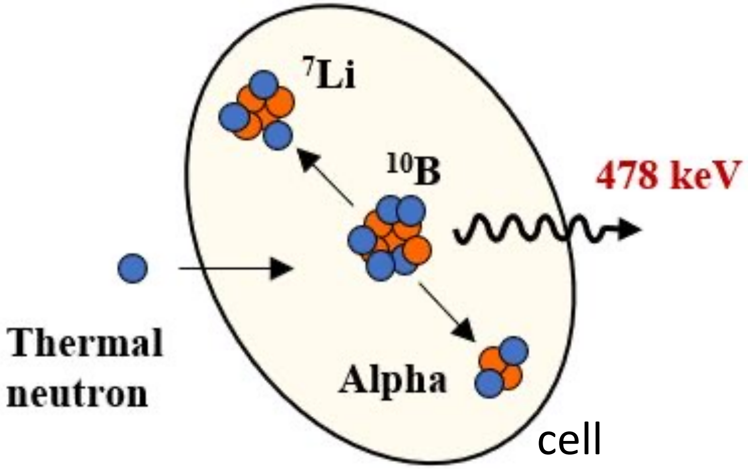
SPOC

SPect for Online boron dose verification in bnCt

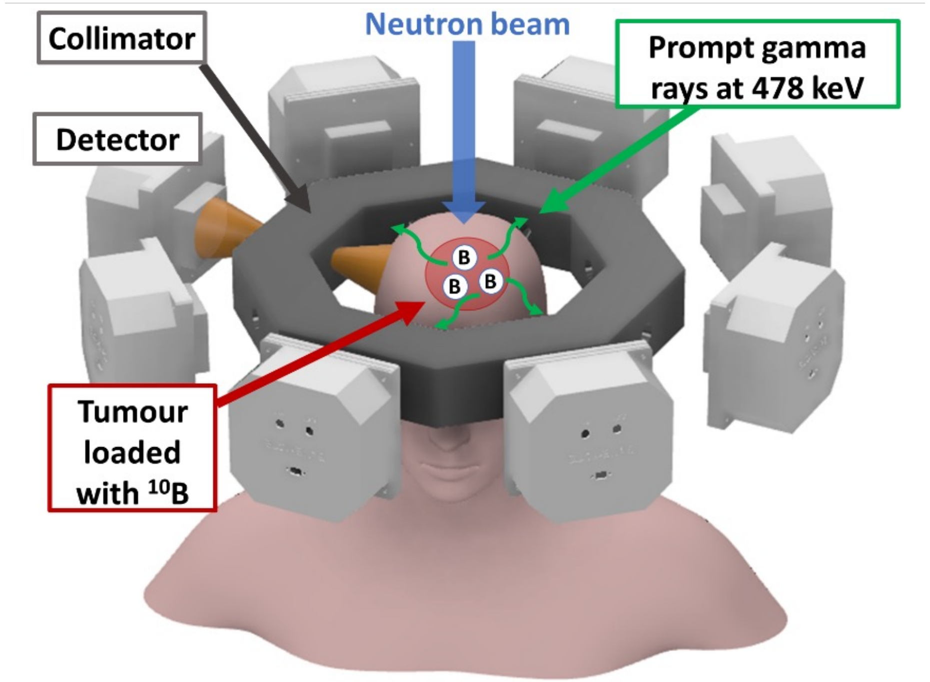
(2024-2026)

GOAL: dose verification in BNCT by online imaging of ^{10}B-capture prompt-gamma rays



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

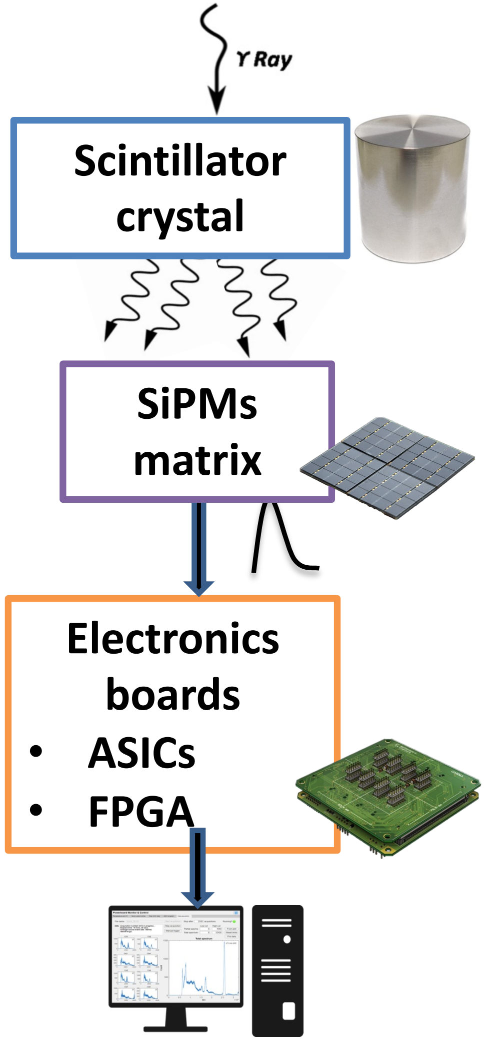
Detection of emitted **478keV gamma photons** to estimate ^{10}B neutron captures and support therapeutic outcome (personalized dosimetry).



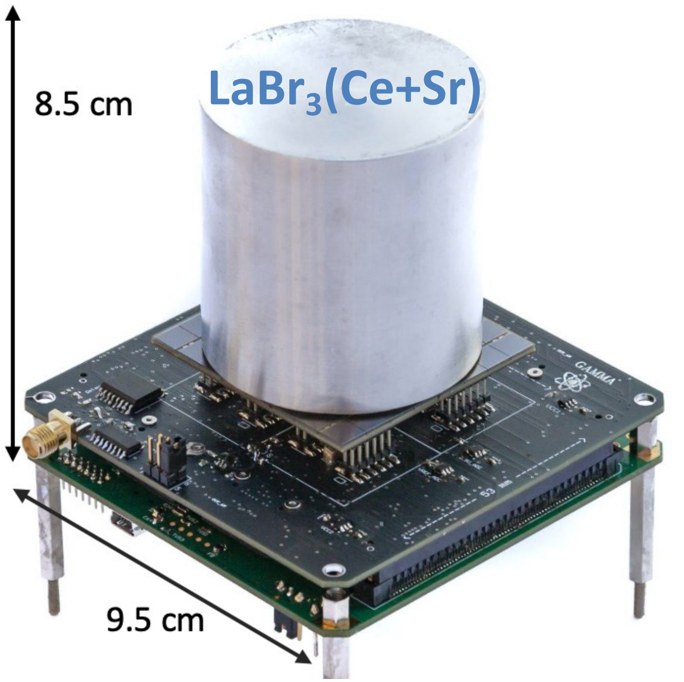
SPECT main specifications:

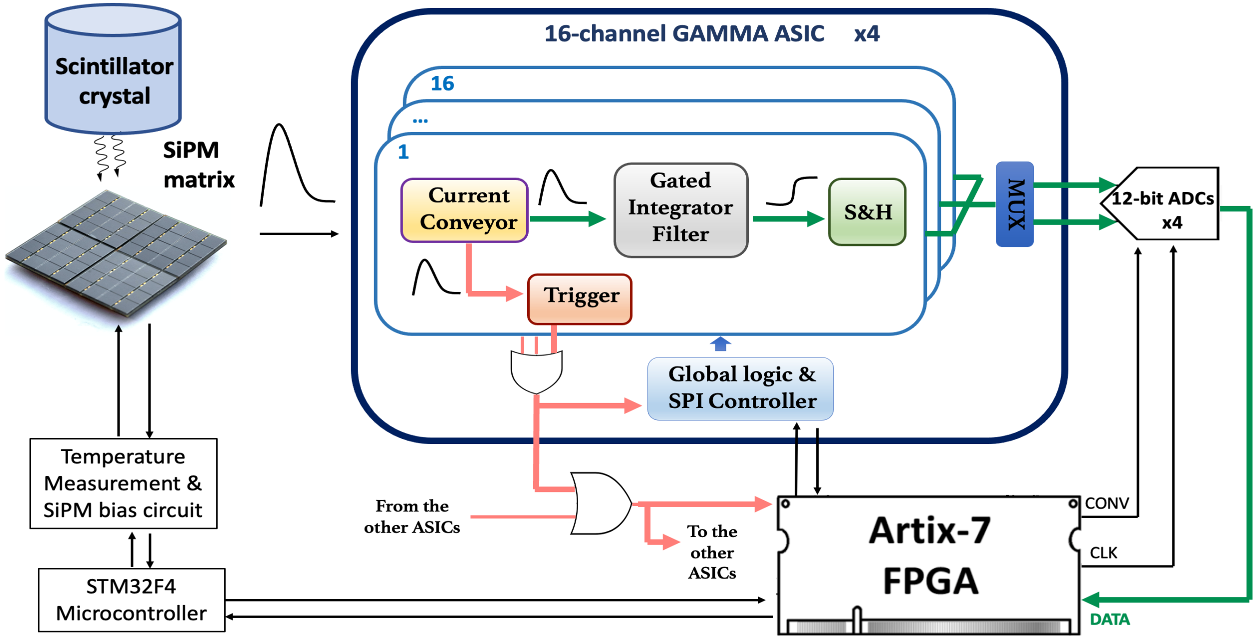
- Good efficiency and energy resolution at 478keV (to separate it from 511keV annihilation photons)
- Spatial resolution: 5-10mm (limited by the collimator)
- Possibly, extended efficiency up to 2.2MeV (H-capture) for neutron flux estimation

The SPECT gamma-ray detector



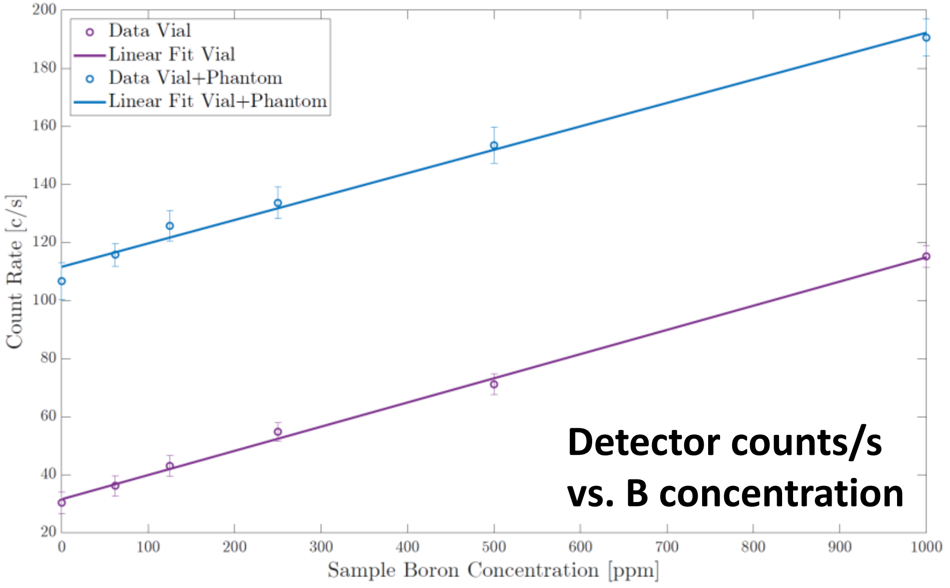
Gamma-ray detection module, based on a 2" **$LaBr_3$(Ce+Sr)** scintillator crystal optically coupled with a matrix of 8x8 **SiPMs**. The SiPMs are read out by 4 custom 16-channels **GAMMA ASICs** and the data acquisition is managed by an **FPGA**.

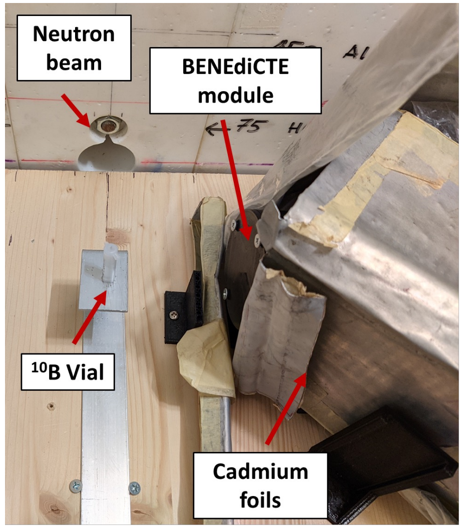




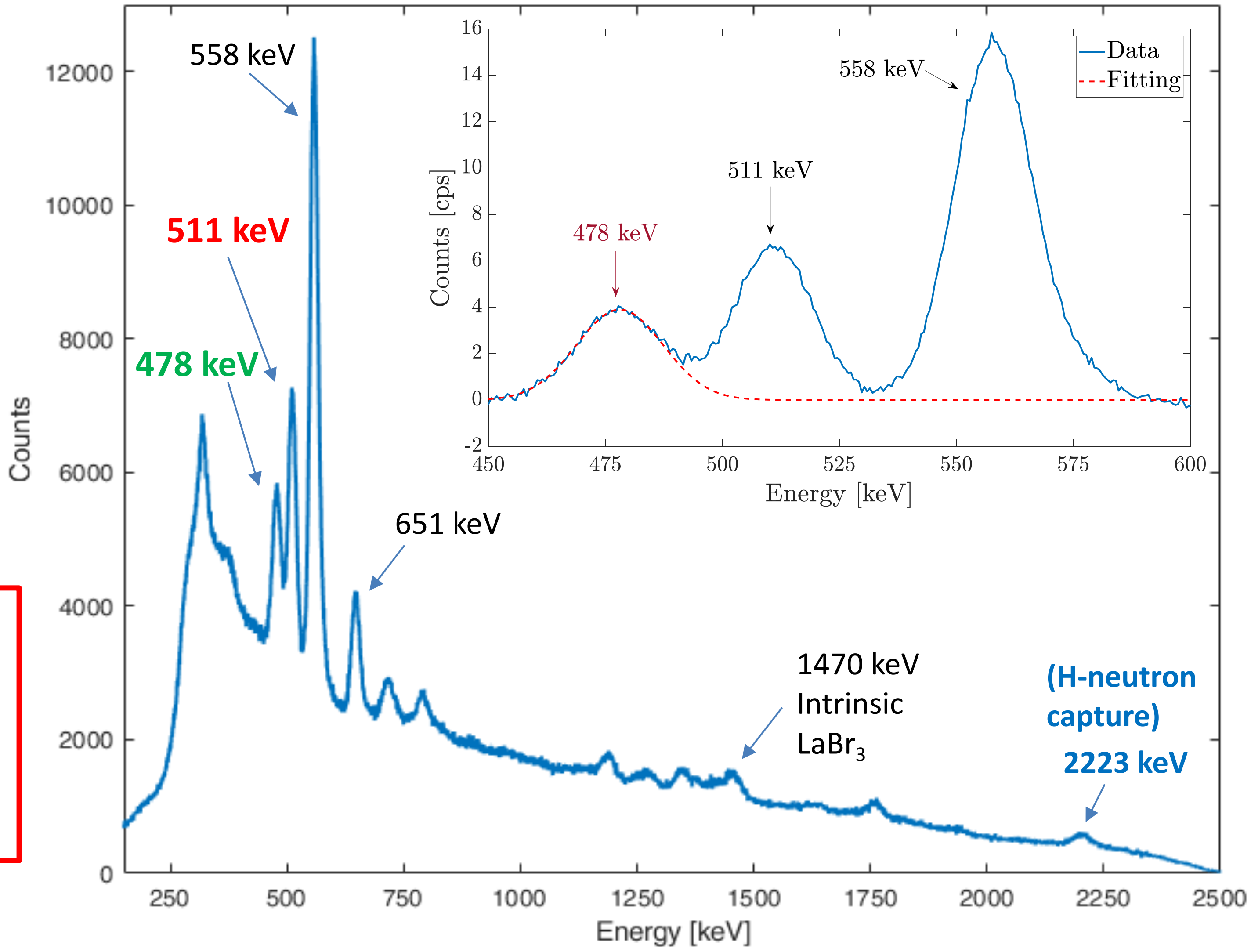
***Ref :** Caracciolo, Anita, et al. "BeNEdiCTE (Boron NEutron CapTurE): a Versatile Gamma-Ray Detection Module for Boron Neutron Capture Therapy." IEEE Transactions on Radiation and Plasma Medical Sciences (2022)*

Preliminary single-detector measurements at LENA reactor in Pavia



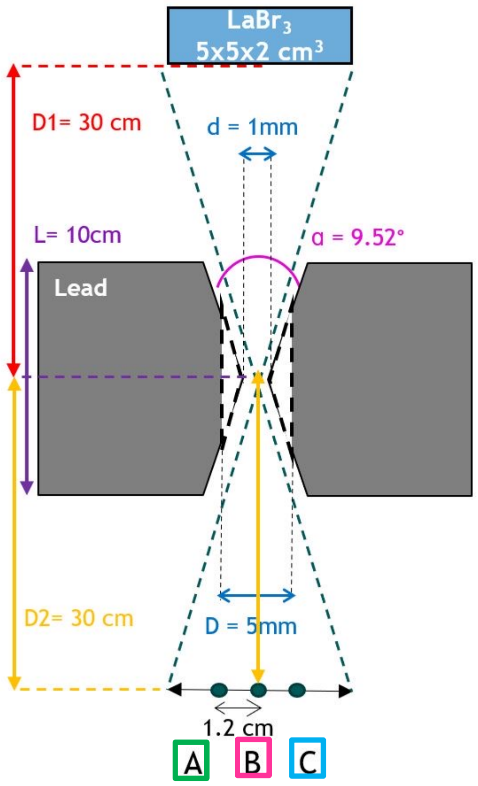


- Capability to identify 478keV γ-rays demonstrated!
- B-concentration down to 65ppm measured!



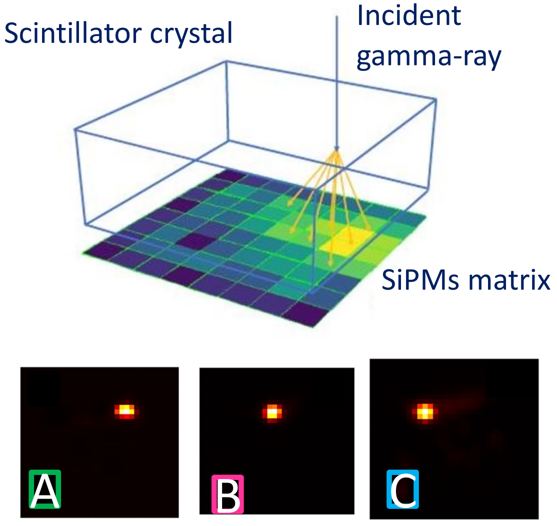
SPECT development: collimator geometry and event recontruction by Neural Network

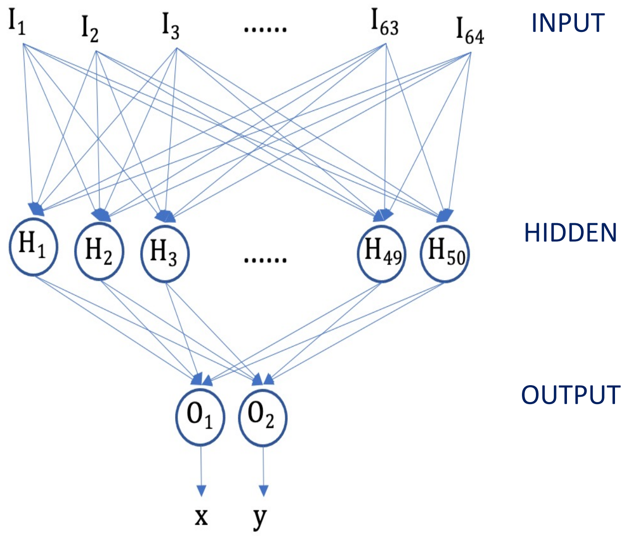
Channel edge pinhole collimator



Artificial Neural Network

- Input: SiPMs signals
- Output: x and y coordinates





- ➢ The **training** of the network was performed by scanning in 320 positions the crystal surface with a 1mm collimated ^{137}Cs source (662 keV)
- ➢ The **ANN** is able to reconstruct the position of a ^{137}Cs source in measurements acquired with the pinhole collimator with a spatial resolution of **3.25 mm**

SPOC: project structure, milestones and timetable

WP1 (INFN-MI): Simulation of **neutron fields and gamma+neutron fluxes on the detector**; computational study of **shieldings** and collimators; **simulation of the SPECT scanner**.

WP2 (INFN-MI): **Development of the SPECT prototype**: gamma-ray detectors, electronics, collimators, mechanics.

WP3 (INFN-BA): BNCT-dedicated **tomographic reconstruction**

WP4 (INFN-PV): **Beam tests** at nuclear reactor and with **accelerator-based BNCT sources** (Birmingham, Helsinki)

Month:	1-3	3-6	7-9	10-12	13-15	16-18	19-21	21-24	25-27	28-30	31-33	34-36
WP1: Simulations of neutron fields, shieldings, scanner geometry				M1		M5		M6				
WP2: Development of the SPECT system: detectors, electronics, collim				M2						M8		
WP3: BNCT dedicated tomographic reconstruction				M3				M7				
WP4: Beam tests at nuclear reactor and with accelerator-based sources				M4								M9

Milestones:

M1 (12m): Simulations of irradiation fields as well as signal and background on the detector.

M2 (12m): First prototype of the detector ready, including subcomponents for the detector procured (scintillator, SiPMs, ASICs) and DAQ system.

M3 (12m): First release of the Tomography reconstruction algorithm.

M4 (12m): Characterization of neutron beam at UNIPV LENA PGNAA facility using neutron activation measurements and Bayesian unfolding methods.

M5 (18m): Conclusion of shieldings studies and procurement.

M6 (24m): Simulations of the optimized SPECT scanner geometry.

M7 (24m): Tomography reconstruction algorithms ready.

M8 (30m): Development of further detector modules (up to 4 additional modules) concluded. Construction of SPECT prototype system concluded.

M9 (36m): Results from beam tests of the prototype in accelerator-based neutron sources. Final release of the BNCT-specific reconstruction algorithm.

SPOC: organization and costs

Partecipanti

Milano	
G.Borghi (**RN**, RTDb)	60%
C.Fiorini (PO)	20%
A.Caracciolo (PhD)	100%
A.Bourkadi Idrissi (PhD)	100%
D.Mazzucconi (Post Doc)	20%
S.Agosteo (PO)	20%
D.Bortot (RTDb)	20%
A.Pola (PO)	20%
Pavia	
N.Protti (**RL**, PA)	40%
V.Pascali (PhD)	100%
Bari	
G.Pugliese (**RL**, PA)	30%
G.Iaselli (PO)	30%
D.Ramos (Post Doc)	30%
N.Ferrara (PhD)	30%
TOT.	**6.2 FTE**

Costi: 2024

Milano	
Missioni	**2,0**
(missioni LENA 0.5k, missione Birmingham 1.5k)	
Inventario	**19,5**
(Scintillatore LaBr3 quadrato 50x50x20, 13k)	
(PC per simulazioni FLUKA 2.5k)	
Consumo	**30,0**
(Tiles SiPMs 9k, PCBs 4.5k, Componenti 5k, FPGA 2k, Setup 1k, Cavi 2k, Meccanica 3k, Collimatore 1.5k, Schermature 2k)	

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

Bari	
Missioni	**3,0**
(missioni LENA 1.0k, missioni Milano 1,0k)	
Consumo *(test setup tomografico)*	**5,0**

TOT. **73.0k**

Costi: 2025+2026

Inventario:	**35k**
Consumo:	**40k**
Servizi:	**10k**
Missioni:	**11k**
Tot:	**96k**

(MI+PV+BA)

Partecipanti

N.Protti (**RL**, PA)	40%
V.Pascali (PhD)	100%
TOT	1.4 FTE

Costi (k€): 2024

Missioni	**0,5**
(missioni @Bari)	
Consumo	**10,0**
(Dispositivi e rivelatori per caratterizzare il fascio di neutroni)	7,0
(Altro consumo per allestire setup misura al LENA)	3,0
Servizi	**3,0**
(Beam time al LENA)	
TOT	**13,5**

Richieste servizi:

0.5 mese servizi officina

0.5 mese servizi elettronica