1st BrightnESS Best Practice Workshop: Engineering aspects of large-scale In-Kind projects

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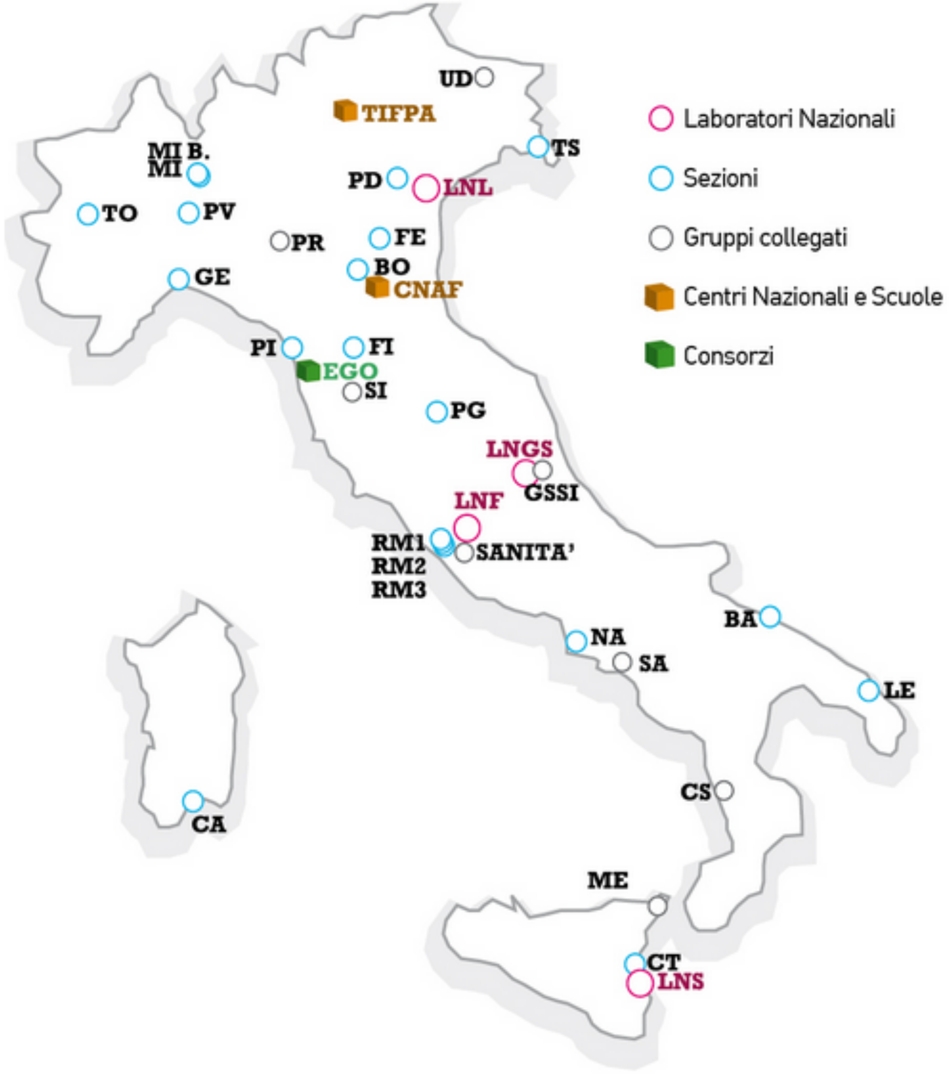
Outline

- Description of Istituto Nazionale di Fisica Nucleare (I.N.F.N.):
  what it is, what it does, how it works...
- I.N.F.N. involvement in ESS;
  source&LEBT;
  DTL;
  medium β cavities;
- RFQ in the IFMIF LIPAc as a working case
  from design, through production, assembly, transportation, handling, to installation;
- Conclusions

Istituto Nazionale di Fisica Nucleare – What it is



- **Story and mission**
  Founded in 1951, I.N.F.N. is a public funded reaserch institute dedicated to fundamental physics research.
- **Personnel**
  ~2000 staff: ~1700 permanent, ~300 temporary,
  ~3000 associate (University, Research Insitutes)
- **Administration**
  Headquartered in Frascati (Rome)
  Sparsely distributed in the Italian territory, with 20 Sections, 4 National Labs, each with local administrative management
- **Scientific Management**
  5 Scientific National Commissions
  - Particle physics
  - Astroparticle physics
  - Nuclear physics
  - Theoretical physics
  - Technological and inter-disciplinary research

  External and special Projects

Istituto Nazionale di Fisica Nucleare – What it does

I.N.F.N. actively participates, through the whole process, in the design, construction, installation, managing and data-taking of **detectors in experiments** and of **accelerators**.

The research activity is carried out with **Italian collaborations**:

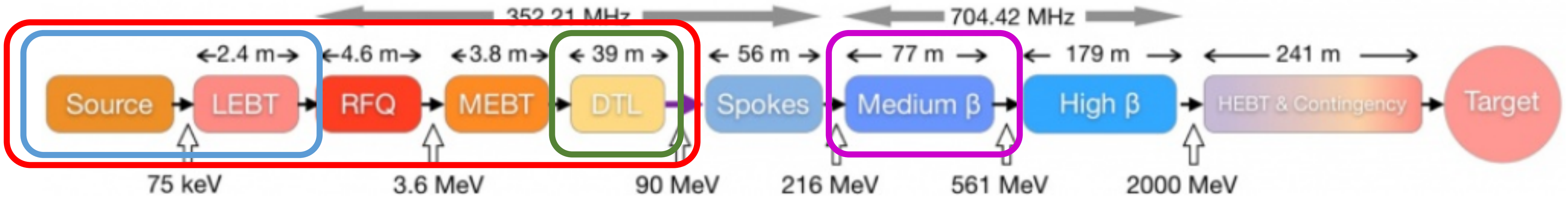
- within the I.N.F.N: collaborations made of different sections/laboratories;
- within Italian scientific community with universities and other Italian research institutes (CNR, INAF, ASI, Elettra-Sincrotrone, ...);

or with **International collaborations**:

- CERN;
- ESS;
- Germany (DESY, GSI);
- France (ESRF)
- USA (Fermilab, Jlab, BNL, SLAC);
- Russia (PNPI, BINP, JINR);
- China (CIAE, IHEP)
- Japan (Riken, KEK, IFERC);
- India (BARC)

Istituto Nazionale di Fisica Nucleare – Involvement in ESS

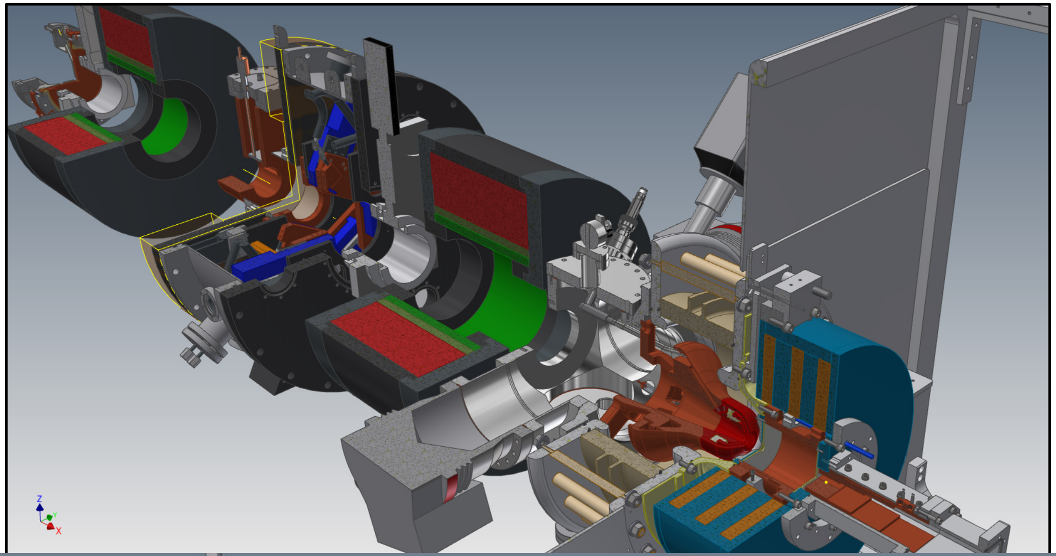
INFN contributes to the construction and operation of ESS with resources made available by the Ministry of Education, University and Research (MIUR).
INFN is the representing entity for Italian contribution to ESS, involving three major Italian insitutes: National Research Council (CNR), Elettra-Sincrotrone and INFN

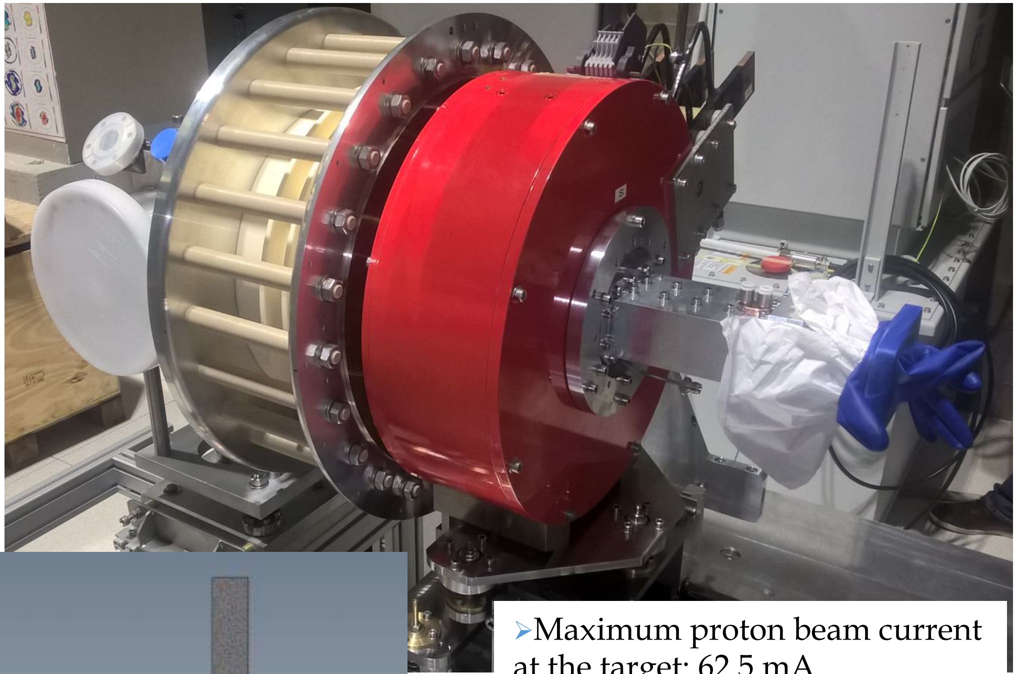


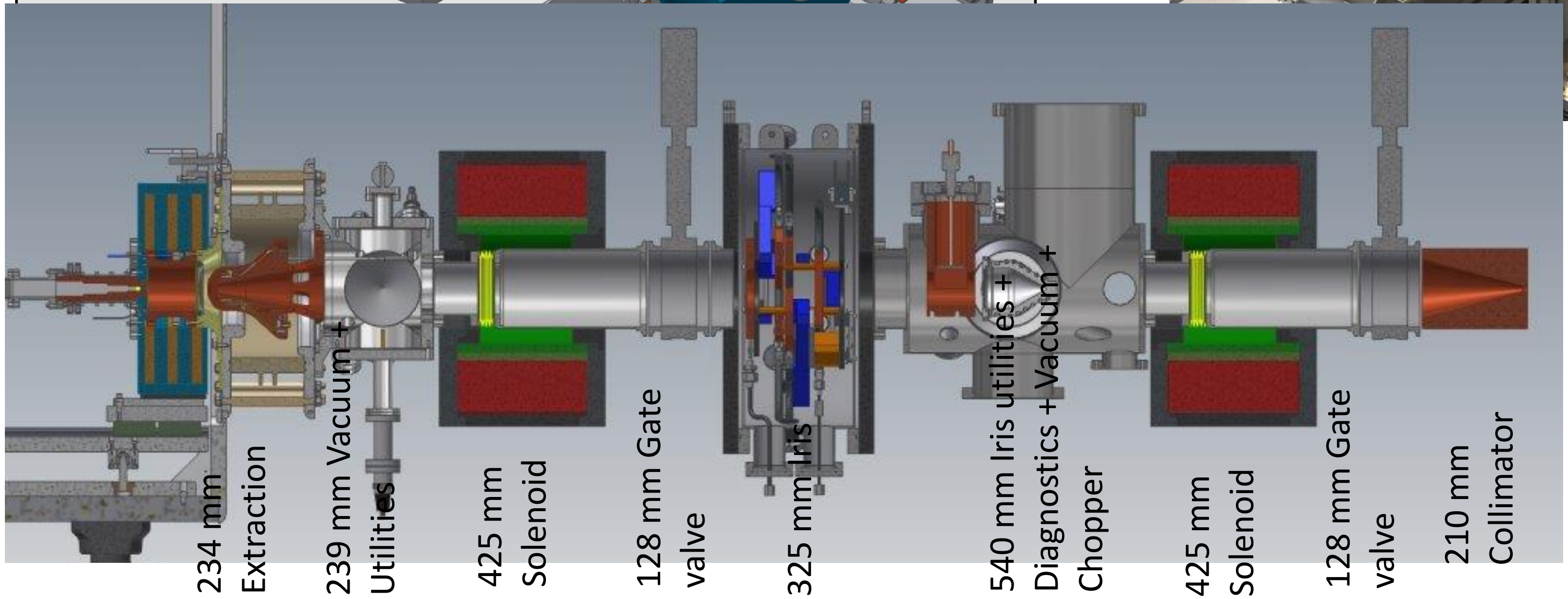
Normal Conducting LINAC WP3 Leader S. Gammino - Source&LEBT (INFN-LNS), RFQ (CEA- IRFU, France) and MEBT (ESS-Bilbao, Spain), DTL (INFN-LNL);

1. Ion Source and LEBT: INFN-LNS;
2. Drift Tube LINAC: INFN-LNL;
3. Mediumβ section of SCRF LINAC: INFN-Milan, LASA.

Istituto Nazionale di Fisica Nucleare – Involvement in ESS



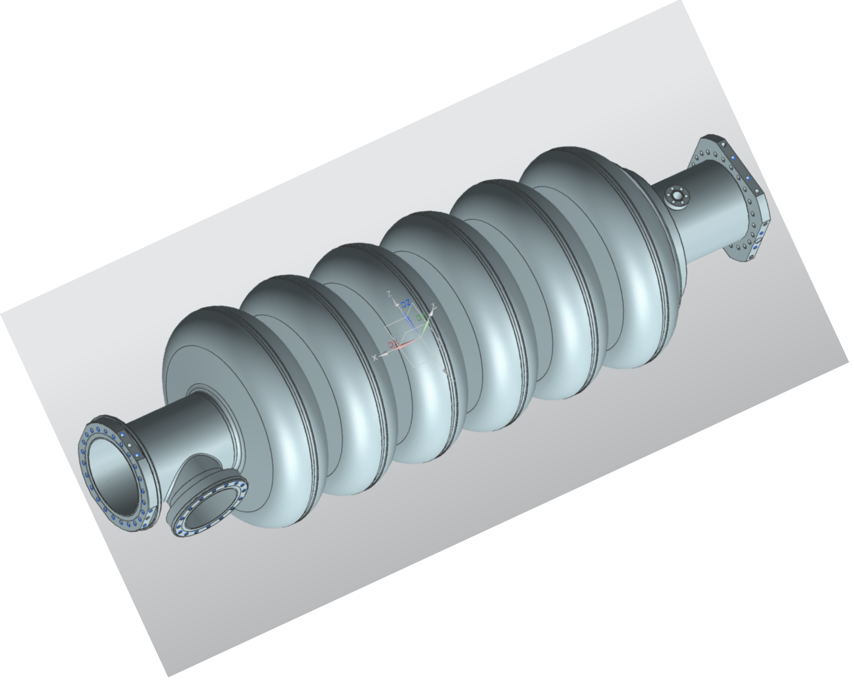


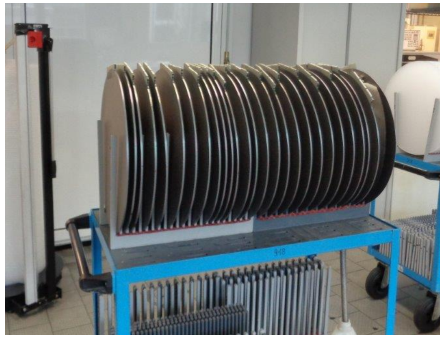


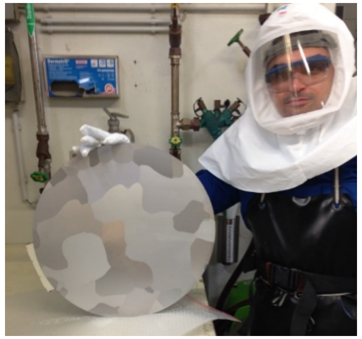
- Maximum proton beam current at the target: 62.5 mA (>90 mA of source's output current)
- Pulse during neutron production: 2.86 ms
- Beam Stability: ±2.5%
- Beam emittance 0.25 π mm mrad
- The peak beam current must be variable from 6.3 mA to 62.5 mA (step size of 6.3 mA, precision of 1.6 mA)

Istituto Nazionale di Fisica Nucleare – Involvement in ESS

Requirements	Medium beta
Frequency (MHz)	704.42
Geometric beta	0.67
Nominal Accelerating Gradient (MV/m)	16.7
Epk (MV/m)	< 50
Cell coupling k(%)	≥ 1.5
RF peak power (kW)	1100
Q ext	$7.5\ 10^5$
Q_0 at nominal gradient	$> 5\ 10^9$

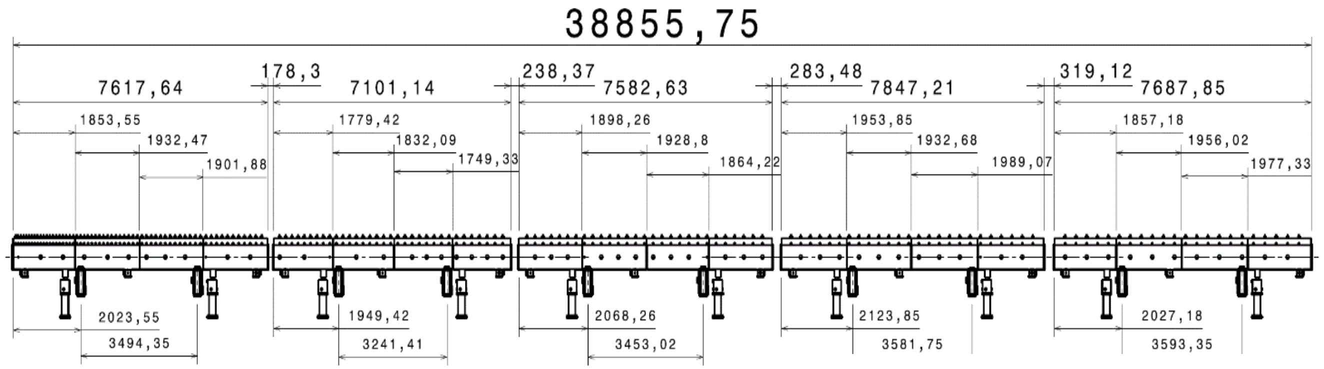


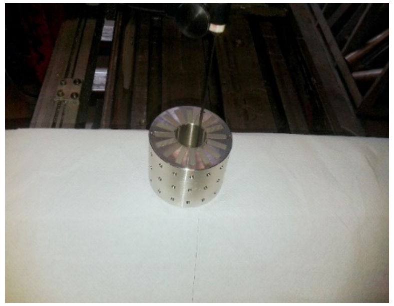


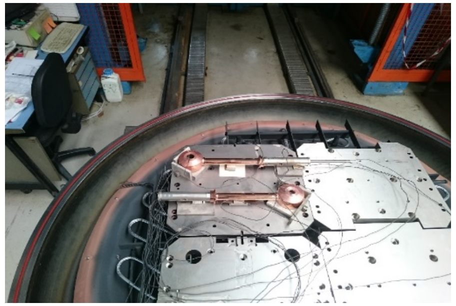


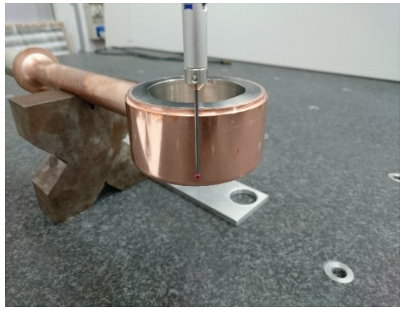
Istituto Nazionale di Fisica Nucleare – Involvement in ESS

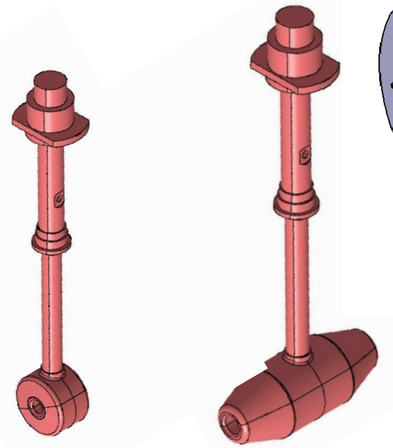
- DTs manufactured with vacuum brazing and EBW
- DTs equipped with:
  - Permanent Quadrupole Magnet;
  - Steering magnets;
  - Beam Position monitor

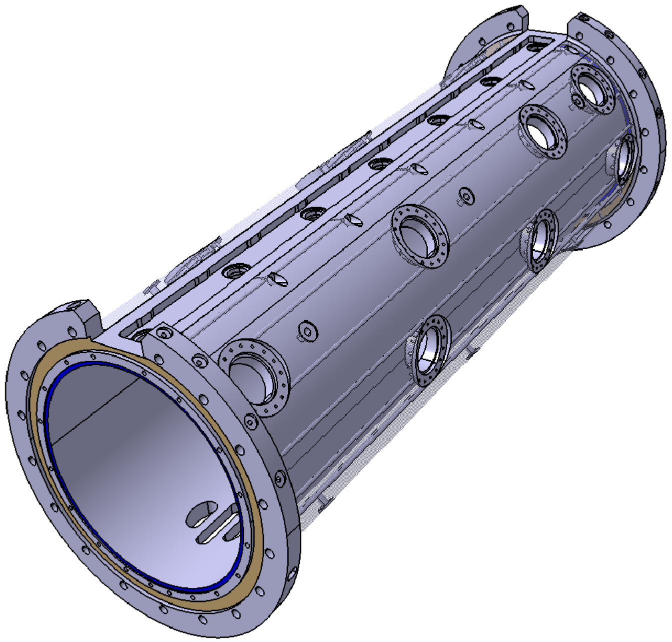












Istituto Nazionale di Fisica Nucleare – How it works

- The Council of Directors is the **central decision-making body of I.N.F.N.** (President, Executive Board, Directors,...), with meetings held on a monthly basis;
- I.N.F.N. has a central administration which supervises/helps/controls the local administrations;
- **Each I.N.F.N. Section/Laboratory is independent within the general I.N.F.N. strategy** usually based on a three year time frame; the **local scientific program is decided by the Director** with the consulence of the local section/Laboratory council, where representatives of the National Scientific Commissions or the special projects are present;
- In I.N.F.N. sections and laboratories there are structures/units (i.e. services), which are devoted to mechanical or electronic design, I.T., mechanical or electronic workshops, with personeel made of engineers, physicists and technicians.
- **The expertises of the services in differents sections/labs are not the same**, depending on the local mainstream activities (i.e. vacuum technology, SS/Alu welding, cooling design, digital/analogic electronics, gaseous detector technology...);
- The CAD/CAE products, either in mechanics or electronics design, are usually managaed within the design services/units;
- **No CAD/CAE indication from central I.N.F.N. management**; the choiche is left to the local services based on past esperiences (which type has been used in the past collaborations, which is better known, which is better cost effectively); eventual consolidation for centralized software procurement.

Istituto Nazionale di Fisica Nucleare – How it works

- Within the freedom of choiche given to the design structure units (services) inside the I.N.F:N. sections/laboratories, there are various mechanical CAD systems presently used:
    - Siemens - NX, SolidEdge,
    - Dassault Systemes - CATIA, SolidWorks,
    - Autodesk - Autocad, Inventor

  Electronic Design Automation;

  Finite Element Analysis
    - Ansys;
    - COMSOL;
    - MSC-Nastran;
    - Simulia
- How these different system can be used in different scientific collaborations, Italian or international, in an harmonized way?

Istituto Nazionale di Fisica Nucleare – How it works

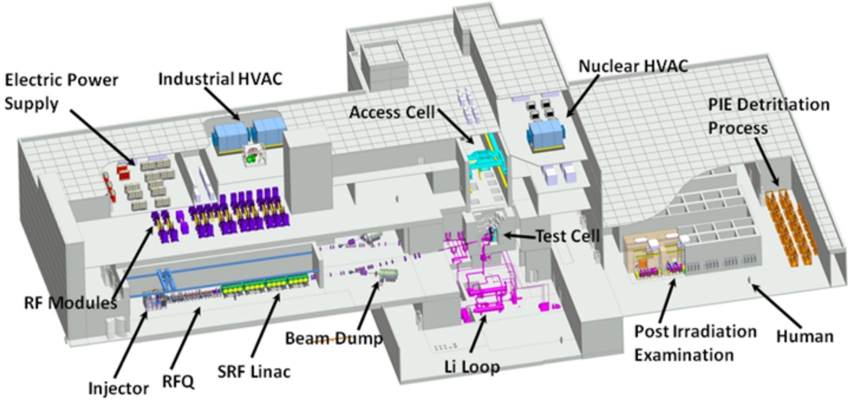
- **Informal or formal agreement** defined at the **early stage of the collaboration** (MoU,SoW, PA, IKPA...), with different approaches, based on the contest of the collaboration and the scope (i.e. a small detector in an experiment, a stand-alone or an integrated equipment, a component, a detector in a big collider experiment, a sub-system of an accelerator);
- **requirements on CAD/CAE systems** may vary from **soft to strong**:
    - You use your own, providing you supply the component/equipment: i.e. a stand-alone keys-in-hand system, with no integration requirements;
    - You use your own, but, for integration purposes, I need the 3D model in a standard exhange format (i.e. STEP): i.e. need to check functional interfaces with other components;
    - You use your own, but I need the the 3D model in my CAD system, without the mathematics/parametric structure: i.e. sharing of the interfaces check and clashes control within the collaboration;
    - I need you to use my system, which is defined in the Procurement Agreement, the 3D model must be native, with mathematics and parametric structure: i.e. Product Lifecycle Management.

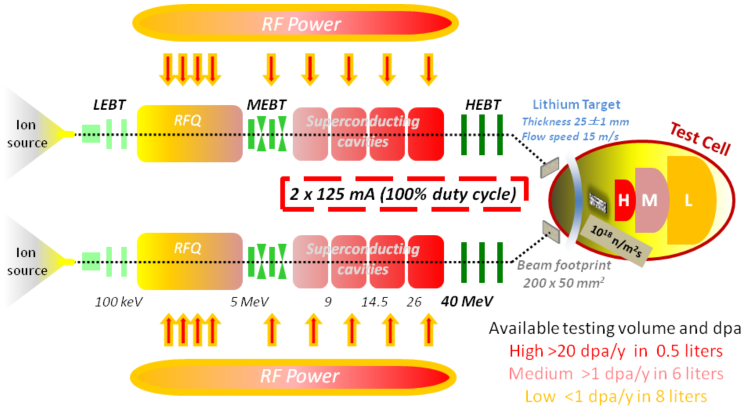
Istituto Nazionale di Fisica Nucleare – How it works

- **The stronger requirements the more complete set of information/details to be given at the early stage of the collaboration**.
  - → Smooth and gentle integration in the centrally-based master 3D Mock-Up;
  - → Interface management system;
  - → More in general the PLM (Product Data Management, Product Structure Mangement, Change Management, Catalog Library...);
  - → Control of the part/product after some time by differeent persons.
- In an ideal world, **dominated by genealogic-tree-based parametric CAD system**, that would be based on actions such as:
  - definition of the way to generate the parts and to organize the product/assembly (origin of CAD parts, how the CAD parts evolve around the origin, origin of the assemblies, constraints and positioning rules of the parts inside the assemblies...);
  - definition of a widely accepted 3D skeleton;
  - definition of the level of details to be put in the model (screws, washers... balance between weight of the model and interfaces/clashes checks);
  - naming convention of the parts/assemblies;
  - level/frequency of training of the involved persons;
  - releases and licenses.

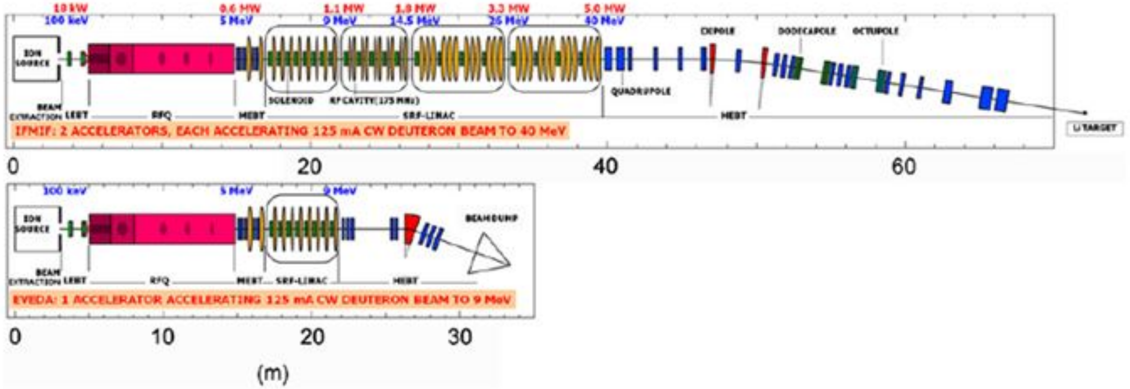
LIPAC RFQ – What it has been done

The **International Fusion Materials Irradiation Facility**, also known as **IFMIF**, is a test facility in which candidate materials for the use in an energy producing fusion reactor can be fully qualified. IFMIF is an accelerator-based neutron source that **produces**, using deuterium-lithium nuclear reactions, a large **neutron flux with a spectrum similar to that expected at the first wall of a fusion reactor.**





Within the IFMIF Engineering Validation and Engineering Design Activities (IFMIF-EVEDA) phase, **the Linear IFMIF Prototype Accelerator (LIPAc) is dedicated to study the accelerator sections up to 9 MeV** (instead of 40 MeV for IFMIF) together with its auxiliaries and the associated infrastructure.

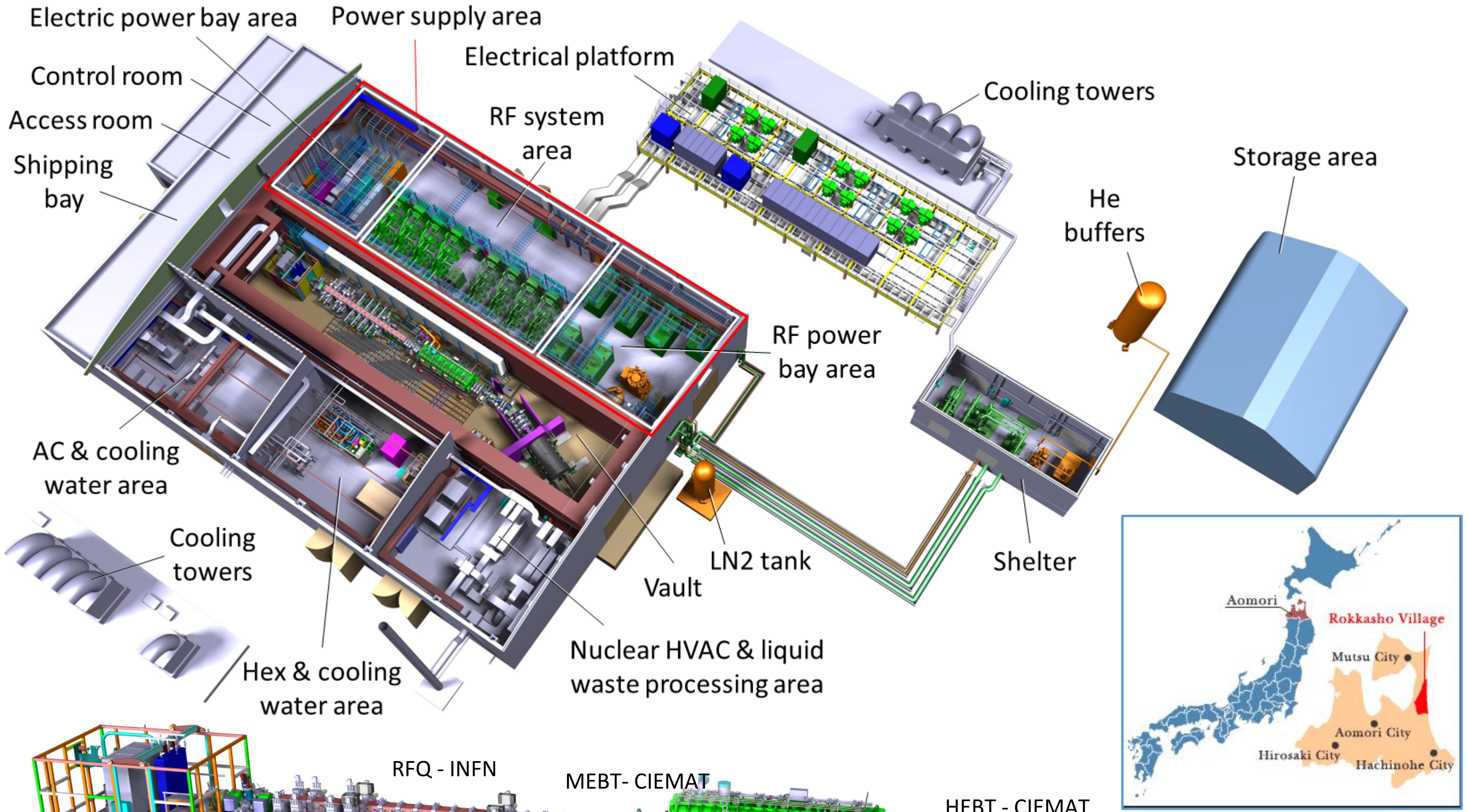


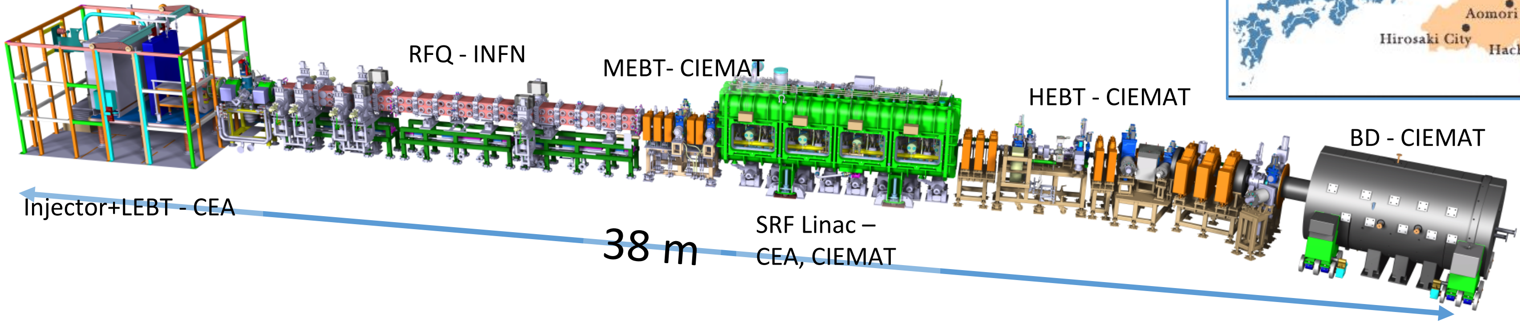
LIPAC RFQ – What it has been done

LIPAc is an European-Japanese challenging joint activity, in which technical and cultural aspects are to be taken into account.

LIPAc Plant Integration Document is a general reference document, **agreed by the collaboration**

- Objectives (description of the facility, accelerator prototype parameters, design, construction and operational requirements);
- Applicable Codes and Standards (QA, Electrical&grounding, mechanical, assembly, pressurized equipments, CAD, seismic requirements,…);
- Safety requirements;
- Alignment requirements and procedures;
- PAs;

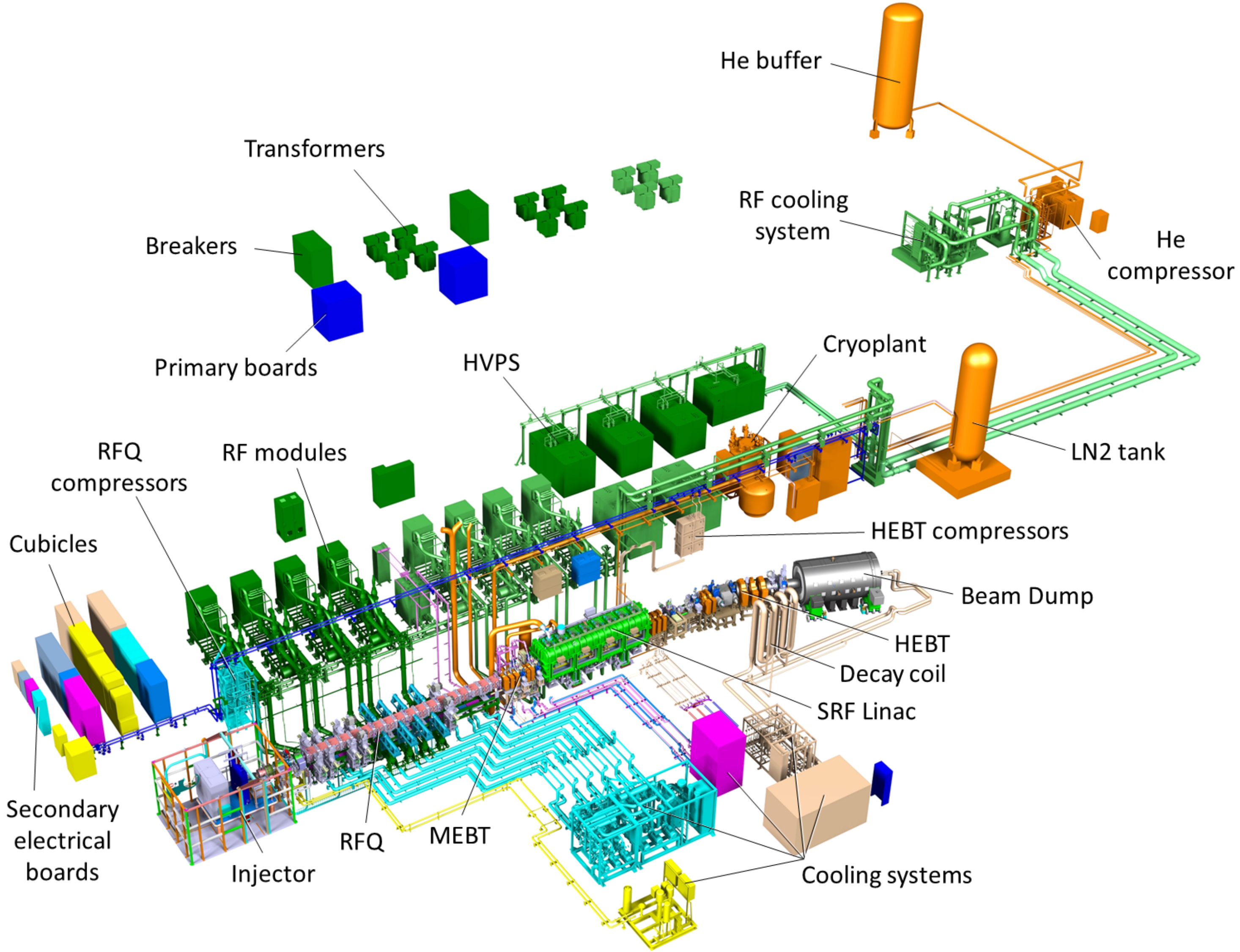




LIPAC RFQ – What is has been done

Approach to 3D Mock-Up, interface management and clash check

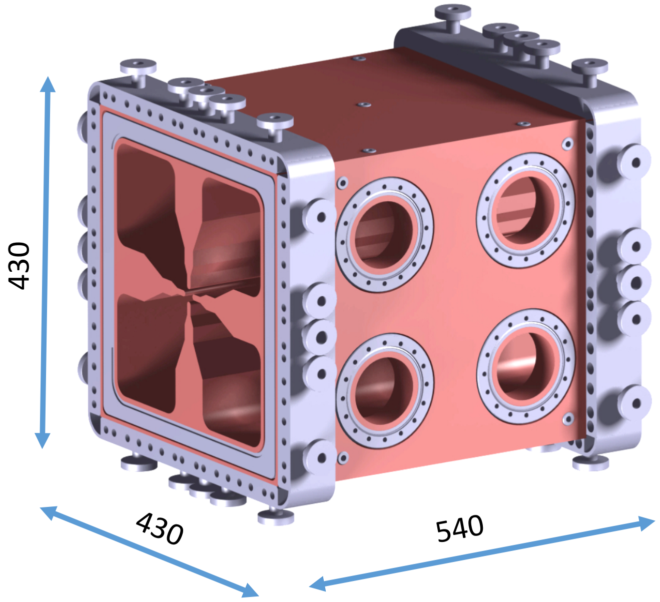
- **Each sub-sub-system** (i.e. Injector, LEBT, RFQ, MEBT, SRF Linac, HEBT and Beam Dump) **provides CAD model hierarchically organized as in the PBS**
- 3DMUs are submitted to accelerator integration officer at F4E in Garching, for **interface management and claches check**
- The LIPAc building 3DMU, generated and validated by Japan team
- **Accelerator and building 3DMU are merged together**;
- Rules to be followed in the generation of the CAD model (Origin, Ref axis orientation, assembly tree, naming convention, skeleton...)

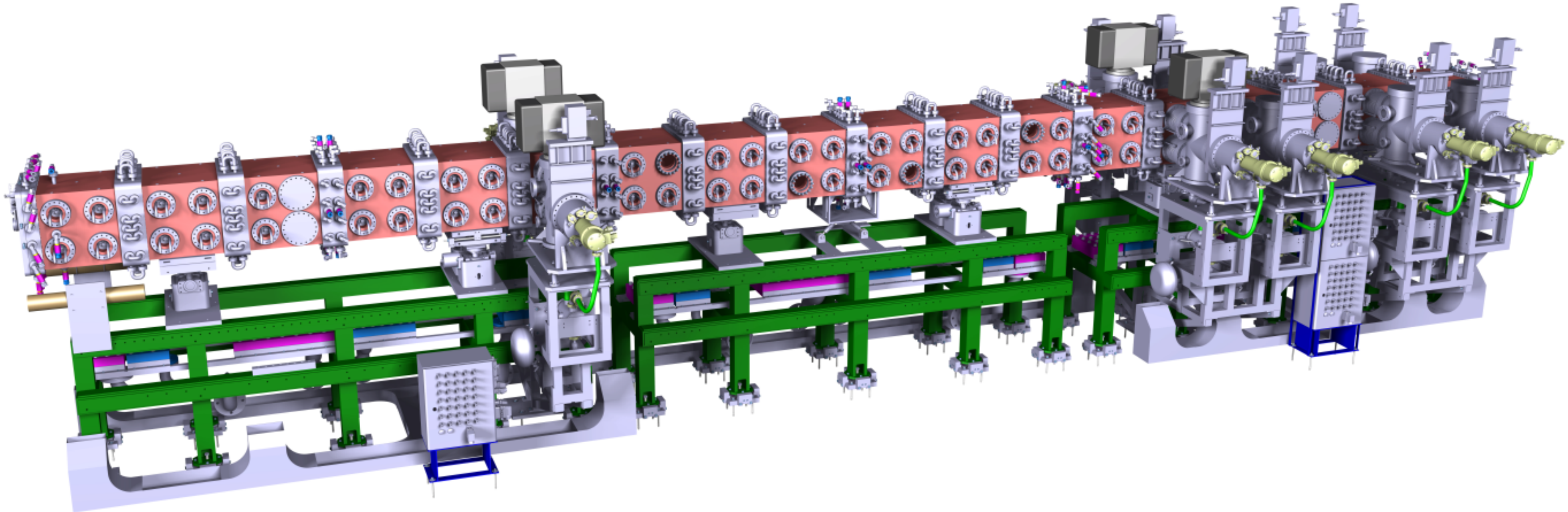


LIPAC RFQ – What is has been done

The **RFQ is a 9,8 m-long structure**, made of 18 modules Each module is **made of precise machined Cu-OFE elements, assembled by UHV furnace brazing** with stainless steel components (i.e. vacuum, tuner and RF coupler ports, and cooling water flanges)

LIPAc Parameters	
Ion type	D+
RF Frequency	175 Mhz
Total lenght	9,78 m
Input energy	100 Kev
Output energy	5 Mev



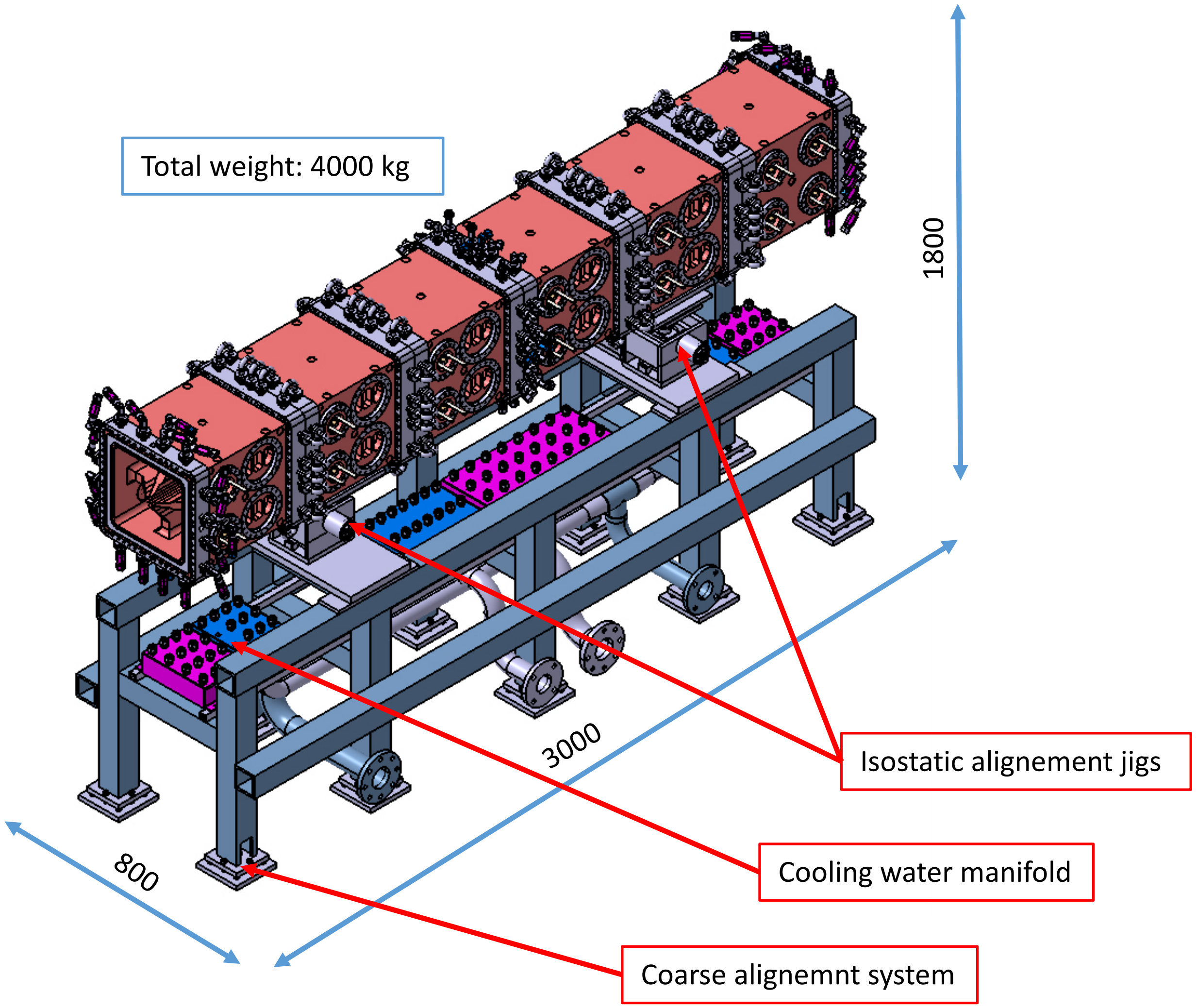


Paolo Mereu - I.N.F.N. Sezione di Torino

LIPAC RFQ – What is has been done

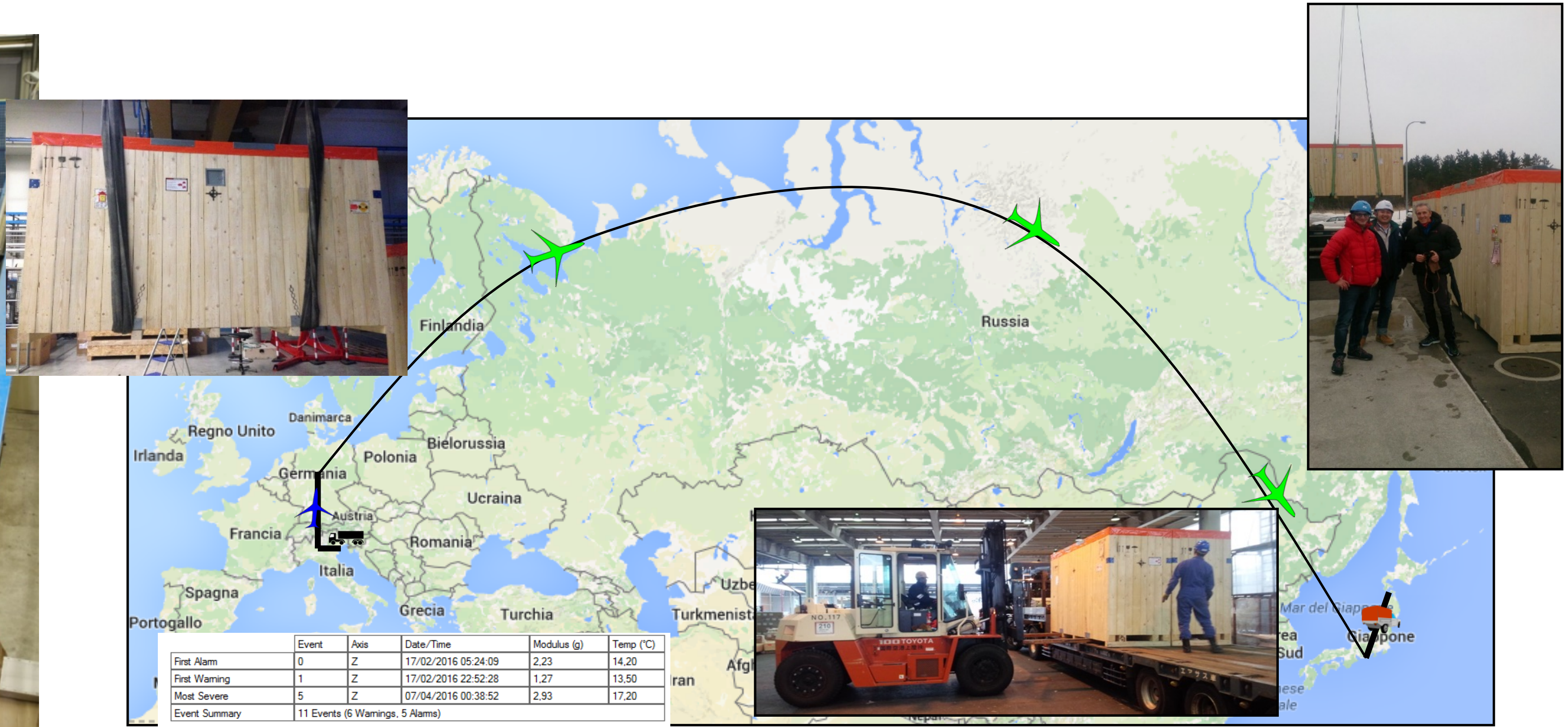
In order to **minimize the assembly time of the entire RFQ** in Japan, and in accordance with the LIPAc assembly time frame, it has been decided to divide the RFQ in **three SuperModules (6 RFQ modules)**, **pre-assembled in Europe** (aligned and vacuum tight) and shipped via airfreight to the IFERC site, where they have been coupled and aligned

- Integrated design (mechanical support frame, coarse alignment system, fine-isostatic alignment jigs, cooling water manifolds, assembly and coupling tools)
- Dedicated handling tool;
- Transportation of the three assembled SuperModules from Italy (Padova) to Japan (Rokkasho)
- Assembly of the three Supermodule in Japan
- Alignment and vacuum tightness check

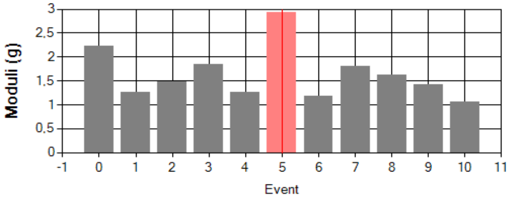


LIPAC RFQ – What is has been done

The journey of the RFQ SuperModules from Italy to Japan

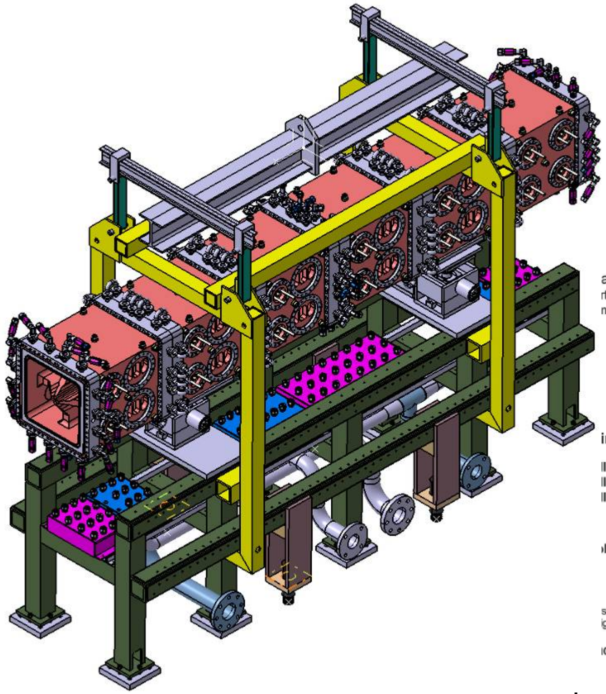


	Event	Axis	Date/Time	Modulus (g)	Temp (°C)
First Alarm	0	Z	17/02/2016 05:24:09	2,23	14,20
First Warning	1	Z	17/02/2016 22:52:28	1,27	13,50
Most Severe	5	Z	07/04/2016 00:38:52	2,93	17,20
Event Summary	11 Events (6 Warnings, 5 Alarms)				



- Tailored anti-shock and anti-vibration system
- Recording 3 axis accelerometers on the RFQ SMs

LIPAC RFQ – What is has been done



conceptual

C & G Engineering Service S.r.l.
Via G.A. Longhin, 71 35127 Padova
Tel. 049/8070412 - 8073734 - Fax 049/8074014

Dichiarazione CE di conformità

Ai sensi della Direttiva 2006/42/CE del Parlamento Europeo e del Consiglio del 17 maggio 2006 relativa alle macchine

Il sottoscritto costruttore:

C&G Engineering Service s.r.l.
Via G.A. Longhin n°71
35129 Padova (Italy)

dichiara sotto la propria responsabilità che il prodotto sotto descritto

ancino
rtata: **4000 kg** Anno di costruzione: **2013**
mero: **001-071-13** Tipo: **Bilancino ad H regolabile**

è conforme alle seguenti Direttive Comunitarie:
Direttiva 2006/42/CE

incipali norme armonizzate e regole tecniche di riferimento

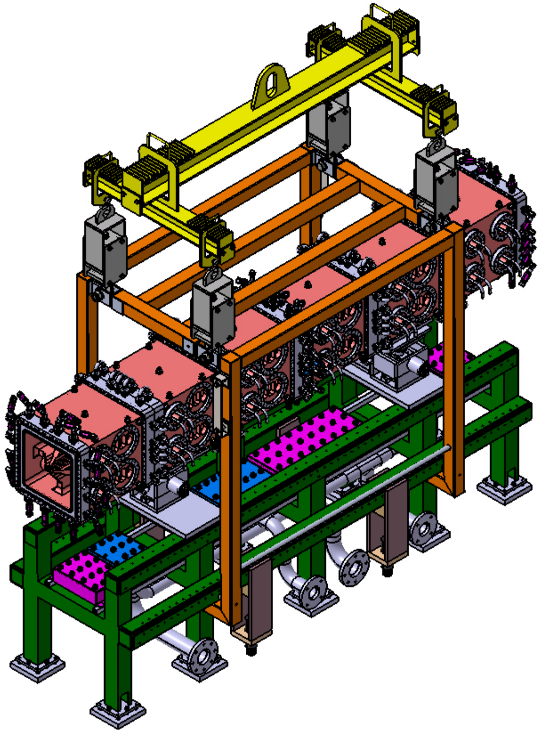
I **EN ISO 12100** (Sicurezza del macchinario)
I **EN 1993** (Eurocodice 3 – Progettazione delle strutture in acciaio)
I **EN 13155** (Apparecchi di sollevamento. Sicurezza – Attrezzature amovibili di presa del

ltre, ai sensi degli allegati III^ e VII^ della Direttiva 2006/42/CE si dichiara c
- la marcatura CE è apposta sull'attrezzatura
- il fascicolo tecnico è a disposizione presso la sede del costruttore

sona autorizzata a: Ing. Virgilio Crema
gere il fascicolo tecnico: Indirizzo: Via Longhin 71, 35129 Padova (ITALIA)

dova, 17/07/2013 UT. resp.
Ing. Virgilio Crema

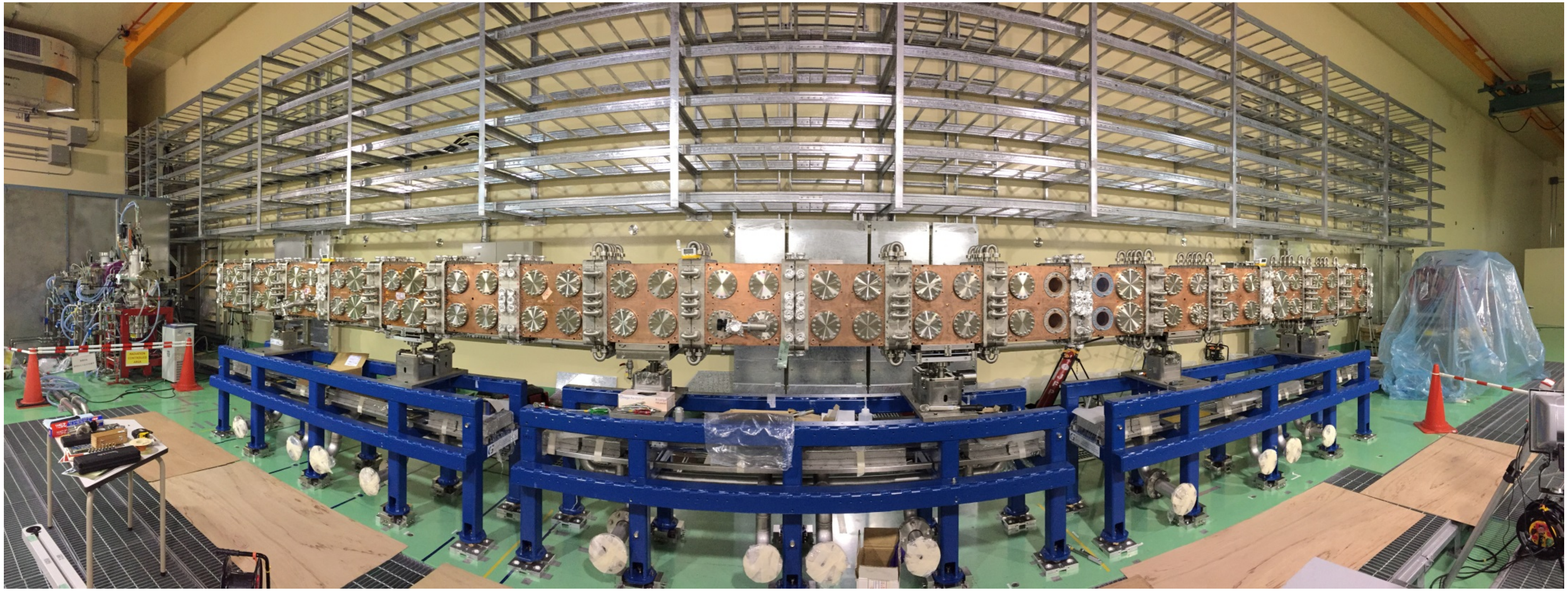
rif. M0003007113RT



actual

- Both lifting tool and each SuperModule mechanical frame have been marked CE (2006/42/CE);
- European standards have been accepted by JAEA, as specified in the PA and in LIPAc PID

LIPAC RFQ – What is has been done



The LIPAc RFQ installed, aligned and vacuum tested at IFERC site in Rokkasho

Conclusions

- **CAD manual;**
  - Release and version;
  - Basic rules on the CAD part models;
  - Origin of CAD part or assemblies;
  - How to properly constrain/fix the part in the assemblies;
  - CAD parts vs. PBS;
  - Naming;
  - ...
- **Define the level of detail of the models in a constestualized way**;
  - Coherent level of detail in two adjacent subcomponents;
  - ...
- **What is needed the model for**
  - Photogrammetry (laser tracker reflectometer visibility);
  - i.e. : design of a distribution line for water (pipes, washers, bolts, nuts...)
  - ...
- **Training;**
- **...**