Status of the FAIR Facility

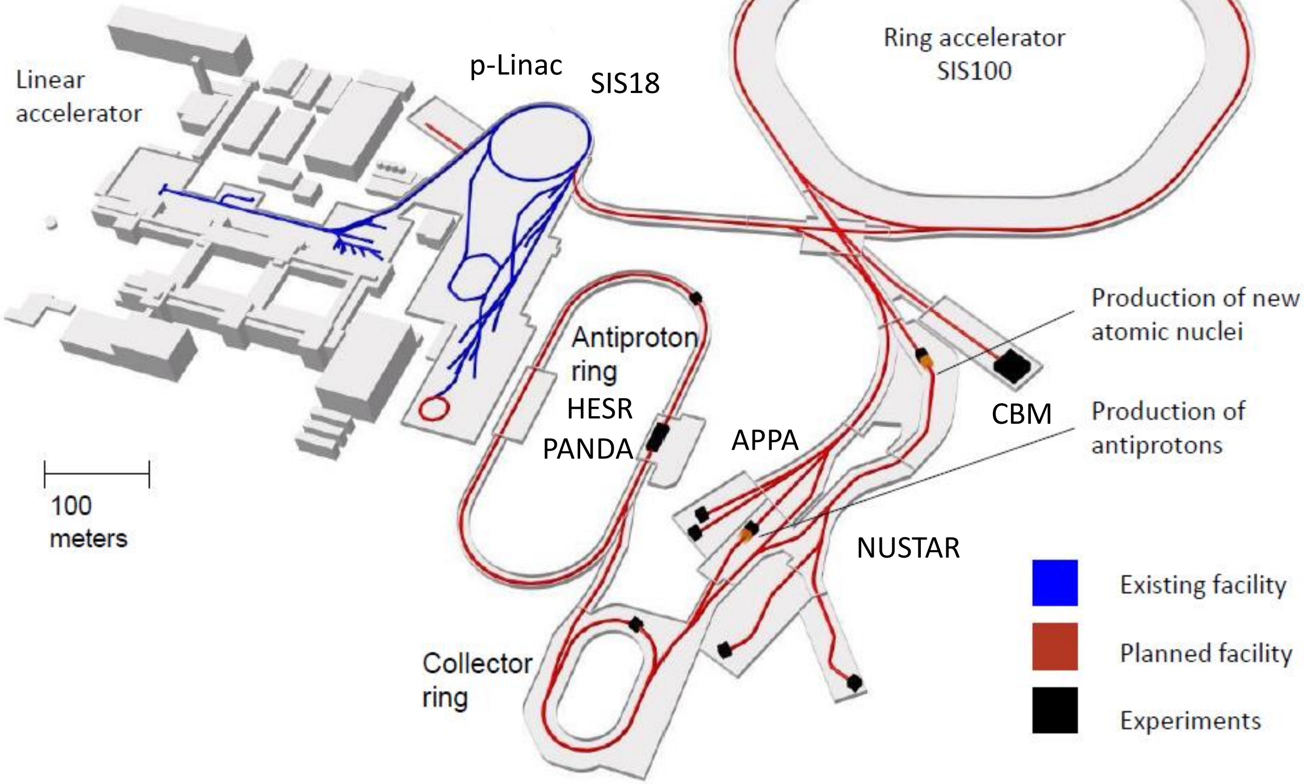
Peter Spiller

HIAT Conference

29.06.22

FAIR Scope

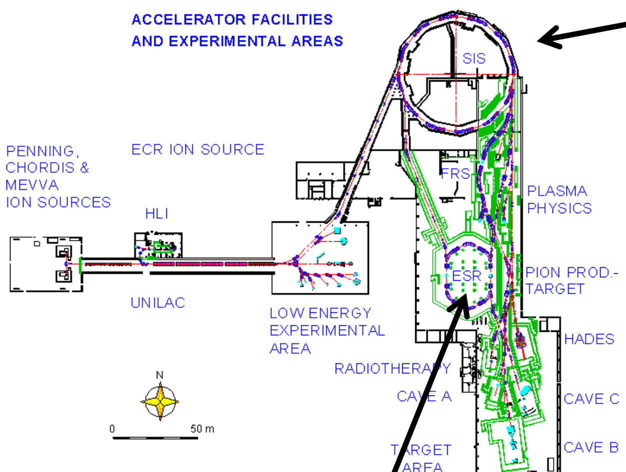
FAIR shareholders:
- Finland
- France
- India
- Poland
- Romania
- Russia
- Sweden
- Great Britain,
- Czech Republic
- Germany



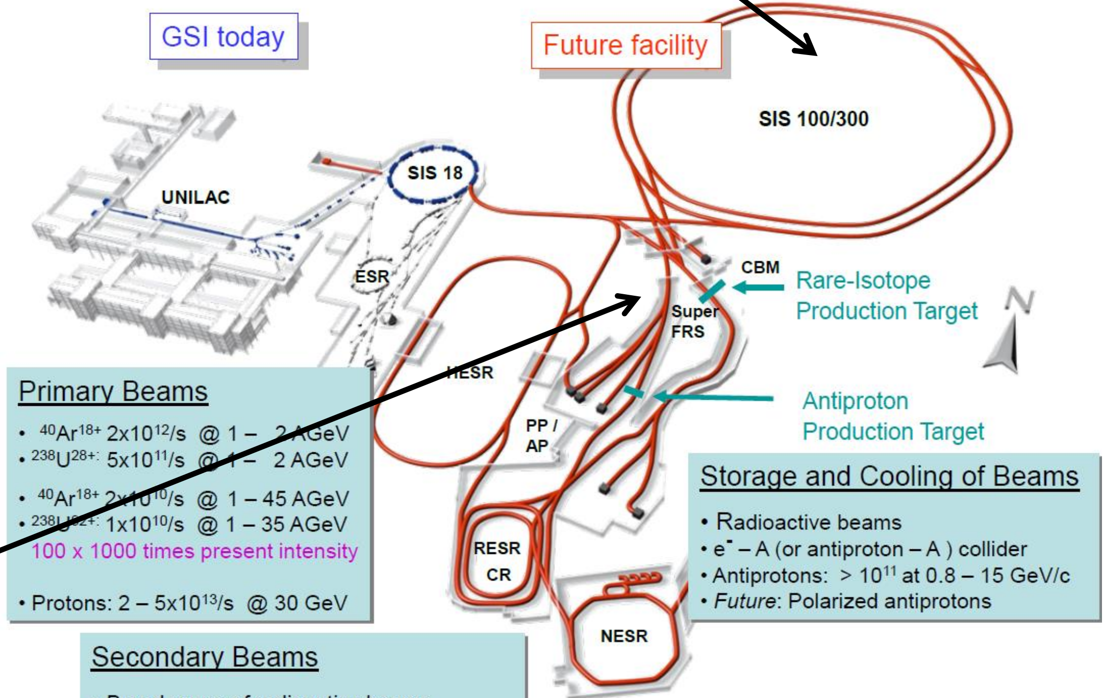
Primary Beams - Secondary Beams

GSI and FAIR consist of primary and secondary beam facilities.

Primary Beams



Secondary Beams



Primary Beams

- $^{40}Ar^{18+}$ $2x10^{12}$/s @ 1 – 2 AGeV
- $^{238}U^{28+}$: $5x10^{11}$/s @ 1 – 2 AGeV
- $^{40}Ar^{18+}$ $2x10^{10}$/s @ 1 – 45 AGeV
- $^{238}U^{92+}$: $1x10^{10}$/s @ 1 – 35 AGeV

100 x 1000 times present intensity

- Protons: 2 – $5x10^{13}$/s @ 30 GeV

Storage and Cooling of Beams

- Radioactive beams
- e⁻ – A (or antiproton – A) collider
- Antiprotons: > 10^{11} at 0.8 – 15 GeV/c
- *Future*: Polarized antiprotons

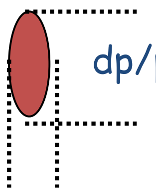
Secondary Beams

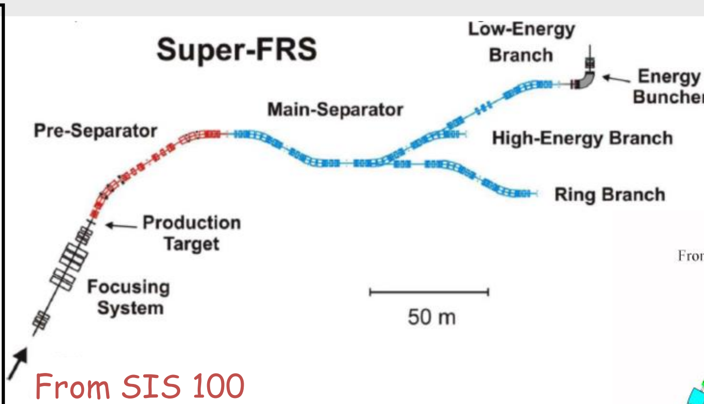
- Broad range of radioactive beams up to 1 – 2 AGeV
- RI- Intensities up to 10 000 over present
- Antiprotons

RIB generation and pre-cooling

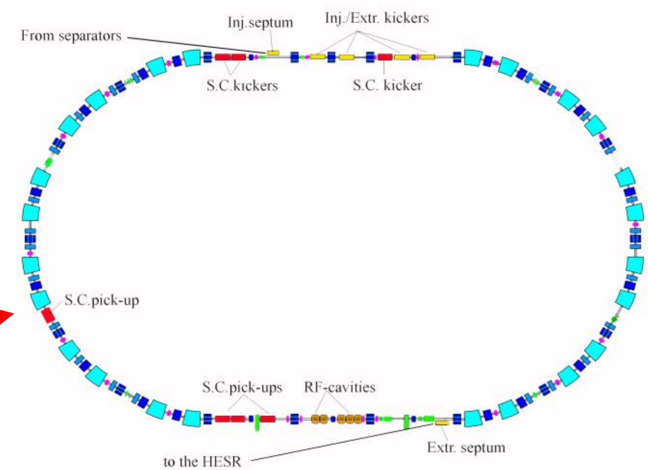
Bunch compression, Target matching, Fast decompression

Short SIS 100 bunches:
- target matching
- RIB/pbar pre-cooling

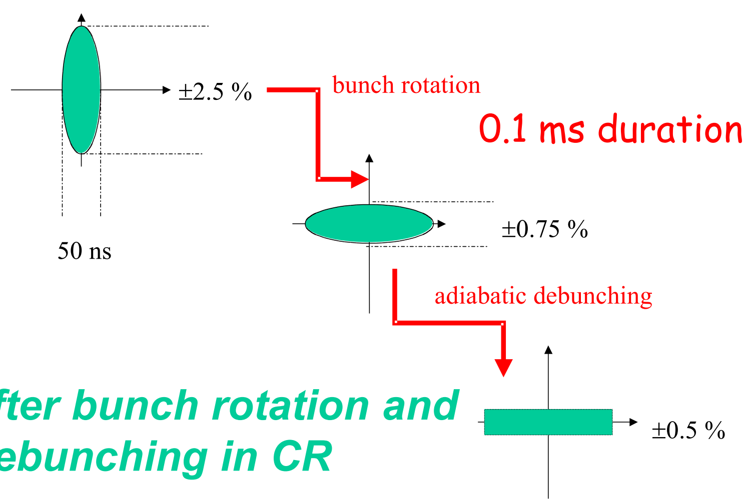




Collector Ring (CR)
circumference 221 m
rigidity 13 Tm



RF voltage in the CR: 200 kV (1.5 MHz)



after bunch rotation and debunching in CR

CR ring properties:

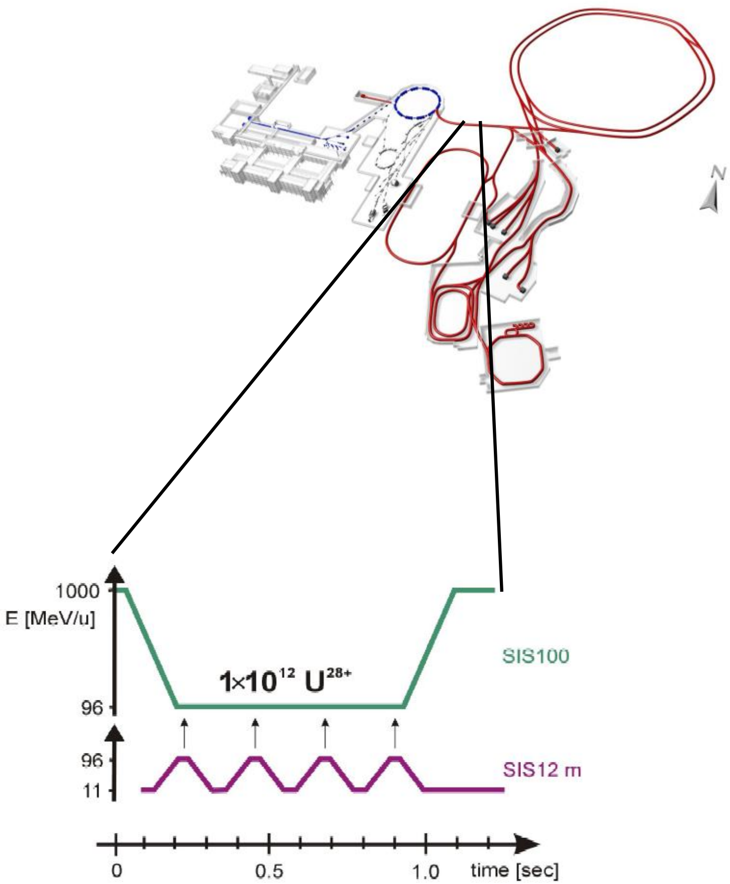
	RIB	pbar
energy	740 MeV/u	3.0 GeV
mom. accept.	± 1.5 %	± 3.0 %
transv. accept.	200x10^{-6} m	240x10^{-6} m
Cooling down time	1.5 s	10 s

Reference Beam Parameters SIS18/SIS100

SIS18	Protons	Uranium
Number of ions per cycle	5 x 10^{12}	1.5 x 10^{11}
Initial beam energy	70 MeV	11 MeV/u
Ramp rate	10 T/s	10 T/s
Final beam energy	4.5 GeV	200 MeV/u
Repetition frequency	2.7 Hz	2.7 Hz

SIS100	Protons	Uranium
Number of injections	4	4
Number of ions per cycle	2.5x 10^{13} ppp	5 x 10^{11}
Maximum Energy	29 GeV	2.7 GeV/u
Ramp rate	4 T/s	4 T/s
Beam pulse length after compression	50 ns	90 - 30 ns
Extraction mode	Fast and slow	Fast and slow
Repetition frequency	0.7 Hz	0.7 Hz

... and all other ion species !



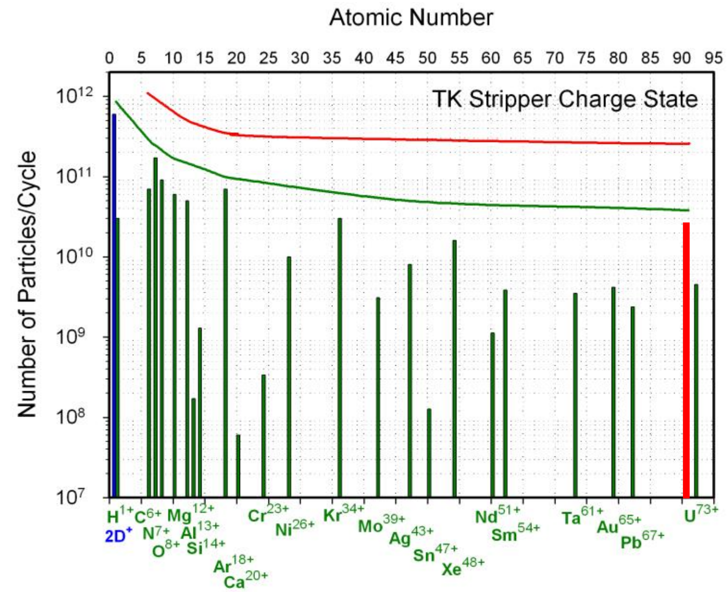
Intermediate Charge States for FAIR

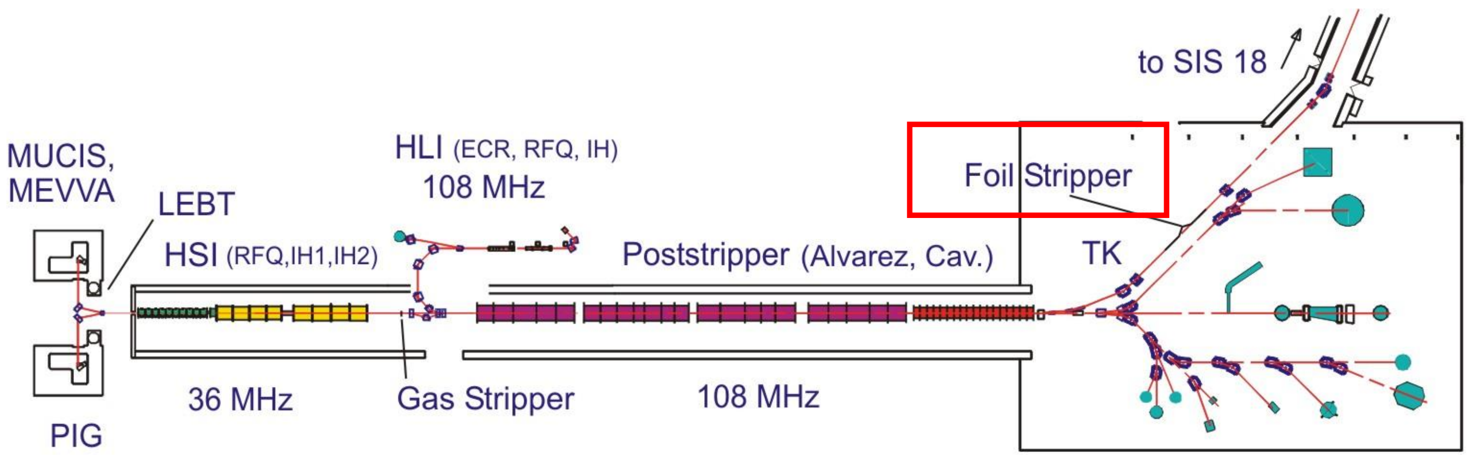
- FAIR intensity goals can only be reached by lowering the charge states
- Incoherent tune shift limits the maximum intensity in SIS18

-dQ $\propto Z^2/A$ > Poststripper charge states will be used

(e.g.: $Ar^{18+} > Ar^{10+}$..........$U^{73+} > U^{28+}$)

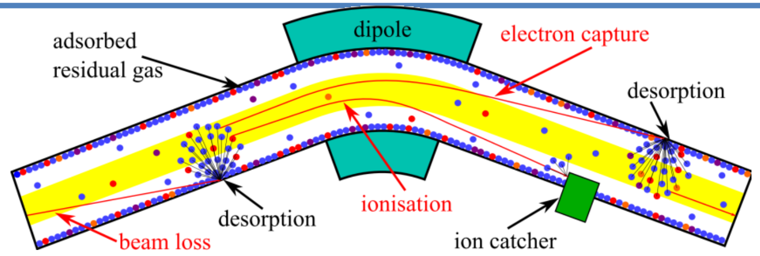
- Without stripping loss (charge spectrum) significantly enhance particle current ($N_{uranium}$ x7) !



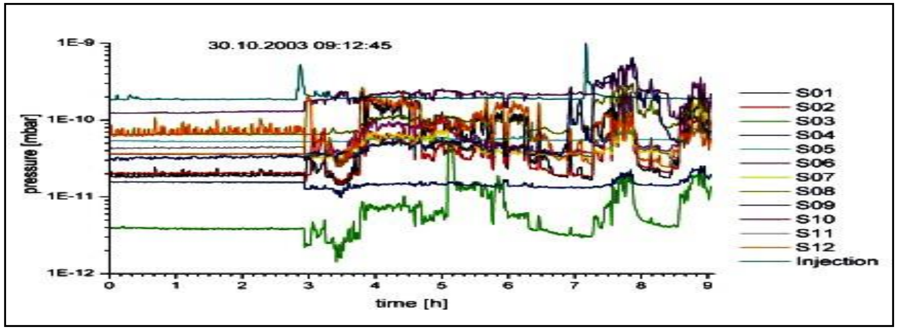


Key Technologies for SIS18 and SIS100: Dynamic Vacuum and Charge Exchange

The Dominating Intensity Limitation for Heavy Ion Beams in Synchrotrons is the Interaction with the Residual Gas and thereby generated Charge State Changes. Due to Desorption Processes at High Beam Intensities the Static Residual Gas Pressure becomes the so called Dynamic Vacuum. Ionization in the Dynamic Vacuum is the dominating beam loss mechanism which appears much below the space charge limit.



Ionisation loss drives pressure bumps which itself accelerates the ionisation process.
> Dynamic vacuum instability



Static (no beam) Dynamic (with beam)

Simulations

STRAHLSIM: Unique code for dynamic vacuum and charge exchange driven beam loss in time and space comprising:

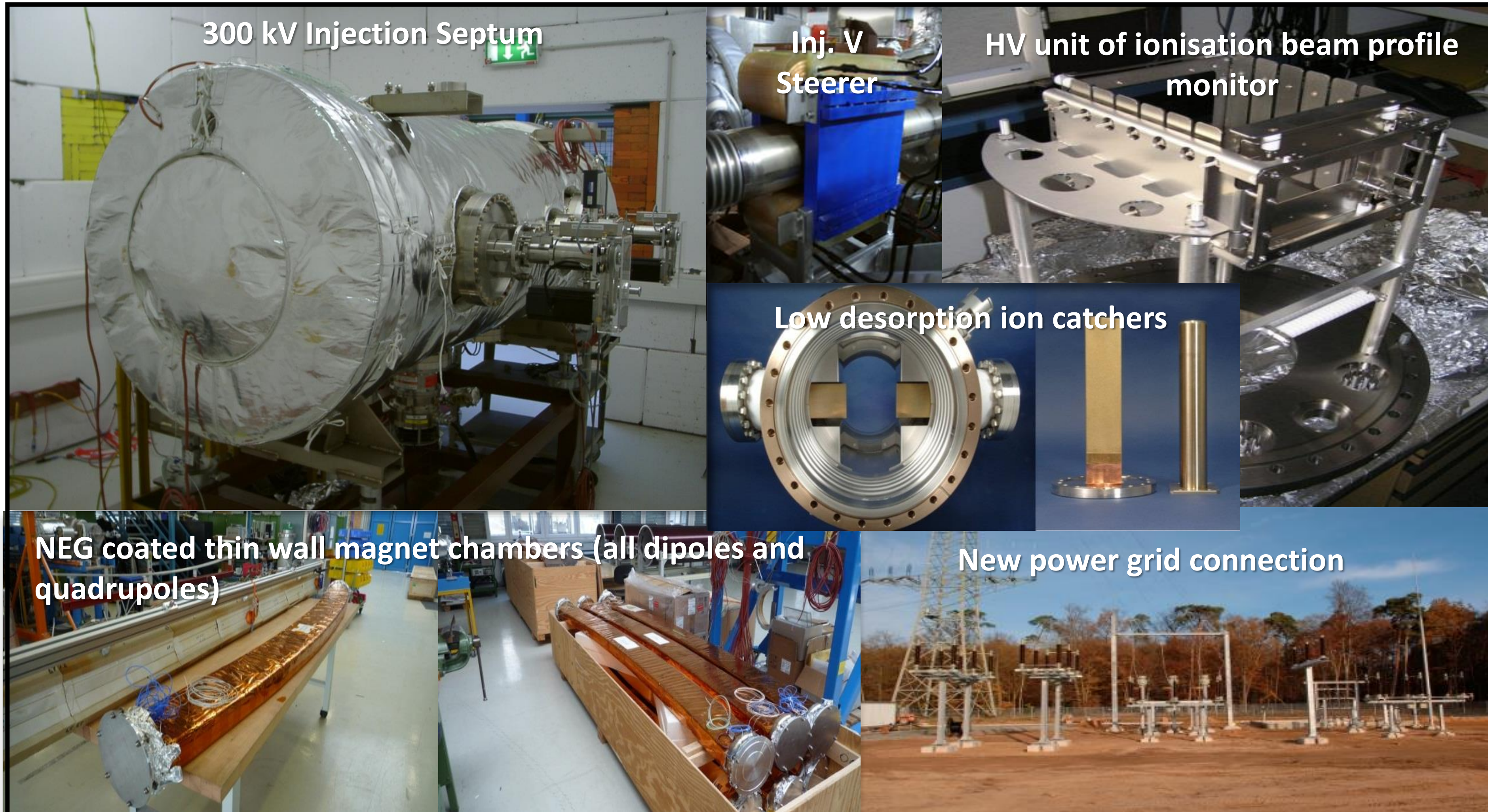
- Machine optics and collimation system
- Atomic cross sections for charge exchange (energy dependent, projectile- and target dependent etc.)
- Properties of pumping system (conventional, cryogenic, NEG. local distributed etc.)
- Ion induced gas desorption processes
- Realistic machine cycles

New Technologies

- New synchrotron optics: Charge separator lattice (peaked distribution of ionization loss)
- NEG coating (distributed pumping)
- Low desorption surfaces and materials
- Ion catcher systems - room temperature and cryogenic
- Cryogenic (actively cooled) magnet chambers (distributed pumping)
- Cryo-adsorption pumps

SIS18 Upgrade Program 2013 – 2018
Implementation of New Key Technologies

The upgrade program is dedicated to intermediate charge state heavy ion operation for FAIR.



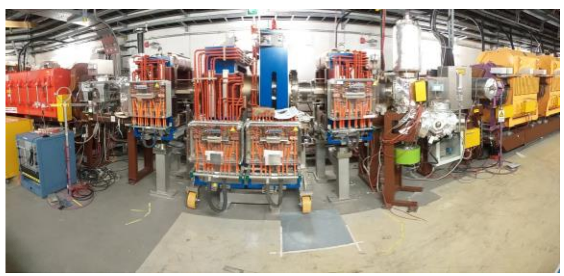
SIS18 Upgrade Program 2013 – 2018
Implementation of New Key Technologies

The upgrade program is dedicated to intermediate charge state heavy ion operation for FAIR.


Three new MA acceleration cavities installed (50 kV, h=2) and power converters


Replacement of main dipole power converter (for 10 T/s, 50 MW)

The EU has supported the upgrade program as an investment in a major European Research Infrastructure.



SIS18/SIS100 IPM monitor system manufactured and installed

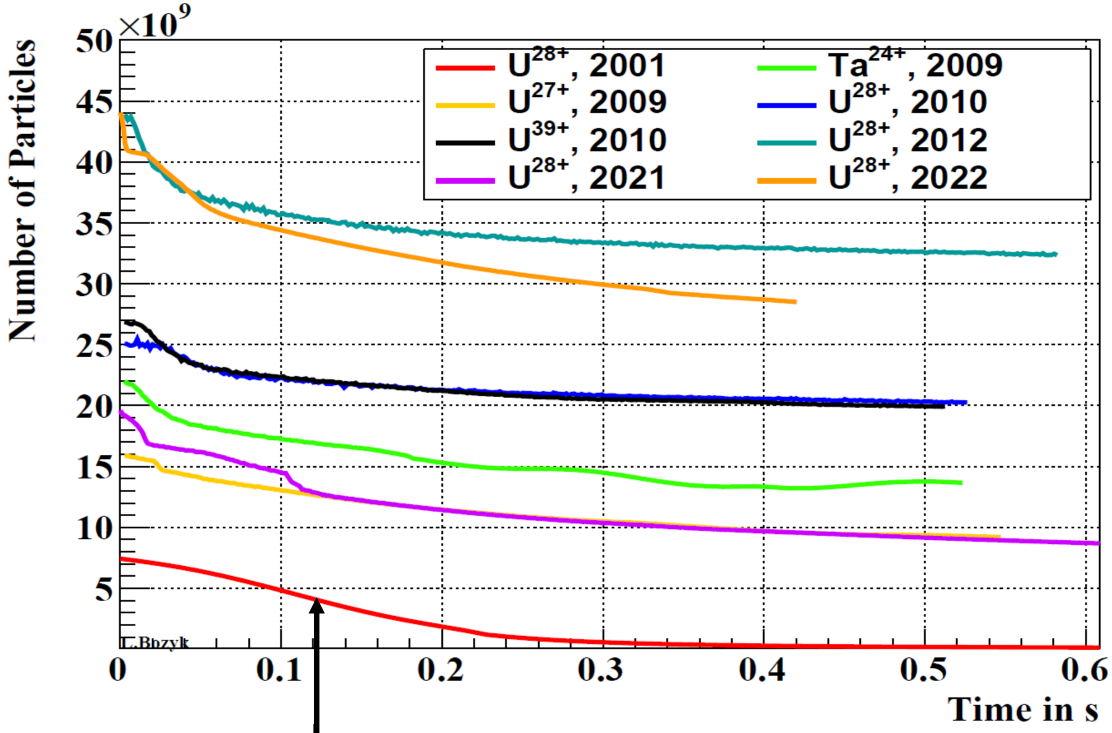

Bipolar dipole magnet and power converter for the connection of transfer line to SIS100

The originally defined SIS18 upgrade program is completed in 2021.

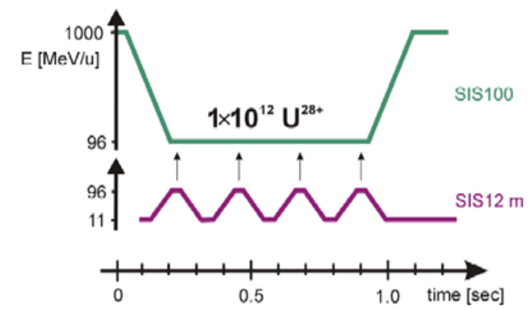
SIS18 Status U^{28+} -Beam Intensity

World record intensity for intermediate charge state heavy ions in heavy ion booster.

The feasibility of high intensities with intermediate charge state heavy ions has been demonstrated.



2001 FAIR conceptual design report (FAIR proposal)



Stacking in SIS100 (4x)

At SIS100 commissioning:

An intensity of U^{28+}-beams of 1-2 $x10^{11}$ per cycle is safe (rep. rate about 0.5 Hz)

Further upgrade measures are investigated for reaching the intensity goal for the most heavy ions (e.g. Uranium with $1.5x10^{11}$ per cycle at a (high) repetition rate of 2.7 Hz.)

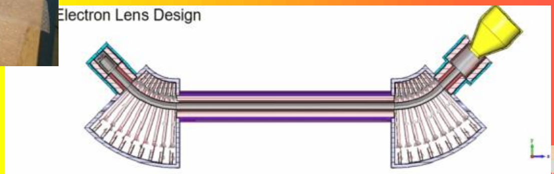
Proposals for SIS18 Upgrade 2

The SIS18 upgrade 2 program addresses issues at
a) operation of SIS18 for the running experiments in FAIR phase 0 and b) the FAIR booster operation.

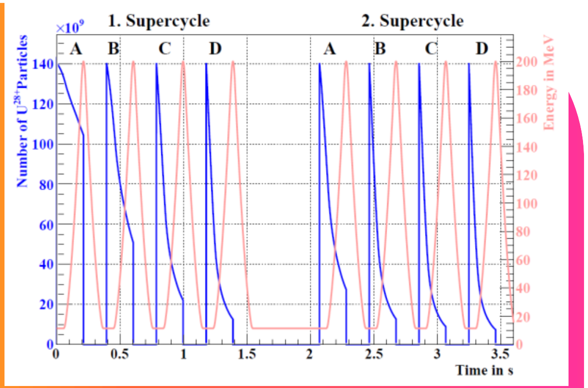
Microspill Cavity

Extraction Septum

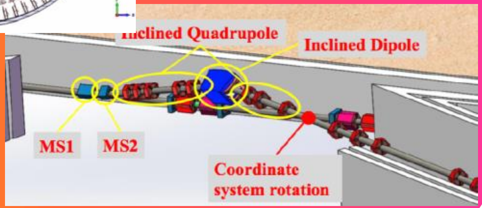
Cryo-Inserts Series



Space Charge Compensation Lens



Ionization beam loss at high intensity and high repetition rate operation

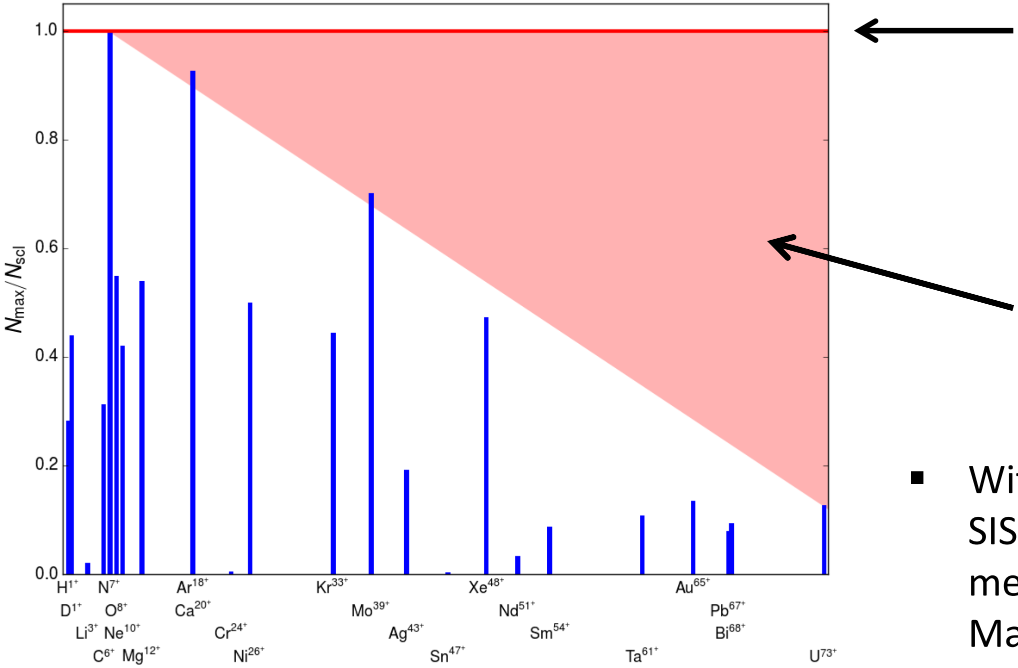


Two Plane Injection or/and Pulsed Skew Quad

?

2022 2023 2024 2025 2026 2027

Actual Peak Intensity versus Space Charge Limit

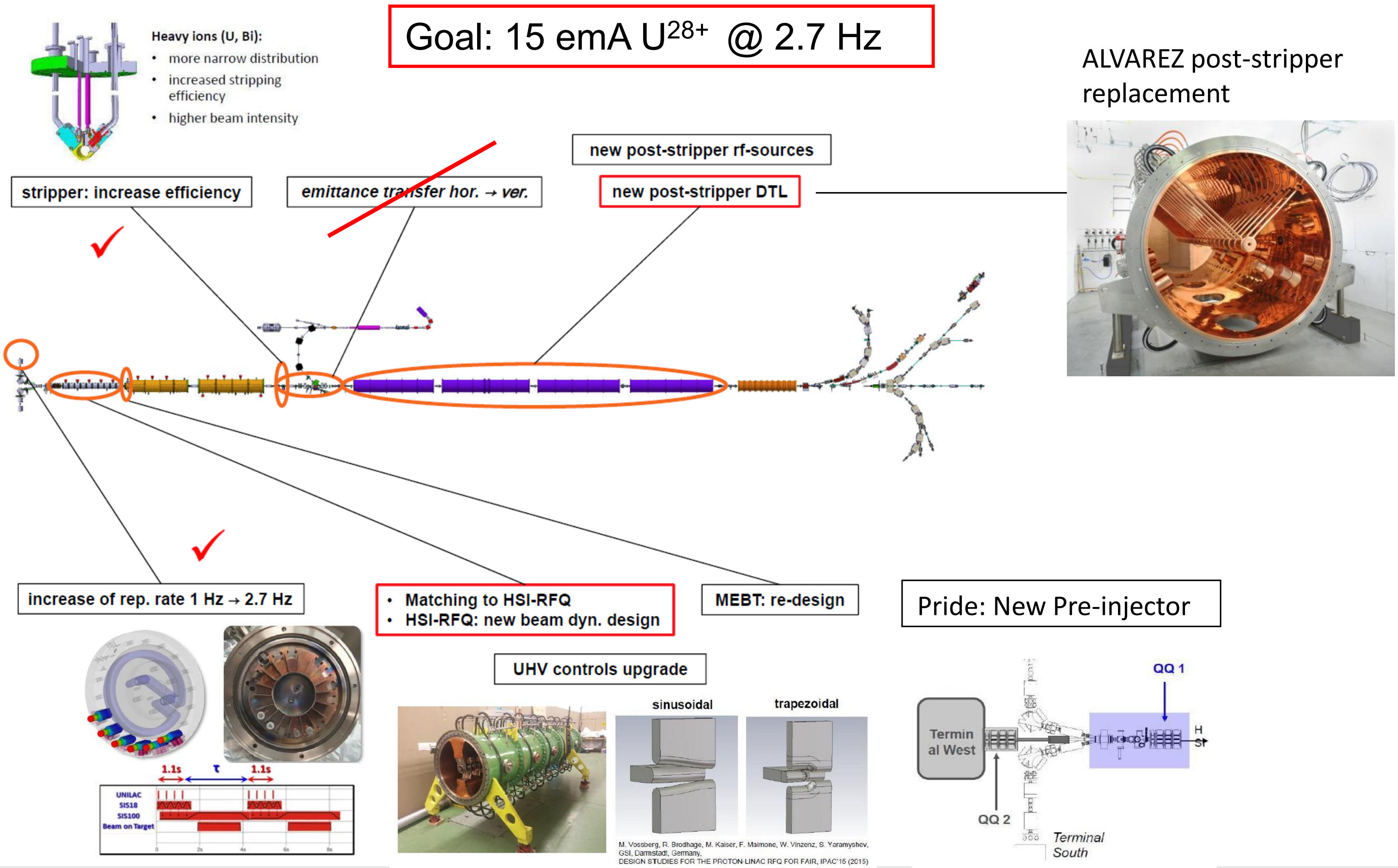


UNILAC currents at SIS18 injection $N_{max/}N_{scl}$

- p^+ ≈ 0.85 (2016)
- Ar^{18+} ≈ 1.0 (2021)
- Bi^{68+} ≈ 0.3 (2020)
- U^{73+} ≈ 0.4 (2022)

- With the completion of the originally defined SIS18 upgrade program, the deficit from medium to high mass ions can not be closed. Major improvements in the UNILAC and the UNILAC/SIS18 interface are required.
- Key parameters for injection: intensity, emittance, momentum spread, 6D distribution fanction, stability over macro pulse etc.
- An UNILAC upgrade matrix has been developed, priorizing all technical measure to achieve ultimate beam intensities and qualities.

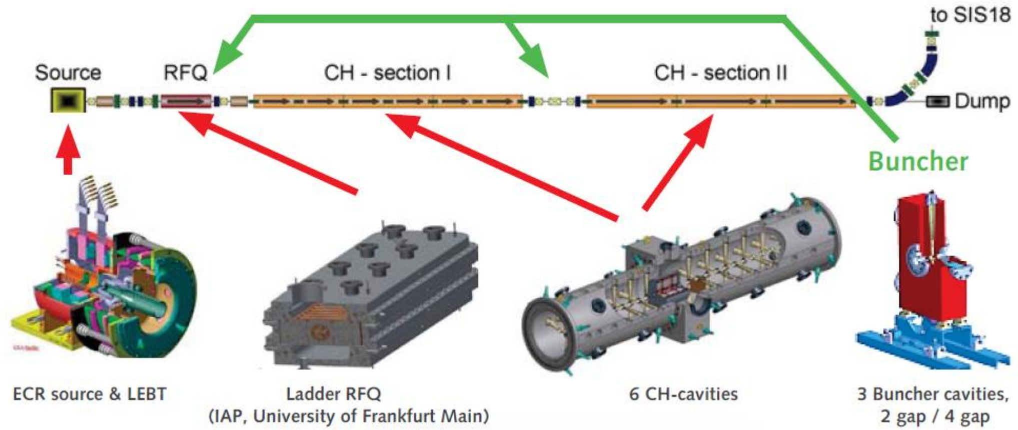
UNILAC Developments



Proton source is Inkind-contribution of France.
Close collaboration in development of Rf linac structures with IAP (institute for applied physics) in Frankfurt/M.

Status of Main Components

- Proton source at CEA, Saclay:
  Based on IPHI sourced design.
  Peak Proton beam 100 mA at 95 keV extracted.
- Successful test of ladder 4-rof RFQ. Excellent agreement of E-field with predictions in terms of field flatness and resonance frequency. Power test at GSI in preparation.
- All (8) Klystrons delivered. Preparation of Rf test stand and Klystron modulator.
- Successful test of prototype CH cavity. FOS series cavity in production at PINK.



ECR Proton source at CEA

Ladder RFQ

FOS CH cavity

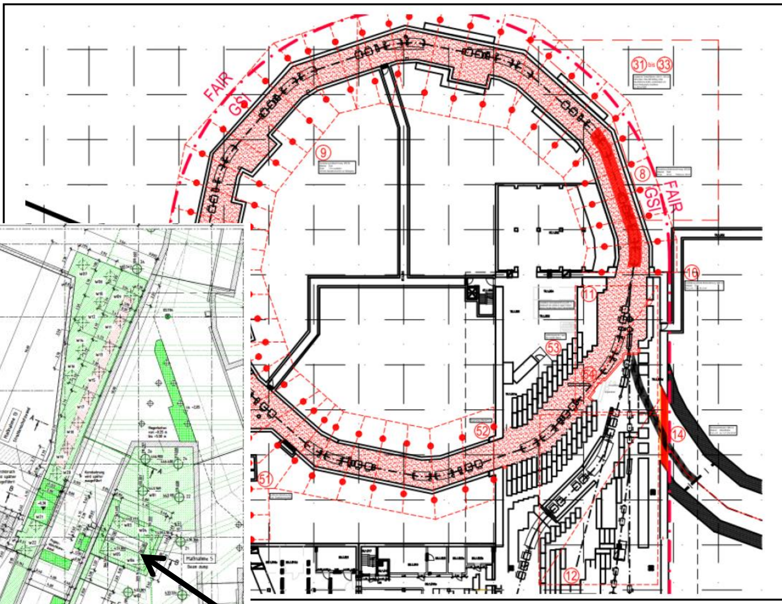
Preparation of the Existing Accelerator Tunnels and Buildings

SIS18 Civil Construction GAF and WTK

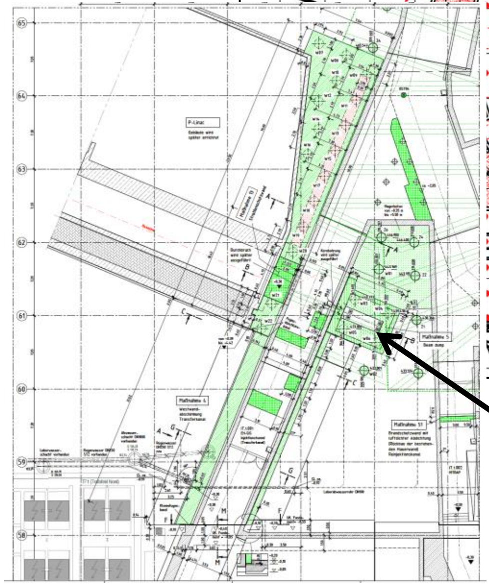
GAF (Gebäude Anbindung FAIR):

- **Shielding enhancement** on top of the existing SIS18 tunnel and at other locations for fast cycled operation with $5x10^{12}$ Protons per Second. (3% Proton beam loss at final energy)

- **Radioactive air management** system
- **Fire prevention system** (nitrogen venting)
- **Interface** to the FAIR tunnel 101
- An inner and outer **reinforcement wall**
- **Power link** of main operation building to new transformer station North



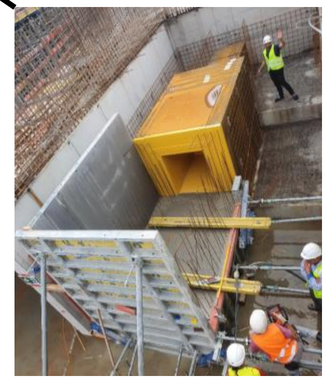
GAF



WTK

WTK (Westwand Transfer Kanal)

- **Beam dump** for the proton linac on the western side of the transfer channel (TK)
- Shielding enhancement of the TK eastern wall and interface for an early construction of the p-linac building



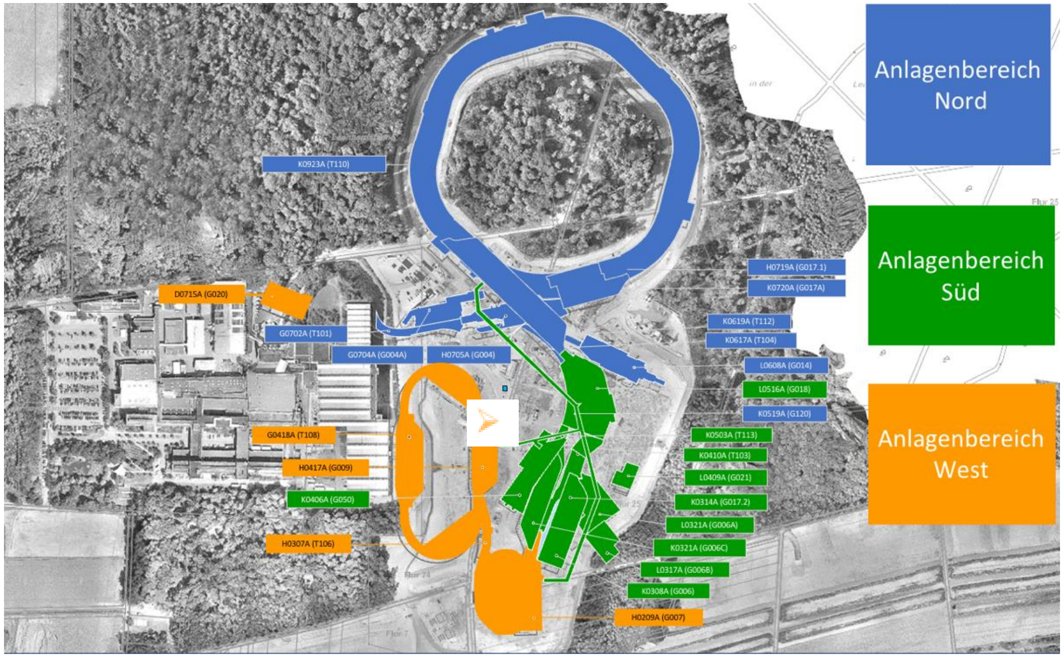
p-linac beam dump

All works are completed.

Status GAF and WTK Project

- All concrete and earth works completed.
- Link to FAIR tunnel 101 and p-Linac building completed.
- Power link to new transformer station North, via new technical building to PC completed.
- VOB acceptance of underground engineering, building shell, interior works
  HVAC installations in tunnel completed.
- Successful commissioning of new N-fire prevention system completed.
- Visitor platform completed.

FAIR Civil Construction Areas



FAIR civil construction area North, South
(Early Science and Intermediate Objective)
and West
full Modularized Start Version (MSV)

FAIR Civil Construction Status

Status SIS100 Tunnel

April 2022

In SIS100 tunnel coating and technical building installations (TBI) are progressing well

Heavy Ion Synchrotron SIS100 Unique Features

SIS100 is a world wide unique synchrotron designed and optimized for the generation of high intensity heavy ion beams.

- It has a **flexible lattice structure**, enabling different optical settings for different user modes.
- It has a lattice cell (**charge separator lattice**) with an optimized design for the control of beam loss by ionization at highest intensities of Uranium beams.
- It has a unique and **extreme XHV system**, making extensive use of cryo-pumping to suppress vacuum instabilities at highest heavy ion intensities
- It is a **fast ramped superconducting** synchrotron with ramp rates up to 4 T/s and a minimum cycle time of less than 1 second.
- It is equipped with **powerful Rf systems** for acceleration, compression, generation of barrier buckets and buckets for longitudinal stabilization.
- It provides **different extraction modes** for fixed target experiments and optimal time structures for matching to production targets and storage rings.
- Its cyrogenics system is designed to **control of a dynamic heat load** of up to 75 % (3.4 kW <> 14,7 kW) with big difference from cycle to cycle in parallel operation of multiple users.

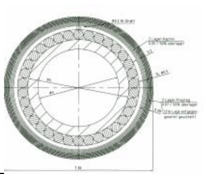
Synchrotron Key Technologies

GSI has a world wide leadership in **fast ramped** superconducting magnets.

1. R&D on fast ramped superconducting, window-frame magnets for SIS100
   4 T/s up to 1.9 T

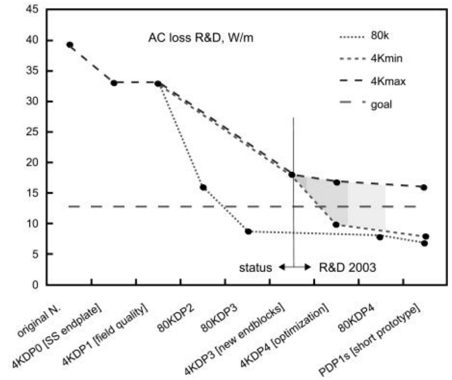
R&D goals:

1. Reduction of eddy/persistent current effects at 4 K (at most in iron yoke)
2. Optimization of field quality
3. Long term mechanical stability for (>$2 \cdot 10^8$ cycles)

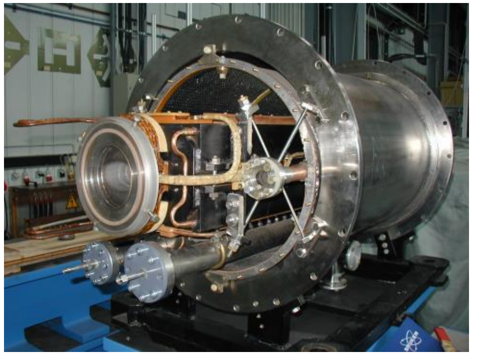


Optimization of Nuclotron Cable:

- Insulation concepts
- Winding technologies
- ANSYS models etc.



AC loss reduction 40 W>15W

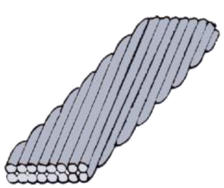


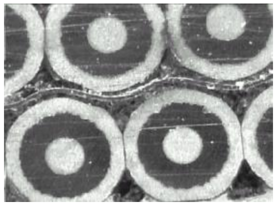
SIS100 Prototype Dipole

2. R&D on fast ramped, superconducting costheta magnets for SIS300 and others
   1 T/s up to 4.5 T (world record ramp rate)

R&D goals:

1. Reduction of AC loss by improved cable and coil design
2. Optimized conductor cooling (e.g. laser cut cable)





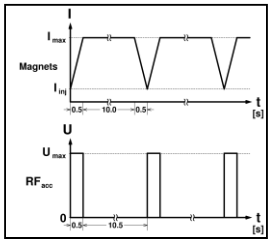
Optimization of Rutherford Cable:

- Reduced filament twist pitch
- Strand coating
- Stainless steel core

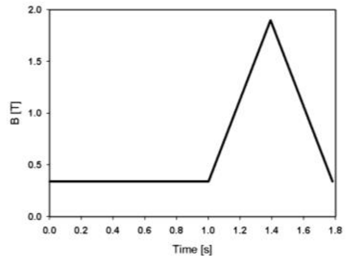
Fast ramped SIS300 Dipole in Cryostat

Synchrotron Key Technologies

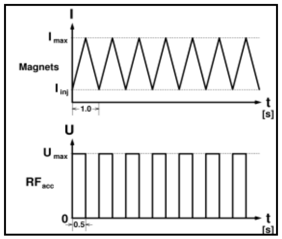
GSI builds the fastest superconducting synchrotrons with full flexibility in cycling



quasi static heat load at long extraction (DC 3.5 kW)



Reference cycle 2c



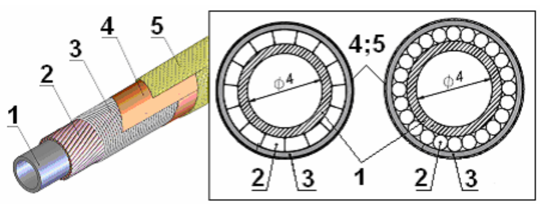
Triangular cycling with fast extraction (AC+DC 14.5 kW)

TABLE II OPERATION CYCLES AND EXPECTED LOSSES

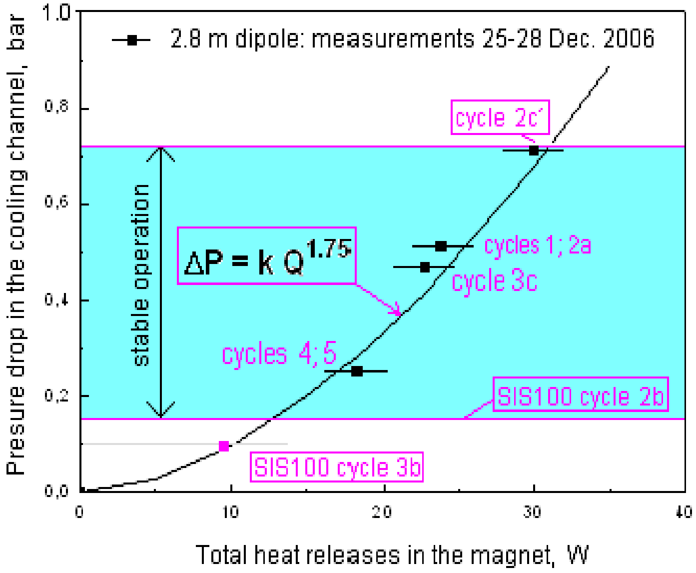
cycle	B_{max} (T)	t_f (s)	cycle period (s)	Q_d (J/cycle)	P_d(W)	Q_q (J/cycle)	P_q(W)
1	1.2	0.1	1.4	35.2	25.2	13.1	9.4
2a	1.2	0.1	1.4	35.2	25.2	13.1	9.4
2b	0.5	0.1	1.0	8.8	8.8	3.3	3.3
2c	2.0	0.1	1.82	89	48.9	24.4	18.9
3a	1.2	1.3	2.6	35.2	13.5	13.1	5.0
3b	0.5	1.0	1.9	8.8	4.6	3.3	1.8
3c	2.0	1.7	3.4	89	26.2	34.4	10.1
4	2.0	0.1	5.0	89	17.8	34.4	6.9
5	2.0	0.1	5.0	89	17.8	34.4	6.9

Control of Magnet Cooling:

- Single layer magnet coil with low hydraulic resistance
- High current Nuclotron cable
- Hydraulically adjusted magnet cooling circuits
- Active heaters to stabilize the cryogenic load
- Variable supply LHe supply pressure
- LHe pumps



Alternative coil design and high current cable

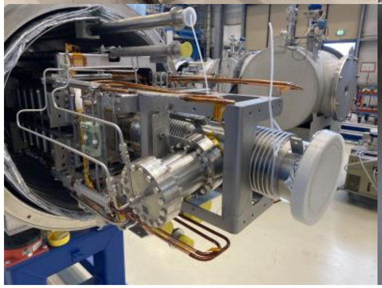


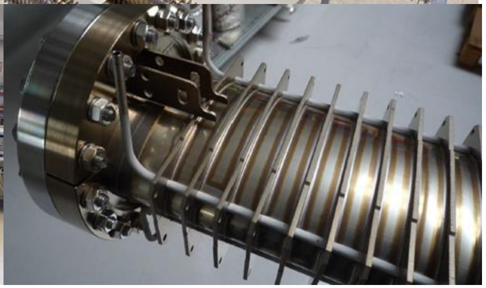
Series Production of S.C. Dipole Modules

Celebration of acceptance of 110. dipole magnet

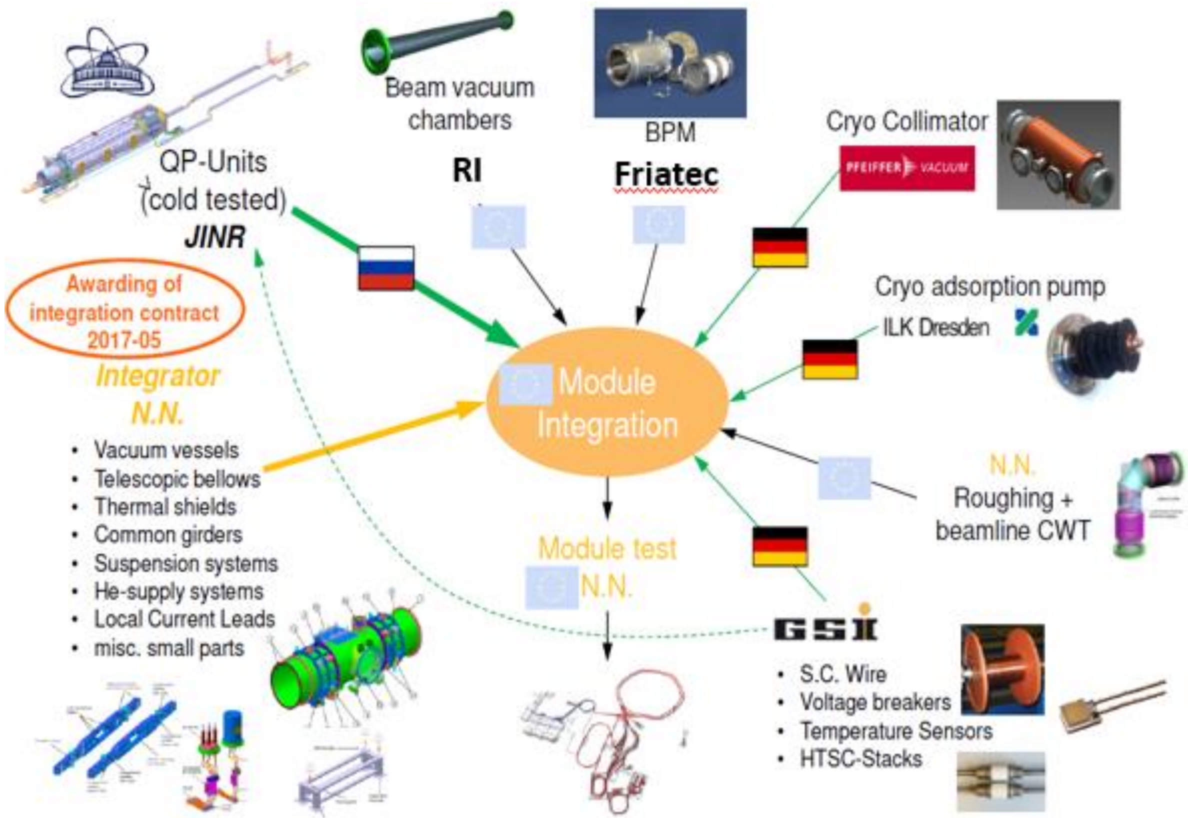
Status:

- Production and cold testing of full series (110) of s.c. dipole magnets completed.
- Integration of cryogenic dipole chambers with and without cryo-adsorption pump.



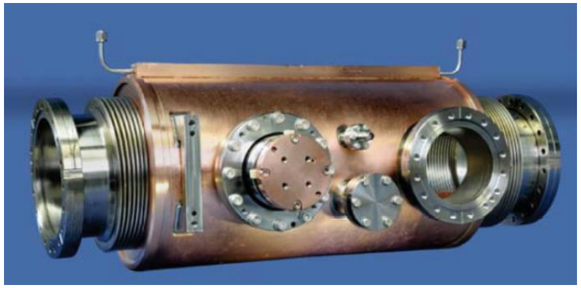


Quadrupole Modules and Integration



Series production of quadrupole units and all GSI supply items required for integration is

a) running (BPMs + signal cables) or
b) completed (quadrupole chambers, cryo ion catcher, cryo adsorption pumps, roughing CWTs).



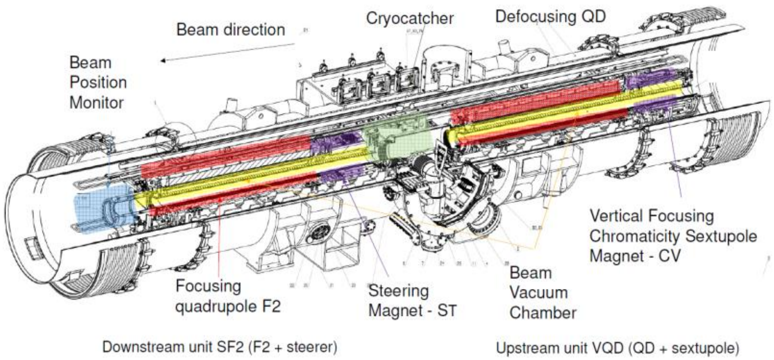
Cryogenic ion catcher

Cryogenic BPM

Quadrupole Modules and Integration

Series Production

Start of series integration: March 2021.
Maximum integration rate: 3 modules / month, still to be demonstrated.
Production of large amount of parts (cryostat vessel, girder, shield etc.) has been released in advance.



FOS module at GSI, STF

Module integration at Bilfinger Noell

World Wide Testing Infrastructure for the Series of Superconducting Magnets

GSI: Series test facility for the SIS100 s.c. dipole magnets, string test, current leads and local cryogenics components.

CERN: Test facility completed for the Super-FRS s.c. dipoles and multiplets

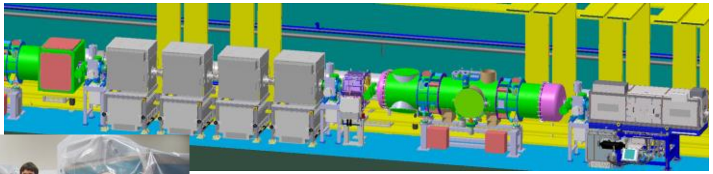
INFN: Test facility in Salerno for testing the series of SIS100 quadrupole modules

JINR, Series test facility in Dubna for testing of the series of SIS100 s.c. quadrupole units

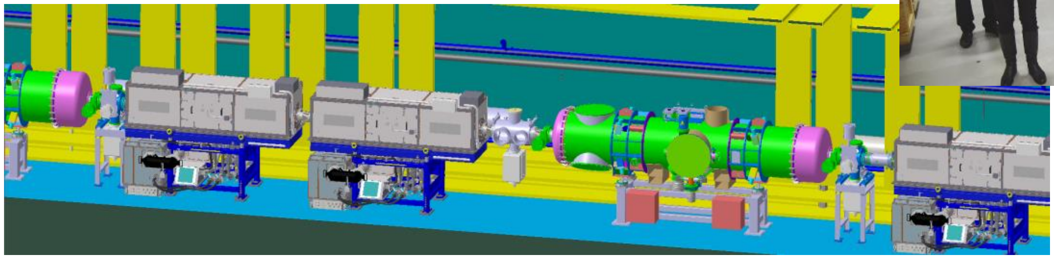
SIS100 Rf Systems

Status:
Series production, testing and acceptance of all acceleration and bunch compression cavities and power converters completed.

Bunch Compression Cavities by AURION



Acceleration cavities in storage area Weiterstadt

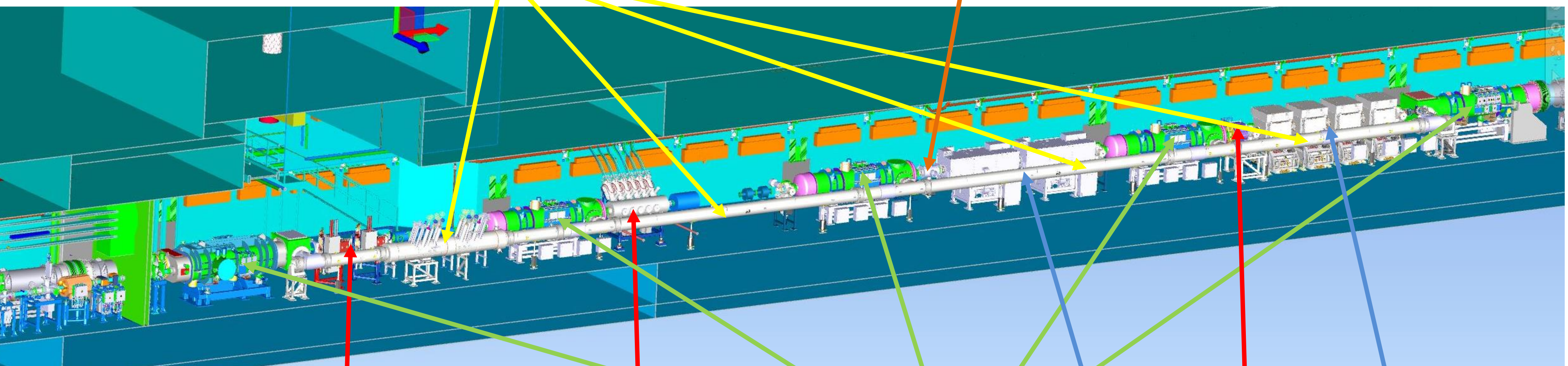


Power converters by OCEM

S6 Injection Straight Section

Cryogenic bypass lines and end boxes: series production running

Standard pumping chambers: series production running



Injection septa: delivered, accepted

Injection kicker: contracted, FOS acceptance tests

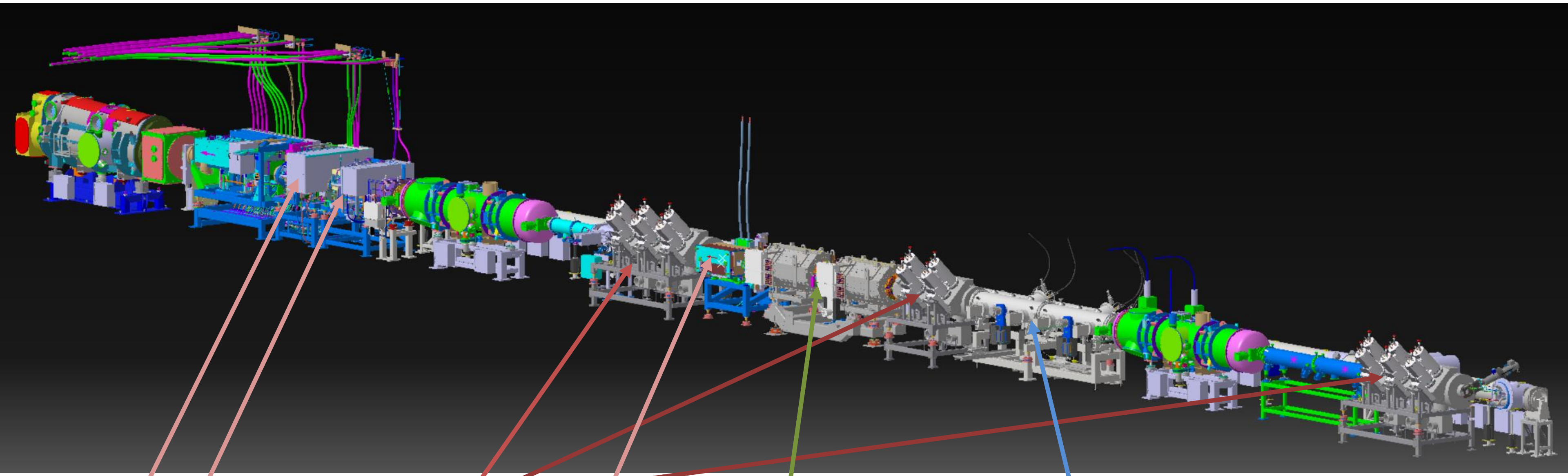
Quadrupole modules: contracted, series production started

Bunch compression cavities: manufacturing completed, power tests missing

Resonance sextupoles: delivered and accepted

Acceleration cavities: delivered and accepted

S5 Extraction Straight Section



Magnetic septa 1,2
Tendering in preparation

EE-kicker system
contracted, CDR

Lambertson Septum,
tendering

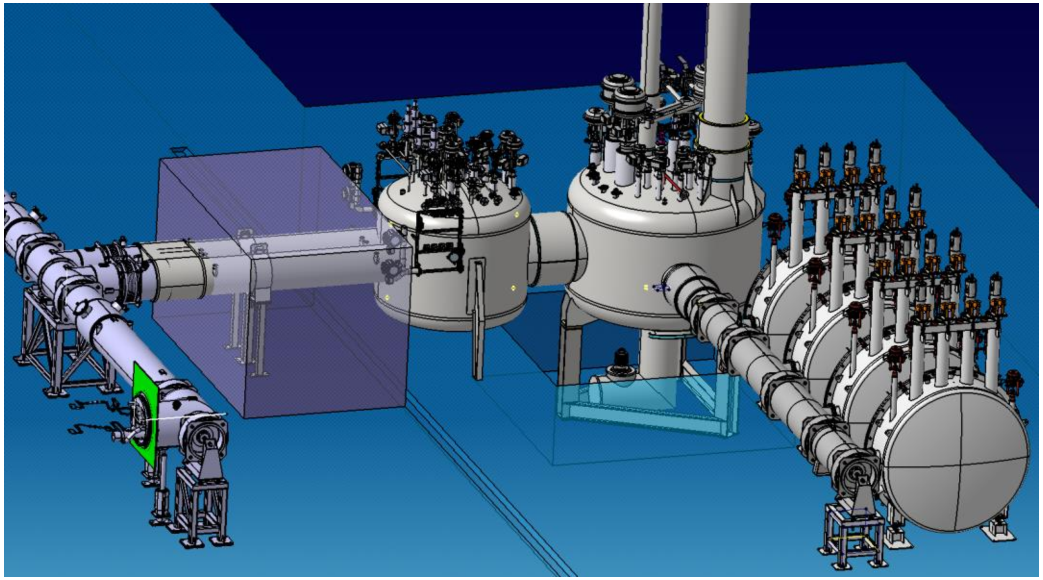
Radiation hard
quadrupole magnets
contracted, CDR

Electrostatic Septa,
contracted, production

Local Cryogenics
Bypass Lines, Current Lead Boxes and Feed Boxes

Current Lead Boxes and Current Lead Box Link

- Conceptual Design Review for Current Lead Boxes completed. Procurement by WUST launched.



Feed-boxes, feed-in line and current lead boxes designed by WUST, Wroclaw

Status Bypass Lines

- Series production of bypass lines running at Kriosystems (Wroclaw). Nominal production rate with parallel assembly on three benches almost reached. Cold testing of types with new inserts at GSI STF successful. 15 of 27 delivered.

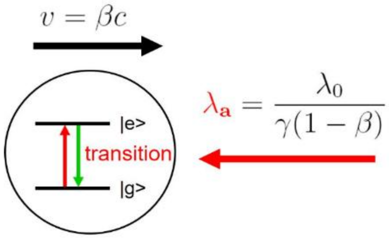
Feed Boxes

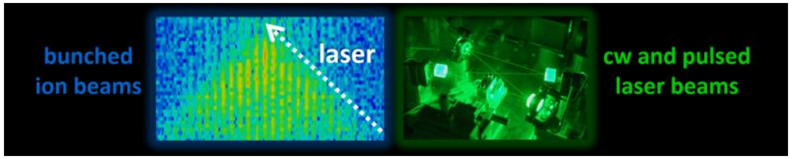
- Due to restrictions in openings and transportation, the feed box has been split into two parts. The design (3D model) has been completed by WUST.
- It is planned to test the first feed-box cold and with power at the GSI test facility. First plans for the set-up are available. Preparations for procurements started. Test should be executed in 2023.

Bypass lines in storage area Weiterstadt

Laser Cooling of Relativistic Heavy Ions

- SIS100 will be the first user synchrotron equipped with a „laser cooler“ world wide.
- Laser-cooled relativistic heavy-ion beams (g up to 13 for Z = 10 - 60)
- Only cooling method at relativistic energies (dp/p<10^{-7})
- Extraction of very cold and very short ultra-relativistic ion bunches





Net cooling force in the direction of the laser light (longitudinal).

- Visiting Scientist Fellowship for Associated Professors of Chinese Academy of Science for D. Winters
- Laser and Particle Beams Young Scientist Award for S. Klammes

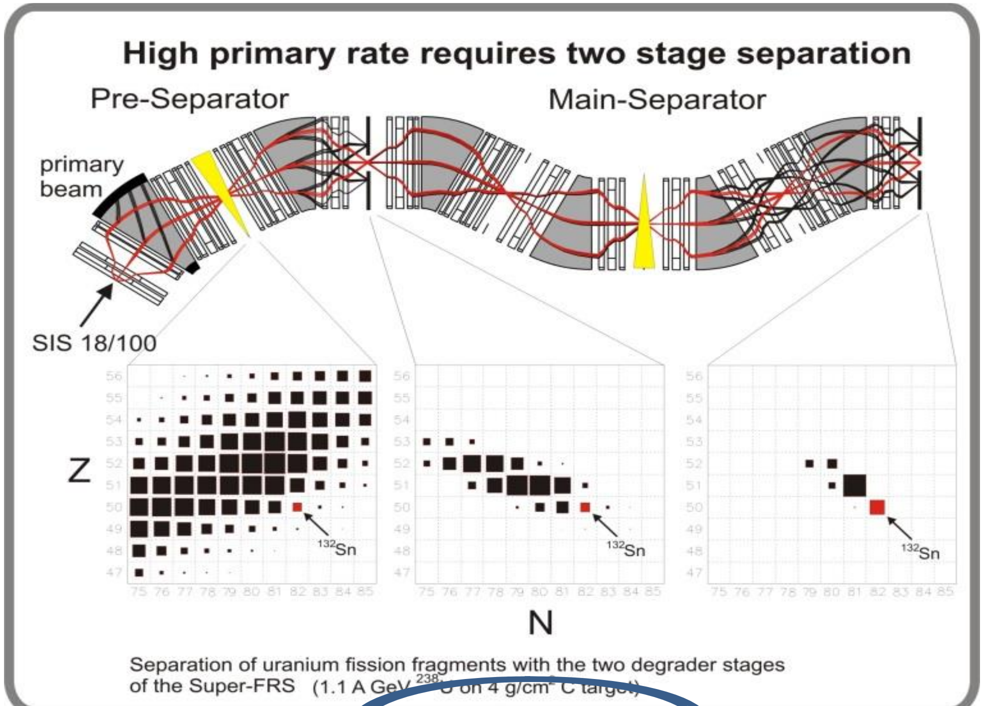
Major highlights:

- Installation of the laser beamline in SIS100 tunnel

Features of Super-Fragment Separator

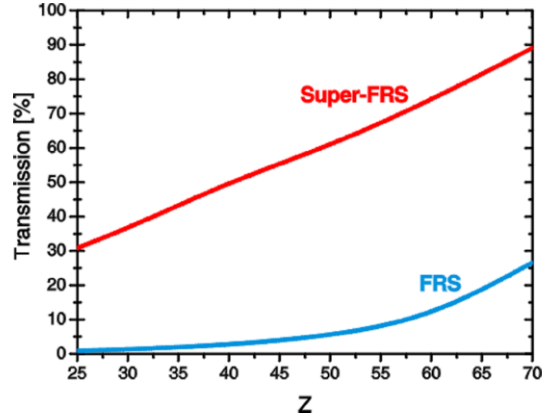
The most powerful in-flight separator for exotic Nuclei world wide

Facility	Max. Magnetic Rigidity $B\rho_{max}$ / [Tm]	Momentum Acceptance $\Delta p/p$	Angular Acceptance ϕ_x / [mrad]	ϕ_y / [mrad]	Momentum Resolution
FRS	18	±1 %	±7.5	±7.5	1500 (ε=20π mm mrad)
Super-FRS	20	±2.5 %	±40	±20	1500 (ε=40π mm mrad)

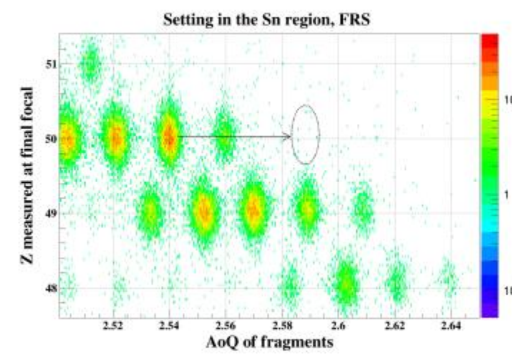


10^{11}/s 1/d

High projectile energy and multiple separator stages to efficiently reduce the background from contaminations



Large Acceptance and Increased Transmission of Fission Products.

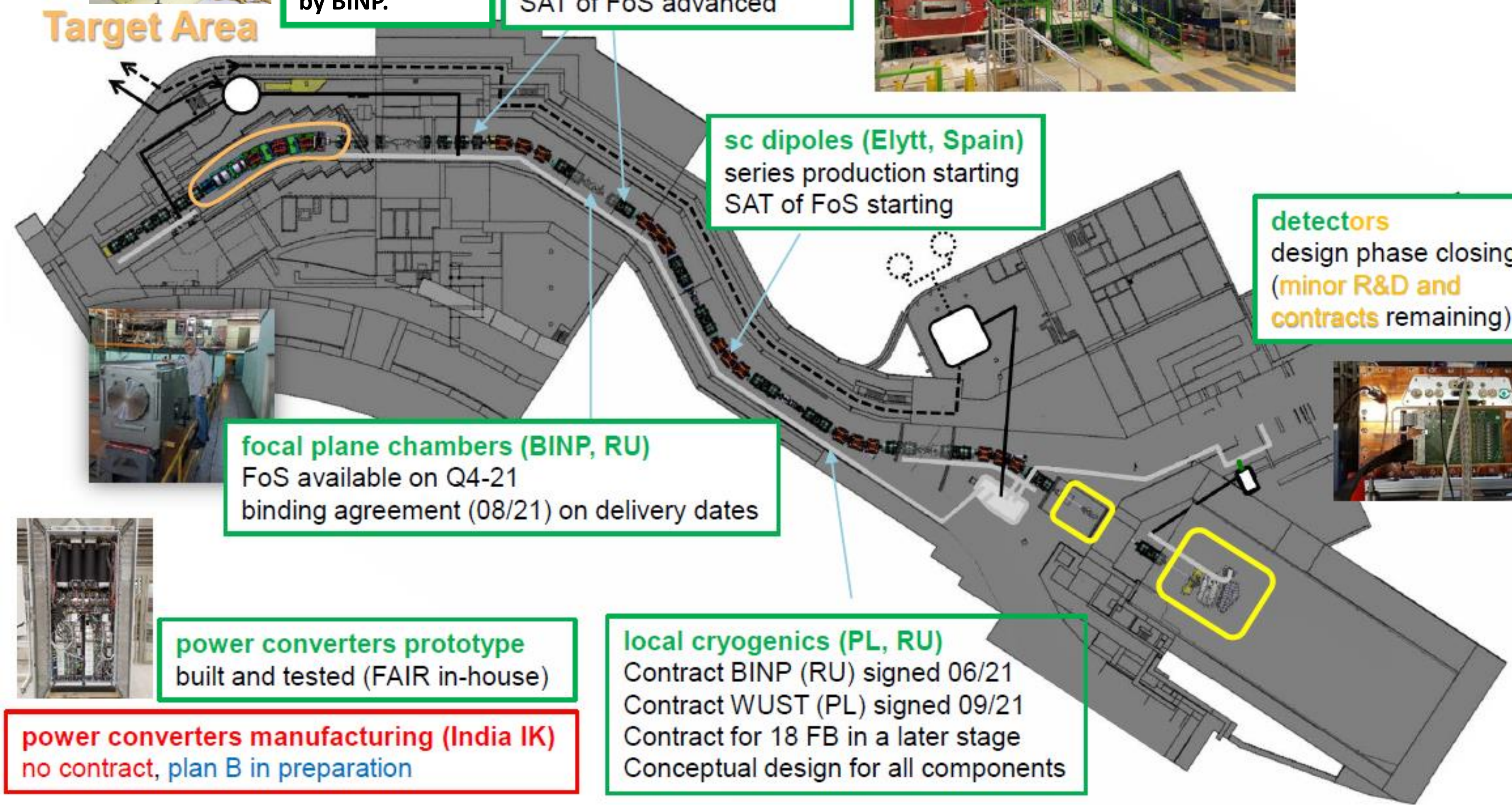


Advantage of high projectile energy: Clean mass/isotope separation without charge state contamination

Super-FRS Status Contracts

Radiation hard dipole.
Prototype build by BINP.

sc multiplets (ASG, Italy)
series production ongoing
SAT of FoS advanced



sc dipoles (Elytt, Spain)
series production starting
SAT of FoS starting

detectors
design phase closing
(minor R&D and contracts remaining)

focal plane chambers (BINP, RU)
FoS available on Q4-21
binding agreement (08/21) on delivery dates

power converters prototype
built and tested (FAIR in-house)

power converters manufacturing (India IK)
no contract, plan B in preparation

local cryogenics (PL, RU)
Contract BINP (RU) signed 06/21
Contract WUST (PL) signed 09/21
Contract for 18 FB in a later stage
Conceptual design for all components

Superconducting Large Aperture Magnets

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

length ≈ 7m
diameter (VC) ≈ 2.6m
weight ≈ 65ton
9 individual magnets

Status

- ✓ Manufacturing contract closed 07/2015 (ASG, Genova, Italy)
- ✓ FAT and SAT FoS SM done, small NCs
- ✓ FAT FoS LM done, SAT running (production ok)
- ✓ FAT 5th series-SM running
- ✓ series production ongoing

E.J. Cho,
H. Müller et al.

Scope

- 21 standard dipoles
  - Type D2: 3 units 11°,
  - Type D3: 18 units 9.75°
- 3 branched dipoles 9.75°
- Warm iron, SC coil , 50 to 60 ton
- Aperture ±190mm x ±70mm

Status

- ✓ Manufacturer Elytt Energy, Spain
- ✓ Production of series started

Super-FRS Local Cryogenic Design

Wroclaw University of Science and Technology

WUST Design activities

- Multiplet Feed Boxes (close to final)
  - piping and valve sizing
  - mechanical and flexibility analysis
  - instrumentation
  - safety valves and analysis
- Transfer Line Pieces (in progress)
- Jumper Connections (in progress)
- End Boxes (started)
- Other Feed Boxes (started)
- Branch Design (hydraulics, safety) (not yet started)

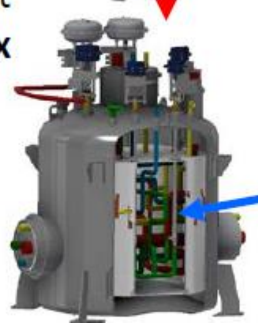
BINP Design activities

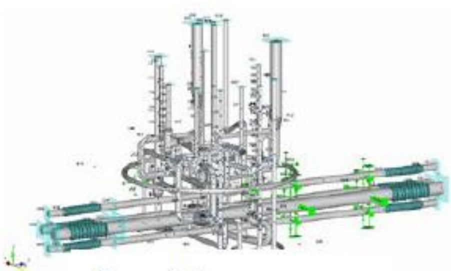
- Branch Box (well in progress)
  - vacuum vessel and platform
  - sub-cooler and heat exchanger
  - Valves and piping sizing (with GSI)
  - mechanical and flexibility analysis
  - instrumentation
  - safety valves and analysis
- Large Transfer Lines (well in progress)
- Warm Piping System (recently started)

Jumper Connection

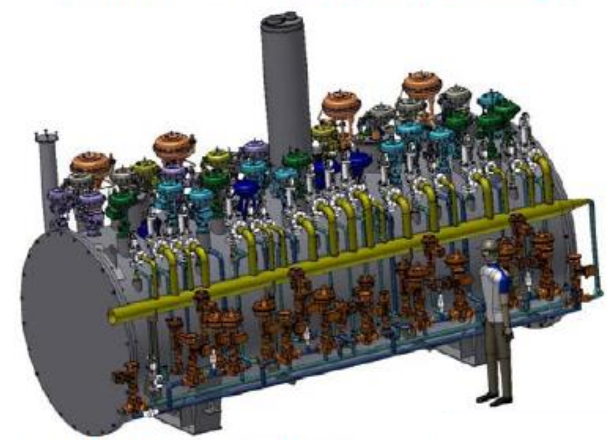
Magnet interface

Multiplet **Feed Box**





Feed Box: **Internal Piping**



Branch Box, including warm lines and valves (14 tons, 4m height, 5.5m length, 3.2m width)

S.c. Magnet Testing at CERN

K. Sugita et al.


CERN Bulletin

FIRST MAGNETS FOR FAIR TESTED AT CERN

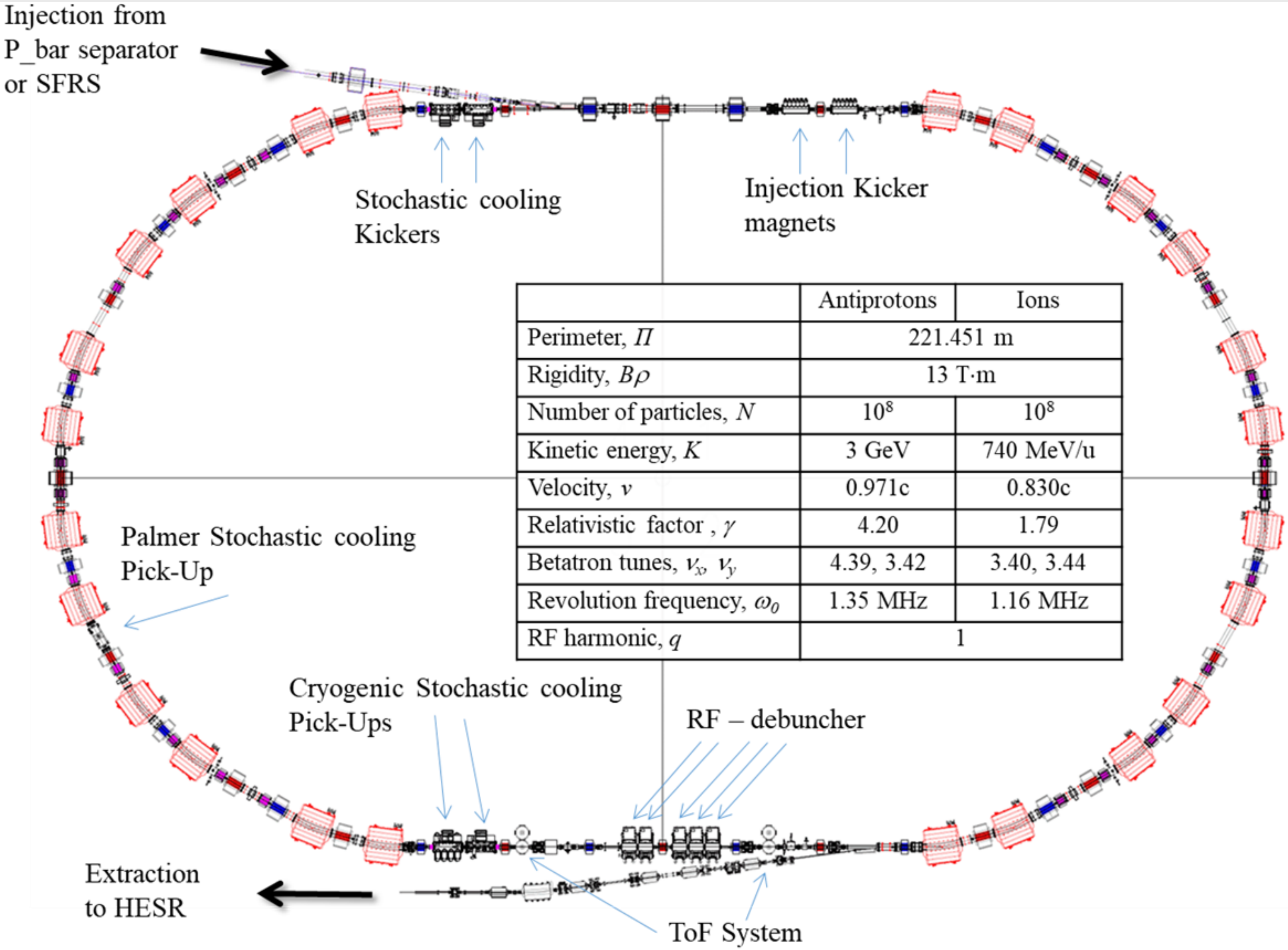
A WORD FROM JOACHIM MNICH

THE CHANGING FACE OF CONFERENCES

In this issue

Collaboration contract between FAIR and CERN on cold testing of s.c. dipoles and multiplets.

Layout of CR Collector Ring



	Antiprotons	Ions
Perimeter, Π	221.451 m	
Rigidity, $B\rho$	13 T·m	
Number of particles, N	10^8	10^8
Kinetic energy, K	3 GeV	740 MeV/u
Velocity, v	0.971c	0.830c
Relativistic factor , γ	4.20	1.79
Betatron tunes, ν_x, ν_y	4.39, 3.42	3.40, 3.44
Revolution frequency, ω_0	1.35 MHz	1.16 MHz
RF harmonic, q	1	

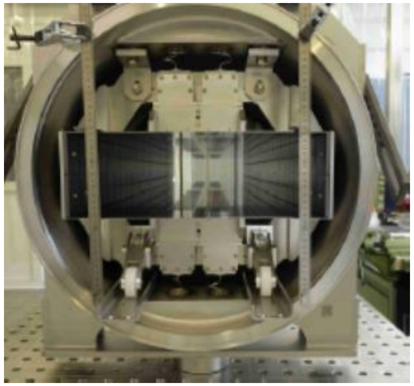
CR Collector Ring

- German Inkind contribution: De-buncher cavities and stochastic cooling system.
- All other components are Inkind contribution of Russia.
- The series (5) production of RF – debuncher system has been completed.
- The series production of Power Amplifier for Stochastic Cooling system has been completed.
- The Palmer Pick-up for Stochastic Cooling system production has been completed.
- FoS CR dipole magnet has been produced and delivered to FAIR

RF-debuncher system

FOS CR dipole design

Palmer pick-up at GSI



Cryogenic Plunging Pick-Up

HESR High Energy Storage Ring

Subproject Responsibility: FZ Jülich (Germany)

- All dipole magnets are produced and preassembly at FZ Jülich and delivered to FAIR (Weiterstadt).
- All quadrupole magnets (QP) and power converter are produced by FZ Jülich.
- Sextupoles, steerers magnets and their power converters are produced (Romanian Inkind),
- MA cavity is manufactured. Beam test in COSY.
- Noval stochastic cooling equipment (slot ring coupler + pick up and kicker) installed in COSY. Successfully commissioned with beam.
- Injection dipole, injection septa are delivered. Injection kicker FOS delivered.
- PANDA chicaine dipoles manufactured and delivered.
- PANDA main dipole in production at BINP.




In total:
360 magnets
172 deliverd

51 Dipole Magnets (11types) (Efremov Institute, St. Petersburg, Russian Federation) and Vacuum Chambers (Budker Institute, Novosibirsk, Russian Federation)

- All magnets and chambers delivered.

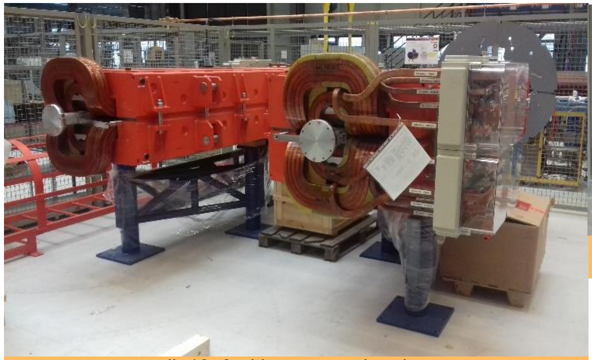
24 Dipole- (9 types), 181 Quadrupole- (5 types), 98 Steerer Magnets (3 types) and Vacuum Chambers (Budker Institute Novosibirsk, Russian Federation)

- 121 magnets (10 Dipole, 56 Quadrupole, 55 Steerer Magnets) delivered


s100 during SAT at GSI


quad2 during FAT at BINP


Vertival deflecting dip10 at GSI


dip13_0 with vacuum chamber


Batch1 pre-assemblies in Weiterstadt

Commons + HEBT

Power Converters (PCs)

- 53 PCs for dipole magnets are awarded to Jäger, Germany

  (FAT FoS Dipole PC (HB.D3) successfully completed)
- 159 PC for quadrupole- and 93 PCs for steering magnets will be mainly built by ECIL,Hyderabad, India), series product running.
- 115 PCs for quadrupole- and 48 PCs for steerer magnets are delivered to GSI/FAIR.
- 9 PC for quadrupole magnets are awarded to Jäger, Germany.

Cable data base set-up finalized with all cable parameters required for a reliable cost estimation and execution of cable related tasks for the project (in total about 6000 km). Procurement in preparation

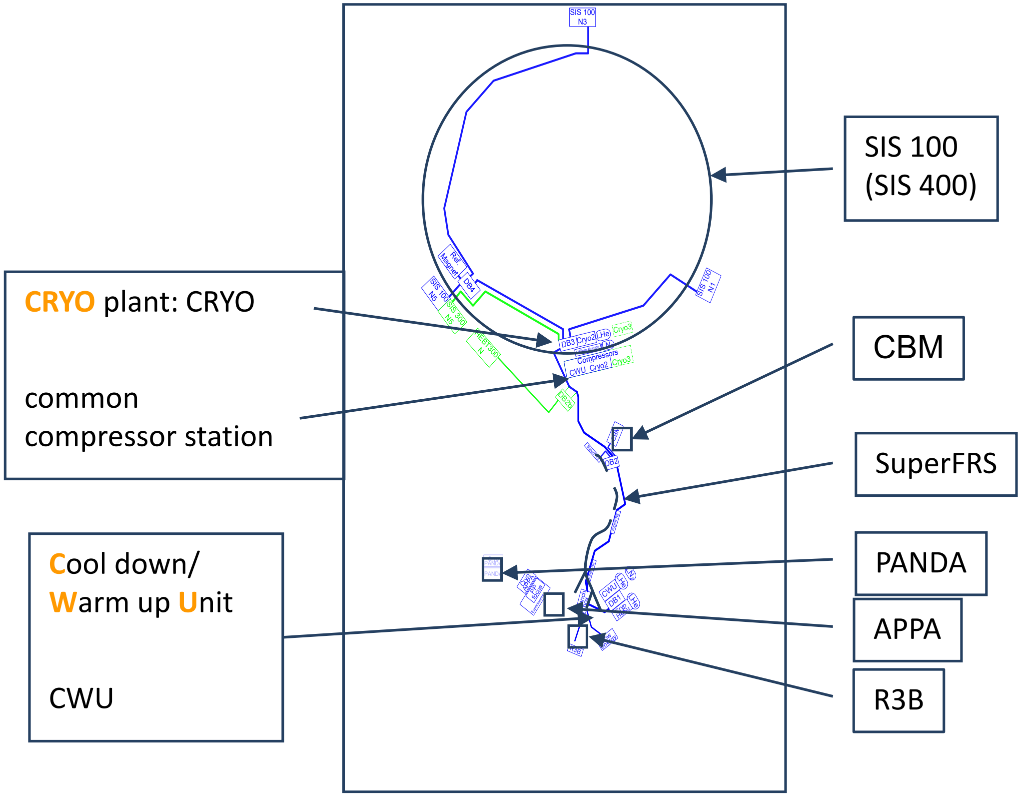
HEBT Quadrupole Power Converter after FAT at ECIL in India

Beam Diagnostics

- For all devices production (chamber, detector, drive, DAQ) running

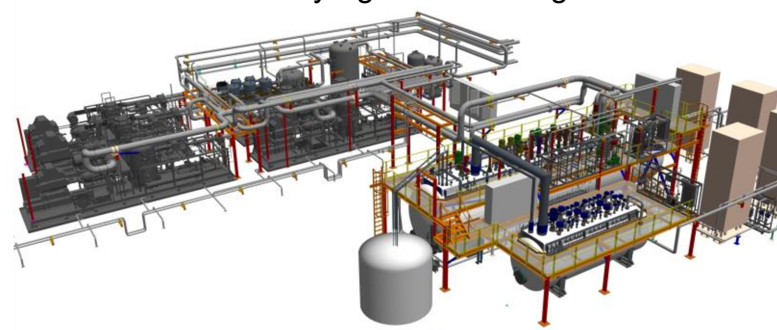
SEM-Grid Scintallating Screens MWPC PDC BLM Chamber, India

FAIR Cryogenics Systems

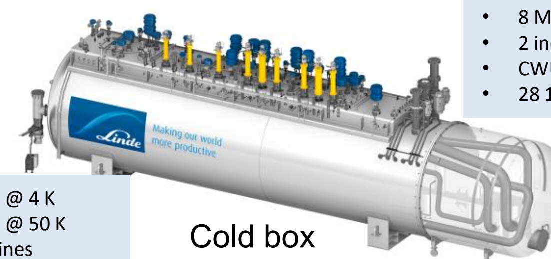


FAIR cryogenics supply and distribution system

Central cyrogenics building



- 2 LP compressors (1 FD)
- 2 HP compressors
- 1 CWU compressor (FD)
- 8 MW power in total
- 2 independent ORS (CRYO2, CWU)
- CWU comp. can be used as redundancy
- 28 100 m^3 gas buffers



Cold box

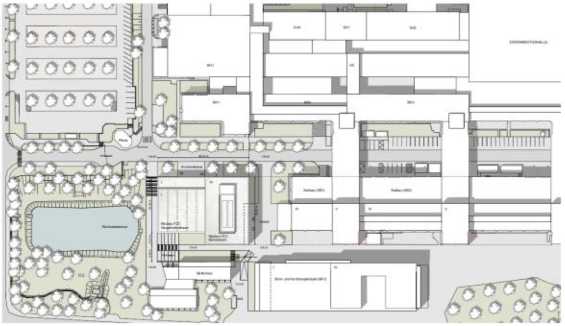
- 14 kW @ 4 K
- 50 kW @ 50 K
- 9 turbines
- 40 g/s liquefaction

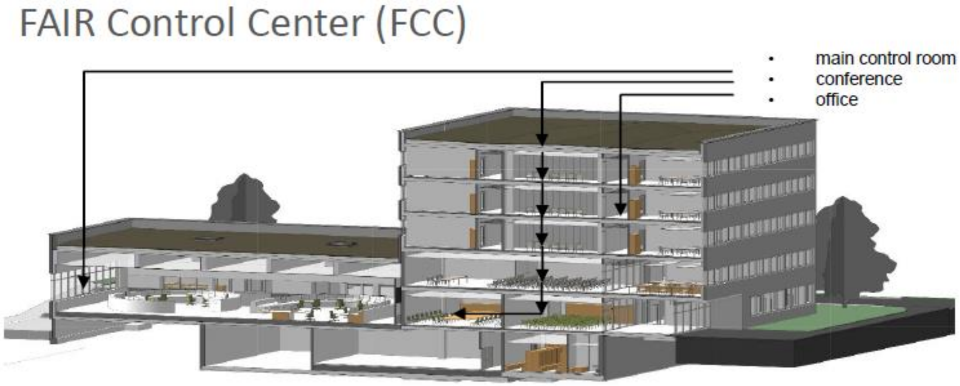
- Main cryogenic plant awarded to Linde (14 kW@4K, 50 kW@50K). Delivery start July/22
- Cryogenic distribution system under construction by Demaco. Start of installation 09/22.

FAIR Control Centre (FCC)

Mechanical Console and Fixed-Display Pre-Design

- Detailed specification approved by SPLs and main users incl. experiments.
- Existing GSI control room refurbished with new prototype FAIR consoles and fixed displays.
- Generic set of control room applications in development.
- Digitization of all analogue signals pushed. Pre-condition for operation from FCC.
- Shell construction ongoing.





Next Tasks

- Continuation and completion of accelerator component procurements, testing and acceptance. Completion of pre-integration (no integration in tunnel), Completion of documentation to reach „ready for installation“.

- Preparation for accelerator installation starting early 2023.
  Large effort of coordination (new subproject: site management) among all parties working on the construction area, LCM planning, day by day meetings etc.)
  Work instructions, quality assurance, acceptance protocols, development of welding techniques, welding instructions, certification, development of tools (e.g. soldering tools), planning of resources and consumable etc.

- Planning for commissioning without and with beam starting from 2024.

- Completion of civil construction and technical building infrastructure by FSB (FAIR site and buildings)


Thank you