



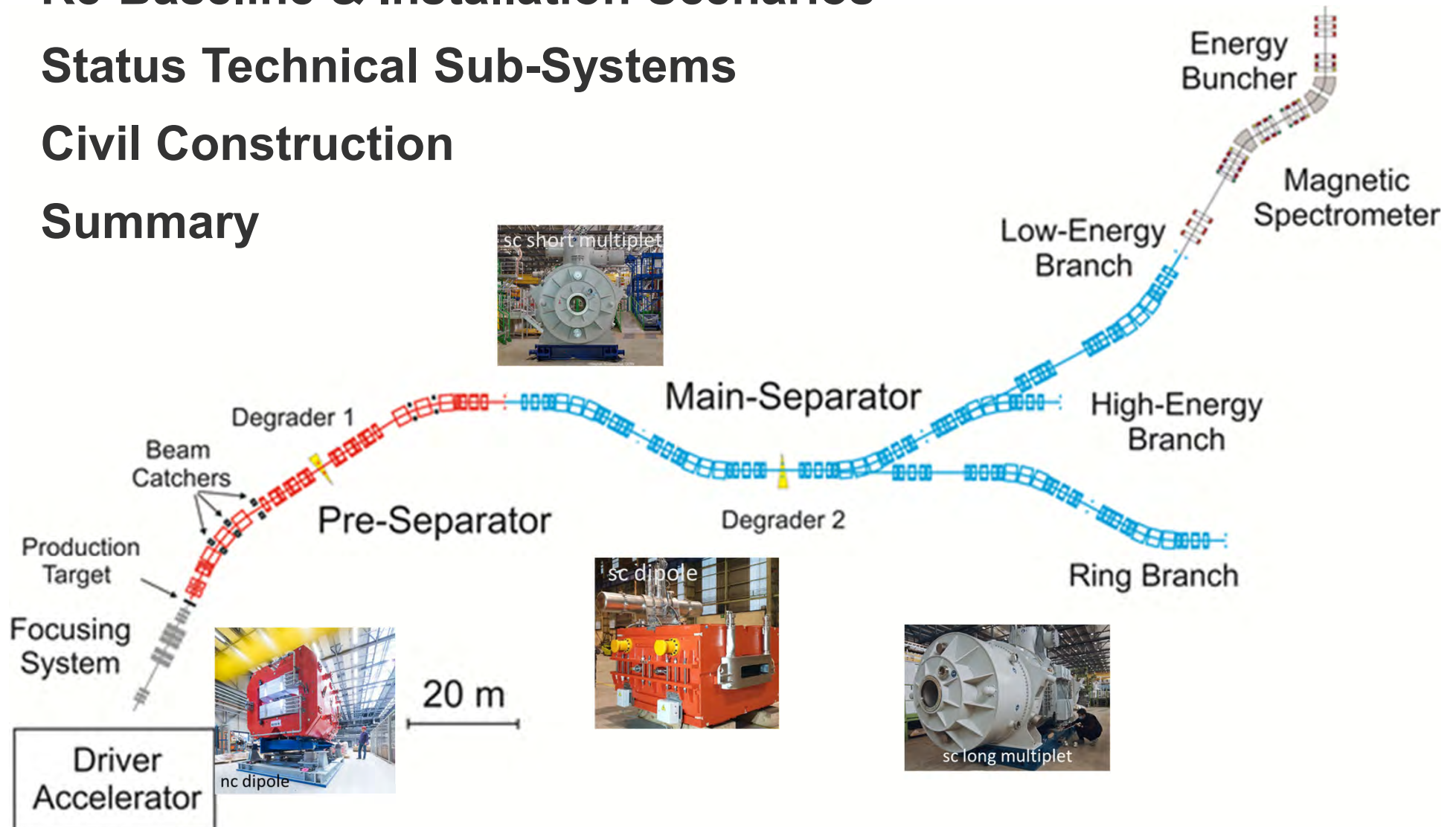
Status of the Super-FRS

M. Winkler

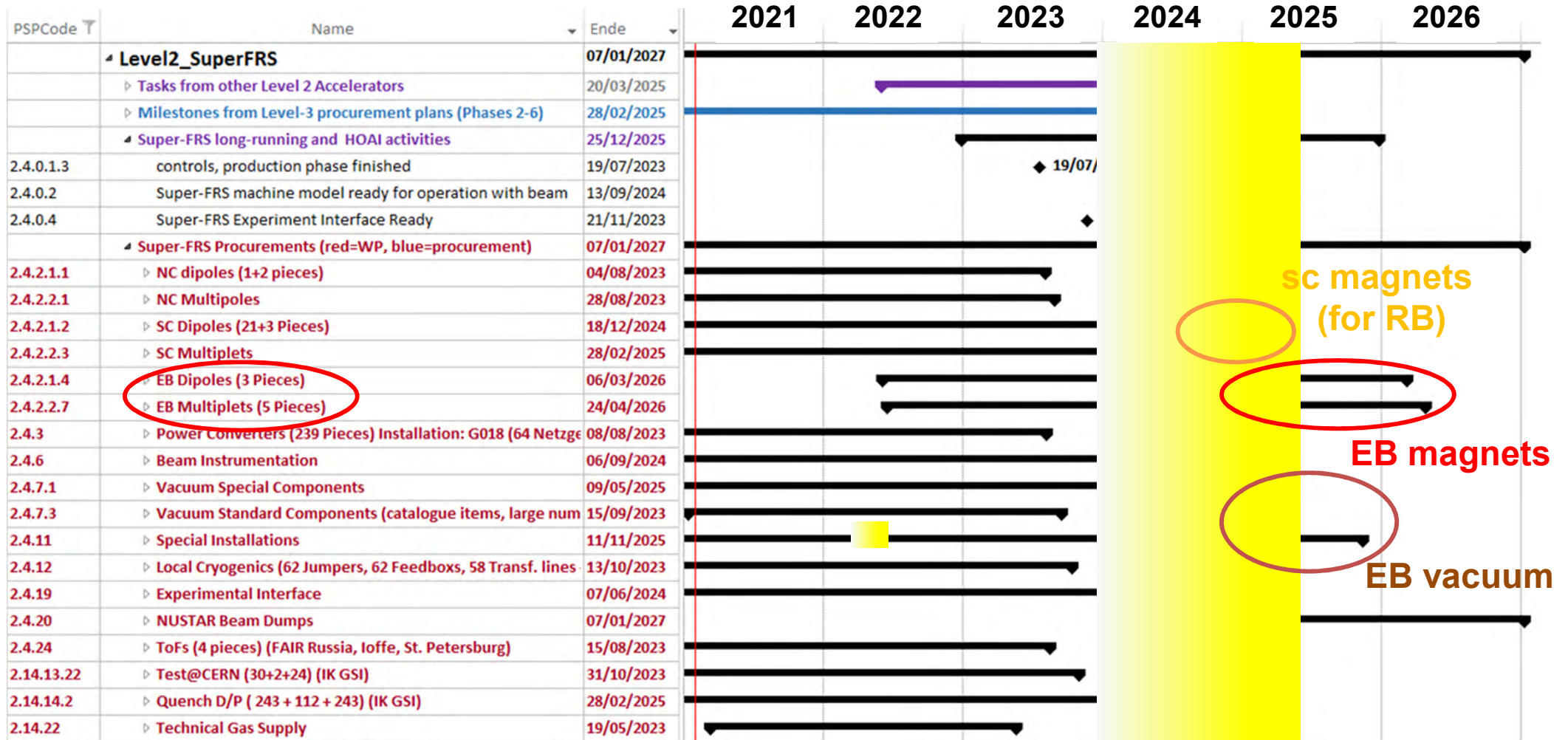
NUSTAR Annual Meeting, GSI, February 24 – 26, 2021

Outline

- 1) Re-Baseline & Installation Scenarios
- 2) Status Technical Sub-Systems
- 3) Civil Construction
- 4) Summary



Overview Level 2 Plan (Procurement Planning)



Installation
Window

Installation Scenarios

Procurement and Installation Planning

1st priority: HEB

2nd priority: LEB (FLF3)

3rd priority: RB

4th priority: Energy Buncher

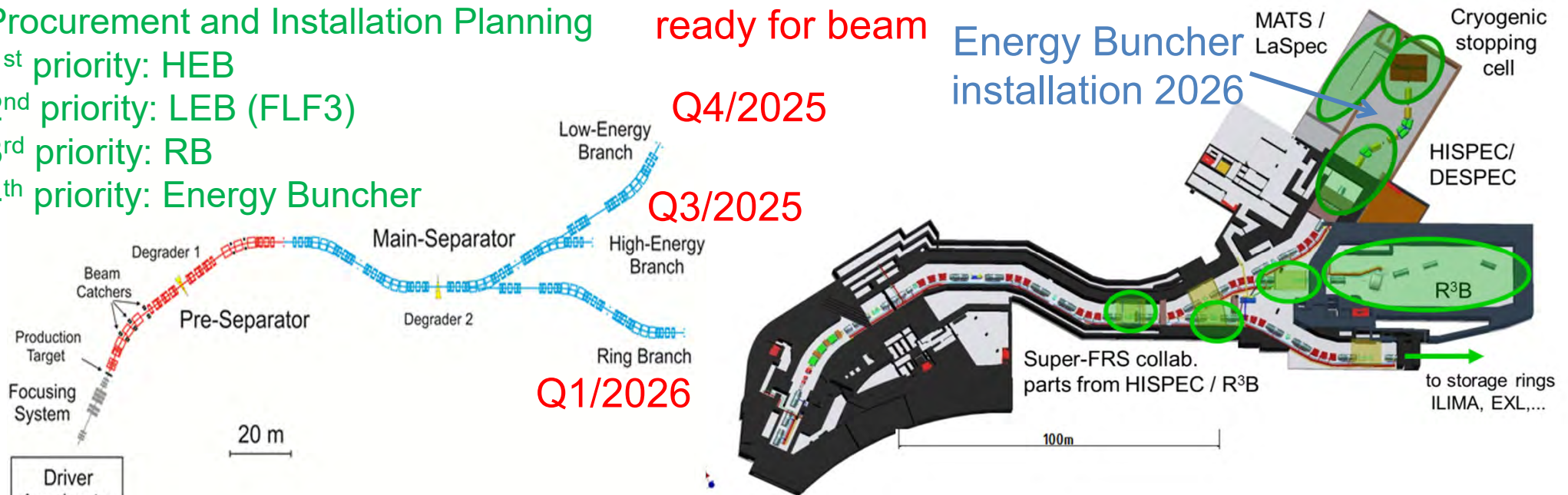
ready for beam

Q4/2025

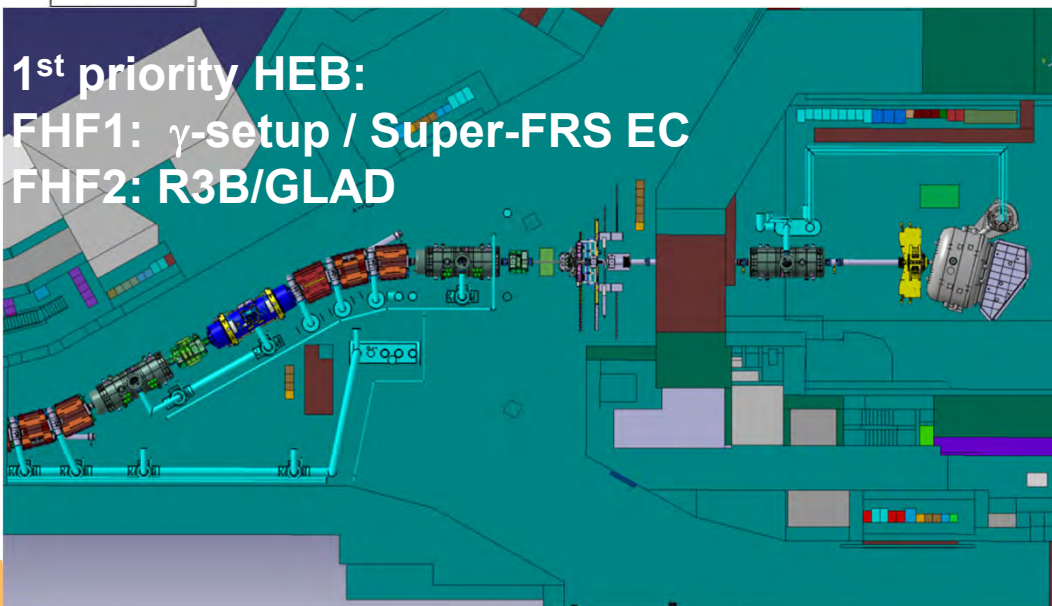
Q3/2025

Q1/2026

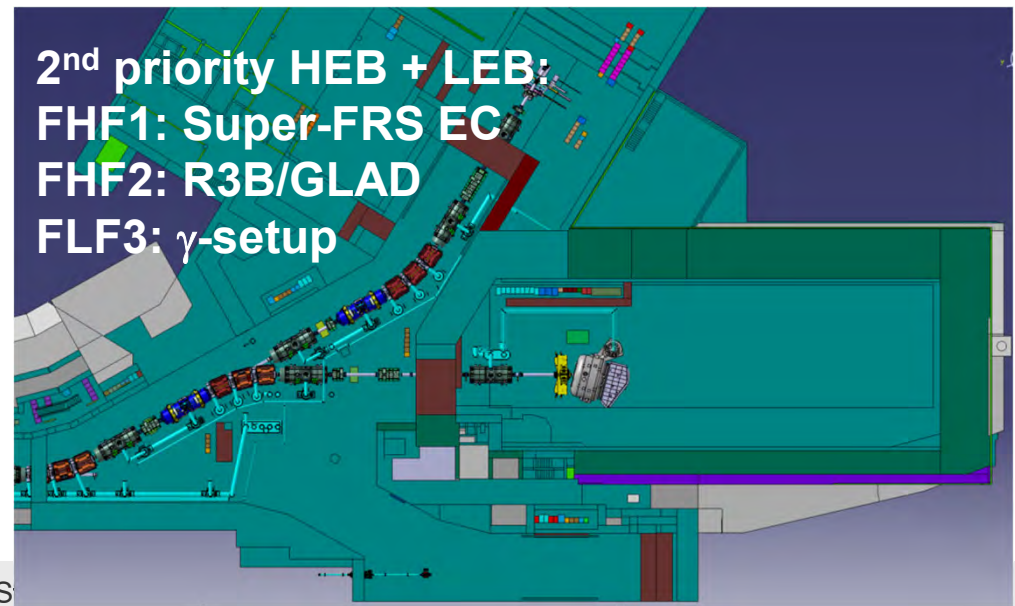
Energy Buncher
installation 2026



1st priority HEB:
FHF1: γ -setup / Super-FRS EC
FHF2: R3B/GLAD



2nd priority HEB + LEB:
FHF1: Super-FRS EC
FHF2: R3B/GLAD
FLF3: γ -setup



SC Multiplets (Overview, SAT FoS LM)

E.J. Cho,
H. Müller et al.



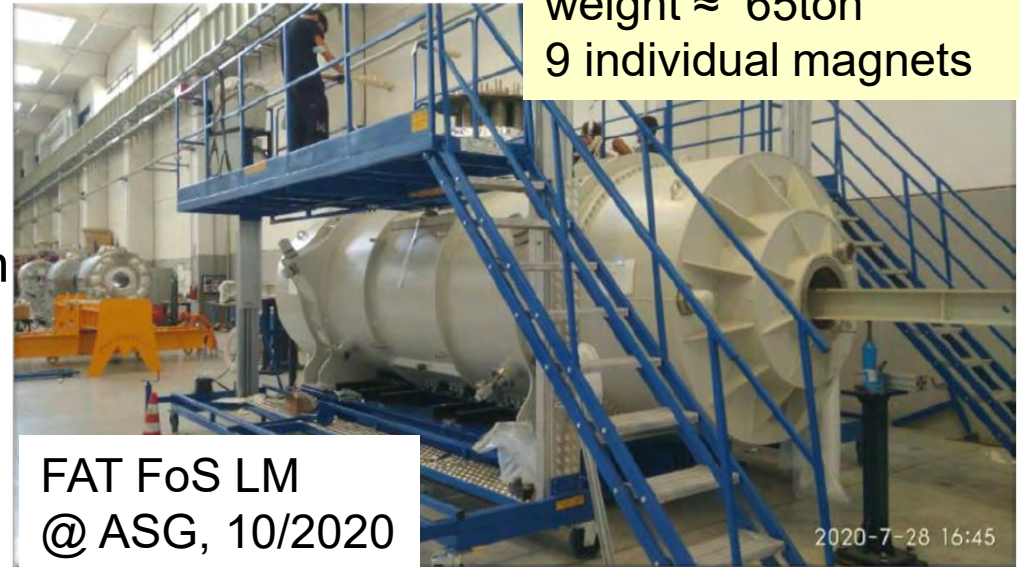
Scope:

- 8 short multiplets, 24 long multiplets
 - QS or QT, including correctors

Main characteristics:

- iron dominated, cold iron, common He bath
- warm beam pipe (38 cm inner diameter)
- individual powering, max. current <300A

length \approx 7m
diameter (VC) \approx 2.6m
weight \approx 65ton
9 individual magnets



FAT FoS LM
@ ASG, 10/2020



Arrival FoS LM
@ CERN, 11/2020

Status / Schedule

- ✓ Contract closed 07/2015 (ASG, Genova)
- ✓ SAT FoS SM done 11/2020 (Covid delay)
- ✓ FAT FoS LM done 10/2020 (Covid delay)
- SAT FoS LM running (including 2nd thermal cycle expected until Q4/2021)
- **Series production phase running**
- **FAT last multiplet Q4/2024**

SC Multiplets (Series Production)

E.J. Cho,
H. Müller et al.



	Actual Planning
FAT SM01	20/03/2021
FAT SM02	26/02/2021
FAT SM03	15/04/2021
FAT SM04	17/05/2021
FAT SM05	15/06/2021
FAT SM06	15/07/2021
FAT SM08	16/08/2021
FAT LM09	15/09/2021
FAT LM10	15/10/2021
FAT LM11	15/11/2021



SM01



SM03



SM05



SM06



SM02



SM04



SM08

SC Dipoles

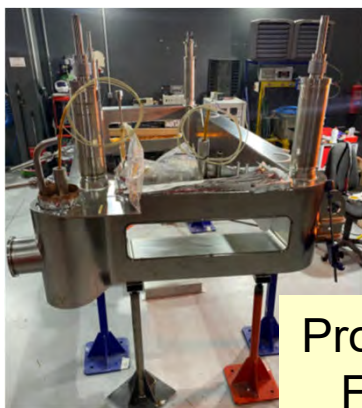


H. Müller,
E.J. Cho et al.
CEA Saclay

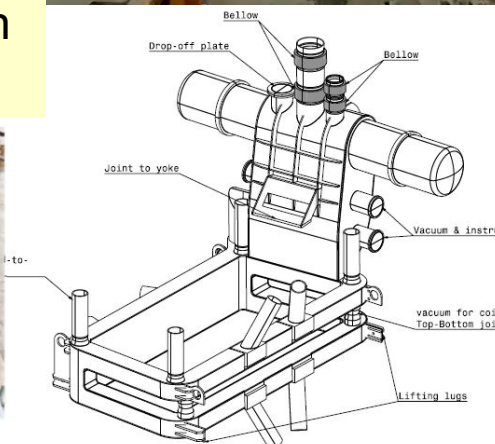
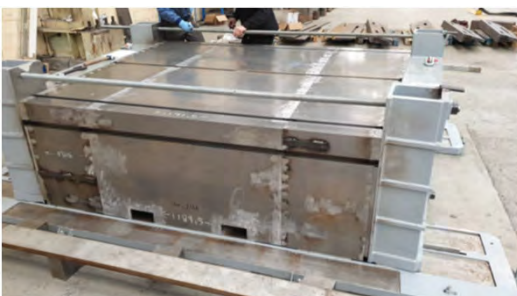


Scope

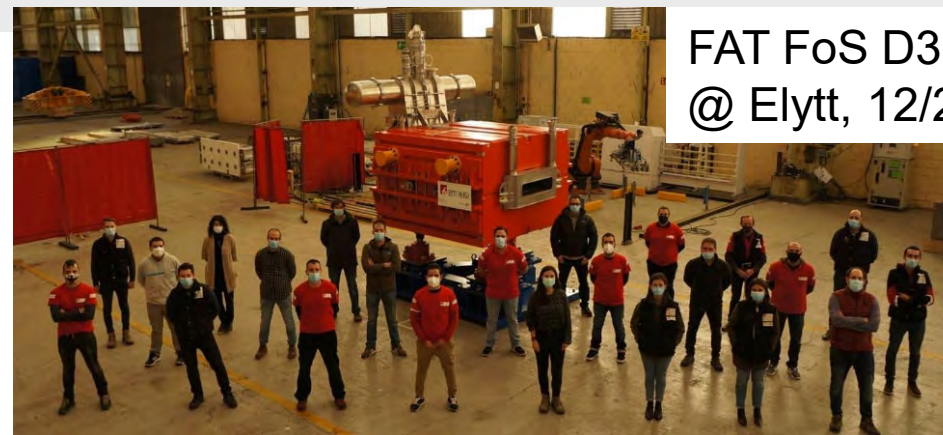
- WP 1: standard dipole incl. support
 - D2: 3 units 11°, D3: 18 units 9.75°
- WP 2: branched dipole incl. support
 - 3 units 9.75°
- Warm iron, SC coil , 50 to 60 ton
- Aperture $\pm 190\text{mm} \times \pm 70\text{mm}$



Production
FoS D2



FDR branched dipole



FAT FoS D3
@ Elytt, 12/2020

Status standard dipole :

- ✓ Contract award Elytt (Sp) 02/2018
- ✓ FAT FoS D3 done 12/2020 (Covid delay)
- Production FoS D2 running, FAT expected for 04/2021
- Production of series D3 in preparation, FAT #2 & #3 expected in Q4/2021

Status branched dipole:

- ✓ Contract award Elytt (Sp) 04/2020
- ✓ Design verification phase completed (CDR 06/2020, FDR 12/2020)
- Production FoS in preparation, (FAT expected Q1/2022)

Testing@CERN (Status)

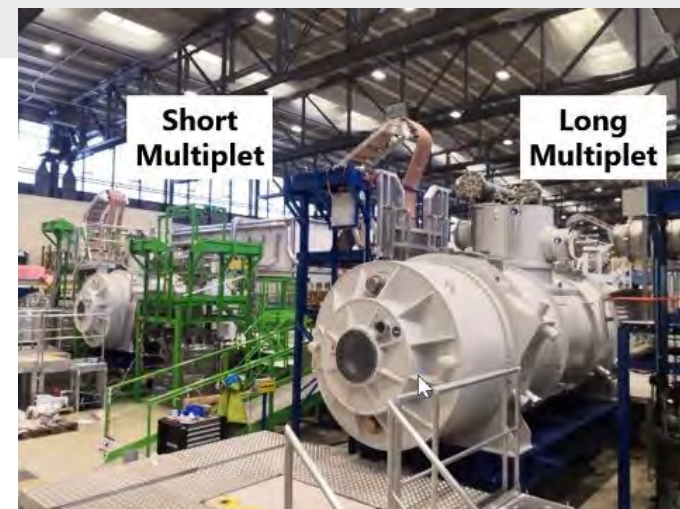
A. Chiuchiolo
K. Sugita et al.



- Collaboration between CERN and GSI
- Cold (4K) testing of the SC magnet modules
- Test facility including 3 test-benches set up
- Facility is operated by GSI personal Team



Feb. 04, 2021



Milestones in 2020

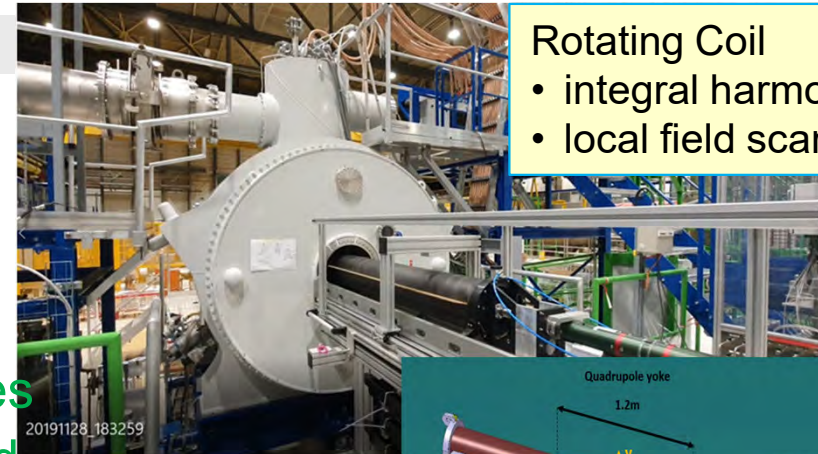
- corona break: mid March - mid June:
magnet floating, testing re-start as "CERN 1st priority"
- 3rd cold test of FoS SM: 07/2020:
 - parallel powering of both magnets,
 - Sextuple magnetic measurements
 - cross talk magnetic measurements
 - cryogenic tests
- 4th cold test FoS SM: Q4 2020:
 - bench-2 commissioning
 - additional cryogenic tests
- Arrival FoS LM 11/2020, start of warm tests
 - One team member left 09/2020

Testing@CERN (Results FoS SM)

A. Chiuchiolo
K. Sugita et al.

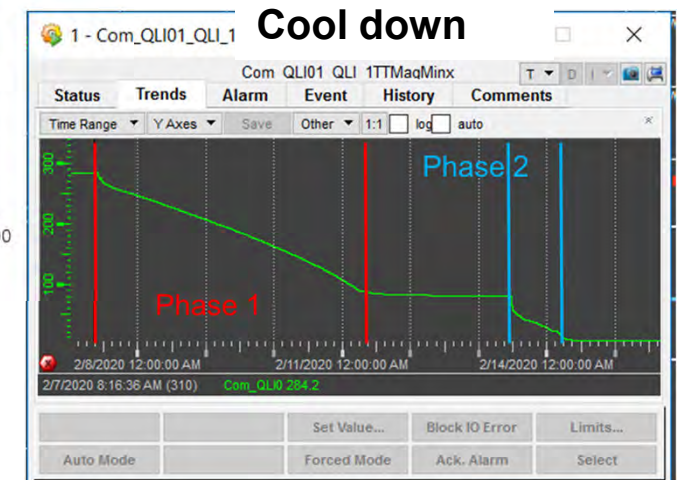
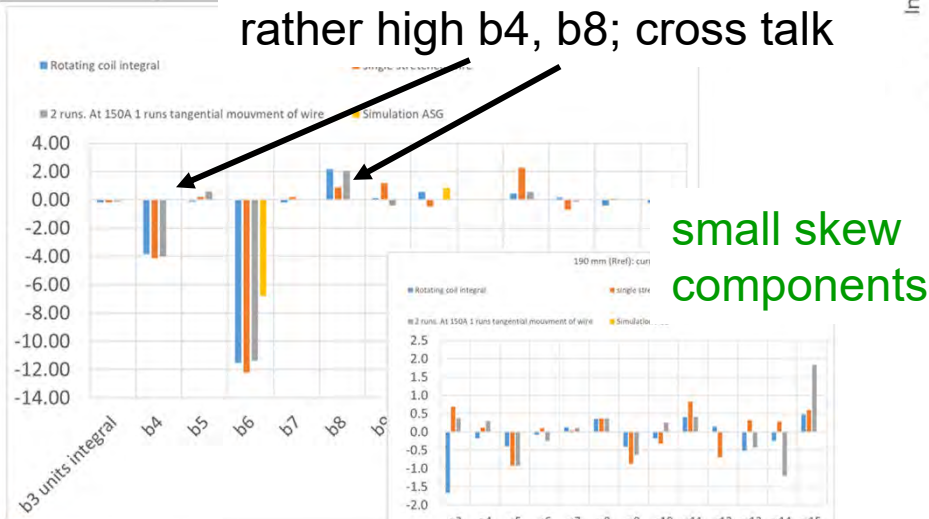
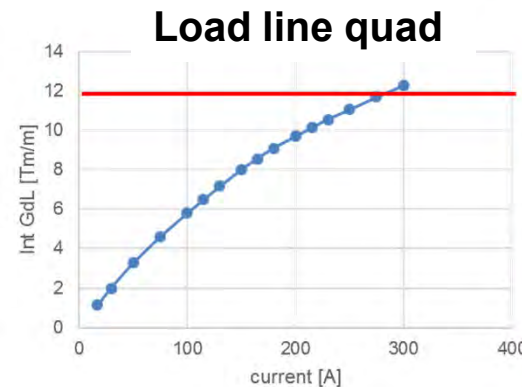
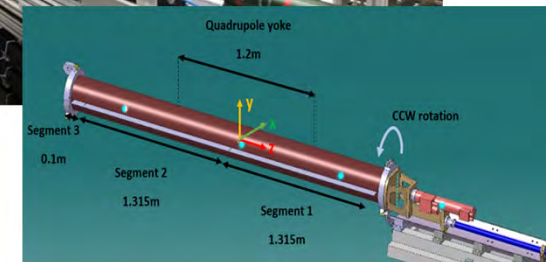


- + Magnetic parameters of magnets ok
 - integral gradient reached
 - field quality: harmonics slightly higher than simulated but acceptable
- + No magnetic axis movement after thermal cycles
- + Cool down time significantly faster than required
- Heat loads higher than expected (evaluation ongoing)
- Leakage of thermal shield pipe (mitigation under evaluation)

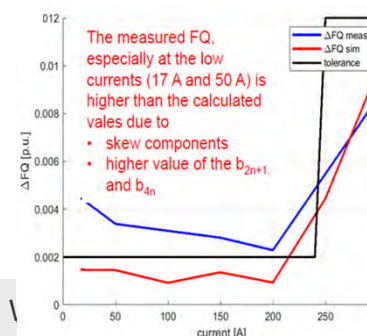


Rotating Coil

- integral harmonics
- local field scan



ΔFQ (meas/sim)



Phase 1: 300 K – 80 K, 4 days
Phase 2: 80 K – 4.2 K, 30 hours
Phase 3: LHe Filling, 4 hours

Testing@CERN (SAT schedule)

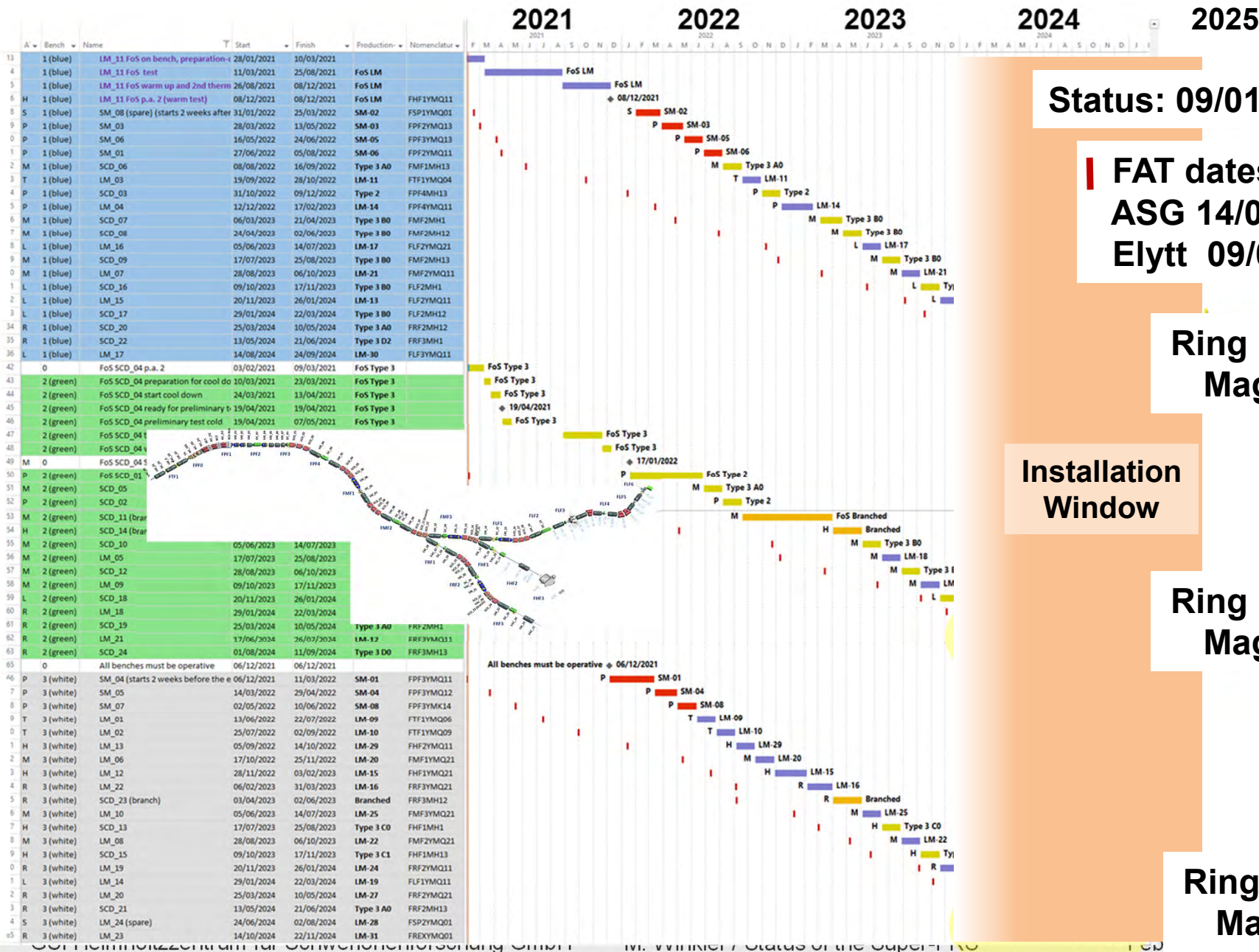
A. Chiuchiolo
K. Sugita
V. Ricciardi
H. Müller
E. Cho et al.



Testbench #1

Testbench #2

Testbench #3



Status: 09/01/2021

FAT dates

ASG 14/09/2020

Elytt 09/09/2020

Ring Branch
Magnets

Installation
Window

Ring Branch
Magnets

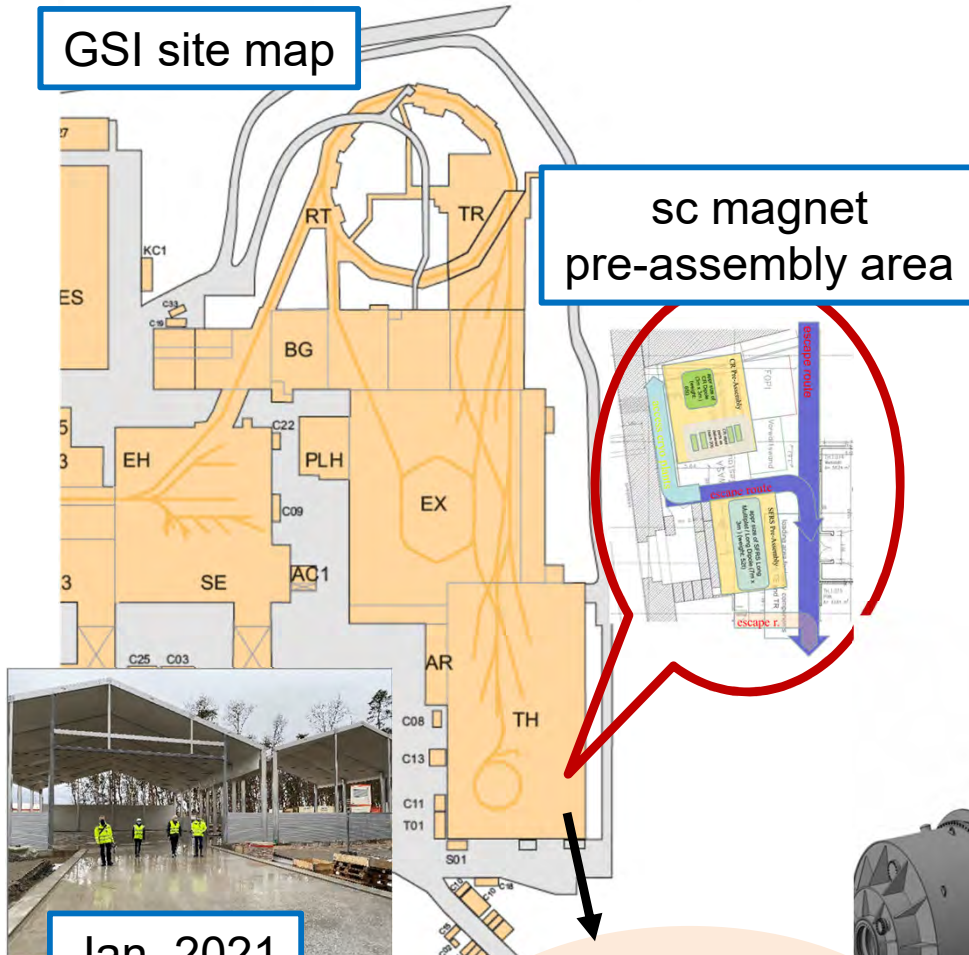
Ring Branch
Magnets

Pre-Assembly (SC Magnets)

V. Velonas
M.M. Schmidt
V. Ricciardi et al



GSI site map



Jan. 2021

new storage
area ~350m²

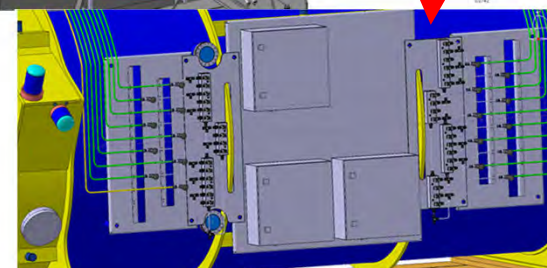
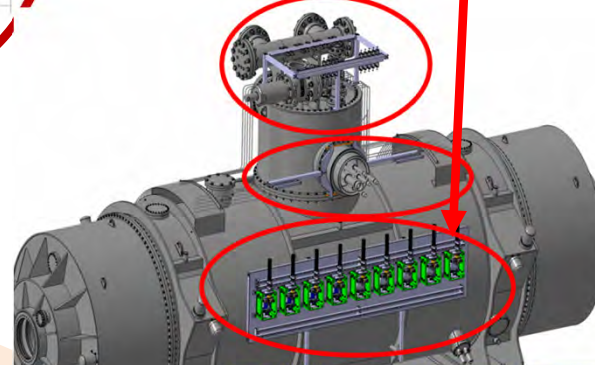
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
transport to target hall assembly of support feet air cushion transport	unpacking incoming rods tests	quench detection only electrical tests 11.20.20 Profanversuch stellen (Vorlage CERN)	mounting terminal boxes electrical tests 11.20.20 Profanversuch stellen (Vorlage CERN)	mounting flexible power cables mounting valve panel 11.20.20 Profanversuch stellen (Vorlage CERN)	inspection report elect. tests 03.02.2020: für current lead control 03.11.20 Mont reguliert benötigt	cleaning vacuum chamber Beam Vacuum leak test	mounting vacuum gauges mounting vacuum valves 03.11.20 Schwierig: 10 bestimmung mit VAC	isolation Vacuum leak test isolation of ports VAC 03.11.20 Schwierig: 10 bestimmung mit VAC	purging filling with nitrogen CRY Notig? Wird geprüft	Preparation transport Documentation in PLM documentation of DMU plans of DMU 4m height to be checked with Schenker	transportation only 1 traverse cur. available add requirement on list of HRS						

■ GSI/FRS
■ External company
■ Responsibility to be clarified

VAC Vacuum Chamber
 PH „Putin Halle“
 DC Diagnostic Chamber
 RFI Ready for installation

■ Work instruction released
■ Work instruction in progress
■ No work instruction available
■ Operating Manual from manufacturer
■ Similar work instruction available

→ Open Point
→ Remark



Local Cryogenics (Project Status)

F. Wamers,
Y. Xiang,
D. Schad,
A. Breidert



✓ Contract-relevant specifications **released**

- **WUST scope** (incl. design and installation):

- Supervision of system- and safety-design
- 45 Feed Boxes (FBs)
- all FB-interconnecting ,short‘ 4-TLs
- all Jumper Connections (JCs)
- 7 End Boxes (EBs)

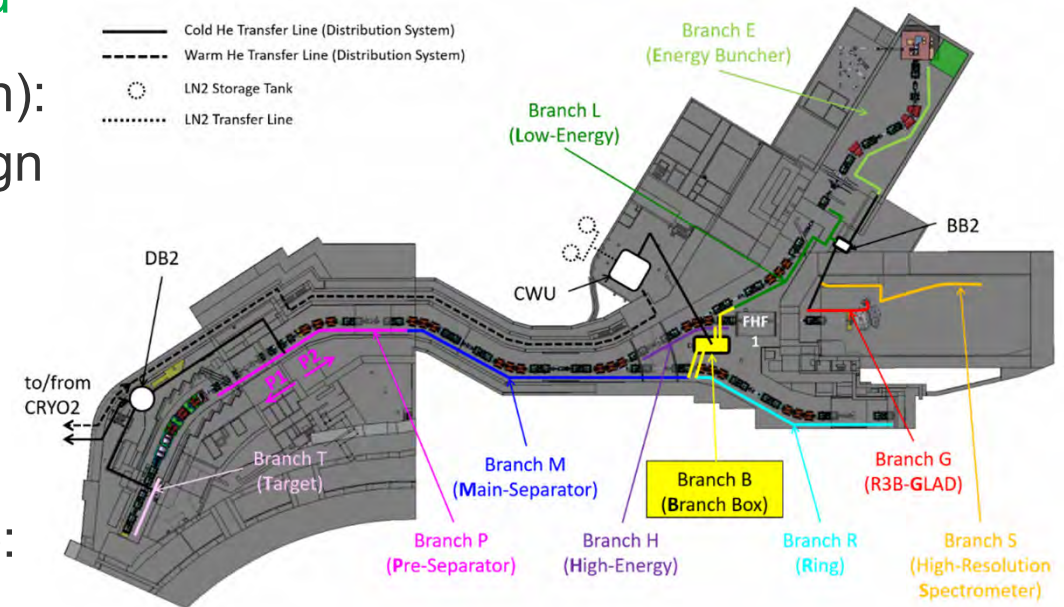
- **BNP scope** (incl. design and installation):

- Branch Box (BB) and its ,long‘ 4-TLs
- all Warm Piping and 1-TLs
- 18 Feed Boxes (manufacturing only)

➤ **IKC: signing expected in 04/2021**

➤ Ongoing design activities

- Installation space management (3D models)
- Interface clarifications
- Design assessments (mechanical, hydraulic)



Outlook (basic schedule)

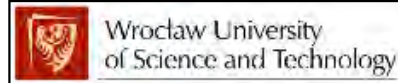
- Design: 2021 → mid 2022
- Production: 2022 → mid 2023
- Installation: 2023 → 2024

Local Cryogenics (Design Activities)

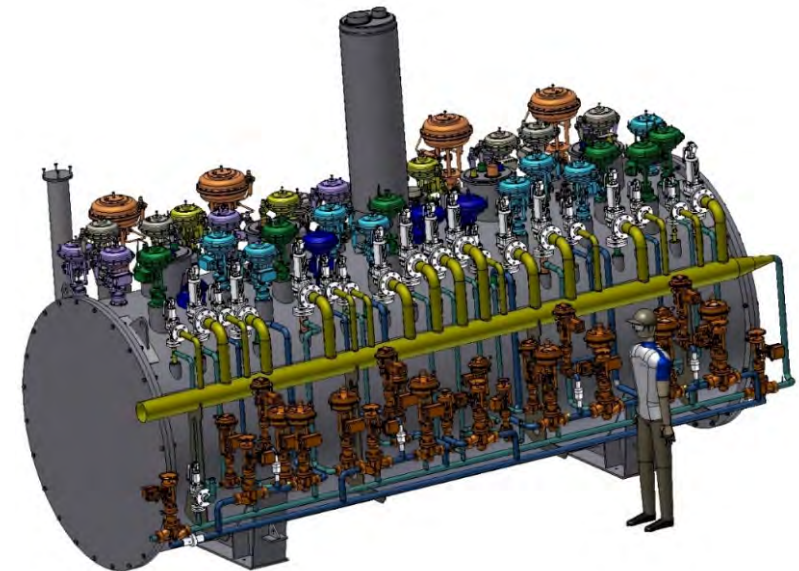
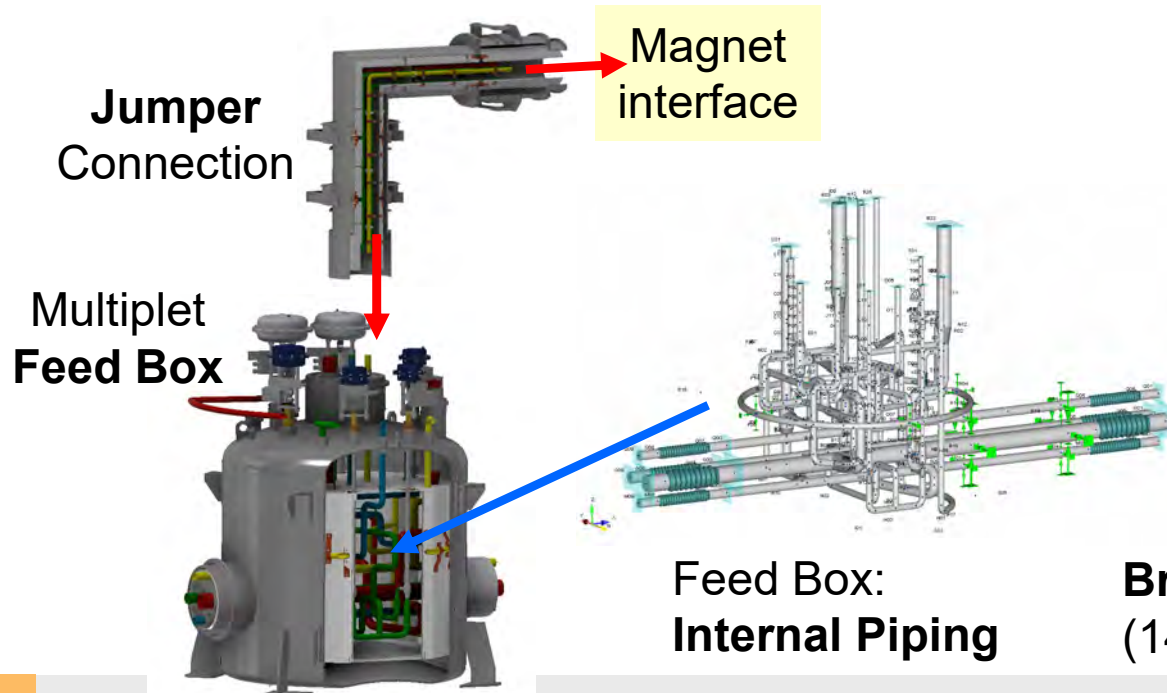
F. Wamers,
Y. Xiang,
D. Schad,
A. Breidert



- Feed Boxes (**in progress**)
 - flexibility and supports analysis
 - piping and valve sizing
 - instrumentation
 - safety valves and analysis
- Jumper Connections (**started**)
- End Boxes (**started**)
- Transfer Line Pieces (**just started**)



- Branch Box (**in progress**)
 - Vacuum vessel
 - Sub-Cooler
 - Internal Piping Sizing and flexibility
 - Valves Sizing, Instrumentation
 - Safety Valves and Analysis
- Large Transfer Lines (**started**)
- Warm Piping System (**not yet started**)



Branch Box, including warm lines and valves
(14 tons, 4m height, 5.5m length, 3.2m width)

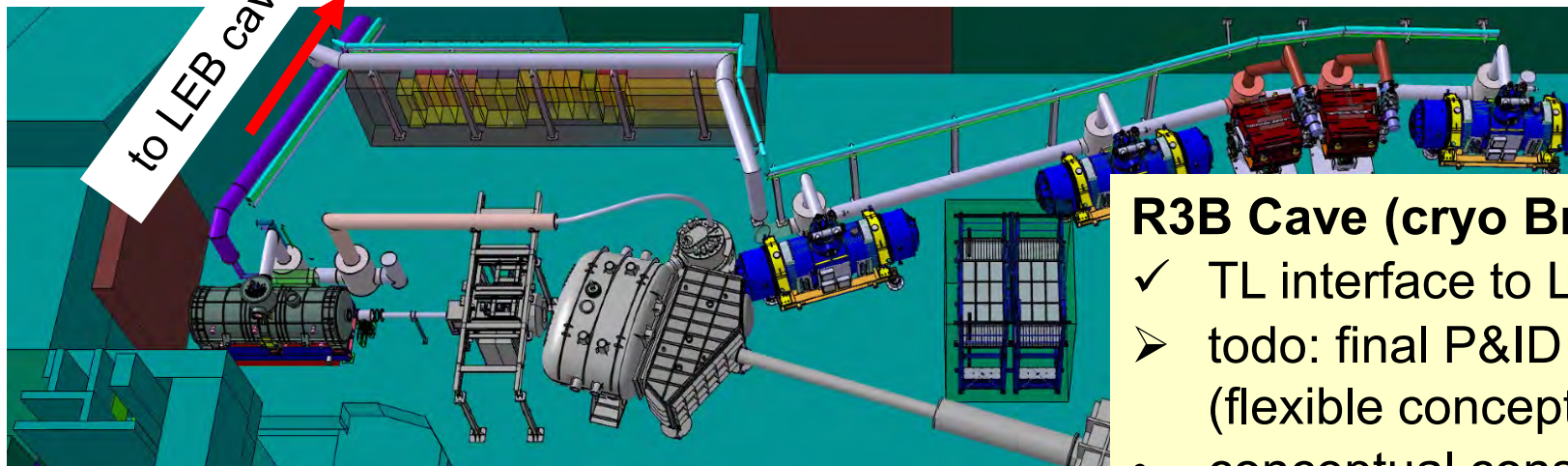
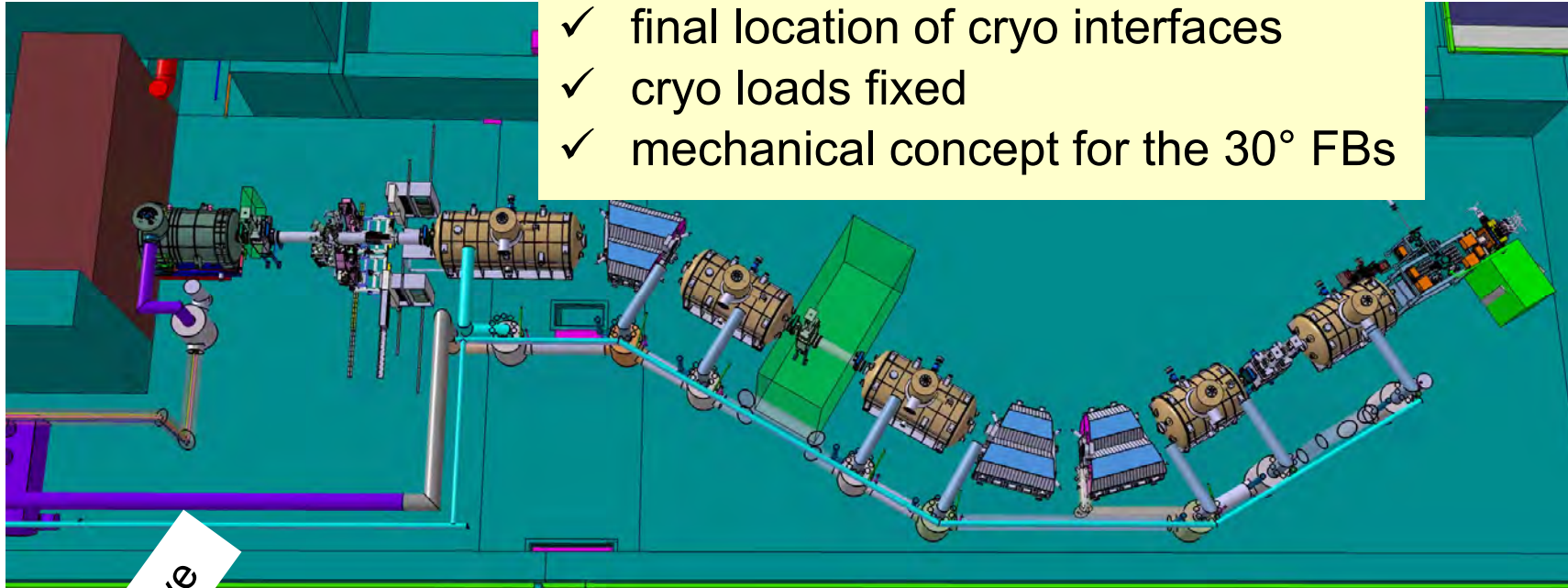
Local Cryogenics (Updates of NUSTAR Caves)

F. Wamers,
Y. Xiang,
D. Schad,
A. Breidert



LEB Cave (cryo Branch E):

- ✓ final location of cryo interfaces
- ✓ cryo loads fixed
- ✓ mechanical concept for the 30° FBs



R3B Cave (cryo Branch G & S):

- ✓ TL interface to LEB cave
- todo: final P&ID of GLAD-FB (flexible concept)
- conceptual consideration for Branch S (out of scope)

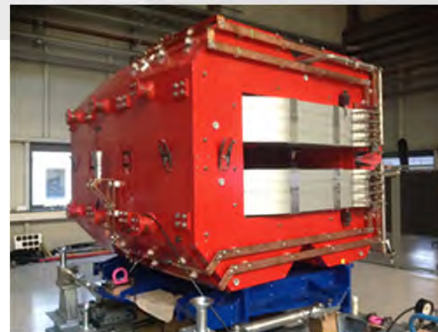
Radiation Resistant Magnets

WP1, NC dipole (3 units):

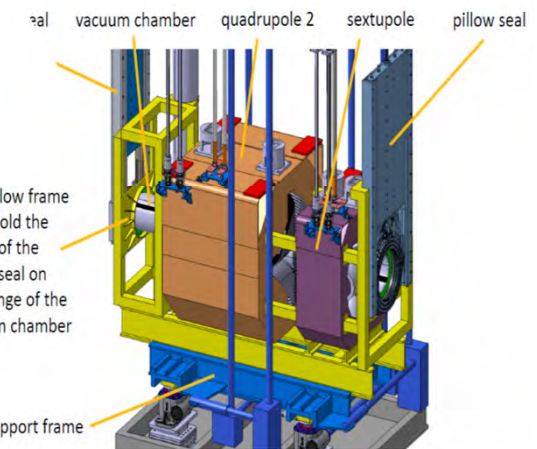
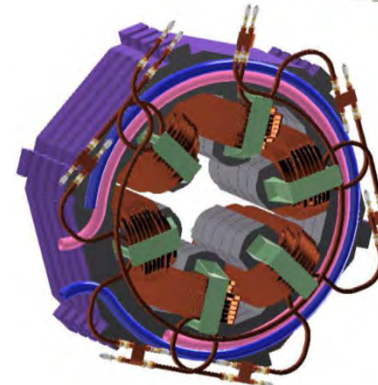
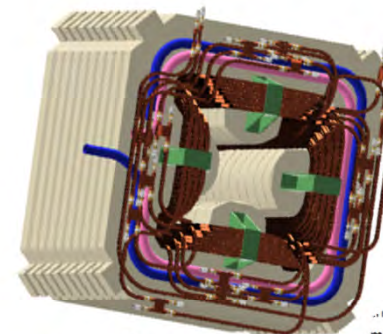
- CC signed with BINP Q2/2019
 - ✓ prototype dipole at GSI
 - ✓ adjustable support frame
 - ✓ Remote connectors and alignment
- CDR 02/2020, **FDR expected Q2/2021**
 - **>1y delay (soon on critical path)**
- ✓ cable (MIC) in-house (FAIR)
- Dipole delivery expected Q4/2023

WP2, NC multipoles (3 quads, 2 sext):

- research contract finalized; BINP 06/2020
 - ✓ conceptual design available
- Magnet tender started 12/2020
 - ✓ qualification round offer phase running
 - contract award expected 08/2021
- Cable procurement by FAIR
 - ✓ negotiation running;
 - delivery expected Q2/22



	Duration	Start	Finish	% Complete	Deadline
execute SATAB (A10) and pre-assembly, dipole 1.2 (BINP)	0 mons	15/03/2021	15/03/2021	0%	16/12/2019
Dipole 1.2 (BINP) ready for installation (M10 please read notes)	13 wks	20/04/2020	24/02/2021	90%	NA
execute the series production (A91), dipole 1.3 (BINP)	2.6 wks	18/02/2021	08/03/2021	0%	NA
Integration of coil	96 wks				
execute factory acceptance tests (A99), dipole 1.3 (BINP)	24 mons				
FAT accepted (M9), dipole 1.3 (BINP) (payment associate)	0 mons				
shipment to FAIR (ATS), dipole 1.3 (BINP)	0 mons				
End of Shipment (M92), dipole 1.3 (BINP) (Payment associate)	0 mons				
Execute SATAA (goods incoming inspection)	78.8 wks				
Dipole 1.3 ready for pre-assembly	10 mons				
execute SATAB (A10) and pre-assembly, dipole 1.3 (BINP)	4 mons				
Dipole 1.3 (BINP) ready for installation (M10 please read notes)	3 mons				
End of warranty (payment associate)	0 mons				



magnet doublet on common platform

Power Converter & QuD

PC prototype delivered Q4/2020

Scope & Features

- in sum ~250 PC required
- 2 PC units in one rack
 - **modular usable** for **sc** & **nc** magnets
- all PC are bipolar
- QuD electronics: rack-integrated

Status / Schedule

- ✓ Prototype PC delivered
 - SAT running: GSI (NC dipole)
- PC India in-kind; **IKC still pending**
 - assigned provider: ECIL Hyderabad
 - Blue print reproduction required
- QuD Electronics (German in-kind)
 - ✓ QuD prototype existing
 - QuD tender running, award soon
 - QuD integration still open
(during production in India or during pre-assembly at FAIR)

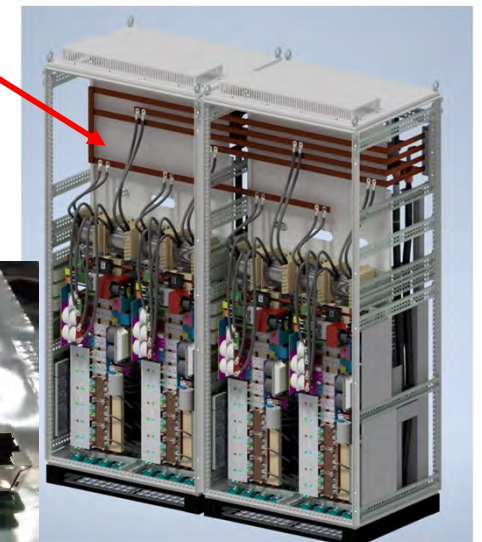
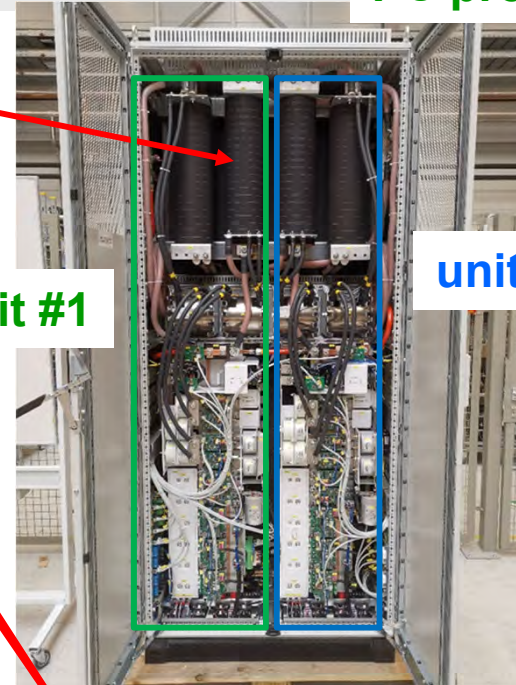
dump
resistor

unit #1

unit #2

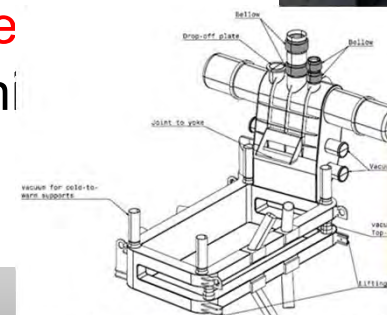
unit series connection

QuD prototype

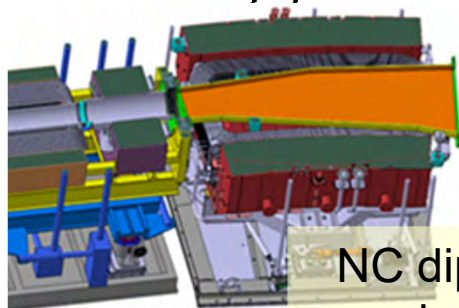


Vacuum System

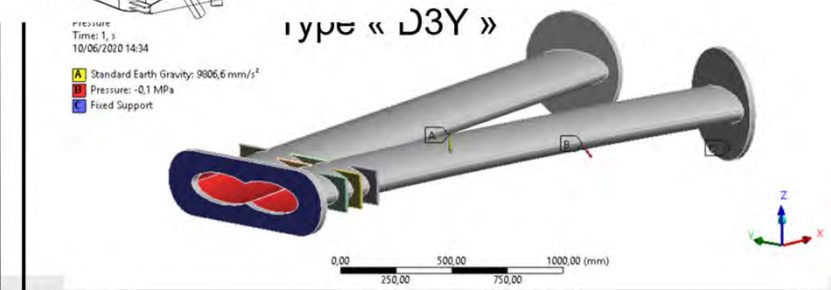
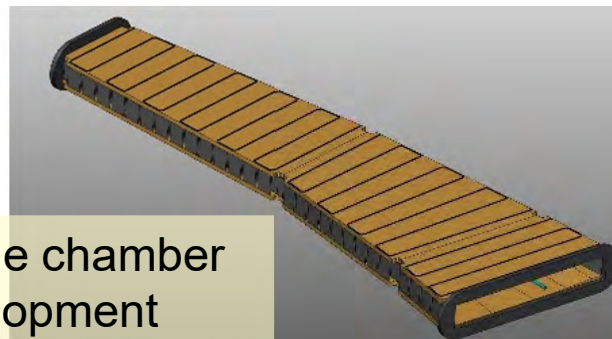
- Procurement of **standard components** is centralized by GSI
- ✓ **special components**: in-kind provider BINP
 - ✓ CC focal plane chambers signed
 - FoS chamber produced, FAT running
 - ✓ CC SC dipole chambers (standard) signed including pumping chambers
 - design phase running, **priority reduced**
- **Collaboration Contracts to come with BINP**
 - SC dipole chambers (branching)
 - ! FoS chamber required prior to FAT of magne**
 - NC dipole chambers (research contract runni
 - Pumping chamber & bellows
 - Beam pipes including supports



SC branched dipole chamber development



NC dipole chamber development



Beam Instrumentation I (Nordic in-kind contribution)

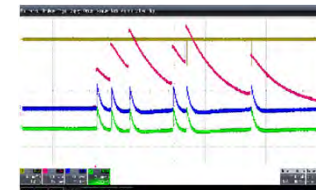
C. Nociforo,
J. Galvis Tarquino,
B. Voss, et al.



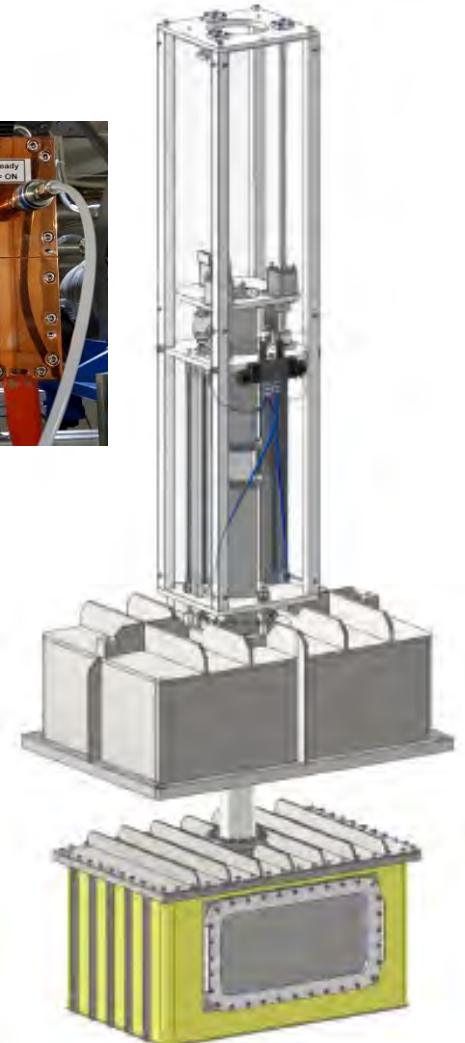
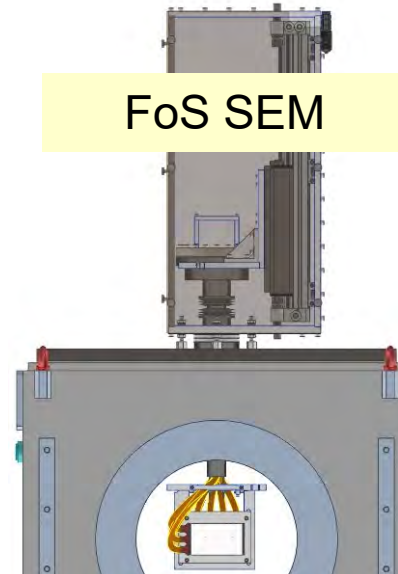
UNIVERSITY OF JYVÄSKYLÄ
JYVÄSKYLÄN YLIOPISTO

FoS MUSIC

- MUSIC (energy-loss, Uni Jyväskylä)
 - ✓ Mesytec preamp successfully tested (May 2020)
 - ✓ **1 FTE (Feb 2021)** for the detector design
- SEM Grid (profile monitor, HIP)
 - ✓ sub-contractor Hbar Technologies, LLC
 - ✓ electronics ordered (POLAND)
 - CDR to come
 - In-beam test in 2021
- GEM-TPC (tracking)
 - ✓ CSA chip under design (GSI ASIC group)
 - ✓ **0.5 FTE (April 2021)** for detector design
 - IKC agreement found, still to be signed ☹
- Position drive (HIP),
 - CDR to come
- Drive control (LUND-Sweden)
 - IKC pending > 3 year ☹



FoS SEM



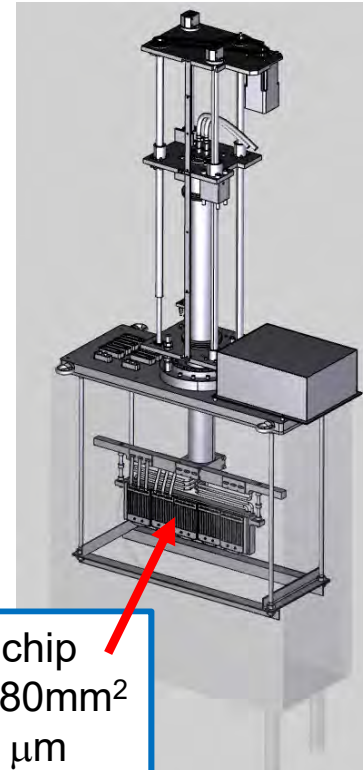
Beam Instrumentation II (other contributions)

C. Nociforo,
O. Kiselev,
J. Galvis Tarquino,
T. Blatz et al.



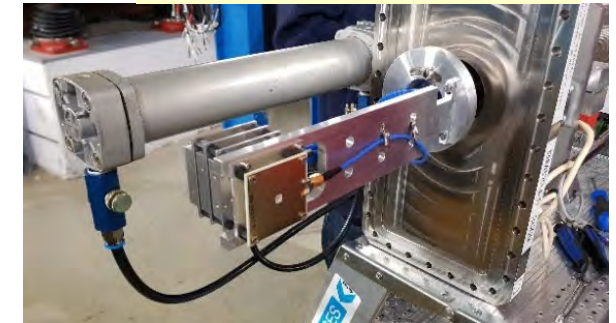
- ToF detector (in-kind Ioffe)
 - ✓ **IKC closed 06/2020**
 - CDR 12/2020, FDR expected 03/2021
- Diamond detector
 - ✓ Beam time 2021
 - ✓ Contract with Ioffe under discussion
- Particle detector Combination (PDC)
 - ✓ FPF4 CDR Q4/20
 - Beam time approved
 - FPF0 CDR in preparation
- Beam Stopper (PAS safety device)
 - ✓ Tender ready Q4/20, second round ongoing
- Spare y-slit to be shipped by KVI soon
 - ✓ Slit media board parts ordered
 - Test of the FAIR control system Q1/21

ToF development

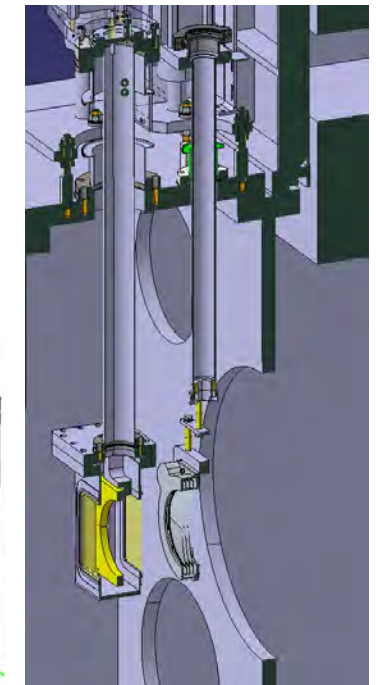


Sensor chip
 $A = 90 \times 80 \text{ mm}^2$
 $d = 300 \text{ } \mu\text{m}$

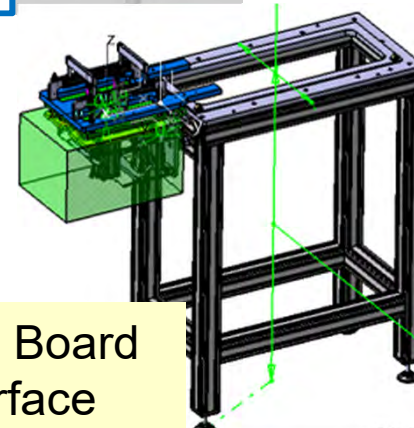
Beam test
(various detectors)



PDC@FPF4



Media Board
interface



Target Area Components

H. Weick,
C. Karagiannis
F. Amjad et al



Target chamber & plug systems:

- ✓ Design by KVI(-CART) via CC
 - FDR still to be conducted
- Manufacturing tender by GSI (to start summer 2021)

Beam Catchers (in-kind India):

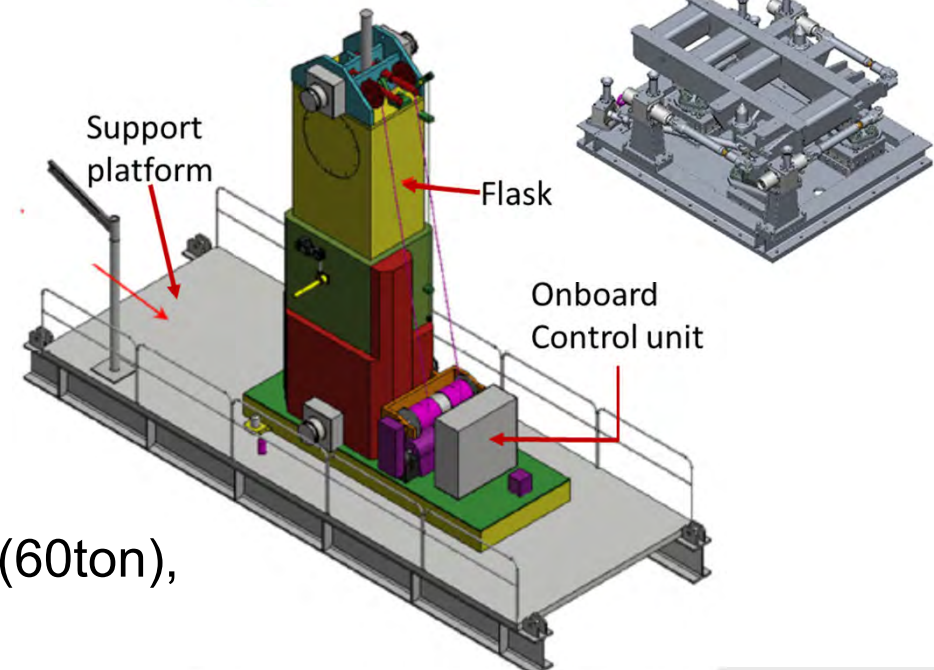
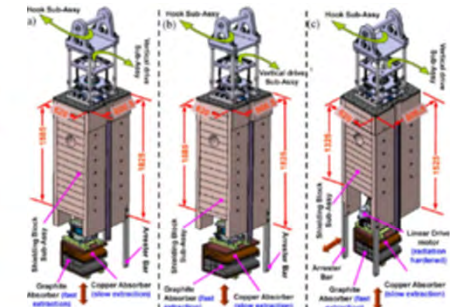
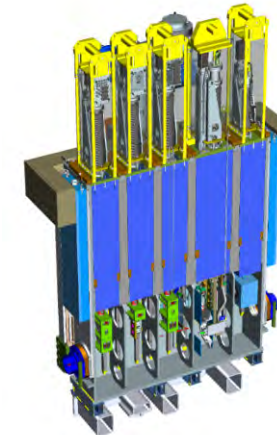
- Design by CMERI, CDR done
 - FDR with provider to come
- Manufacturing tender running by India (critical path)
- IKC with India still pending

Alignment Support (FAIR procurement) :

- Design by GSI; proven by existing support
- Ready for manufacturing tender (by FAIR)

Shielding Flask (in-kind Finland/FAIR):

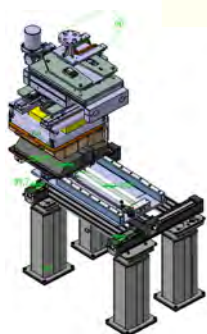
- Procurement by FAIR with Fin & Swe
- ✓ Contract awarded 12/2020, BNG
- Design Phase initiated
 - remote handling of 21 plugs, shielding flask (60ton), support platform (40ton), control system
- Manufacturing planned in 2022



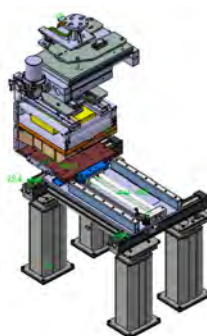
Hot Cell Planning

- Building shell relevant installations via CC
- Establishing of specification for HC equipment
 - Key components: workbench and lifting table
- Lifting table mock-up in preparation
 - Proof of maintenance concepts

workflow: exchange of
beam catcher absorber

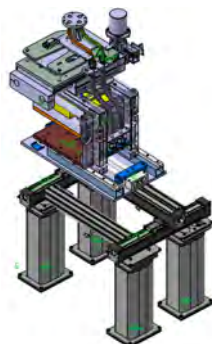


Step 1: dismount
lower absorber
Table position: 90°

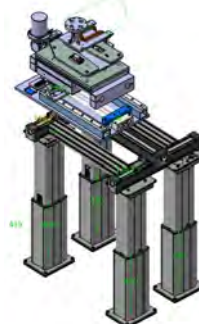


Step 2: dismount
upper absorber
Table position: 0°

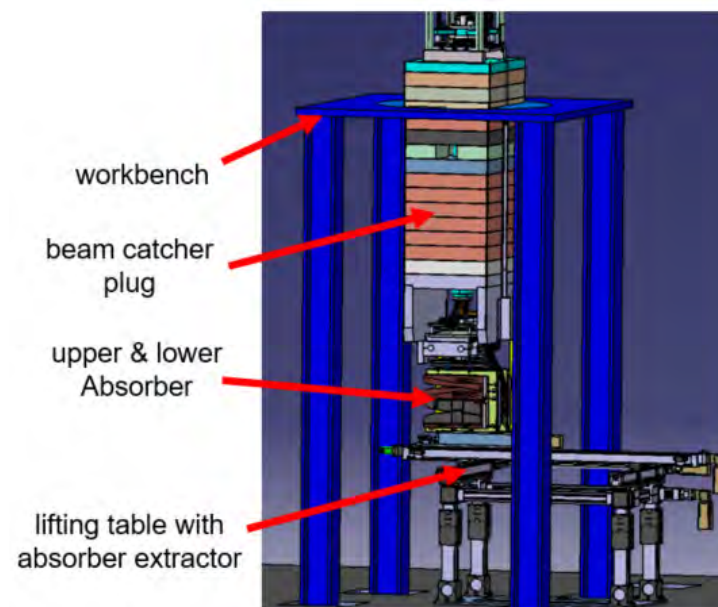
Step 3: dismount
absorber frame
Table position: 180°



Step 4: dismount
linear guide unit
Table position: 90°



beam catcher set-up in hot cell



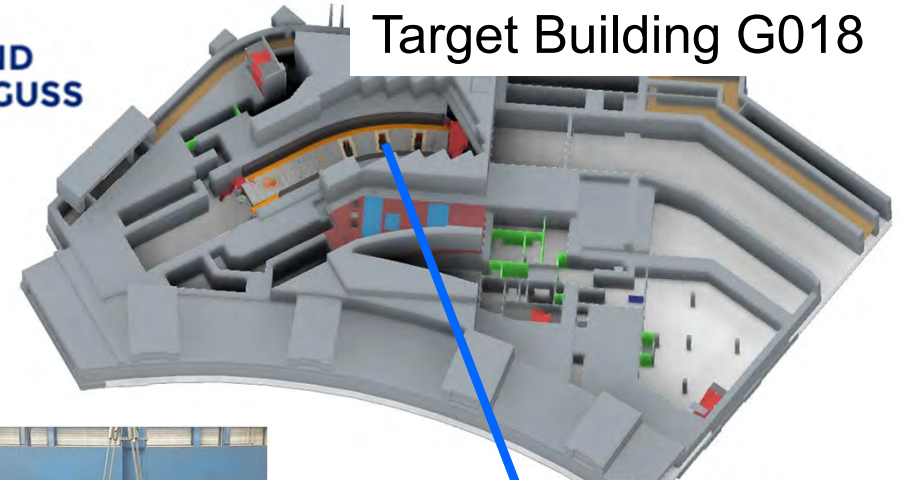
lifting table
01/2021

Target Area Shielding

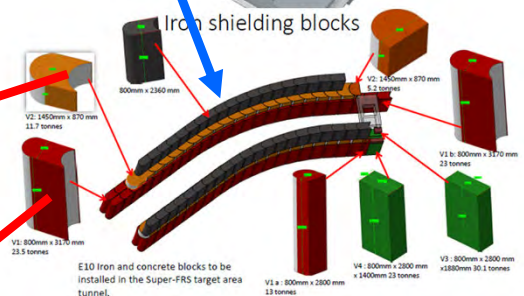
- WP 1: lateral iron shielding
 - ✓ Contract awarded 01/2020, provider: Walzengiesserei Coswig
 - ✓ 2020: design phase and modelling cast
 - ✓ Casting/FAT FoS blocks: 01/2021
 - Delivery start expected for 07/2021
 - **Early installation** intended as concrete formwork Q1/Q2 2022
- WP 2: roof shielding
 - Specifications released
 - Tender preparation interrupted due to EoI announced by India
 - **IKC request 03/2021**



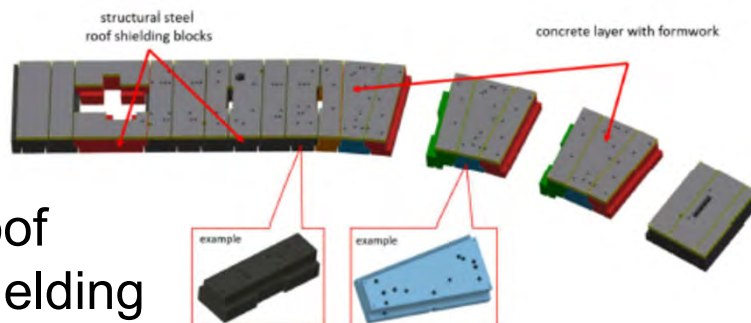
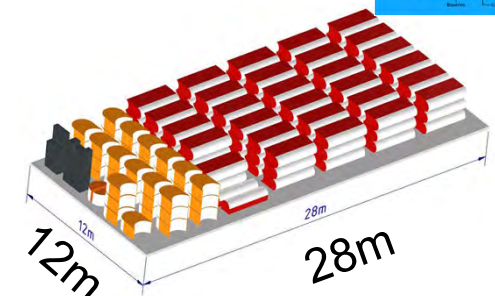
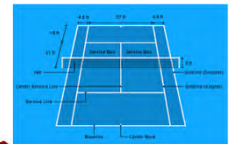
WALZEN-UND
HANDFORMGUSS



Target Building G018



Intermediate
storage space



Roof
shielding

Civil Construction (FAIR South / Super-FRS)

M. M. Schmidt
A. Bergmann et al



- ✓ Tender FAIR building shell south awarded to Züblin/Strabag 04/2020
- ✓ **Concrete work started (R3B building)**
 - Collision planning running
 - Formwork planning running
 - Contracts on Technical Infrastructure expected to be awarded at the end of 2021
 - Contract on cable procurements expected to



Q2/2020



02/2021

The consortium Züblin- Strabag concretes the first floor slab at construction site south. (Building G006 Super-FRS)

Summary

- Re-Baseline planning finalized
 - procurement planning according to early operation scenarios
 - 'ready for beam' expected for Q3/2025 (HEB, ...)
- Major components are contracted and in design and/or construction phase
 - all FoS SC magnets are produced; series production is running
 - production of lateral iron shielding blocks running
 - ToF: CC (finally) signed, advanced design phase
- Still open issues (critical path items)
 - closing of in-kind contracts is too slow (in particular BC/India)
 - design phase of some components takes much longer than expected (in particular NC dipoles)
 - provider of roof shielding not yet decided
- Civil Construction main topic:
 - FAIR building shell south contracted
 - Concrete work started
 - Building services planning running (via FSB)

Thank you for your attention !