Preventivi 2026
CSN V @LNS

Nuovi esperimenti e stato di quelli in corso

G. Torrisi, GrV_LNS CDL_Luglio2025

85 progetti di CSN5 nazionali – nel 2025

(2 sigle con PI nazionale ai LNS)

Accelerators

ALPHA_DTL_BETA
ASTERIX
BOND
CROWN
FUSION
HB2TF
HISOL_NEXT
PLASMA4BEAM2
SL_BETATEST
SUPERMAD

Interdisciplinary Research

ADMIRAL - AIM_MIA
ARTEMIS - ATHENAE
ATOMIQA – AURORA
BIOHOT – BRAINSTAIN
CHNET_BRONZE
CHNET_MAXI - COLOMBA
CUPRUM_TTD - DISCOVER22
EPISE - FORM_3D
FRIDA
GEANT4INFN
HARDLIFE - MATHER3D
MIRO - MOZART
NEXT_NAMASSTE - NGSA
PRAD – QUARTET - SEGNAR -
SPHERE_X - SPOC - *SPRITZ*
TEMPURA
VI_HI
VITA_5

Detectors, Computation and Electronics

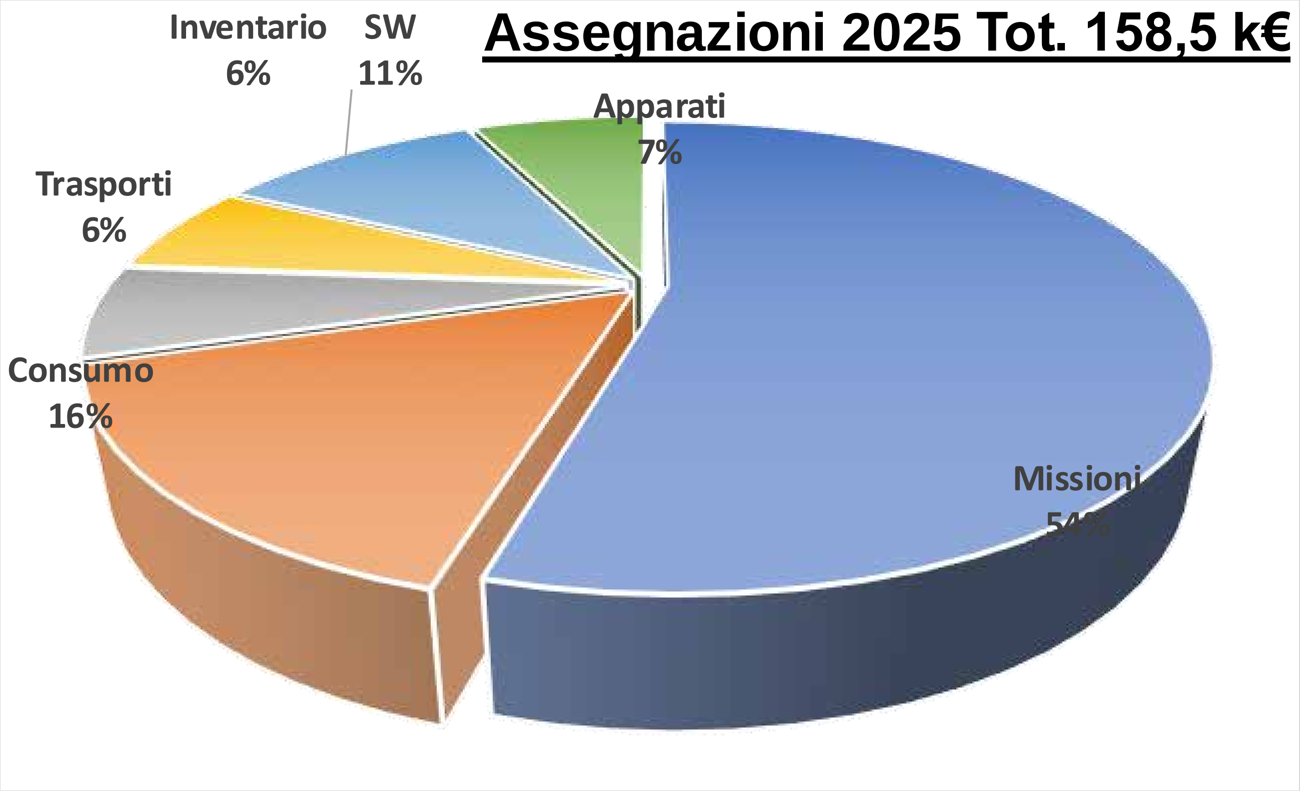
4DSHARE
ACE_SUPERQ - ACROMASS
ADA_5D - AI_INFN
ANNA – APLOMB - ARDE
ASIX - ASPIDES
ASTAROTH_BEYOND
DOCET - DIANA - FEROCE
FERRAD - GREEAT
HASPIDE - HIDRA2
IBIS_NEXT - IONOTRACK
LITE_SLPD - MANIFOLDD
MEMPHYS – NEIS PRIMUS –
OPTIME - OREO - PROVIDE
QUANTEPD - QUTE_FDS
QUISS – QURE - RD_PTOLEMY
RIPTIDE – SHINE - SPECTRE
SQUEEZE – STEEP - T4QC - TEMAN
TIMEPIX4 – UNIDET - UTMOST

GR_V LNS [bilancio 2025]

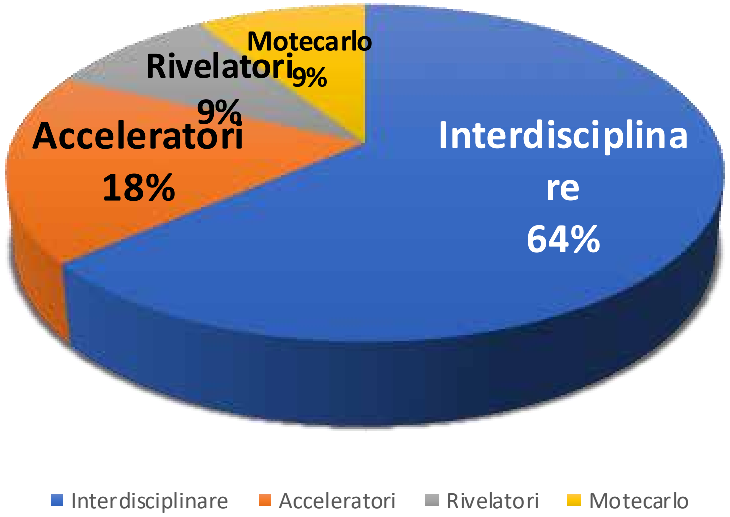
Sigle attive

1. ***ADMIRAL****
2. ***AIM_MIA***
3. ***ASTERIX***
4. ***BIOHOT****
5. ***FRIDA****
6. ***FUSION*** *(richiesta prolungamento 2026)*
7. ***GEANT4INFN***
8. ***HB2TF*** *(Call)*
9. ***MIRO***
10. ***PLASMA4BEAM2***
11. ***SPRITZ***
12. ***TIMEPIX4***

in chiusura 2025



Persone 81 (57 RIC+ 24 TEC)
FTE 45,4
FTE Ric. 35,6
FTE Tec. 9,8
FTE/Pers. 0,63



GR_V LNS *Preventivi*

Sigle attive

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****in chiusura 2025***

Nuove Proposte

- ***GIOTTO***

Giuseppe Torrisi (Resp. Locale), A. Bacci (Resp. Nazionale, INFN-MI)

- **HEARTBEAT**

Pablo Cirrone (Resp. Locale), Lorenzo Manti (Resp. Nazionale, INFN-NA)

- **DIAMIRA**

Pablo Cirrone ((Resp. Locale), C. Verona (Resp. Nazionale, INFN-RM2)

- ***ISOLPHARM APEX***

Giorgio Russo (Resp. Locale)

- **MULTI-GRAPH (Call)**

Manuela Cavallaro (Resp. Locale), Daniela Calvo (Res. Nazionale, INFN-TO)

- ***iDLA***

Giuseppe Torrisi (Resp. Nazionale)

- ***INSIGHT***

Grazia D'Agostino (Resp. Nazionale)

- ***VVIP (Virtual Versatile Ion Production)***

Lorenzo Neri (Resp. Nazionale)

- **Proposta GRANT Giovani**, Sahar Arjmand

GRV LNS *Preventivi*

Sigle attive

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AIM_MIA - Artificial Intelligence in Medicine: focus on Multi-Input Analysis

[INFN-CSN5, 2025-2027]

INFN groups

Resp. Nazionale: A. Retico

Resp. Locali:
- Bari (S. Tangaro)
- Bologna (D. Remondini)
- Cagliari (P. Oliva)
- Catania (M. Marrale)
- Ferrara (G. Paternò)
- Firenze (C. Talamonti)
- Lab. Naz. Sud (G. Russo)
- Pavia (A. Lascialfari)
- Pisa (M.E. Fantacci)

The AIM_MIA project will focus on the following scientific open issue related to the development and validation of AI-based tools for medical data analysis:

1) mining multi-input data.

To make progress in this field it is necessary to address some key aspects such as:

2) handling incomplete/missing/limited datasets;
3) developing a dedicated data and IT platform for secure data management and access to adequate computing resources.

To achieve these goals, sharing data and knowledge within a broad scientific community (networking) will be a fundamental ingredient.

AIM_MIA: Workpackages

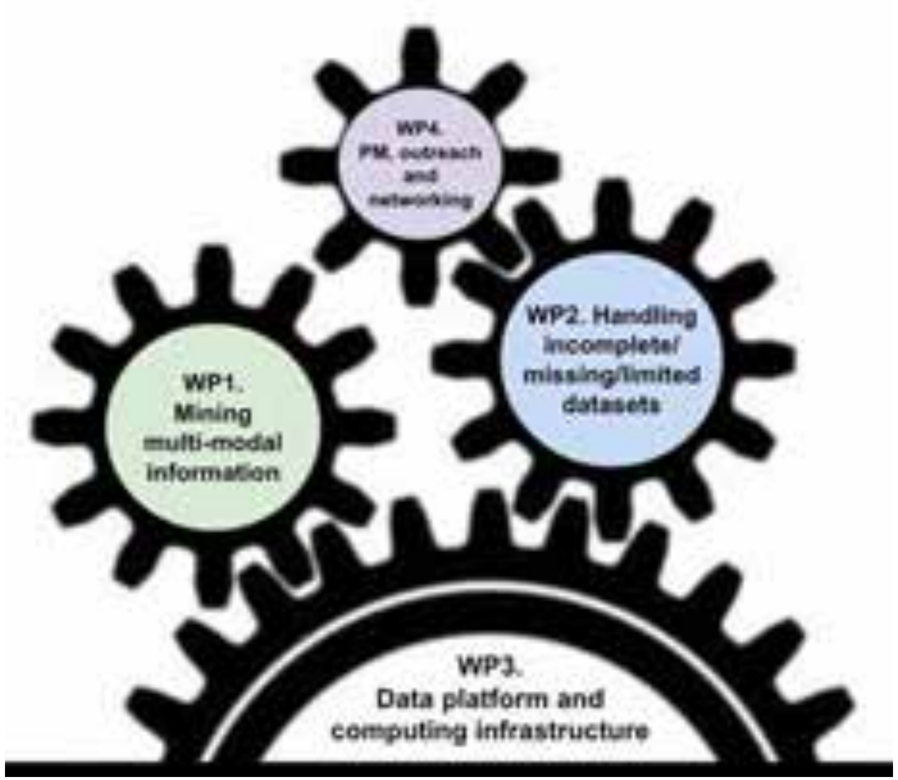
Four work packages will be devoted to address the scientific issues enumerated above.

In ***WP1*** advanced AI-based solutions to analyse relevant data regarding the health status of individuals (including demographic information, medical images acquired with different modalities, clinical scores, etc.) will be developed and validated.

WP2 will be focused on the implementation of the technical solutions for data curation, data augmentation, sample balancing etc., in order to extract as much information as possible from the available datasets which in most real-word cases are incomplete, limited or unbalanced. The growing availability of public data repositories will ensure the feasibility of this project.

The data will be organized and shared among the project collaborators via a dedicated data platform to be developed in ***WP3***, which will rely on INFN computing resources.

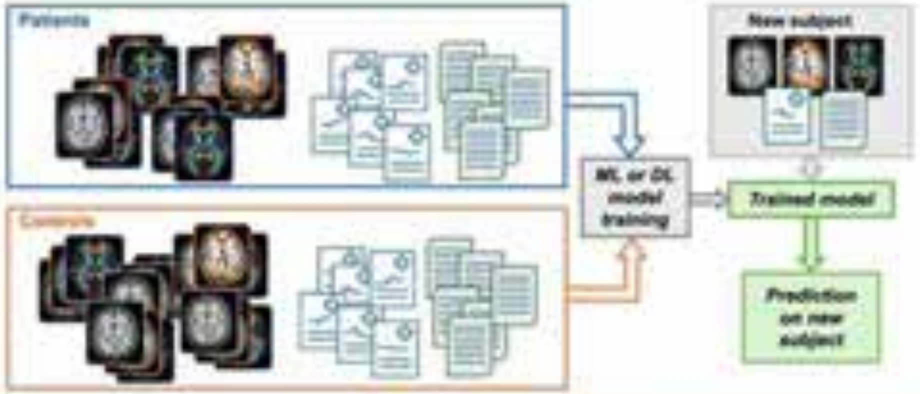
The continuous collaboration with clinical experts, relevant associations in the medical research field, and connections with other research projects funded by INFN or external institutions will be managed in ***WP4***, which is dedicated to scientific networking.



Methods: multi-input analysis (WP1)

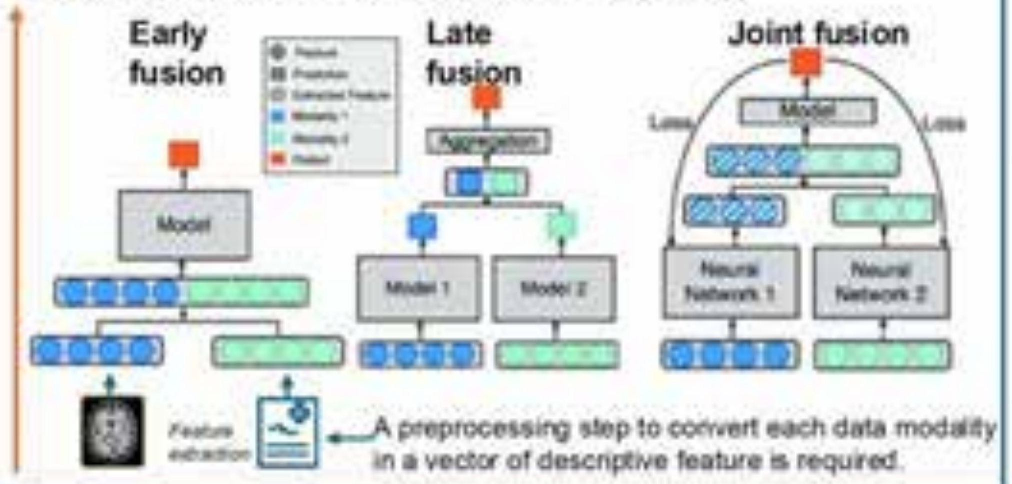
- Data from different sources (image modalities, text and clinical scales, omics data) should be combined

→ **Multimodal Fusion**



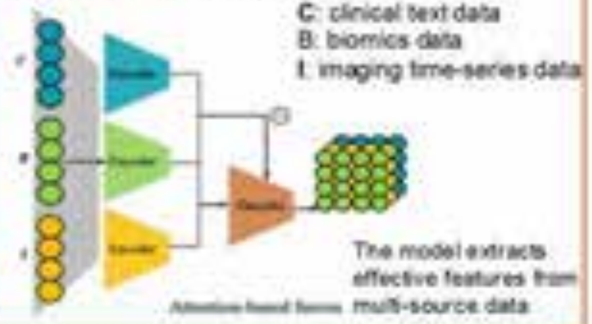
Feature-based approach

Model architectures for different fusion strategies:



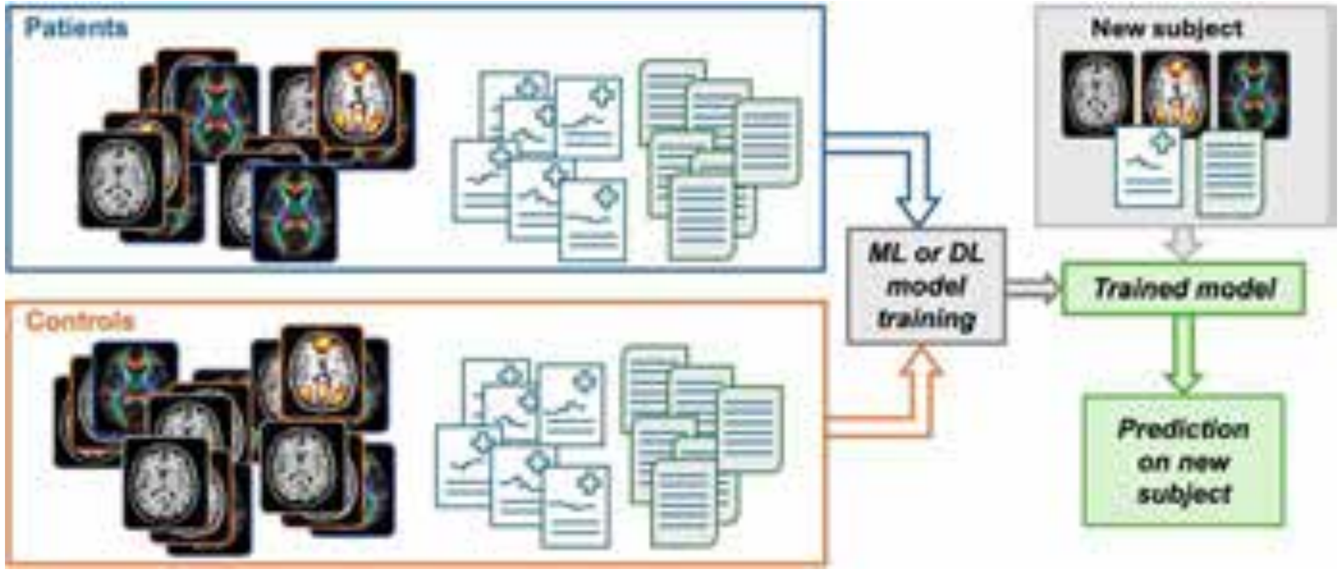
Advanced DL methods

Based on the attention mechanism of the Transformers, the attention-based fusion approach enable to weight the image features according to the information encoded in the clinical text



AIM_MIA: LNS activities

The main LNS research activity of this proposal is to develop robust and effective ***radiomics analysis pipelines*** to make predictions about the health status of an individual, by extracting and combining via ***multi-input AI-based tools*** the complementary and heterogeneous information provided by ***different data sources*** (images, diagnostic tests, and phenotypic data).



FTE e richieste

- Alessandro Stefano – 0,5
- Giorgio Russo – 0,1
- Giovanni Pasini – 0,7
- Riccardo Laudicella – 0,7

Capitolo	Descrizione	Totale/Cap (K-EUR)
consumo	Componenti HW per calcolo e storage.	1
interno	Incontri con altri membri della collaborazione e partecipazione a workshop della collaborazione	2
inventario	Computer portatile Mac per installare matRadiomics (SW sviluppato dal gruppo) e realizzare analisi di radiomica e ML su dati PET in collaborazione con i medici (si veda offerta allegata).	3.5
Totale		6.5

ASTERIX (Accelerating STructures made of multiplE sectoRs In X-Band)

Responsabile Nazionale (L. Faillace, LNF), Resp. Locale LNS (Giuseppe Torrisi)

3 anni (2025-2027)

Units: LNF, LNS, Roma1

Obiettivi generali

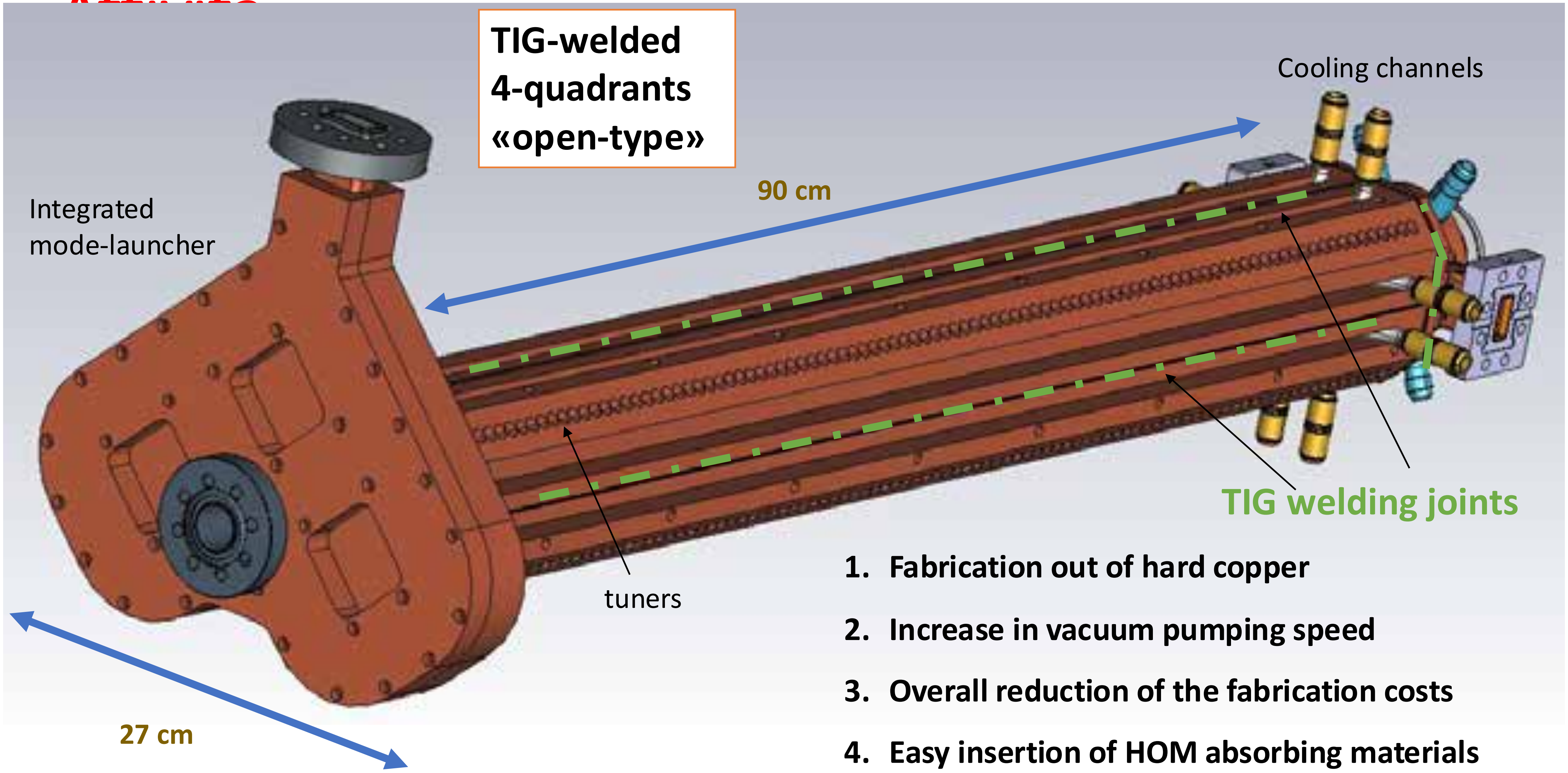
The ***Accelerating gradient*** is the key parameter
for the design, construction and cost of future linear accelerators

Linacs must be **reliable** and **cost-effective**

- Intense and systematic research (SLAC/INFN/KEK/CERN/Tsinghua Uni) on high-gradient accelerating RF structures started with the investment for the construction of normal-conducting linear colliders, new generation X-FELs, etc.

- In order to be feasible the design of linear colliders posed a minimum value on the accelerating gradient → **100 MV/m**.

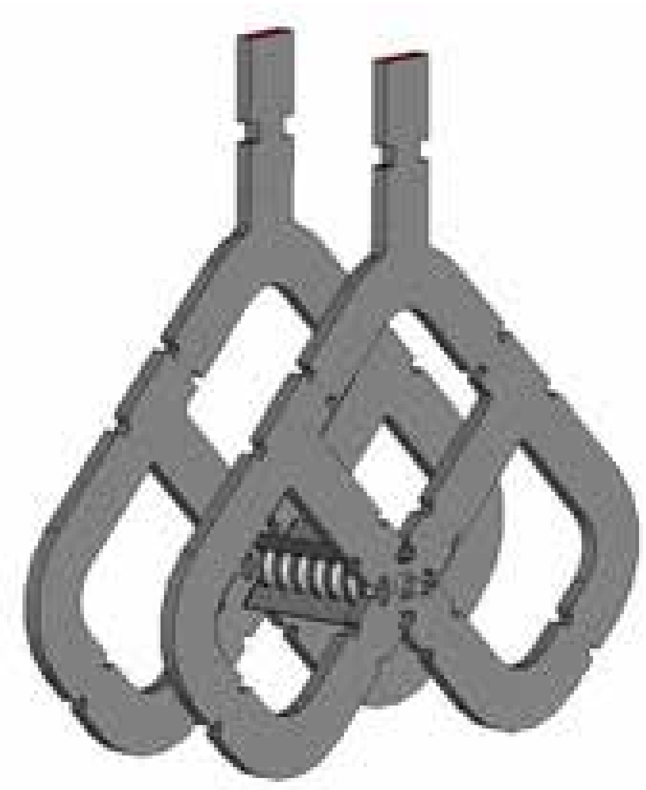
Full TW multi-cell X-band structure

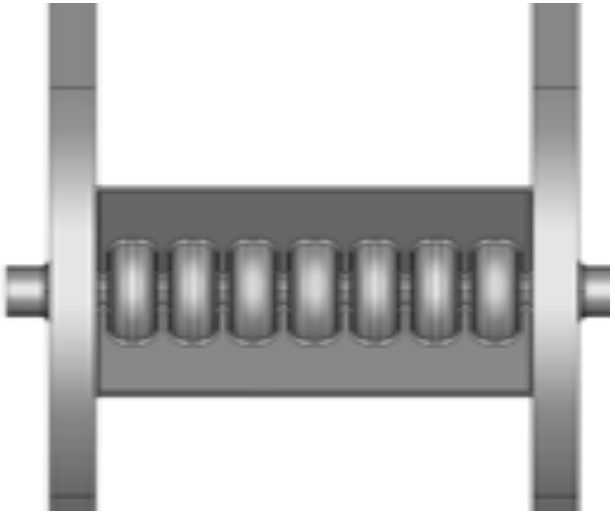


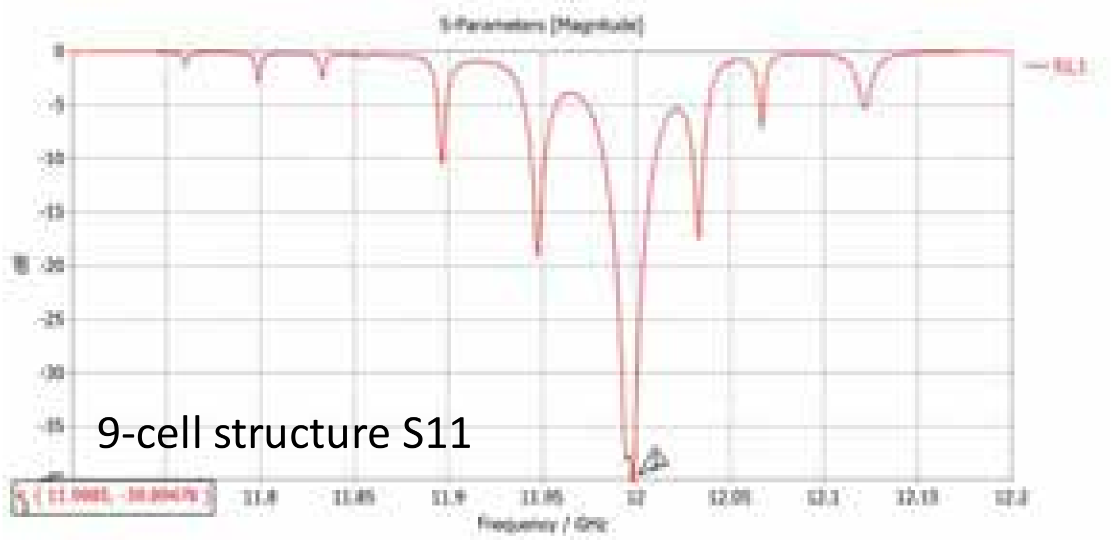
1. **Fabrication out of hard copper**
2. **Increase in vacuum pumping speed**
3. **Overall reduction of the fabrication costs**
4. **Easy insertion of HOM absorbing materials**

Struct + S11(9 cells only)

- TW accelerating structure working in the TM01-$\frac{2}{3}\pi$ mode.
- Full structure will be composed of 120 cells.







9-cell structure S11

G.S. Mauro courtesy

Budget ed FTE

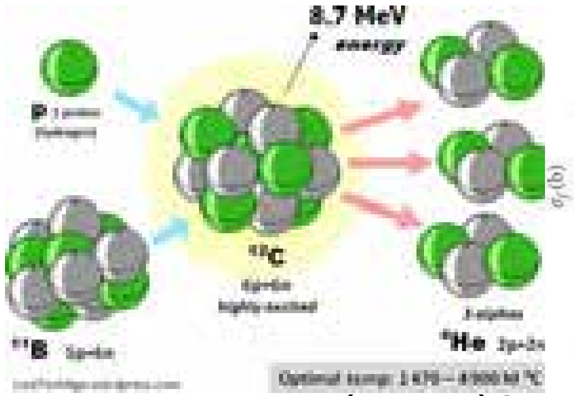
Year		Cost	Notes
2	Software-CST	**€ 16,000.00**	simulazioni coupler
	Missions	**€ 4,000,00**	Partecipazioni misure sui primo prototipi sia a bassa @ COMEB che alta potenza RF a TEX (LNF)
TOT		**€ 20,000.00**	

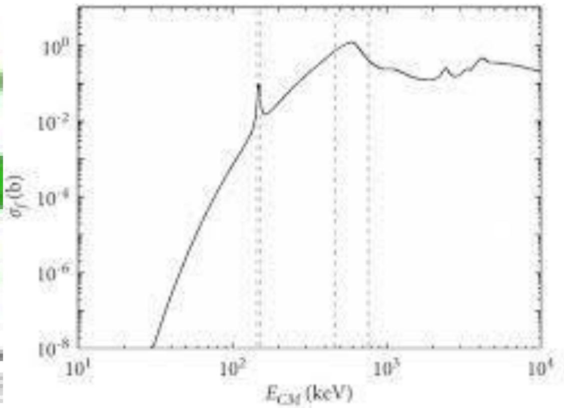
LNS	**FTE**
G. Torrisi (RL)	10
D. Mascali	5
G. Mauro	10
G. Sorbello	20
D. Rifuggiato	10

FUSION

FUsion StudIes of prOton boron neutron-less reaction in laser-generated plasma

National: G A Pablo Cirrone (INFN-LNS) and Fabrizio Consoli (ENEA)

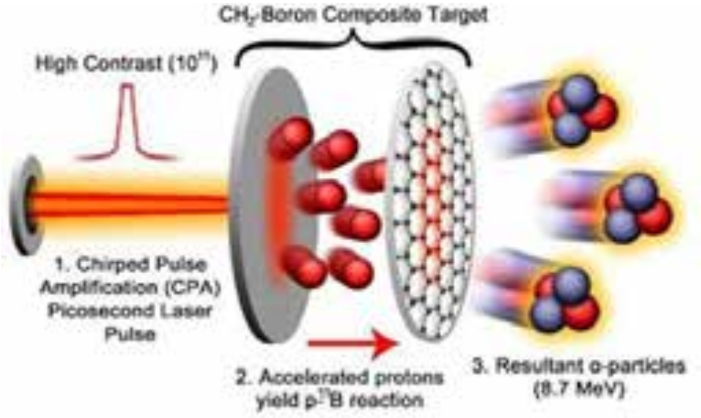




P(11B, a)2a

Two working packages

WP1: study of the p(11B,a)2a reaction in a pitcher-catcher configuration



Basic understanding of fusion mechanism in plasma

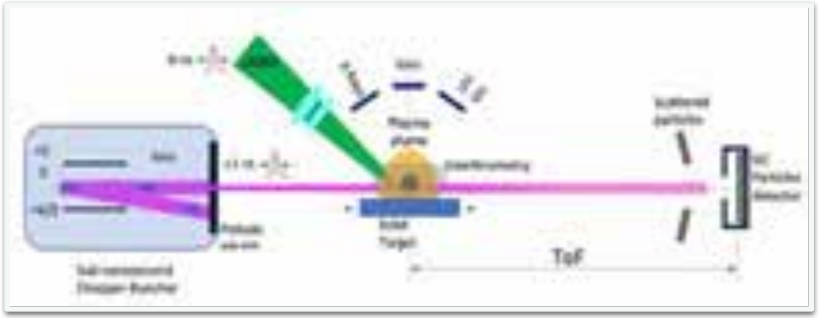
Realisation of new targets for the p11B reaction improvement

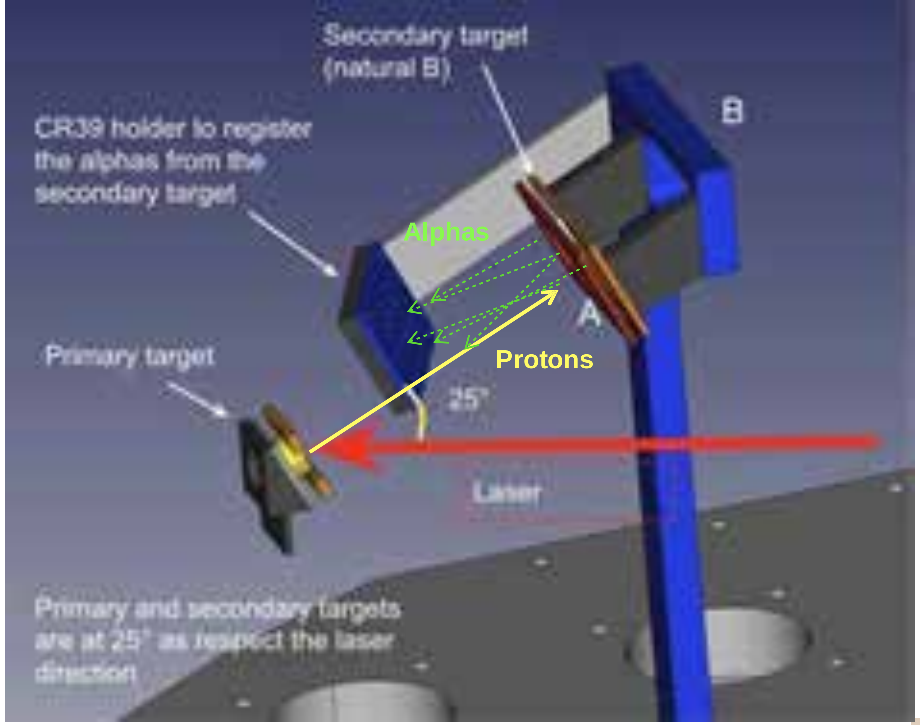
Development of new diagnostics

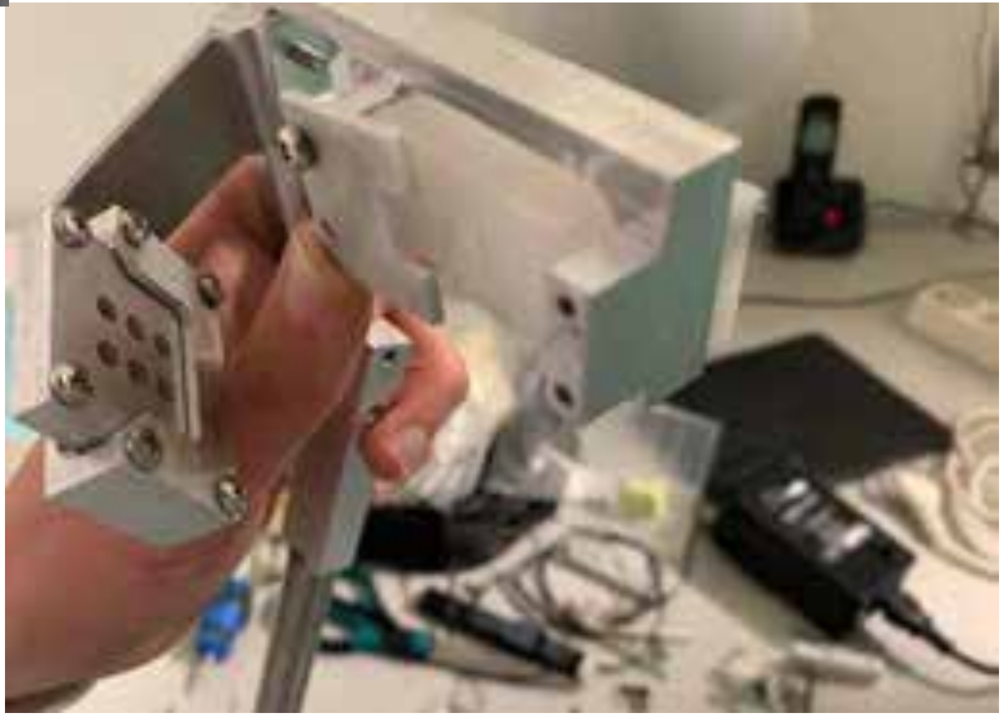
Maximisation of the alpha yields in plasma

Ion stopping power measurements in plasma and development of new computational approach

WP2: stopping power measurement of protons/helium beams in a borated plasma



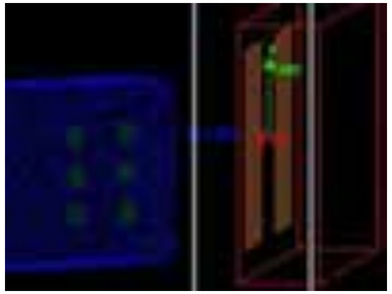

Secondary target
(natural B)
B
CR39 holder to register
the alphas from the
secondary target
Alphas
A
Protons
Primary target
25°
Laser
Primary and secondary targets
are at 25° as respect the laser
direction

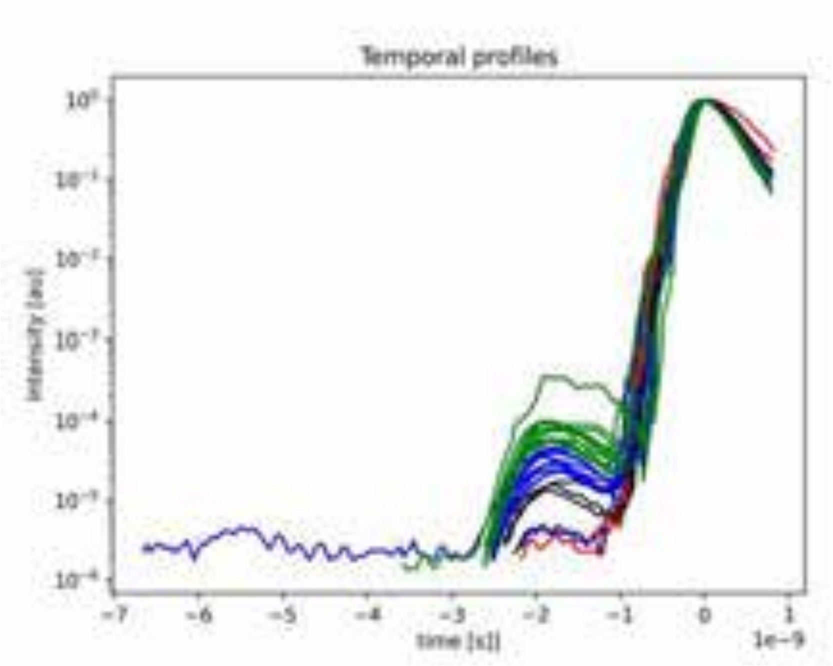


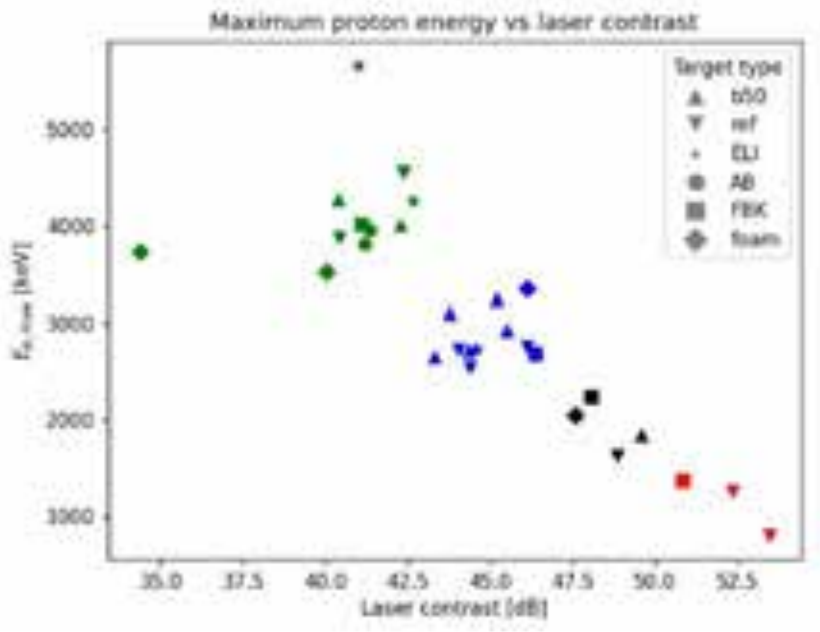
Analysis is ongoing and publications already carried out

- Highest proton energy ever observed at PALS and proton fluxes able to activate the secondary B target p(10B,a)7Be
- Activation measure will give us the measure of the alpha produced in the catcher

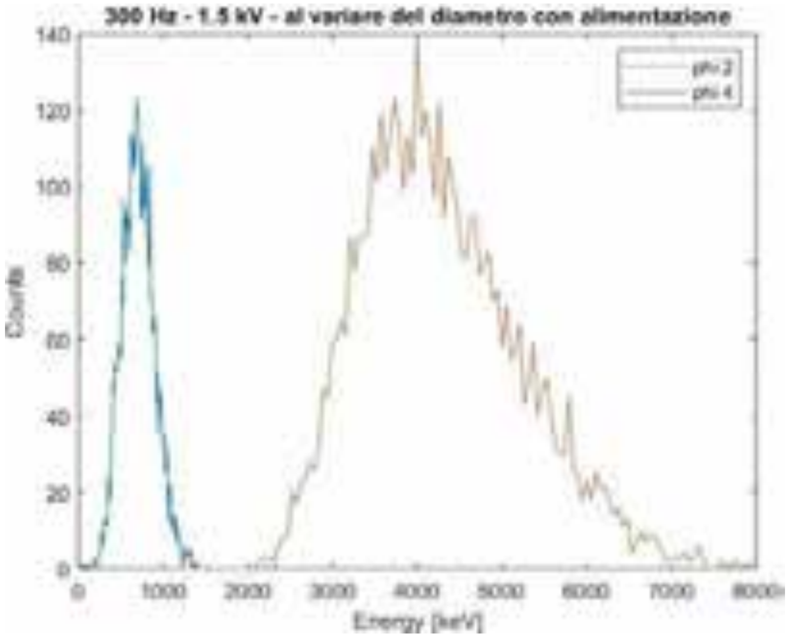
Geant4 simulation of the proton-B interaction







WP 2



Test del Chopper presso il Singletron (DFA-UniCT) con Fascio di Protoni da 1MeV

Spettro di energia (raccolta tramite rivelatore SiC da 10 µm di spessore) durante ogni switch del chopper per due diverse aperture delle slitte

Lug-Dic 2025: test presso il Labec (Firenze) per ottimizzare i settaggi del chopper

2026: Istallazione dell'apparato sperimentale completo al Singletron di Catania (accoppiamento con il sistema di movimentazione, Fascio Laser e sistemi diagnostici) Prime miisurazioni di stopping power in plasma.

Next activities and notes

Experimental test just approved from November 24 to December 19th at the PALS facility (Prague, CZ)

New targets in preparation

Analysis and publications along 2025

WP2 tests in Catania

Next activities and notes on one year extension

COST action PROBONO active until end of 2026

The COST action on Inertial Fusion we proposed (Pablo PI) was rejected but we will retry as HiPER+ consortium

We won three proposals to participate in experiments at ELI on the field of proton fusion for the 2026/2028 years

EUROfusion

Call Details

Reference No.	CfP-FSD-AWP26-ENR-03		Denis Kalupin
Due Date	26/06/2025	Department	Fusion Science Department
		Status	Draft

Call for Enabling Research Proposals in the area of Inertial Fusion Energy (EnR-IFE) for the period of 2026-2027

2 PhD

Richieste ed FTE 2026

Consumabili	2.0
Impianti	0
Attrezzature	0
Altre spese	0
Missioni	2.0
Transport	0

Cirrone	10
Giardina	20
Giuffrida	50
Guarrera	50
Kurmanova	20
Lanzalone	10
Margarone	50
Fiori	100

Geant4INFN

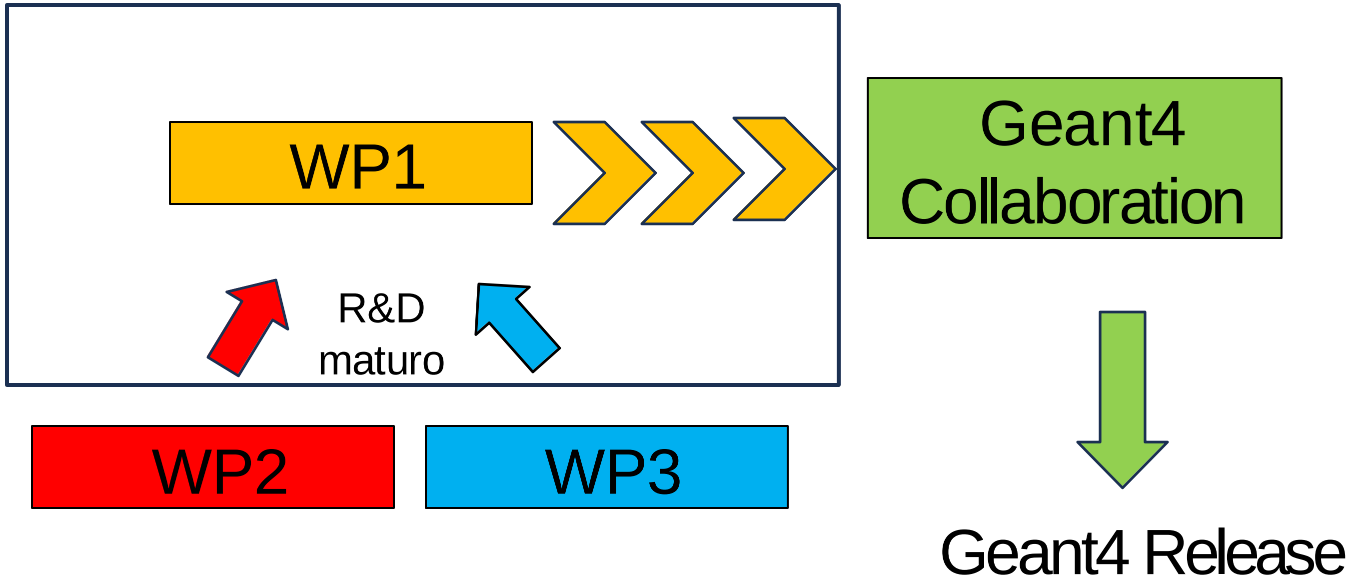
Luciano Pandola (Resp Nazionale)
G.A. Pablo Cirrone (Resp Locale)

Introduzione e contesto

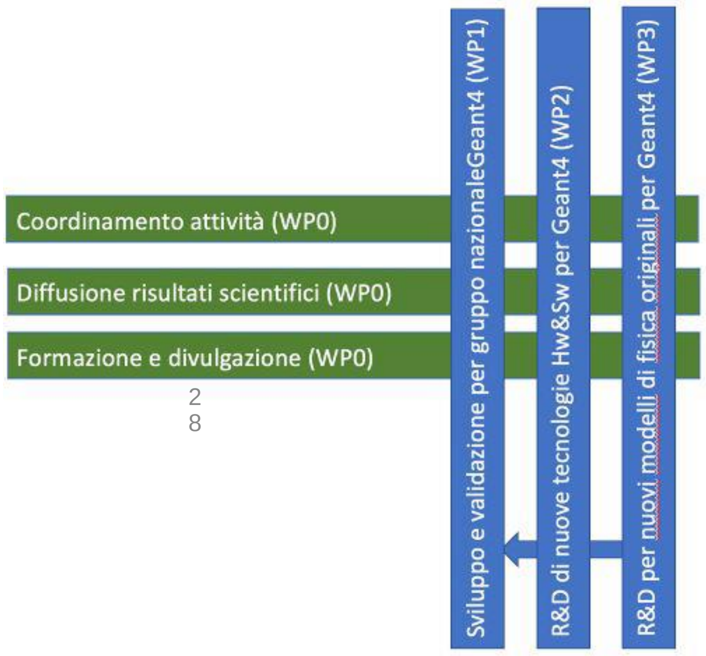
- **Sigla** che ha sostituito **MC-INFN** (in CSN5 dal 2011)
- Progetto **triennale,** approvato **2024-2026**
  - Sezioni Partecipanti: CT, FE, LNS, PV, PG, RM
- Obiettivi Generali:
  - *In primis*, **valorizzare** il contributo dell'Ente alla Collaborazione **Geant4**
  - Manutenzione, **sviluppo**, **validazione** e release del codice di simulazione Monte Carlo Geant4
    - Ci sono sia modelli fisici che *examples* in carico ai vari gruppi INFN
  - **(R&D)** Sviluppo a medio termine di **nuovi modelli originali**, che possano – in prospettiva – essere rilasciati con Geant4
    - Sviluppo e prototipizzazione di tecnologie Deep Learning per l'emulazione di simulazioni MC
    - Sviluppo e validazione modelli di fisica originali, soprattutto nel campo medico e di *examples* a supporto
      - Geant4DNA, modelli radiobiologici, dosimetria (+ campagne di misure dedicate per la validazione)

Organizzazione del progetto e workflow

- Un WP funge da **diretta interfaccia** con la Collaborazione Internazionale
  - Sviluppi "*release-ready*"
- Altri due WP lavorano a **medio termine**



- Previste attività **condivise** di coordinamento, disseminazione, formazione e divulgazione



Attività 2026 (LNS)

- Il gruppo LNS partecipa a **tutti i WP**
  - Responsabilità: L. Pandola (RespNaz), G. Petringa (coordinatore WP0)
- **Coordinamento**:
  - Setup degli strumenti di condivisione
  - Una Scuola di Geant4 (sede da definire) → **trazione LNS**
  - Scuola del 2025 prevista a Catania (Ottobre 2025)
- **Release Geant4** e **manutenzione** delle parti esistenti
  - Parti di kernel ed esempi sotto la responsabilità LNS
- Sviluppi con **Machine Learning**
  - Emulazione di una simulazione MC multiscala con algoritmi ML generativi
- Sviluppi di **nuovi modelli**
  - Geant4DNA: Creazione di nuove geometrie cellulari da confrontare con dati radiobiologici
  - Microdosimetria: modellizzazione in Geant4 del microdosimetro SiC per fasci di neutroni termici adottati in configurazione clinica (BNCT)

Budget & FTE

- Unicamente **MIS**
- **13k** complessivi (da confermare)
  - 2k (WP0): Meeting annuale del gruppo Geant4INFN e mobilità RespNaz
  - 10k (WP1): Partecipazione al Geant4 Collaboration Meeting per presentare le attività svolte nell'ambito del progetto per la nuova release (5 persone x 2 k€)
  - 1k (WP2): Collaborazione e attività a Roma 1 settimana-uomo (Deep Learning)
- Richiesta I anno 14 k€, di cui assegnati 11 k€
- Richiesta II anno 16 k€, di cui assegnati 6+5SJ k€

Ricercatori: 18 (6.64 FTE) - **Tecnologi:** 7 (2.1 FTE)

Impatto su divisioni e servizi LNS, eventuali necessità di spazi

- Supporto da parte del **Servizio Calcolo** e Tecnologie Informatiche
- Nessuna necessità di spazi

Sigla: MIRO (Minibeam Radiotherapy)

Durata proposta: 3 years

Area di ricerca: Interdisciplinare

Responsabili nazionali: Fabio Di Martino (PI), Francesco Romano (CT)

Unità partecipanti: CT, LNS, PI, RM1, TIFPA, TO

WP3 CATANIA (LNS)					
Cost category	**Item**	**I YEAR**	**II YEAR**	**III YEAR**	**Totale**
Consumables	Reagents for inflammatory cytokines study and Luminex assay			7.500,00 €	7.500,00 €
Travels	travel for in-vitro experimental activities at CPFR in PISA with the minibeam	2.500,00 €	2.500,00 €	2.500,00 €	7.500,00 €

T3.1 In Vitro characterization of the overall response to minibeam RT

Task 3.1 focuses on spatially integrated observation of different radiobiological endpoints to elucidate the overall minibeam RT effects on in vitro systems as a function of the average irradiation equivalent dose. The different irradiation conditions and the possible differential effects on different cell lines will be tested.

T3.2 *In vitro* characterization of the local response to minibeam RT

In Task 3.2 a multiscale approach will characterize the pattern-dependent effects both at the cellular and subcellular level. Spatially resolved measurements and advanced fluorescence imaging will locally correlate the cellular position with respect to the irradiation pattern and a quantitative evaluation of molecular determinants associated to cellular damage, repair and functions will be performed.

Task	Deliverable	Description	When	Division
Task 3.1	D 3.1.3	Investigation of minibeam effect in breast tumorigenic and nontumorigenic cells	6-12	LNS, TIFPA
Task 3.2	D 3.2.3	DNA damage high-content analysis induced by minibeam irradiation in breast tumorigenic and non-tumorigenic cells	12-36	LNS, TIFPA

MIRO Working Package 3 (WP3) - Radiobiology

D 3.1.3 Investigation of minibeam effect in breast tumorigenic and non-tumorigenic cells (LNS-TIFPA) (6-12 months) *November 2024*

Now

24-Multiwell

1,5 cm Diameter

Small amount of sample

Pisa, 12th November 2024

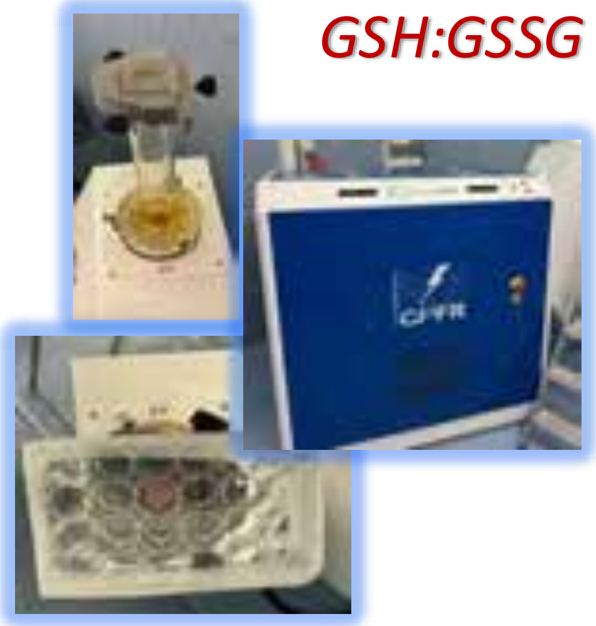
MCF10A Non tumorigenic Breast cell line

MDA-MB-231 Breast cancer cell line

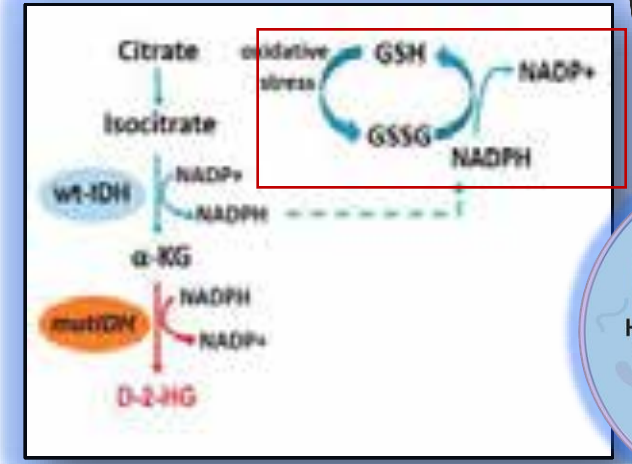
- 9 Gy
- 15 Gy

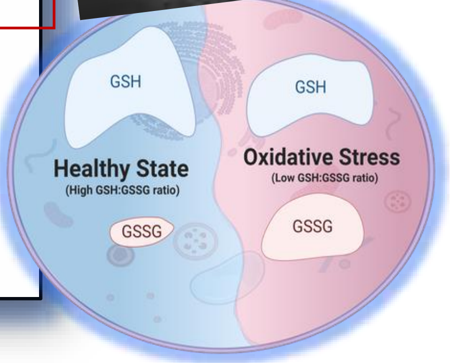
Dose-rate	
Conv	5 Gy/min
Flash	291 Gy/sec
Minibeam-Conv	5,3 Gy/min
Minibeam-Flash	296 Gy/sec

GSH:GSSG ratio quantification as a marker for cellular oxidative stress



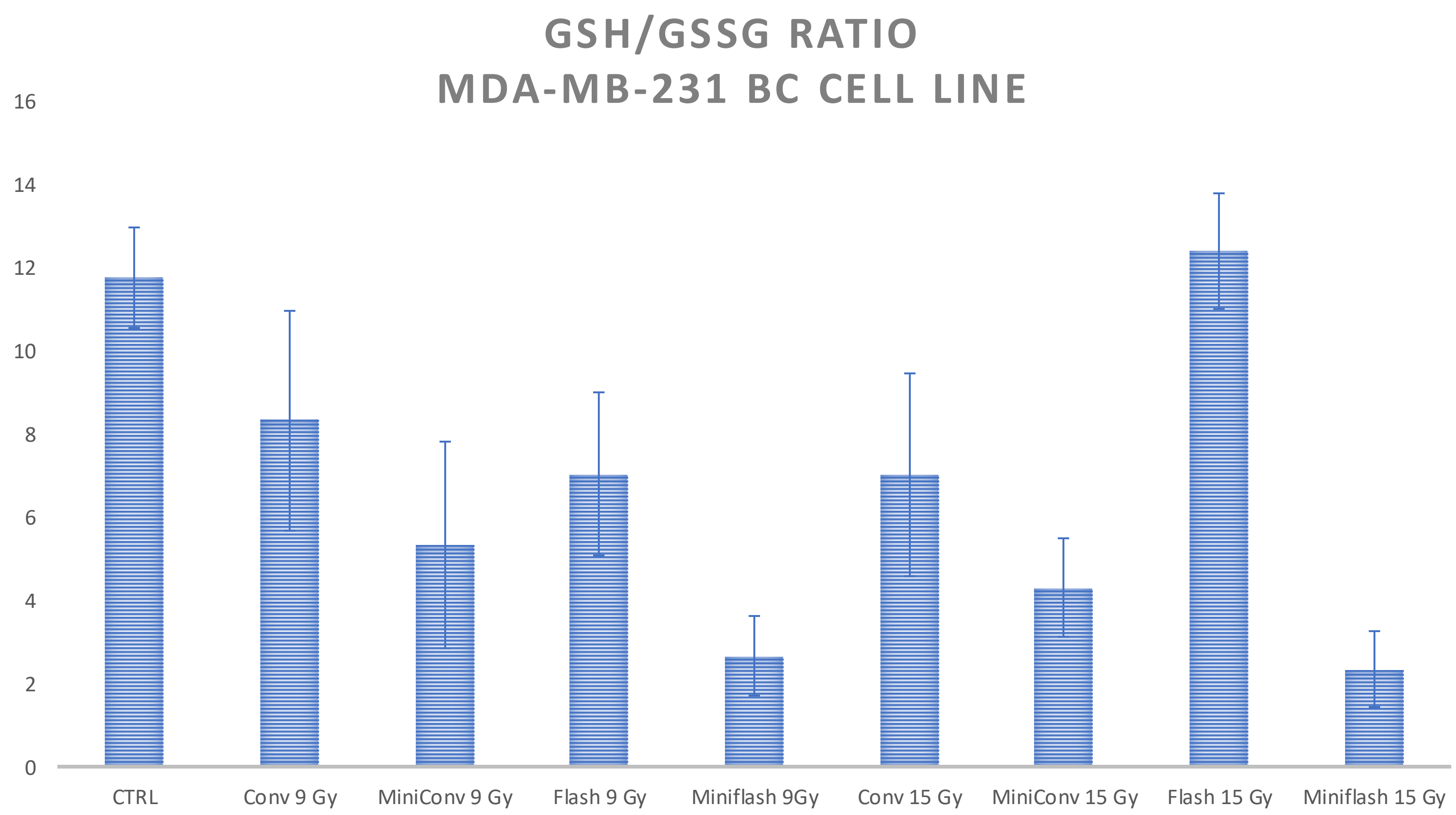
Pellets were collected 24h post RT waiting to be transfered to the Metabolomic laboratory of IBSBC-CNR of Segrate for the GSH/GSSG quantification by LC-QQQ (Liquid Chromatography-Triple Quadrupole Mass Spectrometry).





MIRO Working Package 3 (WP3) - Radiobiology

D 3.1.3 Investigation of minibeam effect in breast tumorigenic and non-tumorigenic cells (LNS-TIFPA) (6-12 months) ***November 2024***



The redox state of glutathione, and therefore the alternation of the oxidized form (**GSSG**) and the reduced form (**GSH**), is a fundamental indicator for defining the redox state of the cell itself.

As shown in the graph, mini-beam irradiation enhances the intracellular oxidative stress, as supported by the decrease in **GSH**/**GSSG** ratio values in all the configurations tested and, notably, it seems not to be strictly linked to the dose (in terms of Gy) as well as to the irradiation beam schedules (conventional or flash) performed.

FTE e BUDGET

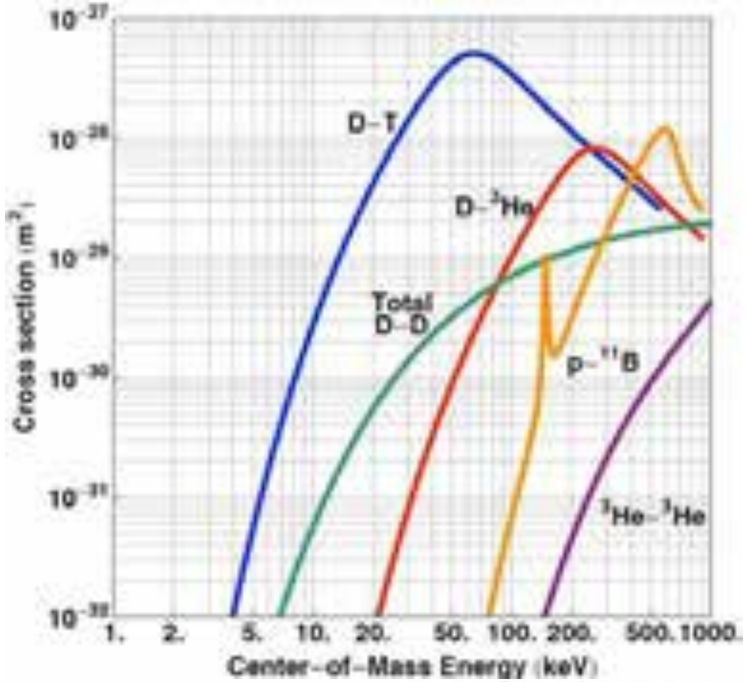
- Giorgio Russo – 0,1
- Giusi Irma Forte – 0,2
- Luigi Minafra – 0,6
- Valentina Bravatà – 1
- Gaia Pucci – 0,5

MIRO -> The request for reagents for inflammatory cytokines and luminex assay is 7,2k€+VAT=8784€.

PLASMA4BEAM2: status

INFN sez. BA, LNL, LNS, MI, MIB; collaboration with RFX, CNR-ISTP, Univ. Padova

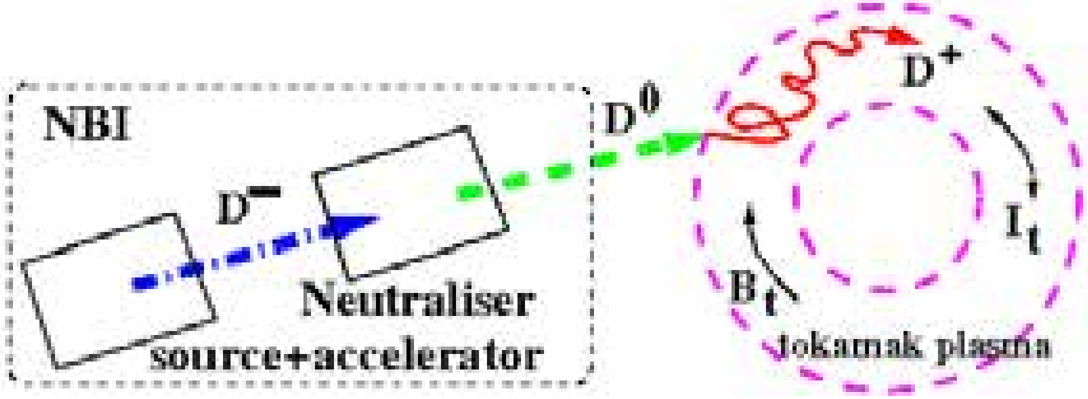
Goal: study of ion, plasma and gas collision physics for transport of beams into collisional media (RFQC cooler), negative ion beams (NIO1) relevant to fusion and photon detectors (GEM) for High Voltage breakdown survey



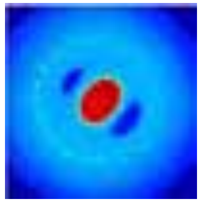
Sedi e responsabili.

Resp. Nazionale	M. Cavenago
LNL	M. Cavenago e A. Ruzzon
MI	M. Rome
MIB	G. Croci
Bari	V. Variale
LNS	G. Castro

Durata: Triennio 2024-2026



2. Workpackage highlights

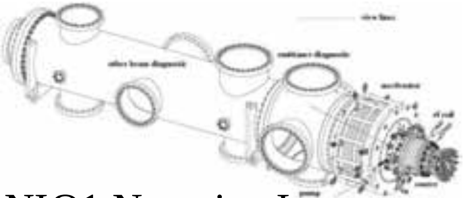


vortici

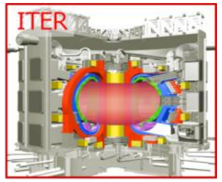
Eltrap

RFQ cooler

WP1: Linear traps of particles (K^+ to Cs^+) interacting with a plasma or a gas (He) as in a RFC cooler. Diagnostic from emittance meter will be integrated with accurate voltage scanning of collector voltages. Feasibility study of other Eltrap-like-machines.



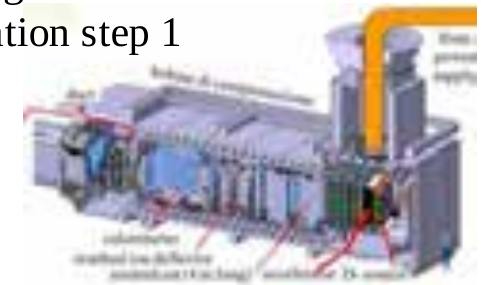
NIO1 Negative Ion Optimization step 1



ITER

1-3 dpa/lifetime

WP2: Production of H^- in reduced-size models of multi-aperture ion sources relevant to fusion (from NIO1 to MITICA and other ion sources). Cesium dynamics and other H^- catalyst . Collaboration to development of proton sources, to easily test equipment and diagnostics of interest also for H^- sources



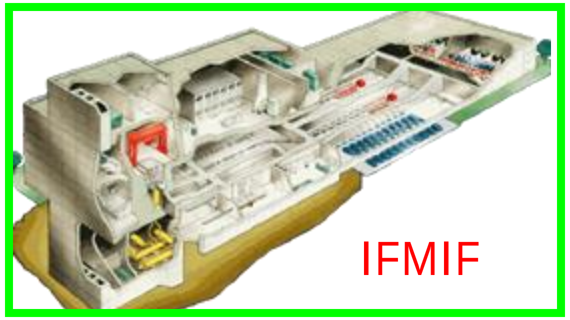
MITICA

WP3: a) development of diagnostics based on GEMs and scintillators to investigate the origin of vacuum discharges between two high voltage electrodes for the development of the compact accelerator for MITICA (NBI of ITER), using HV facilities at Padua University and Consorzio RFX;

b) Development of fast neutron GEM detectors for SPIDER and MITICA;

c) Support to the study of regenerative cascades of secondary particles (ping-pong) especially in cesiated electrode conditions.

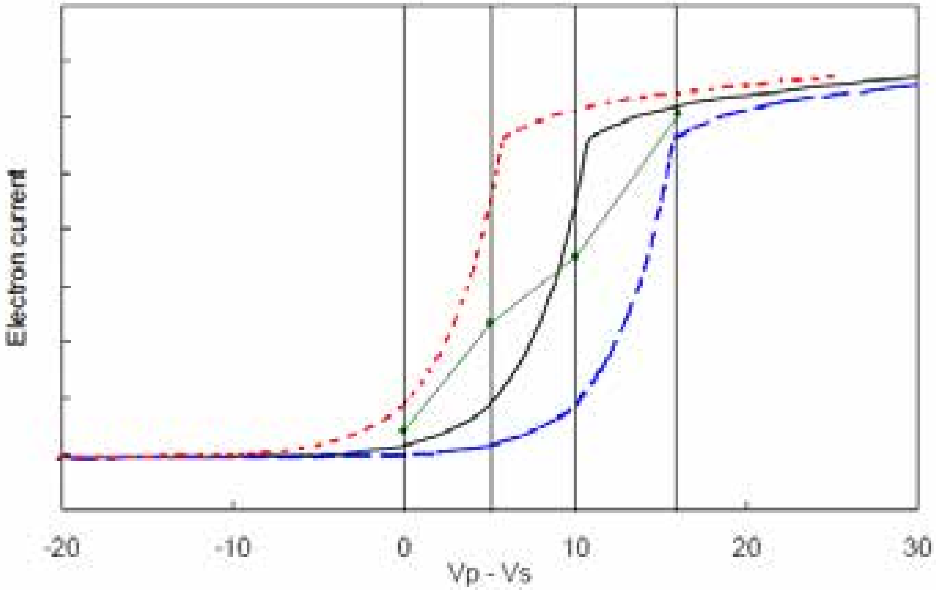
WP4: Theoretical and computational aspects relevant to the previous subprojects. For example, calculation of trajectories of WP1 and WP2, shows for some WP3 electrode geometries the formation of fixed points of the impact positions. Statistical effects or collisions are included with Fokker-Planck or Langevin equations.



LNS contribution in WP2/WP4

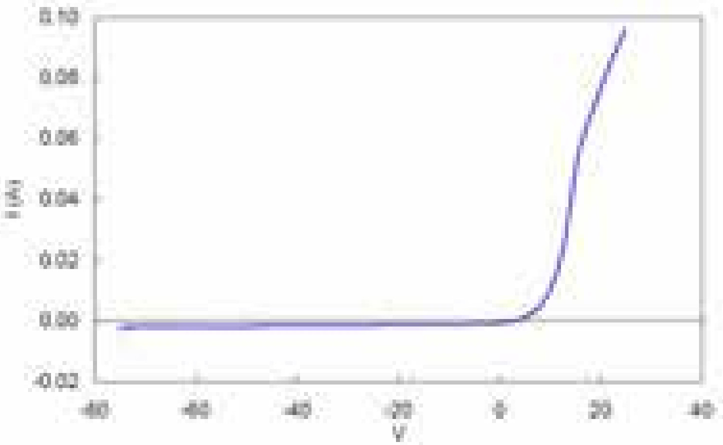
LNS is contributing to the Langmuir Probe Diagnostics of a RF ion source on the MetAlice test-bench.
LP is an invasive diagnostics to measure plasma parameters: electron density, temperature and plasma potential

Langmuir Probe on the MetAlice test-bench LNL(LNS + RFX)

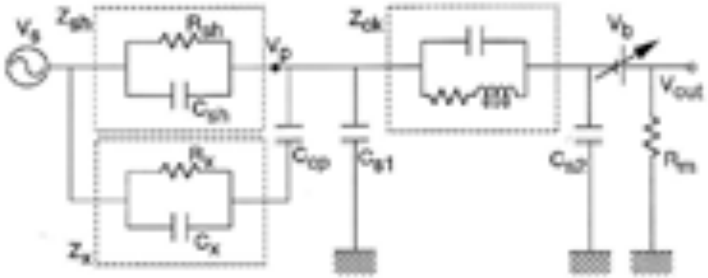


The center curve is the correct *I - V* curve. The dashed ones are displaced by ±5V, representing changes in *V*s. The green dotted line is the time-averaged *I - V* curve that would be observed, differing greatly from the correct curve.

MetAlice test-bench
Concept for multiple frequency matching box



A typical LP measurement



Circuit diagram of a probe-plasma system with rf compensation.

FTE, Budget, Impatto e output potenziale

FTE

LNS	FTE
Giuseppe Castro	0.40
Leonardi Ornella	0.10
Celona Luigi	0.05
D'Agostino Grazia	0.20
Parisi Mattia	0.50
Totale	**1.25**

Impatto su divisioni e servizi LNS

Si richiede supporto Divisione Ricerca/Servizio Sviluppo Apparati Sperimentali (Antonio Caruso per Compensazione RF diagnostica LP).

BUDGET

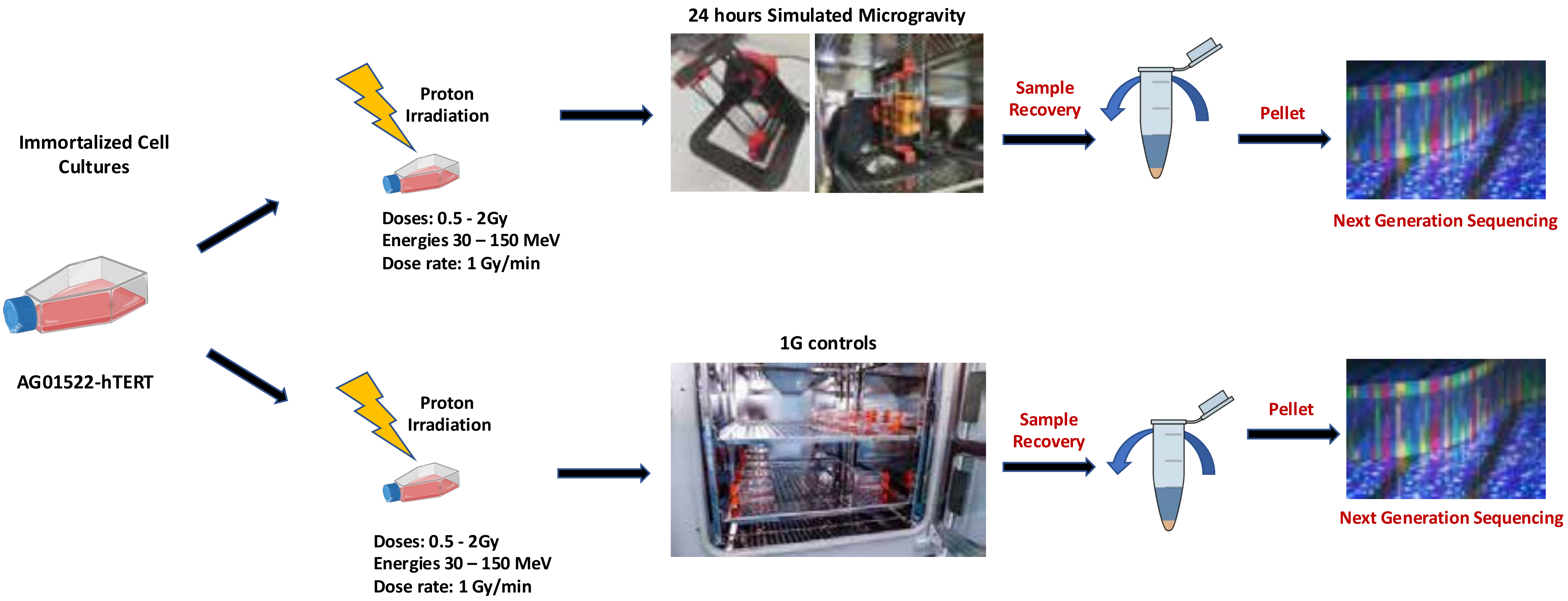
- **Missioni: 2 k€+ 2 SJ** (Misure LP presso Test-bench LNL) – 2 settimane missione x 2 persone: 1 settimana per preparazione esperimento. – 1 settimana per esperimento
- **Consumo: 2 k€** (Metabolismo di consumo)
- **Contributo a Licenze Nazionali** (Comsol – opera, etc.): **4 k€** (da caricare su apposito sito per richieste calcolo).
- **Tot: 8 k€ + 2 SJ**

Potenziale output scientifico (LNS)

- **Pubblicazioni:** ~ 3 articoli su riviste internazionali previste nei prossimi 18 mesi (uno già sottomesso)
- **Talk/contributi a conferenza**: ~ 3 nei prossimi 18 mesi (un contributo già sottomesso ad ICIS)

“**Sp**ace **R**adiation **I**nduced **T**umorigenesis by high **Z** particles: modeling and experimental studies” - SPRITZ

The Campaign of Measurements @ APSS (protons) and CNAO (^{4}He, ^{12}C)



FTE

- Marco Calvaruso – 1
- Giorgio Russo – 0,1
- Luigi Minafra – 0,4
- Gaia Pucci – 0,5

SPRITZ 2k€ missioni

GRV LNS *Preventivi per il 2026*

Nuove Proposte con Responsabili Locali (RL) LNS

- ***GIOTTO***

Giuseppe Torrisi (Resp. Locale), A. Bacci (Resp. Nazionale, INFN-MI)

- **HEARTBEAT**

Pablo Cirrone (Resp. Locale), Lorenzo Manti (Resp. Nazionale, INFN-NA)

- **DIAMIRA**

Pablo Cirrone ((Resp. Locale), C. Verona (Resp. Nazionale, INFN-RM2)

- ***ISOLPHARM APEX***

Giorgio Russo (Resp. Locale)

- ***VAPORADA***

Mario Scuderi (Resp. Locale)

- **MULTI-GRAPH (Call)**

Manuela Cavallaro (Resp. Locale), Daniela Calvo (Res. Nazionale, INFN-TO)

HEARTBEAT

Hadrontherapy with helium and protons as advanced radiotherapy treatment for breast tumors

Responsabile Nazionale: Lorenzo Manti (Uni Caserta)

Responsabile Locale: G.A. Pablo Cirrone

Obiettivi generali

Il progetto HEARTBEAT si propone di valutare nuove strategie di radioterapia avanzata per il trattamento del tumore al seno (Breast Cancer), con particolare attenzione alla riduzione della tossicità cardiaca e al miglioramento dell'efficacia locale, soprattutto nei casi più aggressivi o metastatici.

In particolare, il progetto mira a:

- Confrontare la protonterapia (PT) e l'hadronterapia con ioni di elio (4He) per verificare quale delle due sia più adatta nel trattamento del BC, in termini di controllo del tumore e risparmio del tessuto cardiaco.
- **Studiare la risposta biologica:**
  - Valutando la radioresistenza di due linee cellulari di BC (MCF-7 e MDA-MB-231) e l'effetto di nuovi farmaci anti-metastatici combinati con i fasci ionici.
  - Analizzando cellule endoteliali cardiache umane (HMVEC-C) per misurare stress ossidativo e infiammazione.
  - Esaminando cellule epiteliali mammarie sane (MCF10A) per stimare il rischio di tumori secondari.
- **Implementare modelli biofisici** per prevedere la risposta dei tessuti sani e parametrare gli effetti radiobiologici rilevanti dal punto di vista clinico.
- **Svolgere misure microdosimetriche** per caratterizzare la deposizione di energia su scala subcellulare e correlare parametri fisici e biologici

Attività

Microdosimetry
(LNL, RM2, LNS)

Obiettivo: caratterizzare la deposizione di energia su scala subcellulare per correlare i parametri fisici agli effetti biologici.

Rivelatori impiegati:

- **Mini-TEPC** (LNL): misura di $\bar{y}$ (lineal energy) in gas tessuto-equivalente.
- **Rivelatore a diamante** (Tor Vergata): alta risoluzione e risposta in tempo reale.
- **Rivelatore al silicio** (LNS): misura precisa dell'LET.

Finalità: correlare LETd e spettri microdosimetrici a morte cellulare, stress ossidativo, infiammazione

Biology
(RM3, NA)

1. Linee cellulari tumorali
- **Cellule usate**: MCF-7 (meno aggressiva) e MDA-MB-231 (più aggressiva).
- **Esperimenti**:
  - Curve clonogeniche di sopravvivenza.
  - Trattamenti combinati con nuovi farmaci anti-metastatici.
  - Assaggi di migrazione cellulare (Boyden chamber).

2. Cellule sane
- **MCF10A**: epiteliali mammarie non tumorali → per valutare rischi di secondi tumori.
- **HMVEC-C**: endoteliali microvascolari cardiache → per analizzare:
  - **Stress ossidativo**
  - **Infiammazione**
  - **DSB (γH2AX e 53BP1)**

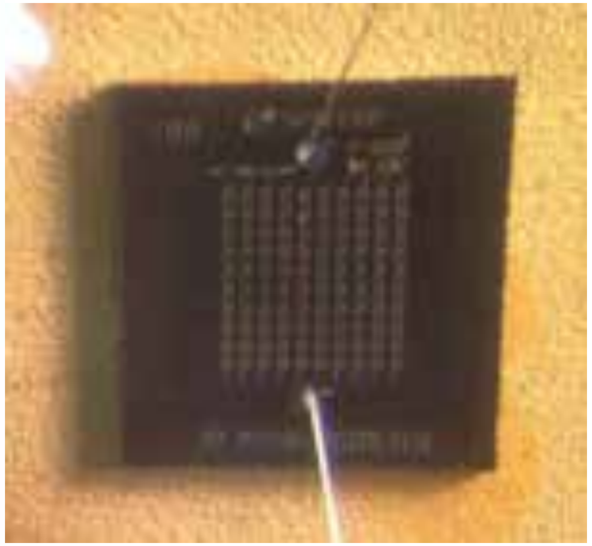
3. mFISH (RM3)
- **Analisi aberrazioni cromosomiche** (CA): complessi, semplici, F-ratio, C-ratio.
- **Cellule MRC-5 normali** usate per analisi citogenetica di alta qualità.
- **Dosi previste**: 2 e 4 Gy all'entrata della SOBP.

Simulations
(RM3, PV, LNS)

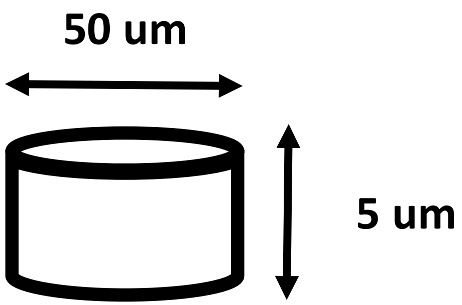
1. Modello BIANCA (PV)
- **Simula**:
  - Sopravvivenza cellulare in MCF7 e MDA.
  - CA in cellule MCF10A.
- **Input necessari**:
  - Risposta a fotoni delle linee cellulari.
  - LET medio per ciascuna posizione.
- **Confronti previsti**:
  - Con esperimenti.
  - Con modello MKM (RM3/LNS).

2. MKM + Survival (RM3, LNS)
- Basato su Monte Carlo (Geant4, PHITS).
- Simula dose/LET, secondari, CA e sopravvivenza.
- Ottimizza i parametri modellistici con dati sperimentali.
- Effettua simulazioni pre-esperimento per scelta geometrie e posizionamenti.

Attività (LNS) - Microdosimetry

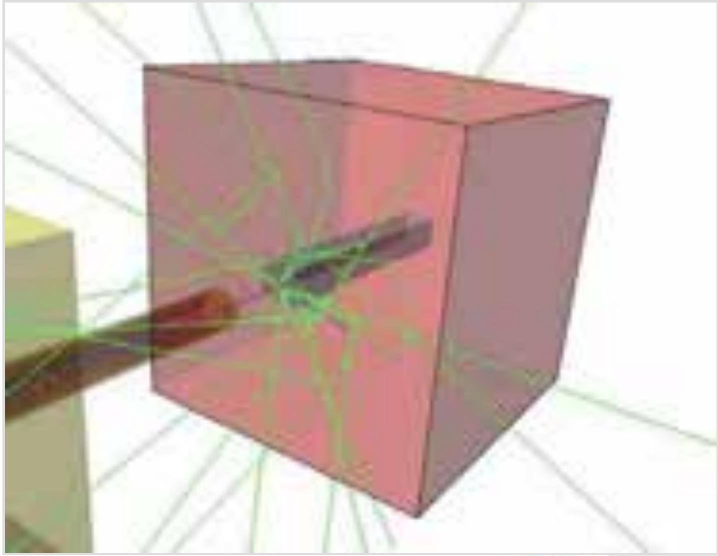


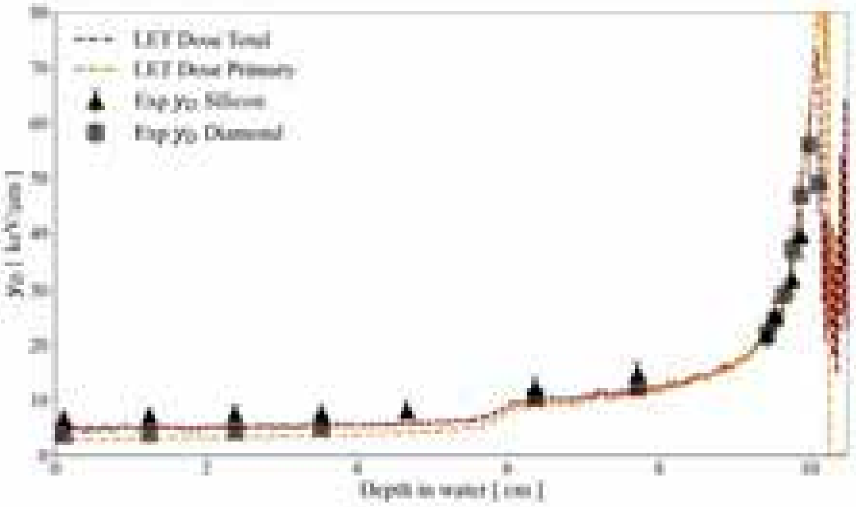
- **LNS metterà a disposizione il rivelatore MicroPlus probe al Silicio (sviluppato da UOW e acquistato nell’ambito del progetto NEPTUNE)**
- **verranno caratterizzati microdosimetricamente i fasci di protoni ed 4He utilizzando un rivelatore spesso 5um (finora mai testato)**
- **gli spettri microdosimetrici acquisiti saranno fondamentali per la ricostruzione del LET nelle due condizioni di irraggiamento**



Array di rivelatori cilindrici aventi pitch pari 50 um

Attività (LNS) - Simulations





- Il ruolo di LNS sarà quello di simulare la condizione sperimentale di irraggiamento che verrà adottata a CNAO. In particolare verrà stimata la distribuzione di dose e LET adottando codici Monte Carlo (Geant4) già sviluppati e validati in quest’ambito
- Tale attività sarà propedeutica al fine di adottare le corrette condizioni di irraggiamento cosicchè da poter confrontare il danno biologico nelle due condizioni
- Verranno inoltre estratte le distribuzioni di particelle secondarie prodotte dal fascio primario cosicchè da poterle confrontare con gli spettri microdosimetrici e la risposta biologica

Potenziale output scientifico

HEARTBEAT si inserisce nel contesto dell'oncologia di precisione per affrontare l'obiettivo di **massimizzare l'efficacia antitumorale** e **minimizzare gli effetti collaterali cardiaci**, colmando un'importante lacuna conoscitiva nella radioterapia del tumore al seno

Alto Impatto scientifico e sociale

===> Inoltre questo sarebbe uno dei primi esperimenti svolti a CNAO con fasci di He

Budget & FTE

2.5 FTE (posizione delle persone PNRR attualmente da definire)

	2026
Consumo	2k€ (per acquisto di film radiocromici)
Missioni	5k€ (per due turni sperimentali a CNAO di due persone)
TOTALE	7k€

DIAMIRA

DIamond-based Array for MIcrodosimetric Radiation Analysis

Responsabile Nazionale: Claudio Verona (Uni Tor Vergata)

Responsabile Locale: G.A. Pablo Cirrone

Obiettivi generali

Il progetto DIAMIRA si propone di realizzare un sistema microdosimetrico innovativo, basato su pixel di diamante sintetico con lettura individuale, per caratterizzare con elevata risoluzione spaziale i fasci clinici di protoni e ioni carbonio, migliorando la qualità, la sicurezza e l'efficacia della terapia adronica.

1. **Sviluppo di microdosimetri a pixel in diamante sintetico**
   con volumi sensibili 3D micrometrici e lettura individuale.
2. **Mappatura spaziale del LET e dell'energia lineare (y)**
   in fasci clinici di protoni e ioni carbonio (PBS e minibeam).
3. **Realizzazione di un sistema di acquisizione avanzato**
   basato su FPGA, lettura multicanale e logica di coincidenza.
4. **Validazione sperimentale e clinica**
   presso CNAO, MedAustron e TIFPA, con supporto di simulazioni Monte Carlo.
5. **Supporto a QA clinica e modelli radiobiologici RBE/LET-guided**
   per ottimizzare la sicurezza e l'efficacia della terapia adronica.

Attività

WP1 Design e fabbricazione dei rivelatori

- Realizzazione di array microdosimetrici su diamante sintetico (CVD + litografia)
- Ottimizzazione geometrica dei volumi sensibili (10–100 µm)
- Caratterizzazione elettrica e con microfasci ionici (IBIC)

WP2 Elettronica di lettura e processamento del segnale

- Sviluppo del sistema di acquisizione con FPGA ad alte prestazioni
- Digitalizzazione multicanale (ADC 250 Ms/s, 16-bit)
- Riconoscimento eventi, misura di carica/tempo, gestione delle coincidenze

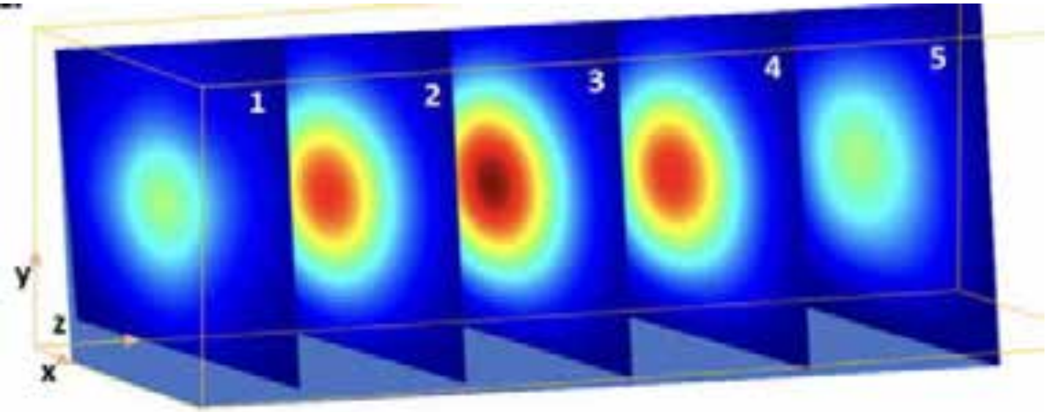
WP3 Simulazioni Monte Carlo

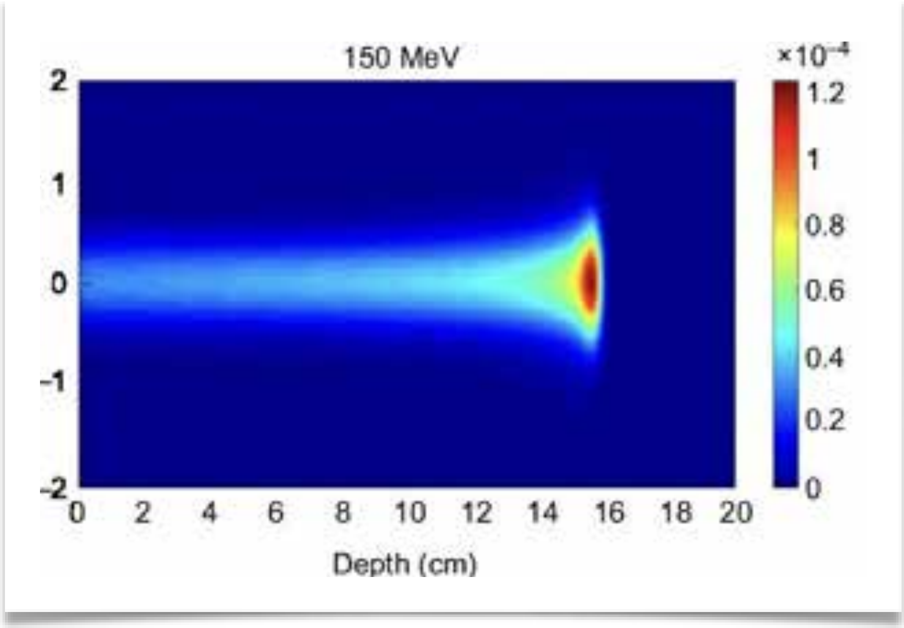
- Ottimizzazione della geometria del rivelatore (pitch, chord length)
- Simulazione di primari e secondari per analisi microdosimetrica
- Ricostruzione di spettri multi-dimensionali tempo/spazio-correlati

WP4 Test Sperimentali

- Validazione in ambienti clinici (CNAO, MedAustron, TIFPA)
- Misure con fasci protonici e carbonio (PBS, minibeam)
- Mappatura LET out-of-field e studio dei frammenti secondari

Attività (LNS) - Simulazioni



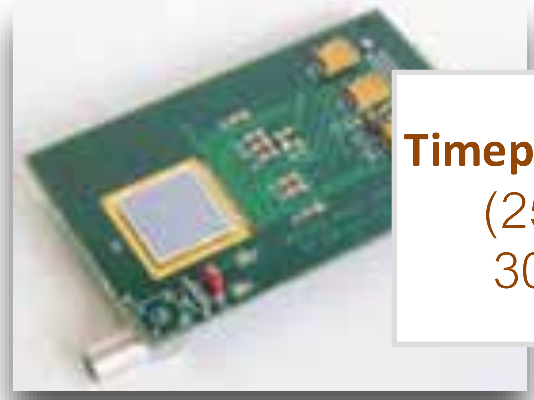


Le simulazioni Monte Carlo saranno impiegate per caratterizzare il campo di radiazione a livello microscopico, includendo sia le particelle primarie che lo spettro delle secondarie prodotte attraverso interazioni nucleari. Questo rappresenta un passaggio fondamentale nella microdosimetria, poiché l'impatto biologico delle radiazioni è fortemente influenzato dalla distribuzione spaziale e dalla natura degli eventi di deposizione di energia. Le simulazioni forniranno informazioni dettagliate su:

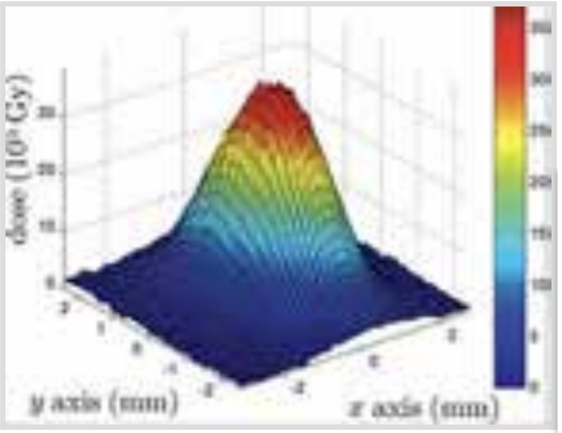
- la distribuzione spaziale ed energetica degli eventi di deposizione di energia,
- l'identità e la struttura delle tracce dei frammenti nucleari,
- la generazione e il trasporto degli elettroni secondari,
- la frequenza e il tipo di interazioni nucleari (es. urti elastici, reazioni anelastiche, frammentazione).

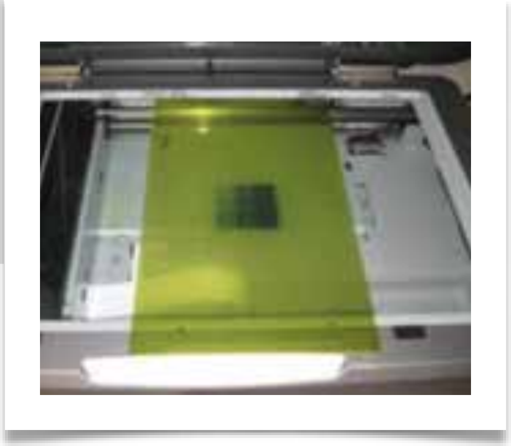
Questa analisi supporterà l'interpretazione dei dati sperimentali e permetterà una comprensione più profonda della risposta del rivelatore, contribuendo alla stima della qualità della radiazione e del potenziale danno biologico. La capacità di mappare la distribuzione spaziale delle particelle primarie e secondarie è essenziale per lo sviluppo di rivelatori microdosimetrici affidabili e per la valutazione del rischio radiobiologico nella adroterapia.

Attività (LNS) - Test Sperimentali



Timepix silicon detector
(256x256 pixels
300x300 mm^2)





Per ottenere informazioni accurate sulla distribuzione laterale della dose, verranno impiegati rivelatori di riferimento dedicati. In particolare, saranno utilizzati un rivelatore pixelato **Timepix-3** e **film radiocromici**, in quanto offrono capacità dosimetriche e risoluzione spaziale complementari.

La combinazione di questi due sistemi garantisce una **validazione incrociata affidabile** e fornisce un riferimento solido per l'interpretazione delle misure microdosimetriche ottenute con l'array di rivelatori in diamante. Questo aspetto è particolarmente importante per valutare i gradienti laterali di dose e il contributo delle particelle secondarie nei fasci clinici di protoni e ioni carbonio.

Budget & FTE

2.5 FTE (posizione delle persone PNRR attualmente da definire)

	2026
Consumo	2k€ (per acquisto di film radiocromici)
Missioni	5k€ (per due turni sperimentali a CNAO/TIFPA/Medaustron di due persone)
TOTALE	7k€

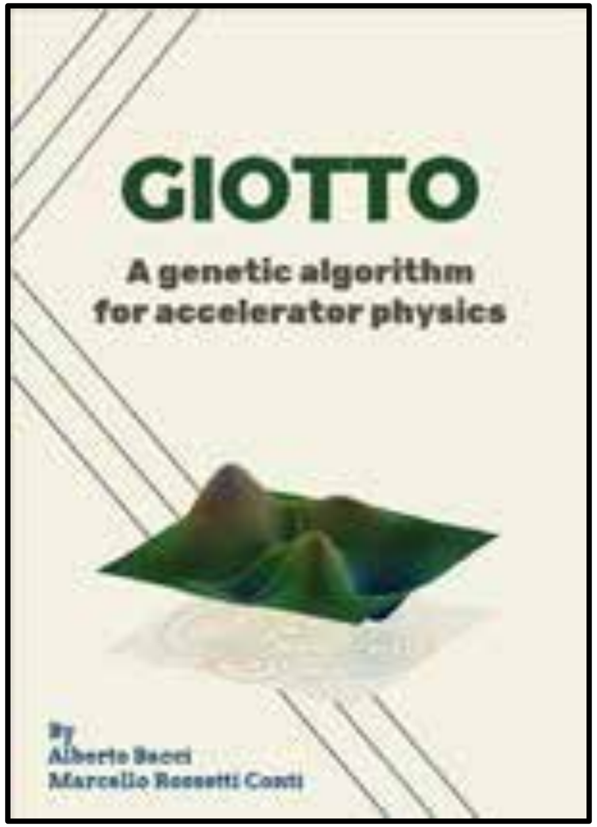
GIOTTO an AI optimizer for accelerators

Genetic Interface for OpTimizing Tracking with Optics

Resp. Nazionale: Alberto Bacci (Sez. Milano)

Participating Sections:

- MILANO
- LNF
- LNS



One of first AI codes for **beam line** design **&** optimization.

Solves complex multi-objective **problems** (correlated parameters, space-charge like) & statistical analysis (machine jitters studies).

Drives the beam dynamics PIC code **ASTRA**. Natively compatible with **NameList** std.

V. 13.0 for **Linux** & **Windows**, parallelized with **MPI**.

Successfully used in important projects**, as:**

Some contributions to publications**:**

- *New approach to space charge dominated beamline design* – PRAB **26** (2023)
- *Two-pass two-way acceleration in a superconducting CW linac to drive low jitter x-ray FEL*–PRAB **22** (2019)
- *Electron beam transfer line design for a plasma driven Free Electron Laser* – NIM A **909** (2019)
- *Electron Linac design to drive bright Compton back-scattering gamma-ray sources* – JAP **133** (2013)

Coming soon:

- *Innovative solutions for high-brightness low-energy ERL injector design: the BriXSinO approach*

GIOTTO proposal main objectives

- Enable chained optimizations **including cavity design tools (e.g., HFSS/ANSYS, CST, SuperFish)**
  main outcomes : DC-gun/DLA matching (iDLA) ; PWFA inj. RF design/BD (Eupraxia); FCC positron capture; etc ...

- Integrate **GIOTTO into accelerator Control Systems** (coming soon application @ SPARC, STAR)
  to achieve, on the machine (or beamline), same performances as predicted by simulations.

- Statistical tools: **the Knobs sensitivity MAP**
  to identify knobs with behaviors hidden by complex correlations

- **GIOTTO as an institutional project within INFN**
  improved usability, broader dissemination, and tangible benefits for accelerator design and operation

INFN involved unities:

- INFN-MI (2 FTE) : RN – Alberto Bacci
- INFN-LNF (1FTE) : RL – Anna Giribono
- INFN-LNS (1FTE) : RL – Giuseppe Torrisi

Budget allocation

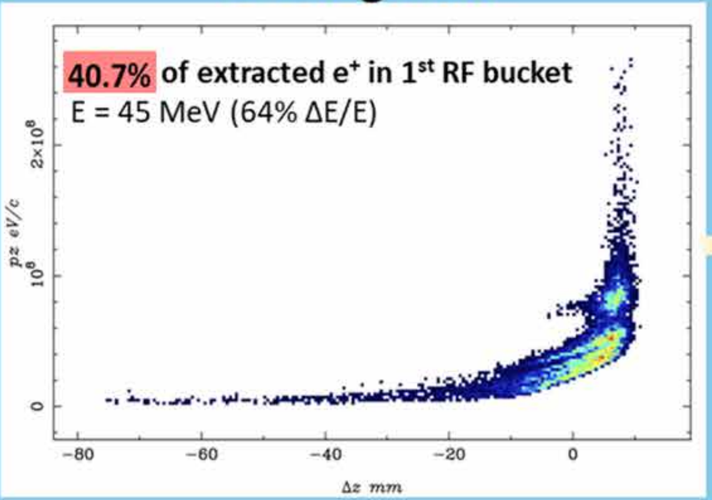
- INFN-MI 17.6 k€, I-year 2x NVIDIA-RTX A 6000 + 10 k€ travel/y
- INFN-LNF 30 k€, I-year 2x WS AMD 128 threads + 5 k€ travel/y
- INFN-LNS 15 k€, I-year 1x WS AMD 128 threads + 5 k€ travel/y

Total:122.6 k€

Example of GIOTTO FCC positron capture beam-line optimization

Without GIOTTO

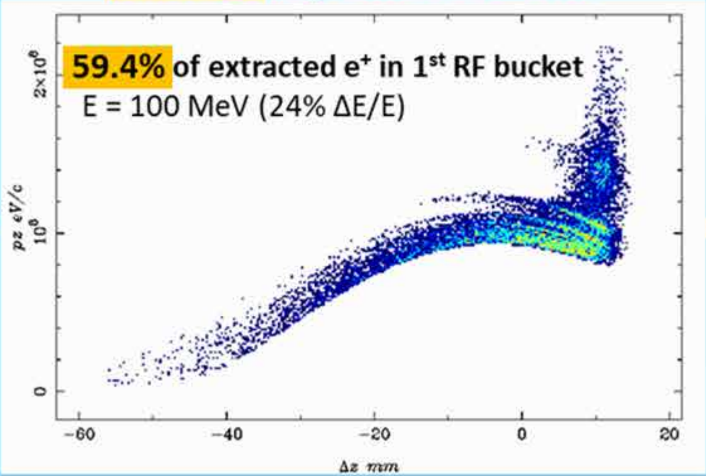
Starting Point



2022-end

GIOTTO 2022 Ver.

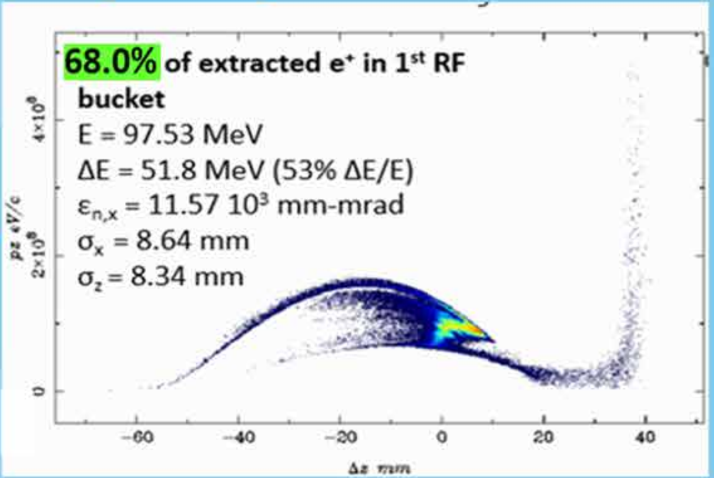
GIOTTO Optimized Point



meanwhile

GIOTTO new Ver. capable to opt. in space-phase windows

GIOTTO windows opt.



2024

Further Credentials

Internazional Users:
@LNF, @CERN, @PSI, @DESY, @JCLab, @PITZ, @Univ. Atene

Seminari su invito relativi a GIOTTO

◊ **Elettra Sinc. 2018**: BD study by using GA's
◊ **CERN, CLEAR, 2018**: LVB & GIOTTO's extreme BD optimizations
◊ **LAL (Orsay), 2017:** BD study using GA's and ELI-np case
◊ **Pitz (DESY,Berlino), 2011**: BD study of HBB using GA's & GIOTTO
◊ **Swiss-FEL (PSI), 2010:** BD study of HBB by using GA's

Richieste e Budget

Capitolo	Descrizione	Parziali (k€)		Totale (k€)	
		Richieste	SJ	Richieste	SJ
missioni	Cross-site travel between LNF, INFN-MI and STAR (UNICAL) will support the modularization of GIOTTO_CL/CS and iterative prototyping. Due to the complexity of the code, online meetings will not always be feasible. This includes project meetings and technical teamwork. Within this budget, we aim to include at least one mission for one person to DESY and/or CANDLE (Yerevan), and/or IJCLab to maintain collaboration with current internation GIOTTO_CL users, developer of ASTRA (K. Floettmann) and potential GIOTTO_CS users. 1k/week per mission. 5k is rescaled on the INFN-MI FTE	5.00	0.00	5	0
inventario	1 x workstation AMD Threadripper PRO 7985 or 9000 64 core - W11 PRO, see quotation attached. This workstations will be mainly dedicated to GIOTTO_CL serving the LNS DLA group for complex beamline optimization and FEM simulations (e.g., HFSS/ANSYS, CST, SuperFish). We did not request INFN centralized resources, as FEM tools like CST and HFSS/ANSYS are not supported. Moreover, GIOTTO_CL development and testing requires a local infrastructure due to its iterative nature. Further, a same architecture across INFN unit simplifies development.	15.00	0.00	15	0
Totale				20	0

		%
Mauro	Giorgio Sebastiano	**20%**
Rifuggiato	Danilo	**10%**
Sorbello	Gino	**20%**
Torrisi	Giuseppe	**20%**

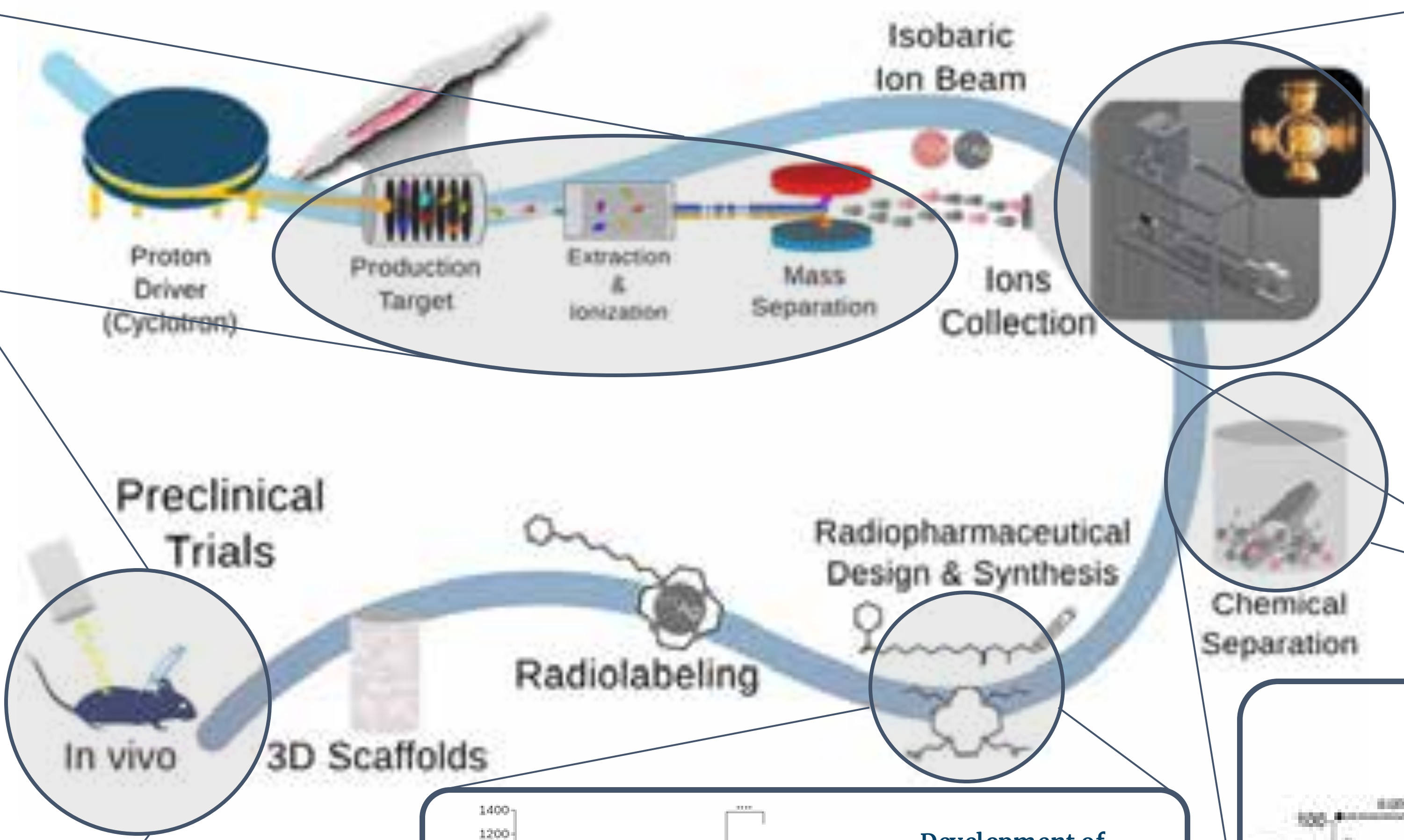
ISOLPHARM_APEX

Laboratori Nazionali di Legnaro – INFN

A new CSN5 experiment proposal

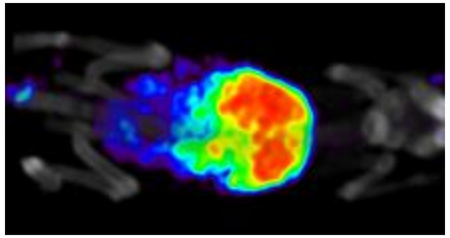
A. Andrighetto, A. Arzenton

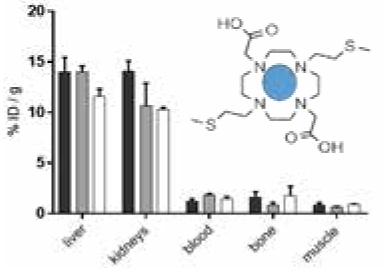
ISOLPHARM method



Design & construction of the IRIS system for radioisotope deposition and spectroscopic characterization

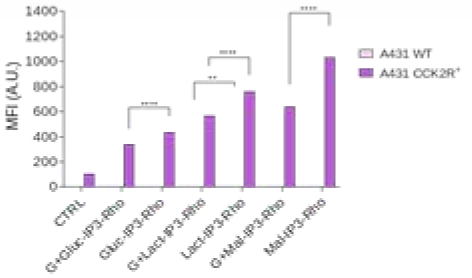
PET/CT fused image 24 h after the radiolabeled compound injection





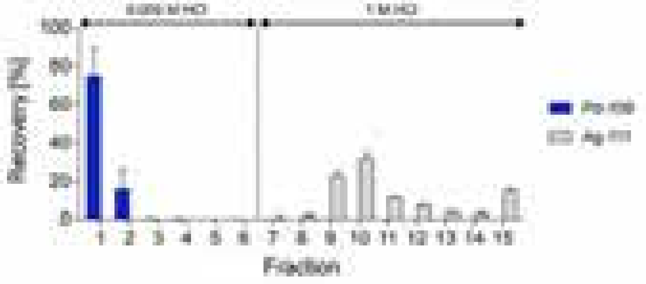
DO2A2S-^{64}Cu ex-vivo biodistributions

Results from ISOLPHARM CSN5 experiments



Development of 2nd gen. ligands: increased uptake and total competition with more hydrophilic linkers

Pd/Ag chemical separation



Project organization

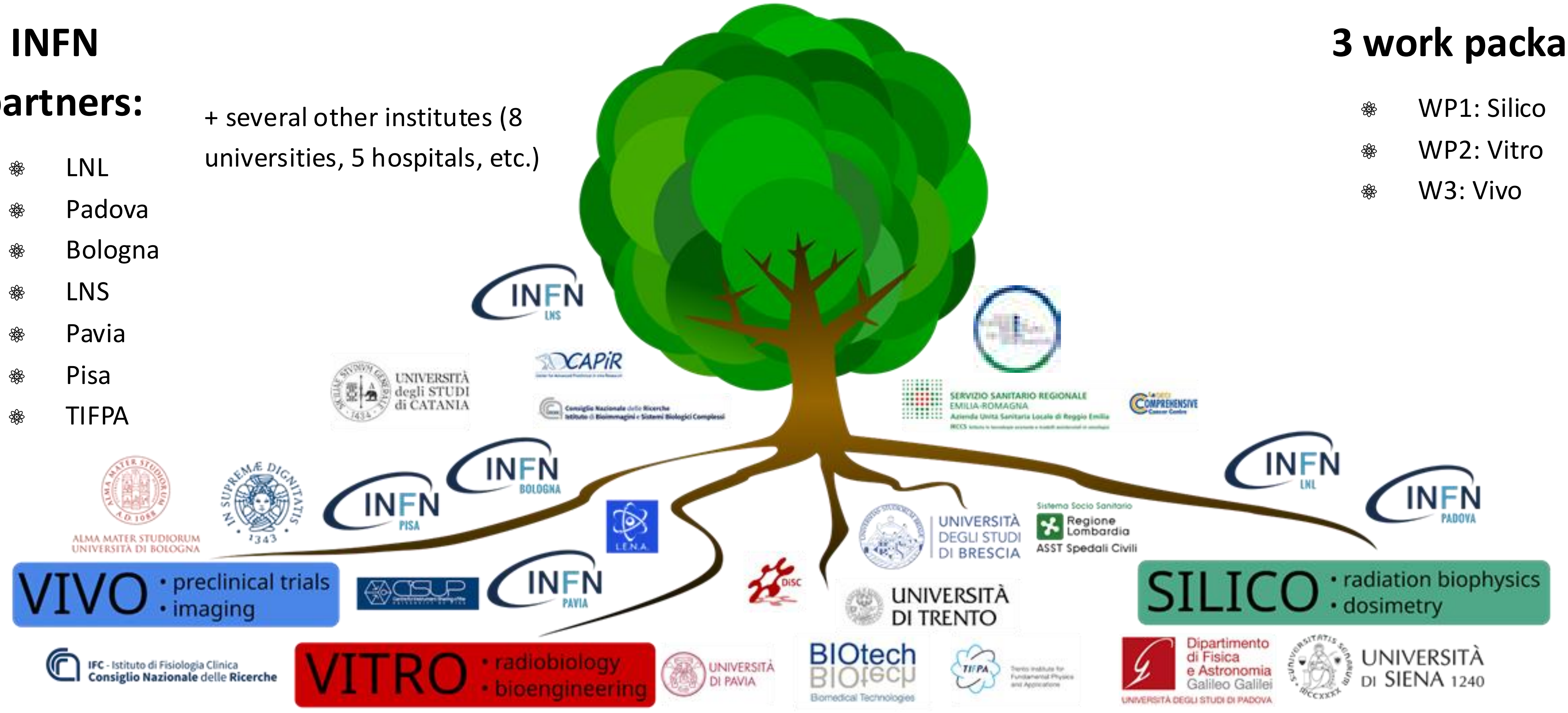
7 INFN partners:

- LNL
- Padova
- Bologna
- LNS
- Pavia
- Pisa
- TIFPA

+ several other institutes (8 universities, 5 hospitals, etc.)

3 work packages:

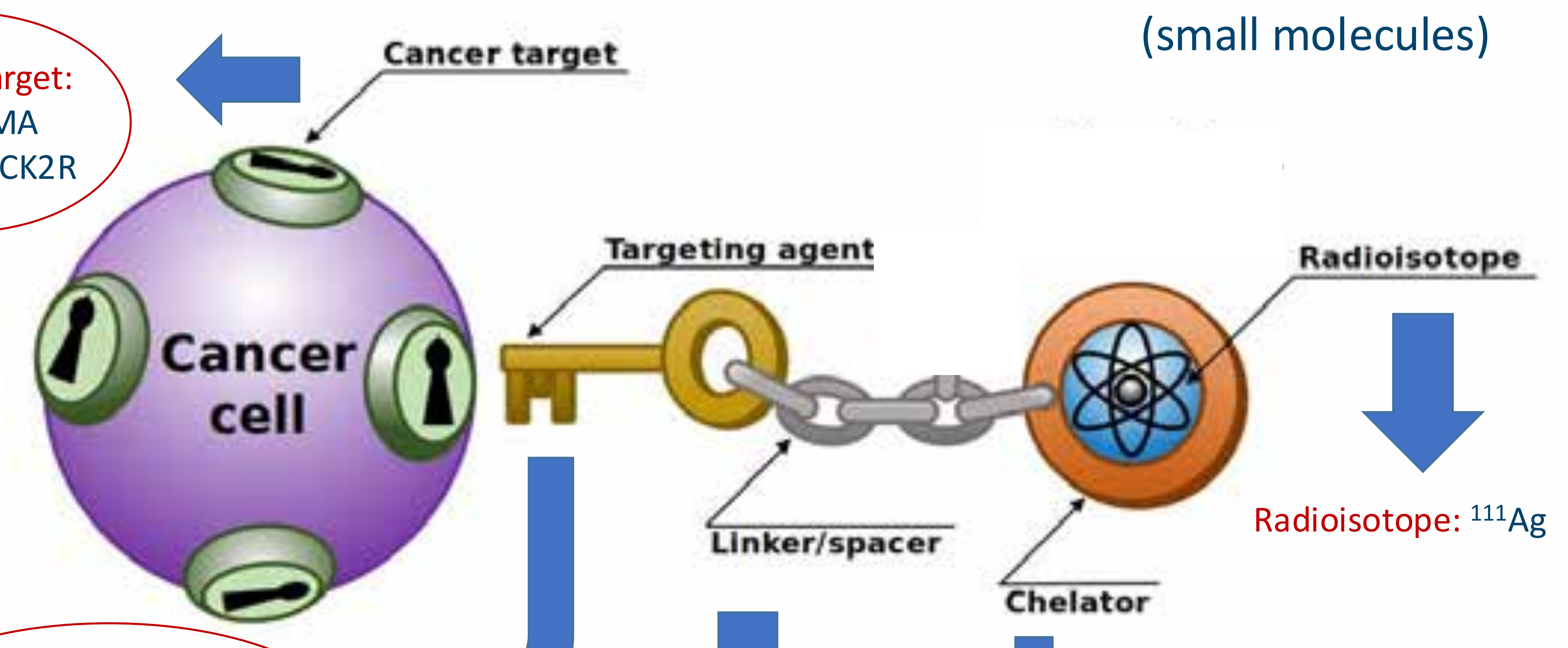
- WP1: Silico
- WP2: Vitro
- W3: Vivo



Radiopharmaceutical frame

(small molecules)

Cancer target:
Now: PSMA
Before: CCK2R



Radioisotope: ^{111}Ag

Targeting agent:
Now: PSMA-617
Before: Z360 (for CCK2R)

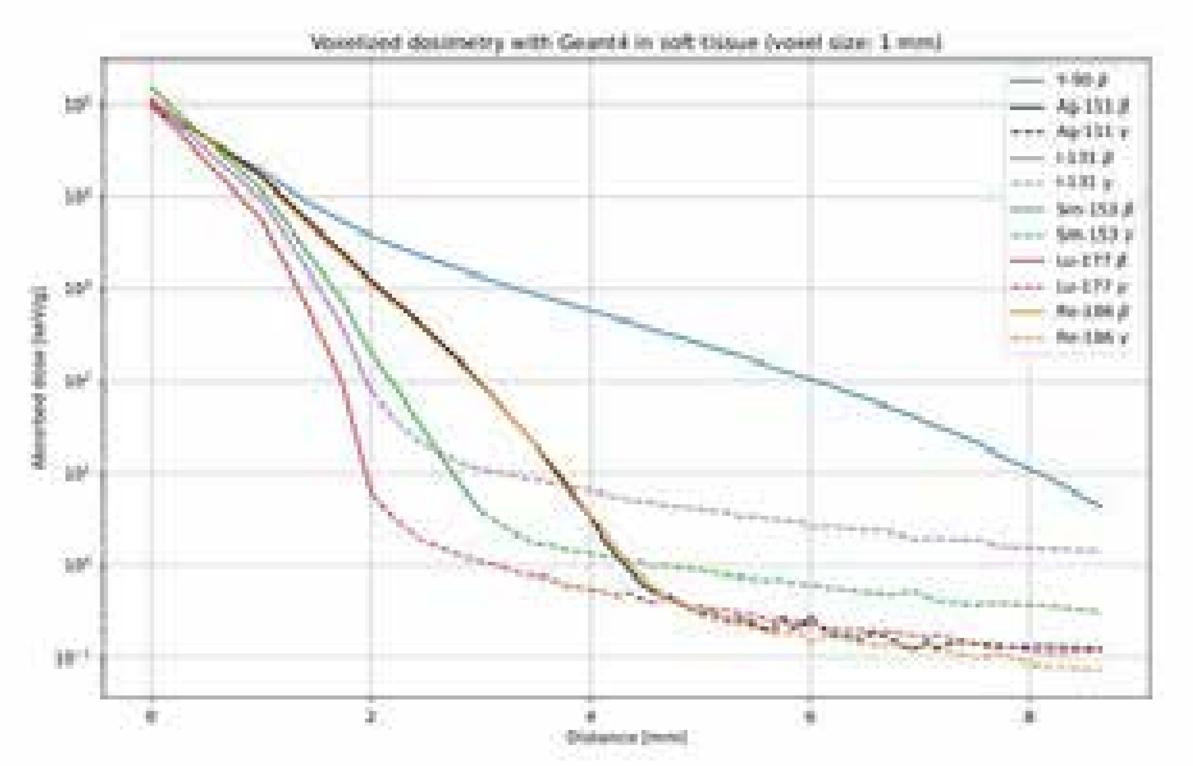
Chelator: DO4S

Linker: Bifunctional

Experiments: why ^{111}Ag?

^{111}Ag properties

- **β⁻ emitter** (average energy **360 keV**)
- Good half-life (**7.45 days**)
- Average tissue penetration (1.8 mm)
- Medium energy γ **rays** -> SPECT?



→ In the market no radiopharmaceuticals radiolabeled with silver-111

→ Silver-111 can be produced @ SPES with high purity & high production rate

→ No isobaric radioactive contamination in the implantation foil (also with LASER off!)

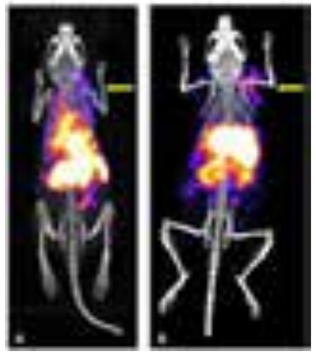
→ ^{111}Ag exhibits theranostic properties similar to ^{177}Lu which was recently approved by FDA

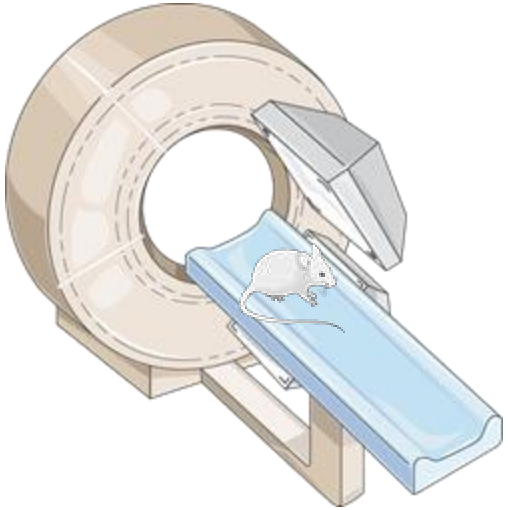
→ ^{111}Ag behaves similarly to ^{186}Re, recently studied in phase I/II clinical trials

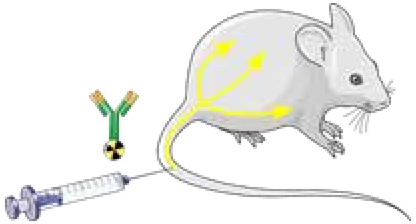
111 Isobaric chain	Half-Life $T_{1/2}$	Decay	Target Yield
Cadmium-111	Stable		**Low yield production**
Silver-111	7.45 days	β⁻	**Good yield production**
Palladium-111	23.4 min	β⁻	**Bad release, short $T_{1/2}$**
Rhodium-111	11 sec.	β⁻	**No release, very short $T_{1/2}$**

WP2 – INVITRO and WP3 – VIVO

- Biodistribution *ex vivo* of ^{111}Ag-PSMA-617
- Preclinical experiments *in vivo* with ^{111}Ag-PSMA-617 and ^{177}Lu-PSMA-617 for comparison
- γ imaging and radiomics







INFN LNS

INFN PISA

INFN BOLOGNA

LNS prospect

LNS							
Type	ID	Item	WP	Year 1 [k€]	Year 2 [k€]	Year 3 [k€]	Total
Consumables	13	Laboratory material	3	1	1	1	3
	14	Mice for in-vivo experiments	3	6	6	6	18
Shipping	15	Shipping of detector, drugs, samples	3	4	4	4	12
Travels	16	Travels for experimental activity	3	2	2	2	6
Total LNS				13	13	13	39

FTE

Alessandro Stefano	Apex	0,3
Francesco Cammarata	Apex	1
Giorgio Russo	Apex	0,3
Giusi Irma Forte	Apex	0,8

Nuovo esperimento CSN5:

VAPORADA

VAlidation **P**rotocol **O**f **RA**diation **DA**mage simulations in HTS for fusion

Durata esperimento: 2 anni (2026-2027)
Area di ricerca: interdisciplinare
Responsabile nazionale: Francesco Laviano(Torino)
Unità partecipanti: Torino, LNL, LNF, Roma, Genova, LNS (ENEA)
Budget totale richiesto ≈ 60 k€ / anno

Abstract:

- **Compact reactors** are a current trend in nuclear fusion research, promising high neutron yields and lower costs with respect to traditional larger projects. In these compact designs, **High Temperature Superconductors (HTS) are the enabling technology.**
- Since in compact reactors the radiation field is very high, **assessing the radiation hardness of HTS in the magnetic system is crucial**. The current understanding of radiation damage in HTS is mainly based on experiments made with fast neutron irradiation in fission reactors and with proxy experiments with high-energy charged particles.
- These **experimental approaches are necessary, but not sufficient** to have a comprehensive picture of HTS radiation damage in a fusion environment due to the broad neutron spectrum with a 14 MeV component and the presence of intense secondary particle fluxes. **Support from models is mandatory.**
- **The VAPORADA project will carry out a feasibility study aimed at validating radiation damage modelling, with a specific series of experiments. This activity will be oriented to define a protocol of microstructural, spectroscopic and electromagnetic characterization of HTS, which have been irradiated with selected high energy beams (photons, electrons, protons, alfas and heavier-ions), in order to find a clear correlation between specific defects in the crystal lattice, as found in the simulations, and changes in T_c and J_c in the HTS.**

Nuovo esperimento CSN5:

VAPORADA

VAlidation **P**rotocol **O**f **RA**diation
DAmage simulations in HTS for fusion

BUDGET: Bozza di richiesta 2026 (LNS):

TIPOLOGIA	**k€**	**Motivazione**
CONSUMO	8	(consumo per preparazione e analisi TEM dei campioni, materiali per la gestione dell'irraggiamento)
MISSIONI	2	(incontri progetto e conferenze)
TOT	**10**	

Unità INFN-LNS → partecipanti:

SCUDERI Mario (Resp. Unità)	0.3
D'ARRIGO Giuseppe	0.2
SCIUTO Antonella	0.2
PANNITTERI Salvatore	0.3

Tot FTE: 1.0

Ruolo Unità INFN-LNS: irraggiamento elettronico campioni, caratterizzazione chimica e strutturale dei campioni pre e post irraggiamento

MULTI-GRAPH

Multilayer graphene with high thermal conductivity, radiation tolerance, and thickness uniformity

Proposta di progetto per la Call della CSN5 –Interdisciplinary research area

Responsabile Nazionale: Daniela Calvo – INFN Torino

Sedi partecipanti: INFN-LNS, INFN-Ge, INFN-Na, INFN-To

Obiettivi generali

The proposal is part of the **graphene production and application field**

The project aims to produce and characterize **multilayer graphene (MLG) foils** (made of thousands graphene layers) with a **thermal conductivity** in the order of 1500-2000 W/(m K), a **thickness** of 1-2 um, a thickness **uniformity** of less than 2%, a **surface area** at least 4 cm^2, and a limited impurities **contamination** (< 5%)

Applications

(1) a **substrate for nuclear target deposition** when a large amount of power is released by an intense particle beam (also as stripper for ion beam). MLG acts as a thermal bridge to a heat sink. Sn evaporation on MLG substrate

(2) in the **cooling system of front-end electronics**, reducing the material budget in the sensitive area of the detectors

(3) **membrane** to increase the purity of gases

(4) possibility of introducing controlled amounts of foreign atoms into the MLG structure through **ion implantation**, intending to **engineer its electrical, thermal, or structural properties** via doping

Attività

Synergy with NUMEN

Production of the MLG foils

MLG samples will be produced by 3 methods at INFN-Genova:

- filtration process starting from e-graphene precursors,
- reduction of graphene oxide dispersions followed by a filtration process,
- carbonization of polymeric films at about 1400°C, followed by the graphitization process at about 3000°C

Characterization

The **order of atoms** and their stratification will be studied with SEM and RX

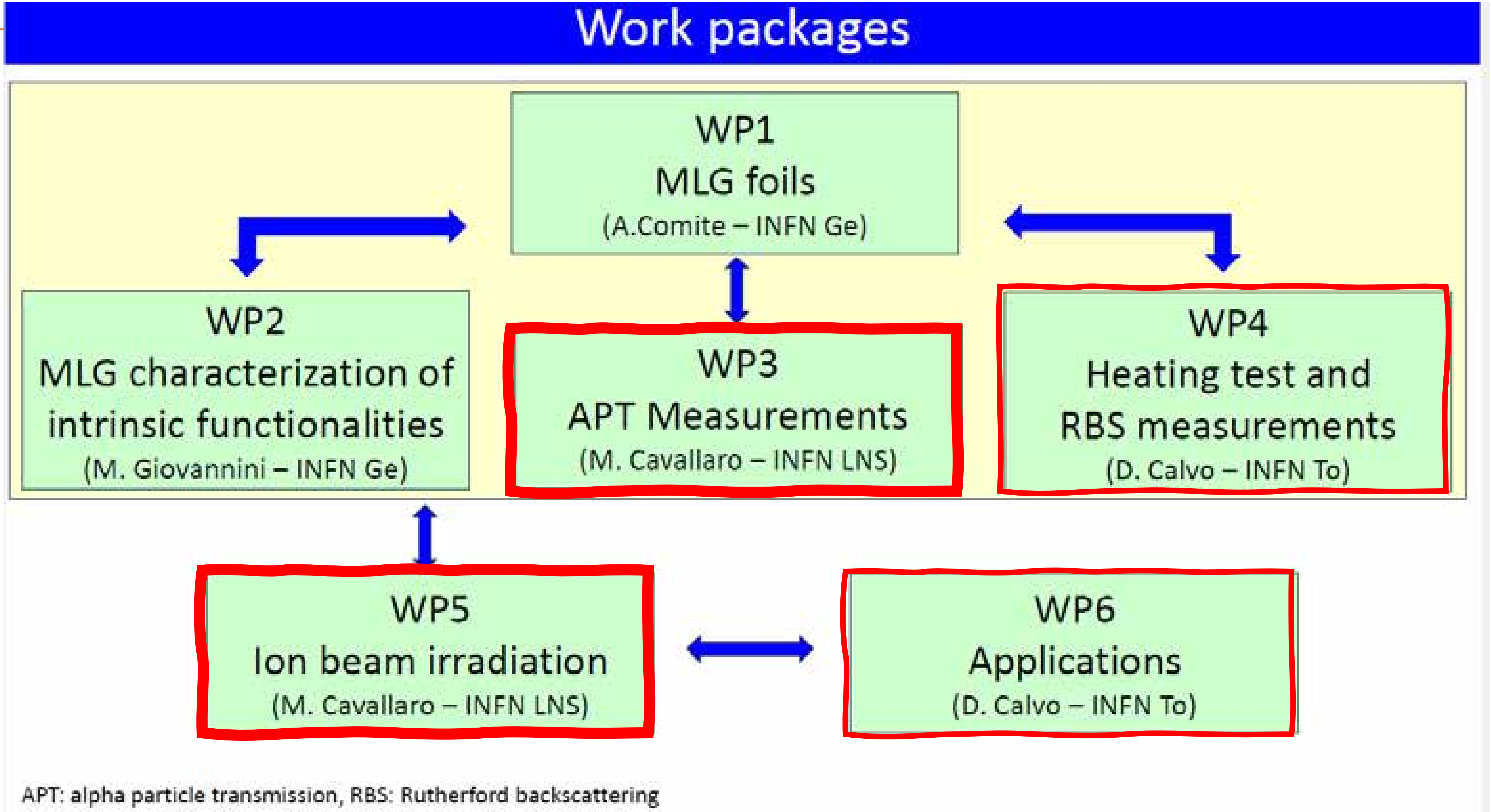
Thermal conductivity will be measured with Raman spectroscopy.

The **thickness uniformity** will be measured using the alpha particle transmission technique (APT) and Rutherford back-scattering (RBS) measurements. The **purity** of the samples will be evaluated too.

Study of radiation damage

with particle beams, which affects the value of the thermal conductivity

Attività



Work packages
WP1
MLG foils
(A.Comite – INFN Ge)
WP2
MLG characterization of intrinsic functionalities
(M. Giovannini – INFN Ge)
WP3
APT Measurements
(M. Cavallaro – INFN LNS)
WP4
Heating test and RBS measurements
(D. Calvo – INFN To)
WP5
Ion beam irradiation
(M. Cavallaro – INFN LNS)
WP6
Applications
(D. Calvo – INFN To)
APT: alpha particle transmission, RBS: Rutherford backscattering

Attività

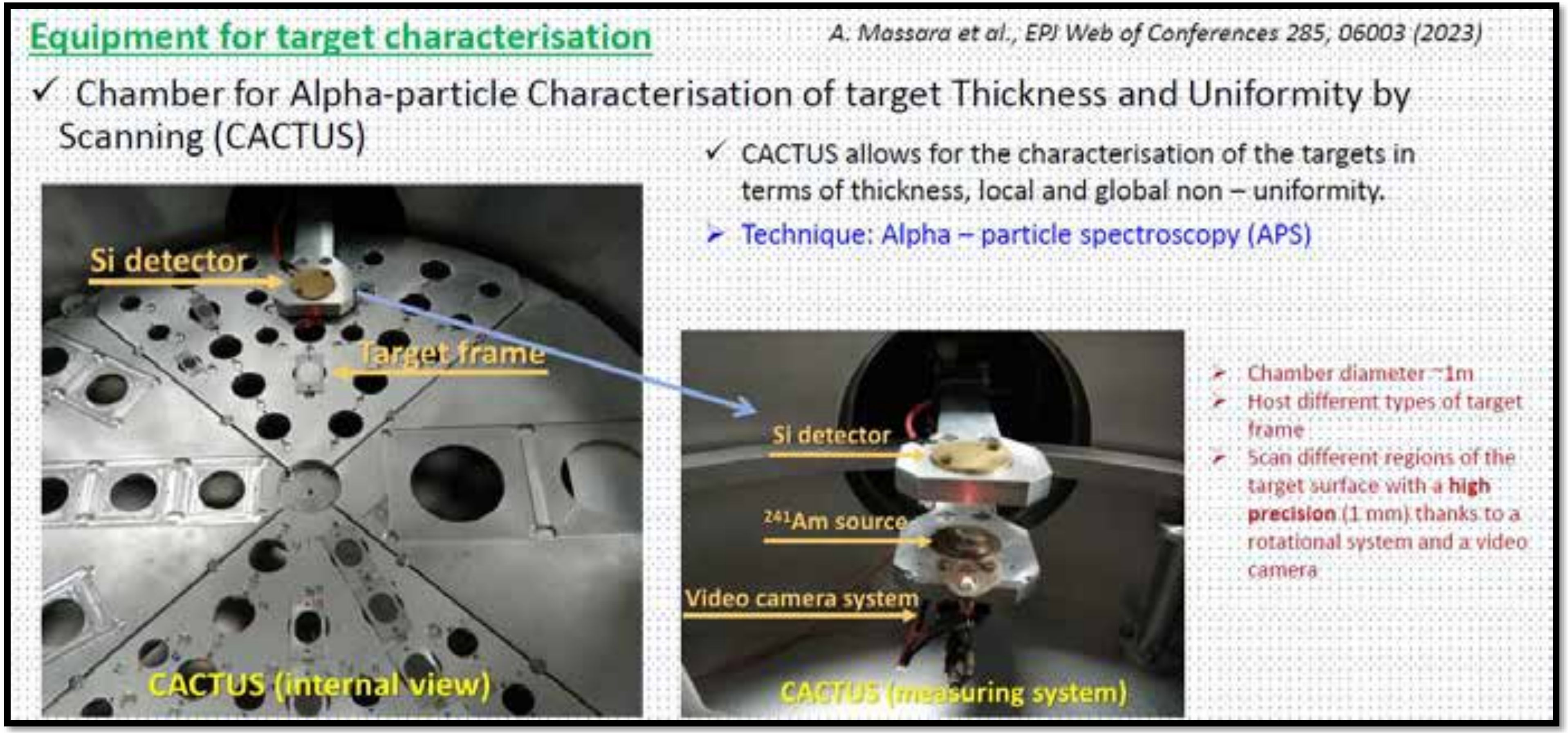
WP3 (APT measurements)

October 2026-March 2028

The Alpha Particle Trasmission (APT) measurements are performed at LNS using the **CACTUS facility**

The goal is to obtain MLG sheets with good thickness uniformity, which is fundamental for the application of MLG material as a substrate for target isotopes deposition.

3 sub-WP corresponding to the MLG prototypes produced by the 3 different processes.



Attività

WP5 (ion beam irradiation)

Jan 2027-Dec 2028 (including calls and schedule for beam time)

This WP5 is dedicated to the **irradiation with ion beams of MLG sheet prototypes** from the 3 processes, Sn **target prototypes** (from application n.1), and **MLG foils with ion implantation** (from application n.4)

The in-beam tests will be performed at **different temperatures of samples**: room temperature, cooled by a Peltier cell system below 20°C, and at cryogenic temperatures. Results will populate information about the behavior of the MLG material under irradiation

Applications for beam time will be submitted for heavy ion beams at **LNL and/or LNS, Ganil and GSI**

Collaborators from foreigner institute will help to arrange beam tests in their laboratories.

Budget

Personnel:

- postdoc position for 3 years (35 keuro/year)
- scholarship for recent graduates (neolaureato) for 3 years (25 keuro/year)

Consumables (5keuro/year):
setup for applications. Shipments of prototypes to the different structures

Travel (23 keuro in 3 years):
1 project meeting /year, 4 RBS measurements with 3 people, 3 irradiations with beams

Tables of financial requests [keuro]

	INFN-Ge	INFN-LNS	INFN-Na	INFN-To	Total
Year 1					
Equipment	250	0	0	10	260
Personnel	60	60	0	60	180
Consumables	5	5	0	10	20
Travel	3	3	1	5	12
Total Structures year 1	**318**	**68**	**1**	**85**	**472**
Year 2					
Equipment	0	0	0	40	40
Personnel	60	60		60	180
Consumables (and shipments)	5	5	0	15	25
Travel	3	10	2	10	25
Total Structures year2	**68**	**75**	**2**	**125**	**270**
Year 3					
Equipment	0	0	0	0	0
Personnel	60	60	0	60	180
Consumables (and shipments)	5	5	0	10	20
Travel	3	10	3	10	26
Total Structures year3	**68**	**75**	**3**	**80**	**226**
Total per Structure	**454**	**218**	**6**	**290**	**968**

FTE

Structures	Local manager	Reserchers	%
INFN-Genova	Mauro Giovannini	Reshma Babu	50
		Antonio Comite	50
		Mauro Giovannini	30
		Marco Ripani	10
INFN-LNS	Manuela Cavallaro	Clementina Agodi	25
		Francesco Cappuzzello	25
		Diana Carbone	25
		Manuela Cavallaro	30
INFN-Na	Dimitra Pierroutsakou	Dimitra Pierroutsakou	10
INFN-To	Daniela Calvo	Carlo De Benedictis	10
		Daniela Calvo	50
		Paolo De Remigis	20
		Paolo Olivero	20
		Federico Picollo	15
		Ettore Vittone	20
		Richard Wheadon	20

+ 2 post-docs hired by the project funds (100%)

Impatto su divisioni e servizi LNS, eventuali necessità di spazi

MULTI-GRAPH requires the support of the **target lab (Reparto laboratorio di tecniche chimico fisiche)** for:

- the use of the CACTUS facility for the **APT measurements**
- the application of MLG sheets as substrate for **Sn evaporation**

GRV LNS *Preventivi*

Nuove Proposte

- ***iDLA***

Giuseppe Torrisi (Resp. Nazionale)

- ***INSIGHT***

Grazia D'Agostino (Resp. Nazionale)

- ***VIP (Virtual Versatile Ion Production)***

Lorenzo Neri (Resp. Nazionale)

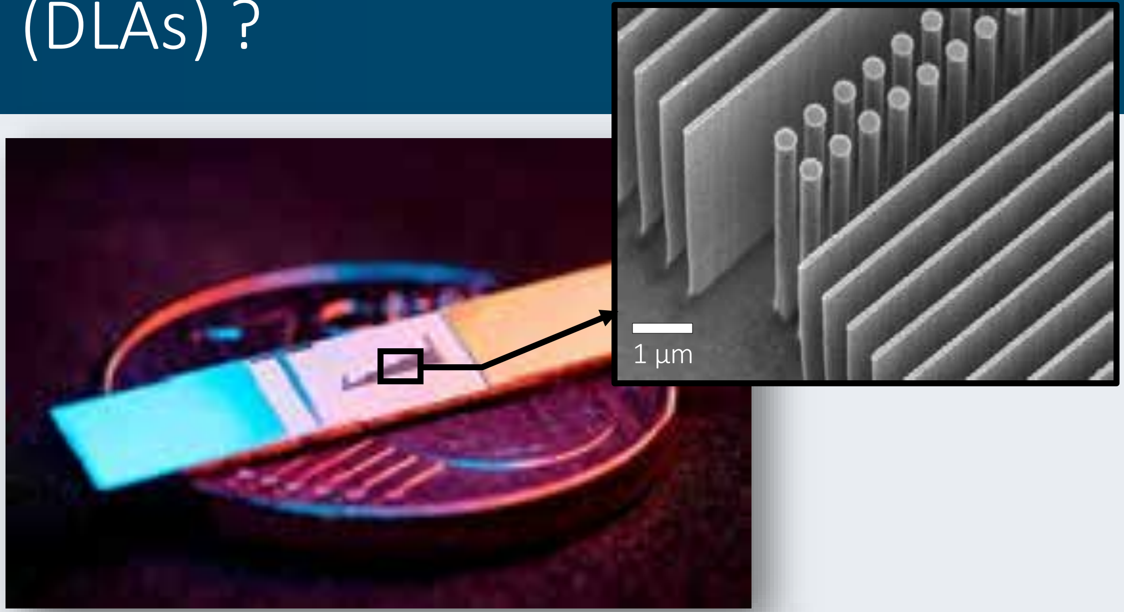
- **Proposta GRANT Giovani**, Sahar Arjmand

Integrated/innovative Dielectric Laser Accelerator (iDLA)

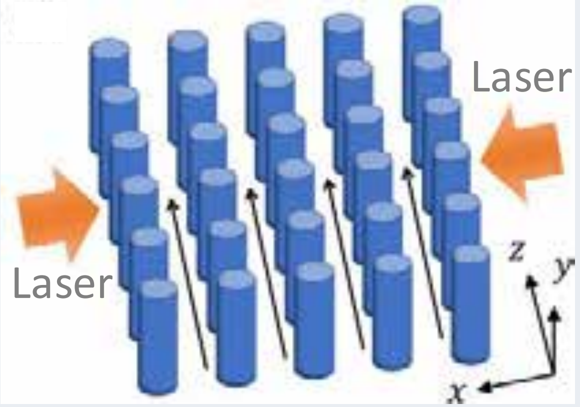
Durata: 3 anni
Area: ACCELERATORI
Responsabile nazionale: *Giuseppe Torrisi, INFN-LNS*
Unità partecipanti: LNS, MI, TO

Resp. Locali:
LNS - Giuseppe Torrisi
MI - Alberto Luigi Bacci
TO - Simone Luigi Marasso

Why Dielectric-based Laser Accelerators (DLAs) ?



	Dielectric materials and optical frequencies	Higher damage threshold than metallic cavities	**Higher gradients and smaller, miniaturized structures**	Much stricter requirements on beam properties	Lower current per channel
DLA	f=150 THz (λ=2 µm) τ=6.6 fs RR ~ kHz-MHz	**>3 GV/m fields**	Gradient >1 GeV/m Physical aperture: ~200 nm	Emittance <100 pm rad (norm)	fA-pA (in single channel)
RF	f=3 GHz τ=333 ps RR ~ Hz-kHz	<200 MV/m	25-50 MeV/m ~1cm	1 µm ~ 1 mm rad	nA-µA and larger



*Multi-channel DLA: Zhao et al., Photonics Research **8** 10, 1586-1598 (2020)*

iDLA Objectives

1) **Design and fabrication** of dielectric laser accelerator (DLA) structures optimized for co-propagating configurations, enabling efficient energy transfer to charged particles over extended interaction lengths.

2) **Demonstrate laser coupling** using co-propagating laser pulses in a sequence of dielectric structures and **SEM-based electron injection setup preparation**

3) leading to a **structured study for the realization of a dedicated testbench**, **the critical requirements for a future experimental DLA setup**

iDLA Experimental Concept

https://www.mdpi.com/2304-6732/1/4/412

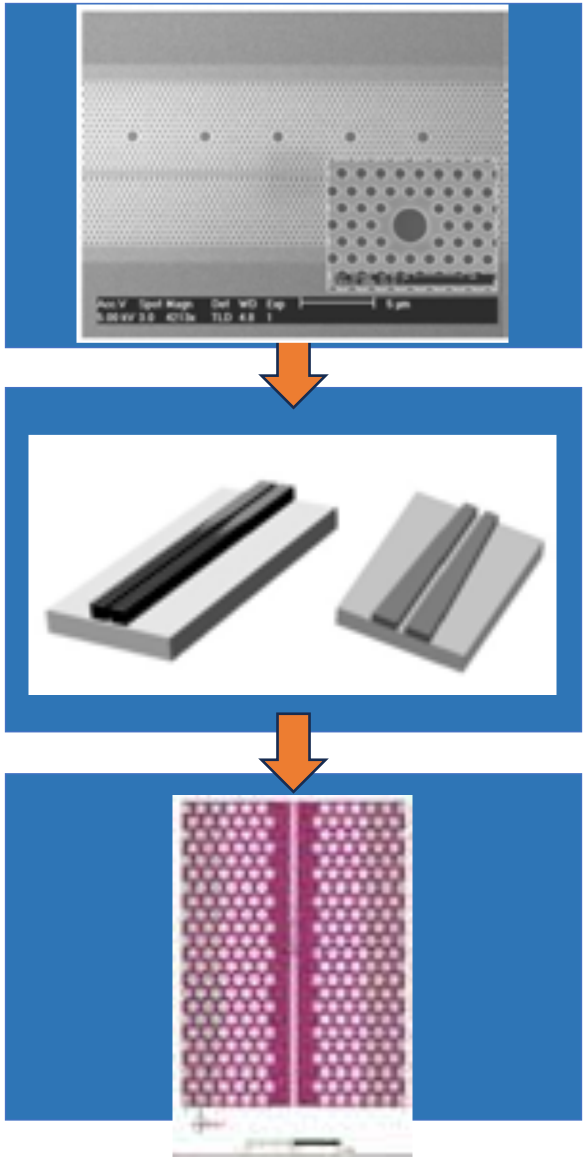
<u>Goal</u>: Test a **<u>cascade of dielectric structures</u>** to increase β from ~0.2 to ~1.
<u>Strategy</u>: progressive increase in β (v/c) from ~0.2 to ~1 using a modular structure chain:

1. High-Q cavities (β ≈ 0.2–0.3):
- Inspired by ACS Nano 2024 design (https://pubs.acs.org/doi/abs/10.1021/acsnano.3c11211)
- Efficient energy coupling and field confinement

2. Slot waveguides (β ≈ 0.4–0.75):
- Based on designs in Optics Express 2023 (https://opg.optica.org/oe/fulltext.cfm?uri=oe-31-23-38891&id=541361)
- Dielectric slots for field enhancement in sub-micron gaps

3. Hybrid Photonic Crystal (PhC)-slot waveguides (β ≈ 0.75–1):
- Slot formed by rib waveguides suspended by PhC membranes
- PhC ensures mechanical support & enhances field via bandgap confinement

Outcome/Deliverable: validate structure chain for increasing β,
targeting high-gradient acceleration (>100 MV/m) up to β ≈ 1.

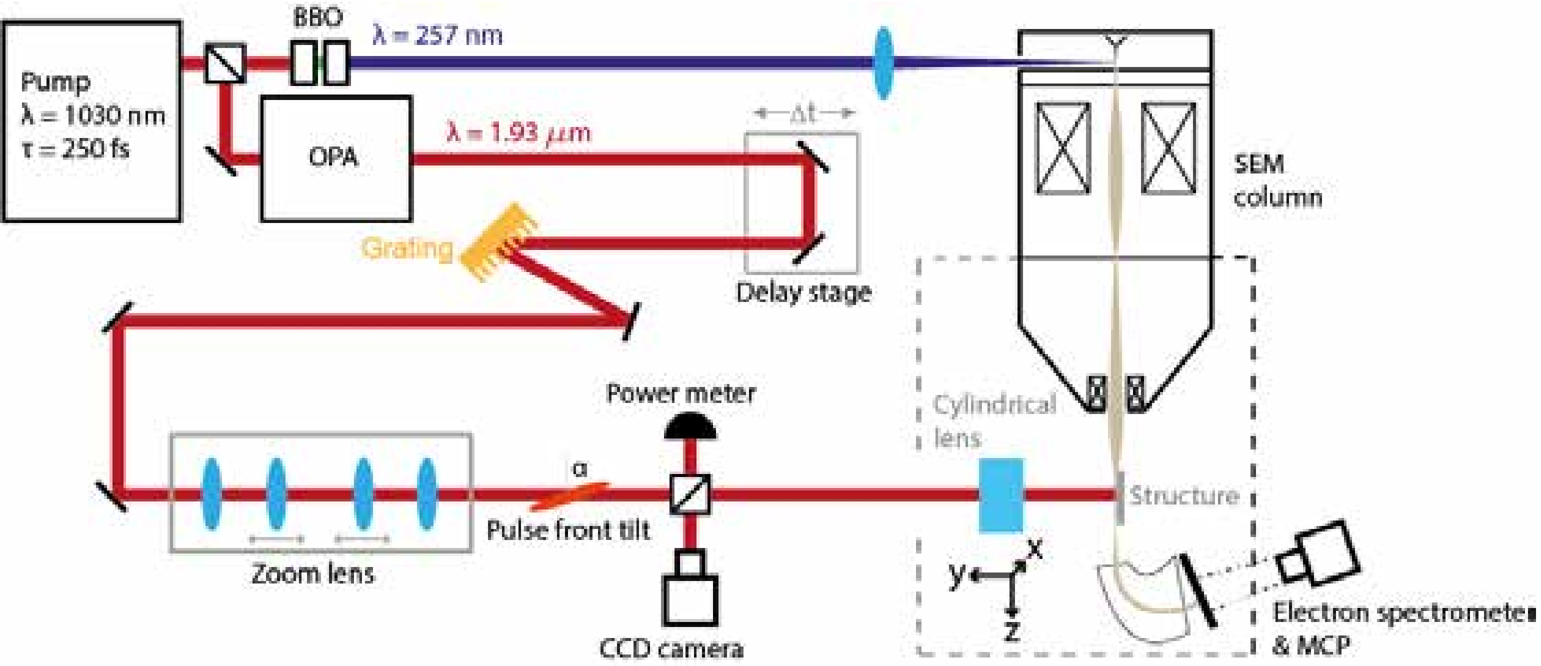


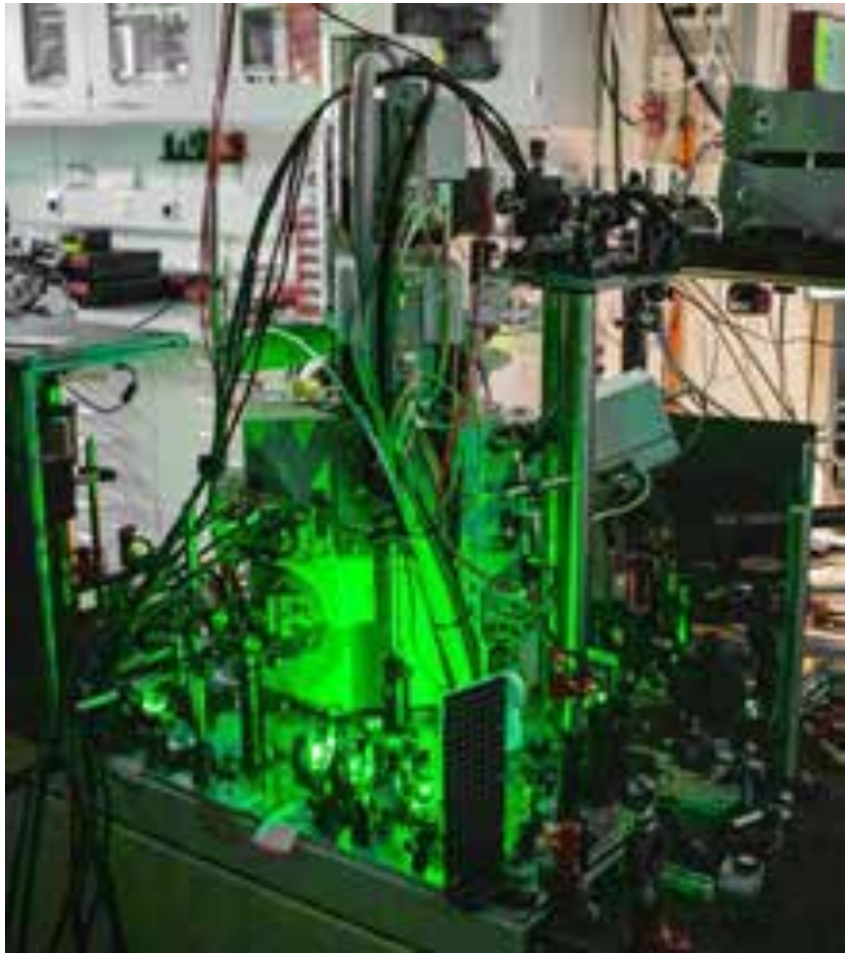
Scanning electron microscope(SEM) –0.5 –30 keV electrons(ß= 0.32)

•Electron emission triggered by UV (257 nm) laser pulse

•Synchronized with accelerator driving pulse (1.93 µm) inside the chamber

•Detection by MCP and magnetic spectrometer





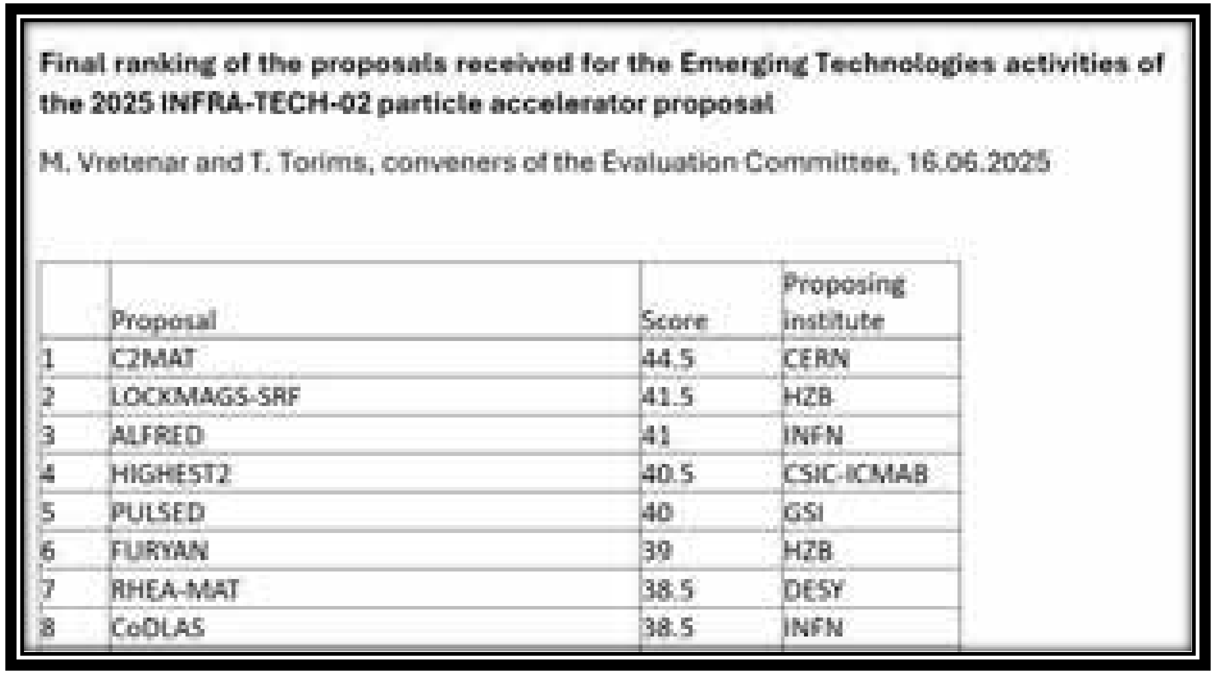
T. Chlouba*, R. Shiloh*, S. Kraus*, L. Brückner*, J. Litzel, P. Hommelhoff, Nature, 622(7983), 476-480.

IFAST2: CODLAS selected to be included

- CoDLAS (Co-Propagating Dielectric Laser Accelerator Structures). **INFN**, **PSI**, **FAU**/Munich University, **THALES**, **SenSiC** GmbH [***Convener***: Giuseppe Torrisi]

Abstract

Dielectric Laser Accelerators (DLAs) use infrared lasers and nanostructured dielectrics for compact, high-gradient acceleration. We will design and test co-propagating DLA structures with electron beams in sub-relativistic and relativistic regimes. For muons, we will use longer wavelengths (~100 µm) and gradients >1 GV/m for rapid acceleration before decay. In addition to accelerating particles, we also will explore the use of dielectric structures to couple fields from relativistic bunches to photonic integrated circuits for beam diagnostics.



Final ranking of the proposals received for the Emerging Technologies activities of the 2025 INFRA-TECH-02 particle accelerator proposal

M. Vretenar and T. Torims, conveners of the Evaluation Committee, 16.06.2025

	Proposal	Score	Proposing institute
1	C2MAT	44.5	CERN
2	LOCKMAGS-SRF	41.5	HZB
3	ALFRED	41	INFN
4	HIGHEST2	40.5	CSIC-ICMAB
5	PULSED	40	GSI
6	FURYAN	39	HZB
7	RHEA-MAT	38.5	DESY
8	CoDLAS	38.5	INFN

Begin forwarded message:

From: Infratech 02 <[illegible]>
Subject: Outcome of your INFRA-Tech-02 Proposal Submission
Date: 17 June 2025 at 17:35:05 CEST
Cc: Infratech 02 <[illegible]>

Dear Applicant,

We are pleased to inform you that your proposal submitted under the "Emerging technologies" internal call for the accelerator INFRA-Tech-02 proposal has been selected by the Evaluation Committee for inclusion in the new accelerator project.
Your proposal was among the top-ranked submissions of a total of 45 proposals received – far more than anticipated – while the budgetary constraints imposed by the European Commission allowed us to support no more than 8. The very high quality of the proposals required a thorough and competitive evaluation process, the outcome of which is reflected in the attached final ranking.

The evaluation criteria and full details of the selection process are available at our page [illegible].
If you wish to receive the detailed scores of your proposal under the various evaluation criteria, please let us know by mail.

Please note that in light of the overall funding limitations, the selection committee has proposed a slight budget reduction for your specific activity. You will be contacted soon for the justification and amount of this reduction.

We will be in touch shortly with information regarding the next steps, including the preparation of the Grant Agreement and integration into the project consortium.

We warmly thank you for your excellent contribution and look forward to collaborating with you on this project.

With best regards,
Maurizio Vretenar and Toms Torims, on behalf of TIARA

Emerging Technologies ranking.pdf

iDLAs_GR5 Objectives

1) Rafforzare la leadership e le competenze INFN (LNS, Torino, Milano), valorizzando anche la collaborazione con l' INRIM, il CNR e una solida compagine universitaria rappresentata da UniCT, UniBS, Reggio Calabria, UniMoRe, e PoliMI.

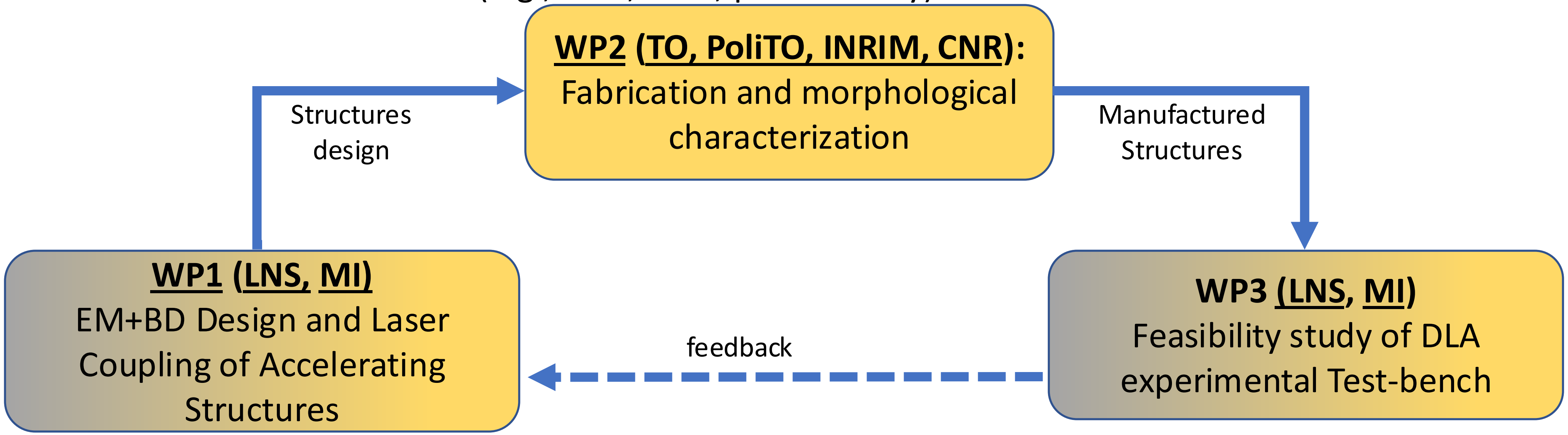
2) Sviluppare prototipi innovativi e tecnologie, focalizzandosi su scale e e approcci tecnologici diversi da quelle di CoDLAs, attraverso l'impiego di metodi di fabbricazione all'avanguardia e materiali innovativi forniti da INRIM e dal centro del CNR PiQuET;

3) Realizzare un testbench INFN con caratteristiche uniche e peculiari, diverse rispetto a quelle del setup di IFAST2.0 che sfrutterà quanto già presente a Erlangen (FAU) per la caratterizzazione delle strutture acceleranti.

iDLA Organization

The project is structured into three tightly integrated Work Packages (WPs)

addresses the **fabrication of dielectric structures, evaluation of manufacturing constraints** and **morphological analysis** (e.g., SEM, AFM, profilometry)



focuses on the **electromagnetic design of dielectric accelerating structures** and the **numerical modeling of beam dynamics**.

focuses on the **experimental characterization** of the fabricated structures. It includes optical **benchmarking**

*The project adopts a **closed-loop development strategy**, where experimental results guide continuous improvement of structure design, maximizing the alignment between theoretical models and real-world performance.*

FTE e BUDGET

Struttura	Su dot.	missioni		consumo		altri_cons		seminari		trasporti		pubblicazioni		manutenzione		inventario		apparati		licenze-SW		spservizi		Totali	
			SJ		SJ		SJ		SJ		SJ		SJ		SJ		SJ		SJ		SJ		SJ		SJ
LNS		4														16				13				33	0
MI		4														16								20	0
TO		4		10.5																2				16.5	0
Totale		12		10.5												32				15				69.5	0

LNS	
NOME	**FTE**
Giuseppe Torrisi	30
David Mascali	10
Giorgio S. Mauro	30
Gino Sorbello	20
Cosentino Gigi	10
Palmeri Roberta	40
Santi Pavone	20
Nunzio Salerno	20
Tommaso Isernia	20
TOT	**200**

MILANO	
NOME	**FTE**
Bacci Alberto	25
De Angelis Costantino	10
Della Valle Beppe	50
Locatelli Andrea	20
Rossetti Conti Marcello	10
Vincetti Luca	10
TOT	**125**

TORINO	
NOME	**FTE**
Simone Marasso	25
Valentina Bertana	20
Eleonora Cara	25
Mario Malerba	25
Alessio Verna	25
TOT	**120**

Table 1: iDLA Team with FTE (Full-time Equivalent).

INSIGHT (INnovative Studies and dIaGnostic tool for High-intensity beam Transport)

Responsabile Nazionale & locale LNS: Grazia D’Agostino, LNS

Area di ricerca: Acceleratori

Unità partecipanti: LNS, LNL

Durata progetto: 3 anni

Introduction

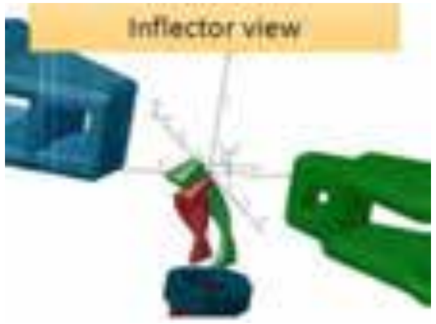
- **Low Energy Beam Transport (LEBT)** faces several key challenges, primarily due to space charge effects and the need for precise beam control at low energies.
- These challenges include managing space charge forces, minimizing emittance growth and ensuring efficient transport of high-intensity ion beams to the accelerator.
- Beam diagnostics is an essential constituent in LEBT for characterizing and monitoring the properties of ion beams, especially when high-intensities are involved.
- **INSIGHT addresses the emerging challenge of efficient beam transport from ion source to the machine entrance, in case of high-intensity beams, by proposing simulation studies and development of innovative devices.**

INSIGHT objectives

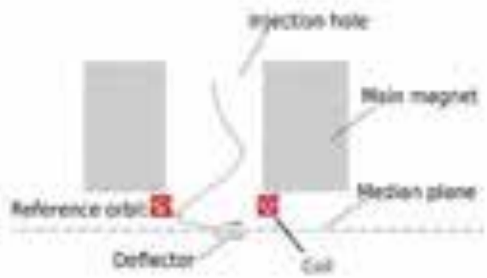
- **Improvement of beam characterization in the low energy domain:**
    - ❖ Study and construction of a non-invasive device for measurement of beam current at different current levels
    - ❖ Device study supported by simulations including space charge
    - ❖ Experimental measurements for different current levels, at CNAO and AISHa ion source@LNS

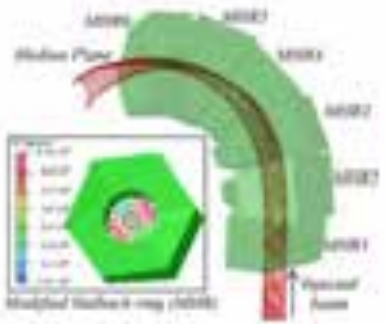
- **Improvement of injection process in compact cyclotrons and investigation of upper current limit injectable:**
    - ❖ Study and construction of innovative beam injection devices:
        - Innovative multi-harmonic buncher
        - New inflector concept: magnetic instead of electrostatic. Passive and active configurations.
    - ❖ Device study supported by simulations including space charge
    - ❖ Experimental tests including device commissioning at LNL cyclotron

Activities in sinergy between LNS and LNL



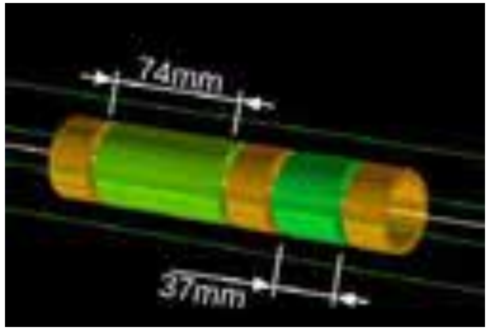
Magnetic inflector

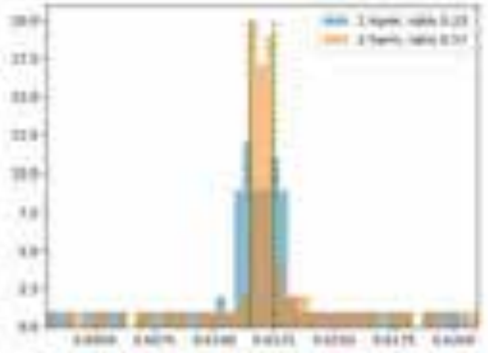




D. Campo, M. Maggiore et al. IPAC2014

New RF buncher concept and injection study





A. Abbondanza, M. Maggiore et al. accepted to be published in JINST (2025)

FTE 2026

FTE	
LNS	2.15
LNL	1
Tot. FTE	3.15

LNS	
Nome	FTE
G. D’Agostino	0.70
G. Castro	0.50
L. Celona	0.25
M. Parisi	0.50
R. Reitano	0.20
Tot. FTE	2.15

Responsabile Locale LNS: G. D’Agostino
Responsabile locale LNL: A. Ruzzon, P. Antonini

External collaboration: CNAO (letter of endorsement)

Budget

LNS – I anno	
Missioni	5 k€
Licenze software	16 k€
Consumo	2 k€
Tot.	23 k€

Stima della richiesta finanziaria totale per tre anni (2026-2027-2028)				
		2026	2027	2028
LNS	Consumo	2 kEuro	2 kEuro	2 kEuro
	Missioni	5 kEuro	4 kEuro	4 kEuro
	Inventariabile		30 kEuro	3 kEuro
	Software (licenze)	16 kEuro	14.5 kEuro	16 kEuro
LNL	Consumo	3.5 kEuro	5 kEuro	3 kEuro
	Inventariabile	4.5 kEuro	25 kEuro	5 kEuro
	Software (licenze)	10 kEuro	7.5 kEuro	
	Missioni	2 kEuro	2 kEuro	2 kEuro
	Tot.	**43 kEuro**	**90 kEuro**	**35 kEuro**

INFN-CSN5

Virtual Versatile Ion Production (VVIP)

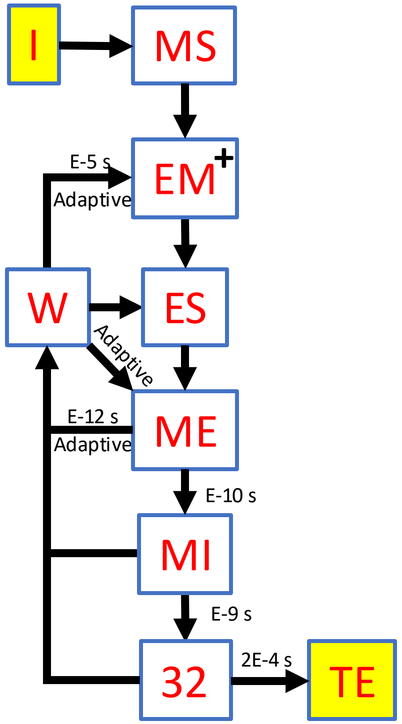
Software tools for the development of various ion sources

P.I. Lorenzo Neri

INFN-LNS

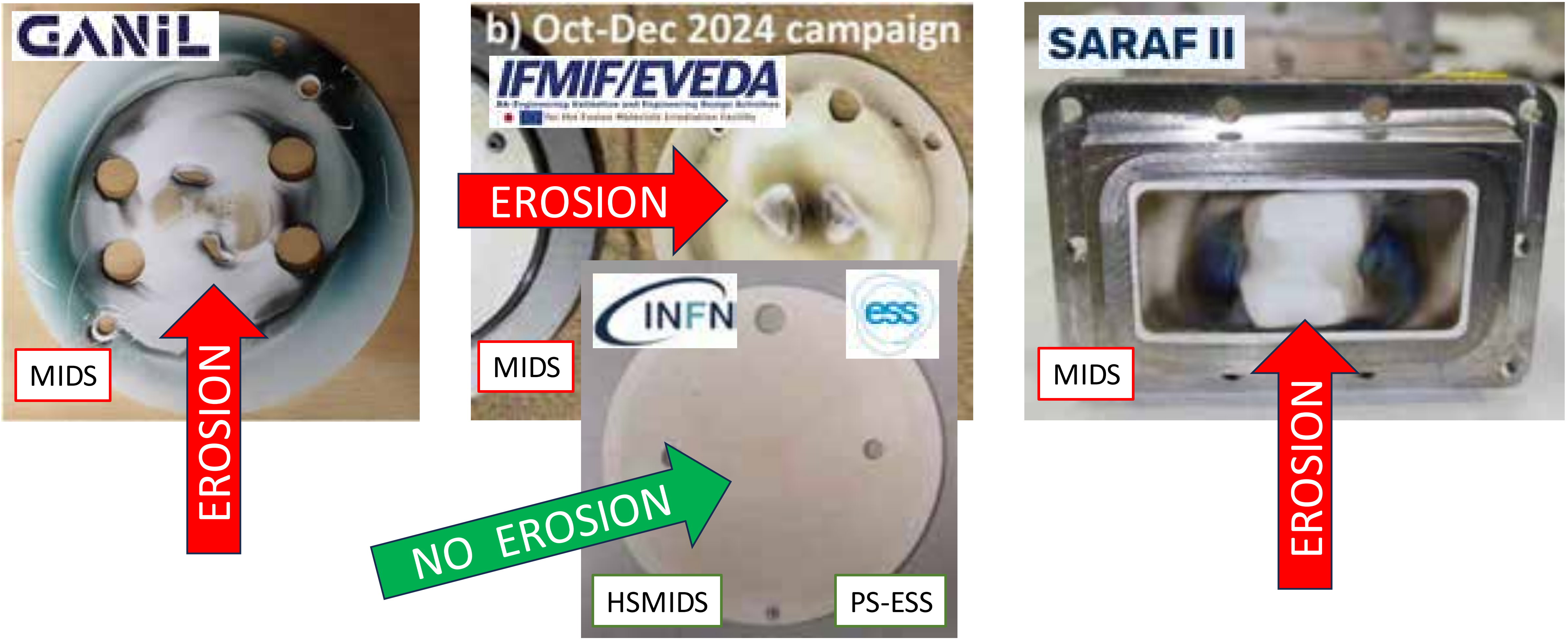
UNICT-DMI, INGV, CNR-ISTP, CERN

Background:
HSMDIS project 2022-2024:

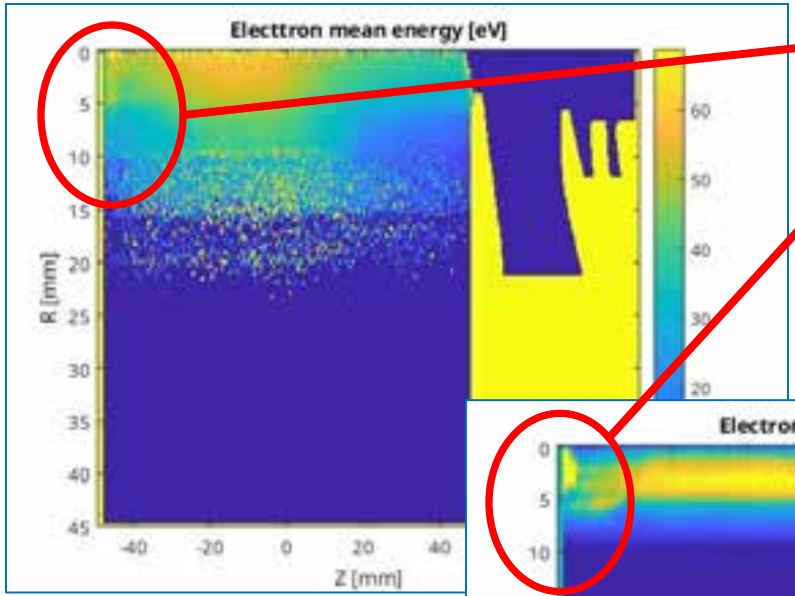


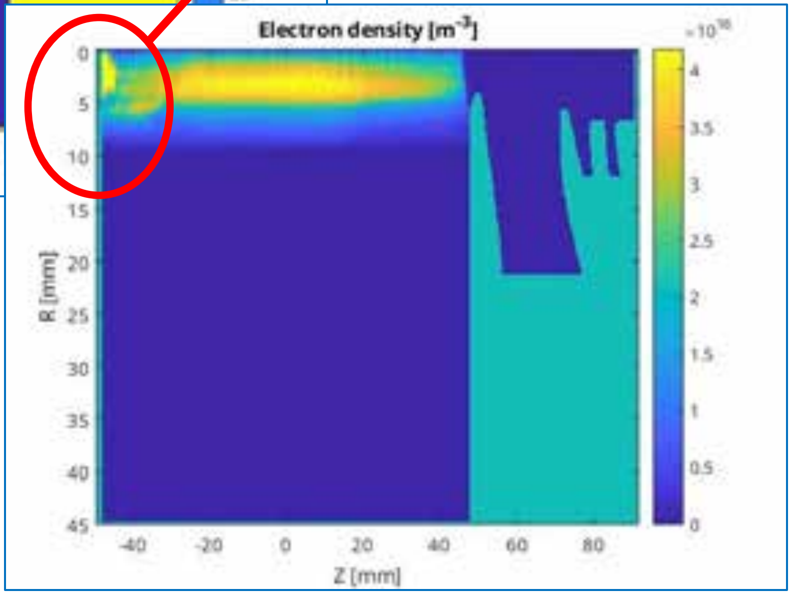
- **3D Initialization** of 1E7 particles
- **3D MagnetoStatic** simulation
- **3D** (2.45GHz) **ElectroMagnetic** simulation with tensorial complex permittivity
  + special treatment of resonances
- **2D Axial Symmetric ElectroStatic** simulation with **adaptive** time step up to 4E-12 s
- **3D Motion of Electrons** (Boris mover)
- **3D Motion of Ions** (Boris mover)
- Different **Adaptive** techniques to speed up the computation
- **3D 32 Plasma reactions** (e^-, H^+, H_2^+, H_3^+, H_2, H, H_2^v, H^n)
- **3D** Interaction with **Walls:** particle loss, secondary electrons, reflection
- **The End**

Background:
HSMDIS project 2022-2024:



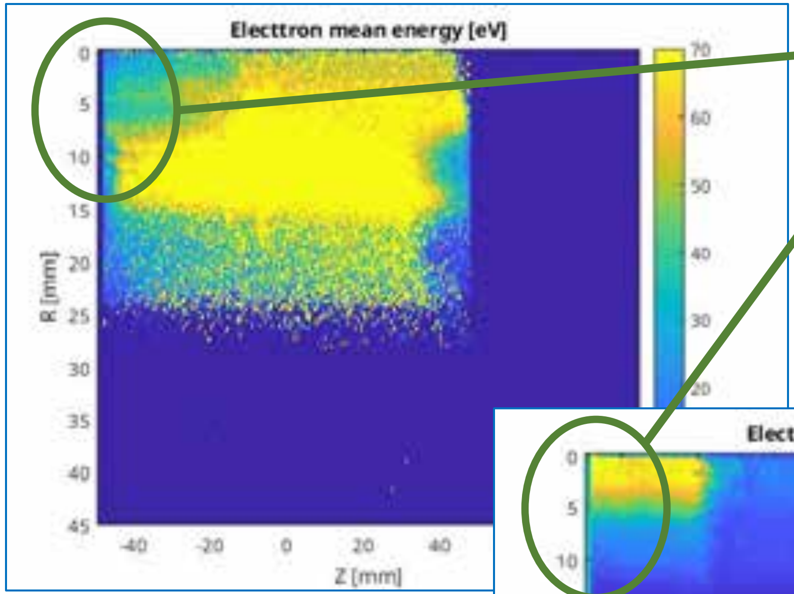
Background:
HSMDIS project 2022-2024:

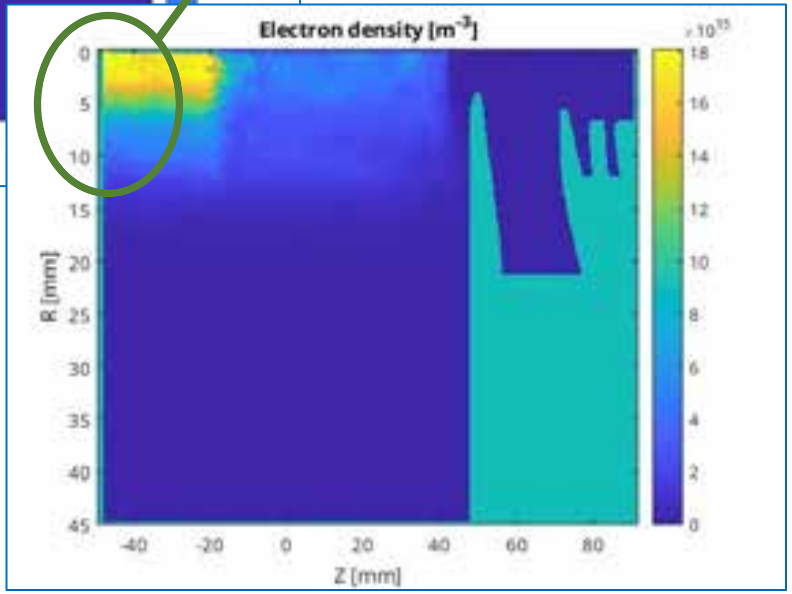




High Temperature
+
High Density
+
Insulating material
=
Overheating

MIDS





Low Temperature
+
High Density
+
Insulating material
=
NO Overheating

HSMIDS

INFN-CSN5

Virtual Versatile Ion Production (VVIP)

Software tools for the development of various ion sources

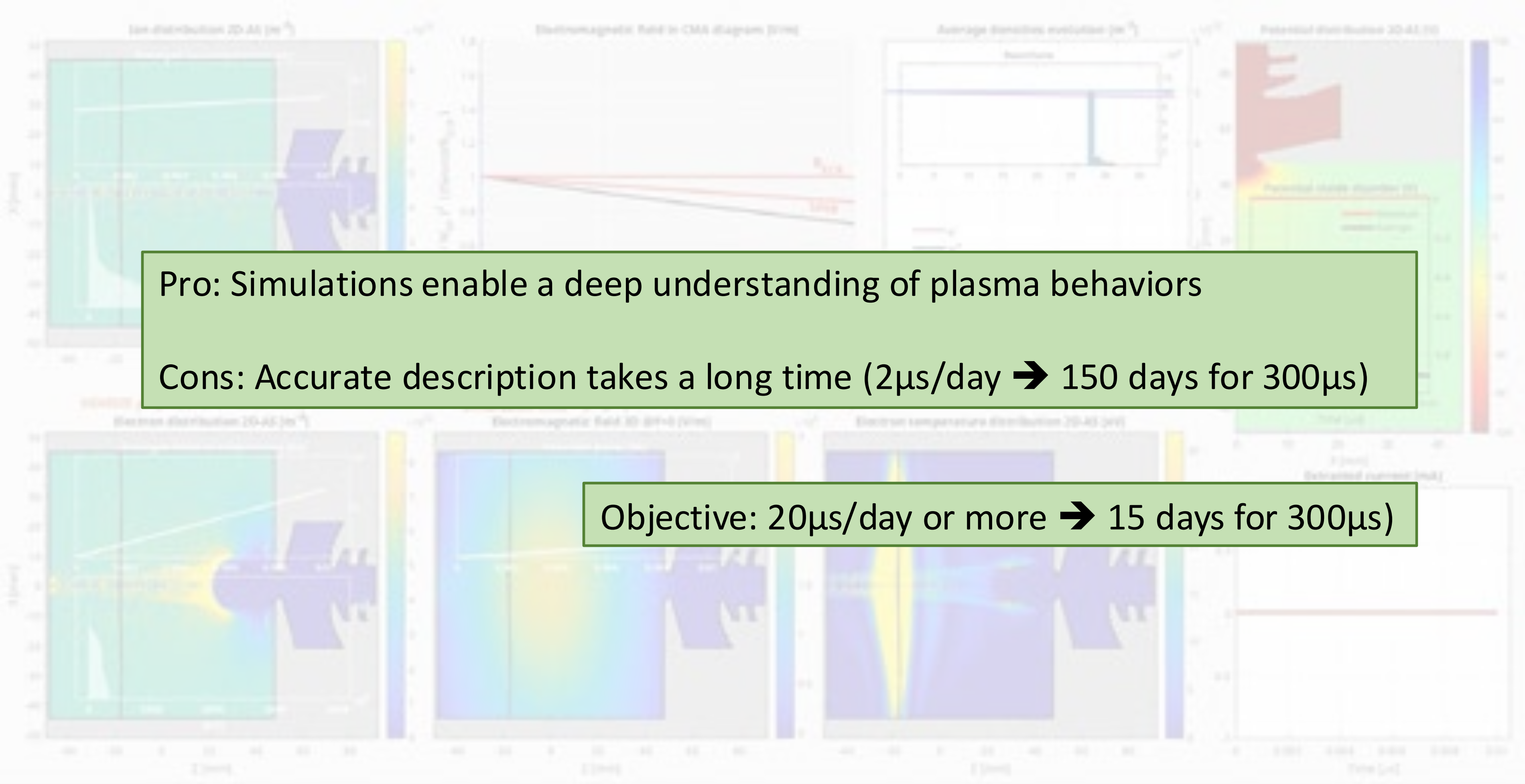
P.I. Lorenzo Neri

INFN-LNS

UNICT-DMI, INGV, CNR-ISTP, CERN

Software tools for the development of various ion sources
Objectives:

1) Optimization of the existing 2.45 GHz ECR H^+ ion source simulation tool



Pro: Simulations enable a deep understanding of plasma behaviors

Cons: Accurate description takes a long time (2µs/day ➔ 150 days for 300µs)

Objective: 20µs/day or more ➔ 15 days for 300µs)

Software tools for the development of various ion sources
Objectives:

2) Development of a (simplified) 3D version for ECRIS at 14-18 GHz (INFN-LNS like)

SERSE

AISHA

CAESAR

Software tools for the development of various ion sources
Objectives:

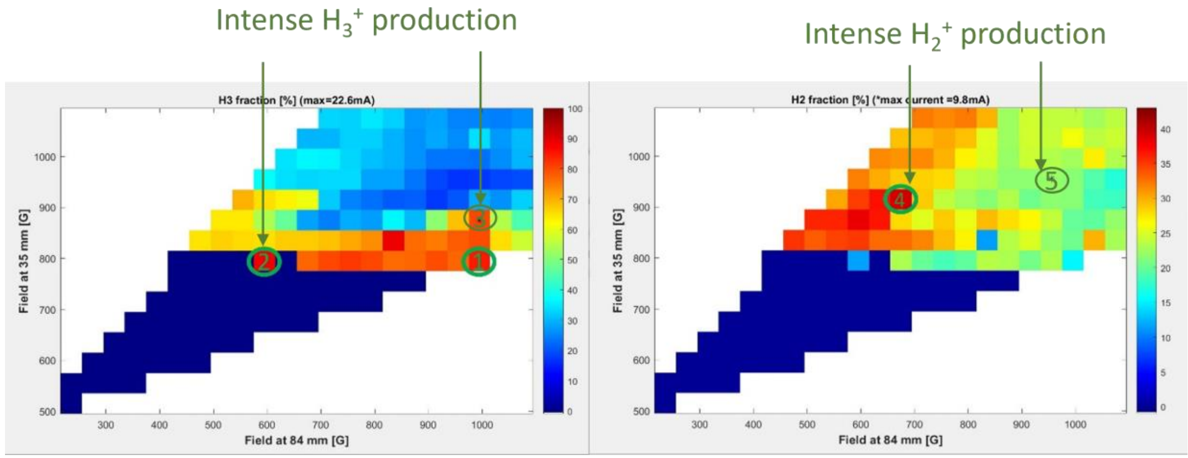
3) Simulation of 2 MHz H^- ion sources (CERN like)

Dear Lorenzo,
Thanks again for our discussion 2 weeks ago.
In view of a collaboration with your source simulations studies we can offer:

- Some beam time at the Linac4 test stand in proton and/or H- mode in quite many configurations (Emittance meter, RFQ box, short LEBT, compact extraction/IS04...). Note that as soon as the L4 spare RFQ is available (by the end of the Summer) priority will be given to its operation until October 26.
- Some beam time at the societal application test stand where we have 3 sources available (2 ECRs and a NEC) where studies are on going on source extractions. At the time, we are operating in proton mode but very soon, one of the source will be switched to He for preparation of the Carbon RFQ commissioning.
- Give you more details on our Linac4 source setup (RF antenna, extraction ,...).
- We can also give you the support of one of the ABP group computing scientist should you find the need.

Let us know if the above sounds good to you and I'll be happy to go further into more details.
All the best,
Jean-Baptiste and Edgar.

Measurements on PS-ESS



Measurements of H_2^+ and H_3^+ production with 2.45GHz I.S. are compatible with Ion-Ion Plasma production for H^- I.S.

Reference: https://doi.org/10.1063/1.5050029

Software tools for the development of various ion sources
Objectives:

1) Optimization of the existing **2.45 GHz** ECR H^+ ion source simulation tool
2) Development of a (simplified) 3D version for ECRIS at **14-18 GHz** (INFN-LNS like)
3) Simulation of **2 MHz H^-** ion sources (CERN like)
4) Investigation about the possibility of producing **H^-** with ECR at **2.45 GHz**
5) Simulation of **He^{++}** ion sources for medical applications
6) Feasibility study of a **custom electromagnetic solver**

Experimental activities

Dear Lorenzo,
Thanks again for our discussion 2 weeks ago.
In view of a collaboration with your source simulations studies we can offer:

- Some beam time at the Linac4 test stand in proton and/or H- mode in quite many configurations (Emittance meter, RFQ box, short LEBT, compact extraction/IS04…). Note that as soon as the L4 spare RFQ is available (by the end of the Summer) priority will be given to its operation until October 26.
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All the best,
Jean-Baptiste and Edgar.

First year: data collection on ECRISs to be compared with simulations

Second year: data collection on Linac4 proton mode to be compared with simulations

Third year: data collection on Linac4 H^- mode to be compared with simulations

(Experiments on ECRISs of INFN-LNS upon availability)

Objective 1: Collect data to design new application versions
Objective 2: Compare data with simulations

Timeline

WP1: CPU-GPU porting

- **2026** MS1 June: Installation of the new PC
- **2026** MS2 December: GPU implementation of 2D-axial-symmetric Poisson solver
  - **2027** MS5 May: Installation of the new GPUs
  - **2027** MS6 December: GPU particle mover fraction of conversion and performance report

WP2: New solvers

- **2026** MS3 December: 3D Poisson solver with new geometry
  - **2027** MS7 December: 3D Poisson solver on GPUs efficiency report
    - **2028** MS11 December: 3D Electromagnetic solver feasibility study report

WP3: Chemistry

- **2026** MS4 December: H*, H2*, and H^- chemistry impact on simulations
  - **2027** MS8 December: He chemistry report

WP4: Applications

- **2027** MS9 December: 20μs/day simulation speed of H^+ 2.45GHz version
- **2027** MS10 December: 14GHz ECRIS version performance and capabilities report
  - **2028** MS12 December: H- 2MHz version performance and capabilities report
  - **2028** MS13 December: H- 2.45GHz version performance and capabilities report
  - **2028** MS14 December: He++ version performance and capabilities report

Full Time Equivalent

• Lorenzo Neri	INFN-LNS	0.9
• Ornella Leonardi	INFN-LNS	0.1
• Giovanni Russo	UNICT-DMI	1
• Armando Coco	UNICT-DMI	1
• Sebastiano Boscarino	UNICT-DMI	1
• Giuseppe Bilotta	INGV	1
• Giampiero Colonna	CNR-ISTP	0
• Annarita Laricchiuta	CNR-ISTP	0
Total		**5.0**

Budget

First year:

- 75 k€ server with 384 cores and 1.5TB RAM compatible with GPU
- 10 k€ IT Consulting for GPU code development
- 1 k€ AI Toolkit for GPU code development
- 4 k€ mission at CERN

Second year:

- 60 k€ NVIDIA H200 GPU
- 5 k€ IT Consulting for GPU code development
- 1 k€ AI Toolkit for GPU code development
- 4 k€ mission at CERN

Third year:

- 2k€ consumo
- 1 k€ AI Toolkit for GPU code development
- 4 k€ mission at CERN

Request for host institution: INFN-LNS

- Hosting a 5U rack-mount server (availability confirmed by Emidio Giorgio)

LAser-Plasma Accelerator with Capillary in thErapy

Dr Sahar Arjmand

INFN - LNS

General Goals

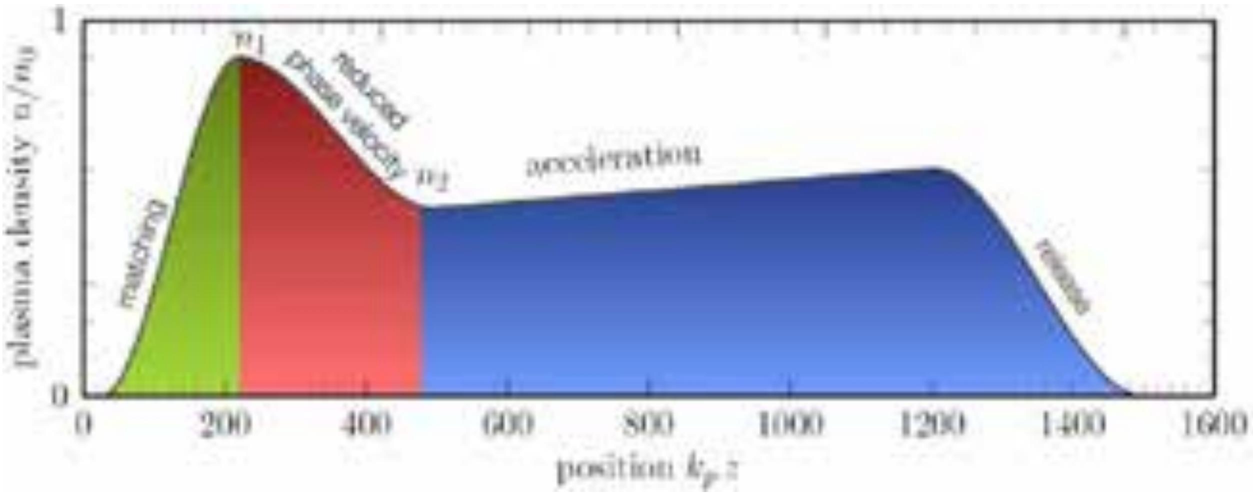
- Developing a novel **electron source** for VHEE beams in the 50–250 MeV range for RT applications using **laser-plasma** approach;
- A **preformed plasma**—created via gas discharge **in a capillary**—serves as a laser waveguide for the formation of a plasma cavity and the acceleration of electrons.
- **Increasing the charge** per bunch to values higher then 200 pC also for possible future FLASH-RT applications;
- **Stabilizing** the energy and the charge of the electron beams;
- Developing a **computational approach** based on the combined use of hydrodynamic and Monte Carlo (MC) simulations coupled with machine learning (ML) approaches, to optimise the capillary shape and its coupling with the laser.

Activity-I, Novel Capillary Design

Developing of a **novel** capillary **never** realised before:

“**One-body, dual-gas capillary enabling two-stage acceleration in a single channel**”.

- Sharp over the first 1 cm long, 350 um diameter
- Tapered over the next 2 cm, 350-300 um diameter



Expected density profile from the new capillary system

Outputs

- Improving the charge per bunch and beam quality and energy for laser-plasma electron acceleration for VHEE applications with potential application in FLASH.
- Realise the first prototype of capillaries in collaboration with the SourceLAB company that will participate with an in-kind contributions
  - Non-disclosure agreement (NDA) already signed;
  - A draft contract has already been negotiated with the INFN Technology Transfer Committee (TTC) and the company and will be finalized if the project receives funding.

Impatto su divisioni e servizi LNS, eventuali necessità di spazi

- “Servizio sviluppo apparati sperimentali” -
  - For mechanical design support
  - For control system support
- “reparto elettronica e rivelatori”
  - For diagnoistic detector configuration
- “Reparto elettronica, convertitori di potenza, diagnostica ed automazioni”
  - Support to the electric circuit for the plasma discharge