

Platforms for characterization, treatments and test of materials at



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G. Olry on behalf of Supratech and Vacuum&Surface Platforms
22-23 June 2023





2 platforms dedicated to accelerators

MOSAIC



Platform dedicated to various ion irradiation/implantation and structural and chemical analysis



Platform dedicated to the surface treatment and surface analysis of UHV components for accelerators

SUPRA*Tech*

Platform dedicated to the surface treatment, testing and assembly of SRF cryomodules



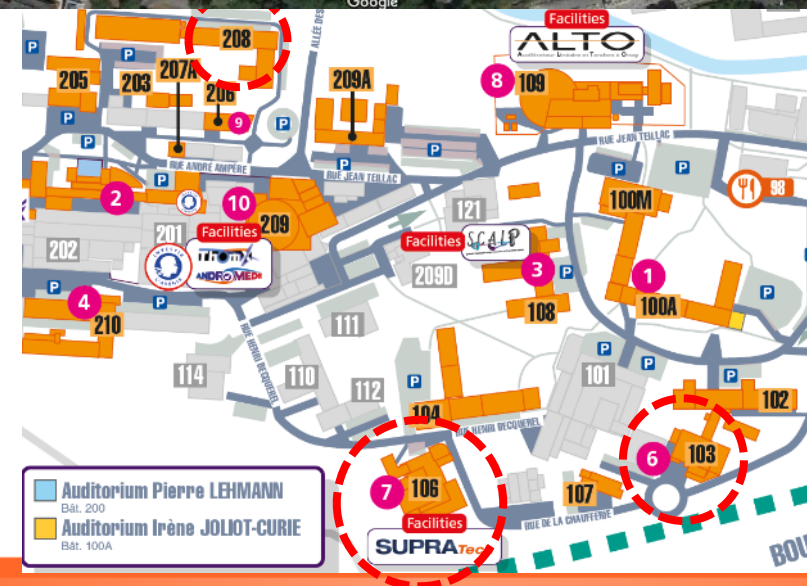
ACCELERATOR AND MAGNET INFRASTRUCTURE FOR COOPERATION AND INNOVATION





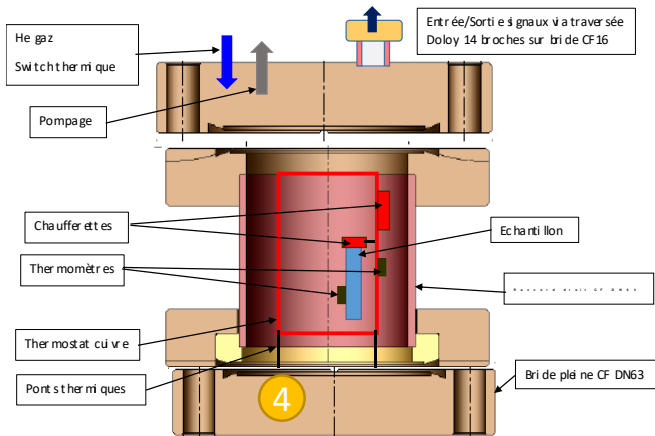
SUPRATECH :

- is the CNRS-IJCLab Technological platform dedicated to the development of **superconducting RF technology** for particle accelerators.
- provides the technical infrastructure to support **R&D or construction** projects and activities related to superconducting accelerators.
- is located in Orsay, in 3 buildings (103, 106 & 208) and represents a ~ 8 M€ total equipment investment
- Operation costs are covered by IJCLab, the Institute (IN2P3) and users (projects).
- is operated jointly by the SupraTech team (depending on lab direction) , RF and cryogenic services (depending on accelerator department).





1. A chemical facility to perform Niobium etching (BCP)
2. Three ISO 4 clean rooms, various size, for final surface processing and clean assemblies of cavities, couplers and full cavity strings. (Including High Pressure Water Rinsing and baking capabilities)
3. A large high temperature vacuum furnace for Nb&Ti cavities (1300°C and 1E-6 mbar)
4. A set of small to med-scale vertical cryostats to perform cryogenic characterization of material down to 1.7K (RRR, heat conductivity, T_c , ...).

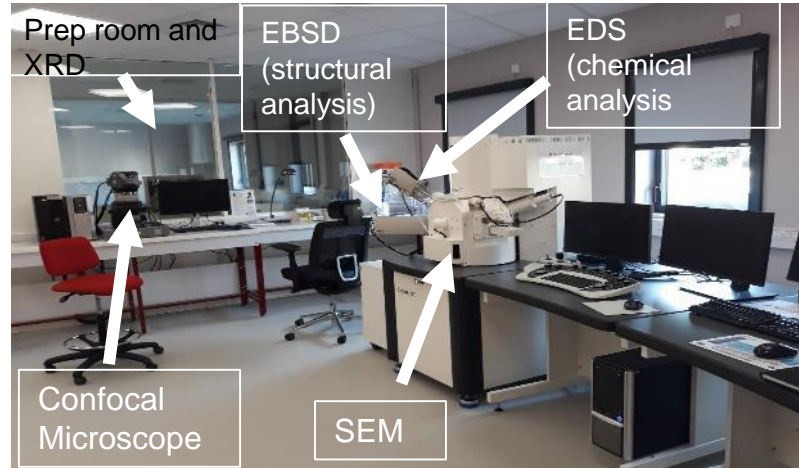




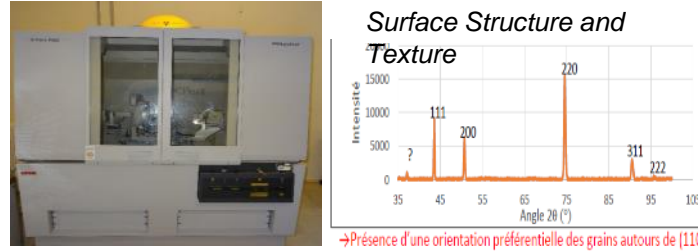
Vacuum & Surface :

- is the CNRS-IJCLab Technological platform dedicated to material, surface and UHV analysis and studies.
- Equipment acquired in collaboration with CEA and financed by P2IO (Labex), Ile de France Region (Sesame), ANR (Equipex+).
- is located in Orsay, in 2 halls (420 m2) since 2022 :
 - 1 Hall hosting commercial equipment for material & surface characterization (SEM+EDS+EBS, SIMS, XRD, XPS, confocal microscope)
 - 1 Hall hosting dedicated test bench and surface treatment (NEG deposition, vacuum furnace, SEY, Outgassing Rate, Desorption energy, ...)
- Operation costs are covered by IJCLab, the Institute (IN2P3) and users (projects).
- is operated jointly by the Vacuum&Surface team and MAVERICS team (Materials for Accelerators, dynamic Vacuum studiEs and innovative Research on superconducting Cavities).

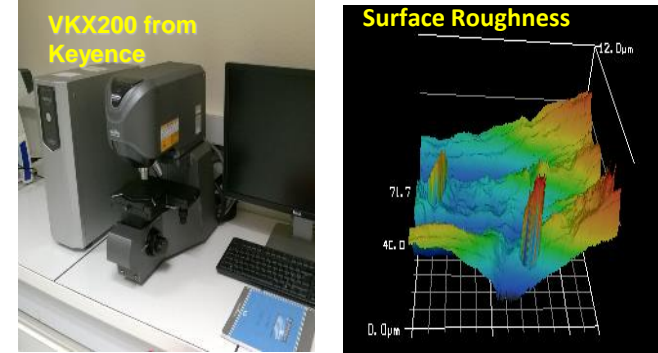




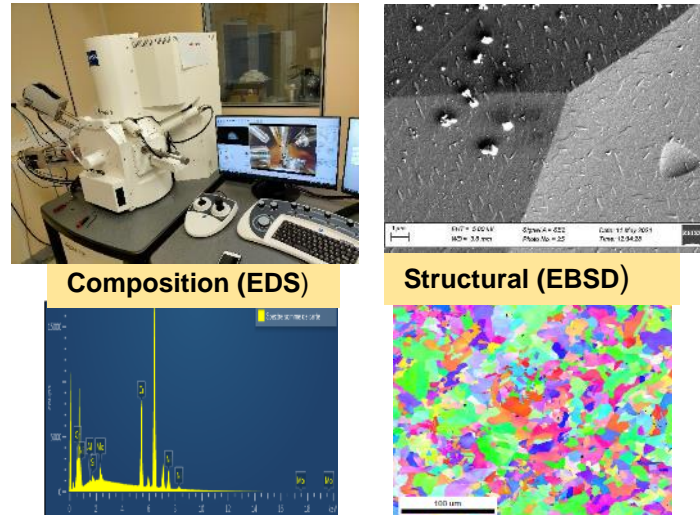
X-ray diffractometer



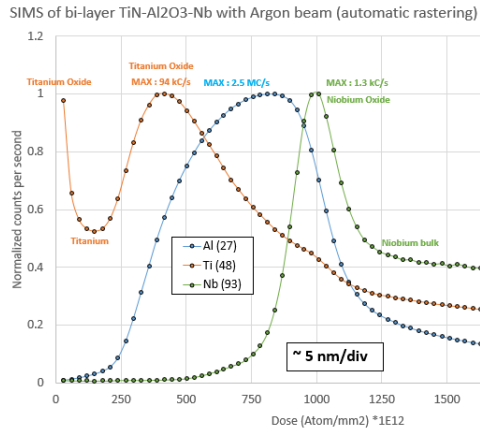
Confocal Microscope



Scanning Electron Microscope



Secondary Ion Mass Spectrometry (SIMS)



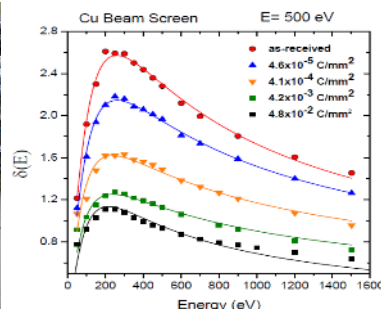
X-ray photoelectron spectroscopy (in Sep. 2023)





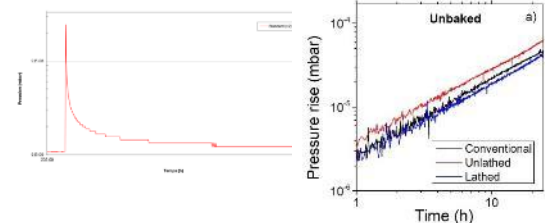
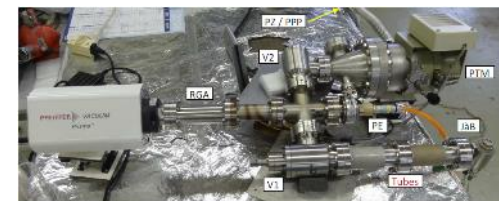
UHV analysis and studies

Secondary Electron Yield (SEY)



Th se S. Bilgen

Outgassing rate

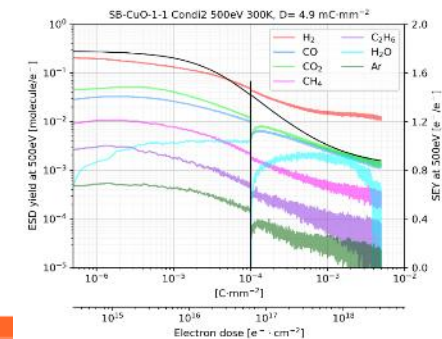


NEG coating chamber (Ti,Zr,V)

Heat treatment (H2)

Molecular desorption energy

Electron Stimulated Desorption





Thank you !



Overview of equipment on Supratech

ISO4 clean room



New Cryomodule assembly hall



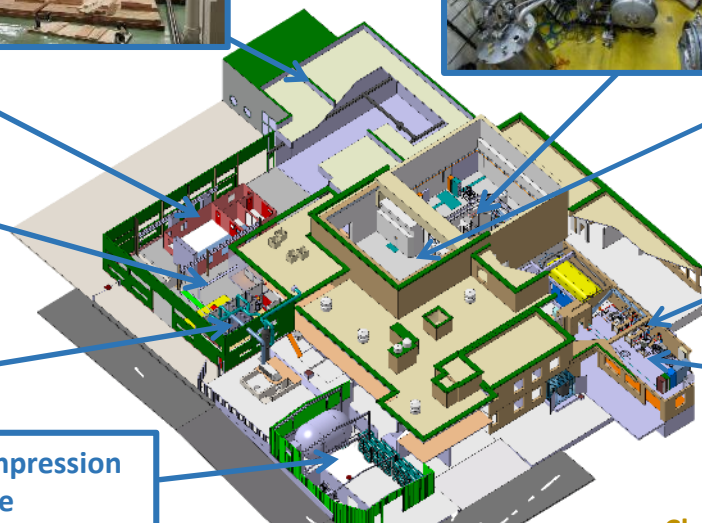
Cryogenic experimental hall



Assembly hall



Bldg 106



Vacuum Furnace for cavity heat treatment



He pumping station for the cryo test hall



Chemical etching facility (BCP)



352 MHz klystron



He gas compression and storage

He liquefier



Bldg 103

Cryogenic experimental hall



Bldg 103

Cryogenic T^o sensors calibration station



Clean room for RF Coupler conditioning



Bldg 208

Clean room for RF coupler assembly





Main projects (2022 -> mid-term)

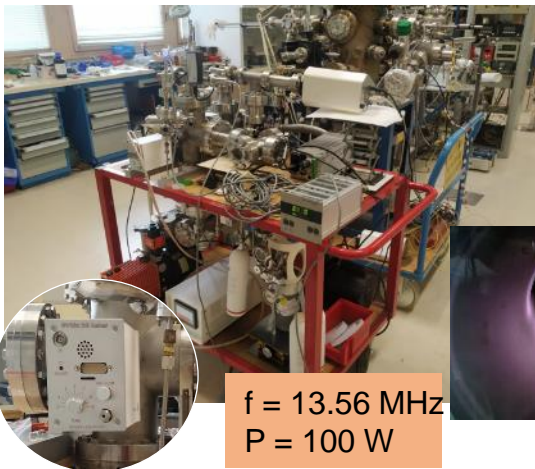
- **European Spallation Source (ESS)** prototype phase and construction phase: main and top priority project since 2015 for the Platform (13+1 Cryomodules, 30 cavities, 30 power couplers, 28 tuners).
- **MYRRHA** :
 - prototyping phase ongoing (cavities, tuners, power coupler) up to the prototype cryomodule assembly and test
 - Contribution to construction (MINERVA) :
 - pre-series cavity tests (2023)
 - Series power couplers preparation and conditioning (2023 – 2025)
 - Series tuner qualification @ 80 K
 - Discussion on-going for potential series cavity test (2023 – 2025)
- **PIP-II contribution**: prototyping phase (-> 2023) and series cavity tests (2024 – 2025)
- **SRF R&D** : Multipacting, Alternative Polishing of Niobium, Plasma processing, heat treatments (doping, mid-T baking), ...
- **Cryogenic R&D** (framework of the in2p3 NG Cryo project) : sub-kelvin refrigeration, cryogenic instrumentation and acquisition, low temperature thermometry, sub-kelvin material properties...

Plasma cleaning set-up

New equipment

Funding : EQUIPEX+ PACIFICS

Particle Accelerators Initiative for Future Innovative and Challenging Systems



$f = 13.56 \text{ MHz}$
 $P = 100 \text{ W}$

with a SPIRAL2 cavity

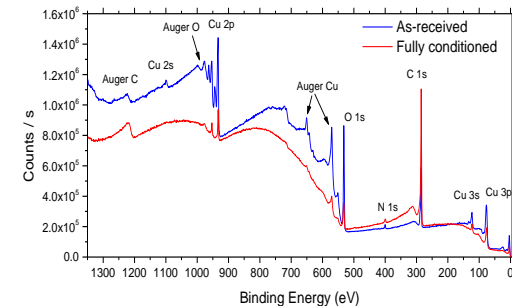
Multi-technical analysis set-up

(recovery of an existing set-up from ICMMO Lab)



2023
SEY
XPS
LEED
RGA
ion gun
@ RT / 1000 K

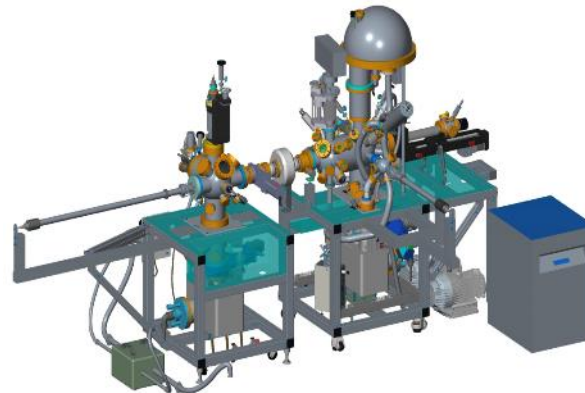
XPS (sept. 2023)



2024

Multi technical set-up – Surface analysis at cryogenic temperature



SEY
XPS
RGA
ion gun
@ 10K





- **Superconducting properties** of surfaces (surface resistance and magnetic shielding of SRF cavities)
- **Dynamic pressure**
 - Stimulated desorption / Collective effects (electron clouds)
- **Interactions between particles** (electrons, photons, ions) **and material surfaces** (secondary electron emission, modification of surface chemistry)

Goal: Improve the performance of high energy particle accelerators

	SRF cavities		Beam lines / vacuum chambers		
	Increase accelerator gradients Reduce RF losses	Multipacting mitigation	Limitation of pressure increases		
Surface treatments	<u>Bulk niobium:</u> Thermal treatments (<i>HELOISE / MP SRF</i>) N doping / infusion (<i>HELOISE/ MP SRF</i>) Polishing (<i>PACCAS/ MP SRF</i>)		<u>All materials:</u> Heat treatments Surface conditioning Plasma cleaning		Surface treatments
Thin layers	<u>Alternative Materials:</u> superconducting multilayers S-I-S (<i>Project AXE SRF / MP SRF</i>)		TiN, amorphous carbon, NEG alloys (<i>Project MULTIPAC du MP SRF + CNRS 80PRIME</i> <i>Project Vacuum / MP NPC-FCC</i>)		Thin layers

→ Analysis of material surfaces → Vacuum&Surfaces platform

- Participation in accelerator design / construction projects (MYRRHA, PIP2, PERLE)
- Participation in the Transverse Group FATI (metal additive manufacturing) / Project FABBAC