Introduction to ISOLDE

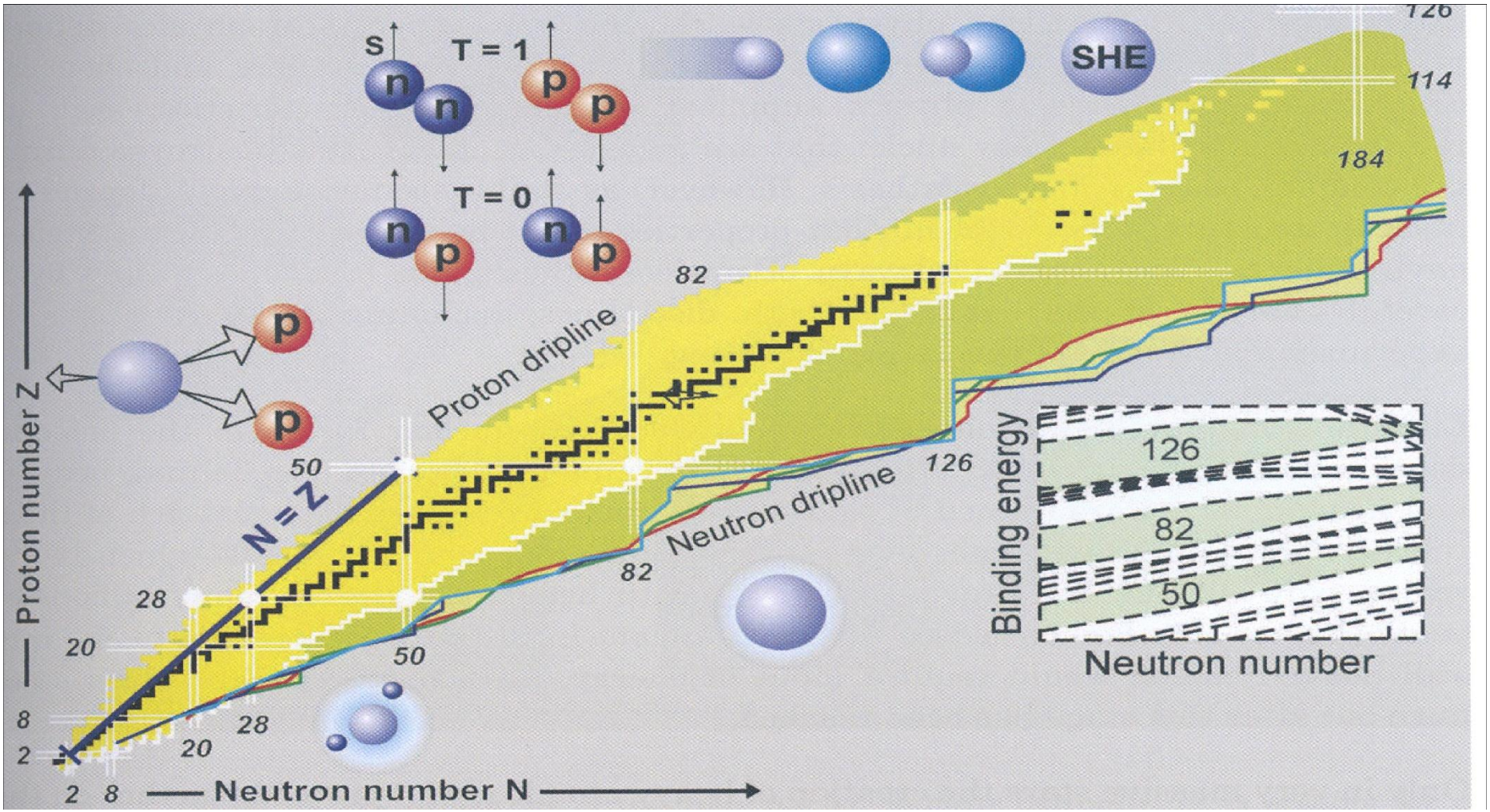
Yorick Blumenfeld

Spokesperson and Physics Group Leader

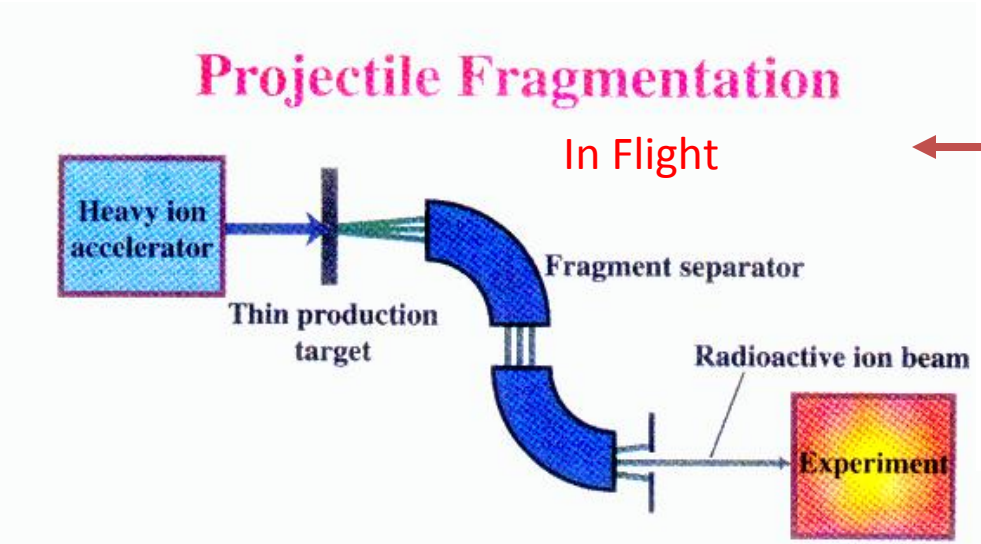
OUTLINE

- Introduction
- The ISOLDE facility
- Physics and Instrumentation at HIE-ISOLDE
- The Organization of ISOLDE
- ISOLDE and HIE-ISOLDE in the European Roadmap

The Nuclear Chart and Challenges



Radioactive beam production: Two complementary methods

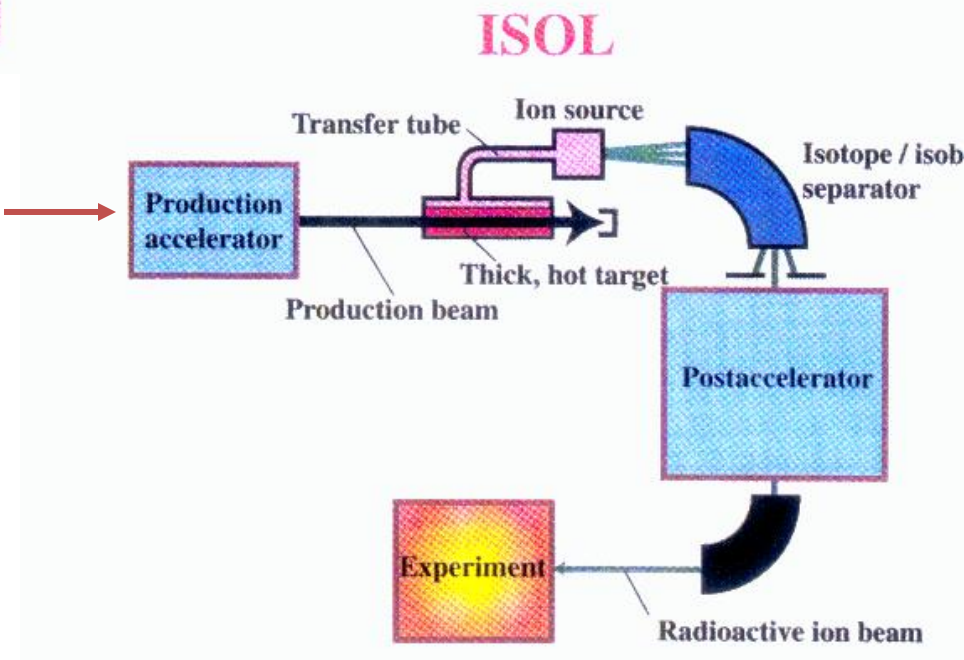


FAIR, FRIB

High energy, large variety of species,

HIE-ISOLDE; SPIRAL2

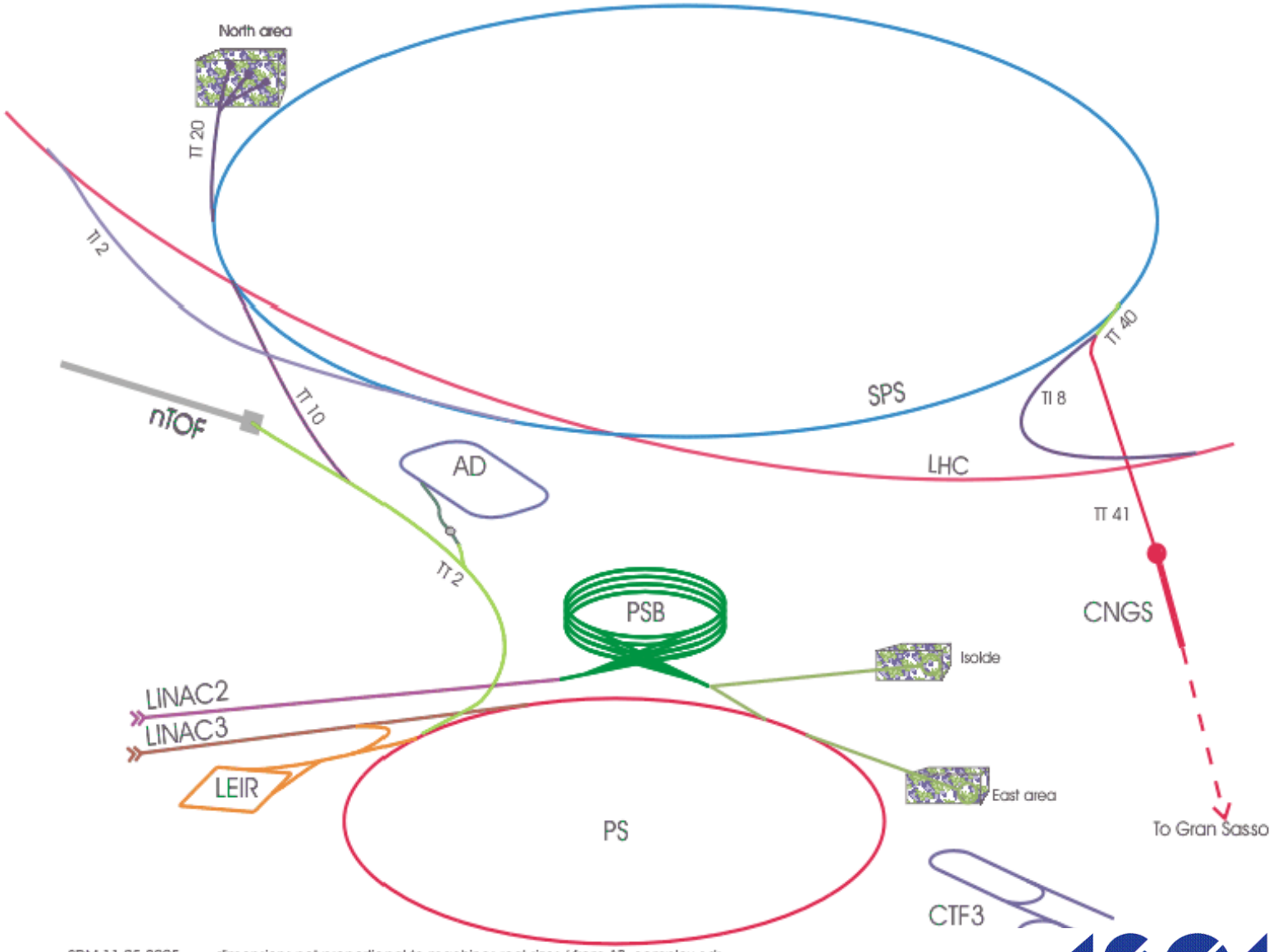
Variable energy, high intensity , good beam qualities

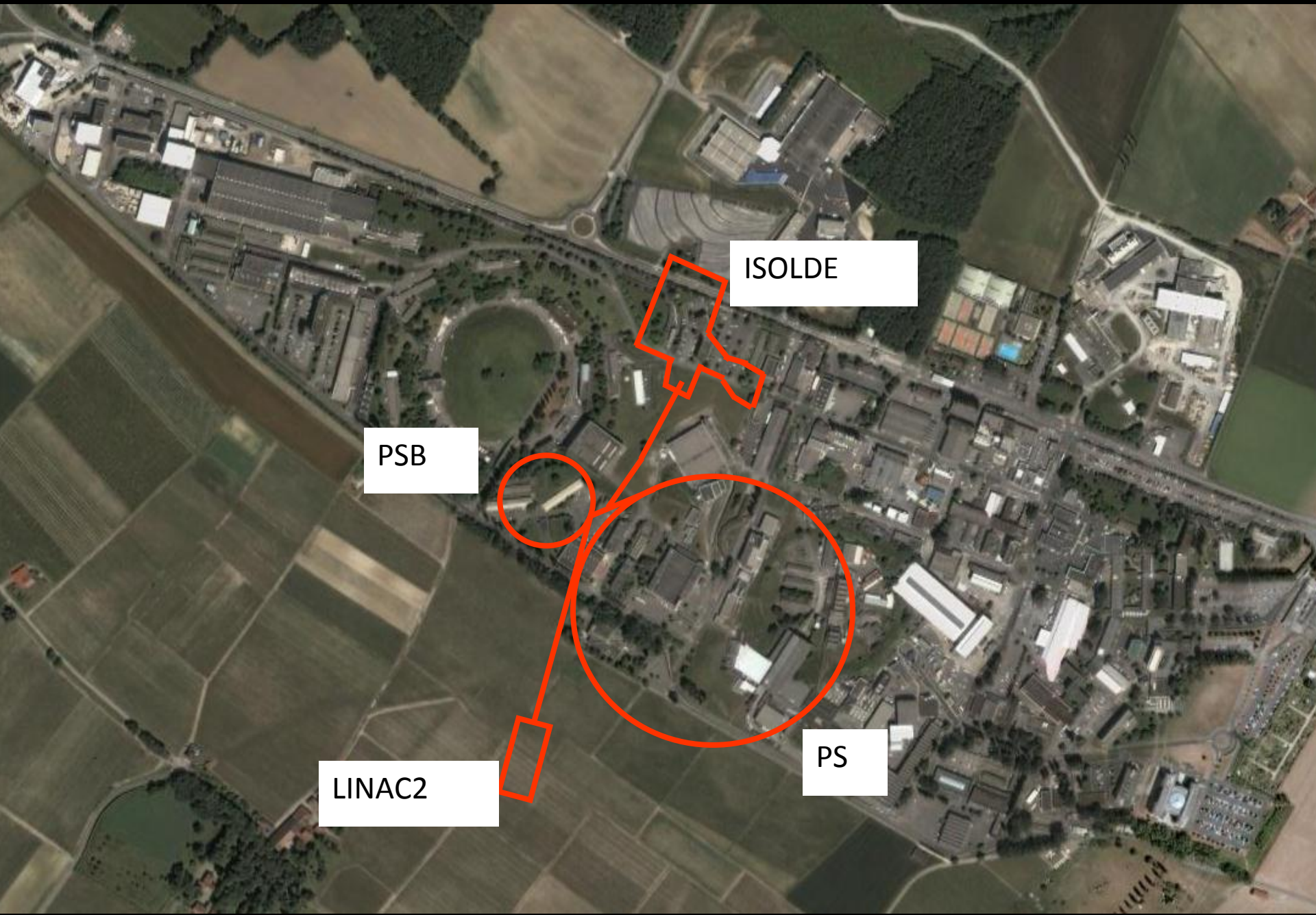


A Few Facts

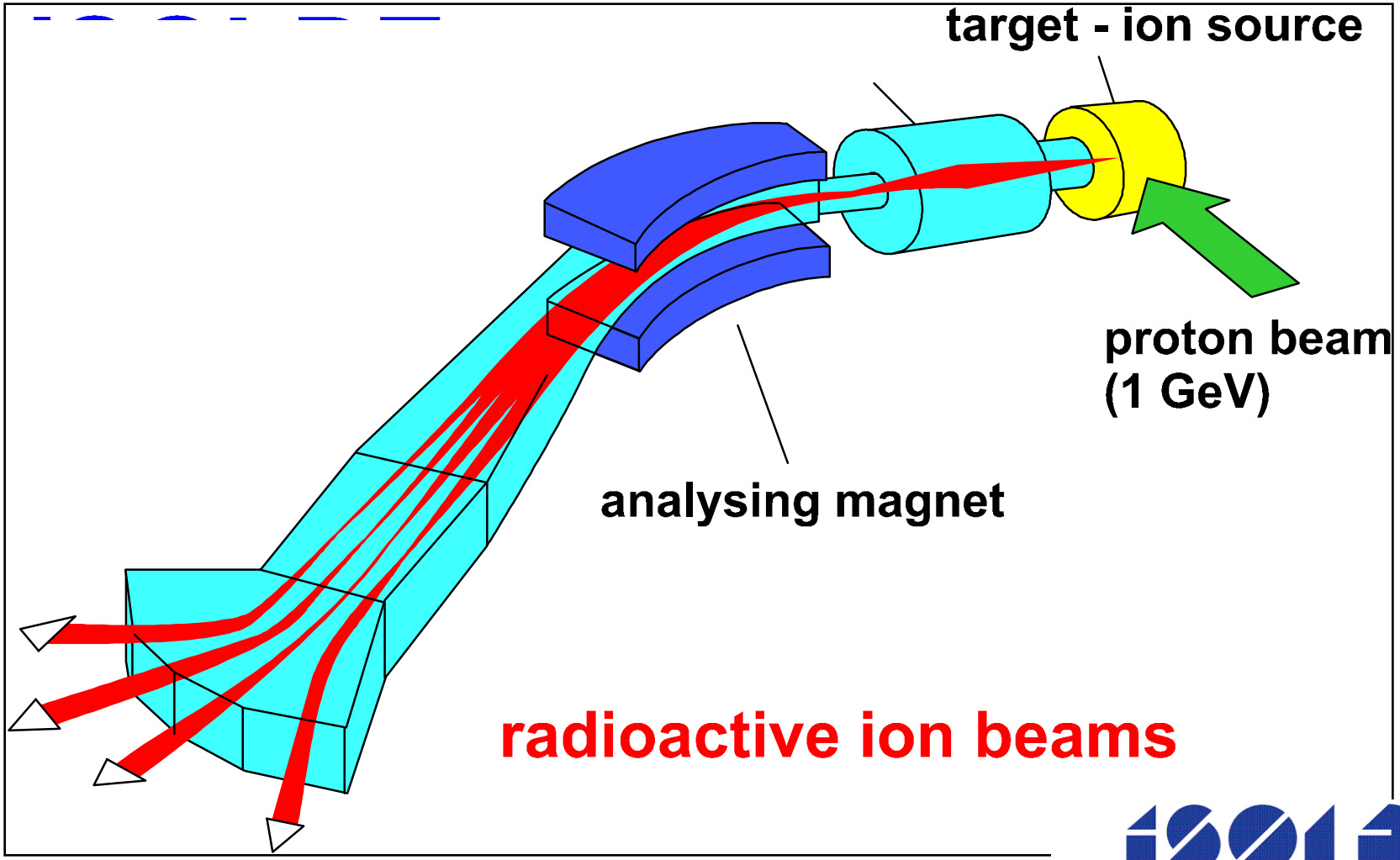
- ISOLDE is the CERN radioactive beam facility
- In operation since 40 years
- The largest selection of isotopes of any ISOL facility worldwide
- Provides low energy or post-accelerated beams
- Run by an international collaboration
- Open to users from around the world

Accelerators at CERN

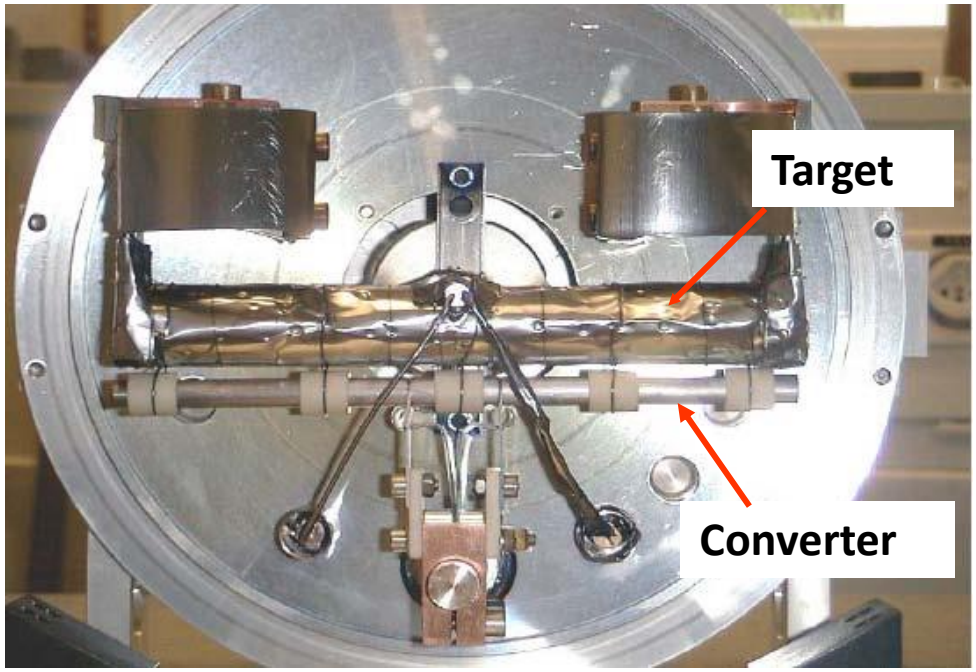



ISOLDE
PSB
PS
LINAC2

ISOL: Isotope Separation On-Line



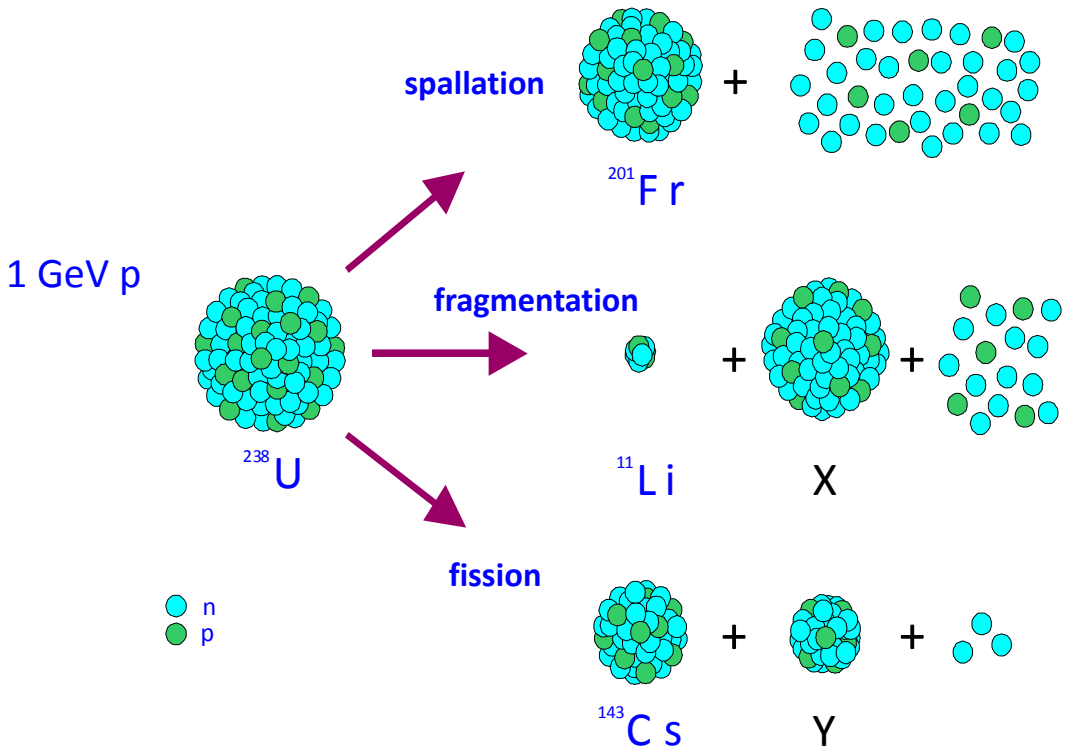
Targets



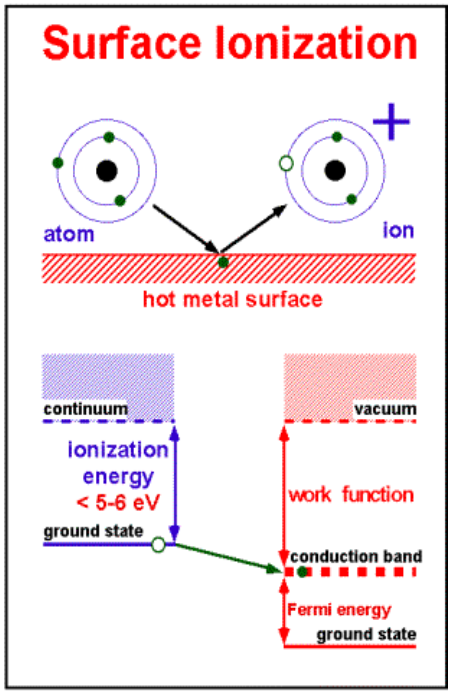
Converter Target

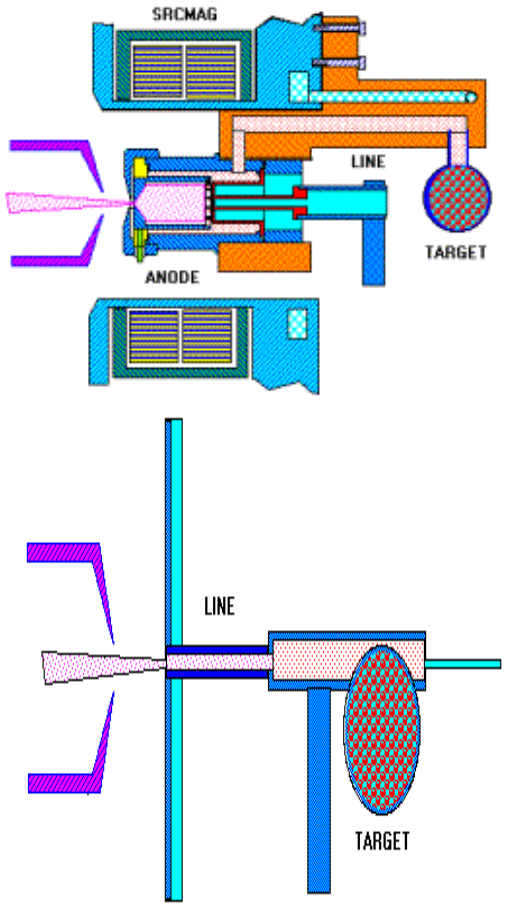
Standard

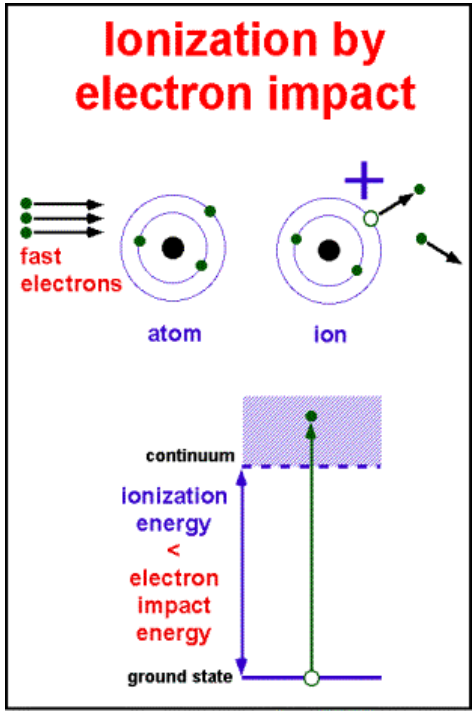
Production of exotic ions



Surface & plasma ionization

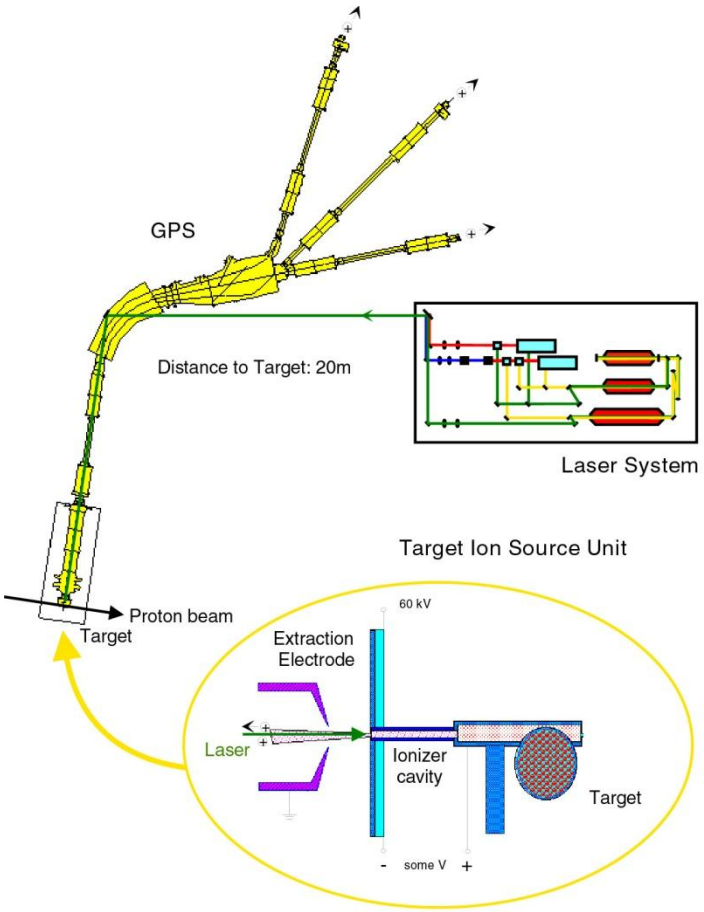


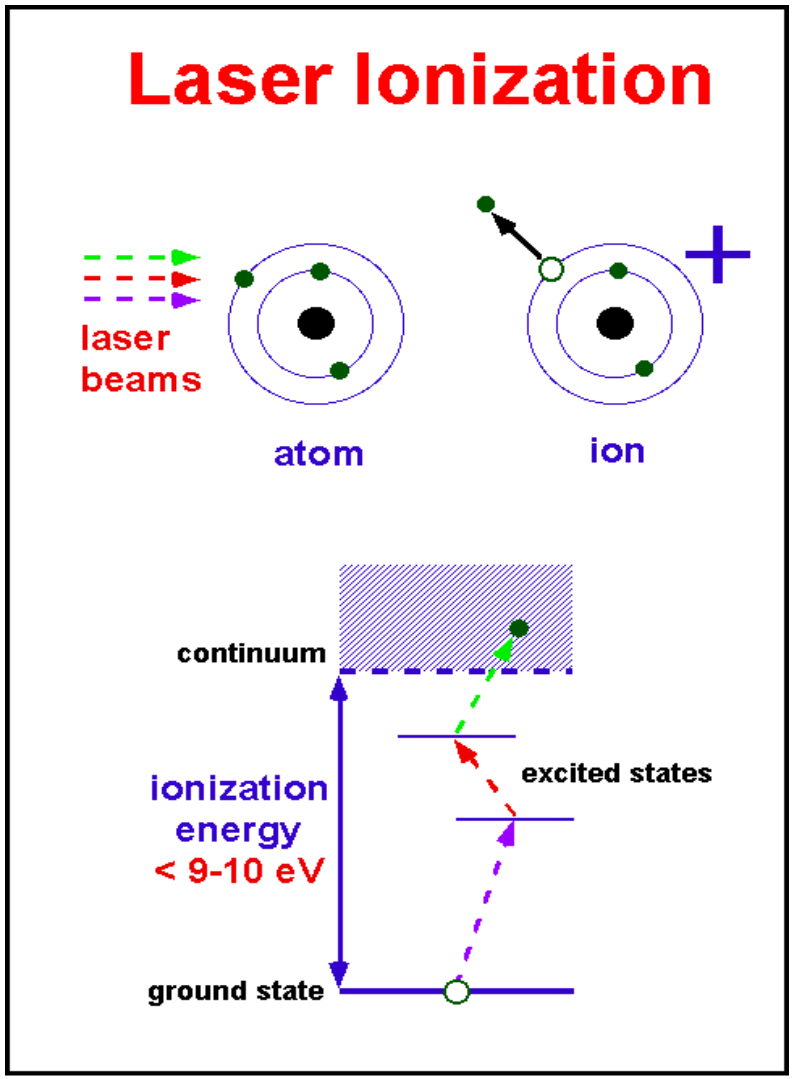




Ion source

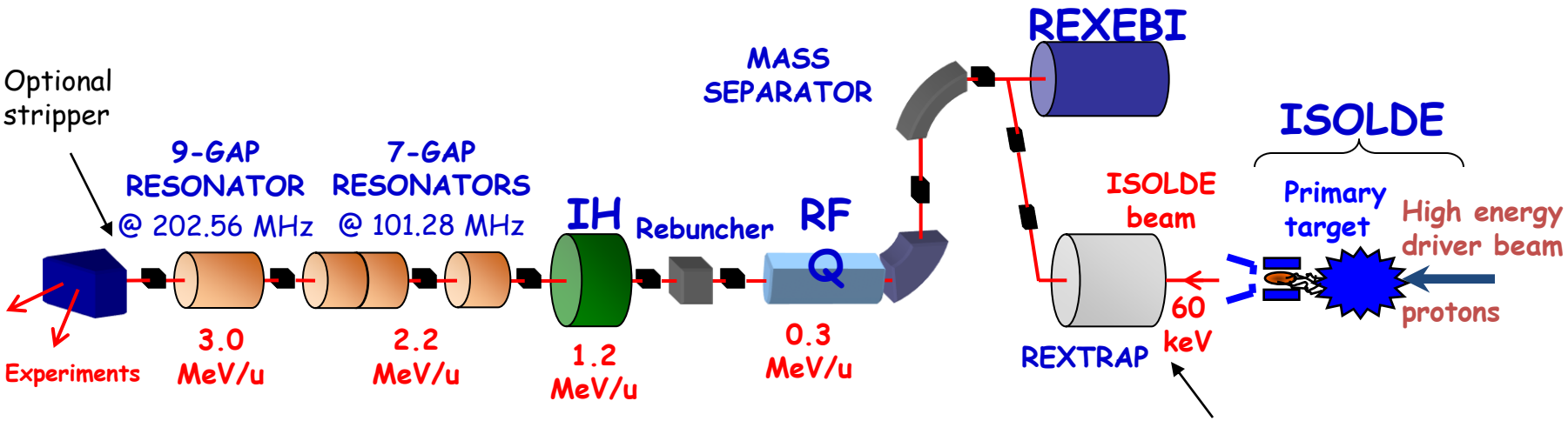
Laser ionization





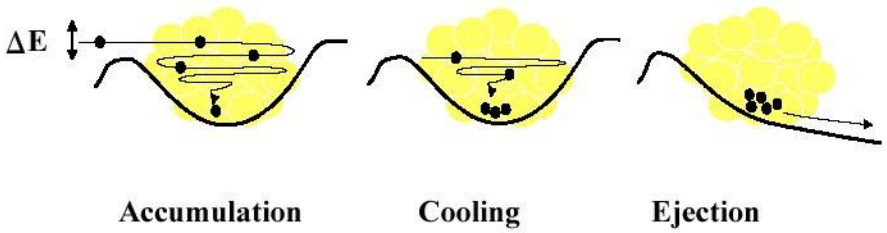
REX-Isolde

* charge breeding
* 1+ ions to n+



* 6 cavities
* 100 and 200 MHz, ~100 kW
* 300 keV/u to 3 MeV/u

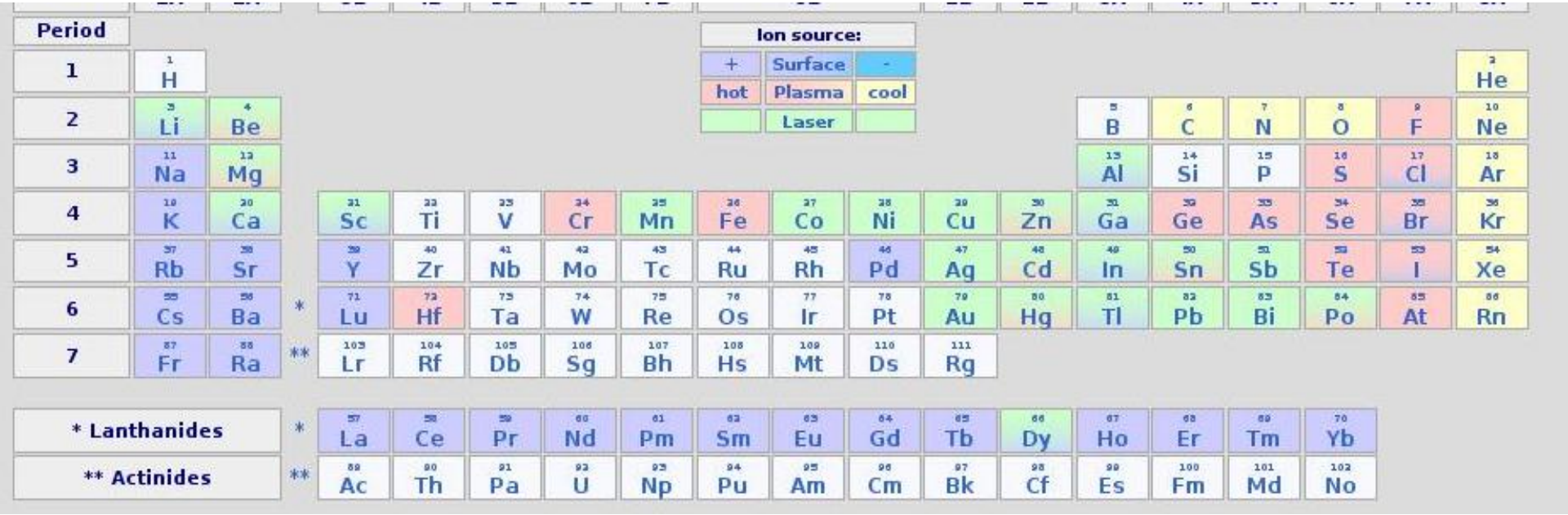
* longitudinal accumulation and bunching
* transverse phase space cooling



D. Voulot

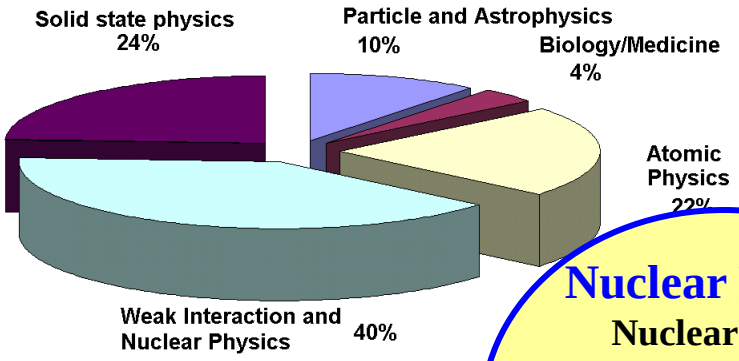
Beam consolidation/development at ISOLDE

Beam evolution in the past 4 years



Beam development: Thierry Stora

Research with Radioactive Ion Beams



Nuclear Physics

Nuclear Decay Spectroscopy and Reactions

Structure of Nuclei
Exotic Decay Modes

Applied Physics

Implanted Radioactive Probes, Tailored Isotopes for Diagnosis and Therapy

Condensed matter physics and Life sciences

Fundamental Physics

Direct Mass Measurements, Dedicated Decay Studies - WI

CKM unitarity tests, search for β-ν correlations, right-handed currents

Atomic Methods

Laser Spectroscopy and Direct Mass Measurements

Radii, Moments, Nuclear Binding Energies

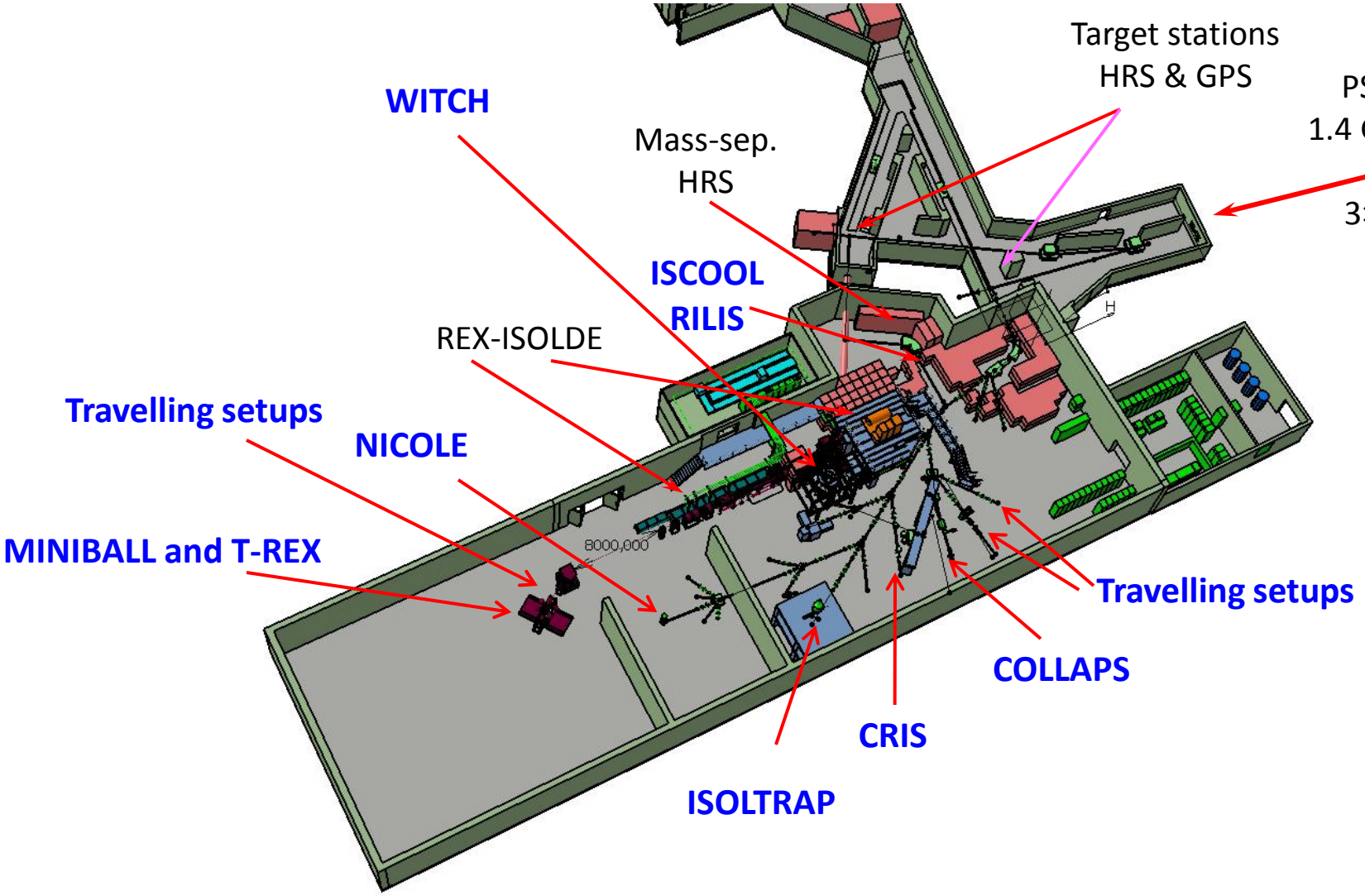
Nuclear Astrophysics

Dedicated Nuclear Decay/Reaction Studies

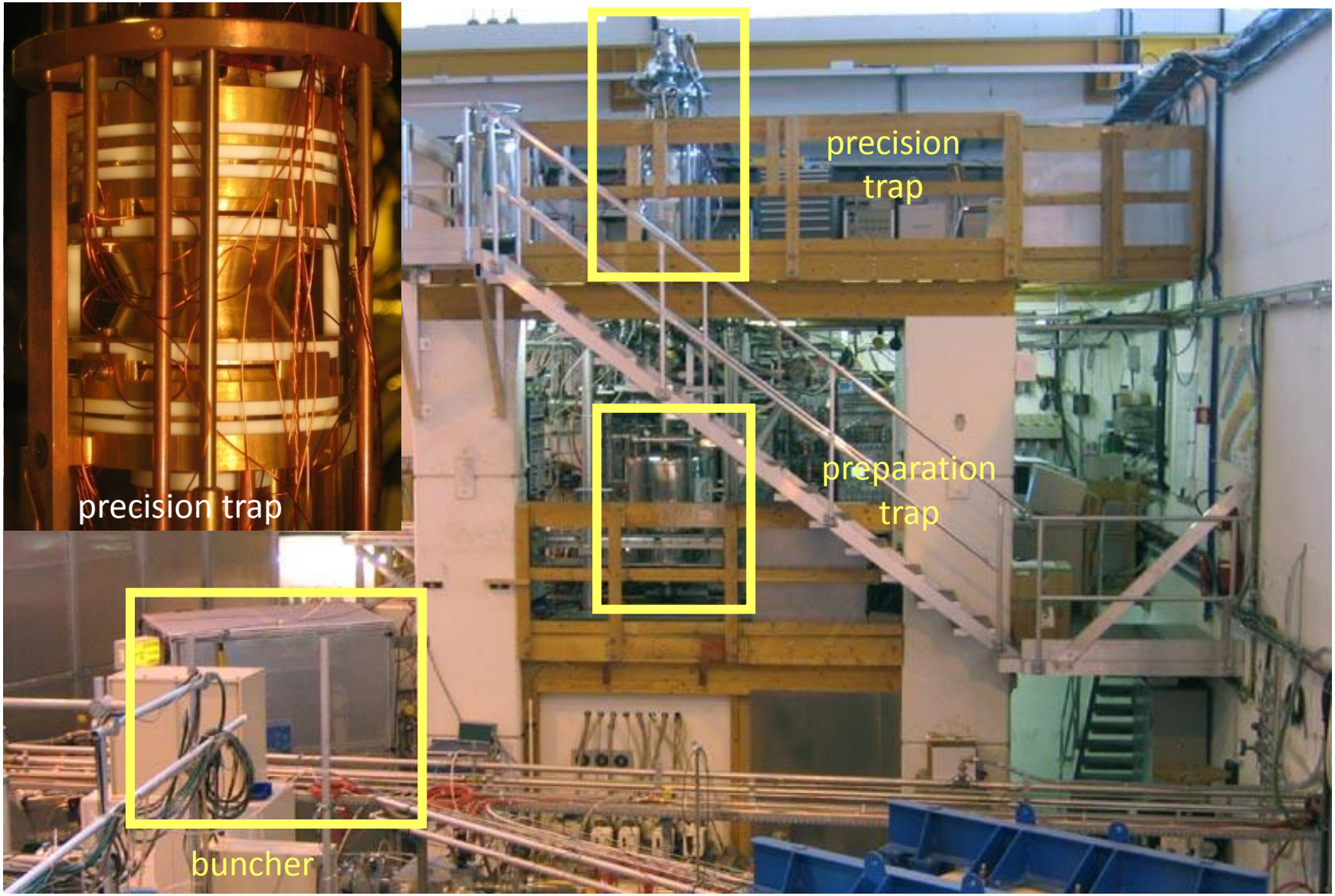
Element Synthesis, Solar Processes

f(N,Z)

ISOLDE Layout



Ion traps at ISOLTRAP

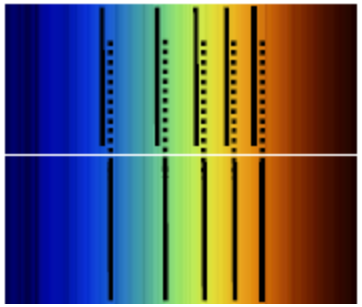


Isotope shifts and charge radii

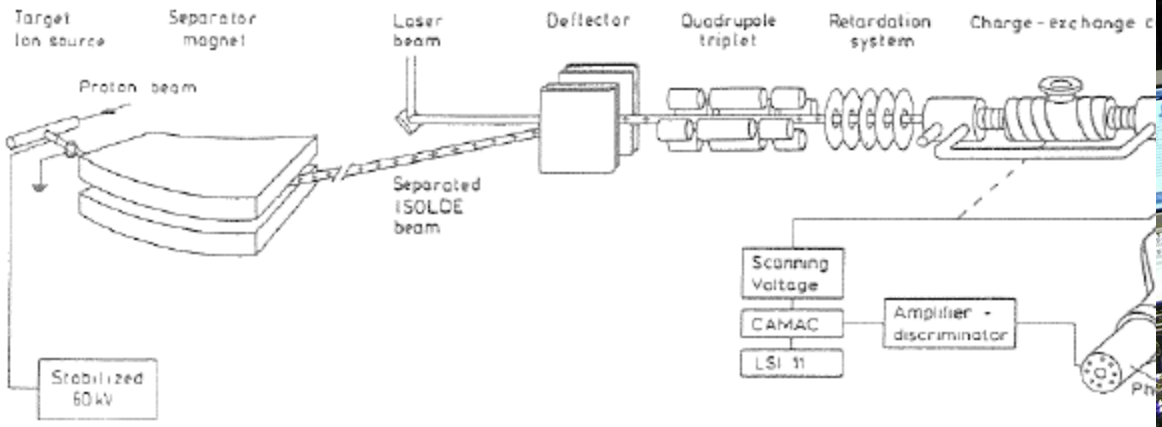
ISOTOPE SHIFT

Finite Size Effect

⇒ **Change of Charge Radius**

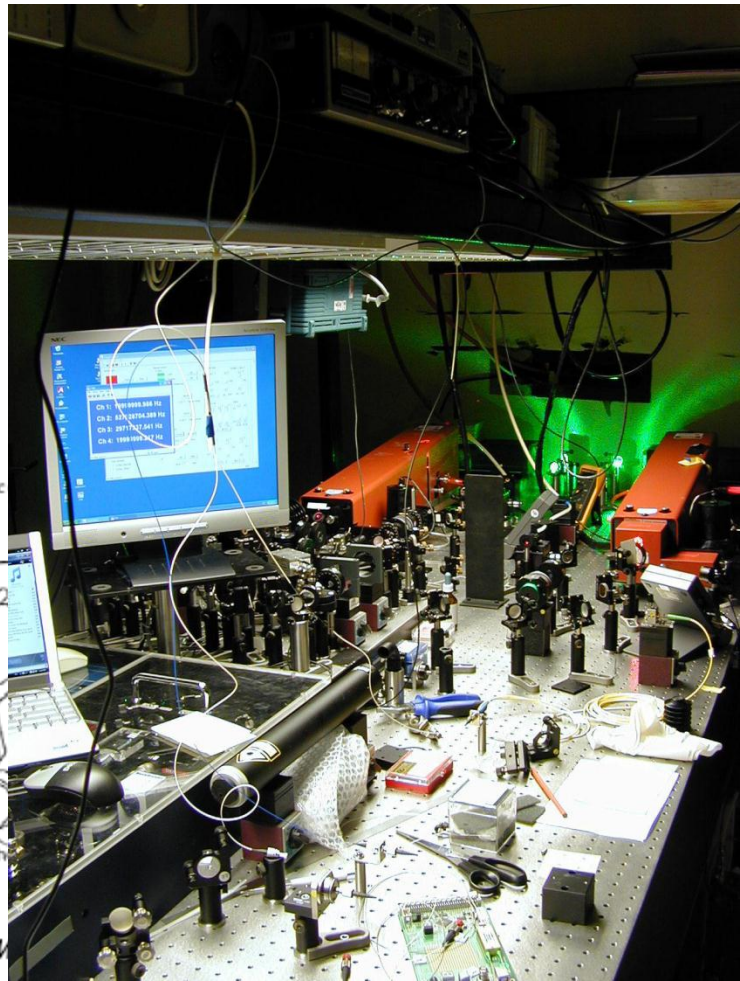


$$\delta\nu_{\mathrm{FS}} = \frac{2\pi Z}{3}\,\Delta|\psi(0)|^2\,\delta\langle r^2\rangle^{A,A'}$$

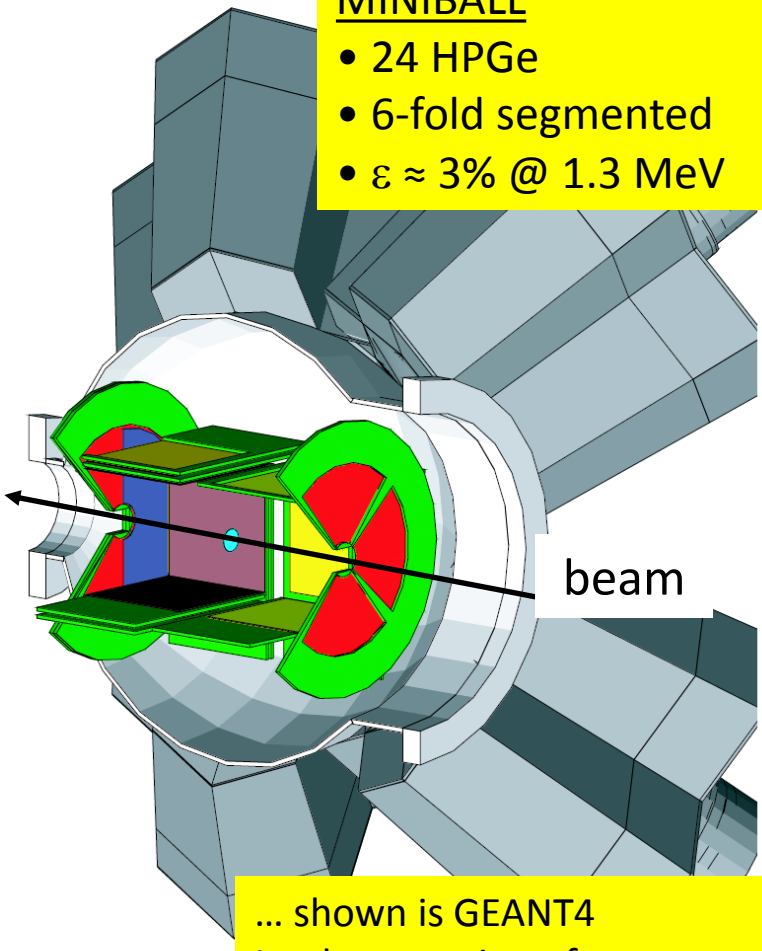


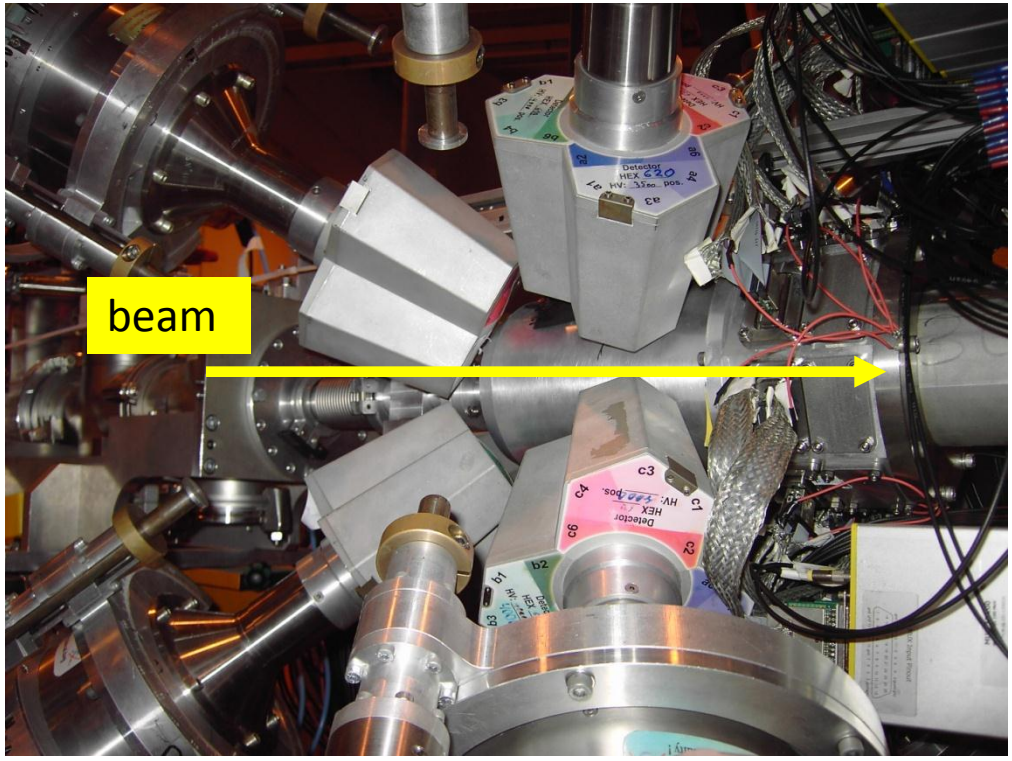
S.L. Kaufman, Opt. Comm. **17** (1976) 309.
T. Meier et al., Opt. Comm. **20** (1977) 397

K.-R. Anton, PRL **40** (1978) 642
E.W. Otten, *Nuclear Radii and M*



Experimental set-up: T-REX &MINIBALL

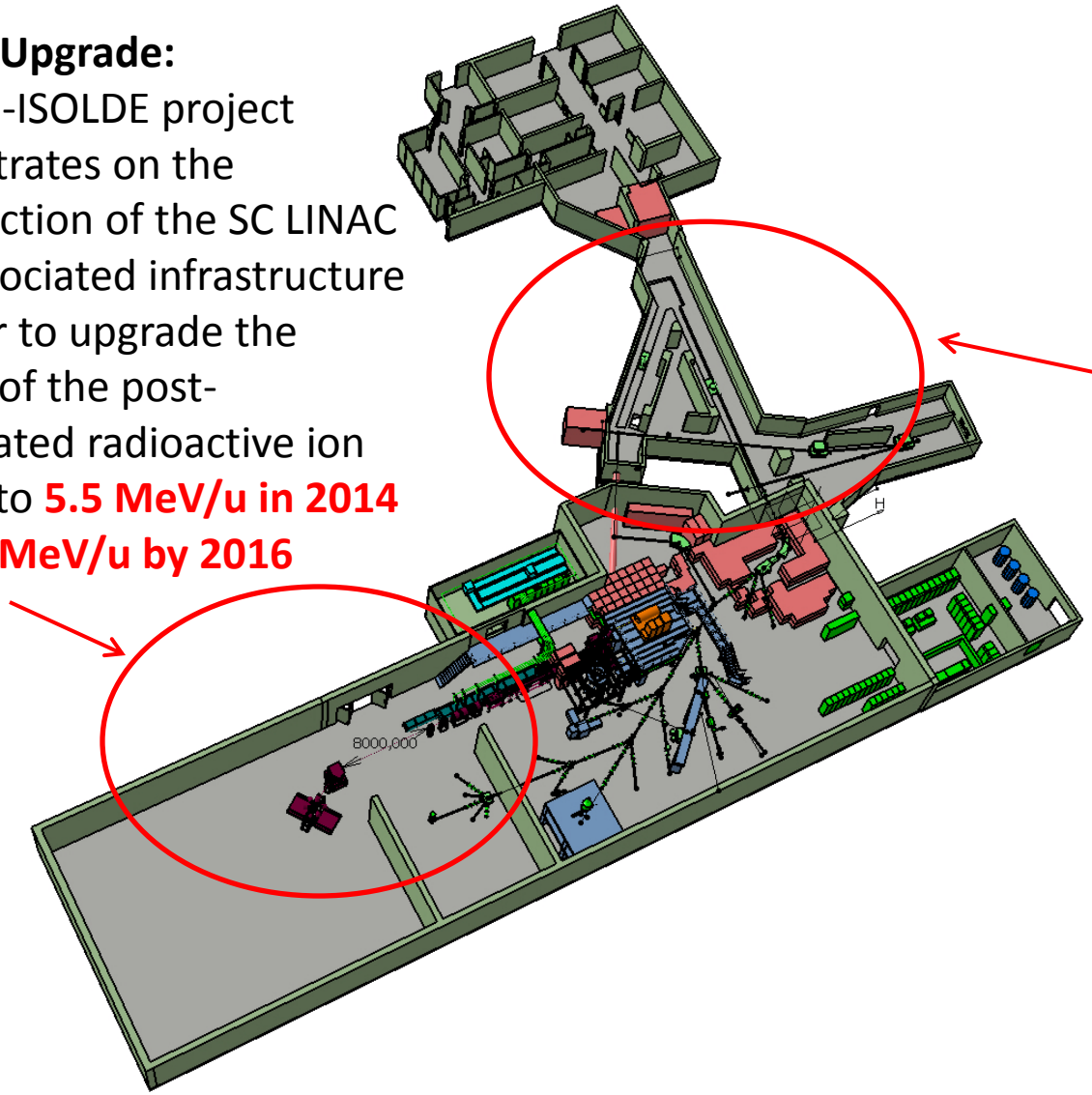




Scope of HIE-ISOLDE

HIE-ISOLDE aims at increasing the energy of these RIB up to 10A MeV and their intensity by a factor 10

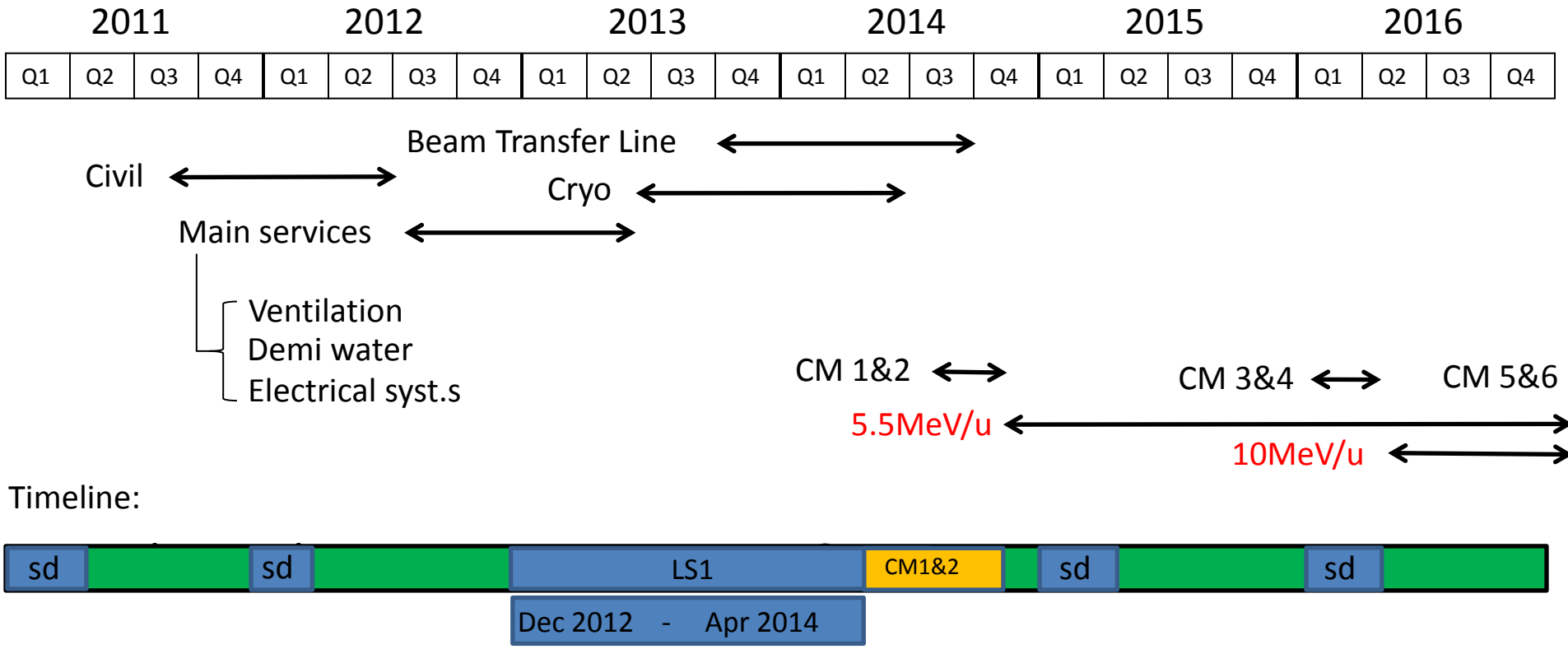
Energy Upgrade:
The HIE-ISOLDE project concentrates on the construction of the SC LINAC and associated infrastructure in order to upgrade the energy of the post-accelerated radioactive ion beams to **5.5 MeV/u in 2014** and **10 MeV/u by 2016**



Intensity Upgrade:
The design study for the intensity upgrade, also part of HIE-ISOLDE, **starts in 2011**, and addresses the technical feasibility and cost estimate for operating the facility at **10 kW** once LINAC4 and PS Booster are online.

Hie-Isolde Planning

A simplified presentation of the different stages:



Call for Letters of Intent

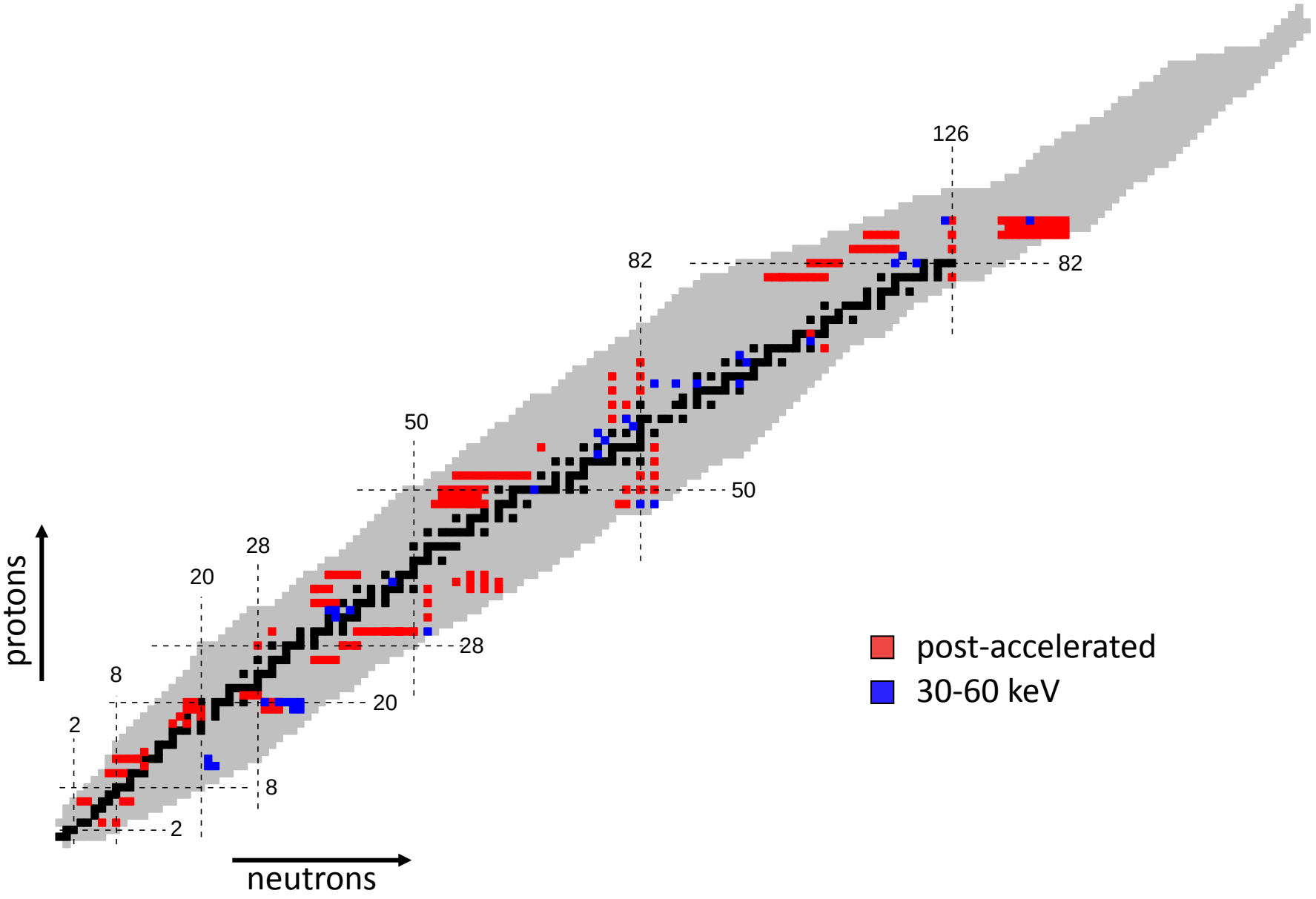
(deadline May 21 2010)

- 34 Letters submitted
- 284 Participants from 76 Laboratories in 22 Countries
- 30 LOIs make use of the Energy and Intensity increases; 4 of the intensity upgrade only
- Major mechanisms are Coulex (13) and transfer(16);

elastic scattering(3); fission(2)

- (3) letters concern masses and moments; (4) astrophysics and (5) major new instrumentation
- Major subjects: Nuclear shapes ; Shell evolution; Halo properties; Nuclear astrophysics

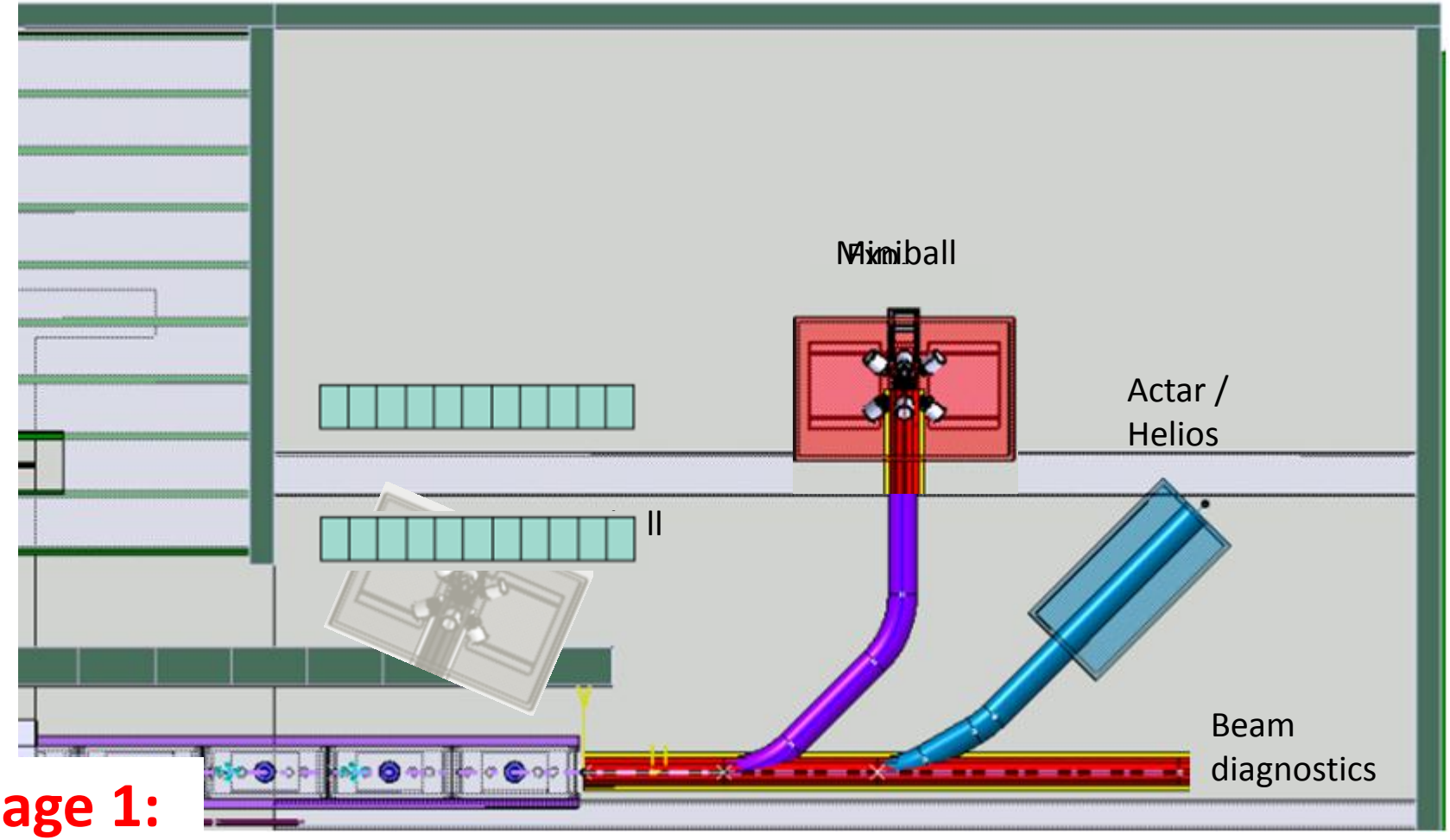
Radioactive isotopes requested in HIE-ISOLDE Letters of Intent



Instrumentation Envisaged

- Miniball + T-Rex (upgrade planned) : COULEX + Transfer
- Multipurpose reaction chamber
- Helios type device: transfer
- ACTAR: resonant scattering + transfer. Test experiment with MAYA should be scheduled in 2012.
- TSR storage ring
- Magnetic spectrometer ?

Beam Transfer Line



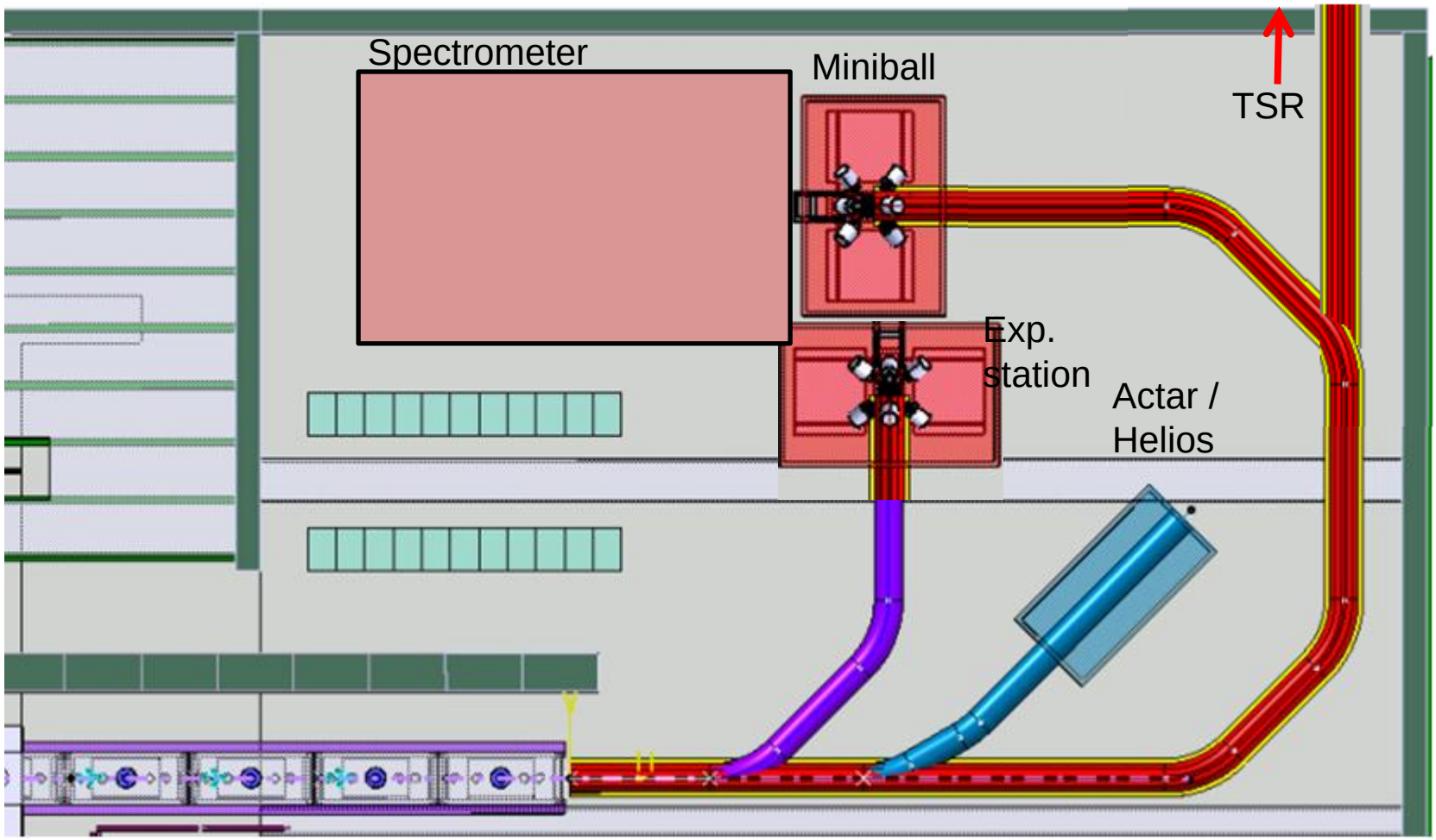
Stage 1:

Straight line with 2 branches – Oct 2013 - Sept 2014

Miniball move: Oct 2013 – April 2014

Courtesy Erwin Siesling

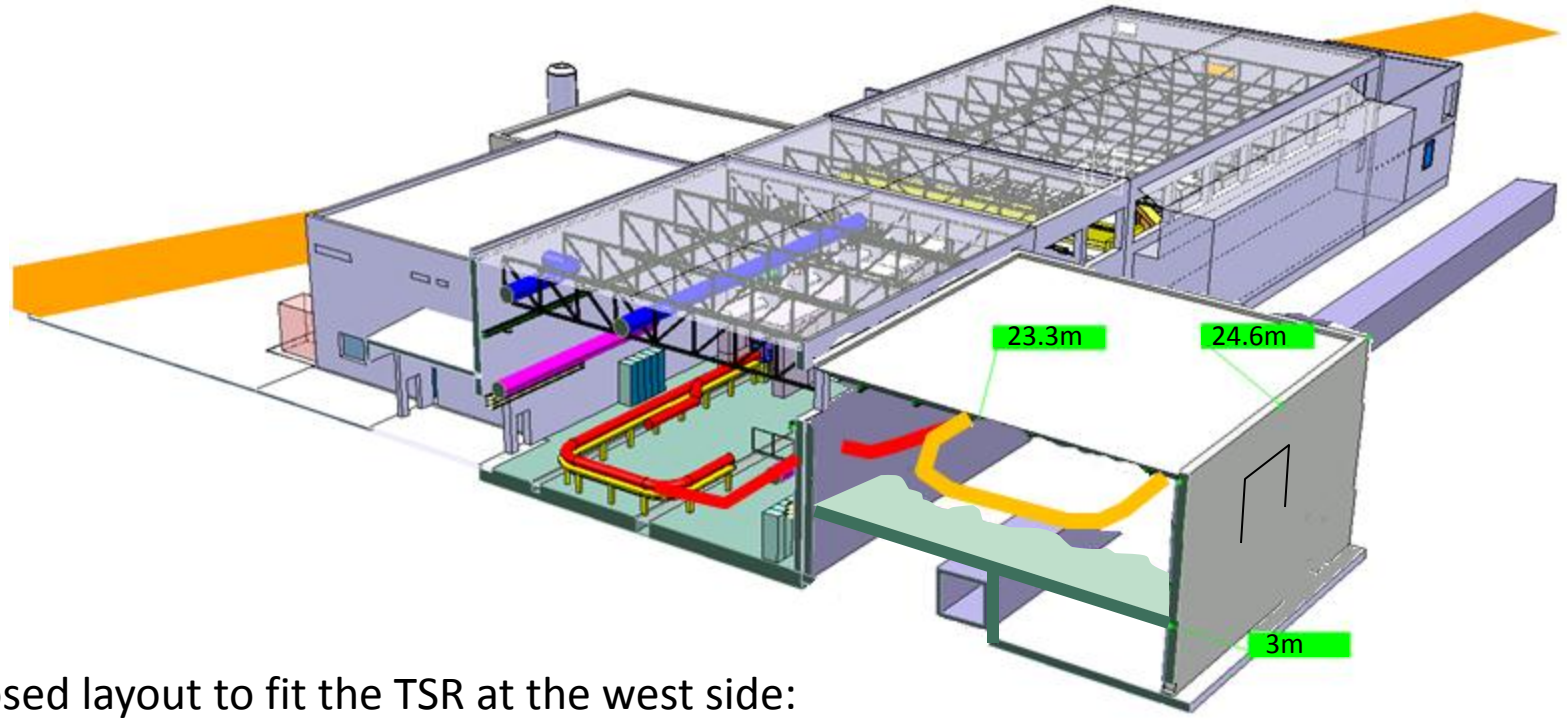
SC Linac & Beam Transfer Lines



Physics cases discussed in the TSR@ISOLDE TDR

1. Half-life measurements of ^{7}Be in different atomic charge states
2. Capture reactions for astrophysical p-process
3. Nuclear astrophysics through transfer reactions
4. Nuclear structure through transfer reactions
5. Long-lived isomeric states
6. Atomic effects on nuclear half-lives
7. Di-electronic recombination on exotic nuclei
8. Atomic physics experiments
9. Neutrino physics
10. Laser spectroscopy experiments in the storage ring

Jura (west) side



Proposed layout to fit the TSR at the west side:
- Installation above the CERN infrastructure-tunnel (**not** negotiable to move the tunnel: houses essential CERN signals and infrastructure)
- Tilted beamline coming up from the machine

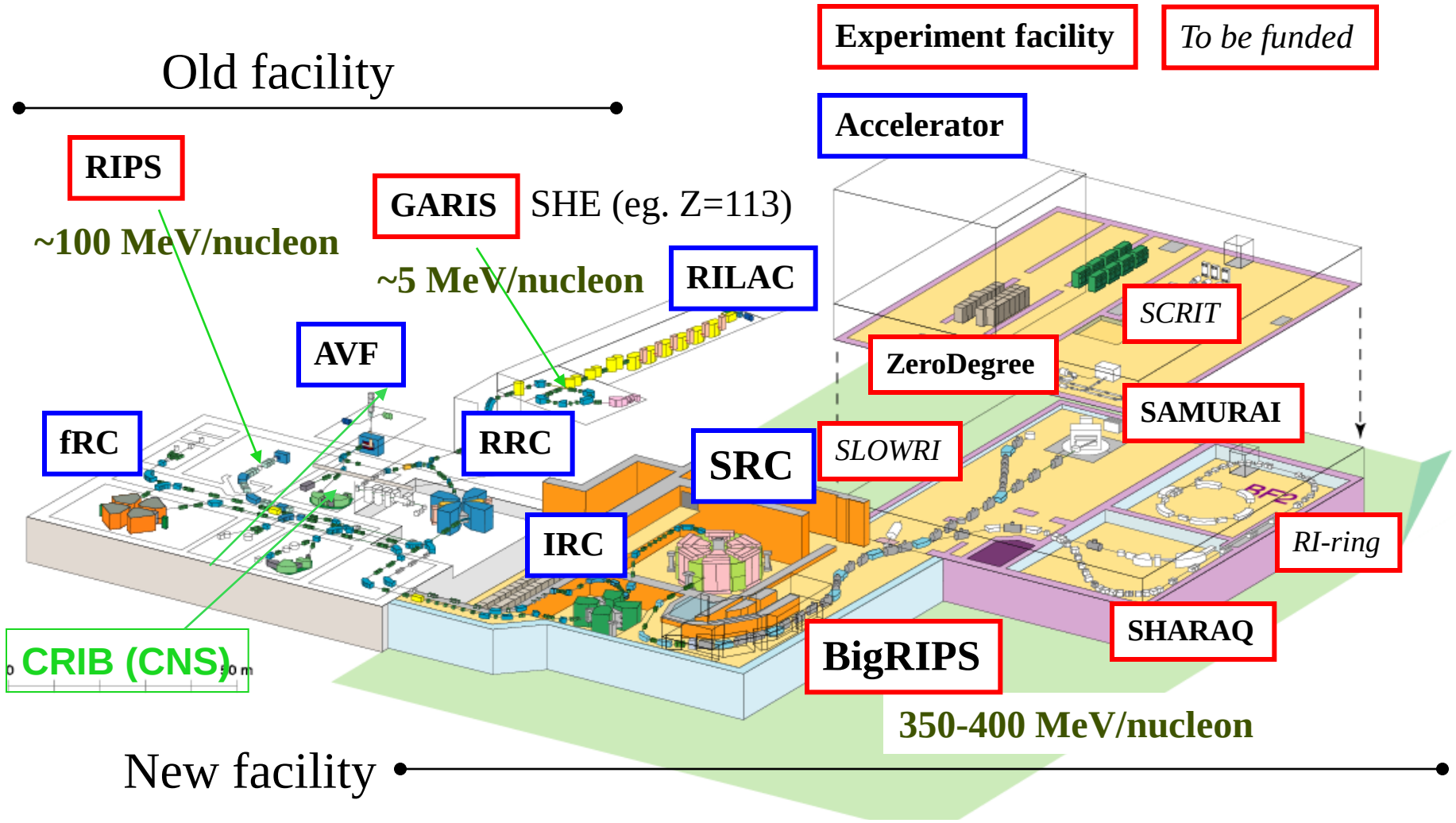
The ISOLDE Collaboration

- ISOLDE is run by a collaboration comprising 13 countries and CERN.
- Each country pays a annual fee of 60 KEuros. This budget is used to support experiments, buy common equipment and consumables, pay some personnel (visitors, secretary….) and contribute to upgrades (HIE-ISOLDE…)
- Each county has a representative on the Isolde Collaboration Committee which meets three times a year. The chair is currently Prof. MJG Borge (Spain)

How to do an experiment @ ISOLDE

- Start with a good idea!
- If it is a new concept or line of research submit an LOI to the INTC (Isolde N-Tof Committee; chair Peter Butler) which meets 3 times/year
- The INTC endorses the LOI and can recommend a few shifts for tests
- Then submit a proposal to the INTC and present it.
- The INTC takes advice from its technical committee and 2 referees.
- The INTC recommends a number of shifts to the research board.
- Request scheduling to the physics coordinator, Magda Kowalska
- Come and do the experiment
- Present results at the annual ISOLDE workshop (this year Dec. 17-19)
- Publish
- Go to top

RIKEN RI Beam Factory (RIBF)



Intense (80 kW max.) H.I. beams (up to U) of 345*A*MeV at SRC
Fast RI beams by projectile fragmentation and U-fission at BigRIPS
Operation since 2007

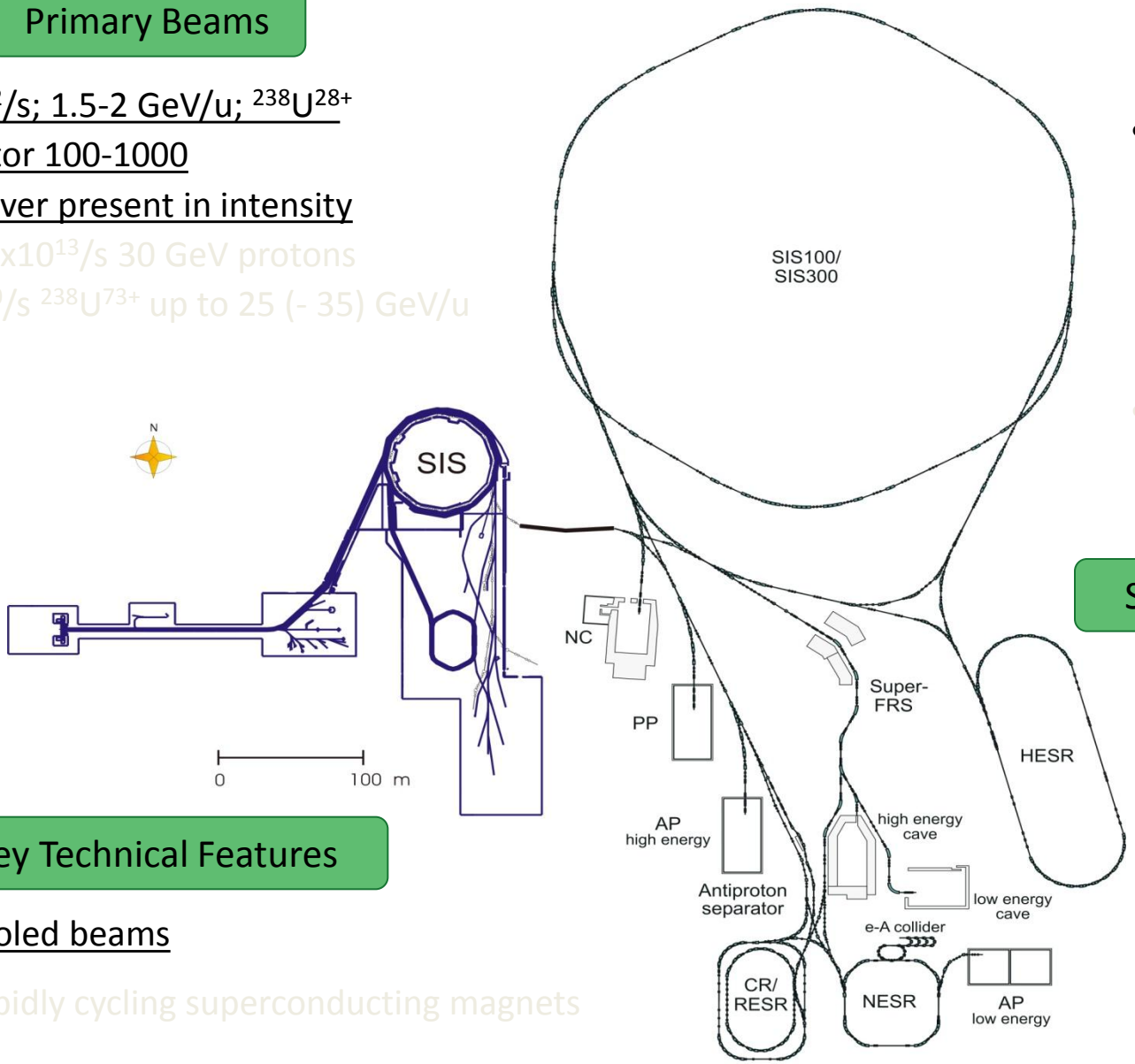
Next Generation Facility: FAIR at GSI

Primary Beams

- 10^{12}/s; 1.5-2 GeV/u; $^{238}U^{28+}$
- Factor 100-1000 over present in intensity
- 2(4)x10^{13}/s 30 GeV protons
- 10^{10}/s $^{238}U^{73+}$ up to 25 (- 35) GeV/u

Secondary Beams

- Broad range of radioactive beams up to 1.5 - 2 GeV/u;
  up to factor 10 000 in intensity over present
- Antiprotons 3 - 30 GeV

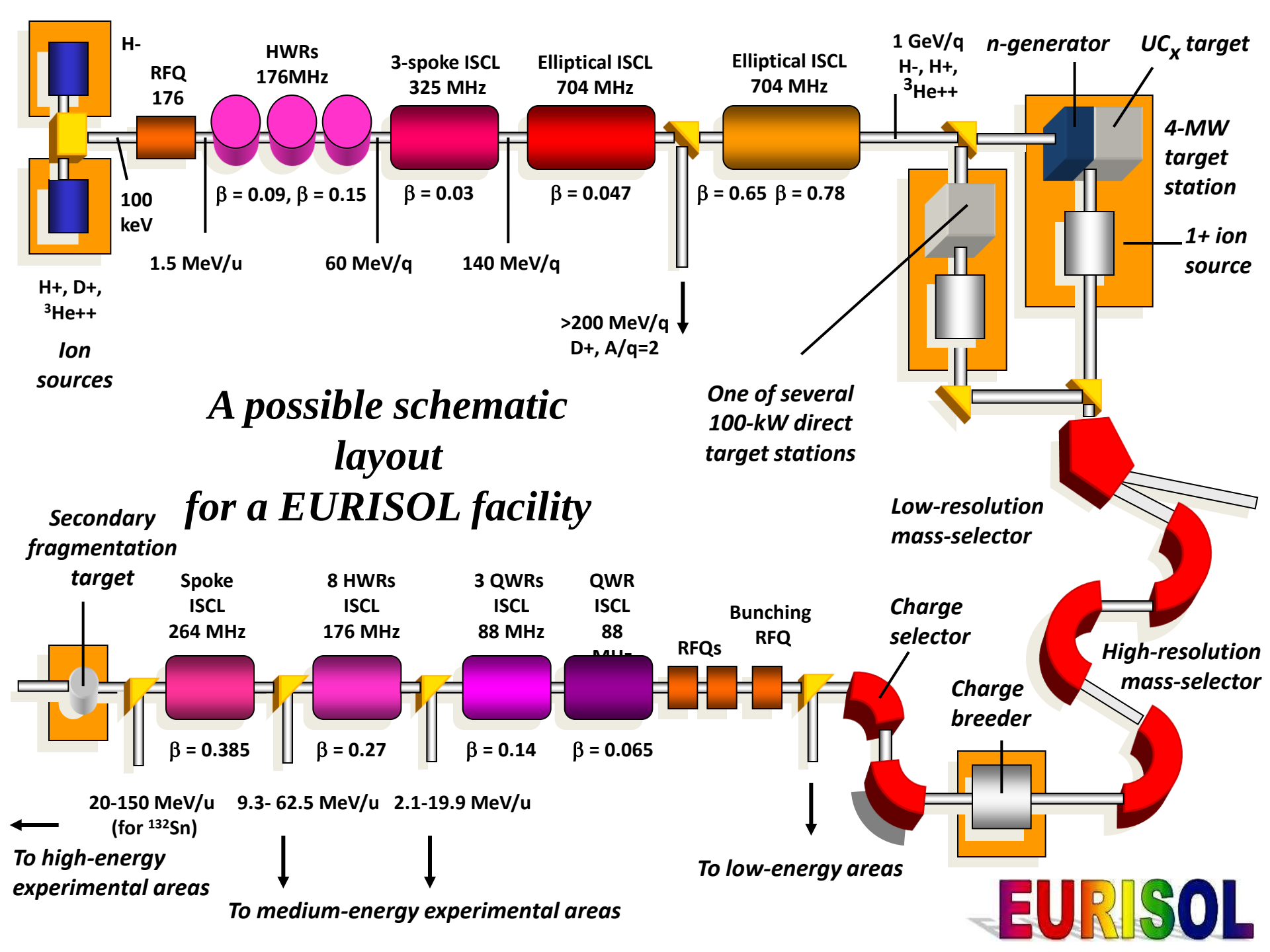


Storage and Cooler Rings

- Radioactive beams
- e – A collider
- 10^{11} antiprotons stored and cooled at 0.8 - 14.5 GeV

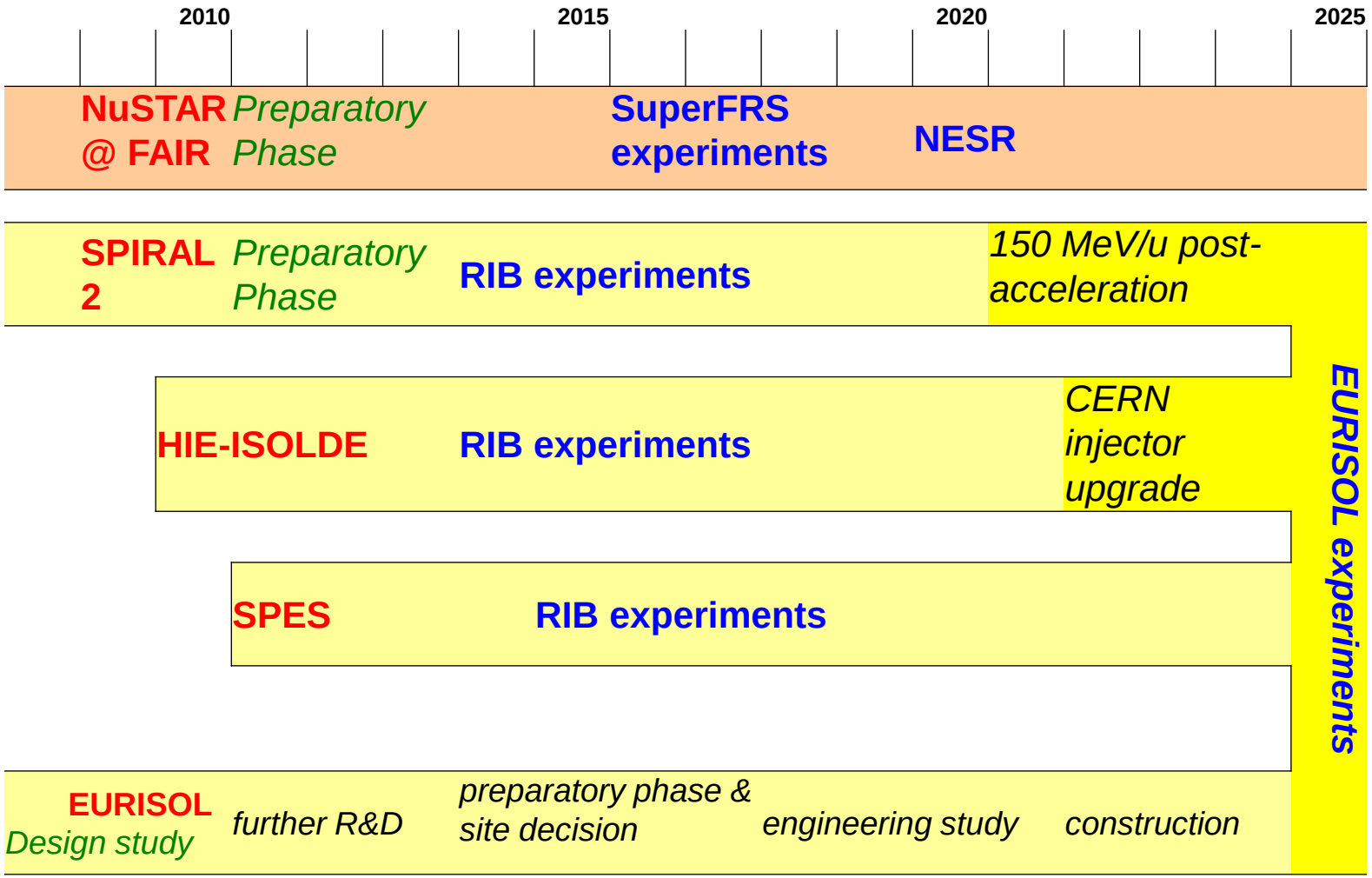
Key Technical Features

- Cooled beams
- Rapidly cycling superconducting magnets


H-
RFQ
176
HWRs
176MHz
3-spoke ISCL
325 MHz
Elliptical ISCL
704 MHz
Elliptical ISCL
704 MHz
1 GeV/q
H-, H+,
3He++
n-generator
UCx target
4-MW
target
station
1+ ion
source
100
keV
β = 0.09, β = 0.15
β = 0.03
β = 0.047
β = 0.65 β = 0.78
1.5 MeV/u
60 MeV/q
140 MeV/q
H+, D+,
3He++
Ion
sources
>200 MeV/q
D+, A/q=2
One of several
100-kW direct
target stations
A possible schematic
layout
for a EURISOL facility
Low-resolution
mass-selector
Secondary
fragmentation
target
Spoke
ISCL
264 MHz
8 HWRs
ISCL
176 MHz
3 QWRs
ISCL
88 MHz
QWR
ISCL
88
RFQs
Bunching
RFQ
Charge
selector
High-resolution
mass-selector
Charge
breeder
β = 0.385
β = 0.27
β = 0.14
β = 0.065
20-150 MeV/u
(for 132Sn)
9.3- 62.5 MeV/u
2.1-19.9 MeV/u
To high-energy
experimental areas
To medium-energy experimental areas
To low-energy areas
EURISOL

What is EURISOL?

NuPECC Long Range Plan 2010 Timeline RIB Facilities



WE LOOK FORWARD TO SEEING YOU AT ISOLDE