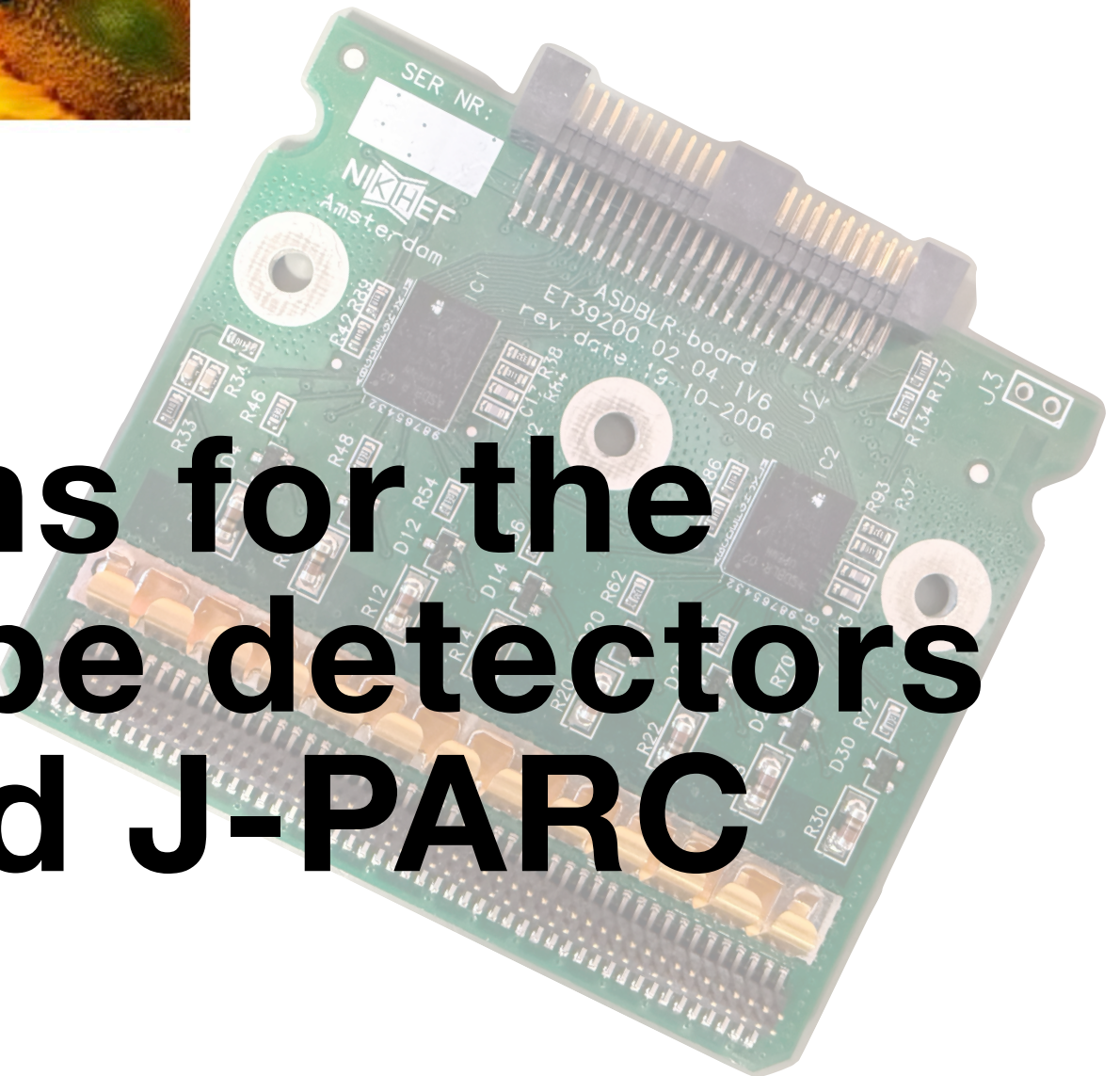


**INTERNATIONAL SUMMER STUDENT
PROGRAM at GSI-FAIR 2026**

July 27 - Sep. 17, 2026



Readout options for the LHCb straw tube detectors at GSI/FAIR and J-PARC



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GSI Summer Student Seminars 2026
September 14, KBW 1.17

1. LHCb Straw Tubes

Donation to PANDA in GSI/FAIR

LHCb sends gift to PANDA

The decommissioned outer tracker of CERN's LHCb experiment embarked on a one-week journey to the FAIR facility in Darmstadt, Germany, where it will be used by the PANDA experiment to study how subatomic particles build up matter

Written by: Sanje Fenkart

05 October, 2023



[CERN News](#)

[GSI News](#)

LHCb sends gift to PANDA



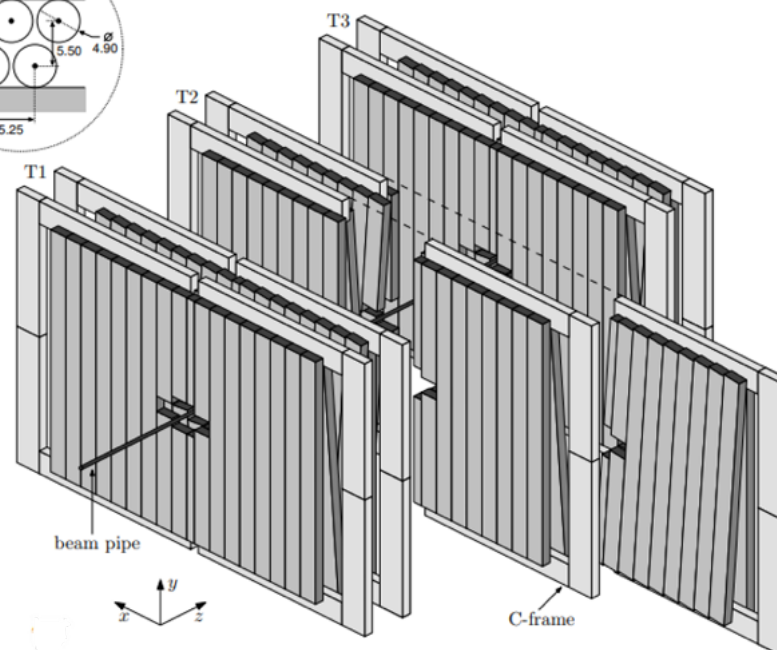
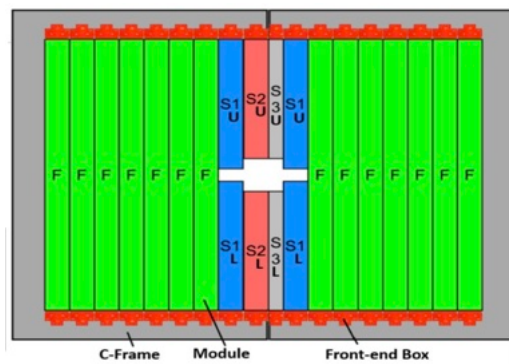
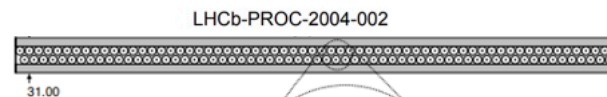
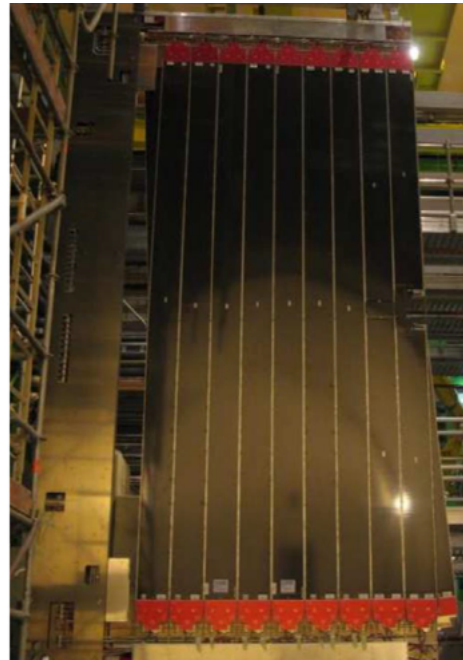
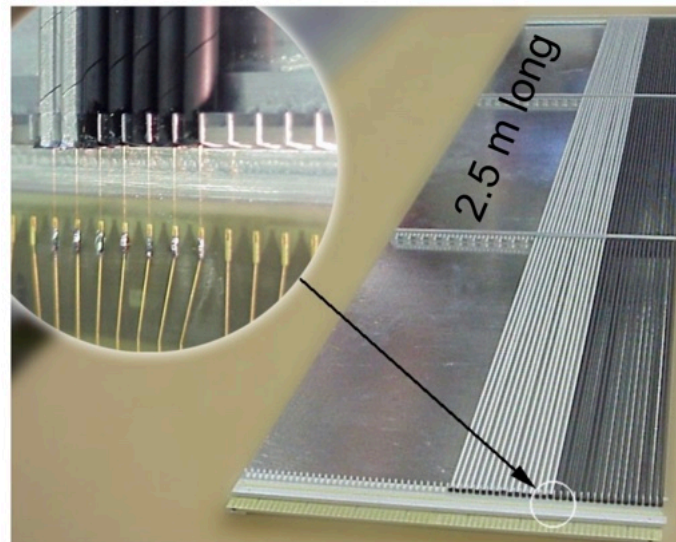
The Outer Tracker has arrived at GSI/FAIR and is being unloaded



11.10.2023 | The decommissioned outer tracker of CERN's LHCb experiment embarked on a one-week journey to FAIR in Darmstadt, Germany, where it will be used by the PANDA experiment to study how subatomic particles build up matter.

1. LHCb Straw Tubes

LHCb Outer Tracker



LHCb Outer Tracker Straw-tube brief specs

Tube elements

- Diameter_(i), length: 4.9mm, 2.5 – 2.3m
- Anode wire: 25μm at 1550 V
- Gas: Ar/CO₂/O₂ (70/28.5/1.5)
- Two staggered layers of 64 tubes (and few 32 tubes, half width)

Module

- Enclosure (5m) has straw tubes in upper (U) and lower (L) parts
- Two staggered layers of 64(32) tubes in each part
- Single sided and independent readout of each part
- Module type S; can be separated into U and L parts
- Module type F; cannot be separated (staggered also in y)

Whole Detector Available @GSI

- **Modules: 216**
- **F-type: 168 , S-type: 48 (or 96 separate U & L parts)**
- **FEE boxes with electronics: 432 for 53,760 straw tubes**
- **C-Frames: 12, mechanics & operations per 2x9 modules**
- **Active area coverage: (5 x 6)m² x12 planes**
- **Mechanic envelope: 6 x 8 m² (per 2 planes)**

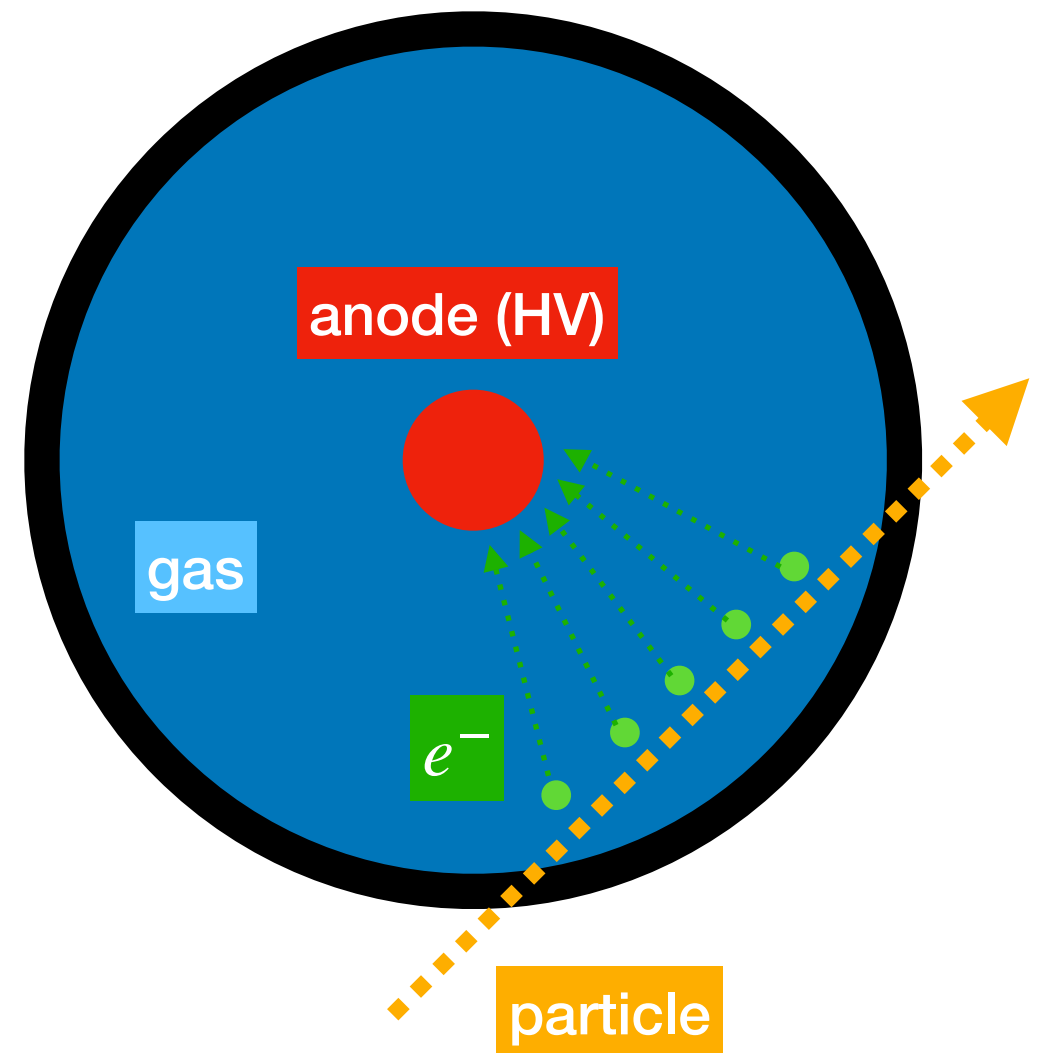
Performance at LHCb (Run1&2)

- $\epsilon \sim 98\%$, $\sigma \sim 170 \mu\text{m}$
- $\delta p/p \sim 0.4\%$ (2-100 GeV tracks)

1. LHCb Straw Tubes

Straw Tube Detectors

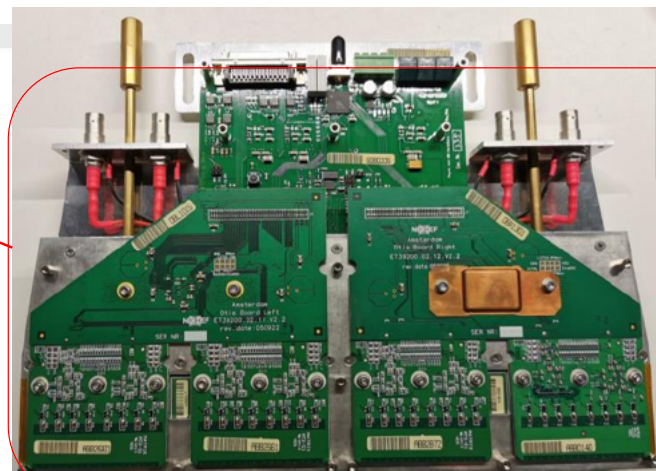
- Each straw tube functions individually as a gaseous drift chamber:
 - particle passes → ionization of gas → electron drift
→ electron avalanche → induced signal
- Expected raw detector signal:
 - sharp leading edge
 - plateau
 - long tail
- We need dedicated electronics to process these signals and pass to DAQ system.



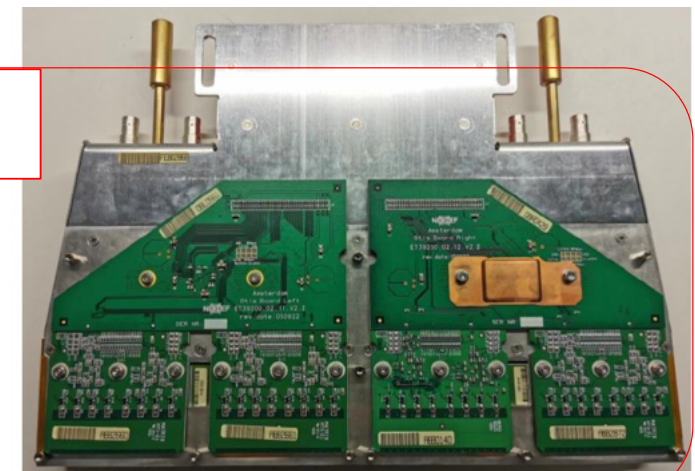
1. LHCb Straw Tubes

Front-End Electronics (FEE)

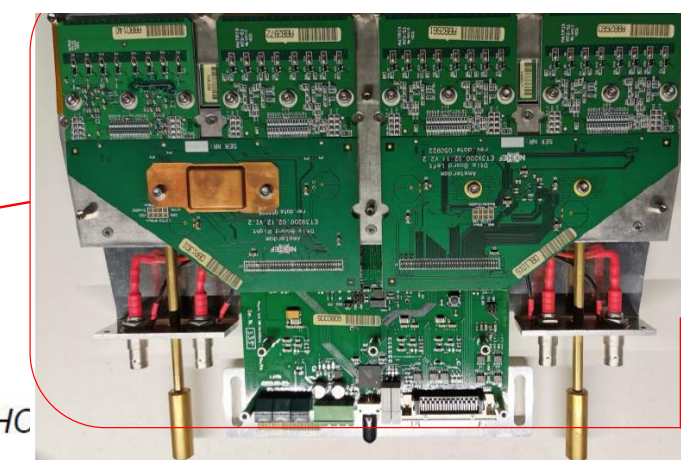
- LHCb OT delivered to GSI consists of original modules in C-frames with all original Front-End Electronics boxes.



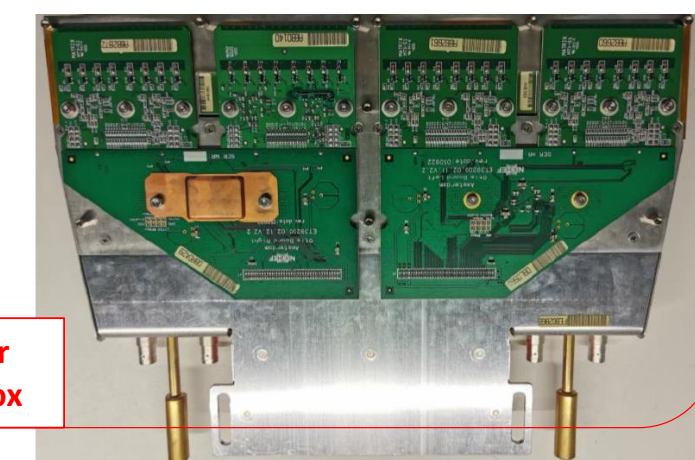
Upper Front - 1st mono-layer 64 straws



Upper Back – 2nd mono-layer 64 straws



Lower Front - 1st mono-layer 64 straws



Lower Back – 2nd mono-layer 64 straws

(middle), FEE Box open (right) (Photos courtesy: LHC)

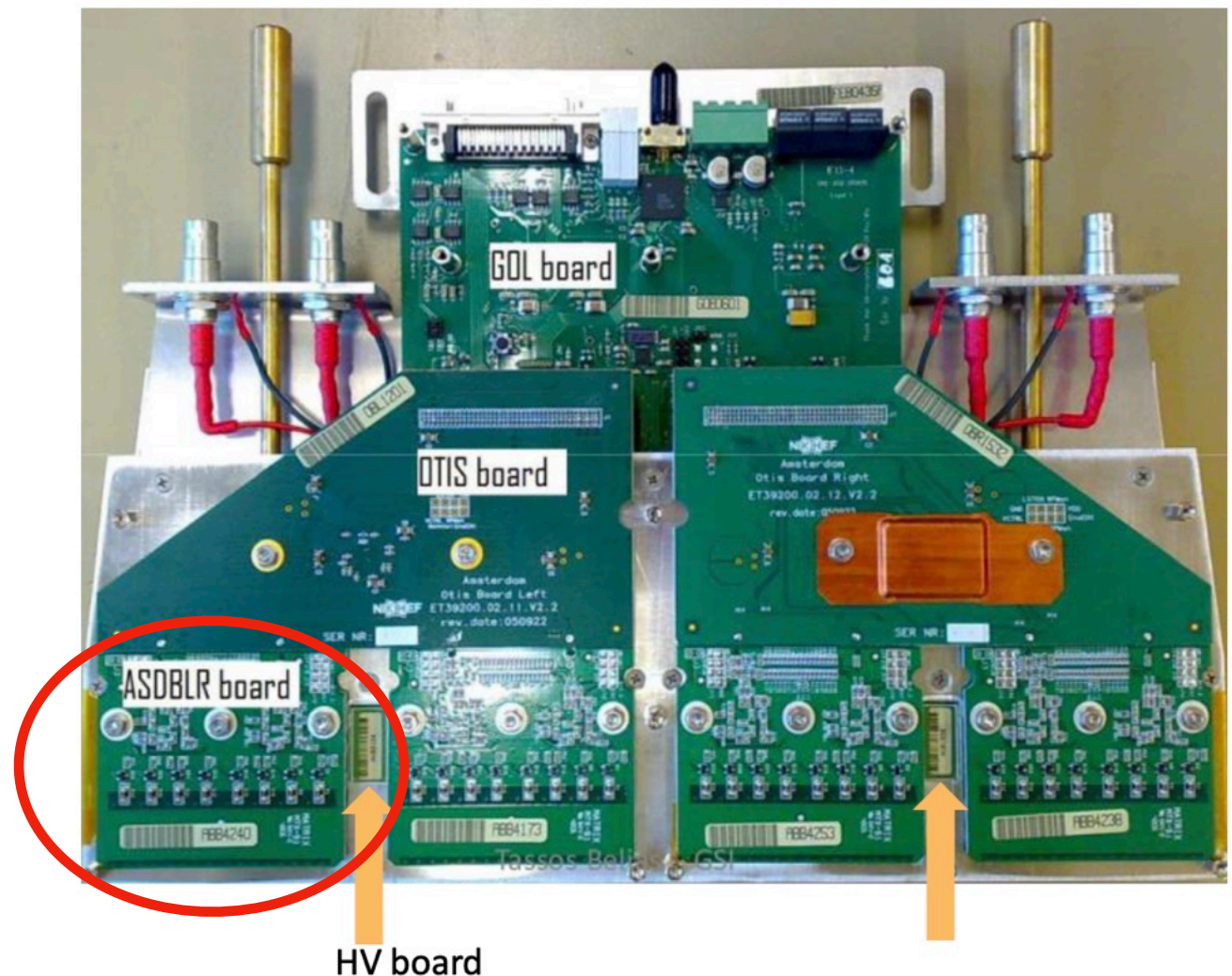
1. LHCb Straw Tubes

Front-End Electronics (FEE)

- Each FEE component serves a different function.
- In this work, we keep original HV and ASDBLR boards.

- GOL (1 board)
 - Transfer of data of 128 channels (+headers) via optical fiber at 1.6Gb/s
- OTIS time-to-digital converter (4 boards)
 - 25ns LHC bunch clock (BX) into 64 TDC bins
 - incorporate up to three BX
- ASDBLR amplifier (8 boards)
 - 2 ASDBLR ASIC /board, 8 channels /ASIC
 - discriminate signal against threshold
 - high speed through elimination of long ion tail by shaping and baseline restoring of signal
 - low noise through differential logic swing
 - low threshold => *good efficiency & resolution*
- HV circuit board (4 boards)
 - 330 pF capacitors decouple signal from HV
 - embedded capacitors reduce leakage currents

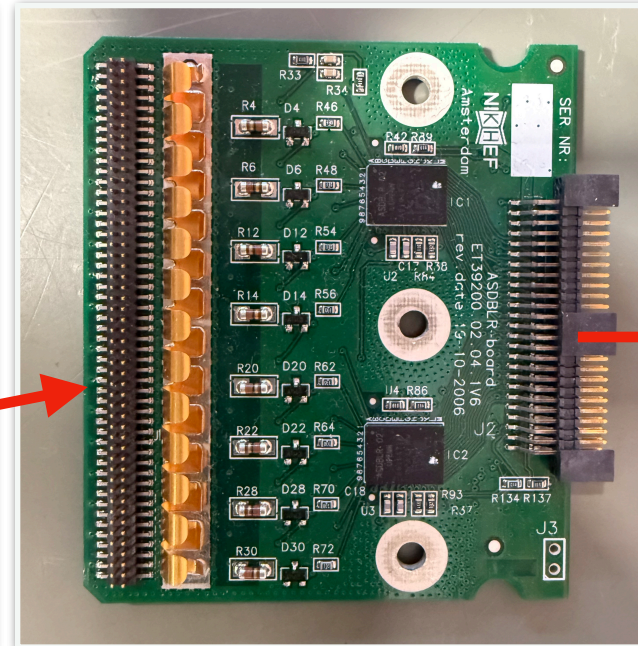
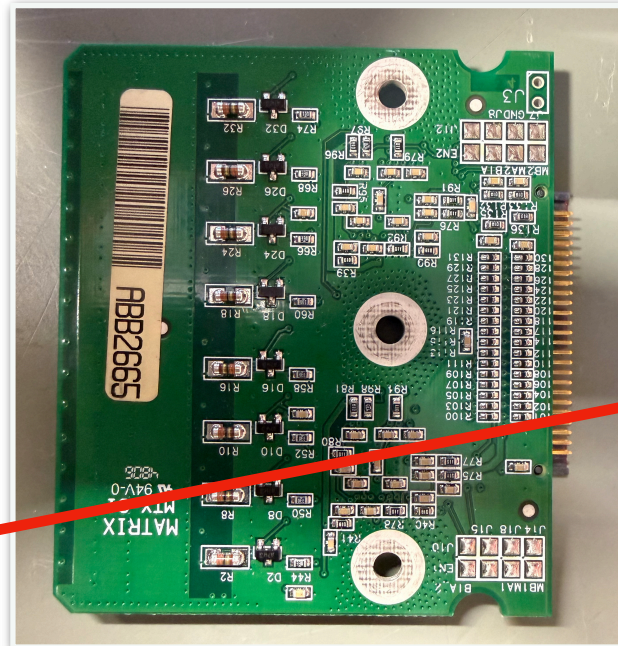
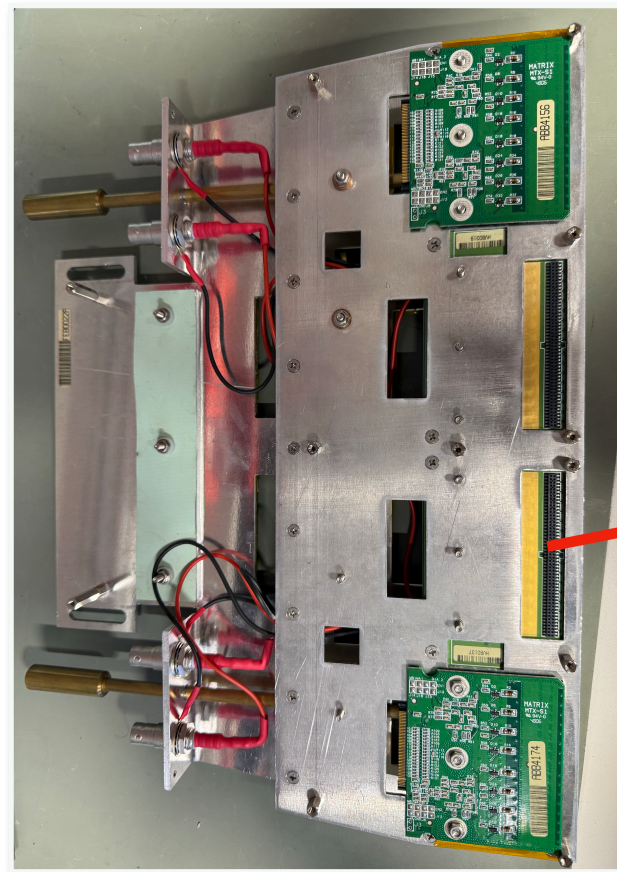
FEE box: Boards on front side



1. LHCb Straw Tubes

ASDBLR ASIC Board

- Output connector: power supply, GND, 8-channel differential signals, TST (test pulse input), THR_D (threshold setting), TempMon



Pin Nr	Signal	Pin Nr	Signal
J2-1	+3V	J2-2	+3V
J2-3	GND	J2-4	GND
J2-5	-3V	J2-6	-3V
J2-7	GND	J2-8	GND
J2-9	TRN1-1	J2-10	TRP1-1
J2-11	TRN2-1	J2-12	TRP2-1
J2-13	TRN3-1	J2-14	TRP3-1
J2-15	TRN4-1	J2-16	TRP4-1
J2-17	TRN5-1	J2-18	TRP5-1
J2-19	TRN6-1	J2-20	TRP6-1
J2-21	TRN7-1	J2-22	TRP7-1
J2-23	TRN8-1	J2-24	TRP8-1
J2-25	TRN1-2	J2-27	TRP1-2
J2-27	TRN2-2	J2-28	TRP2-2
J2-29	TRN3-2	J2-30	TRP3-2
J2-31	TRN4-2	J2-32	TRP4-2
J2-33	TRN5-2	J2-34	TRP5-2
J2-35	TRN6-2	J2-36	TRP6-2
J2-37	TRN7-2	J2-38	TRP7-2
J2-39	TRN8-2	J2-40	TRP8-2
J2-41	GND	J2-42	GND
J2-43	TST_E	J2-44	TST_O
J2-45	THR_D-1	J2-46	THR_D-2
J2-47	TempMonR	J2-48	TempMonRet
J2-49	GND	J2-50	GND

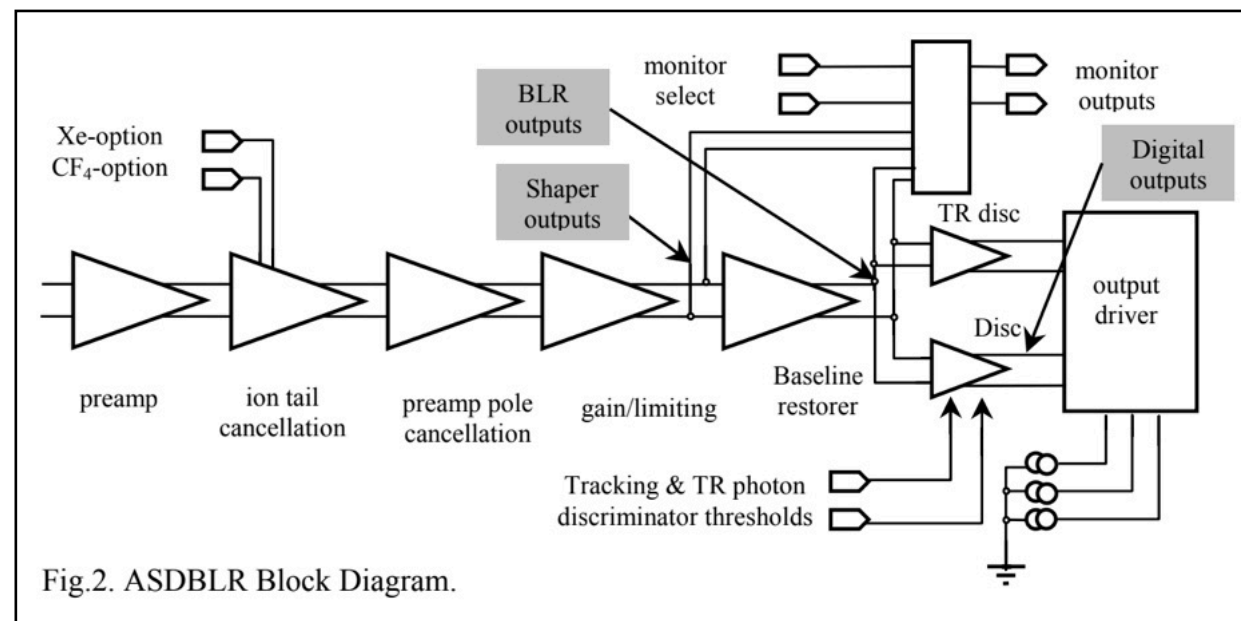
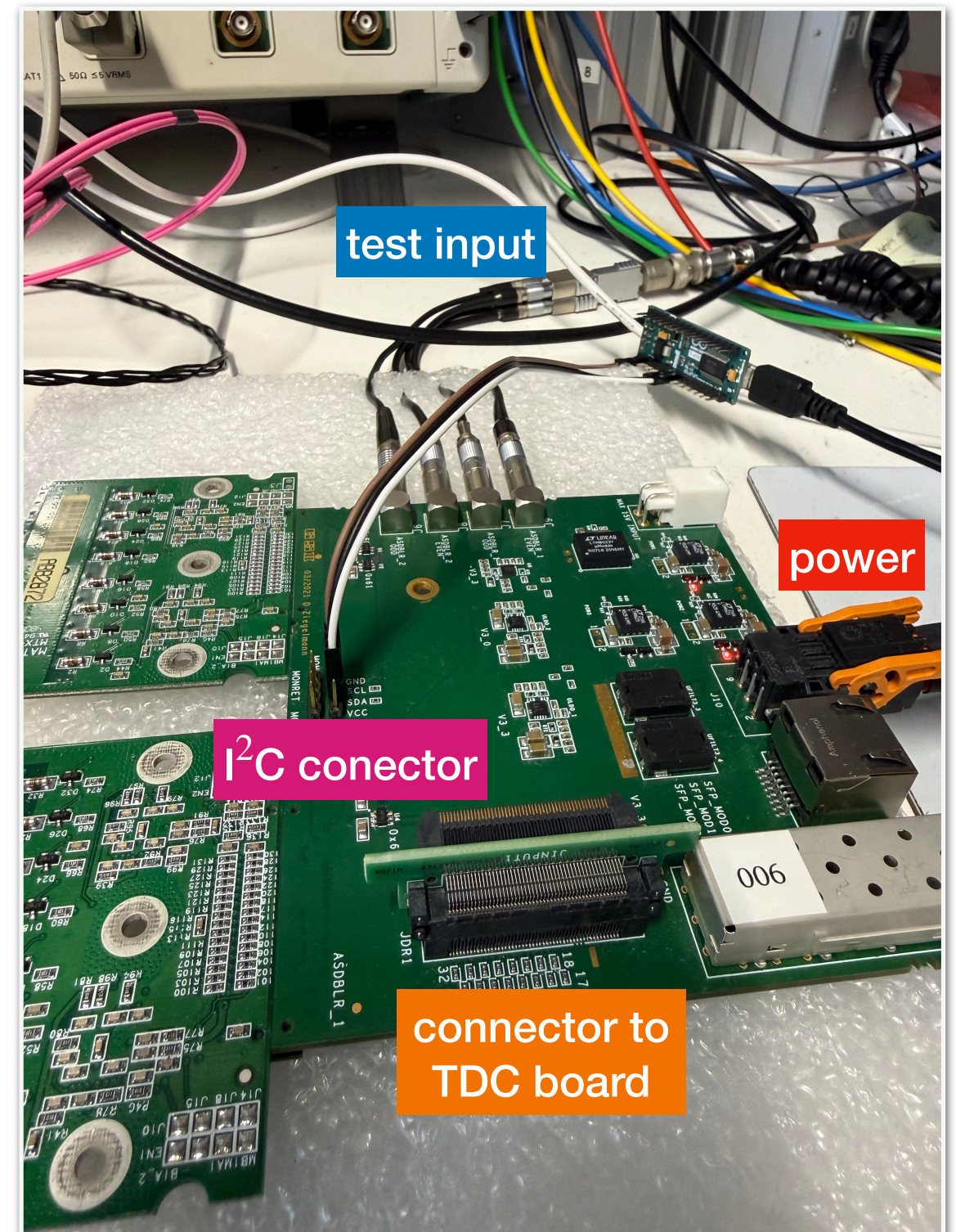
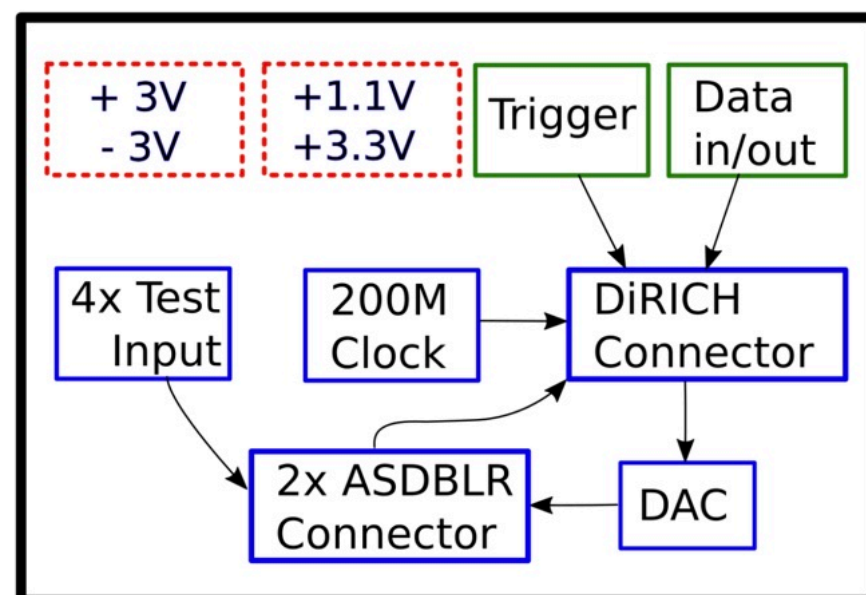


Fig.2. ASDBLR Block Diagram.

1. LHCb Straw Tubes

Interface Board to TDC

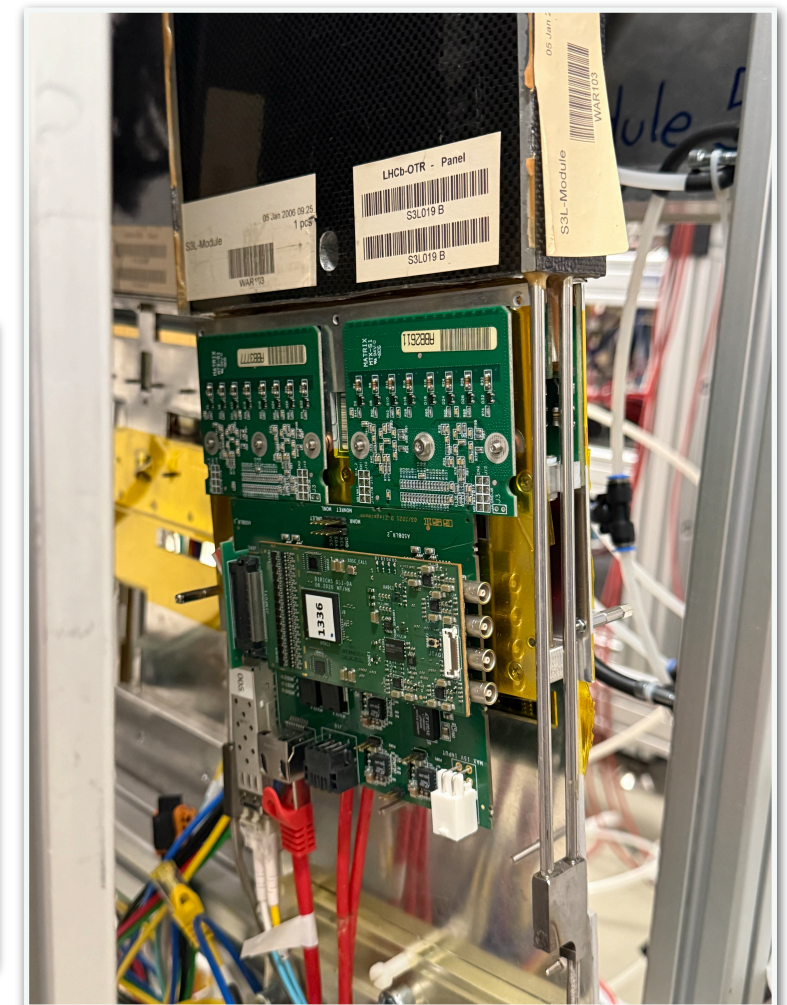
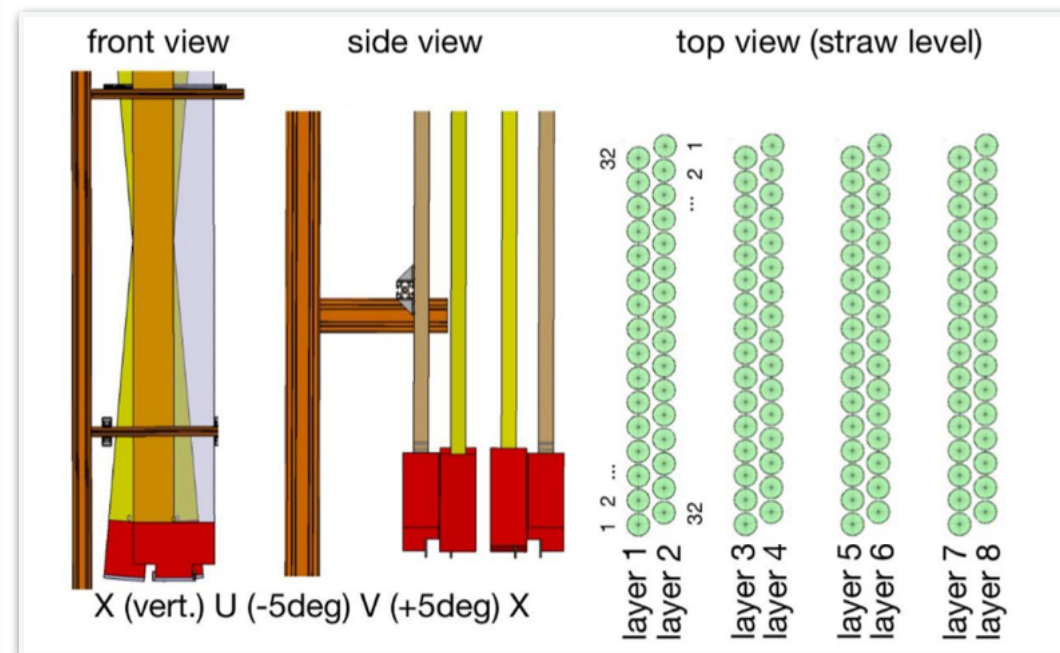
- An interface board has been developed to connect the ASDBLR to a TDC board.
- It also provides additional functionalities:
 - supply low-voltage power
 - input test signals
 - allow DAC programming for threshold settings



2. Readout Options

I. PASTA @ mini-CBM

- One main development of reused straw tubes at GSI is the PASTA (PANDA Straws) setup at the mini-CBM used during the beamtimes in 2025.

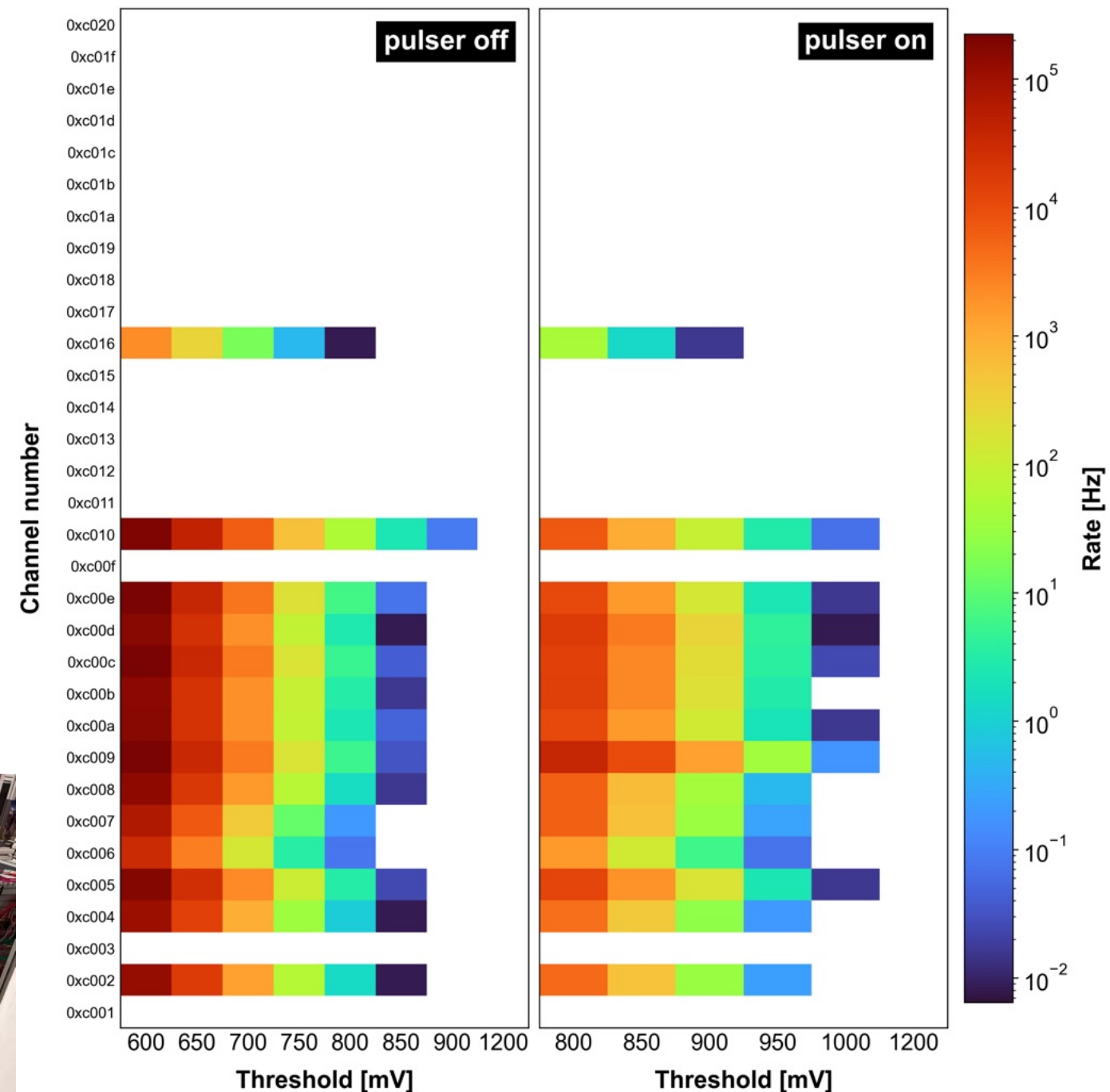
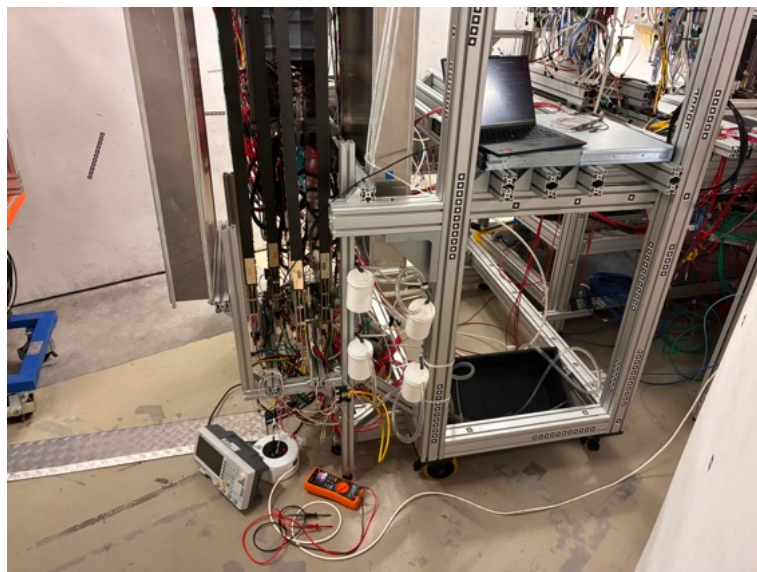


*More info about using Straw Tubes in CBM MUST
→ Sofia L's talk tomorrow!*

2. Readout Options

I. PASTA @ mini-CBM

- Basic operational check of a single layer by conducting a threshold scan, while monitoring the hit rates recorded by the DiRICH TDC.
- We also connect a pulser as test input:
 - amplitude of 800 mVpp
 - pulse width of 140 ns
 - rise time of 20 ns
 - fall time of 40 ns

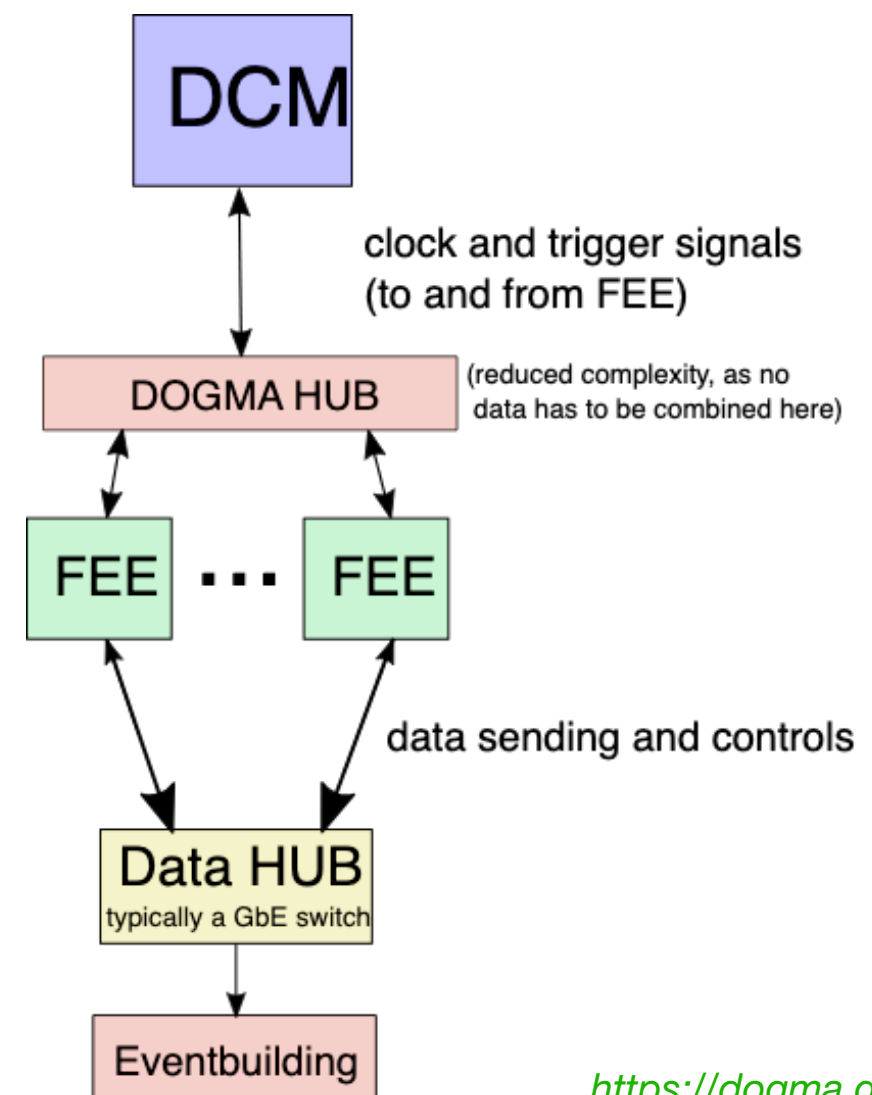
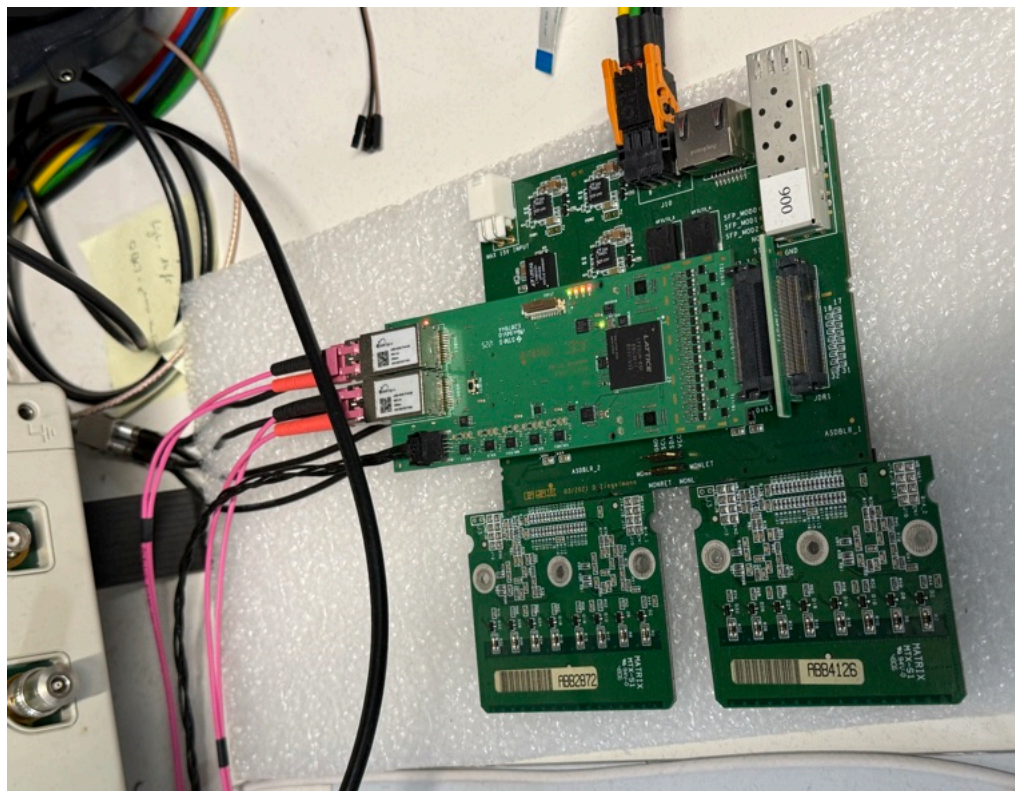


*More PASTA Results
→ Sofian S' talk tomorrow!*

2. Readout Options

II. DOGMA @ GSI/FAIR

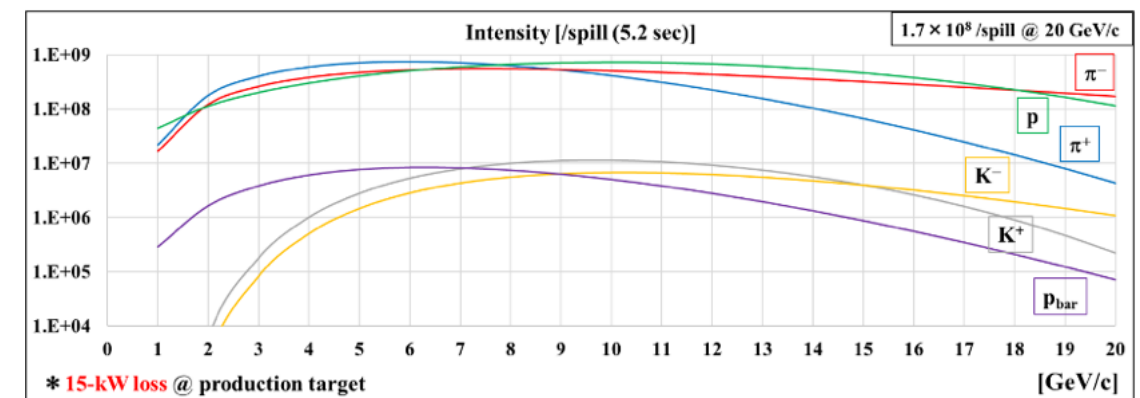
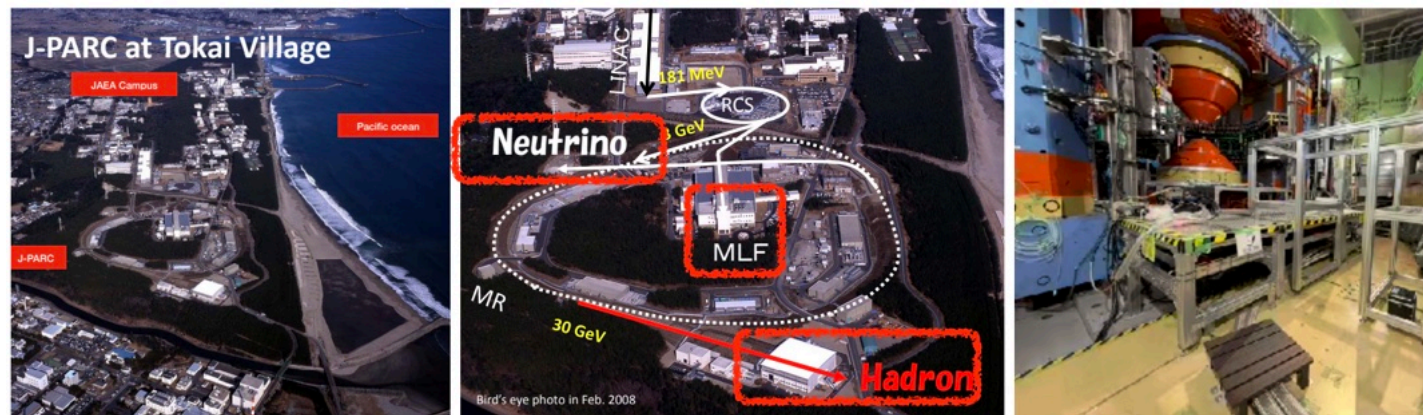
- Next-generation DAQ system currently being developed at GSI for more demanding requirements of future experiments at FAIR such as CBM and PANDA
- Higher beam intensities and complex detector systems will require scalable and reliable DAQ.
- DOGMA separates the precise distribution of timing, synchronization, and control signals from the high-bandwidth detector data



2. Readout Options

III. MARQ @ J-PARC

12

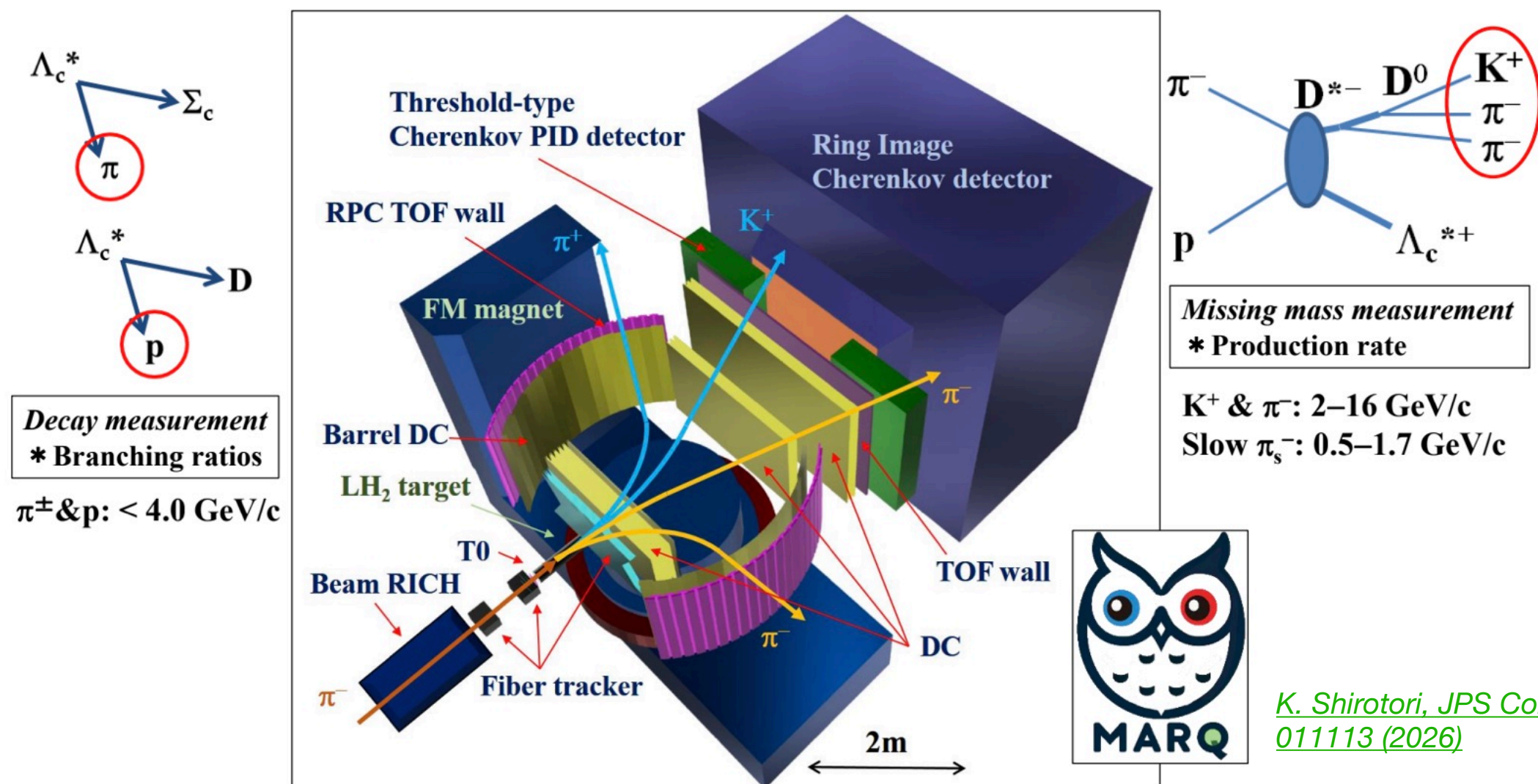


Experiments	Beam	Momentum [GeV/c]
[E50] Charm Baryon Spectroscopy	π^-	20
[E97] Ξ Baryon Spectroscopy	K^-	5-8
[P85] Ω Baryon Spectroscopy	K^-	7-10
[E79] Non-strange Dibaryon Search	p	2.85-4.0
[E95] ϕN Interaction Study	π^-	1.6-2.4
⋮	⋮	⋮

2. Readout Options

III. MARQ @ J-PARC

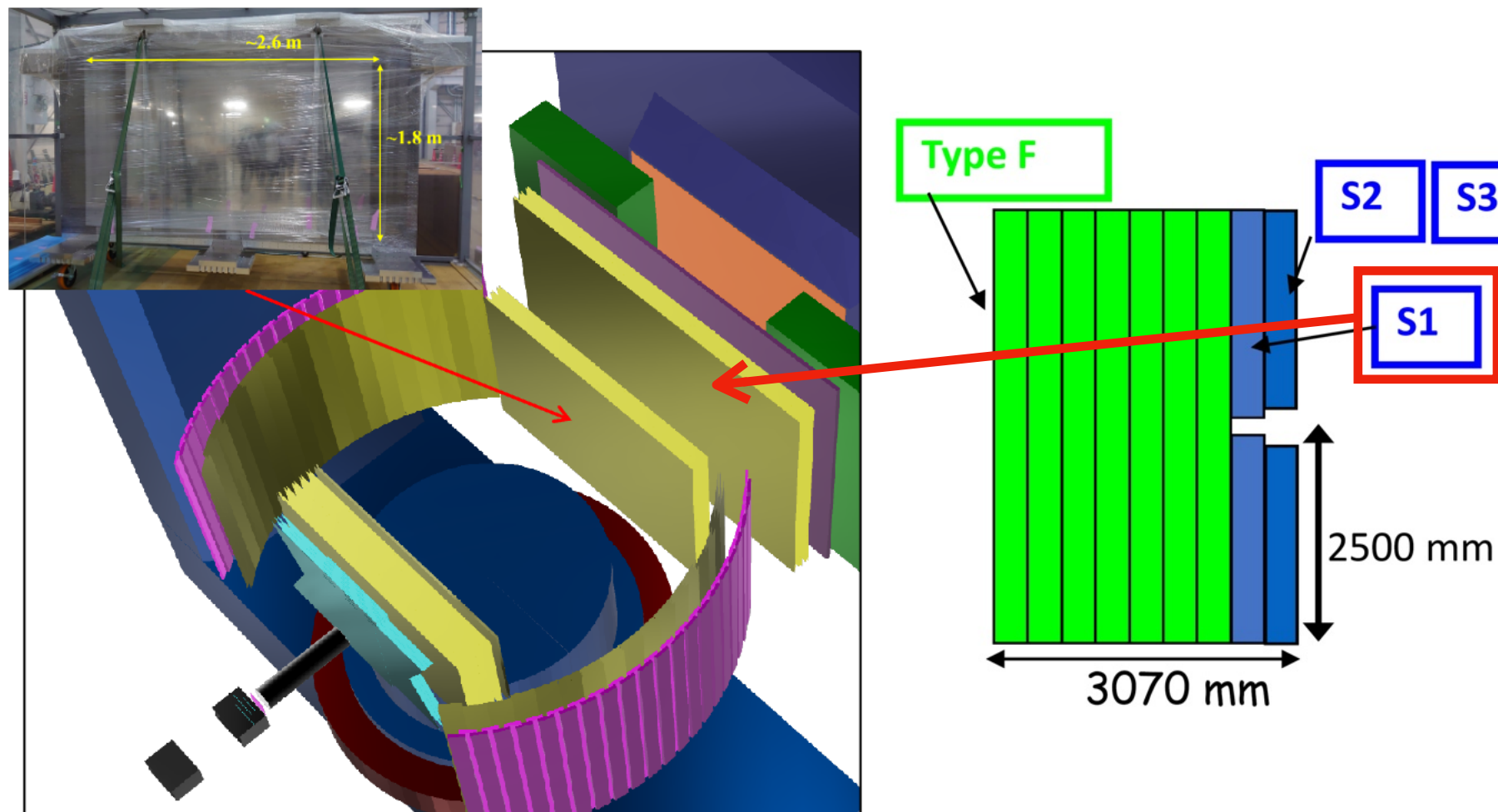
- **M**ultipurpose **A**nalyzer for **R**esonance and **Q**uark dynamics
- For experiments at the J-PARC $\pi 20$ high-intensity high-momentum beam line
- Consists of beam detectors and scattered particle detectors (tracking, PID)



2. Readout Options

III. MARQ @ J-PARC

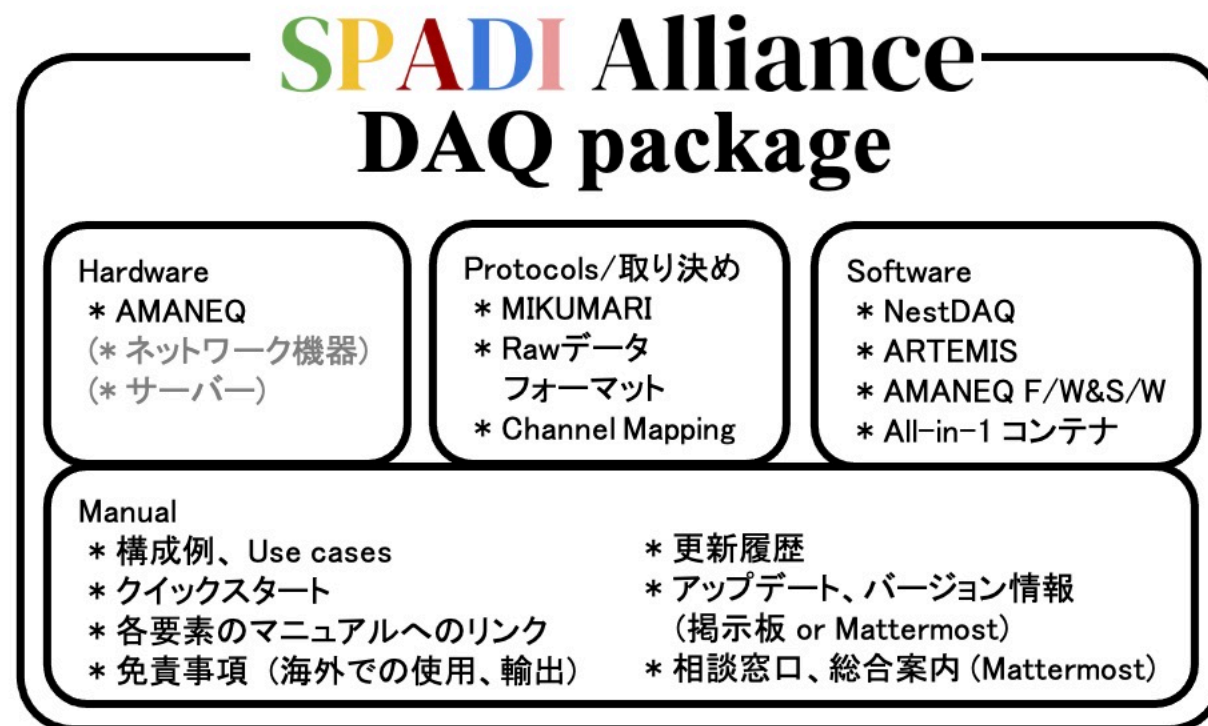
- Magnet downstream trackers: existing LDC + **STT from OT**
- Available Type S1 modules (2.6 m X 1.8 m) can be rearranged to cover acceptance region. 3 stagger layers (6 layers) (X, U(+5°), V(-5°)).



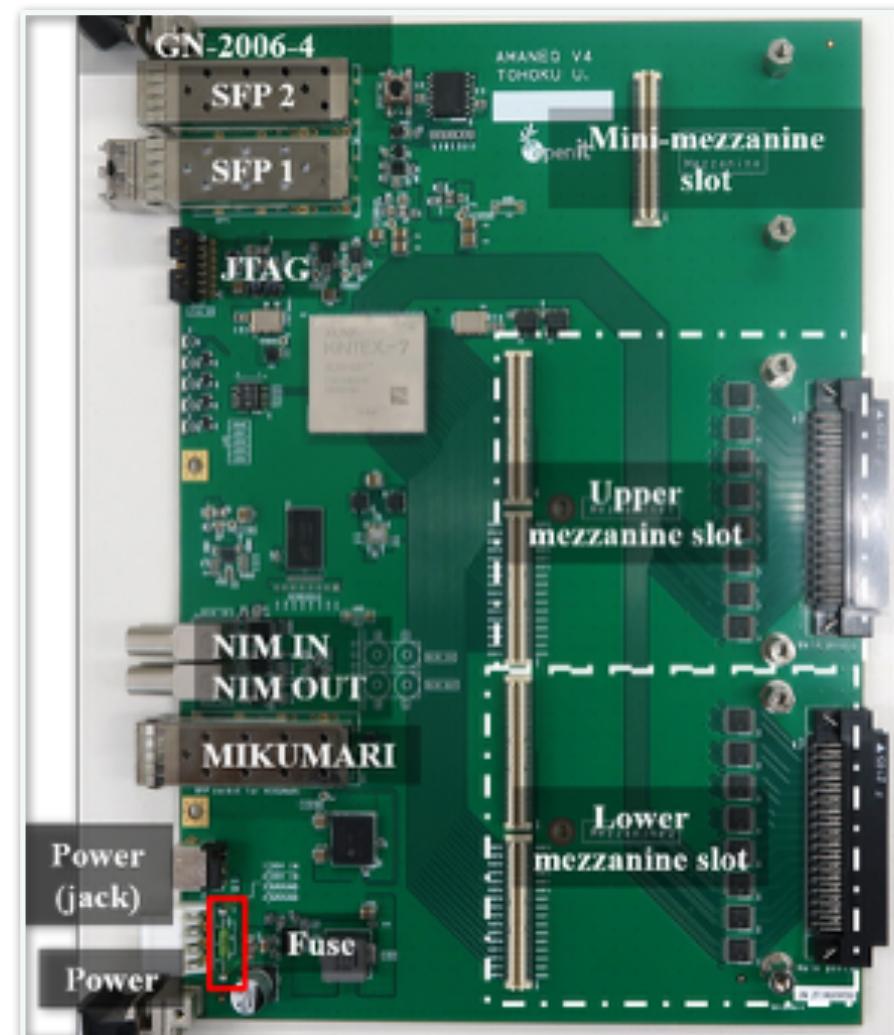
2. Readout Options

III. MARQ @ J-PARC

- MARQ DAQ System using SPADI Alliance System
- Connect to AMANEQ TDC Board (64 channels)
 - FPGA-based electronics module that provides time synchronization and TDC for continuous detector readout, with data transmission performed through high-speed Ethernet.



<https://www.rcnp.osaka-u.ac.jp/~spadi/wiki/>



<https://spadi-alliance.rcnp.osaka-u.ac.jp/ug-amaneq/>

3. Front-End Signals

ASDBLR Signal Chain

- We investigated the signal processing chain of the ASDBLR.

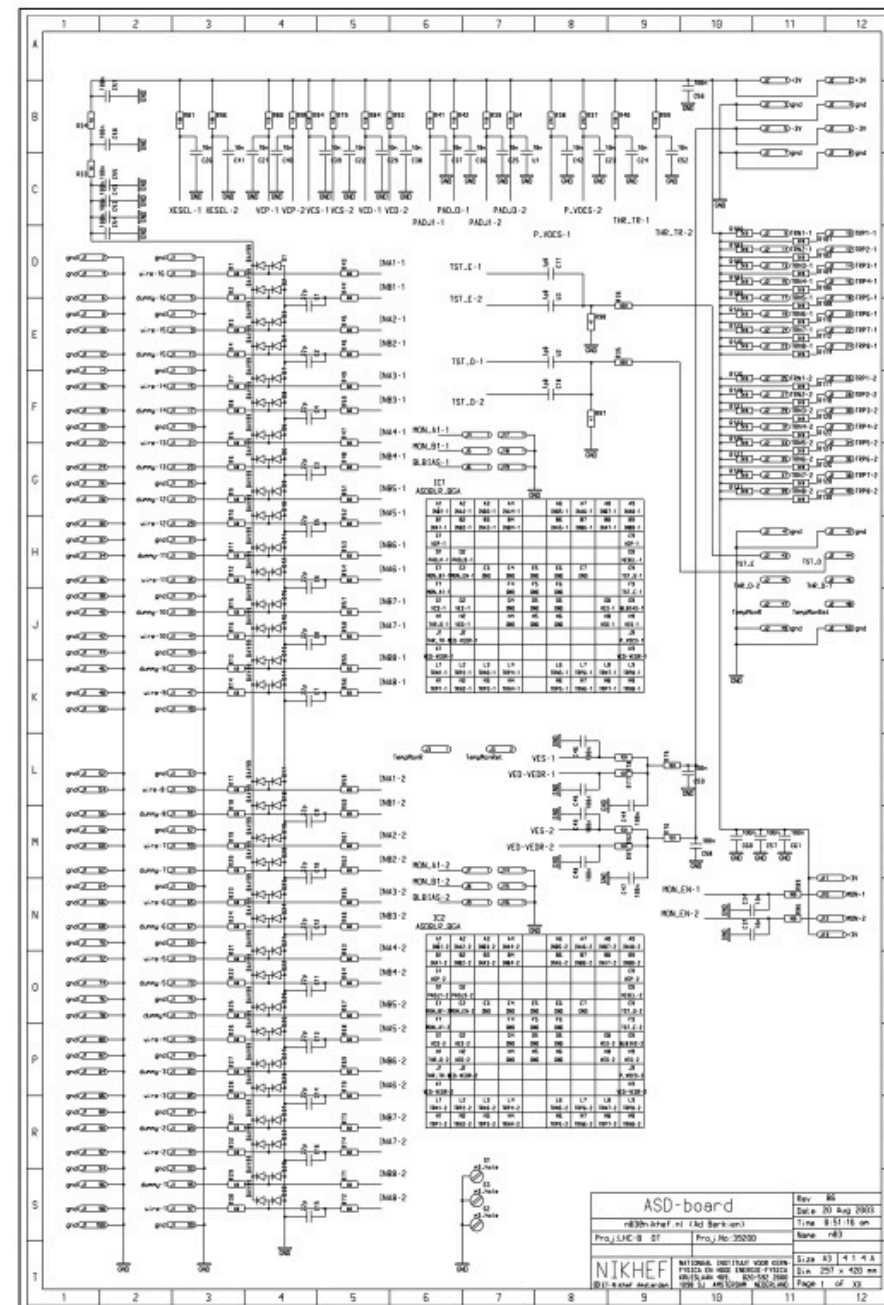
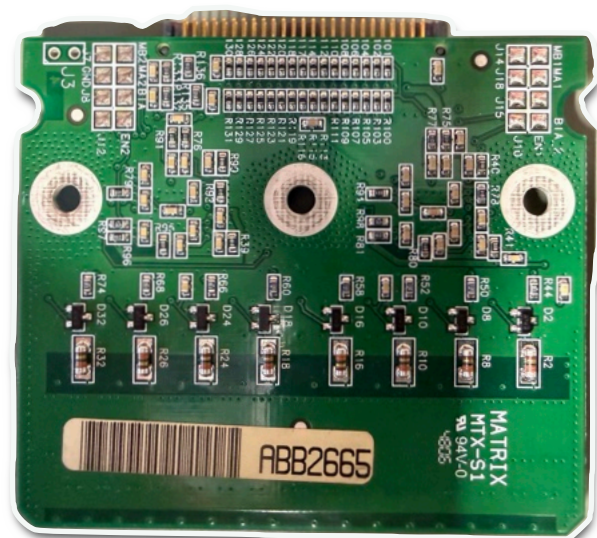
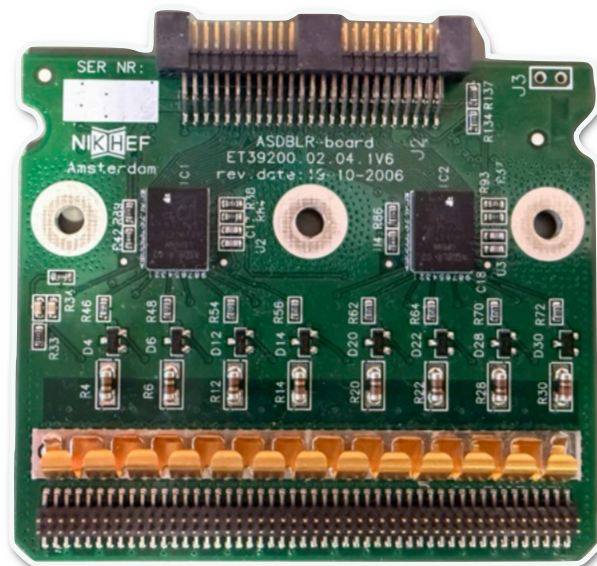


Figure 11: ASDBLR Board Schematics.

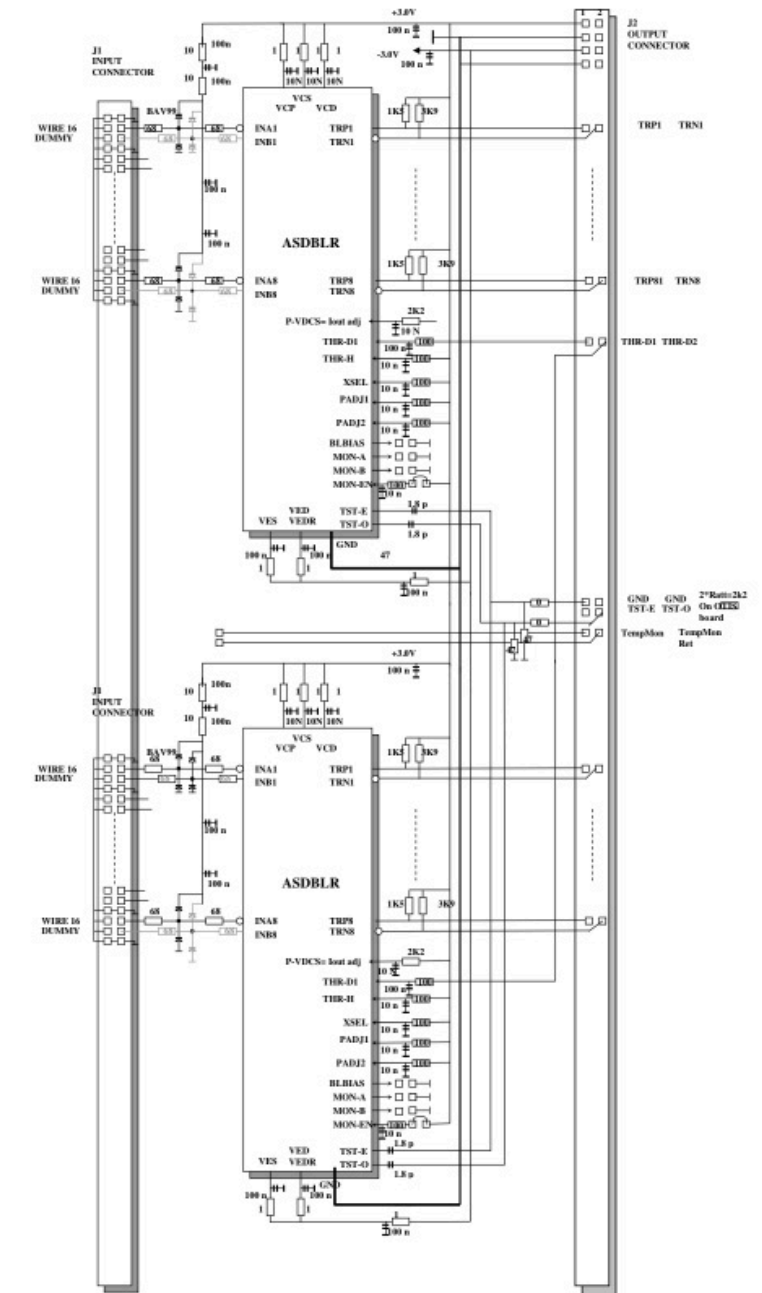


Figure 3: Functional Diagram of the ASDBLR Board.

from LHCb Technical Note

3. Front-End Signals

ASDBLR Signal Chain

- Our aim is to compare actual measured signals with expectations from past works.

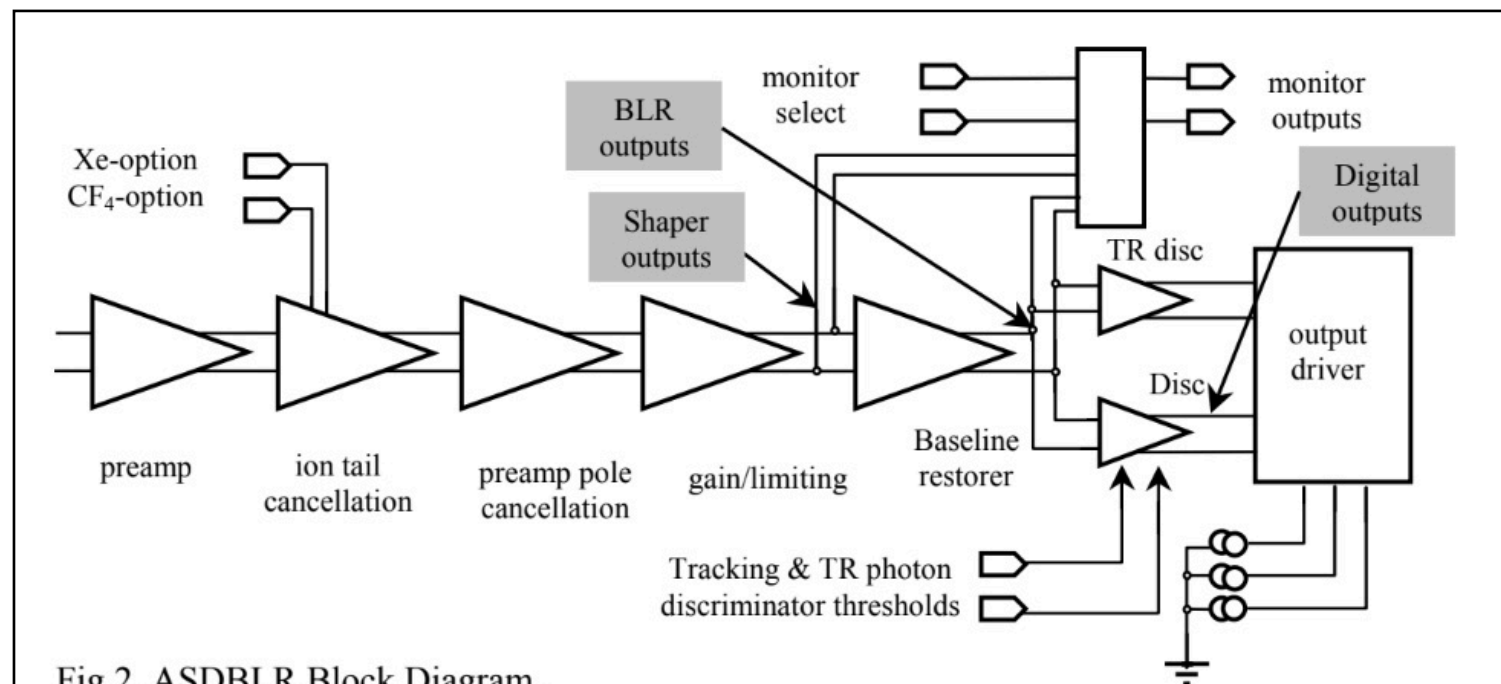


Fig.2. ASDBLR Block Diagram.

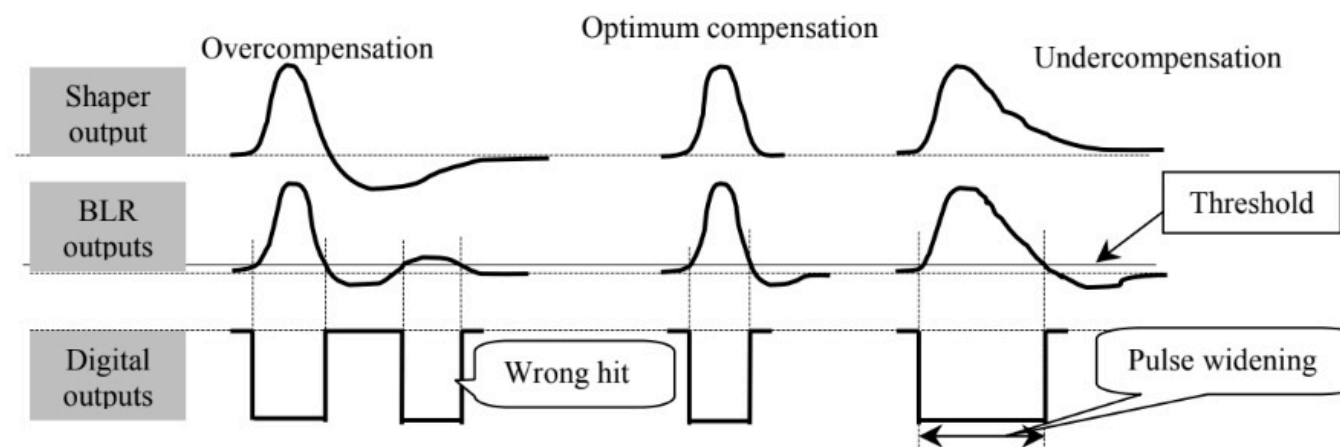
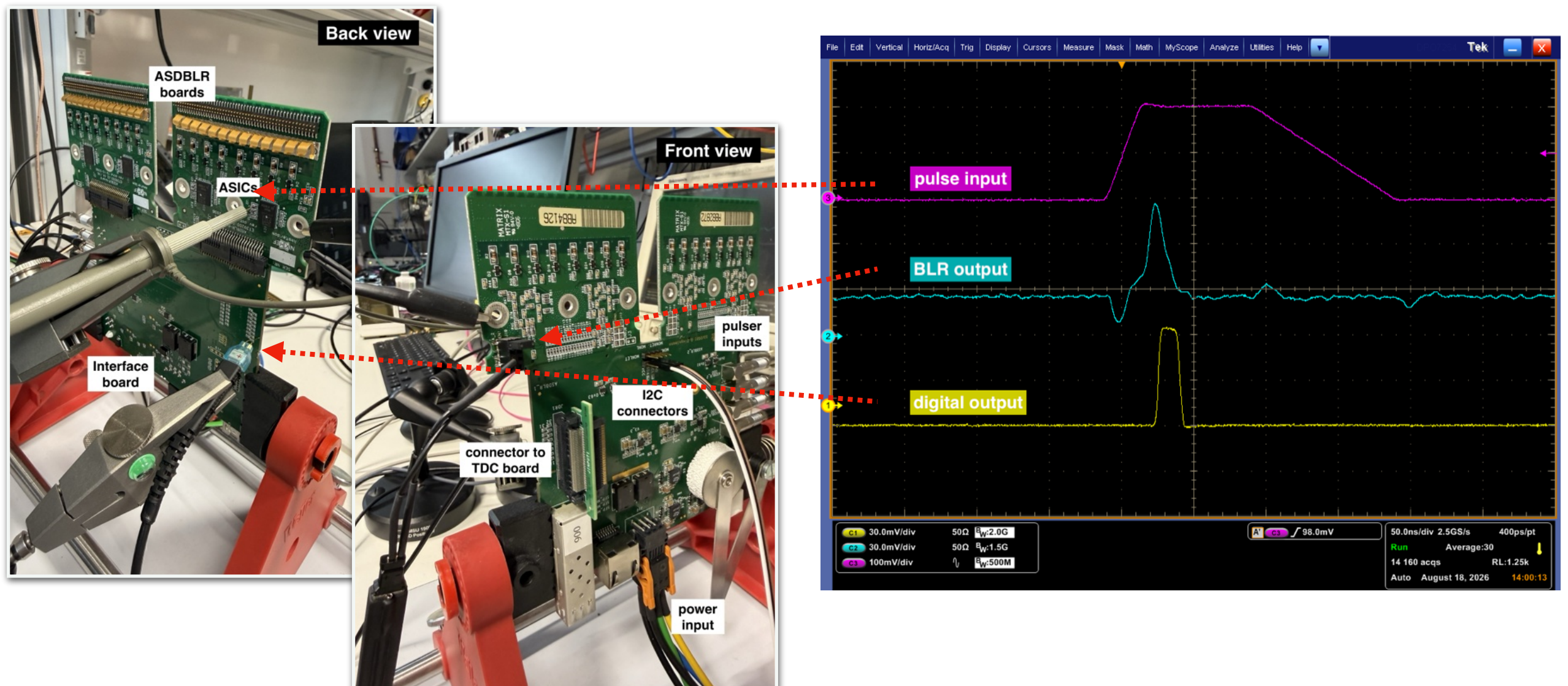


Fig.3. Example of some effects due to incorrect ion tail compensation .

3. Front-End Signals

ASDBLR Signal Chain

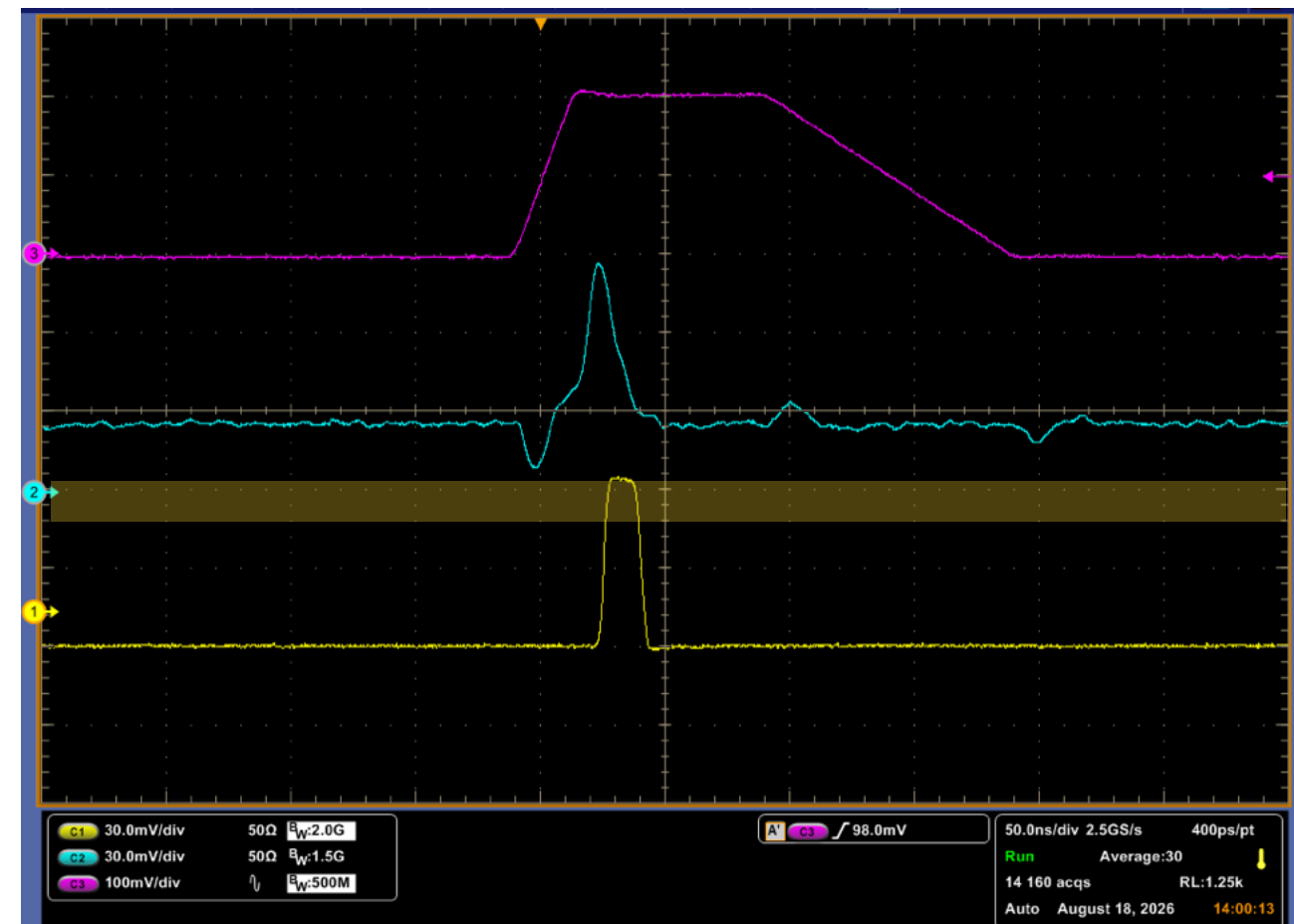
- Probes were used to measure signals from different points on both the ASDBLR and Interface Boards.
- The ASIC threshold was set to 720 mV for this measurement, corresponding to an injected charge of approximately 3 fC.



3. Front-End Signals

Threshold Study

- We performed threshold scans while monitoring the ASDBLR digital output.
- Test signals were generated using a pulser
 - 250 kHz in burst mode
 - 500 cycles delivered over a 2 ms interval
- The oscilloscope was configured with a mask consisting of a 7 mV window around the expected signal peaks.
- The full acquisition window was set to $200\mu\text{s}/\text{div}$ over 10 divisions, corresponding to a total observation time of 2 ms. The waveform measurement was repeated 100 times, resulting in a total of 50,000 injected pulses.

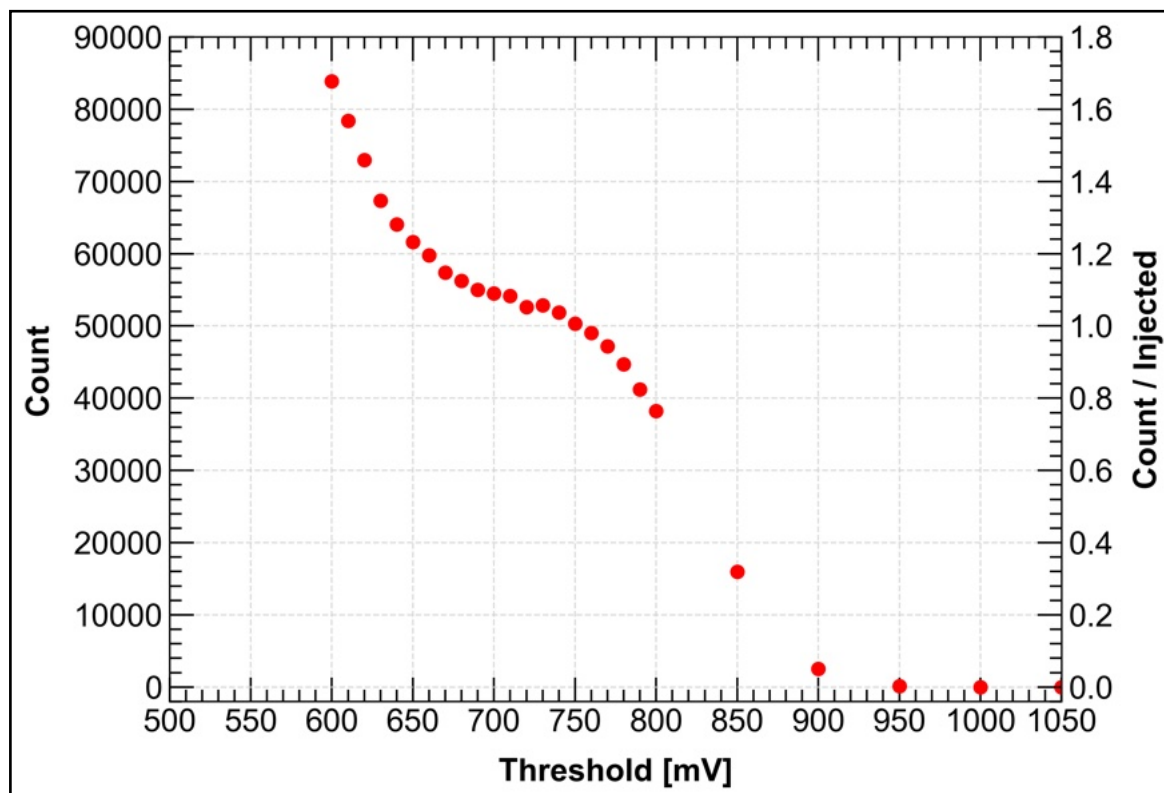


3. Front-End Signals

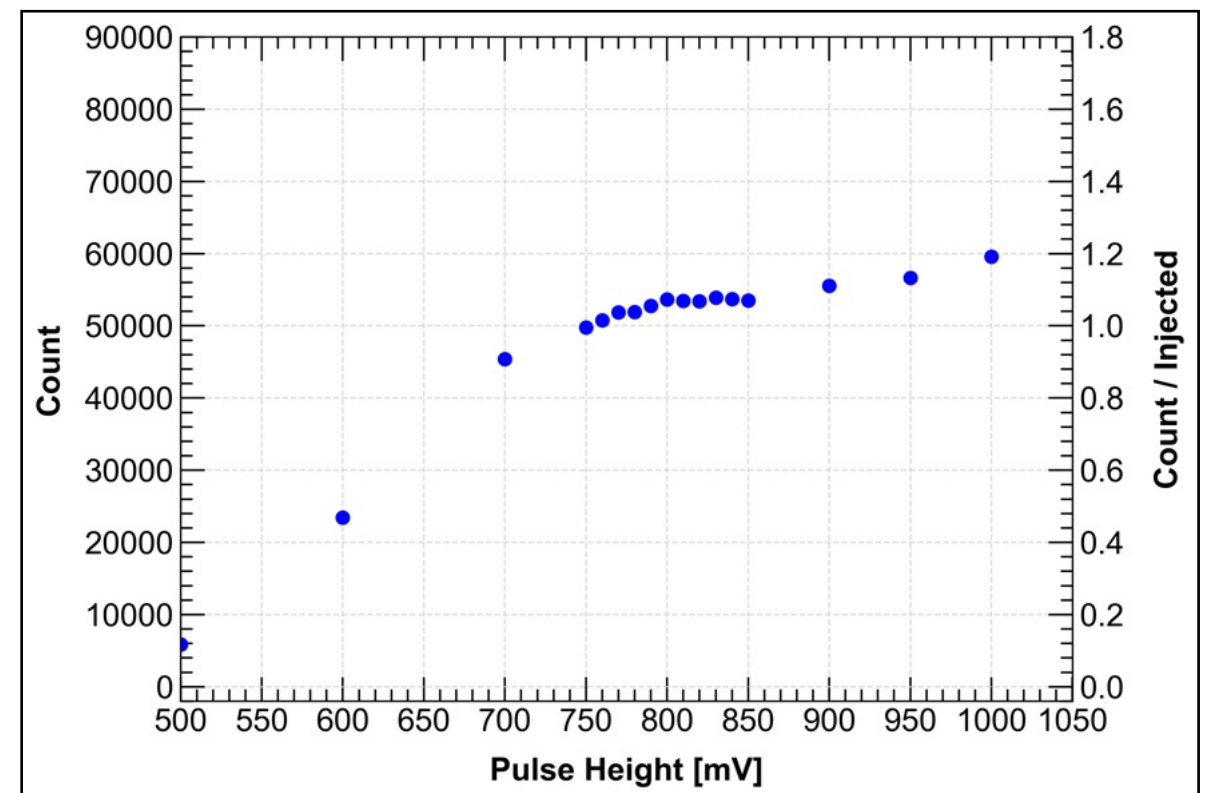
Threshold Study

- Increasing the ASIC threshold reduces the number of detected peaks, whereas increasing the input pulse amplitude results in a higher number of detected peaks.
- However, at low threshold settings and high input pulse amplitudes, the measured peak-to-pulse ratio exceeds unity.

constant pulser 800 mVpp



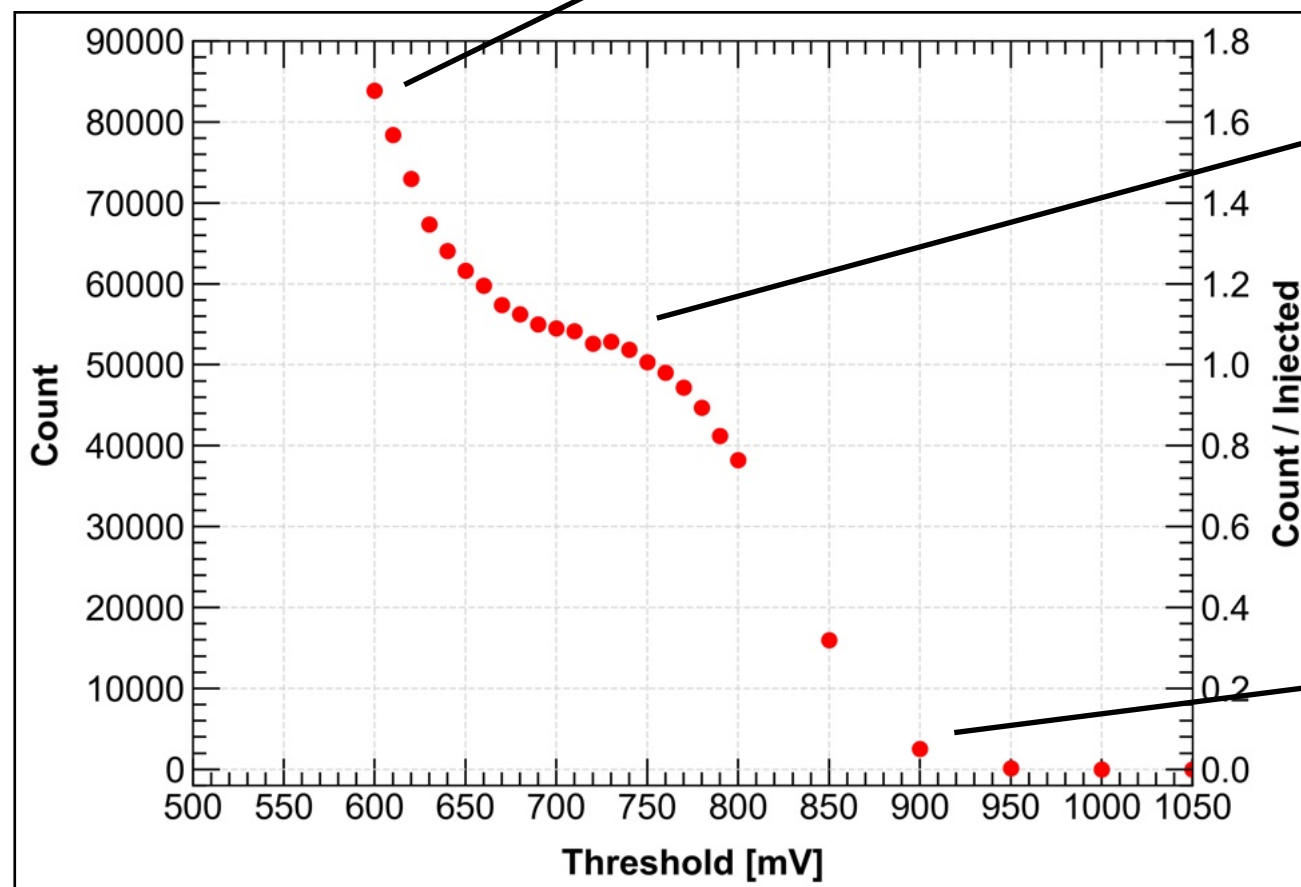
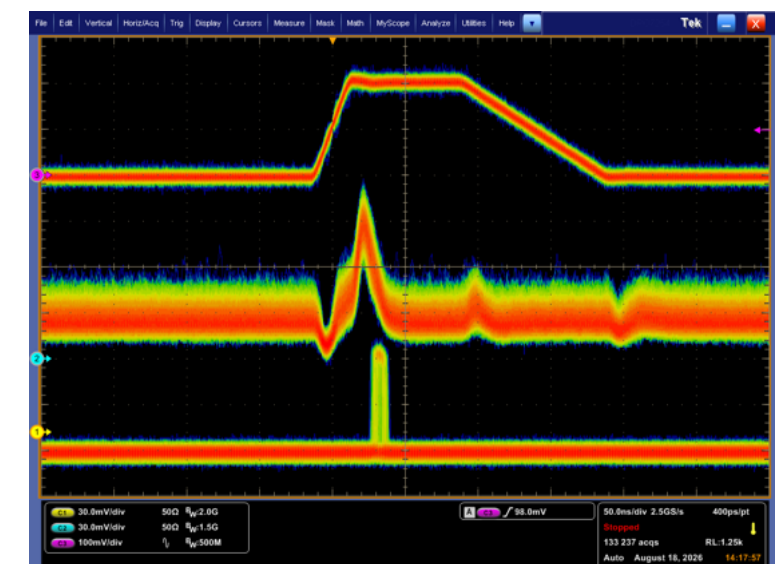
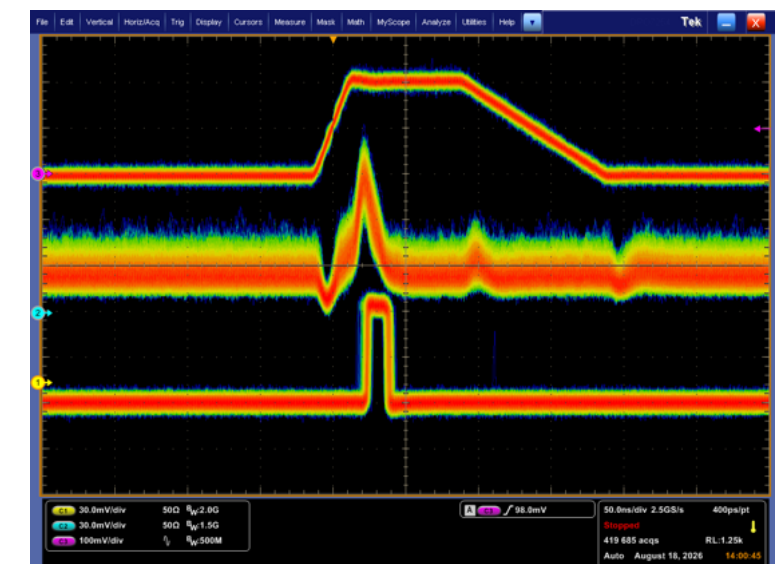
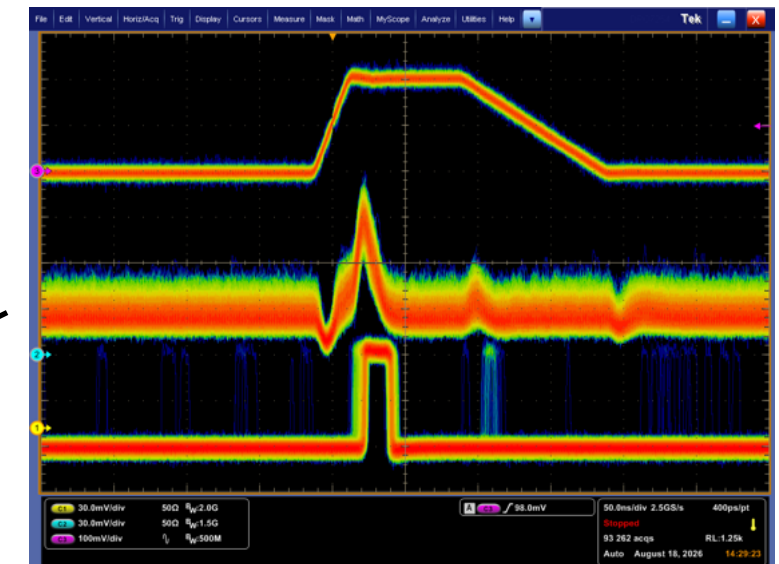
constant threshold 720 mV



3. Front-End Signals

Threshold Study

- This behavior was traced to the appearance of anomalous secondary peaks near the falling edge of the output waveform.
- These additional peaks may originate from imperfections in the signal-processing circuitry or other effects in the readout chain and require further investigation.

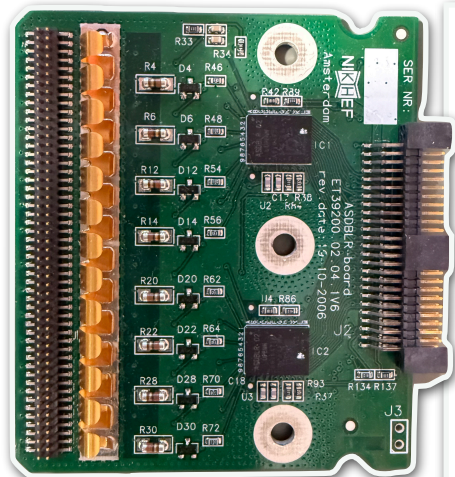


4. Conclusion and Outlook

Characterization of the ASDBLR

- The existing ASDBLR-based front-end electronics were successfully investigated through threshold scans and oscilloscope measurements, demonstrating the expected discriminator response and providing insight into the operational range of the ASIC.
- Future work will focus on developing suitable interface electronics for integration with the other readout systems.

ASDBLR



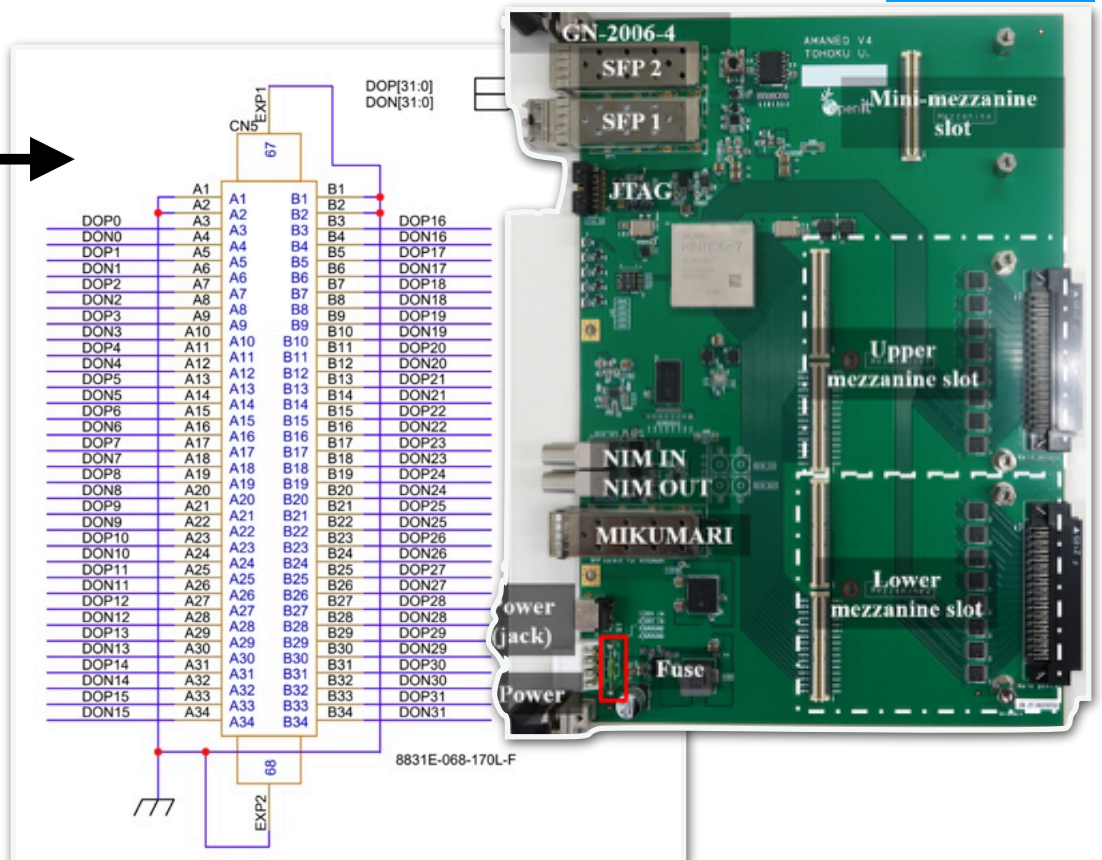
Pin Nr	Signal	Pin Nr	Signal
J2-1	+3V	J2-2	+3V
J2-3	GND	J2-4	GND
J2-5	-3V	J2-6	-3V
J2-7	GND	J2-8	GND
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J2-23	TRN8-1	J2-24	TRP8-1
J2-25	TRN1-2	J2-27	TRP1-2
J2-27	TRN2-2	J2-28	TRP2-2
J2-29	TRN3-2	J2-30	TRP3-2
J2-31	TRN4-2	J2-32	TRP4-2
J2-33	TRN5-2	J2-34	TRP5-2
J2-35	TRN6-2	J2-36	TRP6-2
J2-37	TRN7-2	J2-38	TRP7-2
J2-39	TRN8-2	J2-40	TRP8-2
J2-41	GND	J2-42	GND
J2-43	TST_E	J2-44	TST_O
J2-45	THR_D-1	J2-46	THR_D-2
J2-47	TempMonR	J2-48	TempMonRet
J2-49	GND	J2-50	GND

Power

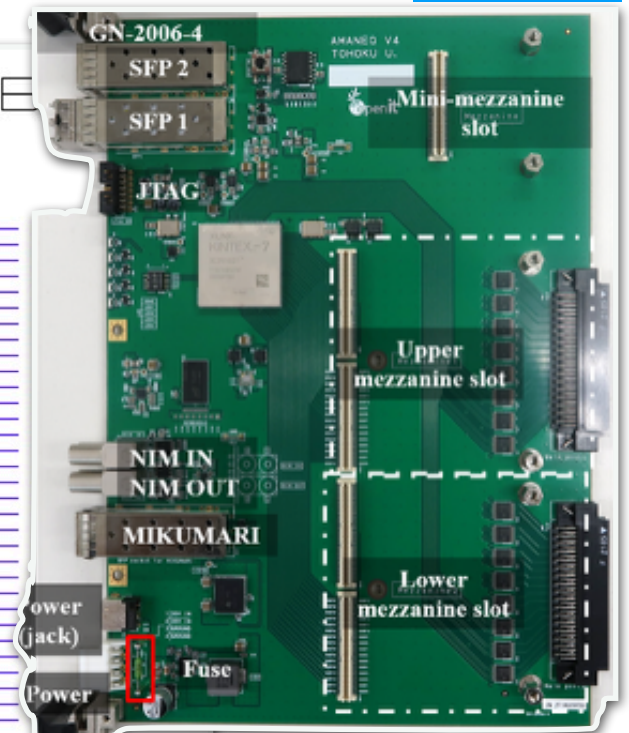
Test Input

Data In/Out

DAC



AMANEQ



Acknowledgments

Thank You Very Much!

- My partner in crime, Sofian Sakr
- Our tutor, Anastasios Belias
- Our 先輩, Luca Schramm
- Colleagues from CBM and EEL
- Colleagues from RCNP, Osaka

