Update on the integration of SRS into the ATLAS DAQ environment

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Outline

- Micromegas @ATLAS DAQ – present situation
- SRS for ATLAS DAQ
- MAMMA L1 Micromegas chamber
- LMU Cosmic ray facility measurements
- Status and Outlook

Motivation

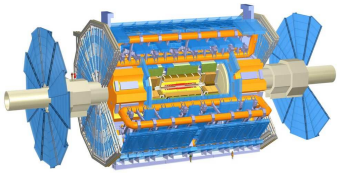
• Micromegas detectors have been chosen as technology for the ATLAS New Small Wheels (2018)

• Small prototype Micromegas detectors have been installed at ATLAS (see Poster from Konstantinos Ntekas), larger ones (O(m^2)) will be installed during this long shutdown

• An integration of these Micromegas detectors into the ATLAS trigger and data aquisition is neccessary to analyze their performance in direct comparison with the current ATLAS muon tracking system

• Therefore an ATLAS compatible ReadOutDriver (ROD) has been developed, that allows the combined readout of the Micromegas together with all other ATLAS subsystems

ATLAS data acquisition chain



Level 1 trigger → Read Out Driver (ROD) — SLINK Link Source Card

Optical ↓ ~ 70 – 100 kHz

Level 2 trigger → Read Out System (ROS) — SLINK Link Destination Card

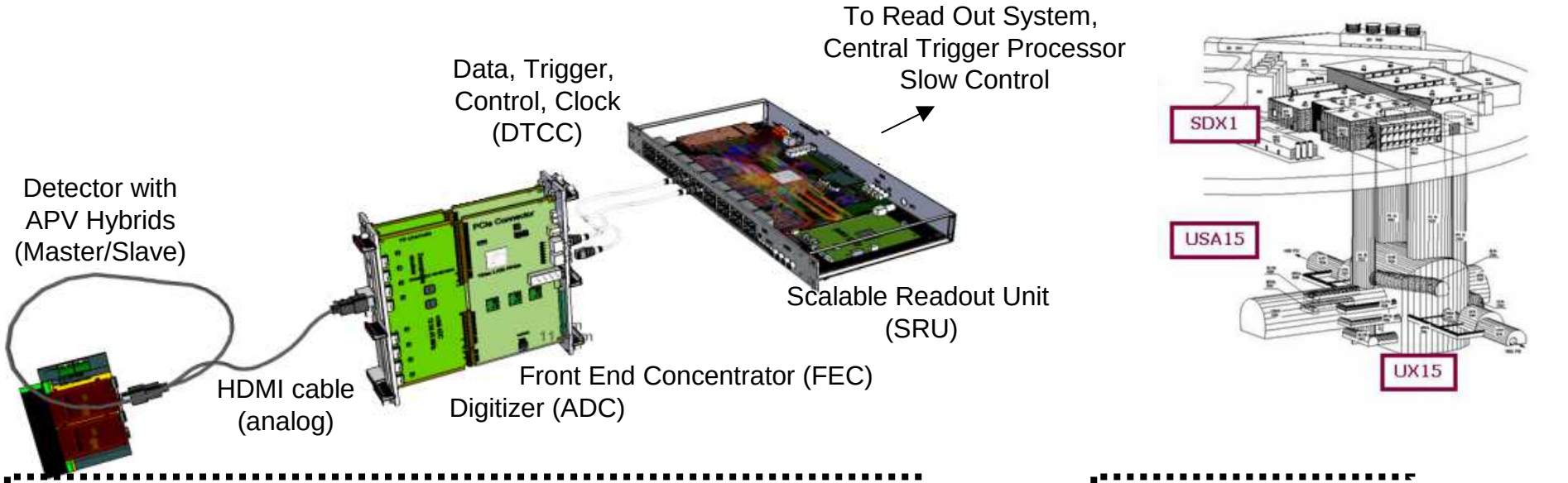
Ethernet ↓ ~ 3 kHz

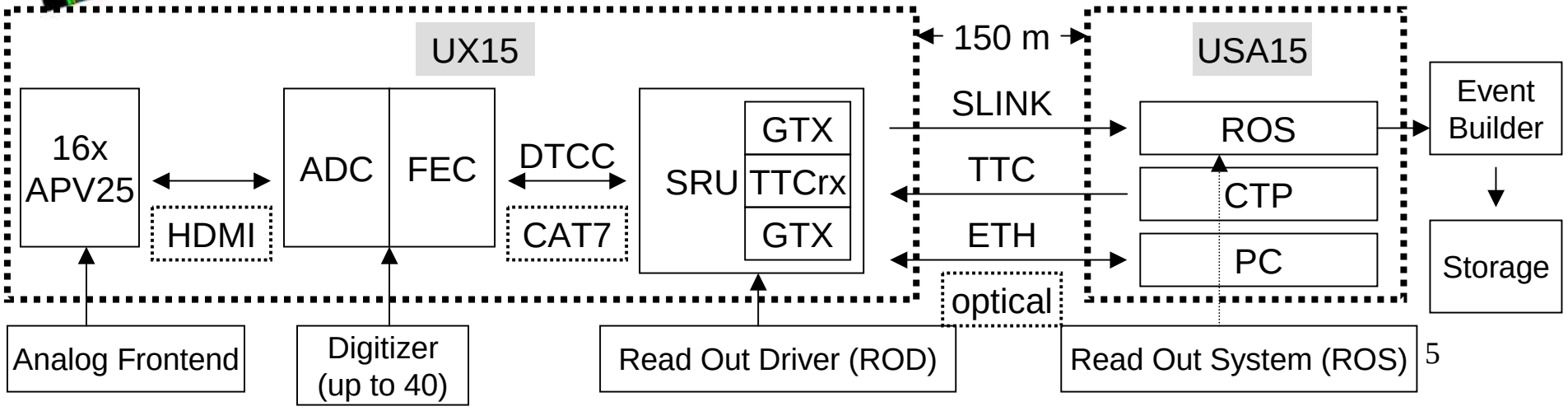
Event filter → Event Builder — O(1000) CPU cores

↓ ~ 200 Hz

Data storage

SRS (Scalable Readout System, RD51 Development)





SRU (Scalable Readout Unit)

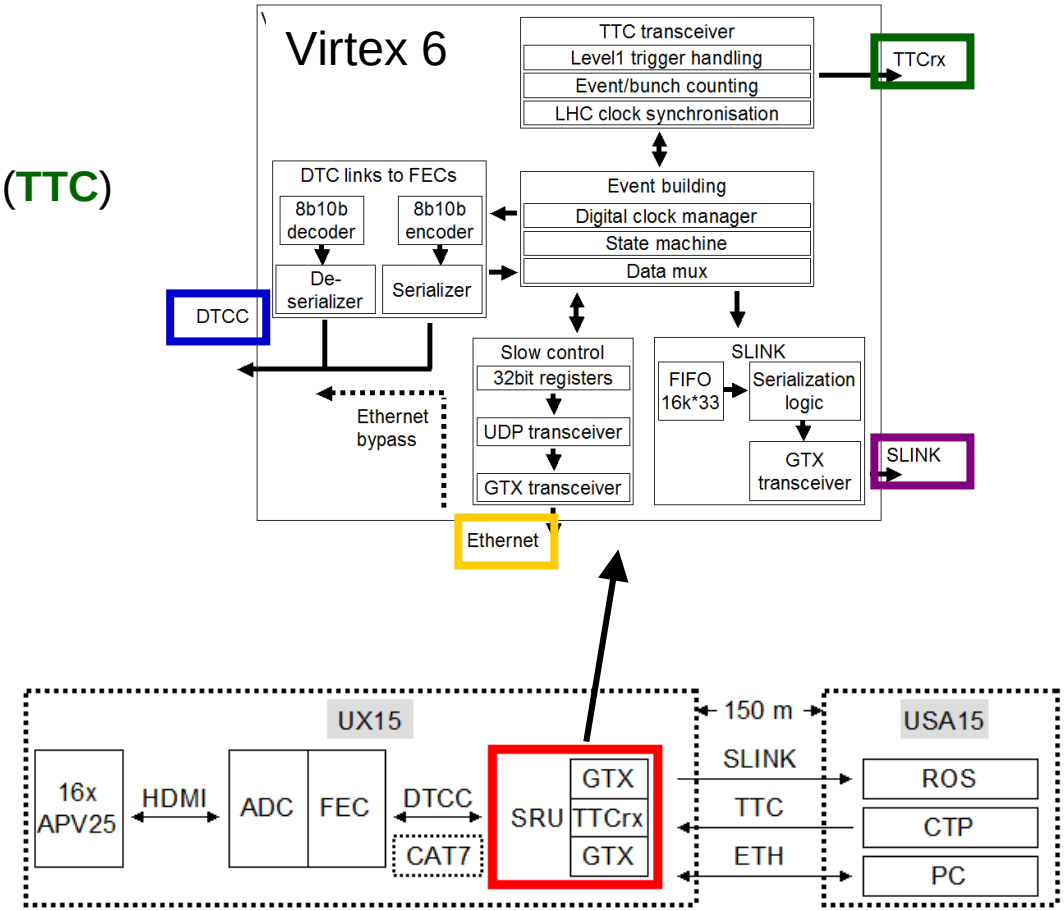
Main tasks:

• Reception and distribution of Level1 triggers, LHC synchronization (**TTC**)
- Event Counter
- Bunch Counter
- Clock Phase
- Bunch Counter reset
- Event Counter reset

• Detector data collection and event building (**DTCC**)
(BCID, EVID, ... , Data)

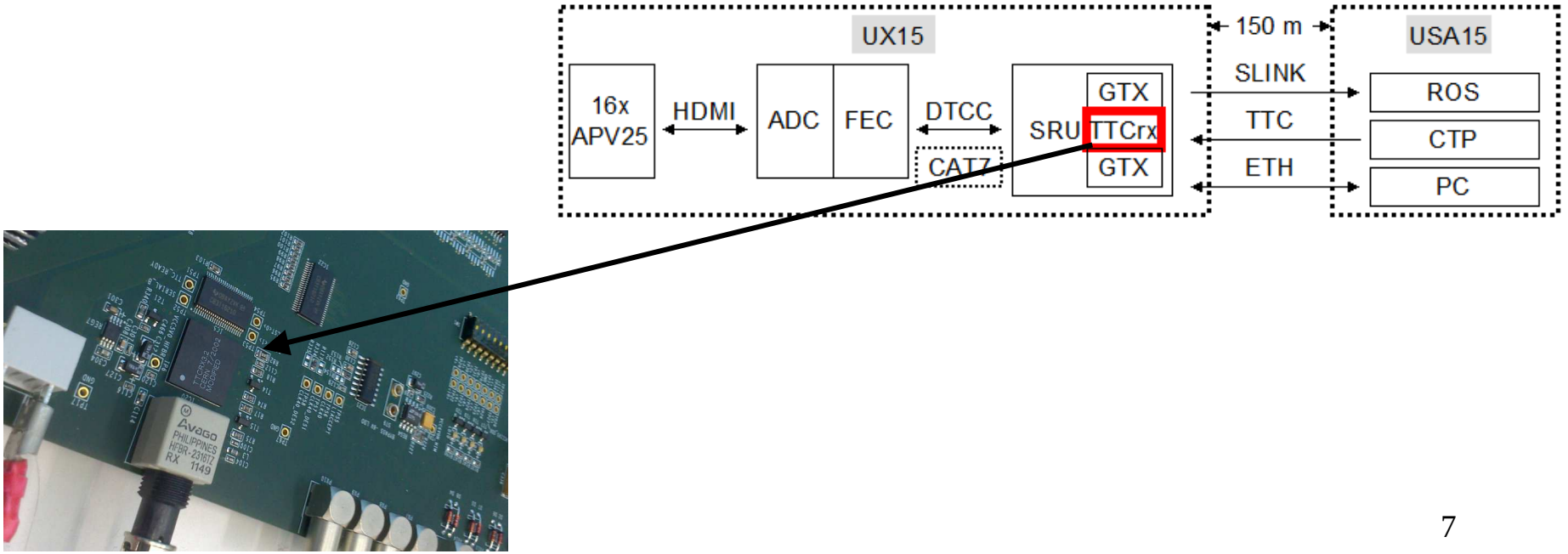
• Data transmission to ROS PC via **SLINK**

• Slow control / DCS / Data preview via **Ethernet**:
Register setting on APV, FEC, SRU, ...



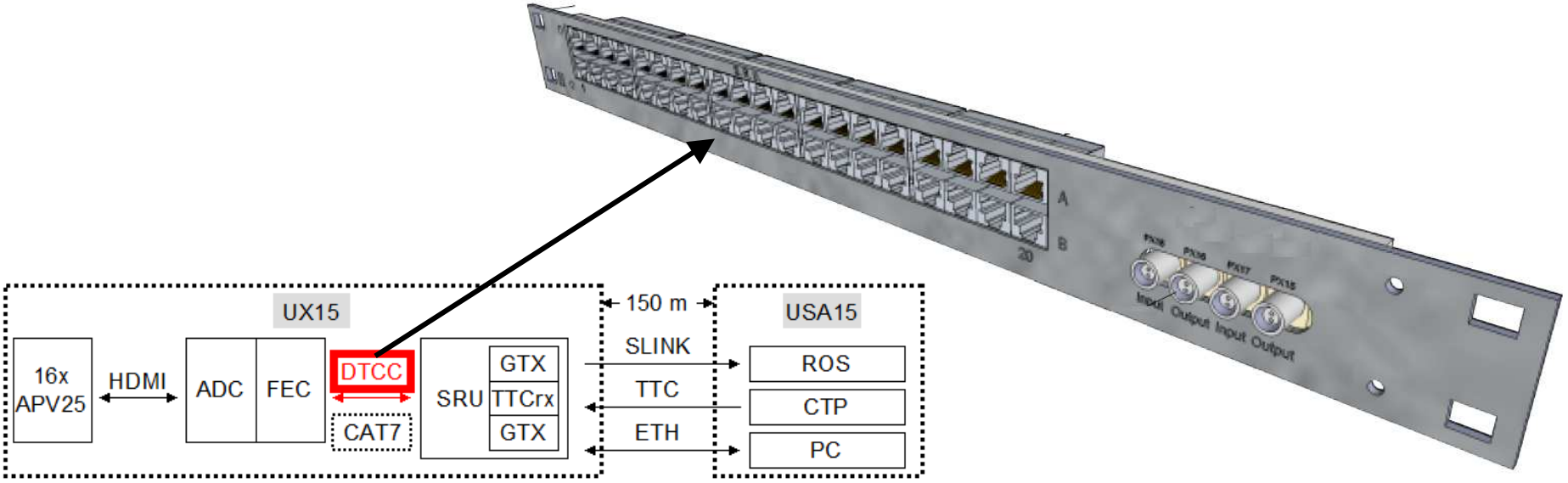
TTC interface (Trigger, Timing, Control)

- Communication with standard ATLAS trigger electronics („TTC-Crate“, ...)
- Receives L1A (Level 1 Accept) trigger, Bunch clock, triggertype, resets of eventcounter and bunchcounter as well as directed or broadcast configuration data



DTCC Link

(A. Martinez)



- Connects FEC Card(s) with SRU to transmit:

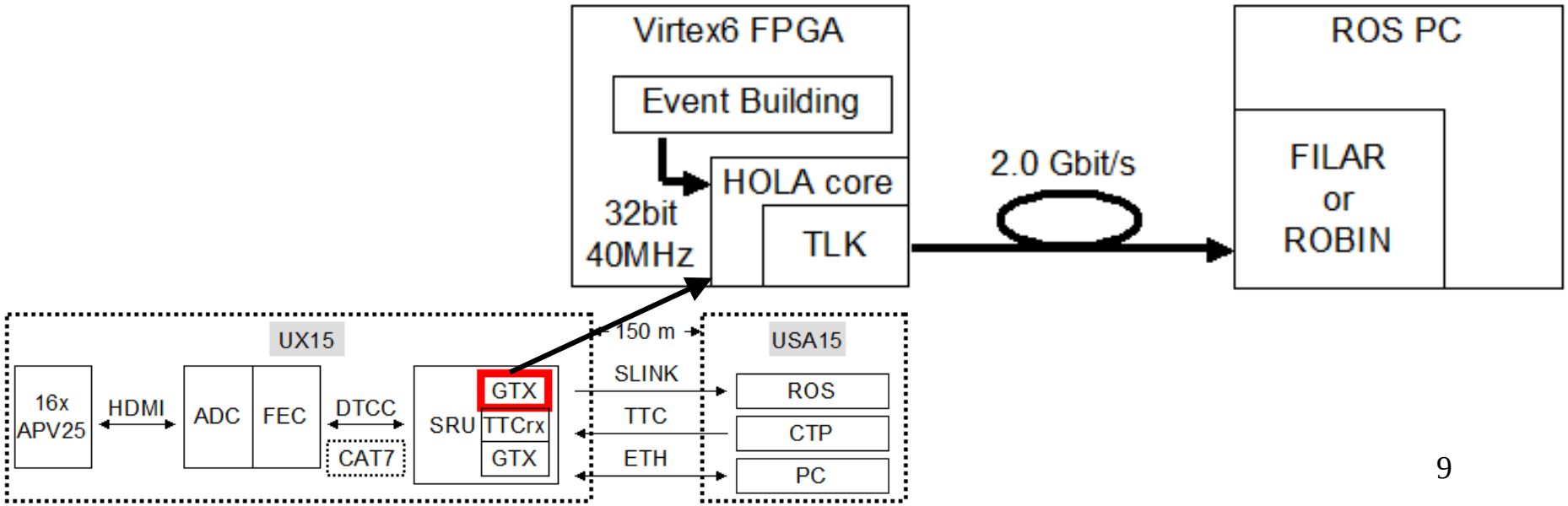
  <= LHC Clock, L1 Triggers and configuration commands from SRU to FEC

  => Detector- and configuration data at 640 Mbit/s from FEC to SRU
- Hot plug ability and automatic resynchronisation
- Support for up to 40 FEC cards (~82k channels with APV25 Hybrids)
- Conventional CAT cable with RJ45 plugs

SLINK implementation

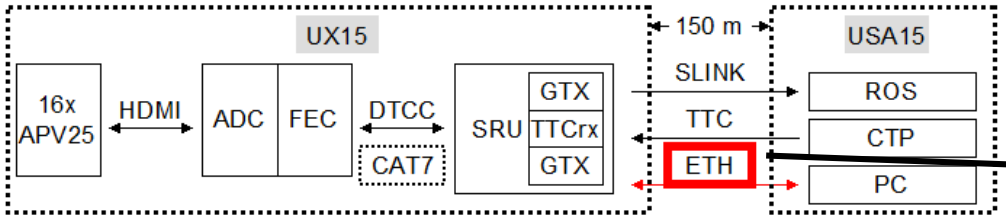
(M. Della Volpe, R. Giordano, V. Izzo, S. Perrella)

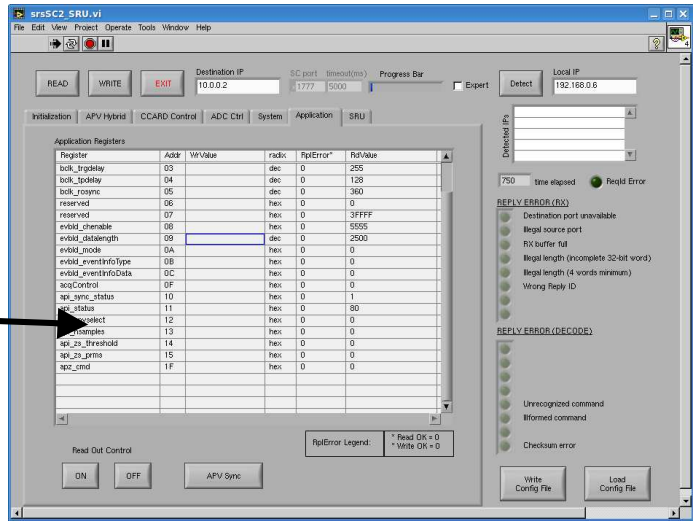
- ATLAS transmits event data from ROD to ROS using **SLINK**
- Now: No longer need of a seperate HOLA daughter card (as used widely in ATLAS), due to implementation of the SLINK serialisation logic IP core in the Virtex6 FPGA (uses one of the FPGA‘s GTX transceivers)
- Successfully tested data transfer to a standard ROS PC.
Valid ATLAS data frames are received.



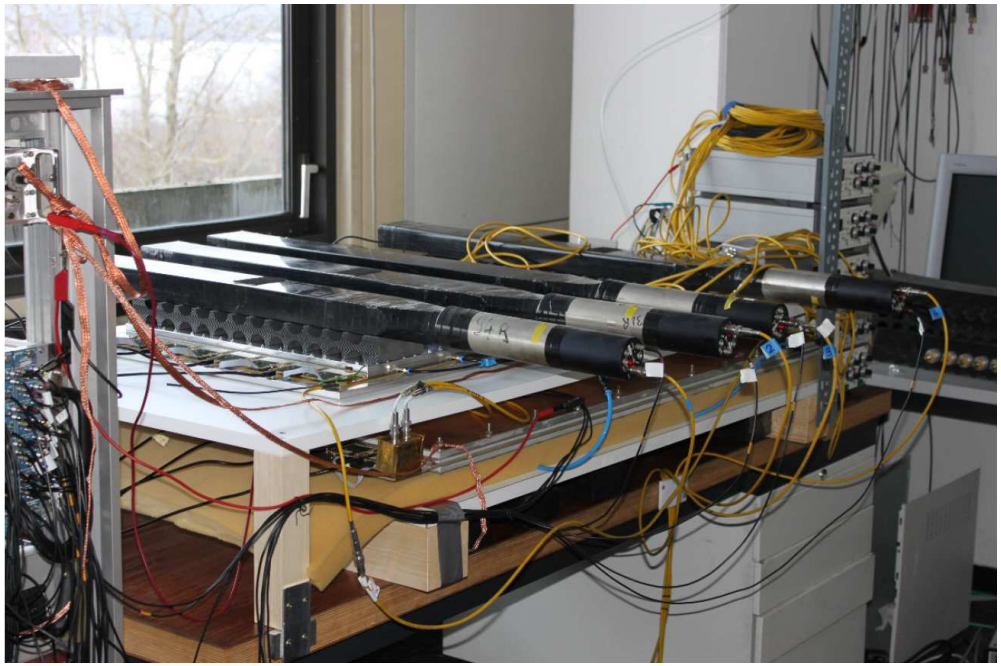
DCS / Slow control

- Slow control via optical Gbit ethernet connection to the SRU
- SRU DCS requests are handled directly, packets for FEC and APV are forewarded via DTC links (ethernet switch functionality within SRU)
- Online access to parameters like run control, error conditions, ...
- Fine tuning of TTCrx, APVs, etc...
- Online results of calibration, data preview, ...





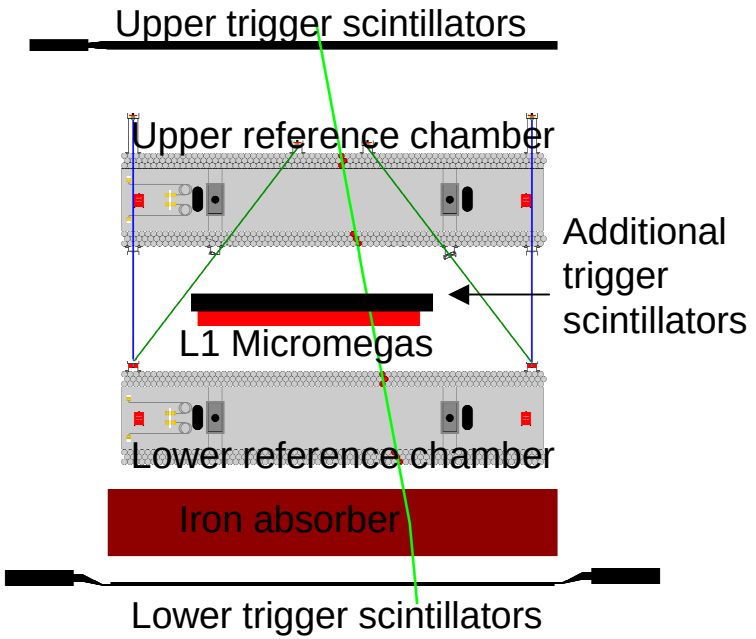
L1 Micromegas chamber

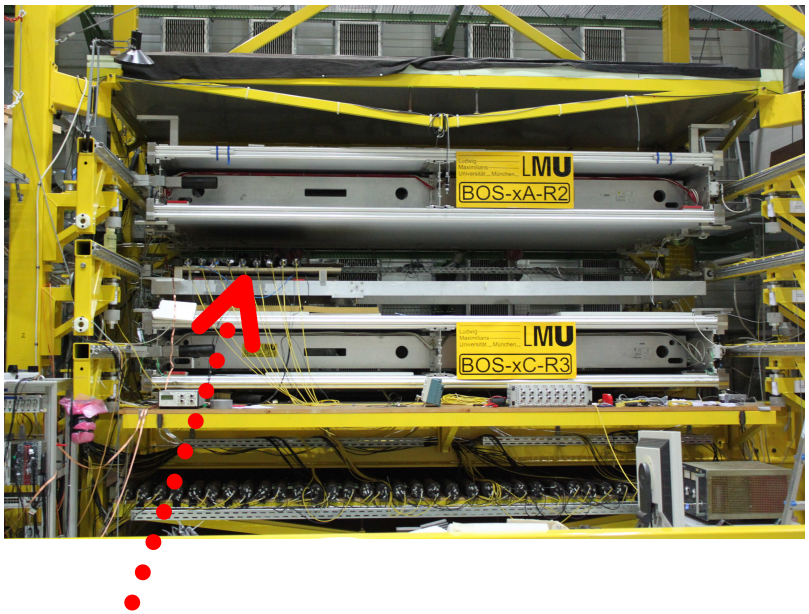


- MAMMA L1 chamber - first sqare meter sized micromegas detector
- Active area: 0.92 x 1.02 m², 2048 channels
- Several successful runs with 160 GeV pions @ CERN beamlines and cosmic muons, using direct reaout of one FEC card via Ethernet

LMU cosmic ray facility (CRF)

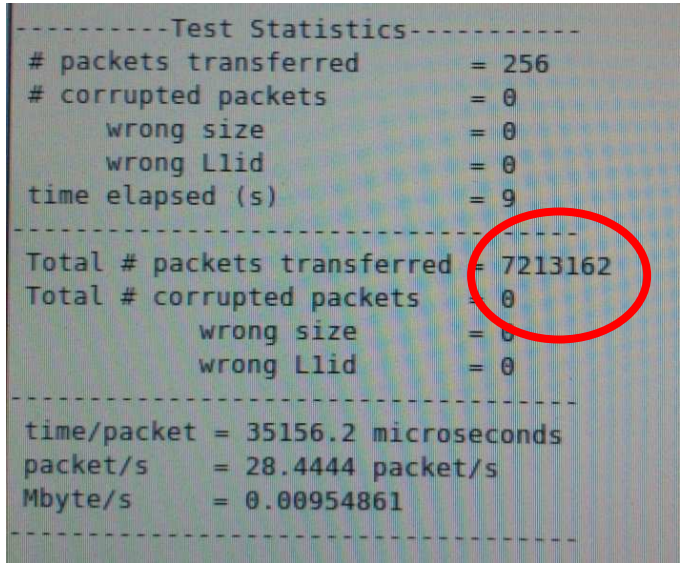
- Two full sized ATLAS BOS MDT muon chambers supply cosmic muon track predictions below 40µm after calibration
- 10cm broad Trigger scintillators cover the full area of 4 x 2.2 m², segmentation along tubes as second coordinate
- Identification of low energy muons by scattering angle
- ~100Hz CRF trigger rate, ~30Hz through L1 chamber

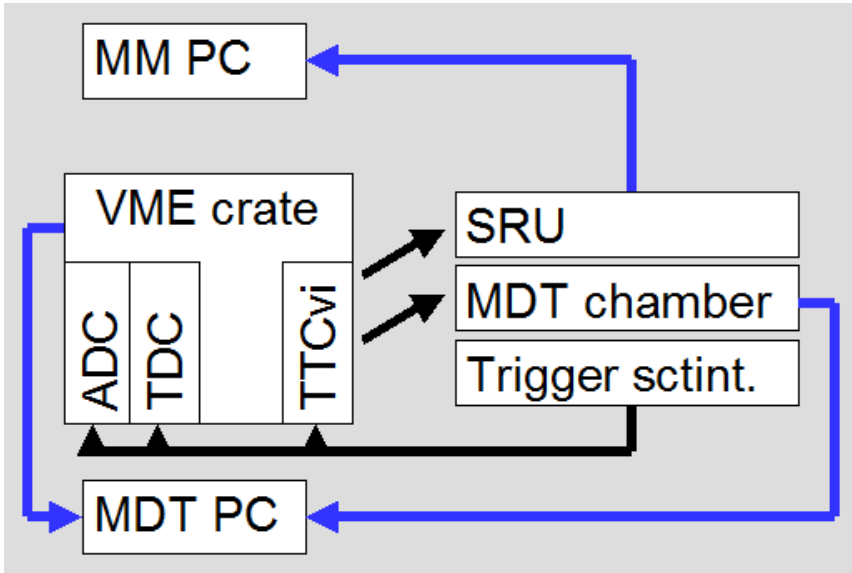




CRF DAQ

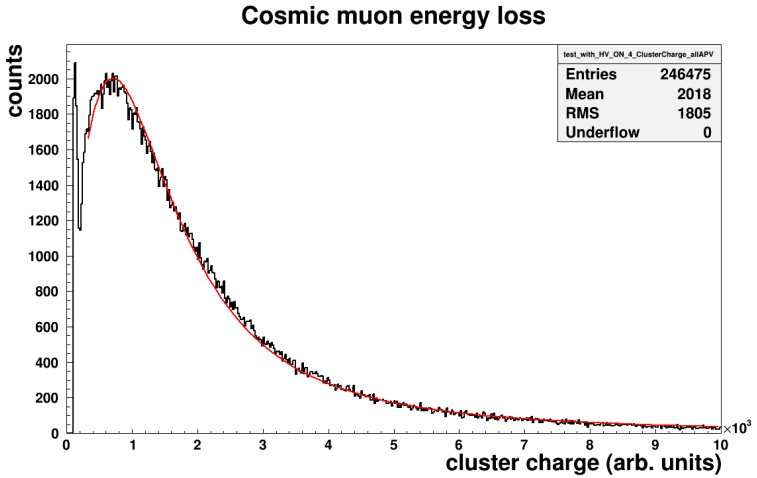
- Three data streams to be synchronized:
  - Trigger time and trigger pattern recorded using VME
  - MDT reference track data are read by a PC with a SLINK FILAR card
  - A second PC reads MM data from the SRU with a SLINK ROBIN card
- No corrupted SRU data have been observed so far, synchronisation of the different data streams with help of the TTC trigger information works without errors

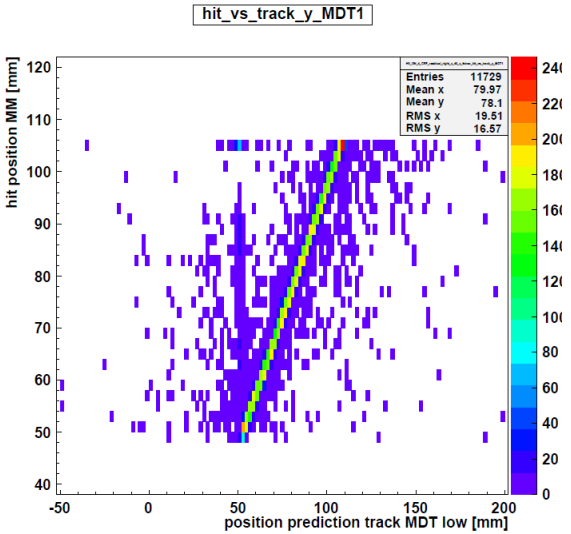




Analysis goals and status

- Comparison of Micromegas Cosmic muon Track measurements with MDT Reference chamber track predictions
- Analysis of residuals, efficiency and amplification as a function of X and Y coordinates over the full L1 chamber area
- Analysis of Micromegas angular resolution (microTPC mode)
- Combined data taking for track comparison started
- FEC based zero suppression of APV data shows same behaviour as the well-tested PC-based data reduction methods

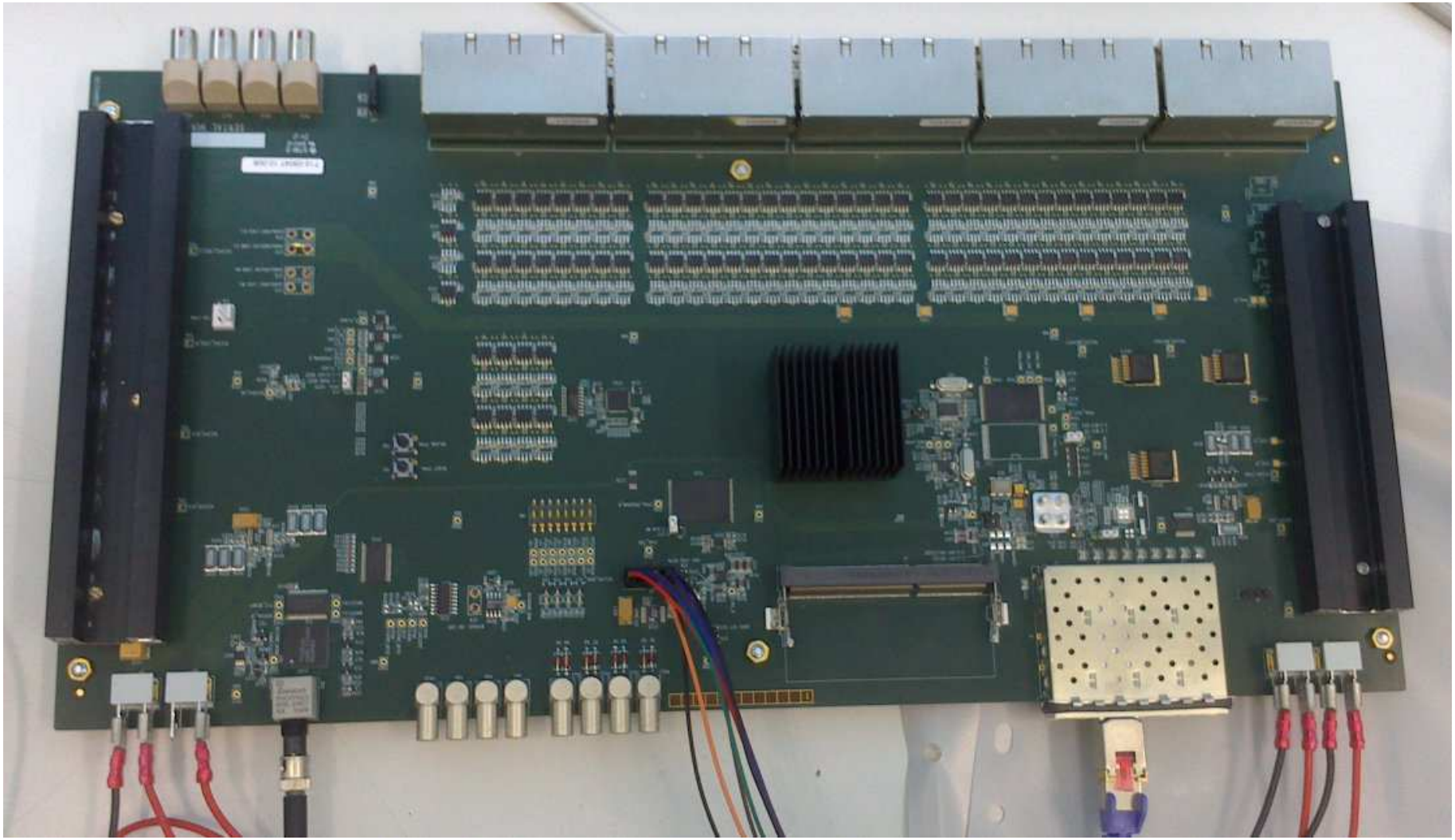




Correlation MM with MDT track prediction

Summary and Outlook

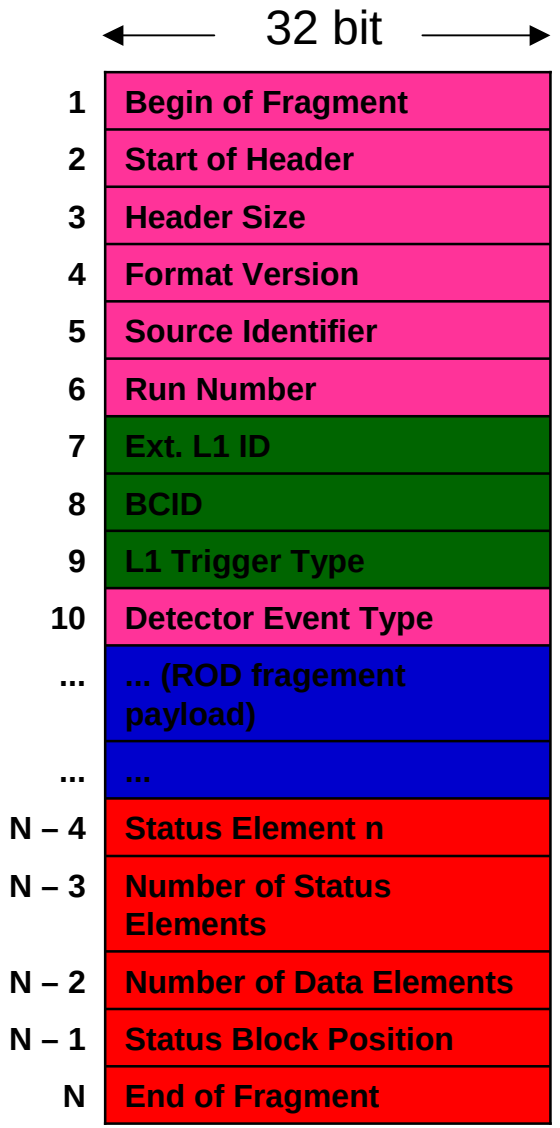
- MAMMA L1 micromegas chamber installed at the LMU cosmic ray facility
- Data aquisition with FEC card and SRU running in an ATLAS-like setup without any errors so far
- Zero-suppression FEC firmware variant shows similar results as the „standard“ version that has been used intensively in the past, but with reduced amount of data, allowing significant higher trigger rates
- Systematic scanning of L1 chamber with cosmic muons has started
- Coincidence trigger rate is ~2.5M events per day
- Extension of the system to 4 chambers (NSW quadruplett) possible
- The developed SRU firmware complies with the demands on an ATLAS compatible ReadOutDriver
- Once LHC restarts in 2014, large-sized Micromegas detectors installed in ATLAS can be read with the SRS system



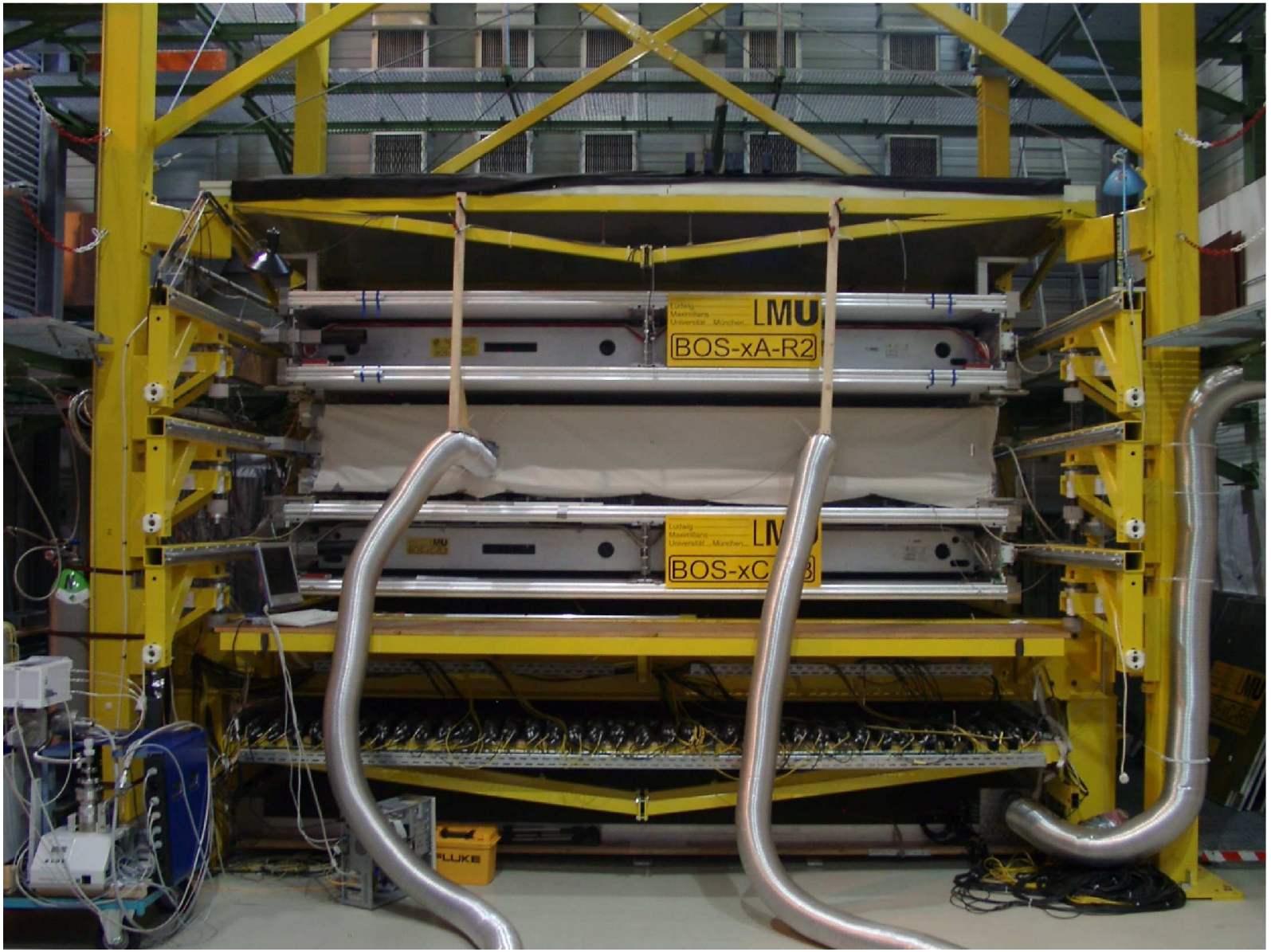

EOA-02075-V4

Standard ATLAS Event Data

- L1A trigger (from **TTCrx** (ATLAS), NIM input (Lab) or slow control (debug)) stored in FIFO memory
- ATLAS Event fragment generated for each trigger
- **Header** and **Trailer** information to identify Detector, Run and Event metadata
- **Converted data** from the APV chips will be zero-suppressed by the FEC and then written (via DTC link) to FIFO memorys in the SRU FPGA
- Full event fragment is formed and sent out via SLINK to the ROS PC



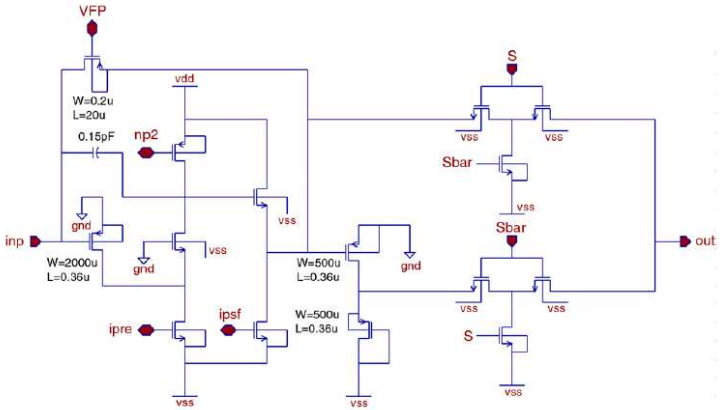
Garching cosmic ray facility

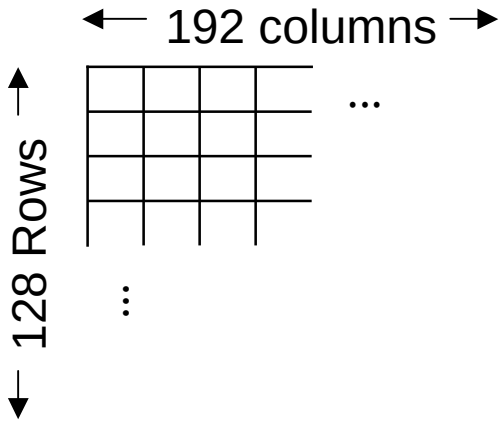


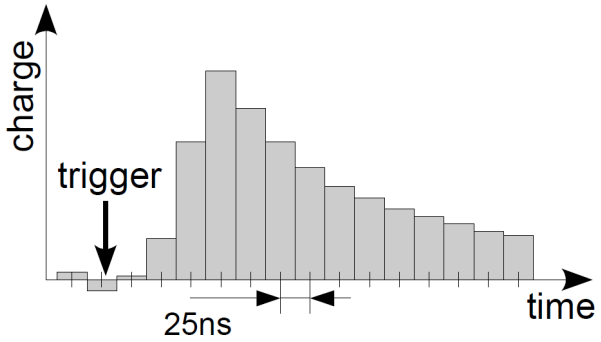
APV25 Charge Sensitive Analog Frontend

- Analogue pipeline ASIC used for read-out of silicon strip detectors in the CMS tracker
- 128 charge sensitive amplifier channels
- Pipeline buffer of 192 cells depth for each input channel, filled consecutively with every clock cycle (40.08 MHz @LHC)
- Blocks of one or more pipeline columns can be read out for each trigger
- => Time evolution of integrated charge signal for each detector channel in steps of ~25 ns

128 preamplifier channels → Analogue pipeline buffer → Selected columns output



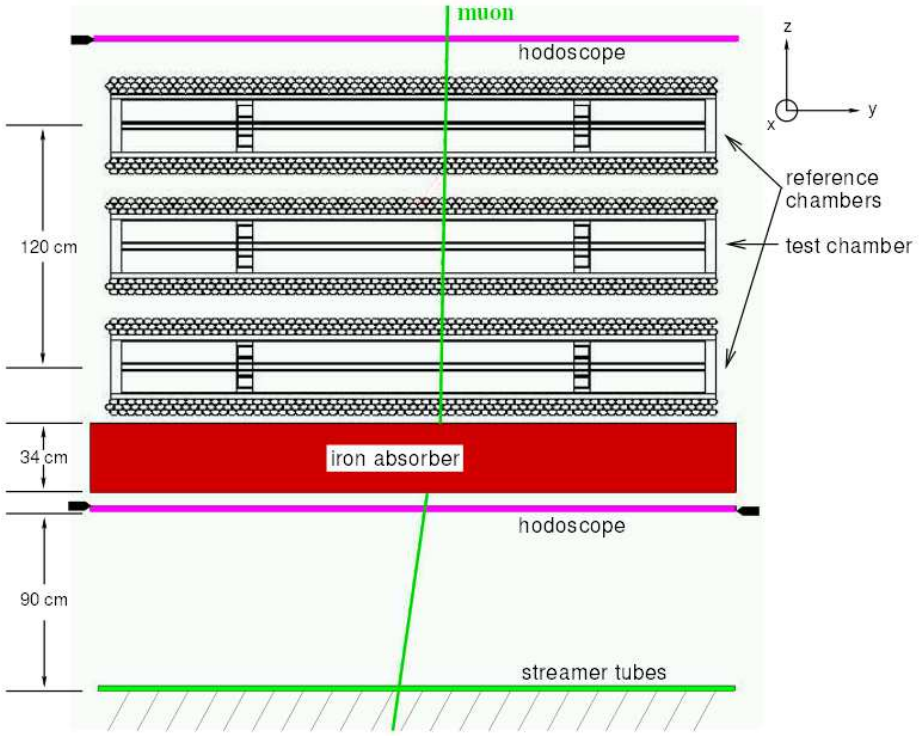




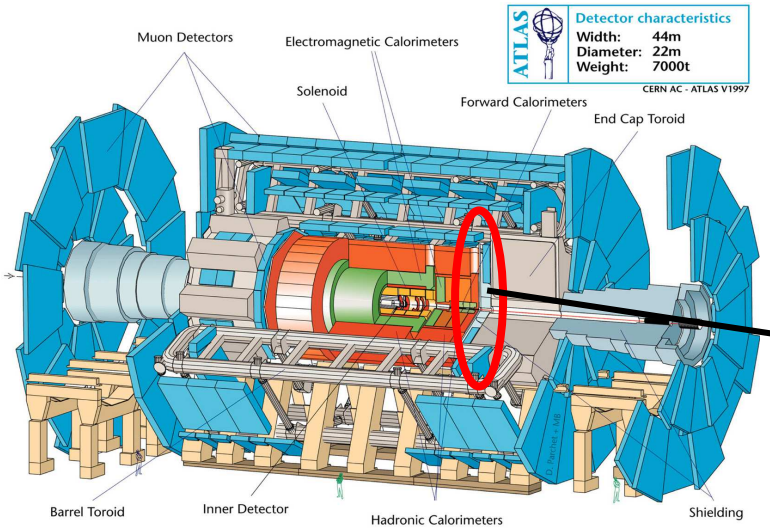
L1A rate vs. APV readout time

- APV readout: 140 clock cycles @40.08 MHz LHC clock frequency
(128 channels + 12 overhead)
- MicroMegas detectors require 10 – 20 time bins to sample signal shape
(1400 – 2800 clock cycles)
- => Mean time difference between Level 1 triggers:
~600 clock cycles @70 kHz trigger rate
- Implementation of busy-logic to decide, which event to process fully
(trigger to APV chips), and which not
- Skipped events also generate ATLAS event frame with no data content
in FIFO buffer to satisfy ROS requirements
- Tested and working with up to 100 kHz random trigger rate

Garching/LMU Cosmic Ray Facility



Installation of prototype chambers in ATLAS



- 2012:4 chambers 9x9 cm²
  @Small Wheel, r ~ 1,7 – 1,8 m
- Goals: - general analysis and validation of SRS readout system
  - compare MM tracks with ATLAS data,
  - particle Identification

First data in ATLAS

- First run taken with ATLAS triggers (L1A 70 kHz)
- LHC bunch structure visible in data -> TTC and DAQ integration works
- Micromegas not included in general ATLAS DAQ („standalone mode“)

  => no Level 2 trigger information

  => no Synchronization with ATLAS muon tracks