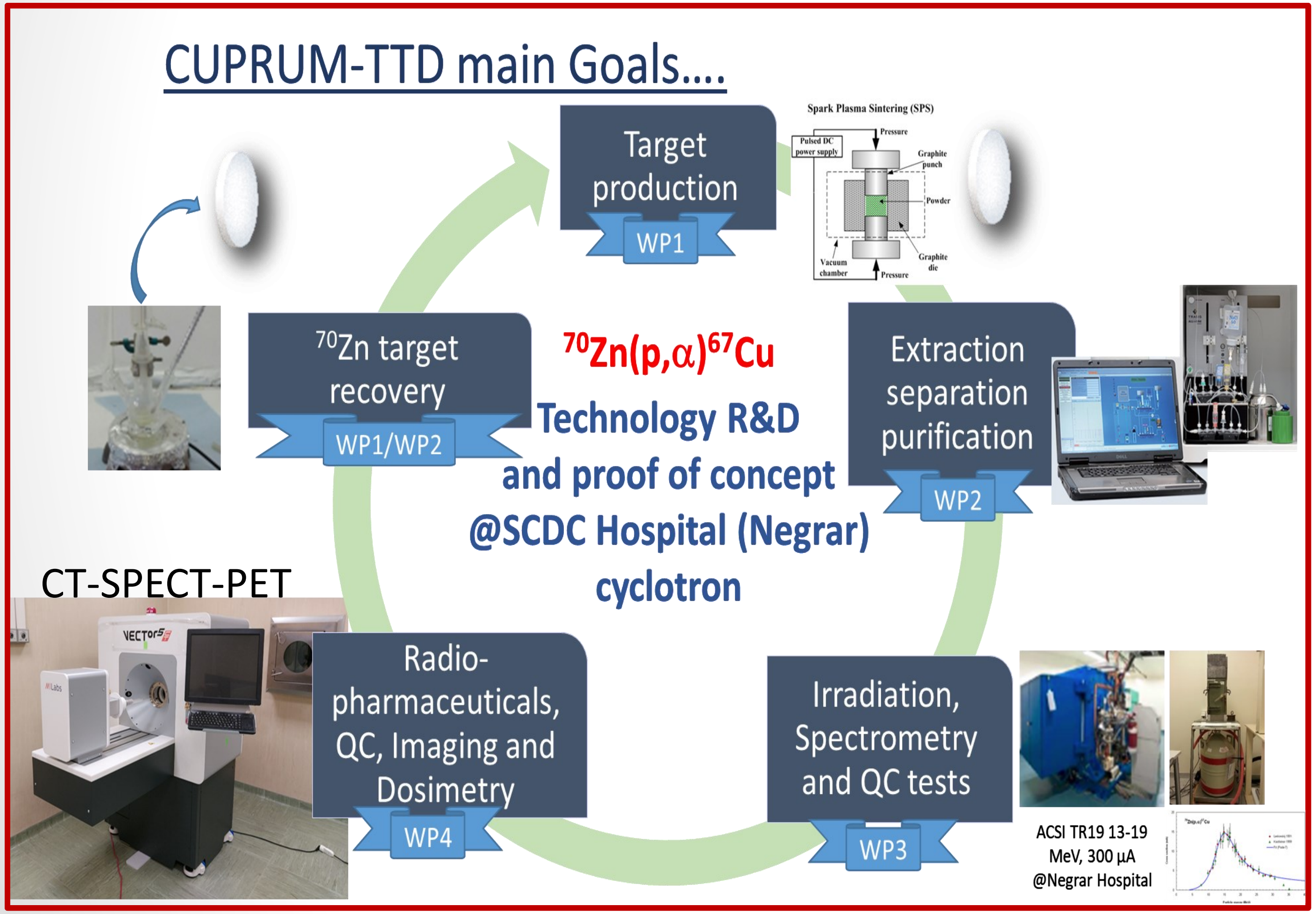
CUPRUM-TTD (2023-25)

Planned activities and Budget Requests 2025

$^{67/64}$CU PRoduction and Use in Medicine – Target Technology Development

CUPRUM-TTD (2023-2025) main project goals

To develop a reliable technology aimed at producing clinical-grade batches of ^{67}Cu- ^{64}Cu by small medical cyclotrons on a routine basis.



a) to acquire a **robust and reliable target manufacturing technology to produce ^{70}ZnO target**

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

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

d) *in-vitro* cells studies with **^{67}Cu-labelleded RPs using NOTA derivate as chelating agent;**

e) **phantom imaging studies of produced ^{67}Cu with pre-clinical and clinical SPECT;**

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

CUPRUM-TTD project organization

CUPRUM-TTD project is organized in Work Packages (WP),interacting each-other in a synergic way

CUPRUM-TTD project
(Juan Esposito)

WP1
Target manufacturing
INFN-LNL/UNIPV
(Sara Cisternino)
- Target R&D and design
- Target manufacturing @ UNIPV
- Target material recovery

WP2
Radiochemistry processing
INFN-FE/SCDCH
(Petra Martini)
- Radchem separation/purification procedure @UNIFE
- Automation @SCDCH Negrar
- QC tests

WP3
Irradiation/spectrometry/QC tests
INFN-LNL/SCDCH/UNIPD/INFN-PD/UNIMI/INFN-MI
(Liliana Mou)
- Target Irradiations tests @TR19 cyclotron SCDCH
- γ-spectrometry analyses @SCSCH
- xs measurements with alpha beams

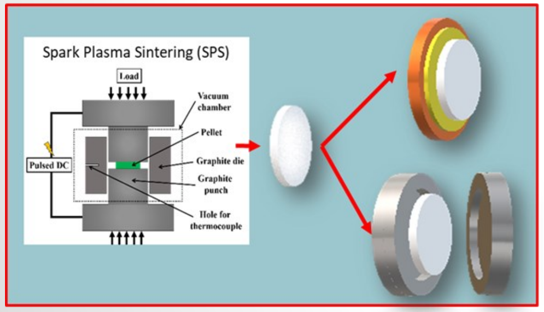
WP4
RPs, QC, Imaging and Dosimetry
IOV/UNIPD/INFN-PD/ICMATE-CNR/UNIFE/INFN-FE
(Laura de Nardo/Laura Melendez)
- synthesis of NOTA-PSMA conjugates @ ICMATE-CNR
- Radiolabelling studies @LARIM
- Image quality @Negrar Hospital (Padua University Hospital)

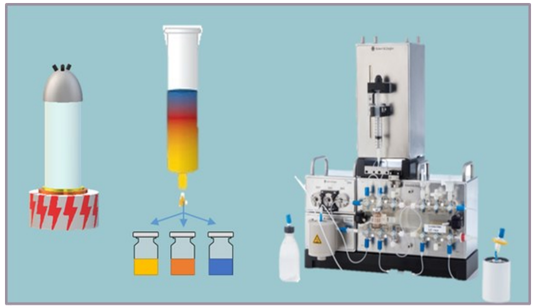
WP1	
Sara Cisternino Juan Esposito Alisa Kotliarenko Giorgio Keppel	LNL
Umberto A. Tamburini	UNIPV

WP2	
Petra Martini Alessandra Boschi Francesca Porto Teresa Ghirardi Licia Uccelli Lorenza Marvelli	INFN-FE UNIFE
Emiliano Cazzola Giancoarlo Gorgoni	HSCDC

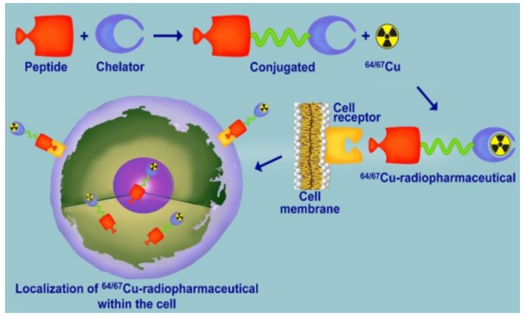
WP3	
Liliana Mou Gaia Pupillo Juan Esposito	LNL
Emiliano Cazzola Giancarlo Gorgoni	HSCDC
Luciano Canton Francesca Barbaro Lucia De Dominicis	UNIPD INFN-PD
Flavia Groppi Simone Manenti Fiorella M. Cagnetta Michele Colucci	UNIMI INFN-MI

WP4	
Laura De Nardo/ **Laura Melendez-A.**	INFN-PD IOV
Alessandra Zorz Marta Paiusco	IOV
Michele Bello Diego Cecchin	UNIPD INFN-PD
Cristina Bolzati	ICMATE CNR
Giov. Di Domenico Angelo Taibi	UNIFE INFN-Fe

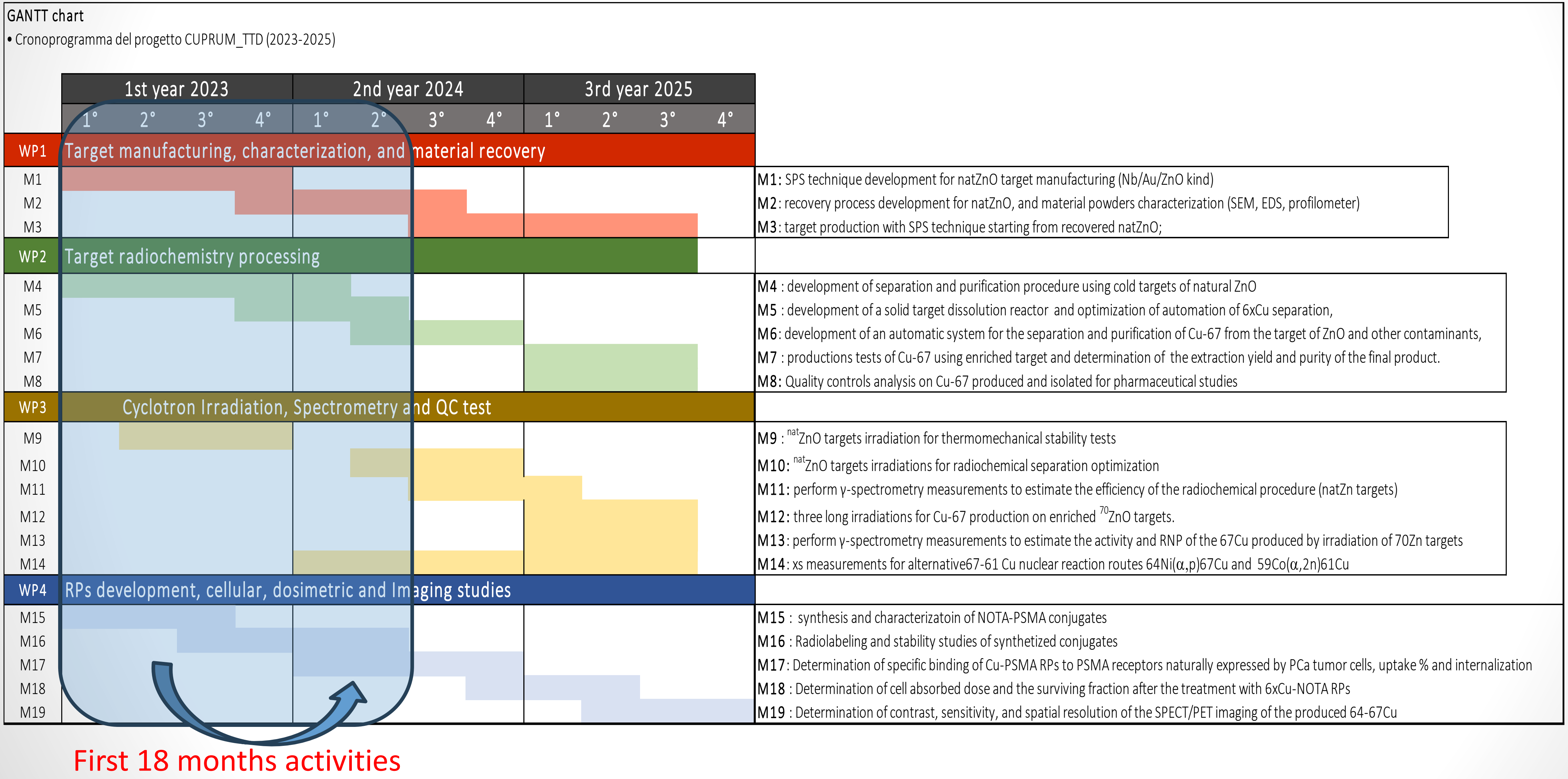





ACSI TR19/300
(13-19) MeV, 300 μA
@Negrar Hospital



CUPRUM-TTD Timetable and milestones planned



Resume on R&D activities performed (as of June 2024)

CUPRUM-TTD WP1 (LNL+FE): Target manufacturing, characterization, and material recovery

	1st year 2023				2nd year 2024				3rd year 2025			
	1°	2°	3°	4°	1°	2°	3°	4°	1°	2°	3°	4°
WP1	Target manufacturing, characterization, and material recovery											
M1												
M2												
M3												

D1: no. 2-3 ZnO targets for surface analyses investigations (WP2);
D2: no. 5 ZnO targets for cold test chemical processing optimization (WP2);
D3: 3 ^{70}ZnO targets for production test;
D4: recovered ^{nat}ZnO powders.

M1: SPS technique development for natZnO target manufacturing (Nb/Au/ZnO kind)
M2: recovery process development for natZnO, and material powders characterization (SEM, EDS, profilometer)
M3: target production with SPS technique starting from recovered natZnO;

Final Target material

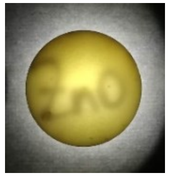
- **2.0 g [^{70}Zn]ZnO-enriched material already purchased** (~ 20$/mg) – 1 target 500 mg → ~ 4 targets manufacturing

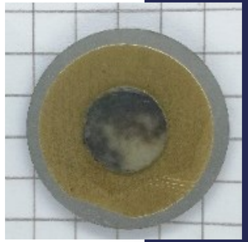
WP1	
Sara Cisternino	LNL
Juan Esposito	LNL
Alisa Kotliarenko	LNL
Gaja Piteo	UNIPD/LNL
U. Anselmi-Tamburini	UNIPV
Petra Martini	UNIFE
Alessandra Boschi	UNIFE
Francesca Porto	UNIFE
Giorgia Speltri	UNIFE
Lorenza Marvelli	UNIFE

Activities shared with WP2

Main activities

- ❑ **Target manufacturing:**





SPS technique

- Sintering of ZnO powder → pellet in a holder for irradiation
- Sintering of ZnO powder and target system investigation (ZnO/Au/Nb)

➢ **@ Pavia** (S. Cisternino and G. Piteo)
- Optimization of ZnO pellet sintering
- ZnO powder and pellets to Ferrara University for chemistry and **recovery studies (WP2)**
- ZnO pellets for irradiation with the **capsule & composite target (WP3)**
- ZnO – baking adhesion trials

- **@ LNL/UNIPD** (S. Cisternino, A. Kotliarenko, G. Piteo)
- SEM, XRD analysis and heat treatments for residual carbon removal

Magnetron Sputtering technique

- Investigation of thick ZnO deposition onto different substrates (Au/Nb – DLC)

A. Kotliarenko et al., First Results on Zinc Oxide Thick Film Deposition by Inverted Magnetro[n] Targets Production. Materials, 16, 10, 3810, 2023. DOI: 10.3390/ma16103810

Suspended activities because SPS technique is more promising at this stage of the project

- ❑ **Target recovery and recycling in collaboration with WP2**

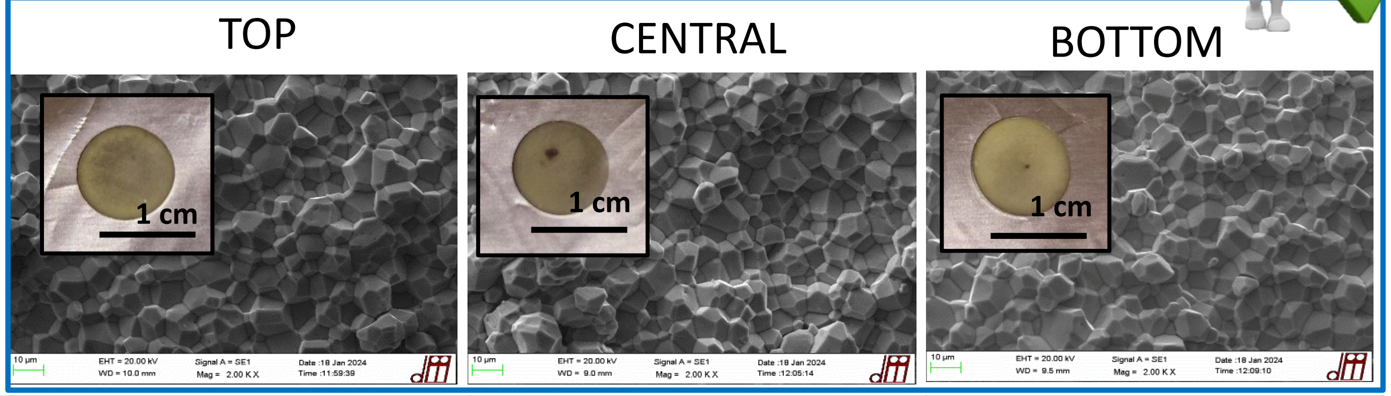
CUPRUM-TTD WP1 (LNL): ^{nat}ZnO pellets SPS R&D program underway

N of EXP	Mass [mg]	SPS parameters						Results				
		step	Temp. [°C]	Force [kN]	Pressure on sample [MPa]	Time [min]	Heating rate [°C/min]	mass after [mg]	mass lost [mg]	thickness [µm]	density [g/cm3]	%bulk density
(n=41)	263.9 ± 5.9	1	600	4	51	0,1	200	**255.9 ± 10.4**	**8.0 ± 7.8**	**612.4 ± 23.1**	**5.3 ± 0.1**	**95.0 ± 2.1**
		2	1000/850	5	64	10	10					
		3	300	5	64	0,1	20					
(n=3)	267.5± 1.2	1 2 3	600 850 300	4 5 5	51 64 64	0,1 10 0,1	200 10 20	**261.7± 0.6**	**5.7± 1.0**	**626.8± 2.0**	**5.3± 0.0**	**94.8± 0.2**

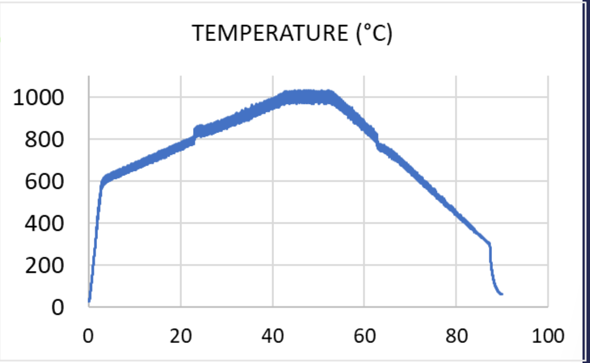
REPRODUCIBLE EXP

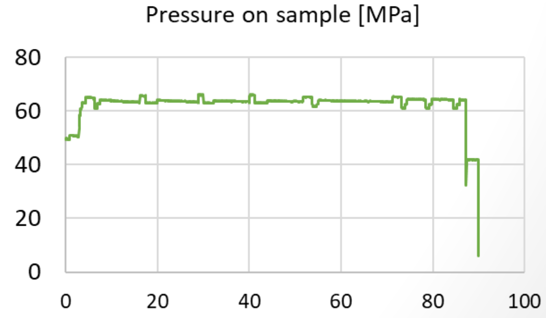
Sintering of 3 pellets at once (in series)

Cross-section view



Density [g/cm³] / % bulk (n=5)	5.31±0.09 / 94.7±1.6%	5.35±0.08 / 95.3±1.4%	5.29±0.09 / 94.4±1.6%





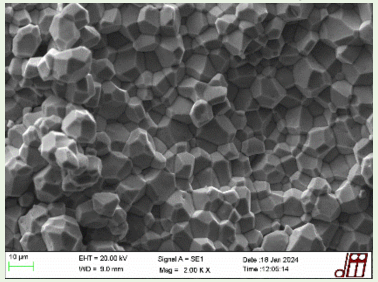
✓ Mass densities and the microstructure are compared to the one-pellet-sintered

CUPRUM-TTD WP1 (LNL):

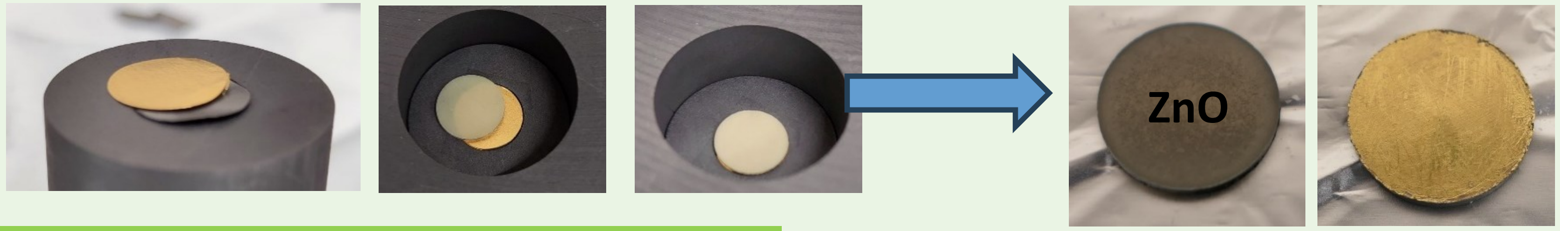
New target configuration - ZnO pellet bonding to backing (Au/Nb) by SPS

1.
ZnO pellet preparation

SEM cross section of pellet

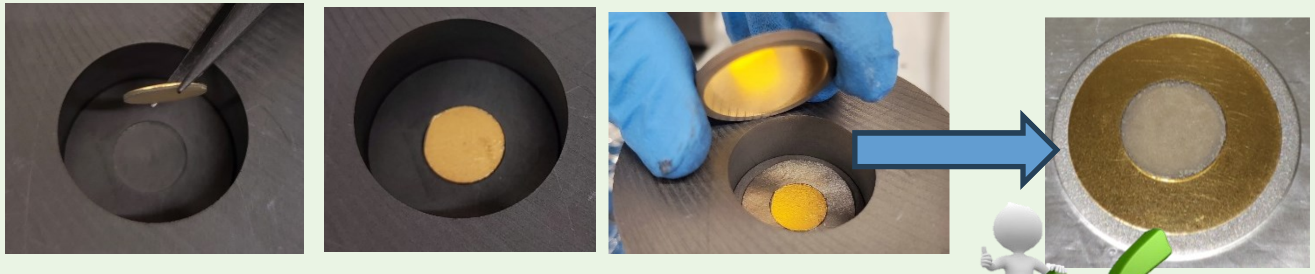


2.
Au-foil-layered ZnO pellet

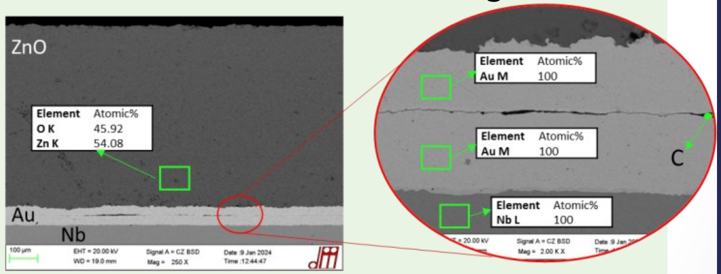


1+2 in one sintering process (3 sample simultaneously)

3.
Adhesion of ZnO-Au to backing (Au-Nb)



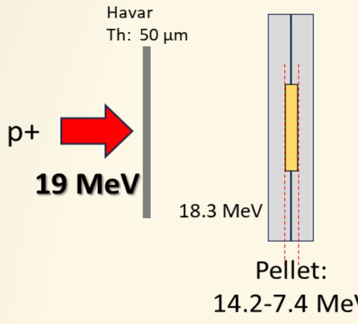
SEM cross section of target



#9 targets from ZnO commercial powder were already realized and tested under irradiation and used for radiochemical processes

CUPRUM-TTD WP1 (LNL+FE): Irradiations for thermomechanical test

Irradiation n. 2 CUPRUM_TTD→ pellet ZnO TT_179 (after HT)
Date: 27/09/2023 @ Negrar



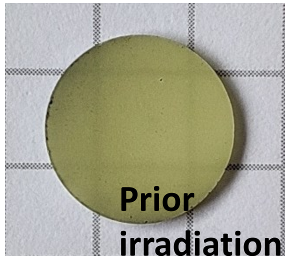
Power density on target system:
700 W/cm²

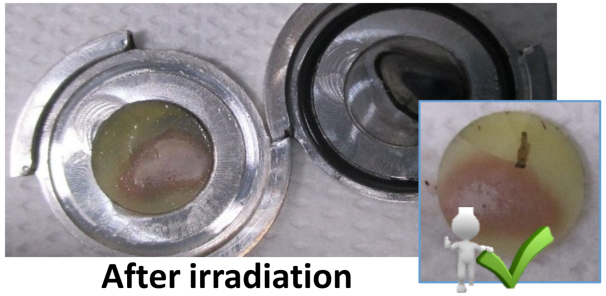
Power density on pellet:
260 W/cm²

#2 irradiations 15-30 µA; 19 MeV; 5 min

@ ACSI TR19/300 Sacro Cuore Don Calabria Hospital cyclotron

Pellet in Al holder configuration:

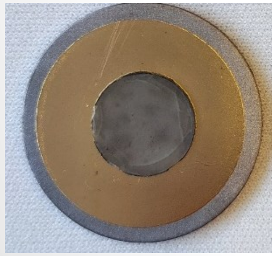

Prior irradiation

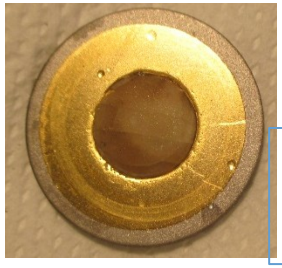

After irradiation

Main considerations
- Not easy to open the capsule
- The pellet is attached to the capsule;
- Energy on pellet 14 MeV, not optimal for ^{67}Cu production

System suitable when low radioactivity batches are needed for research purposes

ZnO-Au/Au-Nb configuration


Prior irradiation

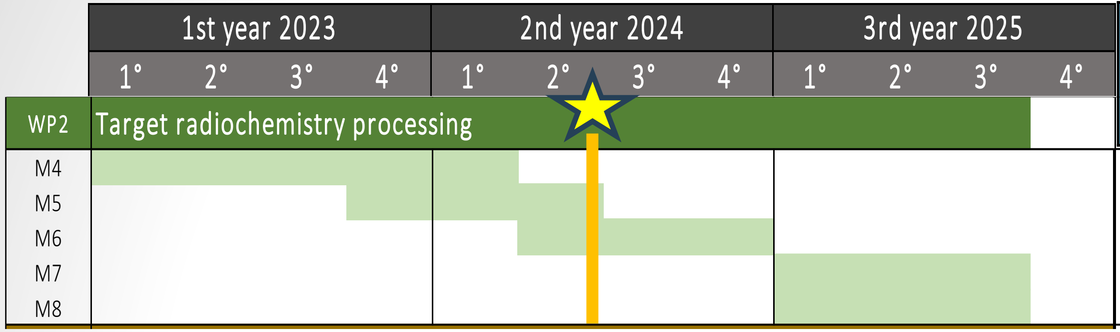

After irradiation

#4 irradiations 15-25-35-50 µA;
19 MeV; 5 min

Max beam power areal density achieved = 1.2 kW/cm²

- ✓ Targets manufactured by SPS LARAMED technology **withstand the maximum proton beam current intensity** available at SCDCH cyclotron (solid target station available)
- ✓ Several irradiation and radiochemistry dissolution/separation/purification tests were performed based upon this target configuration

CUPRUM-TTD WP2 (FE): Target radiochemistry processing

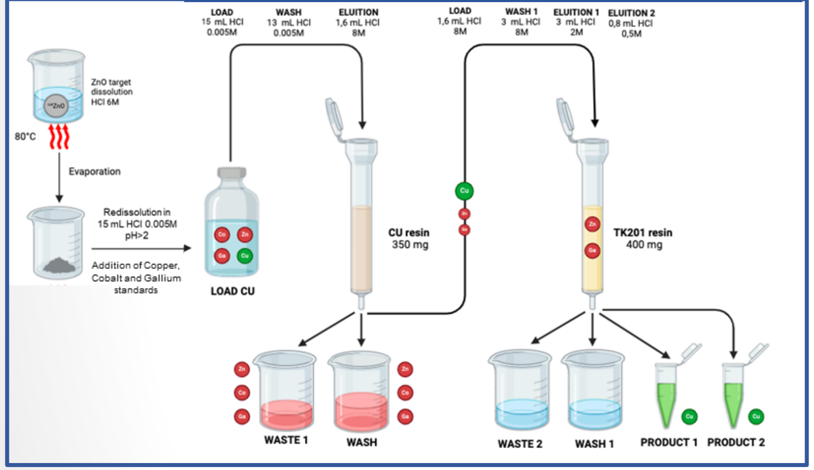


D5: Zn/Cu separation and purification procedure
D6: semi-automatic module for the separation and purification of ^{67}Cu from ZnO target
D7: ^{67}Cu radiochemistry product quality assessment

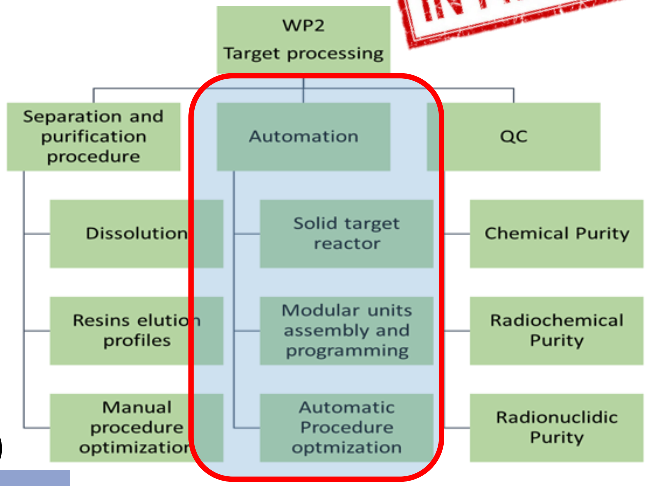
M4 : development of separation and purification procedure using cold targets of natural ZnO
M5 : development of a solid target dissolution reactor and optimization of automation of 6xCu separation,
M6: development of an automatic system for the separation and purification of Cu-67 from the target of ZnO and other contaminants,
M7 : productions tests of Cu-67 using enriched target and determination of the extraction yield and purity of the final product
M8: Quality controls analysis on Cu-67 produced and isolated for pharmaceutical studies

IN PROGRESS

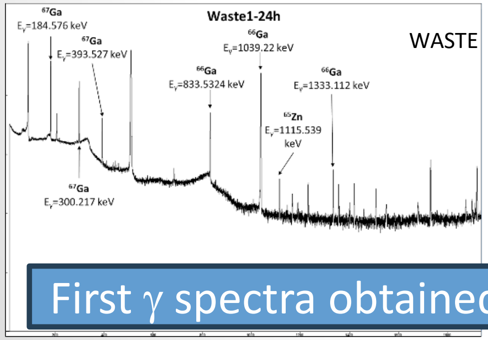
Cold tests for protocol optimization

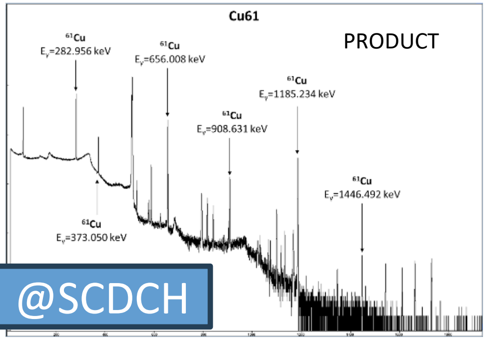


ICP-MS analysis revealed that in the final product **Ga, Co and Zn content is below the instrumental detection limit**.
Recovery yield >98% (reproducibility tests are ongoing)

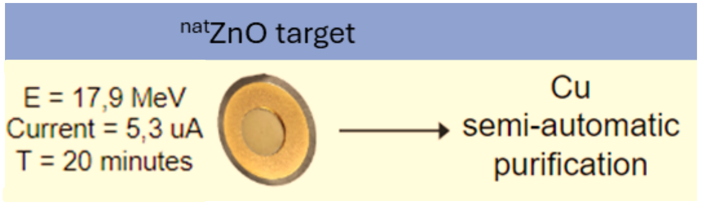


Hot test for validation and SEMI-automation





First γ spectra obtained @SCDCH



- ✓ **γ-spectrometry analysis** revealed that in the final product no Ga, Co and Zn radioisotopes are present
- ✓ Difficulties in the automation and reproducibility of the results due to old and incomplete module (valves not working properly, no gas/air flow control, no pressure control, syringe pumps not calibrated etc….) NOT SUITABLE FOR ENRICHED TARGET PROCESSING TEST
- ✓ Recovery yield ongoing determination

WP2	
Petra Martini	INFN-FE UNIFE
Alessandra Boschi	
Francesca Porto	
Licia Uccelli	
Lorenza Marvelli	
Giorgia Speltri	
Emiliano Cazzola	HSCDC

CUPRUM-TTD WP2 (FE): Target radiochemistry processing

	1st year 2023				2nd year 2024				3rd year 2025			
	1°	2°	3°	4°	1°	2°	3°	4°	1°	2°	3°	4°
WP2	Target radiochemistry processing											
M4												
M5												
M6												
M7												
M8												

D5: Zn/Cu separation and purification procedure
D6: semi-automatic module for the separation and purification of ^{67}Cu from ZnO target
D7: ^{67}Cu radiochemistry product quality assessment

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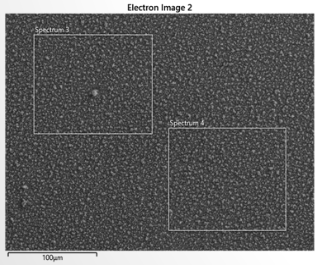
M5 : development of a solid target dissolution reactor and optimization of automation of 6xCu separation,
M6: development of an automatic system for the separation and purification of Cu-67 from the target of ZnO and other contaminants,
M7 : productions tests of Cu-67 using enriched target and determination of the extraction yield and purity of the final product.
M8: Quality controls analysis on Cu-67 produced and isolated for pharmaceutical studies

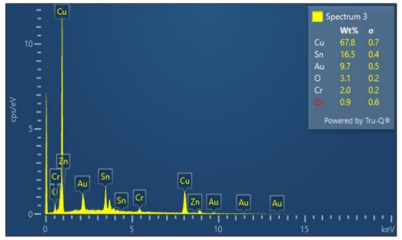
IN PROGRESS

New separation strategy

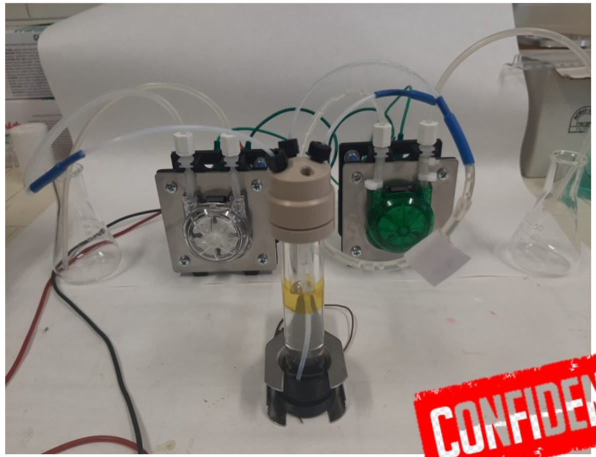
Proof of concept
- Chronoamperometry
- EDS + ICP-MS characterization

Electrode: Gold plated FTO substrate
Reference electrode: SCE
Mother solution: H2SO4 0.1M + ZnSO4 3mM + CuSO4 3mM
Copper deposition at different potentials





New setup for separation tests
- Electrolitic cell
- Electrode: backing Nb/Au
- Counter electrode: Pt



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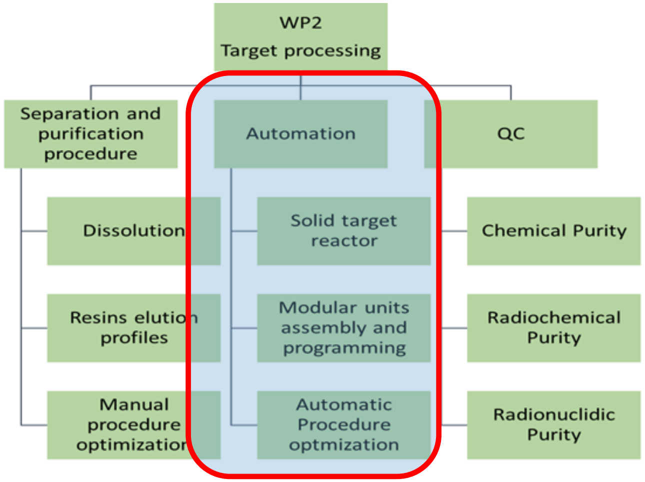


WP2	
Petra Martini	INFN-FE UNIFE
Alessandra Boschi	
Francesca Porto	
Licia Uccelli	
Lorenza Marvelli	
Giorgia Speltri	
Emiliano Cazzola	HSCDC

CUPRUM-TTD WP2 →support to WP1 (LNL+FE):
ZnO recovery processes – closing the Zn target material cycle

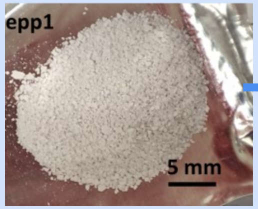
WP1 and WP2

ZnO recovery process steps performed in different conditions:
- Dissolution of pellet or powder in HCl or use of eluate from radiochemistry process
- Precipitation with NaOH at different temperatures
- Evaporation and final calcination

Optimization experiments and analysis of powders and targets still ongoing…

First results:

at 25°C (from pellet)

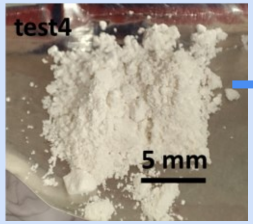


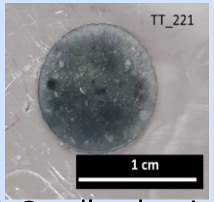
Sample 212

Cold dissolution planned for SEM analysis

ZnO pellet density ~ 95%

at 18°C (from pellet)

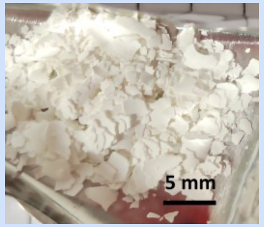




SEM analyses ongoing

ZnO pellet density ~ 95%

at 0°C (from powder)



Flakes→ evaporation condition to be optimized

at 0°C (from pellet)

Modified evaporation protocol

Recovery yield 84.8%±3.6%

Sample 247

irradiation and radiochemical purification planned

ZnO pellet density ~ 84%

at 0°C

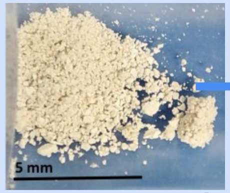
From Zn-rich eluate from radiochemical separation protocol (from powder)

Recovery yield 99%

ZnO pellet density ~ 55%

at 0°C

Starting material: Zn-rich eluate from radiochemical separation protocol (from pellet)→ simulation of real exp



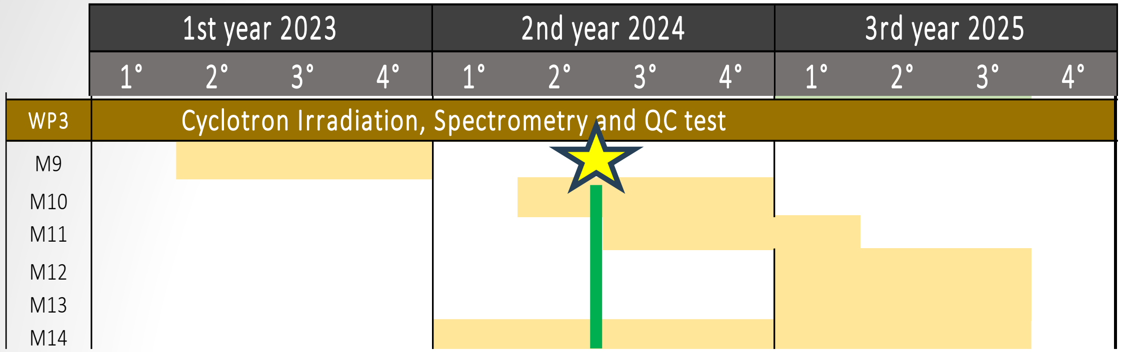
Recovery yield → to be optimized

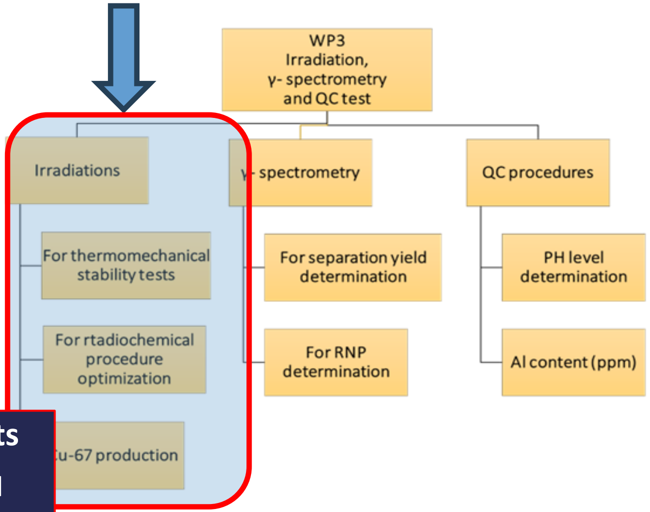
Sample 268

irradiation and radiochemical purification planned

ZnO pellet density ~ 65%

CUPRUM-TTD WP3 (LNL-MI-PD): Irradiation, γ-spectr. and QC test





WP3	
Liliana Mou Gaia Pupillo Lucia De Dominicis Juan Esposito	LNL
Emiliano Cazzola Giancarlo Gorgoni	HSCDC
Luciano Canton Yuliia Lashko Francesca Barbaro	UNIPD INFN-PD
Flavia Groppi Simone Manenti Fiorella M. Cagnetta Michele Colucci	UNIMI INFN-MI

Irradiation runs on $^{nat}ZnO/^{nat}Ni$ for targets and related spectrometry measurements

- selection of beam parameters suitable to yield small batches of ^{67}Cu/ ^{64}Cu based on theoretical calculations;
- ^{nat}-ZnO target irradiations for thermomechanical stability tests
- 3 irradiation runs on ^{70}ZnO for first batches of ^{67}Cu;
- 2-3 irradiations runs on ^{nat}Ni and ^{59}Co with alpha beams for $^{61,64,67}Cu$ optimization production (xs meas. @ARRONAX) UNIMI+INFN-Mi
- 2 irradiations runs on thick target of ^{64}Ni for TTY, RNP, SA det.
- γ-spectrometry analysis for yield and RNP determination

Production Route	Reaction	Natural Abundance (%)	Threshold ^{67}Cu (MeV)	Threshold ^{64}Cu (MeV)
ACCELERATOR	$^{64}Ni(\alpha,p)^{67}Cu$	0.925	4.93	23.49
	$^{70}Zn(p,\alpha)^{67}Cu$	0.61	0	23.83
	$^{70}Zn(p,X)^{67}Cu$	0.61	0	23.83
	$^{70}Zn(d,\alpha n)^{67}Cu$	0.61	0	26.42
	$^{68}Zn(p,2p)^{67}Cu$	18.45	10.12	7.9
	$^{68}Zn(\gamma,p)^{67}Cu$	18.45	0	0
	$^{68}Zn(d,^{3}He)^{67}Cu$	18.45	4.61	10.3
	$^{67}Zn(d,2p)^{67}Cu$	4.04	2.06	17.91
	$^{71}Ga(p,\alpha p)^{67}Cu$	39.89	5.32	23.19
REACTOR	$^{67}Zn(n,p)^{67}Cu$	4.04	0	17.66

Milestones and deliveries planned

M9: ^{nat}ZnO targets irradiation for thermomechanical stability tests

M10: ^{nat}ZnO targets irradiations for radiochemical separation optimization procedure

M11: γ-spectrometry meas. to determine radiochemical procedure efficiency ($^{nat}Zn/^{nat}Ni$ targets)

M12: 3 irradiations on **^{70}ZnO targets for ^{67}Cu batches** production (2 irradiations on **^{64}Ni targets for ^{64}Cu**).

M13: γ-spectrometry meas. to determine the activity and RNP of **^{67}Cu** produced by irradiation of **^{70}Zn** targets

M14 xs measurements for **alternative nuclear reaction route with alpha beams $^{64}Ni(\alpha,p)67Cu$** (energy range 30 – 15 MeV) as well as **$^{59}Co(\alpha,2n)^{61}Cu$**

D8: RNP determination of the produced **^{67}Cu** radionuclides from **$^{70}ZnO/^{64}Ni$**

D9: xs measurements determination with alpha beams for alternative **^{6x}Cu** productions

WORK IN PROGRESS

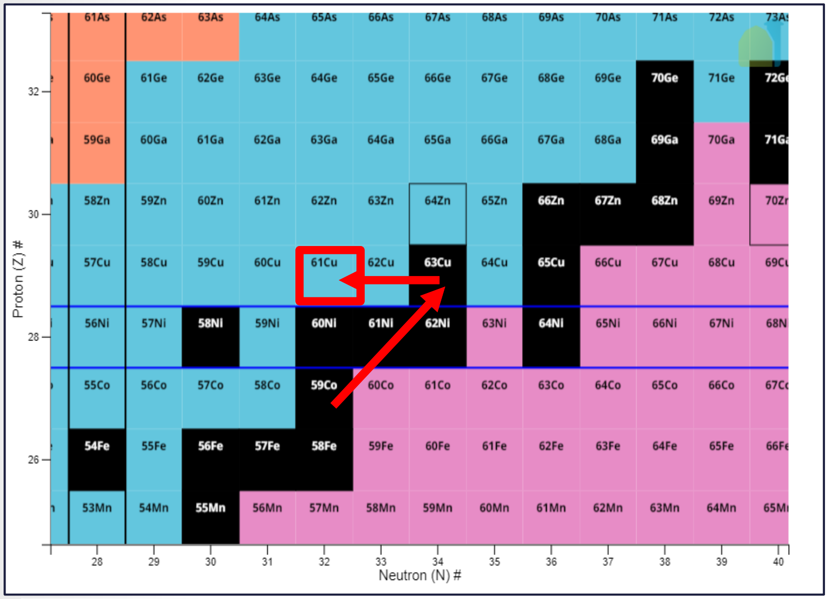
WORK IN PROGRESS

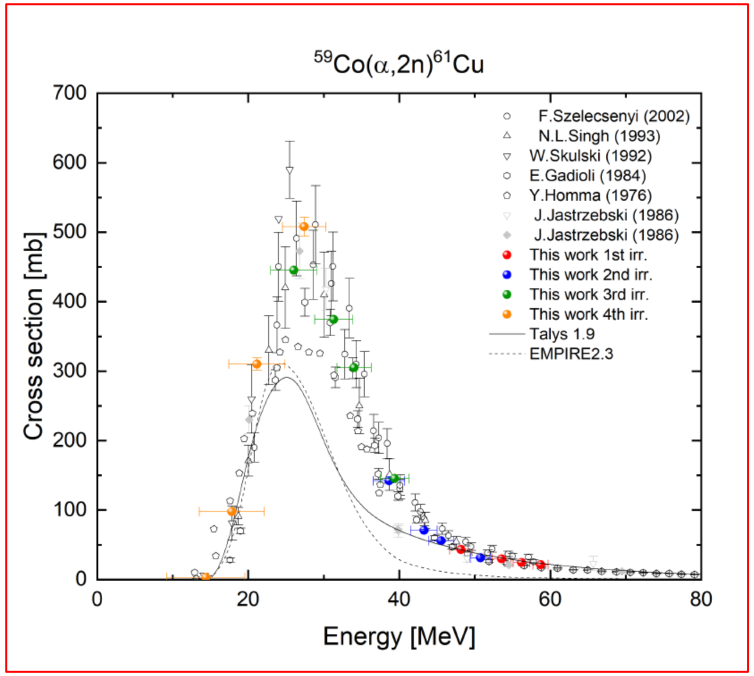
WORK IN PROGRESS

CUPRUM-TTD WP3 (MI): Investigations on alternative nuclear reaction routes with alpha beams $^{59}Co(\alpha,2n)^{61}Cu$

Four irradiation performed with α particles in the 14-59 MeV energy range at GIP ARRONAX.

Gamma spectrometry continued at LASA labs for 4/8 months after irradiations for long lived RN.

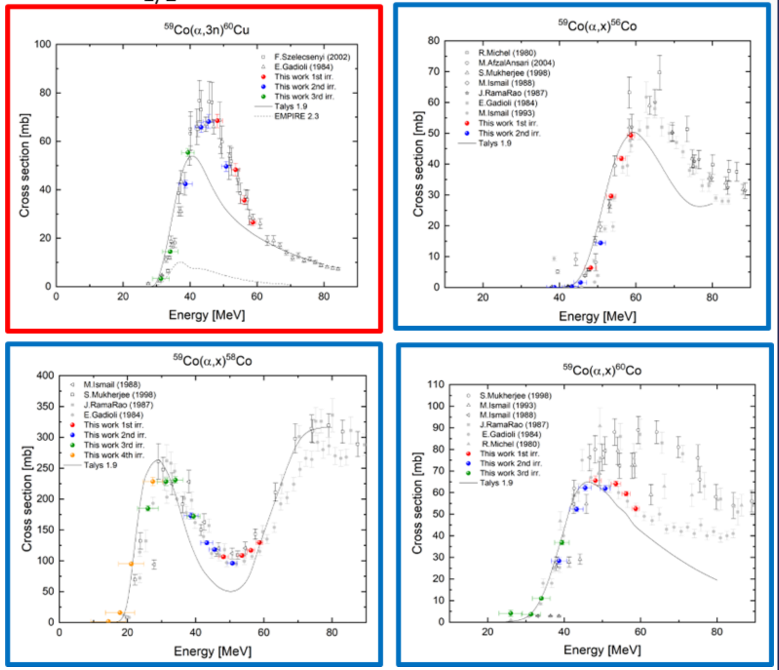




$T_{1/2}$ = 23,7 min

Copper isotopes

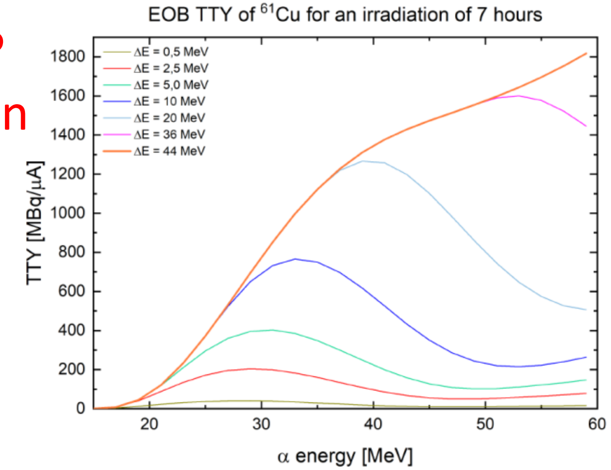
Other contaminants

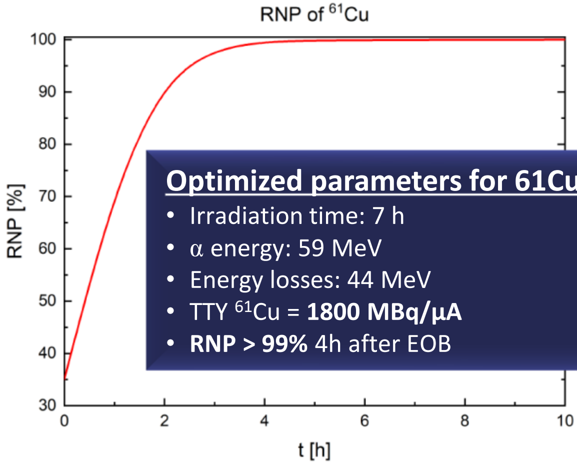


What	Status
Study of the literature	100%
Measurement of the $^{59}Co(\alpha,x)$ at GIP ARRONAX for the production of ^{61}Cu	100%
Measurement of the $^{59}Co(\alpha,x)$ at CAS for the production of ^{61}Cu to obtain precise measurements at low energy (10-30 MeV)	In contact with CAS
Measurement of the $^{64/nat}Ni(\alpha,x)$ at CAS for the production of ^{67}Cu	0%

To do in 2024/2025

TTY and RNP determnation





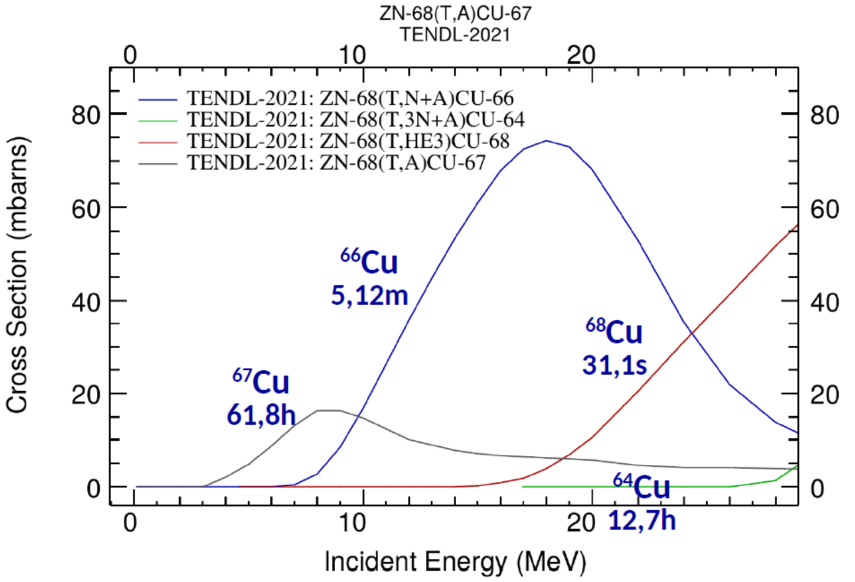
Optimized parameters for 61Cu

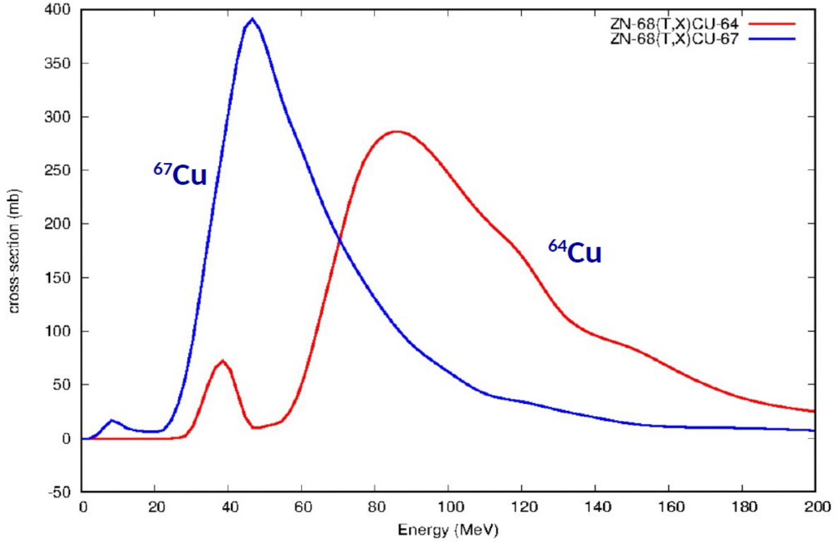
- Irradiation time: 7 h
- α energy: 59 MeV
- Energy losses: 44 MeV
- TTY ^{61}Cu = **1800 MBq/µA**
- **RNP > 99%** 4h after EOB

CUPRUM-TTD WP3 (PD): theoretical activities on alternative nuclear reaction routes to yield ^{67}Cu → ^{68}Zn(t,α)^{67}Cu

UniPD/INFN-PD
F. Barbaro
L. Canton
Y. Lashko

- Started investigation of the triton production route: **^{68}Zn(t,α)^{67}Cu**
- Comparison with the "standard" production routes: **^{68}Zn(p,2p)^{67}Cu, ^{70}Zn(p,α)^{67}Cu**
- Bibliography study and data search
- Started simulation analysis with Nuclear Reaction Codes Talys
- Supervision of a master thesis on this topic



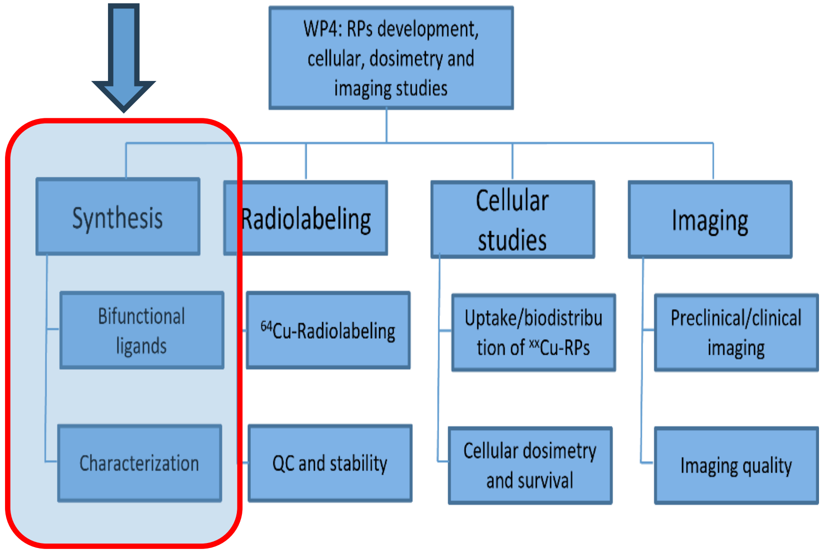


CUPRUM-TTD WP4 (PD-IOV-CNR-UNIFE): RP activities (Synthesis of new Cu conjugates)

	1st year 2023				2nd year 2024				3rd year 2025				
	1°	2°	3°	4°	1°	2°	3°	4°	1°	2°	3°	4°	
WP4	RPs development, cellular, dosimetric and Imaging studies												
M15													M15 : synthesis and characterizatoin of NOTA-PSMA conjugates
M16													M16 : Radiolabeling and stability studies of synthetized conjugates
M17													M17: Determination of specific binding of Cu-PSMA RPs to PSMA receptors naturally expressed by PCa tumor cells, uptake % and internalization
M18													M18 : Determination of cell absorbed dose and the surviving fraction after the treatment with 6xCu-NOTA RPs
M19													M19 : Determination of contrast, sensitivity, and spatial resolution of the SPECT/PET imaging of the produced 64-67Cu

D10: NOTA-PSMA conjugates
D11 A reproducible method to obtain Cu-PSMA RPs with high radiochemical yield
D12: Minimum activity and dimension of the tumour to obtain good imagin

IN PROGRESS



WP4	
Laura De Nardo/ Laura Melendez-A.	INFN-PD IOV
Alessandra Zorz Marta Paiusco	IOV
Michele Bello Diego Cecchin	UNIPD INFN-PD
Cristina Bolzati	ICMATE CNR
Giov. Di Domenico Angelo Taibi	UNIFE INFN-Fe

- As the LARIM laboratory, built in the 1993, did not comply with current safety regulations on the use of experimental animals (2014) and on the use of radioactive material (2020), it was necessary to close it for ~ 1 year to be able to completely renovate it.
- Both civil/electric renovation works are about to be completed.
- The planned activity of synthesis of new conjugates (M15) will be started in the **4th quarter of 2024.**

CUPRUM-TTD WP4 (PD-IOV-CNR-UNIFE): RP activities (Synthesis of new Cu conjugates)

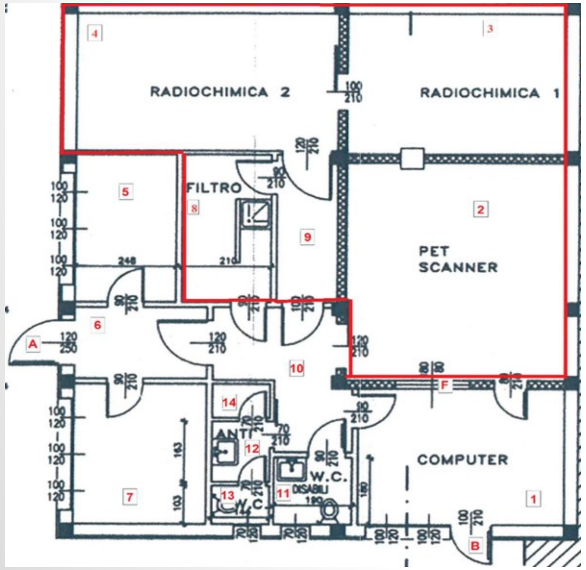
Feasibility of Radiopharmaceutical research studies within LNL→ LARIM (Padua Univ.)

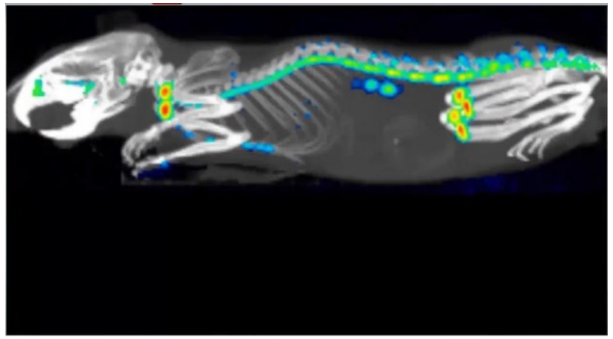
LARIM is located close to SPES building.
Now under renewal of HVAC/Electric/safety plants (Dec. '23 –July '24)
Expected to re-start first operations (new instr. included) on Sept/Oct '24

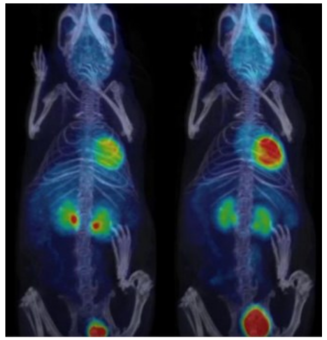
Last-generation small animal scanner: MILABS Vector 5 CT

Set of phantoms with different geometries

HPLC instrumentation in the radiochemistry lab







Radiochemical and Biological hoods

CUPRUM-TTD WP4: Cellular dosimetry calculations

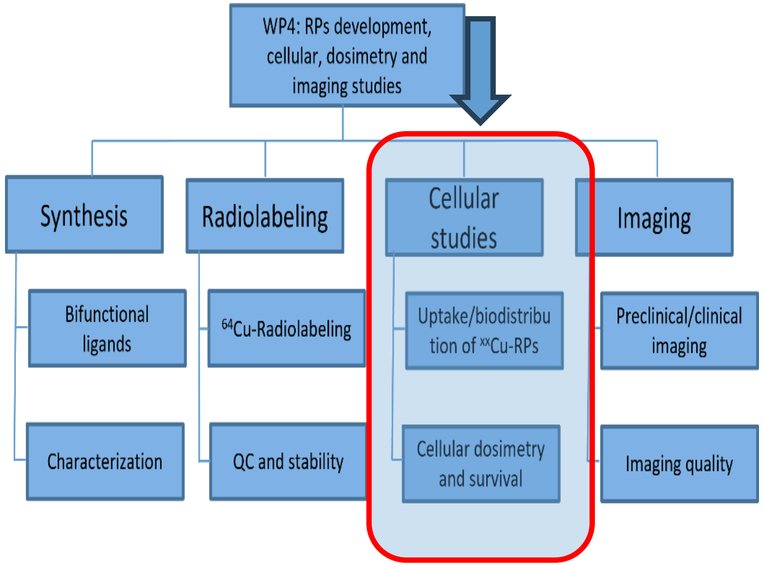
	1st year 2023				2nd year 2024				3rd year 2025			
	1°	2°	3°	4°	1°	2°	3°	4°	1°	2°	3°	4°
WP4	RPs development, cellular, dosimetric and Imaging studies											
M15												
M16												
M17												
M18												
M19												

D10: NOTA-PSMA conjugates
D11 A reproducible method to obtain Cu-PSMA RPs with high radiochemical yield
D12: Minimum activity and dimension of the tumour to obtain good imaging

IN PROGRESS

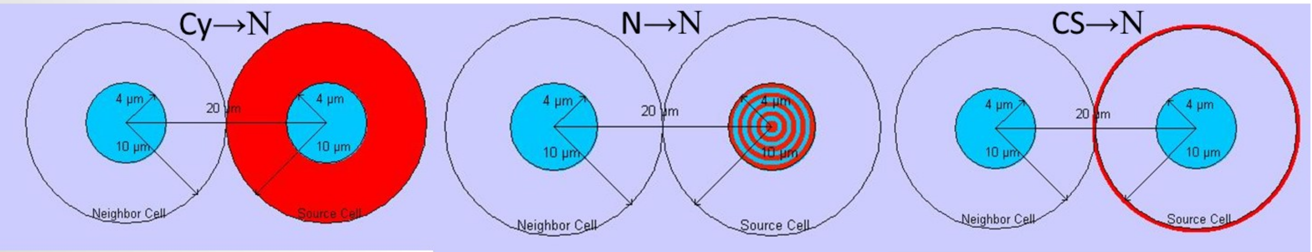
M15 : synthesis and characterizatoin of NOTA-PSMA conjugates
M16 : Radiolabeling and stability studies of synthetized conjugates
M17: Determination of specific binding of Cu-PSMA RPs to PSMA receptors naturally expressed by PCa tumor cells, uptake % and internalization
M18 : Determination of cell absorbed dose and the surviving fraction after the treatment with 6xCu-NOTA RPs
M19 : Determination of contrast, sensitivity, and spatial resolution of the SPECT/PET imaging of the produced 64-67Cu

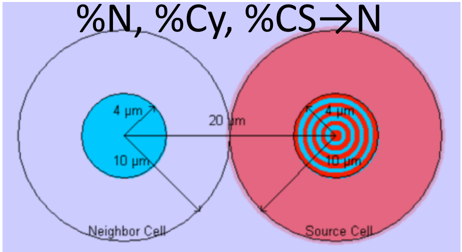
- Input data required: specific uptake and internalization in PSMA-positive and -negative PCa cells.
- MIRDCell calculations for ^{67}Cu and ^{64}Cu in spherical clusters of cells by assuming 100% subcellular distribution of radionuclides in Cytoplasm, Nucleus or Cell Surface provide preliminary information about dosimetric results to be obtained with a realistic distribution of RPs.

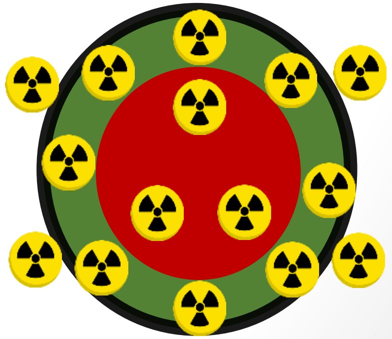


WP4	
Laura De Nardo/ Laura Melendez-A.	INFN-PD IOV
Alessandra Zorz Marta Paiusco	IOV
Diego Cecchin	UNIPD INFN-PD
Cristina Bolzati	ICMATE CNR
Giov. Di Domenico Angelo Taibi	UNIFE INFN-Fe

Source- Target configurations:







CUPRUM-TTD project 2025 FTE (subject to further refinement)

Personnel and FTE distribution expected among units taking part

LNL	FTE
Esposito J. (R.Naz.-Loc.)	0.50
Pupillo G.	0.25
Mou L.	0.20
Cisternino S.	0.70
De Dominicis L.	0.40
Melendez-Alafort L.**	1.00
Bello M.	0.80
Piteo G.	1.00
Anselmi-Tamburini U.	0.20
Cazzola E. #	1.00
Gorgoni G.#	1.00
Cecchin D. §	0.20
	7.25

INFN-Fe	FTE
Martini P. (R. Loc)	1.00
Taibi A.	0.10
Di Domenico G.	0.20
Boschi A.	1.00
Uccelli L.	1.00
Marvelli L.	1.00
Porto F.*	1.00
Speltri G.*	1.00
	6.30

INFN-Mi	FTE
Groppi F. (Res. Loc)	0.40
Manenti S.	0.25
Cagnetta F.M.	0.45
Colucci M.****	0.60
	1.70

TOTALE FTE 17.55

INFN-Pd	FTE
De Nardo L. (R. Loc)	0.80
Canton L.	0.20
Barbaro F.	0.60
Paiusco M. **	0.20
Zorz A. §	0.20
Bolzati C.***	0.20
Lashko Y.	0.10
	2.30

* studenti PhD associate INFN-Fe (da nov 2023)
** personale IOV associato LNL
*** personale CNR associato INFN-Pd
**** studente PhD associato INFN-MI
§ personale UNIPD associato INFN-LNL
\# personale SCDCH associato INFN-LNL

Summary overall budget request CUPRUM-TTD FY2025

Sezioni / Lab	Missioni	Consumo/ Altri consumo	Trasporti	Manutenzione	Inventario	apparati	Sp- servizi	Tot. per sez/lab	FTE previsto
LNL	7,0	10,0	0,0	0,0	0,0???	0,0	0,0???	**17,0**	**7.25**
FE	4,0	15,0	2,0	0,0	17,0	0,0	0,0	**38,0**	**6.30**
PD	1,0	7,0	0,0	0,0	0,0	0,0	0,0	**8.0**	**2.30**
MI	8,5	8,0	8,5	4,0	0,0	0,0	0,0	**29,0**	**1.70**
TOTALE	**20.5**	**40.0**	**10.5**	**4.0**	**17.0**	**0.0**	**0.0**	**92.0**	**17.55**

***Consumables**: Solvents for HPLC analysis, reagents for stability test, buffers and cell culture media, Sep-Pack cartridges for radiopharmaceutical purification, plastic and glassware (4Keuro).
64Cu to radiolabel the developed Radiopharmaceuticals (2x10mCi) (3keuro)

Further developments or applications

- **SPES-MED (Gr III, 2024-26)**

- **Nuclear cross section measurements**

- ^{68}Zn,^{70}Zn(p,x)**^{67}Cu,^{64}Cu** for proton beams with energy higher than 70 MeV, in collaboration with the i-Themba facility (LNL team, 1 and 2 year);

- ^{70}Zn(p,x)**^{67}Cu,^{64}Cu** in the energy range 25-50 MeV at SPES (LNL team, 3 year)

- **DECURTA** *DEvelopment of 67Cu-Radiopharmaceuticals for Theranostic of prostate cAncer* (Bando IOV Ricercatori Sanitari 2023) PI Laura Alafort Melendez

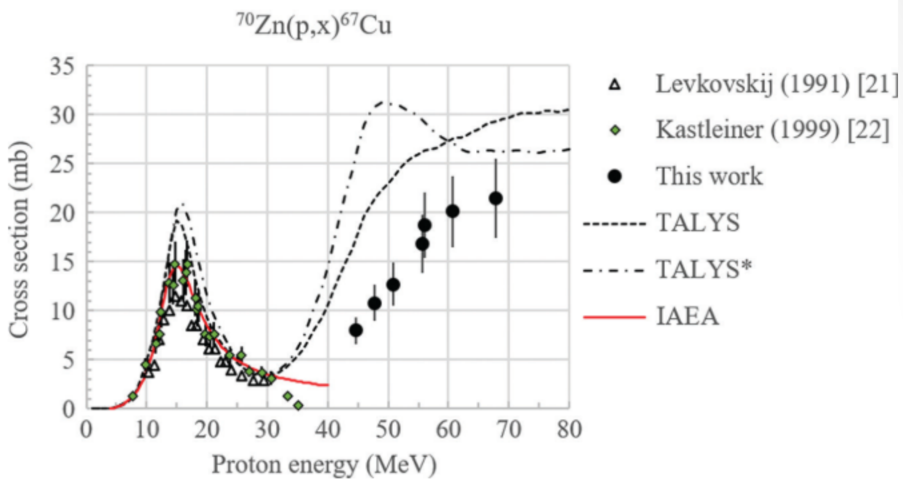


Figure 3: Results of the ^{70}Zn(p,x)^{67}Cu nuclear cross section.

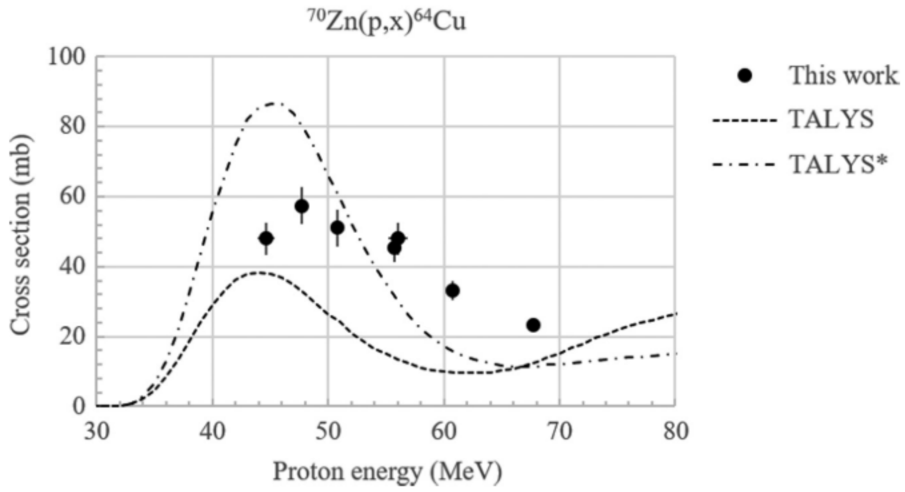


Figure 4: Results of the ^{70}Zn(p,x)^{64}Cu nuclear cross section.

[Pupillo, G. *et al. Radiochim. Acta* **108**, 593–602 (2020)]