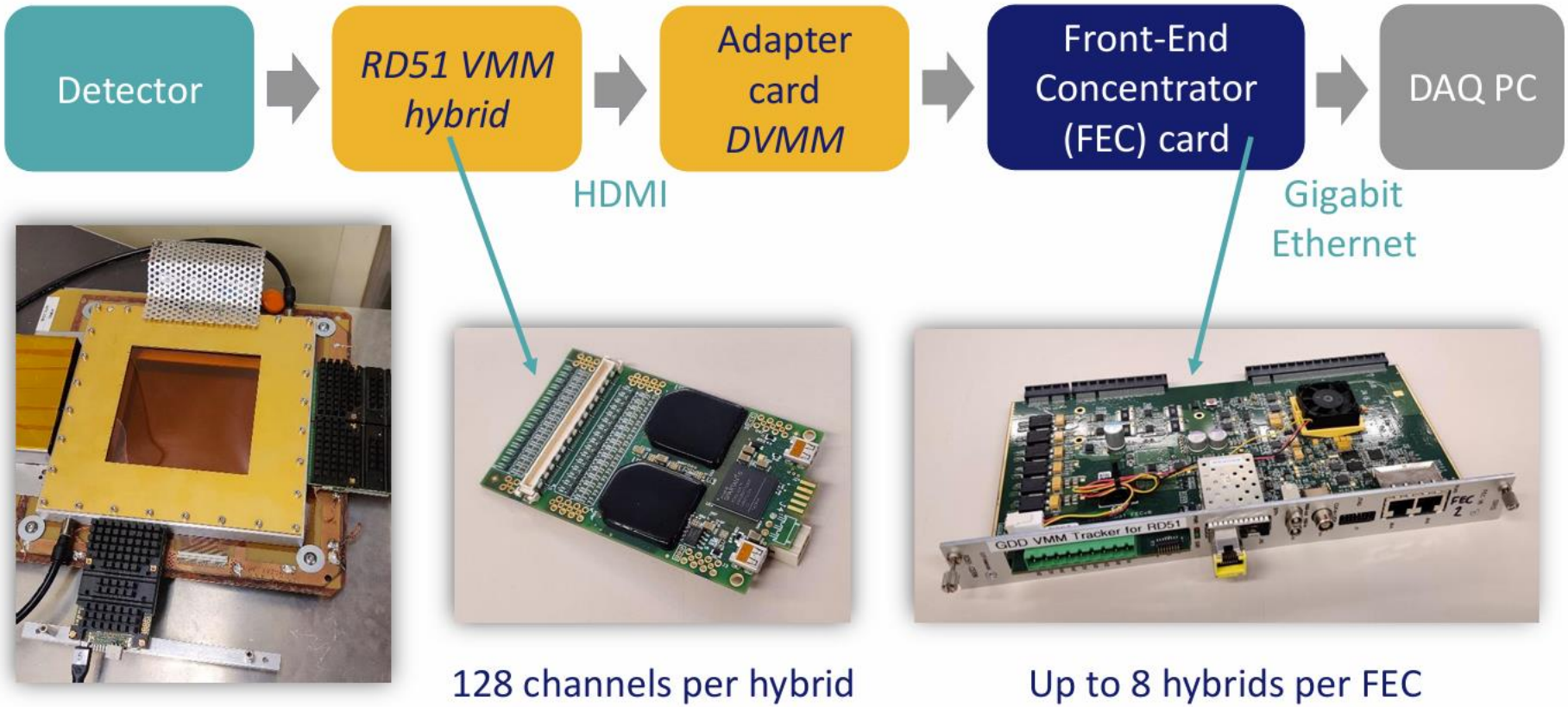
Outline

- Introduction
- Goal
- Main achievements
- Outcome for the community



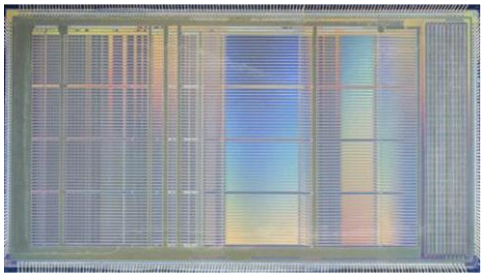
RD51 Scalable Readout System (SRS)

- Common RD51 DAQ system for small R&D set-ups and midsized experiments
- Various front-end ASICs integrated, e.g. APV25, Timepix/Timepix3, **VMM3a**



ATLAS/BNL VMM3a

- Developed for multi-channel readout of gaseous detectors (ATLAS NSW)
- High rate-capability: **9 Mhits/s per VMM** in SRS implementation
- Provides **peak amplitude** (10-bit charge ADC)
- Provides **time of the peak with O(ns) time resolution** (12+8-bit timing)
- Good for R&D applications
  - Adjustable peaking times
  - Adjustable electronics gains
  - Wide range of input capacitances (< 200 pF up to 2 nF)



- Operated with various kinds of MPGDs (GEM, MicroMegas, µRWELL), with straw tubes, scintillators, NIM signals and SiPMs
- Integration of VMM3a into SRS supported by AIDA2020: http://cds.cern.ch/record/2316257/files/AIDA-2020-MS83.pdf

https://indico.cern.ch/event/757322/contributions/3394528/attachments/1838914/3215977/2019_05_06_Iakovidis_VMM.pdf

Activities supported by AIDAinnova

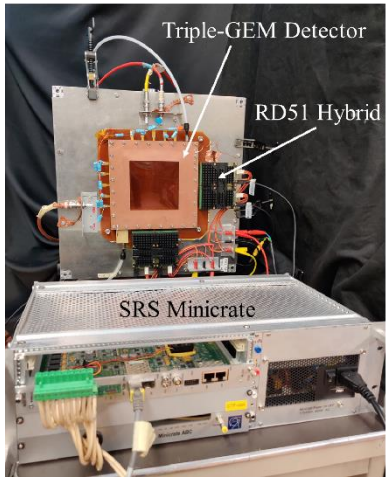
WP3: Test beam and DAQ infrastructure

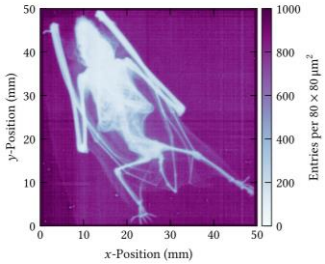
- MS11: Common read-out boards designed
  https://zenodo.org/records/7683968
  → Deliver a complete SRS/VMM3a DAQ (HW, FW, SW) for MPGD-based tracking (50-100 µm) and timing (ns) telescopes
- D3.5: Common read-out boards delivered
  https://zenodo.org/records/13969201
  → Use of the MS11 system at the SPS RD51 test beam campaigns for tracking and timing. Documentation and final report covering HW/SW/FW (https://vmm-srs.docs.cern.ch/)

Goal

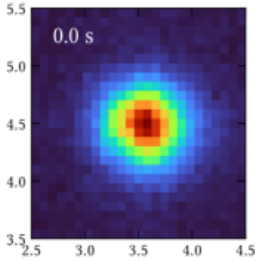
From MHz X-rays to MHz particle beams

After successful laboratory measurements with single detector, profit from SRS scalability and **optimise VMM3a/SRS front-end, such that it can be used to read out beam telescopes**

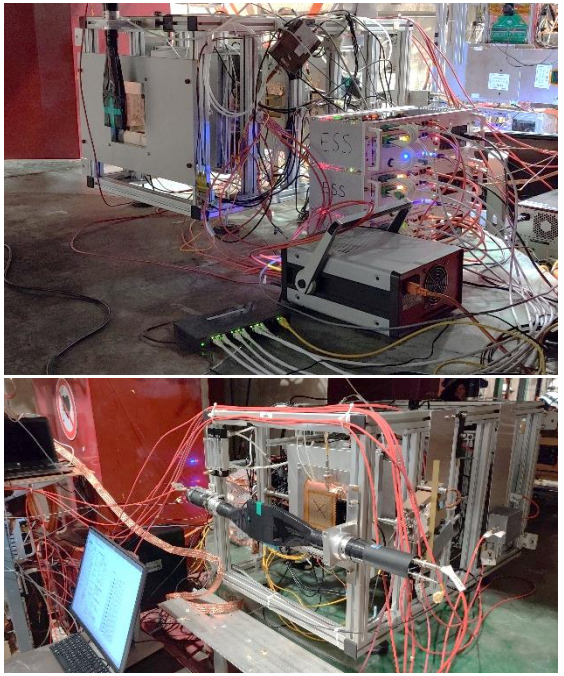




X-ray image of GDD bat



Pion beam profile



Small single-detector set-up

Mid-sized multi-detector telescope

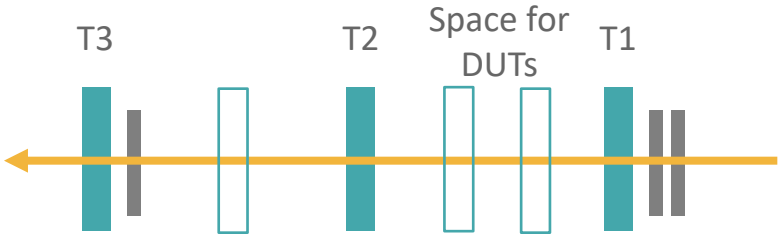
Main achievements

- Increased **system stability**
  - Special ESS firmware version
  - Optimised grounding scheme
  - Improved clock distribution via CTF modification
- **Commissioning studies** during various RD51 test beam campaigns
  - Spatial resolution → **50 µm** resolution of reference detectors
  - Time resolution → **1 ns** for scintillators, 8 ns for reference detectors
  - Rate-capability → up to **1 MHz** interaction rate can be recorded without losses
- System optimisation, meeting **community needs**
  - NIP-box to **synchronise with other DAQ systems** (used by NA61 and MIXE@PSI)
  - Implementation of externally triggered readout mode **by colleagues from FRIB**
  - Ongoing studies of using **Corryvreckan** for track reconstruction
- Development of new, **external powering scheme (PBX)**

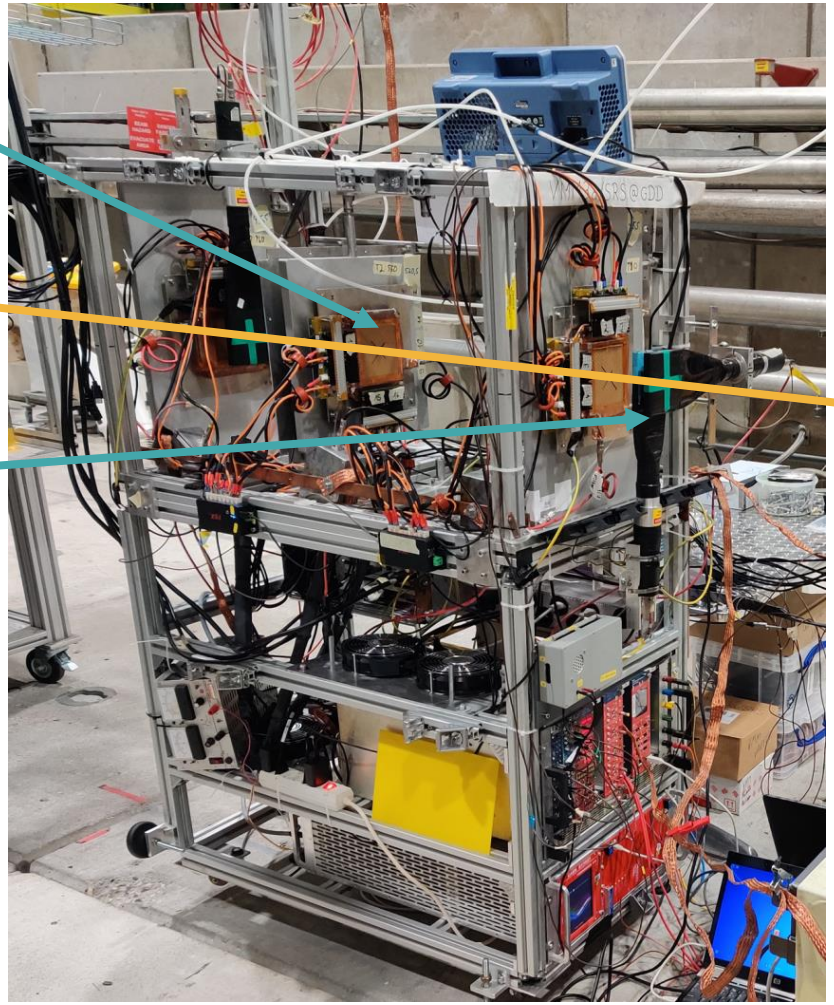
For more details see: AIDAinnova 1st, 2nd and 3rd annual meeting, as well as presentations at BTTB10, BTTB11 and BTTB12.

Result
Stand-alone beam telescope

- 3 reference tracking detectors
  - 256+256 X-Y-triple-GEM (~50 µm spatial res.)
  - 10 x 10 cm² active area

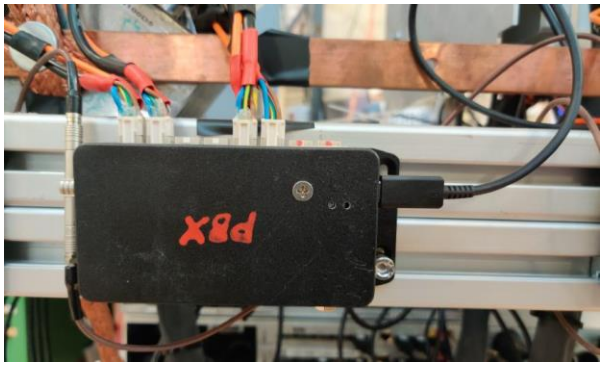


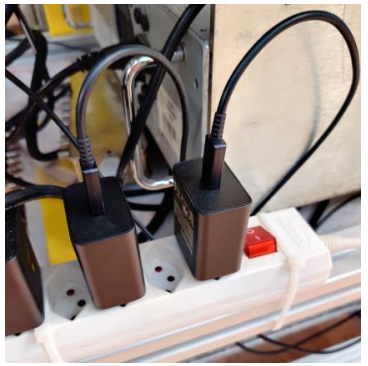
- Scintillators + NIM-logic for timing (~ 1 ns time res.)
- ~ 1 m lever arm
- Everything read out with VMM3a/SRS
  - Fully self-contained with NIM-crate, low voltage and HV power supply
  - Different types of DUTs (GEM, MicroMegas, µRWELL, TPC)

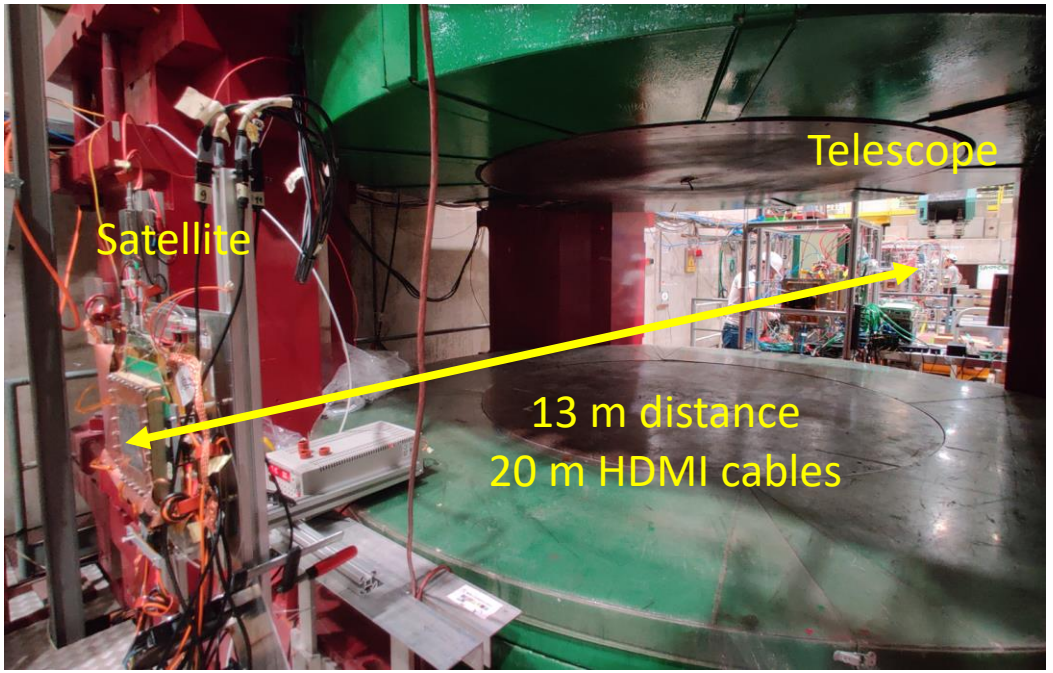


Distributed system

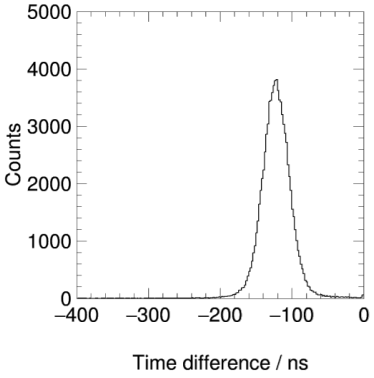
- Use **PBX** (external low-voltage power) for **distributed readout system**
  - Powered with typical 45 W USB-C phone charger
  - See also RD51 CM June 2023
- Long lever-arm telescope (10's of meters length)



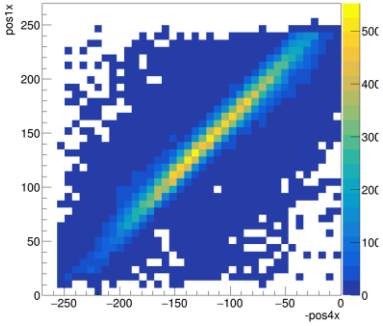




Time correlation satellite telescope



Position correlation satellite telescope



New hardware

Hardware for 2 new telescopes

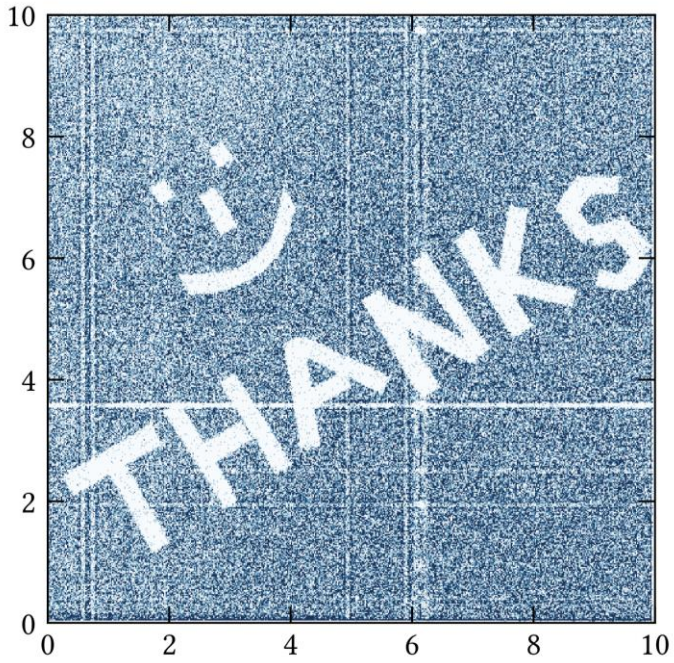
- 48 VMM hybrids V5.2 (128 channels each)
  + 48 HDMI cables
- 5 DVMM adapter cards
- 3 SRS Minicrate 2k
- 4 FECs
- 8 PBX low voltage power-supply
  + 64 PBX power cables
- 2 CTF (1 per telescope)
- 3 µROC (1 per telescope for time reference
  + 1 spare for use in community to test the system)

Delivery of components ongoing (started ~ 2 weeks ago)
They slowly start to pile up in my office

Summary

- CERN EP-DT GDD team received funding from AIDAinnova to acquire **front-end electronics for two new beam telescopes for DRD1** (originally RD51)
  → Hardware available for the community during test beam.
  → Can be shared before beam, to gain experience with the system
- Prototype system has been used by colleagues from INFN Bari, CERN EP-DT gas team, HIP and PSI, as well as within NA61/SHINE
- Costs of development covered by CERN-internal EP R&D programme, Gentner programme and SRS technology, with additional support from ESS

- Documentation:
  - Overview and software: VMM3a/SRS Documentation
  - Hardware: SRS public – Google Drive
  - Tracking with Corryvreckan: ongoing, wait for WG7 session on Thursday afternoon!



for your attention