

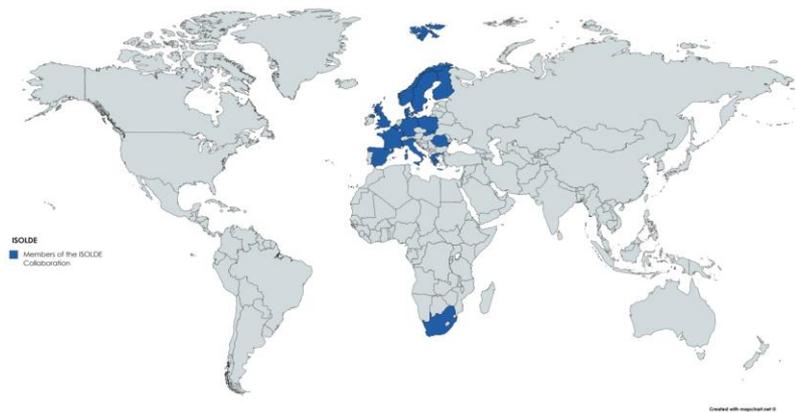
A blue hard hat is the central focus, resting on a metal beam. Below it, a pressure gauge with a white face and black markings is visible, showing a reading of approximately 4.5 bar. The background is a blurred industrial setting.

ISOLDE

CERN's Radioactive Ion Beam Facility

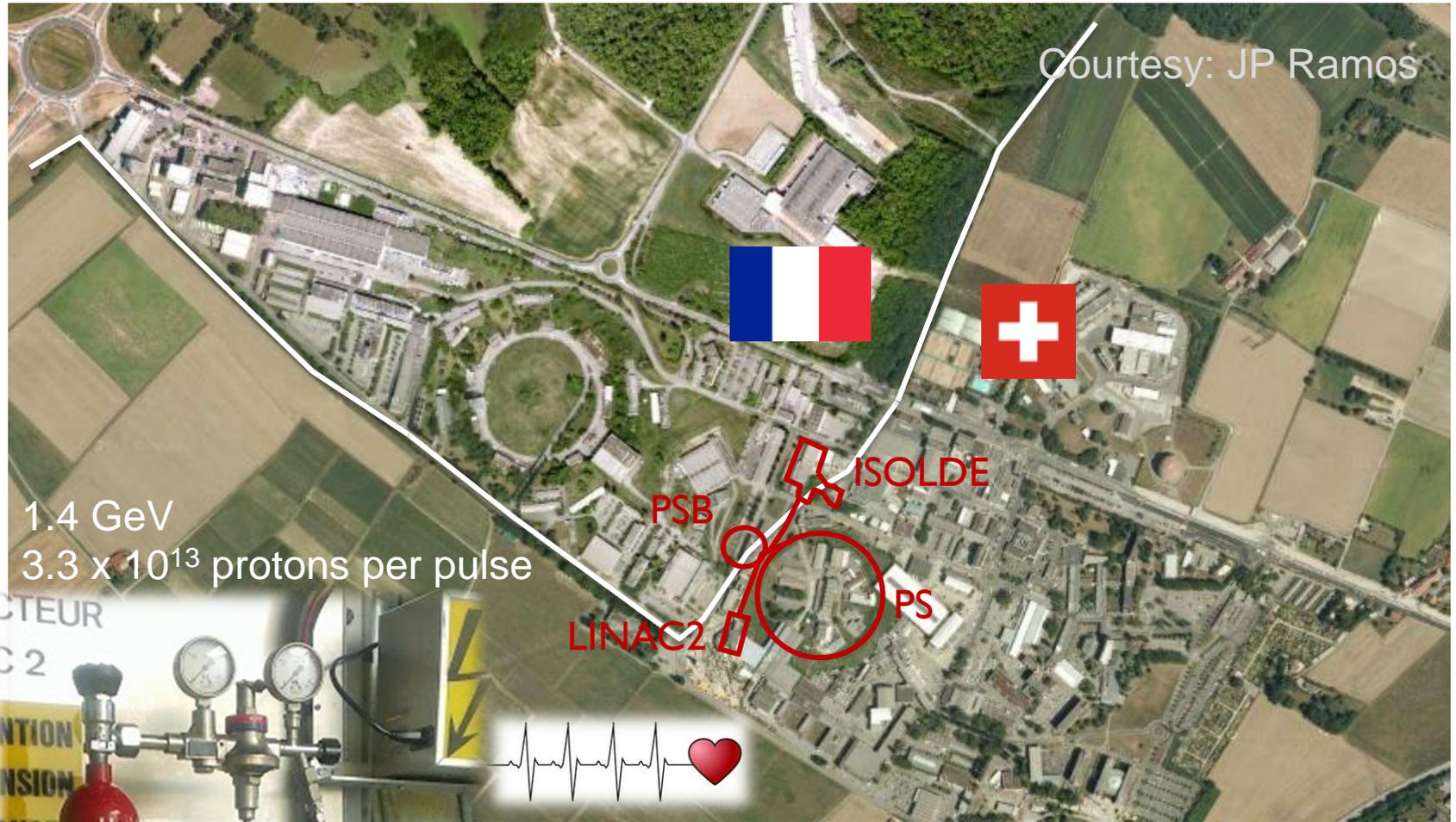
ISOLDE at CERN

- ◆ 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

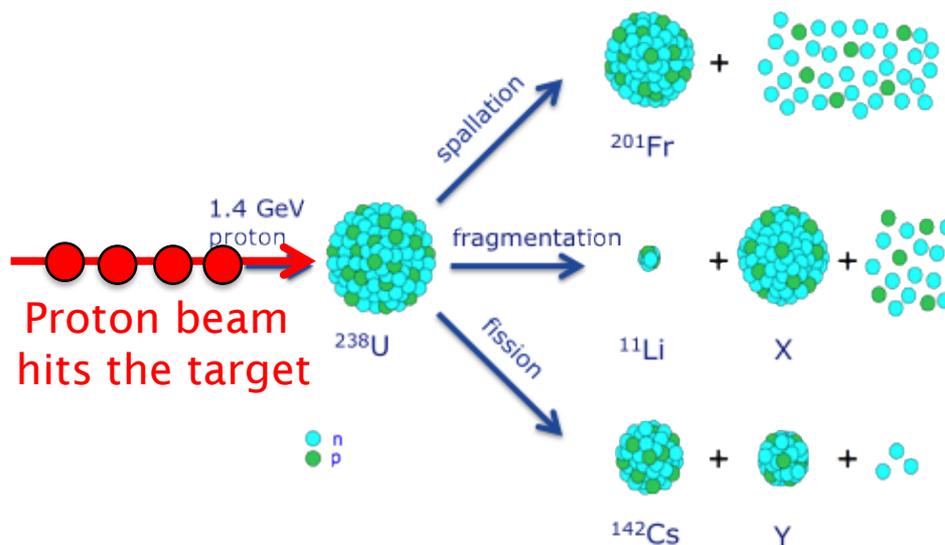


Why at CERN?

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



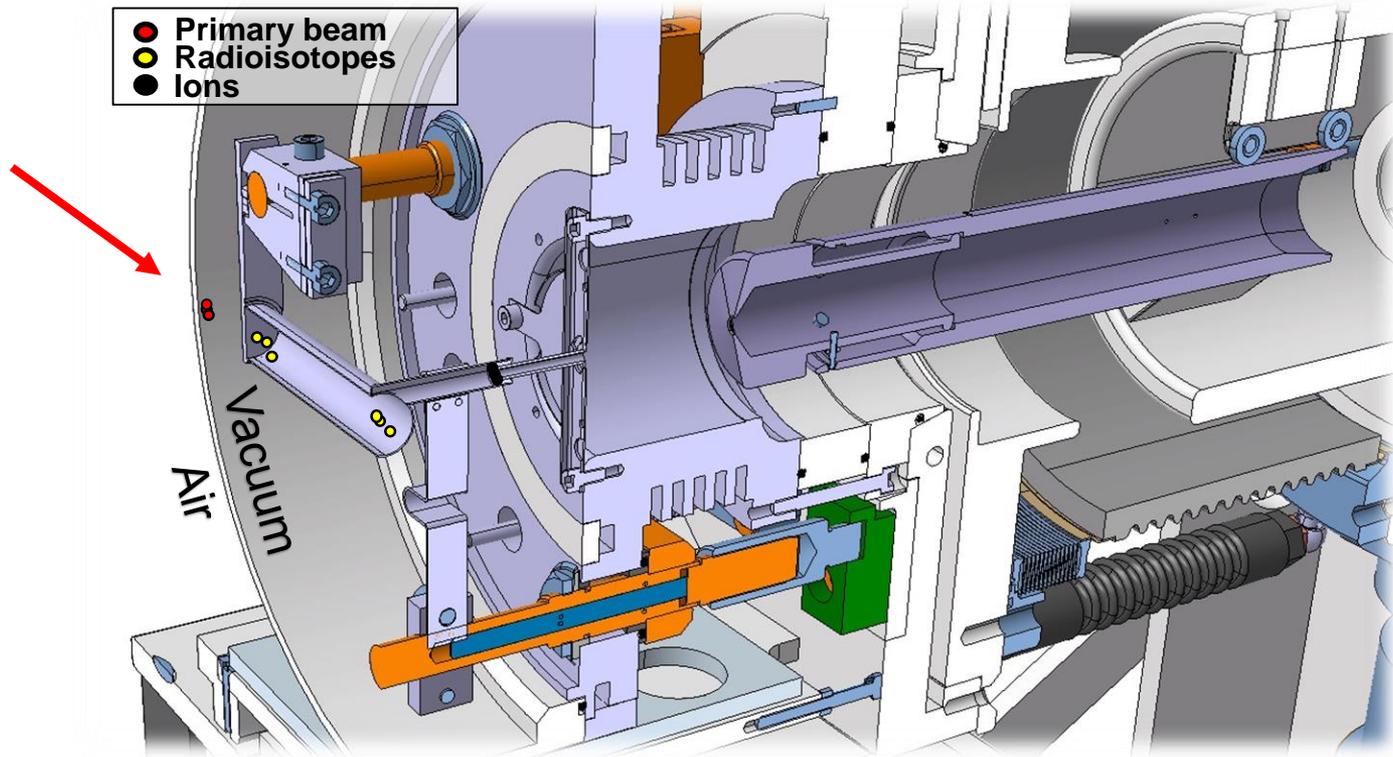
Production: Modern-day alchemy



- ◆ 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

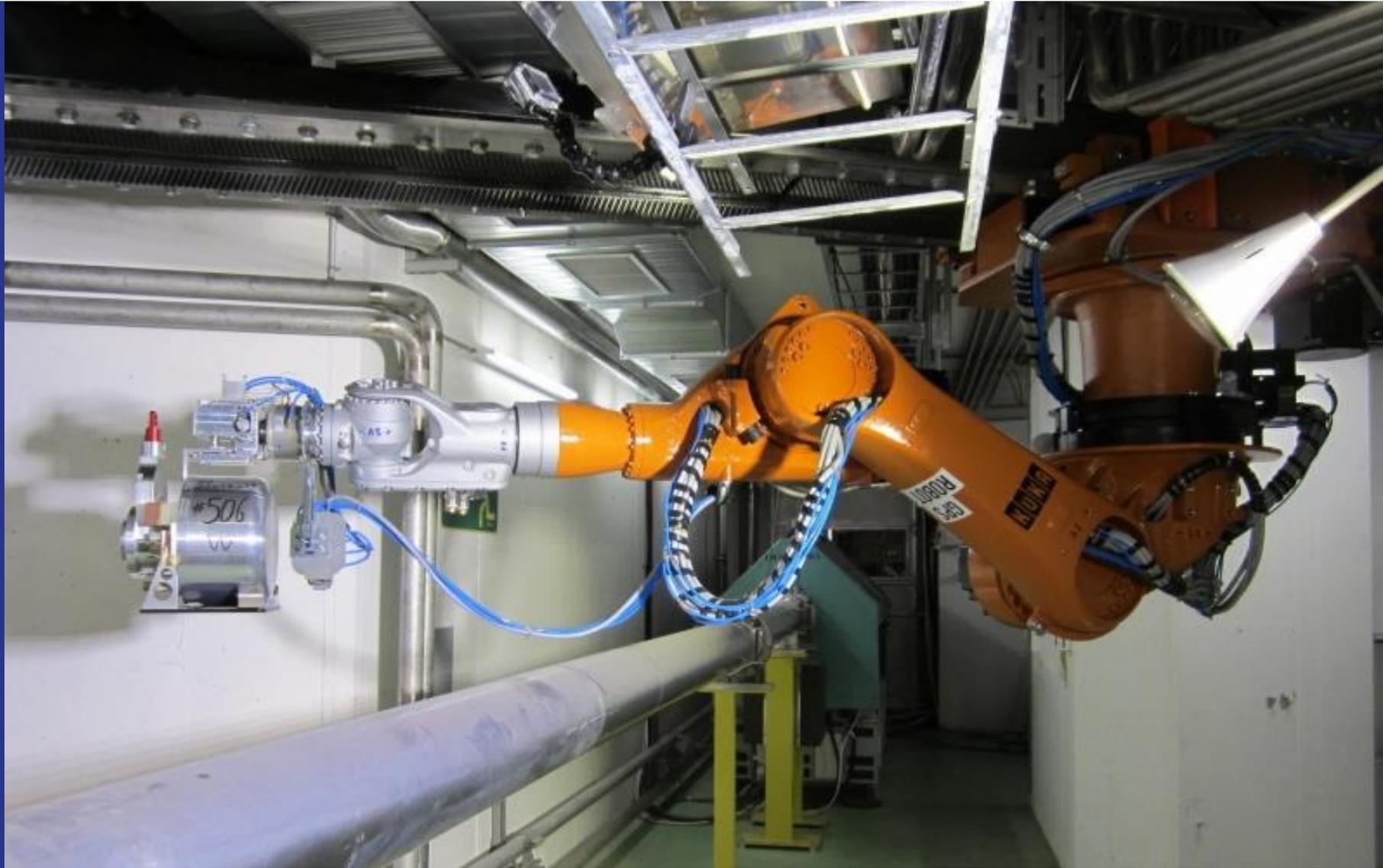
Gold is one of the chemical elements produced at ISOLDE, both stable as well as radioactive isotopes!

Production: Targets



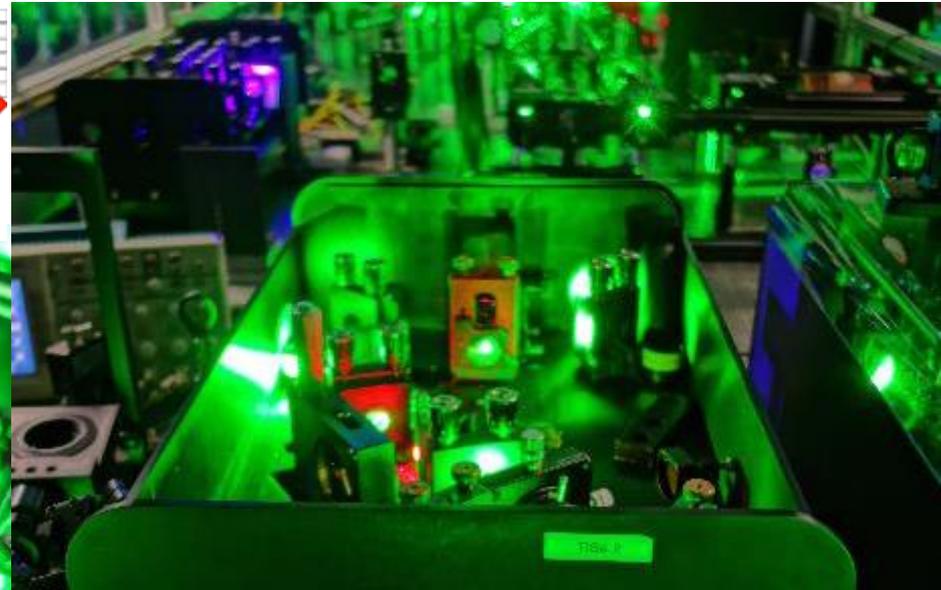
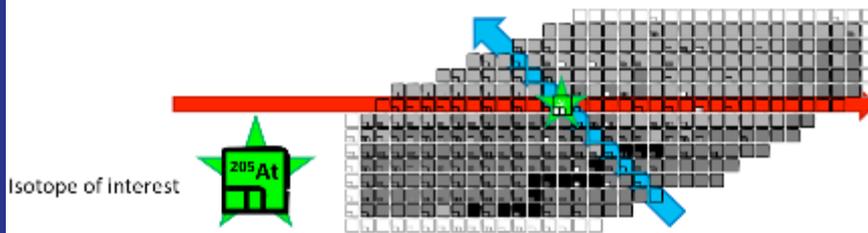
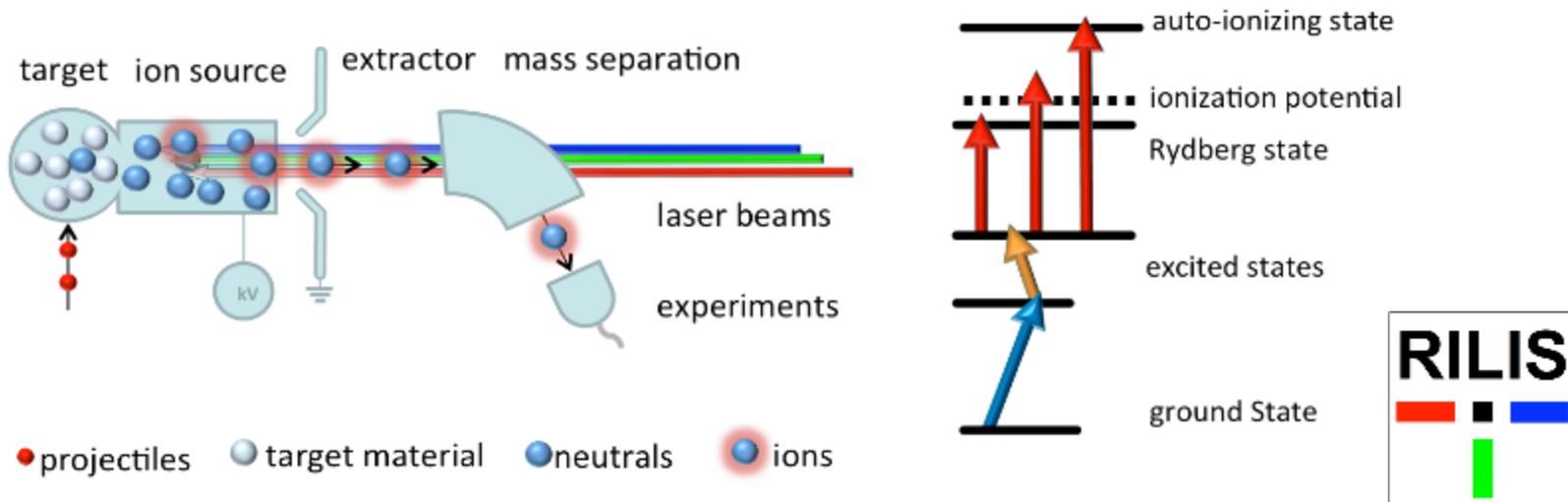
*picture and animation courtesy of M. Delonca

ISOLDE Robots



Ionization: RILIS

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



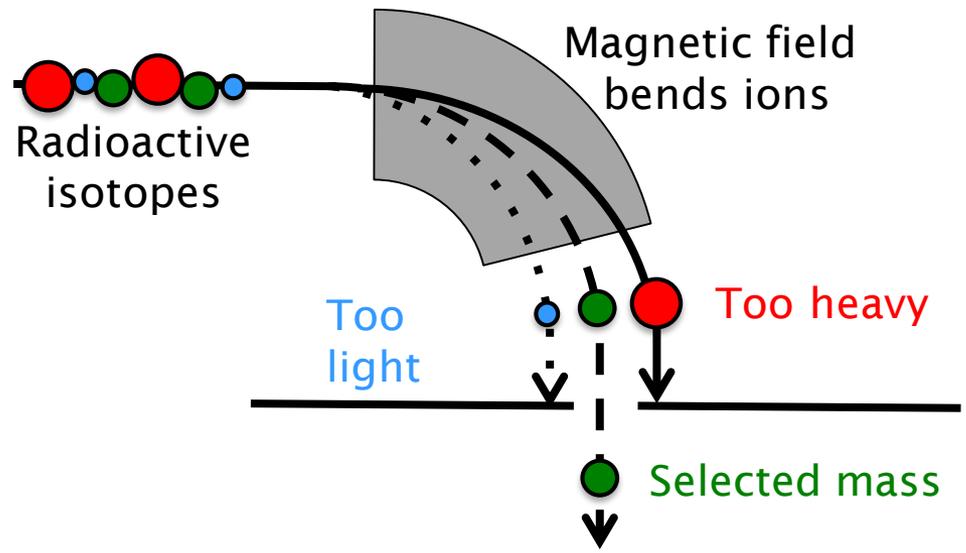
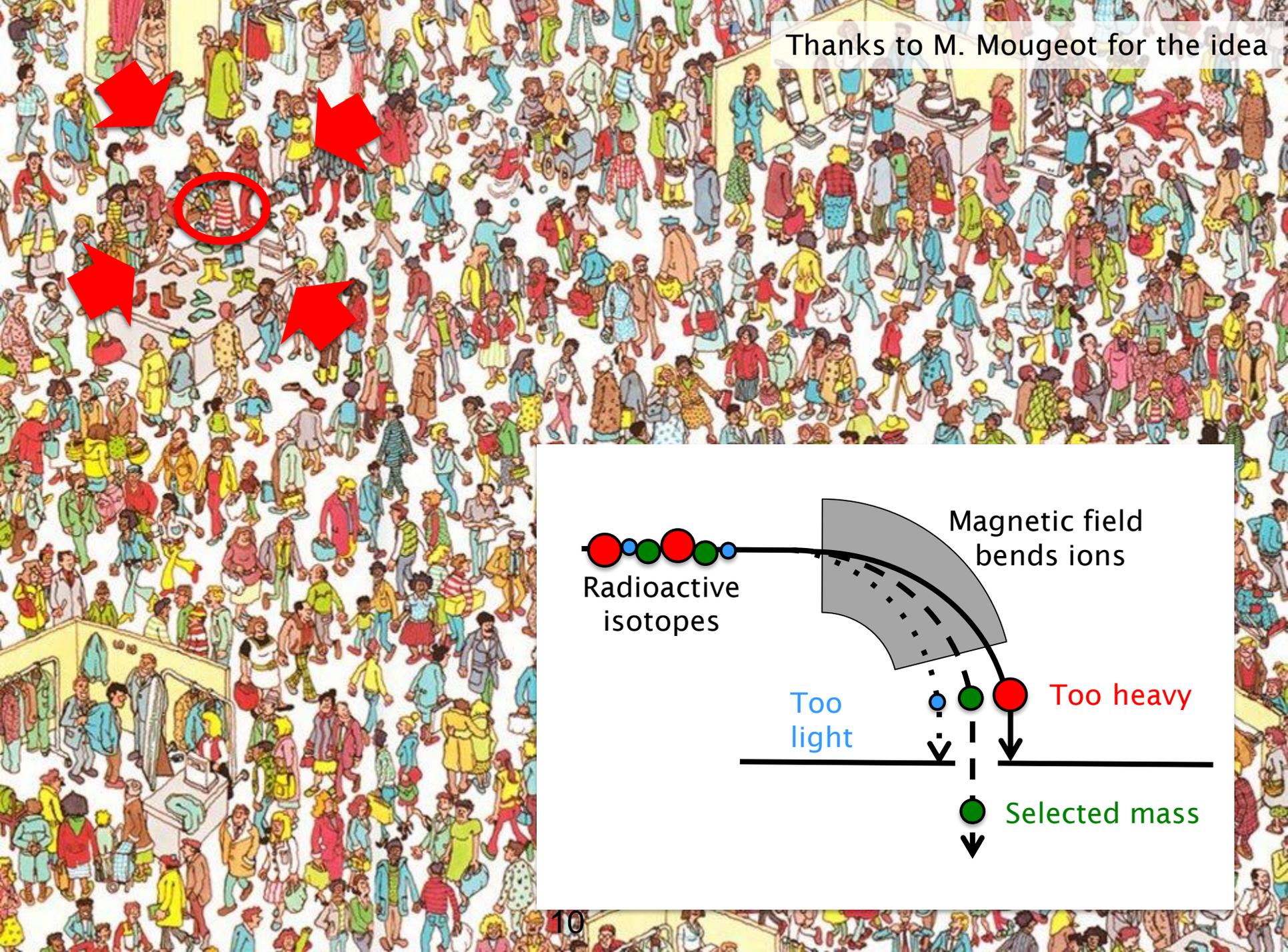
Courtesy M. Mougeot



Separation: where is the ion of interest?

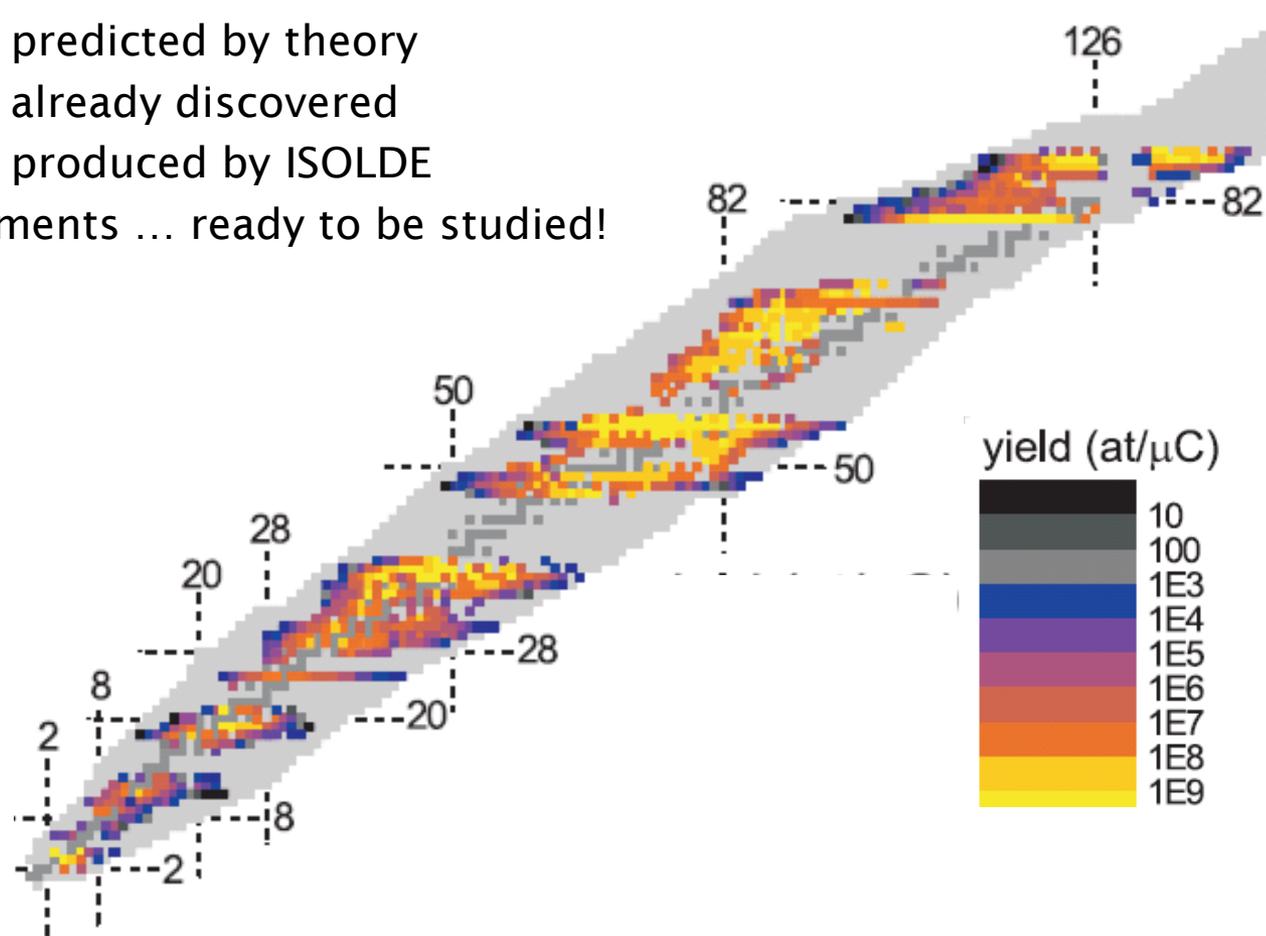


Thanks to M. Mougeot for the idea



What is produced at ISOLDE?

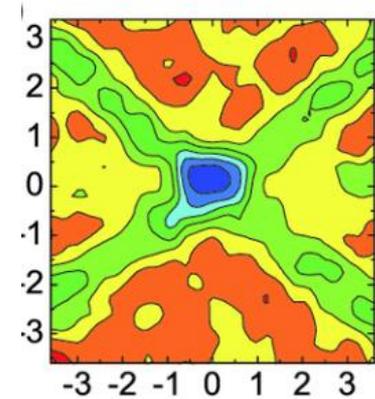
- ◆ ~6000 isotopes predicted by theory
- ◆ ~3000 isotopes already discovered
- ◆ ~1500 isotopes produced by ISOLDE
- ◆ 74 different elements ... ready to be studied!



- ◆ 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

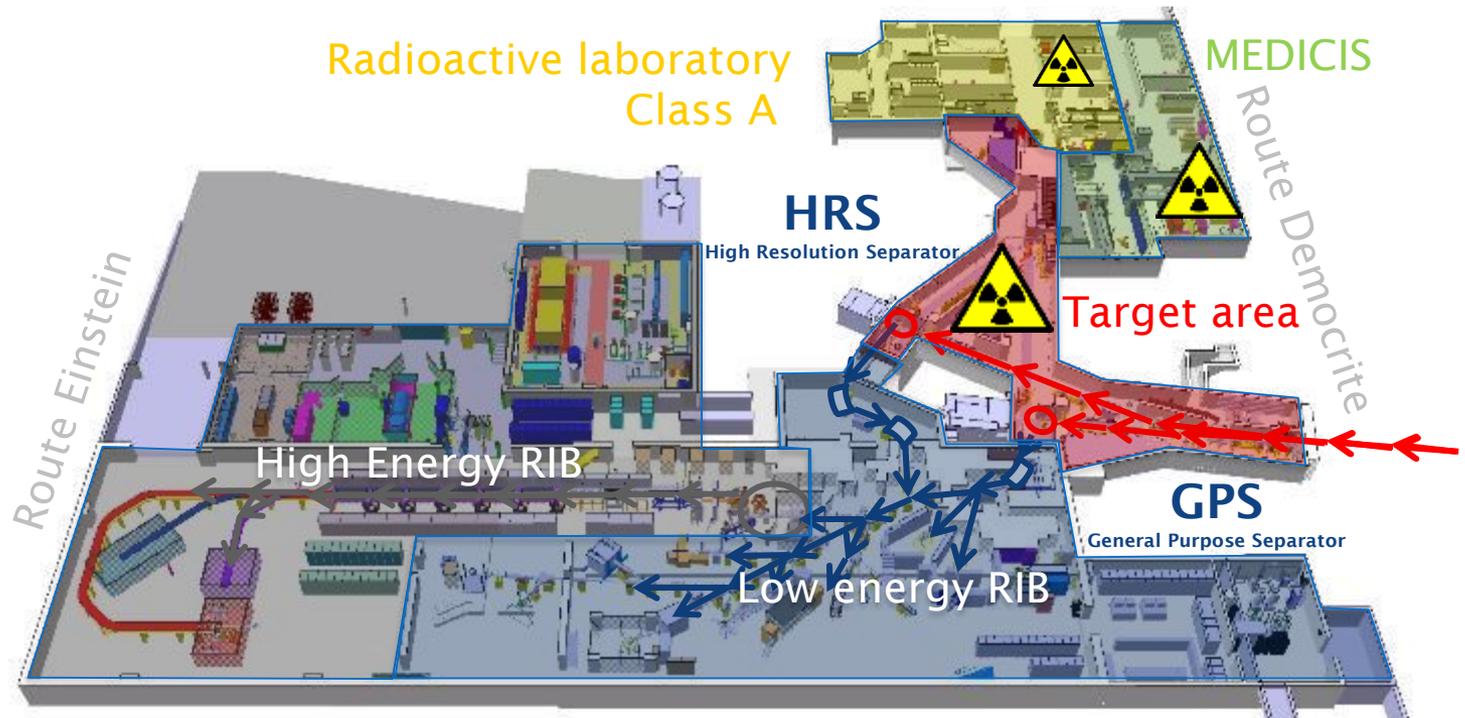
Radioisotopes for
medical
applications

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 set-up
4. Do experiment
 - ◆ ~1 week continuously
5. Analysis, discussion, publication, conferences

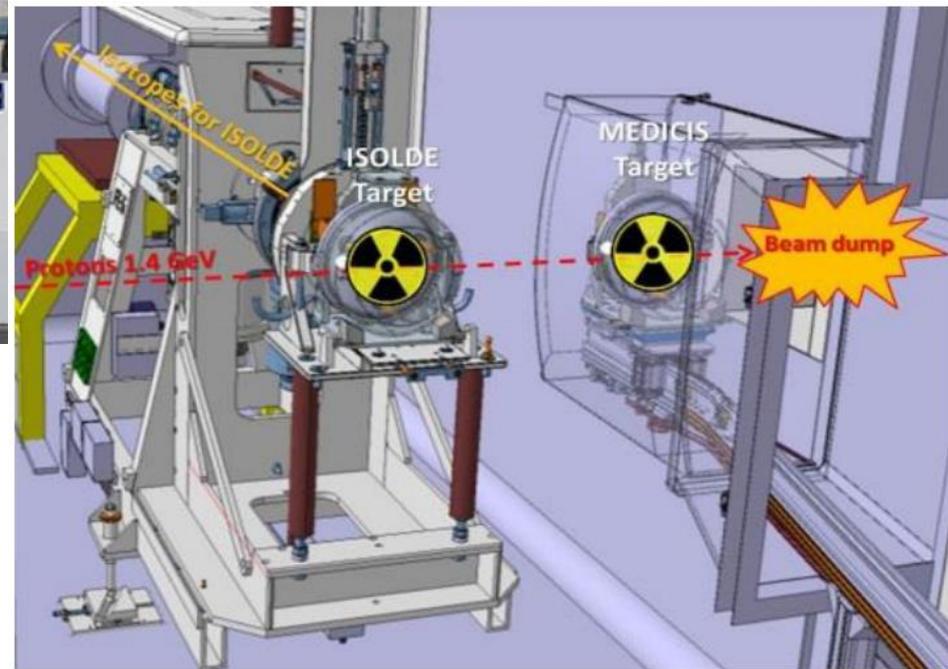


The ISOLDE facility



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

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

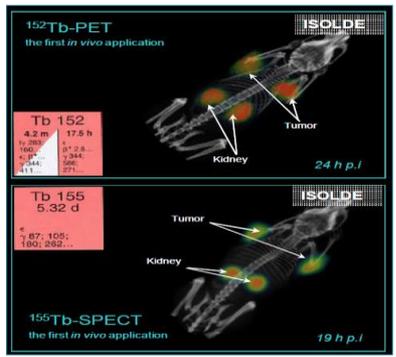
Target



Linker



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

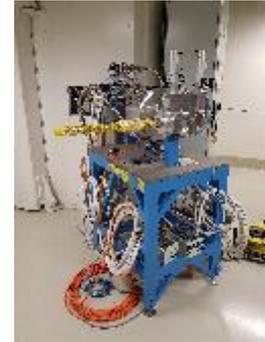
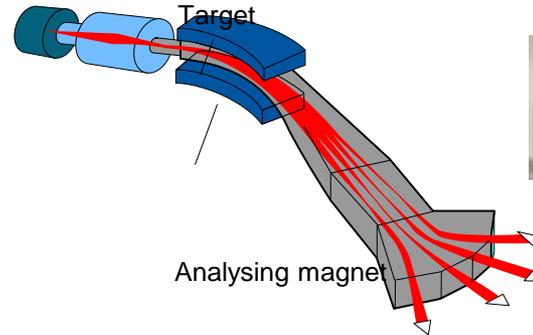
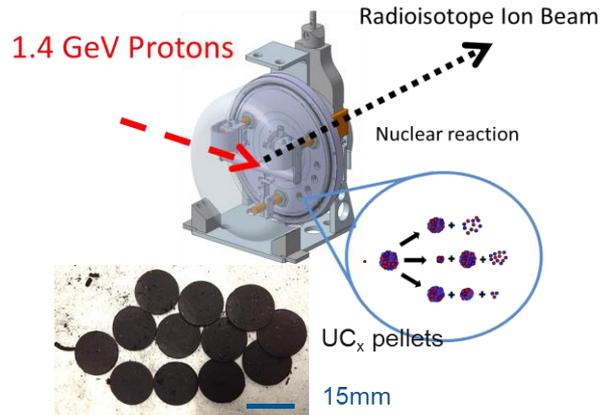
Low LET, long distance in human tissue



Tb 149 4.2 m / 4.1 h β ⁺ 3.99, 796, 165... e 3.97, 1.8, 252, 165...	Tb 152 4.2 m / 17.5 h β ⁺ 2.03, 180... β ⁺ 2.8, 344, 586, 271... γ 344, 271...	Tb 155 5.32 d β ⁻ 87, 105, 180, 262	Tb 161 6.90 d β ⁻ 0.5, 0.6... γ 26, 49, 75... α
--	---	---	---



Medical isotope production



Safety rules in the ISOLDE hall

- ◆ Don't touch anything!
- ◆ No food & drinks allowed, leave your bag here!
- ◆ Always follow the guide, don't wander off!
- ◆ Everyone must wear flat, closed or block-heeled shoes!
- ◆ It is allowed to take pictures!
- ◆ No entry for people:
 - ◆ Younger than 16
 - ◆ Who are pregnant
 - ◆ Who have devices sensitive to magnetic fields