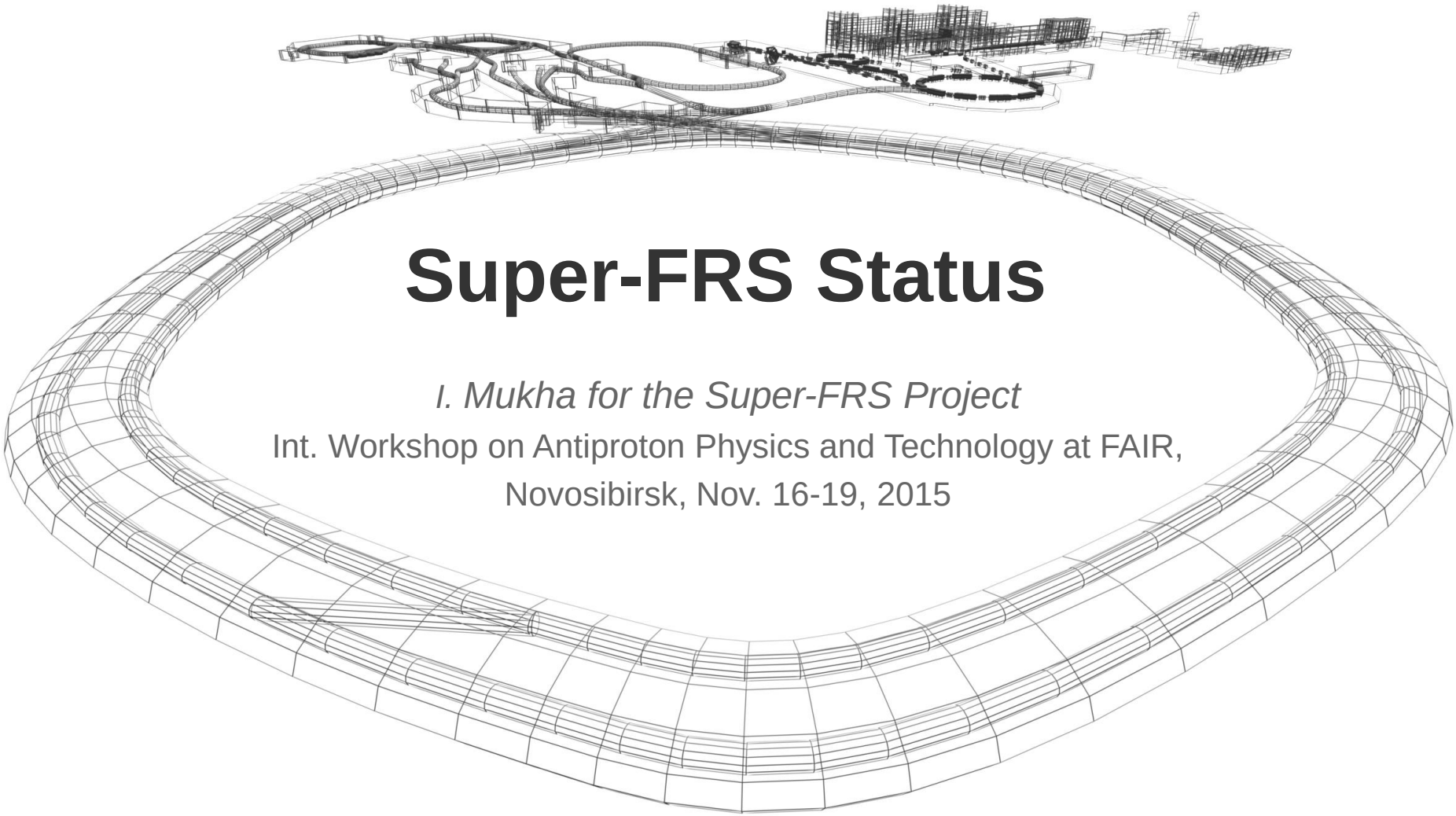
GSI Helmholtzzentrum für Schwerionenforschung GmbH



Super-FRS Status

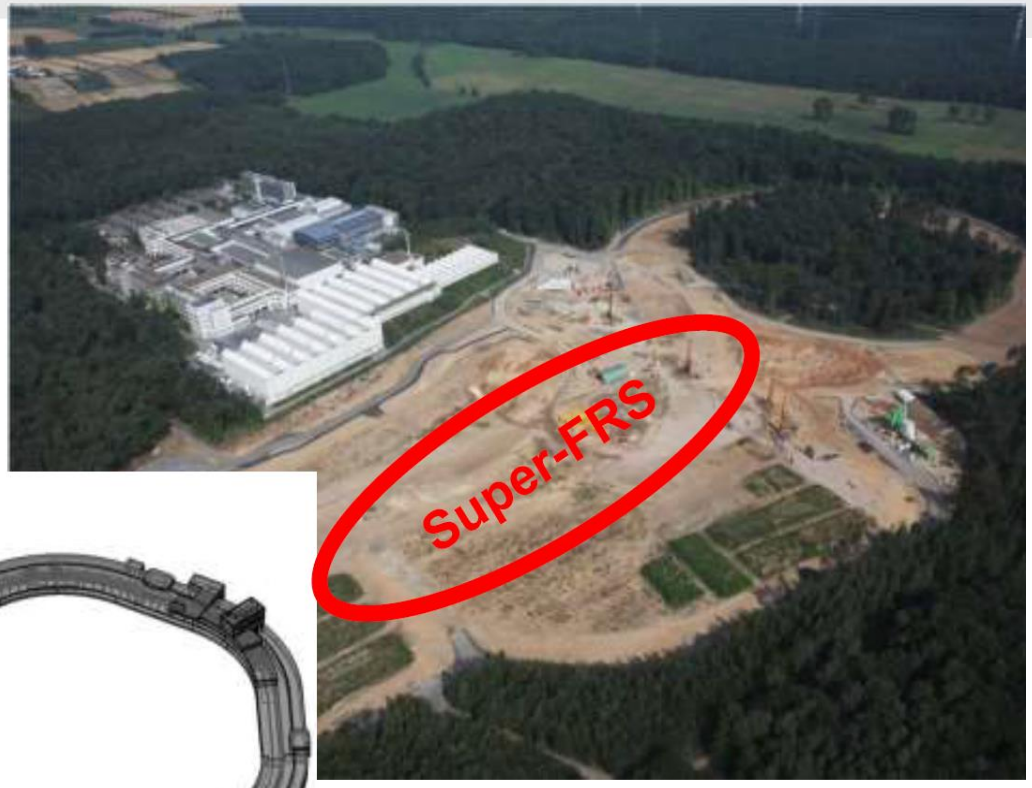
I. Mukha for the Super-FRS Project

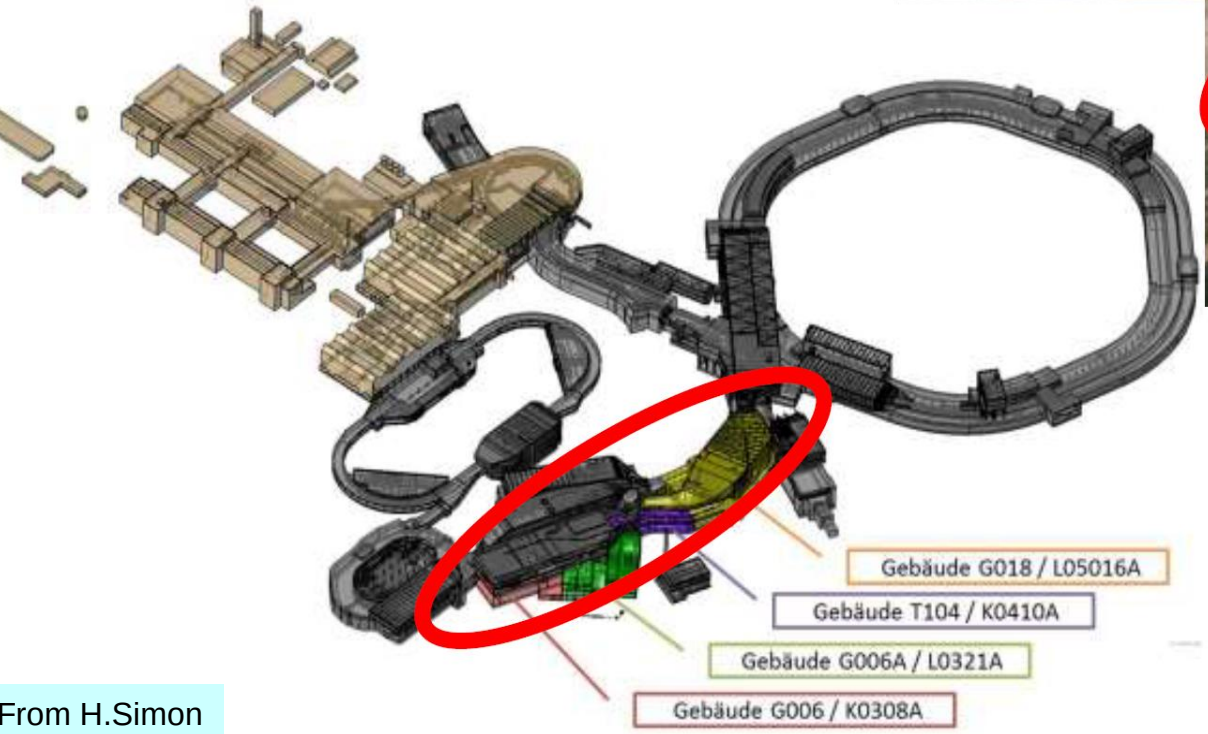
Int. Workshop on Antiproton Physics and Technology at FAIR,
Novosibirsk, Nov. 16-19, 2015

Outline

- Super-FRS Layout and Design Principles
- Civil Construction
- Super-FRS Components
- Project Control
- Summary

Stepping stone towards the facility





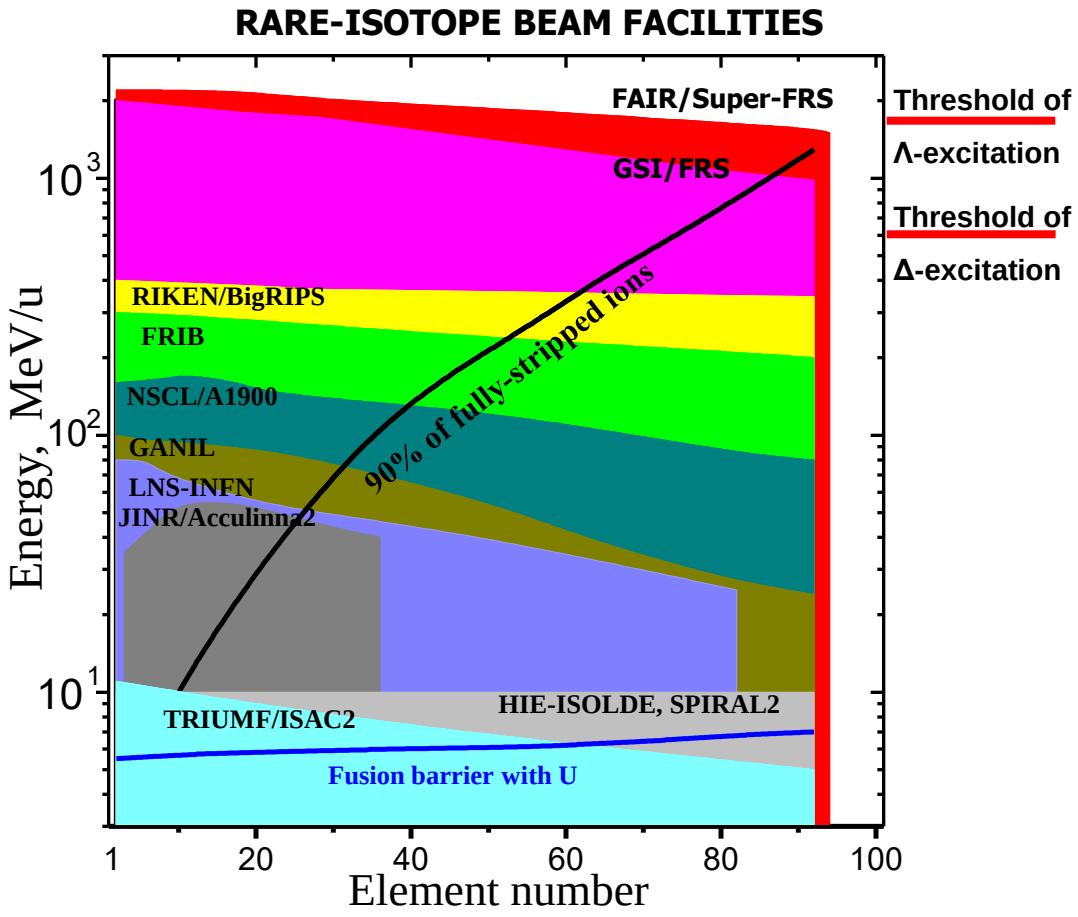
From H.Simon

Unique features of the Super-FRS

- Universal beams: ions of all elements up to uranium
- Beam energies 100...2000 MeV/u
- Spectrometer with high momentum resolution (dp/p~1E-4)
- Flexible ion-optical multiple-mode/multiple-stage operation (isotope separation, dispersion-matched stages, spectrometer modes)

Transition from FRS → Super-FRS

- 100 x higher primary-beam intensity
- 10 x higher transmission for projectile fragments and fission products
- higher ion-optical flexibility: multiple-stage operation/separation/ measurements
- full transmission to the three branches (LEB, HEB, RB)
- new instrumentation at all branches: high-resolution spectrometer and ISOL-type experiments



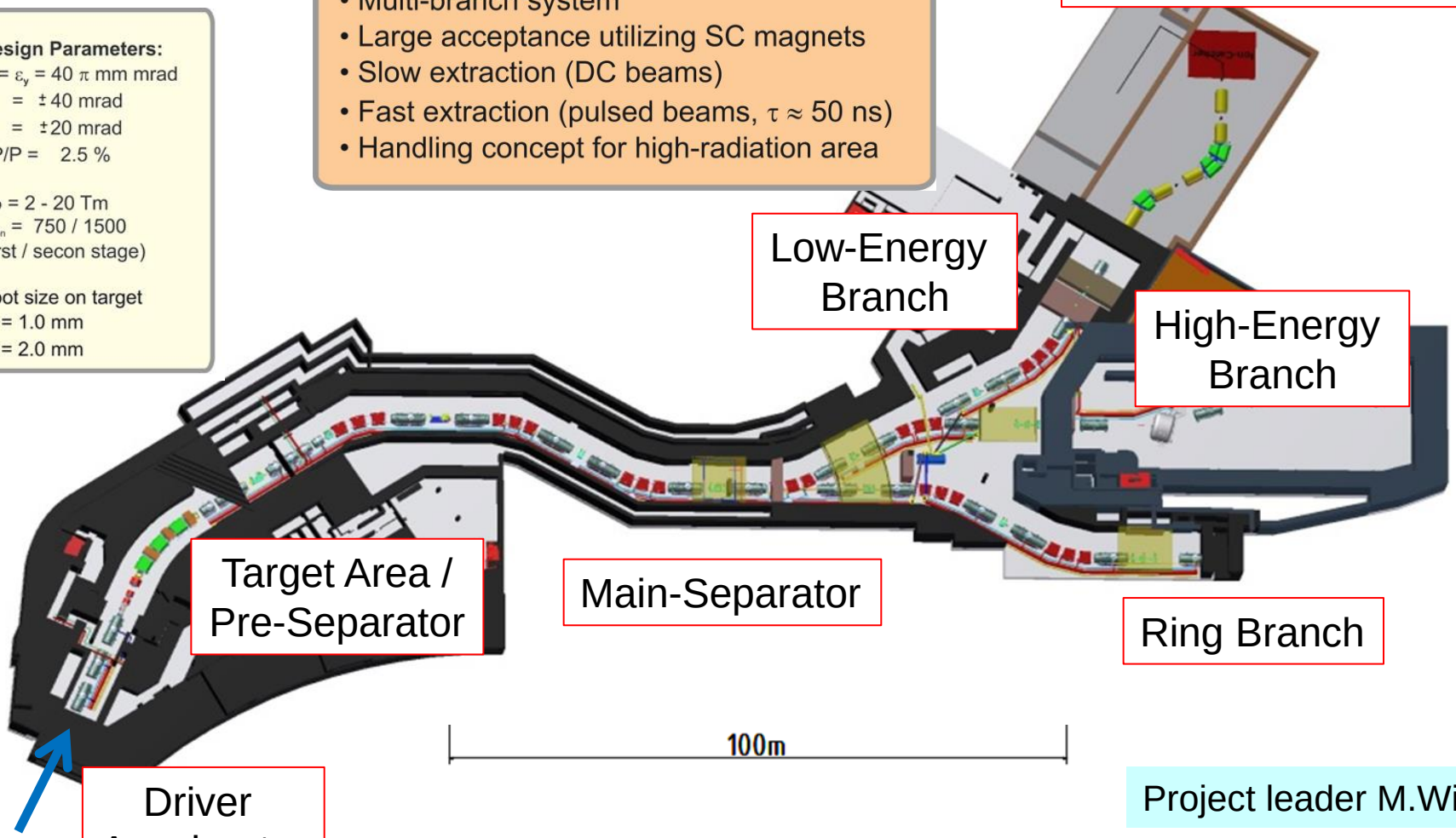
Super-FRS Layout and Design Principles

Features:
- 2 Separator-stages
- Multi-branch system
- Large acceptance utilizing SC magnets
- Slow extraction (DC beams)
- Fast extraction (pulsed beams, $\tau \approx 50$ ns)
- Handling concept for high-radiation area

Design Parameters:
$\varepsilon_x = \varepsilon_y = 40\ \pi$ mm mrad
$\varphi_x = \pm 40$ mrad
$\varphi_y = \pm 20$ mrad
$\Delta P/P = 2.5\ \%$

$B\rho = 2 - 20$ Tm
$R_{ion} = 750 / 1500$
(first / secon stage)

Spot size on target
$\sigma_x = 1.0$ mm
$\sigma_y = 2.0$ mm



Project leader M.Winkler

NUSTAR Buildings

	03_Major_Milestones (Buildings)	
	CC Phase B	
SCC	**Transfer SFRS - Experimente (K0410A) (T103)**	
SCC.MB10-LV	Building ready for installation + Low voltage distribution boards active	14.01.2020
SCC.MB11	Building ready for accelerator commissioning	30.06.2020
SCC	**SFRS (L0516A) (G018)**	
	Kontrolle und Übeprüfung von Ausführungsplanung	01.08.2016
	Start of construction	03.07.2017
	Shell building ready for iron shielding (ESTIMATION!!!)	11.01.2019
SCC.MB09	Building shell completed	03.07.2017
SCC.MB10-LV	Building ready for installation + Low voltage distribution boards active	14.01.2020
SCC.MB11	Building ready for accelerator commissioning	30.06.2020
SCC	**SFRS HE-Cave (K0308A) (G006)**	
SCC.MB09	Building shell completed	03.07.2017
SCC.MB10-LV	Building ready for installation + Low voltage distribution boards active	14.01.2020
SCC.MB11	(K0308A) (G006) Building ready for accelerator commissioning	30.06.2020
SCC	**SFRS LE-Branch (G006B)**	
SCC.MB10-LV	Building ready for installation + Low voltage distribution boards active	14.01.2020
SCC.MB11	Building ready for accelerator commissioning	30.06.2020
SCC	**SFRS Supply (L0321A) (G006A)**	
SCC.MB10-LV	Building ready for installation + Low voltage distribution boards active	14.01.2020
SCC.MB11	Building ready for accelerator commissioning	30.06.2020

- Execution planning: on hold
- Route planning: on hold
- Review 02/2015: consider LEB cave
- Concept Rep. on a target shielding
- Gas supply, gas mixing station
- Establishing cable base

Build. 006a,
Service building

Build. 006
(High-Energy cave)

Build. 018,
(Target building)

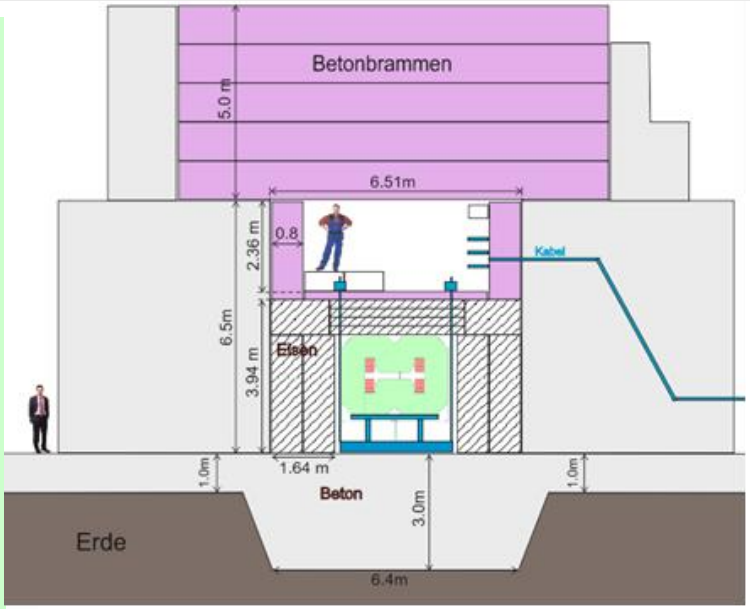
Tunnel 103
(Separator tunnel, supply tunnel)

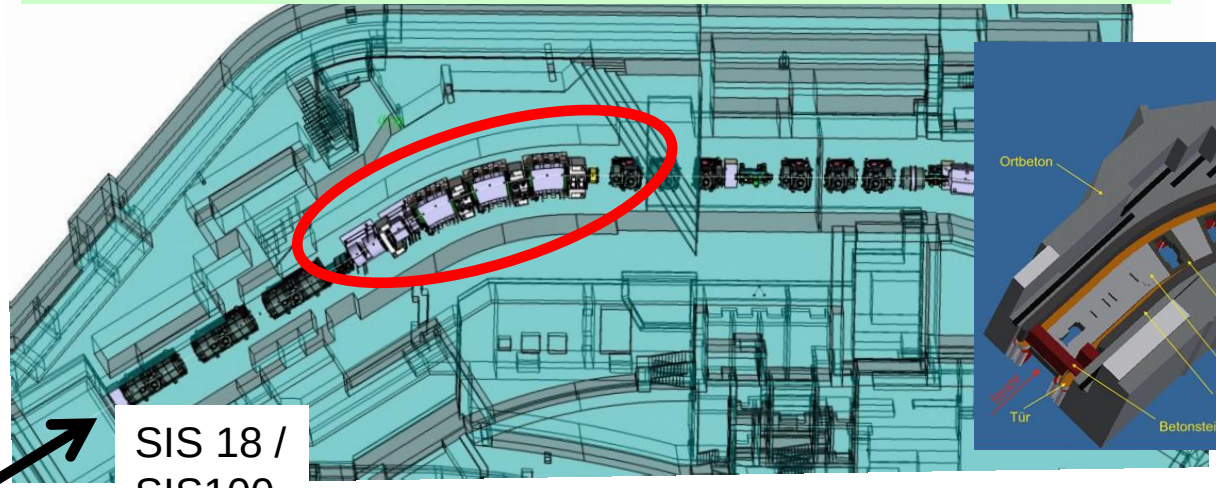
To Coll.Ring

100 m

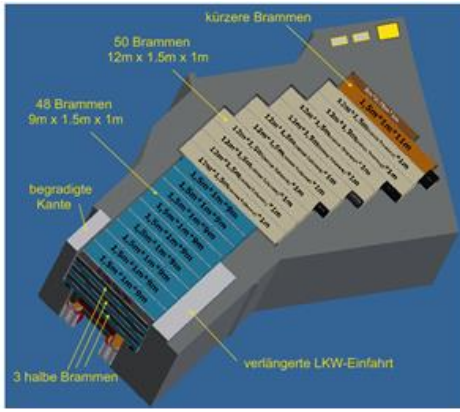
Target Shielding, Build. 018
(CR under approval)

- Detailing of target area shielding planning
  - ➢advanced overhead crane design
  - ➢advanced planning of maintenance-tunnel
- Main measures of proposed changes
  - adapt shielding of beam-tunnel
  - height and shielding of maintenance-tunnel
  - slab shielding of maintenance-tunnel
  - various: front-end access to maintenance-tunnel, storage for plug-insertion, ...

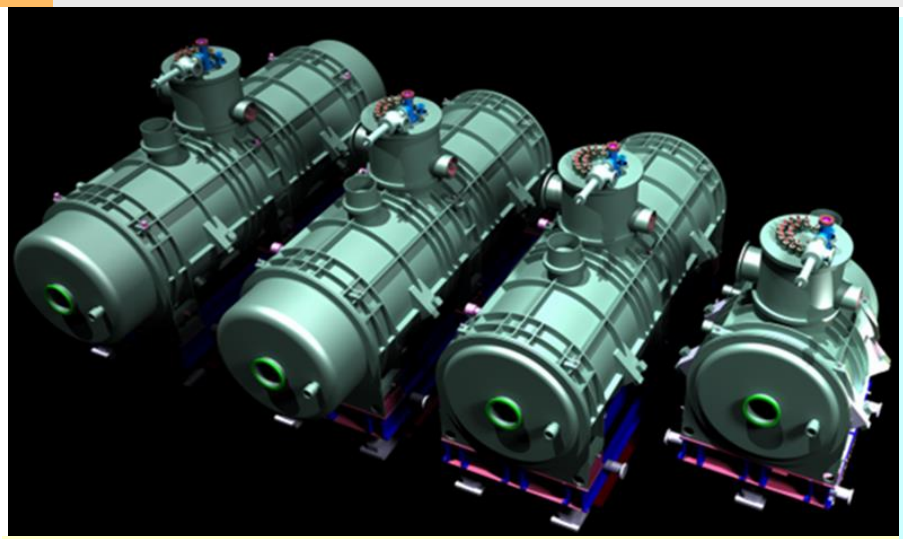




SIS 18 / SIS100



SuperConducting (SC) Multiplets



- 25 long multiplets (mainly Main Sep.)
- 8 short multiplets (Pre-Sep.)
- Quadrupol triplet / QS configuration
- include corrector elements & steerer

- iron dominated, cold iron (≈40 tons)
- common helium bath, LHe ≈ 1.300 l
- warm beam pipe (38 cm inner diameter)
- per magnet 1 pair of current leads
- max. current <300A for all magnets

Tender History:

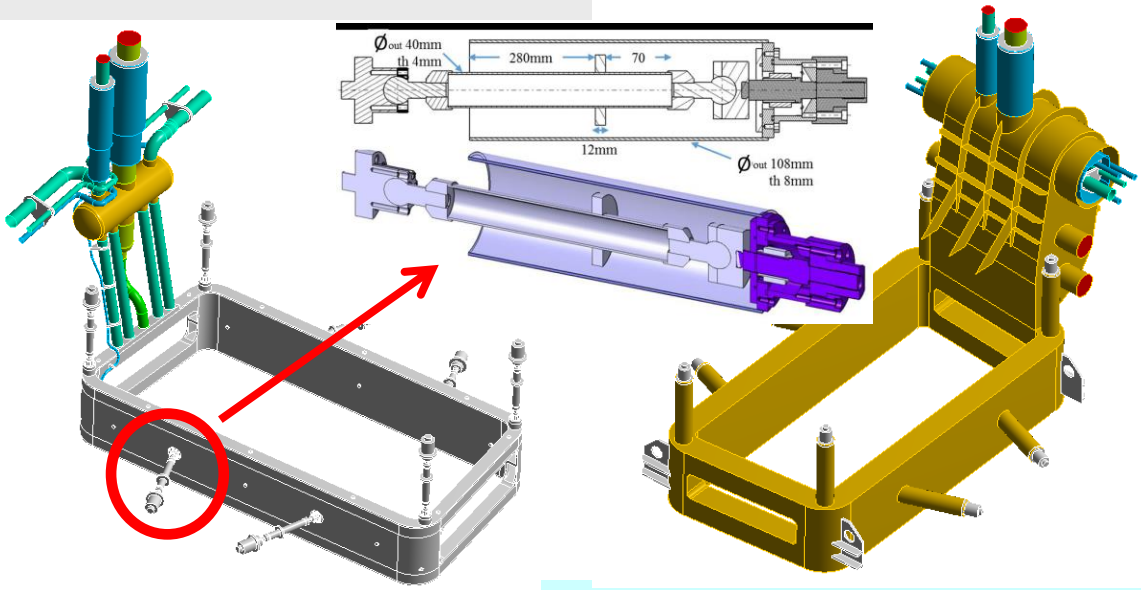
- Tender opened in Q3/2013
  - ✓ qualifying and two negotiation rounds
- Interruption in Q2/2014 (formal aspects)
- Re-opening in Q3/2014,
  - ✓ supervised by lawyer's office
  - ✓ no qualifying, two negotiation rounds
- **Contract award July 1st, 2015 ☺ ☺ ☺**
- Winning company: ASG Genoa
- **Contract volume: ≈ 50 M€**

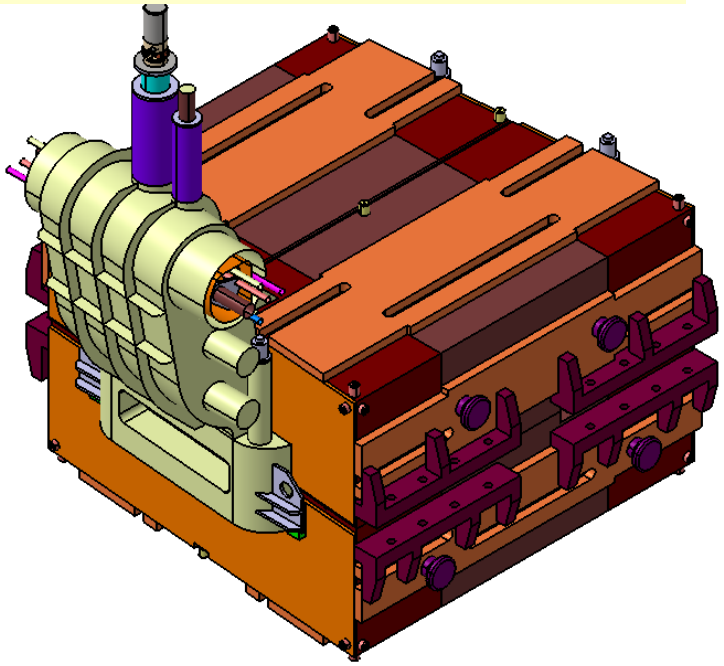
Kick-off, ASG Genoa, July 14, 2015

SC Dipole Magnets I

Scope

- 3 dipole units 11°
- 21 dipole units 9.75°
  - ➢ 3 times modified cryostat
- Warm iron, SC coil
- Aperture ±190mm x ±70mm
- Weight: 50 to 60 ton





Overall Status (branching dipoles are not included):

- ✓ Collaboration agreement with CEA/Saclay:
  - ➢ In-Kind Contribution is under preparation, it includes Detailed design, Technical follow-up
- ✓ Technical Kick-off 01/2014
- ✓ Visit from IMP Lanzhou 04/2014 (CEA & GSI)
- ✓ Pre-DR & Final DR (includes external advisor)
- ✓ Concept DR established,
  Detailed Specifications are under assessment
  - ➢ Documents in release process (EDMS, 10/2015)

SC Dipole Magnets II

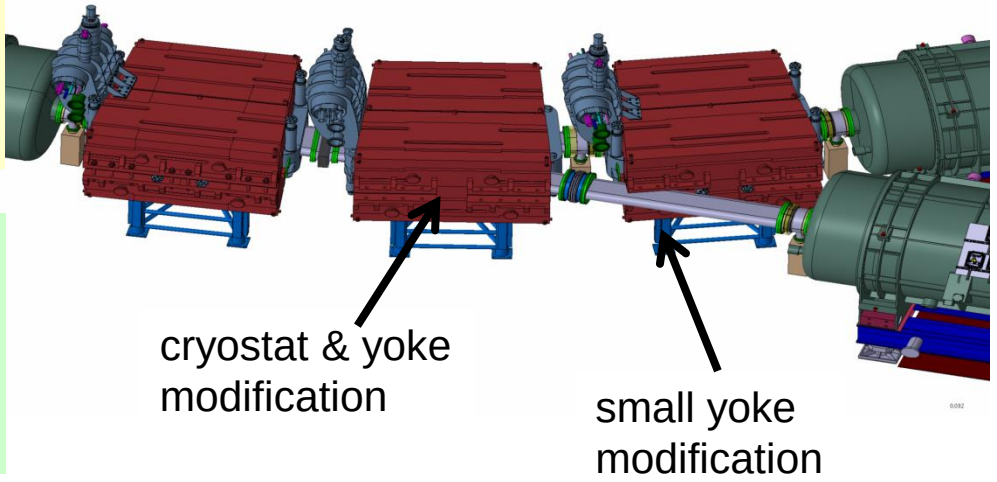
Branching Magnets:

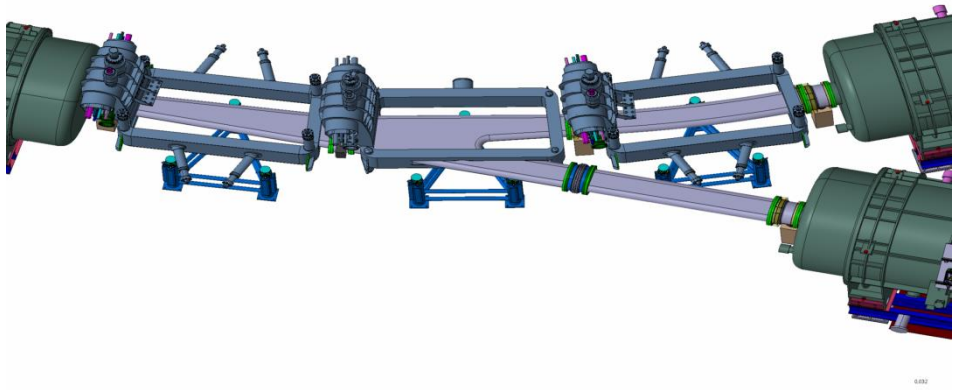
- needs special design for yoke & cryostat
- integration of y-shape vacuum chamber to reinforce cryostat

SC Wire Tendering (closed):

- ➢ Contract award 05/2015
- ➢ Winning Company: Luvata, Finland
- ➢ Delivery 1st batch 05/2016 (-> FOS dipole)

Branching Point



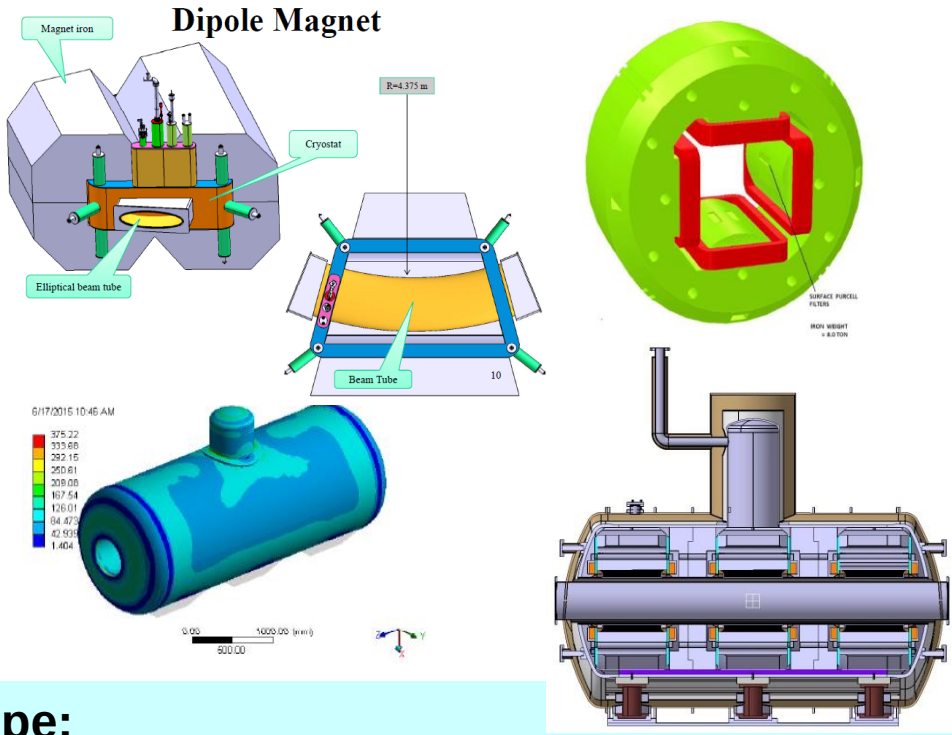


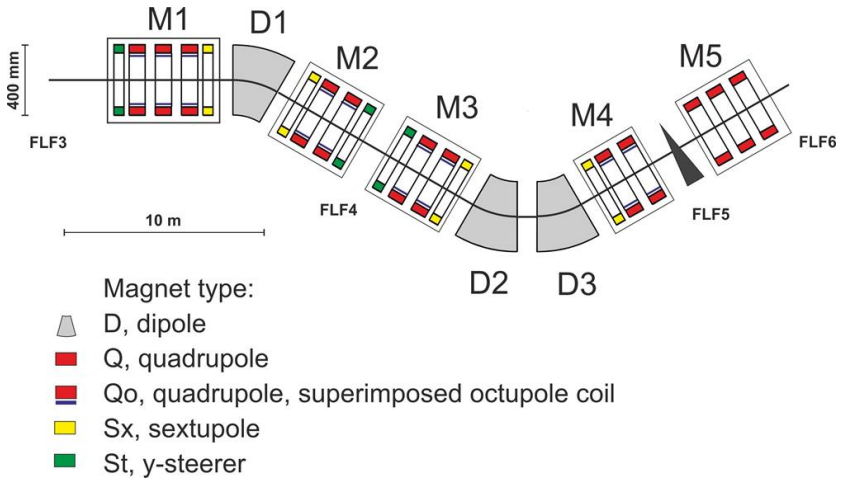
Procurement Dipoles:

- ✓ Pre-bidder information meetings Q4/2014
- Tender opening (by FAIR): Q4/2015
- Contract award expected Q2/2016
- Final DR expected Q4/2016
- Factory Accept. Test of the First-of-Series: Q3/2017
- Site-Accept.Test (CERN): Q1/2018 -> release of series
- Prod. and Test of series: Q2/2018 – Q2/2021

Magnets of the Energy Buncher

Overall status:
- Coll. partner VECC **(Indian in-kind)**
- Regularly meetings established
- Parameters of individual magnets fixed
- Preliminary magnetic designs available
- Preliminary cryostat designs available
  - ➢ Collision within available space
  - ➢ 20 bar design to be verified





Scope:
- 3 dipole units with 30°deflection angle
  - ➢ superferric, warm iron, SC coils
  - ➢ challenging: required field quality
- 5 multiplets, QD or QT configuration
  - ➢ superferric, cold iron
  - ➢ parameters of magnets like in separator

Magnet Testing @ CERN

- Scope (separator magnets):
  - ✓ 24 Dipoles (PS & MS),
  - ✓ 31 Multiplets (+ 2 spare)
  - – does not include EB magnets
- Place: CERN building 180; includes:
  - ➢ testing area, storage area
  - ➢ control room, offices

Facility ready in Q4/2016

3 universal test benches, basically:

- 1 setting-up & cool-down
- 1 measuring
- 1 warm-up & disassemble

each activity ≈15 days

Series measurement time

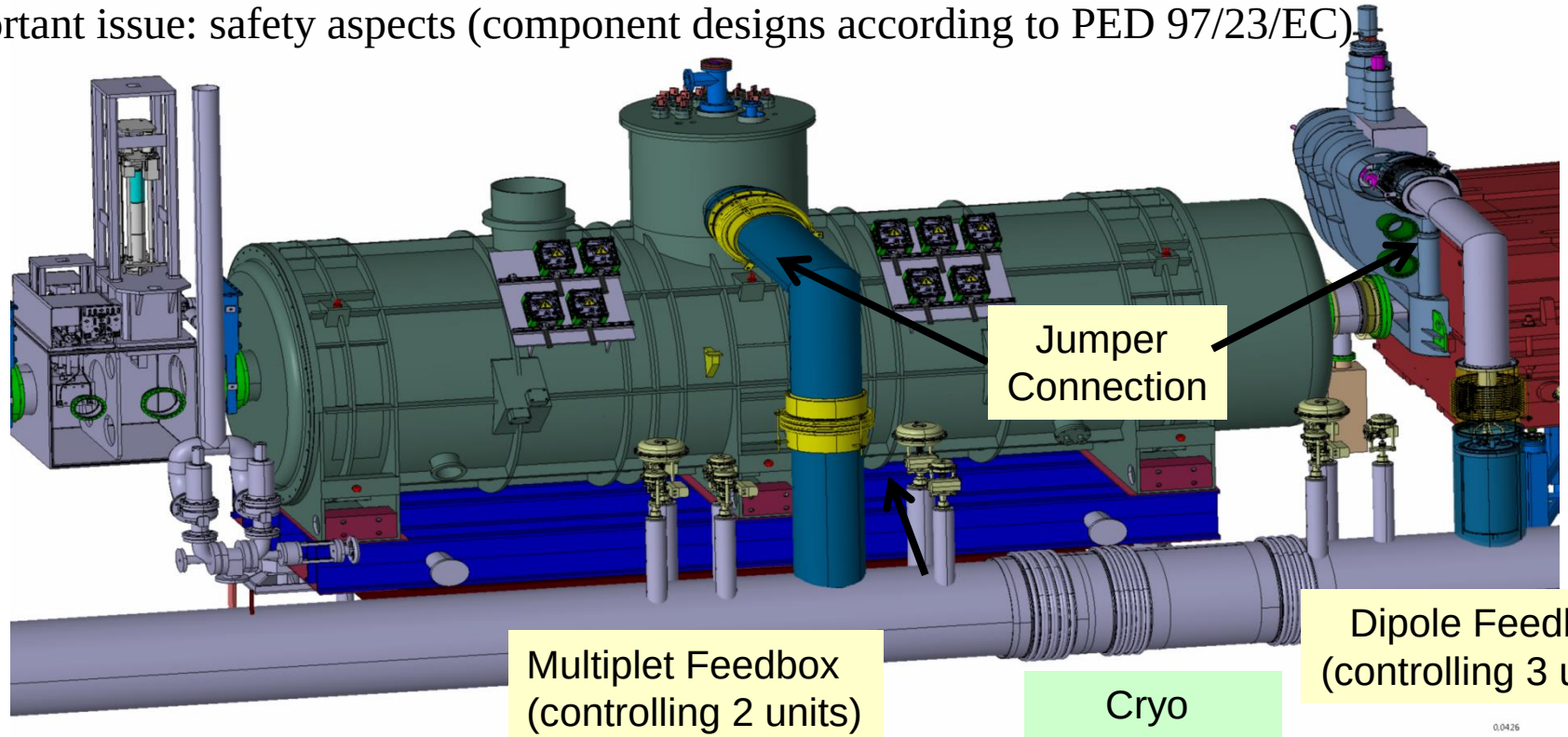
➢ 3 to 3.5 years

Super-FRS Local Cryogenics

Tasks:

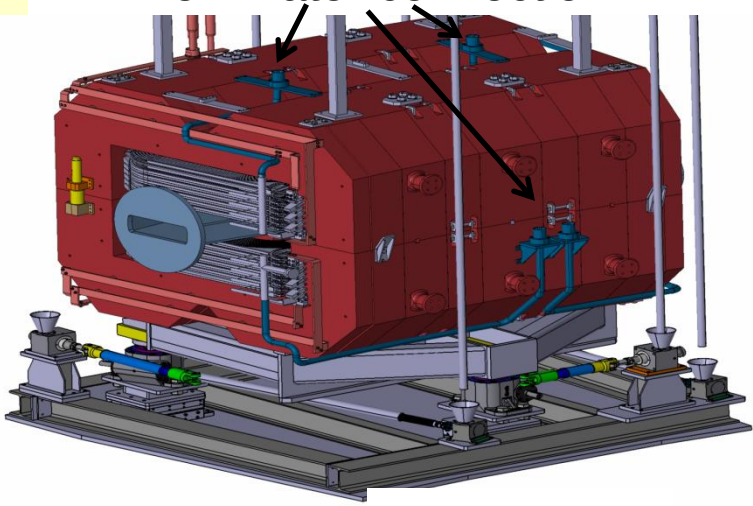
- Design and development of Super-FRS local cryogenic system
- Specifying/developing of main LC components **(Polish In-Kind)**
- Support of Super-FRS SC magnet development
- Support to the design of the testing facility @ CERN

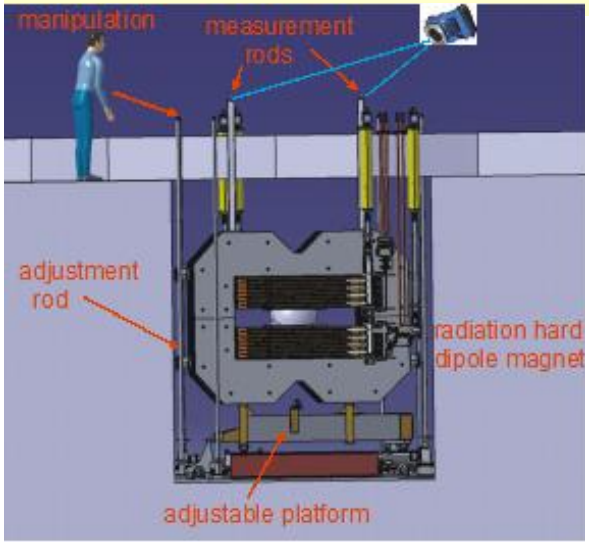
Important issue: safety aspects (component designs according to PED 97/23/EC)

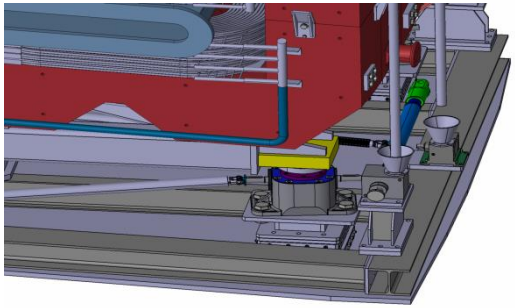


Radiation Resistant Magnets (at the Target Area of Super-FRS)

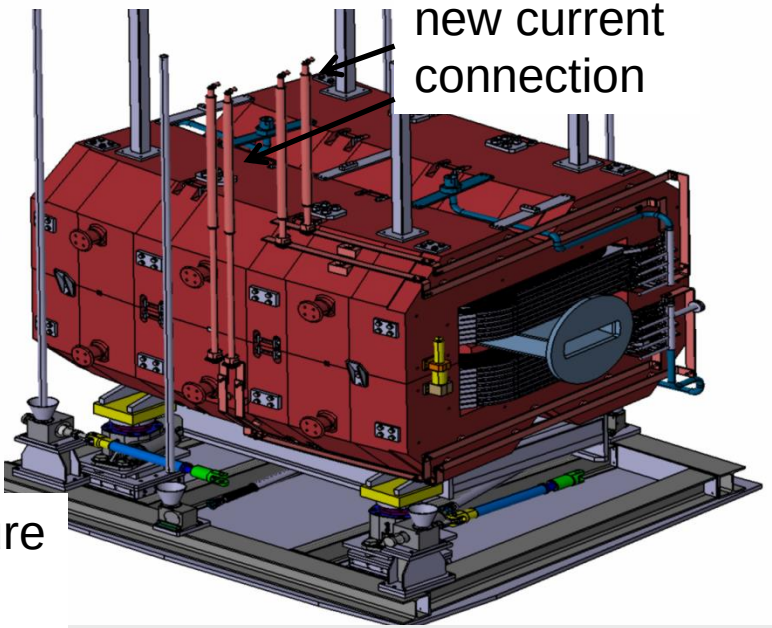
- ✓ Normal conducting magnets using MIC cable
- ✓ 3 dipole units, 3 quadrupoles, 2 sextupoles
- ✓ Prototype dipole (95 ton) built and tested
- ➢ Modification of remote alignment
  - ✓ Design ready
  - ✓ Tender (construction) in preparation
- ➢ Remote connectors under revision
- • **Tendering** of magnets via FAIR (Q3/2016)





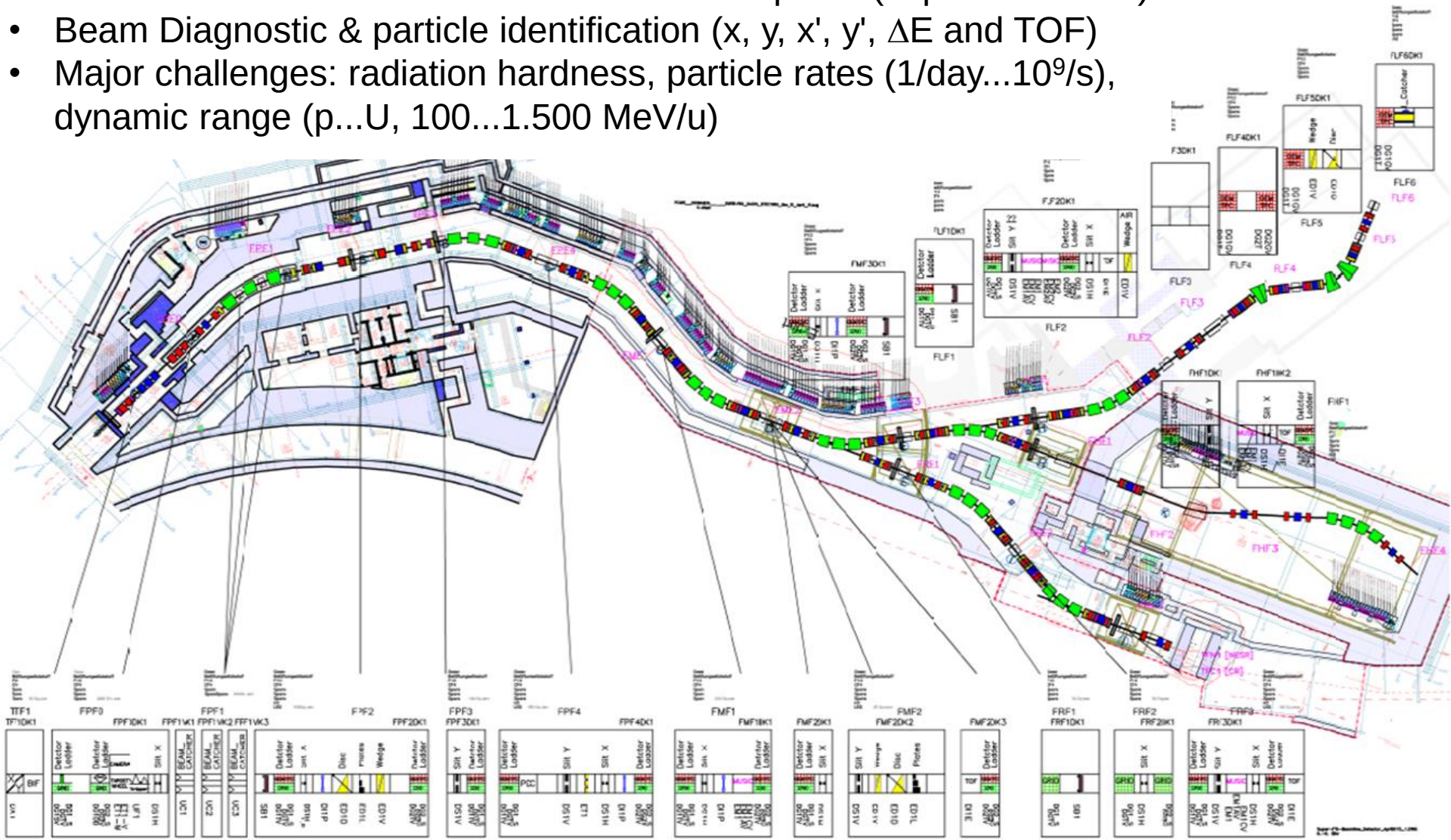


new support structure (lubricants free)



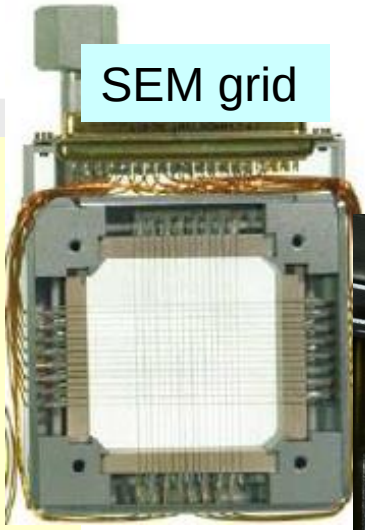
Focal Plane Equipment (Overview)

- Beam instrumentation defined for each focal plane (separator mode)
- Beam Diagnostic & particle identification (x, y, x', y', ΔE and TOF)
- Major challenges: radiation hardness, particle rates (1/day...10^9/s), dynamic range (p...U, 100...1.500 MeV/u)



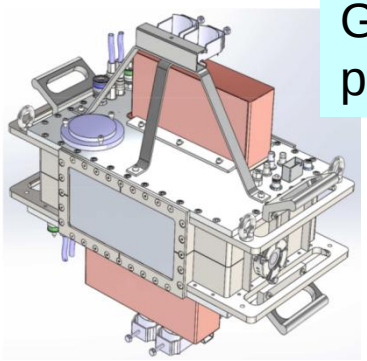
Beam Diagnostics

- Full isotope identification (x, y, x', y', ΔE and TOF)
- Operation modes: fast- and slow-extracted beams
- Detector systems (all are in R&D / Prototype Phase)
  - SEM-GRID & ladder system (**Finnish in-kind, GSI**)
  - GEM-TPC (**Finnish in-kind, U Bratislava, GSI**)
  - Silicon detectors (**Russian in-kind, Ioffe PTI**)
  - Diamond detectors (**Russian in-kind**)
  - Plastics (**Swedish in-kind**)
  - MUSIC detectors **(EoI Finland, GSI, CEA Bruyère**)
- Beam tests in 2015/2016 at: Jyv., LNS Catania, Riken
- DAQ (**Swedish in-kind**) -> NUSTAR EDAQ

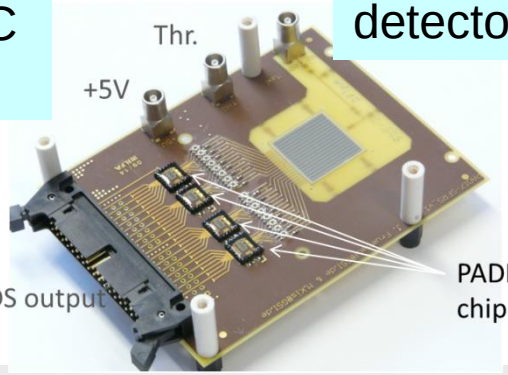


SEM grid

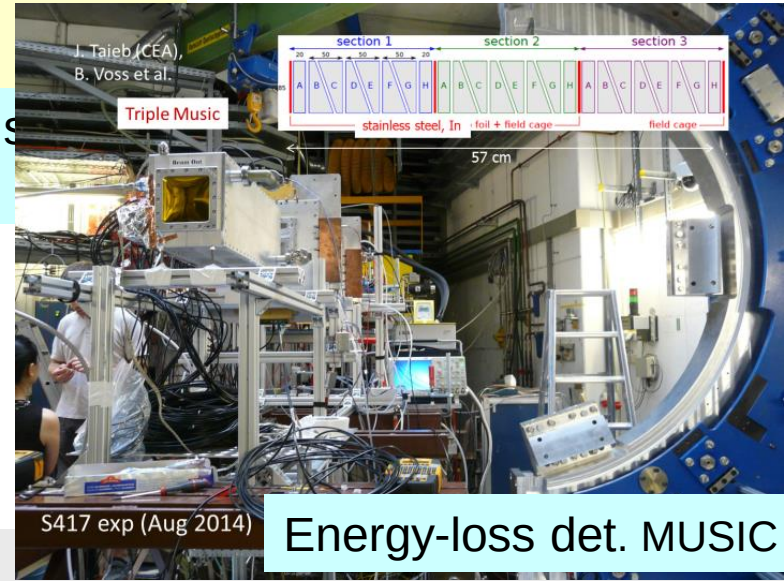
Silicon TOF



GEM TPC prototype



Diamond s
detector



Energy-loss det. MUSIC

Focal Plane Chambers (example: FMF2, midplane MS)

- In total 21 chambers
- Chambers cross section
  - 1x1 m^2
- Chambers length:
  - from ≈0.8 m to ≈4.5 m

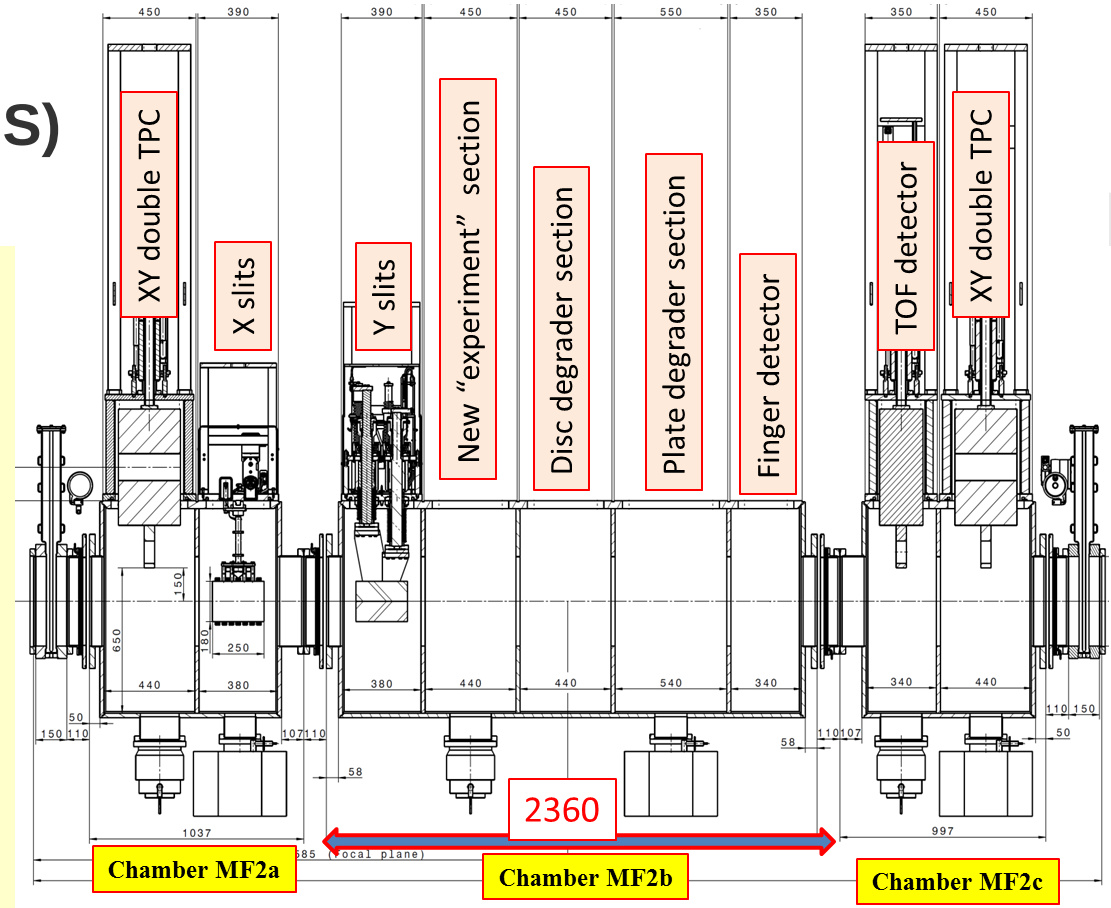
✓ Total weight of 28 tons

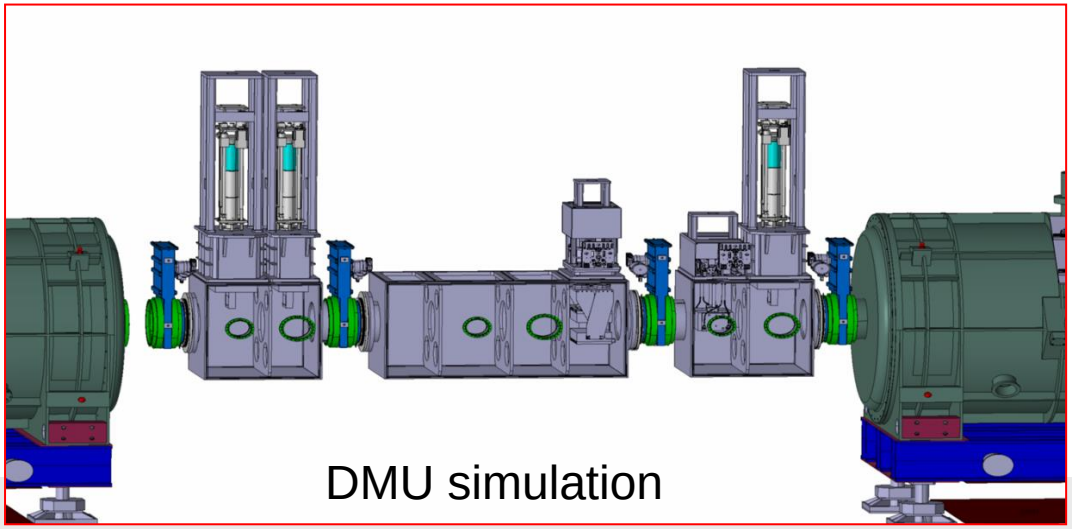
✓ ‘Standardized’ flanges for inserts

✓ Pumping ports and vacuum instrumentation considered

✓ DMU collision checks

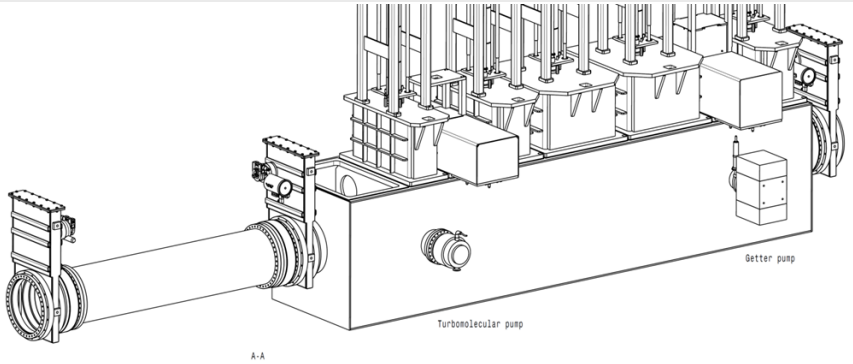
✓ Remote handling capability (robotic @ Pre-Separator)

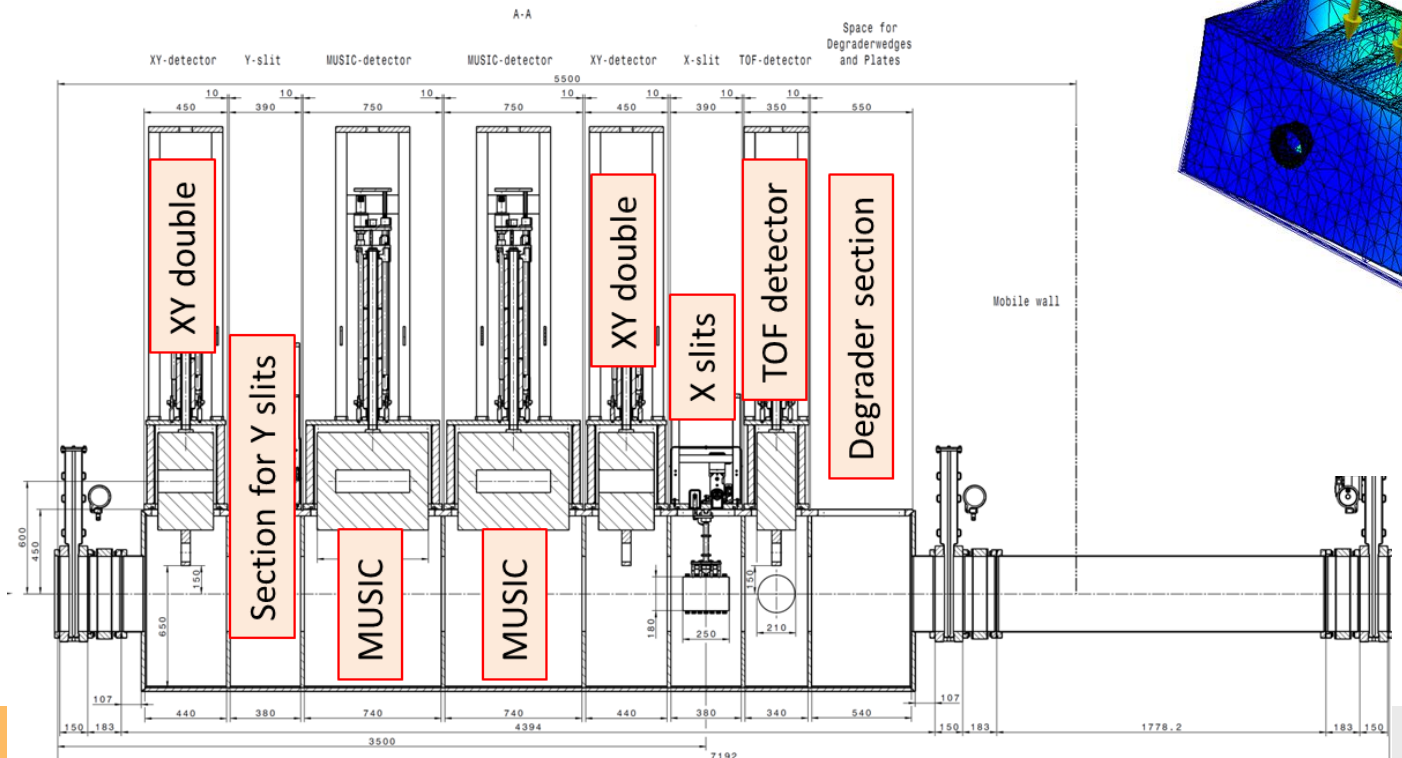


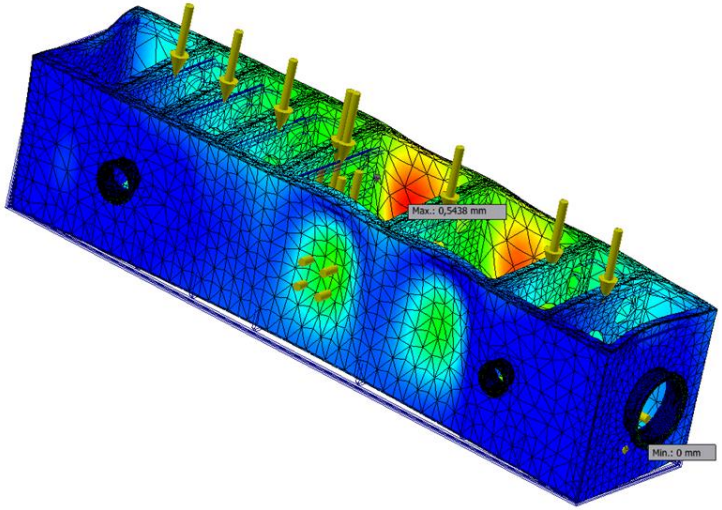


Focal Plane Chambers.
Example: FLF2 at exit of LEB

- The FLF2 area prolonged by 2m
- Chamber has 8 inserts, length ≈4.4 m
- FEM simulation of chamber stability including vacuum and the inserts load







Focal Plane Chambers. Outlook

- In sum 21 chambers, total weight of 28 tons
- Detailed Technical Specifications

  expected in Q2/2016
- **Russian In-kind Contract** (or via Tender)

  expected Q3/2017
  - ~1200 kEur by the EoI FAIR-BNPI
- Final Design Report

  expected Q1/2018
- Delivery

  expected Q2/2018-Q4/2019
- Site Acceptance Tests

  expected Q2/2018-Q1/2020

Device type: SFRS Diagnosekammern, PSP:2.4.7.1.1 , Owner: RBFR

Nr	Name	Nomenklatur	CID	Dimensions, LxBxH	Weight, kg	Drawing number	Last update
1	TFF1	TFF1DK1		1044x960x965	900	TS-1014999-A-V02	27.01.2015
2	TPF0	TPF0DK1		1044x960x965	900	TS-1014999-A-V02	27.01.2015
3	PF2	FPF2DK1		3470x960x1130	2574	TS-1015337-A-V02	27.01.2015
4	PF3	FPF3DK1		1044x960x965	900	TS-1014999-A-V02	27.01.2015
5	PF4	FPF4DK1		3520x960x965	2770	TS-1015140-A-V01.1	24.07.2014
6	MF1	FMF1DK1		3361x960x965	1864	TS-1015035-A-V03	17.07.2015
7	MF3	FMF3DK1		2354x960x965	1948	TS-1015411-A-V02	16.10.2015
8	MF2a	FMF2DK1		957x960x965	900	TS-1015222-A-V03	25.09.2015
9	MF2b	FMF2DK2		2306x960x1130	1890	TS-1015222-A-V03	25.09.2015
10	MF2c	FMF2DK3		997x960x965	782	TS-1015222-A-V03	25.09.2015
11	HF1a	FHF1DK1		1594x960x965	1050	TS-1015081-A-V03	14.10.2015
12	HF1b	FHF1DK2		2674x960x965	2025	TS-1015081-A-V03	14.10.2015
13	LF1	FLF1DK1		1044x960x965	900	TS-1015024-A-V02	27.01.2015
14	LF2	FLF2DK1		4394x960x965	3514	TS-1015200_K5D_V04	19.08.2015
15	LF3	FLF3DK1		997x960x965	782	TS-1015222-A-V02.1	05.08.2014
16	LF4	FLF4DK1		1044x960x965	900	TS-1019672-A-000	12.02.2015
17	LF5	FLF5DK1		2054x960x1130	1476	TS-1019404-A-V01	16.10.2015
18	LF6	FLF6DK1		1044x960x965	900	TS-1015242-A-V02	27.01.2015
19	RF1	FRF1DK1		1044x960x965	900	TS-1015242-A-V02	27.01.2015
20	RF2	FRF2DK1		1454x960x965	1060	TS-1015000-A-V01a	27.01.2015
21	RF3	FRF3DK1		2610x960x965	2041	TS-1015263-A-V02	22.07.2015
	Total	21 stk			27500		

Beam Instrumentation

(slits, degrader, secondary targets, ...)

university of groningen

GSI

X/Y Slit-systems

- Overall 18 slit pairs required
- Remote handling foreseen

✓ Specification established

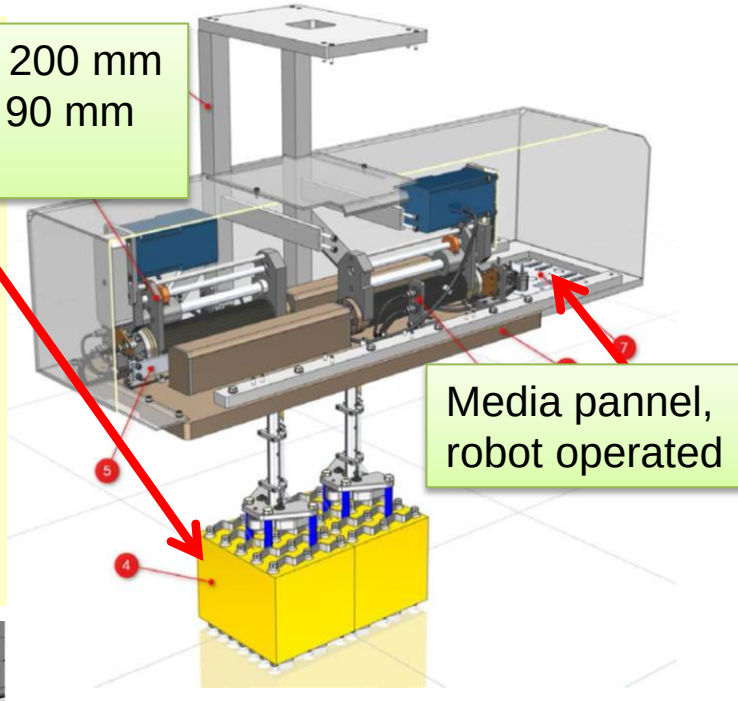
✓ **Collaboration contract with KVI-CART, Nederland**

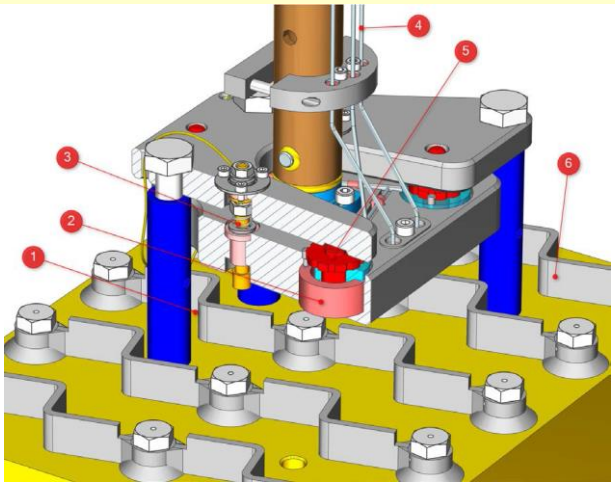
✓ PDR done 08/2014,

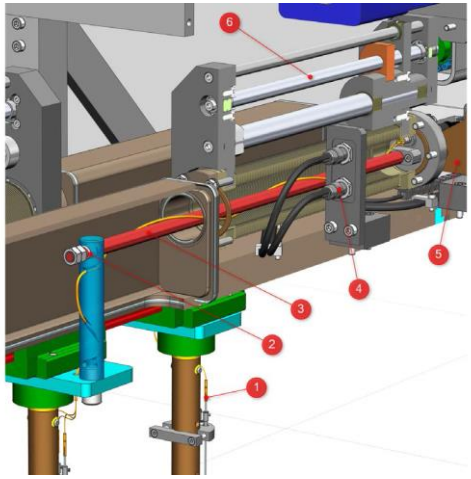
- Pre-design existing
- thermal simulation / cooling issues considered

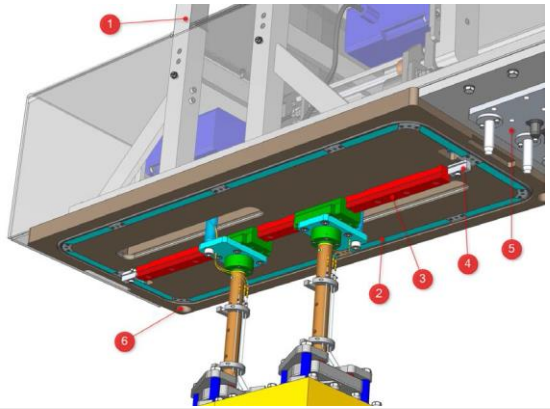
➢ Pre-Series slit-system expected Q3/2015

X-slit size: 200mm x 200 mm
Y-slit size: 400mm x 90 mm
Material: Densimet





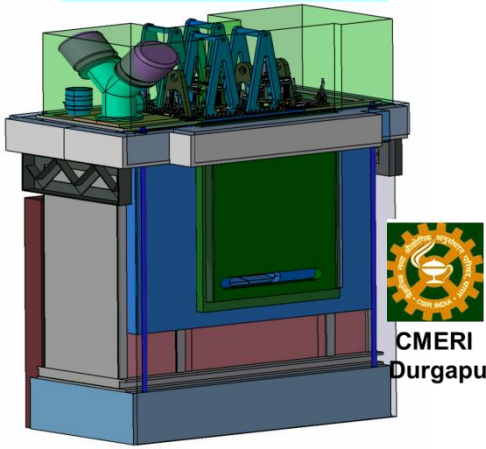


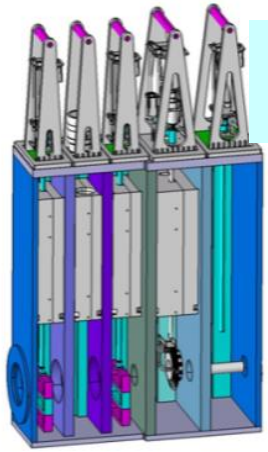


Target Area Installations

- Target chamber & plug inserts **(German in-kind)**
  - ✓ draft specification existing
  - ➢ collaboration contract with KVI-CART in preparation
- Target wheel & plug inserts **(German in-kind)**
  - ✓ Prototype wheel existing, long term R&D running
  - ➢ collaboration contract with KVI-CART in preparation
- Beam catcher (**Indian in-kind**, chamber & plug inserts)
  - ✓ visit of CMERI colleagues in Q4/2014 →
  - ✓ definition report agreed → preparation of specification
- Pillow seals (**German in-kind**)
  - ✓ Prototype set-up (large size) existing

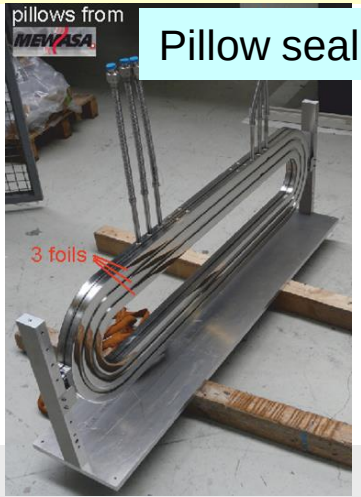
Beam Catcher chamber





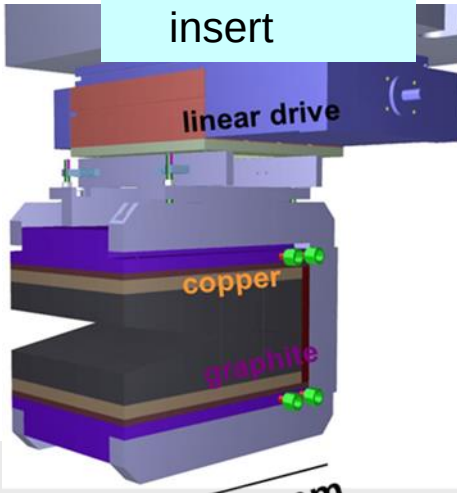
Target chamber

Target wheel



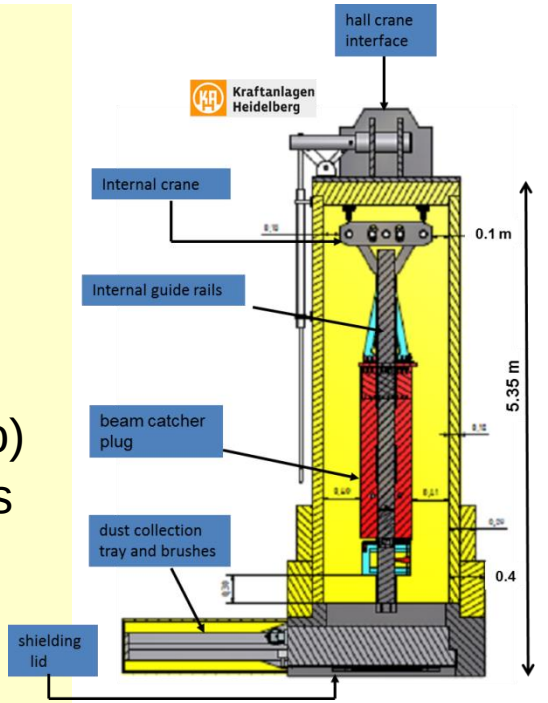
Pillow seal

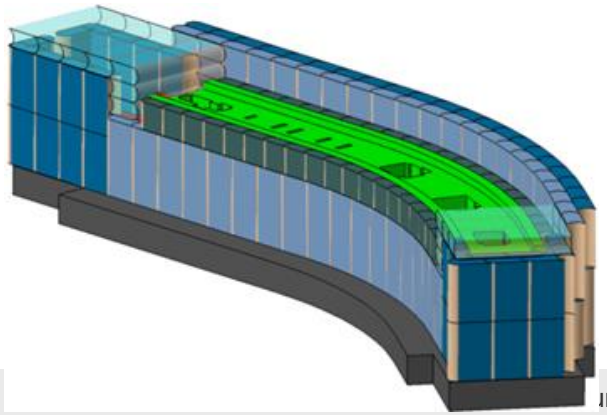
Beam Catcher insert

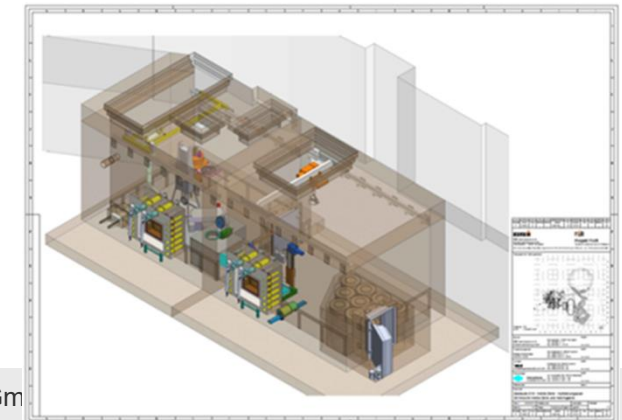


Target Area Infrastructure

- Hot Cell Complex (**German in-kind**)
  - Two-cell concept (maintenance and storage)
  - ✓ Prelim. & approval planning by nuclear eng. company
  - ✓ Mock-up has been installed
- Shielding flask (**Finnish in-kind**, 50 tons)
  - ✓ Draft specification available
  - ✓ Finnish partner identified (Hollming Works LTD, U Aalto)
  - ➢ GSI/FAIR will have responsibility on permissions issues preplanning → approval process → order production.
- Iron shielding (previous ‘missing item’, not yet assigned)
  - ✓ Draft specification available







Project Control

- Project planning and steering based on MS Project
- Comprehensive Project Information
- Weekly report (on machine level)

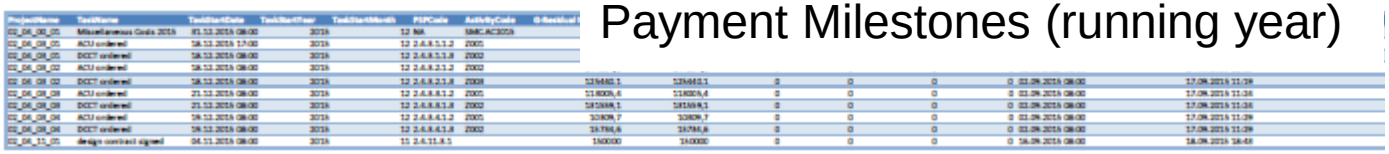
ProjectName	Zuletzt veroeffentlicht	Veroeffentlicht vor X Tagen	ProjectStatusDate	ProjectStartDate	ProjectFinishDate	ProjectPercentCompleted
02_04_12_05	31.07.2015 15:14	-56	31.07.2015 08:00	22.03.2012 08:00	06.07.2020 17:00	7
02_04_12_04	31.07.2015 15:08	-56	31.07.2015 08:00	22.03.2012 08:00	06.07.2020 17:00	8
02_04_12_01	31.07.2015 15:06	-56	31.07.2015 08:00	22.03.2012 08:00	16.03.2020 17:00	25
02_04_00_01	06.08.2015 10:08	-50	06.08.2015 08:00	22.03.2012 08:00	01.01.2022 08:00	34
02_04_Critical_Path	10.09.2015 10:01	-15	10.09.2015 08:00	01.01.2013 08:00	10.11.2022 17:00	21
02_04_07_03	10.09.2015 10:03	-15	10.09.2015 08:00	21.03.2012 08:00	10.09.2021 17:00	29
02_04_00_02	11.09.2015 12:10	-14	11.09.2015 08:00	27.06.2012 08:00	11.11.2021 17:00	5
02_04_02_04	16.09.2015 13:58	-9	16.09.2015 08:00	27.05.2013 08:00	06.04.2022 17:00	14
02_04_02_03	16.09.2015 13:32	-9	16.09.2015 08:00	27.05.2013 08:00	23.03.2022 17:00	8
02_04_02_01	16.09.2015 13:23	-9	16.09.2015 08:00	14.02.2012 08:00	11.11.2021 17:00	11
02_04_12_02	16.09.2015 15:44	-9	16.09.2015 08:00	22.03.2012 08:00	06.07.2020 17:00	17
02_04_02_02	16.09.2015 14:33					
02_04_02_07	17.09.2015 11:38					
02_04_03_01	17.09.2015 11:16					
02_04_02_06	17.09.2015 11:33					
02_04_03_03	17.09.2015 11:24					
02_04_12_03	17.09.2015 08:50	-8	31.07.2015 08:00	22.03.2012 08:00	10.11.2021 17:00	8
02_04_03_04	17.09.2015 11:29	-8	02.09.2015 08:00	19.03.2012 08:00	05.07.2021 17:00	13
02_04_03_02	17.09.2015 11:19	-8	02.09.2015 08:00	02.01.2012 08:00	05.07.2021 17:00	13

Last Project Plan update

ProjectName	TaskIndex	PSPCode	ActivityCode	TaskName	TaskStartDate	TaskFinishDate	% abgeschlossen
02_04_02_02	90	2.4.2.2.3	S002.M5	CD0 (M5)	01.10.2015	01.10.2015	0
02_04_02_02	92	2.4.2.2.4	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_02	93	2.4.2.2.5	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_02	94	2.4.2.2.6	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_02						01.10.2015	0
02_04_02_02						01.10.2015	0
02_04_02_02						01.10.2015	0
02_04_02_02						01.10.2015	0
02_04_02_02						01.10.2015	0
02_04_02_02	100	2.4.7.1.7	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_02	101	2.4.7.2.1.5	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_02	102	2.4.7.2.1.6	S002.M5	Sub-Components (S002.M5)	01.10.2015	01.10.2015	0
02_04_02_03	20	2.4.2.1.4	S002.M3	approval of workpackage description (M3)	26.10.2015	26.10.2015	0
02_04_02_04	19	2.4.2.2.7	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	21	2.4.2.2.8	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	22	2.4.2.3.3	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	23	2.4.7.1.8	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	24	2.4.7.1.9	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	25	2.4.7.2.1.8	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_04	26	2.4.7.2.1.9	S002.M3	approval of workpackage description (M3)	16.10.2015	16.10.2015	0
02_04_02_07	33	2.4.2.2.1	S002.M3	approval of workpackage description (M3)	28.10.2015	28.10.2015	0
02_04_02_07	35	2.4.2.2.2	S002.M3	approval of workpackage description (M3)	28.10.2015	28.10.2015	0
02_04_02_07	36	2.4.2.3.1	S002.M3	approval of workpackage description (M3)	28.10.2015	28.10.2015	0
02_04_02_07	37	2.4.7.2.1.2	S002.M3	approval of workpackage description (M3)	28.10.2015	28.10.2015	0
02_04_02_07	38	2.4.7.2.1.3	S002.M3	approval of workpackage description (M3)	28.10.2015	28.10.2015	0
02_04_06_01	10	2.4.6.1.3	S002.M3	approval of workpackage description (M3)	15.12.2015	15.12.2015	0
02_04_06_01	52	2.4.6.1.4	S002.M3	approval of workpackage description (M3)	15.12.2015	15.12.2015	0
02_04_06_02	10	2.4.6.1.1	S002.M3	approval of workpackage description (M3)	30.11.2015	30.11.2015	0
02_04_06_06	37	2.4.6.2.1	S005.M81	series production started (M81)	10.12.2015	10.12.2015	0
02_04_06_06	86	2.4.6.2.3	S004.M8	pre-series accepted (PR Production Readiness) (M8)	13.10.2015	13.10.2015	0
02_04_06_06	88	2.4.6.2.3	S005.M81	series production started (M81)	13.10.2015	13.10.2015	0
02_04_11_01	35	2.4.11.1	S002.M3	approval of workpackage description (M3)	10.11.2015	10.11.2015	0
02_04_12_03	18	2.4.12.4	S002.M3	approval of workpackage description (M3)	22.10.2015	22.10.2015	0
02_04_12_04	20	2.4.12.5	S002.M3	approval of workpackage description (M3)	28.09.2015	28.09.2015	0

Milestones (next 12 month)

Running activities (≈200)



Payment Milestones (running year)

Summary

- Civil Construction
  - review on target shielding design
  - execution planning ready to be continued
- SC Magnets and Testing (most time critical items):
  - multiplets: contract awarded
  - dipoles: CDR established, tendering in preparation; design of branching units still tbd
  - Test facility at CERN under preparation
- Development and procurement of various components under way (according to the project plan)
- Project control and steering using MS Project

Thanks to M. Winkler