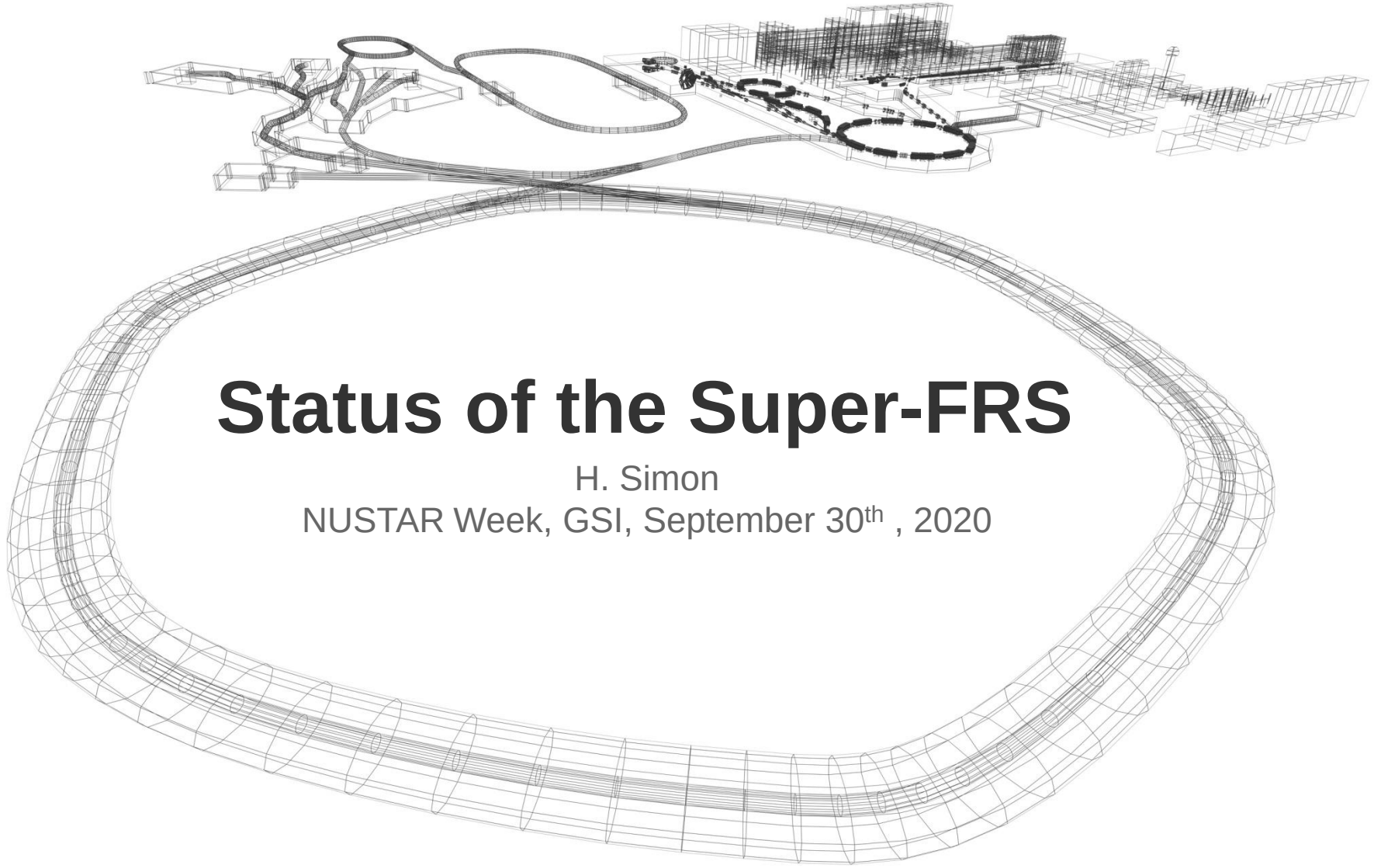


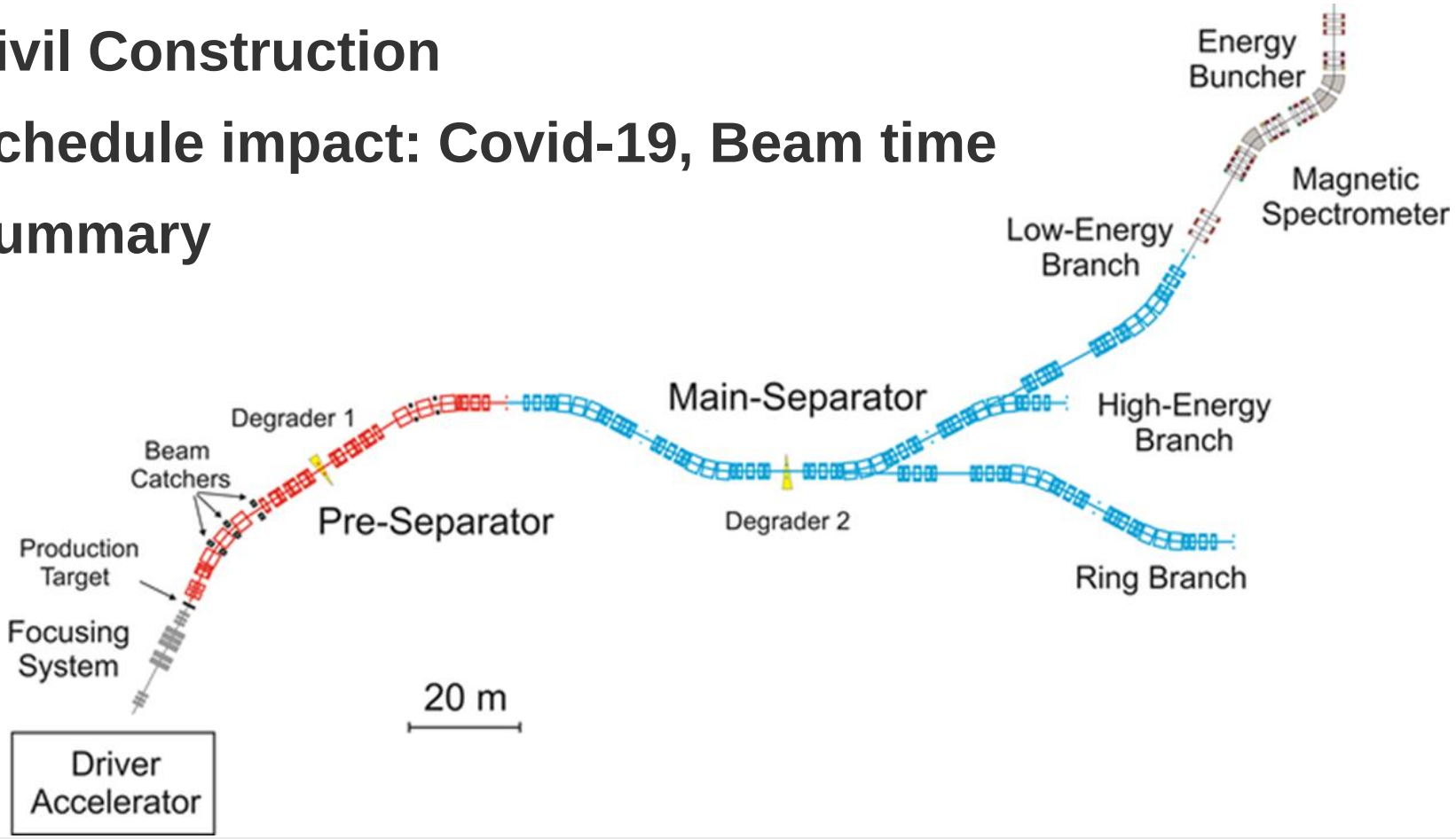
Status of the Super-FRS

H. Simon

NUSTAR Week, GSI, September 30th , 2020

Outline

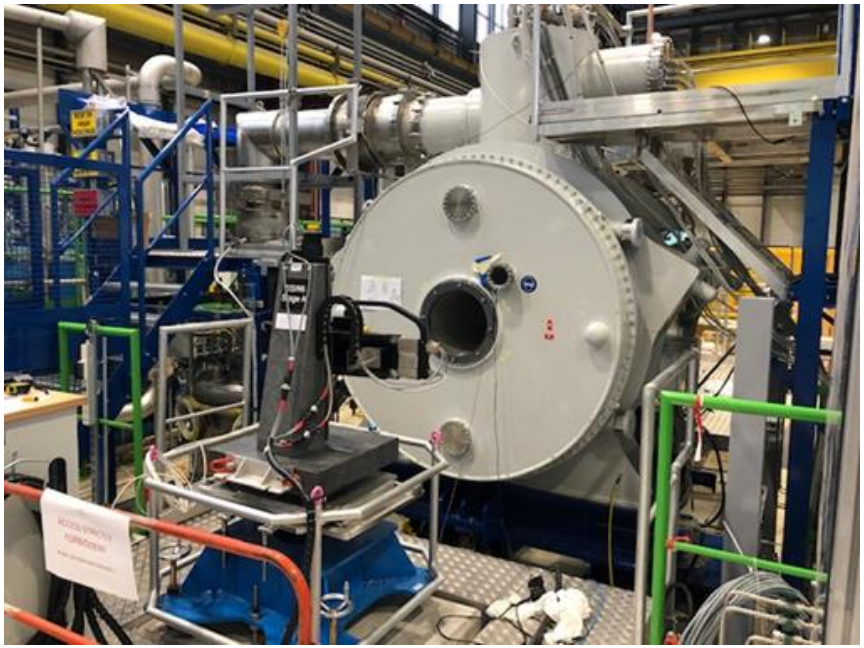
1) Status Technical Sub-Systems
2) Civil Construction
3) Schedule impact: Covid-19, Beam time
4) Summary



sc Magnets
(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**

sc Magnets (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

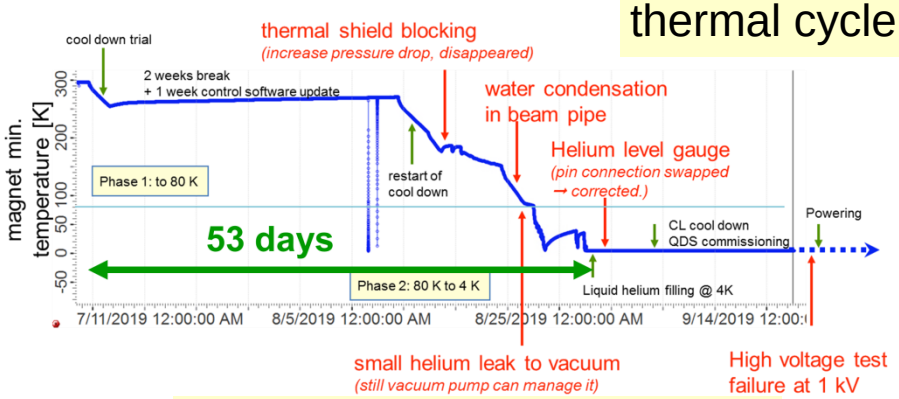
✓ Magnetic axis within specification

✓ Field quality ≈within specification

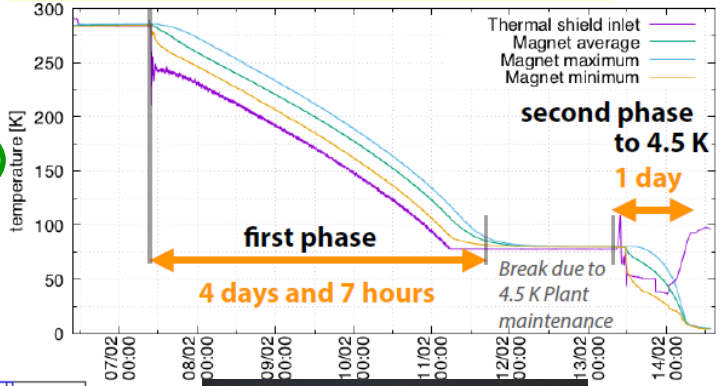
… COVID-19 shutdown

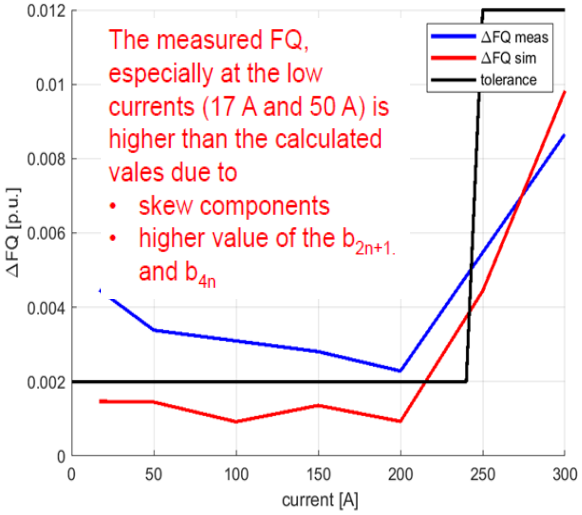
… but early startup !

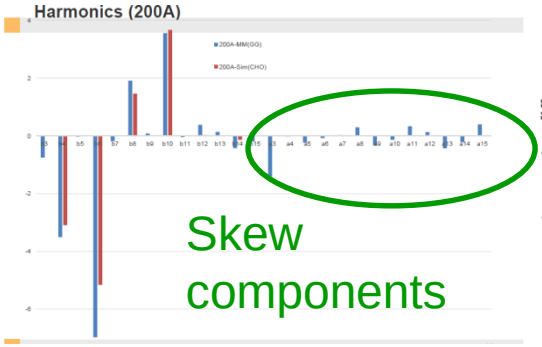
Cool down 1st thermal cycle

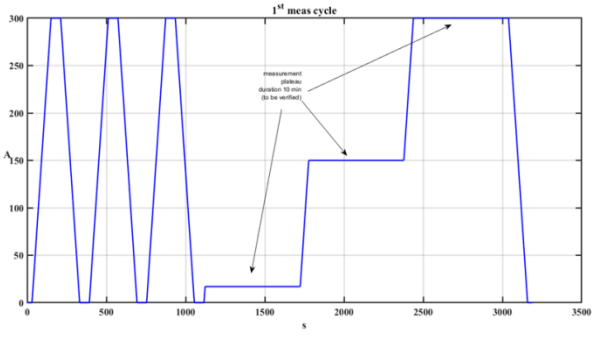


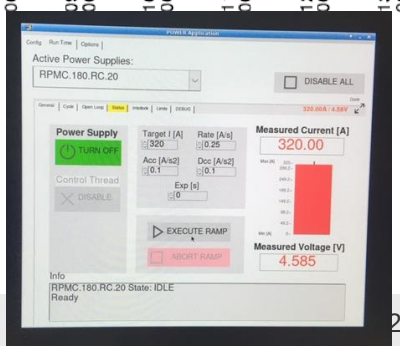
Cool down 2nd thermal cycle







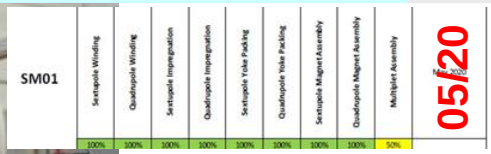


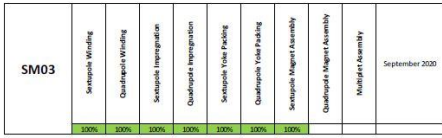


sc Magnets
(SC Mutiplets, Overview)

H. Müller,
E.J. Cho et al.

Series production





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

Status / Schedule

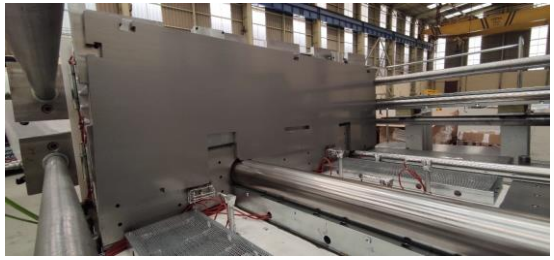
- ✓ Contract closed 07/2015 (ASG, Genova)
- ✓ SAT FoS SM running
- ➢ **FAT FoS LM 03/20**
  - shipment to CERN scheduled 04/2020
    COVID-19
  - shipment to CERN scheduled 10/2020
    About 6m delay

sc Magnets (SC Dipoles)

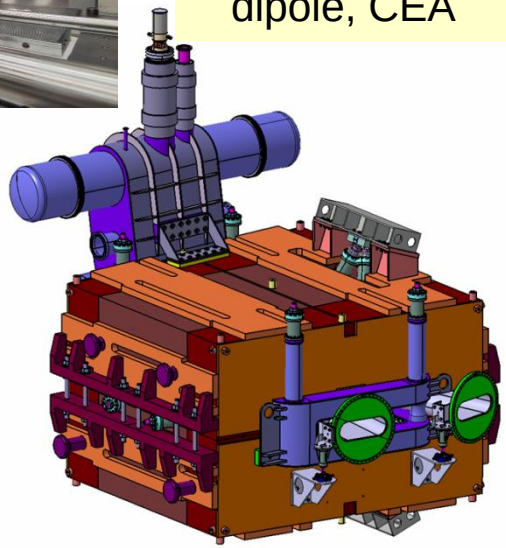
H. Müller,
E.J. Cho et al.
CEA Saclay

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
✓ FDR: 9 Oct. 2019
✓ FOS production running
? FAT of FoS expected 05/20
COVID-19
? Now shifted to 11/20 (about 6m delay)

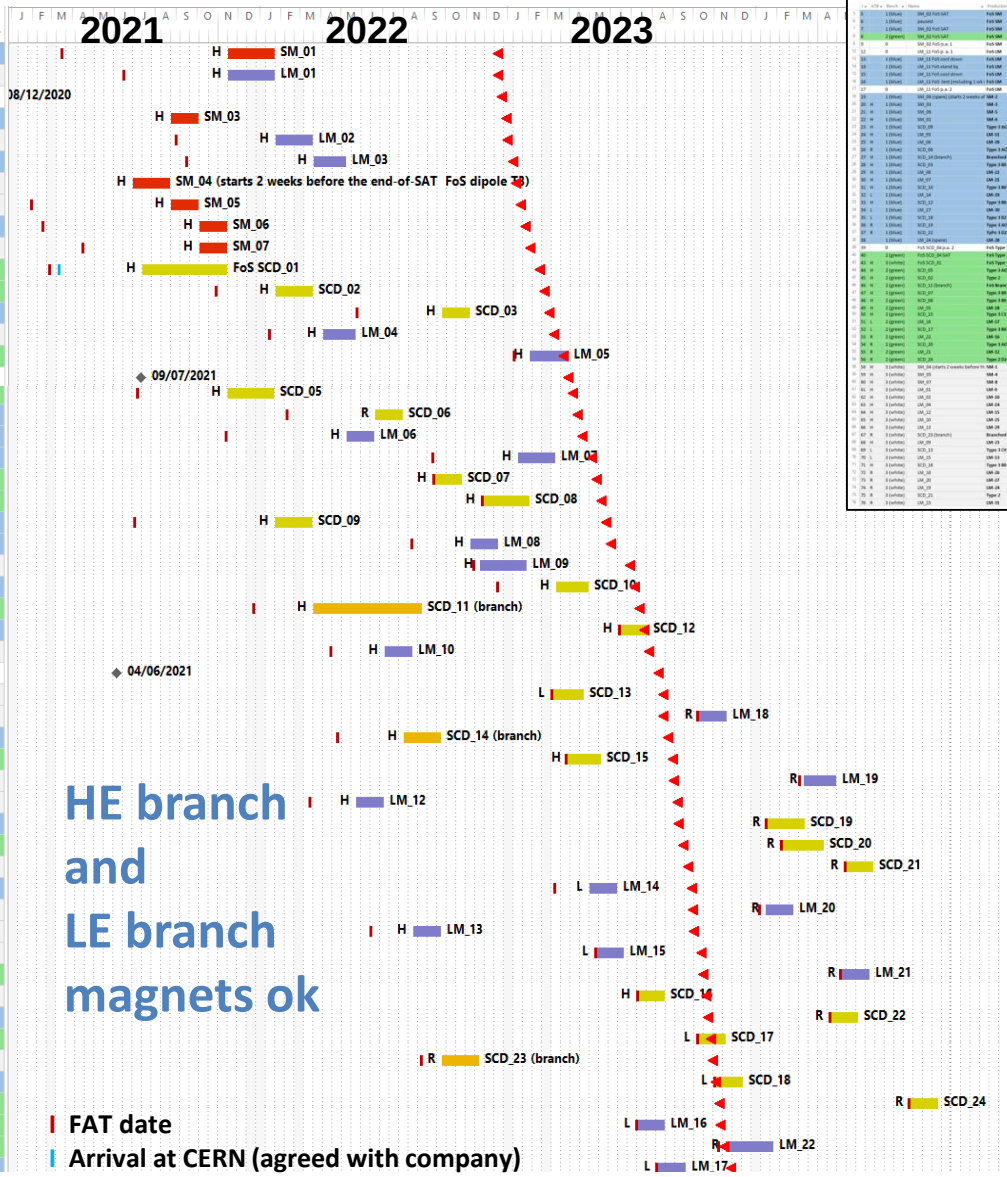
Status branched dipole:

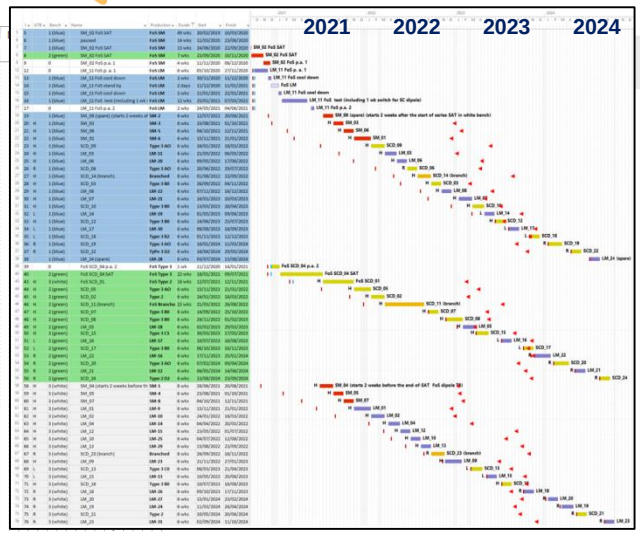
✓ Design phase completed (CEA)
➢ CDR, Spec, 3D Model released 03/19
➢ Contract closed 05/2020
➢ Kick-off done .→ schedule agreed

Magnets Testing. Rescheduling after Covid-19
(Testing at CERN)

Sc magnet SAT plan (at CERN)

I	/	Bench	Name	Durati	Start	Finish
22	H	1 (blue)	SM_01	6 wks	15/11/2021	21/01/2022
61	H	3 (white)	LM_01	6 wks	15/11/2021	21/01/2022
10		0	SM_02 FoS SAT c	0 wks	08/12/2020	08/12/2020
20	H	1 (blue)	SM_03	6 wks	23/08/2021	01/10/2021
62	H	3 (white)	LM_02	6 wks	24/01/2022	18/03/2022
24	H	1 (blue)	LM_03	6 wks	21/03/2022	06/05/2022
58	H	3 (white)	SM_04 (starts 2 v	8 wks	28/06/2021	20/08/2021
59	H	3 (white)	SM_05	6 wks	23/08/2021	01/10/2021
21	H	1 (blue)	SM_06	6 wks	04/10/2021	12/11/2021
60	H	3 (white)	SM_07	6 wks	04/10/2021	12/11/2021
43	H	3 (white)	FoS SCD_01	18 wks	12/07/2021	12/11/2021
45	H	2 (green)	SCD_02	6 wks	24/01/2022	18/03/2022
28	H	1 (blue)	SCD_03	6 wks	26/09/2022	04/11/2022
63	H	3 (white)	LM_04	6 wks	04/04/2022	20/05/2022
49	H	2 (green)	LM_05	6 wks	02/02/2023	29/03/2023
42	H	0	FoS SCD_04 SAT	0 wks	09/07/2021	09/07/2021
44	H	2 (green)	SCD_05	6 wks	15/11/2021	21/01/2022
26	R	1 (blue)	SCD_06	6 wks	20/06/2022	29/07/2022
25	H	1 (blue)	LM_06	6 wks	09/05/2022	17/06/2022
30	H	1 (blue)	LM_07	6 wks	16/01/2023	10/03/2023
47	H	2 (green)	SCD_07	6 wks	14/09/2022	25/10/2022
48	H	2 (green)	SCD_08	6 wks	24/11/2022	01/02/2023
23	H	1 (blue)	SCD_09	6 wks	24/01/2022	18/03/2022
29	H	1 (blue)	LM_08	6 wks	07/11/2022	16/12/2022
68	H	3 (white)	LM_09	6 wks	21/11/2022	27/01/2023
31	H	1 (blue)	SCD_10	6 wks	13/03/2023	28/04/2023
46	H	2 (green)	SCD_11 (branch)	22 wks	21/03/2022	26/08/2022
33	H	1 (blue)	SCD_12	6 wks	14/06/2023	25/07/2023
65	H	3 (white)	LM_10	6 wks	04/07/2022	12/08/2022
18	H	0	LM_11 FoS SAT c	0 wks	04/06/2021	04/06/2021
69	L	3 (white)	SCD_13	6 wks	06/03/2023	21/04/2023
72	R	3 (white)	LM_18	6 wks	09/10/2023	17/11/2023
27	H	1 (blue)	SCD_14 (branch)	8 wks	01/08/2022	23/09/2022
50	H	2 (green)	SCD_15	6 wks	30/03/2023	17/05/2023
74	R	3 (white)	LM_19	6 wks	11/03/2024	26/04/2024
64	H	3 (white)	LM_12	6 wks	23/05/2022	01/07/2022
36	R	1 (blue)	SCD_19	6 wks	16/01/2024	11/03/2024
54	R	2 (green)	SCD_20	6 wks	07/02/2024	09/04/2024
75	R	3 (white)	SCD_21	6 wks	10/05/2024	20/06/2024
32	L	1 (blue)	LM_14	6 wks	01/05/2023	09/06/2023
73	R	3 (white)	LM_20	6 wks	15/01/2024	23/02/2024
66	H	3 (white)	LM_13	6 wks	15/08/2022	23/09/2022
70	L	3 (white)	LM_15	6 wks	10/05/2023	20/06/2023
55	R	2 (green)	LM_21	6 wks	06/05/2024	14/06/2024
71	H	3 (white)	SCD_16	6 wks	10/07/2023	18/08/2023
37	R	1 (blue)	SCD_22	6 wks	18/04/2024	29/05/2024
52	L	2 (green)	SCD_17	6 wks	06/10/2023	16/11/2023
67	R	3 (white)	SCD_23 (branch)	8 wks	26/09/2022	18/11/2022
35	L	1 (blue)	SCD_18	6 wks	01/11/2023	12/12/2023
56	R	2 (green)	SCD_24	6 wks	13/08/2024	23/09/2024
51	L	2 (green)	LM_16	6 wks	10/07/2023	18/08/2023
53	R	2 (green)	LM_22	6 wks	17/11/2023	25/01/2024
34	L	1 (blue)	LM_17	6 wks	08/08/2023	18/09/2023





ASG data 14/09/2020
ELYTT data 09/09/2020

ring-branch magnets stay late relative to 'old' installation window

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

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,…) Specs prepared
- **In Kind contracts not yet signed.**
- ✓ **Collaboration contracts with BINP&WUST**

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)

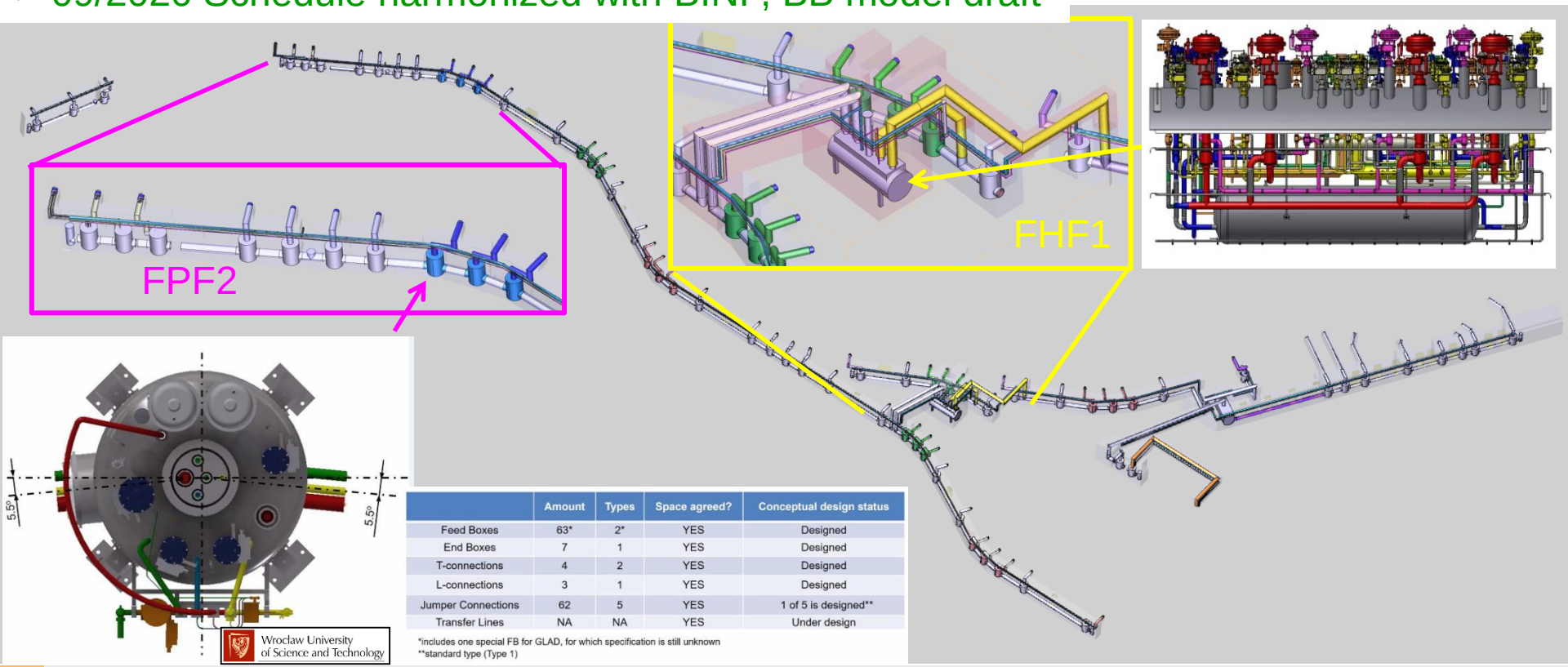
BINP scope (incl. design and installation):
- Branch Box (BB) and its ‚long' 4-TLs
- all Warm Piping and 1-TLs
- 18 Feed Boxes (manufacturing only, design and installation by WUST)

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)

✓ 09/2020 Schedule harmonized with BINP, BB model draft



	Amount	Types	Space agreed?	Conceptual design status
Feed Boxes	63*	2*	YES	Designed
End Boxes	7	1	YES	Designed
T-connections	4	2	YES	Designed
L-connections	3	1	YES	Designed
Jumper Connections	62	5	YES	1 of 5 is designed**
Transfer Lines	NA	NA	YES	Under design

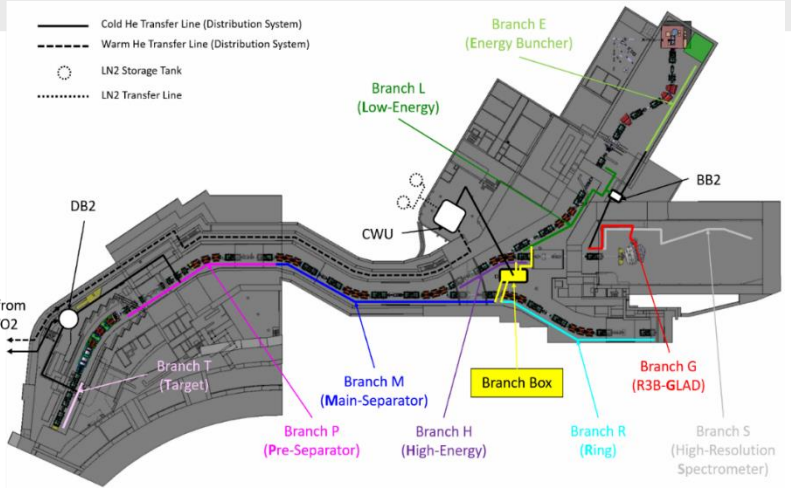
*includes one special FB for GLAD, for which specification is still unknown
**standard type (Type 1)

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…



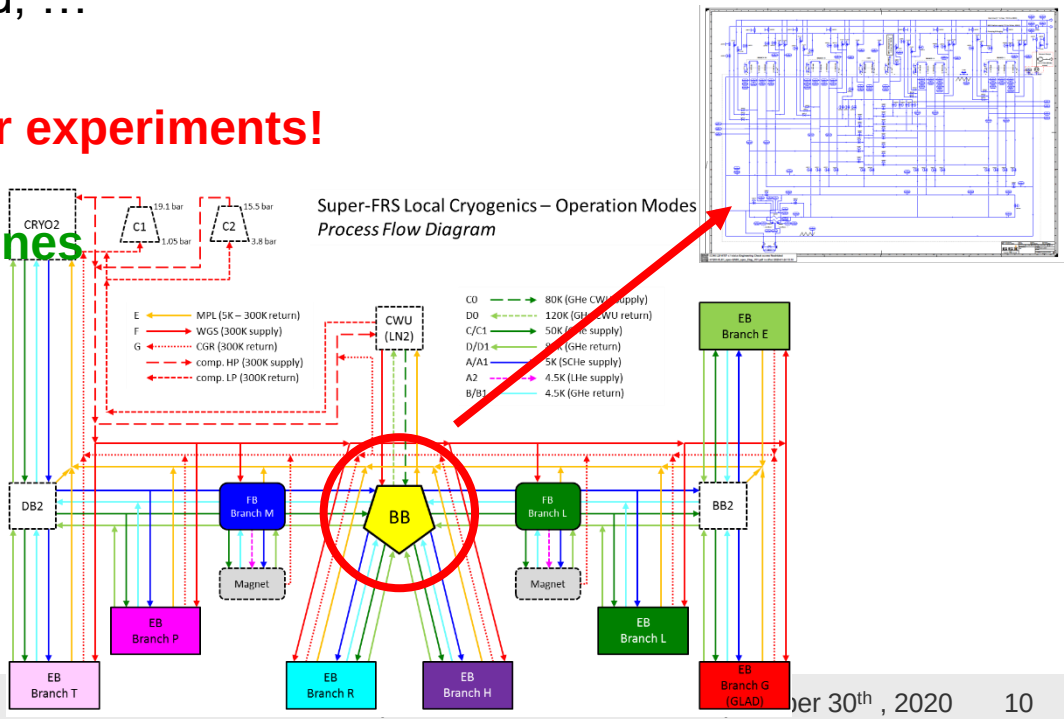
Goal: High availability + flexibility for experiments!

✓09/2020 CDR about 80% done

✓Standardized feed boxes, jumper lines

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

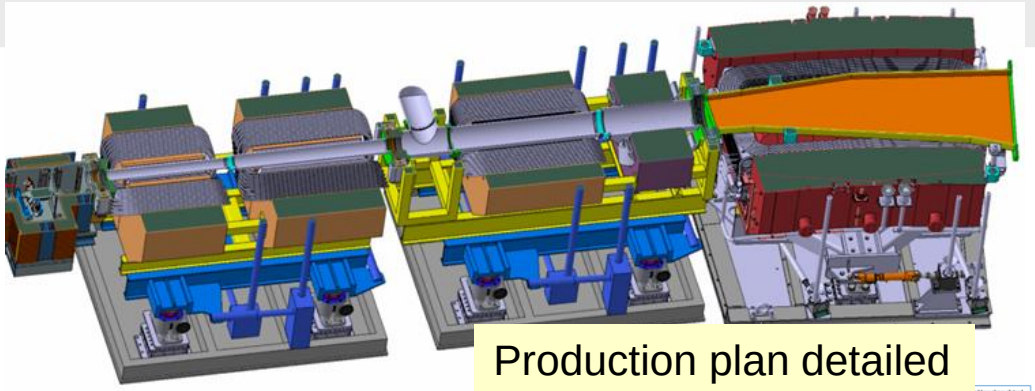


Radiation Resistant Magnets

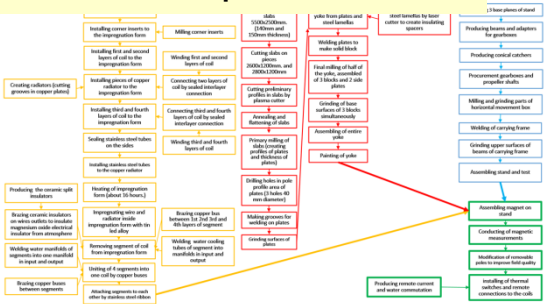
H. Leibrock,
T. Blatz et al.

Scope:

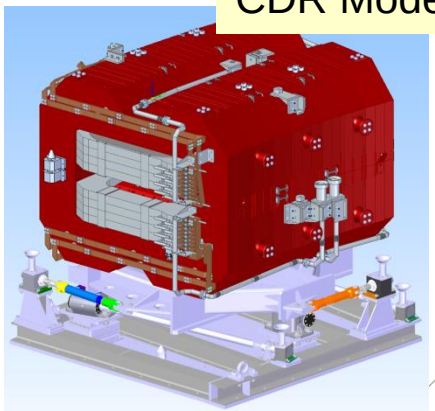
- NC magnets using MIC cable
- WP1: 3 dipole magnets
  (prototype dipole built and tested)
  09/2020 FDR progressing
- WP2: 3 quadrupoles & 2 sextupoles
- Dedicated support frame, designs available
- Remote connectors and alignment



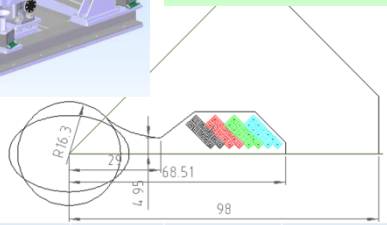
Production plan detailed

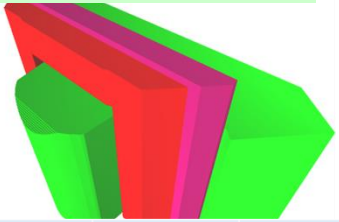


CDR Model



technical realizable solution of coil design found





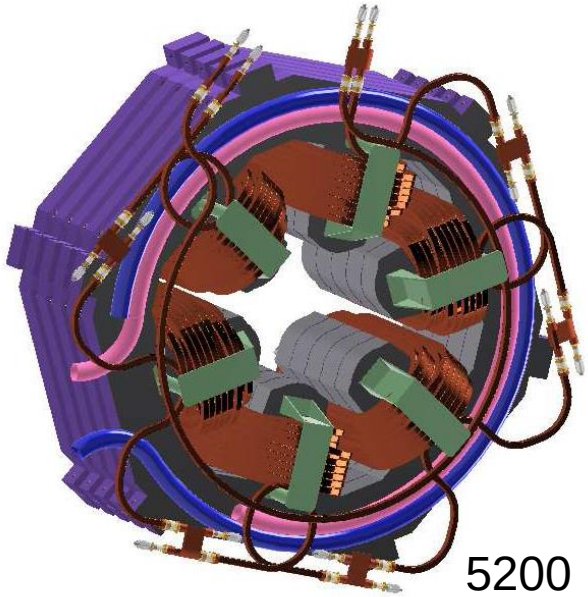
Status / Schedule

- ✓ 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 09/2020
  - ✓ CC with BINP Q3/20, model received
  - ✓ tender preparations started

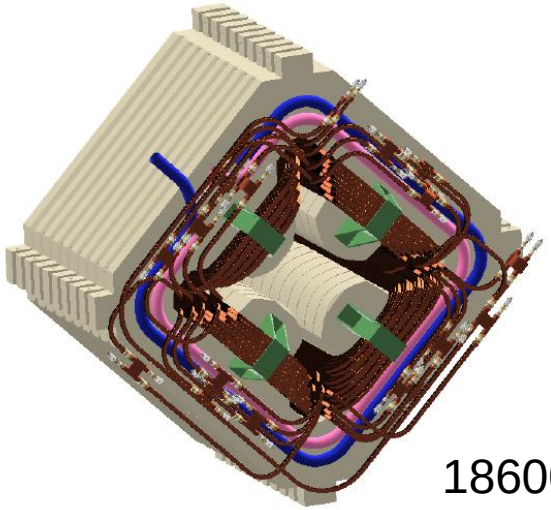
2.4.2.2.1	Quadrupole 1a	1	1.6 T/m	15.4 T/m	0.933	Ø 130	$\pm 1 \cdot 10^{-3}$
2.4.2.2.1	Quadrupole 1b	1	1.2 T/m	11.8 T/m	1.244	Ø 180	$\pm 1 \cdot 10^{-3}$
2.4.2.2.2	**Quadrupole 2**	1	0.6 T/m	6.1 T/m	1.200	380 × 240	$\pm 1 \cdot 10^{-3}$
2.4.2.3.1	**Sextupole 1**	2	3.5 T/m²	34 T/m²	0.600	Ø 380	$\pm 5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

Radiation Resistant Magnets

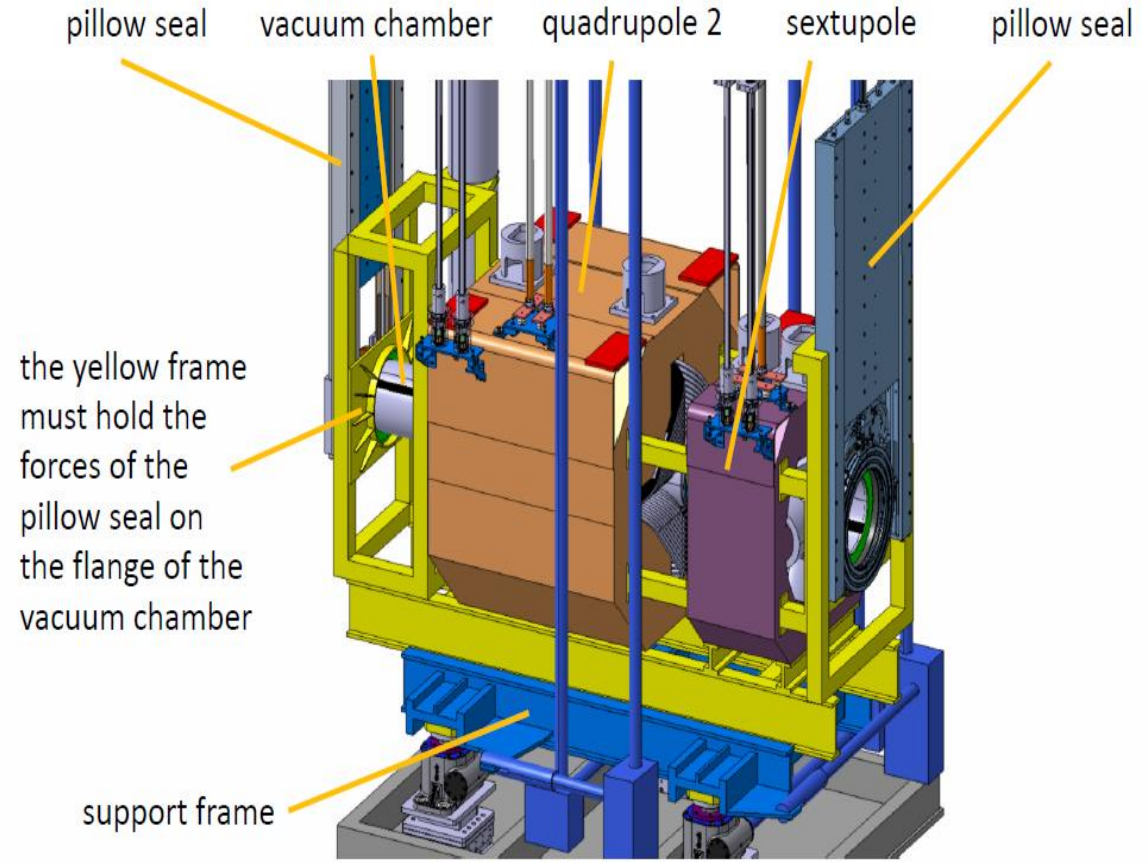
H. Leibrock,
T. Blatz et al.



5200 kg



18600 kg



✓ BINP 09/2019-09/2020

Rad. hard cable export restricted

Tender can be iinitiated – Company cont. promising

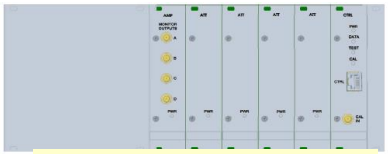
Beam Instrumentation
(some of the systems)

C. Nociforo,
T. Blatz,
F. Schirru,
O. Kiselev, et al.

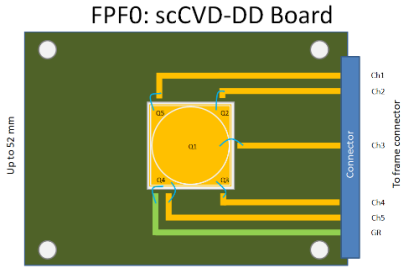
- Beam Position Monitor (BPM)
  - ✓ topic at BINP workshop (Nov 2019)
  - ✓ design of TCR1 BPM by BINP existing
  - – aiming for CC with BINP
  - ✓ full electronics delivered by Instrumentation Technologies (Slovenia)

Libera Hadron

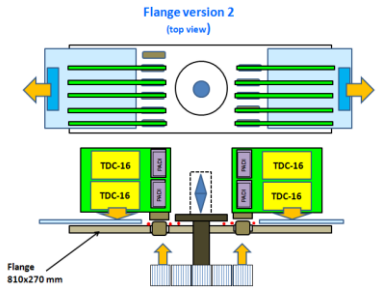
- Particle detector Combination (PDC)
  - ✓ Double drive (IC, SEETRAM) designed in-hous
  - ✓ scCVD-DD under negotiation with CIVIDEC
  - ✓ CDR in preparation
  - – in-beam test needed in 2021

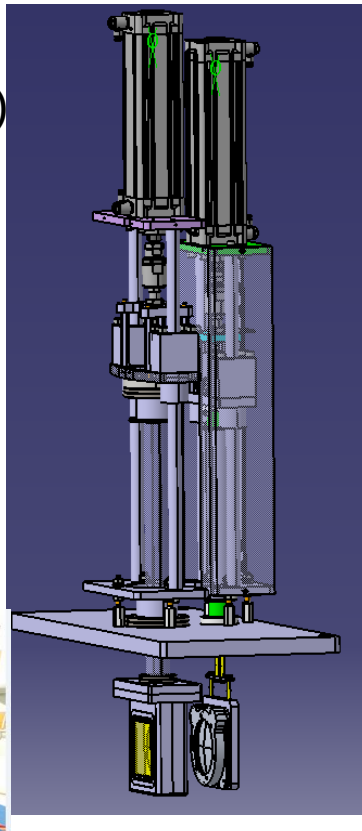


Amplifier 110



- Drive control (LUND-Sweden)
  - – IKC pending > 1 year ☹
- Beam Stopper
  - ✓ specs approved (Jan 2010)
  - ✓ tender running
- plastic scintillators
  - – back to Council Nov 2019 by Sweden ☹
- Time-of-Flight (ToF-Silicon)
  - ✓ IKC signed 26.6.2020, kick-off 4.9.2020, CDR expected this year!





FPF4 PDC (IC, SEETRAM)

Target Area

H. Weick,
C. Karagiannis et al

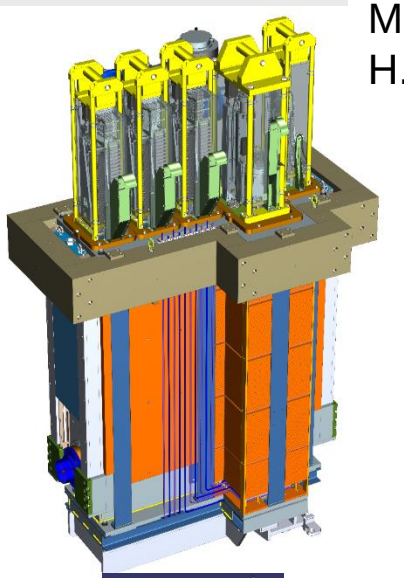
university of groningen

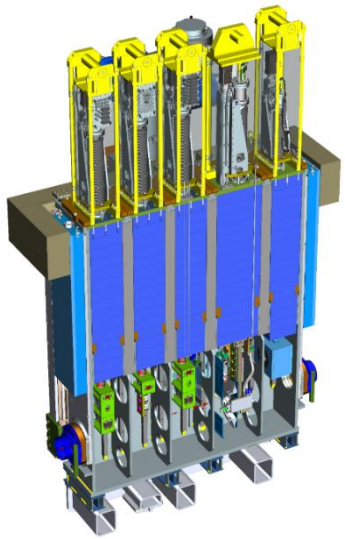
M. Lindemulder,
H. Smit, KVI-CART

Target chamber & plug systems:

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

➢ tender on manufacturing by GSI





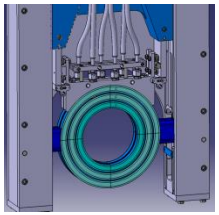
Beam Catchers:

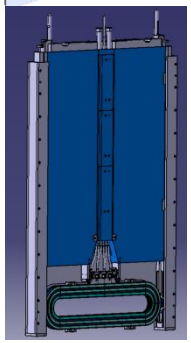
CSIR - CMERI
सी एस आई आर - केन्द्रीय यांत्रिक अभियांत्रिकी अनुसंधान संस्थान
CSIR - Central Mechanical Engineering Research Institute

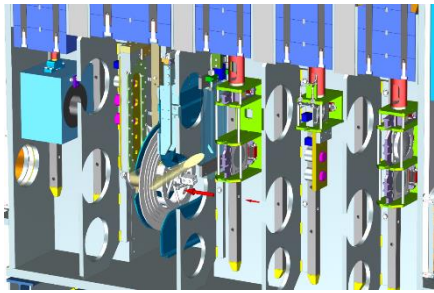
– no in-kind contract yet (issues with other IKC)

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

➢ delays through Covid-19



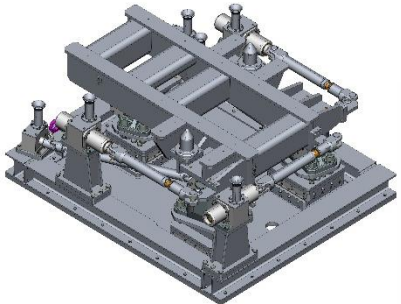


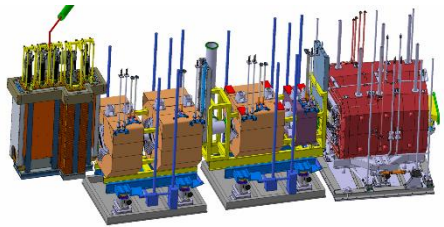


Support Frames:

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

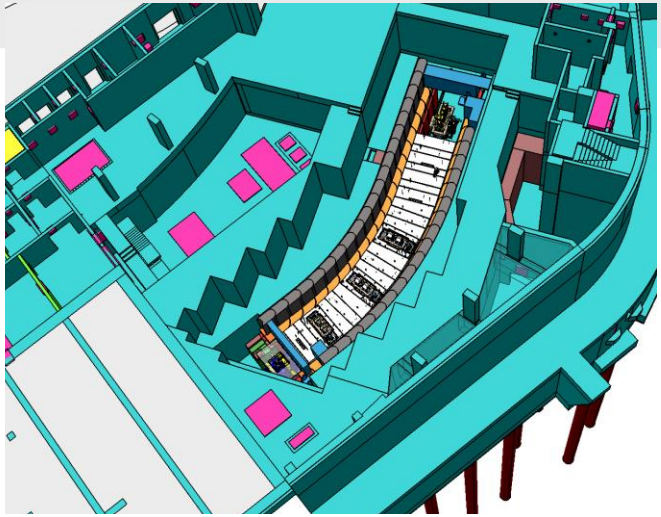
✓ production drawing established





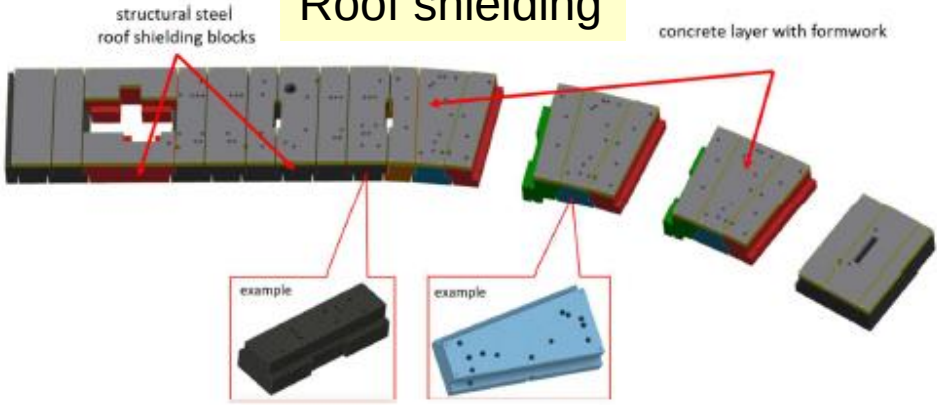
Target Shielding (Iron)

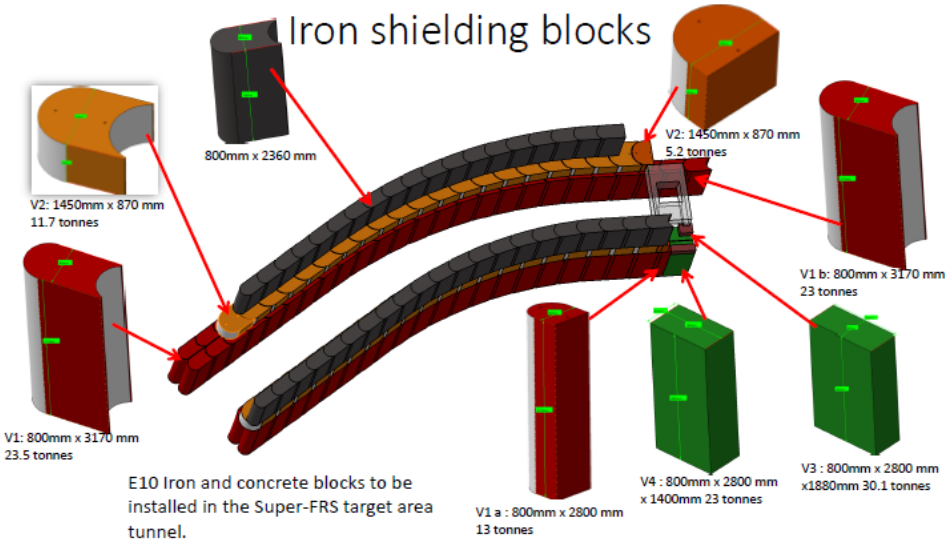
H. Weick,
A. Kratz
R. Knöbel et al



- 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 March 10/11, 2020
  - ➢ CDR 06/20, FDR just ongoing
- WP 2: roof shielding in approval proces
  - ➢ Specifications released
  - ➢ Tender or IK ?

Roof shielding

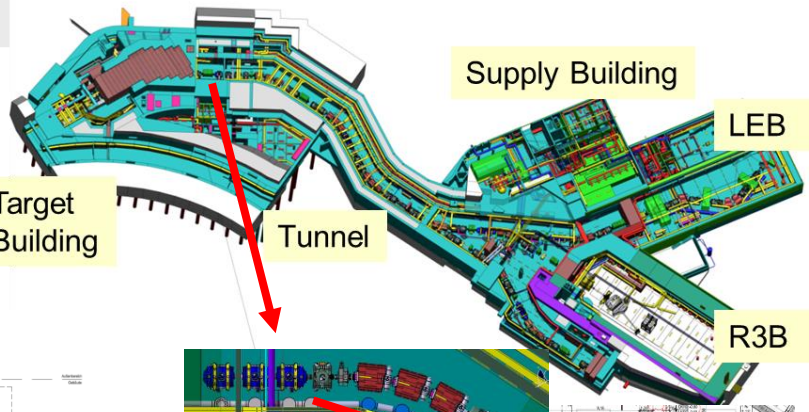


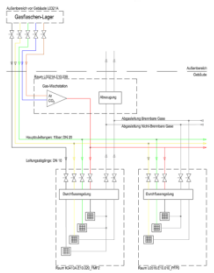


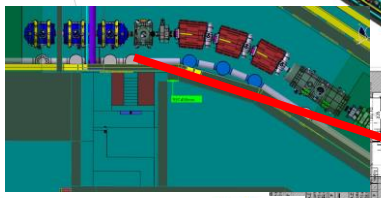
Civil Construction
(FAIR South / Super-FRS)

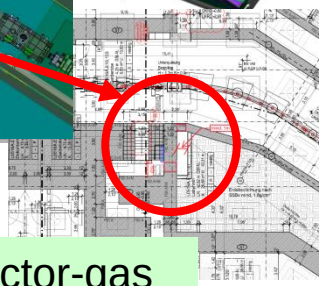
A. Bergmann,
M. M. Schmidt
S. Pietri et al

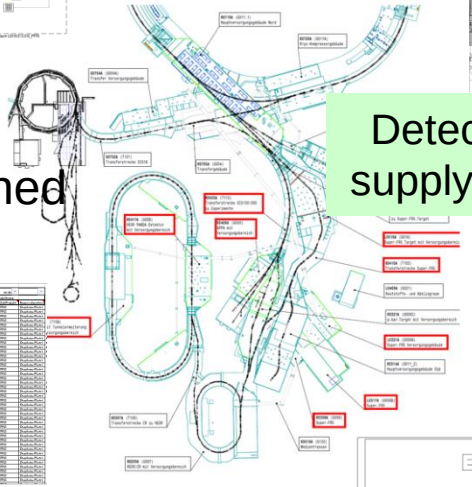
- ✓ FAIR south area construction start
- very final building changes (component detailing)
- formwork planning running
- Building services planning running
  - ➢ Cable planning (CDB) ‘finalized’
    (including connectors)
    cable routing planning outsourced;
    ➔ cable tender
  - ➢ electrical power / cooling power harmonized
- Detector-gas system (Super-FRS + Experiments)
  - ➢ Specs established, full list of gas lines established
    installation space planning ongoing



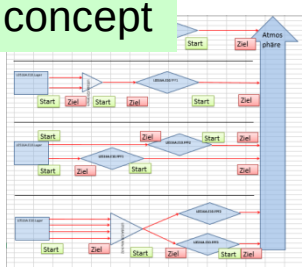


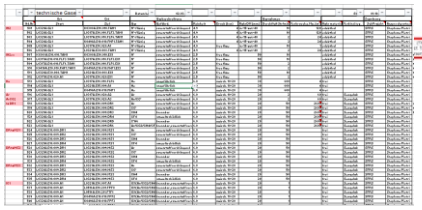




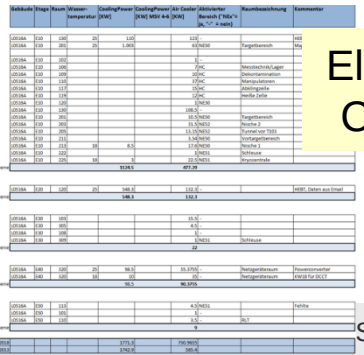


Detector-gas supply concept

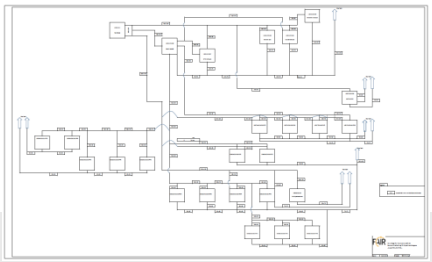




Electrical power
Cooling power



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

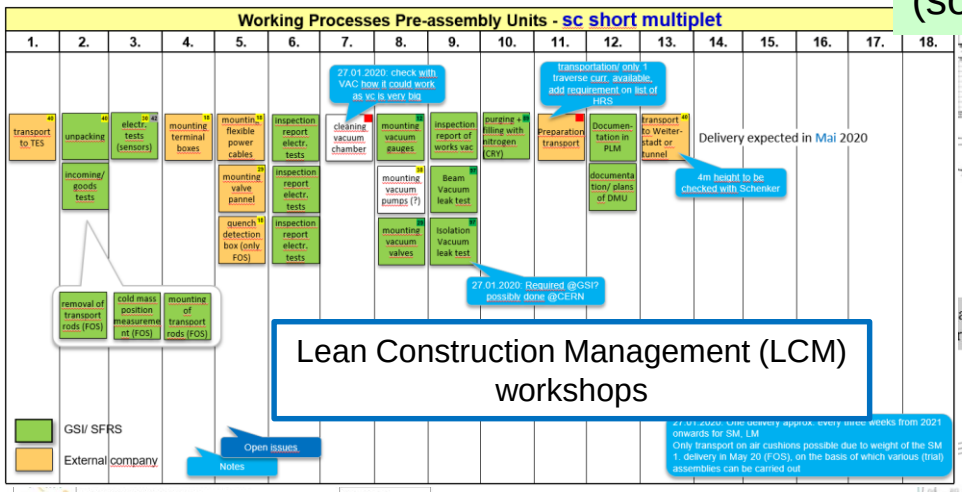


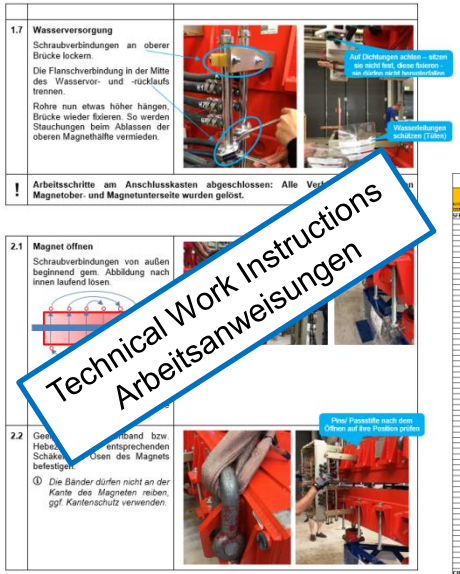
Pre-Assembly
(example: SC Magnets)

M.M. Schmidt
V. Ricciardi et al

target-hall (south exit)

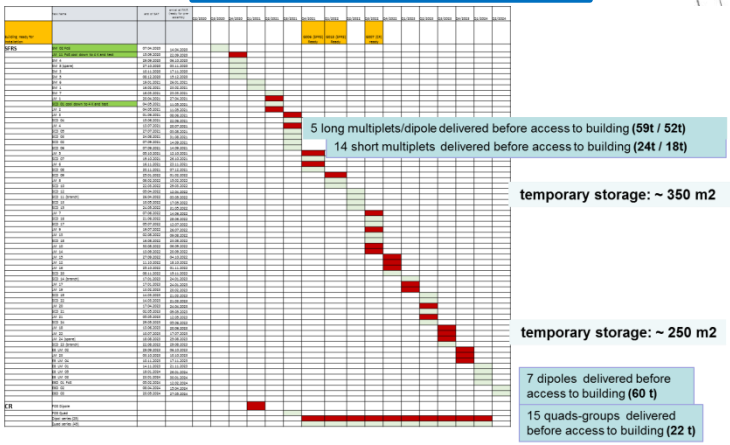
planned storehouse

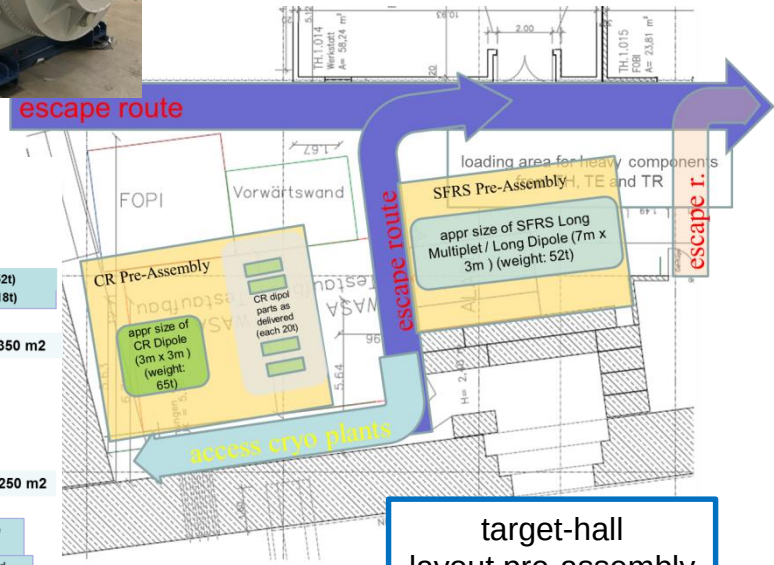




Technical Work Instructions
Arbeitsanweisungen

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





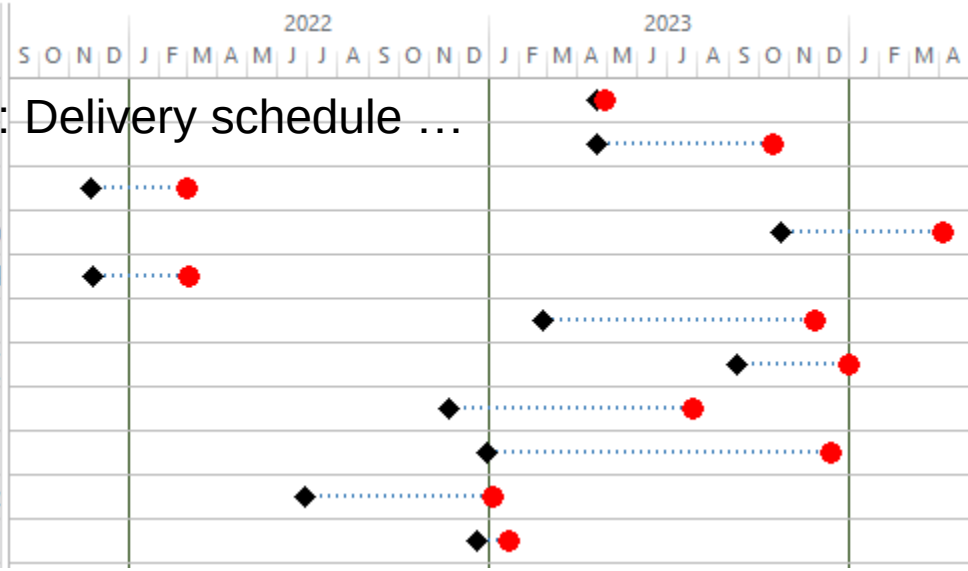
target-hall layout pre-assembly

Impact analysis on project schedule beam time: 2021-23

	Work at FRS	
	Jan-June	July-Dec
Knoebel; Ronja	100%	0%
Mukha; Ivan	100%	0%
Amjad; Faraz	50%	0%
Kazantseva; Erika	50%	0%

Shift crew members, further experts on call !

Startup-Pl	ActivityCode	PSPCode	Task Name
Exp Ph. 1a /	S006.M10	2.4.11.1	Beam Catcher
Exp Ph. 1a /	S006.M10	2.4.11.3.1	Target chamber
Exp Ph. 1a /	S006.M10	2.4.11.3.2	Graphite wheel assembly
Exp Ph. 1a /	S006.M10	2.4.11.3.3	Safety/transport container - Flask
Exp Ph. 1a /	S006.M10	2.4.11.4.1	Iron shielding - Lateral steel block
Exp Ph. 1a /	S006.M10	2.4.11.4.2	Iron shielding - Steel slabs (roof)
Exp Ph. 1a /	S006.M10	2.4.11.4.3	Iron shielding - Remaining steel (
Exp Ph. 1a /	S006.M10	2.4.6.2.1	Target ladder
Exp Ph. 1a /	S006.M10	2.4.6.2.5	Beam Stoppers
Exp Ph. 1a /	S006.M10	2.4.7.1.12.1	Diagnostic chamber (different siz
Exp Ph. 1a /	S006.M10	2.4.7.6.1	Robot Handling



IMPORTANT: only delay on procurement of components estimated; delay on pre-assembly not estimated
No impact on: sc/nc Magnets & testing, Local Cryogenics, better planning allows for further optimizing

- Very rough estimation based on availabilities – Sizable shifts without optimizing
- Would benefit from better resource leveling ➔ proposal presented 14.7.2020
- Shutdown planning as part of CAMPUS Master schedule separately

- **Test FoS sc magnets at CERN**
  - CERN allowed an early start of test facility after Covid lockdown → qualification of sextupole successfully done
  - Test methodology established
  - Commissioning of the **2nd testing bench** started; necessary for testing the FoS sc dipole
- Series **production** multiplets and production FoS dipoles **on track** again (after Covid lockdown)
- **FAT FoS long multiplett** successfully completed (31/07). Arrival at CERN by mid of October.
- **Contract** for **sc branched dipoles** signed with Elytt, Bilbao, Spain (4th May). Kick-off meeting done; combined schedule standard + branched agreed.
- **Lateral iron shielding: FDR** this week. Production starts.
- **BINP workshop** (25-29 May): priorities clarified, nc multipole conceptual design presented, branch box conceptual design presented, several vacuum packages running
- BINP **R&D NC multipoles** completed (27th July)
- **Local Cryogenics:** FAIR-WUST Co-operation Agreement und Implementing Agreement signed on August, 4th. Implementing Agreement GSI-WUST (Poland) signed (31st Aug). Lots of consolidation steps in progress. Production plan in preparation.
- **Beam Stoppers**: Invitation to tender closed, 4 bidders invited to submit an offer
- **ToF detectors**: Contract signed (26th June). Kick-off meeting done (4th Sept), schedule agreed
- Production plans for **SEM detectors** and for **detector ladder** done (27th May) with HIP, Finland
- **Shielding Flask** (IK FI, SW): common tender Super-FRS + p-bar; negotiation with 3 bidders

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
  - ➢ Local Cryogenics, Beam Catchers
  - ➢ some WP concerning beam instrumentation

• Civil Construction main topic:
  - ➢ FAIR south area construction started
  - ➢ Building services revisions (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 !