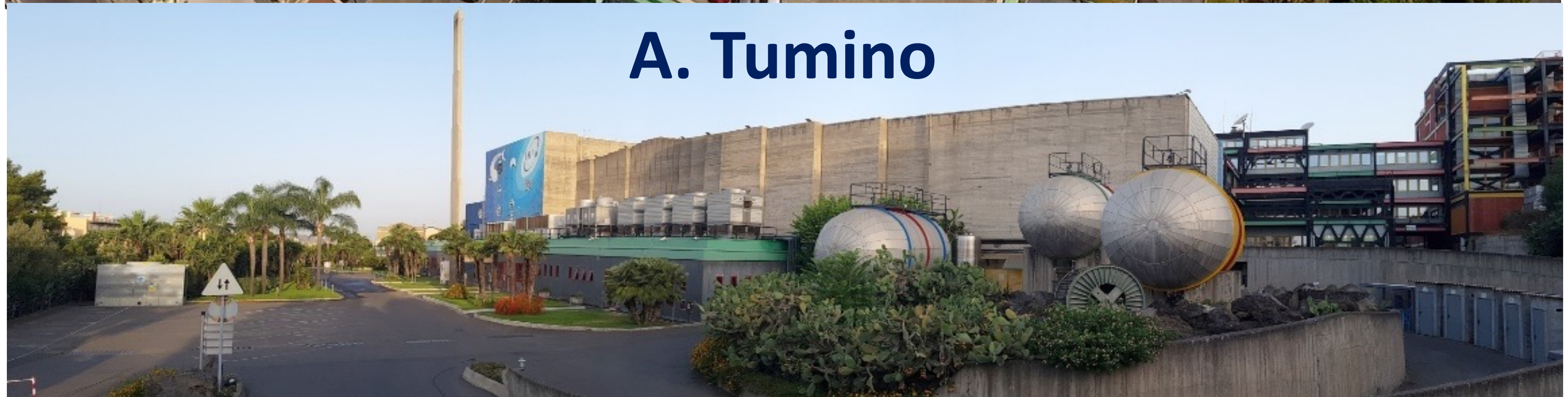
LNS–Users Annual Meeting, 30 September 2024

Activities of the LNS Research Division



A. Tumino

Outline

- ✓ General introduction on research activities
- ✓ Short description of facilities at LNS,
- ✓ Tandem backlog

Research Division

- **Users service (Alessia Di Pietro)**
  to manage relations with scientific users and support their activities
  - Marine technology (Alessia Di Pietro)
  - Management and maintenance of experimental apparata and equipment (coord. Alessia Di Pietro)
  - Laboratory of chemical-physical techniques (coord. Antonio Massara)
  - Laboratory for Electronics and Detectors (coord. Piero Litrico)
- **Scientific Information Service** (coord. Gaetano Agnello)
  dissemination of scientific information and multimedia platforms; LNS library organization, supports Public Engagement initiatives
- **Computing and Information Technology Service** (coord. Emidio Giorgio)
  it takes care of the management and updating of centralized computing systems and computer networks
  - Networks, data transmission and data acquisition
- **Service for the Development of Experimental Equipment and Apparata** (coord. Salvatore Tudisco)
  to assist and support the design, construction and testing of new experimental equipment; it takes care of R&D scientific and technological aspects

Research Division

Activity in 2023-2024

- Experiments: support to all the experiments and projects
- Maintenance of Laboratories, Boost to R&D, IT improvements
- Management of internal and external connectivity services, IT support for Managerial/Administrative users
- Planning for reorganization of new and existing experimental areas. More intense work will start soon after the completion of the PoTLNS infrastructural works
- External Users: EUROLABS for next Transnational Access
- Formation (LNS-UniCt): shared Ph.D. programme and participation to Ph.D. teaching activities, Erasmus Mundus Joint Master Degree
- Outreach-dissemination: seminars, national and international events (European Research Night, EXPLORA, INFN-Kids)

Computing and Information Technology Service

Activities carried out from June 2023 to date (highlights)

- VOIP

Start of migration autumn 2023, starting from Administration and Personnel Management

Upon completion, in parallel with the rewiring

- Network separation: single network bypass 172.16.0.0/16

Already migrated: guest wifi networks, eduroam, INFN dot1x

In programming sub-networks for services: administration, data acquisition, radio prot, systems etc. etc.

- Network access characterization

Definition of user groups and their managers (AGID regulations)

- Implementation of centralized authentication system for network services (mail, VPN, wifi):

One unique password for all services

Scheduled for 2023, suspended for VOIP

Scientific Information Service

Documentation and online access to scientific journals

Web - social media

Dissemination outreach communication

Public engagement collaboration lns

MANAGEMENT OF INFN &LNS DATABASES AND STATISTICAL PRODUCTION events - performance - third mission - seminars - VQR

DESIGN AND IMPLEMENTATION OF LNS ACTIVITY REPORTS

PHOTO DOCU & LNS EVENT SUPPORT

LNS VISITOR CENTRE MANAGEMENT

Service for the Development of Experimental Equipment and Apparata

Highligths of Service-specific tasks

- Mechanical Design (Rescaling Chopper DFA, Microwave device project DTT, PANDORA)
- FRAISE Target positioning system
- I-LUCE Facility control system
- I-LUCE Shield Interaction Room
- R&D

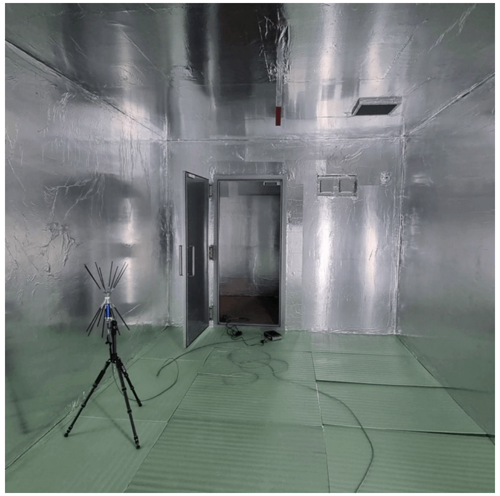
Service for the Development of Experimental Equipment and Apparata

I – LUCE Shielded Interaction Room

Among the various alternatives, the one examined was to create a shielded room with conductive sheets on the walls.

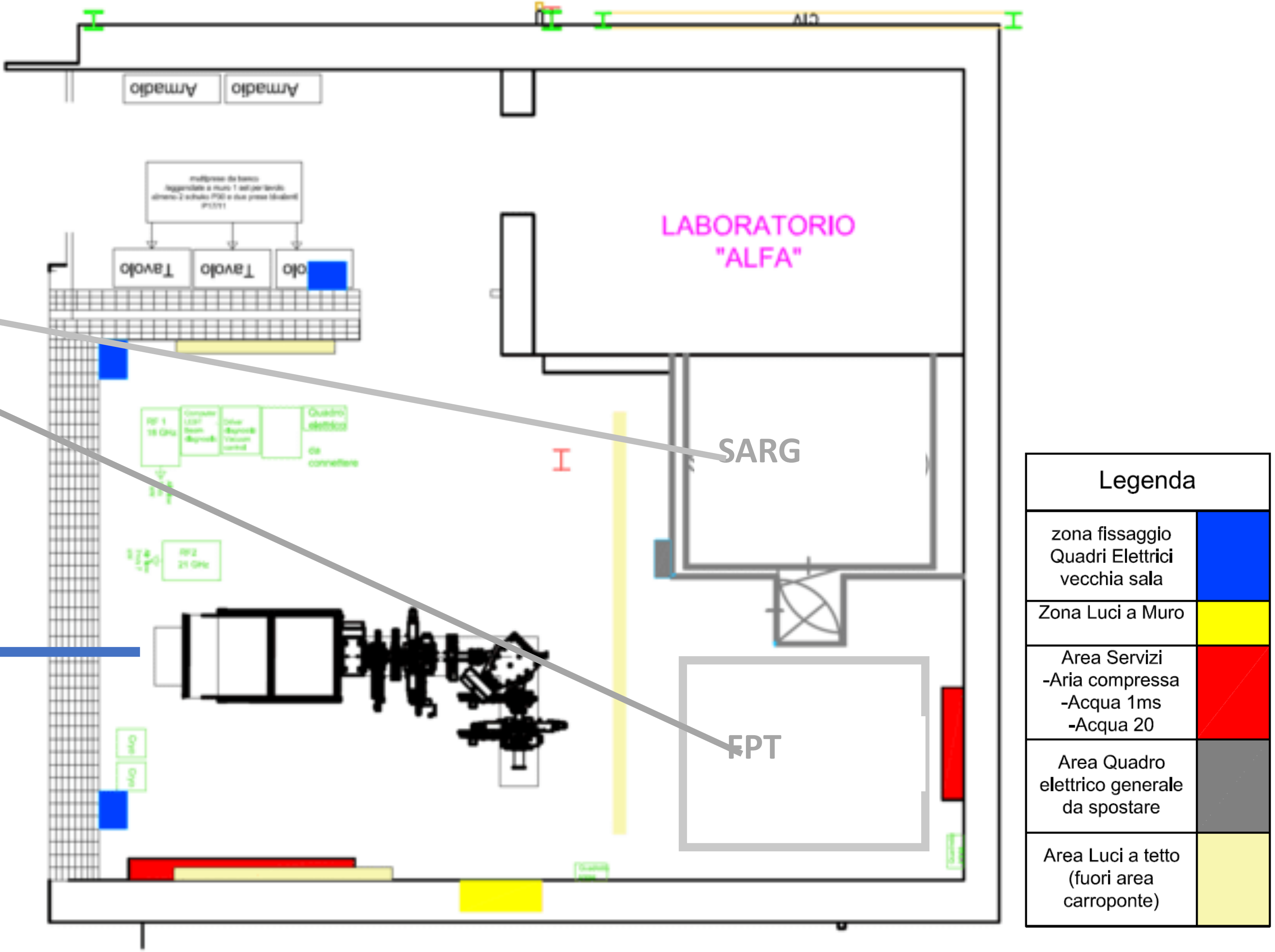
This solution makes it possible to exploit the maximum available space and to comply with quality standards, managing to obtain an attenuation of the electric field between 40 and 80 dB.

The company from which materials and know-how will be supplied is Hollandshielding System BV

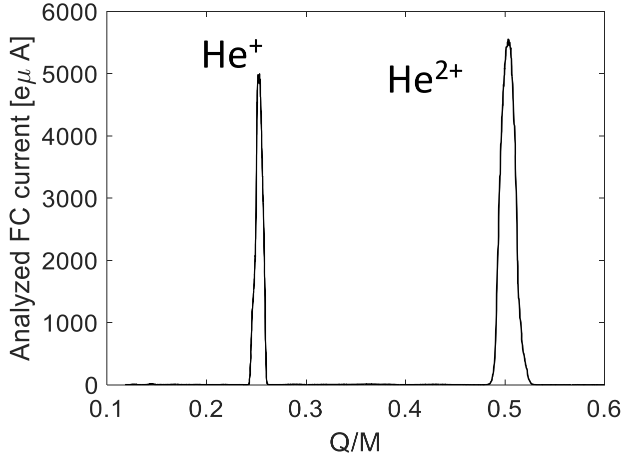


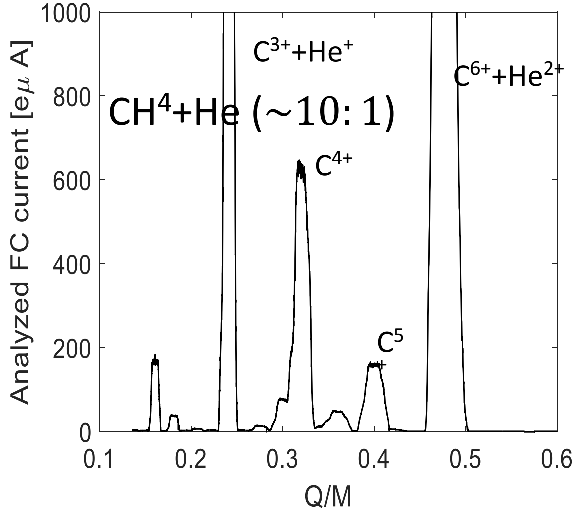
Layout of the new area dedicated to R&D on ion sources

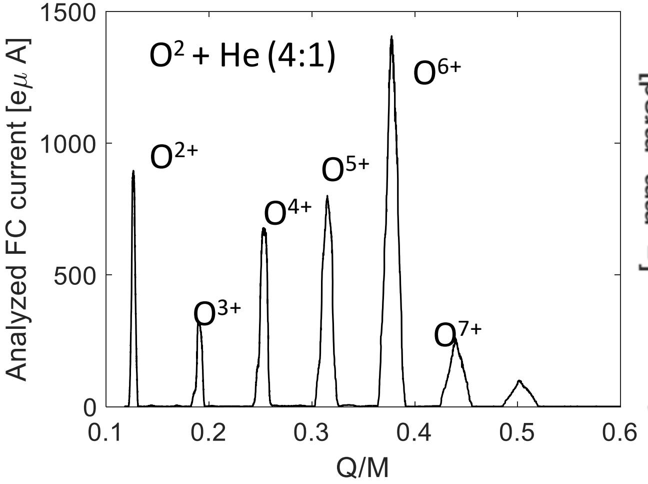
SARG and FPT to be moved in dedicated rooms.

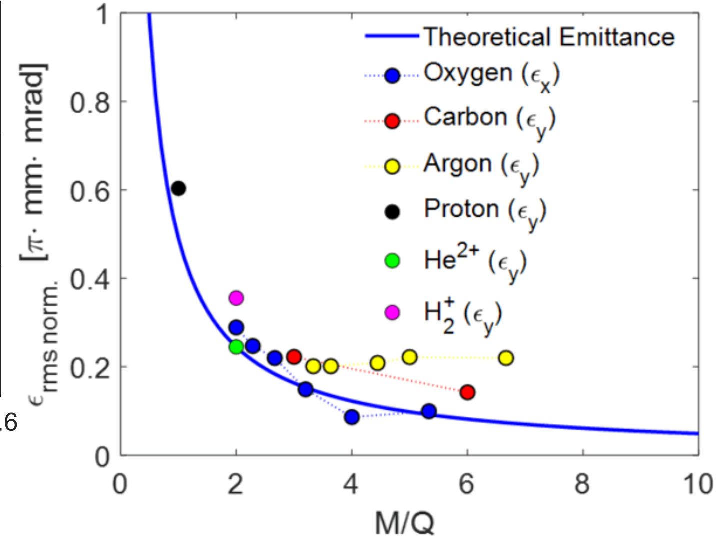


AISHa performances @INFN-LNS (17.3-18.4 GHz – 1.5 kW max)





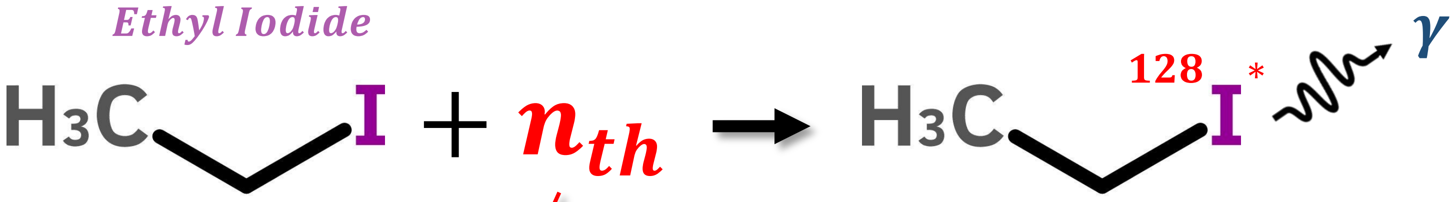




Charge state	Beam intensity [eμA]	$\varepsilon_{rms.norm}$ $[\pi \cdot mm \cdot mrad]$
$^{16}O^{6+}$	1400	0.2198
$^{16}O^{6+}$	225	0.115
$^{16}O^{7+}$	350	0.247
$^{12}C^{4+}$	650	0.272
$^{12}C^{4+}$	150	0.222
$^{12}C^{5+}$	165	---
$^{40}Ar^{11+}$	155	0.201
$^{40}Ar^{12+}$	140	0.201
He^{2+}	5400	0.418
He^{2+}	700	0.245

NUCLEAR and RADIOCHEMISTRY at the ALPHA-LABORATORY of LNS (end of **July 2024** and **September 2024**)

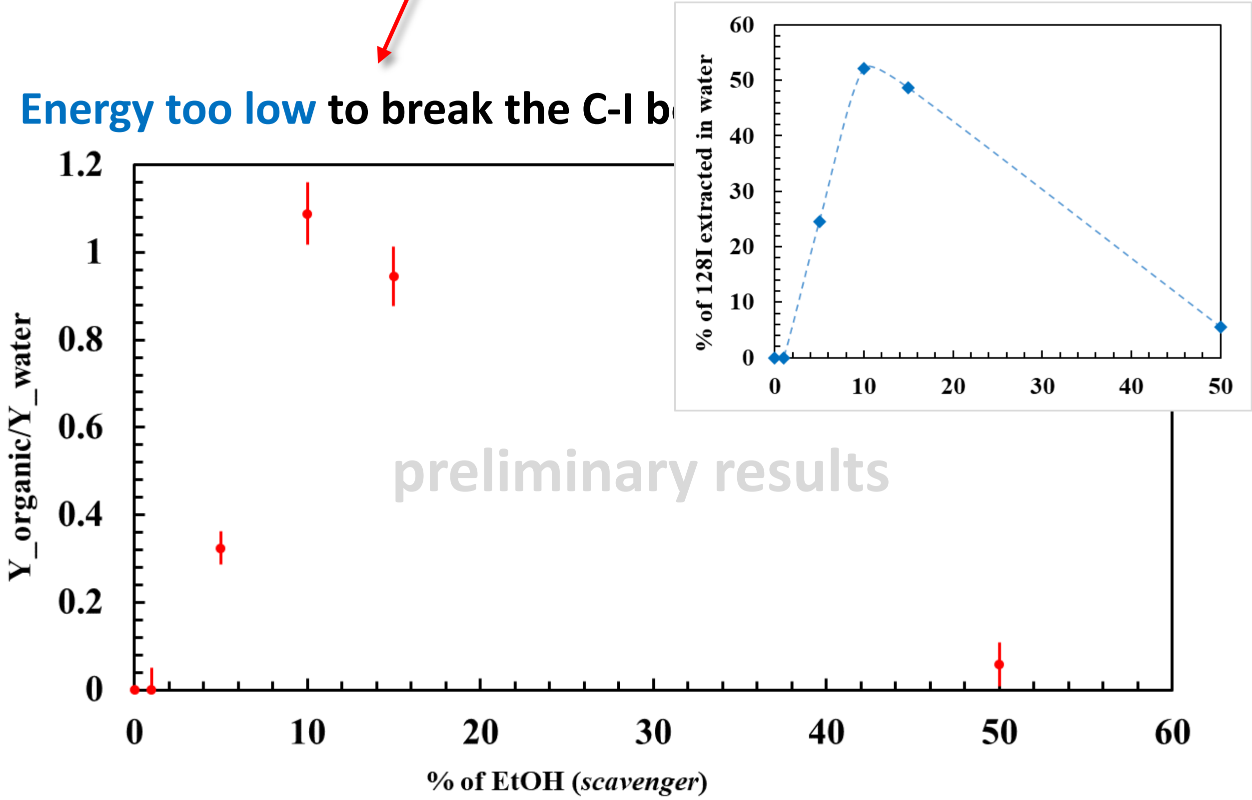
An ethyl-iodide (EtI) solution is irradiated with thermal neutrons, moderated after emi



Energy too low to break the C-I b

I-Cl

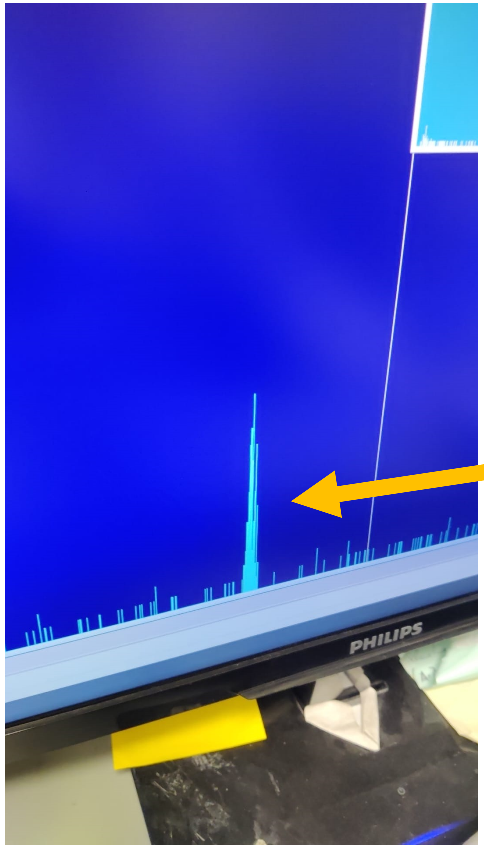
$^{128}I^{*}$

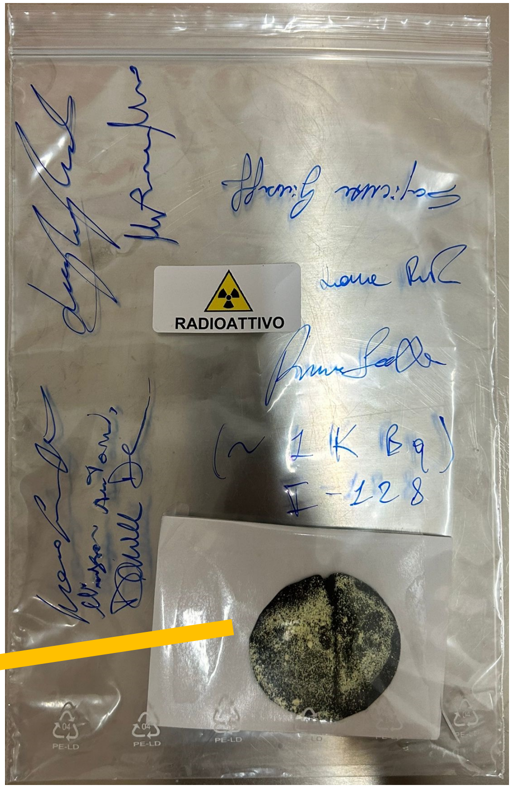


NUCLEAR and RADIOCHEMISTRY at the ALPHA-LABORATORY of LNS (end of **July 2024** and **September 2024**)

SEPTEMBER 17th: Successful extraction of ^{128}I (radioiodine) from the water solution as AgI

ALMOST 100% extraction of radioiodine with I_2 scavenger





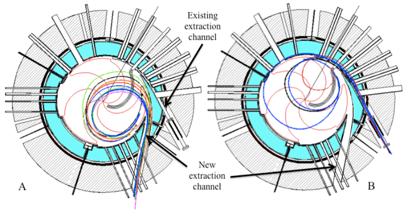
I. Lombardo – UniCT & INFN-CT

July, we studied the retention phenomena of the radioisotope 128-Iodine, produced by the itself "in-house" LNS with the Am-Be source, with the help of a system of two Geiger detectors for self-built liquids. We in this way collected a significant series of data that allowed us to investigate the molecular phenomenon whereby a radioactive iodine nucleus, once freed from the organic molecule used as a target (Szilard-Chalmers process) it is "recaptured" by the radical of the molecule or by a other molecule of the solution. This will be the basis of a publication that is in preparation.

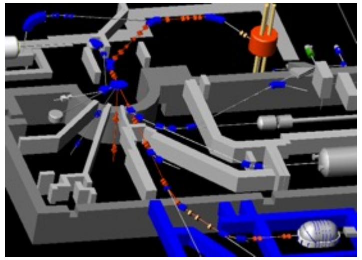
Today, however, we have proceeded to a new, and very demanding, experiment: strengthened by the experience of July, we have carried out the irradiation of a organic solution of Iodoethane, followed by a specific chemical process for the extraction of the radioisotope 128-Iodine from the solution. We have managed to successfully carry out this extraction, with an efficiency (preliminarily estimated) close to 100%; at it In this way, it was possible to obtain a sample of 128-Iodine of about 1 kBq by irradiating only 50 ml of iodoethane with the Am-Be source of LNS. It should be emphasized that this experiment in fast radiochemistry is very complex since the half-life of 128-Iodine is only 25 minutes.

The near future

The POTLNS project aims at upgrading the LNS CS and beam lines to increase the the intensity by about 2 orders of magnitude for ion beams with mass number ≤ 40 and energies between 15 and 70 MeV/amu.



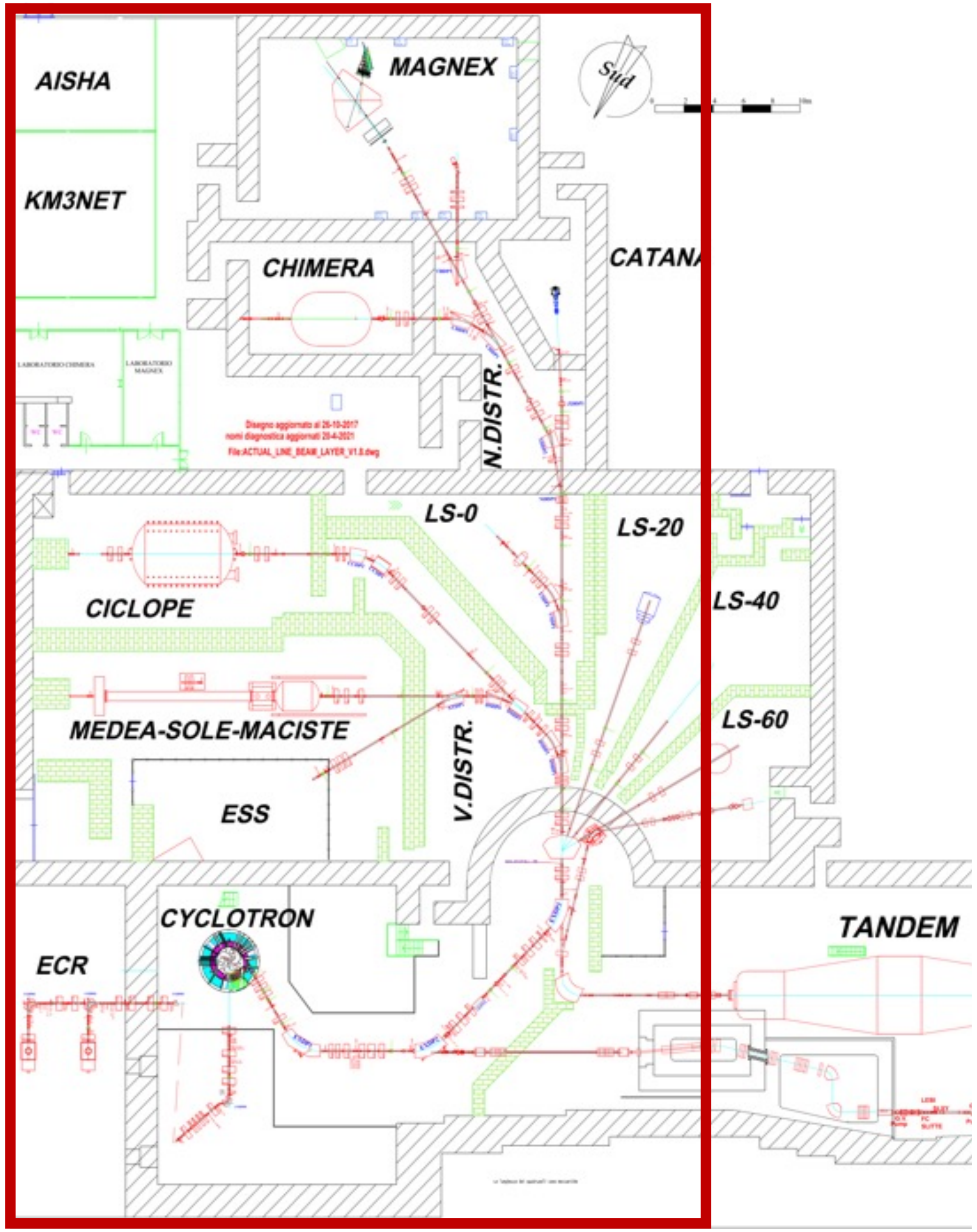
Extraction by stripping



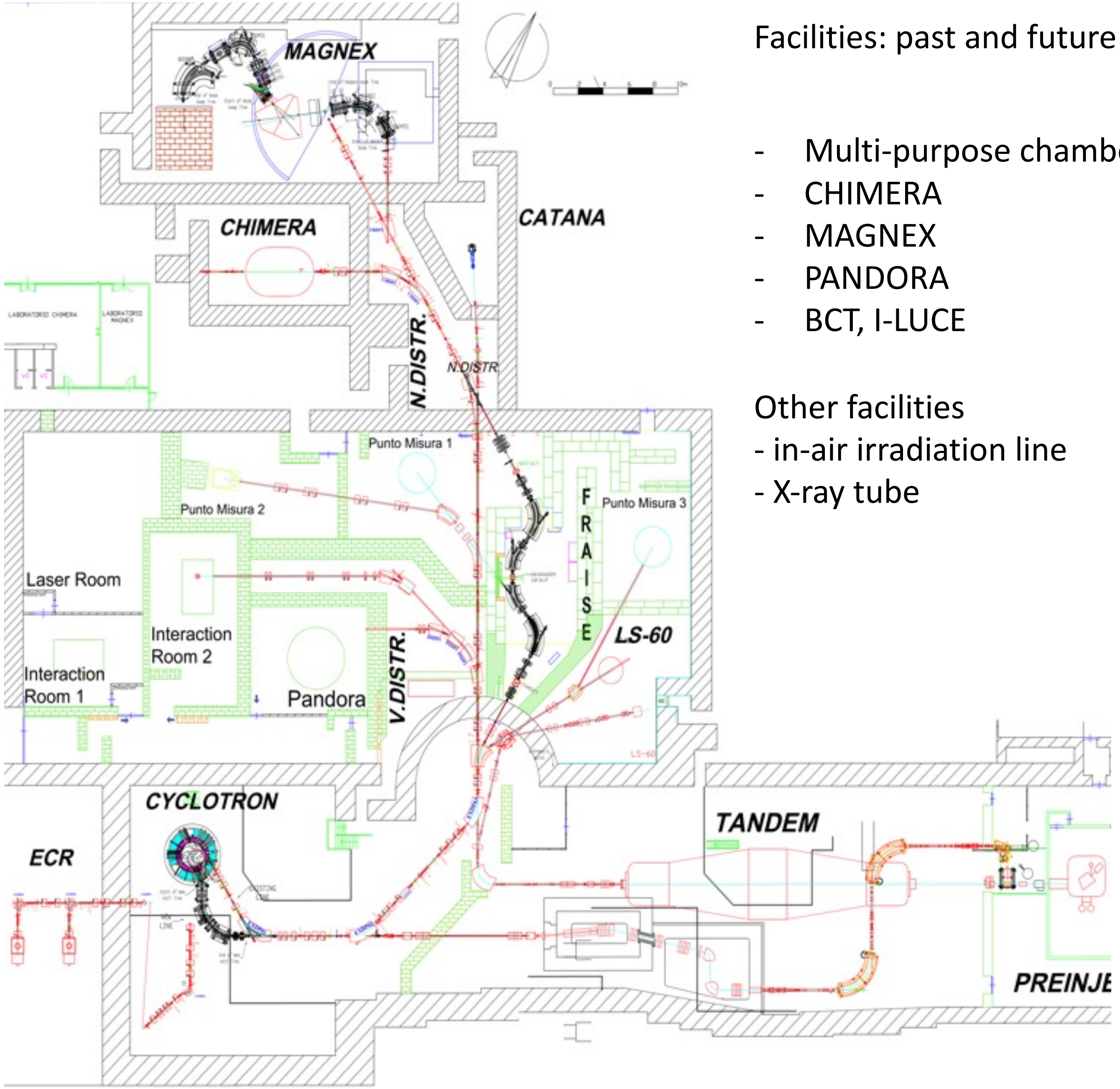
Applications:
- In flight production of RIBs @ FRAISE
- High intensity beams for the study of $0\nu2\beta$ decay (NMEs)

PAST	FUTURE
CT2000 @ 60° beam line	CT2000 @ 60° beam line
80° beam line	80° beam line
20° - 40° beam line	40° beam line
0° beam line	0° beam line
CICLOPE	GIRA
CHIMERA	CHIMERA plus FARCOS CORRELATOR
MAGNEX	MAGNEX upgraded
MEDEA – ESS R&D area	
	PANDORA
	BCT + I-LUCE
CATANA	CATANA + X-ray tube

Past



Future



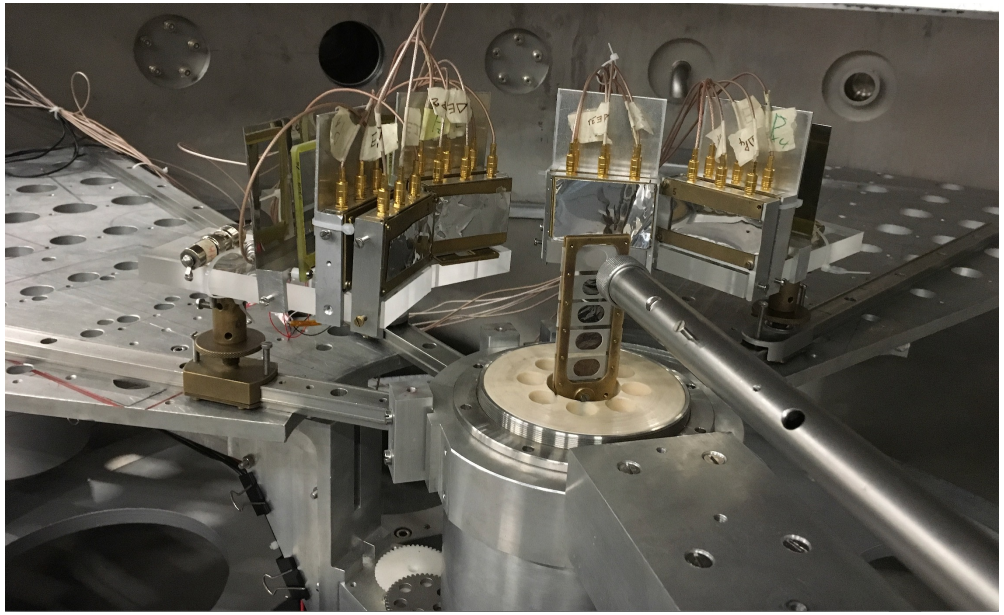
Facilities: past and future

- Multi-purpose chambers
- CHIMERA
- MAGNEX
- PANDORA
- BCT, I-LUCE

Other facilities
- in-air irradiation line
- X-ray tube

CT 2000 scattering chamber

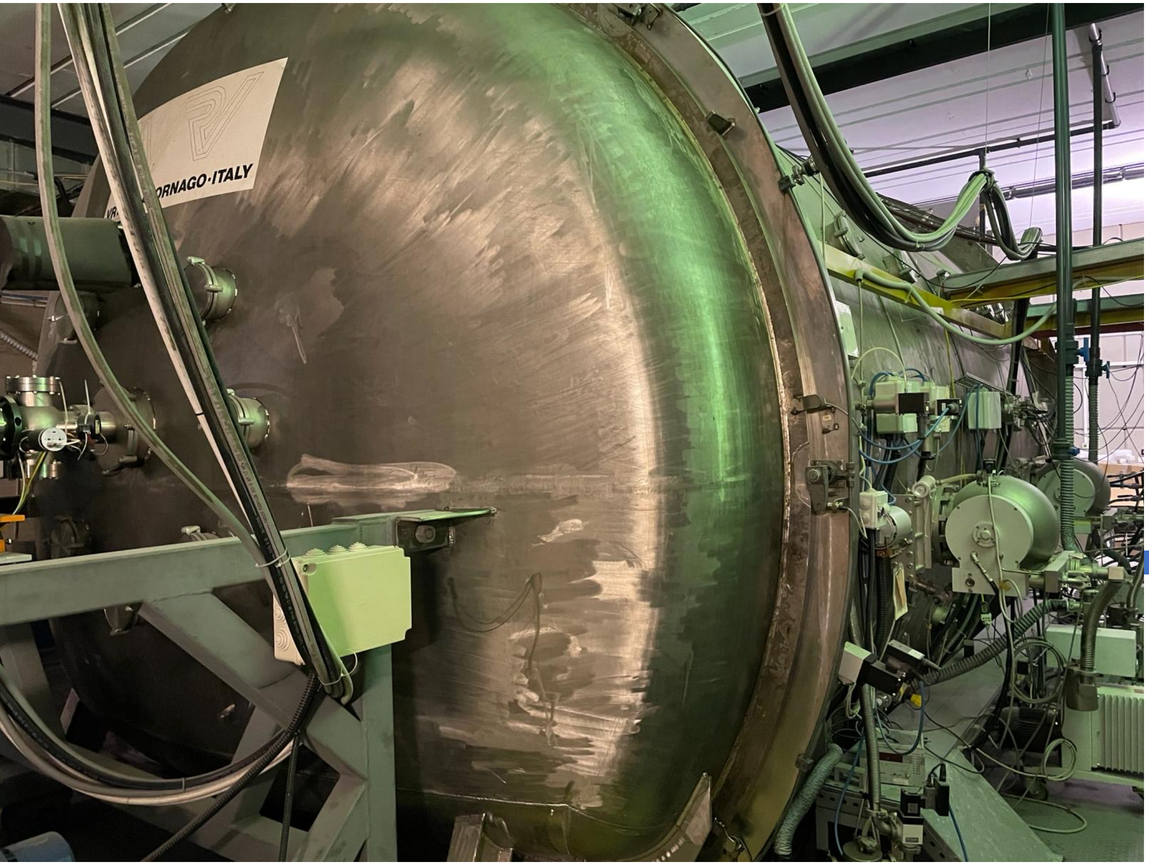
A diameter of 2 m, is equipped with 2 independently rotating arms to host the detectors and a collimation system with a goniometer that allows to measure precise angular distributions. Many flanges with vacuum feedthroughs of various standards are available, allowing to run experiments that generate from few to hundreds of signals.



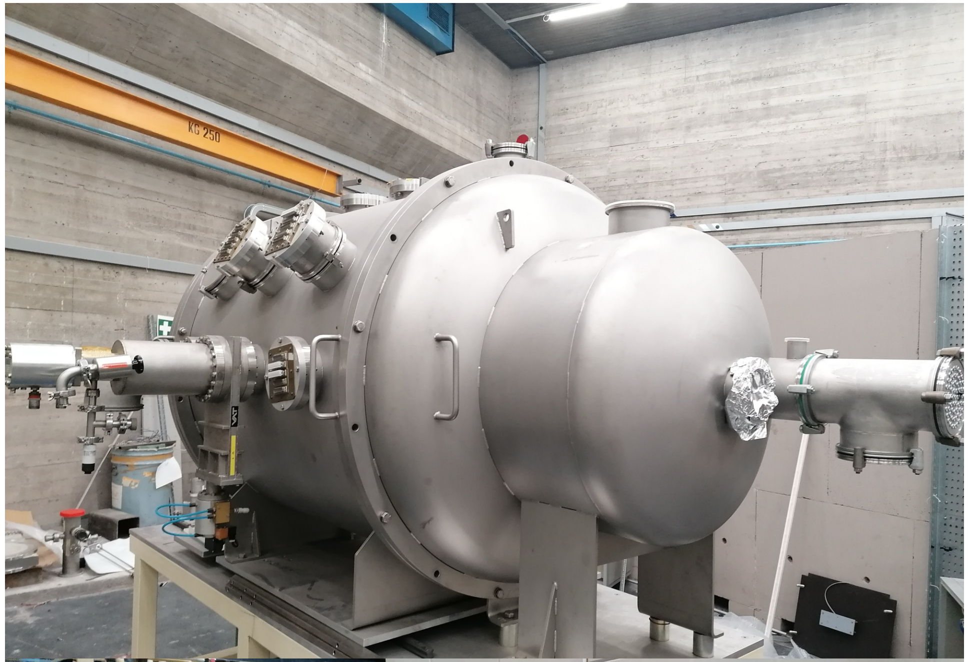
Recovery of vacuum system, purchase of pumps;
Alignment and commissioning of the scattering chamber 2000;
Restore diagnostics, purchase of cables, racks, new crates, ACQ room connection wiring

From CICLOPE to GIRA or refurbished MEDEA

Cylindrical chamber, with a diameter of 2 m and a length of 4 m



Cylindrical chamber, with a diameter of 1.2 meters and a length of 2.1 meters

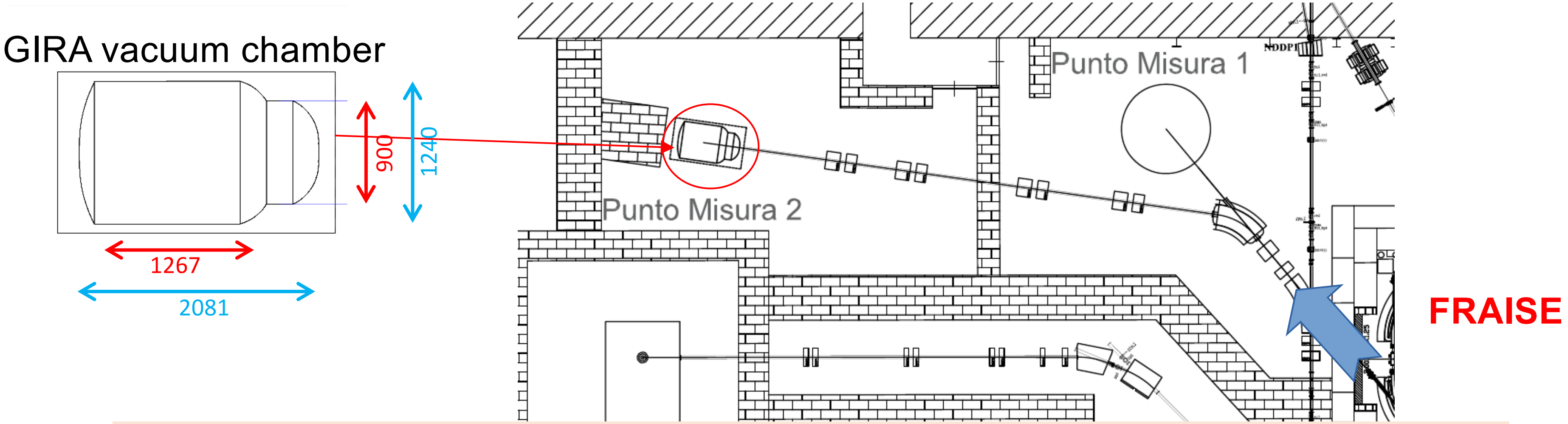


Removal of obsolete experimental apparatus, new shieldings according to the new layout

2026 (after completion of infrastructural work) set up of the new experimental room

Experimental requirements

- Large and well-equipped scattering chamber (2500 mm lenght, 1000 mm wide)
- Good stable and radioactive beam quality at the measure point
- Beam diagnostic

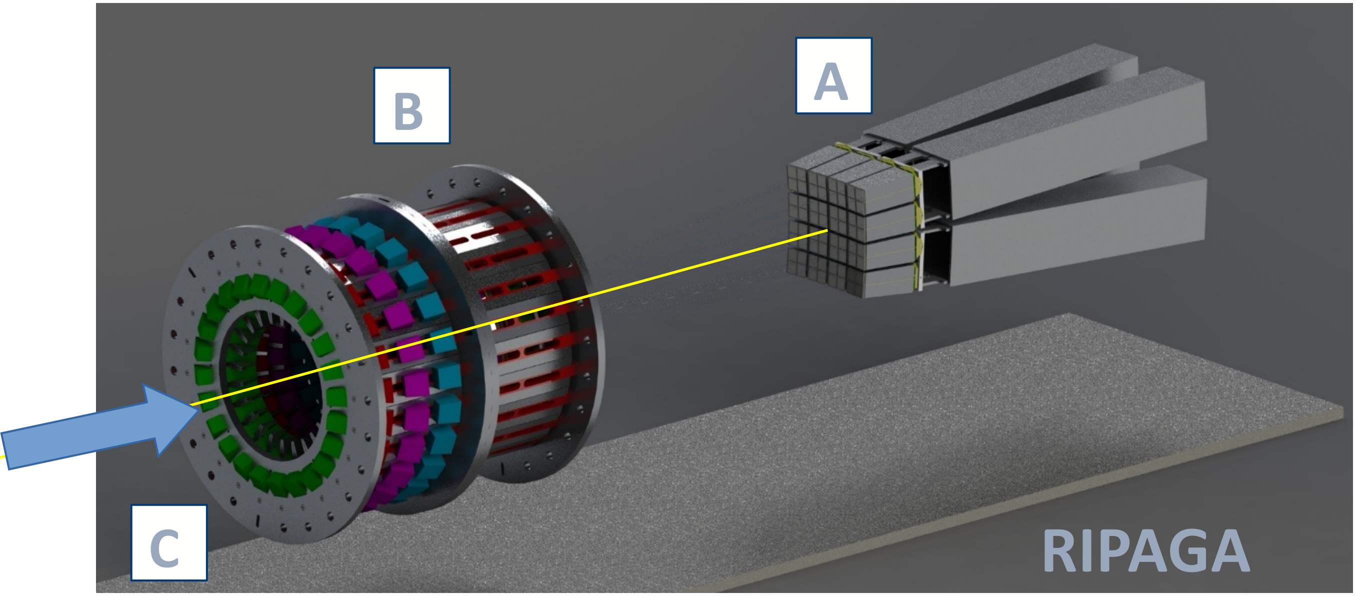


Multipurpose experimental hall **(Punto Misura 2)** in which FRAISE beams will be delivered. Needs for a large scattering chamber for hosting the detectors

- **GIRA** scattering chamber

PROPOSAL (also for CSN3) : The GIRA chamber may be too small for the RIPAGA detector and the future developments. **Is it possible to equip a larger scattering chamber?** (including vacuum system, remotely controlled target holder, beam diagnostic, etc.)

RIPAGA (RIvelatore per PArticelle e GAmma): A new array for charged products and hard gamma rays



C Gamma detector array

- Based on **MEDEA BaF_2 crystals**
- Good energy resolution and efficiency up to 30 MeV
- **SiPM** readout instead of PM

Monitor detector for the cross section normalization

- Plastic scintillators

A Charged particle detector at very forward angles

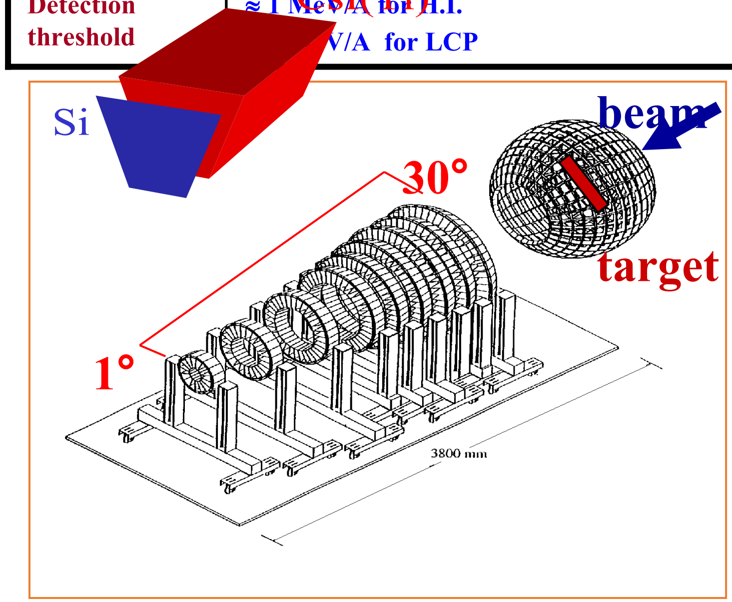
- Based on **FAZIA** three stage **telescopes** (Si + Si + CsI)
- Reasonable granularity
- Good charge and mass resolution
- Possibility to **measure at 0°** with low intensity exotic beams
- Possibility to use **SiC** detectors

B Light charged particles (Z <= 4) detectors at larger angles

- Based on **Garfield CsI crystals**
- CsI crystals (low cost, versatility)

CHIMERA - Charge Heavy Ion Mass and Energy Resolving Array

Granularity	1192 telescopes Si (300μm) +CsI(Tl)
Geometry	RINGS: 688 telescopes 100-350 cm SPHERE: 504 telescopes 40 cm
Angular range	RINGS: 1°< θ < 30° SPHERE: 30°< θ < 176° 94% of 4π
Identification method	ΔE-E E-TOF PSD in CsI(Tl) PSD in Si (upgrade 2008)
Experimental observables and performances	TOF dt ≤ 1 ns dE/E LCP (Light Charge Particles) ≈ 2% dE/E HI (Heavy Ions) ≤ 1% Energy, Velocity, A, Z, angular distributions
Detection threshold	≈ 1 MeV/A for H.I. V/A for LCP



Dynamical range : from fusion, fusion-fission to multifragmentation reactions

(TANDEM & CYCLOTRON Beams)

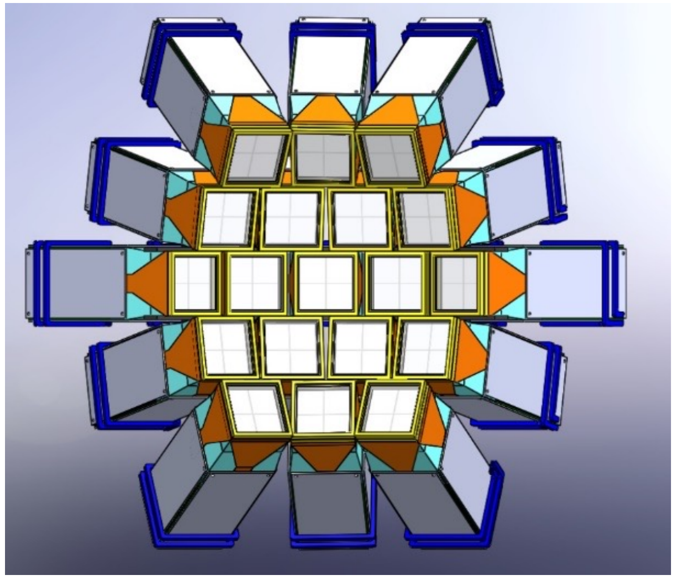
Upgrade activities in progress

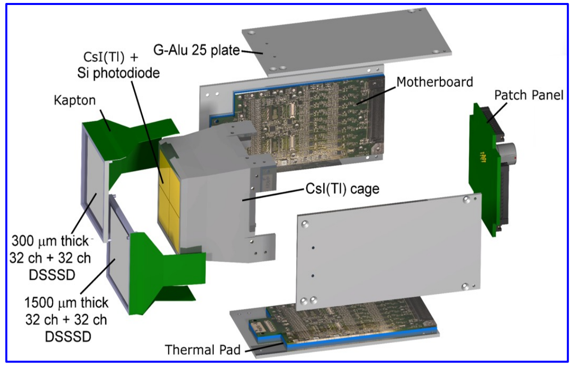
- Development of a new tagging system for RIBS based on SIC technology
- New cabling in CHIMERA implementing differential signal transmission

Next: upgrade the vacum system
maintenance work on the lid opening and closing system

CHIMERA ancillary arrays

FARCOS - Femtoscope Array for COrrelations and Spectroscopy

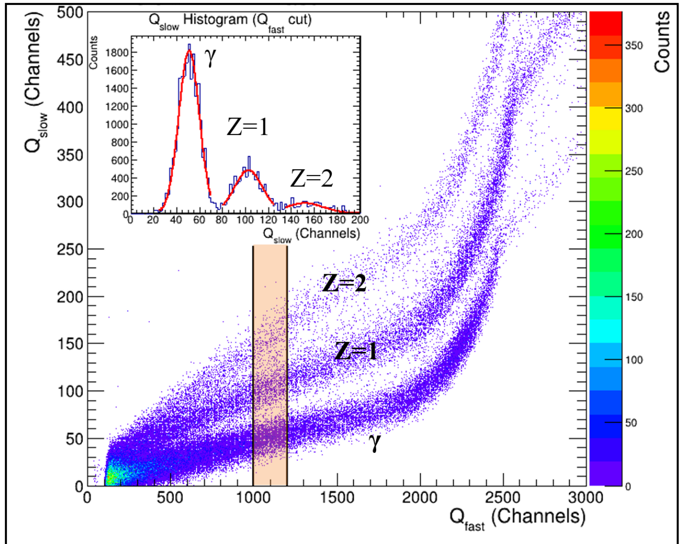




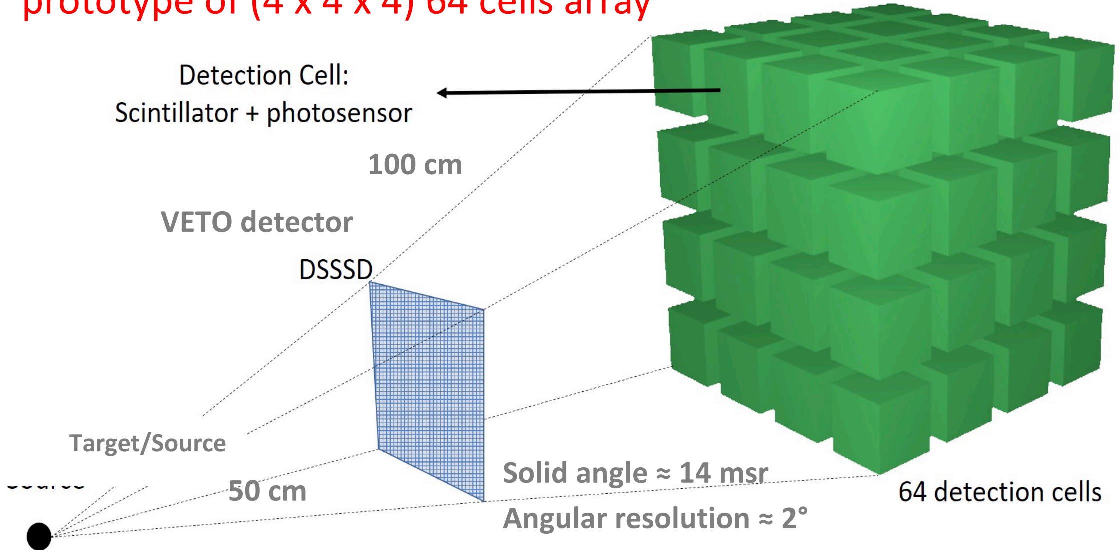
- High energy and angular resolution (δθ, δϕ<0.1°)
- Low thresholds (<1 MeV/A)
- Pulse-shape on first Si layer
- High counting rate (1KHz)
- Large Dynamic range (20MeV to 2GeV)
- Flexibility, Modularity, Trasportability: coupling to 4π detectors or spectrometers
- Integrated electronics (GET)
- DAQ, new digital acquisition system
- 20 clusters

A new hodoscope for n, gamma and Charged Particles: EJ276(G) read by SiPM

EJ-276G + SiPM

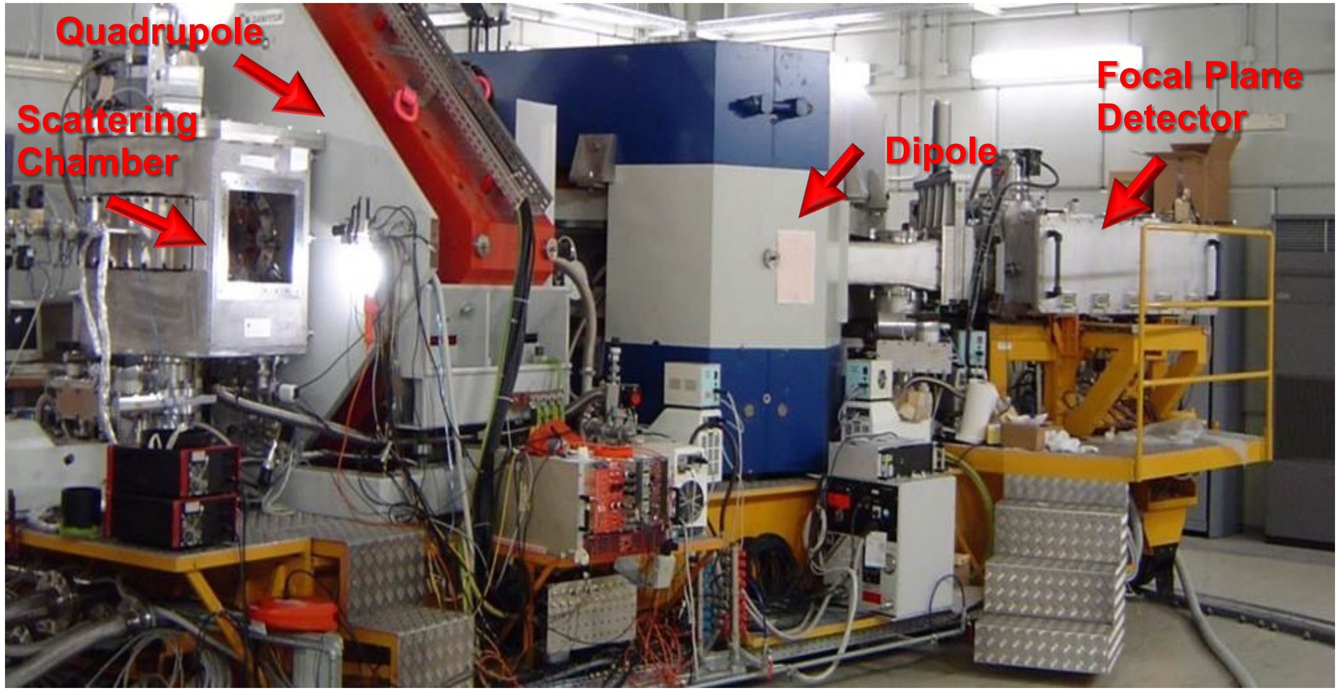


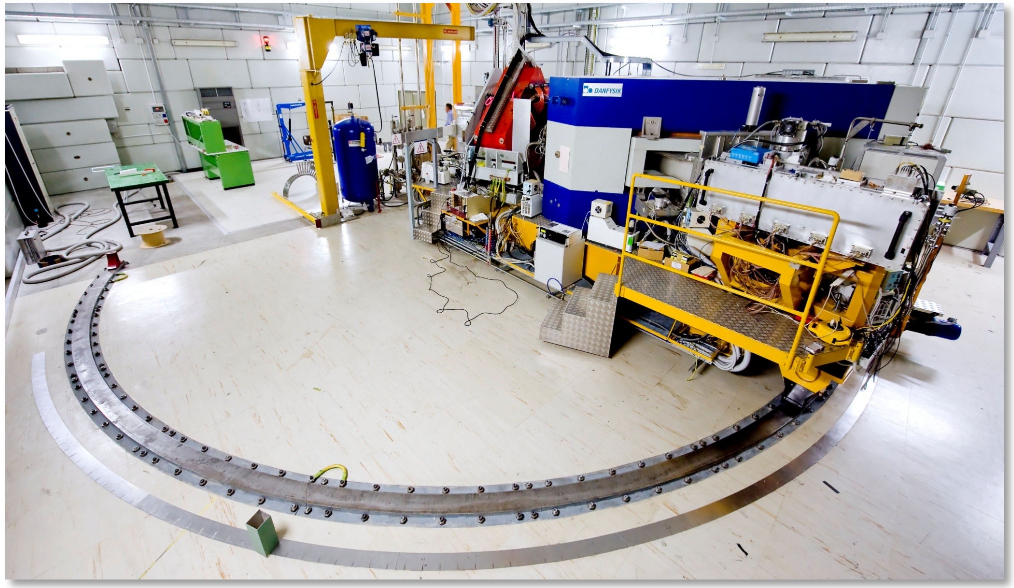
prototype of (4 x 4 x 4) 64 cells array



- 2010 Physics campaigns started

Previous MAGNEX configuration





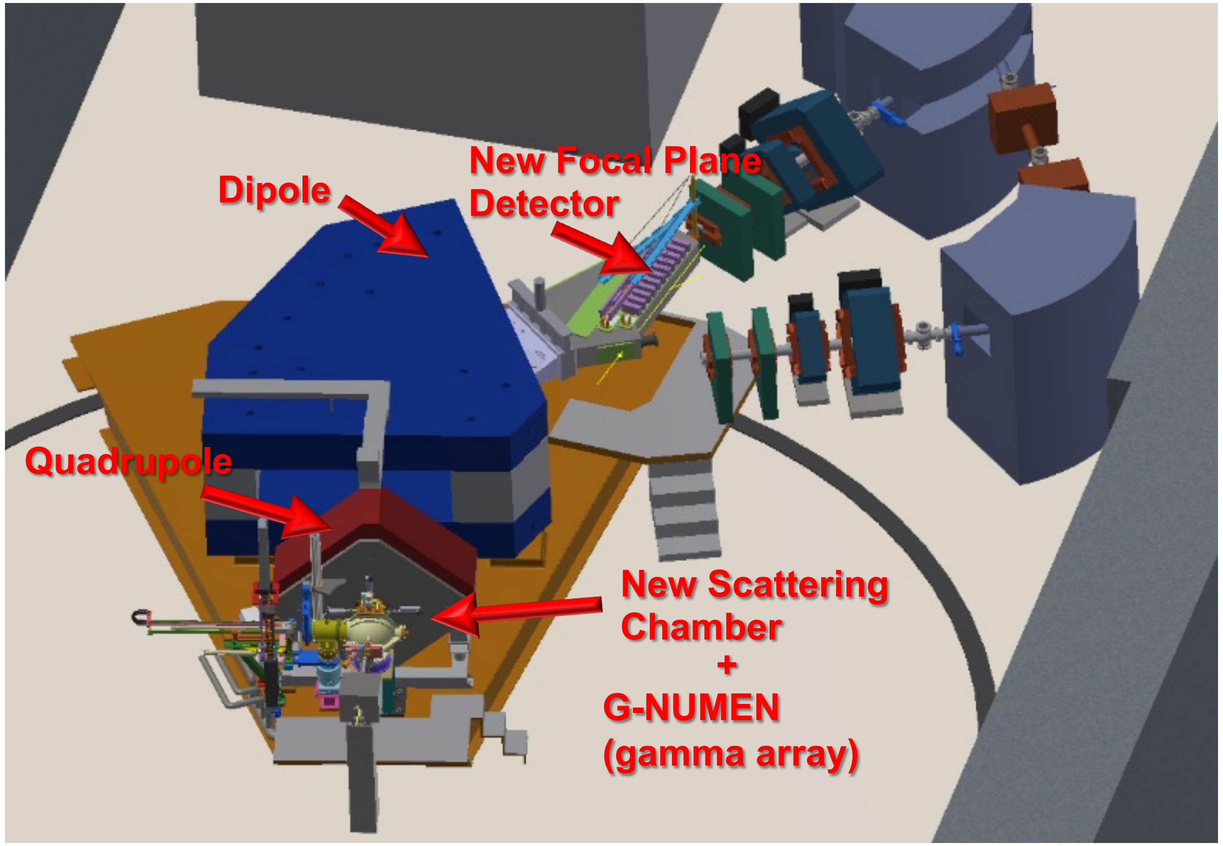
Optical characteristics	Measured values
Maximum magnetic rigidity	1.8 T m
Solid angle	**50 msr**
Momentum acceptance	**-14.3%, +10.3%**
Momentum dispersion for k= - 0.104 (cm/%)	3.68

Achieved resolution
Energy $\Delta E/E \sim 1/1000$
Angle $\Delta\theta \sim 0.2°$
Mass $\Delta m/m \sim 1/160$

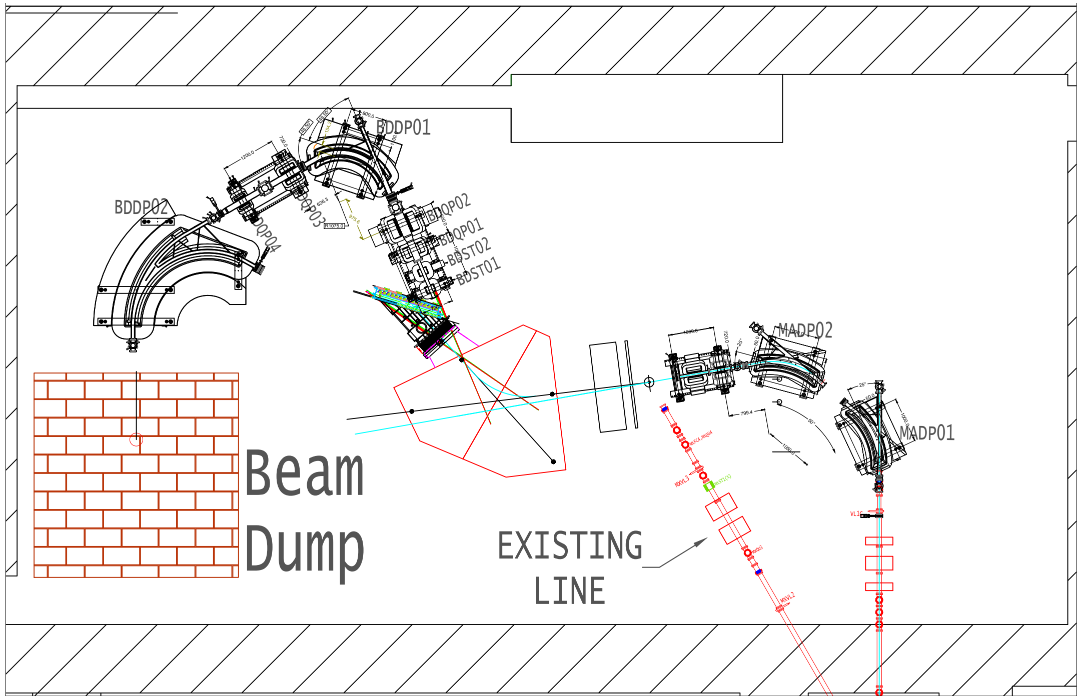
MAGNEX upgrade to sustain high rates while maintaining the current MAGNEX **resolution and sensitivity**

POTLNS project: triggered by the NUMEN physics case

Future MAGNEX configuration



Future MAGNEX hall



Major upgrades

- New focal plane detector (gas tracker and pid wall)
- New gamma detector array (G-NUMEN)
- New exit beam lines and beam dump (for 0° measurements)
- New power supply to reach higher magnetic rigidity (from 1.8 to 2.2 Tm)
- Suitable targets

Recovery and integration of control system; Recovery of vacuum system; Purchase of Cables; Diagnostics;
Replacement of dipole surface coils – delivered in July 2024, ready to be re-installed

PANDORA-GR3

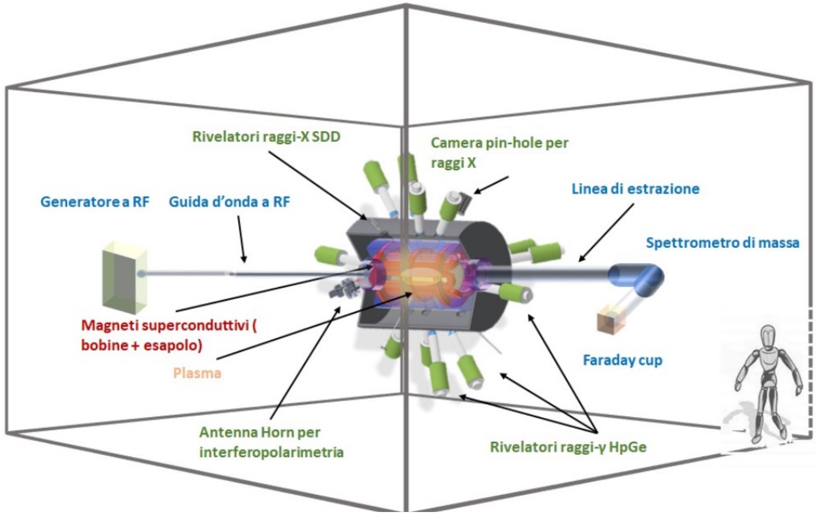
SpokePersons: David Mascali, Domenico Santonocito

2024 : 20 FTE, 45 INFN/70 Collaborators

Status : under construction

- the PANDORA experiment at the LNS is working on the construction of a plasma trap where it will be possible to recreate ionization conditions similar to those of stellar interiors, and **therefore study the beta decay and electron capture rates in plasmas** with total or partial ionization in a range of T from 0.1 to 30 keV with density up to 10^{13} cm^{-3}.

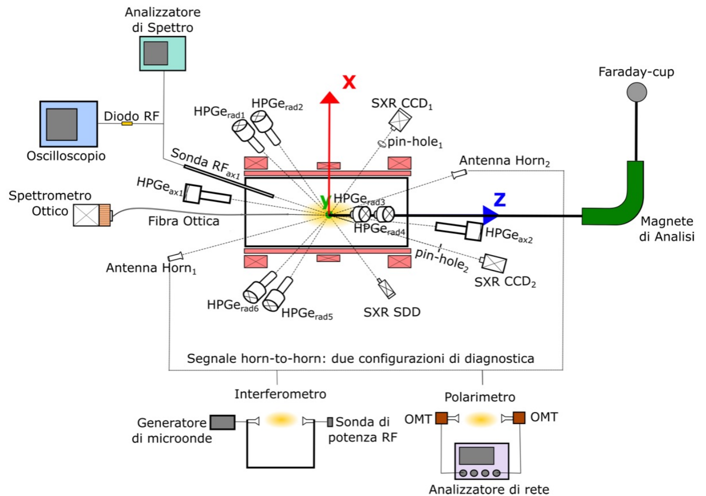
Agreement with the GAMMA Collaboration to have on loan n.16 GALILEO HPGe detectors until the end of 2025 – we will evaluate a possible extension of the times



Already funded items by CSN3 including extraordinary support by GE

ITEM	*Total per item*	Colonna1	Colonna2	Colonna3	Colonna4	Colonna5	Colonna6	Colonna8
		2020	2021 assegnato	2021*	2022	2023	2024	
Plasma Trap	1570,5	91,5	220	990	135	235		1671,5
RF system	490	240	0				0	240
Plasma chamber	225	35	10		0	40	160	245
HV&Extraction Syst.	125					45	80	125
OES+Mass spectr.	155		25		35	95	100	255
HPGe array+mech.	1210				30			1210
Isotope Injection	203,5	5,5	38			0	0	43,5
Vacuum&Controls	150				50		0	50
	4140	372	293	990	250	415	460	3990
				**after TDR approval*				

ca. 600 k€ from GE extra-funding



PANDORA-GR3

Plasmas for Astrophysics Nuclear Decay Observation and Radiation for Archaeometry

Synergic External Funds

- SAMOTHRACE (Ecosistema Innovazione MUR, PNRR): 90 k€ for instruments + 1 RTD 24 months (~ 115 k€)
- NQSTI (Partenariato Esteso, PNRR): 80 k€ for instrumentation + 1RTD 24 months (~115 k€) + 1 CTER 24 months (~ 70 k€)
- EUROLABS: 50 k€ for 1 RTD (call will open soon)

Partner (in-kind contribution):

- GSI-Darmstadt: isotope vaporyzing systems, ca. 130 k€
- CNRS/GANIL: Thomson scattering diagnostics, ca 70 k€

TO BE FUNDED (CSN3 (?) or other sources):

- Microwave Generator KLYSTRON #3: 300 k€
- HpGe Array (now available till end of 2025): 1.3 M€
- Mass Spectrometer: ca. 100 k€
- HpGe support mechanics: 50 k€

I-LUCE - INFN - Laser indUCEd radiation production

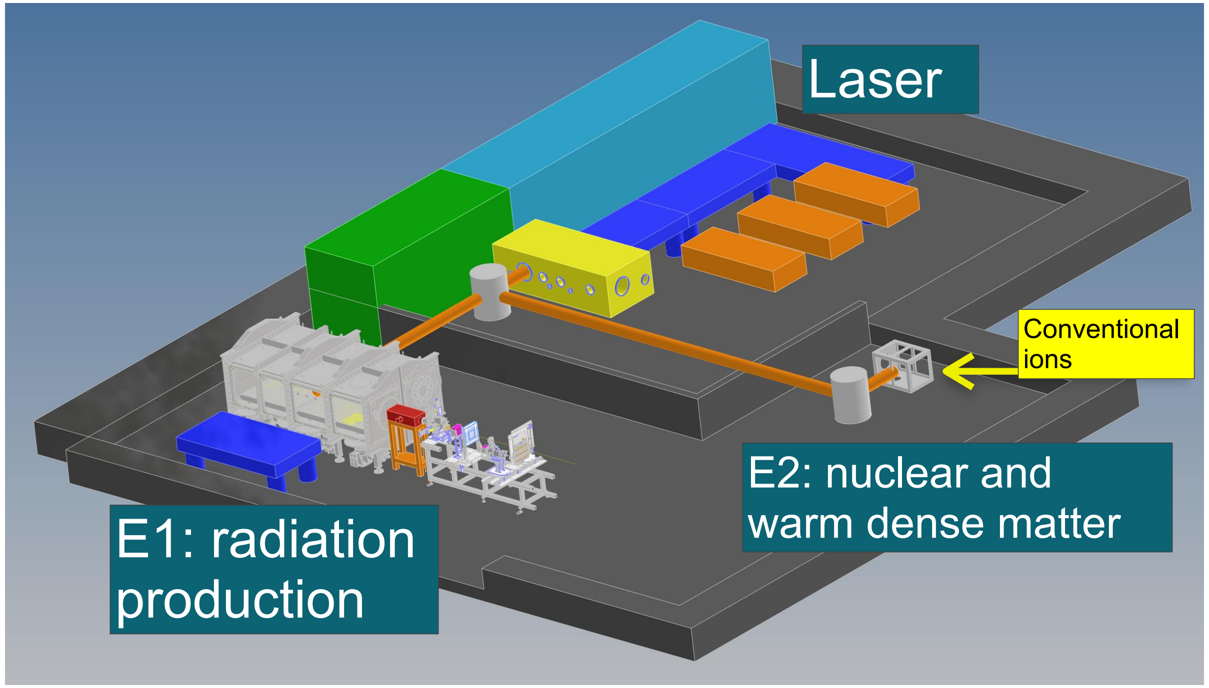
x

high-power (up to 0.5 PW), ultra-short (down to 23 fs) Ti:Sa laser will provide two laser outputs

- 45TW/23fs/10Hz
- 0.5PW/23fs/3Hz

Pulse duration can be scaled down to 500fs (with compressor) and ns scale level with a consequently variation on laser intensity

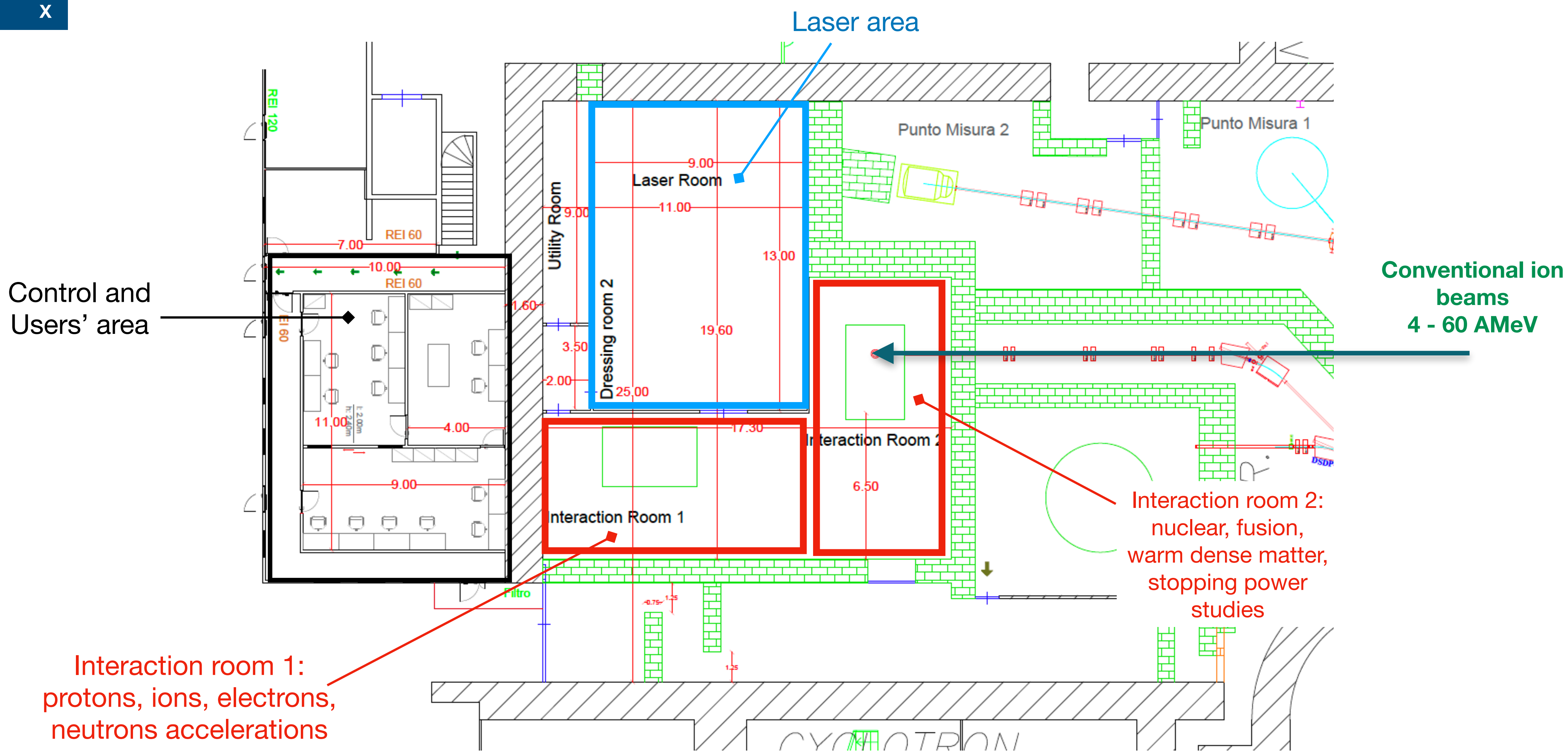
Lasers will be directed towards two different experimental areas E1 and E2



Laser/plasma and ions: world almost unique environment

I-LUCE layout

x



High-power modality: 500TW/3Hz

x

Laser main parameters

Laser Power	500 TW
Energy per pulse	>10 J
Pulse duration	≤ 25 fs
Focusing surface	36 μm^2 or better
Max power density (at the target)	$1.33 \cdot 10^{21}$
$I*\lambda^2$	$8.5 \cdot 10^{20}$
Contrast ratio @100 ps (ASE)	> 10^{10}
Repetition rate	3 Hz

Main radiations

Protons Ions	Max energy	70 MeV
	Particle per pulse (at 30 MeV)	10^{11} MeV^{-1} Sr^{-1}
	Energy spread	100%
	Beam divergency (max)	±20°
Eletrons	Max energy	3 GeV
	Particles per pulse	10^9
	Beam divergency (max)	± 20 mad
Neutrons	Max energy	20 MeV
	Particles per pulse	10^{10}
	Energy spread	100
	Beam divergency	Isotropic
Gamma X-beams	Synchrotron radiation of the Energy	up to 80 MeV
	Beam divergency	Directionality in the beam ropabgation direction

GAP Cirrone, PhD - pablo.cirrone@lns.infn.it

Tandem backlog: (110 BTU @ 60°, 8 BTU @ 0°)

NAMES = 51 BTU (50) (2020) Beams: 23Na, 24Mg @ 1.1 AMeV   Beamline 60 deg
DISFUS = 24 (2019) Beams: 24Mg @ 63, 90 MeV Beamline 60 deg
INVERSE-ALPHA = 21 (2019) Beams: 58Ni, 64Ni @ 196 (only 64Ni) 182, 168, and 154 (only 58Ni) MeV
ELIMED= 12 (15) (2020) Beams: 1H, 4He, 12C @ 5 to 24 MeV   Beamline 60 deg
SPIRIT = 4 (2020) Beam: 1H @ 20MeV Beamline: 0 deg
NANODLIGHT = 4 (2020) 1H @ 14 MeV Beamline: 0 deg

NAMES: measurement of $^{6}Li(^{23}Na,p^{26}Mg)^{2}H$ to improve knowledge on $^{23}Na(\alpha,p)^{26}Mg$ via THM; 23Na beam @

DISFUS: measurement of the fusion excitation functions for the 24Mg + 90, 92Zr systems between 63 and 90 MeV

INVERSE-ALPHA: study of elastic α scattering in inverse kinematics on 58Ni and 64Ni at energies around the Coulomb barrier, [Elab= 196 (only 64Ni) 182, 168, and 154 (only 58Ni) MeV].

ELIMED: to characterize the 2 magnetic systems (prototypes of the ELIMED beam line) with standard accelerators and ii) to calibrate radiochromatic films and CR39 detectors with additional charged particles with the same beam.

SPIRIT: test the radiation hardness of SiPM and CMOS SPADs produced by FBK to check their compatibility with future LHC fluence

NANODLIGHT: low energy protons to create colour centers diamond nanocrystals for their applications as fluorescent bio-markers for drug delivery experiments

Thank you for your attention!