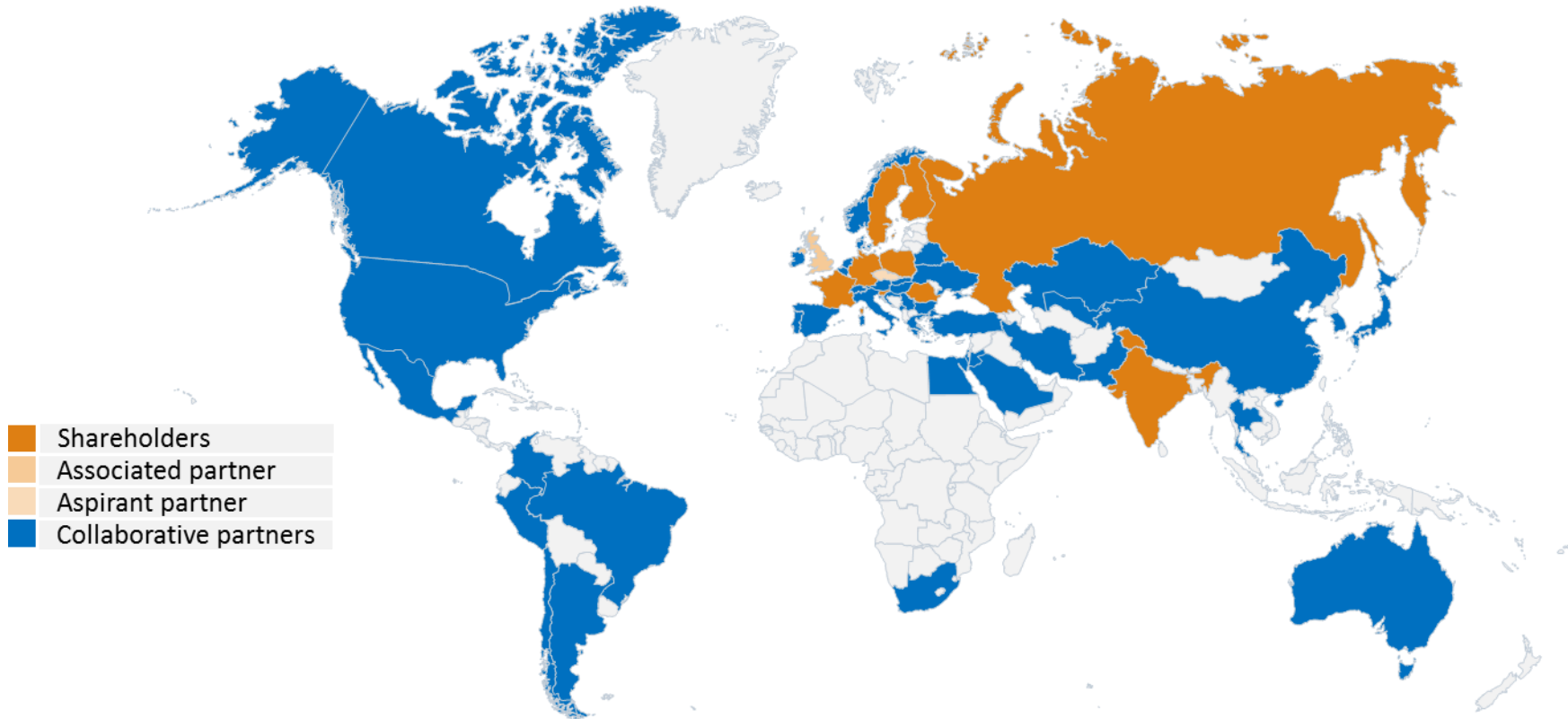


A detailed wireframe model of a particle accelerator complex, showing a large circular ring and various smaller structures and connecting paths.

# The FAIR and Super-FRS Project

**Haik Simon**  
*Martin Winkler*  
*Subproject Super-FRS*

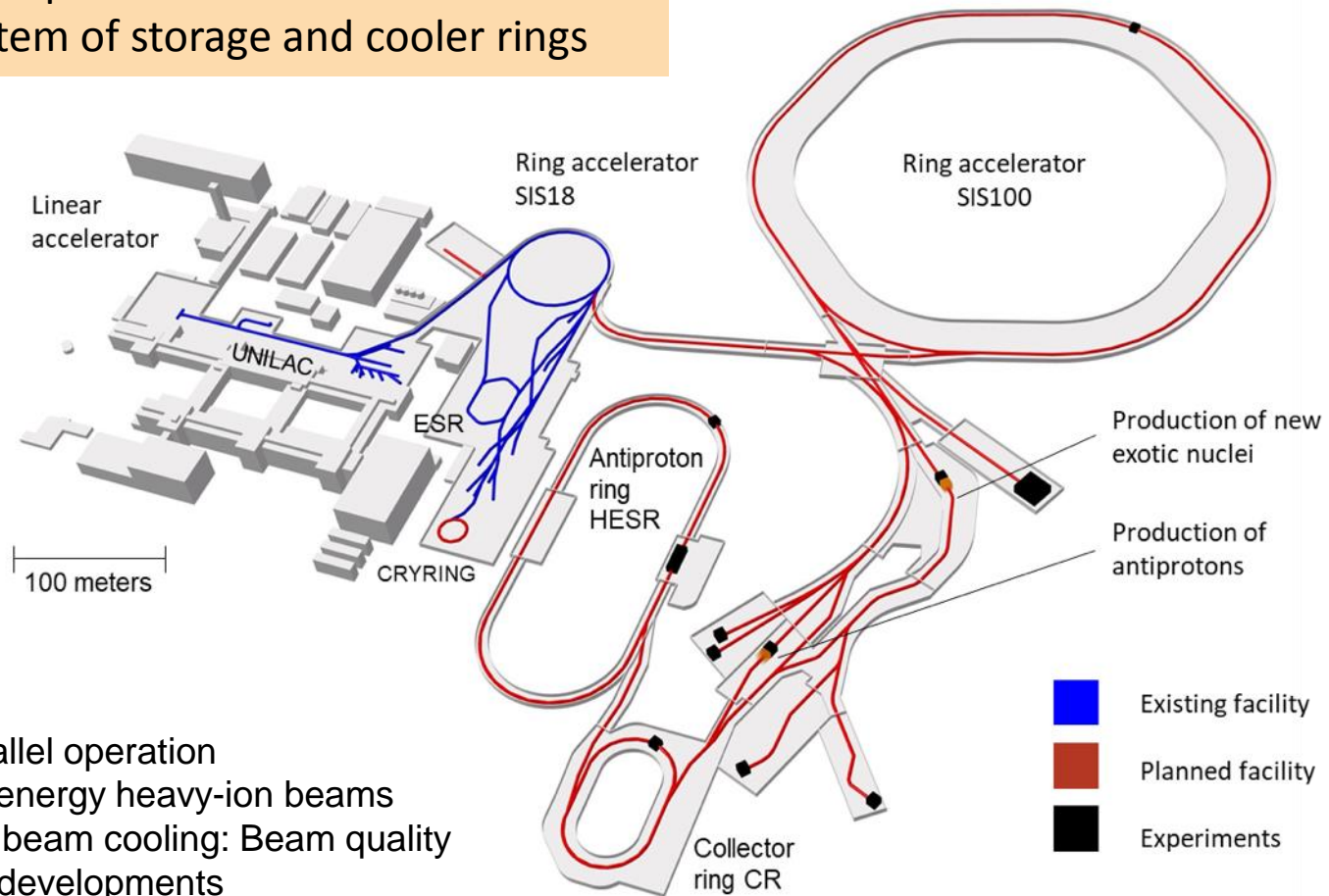
# Participation in FAIR



- **9 international FAIR Shareholders**
- 1 Associated Partner (United Kingdom)
- 1 Aspirant Partner Czech Republic (Since 2018)
- Participation of **3.000 scientists from all continents**

## FAIR – The Facility

- **Intensity gain: x 100 – 1000**
- 10 x energy (comp. to GSI)
- **Antimatter:** antiproton beams
- **Precision:** System of storage and cooler rings



### Unique features:

- Flexibility and parallel operation
- **Intense** and high-energy heavy-ion beams
- Storage rings and beam cooling: Beam quality
- Major accelerator developments

- See videos via

[www.gsi.de/en/researchaccelerators/fair/fair\\_civil\\_construction/photos\\_and\\_videos.htm](http://www.gsi.de/en/researchaccelerators/fair/fair_civil_construction/photos_and_videos.htm)



Bird's view  
19 May 2019

1<sup>st</sup> SIS100 tunnel segment  
concreting completed in April 2019



Transfer Building G004  
construction progressing



# Status of FAIR: Accelerators: construction / procurement progress



41 sc dipole SIS100 modules manufactured at BNG and shipped to GSI. 36 accepted



SIS100 quadrupole units shipped from JINR to BNG for integration into FOS module



All 51 HEBT vacuum chambers of batch 1 delivered (BINP, Russia)



The series production of RF – debunchers



All HESR Dipoles are produced, in Jülich and 65% are delivered to FAIR



Delivery of 1st 6 series Power Converter from India, (ECIL, India)



# Status of FAIR: Accelerators: construction / procurement progress



Two FoS vacuum chambers for the quadrupole doublet modules of the SIS100 arrived from China. They will be installed by the integrator in the quadrupole units



First-of-Series of the Super-FRS short SC Multiplet arrived in February 2019 at CERN test facility for execution of the Site Acceptance Test



First HESR Stochastic cooling pick-up and kicker in operation at COSY



Successfully First-of-Series FAT for the Super-FRS short SC Multiplet took place in Italy at January 2019



Copper plating and first tests of the RFQ accelerator cavity for the pLinac have been completed and match specifications



Three new MA acceleration cavities installed and commissioned with beam



# Distributed testing infrastructure for the FAIR superconducting magnets



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

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

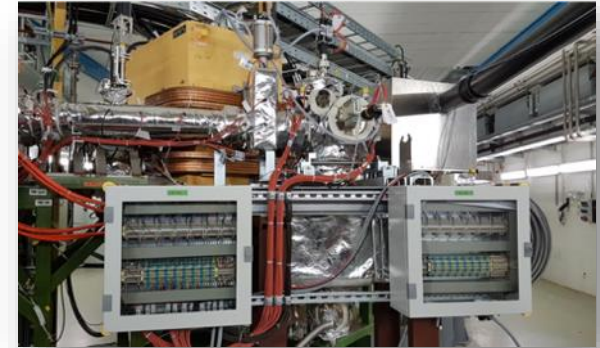
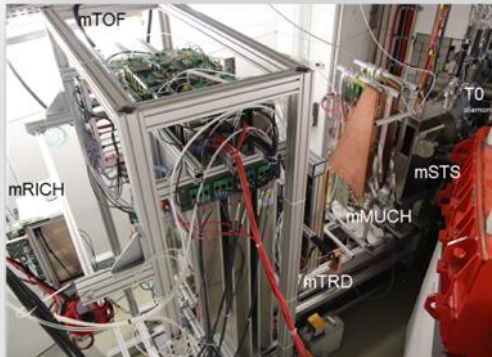


JINR, Series test facility in Dubna for testing of the series of SIS100 s.c. quadrupole units



## FAIR Experiments: A few Highlights from Phase-0

- APPA: CRYRING commissioning (own sources).  
Laser spectroscopy setup for APPA-SPARC



- CBM: mini-CBM completed first test beam campaign (prototypes of CBM detectors + distributed DAQ)

- NUSTAR: R<sup>3</sup>B: First Experiments with the GLAD magnet

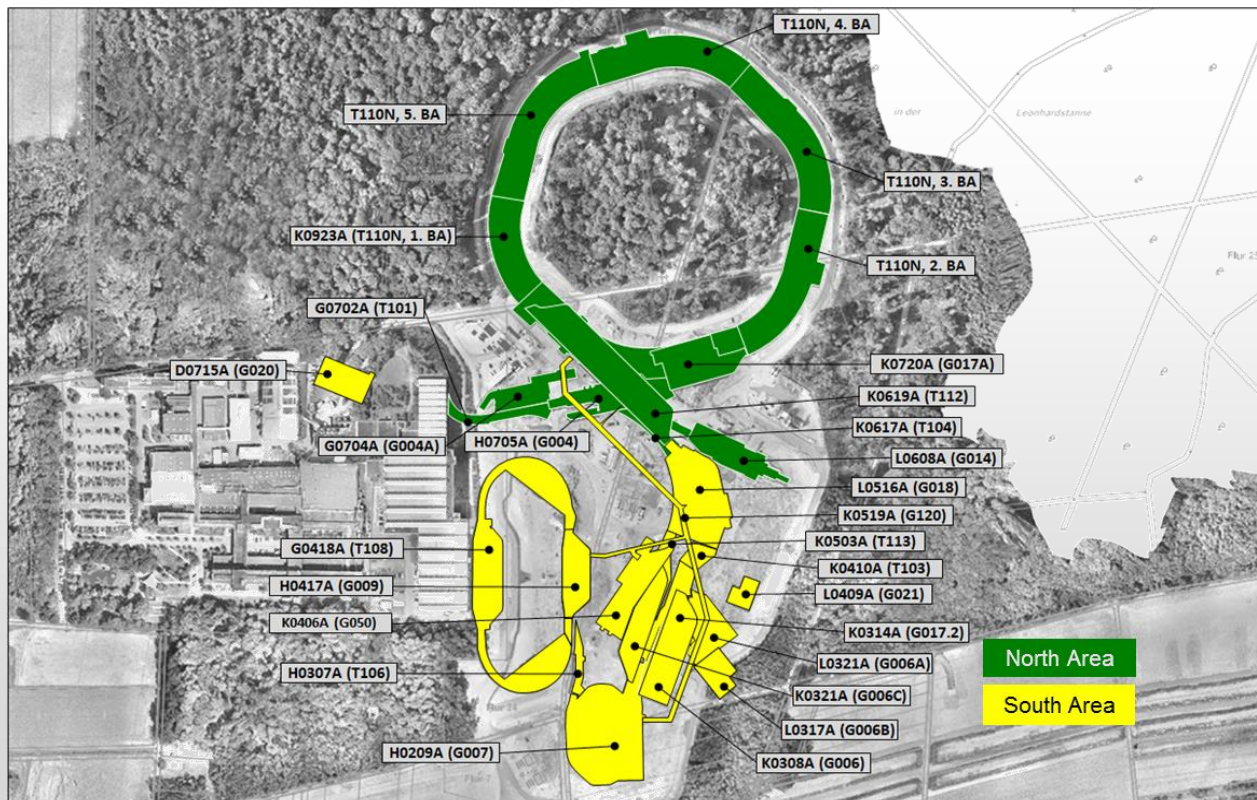


- PANDA: Cluster jet target operated successfully at FZJ

# FAIR Project – Civil Construction



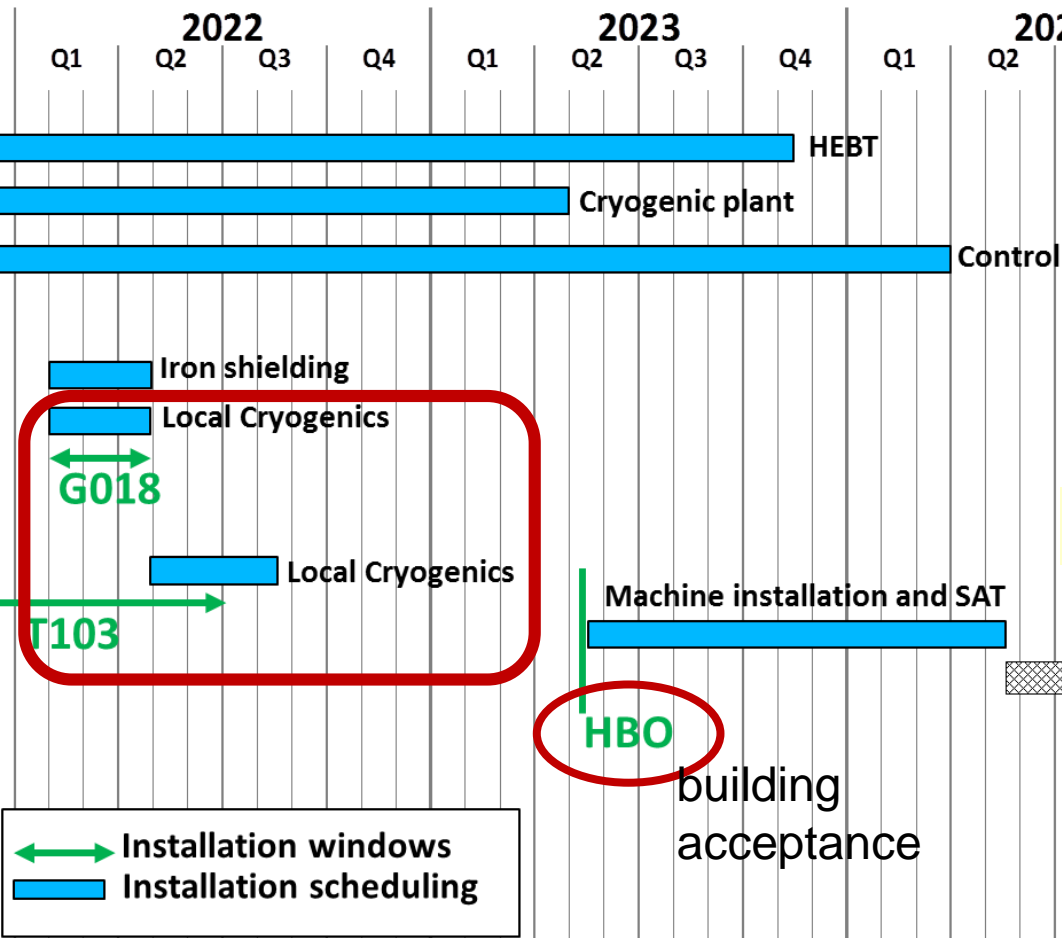
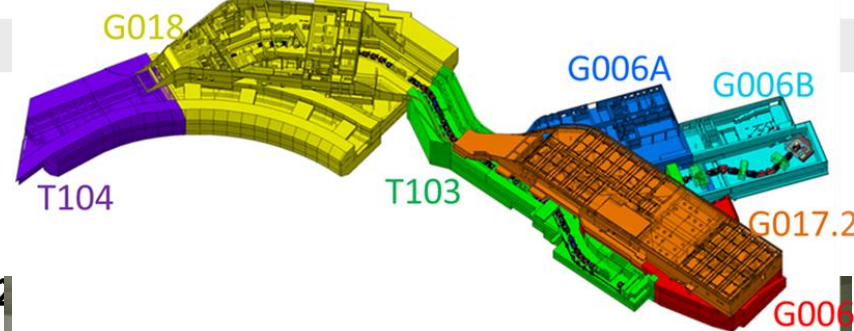
## FAIR Site & Buildings



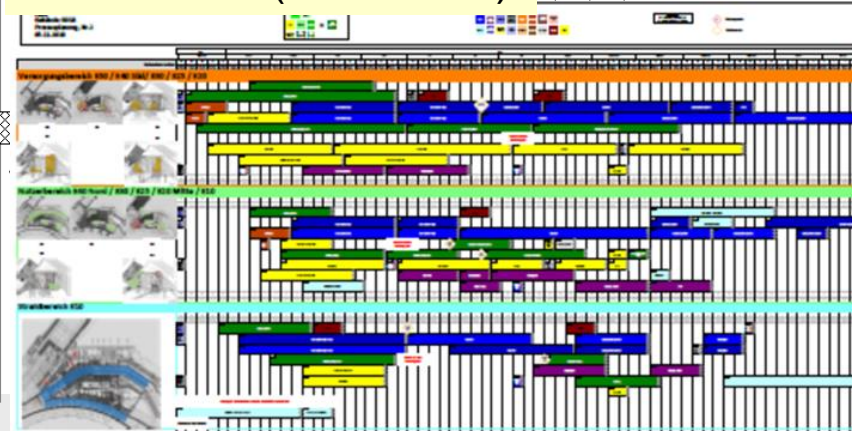
# Super-FRS Installation Plan (LCM Process – South Area)



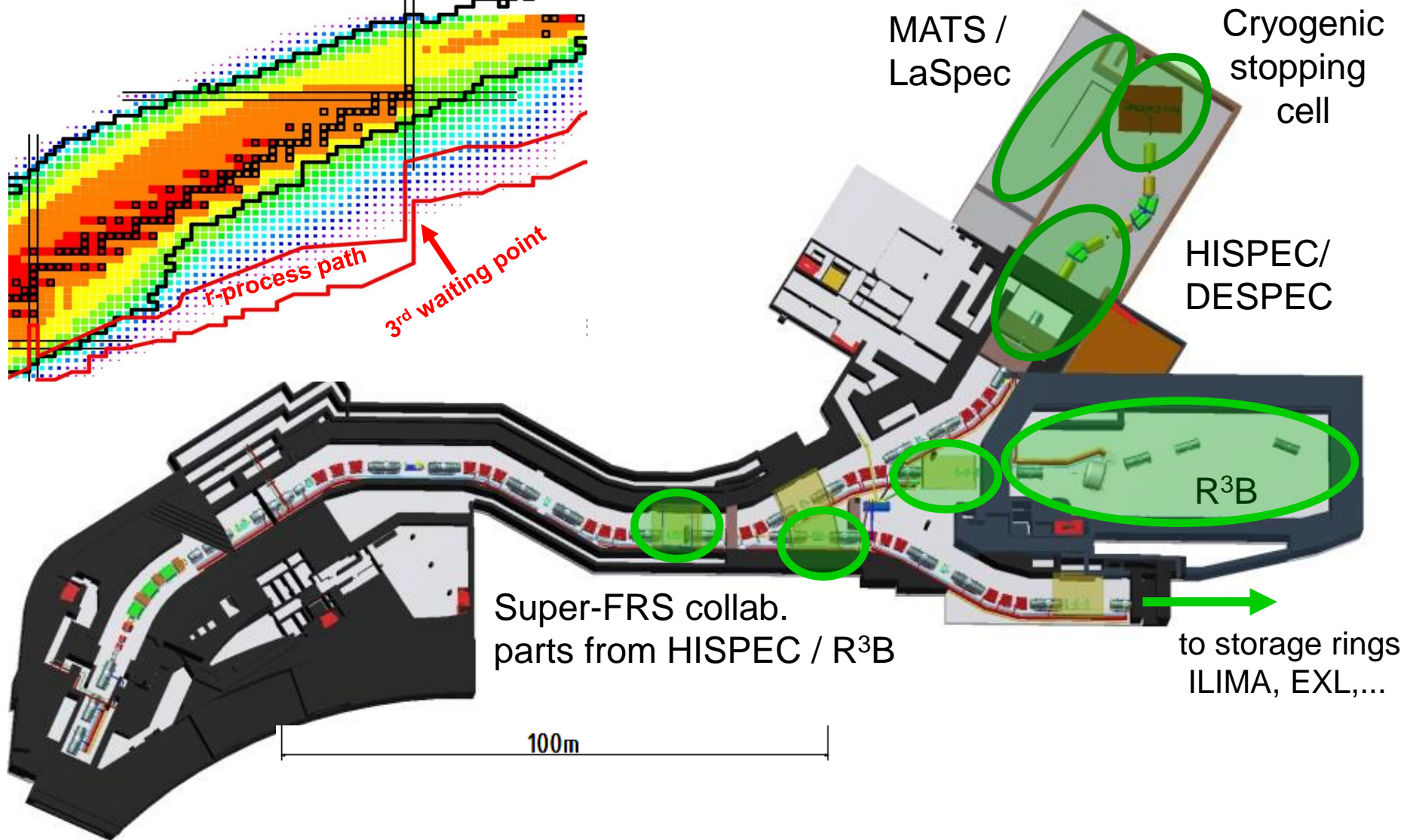
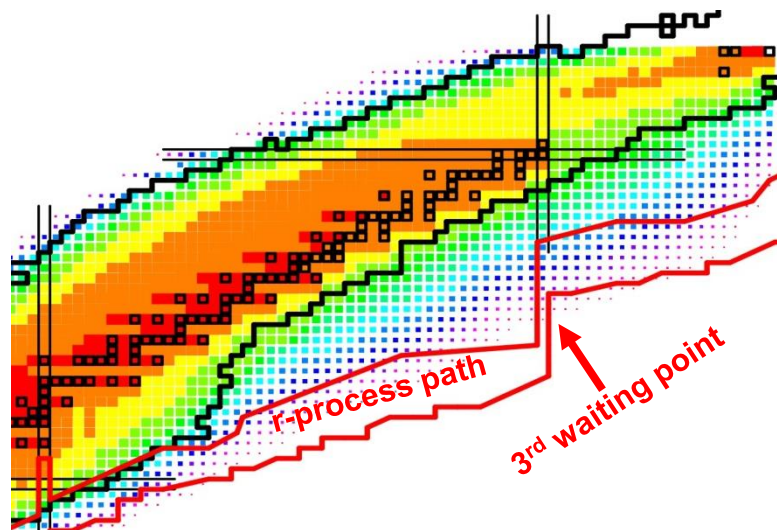
- LCM coordinates installation windows
- two installation windows (for each building)
- defines: who does what, when



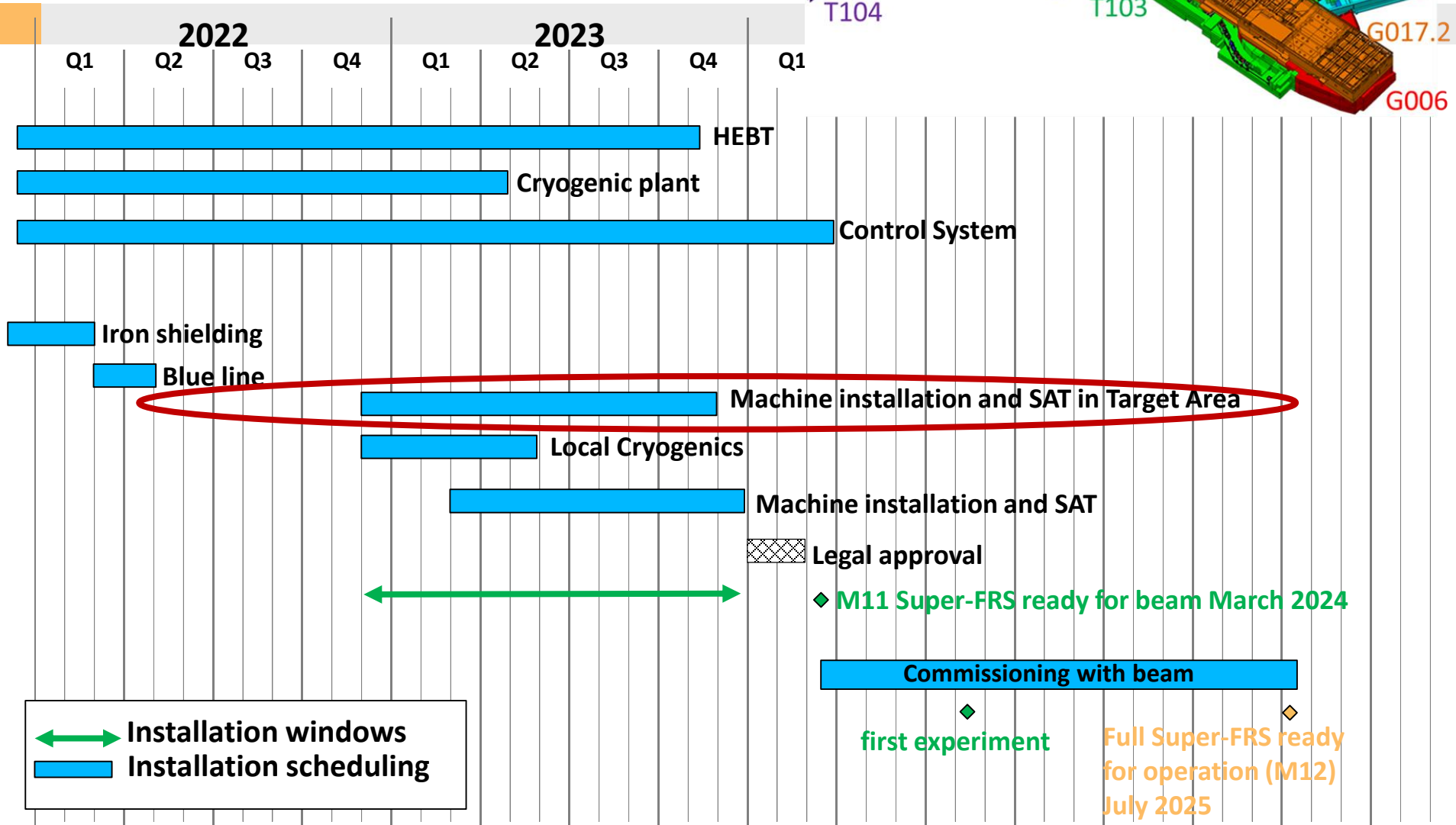
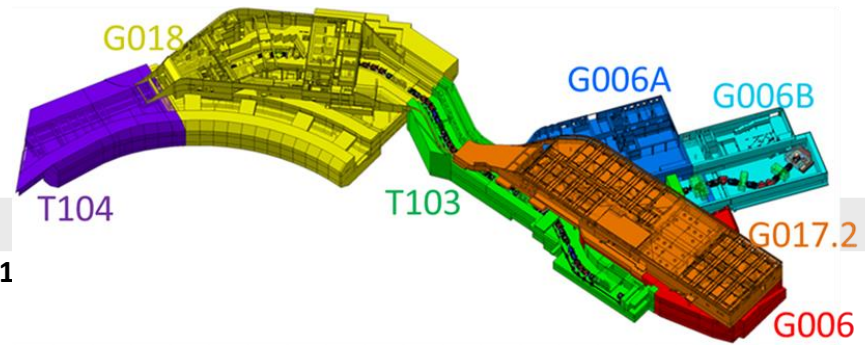
LCM G018 (each floor)



# Super-FRS & NUSTAR facility



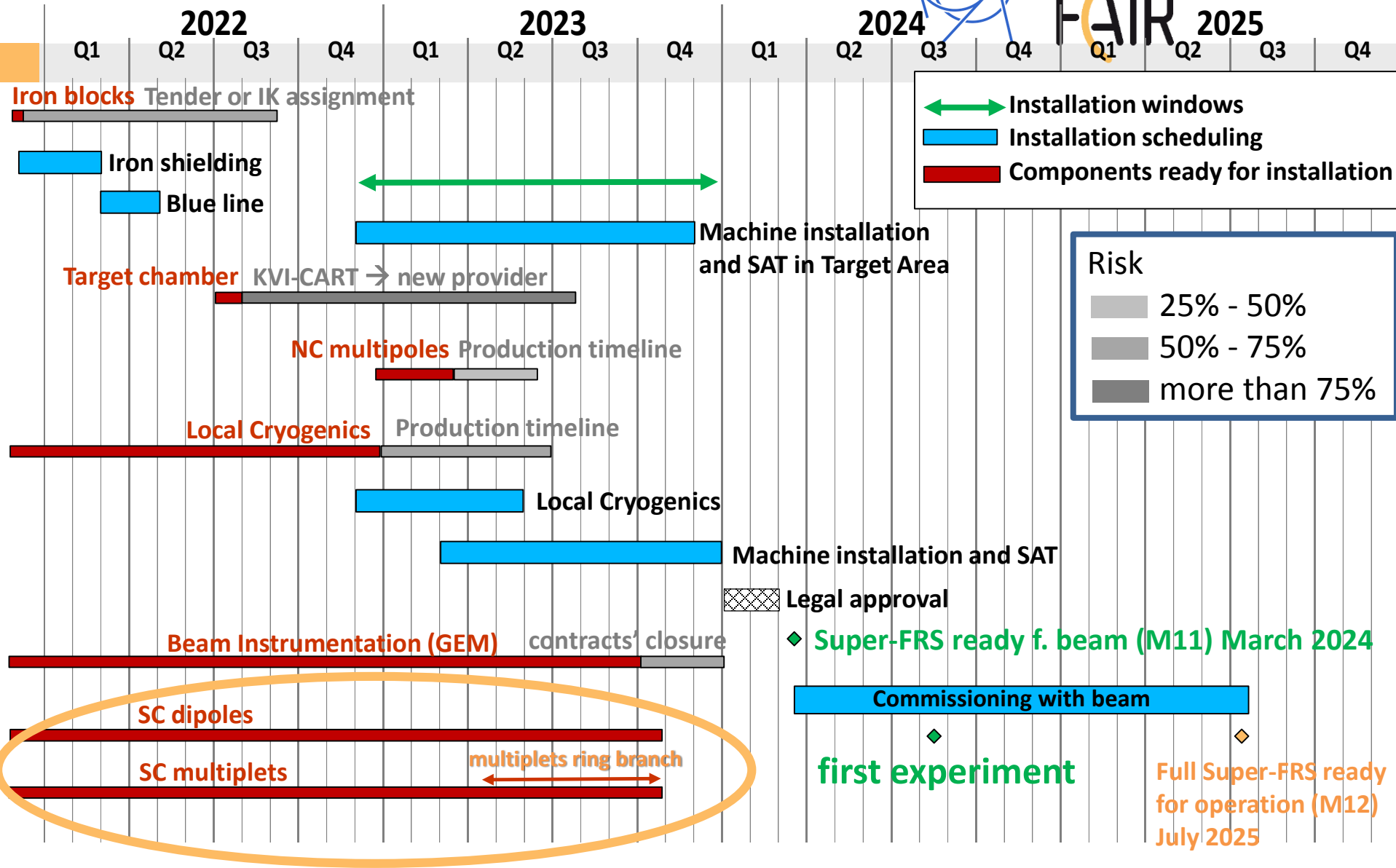
# Installation plan based on LCM (for G018)



↔ Installation windows  
 ■ Installation scheduling

## Building & Installation process interspersed

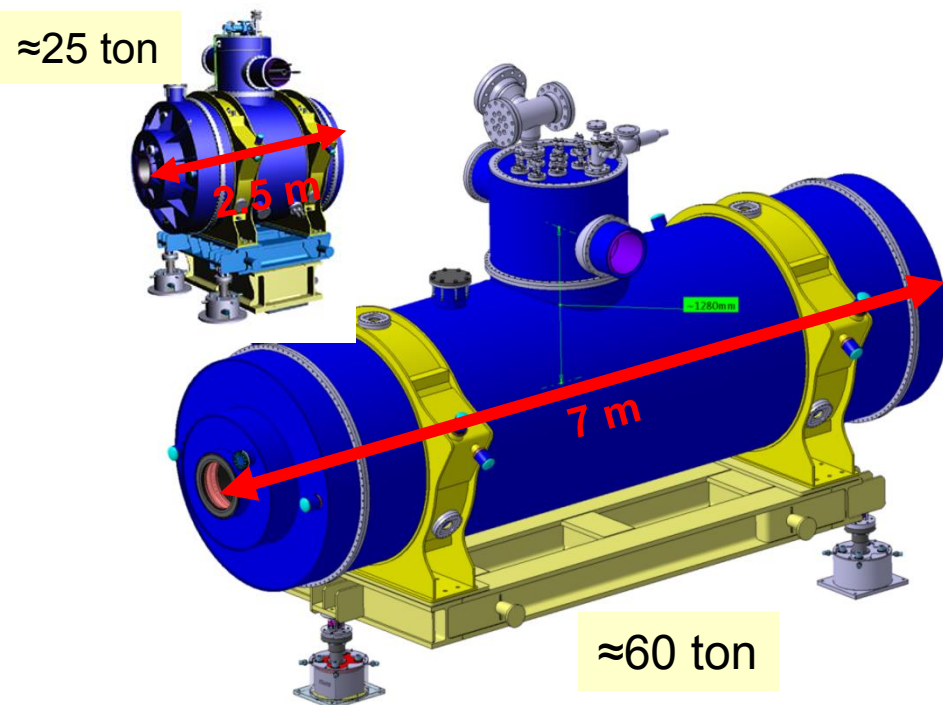
# Installation plan based on LCM (+ risk analysis)



## Sc Multiplets

### Scope:

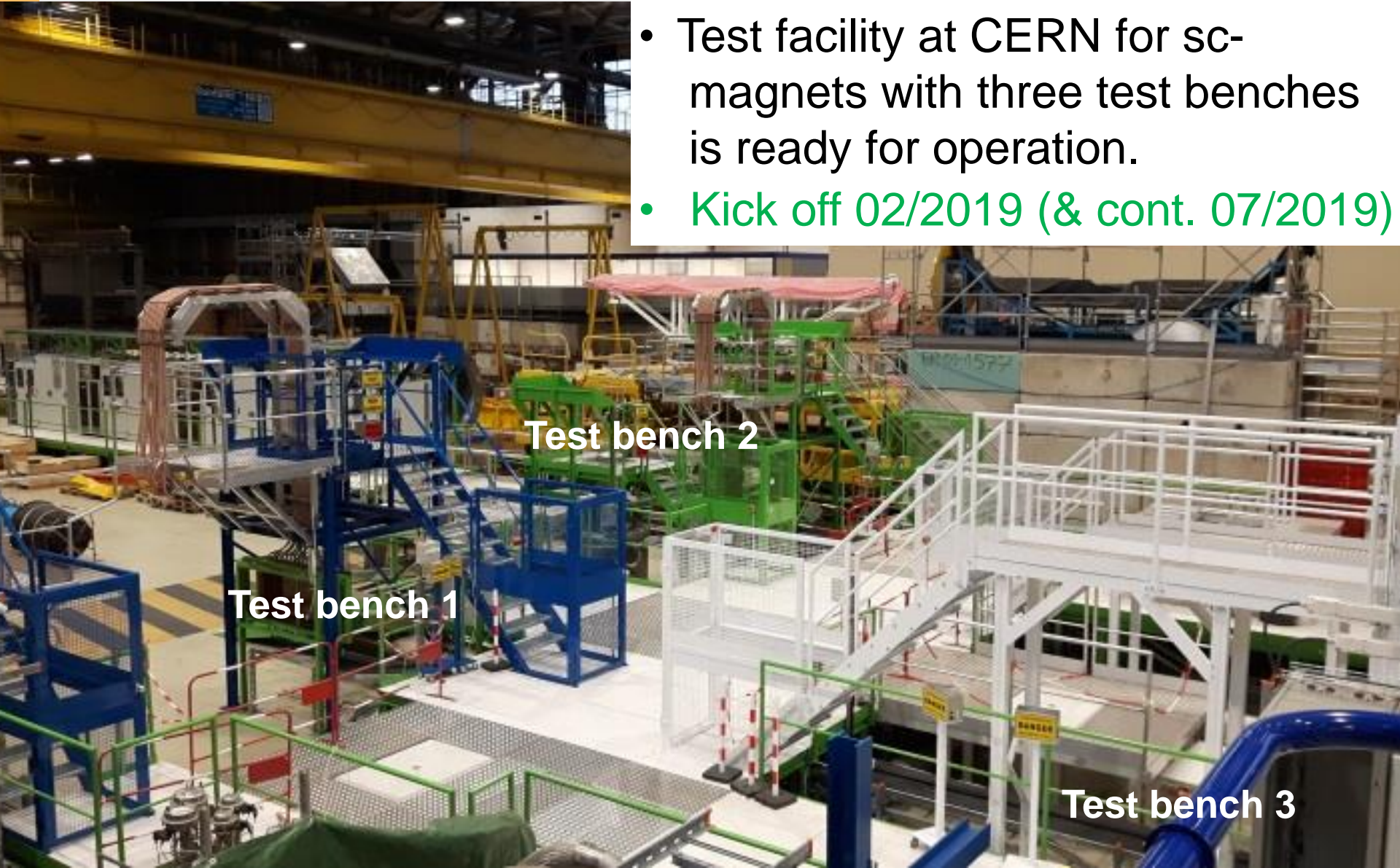
- 8 short multiplets
  - QS configuration
- 25 long multiplets
  - Quadrupol triplet



### Schedule FoS SC multiplets

- ✓ Contract closed 07/2015 (ASG, Genova)
- ✓ Design phase for SM and LM done
  - ✓ FDR 12/16
  - ✓ PRR SM 07/17
  - ✓ PRR LM 12/17
- **Construction phase for FoS running**
  - ✓ FAT FoS SM 01/19
  - **shipment to CERN**
  - **Installation @ CERN finalized**
  - SAT FoS SM 11/19**

- Test facility at CERN for sc-magnets with three test benches is ready for operation.
- Kick off 02/2019 (& cont. 07/2019)



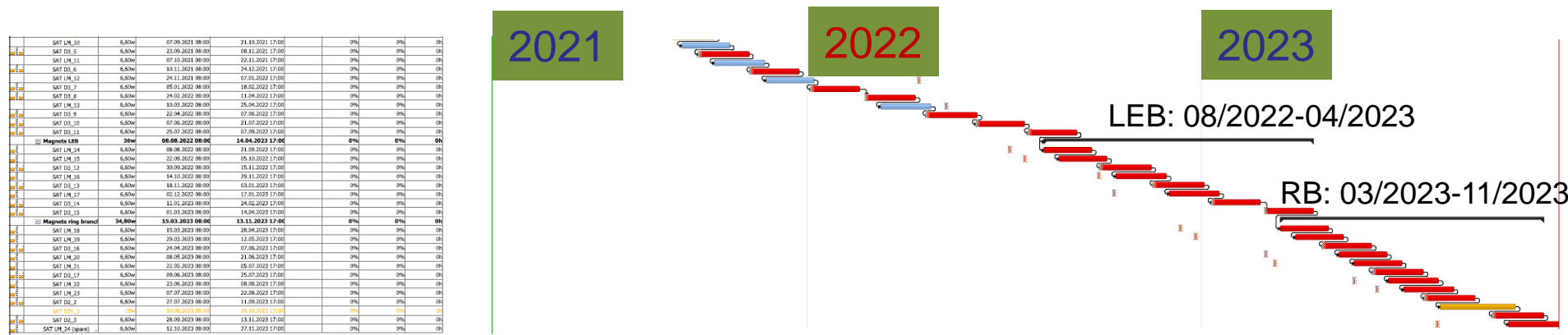
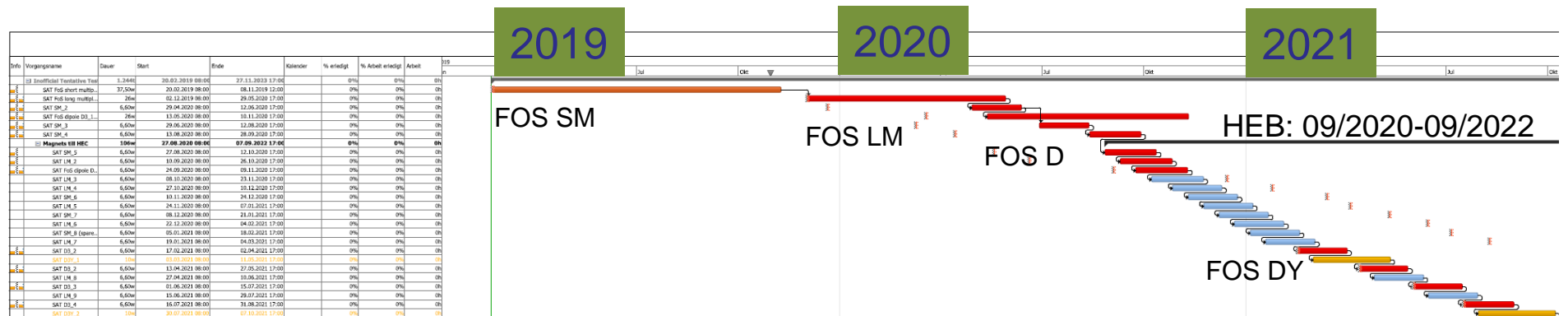
Test bench 2

Test bench 1

Test bench 3

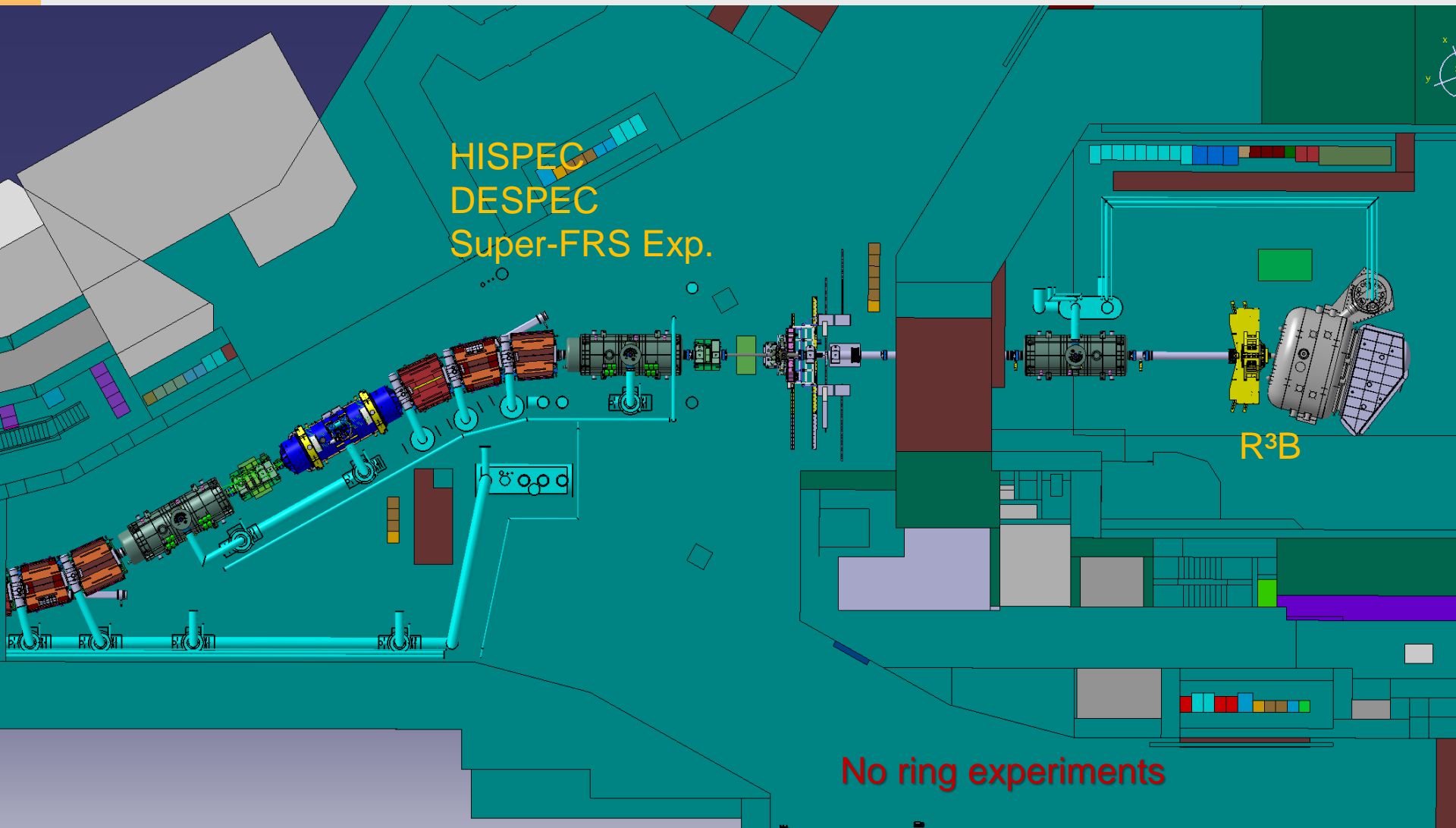


# Sc Magnet testing @ CERN Scheduling in progress:



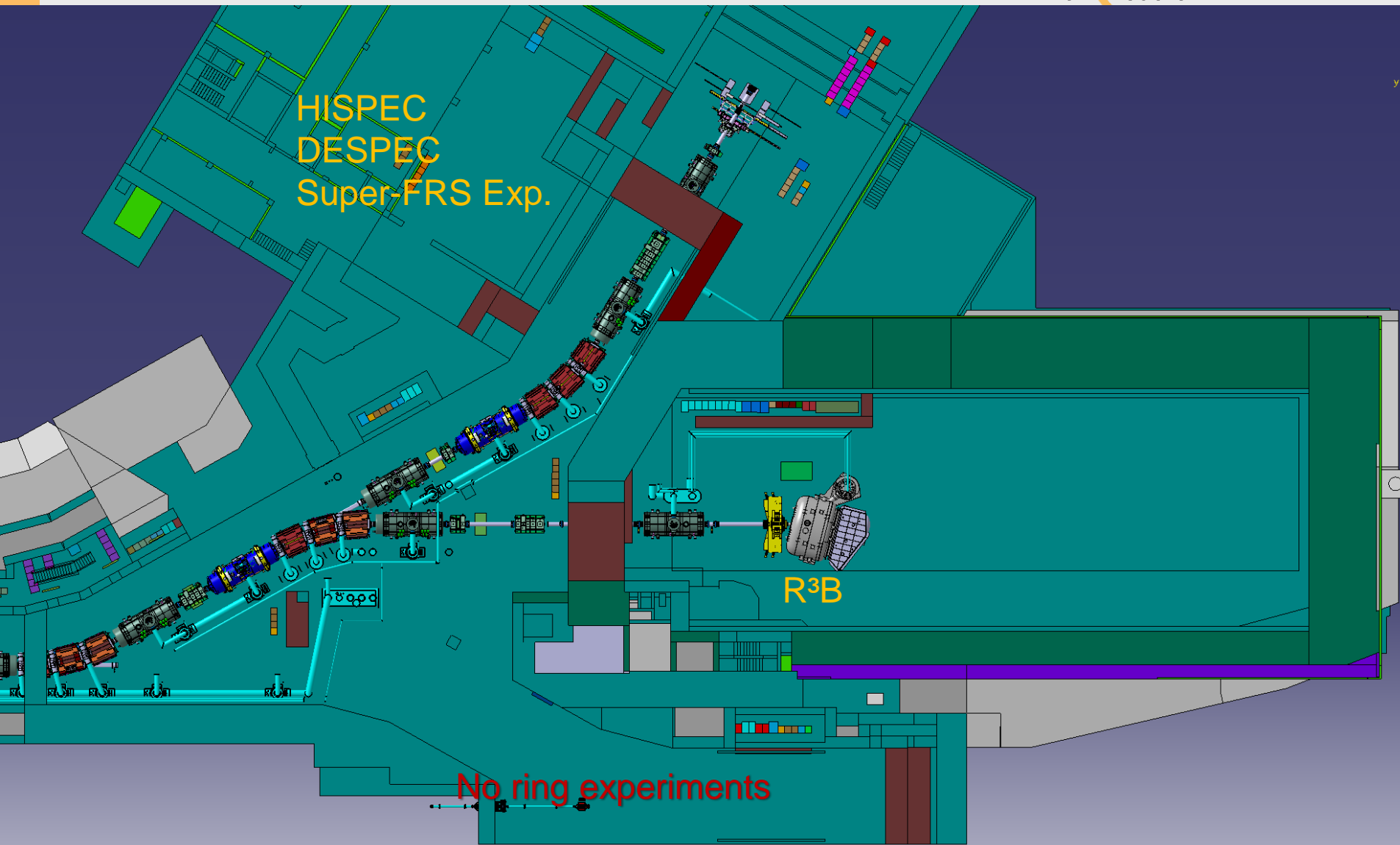
First stage:

-High energy branch ( $\gamma$ -setup @ FHF1) + R3B/GLAD



Most Experiments possible at least in start versions

Second stage:  
-(HEB (R3B/GLAD) +  $\gamma$ -setup @ FRF3



Improved performance for HISPEC/DESPEC experiment



## Commissioning

- Basic tests are performed during installation and SATBa
- Cooling for the whole facility takes 1-2 months
- A commissioning period of 4 month is foreseen after the beam becomes available
- Pilot beam will be used to check the basic functionality of the separator
- In conjunction with ramping up the performance first physics experiments can be envisaged
- Based on BigRIPS startup experience

# History of RIBF commissioning

Dec. 28<sup>th</sup>, 2006

First Beam  $^{27}\text{Al}^{10+}$  345 MeV/u at RIBF-SRC



Winter break at the facility !

March, 2007

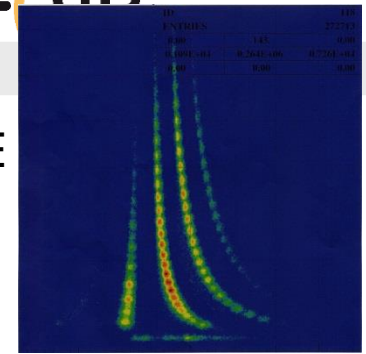
12<sup>th</sup>  $^{86}\text{Kr}^{31+}$  beam at 345 MeV/u several pA.

13<sup>th</sup> First production of RI beams with  $^{86}\text{Kr}$  beam

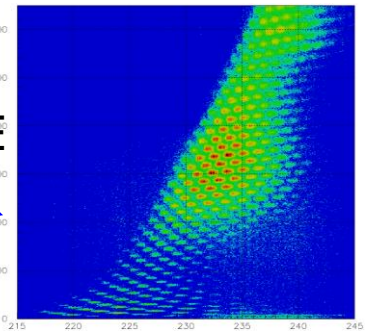
23<sup>rd</sup> First successful acceleration of  $^{238}\text{U}^{86+}$  beam at 345 MeV/u and 0.002 pA

27<sup>th</sup> First production of RI beams with  $^{238}\text{U}$  beam

$\Delta E$



$\Delta E$



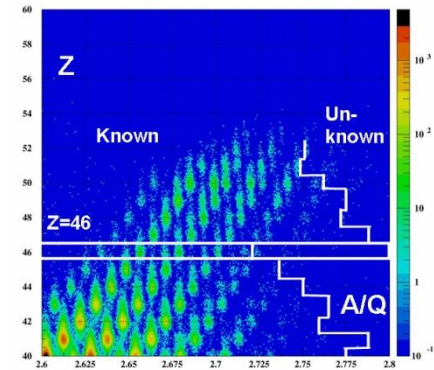
May-June, 2007 (without ZDS)

with  $^{238}\text{U}$  beam at 345 MeV/u and 0.02 pA max

May 16<sup>th</sup>-23<sup>th</sup> BigRIPS commissioning experiment ( $\sim 1 \times 10^8$  pps)

May 24<sup>th</sup> – June 3<sup>rd</sup> Search for new isotopes

End of June (a few days) detector testing



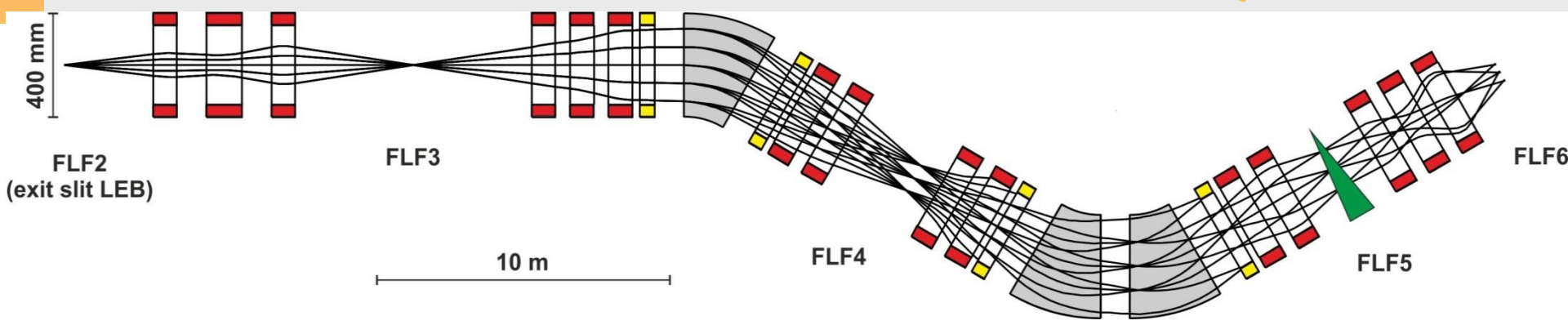
Nov. 2007 acceleration test with  $^{86}\text{Kr}$  beams, 30 pA

Few months from

pilot beams to first experiments

T. Kubo RIKEN / Separator Expert Meeting

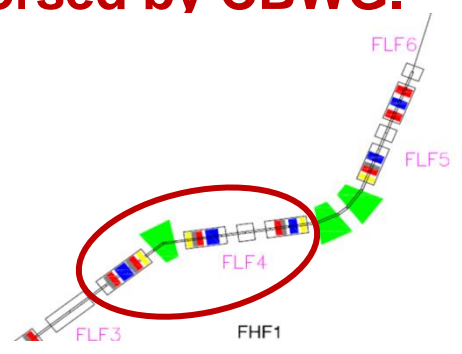
# Energy buncher - long version of the LEB - in new S-shape layout (using standard multiplet magnets)



- The energy buncher at the low energy branch allows to fill the cryogenic stopping cell serving the low energy experiments MATS and LASPEC

Indian in-kind about to be returned, potential interest of France on dipoles, multiplets should be procured within existing contract with ASG.

**Endorsed by CBWG.**



Design for dipoles still to be done  
 magnets are last in testing sequence  
 → Installation of the long version of the LEB starts in 2025.

# Summary

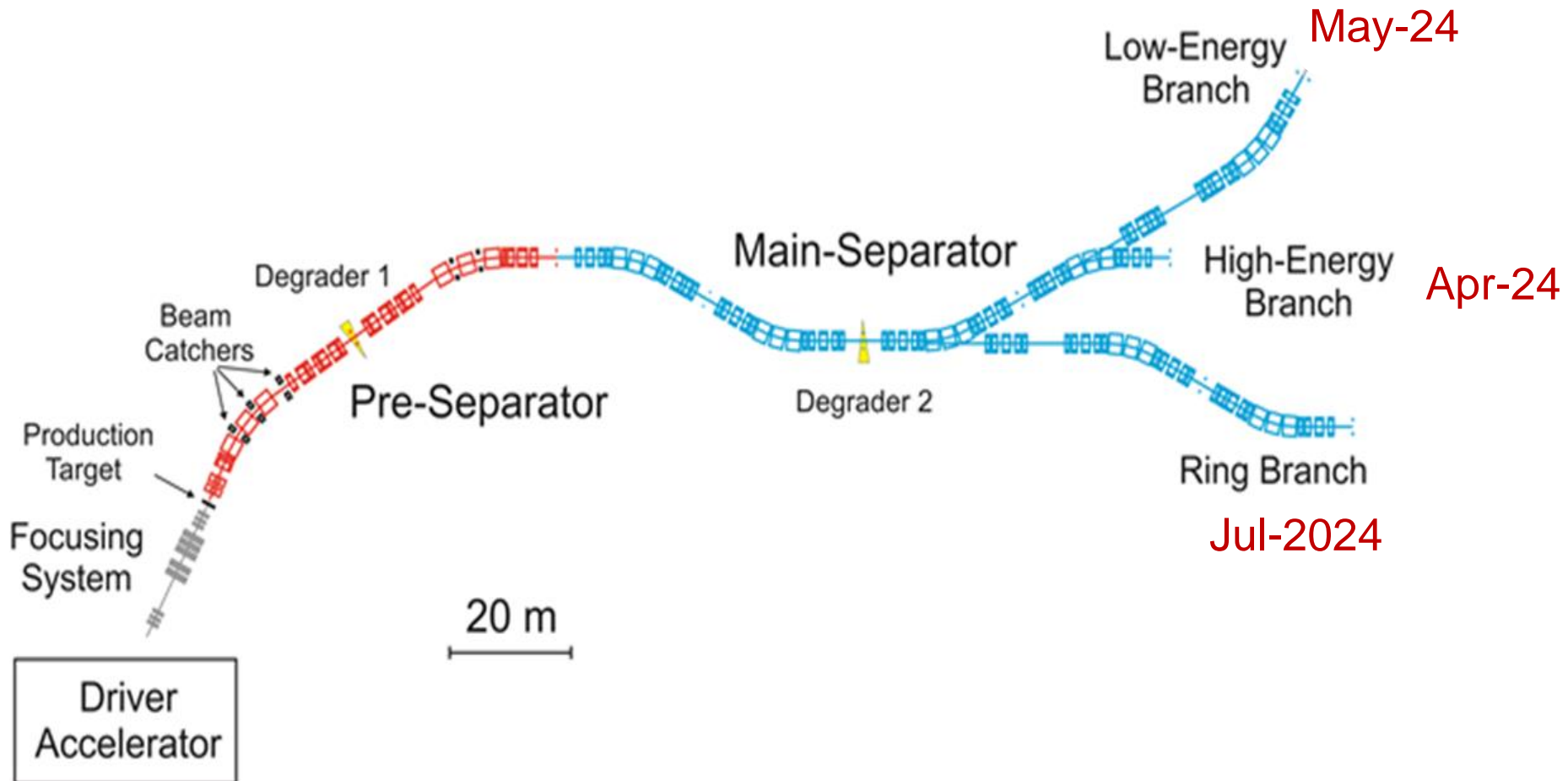


- Super-FRS can be ready for operation in 2025
- Time schedule: ambitious but realistic
- Allows for early experiments in Q4/2024-Q1/2025
- Risk profile in regards to machine considered as manageable **as long as contracts can be closed as per schedule and in-kind partner comply with schedule needs**
- Staged installation of Super-FRS allowing for early experiments in case time schedule risks materialize **(branches not pre-sep.)**
- Schedule driven by manufacturing and delivery of components
  
- CERN testing is one of the key elements for be able to adhere to the schedule
- Looking forward to a fruitful kick-off meeting





# Installation Scenarios



**Staged realisation of branches in case of late deliveries**