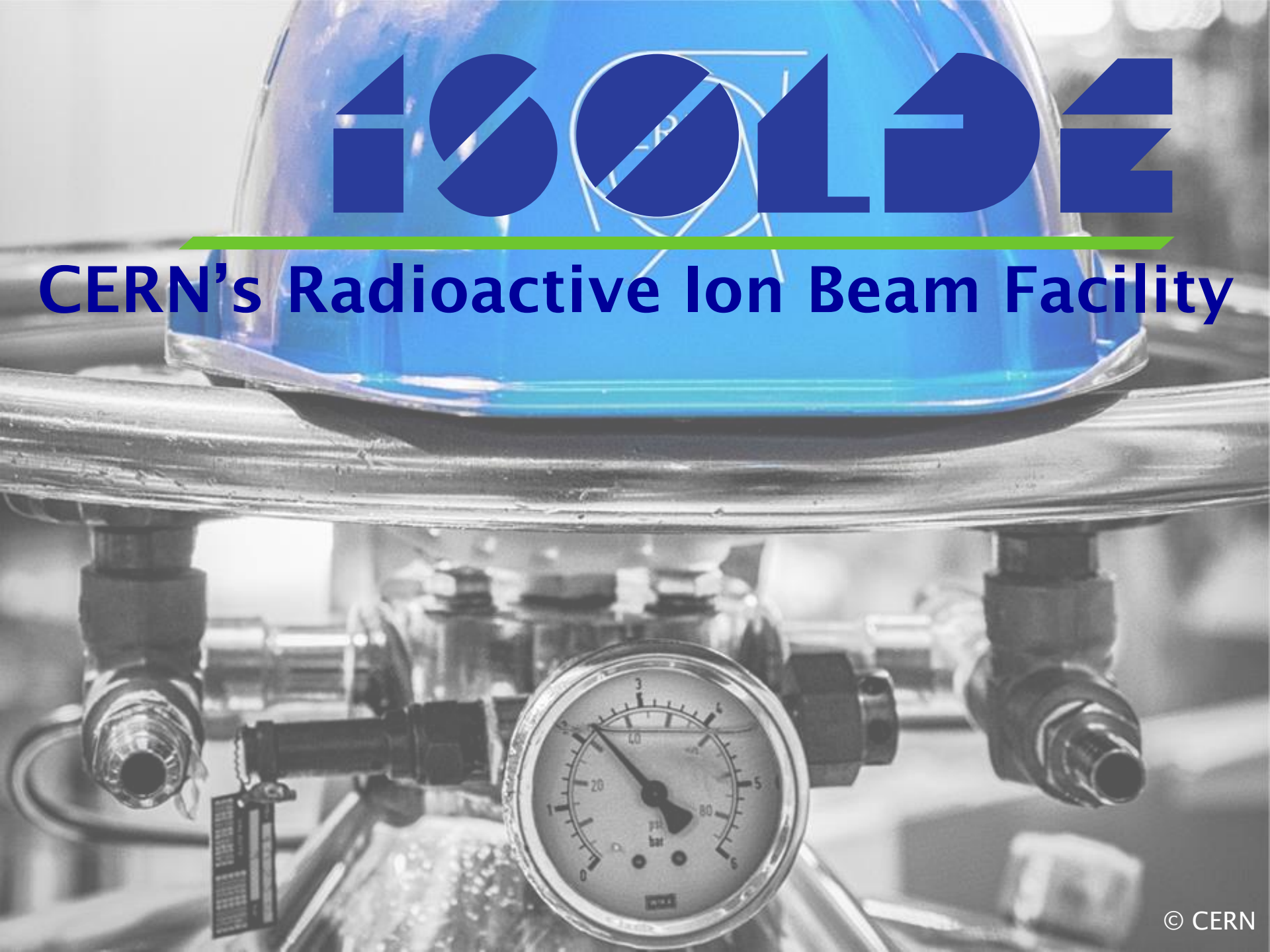
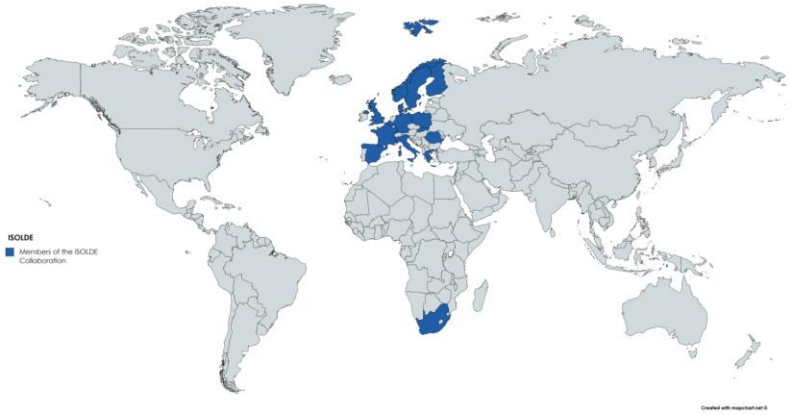

ISOLDE
CERN's Radioactive Ion Beam Facility
© CERN

ISOLDE at CERN

- Isotope Separator OnLine Device

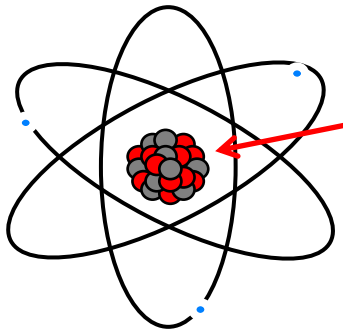
- Approved by the CERN council in 1964, first beams in 1967
  - Initially used 600 MeV protons from SC
  - Then used 1.0 GeV (later 1.4 GeV) protons from the PSB
- A small facility with a big impact!
  - ~0.1% of the CERN budget
  - ~7% of the CERN scientists
  - ~50% of the CERN protons



- 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

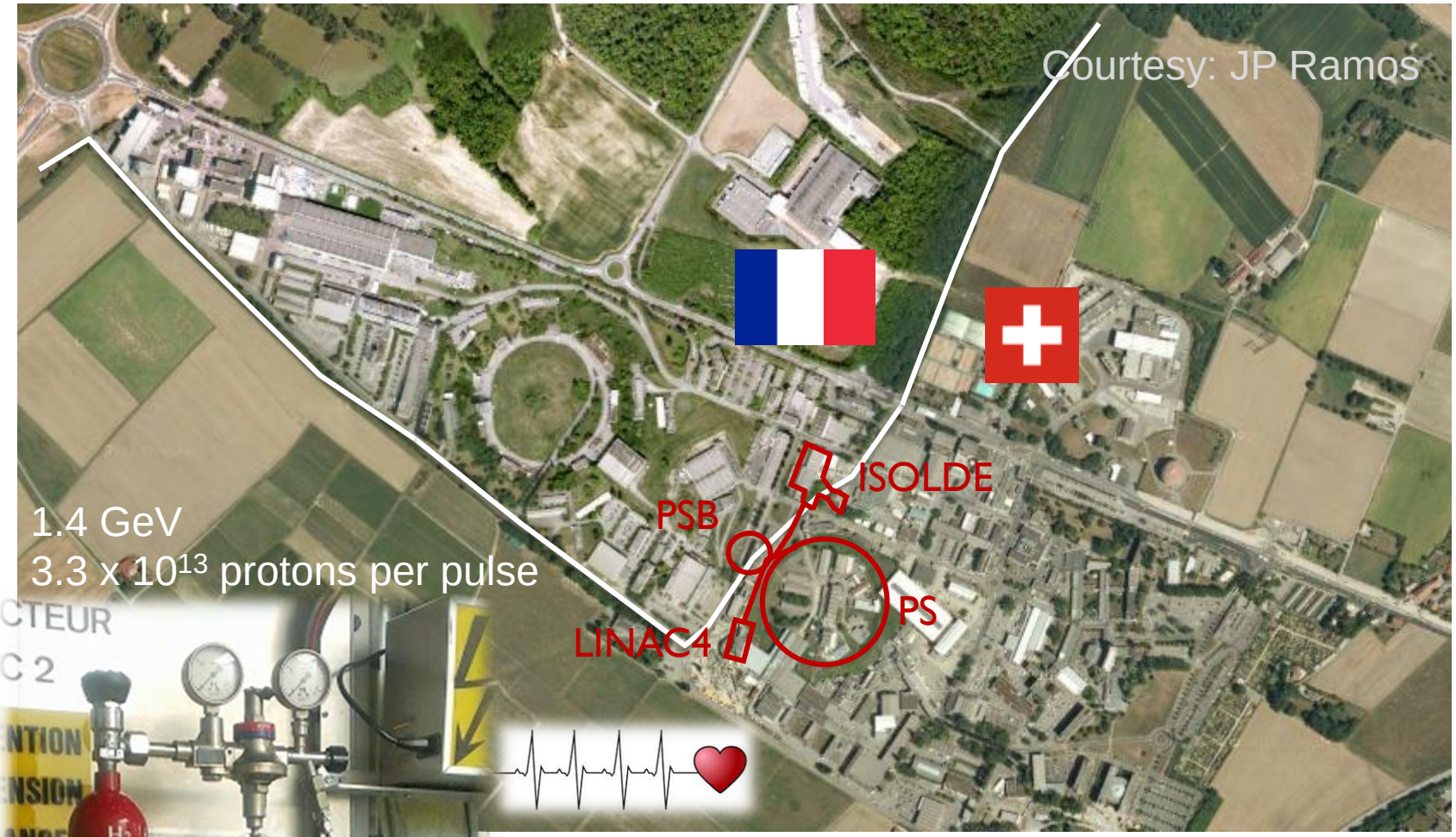
- ISOLDE is a radioactive isotope facility where the nuclear chart is our playground!



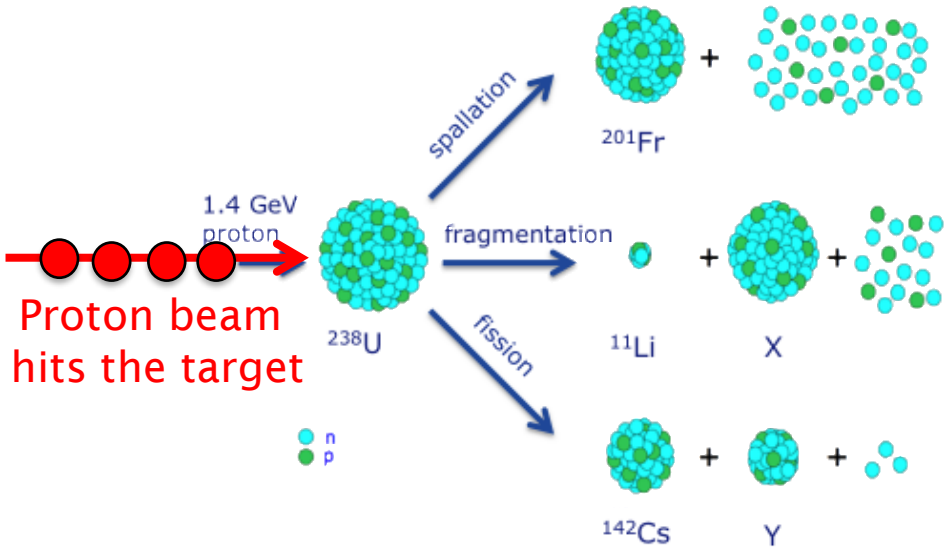
"Atomic nucleus"

Why at CERN?

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



Production: Modern-day alchemy



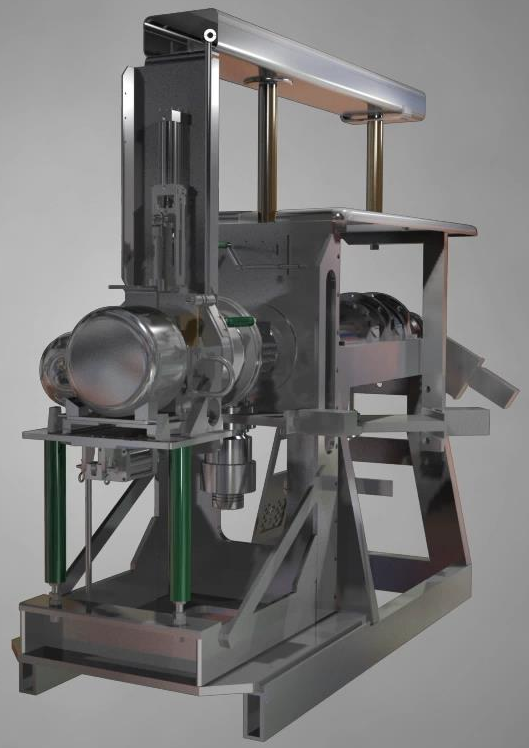
- The protons split up the heavy nucleus to produce a wide variety of nuclei **simultaneously**!

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

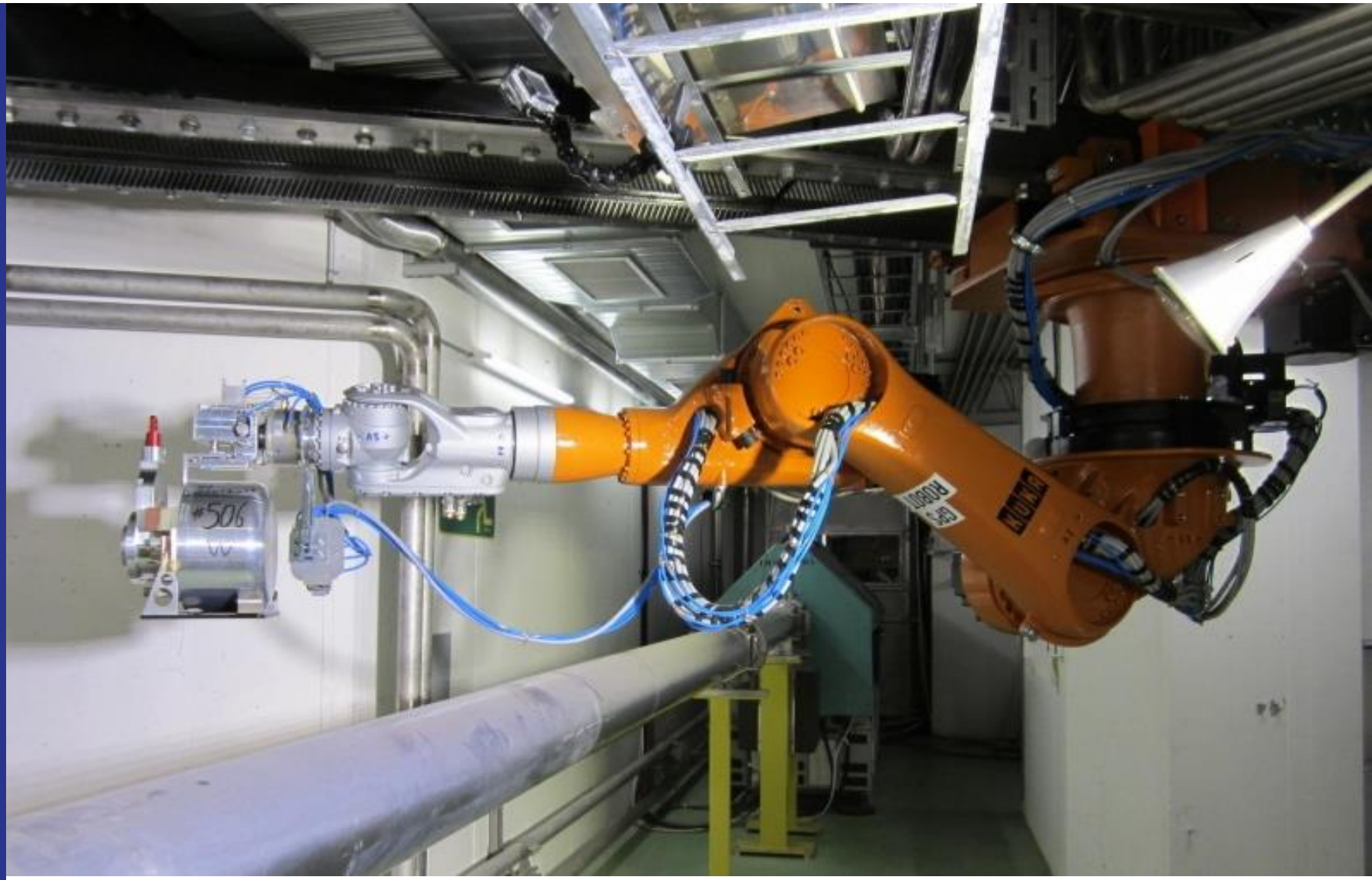
- Different stages of preparation
  - Production
  - Ionization
  - Separation

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

Production: Targets

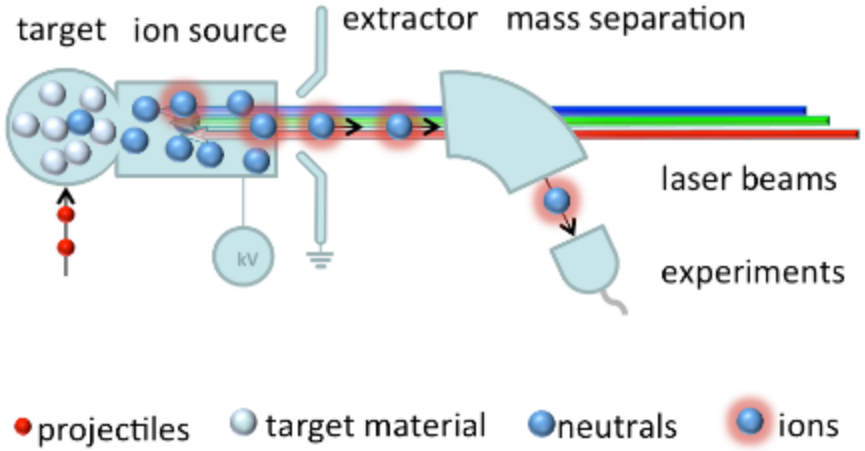


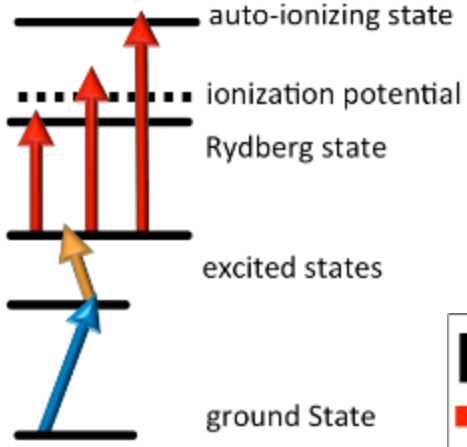
ISOLDE Robots



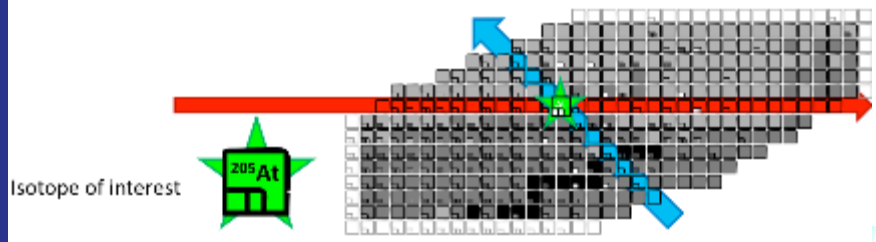
Ionization: RILIS

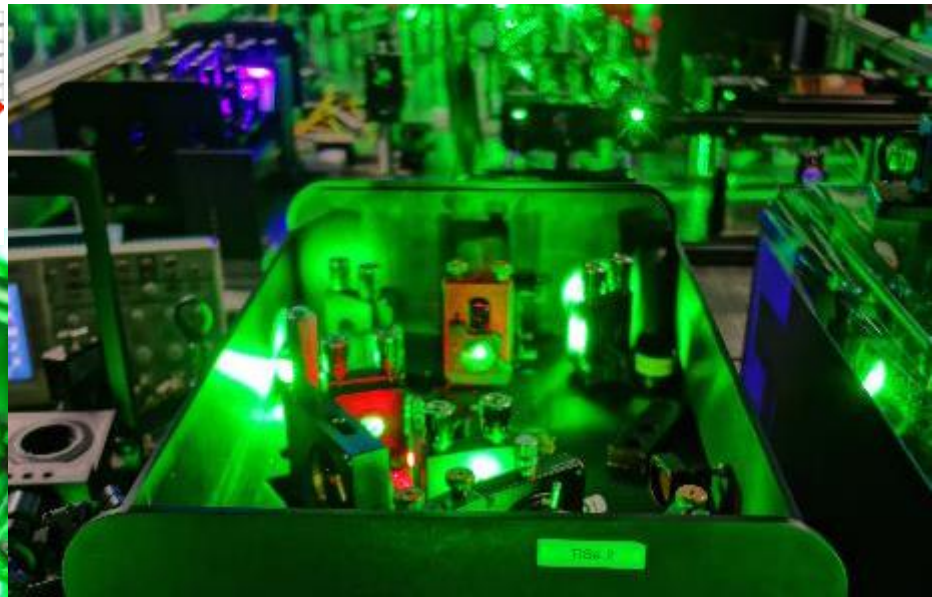
- Resonance Ionization Laser Ion Source
- Uses lasers to selectively ionize a particular element (isotope/isomer)





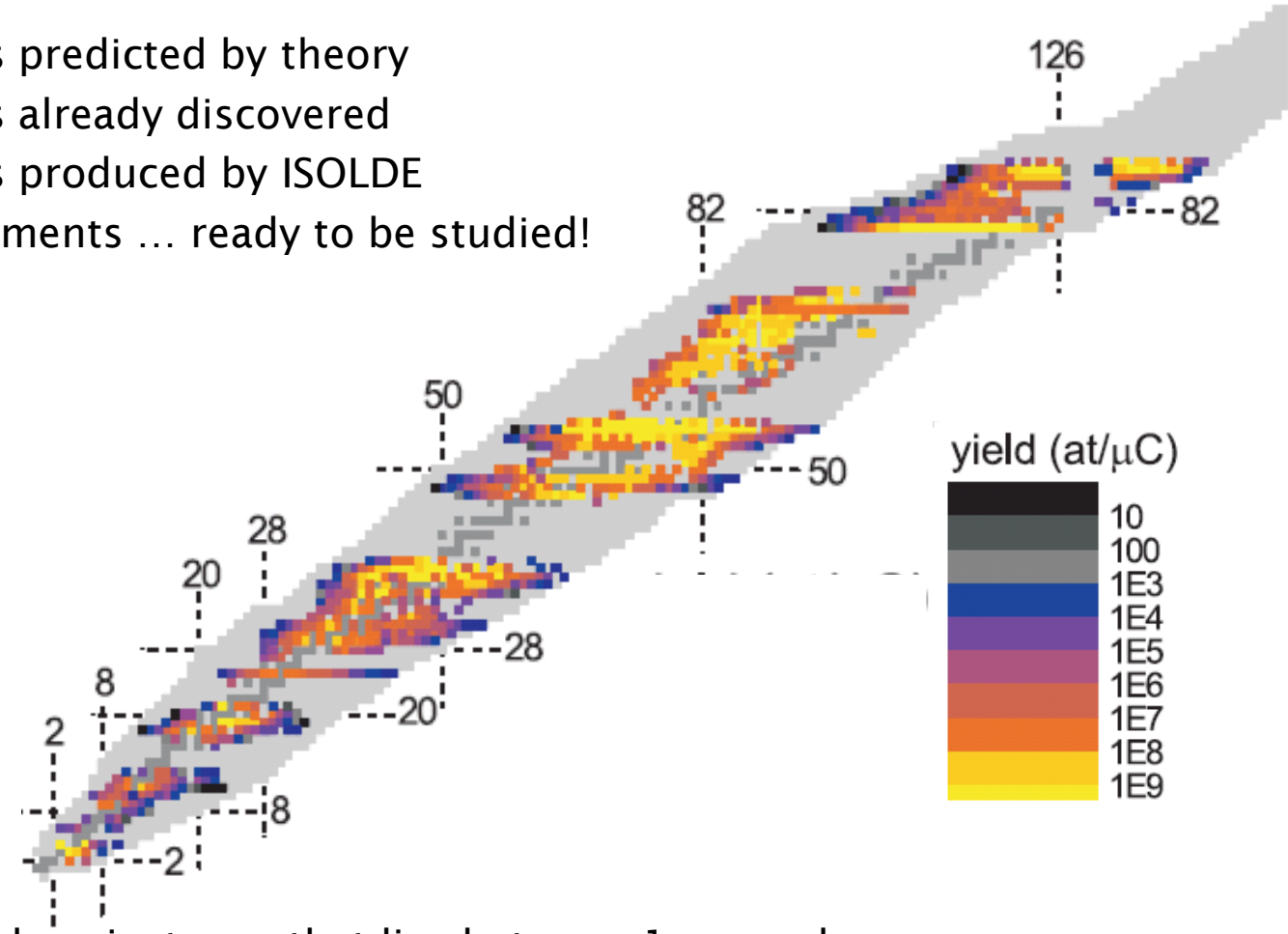
RILIS





What is produced at ISOLDE?

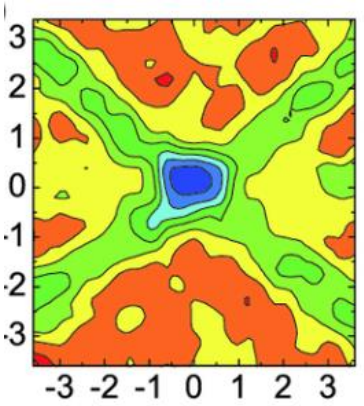
- ~6000 isotopes predicted by theory
- ~3000 isotopes already discovered
- ~1500 isotopes produced by ISOLDE
- 74 different elements … ready to be studied!

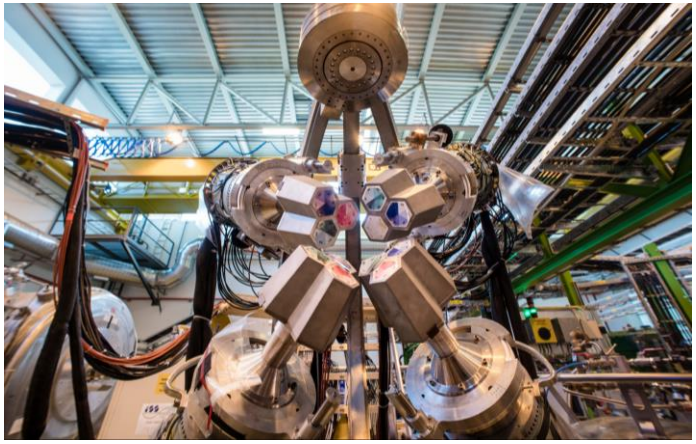


- ISOLDE can produce isotopes that live between 1 ms and 10^{12} years
- Production rates range from < a few per hour to $>10^{9}$ a second

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?



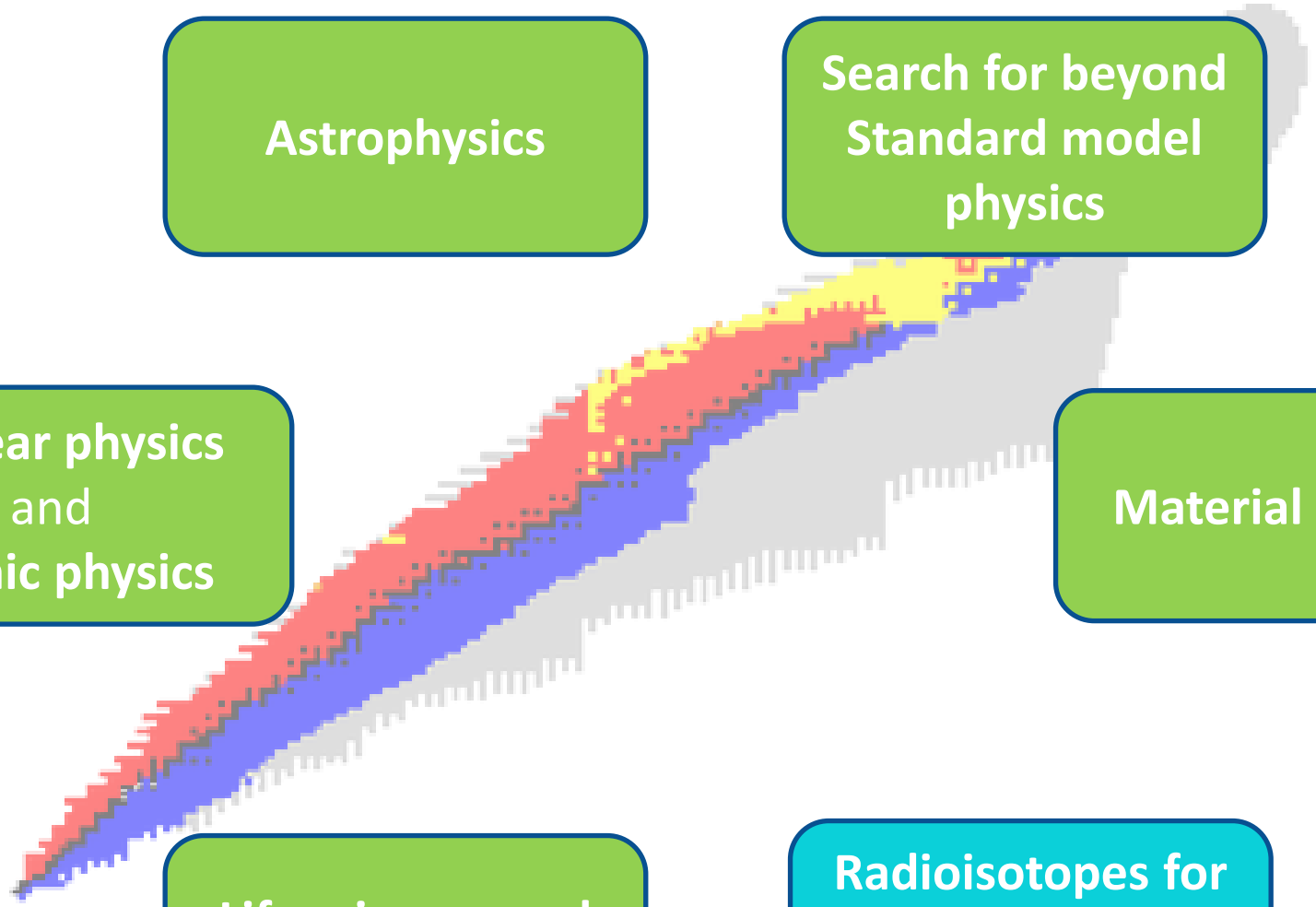


Research with radioactive beams

Astrophysics

Search for beyond Standard model physics

Nuclear physics and atomic physics



Material science

Life sciences and biophysics

Radioisotopes for medical applications

ISOLDE

Doing experiments at ISOLDE

1. Propose experiment for board of experts

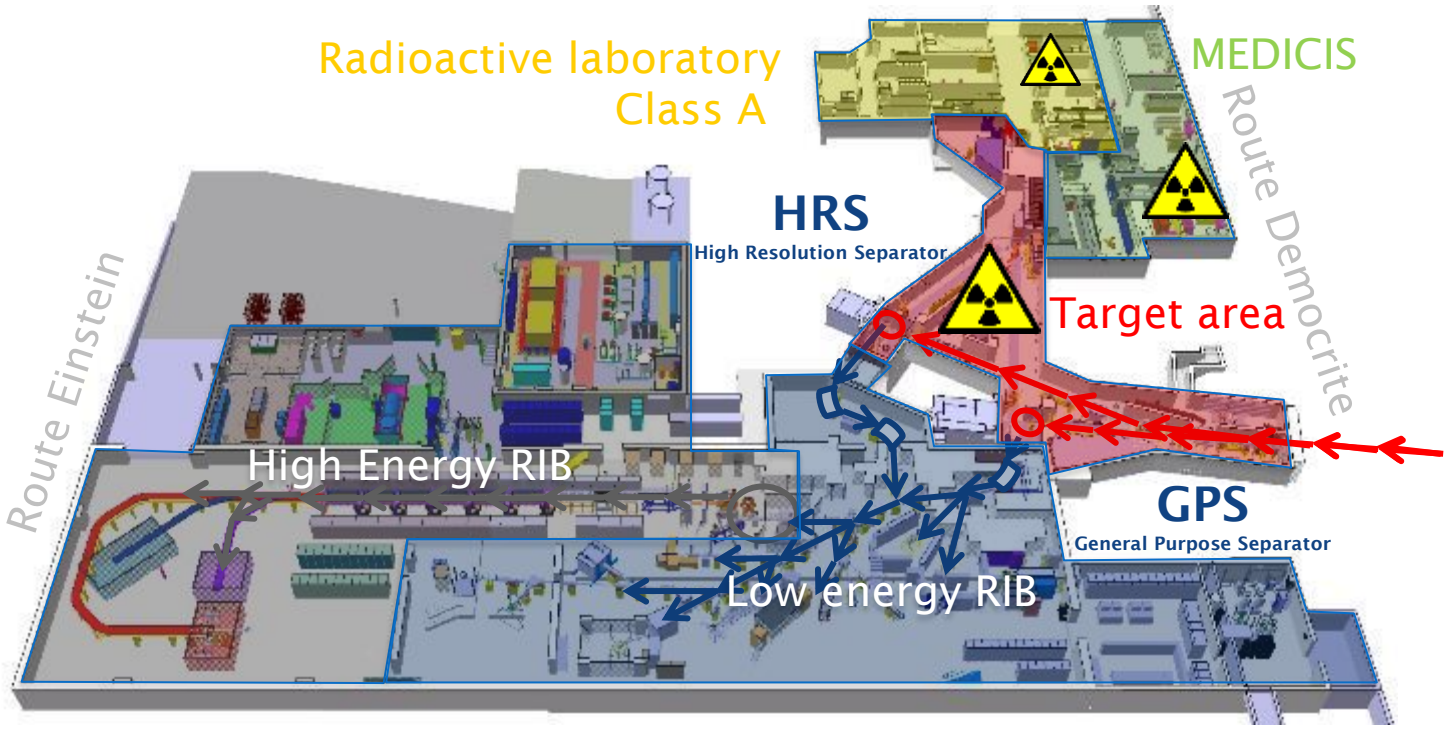
2. Experiment gets scheduled
   - Winter: shutdown
   - April – November: beam times
   - → ~8 months/year, 24/7

3. Prepare set-up

4. Do experiment
   - ~1 week continuously

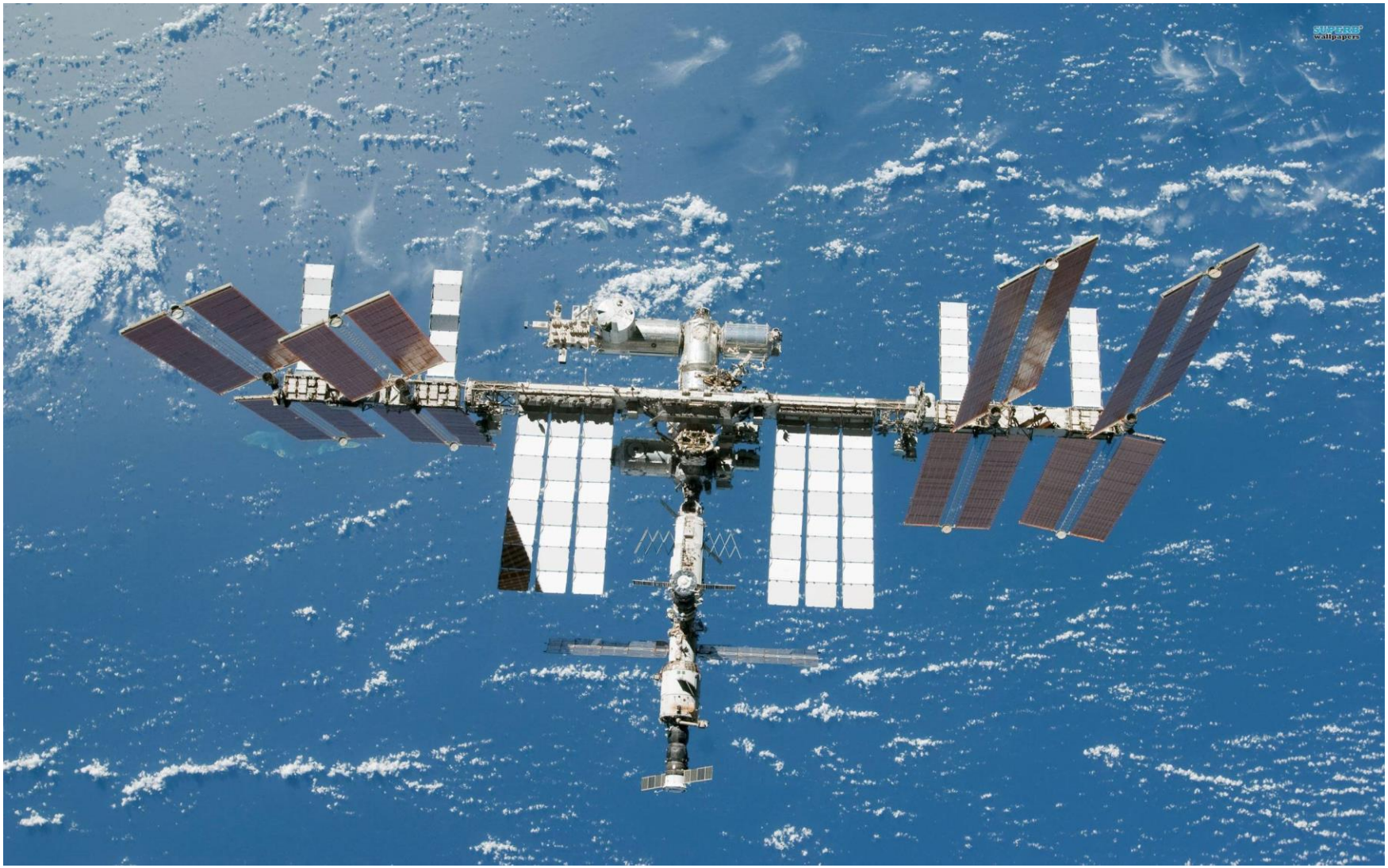
5. Analysis, discussion, publication, conferences

The ISOLDE facility

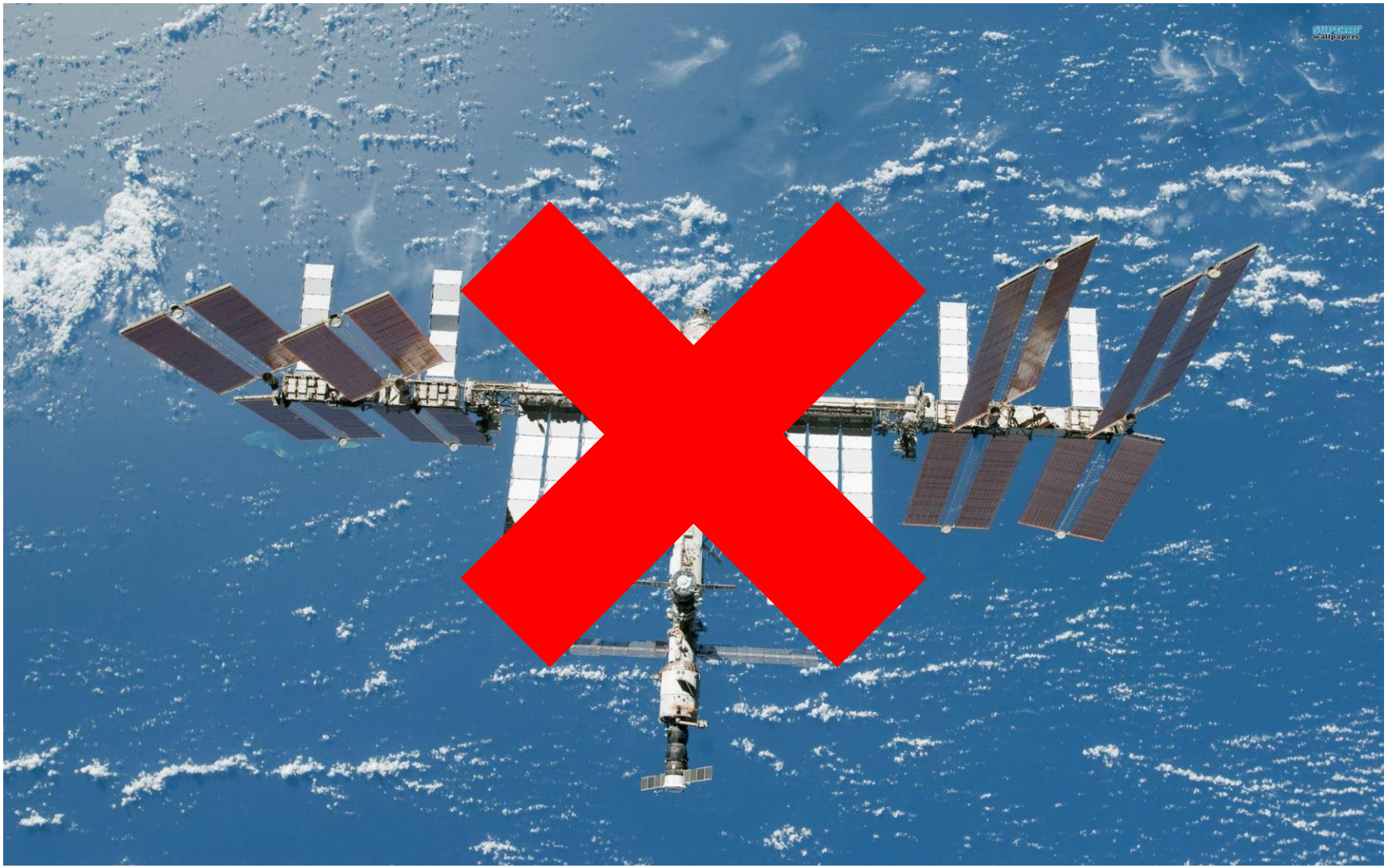


- Protons (1.4 GeV)
- Low energy RIBs (up to 60 keV)
- High energy RIBs (up to 10 MeV/u)

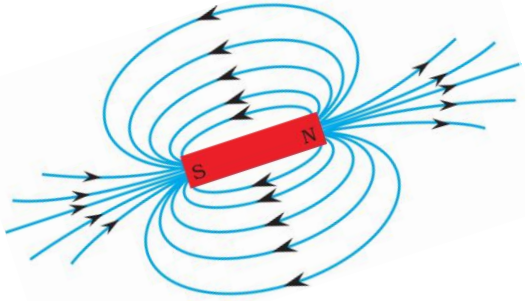
ISS

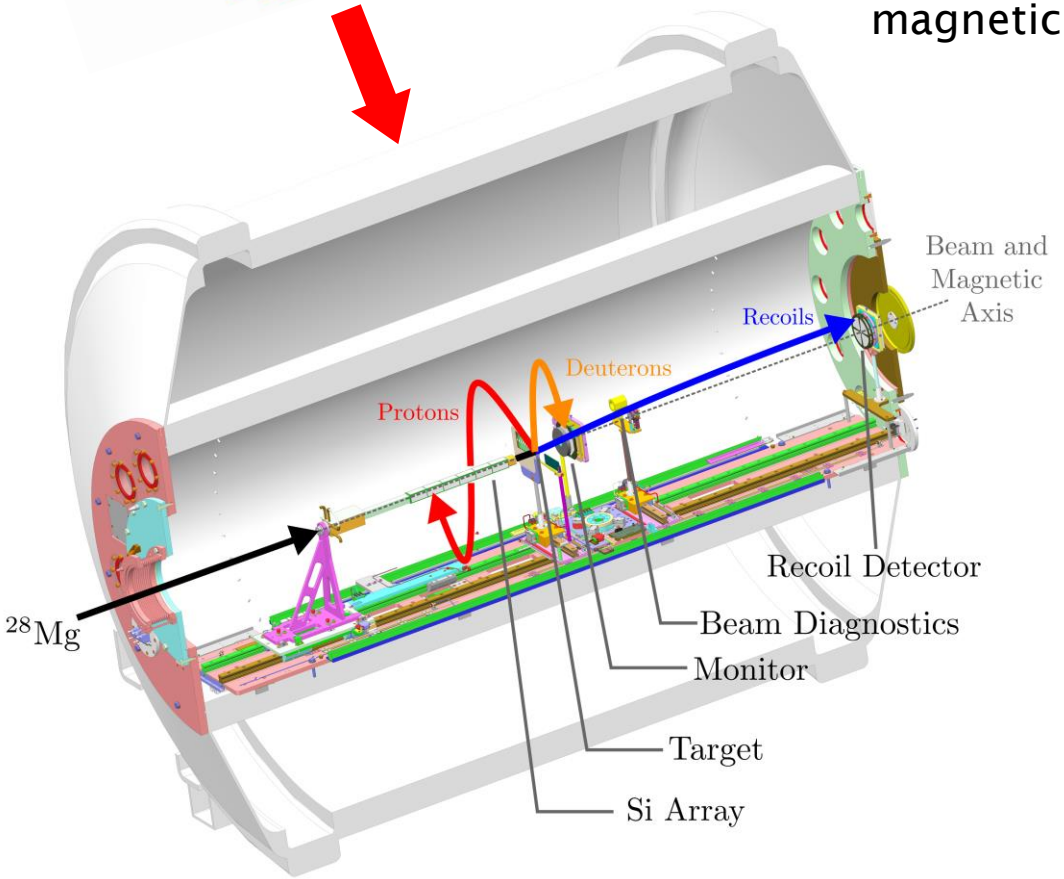


ISS

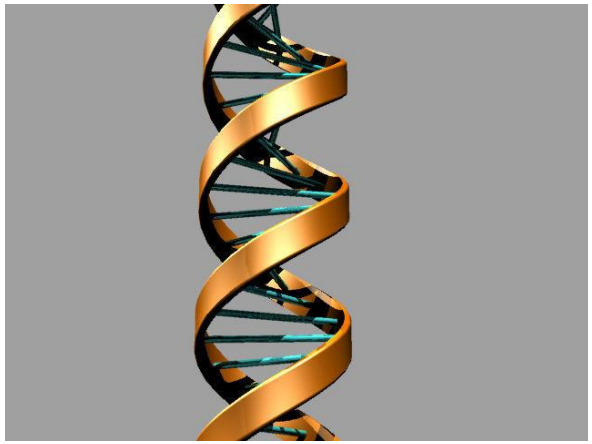


ISOLDE Solenoidal Spectrometer





- ISS made from a repurposed MRI magnet.
- Must use radioactive beams because studying radioactive targets is difficult.
- Surround everything with a strong magnetic field (1M × Earth's)
  - Particles move in helical orbits and land on detectors

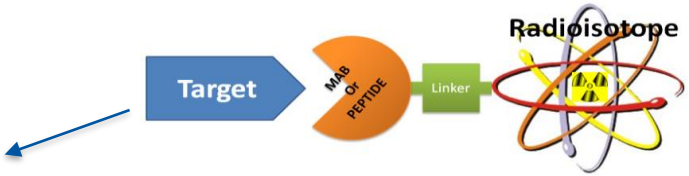


MEDICIS: recycling protons for society

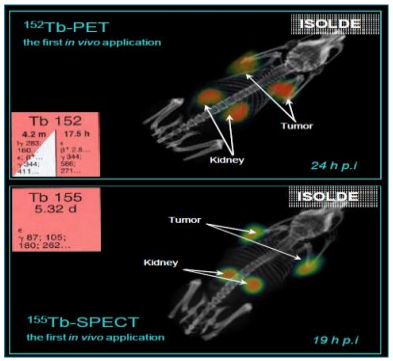
- Production of non-conventional radioisotopes for medical research
  - 80-90% of the proton beam goes through the ISOLDE target unaffected
  - Use these (free!) protons to create more radioisotopes

Theranostics

DiagNOSTICS



THERApy



β⁺-emissions

PET E(γ) = 511 keV

γ-emissions

SPECT
100keV<E(γ)<200keV

α-emitter

High LET, short distance in human tissue

β-emitter

Low LET, long distance in human tissue

Advanced Accelerator Applications
BRIDGING SCIENCE WITH LIFE

Medical isotope production