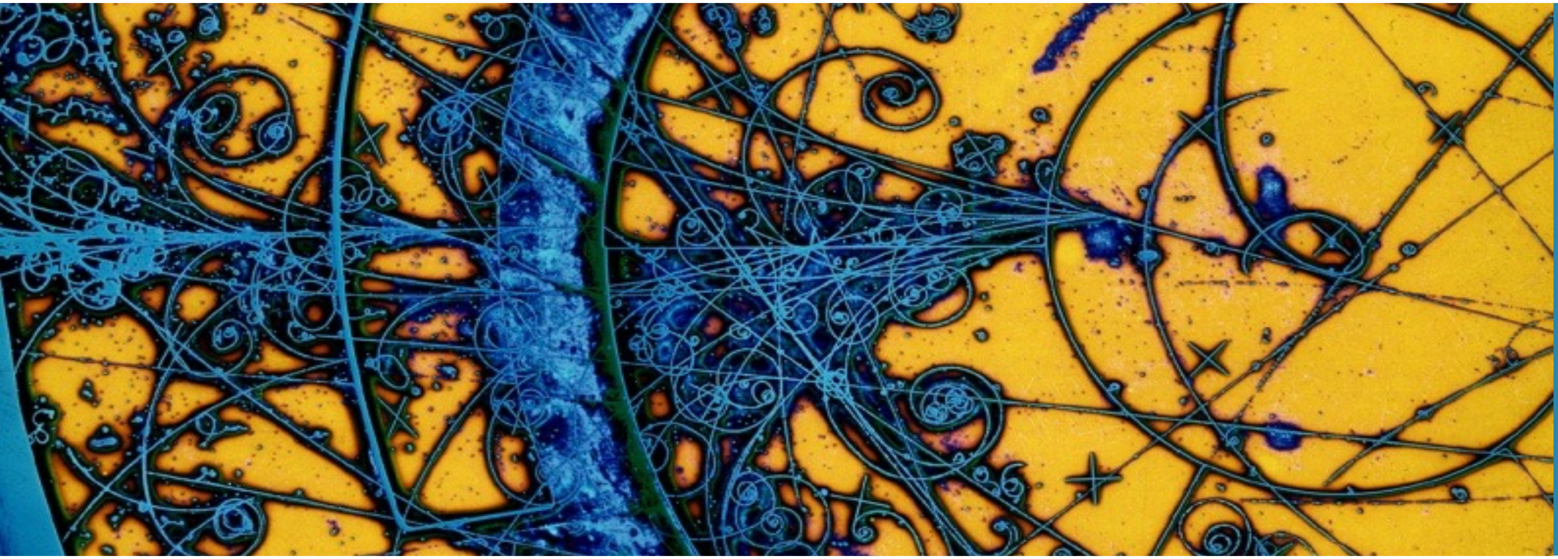
Attività INFN-NA su acceleratori: stato e prospettive

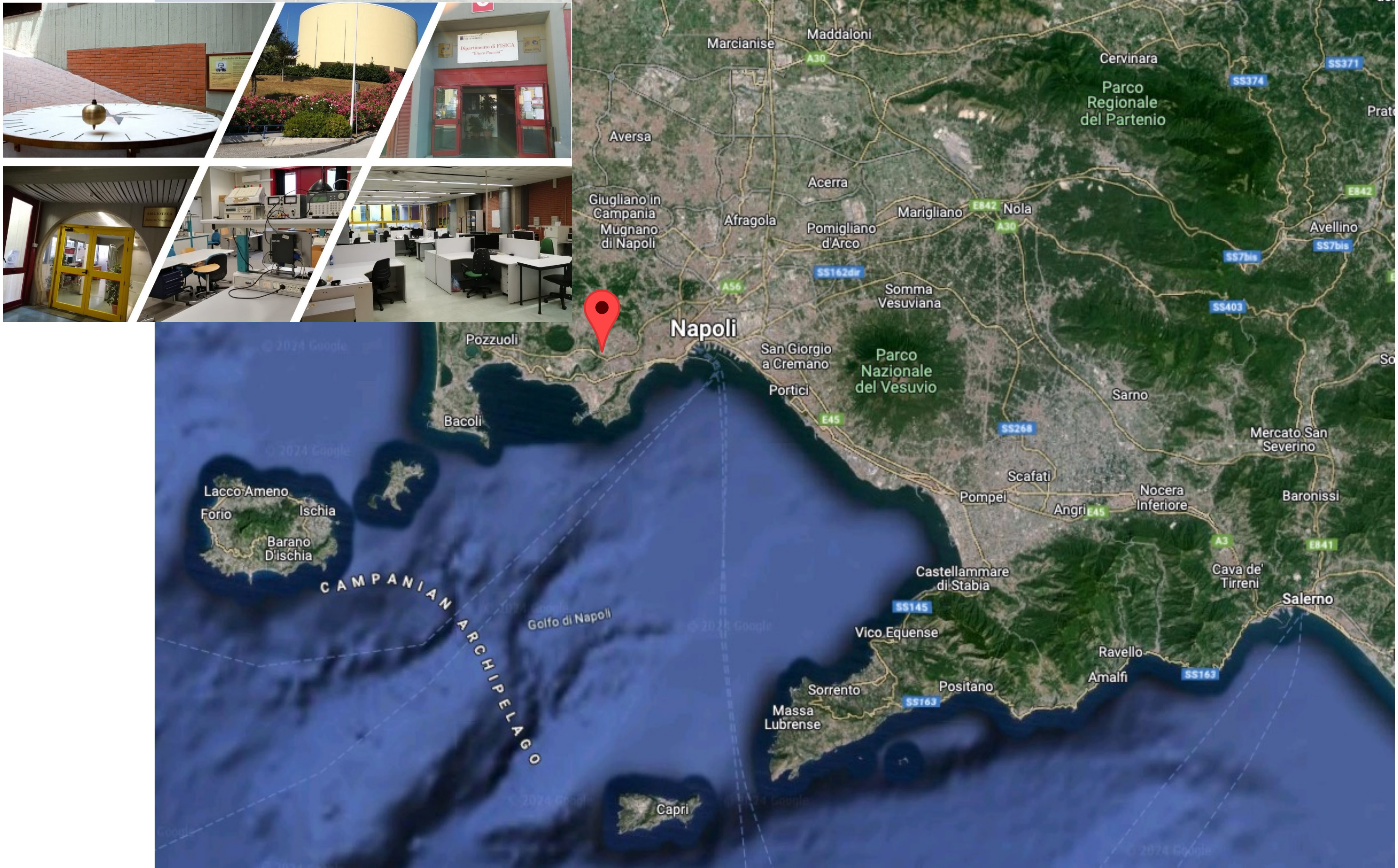
04/04/2024



Istituto Nazionale di Fisica Nucleare
The Italian National Institute for Nuclear Physics

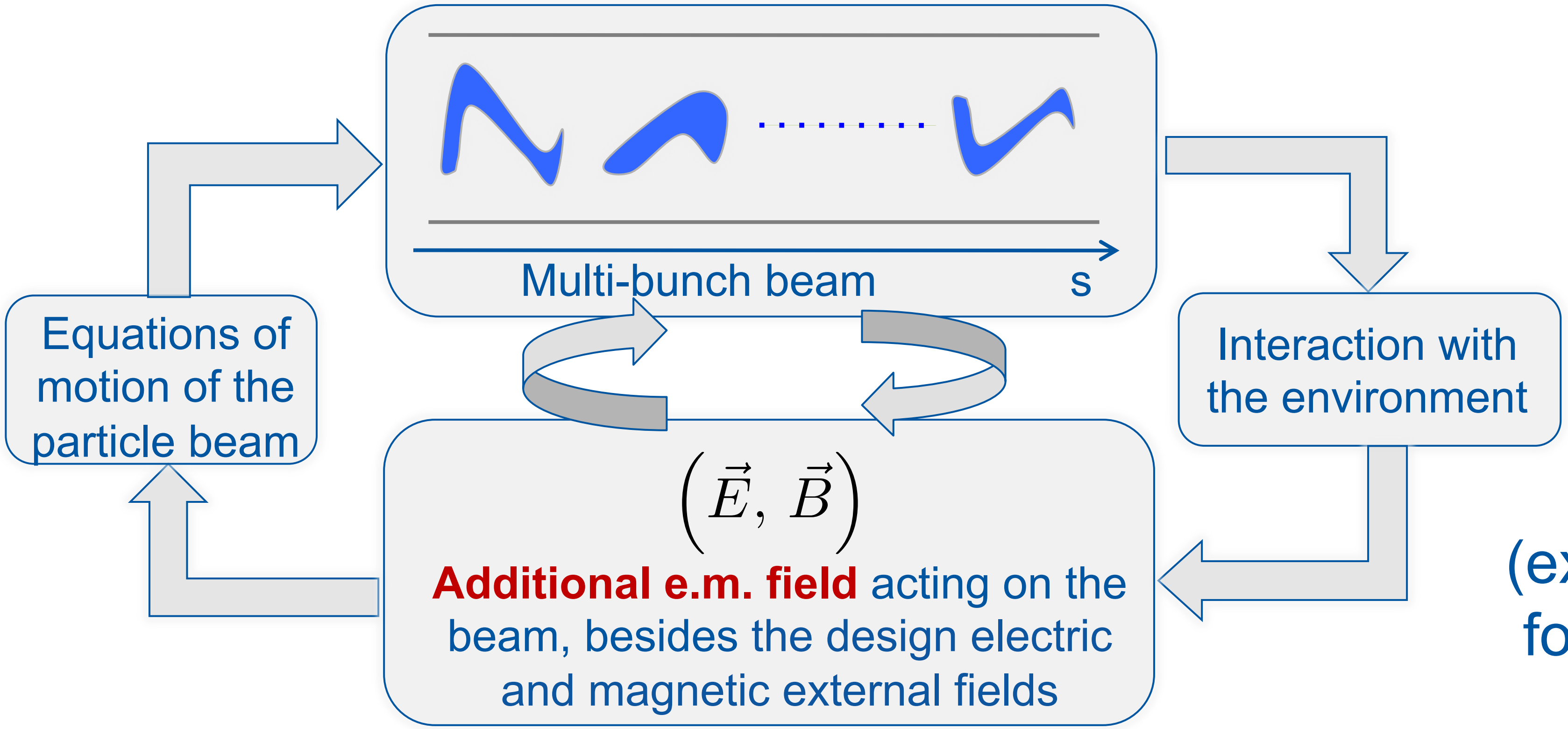
Andrea Passarelli

Complesso Universitario Monte Sant'Angelo, Napoli



Activity framework - Napoli

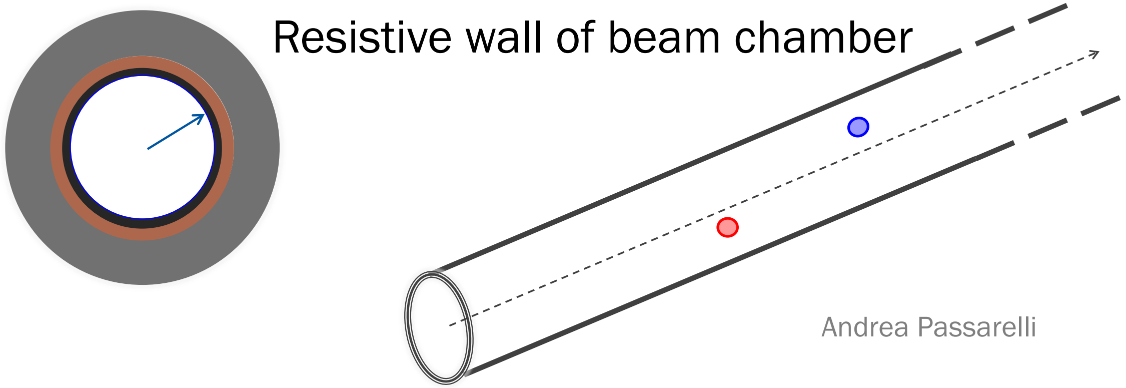
A. Passarelli, M.R. Masullo

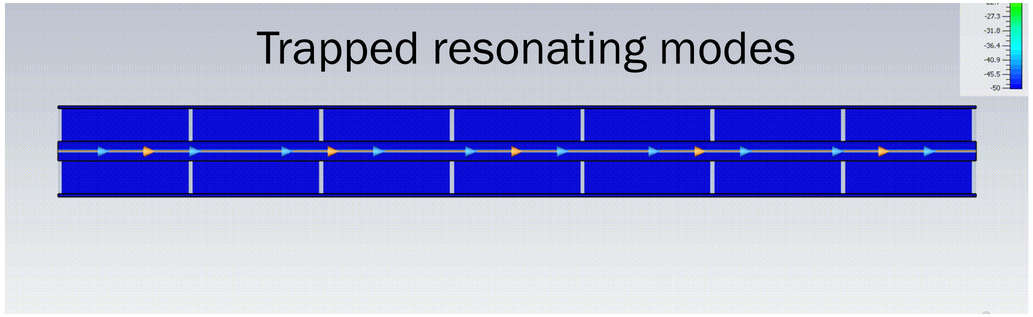


When the loop closes, the beam might develop an undesired instability

EM analysis (experimental/simulation activity) for evaluating Collective Effects

Study the link between the beam current and EM fields inside the devices (Beam coupling impedance)





ARYA (2020-23) Resp. nazionale dal 2021 Iaia Masullo

SurfAce and mateRial studies for Accelerator TechnologY And related topics

- Reducing instabilities due to interaction beam and vacuum chamber. Instabilities can be caused by:
  - impedance (both geometric and due to the conductivity of the surface);
  - dynamic vacuum effects (thermal or electron induced desorption);
  - formation of cloud of electrons (known as e-cloud) which interacts with the beam.
- The project is subdivided in **4 Working Packages (WP's).** Each dedicated to the study of a part of the problem in international collaborations for **HL-LHC, FCC and other accelerators.**

WP	Titolo	Unità coinvolte	Responsabile
WP1	Studio comparativo e caratterizzazione del desorbimento stimolato indotto da elettroni e fotoni.	LNF-INFN CERN	M Angelucci L. Spallino
WP2	Dinamica di fascio e materiali innovativi per acceleratori	Roma1-INFN Na-INFN LNF-INFN CERN	M. Migliorati
WP3	Studi di Impedenza e metodologie di riduzione; realizzazione e caratterizzazione di superfici strutturate per ablazione laser	**Na-INFN** Roma1-INFN CERN LNF-INFN	M.R. Masullo A. Passarelli
WP4	LHCspin: Validazione delle proprietà di superficie della cella di accumulazione con H atomico.	CERN LNF-INFN	R. Cimino

ARYA Project

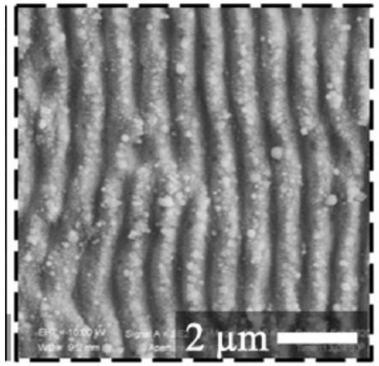
Coated and laser structured surfaces in particle accelerators to avoid undesirable effects and maximize machine performance

- Non-Evaporable Getter (NEG): ultrahigh vacuum and e-cloud
- Amorphous Carbon (a-C): e-cloud
- Laser Induced Periodic Surface Structures (LIPSS): e-cloud

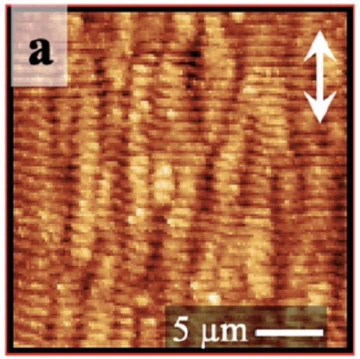
Sample characterization

Morphological

SEM

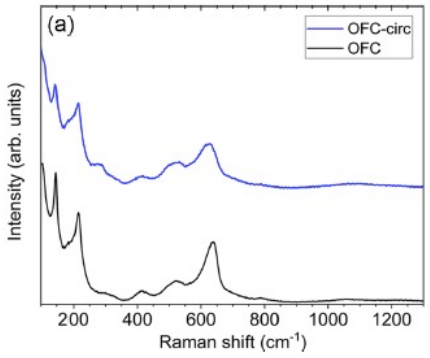


AFM

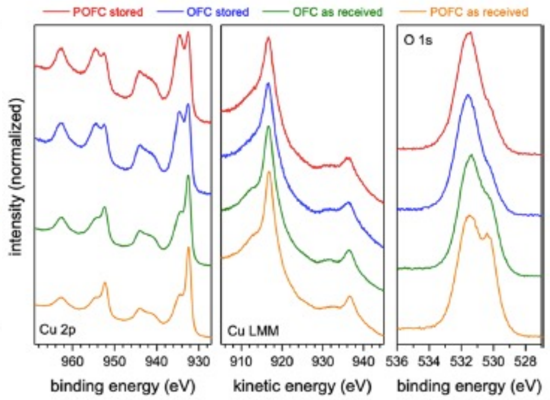


Chemical

Raman

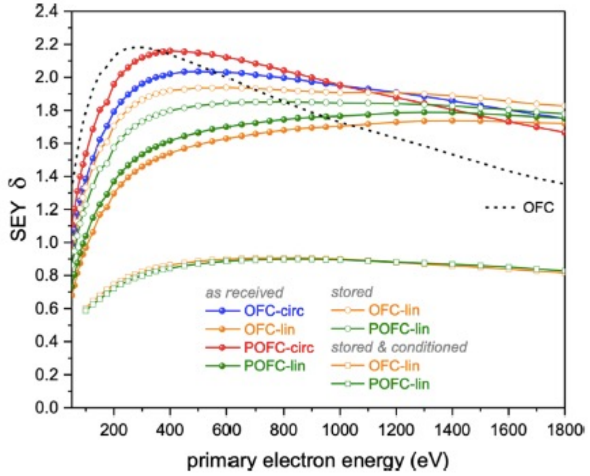


XPS



Functional characterization

$SEY = I_{out}/I_{in}$



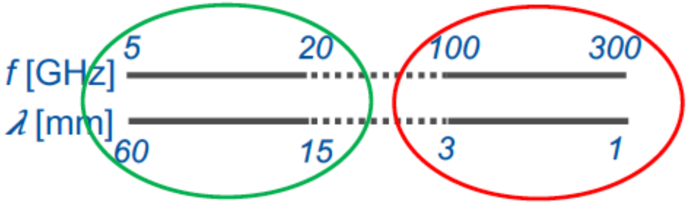
Electromagnetic → next slide

J.J. Nivas et al.

Electromagnetic characterization: two different methods

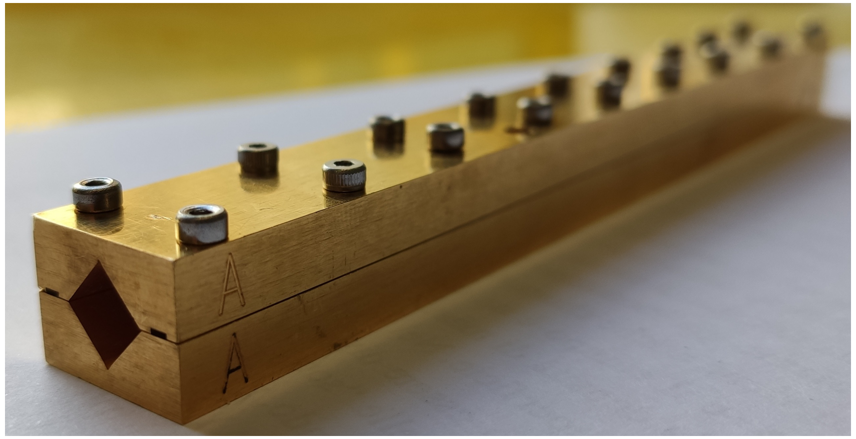
Dielectric resonator

- high sensitivity



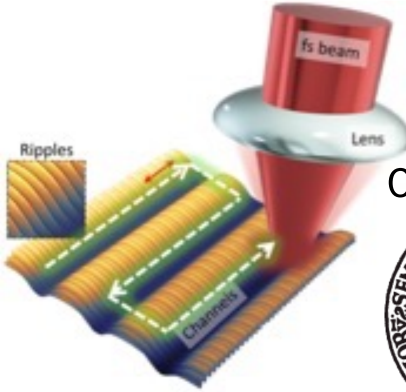
Sub-THz waveguide

- small skin-depth

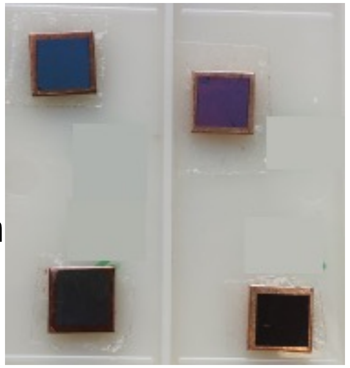


LIPSS: Laser Induced Periodic Surface Structure

- conductivity compared with copper
- small samples



Collaboration



NEG (Non-Evaporable Getter)

- homogeneous coating

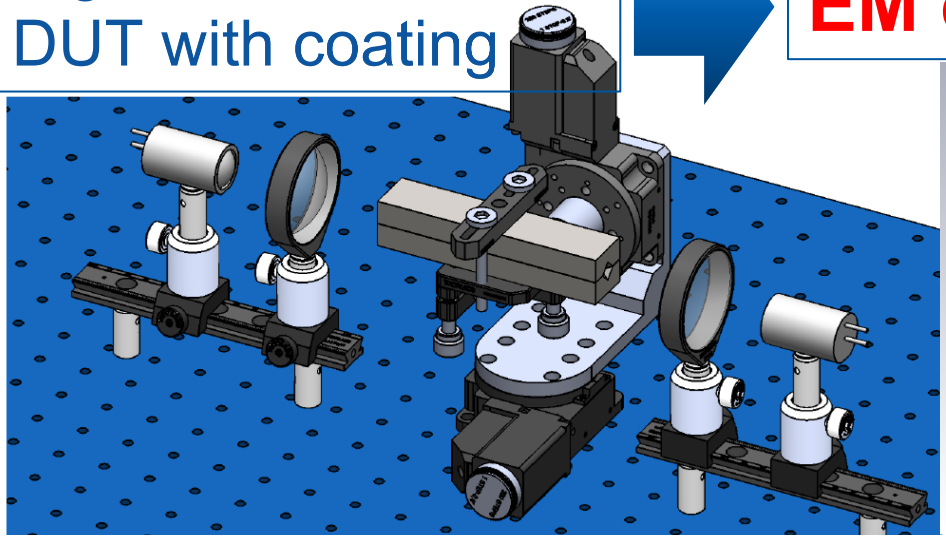
a-C (Amorphous carbon)

- coating thickness issues

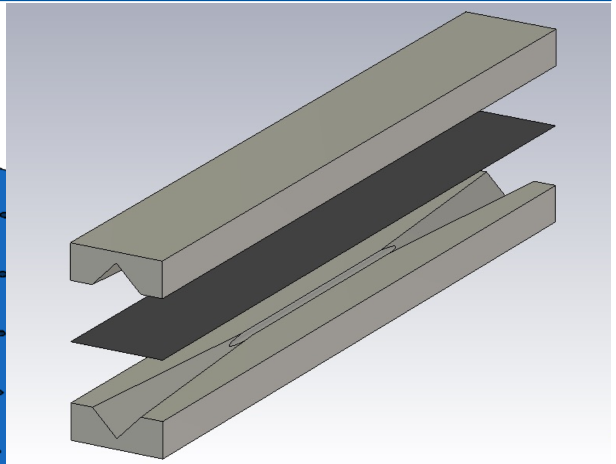
Agreement

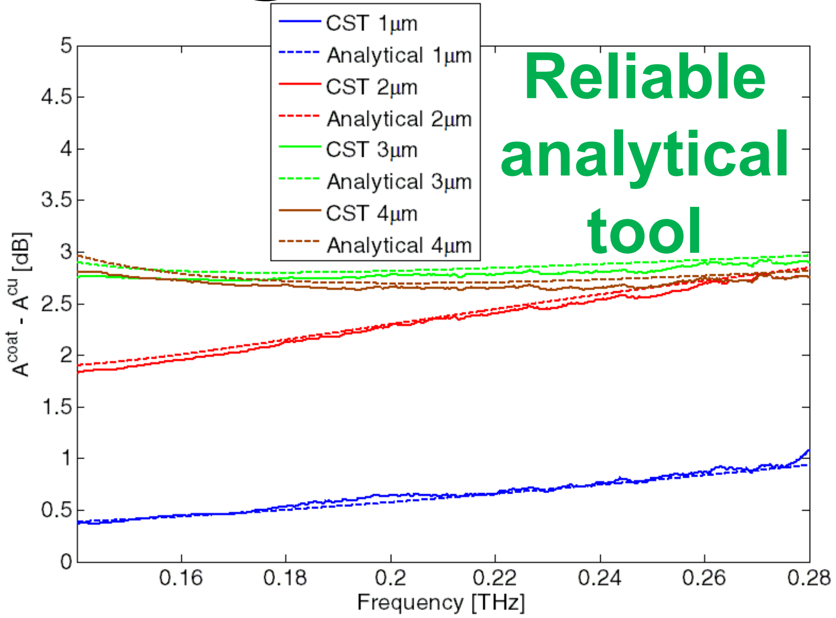
Electromagnetic characterization of coatings in sub-THz

Signal attenuation in DUT with coating



EM characterization





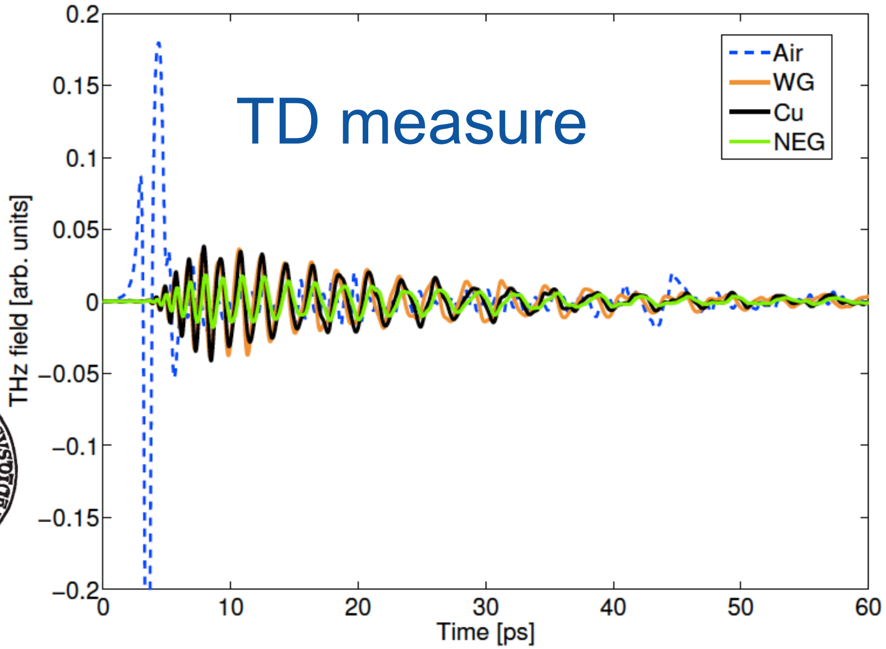
Reliable analytical tool

TERA K15

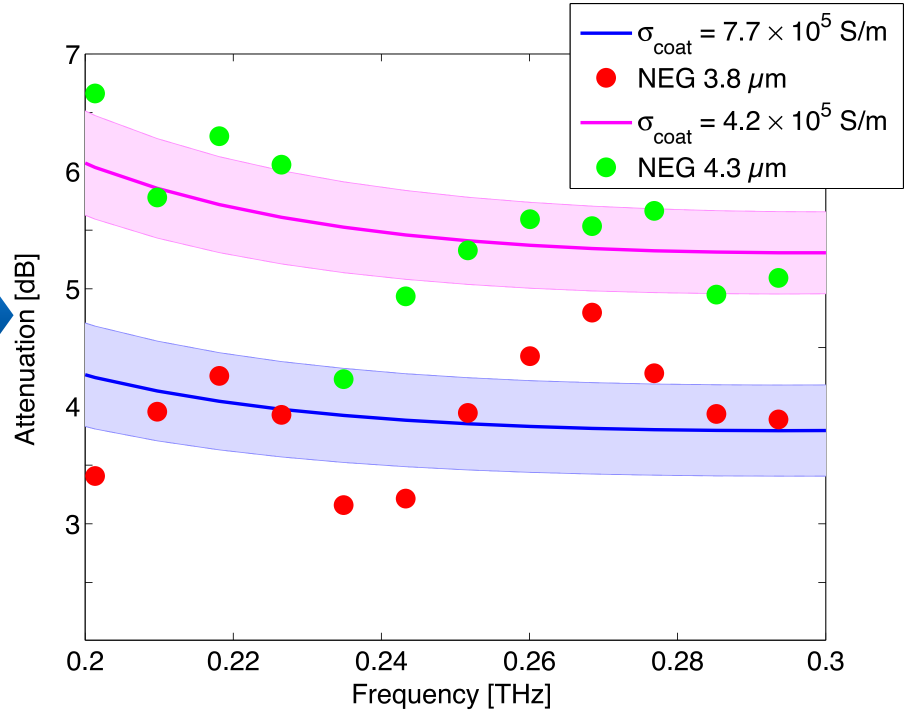
Time-Domain THz Spectrometer

In University of Naples "Federico II" laboratory

TD measure

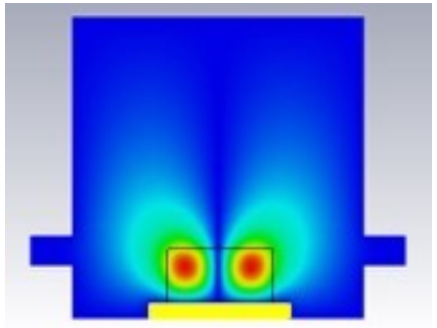


FT

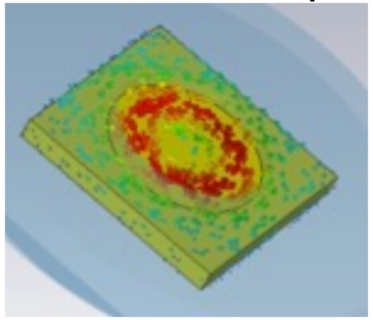


Electromagnetic characterization of LIPSS with dielectric cavity

E field (TE_{011})

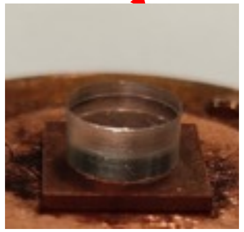


current on sample

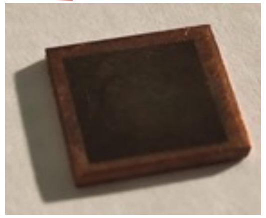


$$\frac{1}{Q} = \frac{1}{Q_{met}} + \frac{1}{Q_d} + \frac{1}{Q_{LIPSS}} + \cancel{\frac{1}{Q_{rad}}}$$

Internal walls

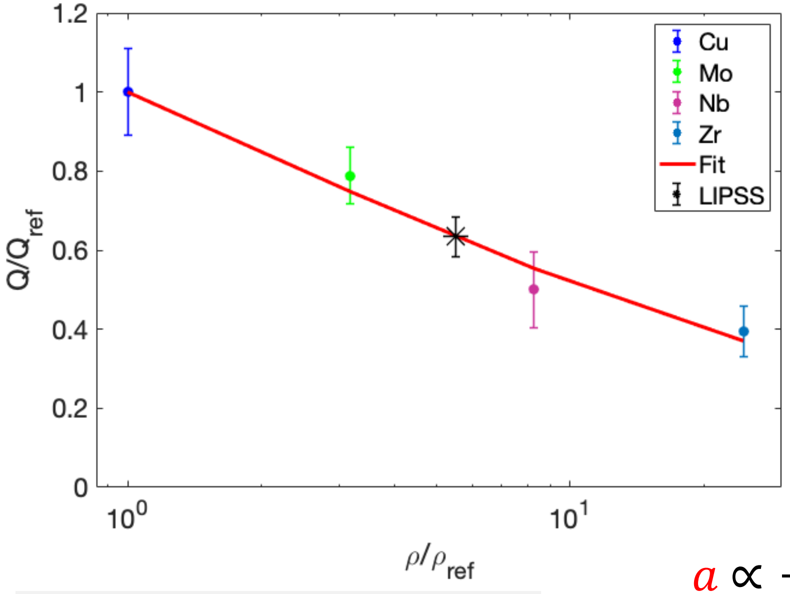


Inside dielectric



On sample

Pure copper as reference material-use a calibration curve



LIPSS conductivity value

σ_{exp} (S/m)	$\sigma_{sim-rough}$(S/m)
$1.05 \pm 0.30 \cdot 10^7$	$1.40 \cdot 10^7$

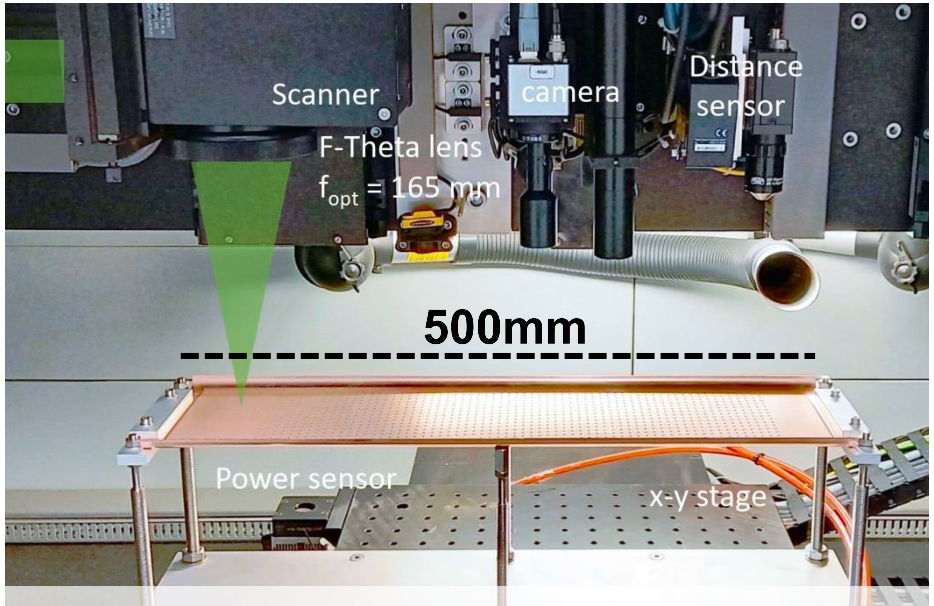
$$\frac{Q}{Q_{ref}} = \frac{a+b}{a \cdot \sqrt{\frac{\rho}{\rho_{ref}}} + b}$$

$$a \propto \frac{1}{Q_{LIPSS}}$$

Losses on the sample

$$b \propto \frac{1}{Q_{met}} + \frac{1}{Q_d}$$

Losses in the rest of the cavity

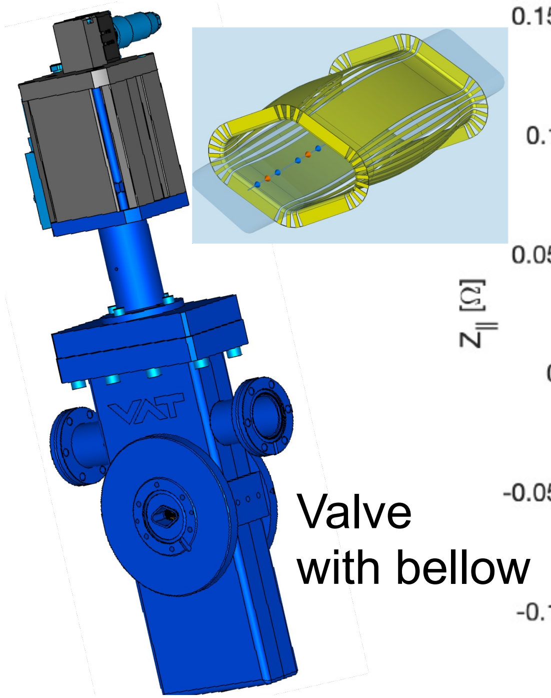


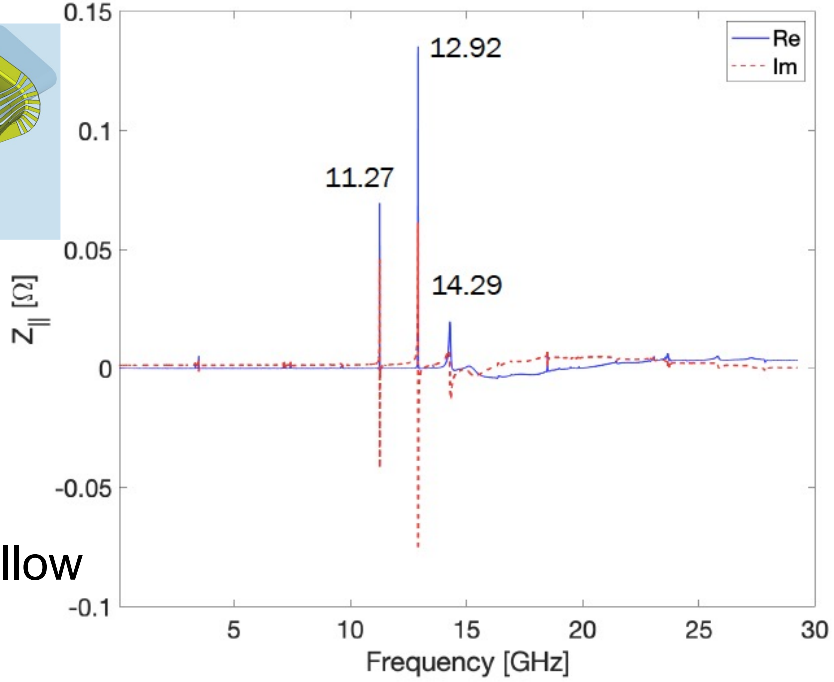
Demonstrator

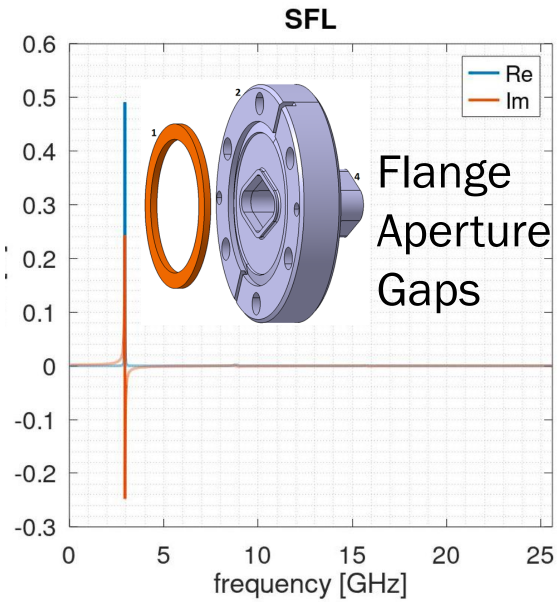
SPS E-cloud monitor liner

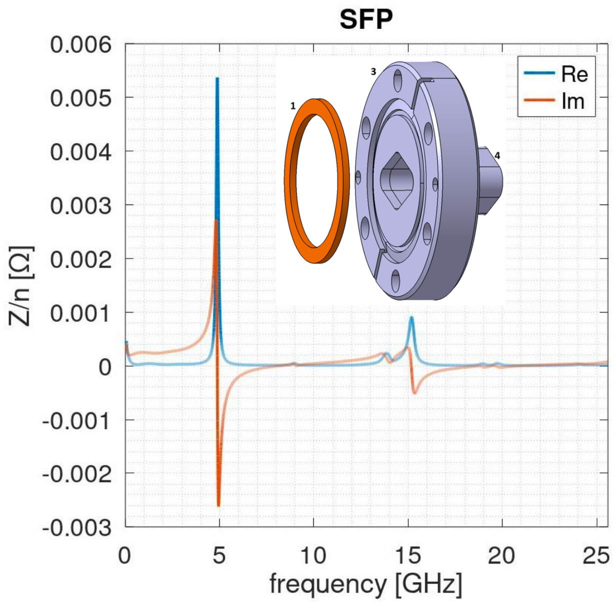
Transfer of information from Naples to Leibniz Institute

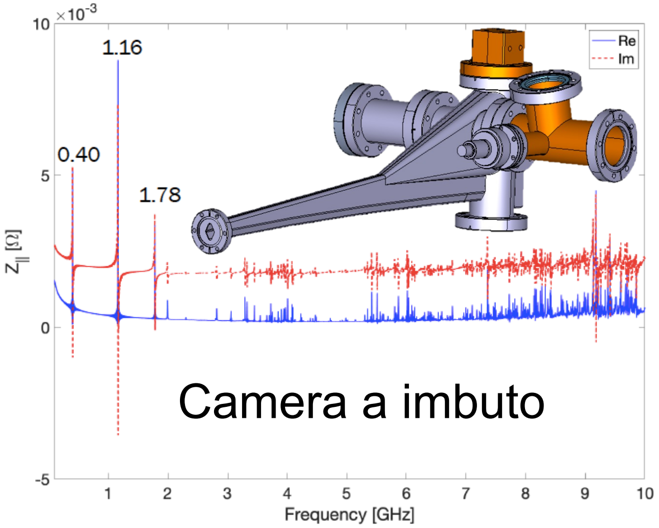
Elettra 2.0 upgrade – beam coupling impedance evaluation



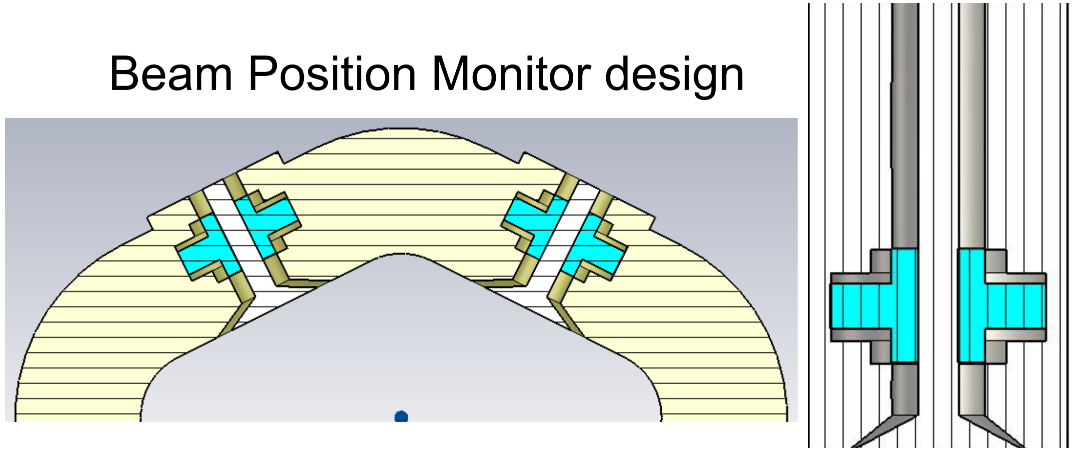








Beam Position Monitor design



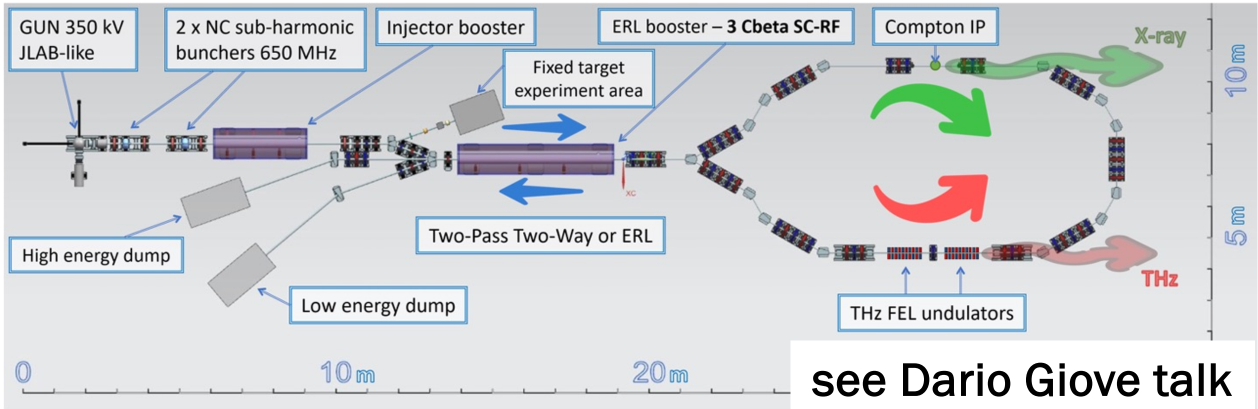
Agreement

Elettra Sincrotrone Trieste

PhD student supervision

INFN

BriXSinO

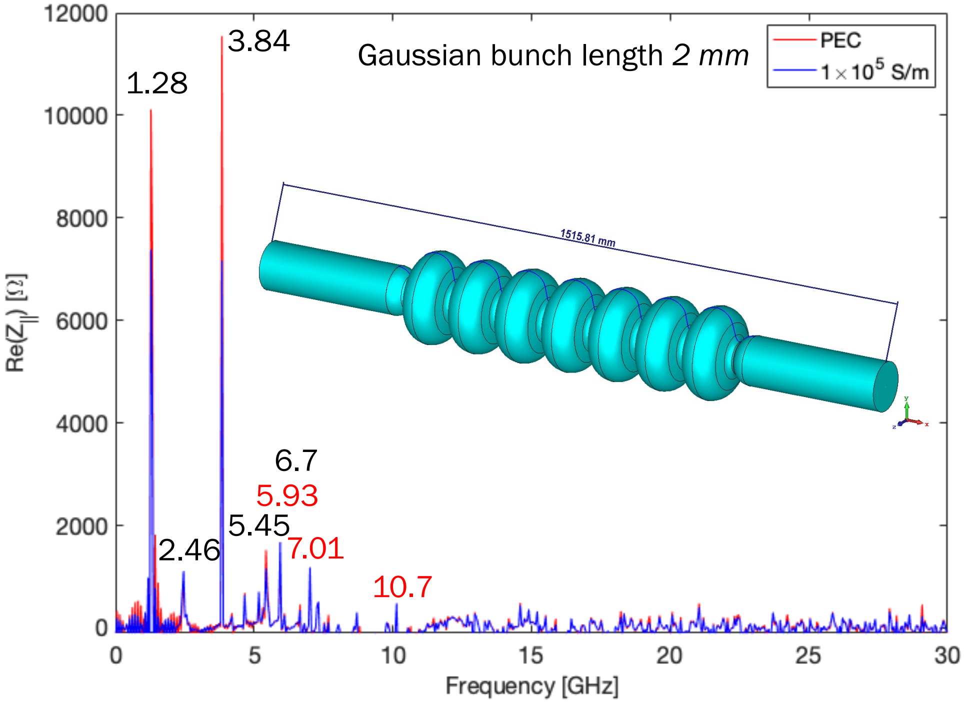


see Dario Giove talk

Cavità a multicella dell'ERL

Studio degli high order mode, se eccitati estraggono energia dal fascio a danno dell'accelerazione.

K-loss used for beam dynamics assessments and instability mitigation



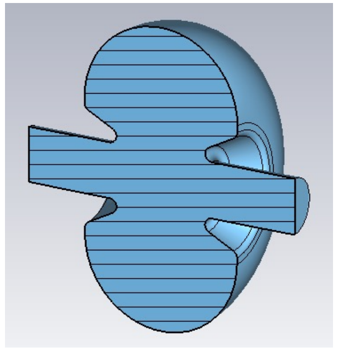
Frequency [GHz]	Kloss [V/pC]
1.28	0.17
2.46	0.60
3.84	0.61
5.45	0.33
5.93	0.17
6.70	0.15
7.01	0.47
10.70	0.51
Untill 40	0.49
TOTAL	3.5

HB2TF (Call di CSN5)

High Brightness Beams Test Facility

Naples unit:
Buncher: Evaluation of High Order Modes
Power Coupler: Design optimization to feed the cavity.

HB2TF buncher



Collaboration

Numerical Mode Matching Technique

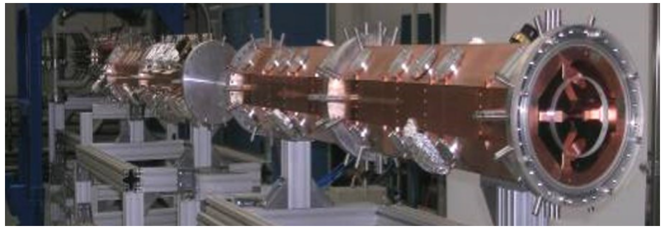
Andrea Passarelli

PNRR - Anthem

AdvaNced Technologies for Human-centrEd Medicine

RFQ to accelerate high proton currents

5 MeV - 30 mA



Be or Li target: protons create neutrons

Target

Change energy and shape of the beam

Beam Shaping Assembly

Patient

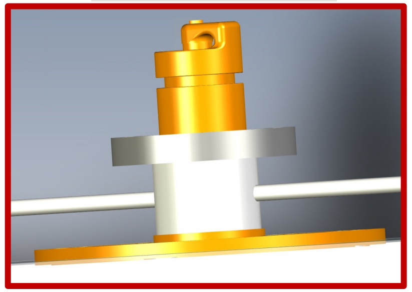
Caserta site

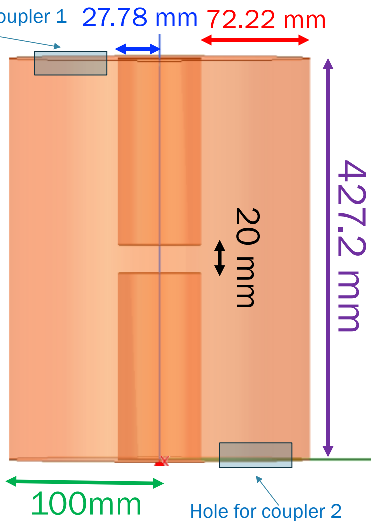
see Francesco Grespan talk

Bridge cavity design – Naples Activity

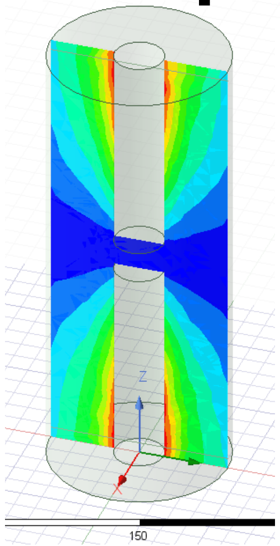
Electromagnetic design for the bridge cavity construction for **coupler conditioning test at nominal power (150kW)**, minimizing reflected and dissipated power

coupler



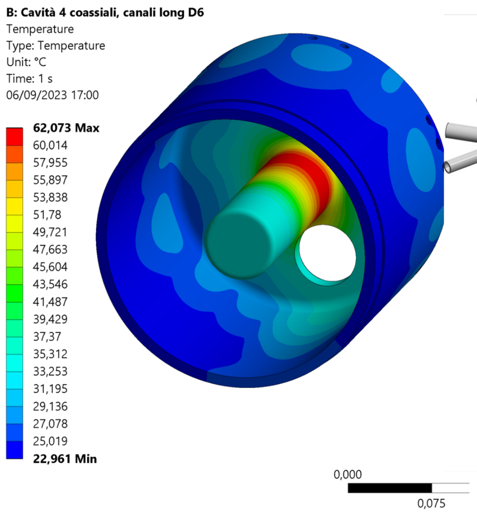


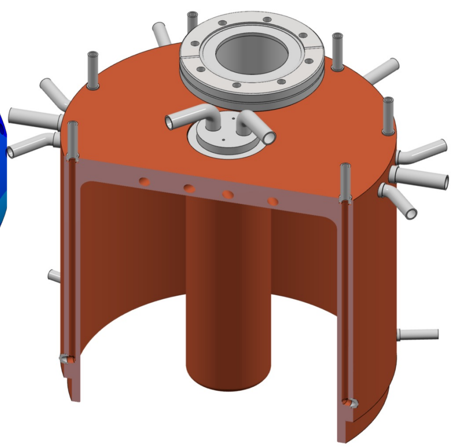
80% transmission coupler 1 ↔ coupler 2



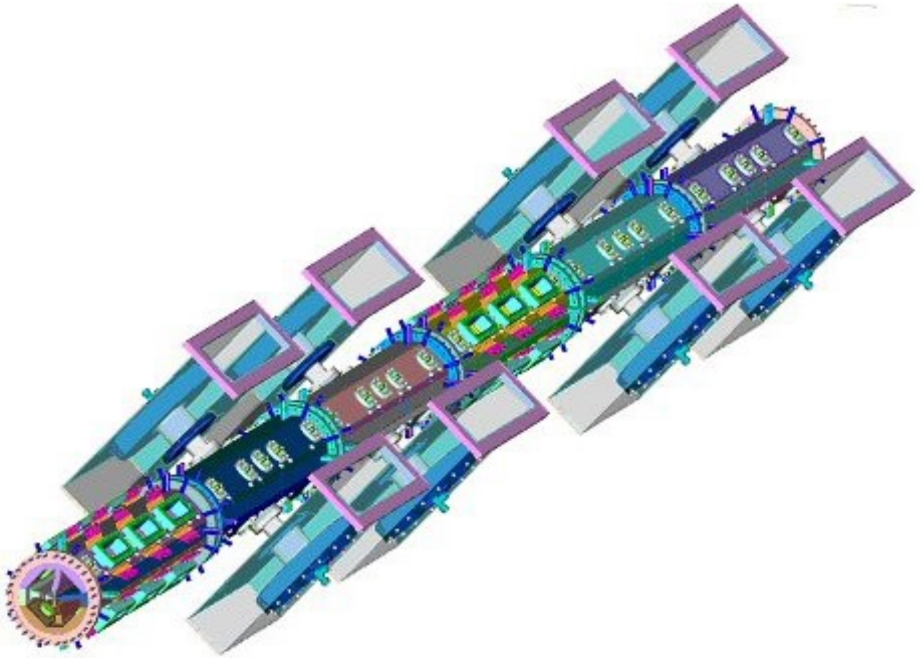
magnetic field distribution

f = 352.2 MHz

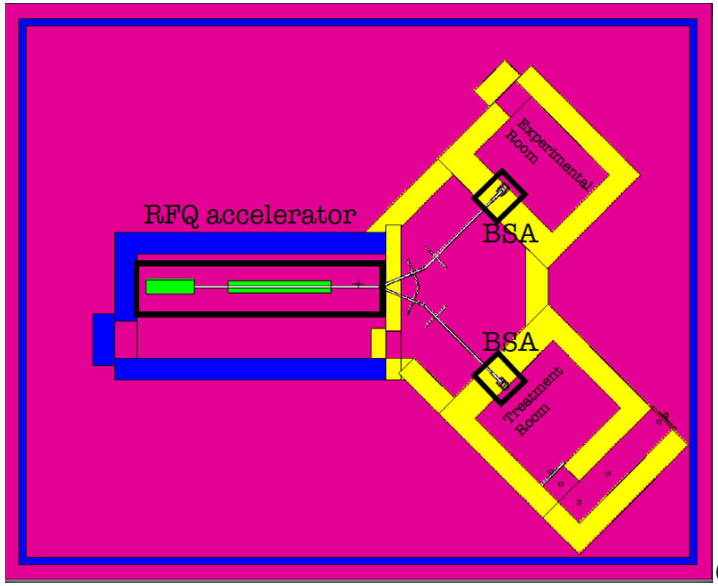




Future work



- **Tuning** of the RFQ cavities
- RFQ Cavity Radio Frequency **Power Amplification System Test**
- Collaboration with construction engineers for the **construction of the bunker** for the accelerator installation

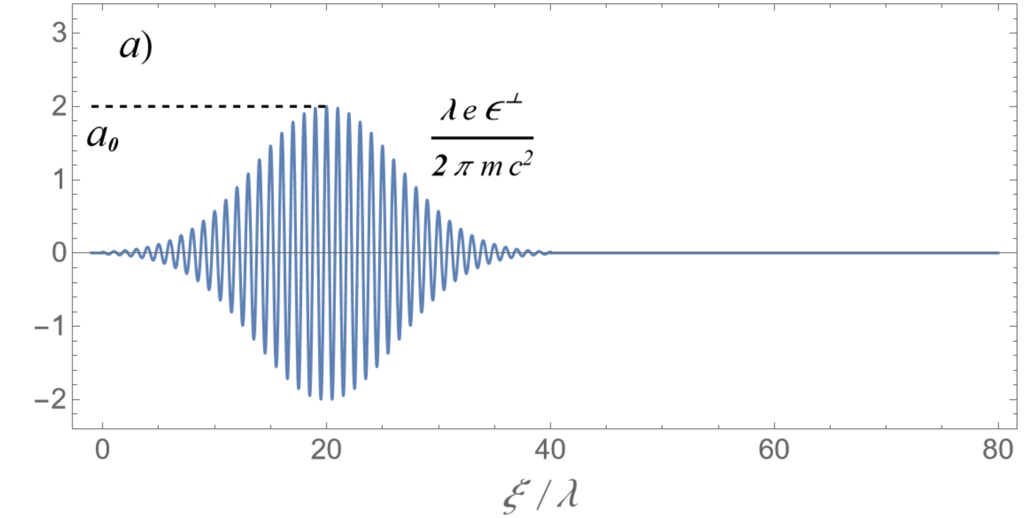


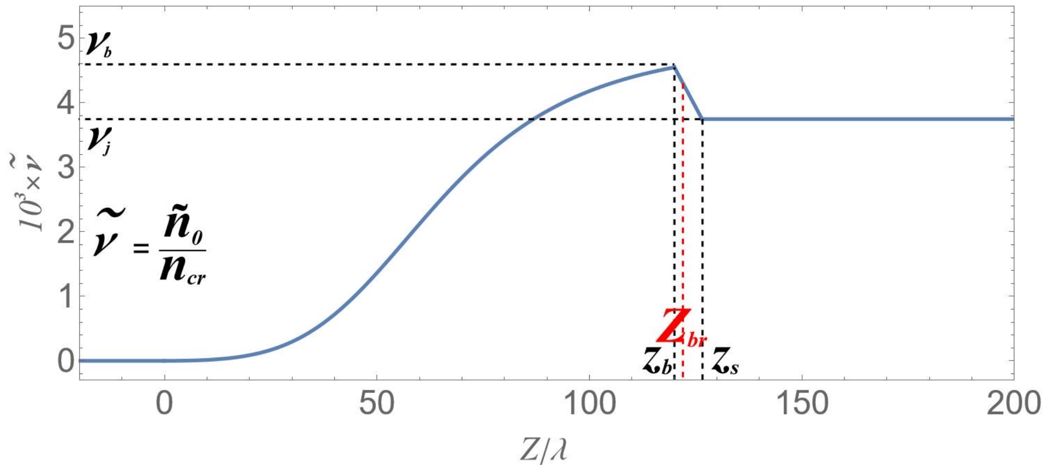
Analytical improvement of laser wakefield acceleration

G. Fiore, R. Fedele, S. De Nicola

- General goal: to find out promising regions in the space of input data (= initial plasma density $\tilde{n}_0$, laser pulse profile $\epsilon^{\perp}$) for an efficient LWFA, before running PIC simulations/experiments.
- We have recently elaborated a (numerically light) procedure in 4 steps to tailor $\tilde{n}_0$ to $\epsilon^{\perp}$ so as to maximize the LWFA of bunches of electrons self-injected by the first wave-breaking (WB) occurring on the density down-ramp.
- To this end we use an improved, fully relativistic plane model whereby the light-like coordinate $\xi = ct-z$ replaces time t as the independent variable, and the Lorentz-Maxwell and continuity PDEs are reduced to a continuous family of pairs of Hamilton equations; these are decoupled up to WB. We extend crucial results to realistic 3D situations by causality arguments.

- a) laser pulse $\epsilon^{\perp}$;
- b) associated optimal plasma density $\tilde{n}_0$





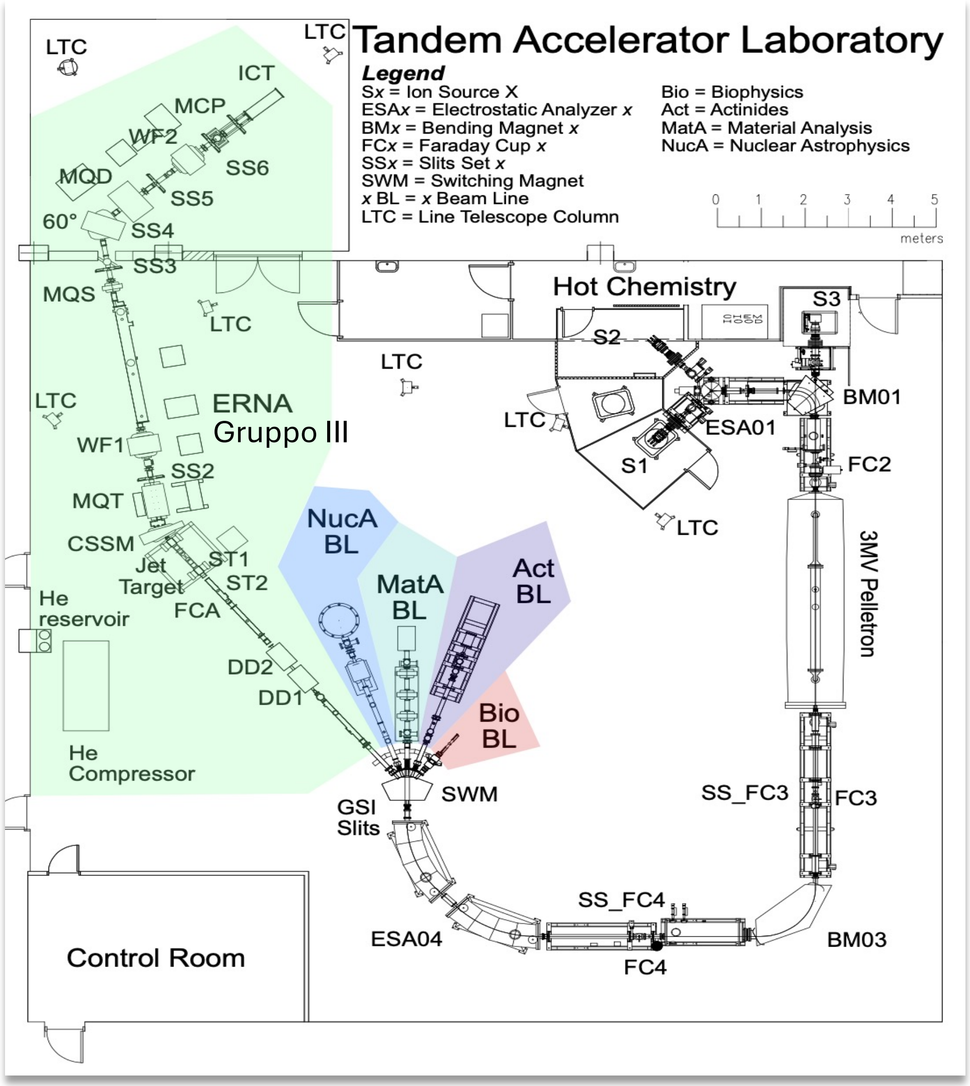
Tandem Accelerator Laboratory Research Laboratory Hub (POLAR), Dept. of Mathematics and Physics, University of Campania - Luigi Vanvitelli

3 MV TANDEM-PELLETRON ELECTROSTATIC MACHINE

1 source SNICS

1 source SNICS for radionuclide

1 source APLPHATROSS (WORKING IN PROGRESS)



Main fields of research:

- Nuclear astrophysics
- Biophysics
- AMS (14C+Actinides) for environmental science, cultural heritage and forensics
- Ion Beam Analysis
- Ion implantation

Production of any type of beam that makes negative ions

IONS	INTENSITY (uA)
^{1}H	100
^{7}Li	3
^{7}Be	10^{-4}
^{9}Be	10
^{10}Be	10
^{11}B	56
^{12}C	100
^{13}C	5
CN(^{15}N)N	20
Si	500
P	100
Al_2	5
VH	10
Ni	40
Cu	100
As	30
Au	150
$^{238}U_{nat}$	0,1
He^-	4

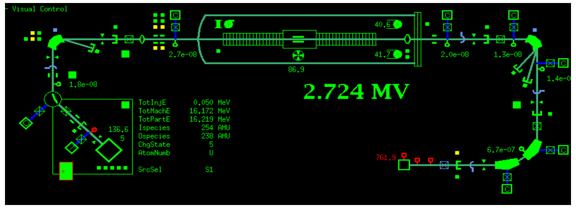
Staff:

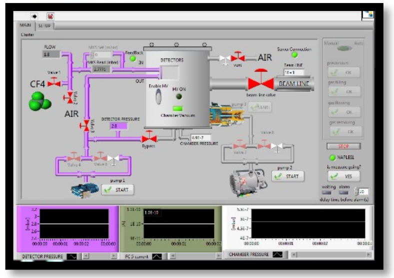
- L. Gialanella Scientific responsible
- R. Buompane Deputy
- G. Porzio Technical infrastructure manager
- F. Marzaioli Head of the AMS service
- Post. Doc: C. Santonastaso , I. Passariello
- PhD. Students: L. Bagnale, E. Formicola, M.L. Mitsou, F. Molitierno.

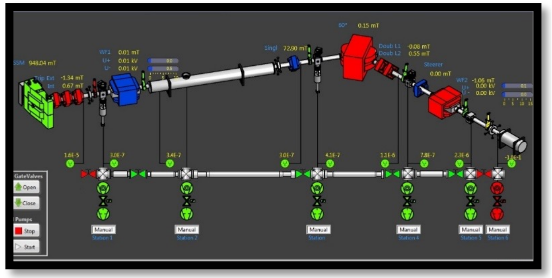
SCADA COOPERATION SYSTEMS AND AI: MEDIUM AND LARGE ACCELERATORS PLANT

AcceleNet (NEC) ⟷ **SCADA Data Bridge: Hardware and Software tools** ⟷ LabView Control SW

SSH-FS



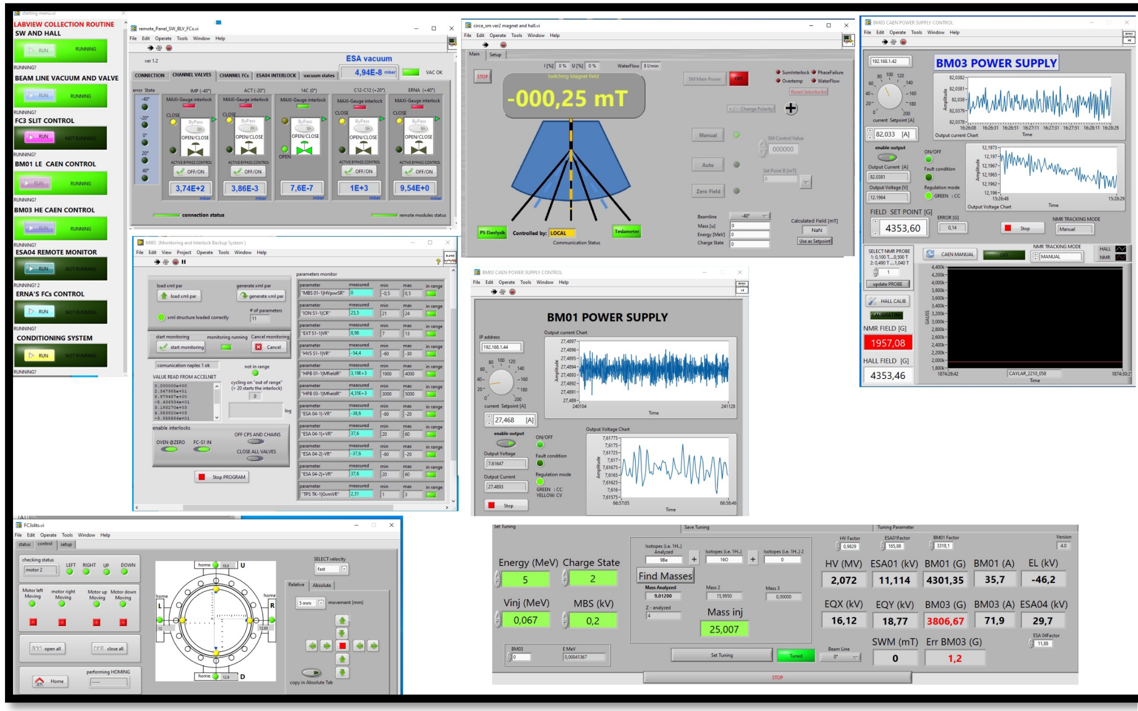




ULISSE
PostgreSQL
DB

ULISSE
User Light Interface for Systems coordination and SurveillancE

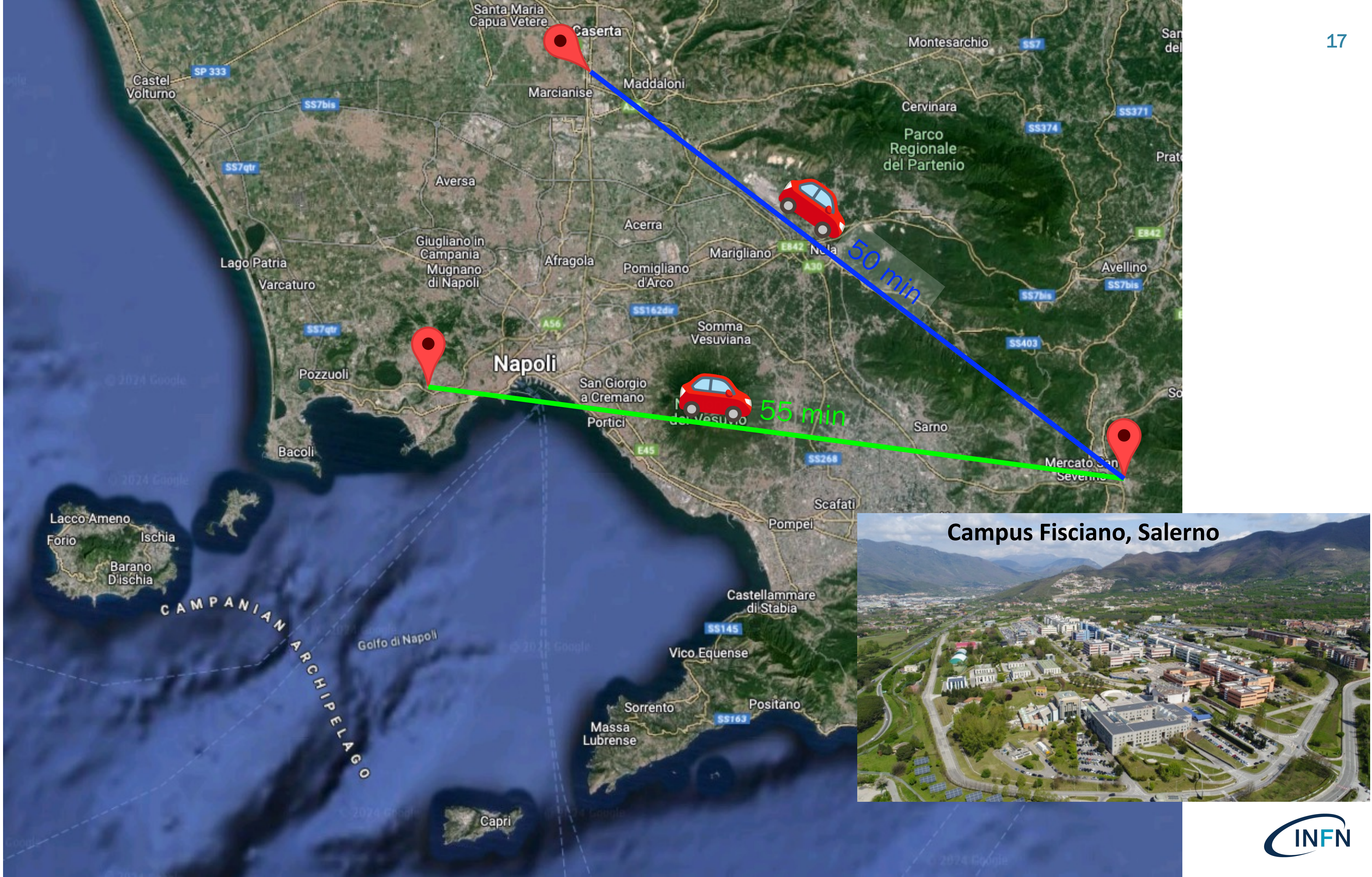
Database that logging 437 parameters 1 Hz of SR



HIT-MAN*
Host In The Middle As iNterface

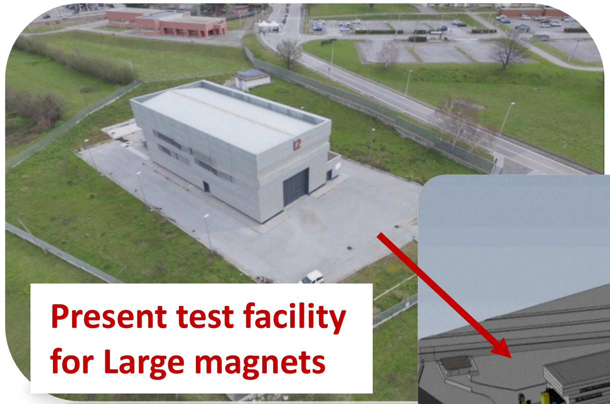
A framework designed ***to extend the lifespan*** of sensors and actuators within the plant

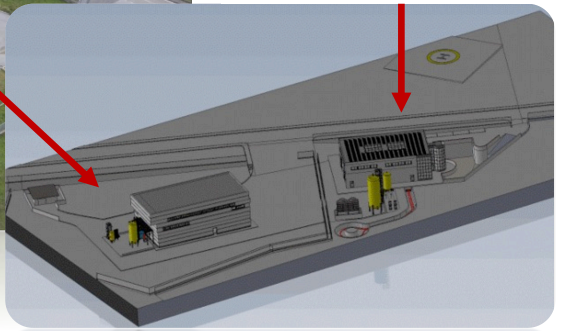
- **Anomalies and maintenance prediction**
- **Trigger alarms and Events coincidence**
- **Quality prediction with AI on 14C AMS measure**
- **Hardware and Software obsolescence Fighting (HIT-MAN)**


Santa Maria Capua Vetere
Caserta
Castel Volturno
SP 333
Marcianise
Maddaloni
Montesarchio
SS7
SS7bis
Cervinara
SS371
SS374
Parco Regionale del Partenio
SS7qtr
Aversa
50 min
Acerra
Giugliano in Campania
Mugnano di Napoli
Lago Patria
Varcaturo
Afragola
Pomigliano d'Arco
Marigliano
E842
A30
Avellino
SS162dir
A56
Somma Vesuviana
SS403
Pozzuoli
Napoli
San Giorgio a Cremano
55 min
Portici
Sarno
Bacoli
E45
SS268
Mercato San Severino
Scafati
Pompei
Lacco Ameno
Forio
Ischia
Barano D'ischia
CAMPANIAN ARCHIPELAGO
Golfo di Napoli
Castellammare di Stabia
SS145
Vico Equense
Sorrento
Positano
SS163
Massa Lubrense
Capri
Campus Fisciano, Salerno

Test Facility for Large Magnets and Superconducting Line at INFN – NA / Gr. Coll. SA

- University of Salerno, Campus Fisciano, Physics Department E. R. Caianiello.
- **THOR** (Test in HORizontal) facility is the existing test stand for large superconducting magnets. The civil construction started in 2014 and nowadays the facility is operational for GSI/FAIR SIS100 magnets.
- **IRIS** (Innovative Research Infrastructure on applied Superconductivity): PNRR program devoted to extend the already existing facility with a dedicated infrastructure to test superconducting transmission line. The civil construction will start in 2024 .

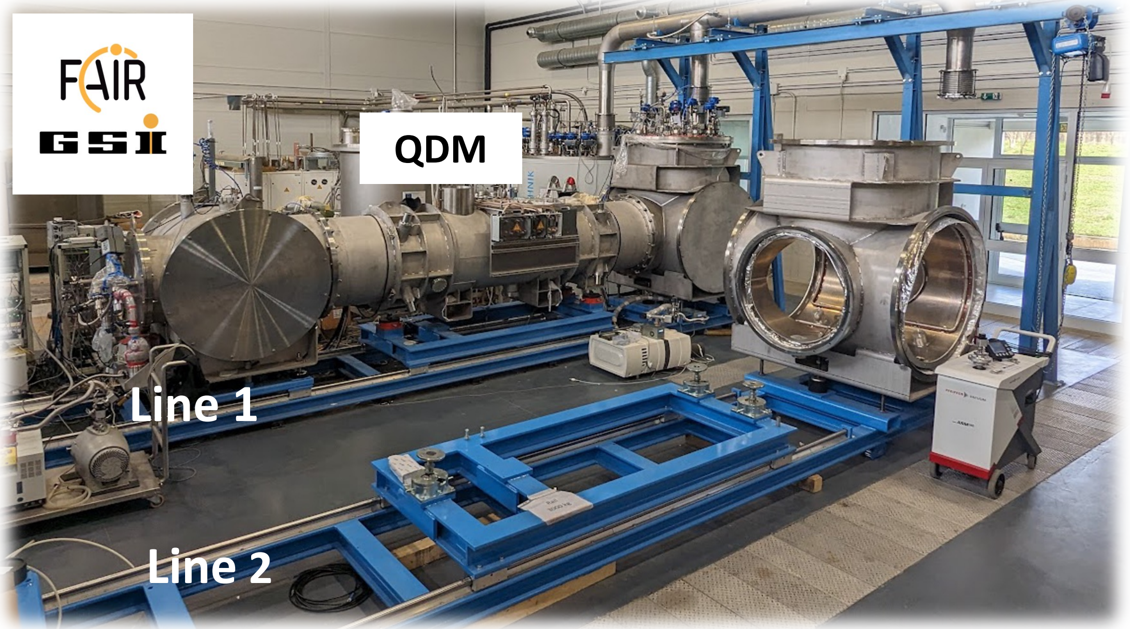




The team: A. Chiuchiolo[a], D. D'Agostino[a], A. Ferrentino[b, a], U. Gambardella[a], R. Gargiulo[a], M. Imran[b, a], E. Leo[a], A. Saggese[b, a], C. Severino[a], F. Severino[a]

(a: INFN; b: University of Salerno)

THOR facility for SIS100 QDM testing



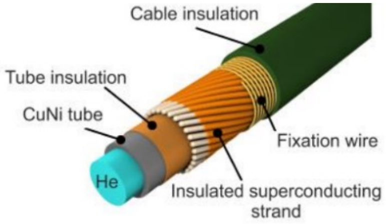
- 450 m^2 working area plus control room and workshop;
- External Helium gas tank (30 m^3 @ 14 bar) and precooling liquid Nitrogen tank (3000 l);
- Kaeser compressor (70 g/s @ 10 bar);
- Cooling tower (20 m^3/h of water at 25°C, 300 kW);
- Cold Box supercritical He (3-7 bar, 200 W @ 4.5 K + 500 W @ 60 K w/o precooling);
- Power converter DC/AC (300 A, 10.5 V, +/- 1250 A/s)
- 300 kW UPS

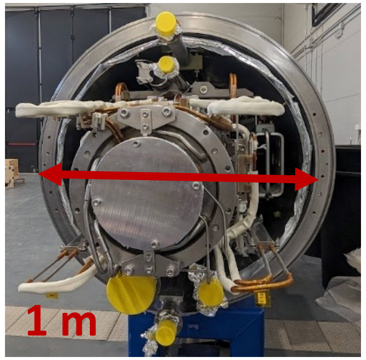
- The facility is designed with 2 horizontal test lines for parallel cooldown and operation of 2 QDMs
- Electronics and software development for sensors monitoring and control (temperature sensors, voltage taps, vacuum gauges, heaters)

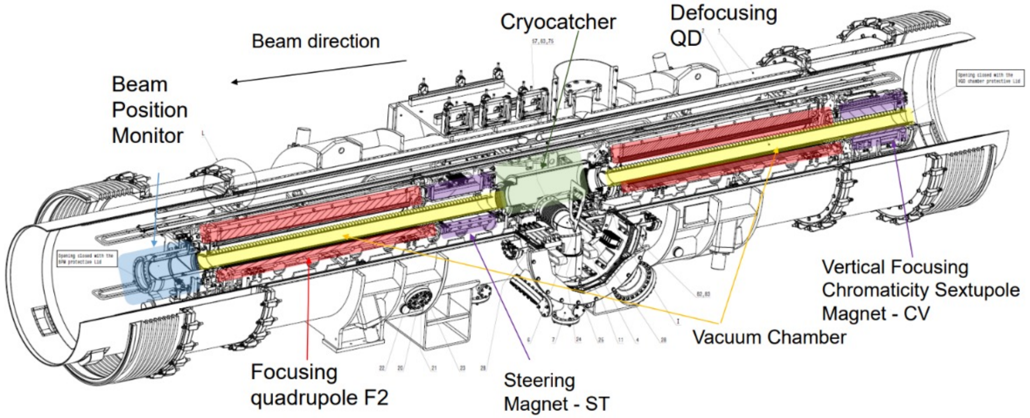
SIS100 quadrupole doublet modules

- QDMs are composed of 2 main quadrupoles and from 2 to 5 corrector magnets (steering dipoles, sextupole and multipoles) integrated in the same cryostat, all based on Nuclotron cable

Magnet	quantity	Maximal Current	Main field at I_{max}	Inductance, mH
Main Quadrupole	169	10.5 kA	28 T/m	0.41 mH
Chromaticity Sextupole	42	± 250 A	232 T/m^2	43 mH
Steerer	83			
Horizontal coil		± 250 A	0.37 T	21 mH
Vertical coil		± 250 A	0.37 T	21 mH
Multipole corrector	12			
Coil 1 (quadrupole)		± 250 A	0.91 T/m	1.1 mH
Coil 2 (sextupole)		± 250 A	31.8 T/m^2	5.6 mH
Coil 3 (octupole)		± 250 A	446 T/m^3	7.4 mH
γt- jump quadrupole	12	±250 A	**)	0.33 mH



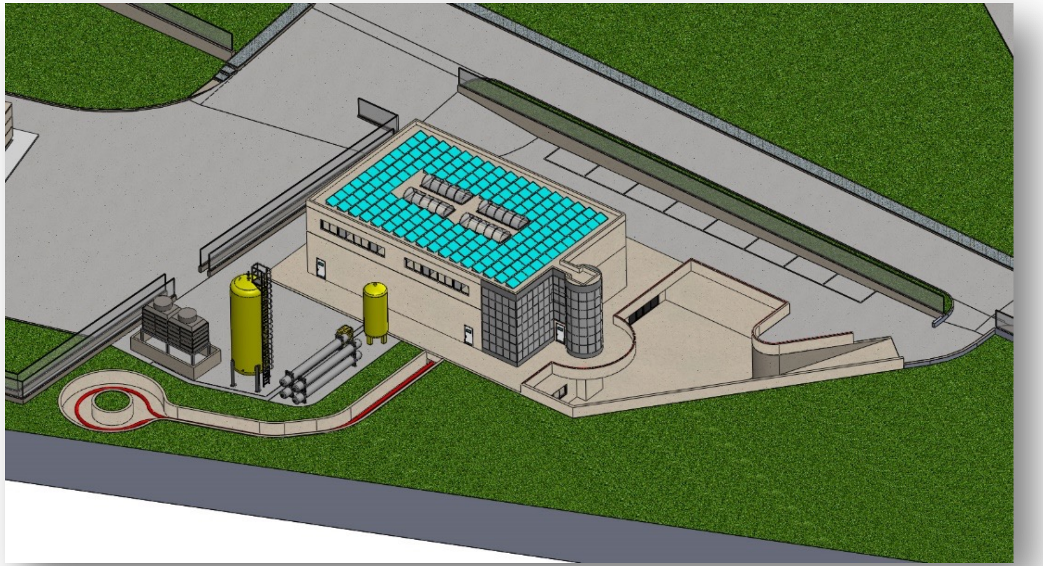




Test Facility for Superconducting line – The IRIS program

- Within the PNRR-IRIS program, the Salerno Pole (UniSA, INFN and CNR) is in charge to set up a **new** test facility for **130 m long superconducting cable** able to carry up to 40 kA of current at 25 kV (i.e. a **1 GW power**)
- In 2023 procurement and hiring process has started
- In 2024 **civil works** will start as well as **the production of the MgB2 line** in ASG (Genova) led by LASA (Milano).
- The superconducting transmission line will be a demonstrator for the **commissioning** of the test facility
- The facility will be maintained at least 10 years giving **open access** to research institutes and companies

See L. Rossi talk



- 130 m long **bunker for cable**
- **He refrigerator** for a total power up to 500 W @ 20 K GHe gas (about 23 g/s)
- **Power converter** up to 40 kA with isolation up to 50 kV
- He storage dewars / LN2 for cable current leads