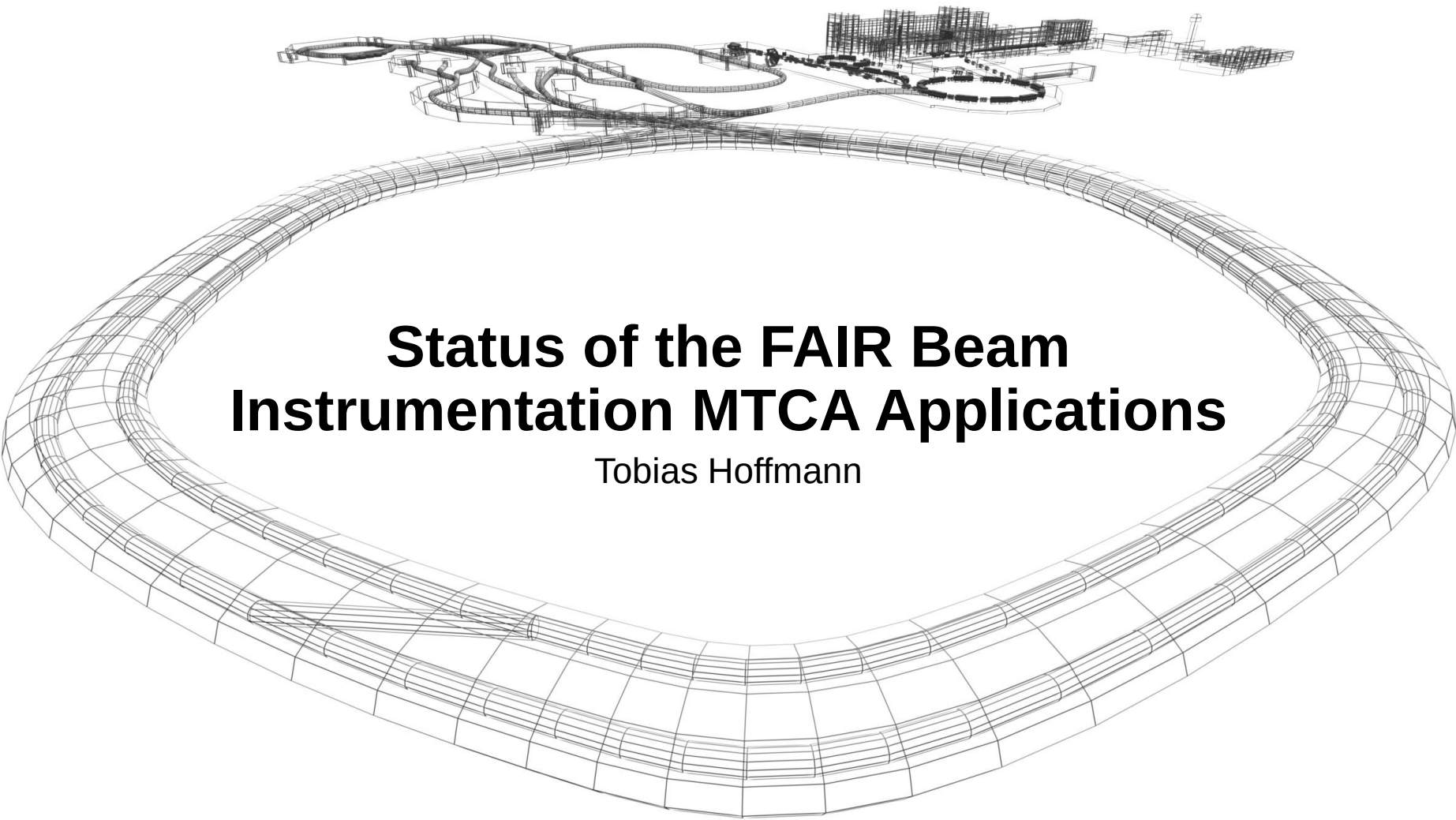


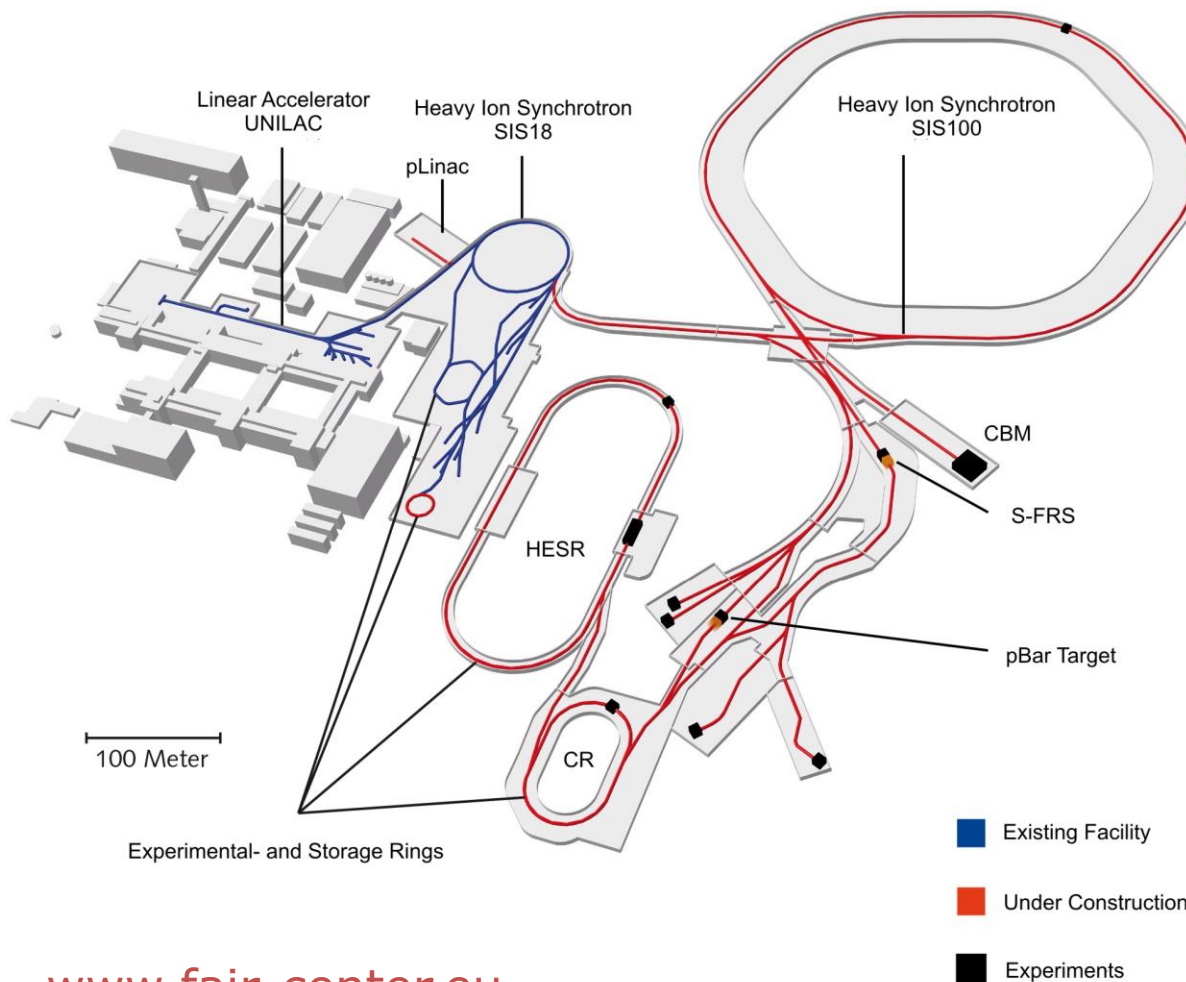


Status of the FAIR Beam Instrumentation MTCA Applications

Tobias Hoffmann



Foto: © D. Fehrenz, GSI/FAIR



primary beams:

- up to 35 GeV/u Uranium
- up to 90 GeV/u Protons

secondary beams:

- broad range of radioactive beams
- antiprotons 0 - 30 GeV

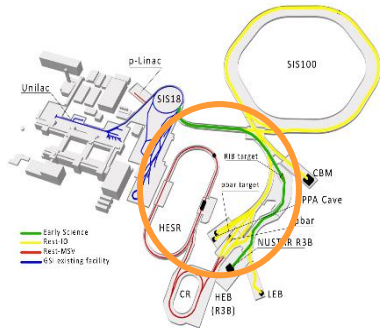
storage and cooler rings:

- radioactive beams
- 10^{11} stored and cooled
0.8 - 14.5 GeV
antiprotons

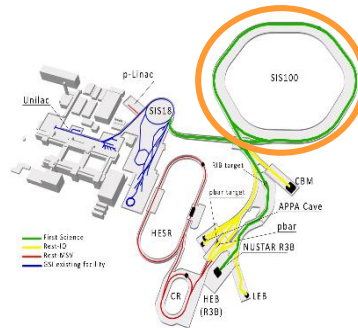
- very high diversity
- all elements from p to U
- parallel beam operation

www.fair-center.eu

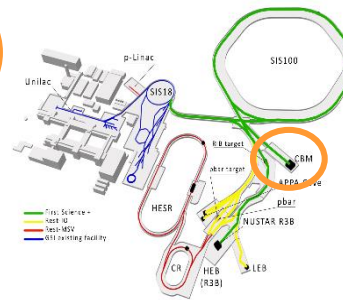
Stepwise approach towards FAIR



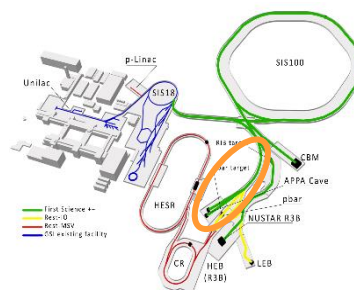
Early Science



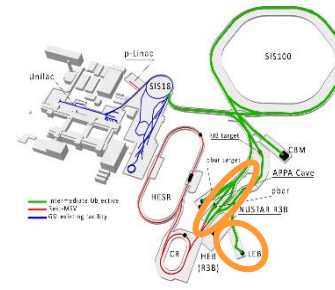
First Science



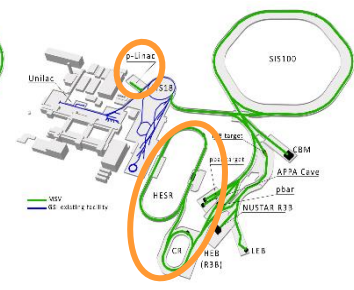
First Science +



First Science ++



Intermediate Objective



Modulare Startversion

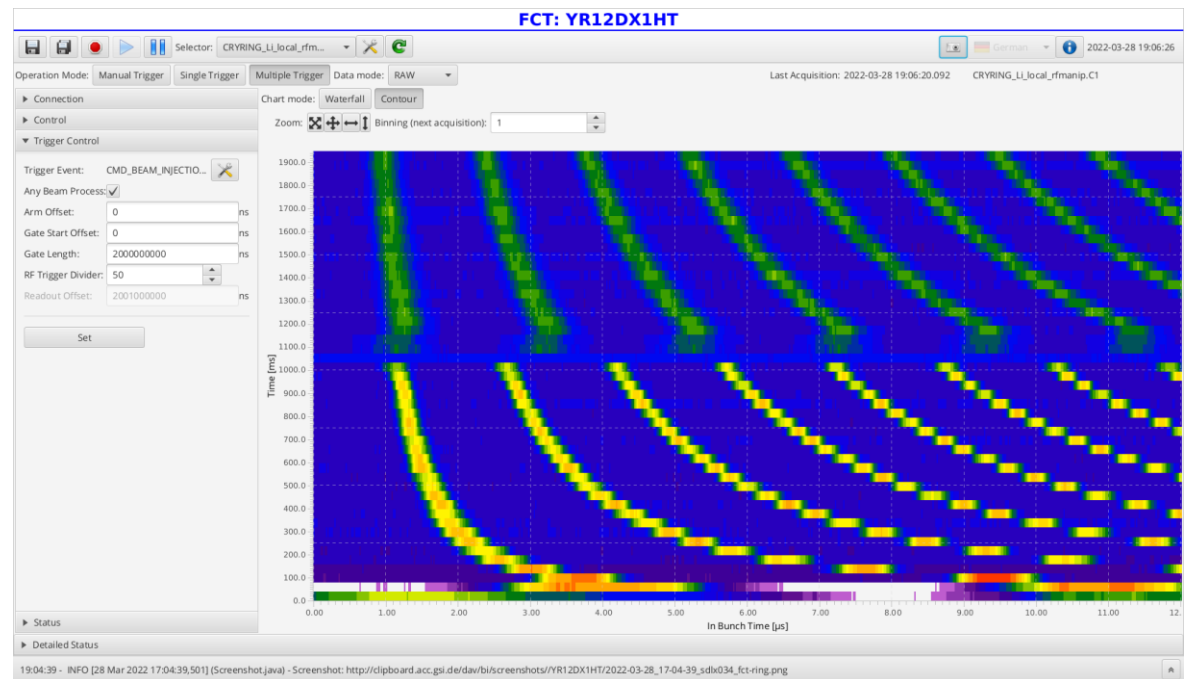
- 1. Fast Current Transformer (2.5GSPS)**
- 2. Resonant Transformer**
- 3. FAIR BI Particle Detector Readout**
- 4. UNILAC Macro Pulse Selector (64 ACTs)**
- 5. UNILAC UNIMON System (Online RF status observation)**

Fast Current Transformer

Status: operational at SIS18, ESR, Crying, foreseen for SIS100, HEBT, HESR and CR

DAQ: SIS8160 + SFMC-AD-2500-14-2 Dual Channel 2.5 GSPS 14-bit Digitizer FMC
SIS8864 64-BIT I/O

Bunch dynamics during RF manipulations



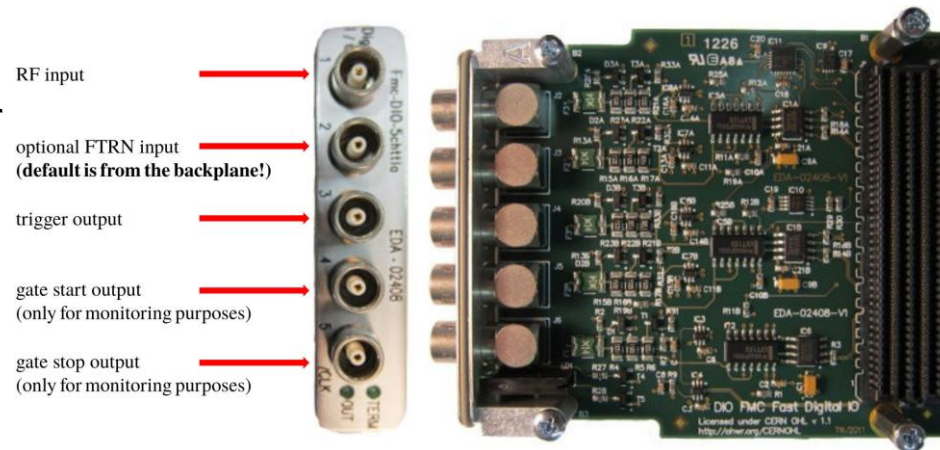
Li⁺ beam from local injector over 2 seconds from injection to flattop with rebunching from h=8 to h=6 in the middle (Crying)

Fast Current Transformer

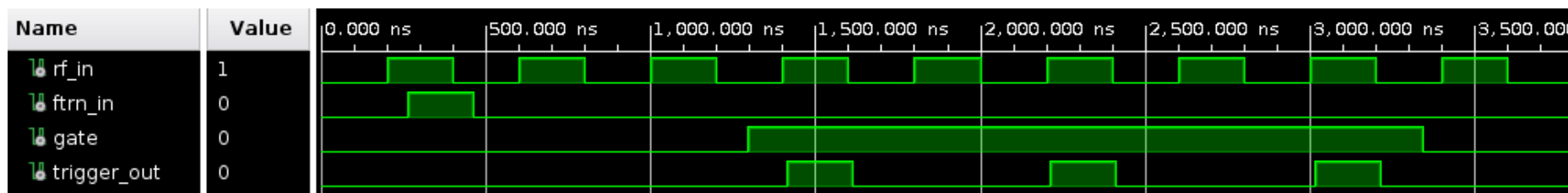
Data acquisition:

- Measure short time periods (few μs) over a longer period using the multi-event capability of the ADC
- Measurement time mostly limited by ADC memory
- Measurement triggered by RF pulses
- Trigger rate reduced by **rate divider**

Photo: ohwr.org



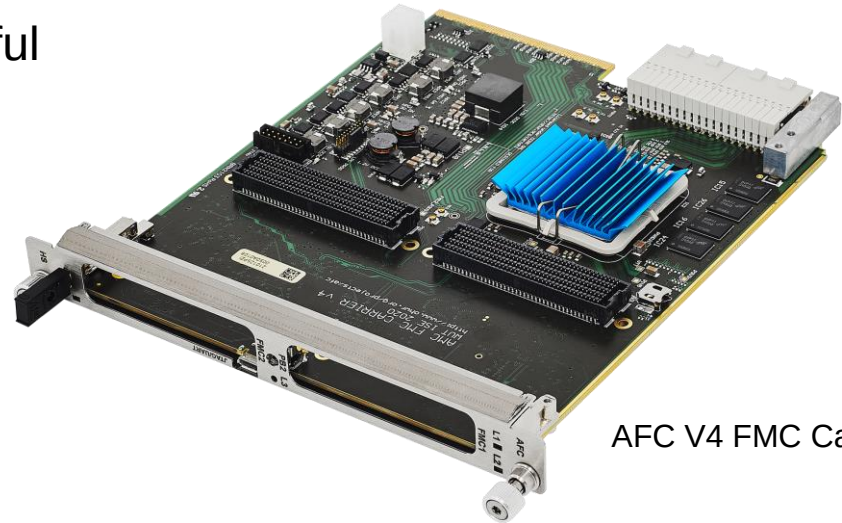
FMC DIO 5ch TTL as rate divider on AFC V3.1



Resonant Transformer

Photos: ohwr.org, LNLS, CERN

Status: tests with beam successful
Location: HEBT
Readout: triggered (fast extraction)



AFC V4 FMC Carrier

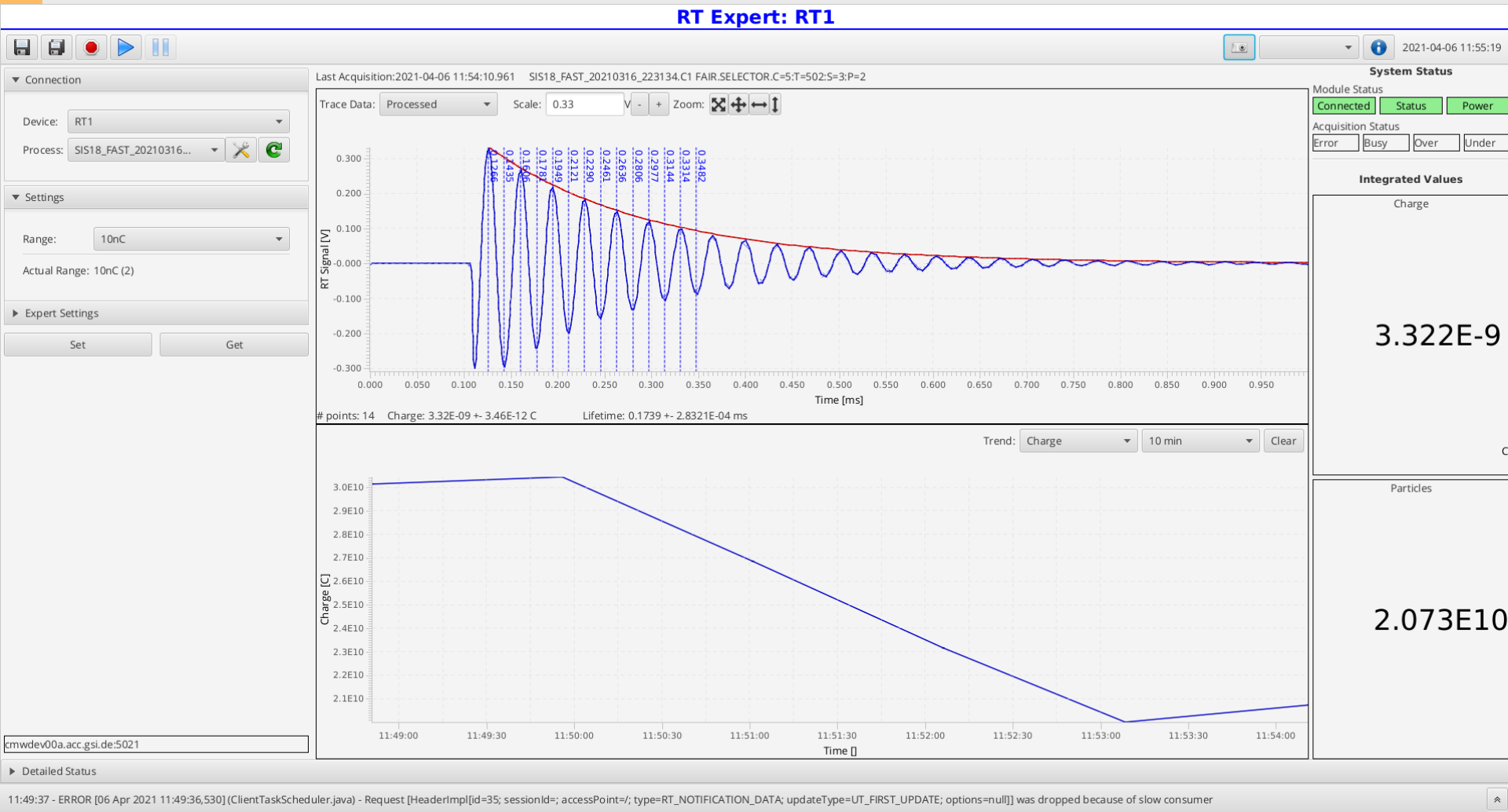
Open hardware project:

- LNLS/WUT development of AFC V4 Carrier
- Firmware integration by LNLS (L. Russo), upgrade to AFC V4 by R. Geißler
- OpenMMC

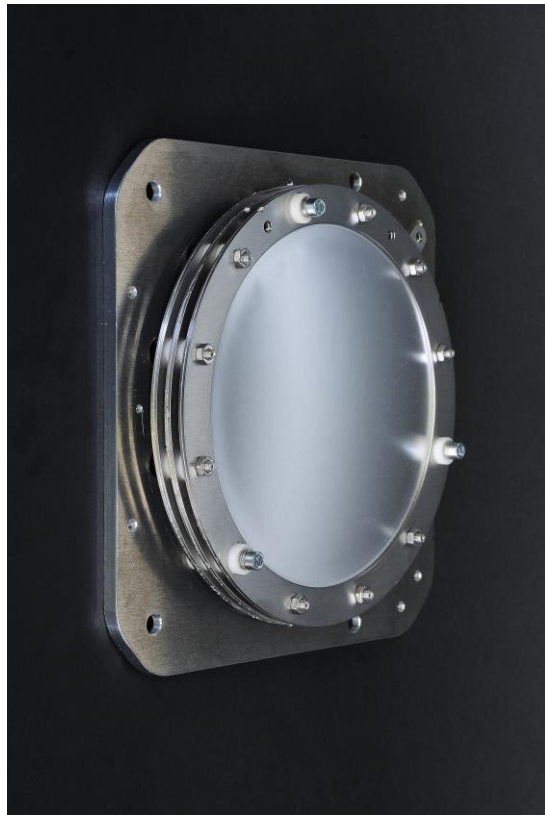


ADC 100MSPS/14Bit

Resonant Transformer



LASSIE: Large Analog Signal and Scaling Information Environment (presented in 2018)



Secondary Electron Monitor (SEM)

- **Online** observation tool for operating team
- Multichannel scaler system (SIS8800)
- Modular, scalable (6-Slot or 12 Slot MTCA.4 Chassis)
- Analog signal discrimination (SIS8980)
- DAQ system for:
 - Ionisation Chambers (IC, IFC)
 - Secondary Electron Monitors (SEM, IFC)
 - Collimators (IFC)
 - Plastic Scintillators (Sc, LE-Disc.)
 - Beam Loss Monitors (BLM, LE-Disc.)
 - Virtual Signals (UFC)
 - ❖ DC Transformer
 - ❖ Cavity rf
 - ❖ Master rf
 - ❖ Magnet ramps
- Low resolution, not suitable for high quality measurements, **limited to 1 kHz latching frequency**

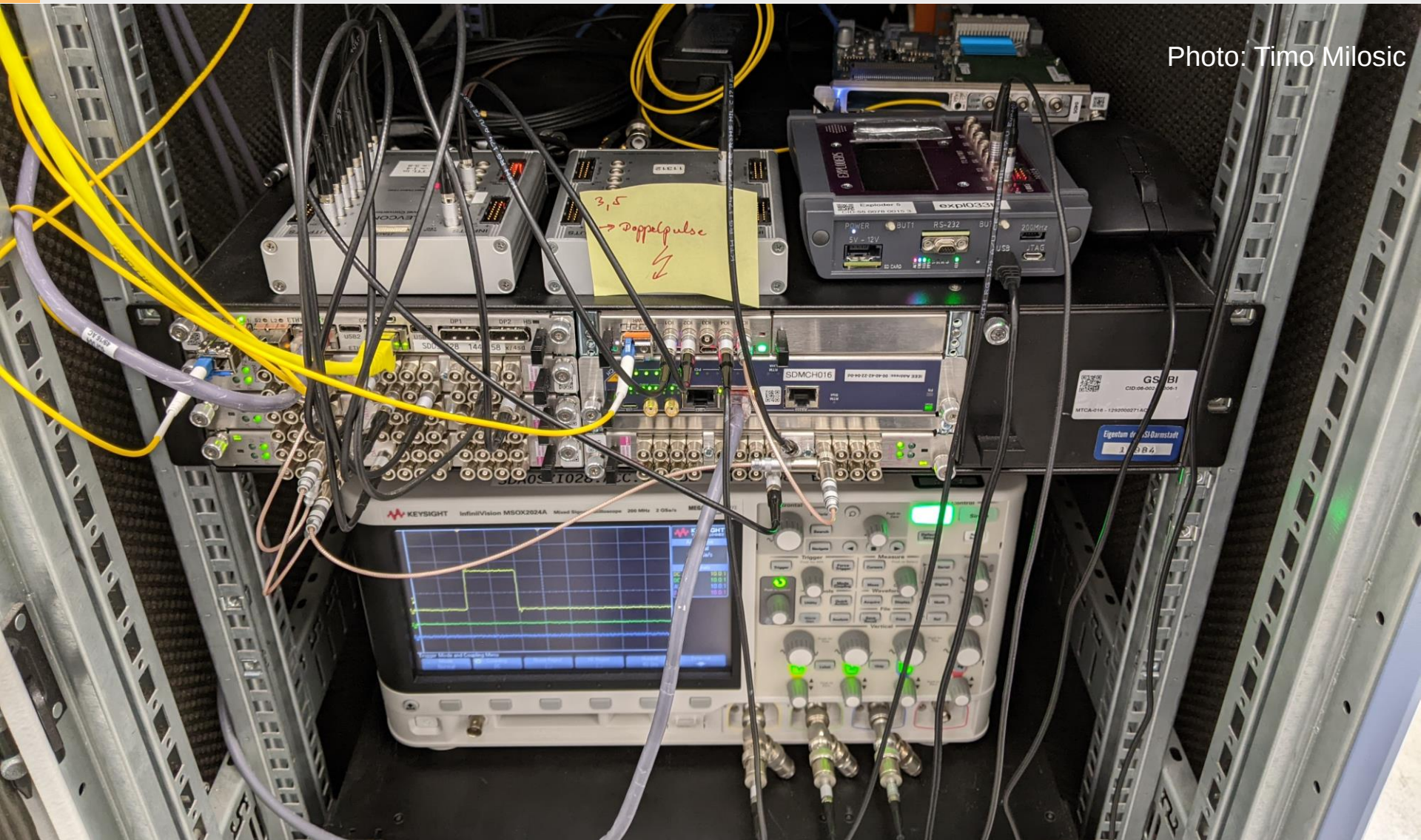
What is LASSIE Expert?

- Independent scaler-based spill micro structure measurement (safety/efficiency)
- External latch via backplane by FTRN-AMC, defines times slices (LNE)
- Optional, Zone 3 RTM discriminators SIS8980
- Online and offline expert system with data storage and analysis tools (e.g. FFT)

LASSIE Expert aims for:

- High latching frequencies ~ 1 MHz
- Performance (dep. on data size, amount of channels, modules, and LNE freq.)
- Focus on timing reliability, timing precision/alignment between channels
- Local data storage for high precision data
- All timing messages recorded in data frames and available (advantageous for offline analysis)

Photo: Timo Milosic



Readout path:

- MCS (Multi-Channel Scaler Mode) and DMA on 2 GB DDR3 memory
- Fastest option, reads raw data from memory
- Reached: 4 modules (x 32 ch) at 10 MHz LNE incl. processing using CCT AM G64 CPU, target is 1 MHz
- Continuous readout with pipelining concept *

Good support by Struck (SIS):

- Firmware v0109: Implementation of requested new readout feature „Raise interrupt after user-defined number of LNEs (continuously)“

Next steps need to be tested / benchmarked:

- Locally, high-bandwidth full info dumps to fast PCIe M.2 SSD
Tested => able to continuously write 2 GB/s
- GUI development,
- Development of performant analysis tools

* See: IBIC '21: SUB-NS SINGLE-PARTICLE SPILL CHARACTERIZATION FOR SLOW EXTRACTION AT GSI SYNCHROTRONS
T. Milosic et al.

GSI Macro Pulse Selector (MAPS)

- Upgrade of Unilac transformer system
- Digitisation of 128 channels
- White Rabbit based timing system
- Digital I/O for adapter interface: SIS8864
- Digitizer:
 - TEWS TAMC532 + RTM
 - 32 Ch. via RTM with 8x RJ45
 - 75/50 MSPS 12/14 Bit
 - triggered readout at 50Hz (Unilac)

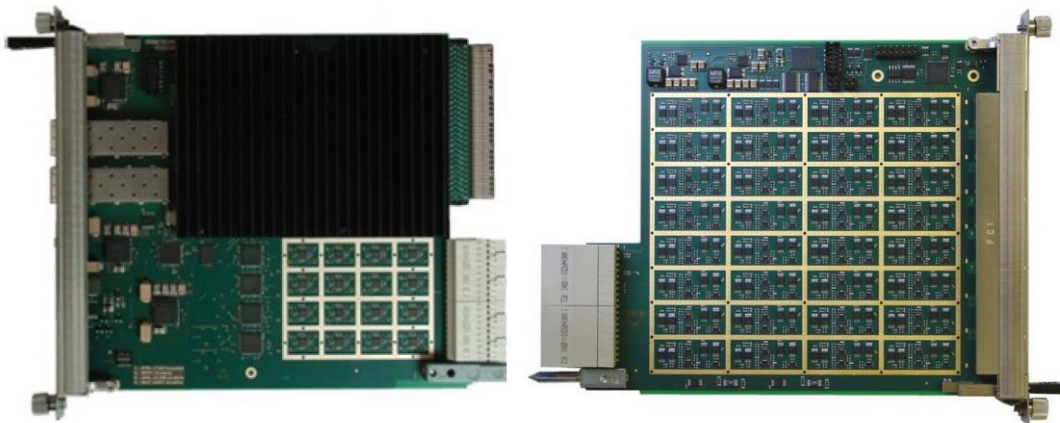
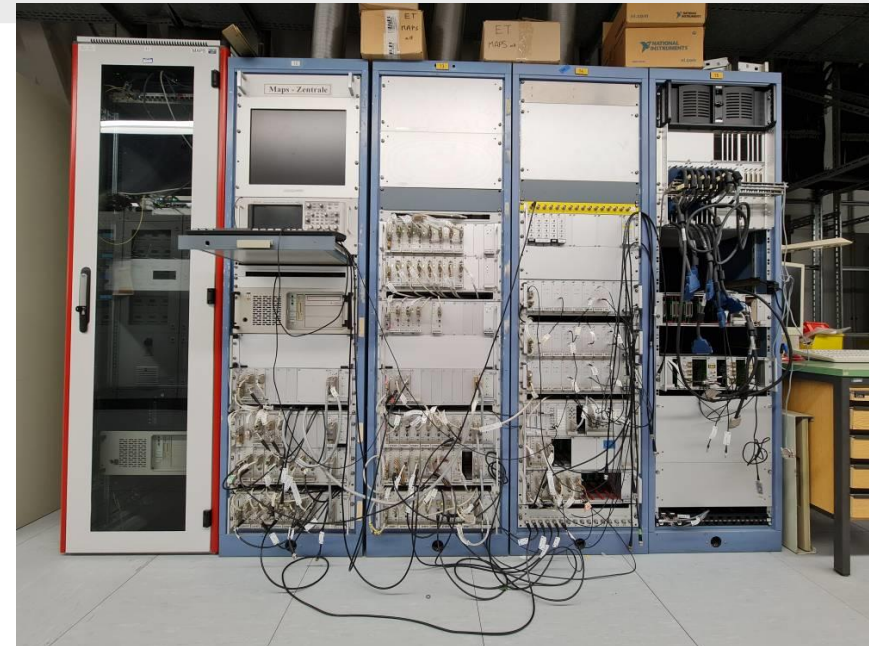
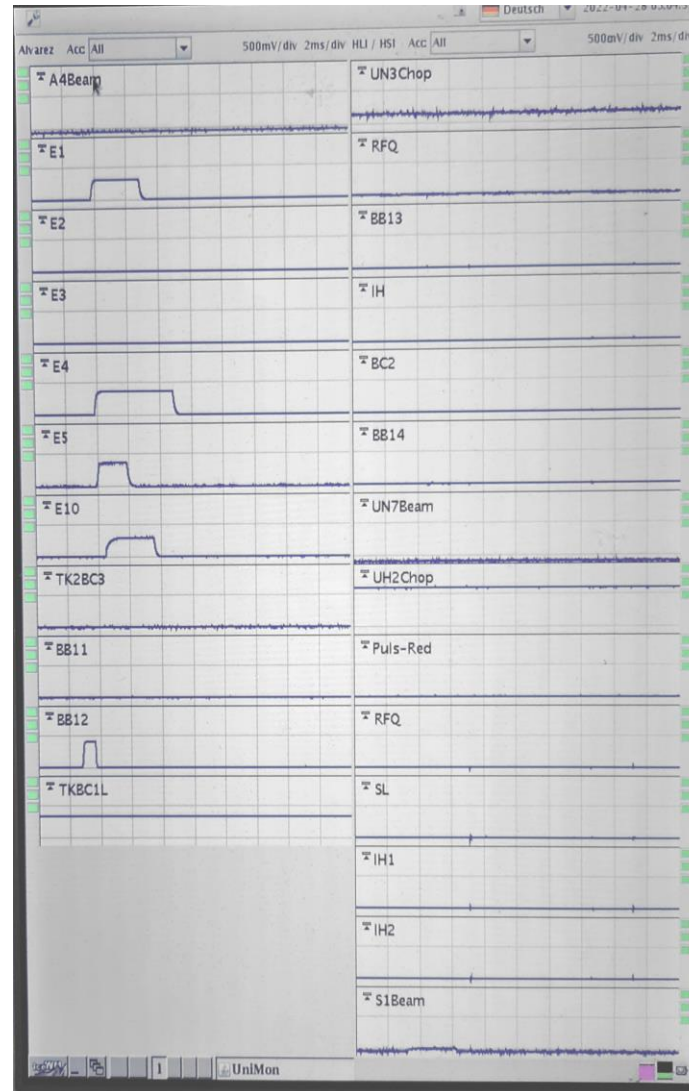
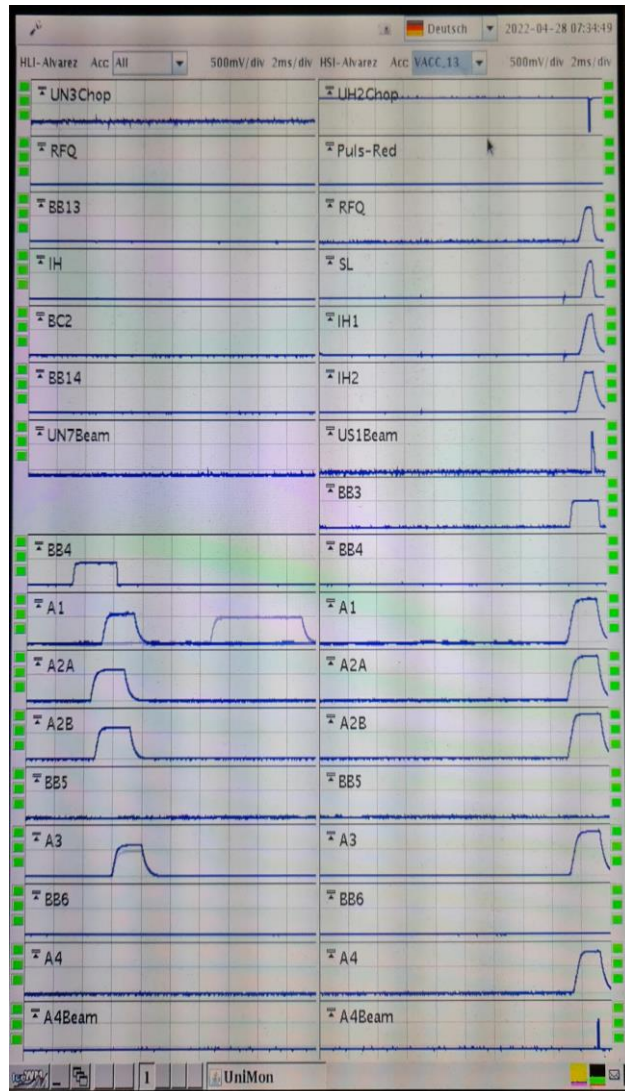


Photo: Powerbridge / TEWS

GSI UNIMON (UNILAC rf Monitor)



GSI UNIMON (UNILAC rf Monitor)

- Multichannel online display for operating
- Up to 80 channels of UNILAC rf signals
 - buncher, chopper, IH, RFQ and Alvarez
- Continuous readout
- Sample rate of ADCs configurable between 1 kHz and 5 MHz
- WR timing on backplane
- Simple hardware software interface via virtual file access

IOXOS FMC (HPC) ADC_3117:
20 channels ADC 16-bit @ 5 Msps

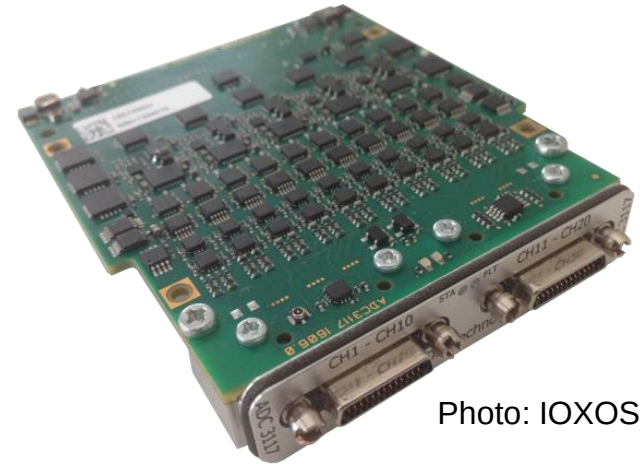


Photo: IOXOS

mounted on OHWR.org
AFC V4 FMC Carrier

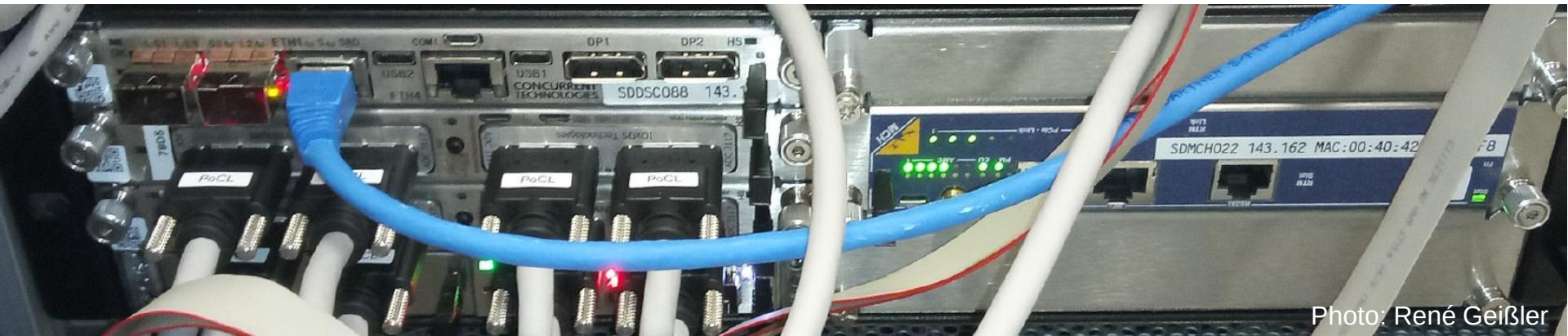


Photo: René Geißler

- FAIR is nicely progressing, but in a limited version
- Using MTCA for GSI and FAIR beam instrumentation has proven its worth in daily operation
- COTS and OHWR can go together

The End

Thank you for your attention !

Special thanks to GSI-BEA-DAT:

T. Milosic, H. Bräuning, R. Geißler, R. Haseitl, S. Hammoumi, R. Lonsing
GSI

Questions?

Foto: © D. Fehrenz, GSI/FAIR

FAIR Timing Receiver Node (FTRN)

- White Rabbit
- Developed by COSYLAB as FAIR In-Kind partner
- Obeys MTCA **AND** Libera Hadron Specs



Photo: G.Otto, GSI

- Single width, mid size AMC
- Open hardware
- Bi-directional I/Os
- Trigger over backplane
- Clock and time
- Time-stamping
- Generate digital pulses and clock signals
- Generate specified interrupts at given times
- Custom functionality via LM32 cores