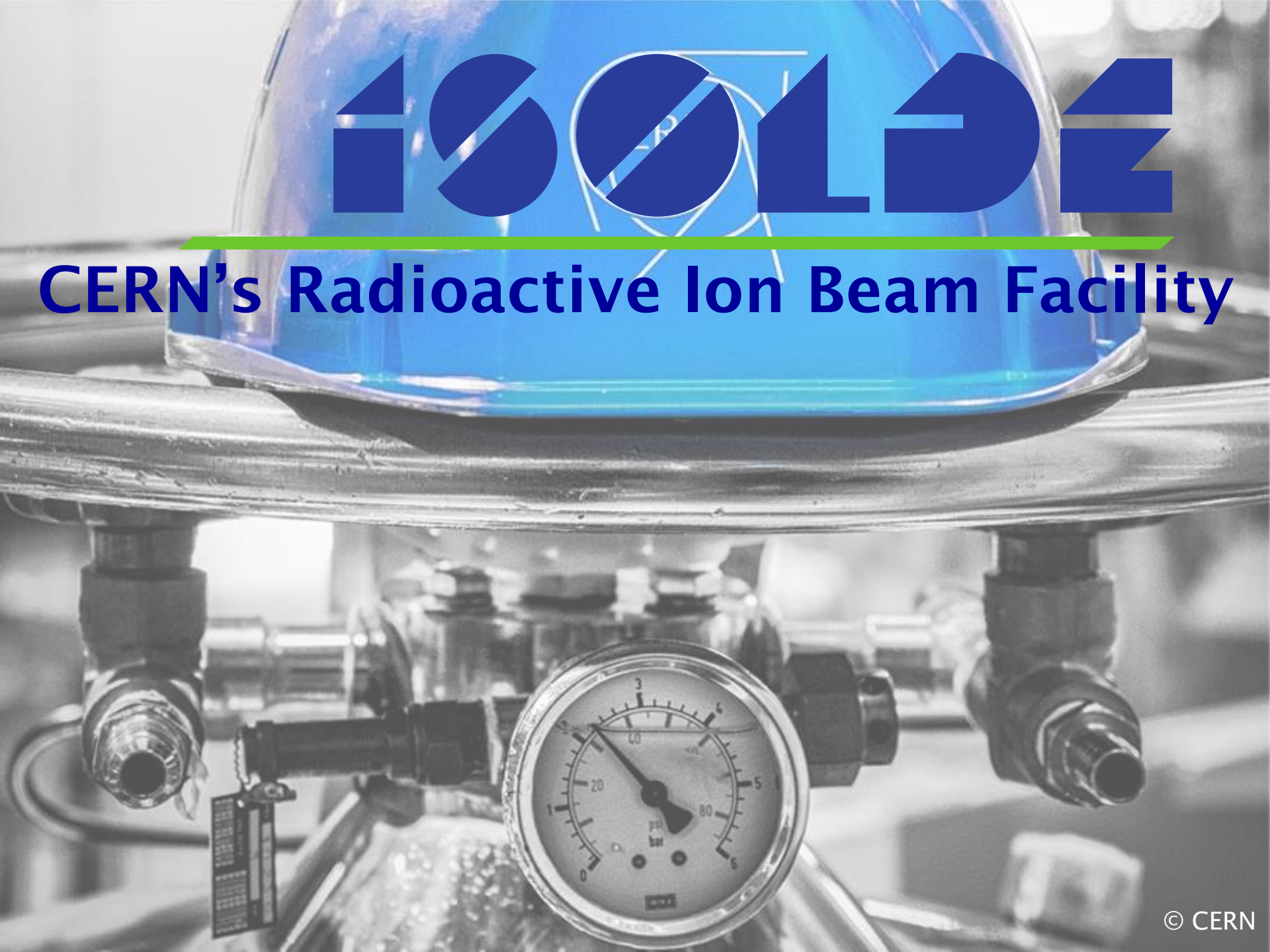
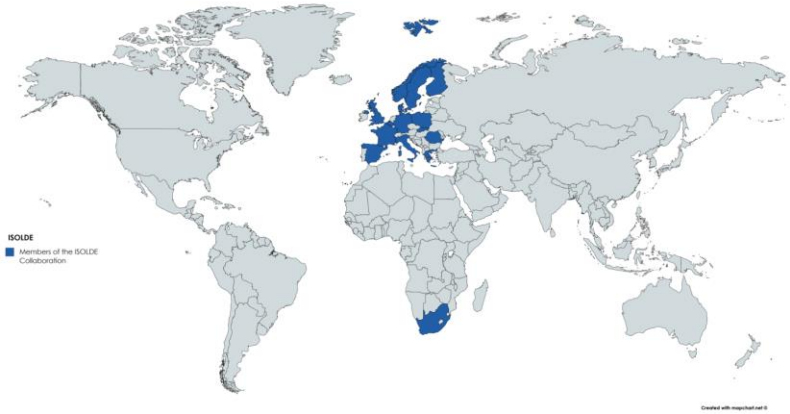

ISOLDE
CERN's Radioactive Ion Beam Facility
© CERN

ISOLDE at CERN

- Isotope Separator OnLine Device

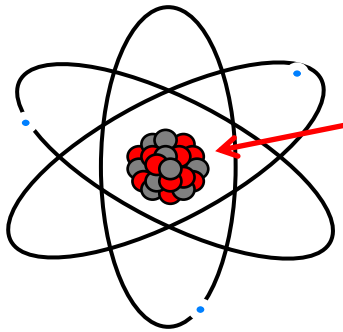
- A small facility with a big impact!
  - ~0.1% of the CERN budget
  - ~7% of the CERN scientists
  - ~50% of the CERN protons

- Run by international collaboration
  - CERN, BE, DE, DK, FI, FR, GR, IT, NO, PL, RO, SK, ZA, ES, SE, UK
  - ~50 staff/students/fellows
  - ~1500 users



The nuclear playground

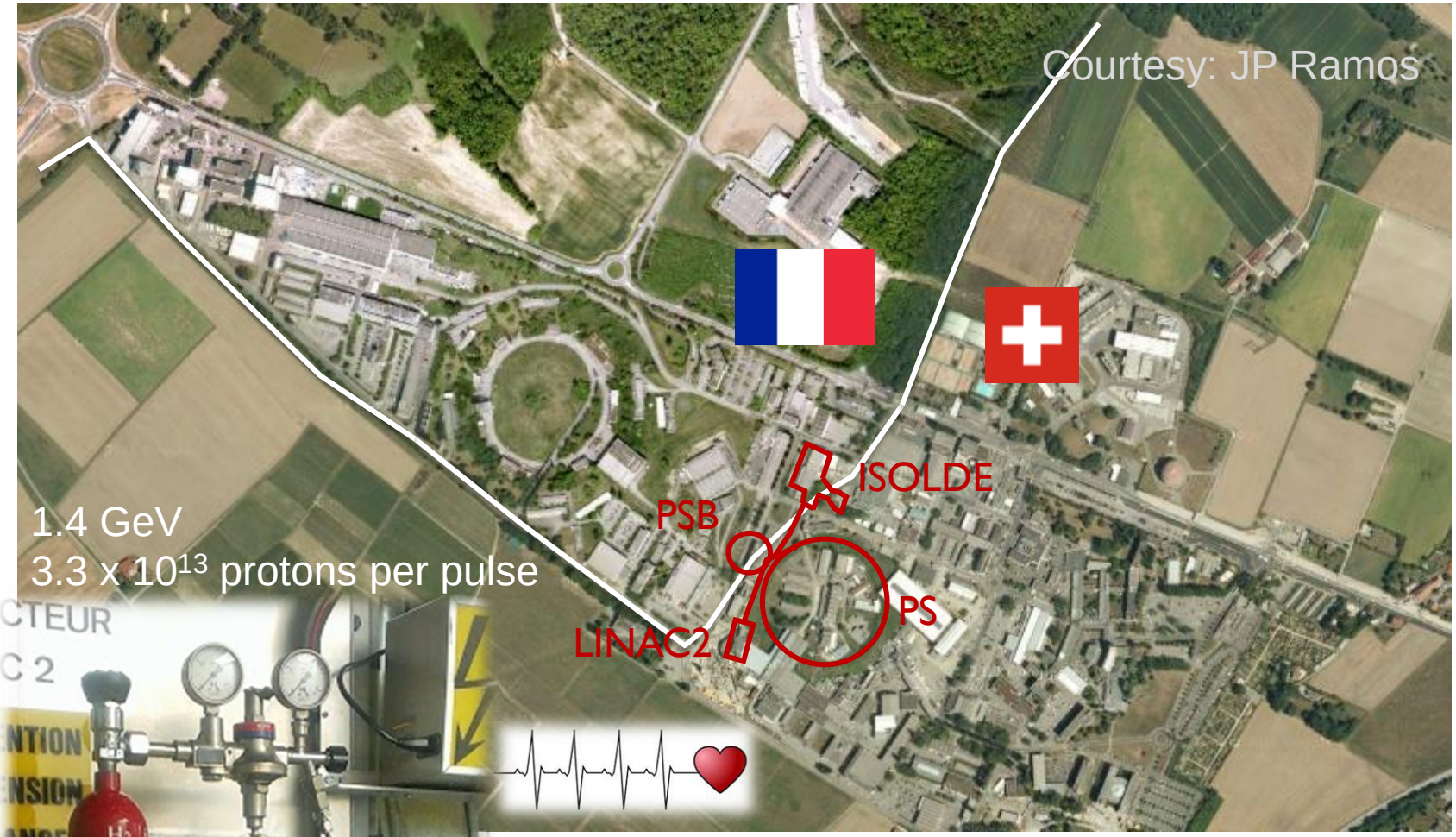
- ISOLDE is a radioactive isotope facility where the nuclear chart is our playground!



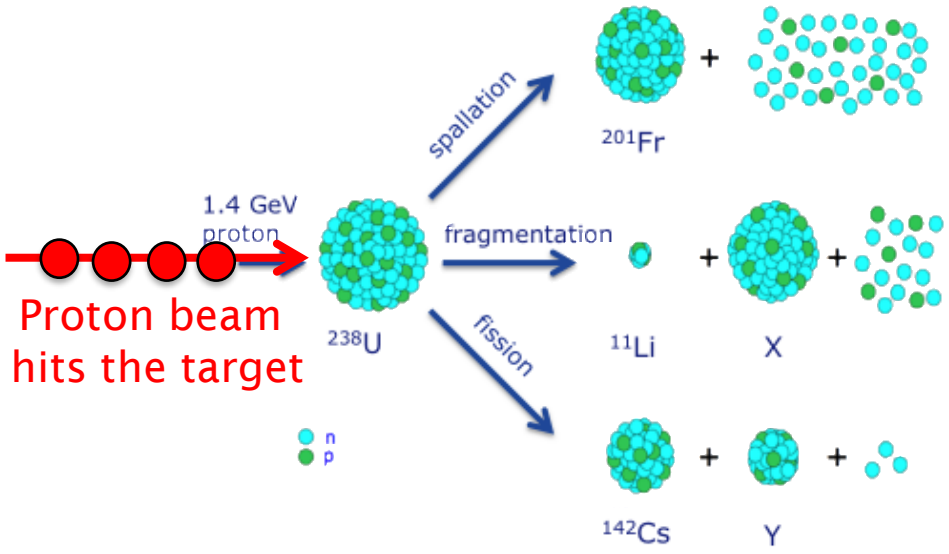
"Atomic nucleus"

Why at CERN?

At 1.4 GeV, protons travel at ~90% of the speed of light!



Production: Modern-day alchemy



- The protons split up the heavy nucleus to produce a wide variety of nuclei **simultaneously**!

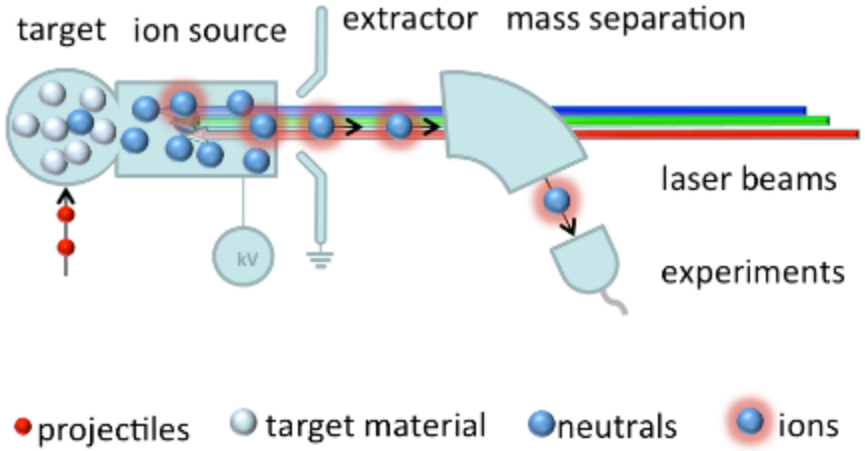
- Requirements for experiment:
  - High production
  - Pure radioactive beams: 1 kind of isotope

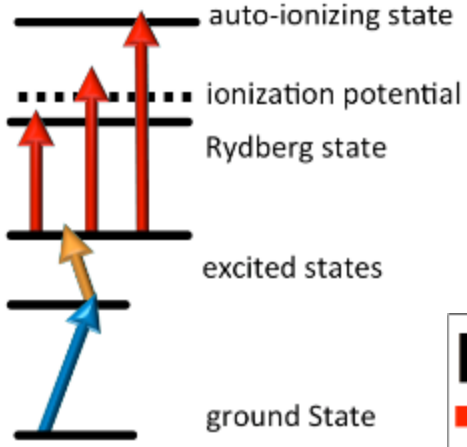
- Different stages of preparation
  - Production
  - Ionization
  - Separation

Gold is one of the chemical elements produced at ISOLDE, both stable as well as radioactive isotopes!

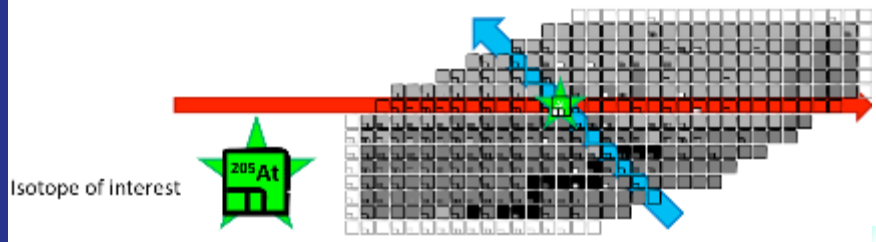
Ionization: RILIS

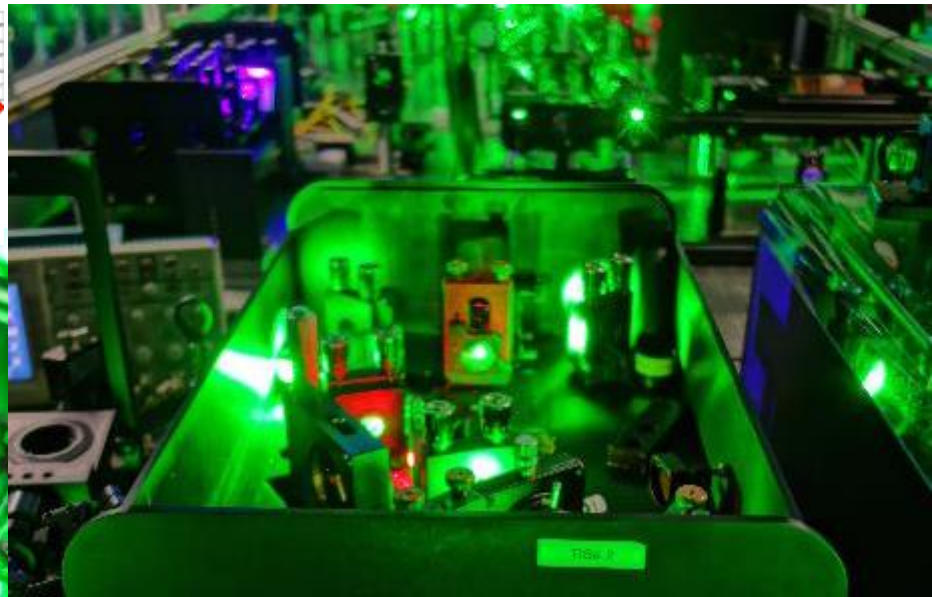
- Resonance Ionization Laser Ion Source
- Uses lasers to selectively ionize a particular element (isotope/isomer)

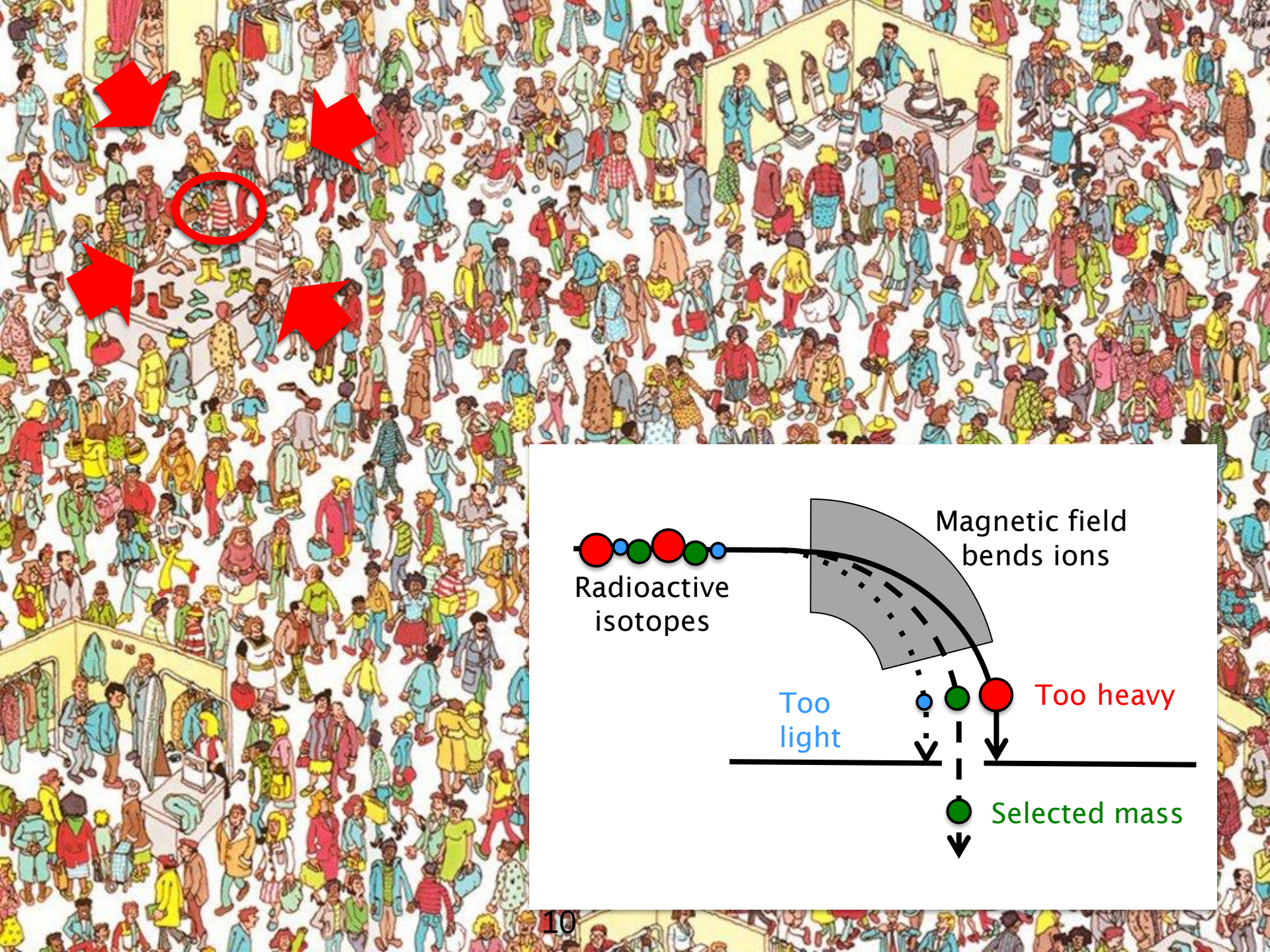




RILIS

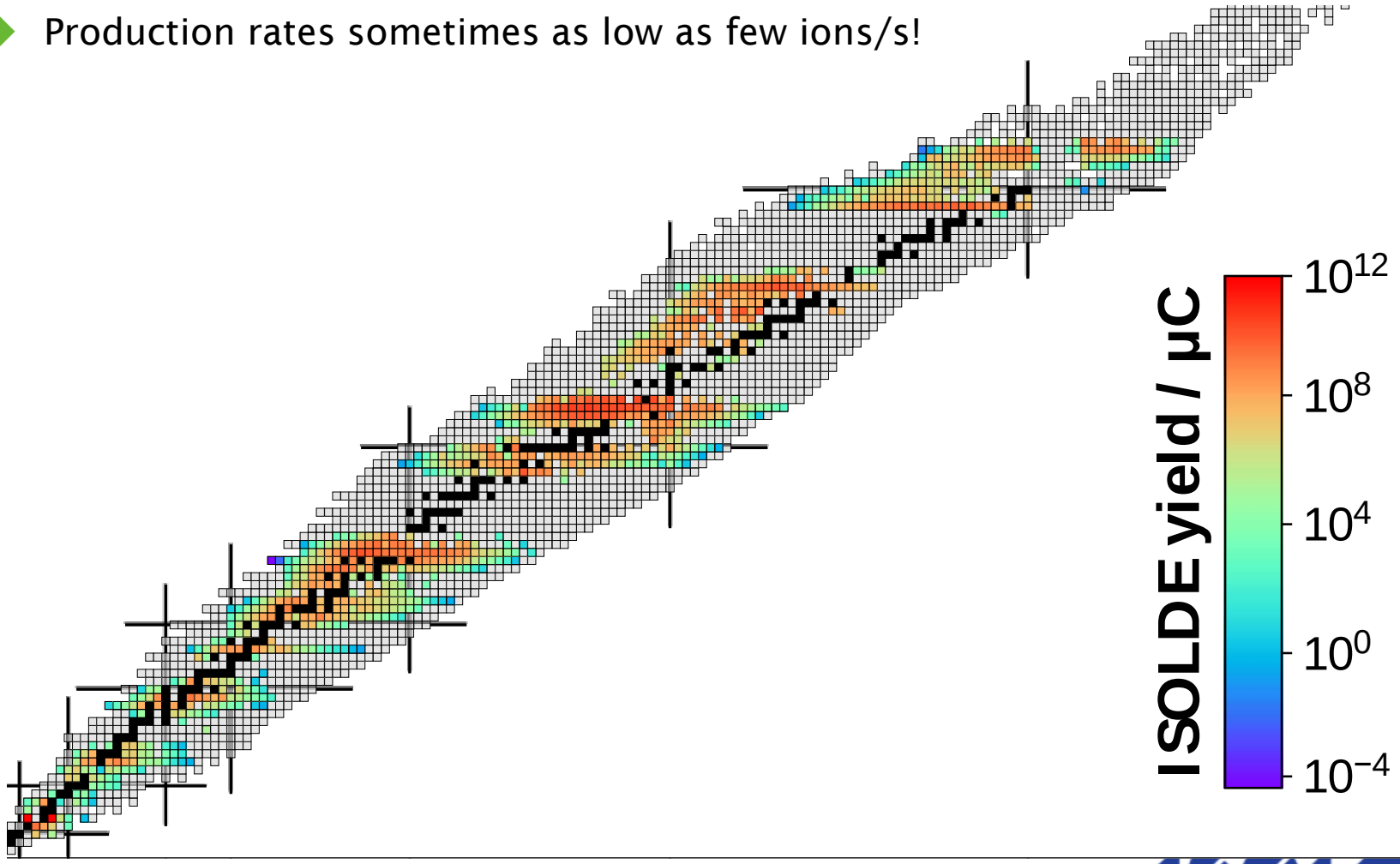





Magnetic field
bends ions
Radioactive
isotopes
Too
light
Too heavy
Selected mass

What is produced at ISOLDE?

- More than 1500 isotopes of 74 different chemical elements
- Half-lifes from 1 ms and 10^{12} years
- Production rates sometimes as low as few ions/s!

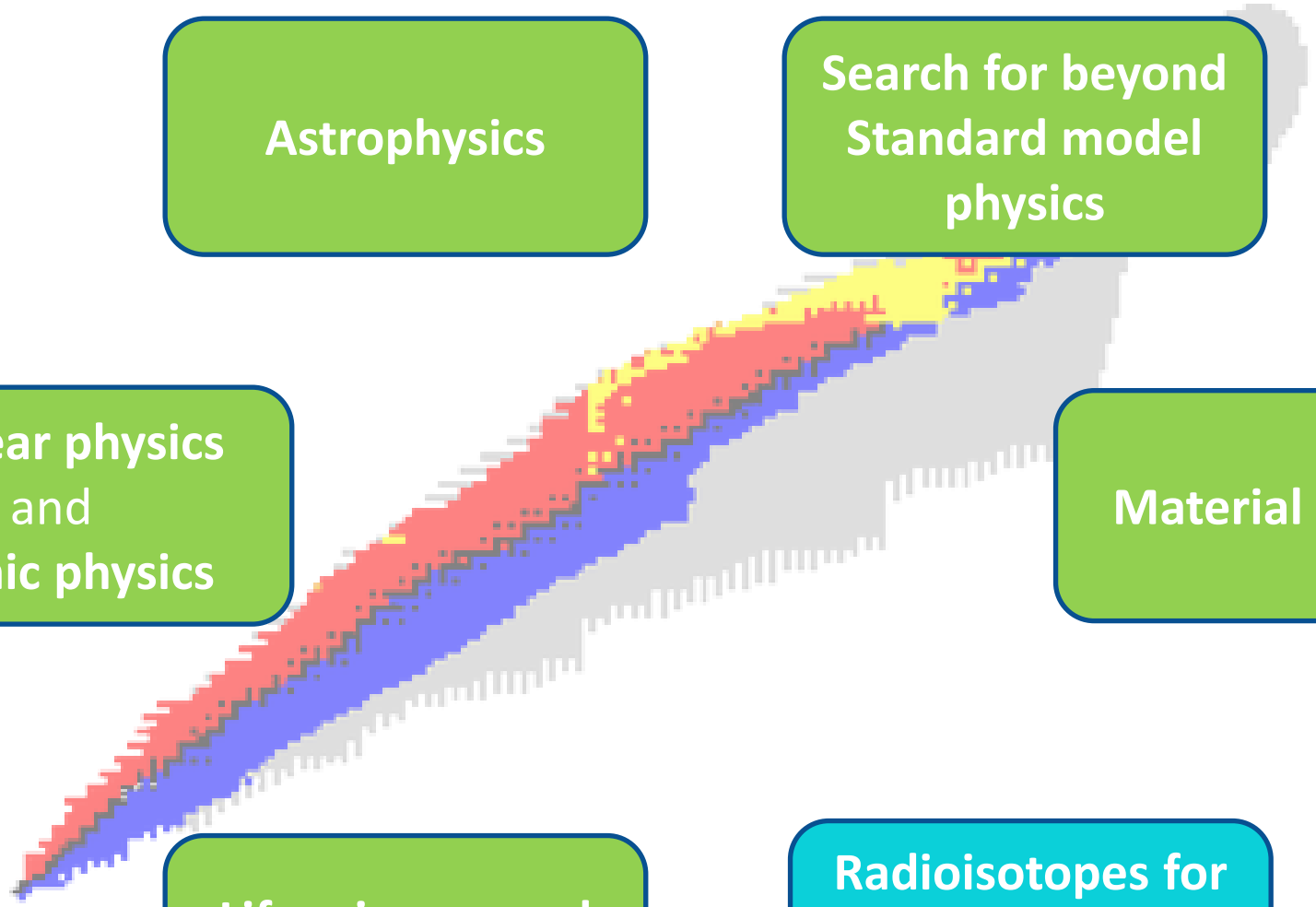


Research with radioactive beams

Astrophysics

Search for beyond Standard model physics

Nuclear physics and atomic physics



Material science

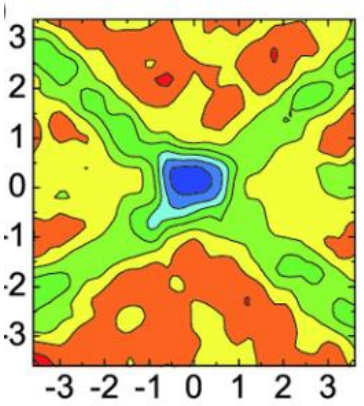
Life sciences and biophysics

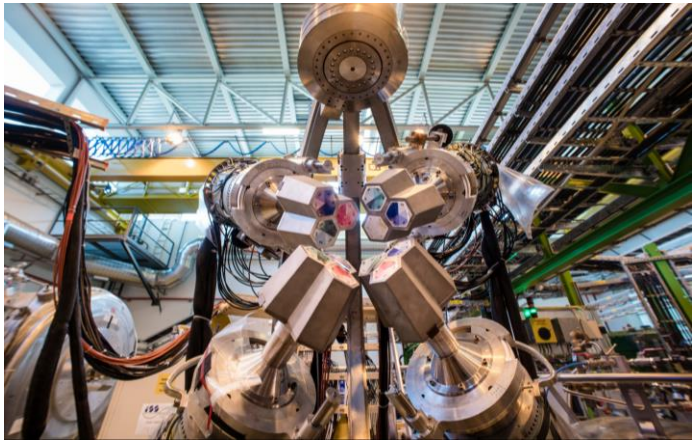
Radioisotopes for medical applications

ISOLDE

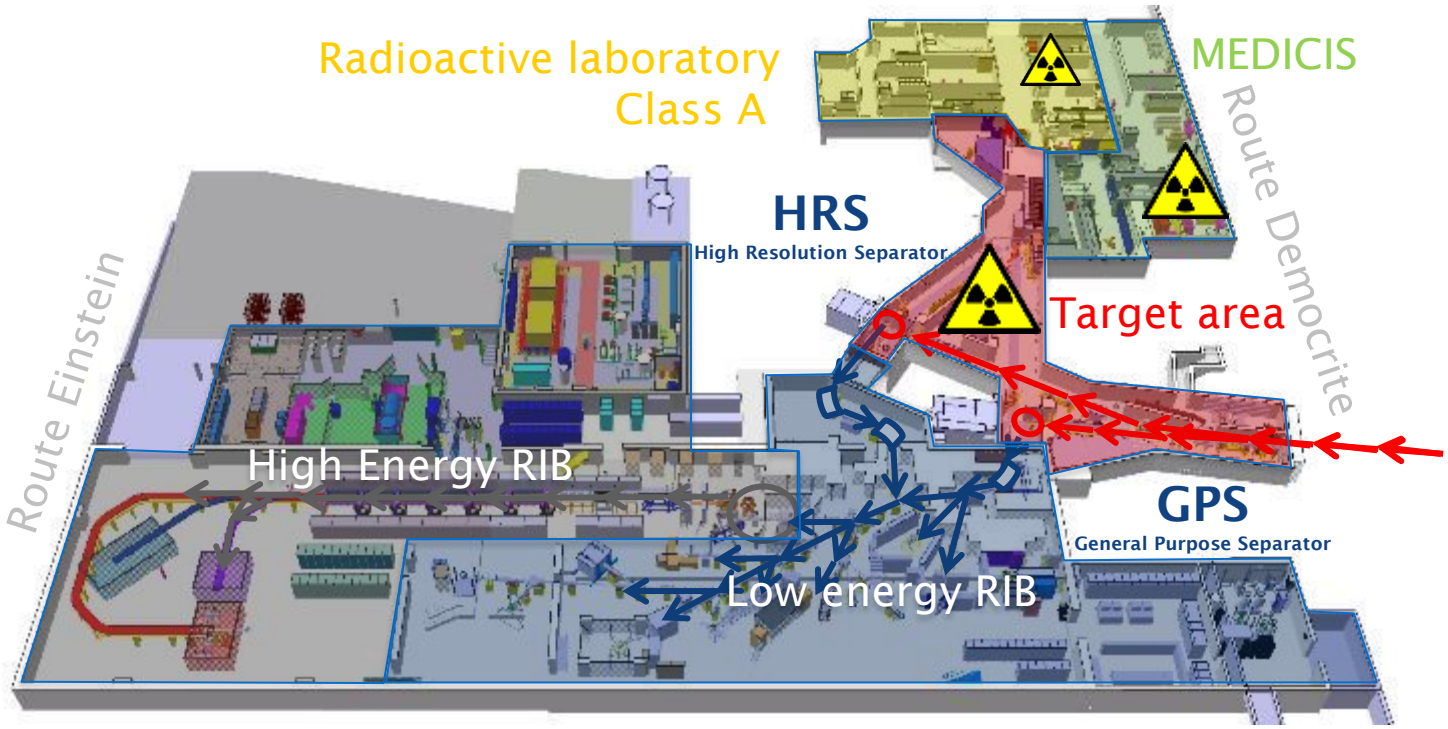
Research with radioactive beams

- How much do nuclei weigh? How big are they? What shape do they have?
- How and where in the universe are chemical elements produced?
- Why can protons and neutrons be bound together in many 1000 combinations? What are the limits of nuclear existence?
- How can we use the unique properties of radioactive nuclei for diagnosing and treating cancer?
- What's the location of impurities in crystals and biological samples?





The ISOLDE facility

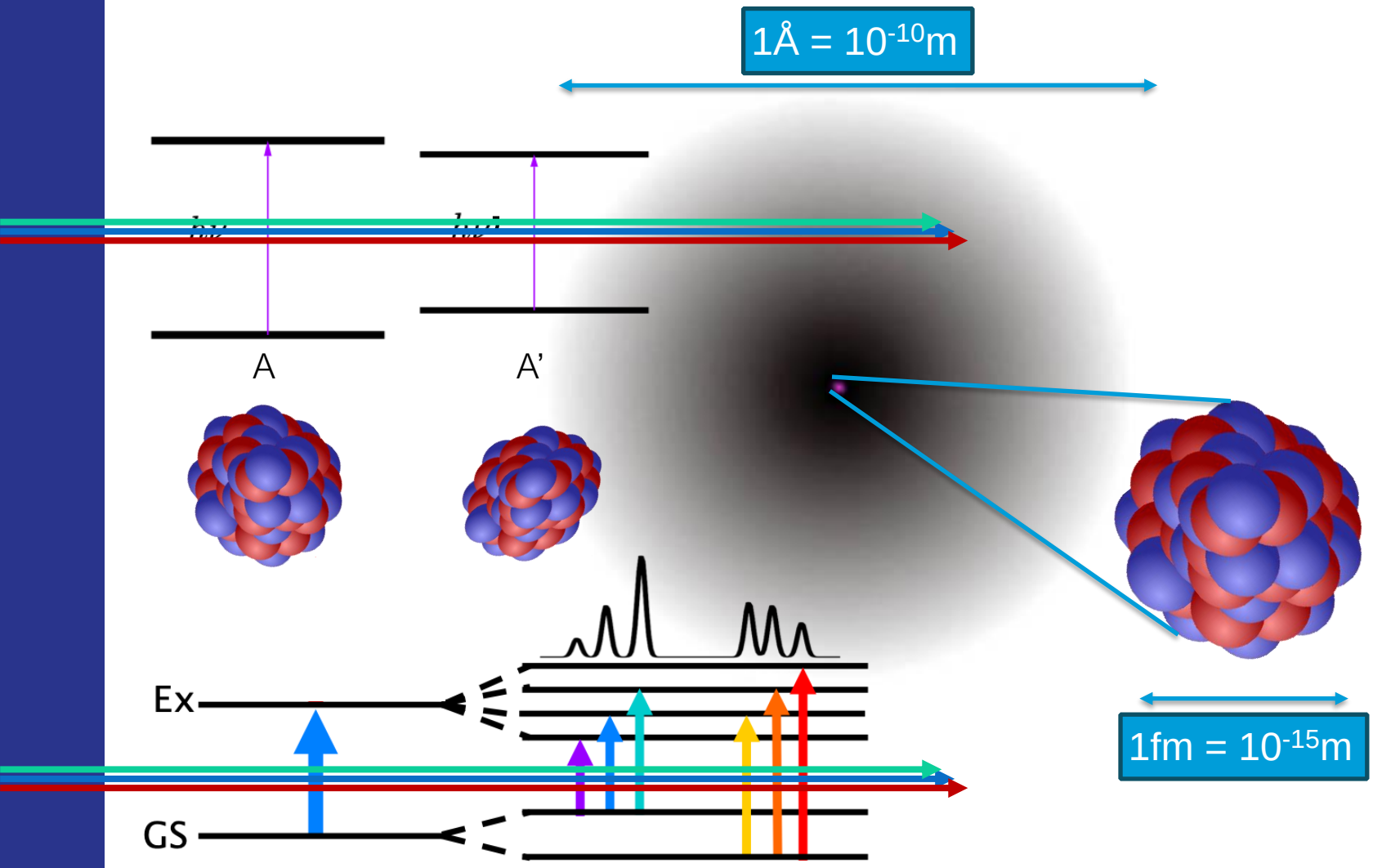


Protons (1.4 GeV)

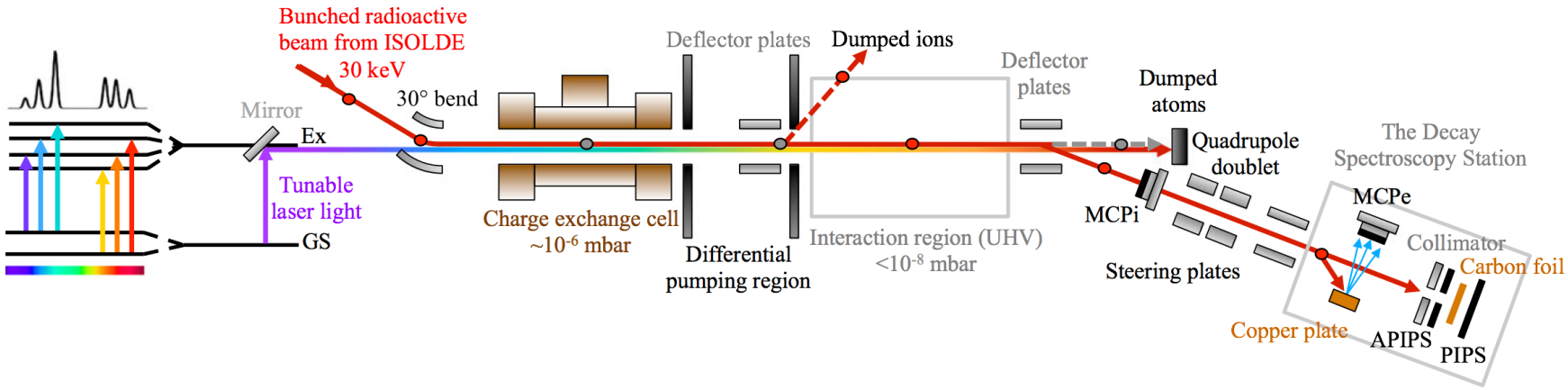
Low energy RIBs (up to 60 keV)

High energy RIBs (up to 10 MeV/u)

CRIS



CRIS

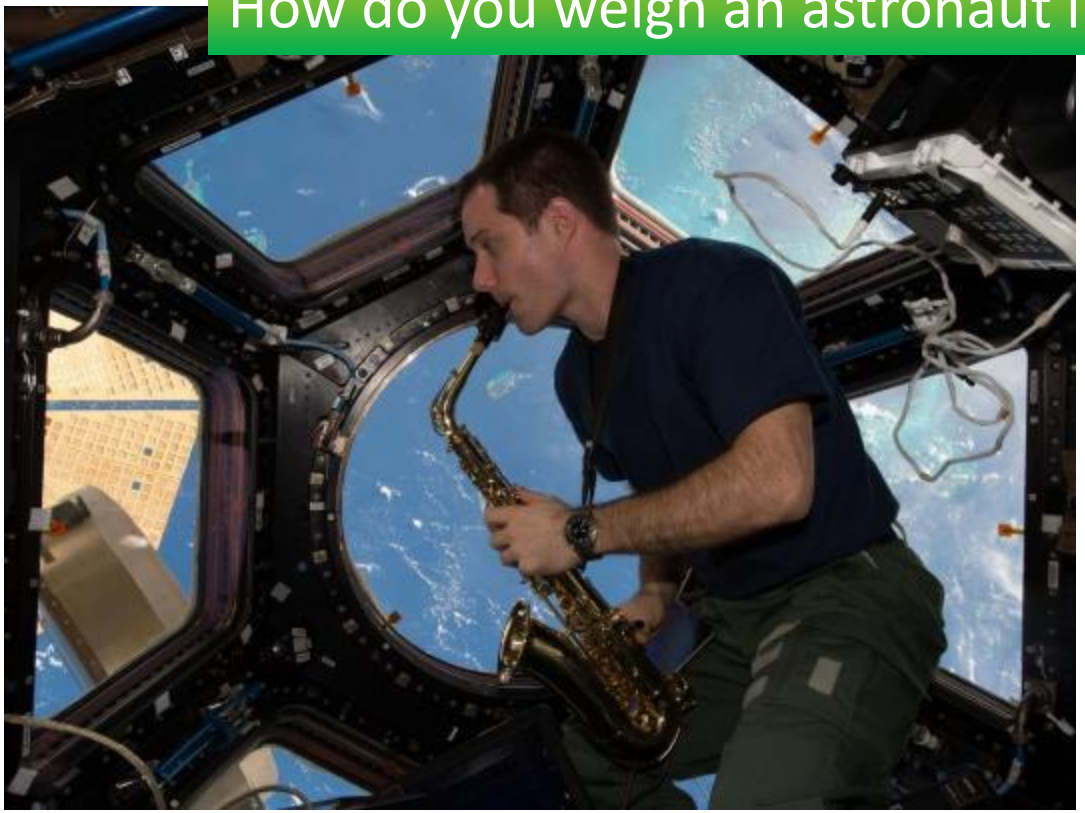

Bunched radioactive
beam from ISOLDE
30 keV
30° bend
Mirror
Ex
Tunable
laser light
GS
Charge exchange cell
~10-6 mbar
Deflector plates
Differential
pumping region
Dumped ions
Interaction region (UHV)
<10-8 mbar
Deflector
plates
Dumped
atoms
Quadrupole
doublet
MCPi
Steering plates
The Decay
Spectroscopy Station
MCPe
Collimator
Carbon foil
Copper plate
APIPS
PIPS

ISOLTRAP

How do you measure flour for a cake?

ISOLTRAP

How do you weigh an astronaut in space?

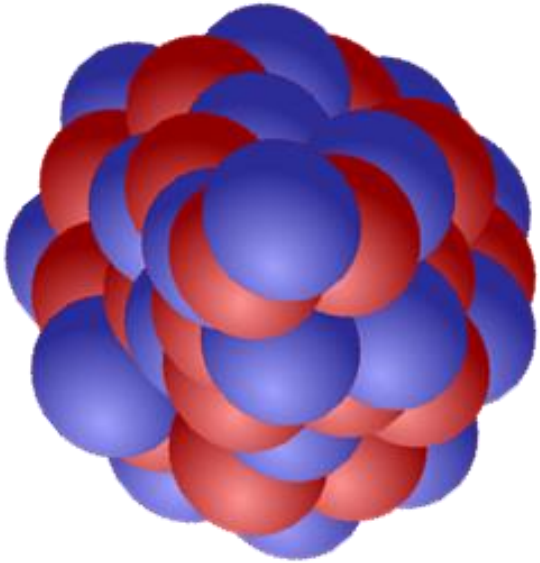


$$\sum F = ma$$

If gravity is not the force to use anymore, then you can use tension!

ISOLTRAP

How do you weigh an atom?



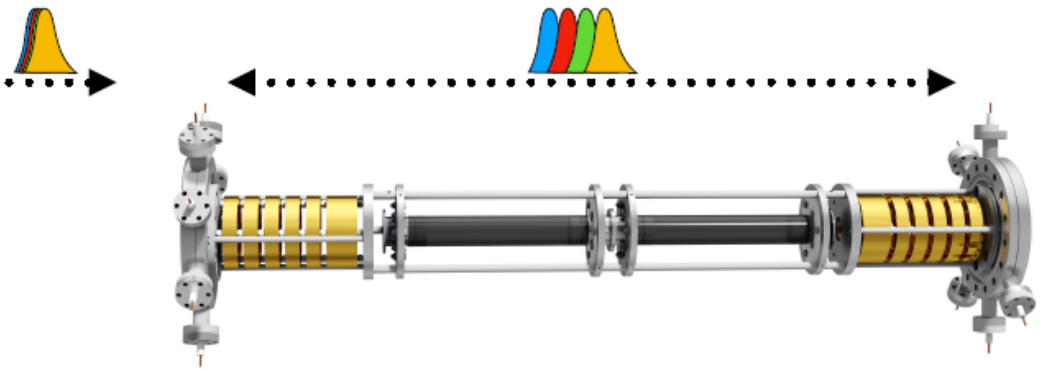
$$\sum F = ma$$

If gravity and tension won't work, then you must search for something else!

$$E = \frac{1}{2}mv^2$$

Electromagnetic forces

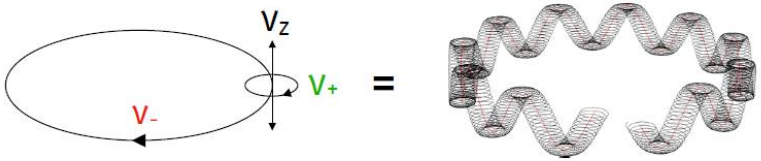
ISOLTRAP



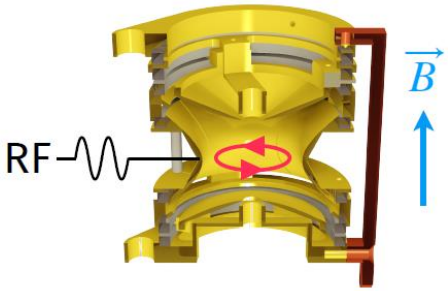
$$t = \alpha \cdot \sqrt{m} + \beta$$

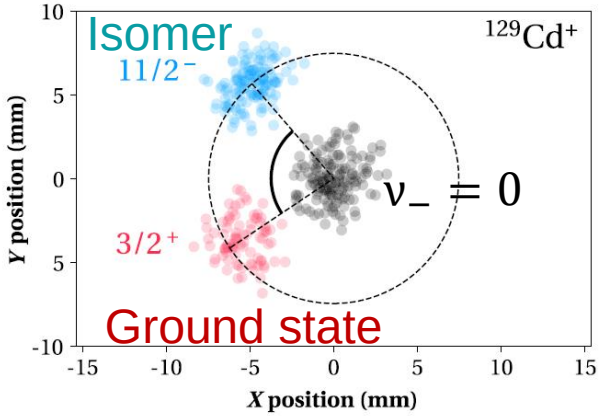
- t_{meas} ~ 5 - 20 ms
- $m/\Delta m$ ~ 10^5
- $R_{contamination}$ > 10^4

ISOLTRAP

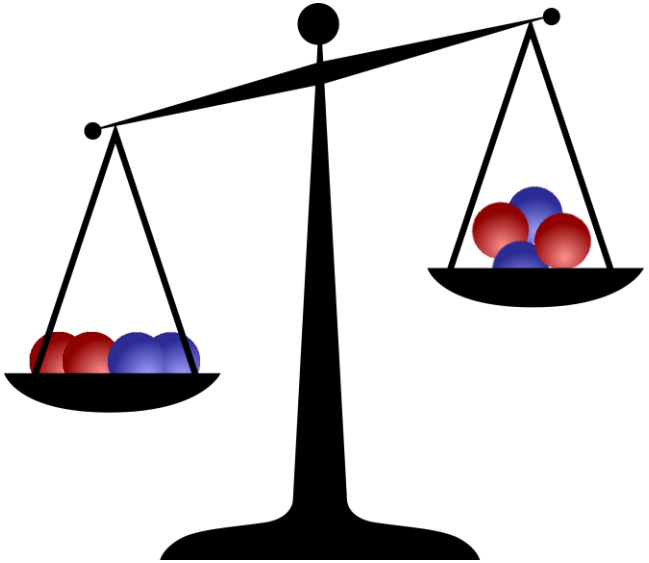


$$\nu_c = \nu_- + \nu_+ = \frac{B \cdot q}{2\pi \cdot m}$$





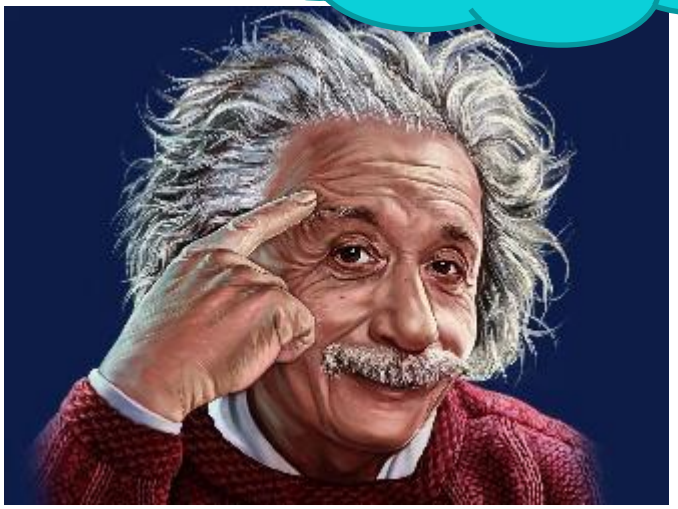
ISOLTRAP



Binding energy

$$BE = m_A - \sum_N m_n - Z \sum m_p$$

$$E = mc^2$$



Daily life at ISOLDE

1. Propose experiment for board of experts

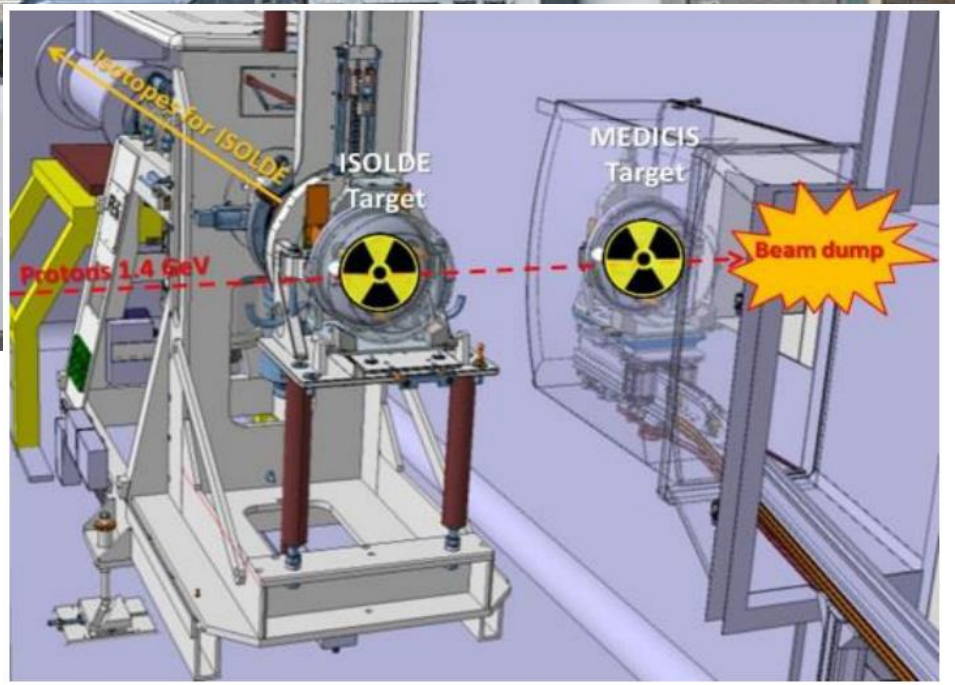
2. Experiment gets scheduled
   - Winter: shutdown
   - April – November: beam times
   - → ~8 months/year, 24/7

3. Prepare setup

4. Do experiment
   - ~1 week continuously

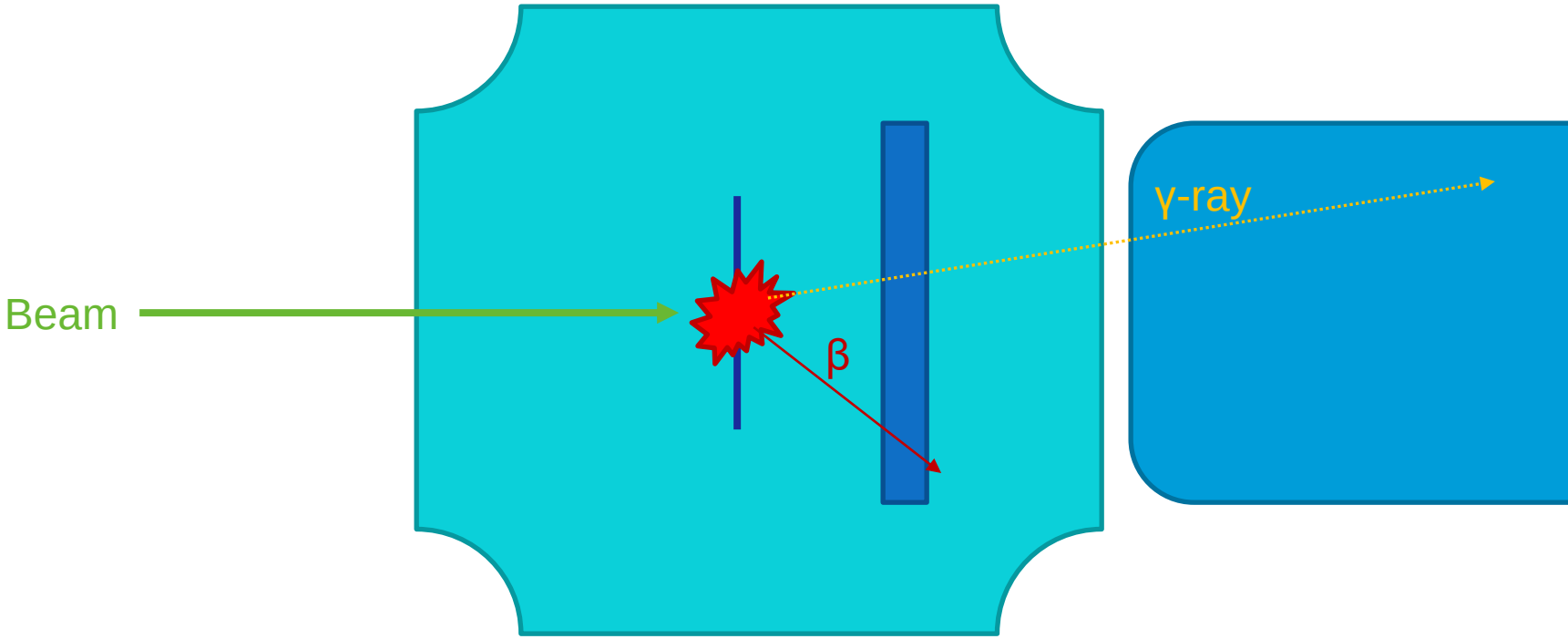
5. Analysis, discussion, publication, conferences

MEDICIS: recycling protons for society

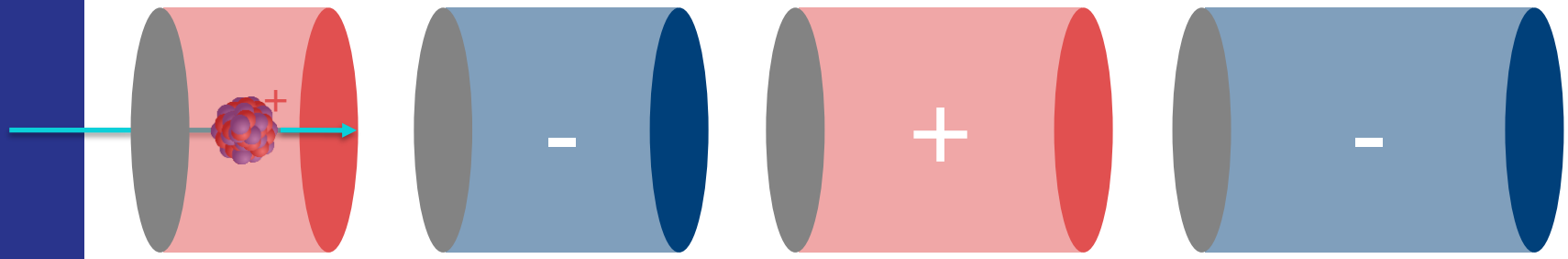


- Production of non-conventional radioisotopes for medical research
  - 80-90% of the proton beam goes through the ISOLDE target unaffected
  - Use these (free!) protons to create more radioisotopes

ISOLDE Decay Station IDS



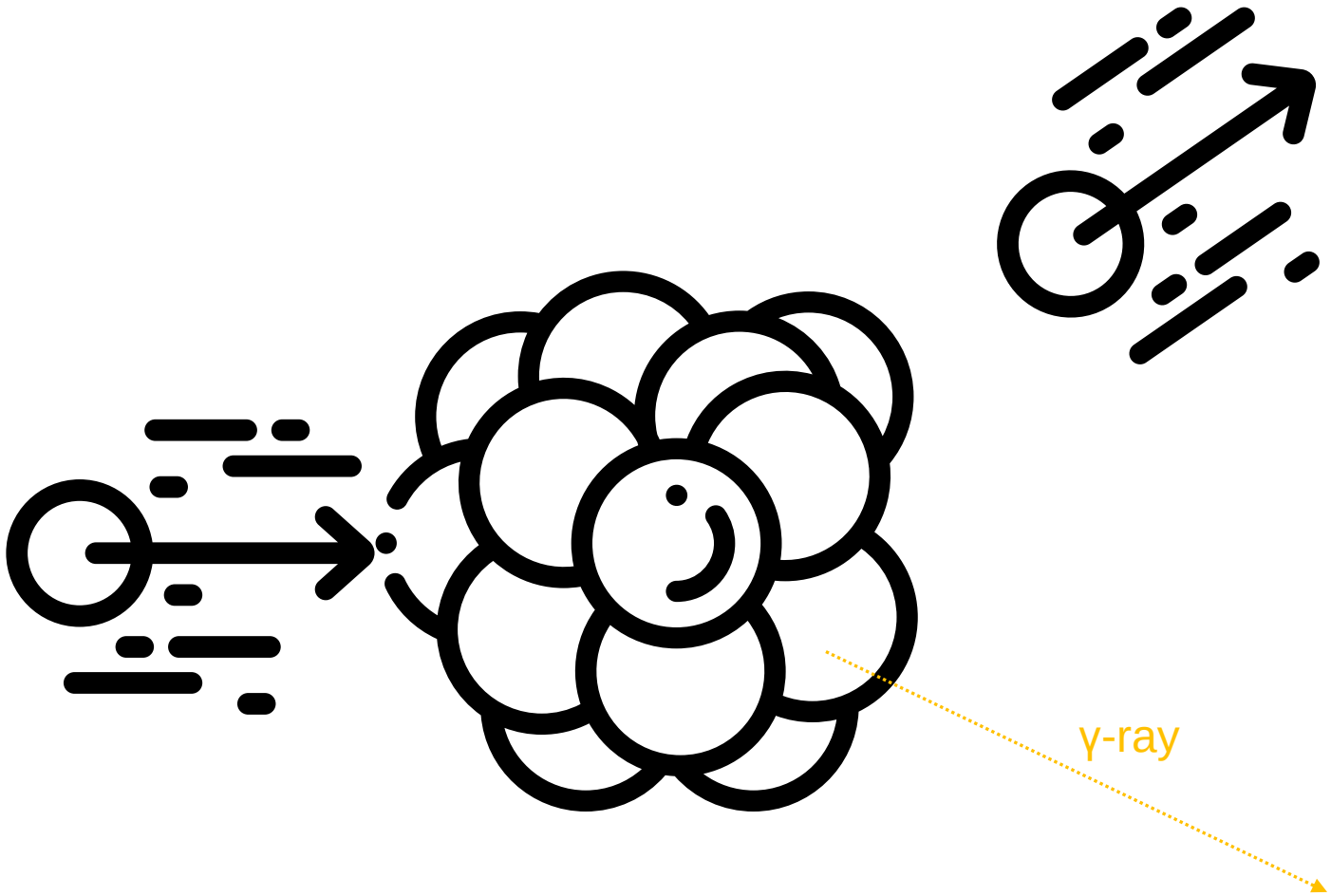
DTL



The polarity of the electrode is then switched while the ion is inside.

It would like falling into a lift, and when you reach the bottom of the lift, the lift has brought you back to the top so that you may fall again further!

Nuclear reactions



Merci! Bedankt! Thank you!


Sarina Geldhof


Thomas Elias Cocolios


Maxime Mougeot

https://isolde.cern

https://medicis.cern

And some behind the scenes!