Status Report on Super-FRS

M. Winkler

Annual NuSTAR Meeting
GSI, February 27 – March 1, 2013

Outline

1) Super-FRS Layout (Full Version)
2) Status of Components
3) Status of Civil Construction
4) Integrated Project Plan
5) Summary

Layout off the Super-FRS (Full Version)

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

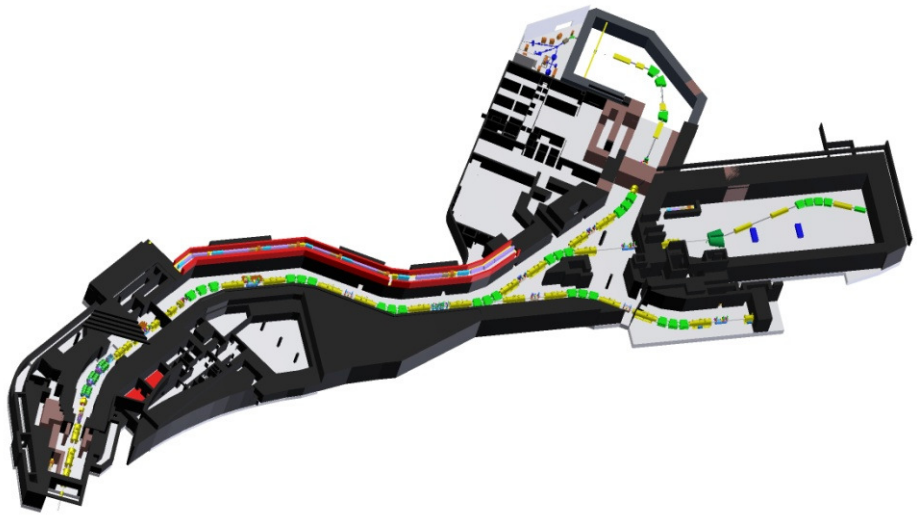
$B\rho = 2 - 20$ Tm
$R_{ion} = 750 / 1500$
(first / secon stage)

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

Projectile:
- Elements p - U
- Energy up to 1.5 GeV/u
- Intensity up to 10^{12} /s (depending on element)
- DC or pulsed operation

In-Flight Separation:
- Universal (all elements)
- Fast (submicroseconds)
- Efficient (kinematic focusing)
- Mono-isotopic or cocktail beams

Energy Buncher
Magnetic Spectrometer
Low-Energy Branch
High-Energy Branch
Main-Separator
Degrader 1
Beam Catchers
Pre-Separator
Degrader 2
Production Target
Focusing System
Ring Branch
Driver Accelerator

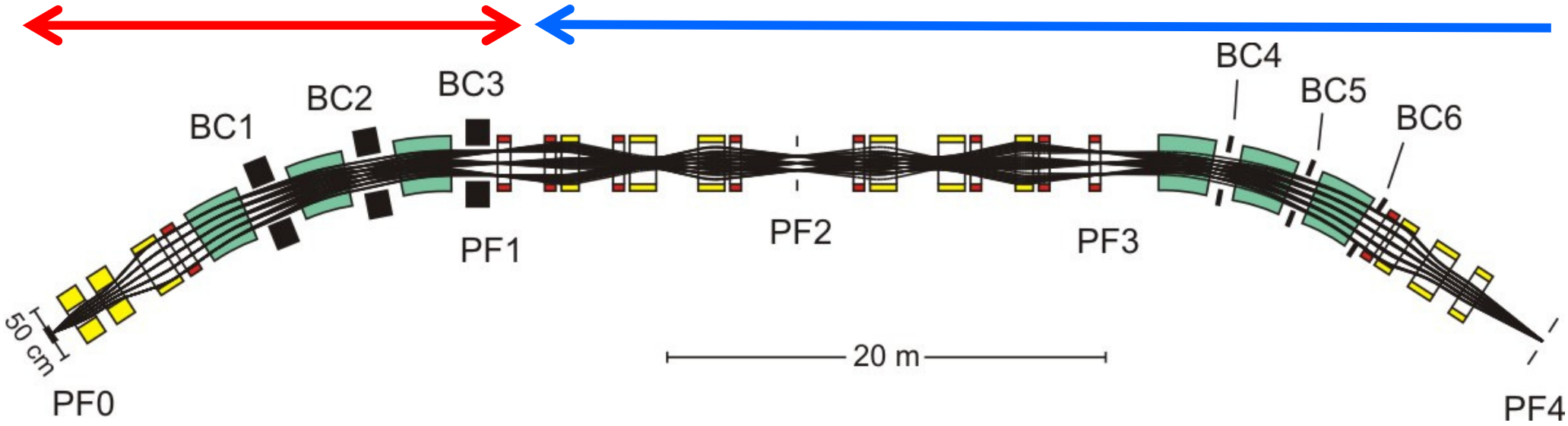


Features:
- Two Separator-stages
- Multi-branch system
- Large acceptance utilizing sc magnets
- Handling concept for high-radiation area

Layout of the Pre-Separator

High-radiation level

→ Normal conducting Super conducting

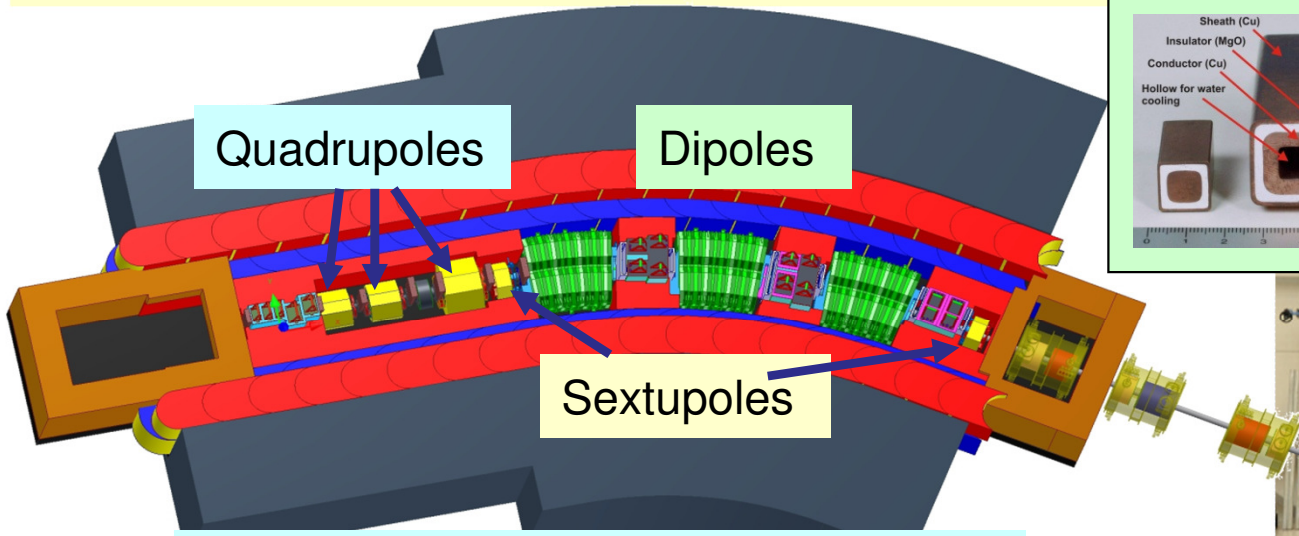


- Dipole magnet divided into three parts.
  - ➢The space in between (2.4 m) is used to integrate the primary beam catchers (access for maintenance purpose).
- Magnets in high-radiation fields will be radiation-resistant NC magnets.
- 3 dispersive focal planes are foreseen.
- All sextupole magnets are placed separately (stand alone).

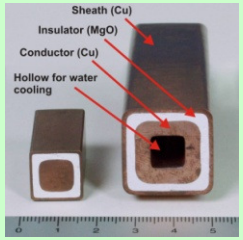
Radiation Resistant Magnets

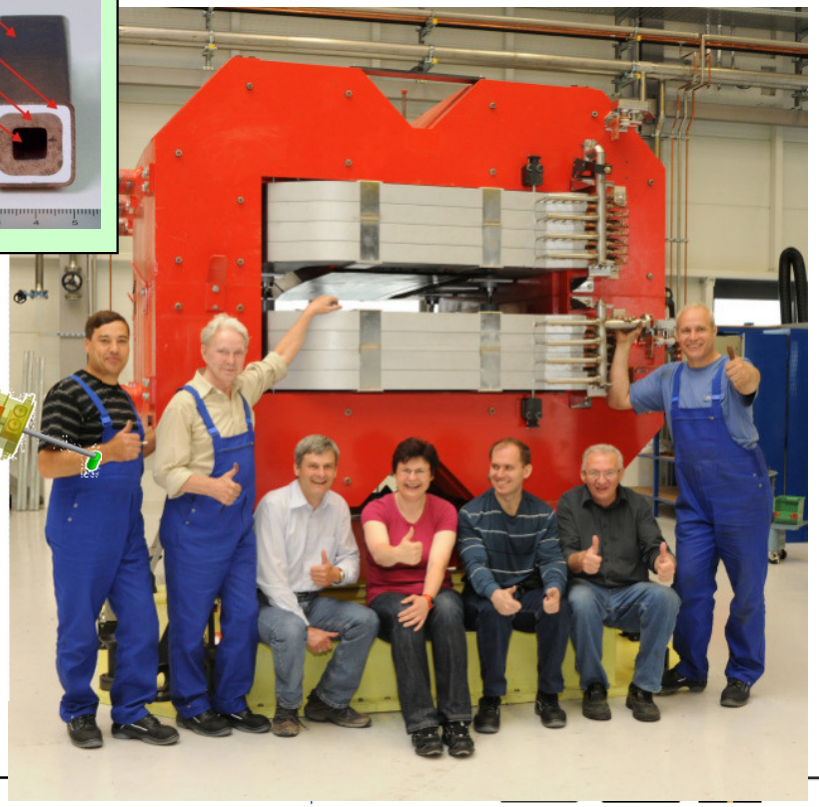
C. Mühle
C. Will
P. Vobly et al.

- 3 dipole, 3 quadrupole, and 2 sextupole magnets are required
- Normal conducting magnets using mineral insulated cable (MIC)
- Remote connectors and alignment
- Prototype dipole built (95 ton) and tested by BINP
- Prototype dipole is delivered and assembled at GSI;
- Handling test at GSI is under way
- Production time is estimated to be ≈3 year
- No In-kind, but Russia gave a quotation



MIC cable



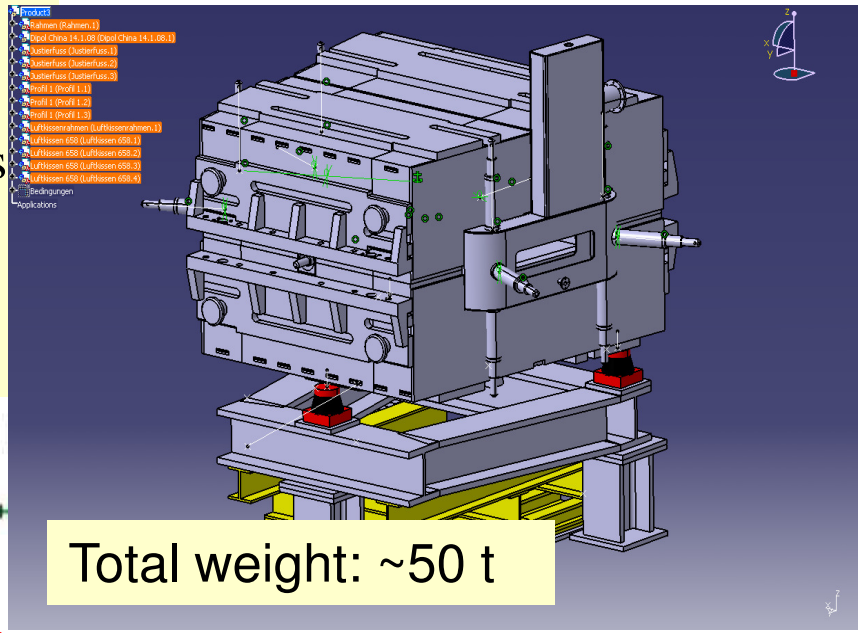


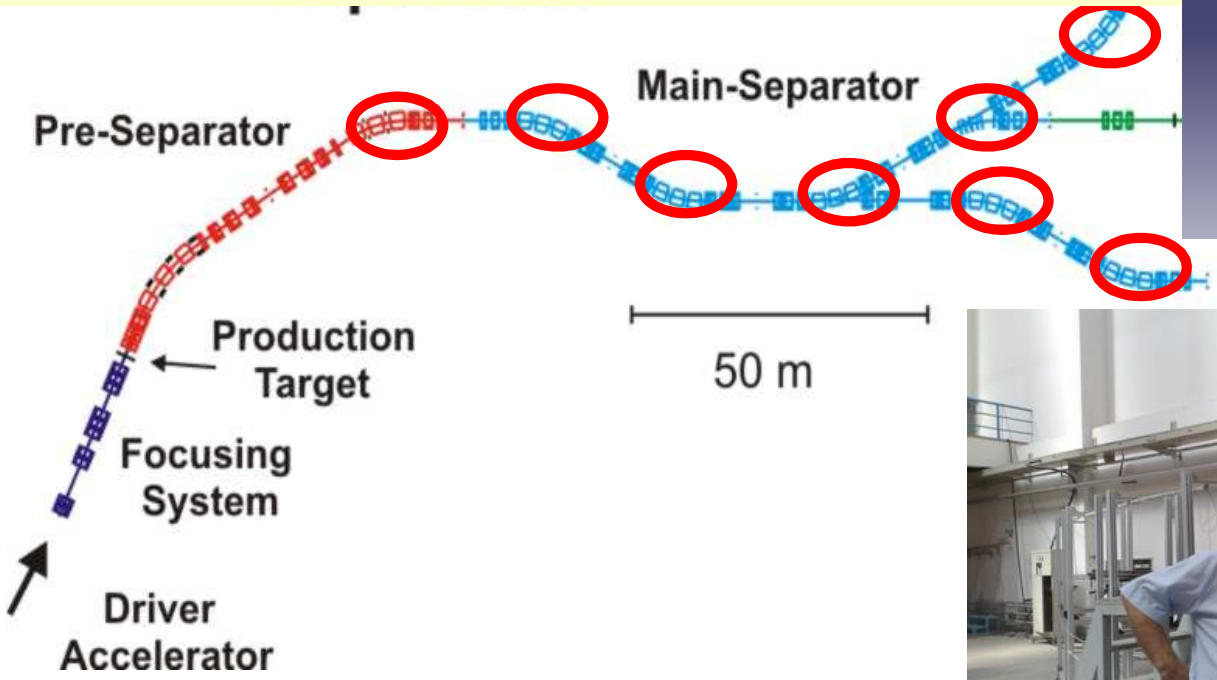
No failure/replacement due to radiation exposure is expected during lifetime. Power consumption (P_{Max} ≈ 1MW).

Superferric Dipole Magnets

H. Leibrock
M. Müller, et al.
FAIR China Group

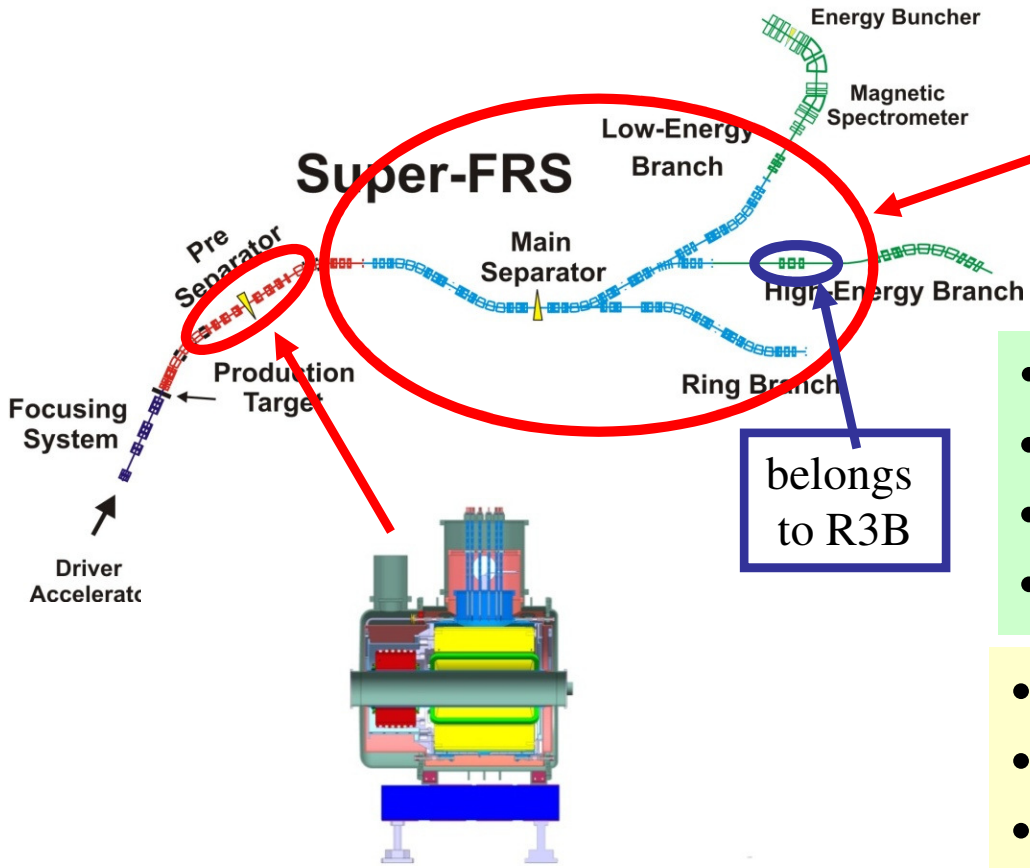
- 24 dipole units are required
- Iron dominated, warm iron, SC coil
- Large aperture ±190mm x ±70mm; 50 ton
- Prototype built and tested by FAIR China Group
- Some small modifications are required for the series
- Last FAIR Council decided that tendering will be carried out by FAIR (foreseen in 2013)
- Specifaication documents are in preparation

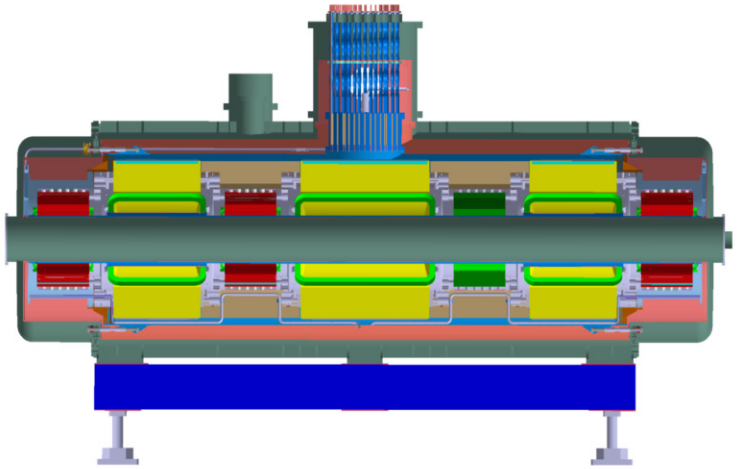




Superferric Multiplets

H. Müller,
H. Leibrock et al.





- 24 long multiplets (up to 7 m)
- Quadrupol triplet
- up to 3 sextupoles and 1 steerer
- Octupole coils in short quadrupoles

- iron dominated, cold iron (up to 37 tons)
- common helium bath
- warm beam pipe (38 cm inner diameter)
- per magnet 1 pair of current leads
- max. current <300A for all magnets

- 7 short multiplets (2.6 m)
- QS configuration
- Octupole coils in short quadrupoles

- German in-kind contribution
- Tendering in preparation
- Magnet testing/mapping is foreseen at CERN

Magnet Testing

P. Schnizer et al.

- Collaboration with CERN
- Technical discussion on Work Packages
- Contract → **Collaboration Committee**

  CERN: Frederic Bordry, Lucio Rossi

  GSI: Oliver Kester, Egbert Fischer

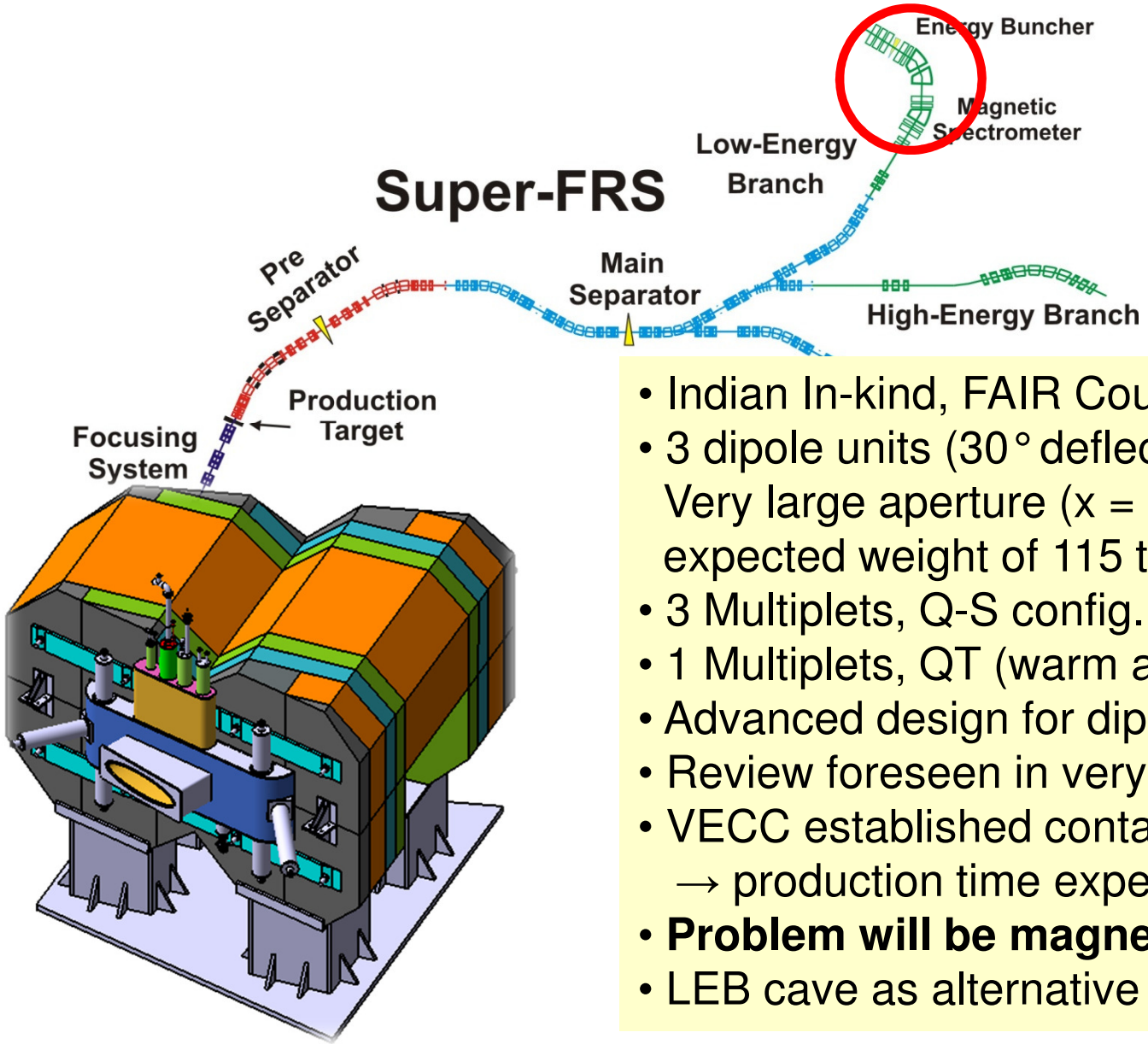
  Technical Coordinators

  CERN: Johan Bremer

  GSI: Pierre Schnizer
- CERN: **ready for testing Q1 / 2015**
- Next steps: Working out the details of work packages

  (so far 7 WP are identified: Cooling & Ventilation, Cryogenics, Electrical Power, Magnetic measurements, Power converters, Preparation for operation, Quench protection/energy extraction)

Energy Buncher (SC Magnet)



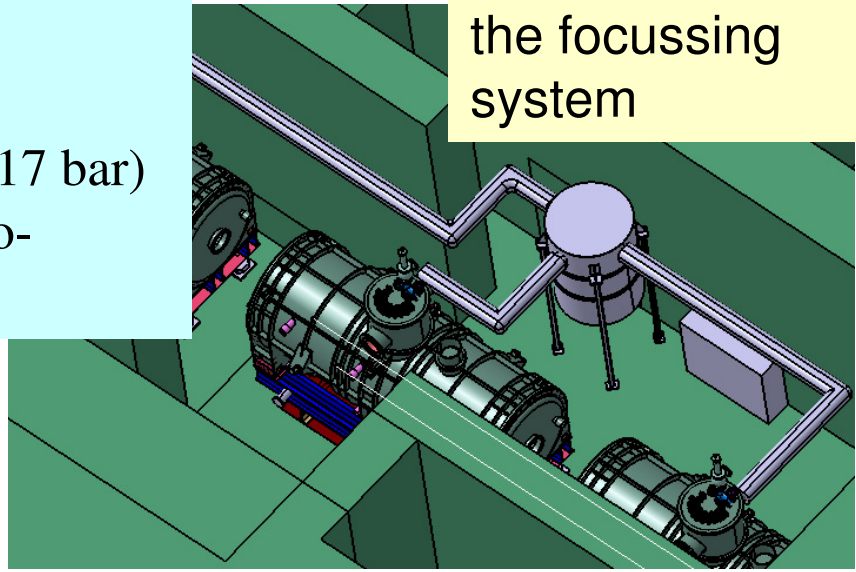
- Indian In-kind, FAIR Council approved
- 3 dipole units (30° deflection angle, superferric)
  Very large aperture (x = 350mm, y = 100mm);
  expected weight of 115 ton
- 3 Multiplets, Q-S config. (warm aperture 300mm)
- 1 Multiplets, QT (warm aperture 300mm)
- Advanced design for dipole (VECC);
- Review foreseen in very near future
- VECC established contact to industry,
  → production time expected to be ≈3 years (dipoles)
- **Problem will be magnet testing (on-site ?)**
- LEB cave as alternative testing hall under discussion

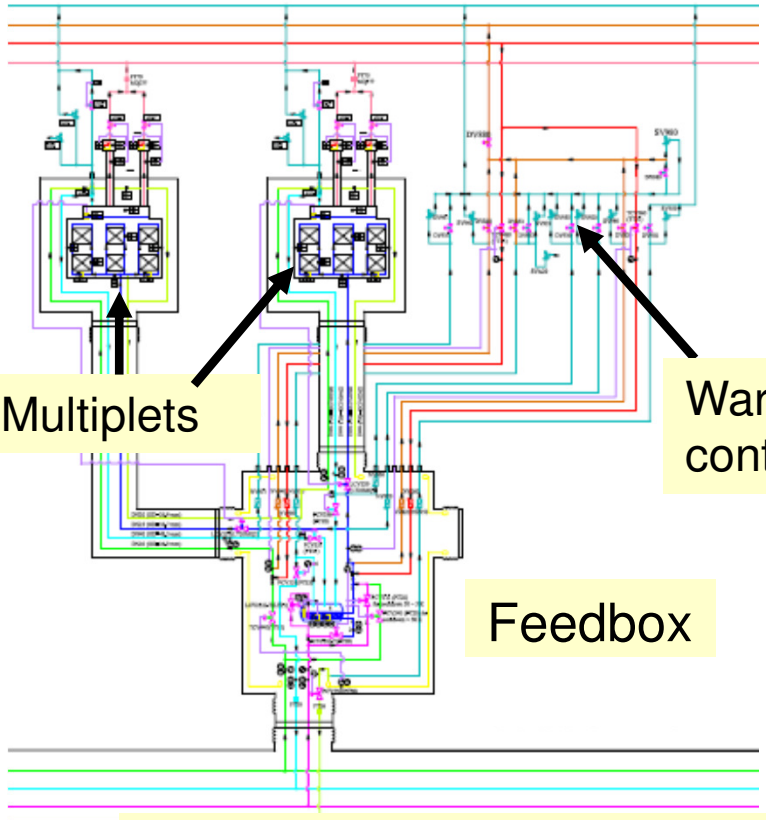
Local Cryogenics for Super-FRS

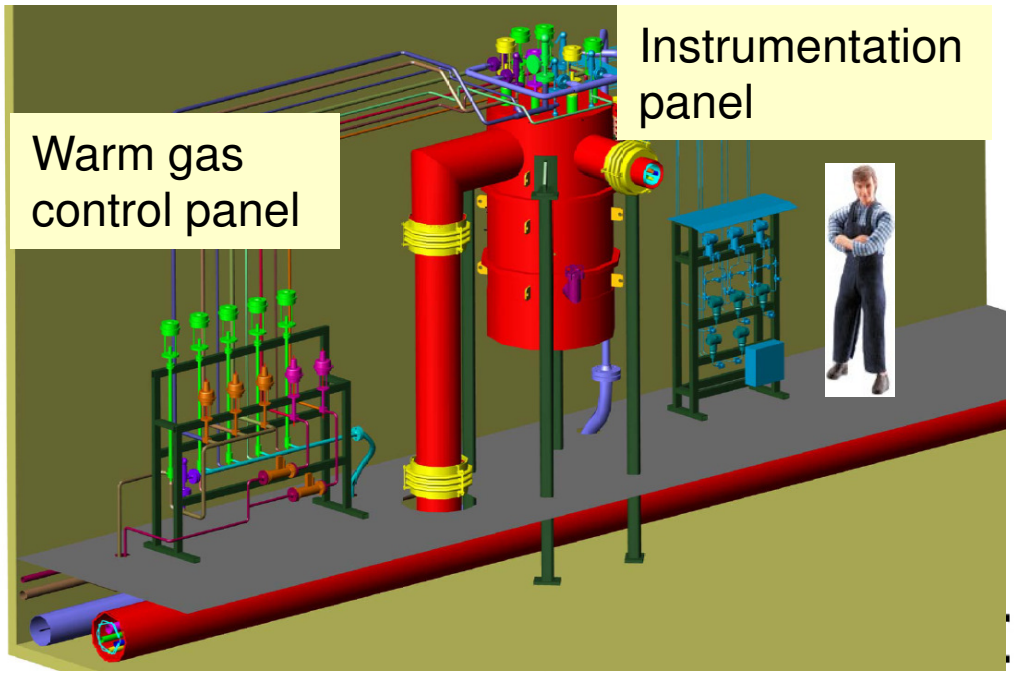
Y. Xiang et al.

- Method: bath cooling
- Rather high LHe inventory (>1.500 l/multiplet)
- Grouping of several cryostats using one feedbox
- Feedboxes provide: 1-5K LHe (3 bar), 4-50K He gas (17 bar)
- Poland will contribute as in-kind to feedboxes and cryo-transferline

Installation at the focussing system



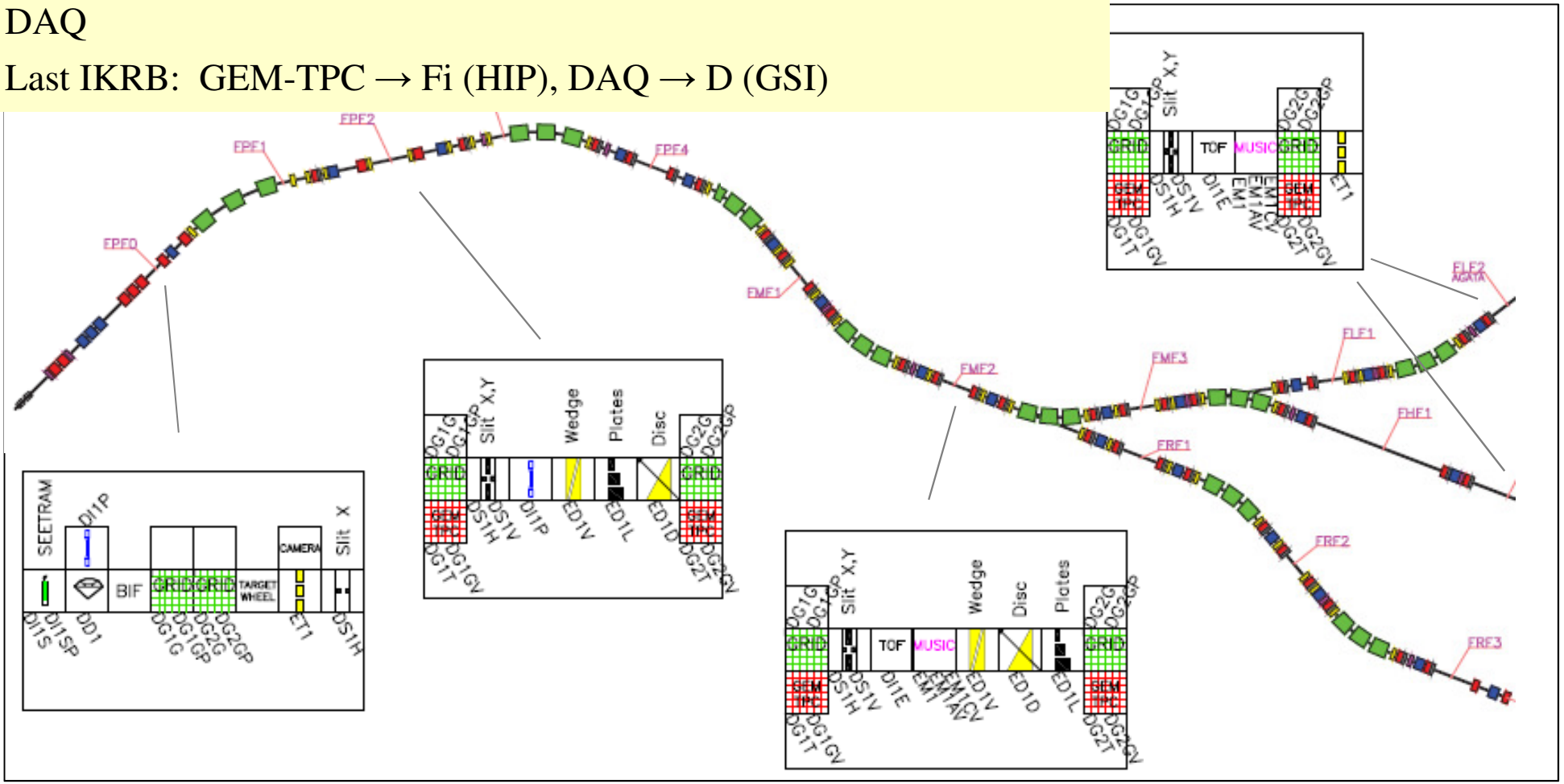




Beam Diagnostic and Detector Developmen

C. Nociforo,
S. Pietri,
B. Voss et al.

- Beam diagnosis
- Experiments → full isotope identification (x, y, x', y', ΔE and TOF)
- Operation modes: fast- and slow-extracted beams
- Special devices (slits, secondary target station, ...)
- Controls → machine safety
- DAQ
- Last IKRB: GEM-TPC → Fi (HIP), DAQ → D (GSI)



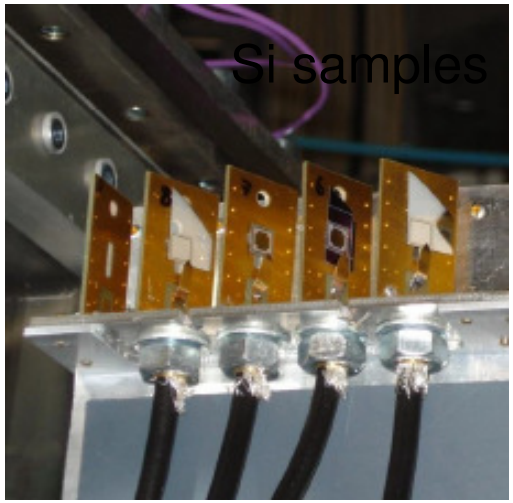
Intensity 10^{12} /s $<10^{10}$ /s $<10^{9}$ /s $<10^{7}$ /s $<10^{5}$ /s

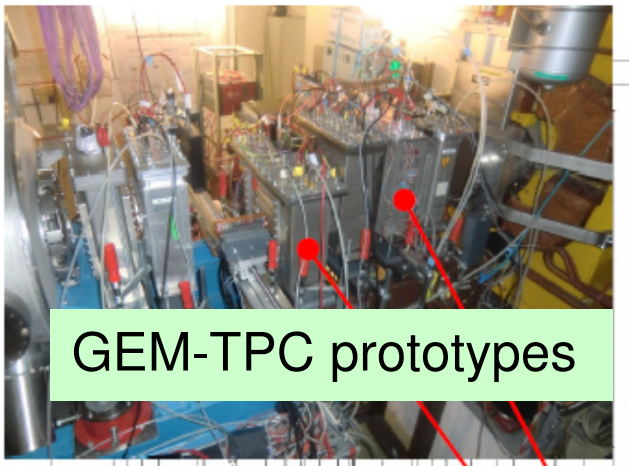
Detector Development

A. Prochazka,
O. Kiselev et al.

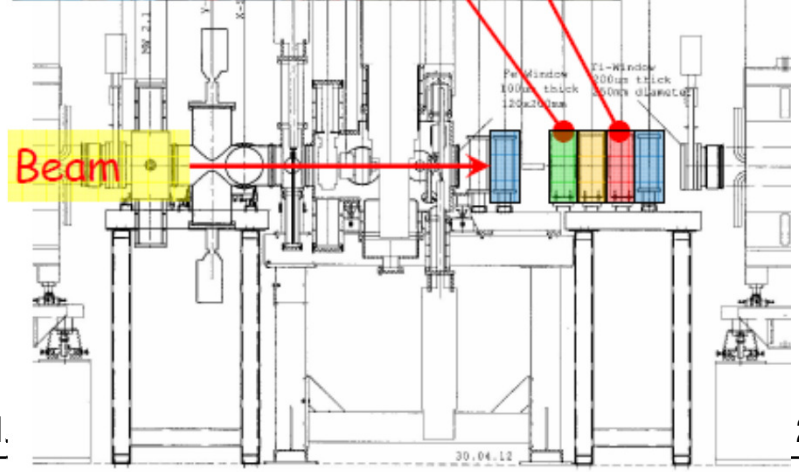
Test with SIS Au(750MeV/u)/U(350MeV/u) beams

- GEM-TPC gas tracking detectors $\sigma_x \sim 0.2$ mm
- single-channel readout electronics (GEMEX)
- Finnish in-kind contribution



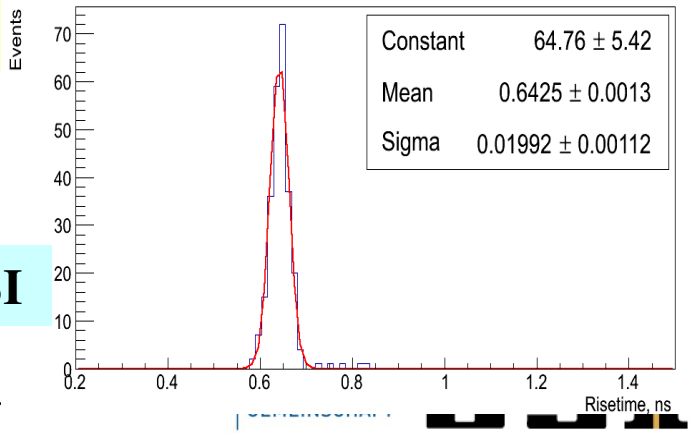


Helsinki, Bratislava, GSI



- 0.1/0.3/0.6 mm tick, matched to Si-strip capacity
- digital waveform sampled with 5GS/s scope
- time jitter ~ 20-40 ps
- no deterioration of time properties after ~1kGy irradiation
- Russian EoI

St. Petersburg, GSI

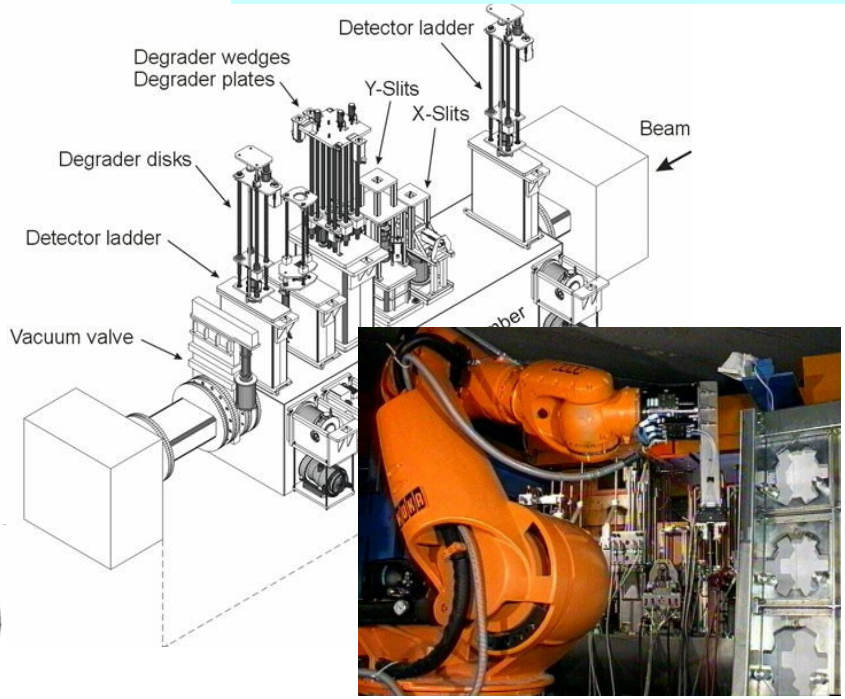


Vacuum System and Components

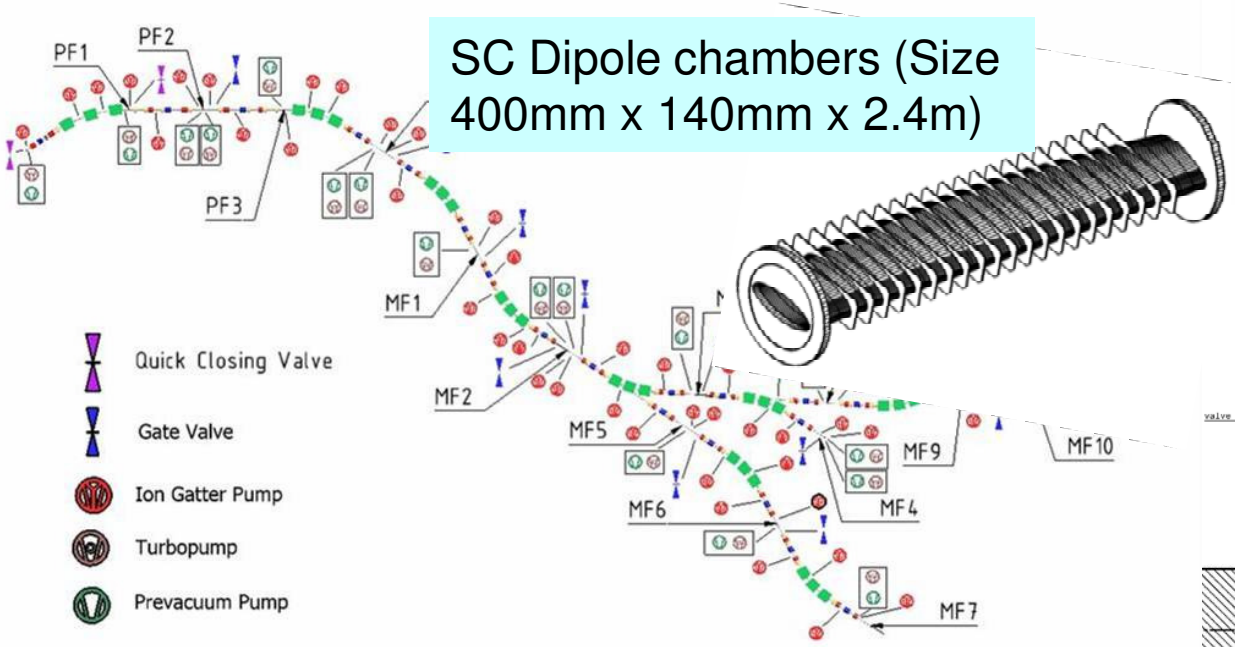
K.H. Behr
C. Schlör,
I. Mukha et al.

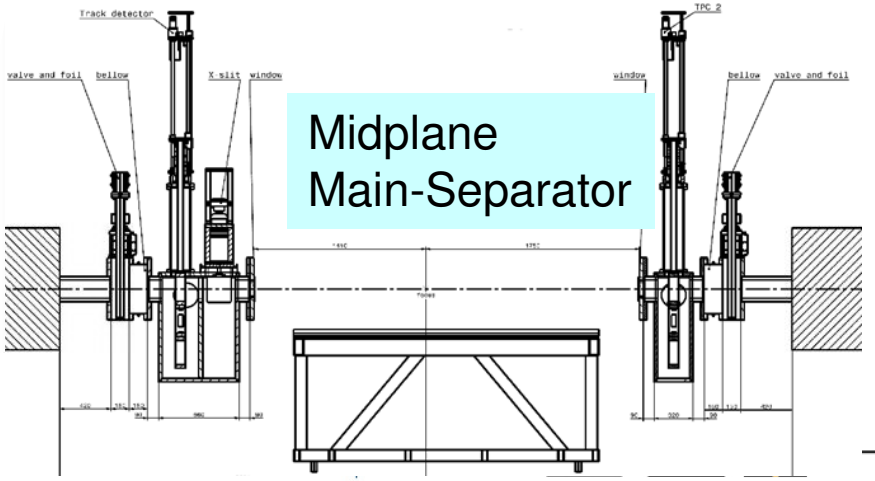
- Goal: vacuum in the 10^{-7} mbar range
- Large and very large size chambers (target, beam catcher, magnet chambers, focal plane chambers)
- Remote handling capability in the target area (e.g. pillow seals) and at the Pre-Separator (e.g. robotic)
- German in-kind for standard vacuum components
- Russian in-kind for focal plane chambers

Remote handling capability at the Pre-Separator



SC Dipole chambers (Size 400mm x 140mm x 2.4m)



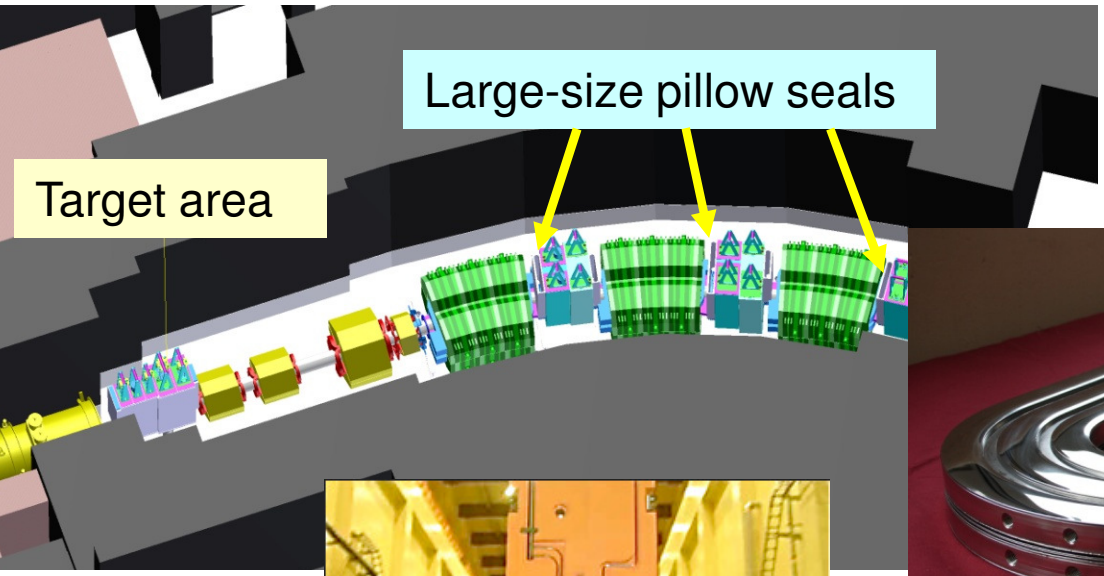


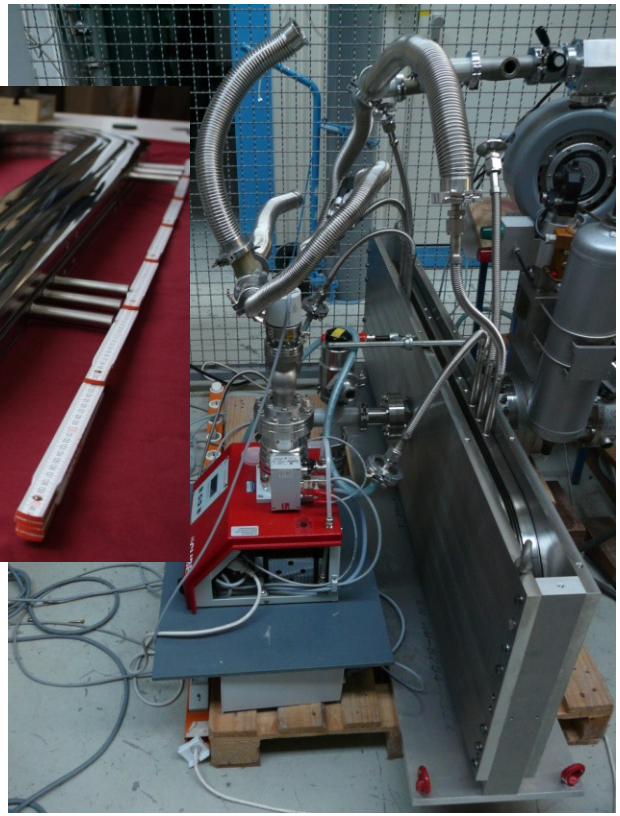
Midplane Main-Separator

Remote Handling / Pillow Seal Development

K.H. Behr,
A. Kratz et al.

- Connects vacuum parts, seals only with metal foils pressed on polished surface
- Huge pillow seal vacuum test succesful Ø=500mm
- Large-size race track shaped seals (1200mm x 160mm)



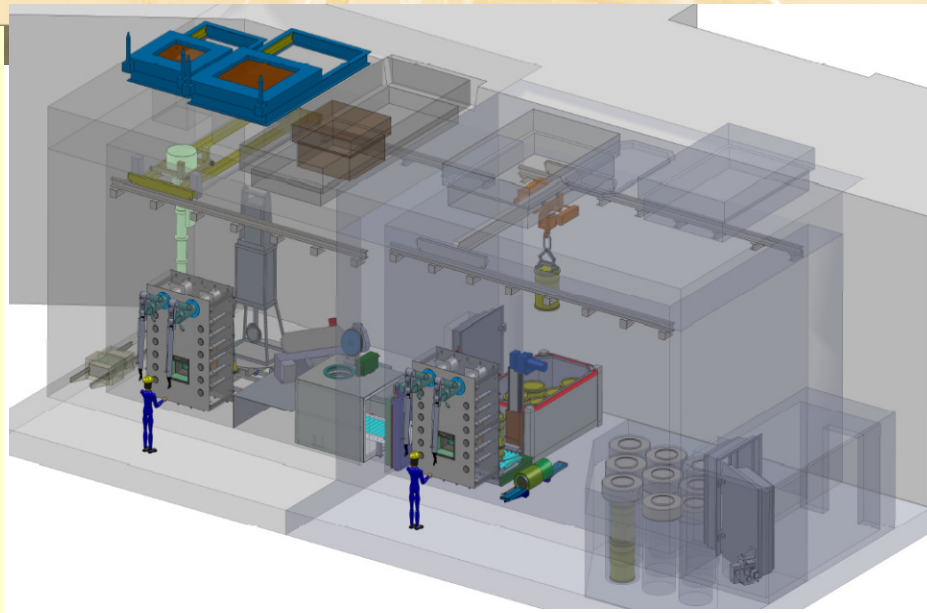


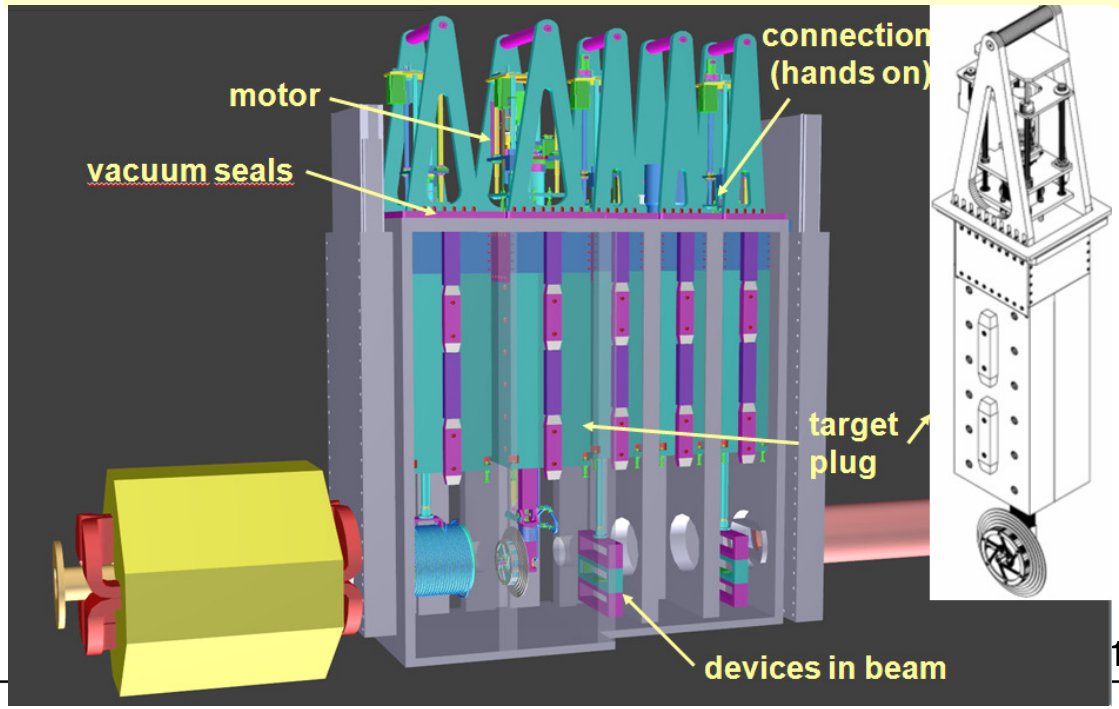
Ø=400 mm seal with plug at J-PARC

Special Installation

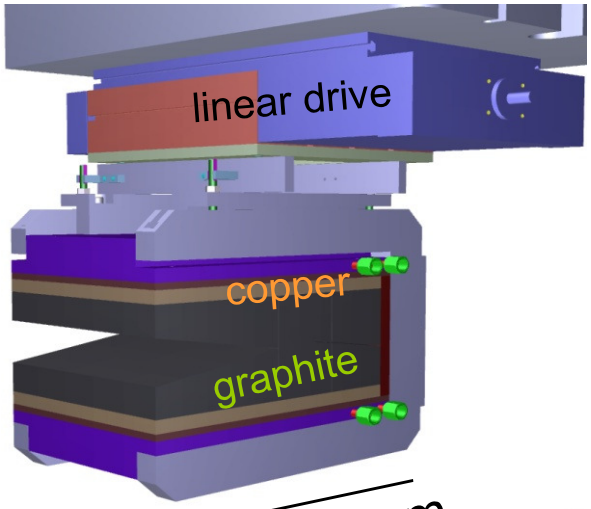
H. Weick
Ch. Karagiannis et al.

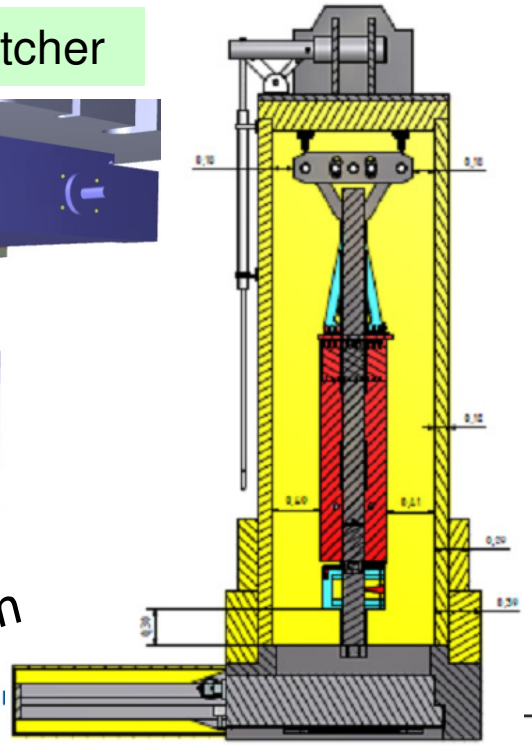
- Target chamber with plug inserts (target wheel, collimator, detectors) , German In-kind
- Target wheel, prototype available, bearing under long-term test (German In-kind)
- Hot cell (German In-kind)
- Transport flask (Finish EoI)
- Beam catcher (Indian EoI), so far mainly simulations and conceptual designs are preformed,
- Energy degrader; plates, wedges, discs
  standard use at GSI (size needs to be doubled)





movable beam catcher



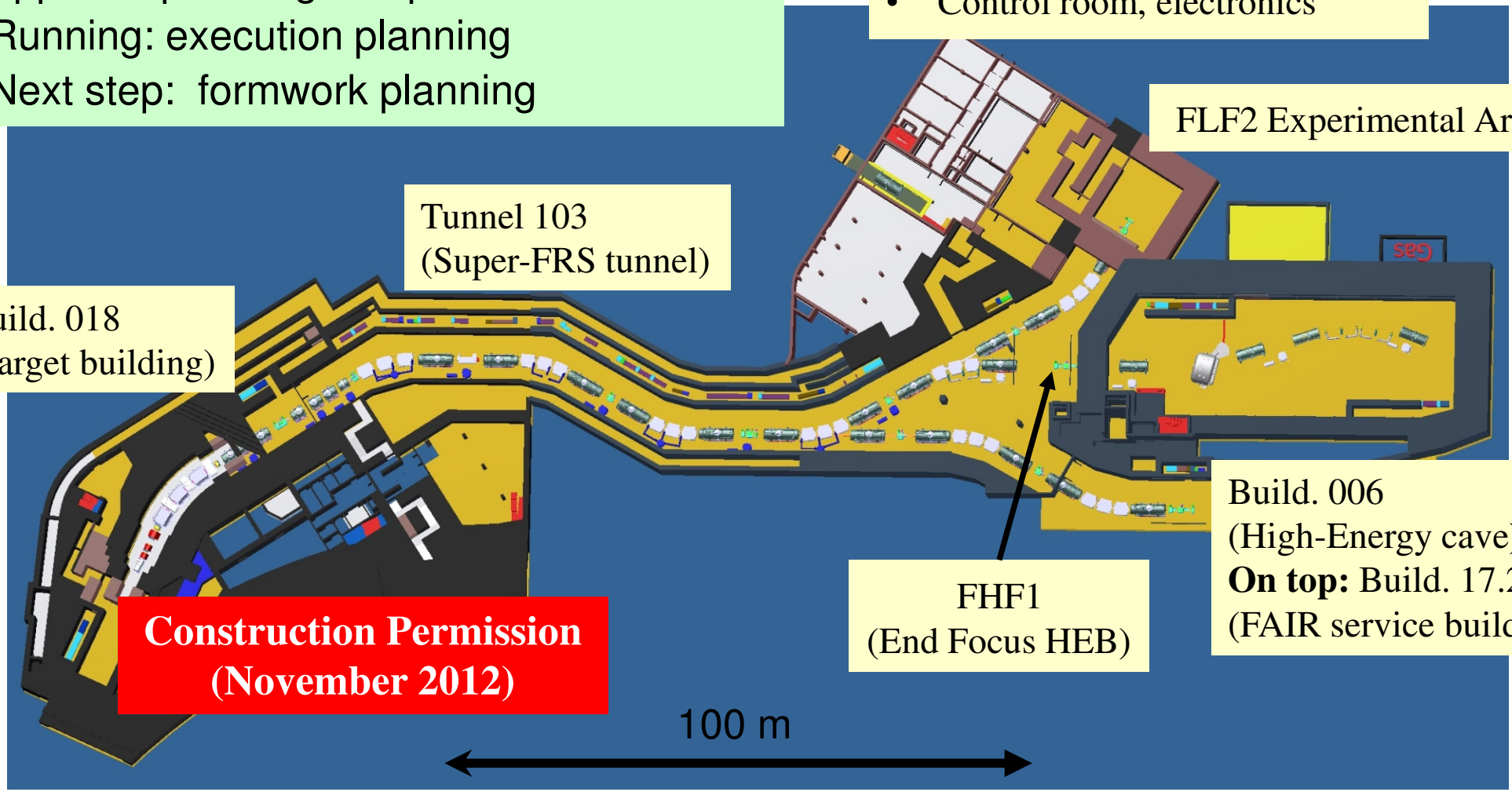


Super-FRS Buildings (MSV, Overview)

Goal: Buildings ready for Installation at end 2016

- Basic evaluation completed
- Preliminary planning completed
- Approval planning completed
- Running: execution planning
- Next step: formwork planning

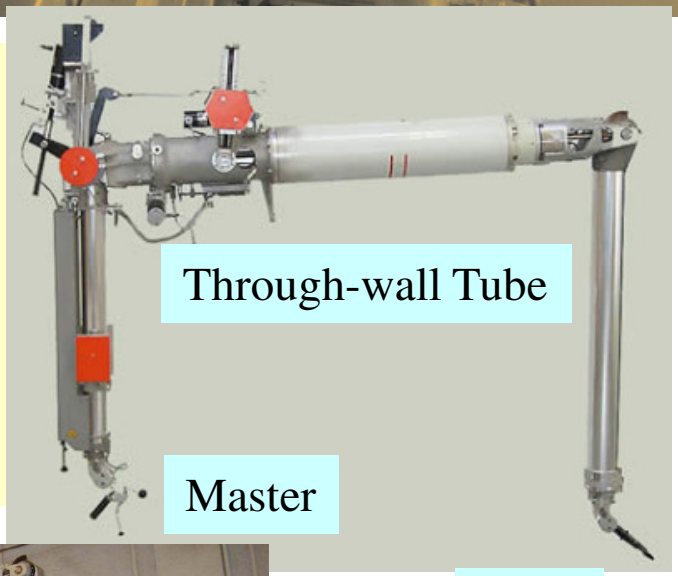
Build. 006a, Service building
- 3 floors (~2000 m²)
- Technique (PS, controls, ...)
- Experimental preparation
- Control room, electronics

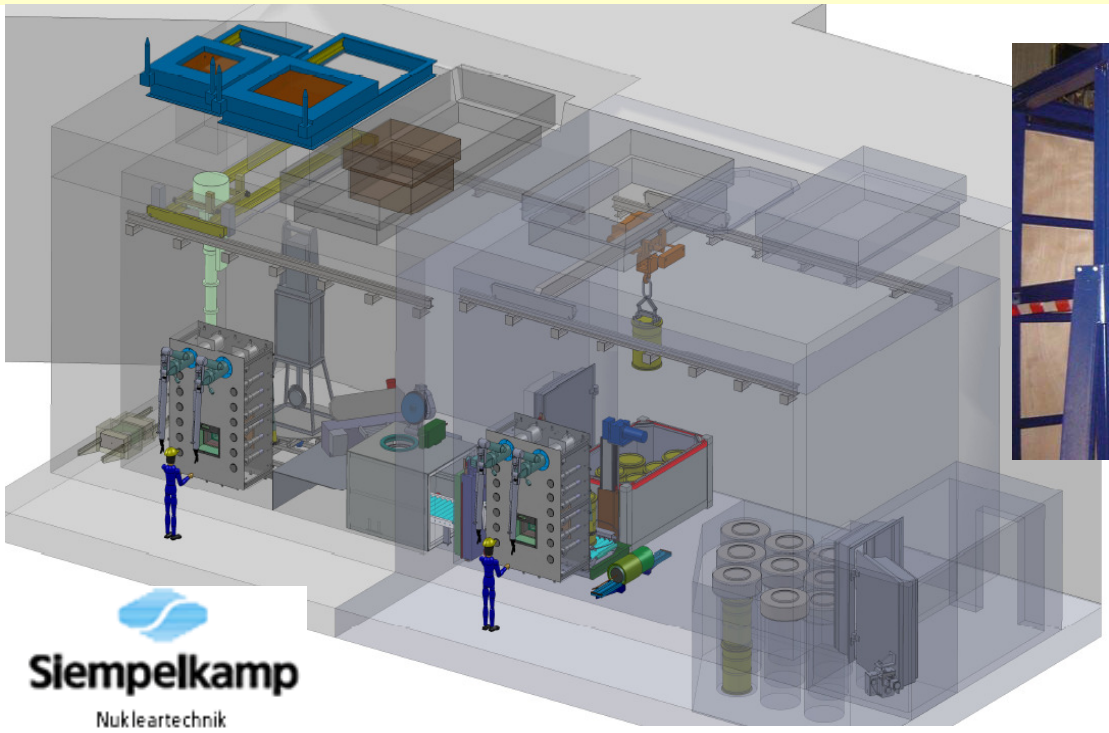


Hot Cell / Test Stand

H. Weick
Ch. Karagiannis et al.

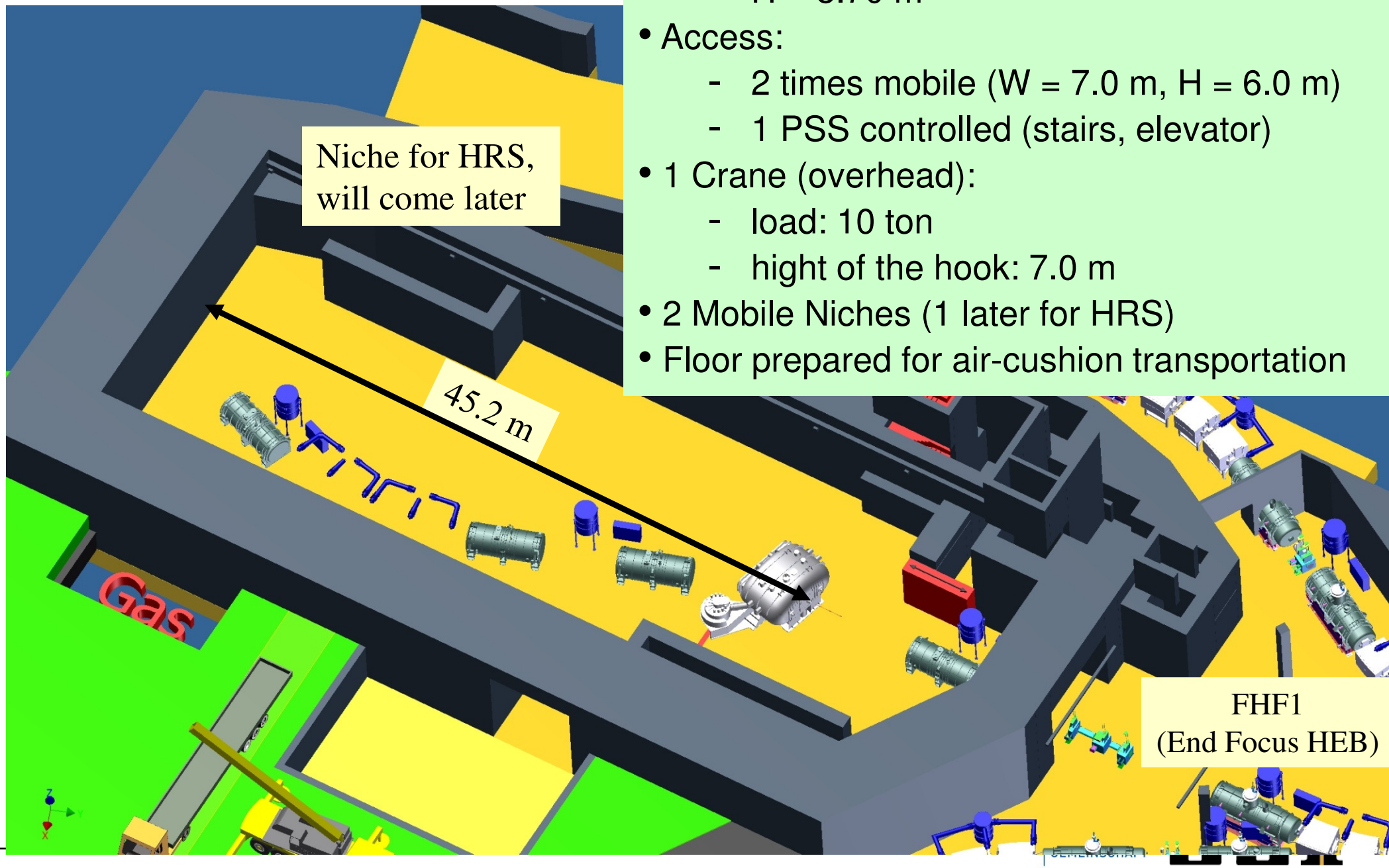
- Based on study by nuclear engineering company
- approval §7 StrlSchV partially
- Test stand planned (RH component development, training)
- Master-slave manipulators ordered delivery 6/2013
- Collaboration with SPIRAL 2 (partially EU CRISP)
- For full realization larger contract with company planned



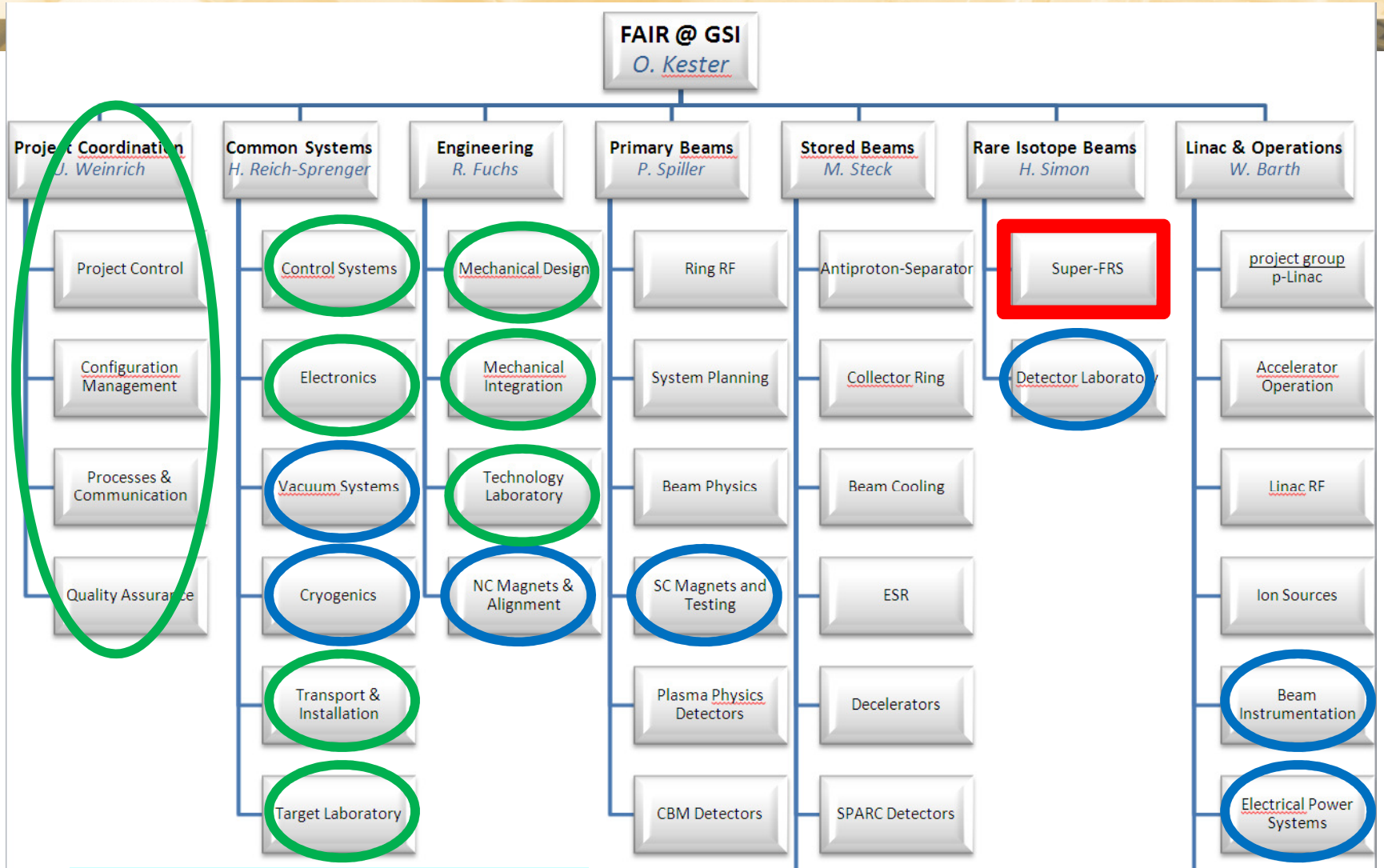


R³B Cave

- Cave size (overall):
  - L = 61.13 m
  - W = 21.65 m
  - H = 8.70 m
- Access:
  - 2 times mobile (W = 7.0 m, H = 6.0 m)
  - 1 PSS controlled (stairs, elevator)
- 1 Crane (overhead):
  - load: 10 ton
  - hight of the hook: 7.0 m
- 2 Mobile Niches (1 later for HRS)
- Floor prepared for air-cushion transportation



Super-FRS within FAIR@GSI



direct WP responsibility

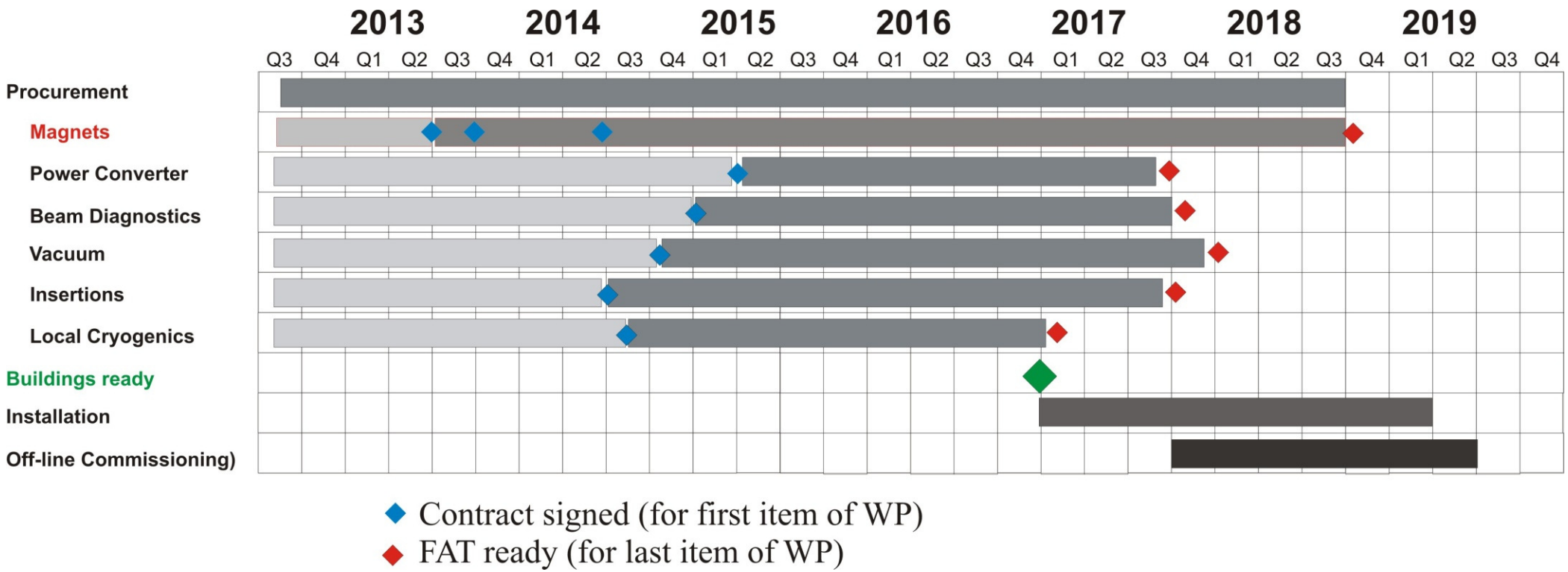
WP support

List of Major Project Milestones

	All contracts closed for major component	All major component series production started	Building and infrastructure ready for assembly	All components ready for installation (incl. testing)	Assembly and alignment finished	Commissioning without beam finished
Super-FRS	-	-	Q4/2016	-	-	Q2/2019
Multiplets	Q2/2013	Q4/2015	-	Q4/2018	Q1/2019	-
Dipoles	Q3/2013	Q2/2015	-	Q2/2017	Q1/2019	-
Magnet Testing	Q1/2012		Q4/2013	-	-	-
Target	Q4/2014	Q2/2015	-	Q4/2016	Q1/2017	-

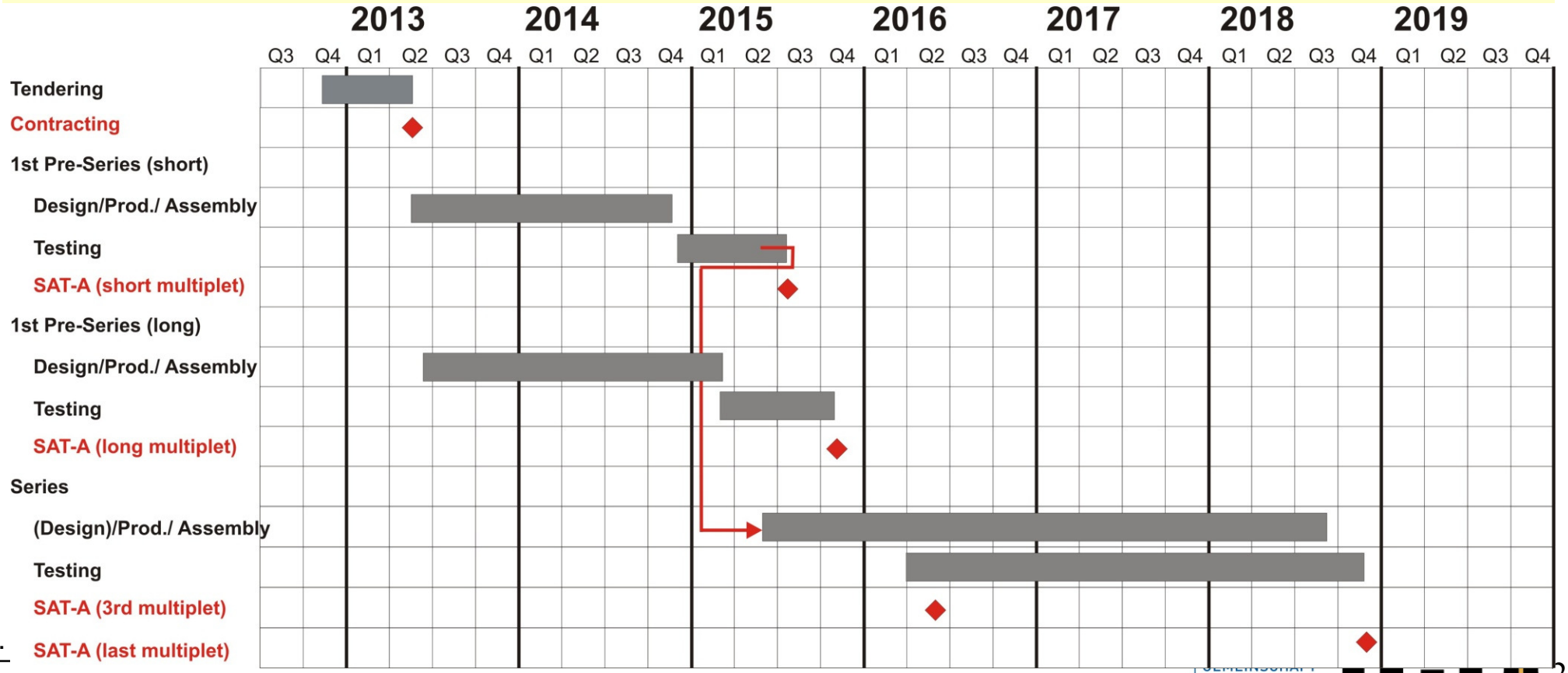
Timeline Super-FRS

- Long running items are the SC Multiplets
- Begin of installation is determined by civil construction
- THE projects includes only ‚off-line commisioning‘



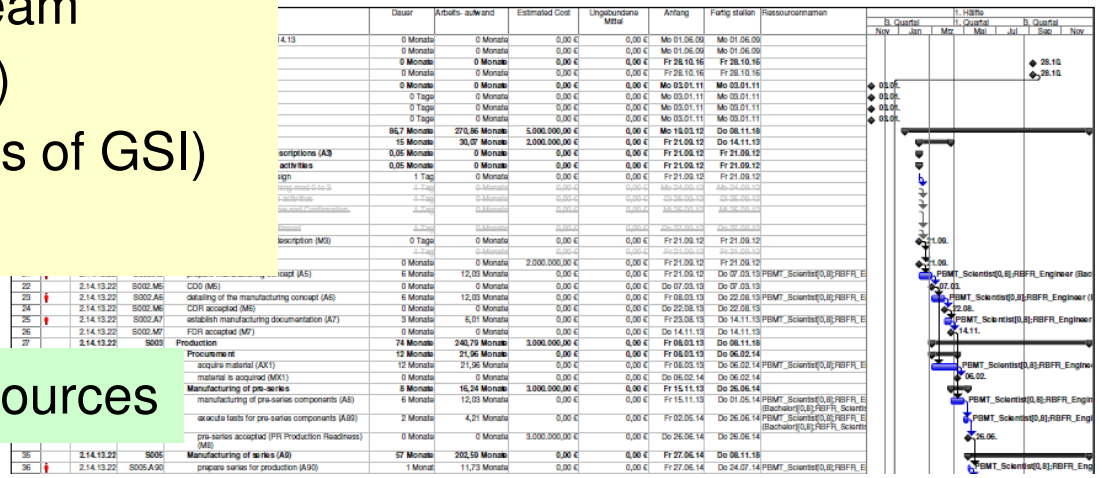
Timeline Superferric Multiplets

- Approved by FAIR council as German In-Kind
- Strategy: first production of one long **and** one short pre-series multiplet
- Advance talks with selected industry representatives
- Specification in approval process
- Tendering documents in preparation in parallel
- Series production: delivery of approximately one multiplet per month is expected

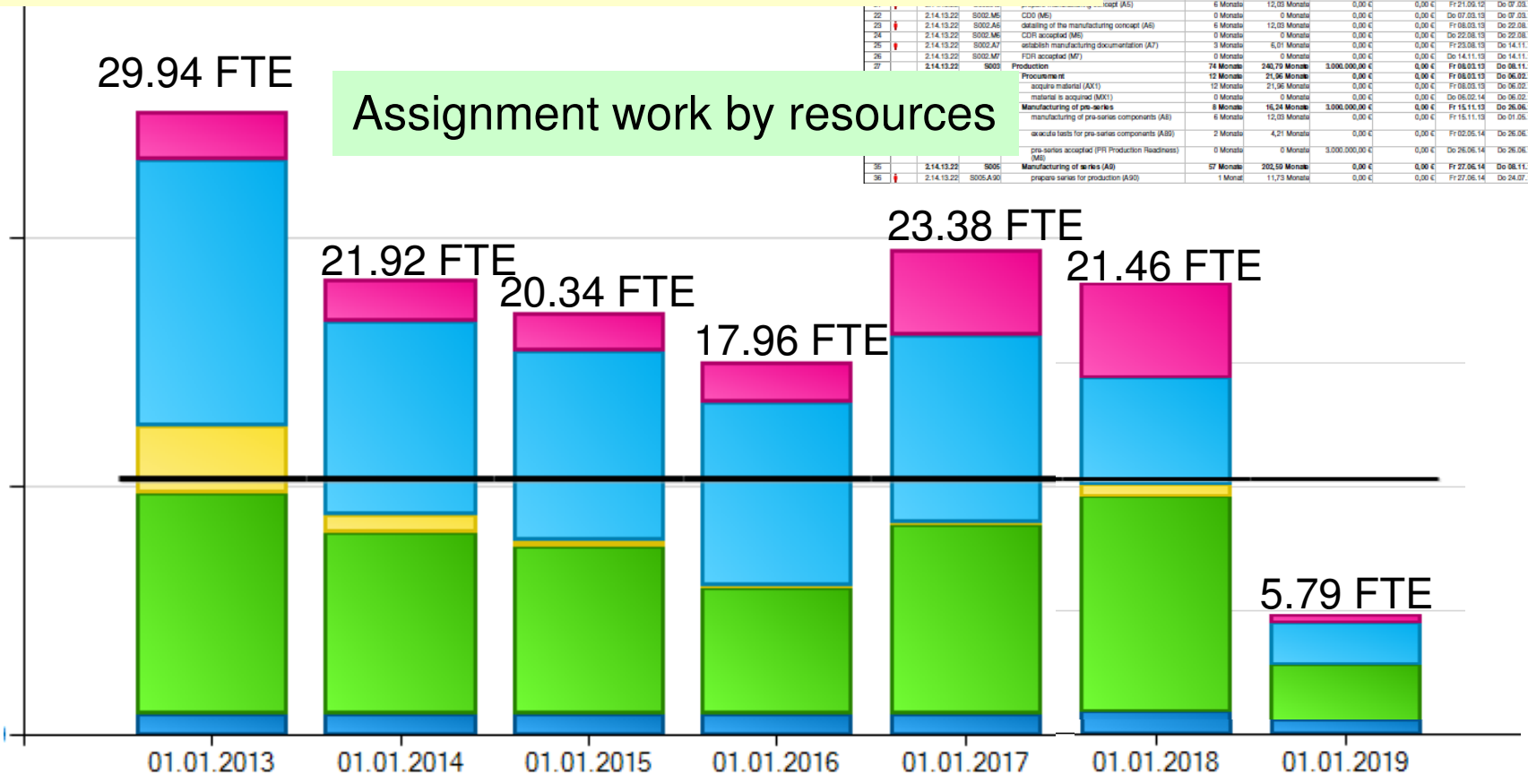


Integrated Project Planning

- Based on MS Project 2010
- Planned up to ‚Commisioning without beam‘
- 30 individual Time-Plans (PSP grouping)
- Resources (including supporting sections of GSI)
- Budget (GSI funding)



Assignment work by resources



Summary

- Two separator stages, multi-branch system
- Large-acceptance device using large-aperture SC magnets
- R&D for major components as well as civil construction under progress
- Integrated project plan established
- SC multiplets are the long-running items
- Begin of installation in 2017,
- Off-line commissioning is expected until mid 2019