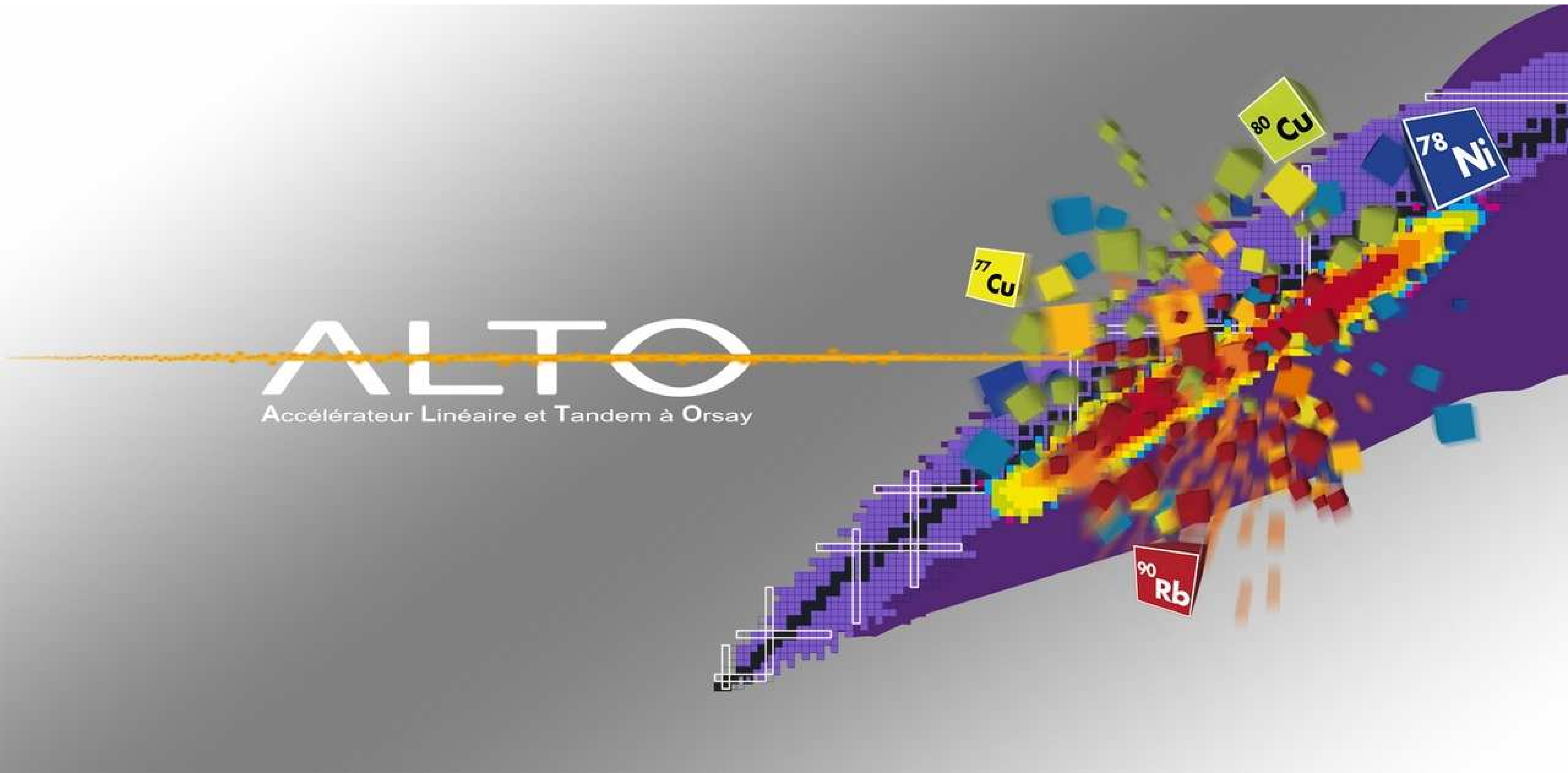
The Alto photofission facility at IPN Orsay

Serge Franchoo



The Alto facility

360 staff members
250 outside users (30 countries) /y

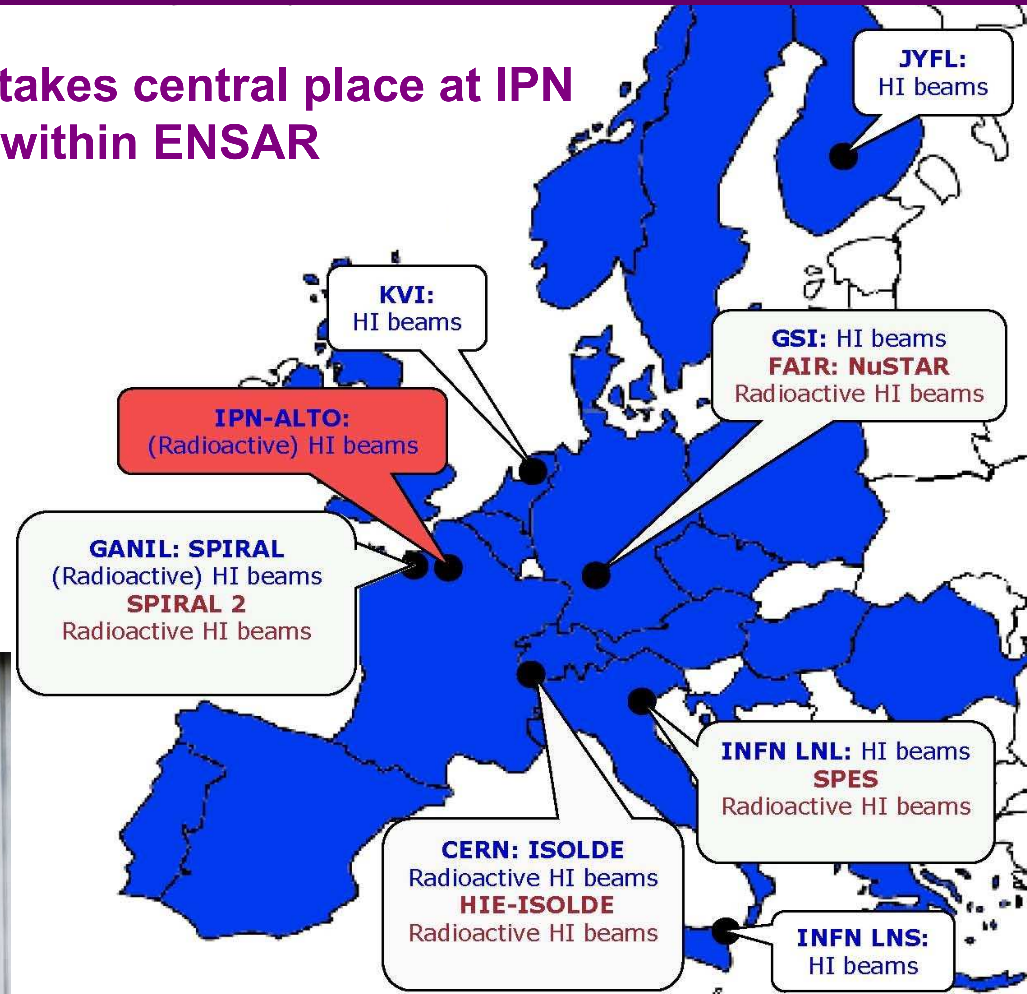
Stable beams (2013)	**3928 h /y**
25% light ion beams	984 h
75% heavy ion beams	1964 h
RIB (2013)	**360 h /y**

IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

UNIVERSITÉ PARIS SUD

The Alto facility

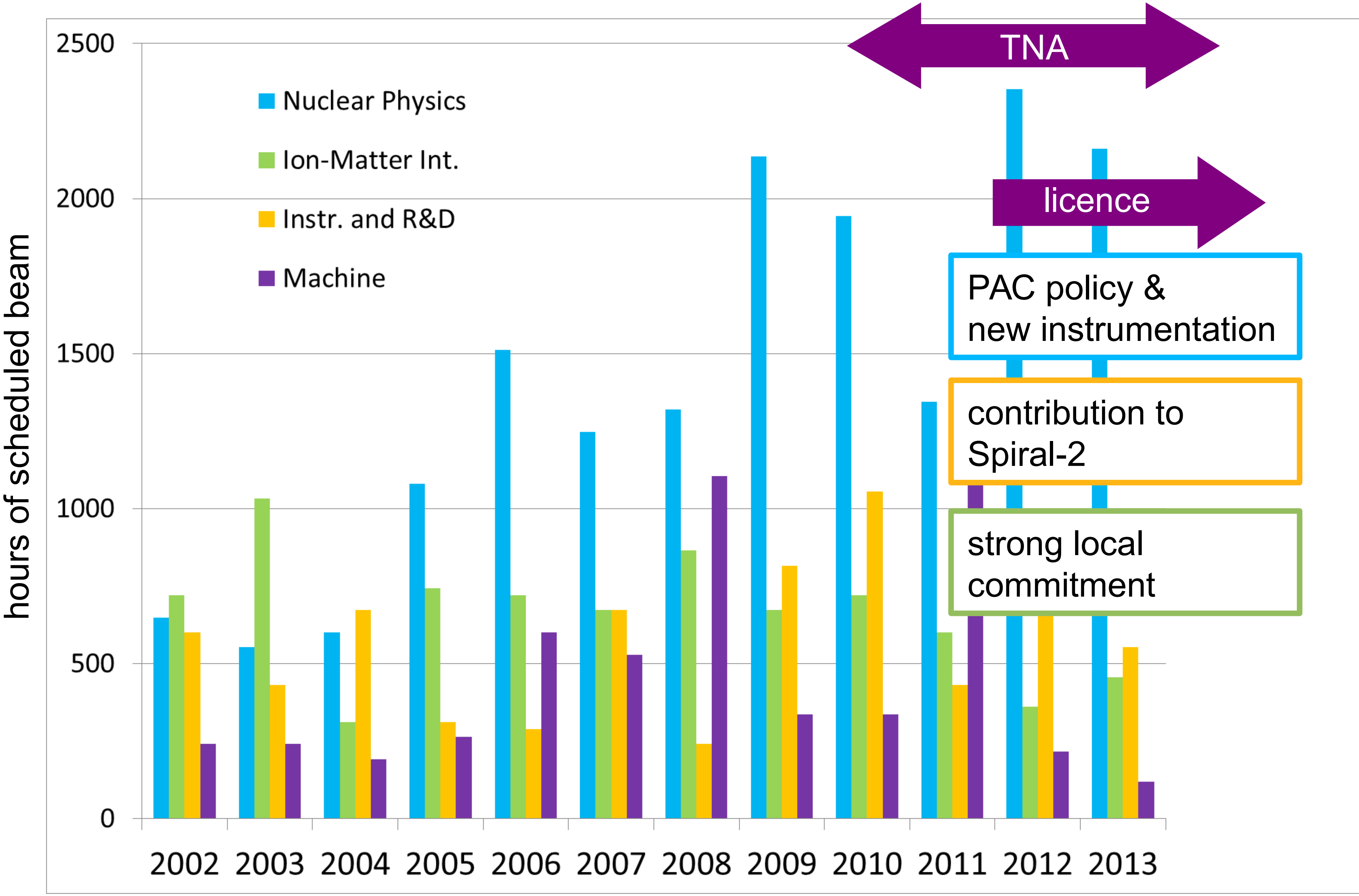
Alto takes central place at IPN TNA within ENSAR



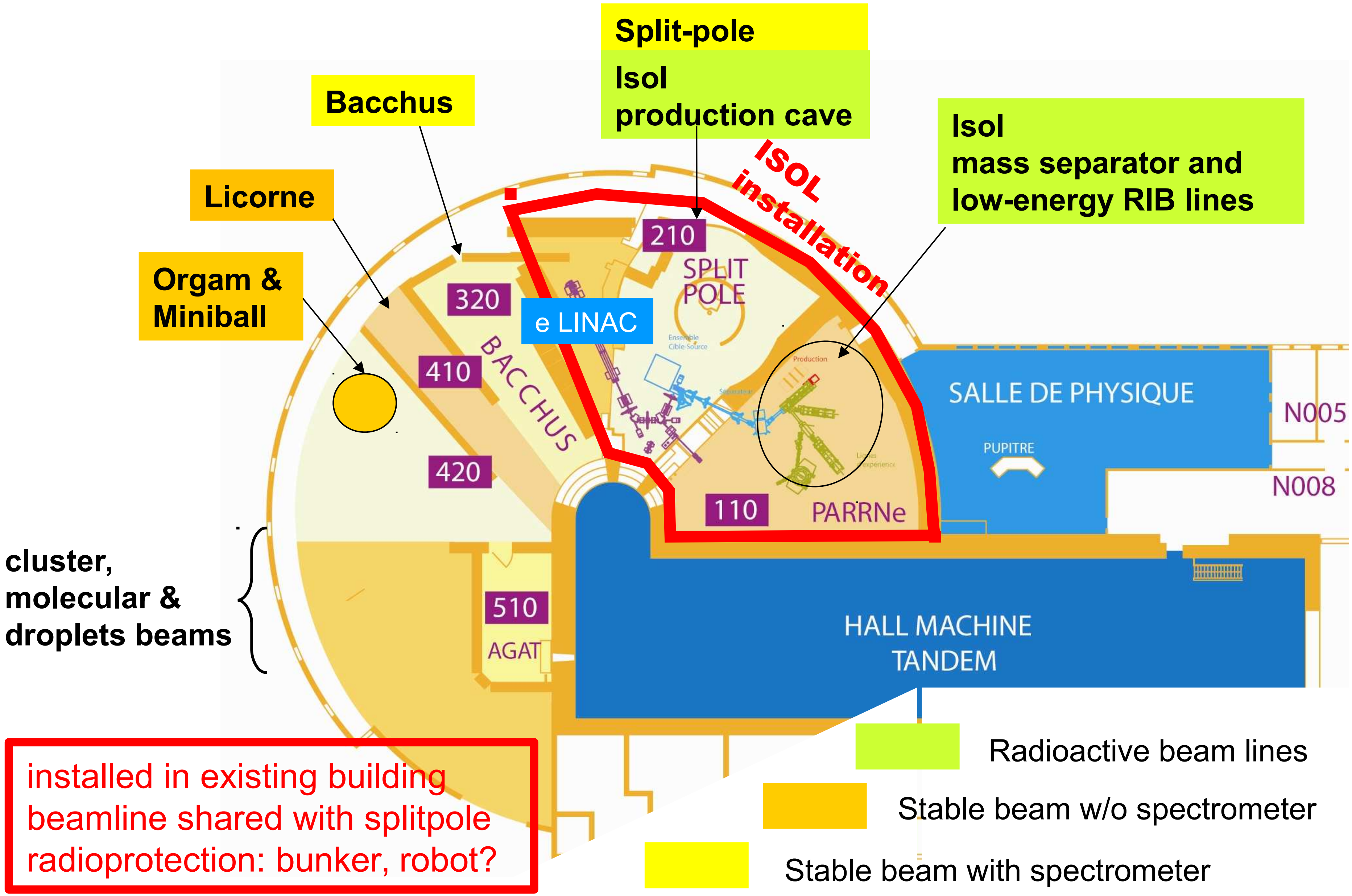
March 2012: operating licence

May 2013: Alto workshop

The Alto facility



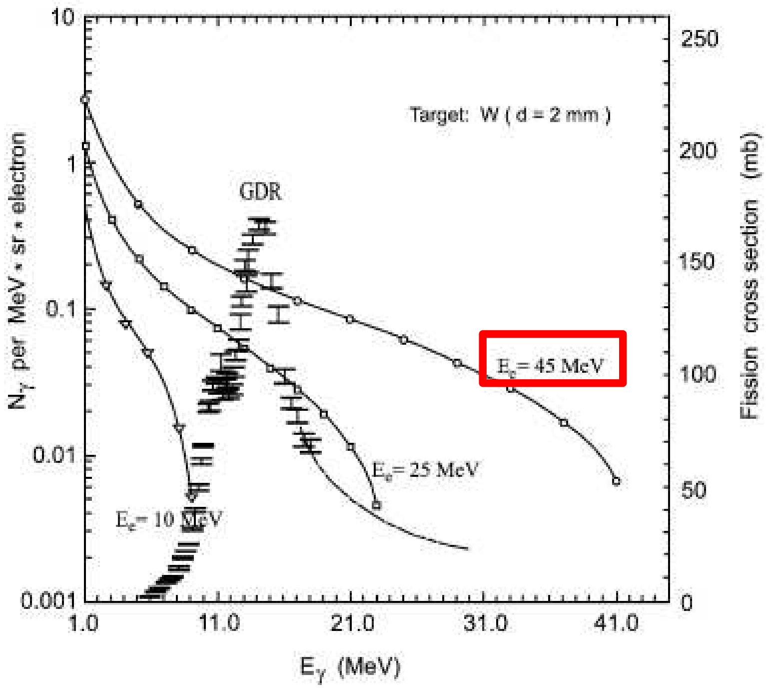
The Alto facility

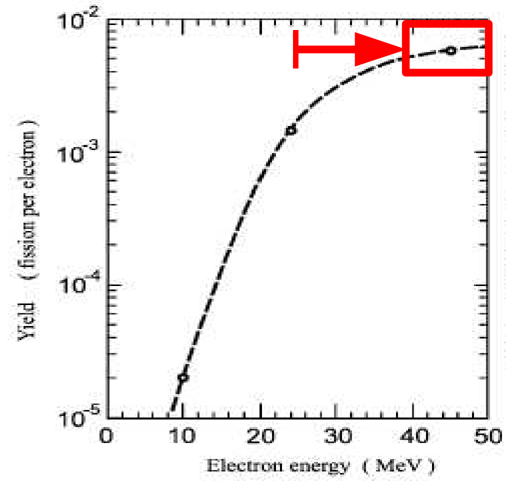


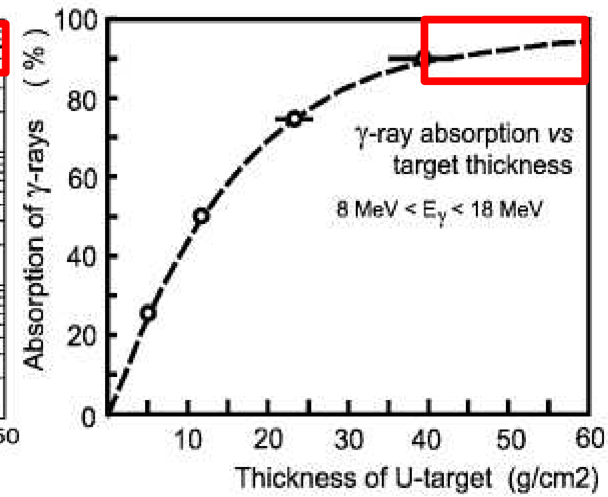
installed in existing building
beamline shared with splitpole
radioprotection: bunker, robot?

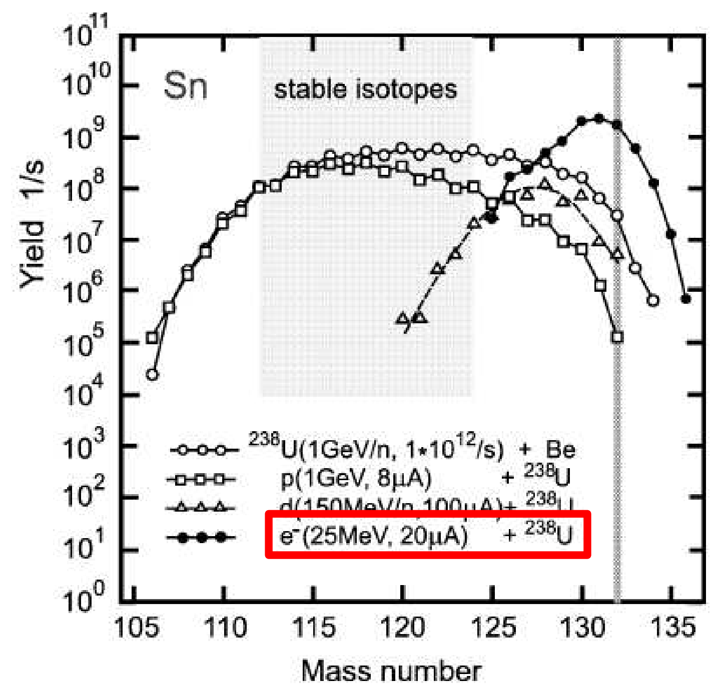
Photofission

20 μA 25 MeV e^- + 40 g/cm^2 ^{238}U
1.5 10^{11} f/s





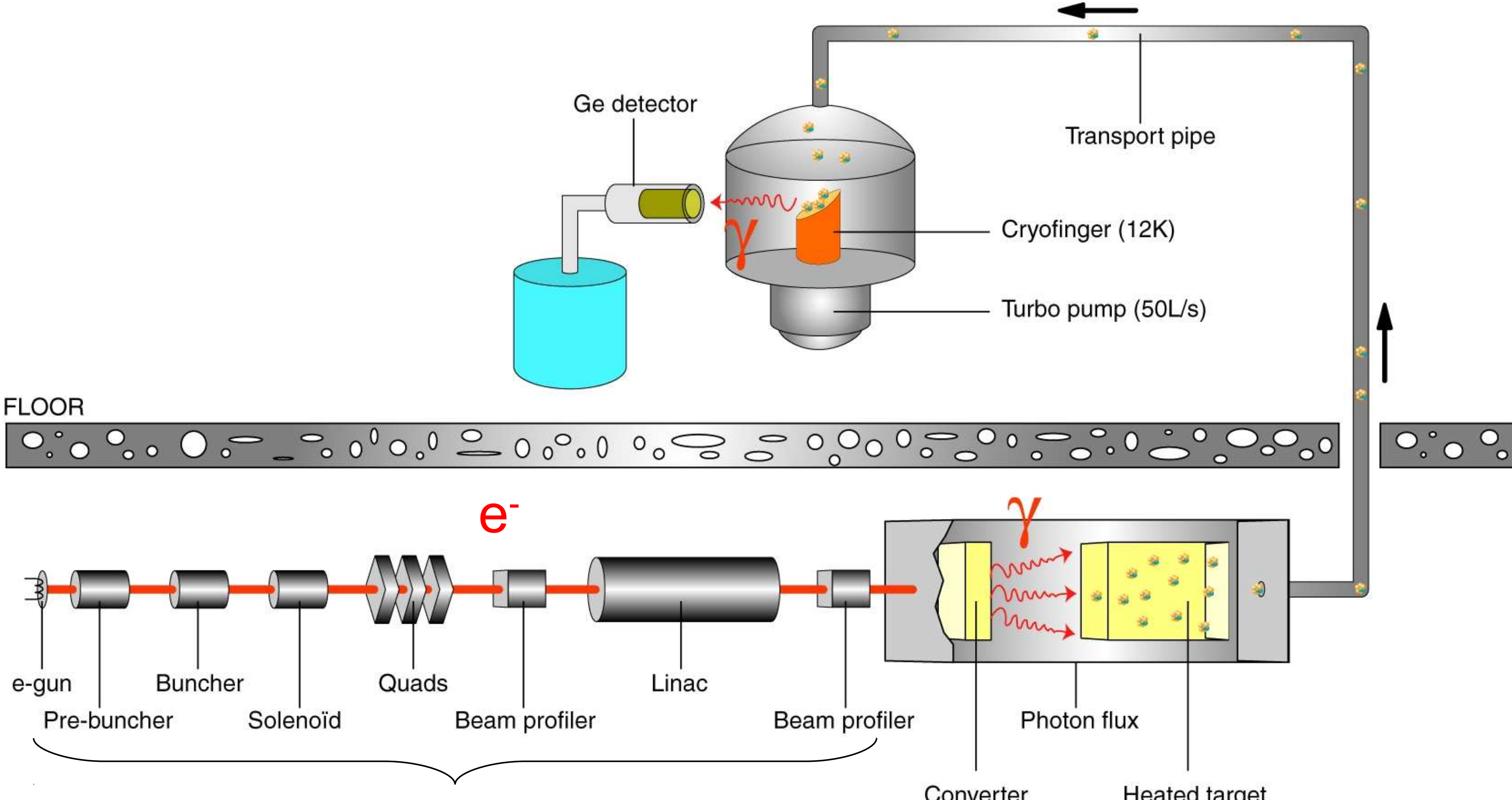




^{238}U(γ,f) cross section from Caldwell et al, PRC 21 (1980)

figures from Y Oganessian et al, NPA 701 (2002)

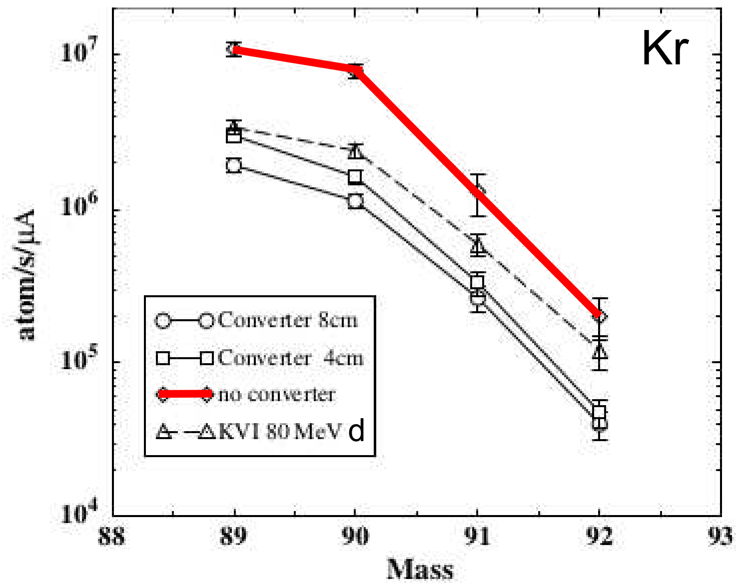
Photofission at Cern-LPI

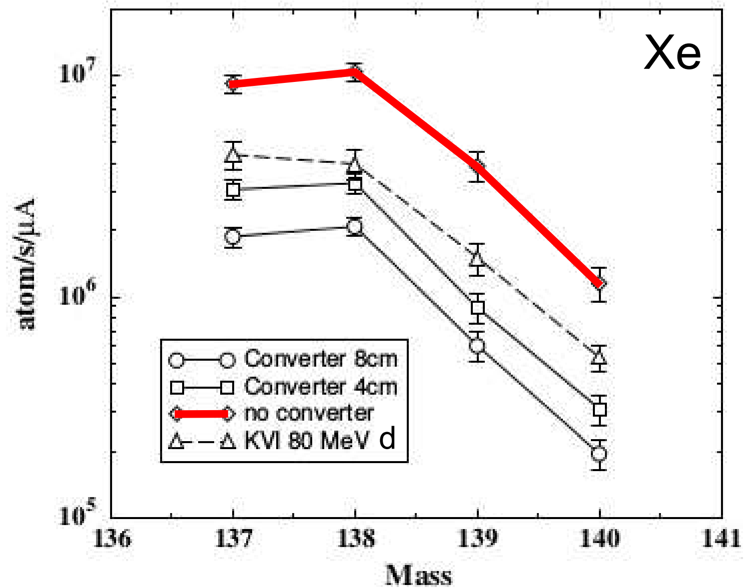


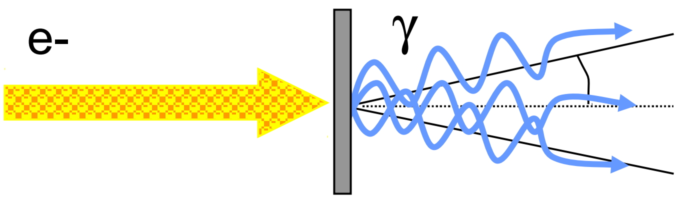
LEP injector: 50 MeV e^-

F Ibrahim et al, EPJ A 15 (2002)

Photofission at Cern-LPI







10 µA x 50 MeV e- = 500 W at Alto vs 1 µA x 26 MeV d = 26 W at Parrne
30x gain expected: 3x cross section, 10x intensity

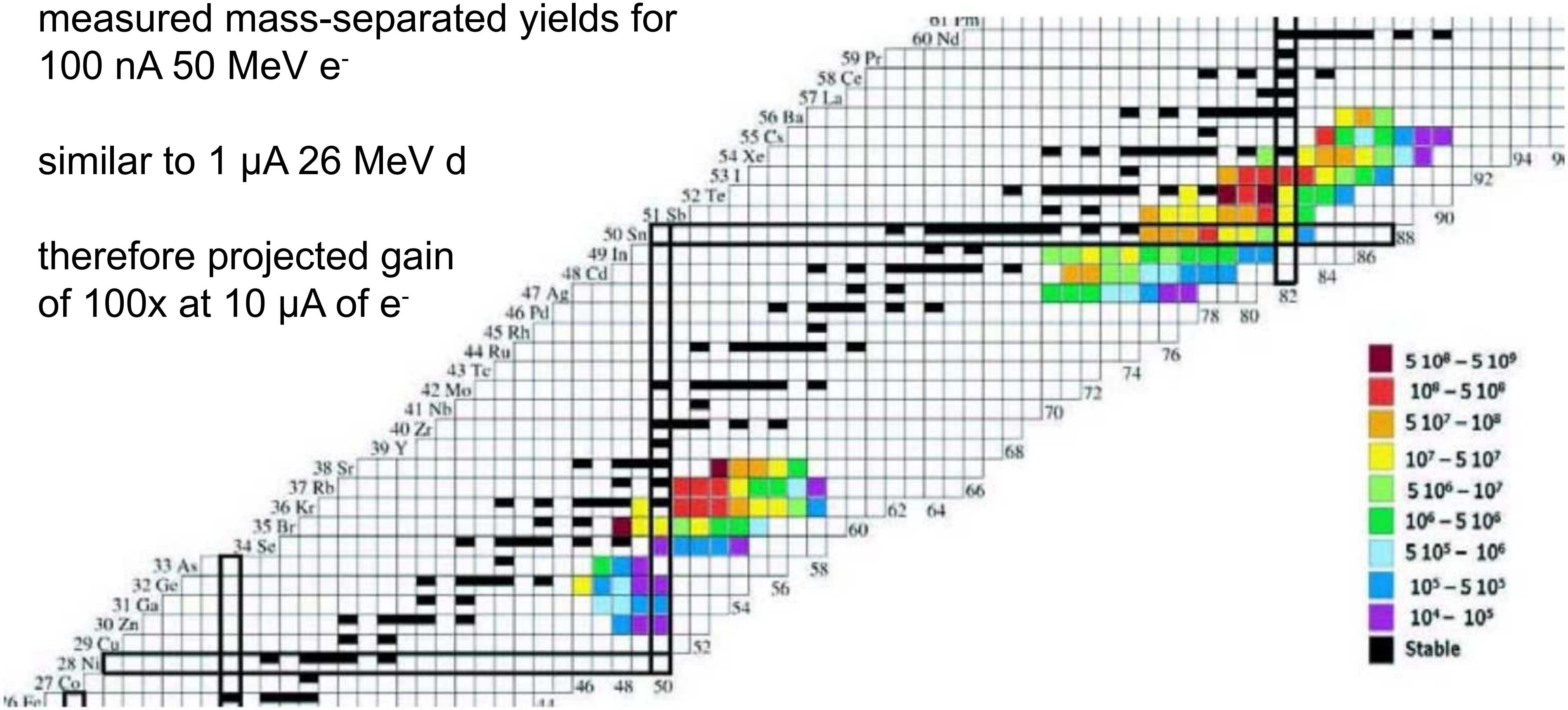
F Ibrahim et al, EPJ A 15 (2002)

Photofission at Alto

measured mass-separated yields for 100 nA 50 MeV e^-

similar to 1 µA 26 MeV d

therefore projected gain of 100x at 10 µA of e^-

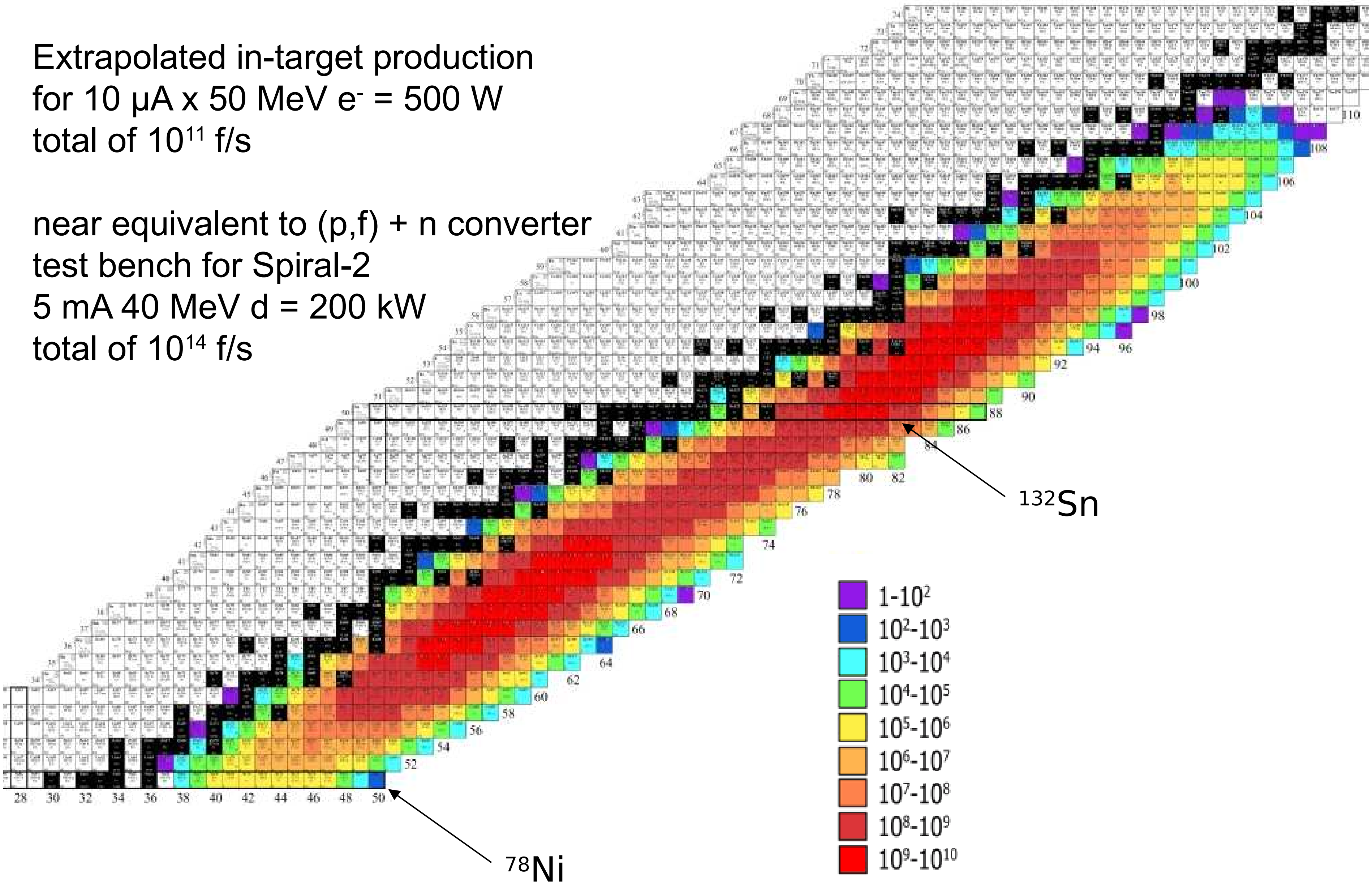


F Ibrahim et al, International Topical Meeting on Nuclear Research Applications and Utilisation of Accelerators, Vienna (2009)

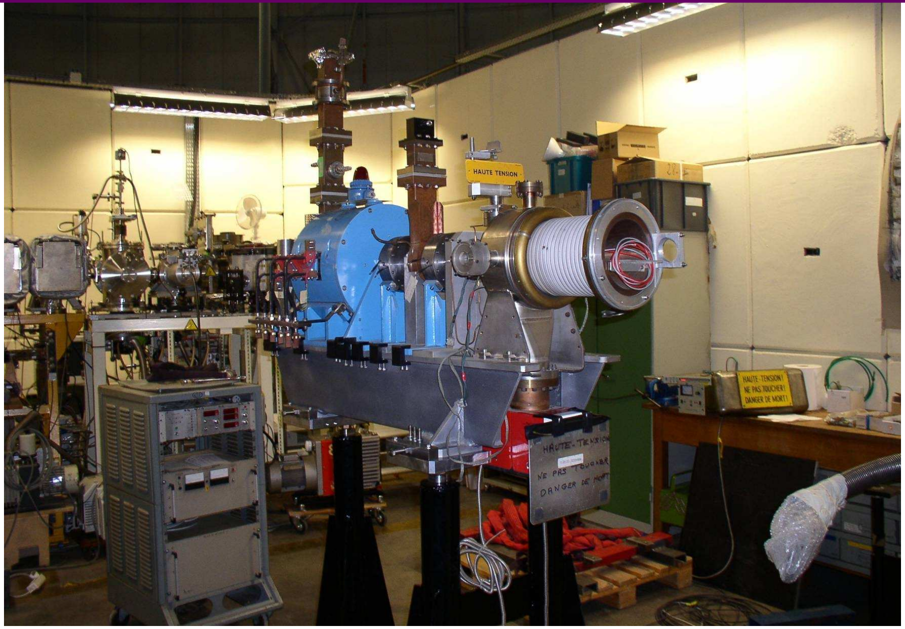
Photofission at Alto

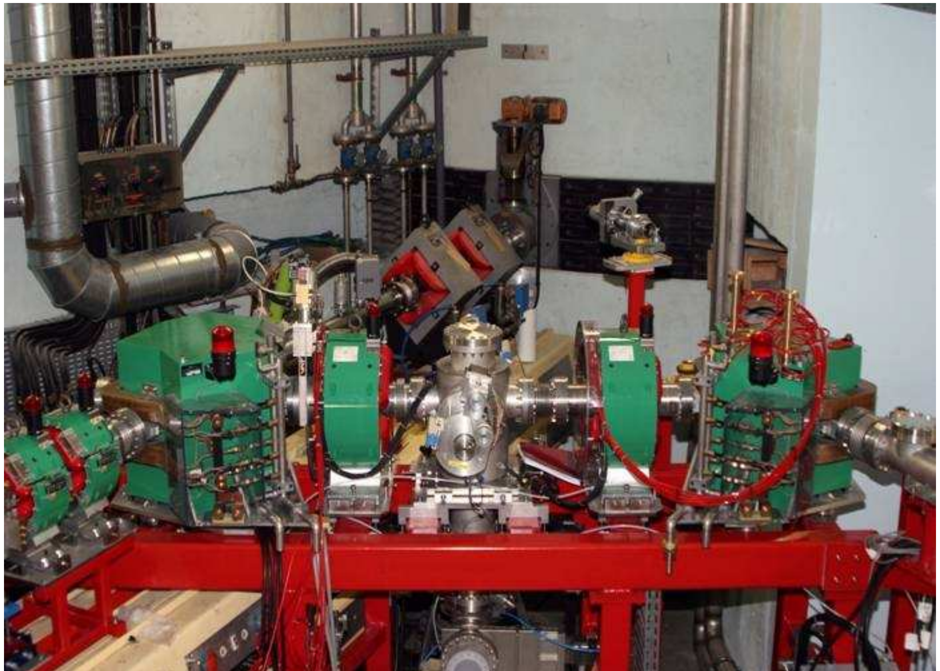
Extrapolated in-target production
for 10 μA x 50 MeV e^- = 500 W
total of 10^{11} f/s

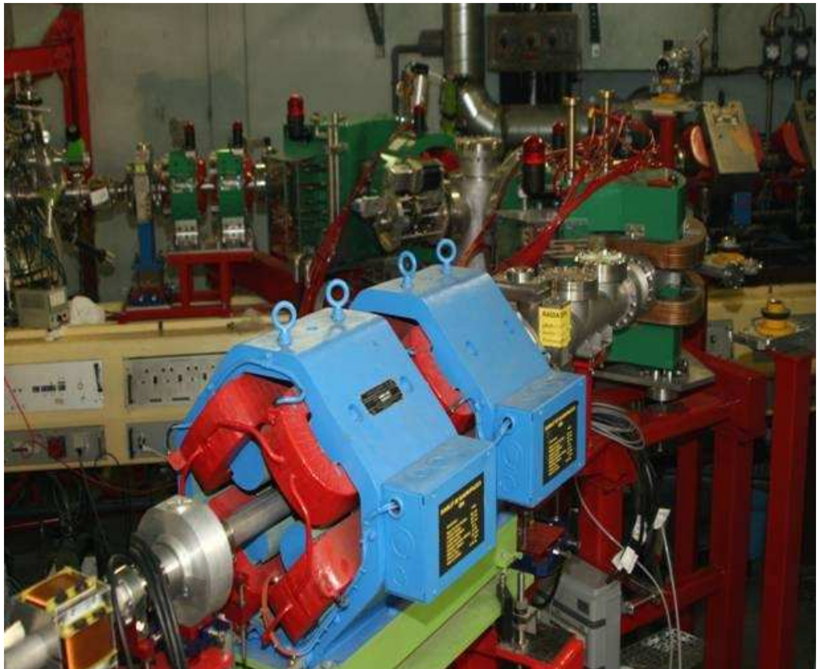
near equivalent to (p,f) + n converter
test bench for Spiral-2
5 mA 40 MeV d = 200 kW
total of 10^{14} f/s



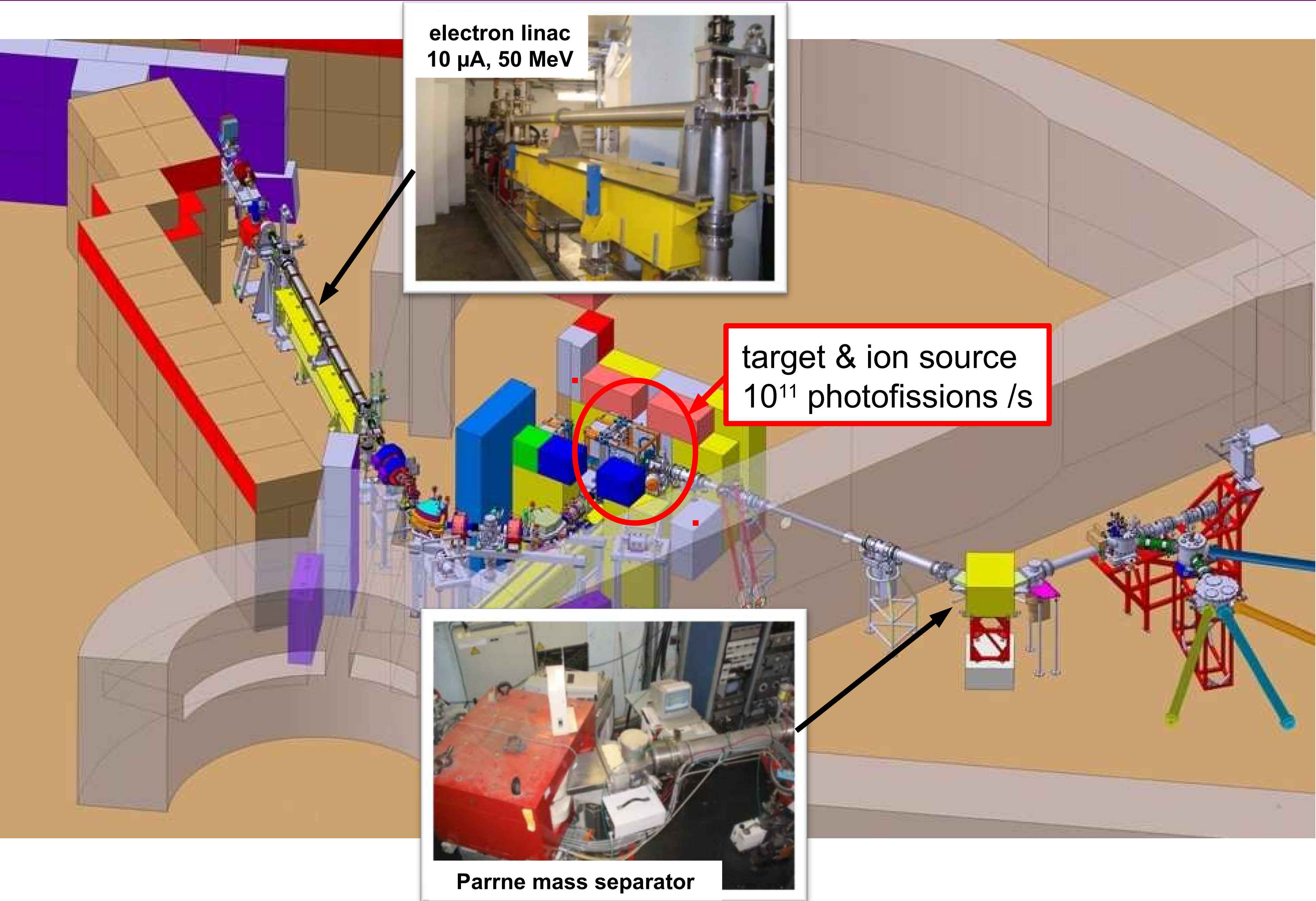
Photofission at Alto



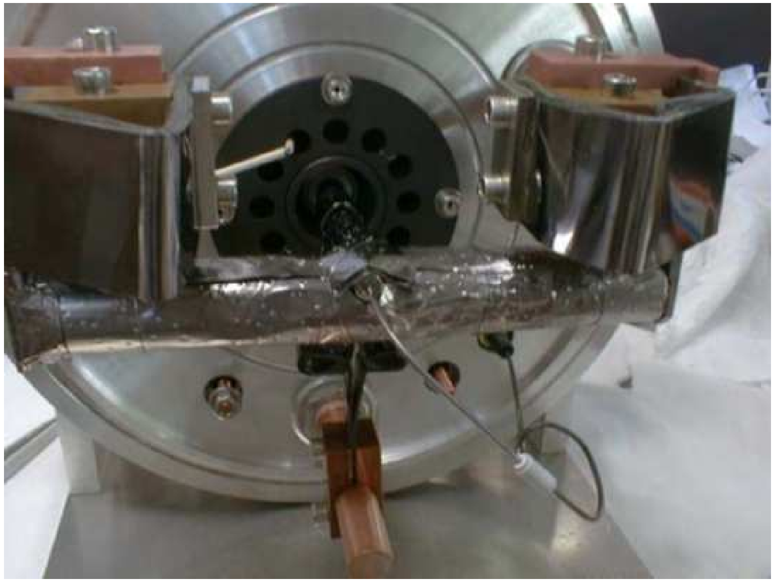




Photofission at Alto



Target and ion source

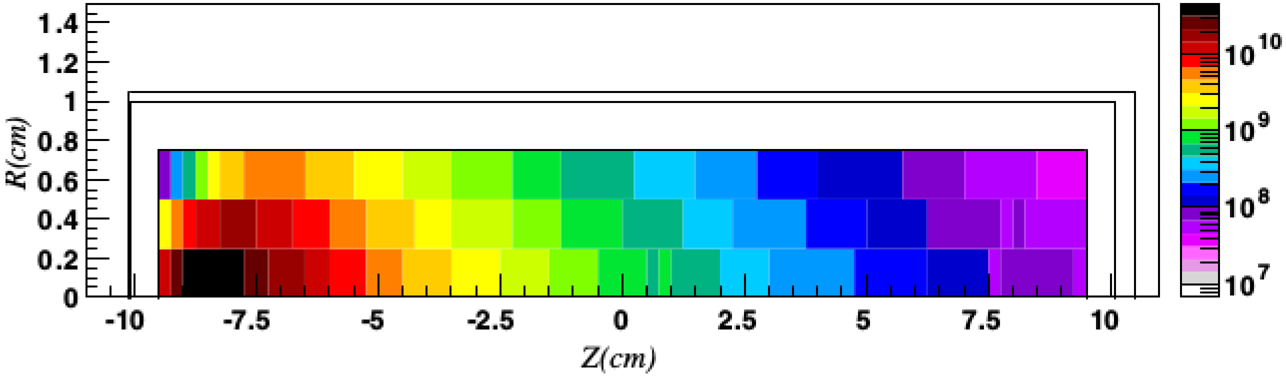


standard Isolde target
with external oven for mass marker

$\varnothing$ = 14 mm
L = 140 mm
ρ = 3.2 g/cm^3
T ≤ 2000 °C

further target optimisation is possible:

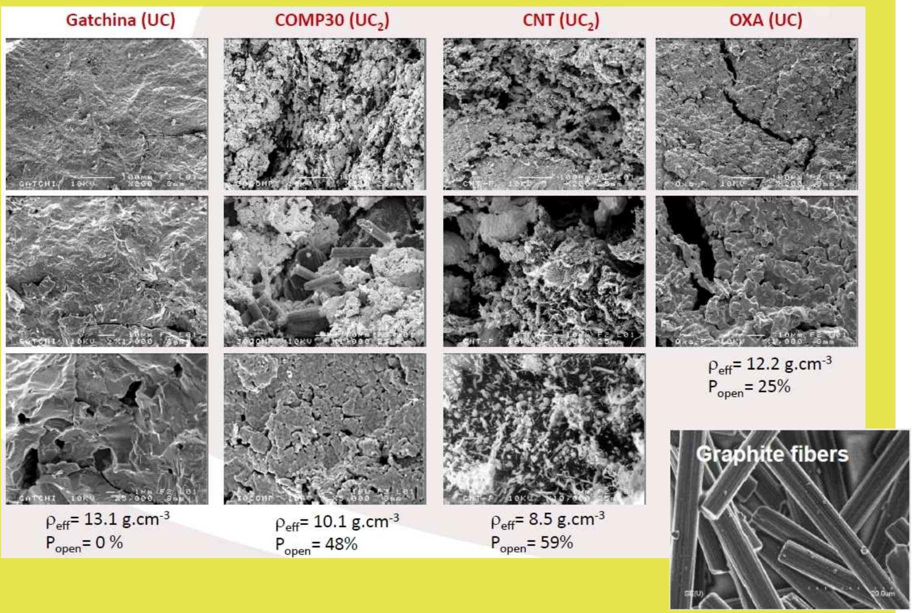
e- energy deposit in first 2.65 cm



Fluka fission rate in 3.2 g/cm^3 UC_x target

M Cheikh et al, NIM B 266 (2008)

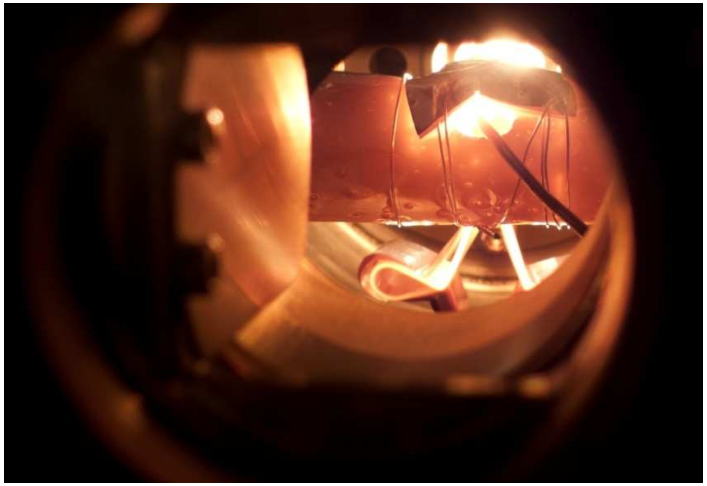
Increase UC_x density to 13 g/cm^3
control porosity
nanostructured UC_x, RVCF (reticulous vitreous carbon fiber)...



B Hy et al, NIM B 288 (2012) 34

Ensar Actilab: IPN, Cern, CMMO, Ganil, INFN, Univ Rennes

Accelerate release of Ln and chemically reactive elements via **fluorinated molecular beams**

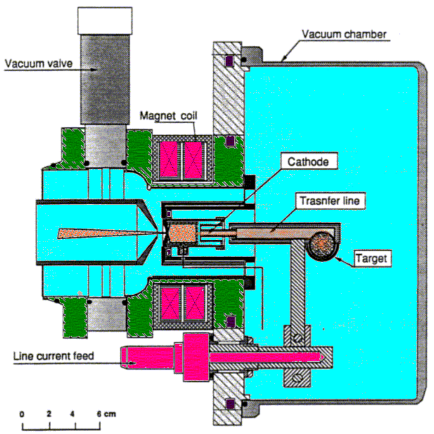


Physics: B(E2) through fast timing
B Roussière et al, EPJA 47 (2011)

Collaboration IPN, CSNSM, INRNE-Sofia, Tandar-Buenos Aires

Target and ion source

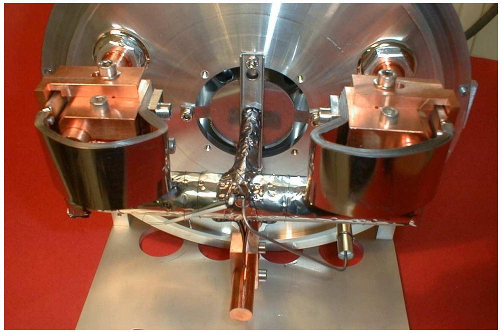
Hot plasma source



High temperature (2000 °C)

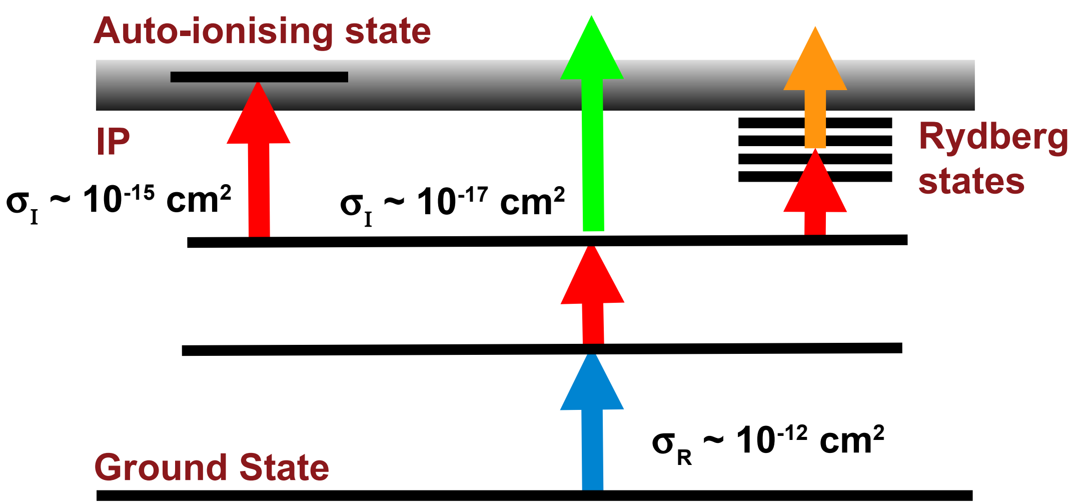
Up to 30% efficiency for gaseous elements

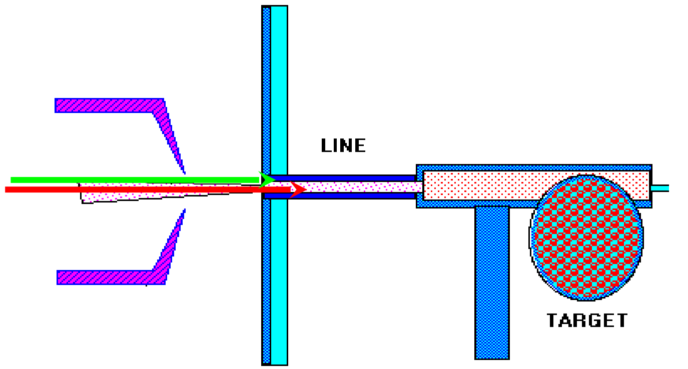
Surface ionisation



High efficiency for alkalines ($E_i < 6$eV)

Laser ion source



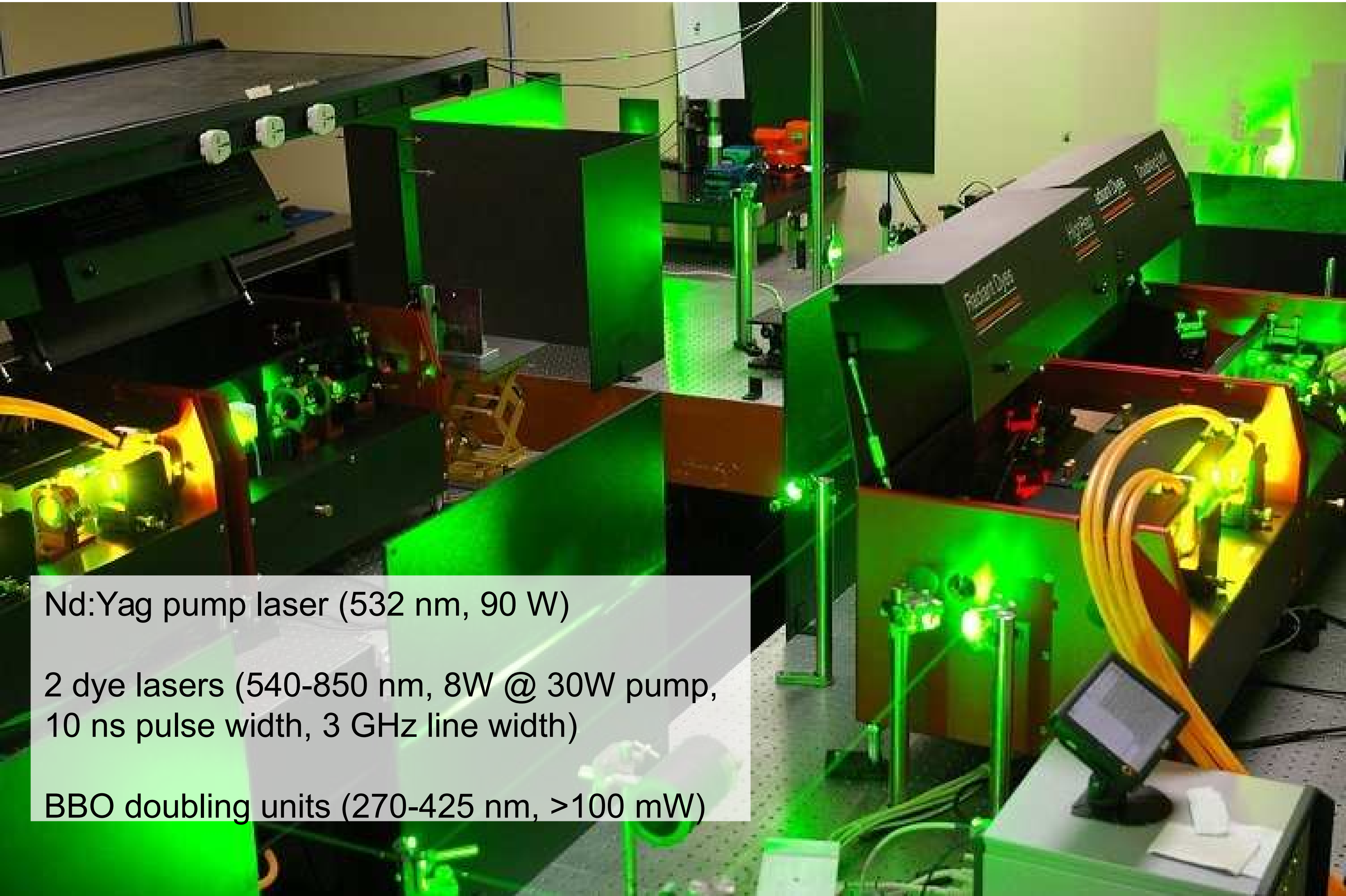


Selective

Near-universal

Efficiency 3-30%

Rialto: Resonant laser ionisation at Alto



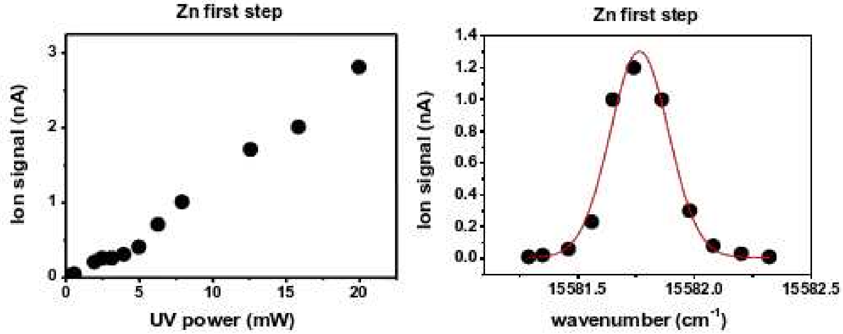
Nd:Yag pump laser (532 nm, 90 W)

2 dye lasers (540-850 nm, 8W @ 30W pump, 10 ns pulse width, 3 GHz line width)

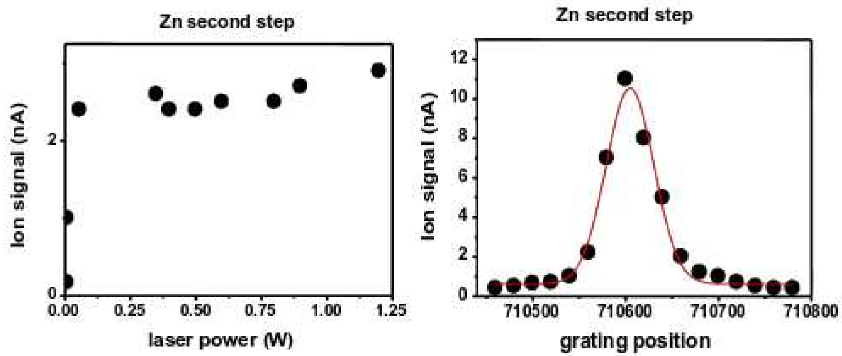
BBO doubling units (270-425 nm, >100 mW)

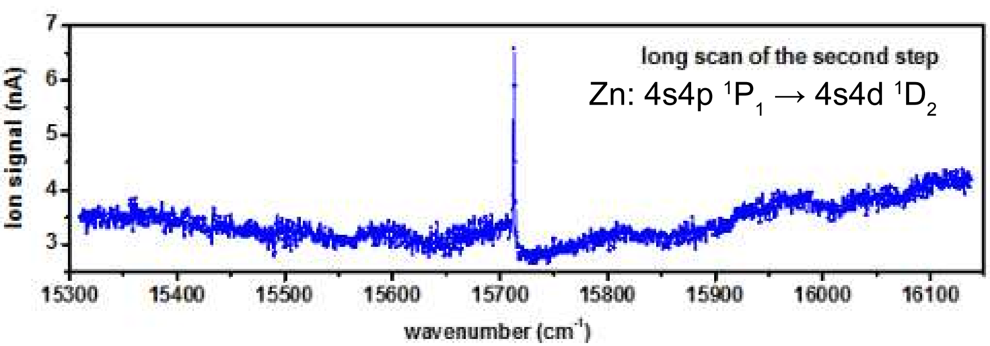
Rialto: Resonant laser ionisation at Alto

First step



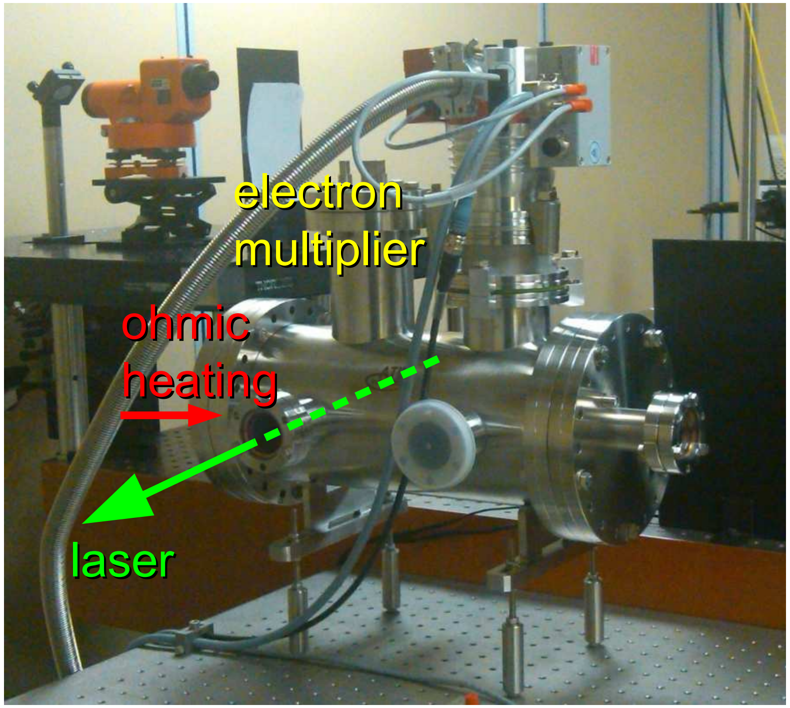
Second step



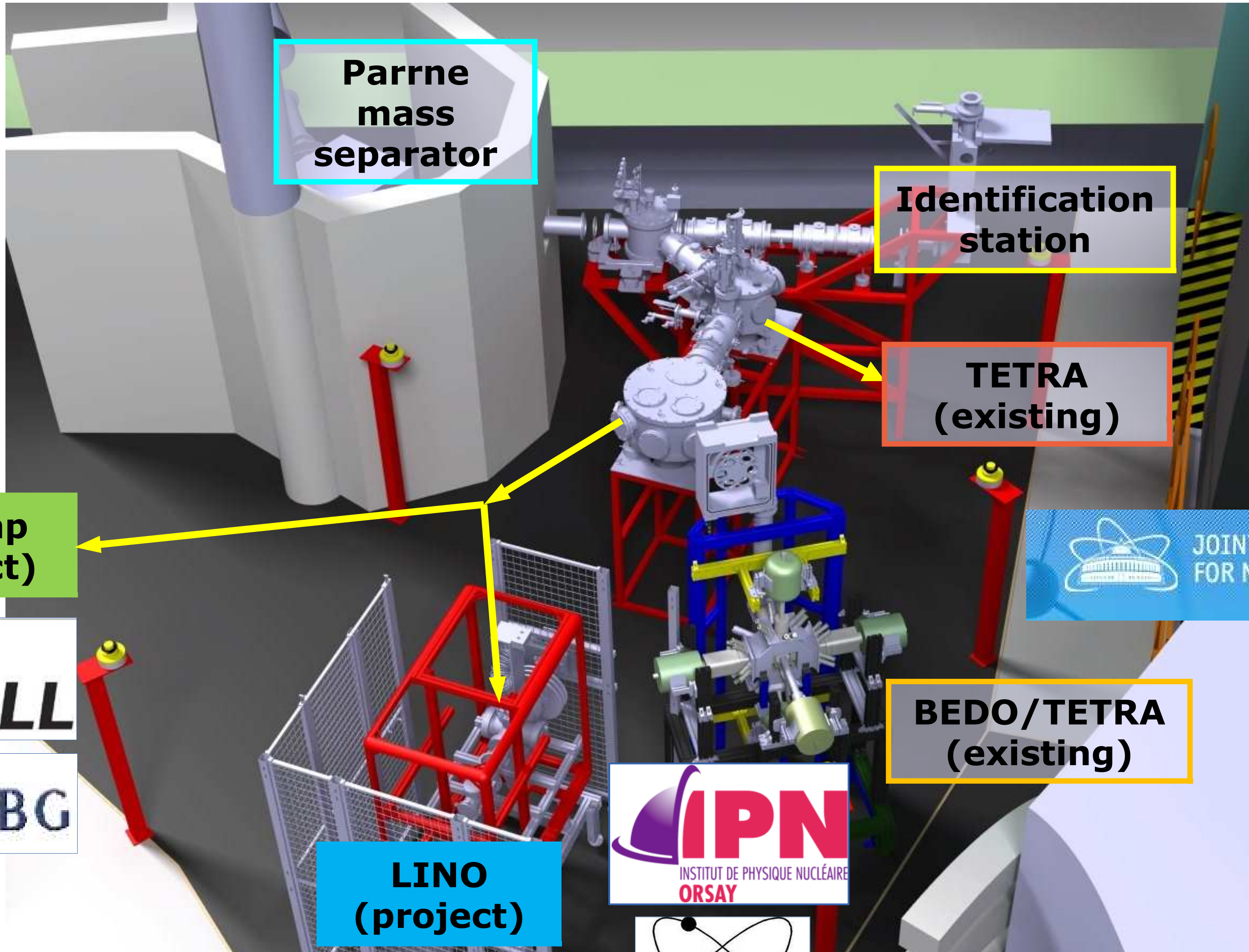


2011, 2012: gallium with two ionisation schemes
2013: zinc with frequency tripling
2014: off-line chamber for development of laser schemes

Collaboration IPN Orsay, Isolde, Univ. Manchester, Univ. Mainz

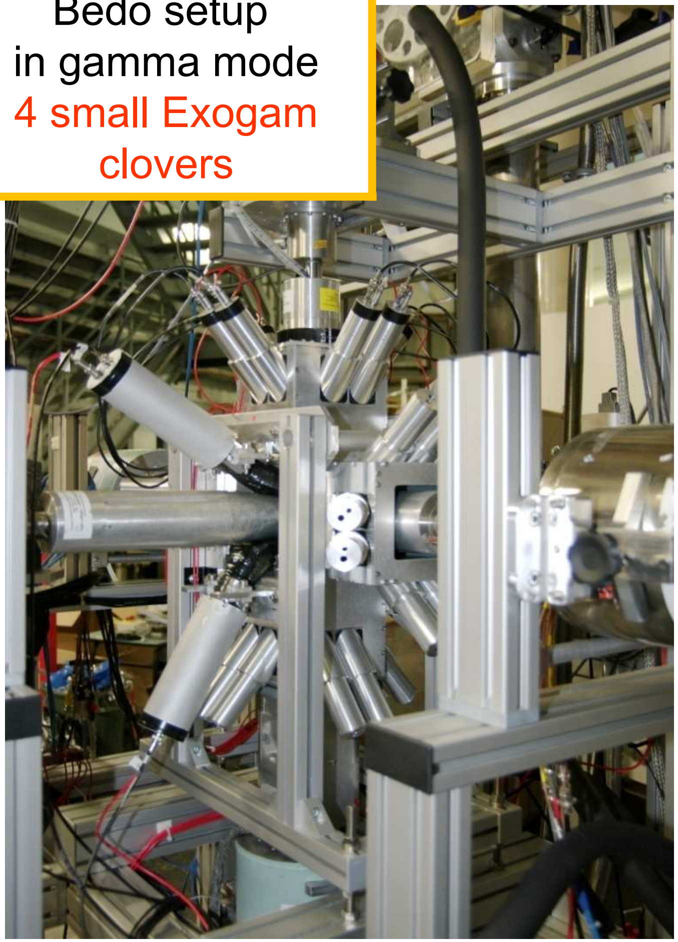


Low-energy radioactive ion beams at Alto



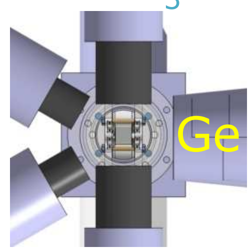
Bedo: Beta decay at Orsay

Bedo setup
in gamma mode
4 small Exogam
clovers



up to 5 Ge detectors ε = 5-6%
4π β trigger
BGO anti-Compton

fast timing



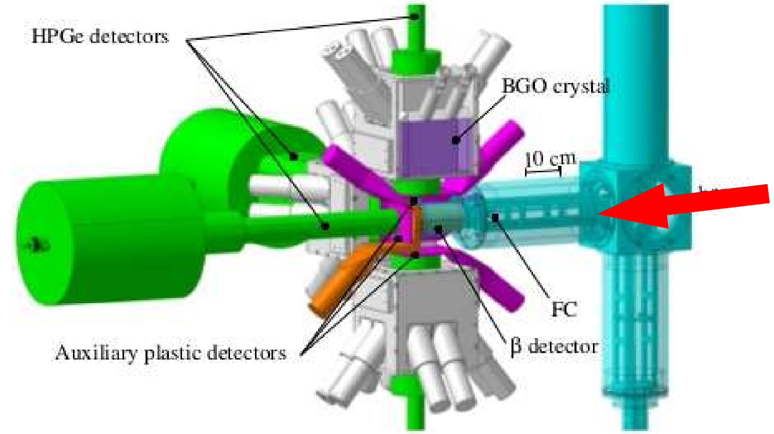
Bedo setup
in neutron mode
JINR neutron
detector Tetra

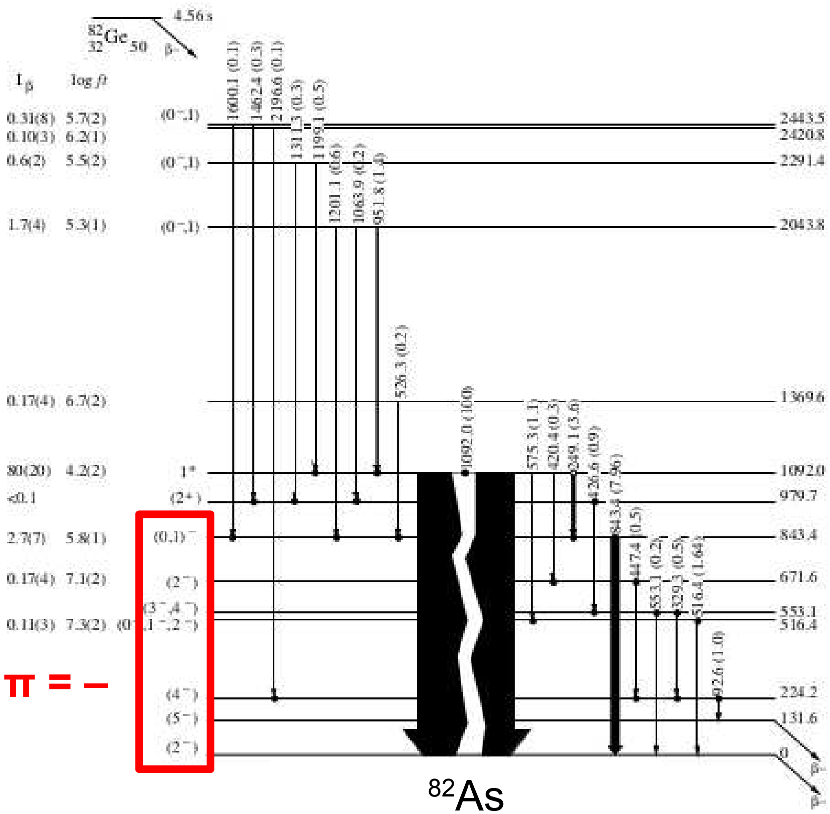
80 ^{3}He tubes ε(^{252}Cf) = 53(2)%
borated polyethylene shielding

Near Z=28

- β decay of ^{82}Ge
  A Etilé et al, submitted to PRC (2015)

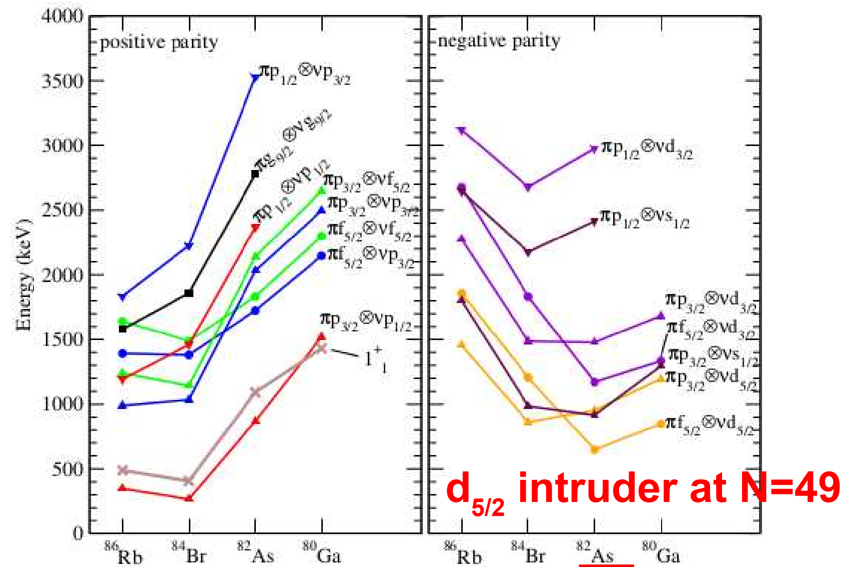
commissioning of Bedo





π = –

^{82}As
(Z=33, N=49)

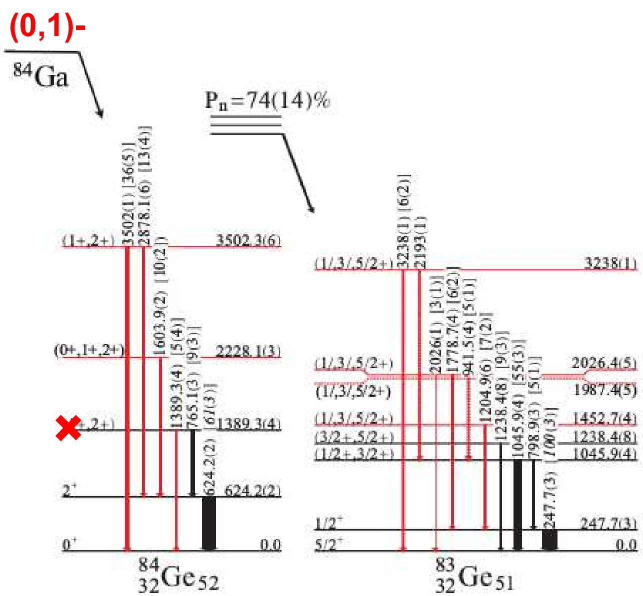


$d_{5/2}$ intruder at N=49

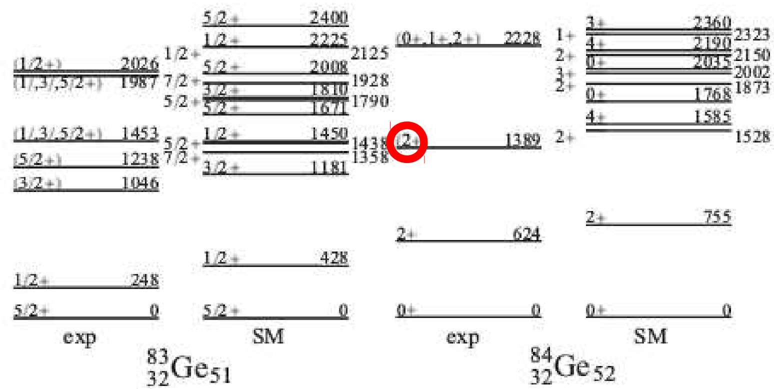
Bedo: Beta decay at Orsay

Near Z=28

- β decay of ^{82}Ge
  A Etilé et al, submitted to PRC (2015)
- β decay of ^{84}Ga
  K Kolos et al, Physical Review C 88, 047301 (2013)



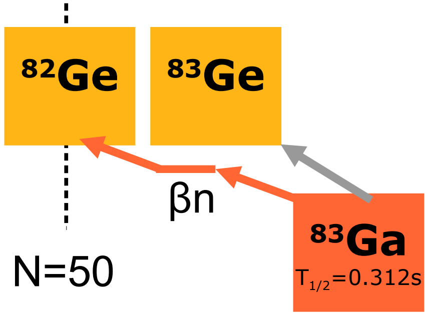
better statistics thanks to laser ionisation and 10 μA electrons



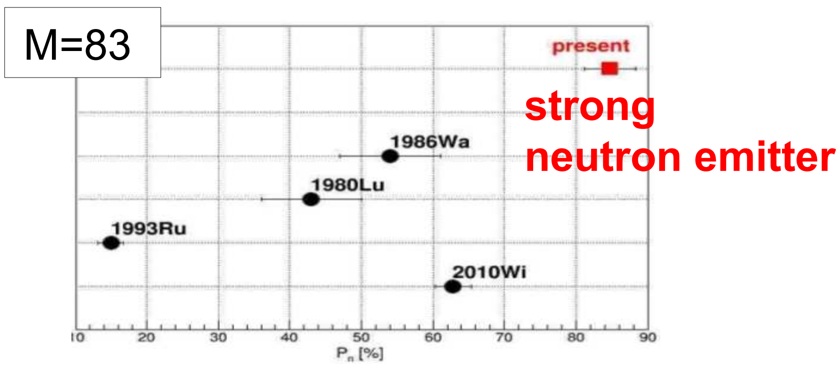
- β and βn decay of $^{80-84}$Ga
  D Testov et al, submitted to NIM A (2015)
- Zn laser-ionised with tripled UV step but accelerator breakdown

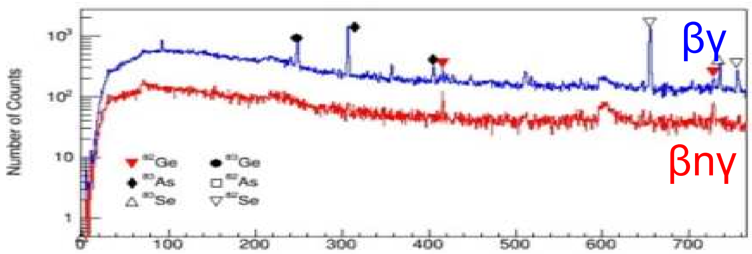
Near Z=50: β decay of $^{123-125}$Ag and $^{127-128}$In, βn decay of ^{126}Cd
D Testov et al

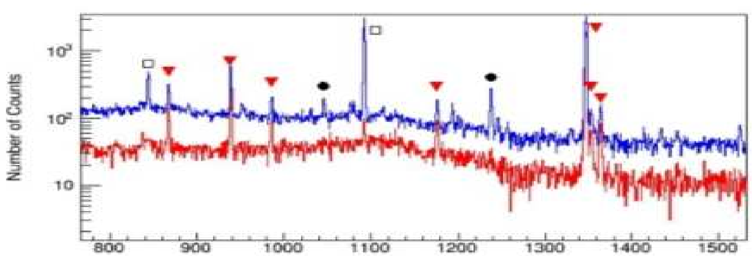
Tetra: Beta-delayed neutron emission



P_n = 85(4)%
this work



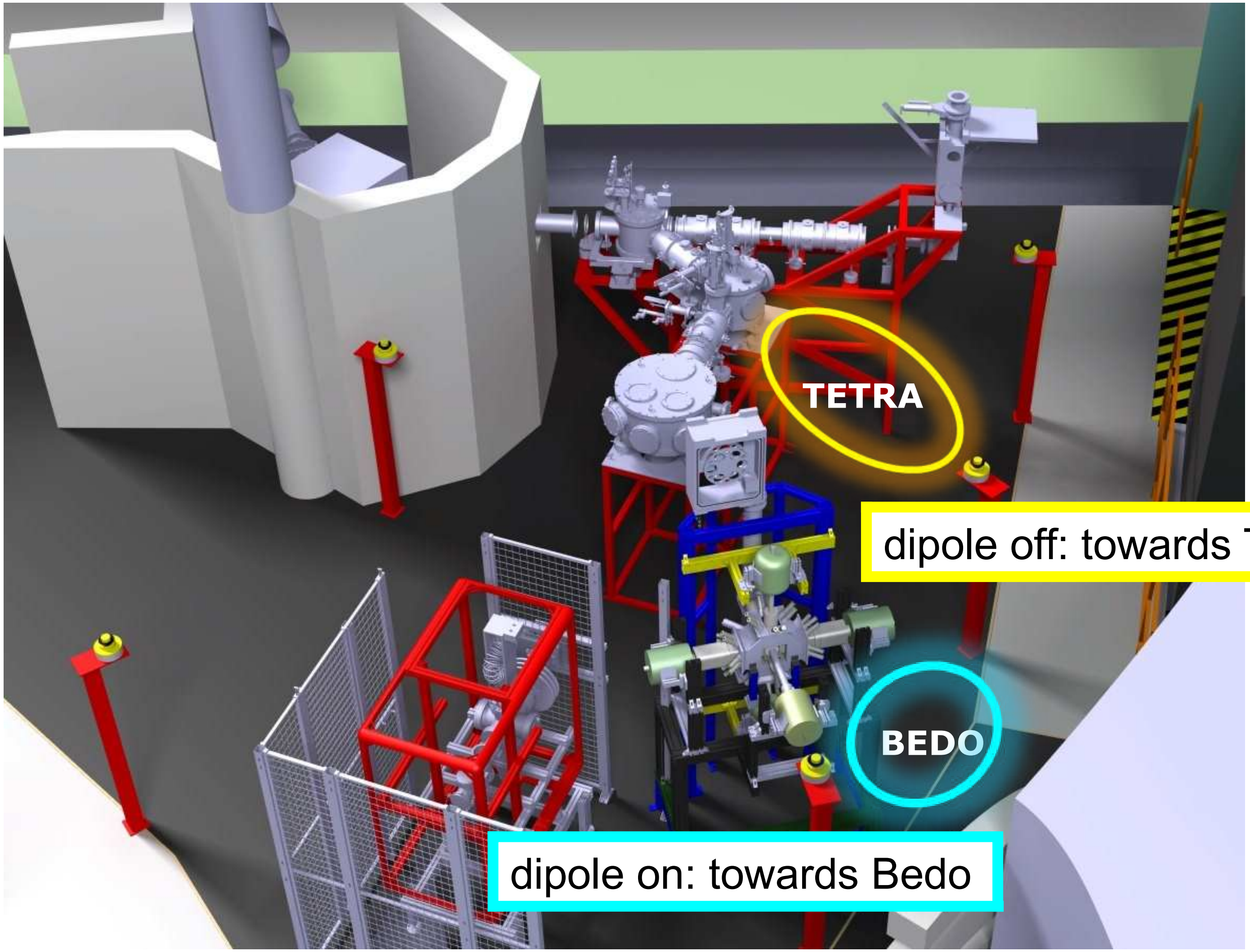




laser-ionised ^{83}Ga beam
4π neutron detector
4π β & 1 Ge detector

D Testov, submitted to NIM A

Tetra and Bedo in alternating mode

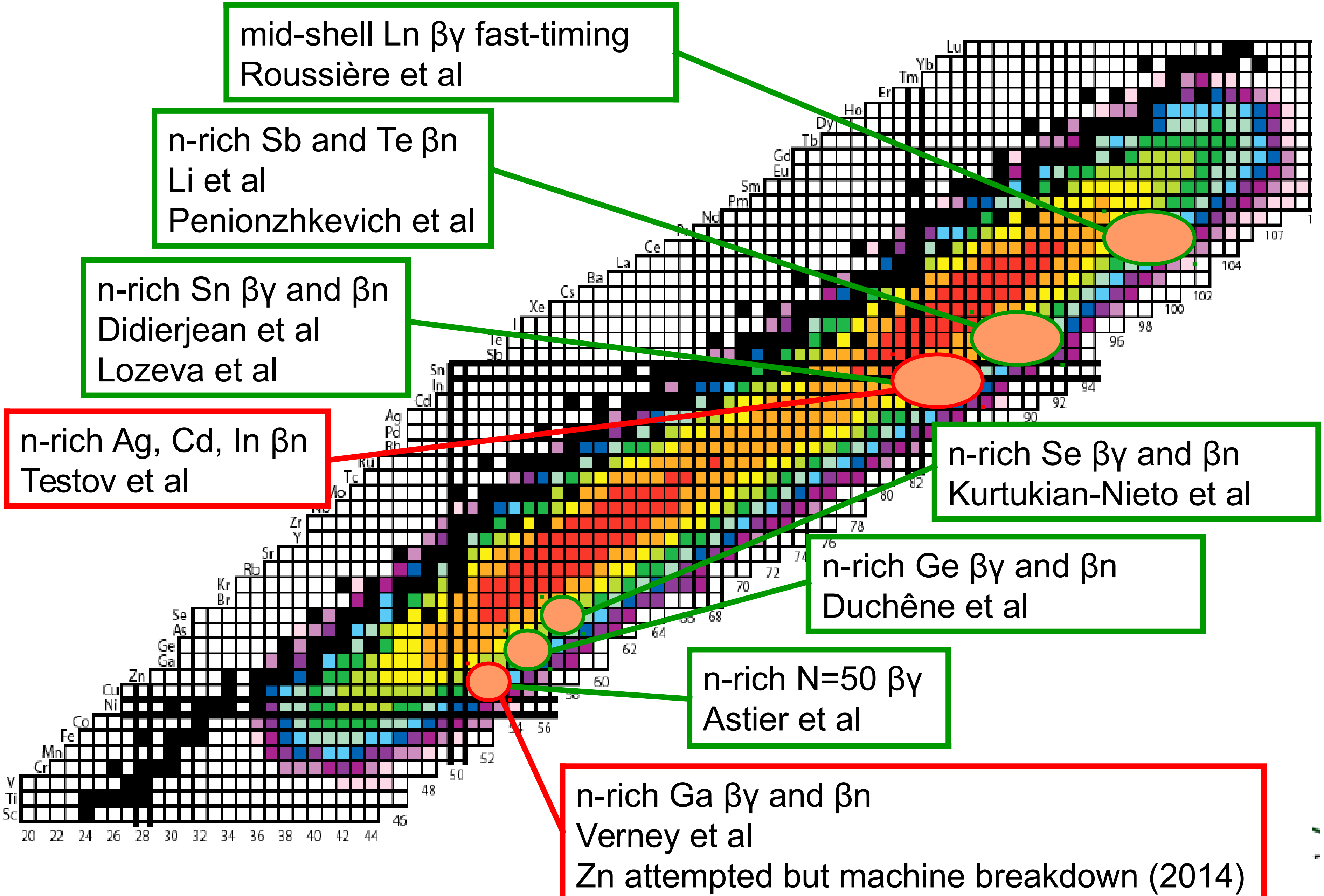


Collaboration IPN
Orsay - FLNR Dubna

IPN INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

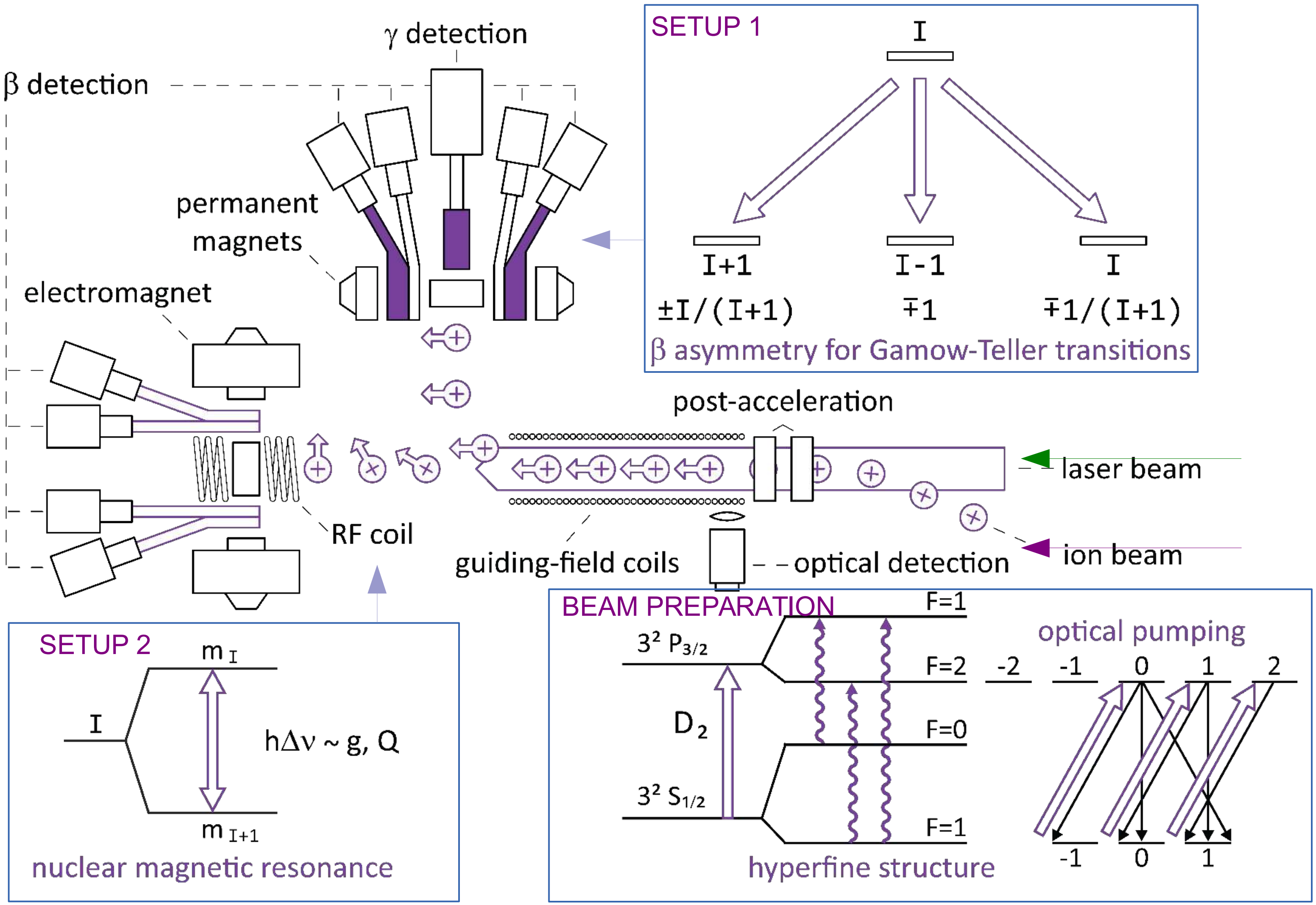
JOINT INSTITUTE FOR NUCLEAR RESEARCH

Tetra and Bedo in alternating mode



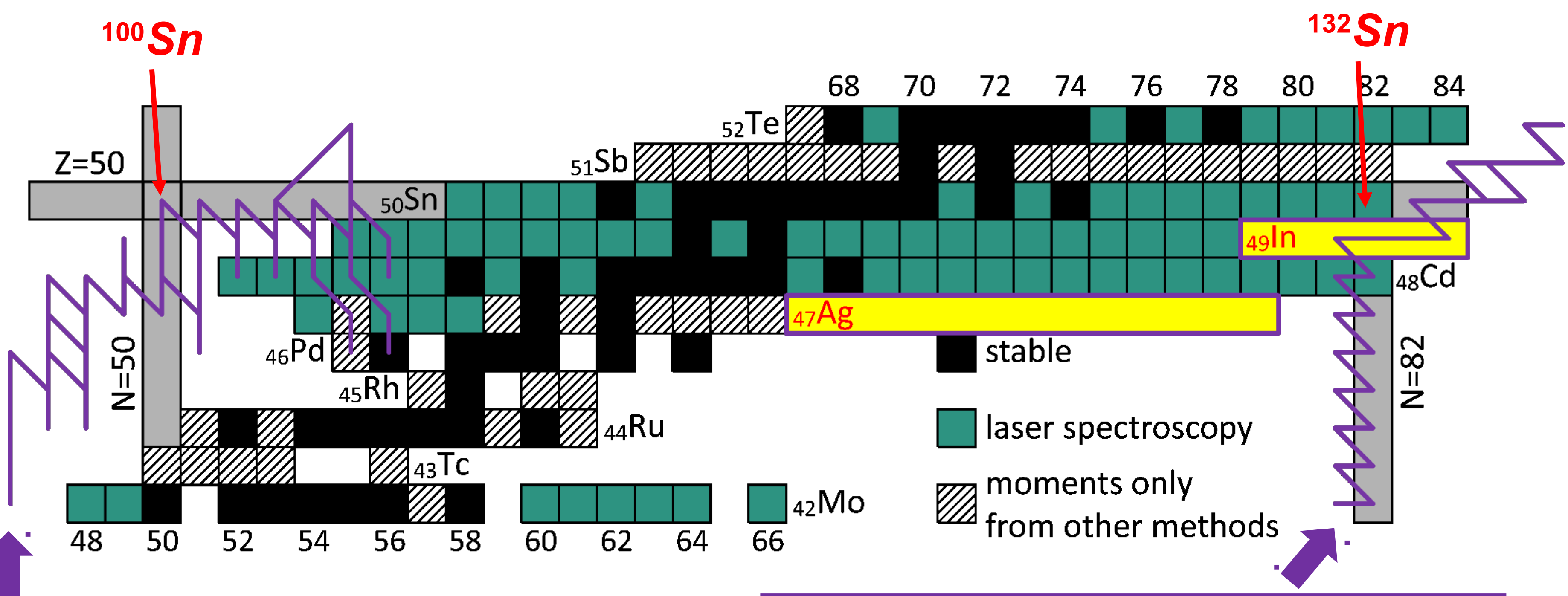
Lino: Laser-induced nuclear orientation

- polarisation by optical pumping
- μ & Q from nuclear magnetic resonance
- β-delayed spectroscopy of laser-polarized beams



Lino: Laser-induced nuclear orientation

laser spectroscopy near Sn:
ground and isomeric state properties of $^{110-126}$Ag and $^{128-133}$In
β-decay of polarised $^{121-126}$Ag and $^{128-133}$In

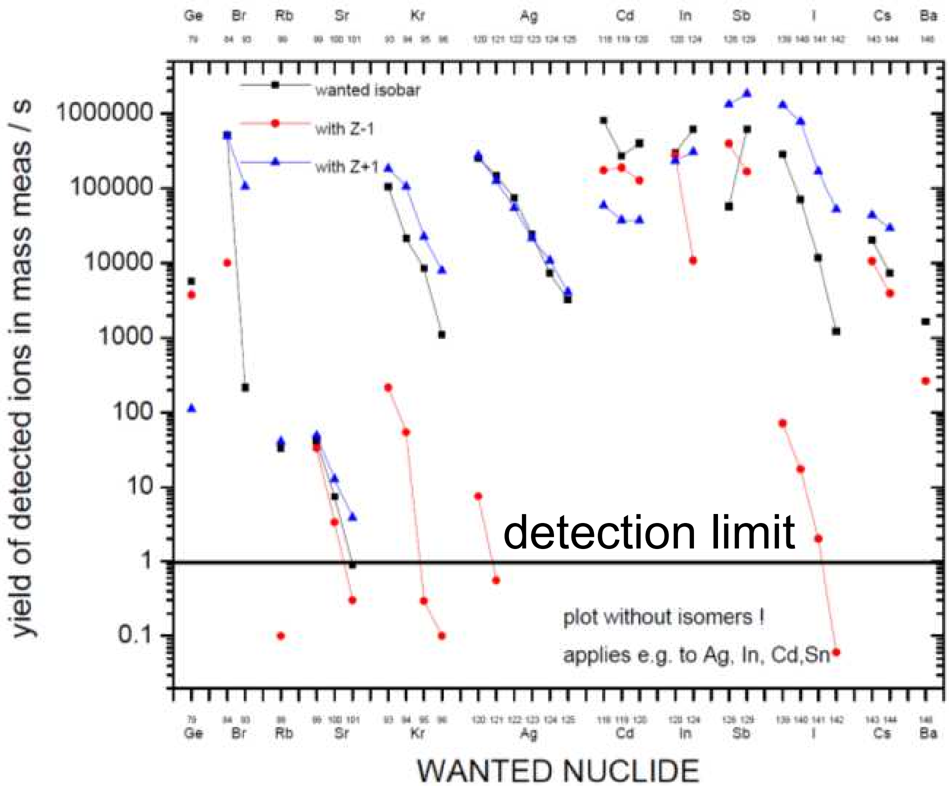


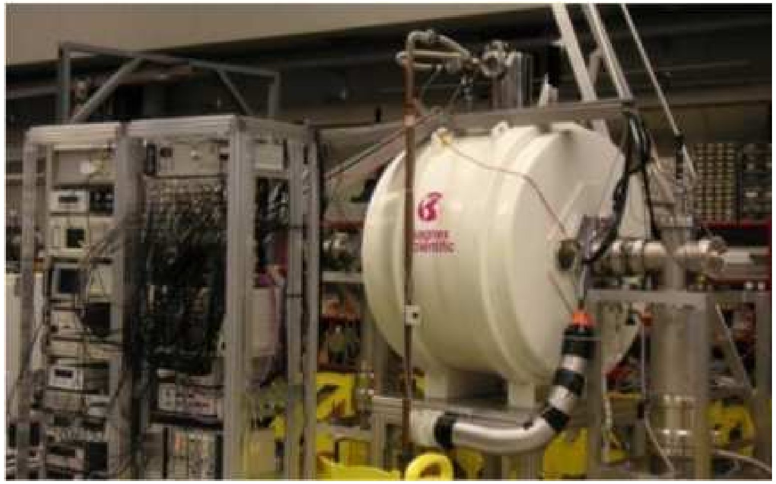
rp process

r process

- **more accurate theoretical lifetimes of N=82 isotones below ^{129}Ag**
- **shell quenching vs deformation**
- **shell effect in radii**

MLLtrap: Mass measurements

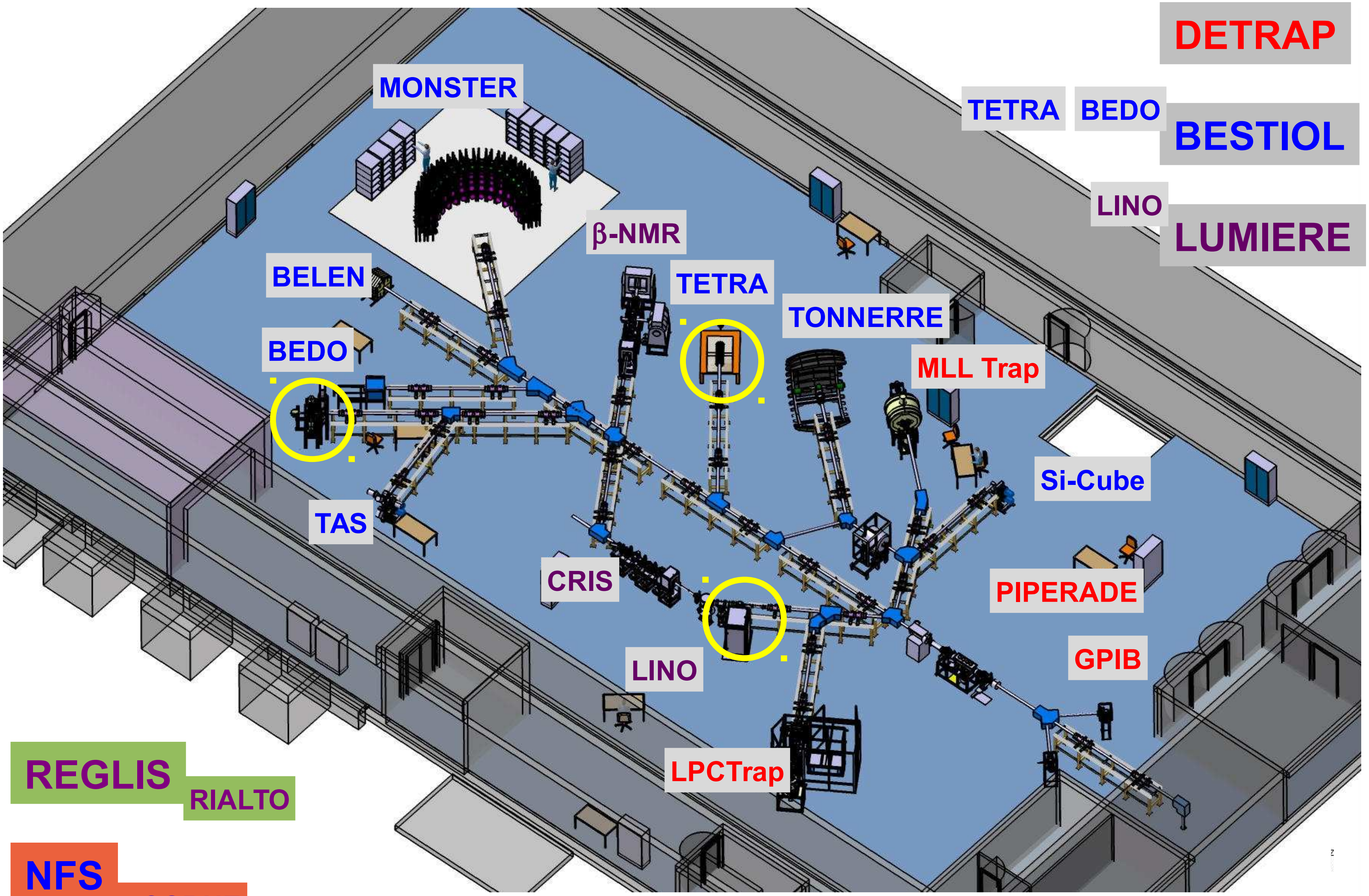




- double Penning-trap mass spectrometer
- superconducting solenoid $\Delta B/B < 0.3$ ppm/cm^3 at 7 T
- mass resolving power $m/\Delta m \sim 10^5$ in the 1st (purification) trap
- statistical uncertainty $\delta m/m = 2.9\times10^{-8}$ in the 2nd (precision) trap

V Kolhinen et al, NIM A 600 (2009)

Initiate the physics for Spiral-2 at Ganil:
Desir, S3, NFS



DETRAP

TETRA BEDO BESTIOL

LINO LUMIERE

REGLIS RIALTO

NFS LICORNE

► niche with stable beams
► R&D on Isol & RIB
► low-energy physics programme based on photofission
► R&D and physics at Alto pave the way to Spiral-2 at Ganil: initiate physics programme, train new generation of isol physicists, develop instruments and methodologies