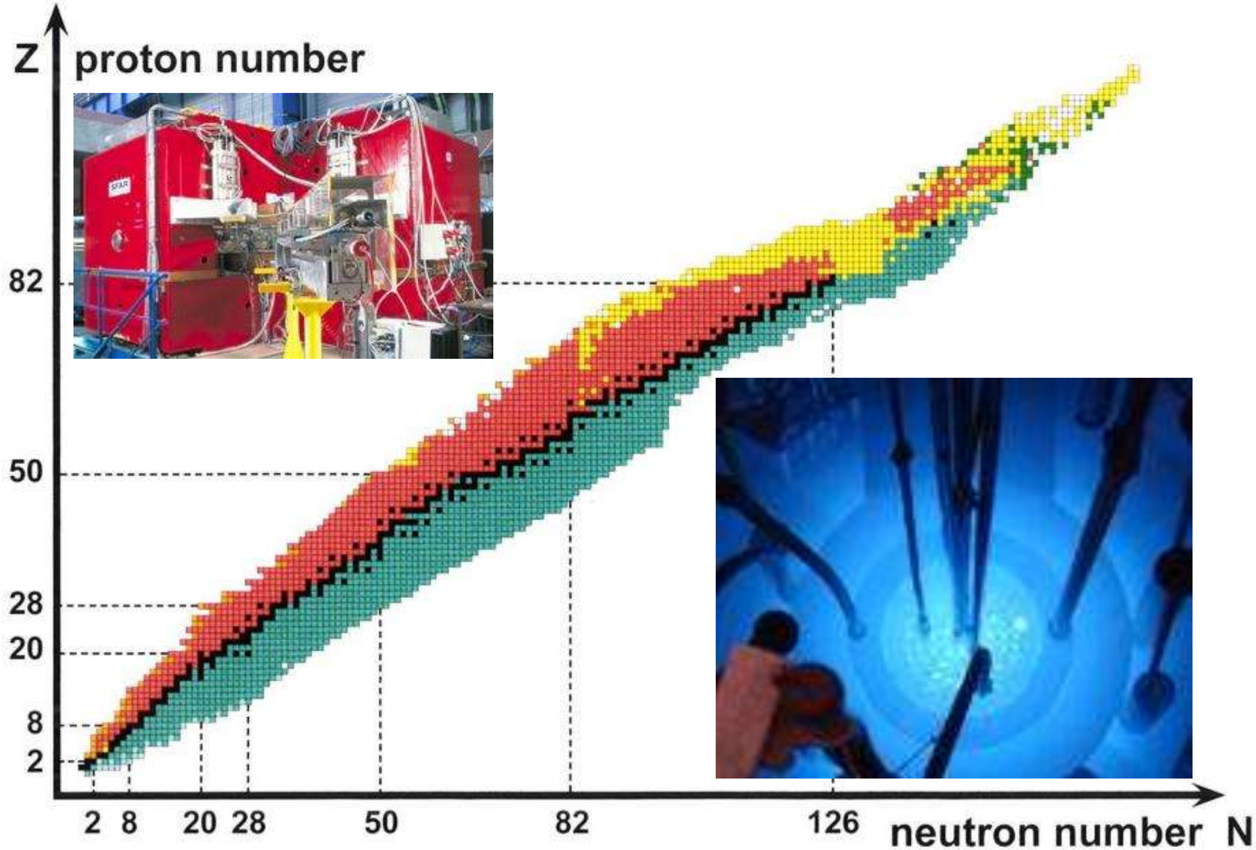
Radioisotopes: technical perspective



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Ulli Köster

Institut Laue-Langevin

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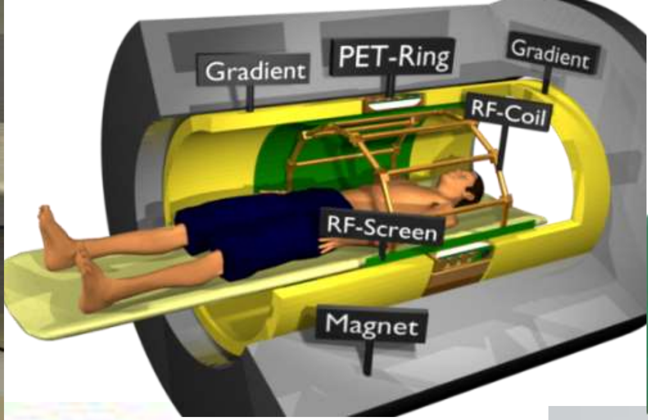
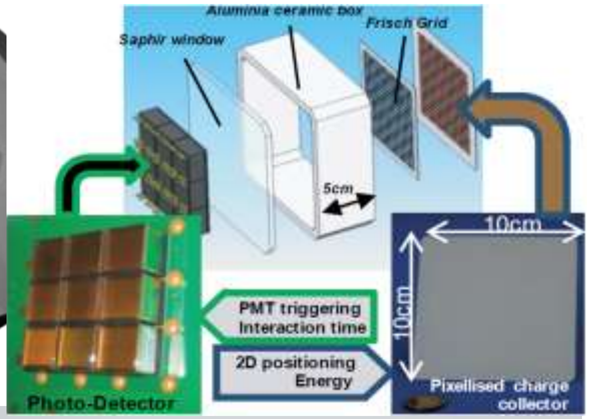
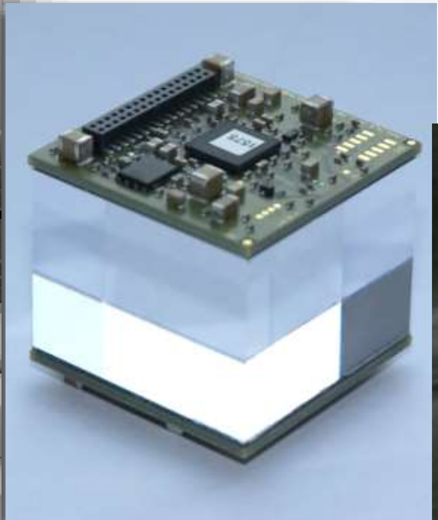
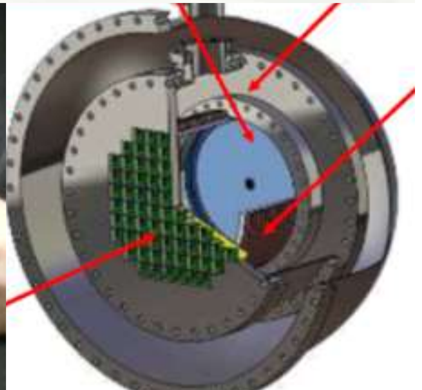
ClearPEM Sonic

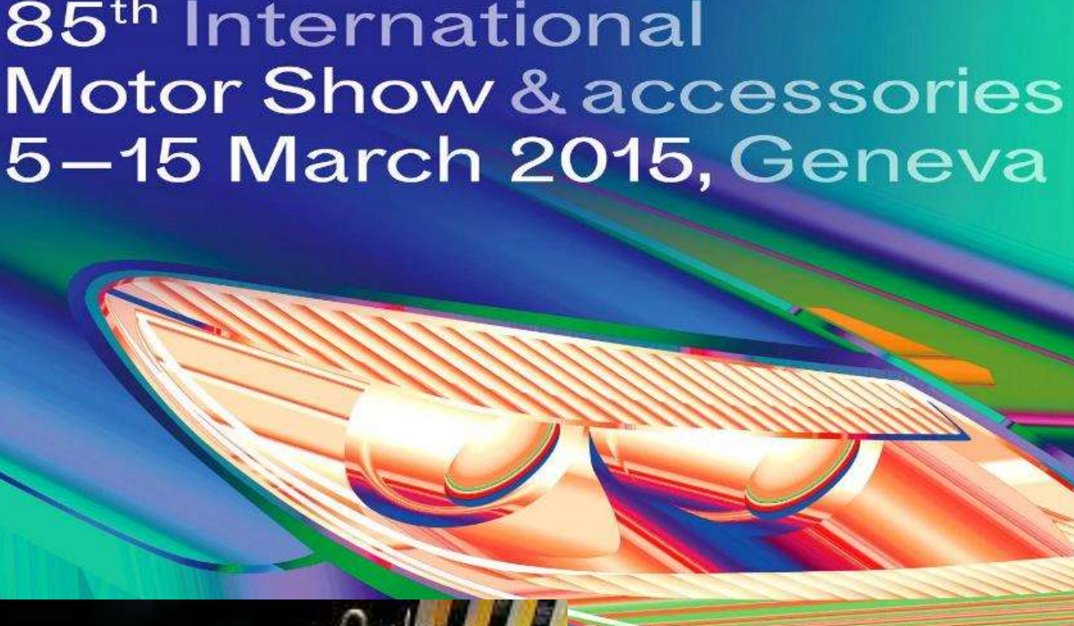

Gradient
PET-Ring
Gradient
RF-Coil
RF-Screen
Magnet


Alumina ceramic box
Saphir window
Frisch Grid
5cm
10cm
10cm
PMT triggering
Interaction time
2D positioning
Energy
Pixellised charge collector
Photo-Detector


IRM
PET





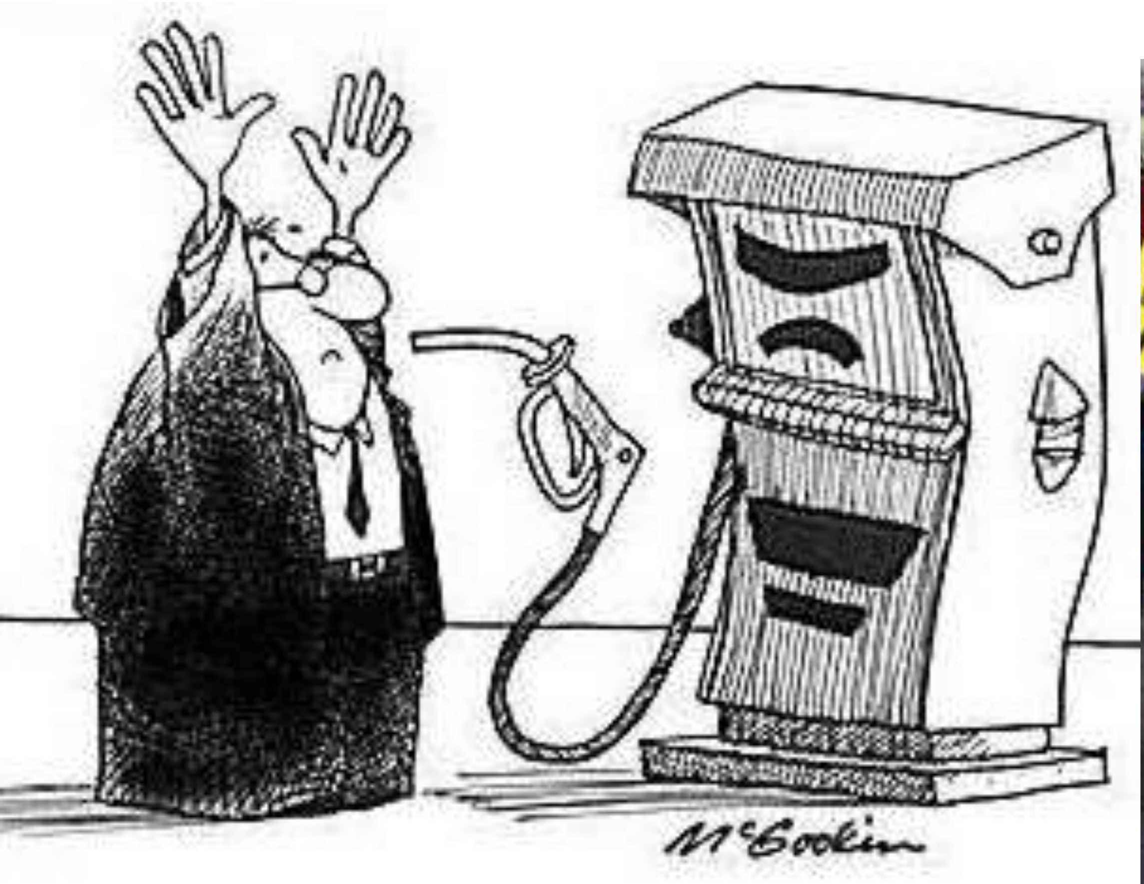

85th International
Motor Show & accessories
5–15 March 2015, Geneva


P1 GTR


ABT


Ferrari

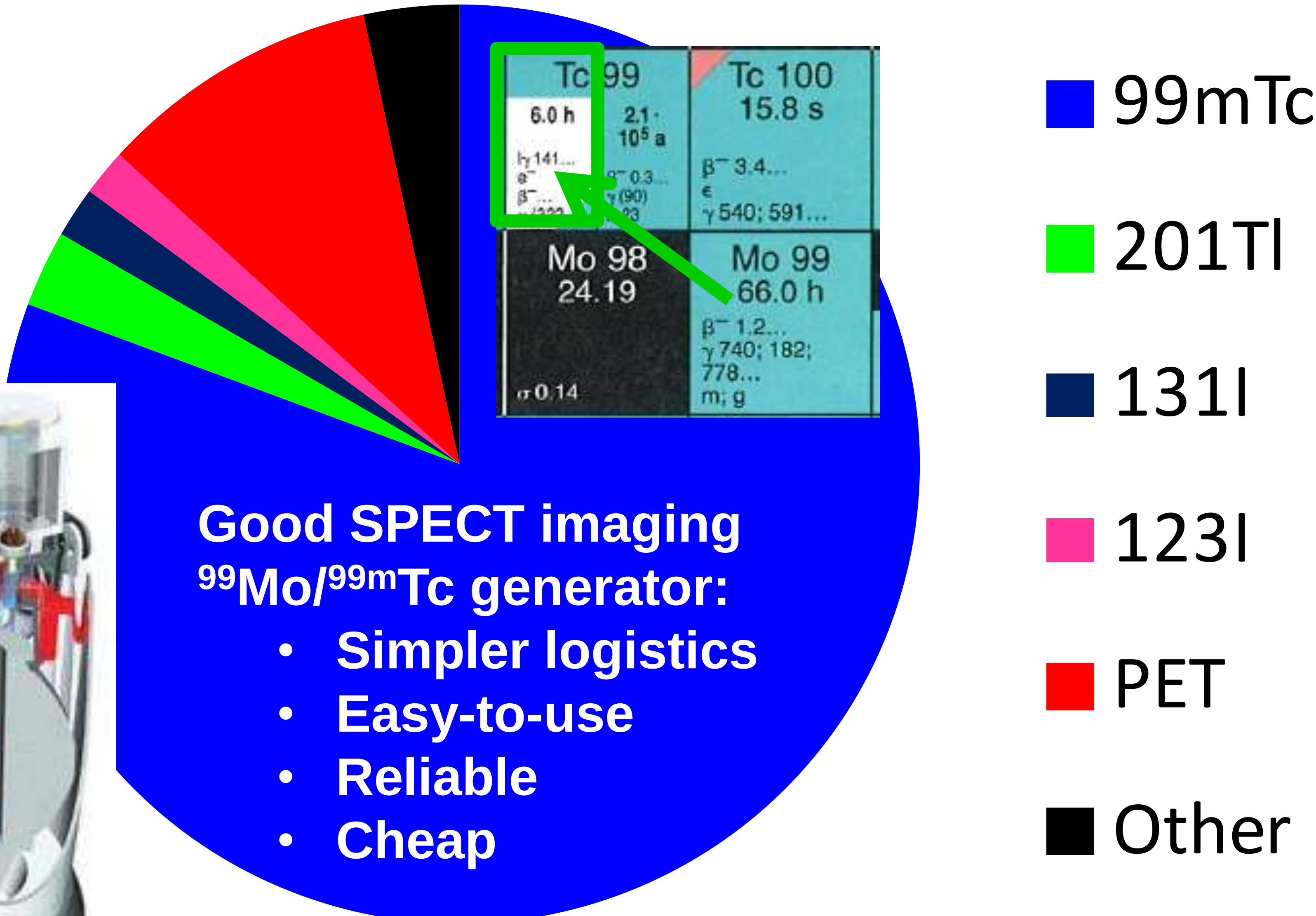
Don’t forget the fuel!



Take home messages

1. Radioisotopes are the “fuel” for nuclear medicine

Cumulative use of diagnostic isotopes in Europe

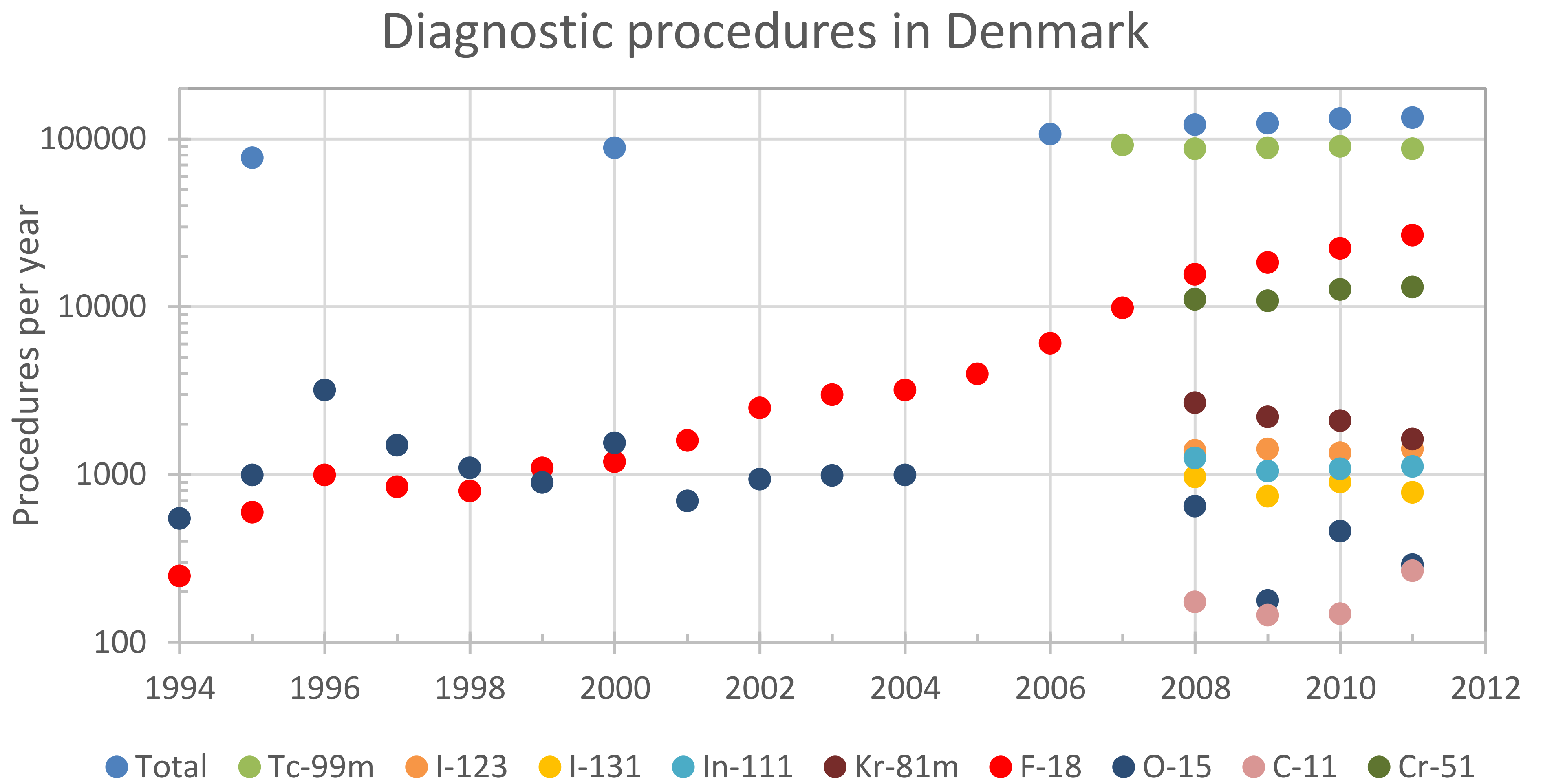


Good SPECT imaging

^{99}Mo/^{99m}Tc generator:

- **Simpler logistics**
- **Easy-to-use**
- **Reliable**
- **Cheap**

http://www.nupecc.org/npmed/npmed2014.pdf



The State Institute of Radiation Protection Denmark.

2011 breakdown:

69% SPECT/scintigraphy - 21% PET - 10% Cr-51 EDTA (kidney)

PET: 93% FDG - 4% other F-18 tracers - 3% other isotopes

Production: 76% reactor – 24% cyclotron

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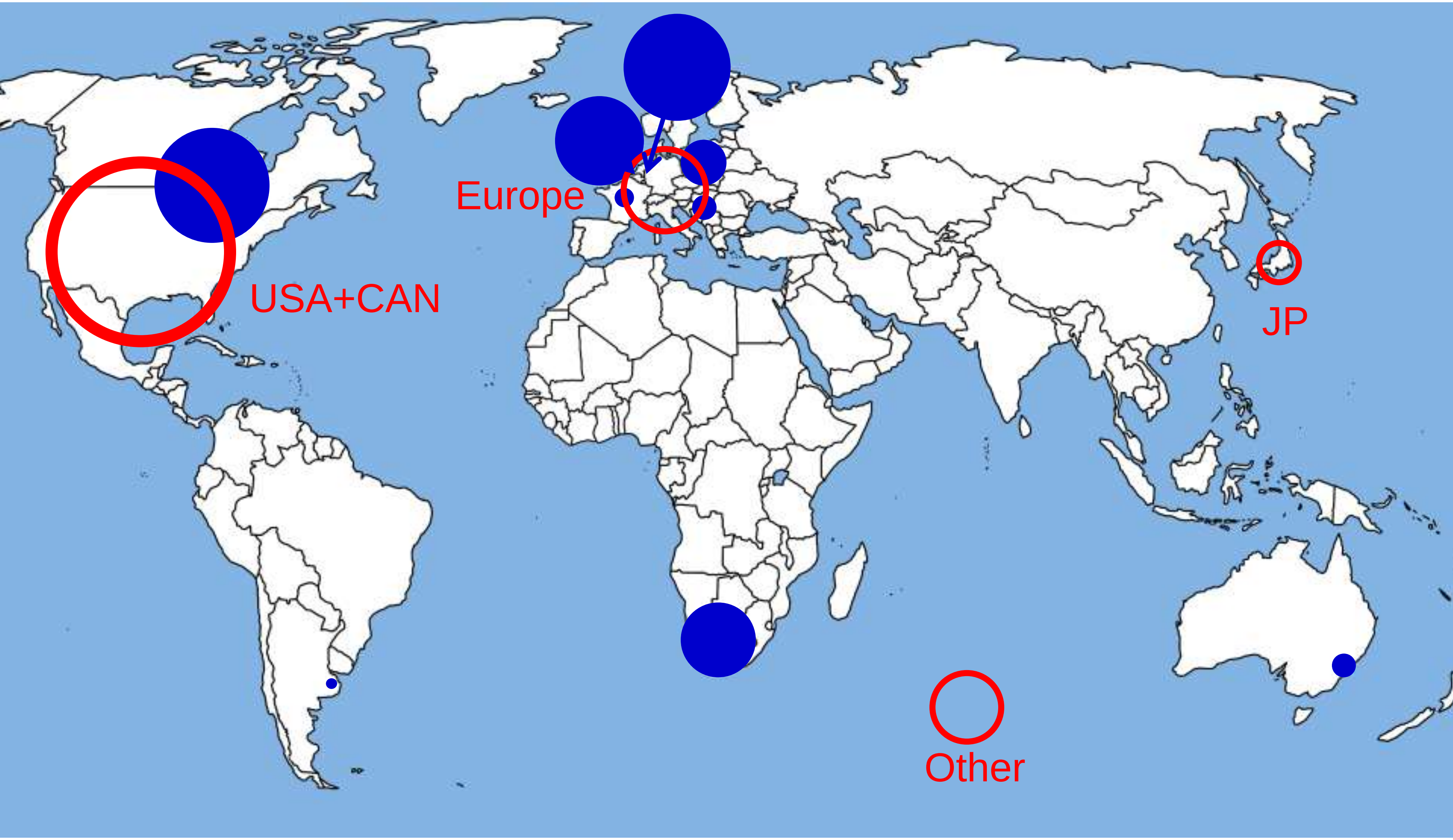
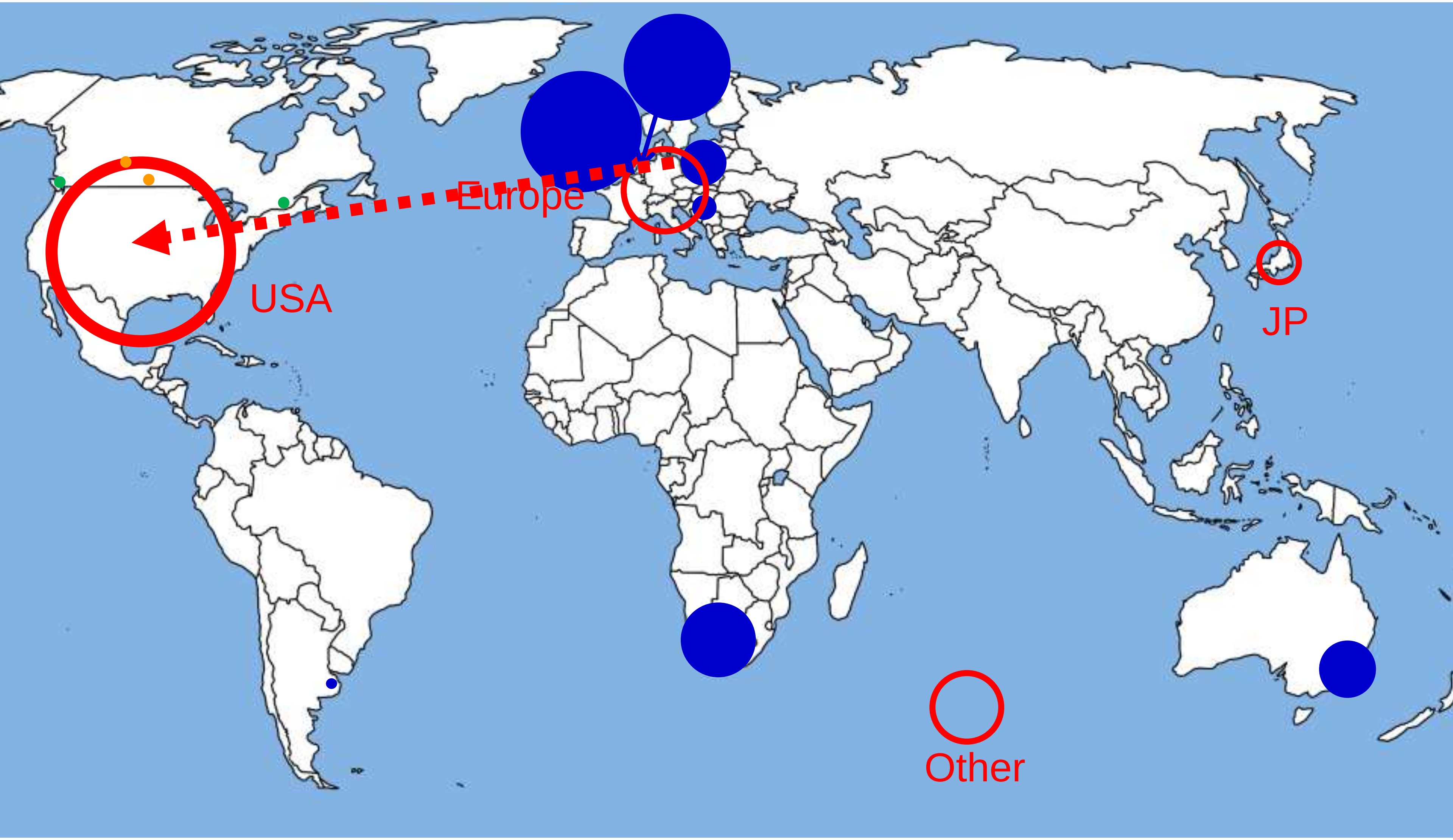
2014: ^{99}Mo production capacity and demand



Circle diameter proportional to annual reactor capacity (blue) and demand (red).

End 2016: ^{99}Mo production capacity and demand



Circle diameter proportional to annual production capacity (blue: reactor; green: cyclotron; orange: LINAC) and demand (red).

Isotope shortage means a healthcare crisis

European hospitals cope with Mo-99 supply crisis

EUROPE
MOLYBDENUM SUPPLY

L'inquiétante pénurie d'isotopes pour l'imagerie

Engpässe in der Tumormedizin

Medical isotope shortage reaches crisis level

Krebsärzten gehen die Diagnosemittel aus

Médecine nucléaire : il faut prolonger le réacteur Osiris

We Need to Expand Medical Isotope Production!

ANALYSIS | The made-in-Canada isotope shortage facing medical scans

Desperately Seeking Moly

Isotopes médicaux - Crise mondiale à l'horizon

Aucune solution n'existe pour résoudre le problème d'approvisionnement

Isotope shortage to get worse with closing of more reactors

L'OCDE s'inquiète des risques de pénurie d'isotopes médicaux

Mangel an medizinisch verwendbaren Isotopen

Szintigraphien fallen aus, für Februar droht der Notstand

Mo-99 crisis

Niowave broke ground last month on a $79 million isotope production facility that looks out on the runways of Capital Region International. The company expects to move in by the end of the year, to make its first medical isotopes early next year, to be producing them commercially by early 2016. It expects to add 90 jobs to its 70-member staff in the process.

UBC SCIENTISTS HELP AVERT A NUCLEAR MEDICINE MELTDOWN

January 8, 2015

Moly 99 reactor using Sandia design could lead to U.S. supply of isotope to track disease

Commodities | Sat Feb 7, 2015 4:11am IST

Canada seeks to avoid medical isotope shortage, extends nuclear reactor

Isotope breakthrough may stave off shortage concerns

MARCH 12, 2015 BY PAUL MAYNE

Coquí Pharma completes design of medical isotope facility

09 April 2015

Lab confirms new commercial method for producing medical isotope

June 15, 2015 **(Argonne)**

NorthStar Medical Radioisotopes ready to begin Mo-99 production

Michael Walter

Aug 31, 2015

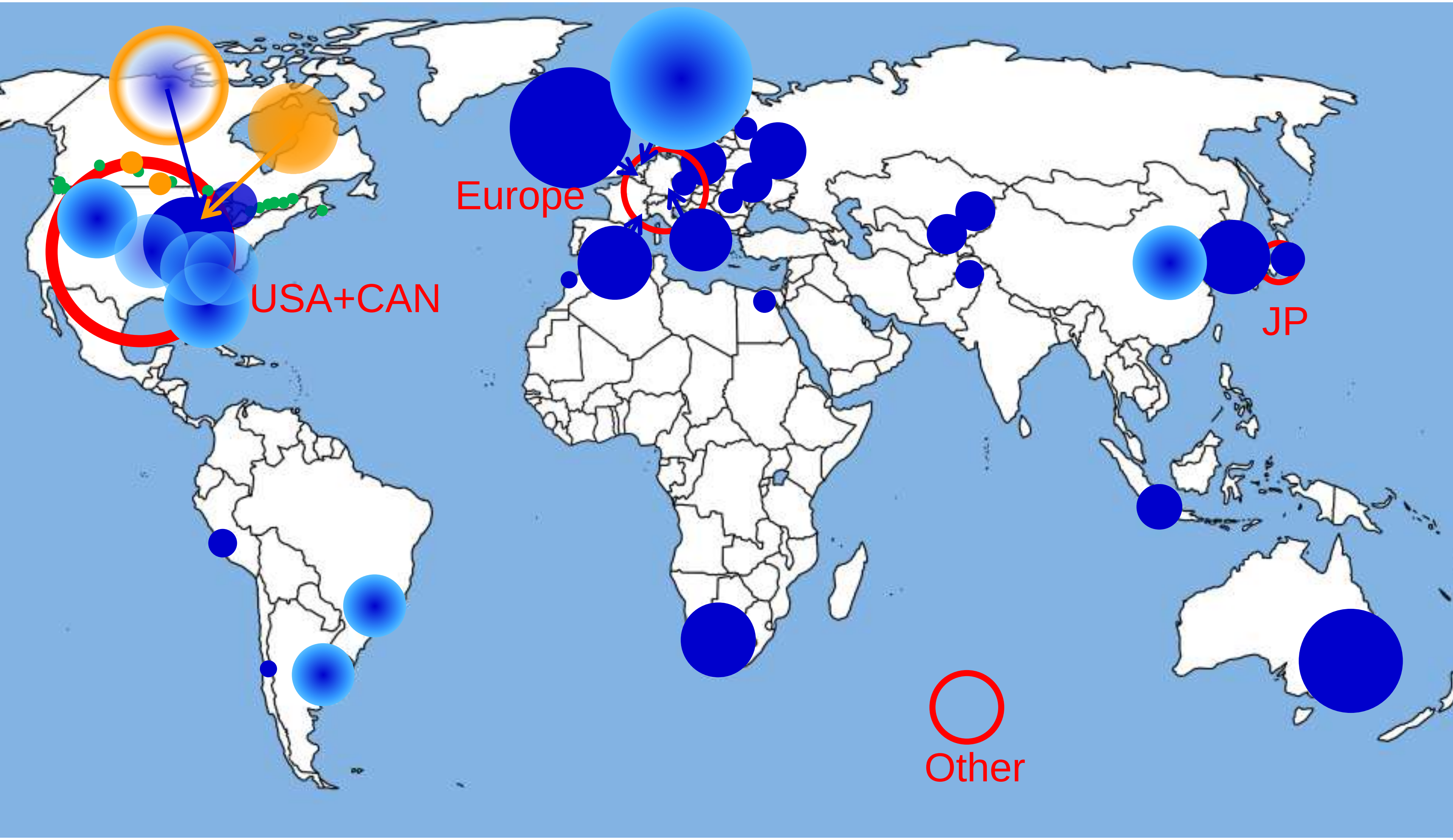
It Takes Two: GE Healthcare and SHINE team up to solve longstanding radiopharmaceutical supply concerns in medical imaging

Successful generation of Tc-99m is a supply chain advancement that can help ensure patient access to critical medical imaging scans.

CHALFONT ST. GILES, UK – 9 November 2015 – Technetium-99m (Tc-99m) is used in more than 40


A STEVEN SPIELBERG FILM
tom hanks
saving isotope Tc-99m
edward burns matt damon tom sizemore
the mission is a nuclide.
july 24

2022: ^{99}Mo production capacity and demand



Circle diameter proportional to annual production capacity (blue: reactor; green: cyclotron; orange: LINAC) and demand (red).

Take home messages

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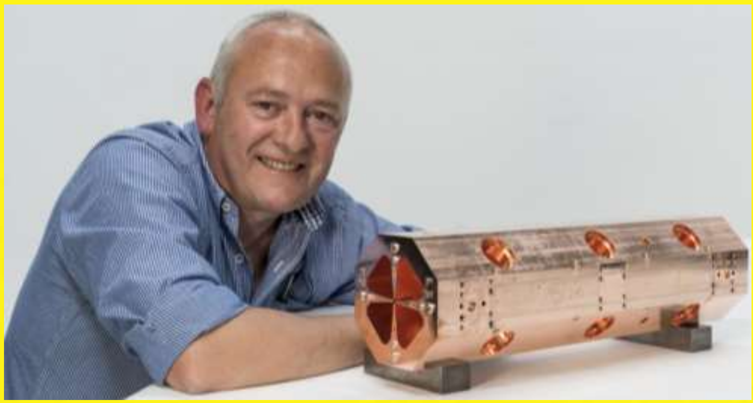
2. ^{99m}Tc and ^{18}F are the main fuel, alternative fuels catching up
3. ^{99m}Tc is an industrial/economic challenge, not a scientific one

THE 11TH FILM BY QUENTIN TARANTINO

KILL TC



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Facilities producing ^{82}Sr

LANL, USA – 100 MeV, 200 µA

BNL, USA – 200 MeV, 100 µA

INR, Russia – 160 MeV, 120 µA

TRIUMF, Canada – 110 MeV, 70 µA

iThemba, South Africa – 66 MeV, 250 µA

ARRONAX, France – 70 MeV, < 750 µA

SPES, Italy – 70 MeV, < 1000 µA

Zevacor, USA – 70 MeV, < 750 µA

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The rising star for therapy

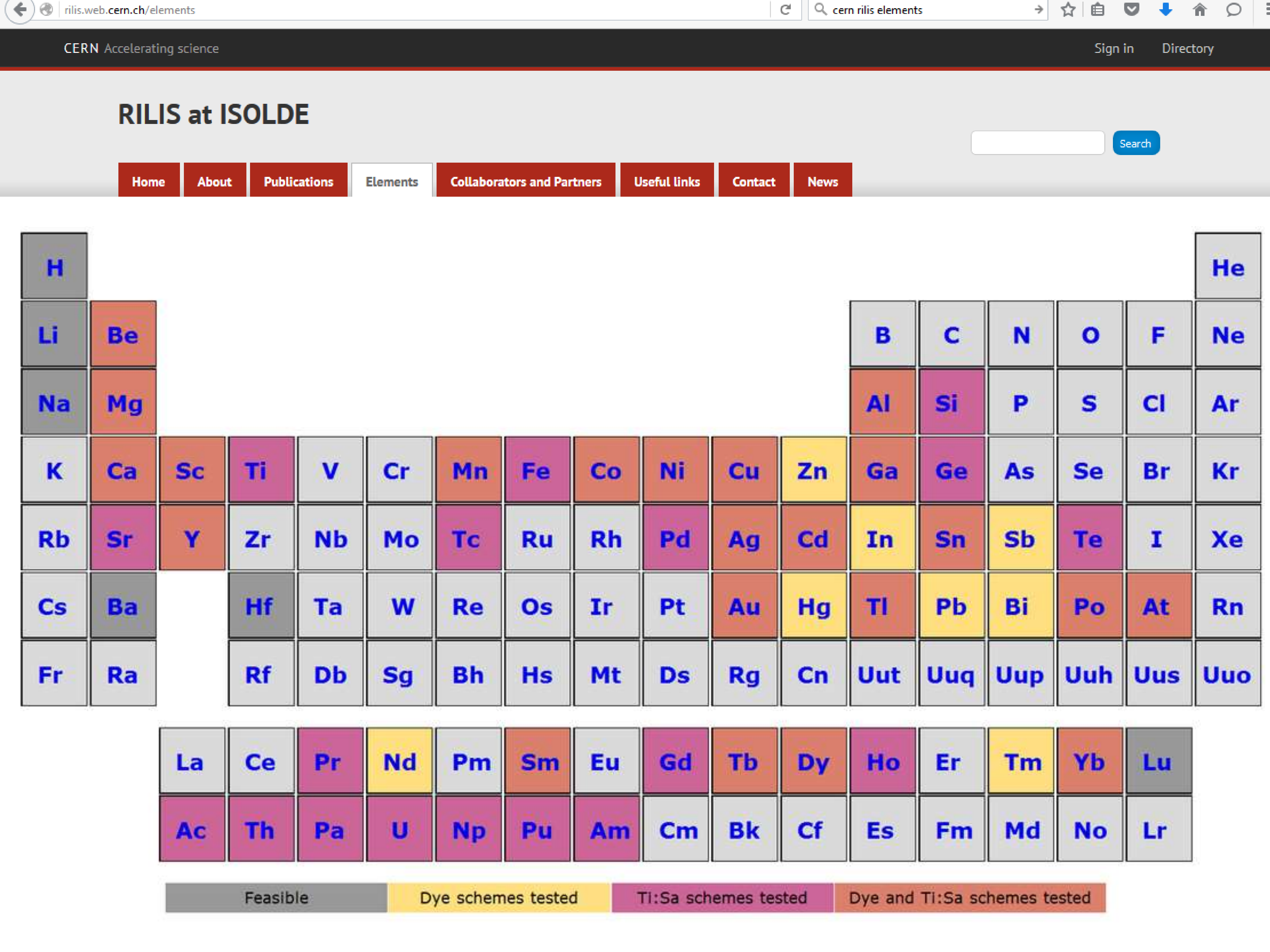
Production of non-carrier-added ^{177}Lu

1. Enrichment of stable isotope (> 99.8% ^{176}Yb)

2. Irradiation in high flux reactor

3. Radiochemical separation of n.c.a. ^{177}Lu

Resonant Laser Ionization for Isotope Separation



rilis.web.cern.ch/elements
cern rilis elements
CERN Accelerating science
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Directory
RILIS at ISOLDE
Search
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About
Publications
Elements
Collaborators and Partners
Useful links
Contact
News
H
He
Li Be
B C N O F Ne
Na Mg
Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
Cs Ba Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
Fr Ra Rf Db Sg Bh Hs Mt Ds Rg Cn Uut Uuq Uup Uuh Uus Uuo
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr
Feasible
Dye schemes tested
Ti:Sa schemes tested
Dye and Ti:Sa schemes tested

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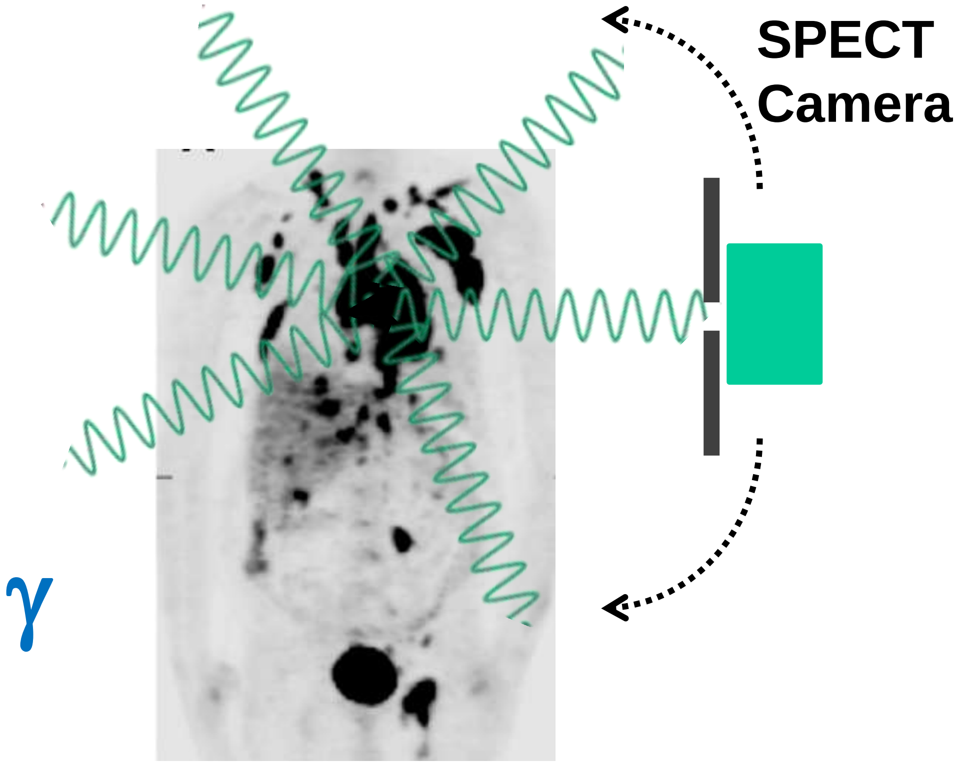
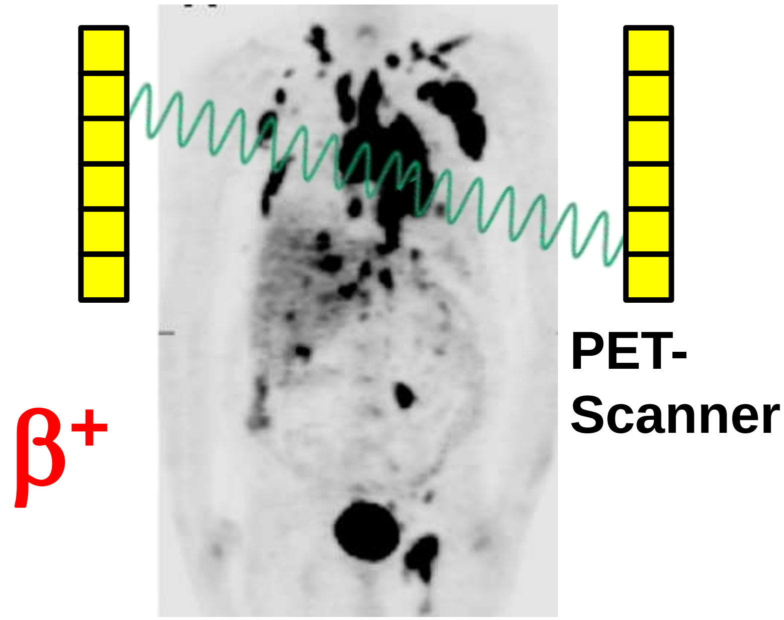
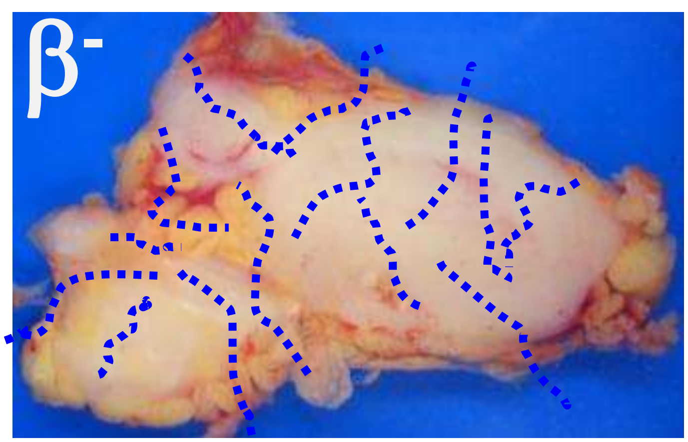
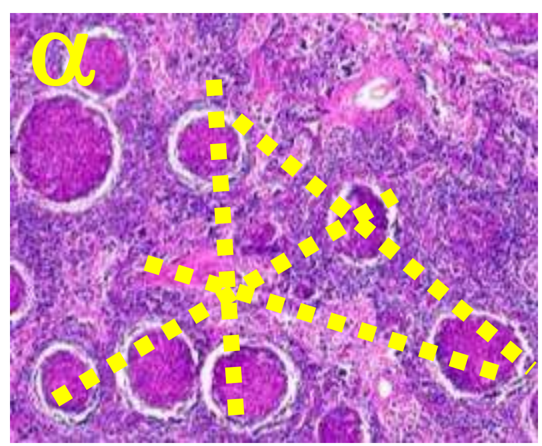
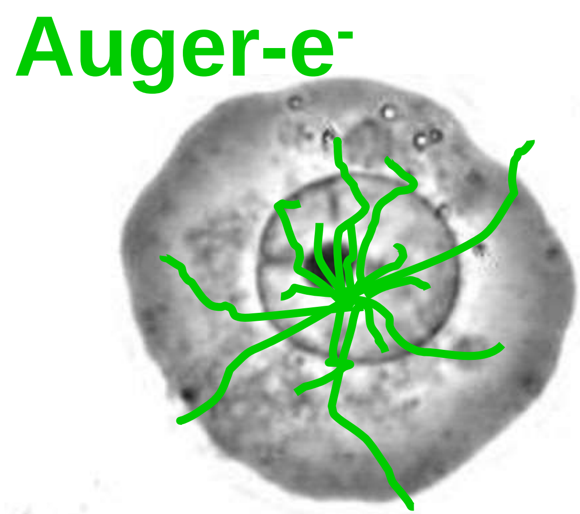
The Nuclear Medicine Alphabet





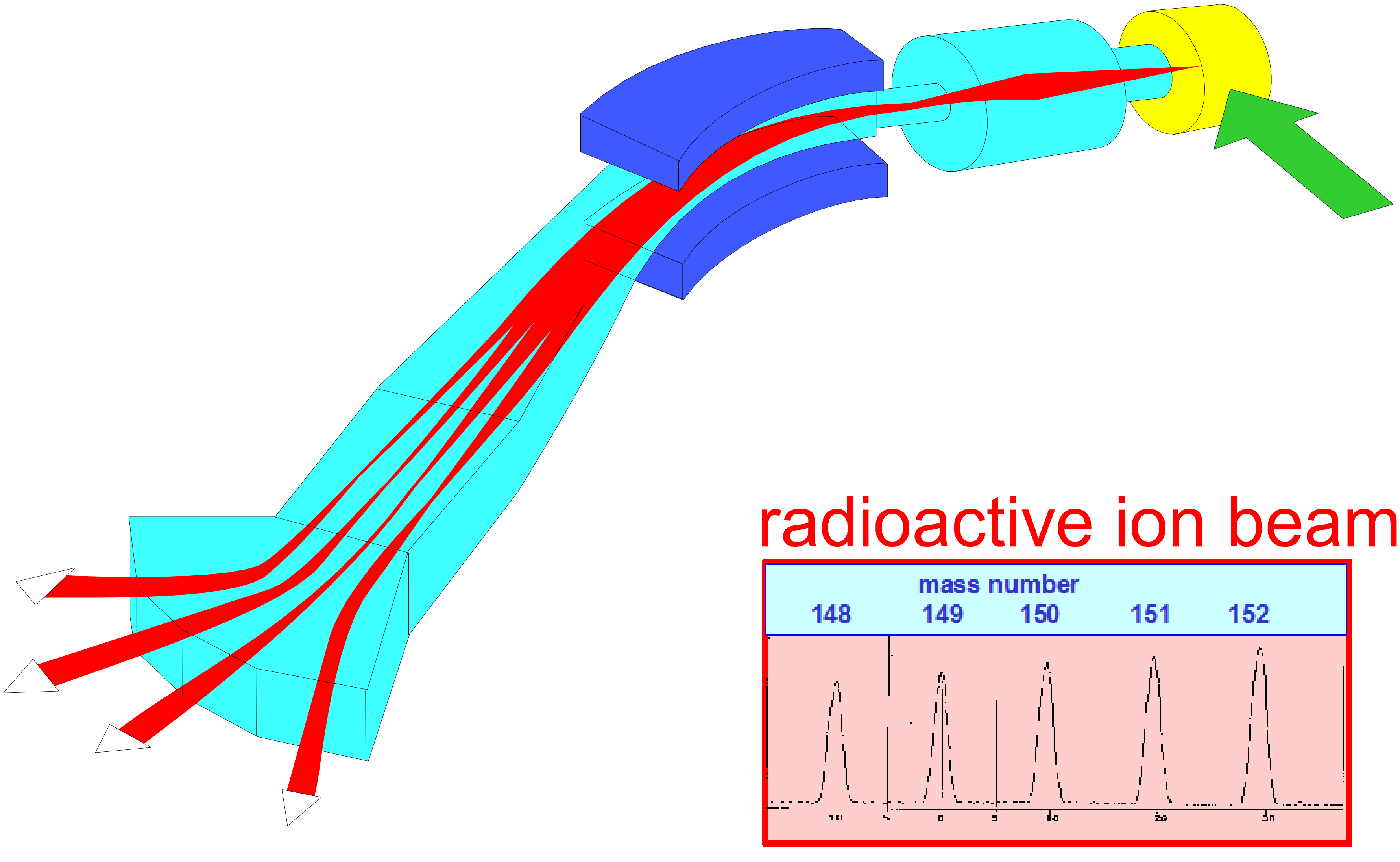




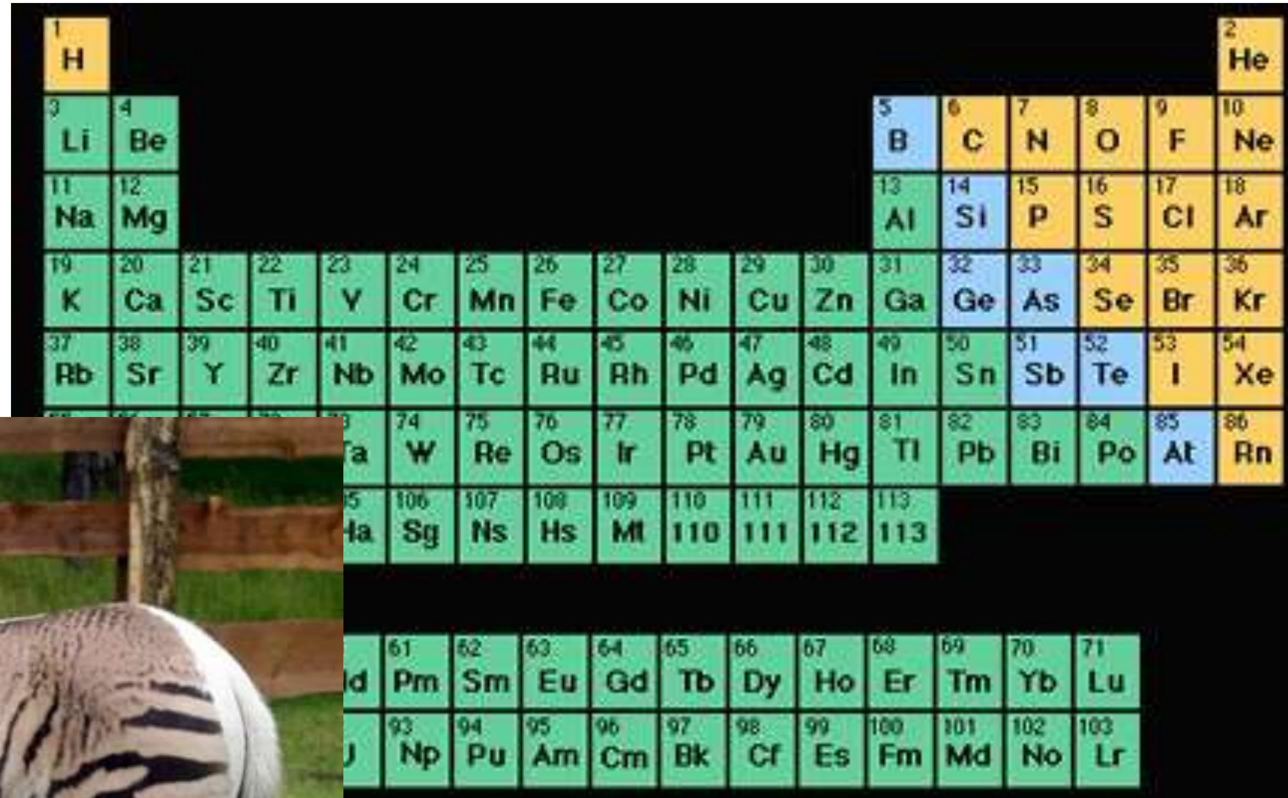


Radio-nuclide	Half-life	Daugh-ters	Half-life	Cumulative α/decay	E_α mean (MeV)	Range (μm)
Tb-149	4.1 h			0.17	3.97	25
Pb-212	*10.6 h*	Bi-212 Po-212	1.01 h 0.3 μs	1	7.74	65
Bi-212	1.01 h	Po-212	0.3 μs	1	7.74	65
Bi-213	*0.76 h*	Po-213	4 μs	1	8.34	75
At-211	7.2 h	Po-211	0.5 s	1	6.78	55
Ra-223	11.4 d	Rn-219 Po-215 *Pb-211* Bi-211	4 s 1.8 ms *0.6 h* 130 s	4	6.59	>50
Ra-224	3.66 d	Rn-220 Po-216 *Pb-212* Bi-212	56 s 0.15 s *10.6 h* 1.01 h	4	6.62	>50
Ac-225	10.0 d	Fr-221 At-217 *Bi-213* Po-213	294 s 32 ms *0.76 h* 4 μs	4	6.88	>50

Production of ^{149}Tb, ^{152}Tb and ^{155}Tb at ISOLDE



Astatine: a chemical hybrid – halogen/metalloid

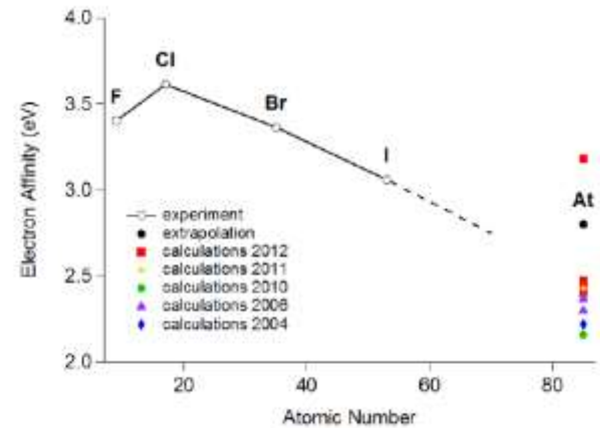


Challenges of Astatine

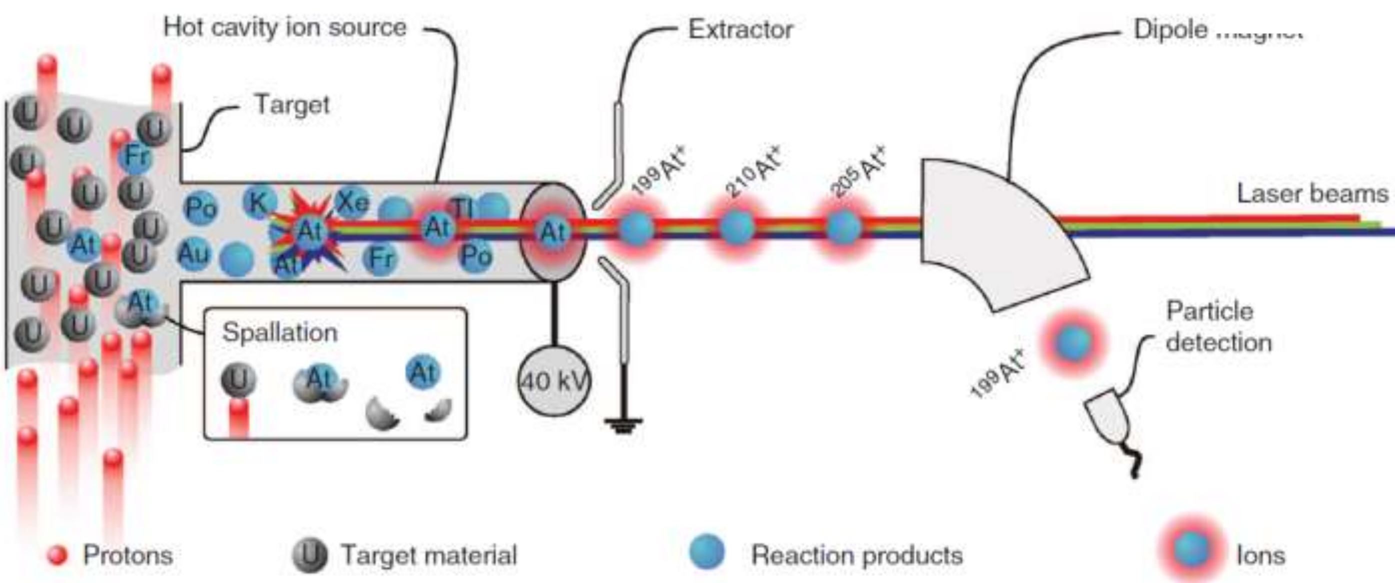
nature COMMUNICATIONS

Measurement of the first ionization potential of astatine by laser ionization spectroscopy

S. Rothe[1,2], A.N. Andreyev[3,4,5,6], S. Antalic[7], A. Borschevsky[8,9], L. Capponi[4,5], T.E. Cocolios[1], H. De Witte[10],



Dag Hanstorp et al.
INTC-I-148



IP(At) = 9.317510(8) eV

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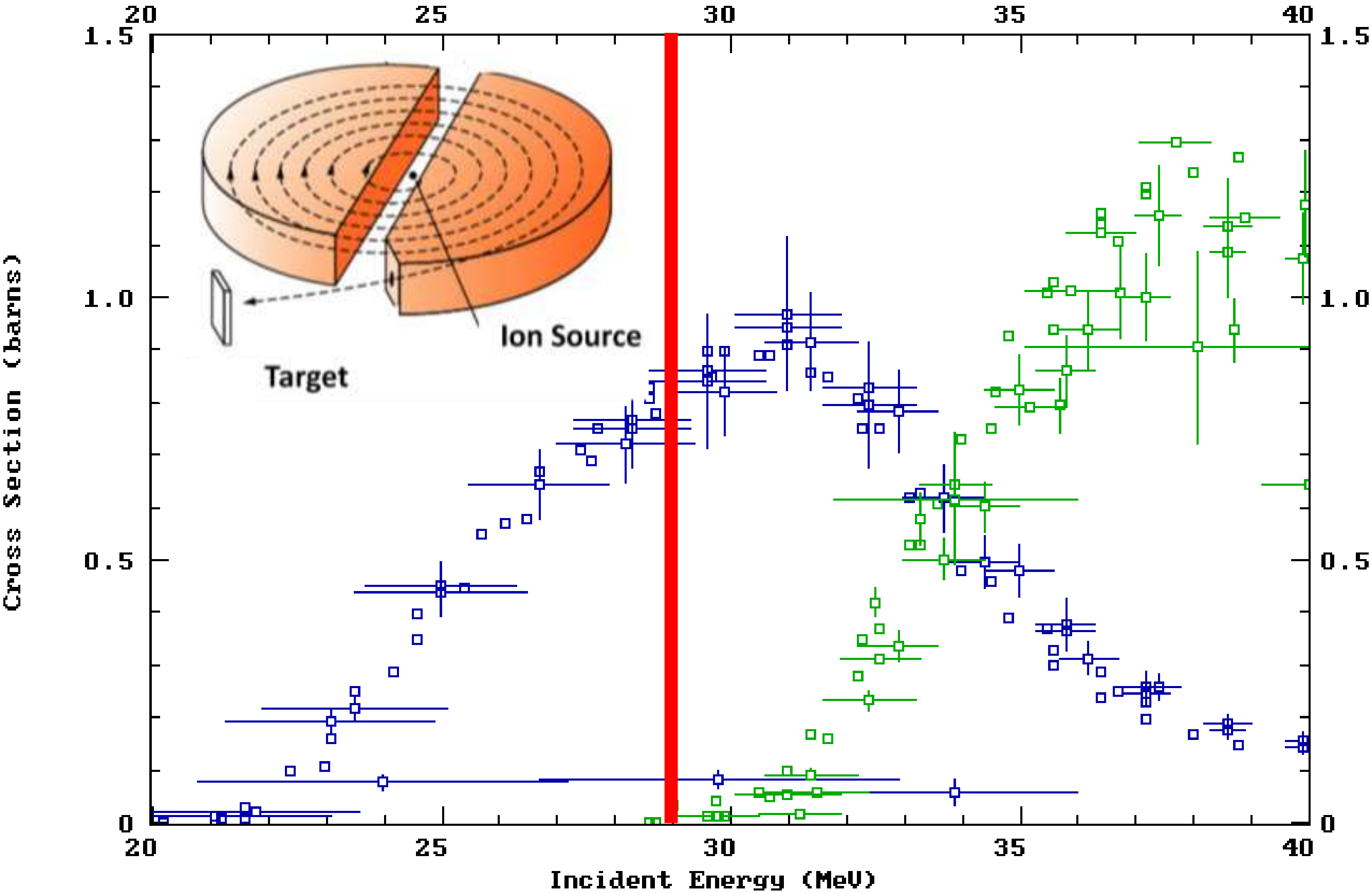
6. Efficient enrichment of rare isotopes
7. Provide high quality alpha emitters (^{149}Tb, ^{211}At, ^{225}Ac):
   mass sep. at ISOLDE/MEDICIS & radiochemically purified

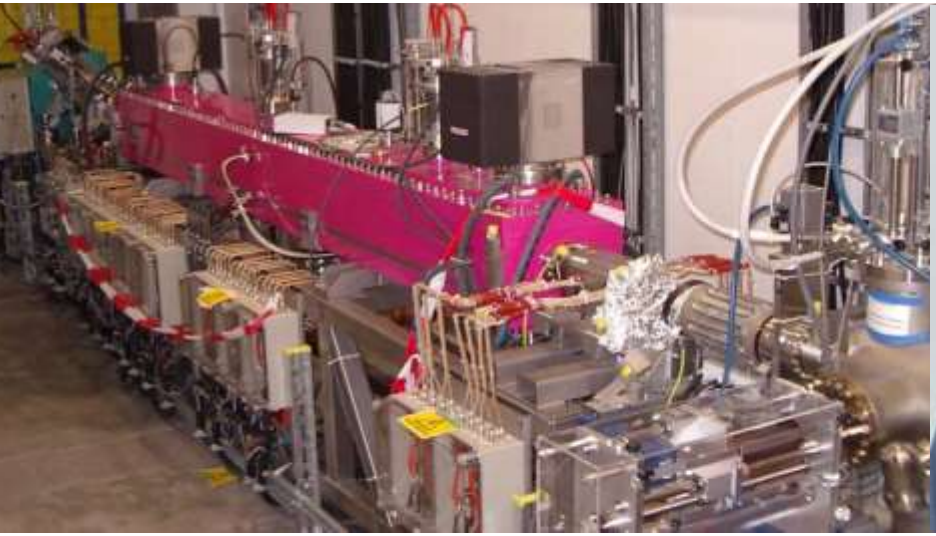
^{211}At production

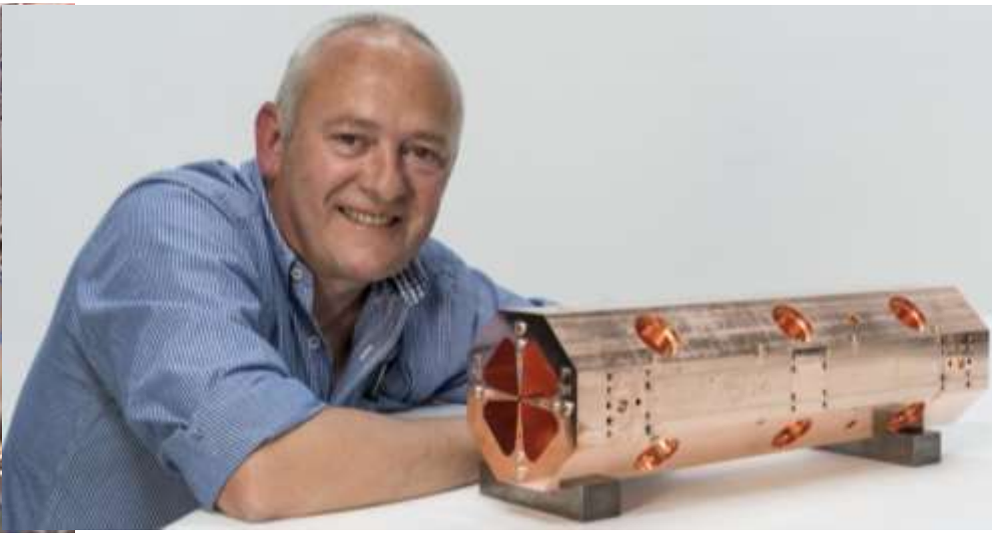
^{209}Bi(α,2n)^{211}At

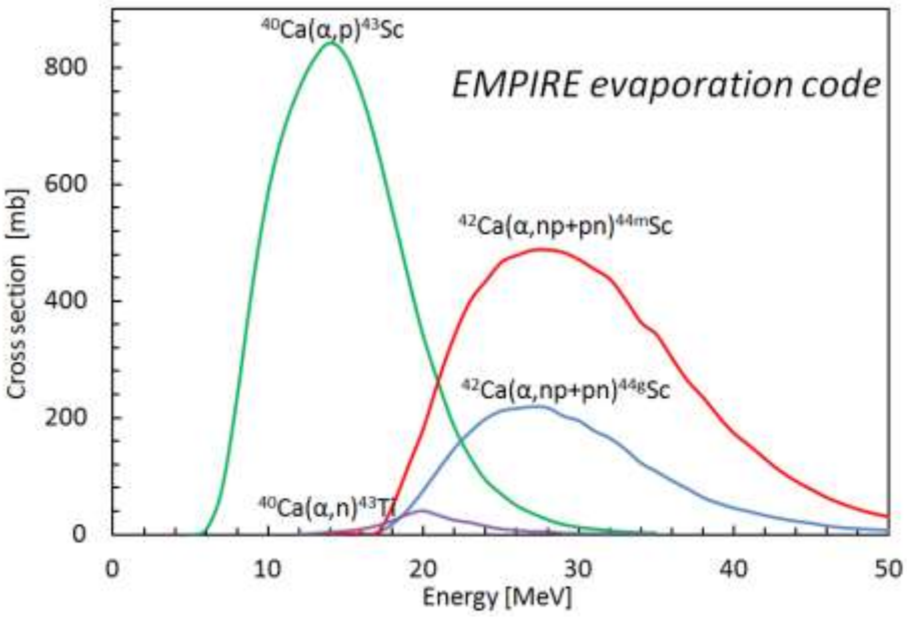
^{209}Bi(α,3n)^{210}At > ^{210}Po



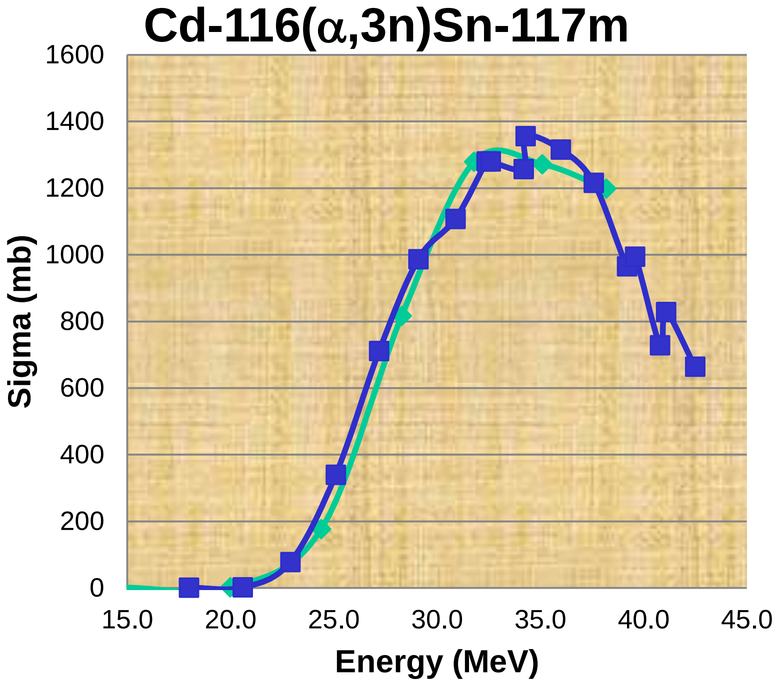
7.2-11 MeV/u light ion LINAC A/q=2







J. Jastrzębski. ICTR-PHE2016



N. Stevenson. ICTR-PHE2016

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Which medical isotopes will we need in 2030 ?

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: December 4, 1958

Today >30 million clinical applications per year !

TO: Addressees Below

FROM: Daniel M. Schaeffer, Head
BNL Patent Office

SUBJECT: P-701 and P-702 - PREPARATION OF CARRIER-FREE MOLYBDENUM AND OF TECHNETIUM FROM FISSION PRODUCTS

The New York Patent Group has carefully studied the information available relative to the above-identified item. The AEC does not at present desire to prepare a patent application on this item for the following reason:

"The method of producing carrier-free molybdenum-99 from fission products is disclosed in U. S. Patent Application S.N. 732,108, Green, Powell, Samos & Tucker (BNL Pat No. 58-17). It is noted that molybdenum-99 may be separated from its radioactive daughter, technetium-99, by absorption of a solution of molybdenum-99 on alumina and subsequent elution of its daughter with .1 nitric acid. While this method is probably novel, it appears that the product will probably be used mostly for experimental purposes in the laboratory. On this basis, no further patent action is believed warranted."

...

believe that this attitude is significant. We are not aware of a potential market for technetium-99 great enough to encourage one to undertake the risk of patenting in hopes of successful and rewarding licensing. We would recommend against filing on the Tucker, Greene and Murrenhoff separation process."

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Radioisotope production is outside of ILL’s normal sphere of activity, but we have a moral imperative to do this work.
It’s a great example of how a publicly funded facility can have a totally unexpected and unpredictable payoff for society.
Prof. Andrew Harrison (former ILL Director)

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NEUTRONS FOR HEALTH