



## International Collaboraton

# View from INFN

Carlo Pagani – Univ. of Milano & INFN-LASA  
PIP-II CD-1 Independent Project Review  
12-14 December 2017

In partnership with:  
India/DAE  
Italy/INFN  
UK/STFC  
France/CEA/Irfu, CNRS/IN2P3

---

# Outline

- Context: long tradition of Fermilab and INFN collaboration
  - Physics
  - Accelerators: TESLA, ILC, S1-Global, ...
- Other SRF experience at INFN-LASA:
  - LEP-II with Industry
  - ADS: beam dynamics, reliability, elliptical cavities, ...
  - SNS cavity design
  - European XFEL: cold masses, cavities, 3H module, ...
  - ESS: 36 MB cavities, dressed and qualified
  - PIP-II: in progress!

# INFN and Fermilab Collaboration

- INFN and Fermilab have a long tradition of fruitful collaboration on High Energy Phys. and accelerator physics and technology
- INFN Scientists spent years at Fermilab contributing to the top discovery (Tevatron)
- INFN Scientists are participating in the Fermilab neutrino and muon programs
- INFN/Fermilab joint effort in TESLA contributed significantly to the setting of the modern SRF technology.
- After the Cold Recommendation for the global Linear Collider, INFN-LASA helped Fermilab to setup ILC SRF Infrastructures.
- Fermilab and INFN-LASA jointly contribute to the S1-Global experiment at KEK

**Summer Students at Fermilab and other US laboratories**  
Emanuela Barzi, Giorgio Belletini, Simone Donati



**UNIVERSITY OF PISA/FERMI/CAIF SUMMER SCHOOL**  
MASTER STUDENTS OF EUROPEAN UNIVERSITIES  
PHYSICS/APPLIED PHYSICS  
ENGINEERING, MATERIALS SCIENCE, COMPUTING SCIENCE

**ADMISSION**  
CV + RECOMMENDATION LETTERS + INTERVIEW + ENGLISH

**ACTIVITY AT FERMI/AB**  
AUGUST-SEPTEMBER (9 WEEKS)  
TRAINING PROGRAM SUPERVISED BY ONE FERMI/AB EMPLOYEE  
MIDTERM REVIEW, FINAL REVIEW, WRITTEN REPORT

**UNIVERSITY CREDITS**  
FINAL EXAM WITH A UNIVERSITY OF PISA COMMITTEE  
AWARDS 6 ECTS CREDITS (6 CFU IN THE ITALIAN SYSTEM)

**SPONSORS**  
INFN AND DEPARTMENT OF ENERGY  
UNIVERSITY OF PISA AND SANT'ANNA SCHOOL (PISA)  
ASI-CAIF FOR SPACE SCIENCE LABORATORIES  
ZERO COST FOR THE STUDENT, ~9.000 \$/STUDENT FOR THE SPONSOR

**FERMI/AB IS USA'S PARTICLE PHYSICS AND ACCELERATOR LABORATORY**  
1750 EMPLOYEES, AND MANY MORE VISITING SCIENTISTS AND ENGINEERS FROM ALL OVER THE WORLD

**PARTICLE PHYSICS DIVISION**  
DETECTOR DEVELOPMENT AND FERMI/AB EXPERIMENTS  
COLLABORATION WITH CMS AT CERN LHC  
SHORT/LONG BASELINE NEUTRINO EXPERIMENTS  
THEORETICAL PHYSICS AND ASTROPHYSICS DEPARTMENT

**ACCELERATOR DIVISION**  
DEVELOP NEW ACCELERATOR TECHNIQUES  
PROVIDE PARTICLE BEAMS FOR FERMI/AB EXPERIMENTS

**TECHNICAL DIVISION**  
DEVELOP NEW TECHNOLOGIES FOR PARTICLE PHYSICS EXPERIMENTS

**COMPUTING DIVISION**  
COMPUTING INFRASTRUCTURE FOR DATA HANDLING AND ANALYSIS

**IDEAL ENVIRONMENT FOR STUDENTS' HANDS-ON TRAINING**

**ONLY ONE COMMANDMENT**

**THE BEST STUDENT FOR THE BEST TRAINING PROGRAM**

**ALMOST 500 STUDENTS SINCE 1983**

Years 2010-2017  
209 students  
112/97 Physics/Engineering



MESSINA, FIRENZE, ANCONA  
LECCE, FERRARA, L'AQUILA, BARI  
BRAZIL, CZECH REPUBLIC, ISRAEL,  
POLAND, LITHUANIA

MANY EXTENDED COLLABORATION WITH MASTER & PHD

**NEW COLLABORATION WITH THE UNIVERSITY OF OXFORD**

3 FERMI/AB SUMMER STUDENTS HOSTED AT THE DEPARTMENT OF PHYSICS FOR A 4-WEEK PRE-TRAINING IN NEUTRINO PHYSICS FOLLOWED BY THE 9-WEEK INTERNSHIP AT FERMI/AB IN A NEUTRINO EXPERIMENT



Apply by April 04, 2017

**INTERNSHIPS AT OTHER US LABORATORIES**



26 SUMMER STUDENTS OUTSIDE FERMI/AB IN 2010-2017  
FINANCIAL SUPPORT FROM ASI, INFN, INFN, ISSNAE, CAIF

**MUSE** MUSE outreach program for University students

**"The High Intensity Frontier at the Fermilab Muon Campus"**

SUMMER SCHOOL NOW PART OF THE OUTREACH PROGRAM OF TWO H2020-INFN-CAIF-RISE PROJECTS COORDINATED BY INFN

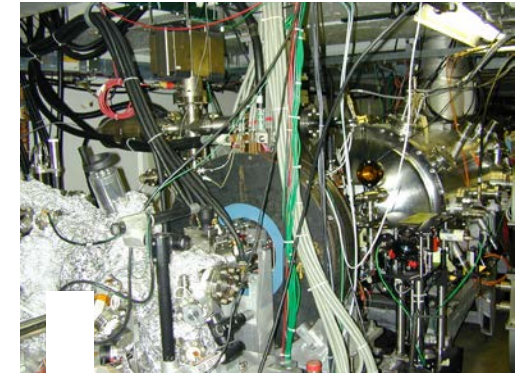
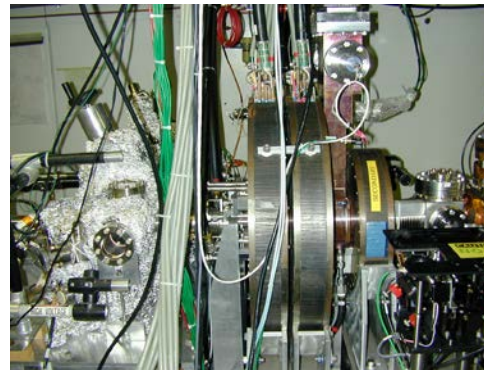
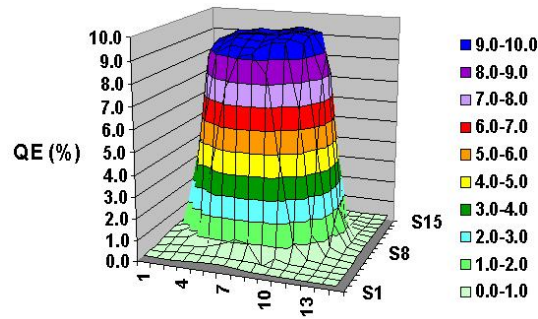
"MUON CAMPUS IN US AND EUROPE CONTRIBUTION" ("MUSE", GA 690835)

"NEW WINDOWS ON THE UNIVERSE AND TECHNOLOGICAL ADVANCEMENTS FROM TRI-LATERAL EU-US-JAPAN COLLABORATION" ("NEWS", GA 734303)

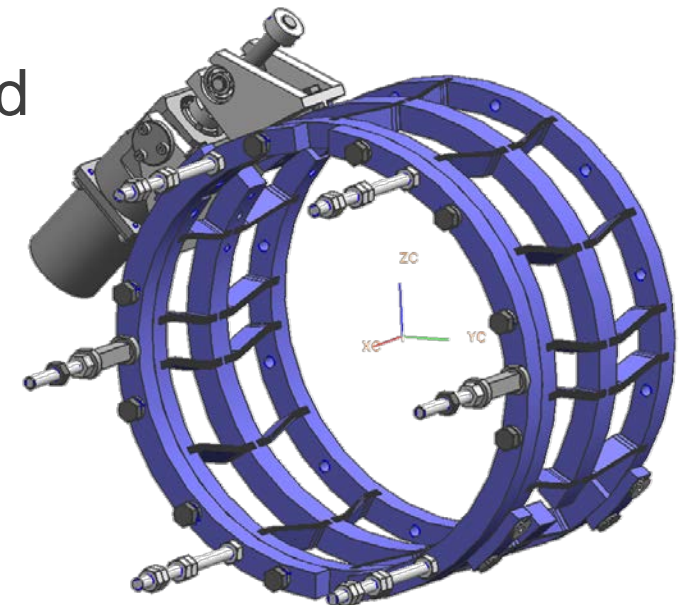


# ILC Components coming from INFN - 1

- Cs<sub>2</sub>Te Photocathode system – in operation since August 1997 for the A0 test facility



- A set of INFN blade-tuners developed to improve the ILC filling factor



# ILC Components coming from INFN - 2

- Cryomodule assembling tools, developed by INFN-LASA for TESLA/XFEL and globally distributed for ILC and LCLS-II





## ILC Components coming from INFN - 3

- Second Cold mass to be equipped with Fermilab ‘short’ cavities and INFN Blade tuners



- Special 4 cavity Module and tuners for S1-Global at KEK



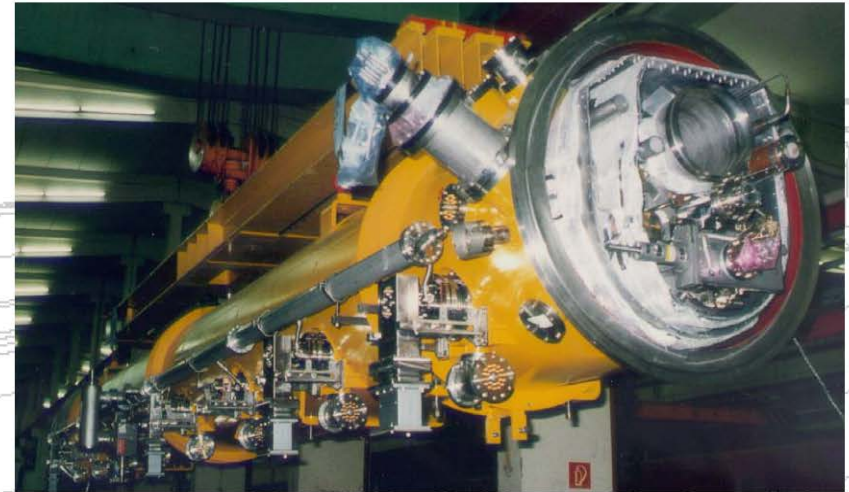
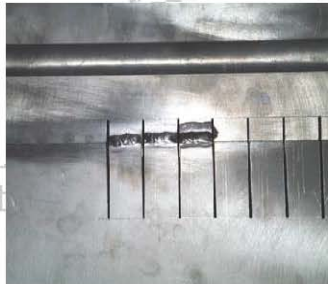
# Recent Work at INFN-LASA: European XFEL

- Half of the cold masses (INFN Design)

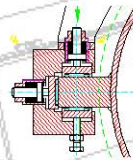
## TTF Cryomodule Design

Three “generations” of the cryomodule design, with increasing simplicity and decreasing costs

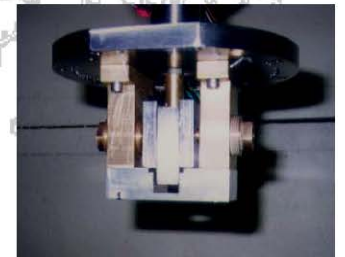
“Finger Welded” Shields



Sliding Fixtures @ 2 K



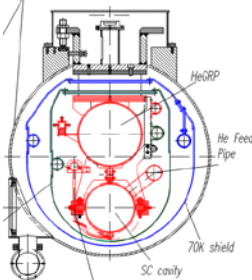
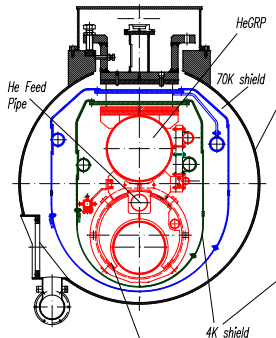
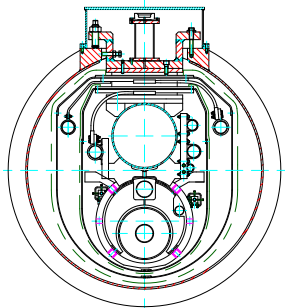
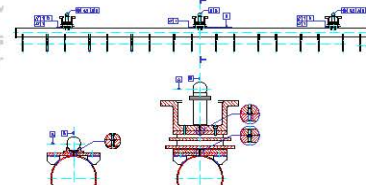
Qualification tests in LASA



Cryomodule Characteristics

- Length 12 m
- # cavities 8
- # doublets 1
- Static Losses @ 2 K 1.5 W
- @ 5 K 8 W
- @ 50 K 70 W

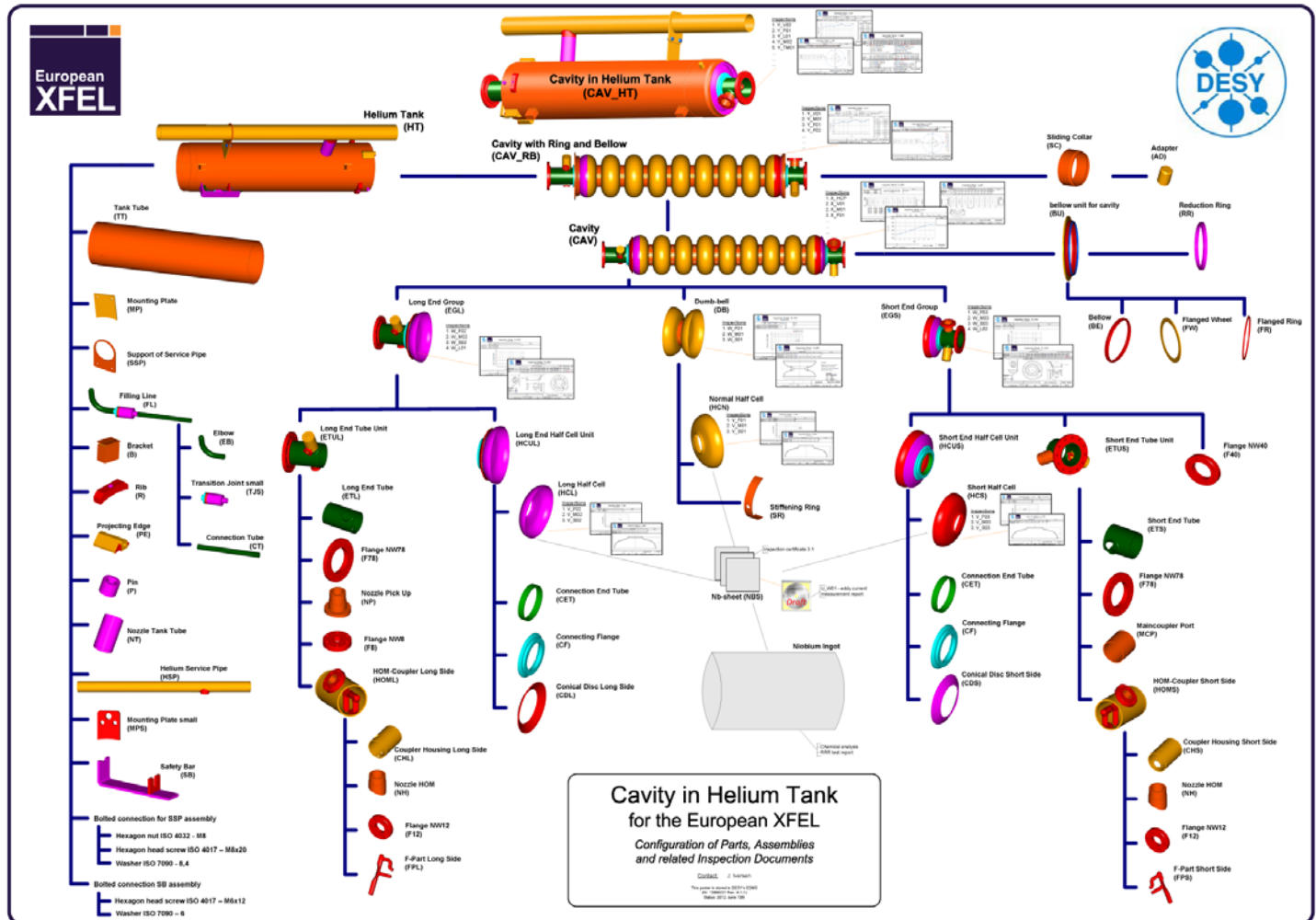
Simplified alignment Strategy





# Recent Work at INFN-LASA: European XFEL

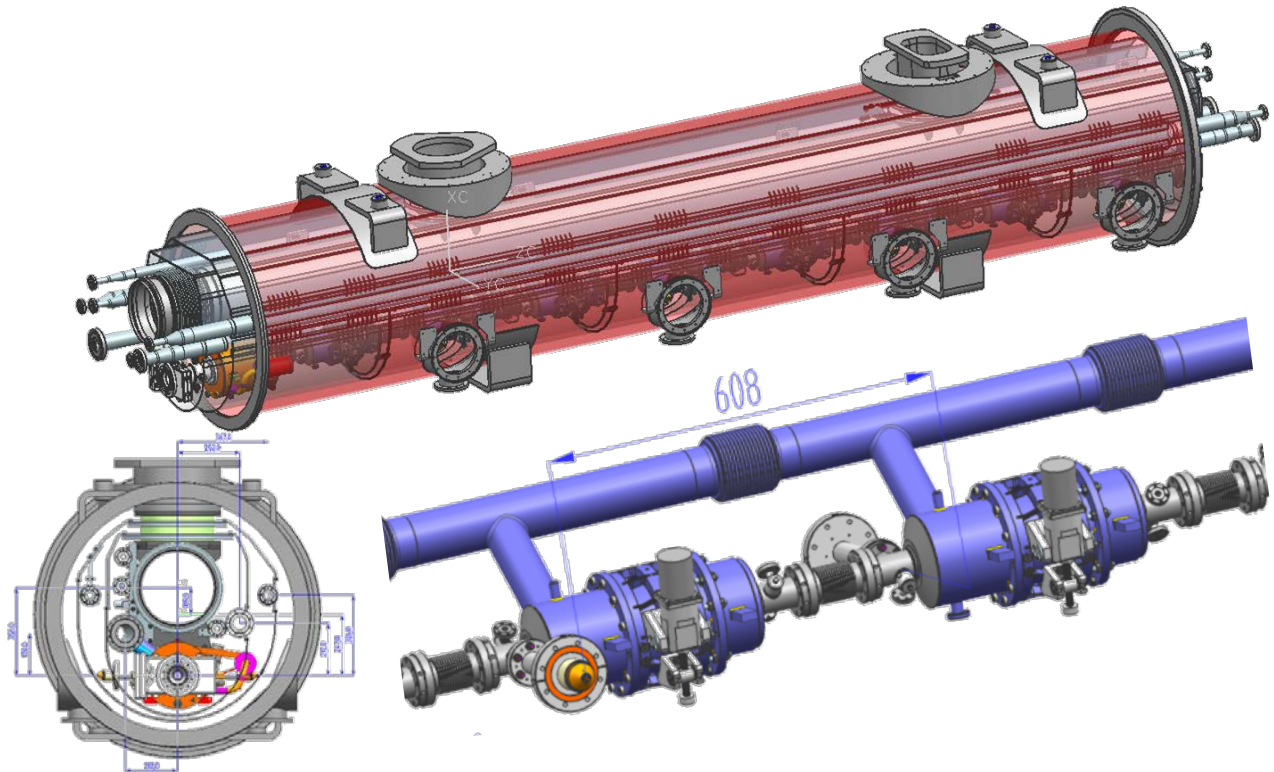
- Half of the 800+ 1.3 GHz SRF cavities: bulk EP + final BCP





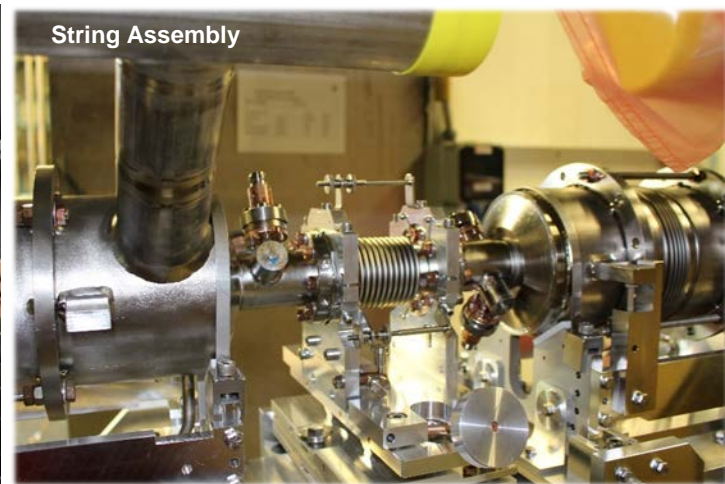
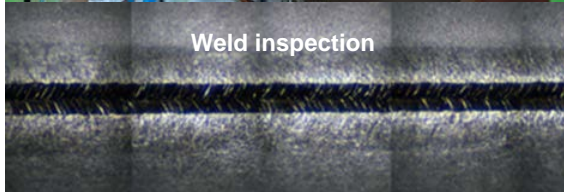
# Recent Work at INFN-LASA: European XFEL

- The Third Harmonic Cryomodule: INFN Design, inspired on FLASH (Fermilab). FPC, cryogenics. and RF from DESY.

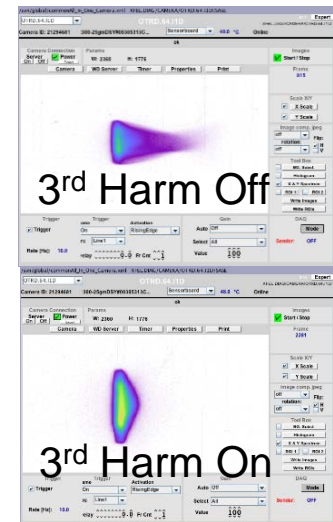
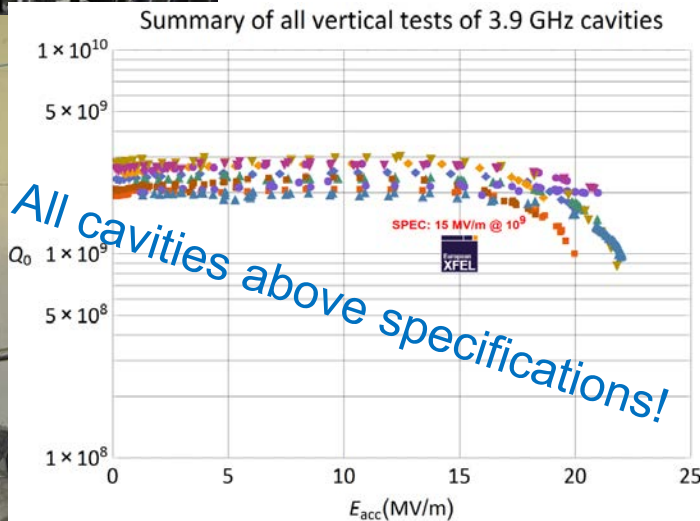


- alternating Power Couplers for kick compensation. Lateral 2-phase He line.
- “slim” type Blade tuner derived by INFN ILC tuner.
- 3rd harmonic module **“Plug compatible”** with XFEL standard modules.

# Recent Work at INFN-LASA: European XFEL

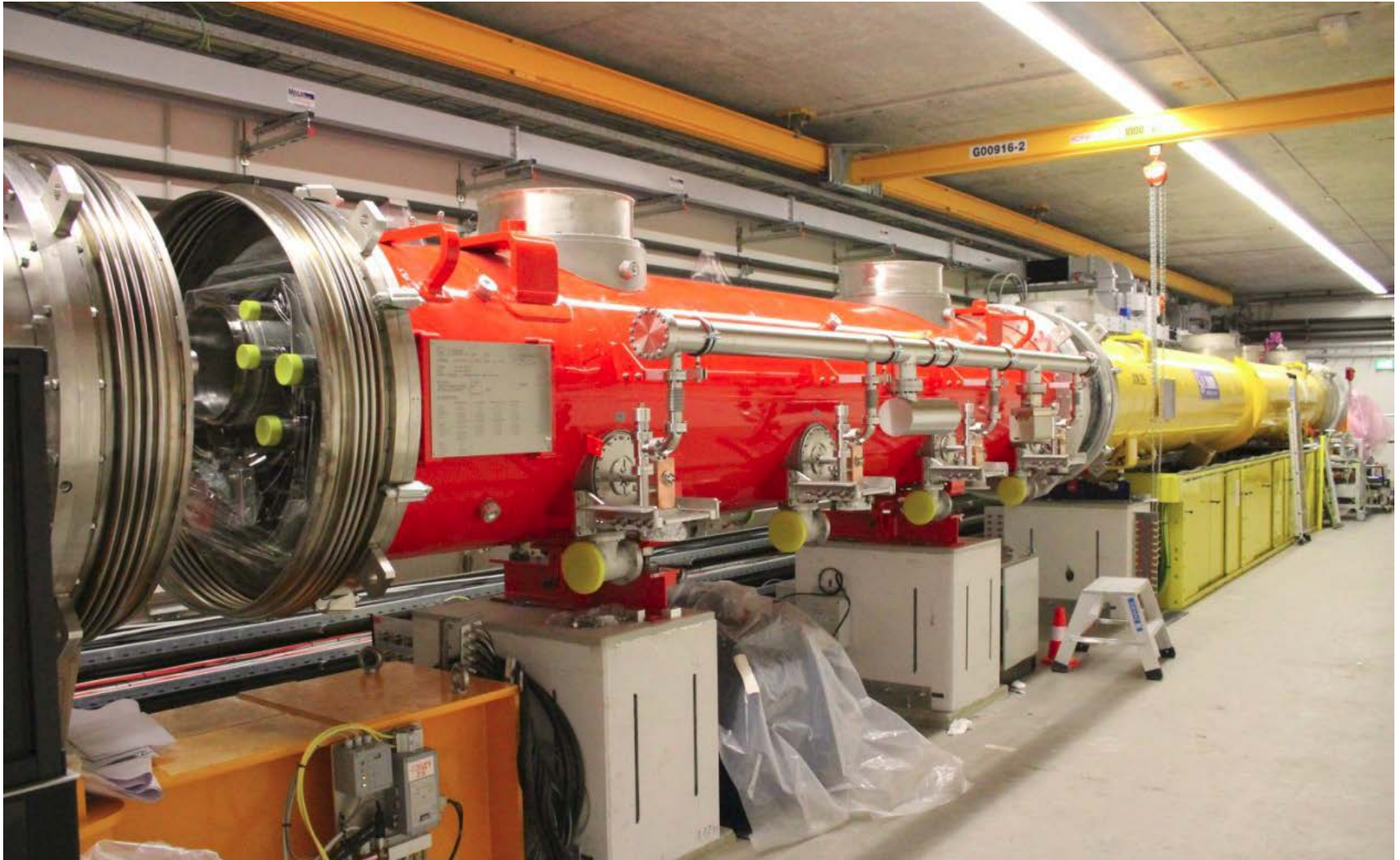


XFEL Injector' Beam





# Recent Work at INFN-LASA: European XFEL



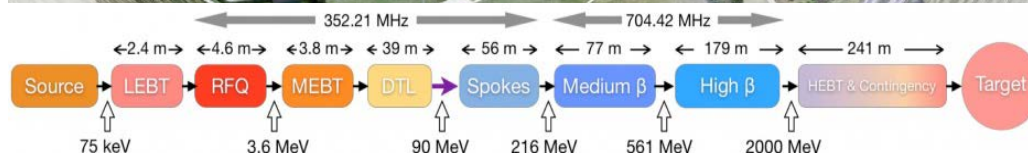


# Present Work at INFN-LASA: ESS - Italy in-kind

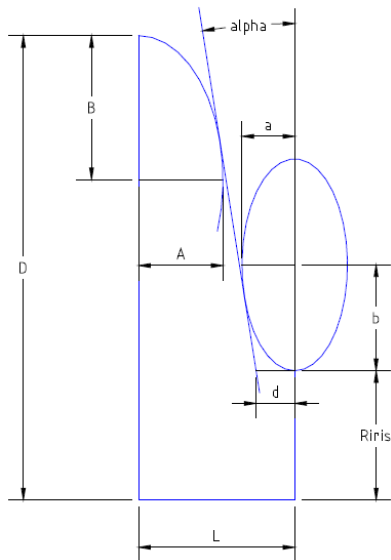
## • 36 medium beta cavities

- Cavity fabrication of 36 medium beta cavities in the industry, including treatments, tuning, Helium tank integration. **Full treatment at the vendor.**
- Certification activities, documentation, ancillaries
- **Cold test in a qualified infrastructure** (DESY).
- Transportation in special boxes and **delivery at CEA** cryomodule assembling facility.

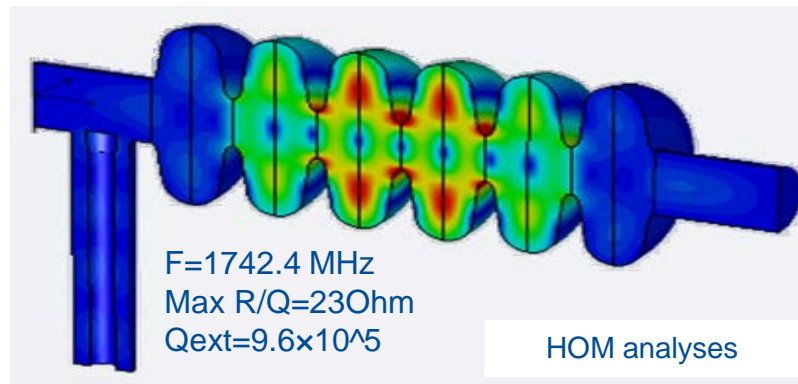
MB cavity technical requirements	
Frequency (MHz)	704.42
Number of cells	6
Geometric beta	0.67
Nominal Acc. Gradient (MV/m)	16.7
$E_{\text{peak}}$ (MV/m)	< 45
RF peak power (kW)	1100
Q external	$5.9-8 \cdot 10^5$
$Q_0$ at nominal gradient	$> 5 \cdot 10^9$



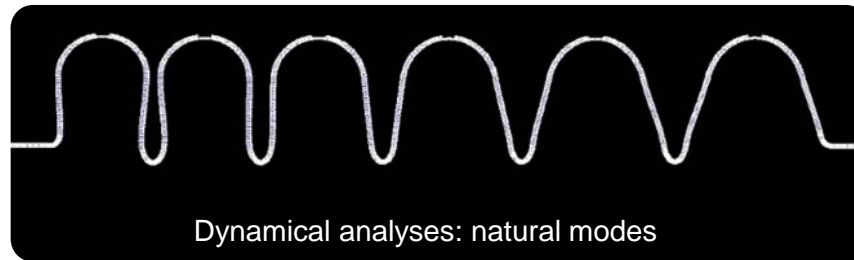
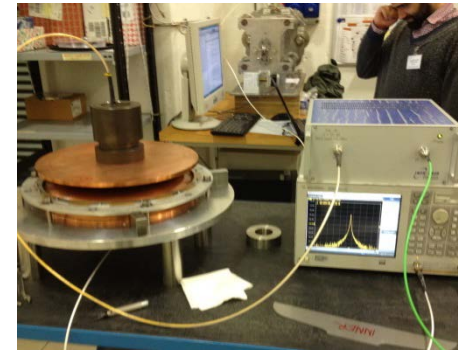
# Present Work at INFN-LASA: ESS Prototypes



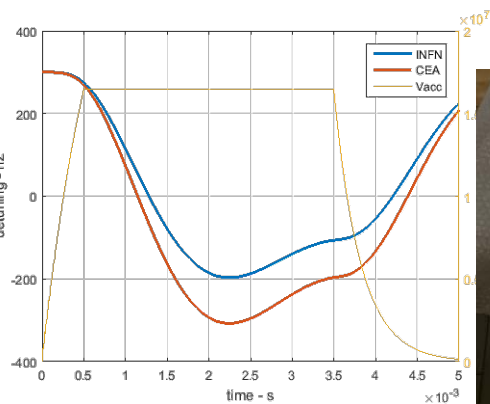
Cell shape design



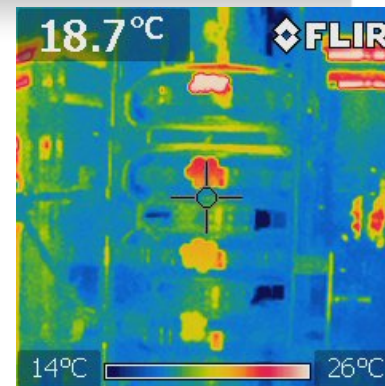
HOM analyses



Dynamical analyses: natural modes

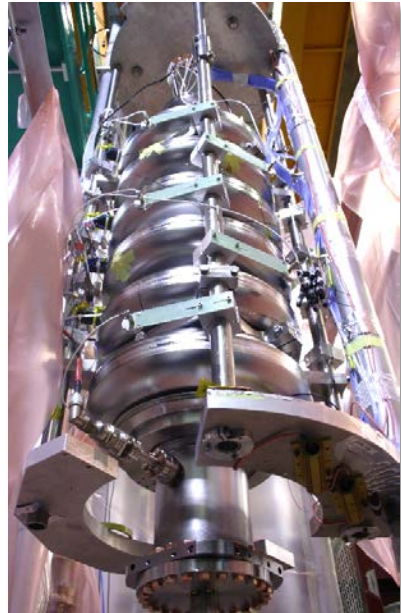


LFD from cavity simulator

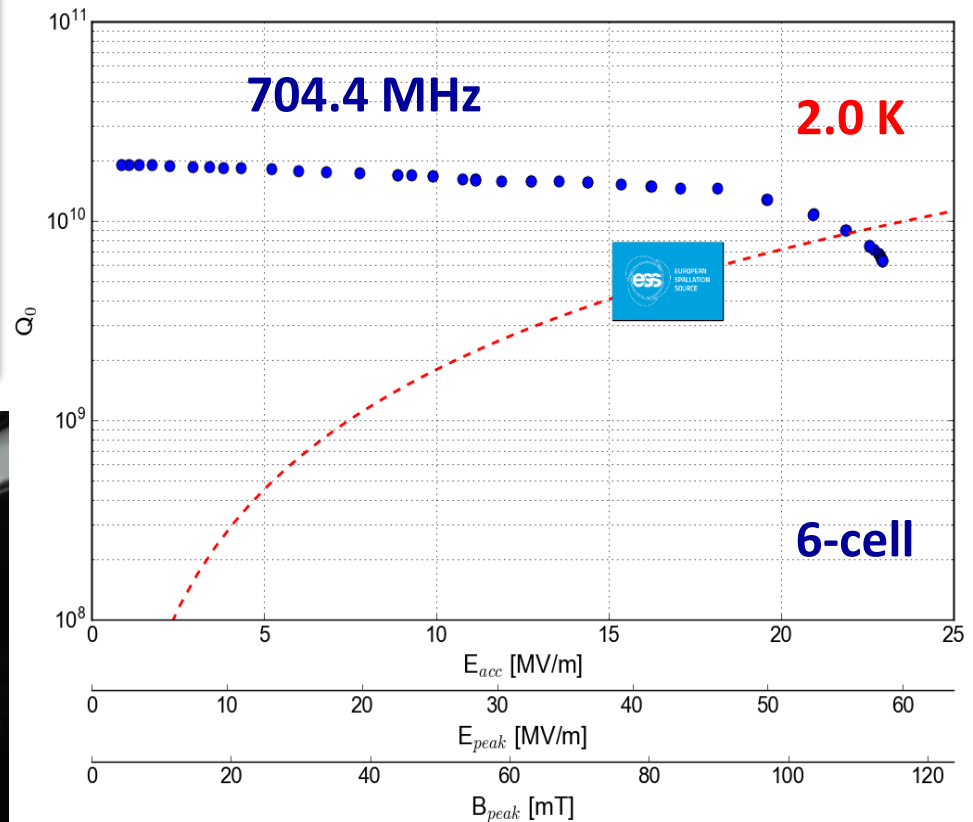




# Present Work at INFN-LASA: ESS Tests at 2 K



Test well above specs  
Series Production approved  
All major orders recently placed



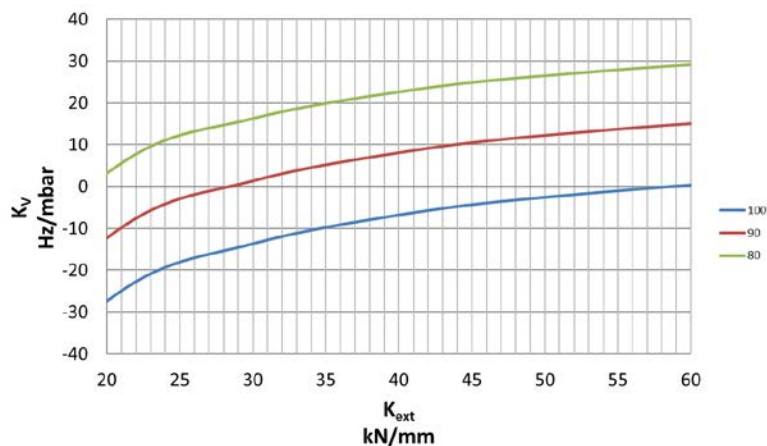


## INFN & PIP-II

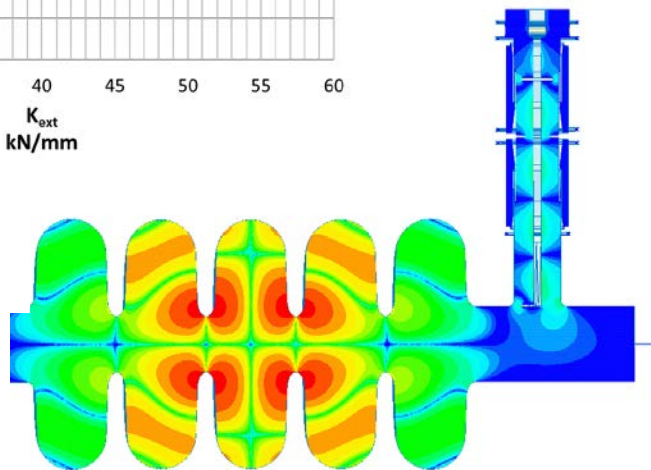
- Well in the frame of the long term fruitful Collaboration between Fermilab and INFN.
- Nicely included in the scientific activities envisaged in the Implementing Agreement signed by DoE and Italian Ministry of Education, University and Research (MIUR) (17.07.2017).
- Neutrino Physics and related high power proton accelerators are specifically mentioned in the Project Annex signed by DoE and MIUR on the same day (17.07.2017).
- Green light from MIUR for an Italian participation to the realization of PIP-II through an in kind contribution mediated by INFN LASA and specifically funded by MIUR/MAECI.
- The envisaged contribution nicely matches with the INFN LASA expertise and it's welcome by the LASA scientists.

# INFN & PIP-II – work so far

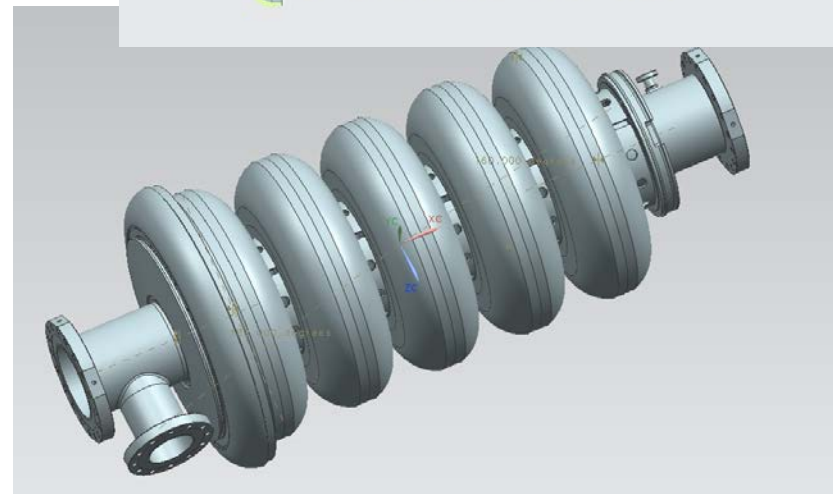
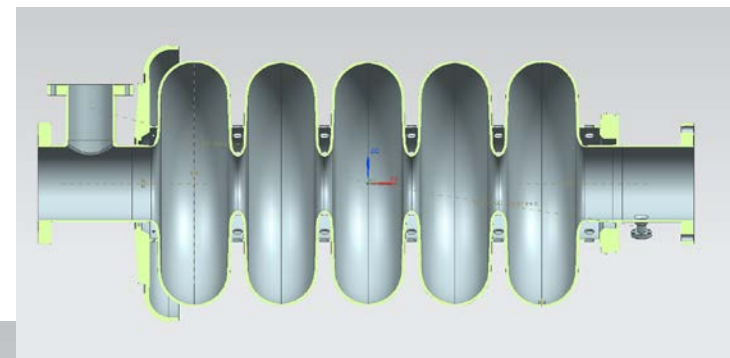
- Several alternative designs have been developed for the LB650 cavity
- The final version from INFN-LASA has been chosen for PIP-II as the best compromise between CW and pulsed operation performances.



Pressure sensitivity analyses around tuner stiffness at 40 kN/mm



Dipole HOM at 1678 MHz analysis, showing partial reflections in the new FPC







# From the 1995 TTC Meeting in Milano

