CdS 12 luglio 2022

Note

Flavia Groppi

Situazione esperimenti presso la Sezione di Milano 2022

Continuano con responsabilità locale:

ASTRACT	RL	Marco Prioli
Ion2neutral	RL	Massimilano Romè
IONS	RL	Andrea Locatelli
MC_INFN	RL	Paola Sala
NAMASSTE	RL	Paolo Arosio
~~PROTHYP~~	~~RL~~	~~Ivan Veronese~~
REMIX	RL	Flavia Groppi
QUANTEP	RL	Valentino Liberali
SL_COMB2FEL	RL	Vittoria Petrillo

Continuano con responsabilità Nazionale:

~~ADAMANT~~	~~RN e RL~~	~~Bruno Paroli~~
ASTAROTH	RN	Davide D'Angelo
	RL	Andrea Zani
ISPIRA	RN e RL	Vera Bernardoni
~~LPA2~~	~~RN e RL~~	~~Dario Giove~~
~~SCARLET~~	~~RN e RL~~	~~Carlo Fiorini~~
~~SL_EXLN~~	~~RN e RL~~	~~Andrea Renato Rossi~~
~~TRAMM~~	~~RN e RL~~	~~Daniele Sertore~~

30 sigle in corso nel 2022.
Chiudono **8 sigle** di cui **2** che avevano chiesto il prolungamento

Nuovi con responsabilità locale:

DIODE	RL	Alberto Fazzi
MICRON	RL	Alberto Bacci
NEXT_ AIM	RL	Cristina Lenardi
QUB_IT	RL	Stefano Carrazza
SAMARA	RL	Michele Bertucci

Nuovi con responsabilità Nazionale:

ETHIOPIA	RN	Vittoria Petrillo
	RL	Gianluca Galzerano

CALL:

* ~~ARCADIA~~	~~RL~~	~~Massimo Caccia~~
* ~~NEPTUNE~~	~~RL~~	~~Stefano Agosteo~~
N3G	RL	Stefano Capra
FRIDA	RL	Dario Giove
HASPIDE	RL	Valentino Liberali
HYDRA2	RL	Romualdo Santoro
SIG	RN	Lucio Rossi

Grant Giovani:

* ACTIS	RN e RL	Marcello Rossetti Conti

Legenda

Acceleratori e Tecnologie Applicate:	8 + 1 +1
Rivelatori, elettronica e informatica:	7 + 3
Fisica Interdisciplinare:	7 + 2

*** Chiede prolungamento 2022**

Situazione esperimenti presso la Sezione di Milano 2023

Continuano con responsabilità locale:

ASTRACT	RL	Marco Prioli
DIODE	RL	Alberto Fazzi
Ion2neutral	RL	Massimilano Romè
IONS	RL	Andrea Locatelli
MC_INFN	RL	Paola Sala
MICRON	RL	Alberto Bacci
NAMASSTE	RL	Paolo Arosio
NEXT_ AIM	RL	Cristina Lenardi
QUANTEP	RL	Valentino Liberali
QUB_IT	RL	Stefano Carrazza
REMIX	RL	Flavia Groppi
SAMARA	RL	Michele Bertucci
SL_COMB2FEL	RL	Vittoria Petrillo

Continuano con responsabilità Nazionale:

* ASTAROTH	RN e RL	Davide D'Angelo
ETHIOPIA	RN e RL	Gianluca Galzerano
* ISPIRA	RN e RL	Vera Bernardoni

30 sigle in corso nel 2022 diventano
28 nel 2023
di cui **3** chiedono il prolungamento

Nuovi con responsabilità locale:

CUPRUM_TTD	RL	Flavia Groppi
FUSION	RL	Davide Bortot
MATHER_3D	RL	Ivan Veronese

Nuovi con responsabilità Nazionale:

BNCT_SPECT	RN e RL Carlo Fiorini
MOONLIGHT	RN e RL Bruno Paroli

CALL:

FRIDA	RL	Dario Giove
HASPIDE	RL	Valentino Liberali
HB2TF	RN e RL	Dario Giove
HYDRA2	RL	Romualdo Santoro
N3G	RL	Stefano Capra
SIG	RN	Lucio Rossi

Grant Giovani:

* ACTIS RN e RL Marcello Rossetti Conti

Legenda

Acceleratori e Tecnologie Applicate:	7 + 2 + 1
Rivelatori, elettronica e informatica:	7 + 3
Fisica Interdisciplinare:	7 + 1

*** Chiede prolungamento 2023**

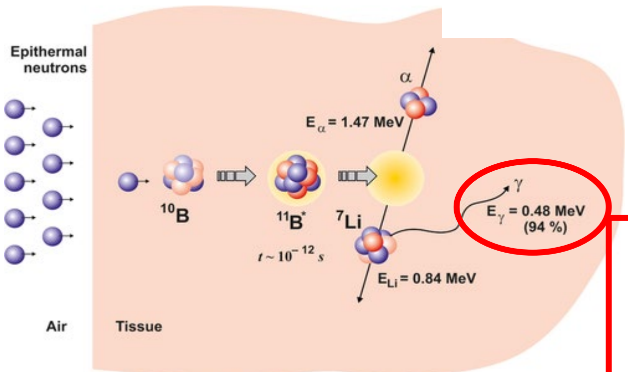
NUOVI ESPERIMENTI con

Responsabilità NAZIONALE e LOCALE

BNCT_SPECT
Development of a SPECT prototype for dose measurements in BNCT (Boron Neutron Capture Therapy)

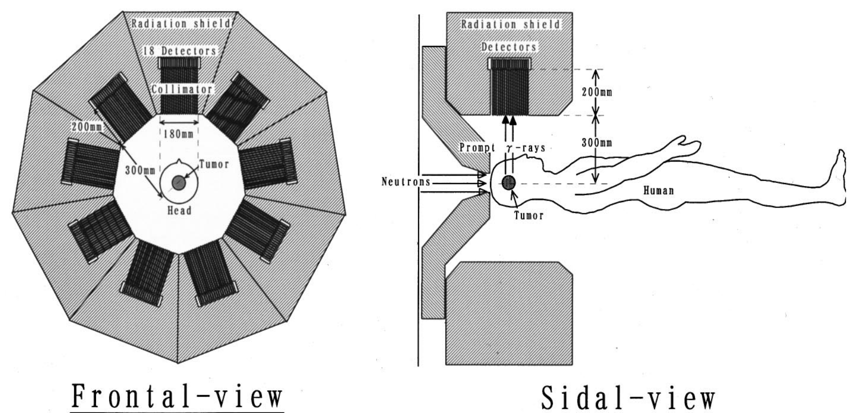
The problem: dose verification by online imaging of ^{10}B-capture prompt-gamma rays

$$^{10}B + n \rightarrow {}^{7}Li + \alpha + 2.79\ MeV \quad (6.1\%)$$
$$^{10}B + n \rightarrow {}^{7}Li^{*} + \alpha + 2.31\ MeV \quad (93.9\%)$$
$$^{7}Li^{*} \rightarrow {}^{7}Li + \gamma + 0.478\ MeV$$



Detection of emitted **478 keV gamma photons** may let to estimate ^{10}B neutron captures and support therapeutic outcome (personalized dosimetry).

BNCT: tumor cells are damaged thanks to neutron capture by ^{10}B in neutron-irradiated tissues. New accelerator-based neutron sources are now available.



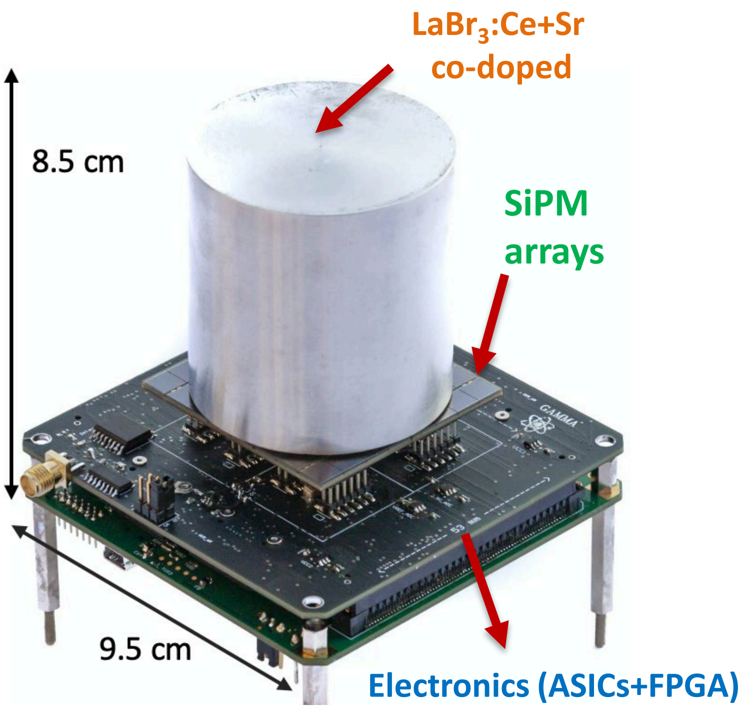
(T. Kobayashi et al. Med Phys. 2000)

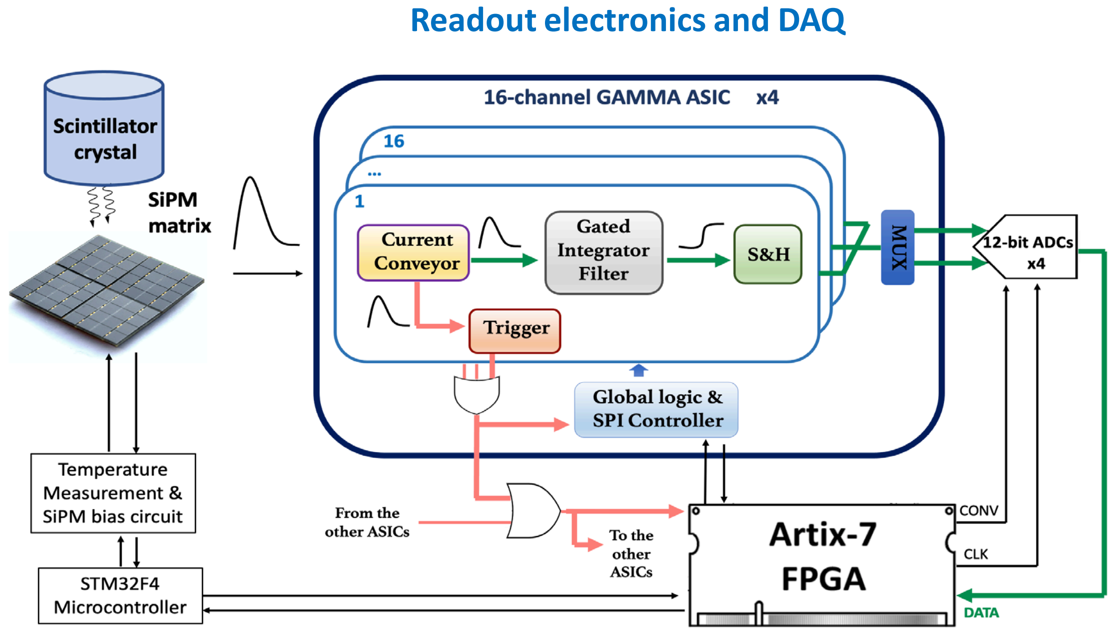
Main detector specifications:

- Good efficiency and energy resolution at 478 keV (to separate it from 511 keV annihilation photons)
- Spatial resolution: 5-10mm (limited by the collimator)
- Possibly, extended efficiency up to 2.2 MeV (H-capture) for neutron flux estimation

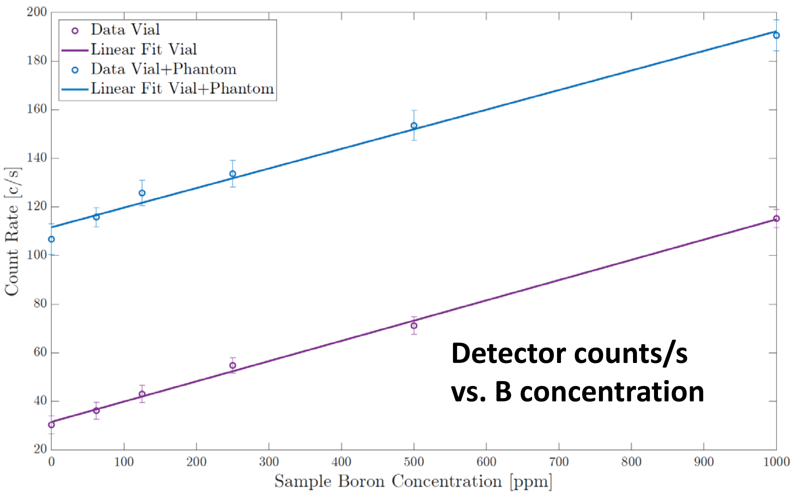
Preliminary studies: the BENEDICTE detector

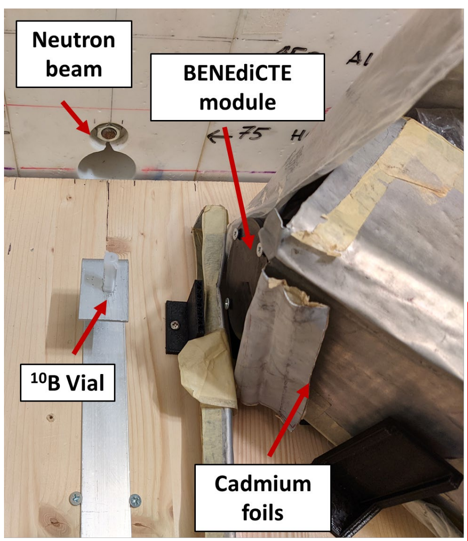
BENEdiCTE (Boron Enhanced NEutron CapTurE) is a gamma-ray detection prototype, based on a $LaBr_3$:Ce scintillator crystal optically coupled with a matrix of 8x8 **Silicon Photomultipliers**. The SiPMs are read out by 4 custom 16-channels **ASICs**.



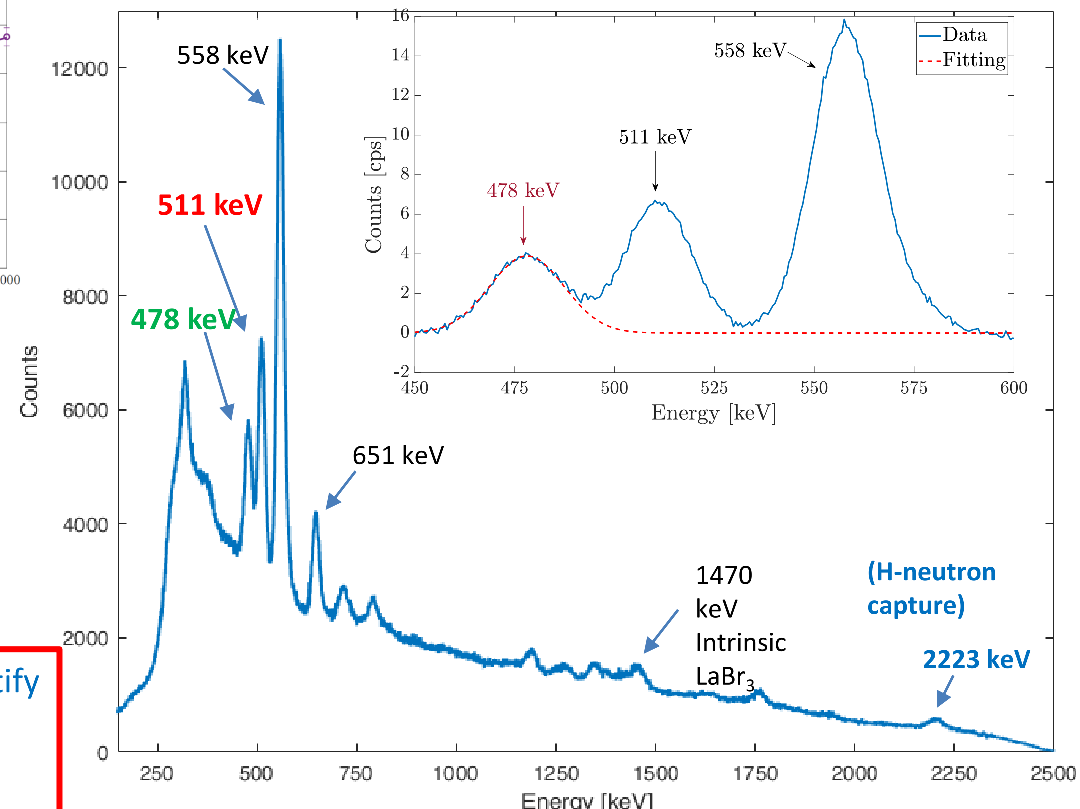


Measurements at TRIGA MARK II nuclear reactor in Pavia





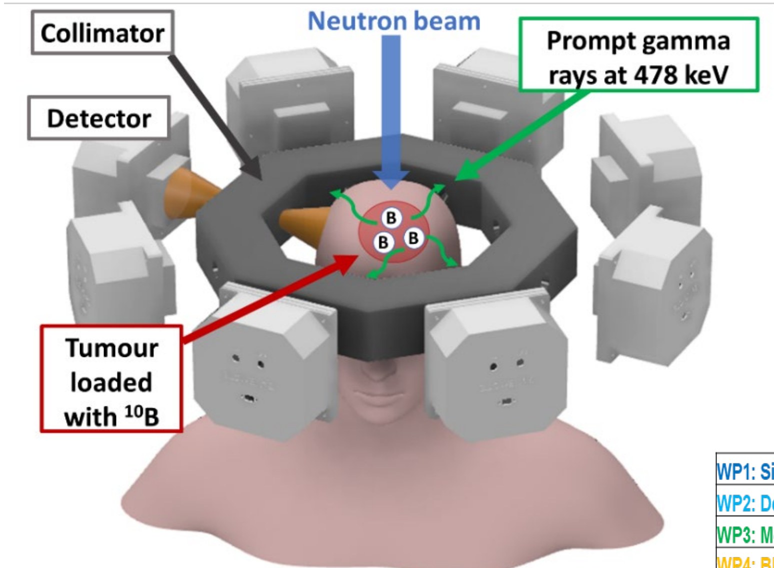
- Capability to identify 478 keV γ-rays demonstrated!
- B-concentration down to 65 ppm measured!



POLITECNICO MILANO 1863
INFN

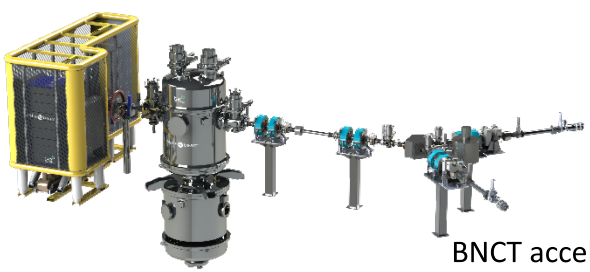
BNCT_SPECT: objectives, structure and goals

Goal: Development and validation of a SPECT detector for dose measurements in BNCT



WP1 (INFN-MI): Simulation of neutron fields and gamma+neutron fluxes on the detector; computational study of shieldings and collimators.
WP2 (INFN-MI): Development of the gamma-ray detector, electronics, collimation system.
WP3 (INFN-MI): Characterization measurements in laboratory: spectroscopy and imaging.
WP4 (INFN-BA): BNCT-dedicated tomographic reconstruction
WP5 (INFN-PV): Beam tests at nuclear reactor and with accelerator-based BNCT sources (CNAO, Birmingham, Helsinki)

Month:	1-3	3-6	7-9	10-12	13-15	16-18	19-21	21-24	25-27	28-30	31-33	34-36
WP1: Simulations of neutron fields. Study of shieldings				M1		M5						
WP2: Development of the gamma-ray detector, electronics, collimator				M2						M8		
WP3: Measurements in laboratory: spectroscopy and imaging								M6				
WP4: BNCT dedicated tomographic reconstruction				M3				M7				
WP5: Beam tests at nuclear reactor and with accelerator-based sources				M4								M9



p-Li reaction
Proton energy 2.5 MeV
Intensity 10-15 mA

BNCT accelerator @CNAO (>2023)

Milestones:

M1 (12m): Simulations of irradiation fields as well as signal and background on the detector.
M2 (12m): First prototype of the detector ready, including subcomponents for the detector procured (scintillator, SiPMs, ASICs) and DAQ system.
M3 (12m): First release of the Tomography reconstruction algorithm.
M4 (12m): Characterization of neutron beam at UNIPV LENA PGNAA facility using neutron activation measurements and Bayesian unfolding methods.
M5 (18m): Conclusion of shieldings studies and procurement.
M6 (24m): Results from experimental characterization of the detector in the laboratory (spectroscopy and imaging) and in beam test at the reactor.
M7 (24m): Tomography reconstruction algorithms ready.
M8 (30m): Development of further detector modules (up to 4 additional modules) concluded. Construction of SPECT prototype system concluded.
M9 (36m): Results from beam tests of the prototype in accelerator-based neutron sources. Final release of the BNCT-specific reconstruction algorithm.

2 mesi uomo officina per realizzazione involucro meccanico rivelatore e altre lavorazioni.

BNCT_SPECT: organization and costs

Partecipanti

Milano-INFN	
C.Fiorini (**RN**, PO)	40%
A.Caracciolo (PhD)	100%
A.Bourkadi Idrissi (PhD)	100%
B.Pedretti (Post Doc)	100%
D.Mazzucconi (Post Doc)	20%
S.Agosteo (PO)	10%
D.Bortot (RTDb)	10%
A.Pola (PA)	20%
Pavia-INFN	
N.Protti (**RL**, PA)	20%
V.Pascali (PhD)	100%
Bari-INFN	
G.Pugliese (**RL**, PA)	20%
G.Iaselli (PO)	20%
D.Ramos (PhD)	100%
TOT.	**6.6 FTE**

Costi: 2023

Milano-INFN	
Missioni	**2,1**
(missioni LENA 0.6k, missione Birmingham 1.5k)	
Inventario	**15,0**
(Scintillatore LaBr3 quadrato 50x50x20, 13k)	
(PC per DAQ e controllo strumentazione in misure al reattore/fascio 2k)	
Consumo	**52,5**
(Tiles SiPMs 9k, ASICs 15k, PCBs 5k, Componenti 6k, FPGA 2k)	
(Setup 3k, Cavi 2k, Meccanica 3k, Collimatore 2.5k, Schermature 5k)	

Pavia-INFN	
Missioni	**0,5**
(missioni Bari 0.5k)	
Consumo	**10,0**
(Dispositivi e rivelatori per caratterizzare il fascio di neutroni)	7,0
(Altro consumo per allestire setup misura al LENA)	3,0
Servizi	**5,0**
(Beam time al LENA 5k)	

Bari-INFN	
Missioni	**1,0**
(missioni LENA 1.0k)	

TOT. **86.1k**

Costi: 2024+2025

Inventario:	**35k**
Consumo:	**37k**
Servizi:	**10k**
Missioni:	**11k**
Tot:	**93k**
(MI+PV+BA)	

RICHIESTA SERVIZI:
2 mesi uomo officina per realizzazione involucro meccanico rivelatore e altre lavorazioni.

Proposta nuovo esperimento CSN5

Quantum protocol via local detection of OAM entangled states in pulsed light *MOONLIGHT*

Sezioni coinvolte: **Milano**
Coordinatore Nazionale: **Bruno Paroli (INFN-MI)**
Durata**: 2 anni**

Obiettivo Esperimento:

Sviluppo teorico e sperimentale di un protocollo quantistico del tutto innovativo, che permetta il trasferimento d'informazione usando solo una piccola porzione del fascio ricevuto e realizzi di fatto il trasferimento d'informazione quantistica, sfruttando le proprietà uniche degli stati di momento angolare orbitale di fotoni entangled.

Introduzione:

Il nostro fine è sviluppare un protocollo che codifichi l'informazione quantistica degli stati di momento angolare per comunicazioni a lunga distanza ed alta densità.

Quindi abbiamo tre obiettivi da raggiungere:

1) Codificare più stati quantistici di momento angolare orbitale utilizzando un laser pompa impulsato per trasferire codici, che possano essere distinti nel tempo.

2) Sviluppare un sistema parallelo di comunicazione classica, perfettamente integrato e sincronizzato al sistema di comunicazione quantistica, che permetta di selezionare le coppie di fotoni entangled a distanza.

3) Utilizzare tecniche di proiezione degli stati di momento angolare orbitale ad elevata efficienza.

Inoltre, punto fondamentale:

Novità: Realizzare la decodificata dell'informazione quantistica, sfruttando solo una piccola porzione del fascio ricevuto.

Attività previste primo e secondo anno

Il progetto è basato su tre Work-Packages (WP): WP1: sviluppo modello del protocollo quantistico, WP2: sviluppo della sorgente impulsata e rivelatore locale, WP3: sviluppo del sistema di sincronizzazione a lunga distanza.

WP1: dedicato allo sviluppo del modello con la definizione del protocollo per il trasferimento d' informazione quantistica e per lo sviluppo dei metodi di codifica/decodifica.

WP2: dedicato alla realizzazione della sorgente impulsata di Parametric Down-Conversion (PDC) per la codifica delle informazioni, utilizzando fotoni entangled, nella variabile momento angolare orbitale, e all'integrazione del rivelatore locale per la ricezione e decodifica delle informazioni.

WP3: dedicato alla realizzazione di un sistema ottico di proiezione degli stati di momento angolare orbitale ad alta efficienza e al sistema di trasmissione classico per sincronizzare il trasmettitore e il ricevitore a lunga distanza.

Personale Milano

B. Paroli (Resp.N.) (PA)	60%
M. Paris (PO)	30%
S. Olivares (PA)	20%
M. Potenza (PA)	40%
S. Cialdi (PA)	30%
M. Siano (assegnista)	50%
TOTALE FTE	**2.3**

Preventivi primo anno

Sezione	Missioni	Consumo	Inventariabile	TOT
Milano	0	28 k€ Laser a diodo, accoppiatori in fibra, materiale per sviluppo trasmettitore e sorgente impulsata, elementi ottici per sviluppo sistema di proiezione degli stati.	0	**28 k€**

NUOVI ESPERIMENTI con

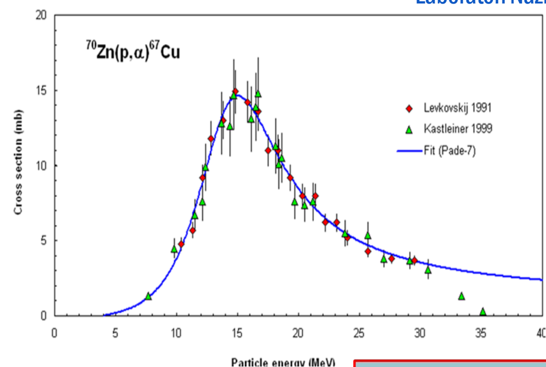
Responsabilità LOCALE

CSN5 INFN new research project proposal
(2023-2025)

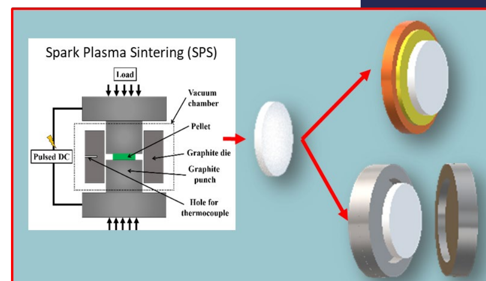
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

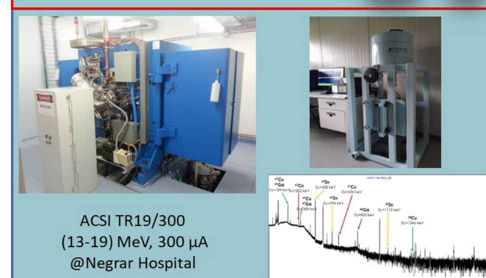
CUPRUM-TTD

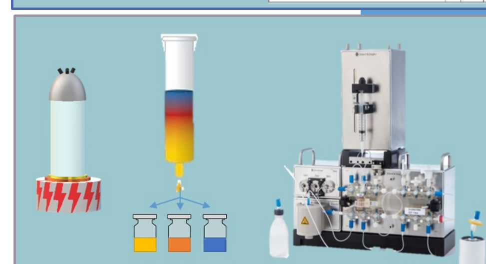
67/64CU PRoduction and Use in Medicine – Target Technology Development



J. Esposito *(RN e LNL) Sezioni partecipanti + UNIPD / UNIFE / SCDC (Negrar, VR) / IOV/ Padua Univ. Hospital /ICMATE CNR Padua)*







Anagrafica LNL 2023	FTE: 4.8
Esposito J.	0.5
Pupillo G.	0.2
Mou L.	0.2
Sciacca G.	0.5
Cisternino S.	0.4
Melendez-Alafort L.	0.4
Bello M.	0.8
Kotliarenko A.	0.5
Keppel G.	0.1
Anselmi-Tamburini U.	0.2
Borsista***	1.0

Anagrafica INFN-PD 2023	FTE: 1.5
De Nardo L.	0.5
Canton L.	0.1
Zorz A.	0.2
Paiusco M.	0.2
Cecchin D.	0.2
Bolzati C.	0.2
Barbaro F.	0.1

Anagrafica INFN-FE 2023	FTE: 3.95
Martini P.	0.55
Di Domenico G.	0.1
Taibi A.	0.1
Boschi A.	0.7
Uccelli L.	0.5
Marvelli L.*	1.0
Carnevale A.*	1.0

Anagrafica INFN-MI 2023	FTE: 2.2
Groppi F.	0.4
Manenti S.	0.4
Cagnetta F.	0.4
Bolchini F.C.**	1.0

* associazione INFN-Fe da settembre 2022
** associazione INFN-Mi da settembre 2022
*** contratto da firmare a ottobre 2022

TOTALE FTE 12.45

Richieste finanziare 2023: 120 kEuro

State of the art and background experience on emerging Cu radiometals

Cu-67 ($T_{1/2}$ ≅ 62 hrs) **promising radionuclide** for **Theranostic and Radio Immuno Therapy (RIT) applications,** as single isotope, or in pair with **^{64}Cu** ($\beta^{+/-}$emitter, $T_{1/2}$ 12.7 h).

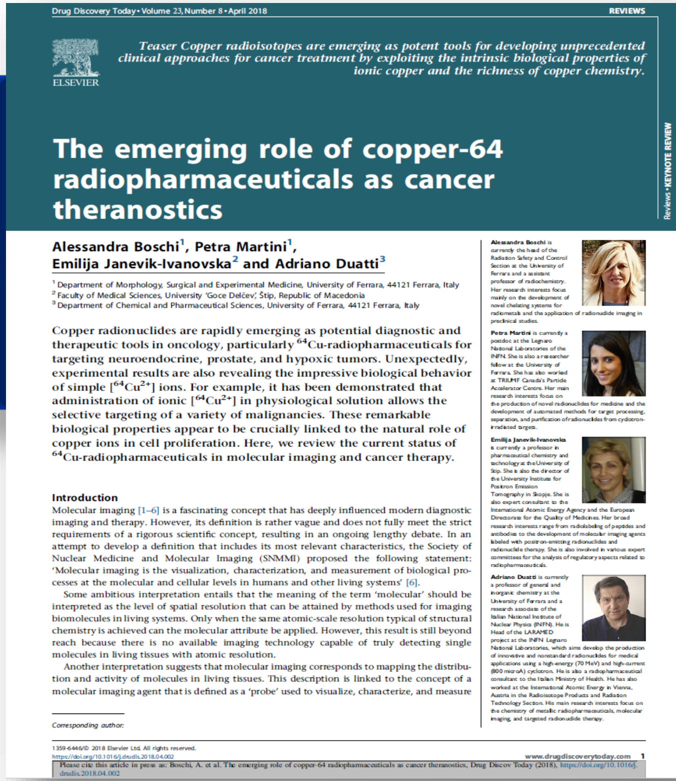
- ^{64}Cu is ALREADY used in nuclear medicine for PET diagnostic procedures
- ^{64}Cu seems to provide excellent results also in THERAPY (under simple $^{64}CuCl_2$) for brain tumors

What will it happen by using **^{67}Cu** ?

- ^{67}Cu's limiting factor: Still lacking a **REGULAR availability worldwide**
- Only recently become available in US in enough quantities for **medical research applications (DOE-IP)**
- Production capability upon request **@ ANL-LEAF via $^{68}Zn(\gamma,p)$ nuclear reaction (BNL through the $^{68}Zn(p,2p)$)**
- **→ ^{67}Cu future supply in Europe: Goal both for ARRONAX and LARAMED!!!**

Theranostic = Therapy + Diagnostic

Cu-67 61.83 h	γ-ray [keV]	γ-ray [%]	β energy [keV]	β int [%]	Auger [keV]	Auger [%]
	SPECT		THERAPY			
β- : 100 %	184.6	48.7	51	1.1	0.99	19.14
(Zn-67)	209.0	0.115	121	57	7.53	6.87
	300.2	0.797	154	22.0	83.65	12.09
	393.5	0.220	189	20.0	Mean β- : 141 keV	


Drug Discovery Today • Volume 23, Number 8 • April 2018 REVIEWS

ELSEVIER

Teaser Copper radioisotopes are emerging as potent tools for developing unprecedented clinical approaches for cancer treatment by exploiting the intrinsic biological properties of ionic copper and the richness of copper chemistry.

Reviews • KEYNOTE REVIEW

The emerging role of copper-64 radiopharmaceuticals as cancer theranostics

Alessandra Boschi[1], Petra Martini[1], Emilija Janevik-Ivanovska[2] and Adriano Duatti[3]

[1] Department of Morphology, Surgical and Experimental Medicine, University of Ferrara, 44121 Ferrara, Italy
[2] Faculty of Medical Sciences, University 'Goce Delčev', Štip, Republic of Macedonia
[3] Department of Chemical and Pharmaceutical Sciences, University of Ferrara, 44121 Ferrara, Italy

Copper radionuclides are rapidly emerging as potential diagnostic and therapeutic tools in oncology, particularly ^{64}Cu-radiopharmaceuticals for targeting neuroendocrine, prostate, and hypoxic tumors. Unexpectedly, experimental results are also revealing the impressive biological behavior of simple [$^{64}Cu^{2+}$] ions. For example, it has been demonstrated that administration of ionic [$^{64}Cu^{2+}$] in physiological solution allows the selective targeting of a variety of malignancies. These remarkable biological properties appear to be crucially linked to the natural role of copper ions in cell proliferation. Here, we review the current status of ^{64}Cu-radiopharmaceuticals in molecular imaging and cancer therapy.

Introduction

Molecular imaging [1–6] is a fascinating concept that has deeply influenced modern diagnostic imaging and therapy. However, its definition is rather vague and does not fully meet the strict requirements of a rigorous scientific concept, resulting in an ongoing lengthy debate. In an attempt to develop a definition that includes its most relevant characteristics, the Society of Nuclear Medicine and Molecular Imaging (SNMMI) proposed the following statement: 'Molecular imaging is the visualization, characterization, and measurement of biological processes at the molecular and cellular levels in humans and other living systems' [6].

Some ambitious interpretation entails that the meaning of the term 'molecular' should be interpreted as the level of spatial resolution that can be attained by methods used for imaging biomolecules in living systems. Only when the same atomic-scale resolution typical of structural chemistry is achieved can the molecular attribute be applied. However, this result is still beyond reach because there is no available imaging technology capable of truly detecting single molecules in living tissues with atomic resolution.

Another interpretation suggests that molecular imaging corresponds to mapping the distribution and activity of molecules in living tissues. This description is linked to the concept of a molecular imaging agent that is defined as a 'probe' used to visualize, characterize, and measure

Corresponding author:

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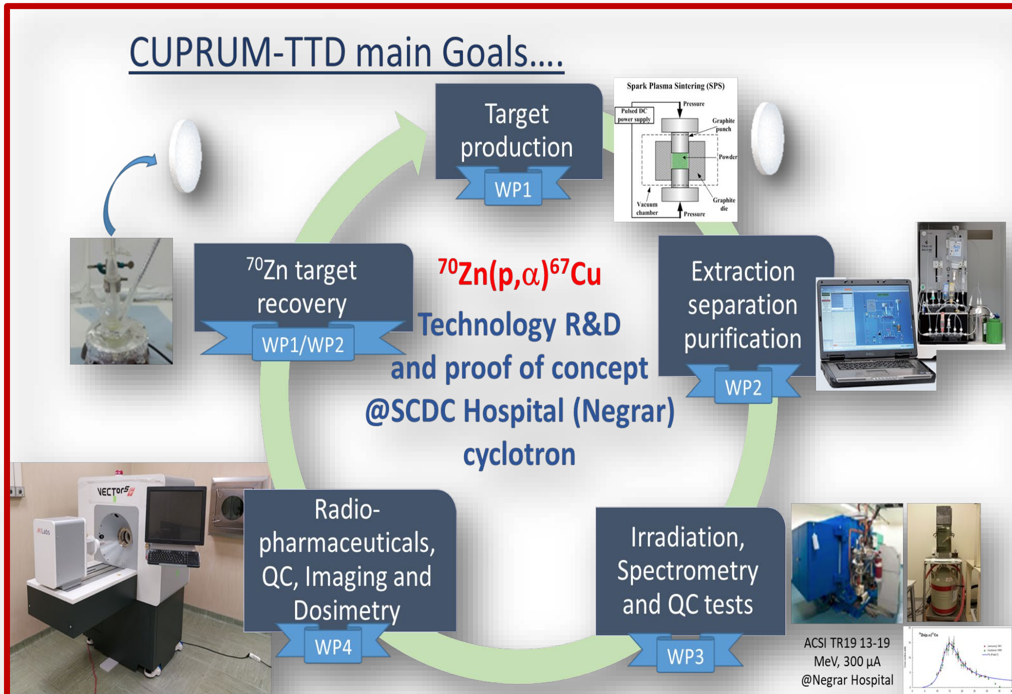
https://doi.org/10.1016/j.drudis.2018.04.002

Please cite this article in press as: Boschi, A. et al. The emerging role of copper-64 radiopharmaceuticals as cancer theranostics, Drug Discov Today (2018), https://doi.org/10.1016/j.drudis.2018.04.002

www.drugdiscoverytoday.com 1

CUPRUM-TTD (2023-2025) research project development

In view of the next preclinical/clincal applications the goal of the current research proposal is therefore to develop beforehand a reliable technology aimed at **producing clinical-grade batches of ^{67}Cu- ^{64}Cu, on a routine basis by small medical cyclotrons.**



Main project GOALS:

a) to acquire a **robust and reliable target manufacturing technology to produce ^{70}ZnO target** (and ^{nat}Ni targets for first ^{64}Cu yield batches from ^{64}Ni(p,n)^{64}Cu at a later stage **);**

b) to design and construct proper targets, able to sustain **beam power levels from medical cyclotrons (i.e. 18-20 MeV, 2/3 kW max)**;

c) to develop/optimize the **radiochemistry separation/purification methods: Zn→Cu** to achieve a clinical-grade **^{67}Cu radionuclide**;

d) Implementation of *in-vitro* survival studies;

e) Pre-clinical and clinical phantom imaging;

f) to develop /optimize technology for the **costly ^{70}Zn-enriched target material recovery.**

CUPRUM-TTD (2023-2025) proposed approach for **phase 1 project:** Target radiochemistry processing studies from ^{nat}ZnO targets @HSCDC

To develop the optimized ^{nat}ZnO targets dissolution / separation /purification system following the first irradiation tests

Tests to be carried out :

- **ICP-OES analysis** (in collaboration with UniFE);
- **gamma-spectrometry measurements** and **QC assessment** (in collaboration UniFE, **UniMI** and HSCDC, Negrar-VR) – MI can support both for the gamma spectrometry measurements and QC assessment with the transportation at LASA of the samples.

CUPRUM-TTD (2023-2025) proposed approach for **parallel phase 2**

To seek for alternative nuclear production routes…

^{67}Cu/ ^{64}Cu (^{61}Cu) **with alpha-induced reactions @ARRONAX– Milan contribution**

- **^{61}Cu**: ^{nat}Ni(α,pxn)^{61,64,67}Cu → energy range 70 – 8 MeV → target: ~20 μm ^{nat}Ni

with the study of contaminants and the determination of: RNP and SA by using the Triga Mark II Nuclear Reactor in Pavia.

- **^{67}Cu**: ^{64}Ni(α,p)^{67}Cu → energy range 30 – 15 MeV → Thick Target Yield, using a thick target produced @LNL
- **^{61}Cu**: ^{59}Co(α,2n)^{61}Cu → energy range 70 – 8 MeV → target: ~20 μm ^{59}Co

with the study of contaminants

Summary overall budget request CUPRUM-TTD FY2023

Sezioni / Lab	Missioni	Consumo/ Altri consumo	Trasporti	Manutenzione	Inventario	apparati	Sp- servizi	Tot. per sez/lab	FTE previsto
LNL	10.0	27.0				26.0		**63.0**	**4.8**
FE	2.5	18.0						**20.5**	**3.95**
PD	0.5	4.0			7.5			**12.0**	**1.5**
MI	8.5	5.0	7.5	4.0				**25.0**	**2.1**
TOTALE	**21.5**	**54.0**	**7.5**	**4.0**	**7.5**	**26.0**		**120.5**	**12.35**

Budget request outlook CUPRUM-TTD FY2024 ~ 220 kEuro (circa 110 kEuro modulo automatico +40 kEuro per ^{70}Zn)
FY2025 ~ 70 kEuro

TOTAL BUDGET request (outlook 3yrs) ~ 410 kEuro

FUSION

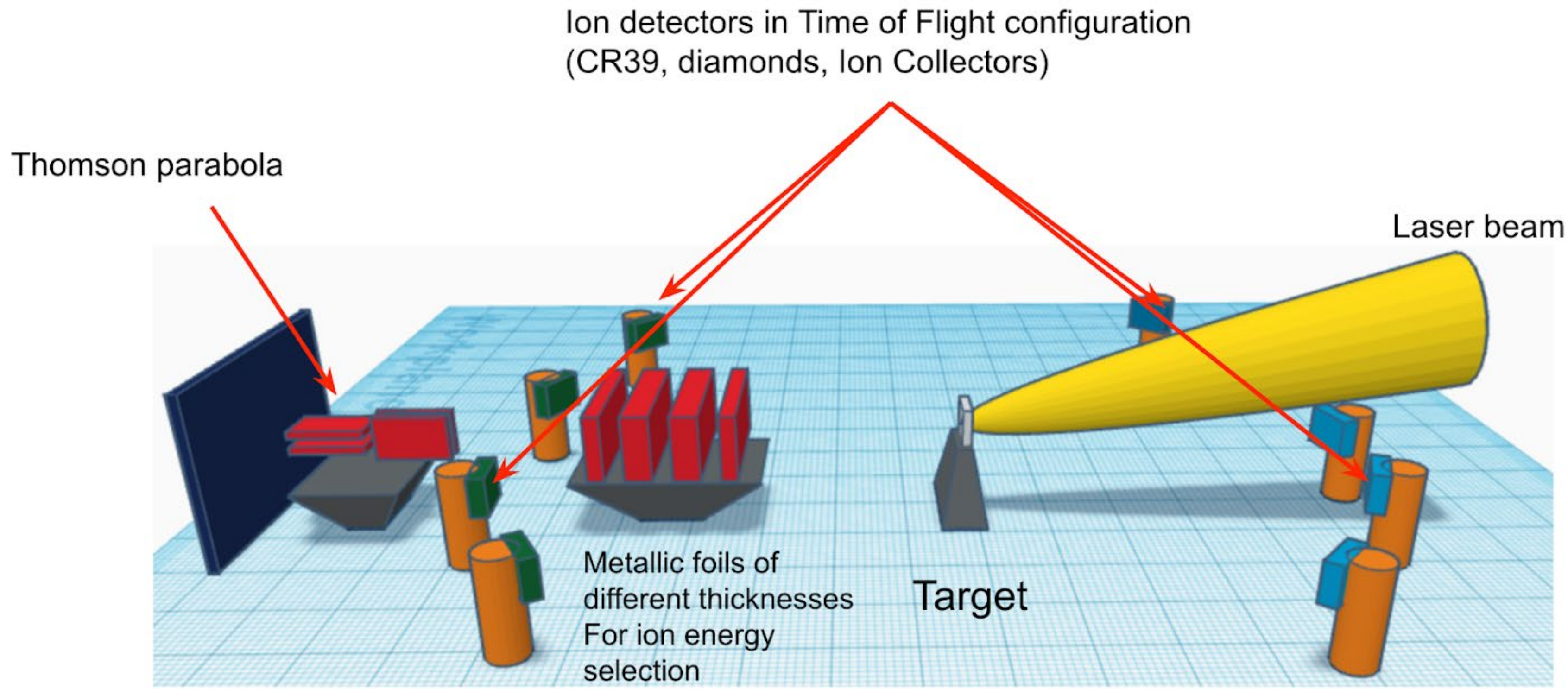
FUsion StudIes of prOton boron Neutronless reaction in laser-generated plasma
2023-2025

Sezioni INFN partecipanti: Catania, Lecce, LNS, **Milano**, Roma2, Torino, TIFPA, Bologna, LNGS, Firenze
Istituti in collaborazione: ELI-Beamlines, HILASE, Physic Institute of Czech Academy of Science (CZ)

Resp. Nazionale: Pablo Cirrone - LNS (FTE 0.5) + Fabrizio Consoli - ENEA (FTE 0.5)
Resp. Locale: Davide Bortot – INFN Milano e PoliMi

Objectives of the FUSION project

Study of the p-11B reaction in a laser generated plasma in order to investigate its possible applications for energetic and multidisciplinary applications



Objectives of the FUSION project

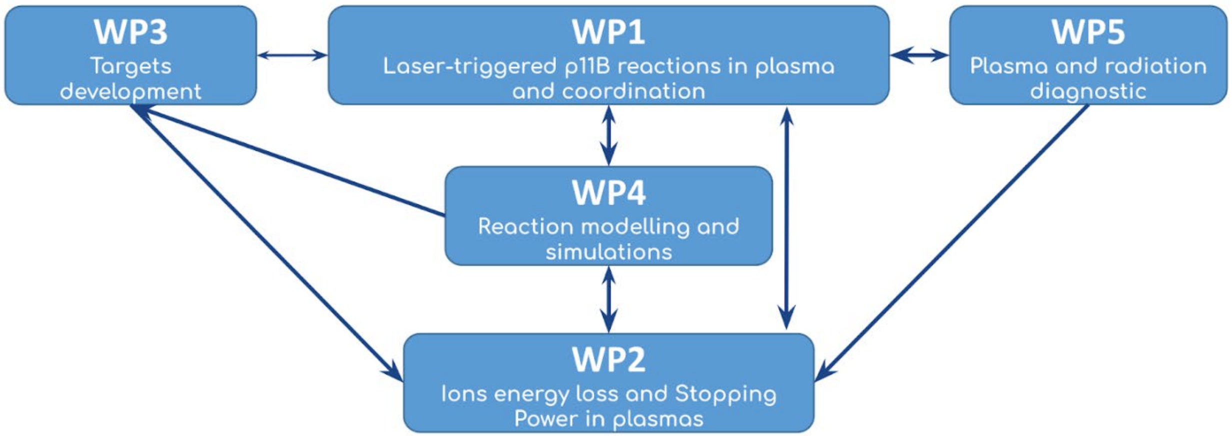
POLITECNICO MILANO 1863

FUSION main goals

- ***Maximisation of the p-11B reaction rate in plasma (WP1).*** This will be done studying the interaction of laser systems of different characteristics with targets of different materials and configurations that will be developed (WP3) and optimized (WP4) with both Particle in Cell (PIC) and fluid-dynamic simulations.

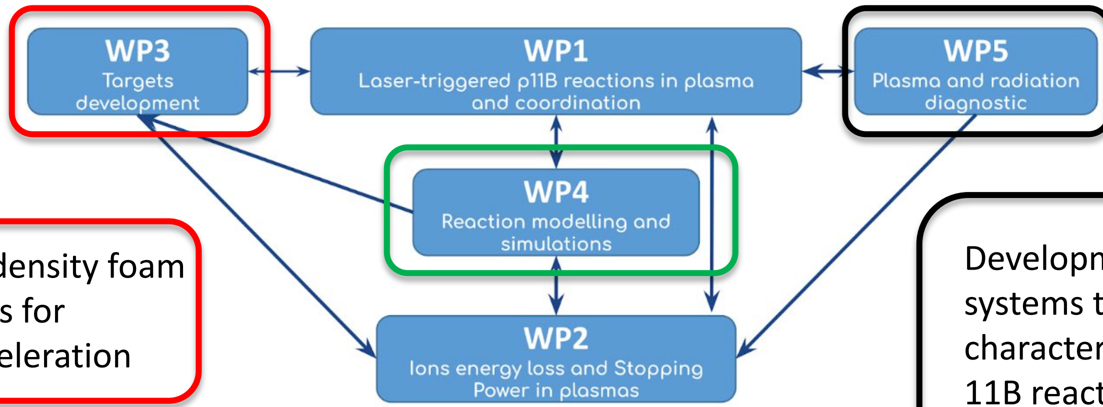
- ***Development of innovative diagnostic (WP5) able to estimate the p-11B reaction rate*** by either looking at the alphas and protons products and investigating reaction channel where neutrons are produced. The diagnostic shall also operate in real-time and able to work at laser shots repetition rate of at least 1 Hz.

- ***Understanding of the physics laying at the basis of the observed p-11B reaction rate***. This will be done studying the interaction of conventional protons and alphas in a Borated expanding plasma (WP2) and coupling them with PIC and Monte Carlo simulations (WP4).



Activities of INFN-Milano (WP3, WP4, WP5)

INFN-Milano. The POLIMI NanoLab is expert in nanostructured and novel materials and on their interaction with lasers. The POLIMI Laboratory of Nuclear Measurements and Electronics and the INFN-LASA group are expert in radiation diagnostic.



Development of low-density foam coatings on Boron foils for enhancing proton acceleration

Development of diagnostic systems that will improve the characterization of radiations in p-11B reactions initiated by laser-matter experiments

Simulation of the physical phenomena at the basis of the laser-matter interaction in the various laser regimes proposed for the project

Activities and requests for 2023

- *Optimization of boron targets for the experiment in laser facilities*
- *Simulations for target parameters optimization*
- *Study and development of a new imaging system based on scintillating fibers*
- *Test of new silicon telescopes for alpha particle characterization with conventional beams*

Nominativo	Qualifica	FTE
Davide Bortot (RL)	RTDb PoliMi	30
Stefano Agosteo	Prof. Ordinario PoliMi	20
Alberto Fazzi	Prof. Associato PoliMi	10
Dario Giove	Ricercatore INFN-LASA	15
Andrea Pola	Prof. Associato PoliMi	20
Davide Mazzucconi	Assegnista PoliMi	10
Matteo Passoni	Prof. Ordinario PoliMi	20
Alessandro Maffini	RTDa PoliMi	30
Davide Orecchia	Dottorando PoliMi	30
Giovanni d'Angelo	Tecnico PoliMi	50
Valeria Conte	Ricercatrice INFN-LNL	0

1st year (2023)		k€
Consumables (15.4 k€)	2 Boron targets	3.7
	Low-noise cables and connectors	2
	Scintillating fiber	2.7
	Fiber lapping and gluing	3
	Micromechanical processing for fiber bundles	4
Instrumentation (14 k€)	CAEN DT5780SCM - Dual Digital MCA+HV	6.8
	Matrix CCD camera + optics	1.9
	Linear camera + telecentric optics	5.3
Travels (5 k€)	Meeting	1
	Experimental campaigns at Catania for test of silicon telescopes	3
	Experimental campaigns	1

MATHER3D (new project)

MAgnetic hyperthermia and hadron THERapy applied to 3D cellular scaffolds

Duration of the project: 3 years

RN – Alessandro Lascialfari (PV)

INFN Units

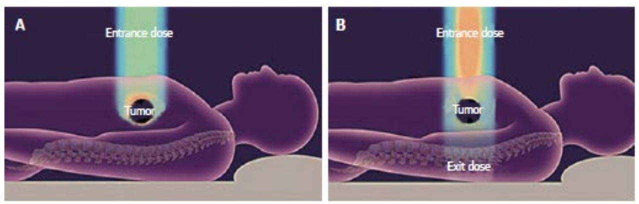
Pavia	-	RL Manuel Mariani
Milano	-	RL Ivan Veronese
Firenze -		RL Claudio Sangregorio

External participants

Fondazione CNAO	- Pavia
IRCCS S. Matteo	- Pavia
Fondazione Maugeri	- Pavia

INTRODUCTION : the clinical techniques

Hadron Therapy (HT)



(A) targeted proton therapy deposits most energy on target;
(B) conventional radiation therapy deposits in a wider area

CNAO

Magnetic Fluid Hyperthermia (MFH)

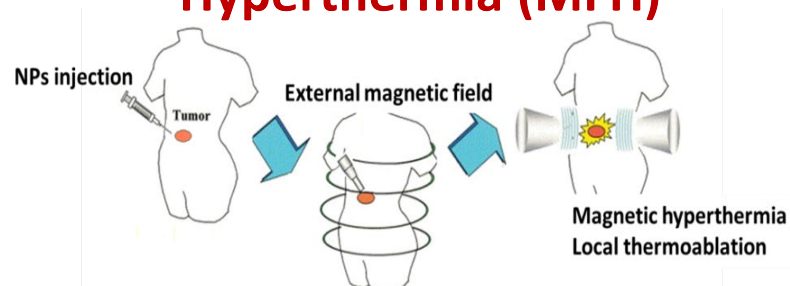
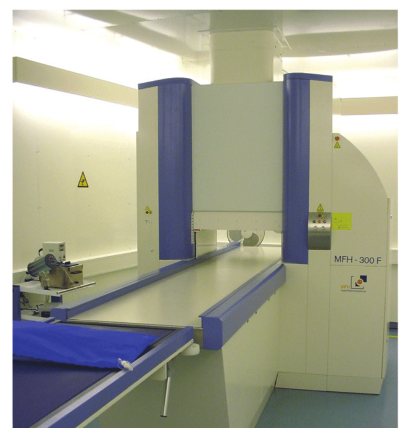


Illustration of MFH concept



Makes use of Magnetic NanoParticles (MNPS)

Clinic (mainly glioblastoma) : Germany, Poland, USA, France, Spain, UK,....

INTRODUCTION : old projects and the new one

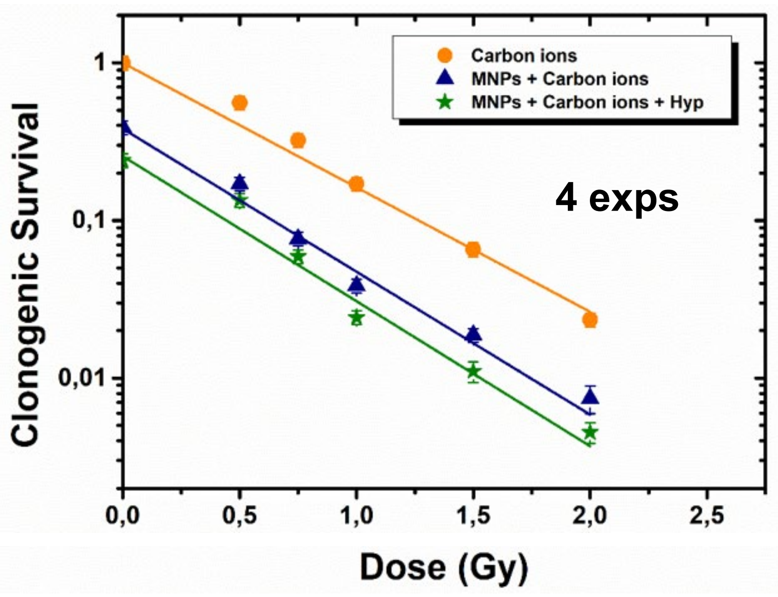
Hadron Therapy and Magnetic Fluid Hyperthermia:

treatments for cancers **where the "classical" therapies fail** - their combination is clinically un-explored

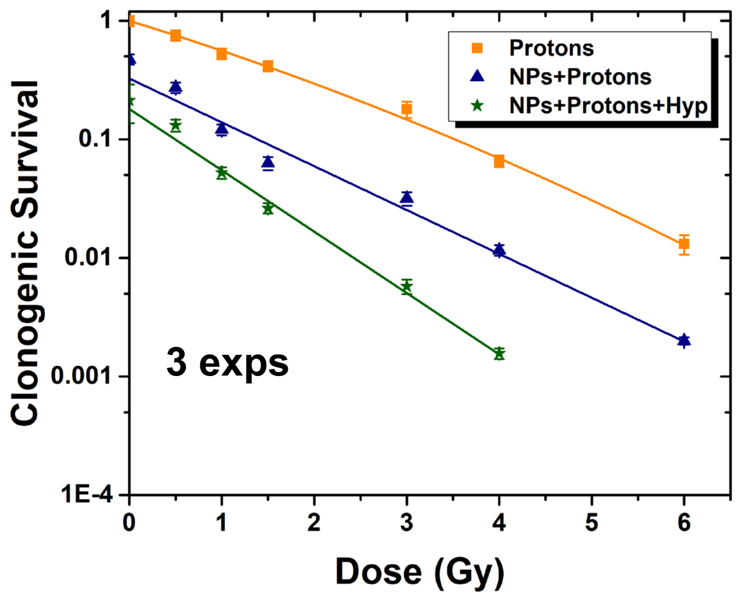
Previous INFN experiments **on BxPC3 pancreatic tumor cells →**

combined HT and hyperthermia work!

HADROCOMBI (carbons), HADROMAG (carbons)



PROTHYP (protons)



Currently proposed experiment : same combination on 3D scaffolds charged with BxPC3 cells containing MNPs

OBJECTIVES

Combined action of HT and MFH techniques
on 3D scaffolds containing **pancreatic BxPC3 tumor cells.**

To translate to clinic : IN-VIVO PRECLINICAL MODELS ARE NECESSARY
but CNAO has not still the beam available for this.

Other translational aspect: HOSPITALS ARE GOING TO INSTALL PROTON THERAPY

*1) **Synthesis** and optimization of **magnetic nanoparticles** and their SAR optimization*

*2) **3D Scaffolds preparation** (natural and, contingency plan, artificial)*

*3) **Inclusion of Cells + MNPs in 3D scaffolds***

*4) **Combined therapies** on 3D scaffolds containing cells+MNPs*

*5) **Effects of therapies on 3D scaffolds** : morphology, DBSs, clonogenic survival*

METHODS : schematic workflow (feedbacks not marked)

Synthesis of Magnetic NPs
(thermal decomposition)

↓

Characterization of MNPs
(SQUID susceptibility and magnetization, NMR, ….)

↓

MFH in solution
(SAR by calorimetric measurements using AC fields with chosen f,H_{AC})

Cells uptaking the MNPs
(24/48 hrs uptake)

3D scaffolds preparation
(de-cellularization of liver parts, synthetic scaffolds)

Preparation of 3D scaffolds charged with cells+MNPs
(to be optimized…………)

MFH on 3D scaffolds containing cells+MNPs
(calorimetry)

↓

Irradiation with combined hadron-therapy and MFH techniques
(protons/carbons irradiation + calorimetric MFH)

↓

Morphological studies, clonogenic survival, DSBs, apoptosis
(biological methods)

Budget (tentative) and FTE-Milano

Budget Milano

Total 18 kEuro

Consumables 16 kEuro
7 reagents/kit for bio exps; 7 ICP/imaging scaffold;
2 AFM/ipertermia materials

Missions 2 kEuro

Other Units Budget

Pavia 50 kEuro
(8 scaffolds; 23 plast/reagents/suppl.; 8 immunoist., etc; lab spares chemicals, electronics, … ; 3 MRI consumables; 4 liquid helium and nitrogen; 1 Laptop for MFH; 3 missions)

Firenze 15 keuro
(5 elio liq+reagenti chimici; 8 gene expression, kit reagents for RNA extraction, primary monoclonal and polyclonal antibodies, etc; 2 missions)

Anagrafica di Milano 2023 – 3.1 FTE

Ivan Veronese (RL) – PA – UNIMI	0.6
Cristina Lenardi - PO - UNIMI	0.2
Flavia Groppi – PA – UNIMI	0.1
Francesco Orsini – PA – UNIMI	0.2
Paolo Arosio – RTDB – UNIMI	0.1
Salvatore Gallo – RTDA -UNIMI	0.6
Simone Manenti - postdoc -UNIMI	0.1
Marco Piazzoni – postdoc–UNIMI (assoc in corso)	0.6
Silvia Locarno – postdoc–UNIMI (assoc in corso)	0.6
TOTALE	**3.1**

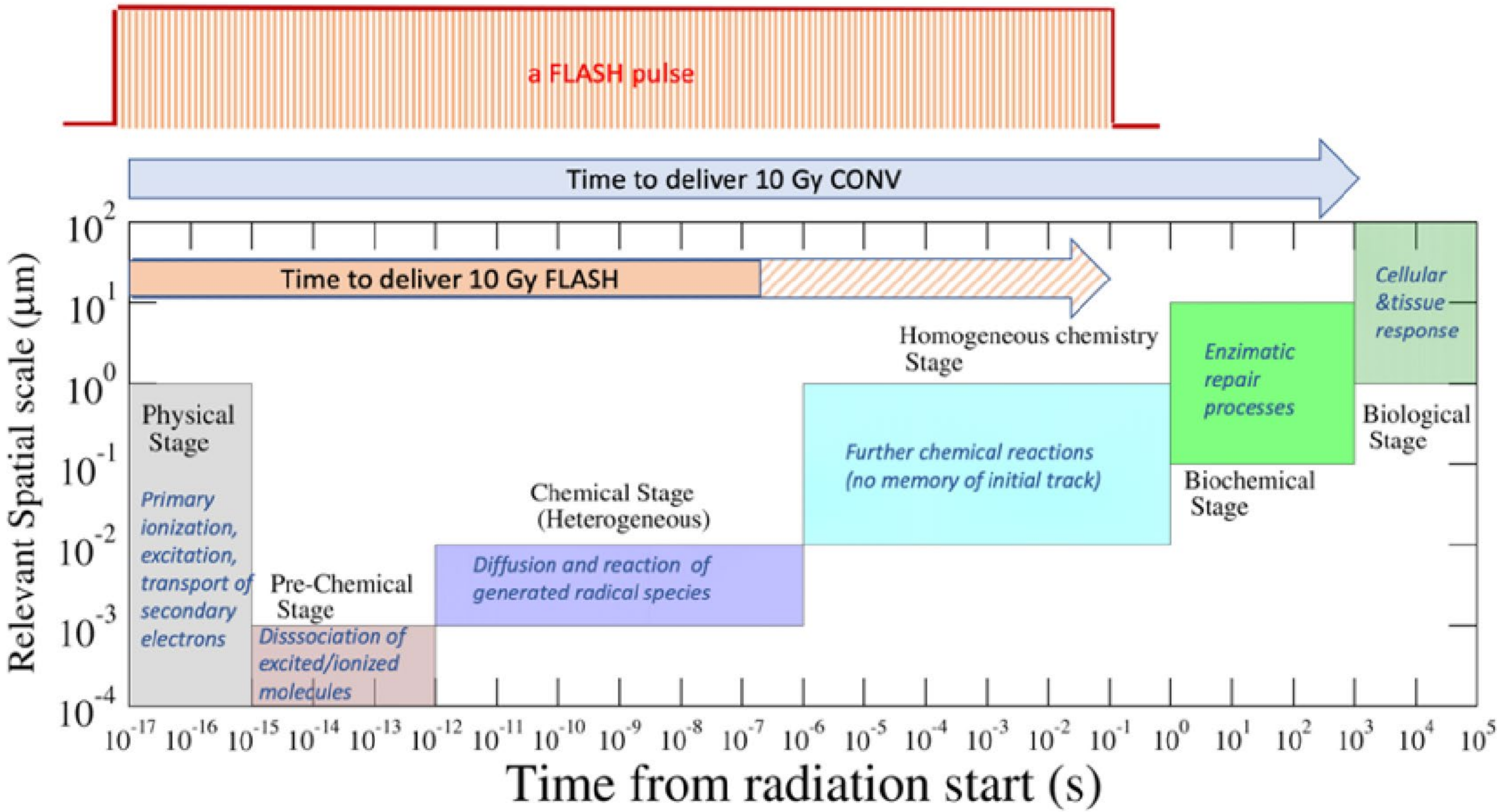
CALL

CALL

FRIDA
FLASH Radiotherapy with hIgh Dose-rate particle beAms

The external beam radiotherapy research community is currently experiencing an exciting time: experimental evidence is growing, supporting the evidence of a considerable normal tissue sparing effect when treatments are delivered with dose rates much larger (100 times or more) with respect to the conventional ones. If confirmed, this so-called ‘FLASH effect’ has the potential to re-shape the future of radiation treatments especially with charged particles, with a significant impact on many oncology patients.
The FRIDA project addresses several challenges posed by this potential revolution. A crucial task is represented by the mechanistic understanding and modeling of the effect. Another key ingredient is the necessary research and development phase in the acceleration and beam delivery fields to provide the required dose rates with a clinically acceptable precision. A final word on the FLASH effect will be said only if novel beam monitoring and dosimetry techniques capable of sustaining very high dose rates will be developed. Finally, software tools for FLASH treatments planning are needed to evaluate the technique potential and enable clinical applications.
Within INFN and CSN5 activities, the knowhow and expertises needed to make a step forward in this field are presently available. Experiments will be carried out at FLASH beam facilities that are (or will be in the near future) available, complementing the multiscale FLASH mechanism modeling efforts. LINAC and laser-plasma techniques will be applied to the delivery of FLASH e- and p beams. Detection and monitoring techniques will be developed and tested, as well as the implementation of software tools needed for the simulation and treatment optimization tasks. All these contributions can be seen as steps towards the FLASH enabling technology.
The FRIDA deliverables will place on solid grounds the future steps made when aiming for the FLASH effect confirmation or disprove and its possible clinical implementation

RL: Dario Giove


a FLASH pulse
Time to deliver 10 Gy CONV
Time to deliver 10 Gy FLASH
Relevant Spatial scale (μm)
Time from radiation start (s)
Physical Stage
Primary ionization, excitation, transport of secondary electrons
Pre-Chemical Stage
Disssociation of excited/ionized molecules
Chemical Stage (Heterogeneous)
Diffusion and reaction of generated radical species
Homogeneous chemistry Stage
Further chemical reactions (no memory of initial track)
Enzimatic repair processes
Biochemical Stage
Cellular &tissue response
Biological Stage

La call FRIDA è organizzata in 4 WP:

WP1:	FLASH effect understanding	(Milano: Silva Bortolussi)
WP2:	FLASH beam delivery	(Milano: D. Giove, L. Serafini, F. Broggi, P. Russo, G. Mettiver, A. Sarnu, R. Massa
WP3:	FLASH Beam Monitoring and Dosimetry	
WP4:	FLASH Treatment Planning	(Milano: G. Battistoni, I. Mattei, S. Muraro, Y. Dong)

Le richieste finanziarie di Milano sono cosi riassumibili:

Missioni	7 Keuro
Inventariabile (WP2)	6 Keuro
Consumo	1 Keuro

HASPIDE: HAmorphous Silicon PIxel DEtector for ionizing radiation

Obiettivo: **Studiare l'uso di silicio amorfo idrogenato (a:Si-H) come rivelatore di particelle per dosimetria clinica e per applicazioni spaziali**

Durata: 2022-2024 (2023: secondo anno)

Unità partecipanti: PG, FI, LE, LNS, MI, TO
Resp. Naz.: Leonello Servoli (PG)
Resp. Loc.: Valentino Liberali
Partecipanti per Milano:

- Valentino Liberali 40%
- Alberto Stabile 20%
- Luca Frontini 20%
- Fabrizio Armani 30%
- SeyedRuhollah (Jafar) Shojaii 20%

HASPIDE: attività di Milano (WP2)

Progettare un chip di lettura del segnale in tecnologia CMOS 28 nm (per dosimetria clinica) e due schede di interfaccia/acquisizione dati (una per dosimetria clinica e una per applicazioni spaziali)

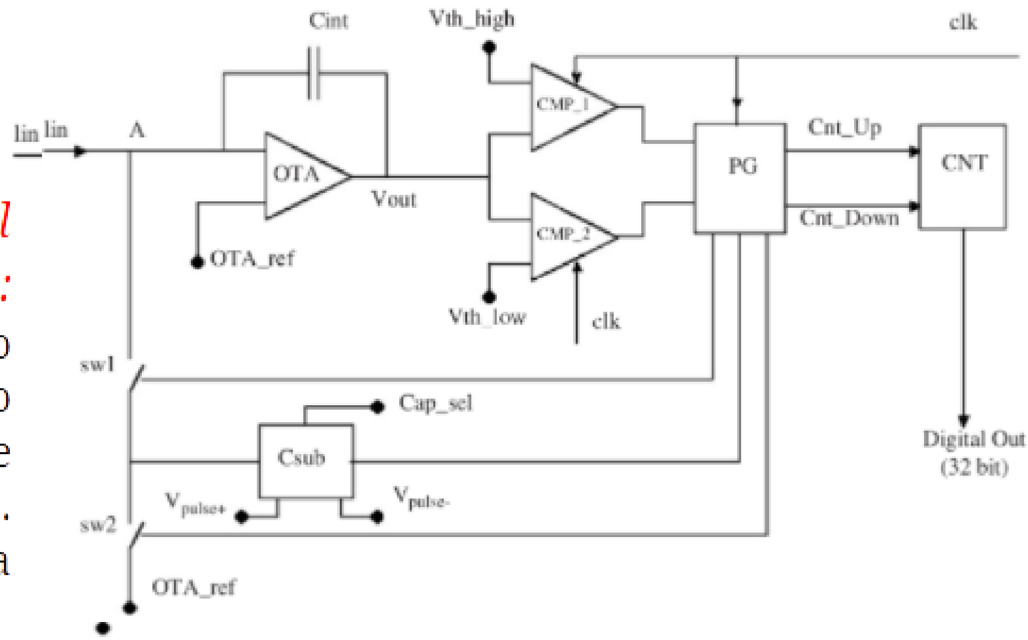
Come chip di lettura per applicazioni spaziali verrà usato un chip già sviluppato dalla sede di Torino.

Unità partecipanti: PG, LNS, MI, TO

Schema di circuito di front-end per il rivelatore per dosimetria clinica:

La corrente generata viene integrata fino al superamento della soglia (positiva o negativa), e viene iniettata una carica che compensa l'integrale.

Il conteggio degli impulsi in uscita dà la misura della dose.



HASPIDE: attività e richieste

Attività e obiettivi 2023:

- Progetto e integrazione del secondo miniASIC
- Progetto della scheda di test per le prime versioni dei rivelatori
- Caratterizzazione dei prototipi e delle schede e interfacciamento con la scheda di lettura

Richieste 2023:

- 20 k€ per 1 miniASIC
- 10 k€ per 2 schede di test (progettazione, fabbricazione e montaggio)
- 24 k€ per assegno di ricerca (1 anno, da chiedere SJ in attesa di capire meglio le nuove regole)

The HB2TF Proposal for a CALL

High-brightness electron beam source is a critical element in the path to the success of upcoming projects, such as linac-based light sources and industrial-scale UV lasers.

Disparate needs are driving injector design in different directions: high beam power for IR and UV FELs, low transverse emittances for linac-based x-ray light sources, and emittance aspect-ratio control for linear colliders.

There are elements common to most of these areas of application, however, which must be addressed regardless of the final application. They include:

- Increasing the duty factor, for higher average performance figures;
- Improving the beam quality, for higher single-bunch performance figures;
- Improving the techniques used to build the guns;
- Increasing the operational reliability of the entire injector system;
- Improving the fundamental electron source, e.g., cathodes and cathode research;
- Improving the basic tools (theory and simulation) used to understand and design injectors.

The present proposal is related to **the development of a High Brightness Beams Test Facility (HB2TF) at the INFN-LASA laboratory**.

The HB2TF Proposal for a CALL

The Test Facility setup will comprise a high-performance laser driven DC Gun followed by a normal conducting RF buncher-acceleration section to provide 1 MeV 5 mA CW electron beam.

The engineering design of a Superconducting RF booster linac able to increase the electron energies up to 5-10 MeV maintaining beam current up to 2.5 mA will be part of the proposal even if its financing and realization will be delegated to other requests.

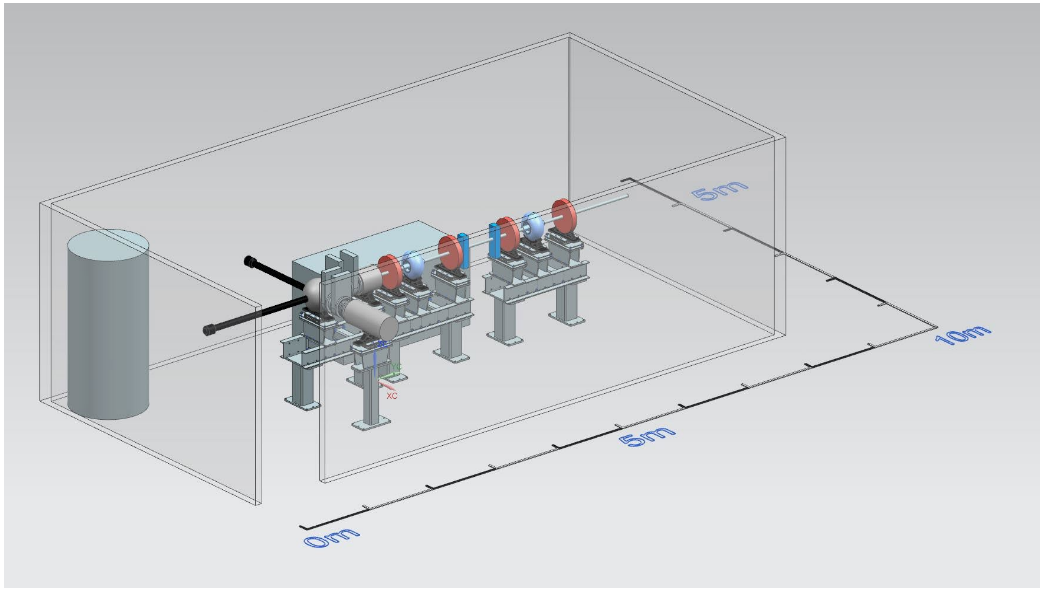
The proposal is aimed to pool different experiences and capabilities so far available in research groups at the LASA laboratory along with the contribution from accelerator groups in other INFN sites and in foreign labs.

Unit	Unit Responsible	FTE Unit	No. Of members
Milano	Giove Dario	5.2	27
LNL	Azzolini Oscar	1.0	5
LNF	Faillace Luigi	0.75	6
LNS	Celona Luigi Giuseppe	0.3	3
Bologna	Sumini Marco	1.0	2
Napoli	Masullo Maria Rosaria	0.5	2
	TOTAL		

The HB2TF Proposal for a CALL

The HB2TF proposal aims to provide a high power and high brightness CW beam. The beam will provide different bunch charges at different repetition rate and energies, as summarized in the table below. This impressive flexibility is part of the originality of the facility and will allow the usage of the beam for some advanced experiments.
To achieve these parameters, we have done an extensive simulation activity to select optimal components and their characteristics to get the design goals.
Under these assumptions, the Facility is composed of different elements that can be grouped into the following sections:

- The DC gun with focusing solenoids.
- The two 650 MHz sub-harmonic bunchers.
- Transport optics.



The HB2TF Proposal for a CALL

The establishment of a Test Facility aimed to the development of high brightness electron beams that may be tuned to allow specific analysis opens the way to future applications in different areas.

Plasma Acceleration Tests
Preliminary simulations carried out on the electron beams produced at HB2TF show that it would be possible their use to verify emerging physical limits and to investigate specific behaviors in plasma acceleration.
Plasma relaxation times to investigate the minimum temporal distance between two successive acceleration processes in the same target: this may be referred as repetition rate limit.
Thermal load limits, due to the effect that any driver-plasma interaction deposes an amount of energy in the plasma itself (i.e. energy not extracted by the witness beam) and, subsequently, in the whole plasma target, increasing its temperature and requiring to correctly dimension a cooling device for avoiding damages.
Setting the HB2TF beam line to have a narrow beam envelope compatible with the plasma target transverse aperture and a bunch short enough to efficiently couple with the plasma wave, may result in the possibility to carry out plasma target stress tests.

keV Ultrafast Electron micro-Diffraction
Recently, a team at Cornell University has designed and commissioned an Ultrafast Electron micro Diffraction (UED) apparatus with sub-picosend temporal resolution. This apparatus is based on a 200 kV DC Gun, two solenoids and a 3 GHz buncher. Using a alkali antimonied photocathode, they generated beams with low intrinsic emittance allowing for micron scale probe size. The HB2TF accelerator is a natural place where the techniques developed at Cornell might have their natural implementation and evolution.

Positronium Beam Generation
The availability of an intense and high quality electron beam as the one specific of this experiment may be very beneficial to carry out tests for a Positronium beam generation as the one foreseen in the QUPLUS experiment.

The HB2TF Proposal for a CALL

The financial request described below has been conceived taking into consideration various aspects:

•the upper boundary in the funding available for the proposal
•a strong reuse of components available at LASA, even though most of these are dated (they are reported in the plan at cost 0 Euros)
•the possibility to proceed with the consolidation of a solid base, even reduced with respect to the optimal one, which can evolve according to additional funding
•the possibility of accessing additional funding during the CALL to complete the structure (for example, the funding request shows only one buncher and the absence of a circulator to protect the power amplifier)

Funding Request

2023	Euro 333.100
2024	Euro 412.000
2025	Euro 254.600
Total	Euro 999.700

WP#	WP name and related milestones	2023				2024				2025			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1	**Project Management**												
	Design of the Test facility Setup	■	■										
	Detailed design og the requirements in terms of power, cooling water, radioprotection and other onventional plants			■	■								
	Project management	■	■	■	■	■	■	■	■	■	■	■	■
WP2	**The Beam Source**												
	Photocathode transfer system adapted to DC gun	■	■										
	DC Gun technical specification ready for call for tender	■	■										
	Laser Pulse for Photocathode generated	■	■	■	■								
	DC Gun Components at LASA					■	■						
	Start of DC Gun assembling						■	■					
	Laser pule characterization and transport to photocathode					■	■	■					
	First Beam with CS2Te photocathode								■	■			
	DC Gun commissioning completed					■	■	■	■	■	■		
WP3	**The Radiofrequency System**												
	EM design of the buncher cavities	■	■										
	Technical Specifications ready for call for tender for all items			■	■	■	■						
	First buncher, RF power chain and control system at LASA							■	■	■			
	Installation complete									■	■	■	
	Commissioning complete										■	■	■
	SC booster linac engineering design report						■	■	■	■	■	■	■
WP4	**The Beam Physics**												
	Machine optimized layout	■	■										
	Optimized WOP for high brightness and space charg dominated beam dynamics			■	■								
	Optimized WOP for Plasma Target Sress Test					■	■						
	Optimized WOP for ultrafast electron micro-diffraction							■	■				
	Machine characterization									■	■	■	■

HiDRa: High-Resolution Highly Granular Dual-Readout Demonstrator

Romualdo Santoro
Univeristà dell'Insubria and INFN-MI

HiDRa: main goal

The project aims at designing, constructing and qualifying on beam a longitudinally unsegmented, highly granular, fibre-sampling DR calorimeter prototype to assess:

- a stand-alone hadronic resolution around 30%/√E or better, for both single hadrons and jets, while maintaining a resolution for isolated electromagnetic (em) showers close to 10%/√E;
- a transverse resolution of O(1 mrad)/√E;
- a longitudinal resolution of a few cm (through timing);
- a modular and scalable construction technique;
- an innovative readout architecture based on SiPMs;
- the performance of Deep Neural Network algorithms in exploiting such a large amount of (3D) information
- ~~The design of a Digital-SiPM that would lead to a simpler and more robust readout architecture (blue–sky R&D)~~

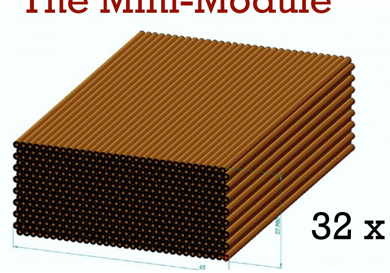
Project Organization

- PI: Roberto Ferrari (PV)
- WP1: Mechanics and fibre characterisation (MI, PI, PV)
  - Responsible: G. Gaudio (PV)
- WP 2: Light sensors (SiPM) (BO, CT, MI, TIFPA)
  - Responsible: M. Caccia (MI)
- WP 3: FEE and DAQ development (BO, CT, MI, PV, TIFPA)
  - Responsible: R. Santoro (MI)*
- WP 4: Performance assessment (MI, PV, RM1)
  - Responsible: G. Polesello (PV)

*Responsabile Locale INFN-MI

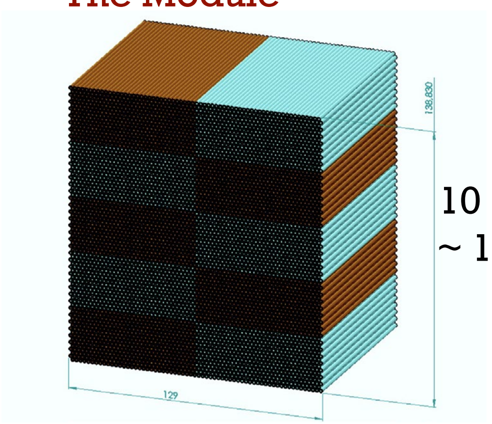
Prototype with hadronic containment

The Mini-Module



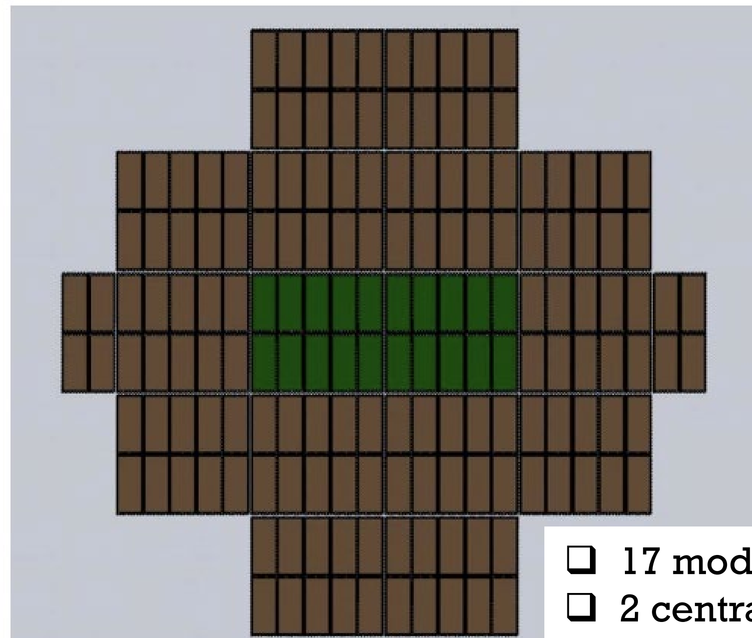
32 x 16 capillaries

The Module



10 Mini-modules
~ 13 x 13 x 200 cm^3

The hadronic prototype

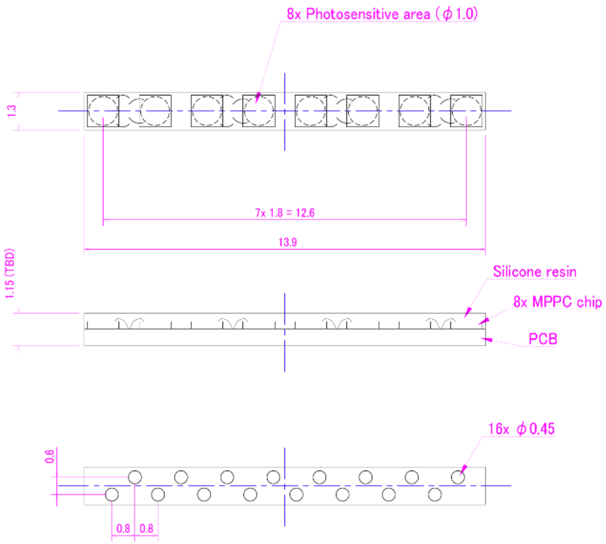


- ❑ 17 modules in total
- ❑ 2 central modules read out with SiPMs
- ❑ 15 modules read out with PMTs
- ❑ ~ 65 x 65 x 200 cm^3

In addition, a small demonstrator equipped with custom designed D-SiPM (64 - channels)

SiPM readout

Custom SiPM module from Hamamatsu

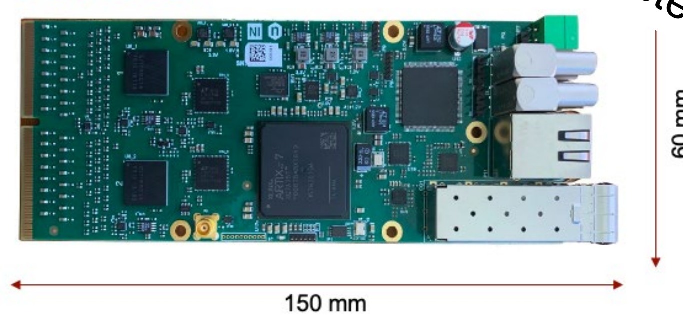


- Custom designed module with 8 SiPMs (1x1mm^2)
- Distance between SiPMs: 2mm
- Two options: 10 and 15 μm pitch
- We are waiting the delivery of a first batch of 10 modules for qualification porpoise

FERS readout system

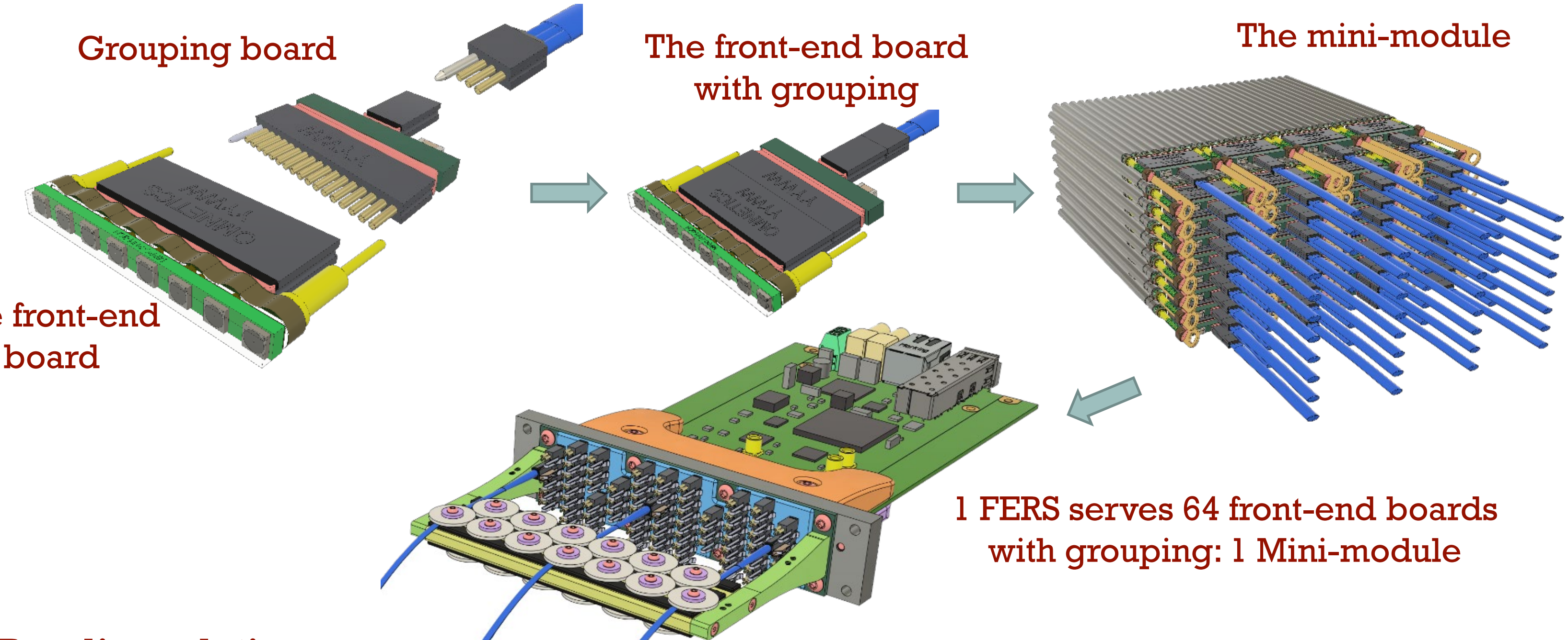
Tested on beam

FERS: A5202



- Two Citiroc1A for reading out up to 64 SiPMs
- One (20 – 85V) HV power supply with temperature compensation
- Two 12-bit ADCs to measure the charge in all channels
- Timing measured with 64 TDCs implemented on FPGA (LSB = 500 ps)
- 2 High resolution TDCs (LSB = 50 ps)
- Optical link interface for readout (6.25 Gbit/s)

FEE-board and cabling

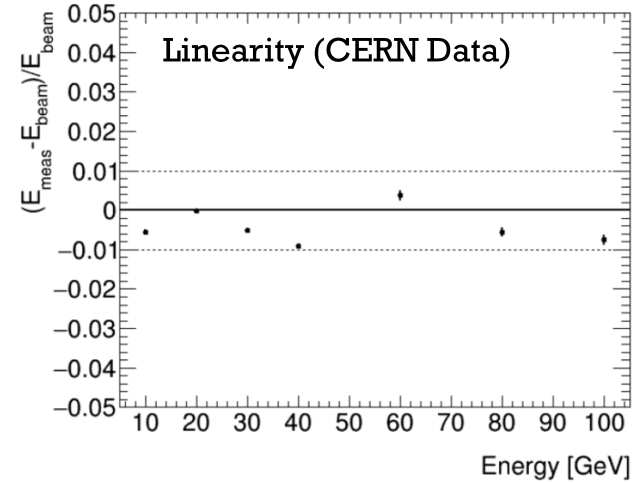


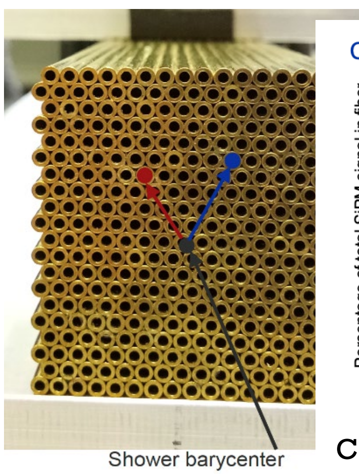
Baseline solution

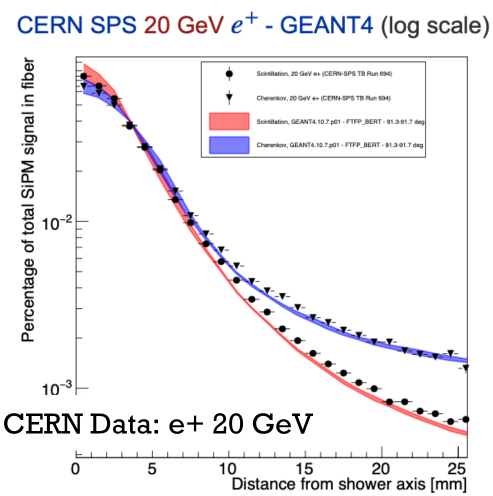
- Each bar of SiPMs will be operated at the same voltage
- The signals from 8 SiPMs is summed up in the grouping board
- 1 FERS operates the full mini-module

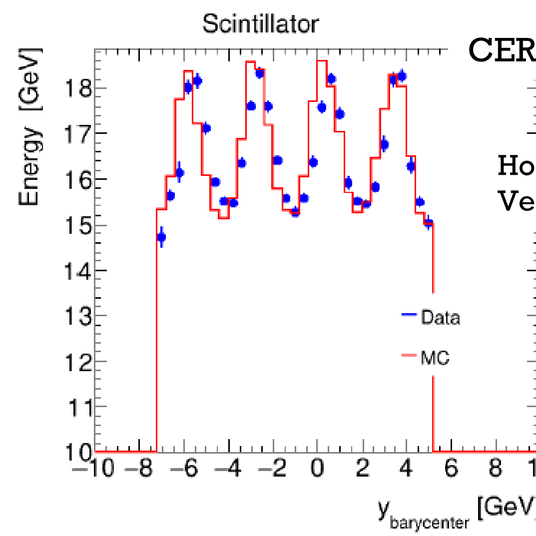
TB results and Monte Carlo comparison

- The 2021 TB data analysis is still ongoing
  - We measured a good linearity with e^+ over the full energy range
  - We are still investigating the impact of instrumental effects on the detector performance
- In this respect a simulation tuned with test beam data is beneficial









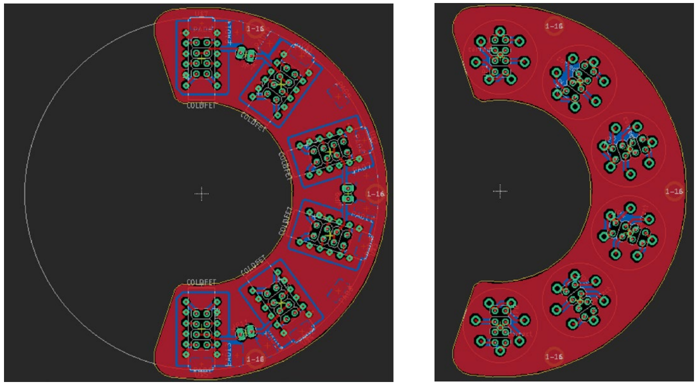
CERN Data: 20 GeV e^+

Horizontal angle: 1.5°
Vertical angle: -0.4°

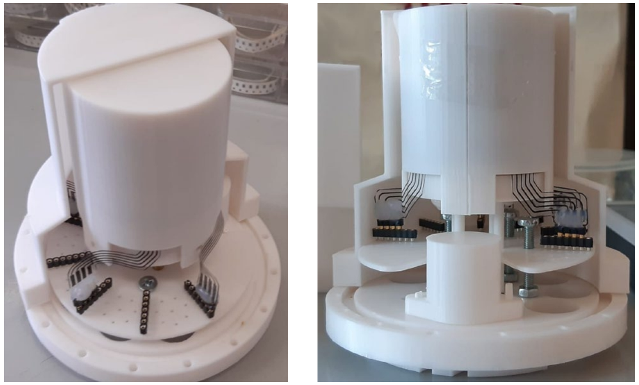
N3G : Next Generation Germanium Gamma Detectors CALL 2021-2023

Res. Nazionale: D. De Salvador[1,2], Resp. Loc. Sez. Milano: S. Capra
[1] INFN-LNL [2] Università di Padova

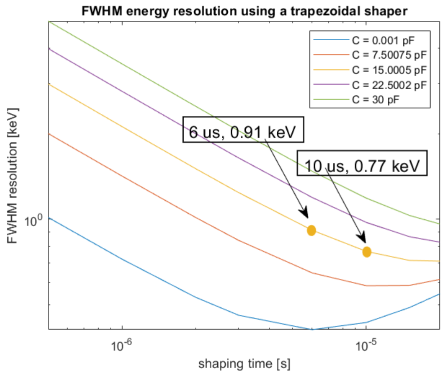
Realizzazione del primo canister per rivelatori HPGe segmentati completo di passanti, getter e manipolatore per valvola a vuoto



Realizzazione di una scheda «a mezzaluna» da montare sul canister che garantisca la compatibilità con i FET freddi in dotazione



Ottimizzazione dei sistemi di connessione flessibile tramite realizzazione di mock-up stampati in 3D e Kapton stampato su acetato

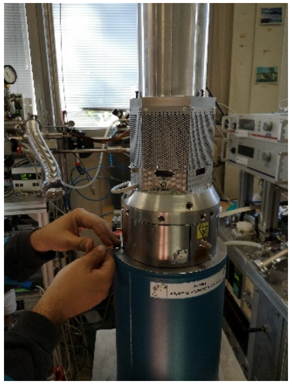
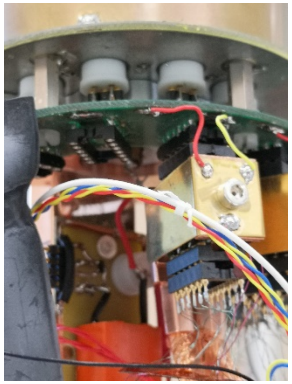


Realizzazione di un nuovo ASIC a più basso rumore e più basso consumo di potenza (solamente 6 mW)

N3G : Next Generation Germanium Gamma Detectors CALL 2021-2023

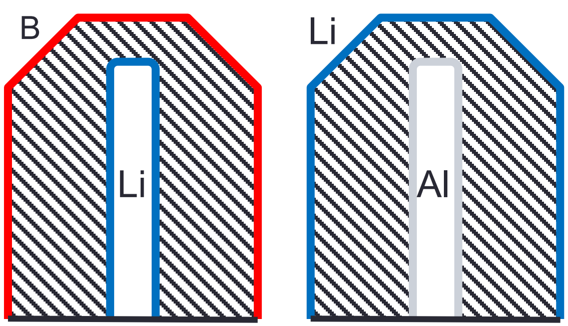
Res. Nazionale: D. De Salvador (INFN-LNL, Università di Padova), Resp. Loc. Sez. Milano: S. Capra

Previsione Attività 2023

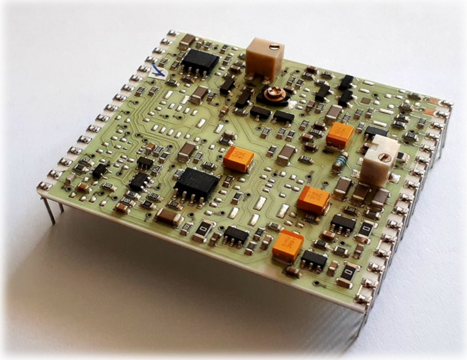
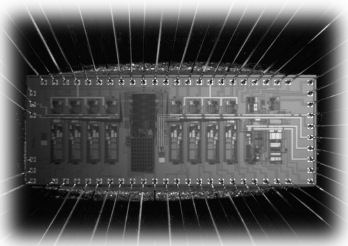



Installazione della prima capsula nel criostato di test. Caratterizzazione del rivelatore e dell'elettronica di front-end


Progettazione e realizzazione del sistema di supporto per i rivelatori con Litio esterno: la cavità interna non può reggere il rivelatore



Installazione del secondo rivelatore, ottimizzazione dell'elettronica esistente per i segnali di polarità opposta

Confronto performance elettronica discreta ed ASIC: installazione dell'elettronica nel criostato

Richieste finanziarie 2023 connesse alle attività previste: WP2

	Voce	Richiesta diretta	Richiesta SJ
Consumo	Stampa in 3D in Allumina del supporto per il secondo prototipo di rivelatore. Seconda prototipazione SJ se necessaria	3.5 k€	3.5 k€
	Nuovo batch di schede flessibili in Kapton	2 k€	
	Realizzazione di nuove PCB interne ed esterne al canister	3k€	
	Acquisto cilindro 60mm x 1m (minimo) di PEEK caricato in fibra di vetro per la realizzazione del bicchiere per il secondo prototipo	0€	1.5k€
	1 ASIC di area minima (7 mm^2)	7 k€	
Missioni	Test sperimentali dell'elettronica sviluppata **recandosi di persona** presso LNL. Montaggio delle PCB nei criostati. Test con impulsatore e sorgenti.	3 k€	
AdR	Rinnovo di un assegno di ricerca con focus su meccanica ed elettronica	24 k€	

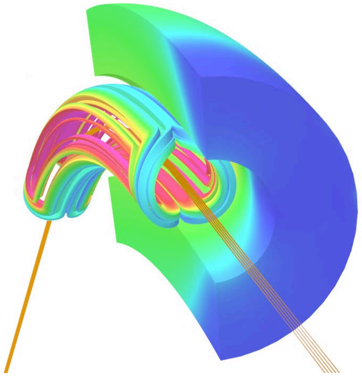
Personale	FTE	VARIAZIONE
Stefano Capra (responsabile locale)	0.5	0
Mauro Citterio	0.1	0
Simone Coelli	0.1	0
Luciano Manara	0.2	0
Bénédicte Million	0.3	0
Alberto Pullia	0.4	0
Giacomo Secci (Assegnista su N3G)	1	+1 rispetto a inizio call

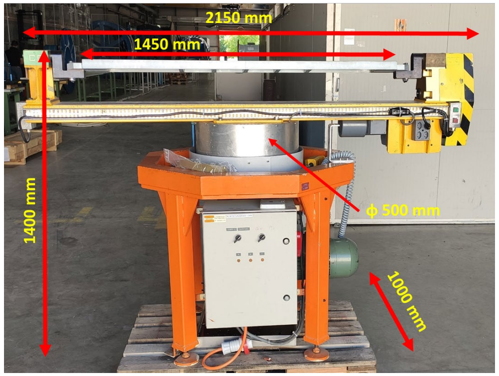
Richiesta servizi	M.U.
Servizio elettronico	1
Servizio di progettazione meccanica	1
Servizio di lavorazione meccanica	1

Il progetto SIG: scopo e sfide aperte

Superconducting Ion Gantry

INFN LASA

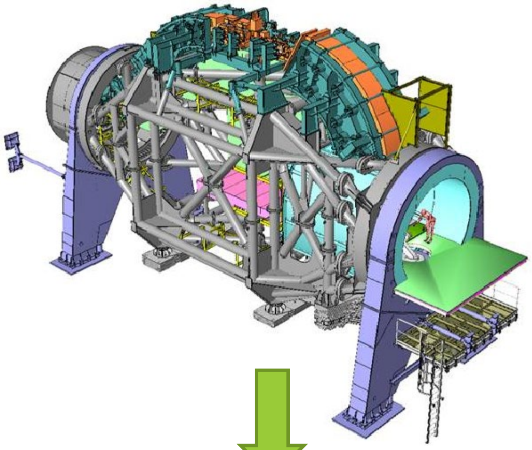


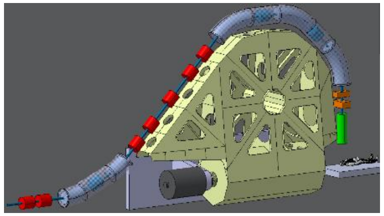


Bobinatrice @ LASA

- Call Gruppo V e accordo quadripartito: INFN – CERN – CNAO – MedAustron
- Scopo generale: rendere più accessibile l'adroterapia con ioni pesanti
  → ridurre ingombro e peso dei gantry grazie alla superconduttività e alla tecnologia dei magneti da acceleratore
- Obiettivo: costruzione di un magnete superconduttore dimostratore curvo
  - 4 T, apertura 80 mm, 45° (1.3 m)
- Sfide aperte
  - Avvolgimento con alta curvatura (ρ = 1.65 m)
  - Raffreddamento indiretto (no elio liquido)
  - Ramp-rate elevato (0.4 T/s) e minimizzazione delle perdite dinamiche
  - Nuova magnet facility @LASA

Heidelberg Gantry ~600 tons





Compact Gantry ~50 tons (L. Gentini)

Il progetto SIG: piano 2023

Milestones & Deliverables

- ✓ 02/22: Firma del framework agreement generale quadripartito
- ✓ 09/22: Firma dell'addendum specifico per SIG (ongoing)
- 12/22: Congelamento del design concettuale del magnete
- 03/23: Fornitura del cavo dummy in rame da parte del CERN
- 06/23: Test di avvolgimento @ LASA
- 09/23: Technical Design Report (TDR)
- 10/23: Fornitura del cavo finale isolato in NbTi da parte del CERN

→ A partire dal 2023 SIG non partecipa più alle assegnazioni di Gr. V poiché ha ricevuto fondi ministeriali dedicati. I referee assegnati continueranno a seguire le attività per conto della CSN5.

→ Richieste servizi 2023
- Supporto progettazione meccanica: 2 mu
- Officina meccanica: 3 mu

FTE 2023

	Personale	FTE
1	Lucio Rossi	0.2
2	Massimo Sorbi	0.1
3	Marco Statera	0.1
4	Francesco Broggi	0.1
5	Marco Prioli	0.3
6	Ernesto De Matteis (AR)	0.3
7	Samuele Mariotto (RTDA)	0.2
8	Riccardo Valente (AR)	0.2
9	Magnus Dam (Borsa x stranieri)	0.1
10	Nuovo AdR SIG	1
	TOT Ricercatori	**2.6**
1	Danilo Pedrini	0.2
2	Maurizio Todero	0.3
3	Arsenio Palmisano	0.2
4	Antonio Paccalini	0.3
5	Nuovo tecnico Elettronico	0.2
6	(Serv. Officina)	0.3
	TOT Tecnici	**1.5**

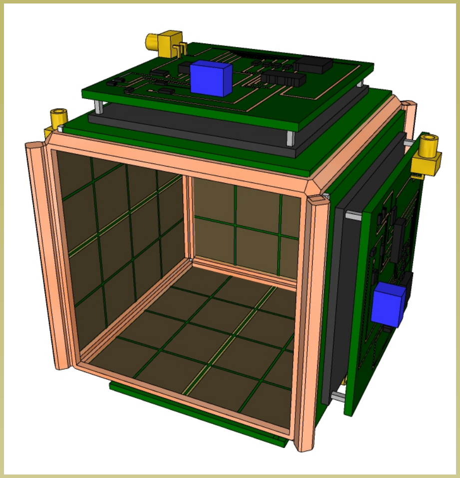
ESPERIMENTI che continuano con

Responsabilità NAZIONALE e LOCALE

ASTAROTH (All Sensitive crysTal ARray with lOw THreshold)

- Dimostratore di rivelatore criogenico per ricerca diretta di Materia Oscura con cristalli scintillanti di NaI(Tl) letti da matrici di SiPM @LAr con soglia inferiore al keV.
- Sigla approvata “in corso d’anno” CSN5 Febbraio 2020 – Richiesta estensione a 2023 per Covid/ritardi ditte produttrici
  - 2020 dedicato al design del rivelatore
  - 2021-22 dedicato a test a freddo di componenti:
    - Cristalli (2, cubico e cilindrico)
    - SiPM arrays (Hamamatsu, FBK)
    - Elettronica di lettura

Sinergia con Progetto FELLINI LITE-SABRE (Zani)

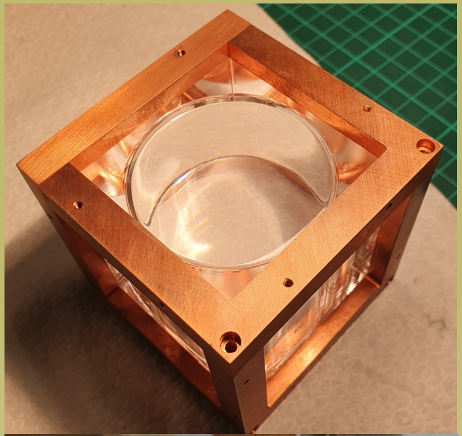


Attività SiPM criogenici in sinergia con Dune (CSN2).

Esperimento al **LASA**
Test a Celoria e PoliMi

Attività 2021-22

- Ricezione camera criogenica in rame (giugno 2022)
- Acquisto e ricezione sistema di pompaggio per camera criogenica
- Continuazione Analisi ad Elementi Finiti (Termica e meccanica) - Servizi meccanici INFN MI e INFN LNGS
- Test meccanici di validazione materiali in criogenia (@ LASA)
- Front-end criogenico per array FBK
- Ricezione primo array FBK (modello DarkSide), attesa per secondo (DUNE)
- Ricezione array SiPM Hamamatsu
- Test di risposta in funzione della temperatura di cristallo nudo @ LNGS
- Test di risposta in funzione della temperatura dei sensori Hamamatsu @ POLIMI.
- Disegnato ASIC per sviluppo digitale del front-end: caratterizzazione tecnologia LFoundry 110nm in criogenia
  - Consegna chip: Luglio 2022
  - Scheda di test under development



Attività previste 2022-23

- Preparazione/installazione area sperimentale al LASA
- Test di validazione camera criogenica (a vuoto)
- Acquisto e ricezione componentistica per supporto cristalli
- Utilizzo camera per
  - Test schede di elettronica per SiPM / con ASIC
  - Test integrati con cristallo incapsulato letto da 1 o 2 array di SiPM

Anagrafica 2022/2023

Personale	Ruolo	% impegno	Sezione	FTE
D. D'Angelo. (RN e RL)	PA	30%	Milano	1.70
A. Stabile	RTD-B	30%		
M. Sorbi	PA	10%		
Chiara Guazzoni	PA	20%		
Andrea Castoldi	PO	30%		
Niccolò Gallice	Dott.	20%		
G. Di Carlo§	Ric.	30%	LNGS	

§ No sigla LNGS, Di Carlo afferisce su Milano

N.B.: + A. Zani (RTD INFN), 100% su progetto sinergico FELLINI LITE-SABRE

+2 laureandi magistrali

Richieste servizi 2023

Servizio officina e progettazione meccanica. 1.5 mesi-uomo, per:

- 1.0 completamento Analisi ad Elementi Finiti camera criogenica in rame
- 0.5 piccole lavorazioni ancillari al progetto

Servizio elettronica. 1 mese-uomo per:

- supporto progettazione amplificatori criogenici

Richieste 2023

Capitolo	Descrizione	Richiesta (kE)	SJ (kE)	Tot. (kE)
Consumo	3 array SiPM Hamamatsu 9(3x6k); PCB per lettura SiPM (3k)	21		21
Altri consumi	LN2	3		3
Costruzione apparati	Linea exhaust	3		3
Consumo bis	1 Cristallo incapsulato		7.5	7.5
Trasporti	Trasporto materiale da/per LNGS	0.5		0.5
Totale	Totale senza Missioni	27.5	7.5	35
Missioni	Trasferte LNGS per test; visite a ditte	5	0	5

- Nel 2022 restituzione di 23.5k SJ (luglio) + 6.5k ? (settembre) -> spese da riprogrammare nel 2023.

N.B.:

- Rimodulazione richieste 2022, dovuta a ritardi ditte e iniezione fondi (per il 2022) da progetto FELLINI LITESABRE

ETHIOPIA

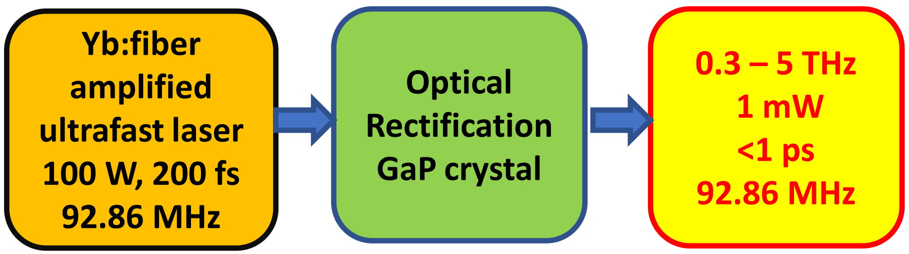
Efficient THz generatIon fOr hypersPectral ImAging and broad-band spectroscopy

Durata proposta:	3 anni (inizio 2022)
Area di ricerca:	Interdisciplinare
Responsabile nazionale:	Gianluca Galzerano
Unità partecipanti:	INFN-Milano (Resp. Locale G. Galzerano): 2.80 FTE
	INFN-Napoli (Resp. Locale B. Piccirillo): 1.20 FTE

Riunione GRV INFN Milano 12 Luglio 2022

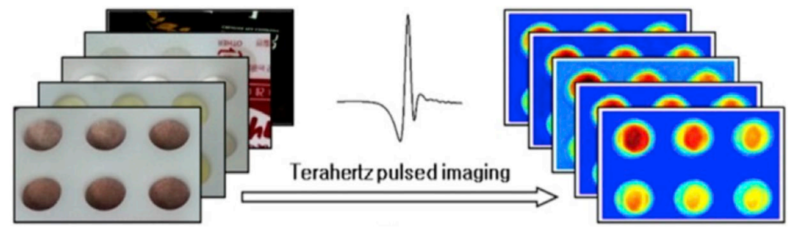
Scopo della proposta ETHIOPIA

L'obiettivo del progetto è la **realizzazione di una sorgente coerente presso il laboratorio LASA** operante **nella regione spettrale da 0.5 a 5 THz con elevata frequenza di ripetizione (100 MHz) e potenze medie sino a 10 mW per la sensoristica per immagini non distruttiva e la biomedicina.** **Questo sfruttando la disponibilità di un avanzato sistema laser e di un laboratorio realizzati nell'ambito del progetto BriXsino.**



Obiettivo 1 - Sorgente THz

Realizzazione della sorgente THz ad elevata frequenza di ripetizione (~100 MHz) mediante il processo non-lineare della rettificazione ottica di un treno di impulsi generato da un sistema laser in fibra ottica drogata Yb



Obiettivo 2 - Imaging Iperspettrale

Sviluppo e validazione di un metodo innovativo che combina l'imaging iperspettrale nel dominio THz con la tecnica della termometria

Sviluppo temporale

Descrizione Work Package (WP)	Primo anno				Secondo anno				Terzo anno			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
WP1 Tabletop THz source (INFN-Milano)												
Task 1.1 Realization of the THz source (INFN-Milano+Napoli)				**D3**								
Task 1.2 Characterization of the THz source (INFN-Milano)						**M2**						
WP2 THz hyperspectral imaging and thermometry (INFN-Napoli)												
Task 2.1 Validation of hyperspectral methodology with PA's spectrometer (INFN-Napoli)					**M1**							
Task 2.2 Novel devices for THz polarization manipulation (INFN-Napoli)								**D6**				
Task 2.3 Implemtation of high SNR hyperspectral THz thermometry (INFN-Napoli+Milano)										**M3**		**M4**
WP3 Management, dissemination, explotation, and communication (All)												
Task 3.1 Project supervision, monitoring and reporting				**D4**				**D8**				**D9**
Task 3.2 Financial, legal, and data management			**D2**			**D5**						**D10**
Task 3.3 Organization of meetings and ongoing support	**ME1**			**ME2**				**ME3**				**ME4**
Task 3.4 Dissemination, explotation, and communication		**D1**					**D7**					**D11**

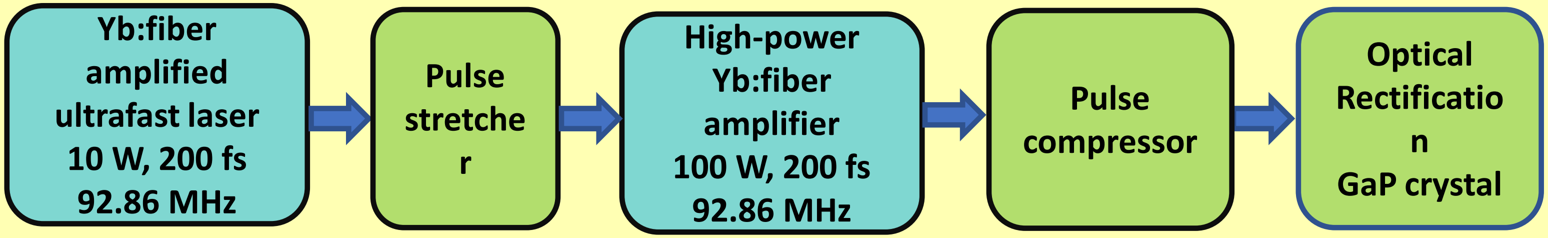
Milestone:
M1: Testing of the hyperspectral imaging capability (T0+14 months);
M2: Validation of the THz source performance (T0+15 months);
M3: Implementation of hyperspectral thermometry (T0+27 months);
M4: Implementation of THz polarization manipulation in hyperspectral thermometry (T0+36 months)

Meeting - ME1: kick-off meeting (T0); **ME2**: intermediate meeting (T0+12 months); **ME3**: intermediate meeting (T0+23 months); **ME4**: final meeting (T0+36 months)

Deliverable - D1: website (T0+3 months); D2: Data management plan (T0+7 months); D3: THz source prototype (T0+12 months); D4: First scientific report (T0+12 months); D5: Intermediate financial report (T0+18 months); D6: THz waveplates and polirizers (T0+21 months); D7: Collection of dissemination, exploitation, and communication activities (T0+21); D8: Second scientific report (T0+25 months); D9: Final scientific report (T0+36 months); D10: Final financial report (T0+36 months); D11: Collection of dissemination, exploitation, and communication activities (T0+36)

Attività in corso 2022-2023

Sviluppo sorgente THz @ INFN-Milano LASA



Acquisizione dei componenti ottici: **pulse stretcher** e **pulse compressor** (INFN) **cristalli di GaP** (CNR).
Realizzazione e caratterizzazione dell'amplificatore ad elevata potenza: P_{out}=60 W @ 100 W
Misure preliminari di rettifficazione ottica in GaP mediante laser impulsato (1 W, 160 MHz, 90 fs)
Installazione dell'amplificatore e della linea di generazione THz presso LASA

Spettroscopia THz @ INFN-Napoli

Sviluppo di un ellissometro operante nella regione spettrale da 0.5 a 2.5 THz basato su spettroscopia THz nel dominio del tempo (Time-Domain THz spectroscopy) con antenne fotoconduttive.
Sviluppo di lamine ritardatrici accordabili basate su cristalli liquidi con elevata trasparenza nel THz.
Caratterizzazione preliminare delle lamine ritardatrici accordabili (mediante il controllo della temperatura del cristallo liquido) con spettrometro THz con antenne fotoconduttive

Piano economico 2023 (secondo anno)

2nd year (2023)	INFN-Milano	INFN-Napoli
Missioni: 7.5 k€	2.5 k€ ()	5 k€ (10 working days two persons)
Inventariabile: 15 k€	10 k€ (200 W pump diode); 5 k€ (pump diode driver) **Subtotal: 15 k€**	-
Consumo: 25.5 k€	4 k€ (near-IR optical components: fused silica aspheric lenses, achromatic waveplates); 6 k€ (THz optical components: parabolic mirrors; waveplates; polarizers); 3 k€ (Mechanical mounts) **Subtotal: 13 k€**	6.5 k€ (crystalline quartz substrates and coating materials with high-transparency in the THz range); 6 k€ (Optical and opto-mechanical components) **Subtotal: 12.5 k€**
TOTALE: 48 k€	**30.5 k€**	**17.5 k€**

Unità partecipanti (FTE 2023)

INFN-MILANO	**FTE**
Gianluca Galzerano (National coordinator)	40%
Dario Giove	20%
Simone Cialdi	30%
Luca Serafini	10%
Francesco Canella	30%
Daniele Sertore	10%
Giorgio Guerini	10%
Dario Giannotti	30%
Bruno Paroli	20%
Ezio Puppin	20%
Marcel Ruijter	20%
Edoardo Suerra	40%
	Tot. 2.80

INFN-NAPOLI	**FTE**
Bruno Piccirillo (local coordinator)	40%
Antonello Andreone	15%
Gianpaolo Papari	15%
Domenico Paparo	15%
Andrea Rubano	10%
Veronica Vicuña Hernandez	5%
Zahra Mazaheri	20%
	Tot. 1.20

Richiesta Servizi per Milano:
servizio officina meccanica per un massimo di giorni 15.

ISPIRA - Integrazione di metodologie sperimentali per la ricerca sull'aerosol carbonioso

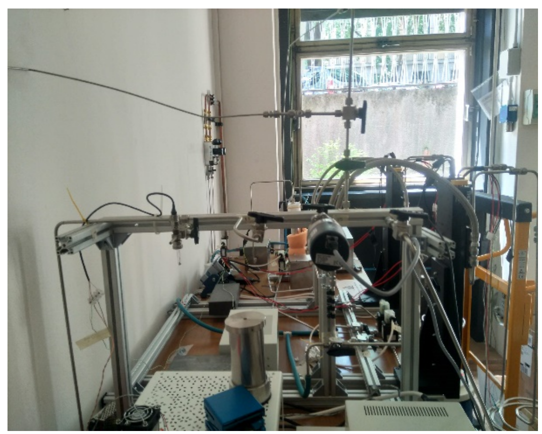
Unità coinvolte: **Milano (RN e RL: V. Bernardoni)**, Genova (RL: D. Massabò), Firenze (RL: M. Fedi)
Referee: Vincenzo Monaco (Torino), Sabina Sonia Tangaro (Bari)

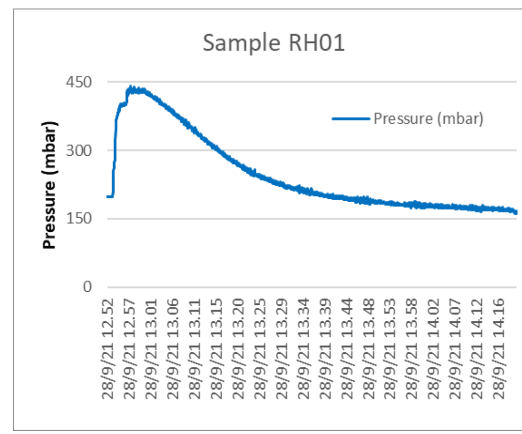
Avanzamenti ISPIRA @ Milano - 2021

Obiettivo finale

Sviluppi sperimentali e **modellistici** che permettano di **migliorare gli attuali approcci di caratterizzazione** delle **componenti clima-alteranti** dell'aerosol atmosferico e gli **approcci modellistici di identificazione e quantificazione delle sorgenti** di emissione *(source apportionment)*.

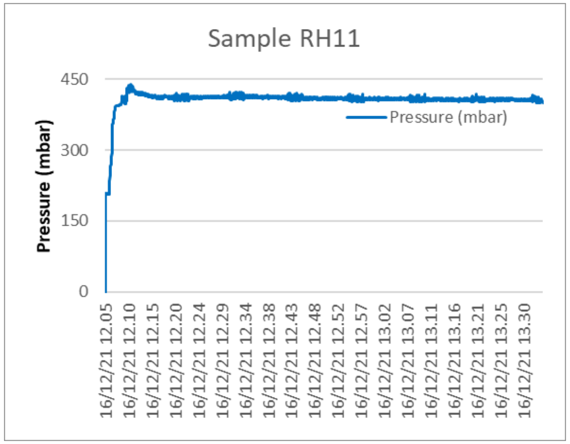
Estate 2021: fine assemblaggio della linea di preparazione campioni per misure di ^{14}C sull'aerosol e realizzazione con **successo dei primi test**, con grafitizzazione dei primi standard/campioni





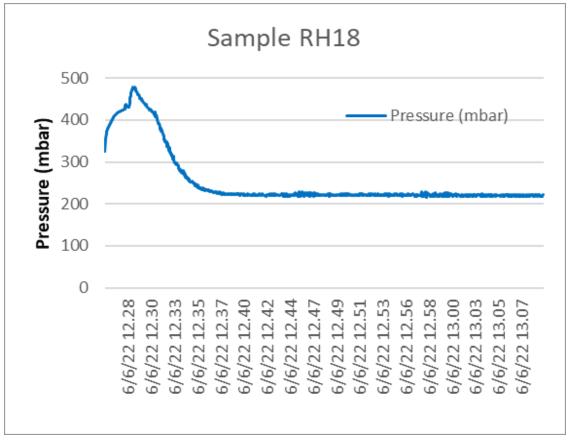
Problemi e loro risoluzione @ Milano – inverno 2021 - 2022

Tardo autunno 2021: problemi imprevisti. Con il procedere delle attività, si è osservato dapprima un rallentamento della reazione di grafitizzazione necessaria per la preparazione dei campioni e in seguito una totale inibizione della reazione.



La risoluzione del problema ha richiesto l'intero inverno e gran parte della primavera 2022:

- la reazione è risultata essere inibita da più cause, che hanno richiesto mesi per l'identificazione e la risoluzione;
- si sono riscontrate difficoltà di approvvigionamento materiali
- la forza lavoro era ridotta (congedo di maternità Vera Bernardoni)



L'attività di **preparazione campioni** è finalmente **ripresa a inizio giugno 2022** (durerà fino a fine anno – inizio 2023)

ISPIRA – Richiesta di possibile proroga su 2023

Gli **ultimi mesi di ISPIRA** – attualmente in scadenza a fine 2022 – avrebbero dovuto essere dedicati a **sviluppi modellistici**. Questa attività si basa sulle misure dei campioni e **non può allo stato attuale essere portata avanti.**

PERÒ

Essendo stati risolti i problemi sperimentali, una **proroga di un anno potrebbe garantire il raggiungimento di tutti gli obiettivi iniziali del progetto.**

Struttura e timeline originale ISPIRA:

In caso di concessione di proroga:

ANAGRAFICA MILANO 2023

	Nome	Cognome	Qualifica	FTE	GRUPPO
RN e RL	*Vera*	*Bernardoni*	*PA UNIMI*	*1*	*5*
	Roberta	Vecchi	PA UniMI	0.3	5
	Federica	Crova	Dottoranda UNIMI	0.3	5
	Gianluigi	Valli	Tecnico laureato UNIMI	0.9	5
	TOTALE			**2.5**	

RICHIESTE MILANO 2023

	Richieste (k€)
Missioni	1
Consumi	1
Totale	**2**

ESPERIMENTI che continuano con

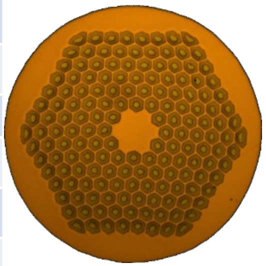
Responsabilità LOCALE

Progetto ASTRACT (2021-2023)

ASTRACT: Analysis of STRain Affected CharacTeristics of brittle SC cables

- Attività di supporto ad altri progetti del gruppo magneti del LASA: magneti per alto campo e magneti curvi per acceleratori e gantry per adroterapia

Property	Value
d_{strand}	1 mm
α=Cu/non-Cu	0.9 ± 0.2
$d_{fil.}$	58 μm
$L_{tp\text{-}fil}$	19 ± 3 mm
RRR, rolled	159 ± 14
T_{HT}	665 K
J_{sc} @ 4.2 K, 16 T	1200 A/mm^2

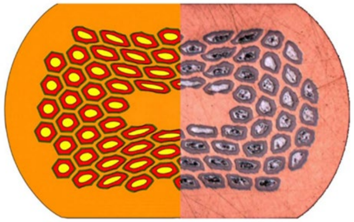


Nb3Sn RRP 162/169
Courtesy of S. Hopkins

- Scopo: studiare gli effetti delle deformazioni meccaniche sulle caratteristiche di cavi/fili su superconduttori “fragili” prima e dopo il trattamento termico
  - Prima del trattamento → Simulazione degradazione di cablaggio
  - Dopo il trattamento → Simulazione effetti forze di Lorentz

- Collaborazione tra INFN Genova (capofila), Milano-LASA e G.C. di Salerno
  - Resp. nazionale: Riccardo Musenich
  - Resp. Locale Milano: Marco Prioli
  - Referee: Cristina Vaccarezza, Giuseppe Cirrone

Strand Nb3Sn deformato

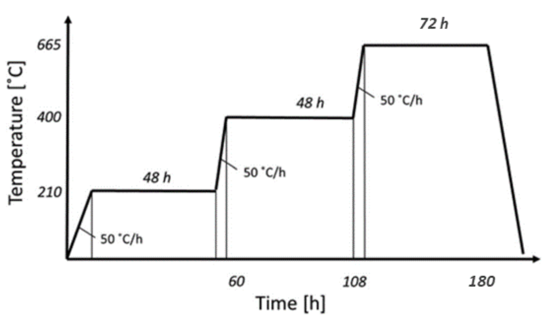


Progetto ASTRACT (2021-2023)

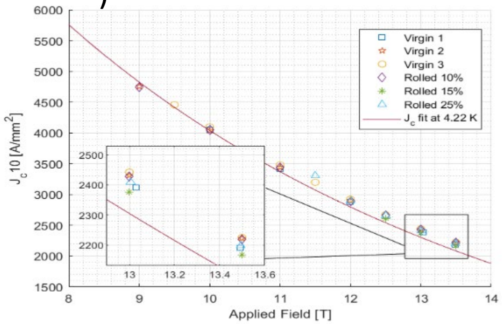
- Obiettivo per Milano: misure di corrente critica (I_C) su campioni di Nb3Sn vergini e deformati meccanicamente prima del trattamento termico
- Attività completate, prima metà 2022:
  - 1/2022: qualificazione del processo di trattamento termico di formazione del Nb3Sn (1) e della misura di corrente critica su fili di riferimento
  - 5/2022: caratterizzazione del comportamento meccanico del filo Nb3Sn di FalconD (2) → nessuna evidenza di degradazione, in accordo con le misure di magnetizzazione svolte a Salerno (3)
- Piano 2023 → contributo di Milano in esaurimento
  - Completamento misure I_C e modellazione numerica
  - Misure di I_C su campioni deformati dopo il trattamento termico → @ Genova
  - Richieste 250 litri LHe (6.5 k€, prezzo volatile) + 3 k€ missioni

	FTE 2023
Marco Prioli	0.1
Riccardo Valente (AR)	0.1
Totale	0.2

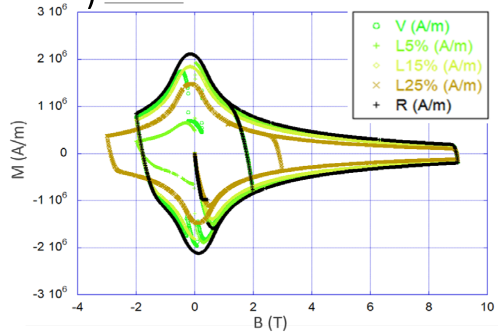
(1)



(2)



(3)



Esperimento 2022-2024 DIODE (2023)

Diamond Integrated fOr haDronthErapy

Unit	Coordinator
UniTV	Claudio Verona
PoliMI	Alberto Fazzi
INFN-LNL	Valeria Conte
INFN-LNS	G.A.P. Cirrone
INFN-Roma3	Andrea Fabbri

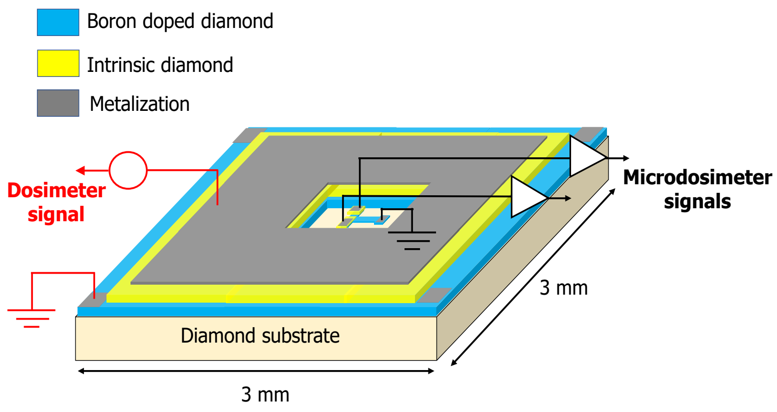
Responsabile Locale	Partecipanti	FTE %	Qualifica	Contratto
Alberto Fazzi	Alberto Fazzi	30	Prof. Associato	Associato
	Stefano Agosteo	20	Prof. Ordinario	Incaricato di Ricerca
	Davide Bortot	30	RTDA	Associato
	Davide Mazzucconi	20	Assegnista	Associato
	Giovanni d'Angelo	40	Tecnico	Associato
TOTALE		1.40		

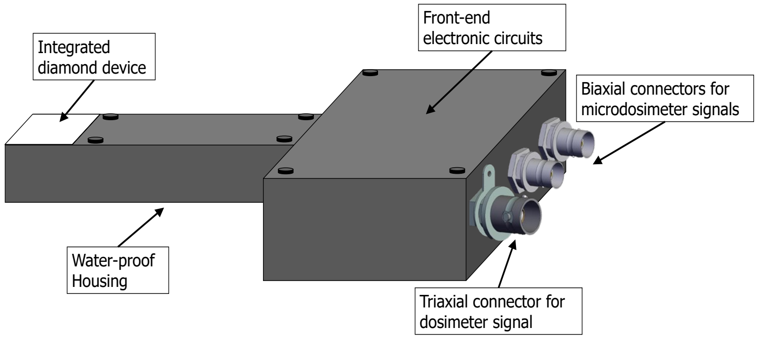
Esperimento DIODE

Diamond Integrated fOr haDronthErapy

L'esperimento si prefigge di studiare, costruire e provare un nuovo strumento per la misura contemporanea della dose assorbita e della qualità della radiazione in campi adroterapici (protoni e ioni carbonio).

La simultanea caratterizzazione dosimetrica e microdosimetrica si basa sullo sviluppo di un nuovo rivelatore in diamante e della relativa elettronica di lettura.





Milestone e deliverable per il 2023

D.3 – Month 17: Dosimetry and microdosimetry electronic circuits.

D.4 – Month 21: Availability of prototype.

M.3 – Month 24: Test of prototype.

D.5 –Month 24: Simulation of the beamline adopted for the experimental tests. The application will be included the LET calculation also.

Richieste di finanziamento (Sez MI) 2023

Consumo: Schede per elettronica di FE (PCB e montaggio) del secondo prototipo 4kE

Missioni: Due test congiunti a UniRM e un turno a TIFPA 2kE + 1kE SJ

ION2NEUTRAL [2020-2023; BA, LNL, MI, MIB]

Enhanced ion source techniques and neutrals detection for particle beam manipulation and fusion application

Attività Luglio 2021 – Giugno 2022

[a] Attività su dinamica fluida del plasma di soli elettroni

L'attività di ricerca è stata focalizzata sulla continuazione degli studi sperimentali su eccitazione e controllo di instabilità trasversali (Kelvin-Helmholtz modes) in una colonna di elettroni. In particolare si sono studiate le proprietà dinamiche e di stabilità di modi di deformazione di vortici magnetizzati non assial-simmetrici, ottenuti con eccitazione tramite campi elettrici rotanti a frequenza fissa e variabile (locking autorisonante). Questi vortici deformati (V-states) sono la generalizzazione a indice azimutale generico di vortici di Kirchhoff (ovvero vortici ellittici di indice azimutale 2).

In particolare:

1 - Si sono evidenziati vari dettagli interessanti della dinamica, per esempio: (a) durante la fase di dinamica forzata, sequenze ripetute di locking e decadimento; (b) in una fase di decadimento libero, a forzante spenta, un transitorio di stabilità del V-state di durata inversamente proporzionale all'ampiezza della deformazione.

2 - La necessità di ottenere sequenze di vortici assial-simmetrici con ottima ripetibilità e profilo di densità radiale controllato ha portato alla messa a punto di un protocollo di generazione e preparazione di stati iniziali a partire dalla ionizzazione RF del gas residuo.

3 - In parallelo sono stati effettuati upgrade al codice di simulazione PIC-2D utilizzato a fini sia predittivi che di confronto con gli esperimenti.

[b] Attività su RFQC (Radio-Frequency Quadrupole Cooler)

E' proseguita l'acquisizione delle parti necessarie all'apparato, mentre si sono verificati ritardi nell'adattamento meccanico e dell'elettronica. Sono stati effettuati upgrade allla simulazione del fascio nell'RFQC (potenziamento del tracciamento di traiettorie con l'emittanza nascente dalle collisioni).

Attività Luglio 2021 – Giugno 2022 - continua

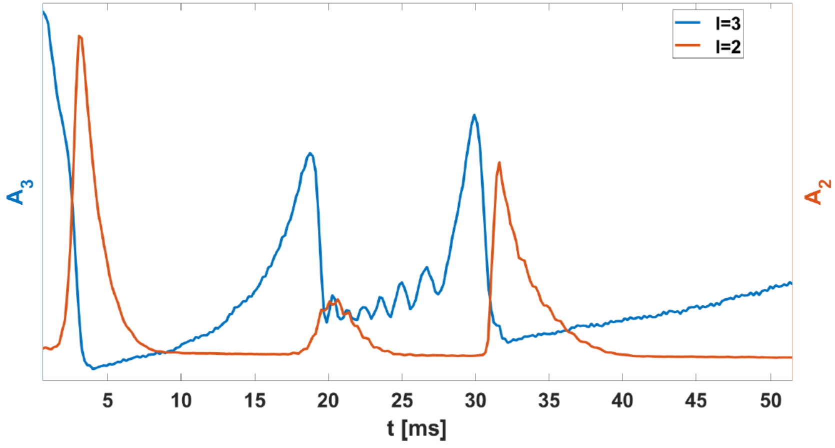


Fig. 1: Plasma response to set-frequency excitation of l=3 mode, with multiple lockings and cascades to mode l=2.

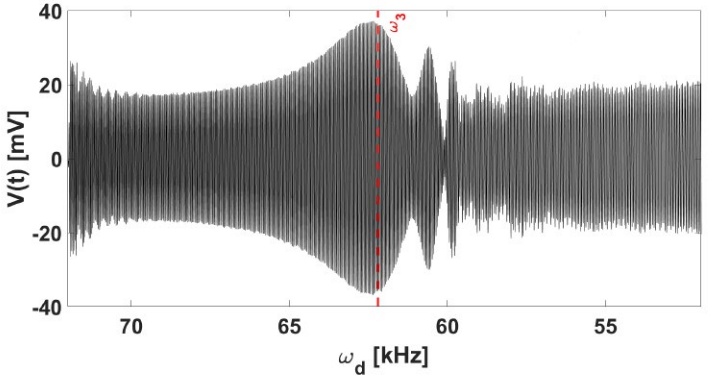


Fig. 2: Plasma response to autoresonant drive exciting the l=3 diocotron mode..

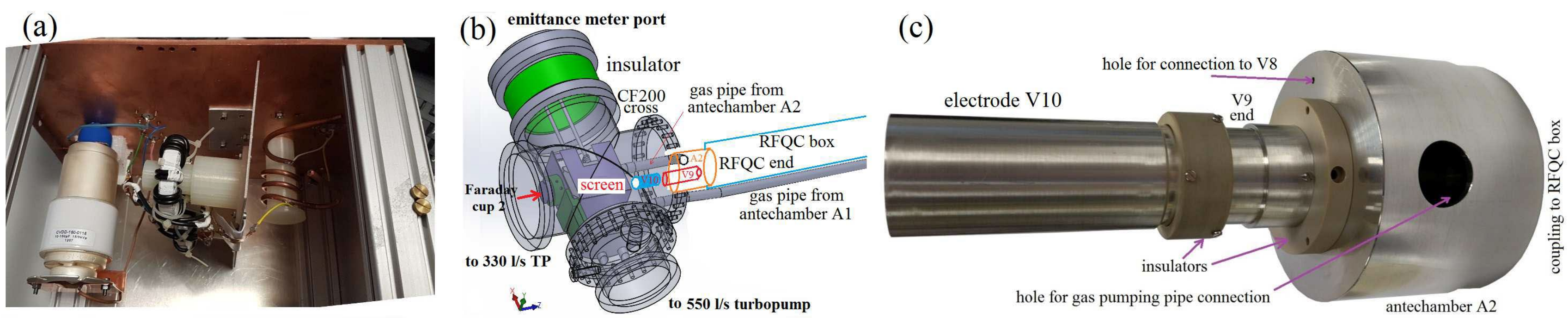


Fig. 3: RFQC: (a) matching box; (b) scheme of emittance meter and pumps; (c) view of triode extraction line.

Pubblicazioni

M. Cavenago *et al.*, J. Phys. Conf. Ser. **2244** (2022) 012064 (doi:10.1088/1742-6596/2244/1/012064)

Partecipazione a conferenze

107th Congresso Nazionale SIF, virtual, September 2021 [G. Maero *et al.*, oral]

48th EPS Conference on Plasma Physics, virtual, June 2022 [G. Maero *et al.*, poster]

Preventivo MI – 2023

	ITEM	k€
Inventariabile	Full range vacuum gauge (sostituzione gauge danneggiato) [2.0 kEuro, convenzione INFN-Pfeiffer], Pirani gauge (misurazione zona ad alta pressione pompaggio differenziale RFQC) [0.5 kEuro, convenzione INFN-Pfeiffer]; RF power supply 2 MHz, 600 W per RFQC [12 kEuro, stima, in attesa di quotazione ufficiale]	14.5
Apparati	Sostituzione cartuccia Cs (utilizzo su tempi superiori alla vita media della sorgente) ion source Kimball Physics IGS-4 per RFQC [stima, in attesa di quotazione ufficiale] (SJ ad effettivo esaurimento della sorgente durante l'anno)	5.5 SJ
Consumo	Lavorazione componenti ceramici per isolatori di elettrodi (sostituzione elementi danneggiati) [1.5 kEuro]; minuteria vuoto [1.5 kEuro]; minuteria elettronica [1.0 kEuro]; 2 passanti 4-pin 5 kV, 25 A e due passanti tubi gas [1.0 kEuro]; cavi coassiali e non coassali per UHV [1.0 kEuro]	6.0
Missioni	Viaggi a LNL e RFX per presa dati Metalice e NIO1 [1.5 kEuro]; 2x partecipazione 2023 European Physical Society Conference on Plasma Physics [2.0 kEuro]	3.5
Manutenzione	Manutenzione sistema di circolazione acqua raffreddamento magneti ELTRAP e DUEL (in particolare controllo temperatura estate/inverno)	2.0
	TOT	26.0+5.5 SJ

Anagrafica MI – 2023

Ricercatore	Qualifica	%
MAERO Giancarlo	PA Unimi	50
ROME' Massimiliano	PA Unimi	50

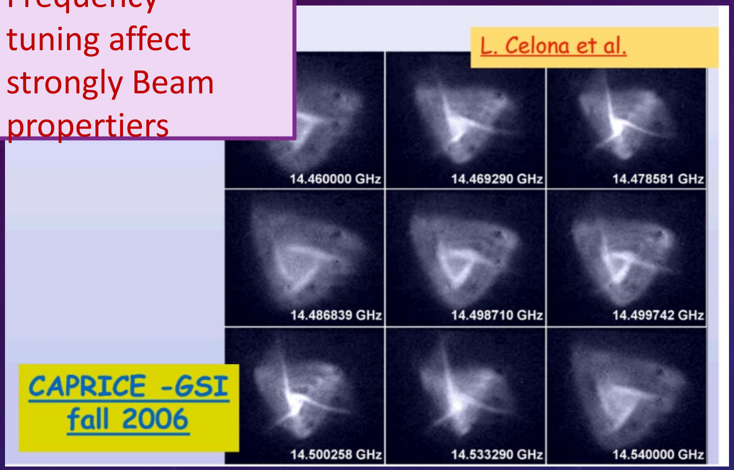
Sviluppo temporale (revised due to the pandemic)

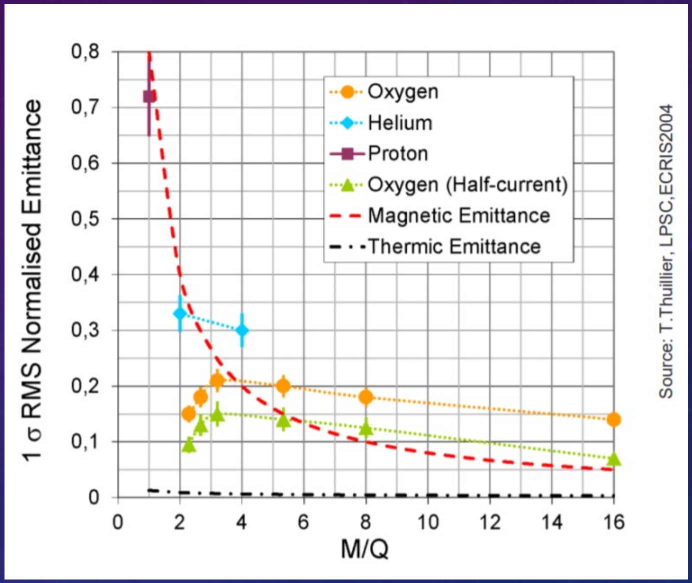
- Studio sperimentale di produzione a radiofrequenza di plasmi in condizioni di parziale neutralizzazione e analisi della loro dinamica, con eventuali applicazioni a sorgenti di particelle cariche: estrazione di fasci continui ed impulsati (elettroni, ioni) [2020-2023].
- Studio sperimentale di dinamica fluida del plasma di soli elettroni [2020-2023]
- Esperimenti di trasmissione del fascio, cattura e raffreddamento nell'RFQC [2022-2023]

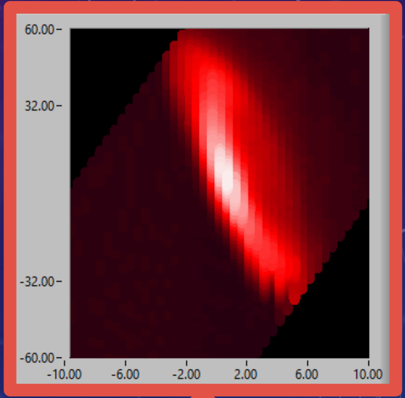
IONS Task 1

Improvement of beam diagnostics of the AISHa testbench

Frequency tuning affect strongly Beam propertiers







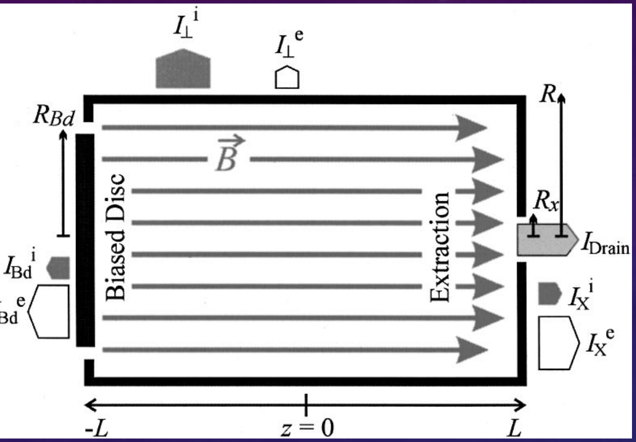
O6+ emit. (60π geom – 0.1π norm.) 0.5emA – Extraction 20 kV – 17.376 GHz – 500W

Installation of Beam viewer and upgrade of current EMU unit needed for beam properties characterization

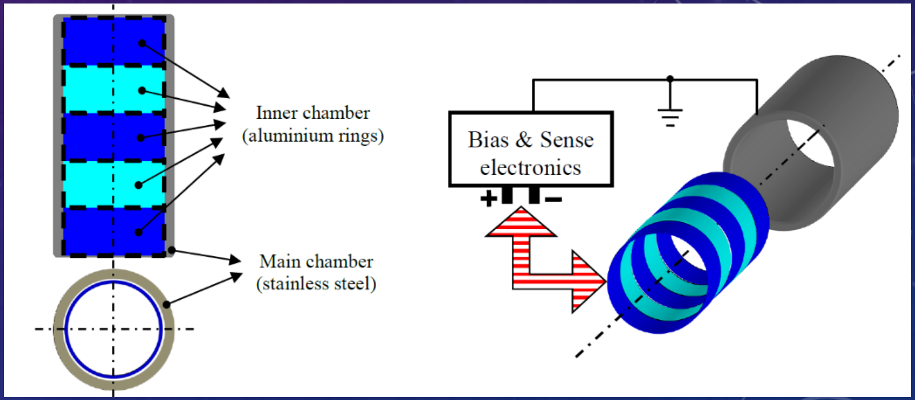
Control of beam properties ------> Ion implantation

IONS Task 2
Design of active plasma chamber for EEDF control

Modification of current losses improve source performances



Active plasma chamber properly biased for Simon current suppression



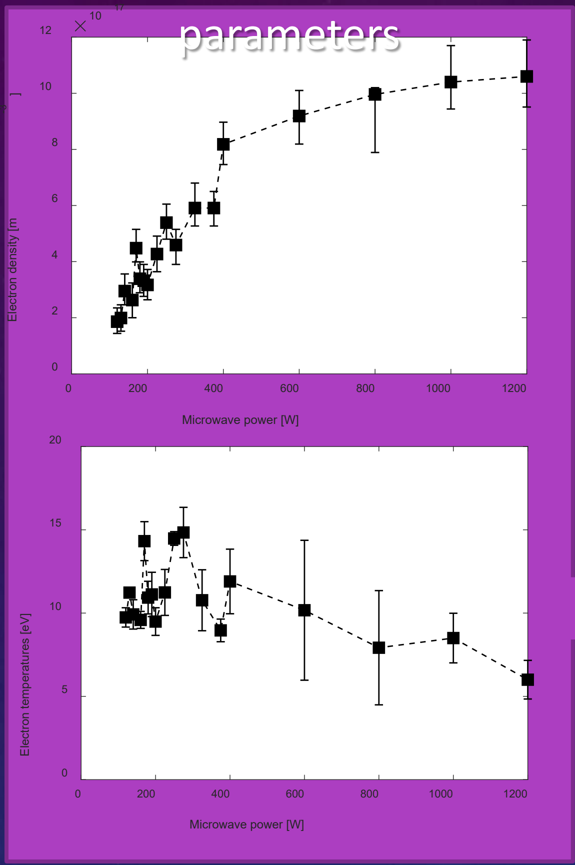
First prototype already funded for Pandora experiment.
R&D will continue on that framework

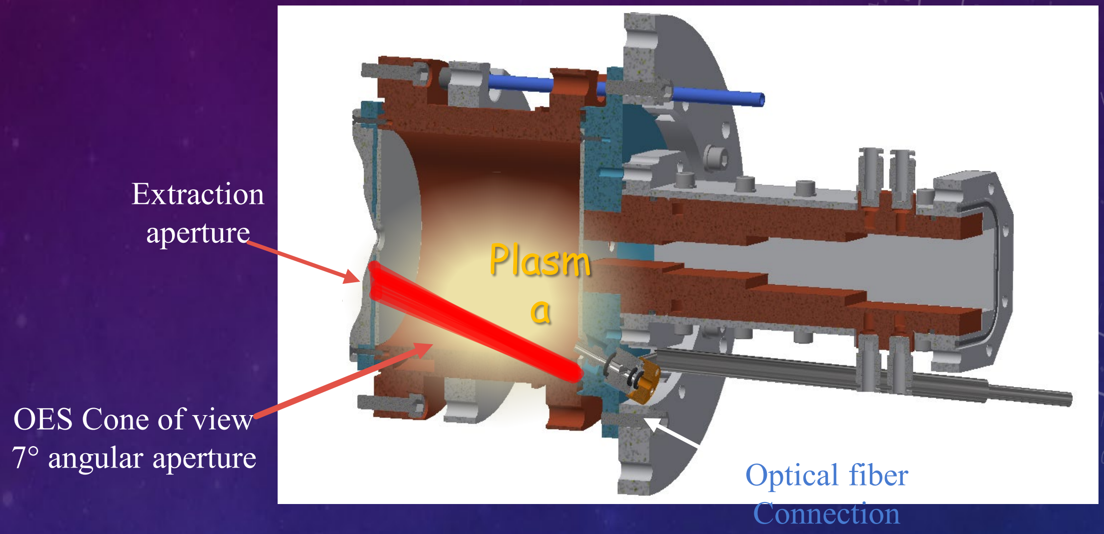
No economic request will be done except the copy of the electronics involved

Segmentation design of the multiring chamber still to be defined
Room for improvement

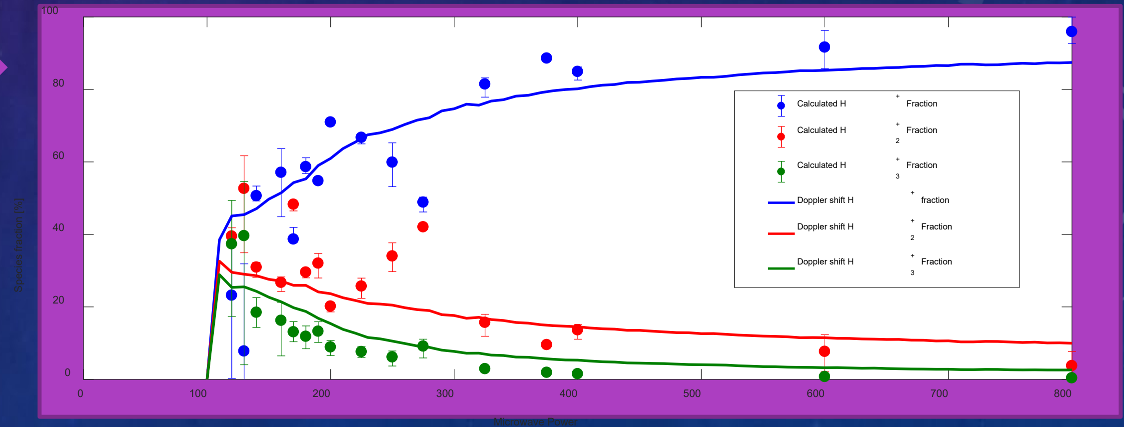
IONS Task 3 - OES investigations in ECRIS

PSESS Plasma parameters

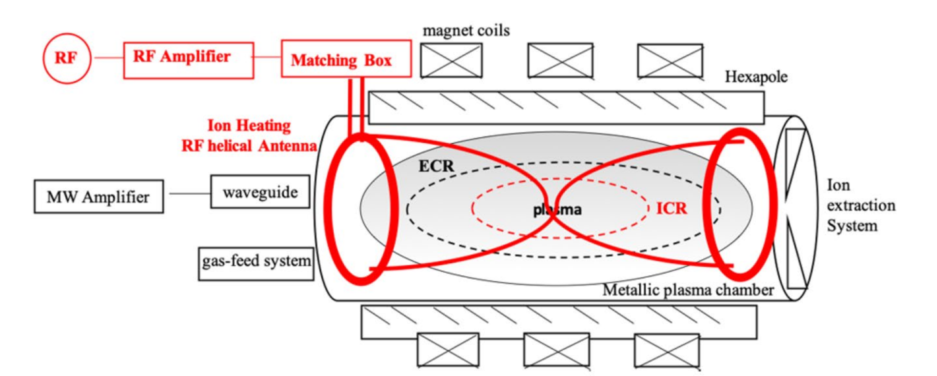




Once plasma paramters are known, it is possible to create a model to predict beam parameters.

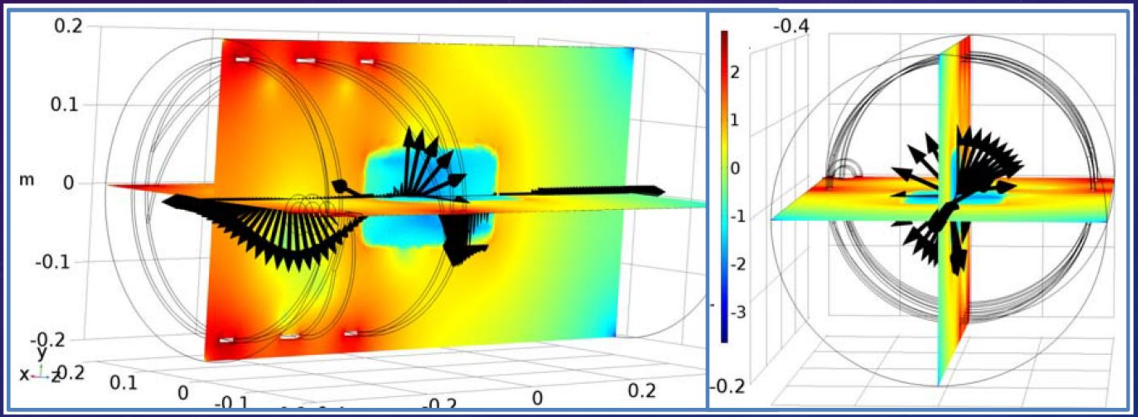


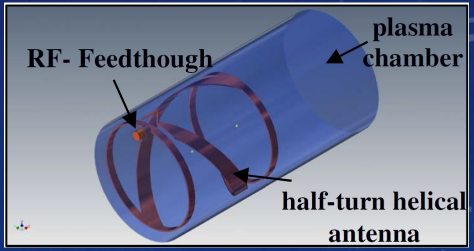
IONS Task 4 - ICRH



Conceptual scheme for ICRH in ECR ion sources.

A half-turn helical copper antenna provides ICRH with a left-handed helicity, matching the direction of ion gyro-rotation at magnetic field situated where waves damp at the fundamental ion resonance on the ICR surface.





Anagrafica e budget IONS 2023

Anagrafica:

Prof. Andrea Locatelli (Università degli Studi di Brescia, RL), 10%

Prof. Costantino De Angelis (Università degli Studi di Brescia), 10%

Prof. Luca Vincetti (Università di Modena e Reggio Emilia), 10%

Prof. Giuseppe Della Valle (Politecnico di Milano), 50%

Dr. Lorenzo Rosa (Università di Modena e Reggio Emilia), 50%

Budget:

Missioni: 2000 euro

Consumabili: 2000 euro

MC-INFN (13° anno)

Sigla che raggruppa le attività di sviluppo e mantenimento dei codici MC con forte partecipazione INFN (FLUKA e GEANT4)

Milano → FLUKA

conveners nazionali : P. Sala (Mi), G. Cirrone (LNS)

- Continuazione principali applicazioni/linee di sviluppo INFN :
- Adroterapia, frammentazione (CNAO, FOOT, INSIDE)
- Neutrini (Nu@FNAL, muon collider),
- Neutroni di bassa energia
- Riorganizzazione della collaborazione internazionale (in attesa, da tempo… di via libera dell' Ufficio Legale INFN)
- Supporto utenti/corsi
- Upgrade sito web (in corso, grazie ad aiuto Centro Calcolo)
- Inizio progetto di routines utente in C++ o Python (ora fortran)

Futuro/ Anagrafica/ risorse

- Continuazione principali applicazioni/linee di sviluppo INFN :
- Adroterapia, frammentazione (CNAO, FOOT, INSIDE)
- Neutrini (Nu@FNAL, muon collider),
- Neutroni di bassa energia
- Riorganizzazione della collaborazione internazionale (in attesa, da tempo… di via libera dell' Ufficio Legale INFN)
- Supporto utenti/corsi
- Upgrade sito web (in corso, grazie ad aiuto Centro Calcolo)
- Inizio progetto di routines utente in C++ o Python (ora fortran)

Anagrafica e risorse

Altre sezioni coinvolte:
Roma2, Bari, Pavia, Pisa,
anagrafica in definizione

Milano:

F. Broggi	20%
M. Campanella	20%
I. Mattei	20%
S. Muraro	20%
P. Sala	50%
A breve: AdR	70%

- Risorse:
- Missioni : da definirsi, richiesta centralizzata a Milano per tutte le sezioni
- Consumo ~1kE

MICRON (MIniaturised aCceleRatOrs Network)

National Coordinator, G. Torrisi (LNS)

INFN-MI Local Coordinator, Alberto Bacci

Contest:
2022 Activities

INFN-MI Activities in Micron WP1 and WP2

The aim of the 1° year have been reached:

Study & analysis of the field distribution inside both the mm metallic and µm dielectric laser acceleration cells/cavities:

- Has been considered millimetric, 10 um (CO_2 Laser) and 1 um wave-length
- A solid EM field model to perform Beam Dynamics (BD) particles tracking has been proven
- Cavities design optimization ad hoc for BD.
- The 64 threads Working Station will arrive in September

Figure (1):
It is shown a **RF-gun setting** for a **millimetric cavity** injection with **100 MeV/m gradient**

on the upper image are shown the **emittance in blue**, **the bunch length in yellow dashed line** and **the bunch envelope in yellow solid line**.

On the lower image is shown the energy gain

The setting is ad hoc for the millimetric cavity injection as shon in the following slide

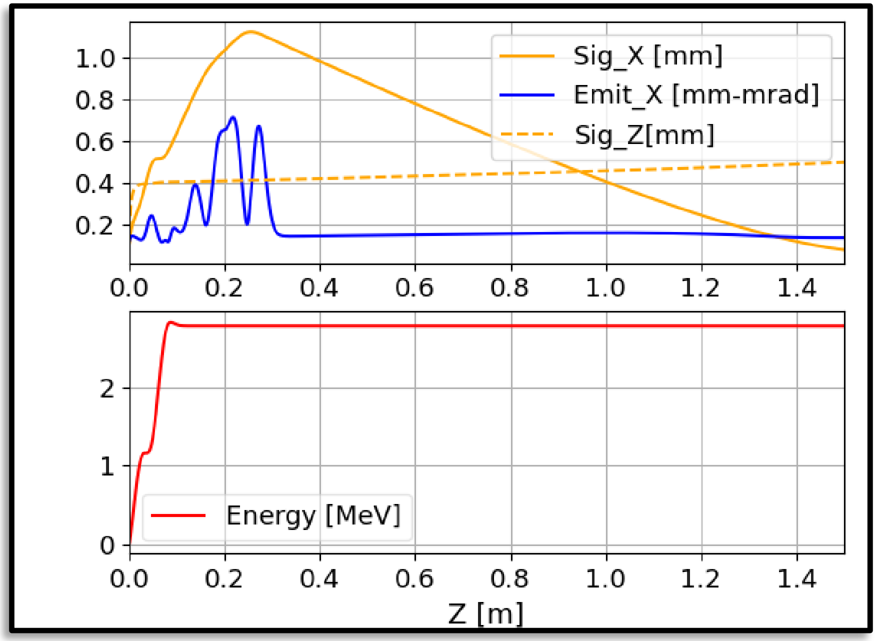


Figure (2):
Injection in to the millimetric cavity.
on the upper image are shown the **emittance in blue**, **the bunch length in yellow dashed line** and **the bunch envelope in yellow solid line**.
On the lower image is shown the energy gain

The image show that the beam is very well matched to the millimetric cavity and as in 10 mm is possible to earn 1 MeV the emittance has a reasonable increased, all the other parameter are frozen.

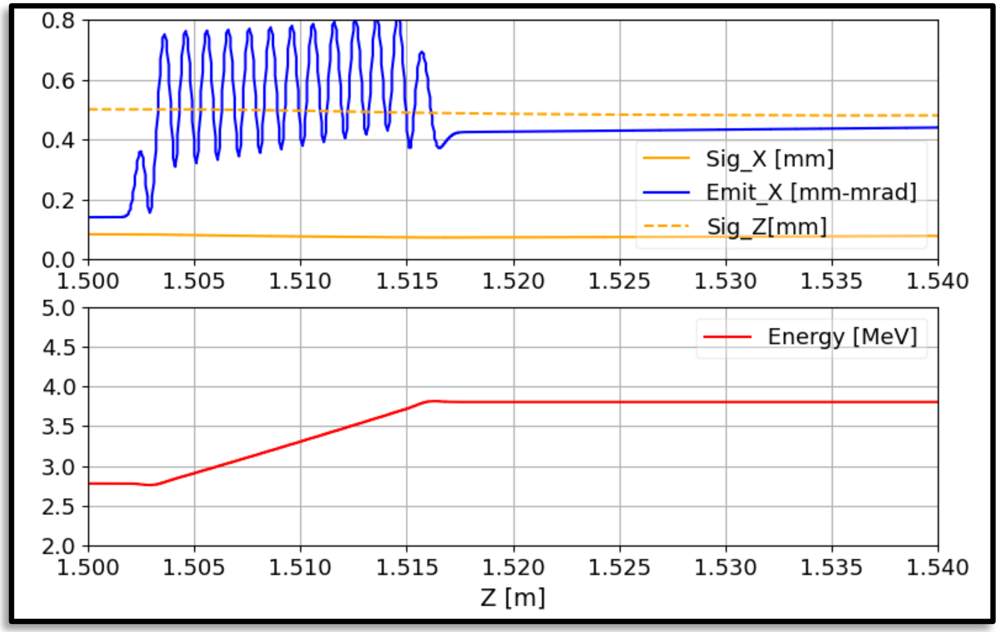
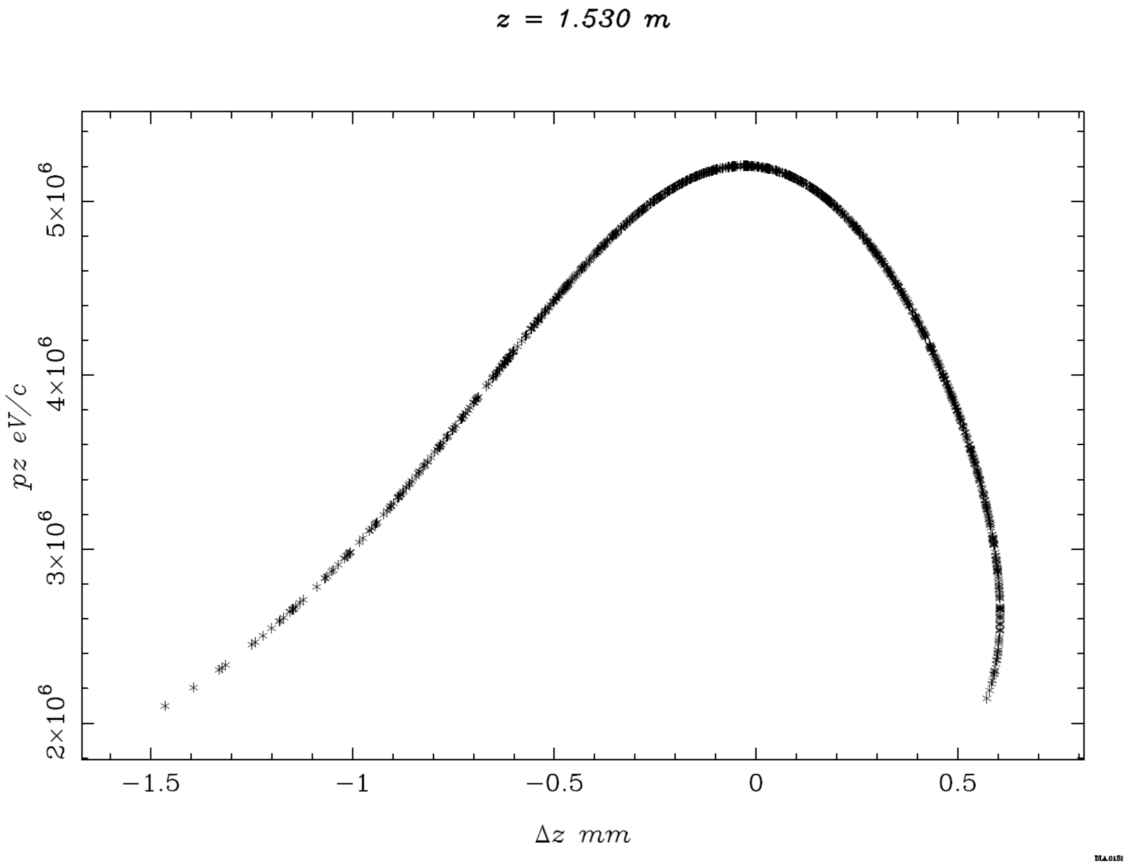


Figure (3):

beam longitudinal phase space.
Because the beam is almost long as the RF acceleration bucket there is a quite large bunch curvature, that can be mitigate exploiting the Velocity Bunching technique together with the acceleration.



FTE: 2023

M.Rossetti Conti: 10
Andrea R. Rossi: 20
Giuseppe Della Valle: 20
Vincetti: 20
Francesco Broggi: 20
Deangelis: 20
Locatelli: 40

TOTALE: 1.5

Next year we'll ask 2 k€ for missions

NAMASSTE (Nanomagnets for Storage and Sensing) - Participants

Participants - Pavia, Firenze and Milano Units		FTE/year	
Manuel Mariani – RU – UNIPV – PI	**Pavia**	**0.5**	2.0
Francesca Brero – Assegnista INFN	Pavia	0.4	
Marta Filibian – Technician - UNIPV	Pavia	0.1	
Elio Giroletti – Senior Member – INFN PV	Pavia	0.2	
Alessandro Lascialfari – PO – UNIPV	Pavia	*0.2*	
Ilaria Villa – Assegnista	Pavia	0.4	
Margherita Porru – PhD student	Pavia	0.2	
Carlo Cialdai – INFN FI	Firenze	0.1	1.7
Fabio Cinti – RTDB – UNIFI	Firenze	0.2	
Maria Fittipaldi – RU – UNIFI	*Firenze*	*0.4*	
Giuseppe Latino – PA – UNIFI	Firenze	0.3	
Angelo Rettori – PA – UNIFI	Firenze	0.2	
Lorenzo Sorace – PA – UNIFI	Firenze	0.3	
Giampaolo Tobia – Technician – INFN FI	Firenze	0.2	
Diego Redigolo – INFN FI	Firenze	0	
Paolo Arosio – RTDB – UNIMI	*Milano*	*0.5*	1.0
Francesco Orsini – PA – UNIMI	Milano	0.5	

External Participant:

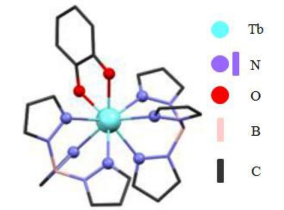
P. Santini – PO, Department of Mathematical, Physical and Computer Sciences, University of Parma

Pavia → Unit 1 **Firenze → Unit 2** **Milano → Unit 3**

INFN Istituto Nazionale di Fisica Nucleare

CSN5

NAMASSTE –work (end 2021- beginning 2022)

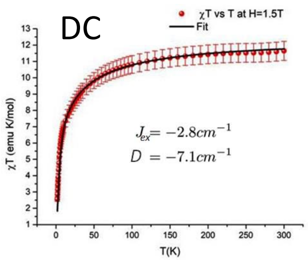


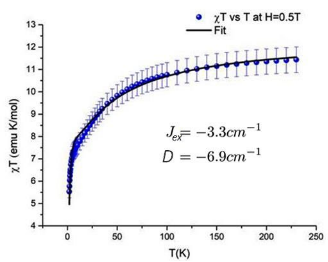
4*f* Single - Ion Magnets (SIMs): **TbSQ**

Quantum storage

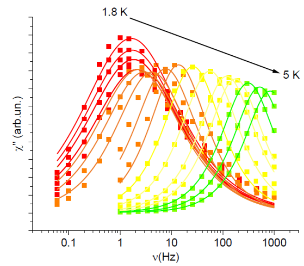
- dc and ac magnetometry in function of magnetic field and T:

DC

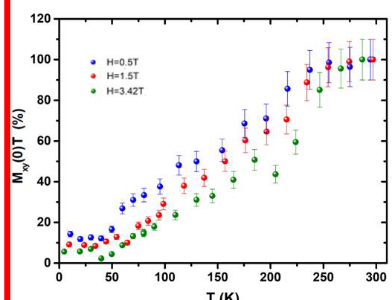




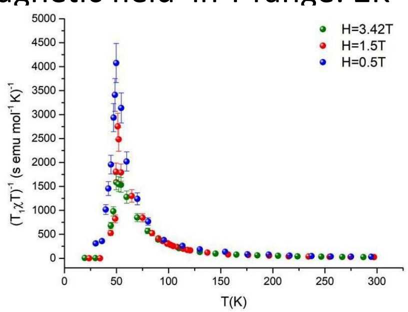
AC



^{1}H NMR measurements at 3 high magnetic field in T range: 2K < T < 300K



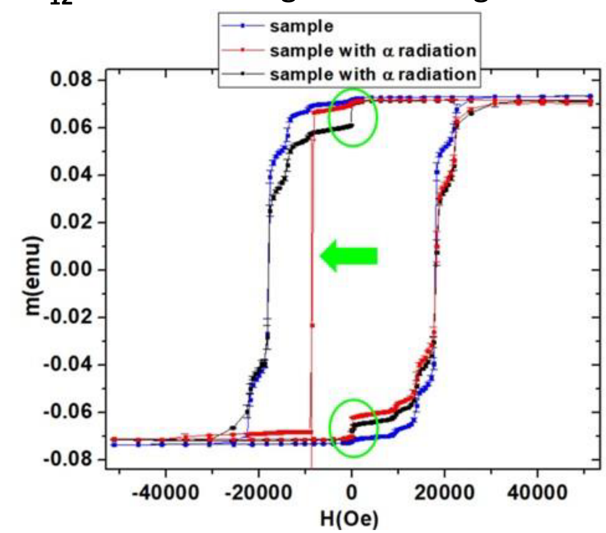
Spin-Spin nuclear relaxation time



$(T_1\chi T)^{-1}$ *vs*T curves

Quantum sensing

First attempts to see avalanche effect on **Mn_{12}** molecules magnet with magnetometry



- on September 15-20th MuSR measurements on Tb-based molecular nanomagnets at PSI (proposal 20213136).
- Next months of 2022: ^{1}H NMR measurements at low magnetic field (< 0,15 Tesla) in Milano labs ... in progress …

INFN Istituto Nazionale di Fisica Nucleare

CSN5

NAMASSTE – Activities Milano during 2023

- NMR characterization of Single Ion Magnet (SIM) Tb-Trp (Terbio-Tropolonato) and e NMR and MUSR (measurement of the superconducting penetration depth) characterization of SIM Dy-Trp (Disprosio-Tropolonato) (Molecular Nanomagnts for quantum memory storage)

- MUSR measurements on Mn_{12} irradiated with alfa particles (Molecular Nanomagnts for quantum sensing)

NAMASSTE – Expenses 2023

INFN Istituto Nazionale di Fisica Nucleare
CSN5

Expense	Motivation	Amount (keuro)
	Pavia Unit (Unit 1)	
CONSUMABLES	Liquid Helium for SQUID and NMR measurements	16
OTHER CONSUMABLES	Low activity beta radioactive source, of not standard size (for insertion in NMR cryostat and SQUID magnetometer)	4
INVENTORY	Pressure gage to be used with bath cryostat to monitor the temperature	2.5
MISSIONS	Missions for Joint and MuSR Experiments: 3 weeks each for 2 PhD/postdoc at Firenze Unit for joint experiments (around 600euro/week); mission at PSI (Villigen-CH) for 3/4 days of MuSR measurements (around 1000euro each)	5
		27.5
	Firenze Unit (Unit 2)	
CONSUMABLES	Liquid Helium for EPR and magnetometry Measurements	18
CONSUMABLES	Synthesis Materials	1.5
MISSIONS	Missions for project meetings and Joint Experiments: 4 weeks for measurements at Pavia and Milano Units for two persons (around 500euro/week)	4
		23.5
	Milano Unit (Unit 3)	
CONSUMABLES	Lab consumable (sample holders, glasses, solvents, etc.) – Spare electronics	0.5
MAINTENANCE	NMR Instrumentation Maintenance: substitution of sample holder	2
INVENTORY	NMR Instrumentation: Integration/substitution of high-resolution Analog to Digital Converter (ADC) Board	1.5
MISSIONS	Missions for joint and MuSR experiments: 2 weeks at Firenze unit (about 500 euro/week); mission to PSI (Villigen-CH), 3/4 days for MuSR measures (~ 1000 euro)	2
		6
		TOTAL
		57

Milano Unit

INFN CSN5
Proposal 2022-2024

nextAIM
(next ARTIFICIAL INTELLIGENCE in MEDICINE)

National Responsible:
Alessandra Retico - Sezione di Pisa
Participating Units:
Sezioni/Laboratori INFN di BA, BO, CA, CT, FE, FI, GE, LNS, MI, NA, PI, PV + PD

ASST Grande Ospedale Metropolitano Niguarda (Milano), *IRCCS Azienda Ospedaliera Universitaria San Martino (Genova); IRCCS Fondazione Stella Maris (Pisa); Dip. Ricerca Traslazionale e delle Nuove Tecnologie in Medicina dell'Università di Pisa; Azienda Ospedaliera Universitaria Meyer (Firenze); Sezione Radioterapia Dip. Scienze Biomediche Sperimentali e Cliniche MarioSerio dell'Università di Firenze, IRCCS Arcispedale S. Maria Nuova Reggio Emilia; IRCCS Istituto ScientificoRomagnolo per lo studio e la cura dei tumori Meldola; IRCCS SDN (Napoli); IRCCS Giovanni Paolo II (Bari); Azienda Ospedaliera Universitaria Policlinico (Palermo).*

Milano Unit

INFN Istituto Nazionale di Fisica Nucleare

INFN CSN5
Proposal 2022-2024

nextAIM

Research context

The current emphasis on the use of artificial intelligence (AI) techniques, including machine learning (ML) and deep learning (DL), in countless fields of research and daily life, fuels a renewed interest in development and implementation of innovative tools based on these technologies also in the medical field.

Objectives

The **nextAIM** experiment aims to address the following specific challenges related to methodological aspects of the application of AI in Medicine (AIM):

- how to manage limited datasets with AI techniques (**n**o-so-big dataset);
- how to make solutions provided by AI models understandable by humans (**ex**plainable **t**echniques for **AIM**).

Milano Unit

nextAIM - Participants

		FTE/year
Cristina Lenardi	**PO**	0.30
Flavia Groppi	PA	0.10
Francesco Orsini	PA	0.10
Ivan Veronese	PA	0.10
Paolo Arosio	RTDB	0.20
Salvatore Gallo	RTDA	0.10
Simone Manenti	Assegnista tipo A	0.10

nextAIM – Expenses 2023

1. **4.0 k€**: GPU
2. **1.0 k€**: Missions/exchange and training of researchers

Milano Unit

INFN CSN5
Proposal 2022-2024

nextAIM – Activity

Milano unit in collaboration with ASST Grande Ospedale Metropolitano Niguarda (Milano)

Contribution to next AIM project (WP3):

AIM - Covid19-Working group: MI, PI, PV, GE, FI, PA, CA

Activity: **RADIOMICS AND DEEP LEARNING ANALYSIS OF CT AND PATIENTS' DATA IN COVID-19.**

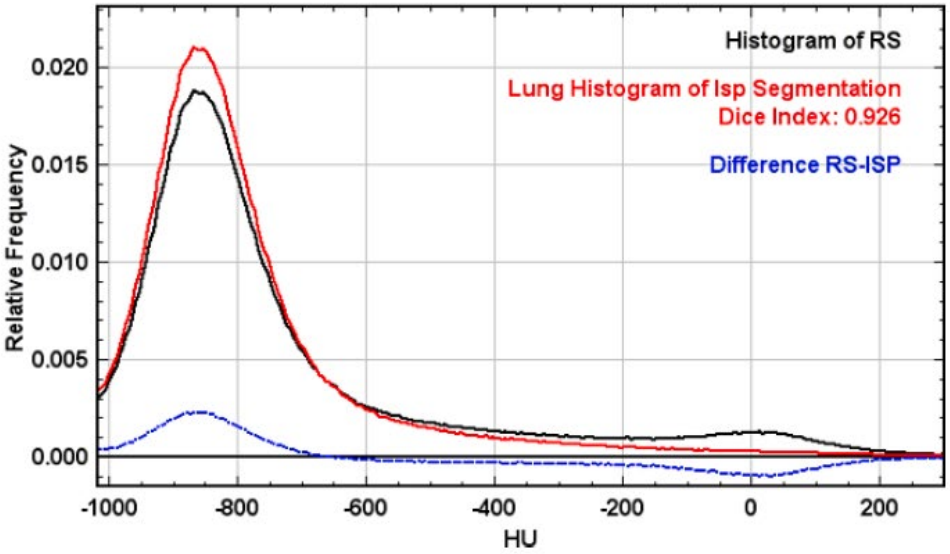
- A new quantification system: **LungQuant**
- Evaluation of **LungQuant** in collaboration with the clinicians

Milano Unit

CSN5

Within the LungQuant project:

Evaluation / Validation of segmentations for automatic feature extraction



L. Berta *et al.,* Automatic lung segmentation in COVID-19 patients: Impact on quantitative computed tomography analysis, **Physica Medica** 87, 115 (2021)

QUANTEP: QUANtum Technologies Experimental Platform

Obiettivo: **Sviluppo di circuiti fotonici quantistici a singolo fotone, integrati in tecnologia SOI (Silicon-On-Insulator)**

Durata: 2021-2023 (terzo e ultimo anno)

Unità partecipanti: RM2, LNL, MI, PI, SA, TO, PG (Camerino)

Resp. Naz.: Andrea Salamon (RM2)

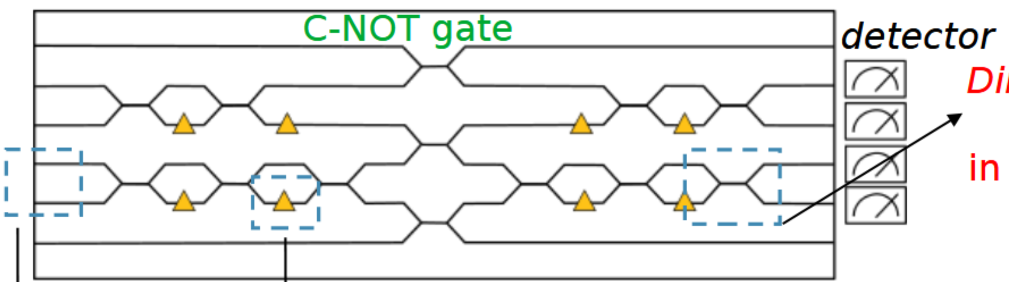
Resp. Loc.: Valentino Liberali

Partecipanti per Milano:

- Valentino Liberali 30%
- Alberto Stabile 10%
- Luca Frontini 50%
- Fabrizio Armani 50%
- SeyedRuhollah (Jafar) Shojaii 30%

QUANTEP: attività di Milano (WP3)

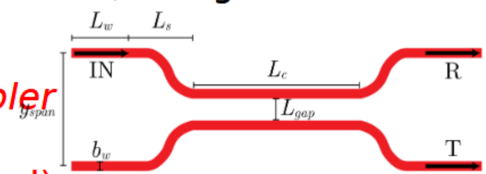
Obiettivo: realizzazione di porta C-NOT (conditional NOT) a singolo fotone, con guide in silicio

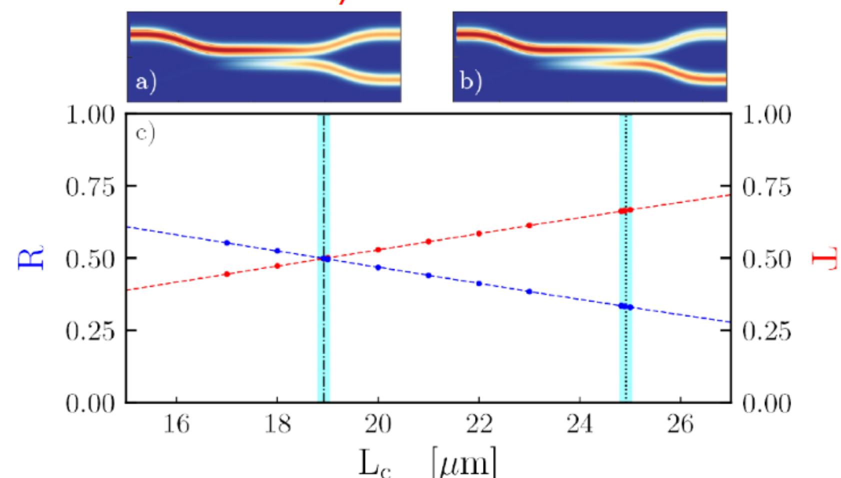


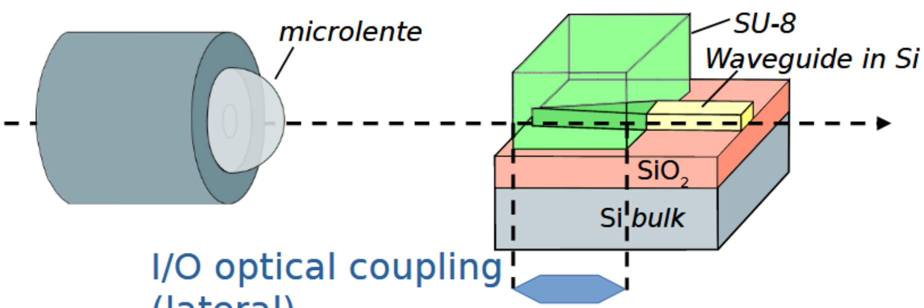
Sfasatore termico (da studiare)

Accoppiatore ottico (in fase di progettazione)

Directional Coupler (progettato in diverse versioni)







I/O optical coupling (lateral)

Variando i parametri geometrici variano i coefficienti di riflessione *R* e trasmissione *T*

QUANTEP: attività e richieste

Attività e obiettivi 2023:

- Misure sui prototipi (attualmente in fabbricazione al Tyndall National Institute, Cork, Irlanda)
- Disegno di accoppiatori ottici per ingresso/uscita, usando uno strato di SU8 (photoresist) e una fibra ottica con microlente
- Studio, disegno e caratterizzazione di sfasatori controllati in temperatura
- Progetto della porta C-NOT completa

Richieste 2023:

- 8 k€ (consumo) per acquisto wafer SOI
- 2 k€ (missioni) per partecipazione alle misure presso Roma Tor Vergata

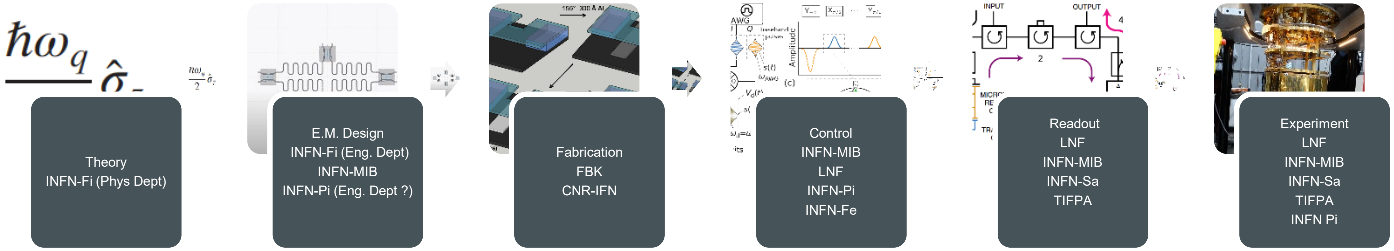
Qub-IT

Objective: Realization of an **itinerant single-photon counter** based on **entangled qubits**

Specific Objectives:

1. Design and simulation of a SC qubit coupled to resonators
2. Fabrication of superconducting circuits with SC qubit
3. Single shot readout of SC qubit with quantum amplifier
4. Control of SC qubit with FPGA-based board
5. Quantum sensing experiment with entangled sensors

ub-IT



Qub-IT 2022-2025
LNF (RN Gatti)
INFN MIB
INFN Mi (RL Carrazza)
INFN Sa
TIFPA
INFN Pi
INFN Fi
INFN Fe
FBK
CNR-IFN

ACTIVITY 2022

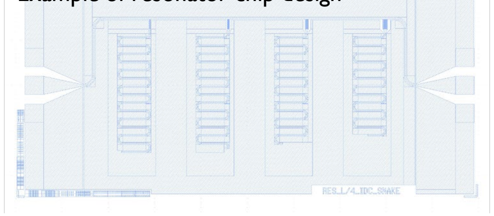
Deliverables:
D1.1 Components design (resonators, capacitors, JJ) (M6) DONE
D1.2 Design of Transmon coupled to 1 resonator (M10) DONE
D1.3 Design 3D Transmon (M12) Starting
D1.4 Design of JPA (M13) DONE

Milestones:
M1.1 Realization of first Transmon chip layout (M6) DONE

Deliverables
D2.1 Fabrication of test chip with components, resonators, capacitors and JJ for process calibration (M9) ONGOING at FKB
D2.3 Fabrication of JPA (M18) ONGOING at FKB (1 year in advance)

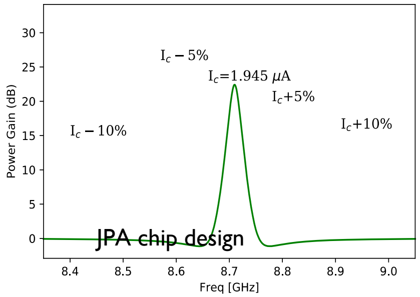
D1.1

Example of resonator chip design

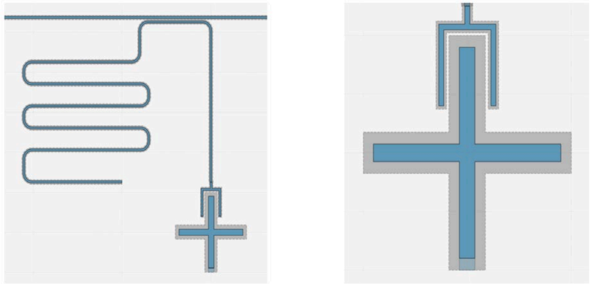


D1.4

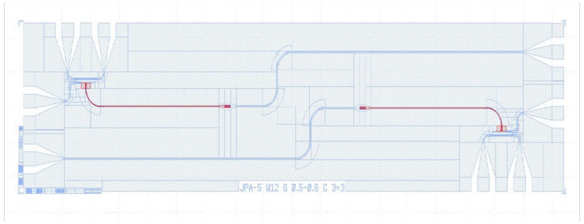
Simulation of JPA Gain



D1.2 and M1.1

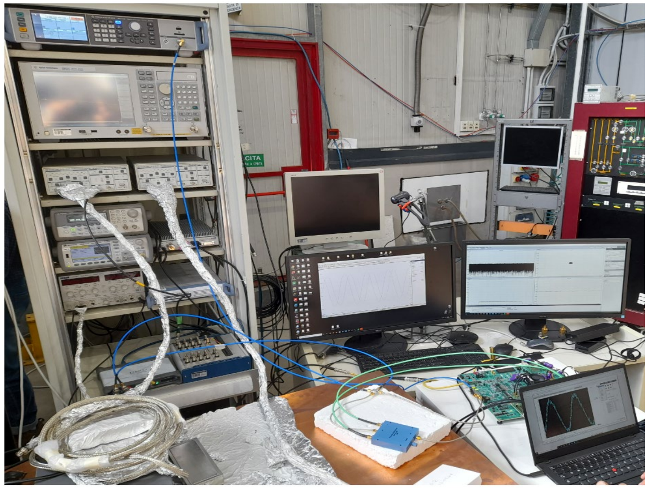


JPA chip design



ACTIVITY 2023

Deliverables (INFN MI):



D3.1 First release of the Qibo qubit hardware control package (M18) We will install and configure Qibo software to control lab instruments for qubit control; FPGA firmware for pulse generation of readout and control of qubits.

D4.1 Circuit components characterization (M12) We will test resonators and junctions

D4.2 Experiments with Transmon coupled to one resonator (M14) We will test the first production of transmon qubits

Milestone:

M4.1 Succesful characterization of first Transmon qubit (M14)

Anagrafica 2023 INFN Mi: 0.2 FTE (dtz)

Richieste economiche 2023 INFN Mi: -

REMIX

Research on Emerging Medical radioIsotopes from the X-sections

Proposta sperimentale in CSN5 (2021 –2022 –2023)

PI: Gaia Pupillo – LNL

Sezioni partecipanti: FE, LNL, MI, PD, PV

Aim of the project

CSN5

Study the production of **theranostic radionuclides** for innovative radiopharmaceuticals.

^{47}Sc and Terbium isotopes

		IMAGING		THERAPY		
Isotope	Half-life	β^+ $E_{average}$ [keV] (I)	x and γ with I > 10% E [keV] (I)	β^- $E_{average}$ [keV] (I)	Conv. & Auger electrons (>1 keV) $E_{average}$ [keV] (I)	α E [keV] (I)
^{43}Sc	3.9 h	476 (88%)	372 (23%)	–		–
^{44}Sc	4.0 h	632 (94%)	1157 (100%)	–		–
^{47}Sc	3.35 d	–	159 (68%)	162 (100%)		–
^{149}Tb	4.1 h	730 (7%)	42–50 (69%), 165 (26%), 352 (29%), etc.	–	32 (85%)	3967 (17%)
^{152}Tb	17.5 h	1140 (20%)	42–50 (65%), 344 (64%)	–	36 (69%)	–
^{155}Tb	5.32 d	–	42–50 (108%), 87 (32%), 105 (25%)	–	19 (204%)	–
^{161}Tb	6.89 d	–	45–53 (39%), 75 (10%)	154 (100%)	19 (227%)	–

Milano

a) Determination of **thin targets yield for the $^{149,152,155,161}Tb$ by deuteron and alpha irradiation at ARRONAX**
b) Determination, by integration of thin target yield, of **Thick Target Yield for the involved radionuclides production**
c) Comparison with the results obtained with simulation of computer codes: **Alice; TENDEL 2017; Empire 3.2.2**

FTE e richieste economiche

Anagrafica Milano - 2023	FTE: 1.9 / 2.9
Groppi F. – PA	0.4
Manenti Simone – Assegno di Ricerca UNIMI	0.4
Cagnetta F. – Docente	0.1
Colucci M. – PhD	1.0
Confalonieri L. – associazione da settembre 2022	1.0

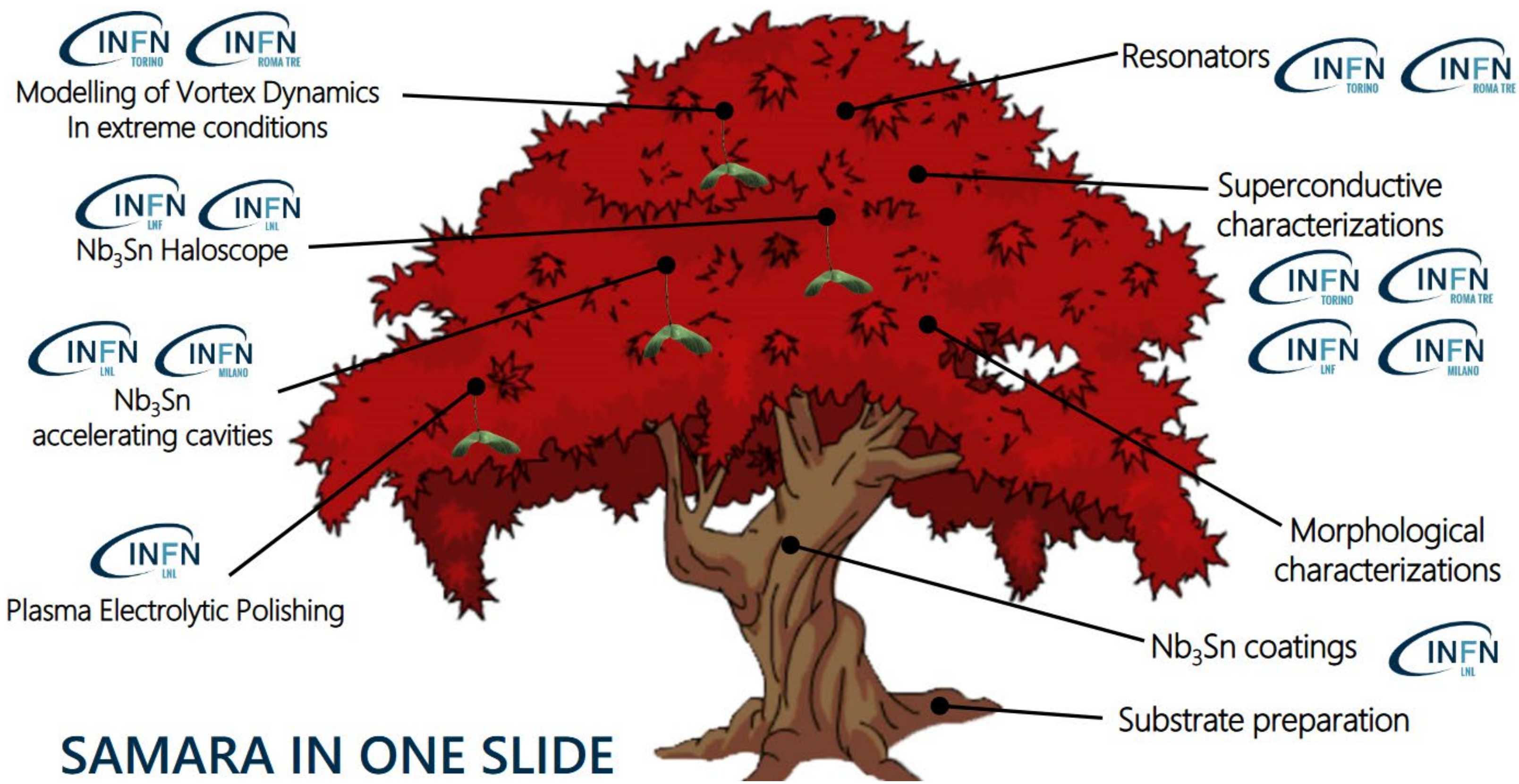
Capitolo	Descrizione	Richieste - keuro
Consumo	Acquisto targhette e materiale da laboratorio	5.5
Missioni	Turni di irraggiamento presso ARRONAX – Nantes	6.5
Inventario	Acquisto modulo NIM, alta tensione per rivelatore HPGe	4.0
Manutenzione	Per il Laboratorio di Radiochimica	3.0
Trasporti	2 trasporti radioattivi da ARRONAX, Nantes (FR) – LASA, Segrate (MI	7.0

SAMARA

Superconducting **A**lternative **M**aterials
for **A**ccelerating cavities and haloscope **R**esonators for **A**xions

R.N:Cristian Pira (INFN-LNL)

R. L. Michele Bertucci (INFN-MILANO)



INFN Milano contribution:

- **Superconductive characterizations:** samples analysis with cryogenic techniques (2022-2023) @LASA
- **Nb3Sn accelerating cavities**: vertical cold tests of 1.3 GHz elliptical cavities (2024) @LASA

INFN Milano activity for 2022 and 2023:
RRR measurement on niobium samples at cryogenic temperatures @ LASA

DC measurement:

- Four-wire technique so to decouple current source and voltage measurement
- Sample measured at room temperature and just above transition temperature (9.2K for niobium)
- Gives only indication **of bulk material properties**

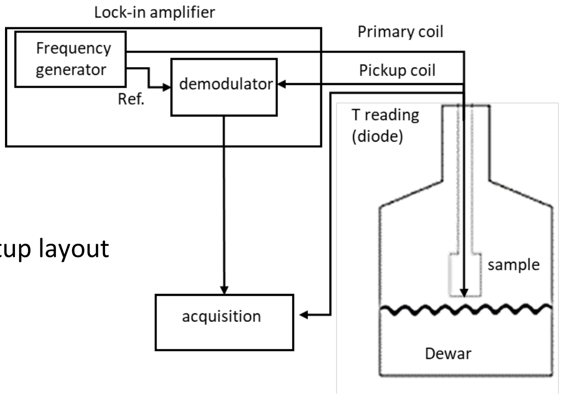
RRR probe sample holder

AC measurement with eddy current probe

- Allows to probe different material thicknesses according to frequency-dependent penetration depth:

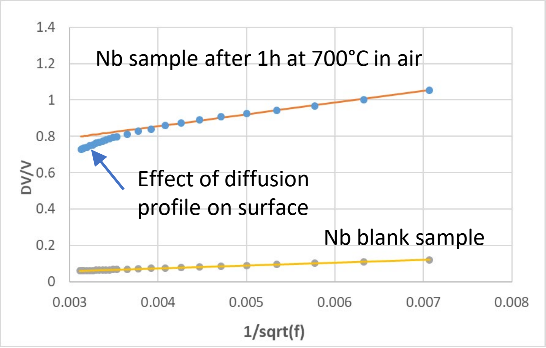
$$\delta(f) = \sqrt{\frac{\rho}{\pi f \mu}}$$

- Pick-up coil induced voltage is measured just above transition temperature (<9.2K) and at 4.2K. Voltage variation is proportional to material skin depth, and therefore to sqrt of resistivity



Setup layout

AC measurement on untreated vs treated Nb sample



- Lock-in amplifier frequency range up to 2 MHz: 1-10 um depth of analysis
- Allows to monitor **surface state**:
  - Interstitial diffusion (contaminations,doping,…)
  - Analysis of biphasic systems (coatings\film depositions)

Future plans

- SAMARA, a CSN5 experiment, ends in 2024.
- FTE in 2022
  - Michele Bertucci 10 %
- FTE in 2023
  - Michele Bertucci 10%

Funds for 2022: 3k

Funds foreseen for 2023: 6k

- We have no special requirements for support in 2023.

SL_Comb2FEL

Informazioni generali	
Area CSN di riferimento (questo dato verrà modificato/aggiornato a breve)	**CSN V**
Linea di ricerca	**Accelerators and related technologies**
Laboratorio ove si raccolgono i dati	**SPARC_LAB Test Facility at Laboratori Nazionali di Frascati**
Sigla dell'esperimento assegnata dal laboratorio	**SL_COMB2FEL**
Acceleratore usato	**SPARC**
Fascio (sigla e caratteristiche)	**Electron beams in single and multi-bunch configuration (Ultra-short comb beams)**
Processo fisico studiato	**Particle-driven plasma wakefield acceleration, Cherenkov radiation, betatron radiation and FEL generation mechanism**
Apparato strumentale utilizzato	**SPARC photo-injector and ancillary components; plasma lab**
Istituzioni esterne all'Ente partecipanti	**CERN, ELI-beamlines, Fermi@Elettra**
Durata esperimento	**5 years**
Call	**No**
Sezioni partecipanti	**Lecce, Lab. Naz. di Frascati, Milano, Napoli, Roma I, Roma II**

SL_COMB2FEL

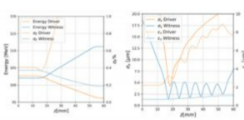
Example of capillary used in the experiment.

SL_COMB2FEL is a five-year experiment (2019-2023) funded by the CSN 5 of INFN and carried out at SPARC_LAB, aiming at demonstrating the high quality electron beams, as generated by particle-driven plasma acceleration (PWFA), through the final measurement of the Free-Electron Laser (FEL) gain curve.For the success of the proposed experiment, the long-lasting collaboration among LNF, Milan, Roma1, Roma2, Naples and Lecce has been renewed, each unit participating with its own expertise.

This research activity is integrated in the framework of Horizon 2020 to prepare the Design Study of EuPRAXIA ("European Plasma Research Accelerator with eXcellence In Applications") for the feasibility of a plasma-based user facility, and is of utmost interest for the future EuPRAXIA@SPARC_LAB test user facility.

Based on the experience gained at SPARC_LAB in SL_COMB, we foresee to study, both with simulations and experimental solutions, the impact of plasma in- and out-ramps, plasma jets and non-uniform plasma density profiles on the acceleration efficiency and on the quality of accelerated electron beams, as required to drive a FEL. Furthermore, the successful measurement of the FEL radiation gain curve is strongly dependent on focusing devices to match and transport the beam to the FEL. At SPARC_LAB we plan to integrate active plasma lenses in the conventional transfer line to proper design the matching to the undulator. A transfer line based on active plasma lenses and collimators must be studied also to remove the driver bunch after plasma interaction, allowing the optimization and transport only of the witness beam, which gains energy in the plasma-accelerating module.

The SL_COMB2FEL approach, using a driver beam to excite the plasma wakefield, that accelerates a properly injected witness beam, can guarantee the necessary beam quality to generate SASE FEL radiation in the SPARC undulator, i.e witness energy spread <0.2% and normalized transverse emittance <1 mm mrad, as shown in figure.

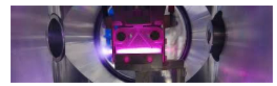


Simulation of the plasma acceleration with real input parameters. Left: Energy and energy spread evolution in the capillary of both driver and witness bunches. Right: Evolution within the capillary of the transverse size and normalized emittance for both driver and witness bunches.

In this regard, we have considered the results obtained through a plasma simulation to evaluate the SASE FEL gain length and saturation power in the case of SPARC beam and undulator parameters.

PUBLISHED ON NATURE THE NEW RESULTS OF SPARC_LAB

31 May 2022 Featured, News



The SPARC_LAB research team at the Frascati National Laboratory has recently demonstrated that the plasma-based acceleration technique allows to obtain an **high-quality particle beam**, comparable to the beams produced in traditional accelerators.

The results of this study have been published on Nature and pave the way to the **realization of compact and portable particle accelerators**, to be used not only in the research context but also in the medical and industrial sectors.

The possibility to accelerate electron beams to ultra-relativistic velocities over short distances by using plasma-based technology holds the potential for a **revolution in the field of particle accelerators**.

Despite the high acceleration gradients produced in a plasma (up to three orders of magnitude higher than the conventional machines based on RF technology), their use has been limited due to the low quality of the beam produced. The study reported on Nature carried out at SPARC_LAB showed that, for the first time, it is possibile to use an high quality beam accelerated by a plasma wave to generate coherent radiation in a Free Electron Laser (FEL) in the infrared range.

The results was obtained injecting two electron bunches (few tens of microns sized) in the plasma contained in a 3 cm long capillary. Firstly it is necessary to create the plasma by ionizing hydrogen gas with a high voltage discharge. Then, the two electron bunches are injected. The first bunch (driver) serves to excite the plasma accelerating waves that are exploited by the second bunch (witness) that is accelerated. The high quality of the witness at the entrance of the plasma is preserved along the acceleration process and, in addition to the high current, is capable of driving a free-electron laser (FEL) by generating coherent light pulses. The experiment conducted at SPARC_LAB allowed the light pulses to reach the energy of 30 nJ.

"The plasma acceleration technique will allow to realize accelerators in small places, limiting the production costs of the hosting infrastructures and making this technology more accessible and available also for medical applications in equipped hospitals, and especially in underground facilities as the ones necessary for accelerators in High Energy physics", says Riccardo Pompili, Principal Investigator of the experiment carried out at SPARC_LAB.

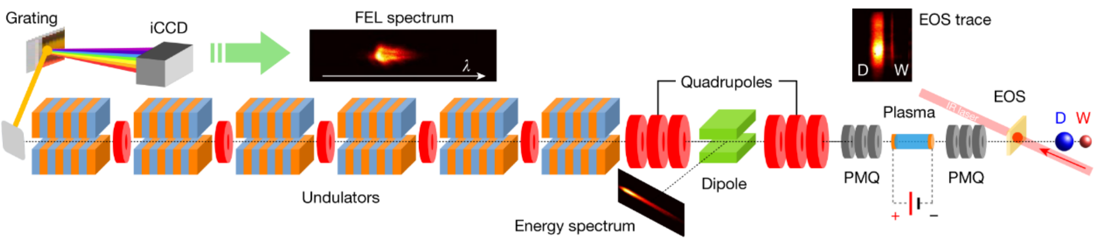
"This result has not only a great scientific relevance per se, but it represents also a milestone towards the realization of the are project EUPRAXIA, that yearns for the construction of the first research infrastructure addressed to users, based on plasma acceleration", explains Massimo Ferrario, responsible of the EUPRAXIA@SPARC_LAB project, financed also by a contribution of the Italian Minister of Research and University (MUR) and recently included in the ESFRI roadmap, the strategic forum for research infrastructures.

In 2021 experimental data have been performed, and published:

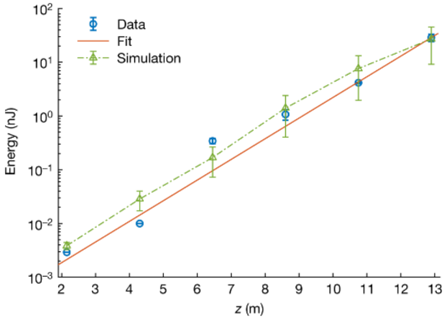
Free-electron lasing with compact beam-driven plasma wakefield accelerator

Pompili, R., Alesini, D., Anania, M.P., ...Zigler, A., Ferrario, M.

Nature, 2022, 605(7911), pp. 659–662



Scheme of the experiment



FEL radiation growth

Another paper have been sent to Nature Photonics.

Descrizione	Data completamento
Optimization of the injection to the plasma capillary to satisfy transverse matching condition	31-05-2022
Optimization of the extraction from the plasma capillary to allow for alternative FEL emission schemes	30-06-2022
Studies of tens of cm long plasma capillaries	30-09-2022
Experimental characterization of PWFA mechanism driven by multi-driver bunches	30-11-2022

Mod. EC/EN 8

(a cura del responsabile nazionale)

	Ricercatori					
	Nome	Età	**Contratto**	**Qualifica**	**Aff.**	**%**
1	**Bacci Alberto Luigi**		Dipendente	Ricercatore	CSN V	**10**
2	**Opromolla Michele**		Associato	Dottorando	CSN V	**50**
3	**Paroli Bruno**		Associato	Ricercatore B Tempo Determinato Tipo B	CSN V	**20**
4	**Petrillo Vittoria**		Associato	Prof. Associato	CSN V	**30**
5	**Rossi Andrea Renato**		Dipendente	Ricercatore	CSN V	**20**
6	**Ruijter Marcel**		Associato	Dottorando	CSN V	**50**
7	**Samsam Sanae**		Associato	Dottorando	CSN V	**50**
			Numero Totale Ricercatori	7	FTE: 2.30	

PREVENTIVO GLOBALE DI SPESA PER L'ANNO 2022

In K€

Struttura	A carico dell'I.N.F.N.										A carico di altri enti
	missioni	consumo	altri_cons	trasporti	manutenzione	inventario	licenze-SW	apparati	spservizi	**TOTALI**	
LE	2.50	10.00								**12.50**	
LNF	3.00	35.50								**38.50**	
MI	2.00					1.00				**3.00**	
NA	7.00	1.00								**8.00**	
RM1	2.00					5.00				**7.00**	
RM2	3.00					12.00				**15.00**	
Totali	**19.50**	**46.50**				**18.00**				***84.00***	

Mod. EC/EN 4

(a cura del responsabile nazionale)

Grant Giovani

ACTIS

Fellowship awarded through call N. 21188/2019 **(Feb 2020 – Dec 2022 -> Jun 2023)**

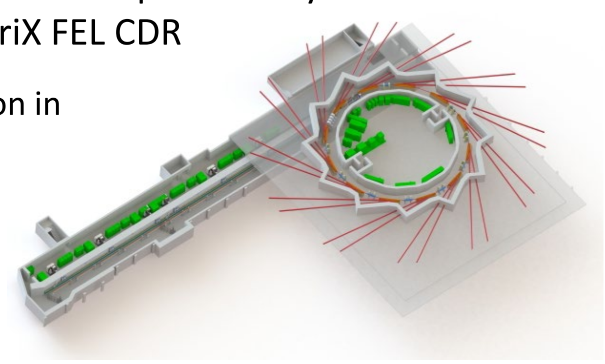
Referees: Cristina Vaccarezza, Pablo Cirrone

Experiment **aim**:

First demonstration of electron beam compression by **Arc Compressors** as studied in MariX FEL CDR

ACTIS takes place @ Solaris synchrotron in Cracow (Poland)

SOLARIS
NATIONAL SYNCHROTRON RADIATION CENTRE



Collaboration:

- **INFN-Milano**
- **Solaris**
- **Elettra - S.T. S.C.p.a.**
- **LNF**

Situation

Russian invasion of Ukraine had an impact on the time schedule:

- 1 order of ad hoc studied components comes from Russian Federation (now being replaced).
- Solaris will be shut down from mid September to January for special mantainence of SR.

Extension:

Requested to extend operations through **mid of 2023 (+6 months)**

Done Up to now:

- The **machine model** has been built from scratch.
- **Bunch length detectors** have been defined and orders are sent.
- **Development** of an **AI** based **optimizer for beam dynamics** optimizations & beamline design.
- High-performance workstation for parallel computing is active and on the job.

Future plans

In the following months:

- Optimization of the ACTIS working point of the machine
- Last two orders will be completed.
- Assemble and align the detectors in Frascati.
- Shipment of detectors to Solaris.

In the first half of '23:

- Detectors installation and testing.
- Experimental activities @ Solaris.

Expenses (In arrangement to request zero additional funding)

Missions (estimated in max 10 man weeks: <= **15 k€**)
- Missions to Solaris (inspection, equipment installation, measurement shifts)
- Mission to LNF (assembly of measurement equipment)

Expeditions (**1 k€**)
- Shipment of the assembled material (two breadboards) from LNF to Solaris (Krakow)

Grazie per l’attenzione

RICHIESTE SERVIZI GR5 - 2023

SIGLA	OFFICINA mesi-uomo	PROGETTAZIONE mesi-uomo	Elettronica mesi-uomo
ASTAROTH	0.5	1	1
N3G	1	1	1
SIG	3	2	
BNCT_SPECT	2		
ETHIOPIA	0.5		
RADIOLAB_C3M	0.2		
TOTALE	**7.2**	**4**	**2**

Prossimi passi

- call_template_22.pdf (infn.it) – scadenza **1 giugno 2022**
- template_nuovo_esperimento.pdf (infn.it) – scadenza **10/07**
- 1 call tematica sull'argomento "Fisica e Tecnologia degli acceleratori« + 1 CALL aperta

- Per i nuovi proposal
  - evidenziare le tematiche mature che siano in grado di mettere in atto delle sinergie.
  - Cercare di confrontarci il più possibile, discutendo i vari aspetti in modo da essere in grado di comprendere al meglio il contenuto delle varie proposte.
  - Non arrivare all'ultimo momento. Tenete in conto che tutto deve essere pronto e caricato per il 10 luglio – 10 giorni prima della riunione di luglio che inizia il 20. Questo indipendentemente dai data base, riunioni di sezione etc.

Operativamente: coloro che intendono proporre dei nuovi esperimenti vengano a discuterne con il Direttore e con me in modo da cercare di massimizzare le sinergie e la probabilità di successo.

VARIE

Calendario futuro:

- ~~**11-12 Aprile** LASA (Org. Groppi-Giove) - Consuntivi sigle chiuse nel 2021.~~
- **20-22 Luglio** Frascati - Selezione proposal per 2023; Relazione panel sulle proposte Call 2023.
- **12-16 Settembre** Perugia (Org. Menichelli).
- **23-24 Novembre** Frascati - Grant giovani 2023.

Workshops

- ~~**7-8 aprile** Milano: Accelerator Workshop~~
- ~~**2-3 maggio** Bologna: WS on AI~~
- ~~**4-5 luglio** Università La Sapienza di Roma: TERA-Days2022~~

Sul sito della CSN5 trovate ulteriori dettagli e le news più aggiornate