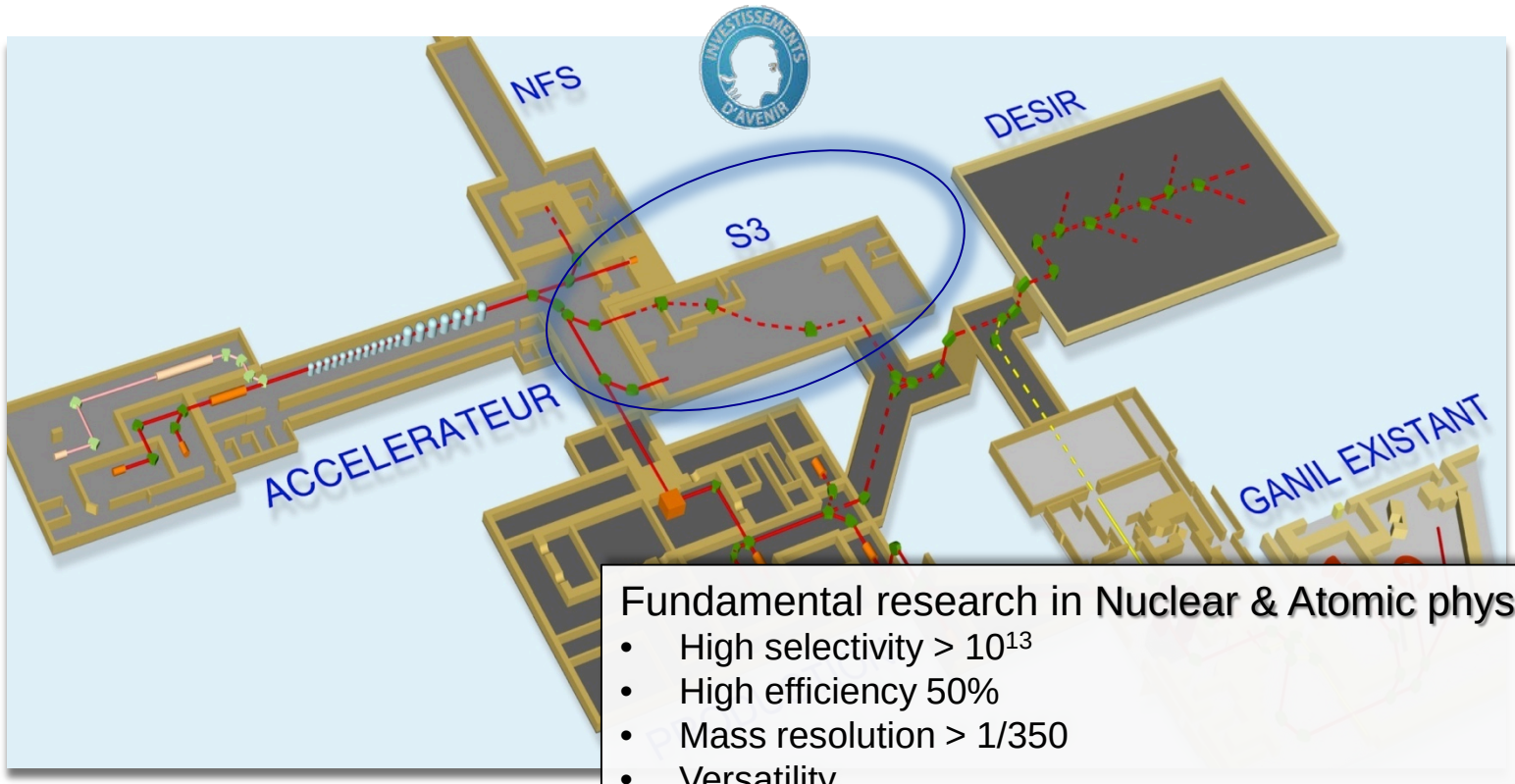
Super Separator Spectrometer

Status of the spectrometer construction

H. Savajols (SM), A. Drouart (DSM), M. Authier (TM), G. Sénécal (GPC)



Fundamental research in Nuclear & Atomic physics

- High selectivity > 10^{13}
- High efficiency 50%
- Mass resolution > 1/350
- Versatility
- Unique instrumentation (SIRIUS – LEB – FISIC)

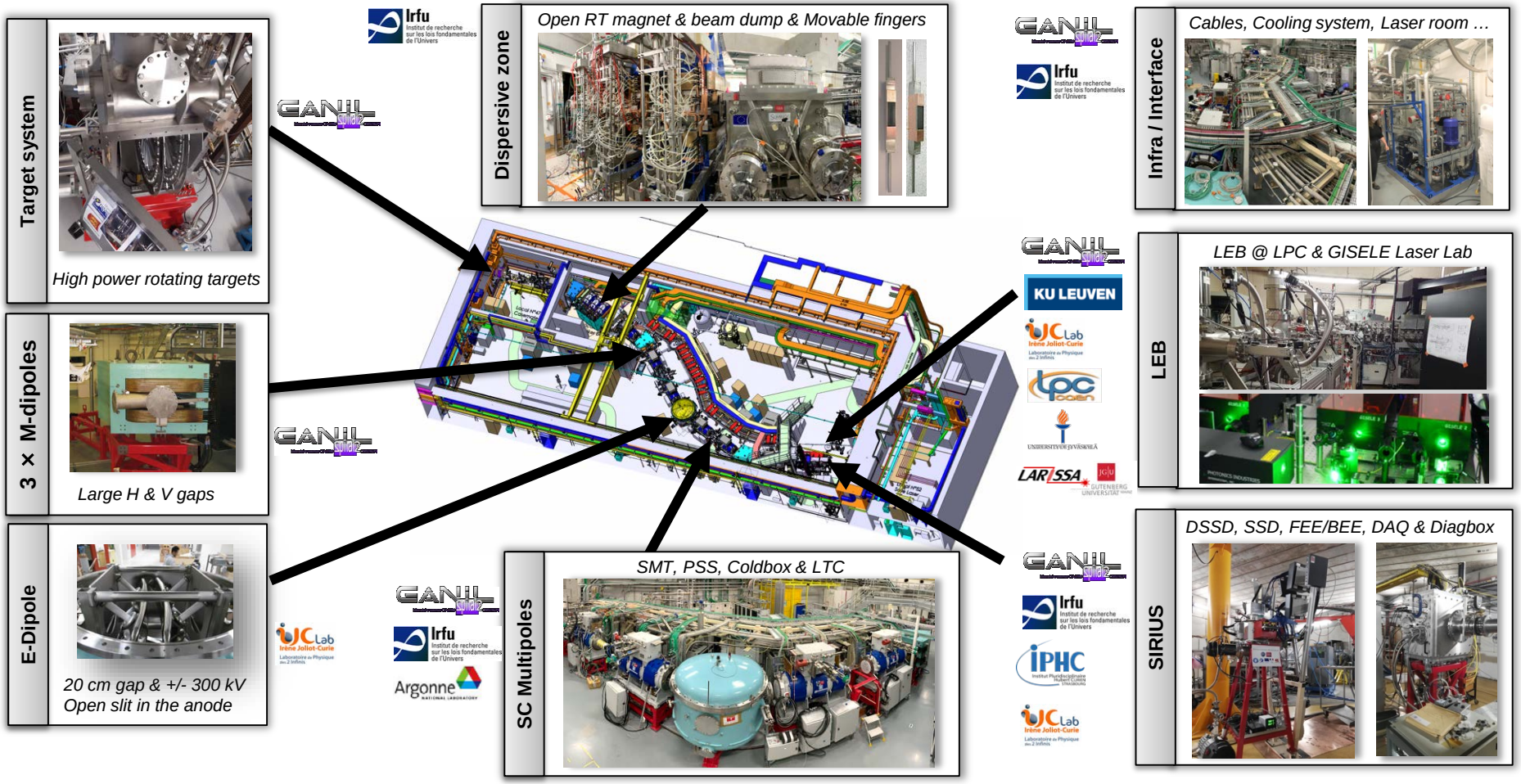
Outline

S^3 Spectrometer construction

- Spectrometer introduction
- Target station
- Dipoles and open Room-Temperature multipole triplet
- Beam Dump
- SMT (Superconducting Multipole Triplets), PSS (Power Supply Systems fors SMT's) and Cryogenics
- Electric Dipole
- Infrastructure
- Risks & Milestones

Super Separator Spectrometer

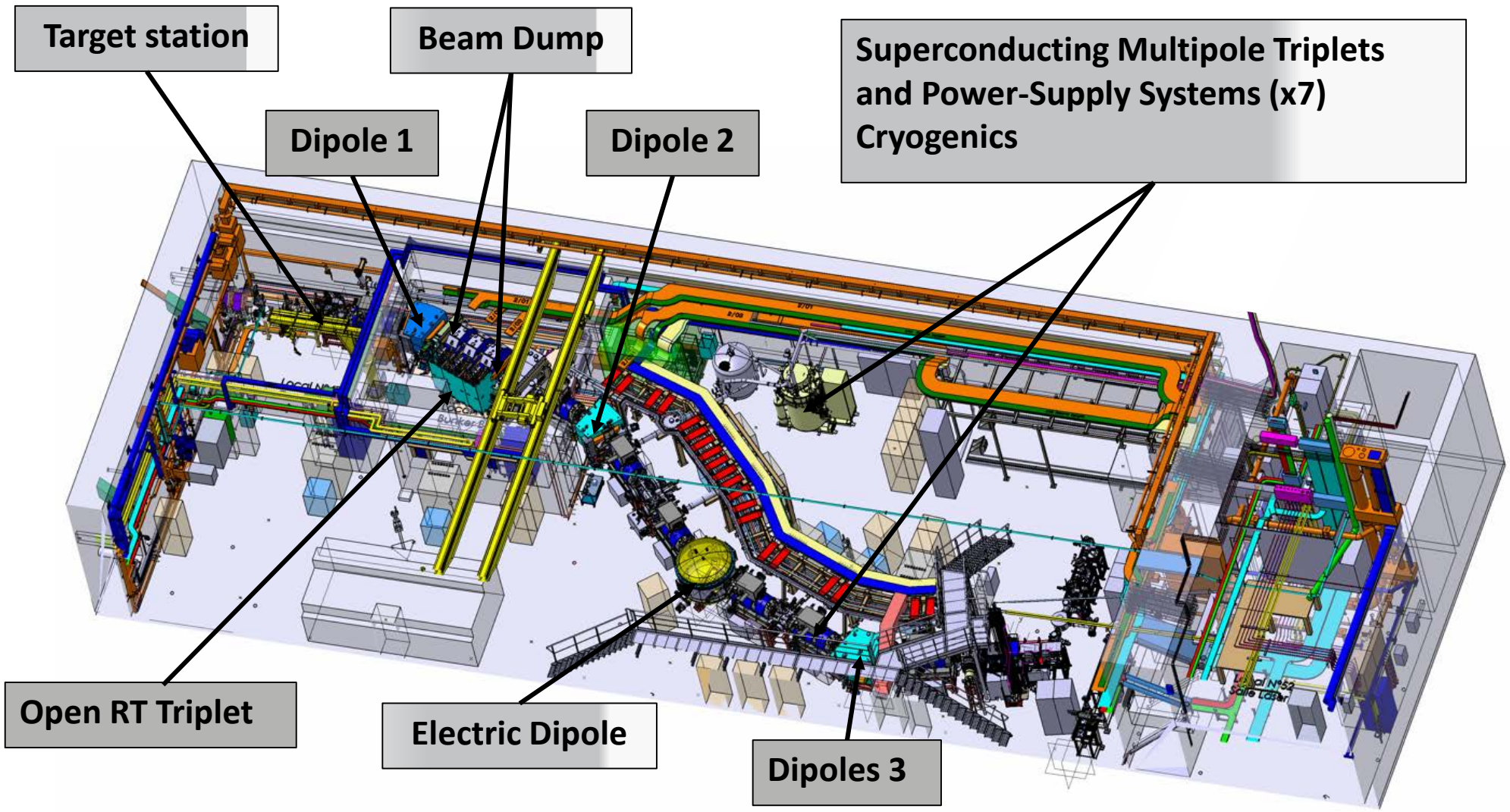
Main equipment and detection setups



- High selectivity > 10^{13} - High efficiency 50% - In flight mass separation > 1/350
- Versatility & unique instrumentation (SIRIUS – LEB – FISIC)

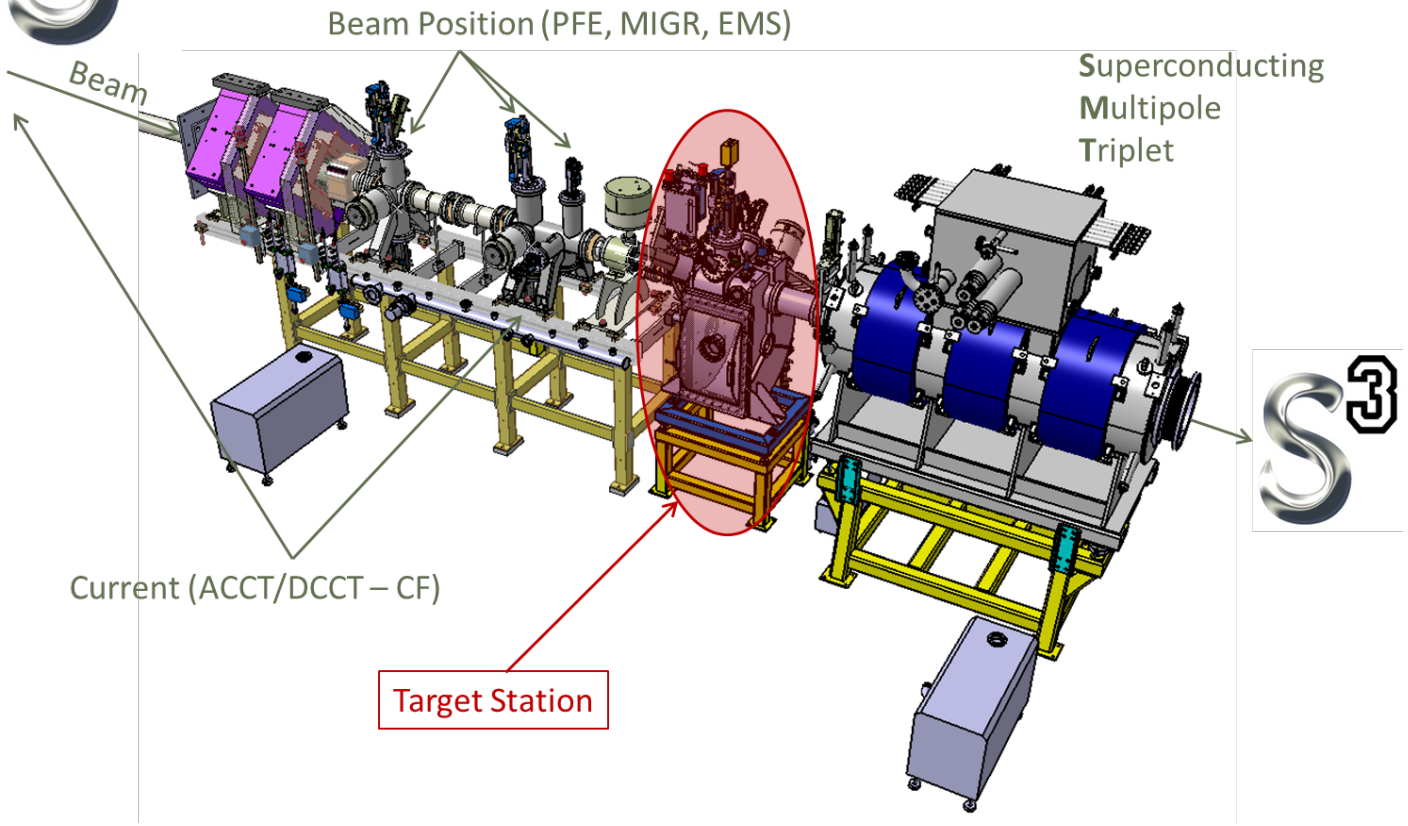
Spectrometer main equipment status

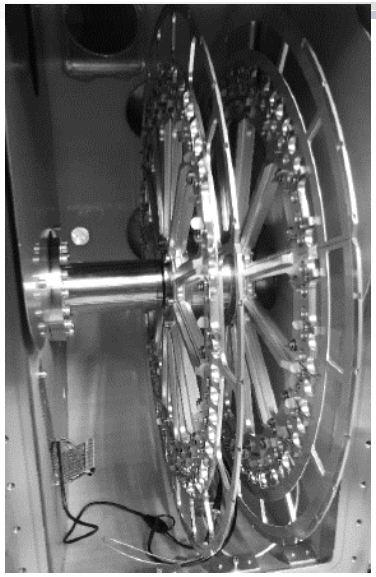
Level of completion

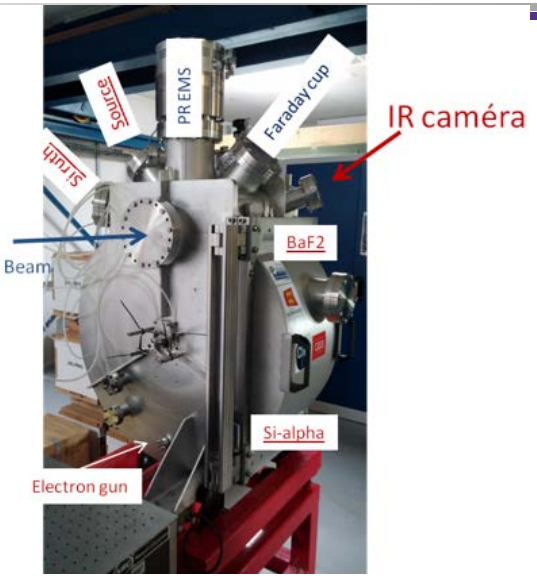


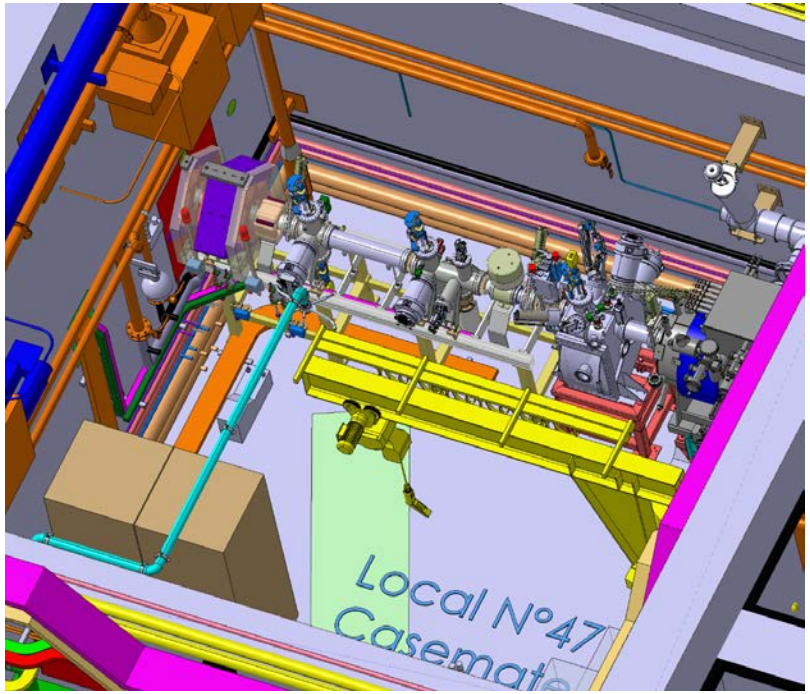
Target station

High power target: >> 1pμA (= 6.10^{12}p/s)









Being tested and commissioned offline before installation in S³ room:

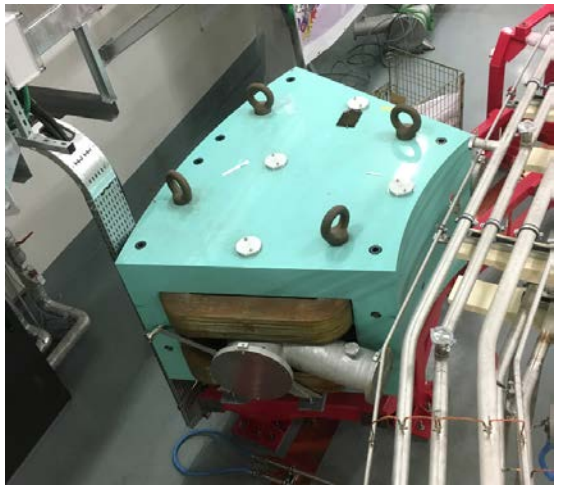
- End of diagnostics integration / qualification
- End of Wheel and insertions Command Control
- On-line commissioning with GANIL beam (request in 2023)

can be done independently from other equipment

Room Temperature magnets

3 magnetic dipoles

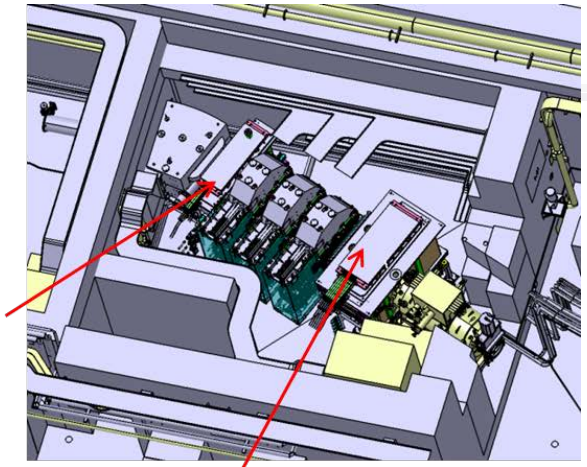
- Built, commissioned at Ganil magnetic measurements facility, partially installed in S^3
- Power supplies and cables installed
- Power-up tests in S^3 in Q1 2023

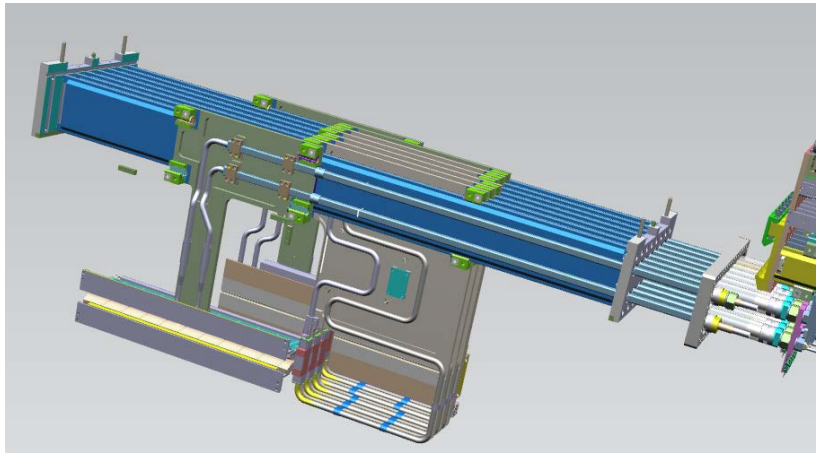


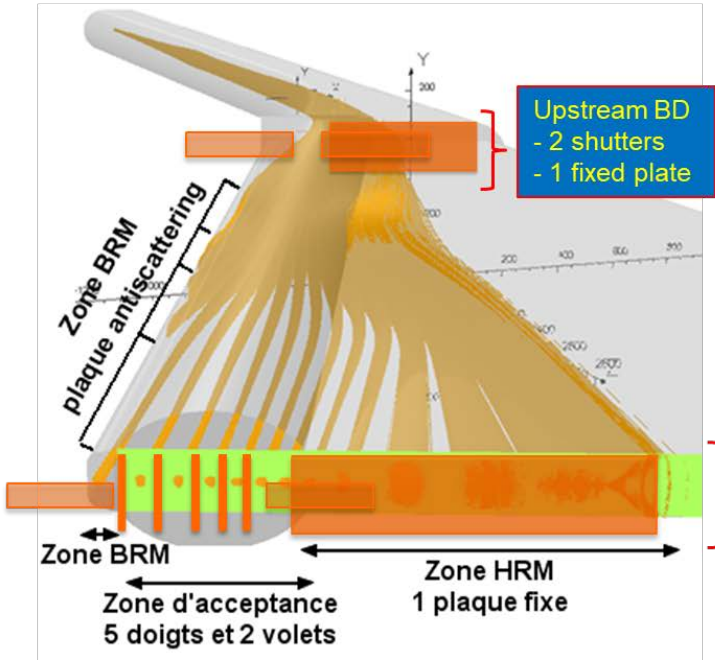
Open RT Open Triplet

- Built, commissioned at Sigmaphi and installed in S^3
- Power supplies and cables installed
- Power-up tests in S^3 in Q1 2023

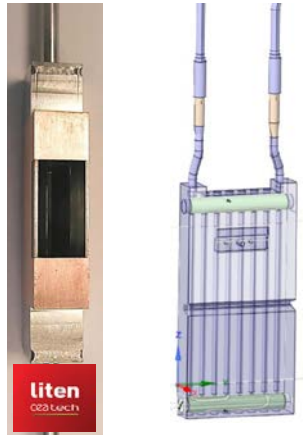
Beam Dump

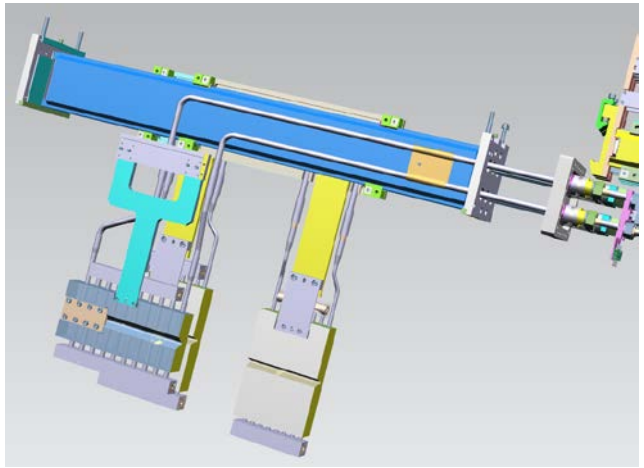






Ready Not ready





- 2 chambers
- 9 translation mechanisms
- 11 dump parts (5 fingers, 4 shutters, 2 stationary plates)
- Shielding: external lead shielding + internal shielding enclosure under vacuum

Everything studied/tested/validated at Saclay

except the dump plates / cooling pipes assemblies (challenging… final architecture just decided)

→ drawings end of 2022

→ dumps parts will be installed in Beam Dump chambers mid-2024. **Not requested for spectro optics commissioning**

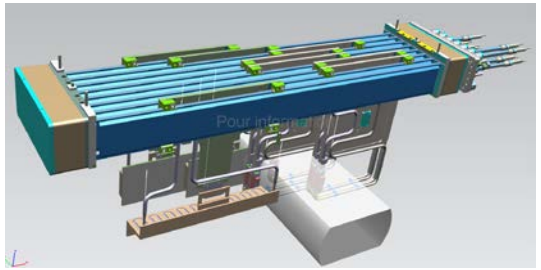
Beam Dump

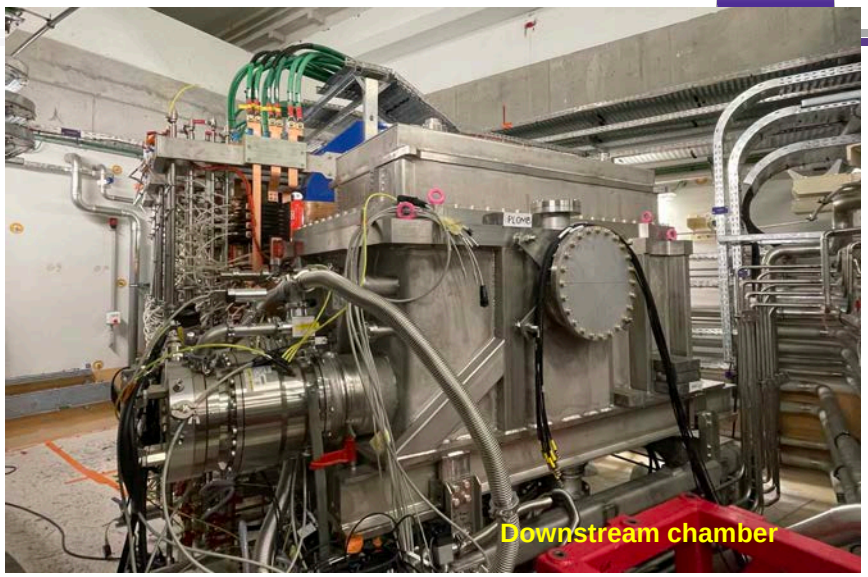
Chambers

Built, installed and vacuum qualified in S^3

Translation mechanisms

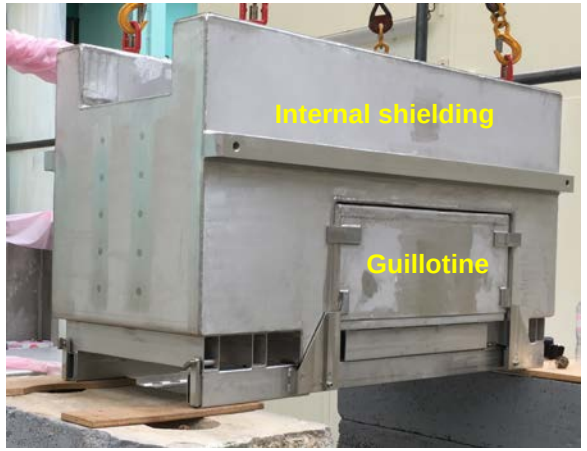
Procured and qualified at Saclay

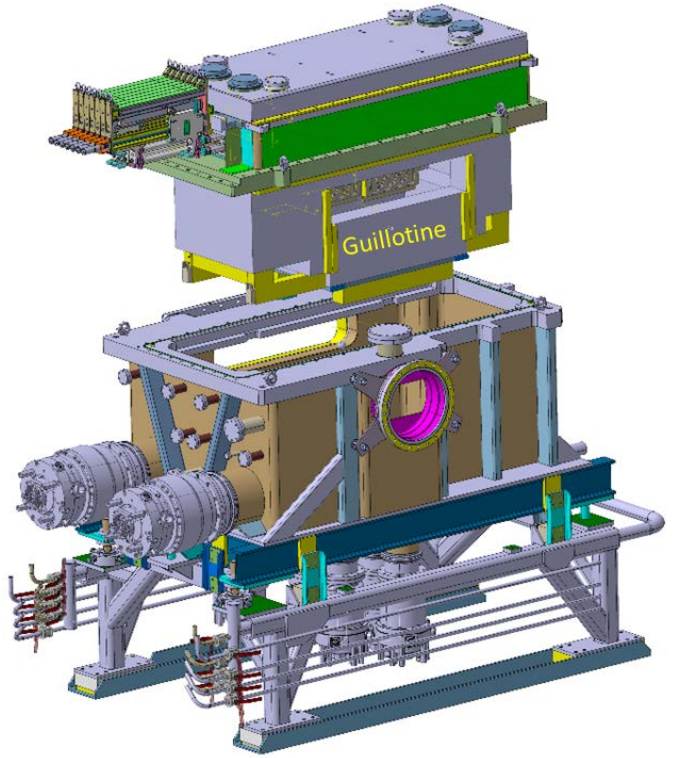




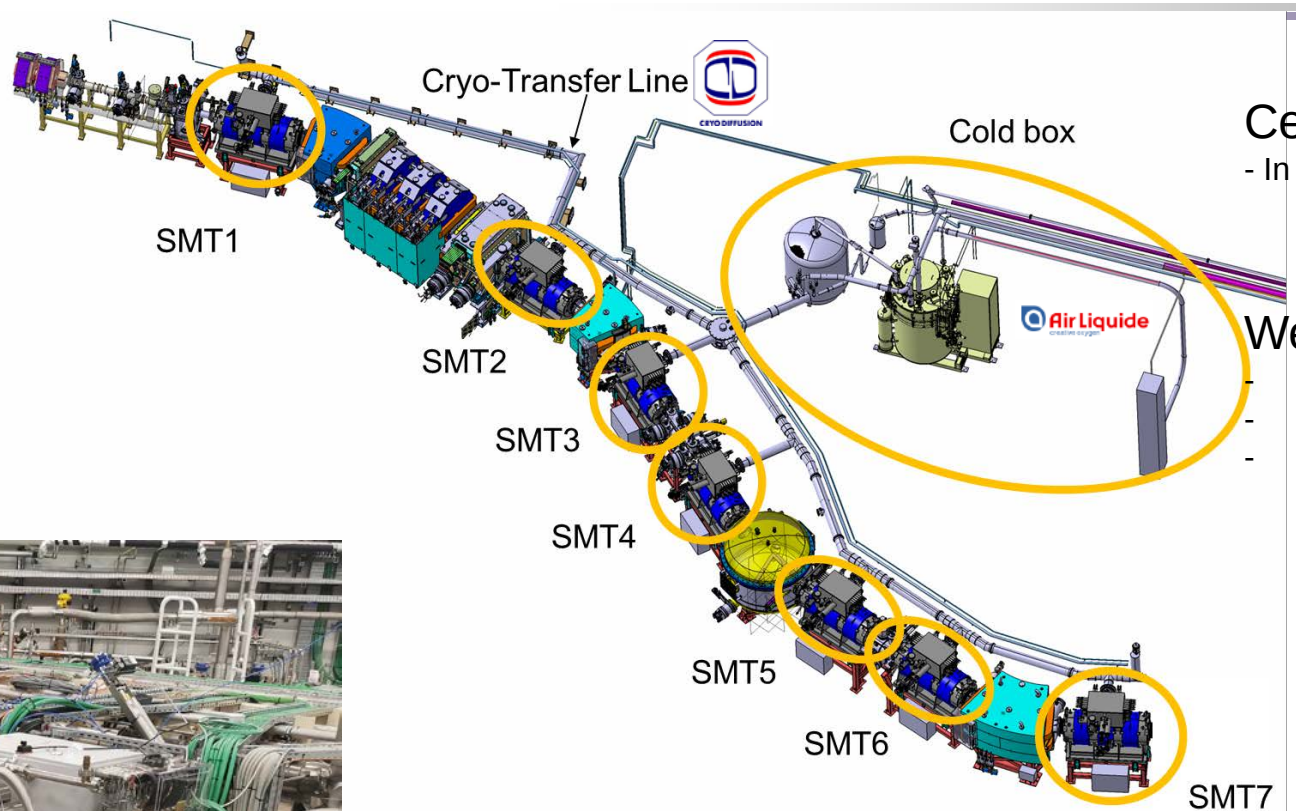
Downstream Beam Dump internal shielding enclosure

- Enclosure and sliding door ("guillotine"): qualified at Saclay
- Guillotine motorization and linkage: installed in S^3



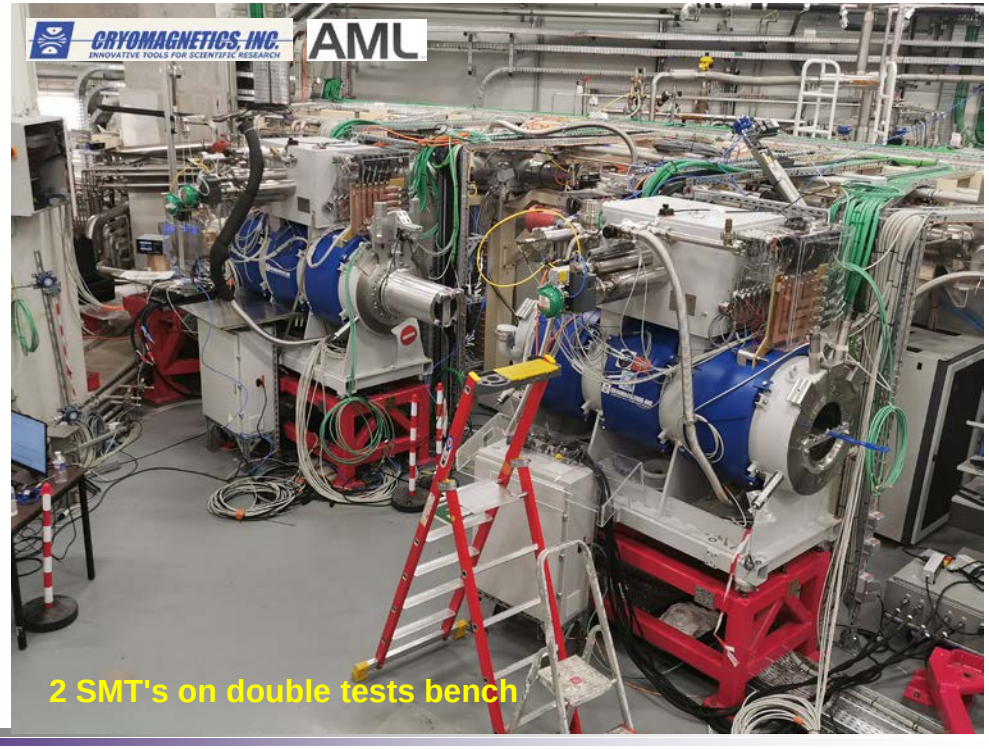


SMT's, PSS and Cryogenics



Central cryoline
- In use since 2019

West & East cryolines
- Built
- Installed Nov-Dec 2022
- Commissioned March 2023



SMT's, PSS and Cryogenics

Cryogenics: cold box turbine broke in May…

- Tentative for LHe manual feeding in June didn't work…
- Reparation @ Air Liquide → turbine available in December

→ Next cool-down in March 2023

6 SMT's delivered:

- SMT1-2-4 OK
- SMT3: to be repaired at Ganil (delamination of YBCO tapes on 2HTS current leads)
- SMT5: some misunderstood quenchs/fast discharges during May quick aborted tests
- SMT6: not tested yet (had to wait for repaired cold box turbine)
- SMT7: will be tested by provider end of October and then shipped

Power Supplies Systems (PSS): commissioned and installed

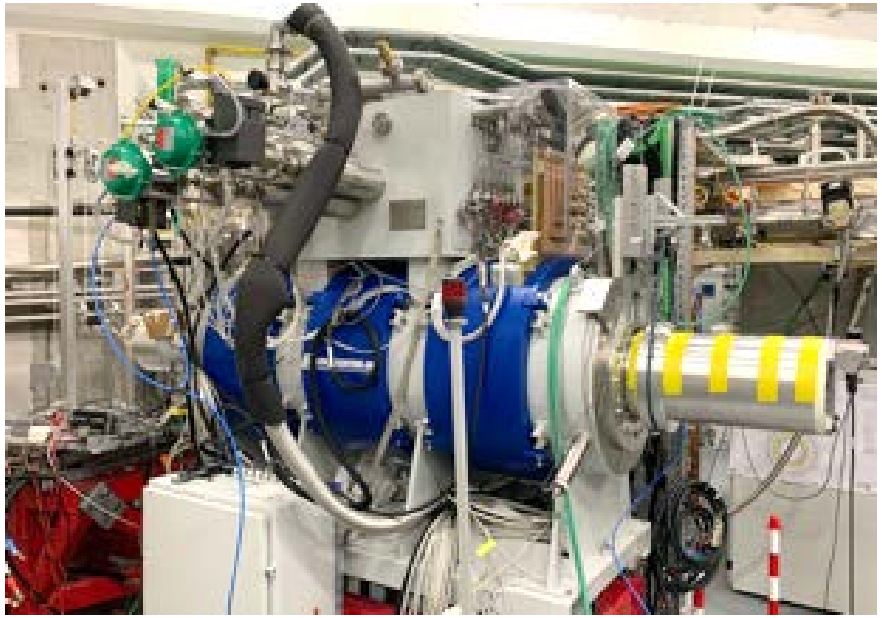
3D mapper

Delivered April 2021 (ANL WP) and first magnetic field measurements & alignment

- 2021-2022 measurements : good agreement for field integrals
- Measurements to be finished in second cool-down sequence in 2023

Next steps

- Install West and East branches of the Cryo Transfer Line (Nov-Dec 2022)
- Tune and commission new turbine
- Commission the complete Cryo Transfer Line
- Test SMT5, SMT6 and SMT7
- Finalize 3D magnetic field measurement & alignment in 2023
- All SMT in final position, tested and connected Q4 2023



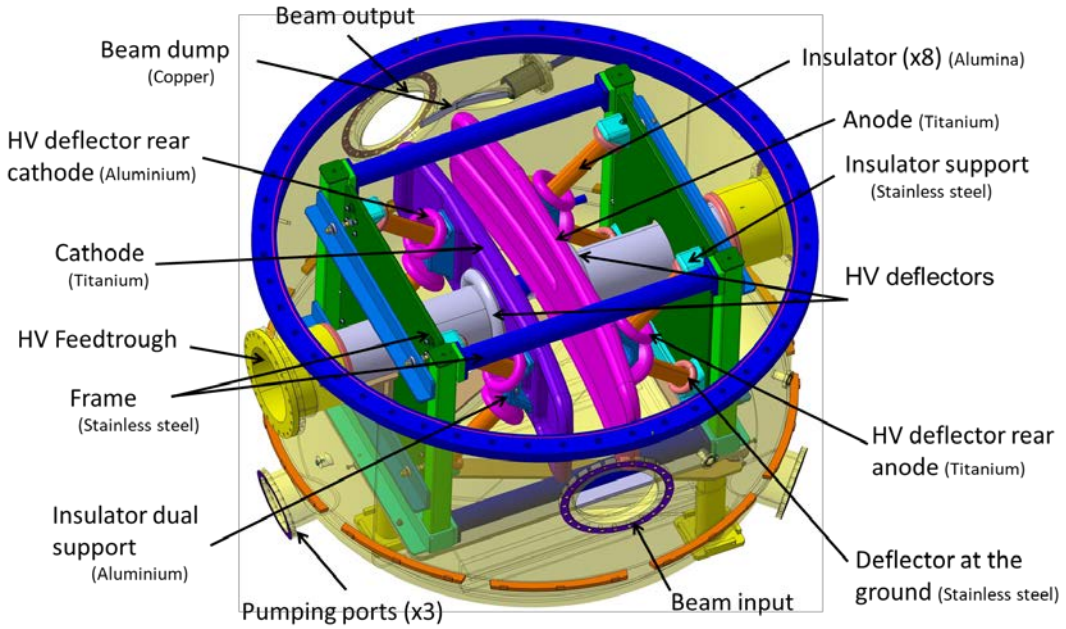
Electric Dipole

Chamber, Ti electrodes installed in S^3
300 kV power-supplies at GANIL

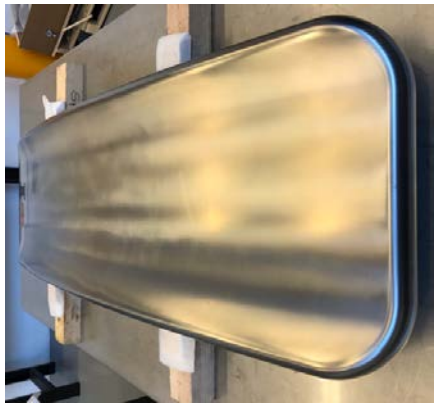
HV Feedtroughs delay (Friatec-Kyocera): +75%!
Delivery January 31st instead of September 30th

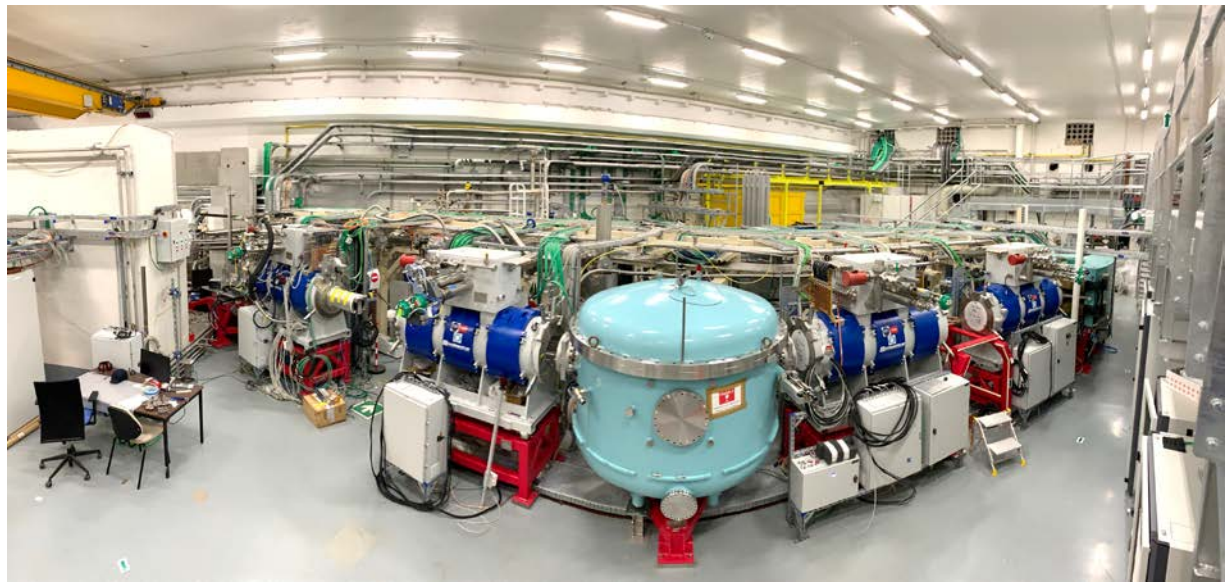
→ first tests delayed and risky constraints on the installation process in 2023…
(S^3 room in forbiden access during tests)

Final conditioning (2 months w/ nobody in the room) January 2024



- Dipole horizontal gap 20 *cm*
- Radius of curvature ρ = 4 *m*
- Bend angle θ = 22 degrees
- Electric field *E* = 3*MV*/*m* (±300 *kV*)
- Vertical acceptance 25 cm

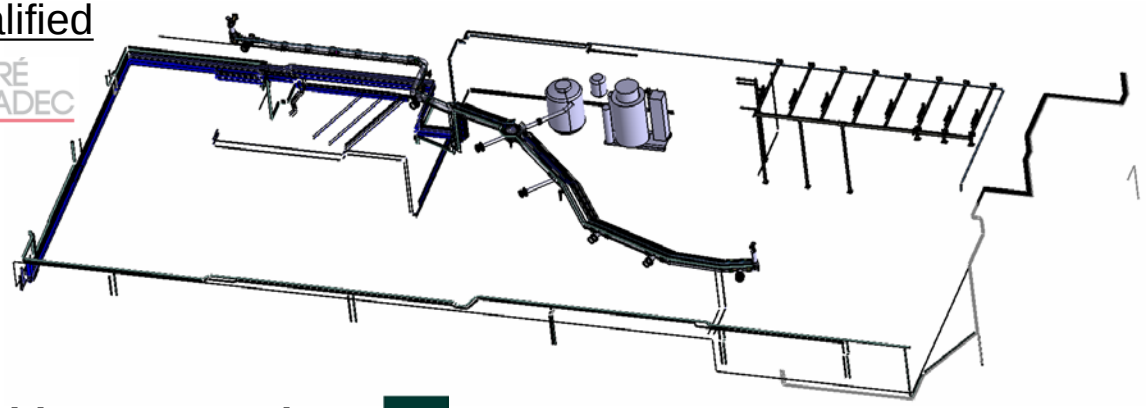




Infrastructure

Utilities supply pipes (cooling water, compressed air, gas, gas recovery)
Achieved & qualified

FOURÉ LAGADEC

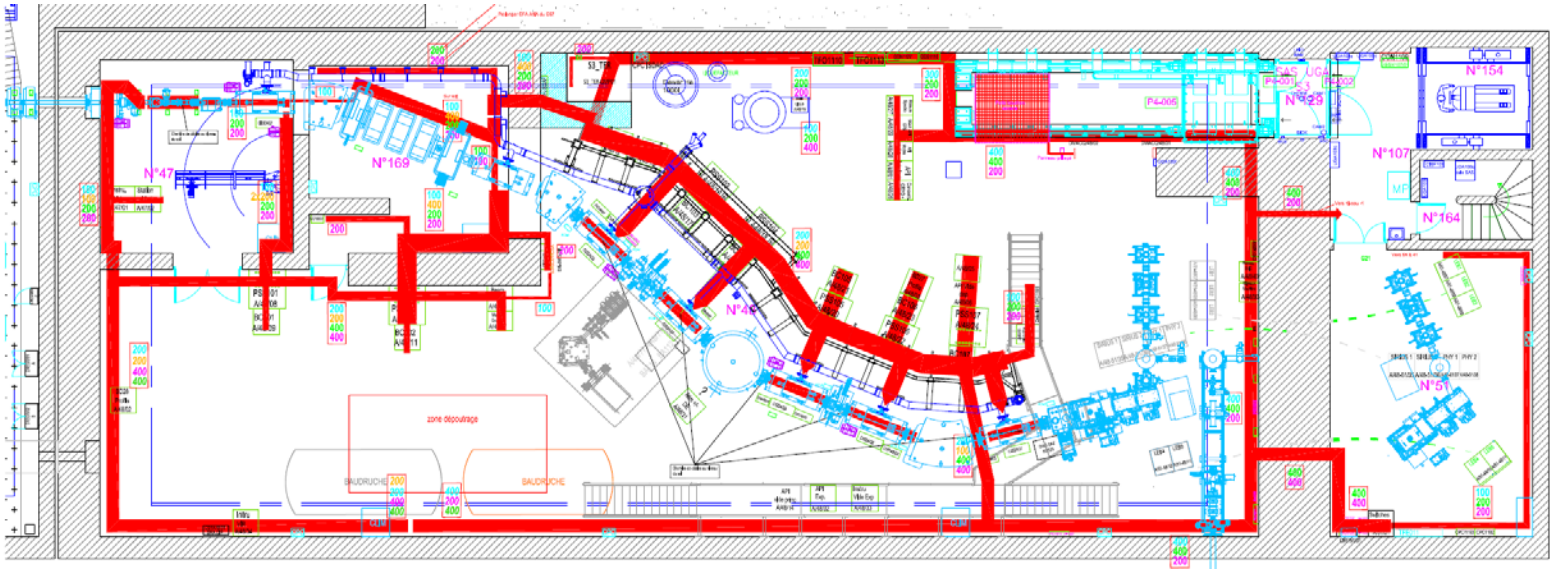


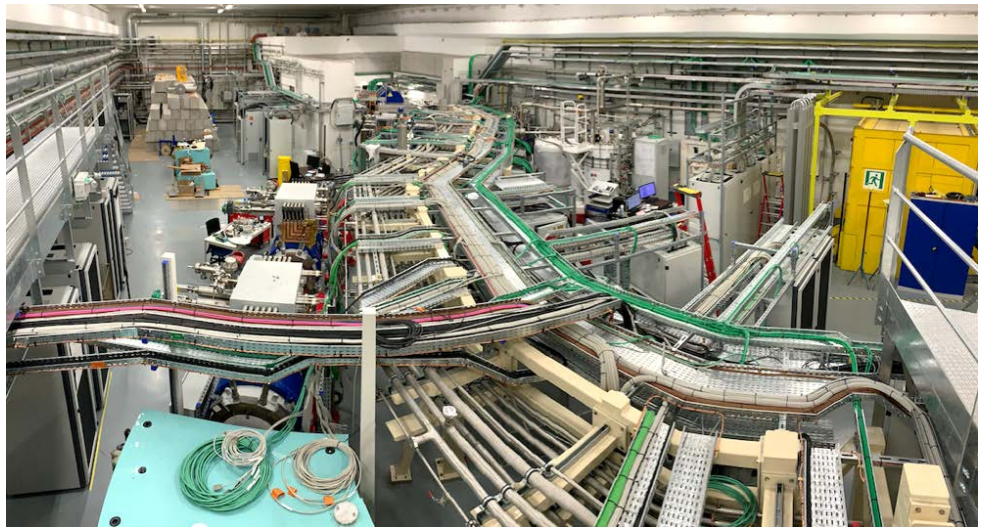
Beam Dump cooling
Achieved & qualified

Cable trays, cables, connections

SNEF

- High power CC cables: achieved beginning of 2018
- High power AC cables and signal cables: 2500 cables (80 km), 2 km cables trays
  - Phase 1: Cable trays, cable connections on cabinets and part of S^3 process: **complete** (95% of the cables in place, 75% of the 4600 connectors)
  - Phase 2: Cable trays and cable connections on remaining S^3 process: beginning of 2023



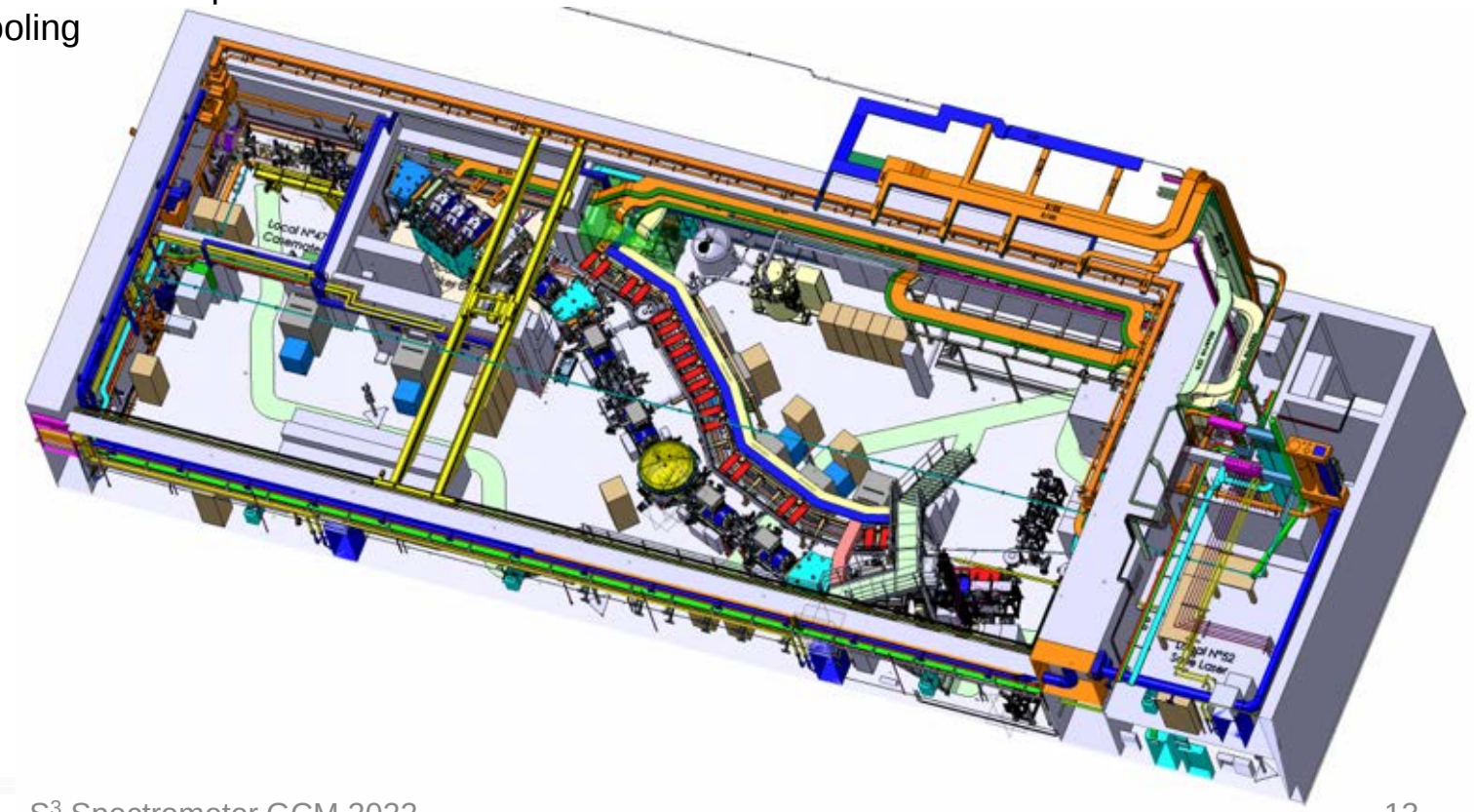


Installation & tests constraints

Sequencing, interdependences

- Because of specific valves configurations, only the 3 more recent SMT's (SMT5, SMT6 and SMT7) can be placed in positions 1 and 2…
  They are not qualified so far…
- Alignment of SMT's at final locations before Cryoline SMT port positioning & welding
- Cryoline installation, then cables final placement&connections enabling Cryoline qualification
- West Cryoline qualification before Downstream Beam Dump re-installation
- Downstream Beam Dump re-installation before SMTpos2 installation
- SMTpos1 before Target station installation
- Walls apertures concrete filling after Cryoline and all SMT's qualification
- Periodic maintenance campaigns preventing cooling

→ Reactive updating of a very precise schedule



Safety

- Temporary waiver for accessing in the West area ends March 27th 2023 (emergency exit won't be finished before 2024)
  → new waiver requested
- Achromatic Point diagnostic chamber to be installed at the very end of the installation (to keep an easy escape from West)
- Spectrometer room in forbidden access during Electric Dipole tests and conditioning (X-rays)

→ Tight relationship with Ganil safety division

Risks

Technical risks → Support of Ganil skills groups

- One of a kind equipment… Each object is a prototype
- 3 SMT's not qualified yet, Electric Dipole not qualified yet
- Early turbine failure not understood yet
- Spare parts expensive for S^3

Industrial risks → Support of Ganil and upper bodies procurements/legal divisions

- Providers and subcontractors often unpredictable
  - Big companies can have other priorities
  - Small companies can't withstand the budget risks associated with expensive objects (SMT's)
  - Human turnovers and strategy changes (PSS, SMT's superconducting coils → no spare coils could be produced!)
  - Raw materials and Today's context

Human Resources → Strengthened relation with Ganil management and the Ganil "Cellule de Coordination des Projets"

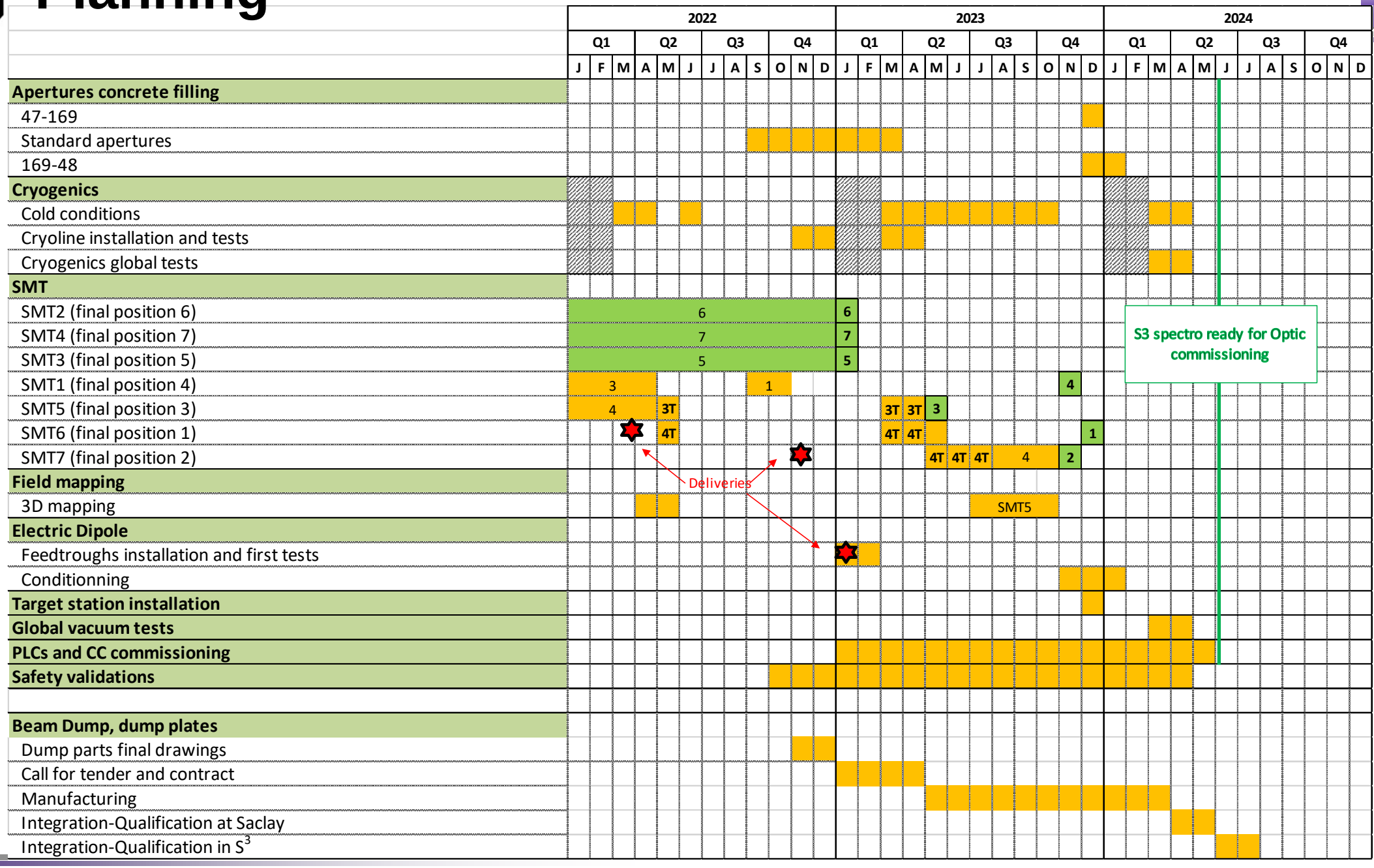
- Turnover (many examples in the past), difficult to anticipate…
- fixed term employees don't provide secure solution in a moving schedule
- fixed term employees can not coordinate transverse WPs through Ganil management structure
- Lack of WP coordinators (permanent staff)
- Human resource constraint in a multiproject context and Ganil + Spiral 2 operation

Budgetary risks

- S^3 budgetary margins almost at zero
- No money left in case of one SMT out of order
- No money for spare parts

→ Periodic S^3 Steering committees

Planning


2022
2023
2024
Q1 Q2 Q3 Q4
J F M A M J J A S O N D
Apertures concrete filling
47-169
Standard apertures
169-48
Cryogenics
Cold conditions
Cryoline installation and tests
Cryogenics global tests
SMT
SMT2 (final position 6)
SMT4 (final position 7)
SMT3 (final position 5)
SMT1 (final position 4)
SMT5 (final position 3)
SMT6 (final position 1)
SMT7 (final position 2)
Deliveries
S3 spectro ready for Optic commissioning
Field mapping
3D mapping
SMT5
Electric Dipole
Feedtroughs installation and first tests
Conditionning
Target station installation
Global vacuum tests
PLCs and CC commissioning
Safety validations
Beam Dump, dump plates
Dump parts final drawings
Call for tender and contract
Manufacturing
Integration-Qualification at Saclay
Integration-Qualification in S3

Milestones

Electric dipole complete	31/01/2023
Last SMT end-to-end tests	31/07/2023
End of 3D mapping	13/10/2023
Last SMT installed	07/12/2023
End of vacuum global tests with PLC	19/04/2024
End of final cryogenics commissioning with all SMTs	19/04/2024
Start of Spectrometer's commissioning with beam	01/06/2024
End of Beam dump installation on spectrometer line	31/07/2024

Planning: ready for beam commissioning June 2024, without dump plates & fingers

Spectrometer construction summary

- All designs finished (except dumps parts: December 2022)
- 2022 not effective for SMT testing because loss of liquefier turbine
- Installation, qualification, infrastructure: significative involvement of Ganil teams
- Schedule led by SMT's end-to-end tests: 2 cold phases in 2023
- Final global tests in S1 2024 and beam commissioning in S2 2024

- Majors risks:
  - No spare parts for major equipment (turbine, High Temperature Superconducting current leads, superconducting coils…)
  - Manpower bottlenecks
  - Non-compliance or delays of industrial realizations