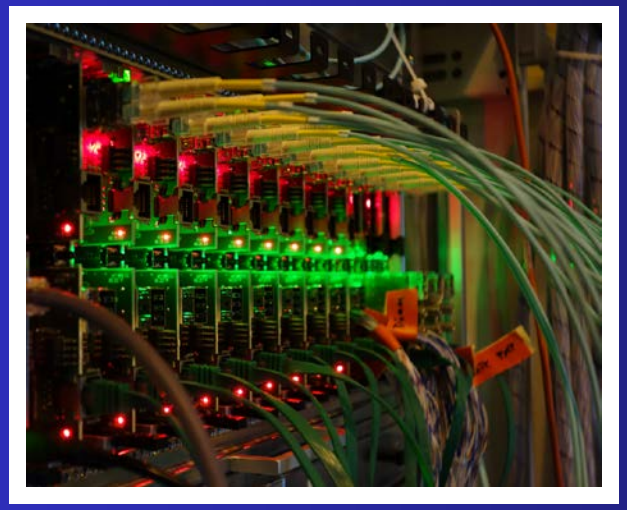
A prototype of the free-streaming data acquisition system for the Compressed Baryonic Matter experiment at FAIR



HK 15.4

David Emschermann
GSI Darmstadt

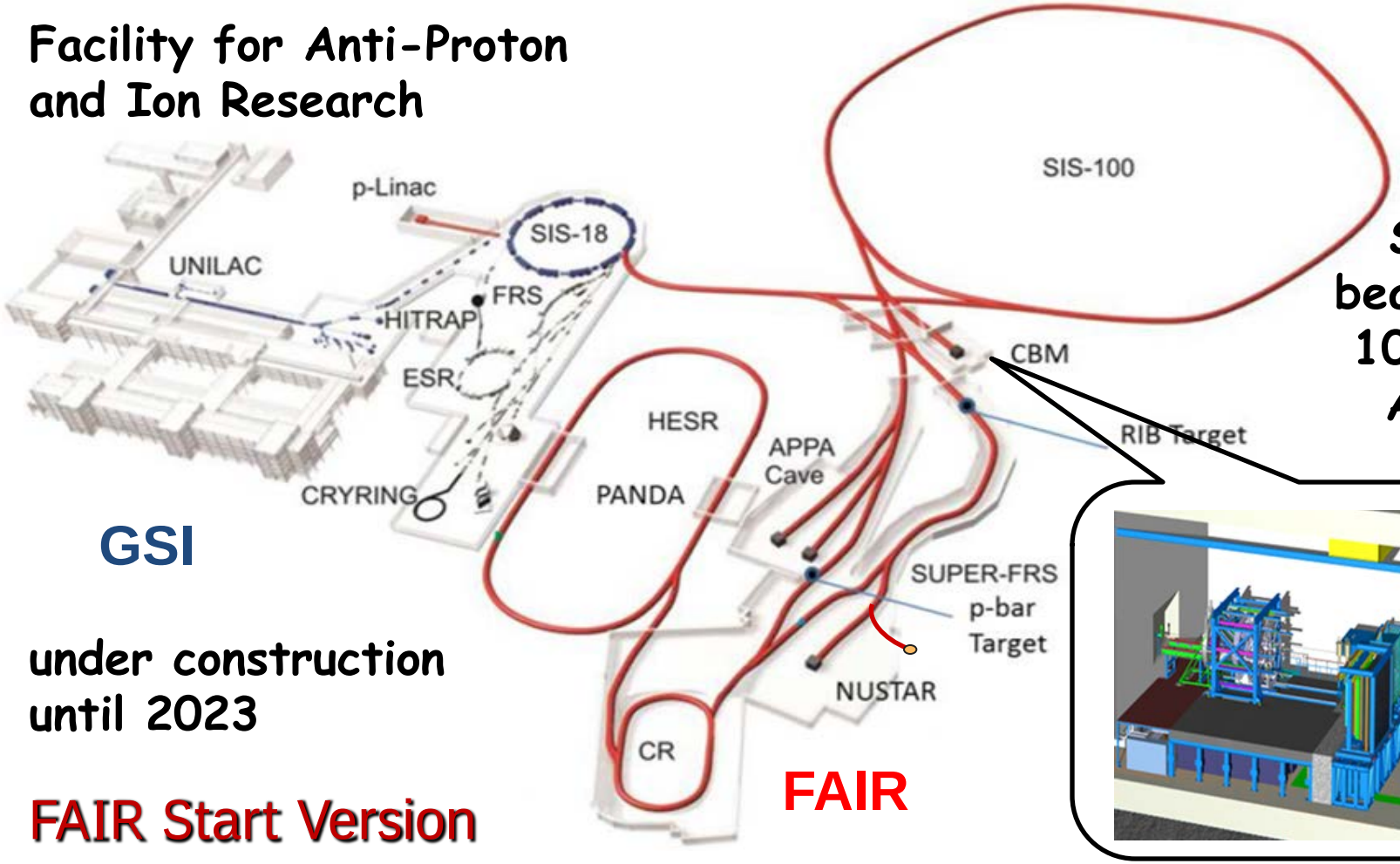
Outline

- Quick introduction to CBM @ FAIR
- Components of CBM DAQ system
- DAQ at the CERN SPS beam test 2016
- Plans for the near future
- Summary

Introduction to CBM

The FAIR complex

Facility for Anti-Proton and Ion Research



GSI

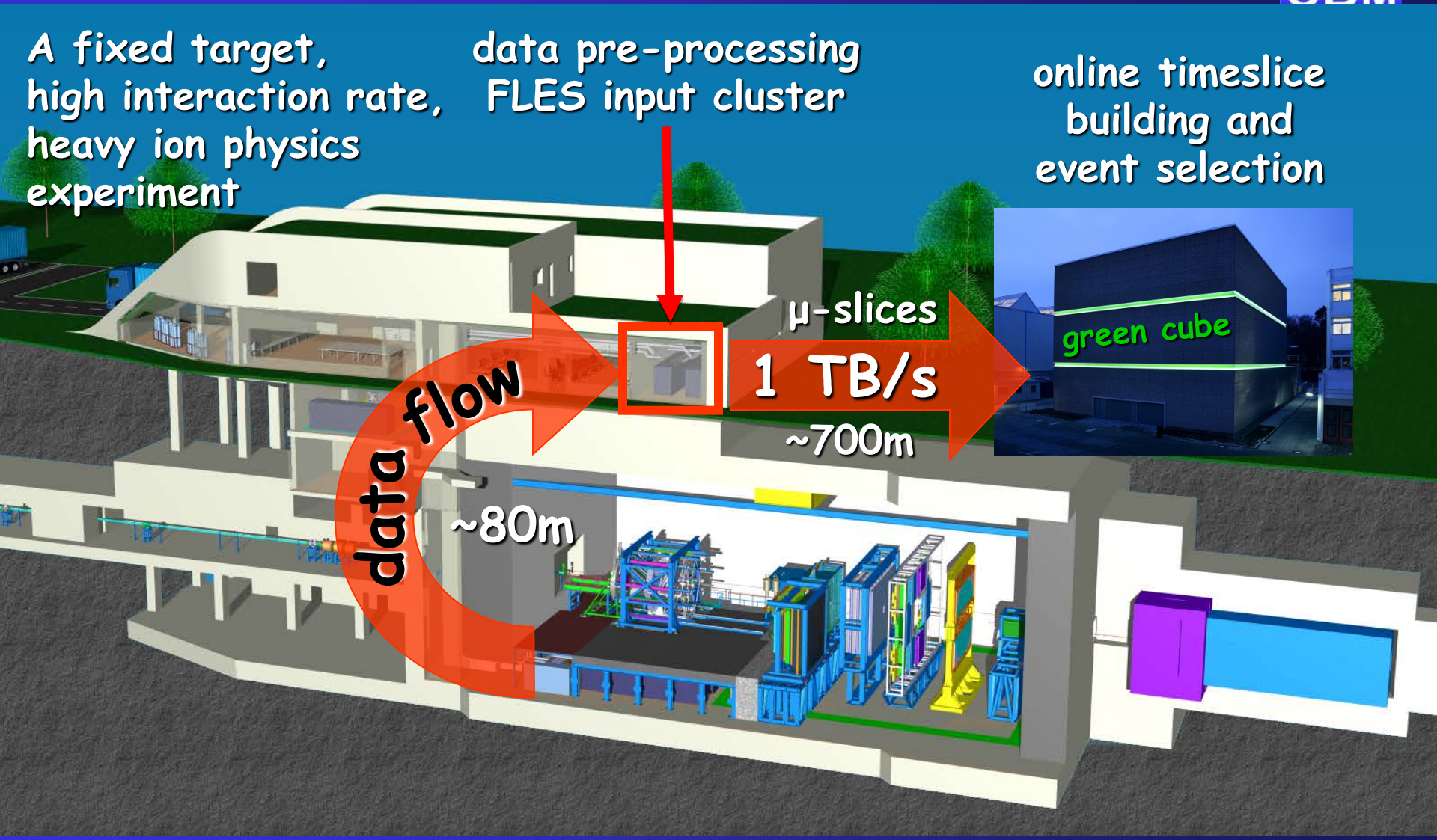
under construction until 2023

FAIR Start Version

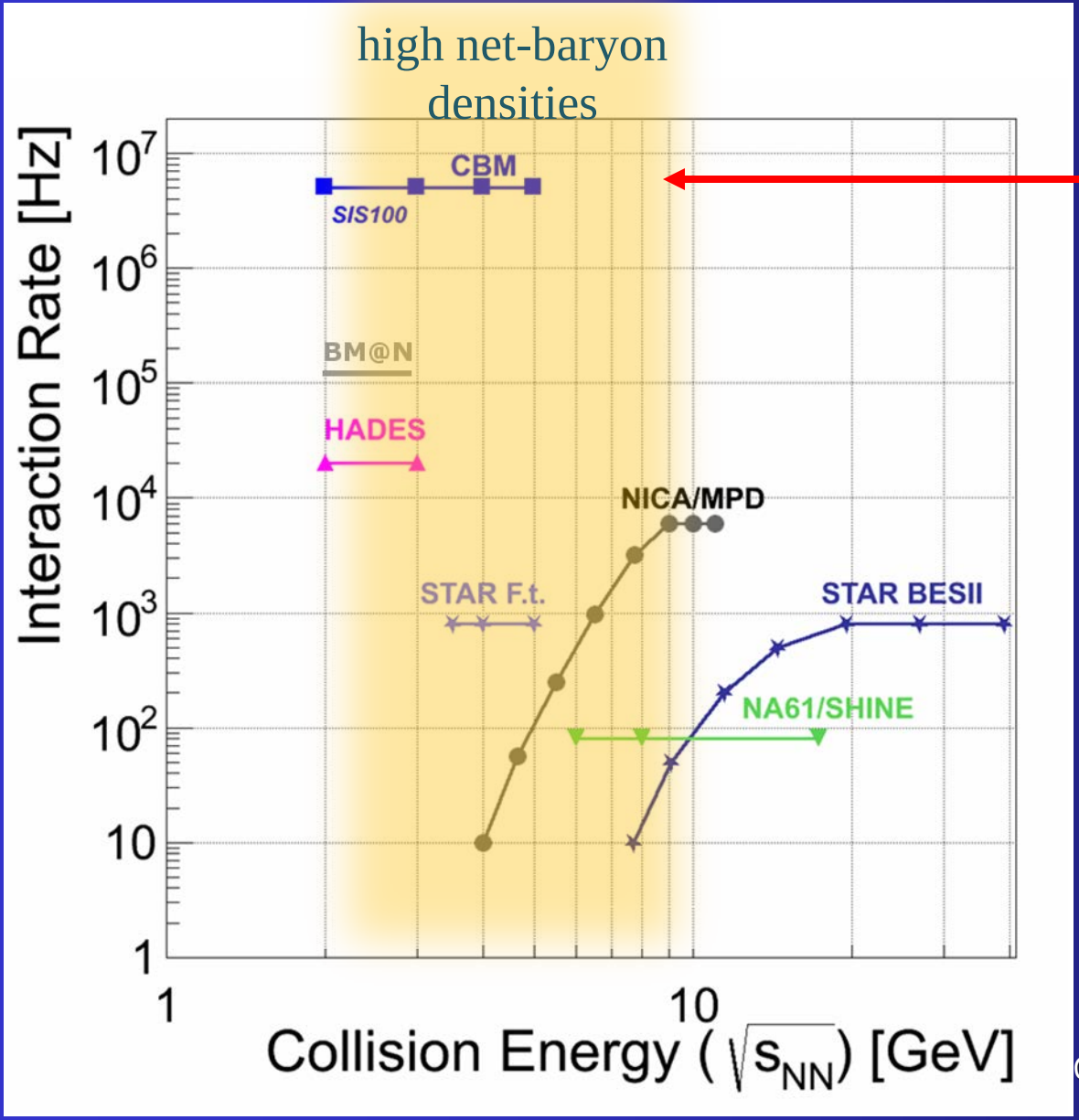
FAIR

SIS100 beam energy 10 AGeV/c Au-beam

DAQ in the CBM experiment



Interaction rate / SPS goals

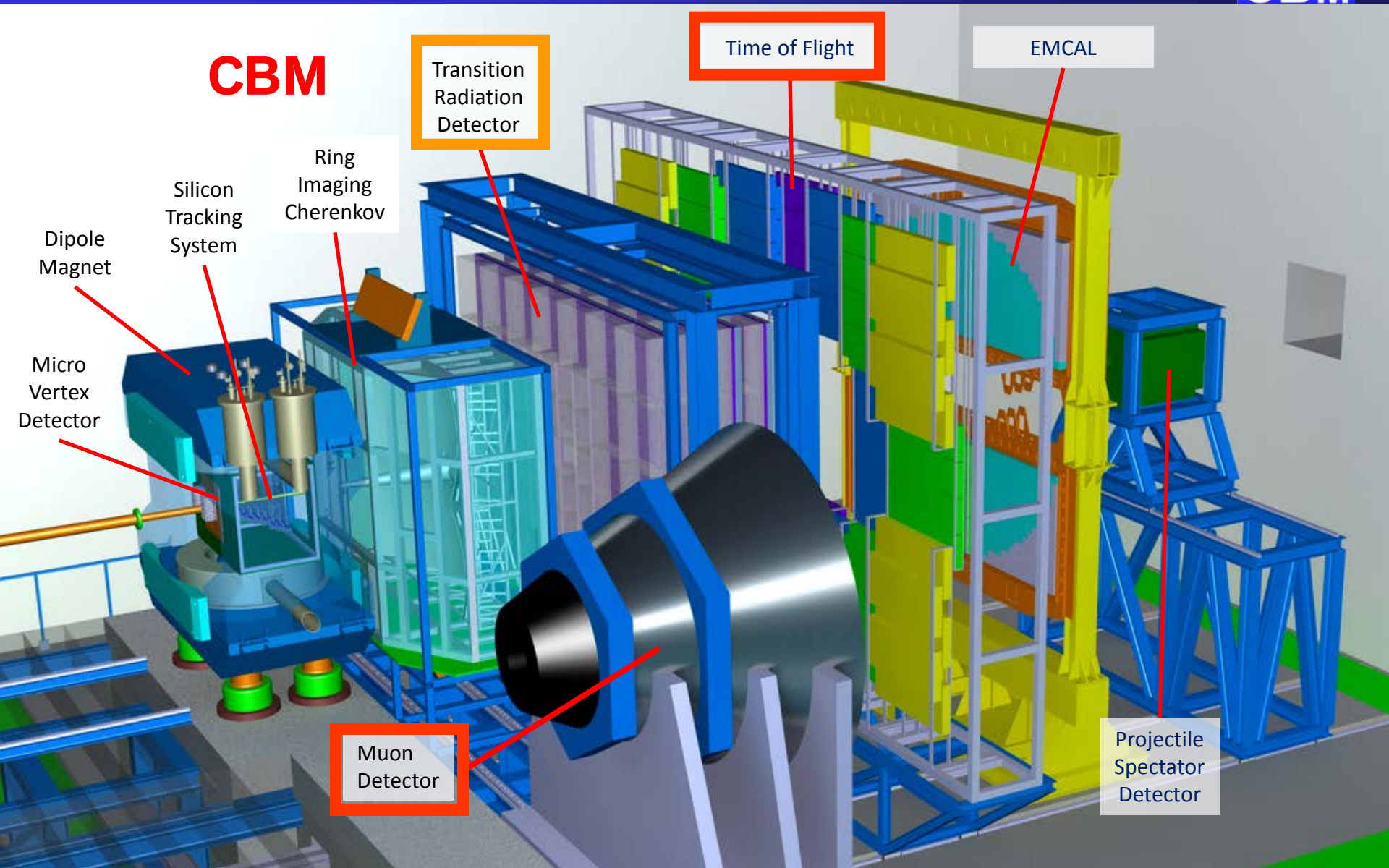


Rate capability of CBM at SIS100

Aim of this beam test: Test pre-series detectors with free streaming front-end electronics in a common readout system under realistic conditions

Pb-beam (few AGeV/c) on Pb-foil target, several kHz/cm^2 hit rate of secondary particles on detectors

Subsystems at the SPS 2016



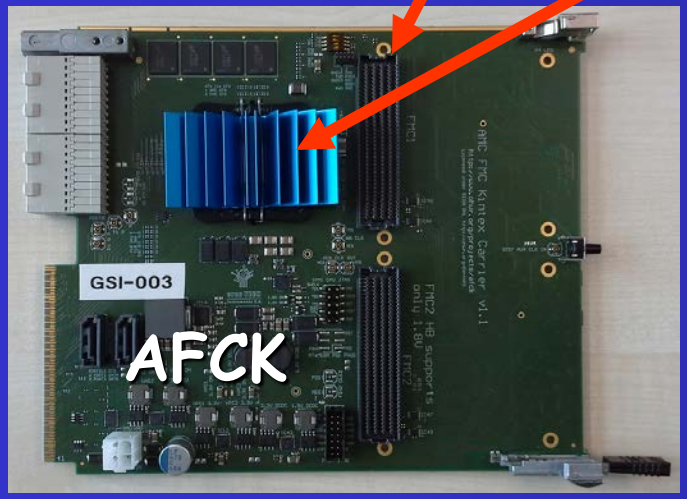
DAQ components

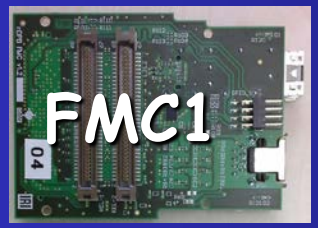
AFCK terminology

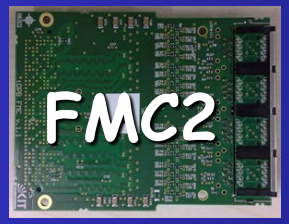
AMC — Advanced Mezzanine Card
-> can be put into µTCA crate

FMC **C**arrier — FPGA Mezzanine Card Carrier
-> can install 2 addon boards

Kintex — -> a Xilinx Kintex FPGA is equipped





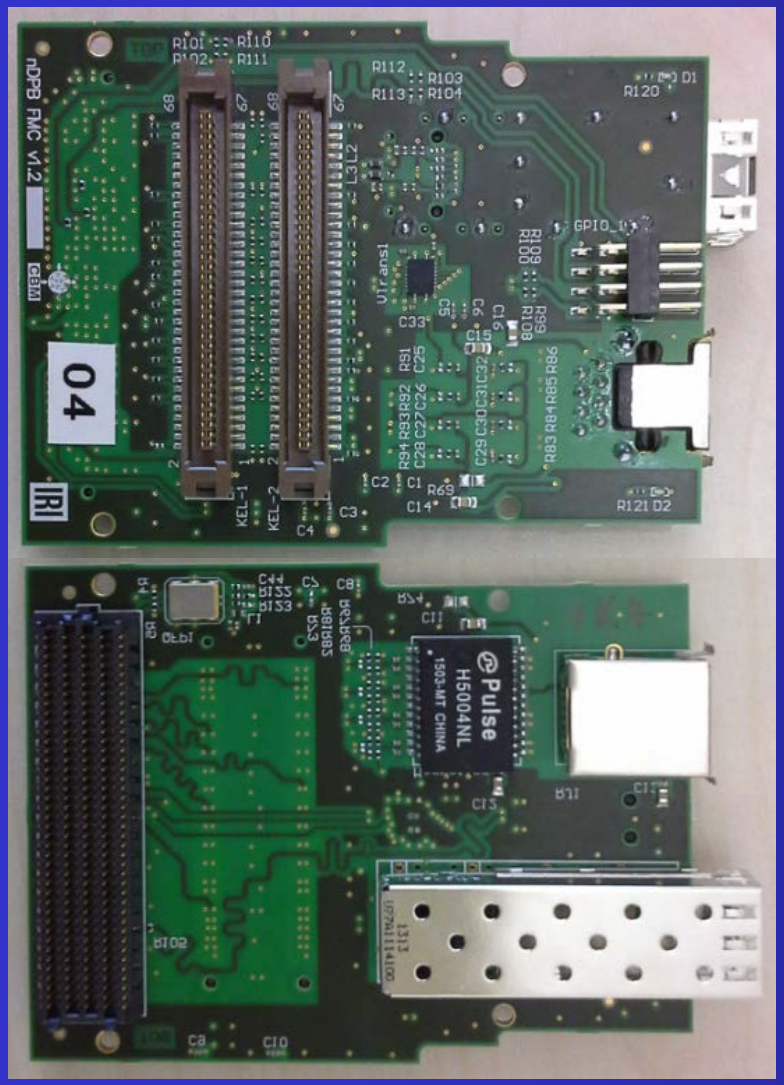


Take 1x AFCK
+ add 1 or 2 FMCs
+ add firmware
=> get a xDPB
Data Processing Board

tDPB FMC

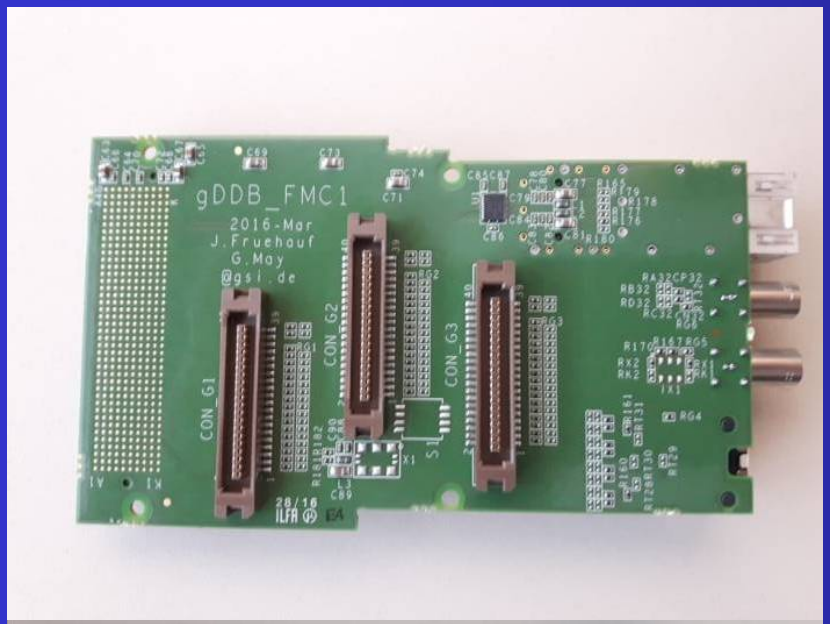
- used for
  Timing and Synchronisation
  between AFCKs
- can take up to
  4x Ethernet patch cables
  (with RJ45 connectors)
- uses 4x wire pairs
  to transmit LVDS signals
- available since February 2016
- design: Lukas Meder (KIT)

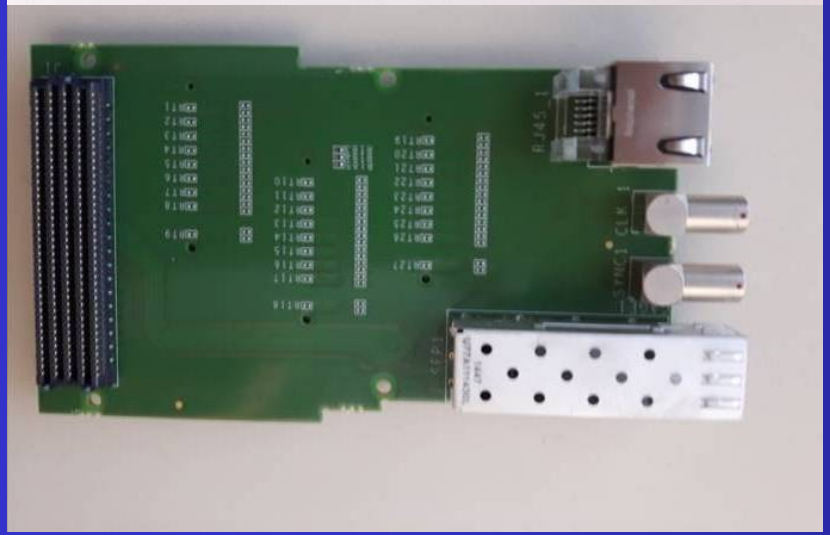
nDPB FMC



- used for n-XYTER FEB-F readout (MUCH, STS)
- 2x FEB-F can be connected
- provides 1x SFP+ slot for 10 GB/s link and 1x RJ45 interface to TS
- GPIO for trigger input
- available since September 2016
- design: Cruz Garcia (IRI)

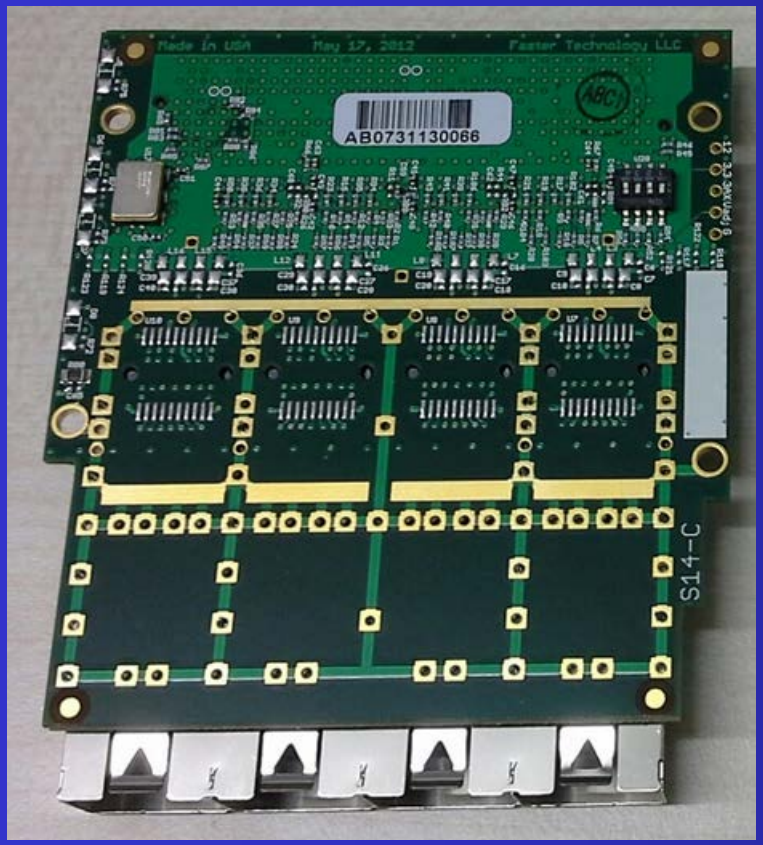
gDPB FMC





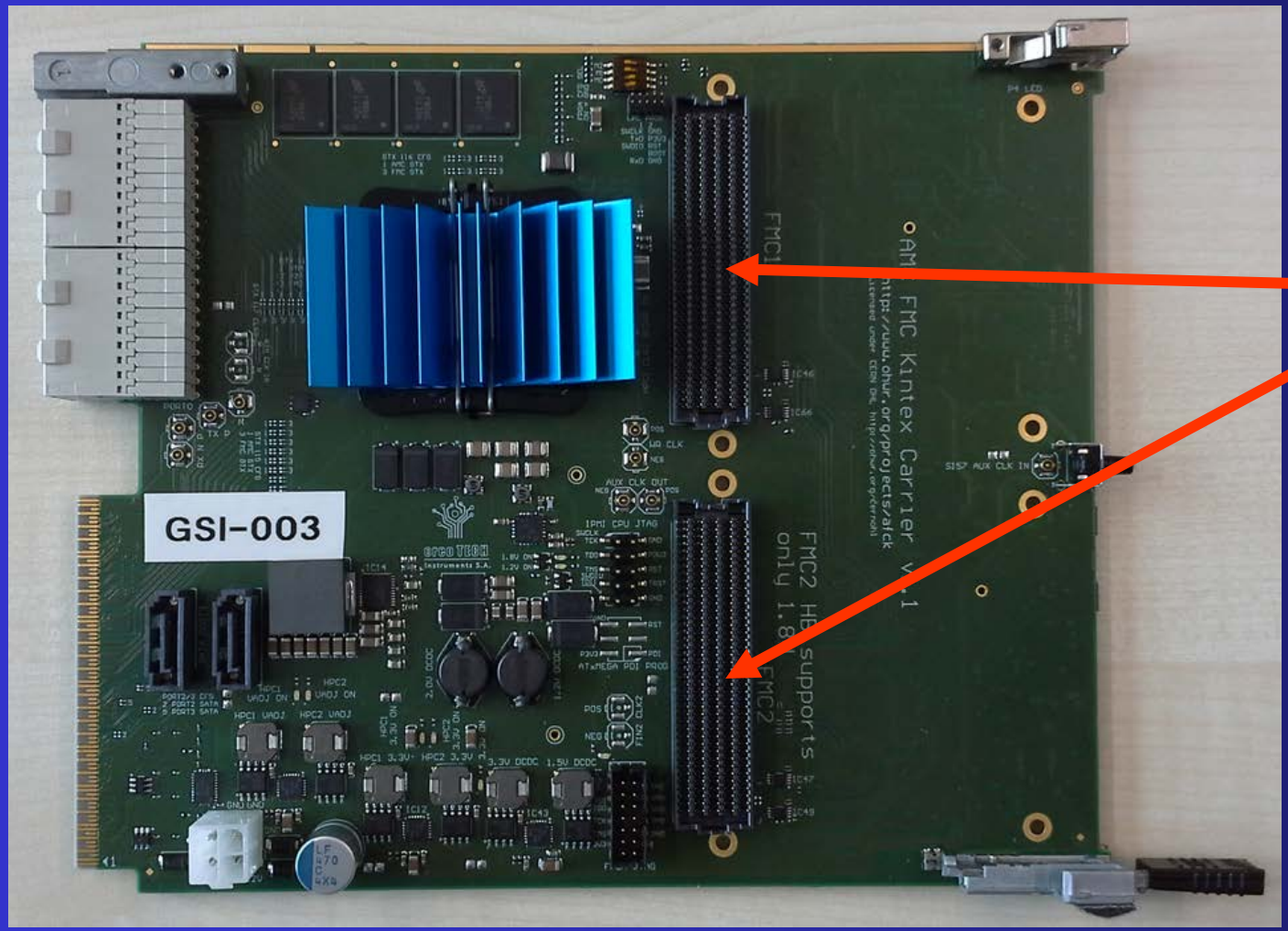
- for GET4 readout (TOF) and for CLOSY input to TS-master
- 3x GET4 FEBs can be connected
- provides 1x SFP+ slot for 10 GB/s link and 1x RJ45 interface to TS and clock input (CLOSY)
- 10 pc available since mid Sept 2016
- design: Jochen Frühauf (GSI)

FM-S14 FMC



- can take up to
  4x SFP+
  to provide
  4x 10 GB/s optical links
- about 20 pcs at GSI
- also used on the FLIBs
- commercial product,
  available from USA

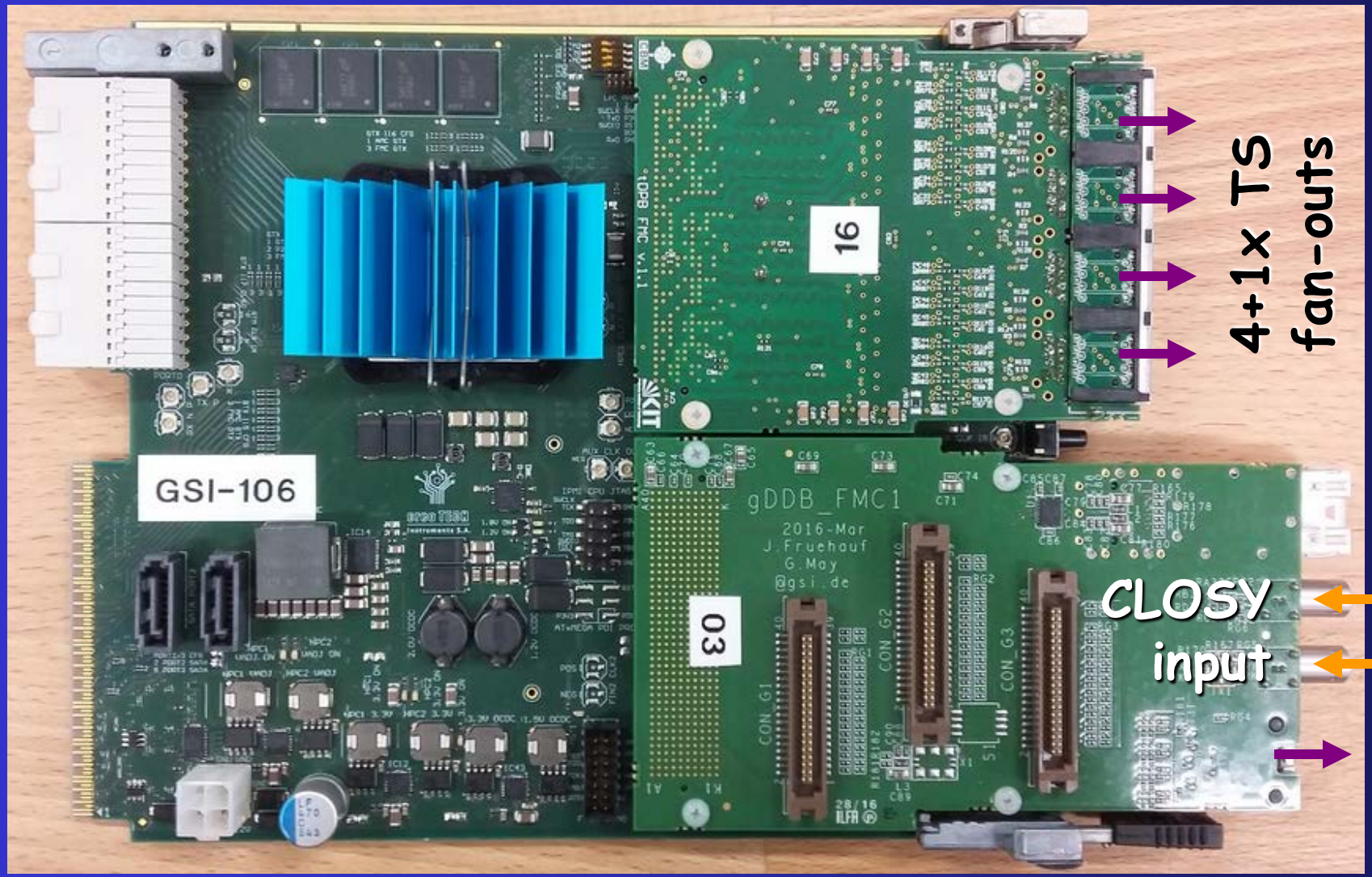
AFCK board



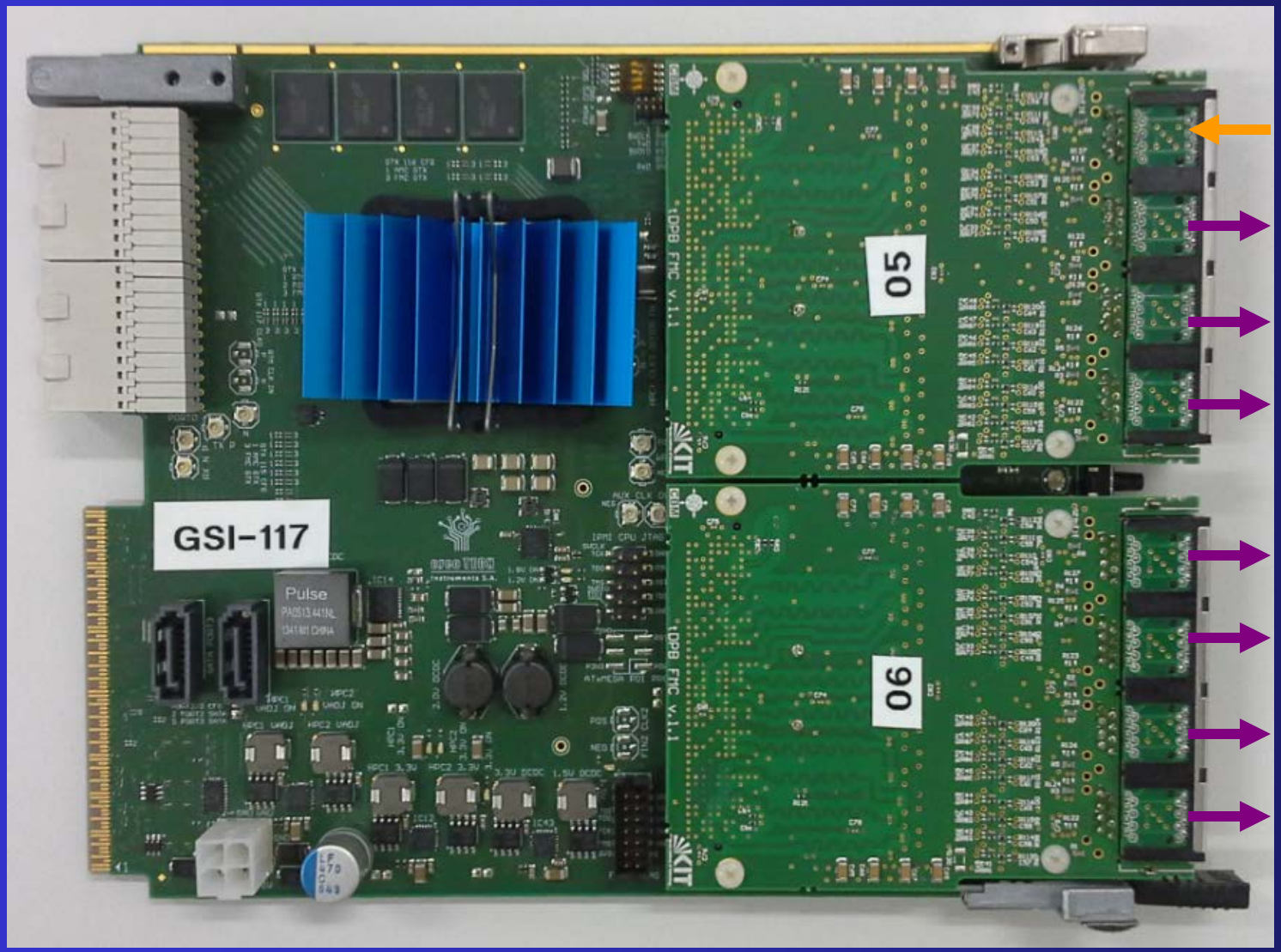
Can be fitted with 2 FMCs (depending on usage)

Operated in a crate or standalone.

TS-Grandmaster



TS-Submaster



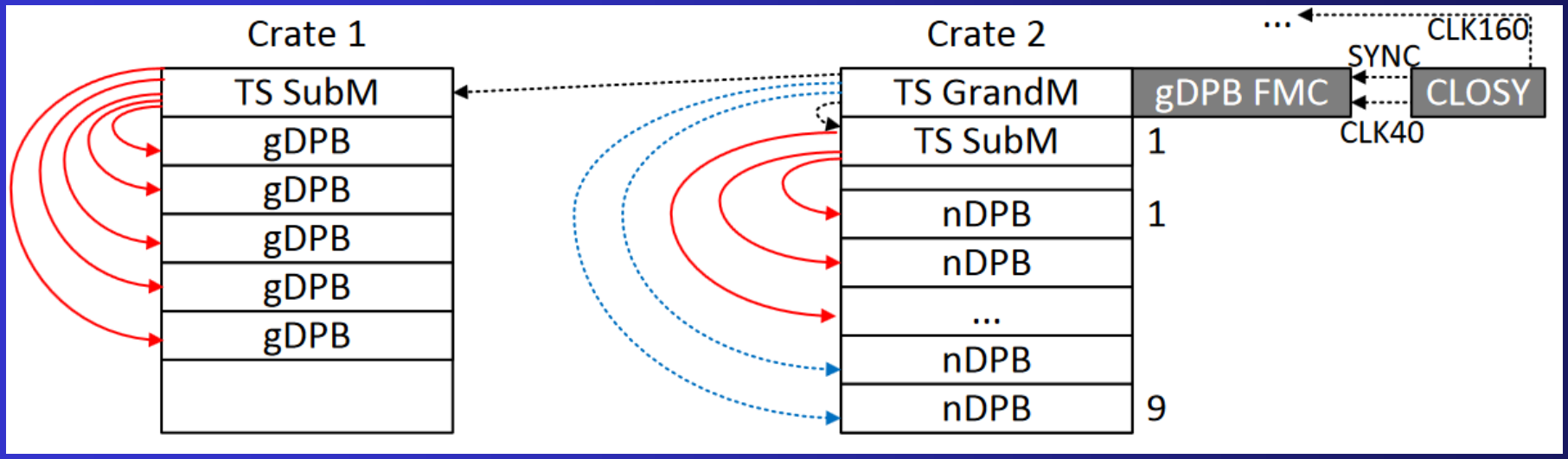
7x TS fan-out, 1x TS input

tDPB FMC

tDPB FMC

Timing setup at SPS

Synchronises all detector front-ends with ns precision.

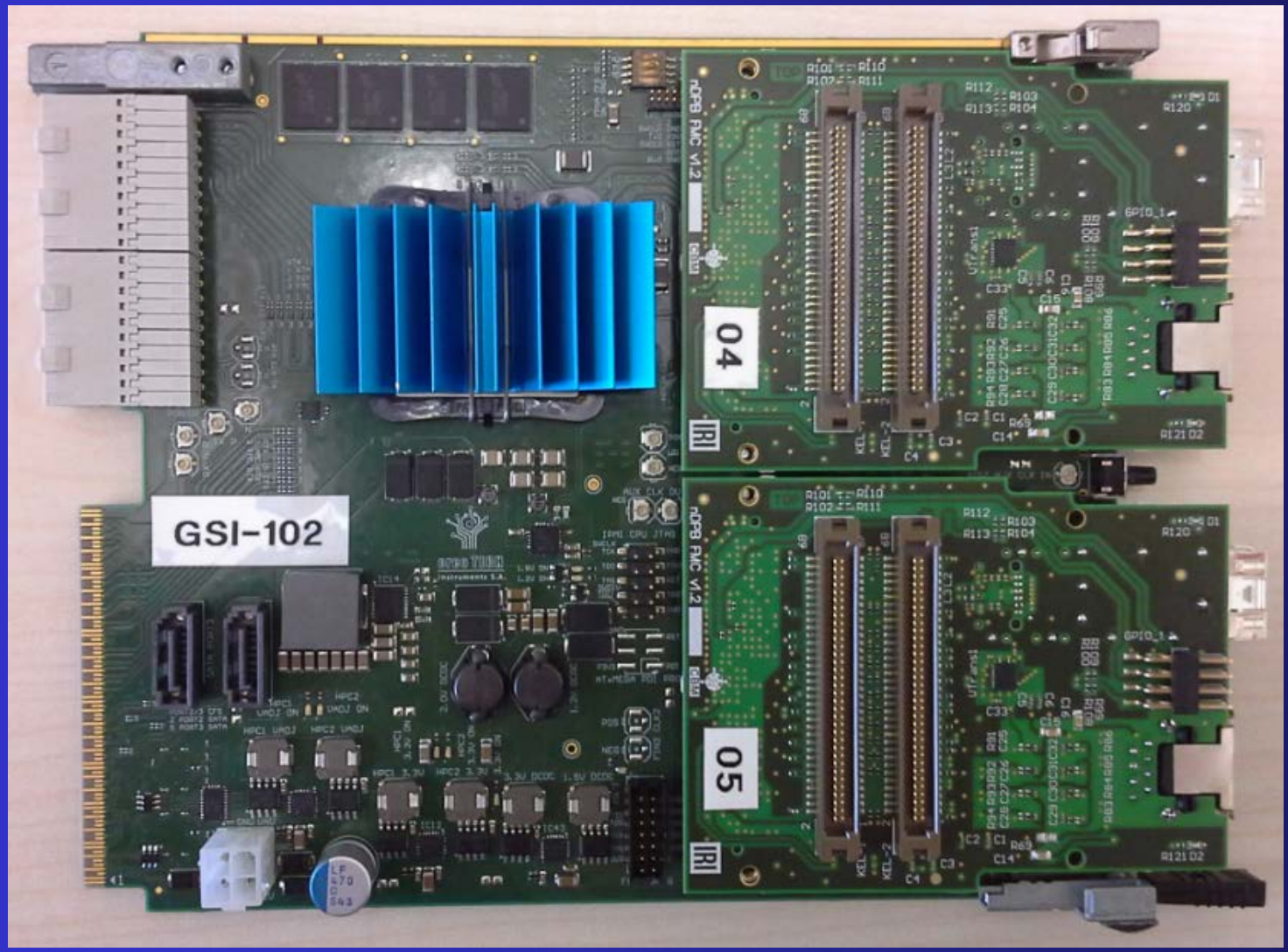


Finally operated at CERN with:

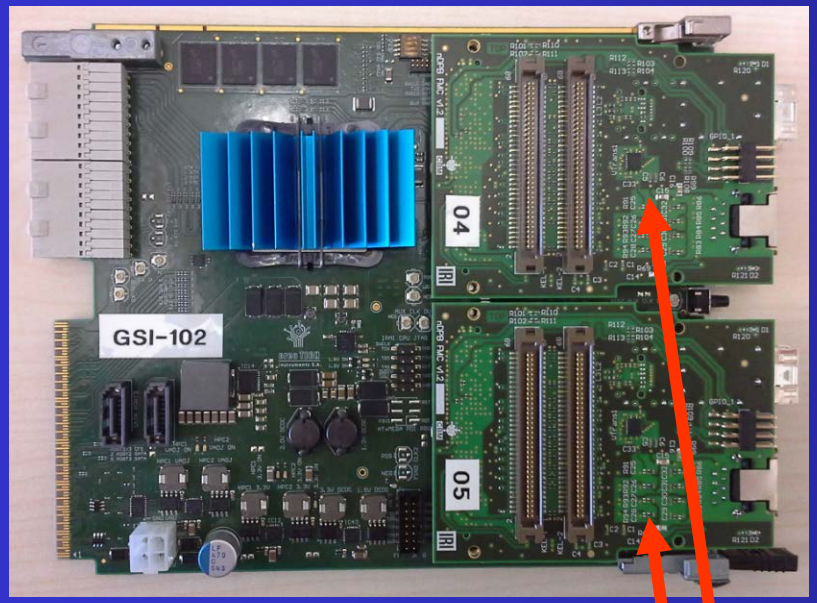
- 2x µTCA crates
- 1x TS Grand-master
- up to 3x TS Sub-master
- up to 14x TS-slaves: nDPB / gDPB

nDPB/gDPB readout chains

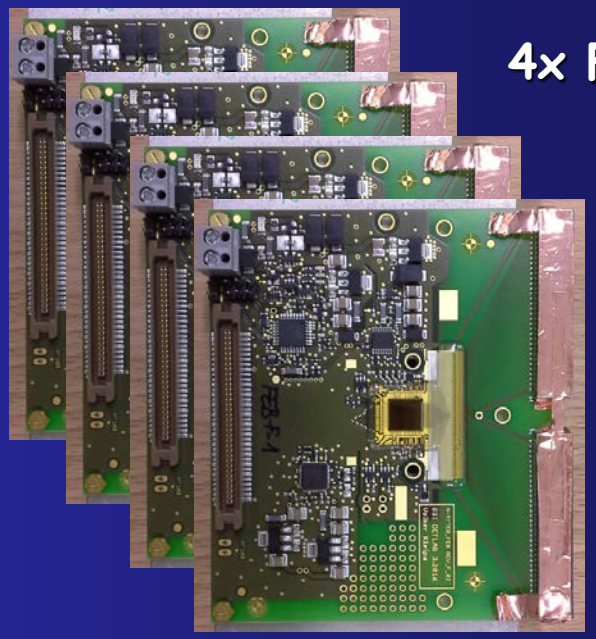
nDPB for MUCH



nDPB (MUCH)



<= <= <= <=

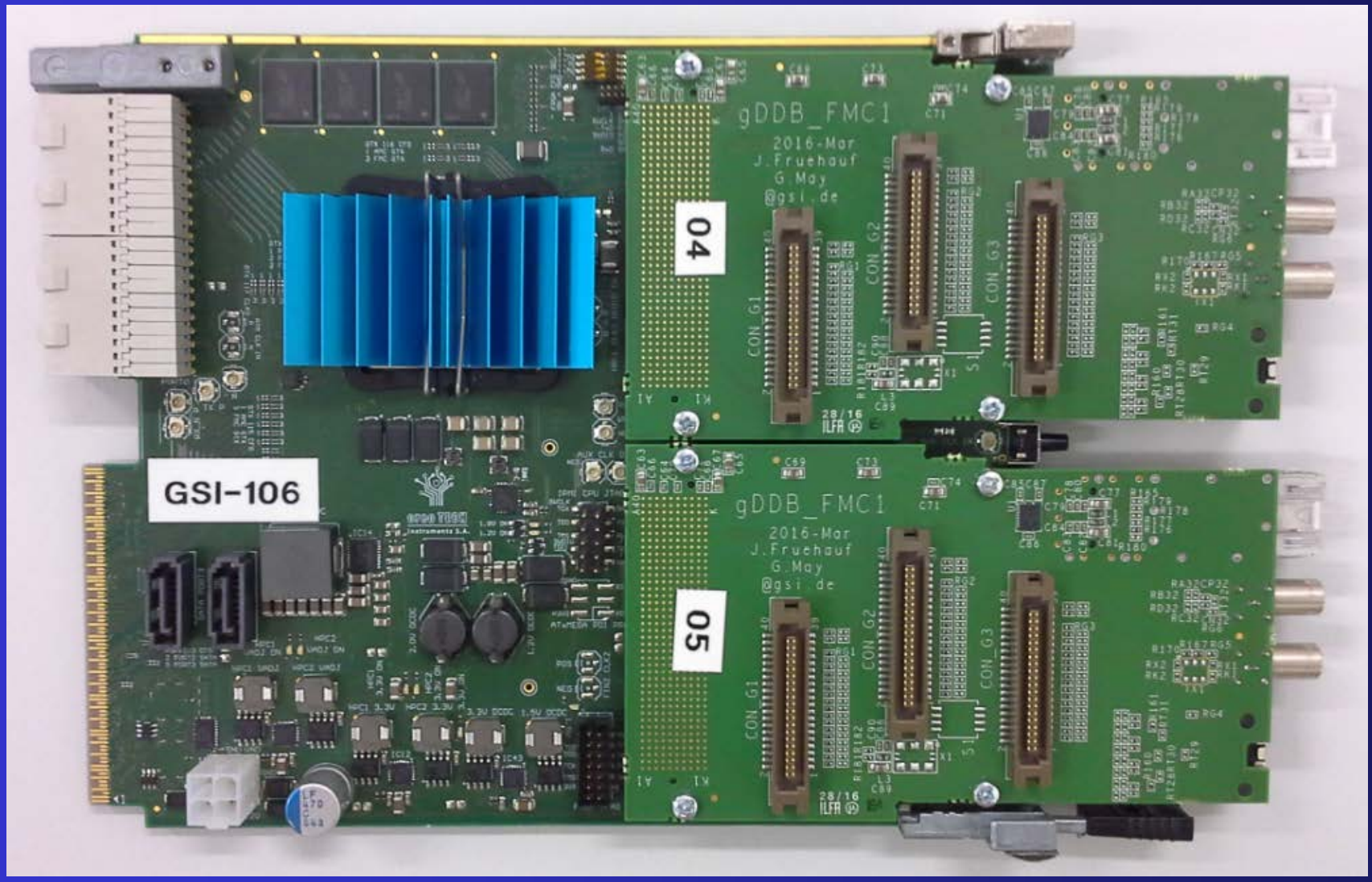


4x FEB-F

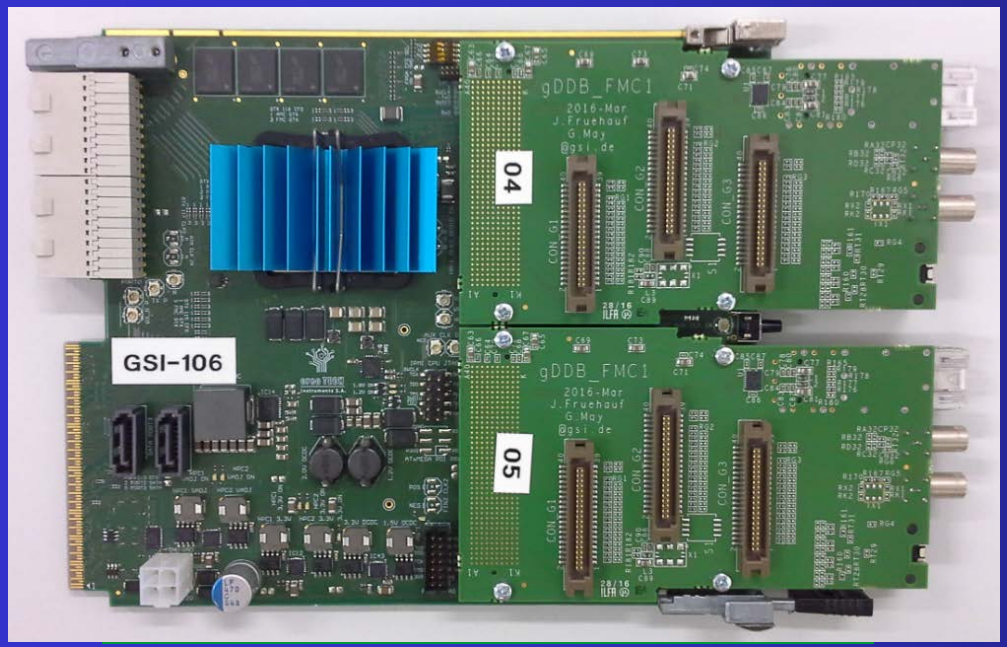
each with 1x nXYTER v2 ASIC

1x AFCK + 2x nDPB FMC + nDPB firmware = nDPB
Up to 4x nXYTER v2 FEB-F per AFCK were readout from the MUCH GEM detectors.

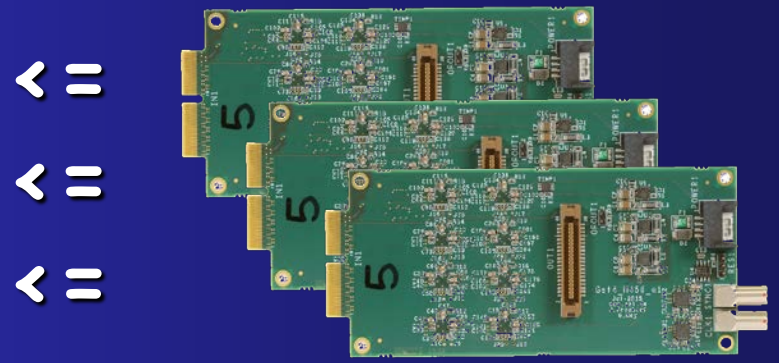
gDPB for TOF


GSI-106
gDDB_FMC1
2016-Mar
J.Fruehauf
G.May
@gsi.de
04
05
CON_G1
CON_G2
CON_G3

gDPB (TOF)



The FM-S14 was finally used as FMC1 at the SPS.



TOF has readout 3x GET4 TDC per 1x gDPB.
The configuration with 2x gDPB FMCs is used at STAR.

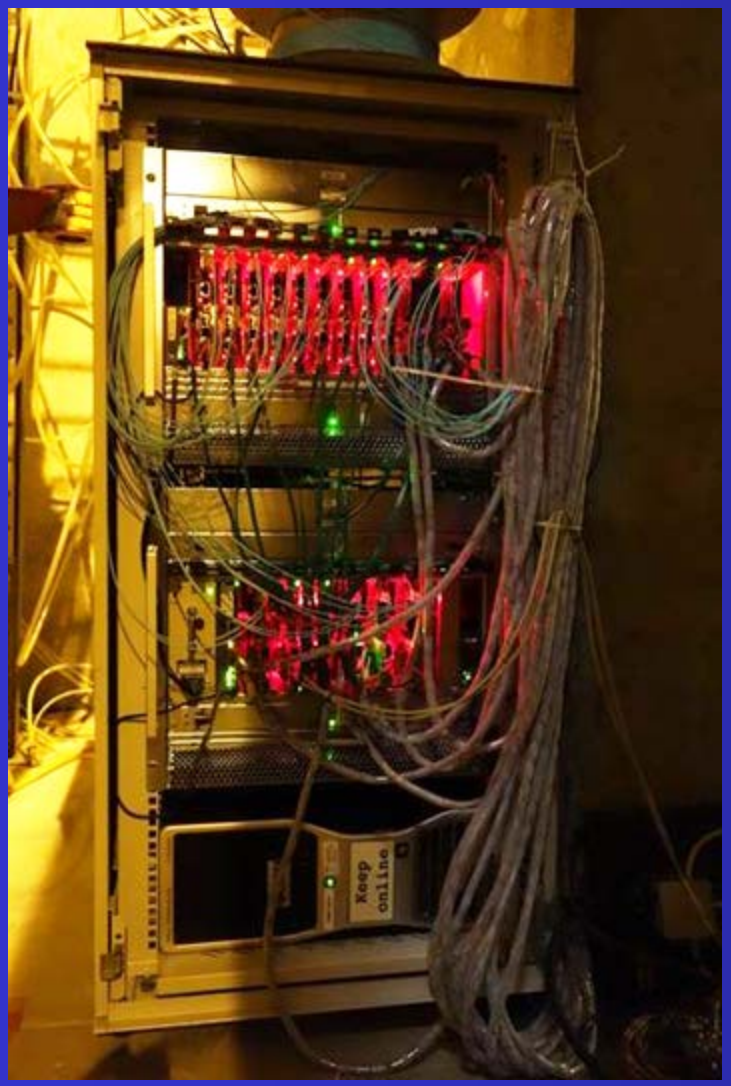
SPS DAQ + mFLES setup

At the SPS 2016 we have operated:

- 8x nDPB (MUCH for 2x M1 module = 30x FEB-F)
- 6x gDPB (TOF for up to 18x GET4 FEBs)
- 4x tDPB boards
- powered in 2x µTCA crates

- upon detection of signals above threshold the front-end timestamps the data and sends it off
- readout with 1x mFLES node (cbmflib20): with 2x 8 optical inputs, 50 m long optical fibers
- 14 TB of timeslice data recorded

FLES readout at the SPS

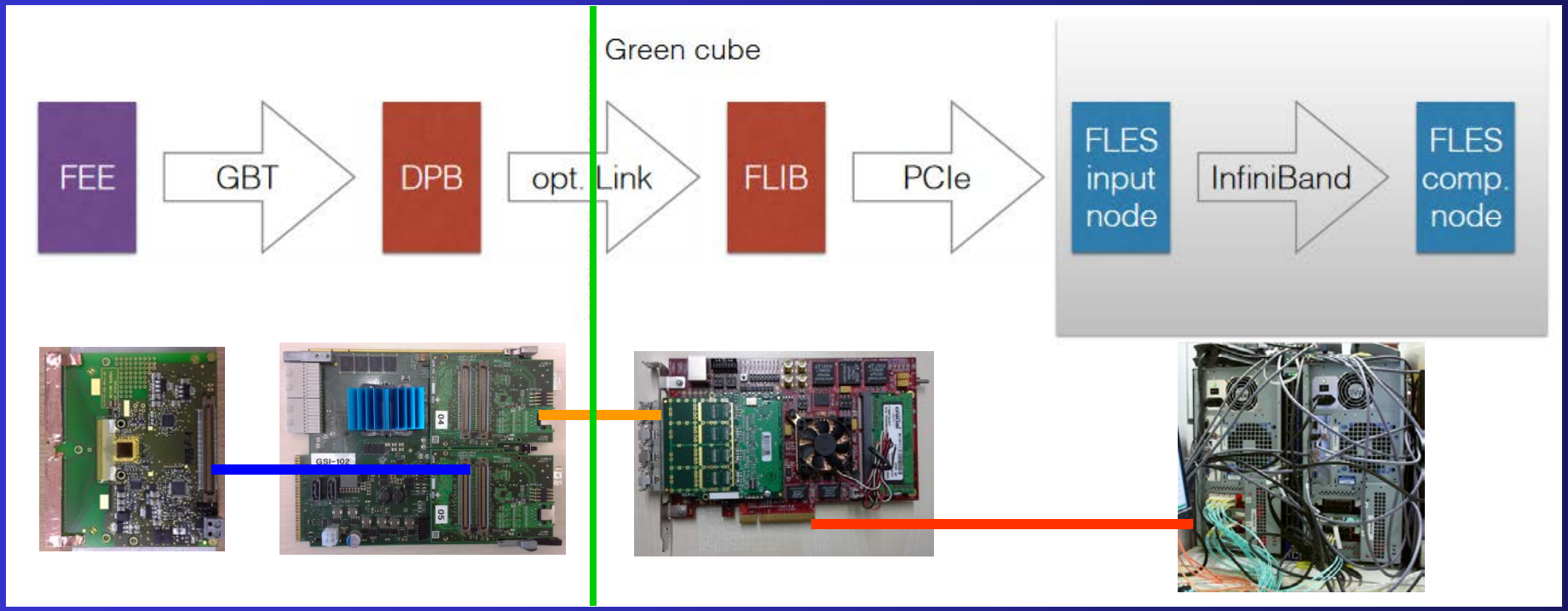


- First common FLES readout of multiple detector systems
- Readout chain from DPB to timeslice like planned for the final system

16x
10 Gbps

50 m

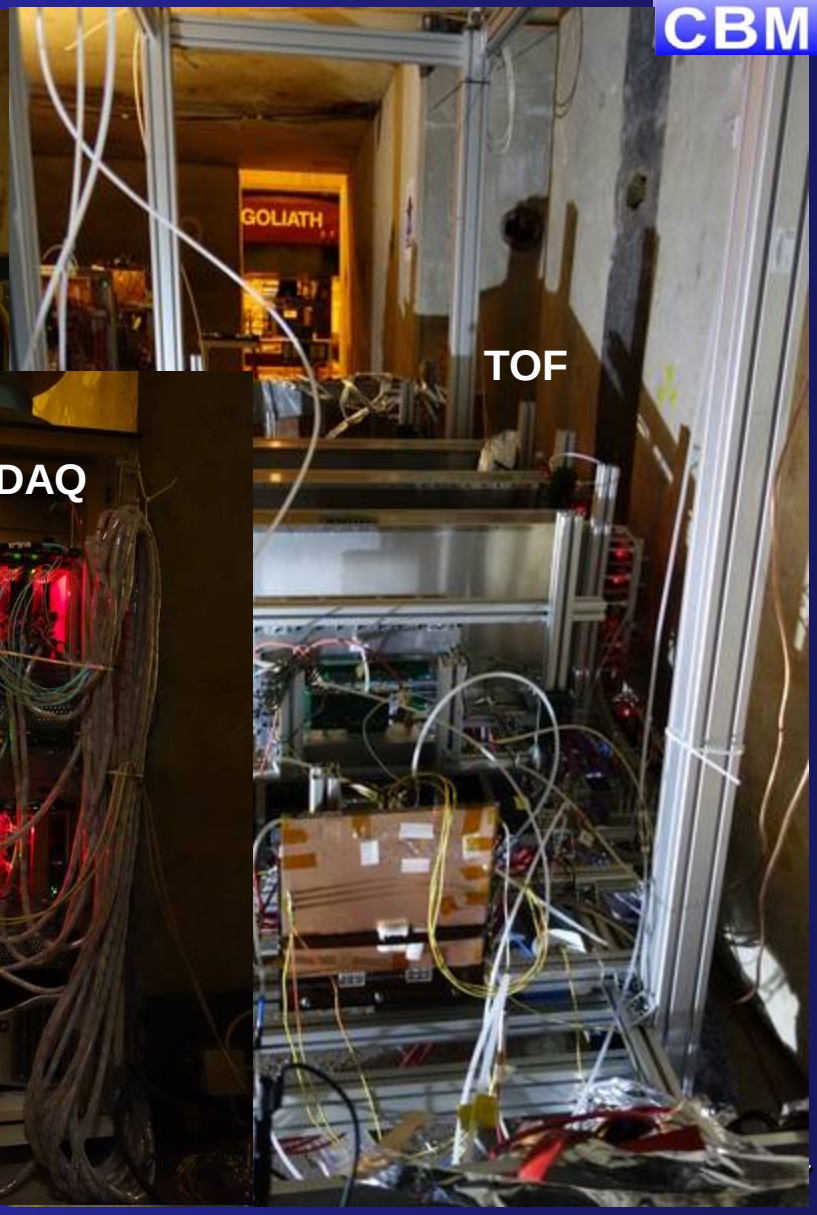
CBM readout chain

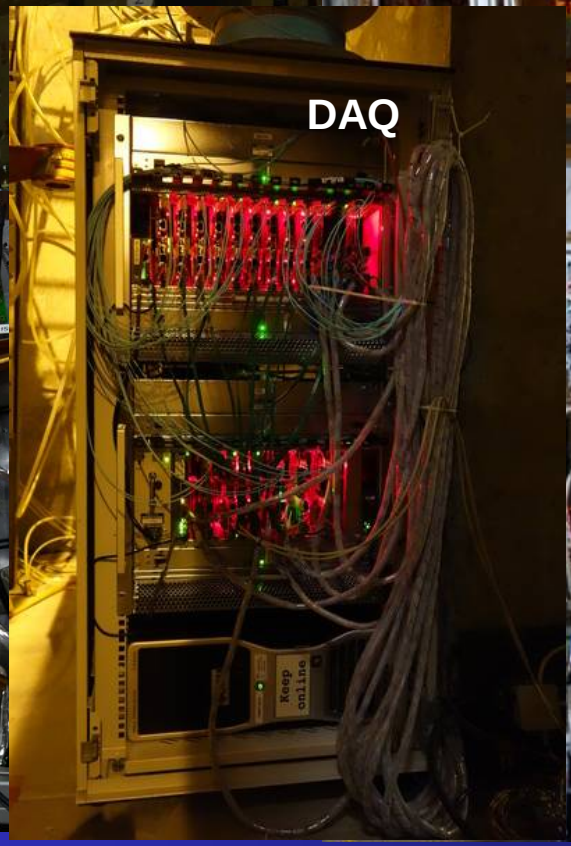


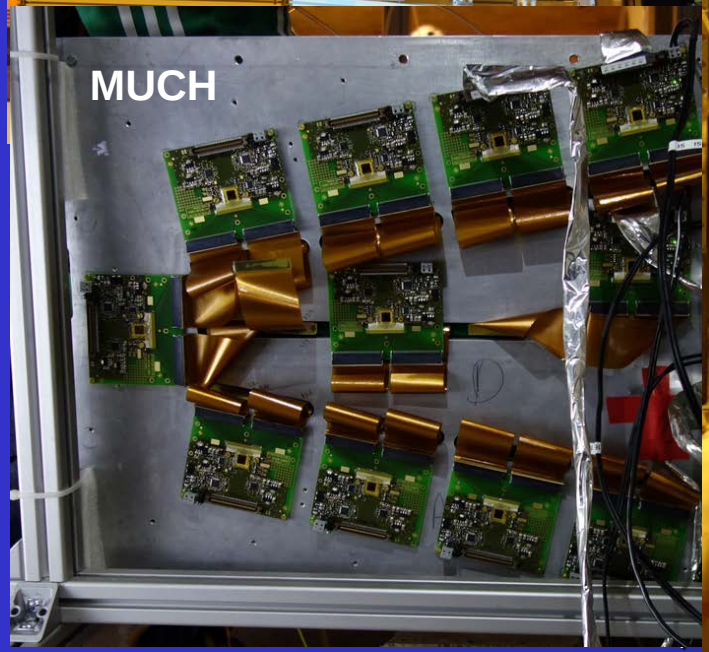
Data from FEE is pre-processed in the DPB stage.
Input to the FLES through the FLIB interface,
followed by timeslice building in the compute nodes.

SPS setup 2016

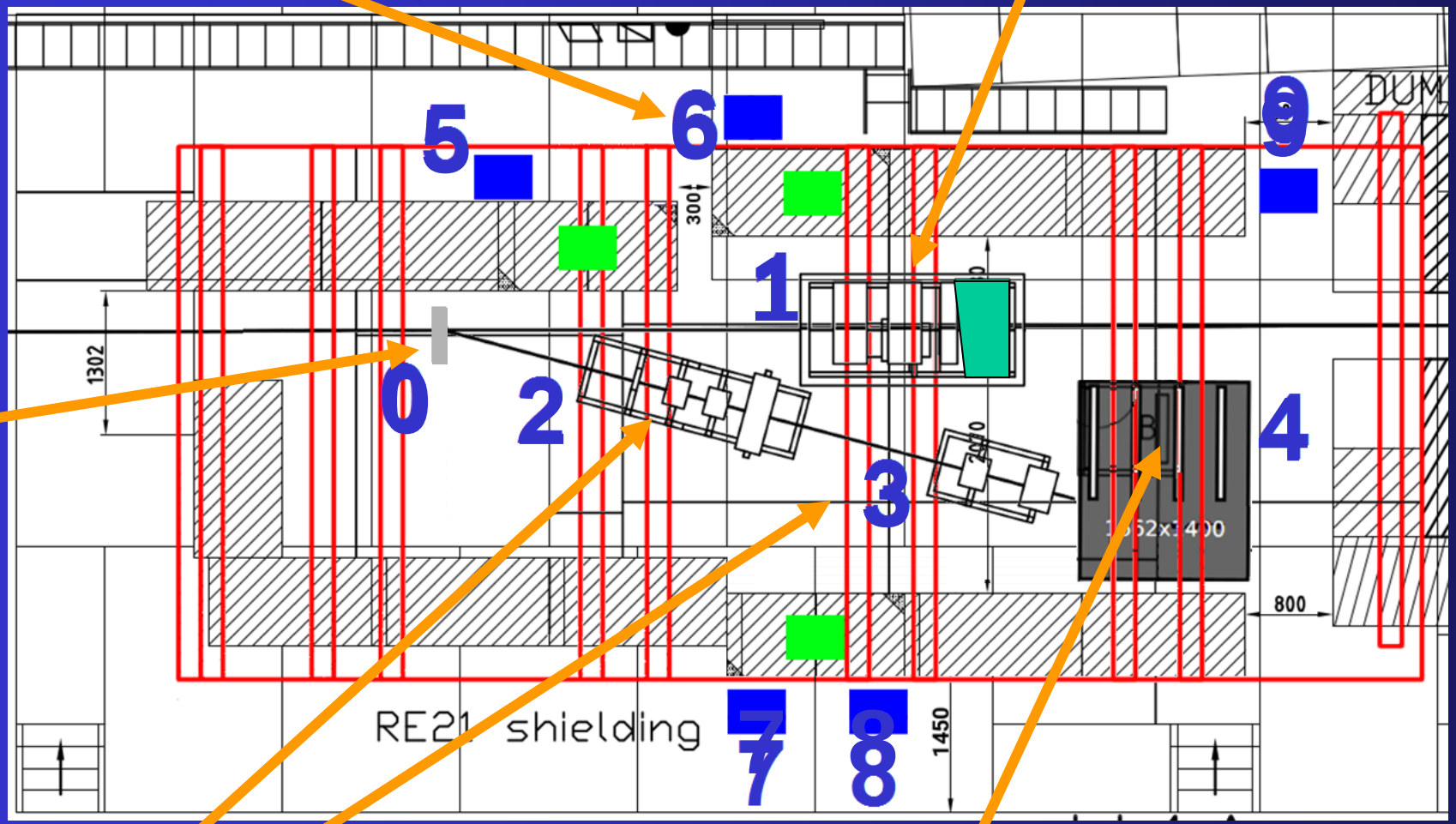
CBM detector systems at SPS



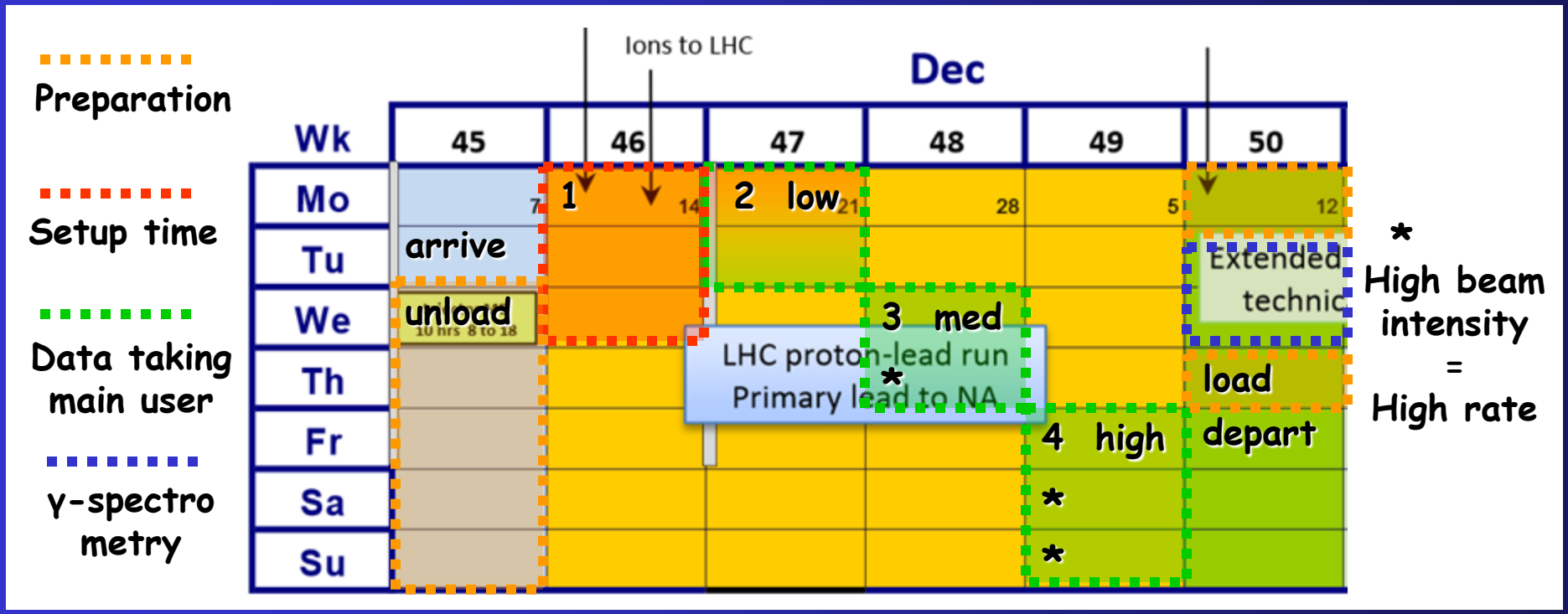




Setup of SPS beam area



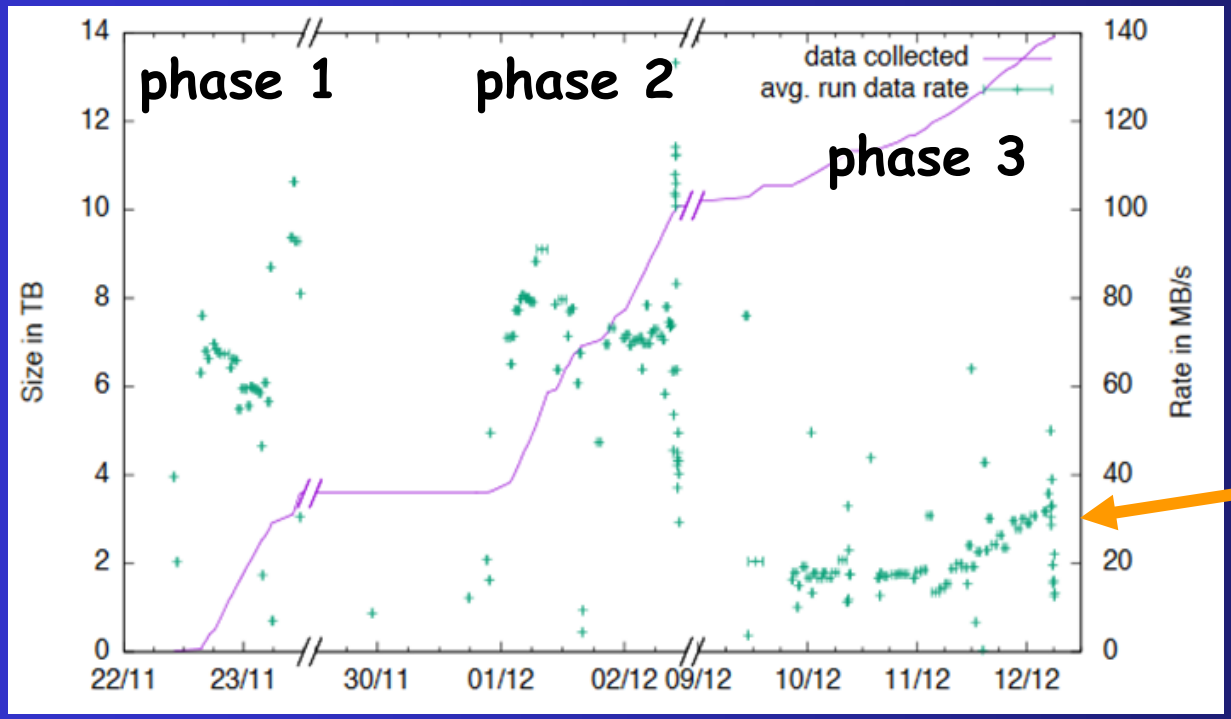
SPS schedule 2016



Data taking as main user was split into 3 blocks of 2-3 days.
High rate limited by radiation protection limits.

DAQ recordings at SPS

see HK63.6 on Friday



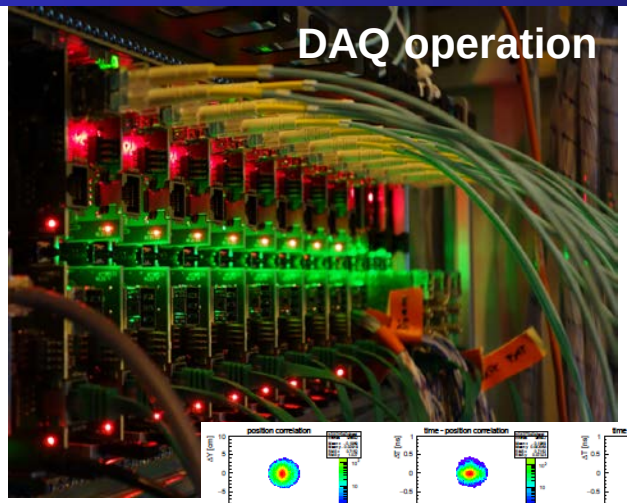
epoch suppression enabled

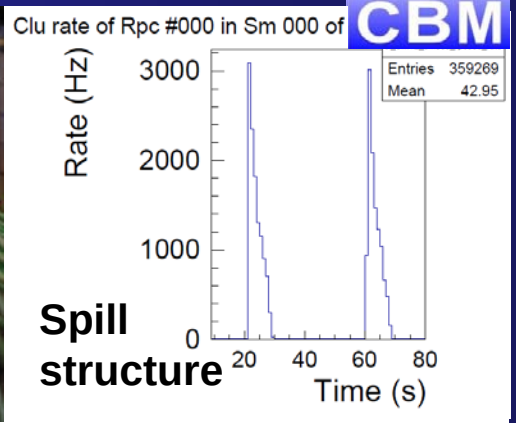
- 206 „physics“ runs in 3 periods
- **176 successful runs** with a total of **14 TB timeslice data**
- 30 unsuccessful runs
  - 9 tries with full disk
  - 2 runs stopped ungracefully
  - 19 runs with front-end init fail

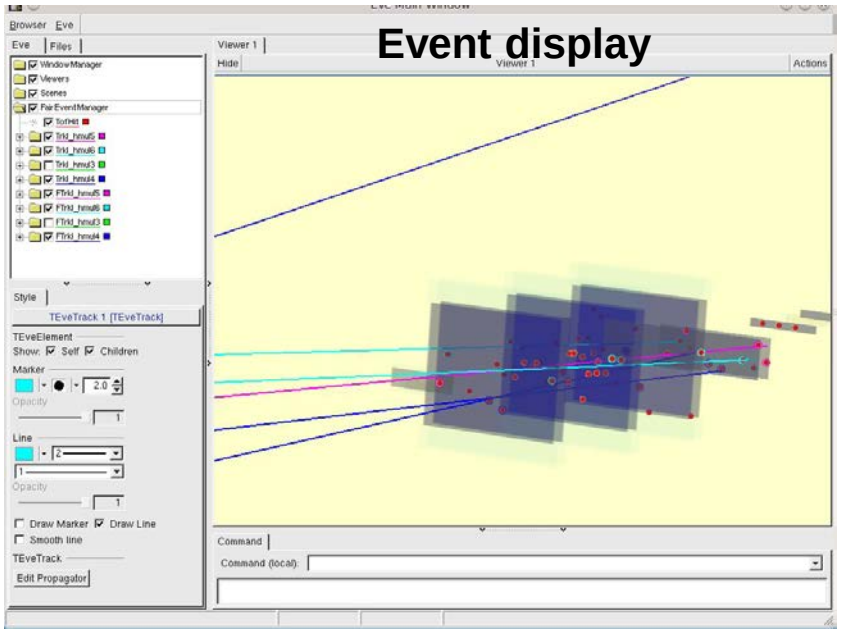
D. Hutter

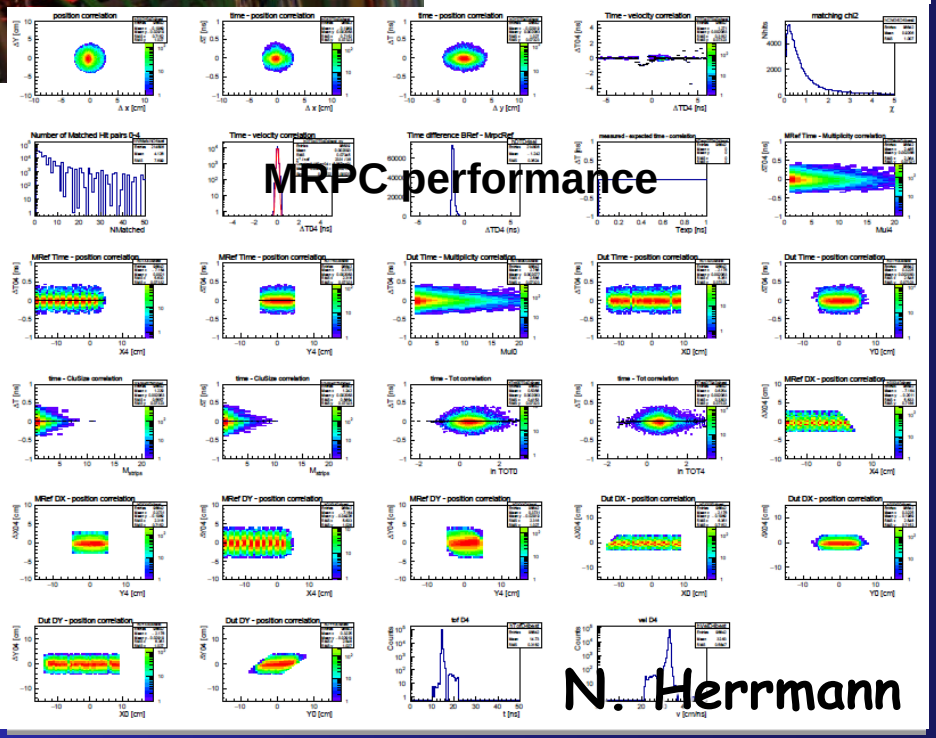
CBM DAQ and analysis

- Flawless operation of the free-streaming DAQ system
- Events successfully reconstructed from free-streaming data
- Data quality allows for investigation of detector performance
- Tracking with MRPCs available





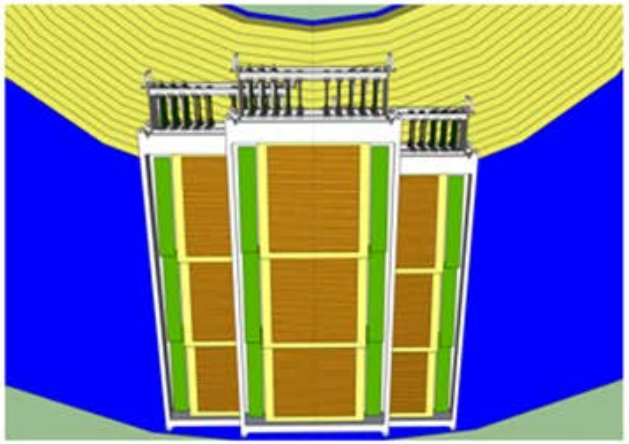




Plans for the near future

eTOF at STAR plans

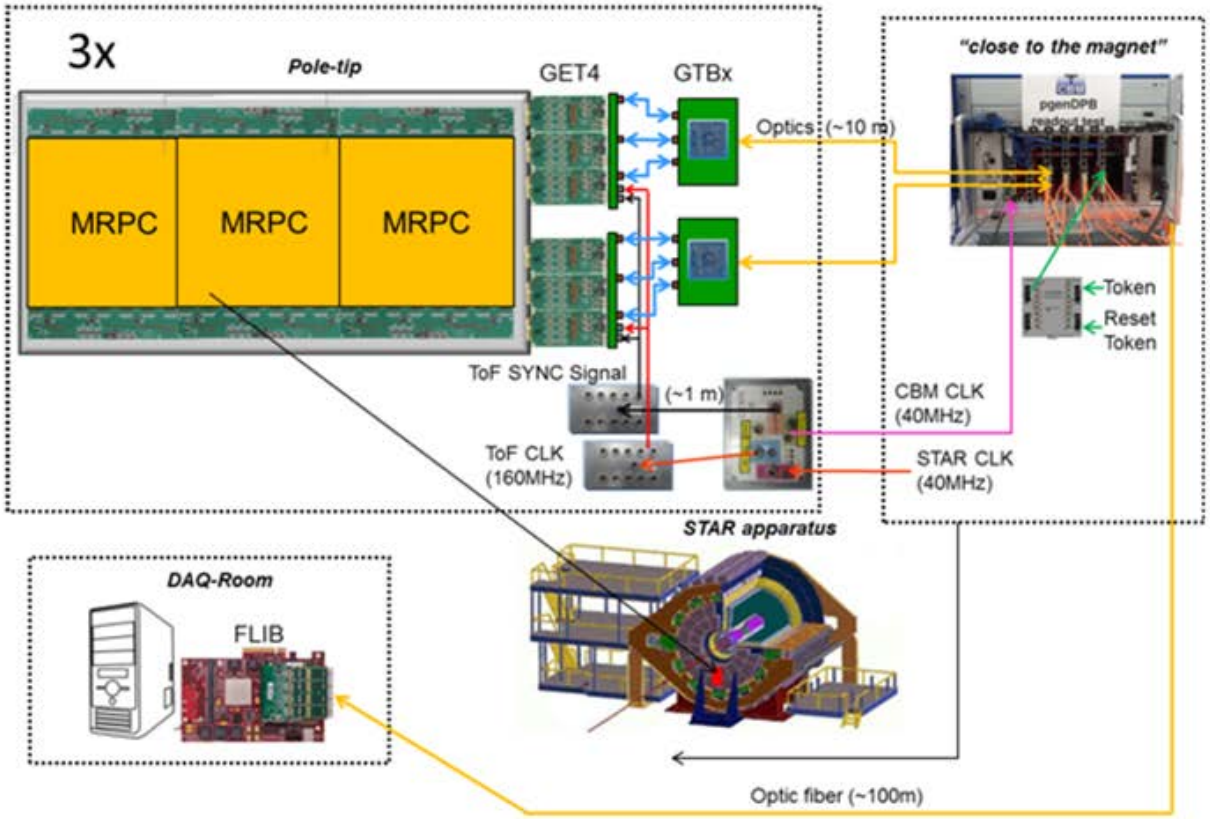
install one full sector @ STAR



Will also be based on AFCKs and µTCA crates.

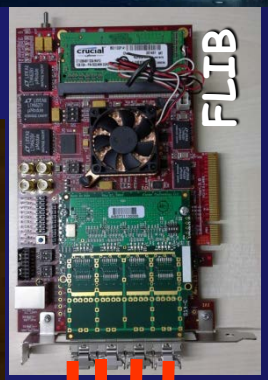
J. Frühauf

Upgrade of the eTOF DAQ towards the end of 2017.

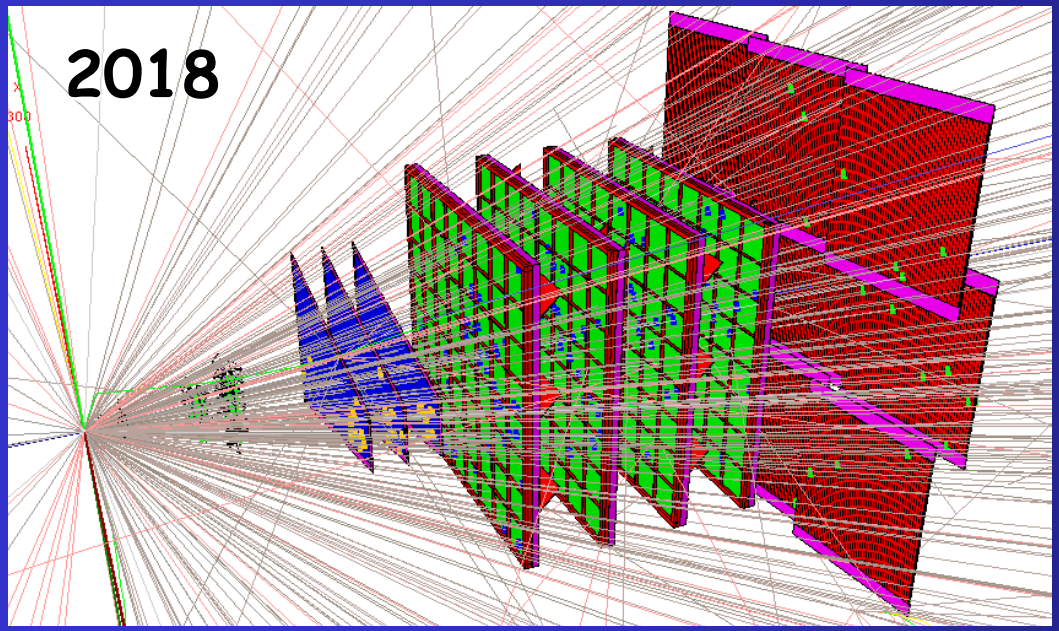


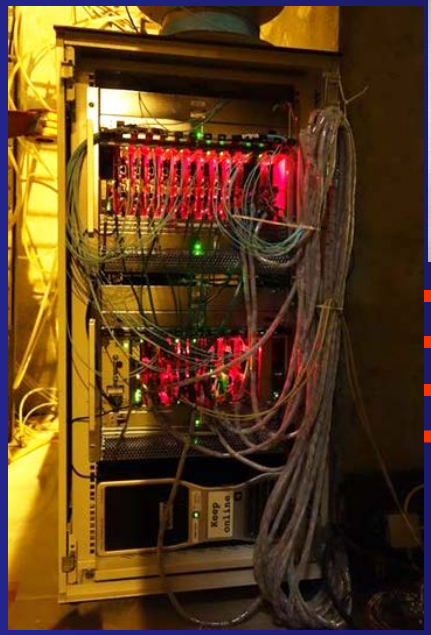
DAQ for mCBM at SIS18

- reuse and extend DAQ system from SPS 2016
- develop GBTx based readout chains for 4 subsystems
- install hardware taken from the miniCube in the greenCube to operate FLIB based input nodes and a small compute cluster as miniFLEs in the greenCube
- be ready for first beam commissioning in Q3/2018

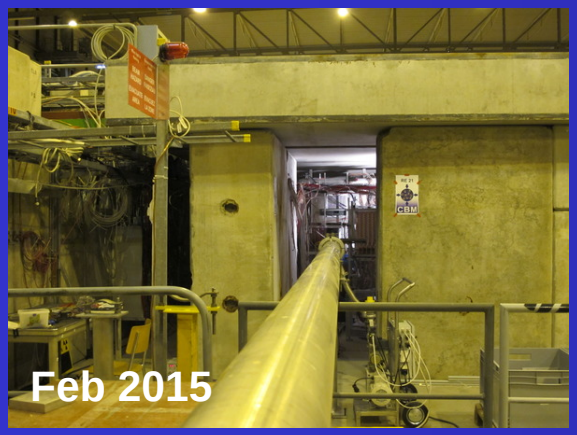


see next talk => HK15.5





Summary

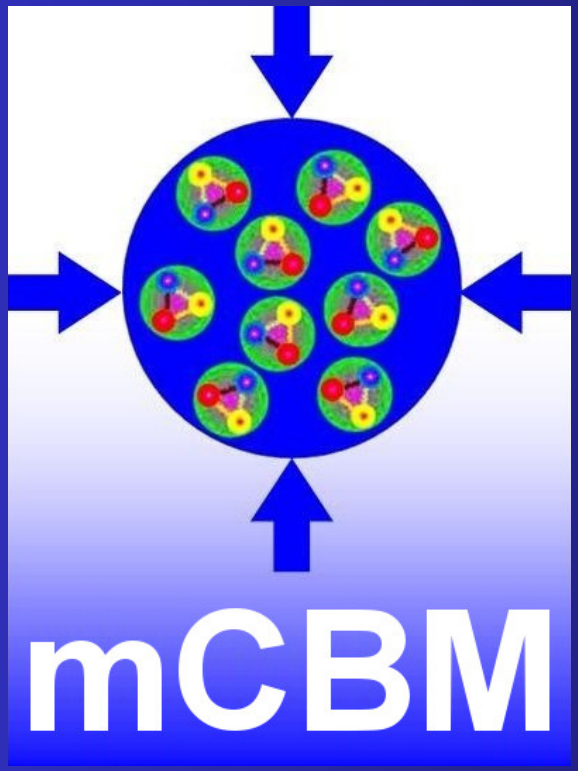


- 3rd CBM HI-beamtest at SPS sucessfully completed
- AFCK based, free-straming DAQ system operated for 4 weeks reading TOF & MUCH
- new DAQ projects on the horizon for 2017/2018 eTOF@STAR, miniCBM@SIS18

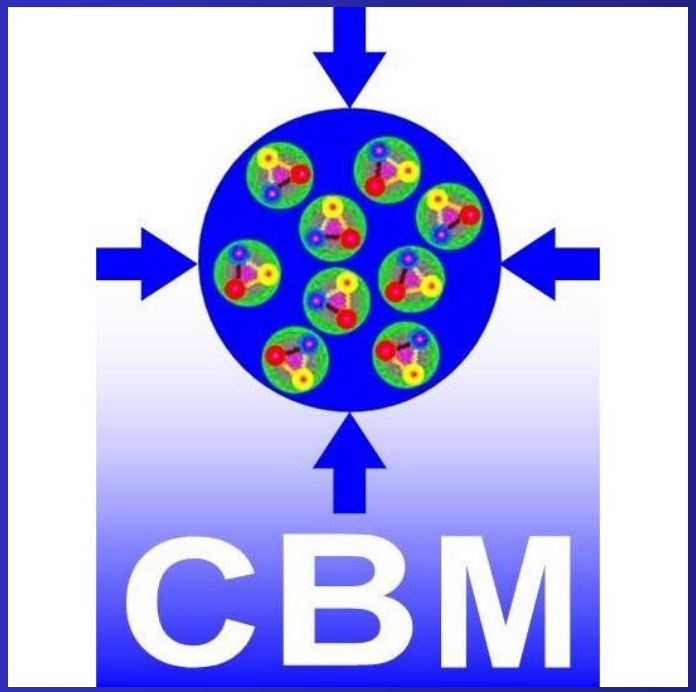
The CBM DAQ team 2016

- Cruz Garcia (IRI) – nDPB FMC, TRD readout
- Lukas Meder (KIT)- TS-system, tDPB FMC
- Jochen Frühauf (GSI) – TOF readout, gDPB FMC
- Pierre-Alain Loizeau (GSI) – Configuration & debugging
- Ajit Kumar (VECC) – nXYTER FEB-F testing
- Jogender Saini (VECC) – nXYTER FRB-F testing
- Jan de Cuveland (FIAS) – FLES data transport
- Dirk Hutter (FIAS) – FLIM interface & FLIB firmware
- Wojciech Zabolotny (WUT) – AFCK guidance
- Junfeng Yang (GSI) – firmware design, all subsystems
- Florian Uhlig (GSI) – online montoring
- David Emschermann (GSI) – hardware & coordination

Thank you



Thank you



Spares

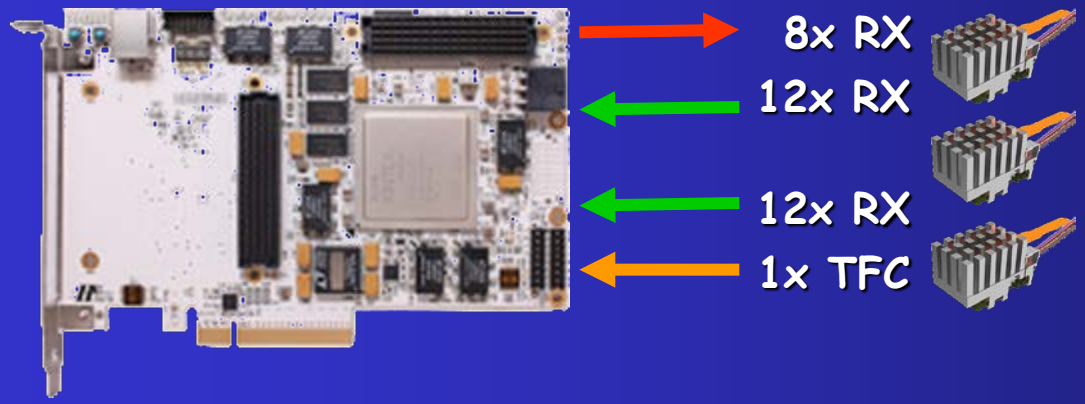
The CBM experiment

A fixed target, high interaction rate, heavy ion experiment

at FAIR, Darmstadt, Germany - start of operation planned for 2023

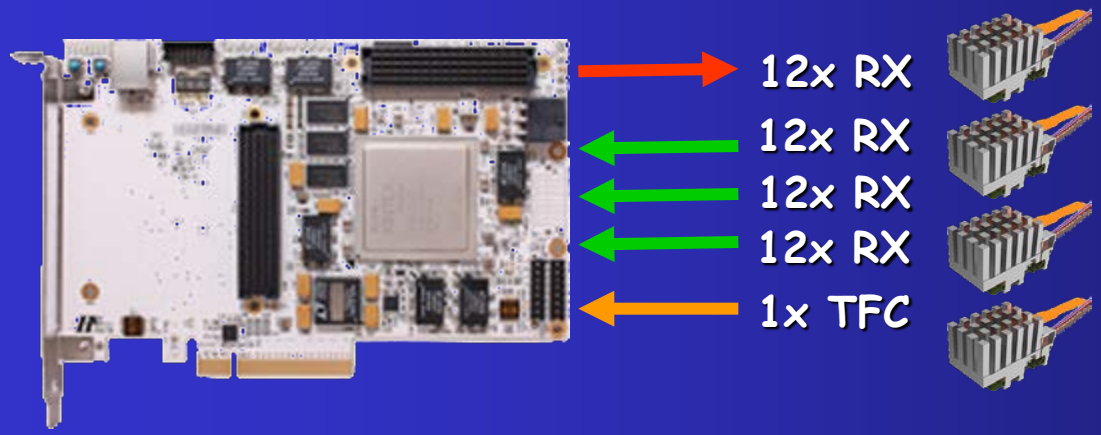
Common FPGA RB variants

24 MGTs



ROB-3 01
ROB-3 02
ROB-3 03
ROB-3 04
ROB-3 05
ROB-3 06
ROB-3 07
ROB-3 08

36 MGTs



ROB-3 01
ROB-3 02
ROB-3 03
ROB-3 04
ROB-3 05
ROB-3 06
ROB-3 07
ROB-3 08
ROB-3 09
ROB-3 10
ROB-3 11
ROB-3 12

DAQ Overview

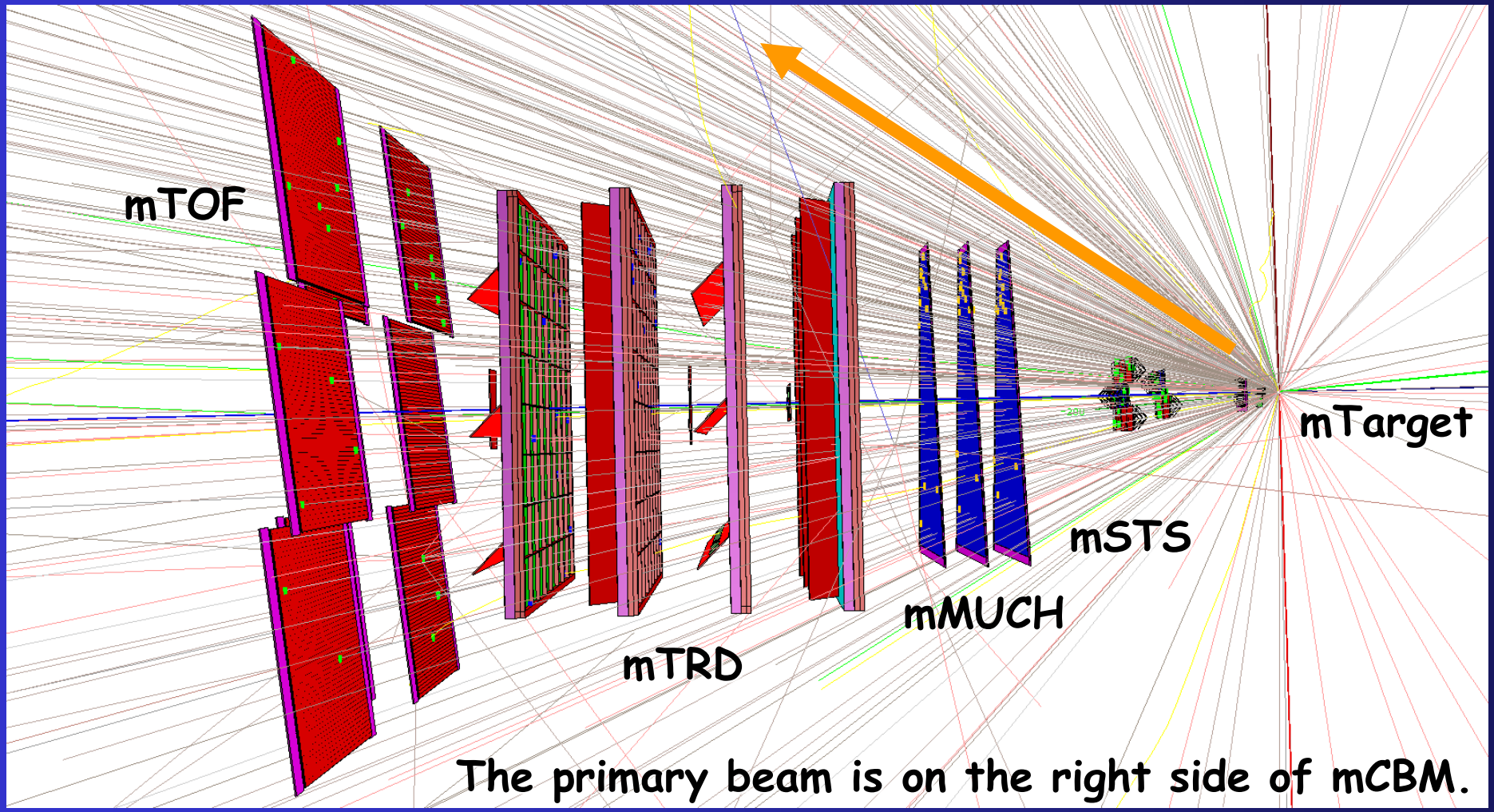
Ingredients for the SPS DAQ:

- µTCA crates
- FMC variants (recently available)
- xDPB combinations
- DAQ setup at SPS beamtime 2016

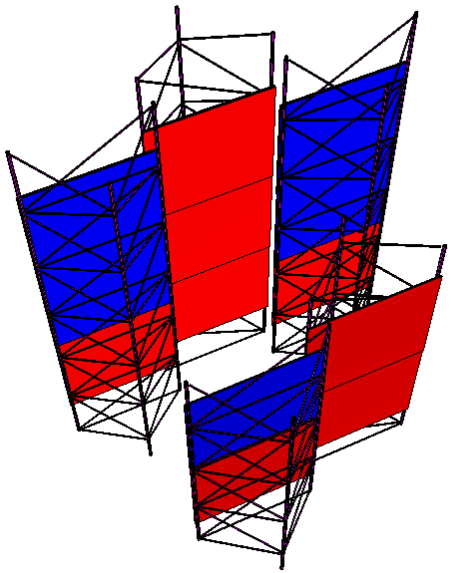
Activities beyond SPS:

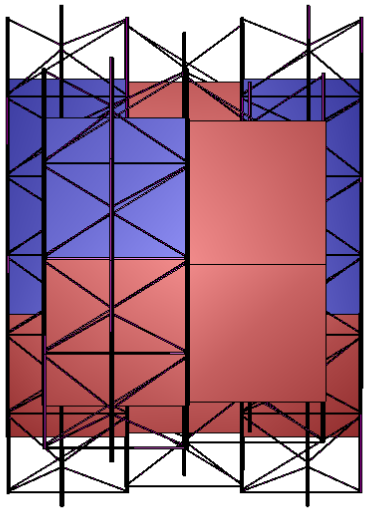
- mCBM contributions (selection of subsystems)
- Online TDR – readout chain considerations

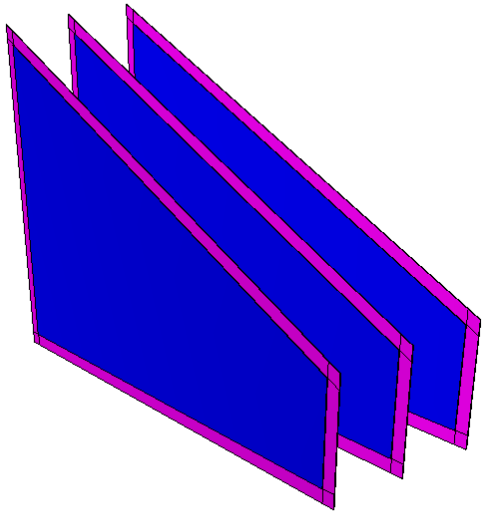
mCBM start version 2018



miniSTS and miniMUCH





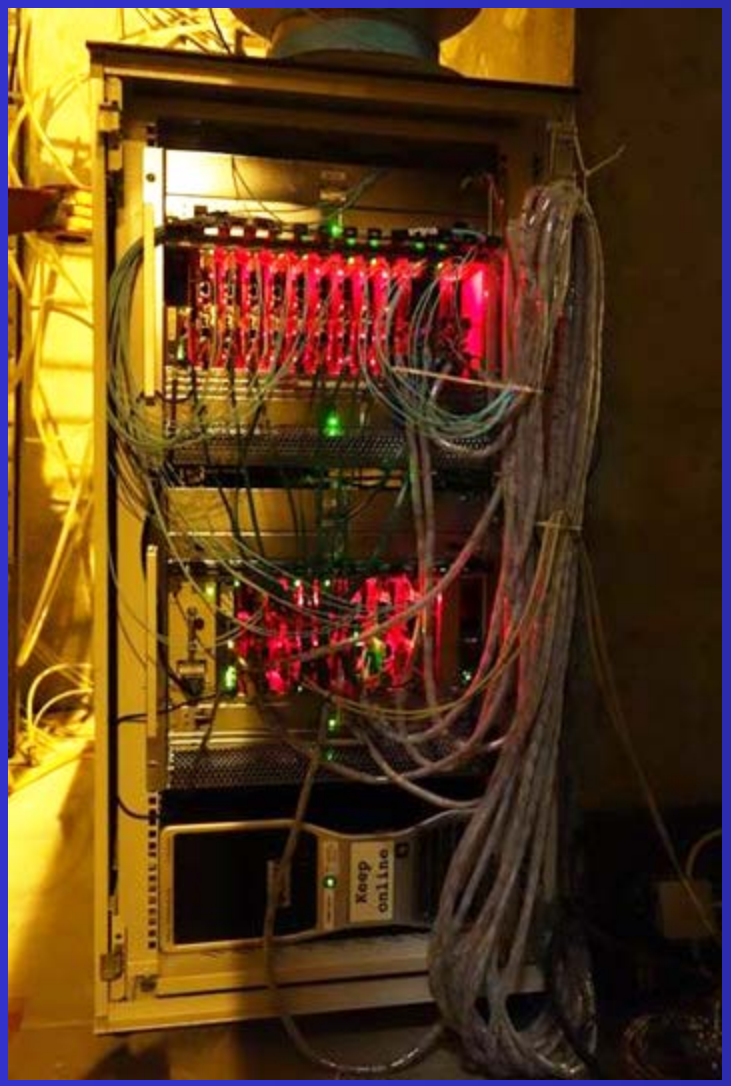


miniSTS - 2 stations:
- front 2x2 modules
- back 3x3 modules

miniMUCH – 3 detectors:
- 3x M2 GEM module
- 18x FEBs per module

	ASICs	FEB-8-1	ROB-3	AFCK
mSTS	208x	26x	6x	3x
mMUCH	108x	54x	6x	3x

Readout for mCBM

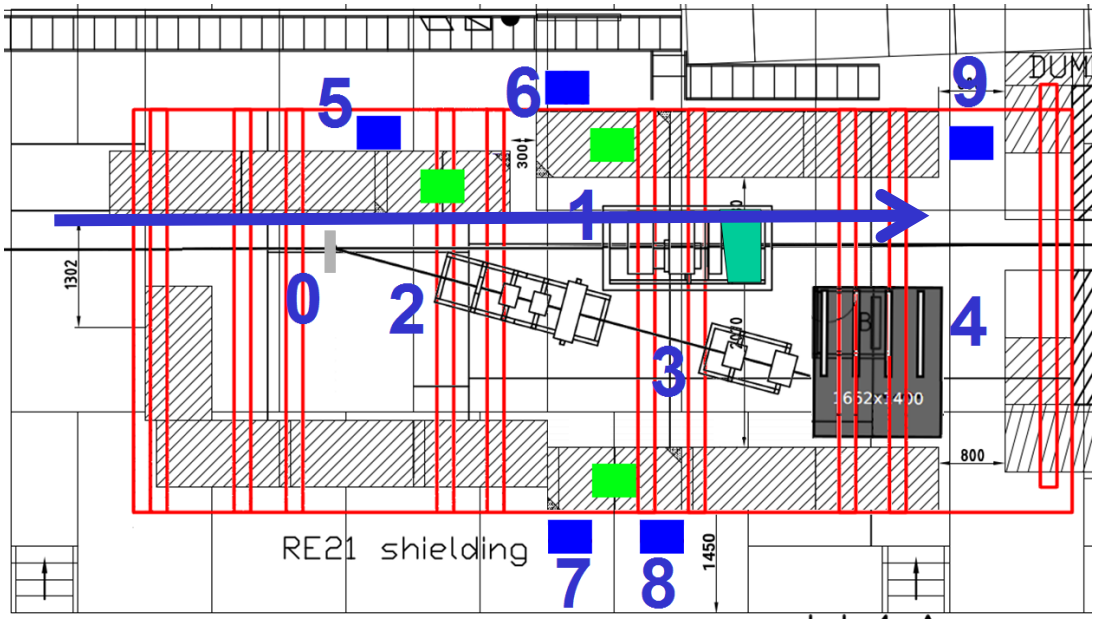


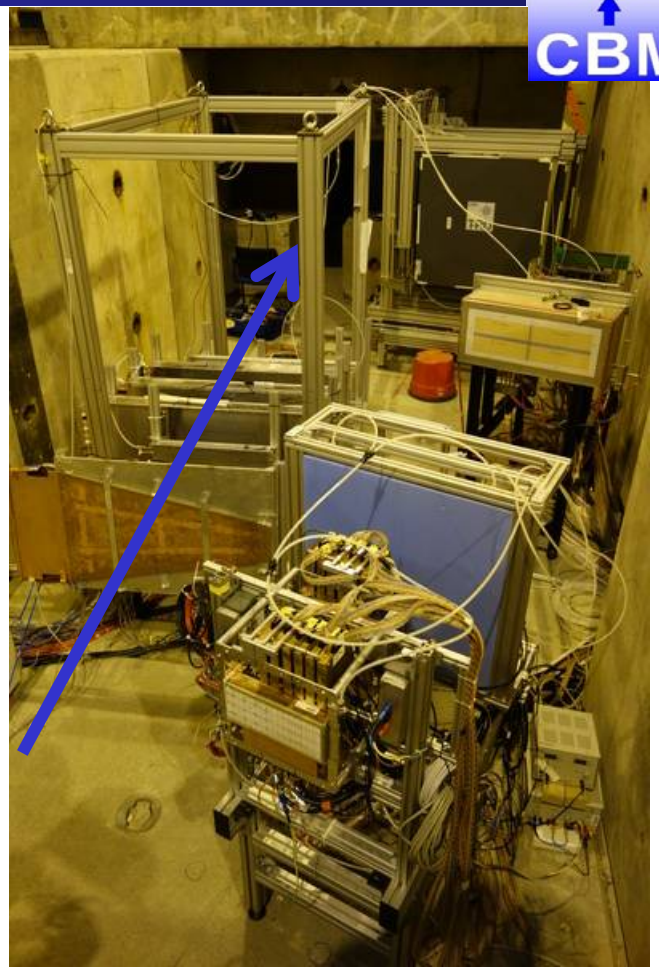
sub-system	ROB-1	ROB-3	AFCK
mSTS		6x	3x
mMUCH		6x	3x
mTRD		4x	2x
mTOF	6x		1x
	6x	16x	9x

- mCBM DAQ will rely on AFCKs as workhorse of the DPB layer until the CRB gets available

CBM/RE21 setup at SPS

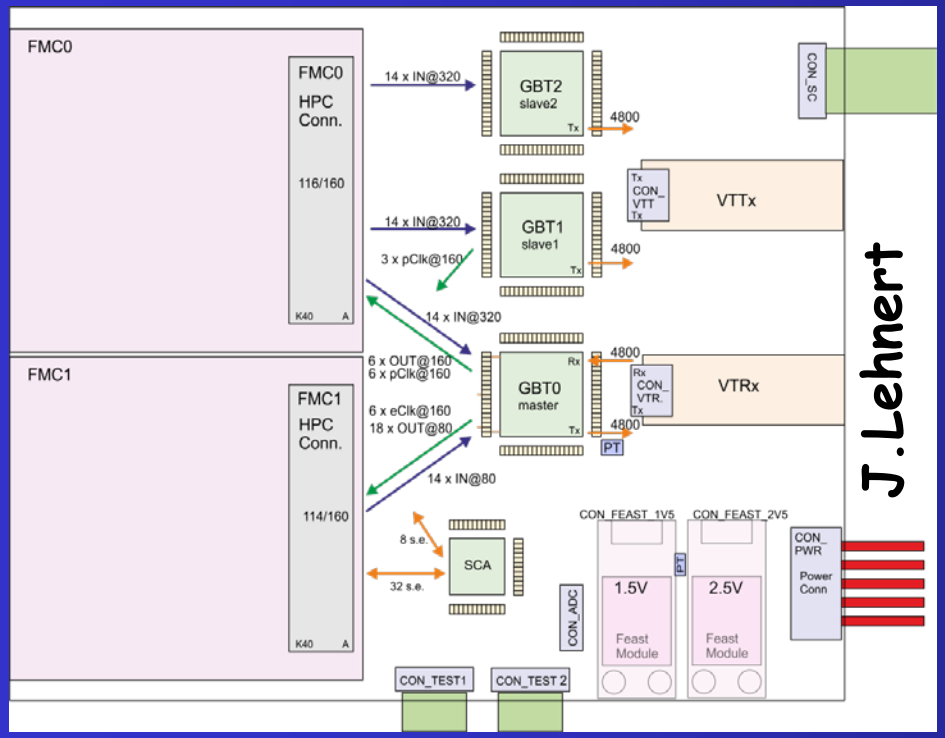
> Installation consisting of:

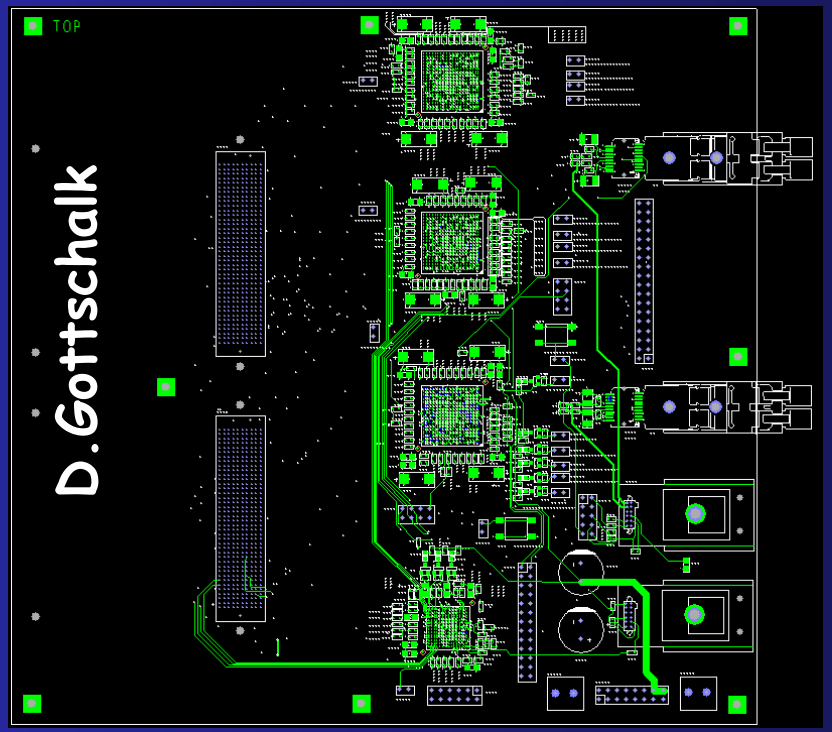




- T_0 diamond detector
- Time Of Flight detector - pre-series MRPCs
- MUon CHamber – GEM prototype modules
- Transition Radiation Detector - final SIS100 size MWPCs
- Common readout with a free-streaming Data AQuisition system

CBM ReadOut Board - CROB





The GBTx based CROB will become available mid 2017.
It is to be integrated in the readout of STS, MUCH, TRD & TOF.
Will be used in the DAQ at startup version of miniCBM in 2018.
It cannot be exported to China/India/Russia for development/use.

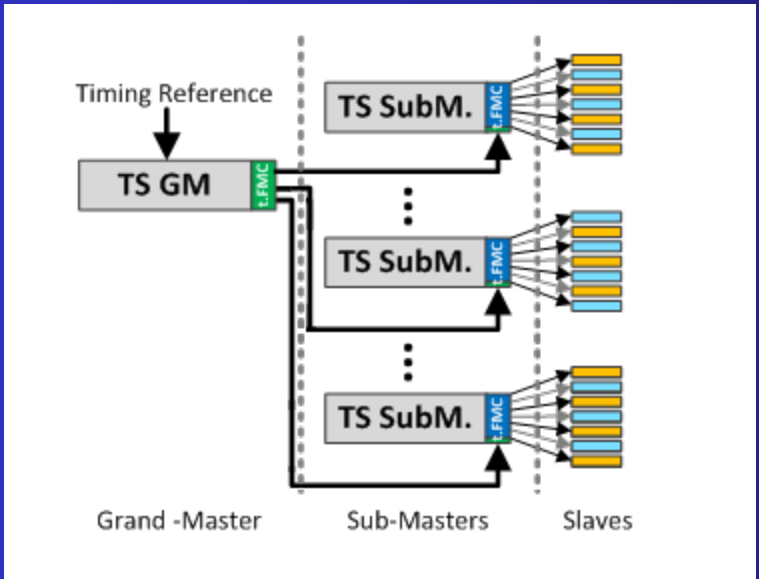
µTCA crates for SPS

2x mTCA crates from GSI were used for the SPS beamtime

standard crate
includes JTAG switch module
12x double mid-size modules
can take 6x gDPB

CERN crate
includes JTAG switch module
12x double full-size modules
can take 3x tDPB + 8x nDPB

TS setup for SPS 2016



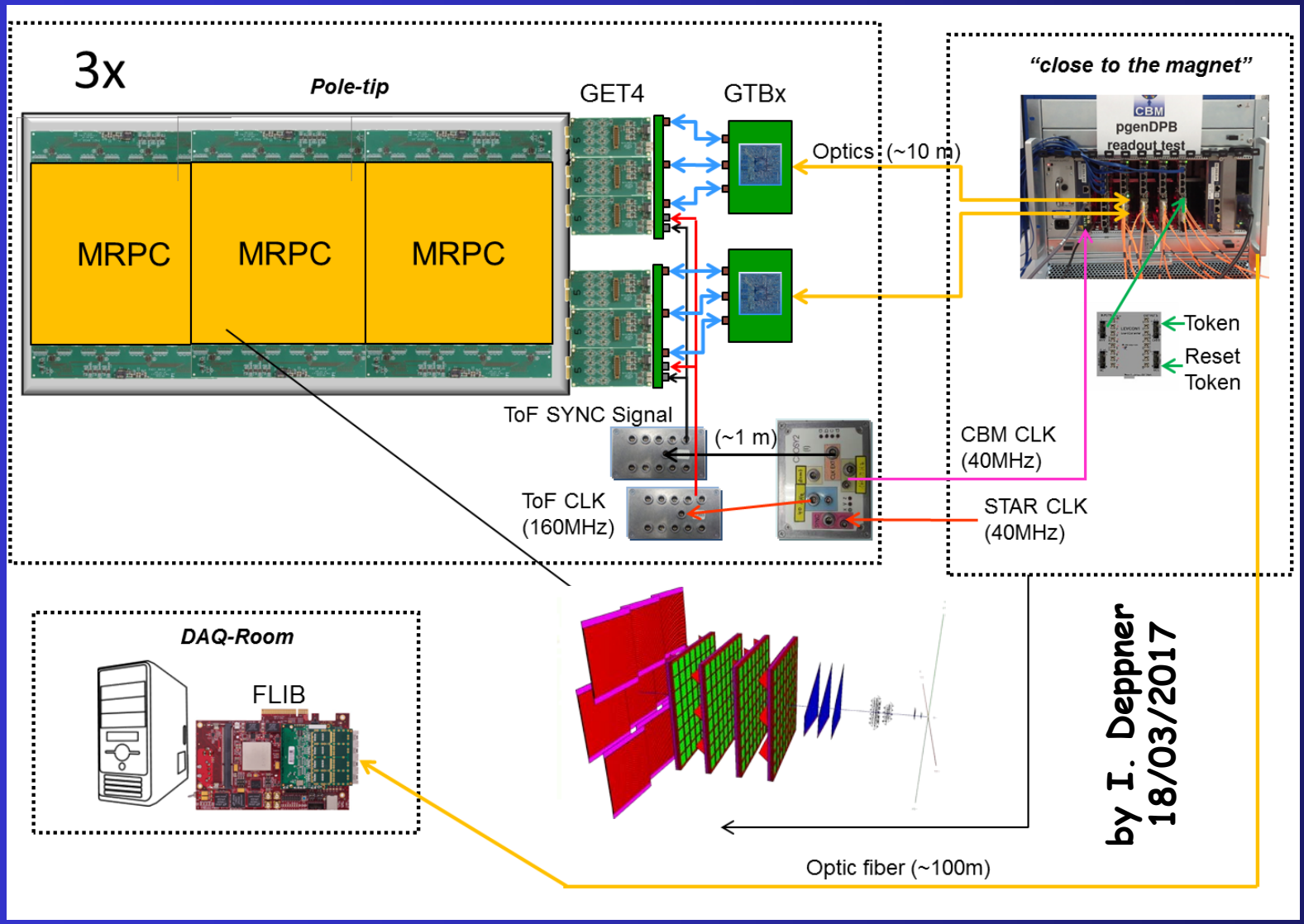
TS system built from 4x tDPBs
for MUCH and TOF at CERN.
1 Grandmaster + 3 Submasters
for up to 21 slaves (nDPB or gDPB).

CBM DAQ installations

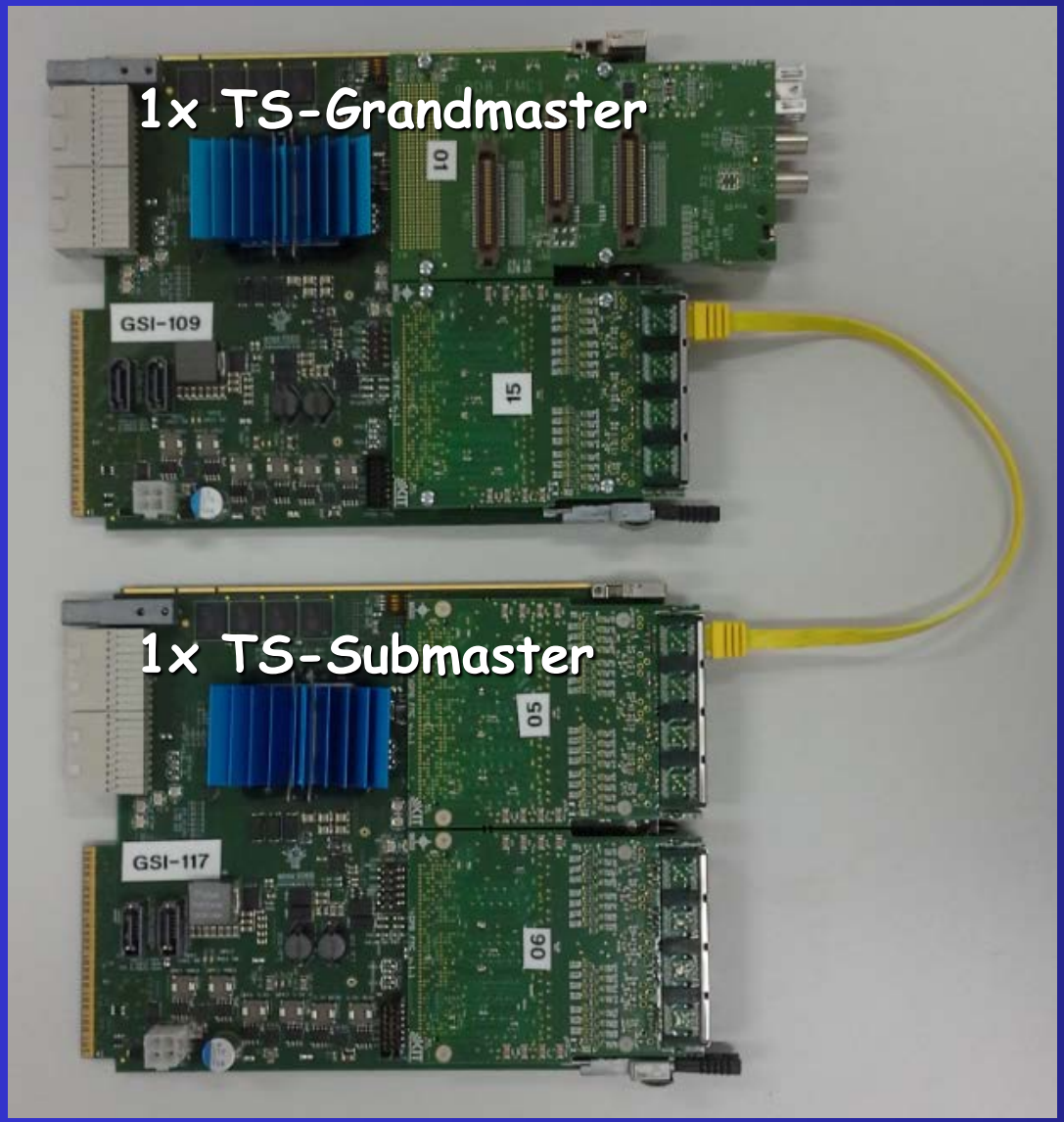
List of AFCK and FLES based DAQ systems within CBM (03/17):

- DAQ system at the SPS 2016 beamtest (completed)
- DAQ operated for eTOF at STAR (running)
- DAQ for STS readout with nXYTER at GSI (being setup)
- DAQ for TOF cosmics stand in Heidelberg (being reinstalled)
- DAQ chain for TRD SPADIC readout in Münster (operating)
- plans for a MUCH DAQ setup at VECC Kolatta
- plans for a STS DAQ setup at JINR in Dubna

miniCBM readout scheme



TS setup example

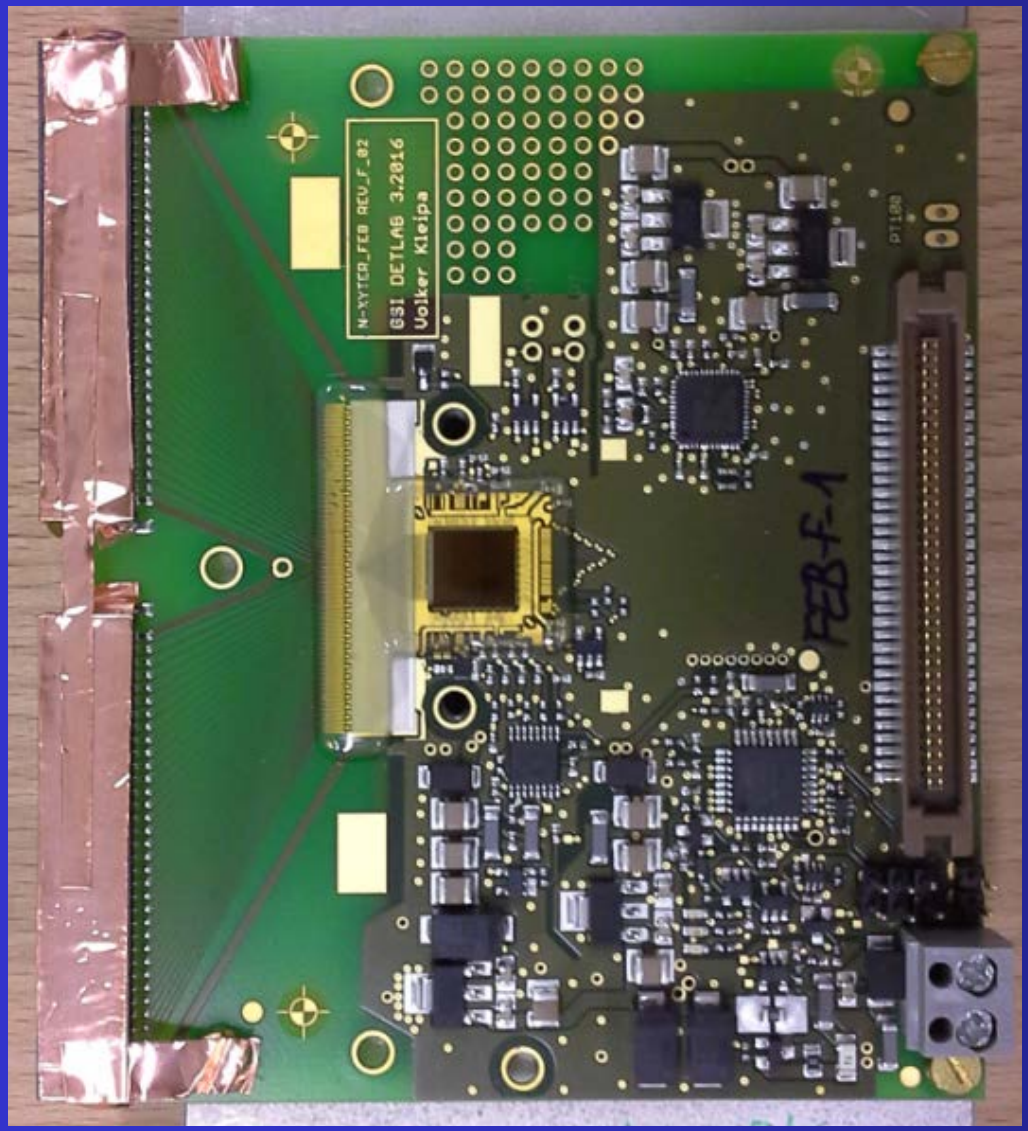


This combination of
1x TS-Grandmaster
1x TS-Submaster

offers 3 + 7 = 10 connections for TS-slaves

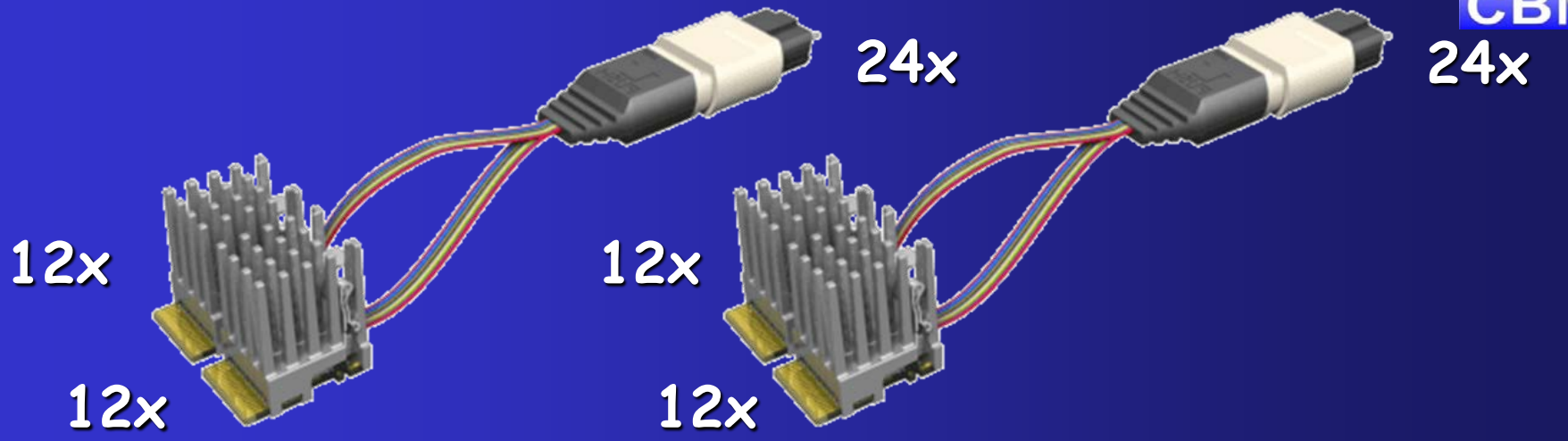
If you need more TS-slaves in your setup then use more TS-Submasters.

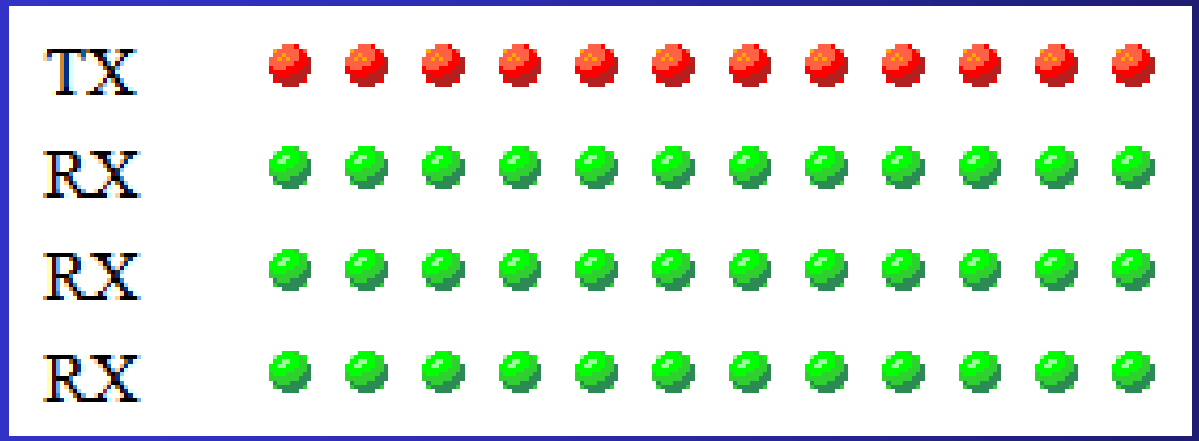
nXYTER FEB-F



- FEB-F used by MUCH
- enough for equipping the M1 GEM module
- 70x FEB-F more to be produced in Oct
- nDPB firmware to link 4x AFCK to 1x nDPB (MUCH) in preparation

Distribution of links to DPB





On the AFCK+ the optical connections will be grouped in 12x down- and 3x 12x uplinks.