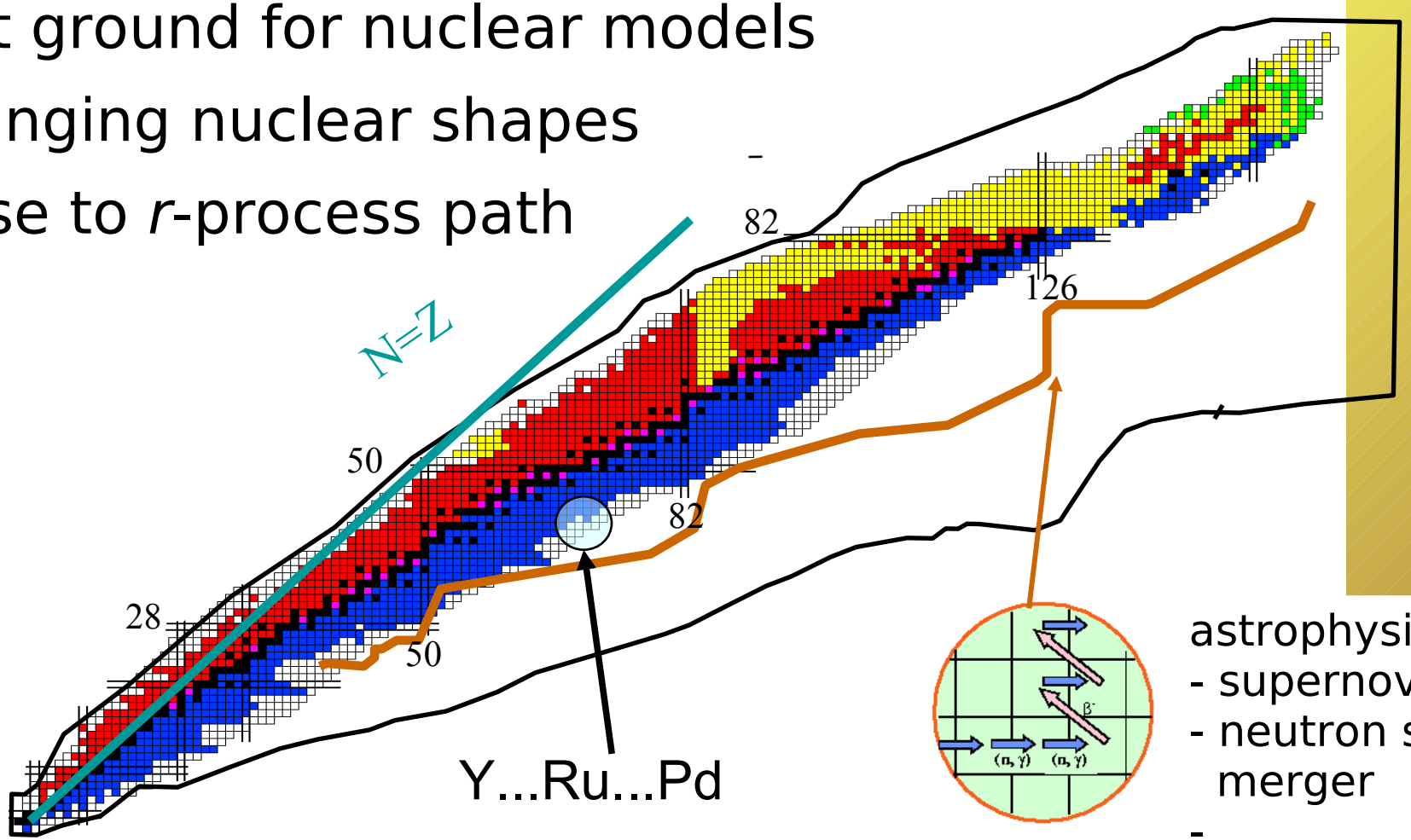
Spektroskopia egzotycznych, neutrono-nadmiarowych jąder o A≈115 za pułapką Penninga

Jan Kurpeta ZSJ IFD UW

Trap assisted spectroscopy

Region of interest

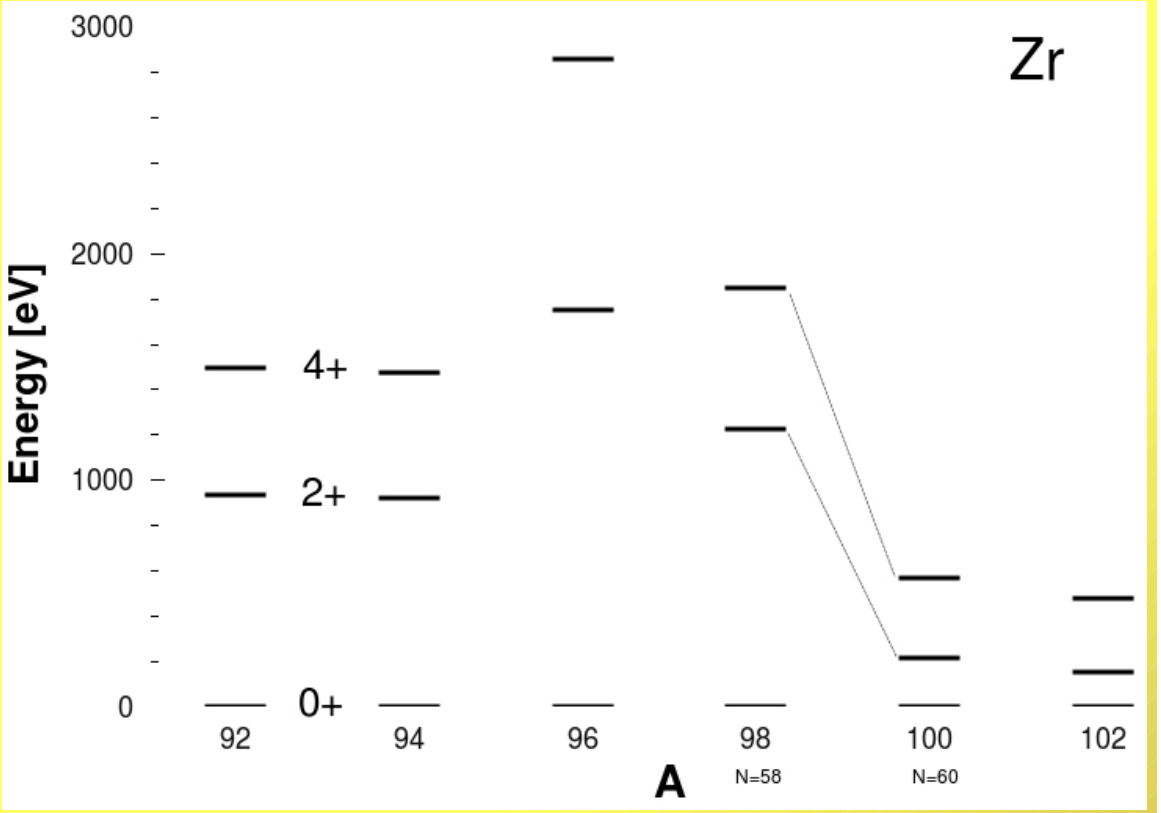
- structure of nuclei far from stability and closed shells
- test ground for nuclear models
- changing nuclear shapes
- close to *r*-process path

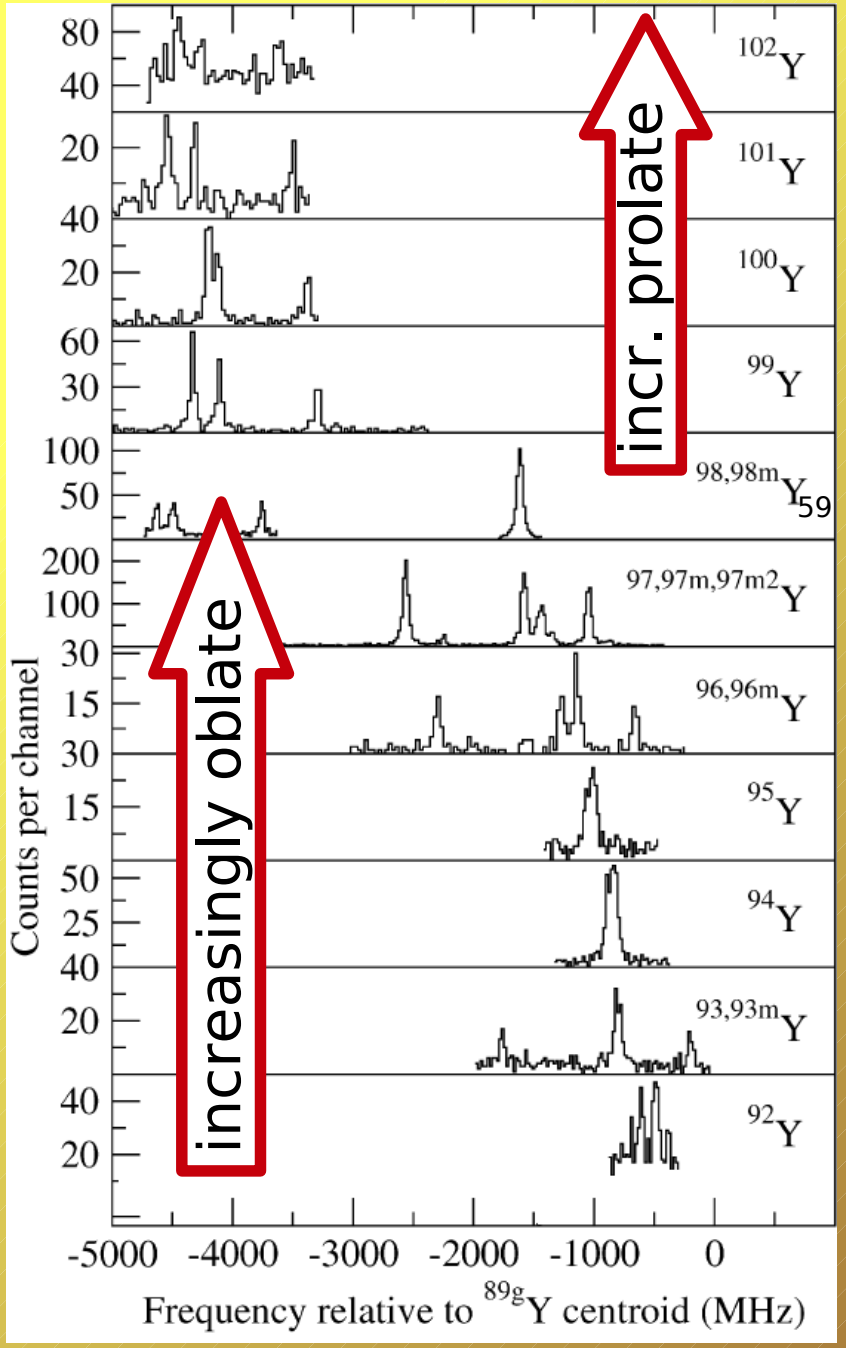


***r*-process**

astrophysical site:
- supernova
- neutron stars merger
- ...

Deformation and shapes

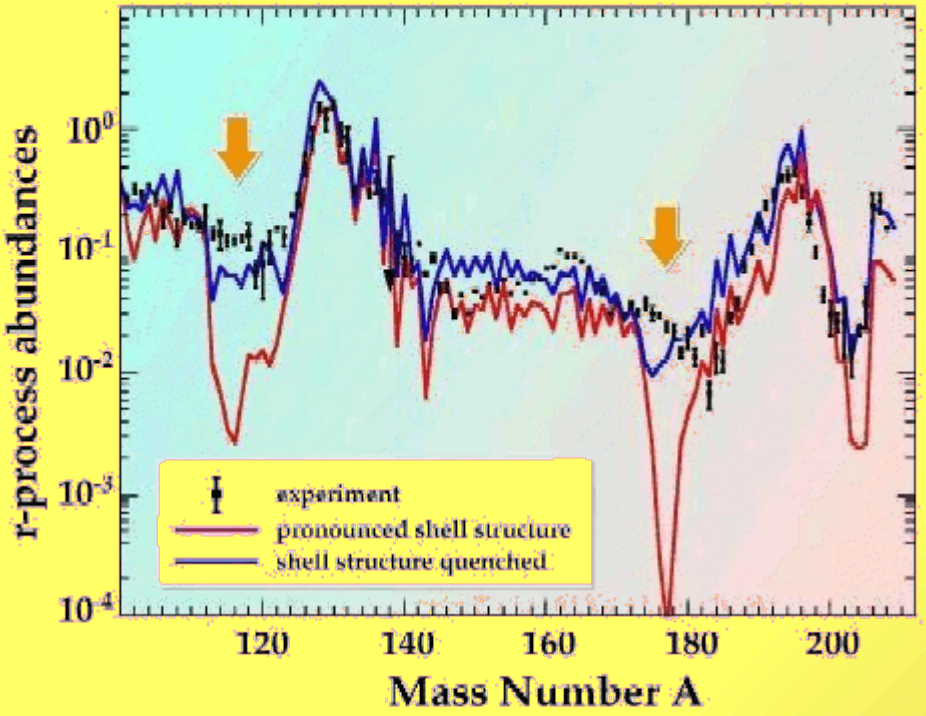


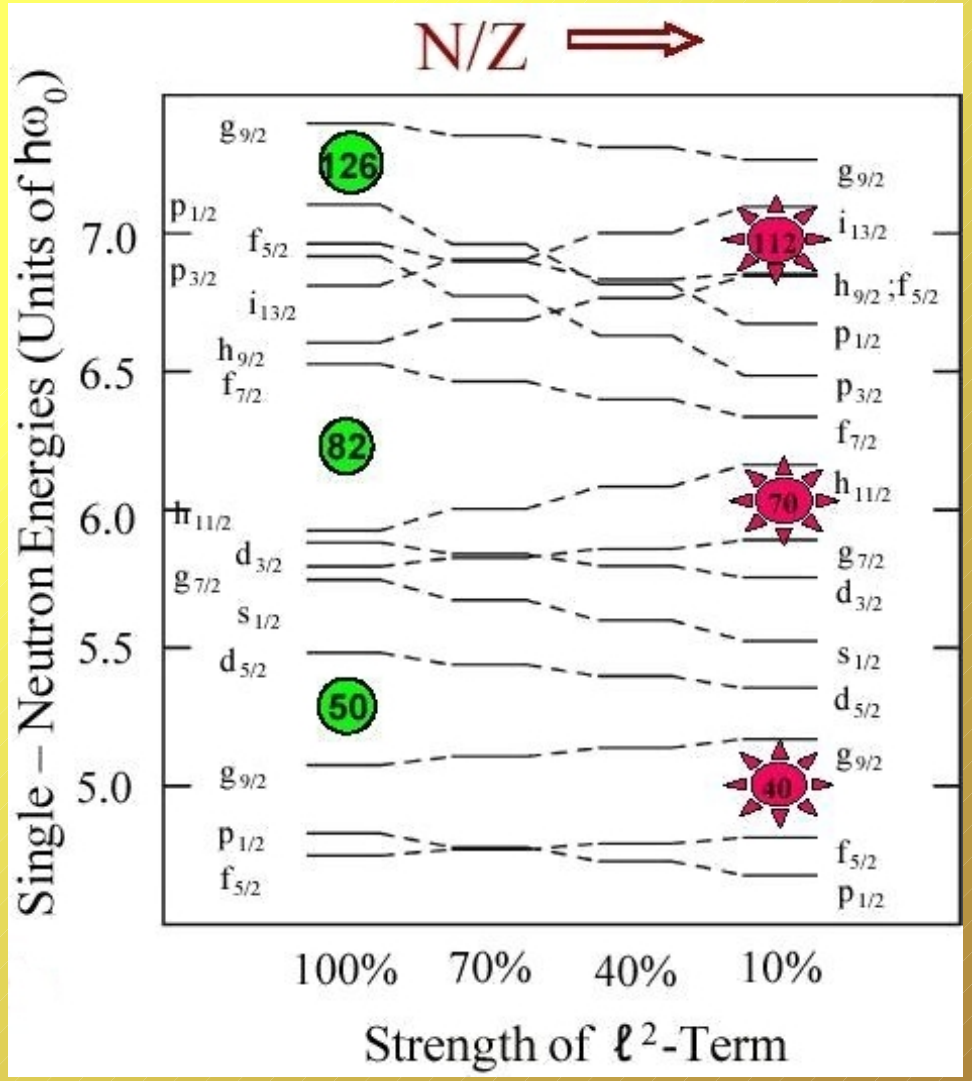


B. Cheal et al., Phys. Lett. B 645, 133 (2007)

γ spec.: onset of deformation in Zr
laser spec.: shape transition in Y

r-process and nuclear structure





weakening of shell structure
-> new magic numbers (?)

r-process modelling: beta decay half-life, bounding energy, neutron separation energy

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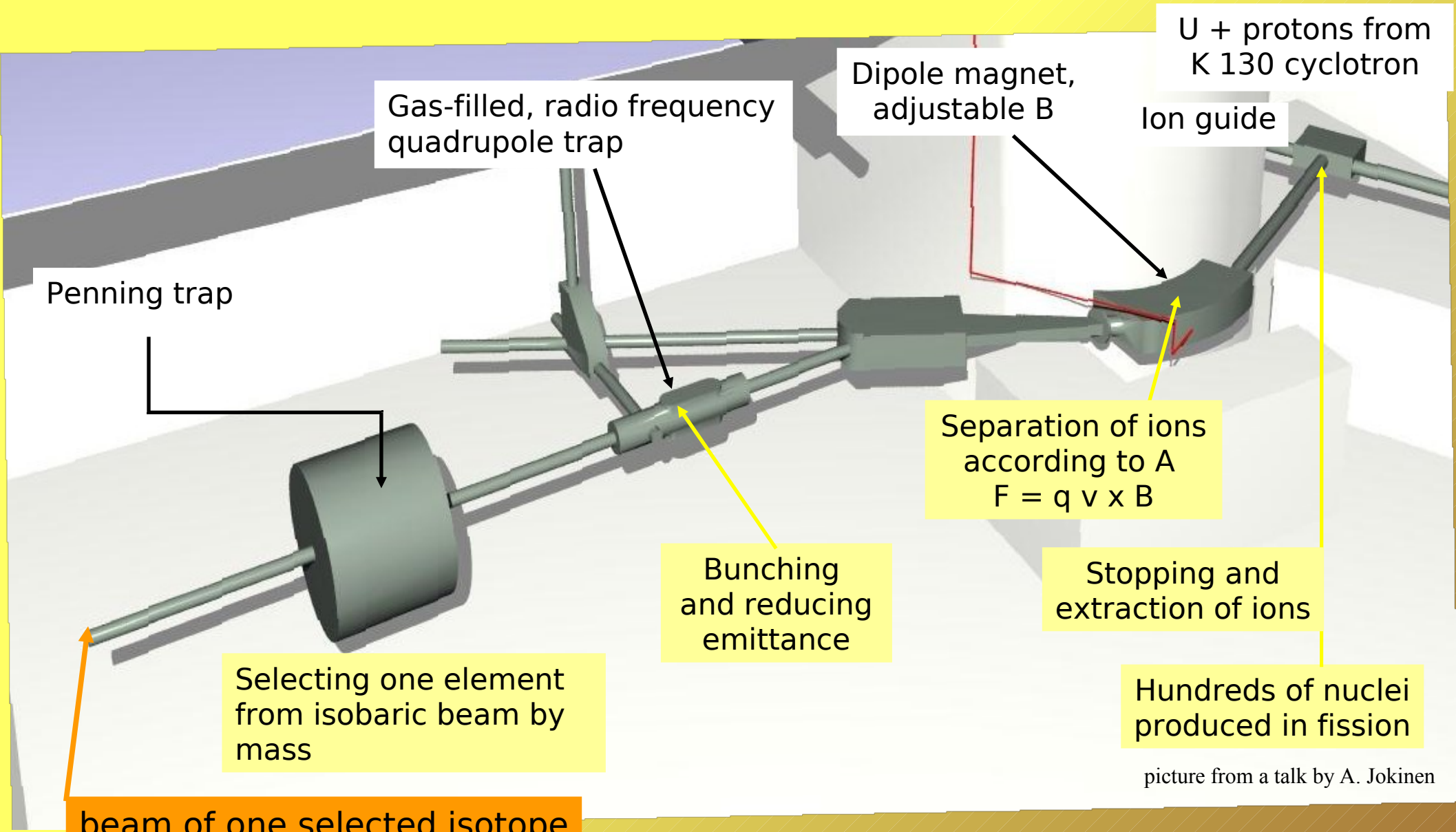
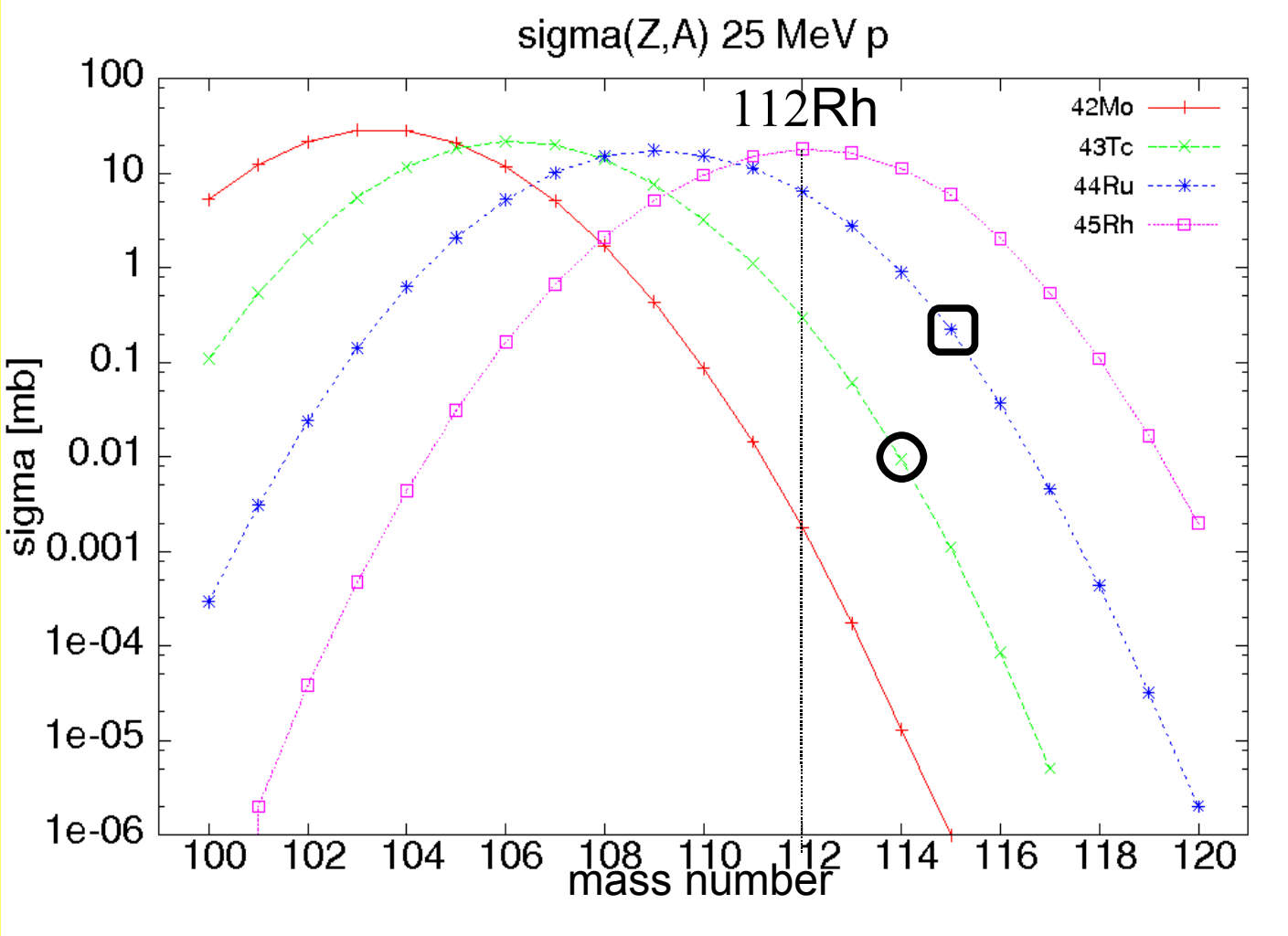
Making monoisotopic beam for spectroscopy



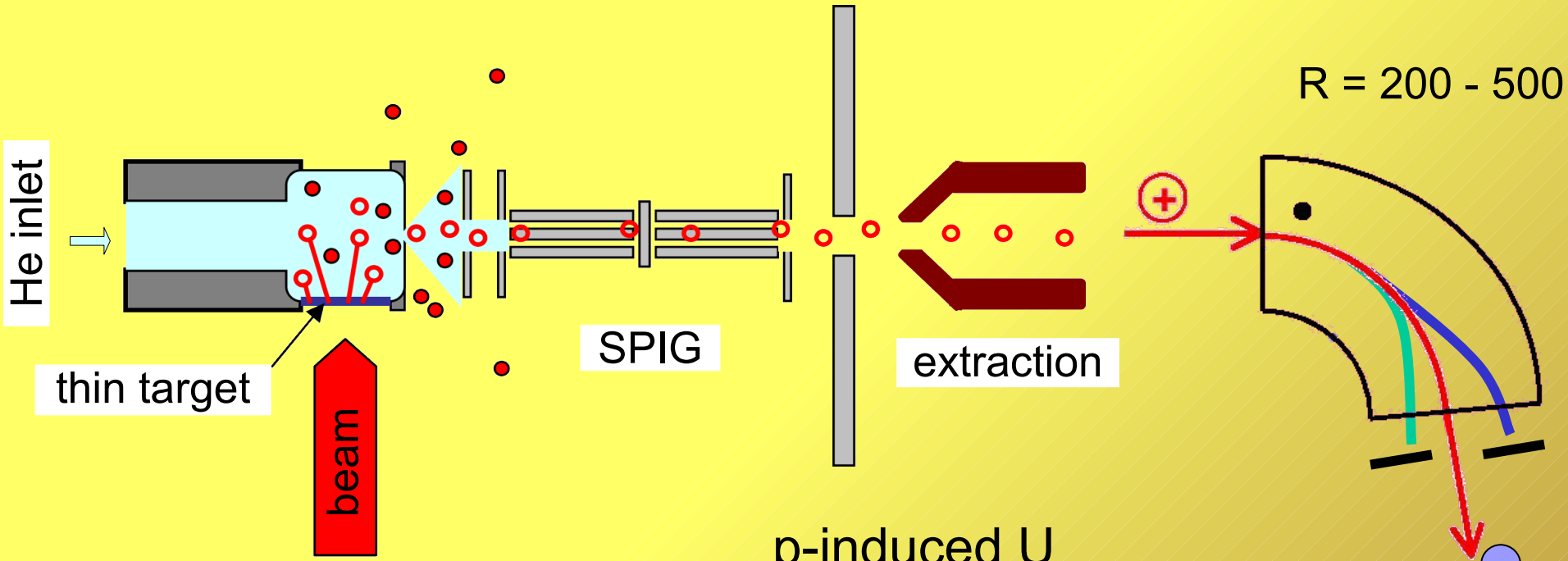
picture from a talk by A. Jokinen

Production of exotic nuclei in fission



Uranium target fission induced by 20-30 MeV protons

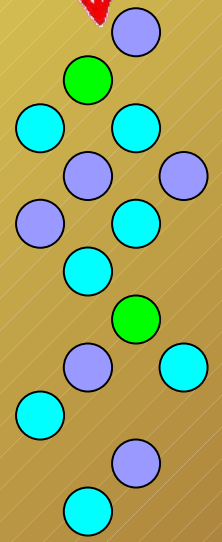
IGISOL operation principle



p-induced U
fission products
+ IGISOL

- stopping in He
- fast (~ 1 ms)
- no chemical selectivity

neutron-rich isotopes
of refractory elements



isobaric beam

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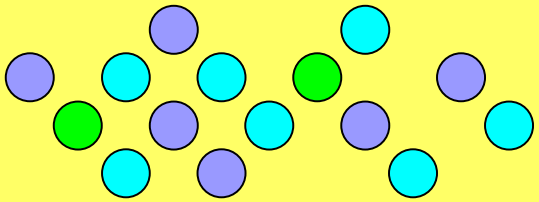
Removing unwanted isobars

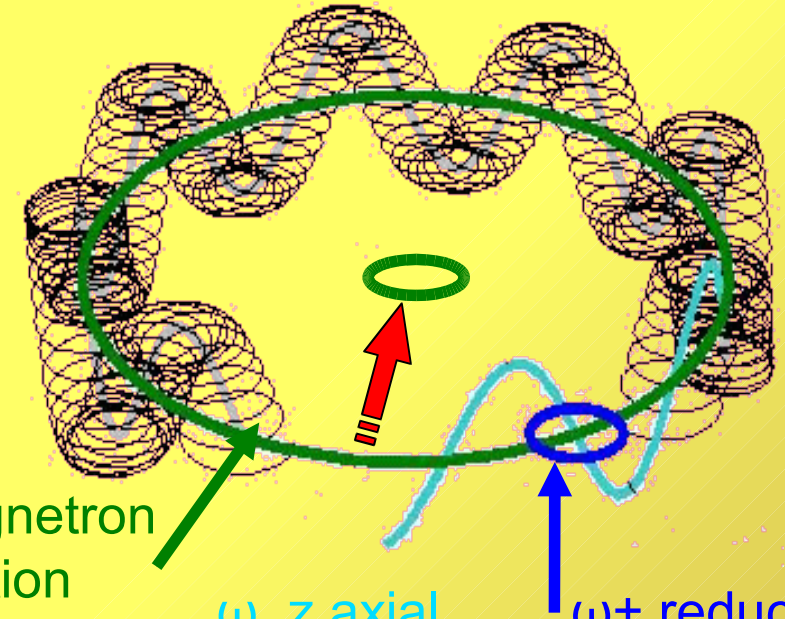


isobaric beam

trap

monoisotopic beam

β-γ, γ-γ coincidence spectroscopy



Highly **mass selective centering** of ions

- quadrupole excitation ω_c couples ω- and ω+ motions
- buffer gas cools fast motion
- final magnetron orbit only for ions with ω_c

$$\omega_c = \omega^- + \omega^+ = q\,B/m$$

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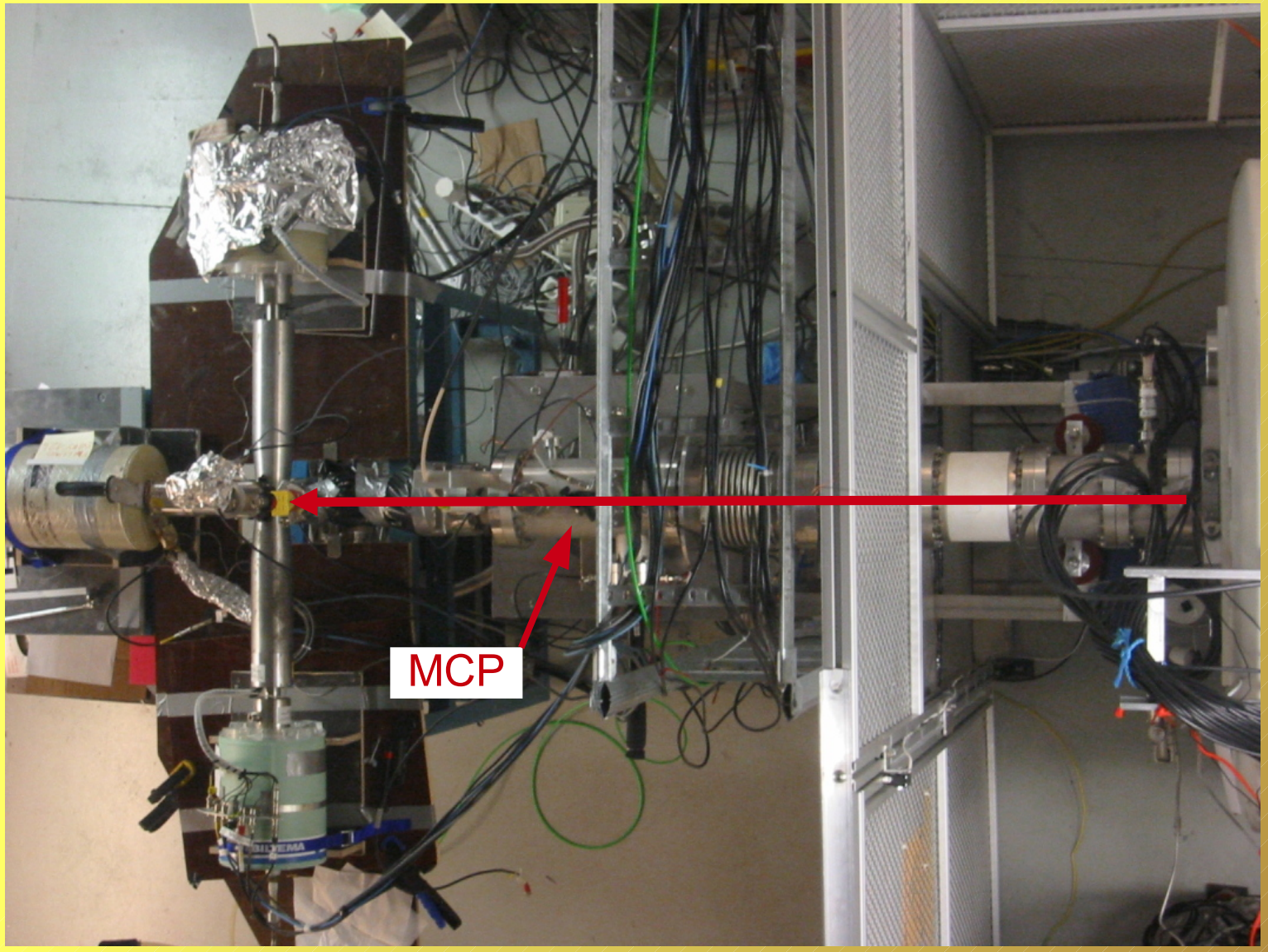
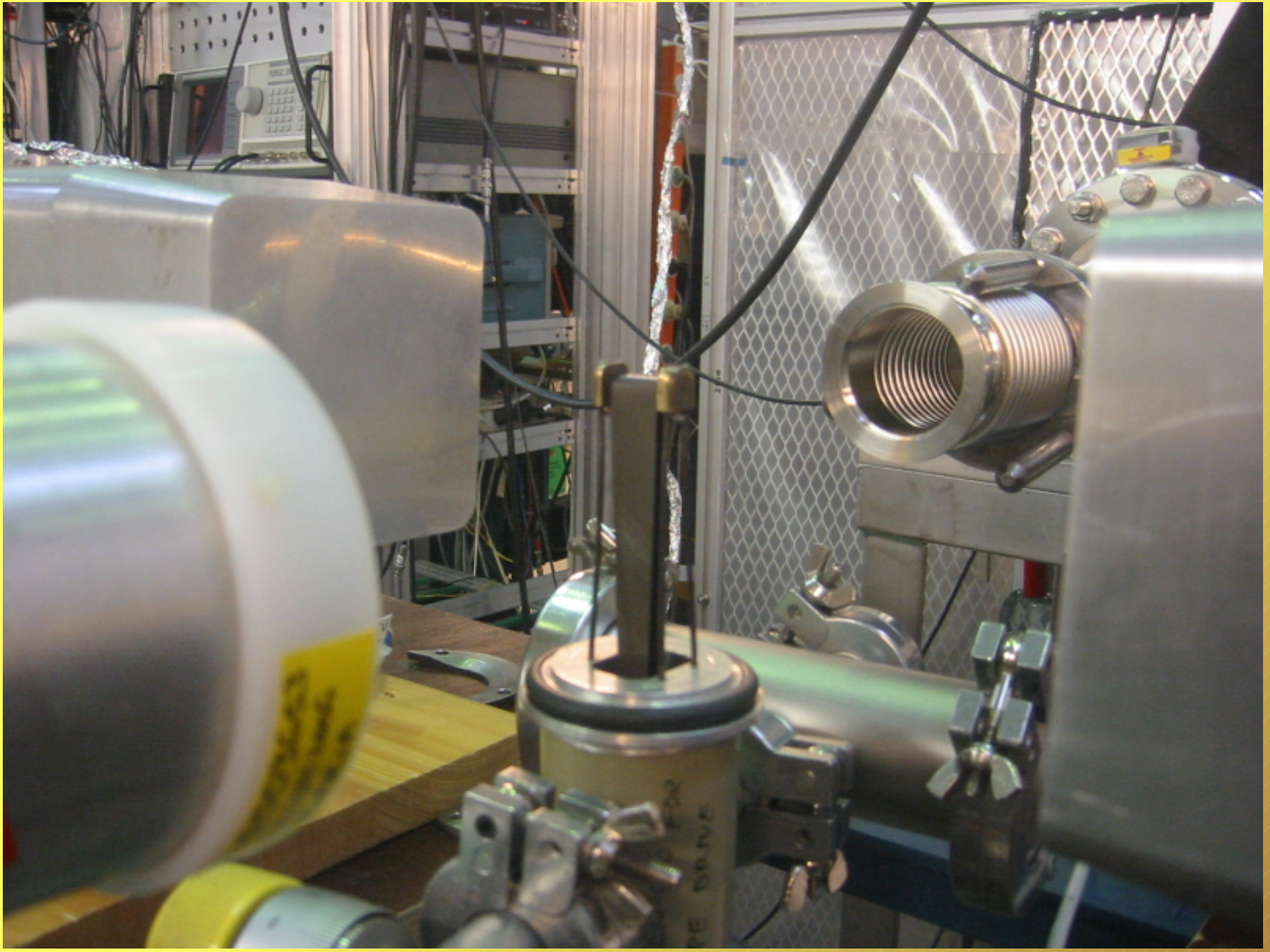
Detector setup after the trap

Gamma-gamma and beta-gamma coincidences



Implantation point



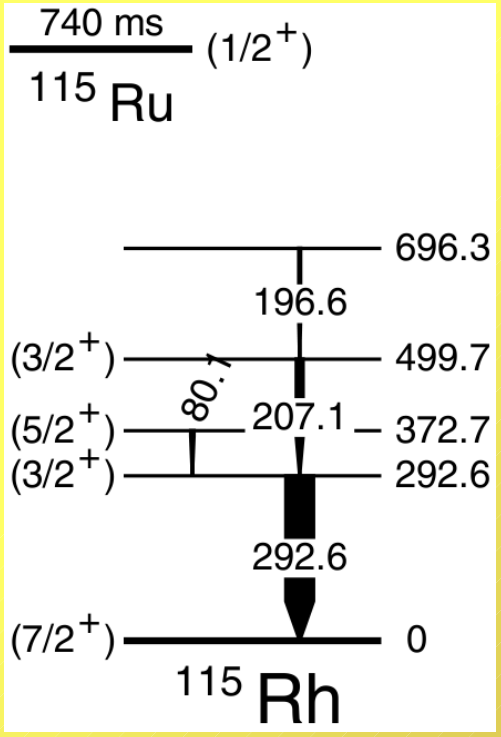
Evolution of 115Ru decay scheme

IGISOL

292.8 keV

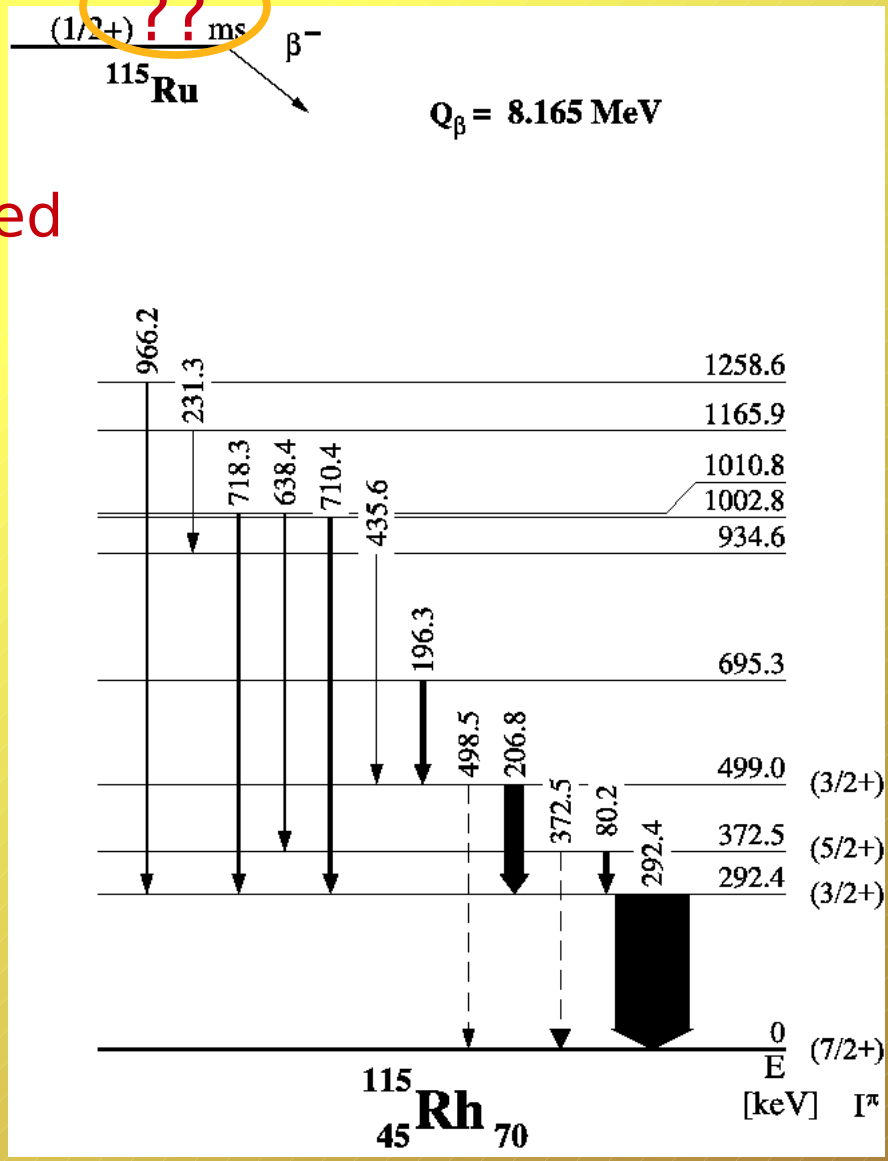
Rh Kα X-ray, β coinc.

Phys. Rev. Lett. 69, 1167 (1992)



trap assisted

Eur. Phys. J. A 31, 263 (2007)



Act. Phys. Pol. B 41, 469 (2010)

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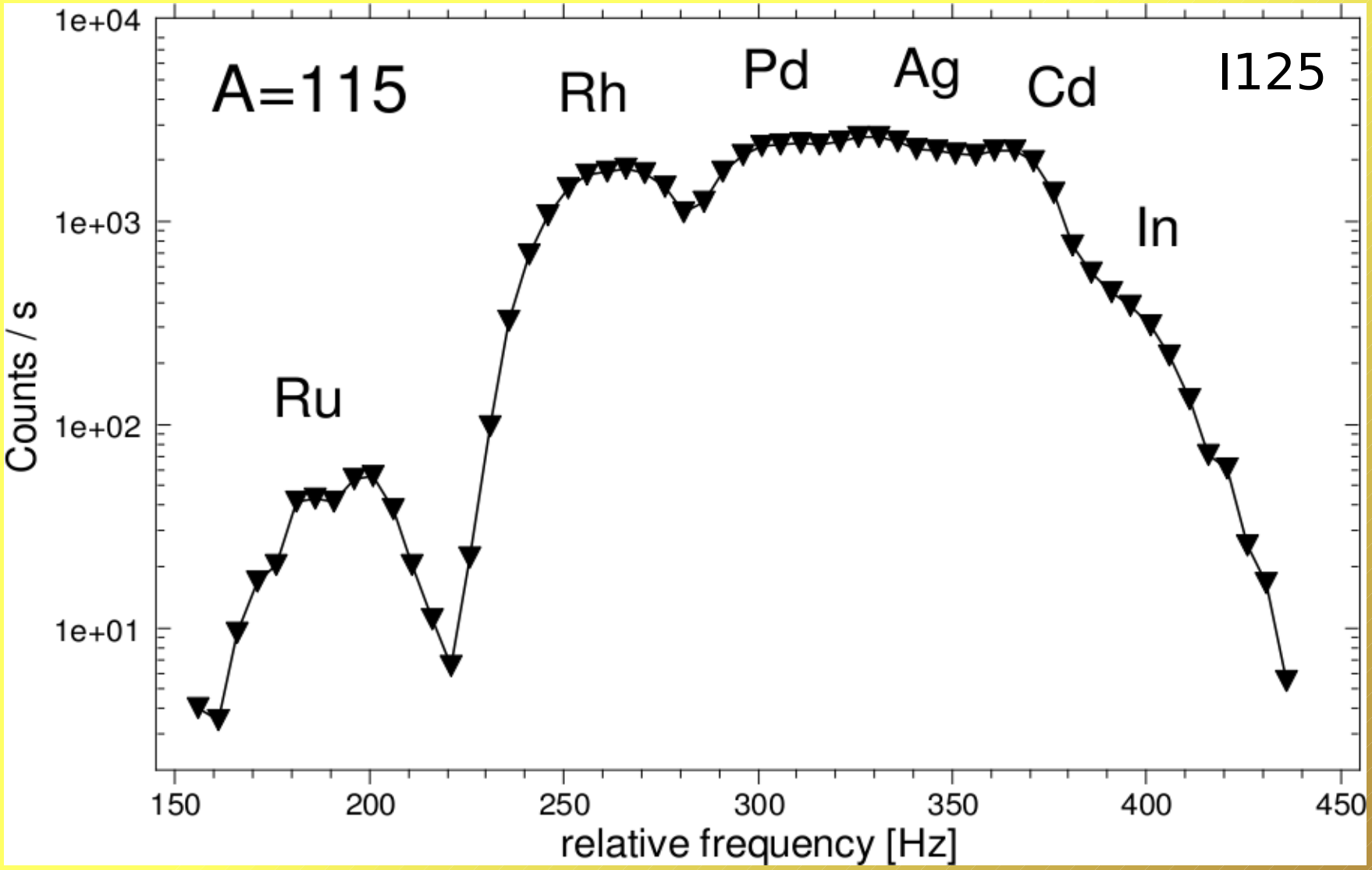
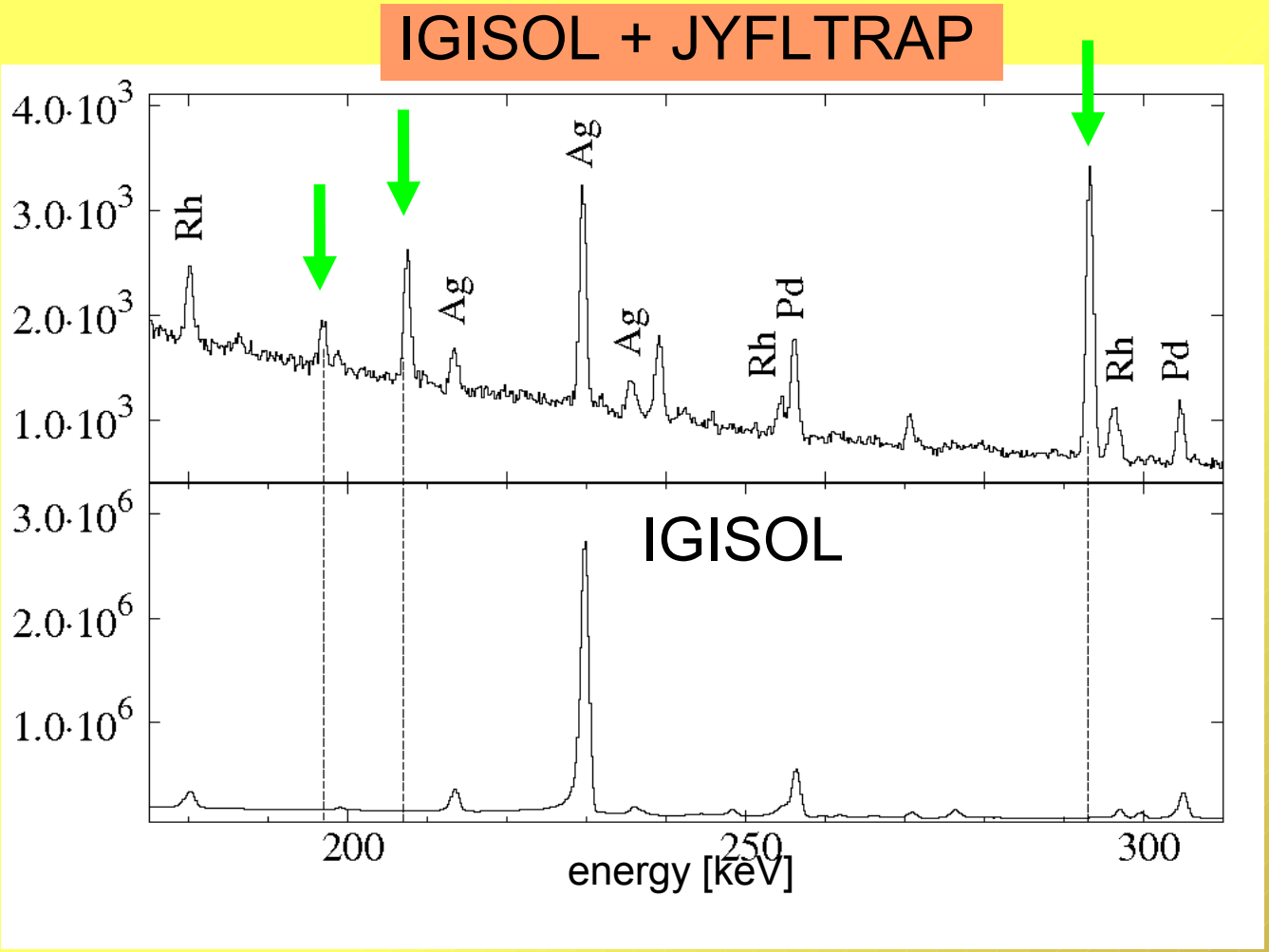
Trap separated A=115 isobars

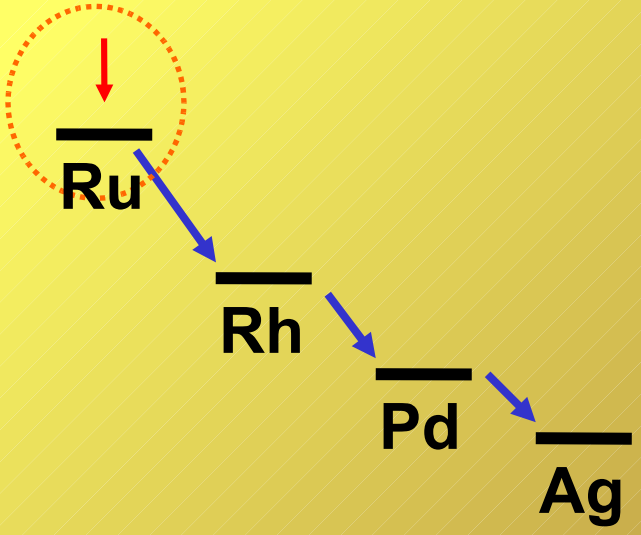


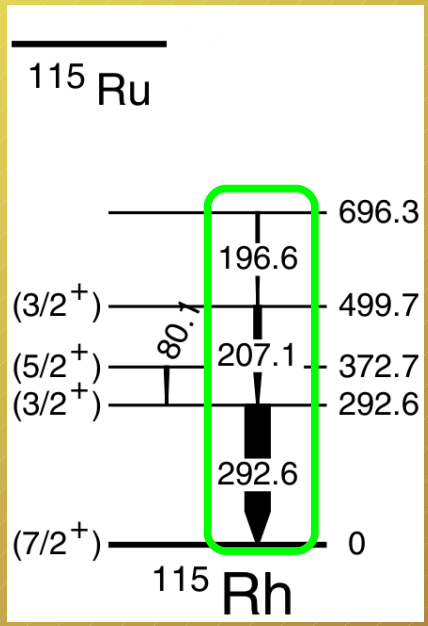
MRP ~ 30000

115Ru 2006: 15 2008: 50 [ions/sec]

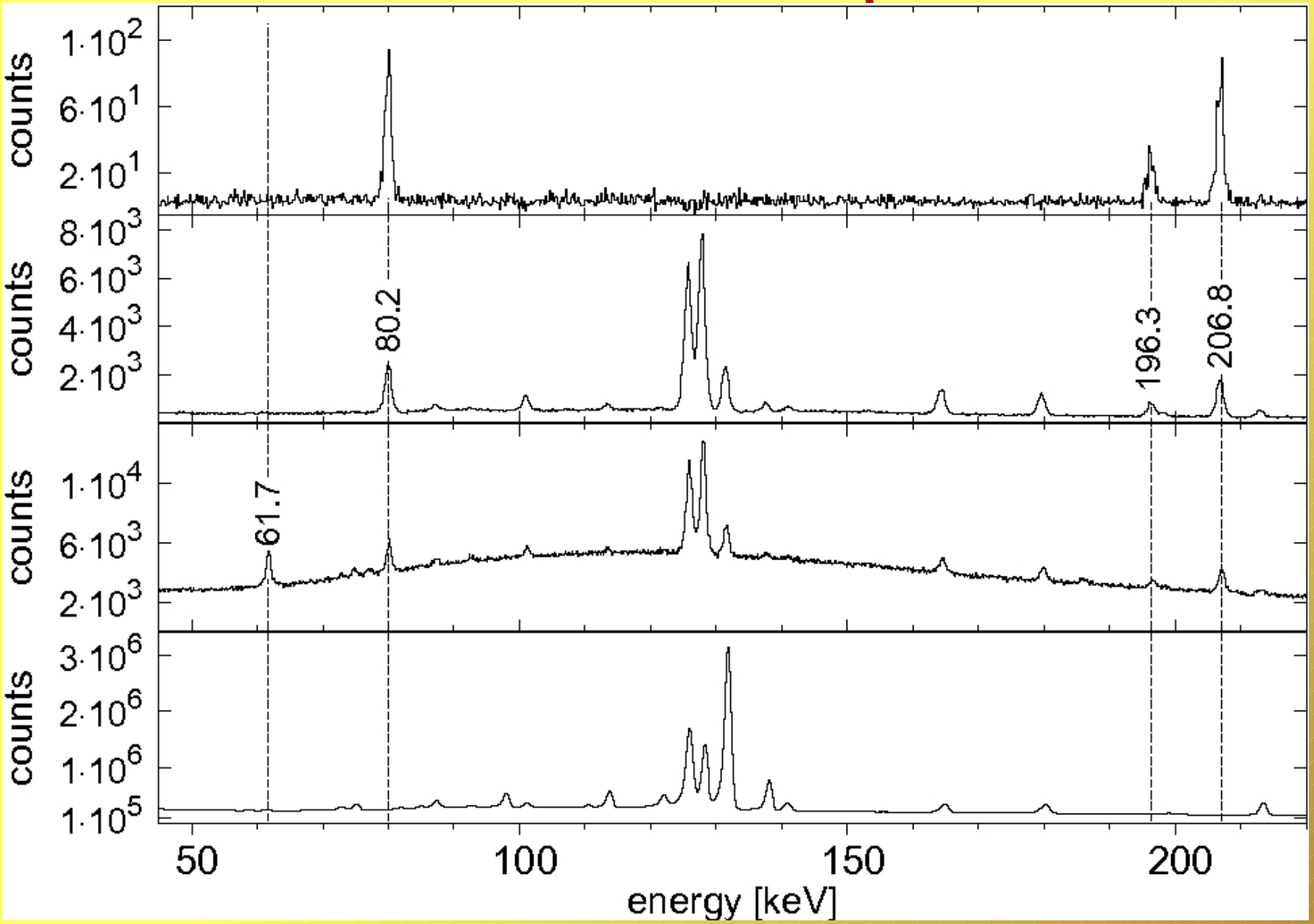
JYFLTRAP versus IGISOL: 115Ru







115Ru: IGISOL + trap + coincidence



IGISOL + trap β gated γ gate 293

IGISOL + trap β gated

IGISOL + trap singles

IGISOL singles

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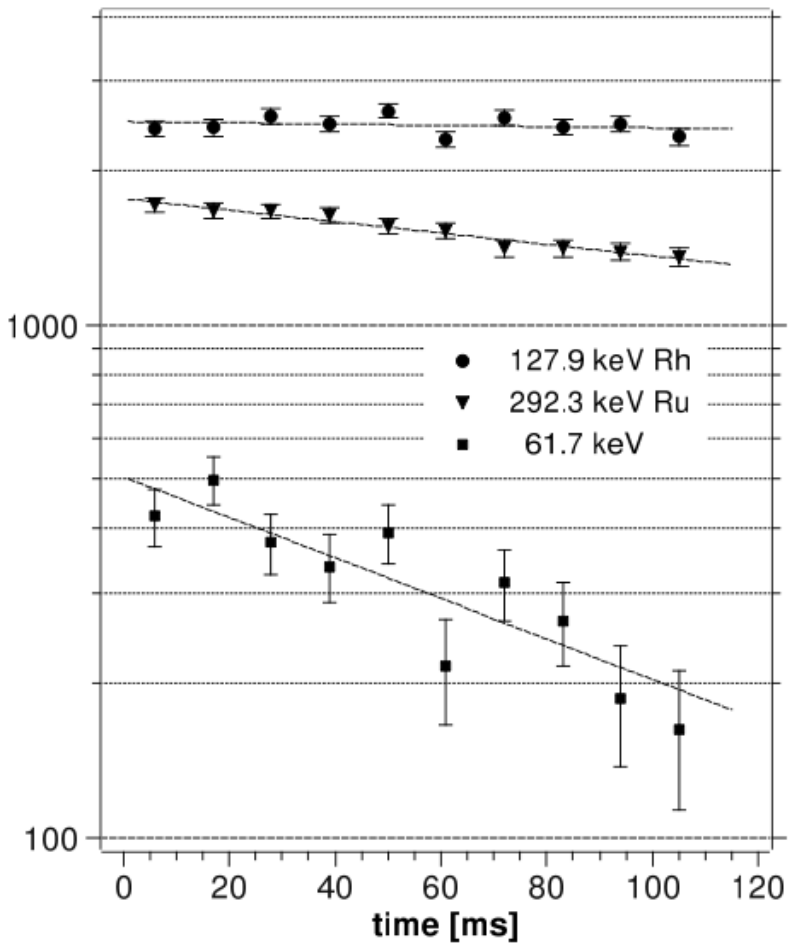
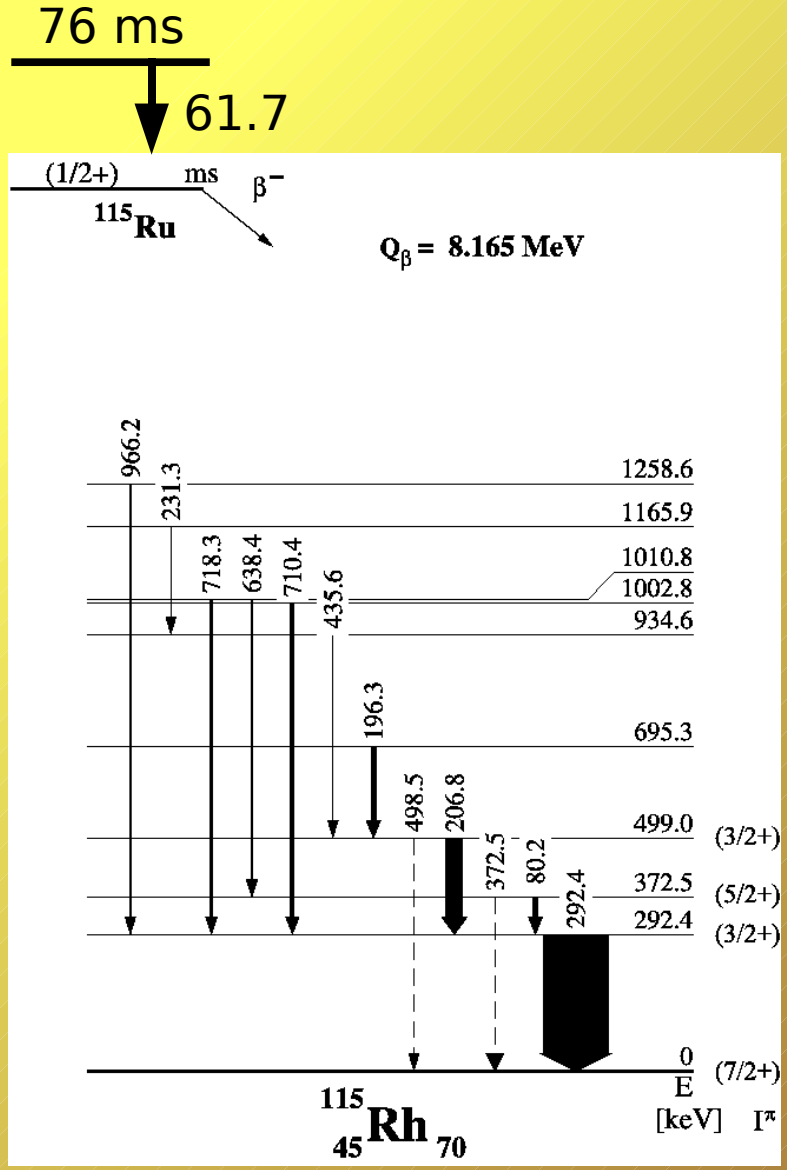
Isomeric state in 115Ru



Act. Phys. Pol. B 41, 469 (2010)



$T_{1/2}$(61.7 keV)= 76(14) ms

Half-life of the 115Ru ground state

Phys. Rev. Lett. 69, 1167 (1992)

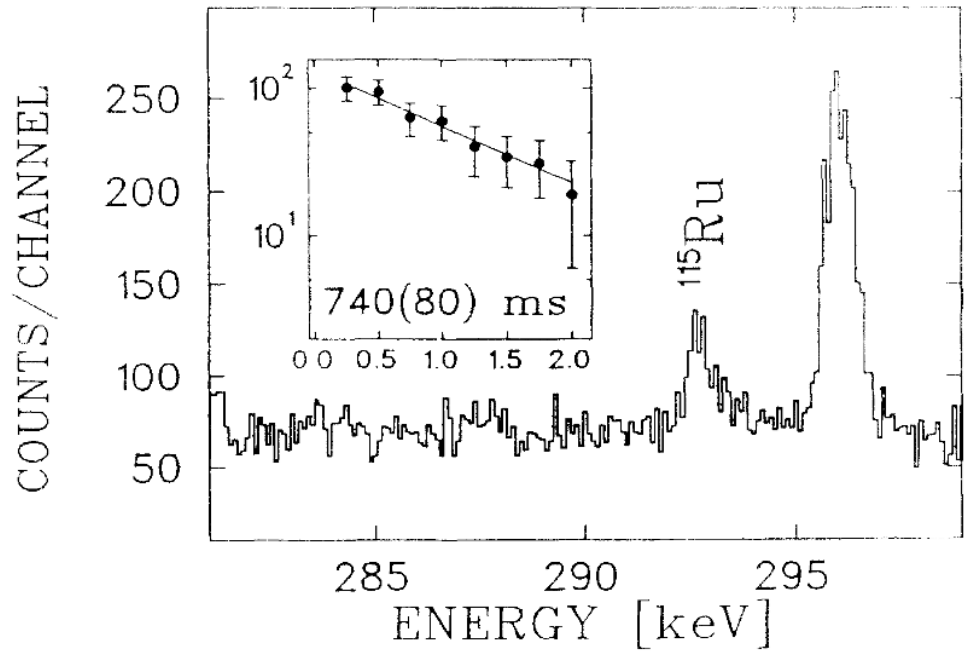
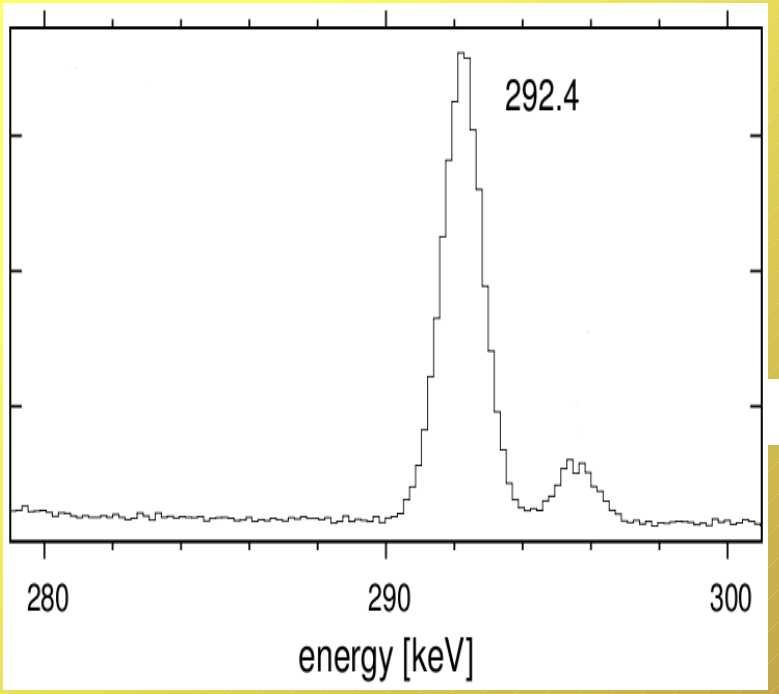
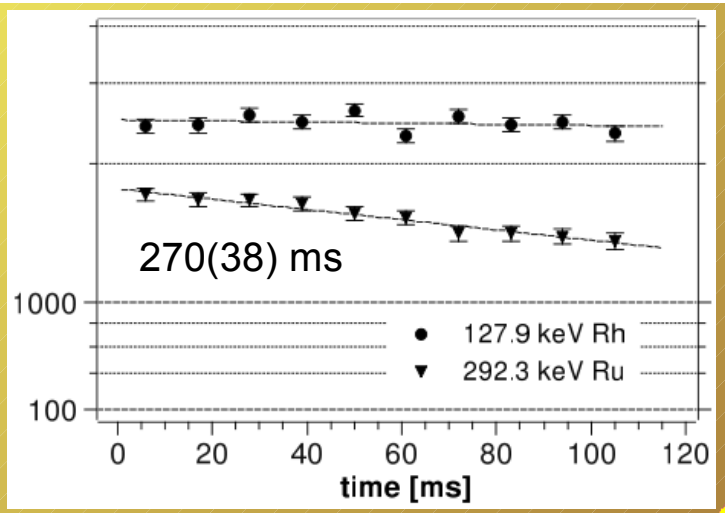


FIG. 2. Top: Time distribution of β-gated $K\alpha$ x rays of ^{107}Mo, the daughter of ^{107}Nb. Bottom: β-gated γ-ray spectrum for $A=115$ activities. Inset: The decay of the 292.8-keV peak due to the β decay of ^{115}Ru.





IGISOL: 740(80) ms time base 2.0 s

(293.6 keV fed by 115Pd β^- $T_{1/2}$=25 s)

IGISOL +Trap:

270(38) ms, time base 0.12 s

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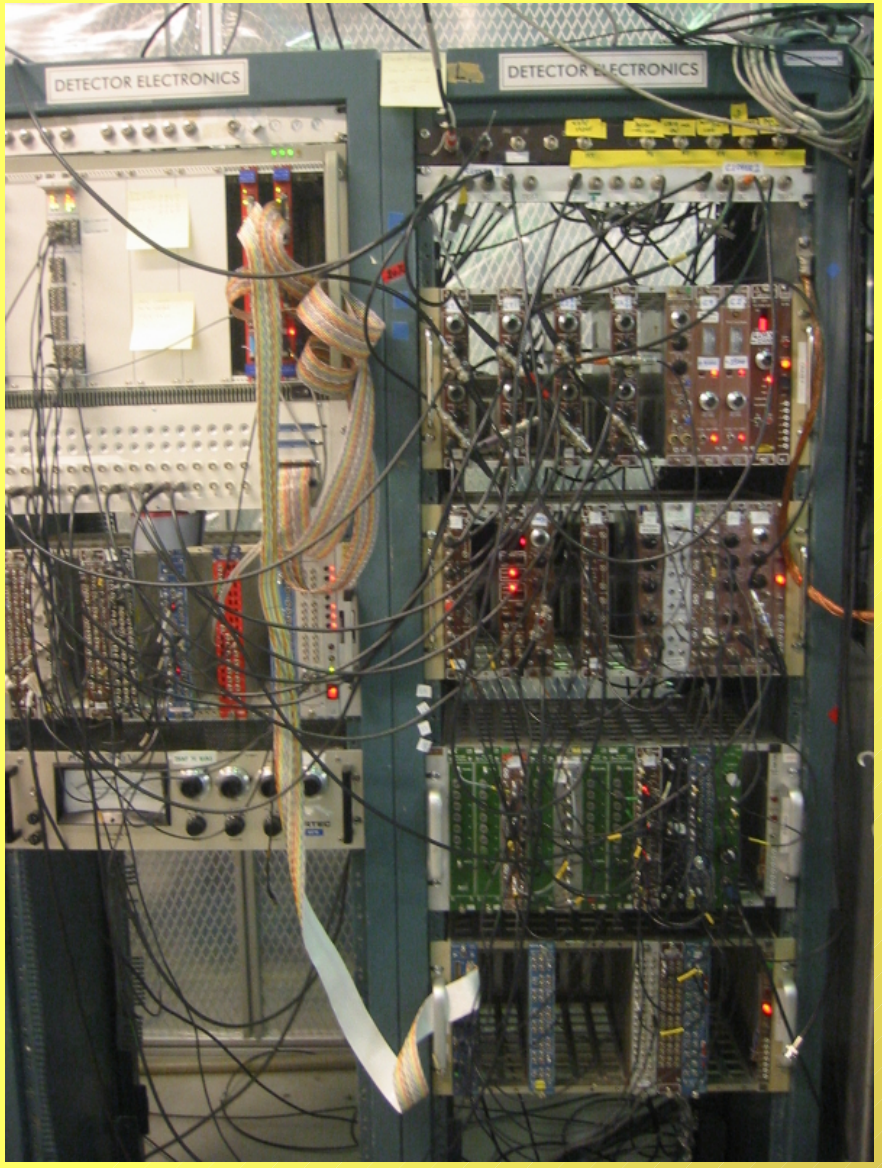
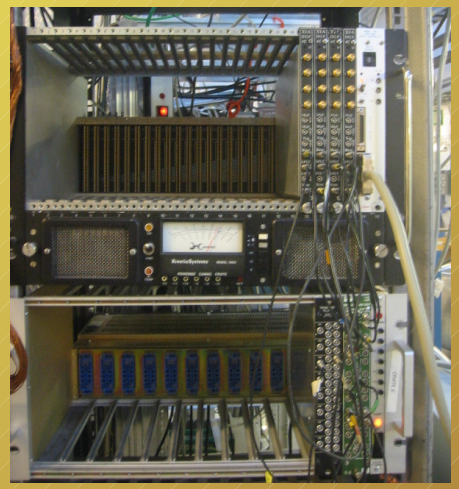
Analog and digital electronics



10 detector signals
3 timing signals



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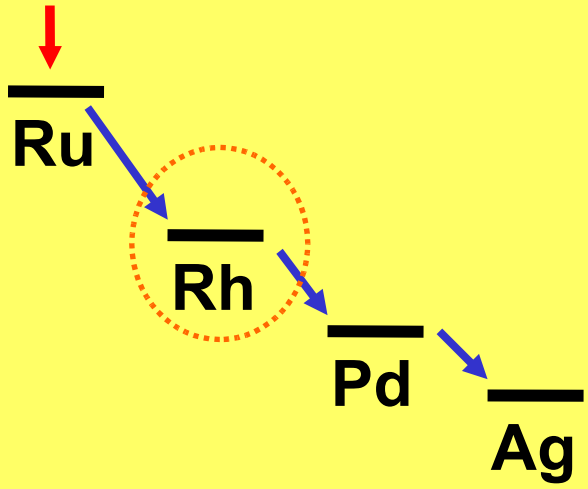
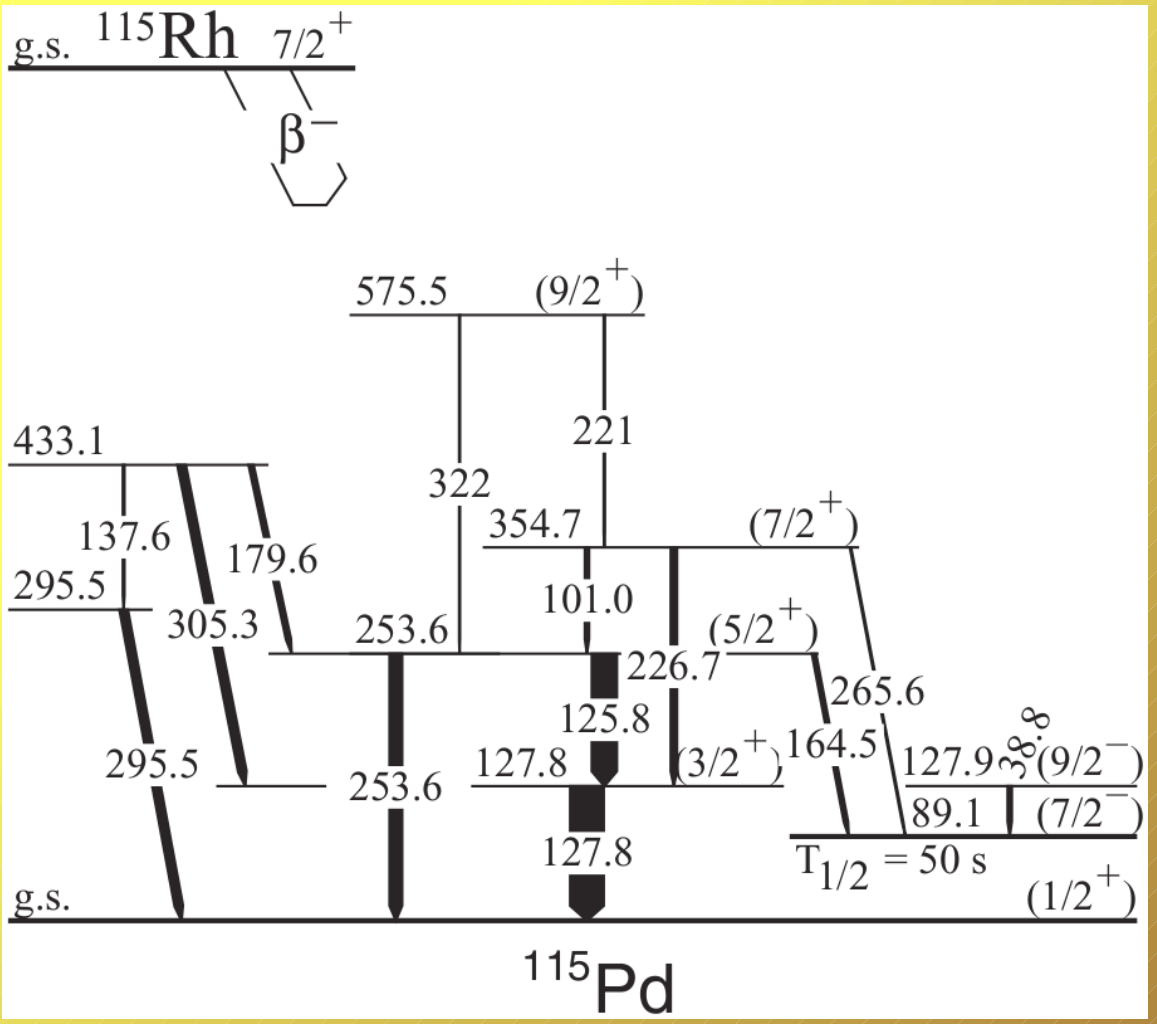
Summary for 115Ru

- 115Ru g. s. spin is most probably 1/2+
- 113Ru g. s. spin changed to 1/2+ based on β decay + fission data (Eur. Phys. J. A 33, 2007)
- isomer in 115Ru $T_{1/2}$=76(14) ms
- half-life of 115Ru ground state is about 300 ms
- projectile fragmentation 115Ru 405 +96 -80 ms F. Montes et al., PRC73, 2006
- extension of 115Ru beta decay scheme

Beta decay of 115Rh



Beta decay chain of monoisotopic 115Ru samples.



1/2+ spin and parity of 115Pd g. s. may be a hint for an oblate shape

Phys. Rev. C 82, 027306 (2010)

Future of IGISOL and JYFLTRAP

JYFL Accelerator News

Accelerator Laboratory, Department of Physics
University of Jyväskylä, Finland

Volume 18, No. 2 September 2010

Coming events:

November 15, 2010

Inauguration of the MCC30/15 Cyclotron

Attended by:
Minister of Education,
Henna Virkkunen

Future physics Workshop

To be organized in conjunction with the cyclotron inauguration

For more information, see
https://www.jyu.fi/physics

IGISOL move has started

Summer students dismounting vacuum components at IGISOL 3

IGISOL components are waiting for the concrete walls to be built up in the new experimental hall.

The last on-line runs - a delayed neutron emission study on fission products and a hot cavity laser ionisation test run - in the facility known as IGISOL 3 took place in June. Since then, the experimental area including the collinear laser line has been dismounted, packed and stored waiting to be re-built in the renewed IGISOL 4 facility in the extension hall of the accelerator laboratory. There the first layer of concrete blocks already mark the new target area.

In particular the IGISOL summer students and UK collaborators deserve special thanks for their efforts in this achievement. Even though taking things apart may be easier - and more fun - than putting them back together again, thus far the move has proceeded extremely smoothly.

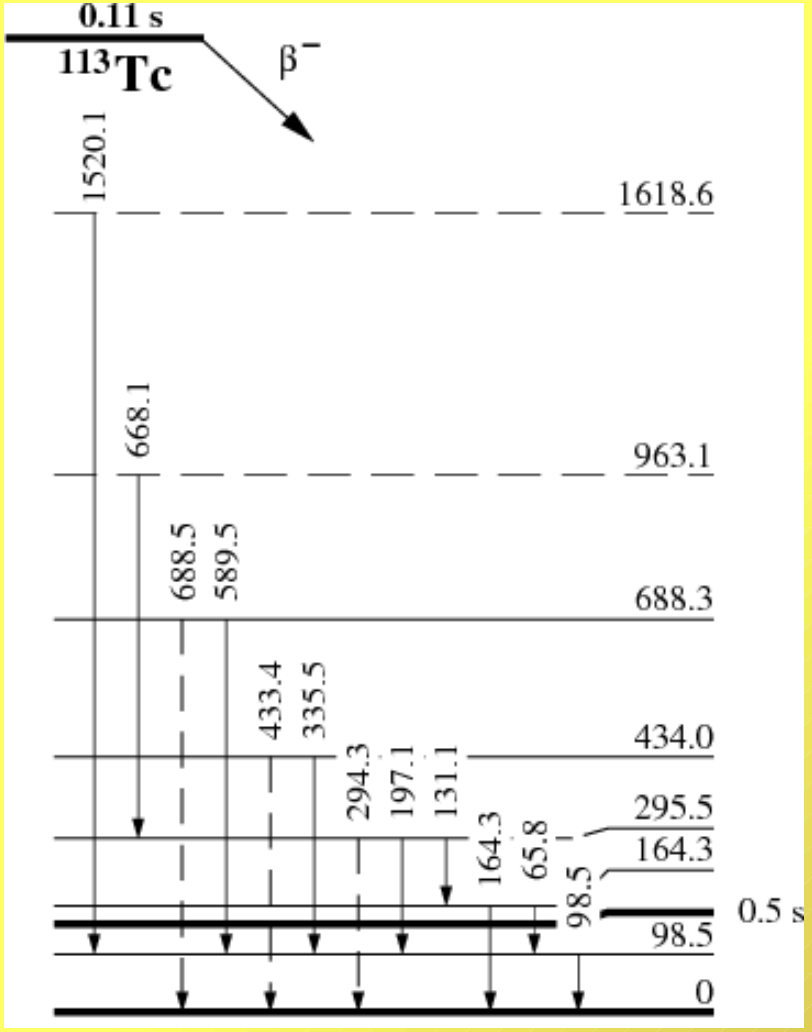
Although main parts of the old IGISOL 3 will be re-used the facility will face a major upgrade in the move. The beam-line lay-out will be modified and extended, new instruments will be installed. IGISOL 4 will have access to high–intensity light ion beams from the new MCC30/15 and a wide selection of heavy ion beams from the old K130 cyclotron. The whole IGISOL crew is heading to the coming long, dark and work-filled winter determined that next summer not only the SUN but also IGISOL 4 will rise and shine.


The End

Complementing fission data

beta decay feeds low spin structures based on the g.s.

spontaneous fission feeds high spin structures, often only relative energ. known

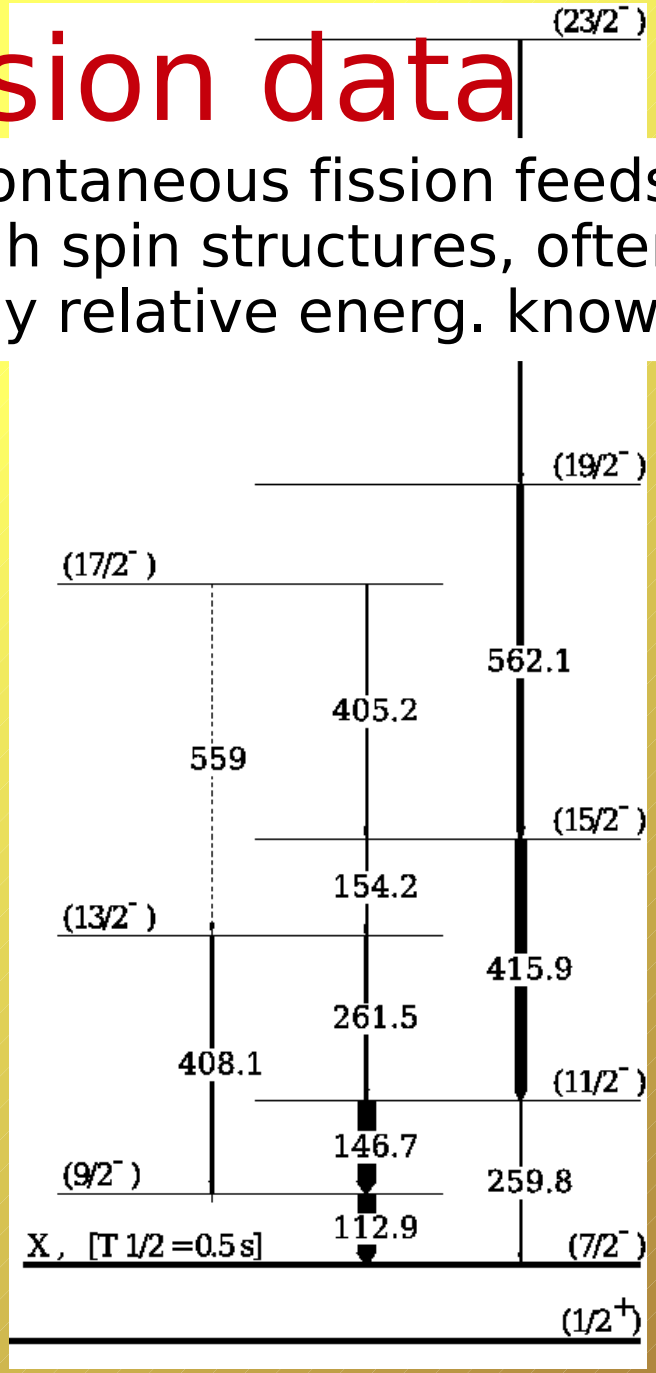


g.s. spin change

5/2+

1/2+

113Ru



Eur. Phys. J. A33, 307 (2007)

IFD UW ZSJ