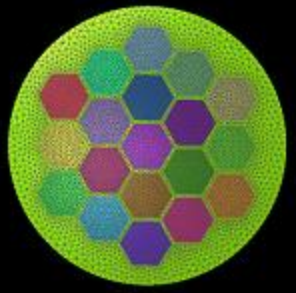


SUPERCONDUCTING TECHNOLOGIES

FOR THE NEXT GENERATION OF MEDICAL ACCELERATORS

WORKSHOP

CERN MEDICIS and MEDICIS-PROMED:
Novel radioisotope production for medical applications

Simon Stegemann on behalf of the MEDICIS Collaboration

AIME-SCMED 2016, 24-25 November 2016, CIEMAT, Madrid

European Commission

MEDICIS Promed

KU LEUVEN

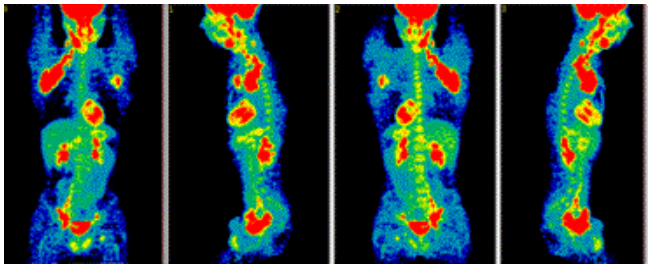
Outline

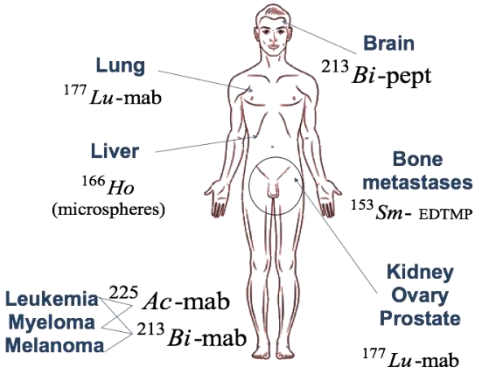
- Introduction
- The MEDICIS facility
- The MEDICIS-PROMED Network
- Objectives
- Training
- Summary

Radionuclides for nuclear medicine

- Radioisotopes are commonly used for functional imaging
- Expanding demand for personalized medicine: Diagnostic testing for individual optimized therapies

PET image





Nuclear diagnostic testing

Individual optimized therapies

➢ But choice of known radioisotopes is restricted due to limited access!

Production of medical isotopes

Neutron-deficient:

- Fusion evaporation
- Moderate energies
- On-site cyclotrons or small linacs

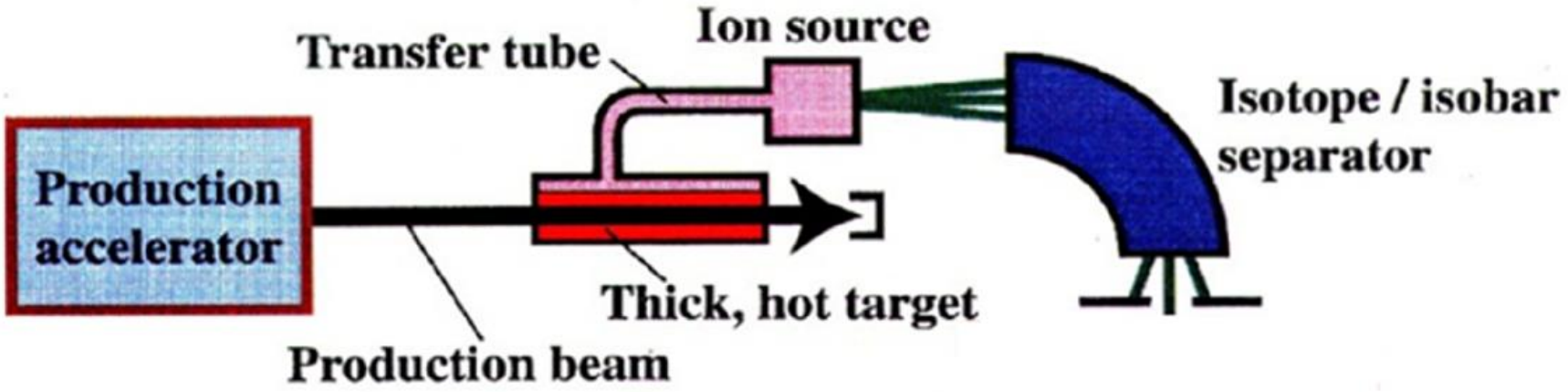
Neutron-rich:

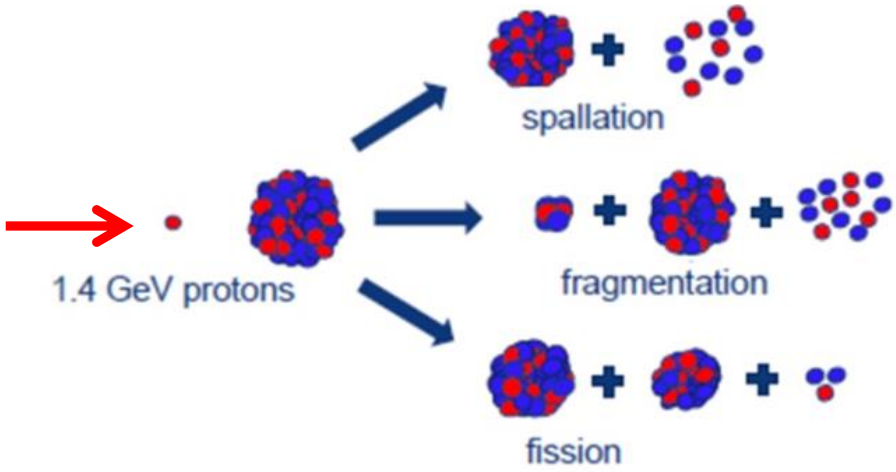
- Neutron capture close to stability
- Typically from enriched targets
- At research reactors

Typical isotopes: ^{11}C, ^{13}N, ^{15}O, ^{18}F, ^{32}P, ^{68}Ga, ^{82}Rb, ^{90}Yb, ^{99m}Tc, ^{111}In, ^{121}I, ^{128}I, ^{131}I, ^{153}Sm, ^{177}Lu, ^{201}Tl, ^{203}Pb, ^{211}At, ^{223}Ra

Isotope production via the ISOL method

(ISOL) Isotope mass Separation OnLine





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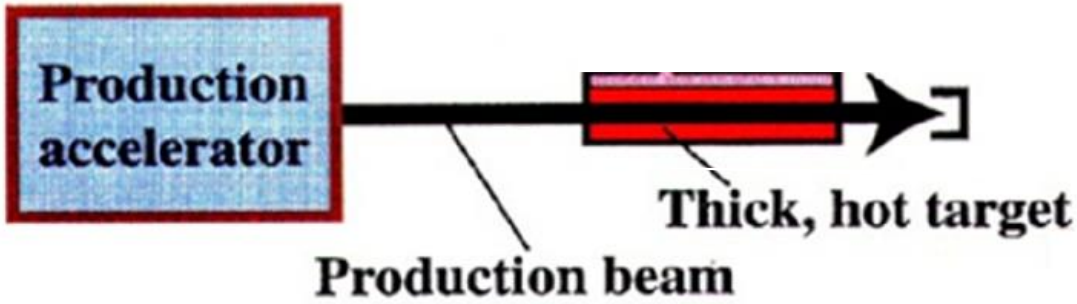
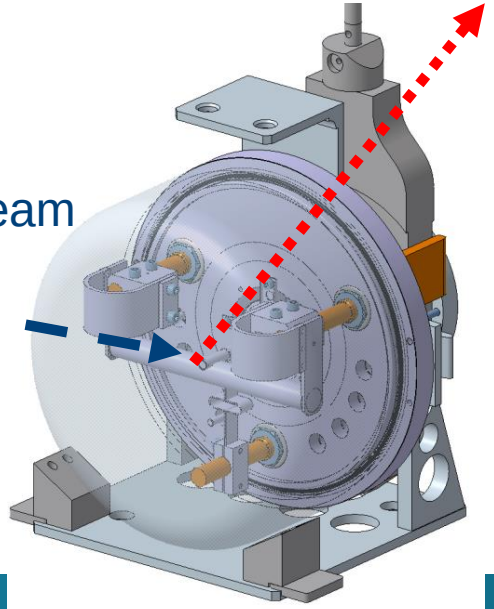


Produced isotopes

(High energy) beam

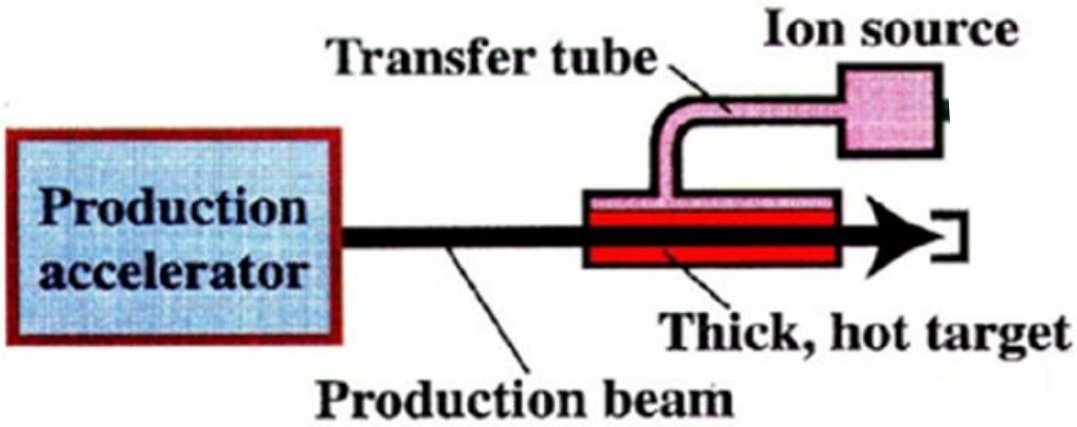


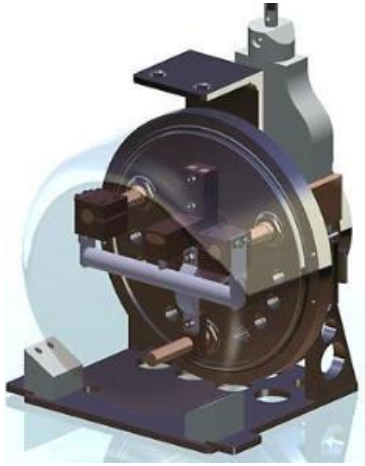
Example of target pellets

UC_2

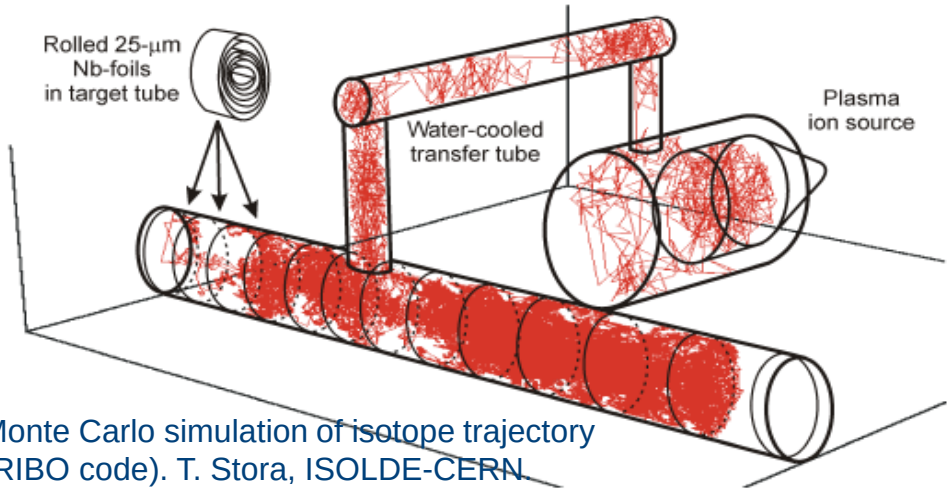
Isotope production via the ISOL method

(ISOL) Isotope mass Separation OnLine





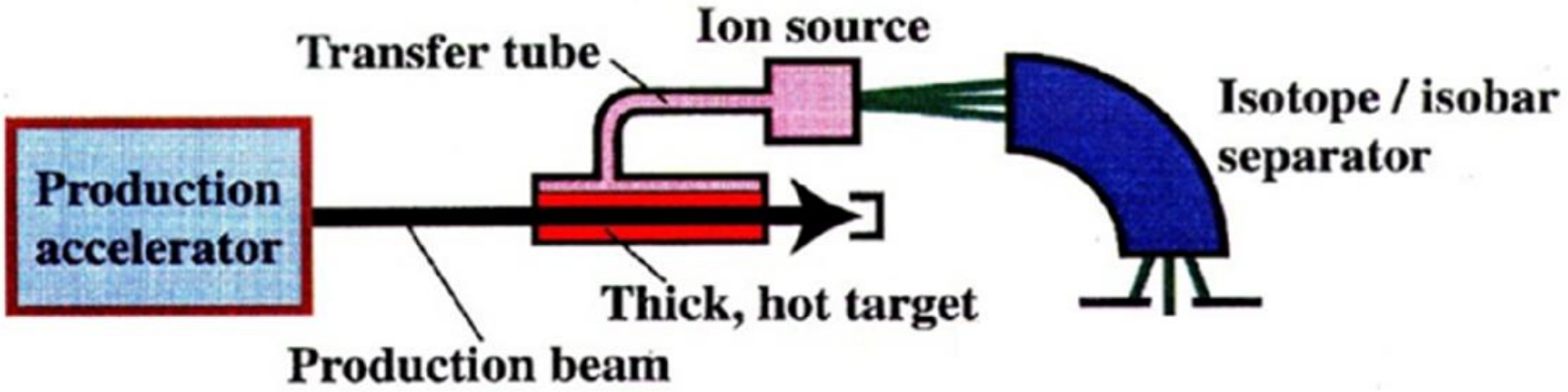
Target-ion source unit



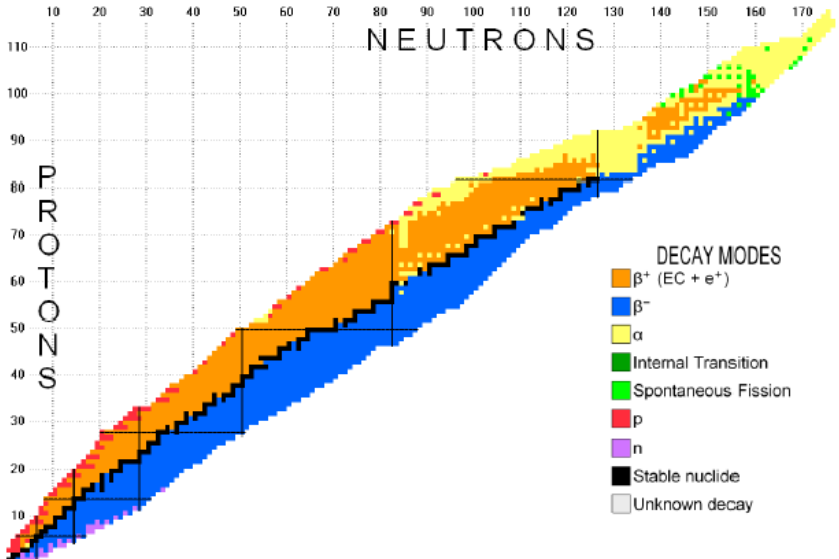
Monte Carlo simulation of isotope trajectory (RIBO code). T. Stora, ISOLDE-CERN.

Isotope production via the ISOL method

(ISOL) Isotope mass Separation OnLine

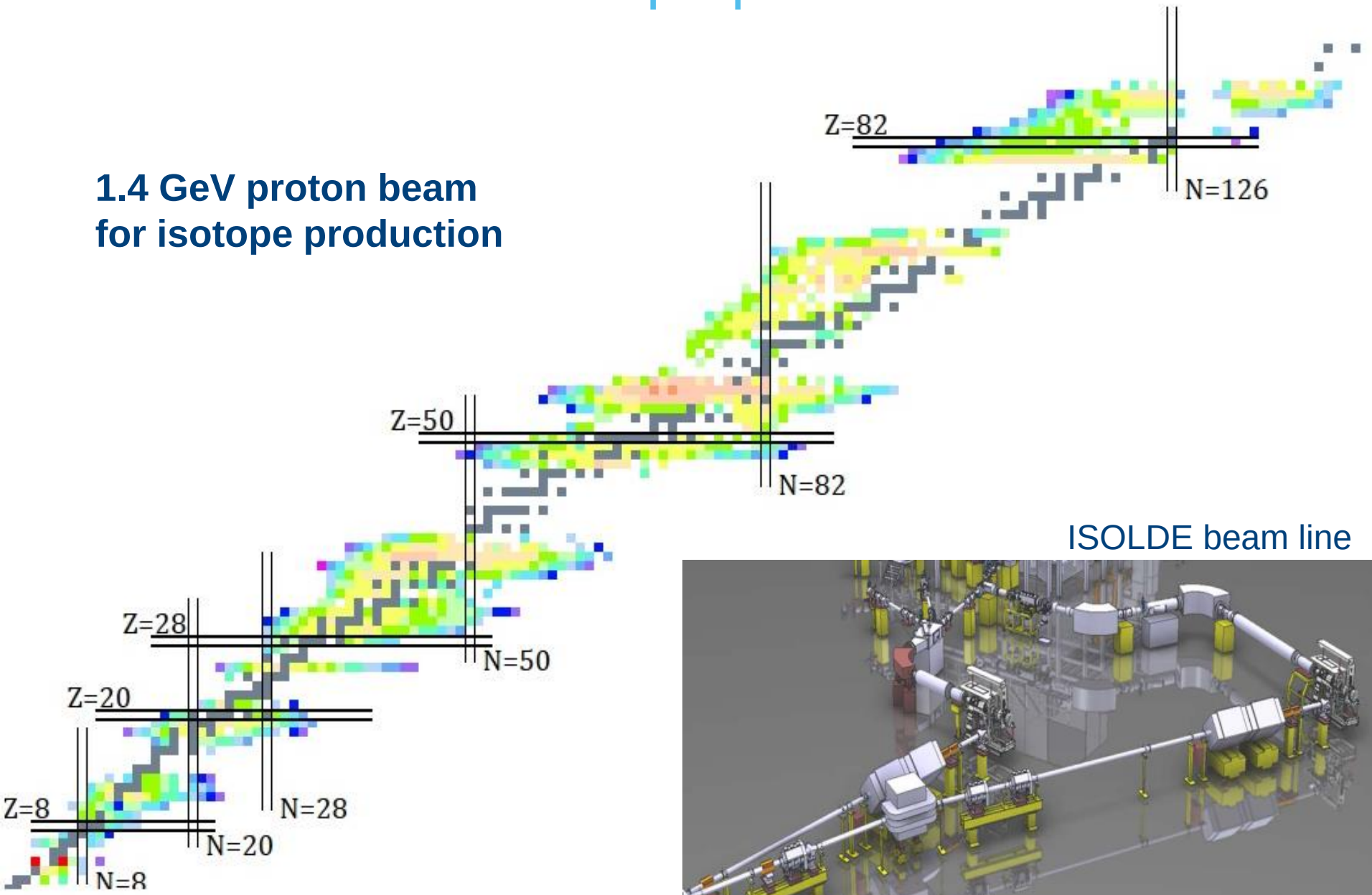


Offers broad access to wide catalog of (radio)isotopes in relatively pure and carrier-free condition



CERN-ISOLDE isotope production

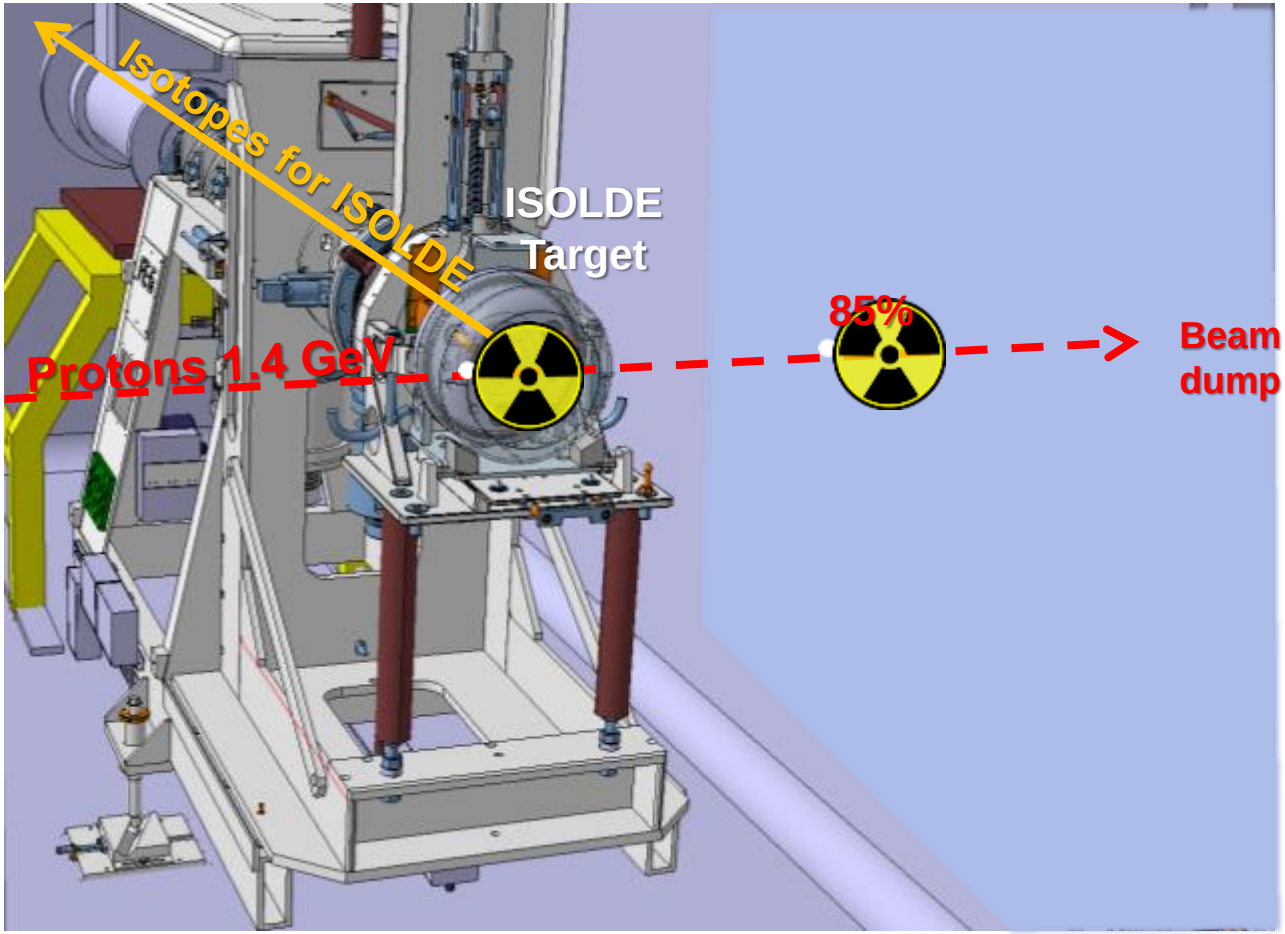
1.4 GeV proton beam for isotope production



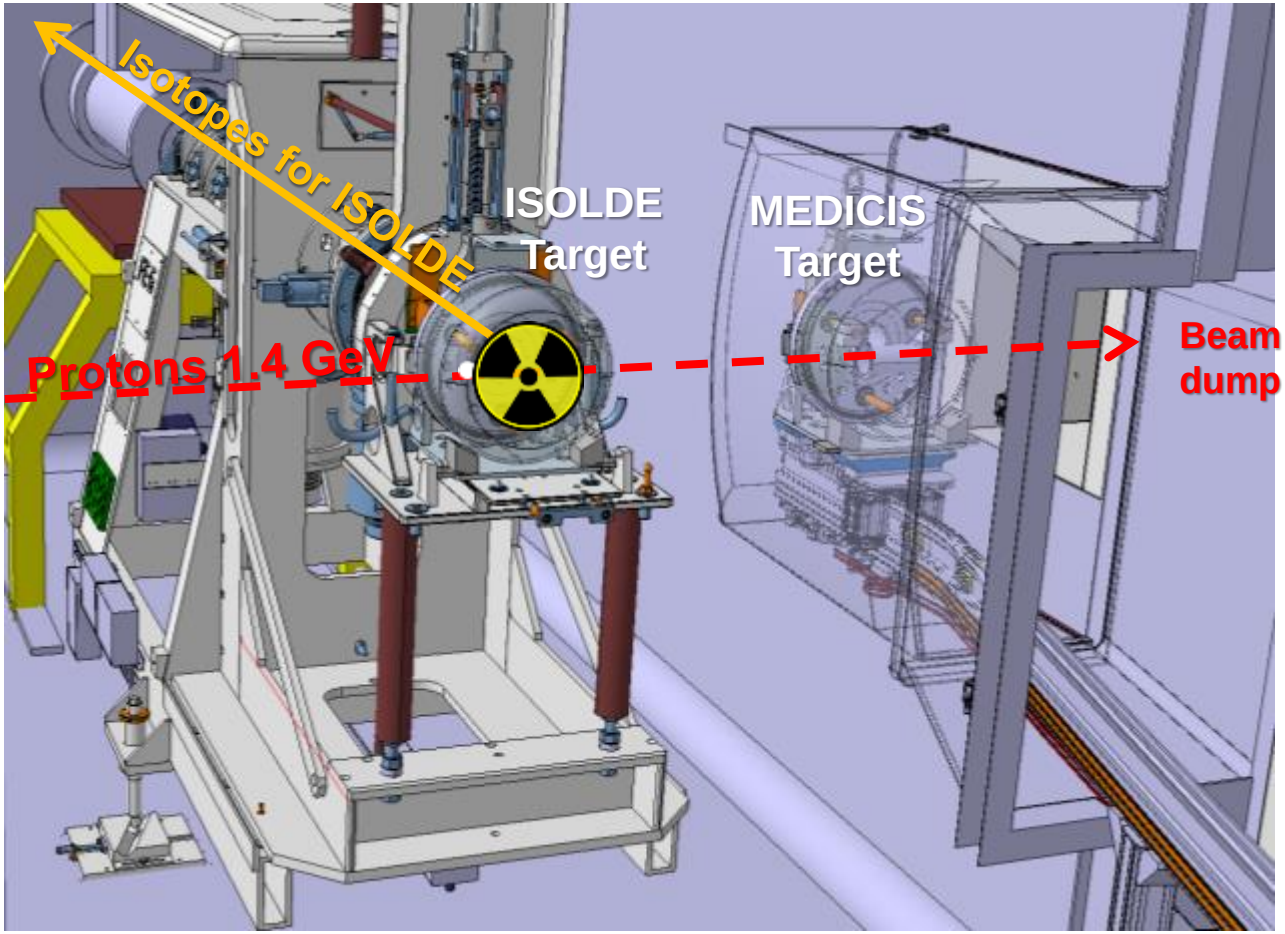
ISOLDE beam line

http://test-isolde-yields.web.cern.ch/test-isolde-yields/

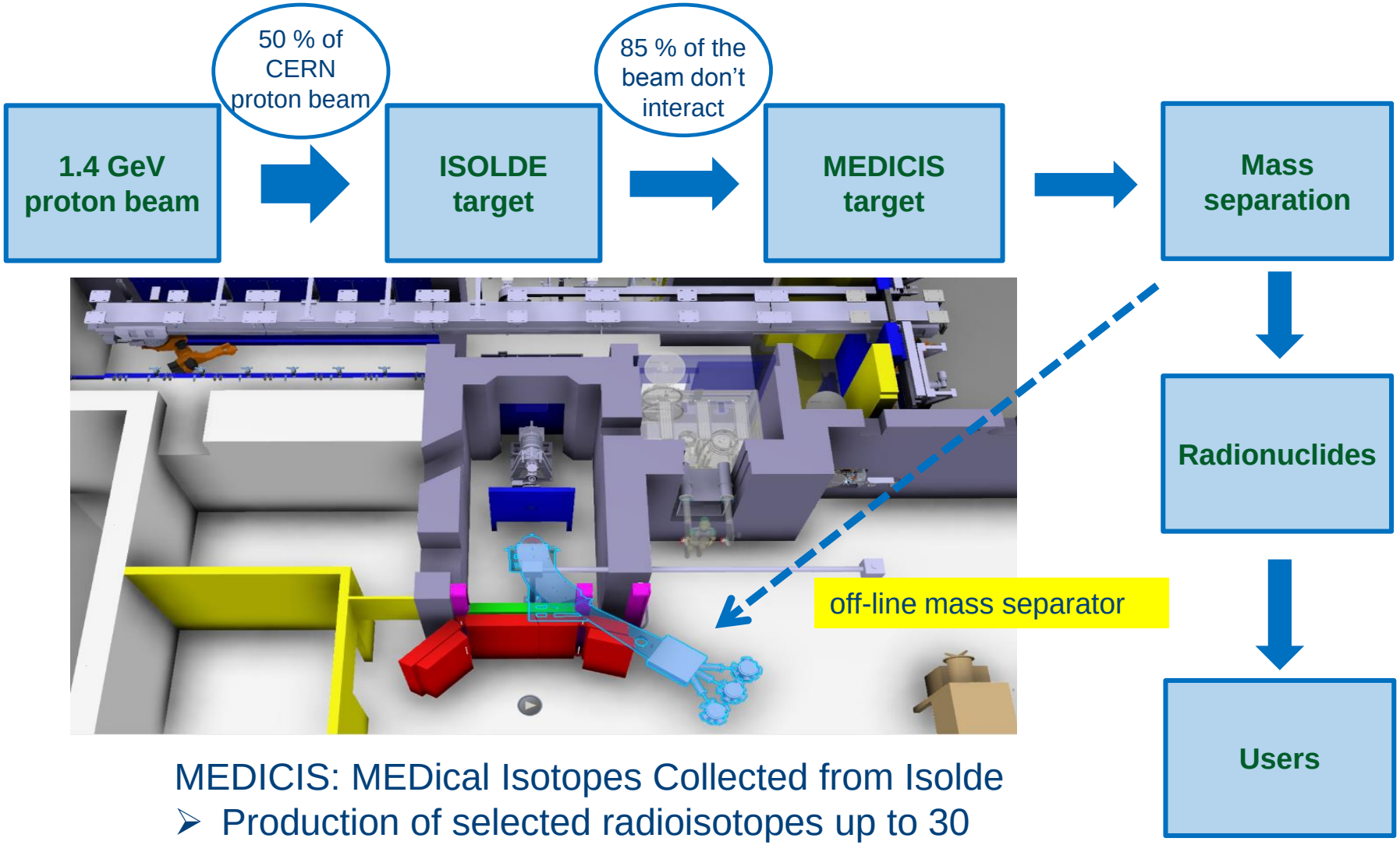
CERN-ISOLDE isotope production



CERN-ISOLDE isotope production



The MEDICIS facility



MEDICIS: MEDical Isotopes Collected from Isolde

- Production of selected radioisotopes up to 30 weeks per year!

MEDICIS timeline

Ground breaking
3 Sept. 2013

Building delivered
15 Oct. 2014

Separator delivered
28 June 2016

MEDICIS timeline

Ground breaki
3 Sept. 2013

Commissioning planned for 2017

Building delivered
15 Oct. 2014

Separator delivered
28 June 2016

The MEDICIS-PROMED Network

- A **Marie-Curie Innovative Training Network** (ITN) coordinated by CERN in Horizon 2020
- Bridging together research, industry, academia and hospitals
- Training of **Early Stage Researchers** (ESRs) for development of new medical applications and accelerator technologies

The MEDICIS-PROMED Network

- Multicultural network with leading scientists in interdisciplinary fields
- ➢ 15 PhD students with different backgrounds/specializations working at partner sites across Europe

Biology

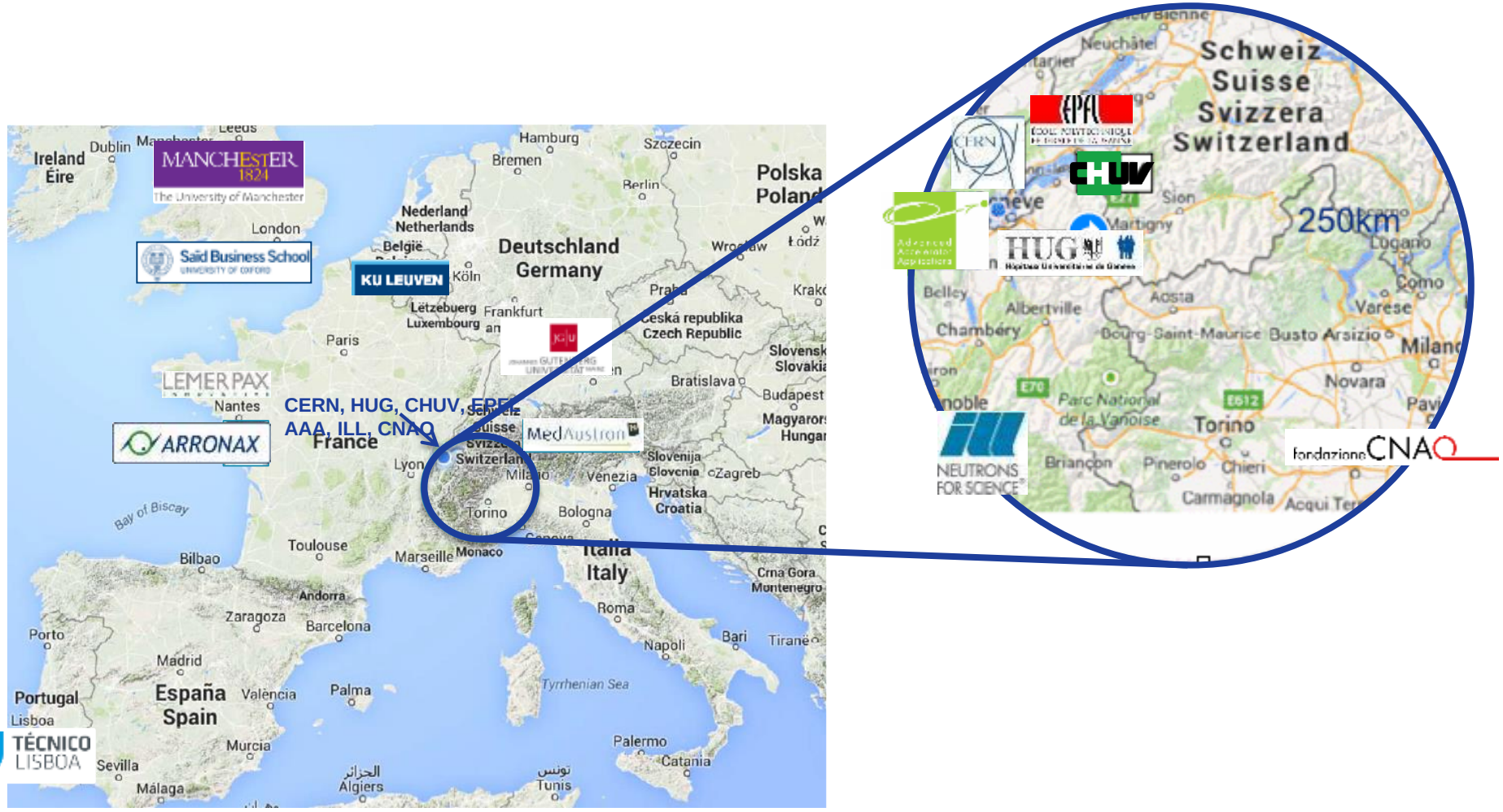
Engineering

Radiochemistry

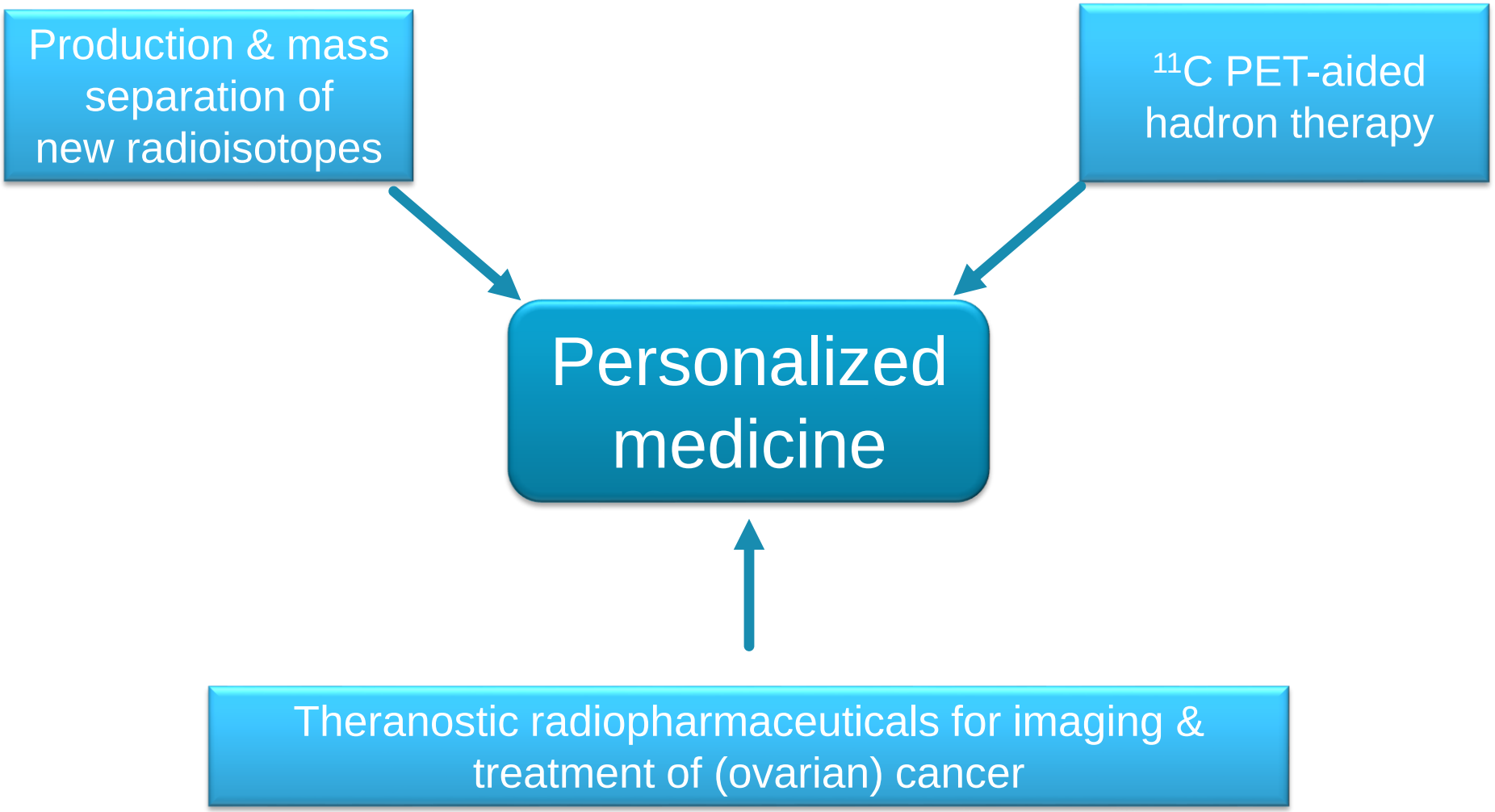
Physics

Medicine

Partners around EU

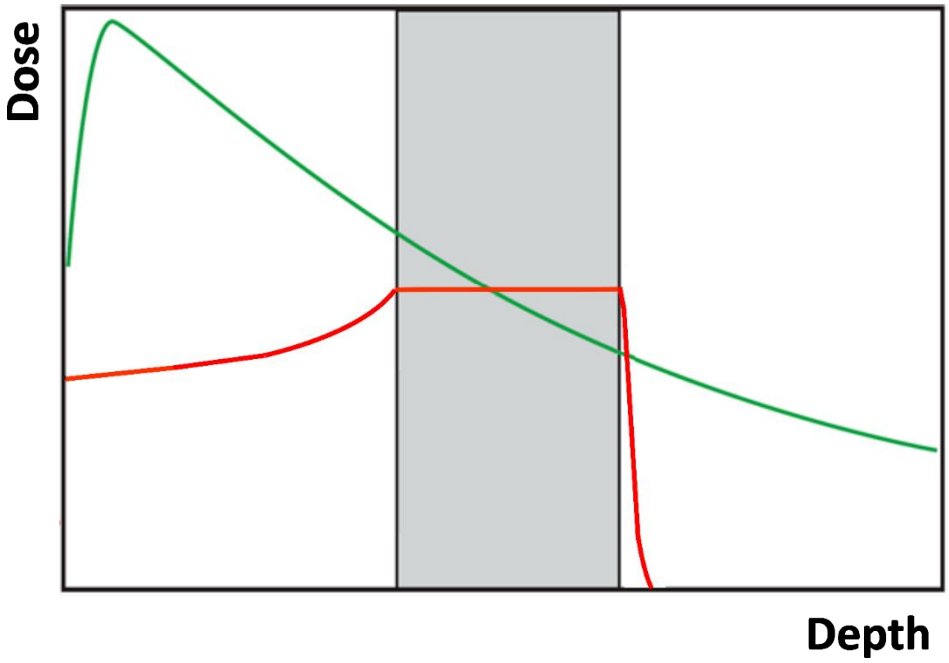


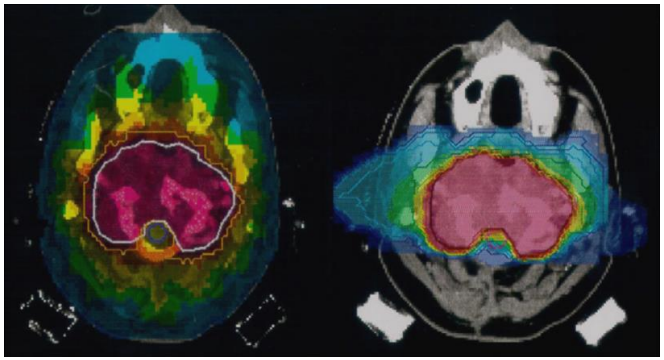
MEDICIS-PROMED: Objectives



^{11}C based hadron therapy

(Heavy) hadron therapy

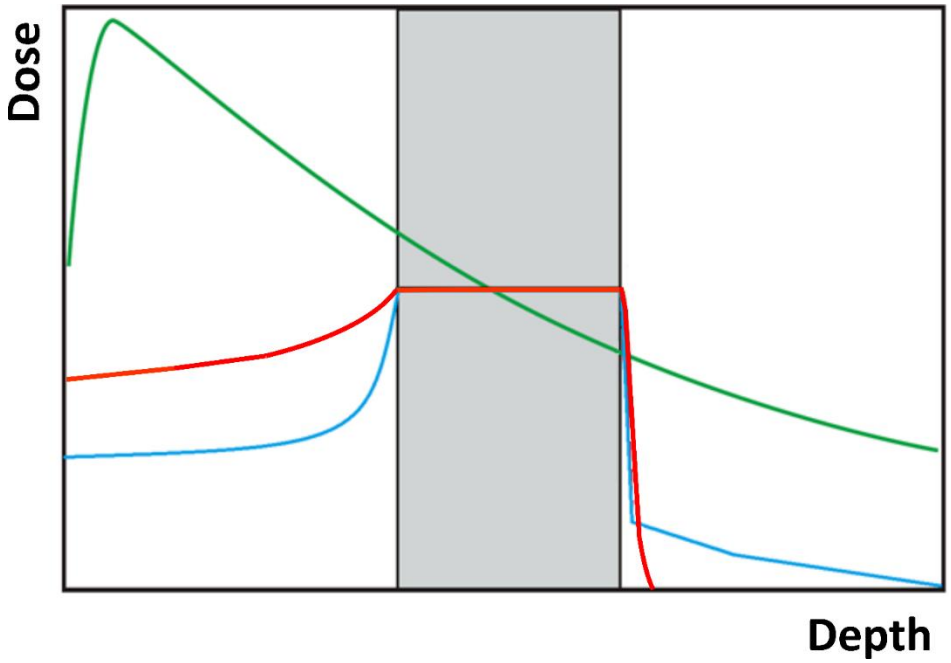


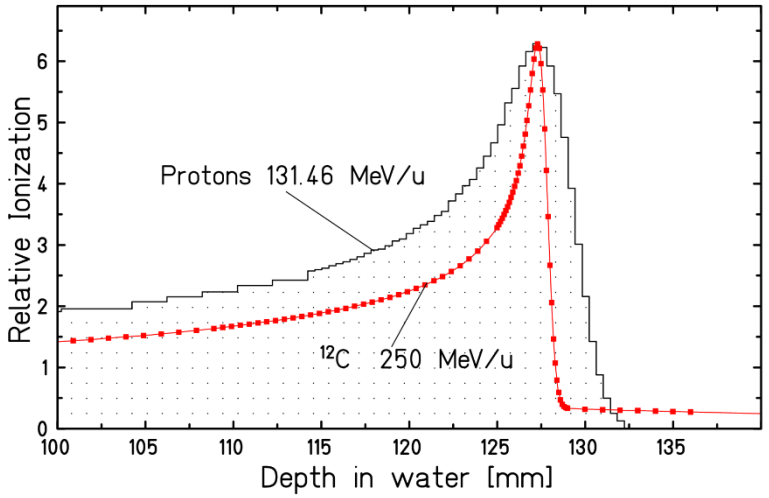


γ p

^{11}C based hadron therapy

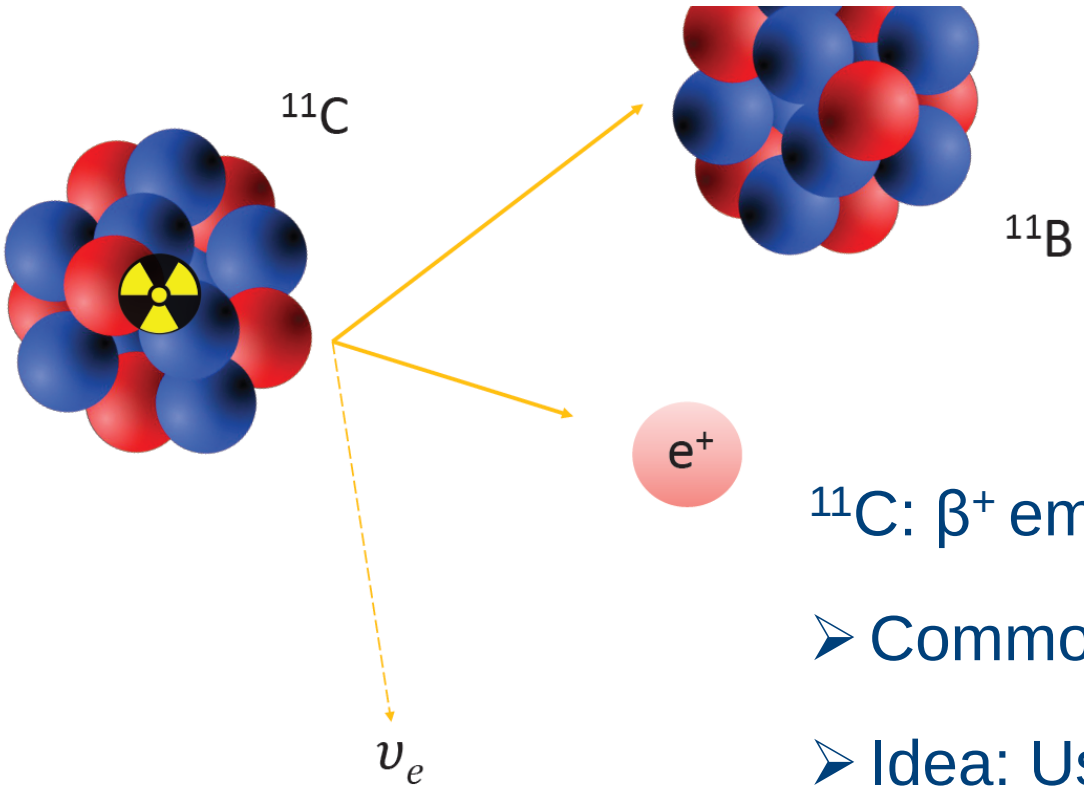
(Heavy) hadron therapy





^{12}C

^{11}C based hadron therapy



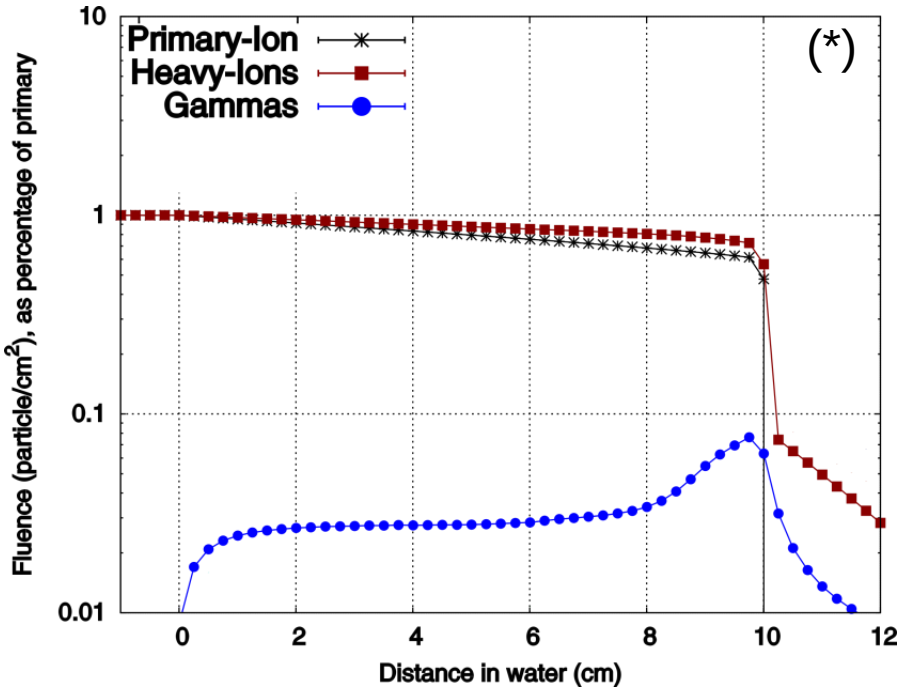
^{11}C: β^+ emitter; $T_{1/2}$ = 20.4 min

- Commonly used for imaging
- Idea: Use directly for treatment

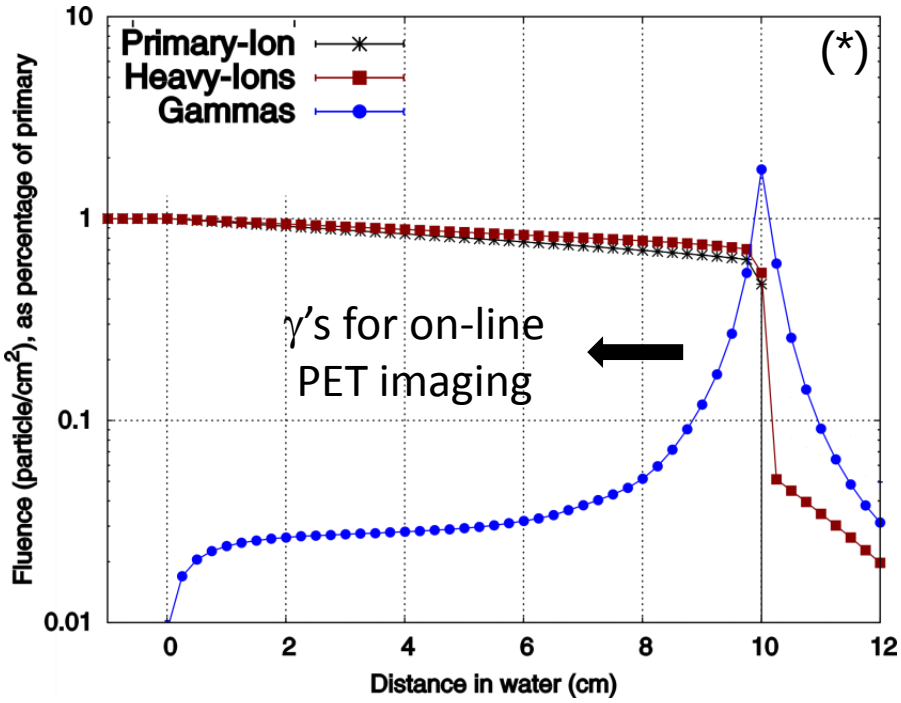
→ Treatment + on-line PET imaging!

^{11}C based hadron therapy

^{12}C



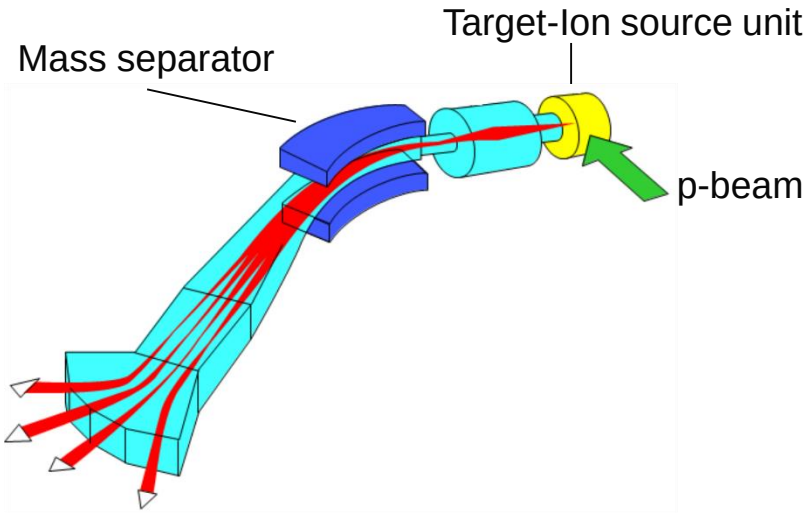
^{11}C



➡ **Post-treatment dose verification!**

(*) R.S. Augusto et al., NIM B 376 (2016) 374-378

^{11}C based hadron therapy

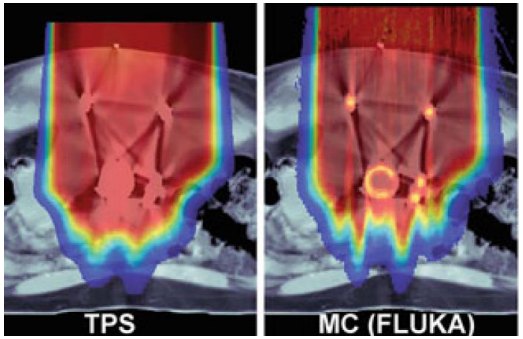


$^{11}CO_x^{1+}$

^{11}C beam preparation

$^{11}C^{4/6+}$

PET-aided treatment



Pre-clinical studies

Advanced Treatment Planning System (TPS)

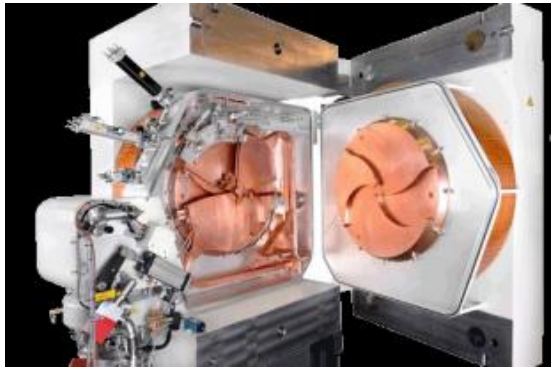
Production of mass separated ^{11}C beams

$4 \cdot 10^8$ ions/s requested for treatment ⟶ High intensity production!

Via ISOL method:

- Target material BN: $^{11}B(p,n)$; $^{14}N(p,\alpha)$
- Carbon is very refractory

➢ Released as CO_x



Small production cyclotron (~ 20 MeV)

- Diffusion and release properties of target are essential

Production of mass separated ^{11}C beams

Next steps:

- ➢ Material studies of boron nitride
- ➢ Activity measurements

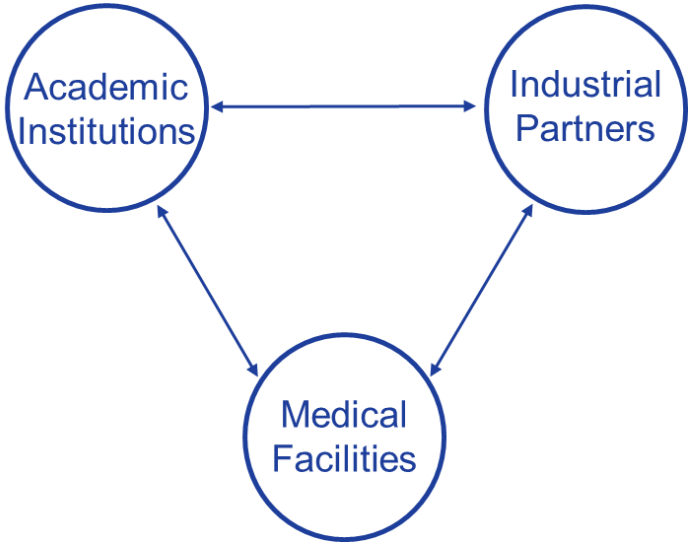
Future missions:

- High efficiency ion source for $^{11}CO_x^+$
- ECR ion source?
- ➢ Design of compact target-ion source unit

Training

MEDICIS-PROMED: Training of new entrepreneurial scientists

Scientific and transferable skills
Exchange programs (secondments)
Workshops
Summer schools
Lectures



Summary

- MEDICIS Facility: Novel medical radioisotope production
- MEDICIS-PROMED: Innovative interdisciplinary network with partners all over Europe
- Exchange between research, industry and hospitals!
- Training of new entrepreuneurial scientists to develop systems for personalized medicine
- Development of new medical applications based on radioactive ion beam mass separation

Acknowledgements

Thank you!

Follow us:

http://medicis-promed.web.cern.ch

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https://medicis-promed.web.cern.ch/simon-stegemann

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