CSN5 INFN-LNF

C. VACCAREZZA COORDINATORE LNF

JULY 6TH 2021

Outline

- CSN5 update
- CSN5-LNF overview
- New Experiment proposals and Calls
- Ongoing experiment report

CSN5 update

- Data base preventivi 2022 open until July 14th 2021
- Data base assegnazioni (richieste aggiuntive, sblocchi sj) open until July 14th 2021
- Next CSN5 meeting: July 19-20-21 2021 at LNF
  - Highligths: New president election

CSN5 overview

People= 208 (+25%) : Ric. 94 (+22%), Tec. 72 (+29%)   FTE= 42 (+11%)

DETECTORS 5	INTERDISCIPLINARY 5	ACCELERATORS 9
• DARTWARS	• GLARE_X (closing)	• ARYA (RN MR Masullo)
• ENTER_BNCT	• OLAGS DTZ	• LEMMAACC (closing ae)
• IDDLS	• PAPRICA (Grant)	• NUCLEAAR (closing ae)
• PEROV DTZ.	• RESOLVE	• SHERPA (Grant)
• SIMP (closing)	• SAMADHA	• SINGULARITY
		• SL_COMB2FEL
		• SL_EXIN
		• TERA (Call – closing ae))
		• TUAREG

- Tra i progetti in cui è coinvolta la farm del calcolo scientifico di Frascati (Tier2 di ATLAS e PADME) c'è: **IDDLS**: Italian Distributed Data Lake for Science, **Gr V**
- Partecipanti: GARR, INFN (CNAF, Bari, LNL, Napoli, Roma1, Pisa, Perugia)

New proposals for 2022

New proposals con RN @ LNF

- Fairtel RN S. Bini, presenter A. Drago
- Impact RN A. Marcelli
- Microspex RN D. Hampai
- Qub-IT RN C. Gatti
- VorTeD RN J. Rezvani

New proposals con RL @ LNF

- MICRON RL L. Faillace
- Plasmi by THz_PbT RL A. Biagioni
- SIG (Call) RL L. Sabbatini (WP3) presenter L. Sabbatini
- SAMARA RL D. Di Gioacchino
- VAC_Crio (call) RL A. Liedl

Ongoing experiments in 2022

Exp ongoing with RN at LNF

• SHERPA*	RN M. Garattini (presenter)
• SL_COMB2FEL	RN E. Chiadroni
• TUAREG	RN D. Alesini
• URANIA_V	RN G. Bencivenni

Exp ongoing with RL at LNF

• ARYA	RL R. Cimino
• DARTWARS	RL C. Ligi
• ENTER_BNCT	RL R. Bedogni
• RESOLVE	RL S. Dabagov
• SAMADHA	RL R. Bedogni
• SL_EXIN	RL M.P. Anania

Exp ongoing on Dotazioni GR5

• OLAGS	RL A. Clozza
• PEROV	RN M. Testa
• SINGULARITY	RN S. Pioli

New proposals with RN@LNF

IMPACT

Improve Materials Performances with Advanced Coatings Technologies

New proposal for 2022-2024 (1+1) [LNF +RM1]

- The goal of this project is to enhance the properties of strategic materials like copper or niobium using advanced coatings technology. The proposal is based on the experience gained within NUCLEAAR and TERA projects [5th National Committee].

  Thin film of transition metals oxides or dichalcogenides can be used to:

  - *Enhance properties of high power RF-cavities made by oxygen free copper*
  - *Improve the emission properties of photo-anode in state of the art seeded FELs.*
  - *Coat high entropy alloys: a new class of materials for the space applications.*

Milestones

Year 1: Synthesis and optical tests at low and high electric field of films with different thickness and degree of cristallinity

Year 2: Plasmonic and polaritonic dynamics investigation of films by THz sources (high power lasers and FELs)

IMPACT

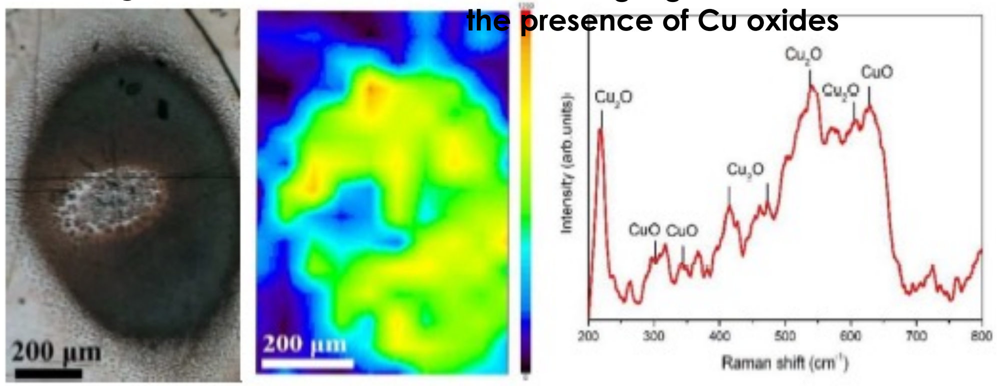
- Starting from the experience and the instrumentation developed in NUCLEAAR we are now able to successfully deposit TM oxides with different degrees of crystallinity. In particular we demonstrated the efficiency of MoO_3 coatings as protective layer for metallic copper. Moreover, due to the increase of the Work Function (WF), and the generation of surface polaritons states we observed extreme confinement of radiation in thin and ultra thin films.

- Knowledge and experience can be extended to others oxides like V_2O_5, another Van der Waals and hyperbolic material with a high WF. In addition extremely low WF materials like $BaO\backslash BaO_2$ can be synthesized and investigated to improve photo-anode materials, e.g., reducing the electron extraction energy density per surface, and generating more brilliant electron beams (and also more brilliant X-ray source)
- Tests on synthesized films and flakes from single crystals will be carried out in collaboration with the Roma1 unit, using the experimental set-up developed with the TERA Project approved by the 5th National Scientific Committee.

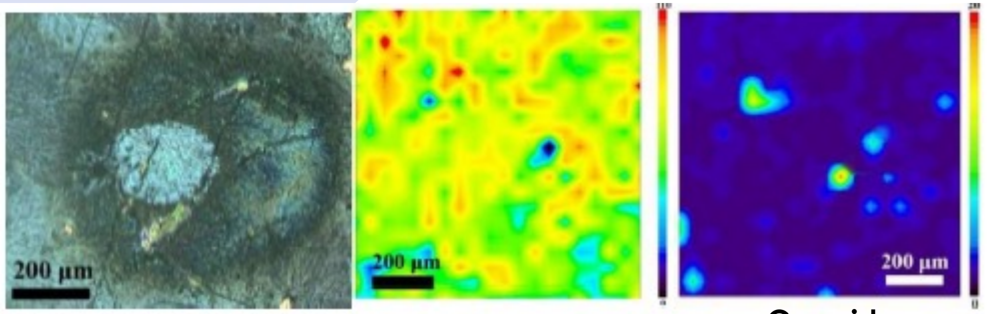
Uncoated Cu exposed to 5000 THz FEL pulses

Optical image

Raman map and spectrum. The yellow areas highlight the presence of Cu oxides



MoO$_3$ coated Cu exposed to 5000 THz FEL pulses



Optical image

Raman map crystalline MoO_3

Cu oxides Raman map

References

- S. Macis et al, Journal of Vacuum Science & Technology A **37**, 021513 (2019) https://doi.org/10.1116/1.5078794;
-S. Macis et al, Condens. Matter (2019) , 4(2) https://doi.org/10.3390/condmat4020041

IMPACT - 2.5 FTE

INFN

Participants LNF 1.5 FTE

- Augusto Marcelli 30%
- Salvatore Macis 30 %
- Paola De Padova 30%
- Javid S. Rezvani 30%
- Zeinab Ebrahimpour 30%
- Bruno Spataro 0%

Participants RM1 1.0 FTE

- Stefano Lupi 30%
- Sen Mou 40 %
- Massimo Petrarca 30%

Collaborazioni

- Cambridge University
- Osaka University
- Seoul National University
- University of Science and Technology of China

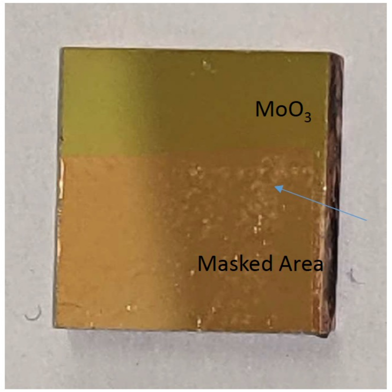
SAPIENZA Università di Roma

OSAKA UNIVERSITY

Cranfield University

The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA

UNIVERSITY OF CAMBRIDGE



Film visible on the masked side

ISIR@Osaka

MoO_3 single crystal

MicroSpeX

MicroSpeX: Sviluppo e validazione di un micro Spettrometro all-in-one per raggi X

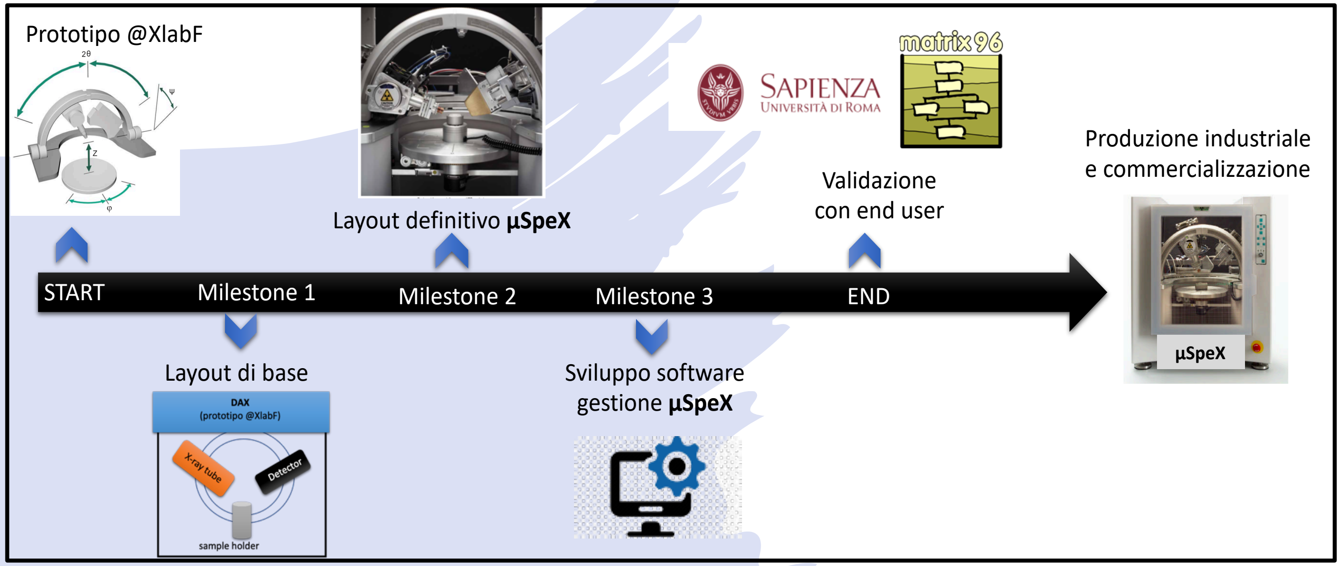
- **Progetto microSpeX:** realizzazione di un prototipo da banco in grado di effettuare **simultaneamente** micro-diffrattometria e micro-fluorescenza X, mediante utilizzo di ottiche per raggi X miniaturizzate (ottiche policapillari) con sorgenti di raggi X convenzionali per il raggiungimento di risoluzioni spaziali micrometriche.

- **Campi di applicazione:** analisi strutturale ed elementale di campioni provenienti da siti archeologici (dipinti, ceramiche, vernici, manufatti antichi, volumi cartacei, etc.), controllo di qualità di prodotti lungo la linea di produzione industriale, studio elementale/strutturale di materiali innovativi in campo avionico e spaziale, studio di inquinanti presenti in aerosol atmosferici e in matrice biologica, caratterizzazione di composti per ambito farmacologico.
- **Durata del progetto:** 3 anni
- **Technology Readiness Level:** attuale **4** → previsto **6/7**
- **Potenziale sfruttamento della tecnologia:** ingegnerizzazione del prototipo realizzato a fine progetto per la sua industrializzazione e immissione sul mercato mediante accordi di trasferimento tecnologico con terze parti (i.e. licenze esclusive di produzione) mantenendo la produzione della core technology (i.e. ottiche policapillari) presso INFN-LNF sotto la supervisione di XlabF.

MicroSpeX

MicroSpeX: piano di sviluppo

- **Roadmap di sviluppo del progetto (3 anni):**
  - ✓ **Obiettivo 1**: Sviluppo, Realizzazione e Validazione di microXRF/microXRD a partire da un prototipo a TRL 4 mediante implementazione di componenti hardware e sviluppo di software dedicato.
  - ✓ **Obiettivo 2**: Test e validazione delle performance attese in condizioni di operatività tipiche di un caso reale quale è l'analisi di un reperto proveniente da uno scavo archeologico o un laboratorio di restauro o di un museo condotta da un end-user (archeologo o studioso dell'antichità) per il raggiungimento del TRL 7.



MicroSpeX – MicroSpectrometry by X-ray		
Caratteristiche	**µXRD**	**µXRF**
Anodo	*Cu*	*Cu*
Spot focale (µm)	*100*	*100*
HV (kV)	*50*	*50*
Corrente (mA)	*1*	*1*
Range 2theta (°)	*1 - 130*	*1 - 130*
Step 2theta (°)	*0.01*	*0.01*

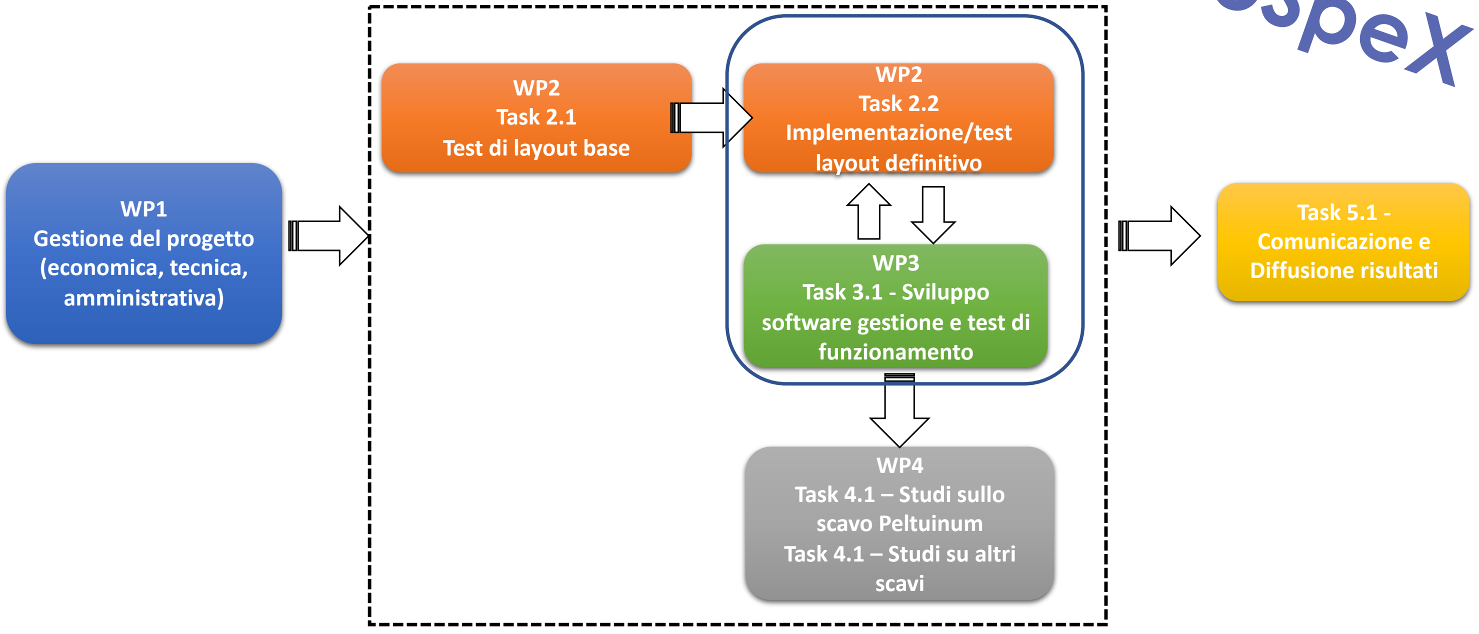
- **Risoluzione del sistema:** FWHM di picco inferiore a 0.04° di 2θ FWHM
- **Linearità del goniometro:** posizione del picco nell'intervallo +/- 0.02°di 2θ
- **Performance a basso angolo:** distinzione picchi con rapporto di intensità fino ad 1°del 2θ, necessario per lo studio di campioni organici o farmaceutici, argille o materiali mesoporosi
- **Pattern XRD su aree micrometriche:** l'uso di lenti polyCO permette analisi di dimensioni micrometriche (50 - 100 µm) e mappature 2D (50x50-100x100 µm^2)
- **Utilizzo in situ:** l'uso delle polyCO accoppiate al tubo RX a bassa potenza, permette la compattazione dello strumento in un box di circa 1 m3 e peso inferiore ai 150 kg, rendendolo trasportabile e utilizzabile in situ (i.e. museo, un sito di scavi archeologici, linea di produzione etc.)
- **Variabilità della camera di misura e del tipo di analisi:** misure in serie, installazione di camere di misura ad hoc (alta P, alta T, criogenia)

MicroSpeX: Struttura complessiva del Progetto

MicroSpeX

Roadmap di sviluppo del progetto (3 anni):

- ✓ **Obiettivo 1**: scelta e implementazione dei controller movimentazioni, e validazione della configurazione
- ✓ **Obiettivo 2**: installazione del tubo RX e rivelatore per XRD/XRF, con lente policapillare, seguito da test di funzionamento del nuovo layout MicroSpeX.
- ✓ **Obiettivo 3**: Sviluppo software di gestione
- ✓ **Obiettivo 4**: Validazione performance di MicroSpeX (Beni Culturali), con analisi µXRD/µXRF su campioni forniti dalla società Matrix96 e da Sapienza.



A tale scopo, sono stati identificati i seguenti WP e milestone:

- ➢ **WP1**: Gestione degli aspetti tecnici, economici ed amministrativi del progetto dedicato alla gestione di tutte le attività che riguardano la conduzione del progetto sia dal punto di vista di sviluppo tecnico che di gestione e di rendicontazione. La durata prevista è di 18 mesi.
- ➢ **WP2**: Sviluppo del prototipo microSpeX deputato allo sviluppo del layout finale, della durata di 15 mesi e che prevede due milestone (mese 6 e mese 15 rispettivamente).
- ➢ **WP3**: Sviluppo software di gestione di microSpeX focalizzato sullo sviluppo e integrazione del software di gestione della macchina microSpeX della durata di 9 mesi, con milestone prevista al mese 15.
- ➢ **WP4**: Validazione del layout definitivo con end-user dedicato alla raccolta di campioni archeologici dai luoghi di scavo e loro studio mediante microXRD e microXRF con tecnologia microSpeX, con contributi della Sapienza e dalla società esterna Matrix96 s.r.l., della durata di 6 mesi.
- ➢ **WP5**: Comunicazione e Diffusione dei risultati che comprende attività di divulgazione dei risultati ottenuti sia ad un pubblico prettamente scientifico (partecipazione a convegni, seminari, workshop) che ad un pubblico di utenti di Beni Culturali attraverso l'organizzazione di seminari dedicati e di "demo days" presso INFN rivolti a potenziali utenti esterni.

MicroSpeX: budget richiesto totale /FTE (per anno)

MicroSpeX

- Personale coinvolto:
  - Hampai D. (Resp. Naz.) 40%
  - Dabagov S. 40%
  - Guglielmotti V. (Ass.) 50%
  - Bini S. 10%
  - Shpakov V. 10%

- Totale: 1.5 FTE/anno

- Richieste CIF
  - Progettazione/realizzazione meccaniche 2 mesi/uomo
  - Progettazione componentistica elettronica 2 mesi/uomo
  - Carpenteria 1 mese/uomo

- Materiale inventariabile
  - Rivelatore XRD 40k€
  - Rivelatore XRF 15k€
  - Controller NI 15k€
  - Controller E1B 3k€

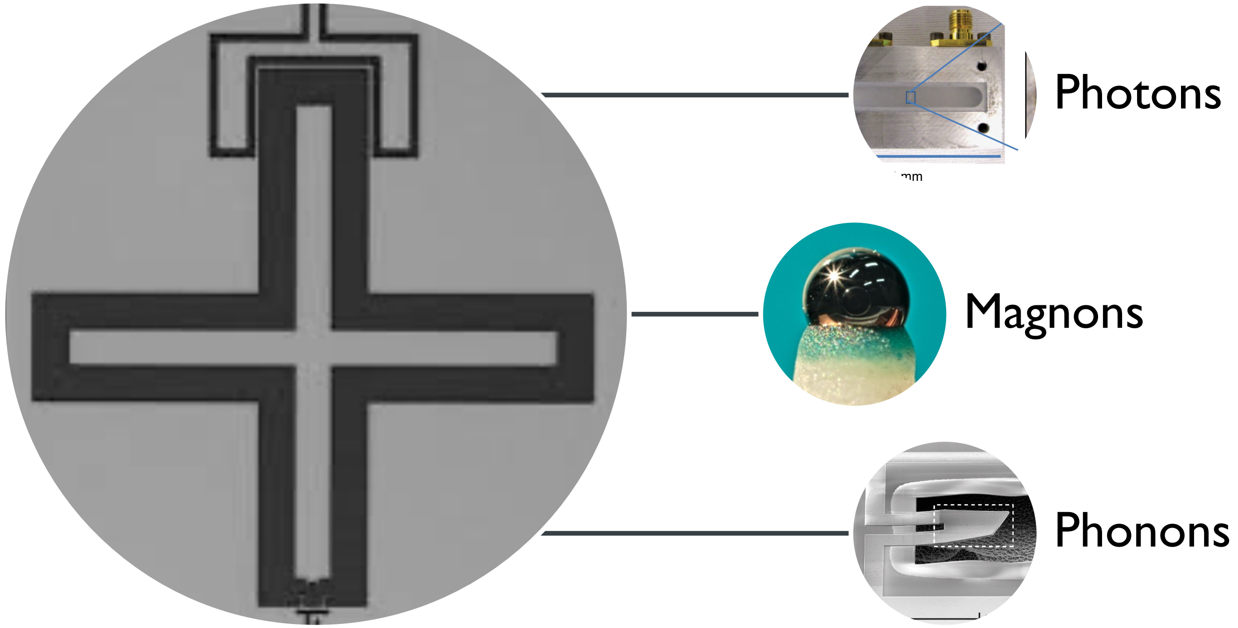
- Materiale di consumo
  - Lente policapillare 10k€
  - Dispositivi optomeccanici 6k€
  - Tubo RX 8k€
  - Materiali cabinet sicurezza 3k€
- Missioni e dissemination: 10k€
- Personale/Assegno di ricerca 75k€

Totale budget (3 anni): 185k€

Qub-IT: Quantum Sensing with Superconducting Qubit for Fundamental Physics

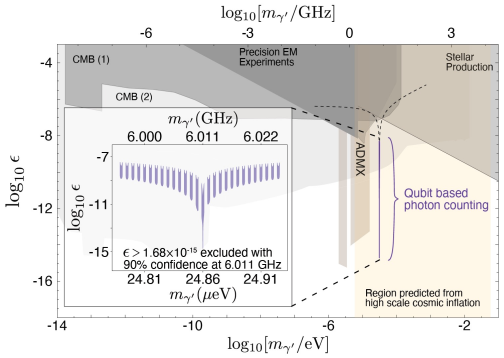
Recent progresses in the ability to measure and manipulate individual quanta such as microwave-photons, phonons and magnons are opening new directions in the detection of Dark Matter and of Fifth Forces, in tests of Quantum Gravity and of Quantum Mechanics in macroscopic objects.

Superconducting qubits constitute a fundamental building block of the progresses in quantum sensing.

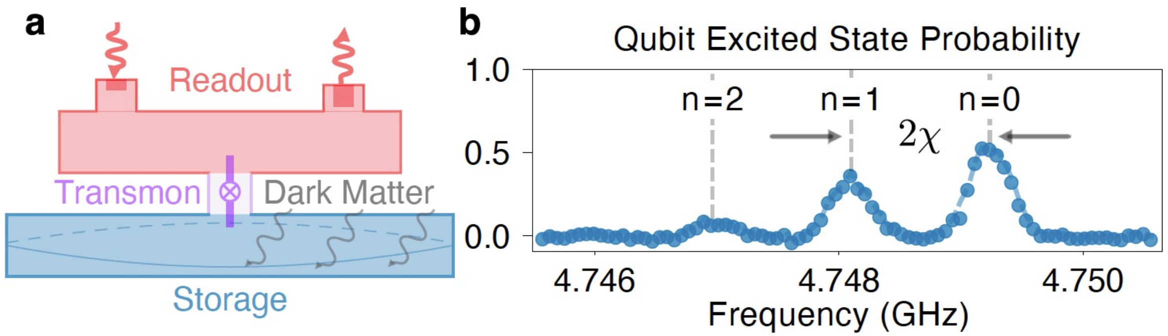


Dark Matter Searches with SC Qubits - State of Art

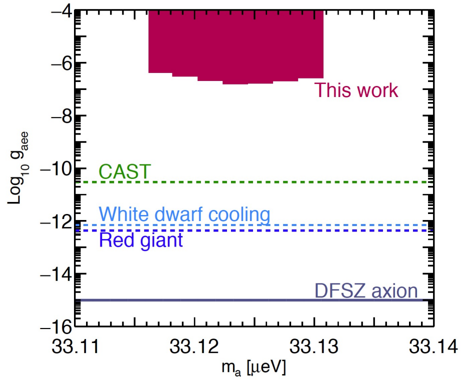
Photon Sensing - Dark Photons



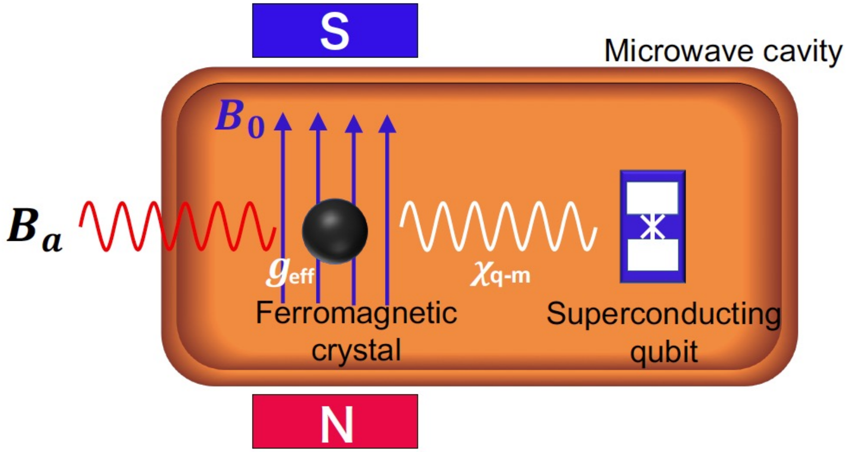
A V Dixit et al., "Searching for Dark Matter with a Superconducting Qubit," Phys. Rev. Lett. 126, 141302 (2021).



Magnon Sensing - Axions



T Ikeda et al. "Axion search with quantum nondemolition detection of magnons," arXiv:2102.08764.



Main Objective:

Realization of an itinerant single-photon counter that surpasses present devices in terms of efficiency and low dark-count rates by exploiting repeated QND measurements of a single photon and entanglement in multiple 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 measurement of SC qubit with quantum amplifier
4. Control of SC qubit with FPGA-based board
5. Quantum sensing experiment with entangled sensors

WP5 – Management (LNF)

WP4 – Experiment (LNF)

WP3 – Control (INFN MiB)

WP2 - Fabrication (TIFPA)

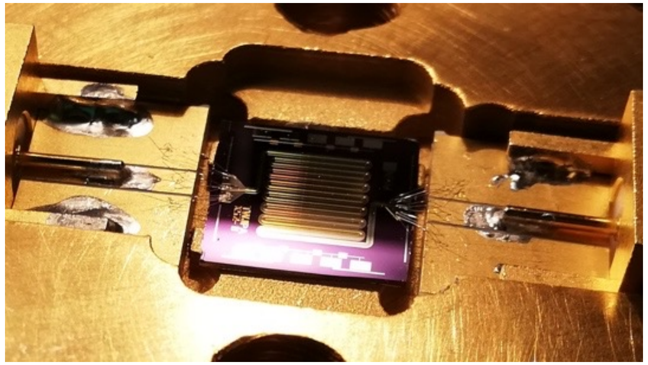
WP1 – Design (INFN Fi)

Qub-IT	FTE
LNF (RN)	2.6
INFN MIB	1
INFN Mi	0.2 (dtz)
INFN Sa	1.5
TIFPA	1.3
INFN Pi	2
INFN Fi	1.5
INFN Fe	0.5 (dtz)
FBK	-
CNR-IFN	-
Tot FTE	10.6

Qub-IT will rely on experience gained by INFN projects using technology based on Josephson junctions

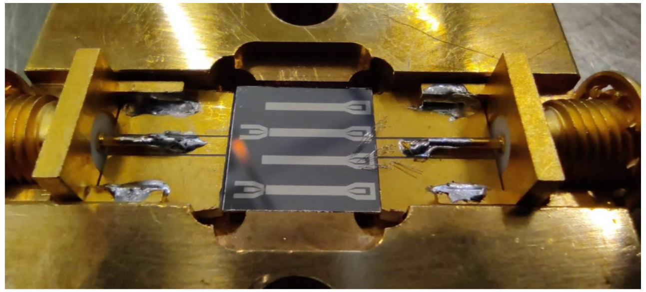
DART WARS

Detector Array Readout with Travelling Wave AmplifieRS



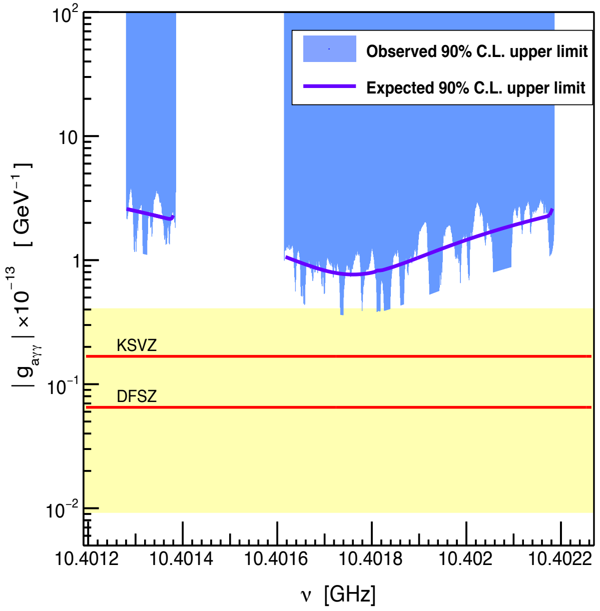
SIMP

Parametric amplification and resonant activation measured with JJ and DC-SQUID



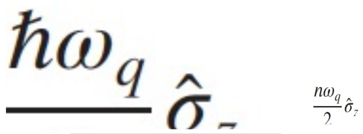
QUAX

Sensitivity to QCD axions reached with a Josephson Parametric Amplifier (JPA)

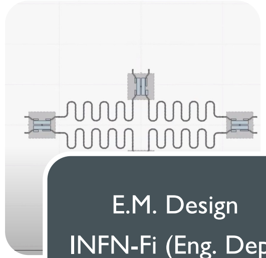


QUAX Coll. Phys Rev. D 103 102004 (2021)

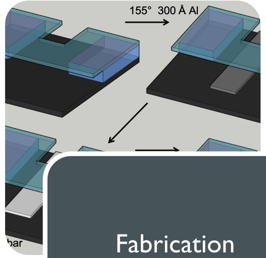
Methodology - Design



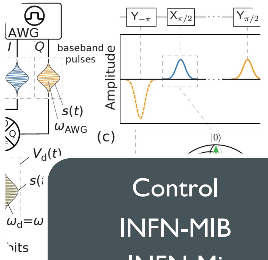
Theory
INFN-Fi (Phys Dept)



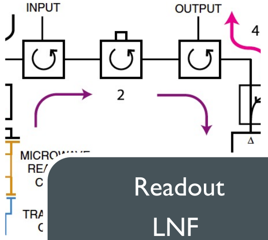
E.M. Design
INFN-Fi (Eng. Dept)
INFN-MIB
INFN-Pi (Eng. Dept)



Fabrication
FBK
CNR-IFN



Control
INFN-MIB
INFN-Mi
LNF
INFN-Pi
INFN-Fe

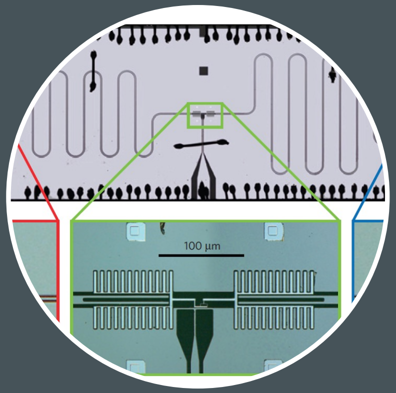


Readout
LNF
INFN-MIB
INFN-Sa
TIFPA

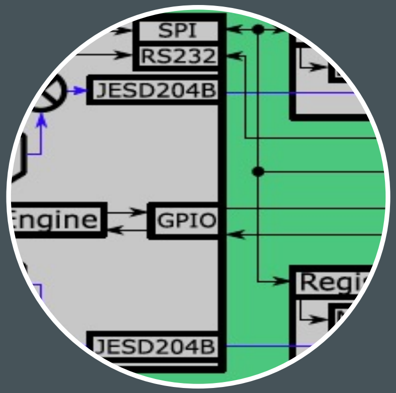
Experiment
LNF
INFN-MIB
INFN-Sa
TIFPA
INFN Pi

- Theoretical model of quantum circtuits (INFN Fi)
- Electromagnetic design (INFN-Fi, INFN-MIB, INFN-Pi)
- Fabrication (FBK, CNR-IFN)
- Qubit control with RF signals (INFN-Mi, INFN-MiB, LNF, INFN-Pi, INFN-Fe)
- Qubit readout with quantum amplifiers (LNF, INFN-MiB, INFN-Sa, TIFPA)
- Experiments (LNF, INFN-MiB, INFN-Sa, TIFPA, INFN-Pi)

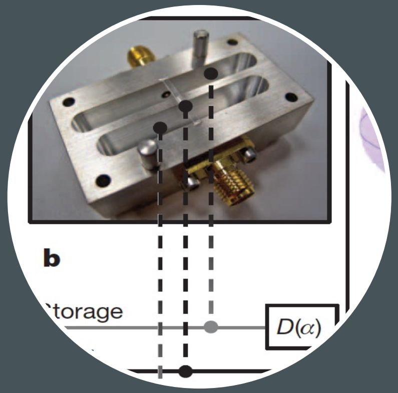
Qub-IT Main Deliverables



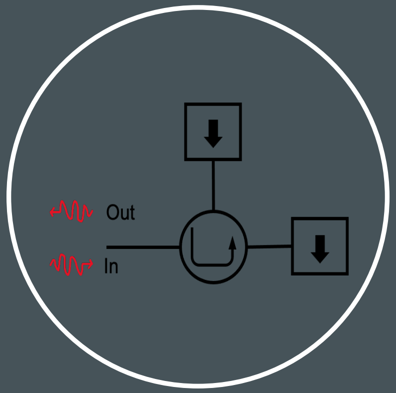
Qubit coupled to resonators



Qubit control and readout



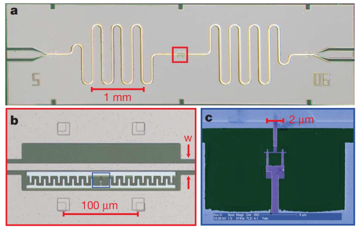
3D qubit



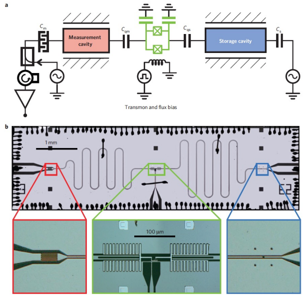
Entangled qubits photon detector

2022 2023 2024

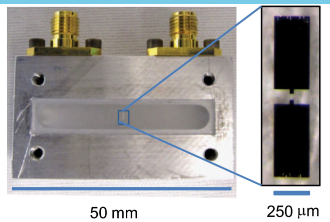
Transmon + resonator D1.2, 2.2, 4.2



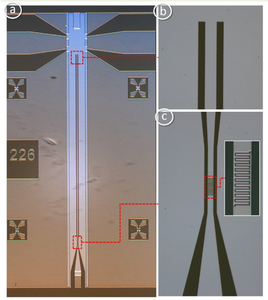
Transmon + 2 resonator D1.5, 2.4, 4.4



3D Transmon D1.3, 2.5, 4.6

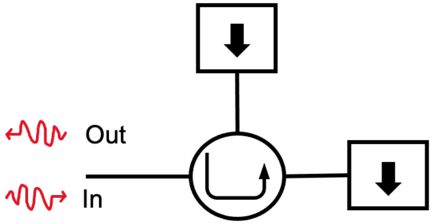


Components Characterization D1.1, 2.1, 4.1



YEAR			Year 1				Year 2				Year 3			
Month			T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
WP1 - Design (Fi)	T1.1	Design		D1.1	D1.2	D1.3		D1.5			D1.6			
	T1.3	JPA					D1.4							
	T1.4	Simulation												
WP2 - Fabrication (TIFPA)	T2.1	Components			D2.1									
	T2.2	2D Tansmon					D2.2			D2.4				
	T2.3	JPA						D2.3						
	T2.4	3D Transmon									D2.5			
	T2.5	Two qubits device										D2.6		
WP3 - Control (MiB)	T3.1	Software				D3.1								
	T3.2	Firmware												
	T3.3	Test						D3.2						
WP4 - Experiment (LNF)	T4.1	Components				D4.1								
	T4.2	2D Transmon					D4.2				D4.4			
	T4.3	3D Transmon										D4.6		
	T4.4	Qubit readout							D4.3		D4.5			
	T4.5	Two qubits device												D4.7
WP5 - Management (LNF)	T5.1	Collaboration Meetings												

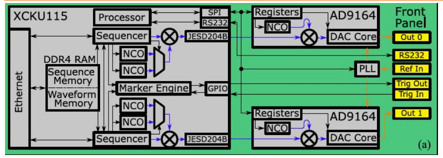
2 Qubits device D1.6, 2.6, 4.7



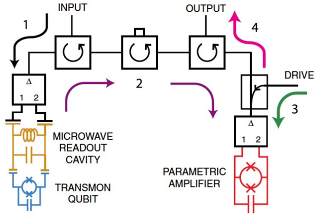
Deliverables

- Components
- Transmon + resonator
- Transmon +2 resonators
- JPA
- 3D Transmon
- 2 Qubits device
- Qubit Control

Qubit Control D3.1, 3.2, 4.5



JPA D1.4, 2.3, 4.3



VorTeD

Proposal for 2022-2023 (1+1)

- The goal of this project is to understand the vortex dynamic properties of superconducting proximity arrays based on novel materials in engineered topologies to be used as low energy photon/particle detectors.
- This proposal is the result of preliminary tests on proximity arrays gained within the frame of the TERA project (Call 5th National Scientific Committee). However, the dynamics of the proximity arrays exploiting novel topologies and materials remained out of the scope of the TERA project while it can lead to a revolutionary class of detectors.

The novel proximity arrays can be used in:

- **Low energy photon detection (RF and THz)**
- **Low energy particle detections (Axions)**
- **Large area superficial detectors and pondermotive generators (spacecrafts)**

These type of detectors are relatively simple to manufacture and industrially feasible.

VorTeD

State of the art- Program

Within the WP3 of the TERA project, tests of the superconducting proximity arrays response illuminated by low energy photons were successfully performed (Fig. 1). An innovative advanced optical setup based on transport properties was assembled in the COLD laboratory of the LNF laboratory (Fig. 2) to perform the tests. The vortex generation mechanism and their dynamics as well as the phase transition from a metallic Mott insulating state as a function of the proximity length, engineered topology and superconducting materials that may lead to a precise control over the dynamical properties is still unknown. **We believe that a systematic study on engineered topology and materials used (controlling the proximity length) in combination with a theoretical backbone can support the design of new large area detectors for low energy photons/particles.**

Milestone year 1: Fabrication of proximity arrays with new topologies and novel materials. Characterization of their dynamics and theoretical modelling

Milestone year 2: The detection response of array devices exposed to low energy photons (THz, RF) close to Tc. Tests at T much lower than Tc for particle detections.

References:

1- *Rezvani et. al* Condensed Matter 5 (2), 33.

2- *Rezvani et. al* Review of Scientific Instruments 91 (075103).

3- *Rezvani et. al* Acta Physica Polonica A 1 (137), 17.

4- *Rezvani et. al* Scientific reports 8 (1), 1-12.

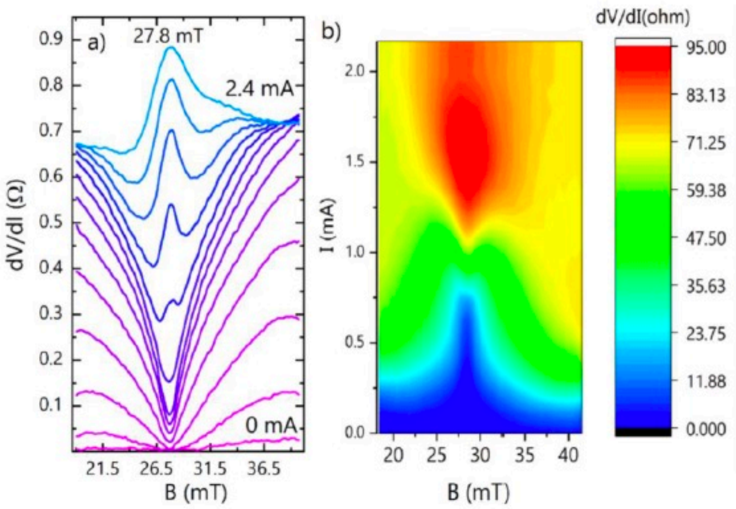


Fig 1. The vortex dynamic control vs. B

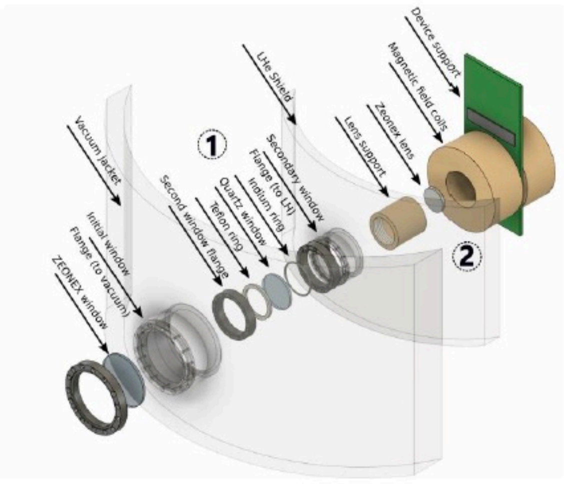


Fig 2. The cryogenic optical system

VorTeD

Participants:

Name	Association	Involvement
S. Javid Rezvani	LNF-INFN	50%
Augusto Marcelli	LNF-INFN	20%
Claudio Gatti	LNF-INFN	0% - Collaborator
Daniele Di Gioacchino	LNF-INFN	0% - Collaborator
Carlo Ligi	LNF-INFN	0% - Collaborator
Stefano Lupi	INFN-Roma1	30%
Mariangela Cestelli Guidi	LNF-INFN	10%
Salvatore Macis	LNF-INFN	30%
Sen Mou	INFN-Roma1	20%
Nicola Pinto	INFN-Perugia	30%

The external collaborators of the project:

Andrea Perali: University of **Camerino**.

Benjamin Mcnaughton: University of **Antwerp**, Belgium.

Sara Cibella: **CNR, ISM**, Roma.

Luca Boarino: **INRIM** Torino.

Duration: 2 Years Budget: 12 KEuros/1st year - 10 Keuros/2nd year

The Budget is designated mainly for fabrication of the devices, liquid He and small instruments required for measuments.

New proposals w RL@LNF

MICRON (MIniaturised aCceleRatOrs Network)

National Coordinator, G. Torrisi (LNS)

INFN-LNF Local Coordinator, Luigi Faillace

Riunione GRV-LNF

MAIN GOAL of the PROPOSAL: **Miniaturization** of Accelerating Structures

High accelerating gradients enable compact/miniaturized particle accelerators

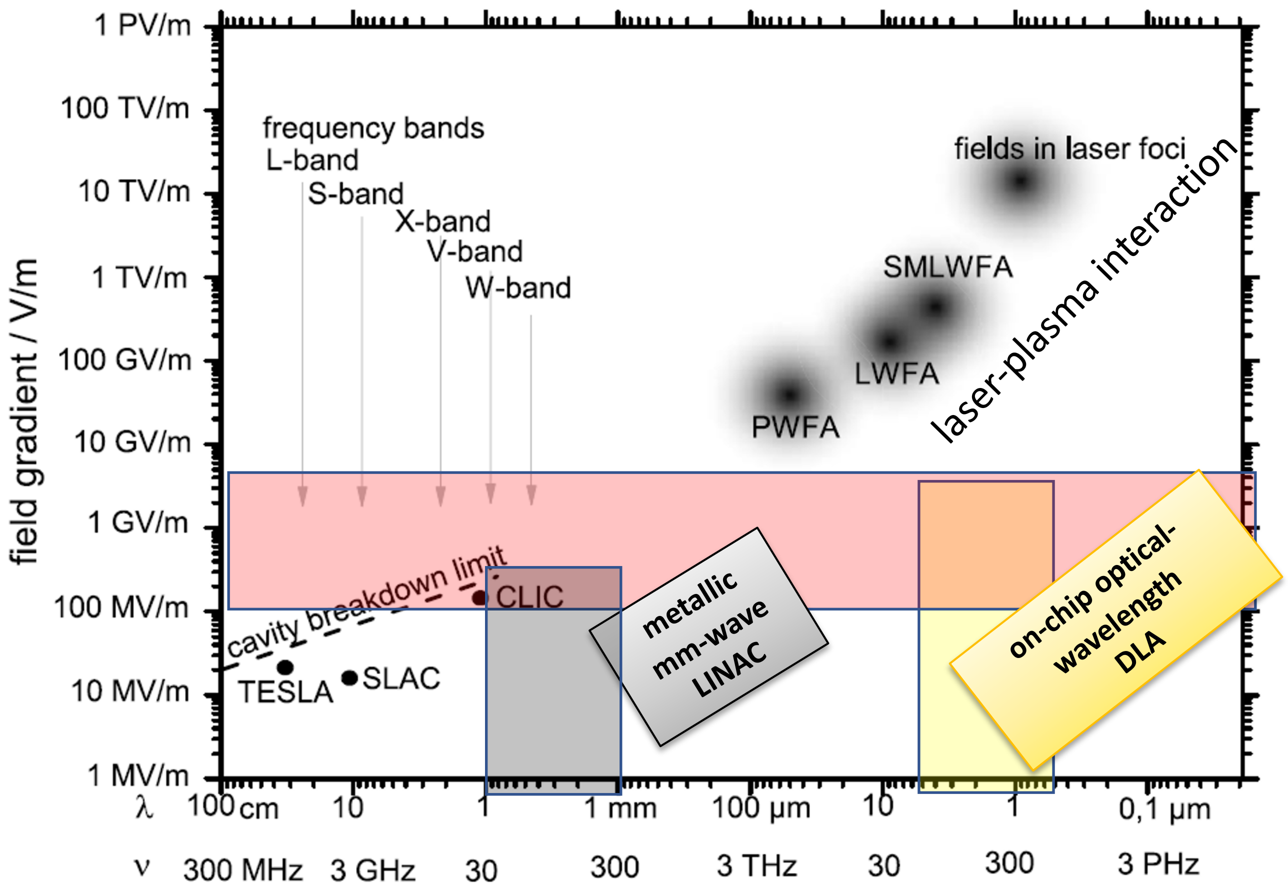
TARGET OF THE PROSAL

Accelerating Gradient: ~ 100 MV/m - 2 GV/m

1) **Metallic Structure from Ka to W-band (35-200 GHz, mm-wavelength)**

2) **Dielectric Laser Accelerator (DLA) structures operating at optical wavelengths (~ 1- 5 µm)**

schematic overview of the accelerating gradient for different types of accelerators



µICRON
MIniaturised aCceleRatOrs Network

obiettivi della proposta

μICRON
MIniaturised aCceleRatOrs Network

DIELECTRIC

Technology-driven modelling

1) "Fabrication Technology-driven" Modeling of Photonic Crystal Dielectric Accelerating Structure having these features:

- **CW laser-pumped**
- **co-linear Coupling**
- **MeVs** final energy
- **Acc. gradient >500 MV/m**

(also by identifying pitfalls & potential showstoppers)

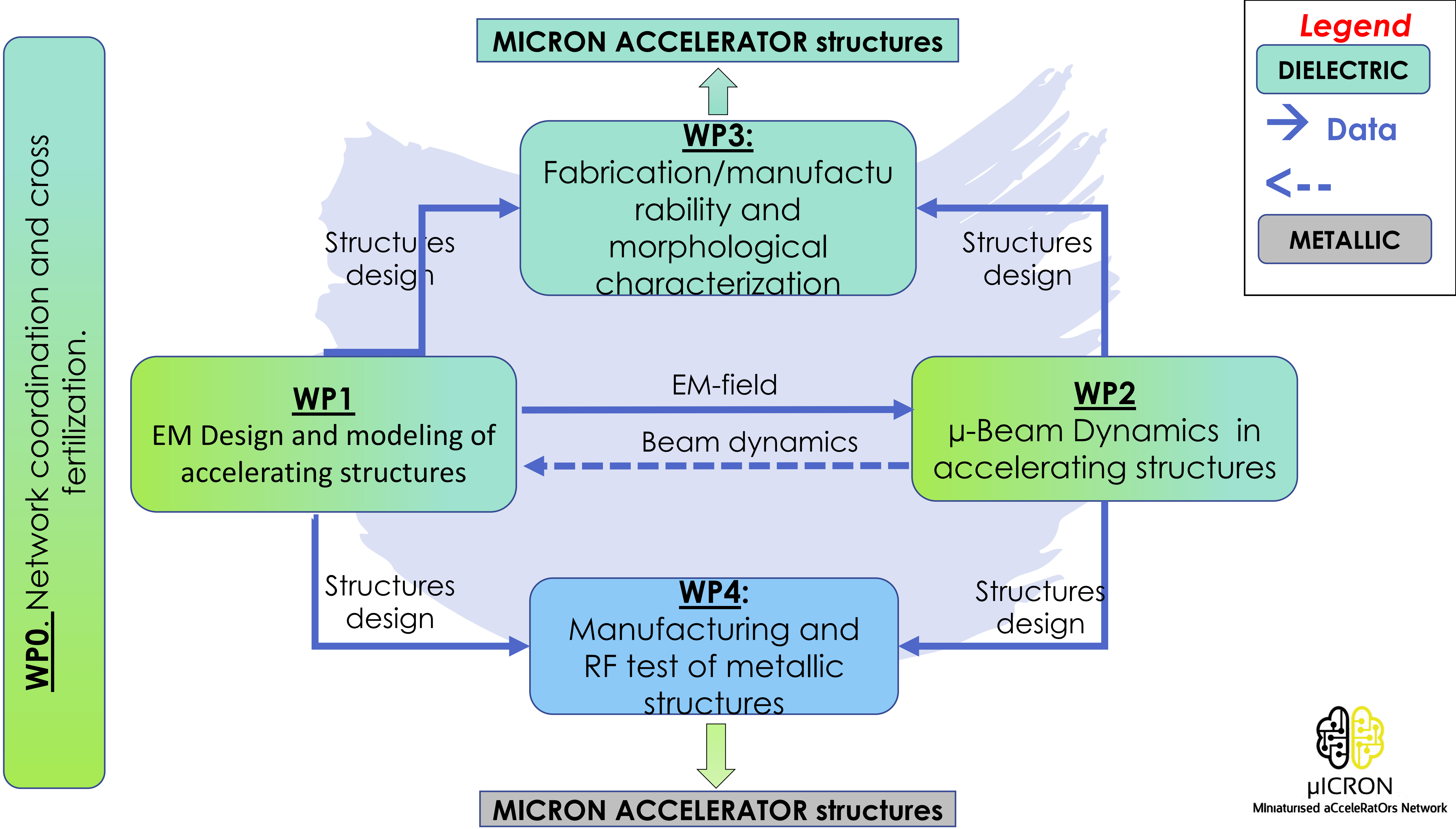
2) **Basic tests** the **of fabrication technologies** to infer tolerances and possible fabrication to inspire configurations/design.

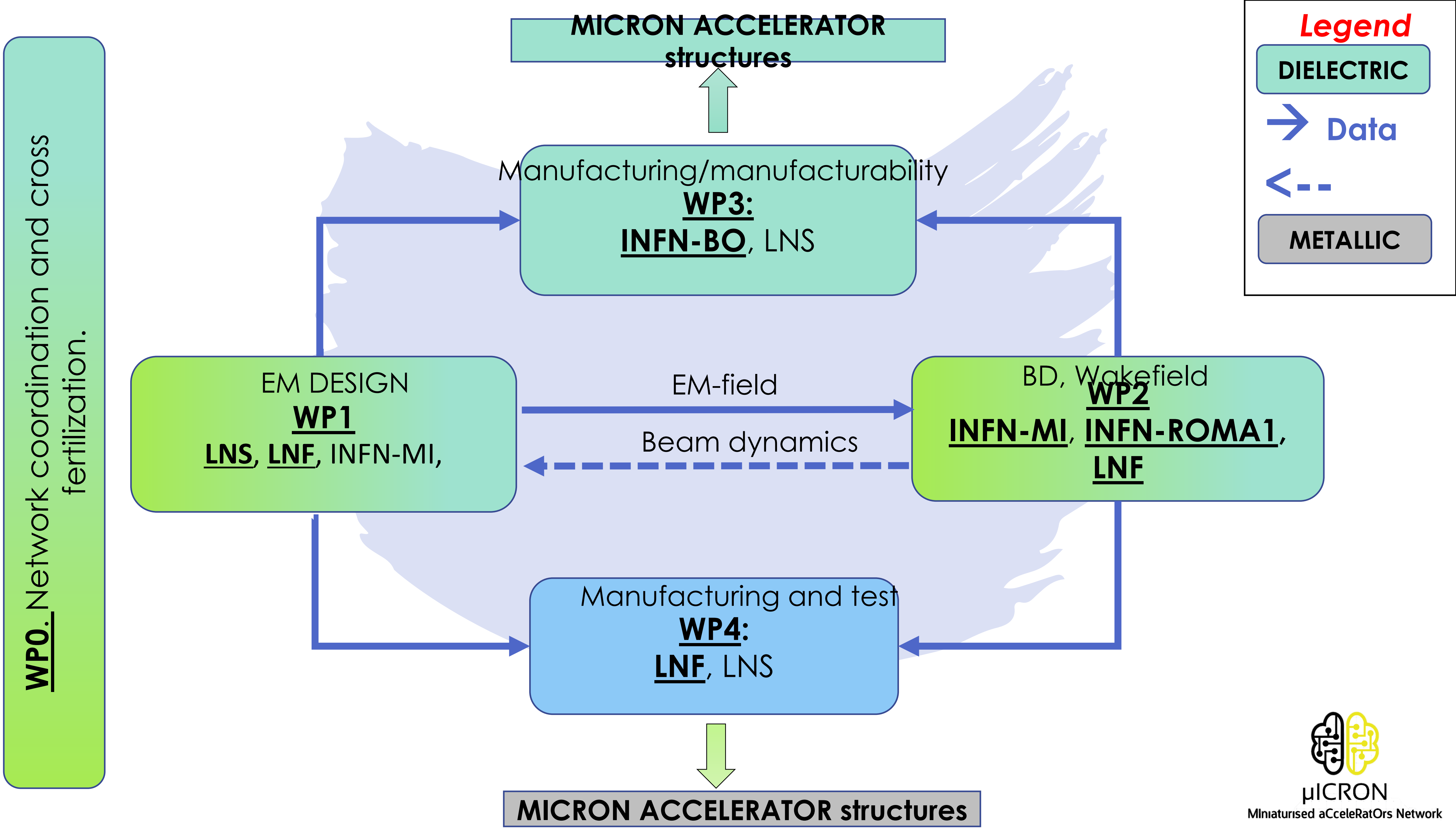
METAL

1) **Modeling** of metallic Ka-band and mm-wave acceleration providing: beam quality (energy spread, emittance), acceptance, charge capability, luminosity potential (repetition rate; charge; power source efficiency) and **acceleration gradient > 100 MV/m**

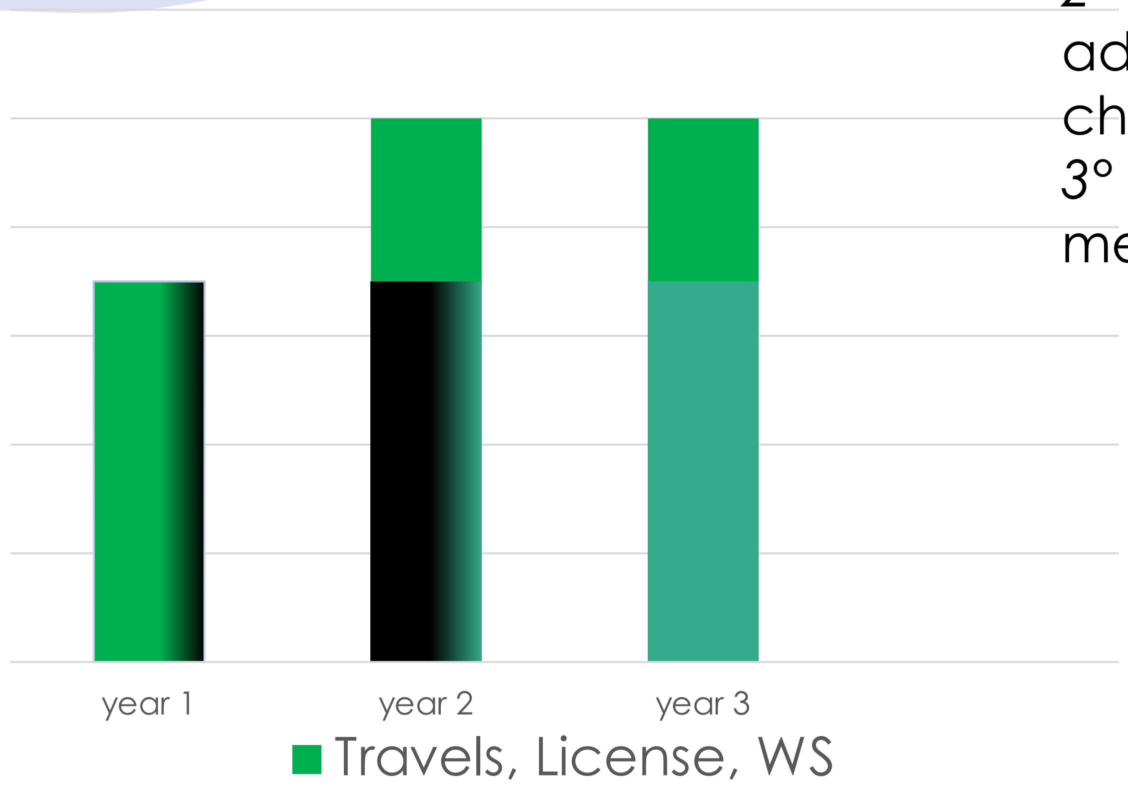
2) **OPEN Structure (jointless)**

3) Prototype manufacturing by CNC high-precision milling (R&D on material and welding techniques)


MICRON ACCELERATOR structures
WP3:
Fabrication/manufacturability and morphological characterization
Structures design
Structures design
WP0. Network coordination and cross fertilization.
WP1
EM Design and modeling of accelerating structures
EM-field
Beam dynamics
WP2
μ-Beam Dynamics in accelerating structures
Structures design
Structures design
WP4:
Manufacturing and RF test of metallic structures
MICRON ACCELERATOR structures
Legend
DIELECTRIC
Data
METALLIC
μICRON
MIniaturised aCceleRatOrs Network


MICRON ACCELERATOR structures
Legend
DIELECTRIC
Data
<- - -
METALLIC
Manufacturing/manufacturability
WP3:
INFN-BO, LNS
WP0. Network coordination and cross fertilization.
EM DESIGN
WP1
LNS, LNF, INFN-MI,
EM-field
Beam dynamics
BD, Wakefield
WP2
INFN-MI, INFN-ROMA1, LNF
Manufacturing and test
WP4:
LNF, LNS
MICRON ACCELERATOR structures
µICRON
MIniaturised aCceleRatOrs Network

first DRAFT Total Budget [1st, 2nd, 3rd] year [50, 70, 50] k€



INFN-LNF Activities in WP1 and WP2

1° year RF desing of Ka- and W-Band metallic cells/cavities and mode launchers, beam dynamics optimization with WP2;
2° *year* Structures Fabrication, technological advancements and material handling, material chracterization (TIG vs e-Welding);
3° *year* Low-power RF characterization and testing of metallic prototypes.

INFN-LNF Local Team

	FTE
Luigi Faillace	0.3
Luca Piersanti	0.1
Fabio Cardelli	0.1
Alessandro Gallo	0.1
Marco Bellaveglia	0.1
Mostafa Behtouei	0.8
Claudio Marcelli	0.1
Bruno Spataro	0
Total FTE	**1.6**

µICRON
MIniaturised aCceleRatOrs Network

Plasma by THz_*PbT*

Development of THz-based compact system for plasma diagnostics

Abstract

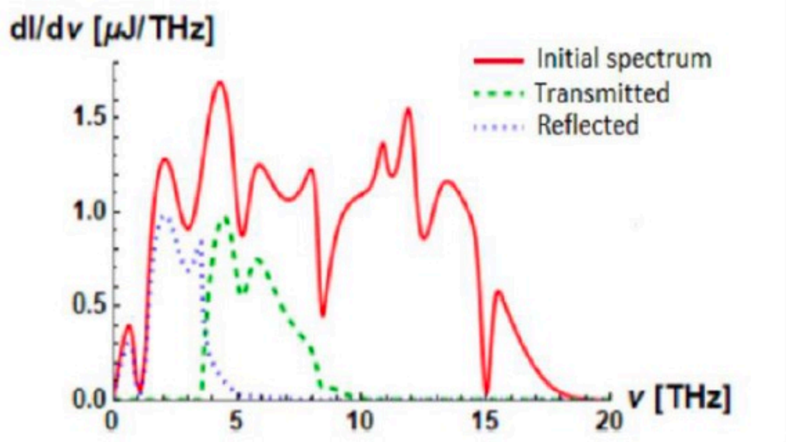
The advent of compact and high-energy plasma accelerators will pose unprecedented diagnostic challenges. The Project ***PbT*** (Plamsa by THz) proposes the development and implementation of an innovative ***compact diagnostic methodology*** based on THz radiation for the characterization of plasma electron density, both for ***LWFA*** (Laser wakefield acceleration) and ***PWFA*** (Particle wakefield acceleration).

The performances of these plasma devices (acceleration and optical stages) are strongly dependent on the plasma properties e.g. **density uniformity** [1]; therefore, they must be monitored constantly and possibly in real-time.

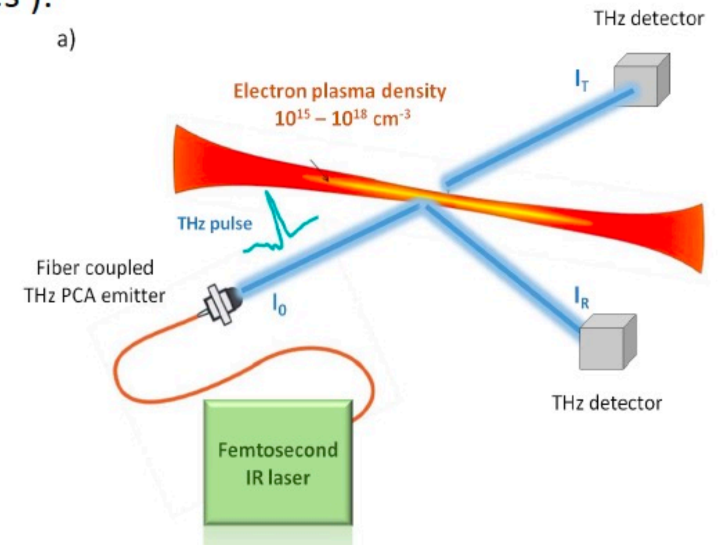
The novelty of the proposed method for plasma diagnostic [2], compared to [3-5] consists in exploiting THz radiation that could be used to map the plasma density inside a capillary structure. THz radiation is particularly suitable to monitor the plasma plume that propagate outside the capillary and that has a density value down to 10^{15} cm^{-3}; this is a too low value to be monitored with the Stark Broadening technique which is commonly used nowadays but it matches well the THz spectrum produced by conventional sources (0.1-9) THz equivaling to (10^{14}-10^{18}) cm^{-3}.

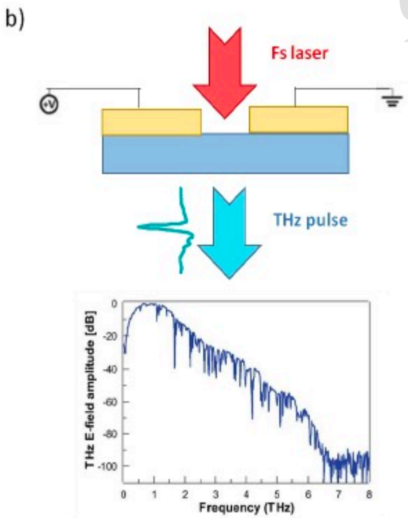
1. M. C. Downer, et al., Rev. Mod. Phys. 90, 035002 (2018).
2. A. Curcio, and M. Petrarca, Opt. Lett. 44 (4), (2019) 1011-1014.
3. B. Kolner, et al., IEEE J. Sel. Top. Quantum Electron. 14, 505 (2008).
4. S. Jamison, Jet al., J. Appl. Phys. 93, 4334 (2003).
5. J. Sun, et al., Proc. SPIE 9297, 929716 (2014).

The start-point of the project is the theoretical model proposed in [2] in which it is described a methodology to monitor the plasma parameters by using the THz time domain (THz-TDS) spectroscopy. The methodology is based on the ***optical criticality of plasmas*** [2], which transmits electromagnetic waves with the frequency greater than the plasma frequency and reflects practically all the frequency below [3-8], (see Figures):



$$\frac{I_T}{I_0} = \int d\omega S(\omega) T(n_e, T_e, \omega)$$





The apparatus is composed by the THz source producing a broadband THz beam (I_0) which illuminates the plasma. The THz broadband source is made of fiber-coupled THz photoconductive antennas (PCAs), powered by a compact, portable and synchronize infrared (IR) femtosecond (fs) laser.

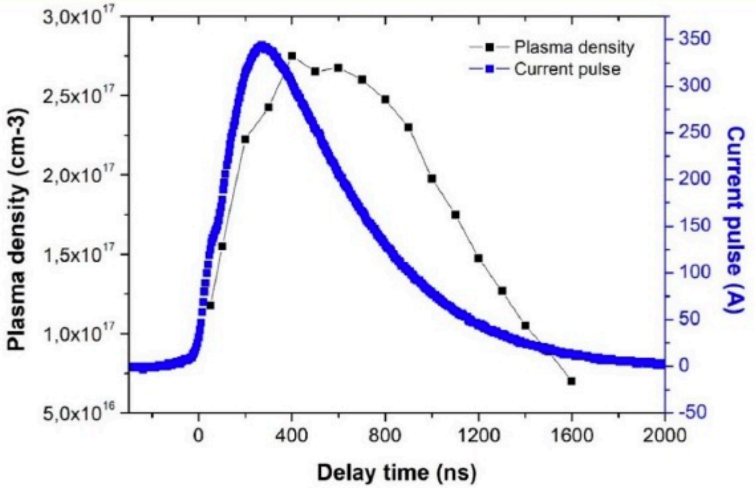
6. B. Kolner, et al., Appl. Phys. Lett. 87, 151501 (2005).
7. K. Kang, D. Jang, and H. Suk, J. Instrum. 12, C11003 (2017).
8. G. Neumann, et al., Rev. Sci. Instrum. 64, 19 (1993).

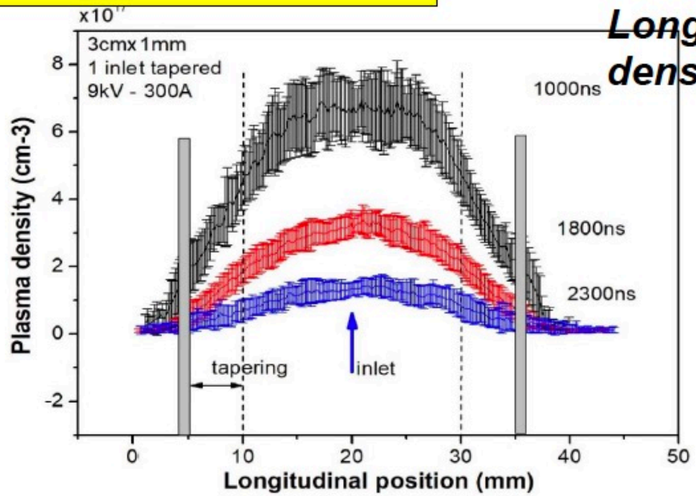
In multi-shot experiment, PCA THz-TDS set-up is used to perform spectroscopy characterization of the plasma, see scheme in fig.2a; the output signal i.e. the transmitted or reflected THz radiation (I_R and I_T) from the THz-receivers, are filtered with a lock-in amplifier and the analogical information due to the signals' demodulation is digitalized to LabVIEW software through a data acquisition card, which manages THz-emitter and the data collection chain.

In single-shot experiment, THz broadband beam is used to map a complete profile of plasma characteristics along its axis. In order to map it, THz beam impinges with an elliptic radiation spot covering the full length of the plasma target, and the differential absorptions along the beam spot can be measured and studied by a THz 2D camera. On each pixel of the camera, it is mapped a longitudinal portion of the plasma. From the absorption it will be possible to retrieve the plasma density [6].

Results obtained by THz method for plasma diagnostic have to be compared to the conventional plasma diagnostic based on the Stark effect

Plasma characterization by conventional measurement techniques





Longitudinal density profile

Plasma by THz_*PbT*

Objective1: Measurement test of the plasma density by THz-TDS system in the multi-shot configuration.
Objective2: Measurement test of the plasma density in single shot configuration
Objective3: Plasma density profile along the capillary/filament and of the plume from capillary

Unit INFN Roma1					
Professori	**FTE**	**Post-doc**	**FTE**	**PhD-student**	**FTE**
Stefano Lupi	0,4	Sen Mou (INFN)	0,3	Luca Tomarchio	0,3
Massimo Petrarca	0,3				
	0,7		0,3		0,3

Unit INFN-LNF-AD Personnel contribution					
Ricercatori	**FTE**	**Tecnologi**	**FTE**	**Post-doc**	**FTE**
Enrica Chiadroni (1° Ric.)	0,2	Angelo Biagioni (Tecn.)	0,3	Gemma Costa	0,3
Riccardo Pompili (Ric.)	0,1			Salvatore Macis	0,3
Maria Pia Anania (Ric.)	0,1				
	0,4		0,3		0,6

SAMARA

- *SAMARA aims at developing and studying superconducting materials alternative to bulk Nb with low radiofrequency surface impedance at extreme conditions: high radiofrequency -rf- fields and high dc fields.*
- *new applications for SRF are emerging: the FCC beam screen and* ***haloscope resonators for axions detection*** *requires superconductors capable of working in unexplored RF high DC field regimes in which Nb is not suitable*

Superconducting **A**lternative **M**aterials for
Accelerating cavities and haloscope
Resonators for **A**xions

SAMARA tries to precisely meet these important challenges

- The proposal is focused mainly on Nb_3Sn, a BCS superconductor (SC) with double Tc (18 K) and double Hsh (400 Gauss) compared to Nb
- large critical magnetic field H_{c2} makes Nb_3Sn as a natural choice in High DC field applications

The final goal of SAMARA is twofold

- the realization of high performing elliptical accelerating cavities
- the test in high DC field of a Nb_3Sn haloscope

- ✓ This project follows the excellent results obtained in TEFEN project (Gr.V)
- ✓ synergies with the QUAX project (Gr.II)

SAMARA

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

Activity in LNF (Lab COLD) 2022-2024

[synergies with the **QUAX** activity project (Gr.II)]

- ***Accelerating Cavities:*** *Nb_3Sn film coatings*

  Characterization of planar samples: Pinning defects characterization

  - munti-harmonic susceptibility measurements

- ***SRF in extreme conditions :*** *Haloscope resonators*

  Haloscope developments

  - design and production
  - Haloscope measurements at mK

SAMARA

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

Durata proposta:	3 anni (2022-2024)
Area di ricerca:	Acceleratori di particelle
Resp. nazionale:	**Pira Cristian (LNL)**
Unità partecipanti:	LNL, **LNF**, LASA, Roma Tre, Politecnico di Torino

LNF (Lab COLD)

[synergies with the QUAX activity project (Gr.II)]

Personale 2022

Daniele Di Gioacchino	(Ric dip LNF)	**0.3**
Javid Rezvani	(Univ. Camerino ass. LNF)	**0.3**

→ in dotazione Gr. V

Richieste 2022

Consumi:

10000 Eu

a) **Elio liquido** per misure nel criostato con magnete ad 8 Tesla:

1)Test cavità Nb_3Sn,

2) misure suscettività multiarmonica x caratterizzazione film Nb_3Sn

b) **rame** e conseguente lavorazione per cavità in Cu OFHC

VAC_CRIO

R&D on Vacuum and Cryogenics for Einstein Telescope

(National Responsible Ettore Majorana – Rome1)

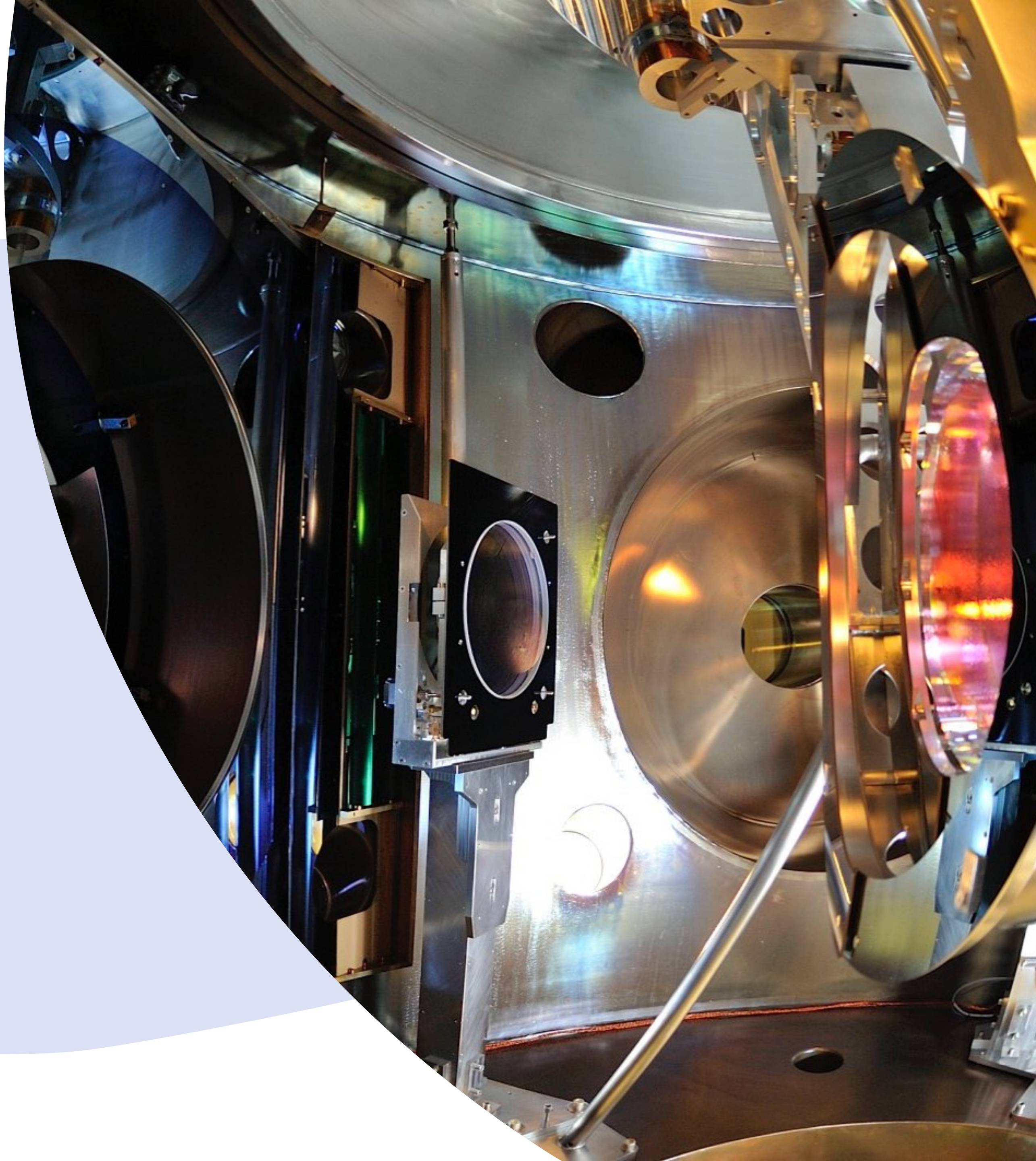
LNF is proposing to contribute and participate to the ET-Italia project, aiming to develop the required R&D to produce a technical design study for the construction of a third generation Gravitational Waves detectors.

The possibility that Italy may host this infrastructure in Sardinia, makes our contribution strategic to enter from the beginning to this exiting enterprise.

The new design will be based on longer arms (10 km each) and cryogenically cooled mirrors

Research Units

Rome 1 – Napoli – LNF – LNL - LNGS



R&D on Vacuum and Cryogenics for Einstein Telescope

Main Task

Vacuum

- **Outgassing** surface treatment studies; inner surface treatments.
- **Bake-out** Needs of In situ bake-out system
- **Procurement of certified materials and corrosion tests** anti-corrosion (external wall of the tube)
- **Pipe VAC projections** Overall feasibility projections

Cryogenics

- **Materials and outgas** Cryostat VAC-CRYO studies: Multi layer cryo super-insulation VS degassing rate. Water presence adsorption/desorption
- **LowT VAC** Cryotraps and Cryostat long pipes.
- **Cold Surfaces and coating** Thermal radiation shields, emissivity studies, radiative cooling.
- **Thermal duct** Cryostat mechanics (includes thermal duct)

VAC_CRIO

R&D on Vacuum and Cryogenics for Einstein Telescope @ LNF

Task

- Emissivity study & test of cryostat thermal shields and UHV vacuum pipes
- Outgassing/absorption study & test of SS inner surfaces
- Cryogenic Vacuum issues: detrimental frost formation on the optics
- Electrostatic charging mitigation

Involved Personell

Andrea Liedl	20%
David Alesini	10%
Simone Bini	10%
Fara Cioeta	10%
Valerio Lollo	10%
Marco Angelucci	20%
Luisa Spallino	20%
Roberto Cimino	10%
Giovanni Delle Monache	20%
Lucia Sabbadini	10%

VAC_CRIO

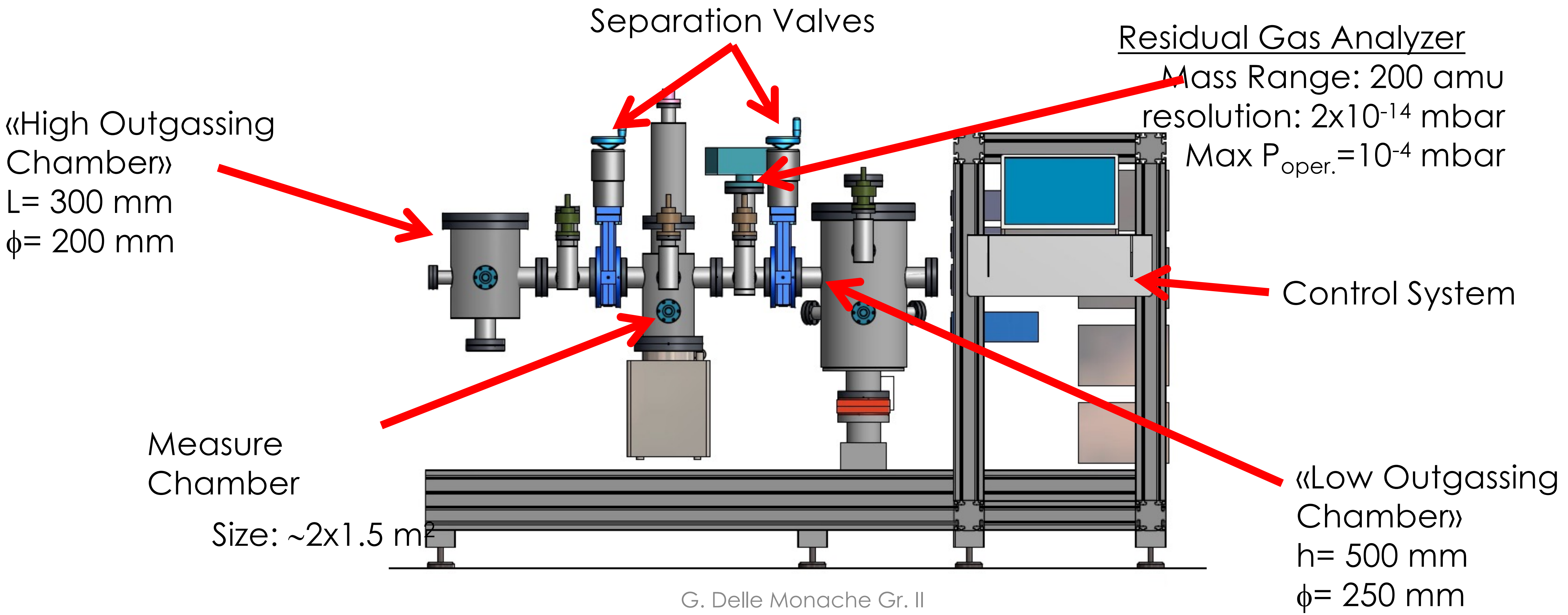
Outgassing rate Measurement

VAC_CRIO

Characterization of the Outgassing rate is a step mandatory part for the R&D of the vacuum chamber's inner surfaces. A system able to measure outgassing, in terms of rate and emitted gases, is needed.

The R&D studies include not only the material choice but also the effects of heat treatments and thin film coatings.

LATINO «OUTGASSING RATE SYSTEM» AT LNF-INFN



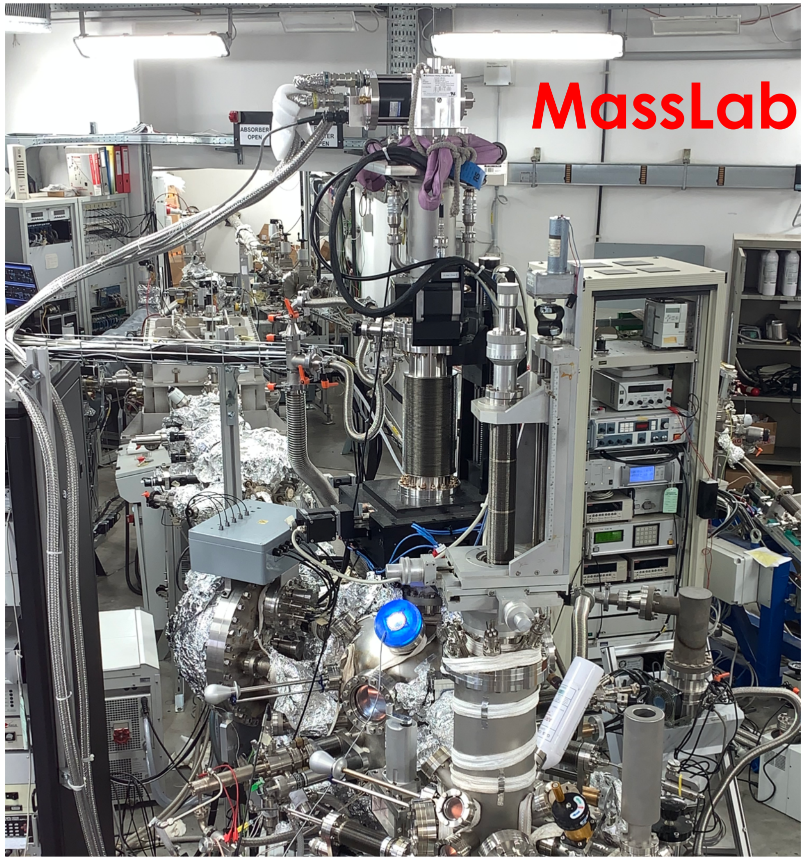
G. Delle Monache Gr. II

LATINO (Laboratory in Advanced Technologies for INnOvation) is a cofunded project (INFN-Regione Lazio) - Call "Open Research Infrastructure"

Cryogenic Vacuum Issues

Mirror Temperature will define tower operating pressure since, **at cryogenic temperature, residual gas will cryosorb on the mirror surface inducing detrimental effects on the optical properties**

An active mitigation method is mandatory to remove the unavoidable frost formation on the optics



Electrostatic charging

Both VIRGO and LIGO optics undergo to **inhomogeneous electrostatic charging that may induce unwanted noise**

The existing mitigation method cannot be applicable at cryogenic temperature since microns of N_2 will cryosorb on the surface

At MassLab there two "state of the art" UHV set-ups equipped with cryogenic manipulators for hosting small samples (10x10mm^2) at <20 K, electron guns, XPS, SEY, QMS and other spectroscopies to perform:

Surface studies of mirrors materials at RT and LT before and after cryosorption of gases and electrostatic charging.

VAC_CRIO


2022 ongoing
experiments

SL_COMB2FEL

Description of the Activity

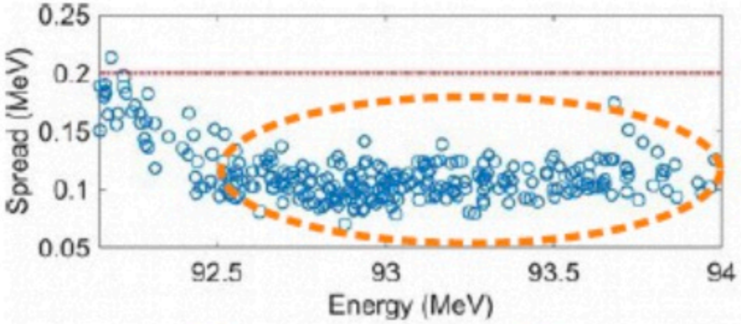
- **Start-to-end simulations** (from cathode to undulator exit) => LNF, Mi
  - study of **plasma ramps** and **real plasma density** profile
  - study and design of the **transfer line from the plasma exit to the undulator**
- **Impact of hydrogen gas flow on the copper photo-cathode Quantum Efficiency**
  - Single layer graphene deposition => Le, LNF
- Extraction transfer line up to the measurement station and to the undulator => LNF, Na
  - **Driver removal**
    - Study of effects of electron scattering in the gas, the effect on the emittance growth and the resulting dose irradiated
  - Plasma lenses (instead of permanent magnet quadrupoles, PMQ) for the injection and the extraction, from the plasma accelerating module to gently focus and capture the accelerated beam
- Demonstration (with measurements) of the high quality of the accelerated beams => LNF, RM2
  - measurement of the **gain growth of the SASE FEL radiation** (LNF, Mi, RM1, RM2)
  - **single shot diagnostics** for bunch length and transverse emittance
- Development of **advanced alignment tools** => LNF, RM1
  - Test bench for X-band integrated beam position monitor (BPM)

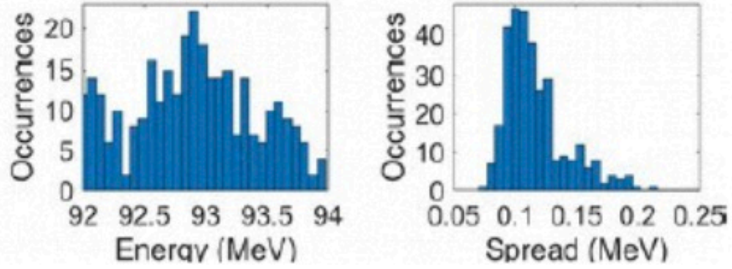
enrica.chiadroni@lnf.infn.it

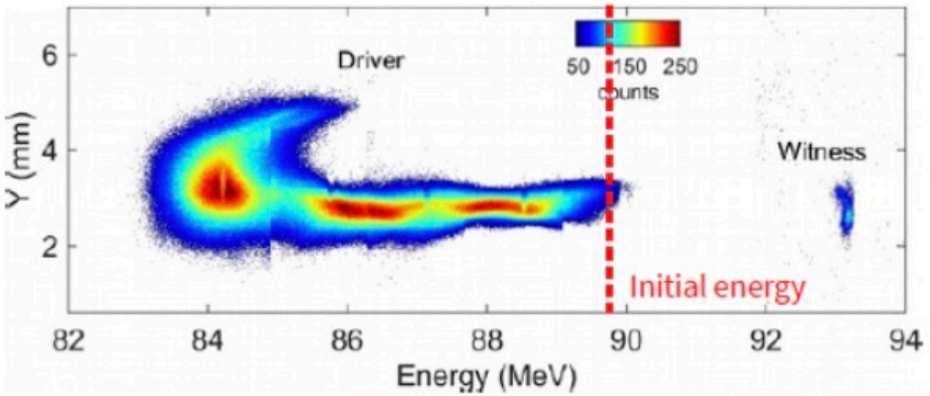
Achievements in 2020

- **Energy spread reduction in the beam driven PWFA experiment**

- 4 MeV acceleration in 3 cm plasma with 200 pC driver
  - ~133 MV/m accelerating gradient
  - 2×10^{15} cm^{-3} plasma density
  - Energy spread from 0.2% to 0.12%



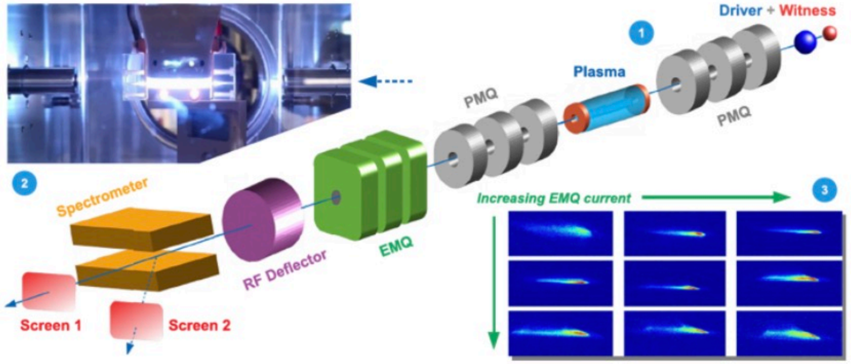




R. Pompili et al., *Energy spread minimization in a beam-driven plasma wakefield accelerator* (2021), Nature Physics, 17 (4), pp. 499-503

Achievements in 2021

- **First transverse normalized emittance characterization**
  - Multi-shot quadrupole scan technique to measure the plasma-accelerated witness normalized emittance



V. Shpakov et al., *First emittance measurement of the beam-driven plasma wakefield accelerated electron beam*, (2021), Physical Review Accelerators and Beams, **24** (5), art. no. 051301

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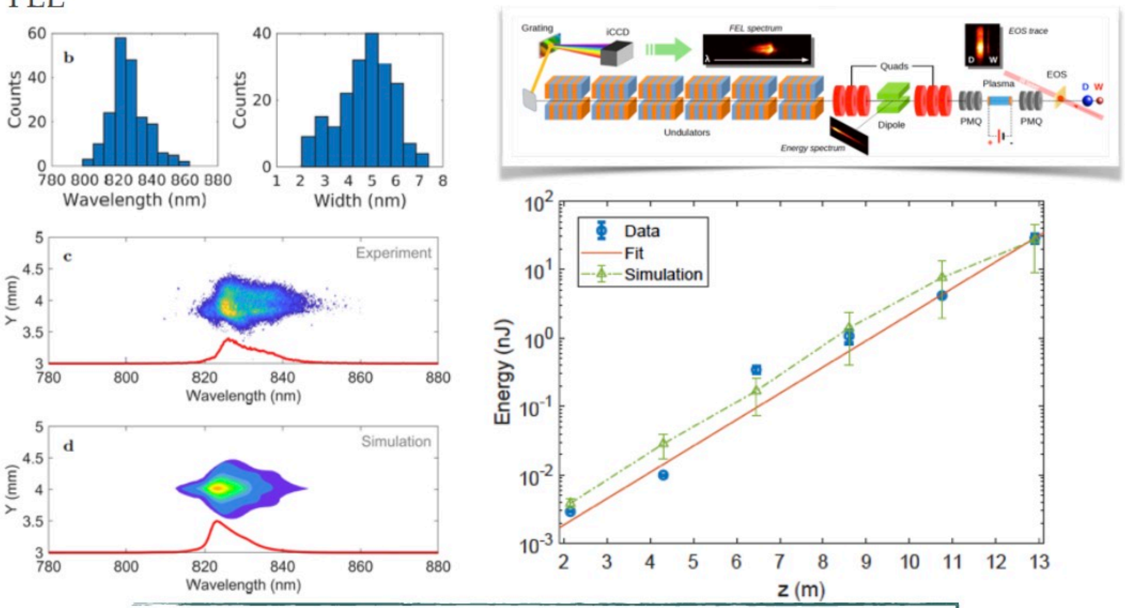
Achievements in 2021

- **First experimental observation of the gain growth** of a plasma-driven SASE FEL



R. Pompili et al., *First lasing of a free-electron laser with a compact beam-driven plasma accelerator*, (2021), submitted to Nature Physics

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- Despite COVID-19 pandemic, the milestones for the 2021 are in good progress

Milestone #	Due date	Description	Progress
M07	31-07-2021	Commissioning of compact beam size monitor	50%
M09	30-09-2021	Start-to-end simulation including FEL code	80%
M10	31-10-2021	Project of the transfer and matching line to the undulator	80%
M11.1	30-11-2021	Single shot ultra short bunch length measurement	30%
M11.2	30-11-2021	Deposition study of graphene via CVD at low temperature (<900 deg)	50%
M12	30-12-2021	Morphological characterization of G/Cu	50%

Foreseen Activity in 2022

SPARC LAB

- Keep on both simulation and experimental studies going to **optimize the acceleration process** with particular attention to the **stability, reproducibility** and **quality** of the accelerated electron beam
  - Start-2-End simulations (including FEL), plasma ramps studies, plasma density optimization, driver removal
- Implementation of **the transfer and matching line to the undulator** to remove the driver beam and preserve the witness beam parameters
- **Experimental studies for witness beam and matching conditions optimization to drive alternative scheme of FEL experiments**
- Installation, operation and commissioning of the new photocathode laser system (End of 2022)

TUAREG (*The Ultra Advanced RF Electron Gun*): STATUS

- *David Alesini*
- *(INFN-LNF, Frascati)*

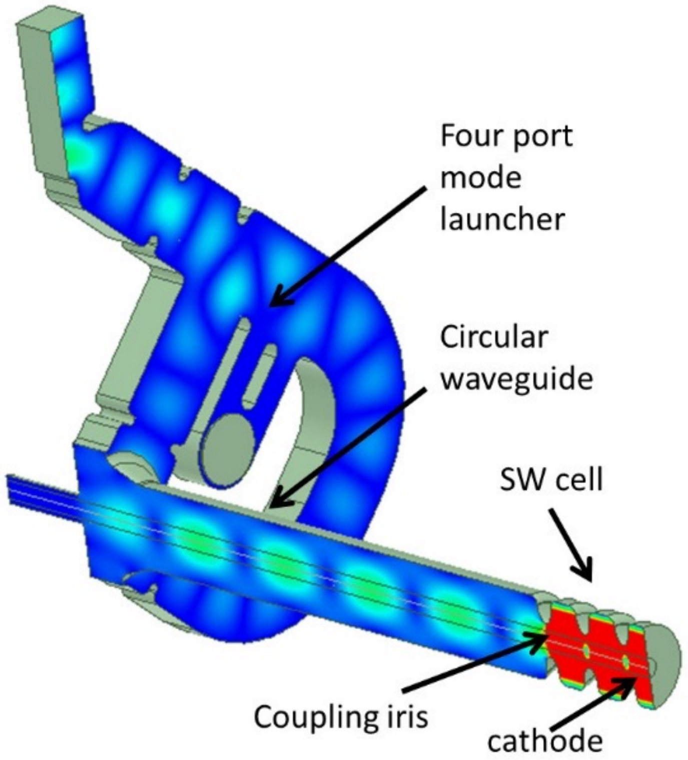
On behalf of the TUAREG team

STATUS

- TUAREG is a three-years experiment proposal (2020-2022) aiming at the **design, construction and high power tests of a C-band (f_{RF}=5.712 GHz)** RF electron gun to be operated at very **high cathode peak field (>200 MV/m) and very high repetition rate (up to 1 kHz)**. The activity is divided in different work packages.

- The realization and test of the C band gun has been selected and inserted in the **I.FAST** proposal funded by the **EU** (WORK TASK 7.4 (Resp D. Alesini). It is a co-funded project, **started on May 2021.**

- **Electromagnetic design** of the GUN and Mode Launcher: DONE
- **Mechanical design** of the GUN and MODE Launcher: DONE
- **Order of the GUN**: DONE
- **MODE LAUNCHER** Construction in charge of COMEB in I.FAST
- **ISOLATOR**: To be ordered with the co-funding of I.FAST (fall 2021)
- **SOLENOID**: Design to be completed and ordered (co-funding with I.FAST) on 2022

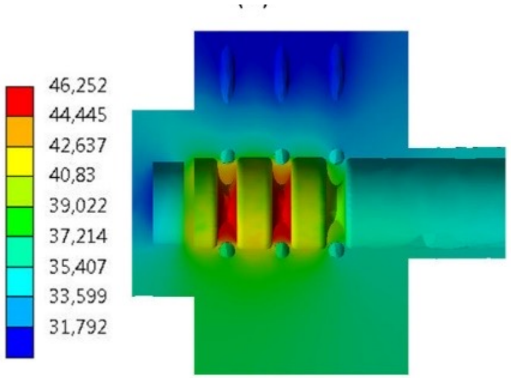


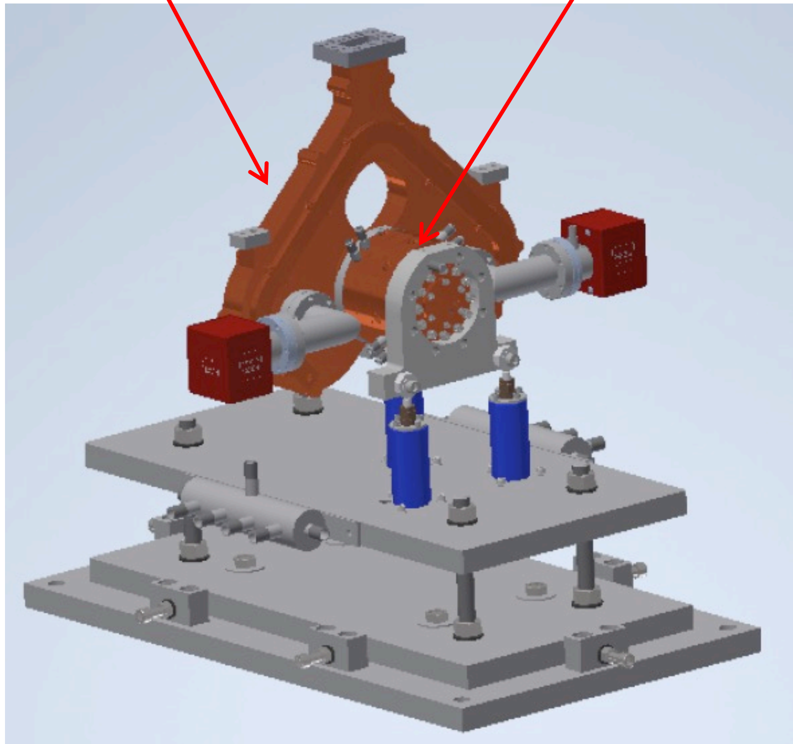
DETAIL OF THE GUN AND DESIGN

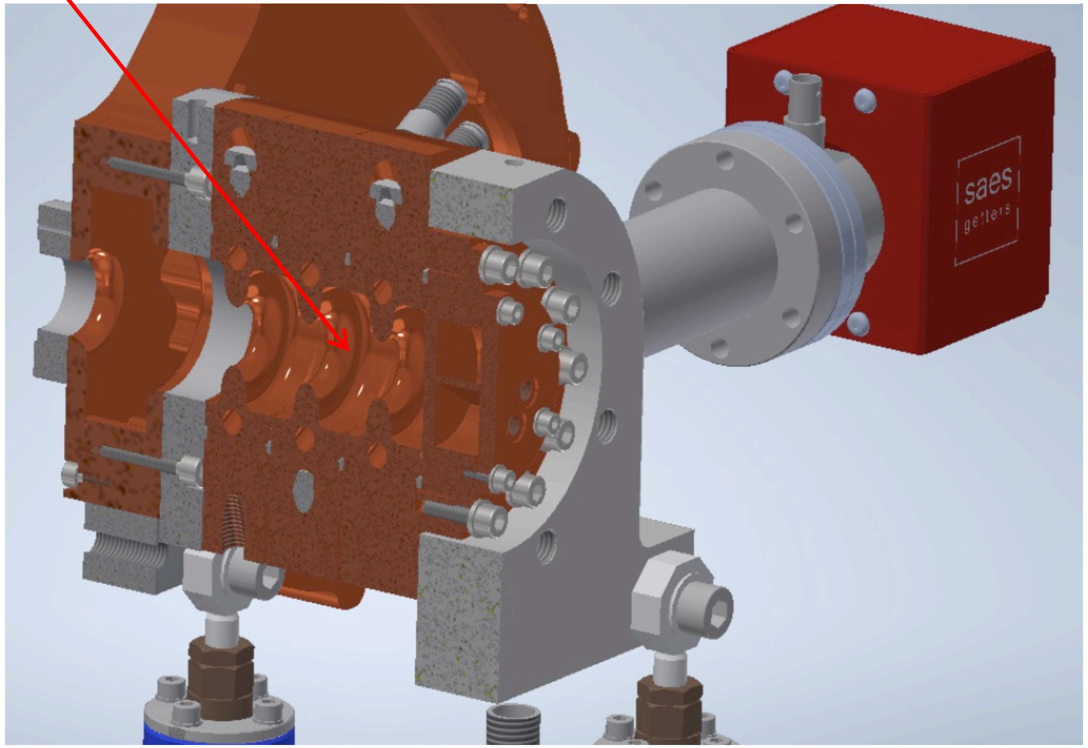
GUN

Mode launcher

Temperature at
1 kHz rep. rate







uRANIA-V

- **Obiettivo: sviluppo di un rivelatore di neutroni** basato su **tecnologia Resistive-Gaseous Detector (uRWELL + …)** per applicazioni in **homeland security e radioactive waste monitoring**
- **Durata: 2021 - 2023**

u	micro
R	esistive
A	dvanced
N	eutron
I	maging
A	pparatus

INFN - Ferrara (1.1 - FTE)

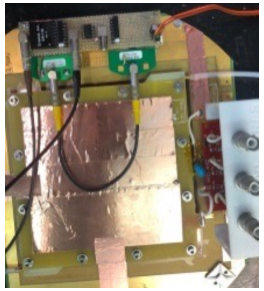
G. Cibinetto (resp.loc)	**0.15**
I. Balossino	**0.2**
R. Farinelli	**0.1**
I. Garzia	**0.25**
M. Scodeggio Marco	**0.2**
A. Cotta Ramusino	**0.1**

+ **0.1** FTE dal servizio meccanico

INFN - LNF (1.0- FTE)

G. Bencivenni (resp. naz.)	**0.4**
G. Felici	**0.2**
G. Morello	**0.2**
M. Poli Lener	**0.2**
M. Giovannetti	**0**

The pillars



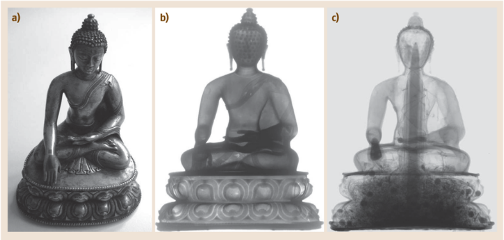
- **Resistive Gaseous Detectors** (μ-RWELL + …)
- **Neutron Boron-Converters:**
  - planar Boron coated cathodes/electrodes
  - Boron coated metallic meshes
  - Boron coated grooved-cathodes

$$n + {}^{10}_{5}B \begin{cases} {}^{7}_{3}Li(1.02MeV) + \alpha(1.78MeV) & 6\% \\ {}^{7}_{3}Li(0.84MeV) + \alpha(1.47MeV) + \gamma(0.48MeV) & 94\% \end{cases}$$

- detection of thermal neutrons (E_k ~ 25meV) with $^{10}B_4C$ deposition on detector electrodes/cathodes
- neutron conversion in ionizing particles (α/^{7}Li back to back → mutually exclusive events)
- not negligible α/^{7}Li cross-section with $^{10}B_4C$ → thickness optimization.

- **Counting-mode electronics**
- **Neutron-radiography imaging**

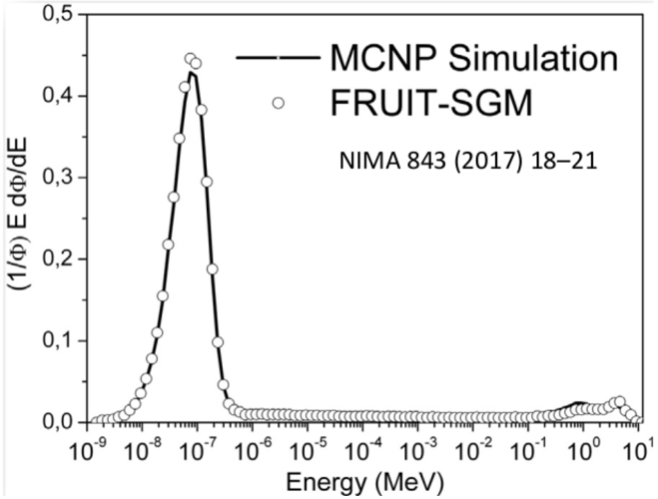
with fine micro-strip readout (σ ~ 100 μm)

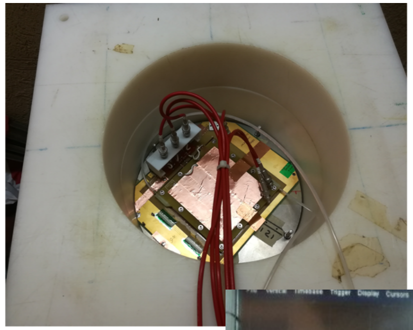


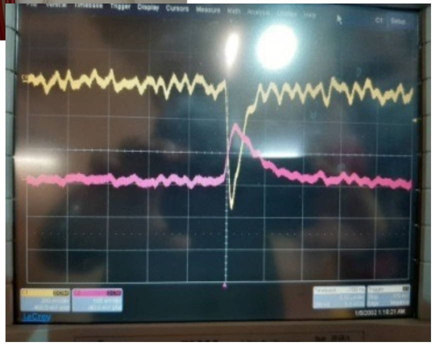
Summary results @ HOTNES (5/2021)

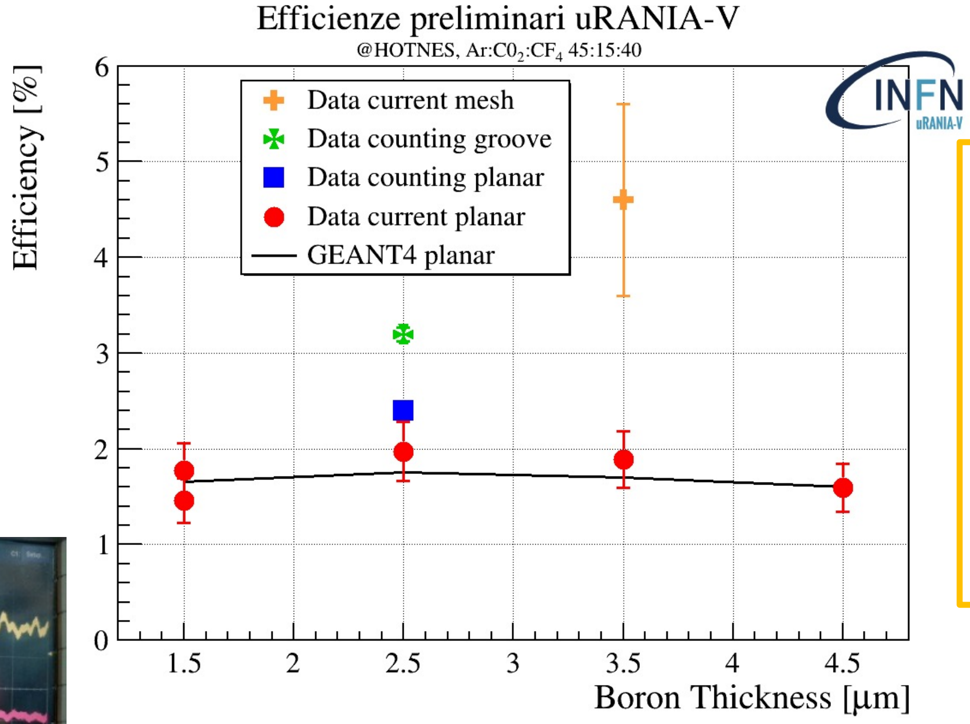
Preliminary

$$n+{}^{10}_{5}B \begin{cases} {}^{7}_{3}Li(1.02MeV) + \alpha(1.78MeV) & 6\% \\ {}^{7}_{3}Li(0.84MeV) + \alpha(1.47MeV) + \gamma(0.48MeV) & 94\% \end{cases}$$



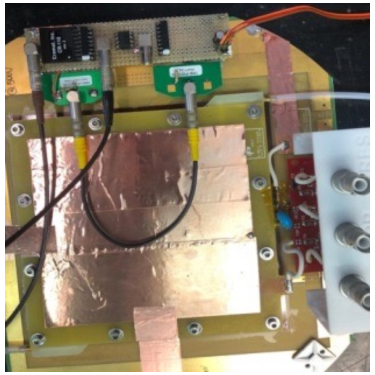


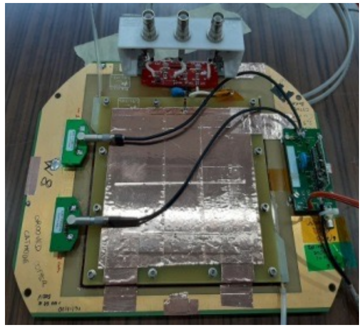




single detector layer

neutron energy spectrum @ HOTNES- ENEA





Max neutron efficiency @ HOTNES (100 meV, FWHM 290 meV) ≈ 3 ÷ 5%

Corresponding to efficiency for thermal neutron (@25 meV) ≈ 6 ÷ 10%

2022 program

The **GOAL** is the **construction and test** of the **first prototype of the detector-tile based on uRWELL technology with suitable converters & integrated counting-mode electronics**

- Finalizing the design of the detector PCB-RWELL (10x10cm^2)
- Finalizing converters design (planar/grooved cathodes – metallic mesh …)
- Finalizing electronics based on CREMAT CR110 (+ discrimination + counting + … *display + beep*)
- Integrated HV system based on DC-DC converter

In **parallel** we would like to do some **preliminary tests** of a **neutron device based on mono-gap sRPC technology** in **hybrid configuration (DLC + 10B4C electrodes):**

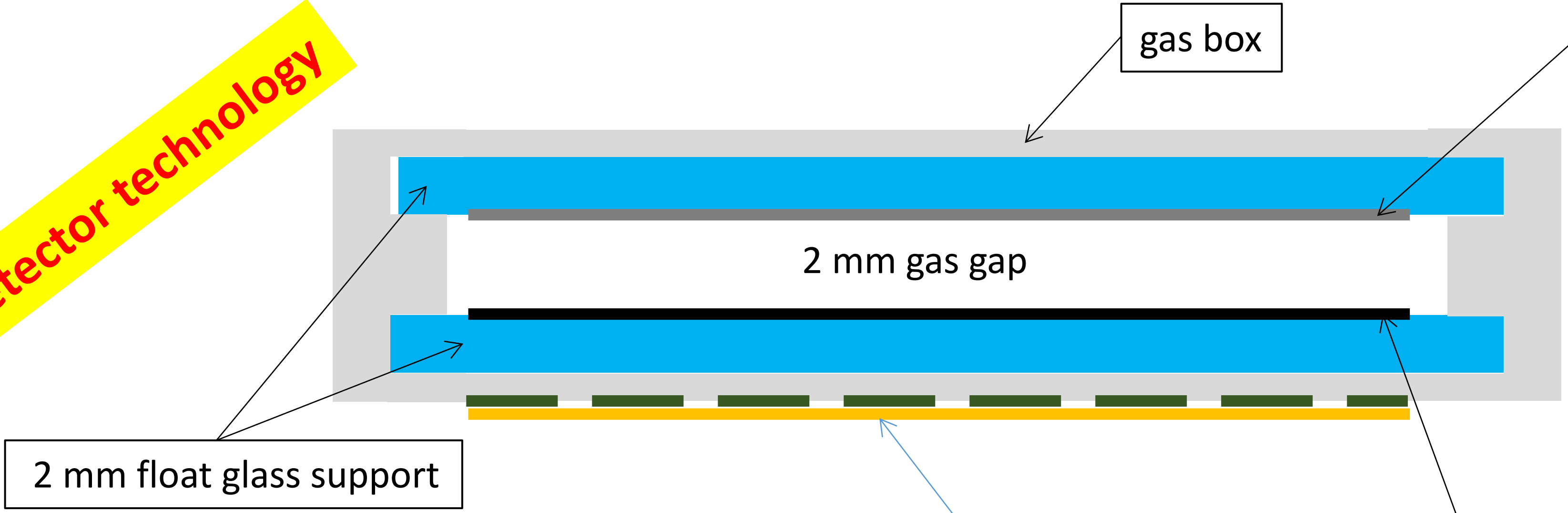
- Design/construction of kapton electrodes w/DLC coating and 10B4C
- Design/construction of detector mechanics
- PCB readout
- Electronics readout board based on CREMAT CR112

Still to be approved by Referees

sRPC for Thermal Neutron Detection

The **sRPC** is based on a **new concept of surface resistivity thin electrodes (1-10 GOhm/square)** manufactured with **industrial DLC coating techniques** on flexible or semi-rigid supports.

new detector technology



Hybrid sRPC:

- the **anode**, with high resistivity **DLC coated kapton foil**, acts as "voltage-quencher", ensuring the correct operation of the detector
- the **cathode**, with low resistivity **10B4C coated kapton foil,** acts as "neutron-converter"

Brevetto Italia N. 102020000002359 (submitted to INFN 10 Sept 2019 - deposited to Ufficio Brevetti 6 Feb 2020)
INFN – "ELETTRODO PIANO A RESISTIVITÀ SUPERFICIALE MODULABILE E RIVELATORI BASATI SU DI ESSO."

Approved experiment 2020-2024:

ARYA

SURFACE AND MATERIAL STUDIES FOR ACCELERATOR TECHNOLOGY AND RELATED TOPICS

- L'INFN ha una lunga tradizione e ha competenze specifiche su questioni relative a vari aspetti di R&D in fisica degli acceleratori.
- Il progetto **ARYA** è suddiviso in Working Packages (WP).
- Tutti i WP affronteranno la ricerca e le sfide e contribuiranno attivamente, in collaborazioni internazionali, a studi sia specifici che di carattere generale, per HL-LHC, FCC, EIC e altri R&D.
- L'obiettivo di questa proposta è quello di garantire le risorse necessarie per contribuire al meglio alle collaborazioni in corso e future evidenziando il ruolo dell'INFN sugli studi sugli effetti collettivi e sulle proprietà dei materiali per i futuri acceleratori.

ARYA WP'S

I WPs di ARYA sono:.

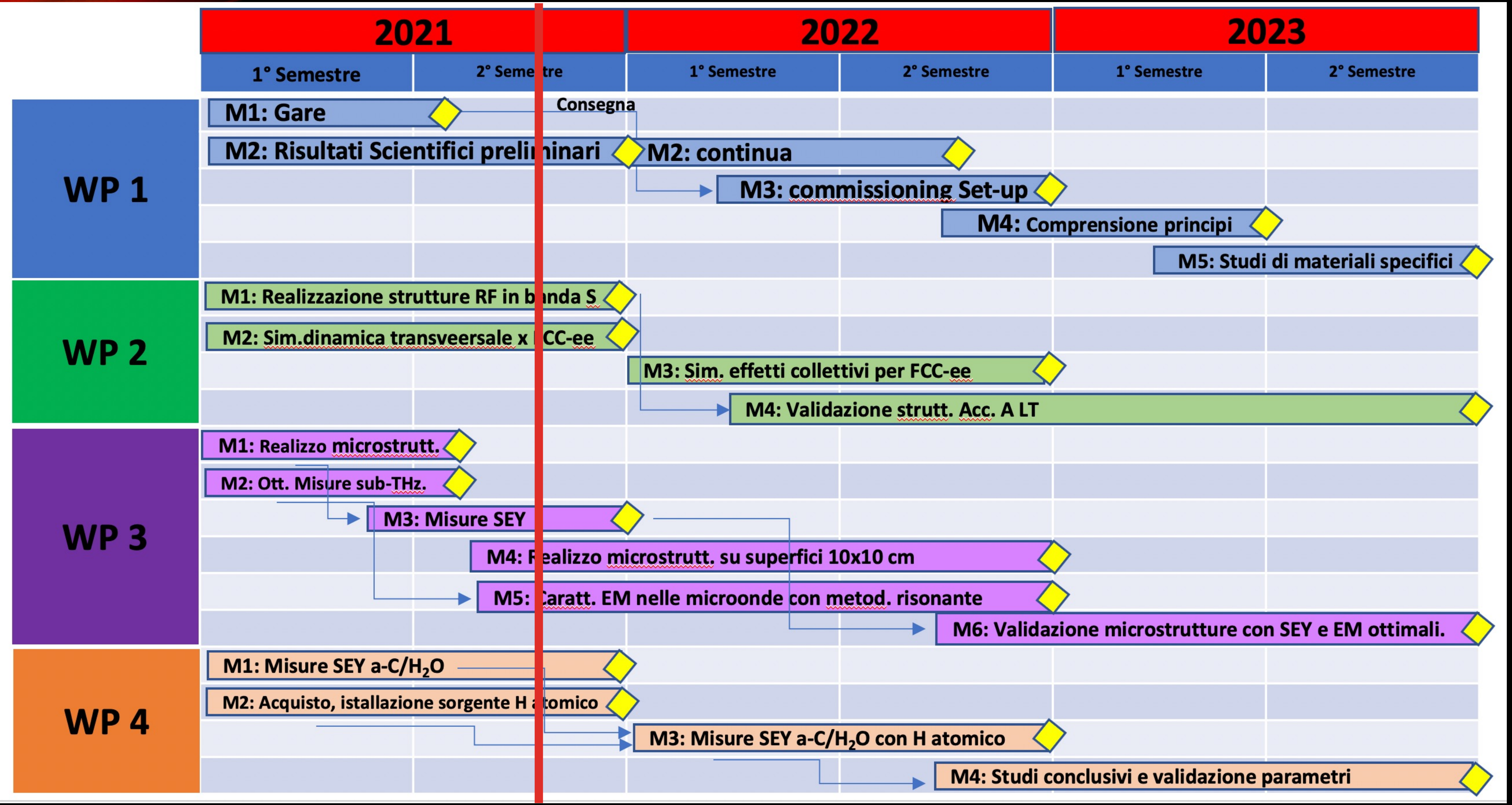
Iaia Masullo (Na) is now the National Responsible

	WP	Titolo	Unità coinvolte	Responsabile
Ai LNF	**WP1**	**Studio comparativo e caratterizzazione del desorbimento stimolato indotto da elettroni e fotoni.**	**LNF-INFN** **CERN**	**M Angelucci & L. Spallino**
	WP2	**Dinamica di fascio e materiali innovativi per acceleratori**	**Rome1-INFN** **Na-INFN** **LNF-INFN** **CERN**	**M. Migliorati**
	WP3	**Riduzione di Impedenza e caratterizzazione di superfici strutturate per ablazione laser**	**Na-INFN** **Rome1-INFN** **CERN** **LNF-INFN**	**M.R. Masullo**
Ai LNF	**WP4**	**LHCspin: Validazione delle proprietà di superficie della cella di accumulazione con H atomico.**	**CERN** **LNF-INFN**	**P. Di Nezza**

ARYA CRONOPROGRAMMA

WE ARE HERE!
IN LINE WITH THE PROGRAMME

Ai LNF



Ai LNF

WP1	Studio comparativo e caratterizzazione del desorbimento stimolato indotto da elettroni e fotoni.	LNF-INFN CERN	M. Angelucci & L. Spallino

Abbiamo lanciato le gare e assegnato la tender (XPS Analyser, X-ray Mono. source and the μ-metal chamber) ricevendo un significativo supporto dai LNF. (~50%). Consegna prevista ad inizio 2022.

Meanwhile we continue our studies, publishing in 2020:

1. E. La Francesca, et al. **Phys. Rev. Accel. Beams**, 23, 083101 (2020)
2. Marco Angelucci and Roberto Cimino “Proceedings SILS 2019. Springher series 2020.
3. M. Angelucci, et al. **Phys. Rev. Research Rapid. Comm.**, 2, 032030(R) (2020)
4. A. Novelli, et al. in Proceeding of IFCA mini workshop MCBI 2019 **CERN Yellow Reports**: CERN-2020-009 p 186.
5. L. Spallino, et al. **Phys. Rev. Accel. Beams 23**, 063201 (2020)
6. L. Spallino, J. Vac. Sci. Technol. B, 38, 032803 (2020)
7. R. Cimino, in: **Proceedings of the 2017 course on vacuum for particle accelerators. CERN-ACC-2020-0009. – 2020**
8. R. Cimino, et al**. Journal of Electron Spectroscopy and Related Phenomena**, Volume 241, 2020, 146876,
9. R. Cimino and F. Zimmermann ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**)
10. Liedl, et al. ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**) pp.125-130
11. R. Cimino and F. Zimmermann ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**) pp.229-236
12. L. Spallino, et al. ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**), pp.153-158.
13. R. Dupuy, et al. ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**), pp.147-152.
14. L. A. Gonzales, ECLOUD18: Proceedings of Electron-Cloud Effects (**CERN-2020-007**) pp.119-123
15. Contributi (talks) a: IPAC 21 e FCC21.

WP1	Studio comparativo e caratterizzazione del desorbimento stimolato indotto da elettroni e fotoni.	LNF-INFN CERN	M. Angelucci & L. Spallino

Per lo studio simultaneo e comparativo degli effetti della Luce di Sincrotrone e/o dell'irraggiamento con elettroni sia sui gas desorbiti che sulla chimica della superficie, abbiamo bisogno di completare l'istallazione del sistema (impatto sul consumo) e di un contributo per l'acquisto di un cannone elettronico.

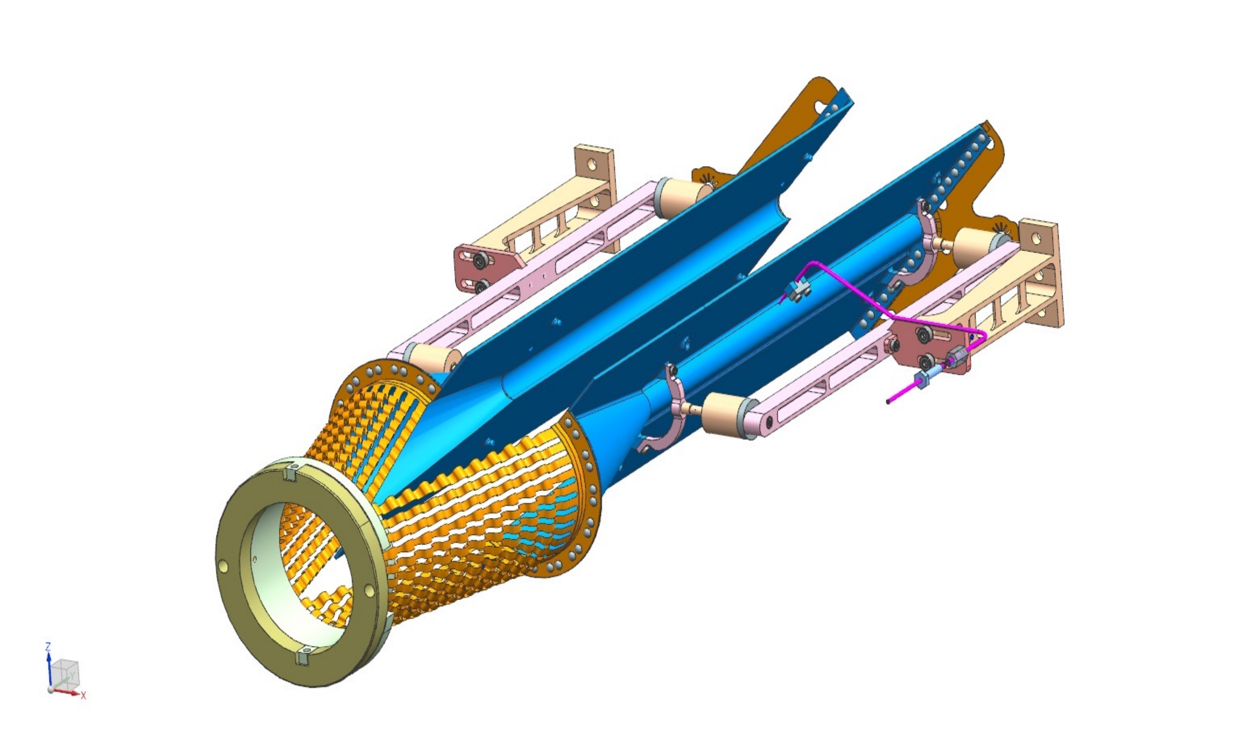
N.B. Se tutto va bene si organizzera' fine Settembre Ecloud'22 all'isola d'Elba.

WP1: Richieste 2022

- Missioni: 20 k€
- Consumo: 35 k€
- Inventariabile: 25 k€

WP4	LHCspin: Validazione delle proprietà di superficie della cella di accumulazione con H atomico.	LNF-INFN CERN	P. Di Nezza

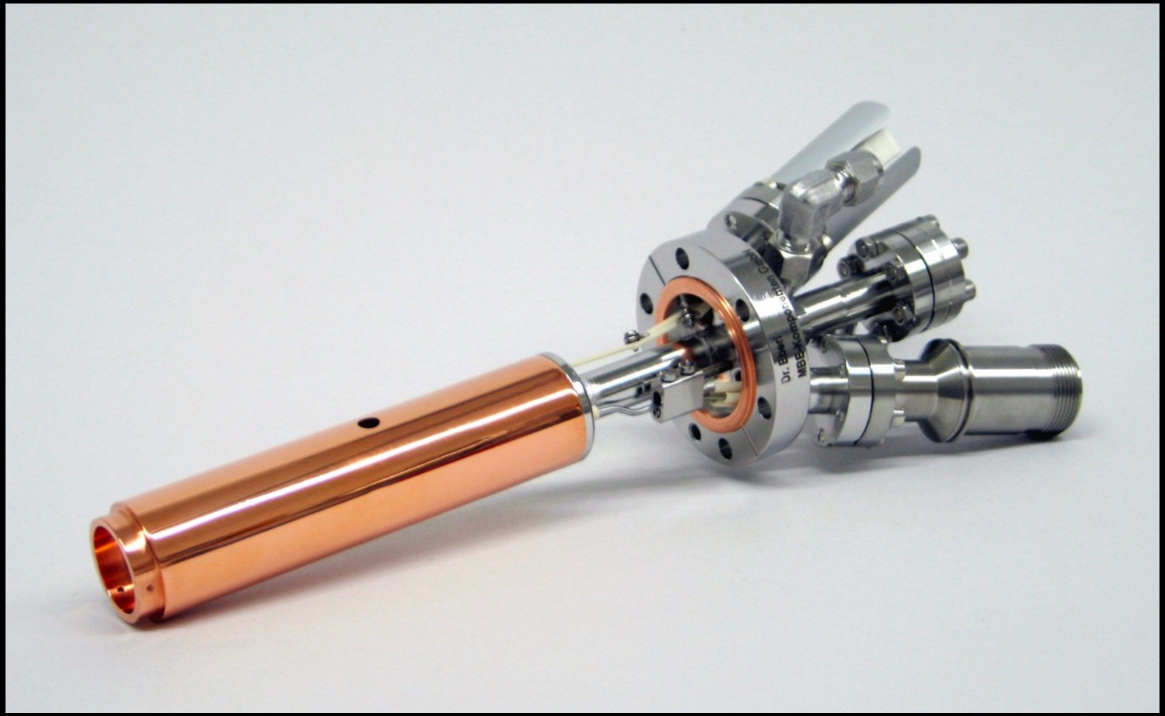
Questo WP è un R&D per la camera di scattering da posizionare davanti al rivelatore LHCb durante il «long Shutdown 3» di LHC (2024-2026). Questa nuova camera di vuoto sarà riempita con vari gas e, in particolare, con idrogeno atomico polarizzato e deuterio, portando, per il prima volta, fisica polarizzata all'LHC.



Bisognerà definire il ricoprimento superficiale adatto ad inibire la ricombinazione (e quindi la depolarizzazione). La camera e il suo ricoprimento devono pero' necessariamente soddisfare soddisfare i requisiti di LHC su vuoto, SEY, e-cloud indotta ecc.

Un film sottile di a-Carbon , coperto da un sottile condensato d'acqua a bassa temperatura, sembra essere la soluzione da studiare, ottimizzare e validare, anche sotto bombardamento di H atomico

- Studi SEY in funzione dello spessore e della temperatura del film sottile di H_2O su substrato a-C (dalla grafite a a-C porosa altamente disordinata).
- L'effetto dell'assorbimento su quelle Superfici dell'idrogeno atomico (o deuterio atomico) per vedere se rimangono imperturbati o se ne sono in qualche modo modificati nel SEY.



Gia' acquistata (anticipi 2020) e appena arrivata la sorgente «separatore» di H_2 compatibile con l'uso in Ultra alto Vuoto per la produzione di H atomico. Installazione completata e commissioning ongoing.

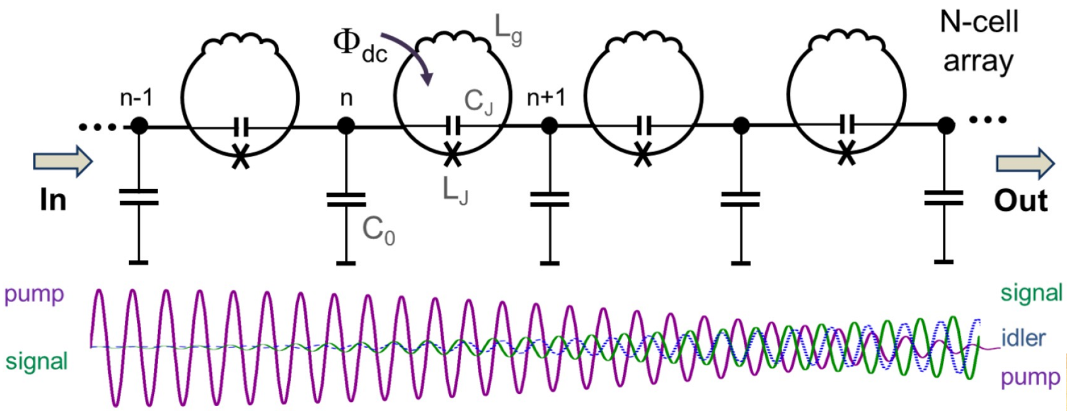
WP3: Richieste2022
- Missioni: 10 k€
- Consumo: 15 k€

LNF – FTE ~ 6   per un totale di 12 partecipanti .

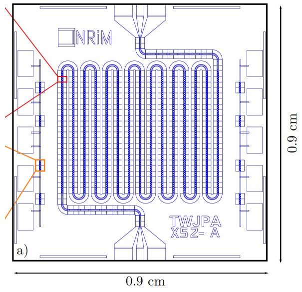
chi	Ruolo	Posizione	%
Roberto Cimino	~~National and~~ Local resp.	Dir. Ric. LNF	70
Rosanna Larciprete		Dir. Ric. CNR & ass. @ LNF	100
Mikhail Zobov		Dir tecnologo. LNF	10
Antonio Di Trolio		Ricercatore CNR & ass. @ LNF	100
Marco Angelucci		Tempo Determinato - @ LNF	60
Pasquale Di Nezza		1° Ricercatore @ LNF	10
Luisa Spallino		Assegnista di ricerca @ LNF	70
Fara Cioeta		Tecnologo @ LNF	10
Simone Bini		tecnologo @ LNF	10
Antonella Balerna		1° ricercatore @ LNF	20
Andrea Liedl		Tempo Determinato @ LNF	10
Armando Novelli		dottorando in fis. Acc.	100
		TOTAL FTE	**5.7**

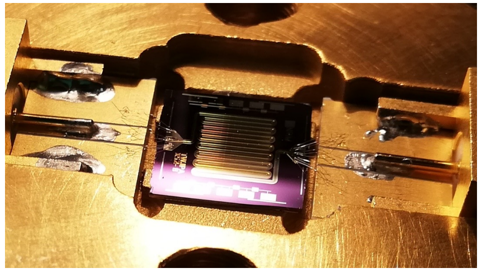
DART WARS: Detector Array Readout with Travelling Wave AmplifieRS

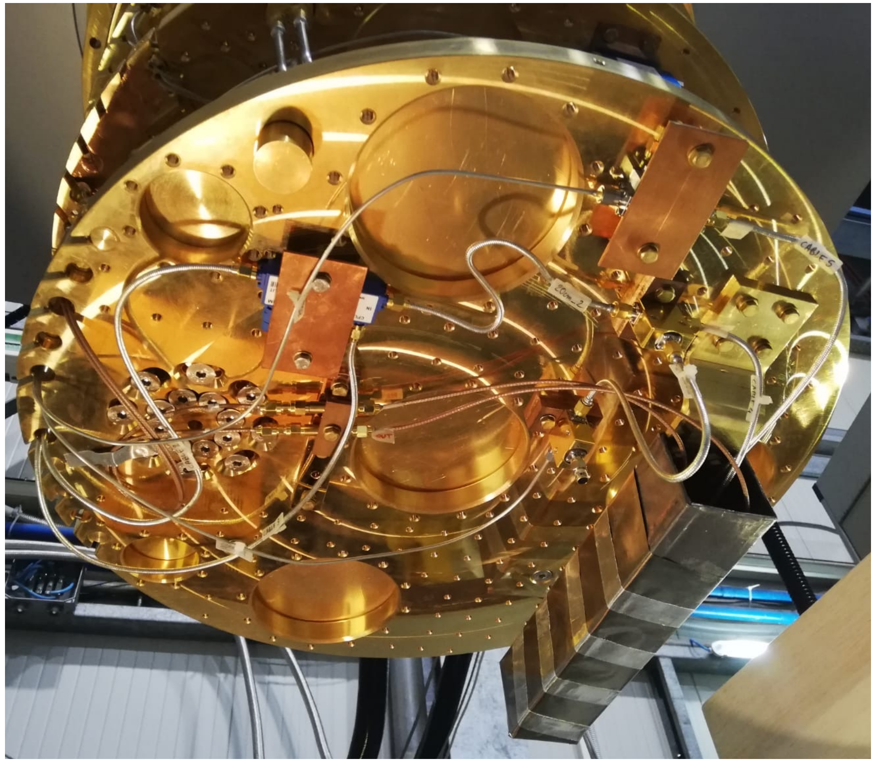
Travelling Wave Josephson Parametric Amplifiers amplify microwave signal over a broad range adding the minimum noise set by quantum mechanics.



INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA



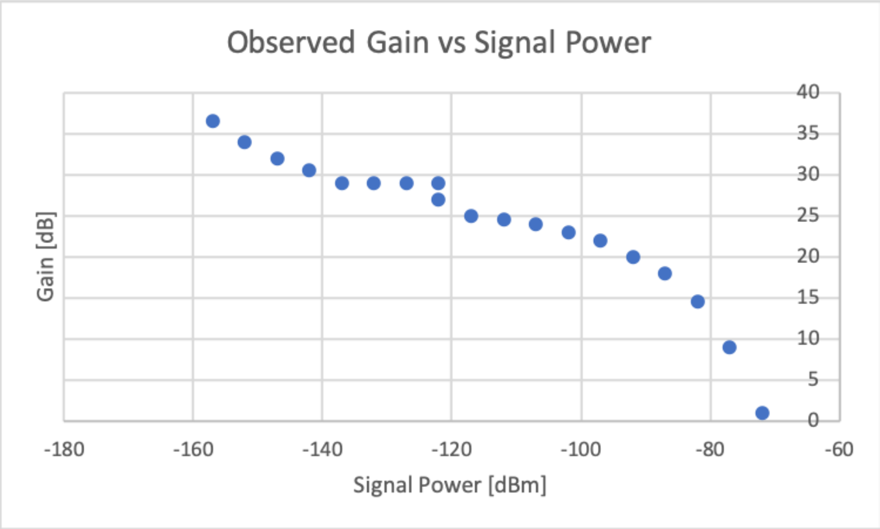


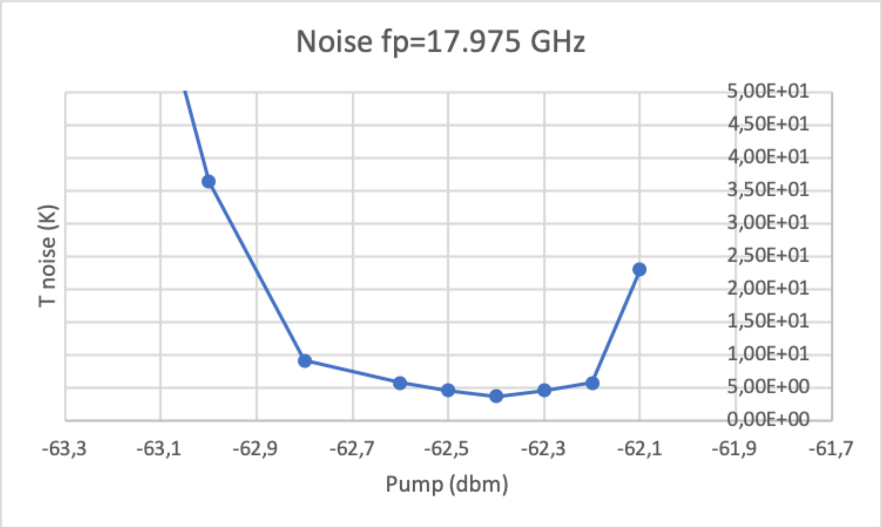


DART WARS 2021-2023 (Call GR V)
MIB (PI)
LNF (RL Ligi)
INFN Sa
TIFPA
INRIM
INFN-Le

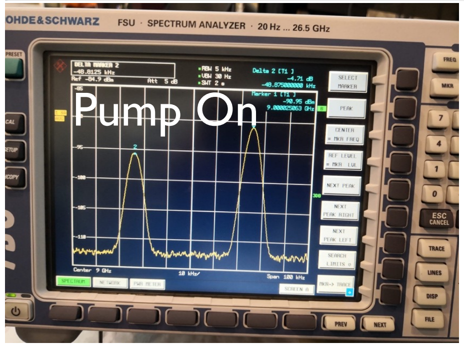
DART
WARS

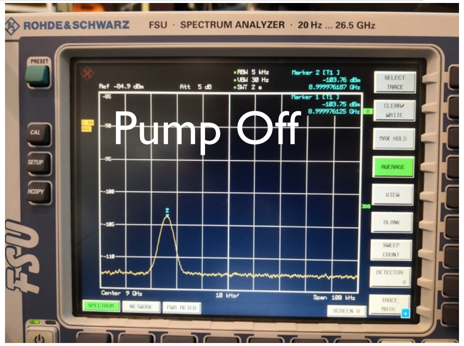
DART WARS: Test Of First TWJPA At LNF





	frequency	Power
Pump	17.975 GHz	-62.6 dbm
Signal	$f_p/2$	-132 dbm





ENTER_BNCT 2020-2022

Filling the technology gap between research and clinical application of Boron Neutron Capture oncologic Therapy (BNCT)

R.N. Saverio Altieri (Pavia)

2022

Sezioni: Pv, To, LNL, LNF

LNF 1.1 FTE

R. Bedogni (dip, 0.3), C. Cantone (dip, 0.1), J.M. Gomez-Ros (ass, 0.3). A. Pietropaolo (ass, 0.4), A. Fontanilla (ICTP fellowship)

ENTER_BNCT

BNCT

- l'isotopo stabile ^{10}B in farmaco si concentra nelle cellule cancerogene
- un fascio di neutroni induce reazioni $^{10}B(n,\alpha)^{7}Li$ preferenzialmente nelle cellule tumorali "marcate" col Boro
- I prodotti di rezione α e ^{7}Li sono densamente ionizzanti (range 5-9 um) e danneggiano il tumore selettivamente e localmente.

CNAO costruirà una linea BNCT e potrebbe divenire il primo centro al mondo in grado di somministrare terapia adronica (protoni, carbonio) e BCNT anche in combinazione.

Componenti di ENTER_BNCT

LNL. Fasci di protoni e neutron targets

PV. Neutron Beam shaping, treatment room design, misure in-vivo di dose-Boro

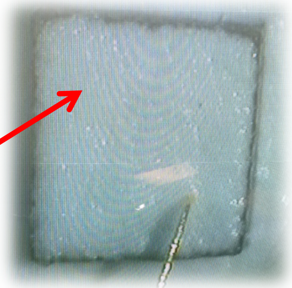
LNF, To. Sviluppo di diagnostiche per il fascio di neutroni terapeutico.

NCT-WES = spettrometro da termico ai MeV

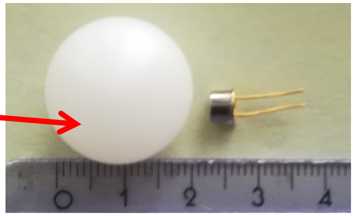
CONES = sonde per dosimetria in fantoccio

ENTER_BNCT

Attività LNF 2021



- Qualificazione di sensori rad-tolerant al **carburo di Silicio** per equipaggiare lo spettrometro NCT-WES in vista delle elevatissime fluenze terapeutiche (1E+9 cm^{-2}s^{-1})
- Sviluppo delle sonde per dosimetria in fantoccio (CONES)



Attività previste per il 2022

- Test delle diagnostiche NCT-WES e CONES su reattore (Pavia) e su campi clinici esistenti (Helsinki)
- Richieste alla CSN 5
  - ✓ Materiali e lav meccaniche (supporti, fantocci) 4.0 k€
  - ✓ Consumo elettronica 3.0 k€
  - ✓ spedizione materiali 5.0 k€
  - ✓ Missioni 4.0 k€
- Non ci sono richieste ai servizi LNF

Istituto Nazionale di Fisica Nucleare

SAMADHA 2021-2023

South Atlantic Magnetic Anomaly Dosimetry at High Altitude

R.N. Silvia Vernetto (To)

2022

26 participants in 5 units
Torino, Trieste, LNF, Firenze, Napoli

LNF 1.1 FTE
R. Bedogni (dip, 0.3), C. Cantone (dip, 0.1), J.M. Gomez-Ros (ass, 0.3). A. Pietropaolo (ass, 0.4), A. Fontanilla (ICTP fellowship)

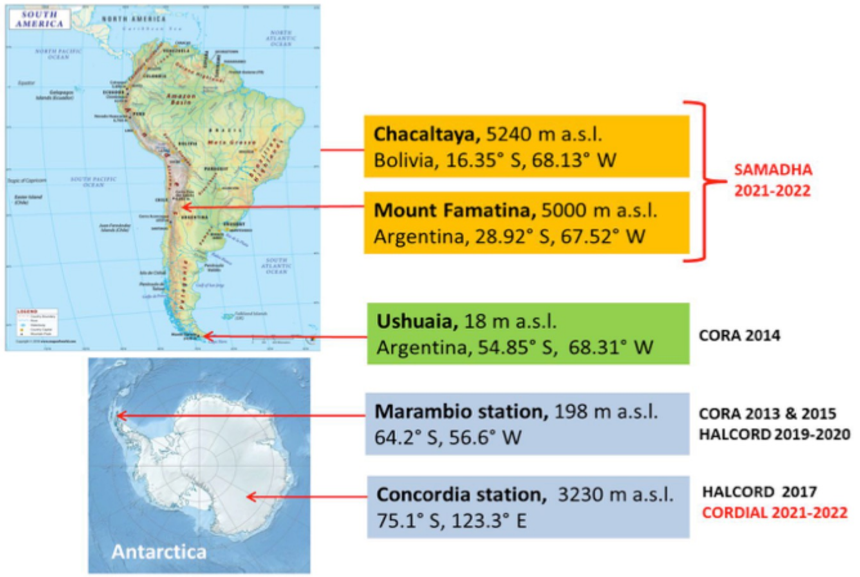
SAMADHA

Secondary neutrons produced by the interaction of cosmic particles with Oxygen and Nitrogen in atmosphere **account for about one half of the effective dose** received by humans at high-altitudes (ex. commercial flights 5000-7000 m).

SAMADHA is planning ambient dosimetry campaigns at high-altitude in the South Atlantic Anomaly (SAA) region

- Chacaltaya Lab (5240 m) Bolivia
- Mt. Famatina (5000 m) Argentina

- Study the relation between **dose rate** and **space weather / atmospheric phenomena** in a region (SAA) where few or no data are available



Task di Frascati

- ✓ Costruire un sistema di spettrometria neutronica a sfere di Bonner adatto per operare lunghi periodi in stazioni non presidiate in quota
- ✓ Gestione ed elaborazione dei flussi di dati

SAMADHA

INFN LNF Istituto Nazionale di Fisica Nucleare

Attività LNF 2021

- Costruzione sistema di 8 sfere di Bonner e altrettanti rivelatori ad 3-He (10 bar x 3 cm^3) per la spettrometria in quota
- Software di controllo e formattazione dati
- Sistemi ancillari per l'operatività "unattended"

Attività previste per il 2022

- Spedizione ed istallazione presso i siti di monitoraggio, inizio della fase di presa dat
- Richieste alla CSN 5
  - ✓ Materiali e lav meccaniche 3.0 k€
  - ✓ Consumo elettronica 3.0 k€
  - ✓ Spedizione materiali 10.0 k€
  - ✓ Missioni 8.0 k€
- Non ci sono richieste ai servizi LNF

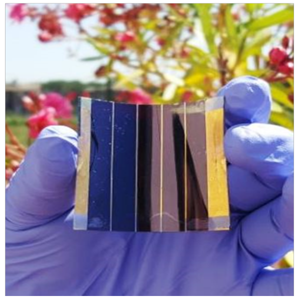
PEROV

R&D for photodetectors based on Organo-Metal Halide Perovskite material

LNF-INFN (Resp. Naz.)
INFN Sezione di Roma 1
Uniroma2 – Dip. Ing. Elettronica
UniMi– Dipartimento Chimica
CNR – NanoTec,ISR,ISM

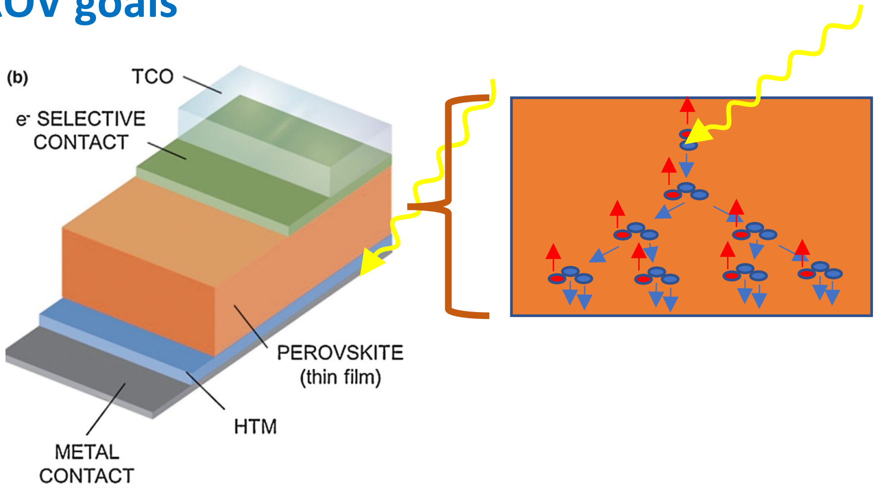
Organo Metal-Halide Perovskites = class of hybrid organic-inorganic semiconductors

- emerging as new generation photovoltaic material
- grown in solution
- **promising candidate as <u>large area and flexible</u> sensitive photodetectors → interest for HEP detectors !**



PEROV goals

1) **Observation or exclusion of internal avalanche multiplication**
   - not yet observed so far
   - no first principle preventing it



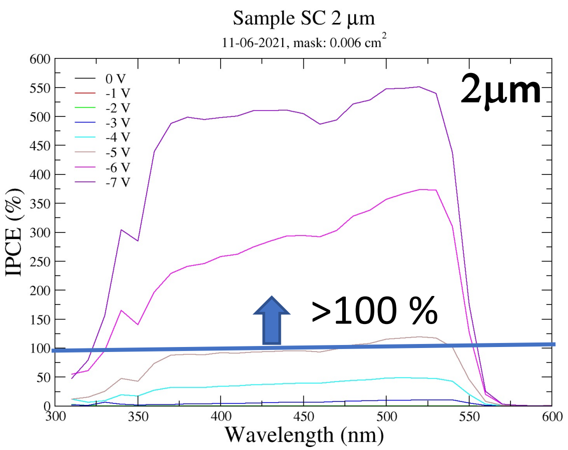
2) Study Stability under:
   - Time under reverse bias
   - Radiation hardness under synchrotron radiation at DAFNE

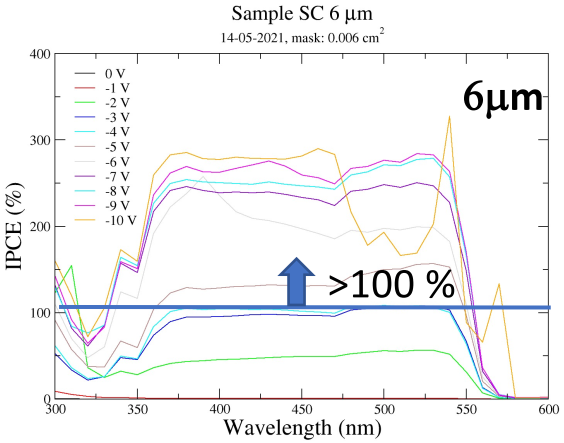
ethodology

Results in 2021

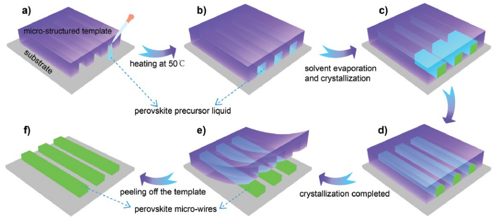
Microfluidics-assisted microwires fabrication (CNR- Nanotech)

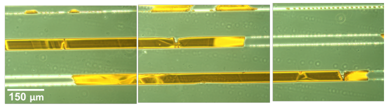
150 x 250 x 2 (6) μm^3



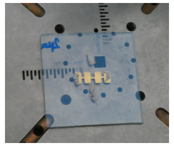


Incident photon to current efficiency (IPCE) > 100 % → **Gain observed**

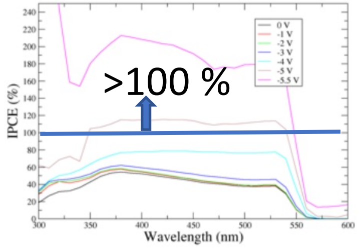




Mask by 3D printing at LNF (T. Napolitano)

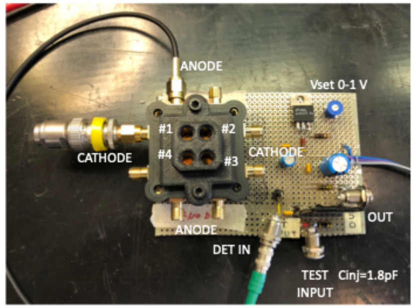


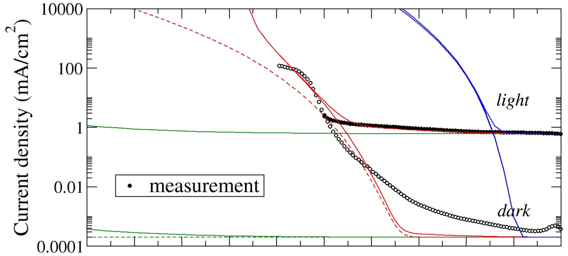
First perovksite deposition on patterned ITO with microfluidics



Film device: 3mm x 3mm x 300 nm (Roma2 Dip. Ing. Elet.)

Gain observed: IPCE>100%





Gain modelled:

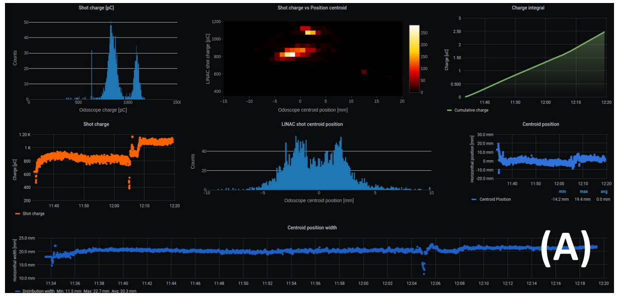
- Rise in dark JV explained either by
  - impact ionization
  - tunneling through the TiO_2/perovskite barrier

Setup by Electronic Service (G. Papalino, G. Felici)

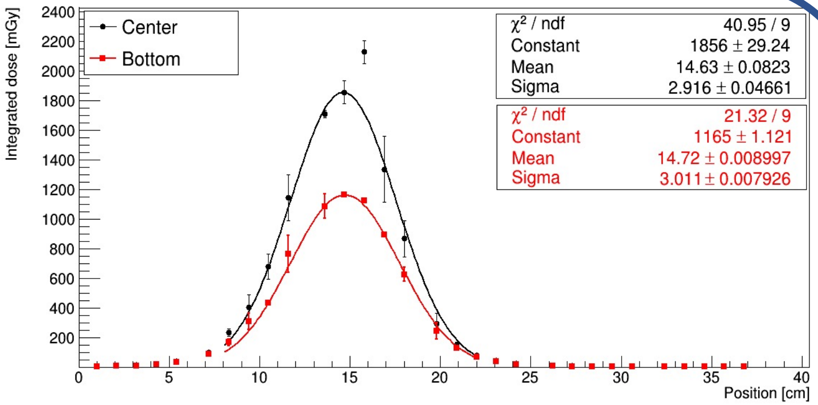
Results in 2021

Radiation hardness

The delivered dose behind the LINAC odoscope beam dump (lead brick) is expected to increase linearly withe the beam charge integral.

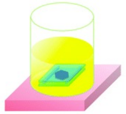


Dedicated diagnostics (A) has been realized to monitor beam charge and position stability during exposure.

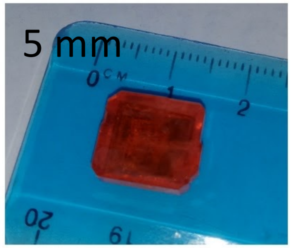


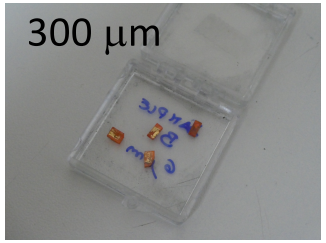
Measurement are in progress to map delivered dose versus position with Termo-Luminescent Dosimeters (TLD). The beam profile appear gaussian with 3 cm width.
Data courtesy of LNF Radio-Protection service

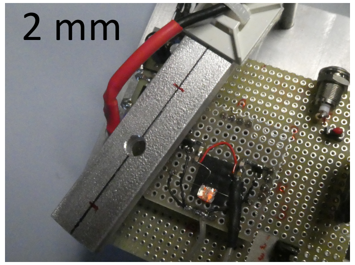
Seeding Techniques - Dip. Chimica Milano

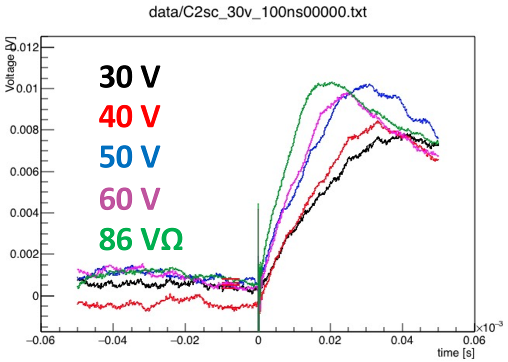


Several mono-crystals from 300 μm to 5 mm thickness
Target: radioactive sources and/or electrons from BTF









Setup realized by Electronic Services (G. Papalino, G. Felici);
mechanical movements by A.Raco

Financial request for 2022 (TBD)

	Scope	Type of request	Cost
LNF, Roma2, UNiMi, CNR (associati a LNF)	• chemicals • lab materials materials	Consumables	• 1.5 kE • 2.0 kE
LNF	• 9kE Oscilloscope • 4kE dosimeter	Equipment	• 9kE • 4 kE SJ preventivo
CNR NanoTec (associato a LNF)	• Realization of substrates at CHOSE RM2 for microcrystals from Lecce, with both experts	Travel from Lecce to Roma2	0.5 kE Nor used in 2020

- Sum of FTE for 2022: 1.9

Possibili variazioni del ~20%

- Sotto suggerimento referee:
  - richiesta sigla per 2 anni
    per finalizzare gli studi prelimianri finanziato sotto Dtz Gr5

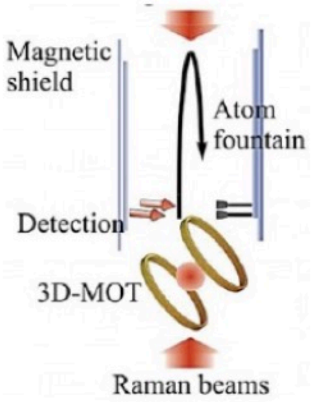
OLAGS

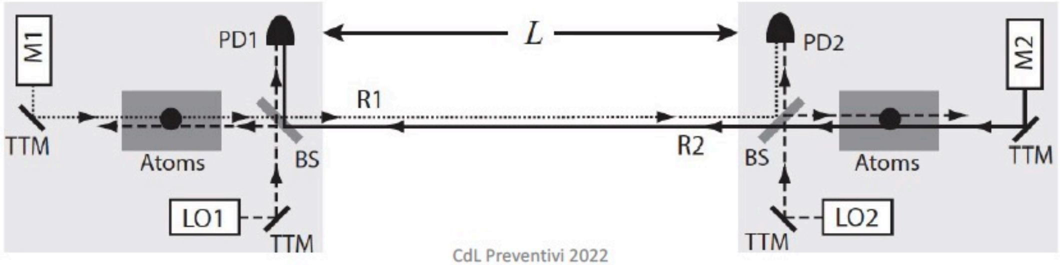
OLAGS
Optical Links for Atomic Gravity Sensors

Coord. Naz. F. Sorrentino

Coord. Locale A. Clozza

- GRAVIMETRI ATOMICI
  - Sono basati sull'interferometria atomica: laser cooling + manipolazione coerente di pacchetti d'onda atomici
  - Il rumore sismico è uno dei principali limiti di sensibilità (LNF)
- Concetto di Base
  - Dimostrare la possibilità di misurare il gradiente gravitazionale con due sensori atomici distanti interconnessi mediante un link ottico coerente
- Ambiti applicativi
  - Fisica terrestre e dell'ambiente
  - Rivelazione di onde gravitazionali
  - Fisica fondamentale





OLAGS

Attività LNF (0.4 FTE)

- 2021
  - Sviluppo elettronica di controllo delle movimentazioni antisismiche
    - Questa attività ha subito un ulteriore rallentamento a causa del perdurare dell’emergenza COVID-19
    - Assegnati 5 keuro S.J. Sbloccati a fine 2020 e subito impegnati.
- 2022
  - Le richieste sono per ottimizzazioni e ulteriori sviluppi dell’elettronica e della meccanica di controllo.
    - 7 keuro consumo per sviluppo di schede elettroniche di controllo movimentazioni antisismiche
    - 1.5 keuro missioni

Singularity

RN S. Pioli

The aim of the "Singularity" project is to investigate the feasibility of a complete automation of an accelerator facility through the combined development of artificial intelligence (AI) software applications and a safety hardware able to control and monitor accelerator's devices. The proposed hardware development, according with popular international safety standards, is going to produce a useful device suitable for both personnel and machine safety. On the other side, the software development will produce a Middle Layer for accelerator control systems to handle normal operations, conditioning, beam diagnostics and fault detection.

	Ruolo	Struttura	FTE 2020	FTE 2021
S. Pioli	Tecnologo	INFN-LNF	0.9	0.9
B. Buonomo	Tecnologo	INFN-LNF	0.3	0.3
C. DI Giulio	Tecnologo	INFN-LNF	0.2	0.4
L. G. Foggetta	Tecnologo	INFN-LNF	0.1	
R. Pompili	Ricercatore	INFN-LNF	0.1	0.1
P. Ciambrone	Tecnologo	INFN-LNF		0.2
M. Beretta	Tecnologo	INFN-LNF		0.1
P. Valente	Ricercatore	INFN-Roma1	0.1	0.1
A. Variola	Ricercatore	INFN-Roma1	0.1	0.1
E. Leonardi	Tecnologo	INFN-Roma1	0.1	0.1
		Totale:	**1.9**	**2.3**

Singularity - Milestone 2021

Milestone	Deadline
Fault prediction	
• Benchmark algoritmo Fault detection su dati retrospettivi di DAFNE utilizzano 3 o più informazioni (RF Power, Vacuum)	30/6 Done
• Benchmark algoritmo Fault detection integrato nel sistema di controllo del LINAC di DAFNE utilizzano 3 o più informazioni (RF Power, Vacuum)	31/12 On going
Gestione acceleratore	
• Sviluppo e validazione di algoritmi di Reinforcement Learning per ottimizzare carica (e separatamente, l'energia) del linac	30/6 Done
• Benchmark di algoritmi di Reinforcement Learning per ottimizzare carica (e separatamente, l'energia) applicato al'acceleratore	31/12 On going
Monitor dinamica di fascio virtualizzata	
• Benchmark rete neurale per virtualizzazione diagnostica di fascio su simulazioni di SPARC_LAB	delayed 31/12

Singularity - Costing, Milestone and FTE 2022 – 1/2

	Milestone
Fault prediction	
• Sviluppo e validazione di algoritmi di Fault Detection integrato nel sistema di controllo di strutture acceleranti a su tutto il linac di Dafne	31/12
Gestione Acceleratore	
• Sviluppo e validazione di algoritmi di Reinforcement Learning per pilotare l'intero linac di Dafne	30/6
• Benchmark di algoritmi di Reinforcement Learning per pilotare l'intero linac di Dafne	31/12
Monitor dinamica di fascio virtualizzato	
• Test rete neurale su SPARC_LAB con shifts dedicato e training su dati reali dell'acceleratore.	6/22
Machine Learning over FPGA	
• Acquisto Digital Processor e Analog Interface per Up/Down-conversion in X band di segnali RF in banda IF.	6/22
• Off-line training di una rete neurale per il riconoscimento di RF Breakdown su segnali storicizzati.	6/22
• Setup Digital LLRF presso RF Lab in configurazione open/closed loop.	12/22
• Test e benchmark neural network installato sul DLLRF FPGA.	6/23
• Test completo del sistema in real-time a TEX per pilotare Sorgenti RF e strutture acceleranti.	12/23
	Budget
• Acquisto Digital Processor (FPGA, ADC e DAC)	10k€
• Acquisto Analog Interface (Up/Down-Conversion RF)	10k€

THANKS
FOR YOUR
ATTENTION