EUROPEAN SPALLATION SOURCE

The Superconducting Accelerator for the ESS project

Felix Schlander

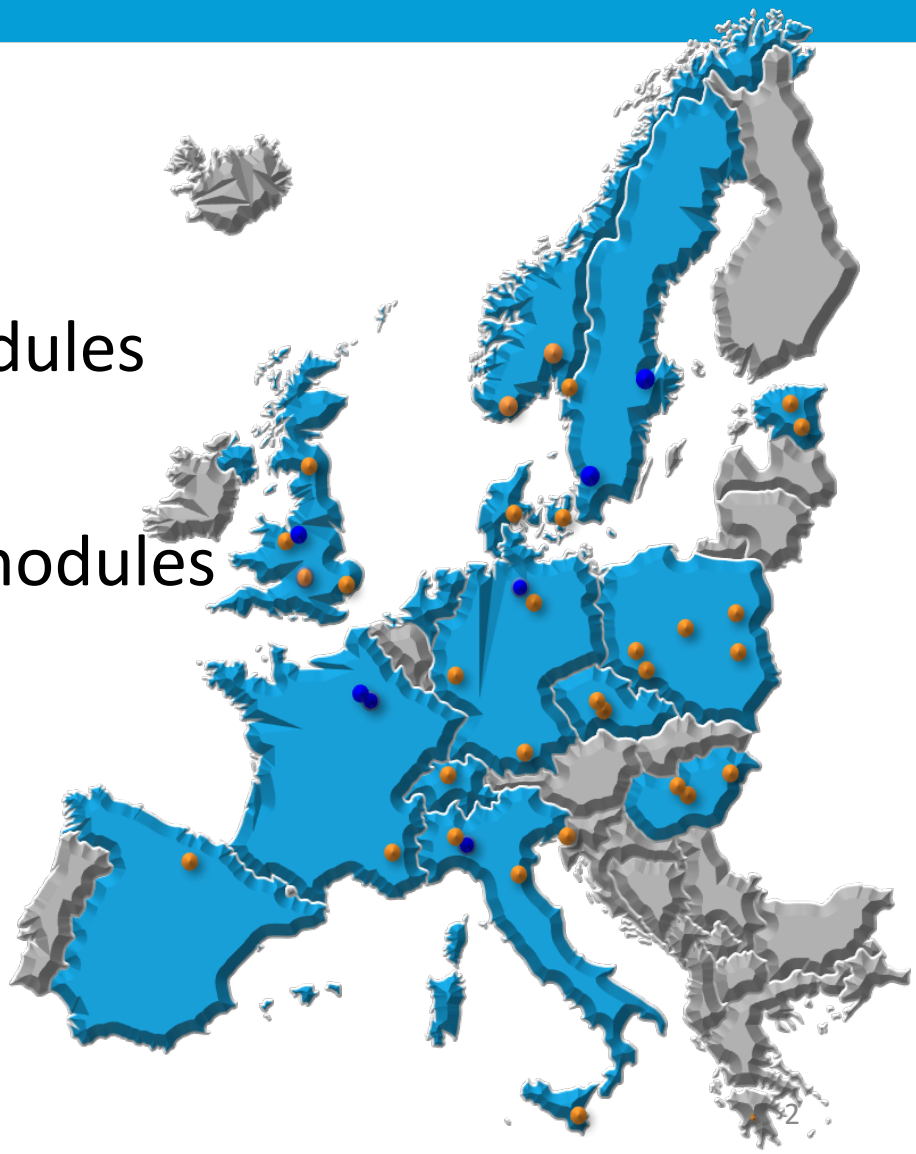
for the ESS SRF collaboration

www.europeanspallationsource.se

16 July, 2017

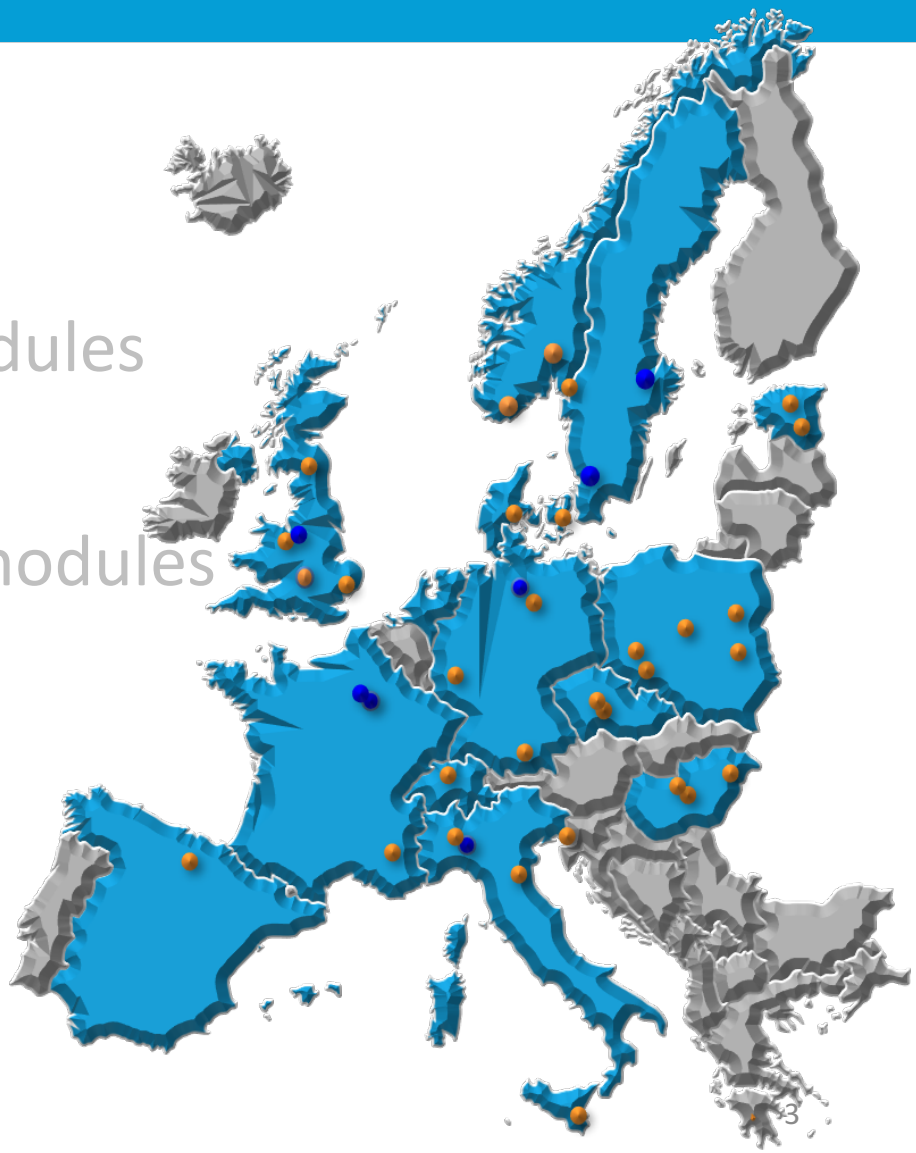
Outline

- Introduction
- Spoke cavities and cryomodules
- Elliptical cavities and cryomodules

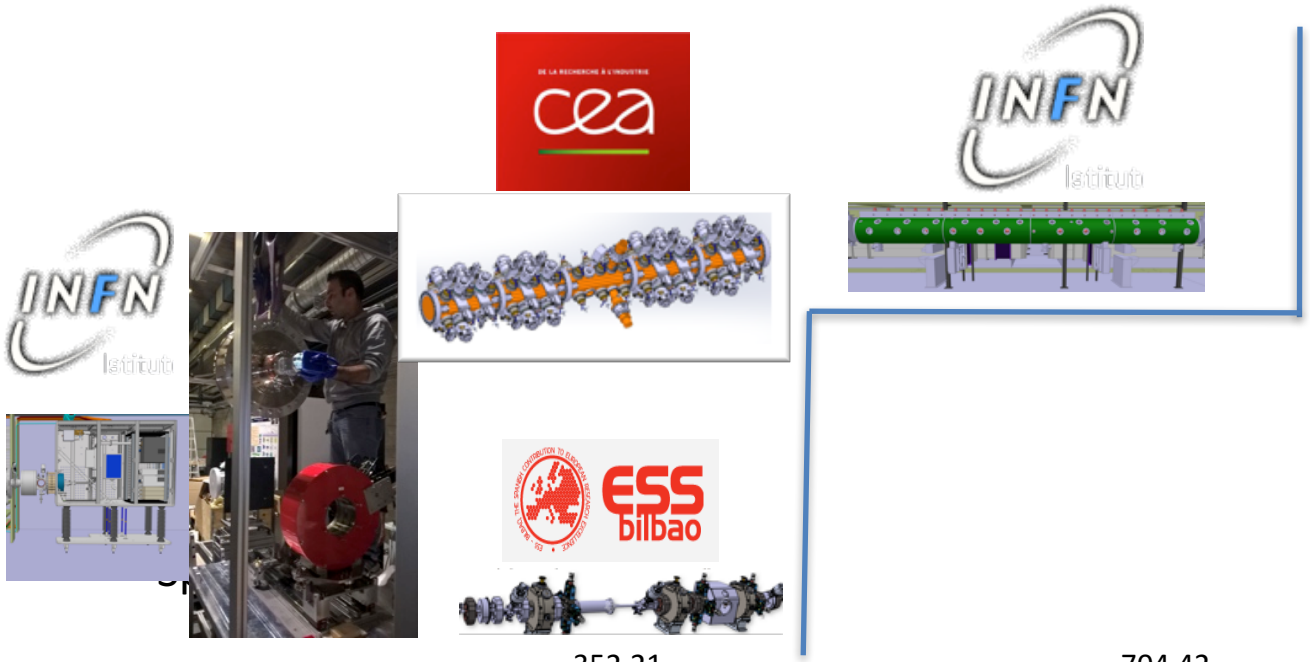


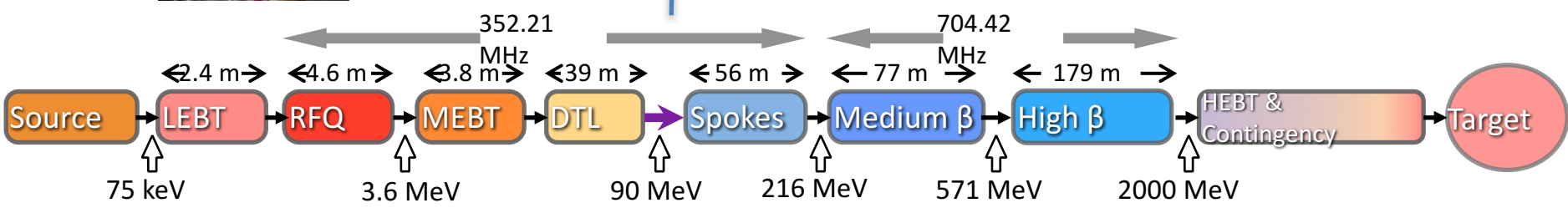
Outline

- Introduction
- Spoke cavities and cryomodules
- Elliptical cavities and cryomodules



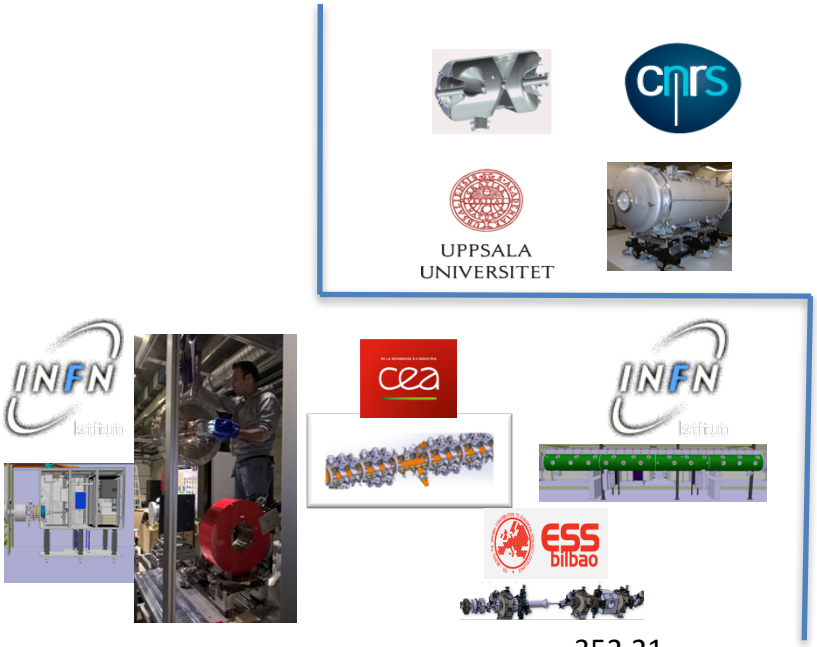
The ESS accelerator

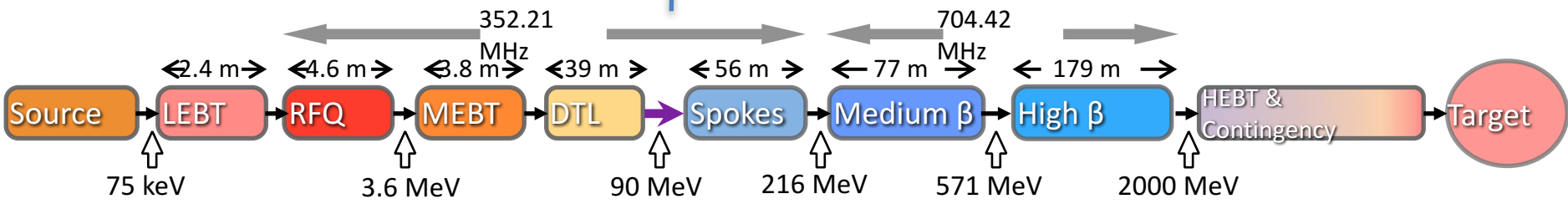




The ESS accelerator

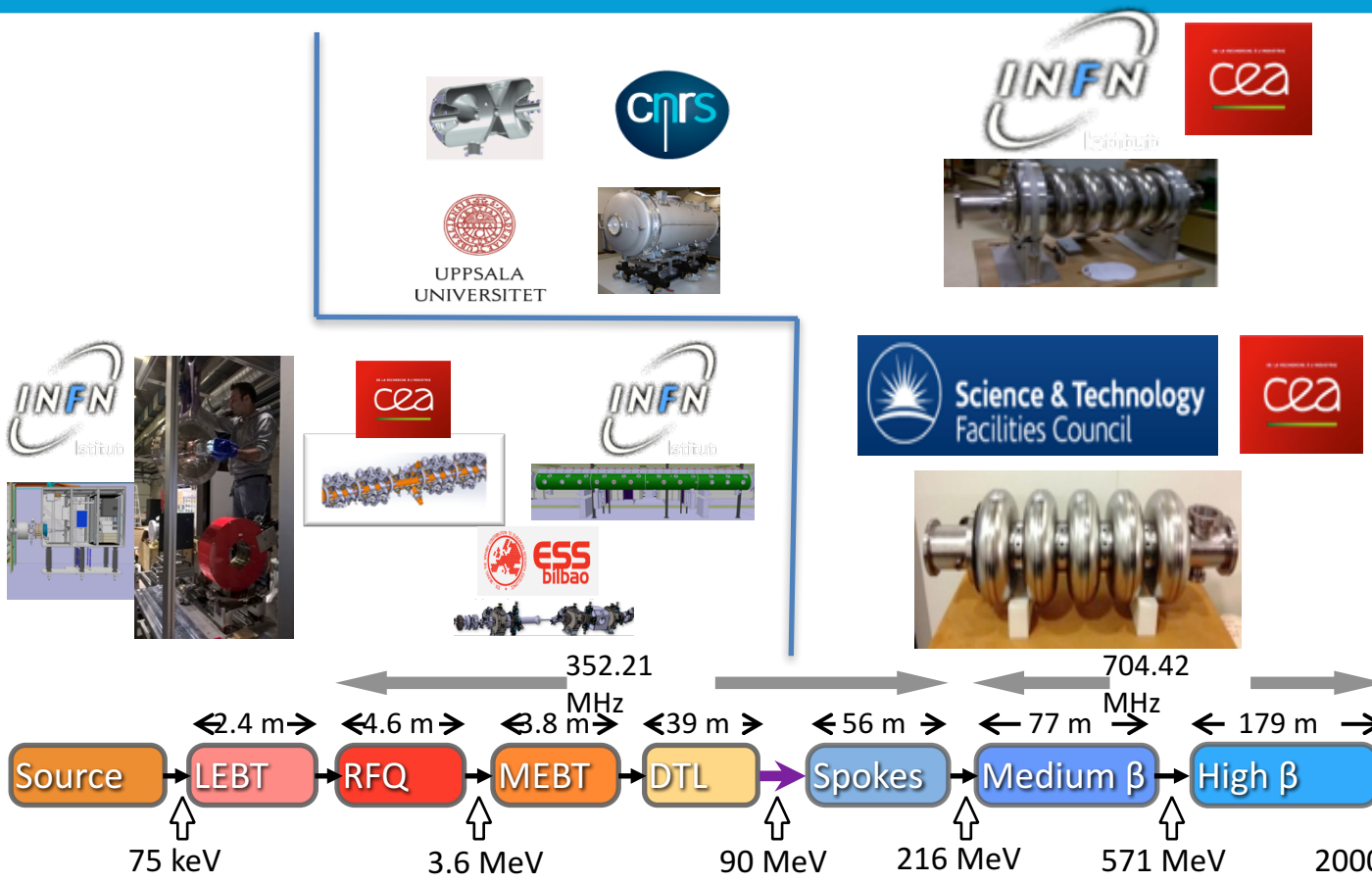
EUROPEAN SPALLATION SOURCE





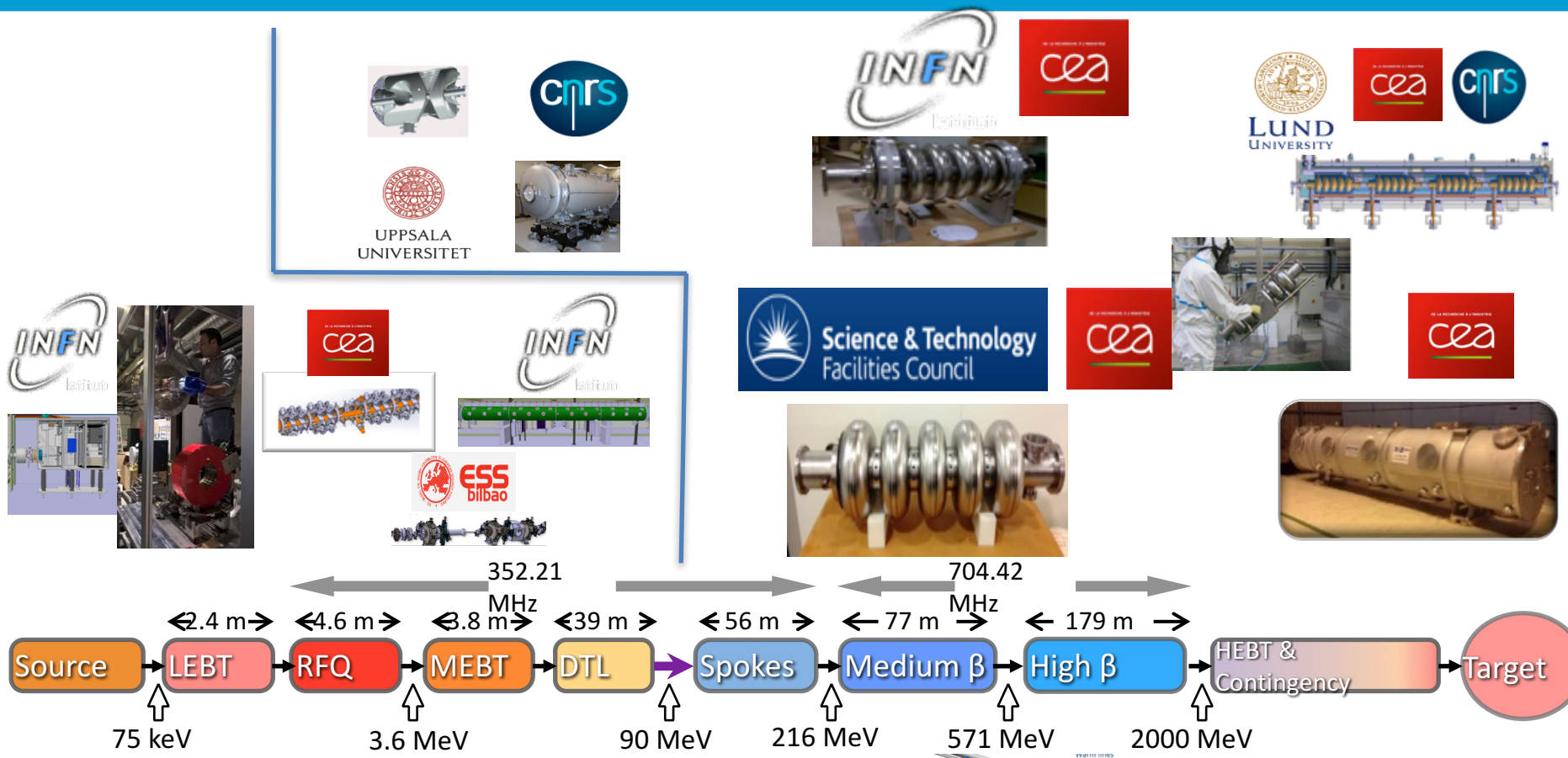
The ESS accelerator

EUROPEAN SPALLATION SOURCE



The ESS accelerator

EUROPEAN SPALLATION SOURCE



96 % of the beam acceleration by SRF

Cavity & cryomodule parameters

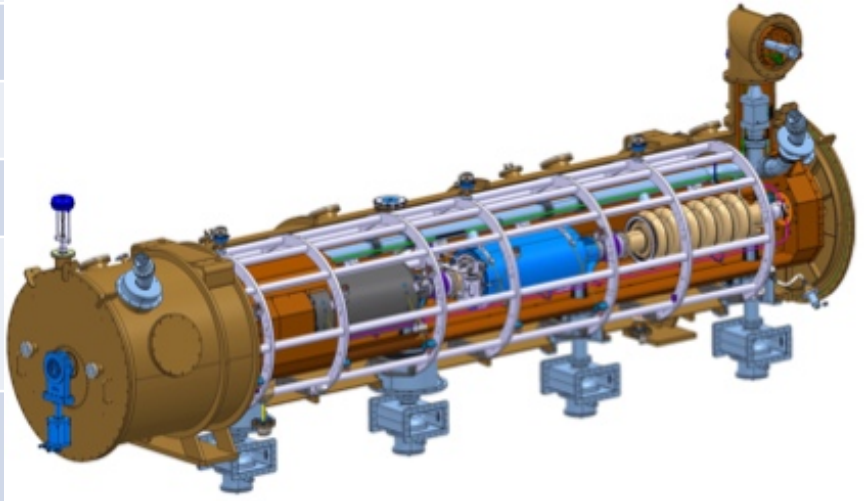
EUROPEAN SPALLATION SOURCE

	← 56 m →	← 77 m →	← 179 m →
	Spokes	Medium β	High β
Number of modules	13	9	21
Type of cavity	spoke	elliptical	elliptical
Cavities per module	2	4	4
Spokes / cells	2	6	5
Frequency / MHz	352.2	704.4	704.4
Geom. β	0.5	0.67	0.86
E_{acc} / MV/m	8	16.7	19.9
Cavity supply	IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY	INFN Istituto Nazionale di Fisica Nucleare	Science & Technology Facilities Council
Cryomodule supply	IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY	CEA – Saclay	CEA – Saclay

Cavity & cryomodule parameters

EUROPEAN SPALLATION SOURCE

	← 56 m →	← 77 m →	← 179 m →
	Spokes	Medium β	High β
Number of modules	13	9	21
Type of cavity	spoke	elliptical	elliptical
Cavities per module	2	4	4
Spokes / cells	2	6	5
Frequency /			
Geom. β			
E_{acc} / MV/m			
Cavity supply			
Cryomodule			

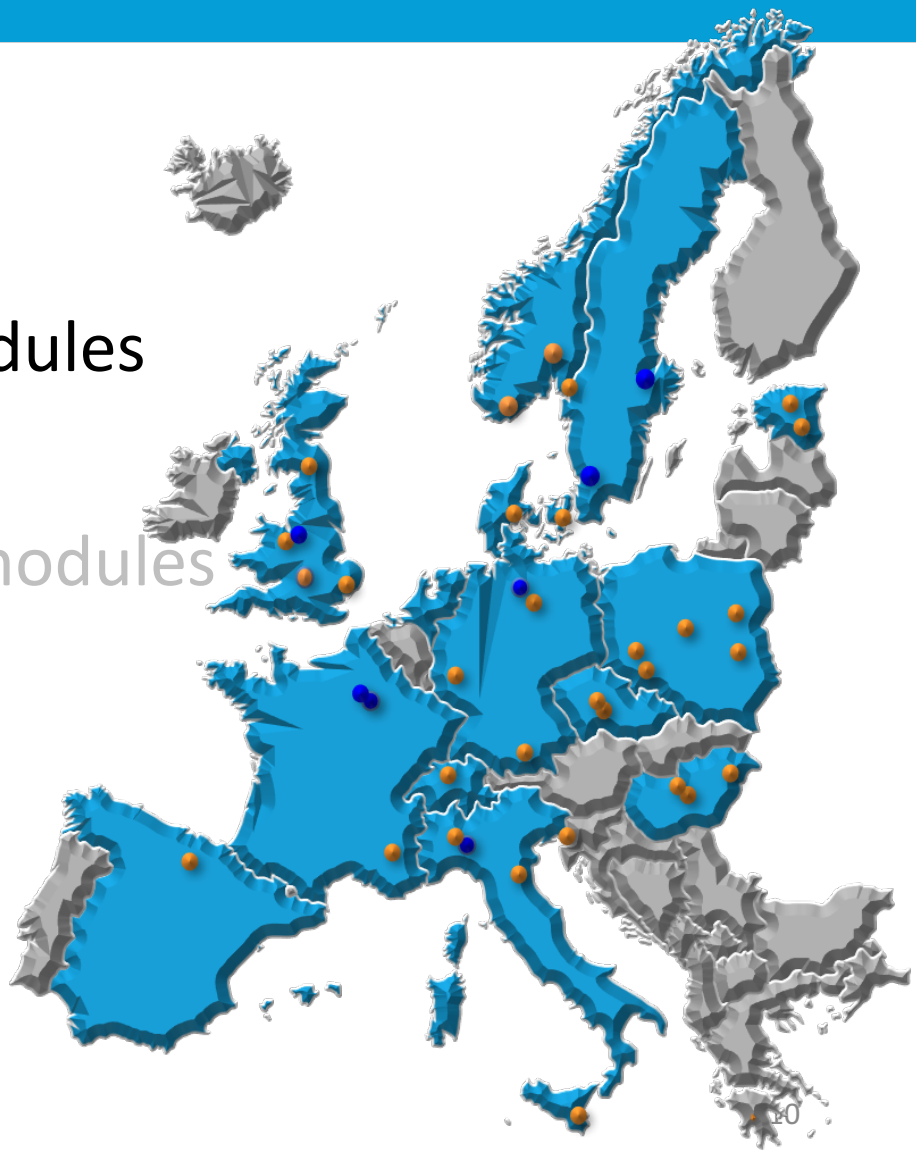


INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

CEA - Saclay

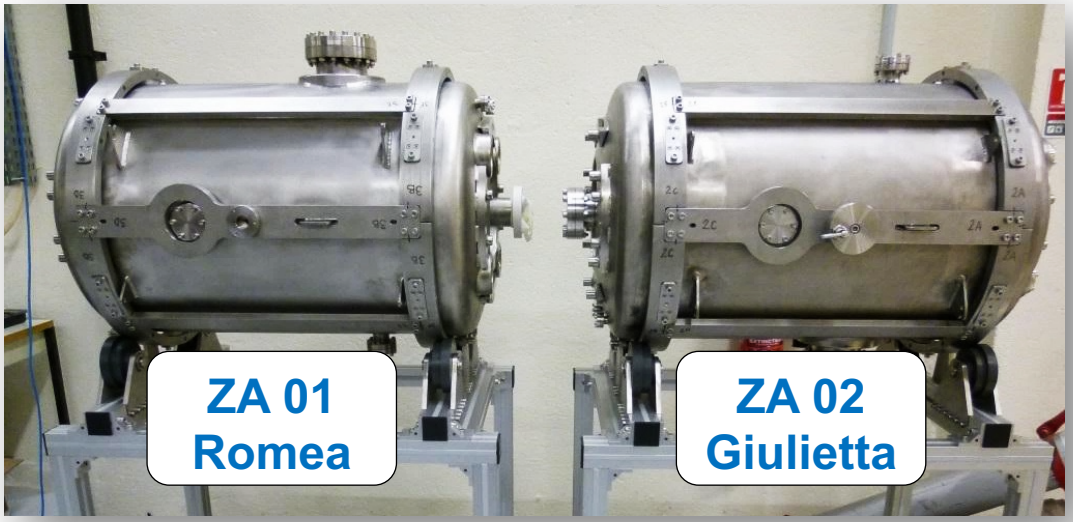
CEA - Saclay

- Introduction
- Spoke cavities and cryomodules
- Elliptical cavities and cryomodules



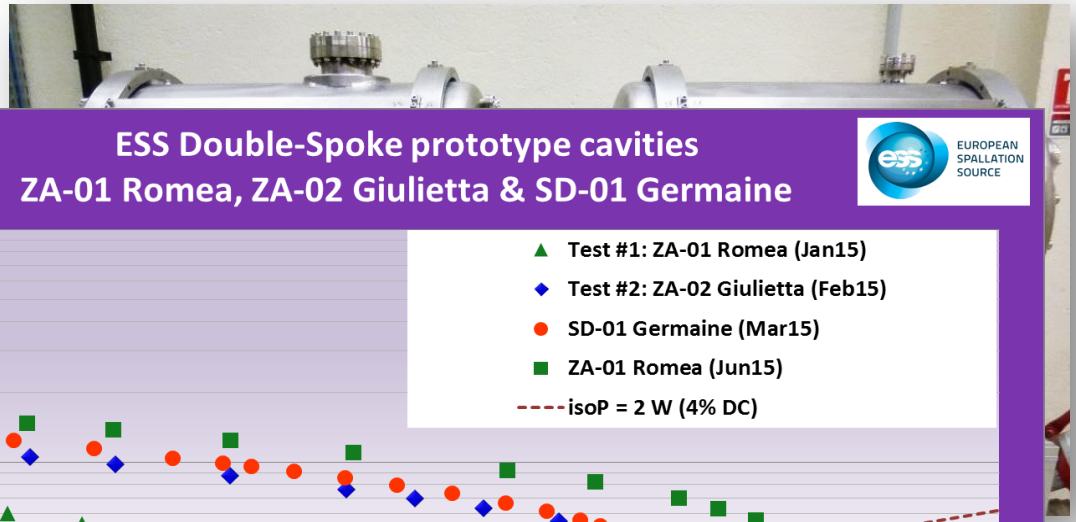
Spoke cavities – vertical test results

DOUBLE-SPOKE CAVITY	
Frequency [MHz]	352.21
Beta_optimum	0.50
Operating gradient [MV/m]	9.0
Temperature (K)	2
Bpk [mT]	61
Epk [MV/m]	38
G [Ohm]	133
r/Q [Ohm]	427
Lacc (=beta optimal x nb of gaps x λ /2) [m]	0.639
Bpk/Eacc [mT/MV/m]	6.8
Epk/Eacc	4.3
P max [kW]	335

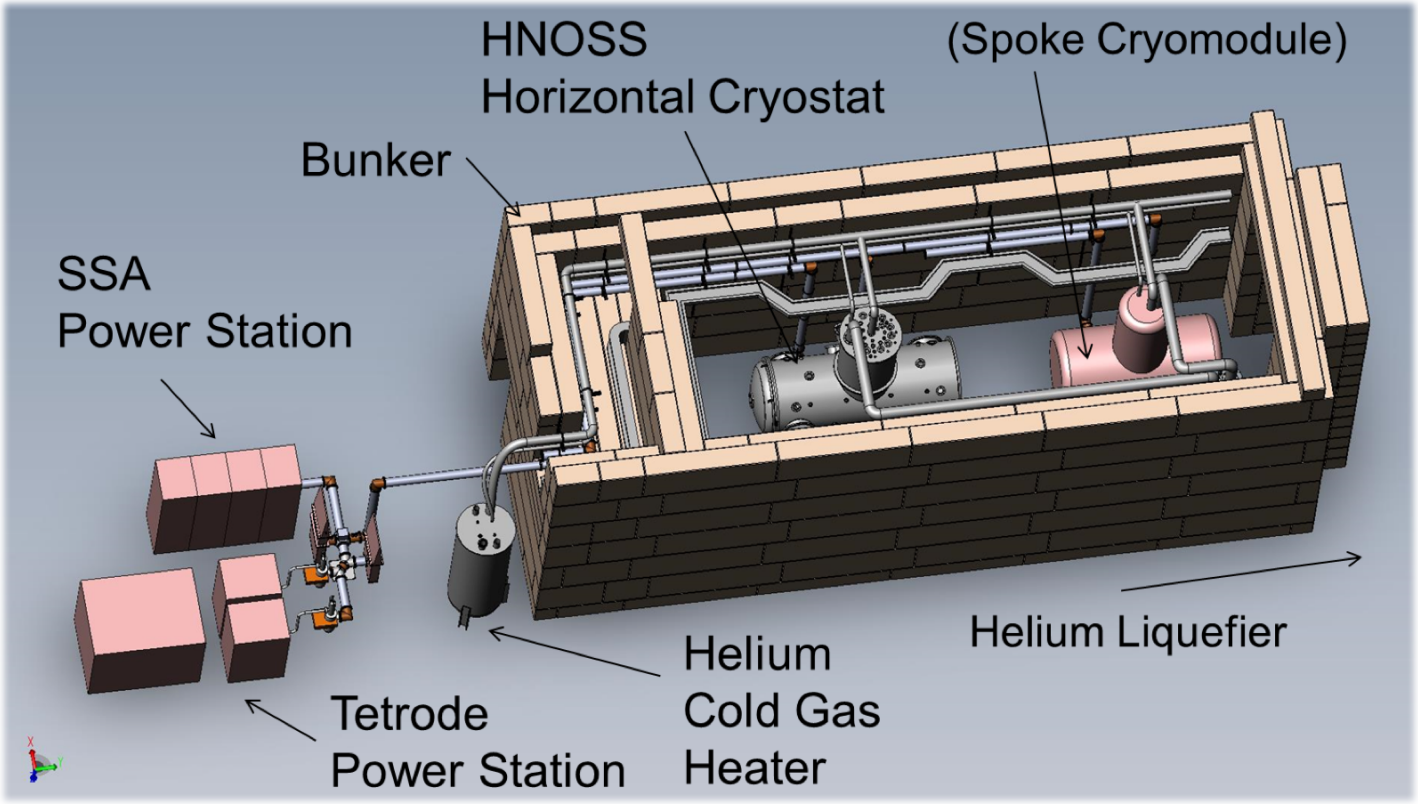


Spoke cavities – vertical test results

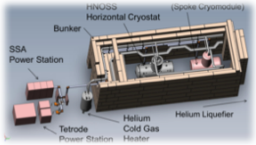
DOUBLE-SPOKE CAVITY	
Frequency [MHz]	352.21
Beta_optimum	
Operating gradient [MV/m	
Temperature (K)	
Bpk [mT]	
Epk [MV/m]	
G [Ohm]	
r/Q [Ohm]	
Lacc (=beta optimal x nb of gaps x λ /	
Bpk/Eacc [mT/MV/m]	
Epk/Eacc	
P max [kW]	

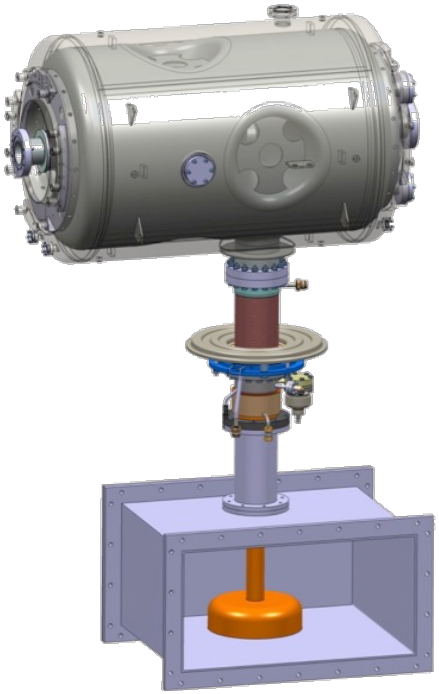


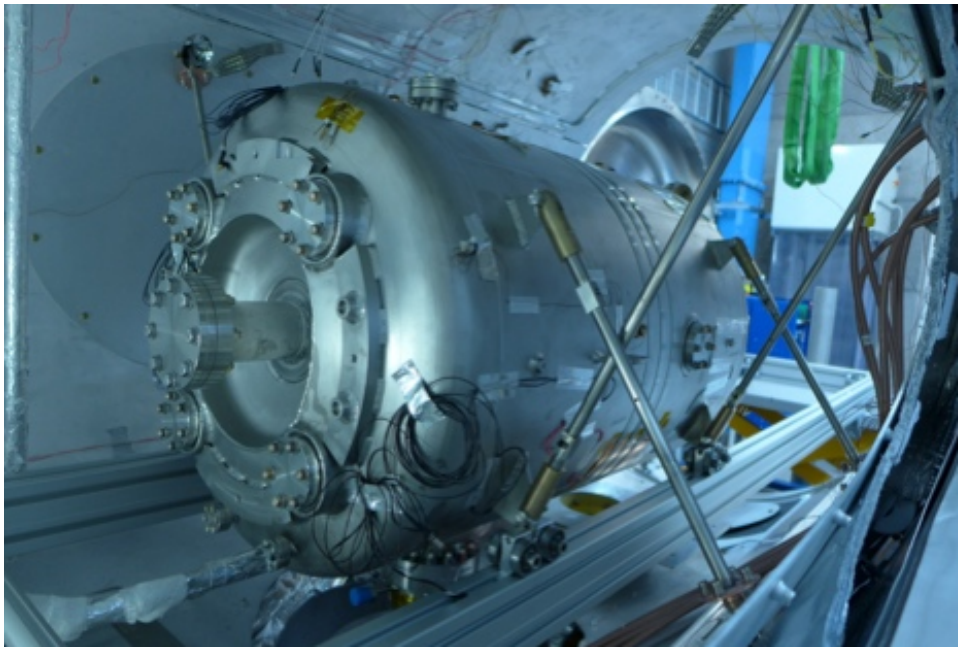
Romea High Power test @ FREIA



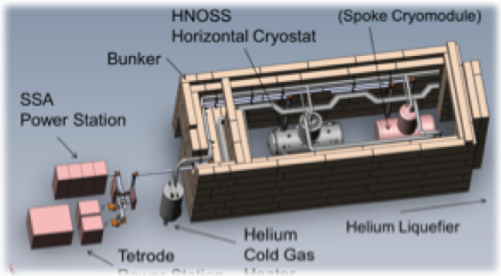
Romea High Power test @ FREIA

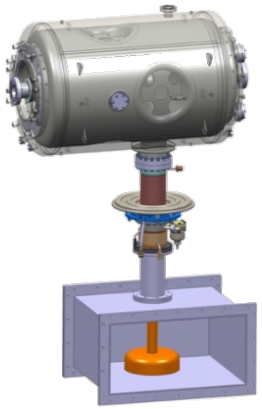


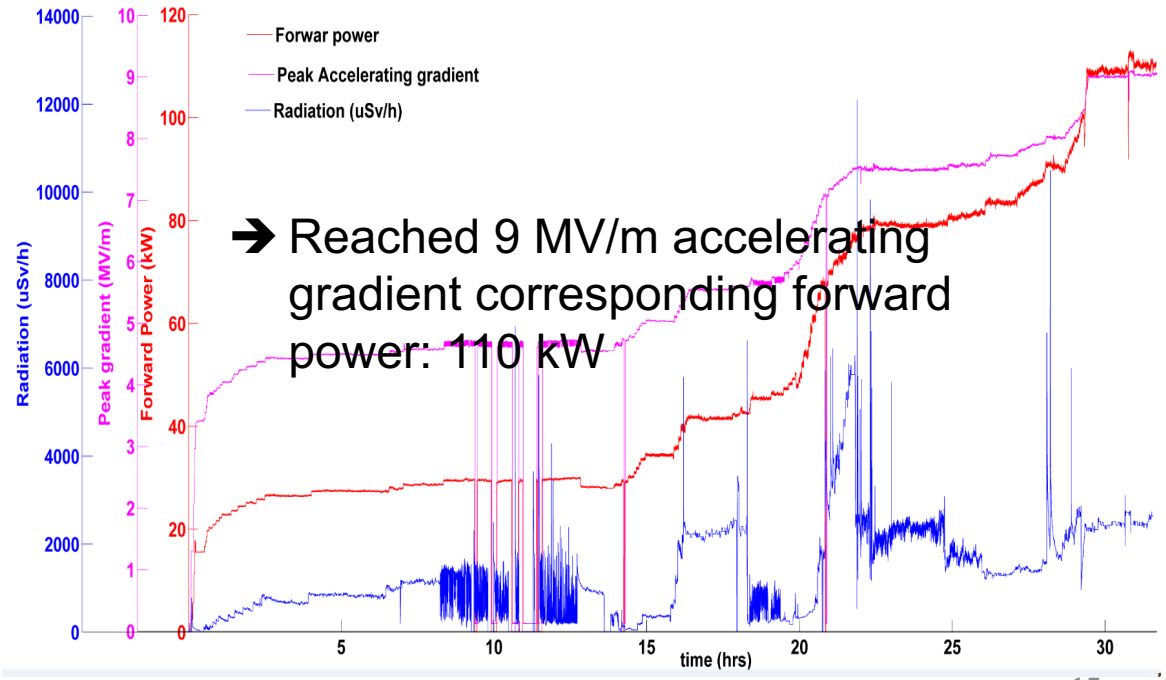




Romea High Power test @ FREIA



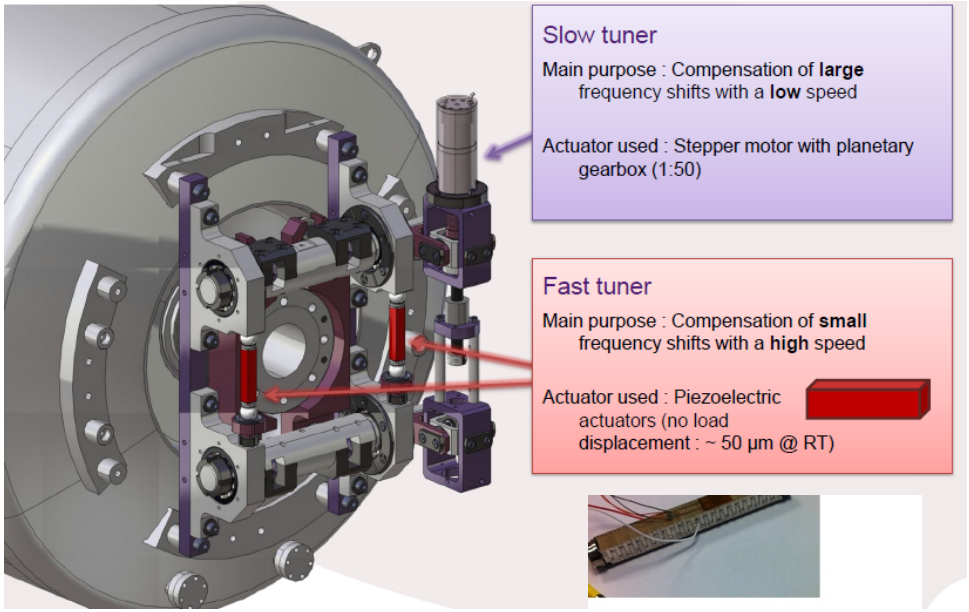




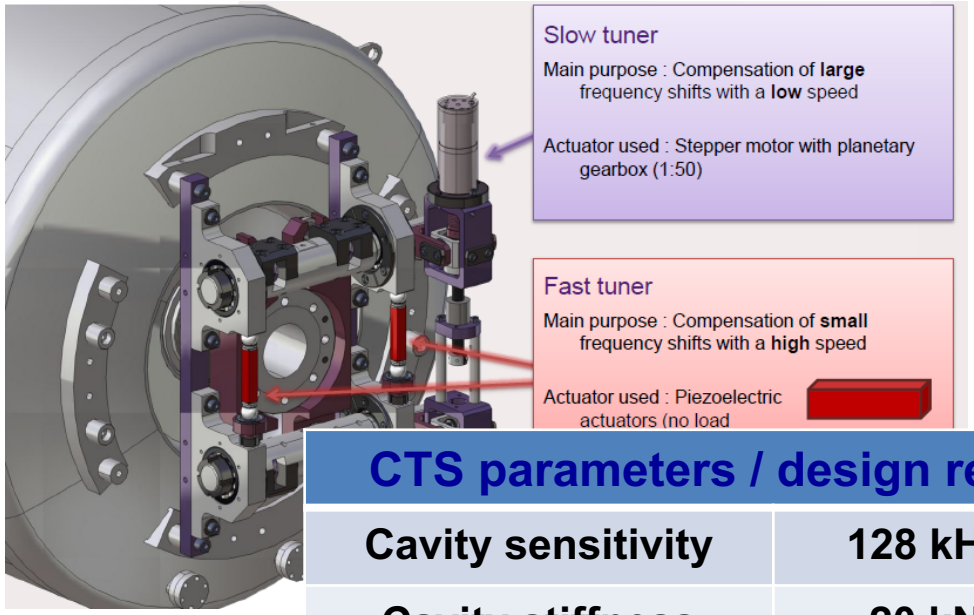
THPB035 – H. Li

Thanks to: H. Li, M. Jobs, R. S. Kern, A. K. Bhattacharyya, R. Ruber, L. Hermansson

Spoke cryomodule prototype - tuner



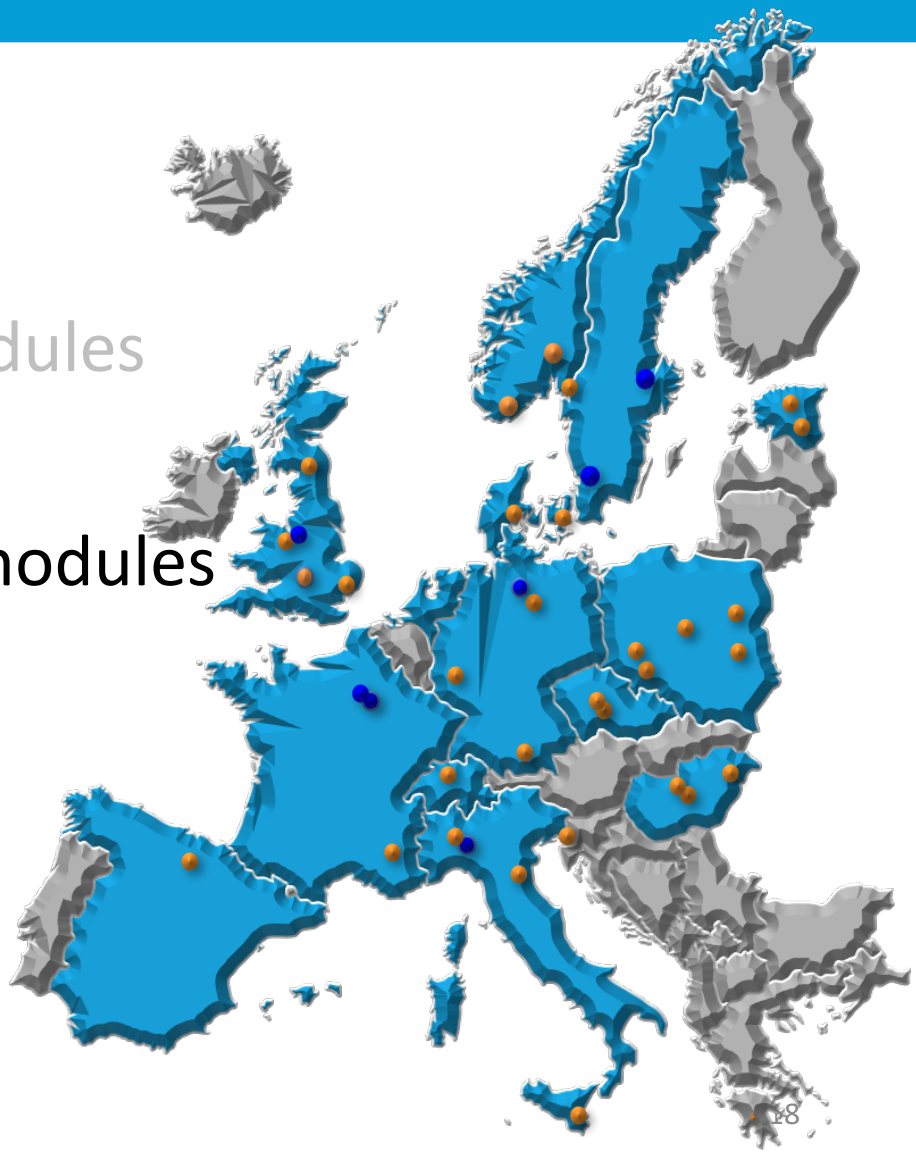
Spoke cryomodule prototype - tuner



CTS parameters / design results	
Cavity sensitivity	128 kHz/mm
Cavity stiffness	20 kN/mm
Max cavity deformation	1.28 mm
Coarse tuning range	1.28 mm / 160 kHz
Resolution	1 Hz/step
Piezo range @RT @2 K	~ 1.5 kHz *~ 675 Hz*

EUROPEAN SPALLATION SOURCE

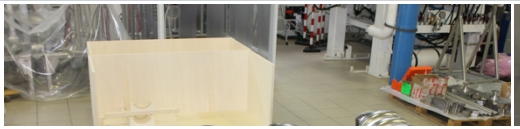
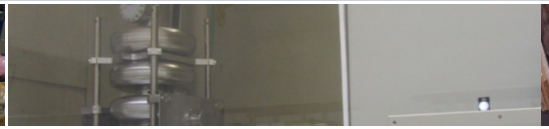
- Introduction
- Spoke cavities and cryomodules
- Elliptical cavities and cryomodules

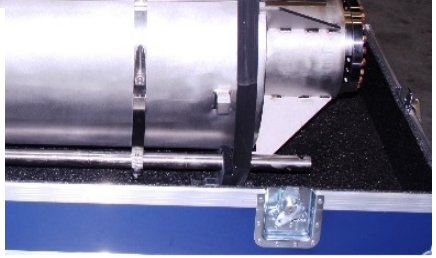


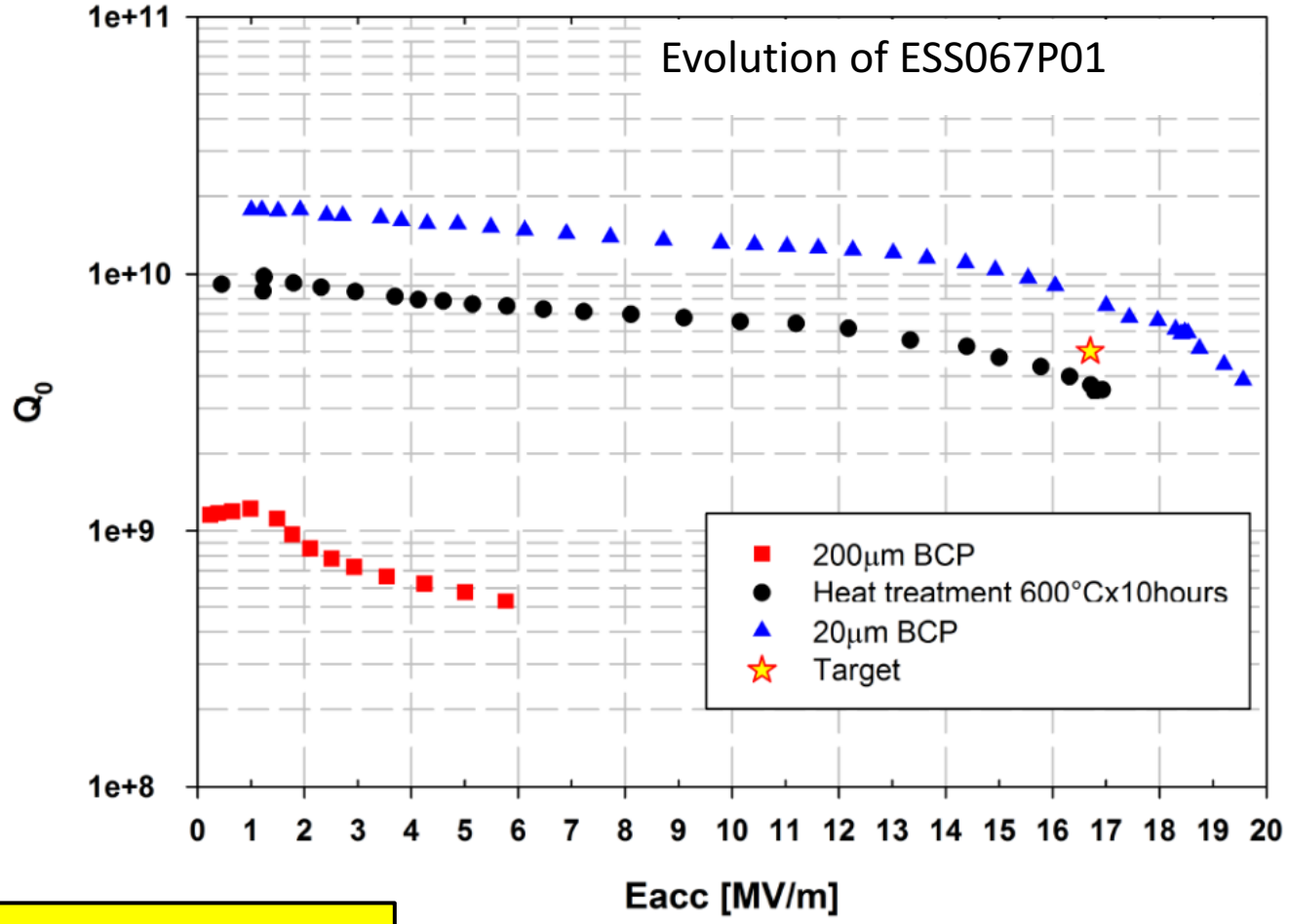
Elliptical cavity prototypes @ CEA

TUPB007 – E. Cenni

Elliptical cavity prototypes @ CEA

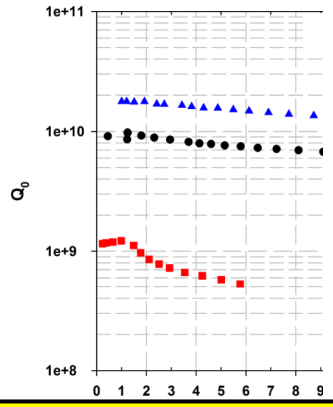



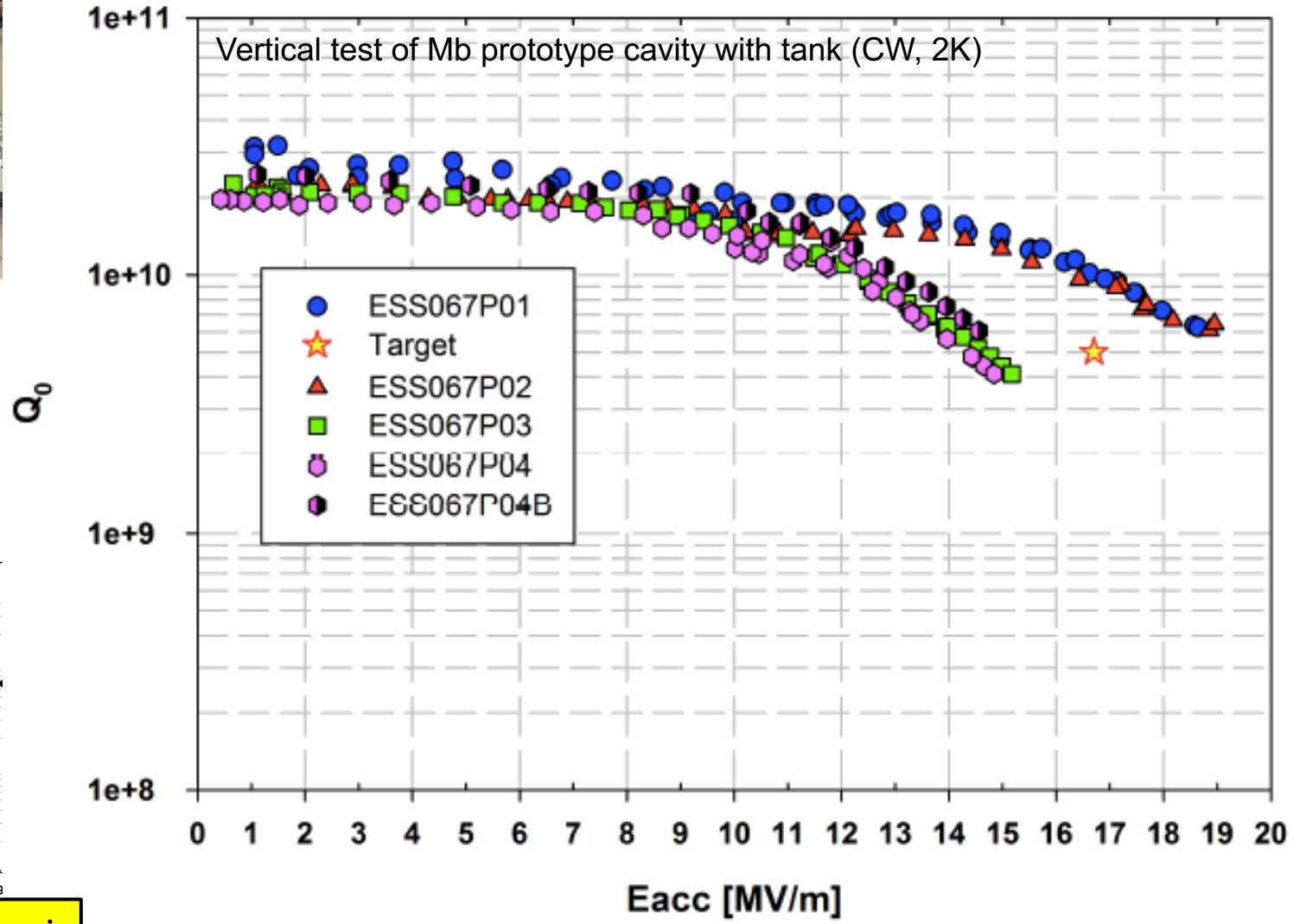





TUPB007 – E. Cenni

Elliptical cavity prototypes @ CEA



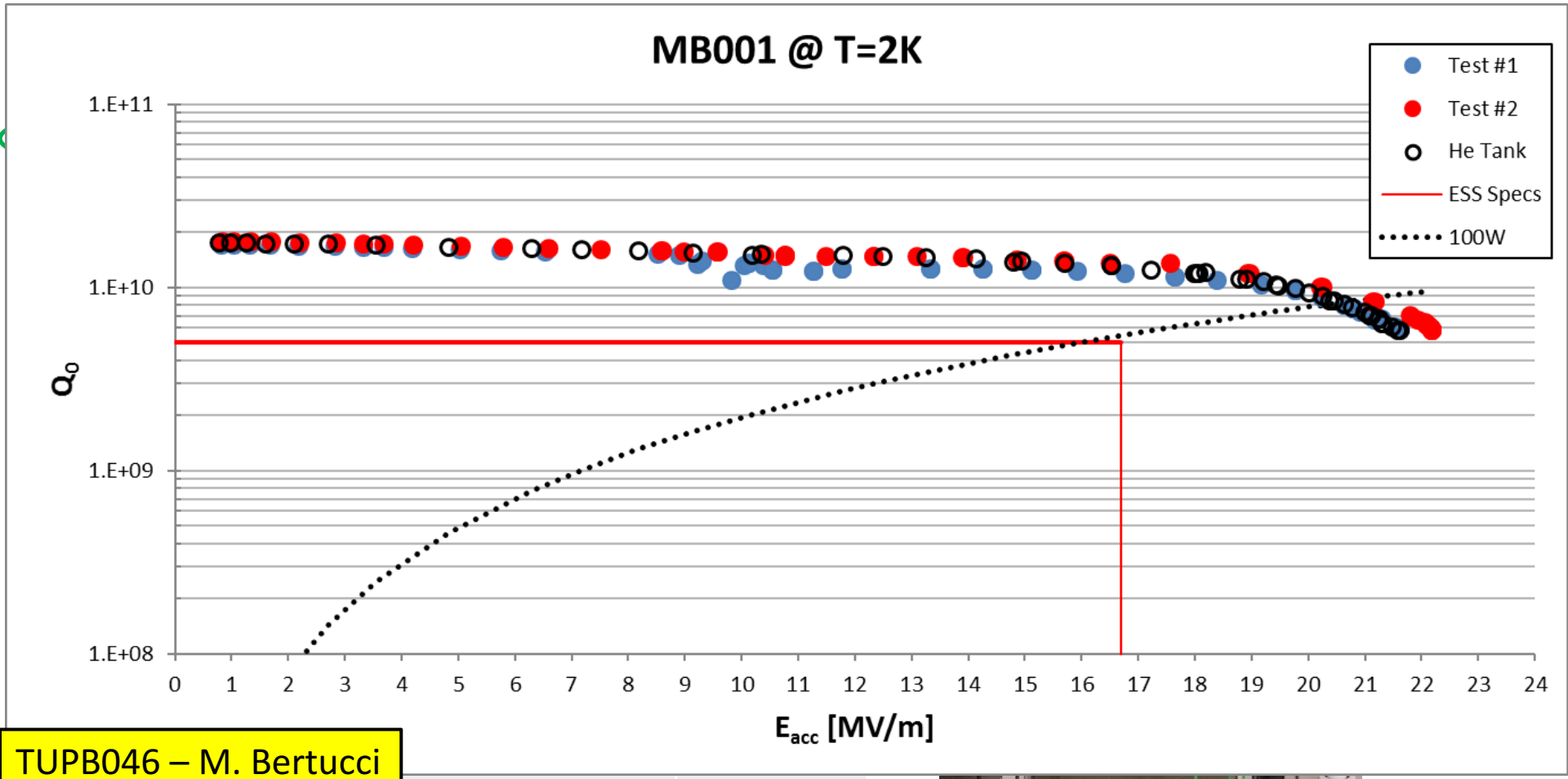


TUPB007 – E. Cenni

Medium-beta prototypes @ LASA

Parameters	INFN design	ESS req.
R_{iris} (mm)	50	≥47
Cell to cell coupling k	1.55%↗(+26%)	
π-5π/6 mode sep.(MHz)	0.70↗(+30%)	>0.45
G (Ω)	198.8	
Optimum beta, β_{opt}	0.705	0.705
Max R/Q at β_{opt} (Ω)	374 ↘ (-6%)	
E_{acc} at β_{opt} (MV/m)	16.7	16.7
E_{peak}/E_{acc}	2.55 ↗ (+7%)	
E_{peak} (MV/m)	42.6	< 45
B_{peak}/E_{acc}(mT/MV/m)	4.95 ↗ (+3%)	
Q_0 at nominal gradient	$>5\times10^9$	$>5\times10^9$
Q_{ext}	7.8×10^5	$5.9\sim8\times10^5$

Medium-beta prototypes @ LASA

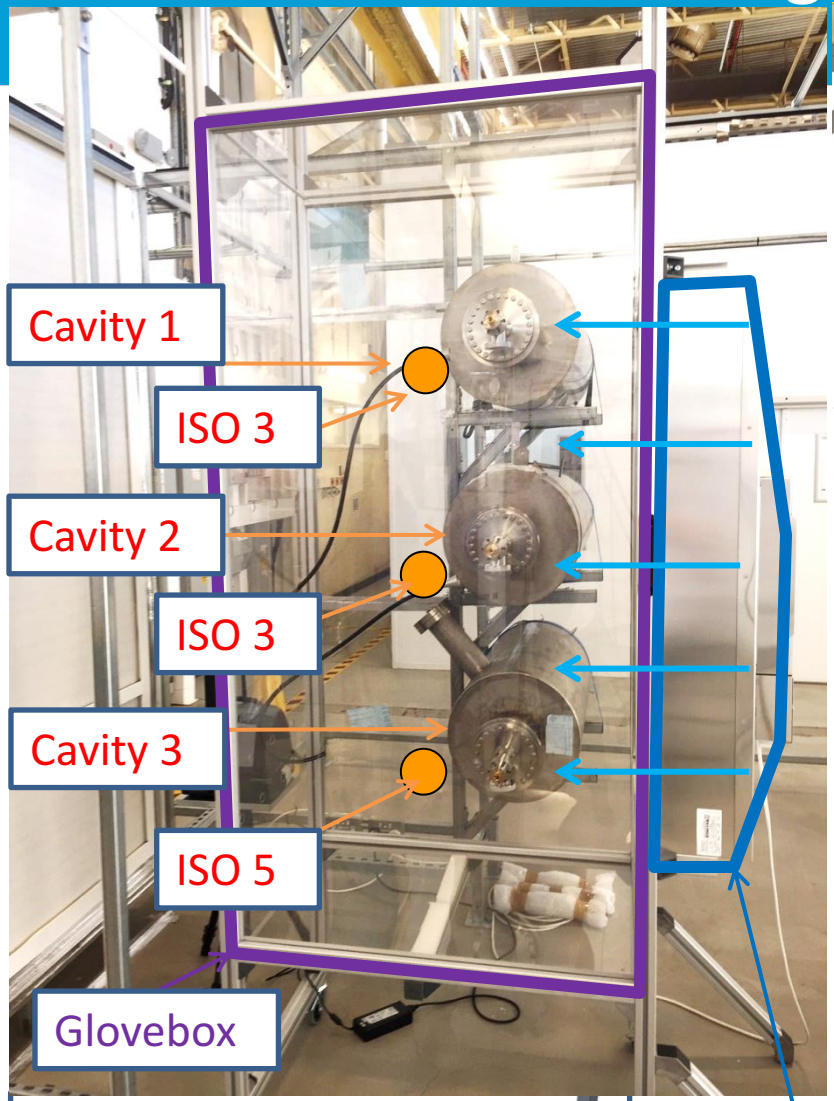


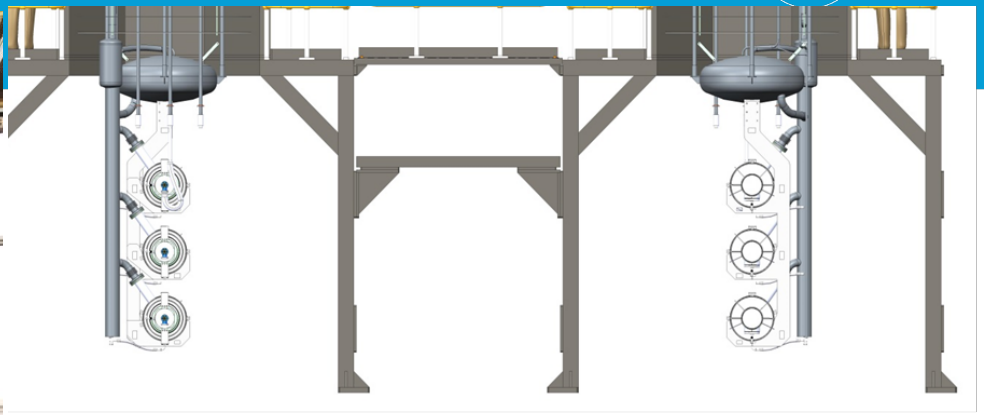
TUPB046 – M. Bertucci

TUPB047 – J. Chen

TUPB048 – D. Sertore

Status @ STFC for high-beta cavities

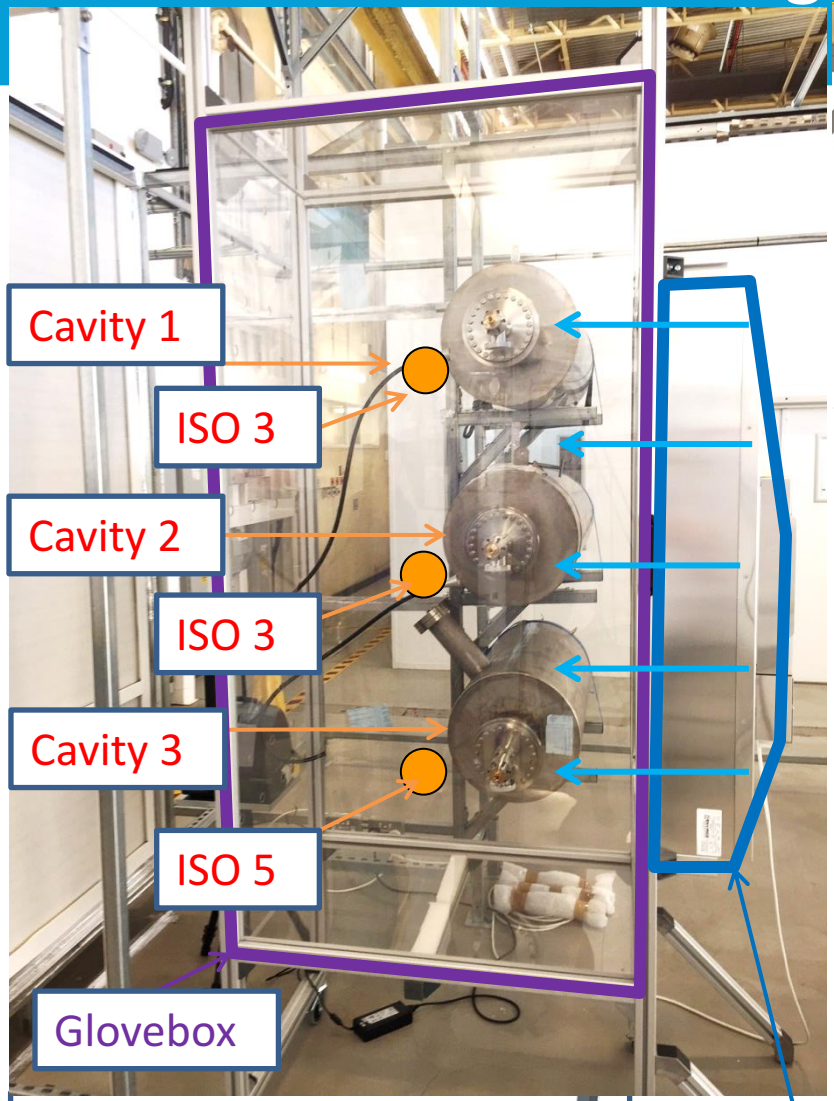


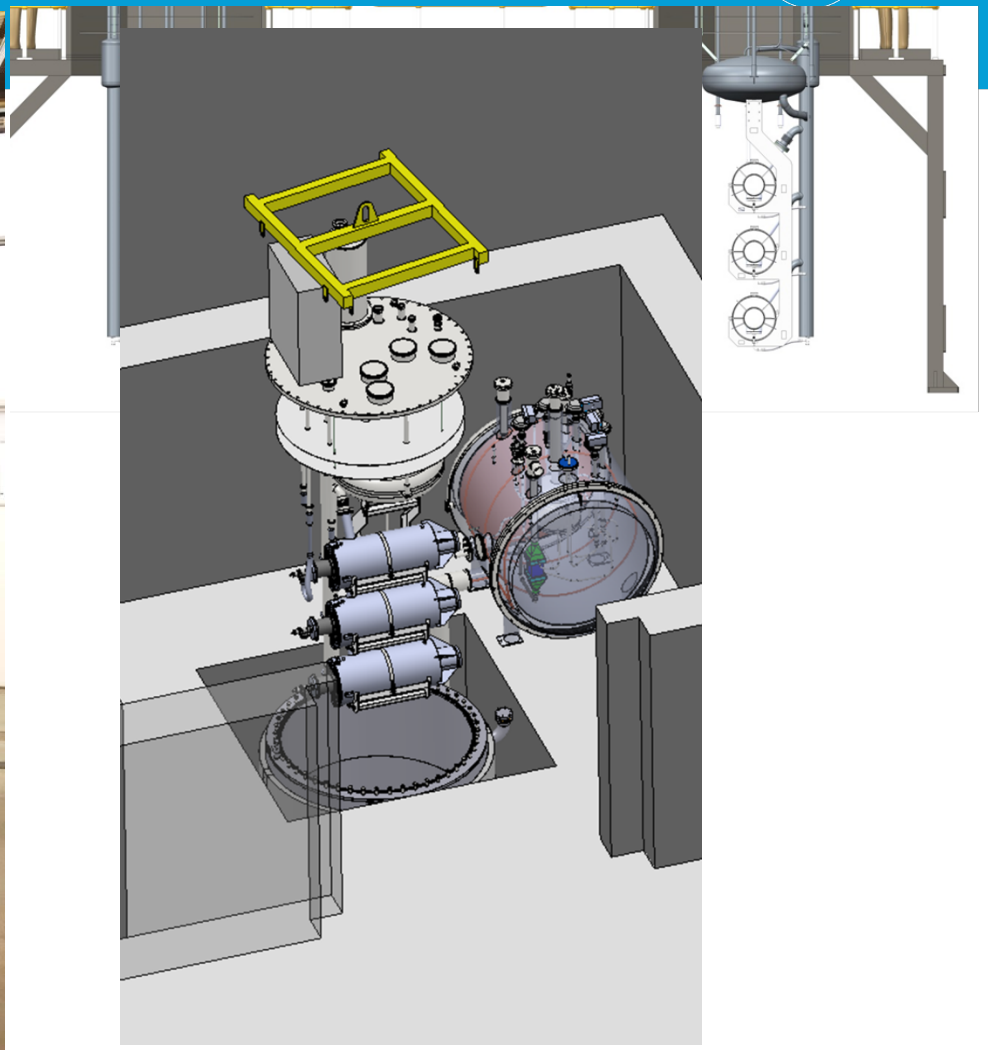


Laminar Flow Unit

Thanks :
Mark Pendleton & Phil Davies

Status @ STFC for high-beta cavities





Thanks :

TUPB060 – L. Bizel-Bizellot

Status @ STFC for high-beta cavities

Status @ STFC for high-beta cavities

Status @ STFC for high-beta cavities

EUROPEAN SPALLATION SOURCE

Step 1: Copper coax cavity, 300K **(complete)**
- validates freq tracking of the LLRF system
  - Q~5000 $\tau_L = QL/\omega \sim 1\mu s$
  - Heated & cooled ± 10-20°C approx
- SEL –works, ioc software with labview being developed

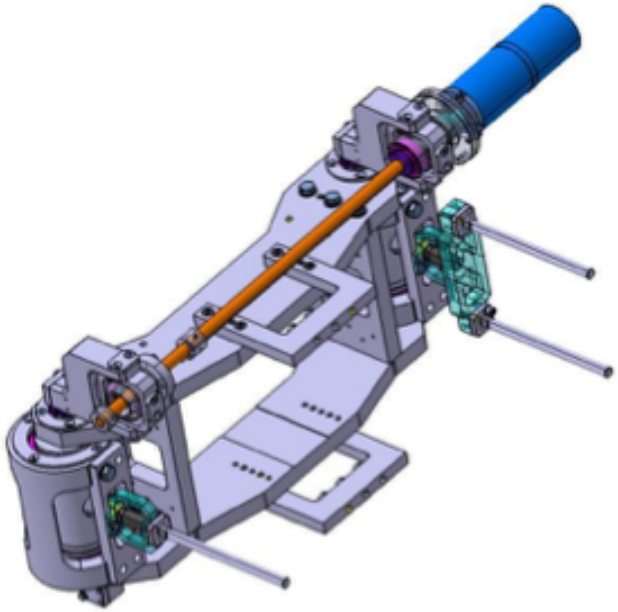
Step 2: Niobium coax cavity < 9.3K **(ongoing)**
- Cryocooler being configured
  - $Q \sim 10^7$ to 10^8; $\tau_L \sim 23ms$
  - Higher Q test of LLRF
  - Low power testing of rack & control SW
- Aluminium mock-up (right) to check 'clean' assembly method

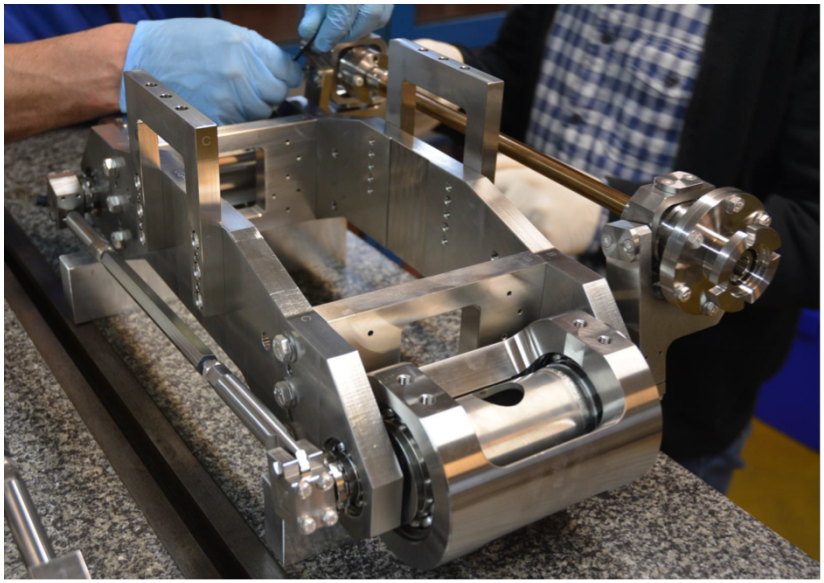
Step 3: Niobium elliptical HB cavity P02 (CEA) **(planning)**
- Step-by-step commissioning of Vertical Test Facility
- High power testing
  - $Q \sim 5 \times 10^9$ at ~20MV/m
  - Needs radiation shield & large cryostat!
- Also testing handling, loading, cryostat etc

MOPB040 – P.A. Smith

Elliptical tuning system

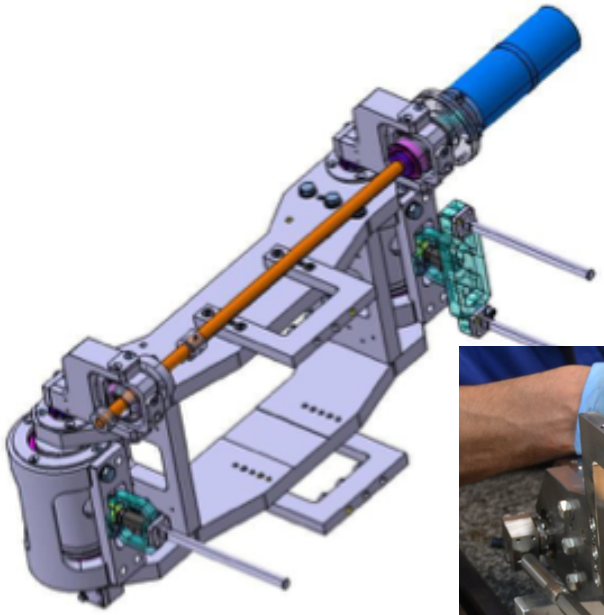
Saclay V tuner, adapted for ESS cavities





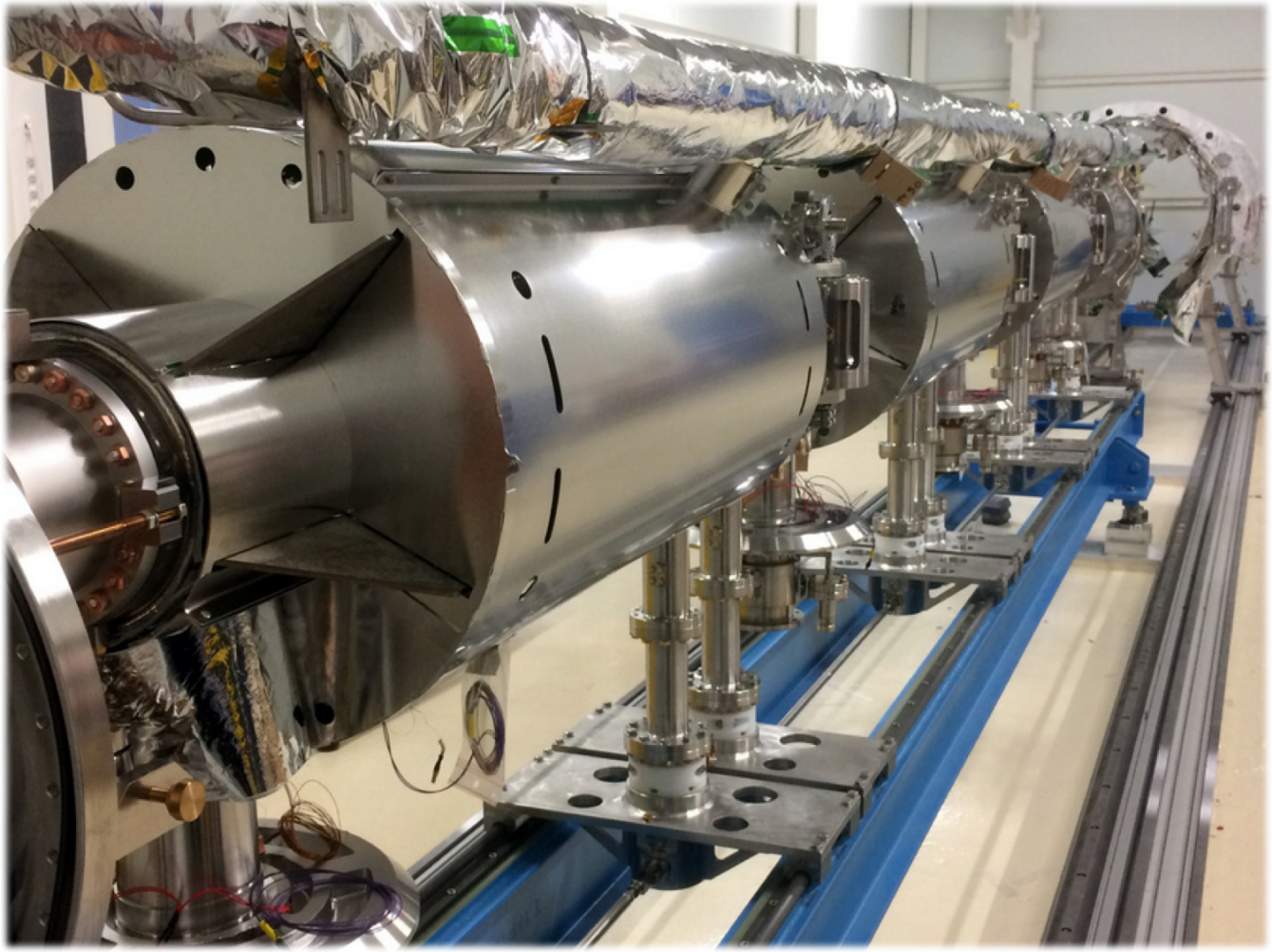
Elliptical tuning system

Saclay V tuner, adapted for ESS cavities



CTS parameters / medium-beta	
Cavity sensitivity	215 kHz/mm
Cavity stiffness	1.3 kN/mm
Coarse tuning range	650 kHz

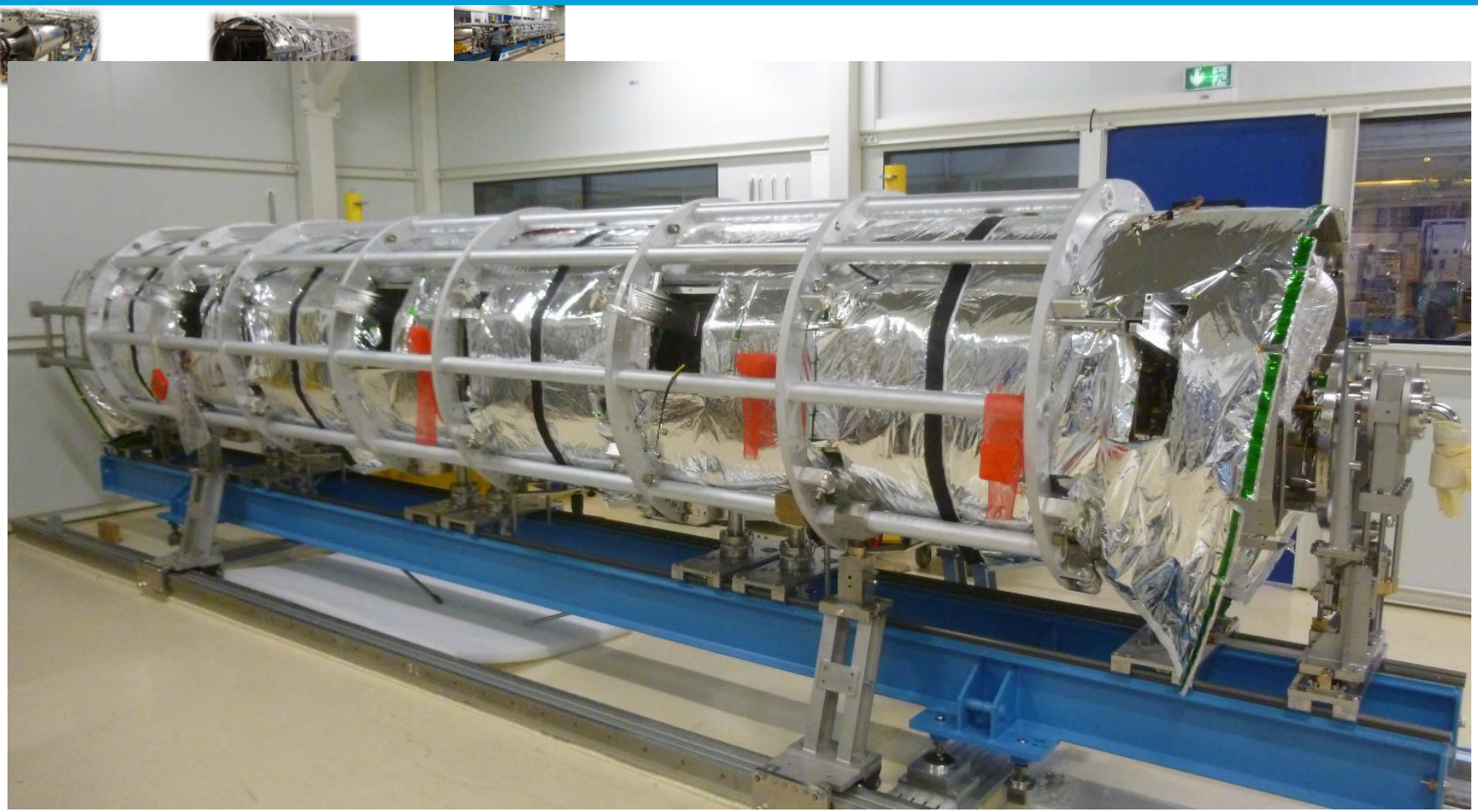
Medium-beta prototype cryomodule



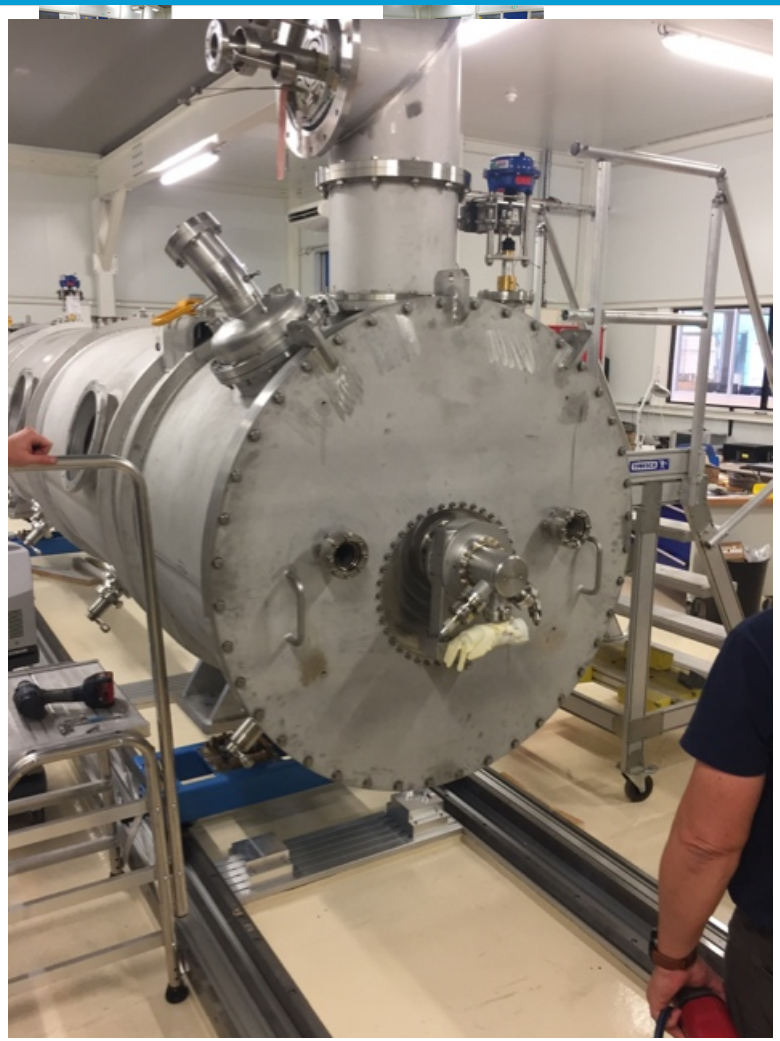
Medium-beta prototype cryomodule

Medium-beta prototype cryomodule

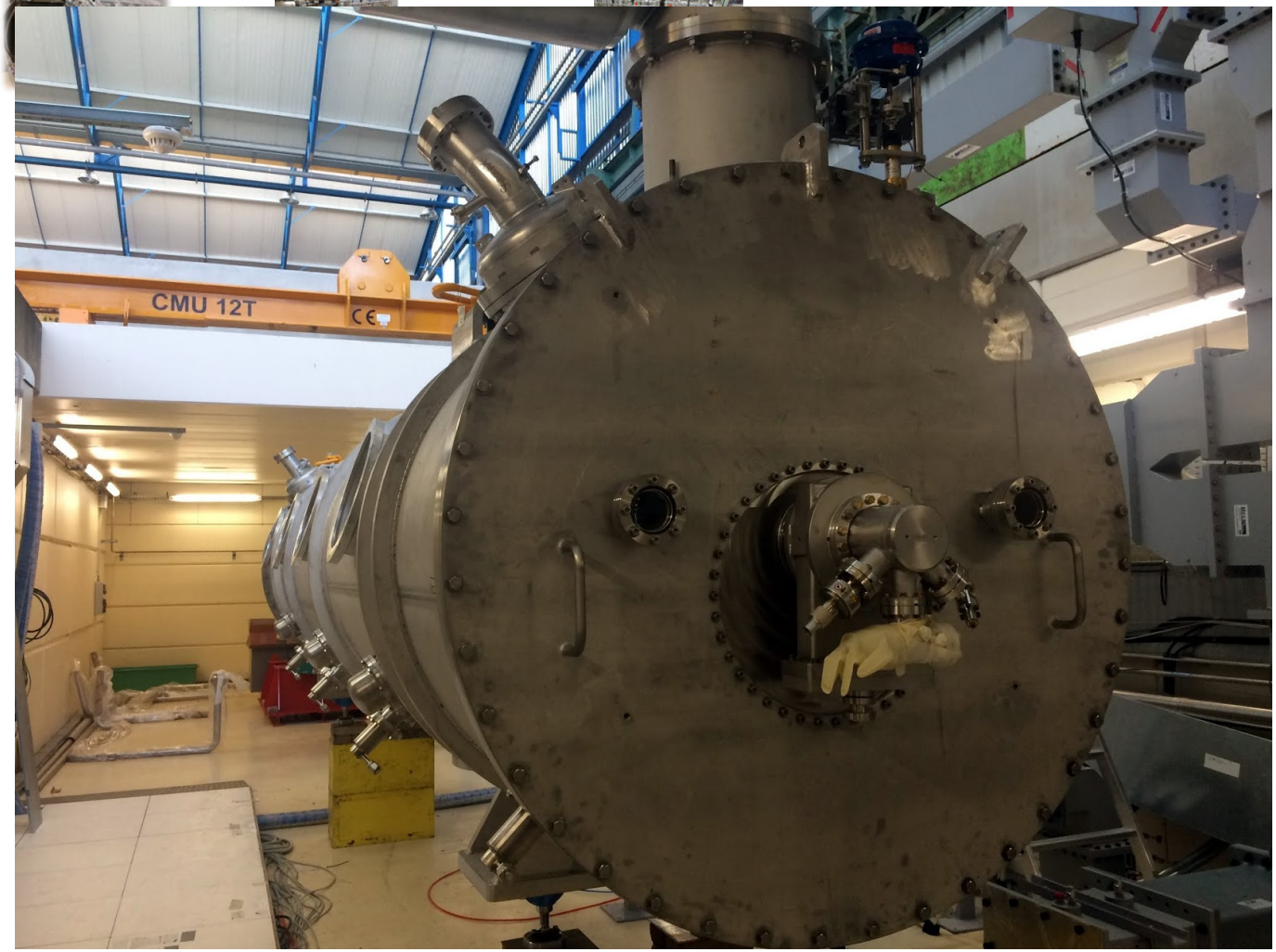
Medium-beta prototype cryomodule



Medium-beta prototype cryomodule

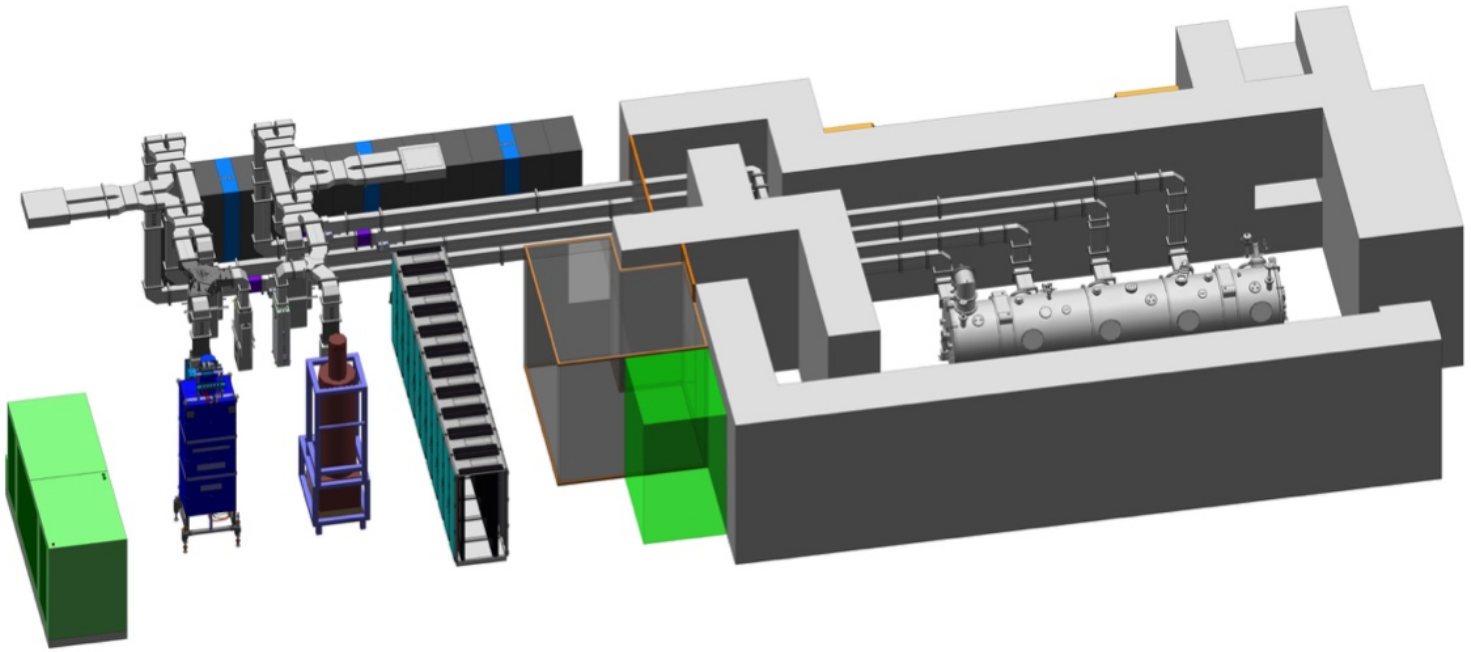


Medium-beta prototype cryomodule



THYA05 – F. Peauger

Testing at test stand 2 @ ESS



MOPB018 – N. Elias

ESS related contributions at

EUROPEAN SPALLATION SOURCE

MOPB018	Testing of SRF cavities and cryomodules for the European Spallation Source	**N. Elias**, E. Asensi Conejero, C. Darve, F. Håkansson, W. Hees, C. . Maiano, F. Schlander
MOPB019	Interface Challenges for the SRF Cryomodules for the European Spallation Source	**F. Schlander**, C. Darve, N. Elias, C. G. Maiano, P. Bosland, G. Olry
MOPB020	An Optimal Procedure for Coupler Conditioning for ESS Superconducting Linac	**R. Zeng**, E. Asensi Conejero, C. G. Maiano, H. Li
MOPB040	ESS High Beta Cavity Test Preparations at Daresbury Laboratory	**P. A. Smith**, L. Bizel-Bizellot, K. Dumbell, M. Ellis, P. Goudket, A. Moss, E. F. Palade, S. Pattalwar, M. D. Pendleton, A. Wheelhouse
TUPB007	Vertical Test Results on Ess Medium Beta Elliptical Cavity Prototypes Equipped With Helium Tank	**E. Cenni**
TUPB046	Experience on large-grain multi-cell cavity based on INFN-LASA medium-beta design for the ESS	**M. Bertucci**, A. Bignami, A. Bosotti, J. Chen, P. Michelato, L. Monaco, R. Paparella, D. Sertore, C. Pagani
TUPB047	Passband Modes Excitation Triggered by Field Emission in Ess Medium Beta Cavity Prototype	**J. Chen**, M. Bertucci, A. Bosotti, P. Michelato, L. Monaco, R. Paparella, D. Sertore, M. Eshraqi, M. Lindroos, S. Pirani, T. P. Å. Åkesson, C. Pagani
TUPB048	INFN- LASA Medium Beta Cavity Prototypes for ESS Linac	**D. Sertore,** M. Bertucci, A. Bignami, A. Bosotti, J. Chen, P. Michelato, L. Monaco, R. Paparella, S. Pirani, C. Pagani
TUPB060	Innovative Cryogenic Test Facility for Testing SRF Cavity Series Production	**L. Bizel-Bizellot**, M. Ellis, S. Pattalwar, M. D. Pendleton, P. A. Smith, A. Wheelhouse
THPB035	High Power Testing of the First Dressed ESS RF Cavity	**H. Li**, K. Gajewski, L. Hermansson, M. Jobs, R. Ruber, R. Santiago Kern
THYA05	Developments and progress with ESS Elliptical Cryomodules at CEA-Saclay and IPN-Orsay	**F. Peauger**

→ Not mentioned during presentation

Acknowledgements

Special thanks to all partners in the ESS SRF collaboration:
CEA Saclay Freia @ Uppsala University
INFN LASA Milano IPN Orsay
Lund University STFC Daresbury