The National Laboratories of Frascati

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LNF is the oldest and largest national laboratory of INFN.

Founded in 1954, its main mission has always been the construction and operation of particle accelerators

At present, the laboratory covers an area of about **135,000** sqm and operates the **DAΦNE** e^+e^- collider complex and the **SPARC_LAB** plasma acceleration facility

LNF history through its accelerators

- 1954: Foundation of the Laboratori Nazionali di Frascati
    - 1959: First accelerator built: the Sincrotrone
        - 1961: First electron-positron collisions with Ada
            - 1969: Start of operations of ADONE
                - 2000: Start of operations of DAΦNE
                    - 2004: Start of operations of SPARC
                        - 2028: Start of operations of EuPRAXIA

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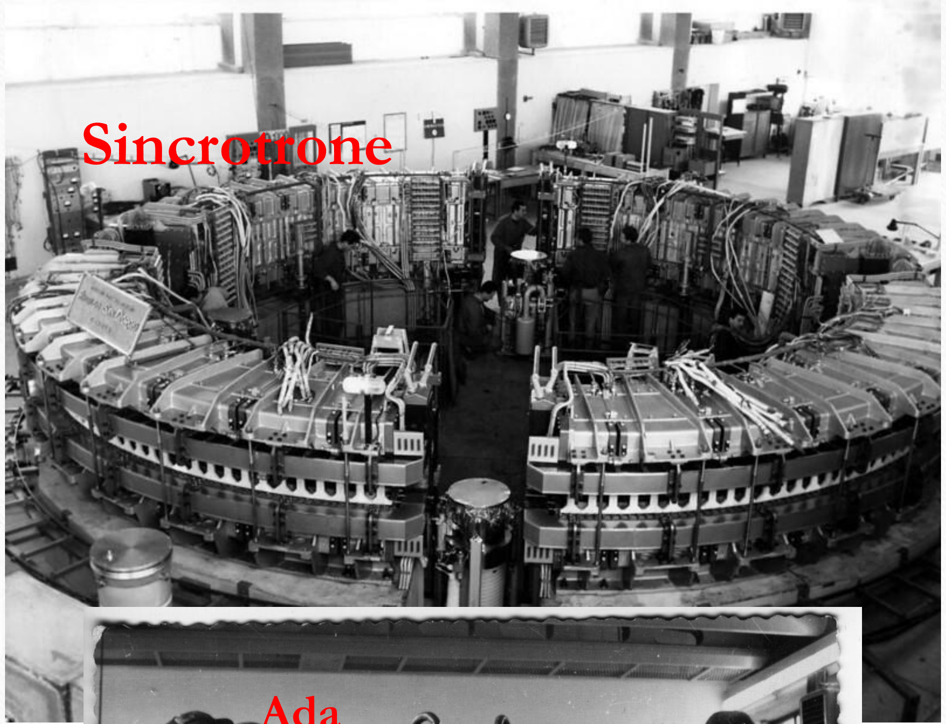

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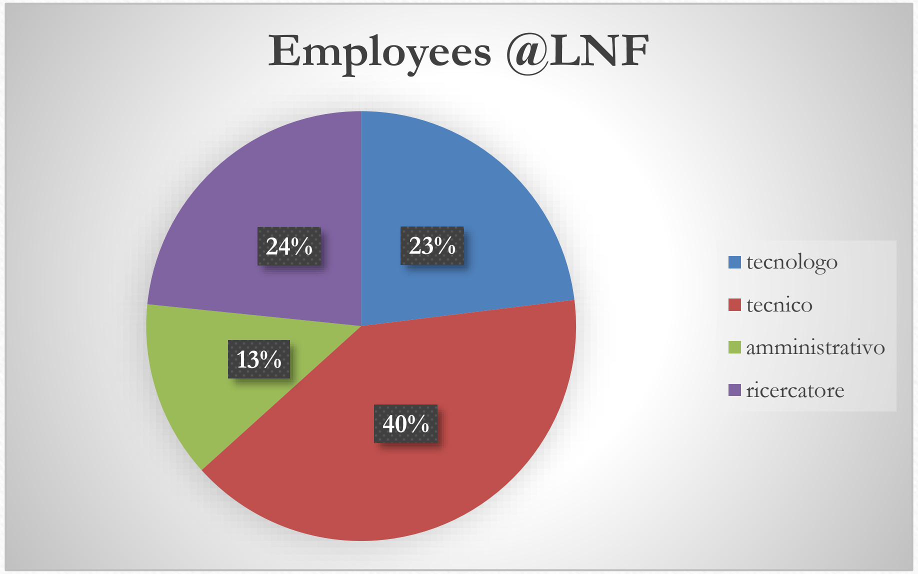
As of Aug. 1 2021 there are **309** permanent or fixed-term employees at LNF (researchers, engineers, technicians, administreatives) and **34** postdocs



Year 2020 budget

Item	k€
General expenses	12047.00
Research budget	5849.00
External Funds	12034.00
Total	**29930.00**

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The scientific strategy of the Laboratory goes well along the lines defined in the European Strategy for PP 2020 for the Large European National Labs

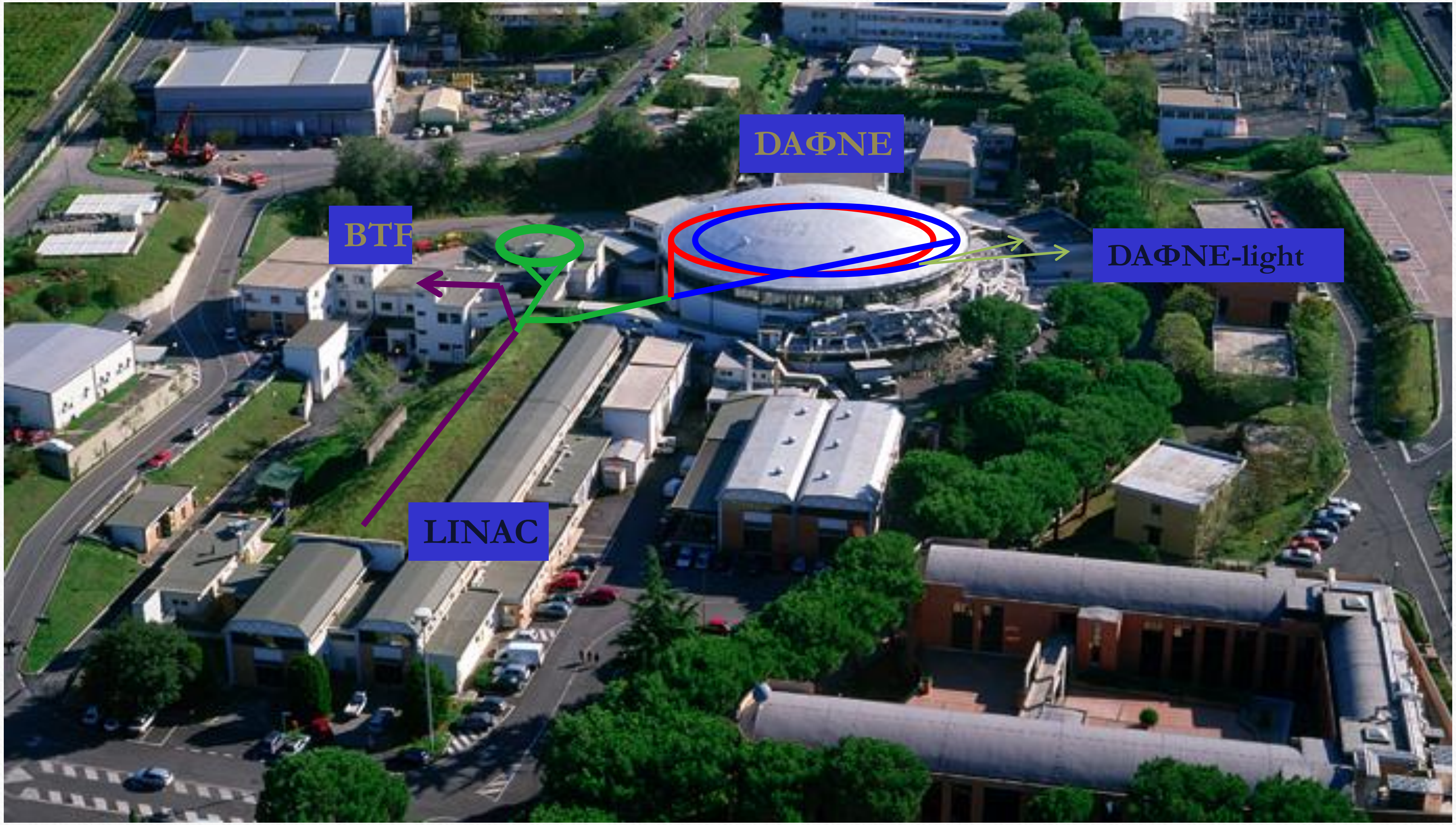
- Running medium scale infrastructures to host fundamental physics experiments
- Running local projects and R&D activities of general interest not replicated elsewhere
- Providing support to large scale projects at CERN or other international laboratories

The **DAΦNE** collider has entered into operations in year 2000, and has provided luminosity since then to 6 different particle and nuclear physics experiments

Experiment	Data Taking period	Int. Luminosity (pb-1)
KLOE	2000-2006	2500
DEAR	2003	60
FINUDA	2003-2007	1200
SIDDHARTA	2008-2009	600
KLOE-2	2012-2018	5000
SIDDHARTA-2	running	800 (goal)

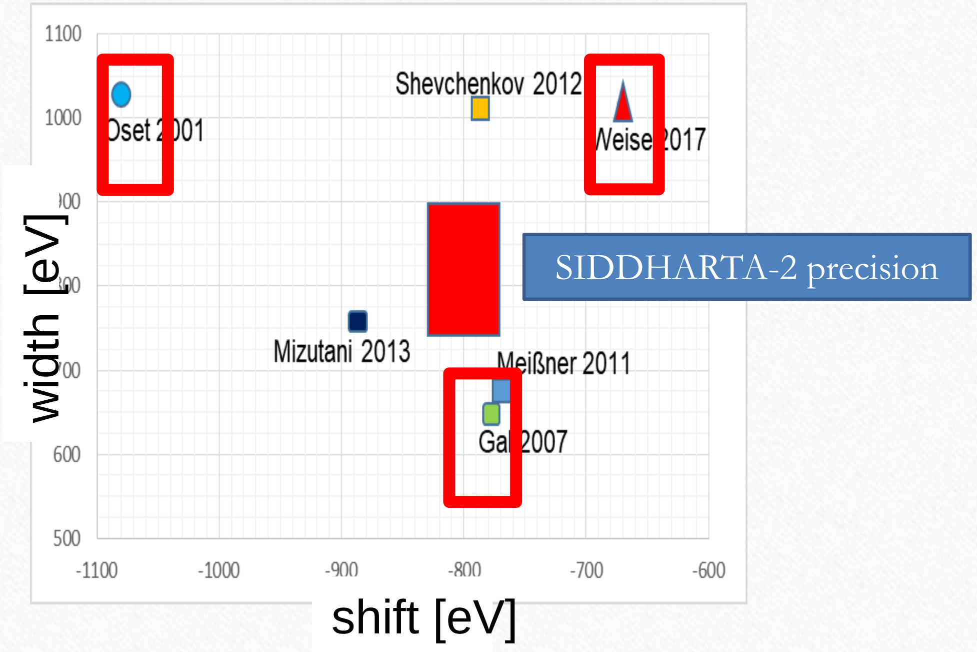
	DAΦNE CW upgrade tested with SIDDHARTA (2009)	DAΦNE KLOE (2005)	DAΦNE (CW) KLOE-2 (2014)
L_{peak} [$cm^{-2}s^{-1}$]	$4.53 \cdot 10^{32}$	$1.50 \cdot 10^{32}$	$2.38 \cdot 10^{32}$
I^- [A]	1.52	1.4	1.18
I^+ [A]	1.0	1.2	0.87
$N_{bunches}$	105	111	106
$\int_{day} L$ [pb^{-1}]	14.98	9.8 (seldom)	14.3

At DAΦNE we also tested for the first time the **crab-waist** collision scheme, which is nowdays considered one key ingredient for the future colliders, including FCCee

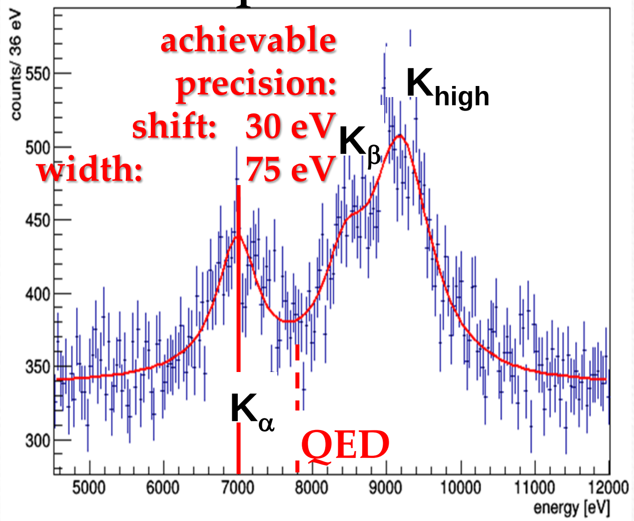

DAΦNE
BTF
DAΦNE-light
LINAC

Currently the **SIDDHARTA-2** experiment is in run

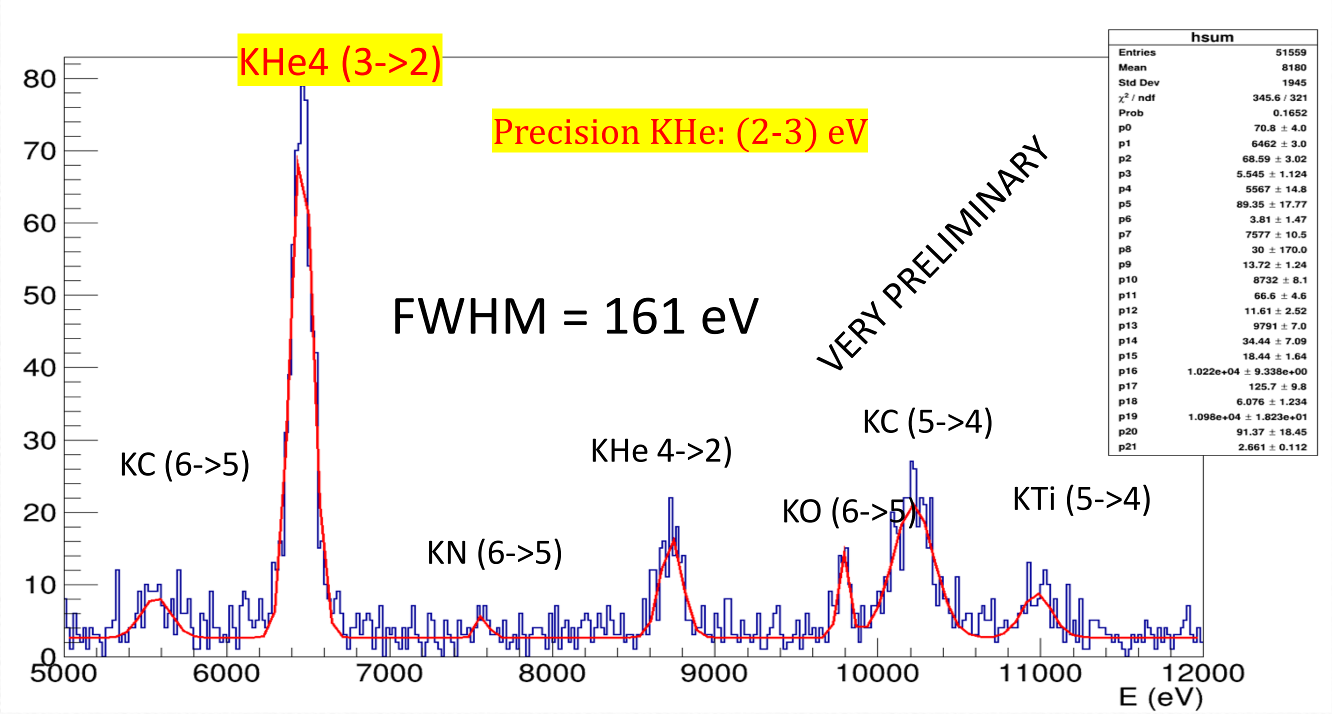
The goal of the experiment is to perform precision measurements of kaonic atoms X-ray transitions,, in particular of the shift and of the width of the 1s level of the kaonic deuterium to be compared with various theoretical models



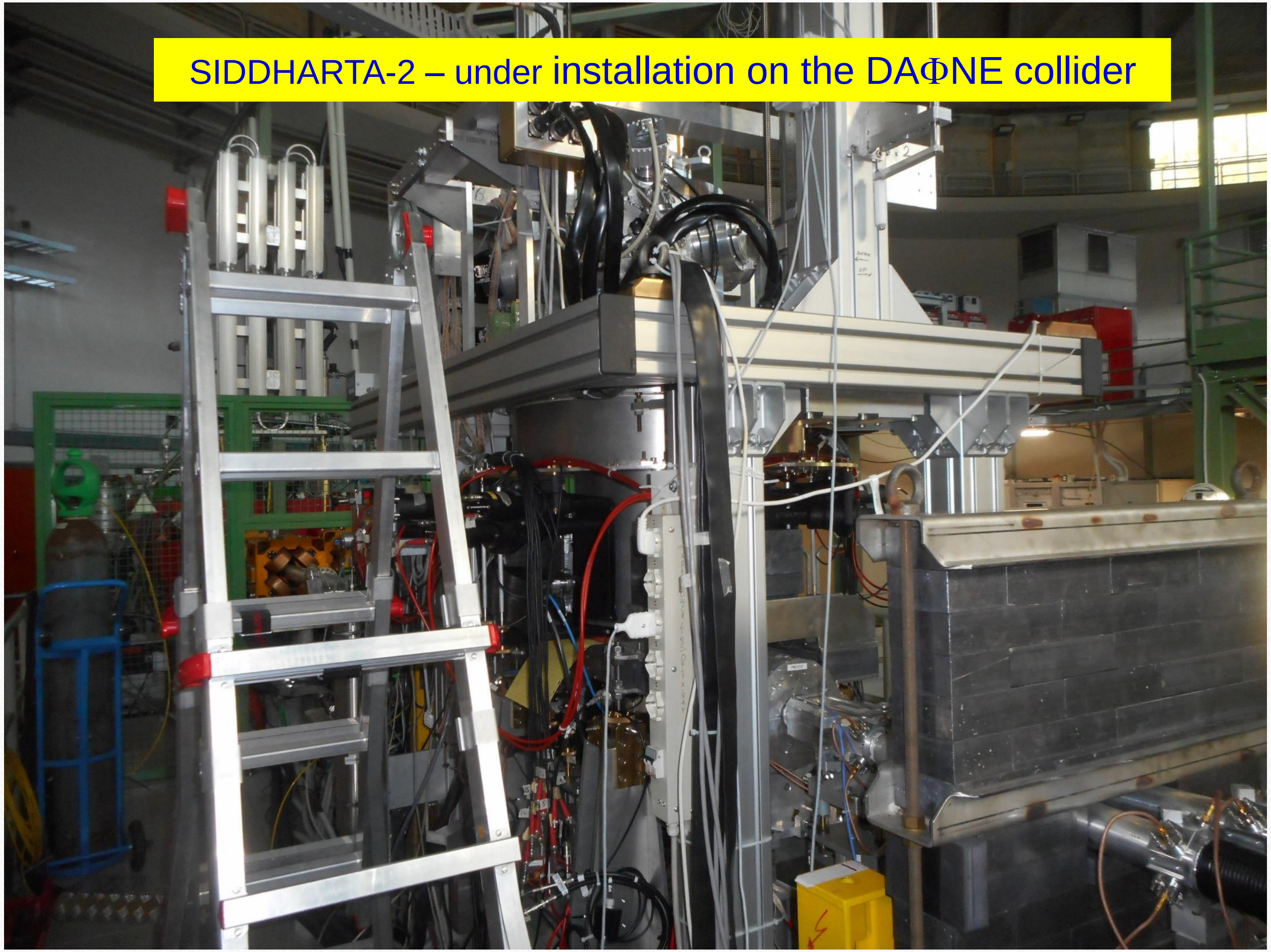
MCarlo Kd spectrum for 800 pb^{-1}



First phase of data taking with 1/6 of SDD detectors performed to optimize run conditions and experimental setup through kaonic helium measurement



Thanks to the excellent performance of the detector interesting results can be extracted by this relatively small (O(50 pb^{-1})) data set, possibly worth of physics publication



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Since 2003 the DAΦNE Linac provides also electron and/or positron beams to the Beam Test Facility (**BTF**) essentially dedicated to testing and calibration of particle's detectors

Access to the BTF is allowed to internal or external groups, generally on a weekly basis, based on dedicated calls managed by a specific Users Committe. The BTF can run also parasitically with collider's operations

The line has also been adapted to perform irradiation tests on electronics components for the aerospace industry

Given the large amount of users requests received so far, a second line (**BTF2**) has been built and succesfully tested in the summer 2021

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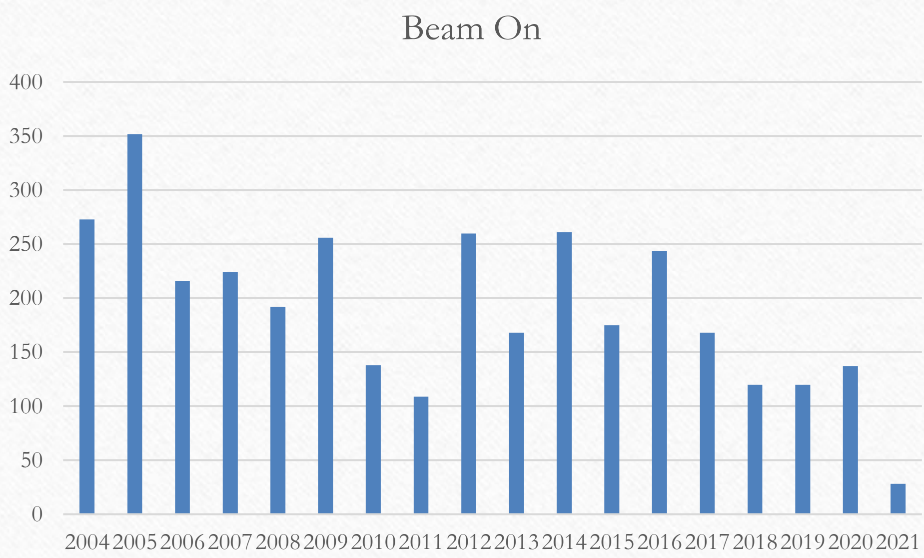

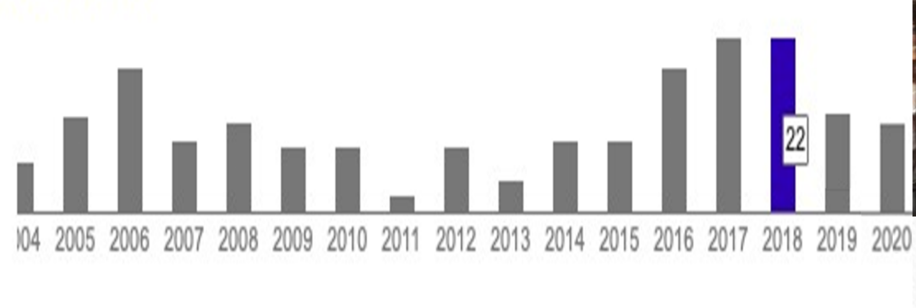

Citations of Nucl. Instrum. Meth. A515 (2003) 524

BTF2 Installation and Commissioning

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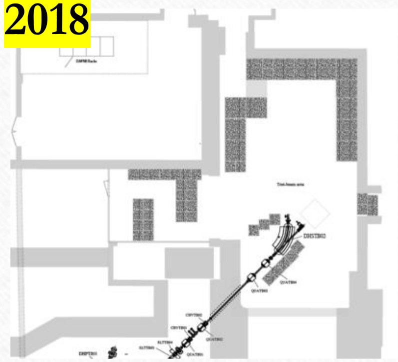
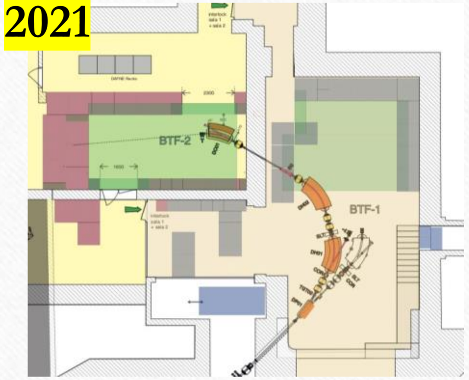
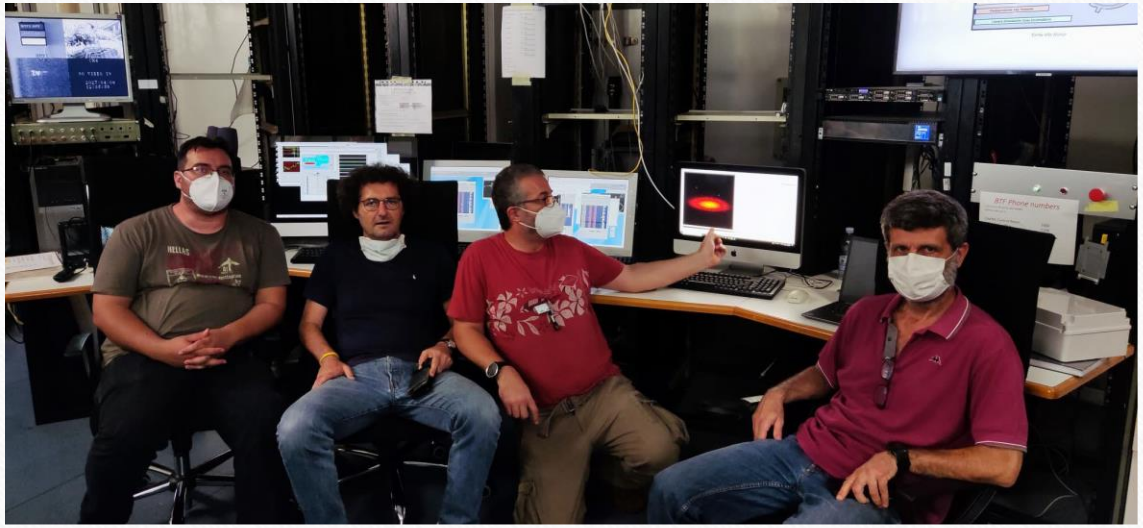
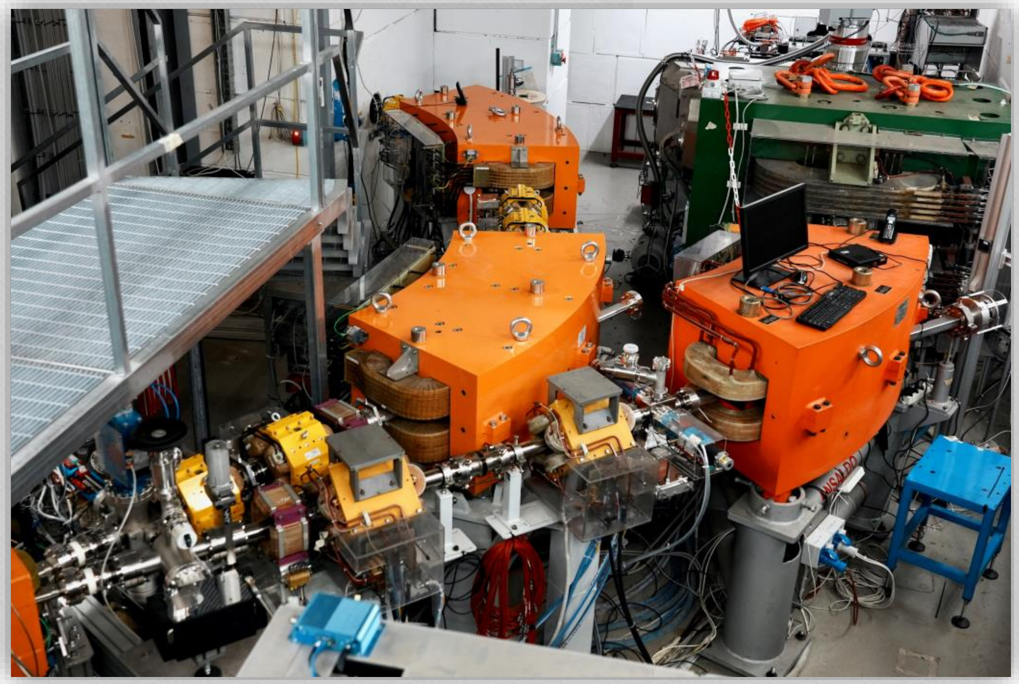
2018



2021



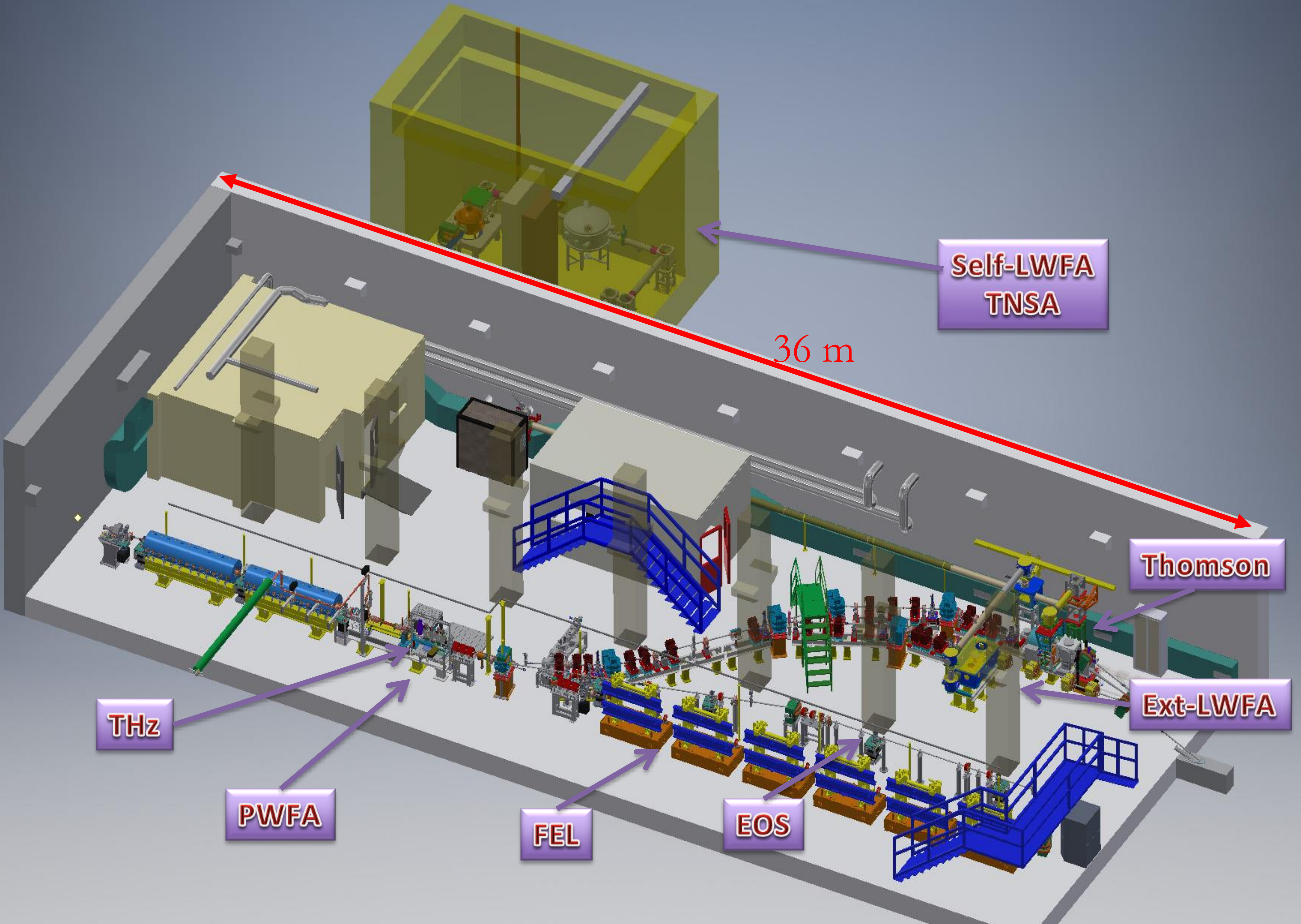


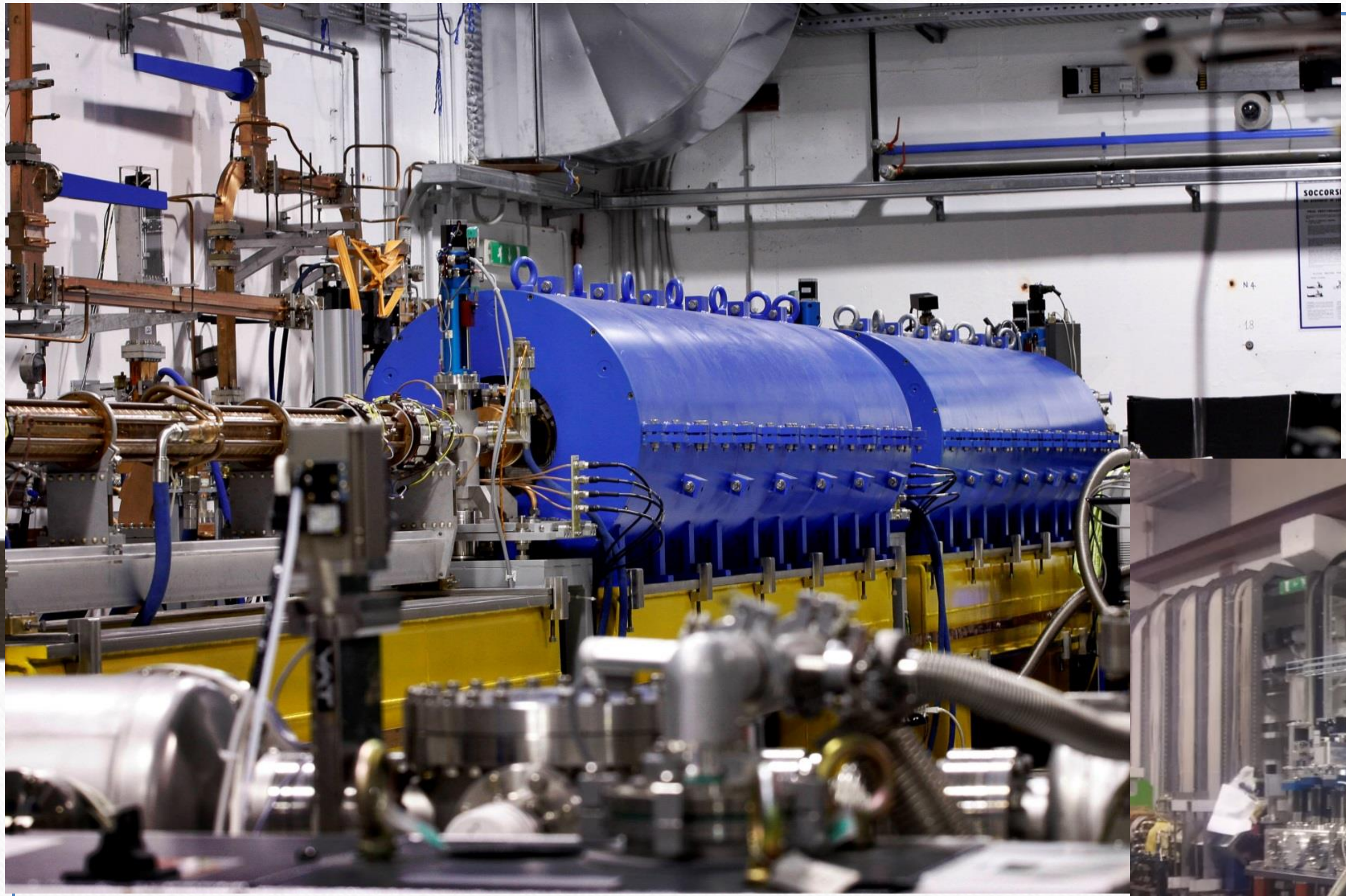


In 2005 new facility, **SPARC_LAB**, was put into operation as a test and training facility for advanced accelerator developments

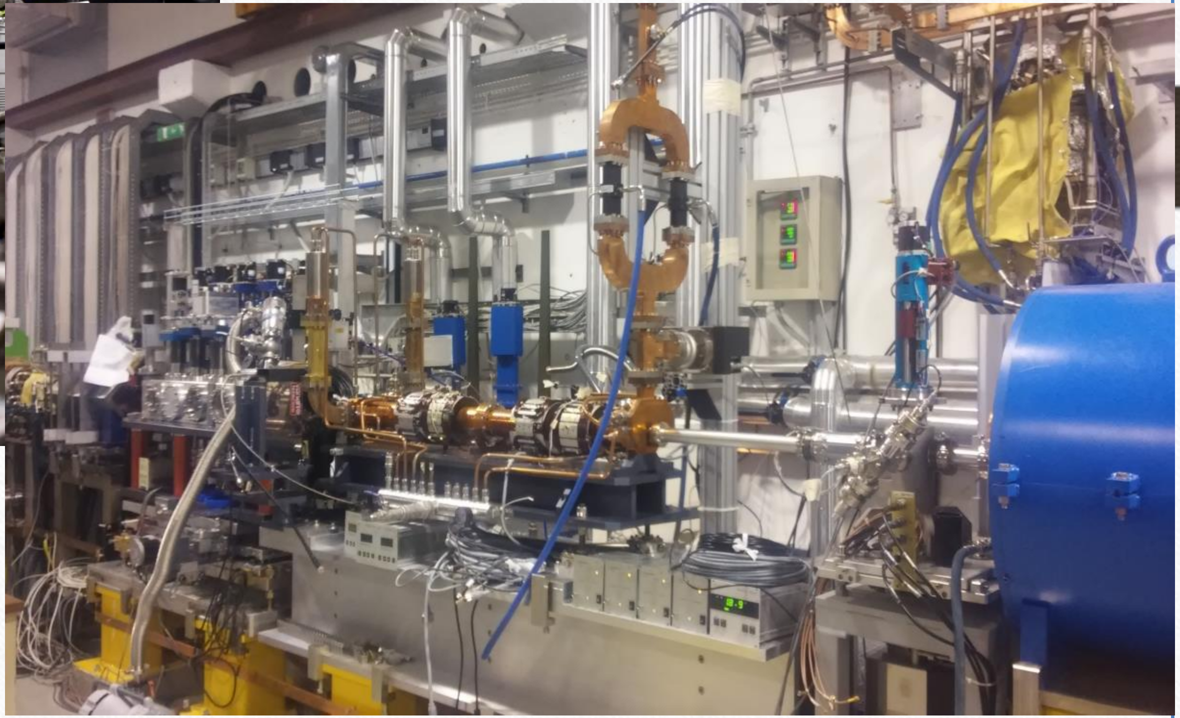
The facility consists of a high-brightness RF photoinjector, SPARC, and a multi-hundred terawatt laser, FLAME, and was initially focussed on performing FEL experiments and in general on the production of new radiation sources

In recent years a dedicated effort has been put in the research on very high acceleration gradients with the plasma wake field technique


Self-LWFA
TNSA
36 m
Thomson
Ext-LWFA
THz
PWFA
FEL
EOS



Plasma Vacuum Chamber



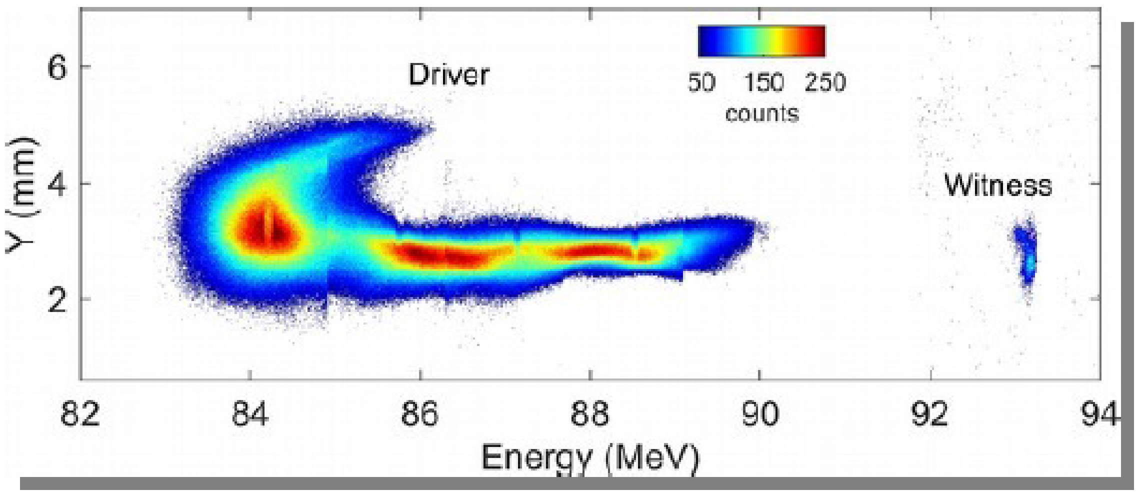
Photoinjector

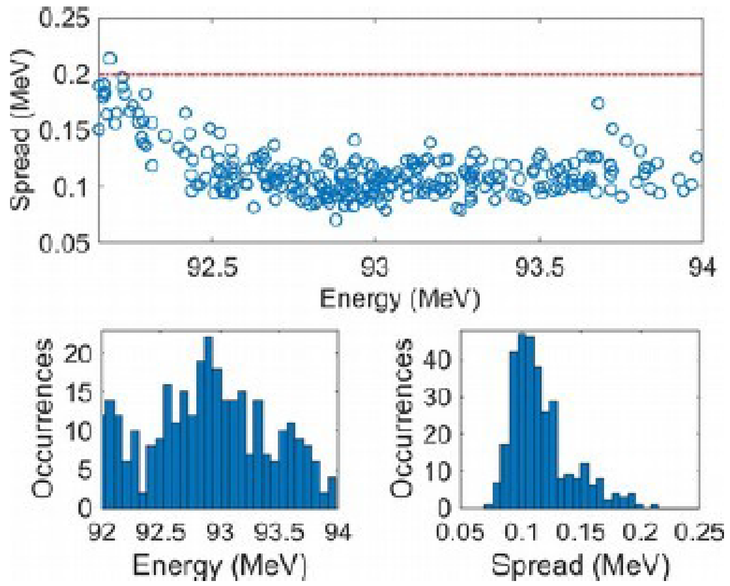
Achieved 4 MeV acceleration in 3 cm plasma with 200 pC driver

- *~133 MV/m accelerating gradient*
- *$2x10^{15}$ cm^{-3} plasma density*

→ demonstration of energy spread compensation during acceleration

- *Energy spread reduced from 0.2% to 0.12%*
- *99.5% energy stability*





Recently also evidence of FEL lasing has been obtined using a PWF accelerated electron beam

Pompili, R., et al. "Energy spread minimization in a beam-driven plasma wakefield accelerator." Nature Physics (2020): 1-5.

These experiments are intended to pave the road for the construction of the new accelerator facility which is planned to deliver its first beams in 2028: **EUPRAXIA@SPARC_LAB**

This is the Italian branch of a multinational project aimed at building two plasma driven FELs, one exploting the beam-driven (in Frascati) and one the laser-driven technique (site yet to be decided)

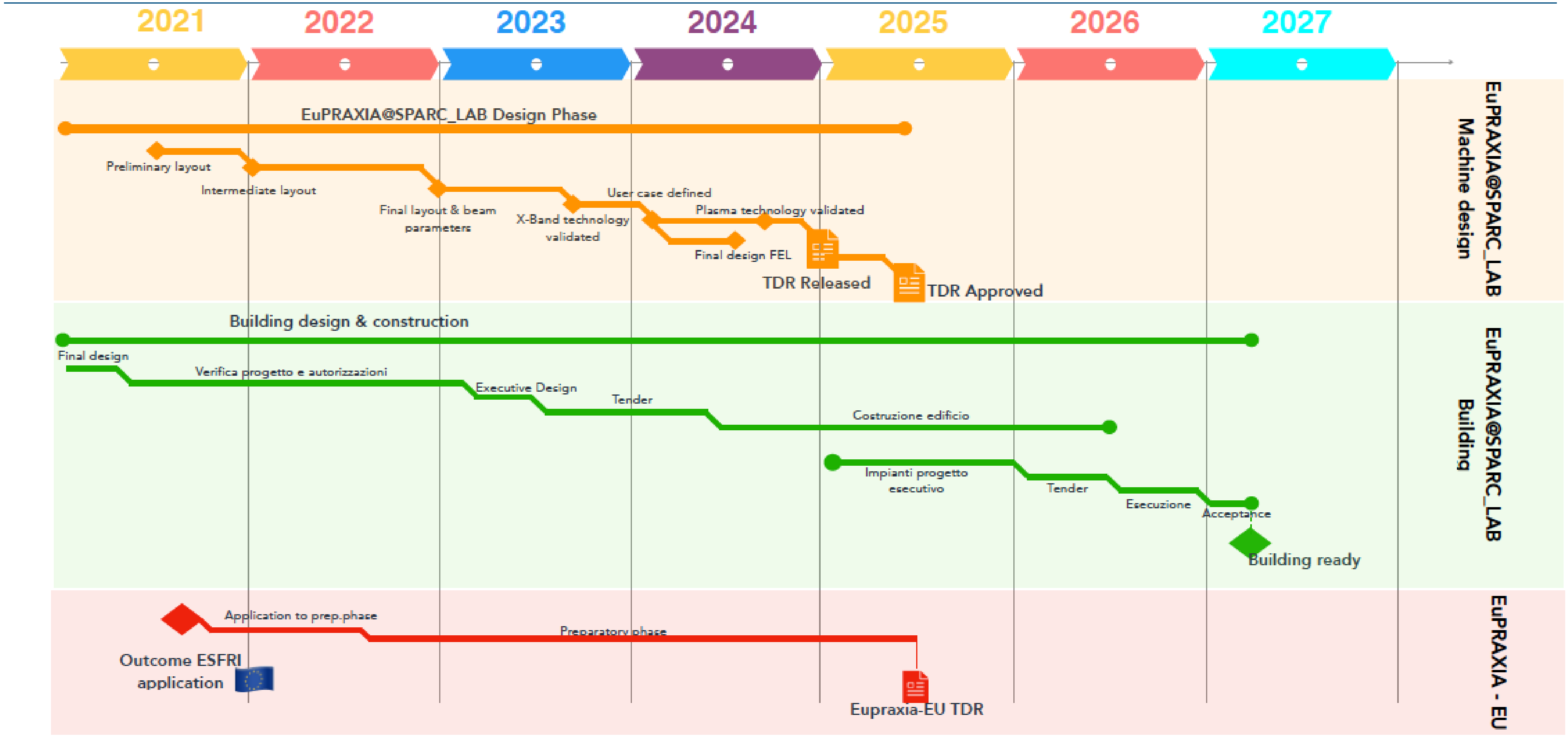
The Frascati project has been granted **108** M€ funding from the Italian government, while the overall project, with INFN leadership, has been inserted recently in the ESFRI raodmap

EuPRAXIA Brings together European Actors in this Field…

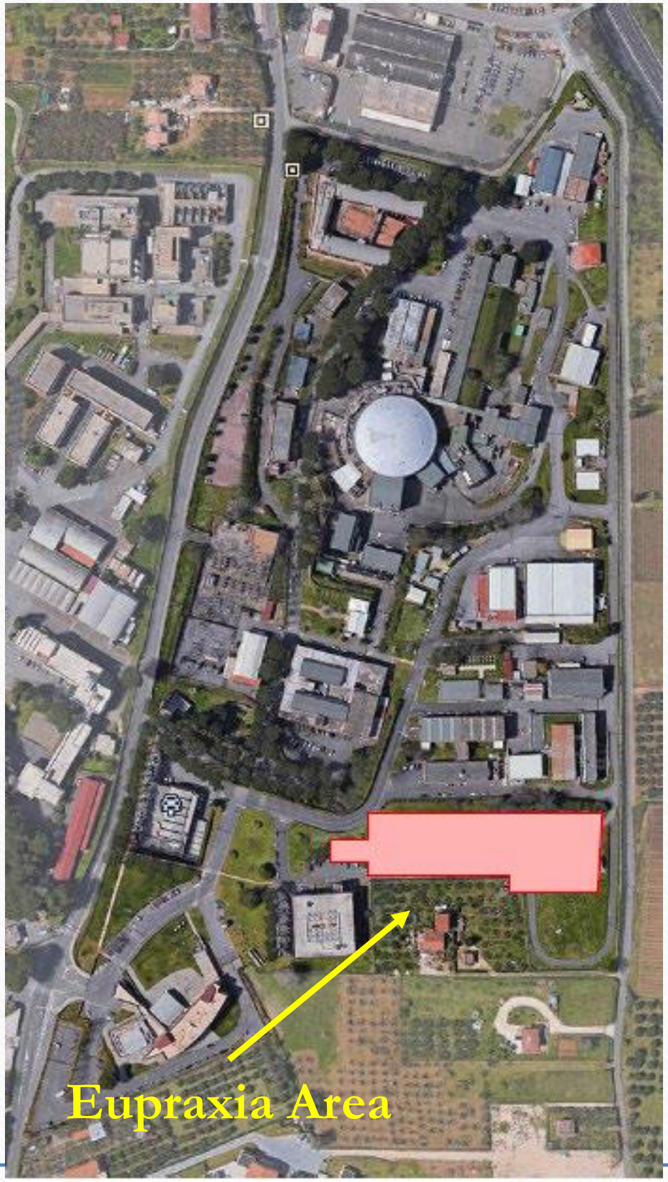
Position Europe as a Leader in the Global Context

- Avoid internal competition, **position Europe globally as lead player** in the compact accelerator “market”, in innovative technology

Road map



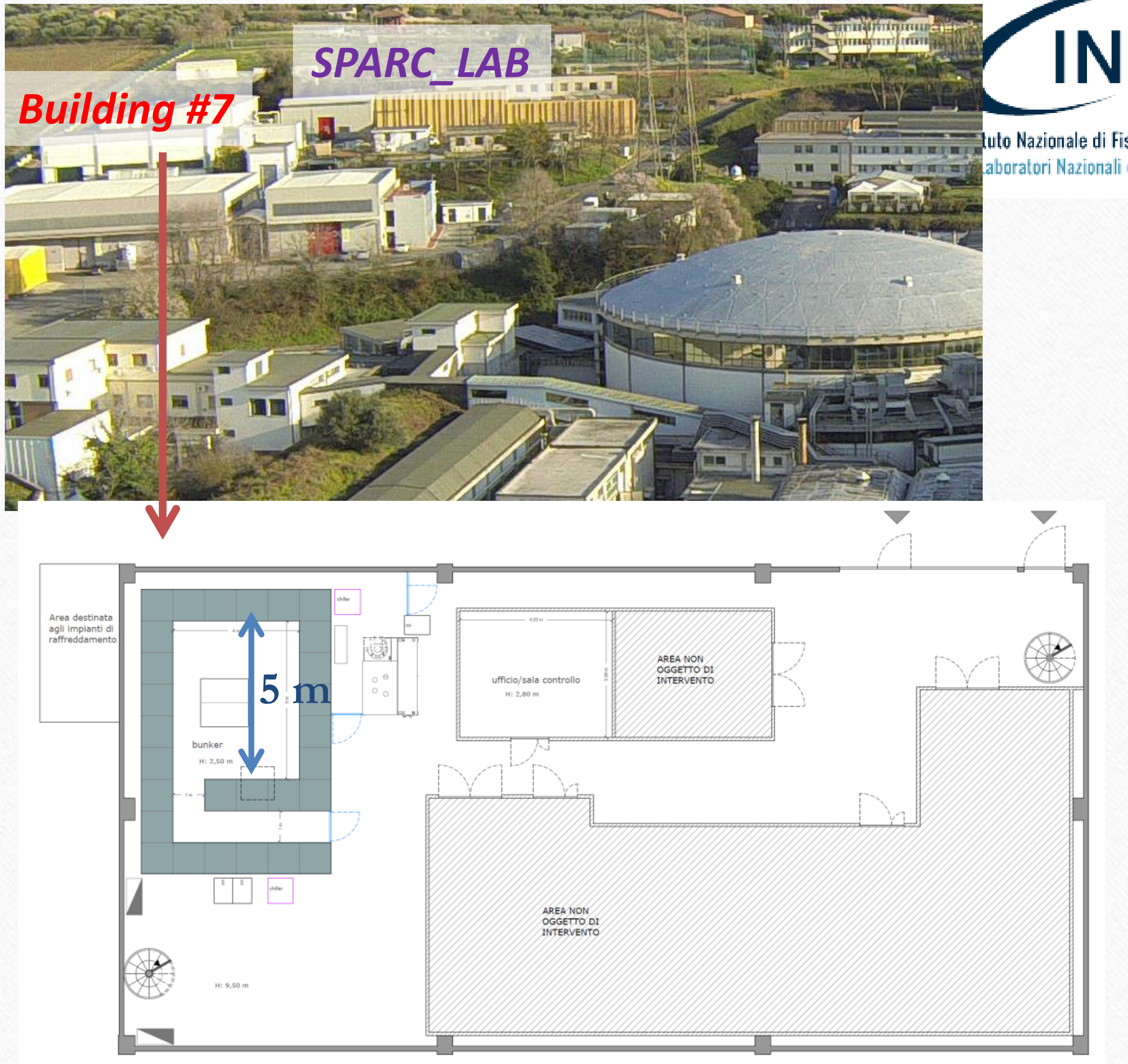
2021
2022
2023
2024
2025
2026
2027
EuPRAXIA@SPARC_LAB Design Phase
Preliminary layout
Intermediate layout
Final layout & beam parameters
X-Band technology validated
User case defined
Plasma technology validated
Final design FEL
TDR Released
TDR Approved
EuPRAXIA@SPARC_LAB Machine design
Building design & construction
Final design
Verifica progetto e autorizzazioni
Executive Design
Tender
Costruzione edificio
Impianti progetto esecutivo
Tender
Esecuzione
Acceptance
Building ready
EuPRAXIA@SPARC_LAB Building
Application to prep.phase
Preparatory phase
Outcome ESFRI application
Eupraxia-EU TDR
EuPRAXIA - EU



The final design for the building has been delivered. We are now starting to work on the authorisation procedures

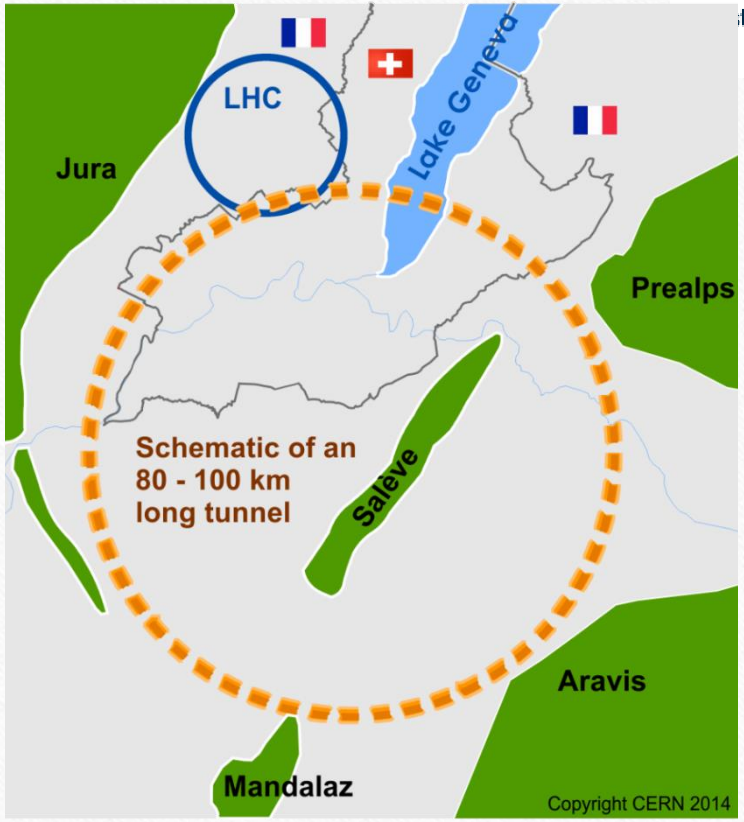
Overall cost of the building estimated to be **32** M€, including all the accessory plants

The LATINO high-power RF Lab is based on the **INFN X-box,** a test stand under construction to test X-band high gradient RF structure similar to the 3 X-boxes installed at CERN. The CERN **CLIC RF** group is supporting this program through a dedicated addendum to the general CERN-INFN MoU.



The Frascati Accelerator Division contributes also to a number of other design or construction enterprises of various accelerators in the world

In particular, a relevant contribution is given to the technical design studies of the 100 km long luminosity frontier circular collider at CERN that is meant to extend Europe's leadership in fundamental physics research during the entire 21° century



CONCLUSIONS

- The LNF has operated since its beginning high quality infrastructures to support fundamental physiscs with accelerators
- Despite the Covid restrictions the last two years have been full of first-class results both on the physics and in the constructions sides
- With EUPRAXIA we have an ambitious plan which will keep the Laboratory at the forefront of accelerator physics research for many years to come
- We will not however forget our historical mission in supporting fundamental physics resarch.
- Being able to win on both tables is a clear management challenge: we are confident that with the help of INFN and of the international community we will be able to succeed in this task