

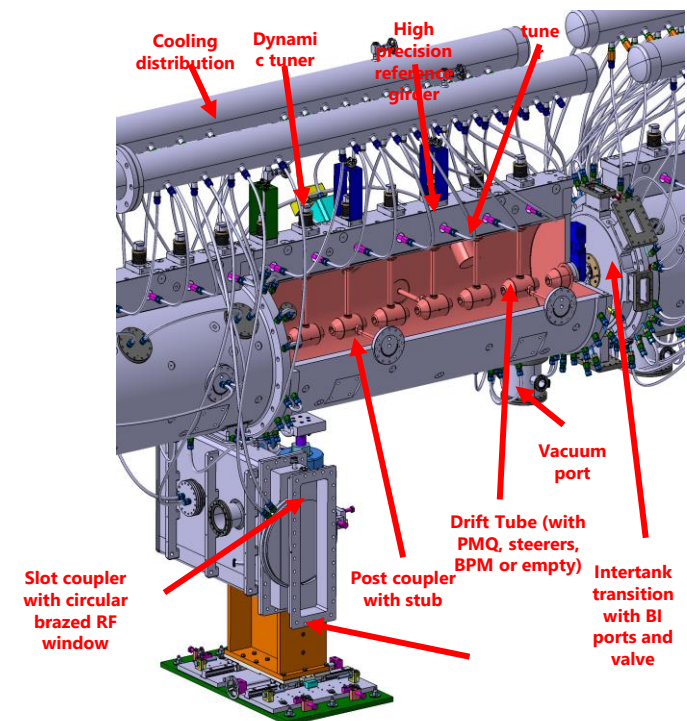
Sviluppo linac di alta intensità

A. Pisent- INFN Laboratori Nazionali di Legnaro

- I progetti in corso
- 3 esempi di sviluppo specifico di componenti di alta tecnologia di interesse trasversale

System	Application	Energy	particle	beam current	duty cycle	beam power	achieved
IFMIF EVEDA RFQ	test of fusion materials	5 MeV	d	125 mA	100%	625 kW	full current
ESS DTL	neutron spallation source	90 MeV	p	67.5 mA	14Hz 2.86 ms	250 kW	full current, RF duty up to 70 MeV
TRASCO RFQ	nuclear waste transmutation and then BNCT	5 MeV	p	30 mA	100%	150 kW	RF duty

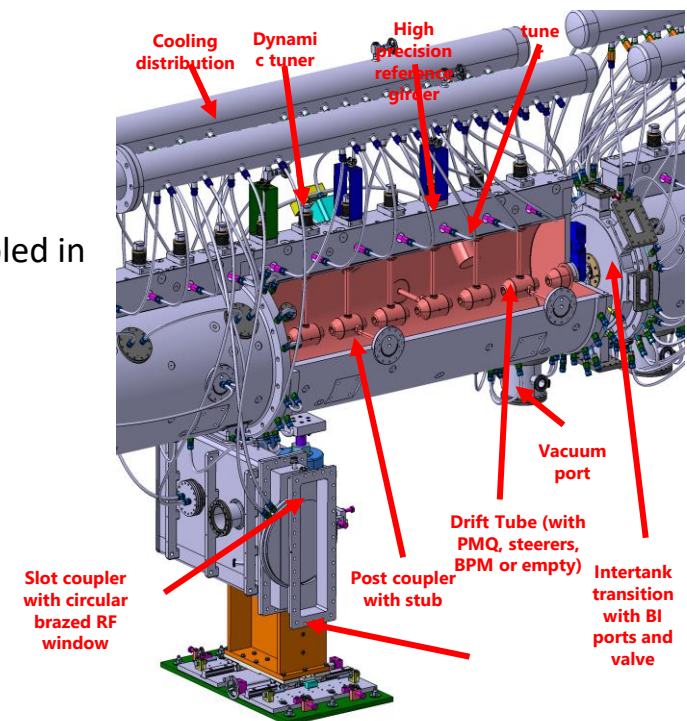
- **Commitment to deliver a complete working accelerator**, from ideation, to design, in-house production, external procurement, beam commissioning
- The complete production cycle implemented in INFN
 - Physics design
 - Prototype and model validation
 - Engineering Design (Mechanics, RF, vacuum)
 - Machining and production (in-house and external industrial partners)
 - In-house vacuum furnace brazing, consolidated design and procedure
 - Management of external tenders (D. Lgs. 50/2016 → D. Lgs. 36/2023)
 - QA/QC
 - Computer control system
 - RF tests (low and high power)
 - Assembly and installation on site
 - Commissioning
- Technical interchange with external partners to build an industrial network capable to deliver accelerator component with scope, timing and quality



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● Progetti in Corso

- ESS DTL (DTL beam tested)
- Anthem (procurement and test of components to be assembled in Caserta)
- IFMIF SPES (assembly phase)
- DONES Decisions this year?
 - Eurofusion WPENS
 - DONES Cons2
 - DONES in kind contribution?



- **High Power couplers**
- **High power neutron production targets**
- **Tuning, integration and commissioning of cw RFQs**

- **High Power couplers**

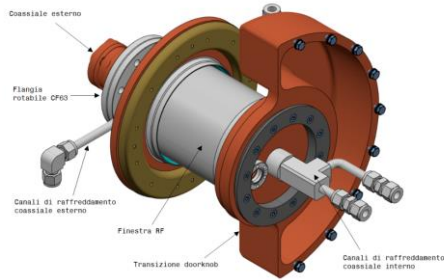
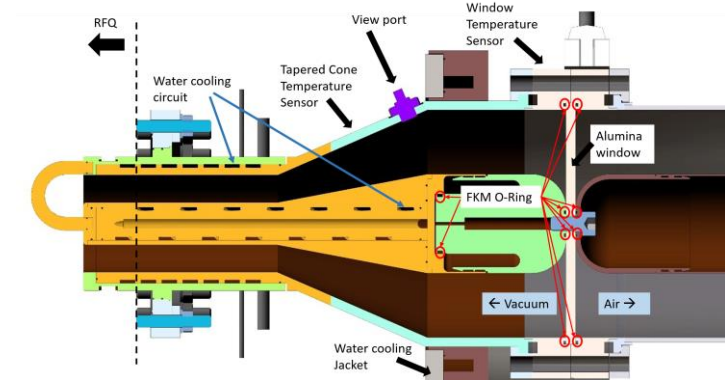


Figure 1: RF coupler system with loop, coaxial transmission line and coaxial alumina window.



IFMIF (and SPES) RFQ 200 kW cw

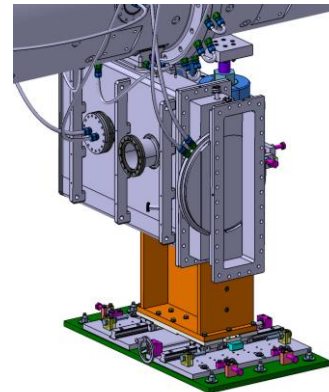
TRASCO Anthem 125 kW cw

The 3 design have reached nominal performances in high power tests (possible at LNL?)

Various Issues with reliability and reproducibility.

Our effort in the three fields

- Study of geometry resistant against multipacting
- Surface science and better procedures to reduce secondary electron yield
- Better vacuum



ESS DTL 1 MW pulsed, 60 kW average

- High Power couplers

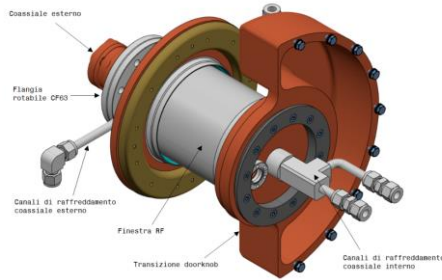
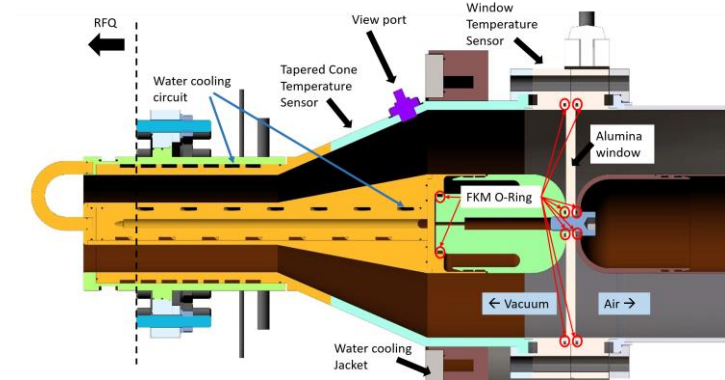


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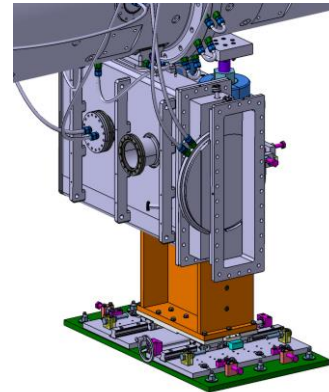
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Under negotiation specific development programs with ESS ERIC and F4E

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- High power neutron production targets

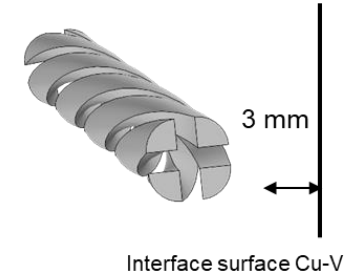
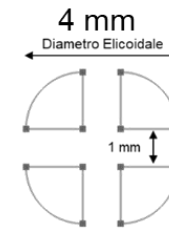
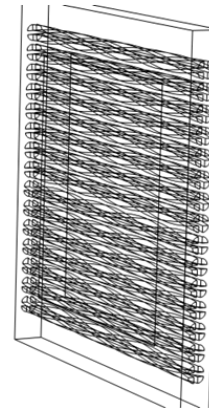
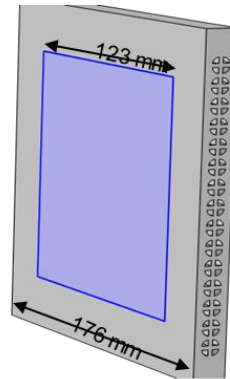
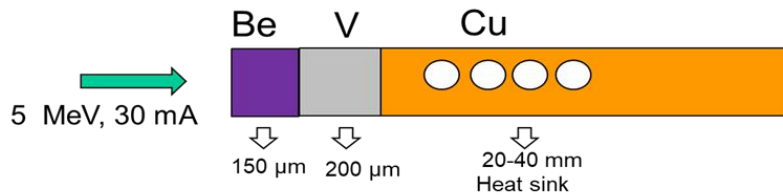
Development started with CSN5 and MUNES, geometry had to be deeply modified



The BNCT Target

150 kW, 220um range in beryllium

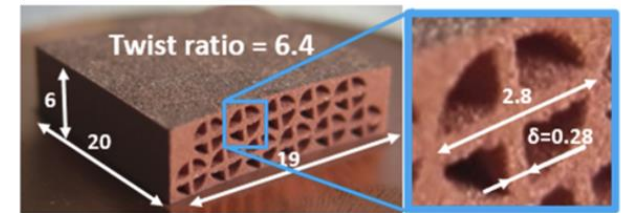
The proposed Be/V/Cu target configuration



Heat-sink manufacturing options under assessment

Produced by **additive manufacturing (Cu-OFE)**

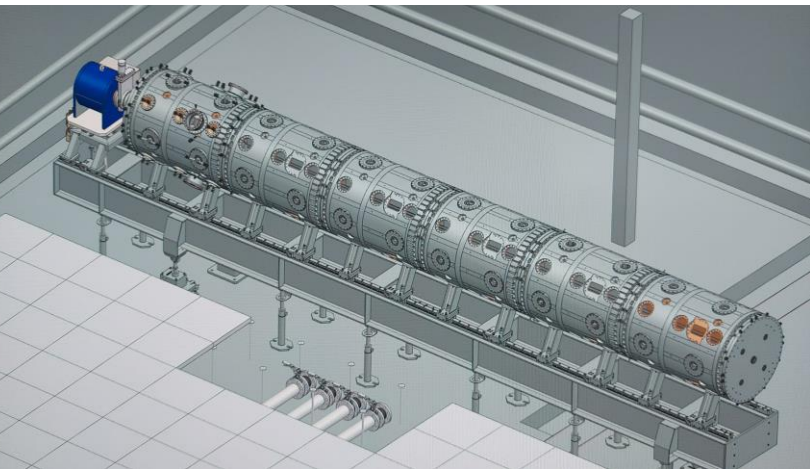
- New heat dissipator configurations unavailable with traditional techniques
- Microchannels (different geometries) to improve water cooling
- Cu-OFE powder technology now very well known with leading-edge Additive Manufacturing
- Be and V coating deposition with Hot Isostatic Pressure (HIP) process
- many advantages in pushing the limits of high thermal power performances
- **operation with 1 kW/cm² → heat transfer coefficient HTC to be maximized $h > 5 \cdot 10^4$ W/m² K)**
- **Total heat load on the target as in a building with 4 medium apartments**



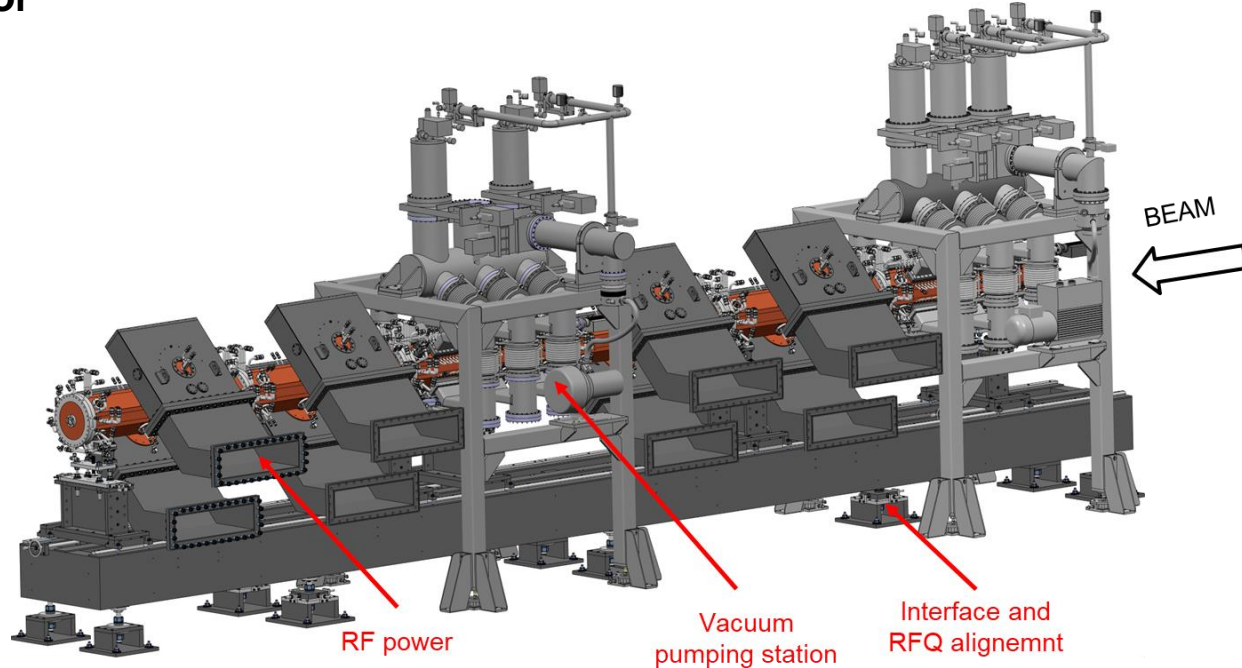
J. Esposito et al. "Experimental and numerical characterization of pure copper heat sinks produced by laser powder bed fusion" Materials & Design Volume 214, February 2022, 110415

- High Power couplers
- High power neutron production targets
- **Tuning, integration and commissioning of cw RFQs**

**SPES RFQ ,
to be integrated in ALPI Hall.
Very specific beam dynamics design for
high efficiency with low beam power
(cfr. M. Comunian Thesis 1993)**

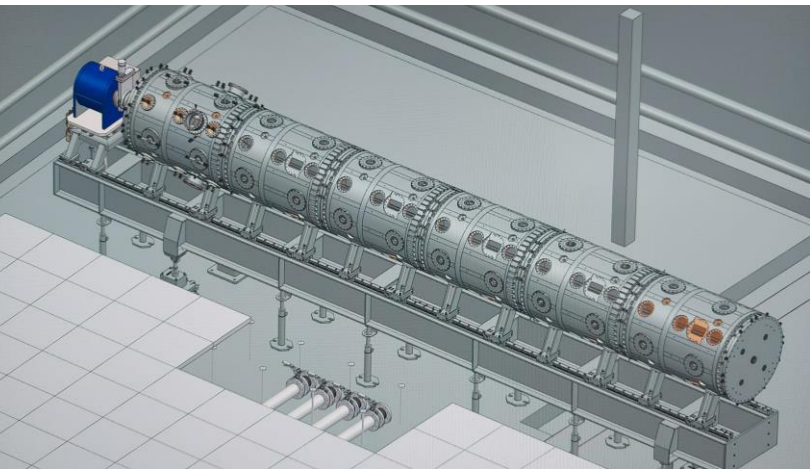


**Anthem RFQ , to be integrated in a medical facility
For BNCT.
System integration and computer control!**

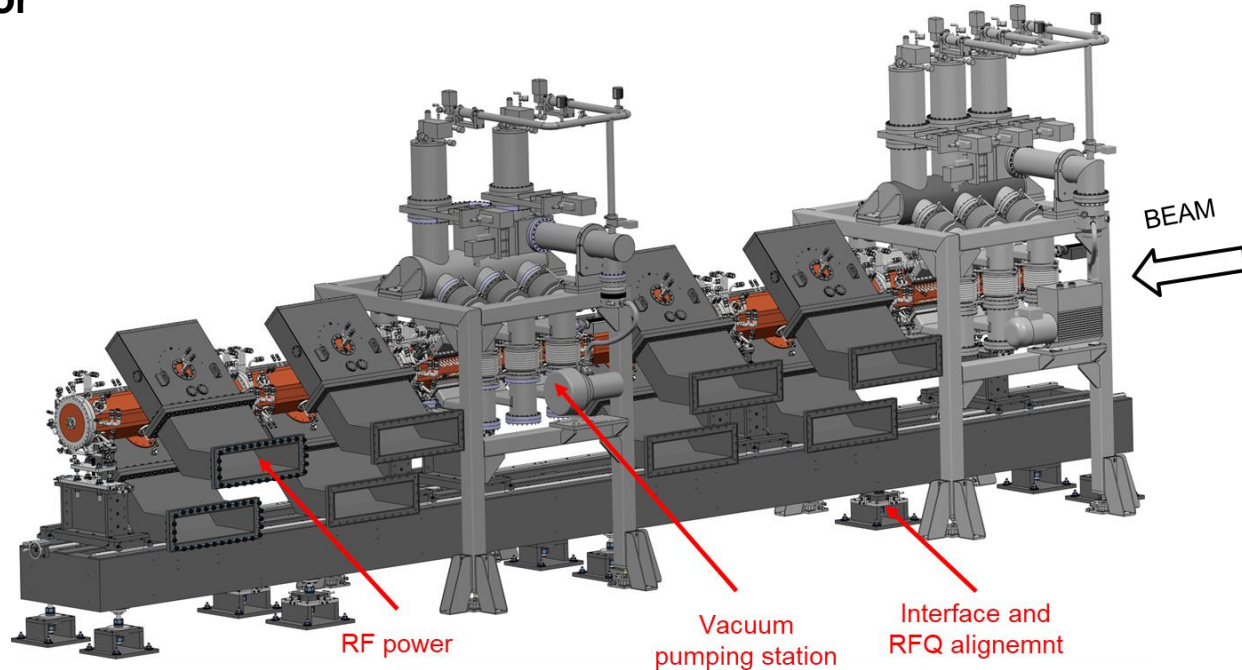


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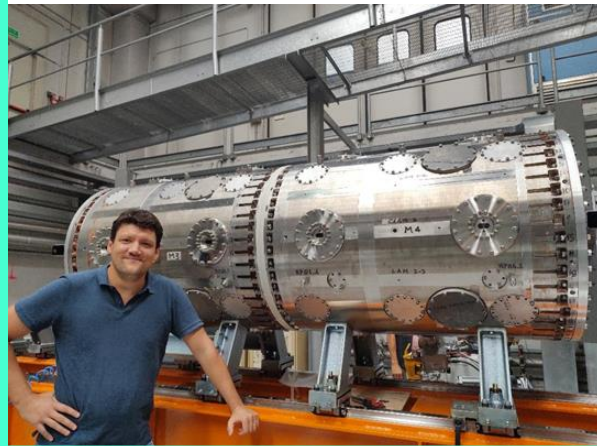
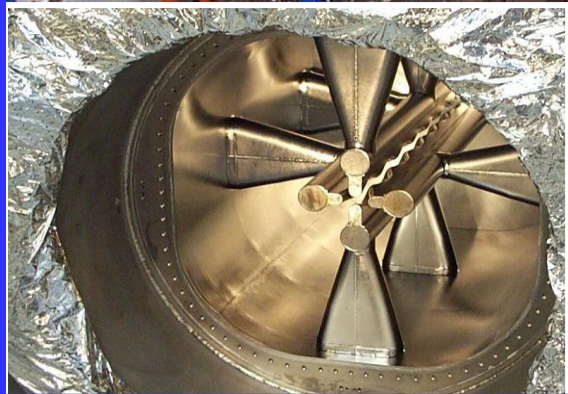
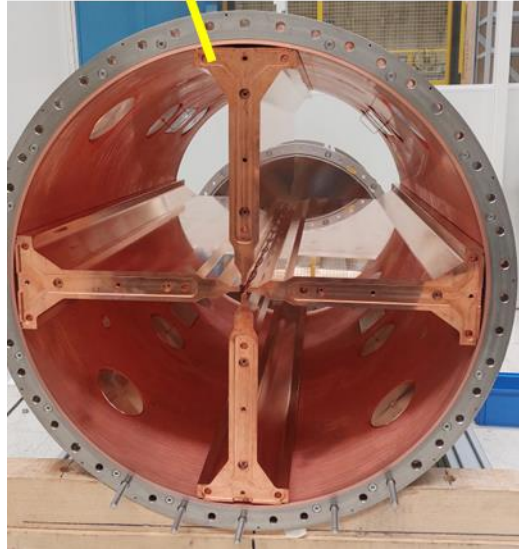
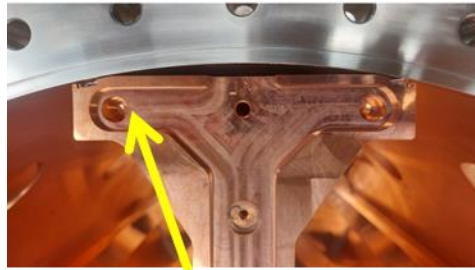
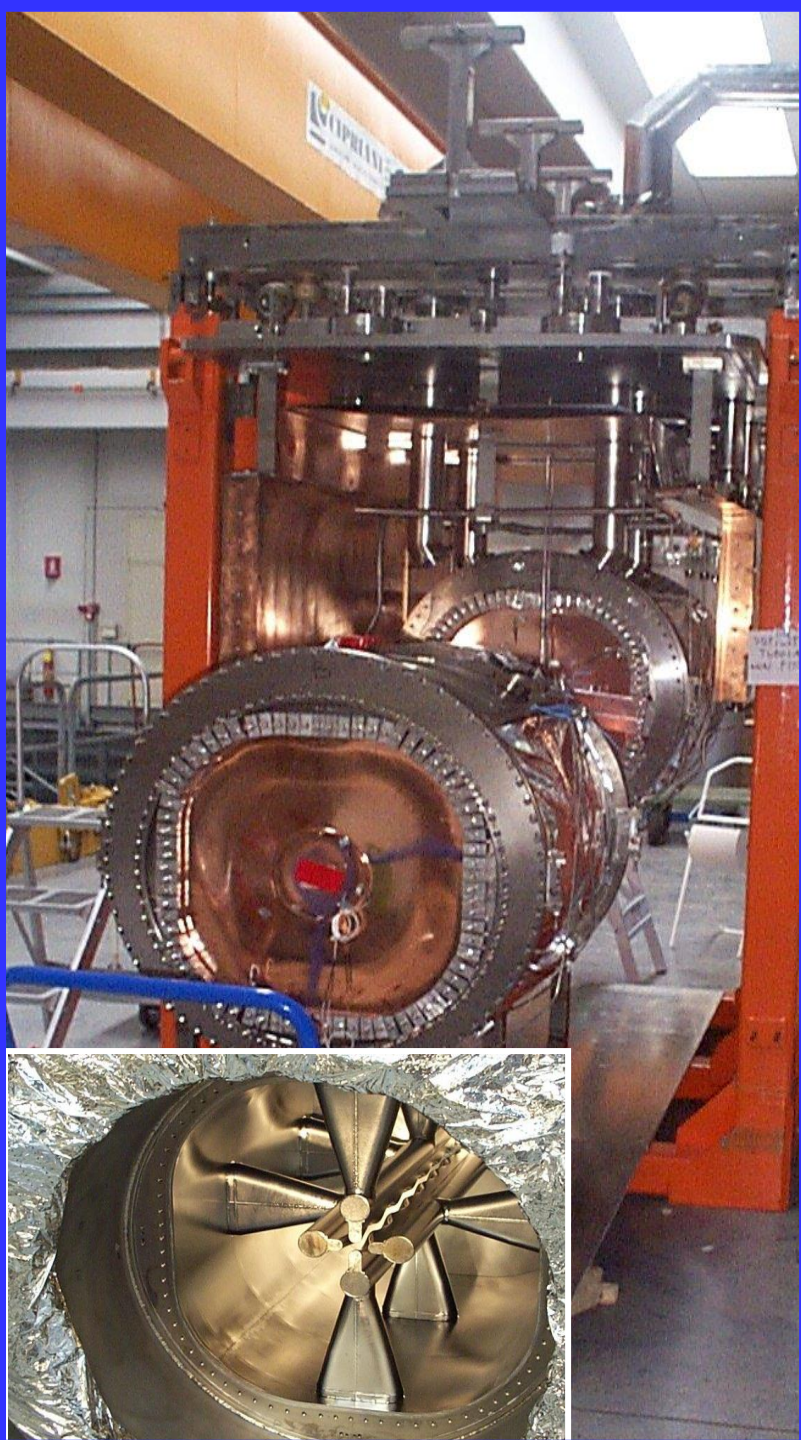
**Nei prossimi mesi dovremo implementare entrambi gli RFQ,
ottima occasione di lavoro efficiente e sinergico**

- **General accelerator physics:** A. Pisent (DT), E. Fagotti (1T), M. Cavenago (DR)
- **Beam dynamics:** M. Comunian (R), L. Bellan (TD), C. Baltador (TD)
- **Diagnostica del fascio.** M. Poggi (1T)
- **Radio frequenza:** A. Palmieri (1T), F. Grespan, (1T), A. Baldo (CTER)
- **Progettazione Meccanica e prototipi** L. Ferrari (T), P. Bottin T (CTER); F. Scantamburlo (congedo F4E a Rokkasho),
- **Computer control** L. Antoniazzi(T), M. Montis(T)
- **Inoltre, principalmente impegnato nei progetti**
 - M. Giacchini,, A. Battistello (CTER), A. Colombo (INFN PD), D. Conventi, R. Panizzolo (CTER),
Parte interdisciplinare di Anthem: J. Esposito, V. Conte, A. Bianchi, A. Selva
- Sia per ESS che per IFMIF è attiva un'intensa collaborazione con INFN TO, Gruppo guidato da P. Mereu (1T), Carlo Mingioni, Marco Nenni, Edoardo Nicoletti [*]

[*] situazione attuale, in passato anche sezione di Padova (A. Pepato et al.) e Bologna (A. Margotti et al.)

Grazie per l'attenzione

RISERVA



SRFQ vs NC-RFQ



Last update (2021) based on industrial quotations for conventional systems and BA expertise for high-technology ones

WBS N°	Task Name	*Low Value (M€)	Base Value (M€)	*High Value (M€)
5.0.0.0.0.	Task Name. DONES Construction, Installation, Test and Systems Commissioning	526,77	643,03	819,85
5.1.0.0.0	Design integration	2,99	3,33	3,82
5.2.0.0.0	Plant Level Integrated analysis	7,61	8,45	9,72
5.3.0.0.0	Site, Buildings and Plant Systems manufacturing, installation and checkout	282,94	332,87	416,08
5.4.0.0.0	Test Systems Manufacturing, Installation & Check out	21,80	29,07	39,25
5.5.0.0.0	Lithium Systems Manufacturing, Installation & Check out	27,69	36,92	49,85
5.6.0.0.0	Accelerator Systems Manufacturing, Installation & Check out	113,72	151,62	204,69
5.7.0.0.0	Project Management	56,68	62,98	72,42
5.8.0.0.0	Central Instrumentation and Control Systems Manufacturing, Installation & Check out	13,34	17,79	24,02
6.0.0.0.0	DONES Integrated Commissioning and Start-up	34,74	40,87	51,09
7.0.0.0.0	DONES Operation	960,84	1130,4	1.413
8.0.0.0.0	DONES Decommissioning	158,33	211,11	285,00

(*) Class 3-4 according to AACE Cost Estimate Classification System

3

- In the next phase of DONES, the INFN could provide, in addition to the **RFQ**, the entire **injector** (ECR source, LEBT line, chopping system) having all the necessary skills and excellent contacts with highly qualified Italian industries.
- Integrating the **RF system** and **injector** under the INFN responsibility would simplify the management of two interfaces between different components that have proved to be very complex in the LIPAc experience.
- Moreover we can participate to the realization of the **SRF linac**, INFN and Italian industry. For example one cavity family

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Survey on possible contributions to the DONES Program

Fields marked with * are mandatory.

Answers to the survey should be given by Country Representatives involved in the DONES Working Group. Answers should by no means be seen as commitments from the represented countries, but rather as informative indications. The main objective is to develop an informed overall view on the possible future contributors to the DONES Program.

