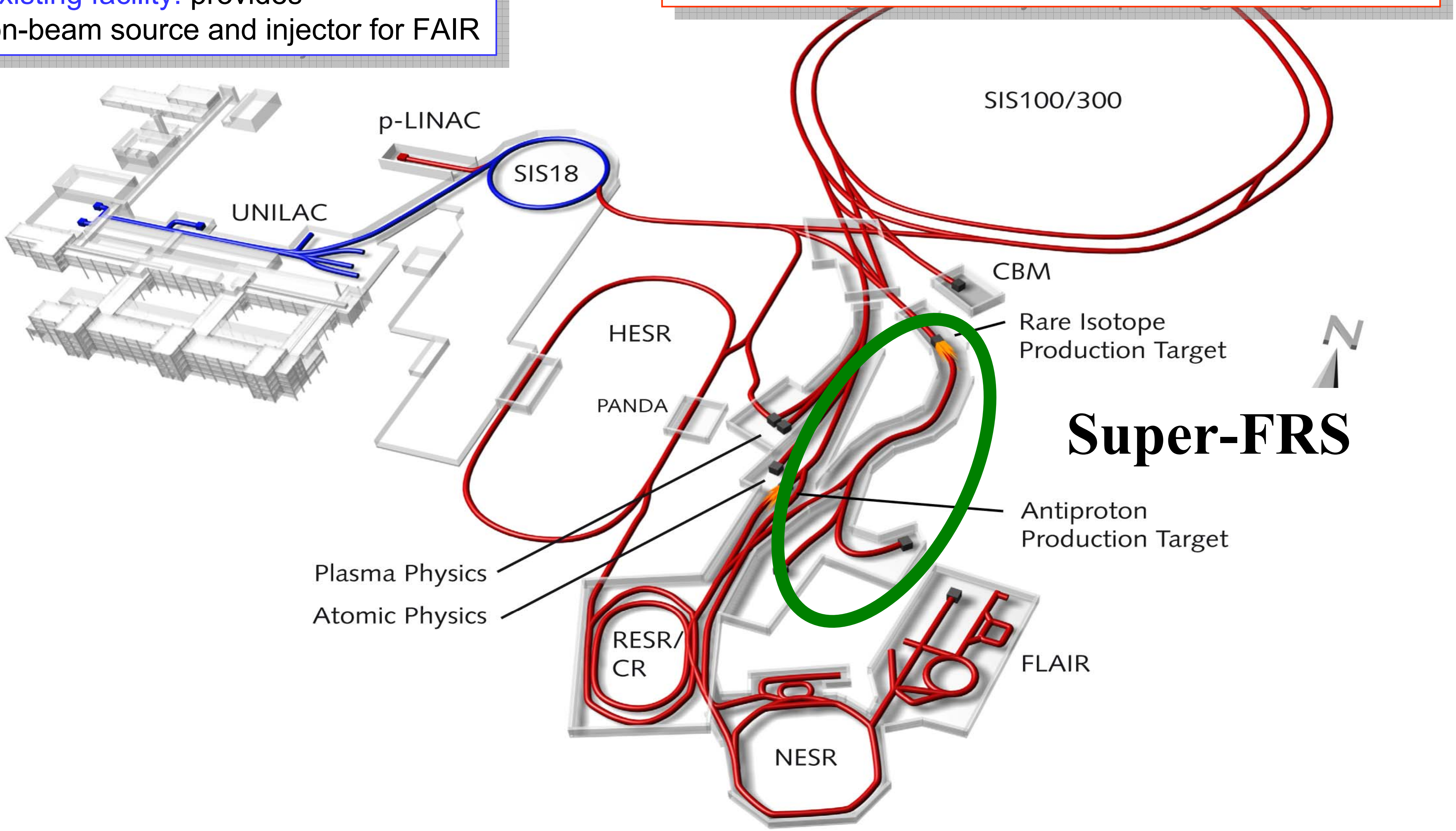
Status Super-FRS

Martin Winkler, EoI/Pre-Consortium Meeting, GSI, October 9, 2008

Existing facility: provides ion-beam source and injector for FAIR

New future facility: provides ion and anti-matter beams of highest intensity and up to high energies



Layout and Design parameters

Goal: Larger Acceptance

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

Design Parameters:

$\varepsilon_x = \varepsilon_y = 40\ \pi$ mm mrad

$\Phi_x = \pm 40$ mrad

$\Phi_y = \pm 20$ mrad

$\Delta P/P = \pm 2.5$ %

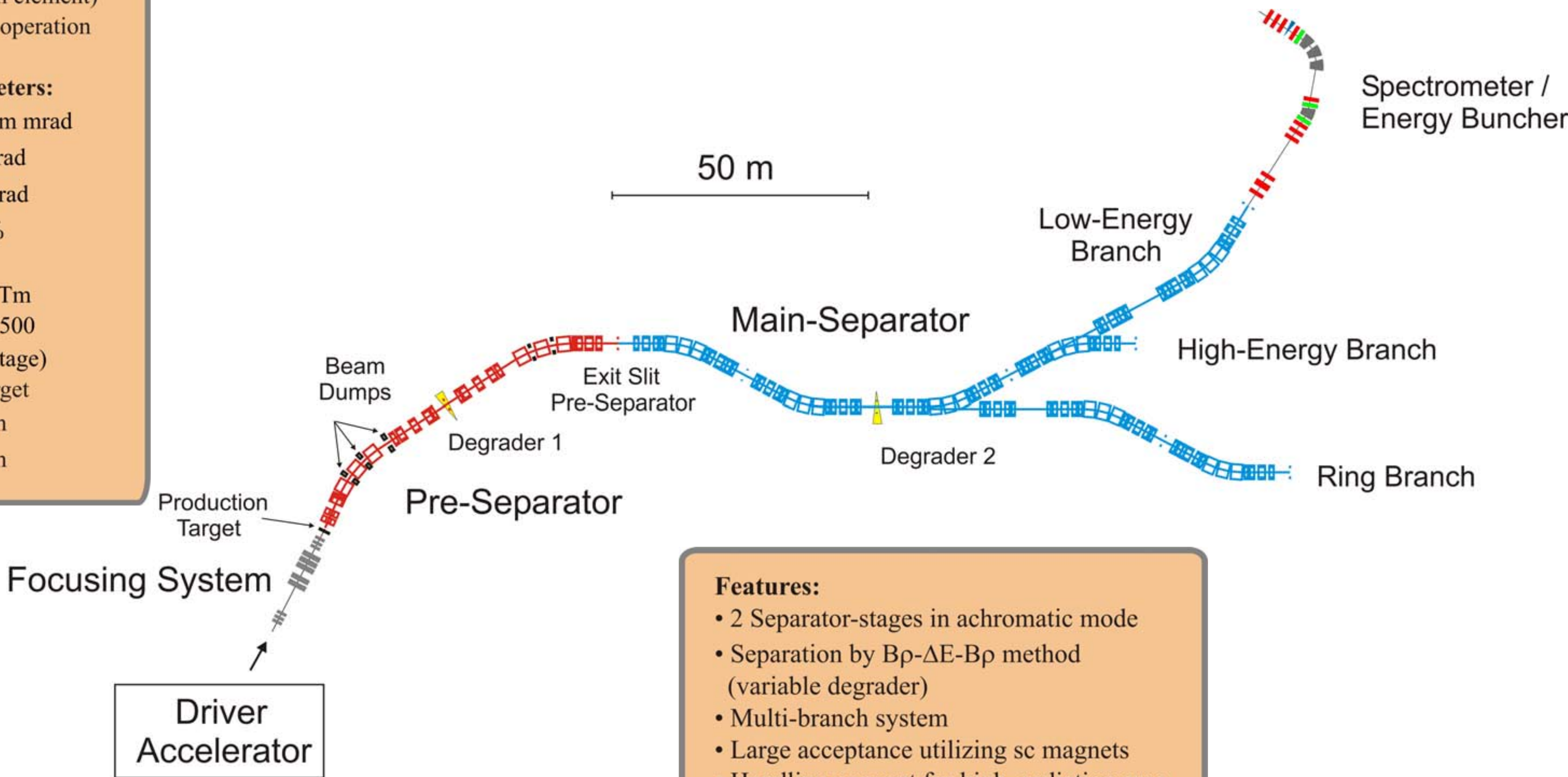
$B\rho = 2 - 20$ Tm

$R_{ion} = 750 / 1500$ (first / second stage)

Spot size on target

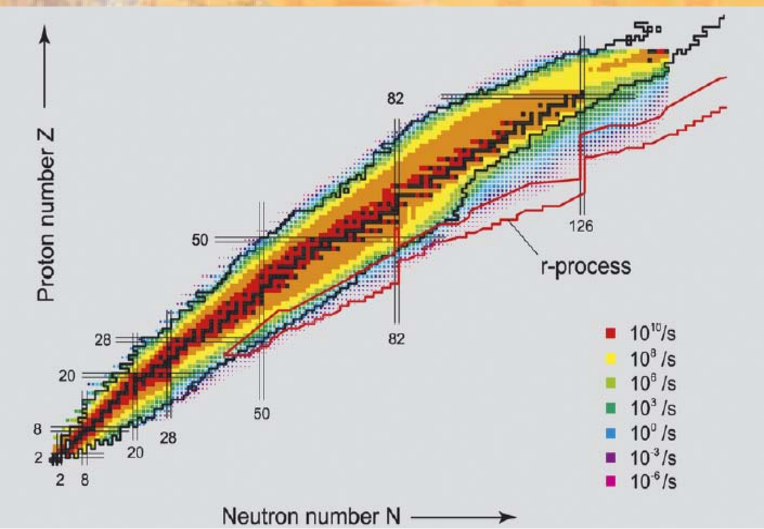
$\sigma_x = 1.0$ mm

$\sigma_y = 2.0$ mm

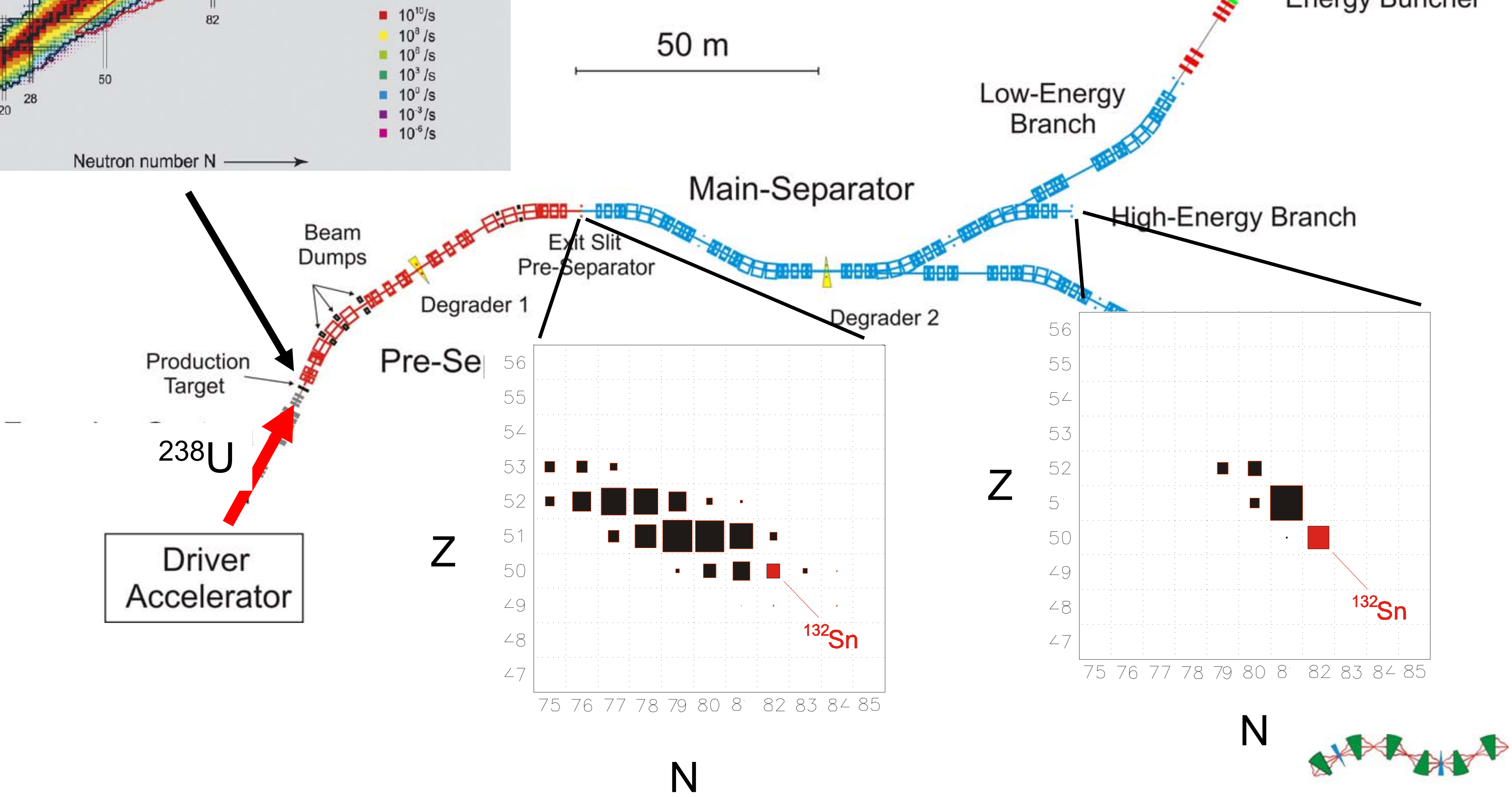


Features:
- 2 Separator-stages in achromatic mode
- Separation by Bρ-ΔE-Bρ method (variable degrader)
- Multi-branch system
- Large acceptance utilizing sc magnets
- Handling concept for high- radiation area

Aim: Production and Separation of Exotic Nuclei Using Super-FRS



Keywords:
Exotic nuclei
Relativistic energies
In-Flight separation



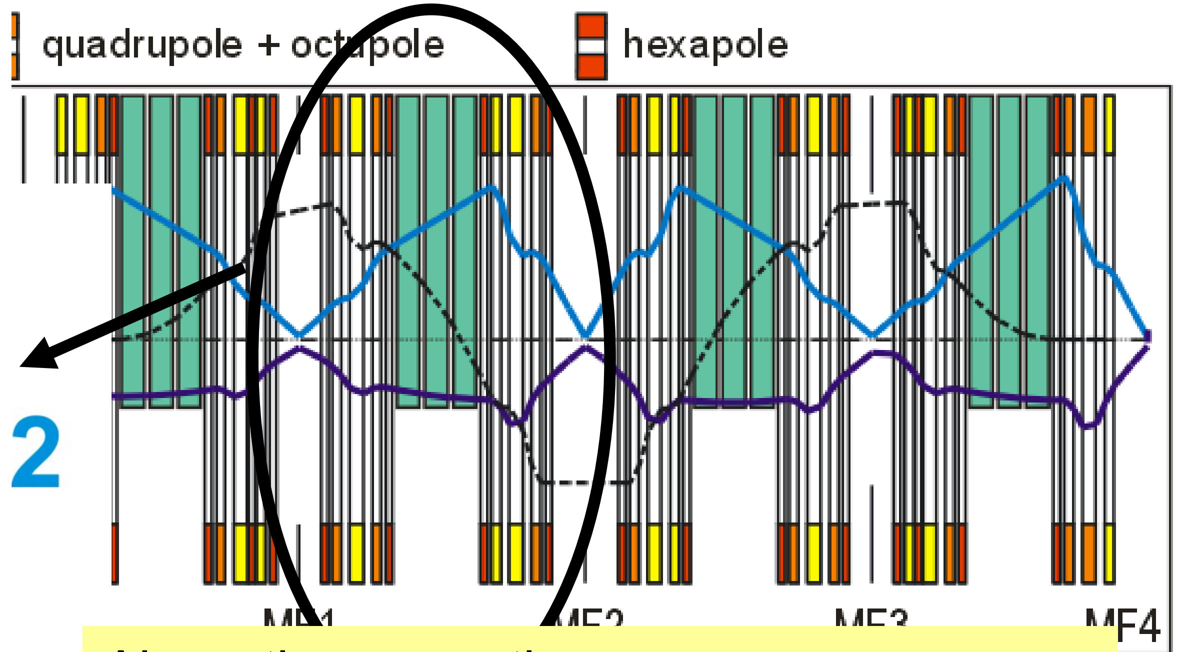
Ion-optical design of the Super-FRS

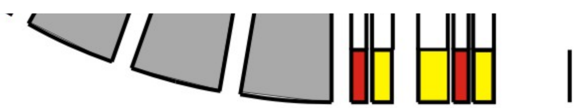
High-Energy Branch (HEB)

Main-Separator

1st order ion-optics of the Main-Separator

Matrix Element	MF1	MF2	MF3	MF4
(x, x)	-2.11	0.97	-2.11	1.7
(x, a)	**0**	**0**	**0**	**0**
(x, δ)	6.50	-5.95	6.50	**0**
(a, a)	-0.47	1.03	-0.47	0.59
(a, δ)	≈0	**0**	≈0	**0**
(y, y)	-1.14	1.25	-1.14	0.52
(y, b)	≈0	≈0	≈0	≈0
(b, b)	-0.91	0.89	-0.92	1.94
free space	4.0	6.0	4.0	3.0+





Aberration correction:

- sextupole magnets
- embedded octupole coils

Alignment correction

- y-steerer (integrated in multiplet cryostat)

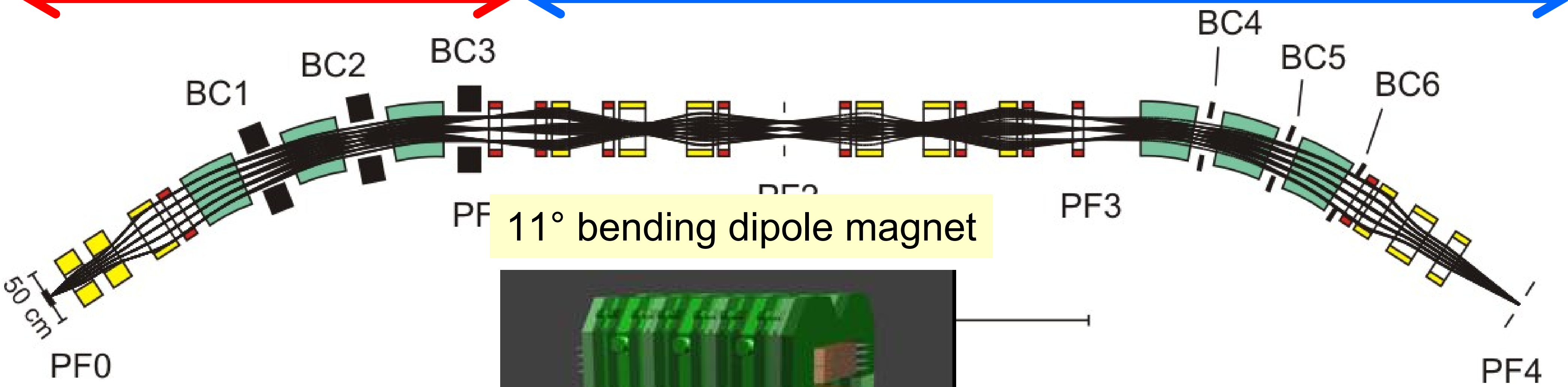
Magnets must be individually powered !

Layout of the Pre-Separator

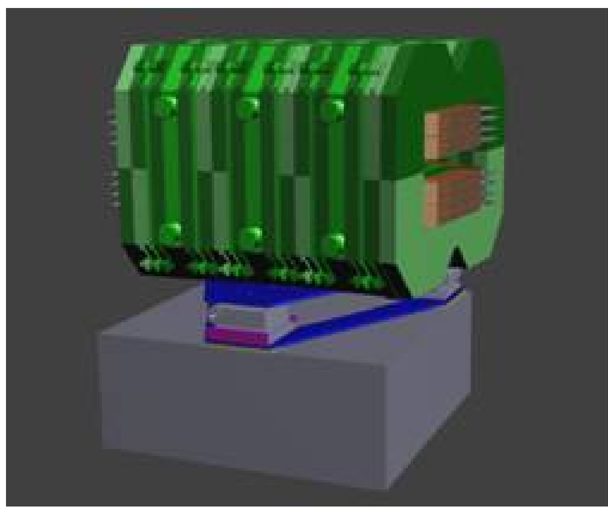
High-radiation level

→ Normal conducting

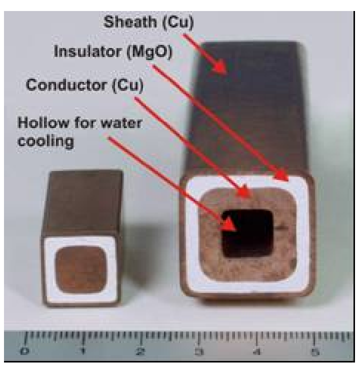
Super conducting



11° bending dipole magnet



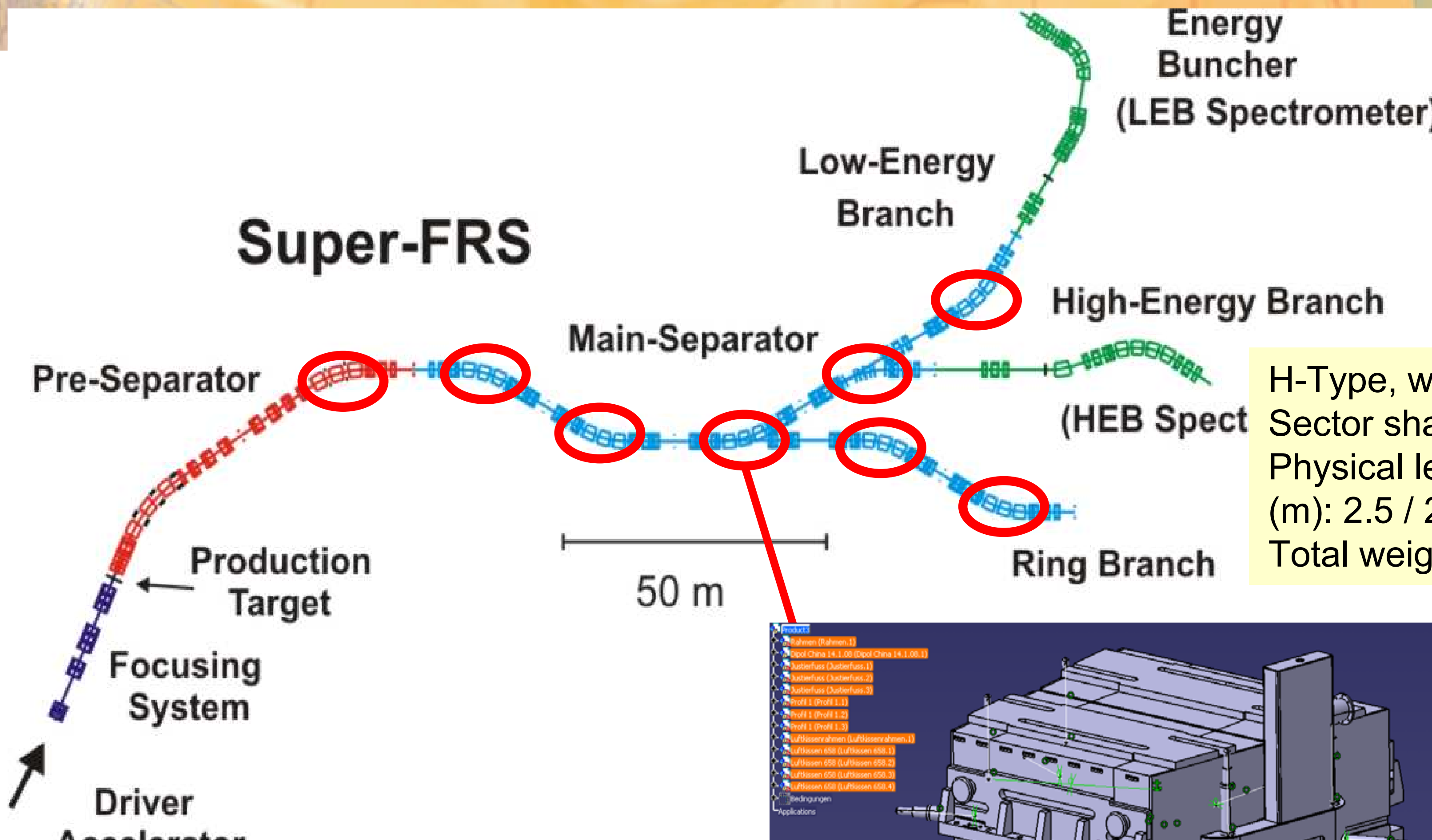
Mineral Insulated Cable (MIC)



- Pole gap height: 180 mm
- Length / width / hight (m): 3.2 / 3.0 / 2.1
- Total weight: 100 t
- Integrated field quality $\pm 3 \cdot 10^{-4}$

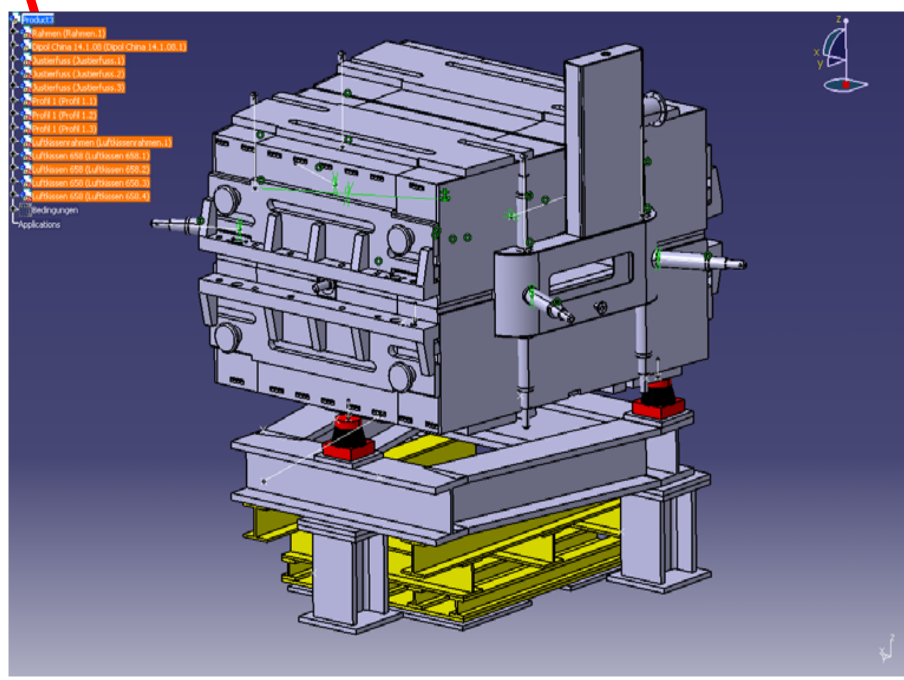
Prototype dipole magnet under construction at BINP

Superferric Dipoles for the Main Separator



H-Type, warm bore, warm iron
Sector shape
Physical length / width / height (m): 2.5 / 2.3 / 1.6
Total weight: ~50 t

Number of main dipoles		21
Dipole field	T	0.15-1.6
Bending angle	Degree	9.75
Curvature radius, R	m	12.5
Effective straight length, $L_{effe.}$	mm	2127
Good field region	mm	±190±35
Pole gap height	mm	170
Integral field quality (relative)		$\pm 3\times10^{-4}$

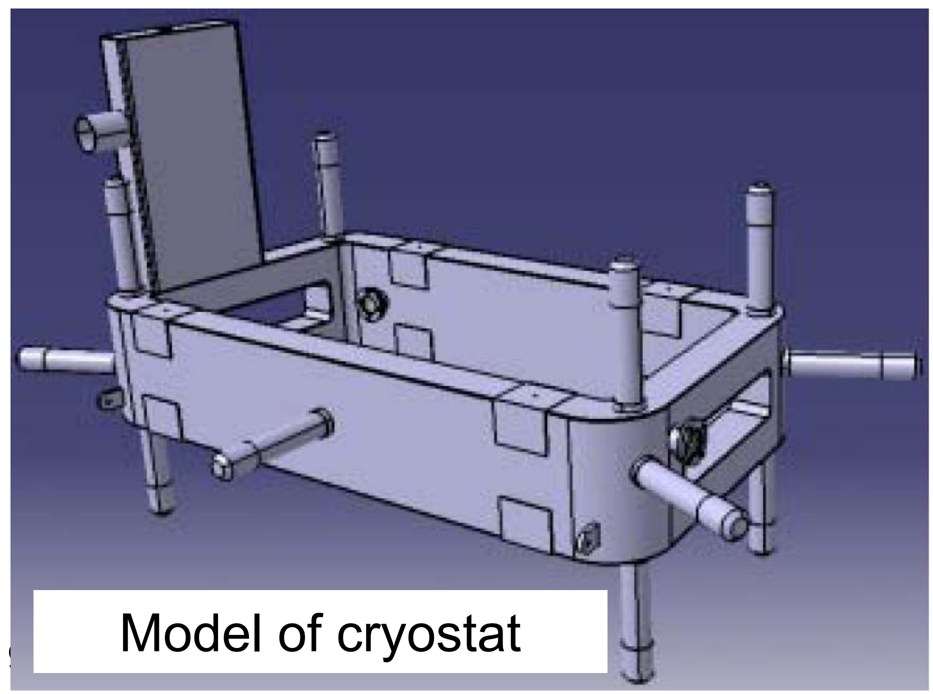


Prototype Dipole Fabrication by FCG

First punched sheet

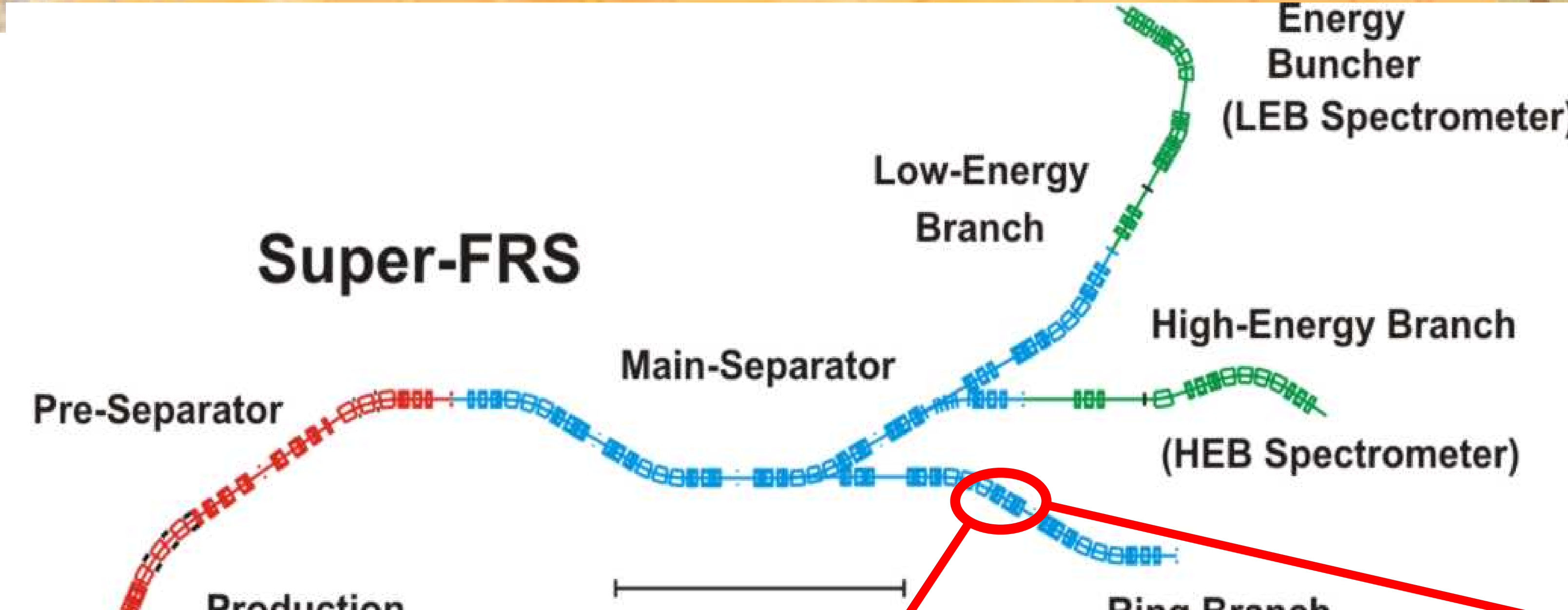
- Prototype fabrication by FCG
  Inst. of Modern Phys. Lanzhou,
  Inst. of El. Eng. Beijing,
  Inst. of Plasma Phys. Hefei
- Prototype status
  Yoke finished
  Test-Coil fabricated and tested
  Cryostat under construction
- Prototype test: end of 2008

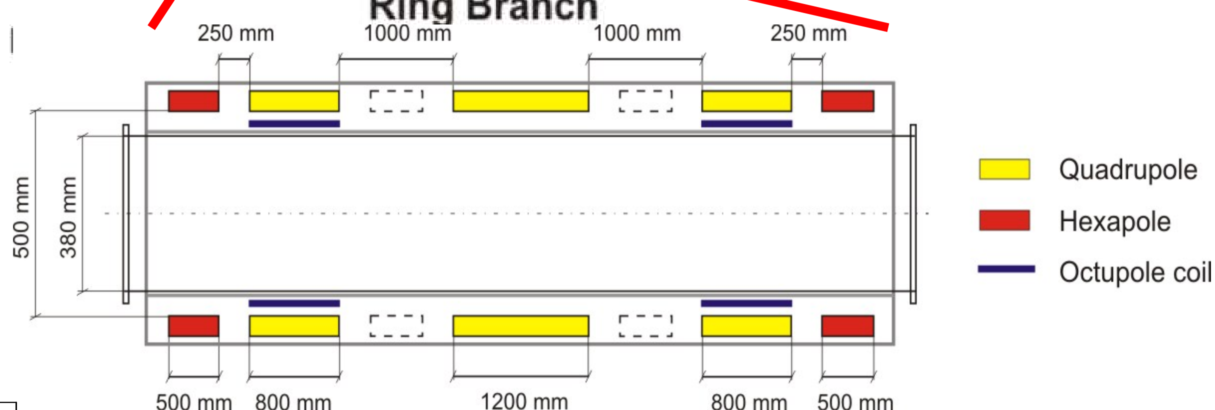
Test-coil



Model of cryostat

Superferric Multiplets for the Super-FRS



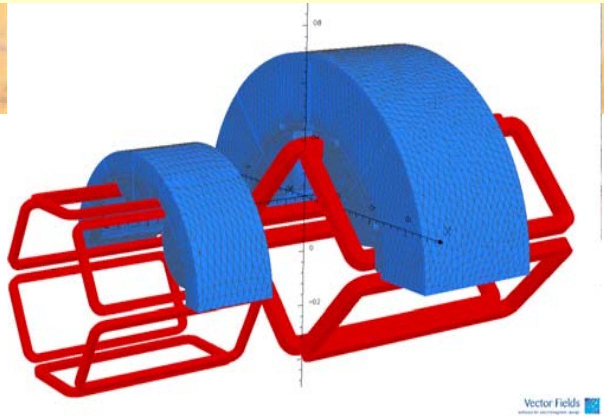


		Type 3 quad	Type 4 quad	sextupole
Number of Magnets		36	21	39
Eff. length, L	m	0.8	1.2	0.5
Gradient range G.		1.0-10 T/m	1.0-10 T/m	4-40 T/m^2
Gradient quality		$\pm 8\cdot 10^{-4}$	$\pm 8\cdot 10^{-4}$	$\pm 8\cdot 10^{-4}$
Useable horizontal aperture	mm	±190	±190	±190
Useable vertical aperture	mm	±120	±120	±120
Embedded octupole (B''')	T/m^3	105		

- Warm bore diameter of 38 cm
- (Iron-dominated, cold iron)
- Quadrupole triplet + separated sextupoles + steering magnet
- Octupole correction coils are embedded

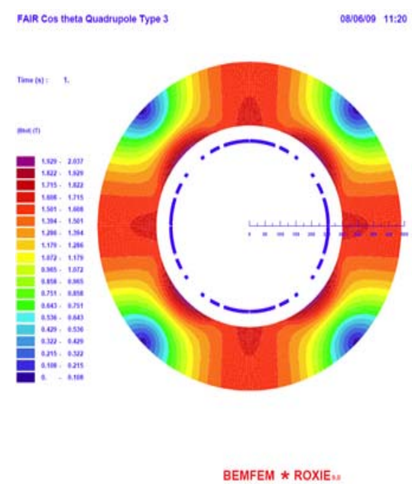
Super Conducting Muliplet Design

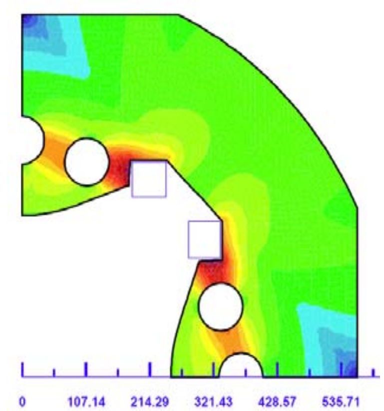
Superferric magnet design made by GSI



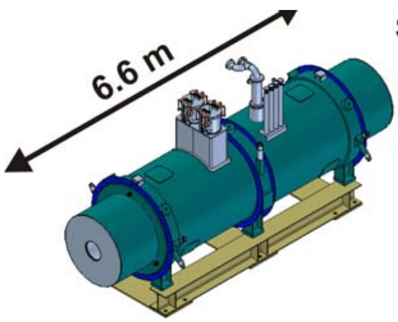
Conceptual designs started by France/Spain (CEA / CIEMAT)

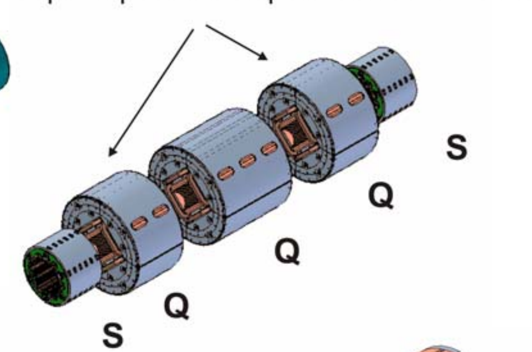
- re-design (superferric)
- alternative solutions



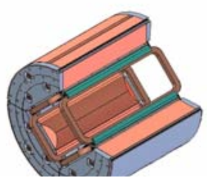


Conceptual design by Toshiba Corporation

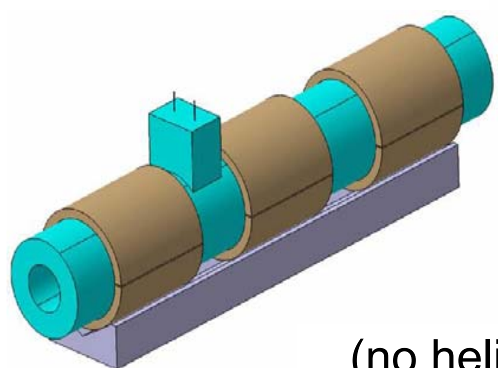


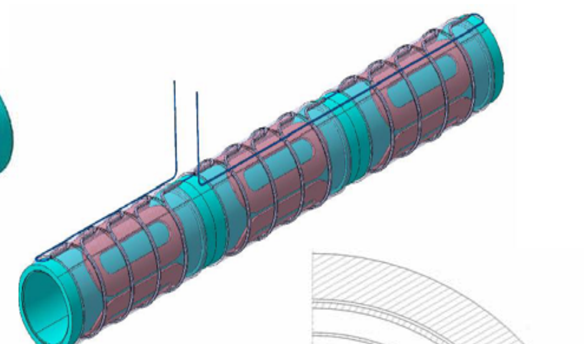


Effective length (quads)	0.8 / 1.2 m
Aperture (warm)	± 190 mm
Pole radius	240 mm
Field gradient	1.0 - 10.0 T/m

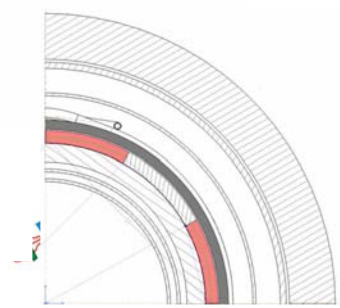


		Type 3 quad	Type 4 quad	sextupole
Number of Magnets		36	21	39
Eff. length, L	m	0.8	1.2	0.5
Gradient range G.		1.0-10 T/m	1.0-10 T/m	4-40 T/m^2
Gradient quality		$\pm 8 \cdot 10^{-4}$	$\pm 8 \cdot 10^{-4}$	$\pm 8 \cdot 10^{-4}$
Useable horizontal aperture	mm	±190	±190	±190
Useable vertical aperture	mm	±120	±120	±120
Embedded octupole (B''')	T/m^3	105		



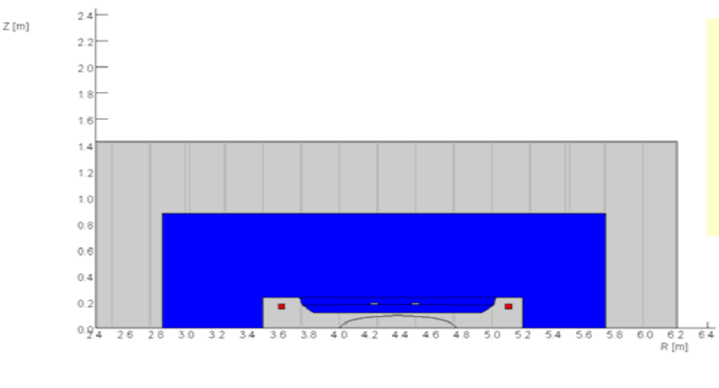


(no helium vessel, indirect cooling)

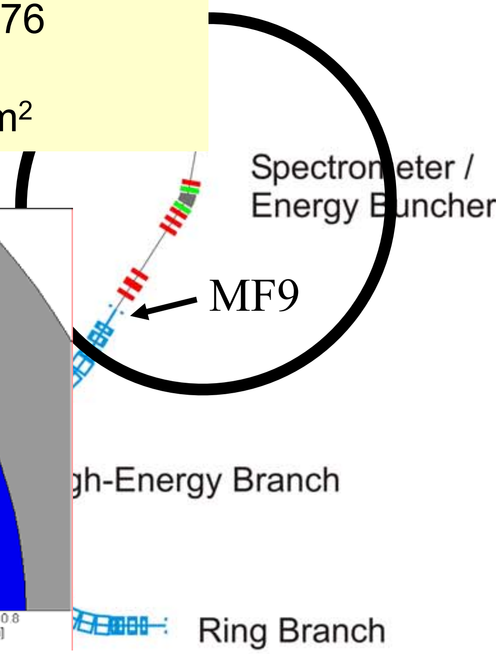


Energy Buncher / Magnetic Spectrometer

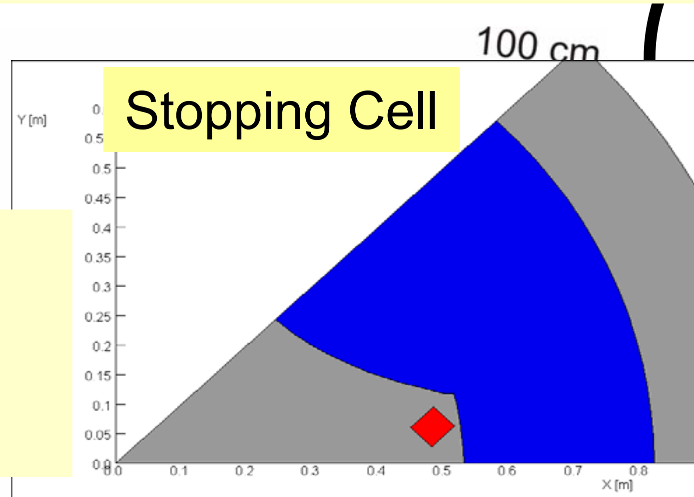
Superferric magnet design made by GSI



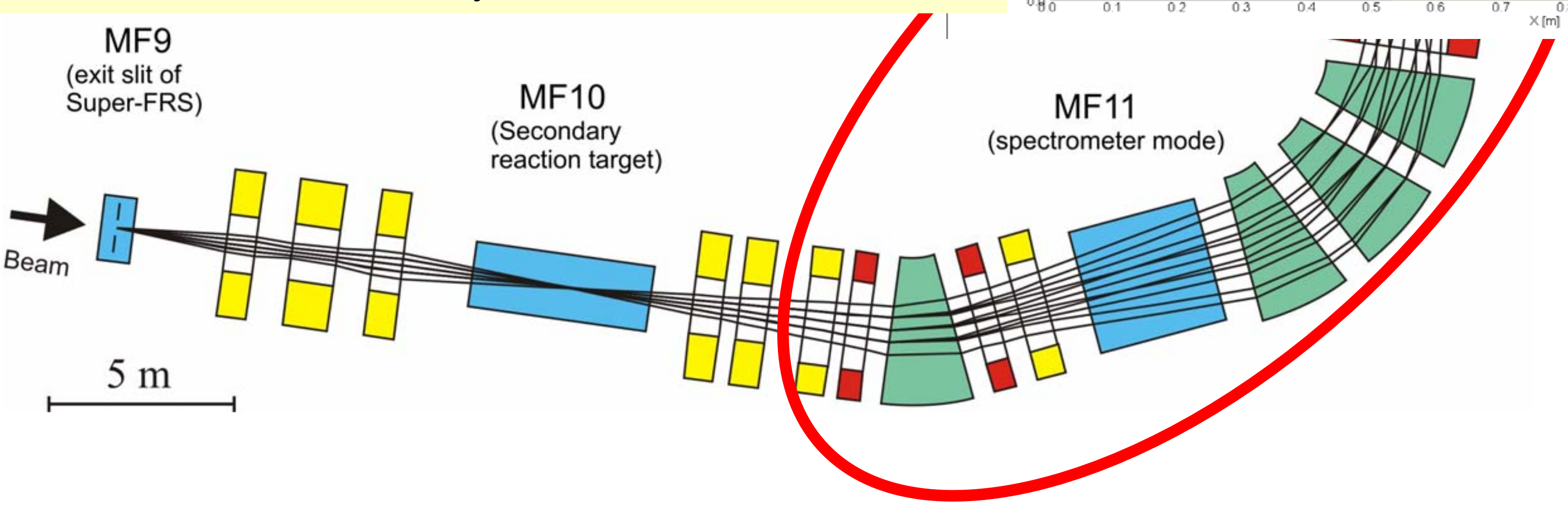
- Pole gap height: 240 mm
- Physical length / width / hight (m): 2.7 / 2.89 / 1.76
- Total weight: 80 t
- Maximum current density in the coil is 104 A/mm²



Stopping Cell

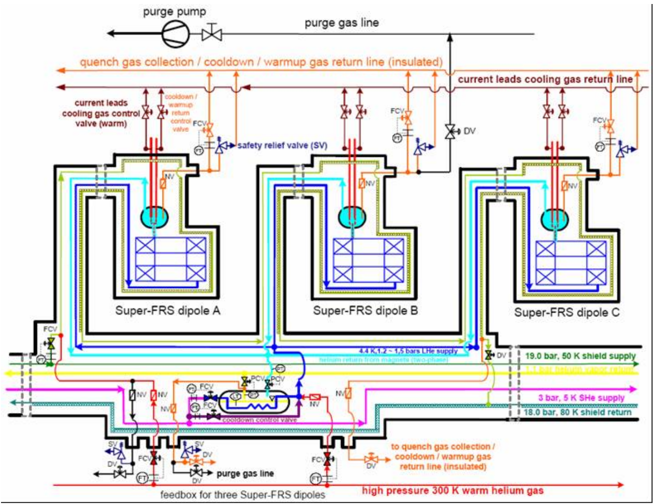


- Pole tip radius: 345 mm
- Yoke length/width/hight (m): 1.2 / 1.7 / 1.7
- Total weight: 17.7
- Maximum pole-tip field: 1.75 T
- Maximum current density in the coil is 110 A/mm²

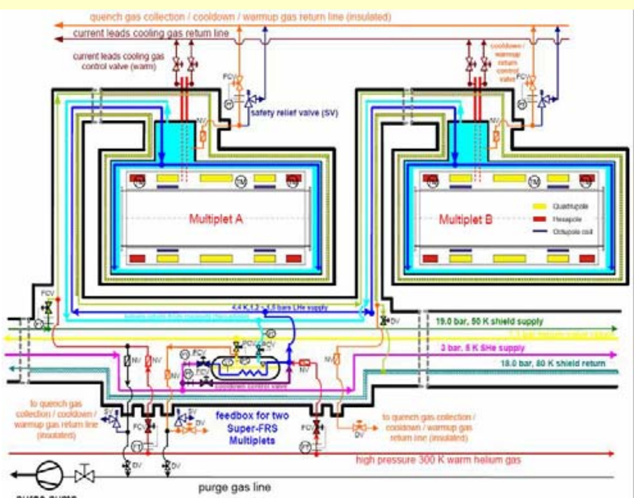


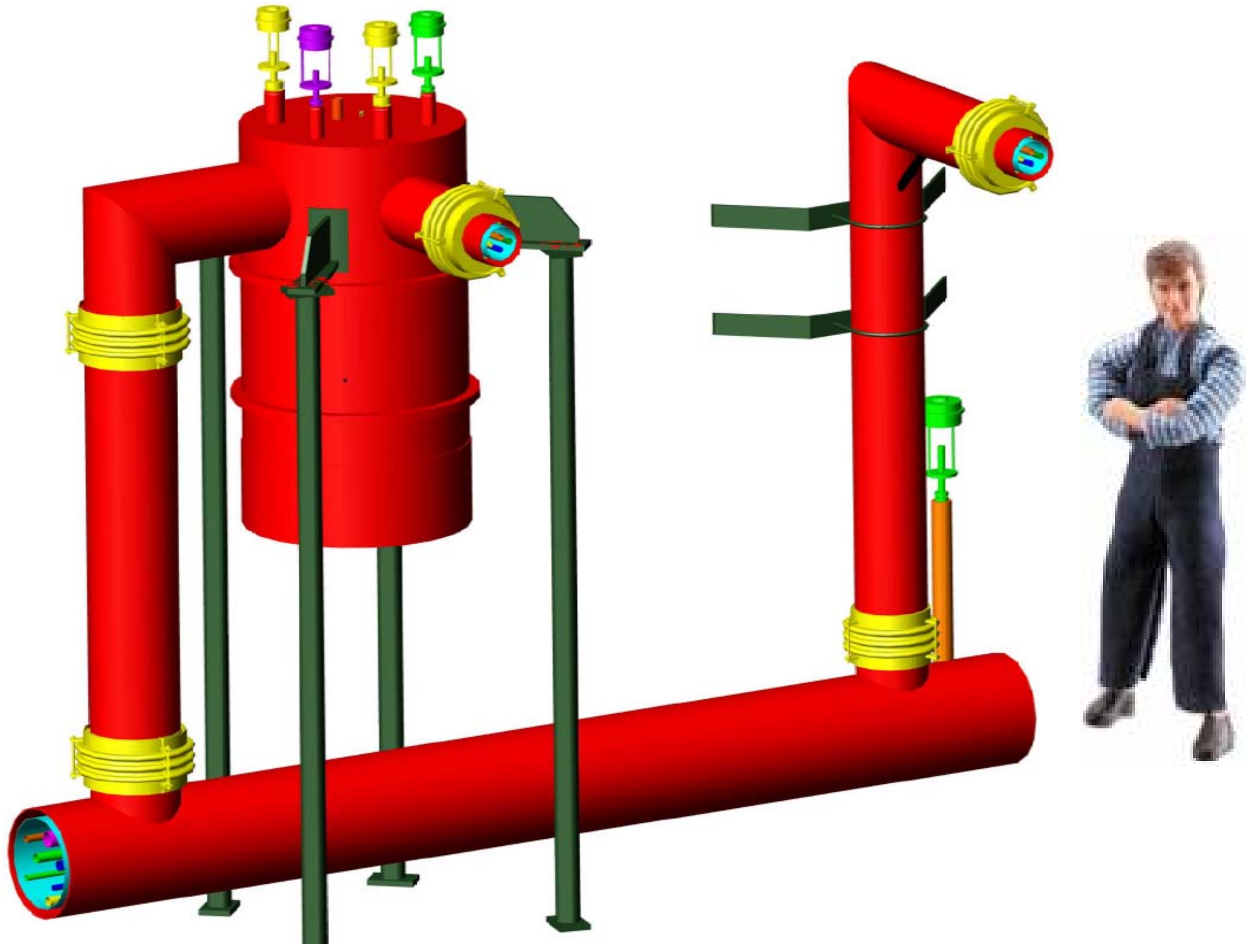
Local Cryogenics

- three dipole units + one feedbox



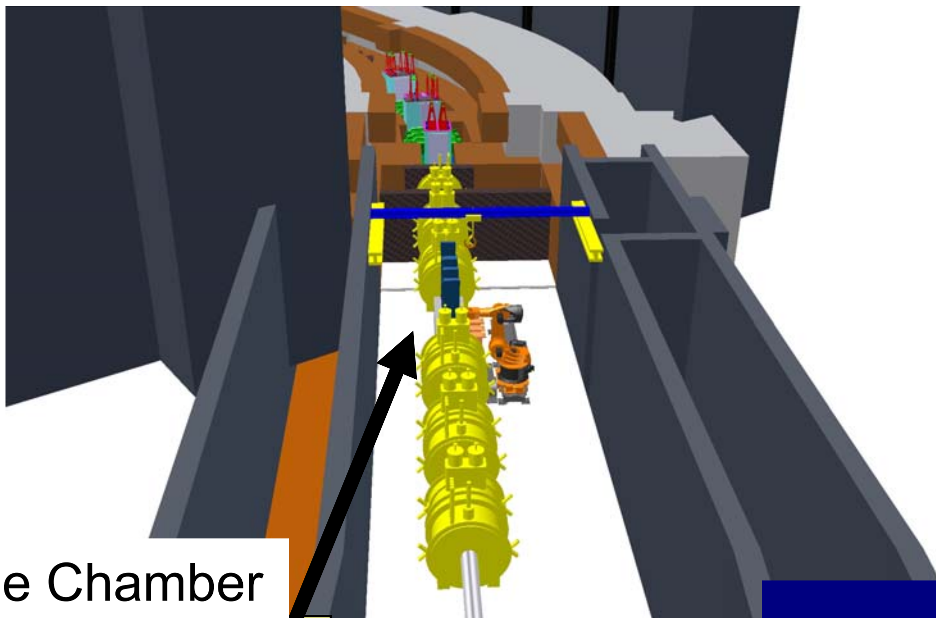
- two multiplet units + one feedbox



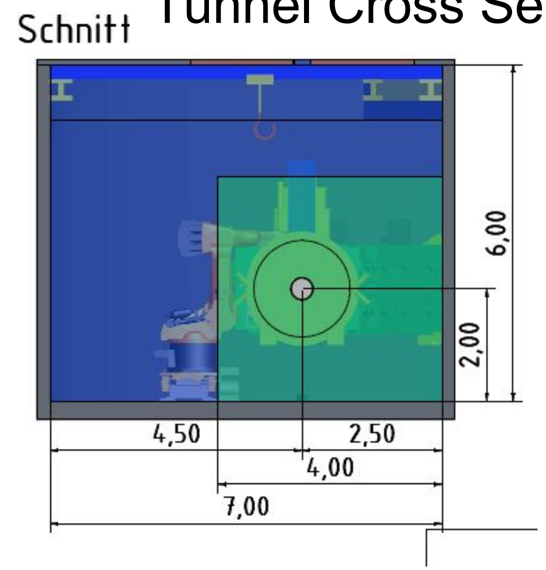


outer diameter of feedbox vacuum vessel	1012 mm (~DN 1000)
height of feedbox (from bottom to top of the valves)	~ 2.4 m

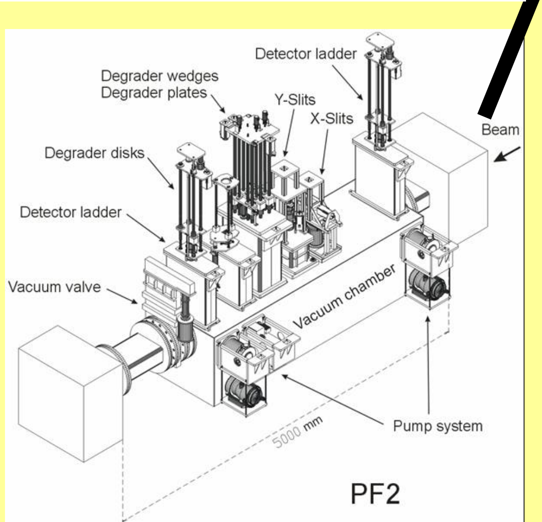
Installation (Tunnel Build. #103)



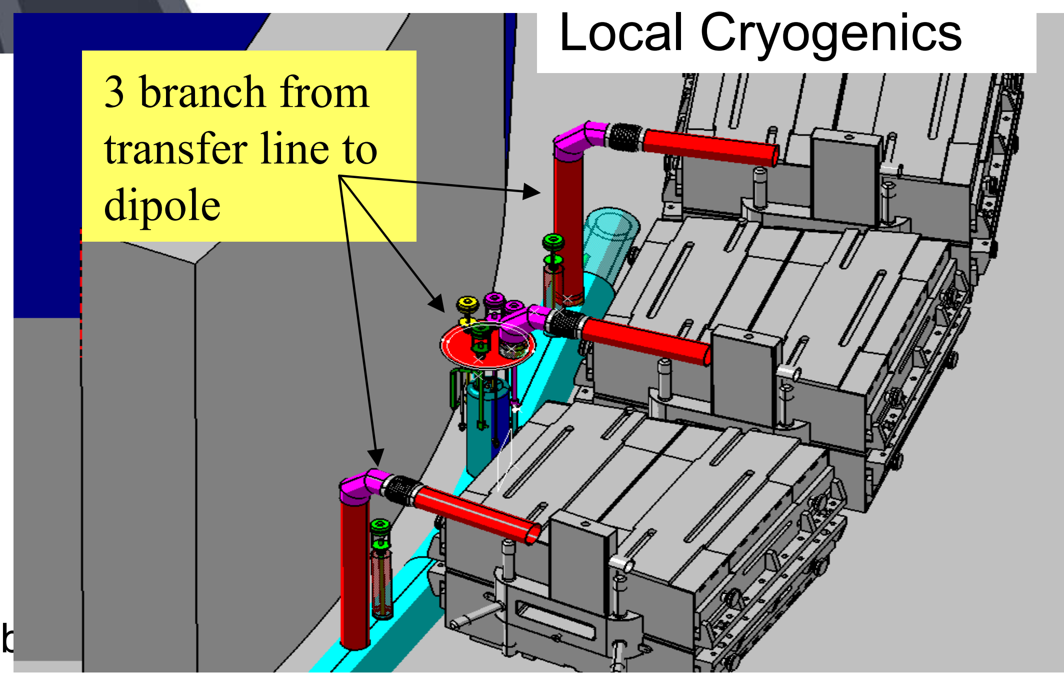
Tunnel Cross Section



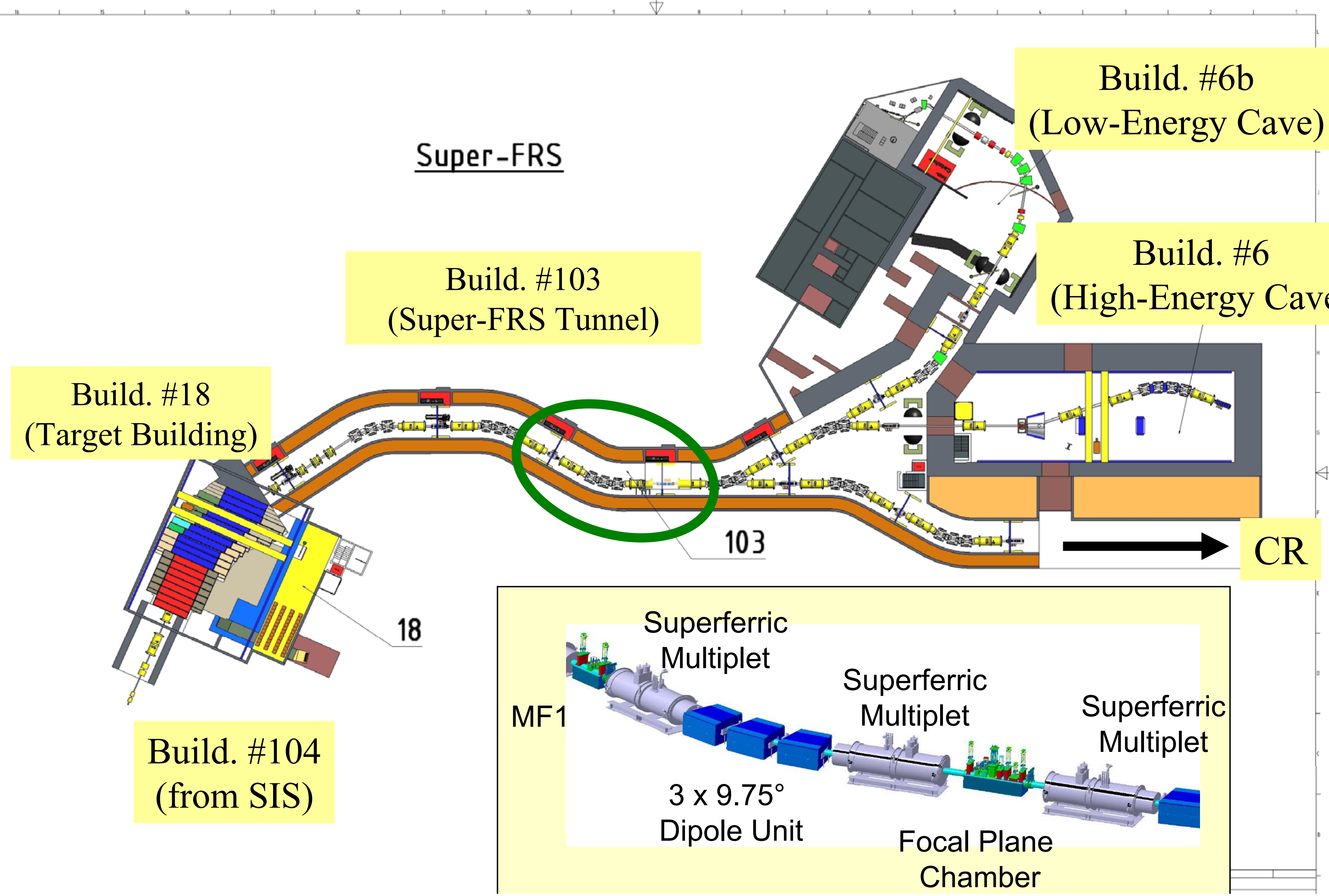
Focal Plane Chamber



Local Cryogenics

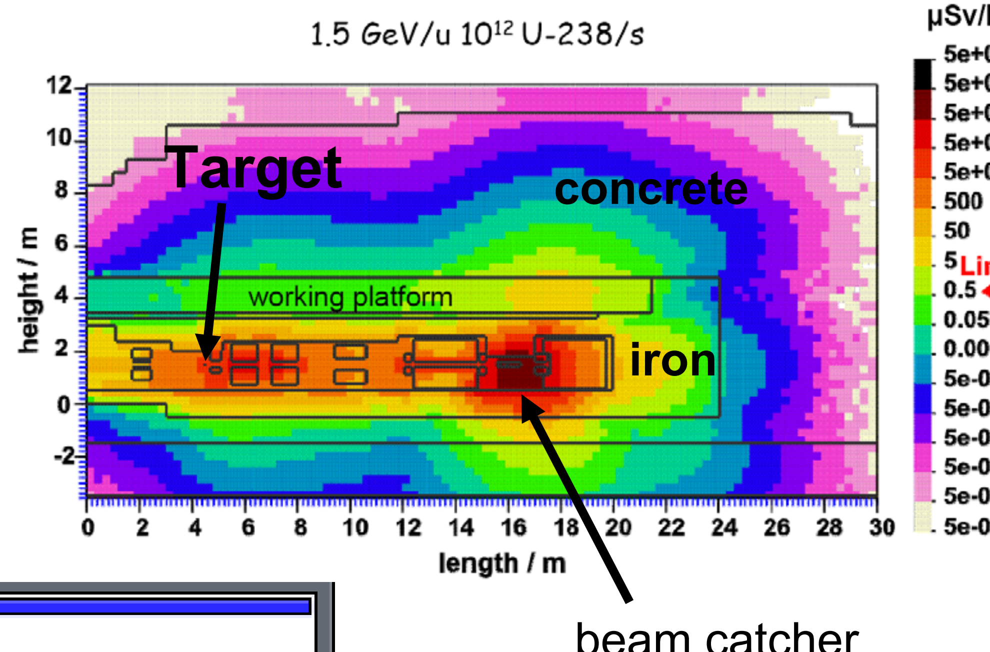


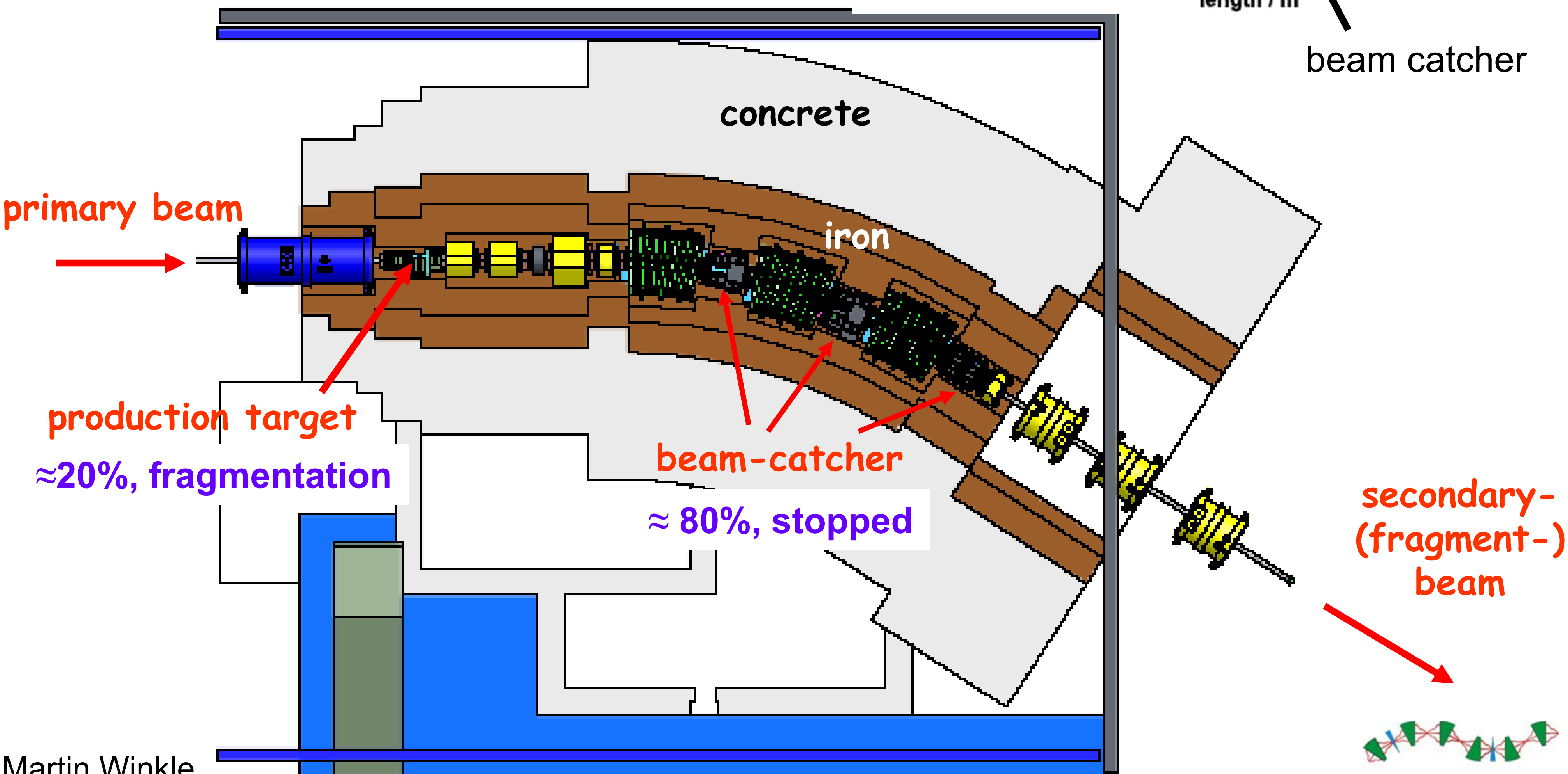
Super-FRS Buildings



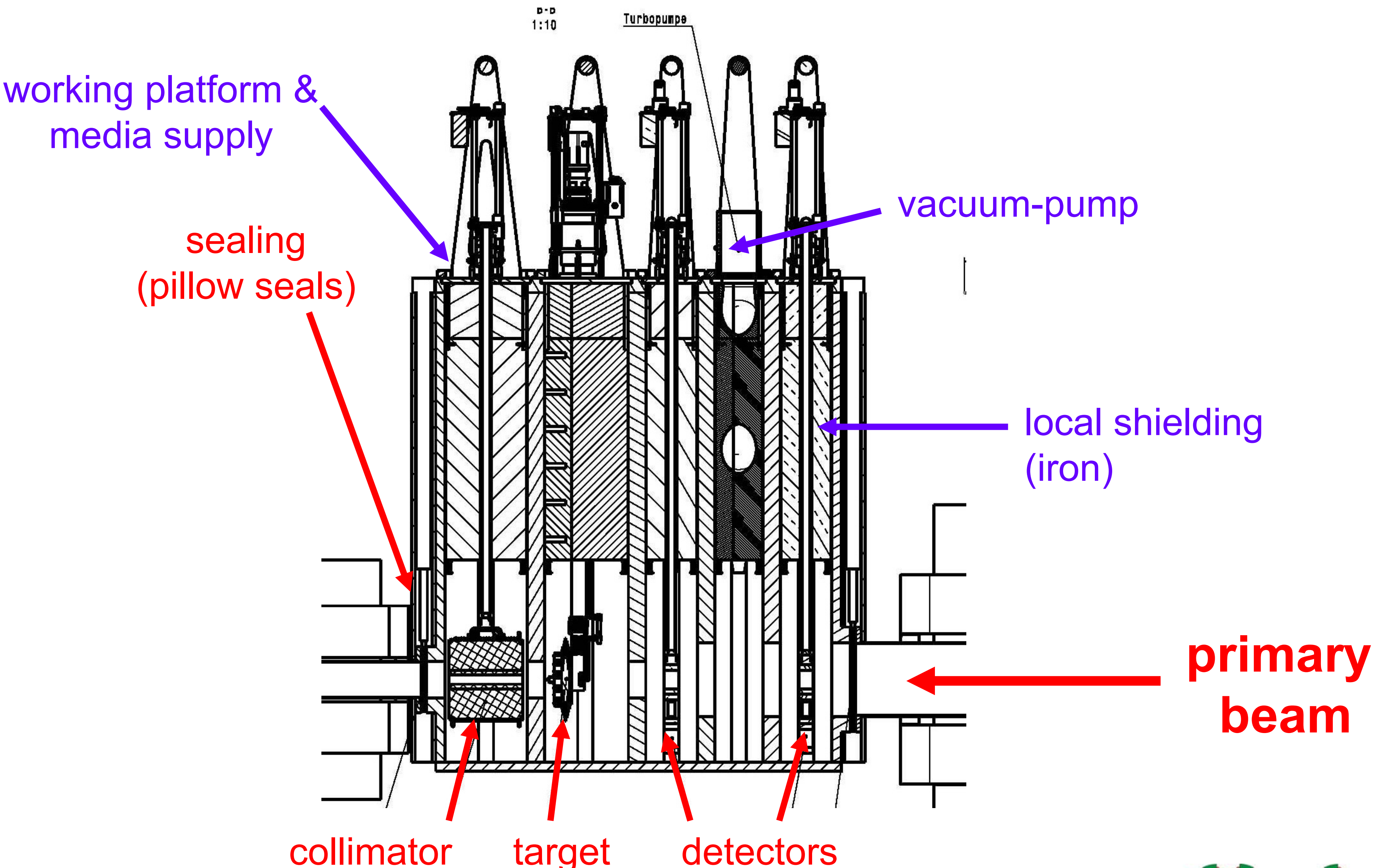
Target Building

100% ≤ 10^{12} Ion/s
1000 MeV/nucleon

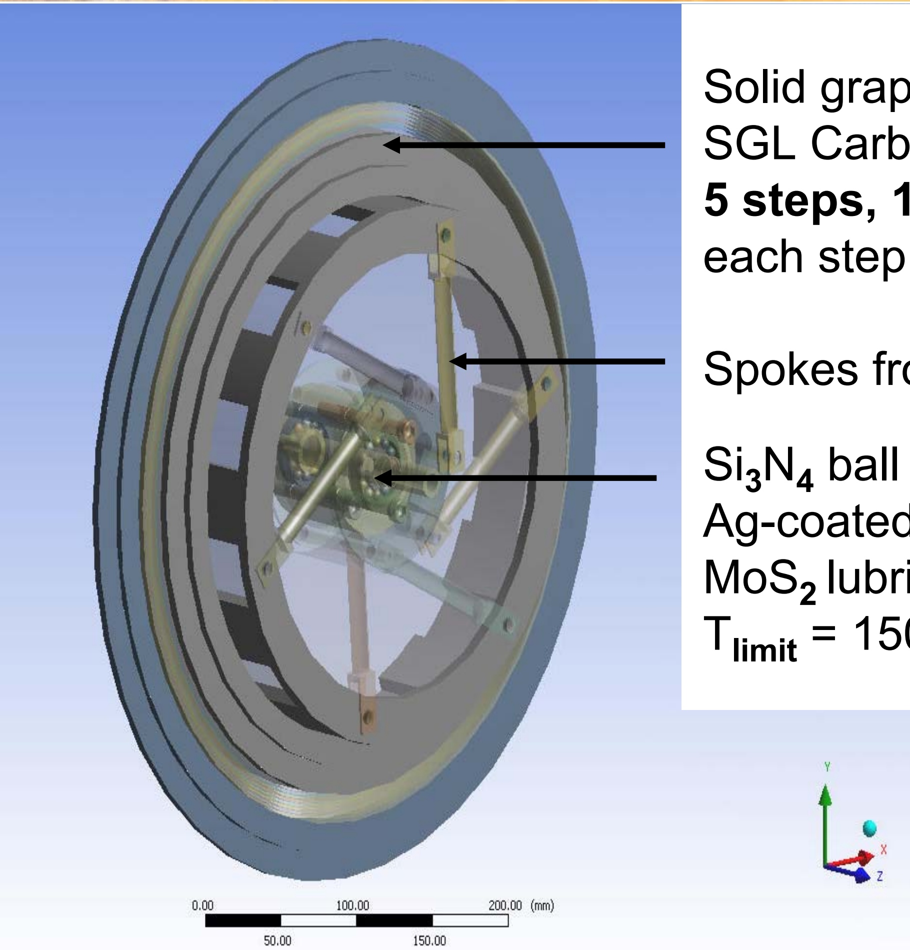




Target Area Equipment



Graphite Wheel Target

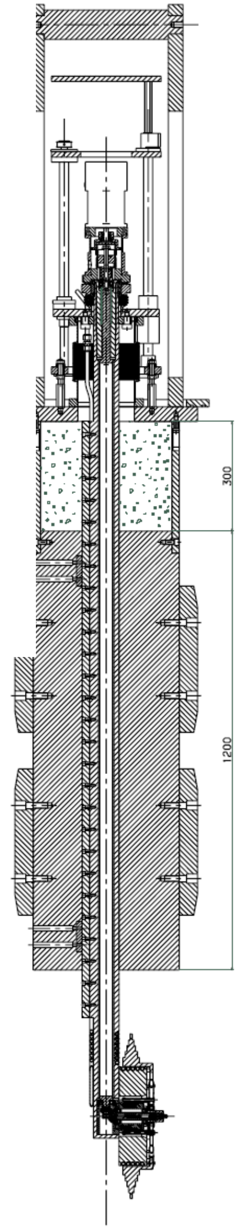


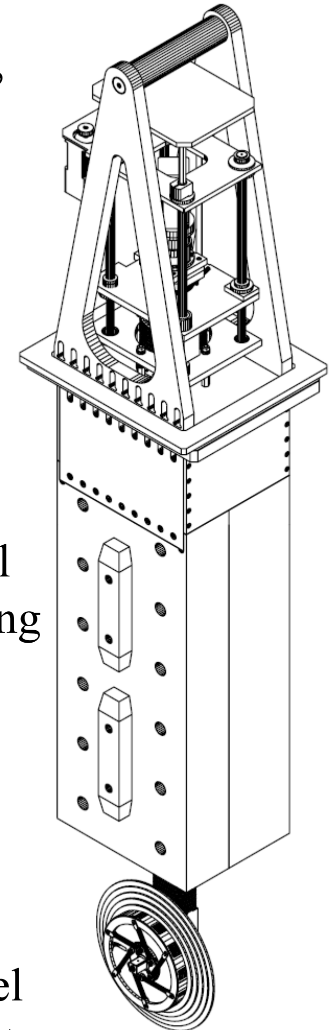
Solid graphite
SGL Carbon R 6400P
5 steps, 1 – 8 g/cm²
each step 16 mm wide

Spokes from INCONEL 600

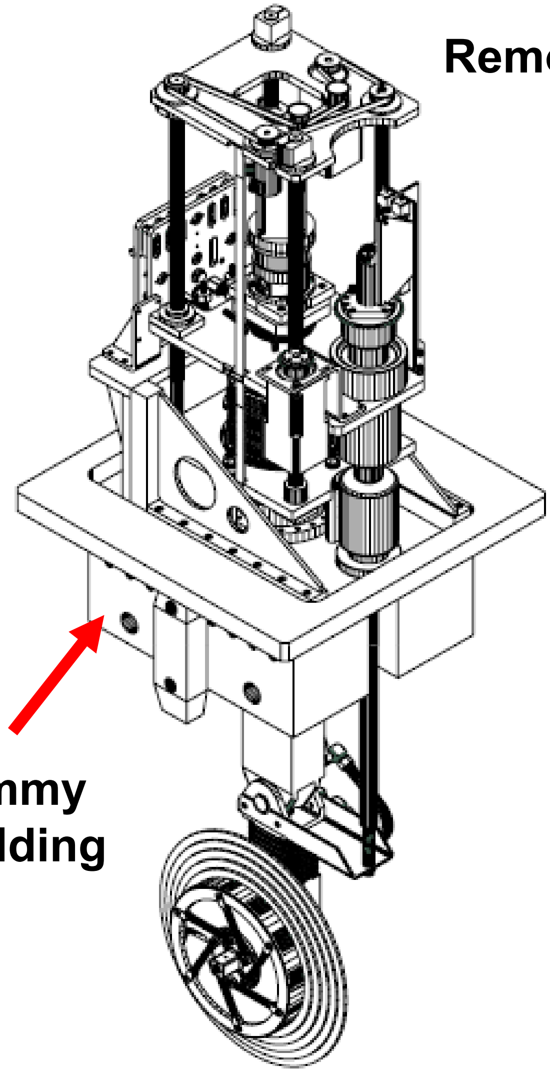
Si_3N_4 ball bearings
Ag-coated cages
MoS_2 lubrication
T_{limit} = 150°C

- cooling only by radiation
- R_{out} = 22.5 cm



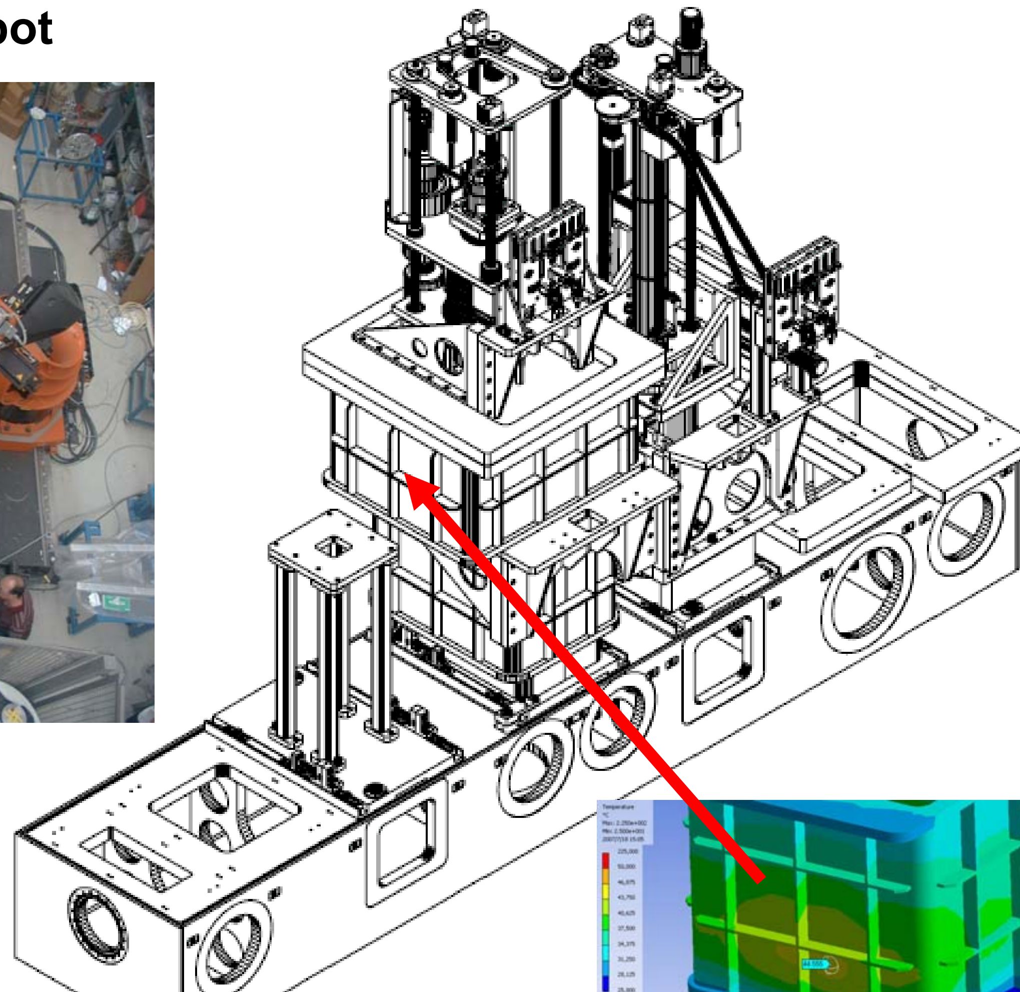


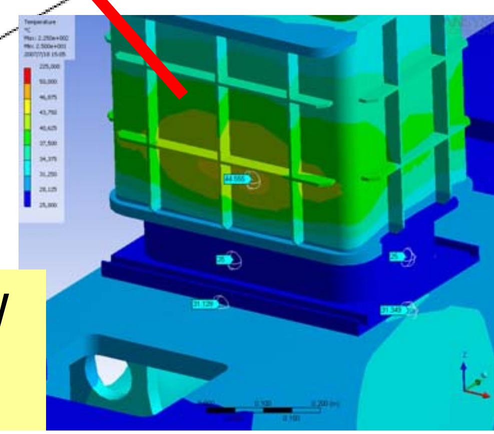
Prototype Target
to be used at FRS with SIS18 beams



Remote handling adapted for FRS target robot

New FRS target chamber





$P_{Max} \approx 600$ W
$T_{Max} \approx 45°C$

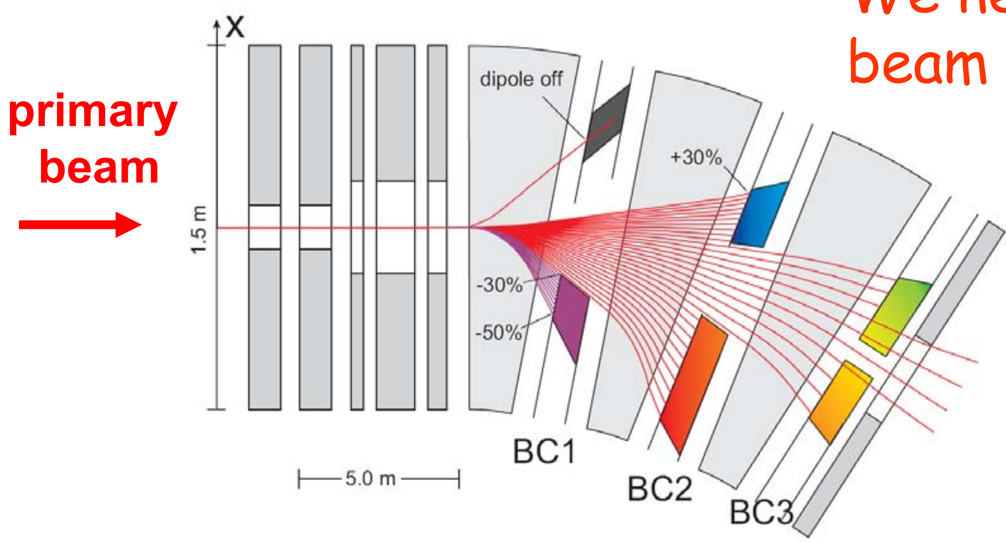
Construction at Fa. Reuter, Germany

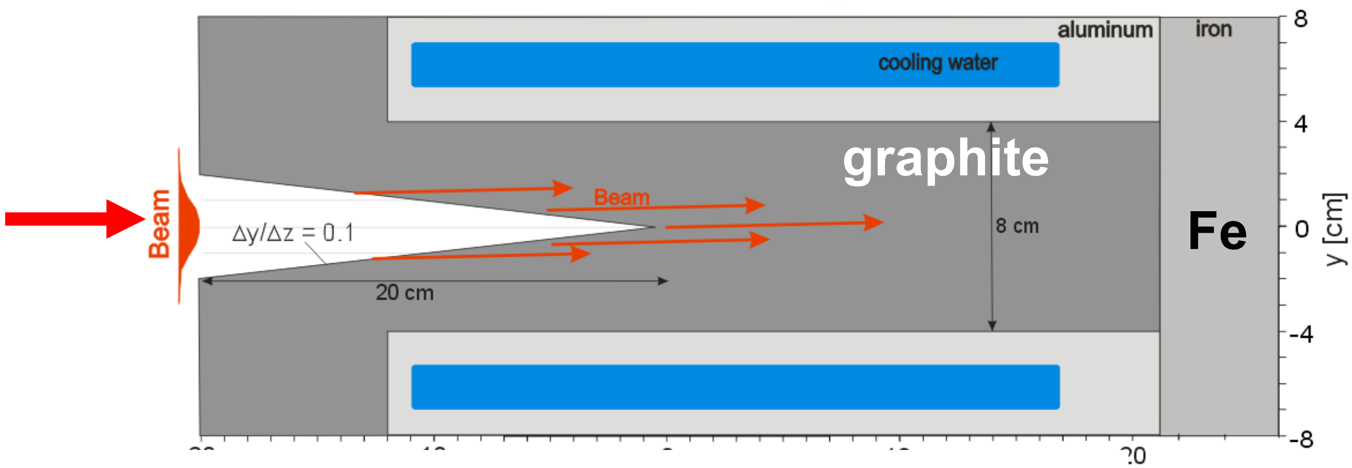
- Fabrication completed in 10/2008

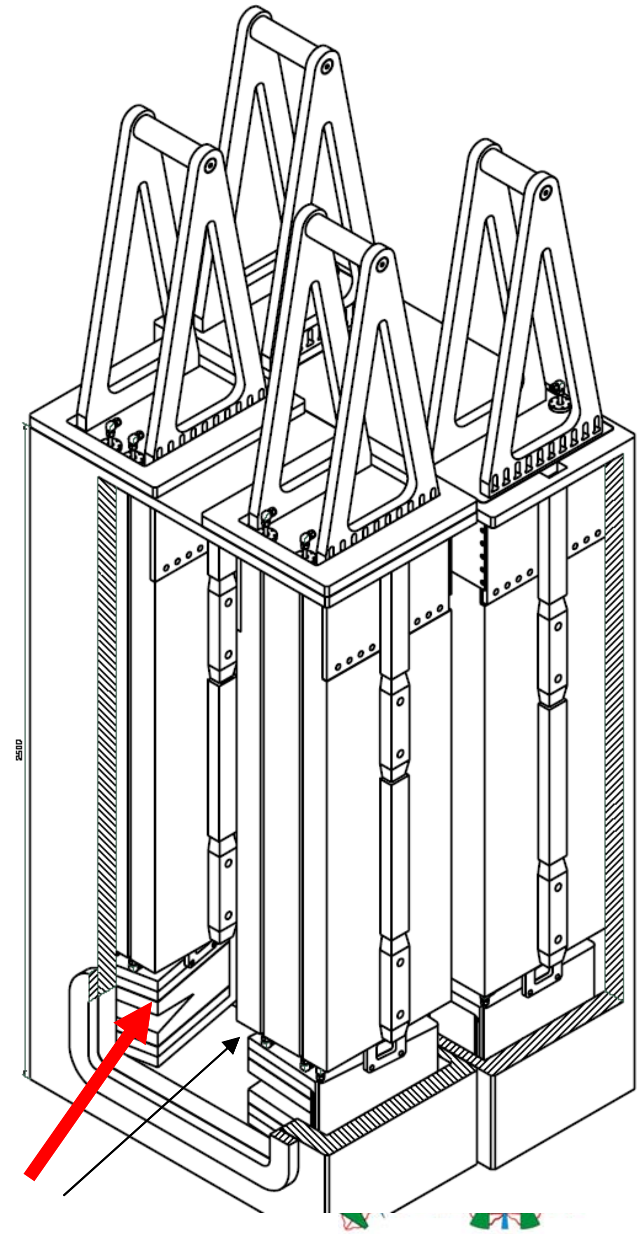
→ Preparation for test @ FRS

Beam Catcher

We need 3x2 beam catcher:

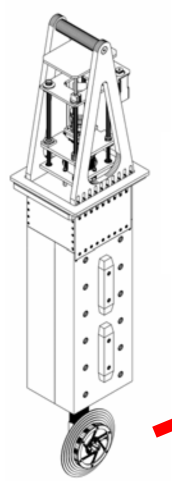


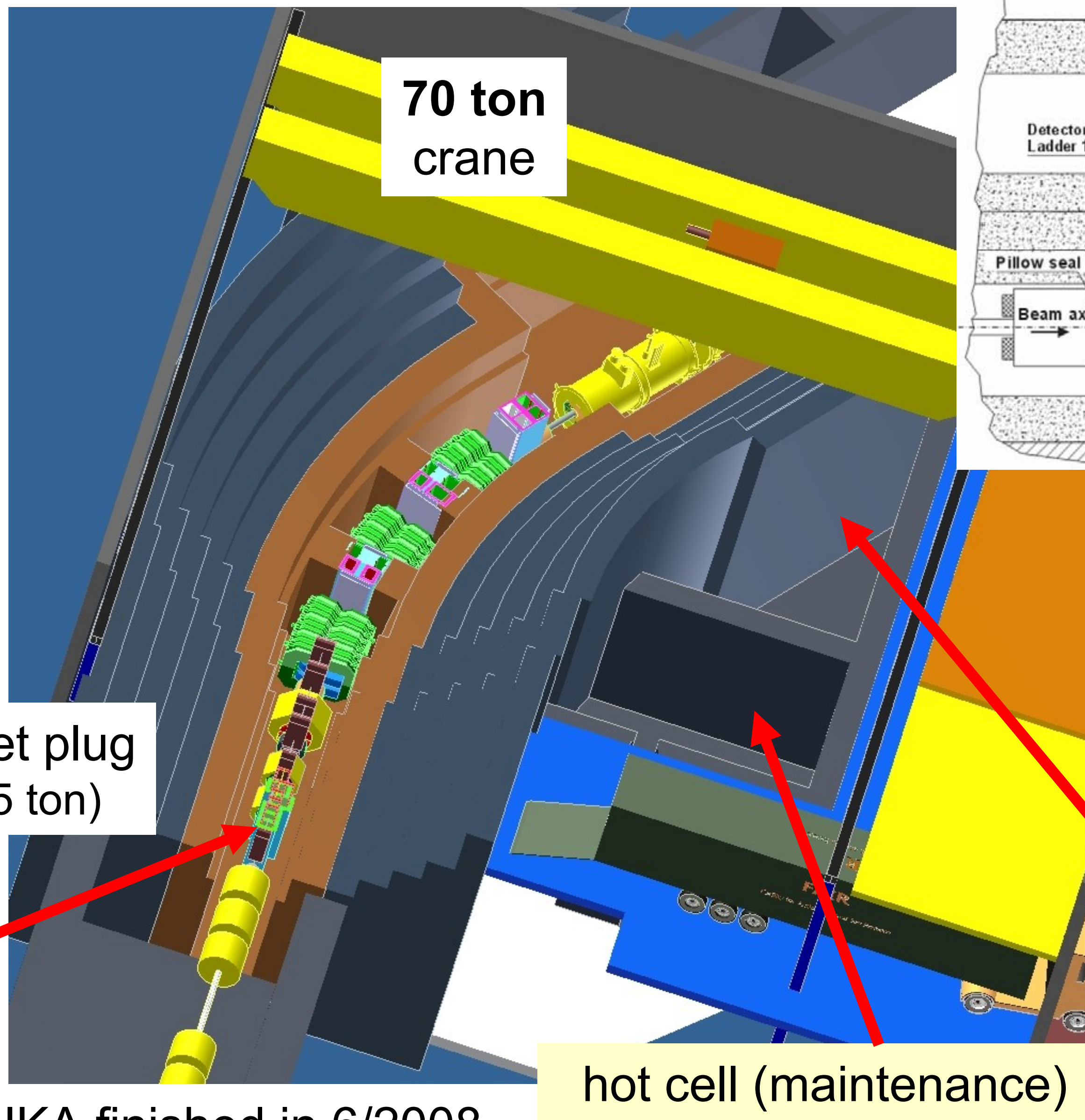




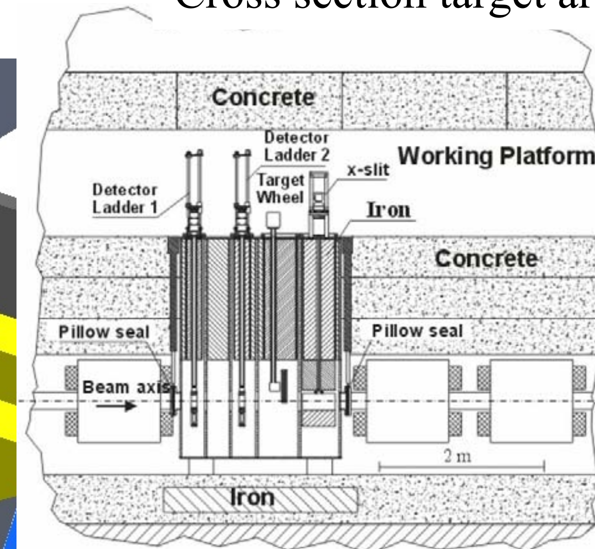
- **Front part**: **graphite** (20cm+) to absorb strong pressure waves, water cooled
- **Back part: iron** (60cm) to absorb protons and neutrons.

Handling Concept
(analog to PSI Villigen/CH)





Cross section target area



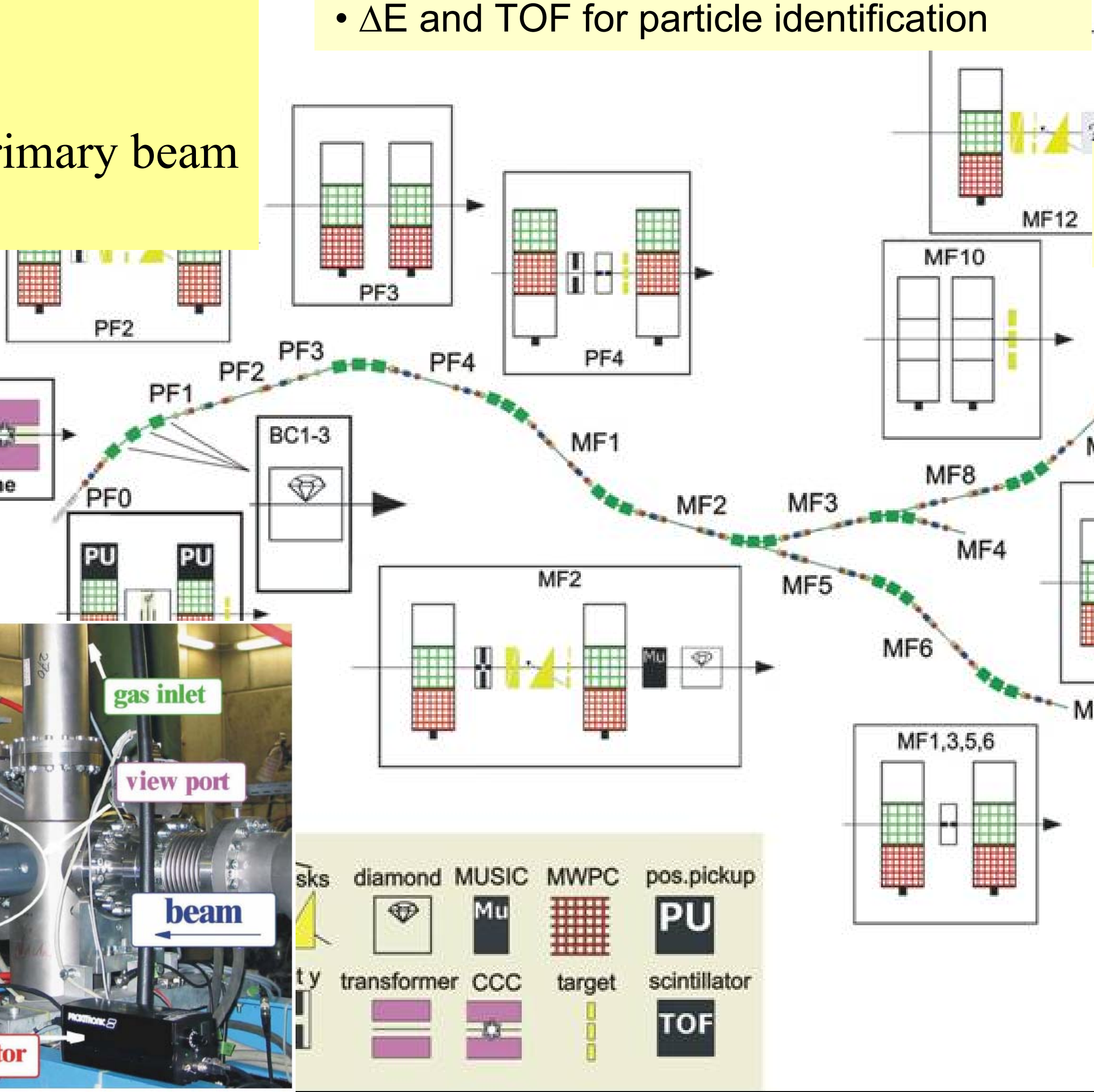
feasibility study at HKA finished in 6/2008

Super-FRS detector system

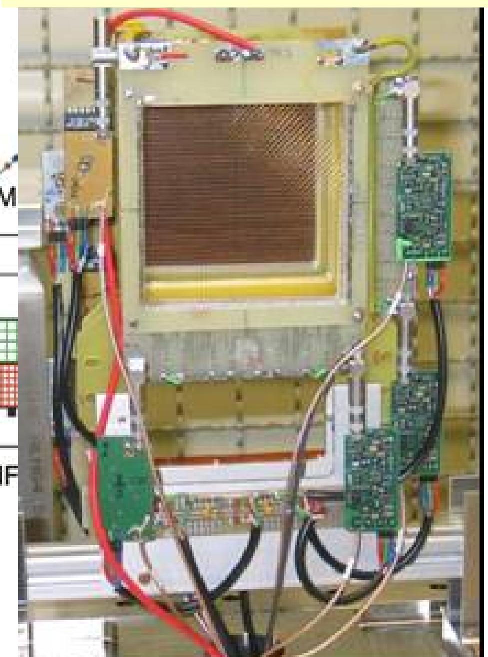
Operation mode
- fast extraction
- slow extraction

Intensity
- high intensity/primary beam
- particle counter

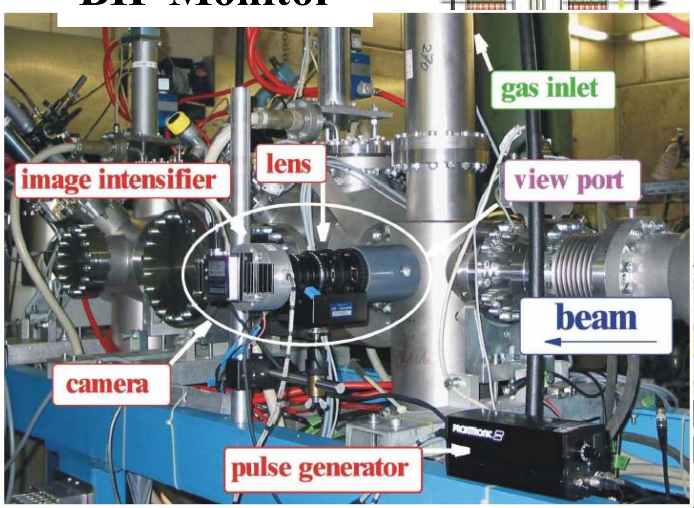
Full isotope identification
- x, y: position measurements → Bρ
- x', y': corresponding angle measurements
- ΔE and TOF for particle identification



Prototype BC Detector (EU Design Study)

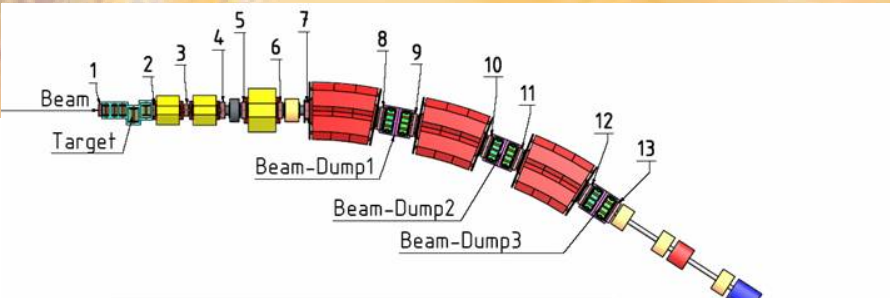


BIF Monitor

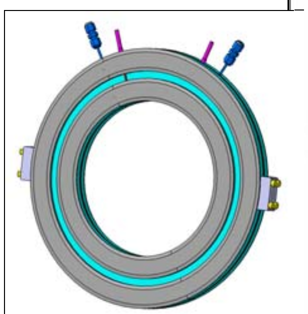


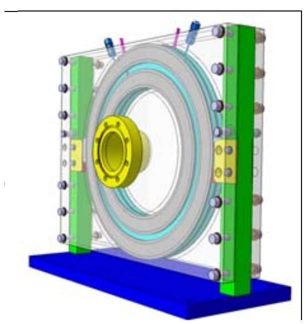
Concept for the Super-FRS vacuum system

Inflatable Pillow Seals in the Pre-Separator

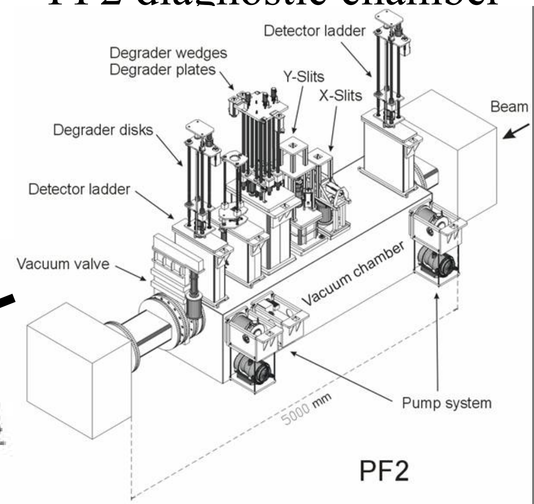


Pos.Nr.	Pillow-Seal inner diameter	Pos.Nr.	Pillow-Seal inner diameter
1	500mm	8	800mm
2	300mm	9	500mm
3	300mm	10	1200mm
4	500mm	11	500mm
5	500mm	12	800mm
6	500mm	13	500mm
7	500mm		

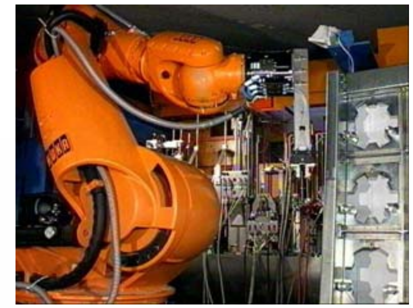


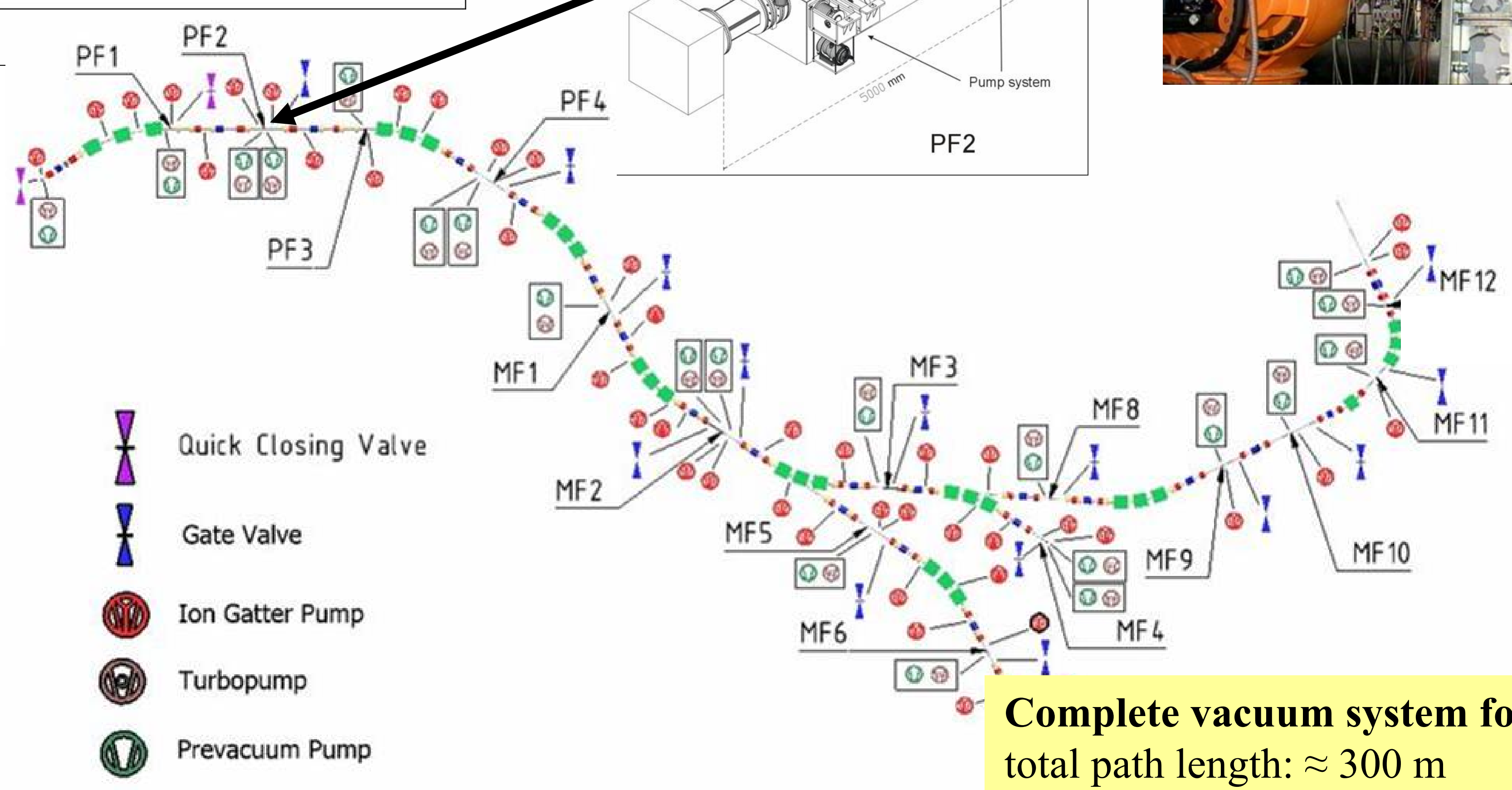


PF2 diagnostic chamber



Robotor handling





Complete vacuum system for:
total path length: ≈ 300 m
pressure: ≈ 10^{-7} mbar

Expressions of Interest for Super-FRS

Super-FRS 2.4	*France has orally expressed interest but not yet specified*	
Dipoles 2.4.2.1	5 Budker (Dip 1) / 1 VECC (LEB) 14 IMP (Dipoles 2 a[redacted]3)	
Quadrupoles 2.4.2.2	5 Bud. (Q 1/2) 1 VECC (LEB) 11 CIEMAT (Types 3 and 4)	
Sextu/Octupoles 2.4.2.3	5 Bud, (Sex 1) / 1 VECC (LEB) 11 CIEMAT (Sext. Type 2)	
other 2.4.2.4/5	11 CIEMAT	
Power Supplies 2.4.3	Interfaces by 13 GSI, about 10% of value	
Beam Diagnostics 2.4.6	Interfaces by 13 GSI, about 10% of value	+ Finnland (8.10.08)
Vacuum 2.4.7	14 IMP, chambers dip 2/3 13 GSI V,G,Boc,NEGch 5 Budker	
Beam Catcher 2.4.11.1	1 VECC 2 Profex (iron plugs)	
Degrad./Ion-Catch 2.4.11.2	2 Profex (degtader plates)	
Production Target 2.4.11.3	13 GSI	
Local Cryo 2.4.12	15 Wroclaw Univ. Technol.	
Stopping cell 2.4.11.2.7 + ?	+ Finnland (8.10.08)	

Events in 2008

- March 2008:
  Technical Design Report
- April 2008:
  1st International EoI Meeting
- May 2008:
  Re-Evaluation of Super-FRS by SRG
- July 2008:
  FAIR CC kick-off meeting
- October 2008
  1st meeting and formation of international pre-collaboration board

Frame for Super-FRS Road Map

2008 Conceptual design, design studies and R&D completed

2009 – 2010(11) Finalization of engineering designs

2010 – 2012 Manufacturing of components

2012 – 2013 Installation and commissioning

Issue for the EoI Discussion

1. Which technical systems **in detail** does your EoI cover ?
2. Is this work package fitting into your available EoI budget ?
3. Which is the road map for your EoI ?

Schedule for the afternoon discussion

1. Presentation of the EoI representatives
2. Discussion of the EoI interpretation
3. Discussion of road map and preconditions/comments