



WP12: Innovative Radio Frequency (RF) Technologies

FROM RESEARCH TO INDUSTRY

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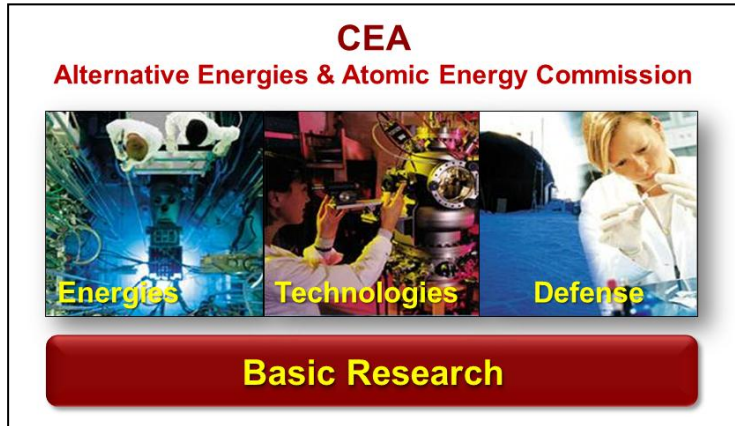


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Short introduction to IRFU and SACM activities

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Head of SACM/LISAH

January 16, 2014

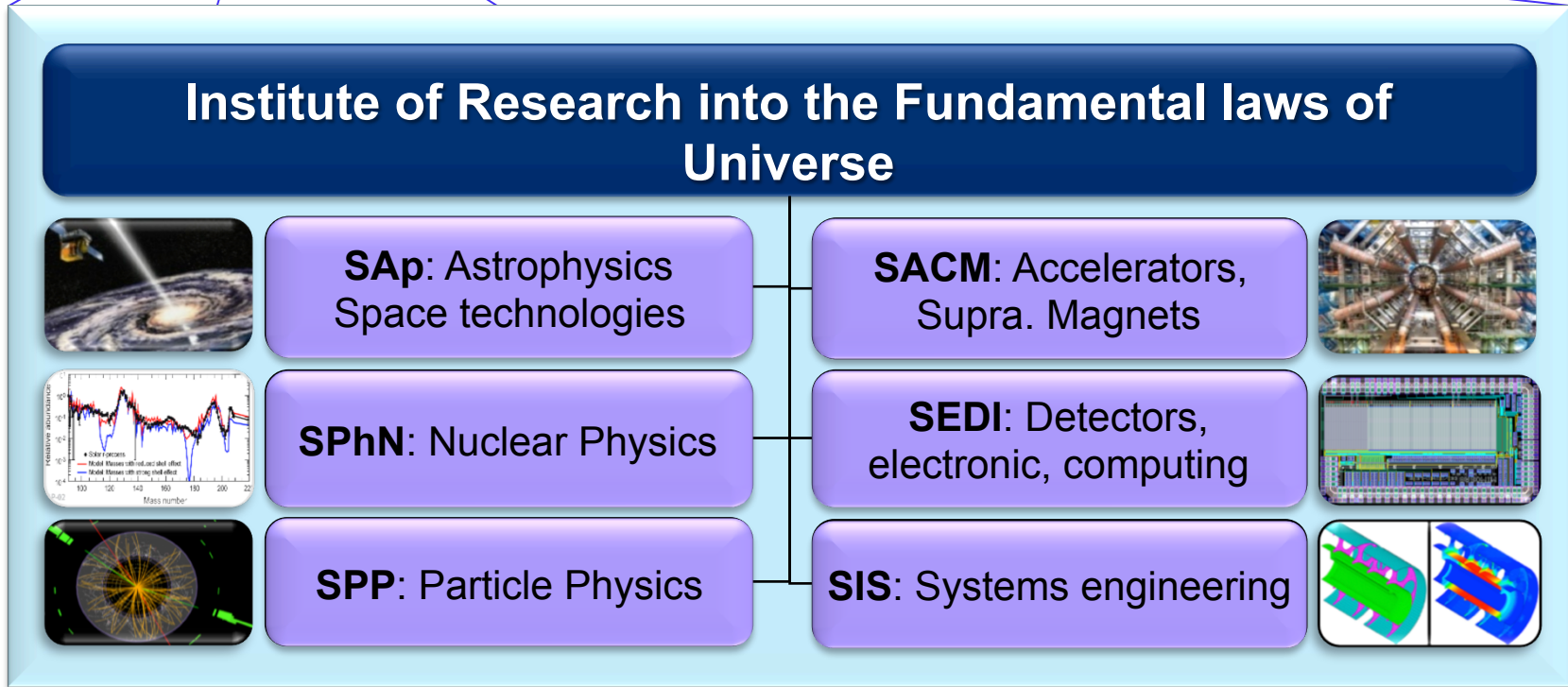
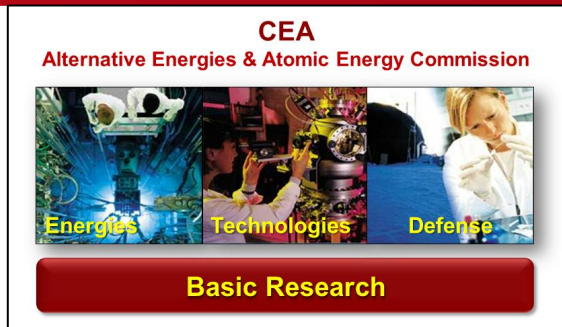


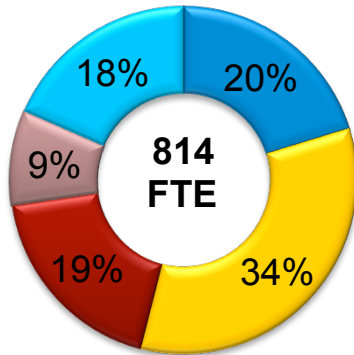
5 scientific poles organized in divisions:

- Direction des sciences du vivant (DSV)
- Direction des sciences de la matière (DSM)**
- Direction de la recherche technologique (DRT)
- Direction des applications militaires (DAM)
- Direction de l'énergie nucléaire (DEN)

Each division is splitted in institutes. For DSM (3850 FTE):

- Inac: Institut Nanosciences et Cryogénie (Grenoble)
- Irfu: Institut de recherches sur les lois fondamentales de l'Univers (Saclay)**
- IPhT: Institut de physique théorique (Saclay)
- GANIL: Grand laboratoire national d'ion lourds (Caen)
- Iramis: Institut rayonnement-matière (Saclay)
- LSCE: Laboratoire des sciences du climat et de l'environnement (Saclay)
- IRFM: Institut de recherche sur la fusion magnétique (Cadarache)



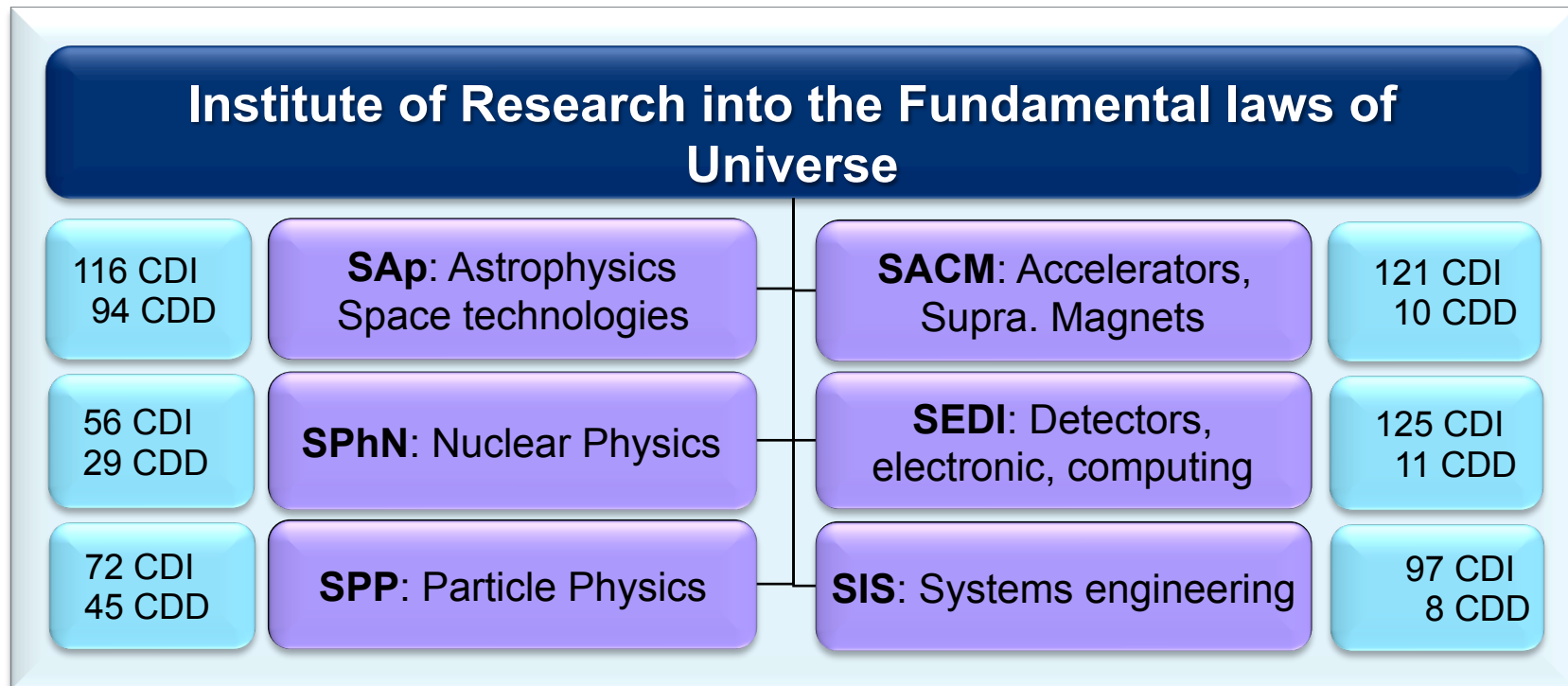
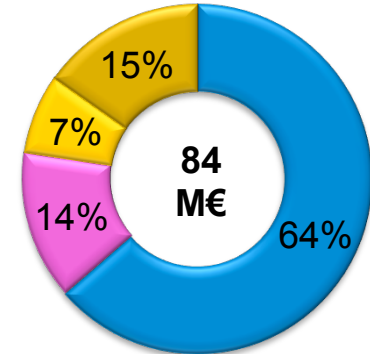


814 FTE
632/615 CDI/CDI-CEA

- Physicists 165 FTE
- Engineers 274 FTE
- Technicians 152 FTE
- Adm. Staff 72 FTE
- PhD & Post Docs 150 FTE

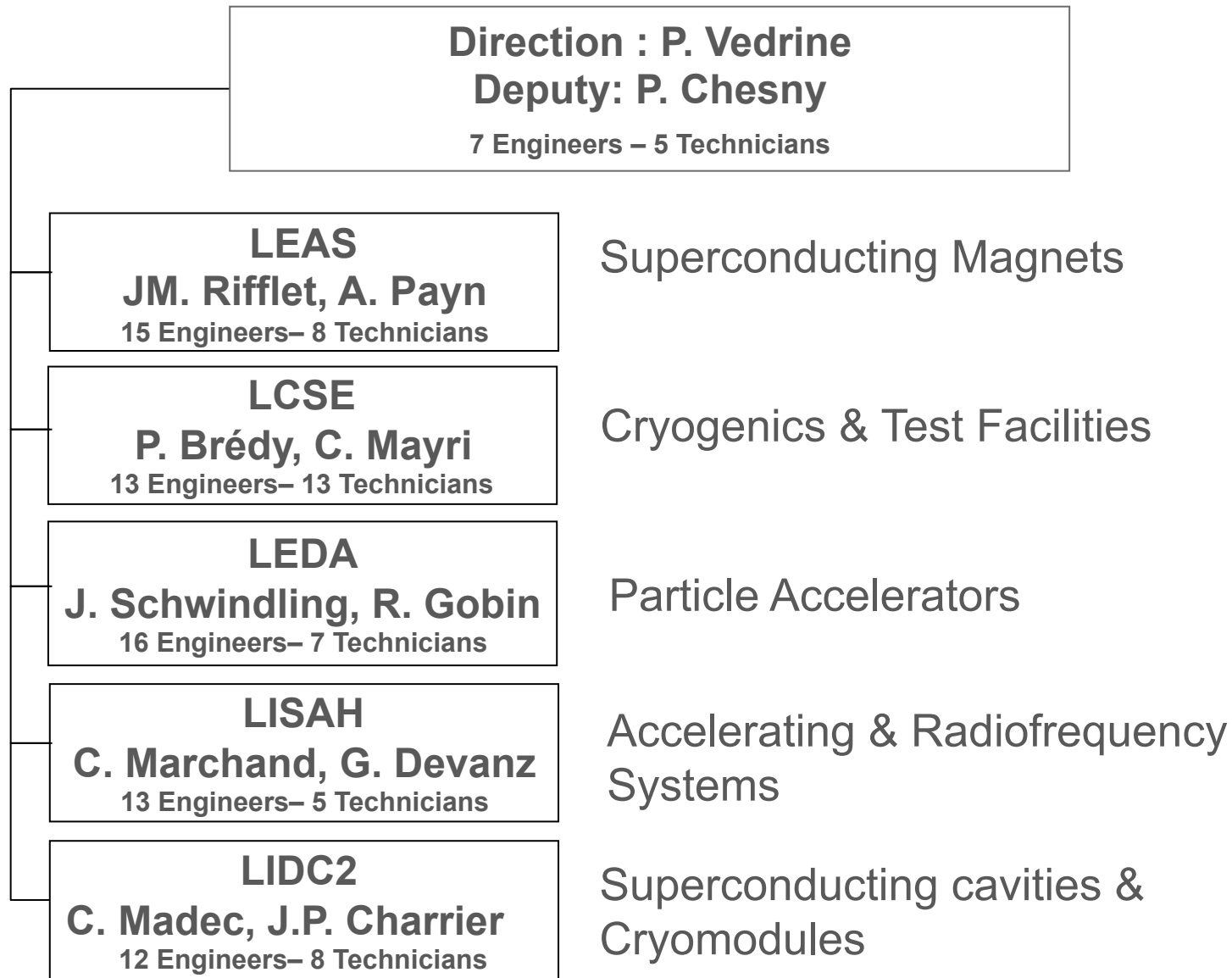
84 M€ (2012)
54 M€ Gov. Subsidies

- Gov. Subsidies 54 M€
- TGI & BA 12 M€
- CEA contracts 6M€
- External contracts 13M€



- Two main themes:
 - Cryogenics and magnetism
 - cryogenic test facilities
 - SC magnets
 - Accelerators
 - sources and injectors
 - SC cavities and cryomodules

- List of main accelerator projects SACM is involved in:
 - European Spallation Source - Sweden
 - Radioactive ion beam SPIRAL2 – France
 - FAIR proton Linac - Germany
 - IFMIF/EVEDA (fusion material irradiation) – Japan
 - X-ray free electron laser (XFEL) – Germany
 - ...



Projects are carried out transversally within the IRFU organisation

| CRYOMAGNETISM | ACCELERATORS |
|---|---|
| Neurospin ISEULT Magnet (11.7 T) | Spiral 2 Cryomodules |
| Neurospin ISEULT Antenna | SPIRAL2 Injector (on site) |
| Nb ₃ Sn coils for FRESCA2 and HTS insert | IPHI (3 MeV, 100 mA) – ESS demonstrator |
| JT60SA Coil test facility | XFEL Cryomodules |
| R3B-GLAD Spectrometer (GSI) | (CLIC – CTF3 – CALIFES) and CILEX |
| R&D on HTS | IFMIF-EVEDA Injector (on Rokkasho site) |
| S3 Spectrometer (for SPIRAL2) | FAIR Proton LINAC injector |
| LNCMI magnet (8.5 T) | LIPAC : IFMIF-EVEDA SC Linac |
| FAIR (GSI) : Super FRS dipoles | ESS : RFQ & Cryomodules |
| 9 large projects | 9 large projects |

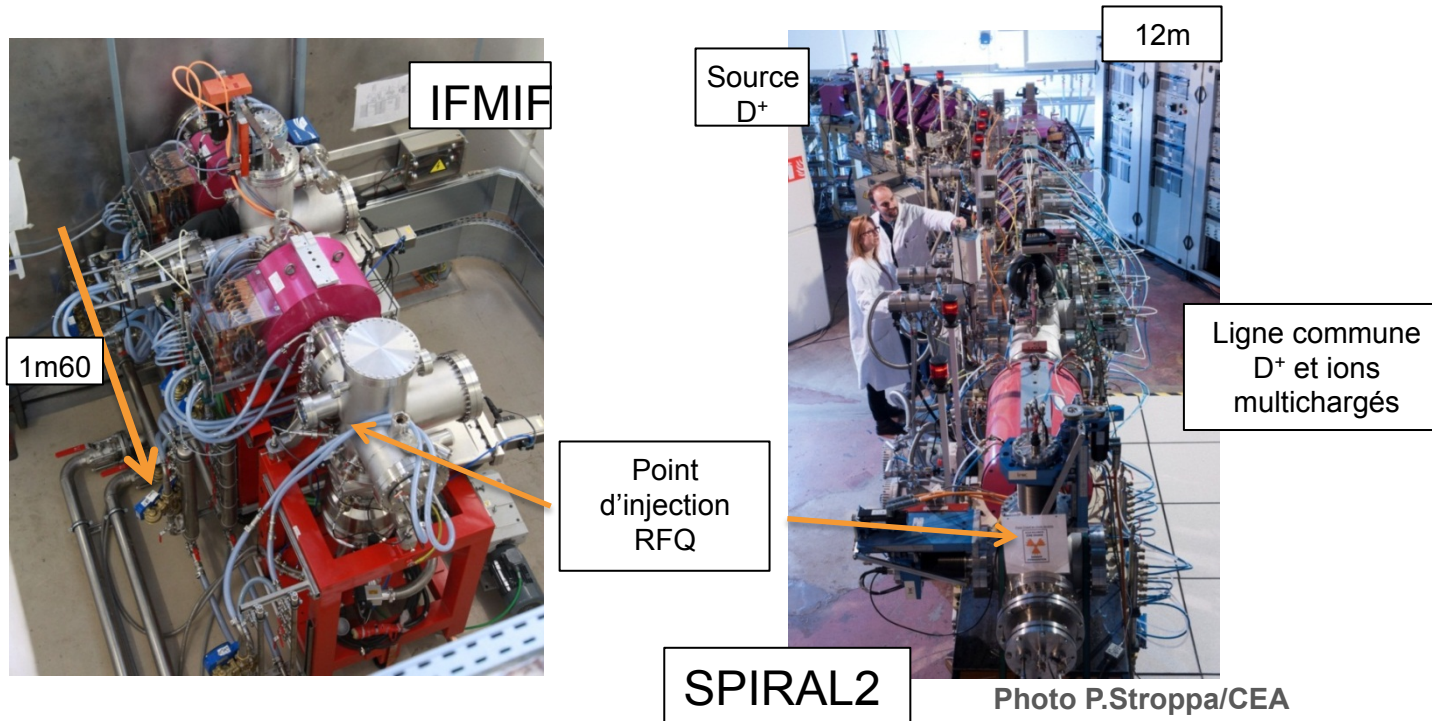
CEA has completely designed and realized the 352MHz, 6 meter, 3 MeV, CW IPHI RFQ.



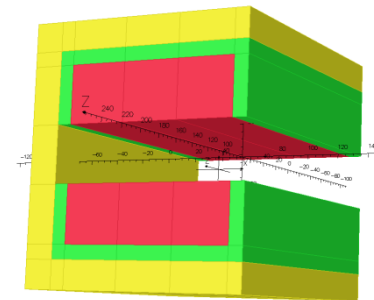
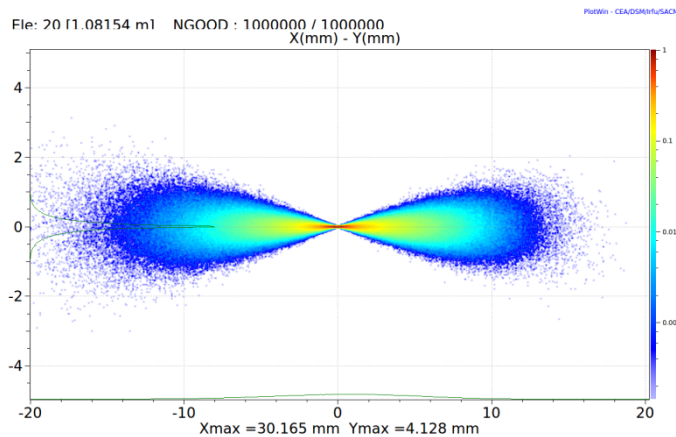
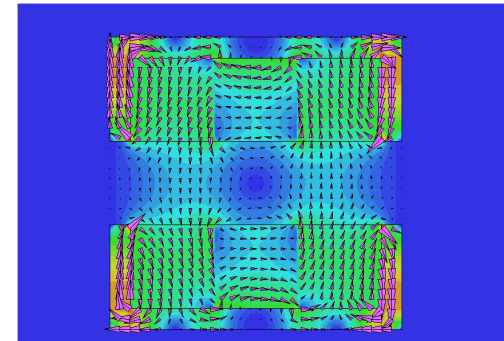
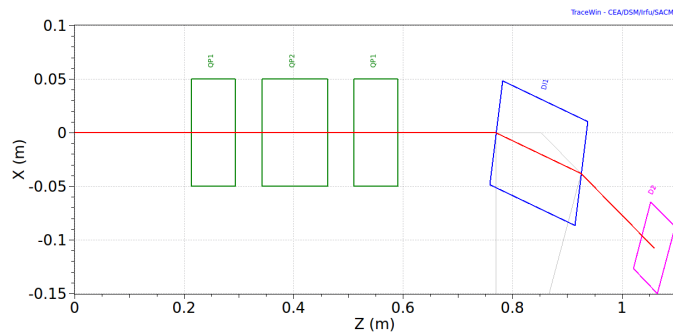
The RFQ is now installed, vacuum tests are OK. The voltage law is set within 1% at low level (bead-pull). Same design and measurements have been done for the CERN LINAC4.

Next steps : for IPHI full power and beam & for ESS: design and construction of RFQ

- Irfu has recently commissioned at Saclay the IFMIF and Spiral2 injectors.
- The complete equipment are now delivered to Rokkasho (Japan) and Caen (Normandy)
- Irfu specialists will contribute to the assembly and commissioning on site
- Bunkers have been dismantled and are presently refurbished for ESS



- SACM is involved in the production and acceleration of electrons by laser plasma interaction(multi-stages) in collaboration with LLR, LAL, IRAMIS, LPGP, LULI.
- SACM is in charge of the transport and characterisation of a $50 \text{ MeV} \pm 5 \text{ MeV}$, $10 \mu\text{m}$ beam with high quality permanent magnet quadrupoles and dipoles.



- The future development of a PIC code is foreseen within this new community

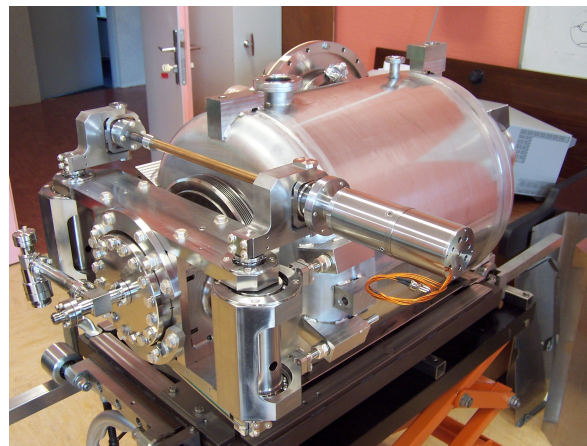
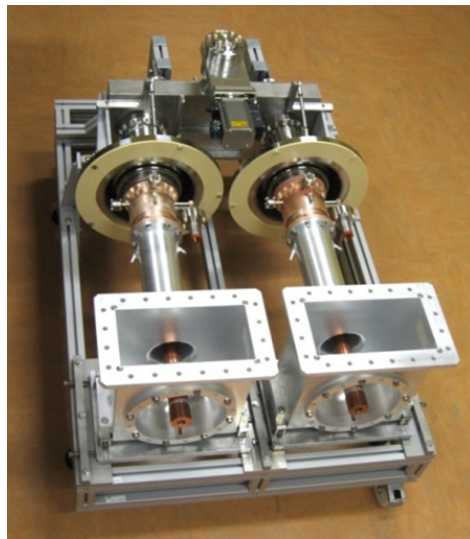
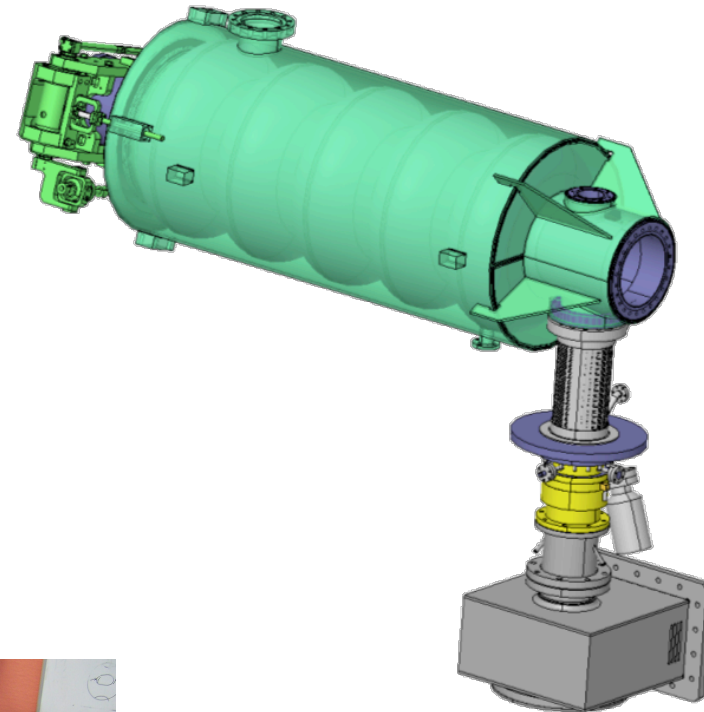
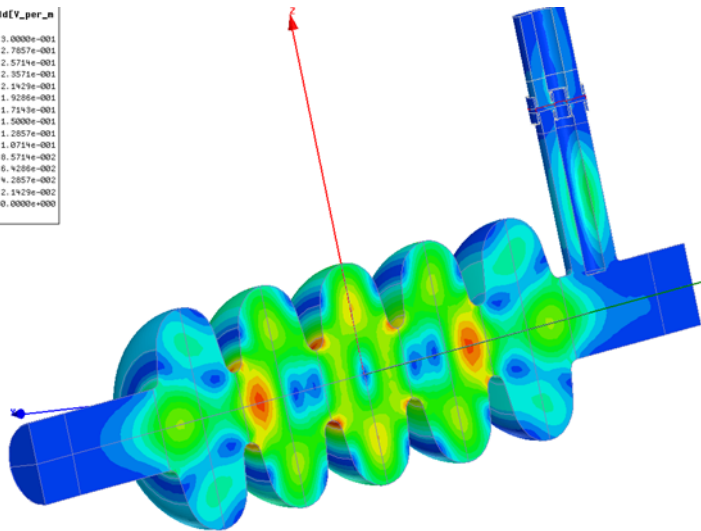
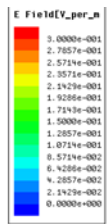
- Based on bulk Niobium, SRF technology is used for most of the linear accelerators since 2000: EU-CARE (SRF, HIPPI), XFEL, ESS
- Motivated by the XFEL developments, accelerating gradients of 30 MV/m can be produced reliably.



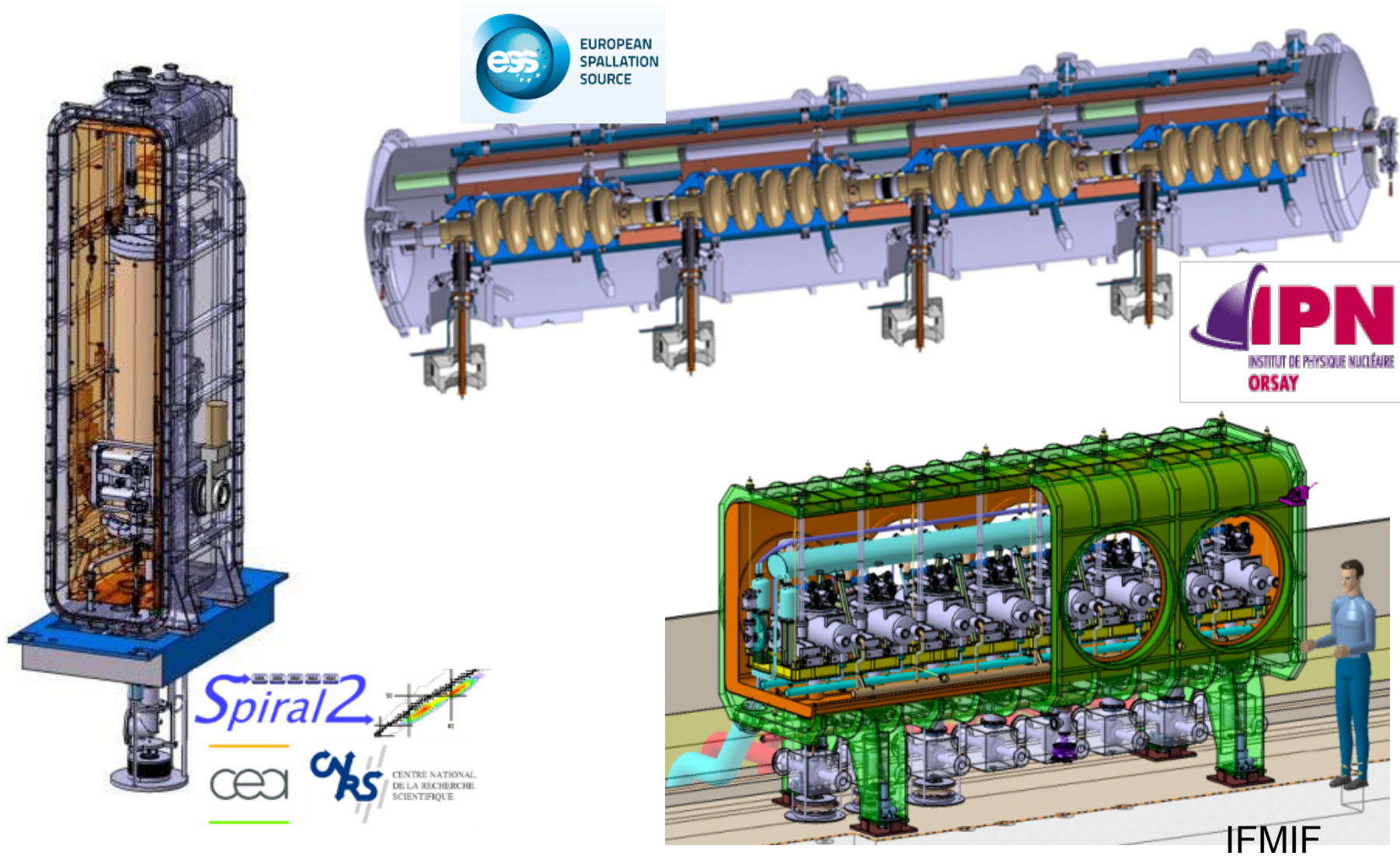
704 MHz cavity developed at Irfu within the EUCARD2 program (similar to ESS high beta):

- 1. after welding*
- 2. during vertical electropolishing process*





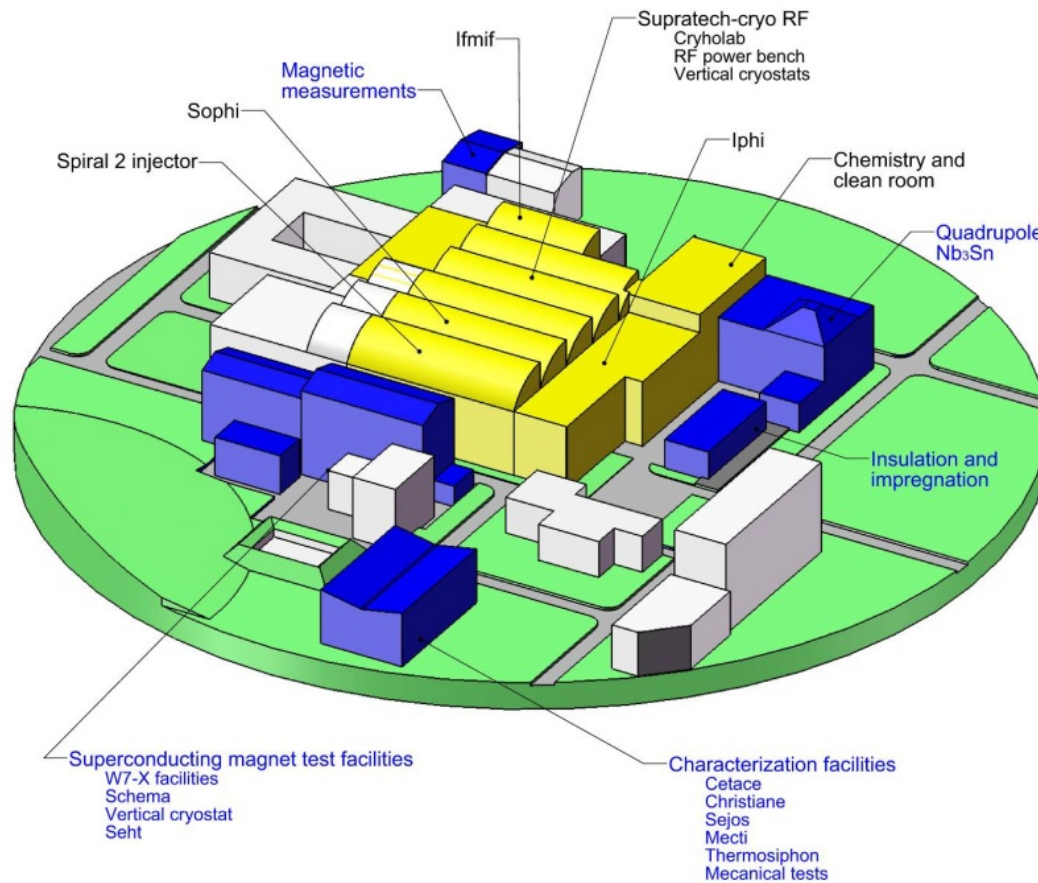
THREE EXAMPLES OF CRYOMODULE DESIGNS SPIRAL2, ESS, IFMIF

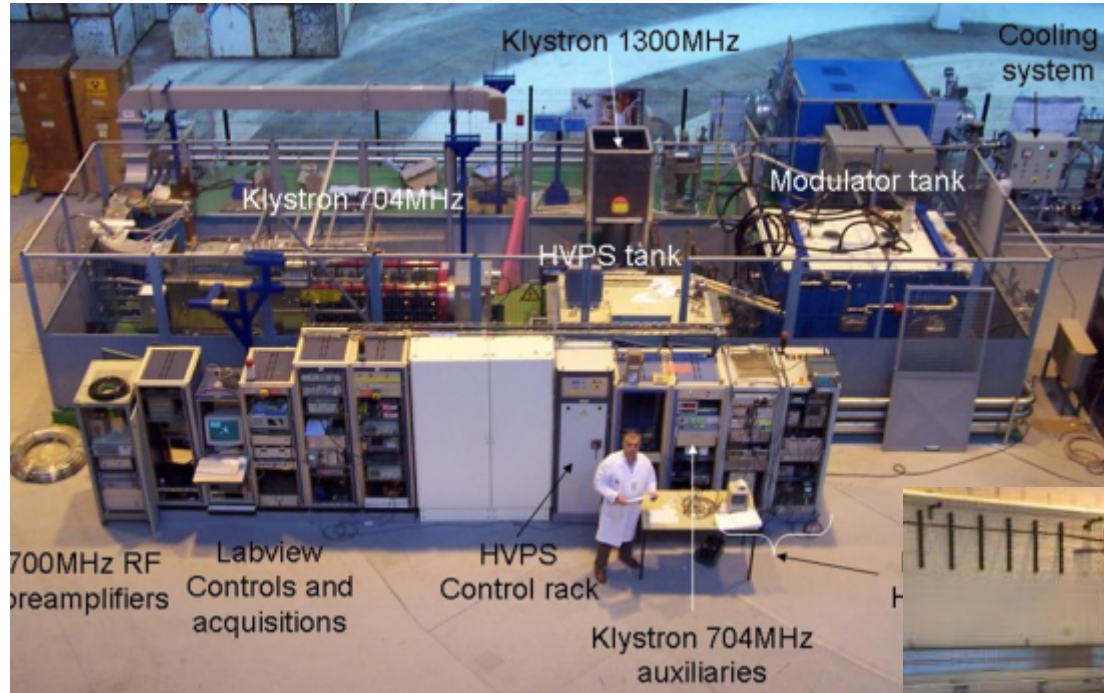




XM-1 cavity string in IS04 Clean Room (final leak test)

The Saclay **Synergium** is an infrastructure for accelerator tests and R&D
 → guided tour tomorrow by Juliette





In the SupraTech Cryo/HF test facility, we can test both cavities and cryomodules (Spiral2 IFMIF , ESS)



RF power sources are available at several frequencies : 352 MHz, 704 MHz , 1300 MHz

Fundamental laws of universe & Large scientific projects : HL-LHC, JT60SA, IFMIF, ESS, MRI, ILC, ITER, VHE-LHC

Generic R&D

- design
- characterization
- Innovation



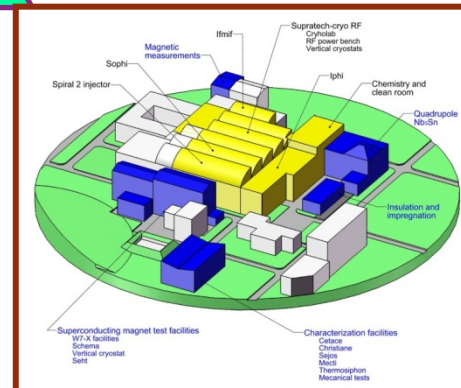
Project

- QA system
- risk management
- industry transfer
- ...



Prototyping

- test facilities
- qualification
- Industrialization
- Networking
- ...



A backbone of Scientific Skills

Technical Platforms

- ESS: construction of the RFQ and of the superconducting linac
 - HL-LHC upgrades and VHE-LHC with winding of Nb₃Sn and HTS magnets
 - JT60SA (fusion): test of the 19 Toroidal coils
 - ISEULT: development of innovative MRI gradient coils
 - ILC: become one of the 3 Regional Hubs for cryomodule production
 - 28 GHz source for Spiral2
 - Plasma acceleration: application of high intensity lasers for future proton and electron sources
 - **However: unbalance between projects and R&D**
- ➔ **need for a new period of “Upstream R&D”**