

Stato e preventivi di spesa esperimenti gruppo 5



Gabriele Simi – Università di Padova e INFN

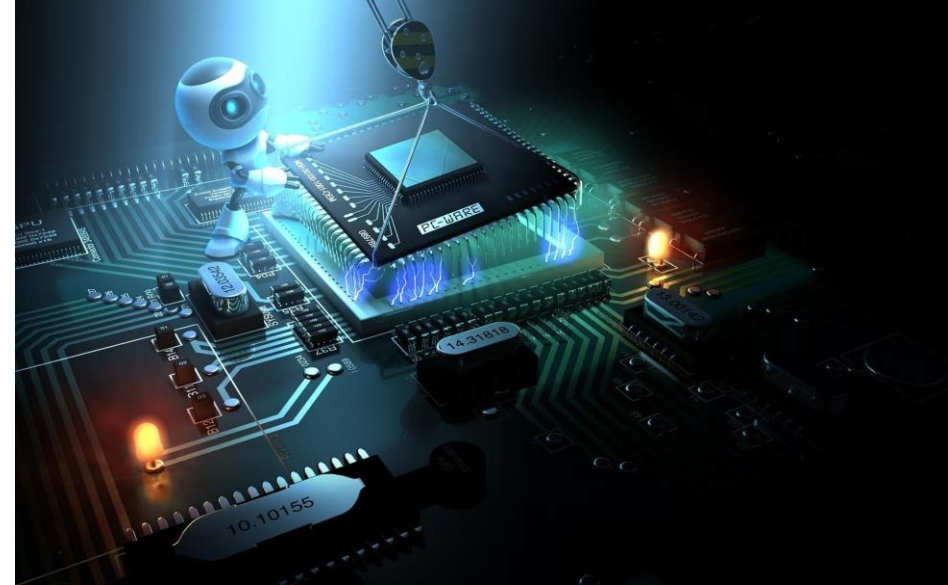


Overview

- Procedure di presentazione e valutazione nuove proposte
- Esperimenti in continuazione
- Nuove proposte

La Commissione 5

La CSN5 coordina le ricerche tecnologiche e lo sviluppo di applicazioni e promuove l'utilizzo, In altri settori, di strumenti, metodi e tecnologie della fisica fondamentale. L'INFN è un solido riferimento a livello nazionale e internazionale per lo sviluppo dei futuri prototipi e la realizzazione degli odierni acceleratori di particelle. Questi sono utilizzati, oltre che nelle ricerche di fisica fondamentale, in altri campi di ricerca e della vita economica e sociale.



- **Acceleratori di particelle**
- **Rivelatori di particelle**
- **Elettronica e software**
- **Applicazioni interdisciplinari della tecnologia INFN**
 1. Applicazioni mediche
 2. Energetica
 3. Ambiente
 4. Beni culturali

Modalità presentazione nuove proposte

Presentazione nuove proposte

- Modalità di presentazione progetto
 - Template progetto disponibile su sito CSN5
 - presentazione progetto entro 10/7 tramite invio all' indirizzo email: csn5.nuoveproposte@lists.infn.it
 - Finalizzazione richieste/personale entro 17/7
- Revisione criteri di valutazione proposte
 - Valutazione nella riunione di luglio
 - Presentazione da parte del coordinatore di 5 slides (titolo e proponenti, introduzione, obiettivi, metodi, numeri - soldi e FTE)
 - Criteri di valutazione da parte della sottocommissione:
 - Impatto scientifico e sugli interessi dell'Ente
 - Chiarezza degli obiettivi e delle metodologie
 - Congruità economica e delle risorse
 - Punteggio
 - ogni voce 10pt, max 30.
 - Sufficienza
 - minimo 5pt per ogni voce, altrimenti cassato

Presentazione nuove proposte

- Referaggio a settembre
 - Due o tre referee di cui uno della commissione
 - Obbligatoria riunione con i referee prima della riunione della CSN5 per discutere criticità e rimodulazione finanziaria
 - Presentazione plenaria da parte dei proponenti con richieste finanziarie finali
- Criteri di valutazione referaggio
 - Stessi criteri/punteggio/sufficienza della slide precedente
 - Approvazione in base alla classifica/budget suddivisi per aree (Rivelatori, Acceleratori, Interdisciplinare)

**Esperimenti in
continuazione/ in
conclusione**

Riassunto Esperimenti

11 sigle in continuazione/in conclusione

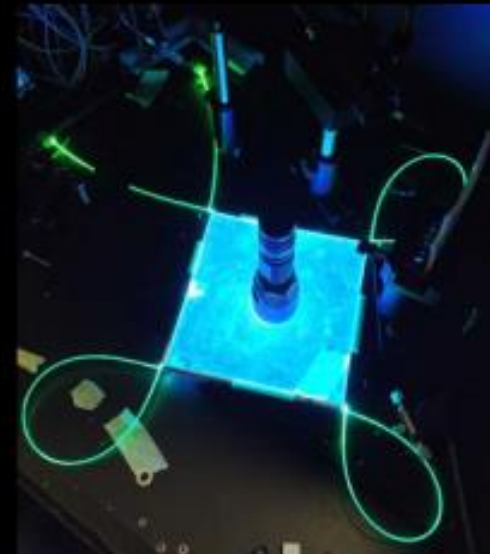
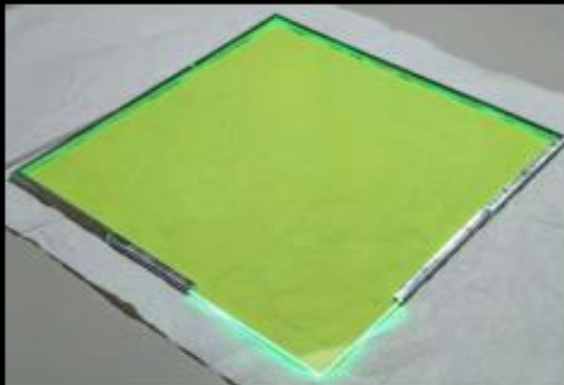
- [FALAPHEL \[call\]](#)
- [ARCADIA \[in chiusura\]](#)
- [ASAP \[in chiusura → nuova\]](#)
- [ISOLHARM EIRA \[in chiusura → nuova\]](#)
- [ML INFN](#)
- [MOPEA \[in chiusura\]](#)
- [N3G \[call\]](#)
- [PHOTOTRAP \[in chiusura\]](#)
- [PHYDES](#)
- [TERAPOL \[in chiusura\]](#)
- [REMIX](#)

6 Nuove Proposte

- NEXT_AIM – A. Zucchetta (Resp Nazionale Pisa)
- FEROCCE – A. Triossi
- ADA_5D – G. Collazuol (Resp Nazionale Pisa)
- ADMIRAL – M. Lunardon (Resp Nazionale LNL)
- CUPRUM_TTD – L. De Nardo (Resp Nazionale LNL)
- HISOL – A. Pepato (Resp Nazionale LNL)

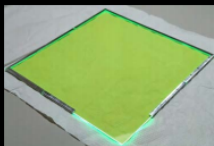
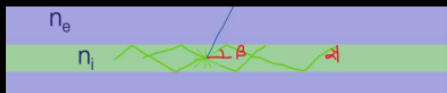
Light trap based photosensors R&D @Padova

Lab Activities report towards the development of a set fully
working photodetectors



WLS as a photo-trap

- WLS molecule absorb light and re-emits light a lower energy in a different random direction. If this process tale place in a dielectric transparent medium, light might be trapped because of internal reflection



- For a "tile" the trapping efficiency is
 - $\text{SIN}(\beta_{\text{lim}})$ where $\beta_{\text{lim}} = \pi/2 - \text{asin}\left(\frac{n_e}{n_i}\right)$
 - := from entrance window to perimeter ->

$n_e \backslash n_i$	1.5	1.6	1.7	1.9
1	74%	78%	80%	85%
1.33	46%	55%	62%	71%

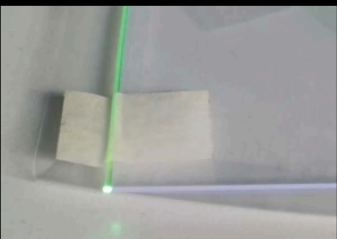
3

WLS as a photo-trap

- For a "tube/fiber " the trapping efficiency is

$(1 - \cos(\beta_{\text{lim}}))$

where $\beta_{\text{lim}} = \pi/2 - \text{asin}\left(\frac{n_e}{n_i}\right)$



$n_e \backslash n_i$	1.5	1.6	1.7	1.9
1	33%	37%	41%	47%
1.33	11%	16%	21%	30%

4

Shopping/procurement

- We bought several tiles (15X15 cm²) and (25x25 cm²) o 2 different WLS

PROPERTIES	EJ-280	EJ-282	EJ-284	EJ-286
Wavelength of Maximum Emission (nm)	490	481	608	425
Wavelength of Maximum Absorption (nm)	427	390	574	355
Decay Time (ns)	8.5	1.9	13	~1.2
Quantum Efficiency (%)	86	93	95	92
Density (g/cc)	1.023	1.023	1.023	1.023
Polymer Base	Polyvinyltoluene			
Refractive Index	1.58			
Softeing Point	75°C			
Vapor Pressure	Vacuum-compatible			
Coefficient of Linear Expansion	7.8 x 10 ⁻⁵ below 67°C			

Shopping/procurement

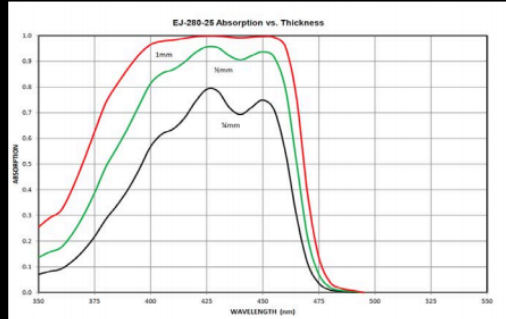
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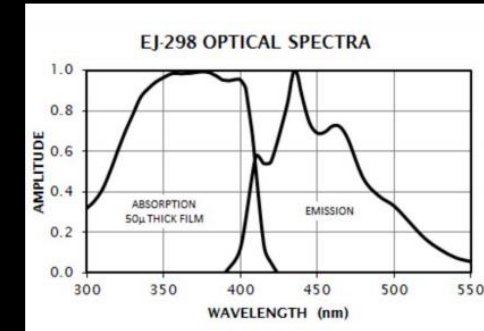
Shopping/procurement

- ◉ To reach saturation in the photon yield conversion in just 1 mm we ask the company a X 25 dopant dose than normal for all the WLS tiles.



Shopping/procurement

- ◉ WLS Paint



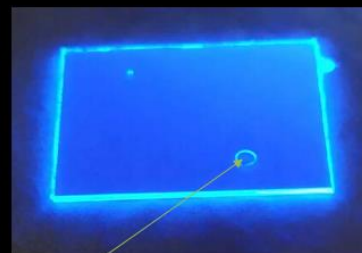
PROPERTIES	EJ-298
Wavelength of Maximum Emission (nm)	435
Wavelength of Maximum Absorption (nm)	375
Decay Time (ns)	2
Quantum Efficiency	> 0.90

Shopping/procurement

- ◉ WLS Paint



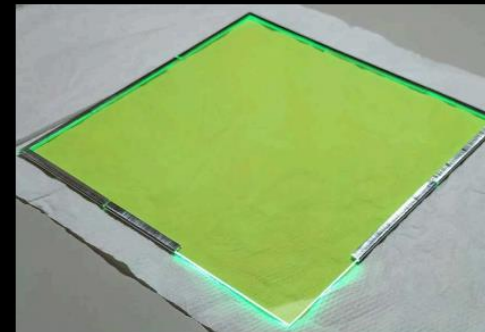
Sandwich of two thin glasses (0.8mm each) with paint in between. After the evaporation of the solvent the paint has a refractive index 1.6



bubble

Main aim

- ◉ Single WLS
 - Compress the light for entrance window to lateral surface/perimeter



Long and thin SiPM can cover part of lateral surfaces, the rest can be equipped with mirrors.

Customized shape SiPM production is bout to be financed hopefully in within this year. The efficiency can be very high: theoretically

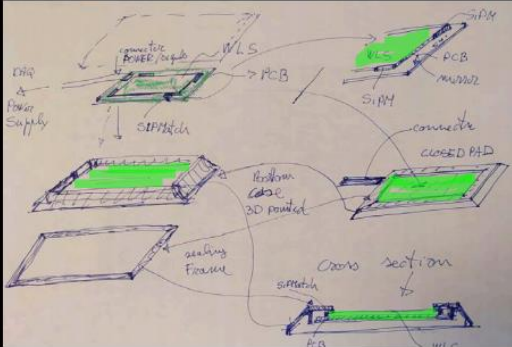
From air to $n=1.6$ 78% of the light goes to perimeter: With a 50% PDE (doable) we can have up to 36% of efficiency!

Some compromise in term of cost/efficiency can be reached with the use of mirror in the perimeter not covered by SiPM

Main aim

Single WLS

- Compress the light for entrance window to lateral surface/perimeter



Long and thin SiPM can cover part of lateral surfaces, the rest can be equipped with mirrors.

Customized shape SiPM production is about to be financed hopefully in within this year. The efficiency can be very high: theoretically

From air to $n=1.6$ 78% of the light goes to perimeter: With a 50% PDE (doable) we can have up to 36% of efficiency!

Some compromise in term of cost/efficiency can be reached with the use of mirror

Different strategy while waiting for SiPM "match"

Double shift WLS

- Compress the light from entrance window to lateral surface/perimeter with a UV->BLU WLS then collect the lateral light with the second WLS BLU->GREEN

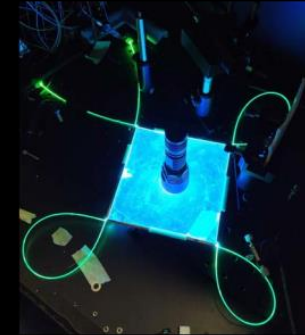


Pros

- Extremely cheap!
- 1 (or 2) small SiPM -> low dark noise
- Easy to fabricate
- No special SiPM production is needed

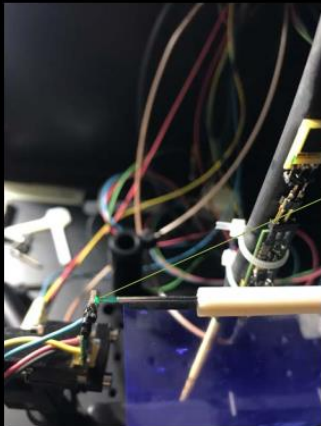
Cons

- Less efficiency
- Lower time resolution (2 shifts)



Double shift WLS

Double shift WLS detector measurement



rise time: 4.3 ns
fall time: 18.6 ns
width: 8.3 ns

rise time: 1.6 ns
fall time: 5.9 ns
width: 2.1 ns

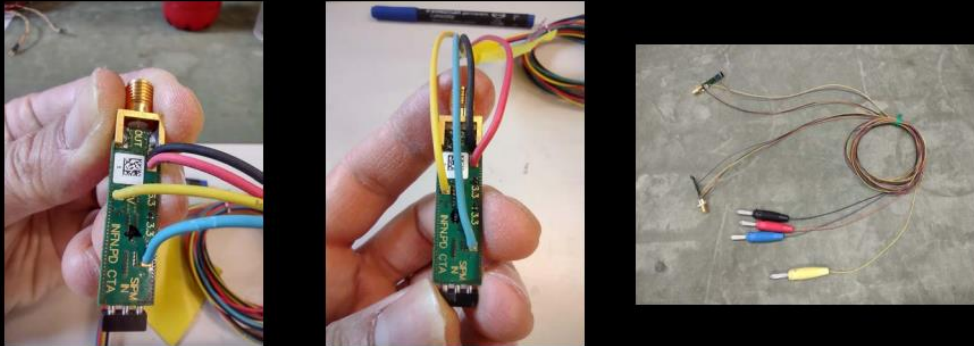
Double shift WLS

Double shift WLS detector prototype fabrication



Front end electronic

© Front end electronic



Avevano pensato di presentare una proposta per una nuova sigla ma l'iniziativa per ora non e' confermata

L'attivita` di R&D comunque continua nell'ambito di SWGO per l'applicazione alla rivelazione di sciame atmosferici in water cherenkov a basso costo e con possibilita' di separare la componente di mu

Fully digital readout proposal.

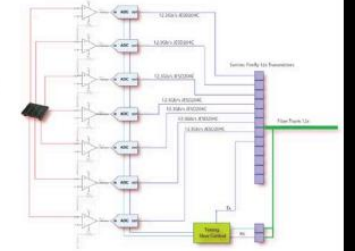
O ~ 10+ channel/unit

A revolution: => Cost/channel should drop significantly

A fully digital signal transportation via optical fibers (with modern and cheap technologies from front-end to counting house.

Demonstrator Proposal

- Readout of a cluster of pixels
- 7 ADC channels @ 12.3 Gb/s/ch
- 1 Firefly 12x TX @ 14 Gb/s/ch
- 1 Fiber trunk 12x
 - 8 fibers for tx channels
 - 2 fibers for rx channels
- 2 spares



CTA Meeting

2





FALAPHEL Call 2022->2024

(Fast Links and RadHard Front End with Integrated Photonics
and Electronics for Physics)

Serena Mattiazzo

Responsabile Nazionale F. Palla (Pisa)

INFN Units: Padova, Pavia, Pisa

External Units: Scuola Superiore S. Anna di Pisa, Dip. Ingegneria
Informazione UniPisa, Dip. Fisica UniMilano

Goal

Problem: technology for high speed data links is not rad hard enough for next generation HEP detectors

- **Goal of the project:** improving the state of the art of **high speed data links** for future high rate pixel detector applications, and of studying the integration of these data links and of analog/digital front-end blocks in a prototype readout circuit
- State of the art LpGBT and Versatile Link
 - Based on 65 nm technology and VCSEL
 - Total dose 2 MGy
 - Total fluence 10^{15} n/cm²
 - cannot be used at HLLHC below ~20 cm radius
 - implies RD53 chips needs e-links to LpGBT (~1 meter away)
- will investigate innovative circuit and system solutions for the **integration of SiPh optical devices and subsystems** and **high-speed electronics for high rate data transmission**, designed to be radiation hard for HEP applications.

Goal – attività' in sezione

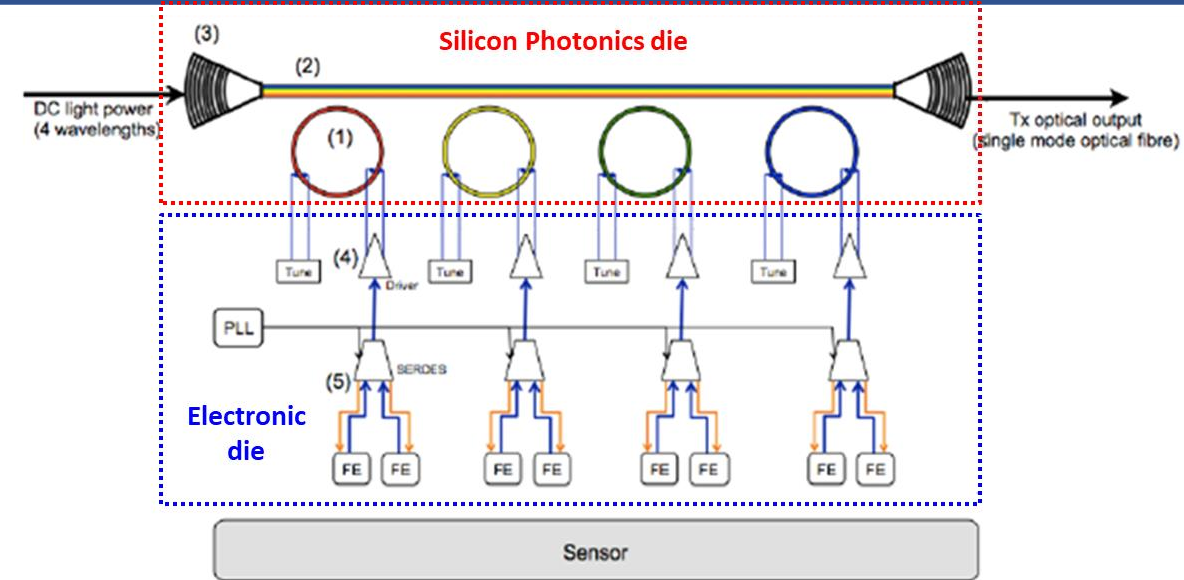
Silicon Photonics demonstrated to be sufficiently rad-hard ($>10^{16}$ n/cm² and tested up to 300 Mrad)

PHOS4BRAIN (CSN5) project showed 65 nm driver to be rad-hard up to 8 MGy and reach ~5 Gb/s, limited by packaging (Aluminum wire bonds)

Design and production of two chips:

- PIC (Photonic Integrated Circuit): Silicon Photonics modulators. Aggregated 100 Gb/s links using wavelength division multiplexing (4 wavelength on a single optical fibre)
- EIC (Electronics Integrated Circuit): high speed radiation hard (≥ 1 GRad) electronics in 28 nm (both digital electronics for high speed data transmission and analog front-end electronics)

The final goal is the design and fabrication of a demonstrator integrating (hybrid or 3D integration) the two chips



WP3: Electronics

Contributo (DEI) al disegno della parte digitale dell'EL

WP4: EIC-PIC integration:

Discussione avviata fra designer e gruppo DIAM di Padova per valutare la possibilità di usare la facility per il raffreddamento dei dispositivi nella fase finale di integrazione

WP5: Radiation hardness:

Total Ionizing Dose (TID):

Single Event Effect (SEE)

2022 activity:

- PDK available only at beginning of December 2021
- 13-15/12 Meeting with Guido Magazzù
 - Redefined IP contribute → $\div 20$ Clock Divider @25GHz
 - Useful as IP for PLL implementation
 - Useful for SERDES test board
- Architecture idea
 - Porting of $\div 10$ Clock Div from 65nm to 28 nm
 - Works @12,5 GHz
 - Adding $\div 2$ Clock Div @25 GHz

2023 activity

- Continue redrawing $\div 10$ ClkDiv in 28 nm
- Drawing of $\div 2$ ClkDiv @25GHz

2022 activity:

- TID:
 - Long shutdown of X-ray facility (end 2021-beginning 2022) for TID
 - April: calibration of INFN Pisa X-ray irradiation machine
- SEE
 - Request of beamtime @RADNEXT for SEE tests (32 hours assigned)
 - SEE test @ LNL (2 days @ July, 2 days in Autumn)

2023 activity

- TID
 - Test on analog frontend
 - Other?
- SEE
 - Test @ UCL
 - Test @ LNL?

Anagrafica Sezione di Padova (2023)

Cognome	Nome	Ruolo	% in FALAPHEL	WP
Bagatin	Marta	RTDb	0.15	WP5
Bonaldo	Stefano	Assegnista	0.10	WP5
Di Ruzza	Benedetto		0.20 (TBC)	
Candelori	Andrea	Docente	0.20 (TBC)	WP5
D Ruzza	Benedetto		0.20	WP5
Gerardin	Simone	Prof. Associato	0.15	WP5
Mattiazzo	Serena	RTDb	0.10	WP5
Paccagnella	Alessandro	Prof. Ordinario	0.15	WP5
Vogrig	Daniele	Prof. Associato	0.20	WP3
Wyss	Jeffery	Prof. Associato	0.50	WP5
			TOT 2.05	

Missioni

- 6 k€ per trasferte per irraggiamenti
- 1 k€ meeting di collaborazione

Consumo

- 5 k€ per l'acquisto di un tubo per la macchina a raggi X
- 5 k€ cavi, connettori (per irraggiamenti), polvere (per DIAM)
- 5 k€ per accesso a facility esterne

Assegno junior (2022)

- Da concordare coi referee se cambiarne «destinazione» (disegno vs radiation hardness)

Supporto eventuali attività di irraggiamento al Tandem nel 2023

- La call per la richiesta di fascio non è stata ancora aperta.

Supporto per la manutenzione della facility a raggi X (tubo, chiller, etc)

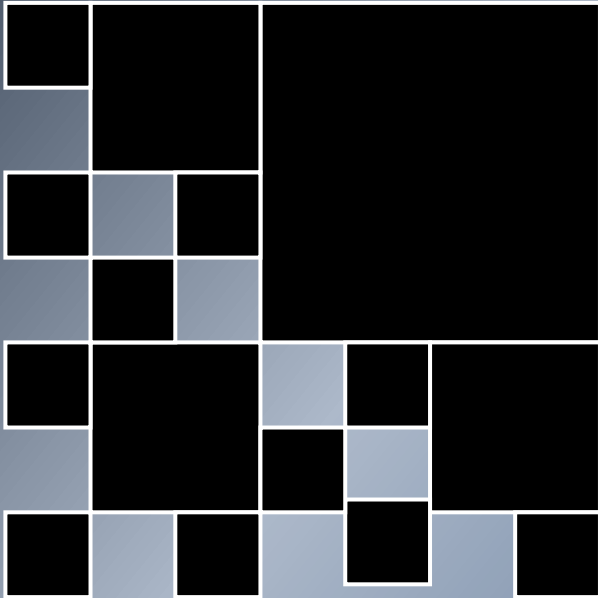
Supporto per la costruzione della meccanica di supporto per gli irraggiamenti

Richiesta:

- 2/3 s.u. al laboratorio di elettronica
- 1 s.u. all'officina meccanica



ARCADIA



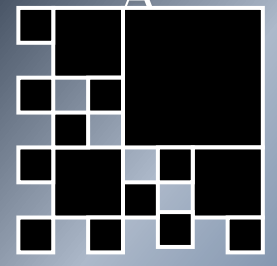
INFN Grp. V project to develop a
LARGE AREA, LOW POWER, MONOLITHIC
active pixel sensor

Sigla 2020-2021, estesa 2022

INFN sections: Bologna, Milano, **Padova**, Perugia, Pavia, TIFPA, Torino.

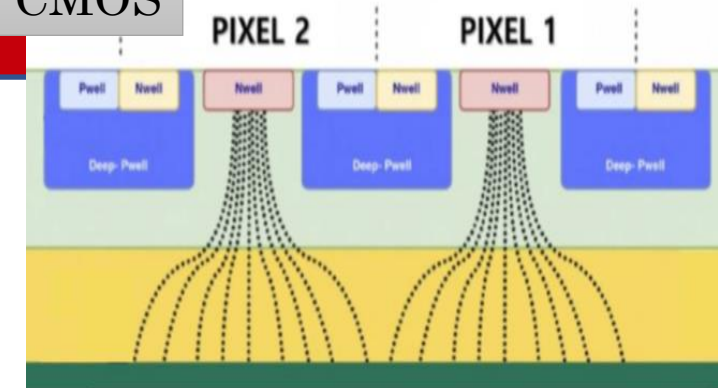
Nat. resp.: Manuel D. Da Rocha Rolo

Loc. Resp.: **Jeffery Wyss**



ARCADIA goals

Large area	Low power	Pixel	Timing	Rate
$> 10 \text{ cm}^2$	$\leq 20 \text{ mW/cm}^2$	$20 \mu\text{m} \times 20 \mu\text{m}$	10 ns	$\geq 10 \text{ MHz/cm}^2$



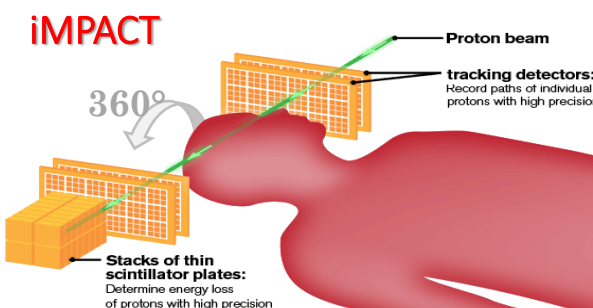
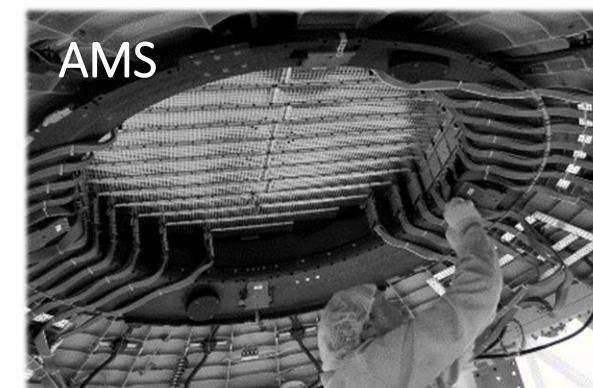
Presently no sensor meets more than two of those specs together.

To meet them all requires dramatic changes in the way detectors are designed and constructed:

Approach of ARCADIA:

- Architecture (Padova tasks!): low power, timing, rate, pixel choice
- Large area: stitching

- ❑ In Space, moving from micro-strip to pixels, allowing high-resolution momentum measurement, is presently not possible (think of AMS-3).
 - ❑ In medical imaging, performant 3D tomography is simply unavailable today.
- ARCADIA is in fact the sensor development part of the iMPACT project.**
- ❑ Experiments at **large colliders**, to improve tracking, require unprecedented ease of assembly, cost-effectiveness and reduced material budget.

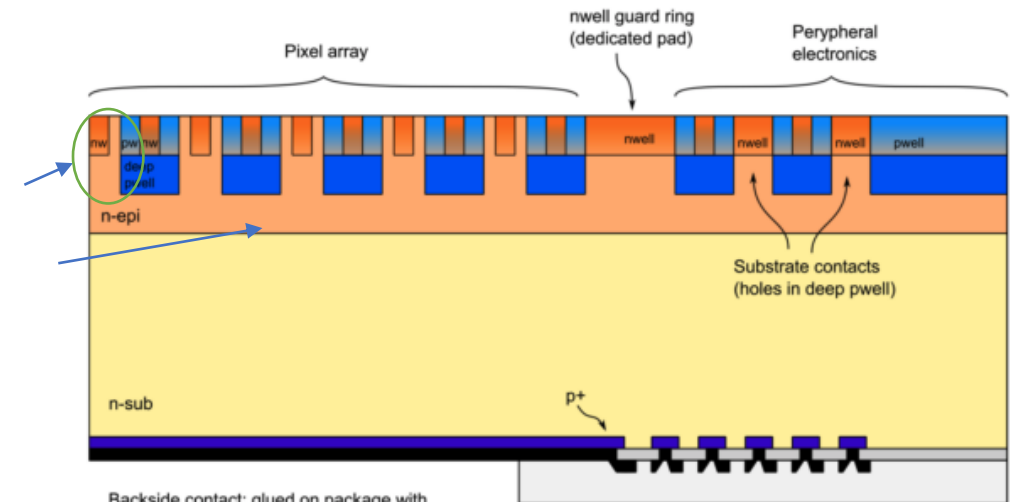


ARCADIA Pixel detector

- Svuotamento → veloci
- Elettrodi piccoli → buon S/N
- Elettronica di lettura in p-wells profonde dentro allo strato epitassiale di tipo n → disaccoppiamento dal substrato svuotato
- Collaborazione con Lfoundry

Applicazione in

- HEP: tracciatori
- Space
- Imaging in Medicina: proton CT, hadron therapy
- Industria: sensori per Photon Electron Emission Microscopy (PEEM) and Low Energy Electron Microscopy (LEEM).



Filippo



Andrea



Davide



Alessandro



Piero

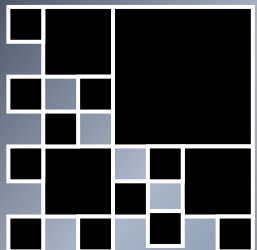


Serena



Jeff





Tasks and Budget

TASKS of Padova

- Architecture: conception, specification, simulation, and development.
- Testing and development: prototypes I/O specifications, actual device testing and data analysis.
- Radiation validation: irradiation with X-Ray and at beam facilities, SEE and total dose characterization

Budget:

940 kEUR from INFN + circa 300 kEUR from the iMPACT (PD) project for devices and test structures production:

one submission in 2020 (150k),

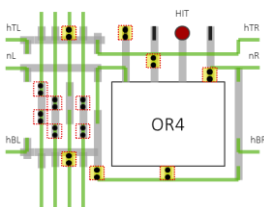
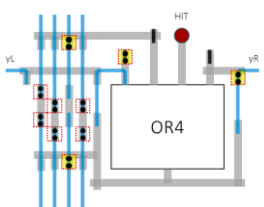
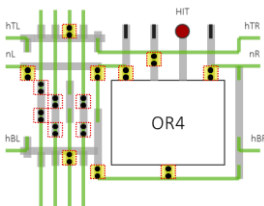
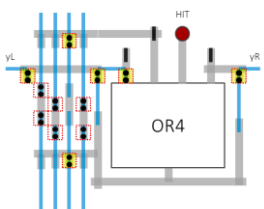
one submission in 2021 (July, 150k),

one in 2022 (March, 150k)

Additional Collaborators UniPD:

Pantano D. , Bonini C.

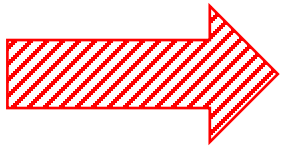
- 1) Development of very low power High-Performance Parallel Hardware (HASH) reading architecture, based on multiple pixel projections: concept development, analytical verification of feasibility, HDL implementation for the synthesis (January 2021 - ongoing)
- 2) Prototyping of the simulation of the incident radiation response with bunches time structure typical of linear lepton accelerators, medical accelerators, space environment (January - March 2021);
- 3) Data taking on test Matisse chips, irradiated with neutrons at the TRIGA reactor of the RIC at the JSI in Ljubljana (June 2021);
- 4) Analysis of the data on the irradiated chips to estimate the effect of radiation damage (July-September 2021);
- 5) Managing of high-speed data cables procurements on behalf of other INFN sections (in particular Torino, Trento, Milano) (May 2021);
- 6) Insertion of the HASH architecture inside the HDL code developed for the autumn submission Main Demonstrators: tentative to submit a first small prototype exploiting HASH concepts (March-June 2021); postponed to mid 2022 to fit within the submissions roadmap





ATTIVITÀ 2022 (estensione)

- 1) HDL completion and simulation of the HASH architecture, writing of documentation and academic reference ([article](#)) to the aforementioned architecture;
- 2) implementation of the [HASH architecture in the second/third silicon prototype](#) (postponed from autumn 2021)



X) BAD production run due to [Synopsis software bug](#), jeopardized the entire schedule. Understood, but impossible to solve (literally carved in silicon).

Emergency plan 2022 (ongoing)

- 1) Re-submission of the device with the software problem addressed
- 2) Take the chance to improve few details
- 3) Re-scope the project toward a minimal demonstrator

ATTIVITÀ 2023 (ghost)

- 4) Complete testing during 2023 with NO extra funding (no official INFN experiment)
- 5) Prepare for a new Call in 2024



Array of Silicon Avalanche Pixels (ASAP)

A vertically integrated CMOS ultra-fast position-sensitive detector for charged particles

Padova:
Collazuol, Mattiazzo, Iacob, Ospina

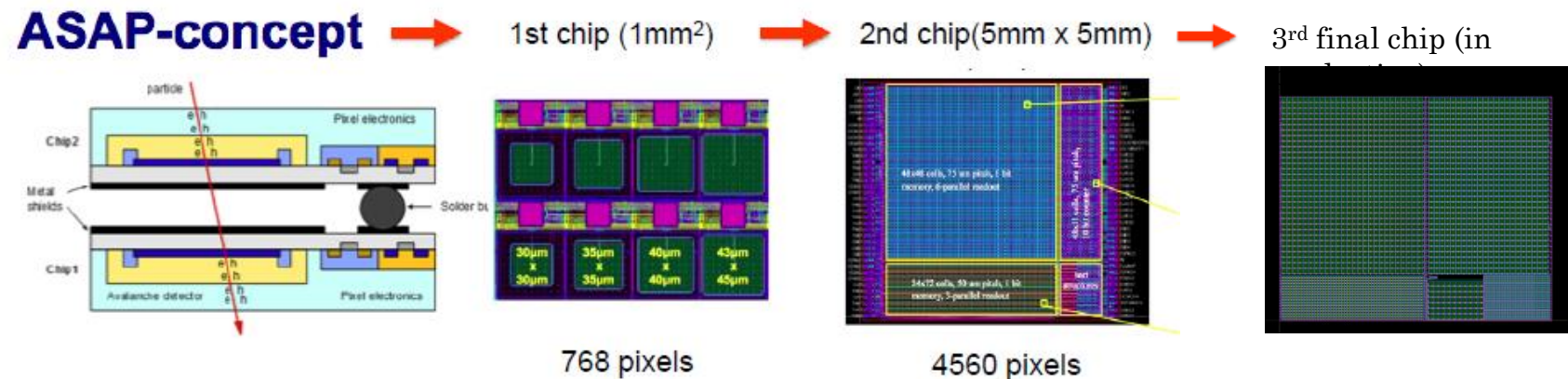
The ASAP Collaboration

INFN Pisa (resp.naz. Pier Simone Marrocchesi)

INFN Padova (resp.loc. Gianmaria Collazuol)

INFN Pavia (resp.loc. Lodovico Ratti)

TIFPA (resp.loc. Lucio Pancheri)



Summary ASAP

Aims

- develop a new generation of **layered avalanche** detectors for charged particles (also for **medical applications**)
- Leveraging **process scaling**, **thinning technologies**, **process tailoring** and **through silicon vias**
- for **improved efficiency**, **reduced DCR** and **buttability** to cover **large areas**

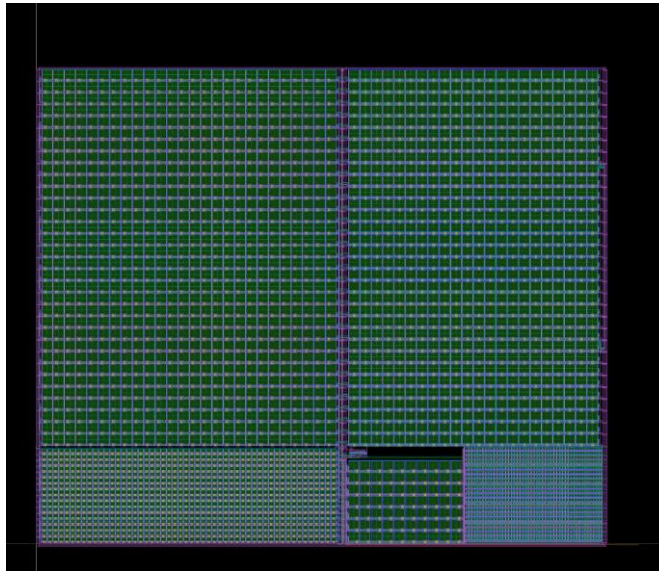
Recent publications / procs.

1. L. Ratti, P. Brogi, G. Collazuol, G.-F. Dalla Betta, P.S. Marrocchesi, L. Pancheri, A. Sulay, G. Torilla, C. Vacchi, **"Layered CMOS SPADs for low noise detection of charged particles"**, *Frontiers in Physics*, vol. 8, 2021, art. no. 607319.
2. L. Ratti, P. Brogi, G. Collazuol, G.-F. Dalla Betta, P.S. Marrocchesi, L. Pancheri, A. Sulay, G. Torilla, C. Vacchi, **"Cross-talk and RTS noise characterization of 1- and 2-tier CMOS SPADs in a 150 nm process"**, presented at the *2021 IEEE NSS-MIC* (virtual), 16-23 Oct. 2021 .

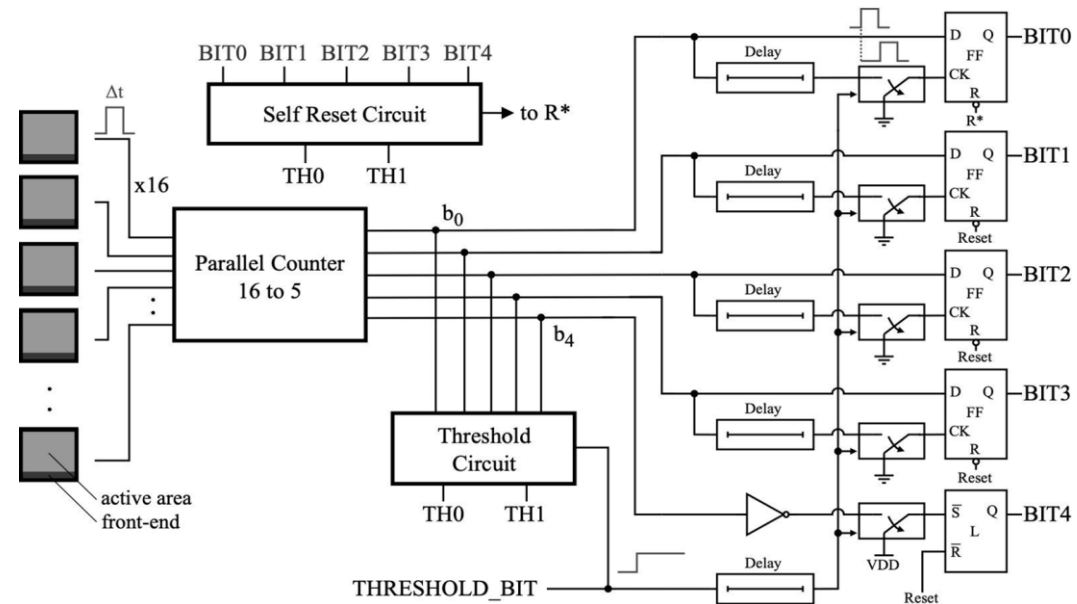
Main results

- Design and characteriz **CMOS SPADs in 150 and 110nm technologies**
 - 150 nm (2 chips) - done
 - 110 nm (1 chip) – in production
- **Single-layer** configuration (for test & characterization) and **dual-layer** configuration read out in coincidence
- Studied **effects both from ionizing and non-ionizing radiation**
- Designed **various readouts** including RO for a wireless β -emitter probe

Final chip – test structures (for future applications)



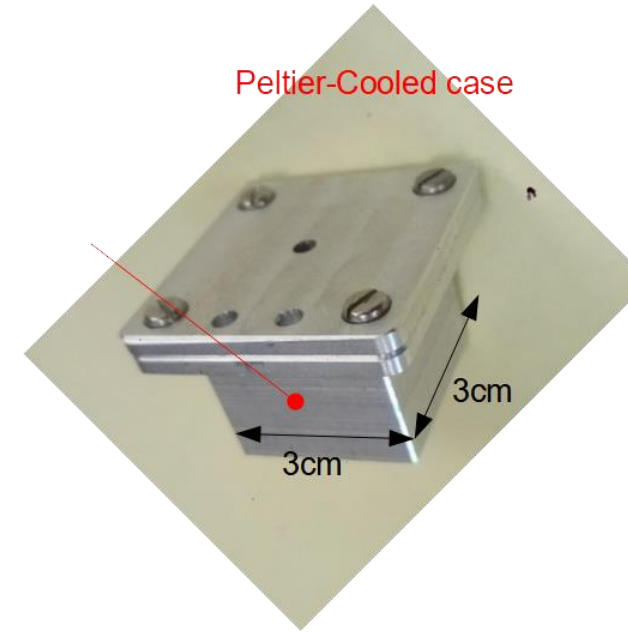
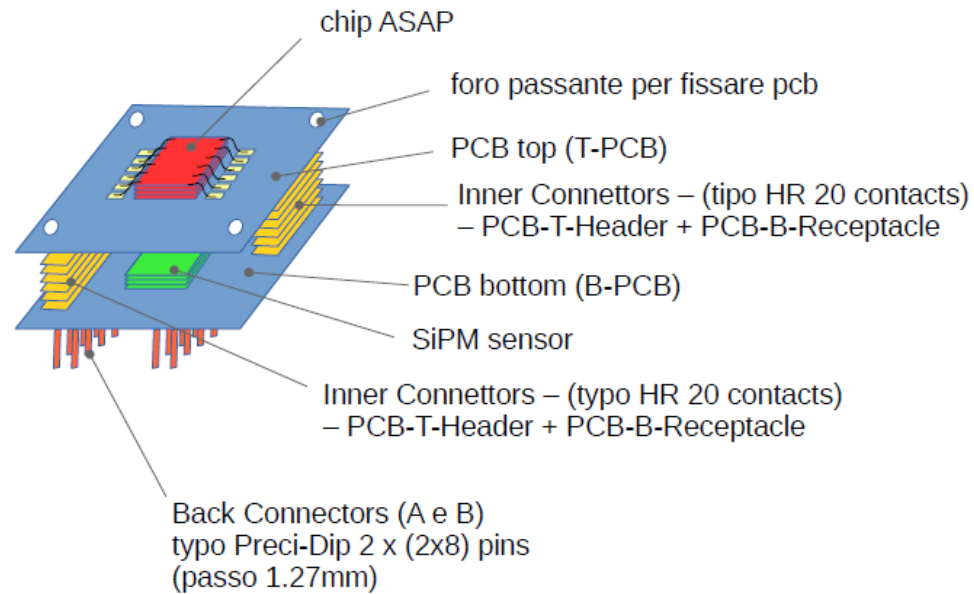
Layout of the test chip in 110 nm CMOS technology - includes four arrays of SPADs with different active area, mini-dSiPMs, SPADs with internal counter



Block diagram of a parallel counter for a 16-cell mini-dSiPM, also including single dark noise hit rejection and adjustable threshold

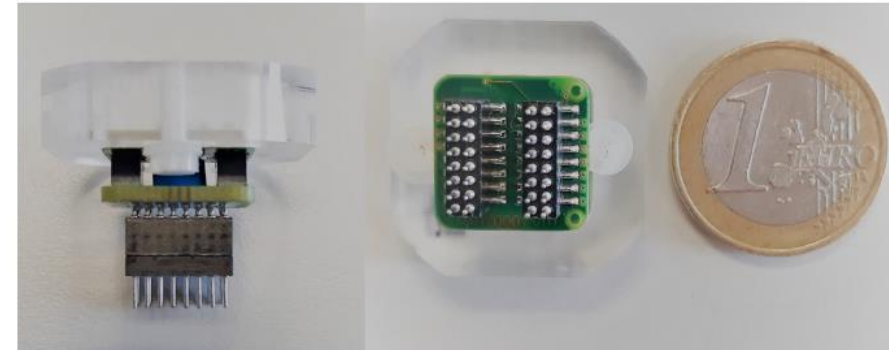
Impact of glitches mitigated by defining the architecture using a specific design algorithm the algorithm which automatically generates a relatively small number of full adders (for balancing the propagation delays taking place in the parallel counter)

Beta Probe



The APIX2LF sensor bonded on the top printed circuit board of a two board stack. The second printed board of the stack houses a commercial SiPM (Advansid ASD-NUV4S-P) with a BC-408 scintillator, mounted below the SPAD sensor for triggering purposes

(INFN Padova)





ML_INFN in breve

Lowering The potential barriers *with ML_INFN*

Employing machine learning techniques often requires:

- specialized hardware and software setup
WP1: provide a centrally maintained cloud-based infrastructure for interactive and batch ML fast prototyping, with access to modern GPU hardware and systems tuned for ML performance



- specific training to identify tools and learning resources

*WP2: organize national training events for INFN users
(Machine Learning hackathons)*



- a community of experts providing support to research use cases

WP3: provide and organize example applications in a knowledge base



ML_INFN in numeri

- **11** strutture INFN coinvolte nella preparazione della knowledge base
BA BO CNAF FI GE NA PD PG PI ROMA1 TO
- **79** ricercatori che dedicano una frazione del loro tempo per promuovere le tecniche ML per la ricerca
- **14** GPU professionali a disposizione accessibili attraverso l'interfaccia di INFN-Cloud
- **110** partecipanti agli hackathon, tra studenti e ricercatori di ruolo

ML_INFEN a Padova

- Federazione di risorse di calcolo (CPU+GPU)
CloudVeneto con INFN-Cloud

- Contributi alla knowledge base:

- [LUMIN: Lumin Unifies Many Improvements for Networks](#) (G. Strong)
- [INFERNO: Inference-Aware Neural Optimisation](#) (L. Layer)
- [Distributed training of neural networks with Apache Spark](#) (M. Migliorini)

- Contributo al training:

- [ML for applications in High Energy Physics](#) (T. Dorigo)

- Contributo a conferenza:

- Artificial Intelligence in Cardiovascular Magnetic Resonance Imaging - A Joint Summit of the EACVI and SCMR
- Royal College of Physicians, London, UK, 5-6 May 2022 (F. Agostini)

Ricercatori					
Nome	Età	Contratto	Qualifica	Aff.	%
1 Dorigo Tommaso		Dipendente	Primo Ricercatore	CSN I	0
Numero Totale Ricercatori			1	FTE: 0.00	

Tecnologi					
Nome	Età	Contratto	Qualifica	Aff.	%
1 Andreetto Paolo		Dipendente	Tecnologo	CCR	10
2 Fanzago Federica		Dipendente	Tecnologo	CCR	10
3 Gianelle Alessio		Dipendente	Tecnologo	CSN I	20
4 Sgaravatto Massimo		Dipendente	Primo Tecnologo	CCR	10
5 Traldi Sergio		Dipendente	Tecnologo	CCR	20
6 Verlati Marco		Dipendente	Primo Tecnologo	CCR	20
7 Zangrando Lisa		Dipendente	Tecnologo	CCR	20
Numero Totale Tecnologi			7	FTE: 1.10	

Dottorato nazionale

Consuntivo

- ML_INFNO ha supportato per tre anni molti esperimenti INFNO (non solo HEP) sia con l'hardware che con la knowledge base per valutare i potenziali benefici del Machine Learning nelle loro ricerche
- ML_INFNO si basa sulle soluzioni di INFNO-Cloud nel federare risorse ottimizzate per il ML sia in modalita' interattiva che batch-like
- Una serie di eventi di training nazionali (ML hackatons) e una raccolta di tutorial e applicazioni reali della comunita' INFNO (knowledge base) hanno contribuito a costruire una rete di praticanti di ML entusiasti e sempre piu' esperti

Prospettive/1

- ML_INFN e' stato approvato per il triennio 2020-2022, siamo quindi nell'anno finale
 - e' previsto in Novembre un training avanzato sul Deep Learning
 - lato infrastrutturale, si sta lavorando per fornire un accesso cloud-based a schede FPGA come acceleratori di ML
- Il Presidente di CSN5 si e' detto interessato a una proposta di continuazione, in una forma ancora da stabilire (anche con i referees)
 - nuova sigla (XXX-next)?
 - altri 3 anni con la stessa sigla?
 - di anno in anno per N anni?

Prospettive/2

- La discussione e' iniziata il 20/6
- C'e' un generale consenso nel continuare il progetto
- Essendo l'aspetto infrastrutturale ben integrato con INFN-Cloud, l'idea e' di dare piu' spazio alla parte scientifica, incluso il training
- La forma finale della proposta va ancora capita bene con il Presidente di CSN5
- Sono previste altre riunioni di ML_INFN con l'obiettivo di finalizzare la proposta entro la prima meta' di Luglio

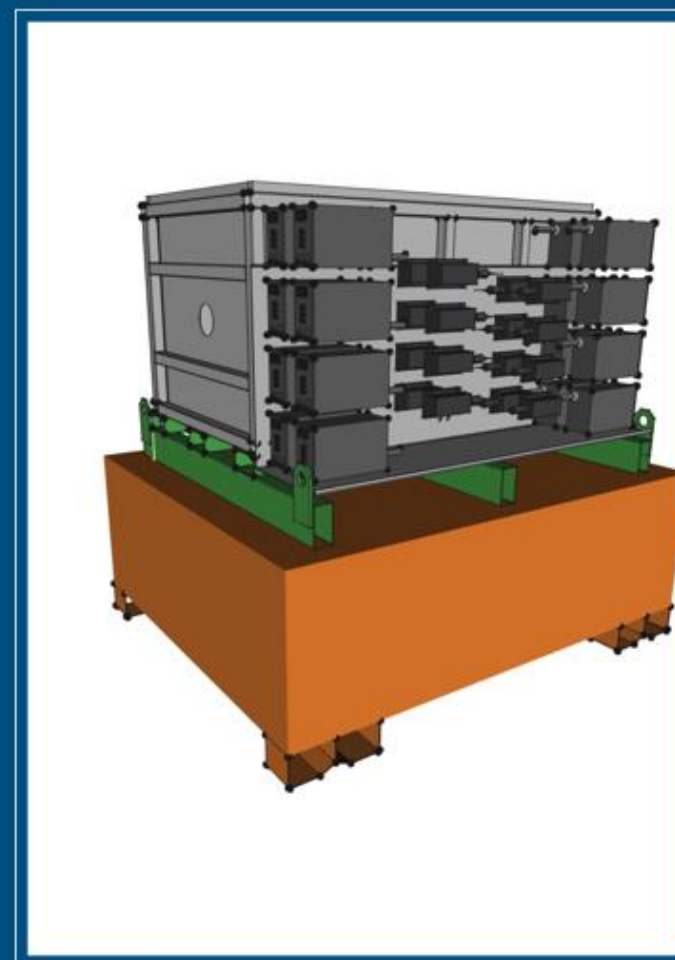
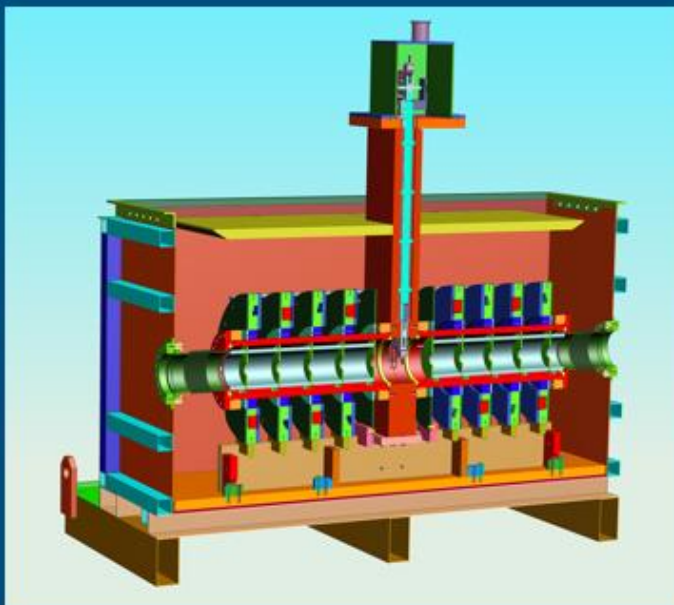


Realizzazione di un Acceleratore Elettrostatico di Nuova Concezione

Acceleratore elettrostatico in versione
tandem da 800 keV

HV sugli elettrodi ottenuta per somma in
serie di moduli invece che per divisione
resistiva

Isolamento elettrico realizzato con liquido
invece che con gas ad alta pressione



MOPEA

- Sigla 2019-2021, estesa al 2022, chiesta estensione al 2023
- Sezioni coinvolte:
 - Padova [Fanin, Zotto (RN), Dal Corso, Montecassiano, Pegoraro]
 - LNL
- Sono riportate le attività da Agosto 2021 a Giugno 2022

Stato attuale

- Meccanica Stripper

Prodotto un prototipo (non utilizzabile) per verificare il sistema di spostamento: va realizzata la versione definitiva (i materiali usati non sono adeguati)

- Contenitore esterno

Realizzato: in attesa di essere utilizzato

- Tubi acceleratori

Prodotto e provato il secondo tubo: performance migliore del primo. Altri due tubi in preparazione

- Dischi HV

Prodotti, provati e calibrati tutti i dischi. Un disco di backup in preparazione

- Assemblaggio

Iniziato l'assemblaggio dei laser e la realizzazione della distribuzione elettrica

Brevetto

Brevetto italiano approvato il 21/5/2021

Publicato un articolo su Review of Scientific Instruments

Titolo

"Comparison of the Performance of a High Voltage Generator Insulated by Gas or Liquid Dielectric".

Review of Scientific Instruments 91, 074712
(2020); <https://doi.org/10.1063/5.0009519>

Prolungamento

- Si supponeva di non richiedere un prolungamento, ma il progetto è strettamente legato alla realizzazione di un'infrastruttura REI con funzioni di radioprotezione deve essere realizzata.
- Senza questa infrastruttura possiamo assemblare l'acceleratore, ma non possiamo accenderlo e quindi verificare il suo funzionamento.

Attualmente

- Collocazione determinata (decisione d'imperio di U. Dosselli)
- Progetto del vano terminato (grazie alle risorse del Dip. Di Fisica)
- In attesa che Legnaro inizi la procedura per piazzare l'ordine
- Fondi per la realizzazione anticipati sul budget MISE (con qualche capriola finanziaria agevolata dai direttori INFN)
- Questi fondi sono distratti da quelli destinati alla realizzazione degli impianti (elettrico idraulico e di sicurezza): saranno reintegrati? Da chi?
- Conclusione: prolungamento richiesto, in fase di discussione

Anagrafica e richieste

Sezione di Padova

Zotto 30%
(Responsabile nazionale)

Dal Corso 30%

Montecassiano 20%

Totale 0.9 FTE

Padova

Missioni 1 keuro

Consumo 1 keuro

Legnaro

Consumo 1 keuro

Sistemi di distribuzione elettrica,
idraulica e interlock per il vano REI 10 keuro (s.j.)

Laboratori di Legnaro

Antonini 5%
(Responsabile locale)

Poggi 5%

Totale 0.1 FTE



N3G : Next Generation Germanium Gamma Detectors

D. De Salvador^{1,2}

Responsabile Nazionale

¹ INFN-LNL

² Università di Padova

CALL 2021-2023

Laboratori di Legnaro
W. Raniero

Sezione Milano
S. Capra

Sezione Ferrara
A. Mazzolari

Sezione Padova
F. Recchia

Aim:

The proposal aims to implement Pulsed Laser Melting technology to produce complex HPGe coaxial detectors and test their potential for the challenge of nuclear spectroscopy experimentation in conditions of high flux and high damage.

Besides the innovatively processed crystals, the implementation of complete prototypes with optimized electronics and DAQs and their testing under damage and annealing will be developed.

All this will lead to two further possible benefits:

- INFN will have the technology to repair existing detectors
- INFN will have the technology to be able to build detector prototypes with innovative geometries, for research in various fields.

Final user:

International Community of Nuclear Gamma Spectroscopy. The core business regards CSN III INFN with possible future implications in space and medical applications.

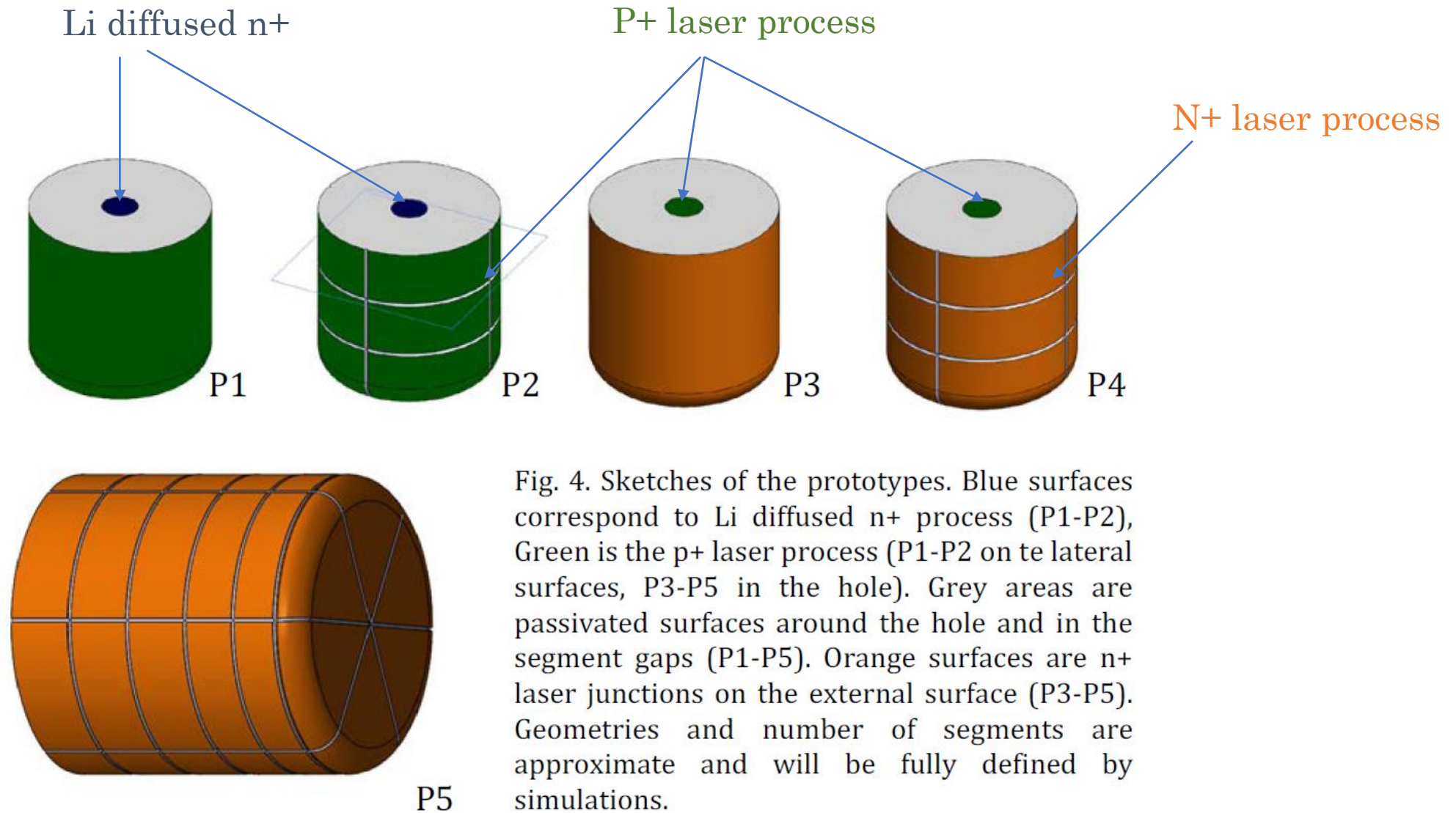
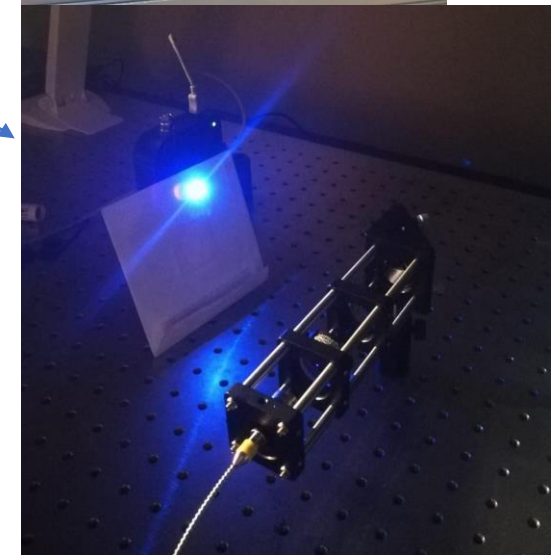
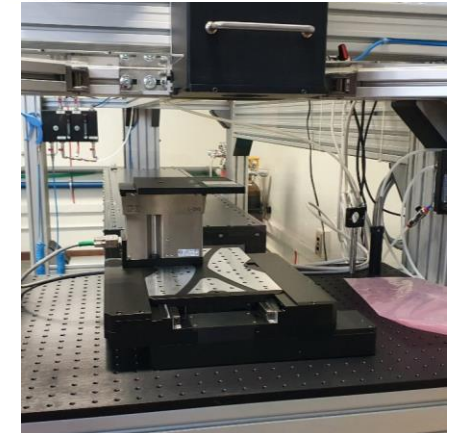
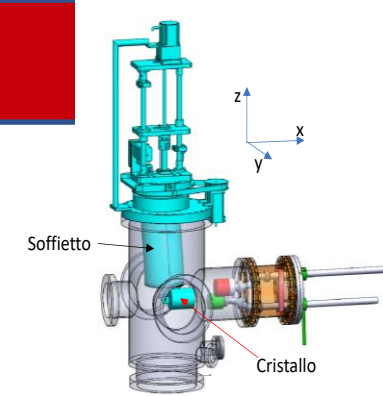
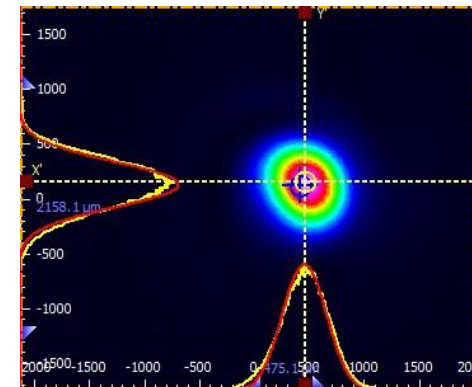
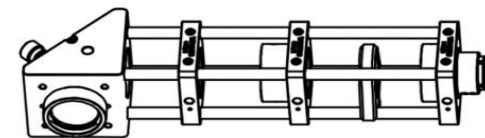
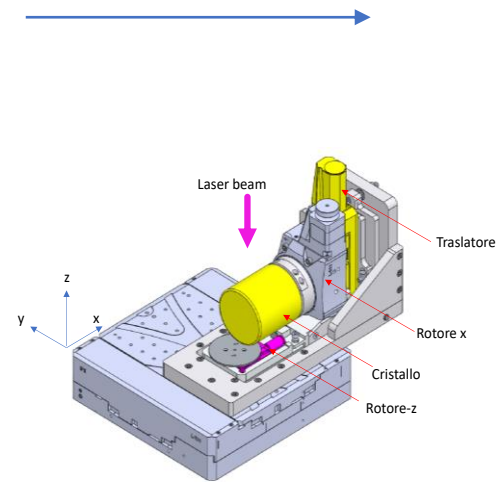


Fig. 4. Sketches of the prototypes. Blue surfaces correspond to Li diffused n+ process (P1-P2), Green is the p+ laser process (P1-P2 on the lateral surfaces, P3-P5 in the hole). Grey areas are passivated surfaces around the hole and in the segment gaps (P1-P5). Orange surfaces are n+ laser junctions on the external surface (P3-P5). Geometries and number of segments are approximate and will be fully defined by simulations.

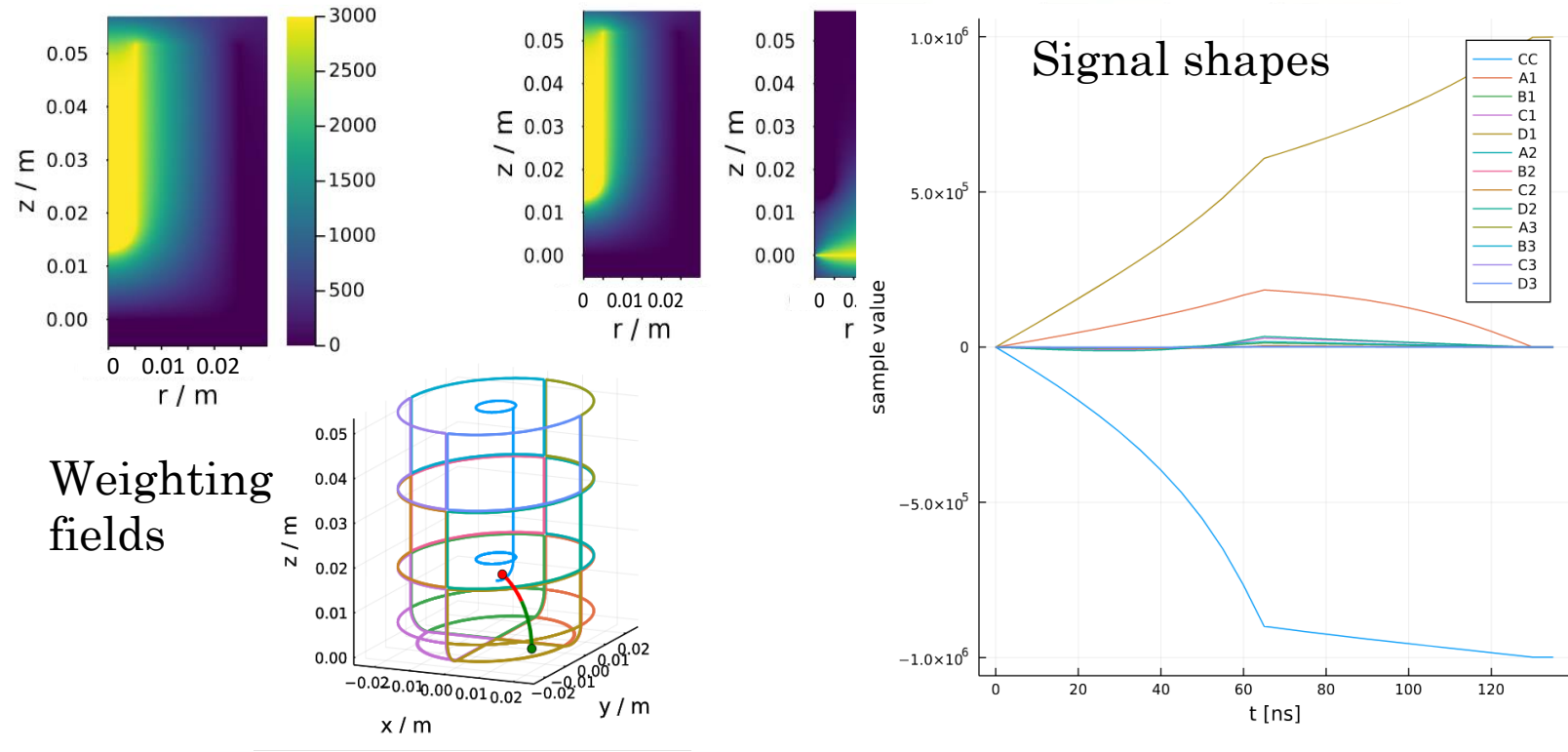
Risultati

- Up-grade dell'apparato di sputtering per permettere sputtering laterale.
- Up-grade scansione laser.
- Realizzazione apparato litografia 3D: Progettata, acquistata e testata apparato per creare pennello laser a 405nm per la scrittura del resist:
- Test di giunzioni su superfici con orientazioni alternative



WP3: Simulazioni del rivelatore e test prototipi

Risultati della simulazione



Piani per i test

- Allestimento tavola di scansione per test con sorgente (già iniziata progettazione e acquistati traslatori). Allestimento sistema per irraggiamento neutronico.
- Assemblaggio DAQ dedicata tipo "Agata" per esecuzione dei test dei prototipi.
- Test del prototipo P2 prima e dopo irraggiamento.

Richieste

- Assegno di ricerca assegnato 2022:
 - Selezione in corso, inizio a breve
- Richieste 2023:
 - Secondo anno di assegno **24kE**
 - Missioni: **4.5 kE**
 - Consumo 4 transceivers: $0.75*4+0.5=$ **3.5 kE**

Personale

- Recchia 30%
- Mengoni 10%
- Bazzan 20%
- Nuovo assegnista 100%, prendera' servizio a dicembre 2022
- Escudeiro e' passato a gamma.



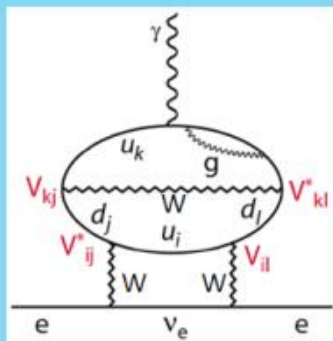
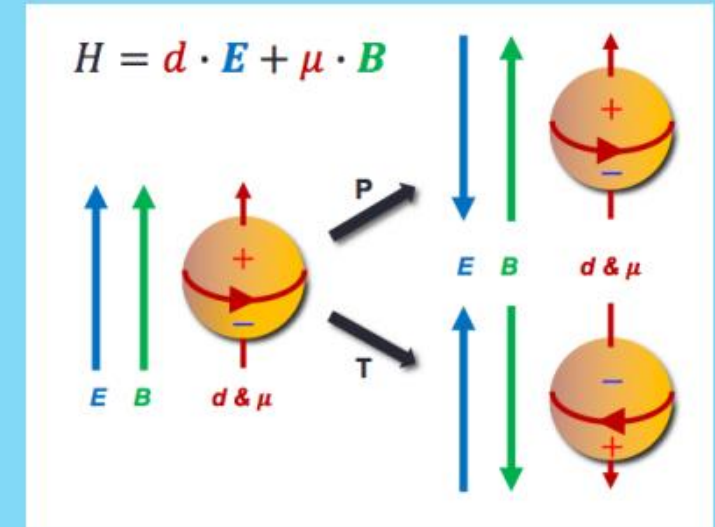
Electric Dipole Moment: Search for New Physics

OUTLINE:

- 1) Probing Physics Beyond Standard Model & Fundamental Symmetries
- 2) Electron EDM measurements
- 3) Reactive Molecules in Para-Hydrogen @ Low Temperature
- 4) Set-up for Isotopic Molecular Beam Production and Crystal Formation & Characterization
- 5) Conclusions

EDM Searches

- The EDM is an asymmetric charge distribution along the particle spin
- The EDM violates time reversal symmetry through CPT conservation – CP violation
- CP violation is required to generate a cosmological matter-antimatter asymmetry.
-
- It is present in the SM, through the complex phase in CKM matrix, however many order of magnitude below what is necessary
- EDM's in SM are tiny ($d_e < 10^{-38}$ ecm), but most SM extensions include new CP violating phases that contribute to EDM's.



four-loop level in
perturbation theory

SUSY electron edm

$$d_e \sim (\text{loop}) \times \frac{m_e}{\Lambda^2} \sin(\phi_{CP})$$

naturally $\sim \alpha/\pi$ ϕ_{CP} phase from soft breaking naturally $O(1)$

scale of SUSY breaking naturally ~ 200 GeV

$\sim 5 \times 10^{-25}$ cm naturally

THIS MAKES EDM's an ideal probe for detecting NEW PHYSICS associated with CP violation and a powerful window on energy scales much larger than those that can be probed directly at LHC

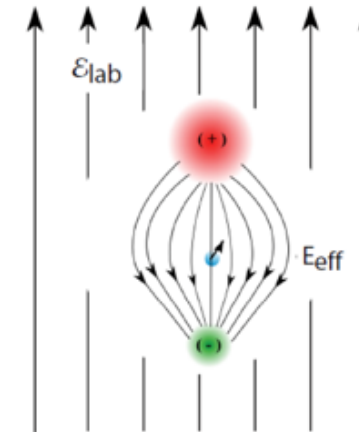
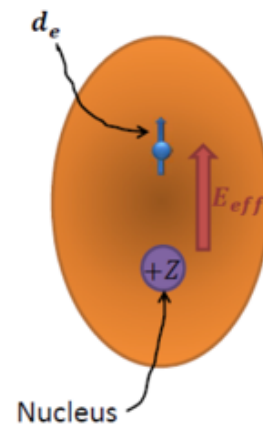
Metodo

Misurare lo sfasamento della precessione dell'elettrone in campo magnetico dovuto all'interazione del momento di dipolo elettrico con il campo di una molecola

Gabrielse

Why Use a Molecule?

→ To Make Largest Possible Electric Field on Electron



Tl atom (best EDM limit till YbF)

$E_{lab} = 123 \text{ kV/cm}$ → $E_{eff} = 72 \text{ MV/cm}$

ThO molecule

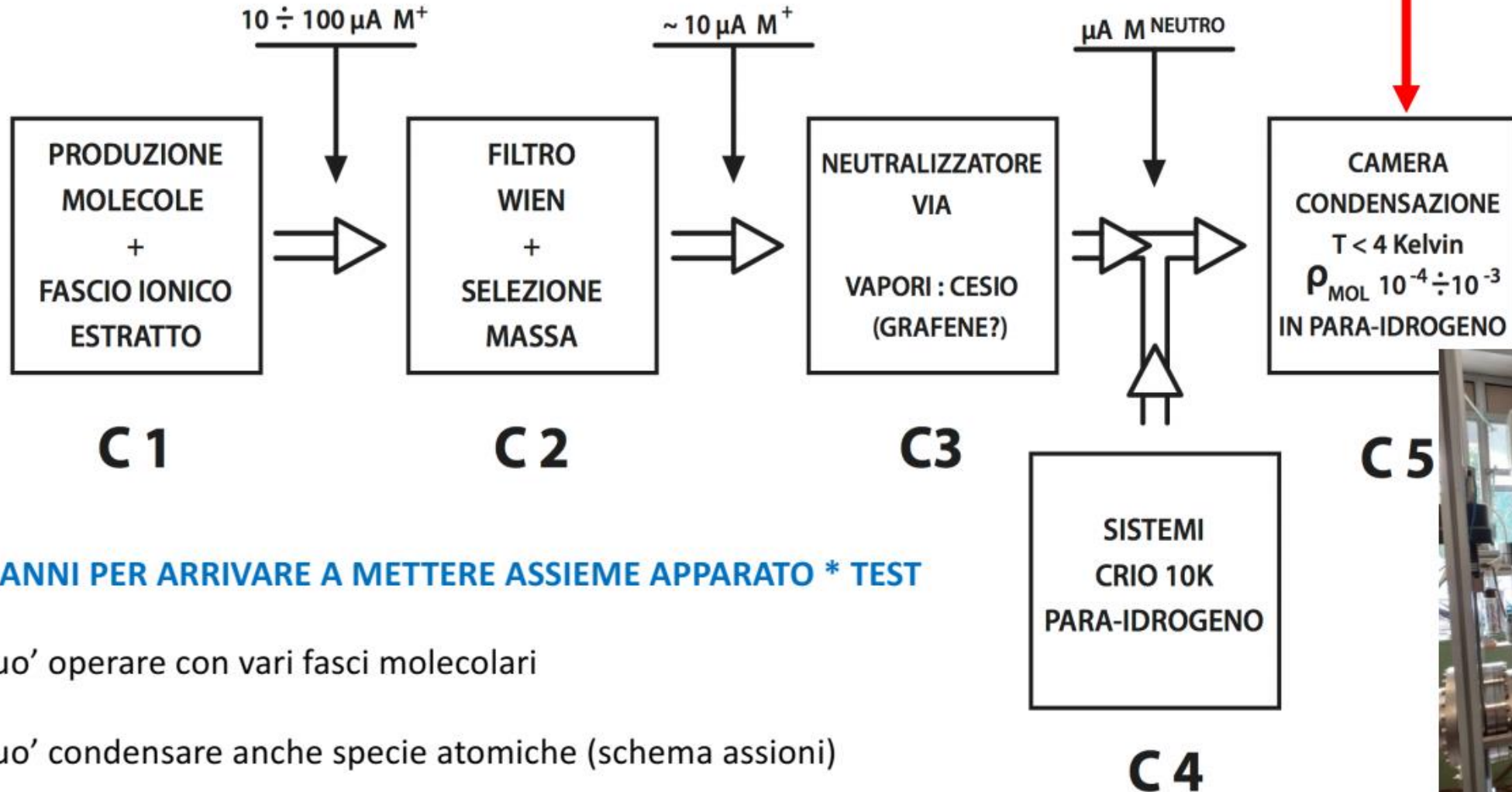
$E_{lab} = 100 \text{ V/cm}$ → $E_{eff} = 100 \text{ GV/cm}$

Molecule can be more easily polarized using nearby energy levels with opposite parity (not generally available in atoms)

EXPERIMENTAL COLD & DOPED CRYSTAL SET-UP

Per studiare l'edm è necessario produrre un cristallo di para idrogeno e drogarlo con la molecola di interesse

1 cm³ ParaHydrogen Crystal doped with BaF molecule



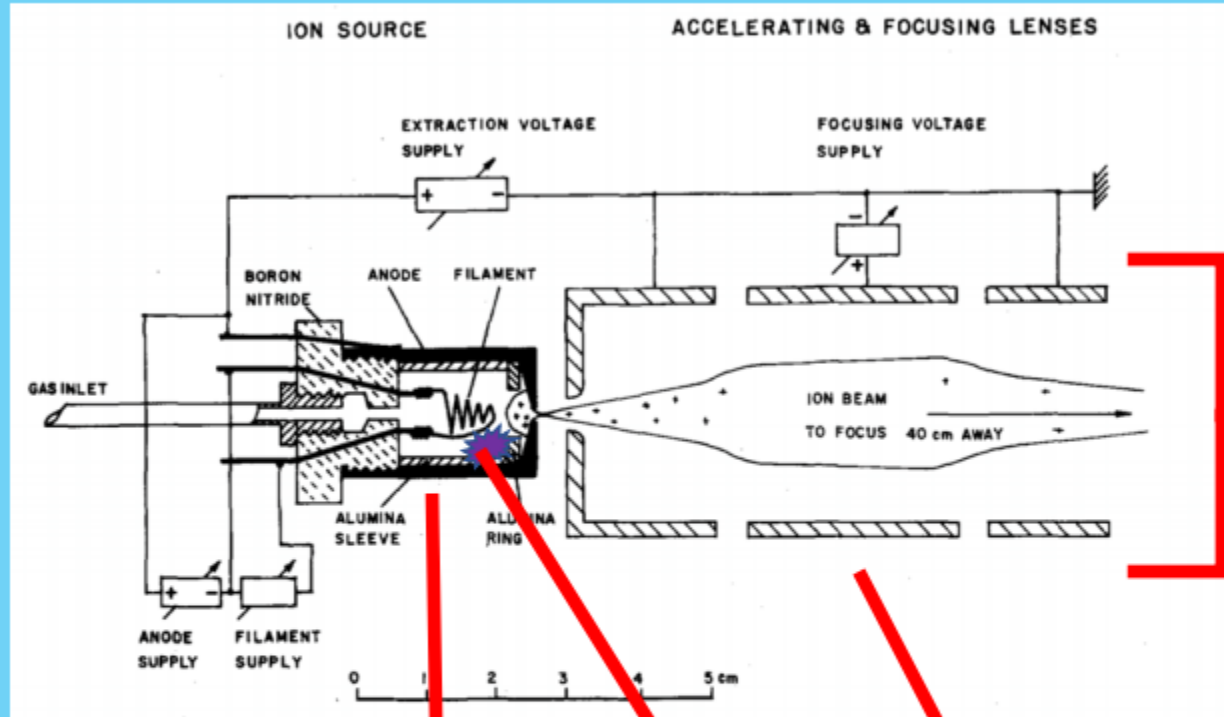
3 ANNI PER ARRIVARE A METTERE ASSIEME APPARATO * TEST

Puo' operare con vari fasci molecolari

Puo' condensare anche specie atomiche (schema assioni)



C1: Camera Produzione Fasci Ionici



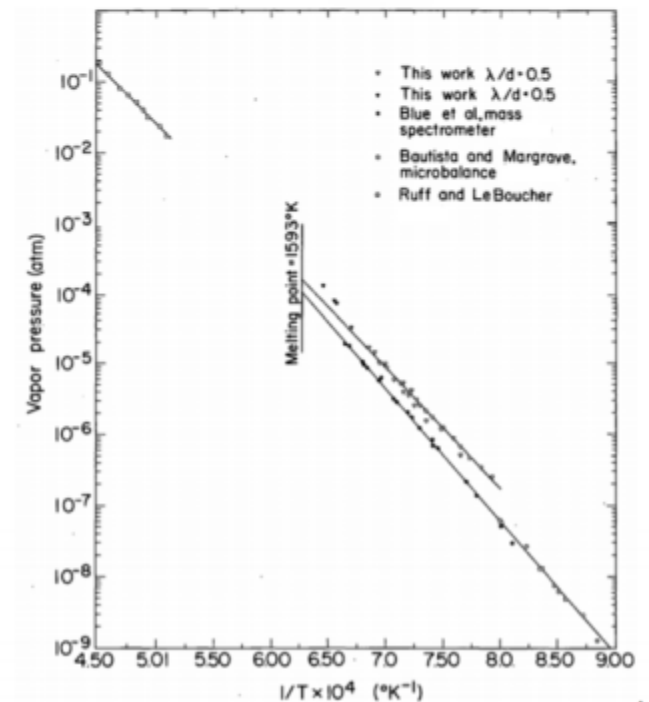
$I_{\text{expected}} > 10 \text{ microAmpere}$

To Wien Filter or Magnetic Analyzer

Emission Head @ 1400 Kelvin

Einzel lenses to transport the Ionic beam

Barium Fluoride Powder



Ion Beam Line: Plasma Source + Accelleration System + Einzel Lens + X-Y beam Monitoring



ION BEAM CHARACTERISTICS

Ion trials with Xe+ @ 6 KeV Energy (A.U. 136)

Current up to 6 microAmpere @ 2 mt distance

Einzel lens Correction Applied

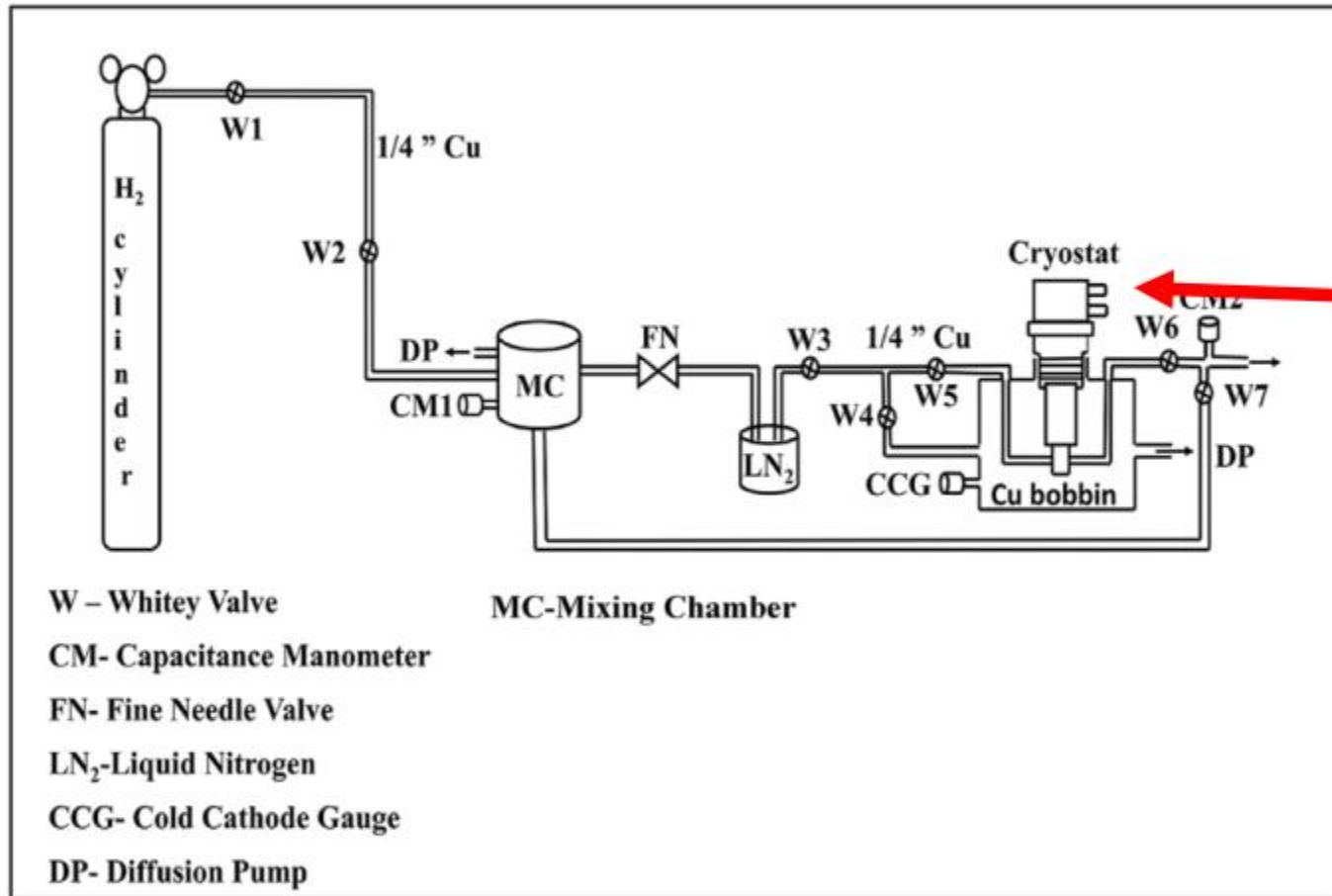
X-Y Wire Grid Beam Monitoring

Over 2 meters beam focalized down to 1 cm

Laser Beam Vacuum alignment

READY FOR BaF Production

C4: ParaHydrogen Production Set-Up



10 Kelvin Cryocooler

PARAHYDROGEN PRODUCTION CHAMBER AT 12 KELVIN



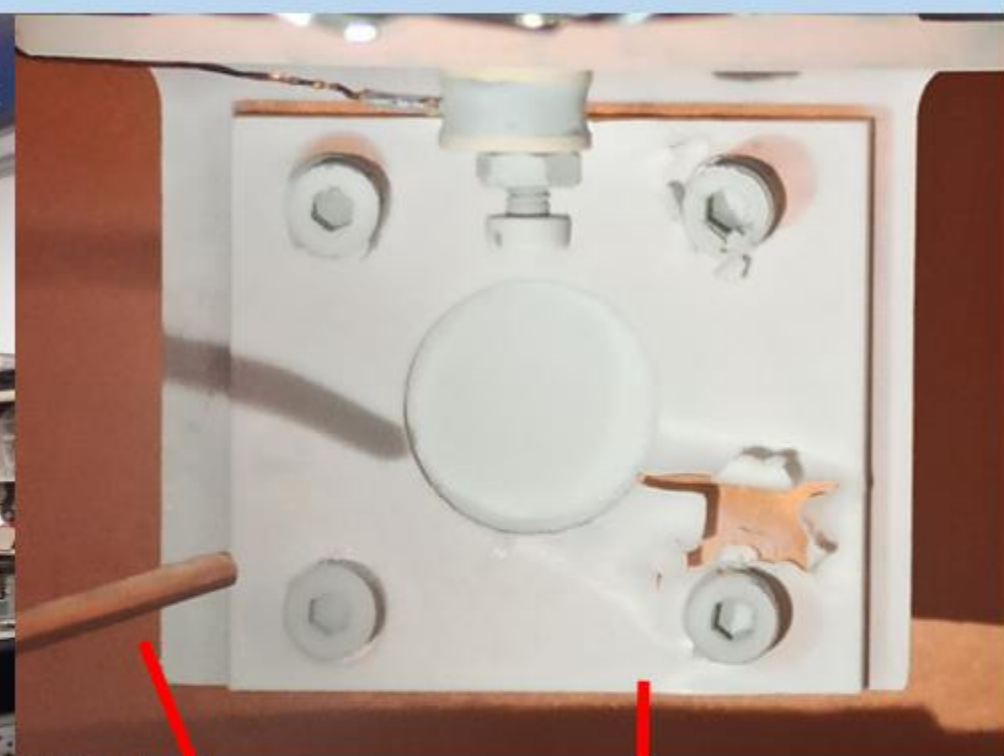
Hydrogen is flux into a ferrous oxide powder @ 12 KELVIN

Inducing an ortho to parahydrogen transition

We measured the impedance of the H₂ flux line was too high

Not Transparent crio-crystals

PARAHYDROGEN CRYOGENIC CONDENSATION CHAMBER



4 Kelvin Plate

Crio Minitube for Parahydrogen Inlet

FTIR Not Working properly

TIME-LINE vs MILESTONES :

- 1^o Anno **2022**:

- a) Camera Sorgente Produzione Fasci Molecolari (Corrente Ionica = 10 microAmpere @ few KeV) **OK**
- b) Camera Produzione Paraidrogeno @ 10 kelvin. **½ OK (Problemi con FTIR)**

- 2^o Anno **2023**:

- a) Camera di Selezione Isotopica Ba₁₃₈ F₁₉ (Wien Filter) e Neutralizzazione (Vapori di Cesio o Grafene)
- b) Camera di Condensazione a 4 Kelvin

- 3^o Anno:

- a) Test crescita Cristalli
- b) Caratterizzazione: assorbimento spettrale e larghezze di linea e polarizzazione sotto Campo Elettrico

- **We need to be the first to check this ROUTE to open such Approach to EDM measurement**

PHYDES

Sezioni INFN partecipanti all'esperimento: **Padova, LNL, LNS (Palermo), Ferrara**

- Resp. Naz.: **Giovanni Carugno**
- **COSTRUZIONE E PRESA DATI ESPERIMENTO @ LNL**
- **FTE-PD-2023 = 2,3** (Carugno 40% ,Borghesani 100% , Gasparini 20%, Zanetti 15% , Pazzini 15%, Gonella 30%,Benettoni 10%)
- **NEWS:**

1)Possibili Sviluppi dal PNRR e Bando Eccellenza Dipartimento (Attendiamo Esito.....)

2)Sottomesso PRIN su fasci molecolari e fisica fondamentale

- **Richiesta Denari INFN : 30 Keuro** (5 Keuro missioni , 15 Keuro consumo , 5 keuro manutenzioni , 5 Keuro Sorgenti laser)
- **Richiesta Servizi : 10 M.U. OM , 8 M.U. STGE , 1 M.U. OE, 1 M.U. Uff.Tec.**



Sigla 2021-2022
in chiusura

THz-TDS to probe Antiferromagnetic Topological Insulators

TERAPOL experiment – INFN CSN5

C. Braggio

June 20, 2022

TERAPOL (TERAHERTZ AXION POLARITON)

- Sezioni: **Padova, Pavia**
- Responsabile Nazionale: C. Braggio
- Durata: 2 anni
- FTE PD: 1.3
C Braggio (50%), F. Borghesani (50%), E. Conti (15%), P. Marchetti (15 %),
- FTE PV: 1.2
F. Pirzio (60%), A. Agnesi (60%)
- Richiesta supporto officina elettronica: 2 settimane

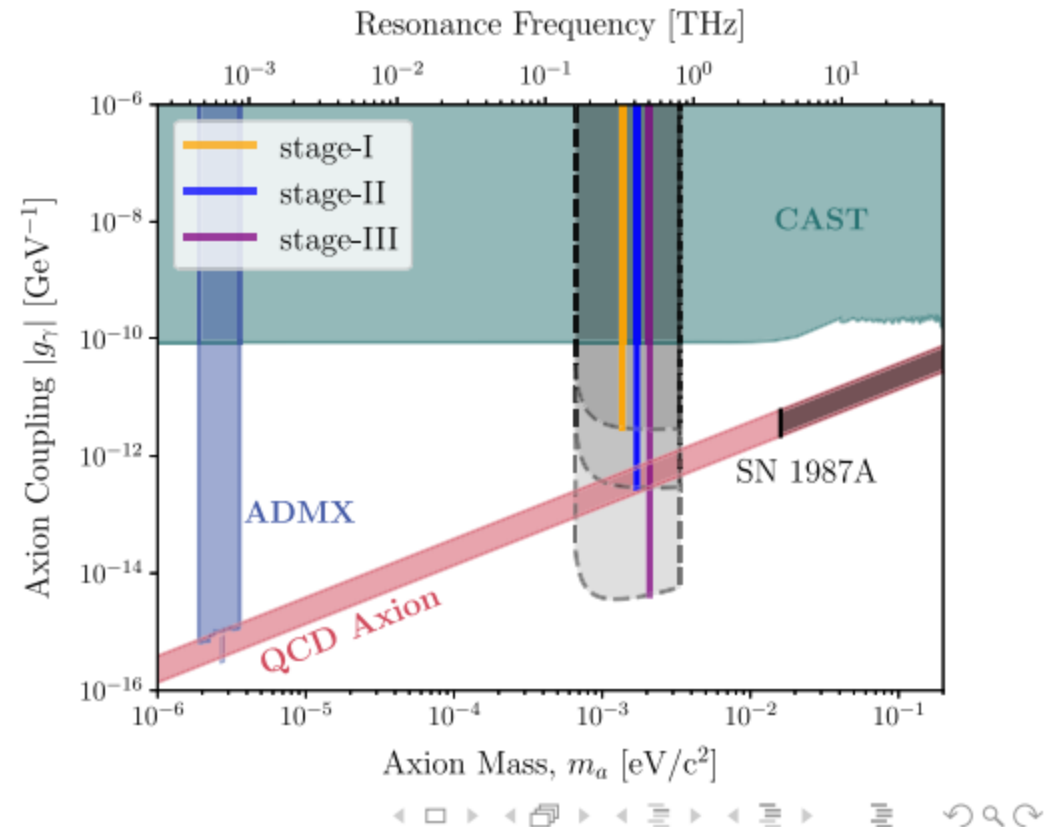
	2022
PADOVA	11 (9 consumabili, 2 missioni)
PAVIA	3 (missioni)

OBJECTIVE

Investigate AntiFerromagnetic Topological Insulators (AF-TIs) (e.g. $\text{Mn}_x\text{Bi}_y\text{Te}_z$) for the development of **axion detectors** by means of a **terahertz time domain spectroscopy apparatus (THz-TDS)**

F-TIs materials can host quasiparticles which are resonantly driven in the presence of axions and emit THz photons which can be detected using a single photon detector

- $0.7 < m_a < 3.5 \text{ meV}$, axion mass interval currently inaccessible to other DM experiments or proposals
- $V_s \lesssim 1 \text{ cm}^3$ (stage I); $\times 100$ (stage II)
- tunability of the resonance with applied magnetic field



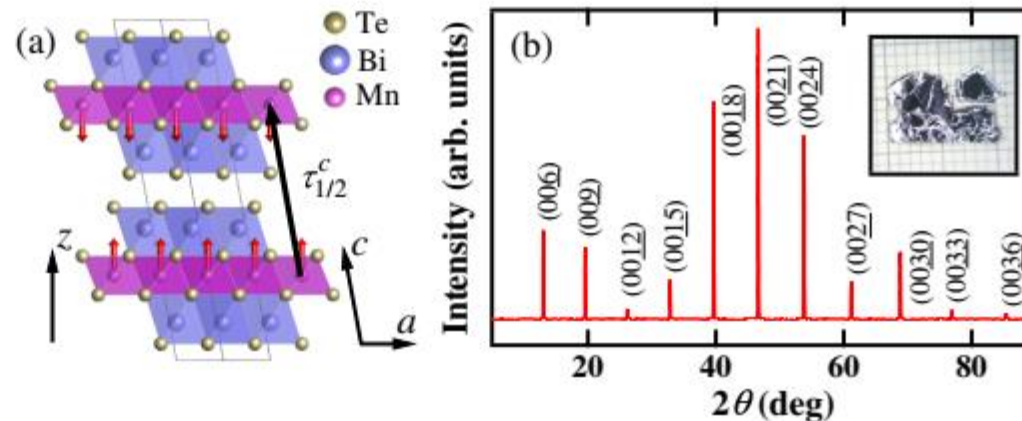
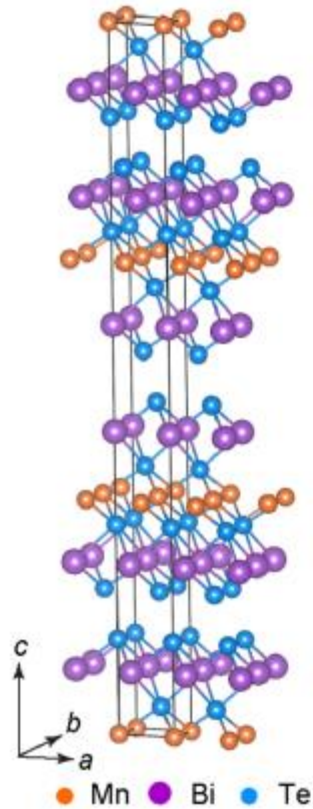
A candidate material for axion detection with AFTI: MnBi_2Te_4

TI are quantum materials that host conducting **Dirac states on their surfaces**, but **electrically insulating the bulk**

AFTI = TI + magnetic order

$$S_\theta = \frac{\theta e^2}{2\pi h} \int d^3x \vec{E} \cdot \vec{B}$$

Realization of an axion insulator requires a *TI layer sandwiched by 2 magnetic layers* whose moments point in opposite directions

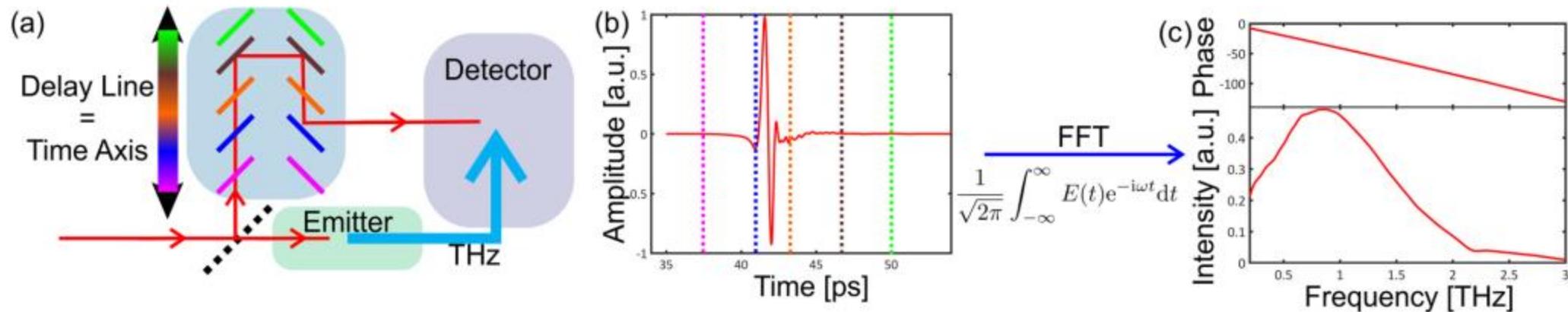


PRX, 041038 (2019)
PRX, 041040 (2019)

TERAHERTZ TIME DOMAIN SPECTROSCOPY (2)

In the transmission spectrum we search for a **resonance** whose frequency and width coincide with the relevant polariton parameters necessary to use AF-TIs as axion dark matter detectors.

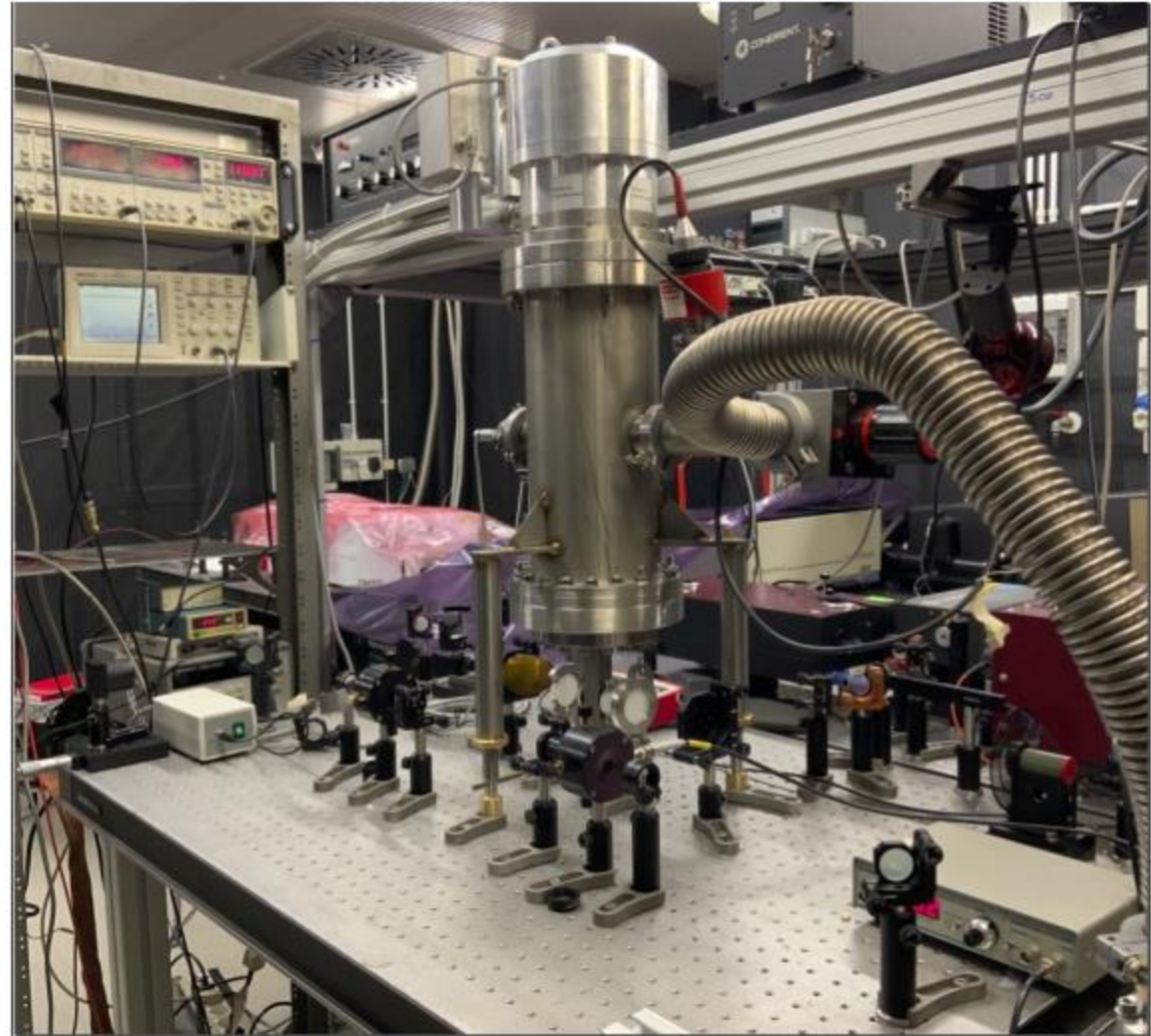
How **time domain** measurements can provide **spectral information**:



1. different colours → different delay-line positions, corresponding to different time points in (b)
2. measured THz time-domain signal (amplitude of the THz field at the detector antenna)
3. the FFT of the signal in (b) is used to infer system dynamic range

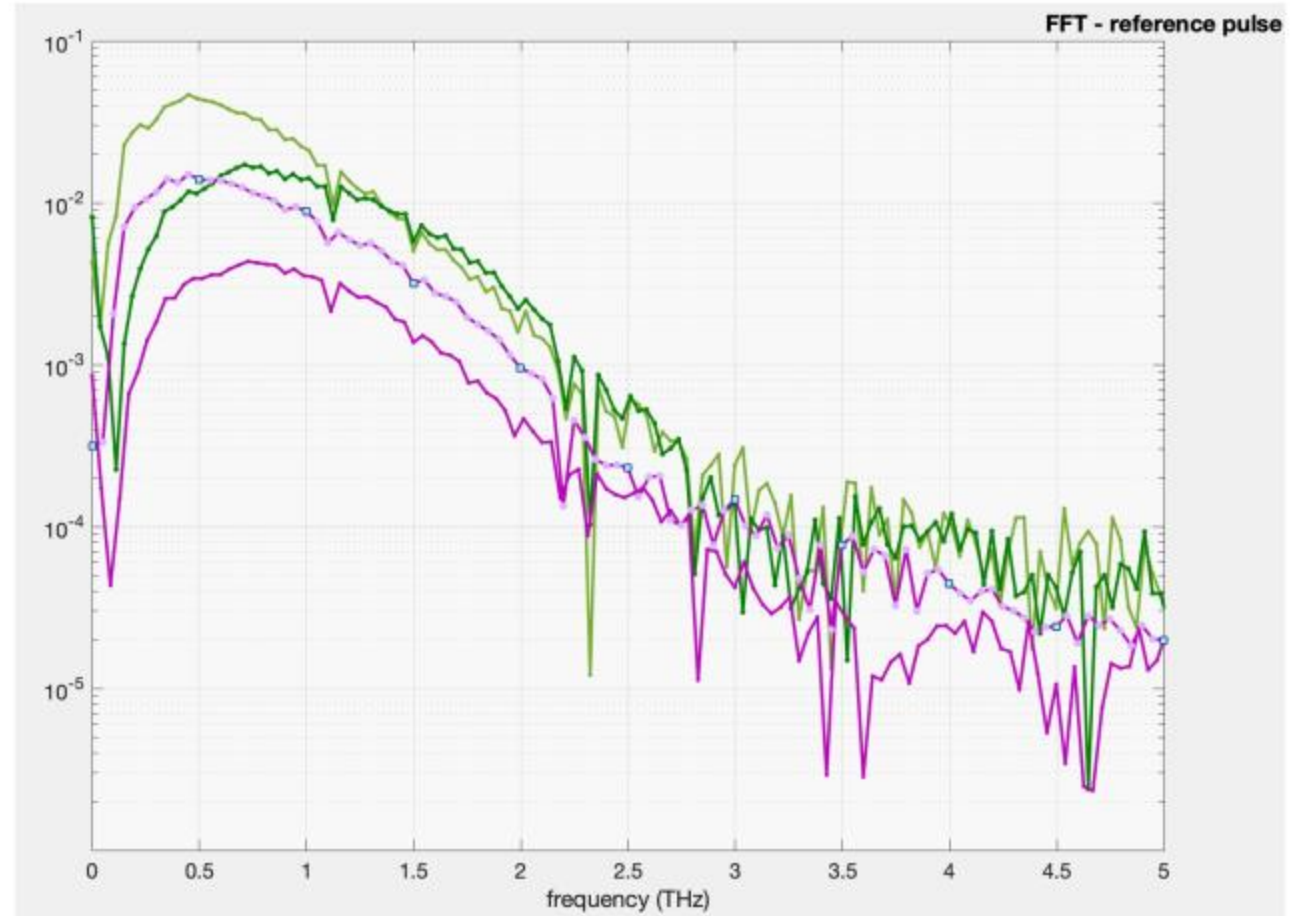
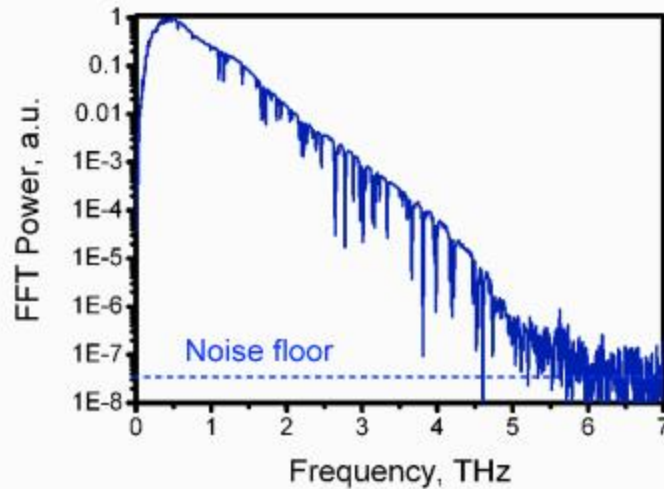
TURNING THE THZ-TDS BACK ON

- components from the previous setup:
Ar-ion pump laser and Ti:Sa oscillator,
photoconductive antennae (Teravil),
parabolic mirrors, pre-amplifier and
lock-in
- new optical delay line and pump laser
installed



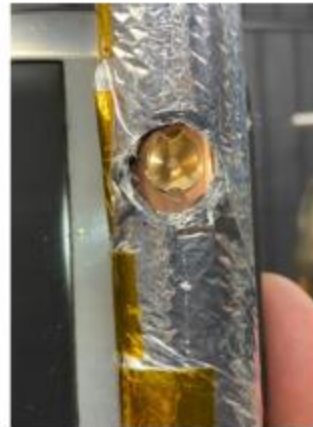
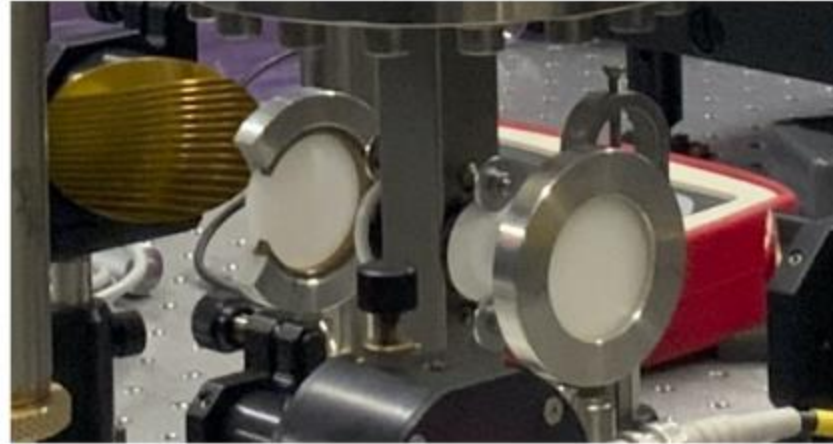
THz-TDS tests: pinholes and long term stability

- THz beam is focused through 1.5 mm-diameter apertures in the cryostat -
reference signal without pinhole is shown in light green/light magenta for comparison
- direct FFT of the reference signals
- removed previous long-term instabilities (magenta vs green, 2h) of the laser system
- lab temperature stable within 1 deg



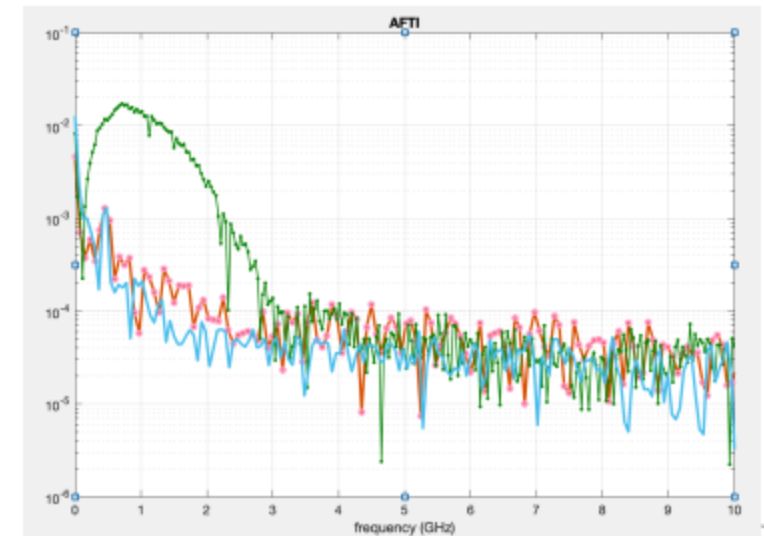
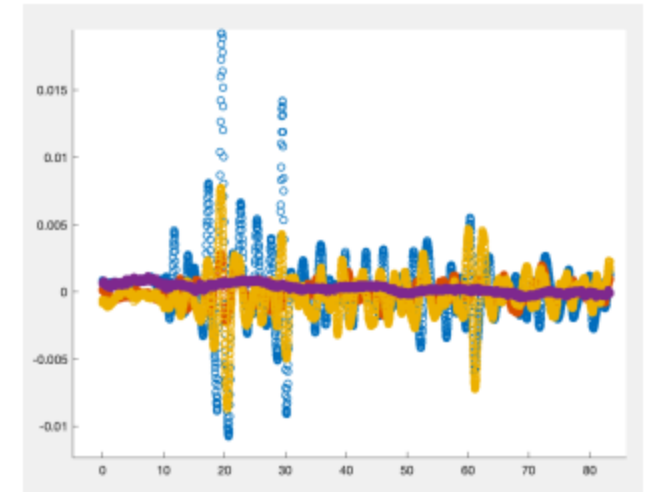
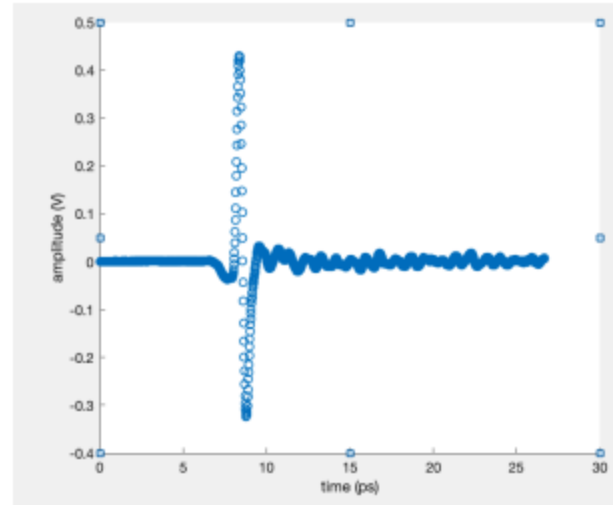
MEASUREMENTS WITH THE FIRST BATCH OF SAMPLES

- samples prepared by: LIU Chang, SUSTech (China)
- 2 samples of MnBi_2Te_4 , one Sb-doped sample for higher resistivity
- thickness ranges from $200\text{ }\mu\text{m}$ to $300\text{ }\mu\text{m}$, useful diameter $\sim 1.5\text{ mm}$
- investigated transmitted THz signal amplitude at 4 K
- transmitted signal not appreciable above noise level through the three tested samples
- **samples have low resistivity $\sim \text{m}\Omega/\text{cm}$!**



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PREVISIONE ATTIVITÀ

Luglio 2021 → Dicembre 2021

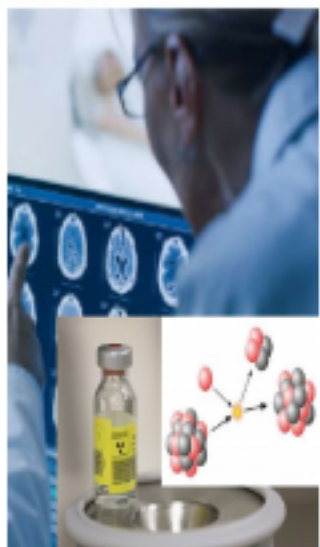
- installazione nuovo laser di pompa (ancora non consegnato)
- segnali di riferimento e DNR; miglioramento della long term stability?
- spettro THz da specifiche antenne fotoconduttive
- si ripetono le misure sui campioni già testati
- studio campioni ricevuti nel 2021 (con drogaggio Sb) attraverso misure in trasmissione a 4 K
- è in corso una discussione su possibile utilizzo di materiali di diversa tipologia, anche non TI (<https://arxiv.org/pdf/2103.02848.pdf>)

Gennaio 2022 → dicembre 2022

- inserimento analizzatori THz per studio polarizzazione
- installazione magnete
- individuazione risonanze e studio al variare del campo magnetico applicato



REMIX Research on Emerging Medical radionuclides from the X-sections



Scopo: Studiare le vie di produzione per uso medico dello Scandio [^{47}Sc] e degli isotopi del Terbio considerando il ciclotrone 35-70 MeV SPES LNL e quello a 19 MeV dell'ospedale Sacro Cuore Don Calabria (Negrar, Vr).

Obbiettivi:

- ~ Misurare sezioni d'urto inesplorate (xs) e/o validare i pochi e obsoleti dati
- ~ Calcoli di modellistica nucleare per individuare energy-ranges e condizioni di irraggiamento ottimali e nuclear data analysis (PD, PV)
- ~ Dosimetria computazionale (OLINDA code) per farmaci marcati con ^{47}Sc e isotopi del Terbio (PD, IOV)

Highlights 2021 **Radioisotopi per la medicina**

- Calcoli teorici sezioni d'urto e di yields targhetta spessa dello ^{47}Sc ottenuti con fasci di p e bersagli di ^{49}Ti e ^{50}Ti . Ottimizzazione spessori e finestre energetiche per la produzione.
- Studio delle sezioni d'urto per le reazioni di produzione del ^{155}Tb da bersagli di Gd arricchito.
- Ricerca di dati in letteratura riguardanti la biodistribuzione di Radio-Farmaci marcati con Sc
- Calcoli dosimetrici per ciascun radiofarmaco marcato con ^{47}Sc e contaminanti, con yields teorici e determinazioni sperimentali. Analisi dell'impatto dei contaminanti.

REMIX Research on Emerging Medical radionuclides from the X-sections

Totale FTE PD	
Canton Luciano, INFN Resp. Locale	0.3
De Nardo Laura, UNIPD	0.5
Paiusco Marta, IOV	0.2
Zorz Alessandra, IOV	0.2
Checchin Diego, UNIPD	0.2
Laskho Yuliya, INFN (assegnista da settembre 2022)	0.1

Acquisto 2021 Server di calcolo 28Cores/56Threads, 128 Gb ram, 1 TB disk. 14 KEu 70% CSN5 30% CSN4 Installato su CLOUDVENETO per nuclear data analysis, ottimizzazione Reference Library per codici di reazione nucleare. Calcolo parallelo basato su algoritmi genetici per ottimizzazione dati nucleari e modellizzazione reazioni nucleari. 2KEu per spese di pubblicazione e 1.5 Keu per missioni.

Risultati

6 Pubblicazioni fra cui Preliminary dosimetric analysis of DOTA-folate ... De Nardo et al *Phys. Med. Biol.* 66 (2021) 025003;
New results on proton-induced reactions... F. Barbaro, L. Canton et al. *Physical Review C* (2021) doi: 10.1103/PhysRevC.104.044619
7 Comunicazioni a Congresso fra cui 3 Applied Nuclear Physics Conference, Praga 2021
1 Tesi triennale Title: Radioisotopi del Terbio per applicazioni teranostiche.
3 Rapporti Interni (2 LNL, 1 HIL)
Collaborazione con LNL, Pavia, Arronax Nantes, HIL Varsavia, IOV Padova



HISOL

High performance **ISOL** systems for the production of radioactive ion beams

Principal Investigator: Mattia Manzolaro

Work Package 1: Development of High Performance ISOL Targets – WP1 leader: Stefano Corradetti

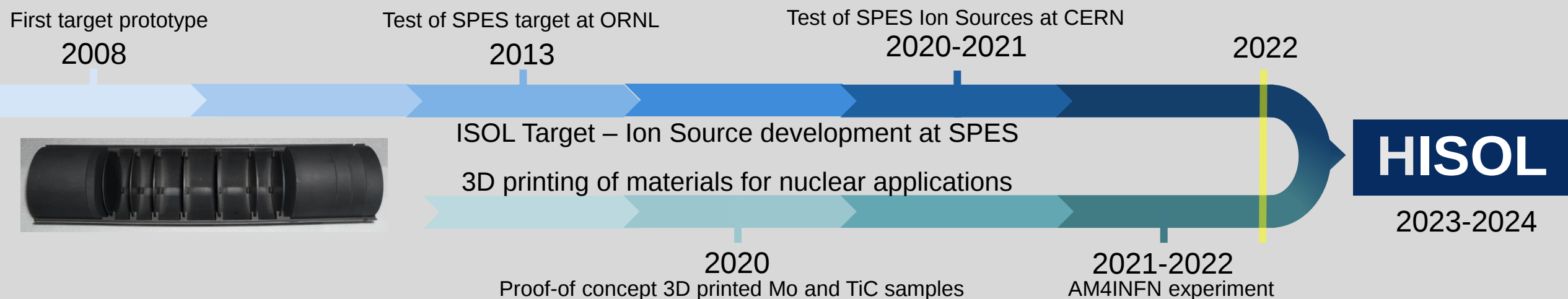
Work Package 2: Development of High Performance ISOL Ion Sources – WP2 leader: Alberto Monetti

Work Package 3: Materials Characterization and Multiphysics Simulation – WP3 leader: Michele Ballan

High intensity and pure Radioactive Ion Beams (RIBs): fundamental for research in various fields (for basic research in nuclear physics, high-level applications such as nuclear medicine)

Improving **ISOL Targets** and **Ion Sources** can increase the **intensity** and the **purity** of **RIBs**.

INFN-SPES project: the **LNL ISOL group** developed a considerable amount of **know-how** (on targets, ion sources, molecular beams, ...) benefitting of prestigious **international collaborations** (ISOLDE-CERN, ORNL, ...).



AM4INFN (supported by INFN_E): 3D printing of high temperature materials such as **SiC**, **TiC**, **Ta**, **W**, and **Mo** (for ISOL systems).

A dedicated **INFN-CSN_5 Experiment** could be great opportunity to define a **New Generation of High Performance ISOL Targets and Ion Sources.**

Production of TiC/SiC samples with regular structures



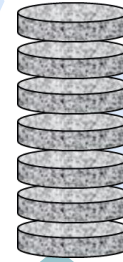
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DI PADOVA



DIPARTIMENTO
DI INGEGNERIA
INDUSTRIALE



Development of High Performance ISOL Targets

Microstructural, thermal and structural characterization



Multiphysics simulations



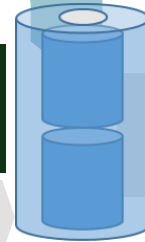
Thermal, electric and structural characterization



DIAM



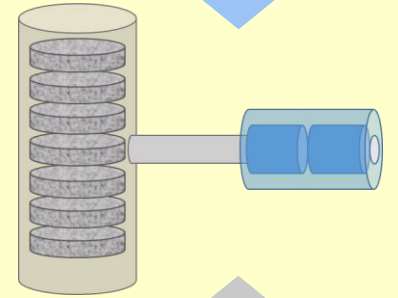
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DI BRESCIA



Development of High Performance ISOL Ion Sources

R&D of complex shape Ion Source components

Development and test
of High performance
ISOL Target – Ion
Source systems

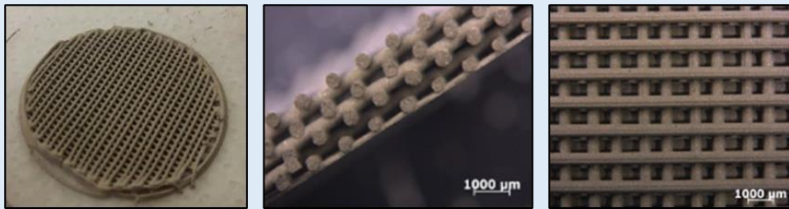


Work package 1: Development of High Performance ISOL Targets

Production of **TiC/SiC** samples with **regular structures** for **characterization** activities



Development of **TiC/SiC** disks with regular structures for **ISOL Targets**



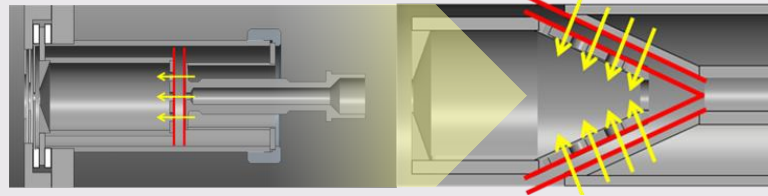
Long term **high temperature test** of a TiC/SiC ISOL Target prototype

Aim: maximize heat transfer and release

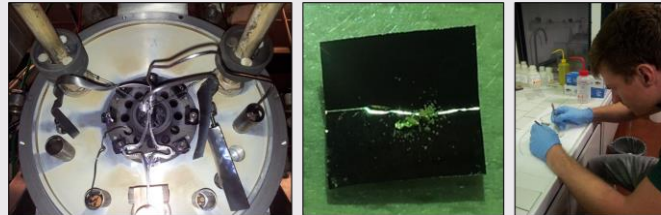
Work package 2: Development of High Performance ISOL Ion Sources

Production and test of **W, Ta and Mo** Ion Source components with **complex shapes**

Alternative anode-cathode interfaces



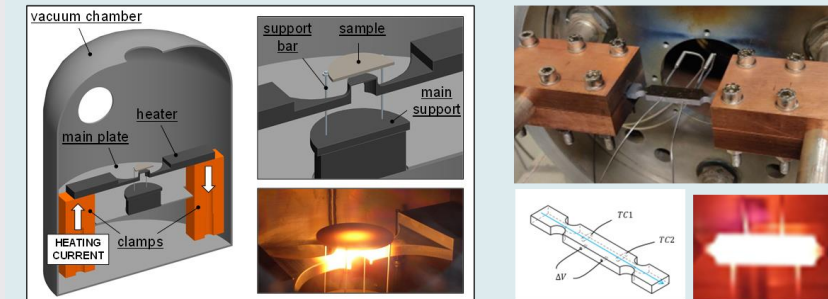
Production of ion beams with the Ion Source prototype (also **molecular beams**)



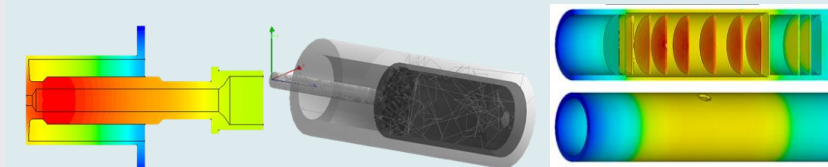
Aim: improve the ionization efficiency, the source stability and reproducibility

Work package 3: Materials Characterization and Multiphysics Simulation

Microstructural, thermal, electrical and structural **characterization**



Multiphysics Simulation of High Performance ISOL Targets and Ion Sources



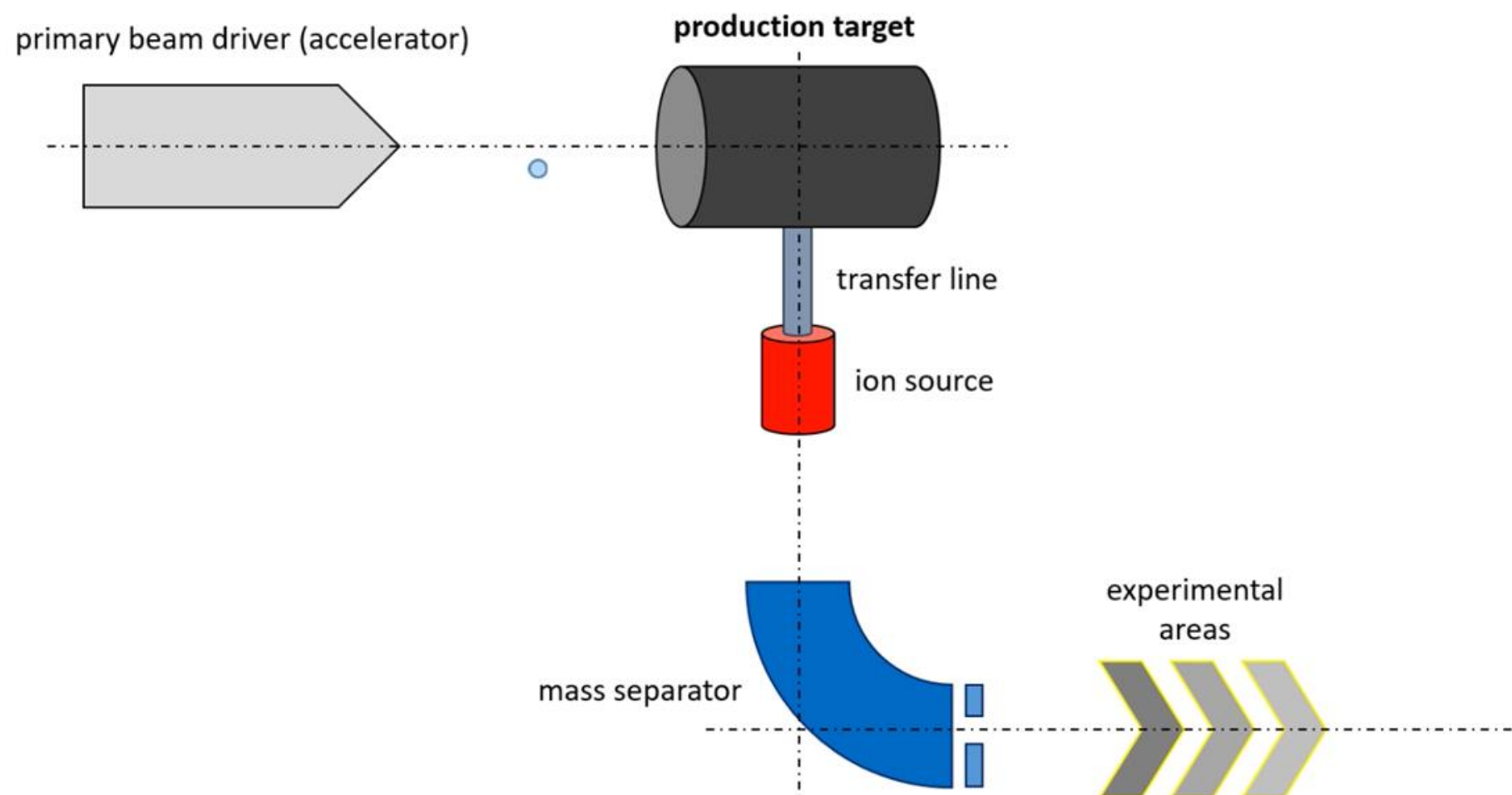
Aim: component characterization

INFN-LNL			INFN-PD		
Name	WP	FTE	Name	WP	FTE
Mattia Manzolaro (National resp.)	1,2,3	0.3	Adriano Pepato (PD local resp.)	2,3	0.1
Stefano Corradetti (LNL local resp.)	1,3	0.1	Pietro Rebesan	2,3	0.1
Alberto Monetti	1,2,3	0.1	Massimiliano Bonesso	2,3	0.1
Alberto Andrichetto	1	0.1	Razvan Dima	1,2	0.1
Michele Ballan	1,2,3	0.1	Simone Mancin	2,3	0.5
Lisa Centofante	1,2,3	0.1	Lisa Biasetto	2,3	0.5
Sara Carturan	1,3	0.1	Paolo Gregori	2,3	0.5
Giovanni Meneghetti	1,3	0.5	Matteo Perini	2,3	0.5
Alberto Campagnolo	1,3	0.5	Total PD FTE		2.4
Paolo Colombo	1,3	0.5	INFN-PV		
Giorgia Franchin	1,3	0.4	Name	WP	FTE
Alice Zanini	1,3	0.5	Valerio Villa (PV local resp.)	2	0.1
Irene Calliari	3	0.5	Antonietta Donzella	3	0.1
Claudio Gennari	3	0.5	Ileana Bodini	2	0.1
Total LNL FTE		4.3	Diego Paderno	2	0.1
			Alberto Giroto	2	1
			Total PV FTE		1.4
Total project FTE				8.1	

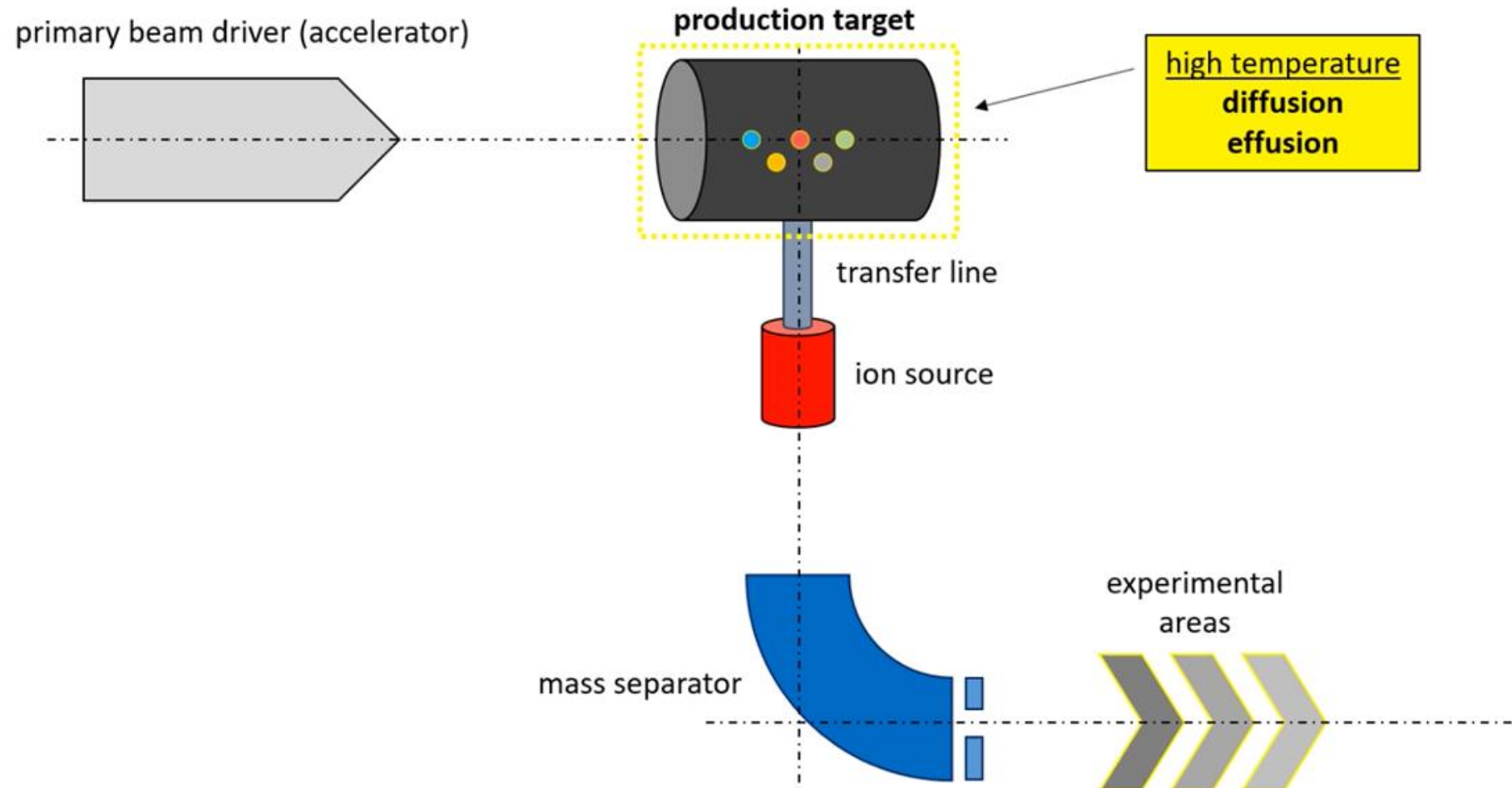
BUDGET REQUESTS year 1 [k€]	
INFN-LNL	
equipment (workstation), DII - Mech. Eng.	3
consumables, DII - Mech. Eng.	7
consumables, DII - Mat. Eng.	7
consumables, DII - Metall.	4
consumables, LNL	3
travel, LNL	1
travel, DII - Mech. Eng.	1
travel, DII - Mat. Eng.	1
travel, DII - Metall.	1
TOTAL	28
INFN-PD	
consumables, PD	9
consumables, PROM	3
consumables, DTG	3
travel, PD	4
TOTAL	19
INFN-PV	
equipment (workstation), UNIBS	3
consumables, UNIBS	4
travel, UNIBS	3
TOTAL	10
TOTAL YEAR 1	
	57

BACKUP

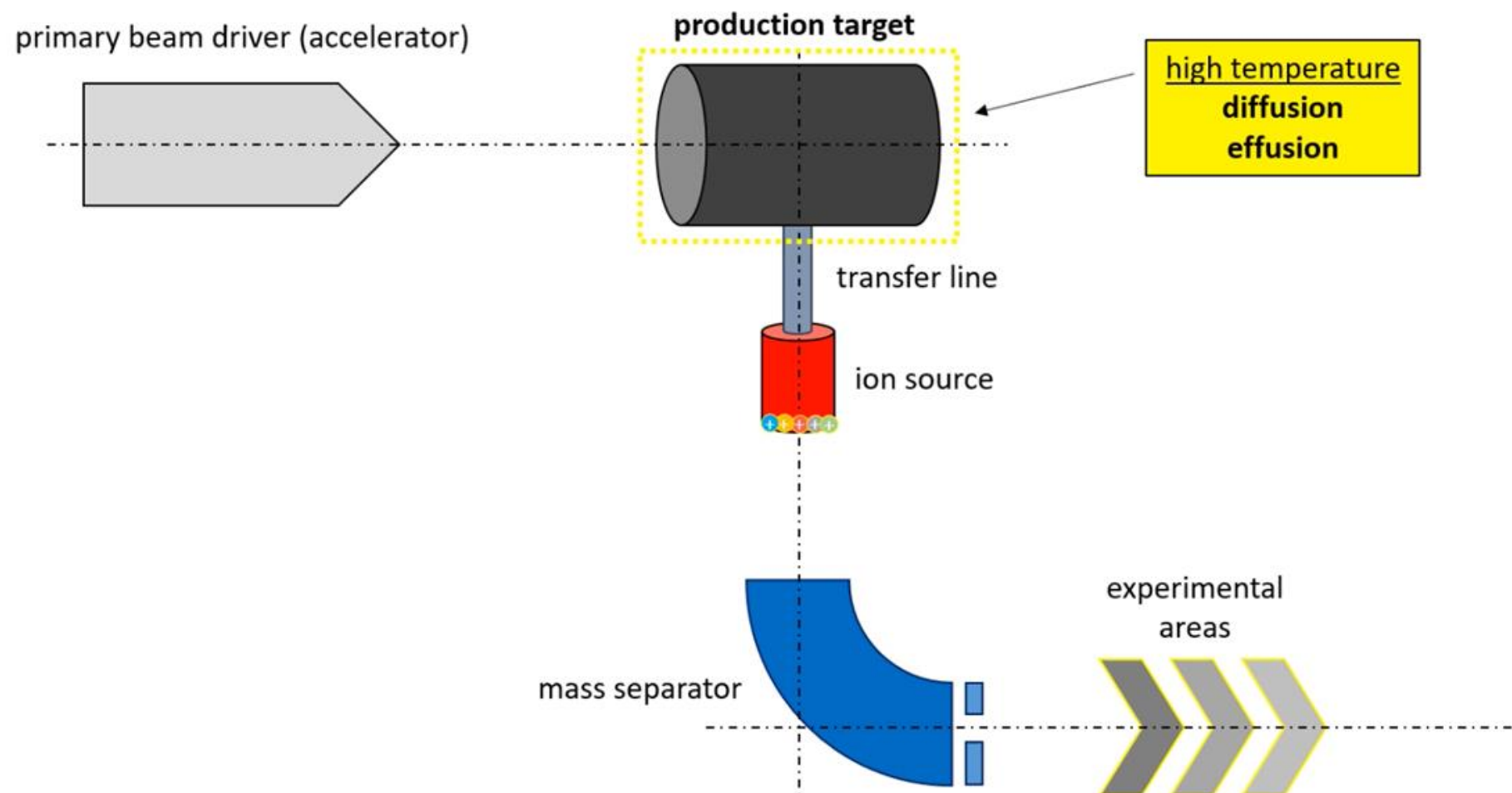
2- Mass Separation Techniques: ISOL (Isotope Separation On Line)



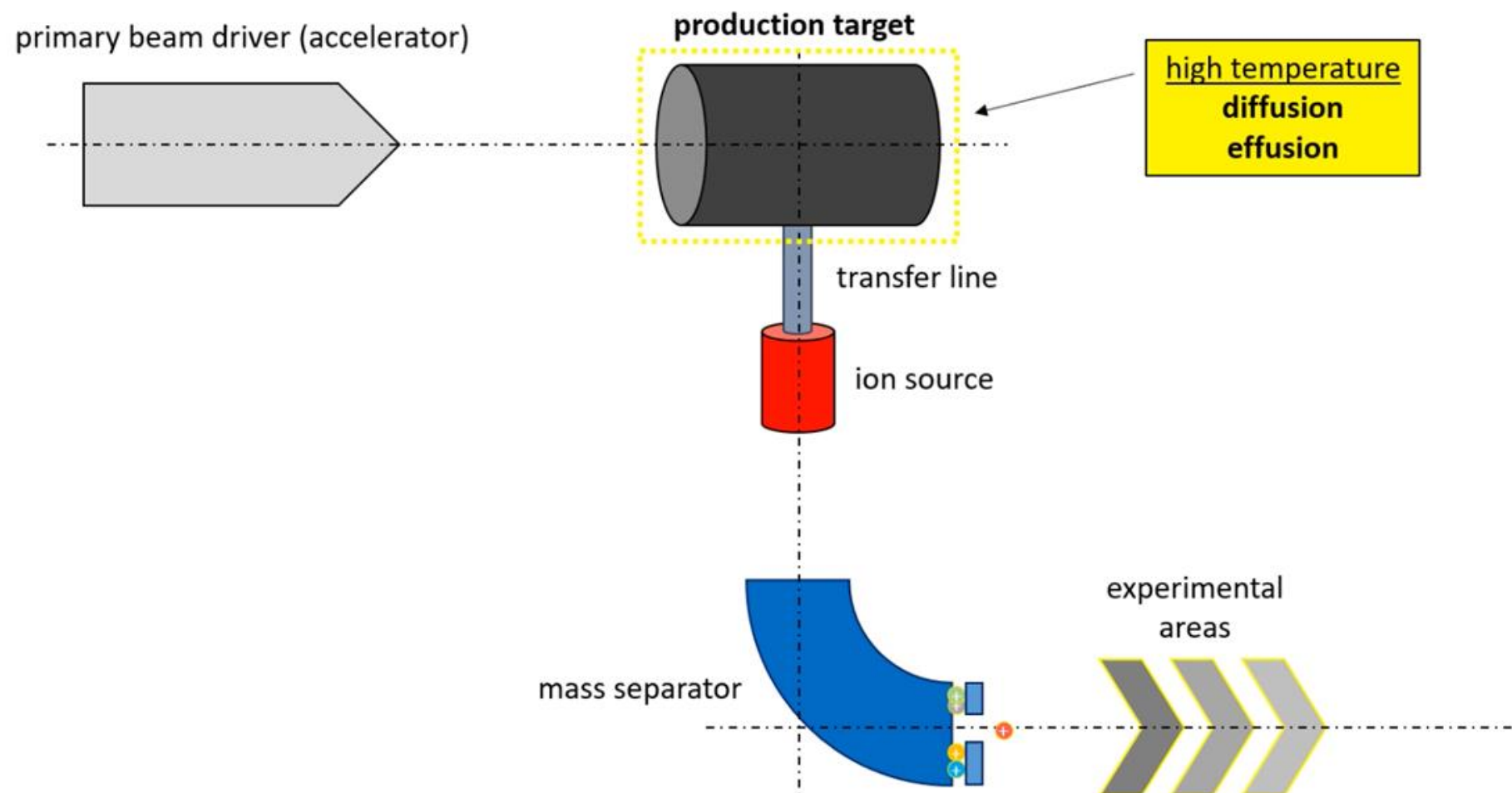
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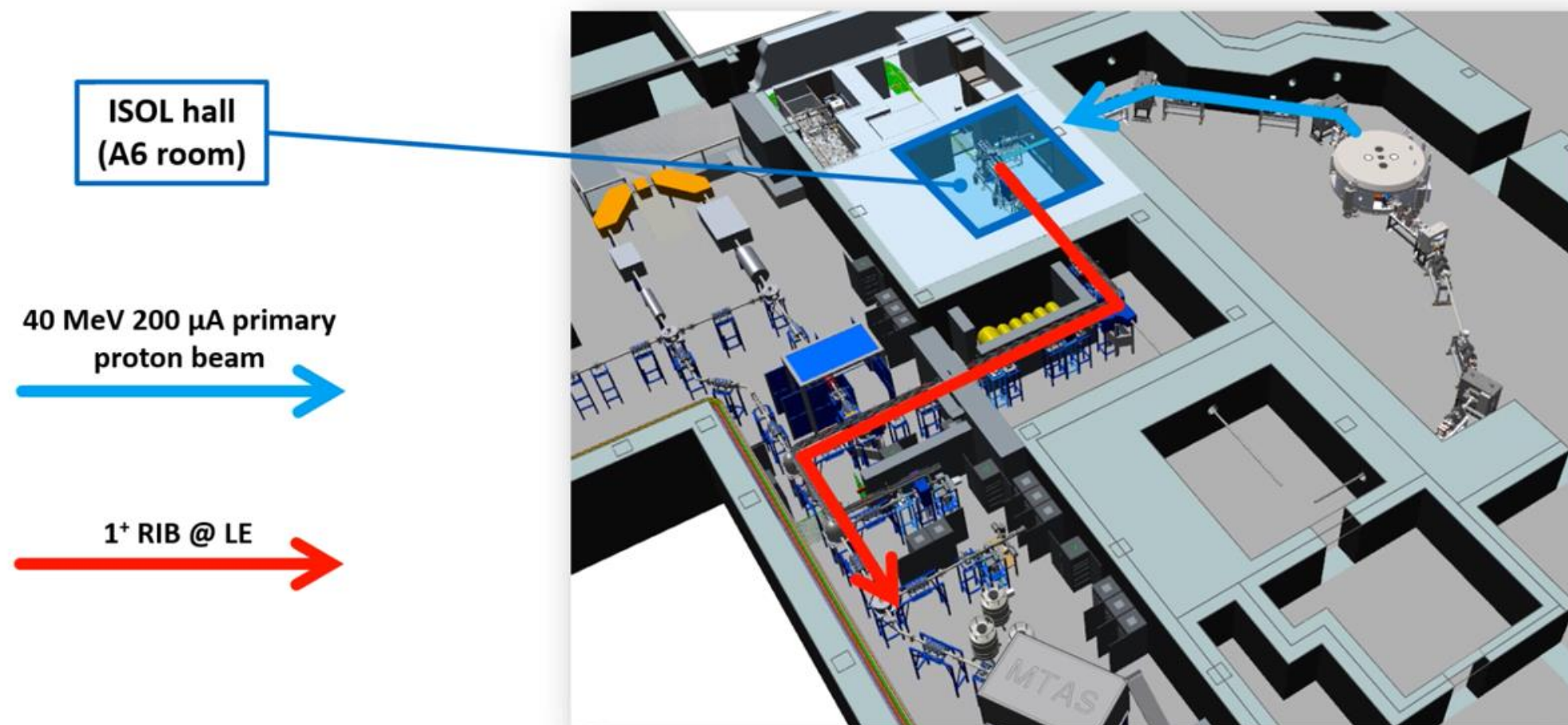
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3- Implementation of the ISOL Technique @ LNL: the SPES Facility

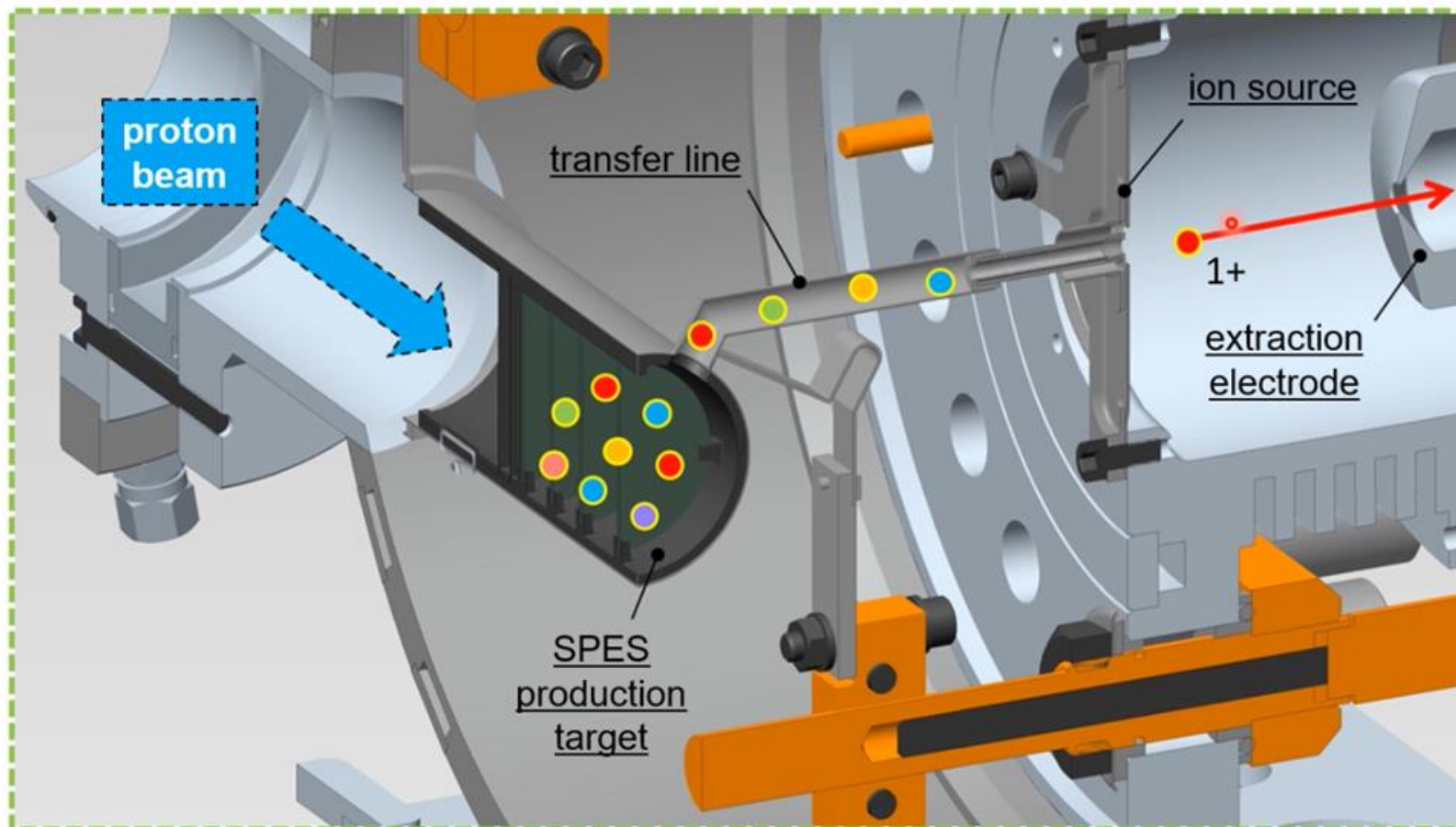
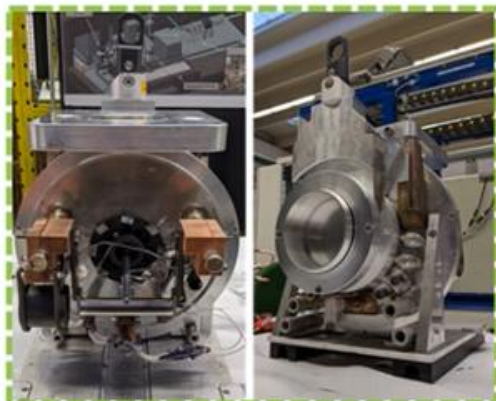


3- Implementation of the ISOL Technique @ LNL: the SPES Facility

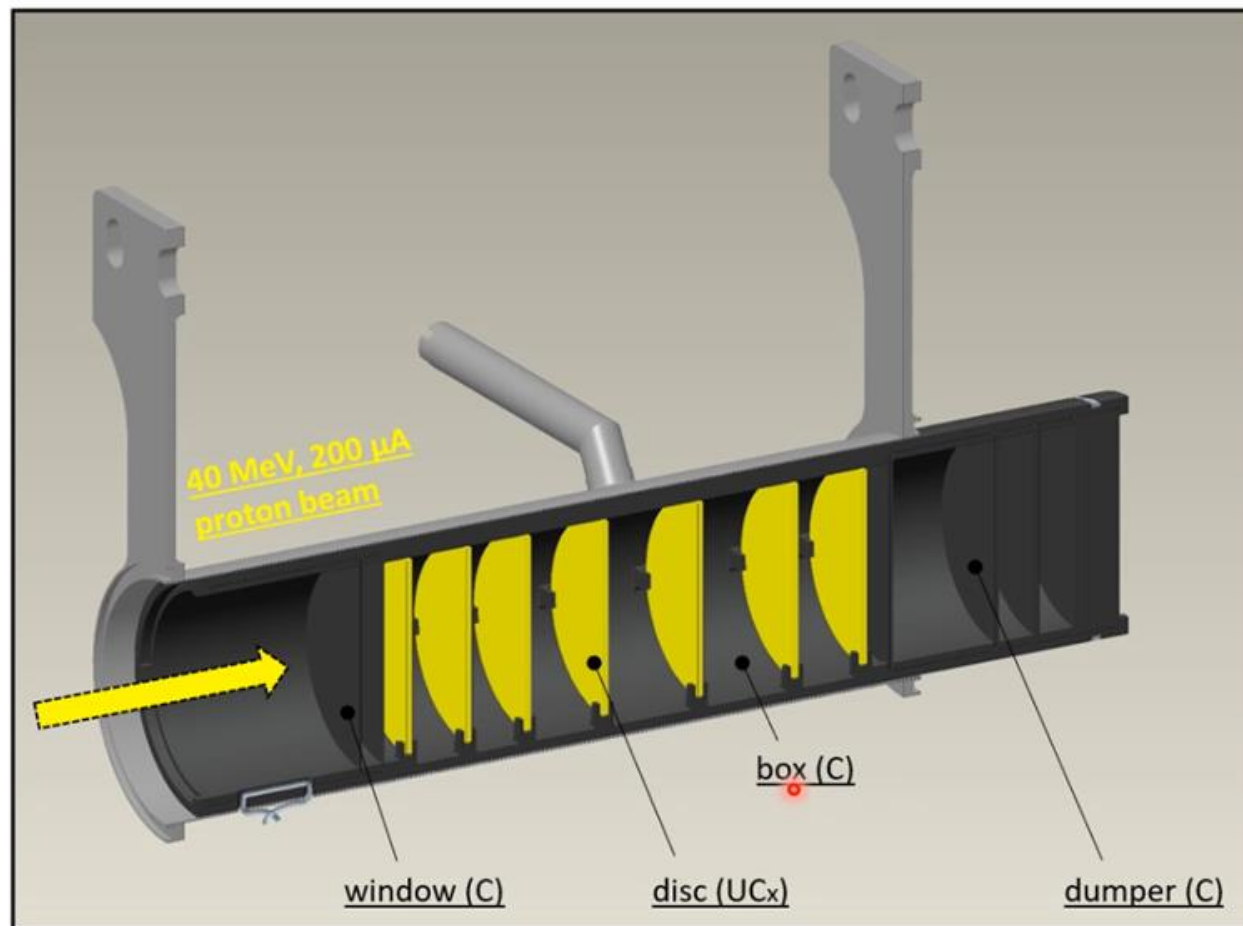
TIS unit:

the Vacuum Chamber containing:

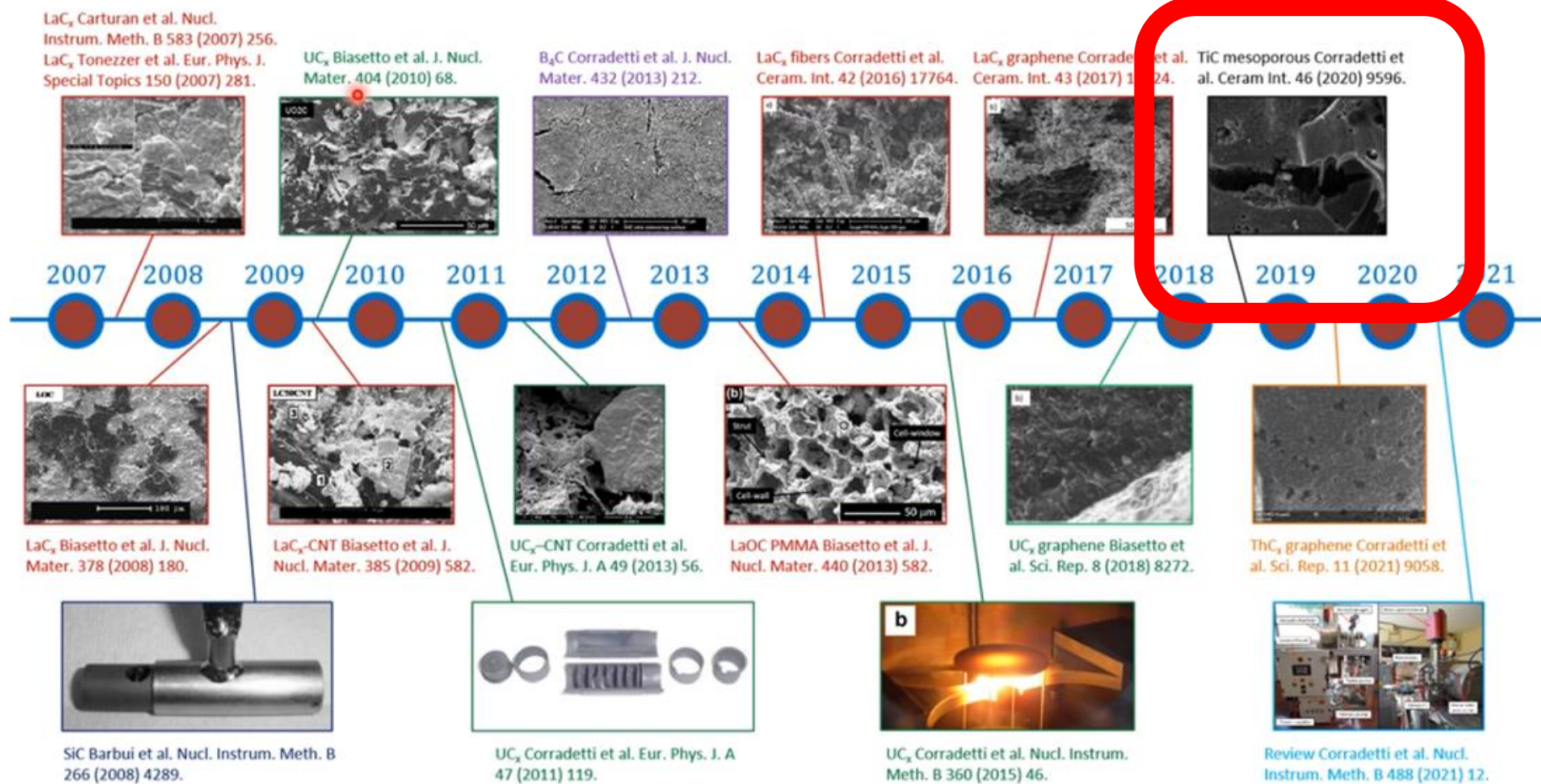
- Target
- Ion Source



4- Targets



4- Targets



5- Ion Sources

																		surface ionization mechanism																			
																		laser ionization mechanism																			
																		electron impact ionization mechanism																			
																		not extracted																			