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e della Ricerca**

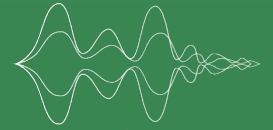


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**Anthem**  
AdvaNced Technologies for Human-centEred Medicine

## PILOT 4.9

# Update on the construction and technological advancements of the ANTHEM BNCT centre in Caserta

**G. Paolisso & G. De Matteis** on behalf of all Pilot 4.9 researchers of Università degli Studi della Campania "Luigi Vanvitelli"  
**A. Pisent & V. Vercesi** on behalf of all Pilot 4.9 researchers of Istituto Nazionale di Fisica Nucleare (INFN)



Università  
degli Studi  
della Campania  
*Luigi Vanvitelli*



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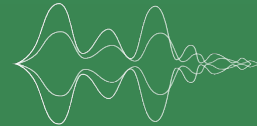


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S. Bortolussi, I. Postuma, S. Fatemi, B. Marcaccio, R. Ramos, C. Pezzi, G. Garini, A. Kourkoumeli Charalampidi, A. Lanza, C. Ferrari, L. Cansolino, E. Delgrosso, U. Anselmi Tamburini, M. P. Demichelis, P. Sommi, A. Pisent, E. Fagotti, L. Bellan, F. Grespan, C. Baltador, J. Esposito, P. Mastinu, V. Conte, A. Selva, A. Bianchi, Y. Ong, P. Mereu, M. Nenni, C. Mingioni, E. Nicoletti, T. Bencivenga, A. Retico, D. Imperio, L. Panza, L. Gialanella, A. D'Onofrio, L. Bagnale, D. Pistone, G. Porzio, R. Buompane, C. Sabbarese, M.R. Masullo, A. Passarelli, L. Manti, S. Pacifico, E. Nigro, S. Piccolella, A. Capuano, L. Altucci, V. Carafa, M. Crepaldi, C. Papulino, E. Martinelli, N. Del Gaudio, S. Cappabianca, M. Barbieri, L. Sciciola, G. De Matteis, S. Di Giacomo, S.J. Gonzalez, A.M. Portu, G.A. Santa Cruz, I. Porras, P. Torres-Sánchez, Y-H. Liu, J. Pan, M. Ying, C. Geng, X. Tang, P. Cirrone, G. Cuttone, S. Paleari, and G. Paolisso, V. Vercesi



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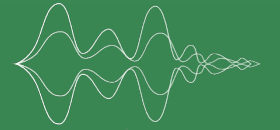


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FEDERICO II



Comisión Nacional  
de Energía Atómica

CONICET



UNIVERSIDAD  
DE GRANADA

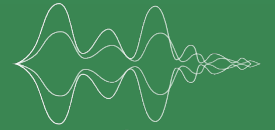


UNIVERSITÀ  
DI PAVIA

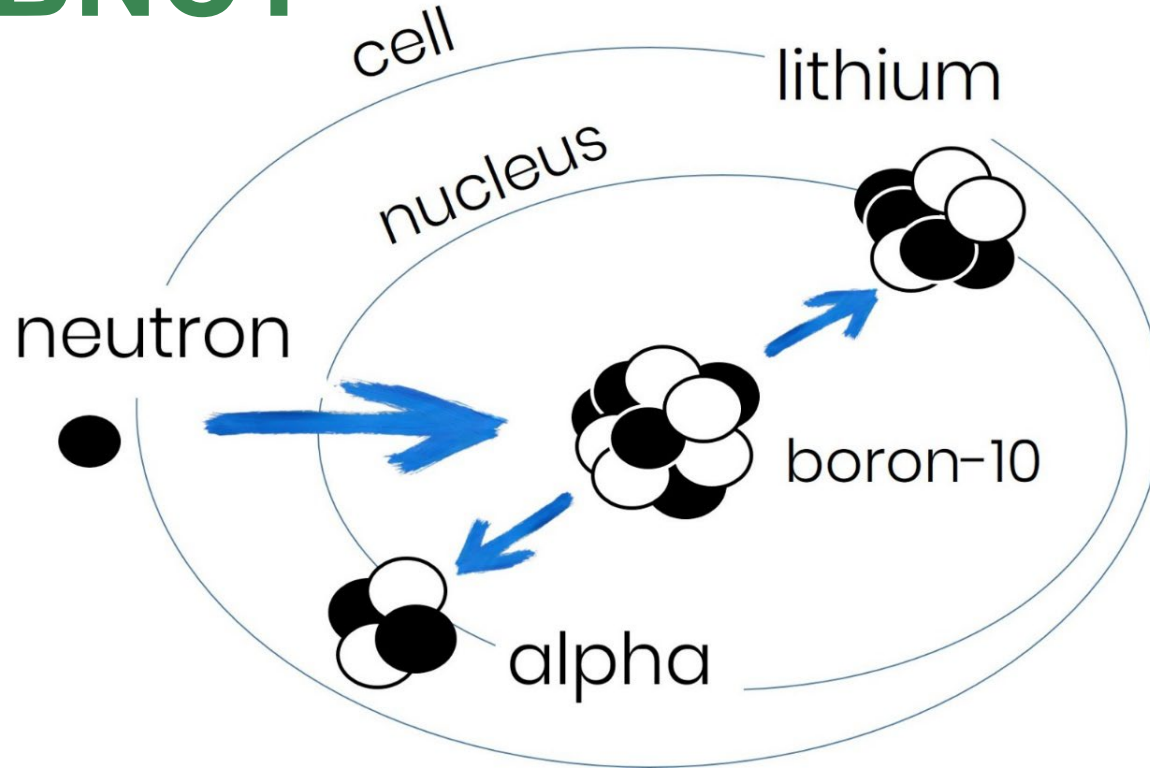
NEUBORON  
中硼医疗



厦门弘爱医院  
XIAMEN HUMANITY HOSPITAL



# BNCT



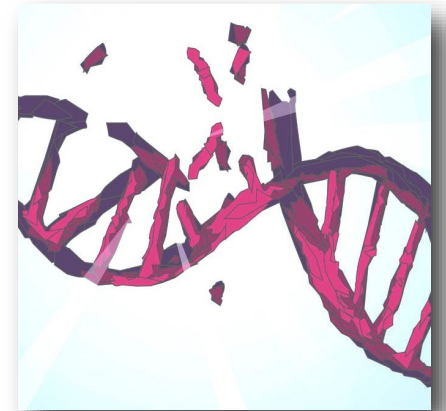
Charged high-LET radiation: high biological effectiveness

Recurrent, infiltrating, radio-resistant, metastatic tumours

## Selectivity

Range of charged particles  
in tissue: around 10 micron.  
Biological targeting, selectivity  
at the cell level

## Effectiveness







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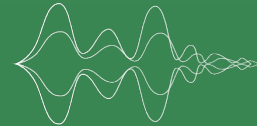


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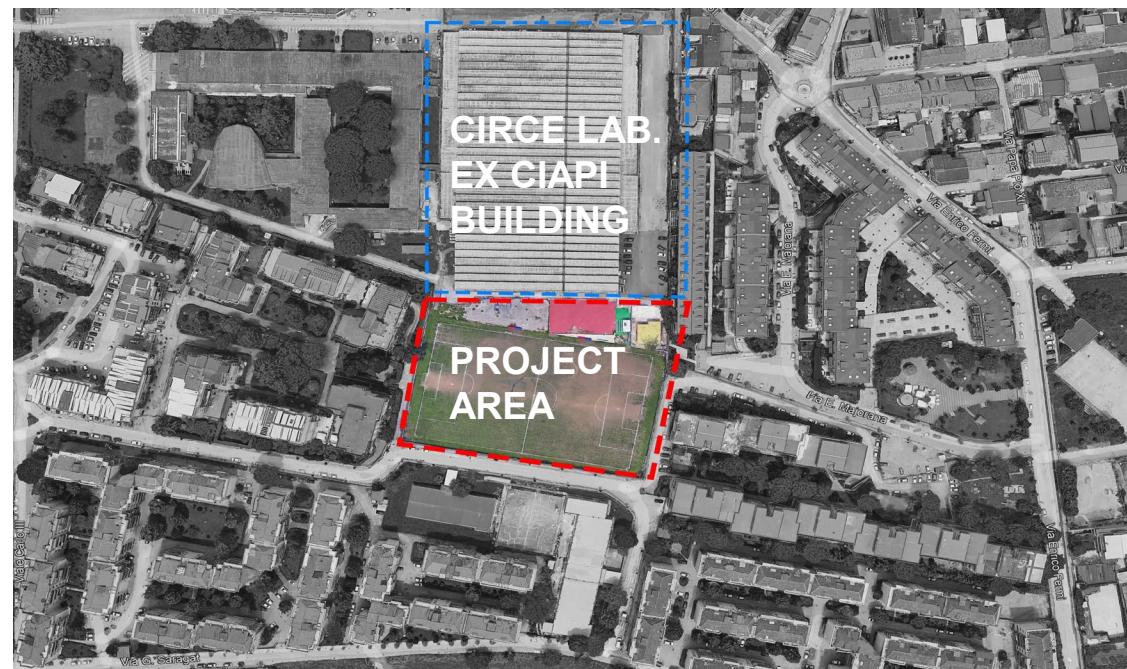
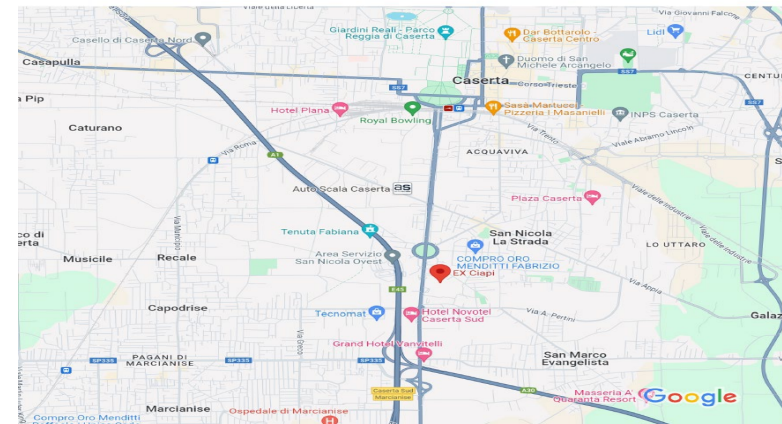
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Design of a new building for BNCT near Caserta, in San Nicola La Strada. The project area is adjacent the *CIAPI* building where the CIRCE laboratory of the University of Campania Luigi Vanvitelli is placed together with some other INFN installations.



The Centre will be the first facility of this kind in all the central and southern Italy (6 clinical centres treating patients in the world, more than 20 in construction for research and/or clinics.)







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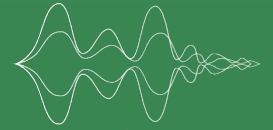


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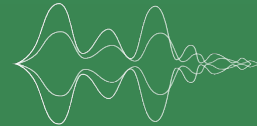
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degli Studi  
della Campania  
Luigi Vanvitelli



INFN  
Istituto Nazionale di Fisica Nucleare



### Phase 01

construction of the bunker and its related treatment rooms, service and functional spaces useful for the commissioning of the building:

Accelerator Control Room

Treatment Control Room

Treatment planning room

Biochemistry Lab

Meeting room and Physical/medical room

Locker room and restrooms.

### Phase 02

expansion of the building, transforming the facility with a clinical area to serve the centre:

Pre-Treatment Spaces

Post - Treatment Spaces

Patient Reception Foyer - triage

Medical Rooms

Additional restrooms to serve the clinic area



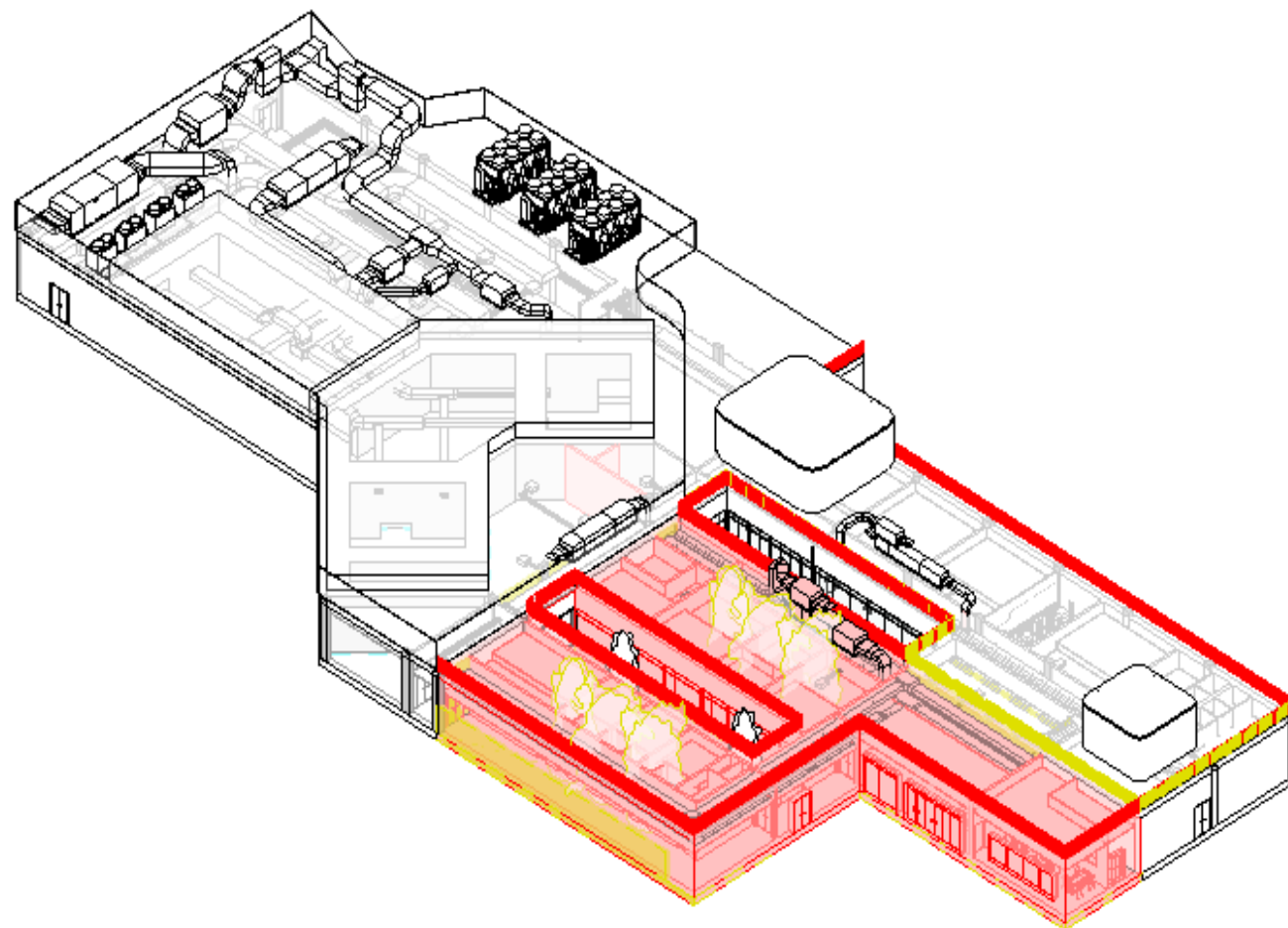
PHASE 1



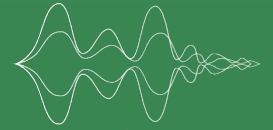
DEMOLISHED IN PHASE 1 AND BUILT IN PHASE 2



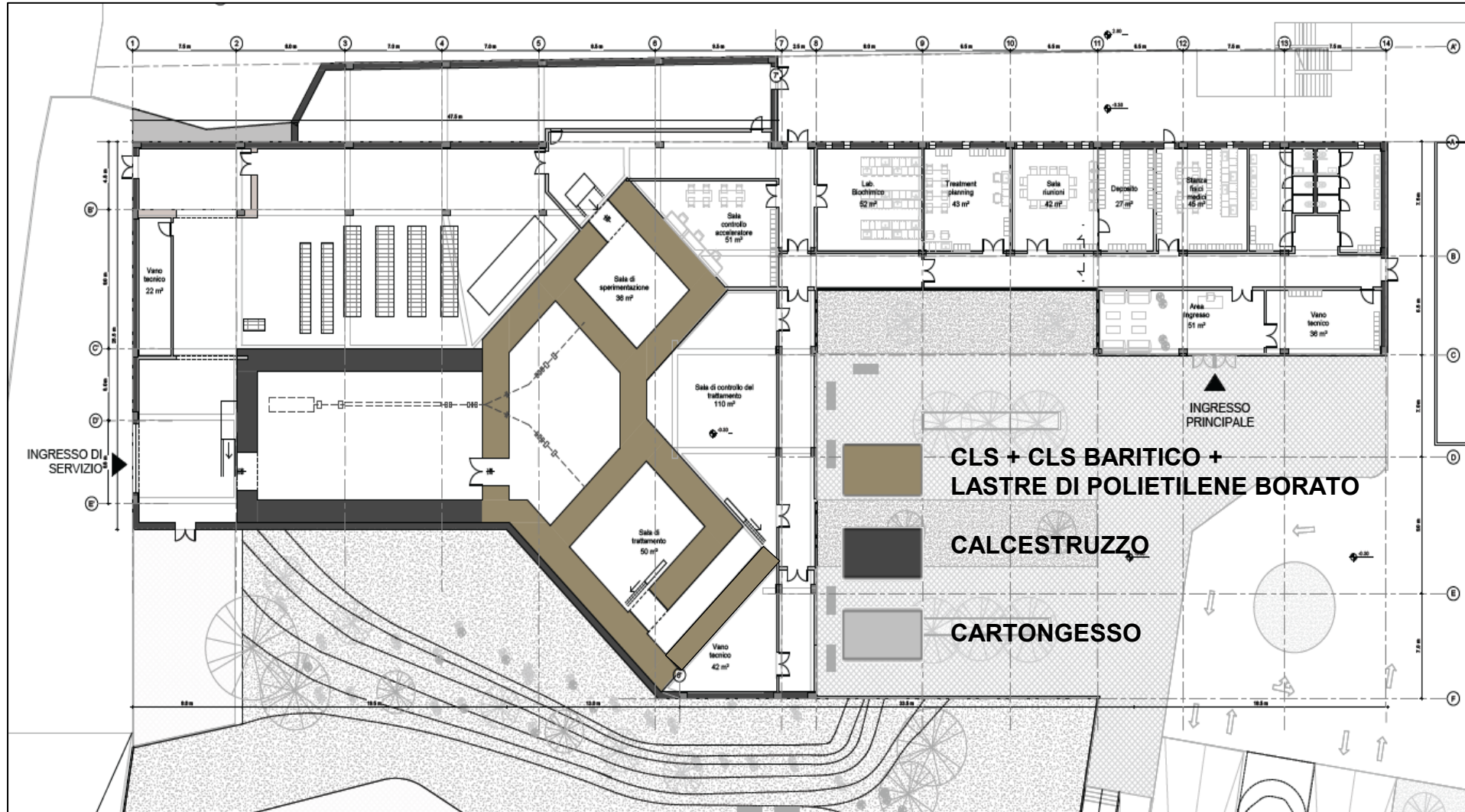
PHASE 2







## FUNCTIONAL LAYOUT-PHASE1



The proposed *technical solutions* are intended to be indicative and will be carefully evaluated during the final and/or executive development phase of the project.





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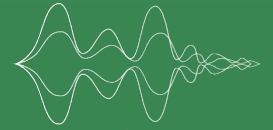


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Obtained resolution of the  
Campania Region for  
financing: money transfer  
initiated

Project transmission to  
Fire Brigade: positive  
outcome

Report on radiation  
protection and  
transmission of the project  
to the regulatory bodies  
(ASL, MASE, ISIN,...)

Transmission of the project  
to the Municipality for the  
release of an urban  
planning opinion – positive  
report obtained

amte.MASE.REGISTRO UFFICIALE.USCITA.0216468.2024-2024



*Ministero dell'Ambiente e della Sicurezza Energetica*

DIPARTIMENTO ENERGIA

Direzione Generale Domanda ed Efficienza Energetica

Divisione V – Nucleare

Posizione: IMP/125

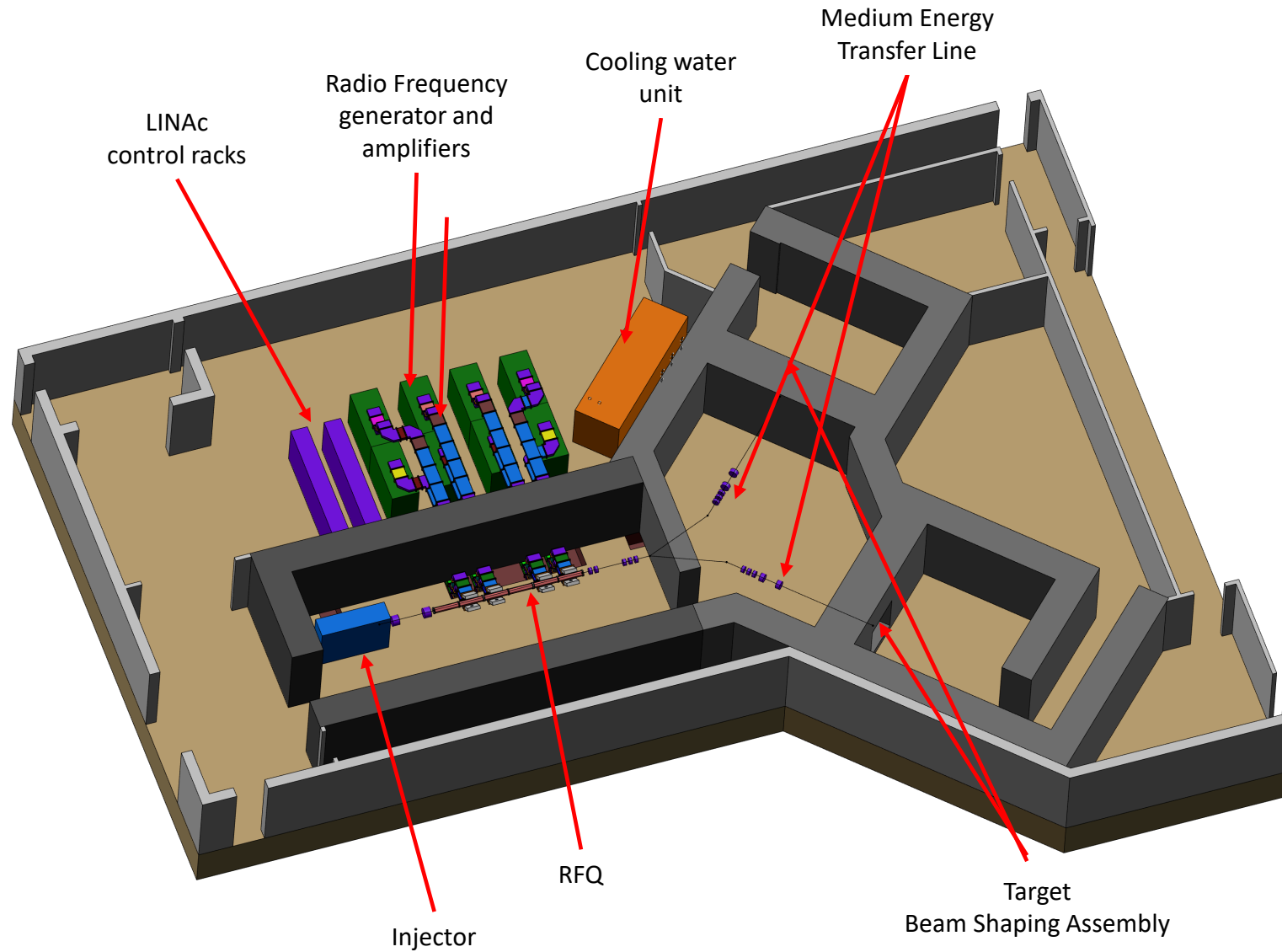
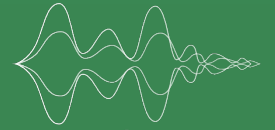
AL DIPARTIMENTO SVILUPPO SOSTENIBILE  
Direzione Generale Valutazioni Ambientali  
Divisione IV  
SEDE

AL MINISTERO DELL'INTERNO  
Dipartimento VV.F., Soccorso Pubblico e Difesa  
Civile  
Direzione Centrale per l'Emergenza, il Soccorso  
Tecnico e l'Antincendio Boschivo  
Ufficio per il contrasto al rischio NBCR e per i servizi  
specializzati  
Piazza del Viminale, 1  
00184 - Roma  
PEC: [dc.emergenza@cert.vigilfuoco.it](mailto:dc.emergenza@cert.vigilfuoco.it)

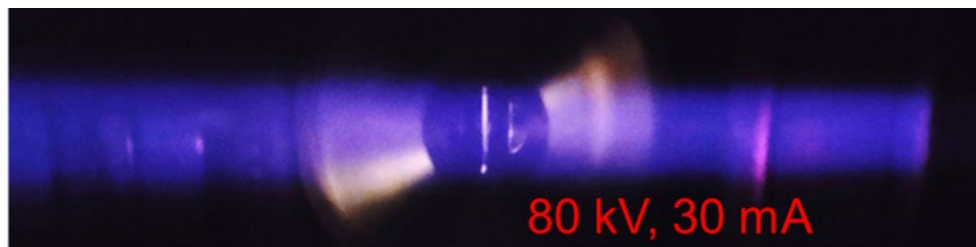
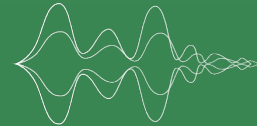
AL MINISTERO DEL LAVORO E DELLE POLITICHE  
SOCIALI  
Direzione Generale per la salute e la sicurezza nei  
luoghi di lavoro  
Via Fomovo, 8  
00192 - Roma  
PEC: [dgsalutesicurezza@pec.lavoro.gov.it](mailto:dgsalutesicurezza@pec.lavoro.gov.it)

AL MINISTERO DELLA SALUTE  
Direzione Generale della Prevenzione Sanitaria - Uff.  
IV  
Via Giorgio Ribotta, 5  
00144 - Roma  
PEC: [dgprev@postacert.sanita.it](mailto:dgprev@postacert.sanita.it)

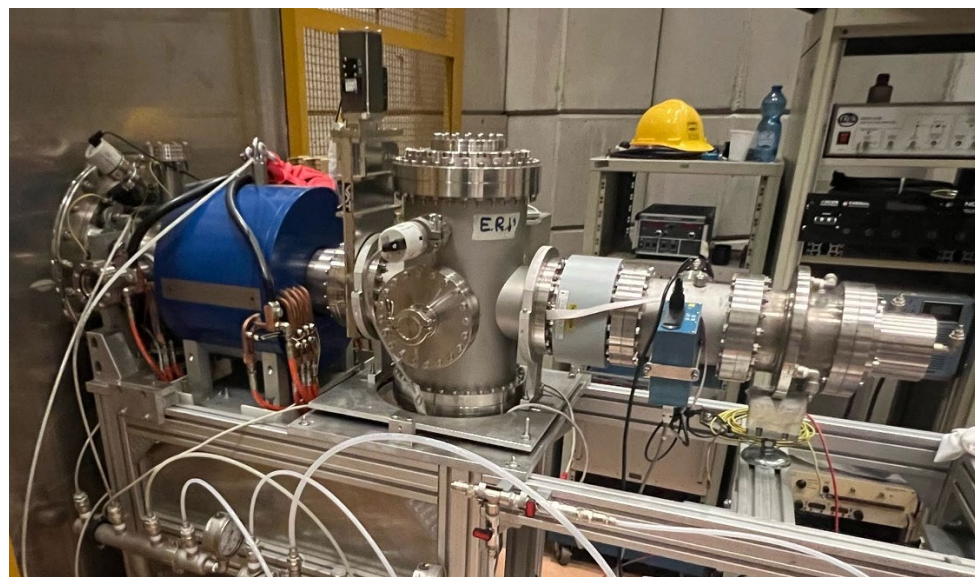
ALL'ISIN  
ISPettorato Nazionale per la Sicurezza  
NUCLEARE E LA RADIOPROTEZIONE  
Via Capitan Bavastro, 116  
00154 - Roma  
PEC: [isin-udg@legalmail.it](mailto:isin-udg@legalmail.it)







Proton source reached  
already operational  
nominal value (30 mA)



Studies ongoing to  
achieve 50 mA value  
(pulsed mode)

Assembled  $\frac{1}{2}$  LEBT

Solenoids tested

Now, under long run  
reliability test





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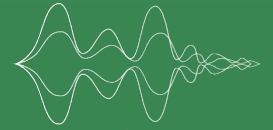


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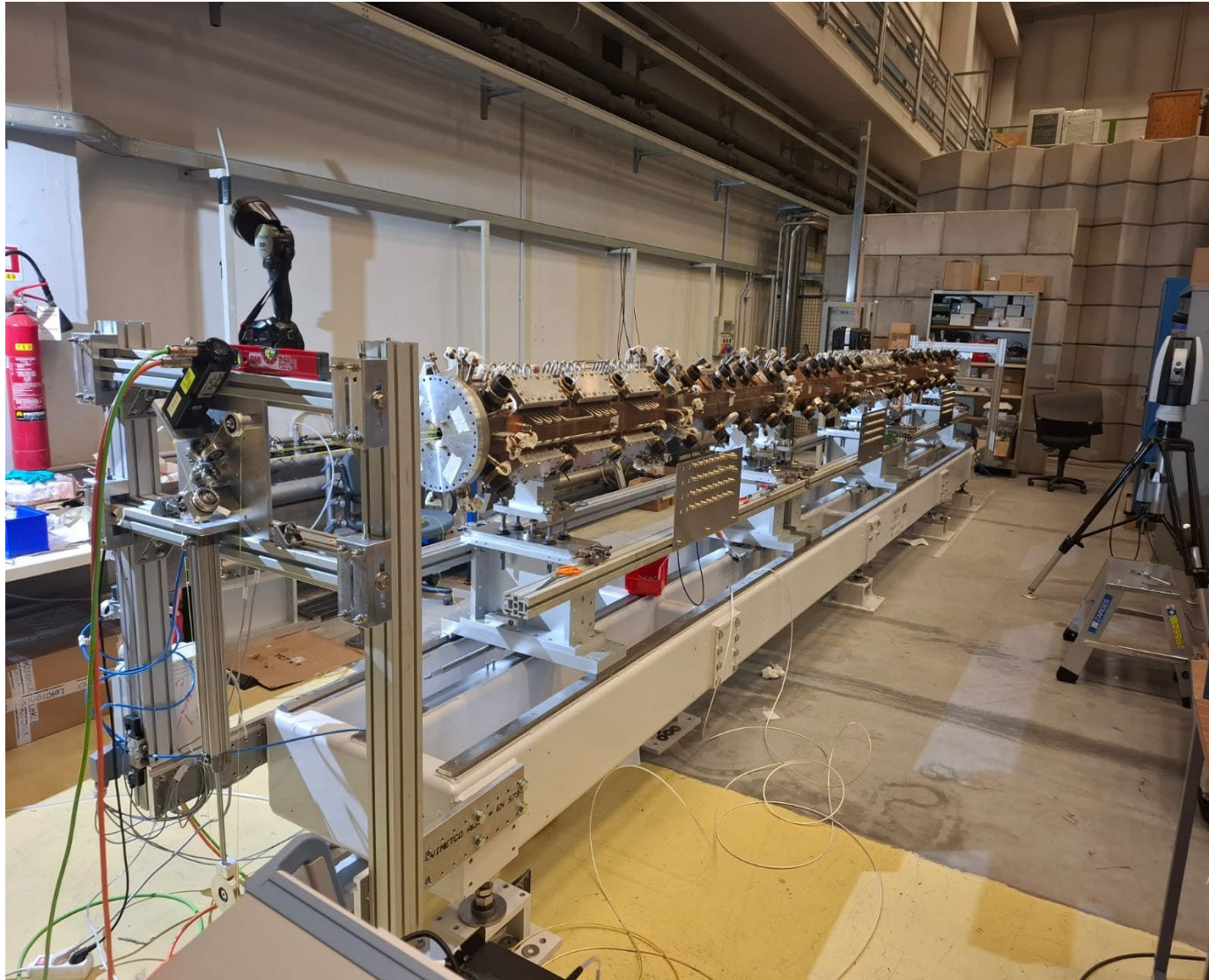
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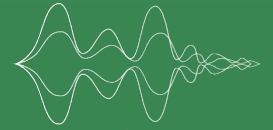


RFQ installed on support

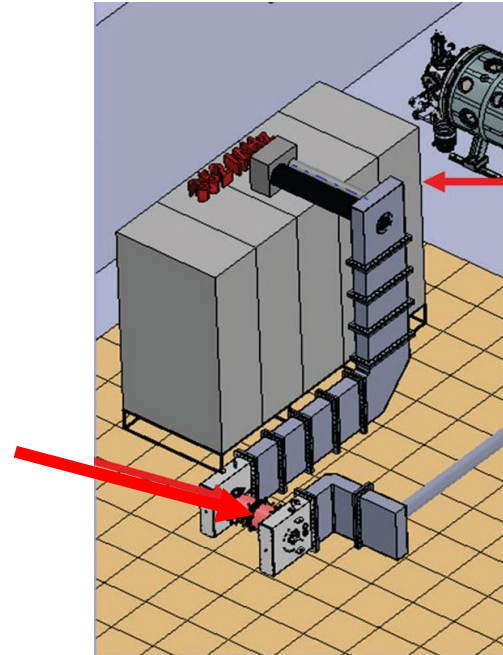
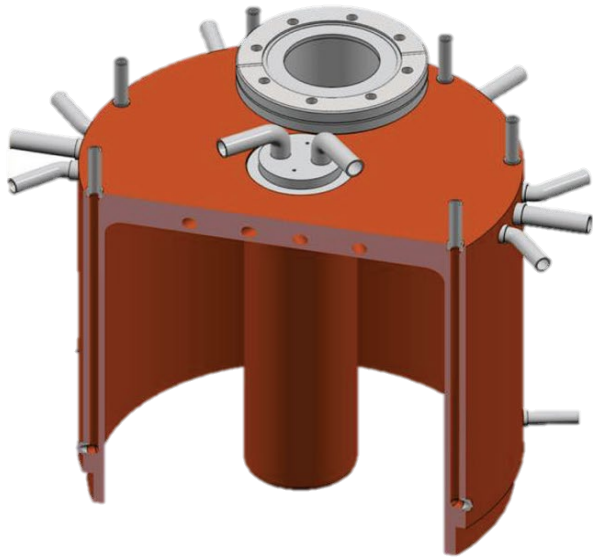
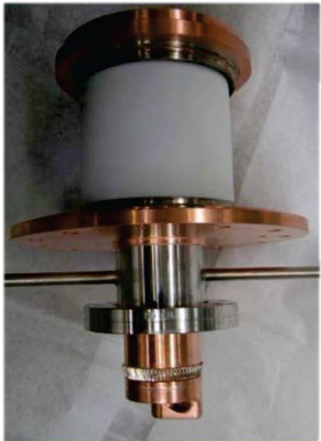
Successfully aligned with  
excellent precision ( $30\mu$  !)

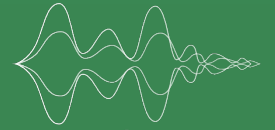
Resonantly coupled RFQ (the  
3rd of the world) tuned!



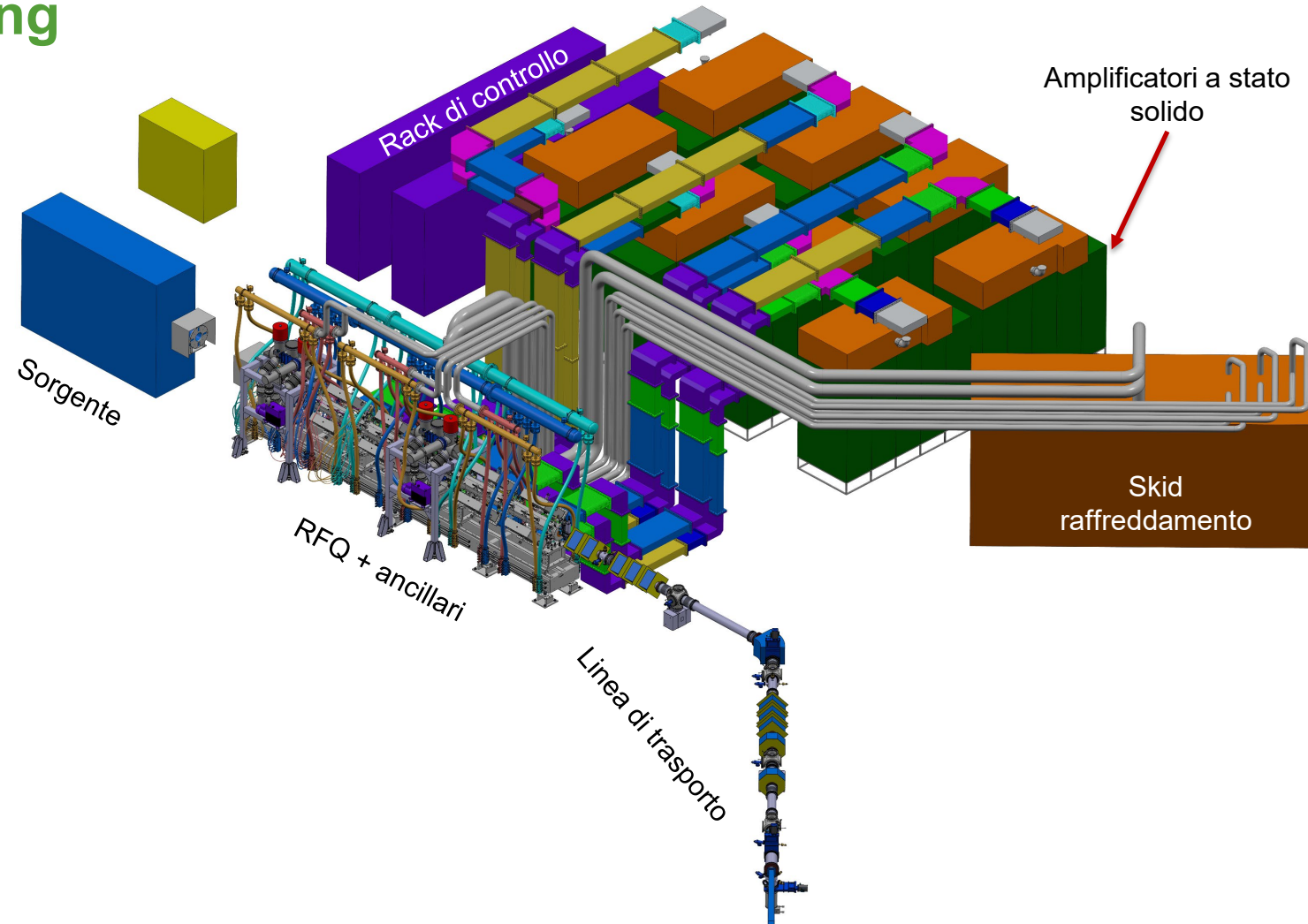


5 already existing solid state amplifiers updated  
3 solid state amplifiers in delivery during 2025  
All solid state amplifiers to be tested in Caserta (CIRCE)  
High power coupler test at LNL  
Tender for test cavity and power couplers ongoing

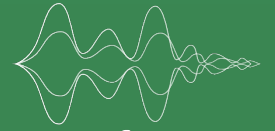




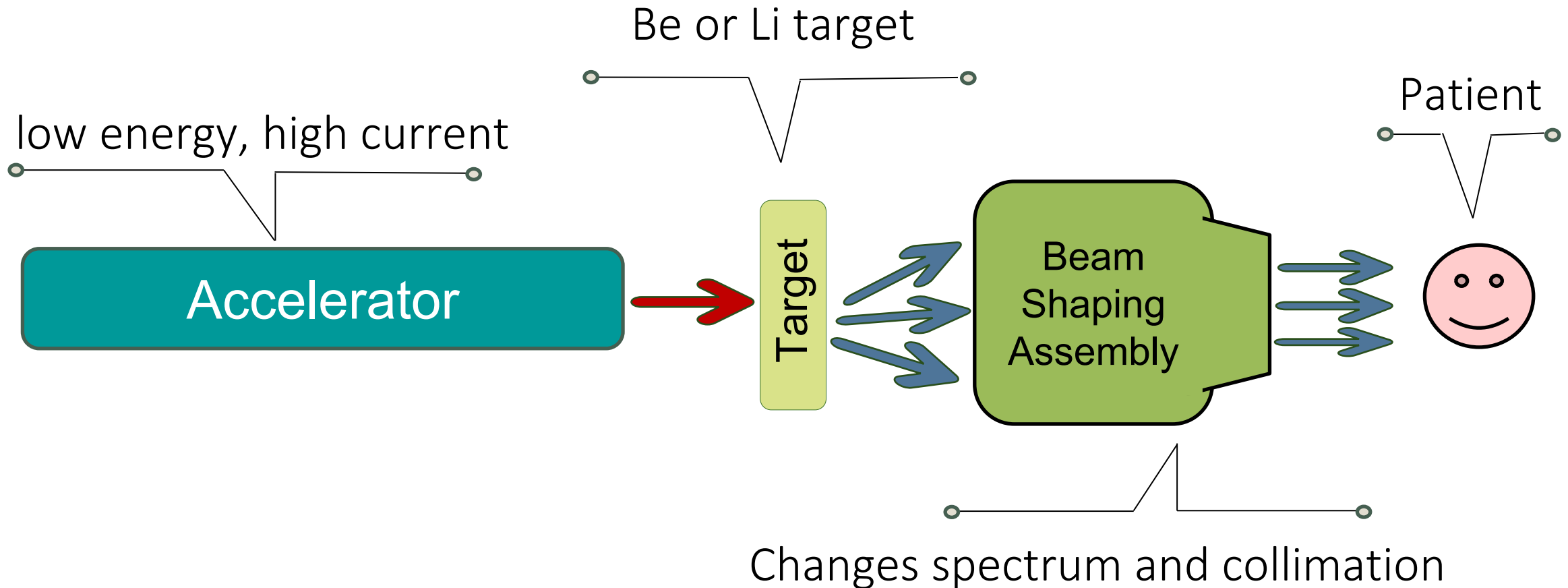
## Integration in building

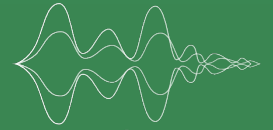




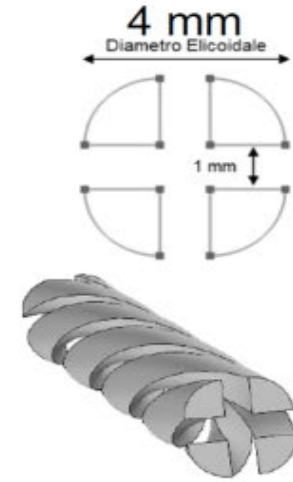
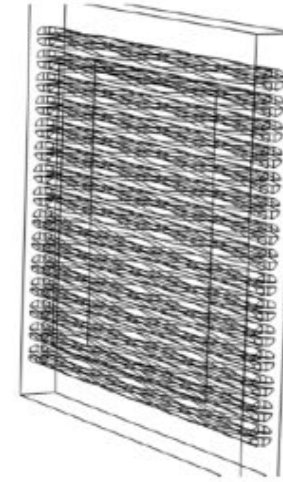
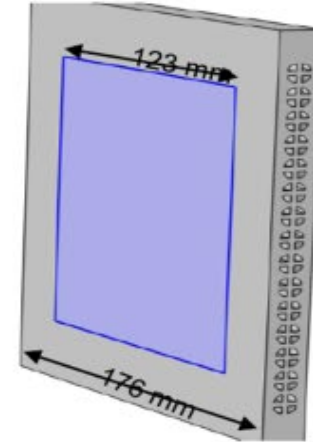
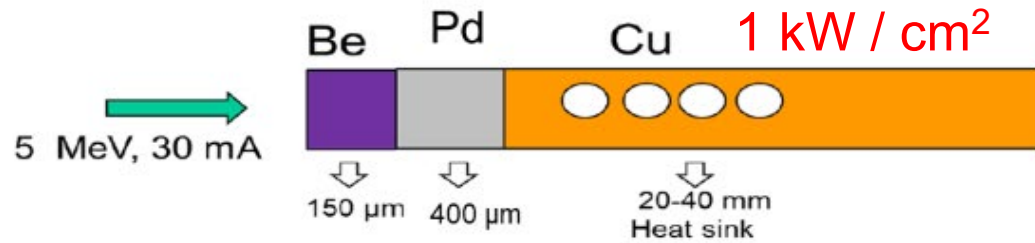


# Accelerator-based BNCT





# The Target



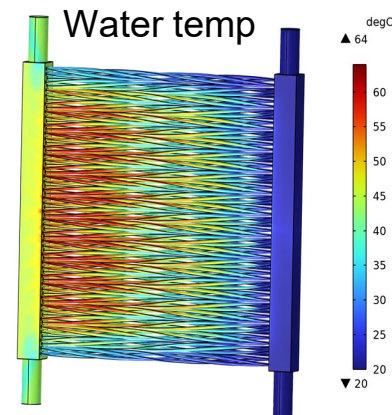
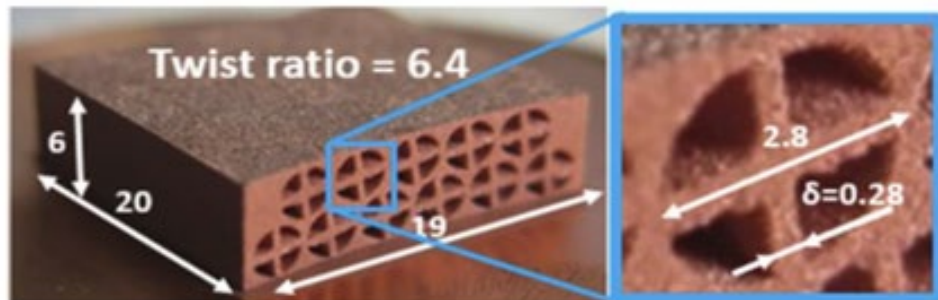
## Composite n-target separated functions:

Be layer → neutron production

Pd layer → proton beam stopper (blistering tolerant material)

Cu bulk → quite efficient heat-sink system

3D printed prototypes are already being produced

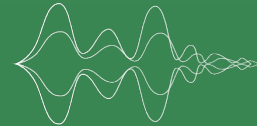


## Complex realization

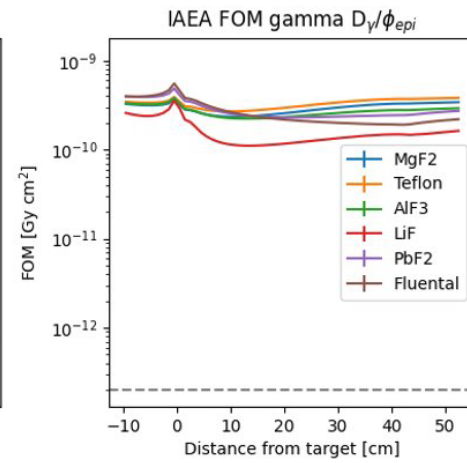
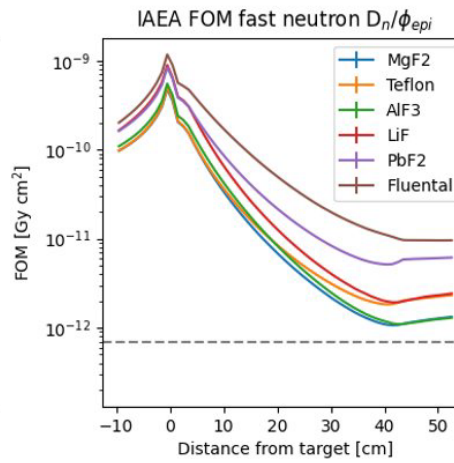
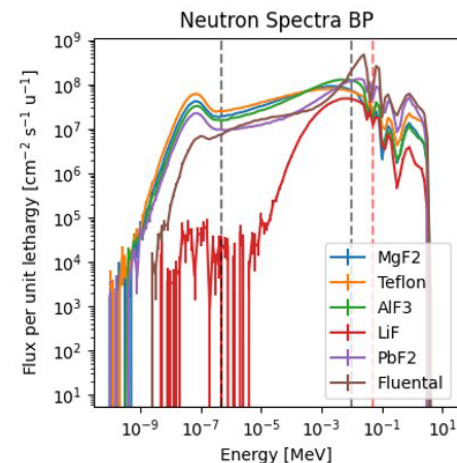
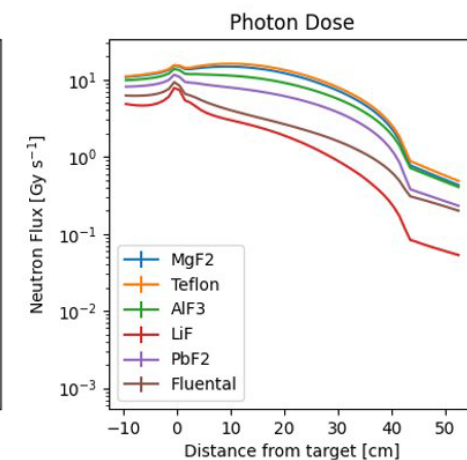
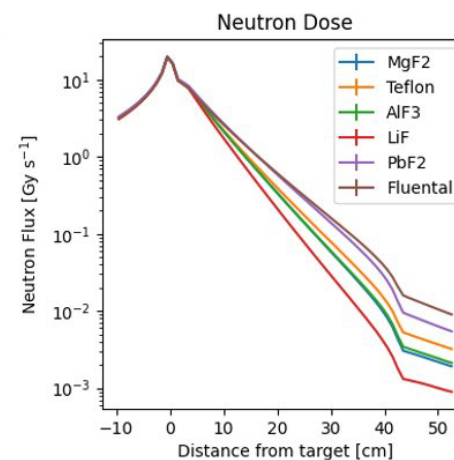
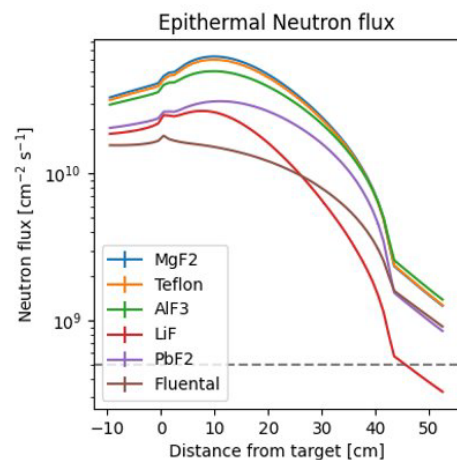
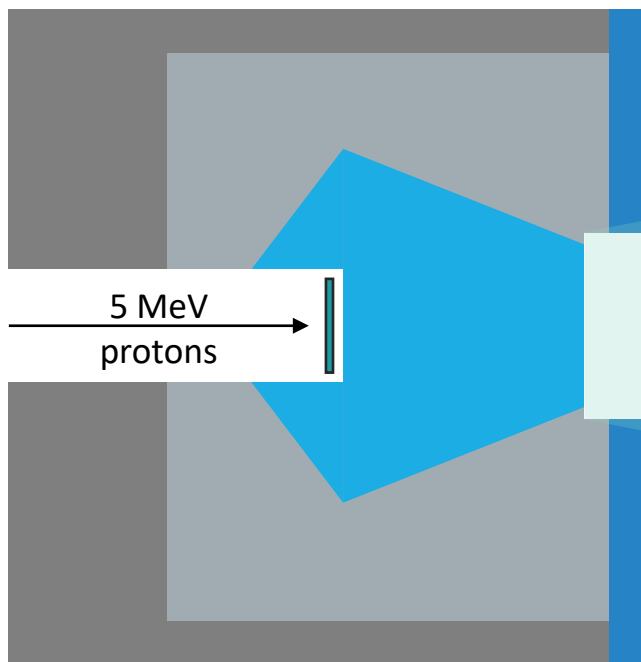
Hot Isostatic Pressing : Be foil + Pd foil  
+ Cu disk

Additive manufacturing: helicoidal  
cooling channels 3D printed  
EBW of case and vacuum pipe





# The Beam Shaping Assembly





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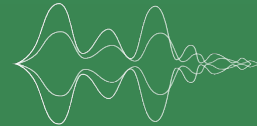


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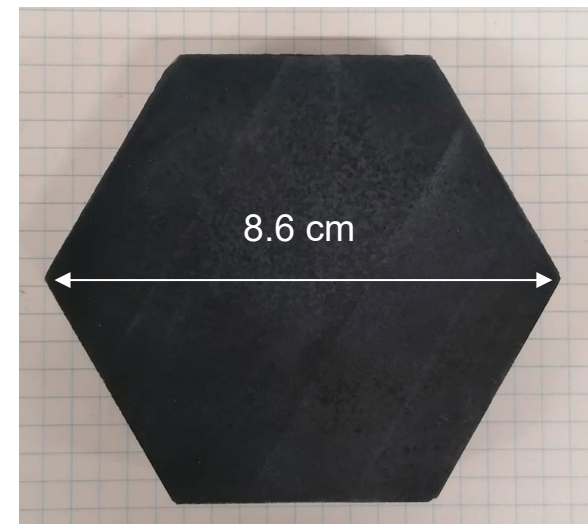
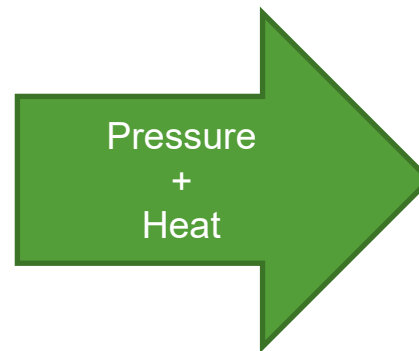
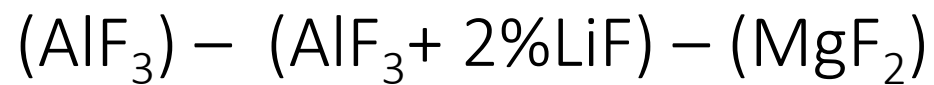


Anthem

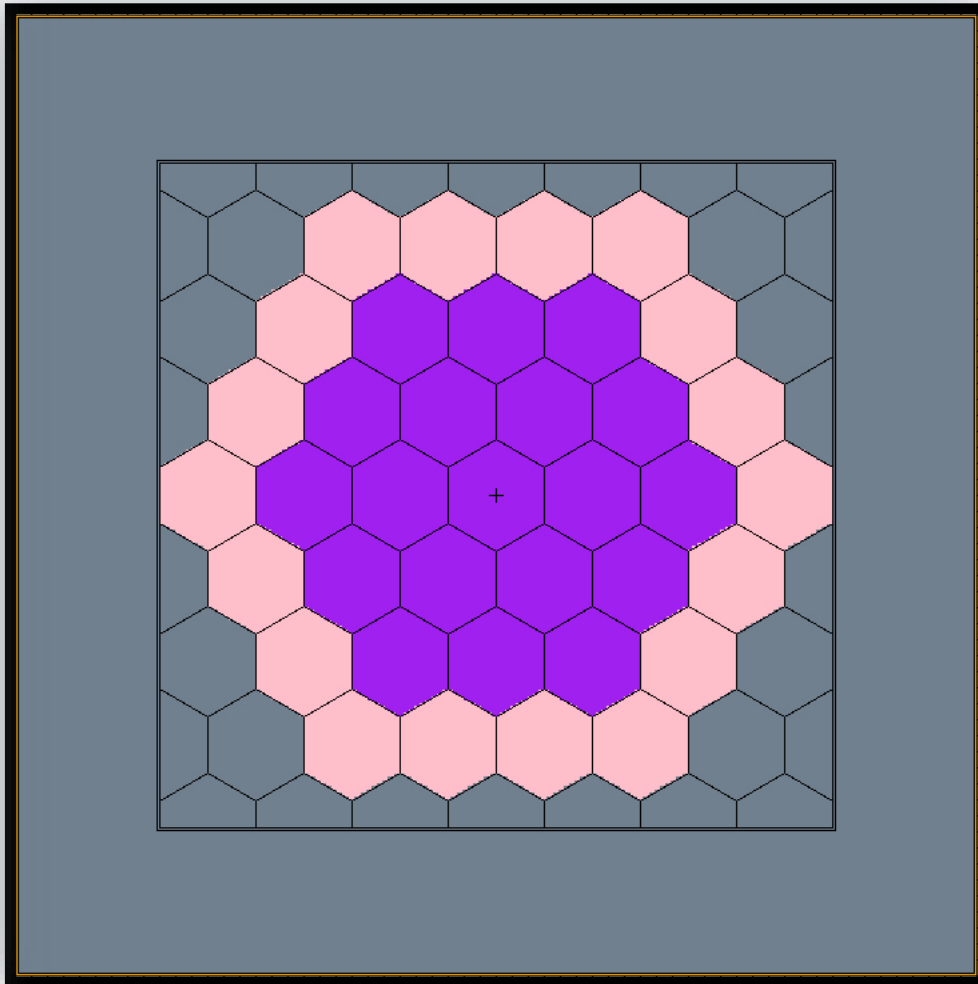
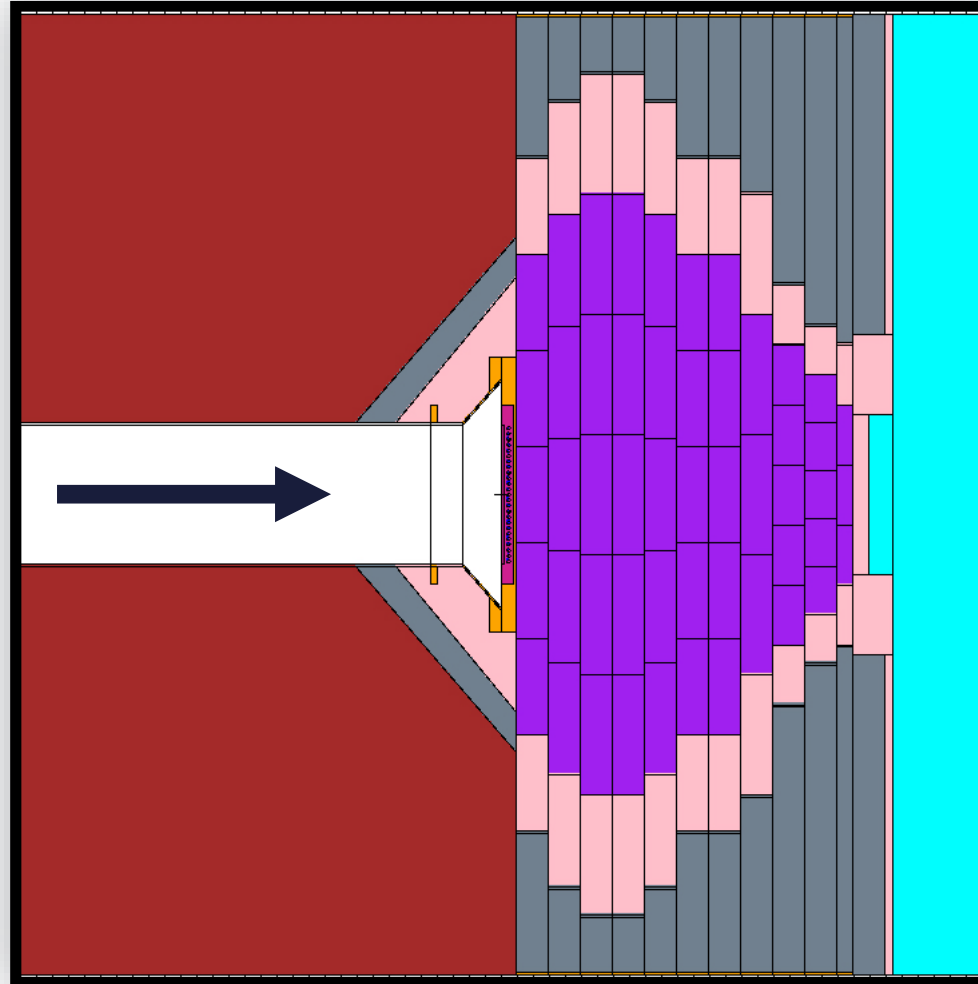
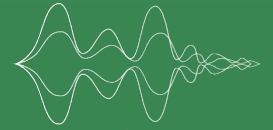
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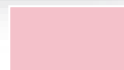
**ISINTER**



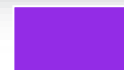




Polietilene Borato



Piombo



AlF<sub>3</sub>+LiF





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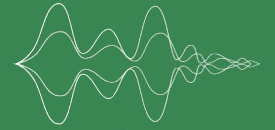


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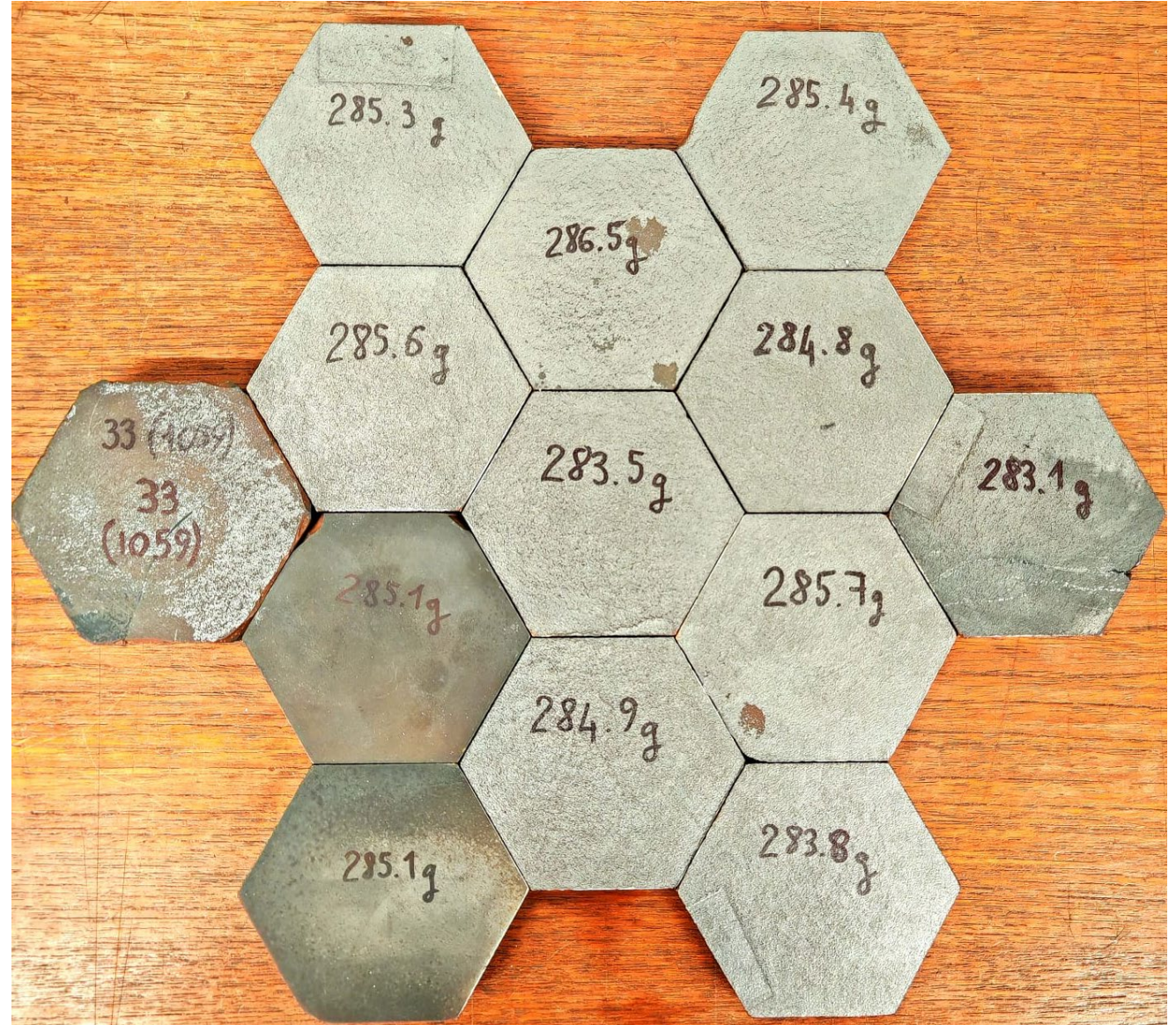
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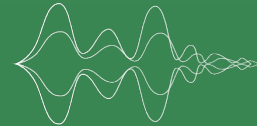


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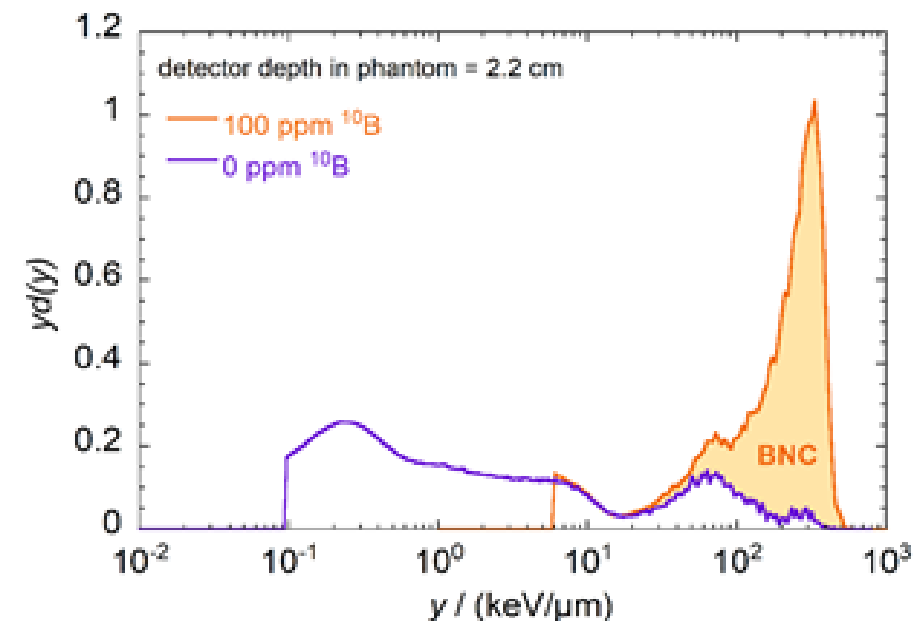


## BNCT Microdosimetry

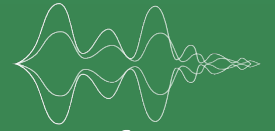


mini-TEPC  
(Tissue Equivalent Proportional Counters)

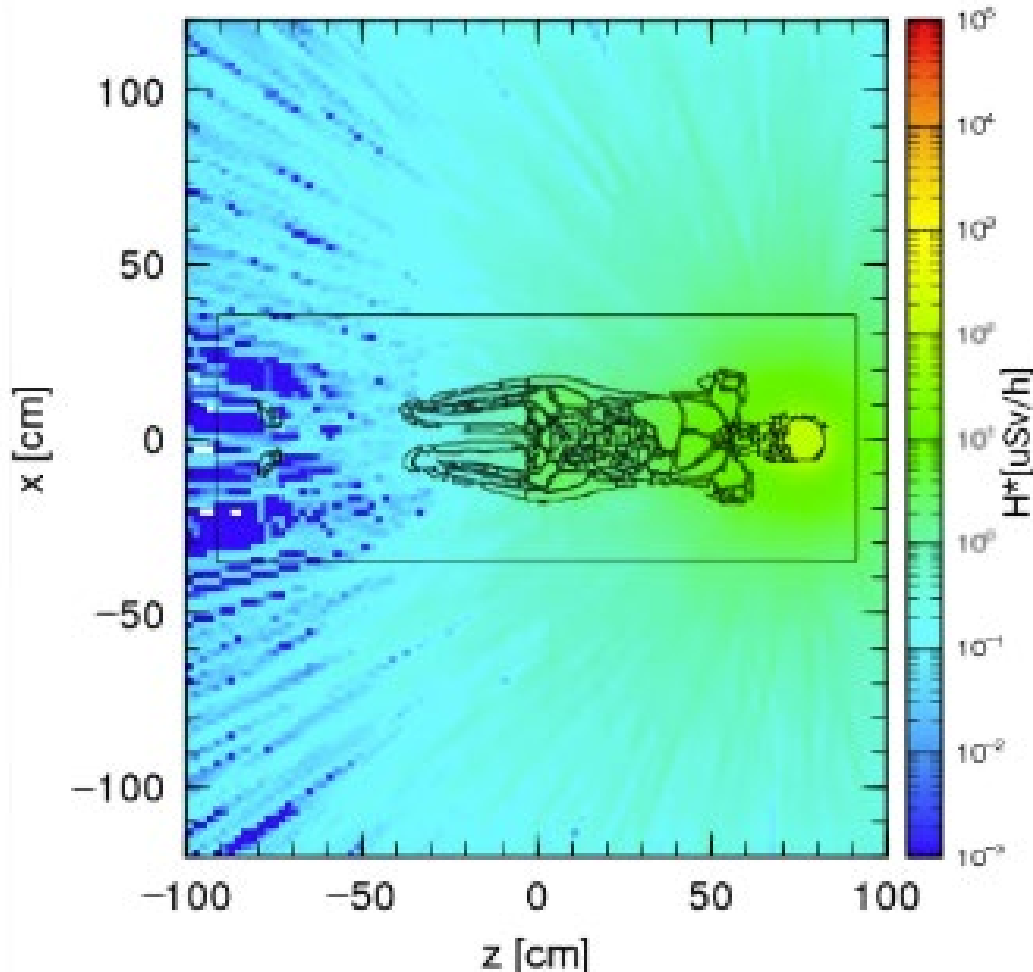
Bridging the gap between the physical characteristics of radiation and its biological effects



Analyse the quality of the beam and the characteristic of its interaction at sites with the size of a cell. **High innovation potential in BNCT dosimetry and treatment planning!**



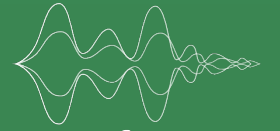
# BNCT Radioprotection aspects: patient activation



Ambient dose due to the activation of a patient treated with BNCT.

Results, compared to ambient dose for treatment with 600 MBq of I-131, confirm the potential for early patient discharge, possibly as soon as 15 minutes after treatment.

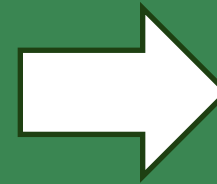




## Deepening the dose-effect relation in BNCT



New boron carriers  
New boron imaging methods  
New biological assays  
New biological models



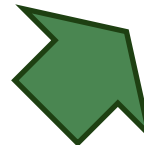
Input for models  
of photon-equivalent  
dose, TCP, NTCP



Photon Isoeffective Dose model

Microdosimetry

Artificial Intelligence methods in treatment planning



Towards more effective  
BNCT treatment planning



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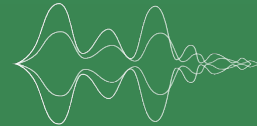


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Piano nazionale per gli investimenti  
complementari al PNRR  
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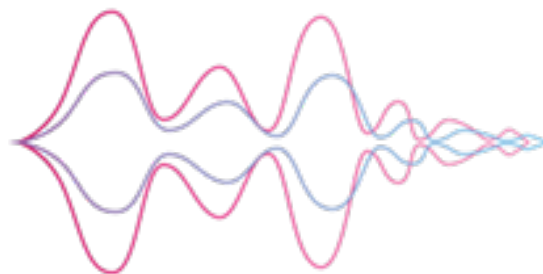


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Hope

is the only  
thing stronger  
than fear



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Grazie