

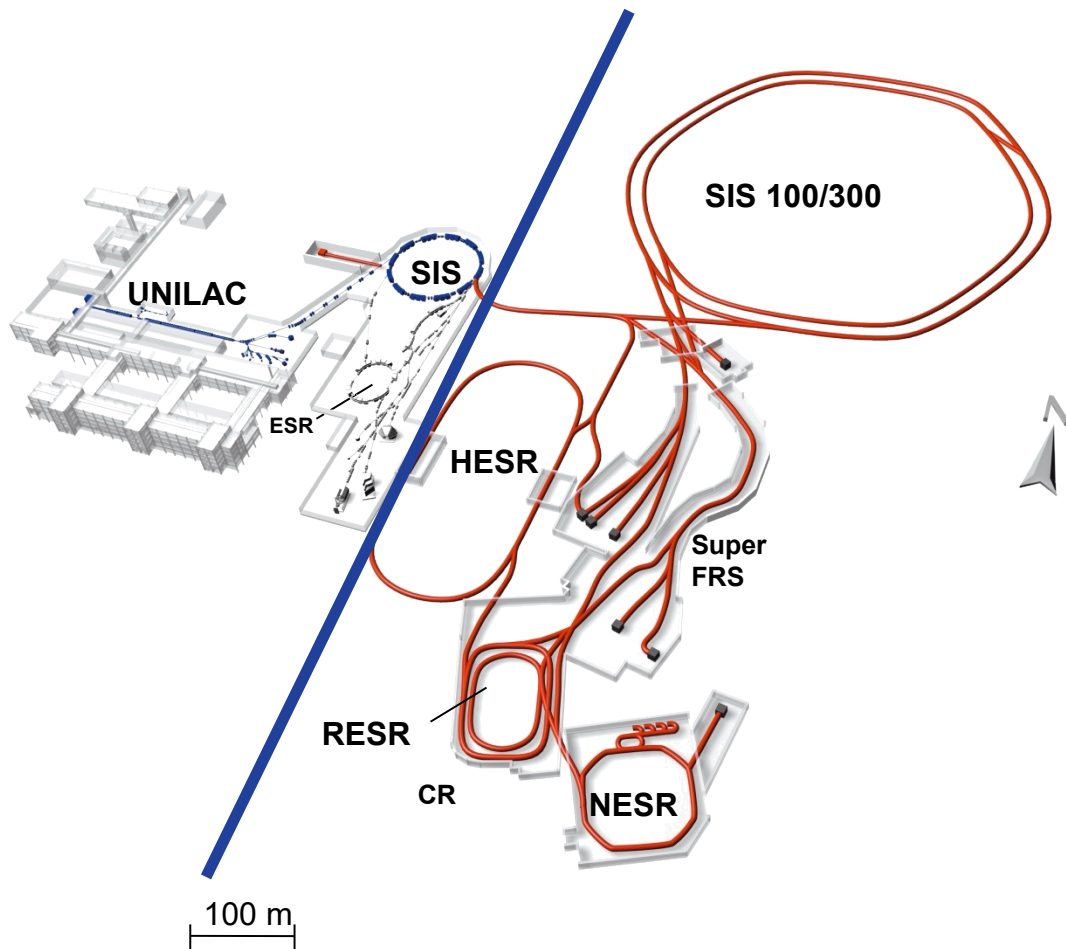


# Progress of the FAIR Cryogenic System

Holger Kollmus

# Outline

- Introduction to the FAIR Project
- Introduction to the Prototype Test Facility (PTF)
- Status Series Test Facility (STF)
- Status Helium Supply Unit (HeSu)
- Refurbishment of TCF20 and TCP50 → from unusable to state of the art (cabinet and controls)
- SIS100 Cryogenic
- SuperFRS Cryogenics
- Cryo Plants for FAIR



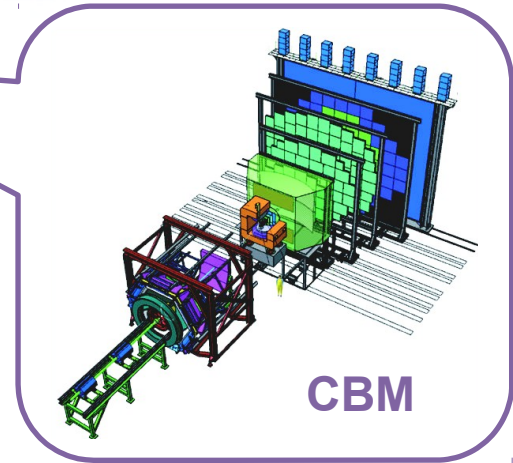
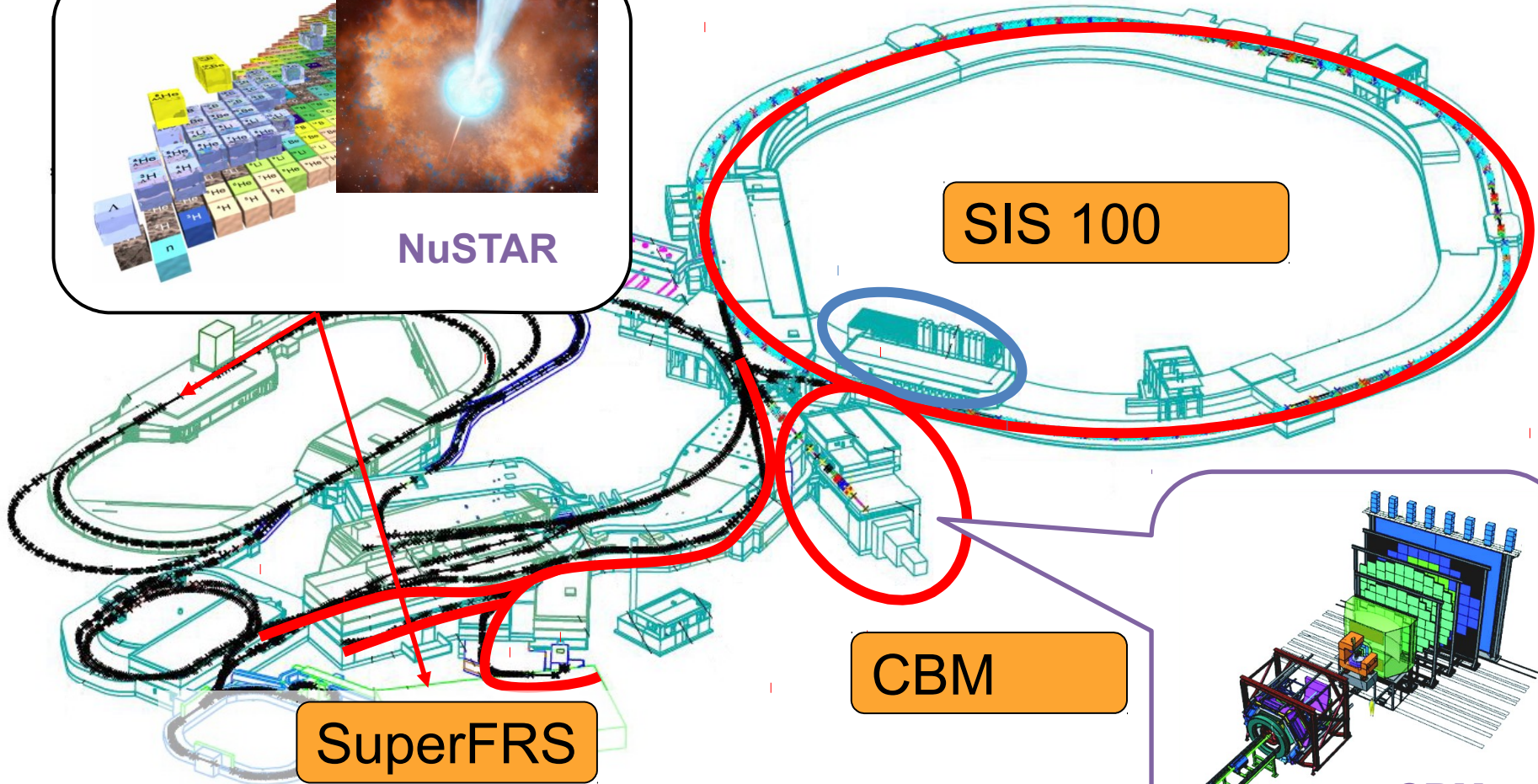
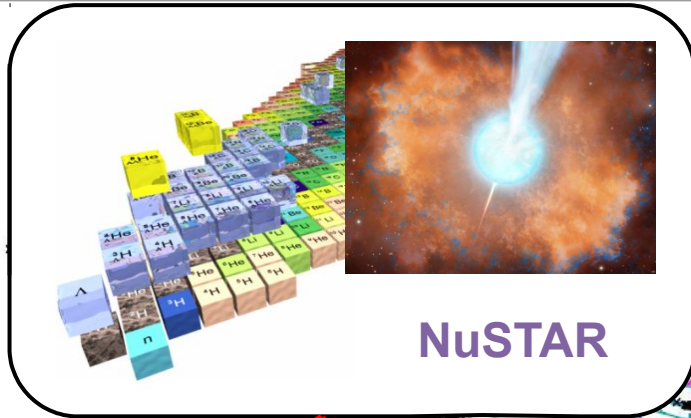
## GSI-Today

- Protons to Uran
- max 1 GeV/u Uran and 2 GeV/u for Neon

## GSI in future / FAIR

- Rare isotopic beams
- Anti protons
- Higher Beam Current
- At higher energies

# SIS100 with SuperFRS and CBM



SIS100, SuperFRS and CBM are using SV magnets supplied by one central plant

# The Prototype Test Facility Operating since 2005

## Cryogenic infrastructure at PTF

- 70,000 h operation at PTF
- 2,200 h with 60 g/s
- 107,000 h total operation of the cryo plant
- only 300 m<sup>3</sup> helium inventory



Test bench area,  
SIS100 prototype,  
and universal cryostat



Preparation area,  
Cryogenic  
infrastructure is  
located in the  
middle of the  
hall

Distribution box (blue)  
Feed boxes and  
universal cryostat



# The Series Test Facility Operating since 2015



- 1.5 kW 4 K equivalent, 6 g/s liquefaction, four test benches
- SIS 100 dipoles, quadrupoles and SuperFRS Magnets can be tested
- Testing of SIS100 and SuperFRS local cryogenics
- Series testing started in summer 2017

# Helium Liquefier (HeSu) Operation since 2015



- Liquefaction rate ~ 20+ l/h
- 3000 l LHe storage, 12,000 l delivered so far
- Decant Station and campus wide recovery system

# R<sup>3</sup>B Cryo Plant

## Refurbished and Migrated to UNICOS



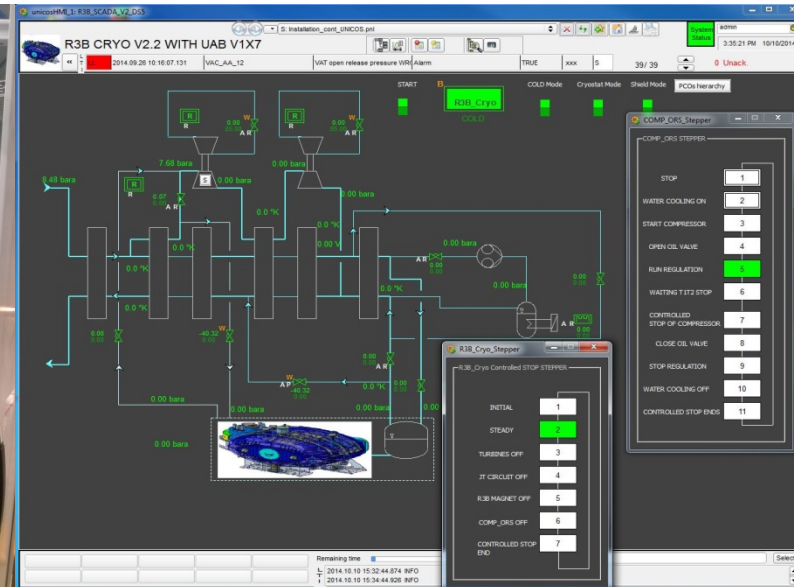
TCF50 including new cabinet



TCF20 → CRYRing electron cooler  
 TCF50 → GLAD magnet

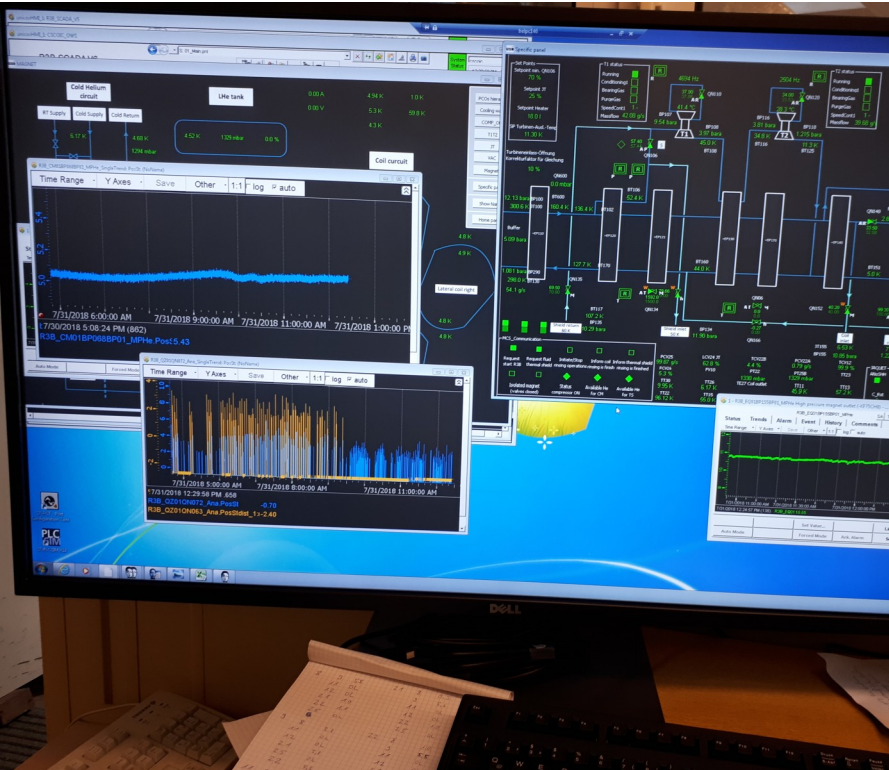
Cabinet

UNICOS + WinCC OA



Supported by CERN and INFN:  
 M. Pezzetti, Ph. Gayet, R. Pengo and B. Gallese





## GSI Large Aperture Dipole:

- 20 t of cold mass
- Presently cold and ready for powering
- Beam time in 2018/2019

# Cryogenic Supply for FAIR



SIS 100  
(SIS 300)

CBM

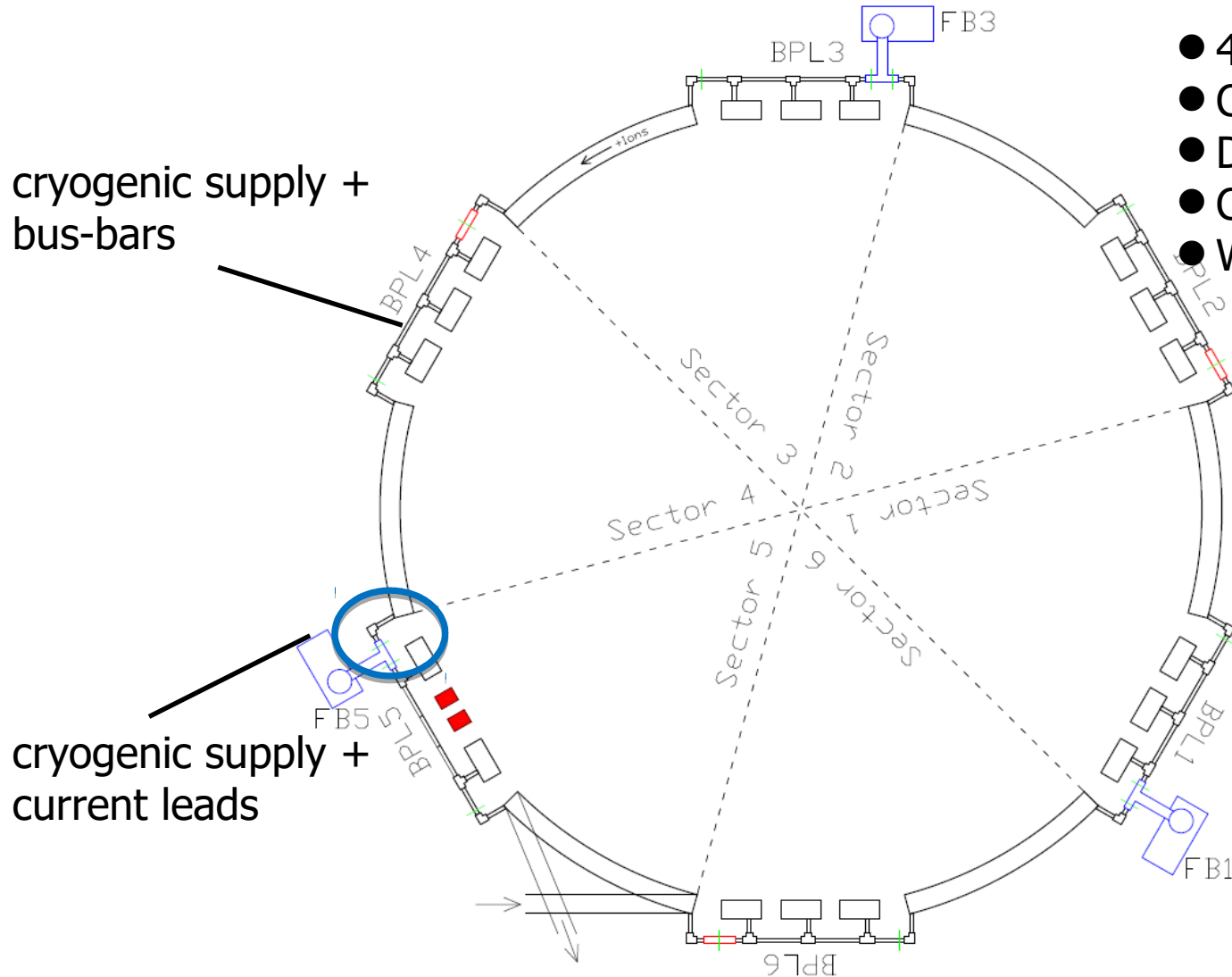
SuperFRS

Panda

APPA

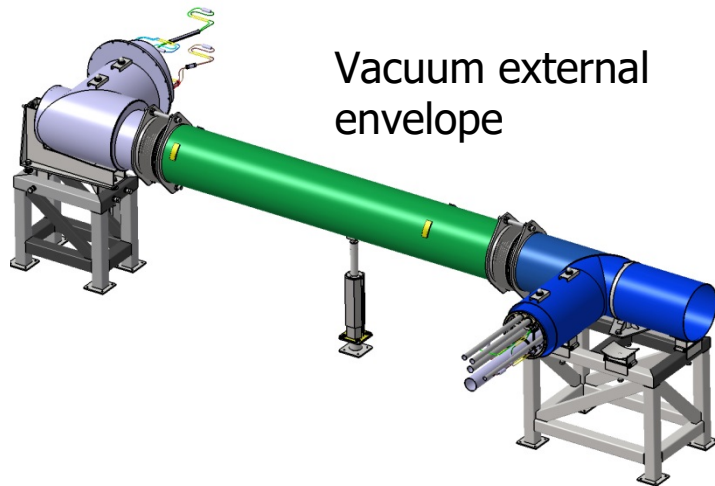
R3B

# SIS100 Local Cryogenics

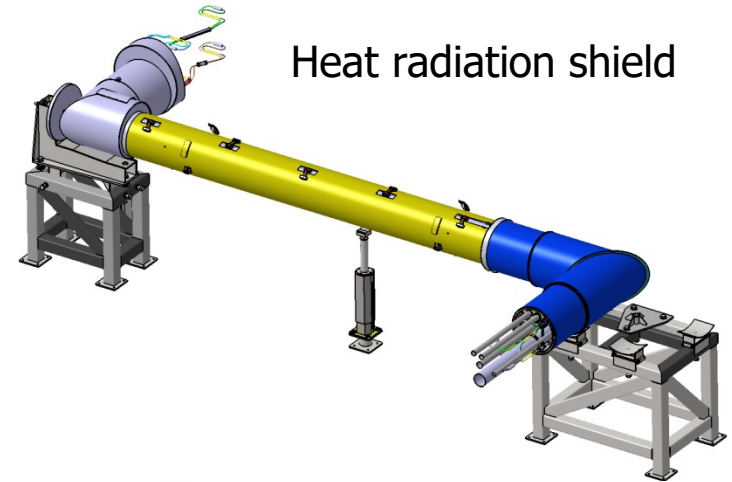


- 400 t of cold mass
- Circumference  $\sim 1.1$  km
- Divided into 6 sectors
- Cold arcs
- Warm straight sections

# SIS100 By-Pass Line



Vacuum external envelope



Heat radiation shield

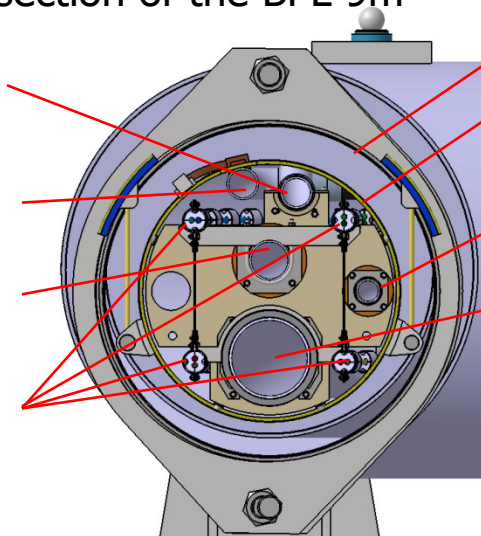
## Cross section of the BPL 9m

He return shield

He supply shield

He supply magnets

4 busbars pairs

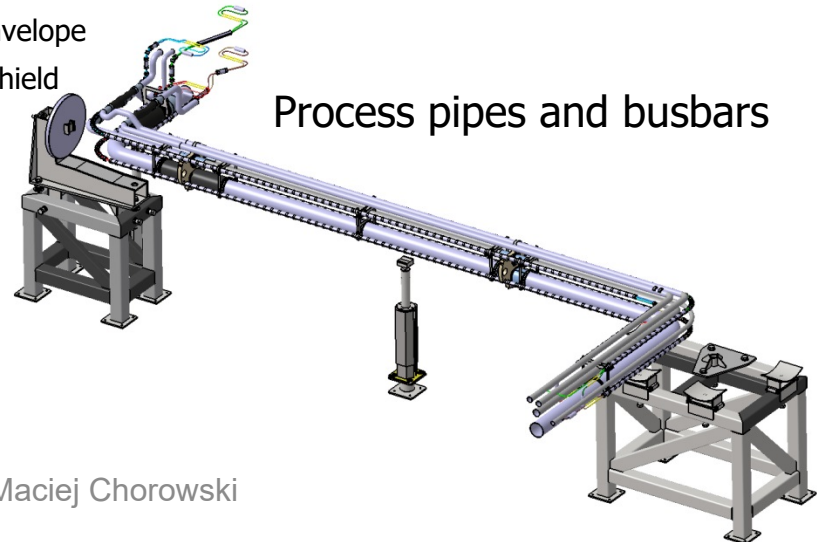


Vacuum external envelope

Thermal radiation shield

He supply VC

He return magnets + VC



Process pipes and busbars

Courtesy of Maciej Chorowski

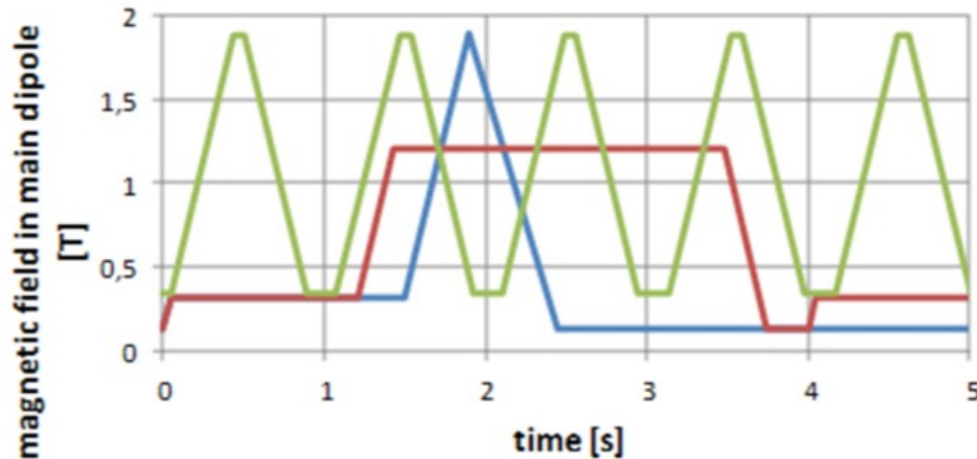
# SIS100 By-Pass Line



- Successfully tested at GSI STF
- Series production in preparation
- Production time until 2021

# Challenges of SIS100 Cooling

High variation in heats loads depending on machine cycle



Proton cycle (5 s)

RIB cycle  $U^{28+}$  (4 s)

Triangular cycle  $U^{28+}$  (1.029 s)

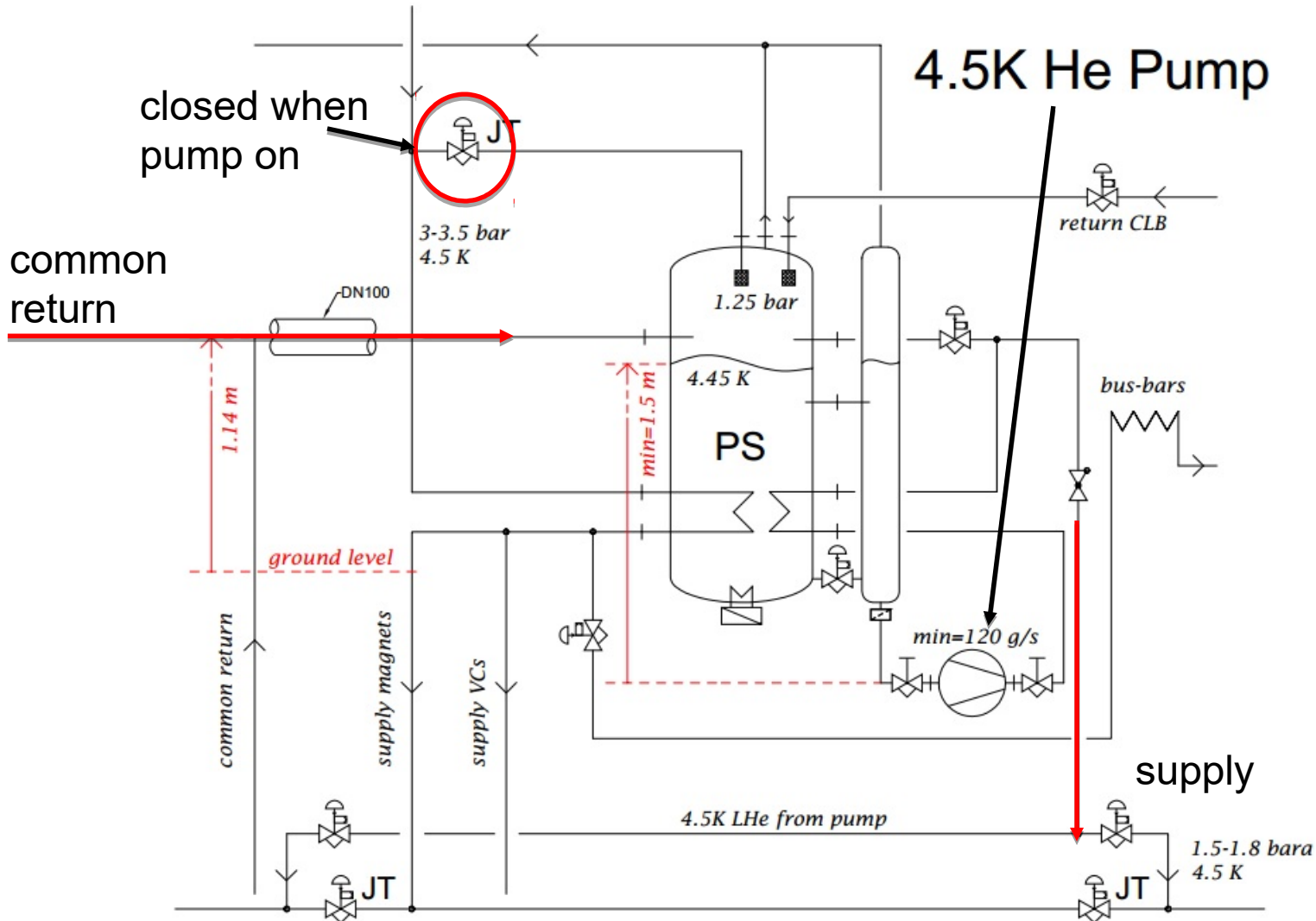
	Static heat load [W]	Dynamic heat load [W] for triangular cycle
DPs	~ 8 *	~ 46
Different QP units	6... 8 **	27.... 33

Adjusting and balancing by tuneable impedance

## Heater-capillary combination



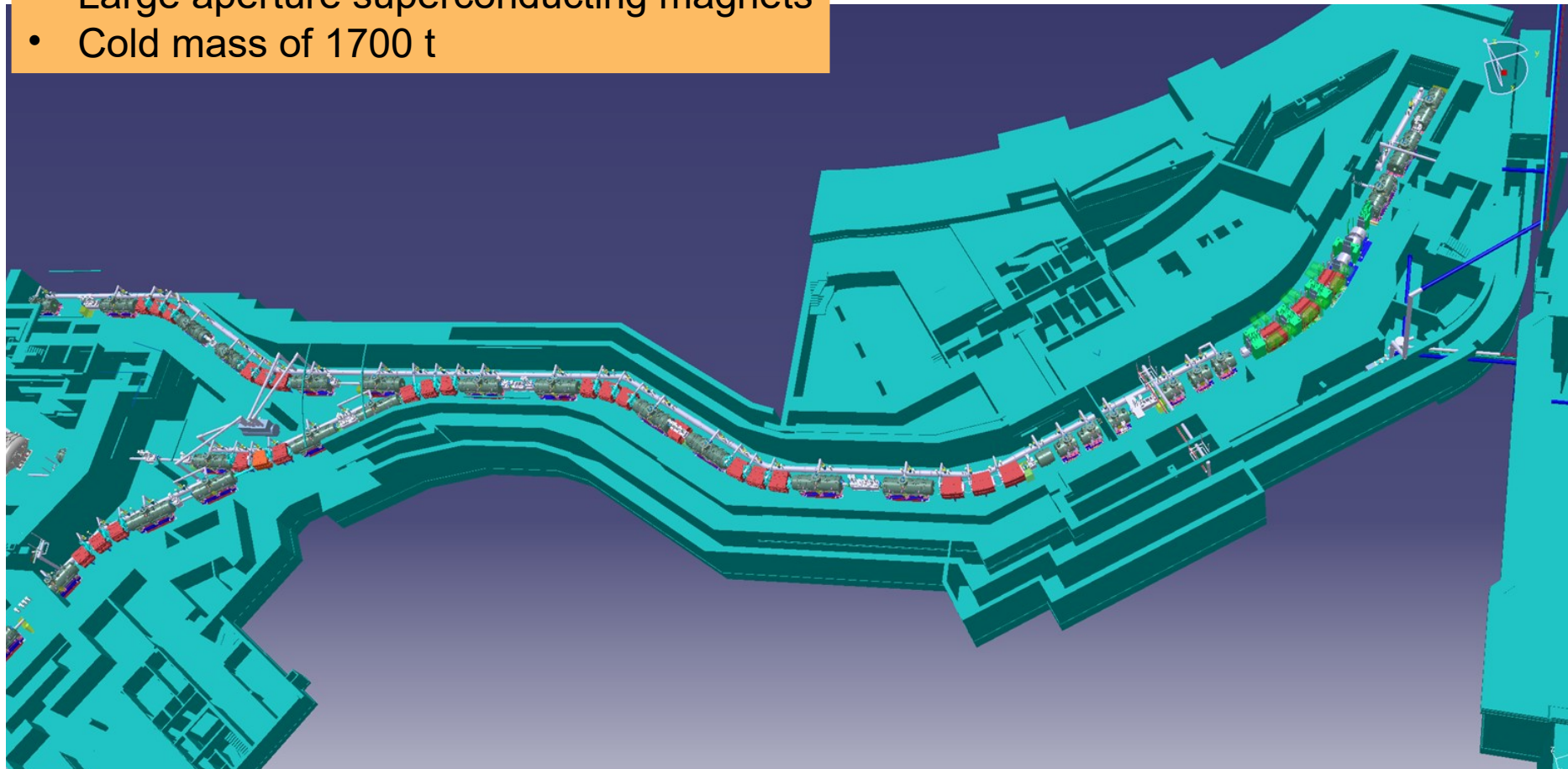
# SIS100 Feed Box Design with LHe Pumps



# The SuperFRS

## Fragment Separator for rare isotopic beams

- Large aperture superconducting magnets
- Cold mass of 1700 t





# Challenges of SuperFRS Cooling

iron dominated magnet design:

dipole: 0.15 - 1.6 T; 21 pcs.

quadrupole: 1-10 T/m; 80 pcs.

Dedicated cool down and warm up unit → 100 [kW@100 K](#)

multiplet:

Total mass: > 50t

cold mass: ~ 37t

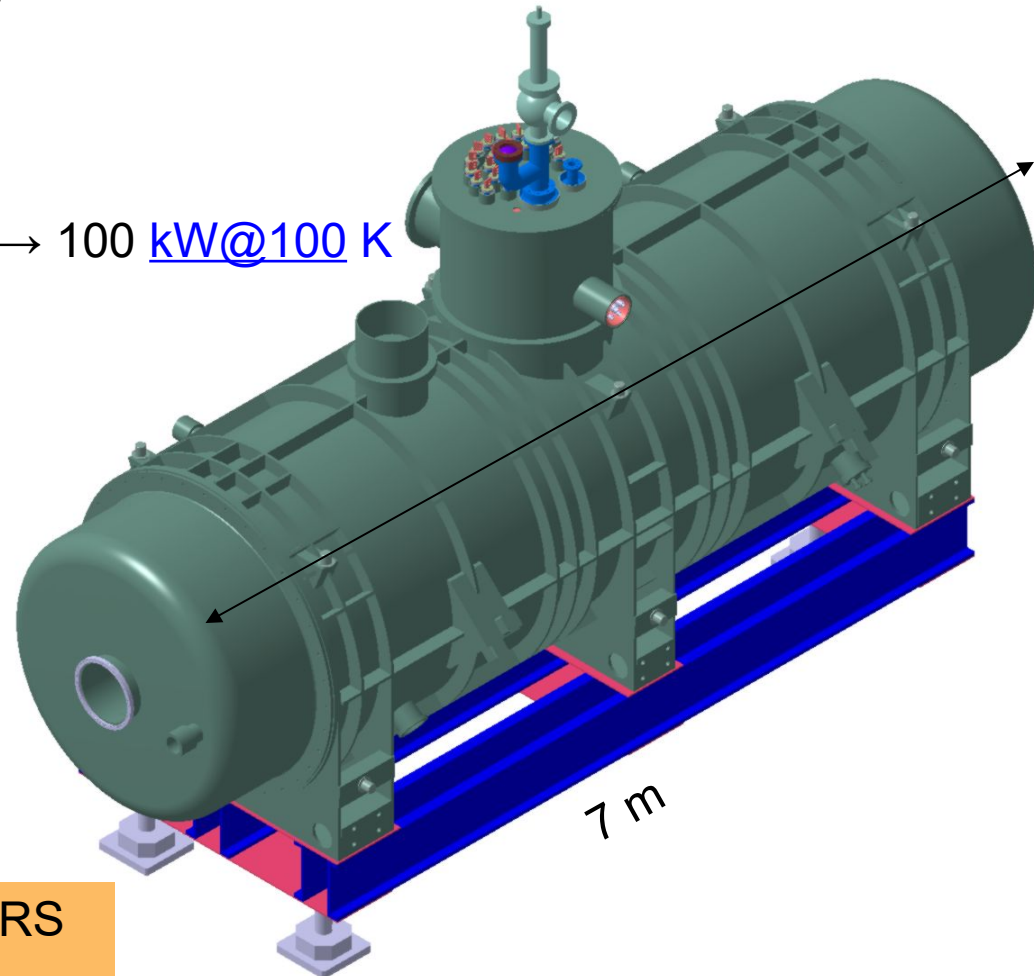
current: ~250 A

Helium inventory: ~ 1500 l

heat load: ~ 30 W

no ramping

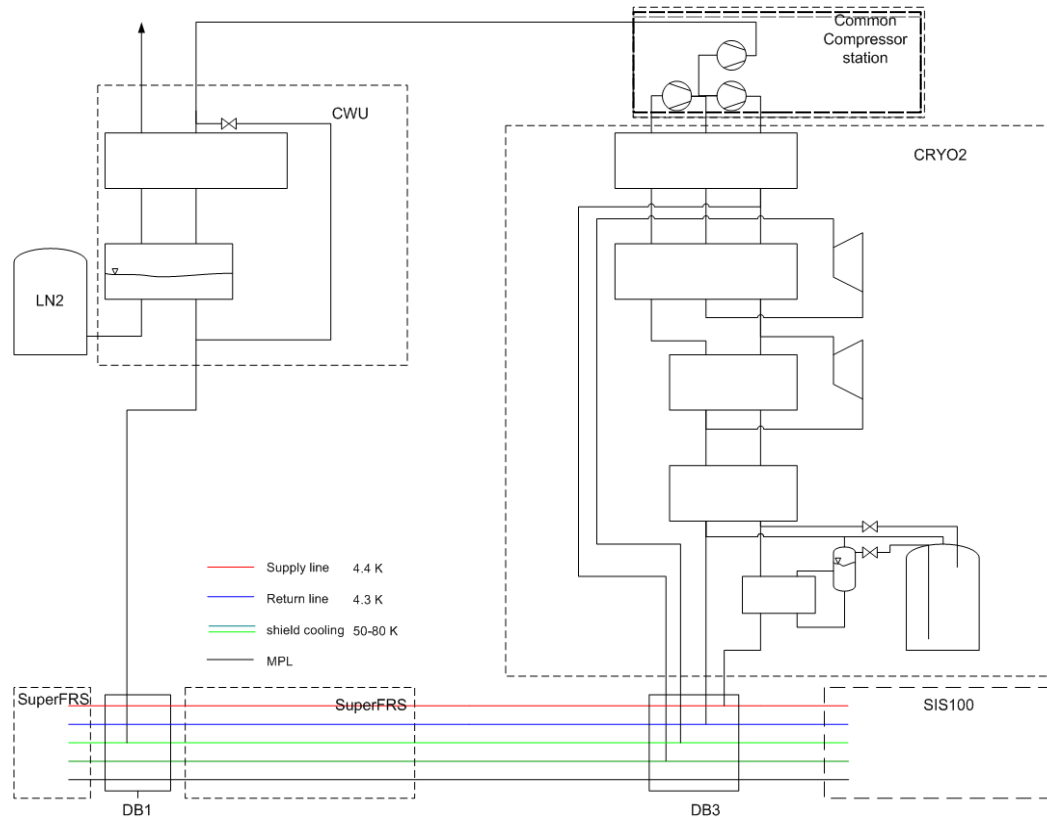
31 pcs.



	SIS100	SuperFRS
Cold mass [t]	400	1700
Helium inventory [t]	1.3	5.9

# Central Cryo Plant for FAIR

normal  
operation  
  
cool down  
SuperFRS  
  
peak load



- Approximately 19 – 23 kW @ 4 K equivalent
- Dedicated Cool Down and Warm Up Unit (CWU) for SuperFRS cool down to 80 K
- Specification approved
- CRYO2, CWU and DB3 are in procurement



**1.327**  
piles

**59 km**  
total length of piles

Thank you very much for your  
Attention

