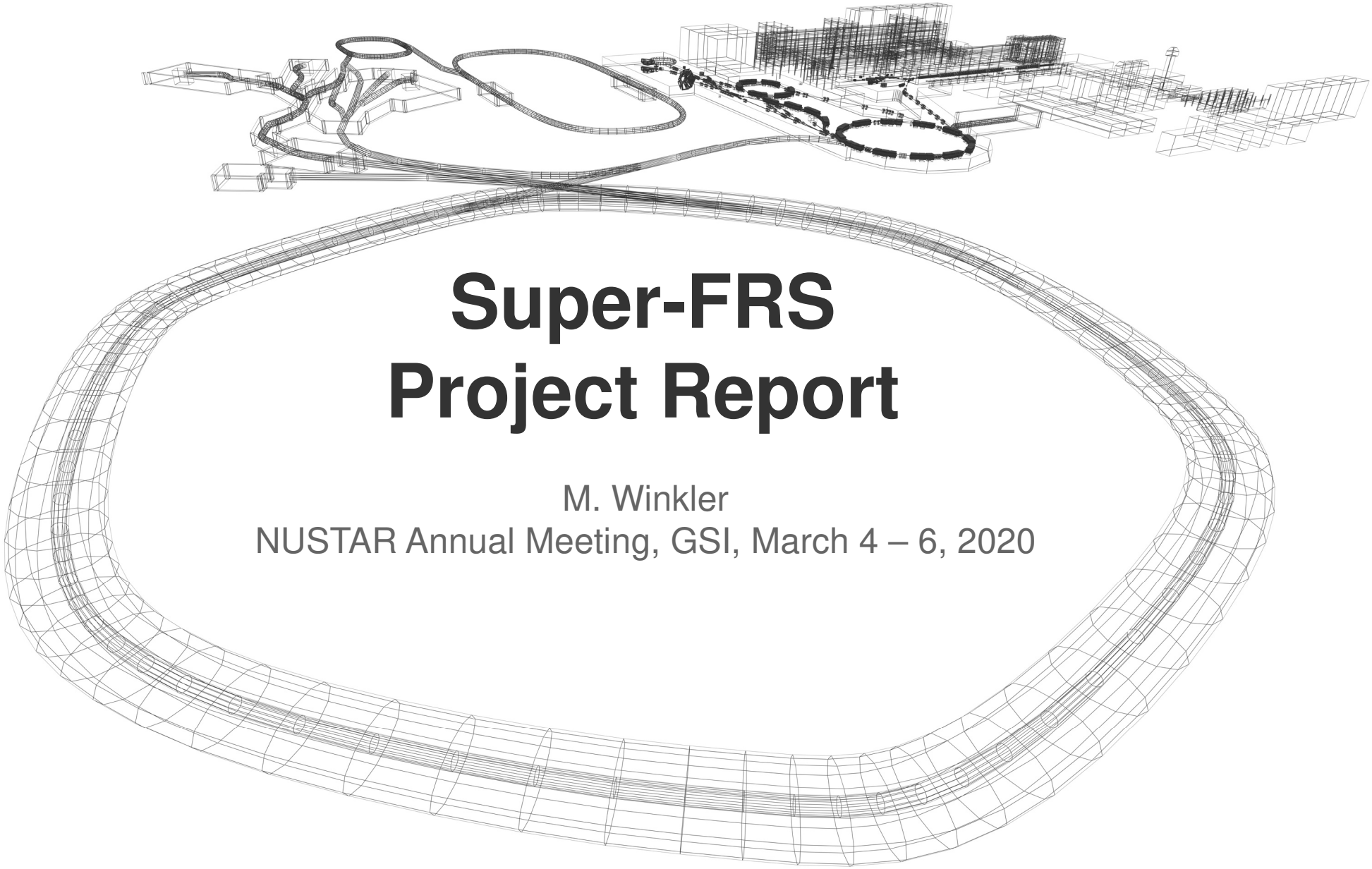


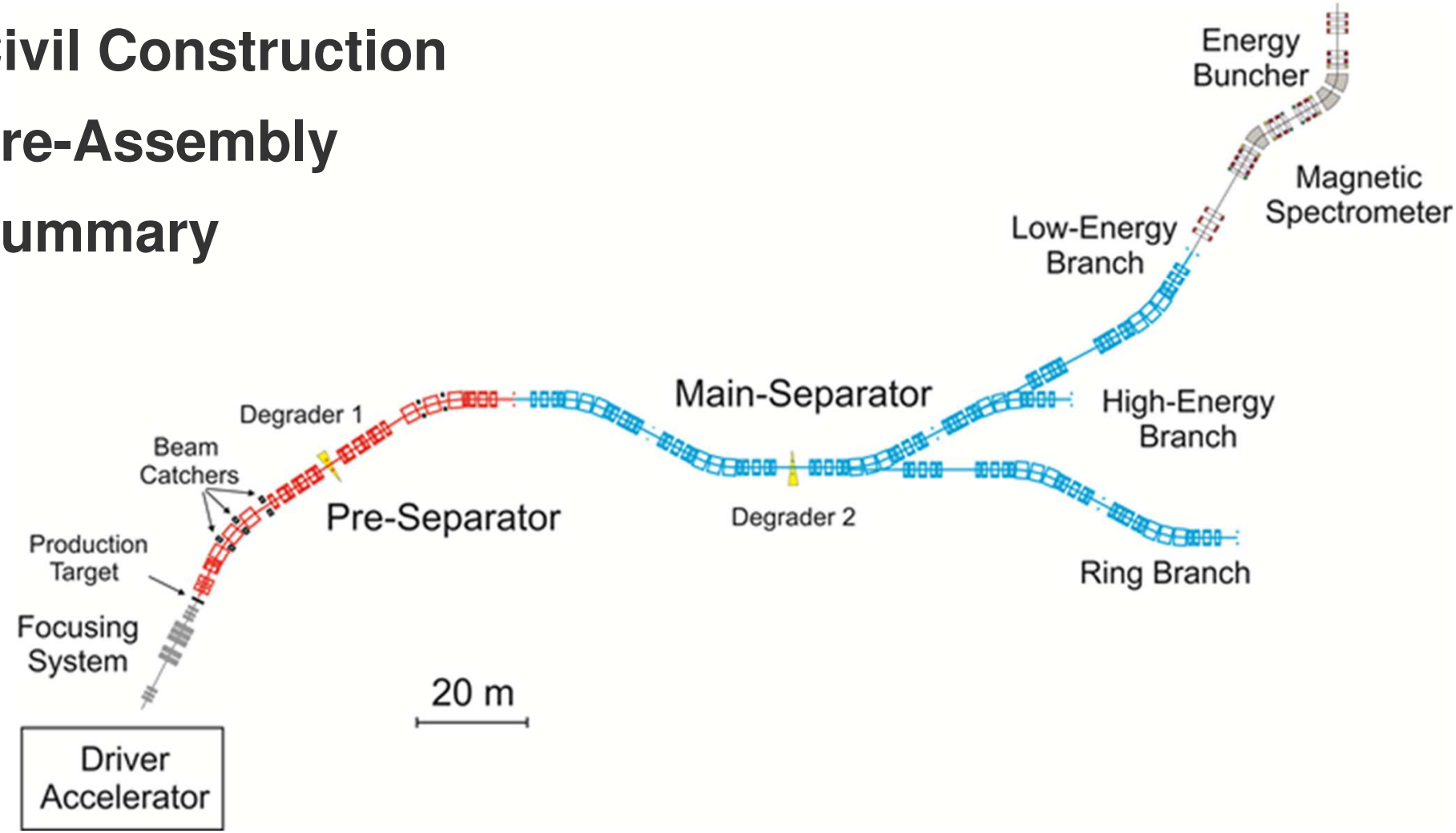
Super-FRS Project Report

M. Winkler

NUSTAR Annual Meeting, GSI, March 4 – 6, 2020

Outline

1) Status Technical Sub-Systems
2) Civil Construction
3) Pre-Assembly
4) Summary



Magnets I
(SC Mutiplets, Overview)

H. Müller,
E.J. Cho 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

FoS long production

Series production

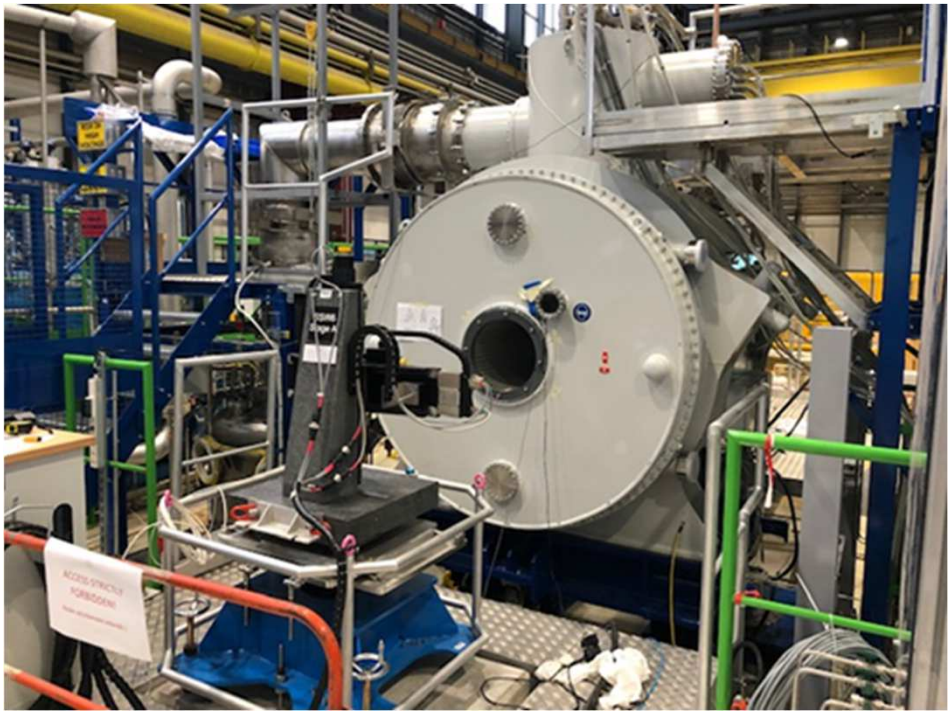
Status / Schedule

- ✓ Contract closed 07/2015 (ASG, Genova)
- ✓ SAT FoS SM running
- ➢ **FAT FoS LM 03/20**
  - shipment to CERN scheduled 04/2020
- **Series production phase**
  - ✓ SM #1, #2, #3, #4 production running
  - ➢ SM #5,#6, #8 production started, FAT anticipated for Q1/2021
- ➢ FAT last multiplet **Q4/2023**

Magnets II
(Testing@CERN, status)

K. Sugita
A. Chiuchiolo
G. Golluccio 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



Milestones in 2019

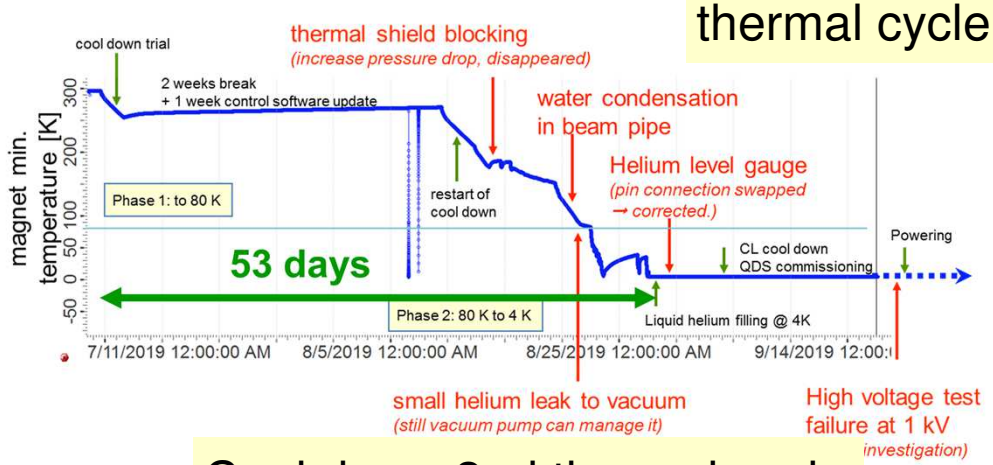
- Commissioning of the facility and devices
- Training of the Team
- Feb. 20, 2019: Arrival of the first multiplet
- May. 7, 2019 Transport to test bench
- July 10, 2019 First cool-down start
- Sept. 18, 2019 Powering Start (quadrupole)
- Dec. 6, 2019 Magnetic Measurement Campaign for quadrupole finished
- Dec. 16, 2019 Start warm-up (winter break)
- Jan. 23, 2020 Multiplet warm
- Feb. 7, 2020 Start of second thermal cycle

Magnets III
(Testing@CERN, results)

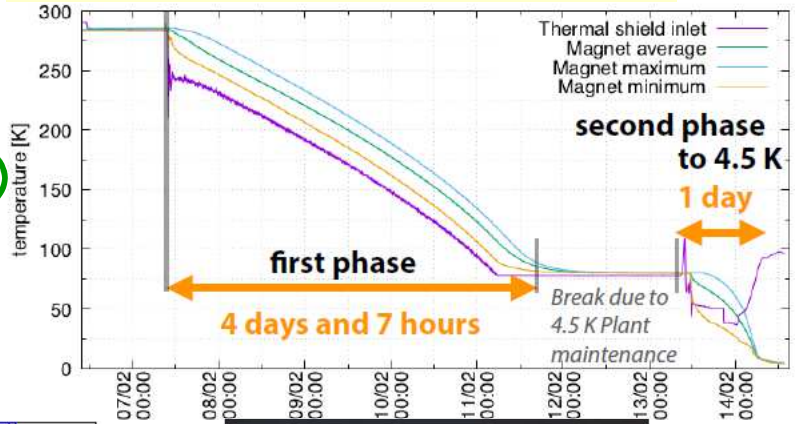
K. Sugita
A. Chiuchiolo
G. Golluccio et al.

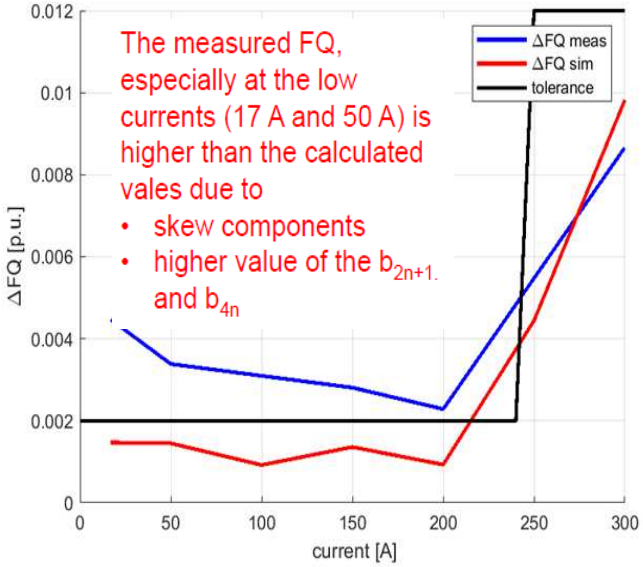
- ! Cool-down rate of ≈1.9 K/h achieved
- ✓ Maximum Current (+7%) achieved
  so far one quench occurred at 2/3 of I_{max}
- ✓ Specified ramping rate of 2.5 A/s achieved
- ✓ Magnet pre-setting cycle verified
- ✓ Magnetic axis within specification
- ✓ Field quality ≈within specification, analysis running

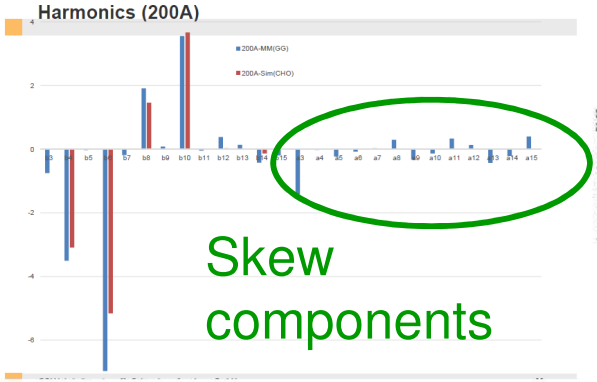
Cool down 1st thermal cycle

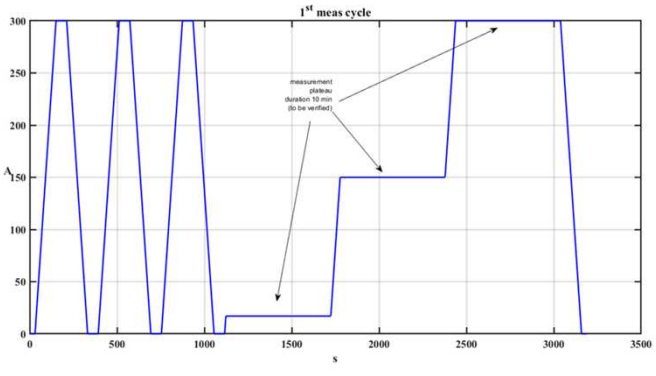


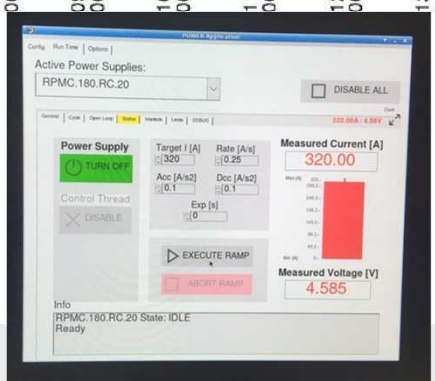
Cool down 2nd thermal cycle











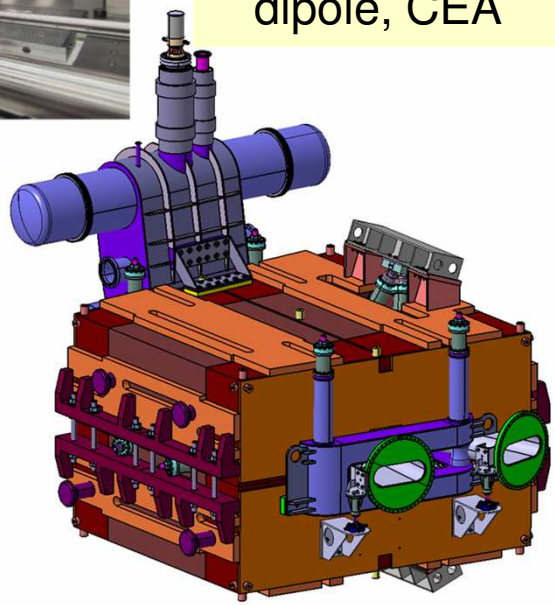
Magnet IV
(SC Dipoles)

H. Müller,
E.J. Cho et al.
CEA Saclay

Scope

- WP 1: standard dipole incl. support
  - 3 units 11°, 18 units 9.75°
- WP 2: branched dipole incl. support
  - 3 units 9.75°
- Warm iron, SC coil , 50 to 60 ton
- Aperture ±190mm x ±70mm

CDR branched dipole, CEA



Status standard dipole :

✓ Contract award Elytt (Sp) Feb. 2018
✓ Design verification phase
  ➢ including Coil mock-up
✓ FDR: 9 Oct. 2019
✓ FOS production running
? FAT of FoS expected 03/20 (→ 05/20)
  - issue: Cryostat delivery from China

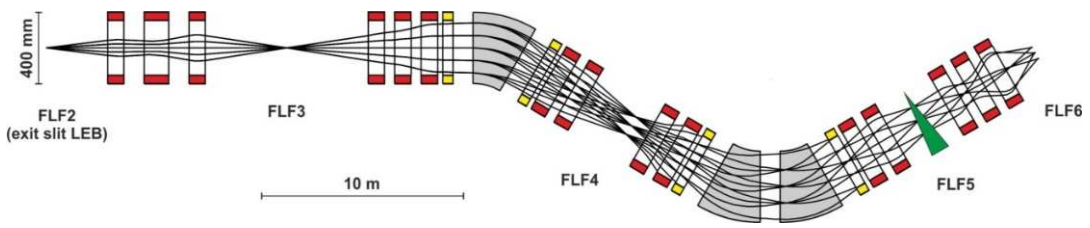
Status branched dipole:

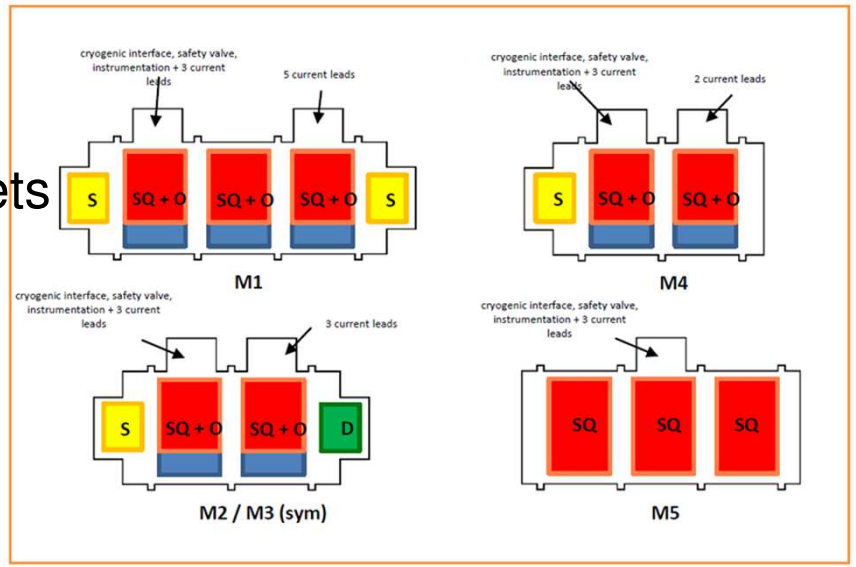
✓ Design phase completed (CEA)
  ➢ CDR, Spec, 3D Model released 03/19
➢ Procurement: contract to be awarded

Magnets V
(Energy Buncher Update)

Scope:

- 3 sc dipole magnets, $B\rho_{max}$=7Tm, α=30°
- 5 sc multiplets,
  - ➢ magnets parameters same like for separator
    however, different magnet configurations





Status / Schedule

- Council 12/2018: India resigned in-kind for magnets
  - CDR established; several design issues
- revised cost estimate (2018)
  - ➢ CB Δ3.8 M€ (CB 2005); CBWG: go for full EB
  - ➢ costs implemented in CB 8 (2019)
- Procurement of magnets by FAIR;
  - ➢ dipoles: potential interest of CEA on design and follow-up;
    3 steering meetings in 2019, including concrete offer from FAIR to CEA; still open
  - ➢ multiplets: design issue with interface-turret;
    potentially tender required; also discussion as a potential in-kind from Italy (if…)
- SAT by FAIR → cold test @ CERN; last in testing sequence (best: 2024/2025)

Local Cryogenics
(Specs and Procurement)

F. Wamers,
Y. Xiang et al

- ✓ **Common Spec. released 09/2919**
  - ➢ scope definition
- **Component Specifications**
  - ✓ Feed Box Spec. released
  - Branch Box Spec: Engineering Check
  - Warm Piping Spec: Draft version in review
- **System Specifications (→ Installation)**
  - Branches (T, P, M,…) Spec: In preparation

In Kind contracts not yet signed.

BINP workshop 11/2019:
Agreement on Scope and Cost Sharing between WUST and BINP

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)

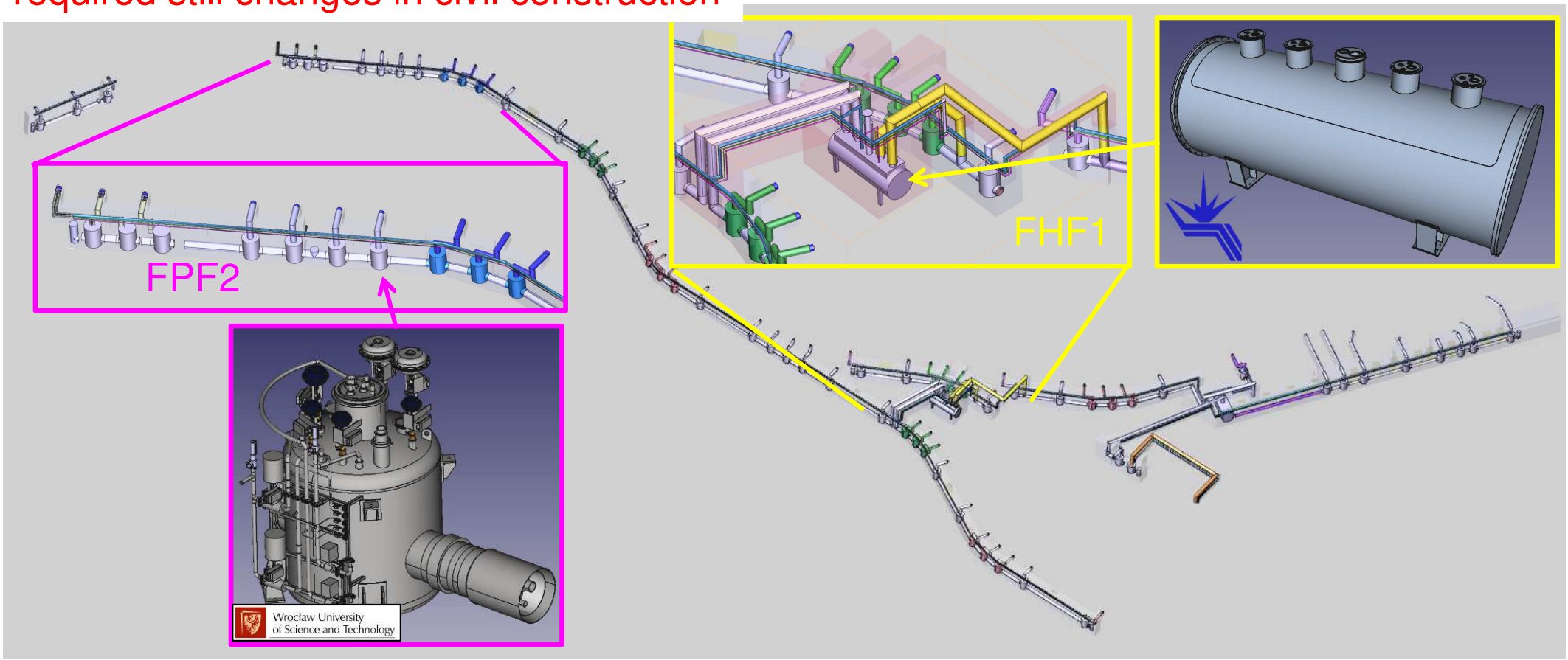
BINP scope (incl. design and installation):
- Branch Box (BB) and its ‚long' 4-TLs
- all Warm Piping and 1-TLs
- 18 Feed Boxes (manufacturing only, design and installation by WUST)

Local Cryogenics
(DMU and Design)

F. Wamers,
A. Breidert et al

- 12/2019: First conceptual 3D model of Feed Box, by WUST
- 12/2019: First conceptual 3D model of Branch Box vacuum vessel, by BINP
- 02/2020: Update of the Local Cryogenics 3D model and installation space
  - ➢ WUST pre-design (new Dipole-FB concept, separate EBs, one FB per cryostat)

required still changes in civil construction



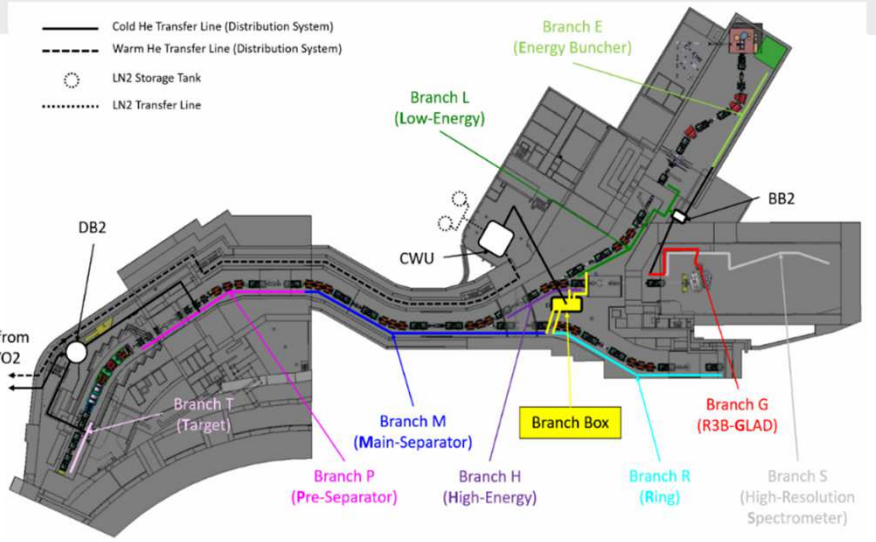
Local Cryogenics
(Cryogenic Operation Modes)

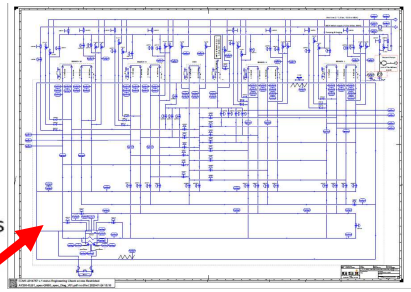
F. Wamers,
Y. Xiang et al

Cryogenic operation modes based on NUSTAR-experiment requirements:

1. Cryo-operation of Branches T, P, M, B
2. Cryo + beam-operation of running experiment Branch (H, L, or R)
3. Cryo-preparation of next-scheduled Branch (beam operation of running Branch ongoing)
4. … floating, warmup, quench, hazard, …
5. … various combinations…

Goal: High availability + flexibility for experiments!





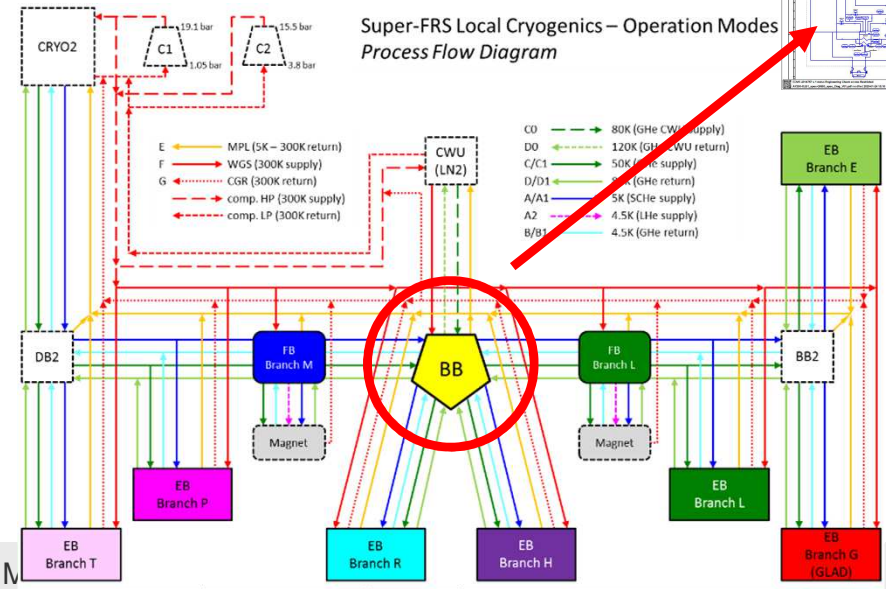


Table 1: Foreseen user (NUSTAR sub-collaboration) requirements for the Cryogenic (4.5 K) Operation of the Super-FRS Local Cryogenics Branches.
Explanations: (X) not all of the magnets in Branch X are needed. (**) none of the magnets in this Branch are needed.*

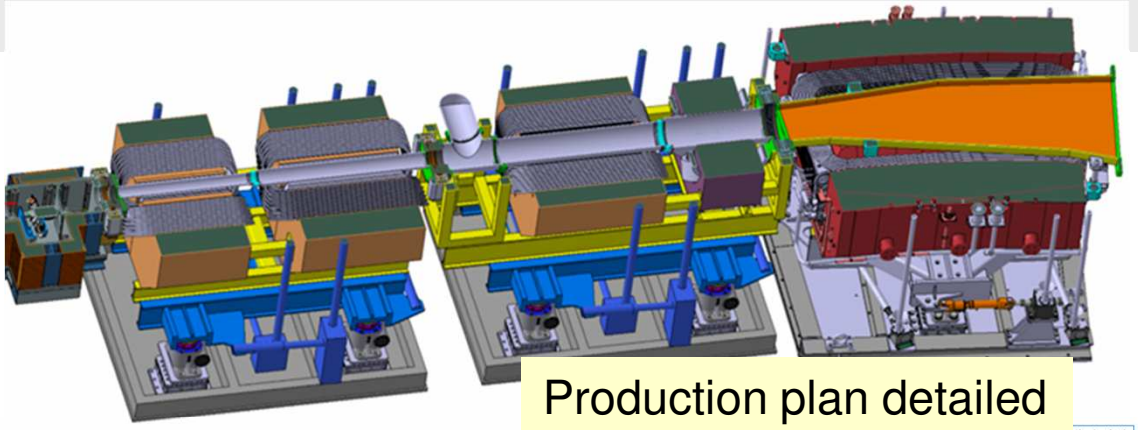
NUSTAR Sub-Collaboration	Focal Planes	Branch T, P, M, B	Branch H	Branch L	Branch E	Branch G, S	Branch R
SEC	FHF1:	Yes (M*)	Yes	No	No	No	No
	FLF3:	Yes (M*)	Yes (*)	Yes	No	No	No
	FLF6:	Yes (M*)	Yes (*)	Yes	Yes	No	No
HISPEC/DESPEC	FLF3:	Yes (M*)	Yes (*)	Yes	No	No	No
	FLF6:	Yes (M*)	Yes (*)	Yes	Yes	No	No
MATS/LaSpec	FLF6:	Yes (M*)	Yes (*)	Yes	Yes	No	No
R3B	FHF2:	Yes (M*)	Yes	Yes (**)	No	Yes	No
	FHF3:	Yes (M*)	Yes	Yes (**)	No	Yes	No
	FHF4:	Yes (M*)	Yes	Yes (**)	No	Yes	No
ILIMA, ELIse, EXL	FRF3:	Yes	No	No	No	No	Yes

Radiation Resistant Magnets

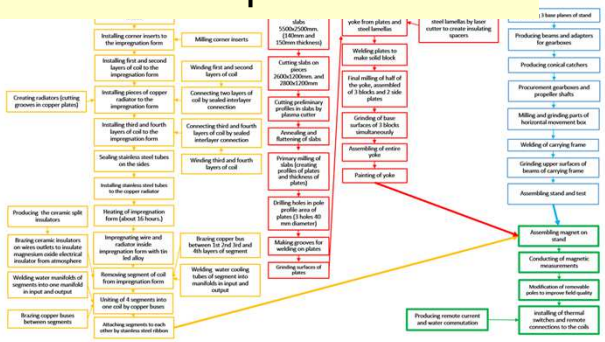
H. Leibrock,
T. Blatz et al.

Scope:

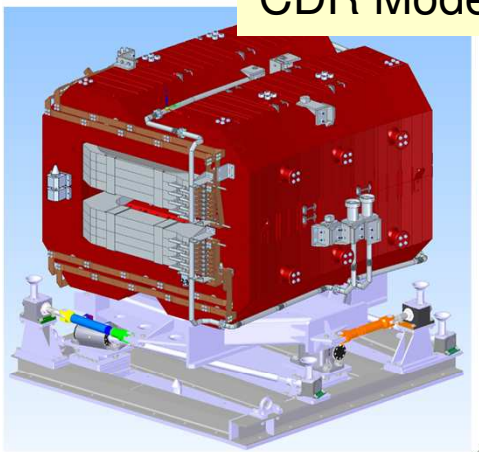
- NC magnets using MIC cable
- WP1: 3 dipole magnets
  (prototype dipole built and tested)
- WP2: 3 quadrupoles & 2 sextupoles
- Dedicated support frame, designs available
- Remote connectors and alignment



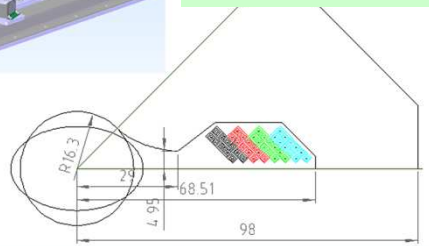
Production plan detailed

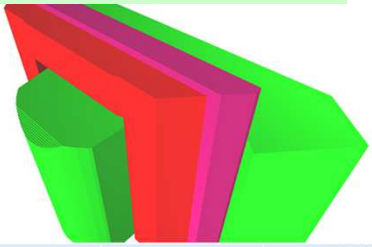


CDR Model



technical realizable solution of coil design found





Status / Schedule

- ✓ WP1: CC signed 04/2019;
- ✓ CDR approved 02/2019
- ✓ MIC procured, in-house
- ✓ WP2: BINP is running R&D phase
  - ✓ research contract signed 09/2019
  - ➢ conceptual design expected Q3/2020
    - decision on IKC expected for 04/2020
    - CC with BINP Q3/20
      (otherwise tender required)

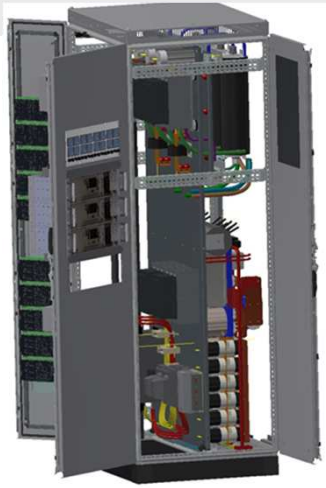
2.4.2.2.1	Quadrupole 1a	1	1.6 T/m	15.4 T/m	0.933	Ø 130	$\pm 1 \cdot 10^{-3}$
2.4.2.2.1	Quadrupole 1b	1	1.2 T/m	11.8 T/m	1.244	Ø 180	$\pm 1 \cdot 10^{-3}$
2.4.2.2.2	**Quadrupole 2**	1	0.6 T/m	6.1 T/m	1.200	380 × 240	$\pm 1 \cdot 10^{-3}$
2.4.2.3.1	**Sextupole 1**	2	3.5 T/m²	34 T/m²	0.600	Ø 380	$\pm 5 \cdot 10^{-3}$

Power Converter

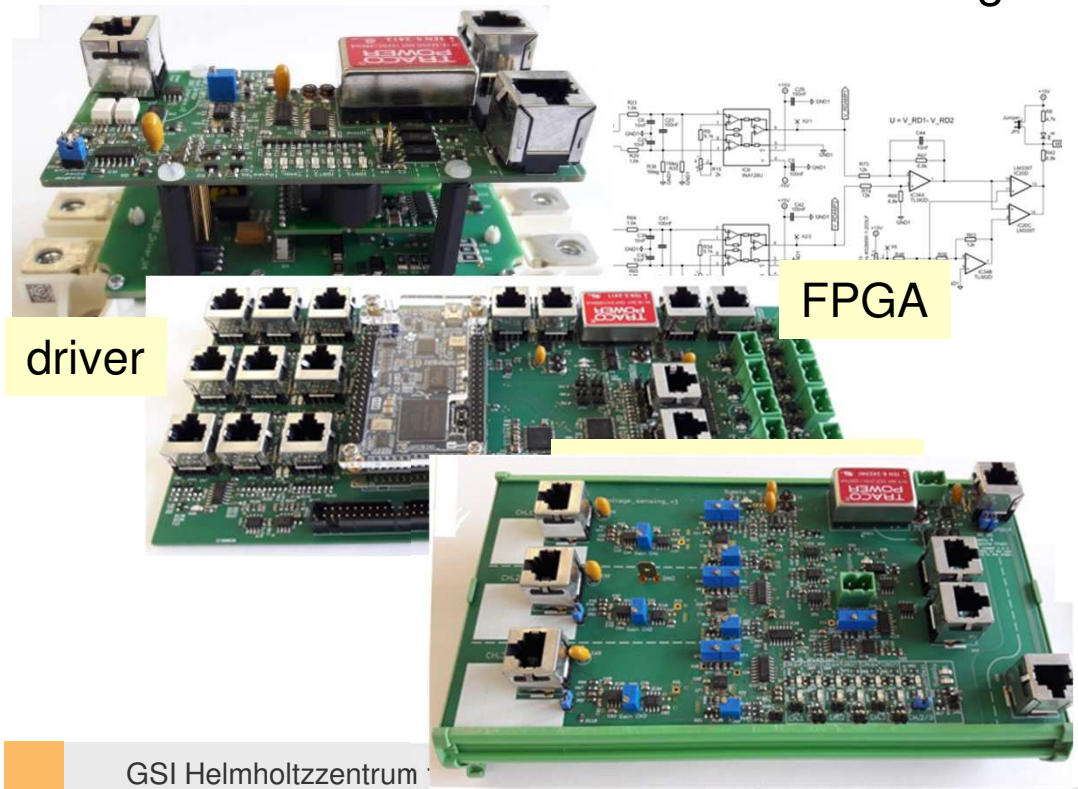
A. Wiest,
W. Freisleben
A. Kratz et al.

Scope & (main) features

- in sum ~250 PC required
- 2 (3) PC units in one rack
- large voltage and current range
- all PC are bipolar
- energy recovery system
- QD electronics: rack-integrated
  - ➢ common infrastructure → cost saving



PC prototype development



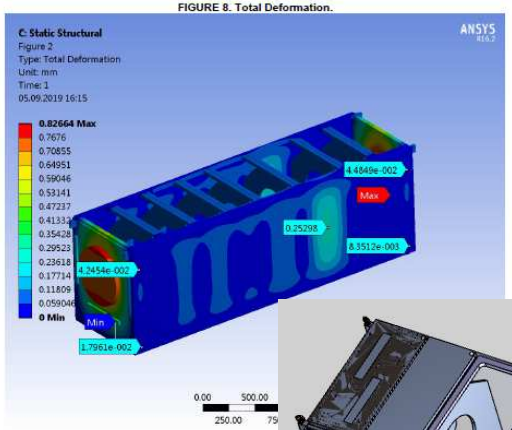
Status / Schedule

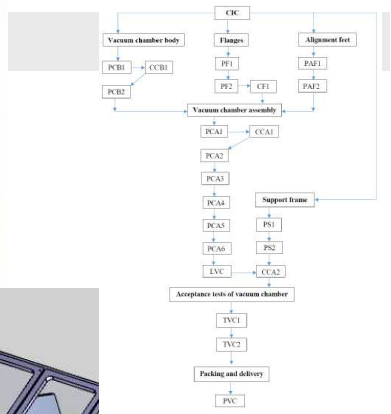
- in-kind assignment India
  - Super-FRS, HEBT, SIS 100
  - ✓ part of electronics: free issue equipment
  - ✓ IKC for HEBT (SIS) signed
  - ➢ Production running
  - ➢ IKC for Super-FRS in loop
- Prototype PC assembly running
  - ➢ blue print provision
  - ➢ mounting: external (at GSI: Q1/2020)
  - ➢ SAT: GSI (NC dipole)

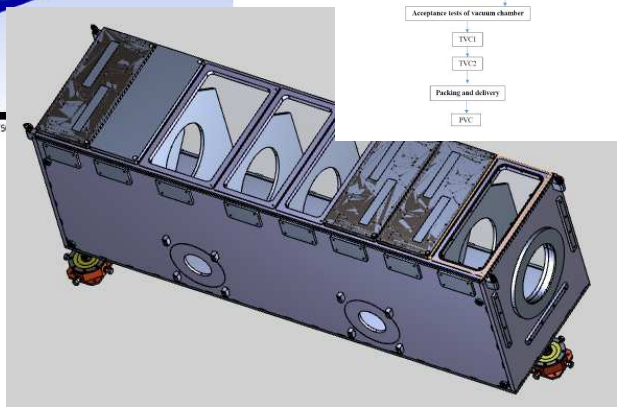
Vacuum System

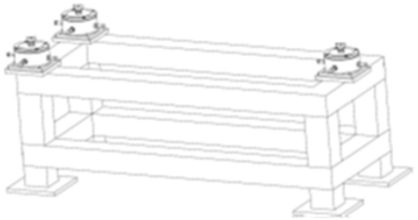
S. Purushotaman,
I. Mukha,
J. Kurdal et al.

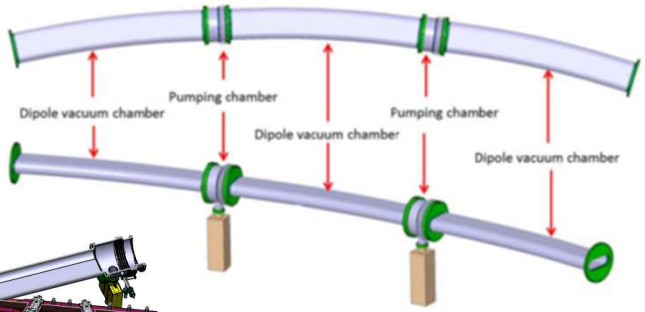
- **special components: in-kind provider BINP**
  - ✓ CC focal plane chambers signed including supports (FDR phase running)
  - ✓ CC SC dipole chambers (standard) signed including pumping chambers (CDR phase running)
- **Collaboration Contracts to come with BINP**
  - ➢ NC dipole chambers (R&D running)
  - ➢ NC multipole chambers
  - ➢ SC dipole chambers (branching)
  - ➢ Pumping chamber & bellows
  - ➢ Beam pipes including supports
  - ➢ BPM, non-destructive, CR type available
- **standard components: centralized by GSI**

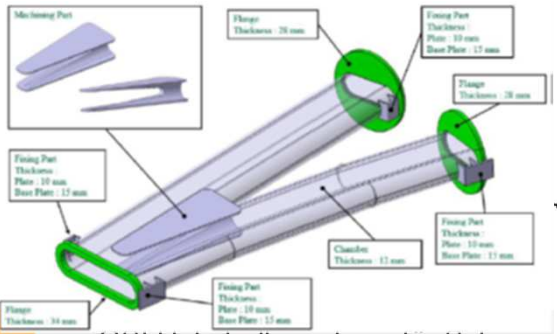


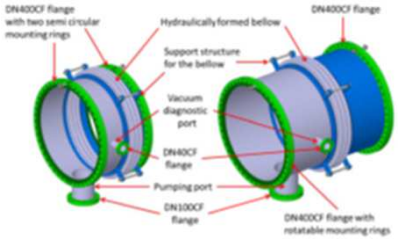


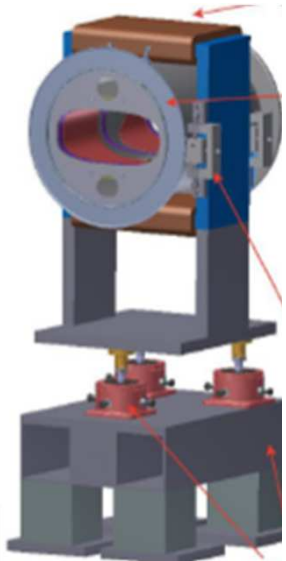










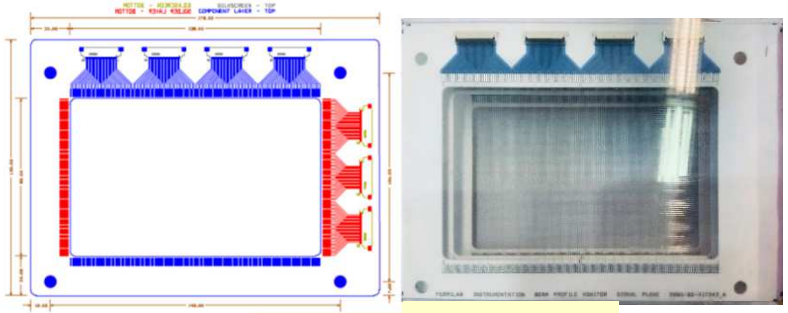


Beam Instrumentation I
(Finnish in-kind contribution)

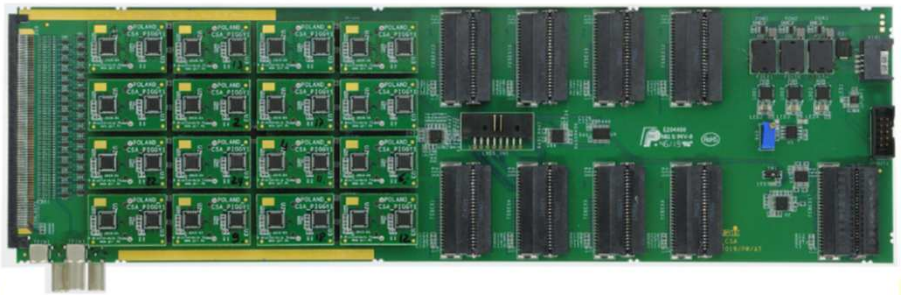
C. Nociforo,
B. Voss,
C. Caesar et al.

- MUSIC (energy-loss, Uni Jyvaskyla)
  - electronics integration (Mesytec board) ongoing
  - GSI beam test in April-May 2020 for FDR of FoS (Q4/2020)
- SEM Grid (profile monitor, HIP)
  - ✓ kick-off meeting (April 2019), CDR preparation
  - waiting for sub-contractor Hbar Technologies, LLC
  - waiting for electronics quotation (POLAND)
- GEM-TPC (tracking)
  - ✓ New preamp board designed by GSI-EE tested at engineering run 2019
  - – final electronics (ADC) to be finalized
  - – calibration tool (SciFi + SiPM) in preparation
  - – IKC to be signed in Q4/2020 ☹
- Position drive (HIP), common drive for SEM and GEM
  - ✓ IKC signed (Dec 2019)
  - CDR in preparation

16-ch Mesytec preamp board



FoS SEM Grid



CSA GEM board (256 ch) in-beam tested, developments shared with HEBT and PANDA coll.

Beam Instrumentation II
(some of the other systems)

C. BNociforo,
T. Blatz,
F. Schirru, et al.

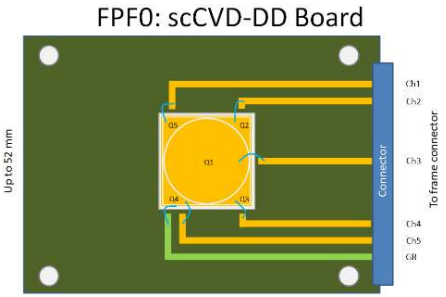
- Beam Position Monitor (BPM)
  - ✓ topic at BINP workshop (Nov 2019)
  - ✓ design of TCR1 BPM by BINP existing
  - – aiming for CC with BINP
  - ✓ full electronics delivered by Instrumentation Technologies (Slovenia)

Libera Hadron

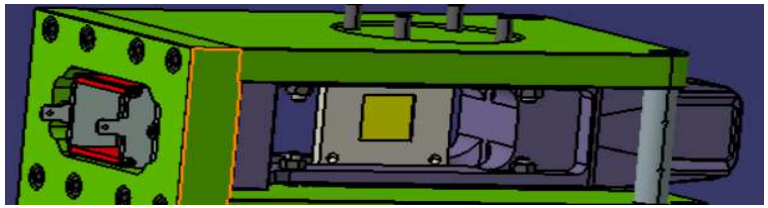
- Particle detector Combination (PDC)
  - ✓ Double drive (IC, SEETRAM) designed in-hous
  - ✓ scCVD-DD under negotiation with CIVIDEC
  - ✓ CDR in preparation
  - – in-beam test needed in 2021

Amplifier 110

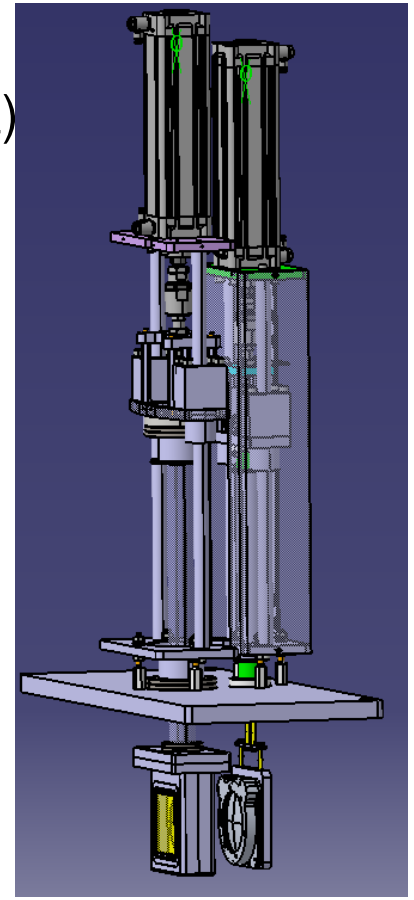
- Drive control (LUND-Sweden)
  - – IKC pending > 1 year ☹



- Beam Stopper
  - ✓ specs approved (Jan 2010)
  - – aiming for tender (Q3/20)



- Plastic scintillators
  - – back to Council Nov 2019 by Sweden ☹
- Time-of-Flight (ToF-Silicon)
  - – CC negotiation with Russia-IOFFE running > 3 years ☹☹☹



FPF4 PDC (IC, SEETRAM)

Target Area

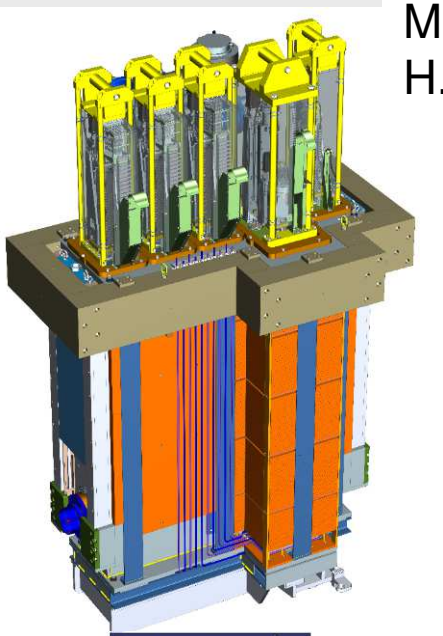
H. Weick,
C. Karagiannis et al

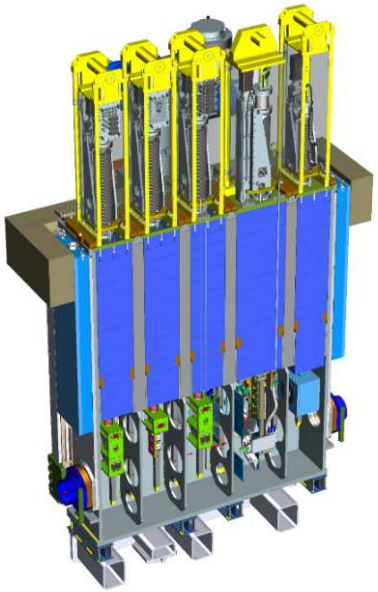
M. Lindemulder,
H. Smit, KVI-CART

Target chamber & plug systems: university of groningen

- Collaboration Contract with KVI-CART
- CDR revision almost done
  - ➢ cooling of chamber/detector ladder;
  - ➢ pillow seal / interface update
- FDR (==production drawings) expected Q3/2020

➢ tender on manufacturing by GSI

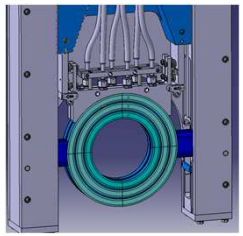


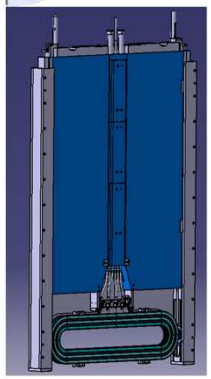


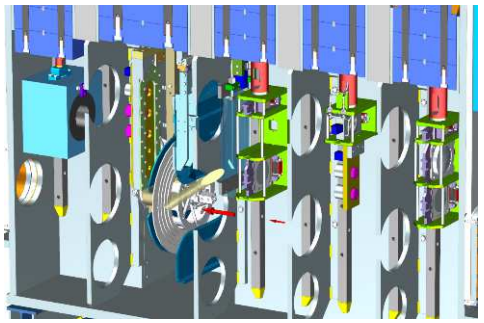
Beam Catchers: CSIR - CMERI
सी एस आई आर - केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान
CSIR - Central Mechanical Engineering Research Institute

– no in-kind contract yet (issues with other IKC)

- Design by CMERI, CDR done,
  - FDR approaching
- Tender (manufacturing) by India



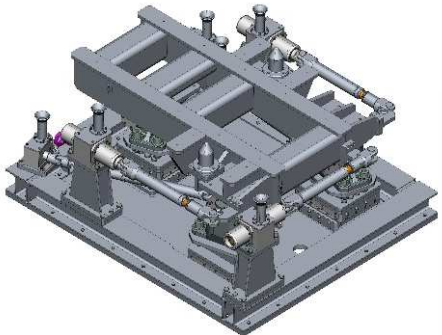


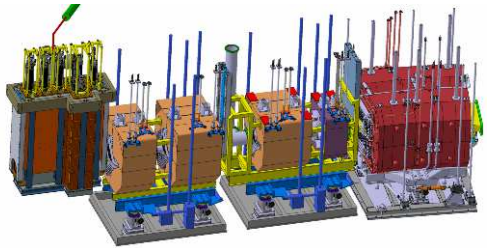


Support Frames:

- 9 supports required; 'remote' alignment
  - ➢ one support developed
  - ➢ 4 supports are scope of magnet delivery
  - ➢ 4 supports have to be tendered (Q4/2020)

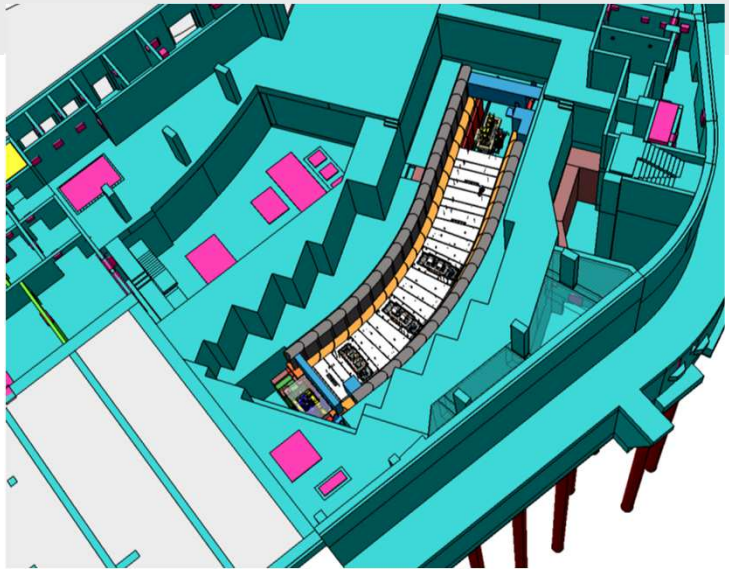
✓ production drawing established





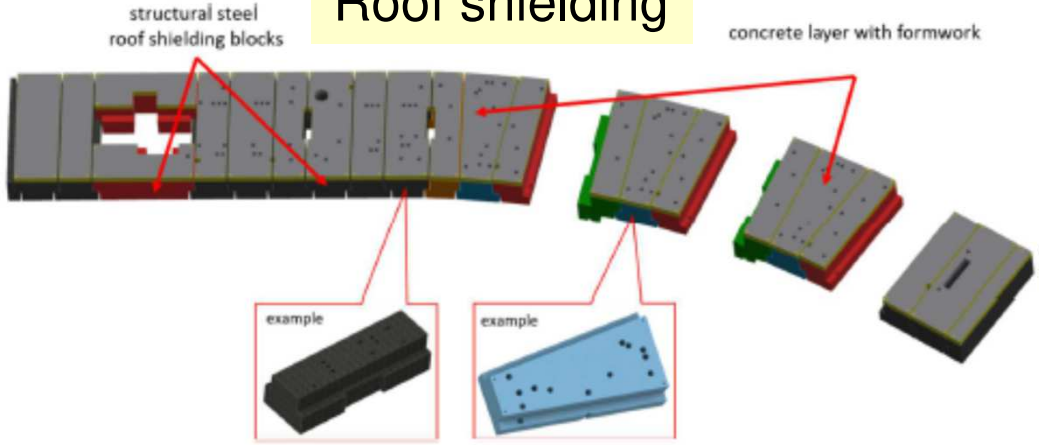
Target Shielding (Iron)

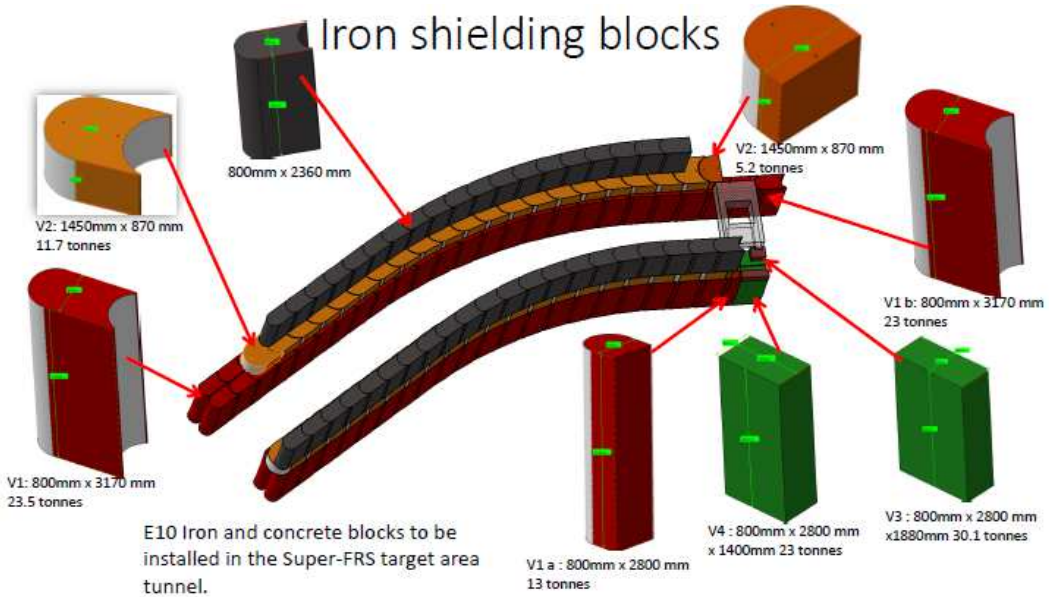
H. Weick,
A. Kratz
R. Knöbel et al



- Funding secured CB 8
- Negotiation with in-kind partner failed
- WP 1: lateral iron shielding **(early installation!)**
  - ✓ Tender started 08/2019
  - ✓ Contract awarded 01/2020, including reproof provider: Walzengiesserei Coswig
  - ➢ kick-off scheduled for March 10/11, 2020
- WP 2: roof shielding in approval procces
  - ➢ Specifications under approval
  - ➢ Tender preparation started

Roof shielding

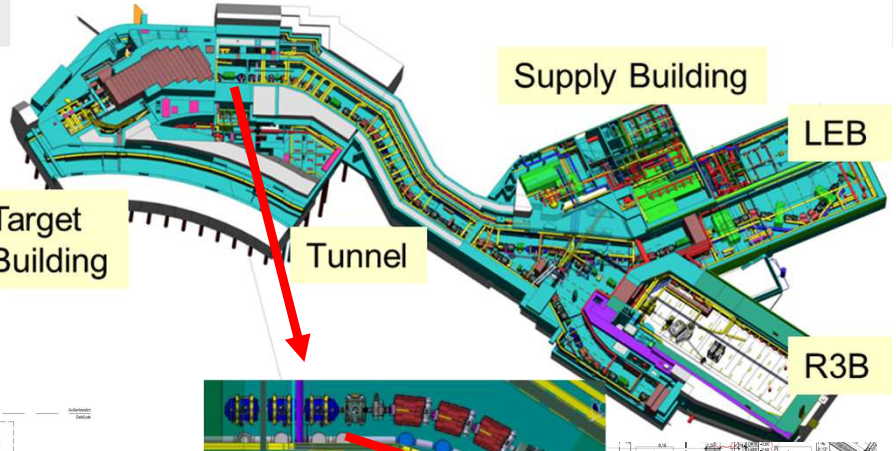


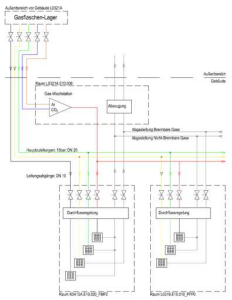


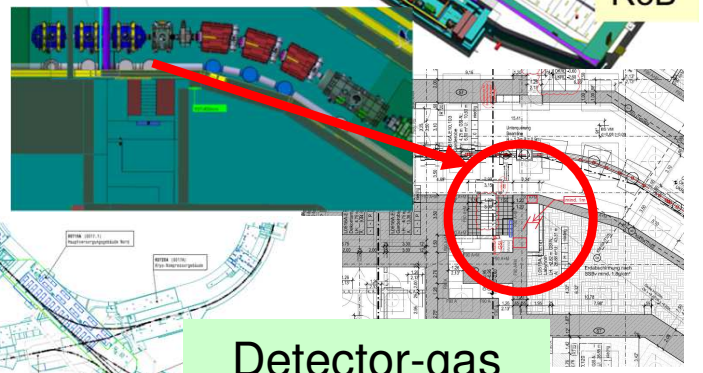
Civil Construction
(FAIR South / Super-FRS)

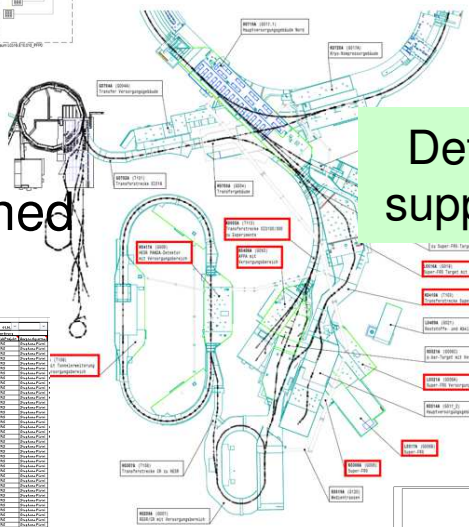
A. Bergmann,
M. M. Schmidt
S. Pietri et al

- ✓ Tender FAIR CC south close to be awarded
- very final building changes (component detailing)
- formwork planning running
- Building services planning running
  - ➢ Cable planning (CDB) ‘finalized’
    (including connectors)
    cable routing planning outsourced;
    cable tender in preparation
  - ➢ electrical power / cooling power harmonized
- Detector-gas system (Super-FRS + Experiments)
  - ➢ Specs established, full list of gas lines established
    installation space planning in preparation
  - ➢ Tender procedure clarified

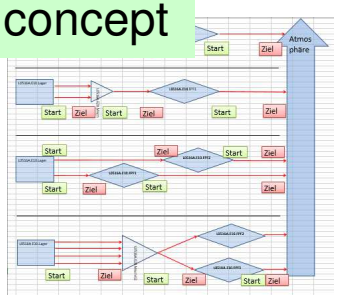


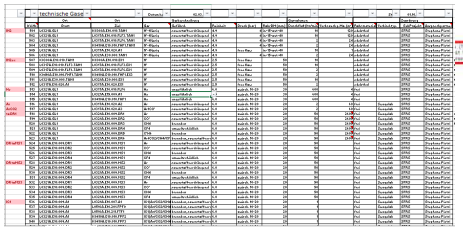




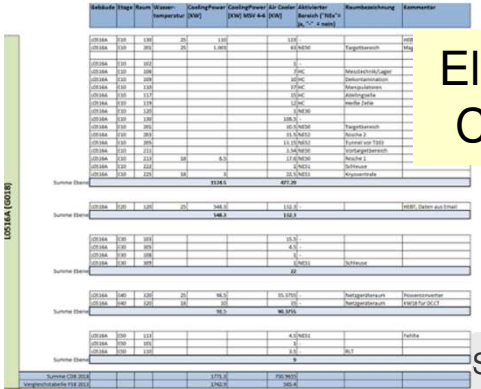


Detector-gas supply concept

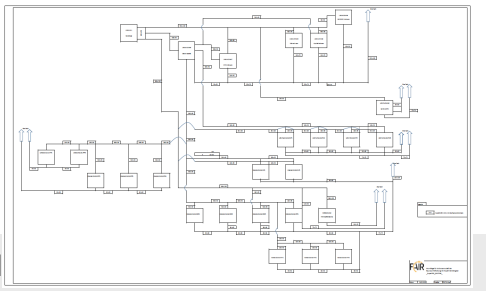




Electrical power
Cooling power



lfdN	Subprojekt	Geb.,neu	Geb., alt	P_H2O (2013)	P_H2O (2018,25°)	P_H2O (2018,18°)	P_H2O (2018,6°)	Δ_H2O	P_Luft (2013)	P_Luft (2018)	Δ_Luft
1	NUSTAR	K0308A	G006	180,00 kW	180,00 kW	47,74 kW	0,00 kW	47,74 kW	295,00 kW	226,22 kW	-68,78 kW
2	NUSTAR	K0314A	G17.2	50,00 kW	0,00 kW	3,44 kW	0,00 kW	-46,56 kW	28,60 kW	22,20 kW	-6,40 kW
3	NUSTAR	L0317A	G006B	342,00 kW	93,38 kW	363,50 kW	90,00 kW	204,88 kW	178,00 kW	440,26 kW	262,26 kW
4	SFRS	K0410A	T103N+S	260,78 kW	425,00 kW	234,80 kW	0,00 kW	399,02 kW	405,79 kW	396,20 kW	-9,59 kW
5	SFRS	L0321A	G006A	1164,00 kW	194,15 kW	282,70 kW	0,00 kW	-687,15 kW	560,50 kW	428,03 kW	-132,47 kW
6	SFRS	L0516A	G018	1742,90 kW	1759,80 kW	21,50 kW	0,00 kW	38,40 kW	585,40 kW	600,47 kW	15,07 kW
				3739,68 kW	2652,33 kW	953,68 kW	90,00 kW	-43,67 kW	2053,29 kW	2113,38 kW	60,09 kW

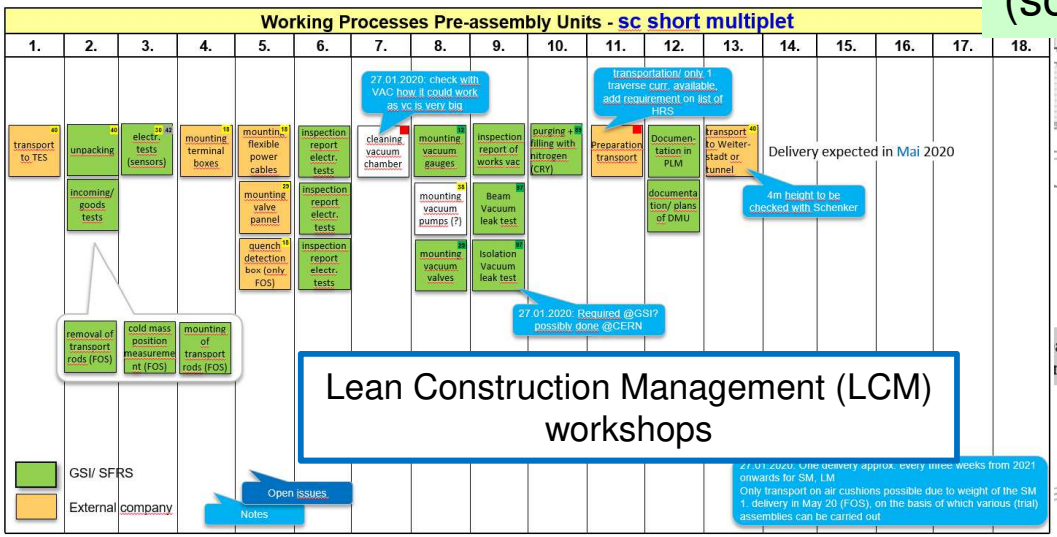


Pre-Assembly
(example: SC Magnets)

M.M. Schmidt
V. Ricciardi et al

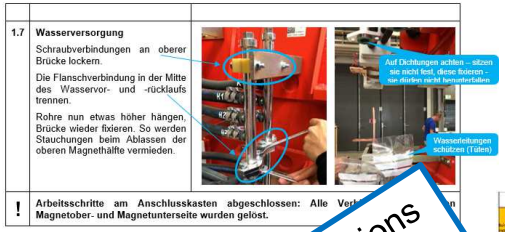
target-hall (south exit)

planned storehouse

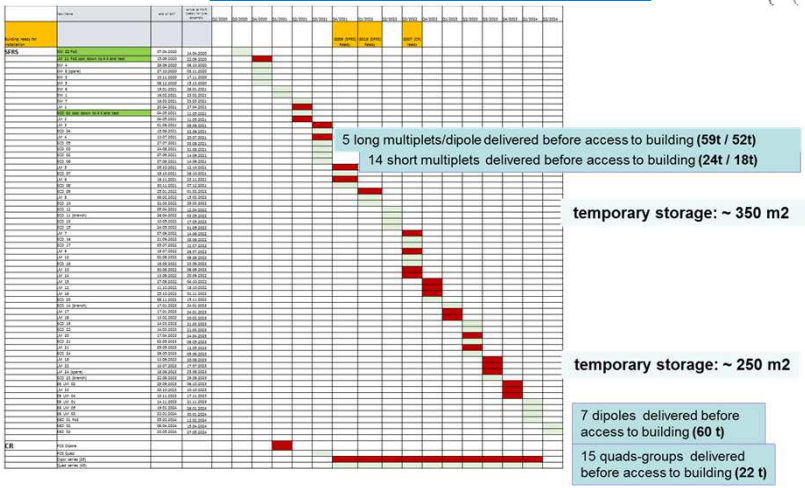


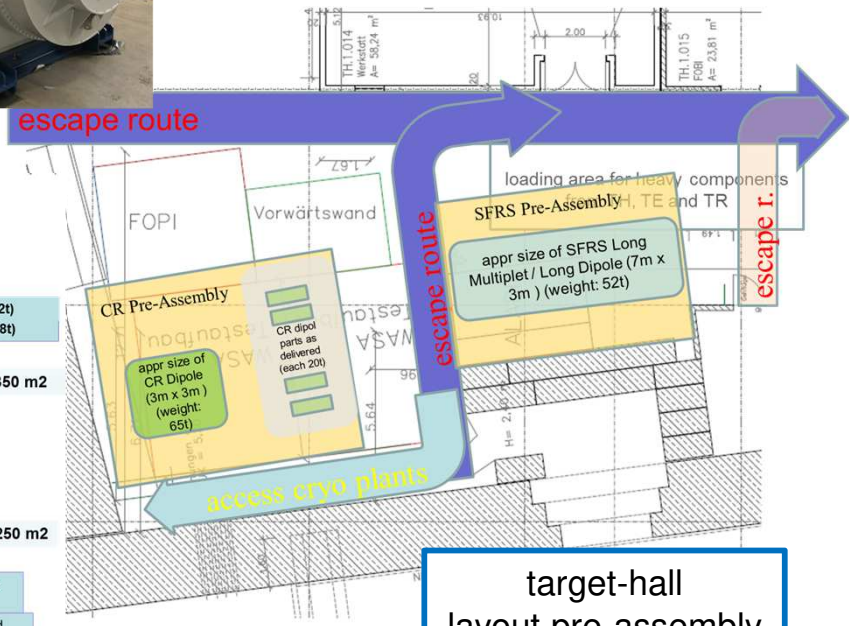
Lean Construction Management (LCM) workshops

Time planning
- 1st SM Q2/2020
- 1st LM Q4/2020
- 1st CR Dipole Q1/2021



Technical Work Instructions
Arbeitsanweisungen





target-hall layout pre-assembly

Summary

+ Major components are contracted and in design and/or construction phase
  - ➢ in particular SC magnets and Testing
  - ➢ lateral iron shielding
  - ➢ (agreement of scope & sharing local cryogenic WP)

– quite some issues with closing in-kind contracts and/or resign of EoI
  - ➢ Energy Buncher magnets
  - ➢ some WP concerning beam instrumentation

• Civil Construction main topic:
  - ➢ Tender FAIR CC south close to be awarded
  - ➢ Building services planning running (via FSB)
  - ➢ Detector-gas planning running (Super-FRS plus all Experiments)

• Pre-Assembly planning running and/or preparation for first component pre-assembly on site

Thank you for you attention !