Nuclear Physics for Human Health: innovative radionuclides at the forefront of Nuclear Medicine

Fisica Nucleare CSN3
Fisica Teorica CSN4
Fisica Applicativa CSN5

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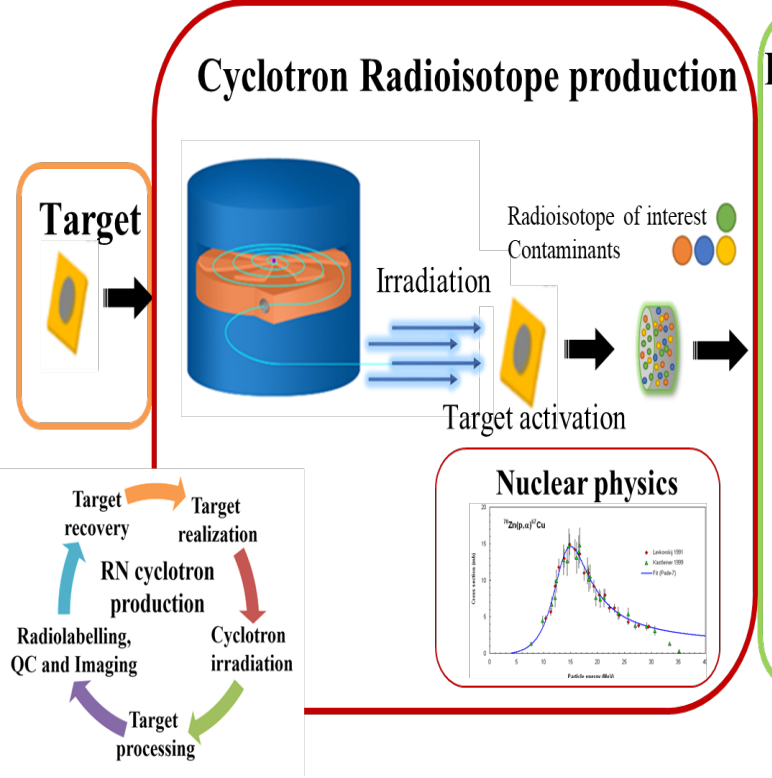

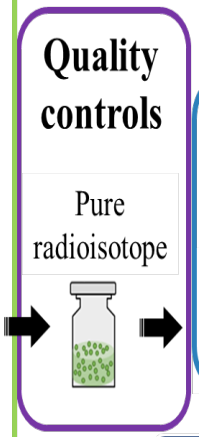

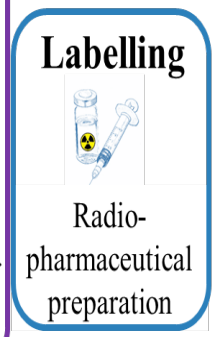

The Cyclotron-based Production of Medical Radionuclides

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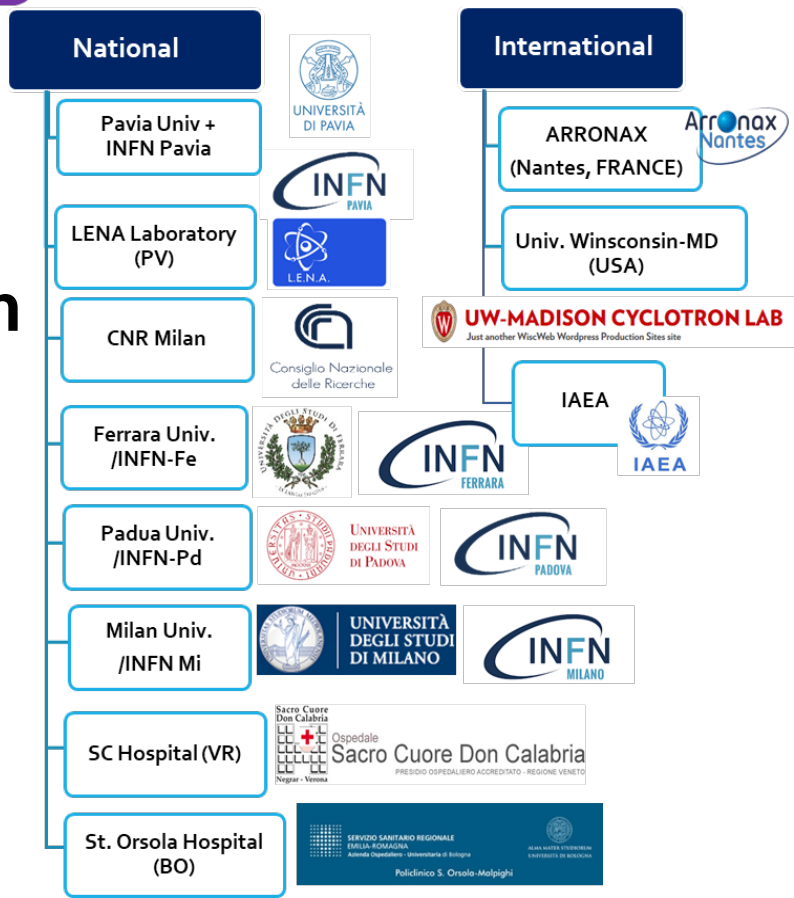
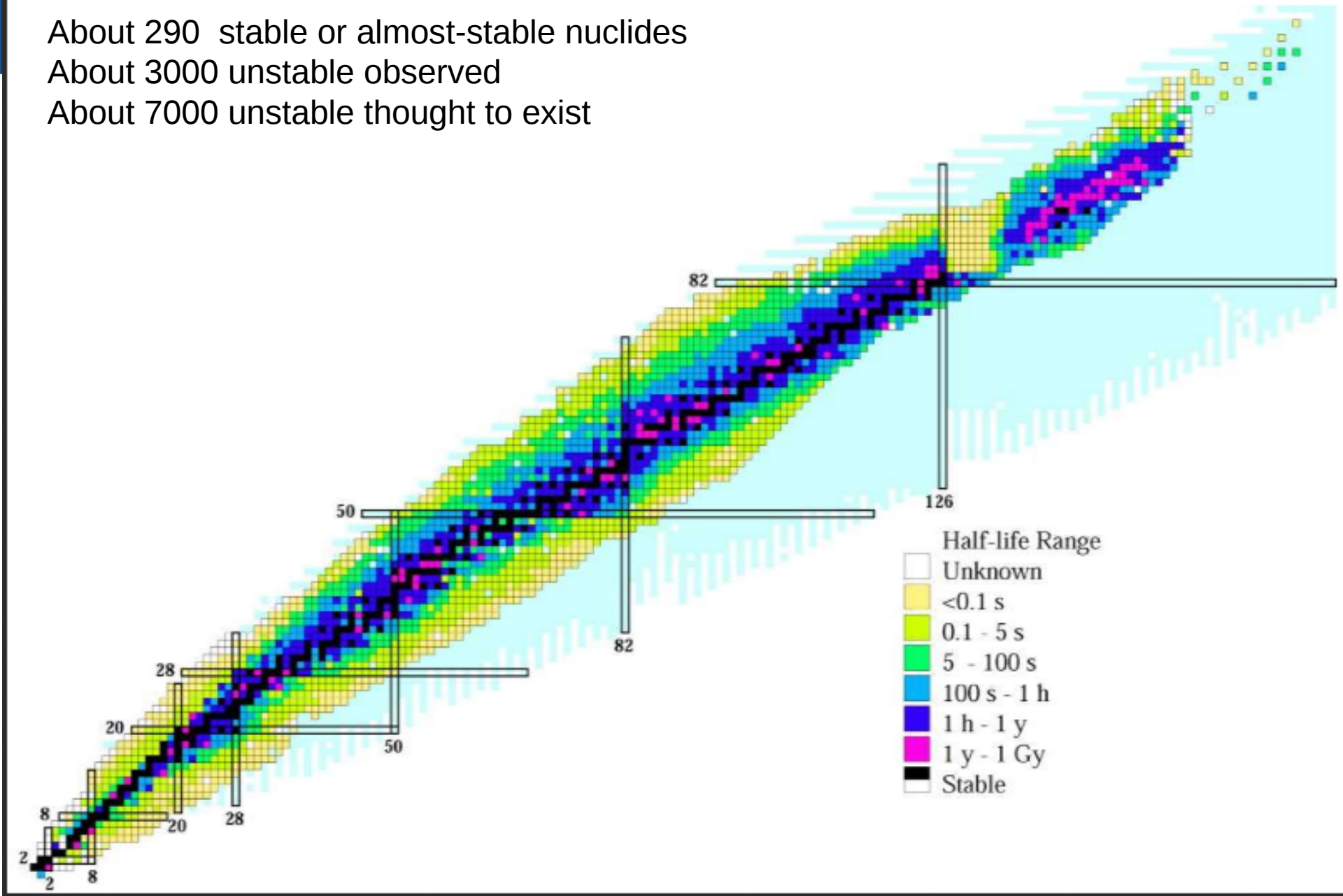
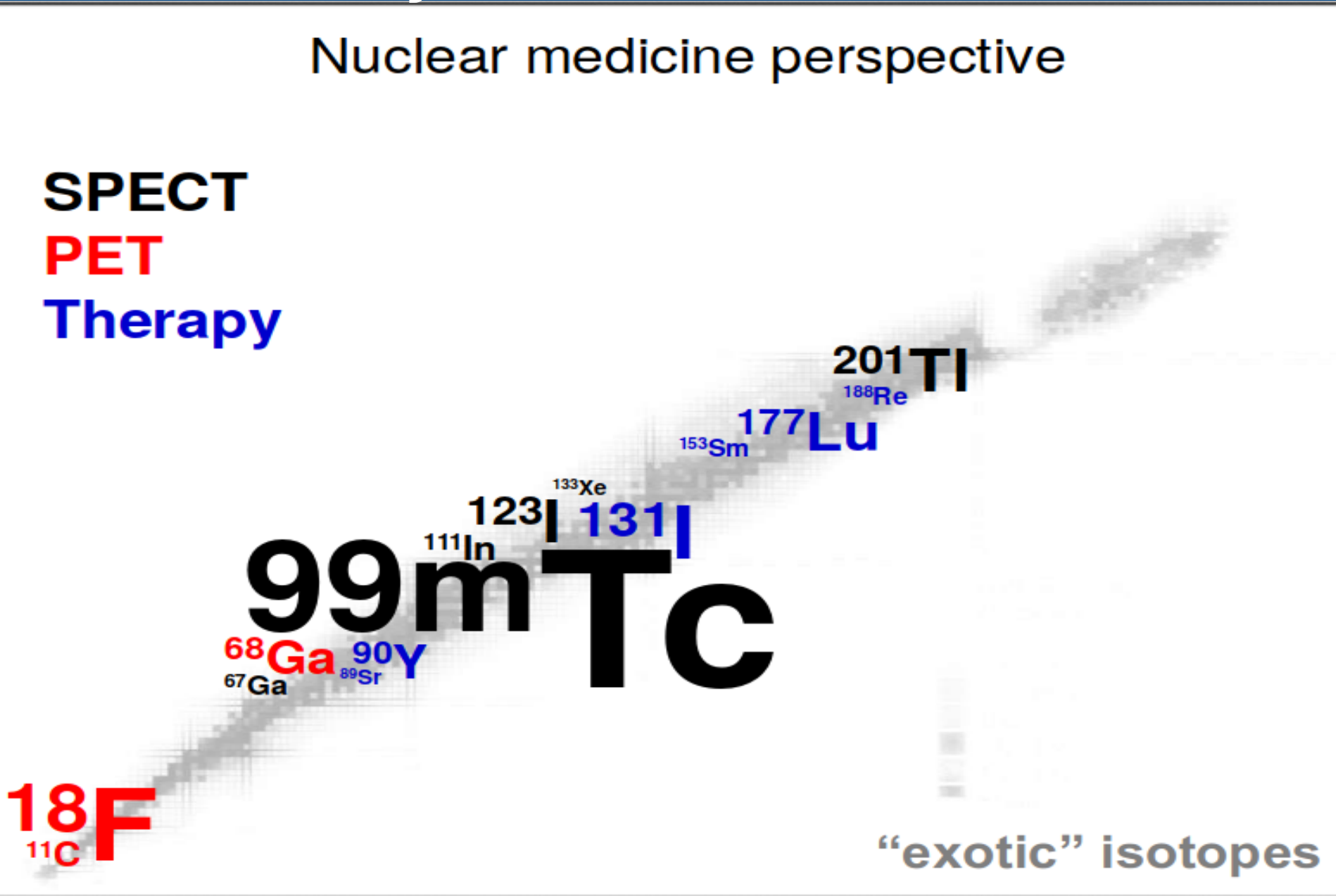


Nuclear physicist perspective

About 290 stable or almost-stable nuclides
About 3000 unstable observed
About 7000 unstable thought to exist



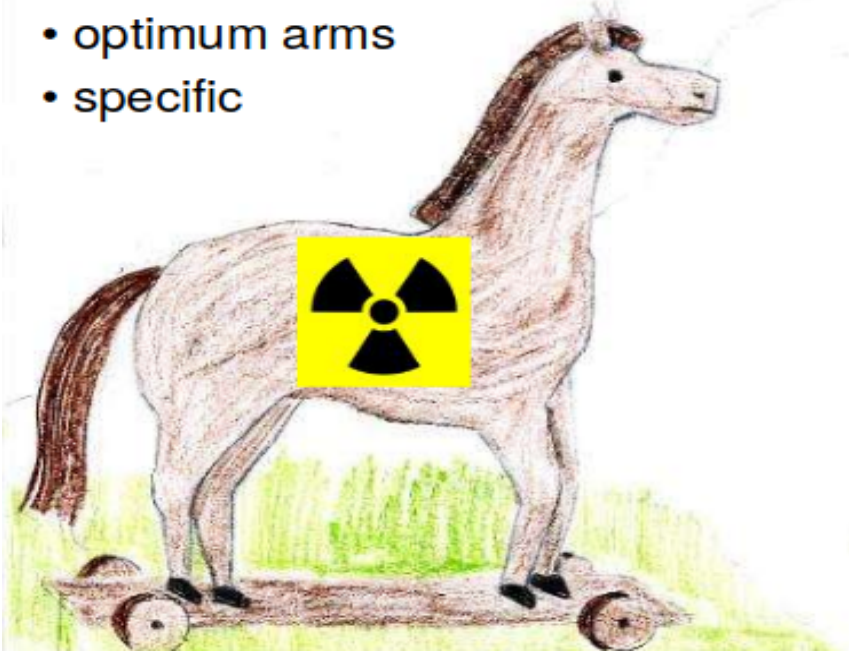
How many are used in clinics ???



Introduction to radiotargeted therapy

The principle of targeted therapies

- “attractive” vector > high uptake by the target
- transportable
- good in-vivo stability
- warriors “not visible”
- delayed uptake > suitable half-life
- limited space > high specific activity
- optimum arms
- specific



Introduction to radiotargeted therapy

New Directions in Radionuclide Applications

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Syed M Qaim,
Lecture IAEA

- **Theranostic approach**

  (combination of PET / Targeted therapy)

  $^{44}Sc/^{47}Sc$, $^{64}Cu/^{67}Cu$, $^{86}Y/^{90}Y$, etc.

- **Multimode imaging**

  (combination of PET/CT and PET/MRI)

- **Radioactive nanoparticles**

  Possible improvement in delivery of radionuclide to tumour

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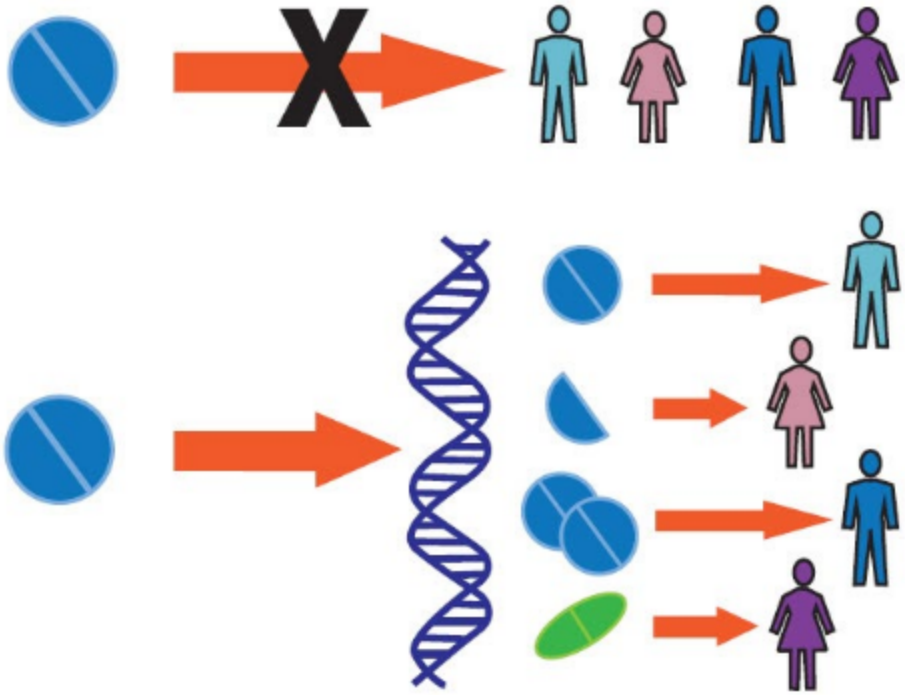
Continuous radionuclide research is underway.

Personalized/Precision Nuclear Medicine

Imaging and diagnosis

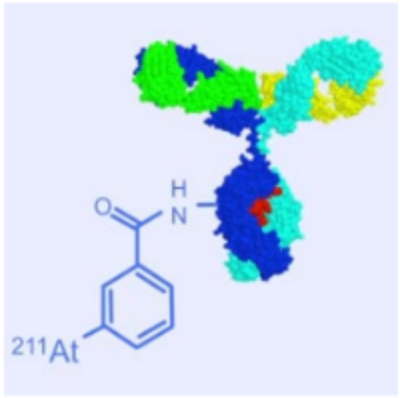
Choose the best treatment

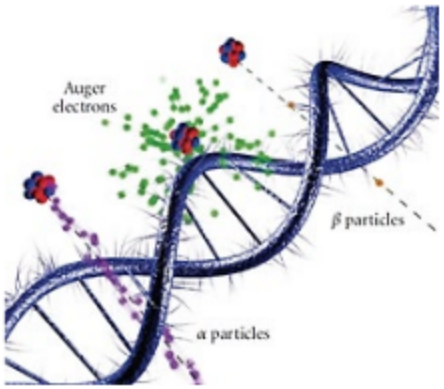
Evaluate its efficacy



Therapy

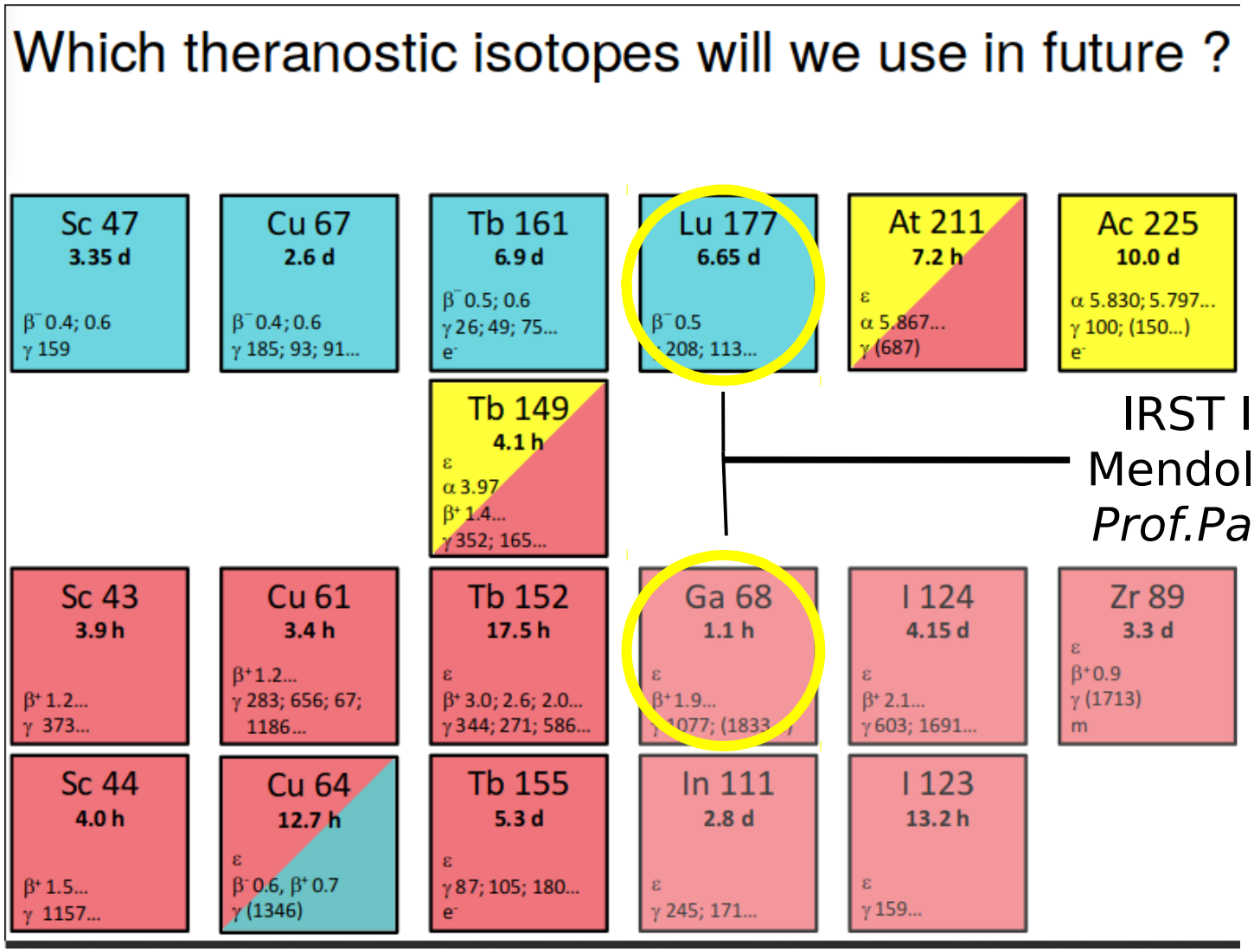
Destroy tumor cells





The Right Drug To The Right Patient For The Right Disease
At The Right Time With The Right Dosage

Introduction to radiotargeted therapy



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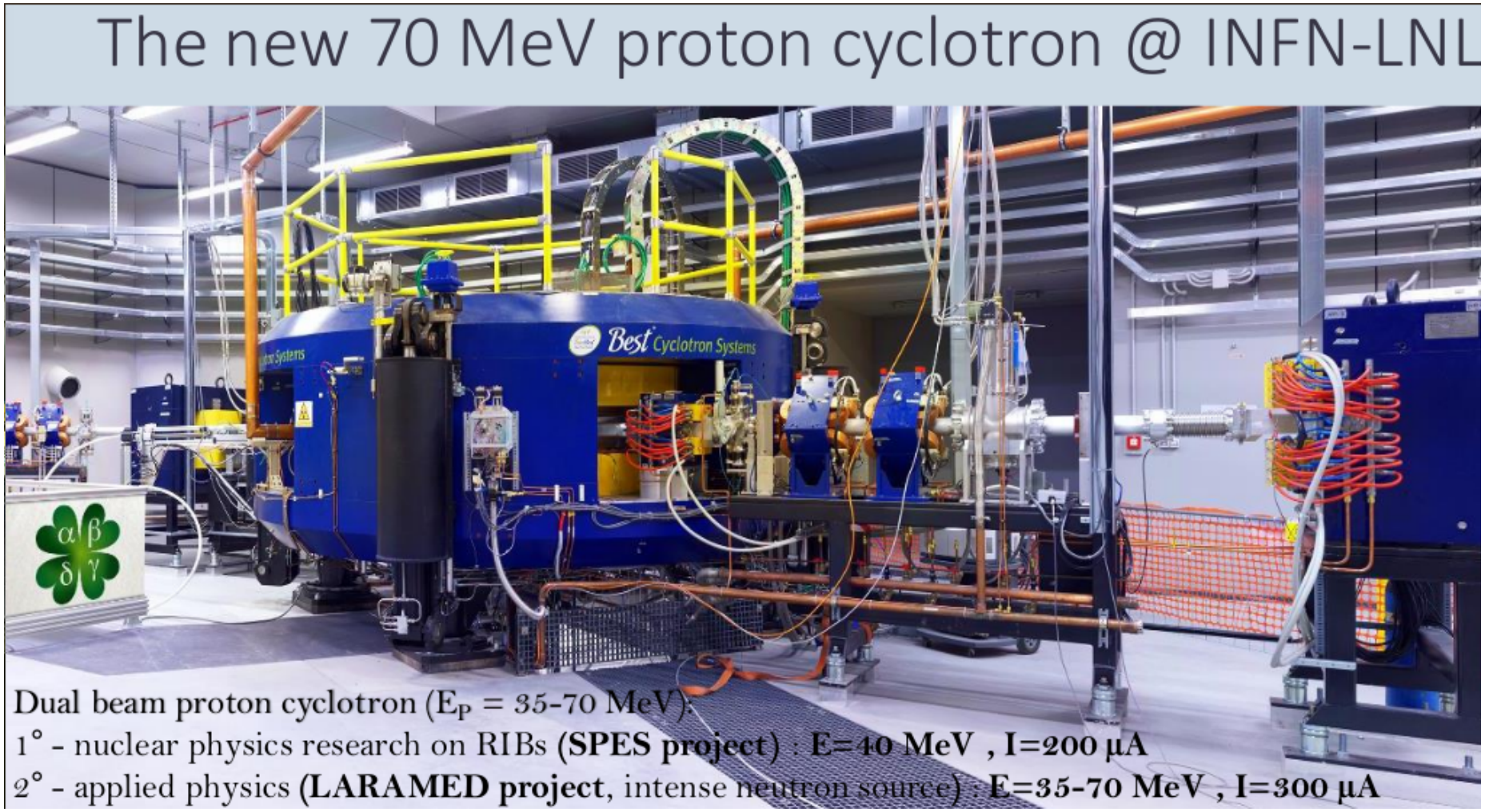

DUAL RADIO PHARMACEUTICAL PRODUCTION: LARAMED - ISOLPHARM

Introduction to radiotargeted therapy

Syed M Qaim, 2018-2021

JÜLICH FORSCHUNGSZENTRUM

Four Pillars of Radionuclide Development Work

- Nuclear data
  - decay properties
  - production cross sections + nuclear code simulations
- High current targetry
- Chemical processing
  - isolation of radionuclide and recovery of enriched target material
- Quality control
  - radionuclidic, radiochemical, chemical, specific activity

Nuclear Physics

Nuclear physicists could have crucial contributions:

- **Identify** reaction channel [spal., fis., act.]
- **Quantify** contaminants
- **Define** waste management process
- **Optimize** production process
- **Produce** the purest product
- **Discuss** with physicians to promote its use

Nuclear data

- **Accurate and reliable** sets of data
- Well defined **production routes and decay properties**
- **Optimum production** of specific radionuclides, minimization / elimination of **impurities**, **realistic dose calculations**

Nuclear codes

- Provide **a large set of nuclear data**
  in terms of targets, projectiles and energy range
- **To constrain and develop** predictive simulation tools of nuclear reactions

CROSS-SECTIONS are very important because all other quantities depend on it !!

Production rate

$$R = \frac{I_0}{z_{proj}\,|e|}\,\frac{N_A}{A}\int_{E_{out}}^{E_{in}} \sigma(E)\left(\frac{dE}{\rho_t\,dx}\right)^{-1} dE$$

Bateman equations

$$\frac{dN_i}{dt} = R_i - \lambda_i N_i + \sum_{j<i} f_{ij}\lambda_j N_j$$

activities

$$A_i(t) = \lambda_i N_i(t)$$

purities

$$RNP(t) = \frac{A_{*x}(t)}{\sum_i A^i{}_x(t)}$$

^{47}Sc production:

We have studied and identified various production routes for

^{48}Ti(p,x) **not suitable**

^{49}Ti(p,x) **not suitable**

^{50}Ti(p,x) **adequate (optimized conditions)**

^{49}Ti(d,x) **adequate (optimized conditions)**

^{nat}V(p,x) **adequate (optimized conditions)**

Deposited in 2023 a patent for ^{47}Sc production

^{155}Tb production:

^{155}Gd(p,n) **adequate (but conditions on target enrichement)**

Currently studing production of Terbium and Copper radioisotopes for the theranostic approach.

Thank-you for the attention !

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Research on Emerging Medical radIonuclides from the X-sections (people and institutions)

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LARAMED: LAboratory for RAdionuclides for MEDicine