OPPORTUNITIES AT COSY

COSY Operation for FAIR beyond 2021

December 14, 2018 I Dieter Prasuhn

OUTLINE

- Motivation
- The COSY facility
- COSY as test facility during POF-3
- Topics for COSY operation in the future

MOTIVATION

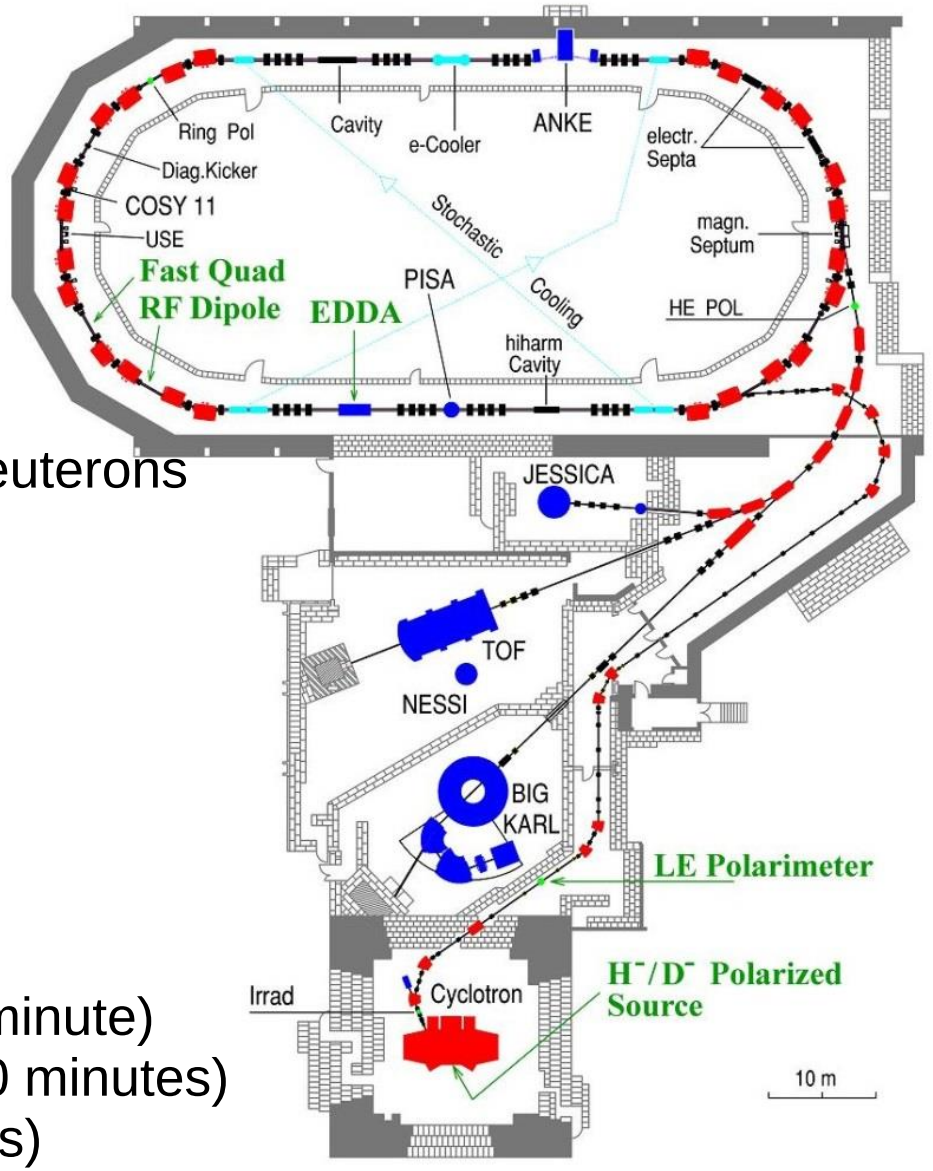
- COSY operation is secured until end of 2021
  - **by POF-3 funding for FAIR tests and developments**
  - by the management of Forschungszentrum Jülich GmbH to fulfill the commitment for Hans Ströher‘s 2nd advanced ERC-Grant

- The supervisory boards of GSI and FZJ have decided the transition of IKP to GSI on January 1st, 2021.
- The responsibility of COSY operation will be in the hands of GSI management

- I will show topics for COSY operation beyond 2021, for the benefit of FAIR

THE COSY FACILITY AS A HADRON PHYSICS USER FACILITY

Circumference:	184 m
Particles:	(un-)polarized protons and deuterons
Injection momentum:	300 MeV/c for protons
	540 MeV/c for deuterons
Maximum momentum:	3.5 GeV/c
Electron cooling:	100 keV electron energy
Stochastic cooling:	above 1.5 GeV/c protons
	above 2.8 GeV/c deuterons
Internal experiments:	4
External experiment areas:	3
Extraction methods:	resonant extraction ($t_{spill} \leq 1$ minute)
	ultra slow extraction ($t_{spill} \leq 20$ minutes)
	kicker extraction ($t_{spill} \leq 300$ ns)



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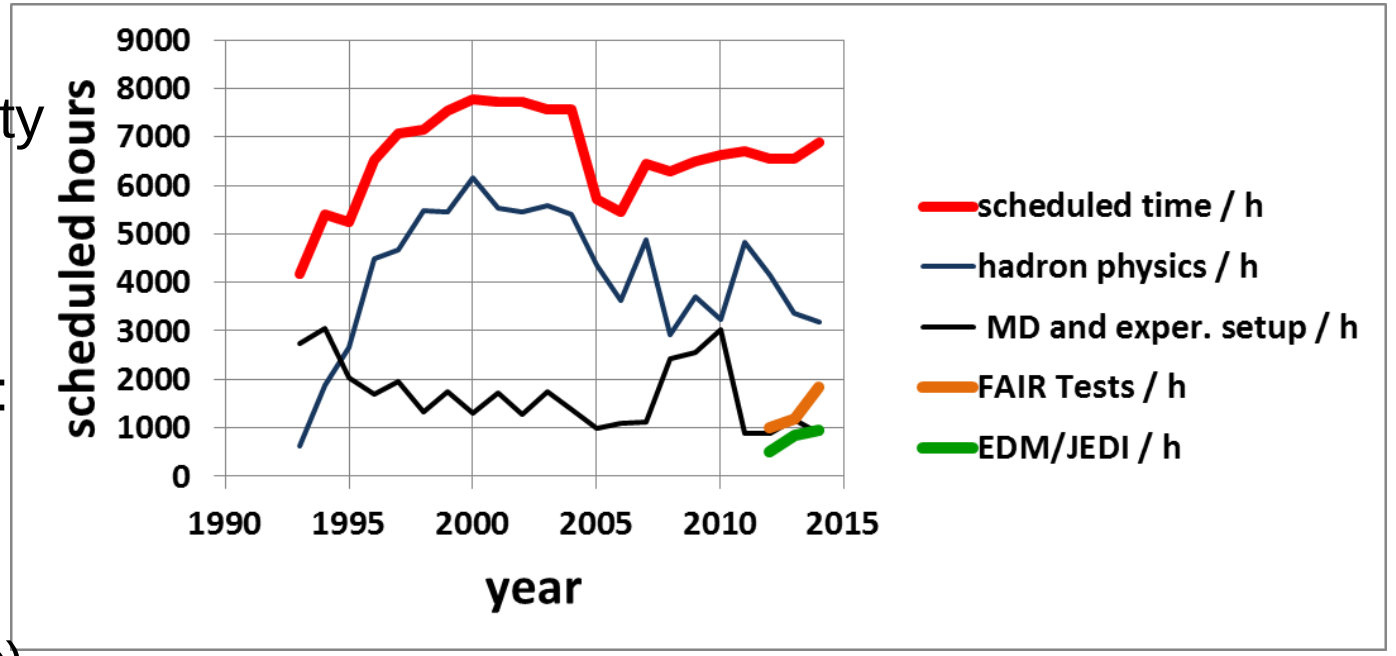
THE PHYSICS PROGRAM OF COSY 1993 TO 2014

- COSY has been operated as a user facility for the hadron community
- Highlights of COSY operation:
  - Operation with different internal targets:
    - Fibre targets
    - Gas cluster and pellet targets
    - Atomic beam targets (with storage cells)
  - Double polarized experiments
  - High resolution experiments with cooled beams, internal and external



In total: 145.184 hours scheduled operation
91.640 hours for hadron physics

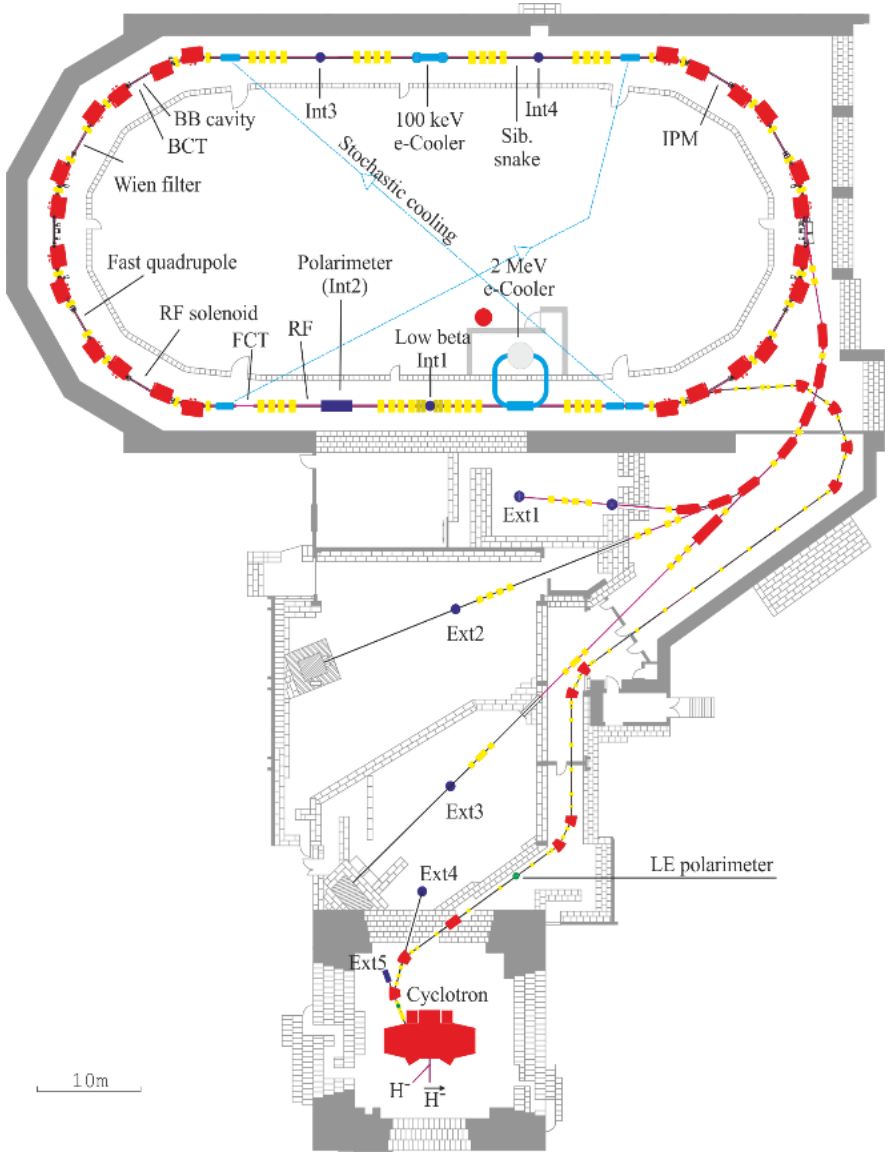
COSY AS TEST FACILITY SINCE 2014

Changes at COSY

External: experiment areas are now used for FAIR tests
a direct beam line from the cyclotron to the experimental area is installed

Internal: WASA and ANKE removed

New installations: low-beta insertion
2 MeV electron cooler
HESR stochastic cooling equipment
Siberian snake
RF Wienfilter and polarimeter
PANDA cluster target



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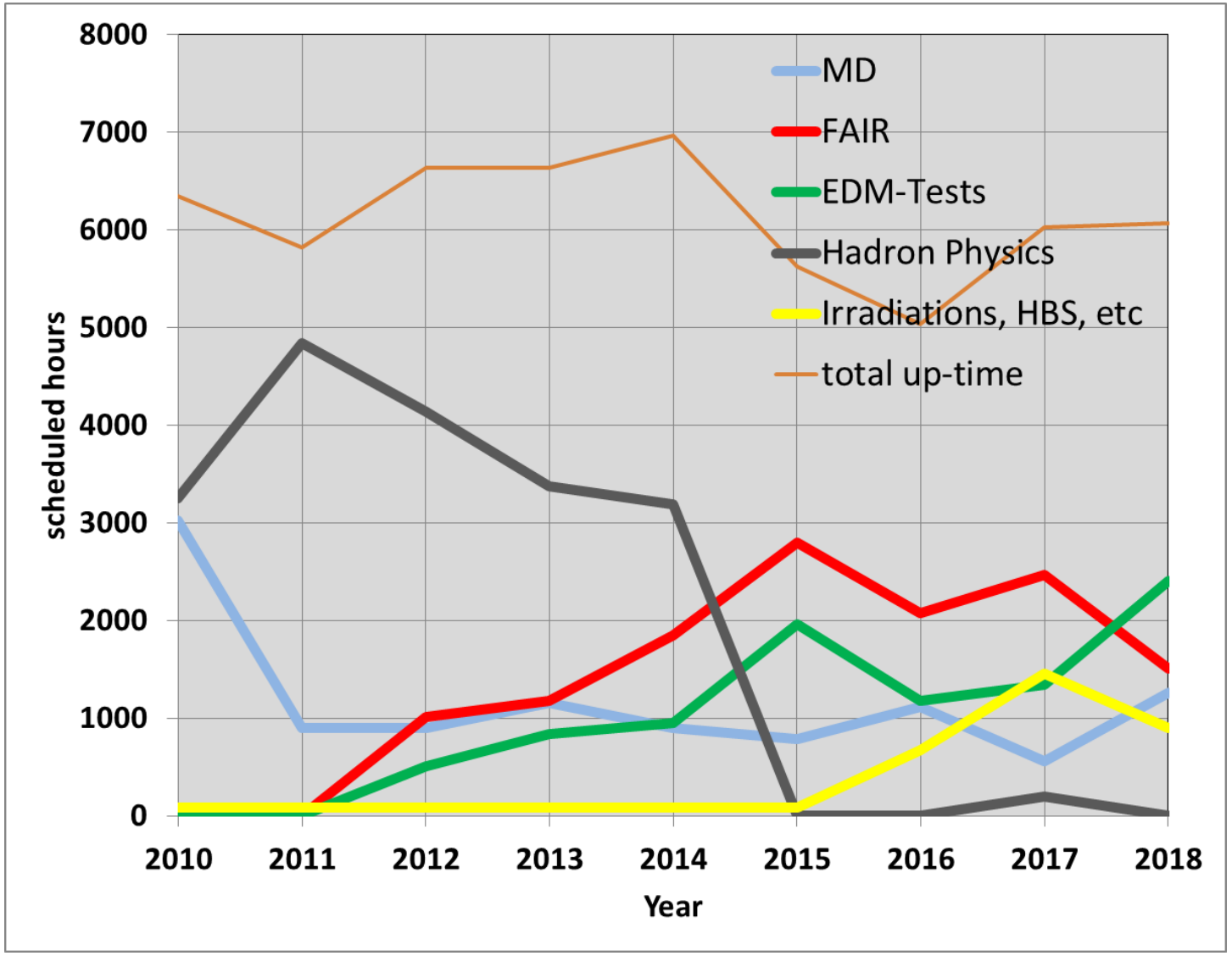
COSY OPERATIONAL TIME OVER THE LAST YEARS



- Hadron Physics is phased out
- FAIR experiments and beam studies use 30% of the up-time
- EDM-tests also use 30% of the up-time
- Irradiations (neuro-medicine and HBS) cover 15% of the time

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RECENT BEAMTIMES FOR FAIR

Accelerator studies: prototype HESR-barrier bucket cavity

HESR stochastic cooling pickup, kicker and amplifier chain

high energy electron cooling

beam studies with cluster target, stochastic cooling and barrier bucket

extraction spill studies

closed orbit correction studies

Experiments:

PANDA: Micro Vertex Detector

Straw Tube Tracker

CBM: TOF

Tracker

NUSTAR: η‘ experiment with NUSTAR detectors

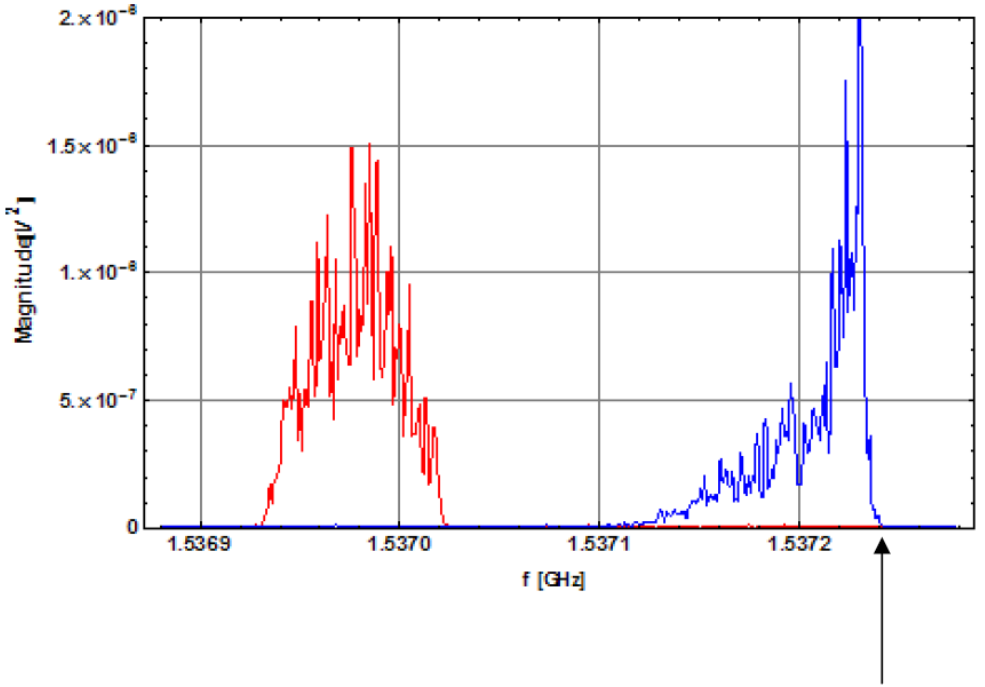
INTERNAL TARGET, BARRIER BUCKET CAVITY AND STOCHASTIC COOLING

Barrier Bucket: OFF

S-Cooling: OFF

Target: ON

N = 8 x 10^8 protons with p = 2.6 GeV/c
above transition energy



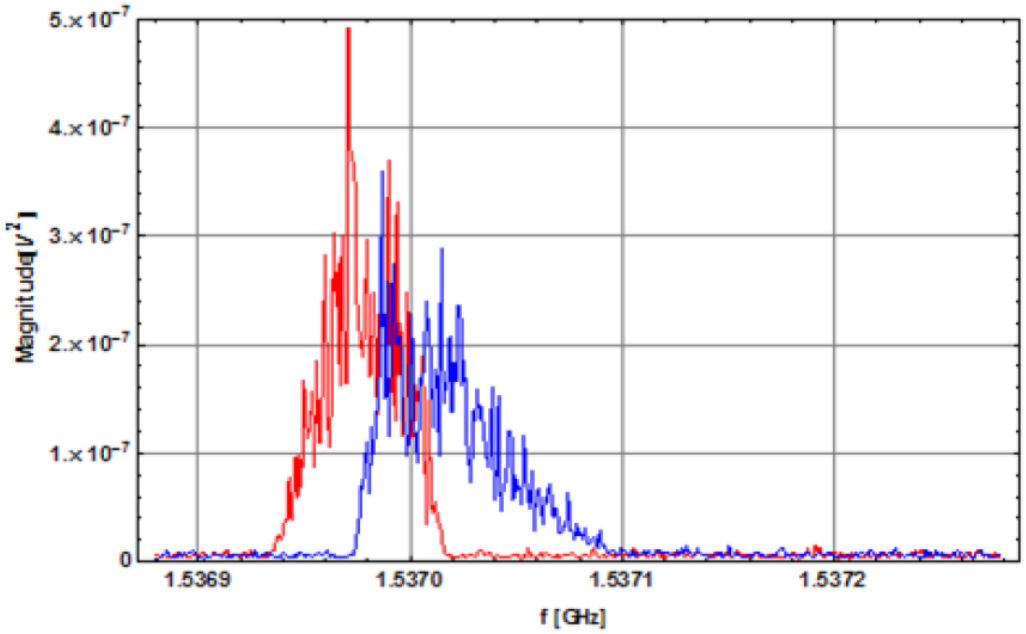
Red: initial
Blue: after 160 s

Barrier Bucket: OFF

S-Cooling: ON

Cooling with band II (1.8 – 3) GHz

Target: ON

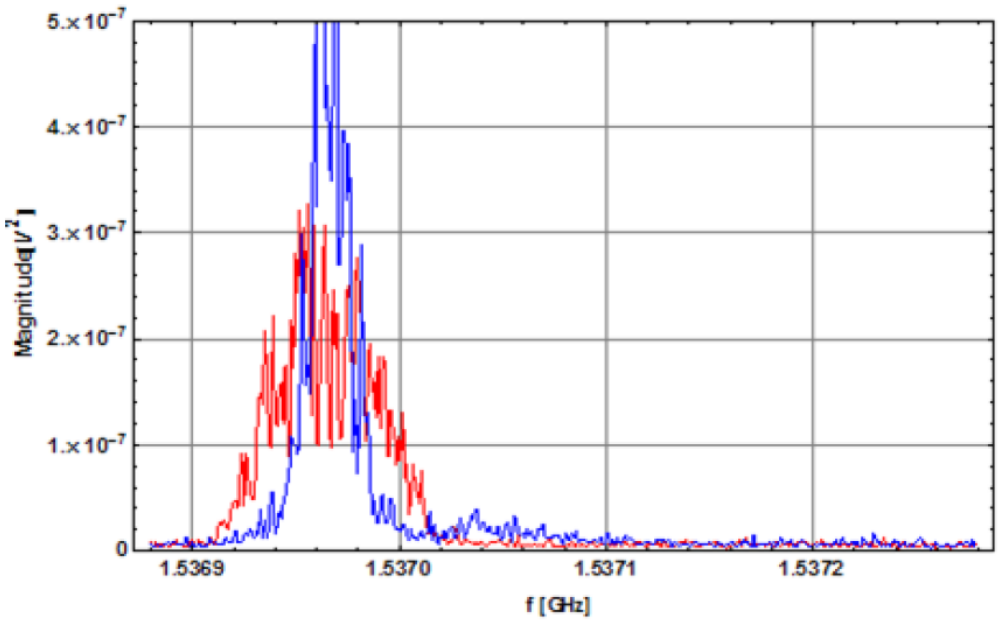


Red: initial
Blue: after 160 s

Barrier Bucket: ON

S-Cooling: ON

Target: ON



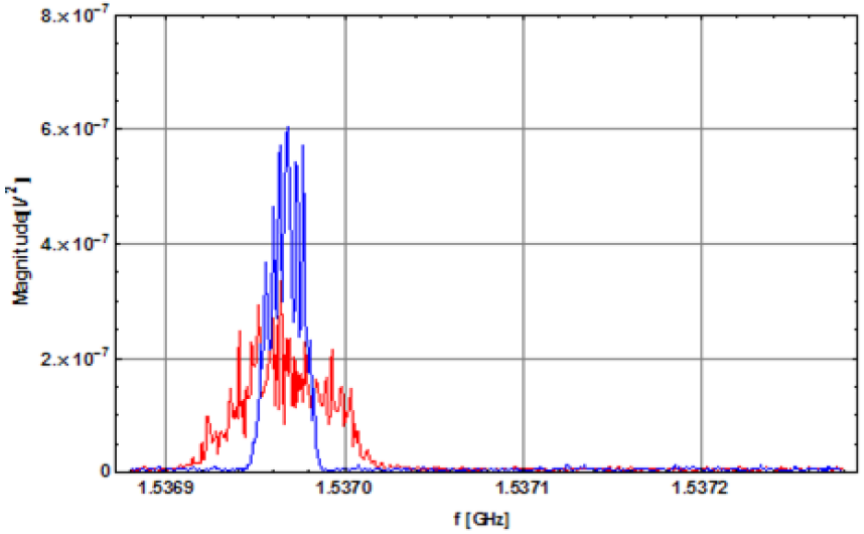
Red: initial
Blue: after 160 s

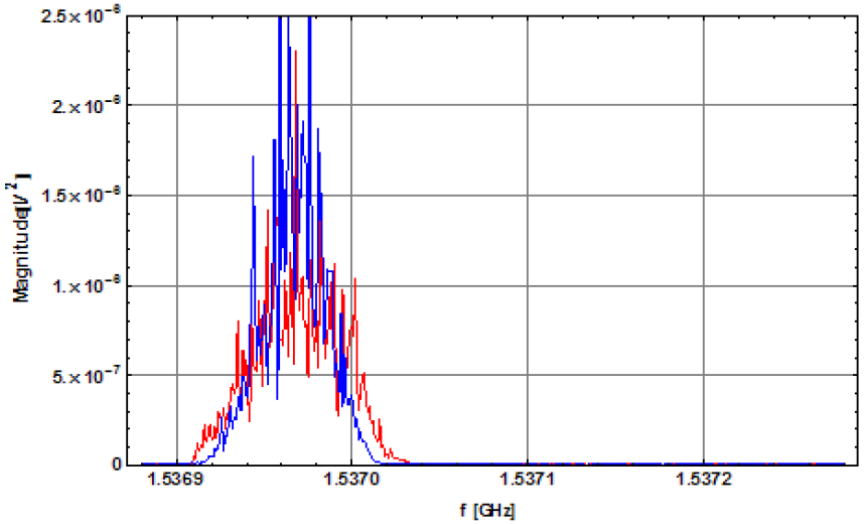
- mean energy losss is compensated
- beam momentum is cooled

ADVANTAGE OF THE BARRIER BUCKET

Stochastic Cooling: On

Target: Off





- Barrier Bucket
- normal h = 1 RF

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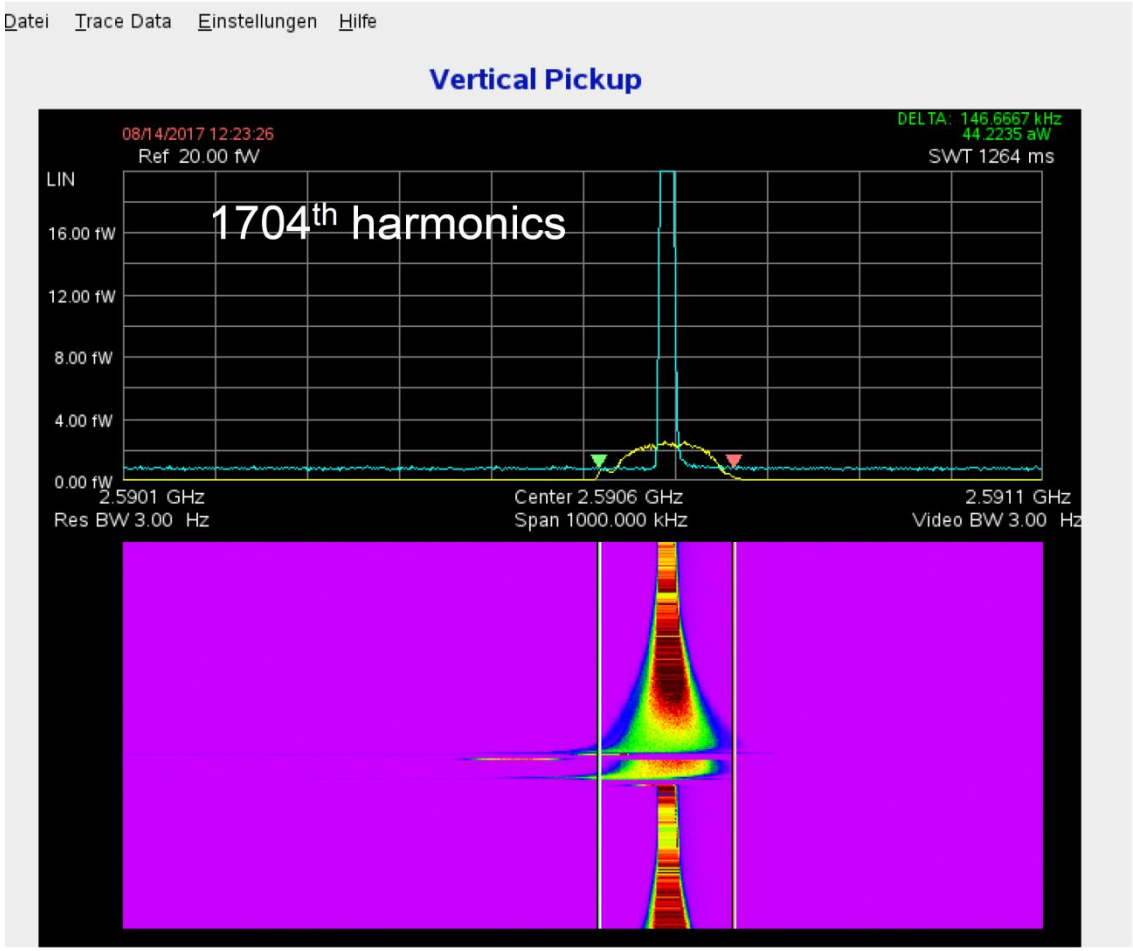
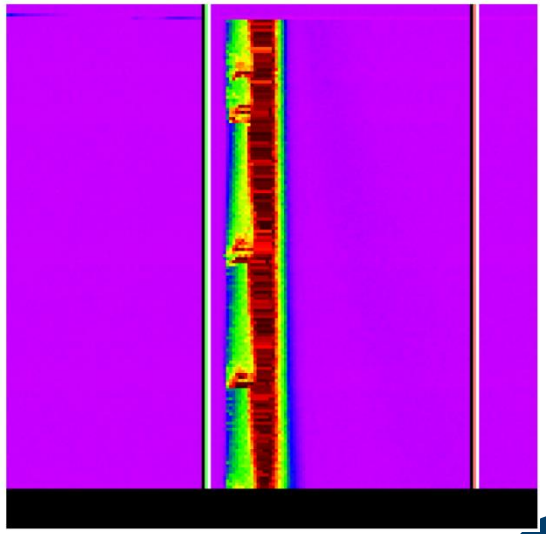
Longitudinal cooling 2E8 particles



Slightly faster cooling and smaller equilibrium
Constant gain!

Instabilities visible, but no beam loss.



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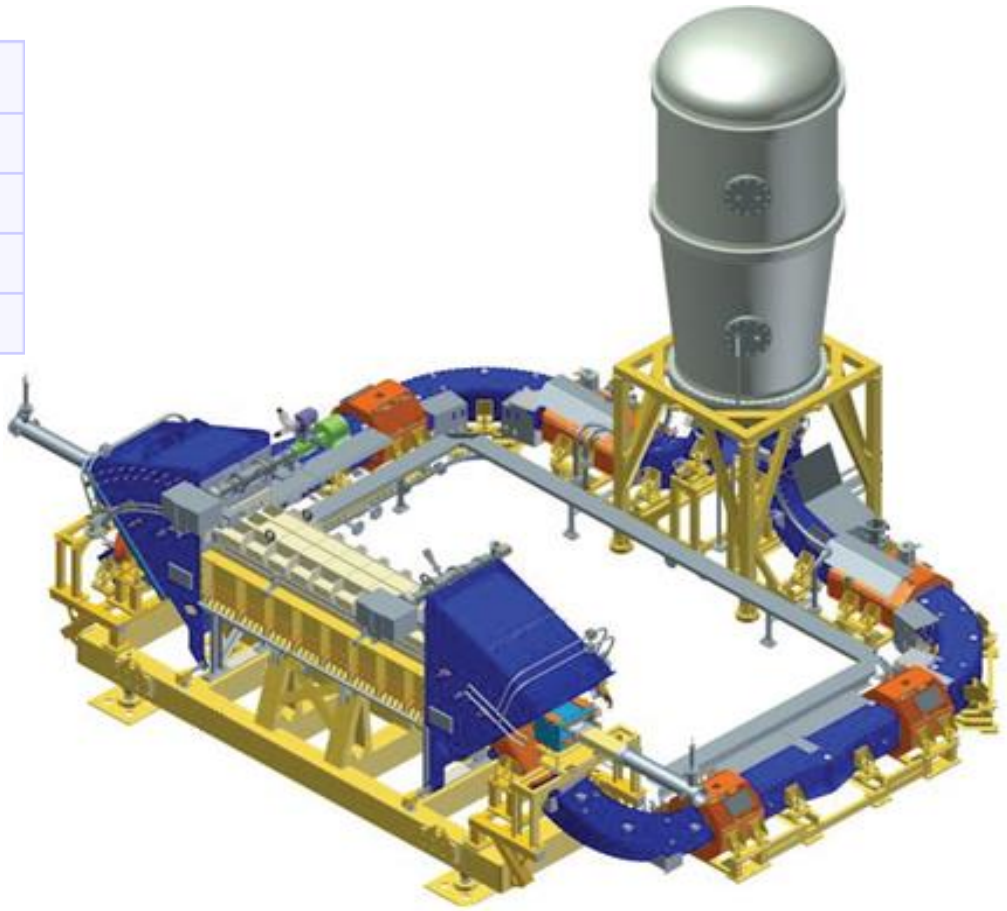
Transverse (vertical) cooling 7E9 particles

Even after beam centering, longitudinal parts visible (due to limited isolation in hybrid), but this does not influence the transvers cooling

CURRENT STATUS OF THE 2 MEV E-COOLER AT COSY

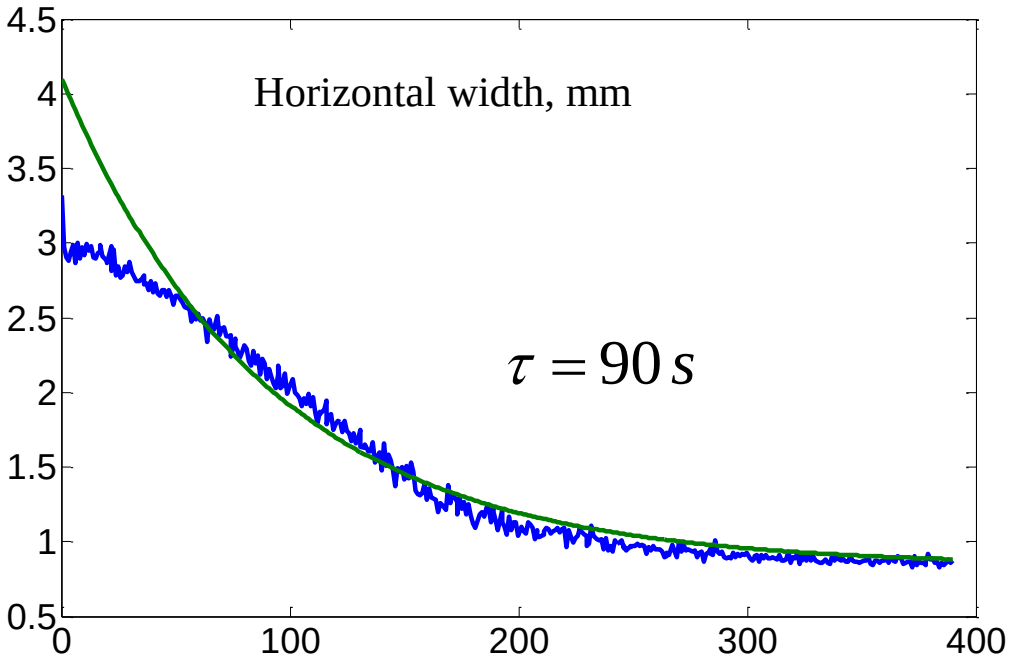
Electron energy, MeV	Electron current, A
0.024	1
1.25	**0.8**
1.5	0.1
1.57	

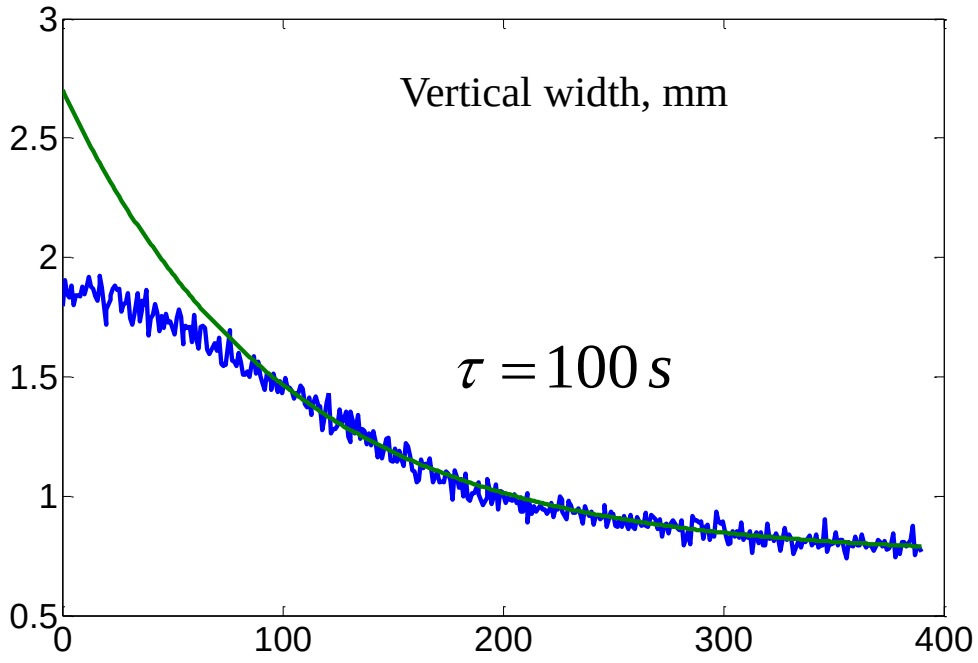
Beam cooling up to
- 1.257 MeV electrons
- 2.3 GeV protons



EXPERIMENTAL RESULTS, TRANSVERSE ELECTRON COOLING

1600 MeV protons, $N_p = 3 \cdot 10^8$, $I_e = 0.8$ A, $E_e = 0.909$ MeV





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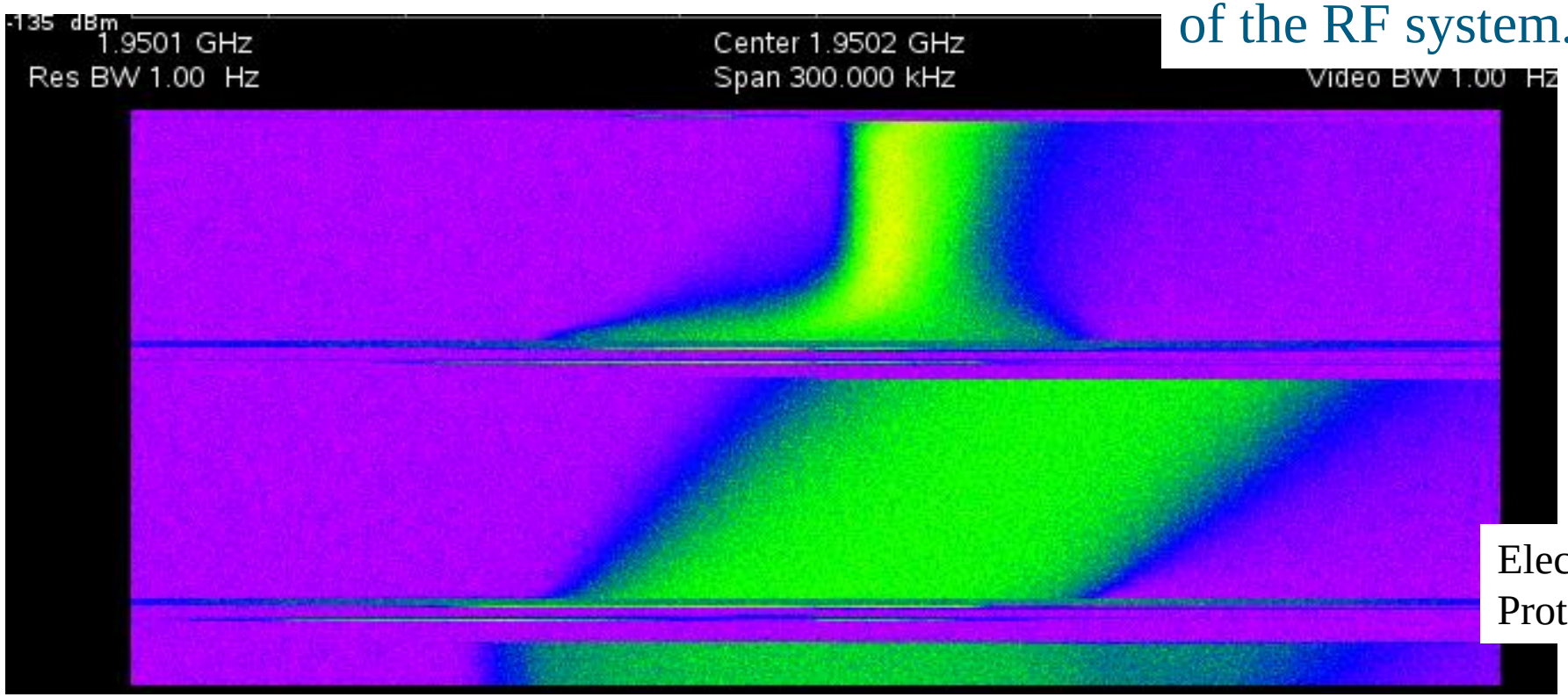
PRELIMINARY EXPERIMENTS WITH THE CLUSTER JET TARGET AT E_E = 1.257 MEV

Electron cooling suppressed the longitudinal effect of the target with density $n_a = 2 \cdot 10^{14}$ cm^{-2} without the help of the RF system.



Electron energy 1.257 MeV, I_e = 0.5 A
Proton energy 2300 MeV

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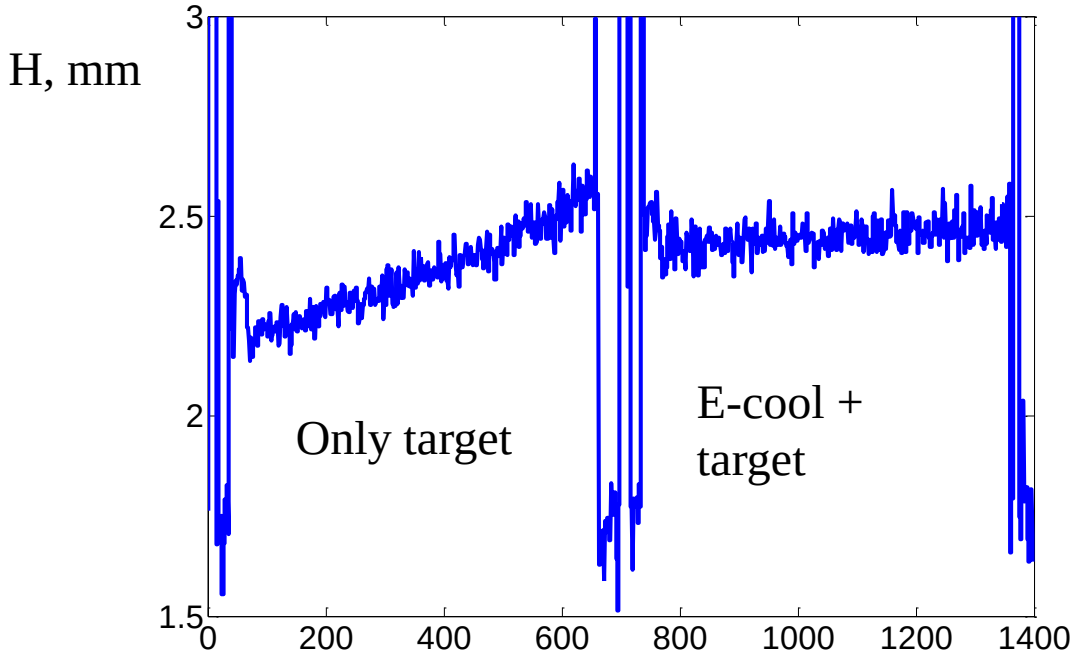
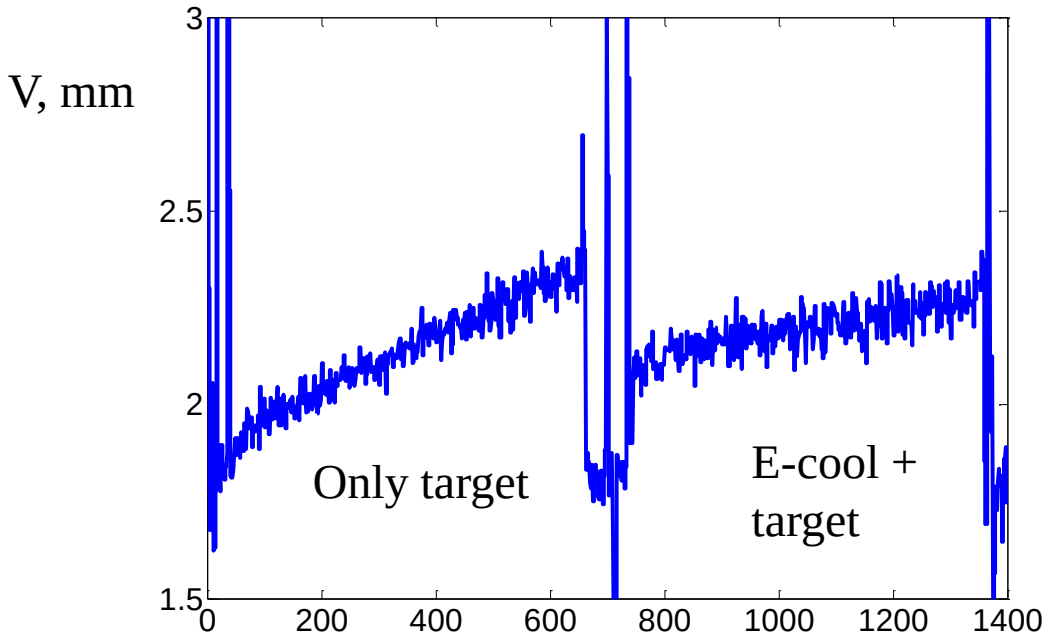
EXPERIMENTS WITH THE CLUSTER JET TARGET AT E_E = 1.257 MEV, TRANSVERSE CASE

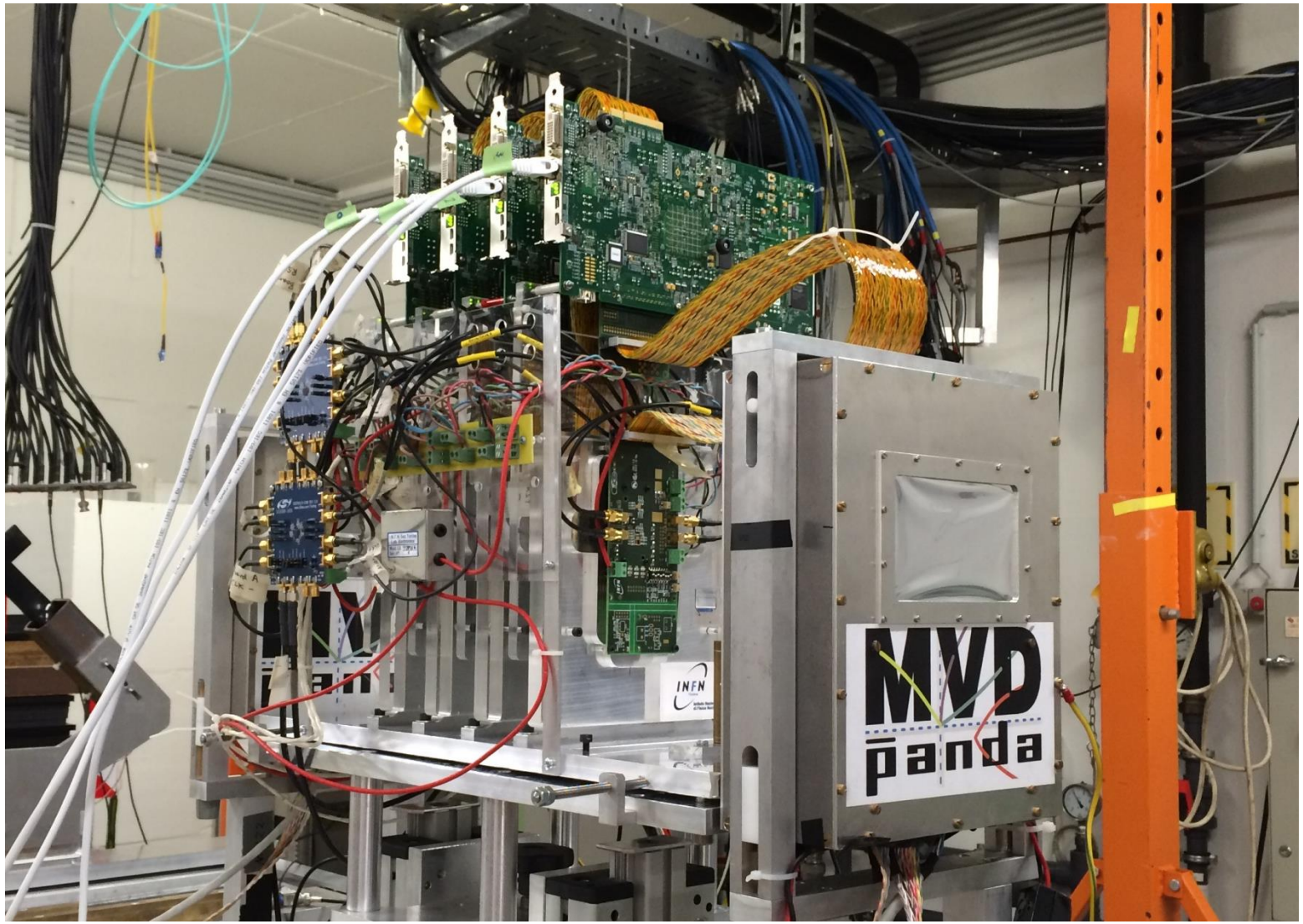
Electron cooling suppressed longitudinal and transverse growth induced by the target



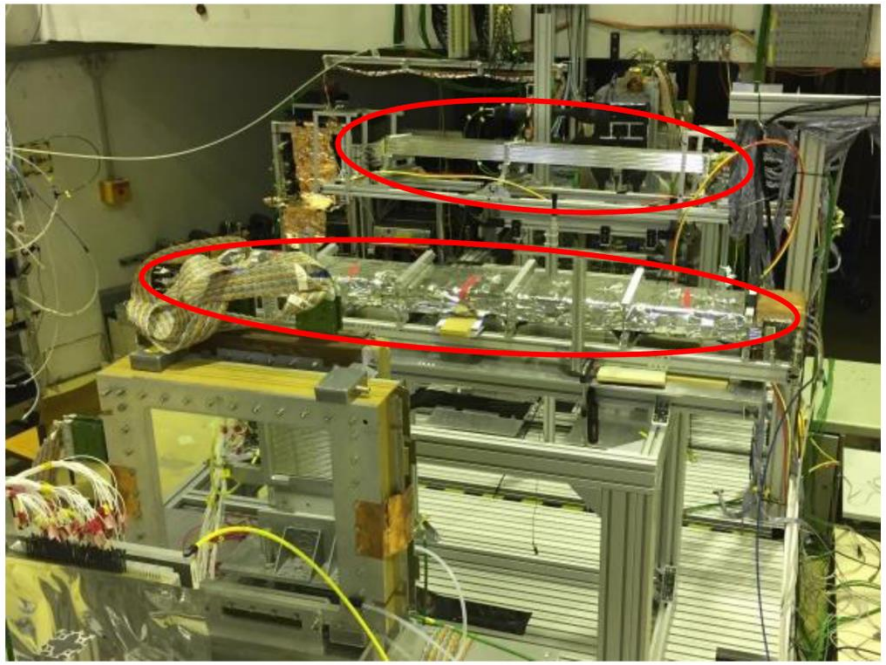


Electron energy 1.257 MeV, I_e = 0.5 A Proton energy 2300 MeV

PANDA MVD



PANDA STT IN THE TOF AREA

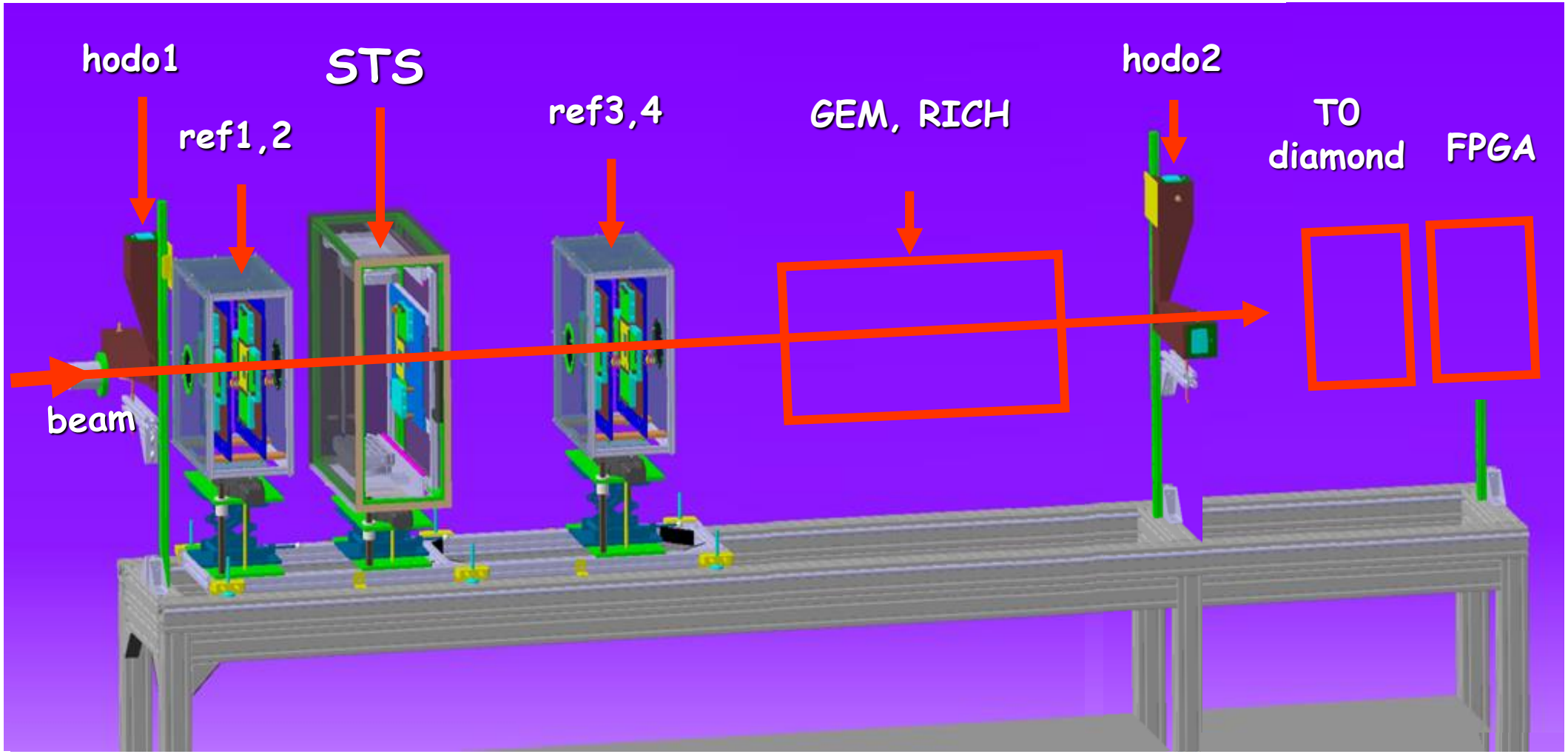


2× Straw testsystems (red circles) for the ADC-based and ASIC/TRB readout. Beam from the back.

Straw testsystem for the ASIC/TRB readout. Beam from the right.

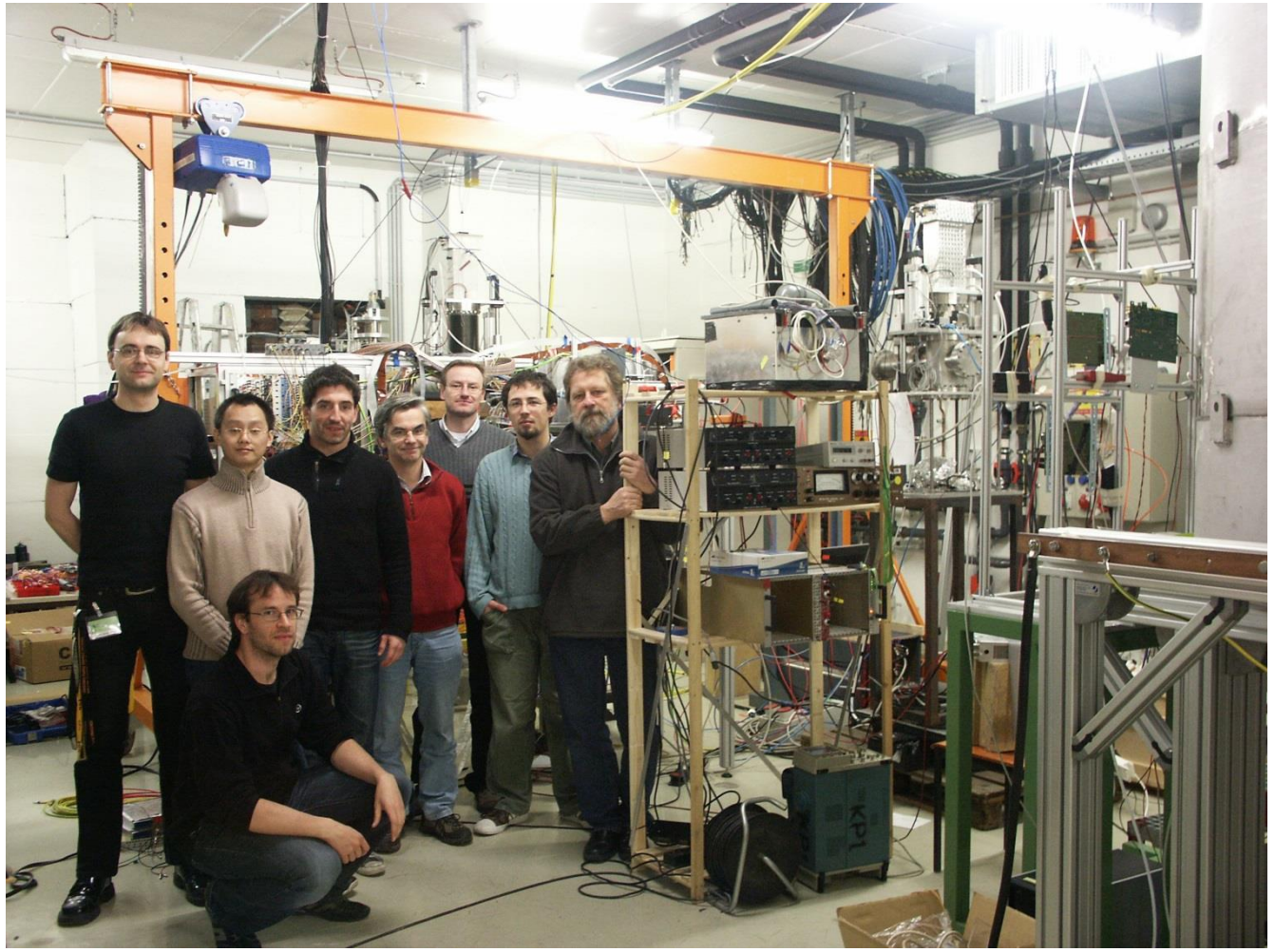
Front-end ASIC boards (pre-series system).

CBM Detector setup in the JESSICA area

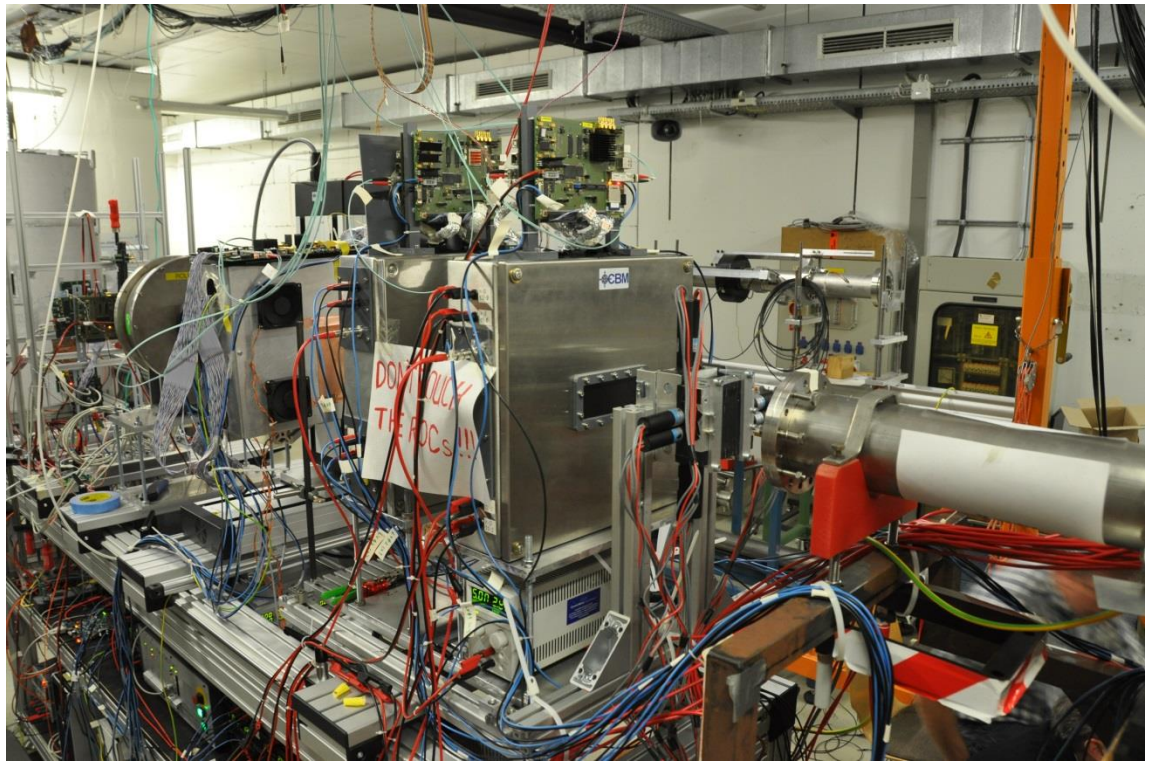


THE CBM-TOF GROUP

in the JESSICA Area



THE CBM-TRACKER GROUP



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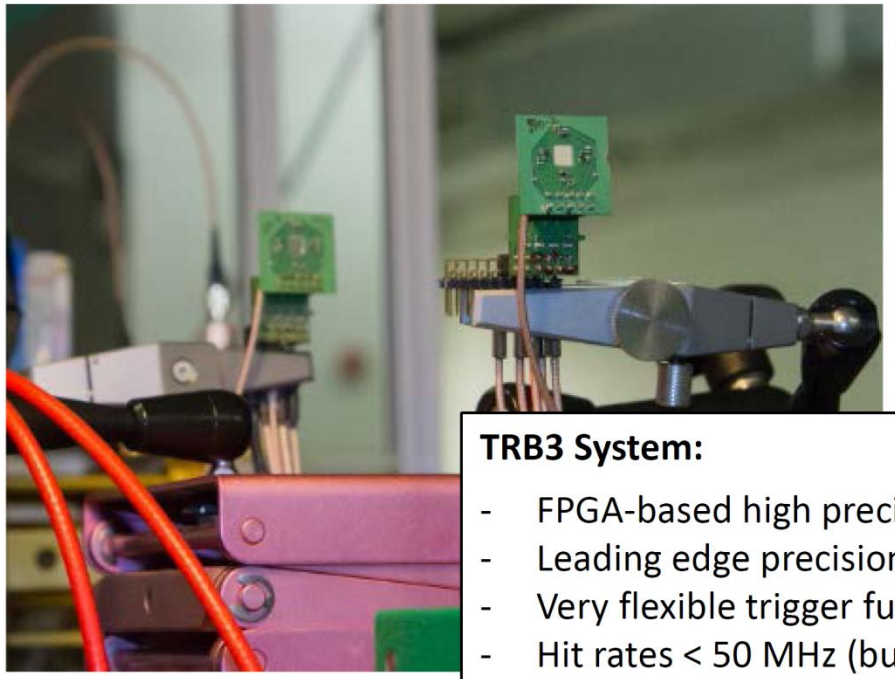
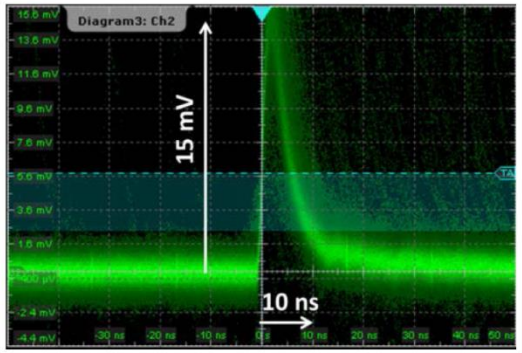
CBM DIAMOND TESTS

Diamond T0 tests with Scope/TRB3 read-ou





TRB3 System:

- FPGA-based high precision TDC measurement and DAQ in one
- Leading edge precision: 8-12ps (RMS)
- Very flexible trigger functionality (FPGA)
- Hit rates < 50 MHz (burst)

Used in many FAIR Projects:

- HADES (diamond/trigger/RICH/ECAL),
- CBM RICH,
- PANDA (Barrel-DIRC/Straw)
- and also outside of FAIR: MUSE, A1, ...

INSTALLATIONS AT COSY FOR FAIR

PANDA Cluster Target

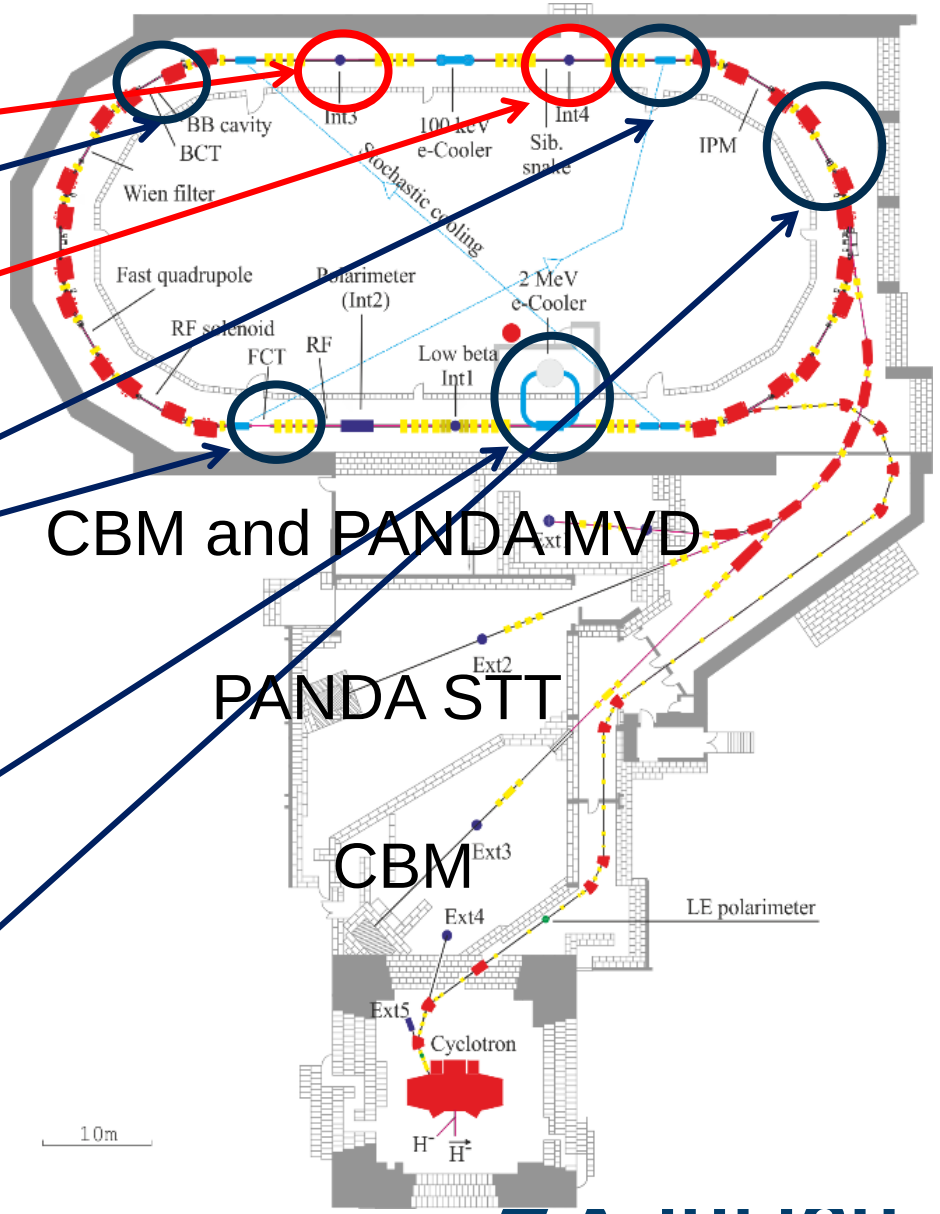
HESR Barrier Bucket cavity

PANDA KOALA

HESR stochastic cooling

2 MeV electron cooler

Ionisation Profile Monitor



TOPICS FOR COSY OPERATION IN POF-4

- Beam dynamic studies (verifications of simulations)
- Sensitivity of closed orbit correction to errors in the machine modelling
- Spill studies and cures for homogenious spill structure with different extraction methods
- Prototype tests **with beam** for other FAIR (ring) components (stochastic cooling equipment CR, diagnostics, etc.)

- Experiments:
  - detector component tests
  - subsystem tests
  - DAQ prototype tests
  - Radiation hardness tests for FE electronics

ADVANTAGE OF COSY

- Easy access
- Flexible ion optics for different modes of operation
- Installation of test equipment in the ring or at external areas possible

MY MAIN MESSAGE

- Operation of COSY is essential for FAIR for the next years (beyond 2021)
- Invitation for proposals by all FAIR groups

Thank you for your attention