MDT Front-end Electronics upgrade of the Cosmic Ray Facility test stand

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LUDWIG-
MAXIMILIANS-
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FSP ATLAS
Erforschung von
Universum und Materie

Cosmic Ray Facility (CRF)

- Detector system consisting of:
    1. 2 MDT BOS chambers
    2. Scintillators used for triggering on the top and bottom
    3. Iron absorber for a hard cut on low energy muons (~600 MeV)

- Tracking in:
    1. x-dir. from the MDTs
    2. y-dir. from the scintillators

- Readout paths:
    1. CSMs and mezzanine cards for the MDTs using legacy FILAR
   2. VME for scintillators
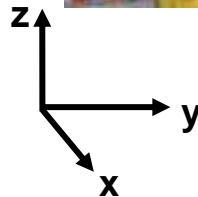
Cosmic Ray Facility (CRF)

- In the past:
  1. Testing and commissioning of the series production of the MDT-BOS chambers

  2. Testing and commissioning of the series production of the NSW-MM detectors

- Present:
  1. Upgrade to phase-II MDT front-end and backend electronics in order to be used a test stand for future ATLAS detector calibrations.
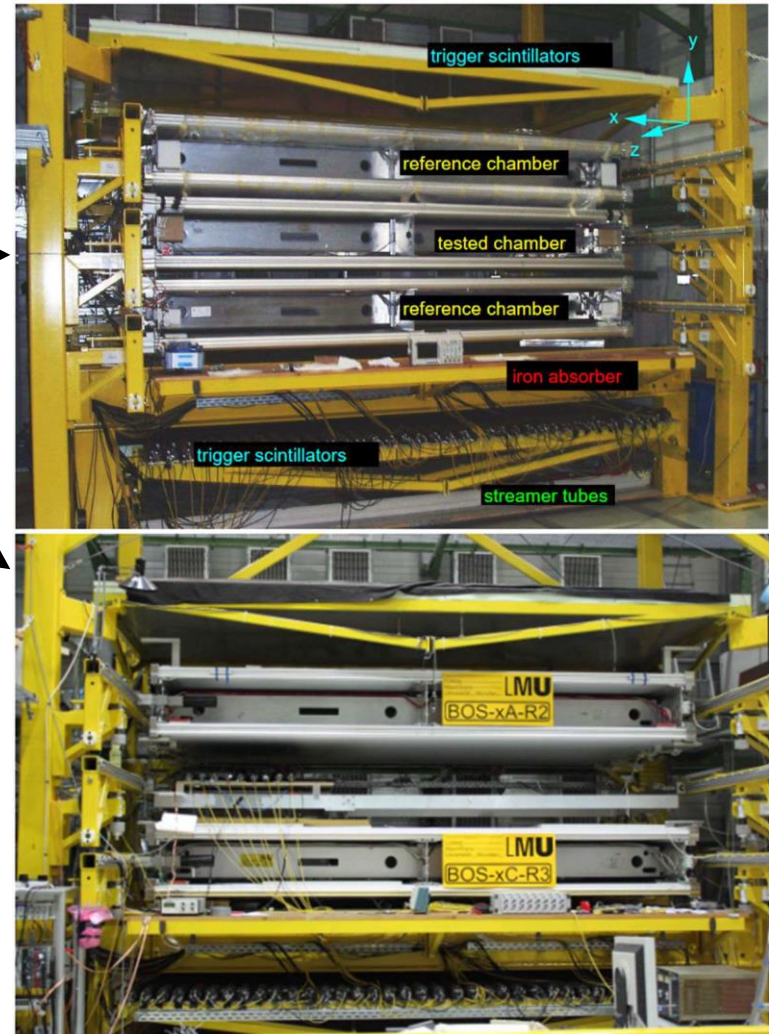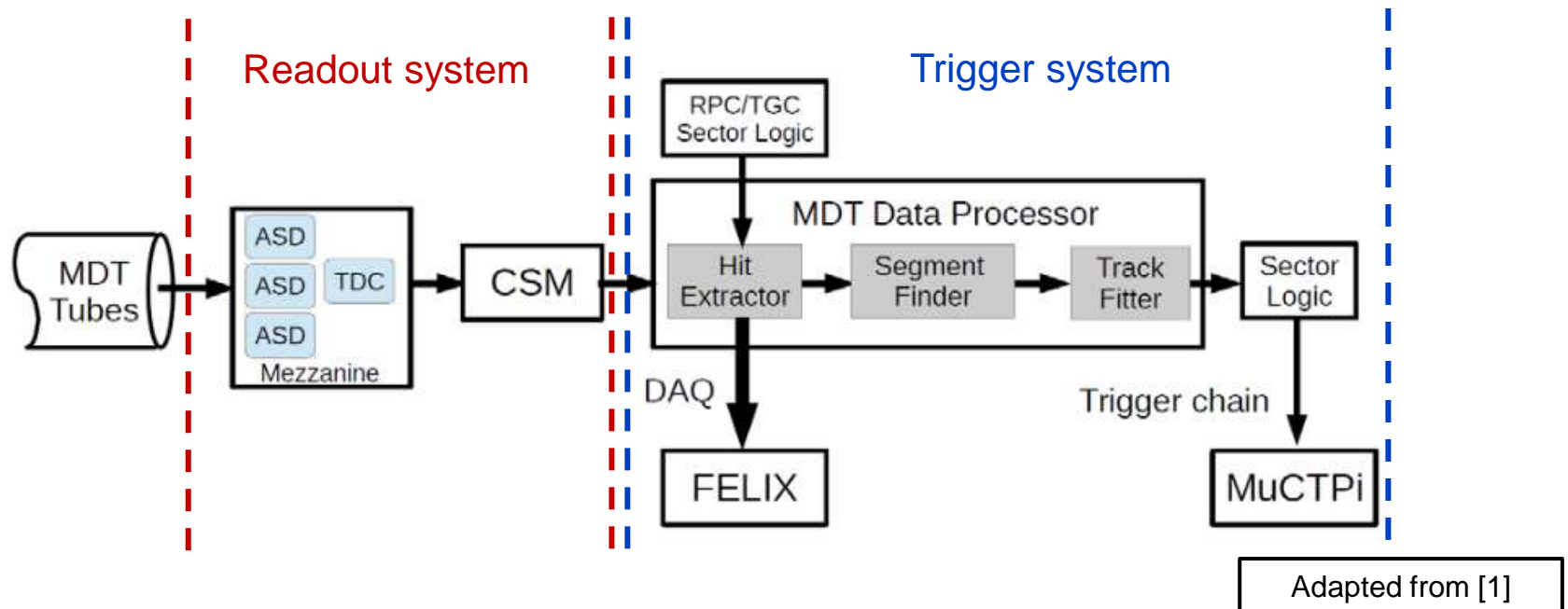
The old CRF MDT Electronics

- Outdated readout electronics

- Differences to the phase-II front-end electronics:
    1. Legacy mezzanine cards
    2. 25 MHz CSM instead of 50 MHz CSM
    3. FILAR card instead of FELIX
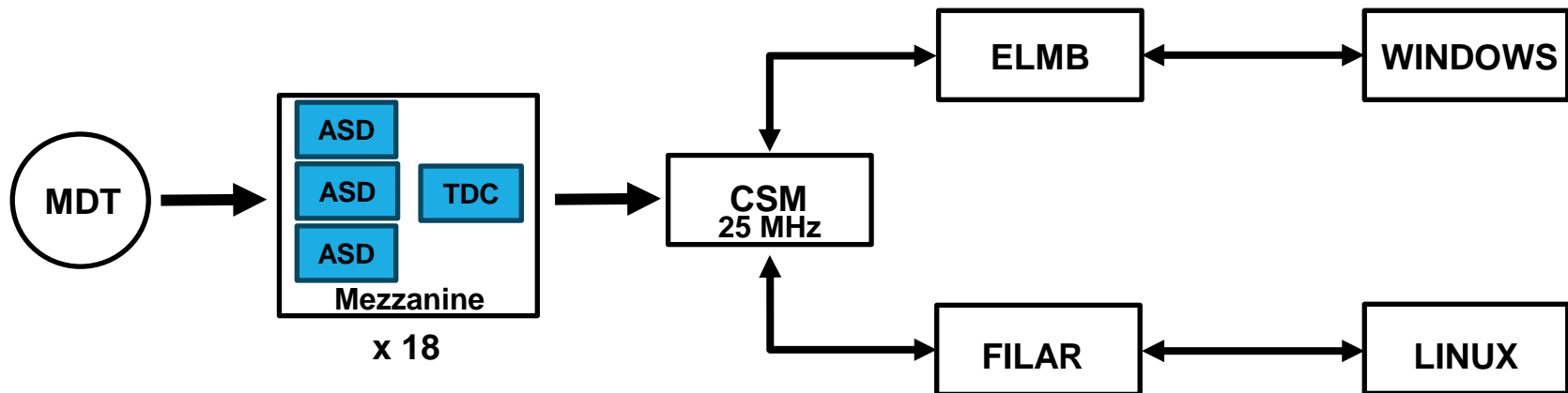
Upgrade to Phase-II MDT Electronics

- The trigger (covered in the next 2 talks by N.Schneider and I. Mesolongitis)
  and readout systems will be upgraded to Phase-II electronics

Readout system | Trigger system

RPC/TGC Sector Logic

MDT Tubes → ASD / ASD / ASD / TDC (Mezzanine) → CSM → MDT Data Processor (Hit Extractor → Segment Finder → Track Fitter) → Sector Logic

DAQ → FELIX
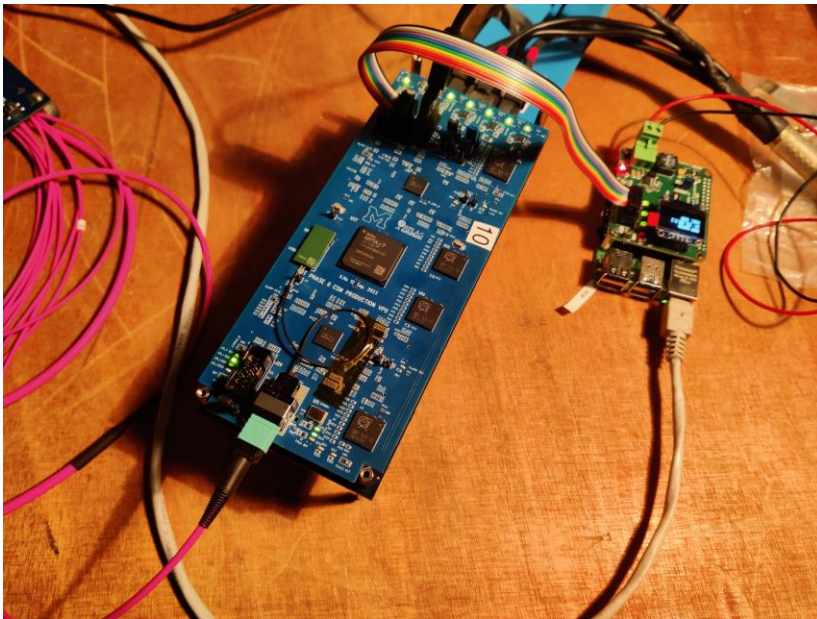
Trigger chain → MuCTPi

Adapted from [1]

[1]. Upgrade of the ATLAS Muon Drift Tube Front-end Electronics for HL-LHC Runs,
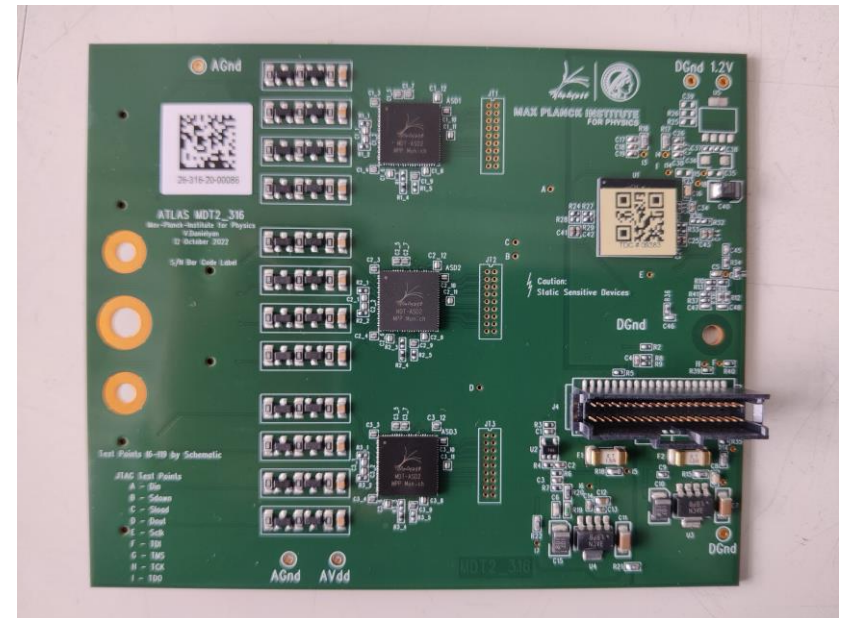X. Hu, University of Michigan (2020)

Upgrade to Phase-II MDT Electronics

- Changes made:
    1. Legacy mezzanine cards → new flat mezzanine cards (MDT316) x 10
    2. 25 MHz CSM → 50 MHz CSM x 1
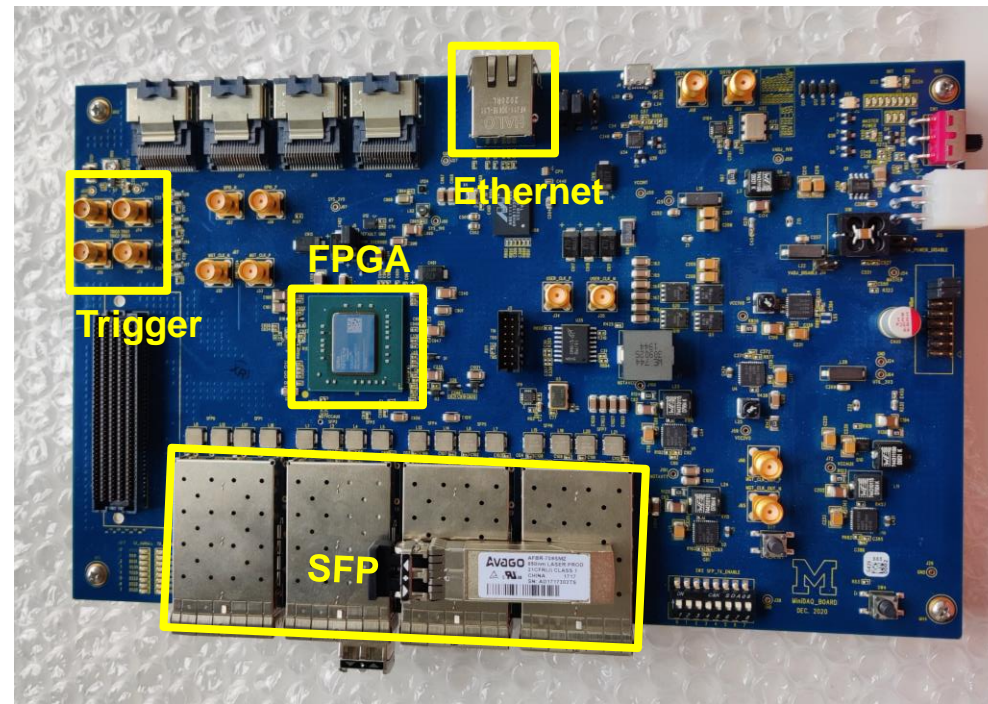   3. FILAR card → MiniDAQ

**50 MHz CSM**

New MDT316 cards (x10)

MiniDAQ Board

- Integration and testing of the FE electronics is very important

- It can be performed with the help of the MiniDAQ board: a lightweight version of the L0MDT (MDT Data Processor)

- Designed for sMDT/MDT chambers + FE electronics integration and commissioning

- Low cost FPGA replaces the need for FELIX

MiniDAQ Board

- MiniDAQ can handle at least 2 CSMs; so it has 4 SFP+ modules (+ 4 more for additional CSMs)

- The board exchanges commands and FE electronics monitoring info. with a PC via a USB-UART interface, and the detector data is sent out for offline storage through the gigabit ethernet interface
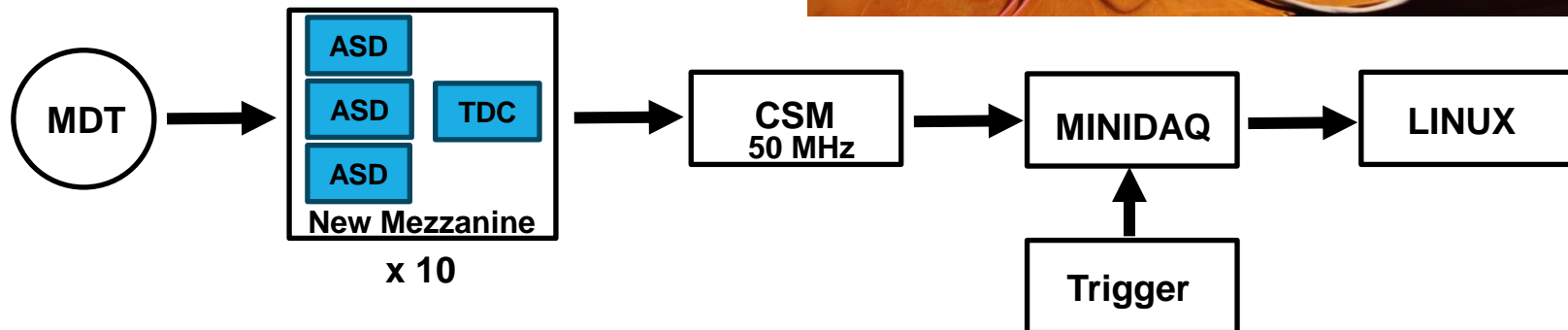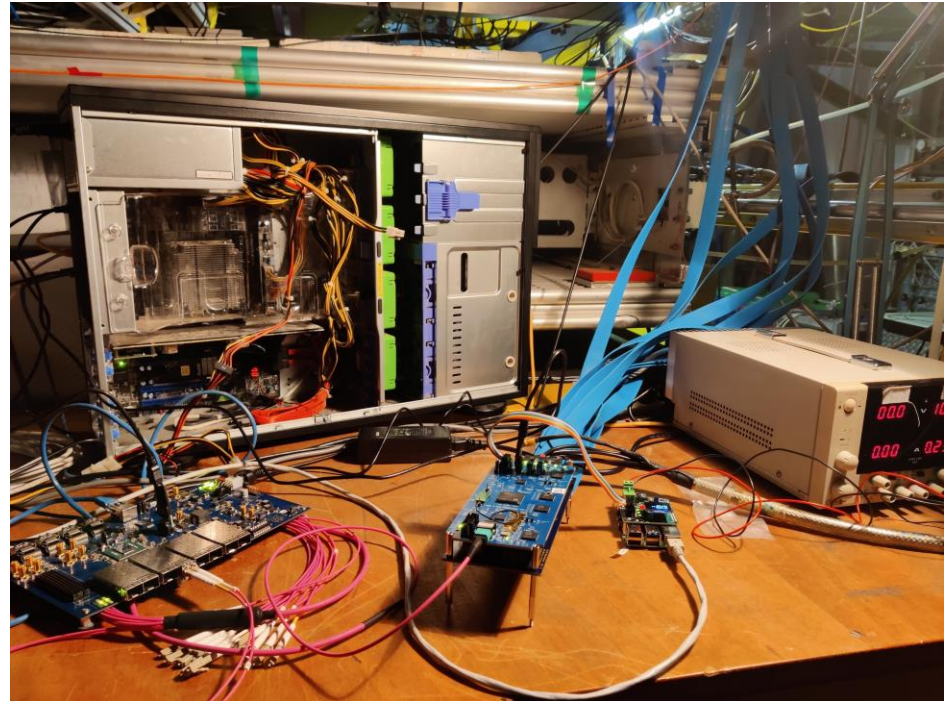

Taken from [2]
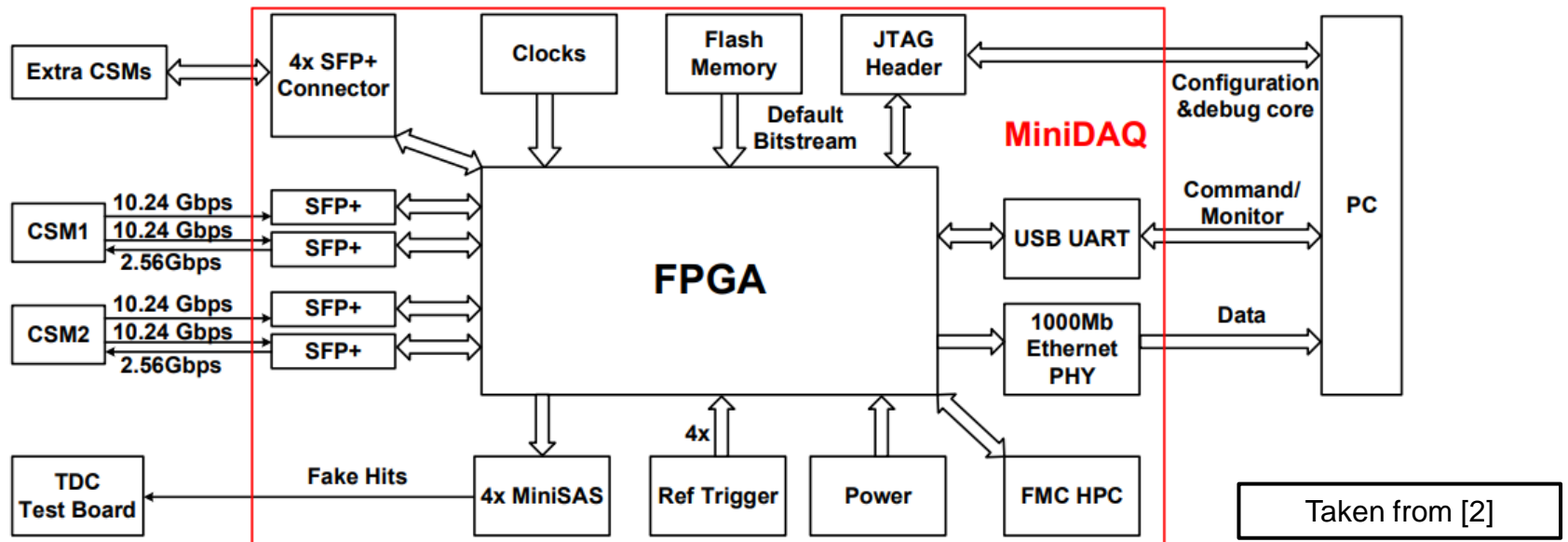
[2] Development and test of a mini-Data Acquisition system for the High-Luminosity LHC upgrade of the ATLAS Monitored Drift Tube detector, Y. Guo, et. al (2023)
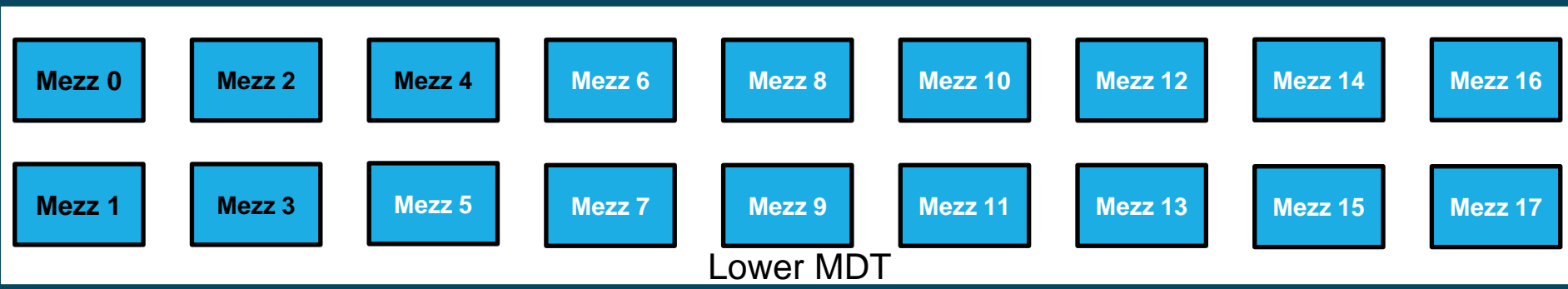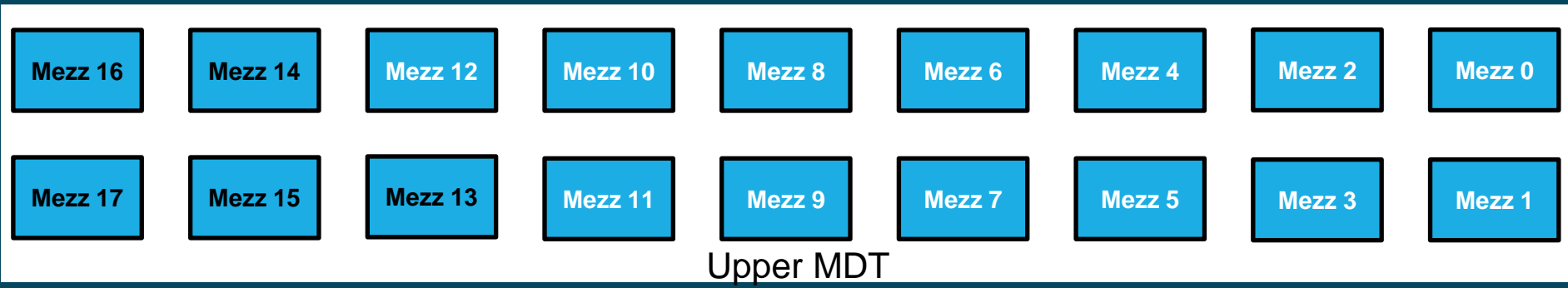
Current CRF Set-up

- Gas mixture used: Ar:CO2 in 93:7% vol. at 3 bar

- HV of MDTs set to 3080 V

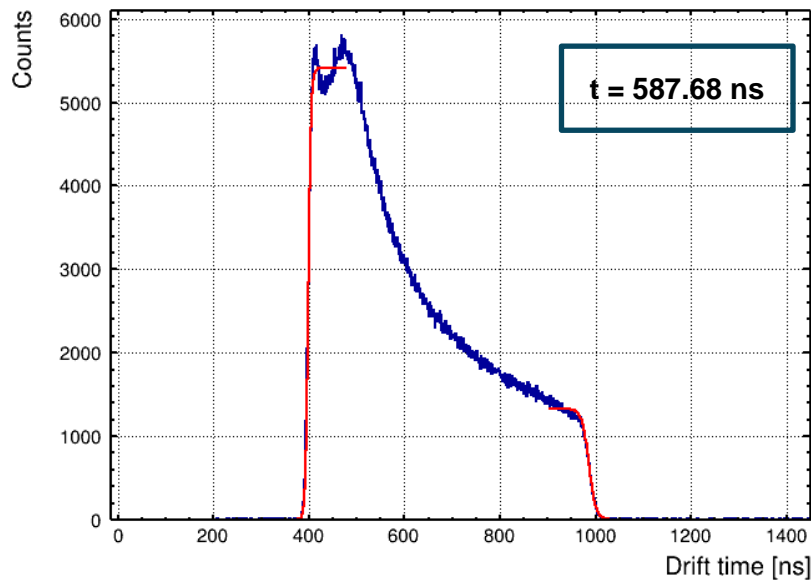- MiniDAQ and CSM configuration successfully completed (many thanks to Yuxiang for the support!)

MDT → **New Mezzanine** (ASD, ASD, TDC, ASD) **x 10** → **CSM 50 MHz** → **MINIDAQ** → **LINUX**

Trigger → **MINIDAQ**

Current CRF Set-up

Mezz 16	Mezz 14	Mezz 12	Mezz 10	Mezz 8	Mezz 6	Mezz 4	Mezz 2	Mezz 0
Mezz 17	Mezz 15	Mezz 13	Mezz 11	Mezz 9	Mezz 7	Mezz 5	Mezz 3	Mezz 1

Upper MDT

Mezz 0	Mezz 2	Mezz 4	Mezz 6	Mezz 8	Mezz 10	Mezz 12	Mezz 14	Mezz 16
Mezz 1	Mezz 3	Mezz 5	Mezz 7	Mezz 9	Mezz 11	Mezz 13	Mezz 15	Mezz 17

Lower MDT

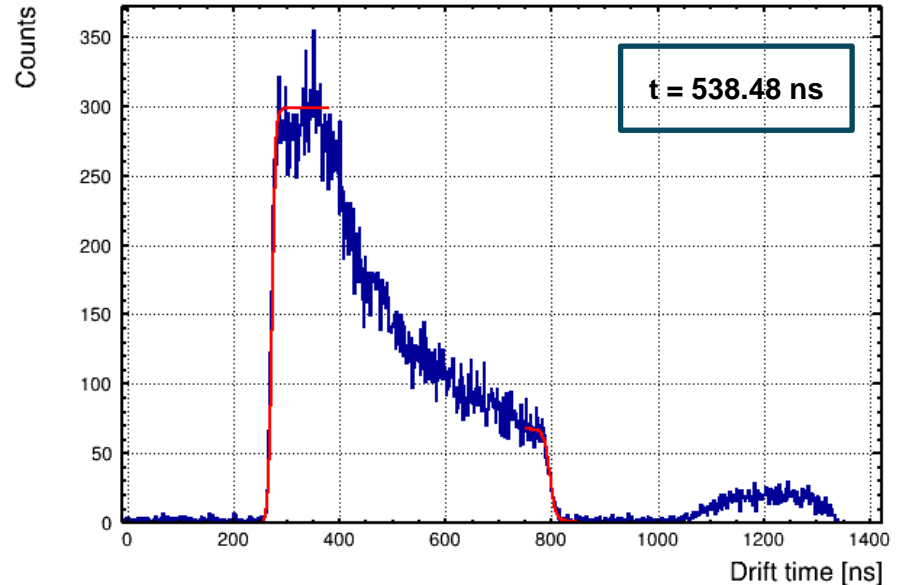| Mezz	→ new MDT316 mezz. cards

Mezz	→ legacy mezz. cards

Data Comparison: TDC Spectra

Old TDC of 216 tubes (1 multilayer)	New TDC of 24 tubes (1 mezz., same multilayer)

t = 587.68 ns

t = 538.48 ns

- TDC spectra compared between the legacy and new FE electronics: some fine-tuning to be added
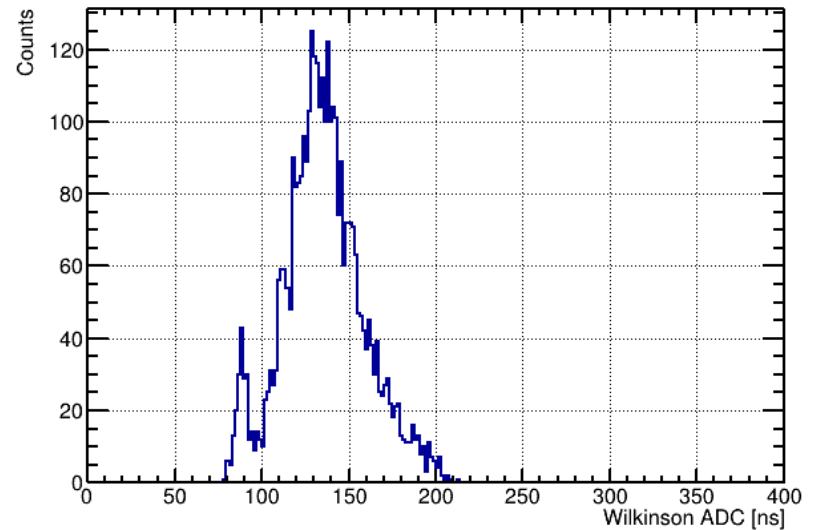
- Trigger matching performed inside the MiniDAQ FPGA

Data Comparison: ADC Spectra

Old ADC of 216 tubes (1 multilayer)	New ADC of 24 tubes (1 mezz., same multilayer)
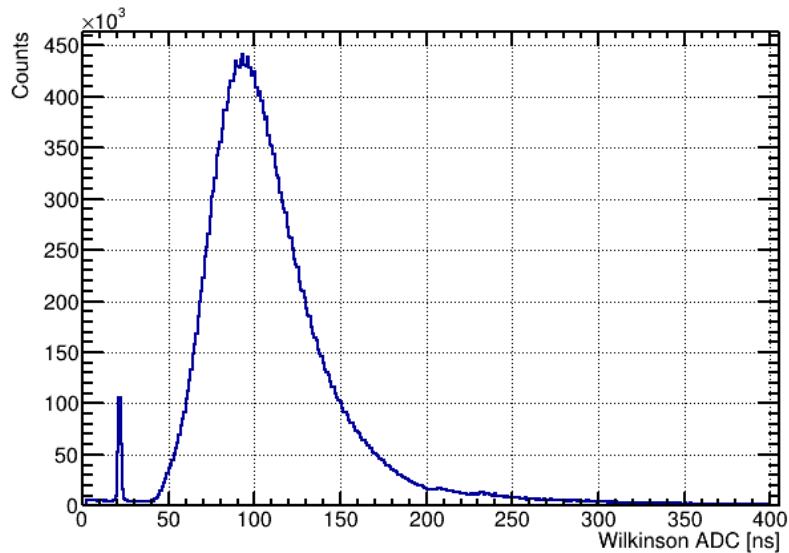
- ADC Threshold: -38 mV
- Cosmic peak seen at 90, with a separated peak

- ADC Threshold: -39 mV (code 108)
- Cosmic peak seen at 130, with the separated peak coinciding with the cosmic peak

Summary

- LMU CRF consists of 2 MDT BOS chambers for tracking and scintillators for triggering

- It is foreseen to use this detector system as a potential test stand for detectors to be installed at ATLAS; electronics upgrade needed

- Phase-II upgrade of the trigger and readout electronics planned

- New FE electronics tested and measurements were successfully taken but some fine tuning still needed

Future Plans

- Running of the track building in the offline analysis provided by U.Michigan

- New MDT316 mezz. cards have been received; can equip the complete 2 MDT chamber with the new mezz. cards

- On the completion of the readout testing and the L0MDT setup, integration process of the front-end and back end is planned to achieve a fully upgraded trigger and readout path

Thanks for listening!

Gas studies