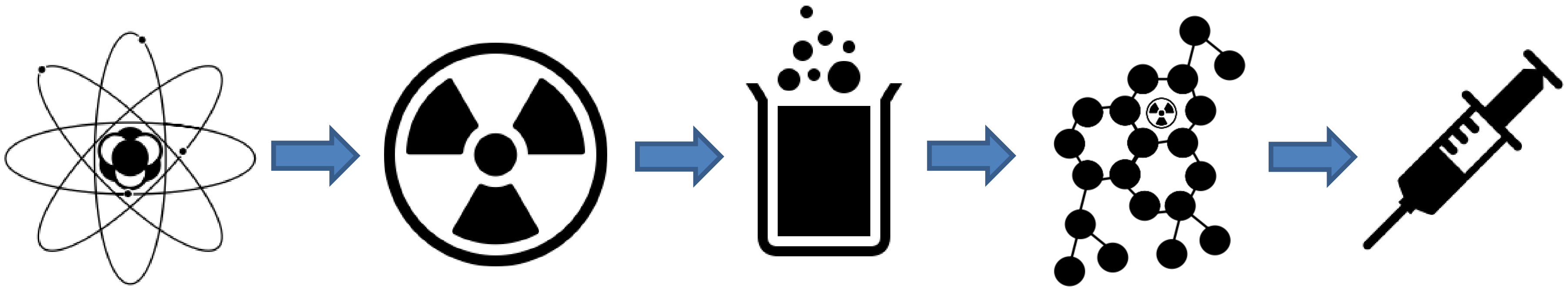
The ISOLPHARM project: ISOL beams for medicine

SPES exotic beams for medicine



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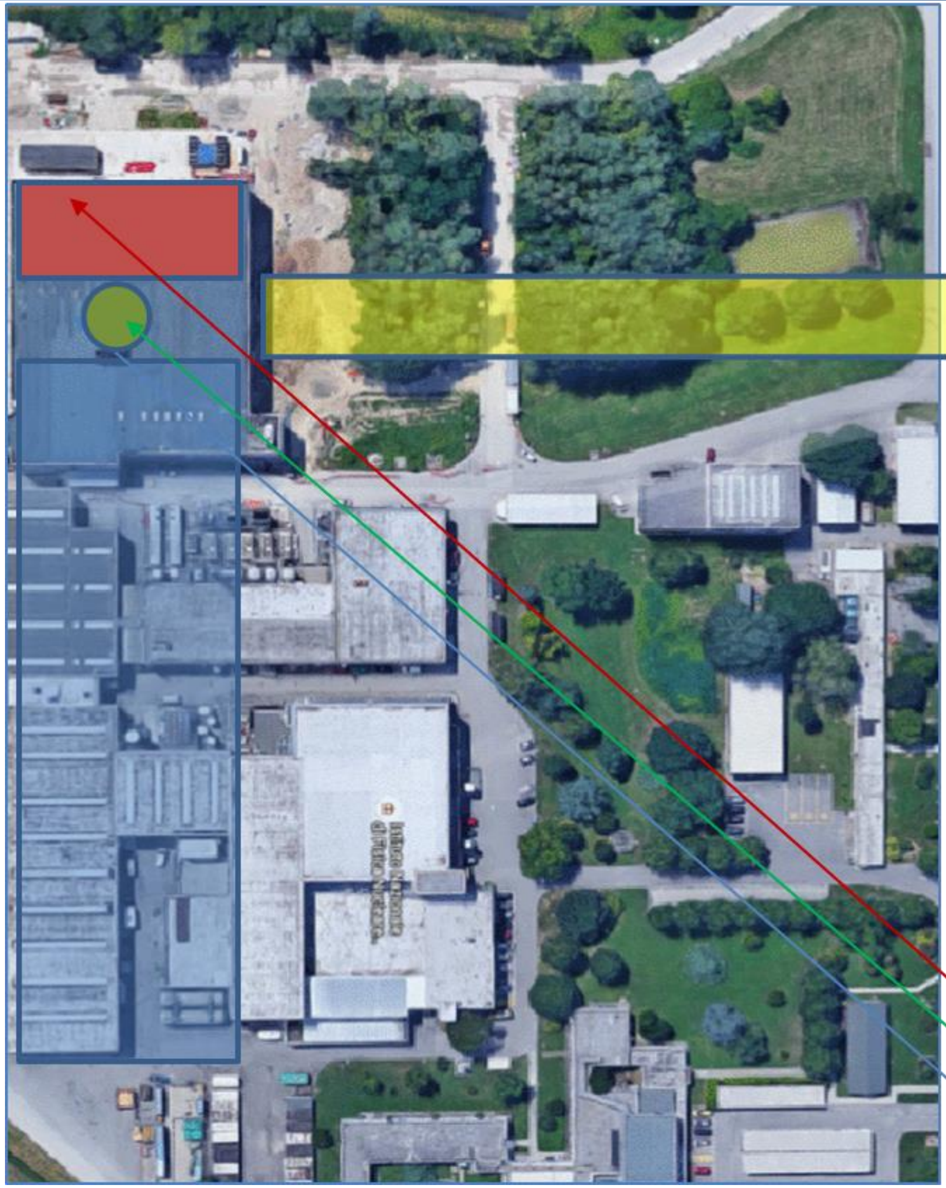
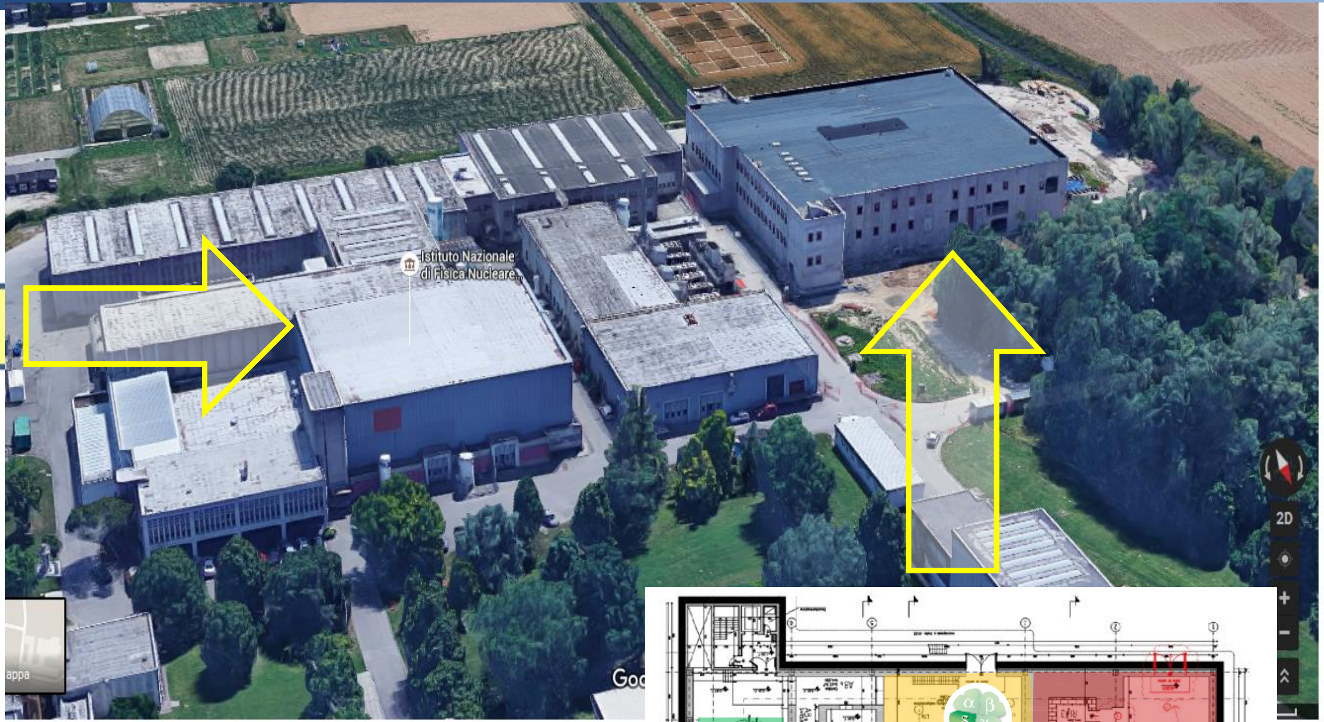
Outline

- The SPES project a LNL: RIB for NP and applications
- SPES radionuclides for medicine: the ISOLPHARM project
- ISOLPHARM R&D activities
- ISOLPHARM_Ag: a case study
- Summary

The SPES project at LNL

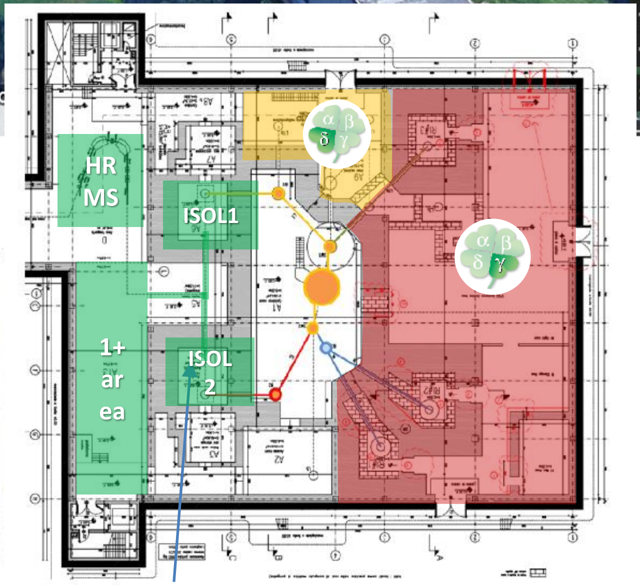




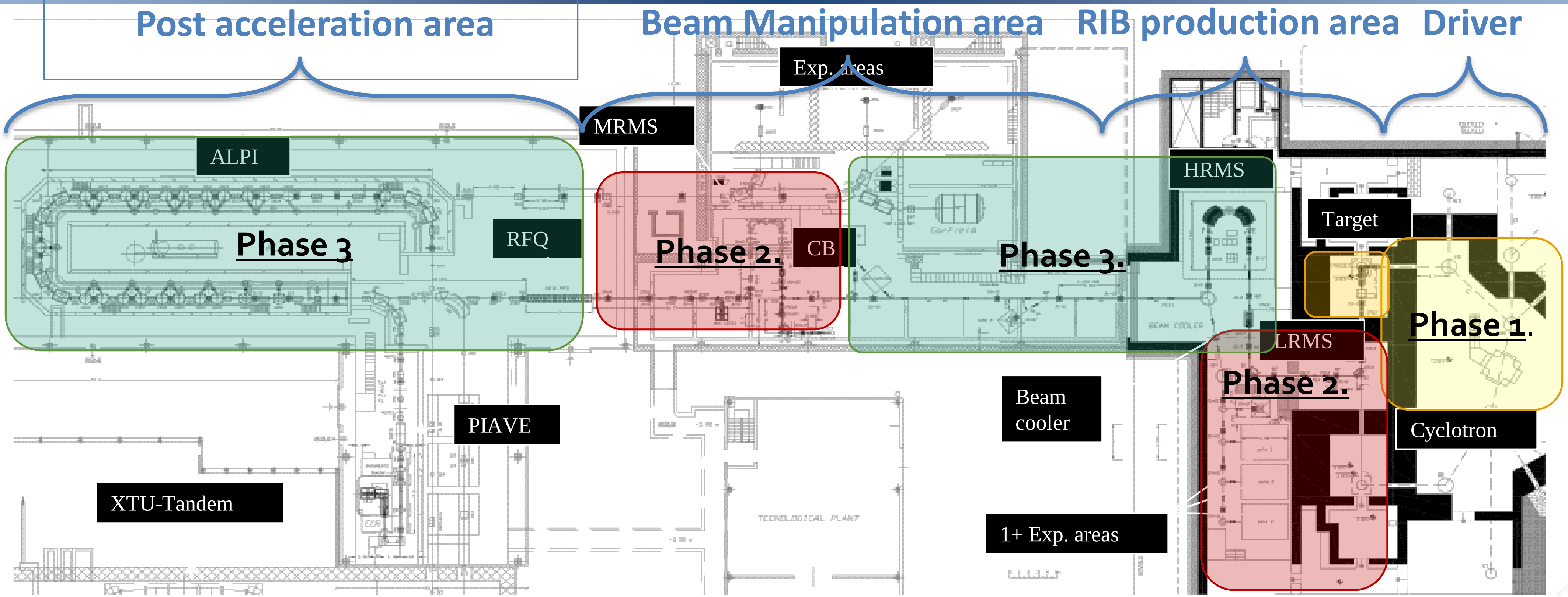
Project financed by INFN

New infrastructure for:

- Application Facility
- Cyclotron
- RIB facility (2th generation ISOL)

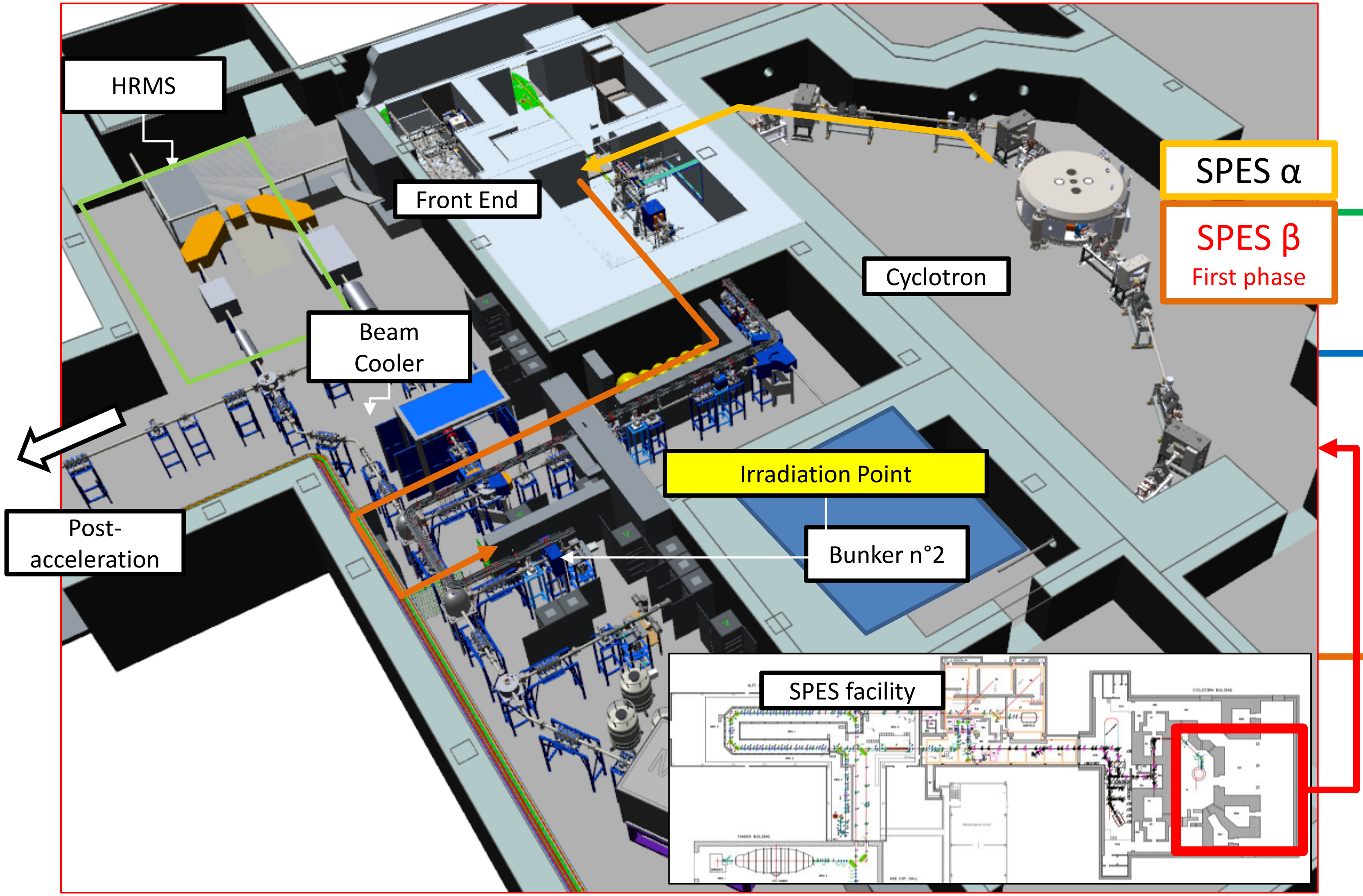


The SPES beta: construction phases



- **Phase 1.** - Building + First operation with the cyclotron
- **Phase 2.** - From C.B. to RFQ + SPES target, LRMS, 1+ Beam Lines
- **Phase 3.** - From the LRMS to the CB + rom RFQ to ALPI

The SPES beta: The 1+ RIB line



1) RIB Bunker

2) 1+ beam line

3) SPES ISOL labs

Commissioning of the Low Energy Beam line (40 MeV 20 μA proton beam > SiC target)

ISOLPHARM:

Between the β and γ phase of the SPES project

Done

α

Cyclotron installation & commissioning:
E=70 MeV proton beam, I= 750 μA

δ

Accelerator based neutron source
(**Proton and Neutron Facility for Applied Physics**)

Awating financing

β

Production and reacceleration of exotic beams,
from p-induced Fission on UC_x

γ

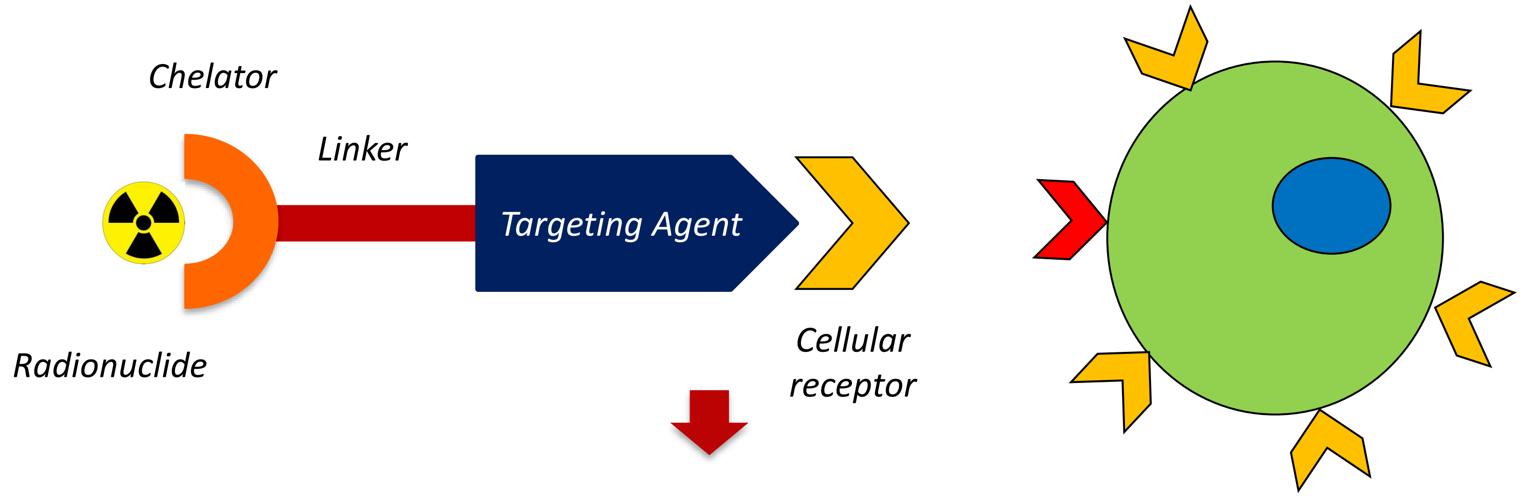
SPES for medicine
Production of radionuclides for nuclear medicine

Work in progress

ISOLPHARM SPES exotic beams for medicine

The main objective of the ISOLPHARM project is the production of carrier-free radionuclides for radiolabeling of bioactive molecules

Radiopharmaceuticals



The radionuclide: Depending on the production method:

- Radioisotopes present in pure form, free of dilution by stable isotope carriers → ***Carrier-free radionuclides*** → (high specific activity).
- Radioisotopes diluted by non therapeutic atoms of the same element → ***Carrier-added radionuclides*** → (low specific activity).

Productiom Methods

1 Cyclotrons (3 Generators) 2 Nuclear reactors

1 Cyclotrons

- ✓ Radionuclides can be produced in big amounts
- ✓ Some High specific activity radionuclides can be produced if enriched targets are used, which are often very expensive
- ✗ Highly activated targets are produced and require processing for purification

2 Nuclear reactors

- ✓ Radionuclides for therapy can be produced in big amounts
- ✓ Parent nuclides for generators can be produced
- ✗ Radionuclides produced by direct reactions are often carrier added

Using accelerators, ISOL Methods: **ISOLPHARM**

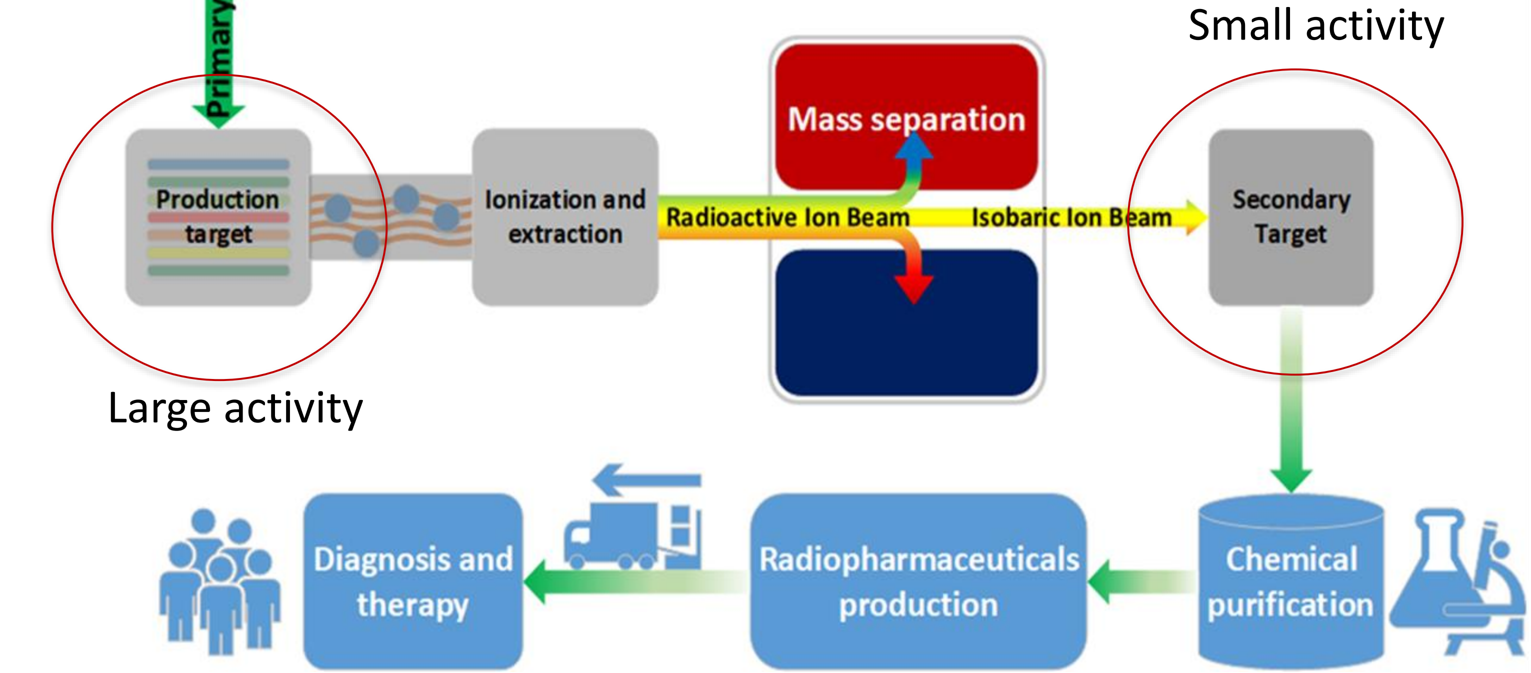
- ✓ Instrinsecally carrier-free radionuclides can be produced (carrier free production)
- ✓ Several radionuclides can be produced only by changing the mass separator settings (versatility)
- ✓ Designing specific targets a wide range of radionuclides can be prodcued (new radionuclide for medicine application…)
- ✗ Production yields are lower than those of cyclotrons and nuclear reactors

The ISOLPHARM method

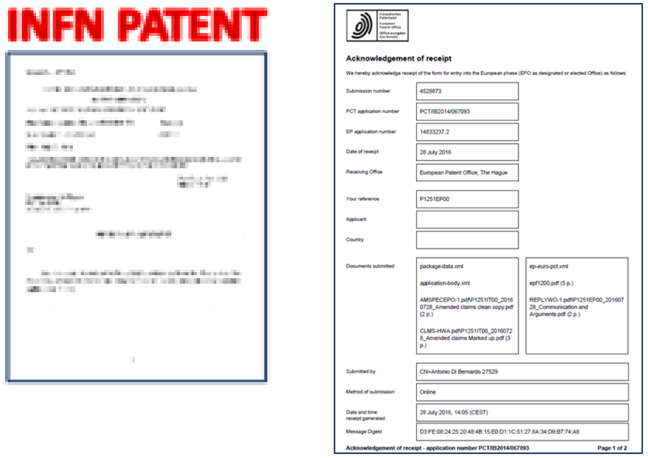
The ISOLPHARM method

The ISOLPHARM method is capable of selecting and isolating a SINGLE RADIO-ISOTOPE

→ ***extremely high specific activity***
→ ***the higher efficacy in therapy and diagnosis***
-> ***versatile method....***

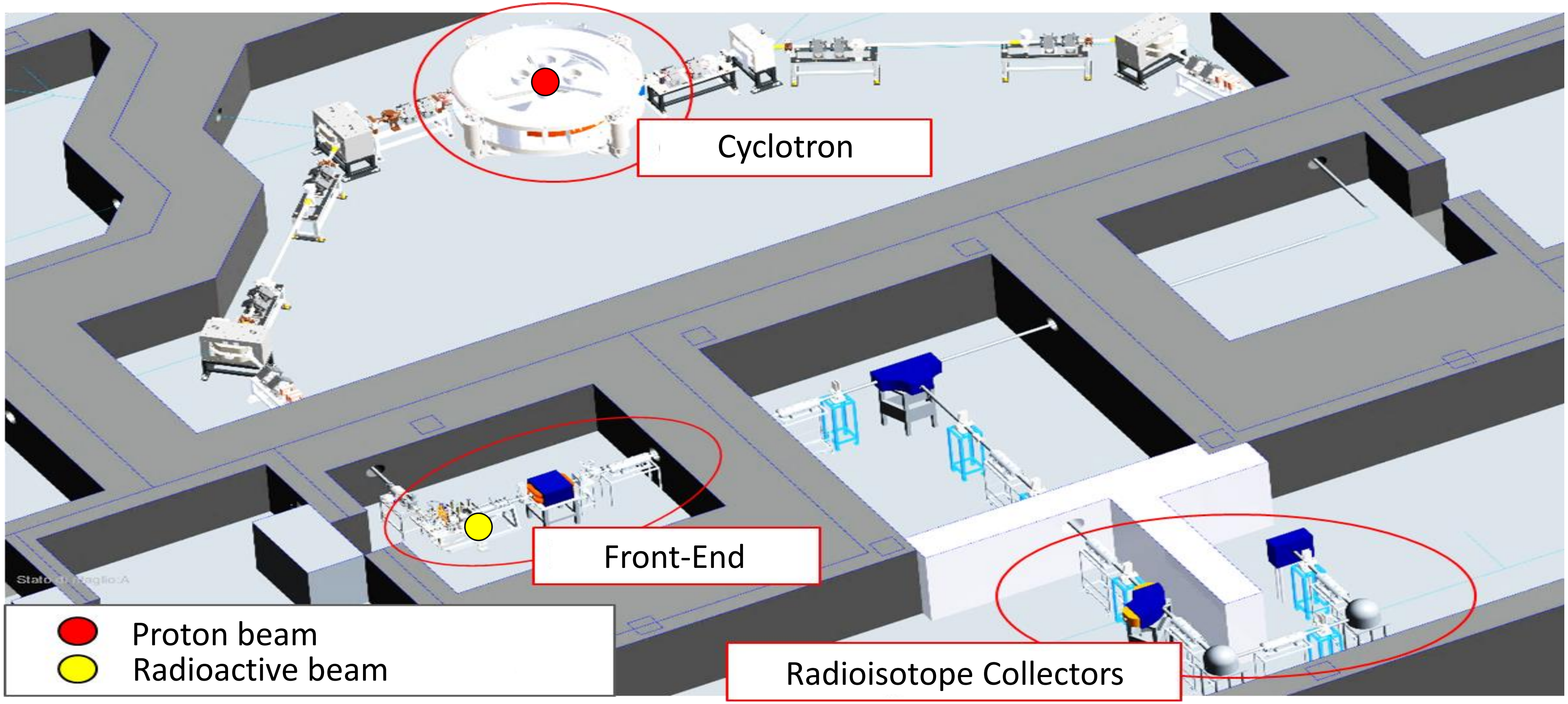


INFN PATENT

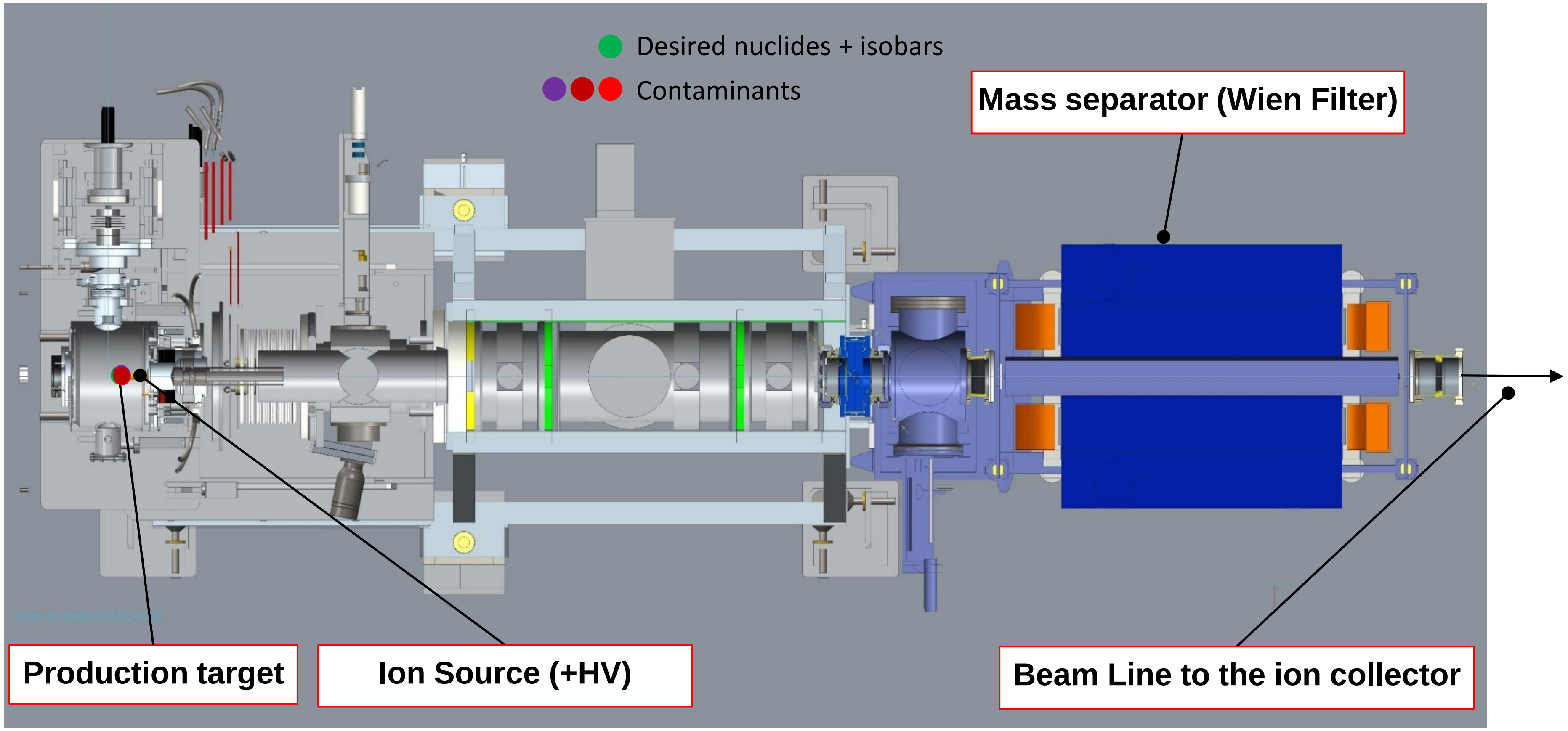


PUBLISHED PAPERS

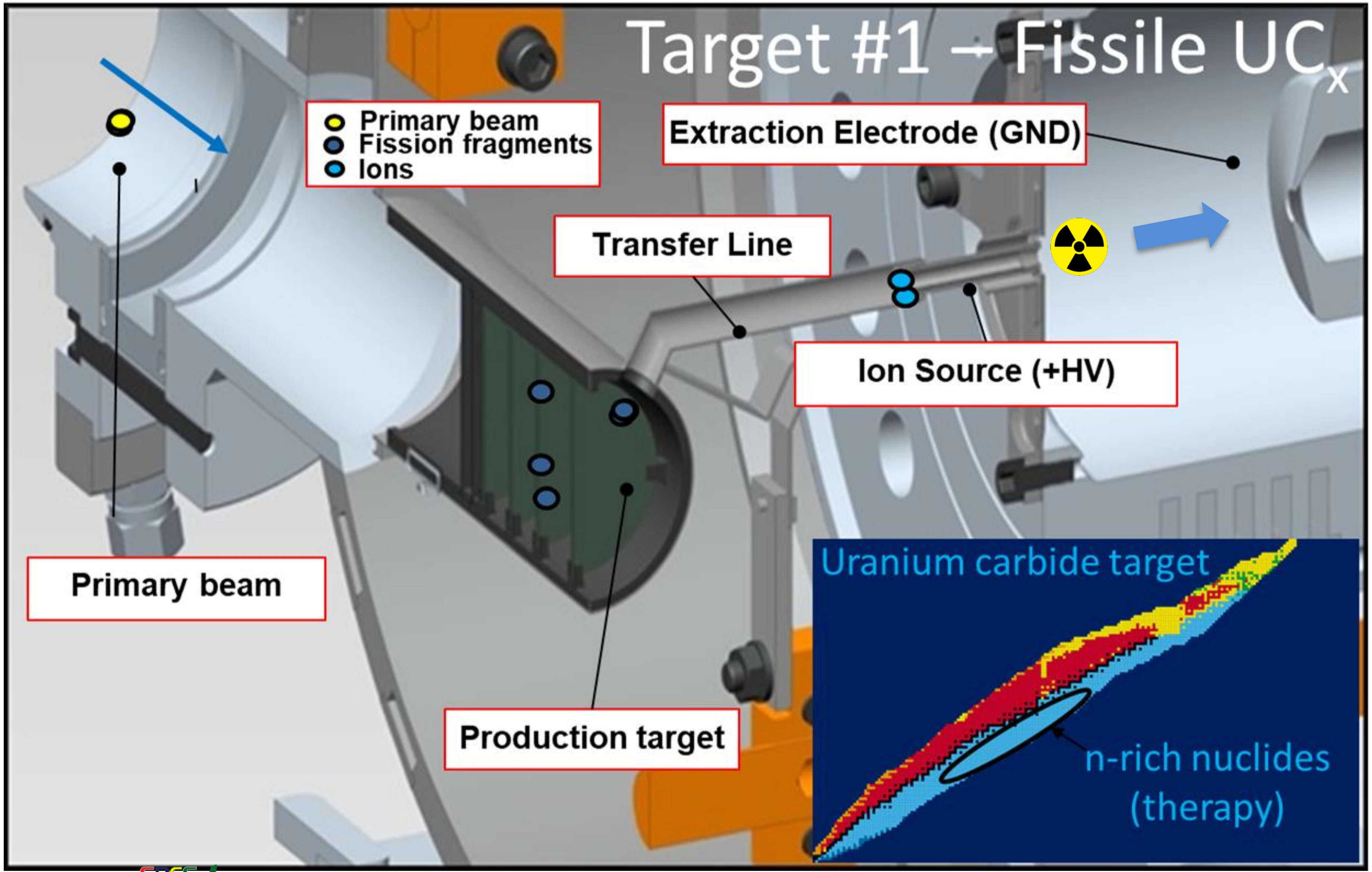
ISOLPHARM production at SPES

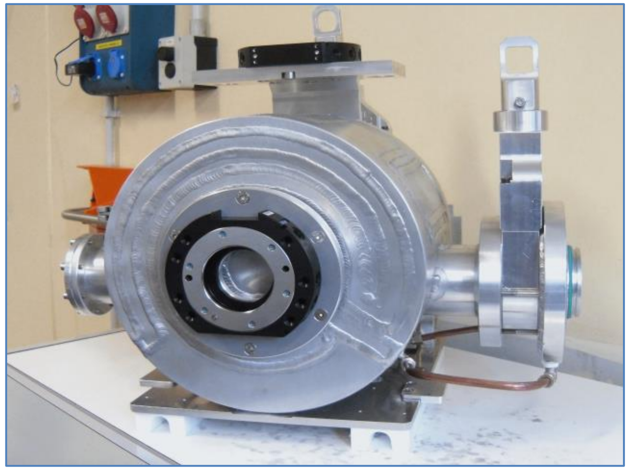


Mass separation

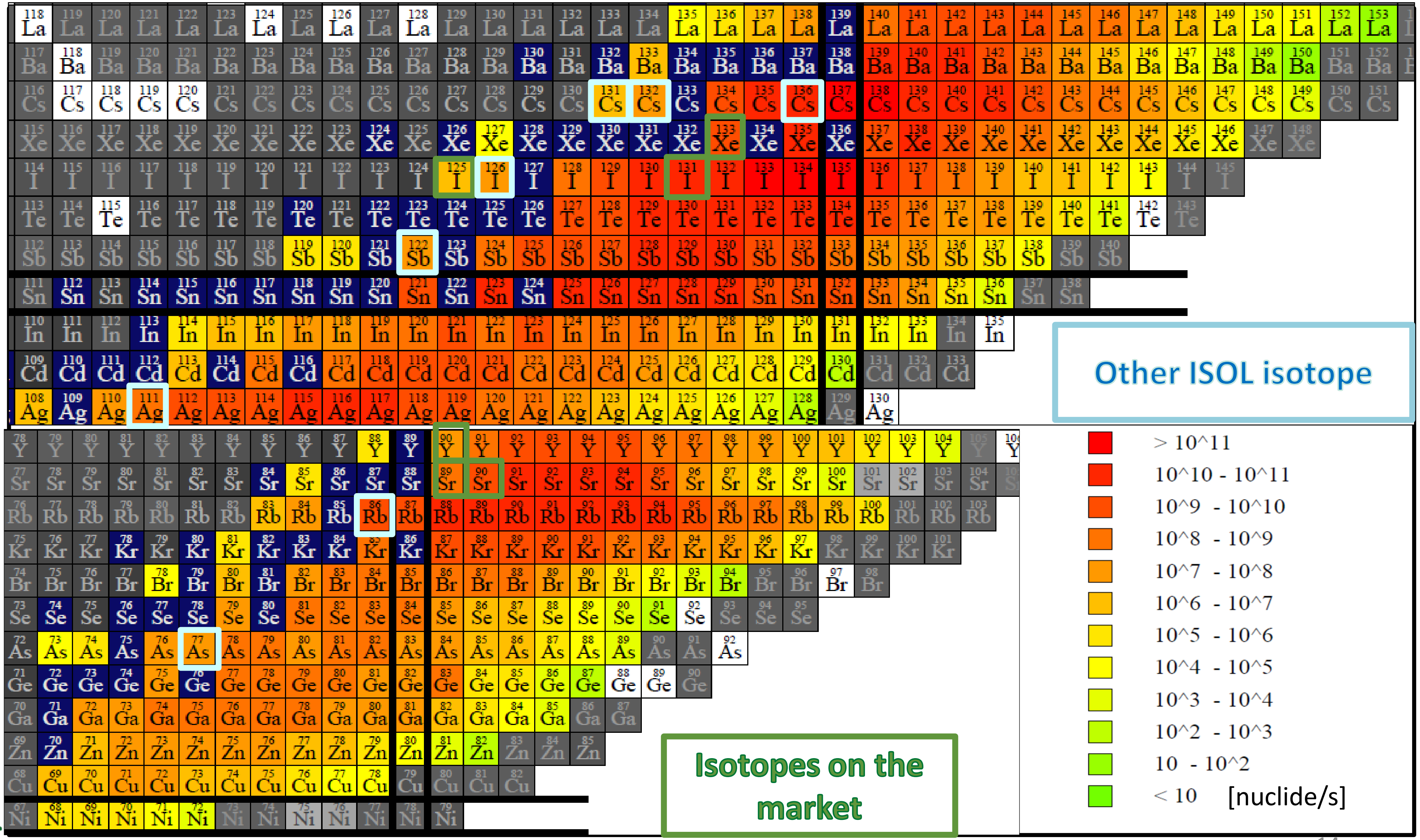


The ISOLPHARM production target

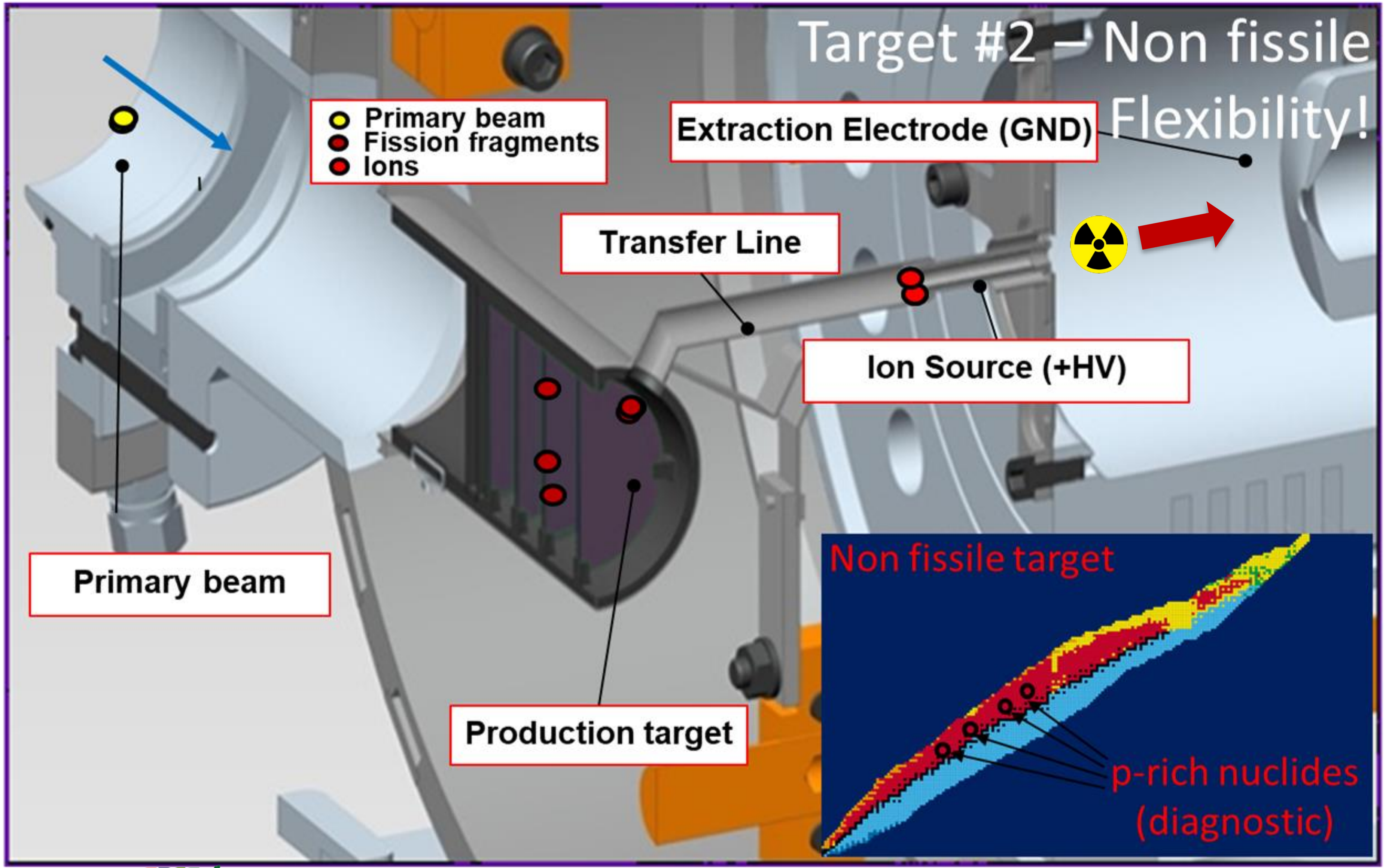


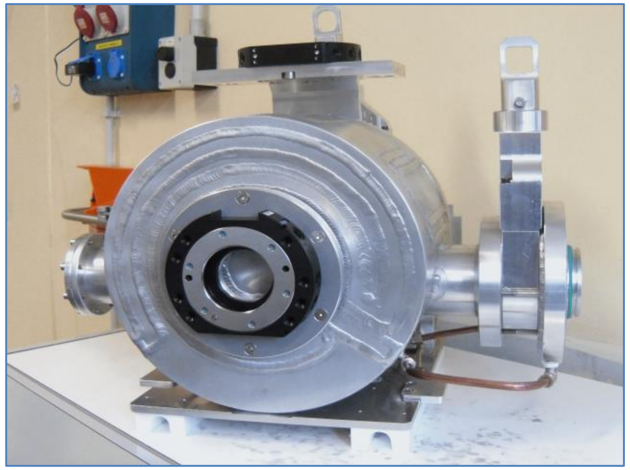


UC_x target: new radionuclides



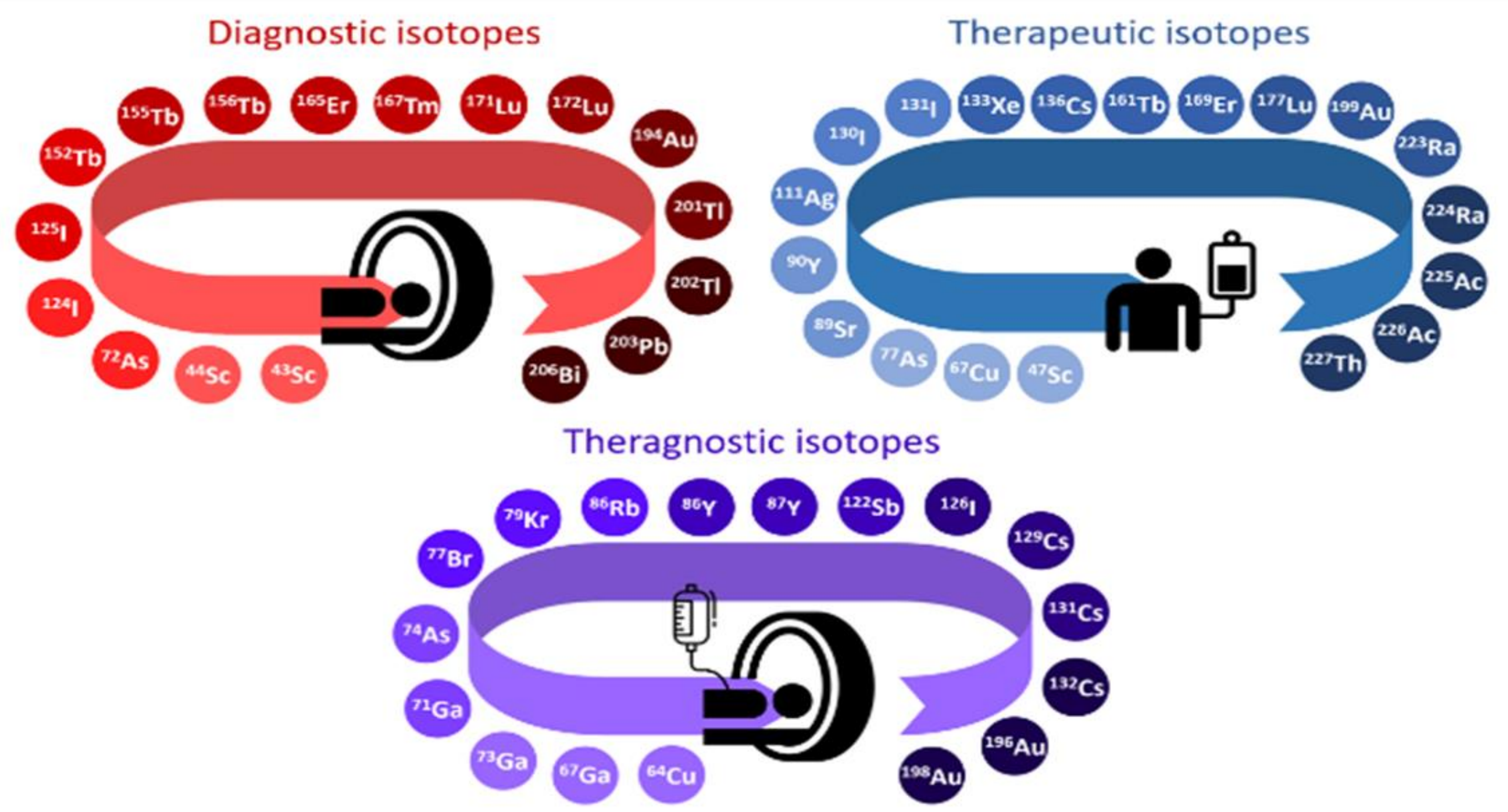
The ISOLPHARM production target





ISOLPHARM:

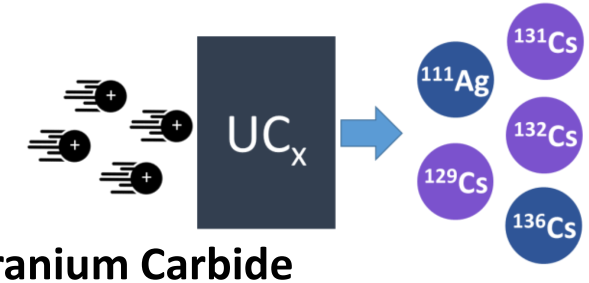
Radionuclides that could be produced at LNL



R&D on production targets

Target concepts currently under investigation and related innovative isotope production:

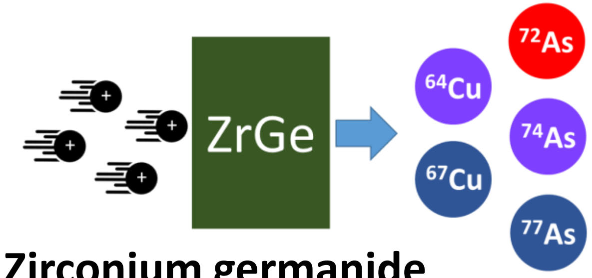
UC_x target (Operation temperature: 2200°C)



Uranium Carbide

Nuclear reactions studied | Designed | Tested

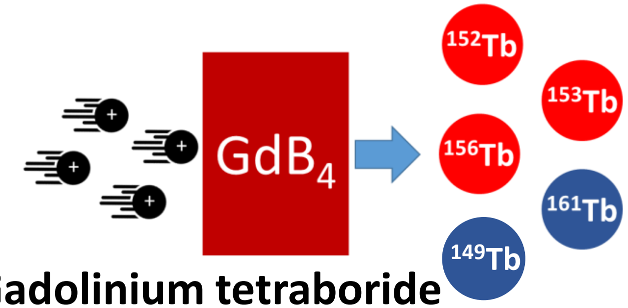
ZrGe target (Operation temperature: 1800°C)



Zirconium germanide

Nuclear reactions studied | Designed | Tested

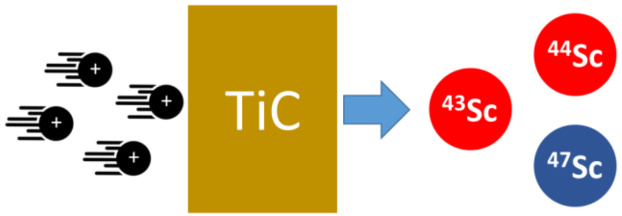
GdB_4 target (Operation temperature: 2000°C)



Gadolinium tetraboride

Nuclear reactions studied | Designed | Tested

TiC target (Operation temperature: 2000°C)



Titanium carbide

Nuclear reactions studied | Designed | Tested

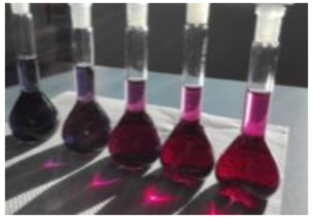
The ISOLPHARM R&D (so far...)

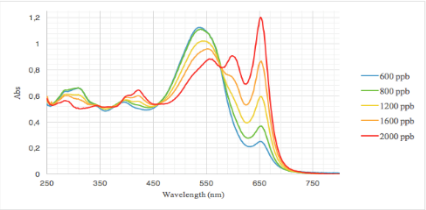
Beam deposition @ LNL

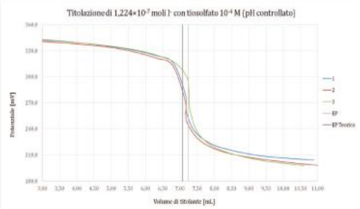
Simulation of the process using stable ion beams thanks to the SPES test bench (front-end off-line)

Activities @ UNIPD-DSF-DSC

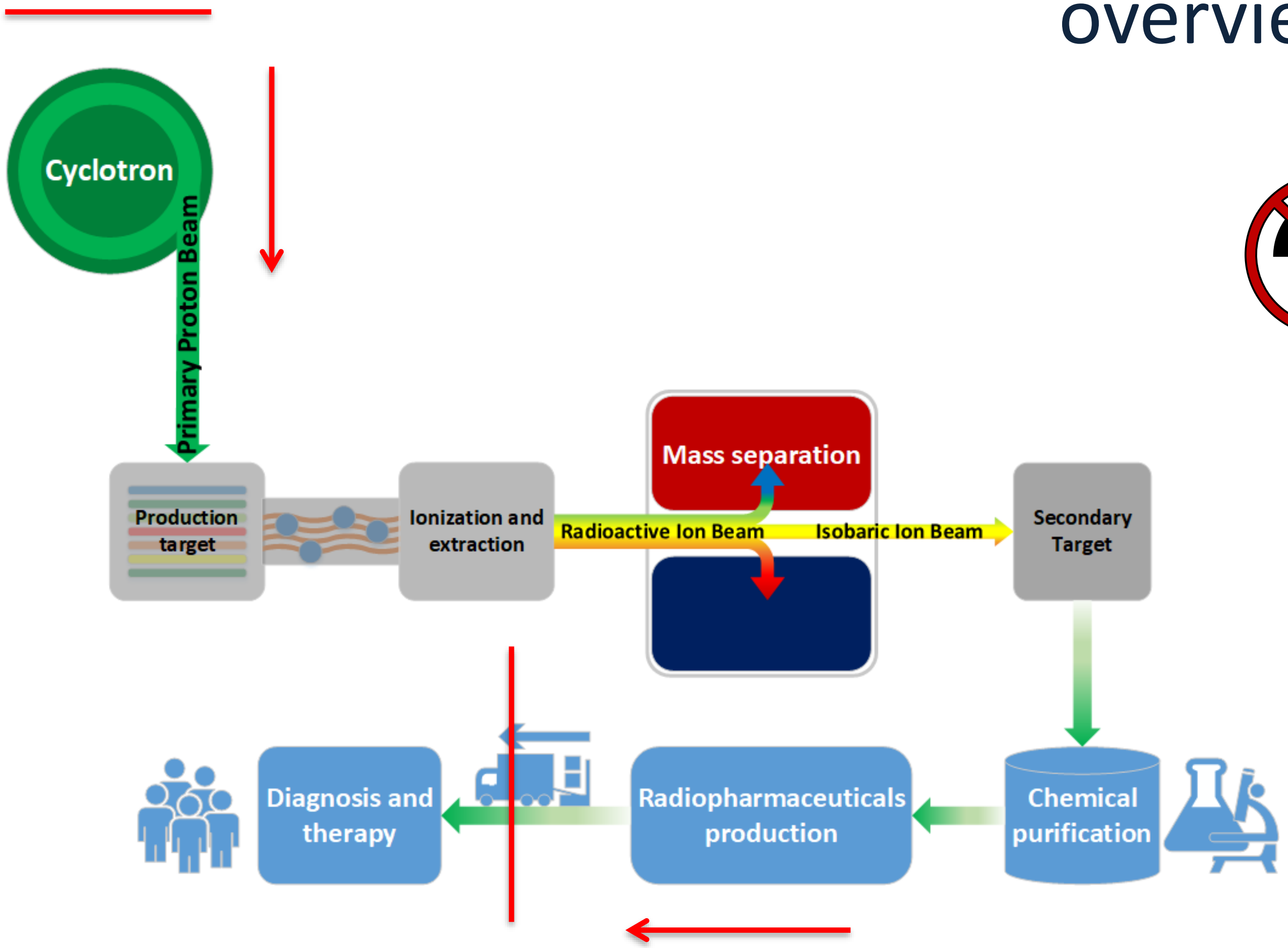
Extraction from the substrate, quantification and chemical separation of the deposited element







Experimental activities: overview



Step 1

The cyclotron commisioning

Step 2

Production targets development

Step 3

Ion beams production

Step 4

Secondary targets development and ions recovery

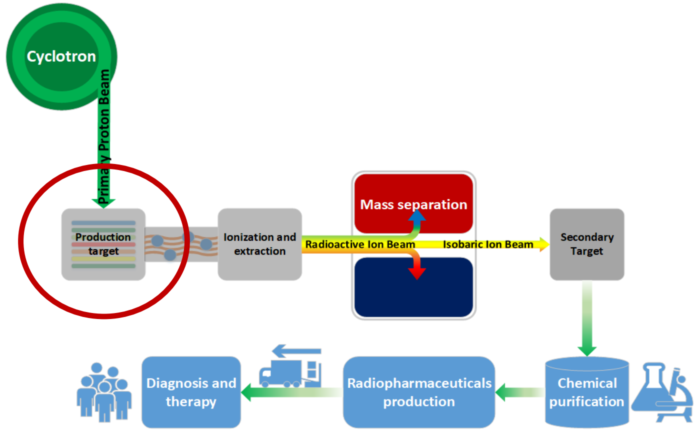
Step 5

Purification processes development

Step 6

Radiolabeling studies

The production targets



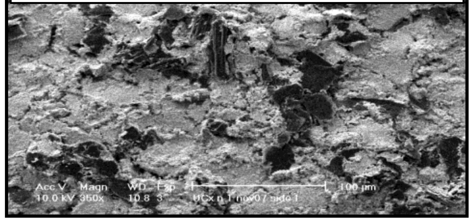
UC_x target already developed and tested on-line!

Other targets under development for specific radionuclides production:

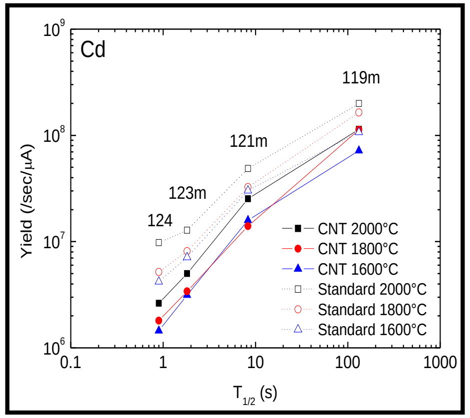
ZrGe: ^{64}Cu, ^{67}Cu

TiC: ^{43}Sc, ^{44}Sc, ^{47}Sc

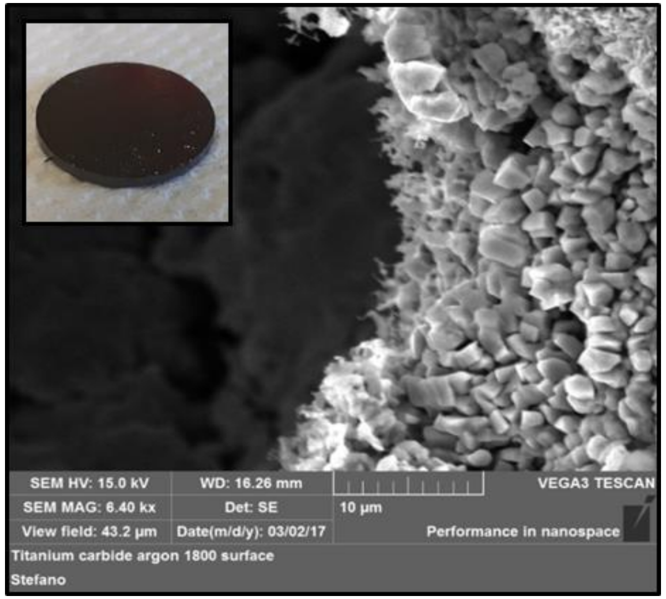
UC_x target prototype



	Standard (graphite)	Low density (MWCNTs)
Density (g/cm³)	4.25	2.59
Diameter (mm)	12.50	13.07
Thickness (g/cm²)	0.41	0.41
Calculated porosity (%)	58	75



Porous titanium carbide (TiC)



INFN

The primary target: MC calculations on the expected yields

ISOLPHARM
SPES exotic beams for medicine

SPES UC_x target production, 40 MeV 200 µA PPB

	^{111}Ag		^{129}Cs		^{131}Cs		^{132}Cs		^{136}Cs	
Time	Produced activity		Produced activity		Produced activity		Produced activity		Produced activity	
[days]	[Bq]	[Ci]	[Bq]	[mCi]	[Bq]	[mCi]	[Bq]	[mCi]	[Bq]	[mCi]
0.5	9.46E+09	0.26	1.14E+06	0.03	4.30E+06	0.12	2.69E+07	0.73	1.30E+09	35.22
1	1.92E+10	0.52	2.02E+06	0.05	8.45E+06	0.23	5.24E+07	1.42	2.57E+09	69.52
1.5	2.85E+10	0.77	2.70E+06	0.07	1.24E+07	0.34	7.66E+07	2.07	3.81E+09	102.94
2	3.74E+10	1.01	3.22E+06	0.09	1.63E+07	0.44	9.96E+07	2.69	5.01E+09	135.49
3	5.40E+10	1.46	3.94E+06	0.11	2.36E+07	0.64	1.42E+08	3.83	7.33E+09	198.07
4	6.92E+10	1.87	4.37E+06	0.12	3.04E+07	0.82	1.80E+08	4.86	9.53E+09	257.44
5	8.29E+10	2.24	4.62E+06	0.12	3.68E+07	0.99	2.14E+08	5.79	1.16E+10	313.75

ZrGe target (100 µA, 70 MeV protons)

	^{64}Cu production ($t_{1/2}$: 61,83 h)			^{67}Cu production ($t_{1/2}$: 61,83 h)		
Time	Activity		Nuclei	Activity		Nuclei
[days]	[Bq]	[Ci]	[#]	[Bq]	[mCi]	[#]
0.5	2.66E+10	0.72	1.75E+15	2.37E+08	6.40	7.61E+13
1	4.03E+10	1.09	2.66E+15	4.44E+08	11.99	1.43E+14
1.5	4.75E+10	1.28	3.13E+15	6.24E+08	16.87	2.01E+14
2	5.12E+10	1.38	3.38E+15	7.82E+08	21.15	2.52E+14
3	5.42E+10	1.46	3.57E+15	1.04E+09	28.14	3.35E+14
4	5.50E+10	1.49	3.62E+15	1.24E+09	33.49	3.99E+14
5	5.52E+10	1.49	3.64E+15	1.39E+09	37.58	4.47E+14

GdB_4 target (100 µA 70 MeV PPB)

	^{149}Tb prodcution ($t_{1/2}$: 4.12 h)			^{152}Tb prodcution ($t_{1/2}$: 17.5)			^{155}Tb prodcution ($t_{1/2}$: 5.32 d)			^{161}Tb prodcution ($t_{1/2}$: 6.91d)		
Time	Activity		Nuclei	Activity		Nuclei	Activity		Nuclei	Activity		Nuclei
[days]	[Bq]	[Ci]	[#]	[Bq]	[Ci]	[#]	[Bq]	[Ci]	[#]	[Bq]	[Ci]	[#]
0.5	3.16E+10	0.85	6.76E+14	4.26E+11	11.51	3.87E+16	1.43E+11	3.86	9.48E+16	8.46E+08	0.02	7.26E+14
1	3.58E+10	0.97	7.67E+14	6.92E+11	18.70	6.29E+16	2.77E+11	7.49	1.84E+17	1.66E+09	0.04	1.42E+15
1.5	3.64E+10	0.98	7.79E+14	8.57E+11	23.17	7.79E+16	4.02E+11	10.88	2.67E+17	2.43E+09	0.07	2.08E+15
2	3.65E+10	0.99	7.80E+14	9.60E+11	25.95	8.73E+16	5.20E+11	14.06	3.45E+17	3.16E+09	0.09	2.71E+15
3	3.65E+10	0.99	7.81E+14	1.06E+12	28.75	9.67E+16	7.33E+11	19.82	4.86E+17	4.52E+09	0.12	3.88E+15
4	3.65E+10	0.99	7.81E+14	1.10E+12	29.83	1.00E+17	9.21E+11	24.89	6.11E+17	5.75E+09	0.16	4.93E+15
5	3.65E+10	0.99	7.81E+14	1.12E+12	30.25	1.02E+17	1.09E+12	29.33	7.20E+17	6.86E+09	0.19	5.89E+15

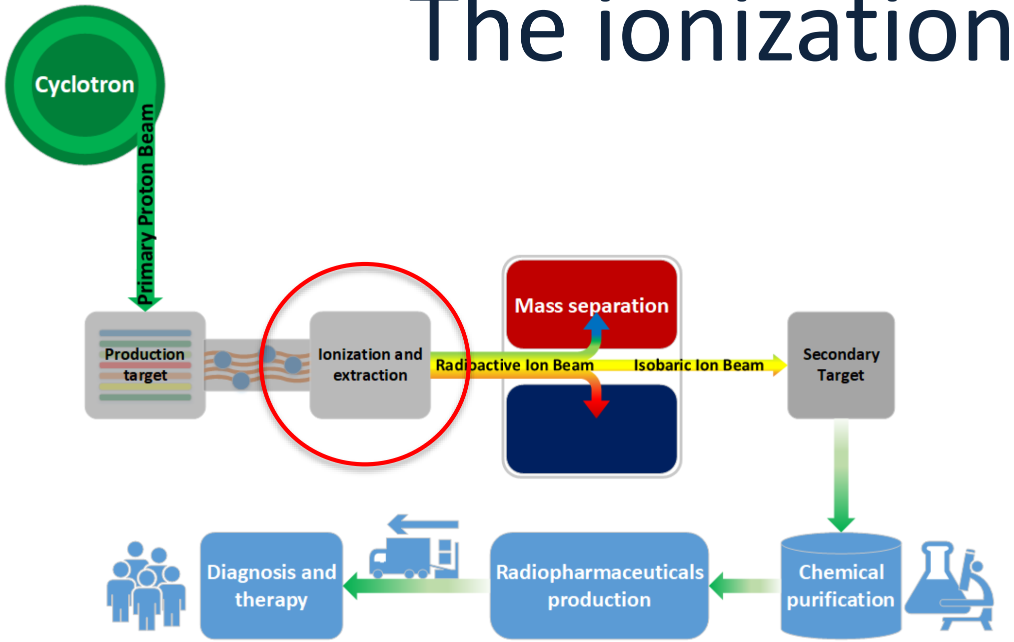
TiC target (200 µA 40 MeV PPB)

	^{43}Sc prodcution ($t_{1/2}$: 3.89 h)			^{44}Sc prodcution ($t_{1/2}$: 3.97 h)			^{47}Sc prodcution ($t_{1/2}$: 3.35 d)		
Time	Activity		Nuclei	Activity		Nuclei	Activity		Nuclei
[days]	[Bq]	[Ci]	[#]	[Bq]	[Ci]	[#]	[Bq]	[Ci]	[#]
0.5	5.70E+10	1.54	1.15E+15	2.64E+11	7.14	5.37E+15	2.48E+10	0.67	1.04E+16
1	6.37E+10	1.72	1.29E+15	3.25E+11	8.78	6.61E+15	4.72E+10	1.28	1.97E+16
1.5	6.45E+10	1.74	1.30E+15	3.57E+11	9.65	7.26E+15	6.74E+10	1.82	2.81E+16
2	6.46E+10	1.75	1.30E+15	3.83E+11	10.34	7.79E+15	8.56E+10	2.31	3.57E+16
3	6.46E+10	1.75	1.31E+15	4.24E+11	11.45	8.62E+15	1.17E+11	3.16	4.87E+16
4	6.46E+10	1.75	1.31E+15	4.55E+11	12.28	9.25E+15	1.42E+11	3.84	5.93E+16
5	6.46E+10	1.75	1.31E+15	4.78E+11	12.91	9.72E+15	1.63E+11	4.40	6.78E+16

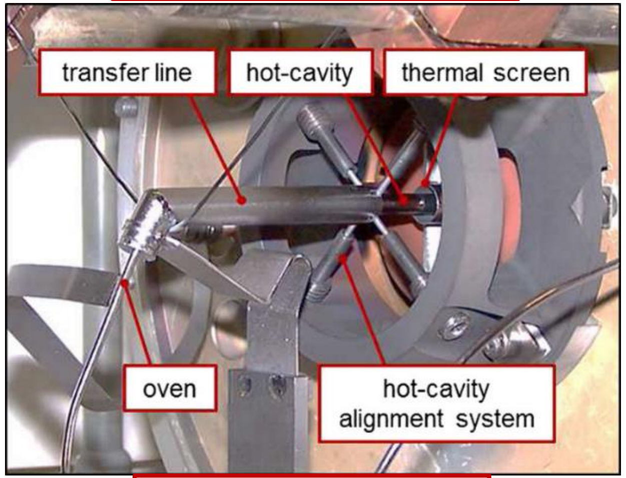
Calculations performed with FLUKA (compared also with other models such as BIC, BERT etc..)

SPES
exotic beams for science

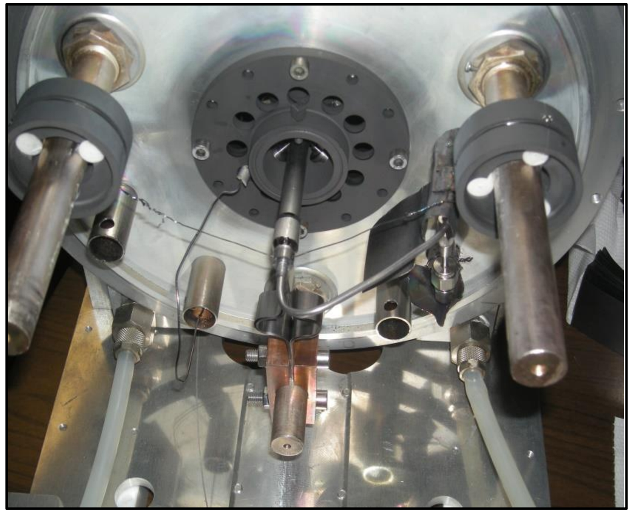
The ionization source



Surface Ion Source (SIS)

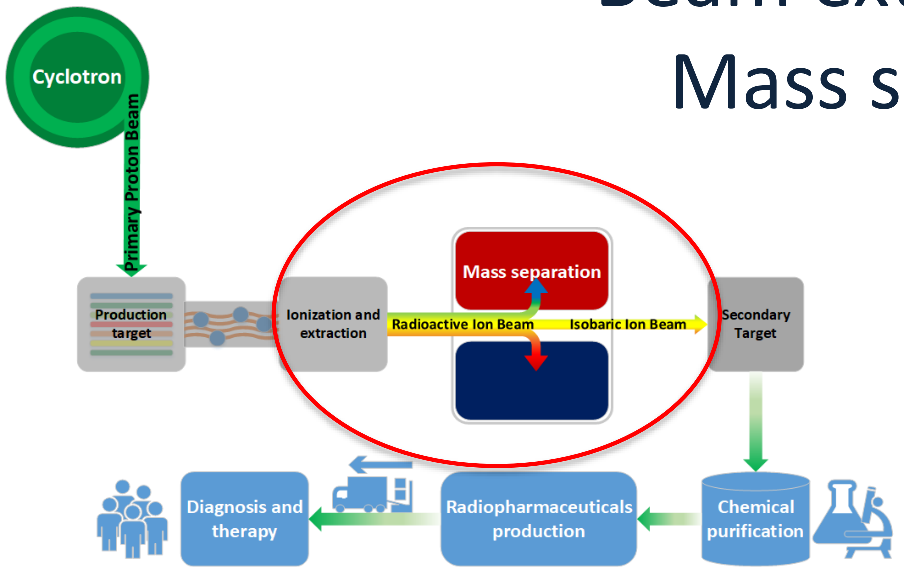


Plasma Ion Source (PIS)

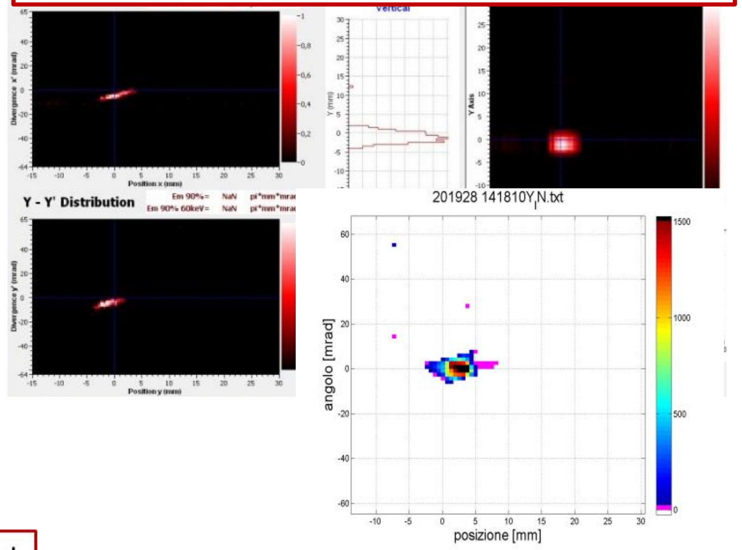


Ionized element	Desired radionuclide	Ionization source	Efficiency
Sr	^{89}Sr, ^{90}Sr/^{90}Y	SIS	~ 20 %
Y	^{90}Y	PIS	~ 1 %
I	^{125}I, ^{126}I and ^{131}I	PIS	~ 20 %
Cu	^{64}Cu, ^{67}Cu	PIS	~ 10 %
Ag	^{111}Ag	PIS	~ 15 %

Beam extraction and Mass separation

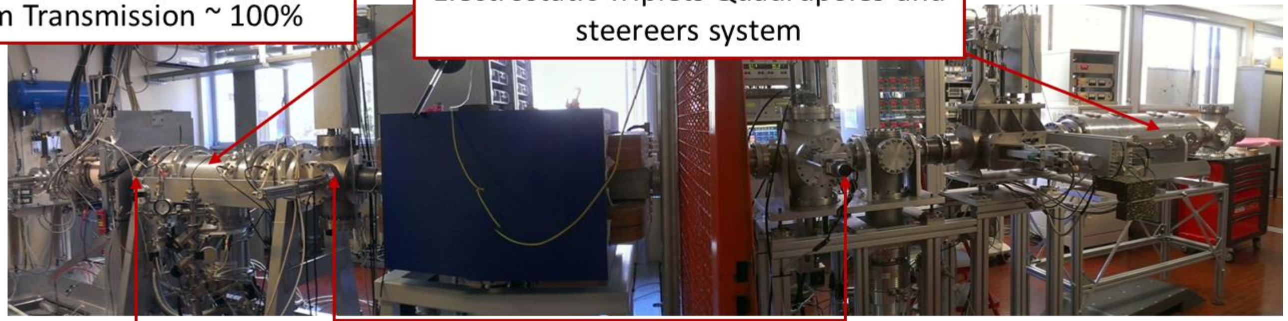


Strontium and yttrium beams focalization



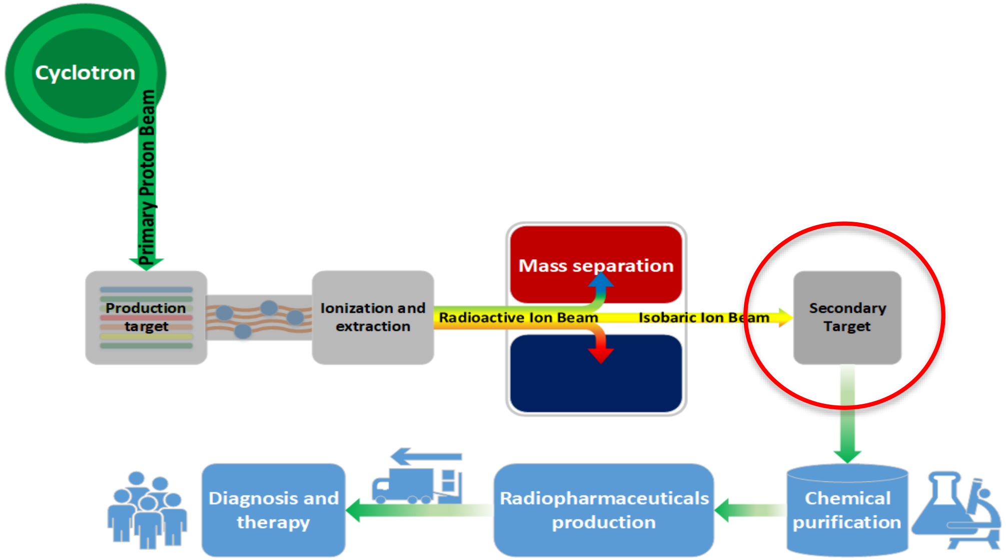
Beam Transmission ~ 100%

Electrostatic Triplets Quadrupoles and steereers system



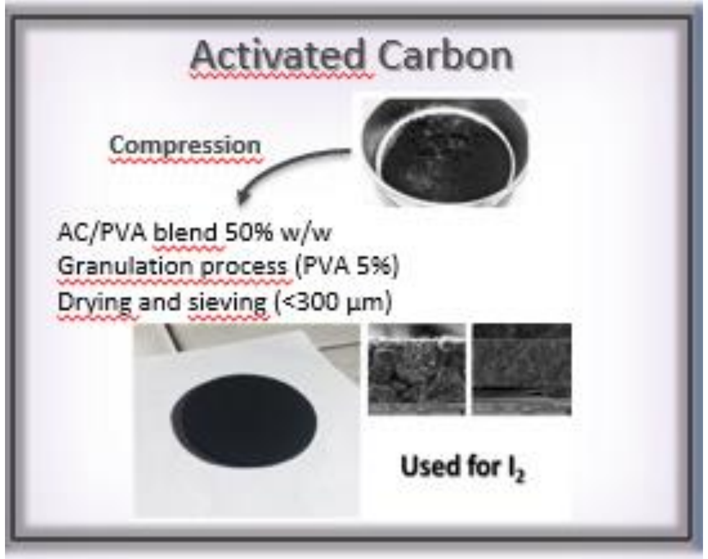
Extraction -> 25 - 40 kV

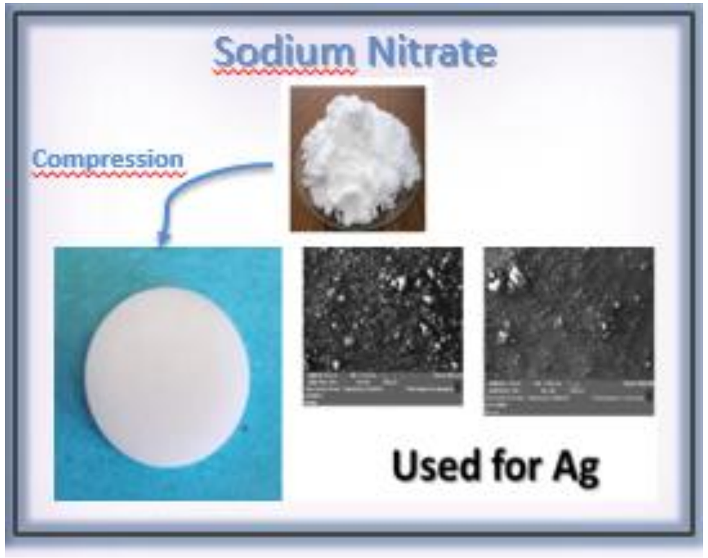
Diagnostic boxes 1 and 2
(2 Faraday Cups and 2 Beam profilers)



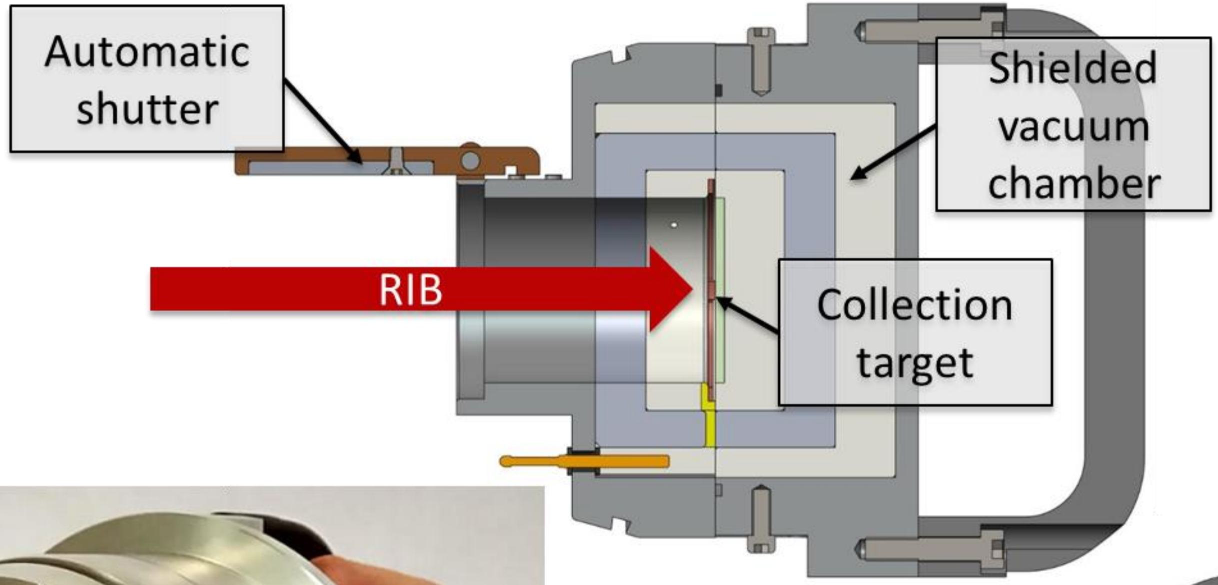
Secondary target requirements:

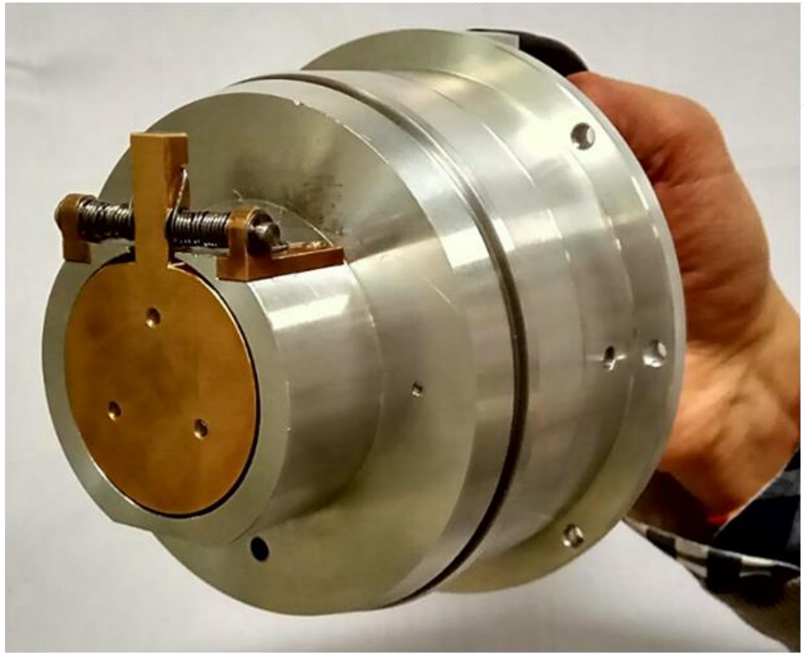
1. Chemical compatibility with the element
2. Absence of metal contaminants
3. No incompabilities with the production of a radiopharmaceutical for human administration
4. No interference with purification processes

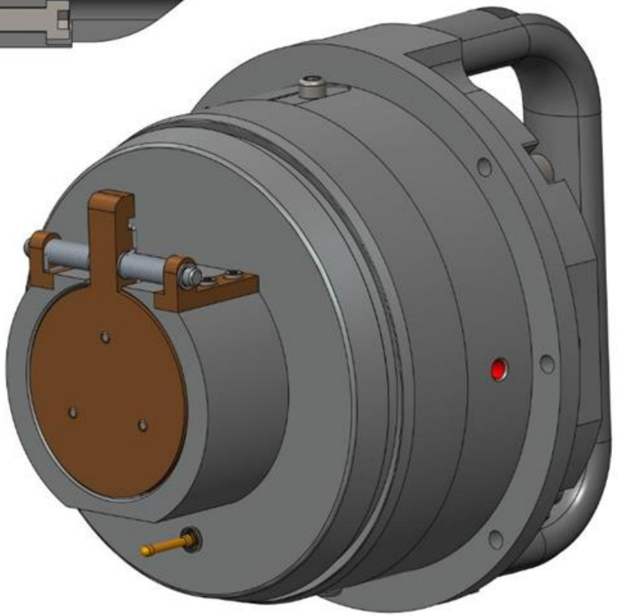




The *ion collector*

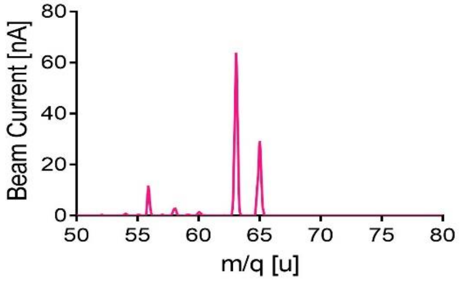




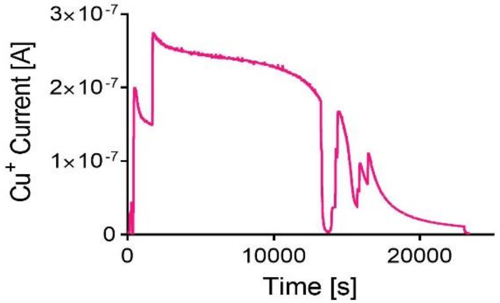


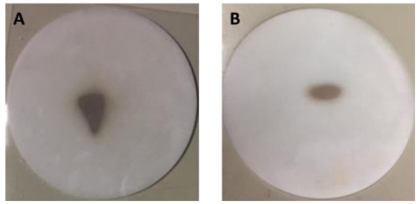
Copper beams

1) ^{63}Cu and ^{65}Cu identification (69.17% and 30.83%)



2) ^{63}Cu deposition

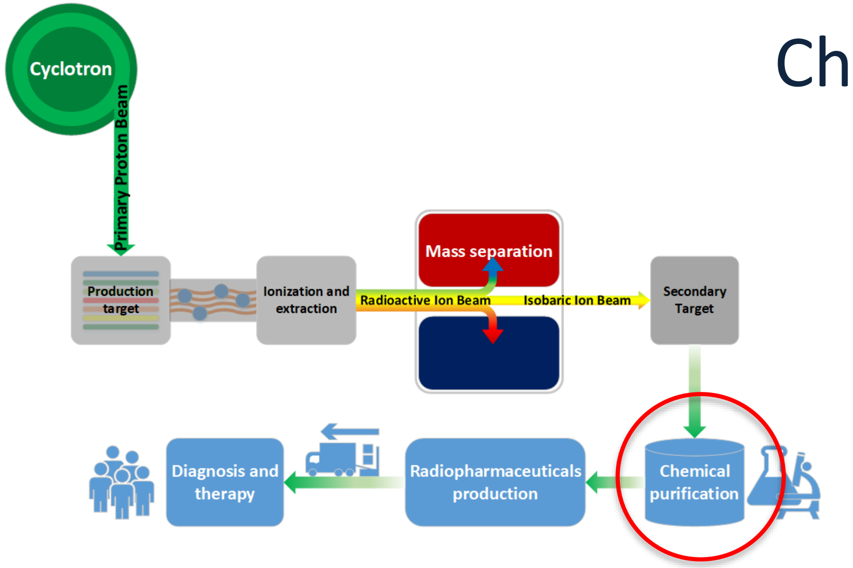


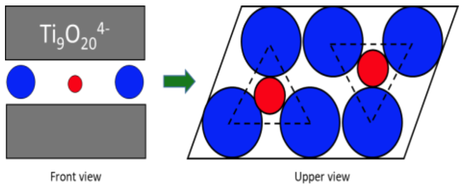


Ionization efficiency: 10%

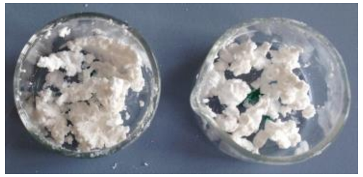
	Copper (current) measured in FC2 and integrated in time [μg]	Copper measured via GF-AAS [μg]	
1st deposition	9.94	1.46	Target dissolved in HNO_3 0.5 M, mild heating
2nd deposition	5.21	1.09	Target dissolved in HNO_3 0.5 M, mild heating
3rd deposition	1.12	0.54	Target dissolved in concentrated HNO_3, 180 °C for 20 min
4th deposition	0.94	0.50	Target dissolved in concentrated HNO_3, 180 °C for 20 min

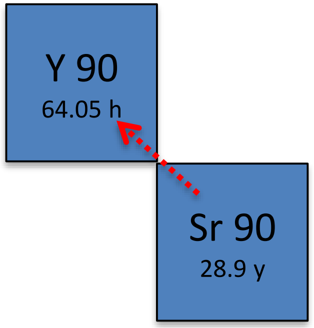
Chemical purification





$$9Ti(OC_3H_7)_4 + 4NaOH \longrightarrow Na_4Ti_9O_6 \cdot xH_2O$$

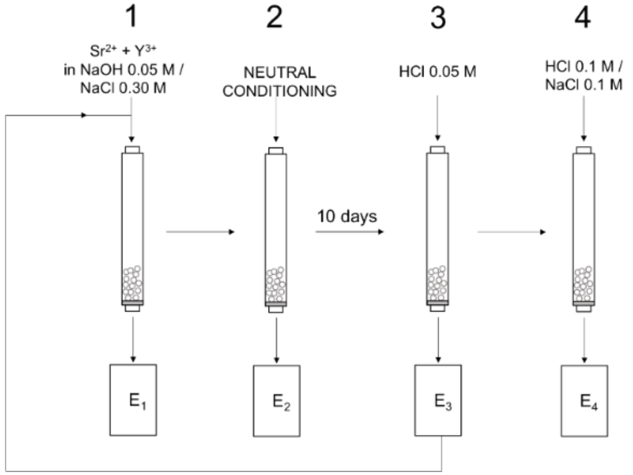




The case of ^{90}Y

^{90}Sr main contaminant, but a source of ^{90}Y as well

^{90}Y directly produced + the ^{90}Y from the decay of ^{90}Sr



ISOLPHARM_Ag: a case study

Istituto Nazionale di Fisica Nucleare
Sezione di Padova

Università degli Studi di Padova | dsf

Università degli Studi di Trento

BIOtech
Biomedical Technologies

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

Università degli Studi di Padova | DiSC

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Trento Institute for Fundamental Physics and Applications

ISOLPHARM_Ag

^{111}Ag

Promising radionuclide for therapy:

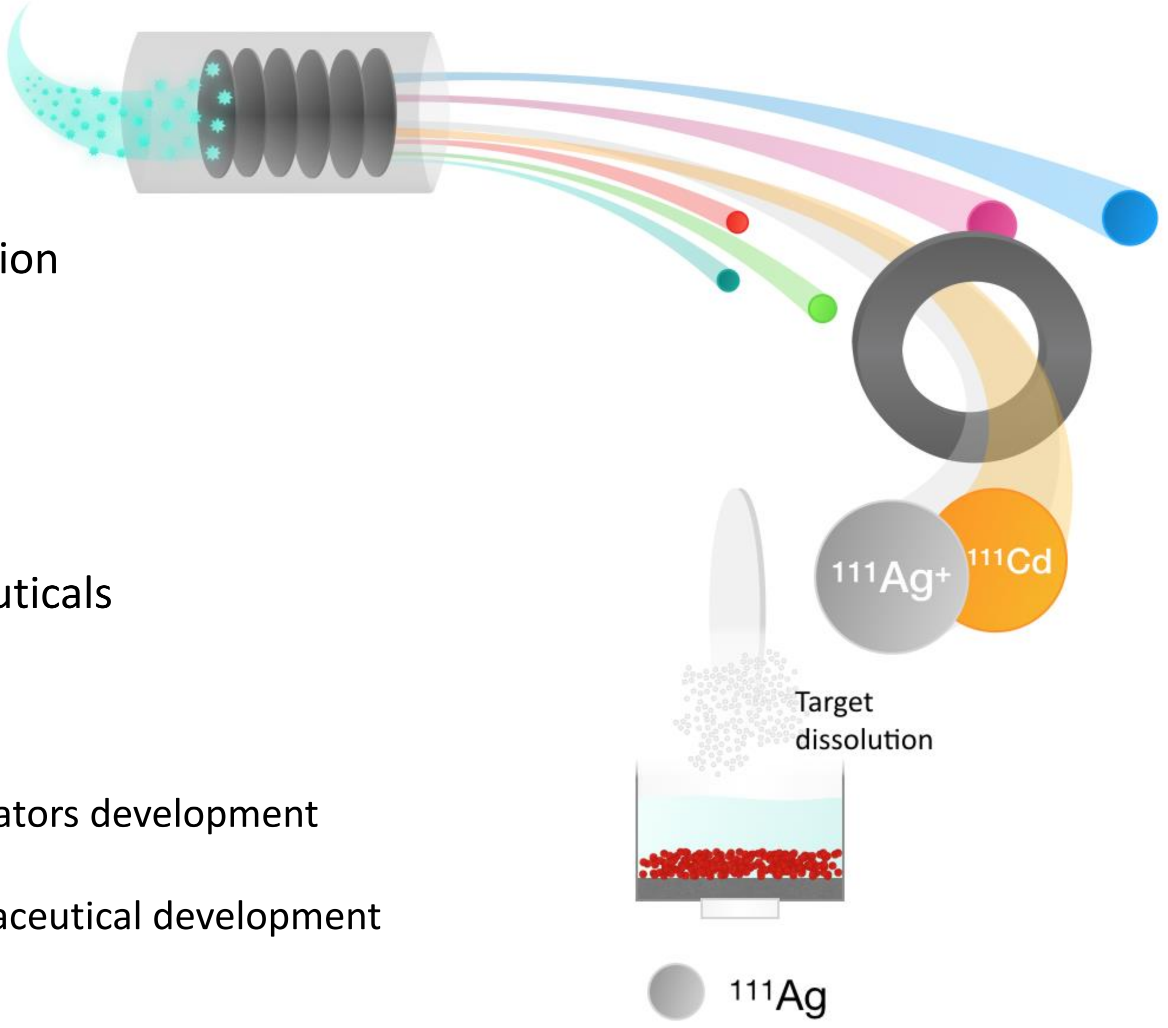
- β^- emitter (average energy 360 keV)
- Low percentage of associated γ-emission (342 keV, 6.7%)
- $t_{1/2}$: 7.45 days

Development of Ag-based radiopharmaceuticals

Task 1: physics and computing

Task 2: production of Ag^+, purification and chelators development

Task 3: cellular targets studies and radiopharmaceutical development



UC_x target

Production of ^{111}Ag

SPES UC_x isotope production (200 µA 40 MeV PPB, 5 irradiation days)												
Isotope	Half-life	Decay radiations								Produced activity		Notes
	$t_{1/2}$	β-		β+/ϵ		γ		Auger		[MBq]	[mCi]	
^{77}As	38,83 h	100%	0,683 MeV	/	/	1,59%	239 keV	0,06%	(9,67 keV)	2,21E+03	59,73	
^{86}Rb	18,642 d	99,99%	1,776 MeV	0,01%	ϵ	8,64%	1077 keV	0,01%	(10,8 keV)	6,06E+01	1,64	
^{89}Sr	50,53 d	100%	1,5 MeV	/	/	/	/	/	/	8,85E+03	239,15	
^{90}Sr	28,9 y	NR	NR	NR	NR	NR	NR	NR	NR	5,16E+01	1,39	^{90}Y generator
^{90}Y	64,053 h	100%	2,28 MeV	/	/	/	/	0,00%	(13,4 keV)	1,88E+02	5,08	
^{111}Ag	7,45 d	100%	1,036 MeV	/	/	6,70%	342 keV	0,04%	(19,3 keV)	8,29E+04	2241,85	
^{122}Sb	2,7238 d	97,59%	1,984 MeV	2,41%	β+	70,67%	564 keV	0,29%	(21 keV)	1,32E+03	35,80	
^{125}I	59,407 d	/	/	100%	ϵ	6,68%	35,49 keV	19,80%	22,7 keV	1,70E+00	0,05	
^{126}I	12,93 d	47,30%	1,258 MeV	52,70%	β+	32,90%	666,33 keV	5,53%	22,7 keV	3,65E+01	0,99	
^{130}I	12,36 h	100%	2,949 MeV	/	/	11,30%	1157 keV	0,19%	(24,6 keV)	2,82E+04	760,84	
^{131}I	8,0252 d	100%	0,970 MeV	/	/	81,50%	364 keV	0,68%	(24,6 keV)	6,57E+04	1774,77	
^{133}Xe	5,2475 d	100%	0,427 MeV	/	/	36,90%	80,99 keV	5,67%	25,5 keV	8,59E+04	2320,76	
^{129}Cs	32,06 h	/	/	100,00%	β+	30,60%	371,92 keV	13,10%	24,6 keV	4,62E+00	0,12	Many Auger e^- emissions
^{131}Cs	9,689 d	/	/	100,00%	ϵ	/	/	9,30%	24,6 keV	3,68E+01	0,99	Many Auger e^- emissions
^{132}Cs	6,480 d	2%	1,279 MeV	98,13%	β+	1,58%	464 keV	9,40%	24,6 keV	2,14E+02	5,79	Many Auger e^- emissions
^{136}Cs	13,04 d	100%	2,548 MeV	/	/	80,00%	1048 keV	1,24%	26,4 keV	1,16E+04	313,75	
^{161}Tb	6,89 d	100%	0,593 MeV	/	/	10,20%	75 keV	1,46%	37,2 keV	1,73E+02	4,67	
^{169}Er	9,392 d	100%	0,351 MeV	/	/	0,00%	109,77 keV	0,00%	(5,67 keV)	1,54E+00	0,04	

Task 1

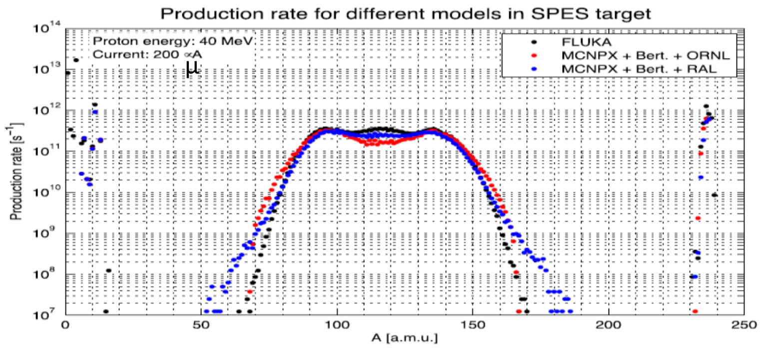
Physics and computing

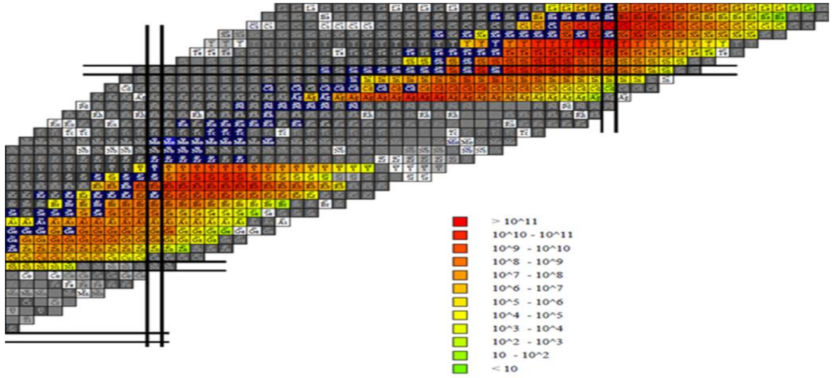
The computing task can be divided into two different case studies, where cloud computing can be an extremely useful tool to perform fast and efficient simulations, related to both the target production and release of radionuclides of interest

Activities of this task:

1. Simulation of radionuclides production in the Isolpharm target

2. Simulation of radionuclides release from the Isolpharm target





Task 2:

activities at LNL, DSF and DSC

1) Ionization and acceleration of Ag^{+} using the SPES Front End in off-line modality, the production of the secondary targets for Ag^{+} deposition and the deposition studies

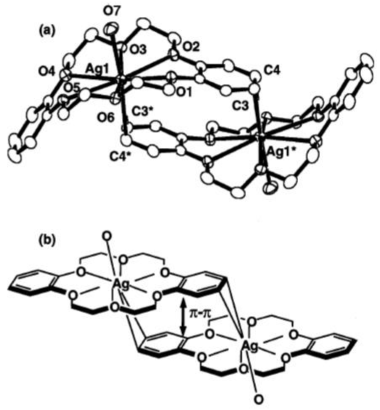
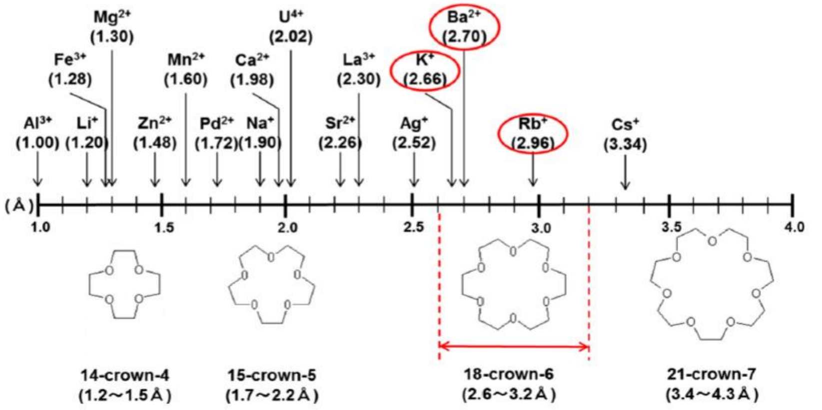


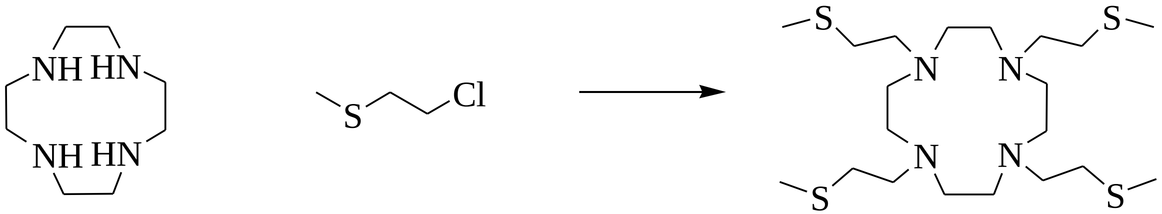
Fig. 1. Partial labelling (a) and schematic view (b) of silver(I)-DB[18]C6 dinuclear unit.

2) Synthesis of a resin for $^{111}Ag^{+}$ purification from $^{111}Cd^{2+}$

Fig. 6 Relationship between of crown ether pore sizes and metal ion diameters

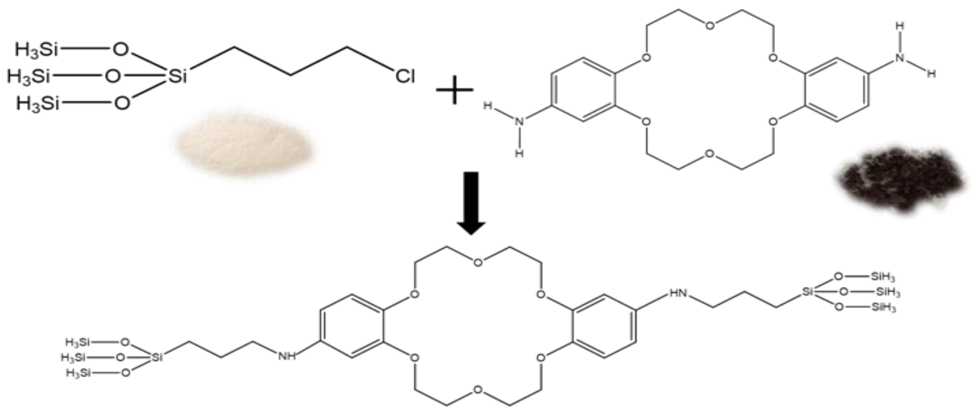


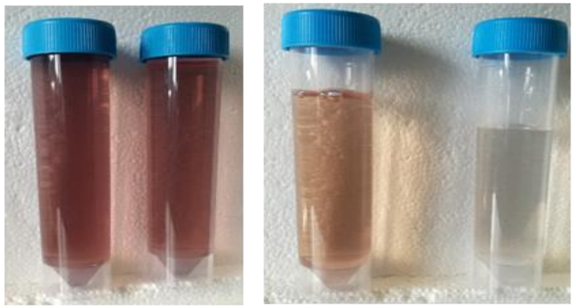
3) Development of chelators for Ag^{+} based on DOTETE and analogues



Chemistry activities

$^{111}Ag/^{111}Cd$ purification



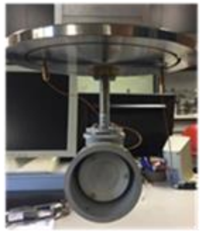


Uptake and release under development

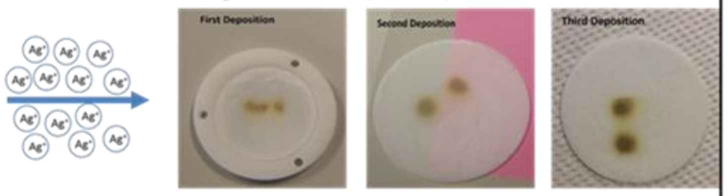
30-09-2018

MS5: Ionizzazione e deposito di Ag stabile presso FE SPES

Deposito Ag^+ su target da 40 mm di $NaNO_3$

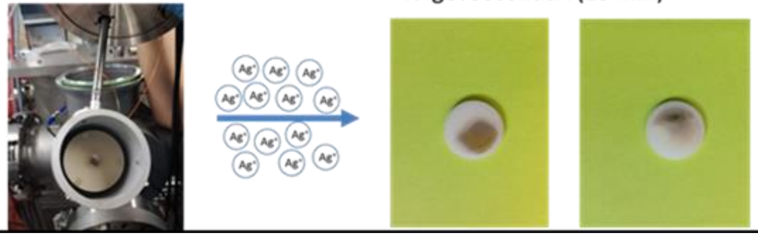


Target secondari (40 mm)



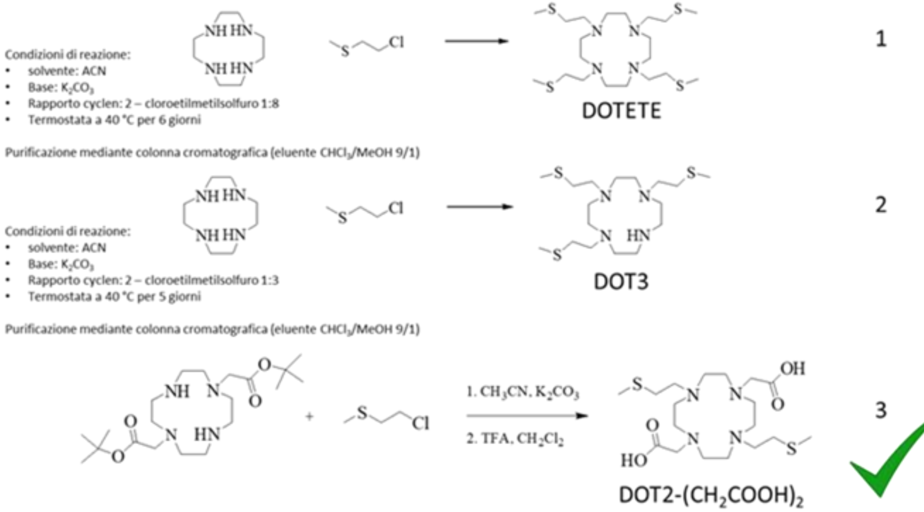
Deposito su target da 13 mm

Target secondari (13 mm)

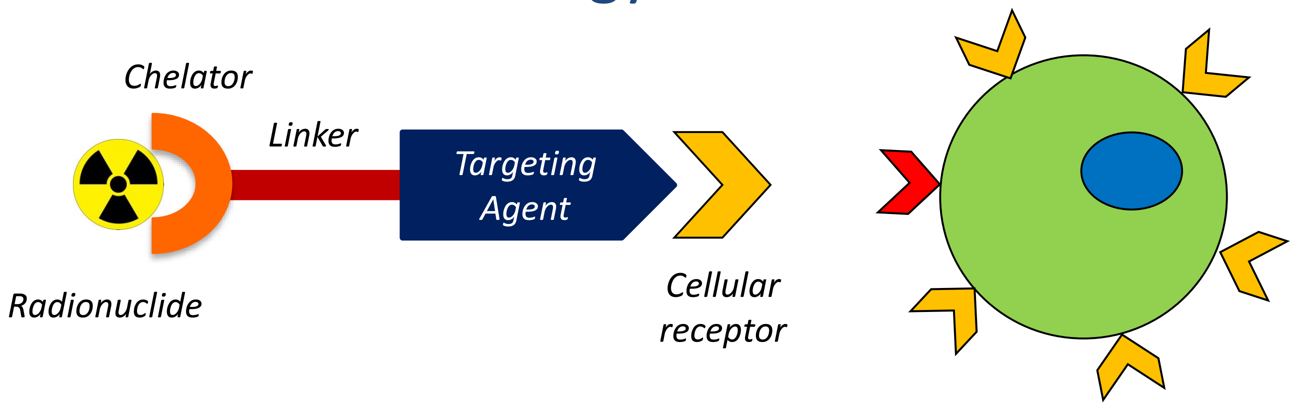


31-12-2018

MS6: Sintesi di una gamma di complessi a base Ag



Pharmacology activities



1) Cholecystokinin receptor (CCK2R and CCK2i4svR)

➡ objective: development of small molecule-based ligands.

- Targeting agent: synthesis ongoing
- Linker moiety
- Chelator

SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA

Azienda Unità Sanitaria Locale di Reggio Emilia
Azienda Ospedaliera di Reggio Emilia
Arcispedale S. Maria Nuova
Istituto in tecnologie avanzate e modelli assistenziali in oncologia
Istituto di ricovero e cura a carattere scientifico

2) Calreticulin (CRT): a potential target for proton therapy combined with targeted radionuclide therapy

➡ objective: development of a targeting agent for CRT

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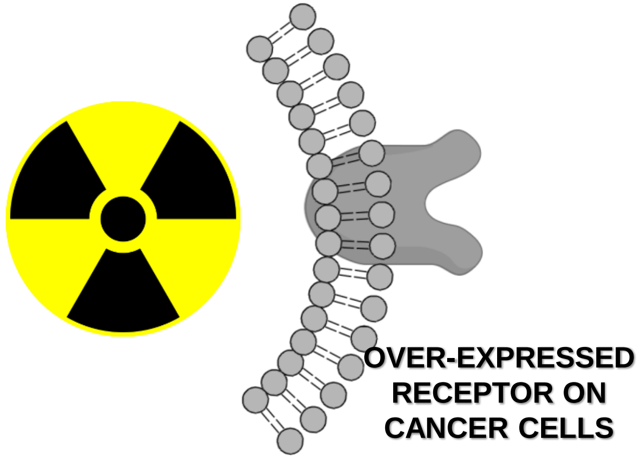
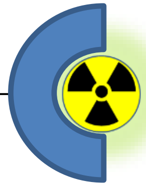
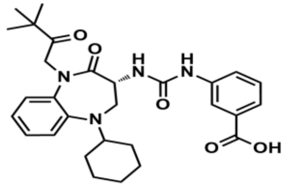
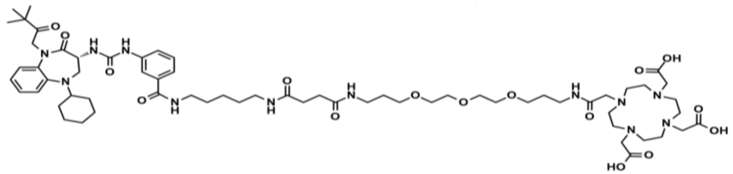
Pharmacology activities

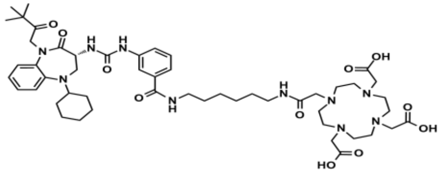


TARGETING AGENT — **LINKER** —  **BIFUNCTIONAL CHELATOR**

Development of targeting agent for Calreticulin and CCK2R







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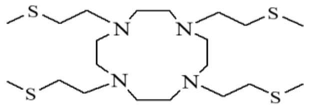
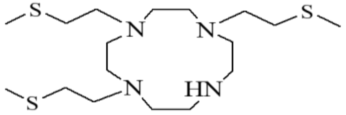
dsf

Development of novel possible bifunctional chelators for ^{111}Ag at Dept. of Chemical Sciences (UNIPD)

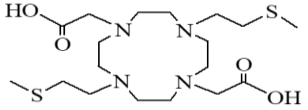
DiSC



DOTETE



DOT3



DOT2(CH_2COOH)$_2$

Summary

Highlight n.1: the ISOLPHARM network

The Italian Network

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Legnaro

Istituto Nazionale di Fisica Nucleare
Sezione di Padova

TIFPA
Trento Institute for Fundamental Physics and Applications

Università degli Studi di Padova

- Pharmaceutical and Pharmacological Sciences
- Chemical sciences
- Industrial engineering
- Management and engineering
- Information engineering
- Physics and astronomy

BIOtech Biomedical Technologies at University of Trento - Italy

Servizio Sanitario Regionale Emilia-Romagna
Azienda Unità Sanitaria Locale di Reggio Emilia
Azienda Ospedaliera di Reggio Emilia
Arcispedale S. Maria Nuova
Istituto in tecnologie avanzate e modelli assistenziali in oncologia
Istituto di ricovero e cura a carattere scientifico

Sacro Cuore Don Calabria Negrar - Verona
Ospedale Sacro Cuore Don Calabria
Presidio ospedaliero accreditato - Regione Veneto

Regione del Veneto
ULSS2 Marca Trevigiana

I.O.V.
Istituto Oncologico Veneto I.R.C.C.S

The International Network

POLATOM

Paul Scherrer Institut PSI

Demokritos
National Center for Scientific Research

Medicis Promed

Highlight n.2: ISOLPHARM participation in future EU projects

INFN is the coordinator of a new JRA in the framework of the ERINS (IA) in Horizon Europe

MAIA (MedicAl Isotopes from Accelerators)

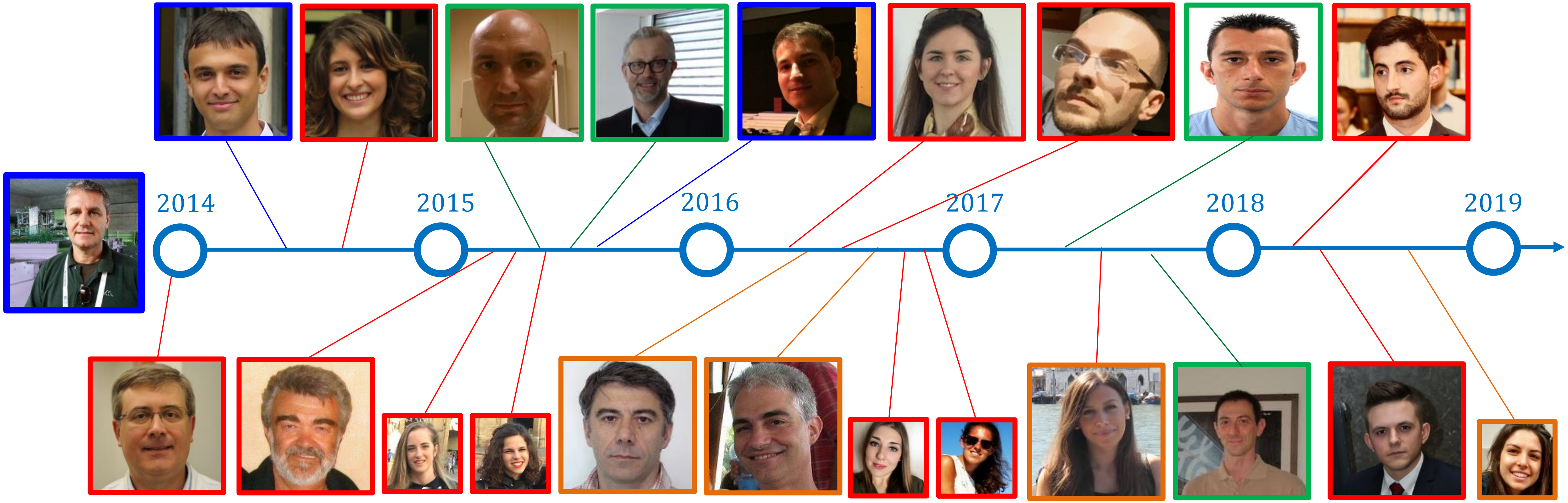
Involved institutions: INFN, CEA & GANIL & ARRONAX/SUBATECH, USC& CSIC-I3M , ELI-NP/IFIN-HH, NPI, HIL

Aim: study and develop new techniques for the production of radioisotopes of medical interest using accelerators

Three different aspects will be part of the project:

- New production methods
- Innovative target design, production and characterization
- From targets to isotopes: purification and processing

Highlight n.3: the ISOLPHARM people



ISOLPHARM needs a structure composed of competences in:

- Nuclear physics, for the generation and collection of nuclides
- Radiochemistry, for the chemical separation and complexation of the collected nuclides
- Radiopharmacy, for the performance of radiolabeling and in vitro/in vivo studies
- Nuclear medicine, for GMP development and possible clinical studies

ISOLPHARM as a training hub: PhD & Master theses

ISOLPHARM
SPES exotic beams for medicine

PhD theses (2)

Università degli Studi di Padova

Head Office: Università degli Studi di Padova
Department of Chemical Sciences

Ph.D. COURSE IN MOLECULAR SCIENCES
CURRICULUM PHARMACEUTICAL SCIENCES
XXX SERIES

PHARMACEUTICAL DEVELOPMENT OF THE ISOL TECHNIQUE FOR THE PRODUCTION OF RADIONUCLIDES AND THEIR APPLICATIONS IN TARGETED RADIONUCLIDE THERAPY

Coordinator: Ch.mo Prof. Leonard Prins
Supervisor: Ch.mo Prof. Nicola Realdon
Co-Supervisor: Dr. Alberto Andrighetto

Ph.D. student: Francesca Borgna

Università degli Studi di Ferrara

DOTTORATO DI RICERCA IN "FISICA"
CICLO XXXI
COORDINATORE Prof. Guidi Vincenzo

Development of targets for the production of radionuclides of medical interest according to the ISOL technique

Settore Scientifico Disciplinare FIS/07

Dottorando Dott. Ballan Michele
Tutore Prof. Duatti Adriano

Anni 2015/2018

Master theses in chemistry and industrial engineering (6)

UNIVERSITÀ DEGLI STUDI DI PADOVA
Dipartimento di Ingegneria Industriale
Corso di Laurea Magistrale in Ingegneria Meccanica
TESI DI LAUREA
ANALISI E PROGETTAZIONE DI UN SISTEMA DI CONTENIMENTO E MOVIMENTAZIONE DI UN BERSAGLIO PER LA RACCOLTA DI ISOTOPI RADIOATTIVI DI INTERESSE MEDICO
Relatore: Prof. GIOVANNI MENEGHETTI
Correlatori: Dott. ALBERTO ANDRIGHETTO[1], Ing. MICHELE BALLAN[1]
[1]Istituto Nazionale di Fisica Nucleare di Legnaro
Laureando: SERGHEI POPA, Matricola: 1132442
ANNO ACCADEMICO 2016-2017

UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI TECNICA E GESTIONE DEI SISTEMI INDUSTRIALI
CORSO DI LAUREA MAGISTRALE IN INGEGNERIA DELL'INNOVAZIONE DEL PRODOTTO
TESI DI LAUREA
Sviluppo di un set-up sperimentale per la misura della conducibilità termica di carburi di titanio per applicazioni in fisica e medicina nucleare.
Relatore: Ch.mo Prof.ssa LISA BIASETTO
Co-relatori: Dott. ALBERTO ANDRIGHETTO, Dott. STEFANO CORRADETTI, Ing. MATTIA MANZOLARO
Laureando: PAOLO TODESCO, Matricola: 1128029
ANNO ACCADEMICO 2016/2017

UNIVERSITÀ DEGLI STUDI DI PADOVA
FACOLTÀ DI INGEGNERIA
Corso di Laurea Magistrale in Ingegneria dei Materiali
Dipartimento di Ingegneria Industriale
Tesi di Laurea Magistrale
Development of porous refractory targets for nuclear physics and medical applications
Relatore: Prof. Paolo Colombo
Correlatori: Dott. Stefano Corradetti, Dott. Alberto Andrighetto
Laureando: Alberto Gerotto
A.A. 2016-2017

UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI INGEGNERIA INDUSTRIALE DII
Corso di Laurea magistrale in Ingegneria dei Materiali
TARGET CERAMICI POROSI PER LA PRODUZIONE DI FASCI RADIOATTIVI PER FISICA E MEDICINA NUCLEARE.
POROUS CERAMIC TARGET FOR THE PRODUCTION OF RADIOACTIVE BEAMS FOR NUCLEAR PHYSICS AND MEDICINE.
Laureando: Federico Gobbo D'incà
Relatore: Prof. Paolo Colombo
Correlatori: Dott. Alberto Andrighetto, Dott. Stefano Corradetti, Dott.ssa Giorgia Franchin
ANNO ACCADEMICO 2017/2018

UNIVERSITÀ DEGLI STUDI DI PADOVA
FACOLTÀ DI INGEGNERIA
Corso di Laurea Magistrale in Ingegneria dei Materiali
Dipartimento di Ingegneria Industriale
Tesi di Laurea Magistrale
Sviluppo di un target refrattario mesoporoso in carburo di titanio per applicazioni in fisica e medicina nucleare
RELATORE: Prof. Paolo Colombo
CO-RELATORI: Dott. Alberto Andrighetto, Dott. Stefano Corradetti, Dott.ssa Sara Carturan
LAUREANDO: Davide Mengarelli
A.A. 2017-2018

UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE CHIMICHE
CORSO DI LAUREA MAGISTRALE IN CHIMICA
TESI DI LAUREA MAGISTRALE
SINTESI E STUDIO TERMODINAMICO DI NUOVI POSSIBILI CHELANTI BIFUNZIONALI PER LA *TARGETED RADIONUCLIDE THERAPY* CON ^{111}Ag (PROGETTO ISOLPHARM-Ag)
RELATORE: CH.MO PROF. VALERIO DI MARCO
CORRELATORE: CH.MO PROF. GIOVANNI MARZARO
CONTROrelatore: CH.MO PROF. GIUSEPPE ZAGOTTO
LAUREANDA: MARIANNA TOSATO
ANNO ACCADEMICO 2017/2018

Master theses in pharmacy (9)

UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
POTENZIALITÀ DELLA TECNOLOGIA *ISOTOPE SEPARATION ON-LINE* (ISOL) PER LA REALIZZAZIONE DI UN RADIOFARMACO A BASE DI ^{89}Sr E PRELIMINARE SVILUPPO TECNOLOGICO DELLA FORMA FARMACEUTICA
RELATORE: CH.MO PROF. NICOLA REALDON
CORRELATORI: DOTT. ALBERTO ANDRIGHETTO[1], DOTT. STEFANO CORRADETTI[1]
[1]Istituto Nazionale di Fisica Nucleare
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
SVILUPPO PRELIMINARE DI UNA PREPARAZIONE RADIOFARMACEUTICA CONTENENTE $^{90}YCl_3$ MEDIANTE TECNOLOGIA *ISOTOPE SEPARATION ON-LINE* (ISOL)
RELATORE: CH.MO PROF. NICOLA REALDON
CO-RELATORI: DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA, DOTT. STEFANO CORRADETTI[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
STUDIO DELLO SCAMBIATORE IONICO SODIO NONATITANATO PER LA PURIFICAZIONE DI UN RADIOFARMACO A BASE DI ^{90}Y DAL CONTAMINANTE ^{90}Sr, PRODOTTO CON TECNOLOGIA *ISOL*
RELATORE: CHIAR.MO PROF. NICOLA REALDON
CORRELATORI: DOTT. ALBERTO ANDRIGHETTO[1], DOTT. SSA FRANCESCA BORGNA, DOTT. STEFANO CORRADETTI[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
SVILUPPO DI UN PROCESSO FARMACEUTICO PER LA PRODUZIONE DI ^{131}I E ^{125}I CON TECNOLOGIA ISOL (*ISOTOPE SEPARATION ON-LINE*)
Relatore: Ch.mo Prof. NICOLA REALDON
Co-relatori: Dott. ALBERTO ANDRIGHETTO, Dott. STEFANO CORRADETTI, Dott.ssa FRANCESCA BORGNA
Laureanda: CHIARA TODESCO, Matricola: 1025063
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
SVILUPPO TECNOLOGICO DI UN PROTOTIPO DI GENERATORE $^{90}Sr/^{90}Y$ E DETERMINAZIONE DELL'EFFICIENZA DI DEPOSIZIONE DI ^{63}Cu PER RADIONUCLIDI PRODOTTI CON TECNOLOGIA *ISOL*
RELATORE: CH.MO PROF. NICOLA REALDON
CO-RELATORI: DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA, DOTT. MICHELE BALLAN[1], DOTT. STEFANO CORRADETTI[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
RICERCA DI UN METODO DI PURIFICAZIONE DELLO ^{89}Sr DAL SUO CONTAMINANTE ^{89}Y PER LO SVILUPPO TECNOLOGICO DI UN RADIOFARMACO E IONIZZAZIONE DELLO ^{45}Sc CON LA TECNOLOGIA ISOTOPE SEPARATION ON-LINE (ISOL)
RELATORE: CHIAR.MO PROF. NICOLA REALDON
CO-RELATORI: DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA, DOTT. MICHELE BALLAN[1], DOTT. STEFANO CORRADETTI[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
PROGETTO ISOLPHARM-Ag: SVILUPPO TECNOLOGICO DI UN PROCESSO FARMACEUTICO PER LA PRODUZIONE DI ^{111}Ag E RELATIVA PURIFICAZIONE
RELATORE: CH.MO PROF. NICOLA REALDON
CO-RELATORI: CH.MO PROF. GIOVANNI MARZARO, DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA[1], DOTT. STEFANO CORRADETTI[1], DOTT. MICHELE BALLAN[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
PROGETTO ISOLPHARM-Ag: IONIZZAZIONE, DEPOSIZIONE E PURIFICAZIONE DELL'^{111}Ag PER LA PRODUZIONE DI RADIOFARMACI AD USO TERAPEUTICO
RELATORE: CHIAR.MO PROF. NICOLA REALDON
CORRELATORI: CHIAR.MO PROF. GIOVANNI MARZARO, DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA, DOTT. MICHELE BALLAN[1]
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UNIVERSITÀ DEGLI STUDI DI PADOVA
DIPARTIMENTO DI SCIENZE DEL FARMACO
CORSO DI LAUREA MAGISTRALE IN FARMACIA
TESI DI LAUREA
SINTESI E CARATTERIZZAZIONE DI MOLECOLE PER IL TARGETING ATTIVO SUL RECETTORE CCK2R
RELATORE: CH.MO PROF. GIOVANNI MARZARO
CORRELATORI: CH.MO PROF. NICOLA REALDON, DOTT. ALBERTO ANDRIGHETTO[1], DOTT.SSA FRANCESCA BORGNA[1], DOTT.SSA FRANCESCA MASTROTTO, DOTT. MATTIA ASTI[2]
[1]Istituto Nazionale di Fisica Nucleare
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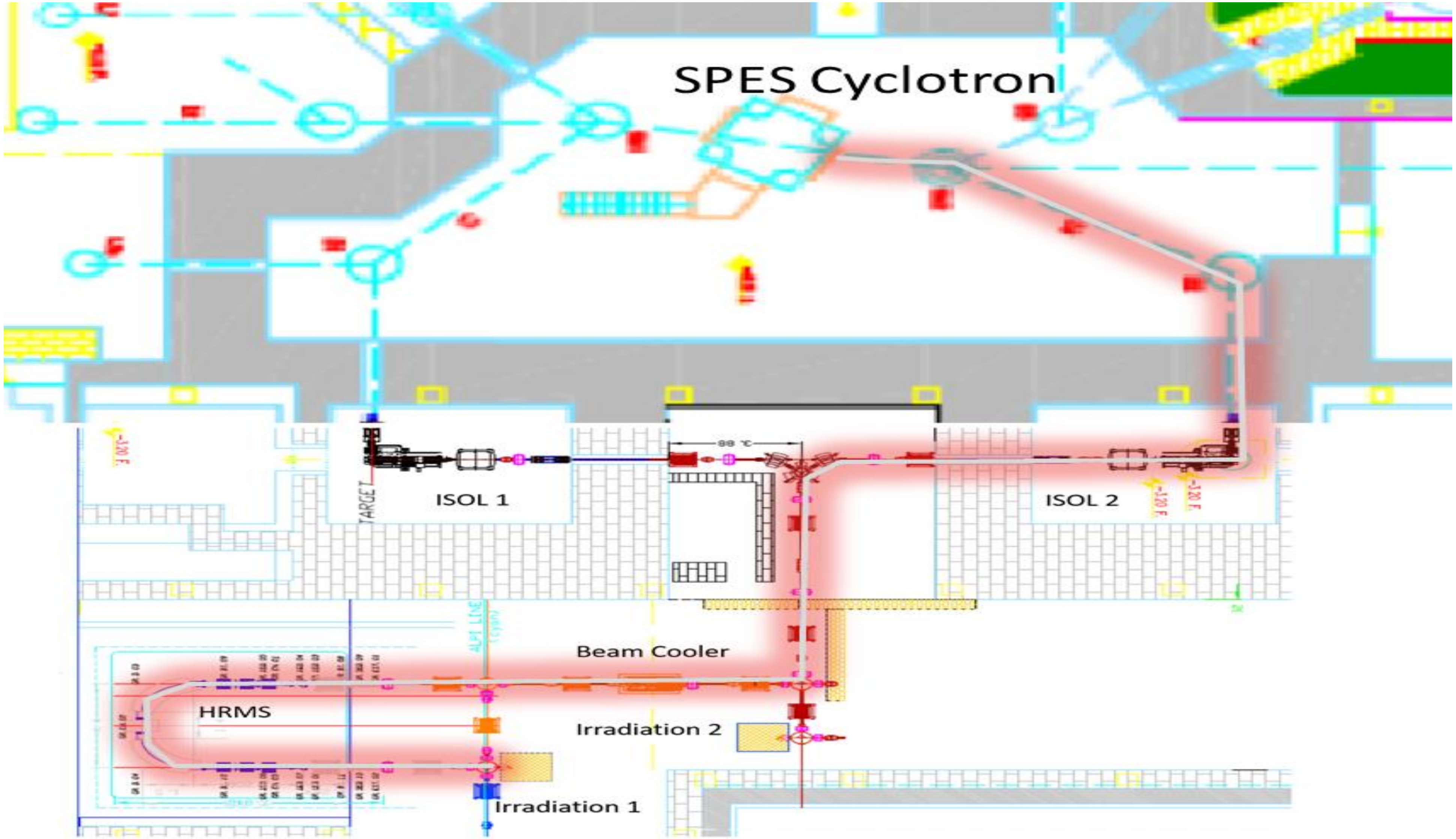
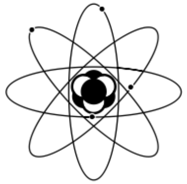
LAUREANDO: MARCO VERONA
ANNO ACCADEMICO: 2017/2018

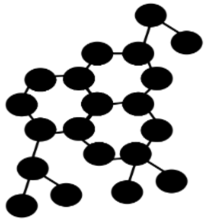
Highlight n. 3: Isolpharm as future facility?



Highlight n. 4:

At SPES it will be possible soon to **produce radionuclides for medical purposes** using the ISOL technique.



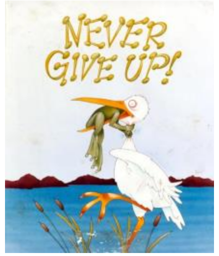


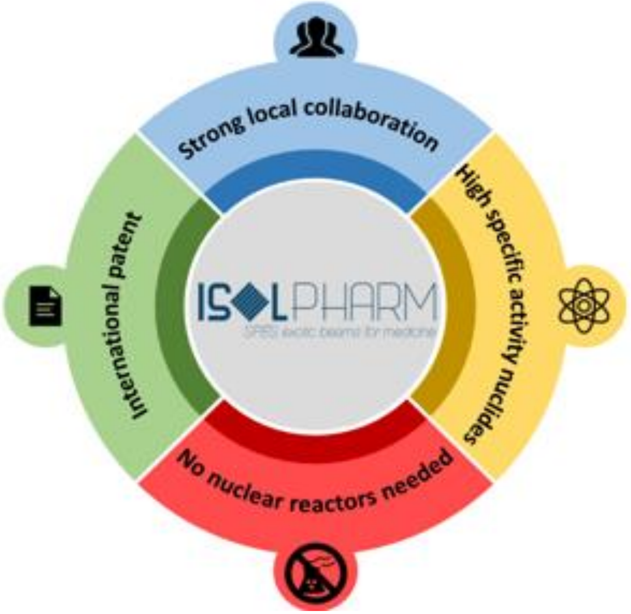
The ISOLPHARM method (patent deposited) is focused on the production of radiopharmaceutical precursors with **high specific activity** using a proton beam ad intermediate energies.

The ISOLPHARM collaboration has started 3 years ago. An increasing **experimental activity** is under development.

Some radionuclides (as ^{111}Ag , ^{43}Sc, etc) are extremely interesting and could be used as precursors for **new radiopharmaceuticals.**

First step: to produce **first radionuclides of medical interest** for research (small quantities) when the first SPES RIB will be delivered.

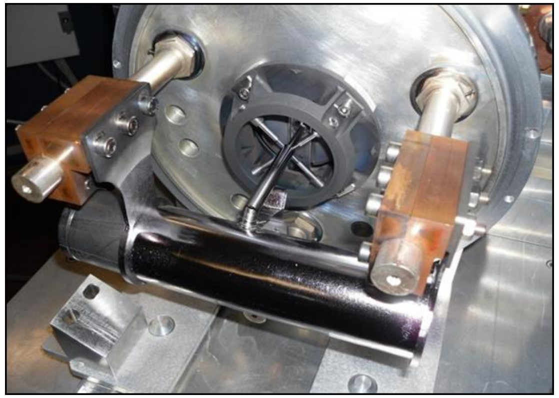




INFN

ISOLPHARM
SPES exotic beams for medicine

thanks for your attention!



ISOLPHARM
SPES exotic beams for medicine

SPES
exotic beams for science