

# SRF phase transition at IJCLab

## From TEM-cavity specialist to Elliptical cavities

CNRS/IN2P3/IJCLab

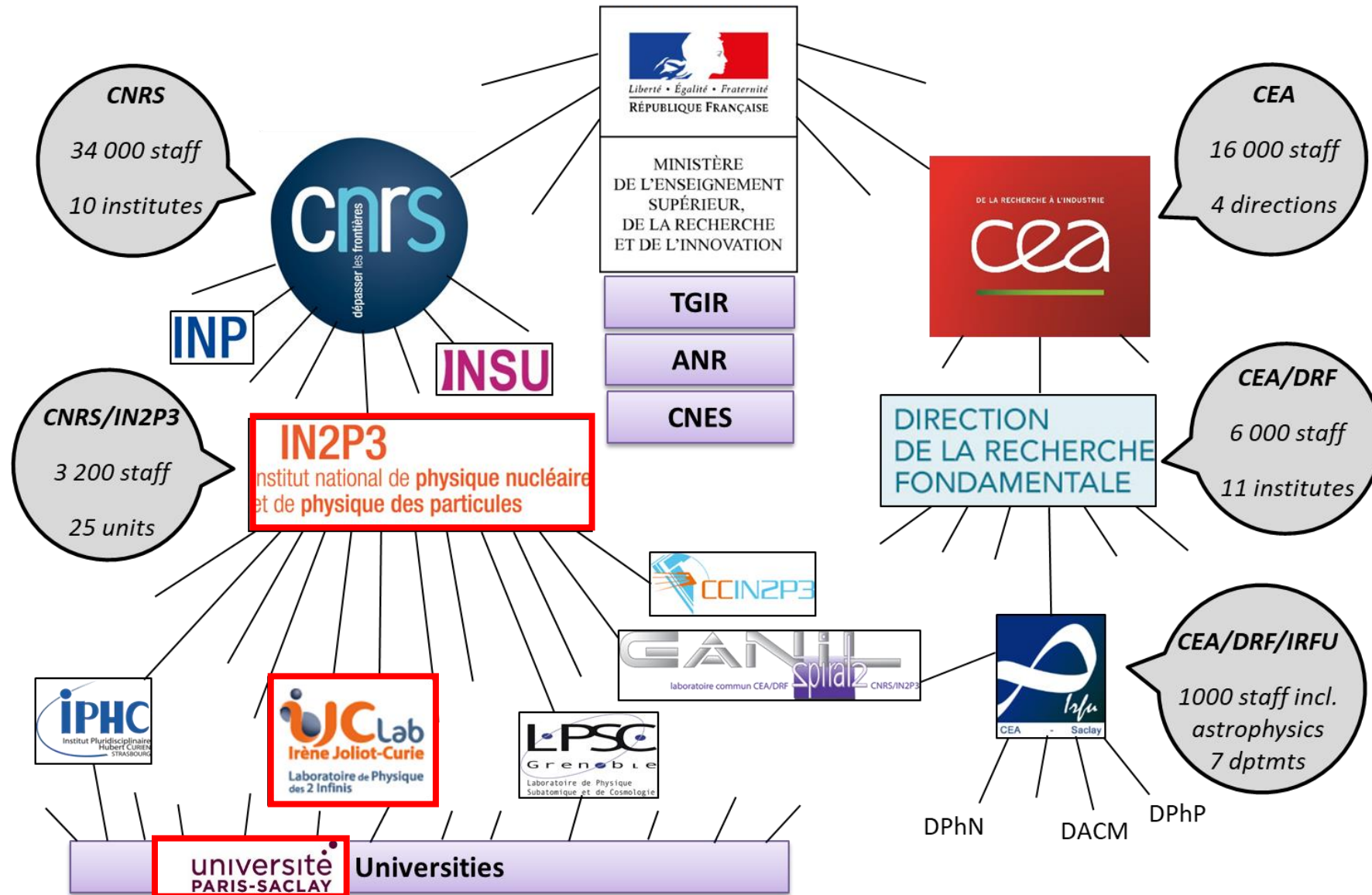
Akira Miyazaki on behalf of SRF team



- Introduction
- TEM cavities
- New activities
- Infrastructure update
- Fundamental studies
- Conclusion



# Introduction : Instances around IJCLab



Credits :  
J.L. Biarrotte



# Introduction : History summary and series production @ Supratech

Prototyping Phase

Series production

R&D



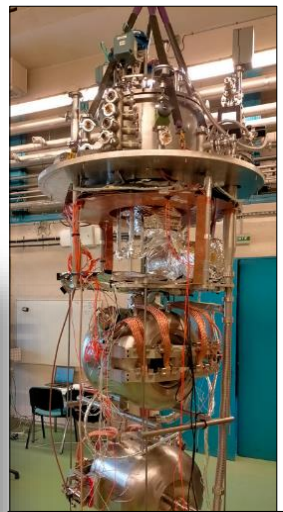
**Spiral2** : Integration and test of 7 cryomodules



**ESS** : - preparation & testing of cavities, couplers and tuners  
- Integration of 14 cryomodules



**LHC** : Calibration of all Cernox thermal sensors (> 6000 units)



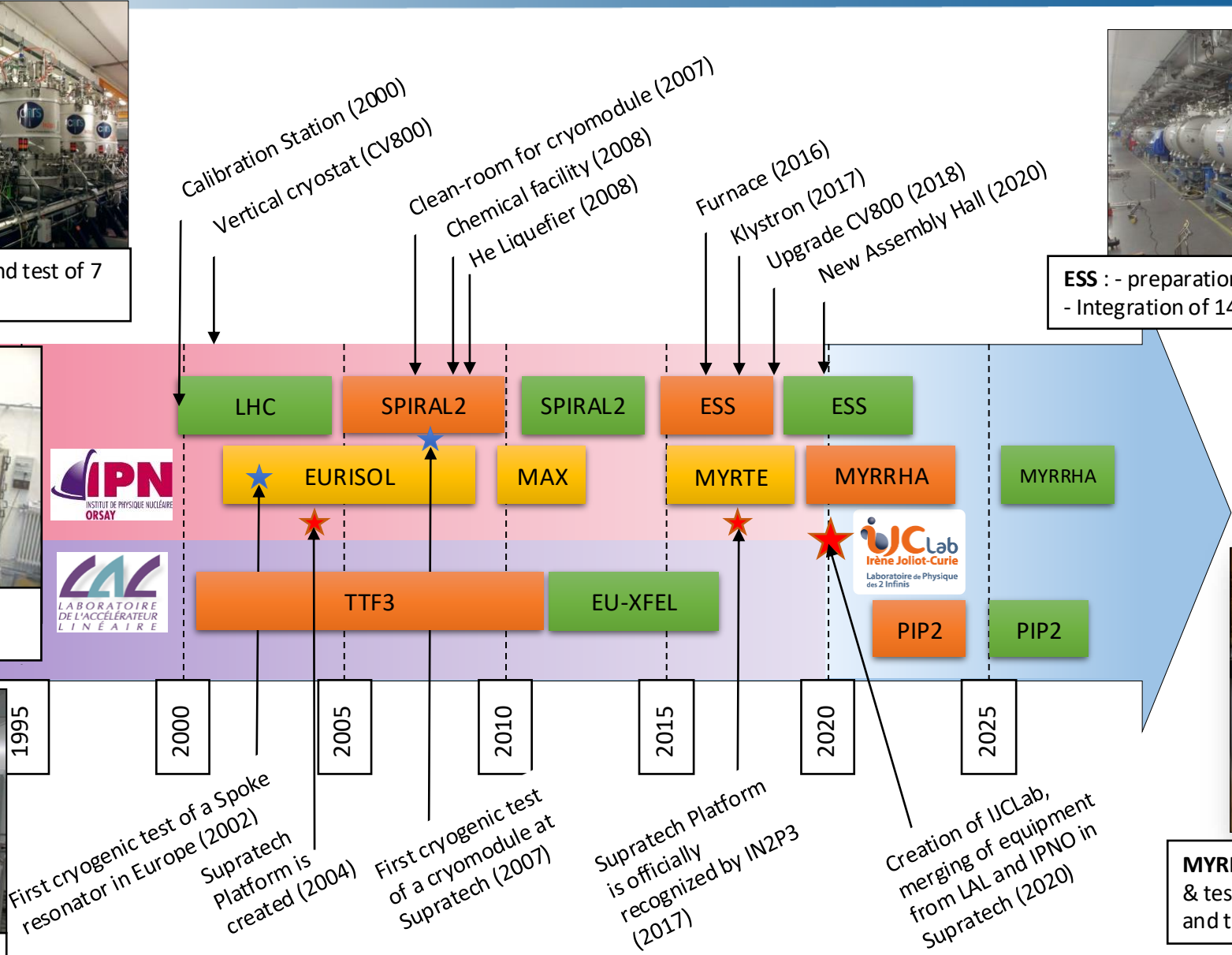
**PIP-II** : Testing of 33 Spoke cavities



**EU-XFEL** : Preparation and power testing of 800 couplers

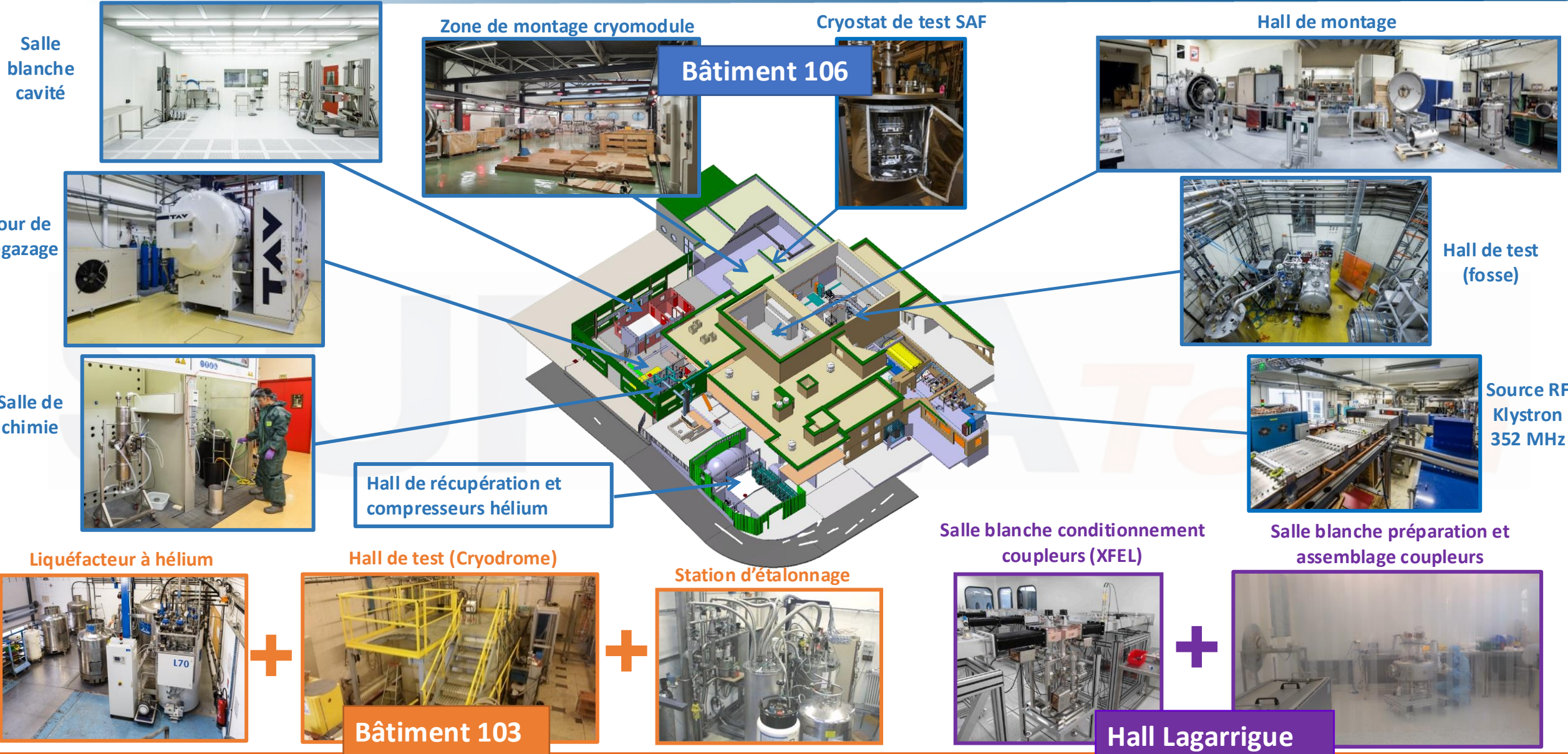


**MYRRHA** : - preparation & testing of 60 couplers and tuners





# Our infrastructure: SUPRAtech Platform





## 3 groups, 2 platforms



### MAVERICS team

(~ 8 people involved in SRF activities)

- Leading R&D effort in SRF
- Driving SRF programs

### VIDE & SURFACES Platform

(Material and surface characterization)

- Material characterization (SEM, EBSD, EDS, XPS, XRD, SIMS, confocal microscop, ...)
- Dedicated set-up (SEY, plasma)



### RF Group

(~ 8 people involved in SRF activities)

- Driving SRF programs
- RF and mechanical design of SRF components (Cavity, tuner, coupler, LLRF)
- Operation and maintenance of RF equipment of Supratech

### SUPRATECH Platform

(Treatment, assembly and test of SRF components)

- Cryostats
- Dedicated SRF facilities (BCP lab, clean rooms, UHV Furnace)
- He Liquefier
- Assembly area for cryomodules

### Cryogenic Group

(~ 6 people involved in SRF activities)

- Expertise in design of cryogenic systems
- Operation and maintenance of cryogenic facilities of Supratech

# SUPRA**Tech**



## Facts and strategy

- **IJCLab is a medium size laboratory in the field of fundamental physics**
  - Mixed CNRS/University but practically VERY university with small non-SRF accelerators
  - Not like large accelerator facilities, such as CERN, FNAL, KEK, DESY, etc...
- **We have certain base funding**
  - Basic R&D is strongly encouraged
  - Somewhat sufficient as a seed funding for small experiments like dark matter, theory, etc...
- **Superconducting RF studies are enormously demanding even for R&D!**
  - Material, fabrication, preparation, testing, etc
  - Not a typical R&D subject with university-level base funding + external competitive grants
- **We have focused on TEM-type accelerator projects**
  - To efficiently profit from the limited resources
  - Scientific R&D results have been byproducts of project contributions
    - Eg) D. Longuevergne, A. Miyazaki, Phys. Rev. Accel. Beams 24 083101 (2021)
    - D. Longuevergne, NIMA, Volume 910, Pages 41-48 (2018)
- **Our infrastructure has been dedicated to TEM-type cavities for small “mass” production**
  - Spiral2 (7 cryomodules, 14 QWR), ESS (14 cryomodules, 28 Spokes), PIP-II (test of 30 Spokes),



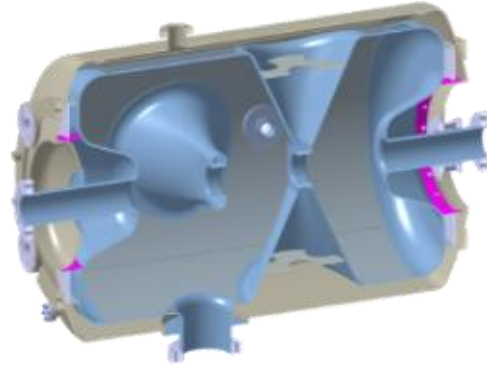
# IJCLab-SRF has been dedicated to TEM cavities



88 MHz



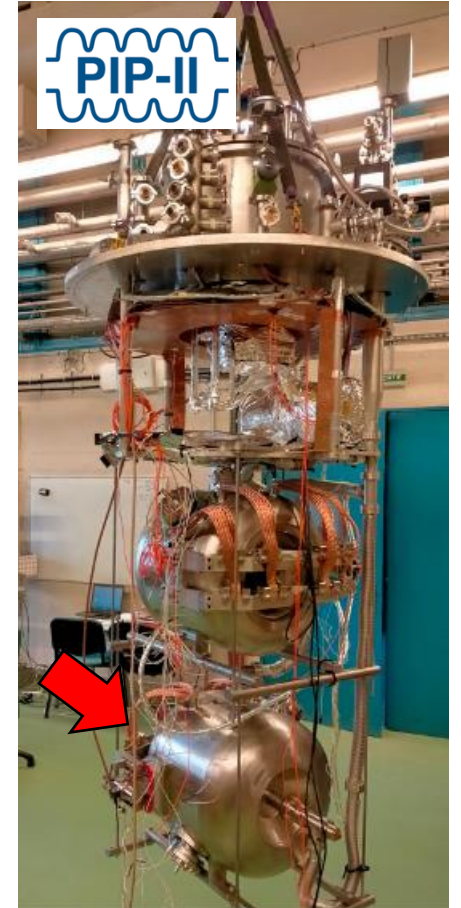
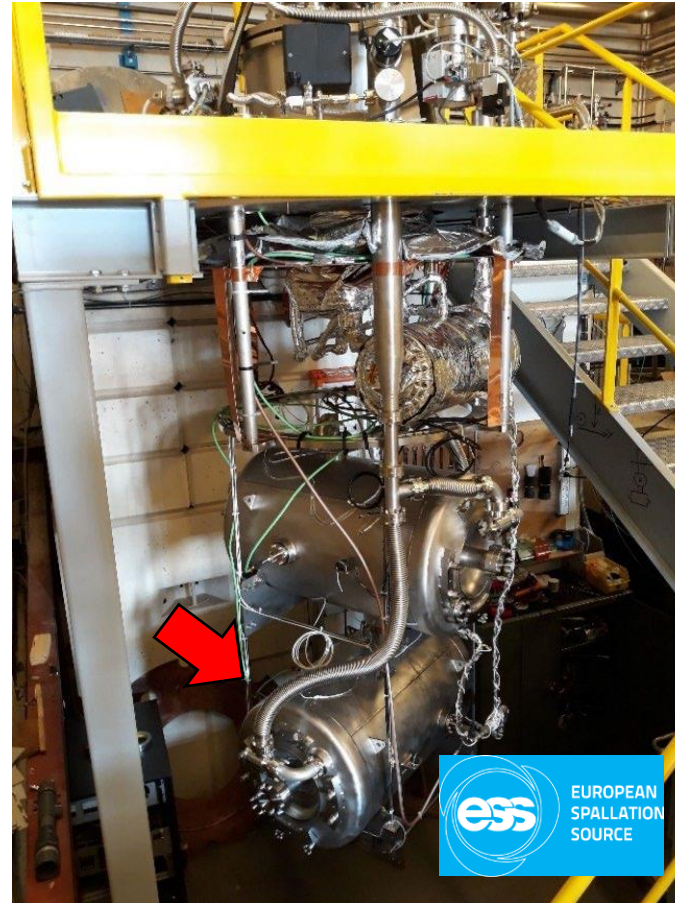
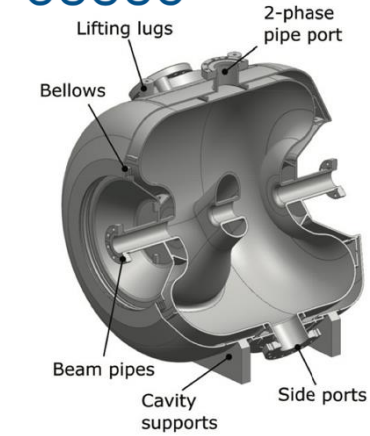
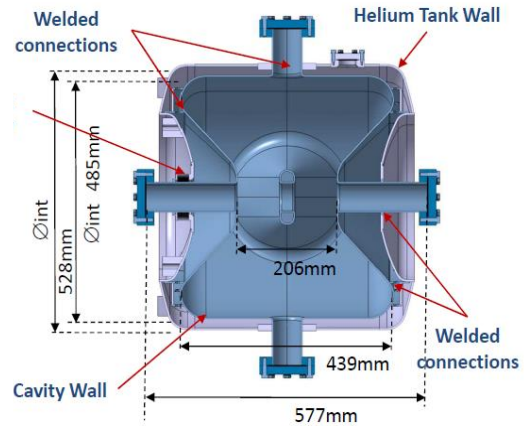
352 MHz



352 MHz



325 MHz





# Recent TEM-type cavity projects

Requalification of Spiral2 cavity



Cleaning and reassembly of ESS cavities & couplers



After accidental venting of one spoke module

MYRRHA prototype CM

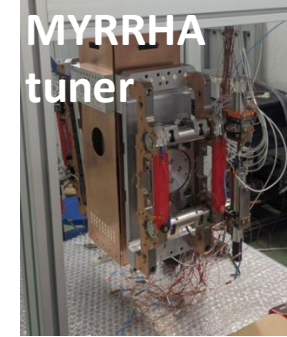


PIPII cavity testing →

- Two prototype SSR2 cavities
- One series SSR1 cavity



PIPII SSR2



MYRRHA tuner



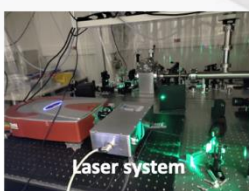
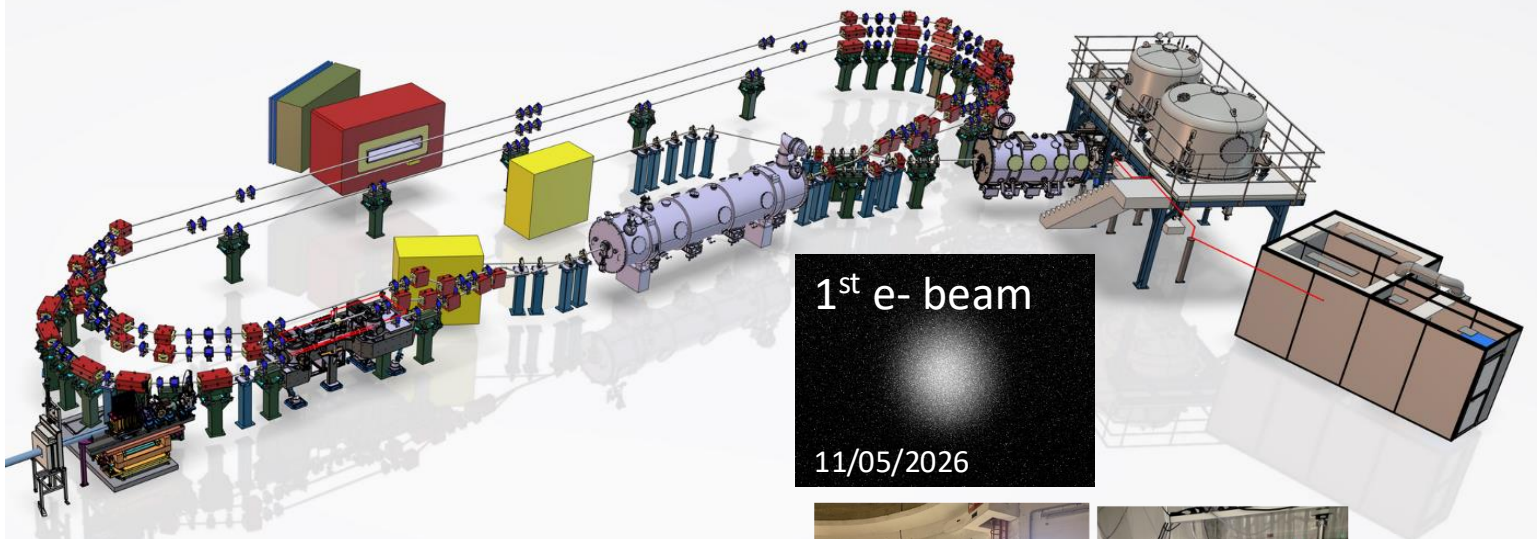
MYRRHA coupler

- ✓ IJCLab is actively working on TEM cavity projects
- ✓ We will keep capability for TEM-type projects
- ❖ **However, new activities are launching 😊**

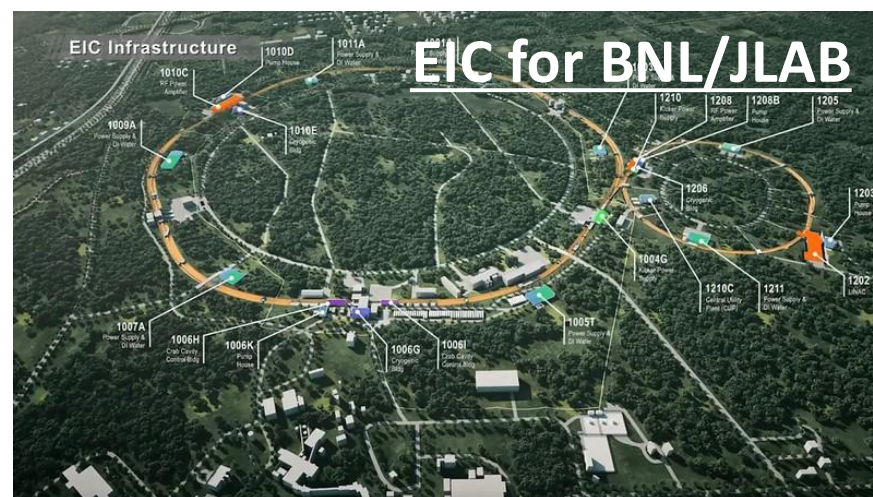
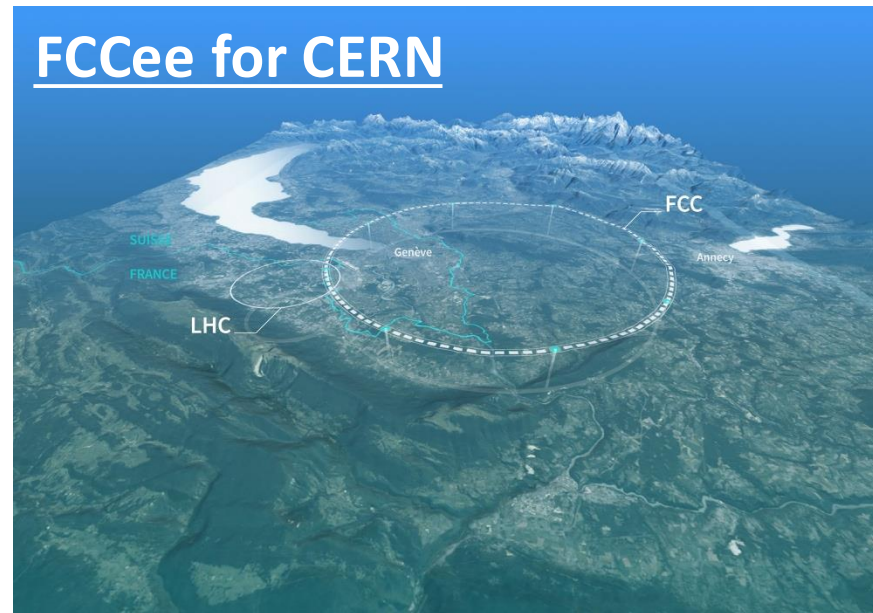


# New SRF projects in IJCLab → high- $\beta$ electron beams

## Local energy recovery linac PERLE



## FCCee for CERN



CW high current → high-Q elliptical cavities!

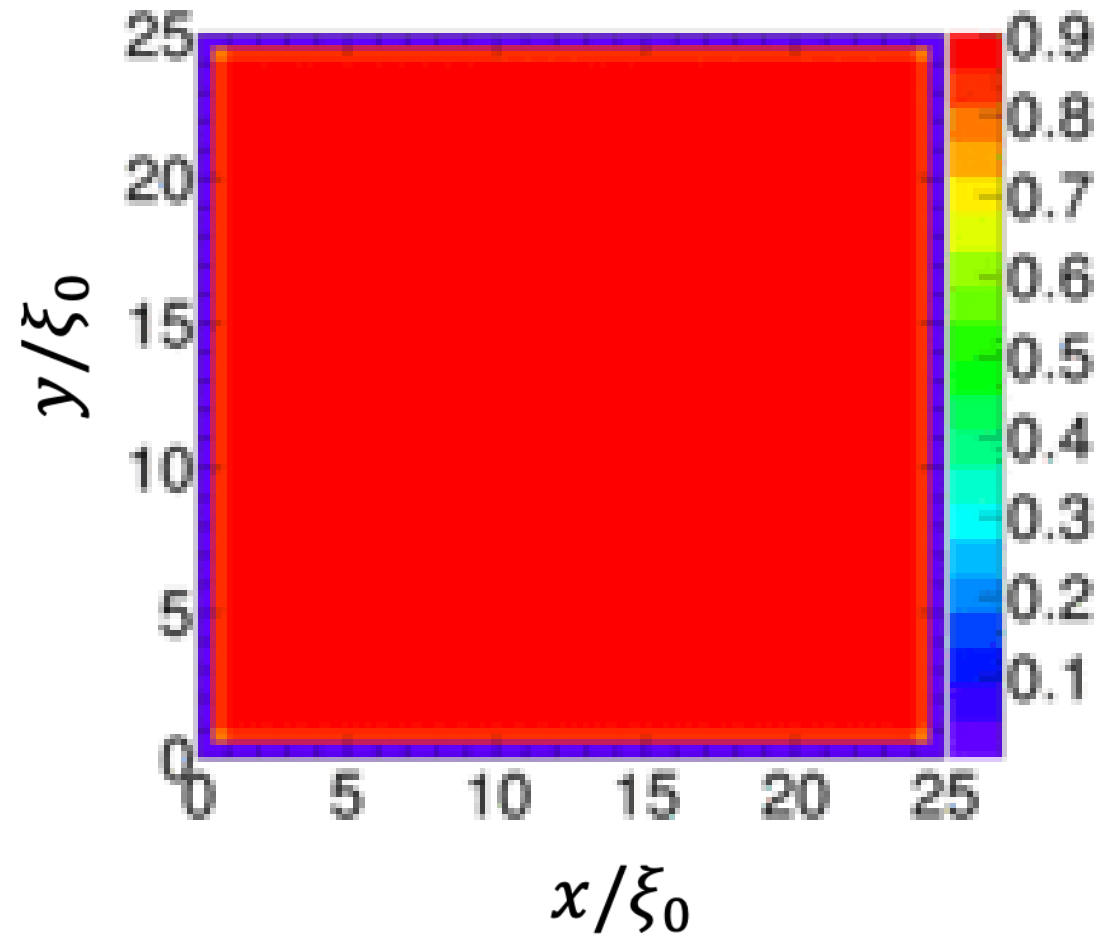


## Meissner state of TEM



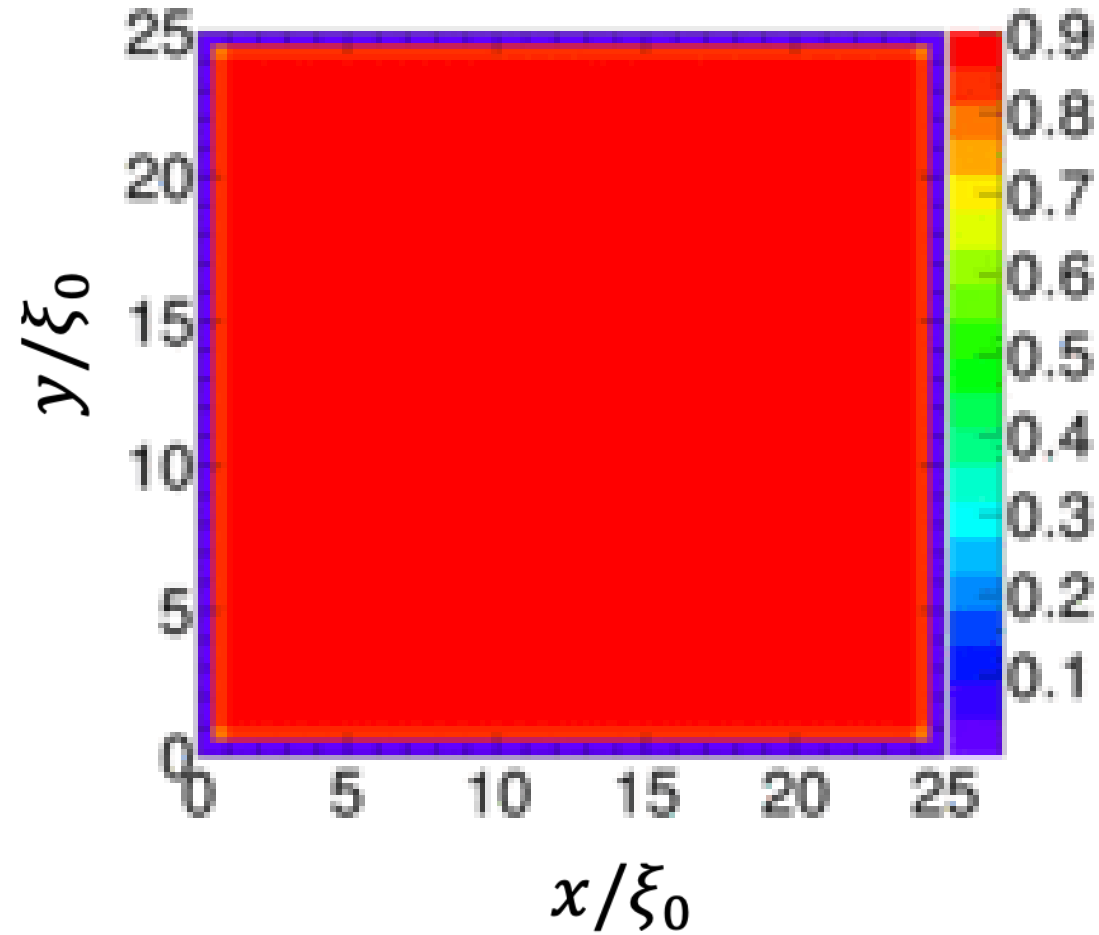


# Meissner state of TEM





# Meissner state of TEM



# Mixed state of TEM + elliptical





# New activities with elliptical cavities

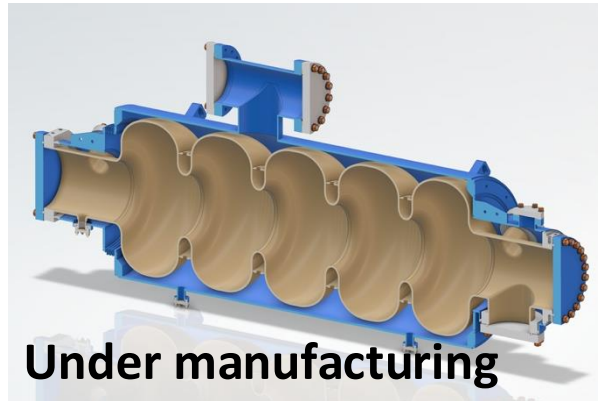
800 MHz  $\beta=1$  cavities

PERLE cavities

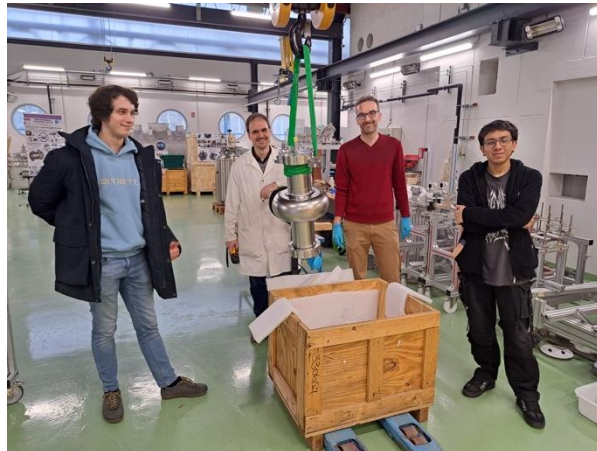
FCC cavities

*Technical synergy*

VEP @ CEA

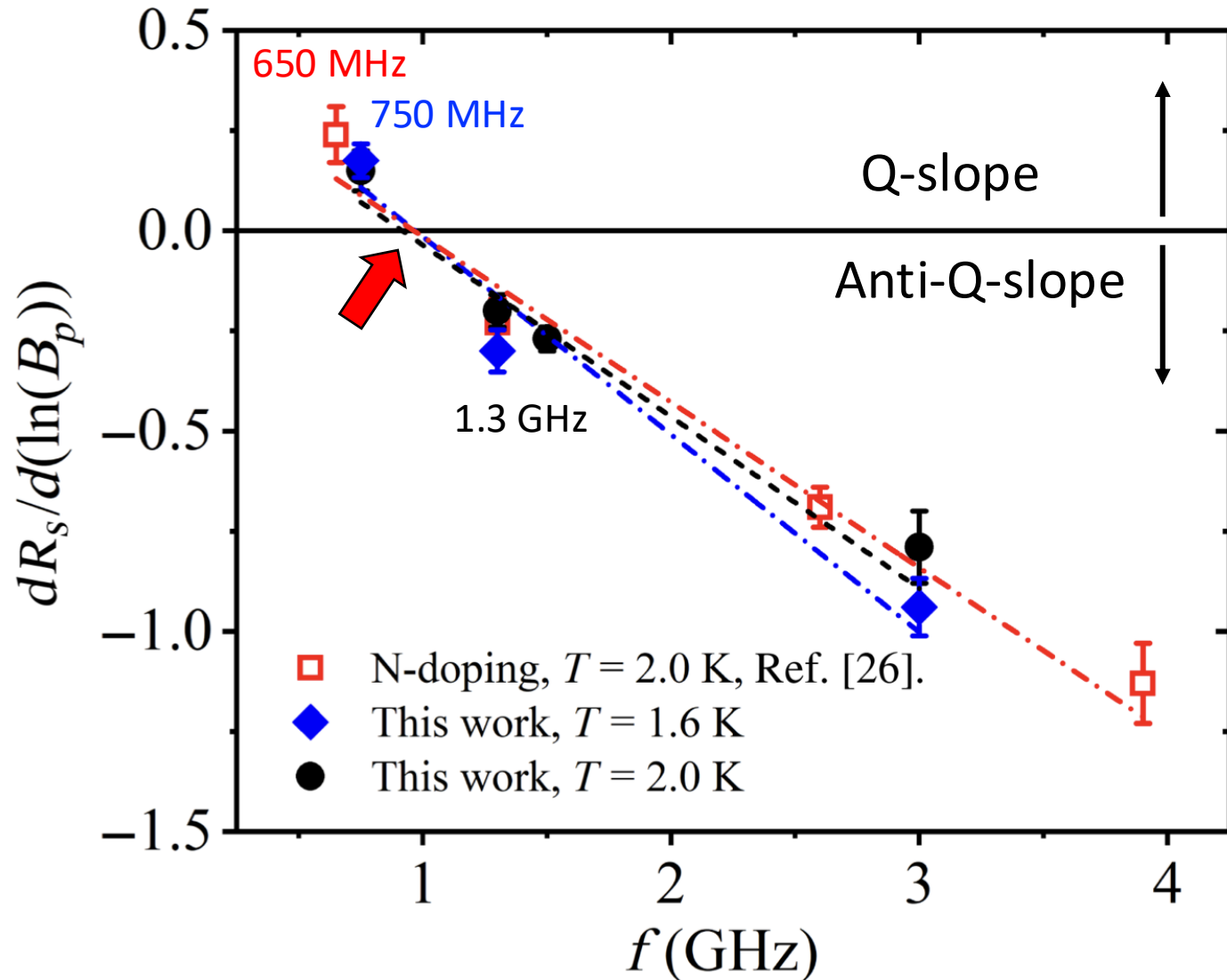


1.3 GHz cavities for R&D

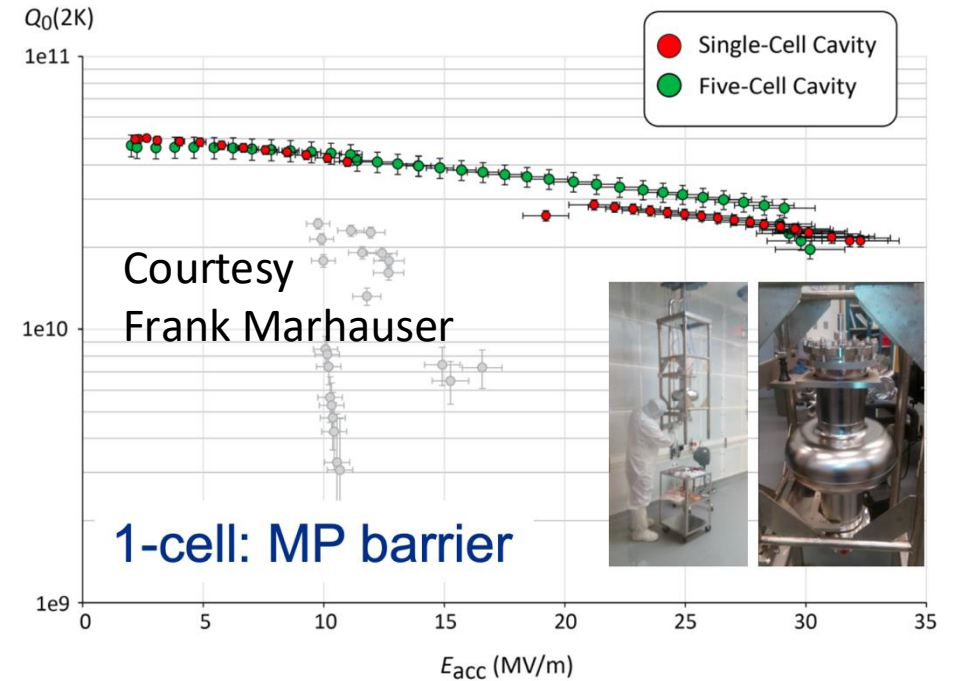




# 800 MHz is crucial not only for projects but also for basic physics



Present 800 MHz result from JLAB in 2018  
Flash EP + 120C bake surface  $\rightarrow$  Q-slope

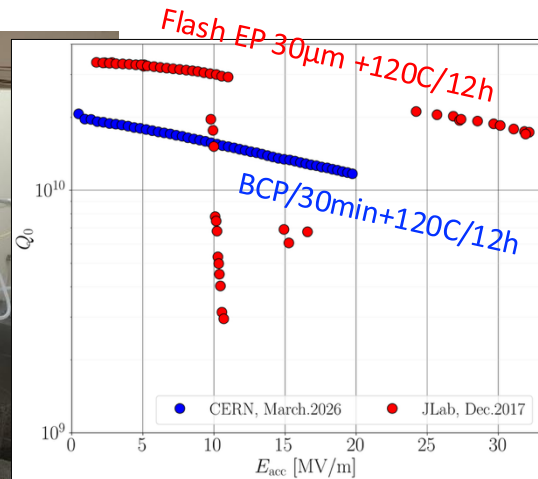


Dose **N-dope** and/or **mid-T** bake generate anti-Q-slope on 800 MHz cavity?



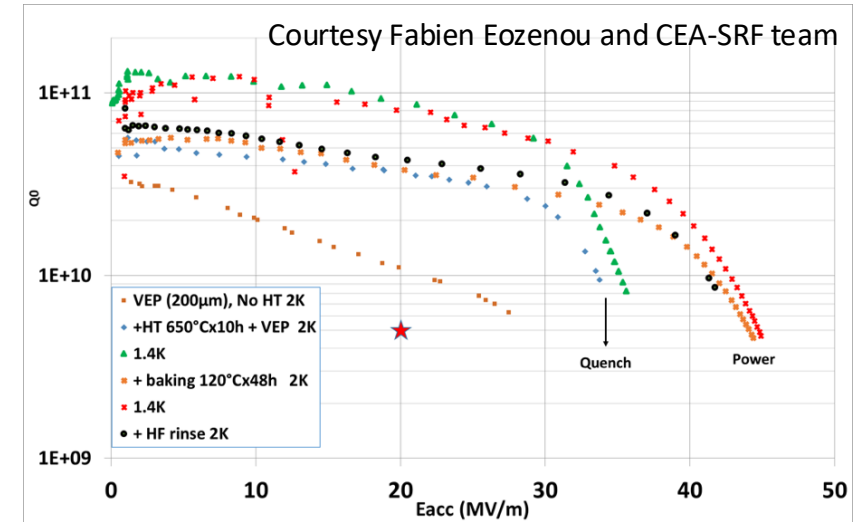
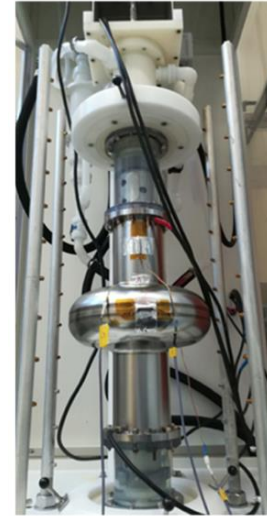
# Infrastructure qualification & development for surface treatment

## BCP @ IJCLab

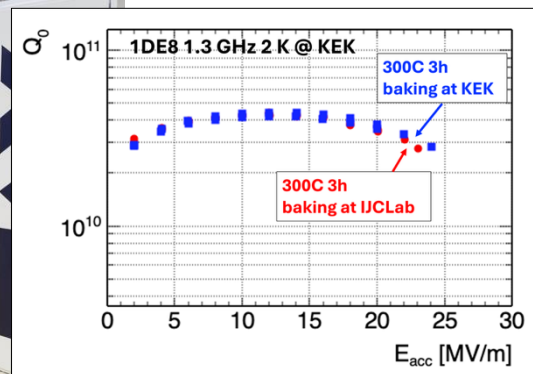
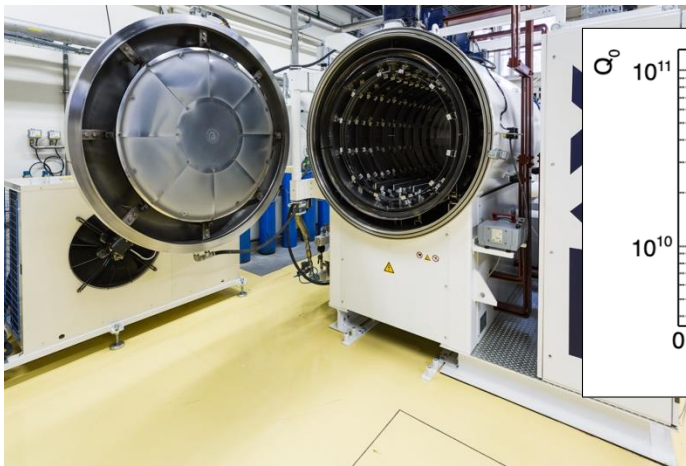


Courtesy Shahnam Gorgi Zadeh and CERN/JLAB SRF team

## VEP @ CEA



## Vacuum furnace @ IJCLab



Courtesy KEK iCASA team

- CEA has a VEP setup qualified for 704 MHz **1-cell**
- IJCLab a furnace qualified for 1.3 GHz 1-cell mid-T
- IJCLab and CEA collaborate on 800 MHz Vertical EP

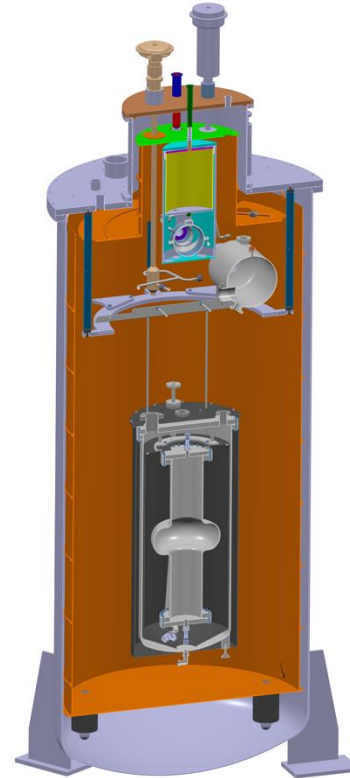
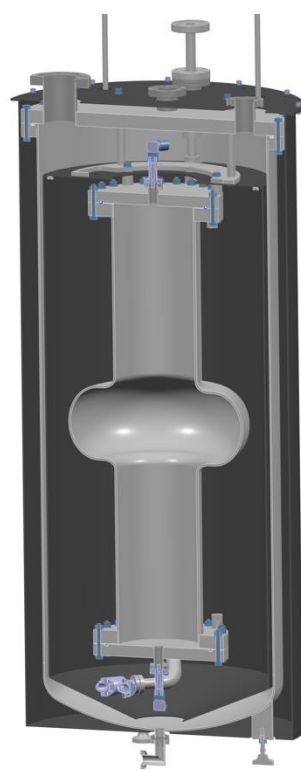
### CW machines need high-Q but not super high-G

- IJCLab investigates BCP + mid-T
- VEP for **multi-cell** may be OK for 25 MV/m
  - Courtesy of Vijay Chouhan



## VT with CV800

→ Demountable He-jacket concept

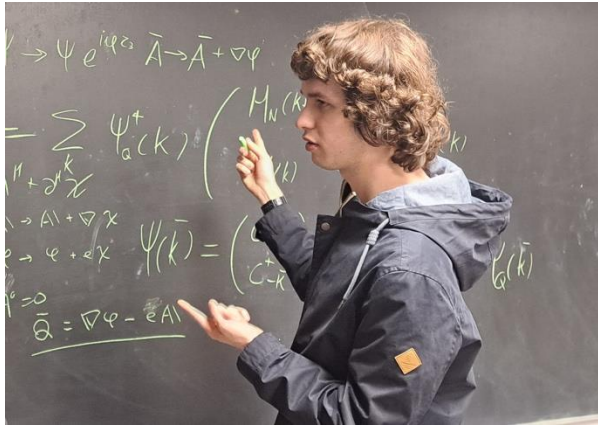


- Successful grant application UPS P2I AAP 2026 « superCav »
  - Successful implementation leads to saving LHe amount
- The components are under commissioning
- 1<sup>st</sup> goal is to reproduce VT results from other labs → exchange cavities within



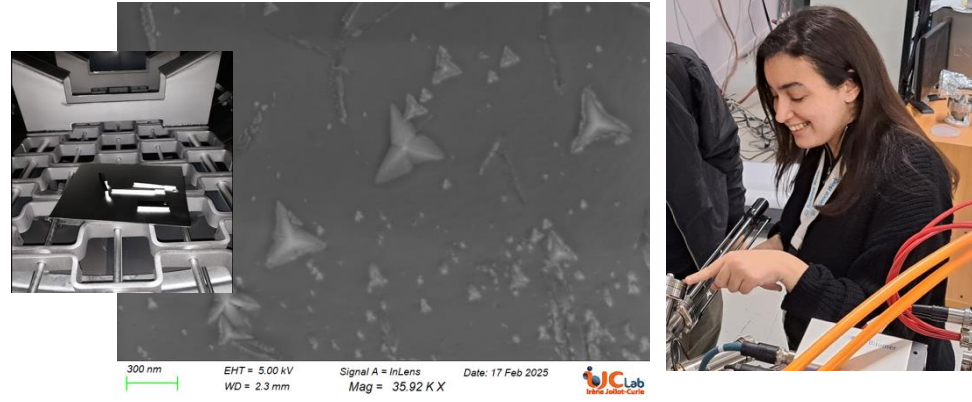
# Individual R&D subjects

## Theory of superconductivity



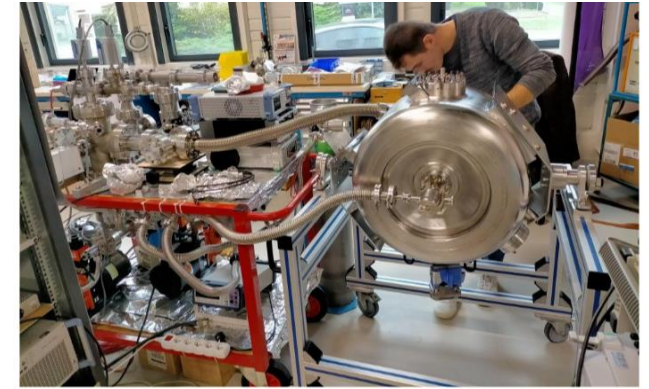
Carlos' talk in WG-1 16h00 on Tuesday  
C. Redondo-Herrero, AM arXiv:2604.03702

## Surface physics and material science



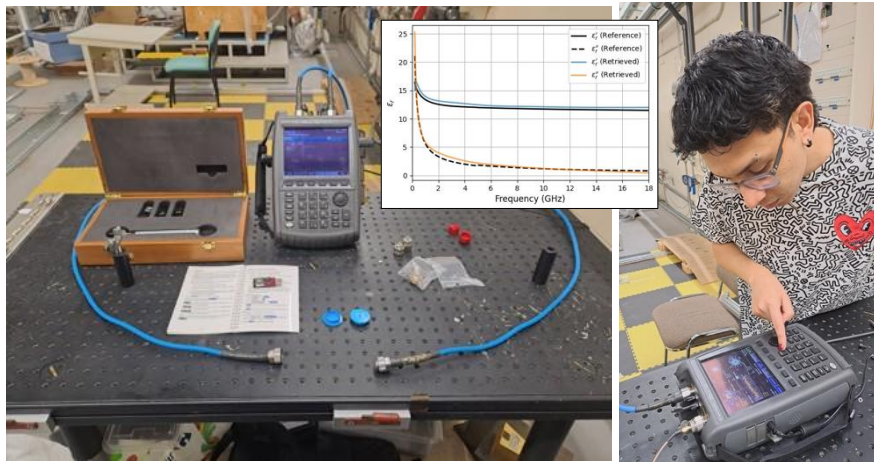
Chahinez's talk in WG-1 11h36 on Wednesday

## Plasma processing



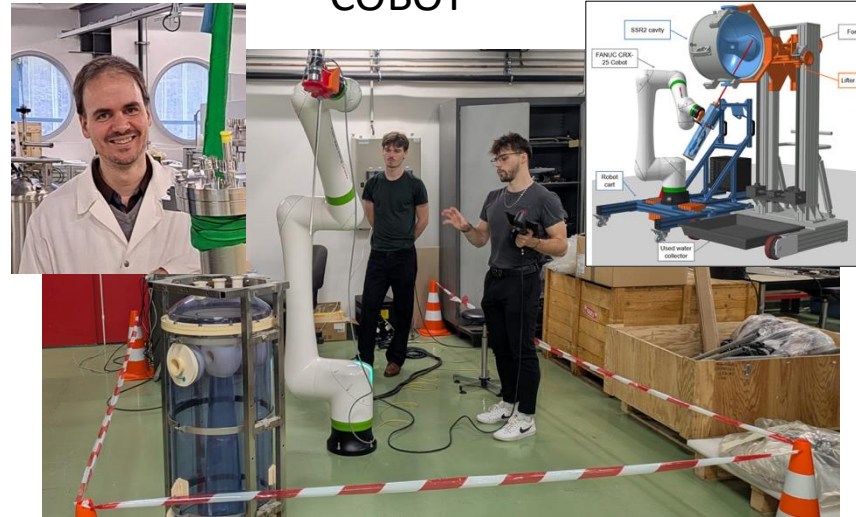
Martin's talk in WG-2 11h15 on Wednesday  
Camille Cheney et al arXiv:2603.04052

## HOM damping



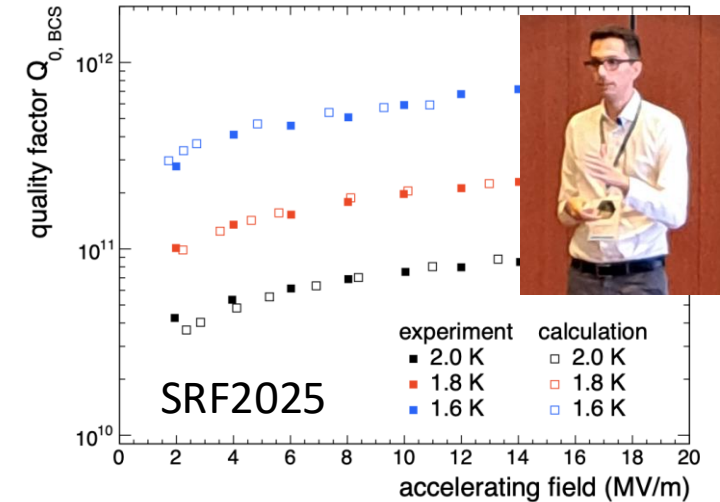
See Axel's talk in WG-4 16h36 on Wednesday

## COBOT

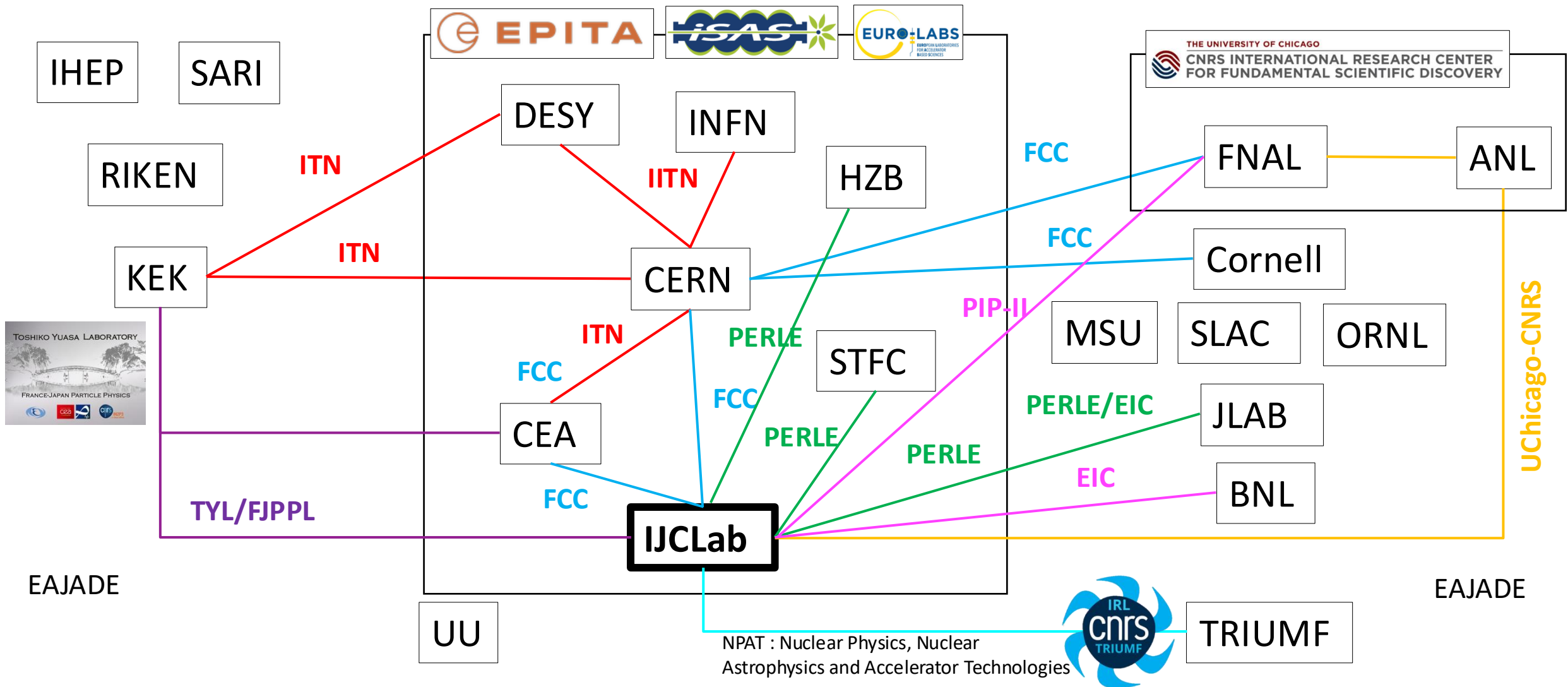
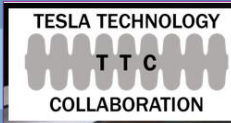


Nicolas' talk in WG-4 14h24 Wednesday

## Experiment & analysis



A. Bianchi, doi:10.18429/JACoW-SRF2025-THA05



We are 100% benefiting from TTC! + bilateral/multi-labs grants 😊



## Conclusion

- IJCLab is a medium-size laboratory of fundamental physics
  - Very large university but still limited resources compared to large accelerator facilities
- IJCLab has been working mainly on TEM cavity projects
  - Successful contributions to Spiral2, ESS, MYRRHA, PIP-II
- New project demands lead us to launching multiple R&D projects in elliptical cavities
  - Local ERL PERLE
  - International colliders FCCee + EIC
- 800 MHz cavities for PERLE and FCC are of primary interest for R&D
  - Cavity manufacturing with industry
  - Infrastructure updates and qualification
- IJCLab is reinforcing basic R&D activities
  - From fundamental theory to robotics
- IJCLab profits from the international network thanks to TTC!