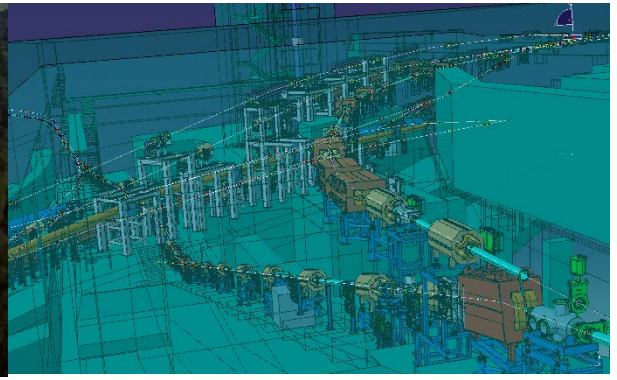



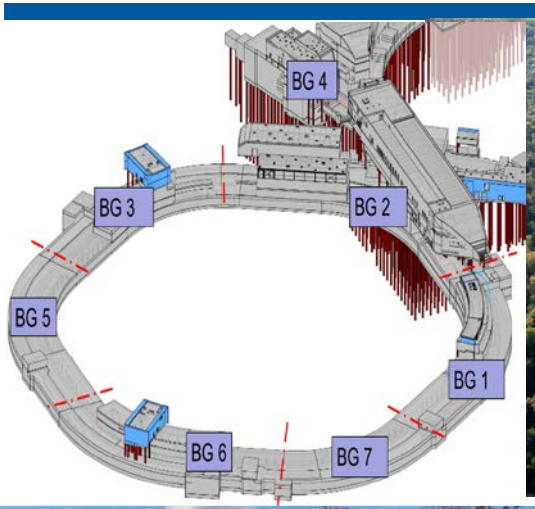
Extension for Status of CERN Recognized Experiment RE-21 (CBM)

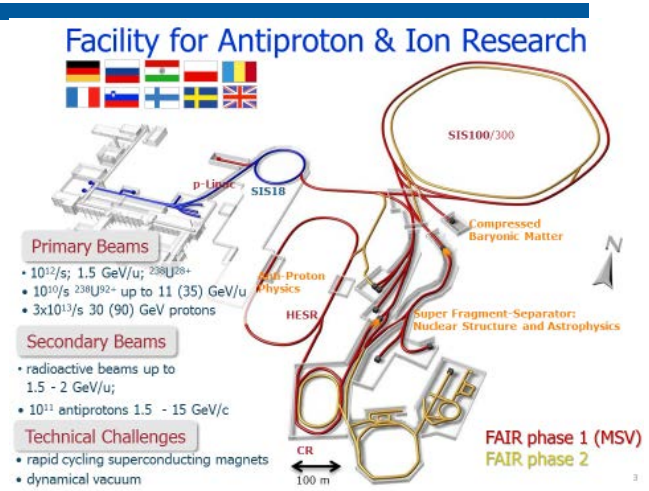
Jürgen Eschke, FAIR
CBM Resource Coordinator

CERN, REC meeting, 23 January 2020

Finland France Germany India Poland Romania Russia Slovenia Sweden United Kingdom Czech Republic FAIR

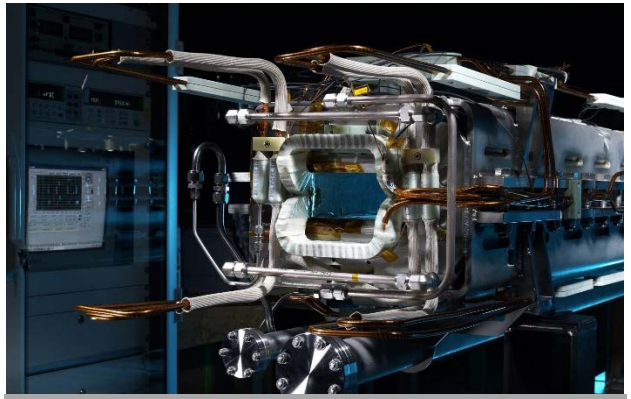
Status of FAIR Project: Progress Civil Construction



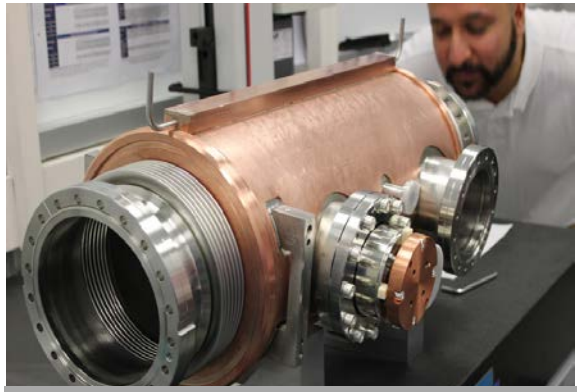


Status of FAIR: accelerators:
construction / procurement progresses well

- e.g. Serial production for major components for SIS 100 is progressing with more than half of the dipole magnets already manufactured.



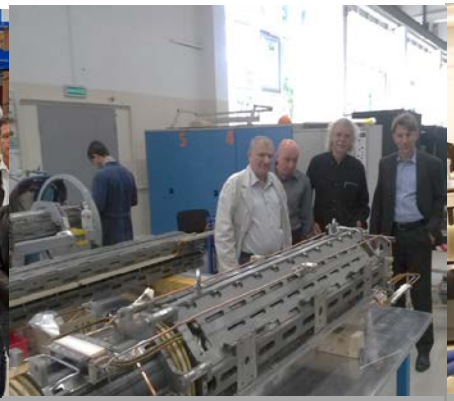
SIS100 Dipole Magnets



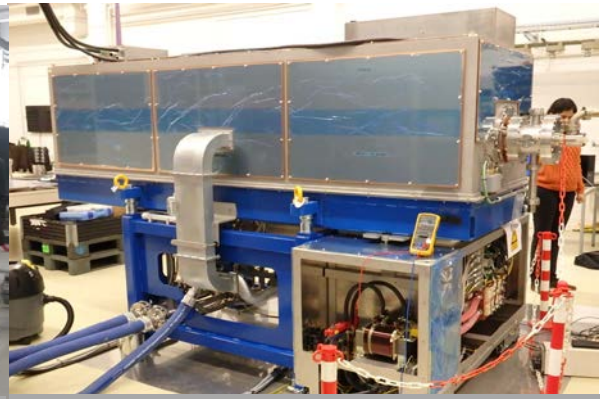
Cryo Catcher

Cryo-Bypass Line

Test facility at CERN for SFRS magnets



Quadrupole Unit



RF Cavity System

FAIR status, timeline and outlook

FAIR progress review in Spring 2019: Committee with external experts
(civil construction, accelerator and experiments), chaired by Lyndon Evans (CERN)

Recommendations:

„The FAIR Modularized Start Version (MSV) is to be constructed and completed in full as soon as possible. All else would be an extreme loss of science and waste of resources.“
“… the science programs of the four FAIR pillars will enable unique, and in many aspects, world leading discovery science. The breadth and reach of these programs will remain unsurpassed at the planned start of FAIR operation in 2025 and for many years beyond.”

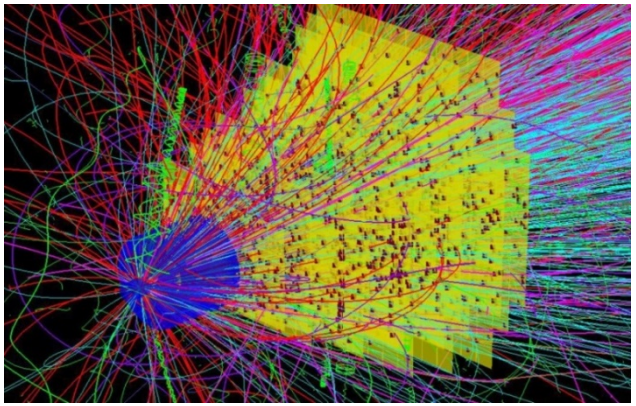
Total construction costs: 1,8 B€ (2005 prices)

Project outlook:

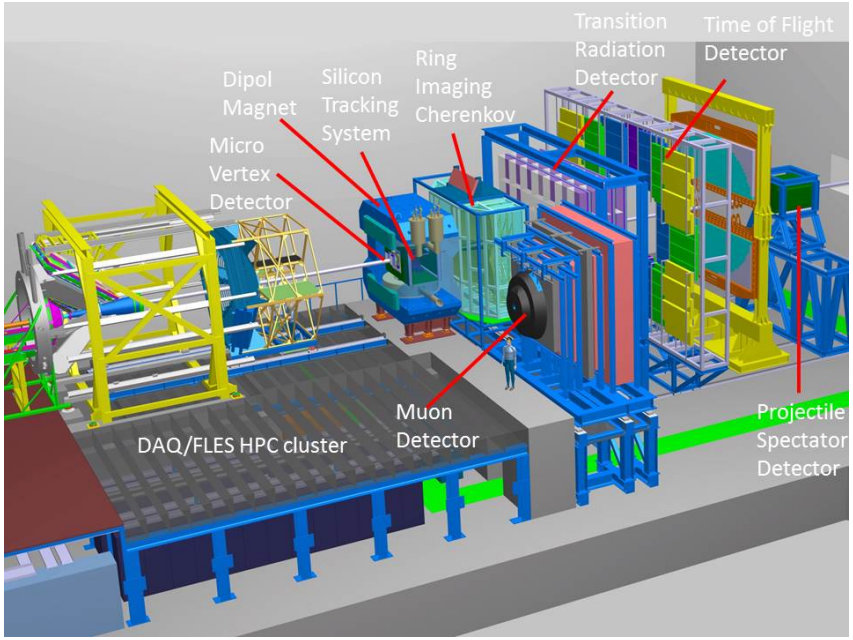
- Council decisions in 2019 support continuation of project execution as per plan
- Award of civil construction area south
- Tendering of Technical Building installation continued as per plan
- Continue resource balancing and recruiting
- Thorough follow-up of manufacturing and delivery of accelerator components
- Finalization of In-kind contracts and FAIR tenders according to FAIR baseline

Start of operation: 2025

CBM - Compressed Baryonic Matter experiment at FAIR



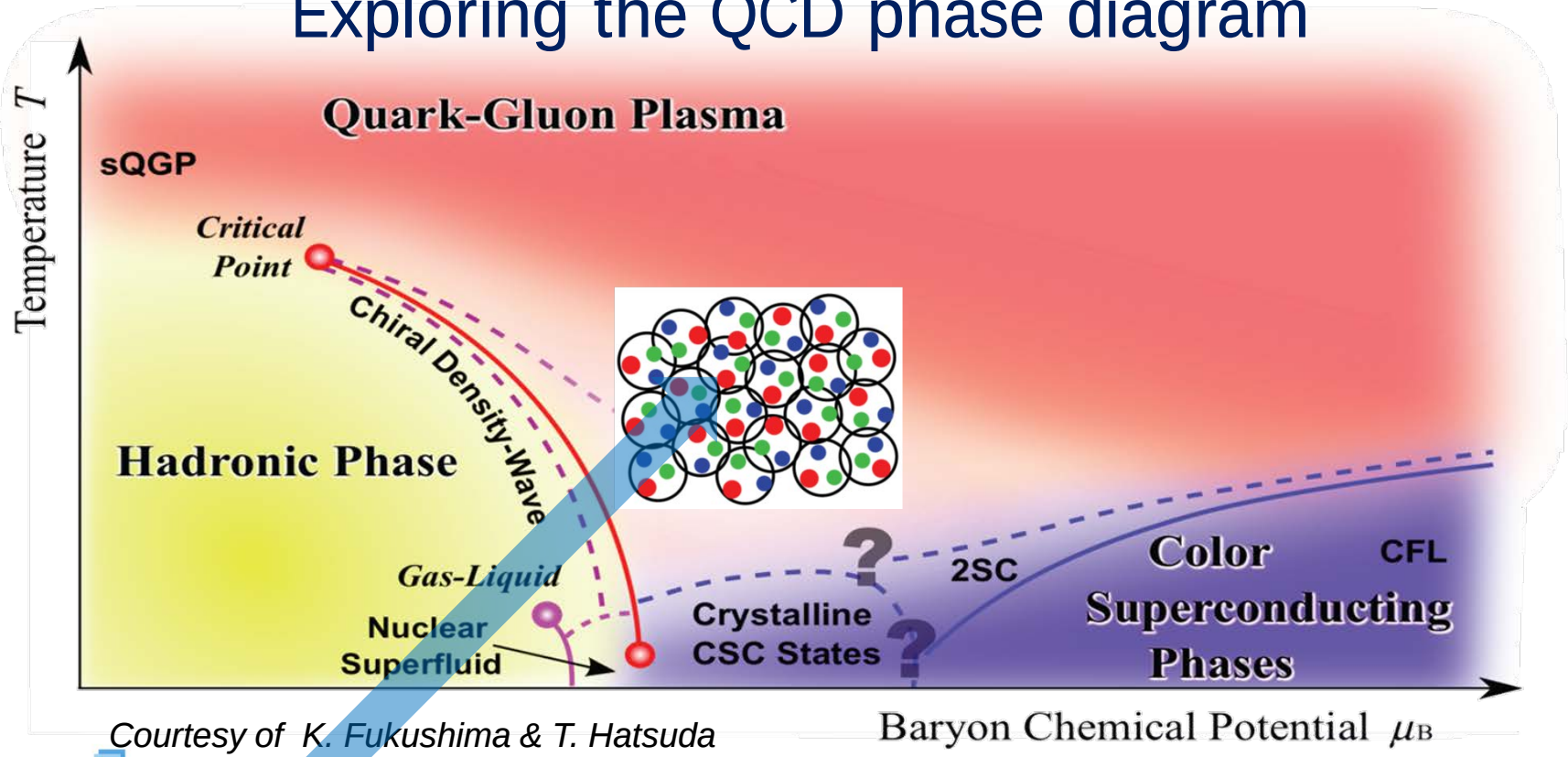
- typical collision system: Au + Au at 4 to 11 AGeV at SIS100
- Day 1: beam intensity: 5×10^7 ions/sec; interaction rate 0.5 MHz
- MSV: beam intensity: 10^9 ions/sec; interaction rate 10 MHz



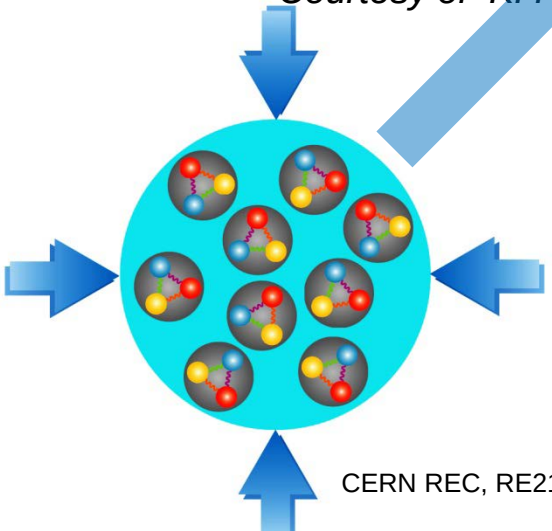
Experimental requirements:

- 10^5 - 10^7 Au+Au reactions/sec
  → peak data flow 1 TByte/sec
- determination of displaced vertices (σ ~ 50μm)
- identification of leptons and hadrons
- fast and radiation hard detectors and FEE
- free-streaming readout electronics
- high speed data acquisition and high performance computer farm for online event selection
- 4-D event reconstruction

Exploring the QCD phase diagram



Courtesy of K. Fukushima & T. Hatsuda

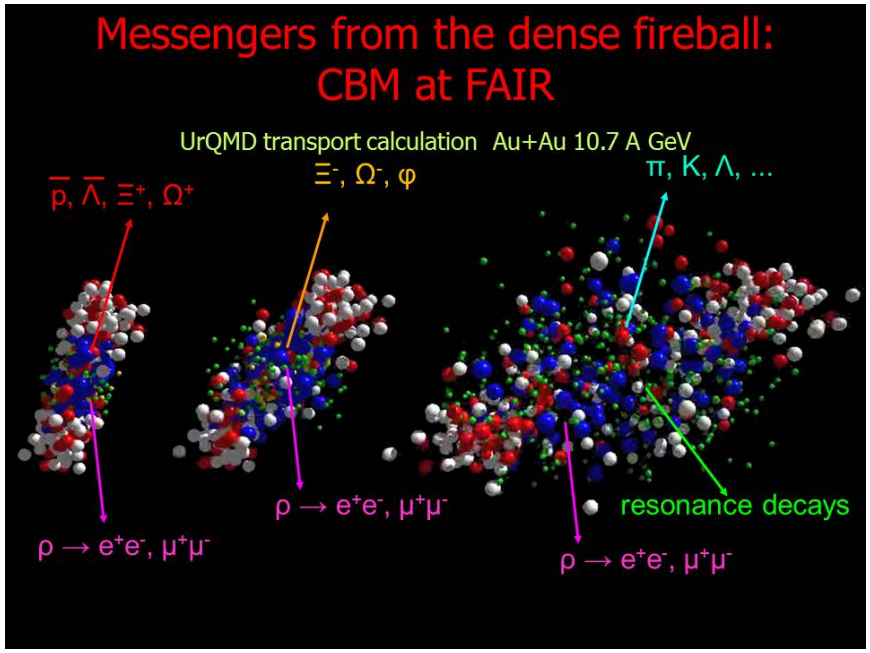


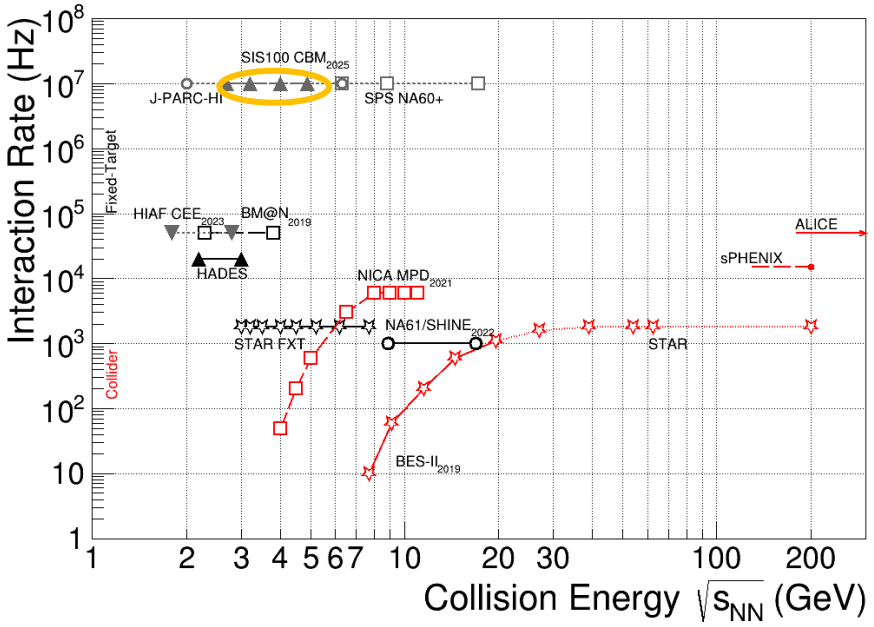
<u>At high baryon density:</u>

- N of baryons >> N of antibaryons
  Densities like in neutron star cores
- L-QCD not (yet) applicable
- Models predict first order phase transition with mixed or exotic phases
- Experiments: BES at RHIC, NA61 at CERN SPS, CBM at FAIR, NICA at JINR, J-PARC

CBM - Compressed Baryonic Matter

CBM Experiment at FAIR: Systematically explore QCD matter at large baryon densities with high accuracy and rare probes, at highest interaction rates





CBM evaluations, status and funding

- Technical status is regularly evaluated by FAIR ECE (Expert Committee Experiments)
- Science case and progress is regularly evaluated by FAIR/GSI Joint Scientific Council

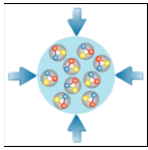
- CBM participates in FAIR Phase-0 programme with
  mCBM@SIS18, RICH@HADES/SIS18,TOF@RHIC and STS&PSD@NICA

- Resource Review Board (RRB) process implemented since 2012 (same as at CERN)
- Funding Level of > 90% reached
- Common Infrastructure (funded by Common Fund) evaluated by ECSG (C. Touramanis)
- Construction MoU to be signed in 2020

- CBM is at beginning of construction phase,
  to be completed in 2023, when detector installation in CBM cave starts

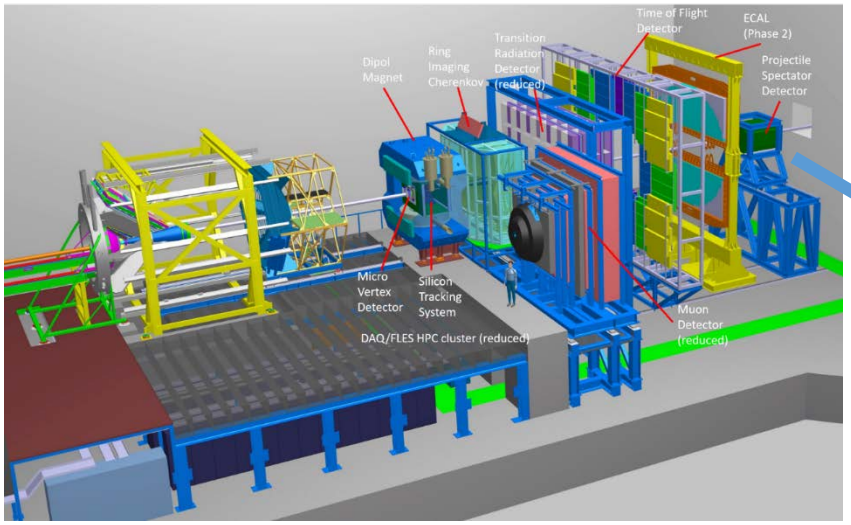
- Commissioning with first SIS100 beam planned for end 2025

CBM Detector Tests as RE-21 at CERN 2017-2018

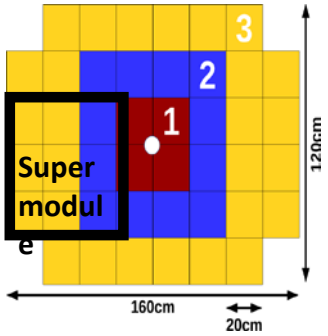


- Focus on qualification of full-sized detector prototypes
  - to reach production readiness status
  - full system tests (multiple detectors + DAQ; slice tests)
- Unique possibilities at CERN:
  - PS T9/T10: Mixed e/π beams
    - PSD supermodule
  - GIF++: Mixed field γ + beam
    - TRD
    - MUCH
  - SPS HI: NA61/SHINE
    - Test of MVD prototype sensor and FEE in real experiment as integrated in NA61 heavy ion environment
    - PSD supermodule

PSD@CBM (FAIR)



PSD – Projectile Spectator Detector.
This forward hadron calorimeter will be used at the CBM to measure centrality of interaction and reaction plane orientation.



PSD - 44 modules, 5.6 λ_{int}

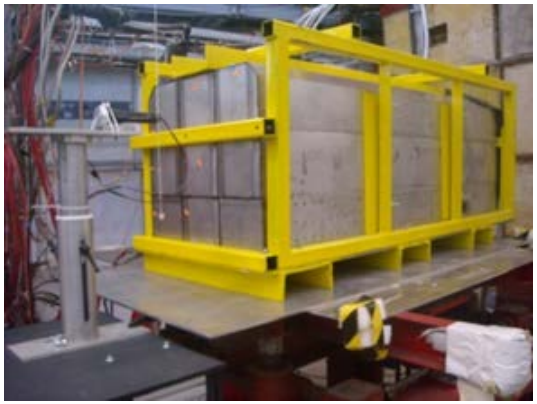
PSD module:
60 lead/scintillator layers,
sampling ration 4:1,
Light collection - WLS fibers,
Light detection:
10 Hamamatsu MPPCs/module

Expected beam intensity at the CBM– 10^8 ions/sec at 3 – 11 AGeV
Interaction rate – 10^6 per sec

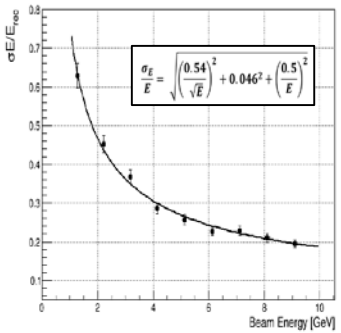
The goals of the PSD supermodule response studies on T9 and T10 in 2018 – 2019:

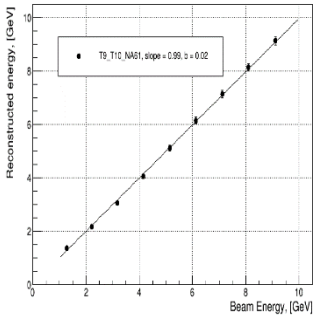
- **Study the PSD response at beam energies 4 -10 GeV. There was no experimental data before these tests.**
- **Study the PSD nodule response with different types of FEE and readout electronics and with irradiated MPPCs.**

Results of CBM PSD supermodule tests at PS T9/T10 and at SPS within NA61/SHINE in 2017 -2018

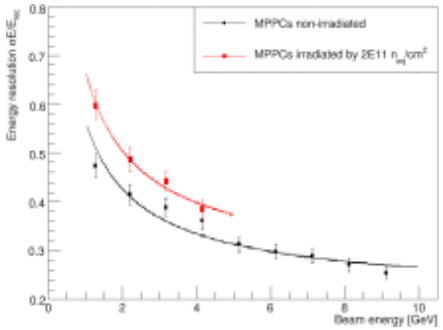


Supermodule – PSD array from 3 x3 modules.
Total size 600 x 600 x1650 mm^3.
Total weight -5000 Kg.





Energy resolution and linearity response



Energy resolution of first half of PSD module with irradiated MPCs

Results of beam tests have been published:

D. Finogeev et al., KnE Energ.Phys.3 (2018) ,333-339

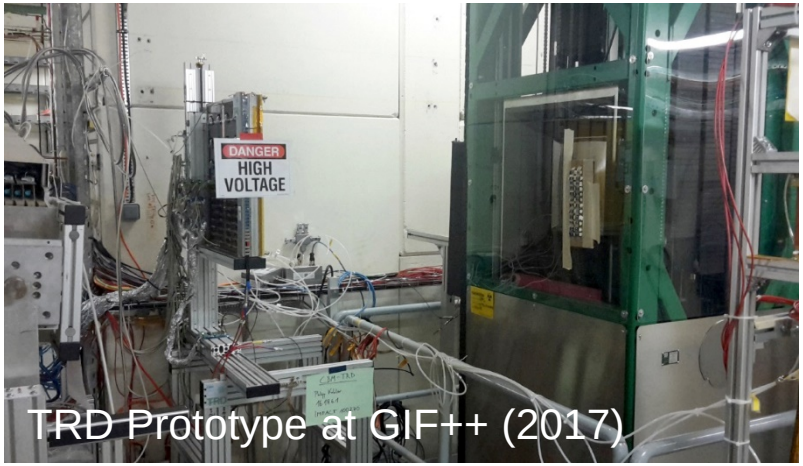
N. Karpushkin et al., NIM A936 (2019) 156-157

Plans for the PSD tests in the framework of RE21 in 2021 – 2024

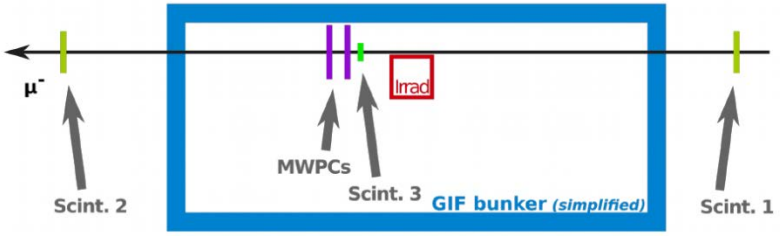
- Study of the PSD module response with irradiated new MPPCs on T10 beam line.
- Study of the FPSD response at high Pb beam rate on NA61.

TRD Test Activities at CERN 2017-2019

- **GIF++:** Sep. 28 – Oct. 12, 2017
  - Test of detector and readout stability
  - Setup: small TRD module + SPADIC2.0-AFCK readout
  - Stable performance of MWPCs and readout at highest γ-irradiation levels confirmed
- **GIF++:** Oct. 24 – Oct. 30, 2018
  - Measurement of muon beams from SPS under irradiation by GIF++ γ-source
  - Setup: small TRD modules + SPADIC2.0-AFCK readout



TRD Prototype at GIF++ (2017)



Planned Test Beams at CERN for TRD

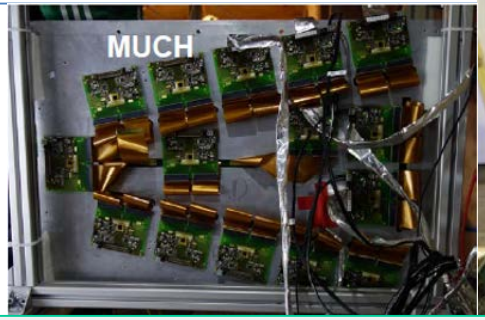
- CERN-PS T9 or T10
  - Mixed electron / pion beam at different beam momenta
  - Purpose: collection of calibration data for electron identification with production TRD modules
  - Required time: 2 – 3 weeks / year
  - Time frame: 2021 – 2023

- CERN-GIF++
  - γ-Irradiation together with muon beam from SPS
  - Purpose: high rate QA tests of production TRD modules
  - Required time: long term setup for γ-irradiation of many modules
  - Time frame: 2020 – 2021

CBM-MUCH test beams at CERN

2016-Dec: Testing of GEMs at SPS with Pb beams

2018: Testing of RPC at GIF++



Major results:

1. first time GEM chambers were tested with self-triggered electronics to show >95% pion efficiency
2. Tests were also done using absorber
3. First level tracking was done using 3 GEM chambers
4. Two large GEM chambers and one small chambers were tested with Pb+Pb collisions
5. First time, GEM chambers were tested with more than one particle
6. High-rate RPCs were tested with self-triggered readout and gives 95% eff with muon beams
7. Efficiency reduces with photon flux

CERN test beam proposal (2020-21), two campaigns:

1. Testing of large GEM chambers with full CBM electronics to study efficiency at SPS
2. RPCs to be tested at GIF++: Real-size RPC for CBM to be tested for
   (a) muon efficiency and optimization
   (b) with photon flux for rate capability

Beam test activities for the CBM Micro Vertex Detector

R&D goals:

- Construction of a vertex detector based on dedicated CMOS MAPS.

CERN based activity: SPS-beam tests.

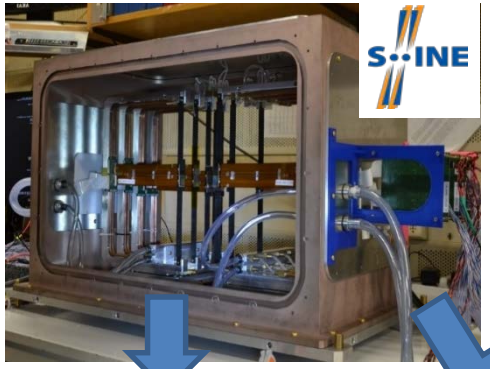
- Sensor R&D (beam tests)
- Full system tests.

2017 – 2019 Activities:

- R&D done by RD21 members as part of NA61/SHINE VD - project.
- Test of MVD prototype sensor and FEE in real experiment as integrated in NA61 – SAVD in heavy ion environment.

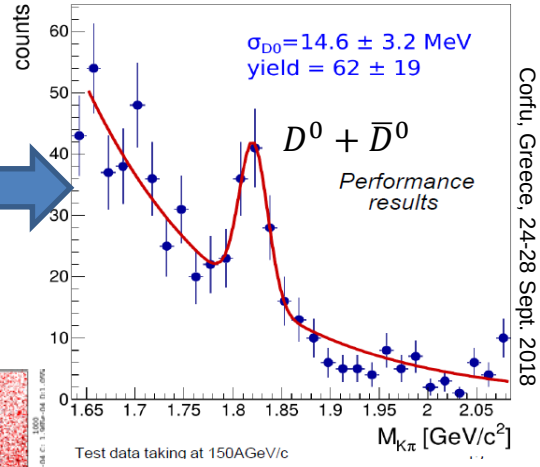
Future Activities:

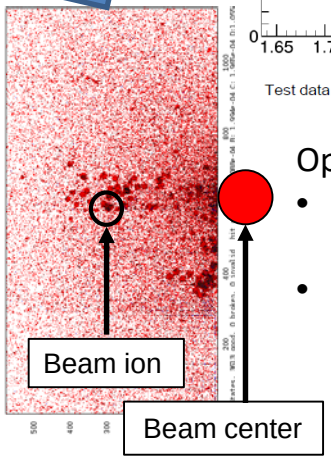
- About 1 week SPS-beam test/year.
- Focus on spatial resolution (few µm).



Station	Jura 2016	Jura 2017
1 – 0	72%	99%
2 – 0	94%	99%
3 – 0	61%	97%
3 – 1	31%	90%
4 – 0	50%	89%
4 – 1	62%	92%

Initially bad compensation of ohmic losses in power cables.

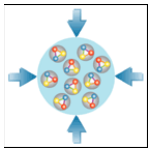




Operate MAPS in beam halo:

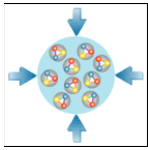
- Rad. damage due to beam halo crucial.
- Meanwhile: CBM beam line modified to control issue…

planned CBM Detector Tests at CERN for 2021-2022 after LS2



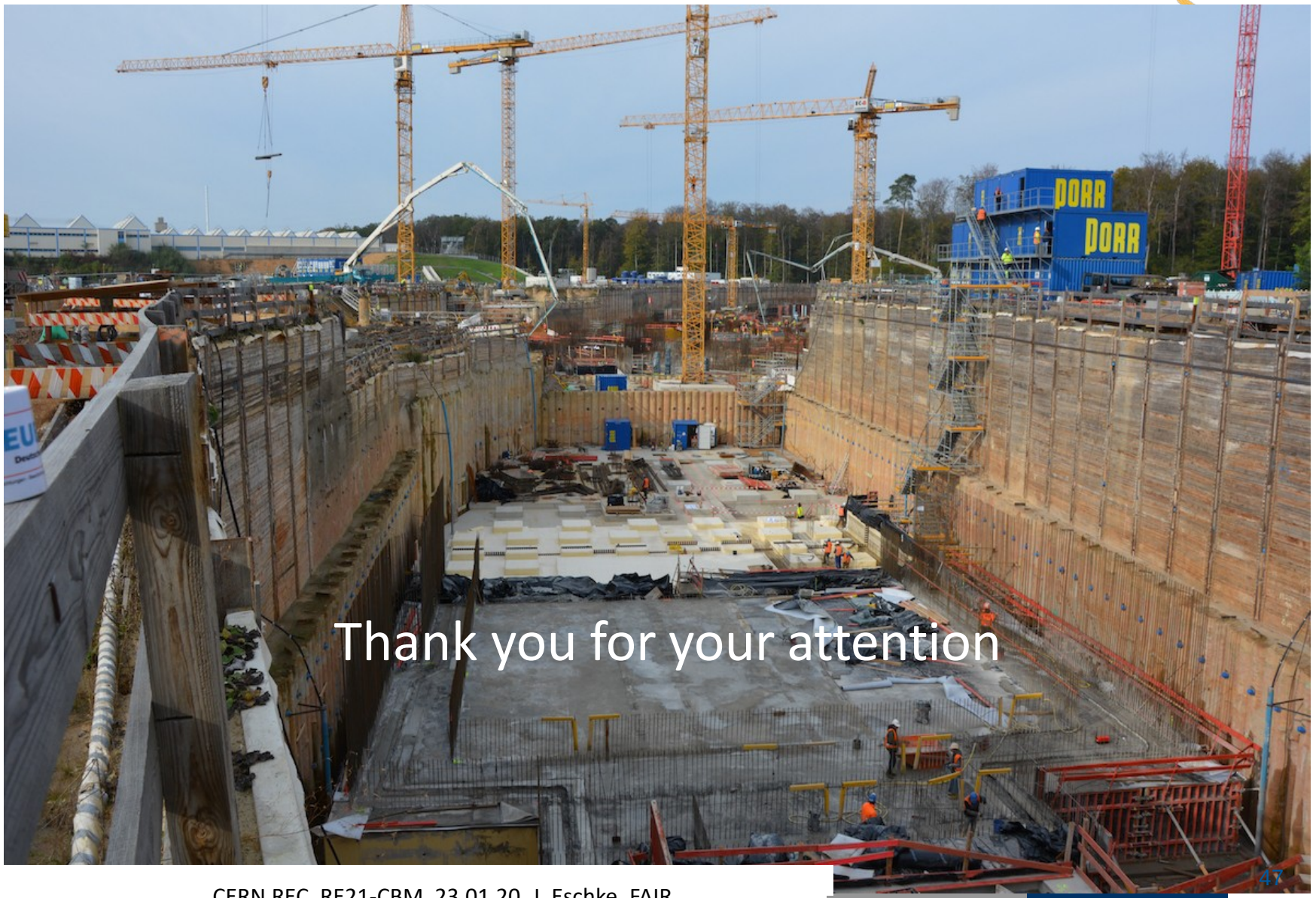
- Focus on final test for verification and calibration
- Unique possibilities at CERN:
  - PS T10: μ and hadron beams
    - PSD module response with irradiated new MPPCs
    - TRD calibration of produced modules
  - SPS HI: NA61/SHINE and H4
    - Study of the F-PSD response at high Pb beam rate on NA61.
    - MVD performance evaluation with focus on spatial resolution (~μm).
    - MUCH (H4)
  - GIF++: Mixed field γ + μ beam
    - TRD - QA tests of production TRD modules
    - MUCH-RPCs - muon efficiency and optimization

CBM Construction & CERN Expertise



- Technical expertise available only at CERN is essential for several aspects of the CBM construction phase:
  - EP-**DT**: **D**etector **T**echnologies
    - Large-size GEM foils for CBM Muon Detector (MUCH)
    - For the development of the cooling system of the main silicon tracker we have established contact with the EP-DT cooling project.
    - For the development of the RPC detector gas systems (used in TOF and MUCH) we have established contact with the PH-DT-DI gas project.
  - EP-**ESE**: **E**lectronic **S**ystems for **E**xperiments
    - CBM uses GBTx and VersatileLink in the DAQ system components (purchased from CERN for about 1.2 MSfr.)
    - CBM ordered FEAST radiation tolerant power converters
    - CBM is interested in the picoTDC
    - The MIMOSIS sensor for the vertex detector, developed at IPHC in Strasbourg, is closely related to the ALPIDE sensor, thus some co-operation with EP-ESE group.

CBM cave November 2019



Thank you for your attention