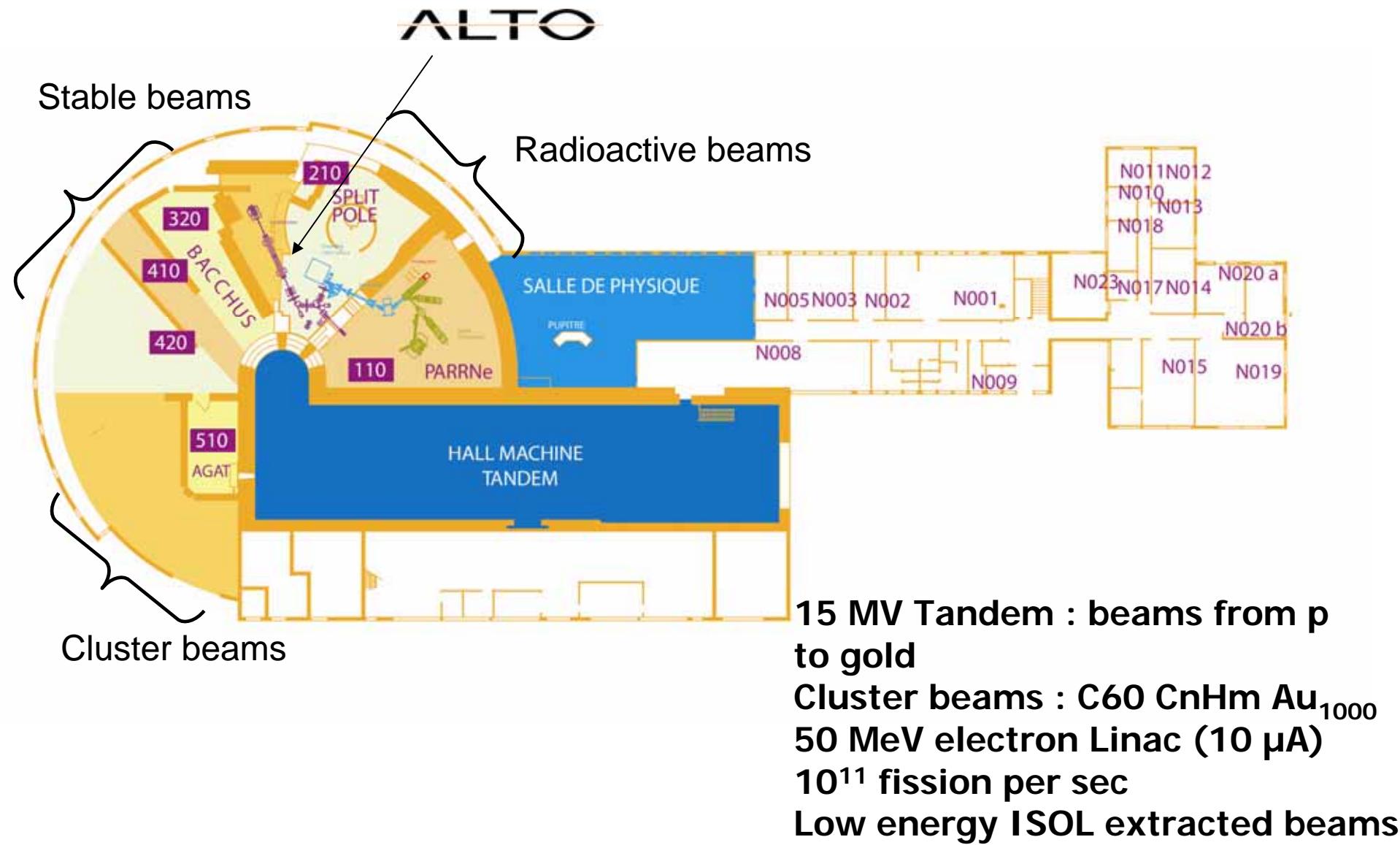
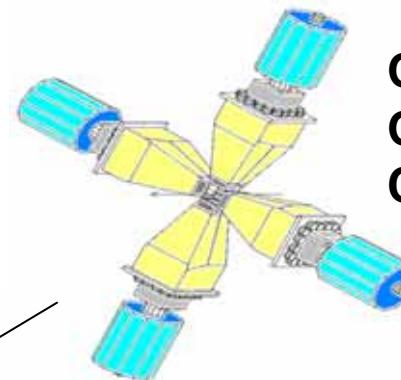
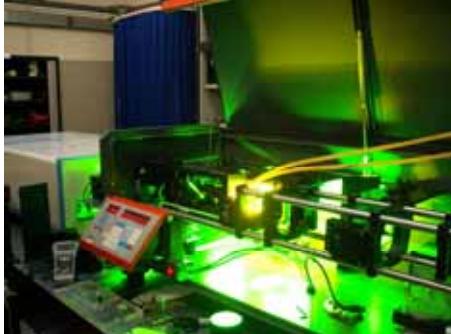


The Tandem ALTO facility

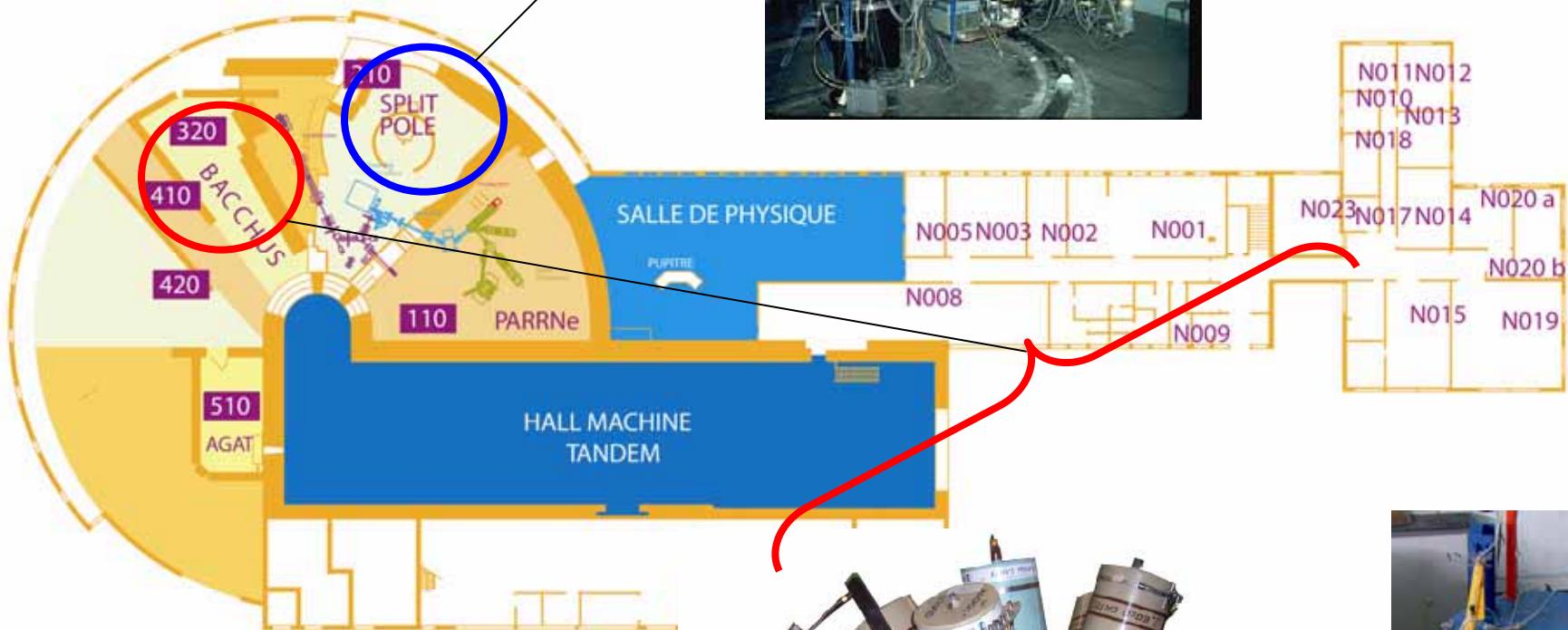
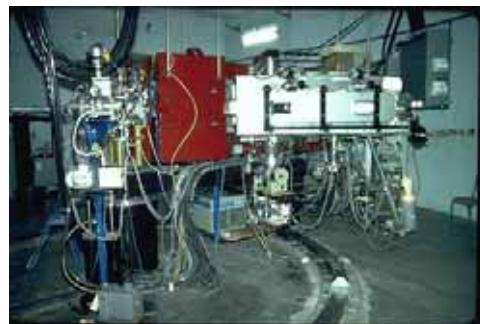




OSCAR
**Orsay Segmented
Clover Array**

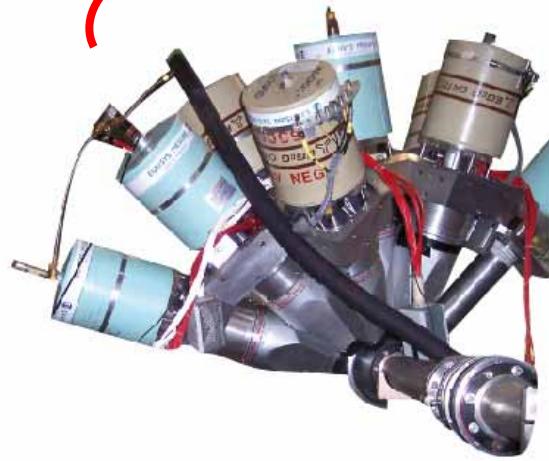


2 magnetic spectrometers
High resolution **Split Pole** Spectrometer



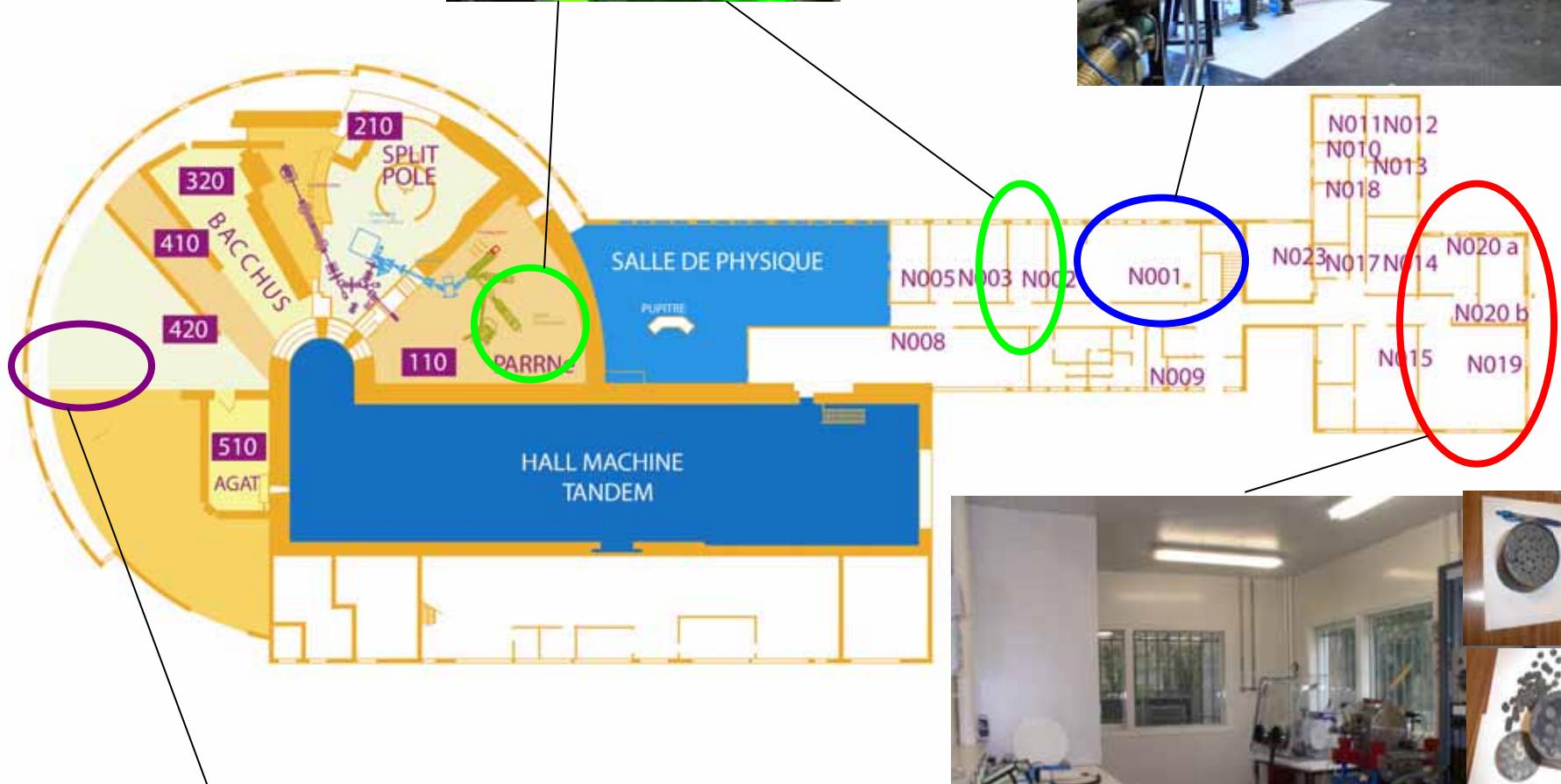
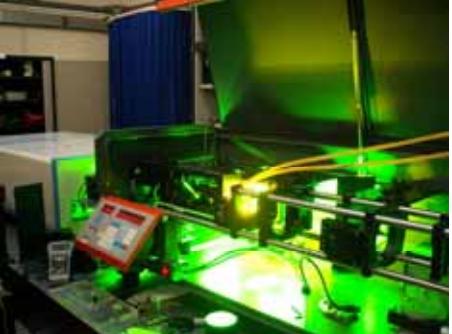
ORGAM + BACCHUS device

30 Ge Det

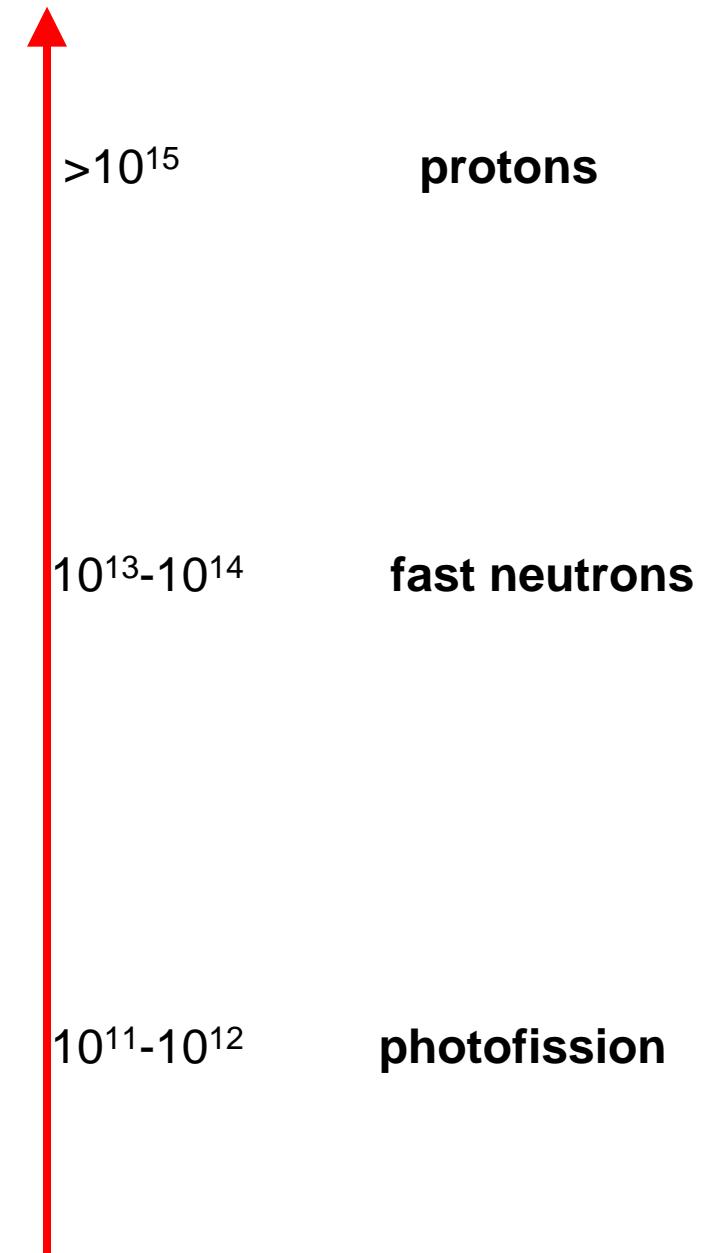
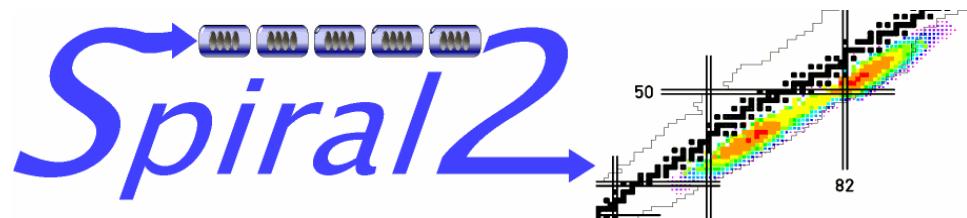


+

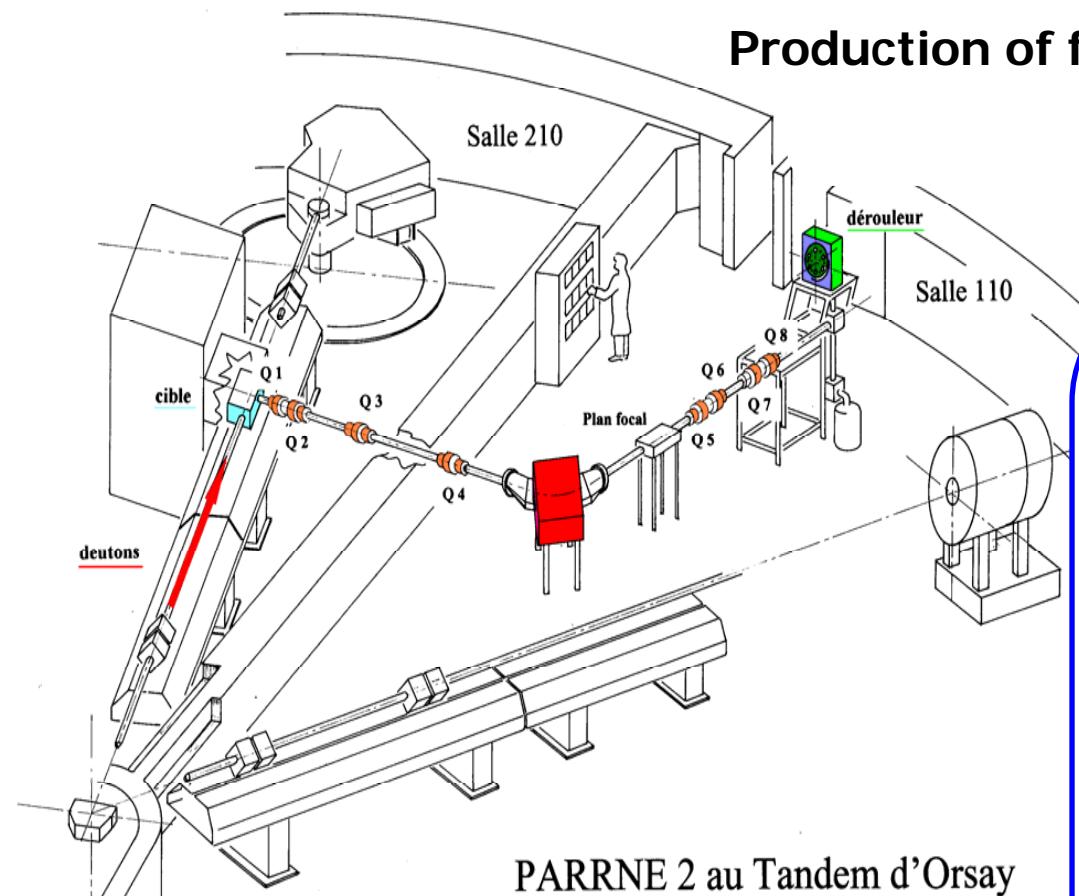




EURISOL



The ALTO project at IPN Orsay



PARRNE 2 au Tandem d'Orsay

Production of fission fragments with photofission ISOL type device

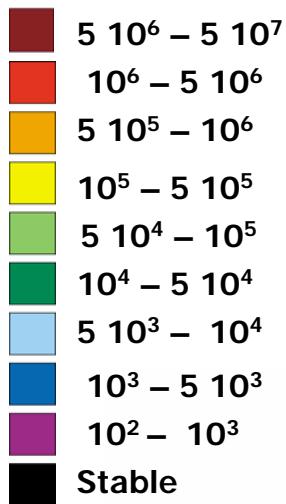
First part : deuterons + ISOL device

Optimization of the different parameters for the production :
R&D target / ion sources

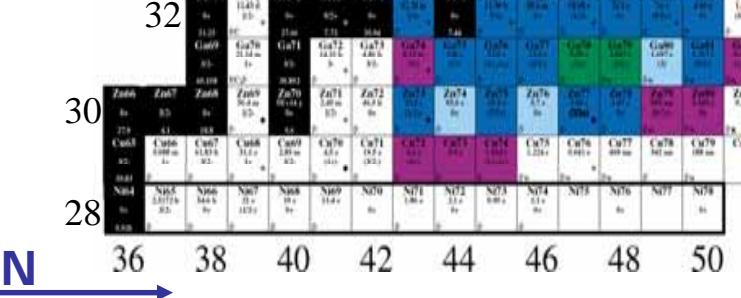
Study of neutron rich Nuclei around $N=50$

Productions at PARRNe

Production /s/ μ A



Z



N

36 38 40 42 44 46 48 50

52 54 56

58

60

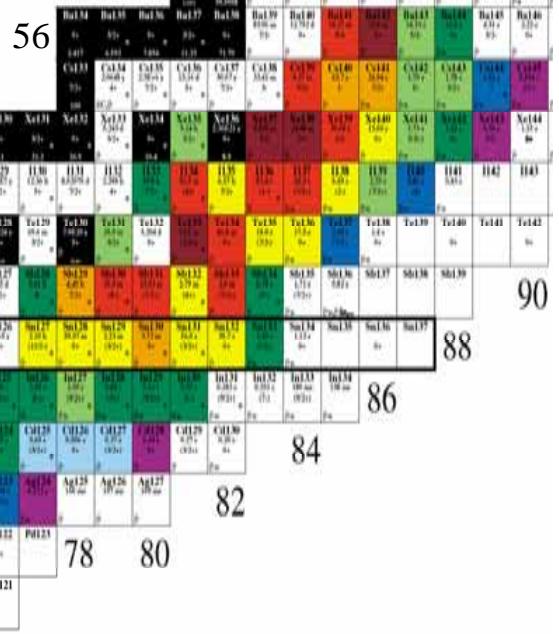
62 64 66 68 70 72 74 76

78 80

50

52

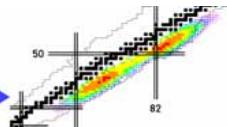
56



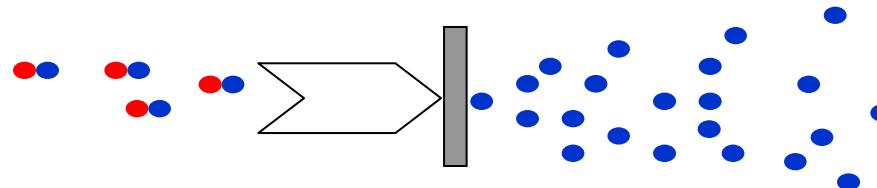
Hot plasma ion source

1 μ A deuterons

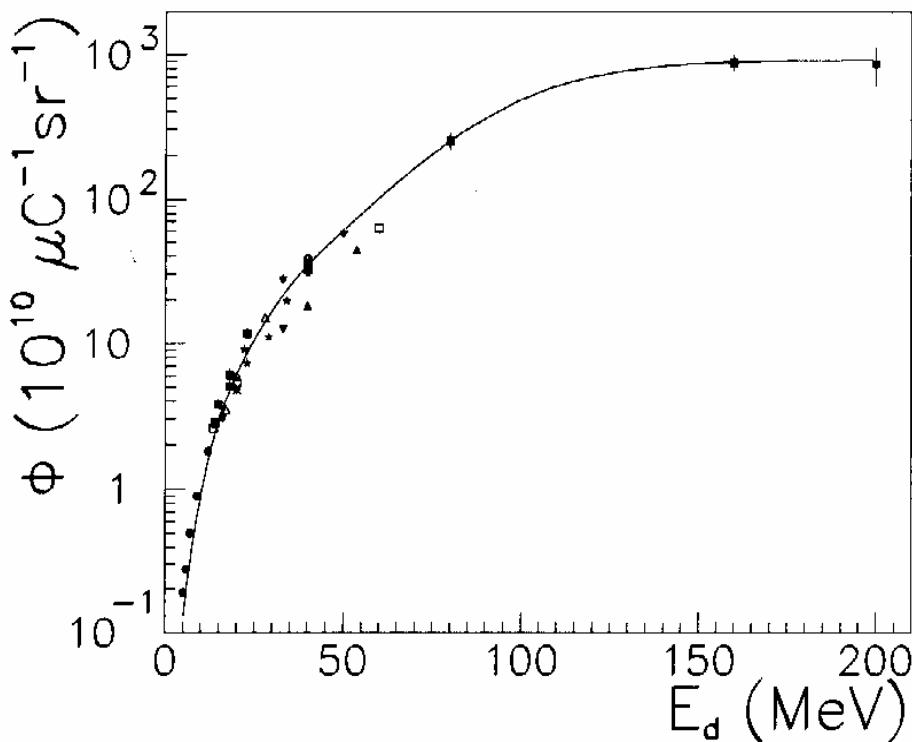
26 MeV



Production of fission fragments using fast neutrons



Thesis Nicolas Pauwels
IPN Orsay



from P.W.Lisowski et al, OECD/NEA Report
NEANDC-305 'U' 1991 p.177

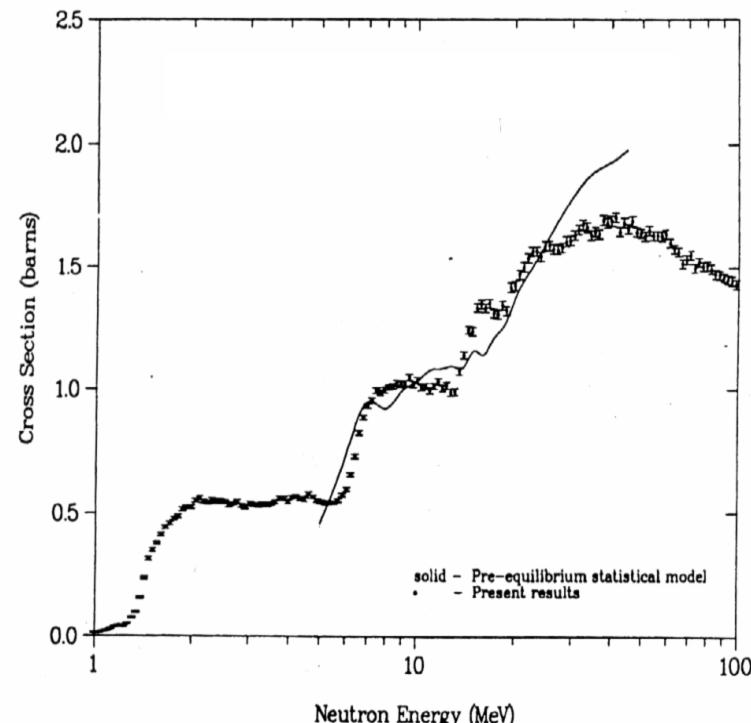
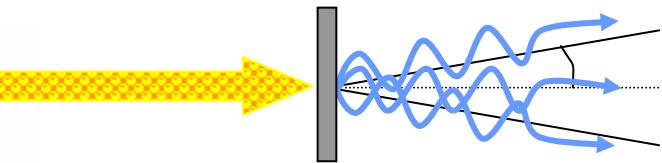
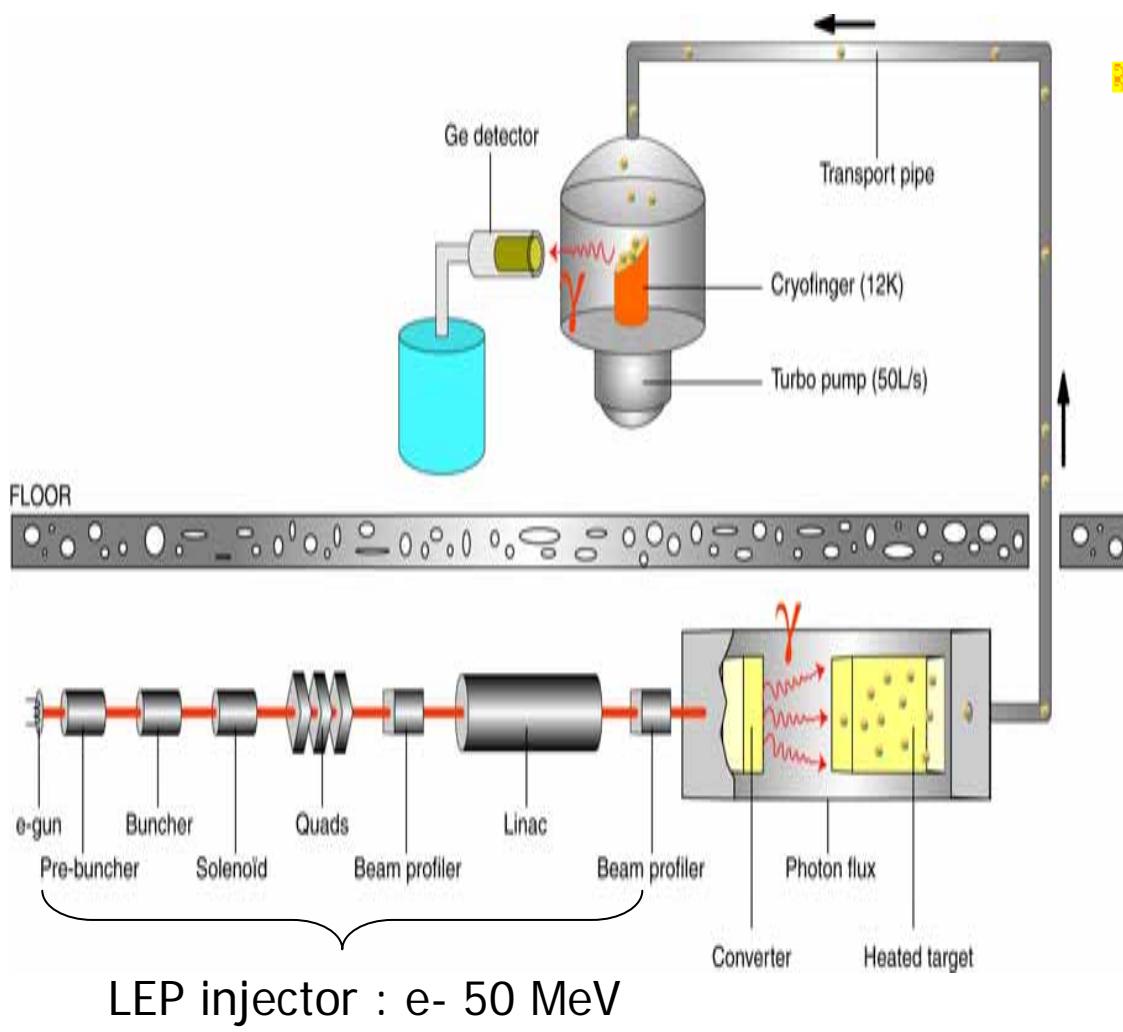


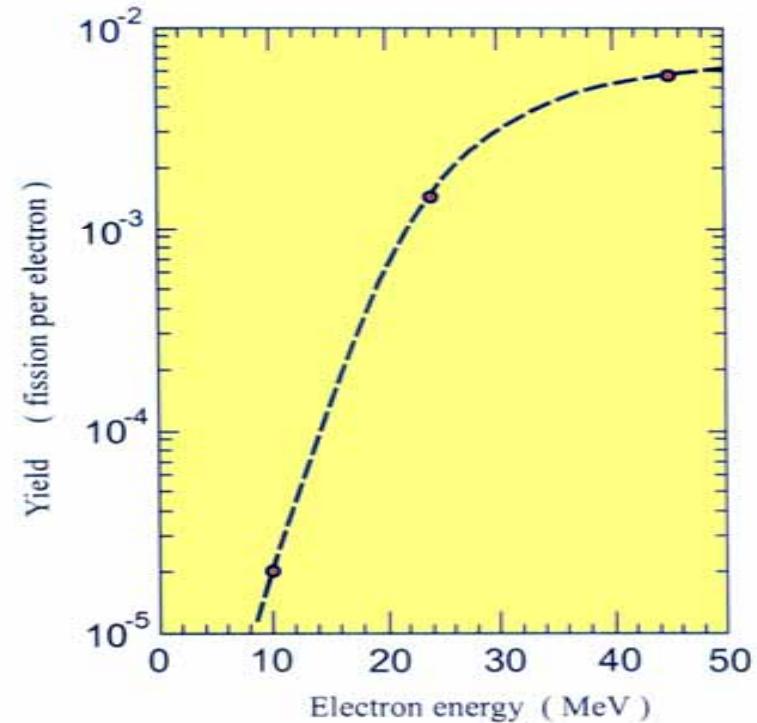
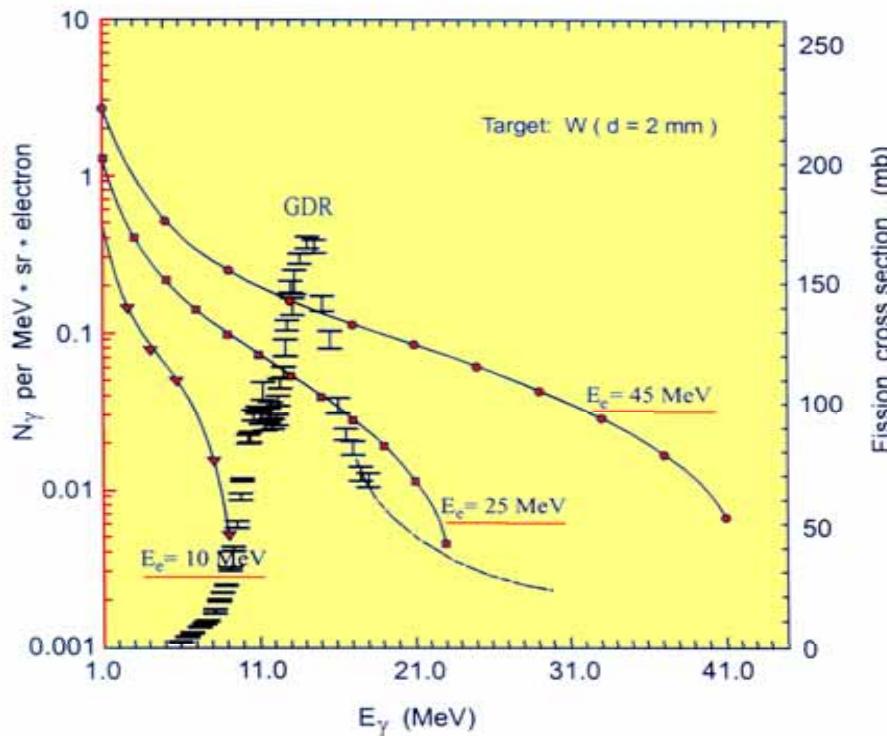
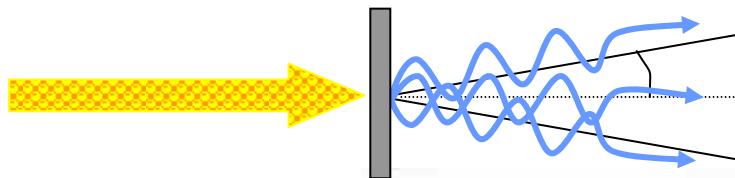
Photo-fission at CERN



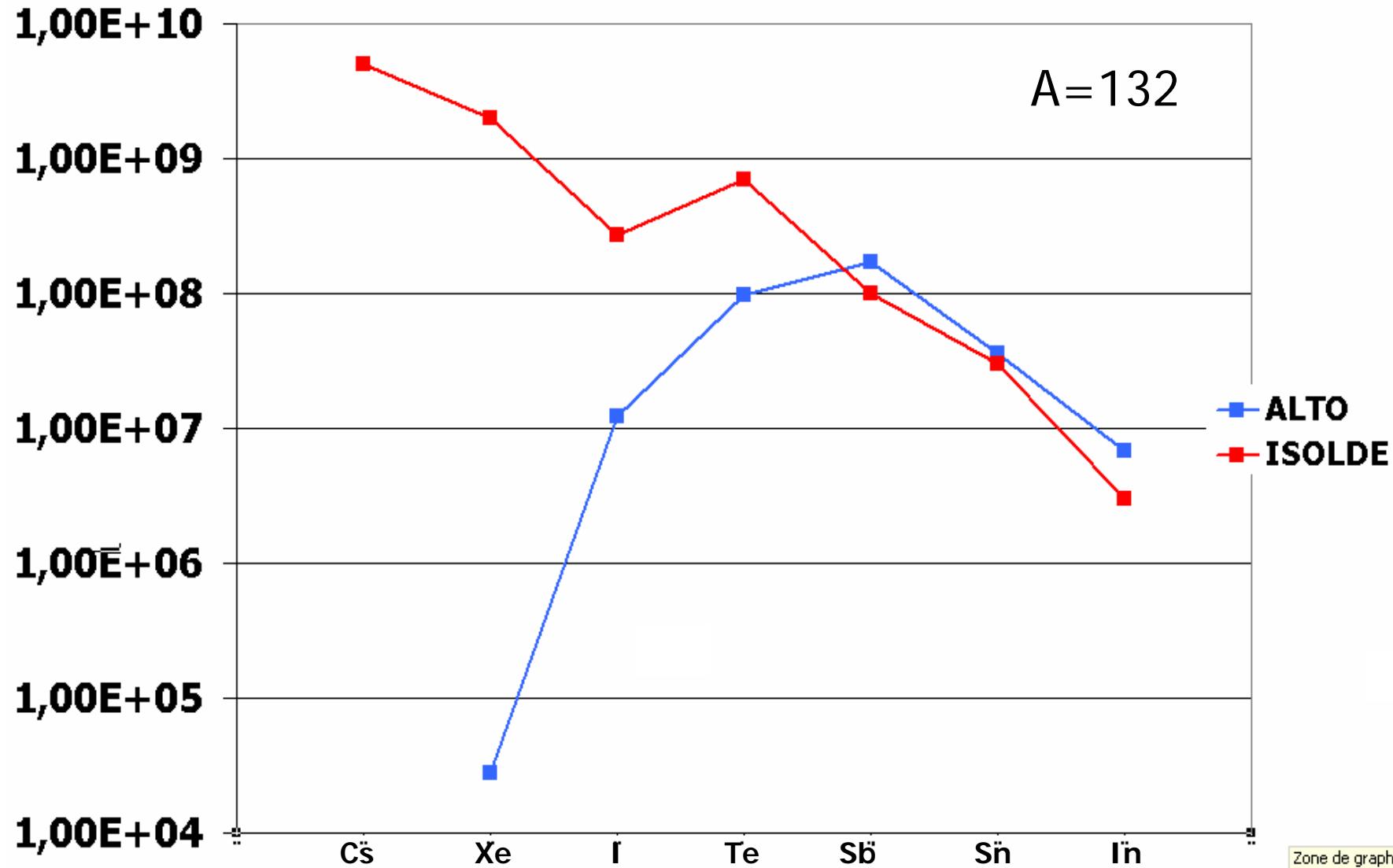
Comparison with experiments
 Performed with the same
 Conditions using deuterons
 20, 26, 50, 80 et 130 MeV

Gain v/s PARRNe
 X 10 reaction
 X 10 intensity
 ↓
 factor 100

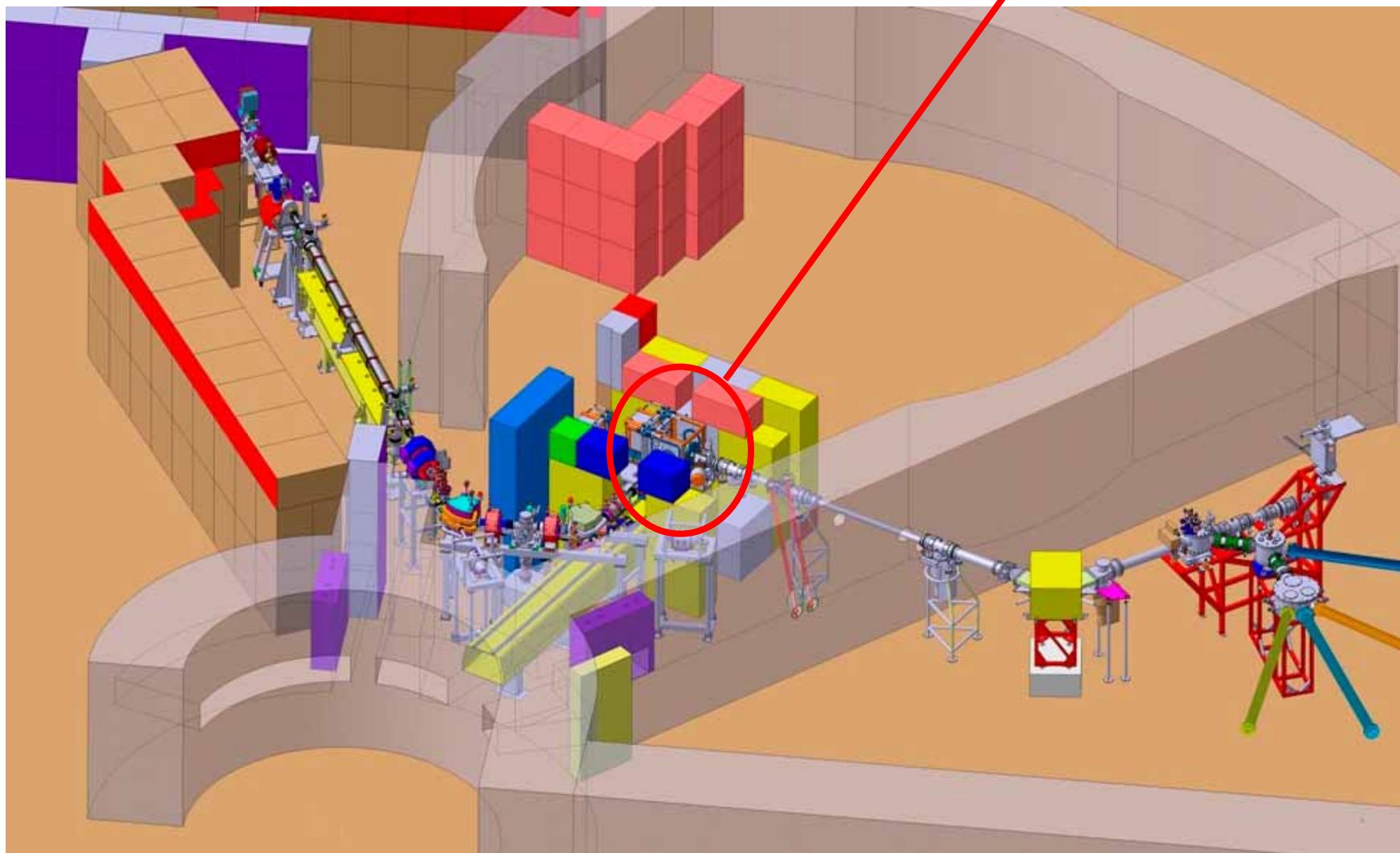
Production of fission fragments by photo-fission alto



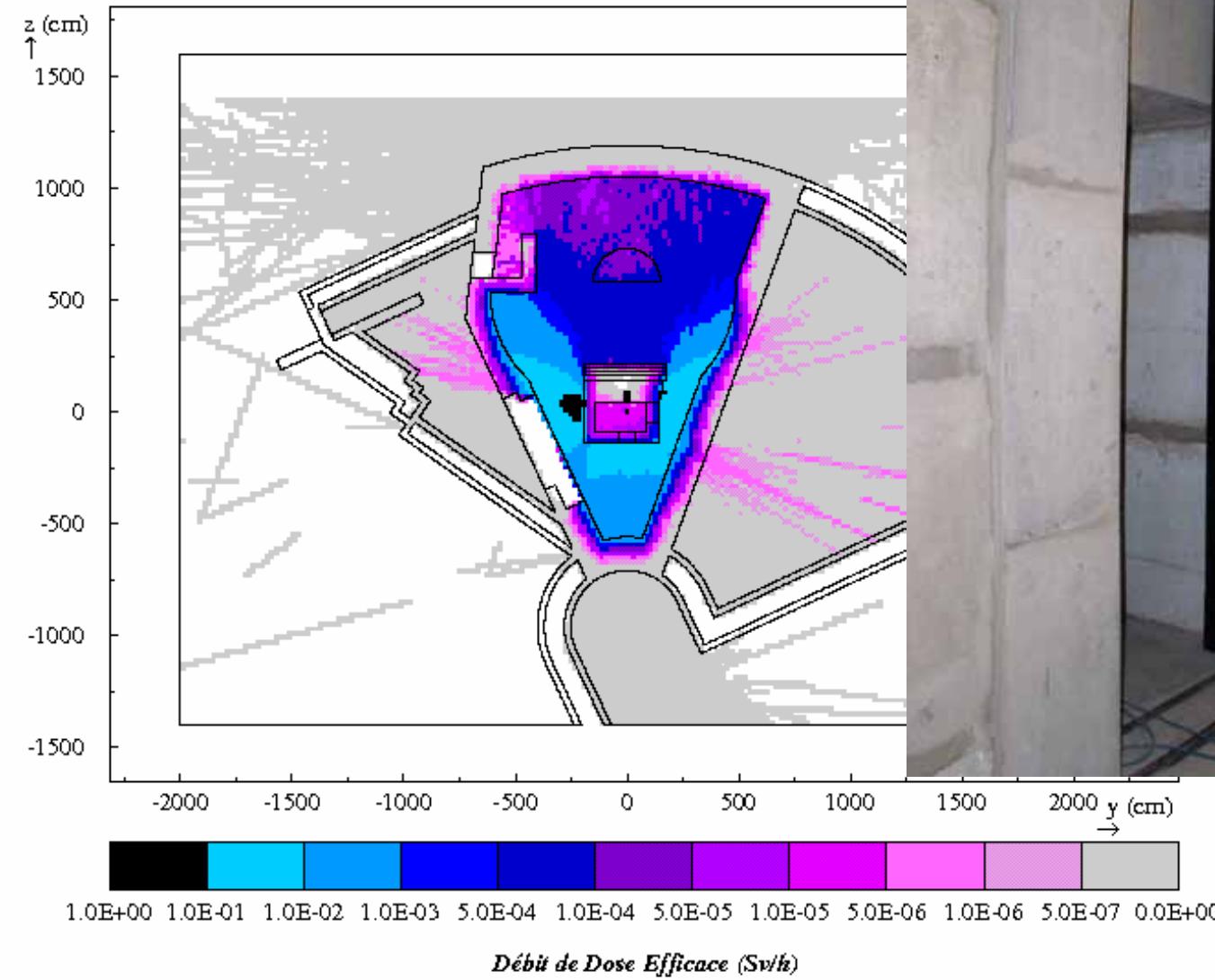
Comparison between cold and hot fission ^{132}Sn region

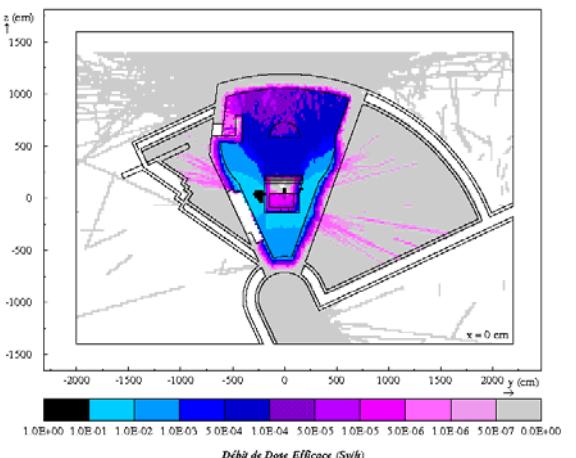


$5 \cdot 10^{11}$ fissions /s



ALTO





DIRE
DIRECTION DES PLANNINGS
DE LA PROTECTION
DU PATRIMOINE
DU TERROIR
DU RISQUE

Pôle, le 07 juillet 2016

DRM1. Autorisation d'utiliser le site non nucléaire ou accélératrice d'électrons et des appartenants dessus lesquels il exerce une activité.

Nouvelle autorisation

Référence : Procédure fait du 15/06/2016 (correspondance)

E.A.I. 1 notification d'autorisation

Appel à projets dont cette correspondance : (RH06)

Madame,

Concernant à votre demande respective au référencement et au application de l'article R.1333-27 du code de l'ordre public, je vous prie de trouver ci-joint la décision d'autorisation qui vous a été accordée par Ministère de la Santé et de la Cohésion Sociale.

Cette décision résulte du décret n° 03-073008 et son message sous le numéro T93061 (référence) à appeler de toute correspondance ultérieure.

J'attire votre attention sur le fait que cette autorisation vous a été accordée à titre personnel et qu'elle n'est transférable ni assujettie à une décision explicite du Ministère de la Santé et des Solidarités.

Je vous prie d'agréer, Madame, l'expression de ma considération distinguée.

Le Chef de la Mission de la Mission Nucléaire
de la Radioprotection,

A. JACQUES

DPE Directeur
Madame Présidente GUILLEMAUD-MULLER
DNPP Université Paris-Sud
2, rue Henri-Clement
91400 ORSAY

www.eaufrance.org

MINISTÈRE DE LA SANTE ET DES SOLIDARITES
Ministère de l'Énergie et du Développement durable

LE MINISTÈRE DE LA SANTE ET DES SOLIDARITES

Le code de la santé publique, notamment au article L.1333-1,L.1333-2,L.1335-4 et R.1333-27,L.1335-14,
ou le code de l'ordre public, notamment au article R.231-73 et suivants.

Signature de la personne prévue par Madame Dominique GUILLEMAUD-MULLER (formulaire daté du 17/06/2016 en tant que mandaté).

DRAPEAU
TITRE II
DISPOSITIONS COMPLÉMENTAIRES

Art. A.1 - Objet de l'autorisation et titulaire

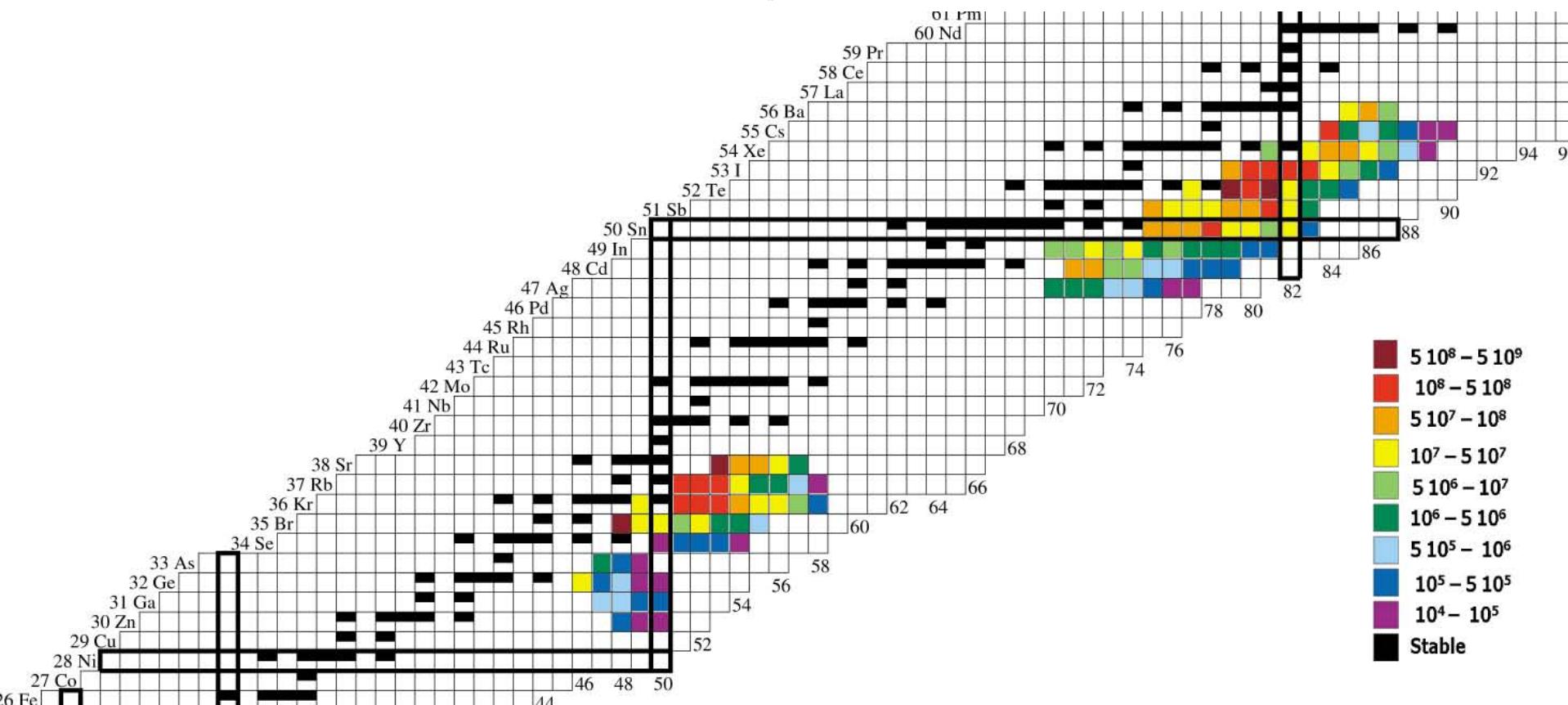
Madame Dominique GUILLEMAUD-MULLER est autorisé à utiliser à des fins non nucléaires des appareils mentionnés sur ce formulaire. Il est précisé que l'autorisation (ALTO), dans les conditions détaillées dans le présent document, concerne les appareils et les installations mentionnés ci-dessous. Il ne peut être accordée qu'après avoir obtenu une permission délivrée dans les projets concernés.

Cette autorisation, délivrée au nom de l'article R.1333-27 du code de l'ordre public, est accordée à Madame Dominique GUILLEMAUD-MULLER pour une durée d'un an renouvelable d'un an à renouveler. Le chargement de toutes personnes évoquées dans ce document est de leur responsabilité.

Art. A.2 - Régularisation de l'autorisation et validité

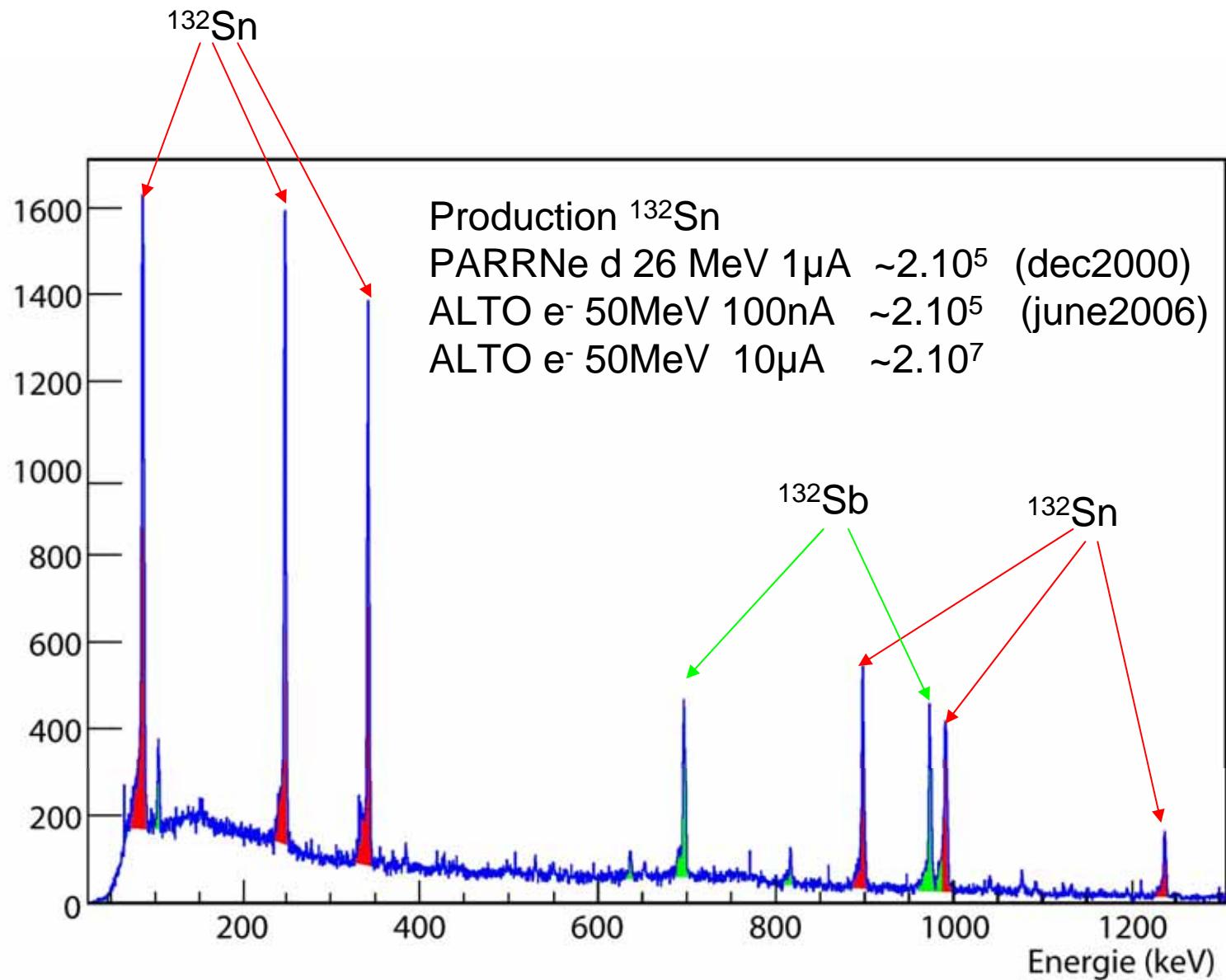
Une autorisation doit être demandée au moins avec une capacité dans les conditions prévues par l'article R.1333-27 du code de la santé publique.

Comment ALTO, cette autorisation ne porte que la place de travail. Pour l'application de l'autorisation, on appelle de manière distincte de celle-ci, une autre autorisation l'autorisation. Brise être donnée avec la décision de protection.

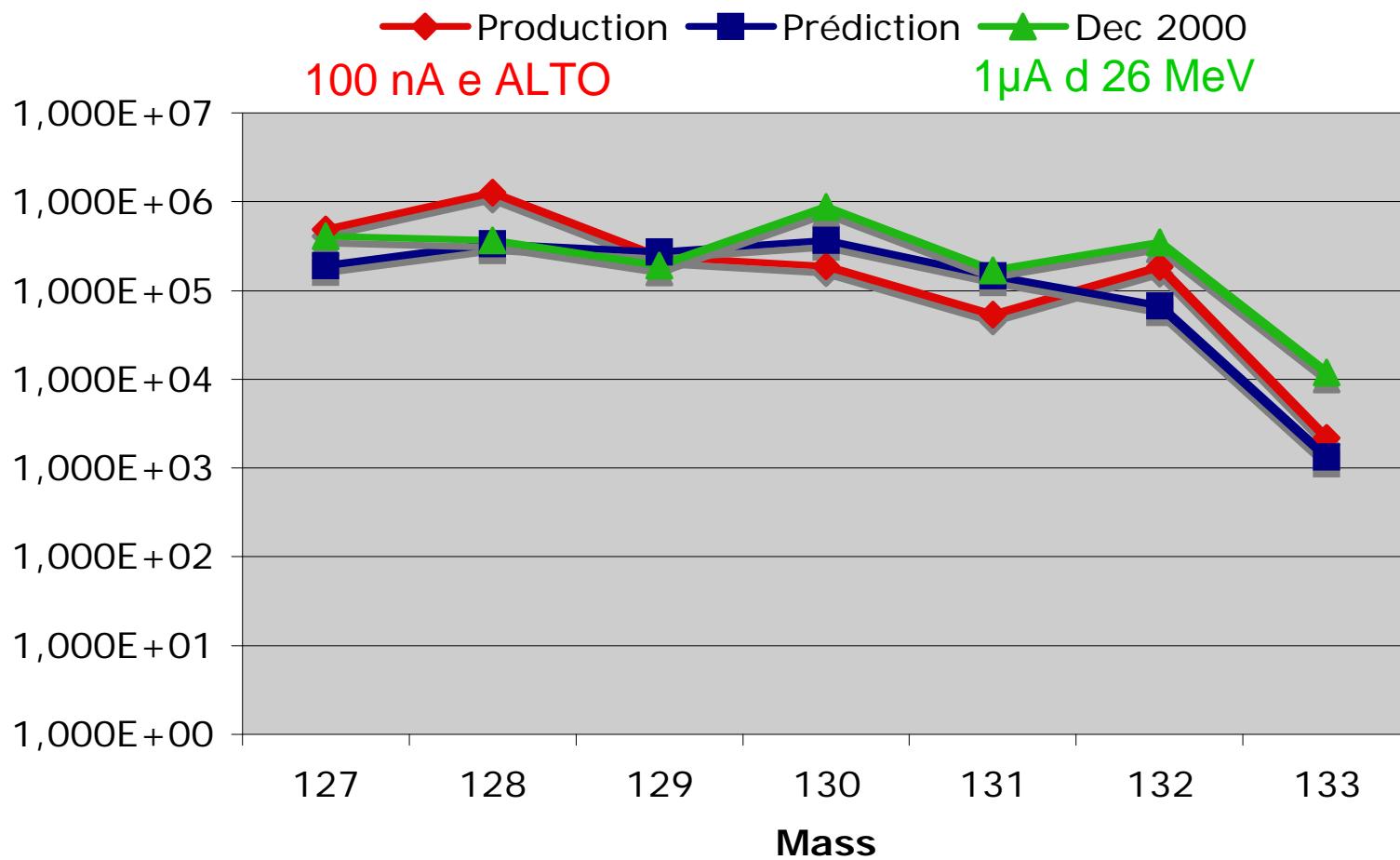


July 2006

First test with target ion source
Confirmation of productions



Yields for Isotopic Chain of Sn



$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon_{target} \cdot \varepsilon_{source} \cdot \varepsilon_{separ} \cdot \varepsilon_{det}$$

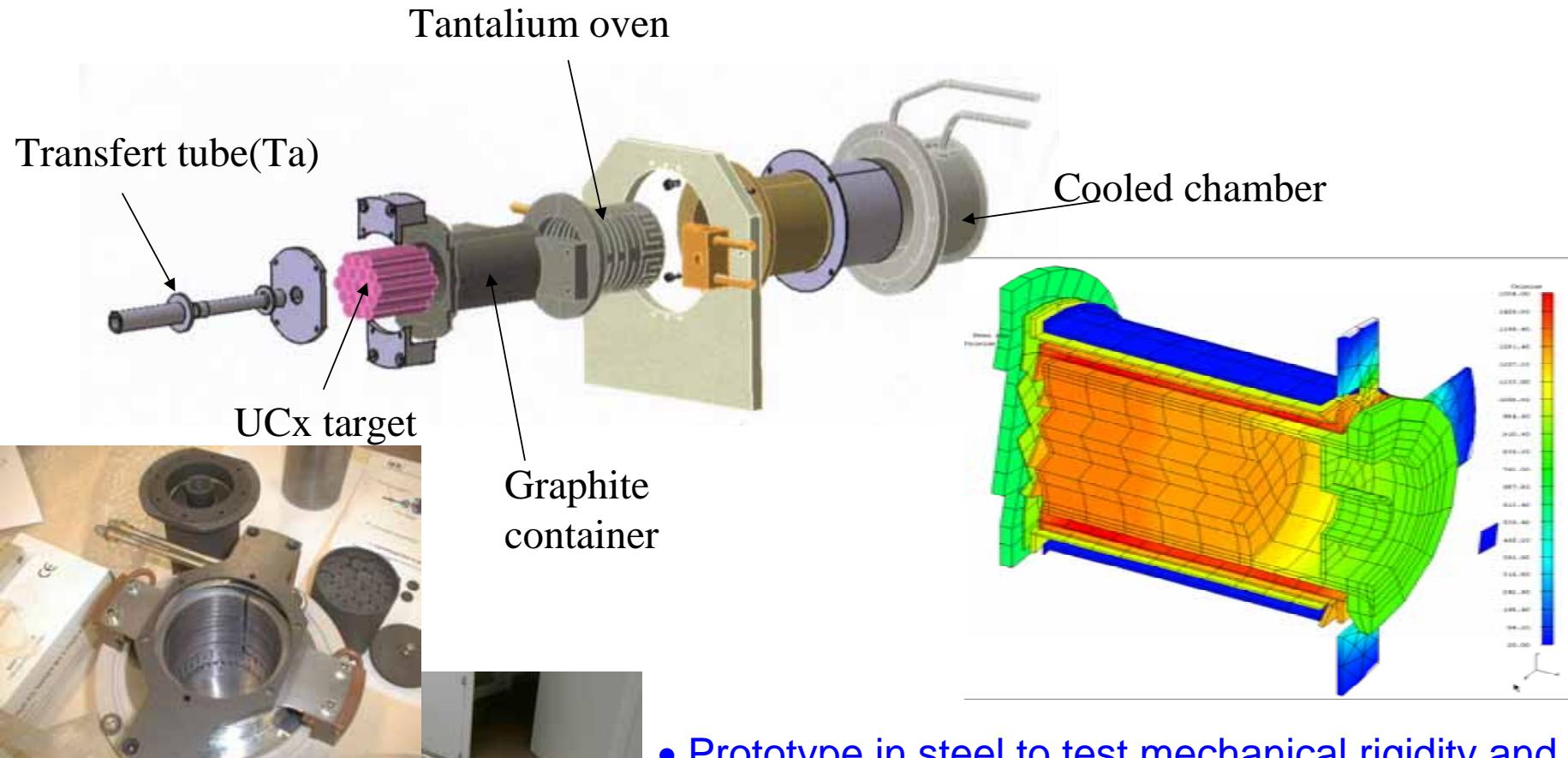
Carburation room, dimensioned for SPIRAL2 targets



Tests of target ion sources for ISOLDE, SPIRAL2 and EURISOL at ALTO
Collaboration with Argonne for dense uranium carbide

$$I = \Phi \cdot \sigma \cdot N \cdot \mathcal{E}_{t \arg et} \cdot \mathcal{E}_{source} \cdot \mathcal{E}_{separ} \cdot \mathcal{E}_{det}$$

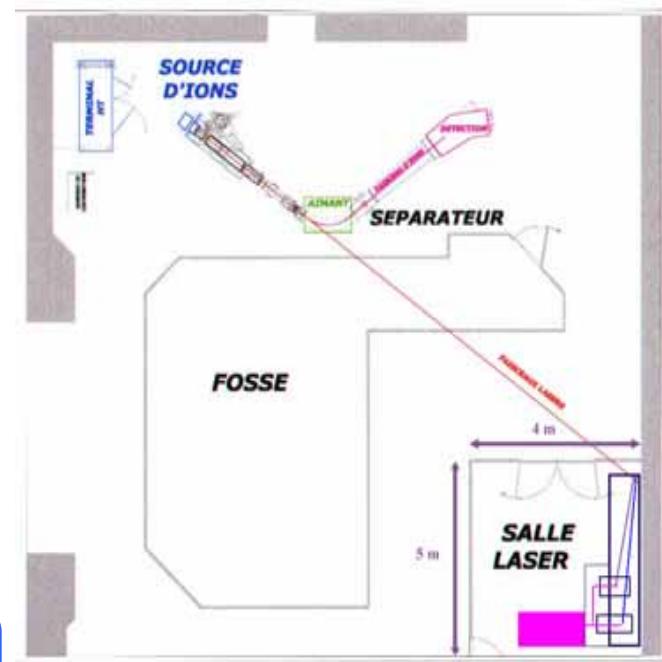
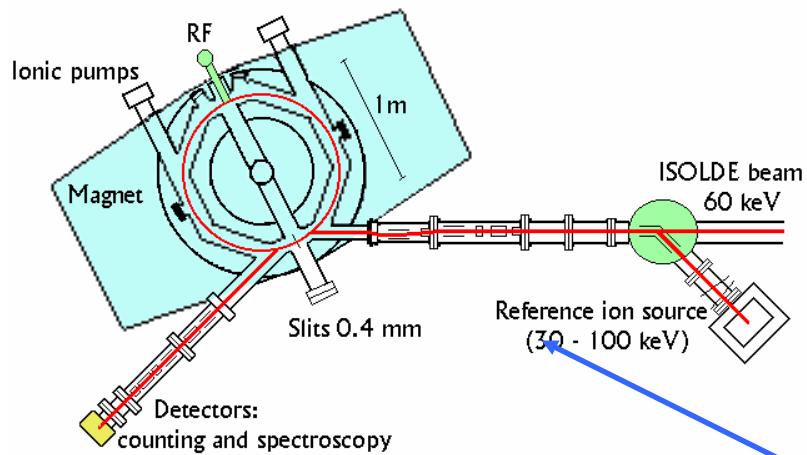
Oven design



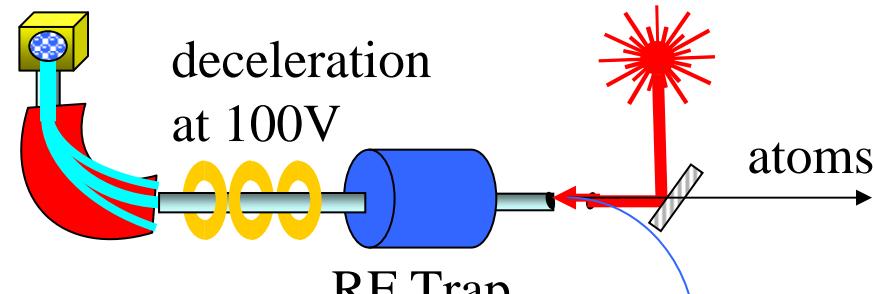
- Prototype in steel to test mechanical rigidity and temperature distribution
- validation of simulations
- Ta prototype under tests of long term heating

$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon$$

t arg et . ε_{source} . ε_{separ} . ε_{det}



Selectivity of the elements



Mc Gill
collaboration

Laser source

Use of molecules
In the ion source
To support the
chemical selection

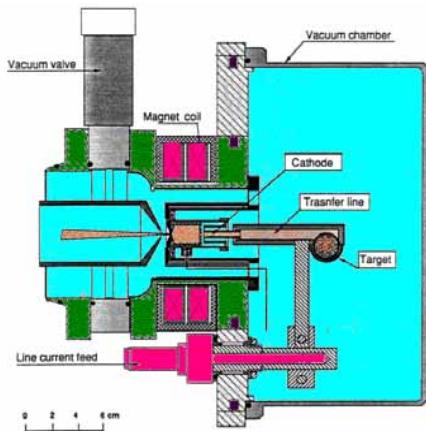
Example : sulfuration of
Sn or Ge

$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon$$

t arg et $\cdot \varepsilon_{source}$ $\cdot \varepsilon_{separ}$ $\cdot \varepsilon_{det}$

Some ion sources currently used

Plasma



High temperature (1900 °C)

Compact: the target is part of the source high efficiency

well adapted for a large number of elements

No selectivity

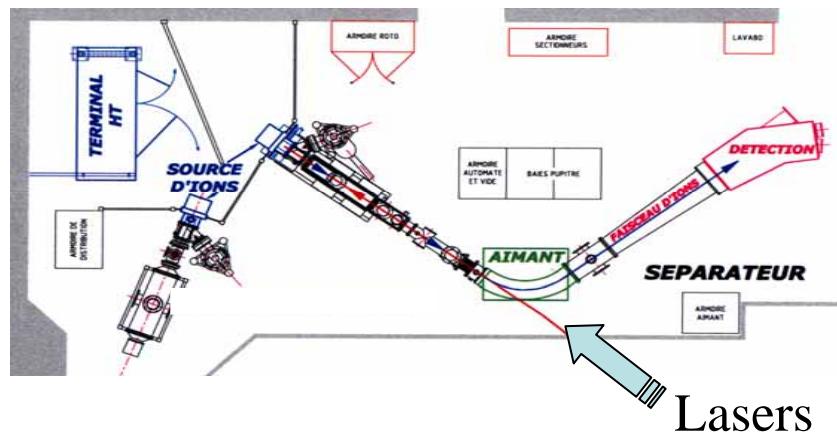
Surface ionization



Very high efficiency for alkaline

Dedicated to alkaline and Ga In

Laser source



Very selective ion source

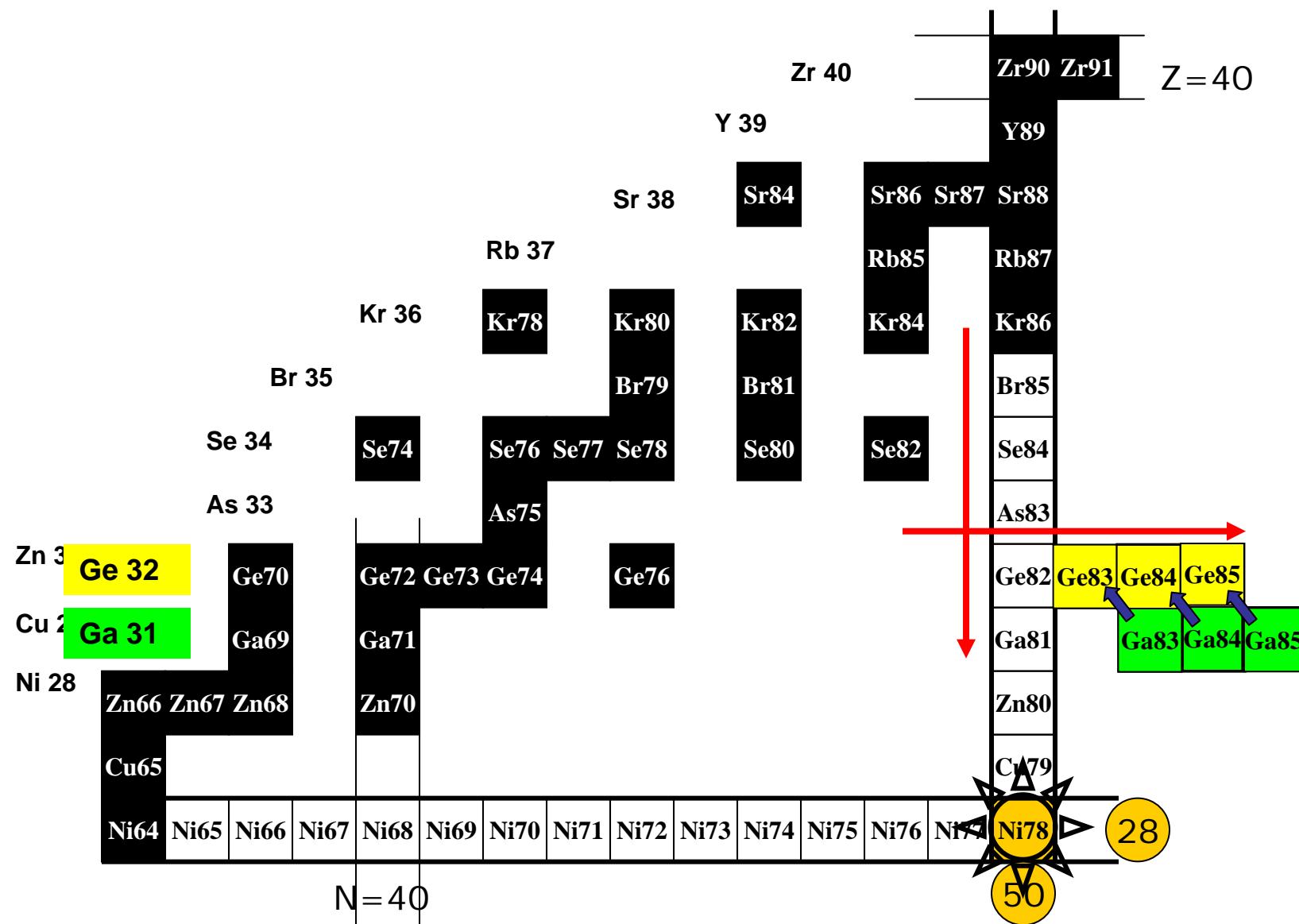
High efficiency depending on the rate frequency of the laser

Large number of elements could be ionized

Contamination with surface ionization

$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon_{t \arg et} \cdot \varepsilon_{source} \cdot \varepsilon_{separ} \cdot \varepsilon_{det}$$

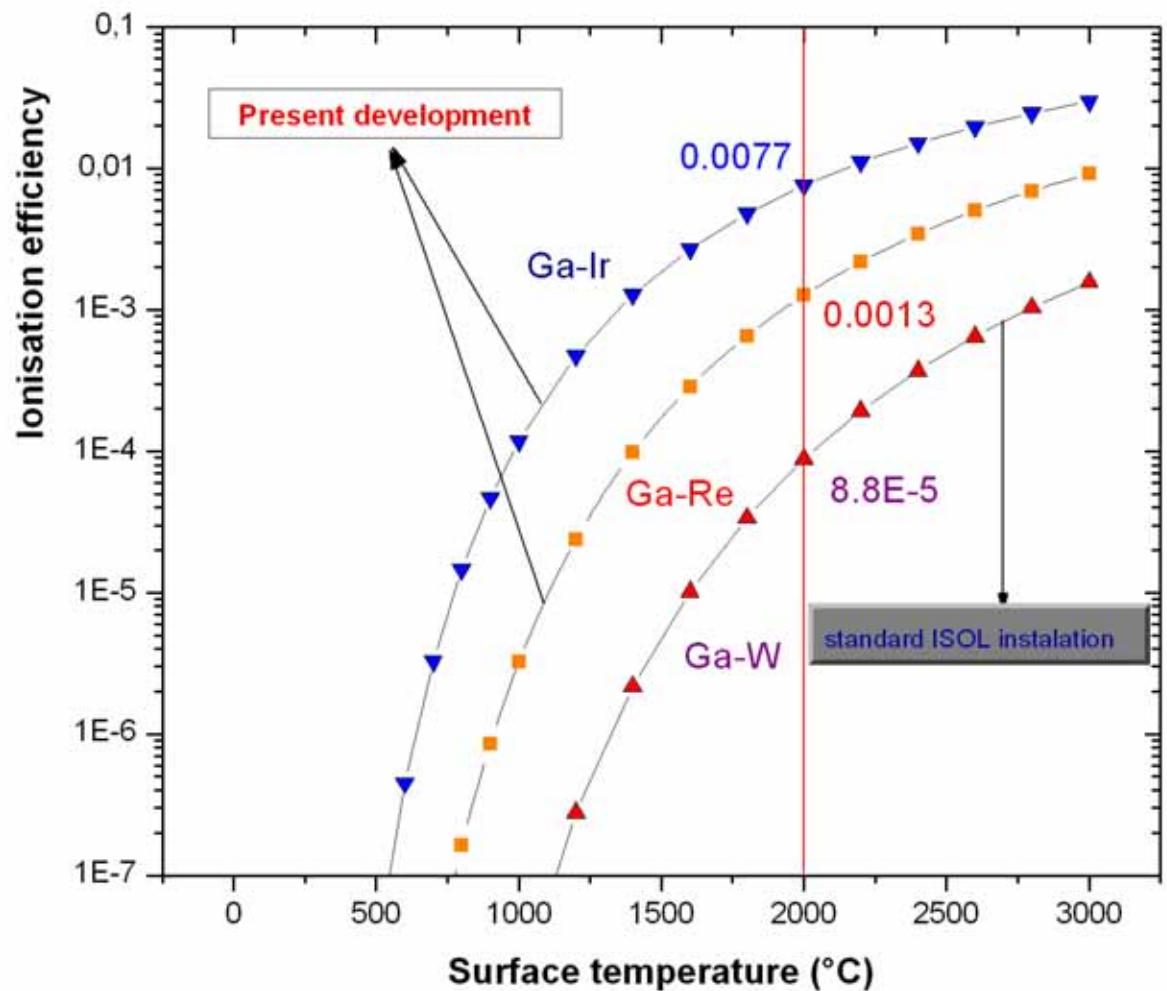
Example: production of a pure Ga beam



$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon$$

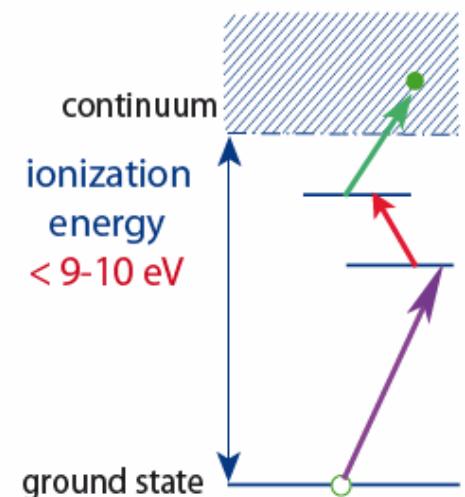
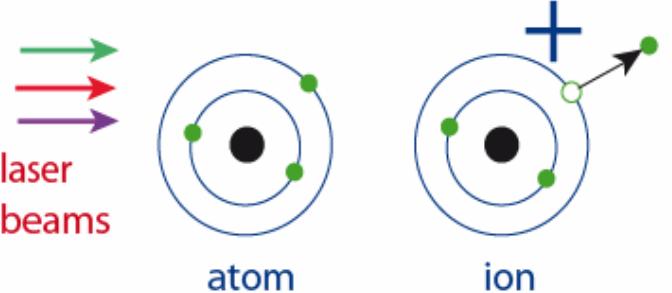
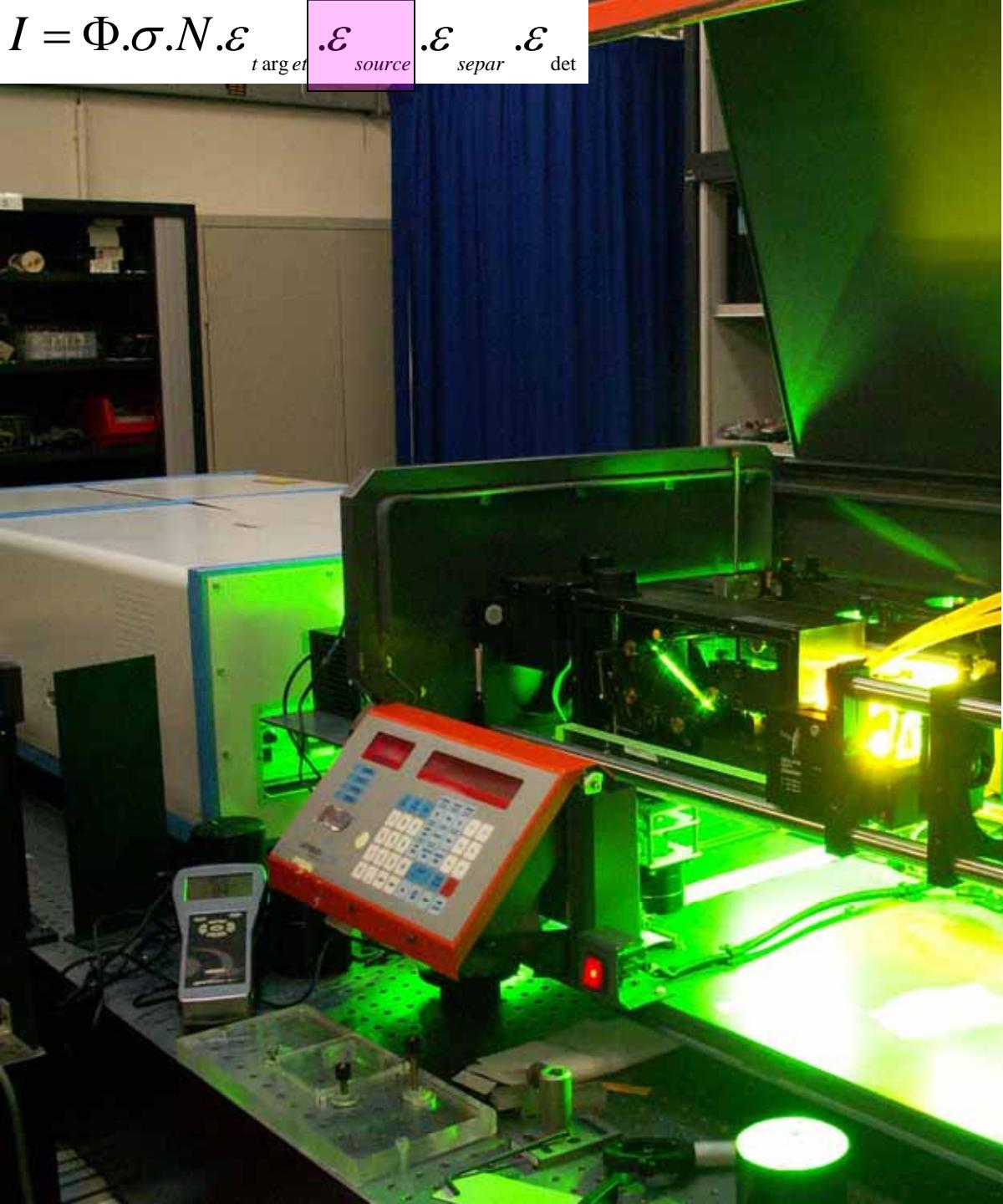
t arg et

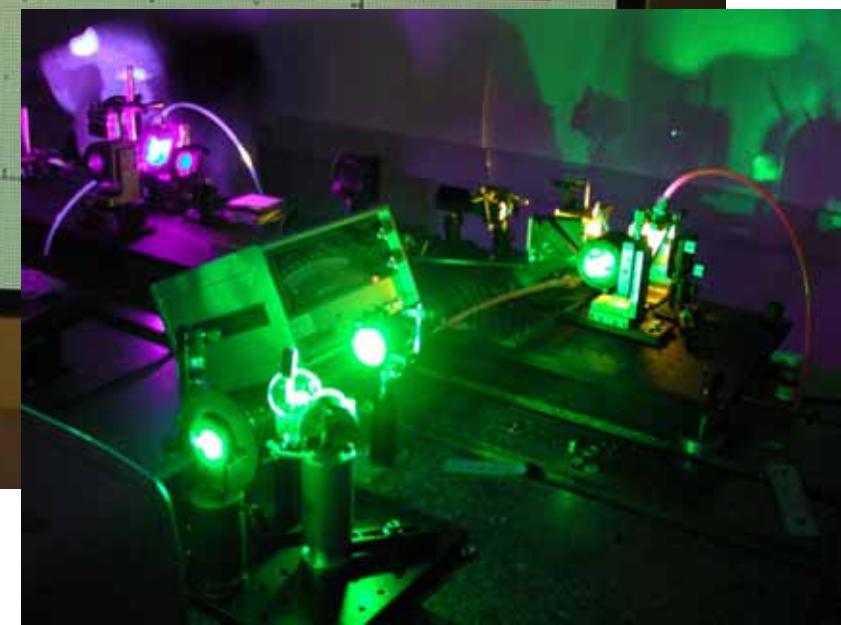
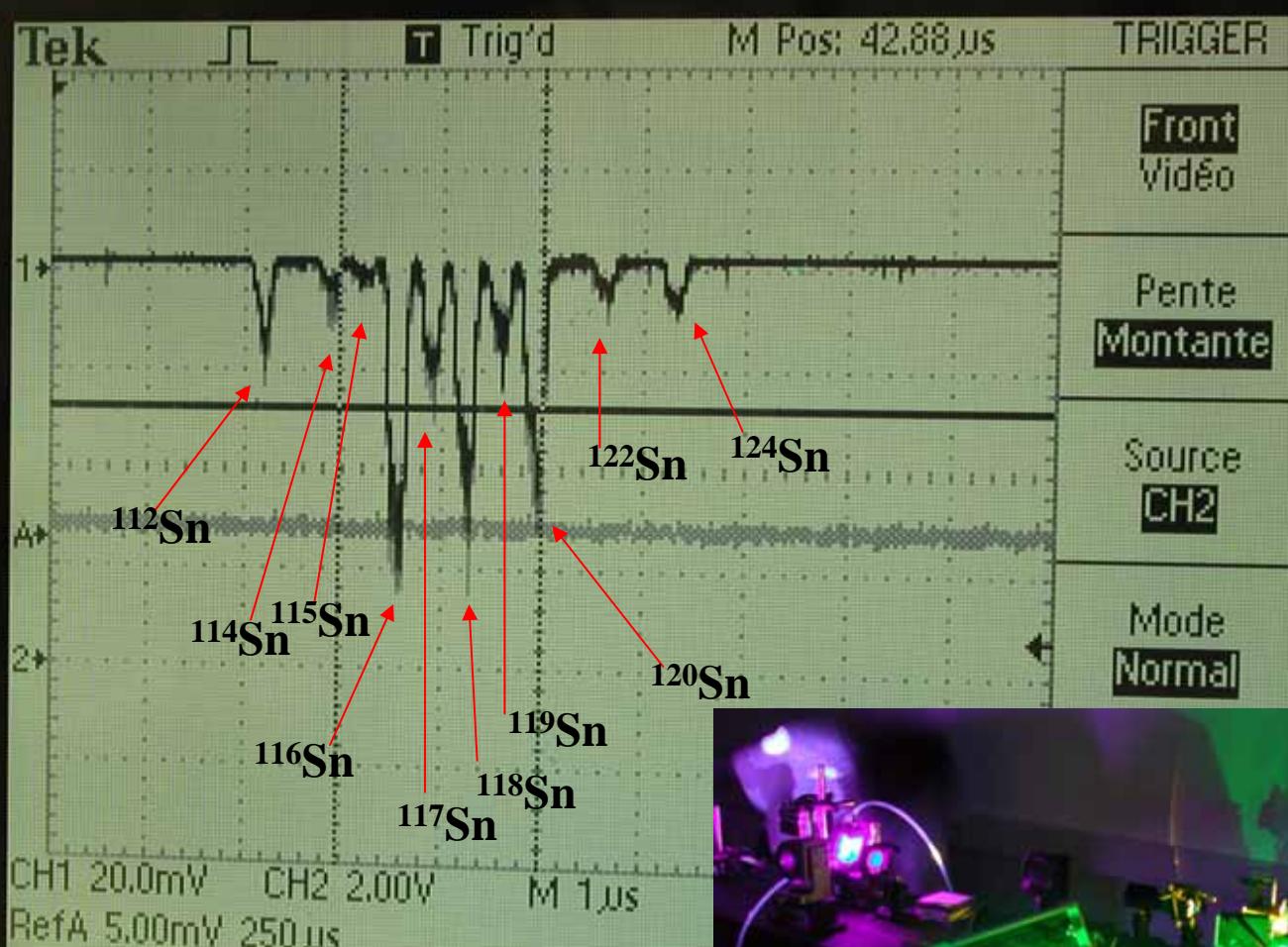
$\cdot \varepsilon_{source}$
 $\cdot \varepsilon_{separ}$
 $\cdot \varepsilon_{det}$



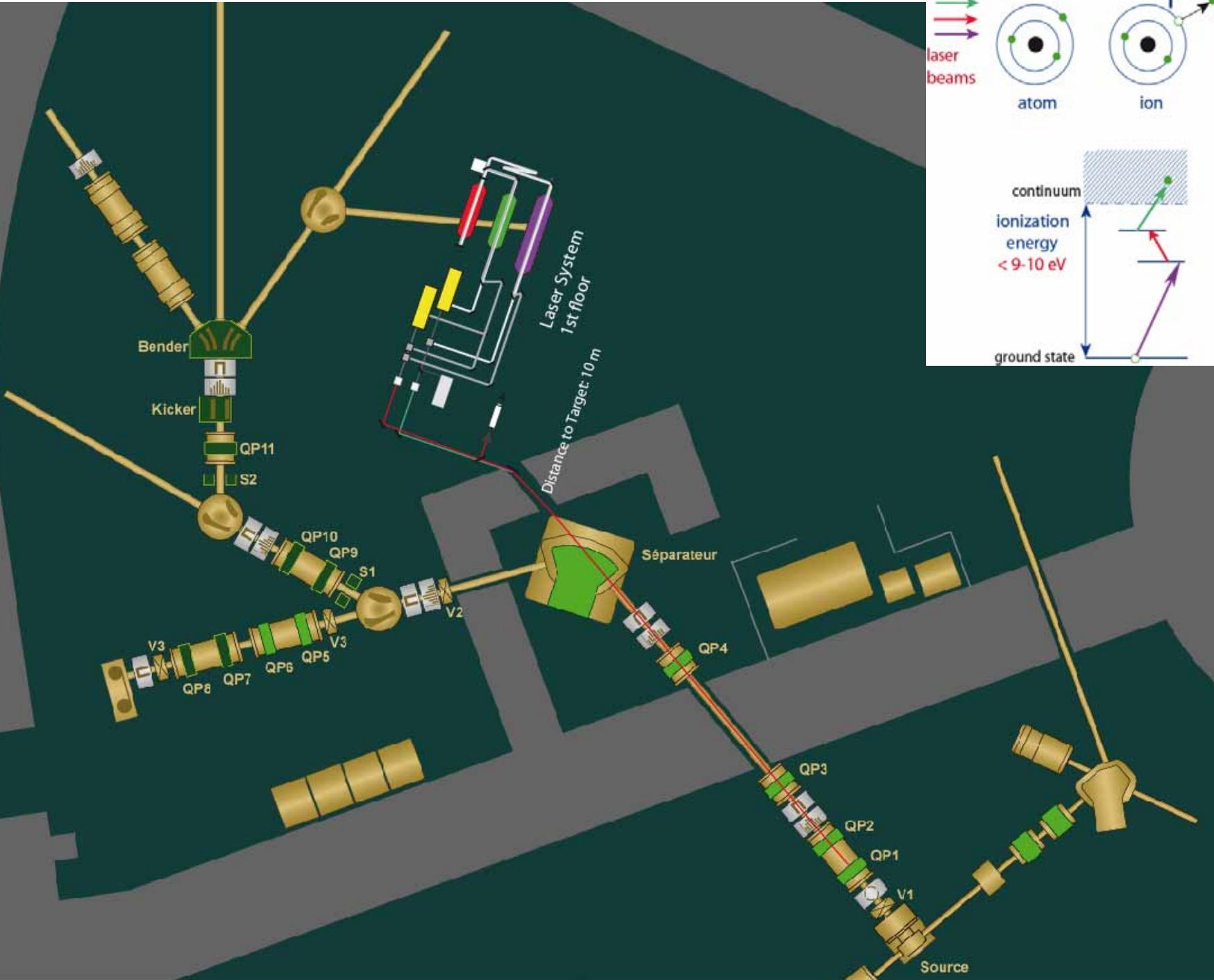
$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon$$

$$t \arg et \quad .\varepsilon_{source} \quad .\varepsilon_{separ} \quad .\varepsilon_{det}$$



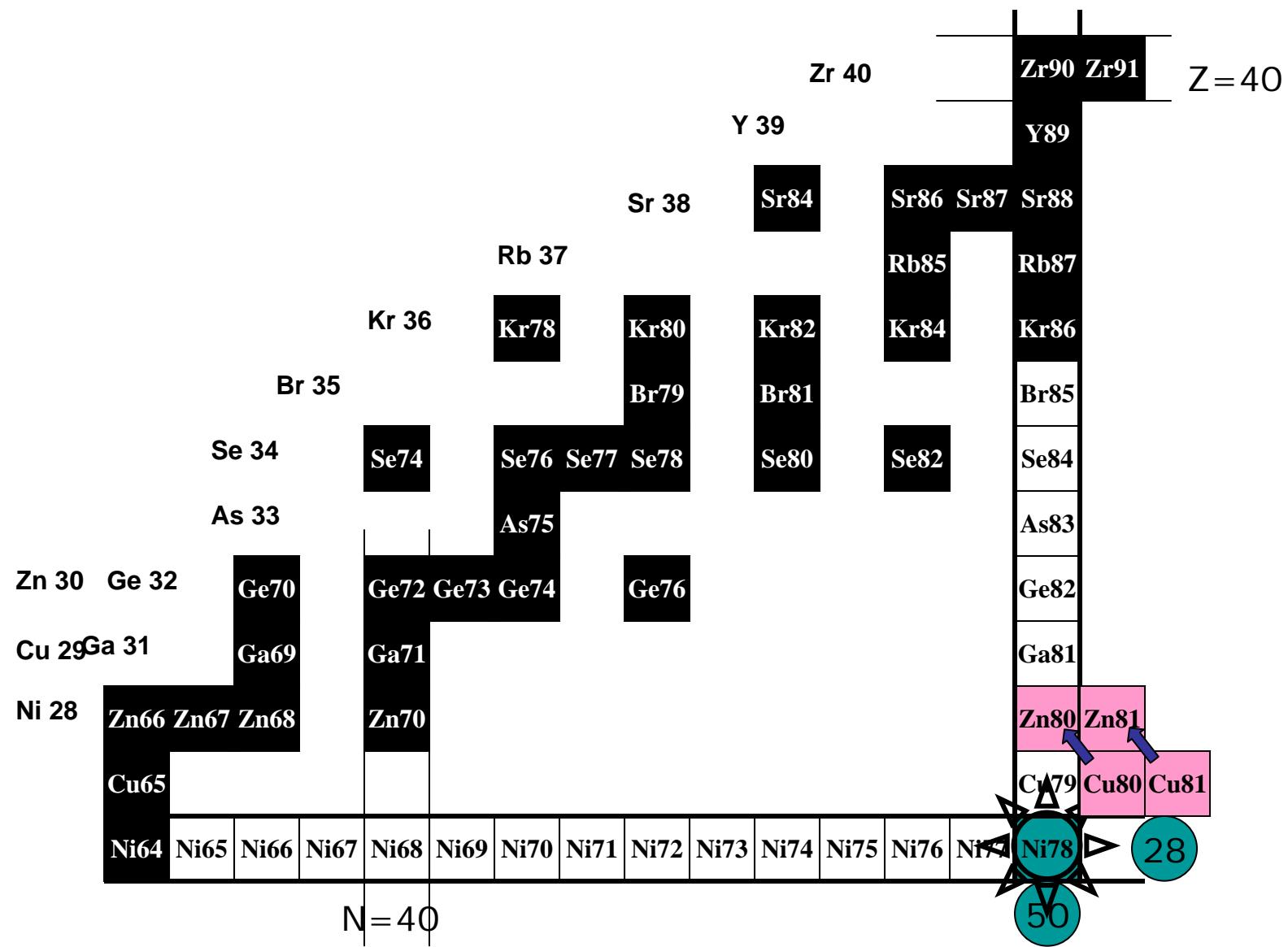


Documents F. Le Blanc et groupe
Cibles sources

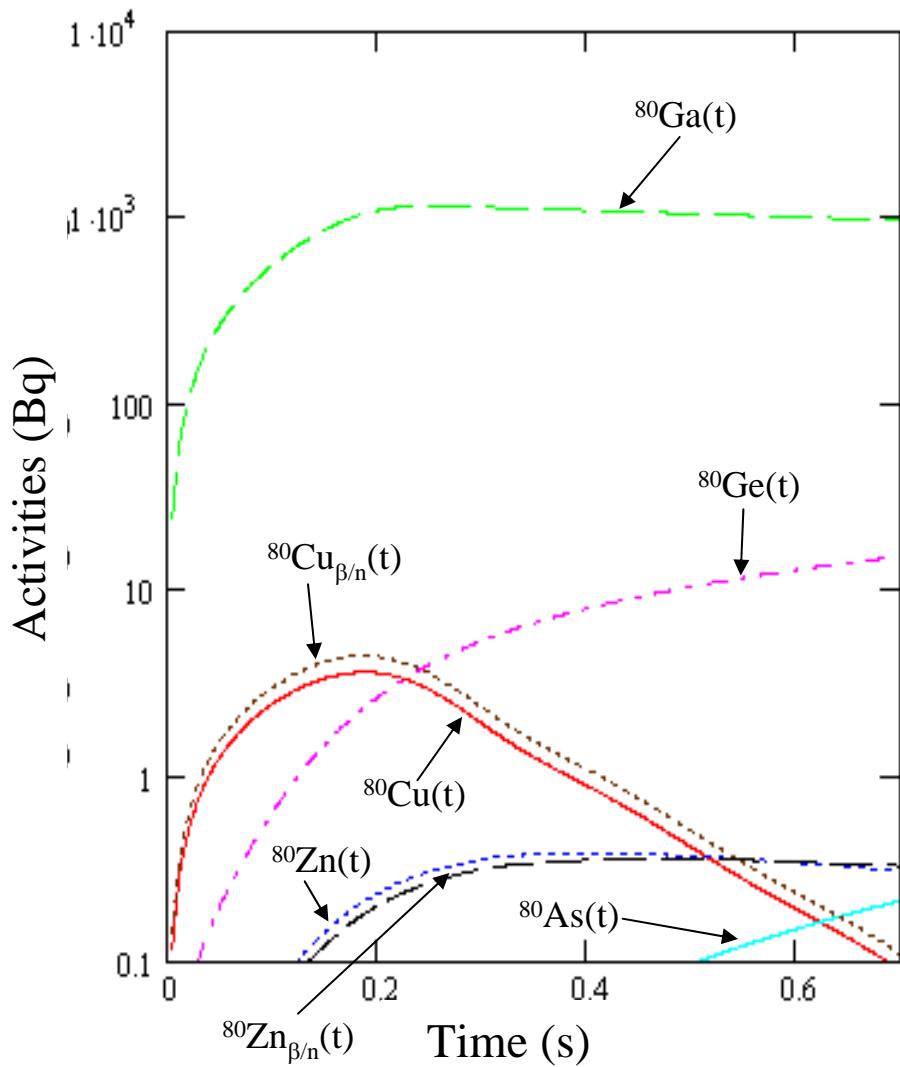


$$I = \Phi \cdot \sigma \cdot N \cdot \varepsilon_{t \arg et} \cdot \varepsilon_{source} \cdot \varepsilon_{separ} \cdot \varepsilon_{det}$$

Example: production of a pure Cu beam



Activities of the different elements produced



^{80}Cu	$T_{1/2}$
	150 ms

I.N. Borzof, PRC 71,
981 (1994)

Collection time: 200ms
Measurement time:
 $3 \times T_{1/2} \approx 1$ s

Production with Laser ionization
(for Cu)

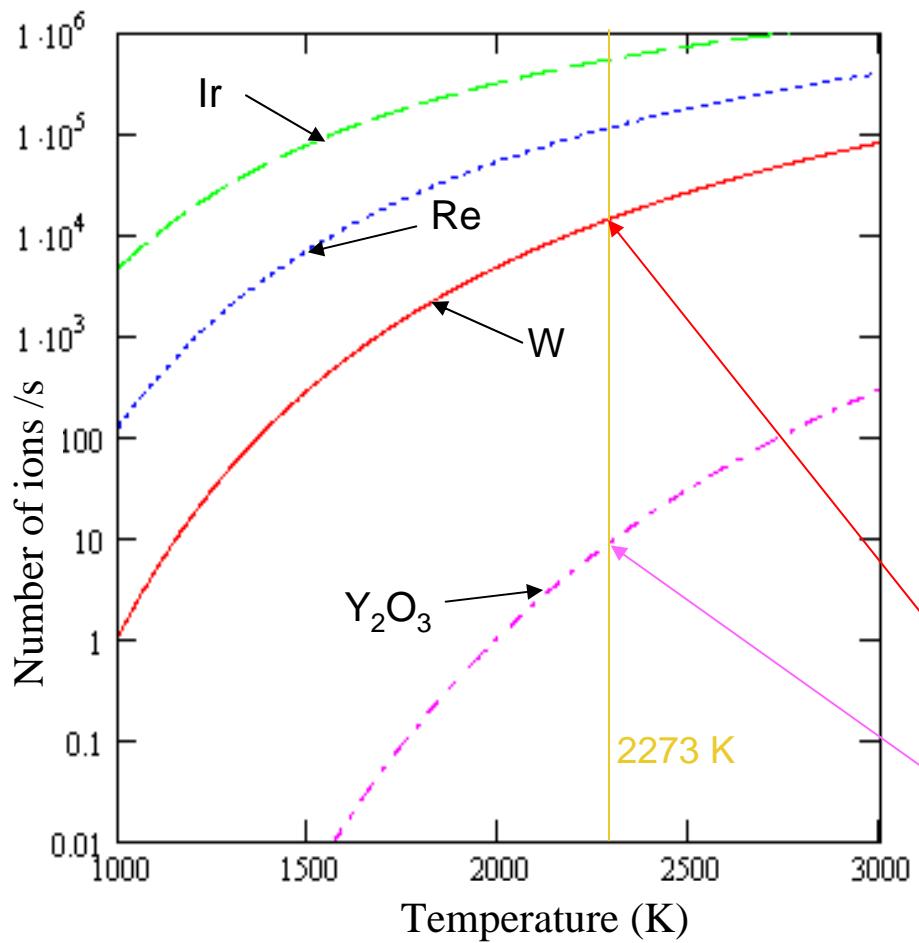
Presence of surface
ionization (for Ga)

Ascendancy of
 ^{80}Ga

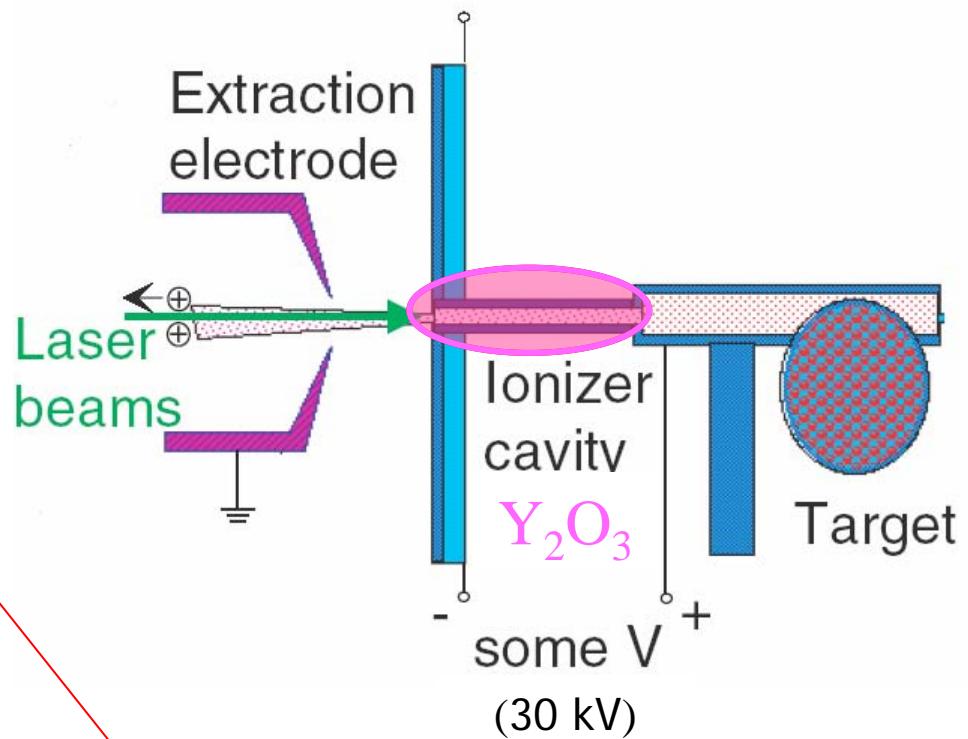
Ionizer : low work function, high melting point, (electrical conductivity?)

Expected Production Rates for ^{80}Ga

Production of ^{80}Ga

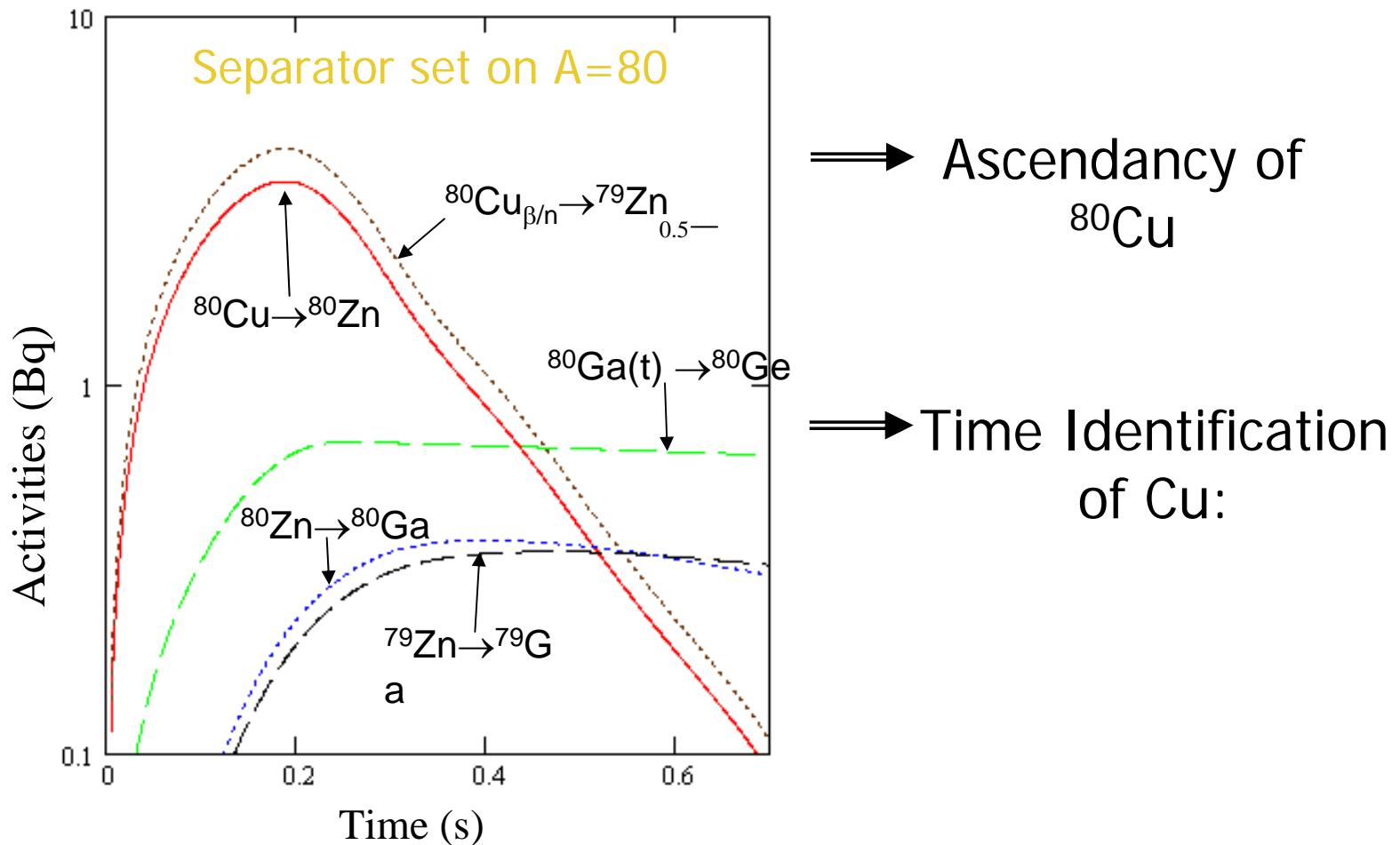


Target Ion Source Unit



Production of $^{80}\text{Ga}: 1.3620/\text{s}$

Activities of the different species for a Y_2O_3 tube



Possible Physics program de physique at a low energy facility

Some examples

Study of neutron rich nuclei around N=50

Laser spectroscopy at ALTO

β strength functions

βn $\beta^2\text{n}$ measurements

Need for a high efficiency Ge set-up and complementary detectors (neutrons, electrons)

Need for pure beams

$$I = \Phi \cdot \sigma \cdot N \cdot \mathcal{E}$$

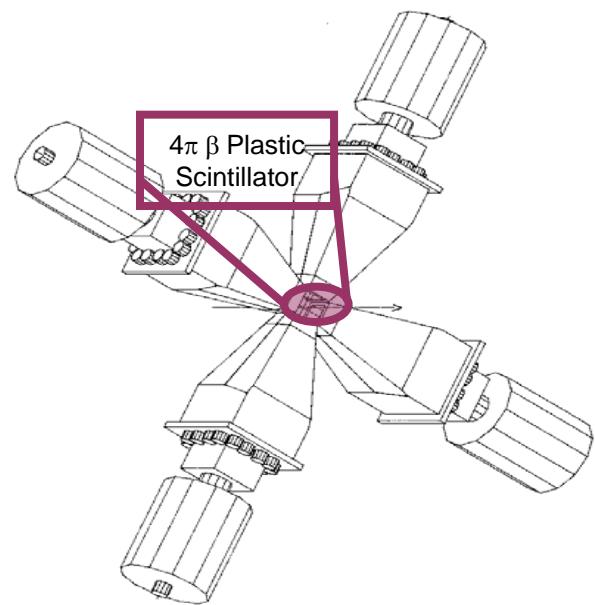
t arg et *.E source* *.E separ* .E det



Neutron detector



Conversion electron detector



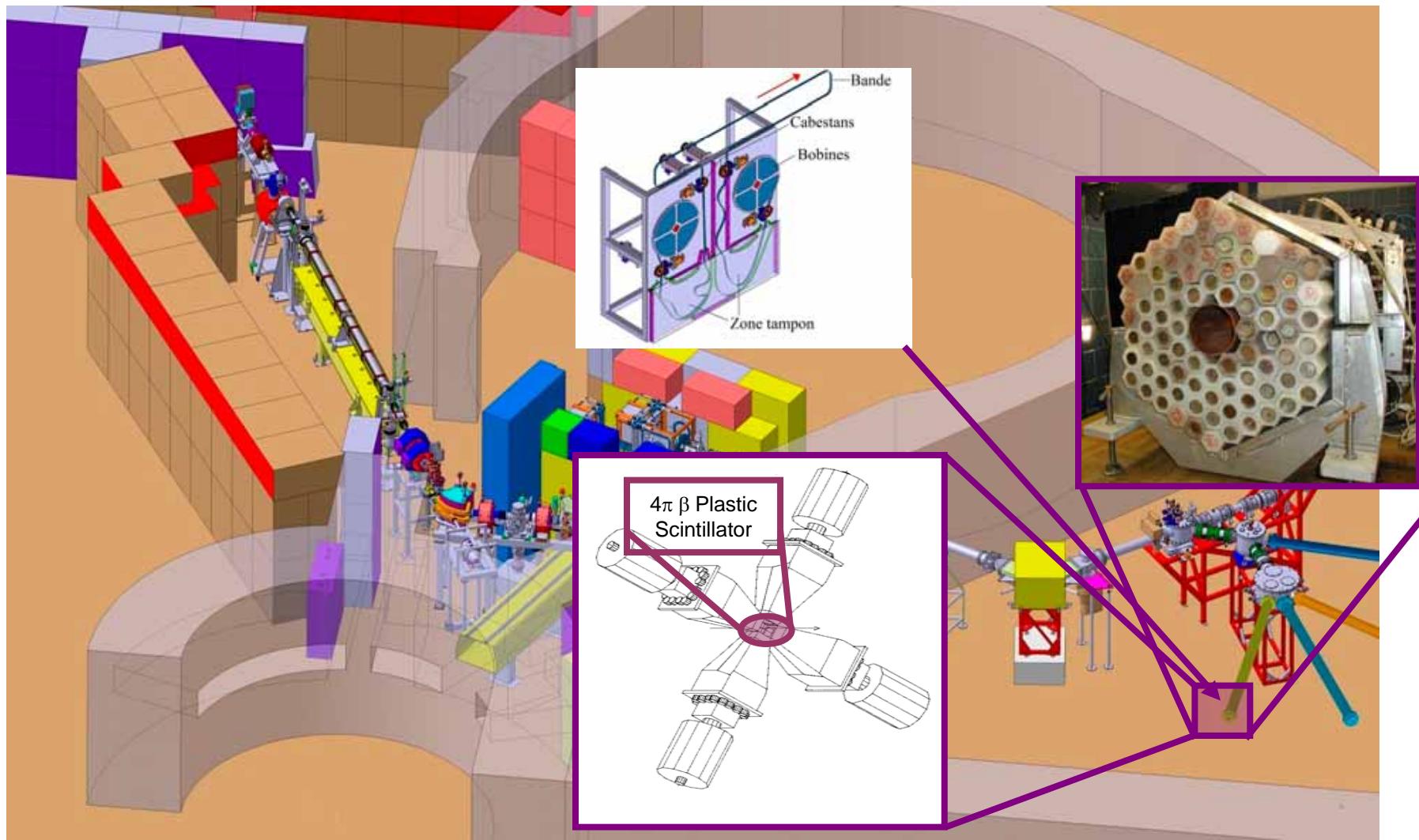
OSCAR: Orsay Segmented Clover Array
 γ -Ring : 4 segmented clovers @ 6cm
~ 10% efficiency

$$I = \Phi \cdot \sigma \cdot N \cdot \epsilon$$

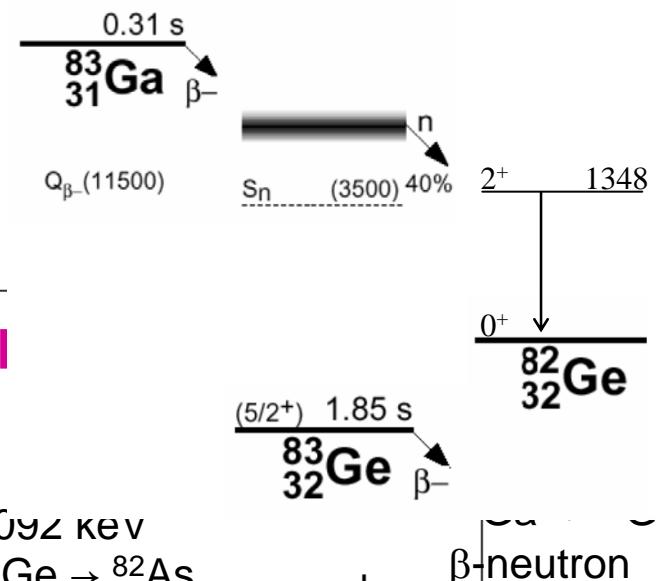
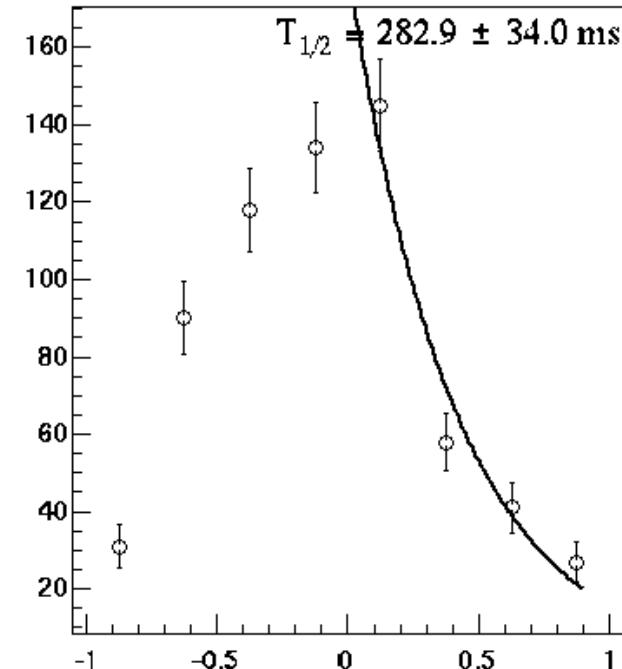
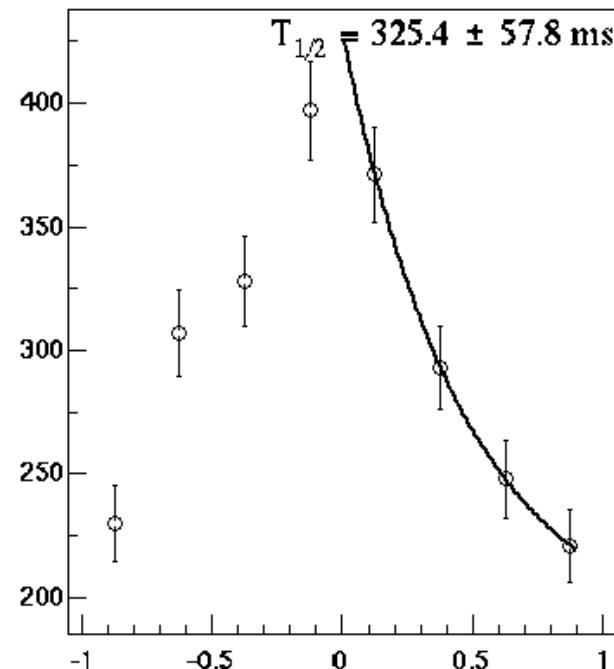
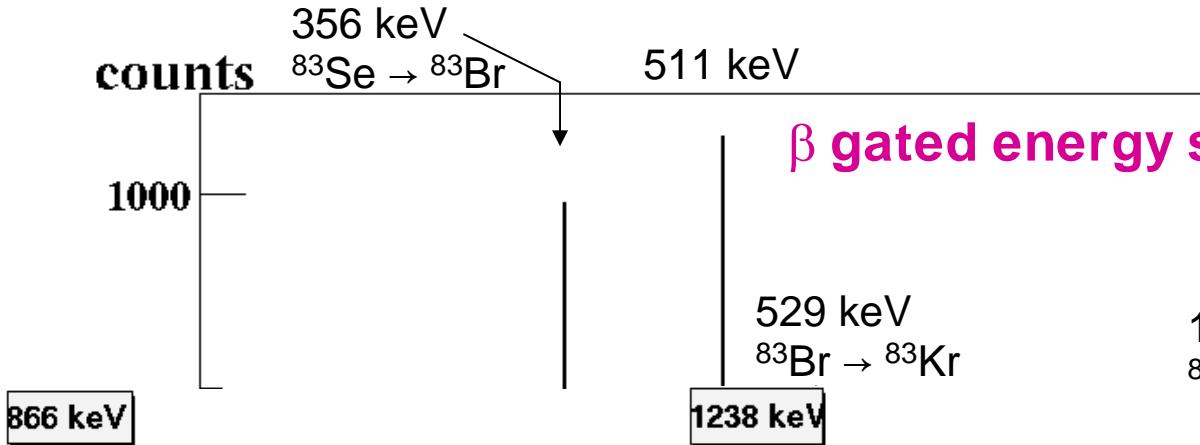
. ϵ_{target} . ϵ_{source} . ϵ_{separ} . ϵ_{det}

β -decay studies of fission fragments as a powerful tool for the exploration of the nuclear structure close to N=50

Typical Experimental Setup



Example 1: the $^{83}\text{Ga}_{52} \rightarrow ^{83}\text{Ge}_{51}$ decay study



$^{83}\text{Ga} :$
 $T_{1/2} = 300 \pm 10 \text{ ms}$

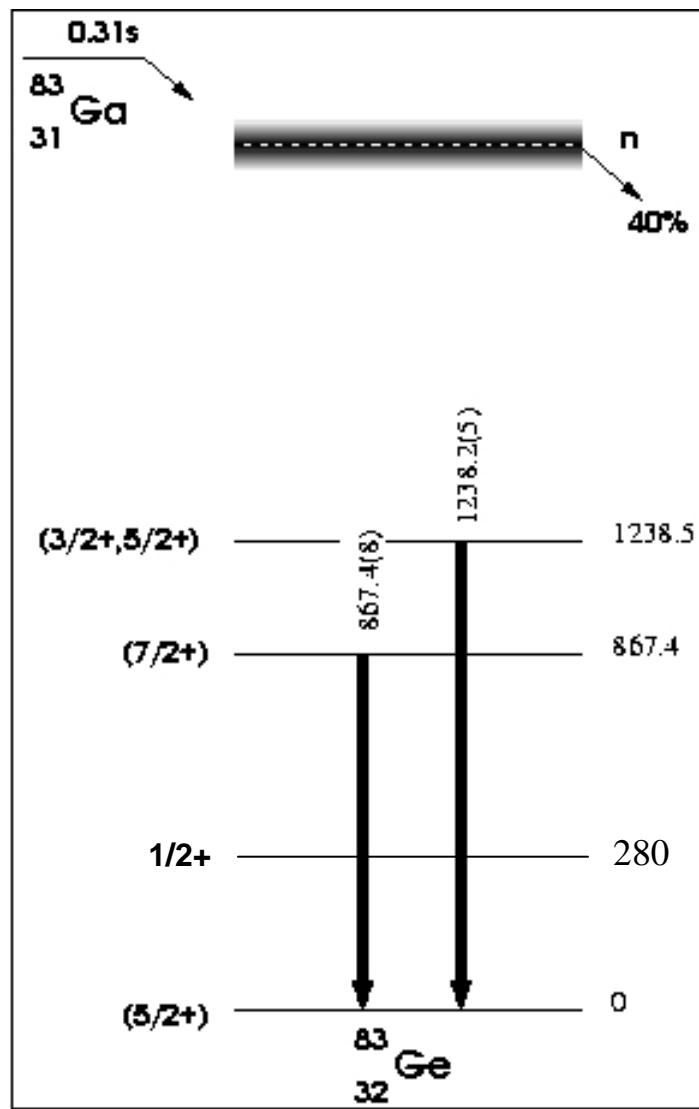
Proposed spin assignment for
the observed levels in $^{83}\text{Ge}_{51}$

$2^+ \otimes vd_{5/2}$

{

vs1/2

vd5/2

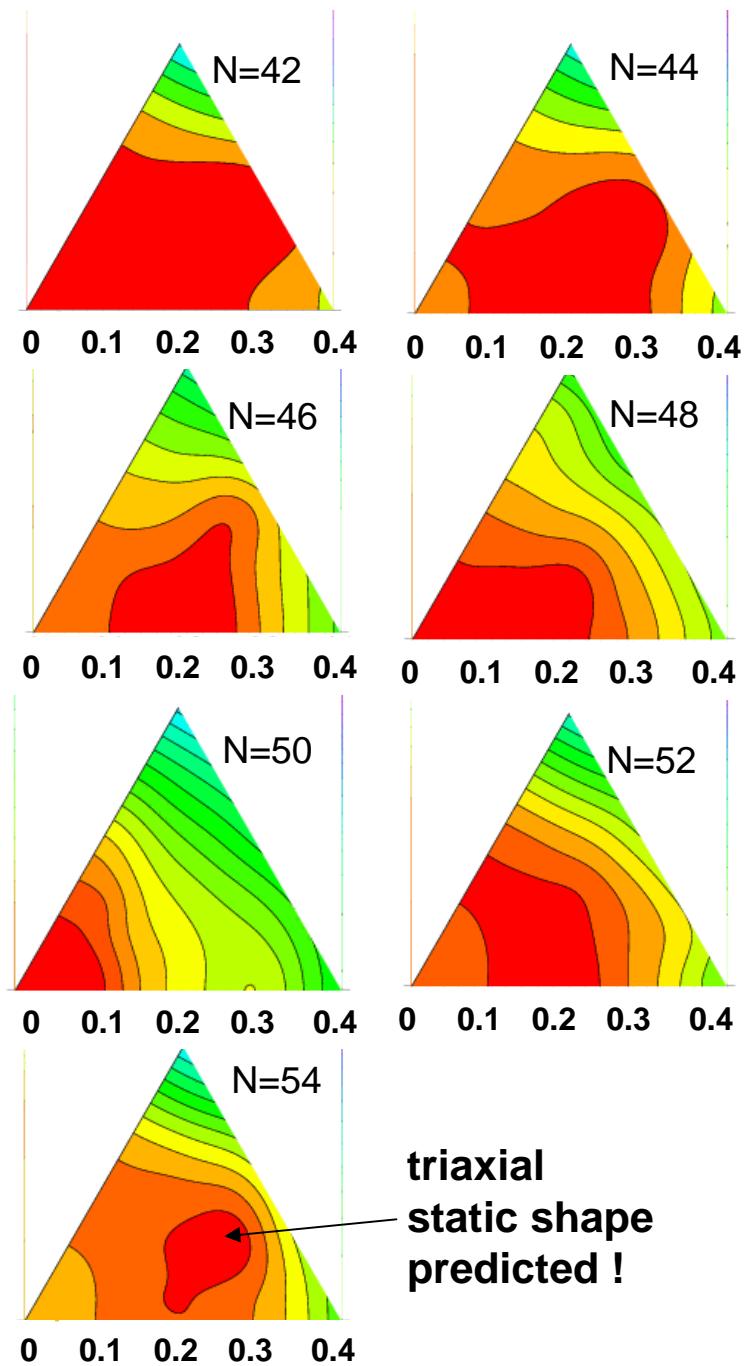
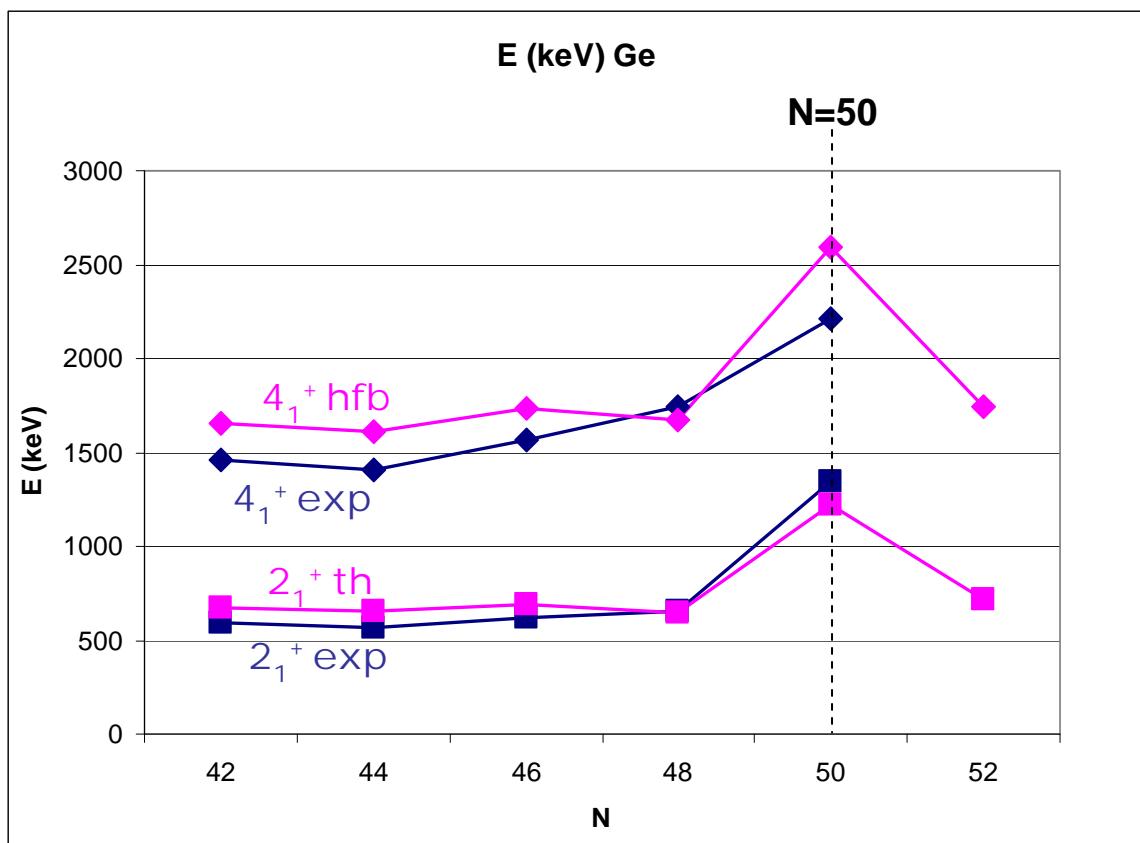


Evidence of a weak coupling
structure in $^{83}\text{Ge}_{51}$

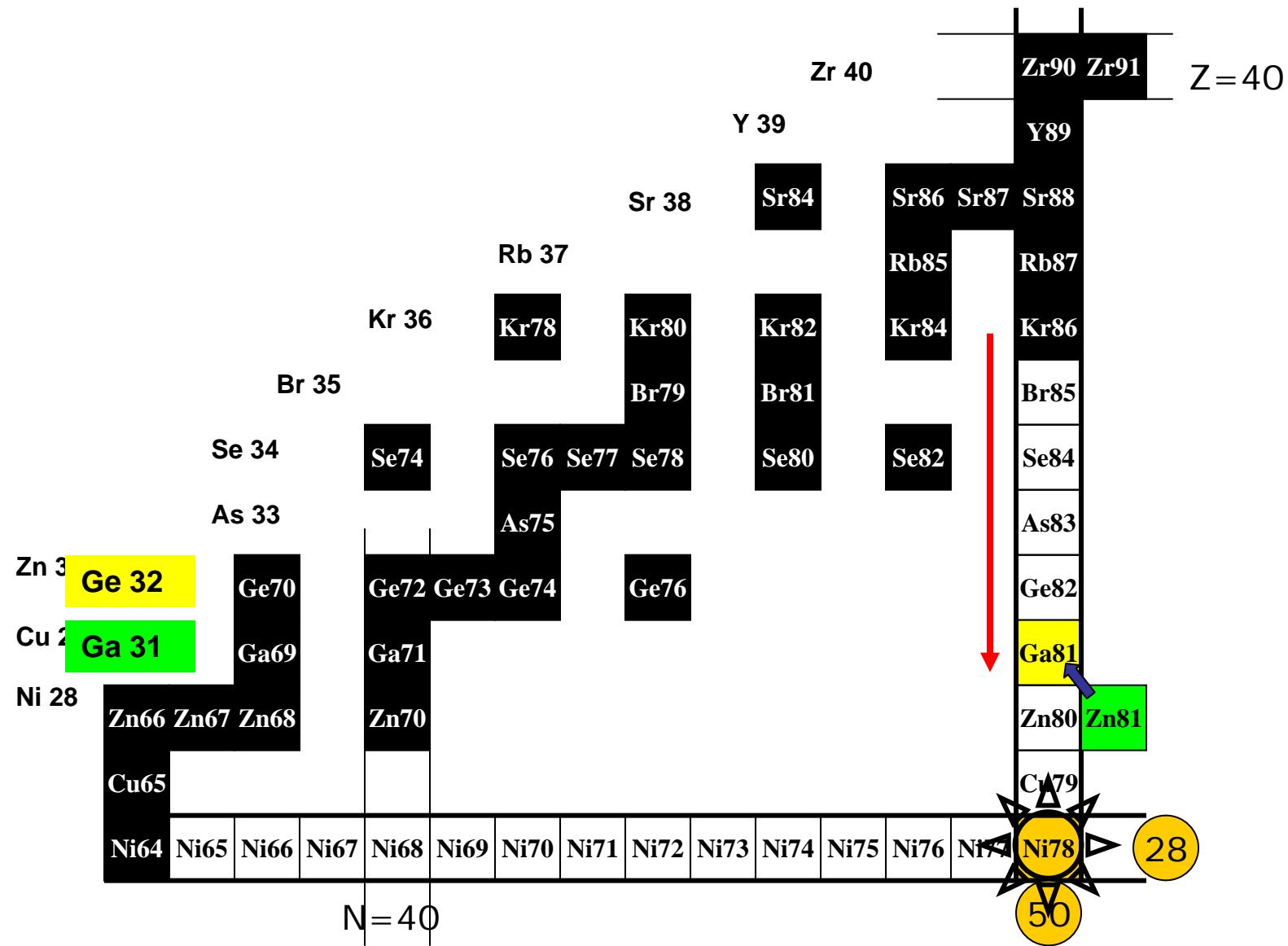
Persistance
of N=50

HFB calculations

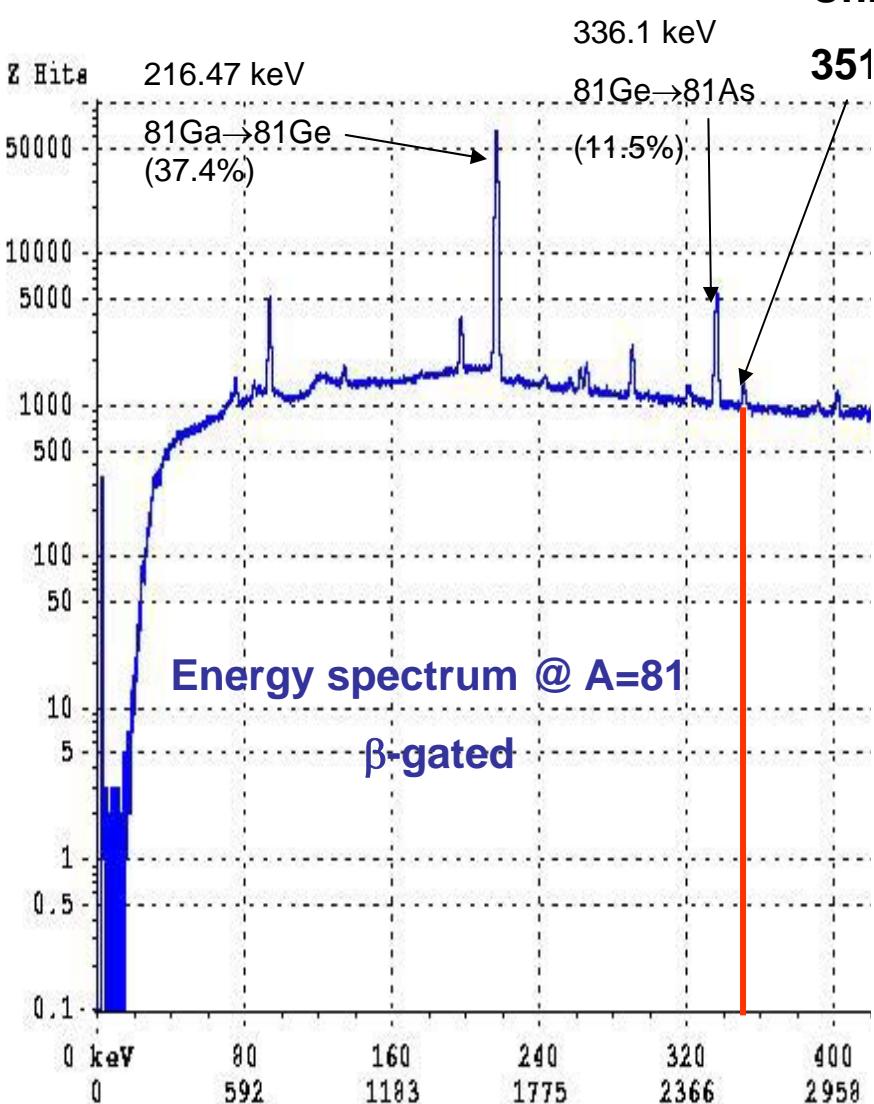
O Perru & J. Libert private communication
 HFB calculation using the Gogny interaction
 $\text{GCM} \rightarrow \text{Bohr dynamics}$



Example 2: the $^{81}\text{Zn}_{51} \rightarrow {}^{81}\text{Ga}_{50}$ decay study



Results from the $^{81}\text{Zn}_{51} \rightarrow {}^{81}\text{Ga}_{50}$ β -decay study



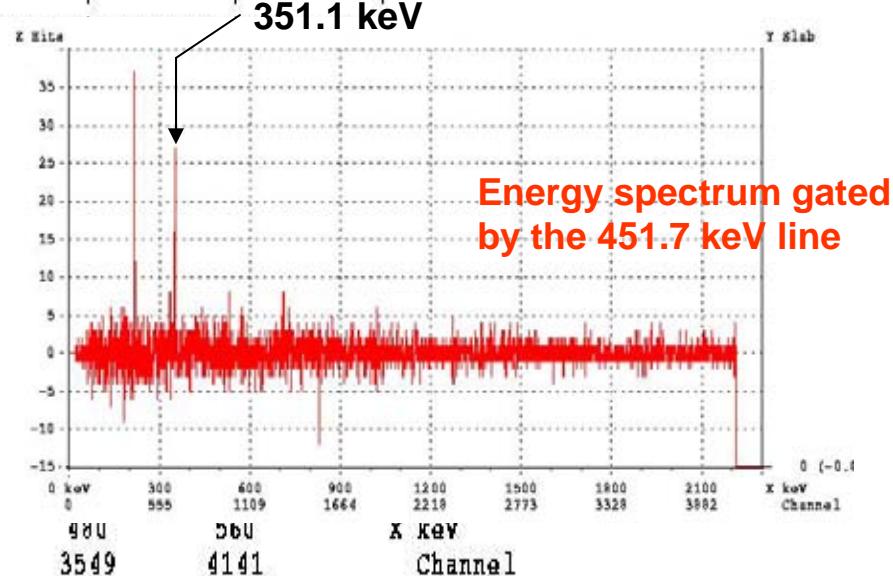
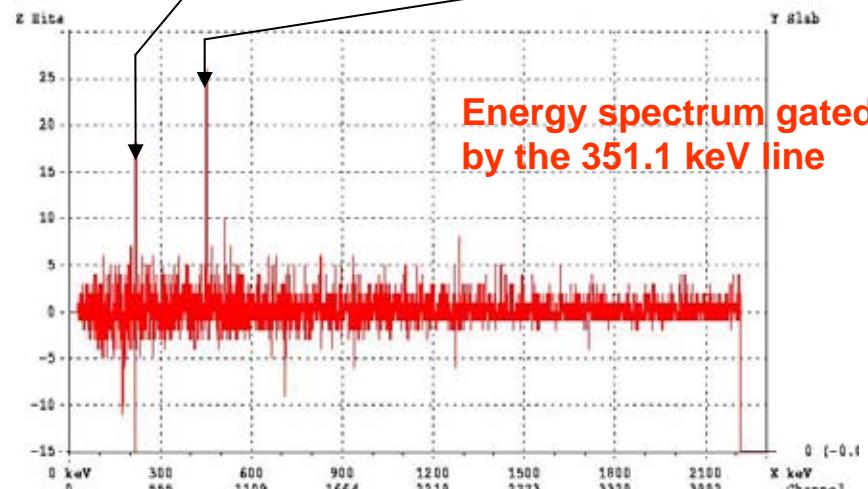
Unknown !

216.47 keV

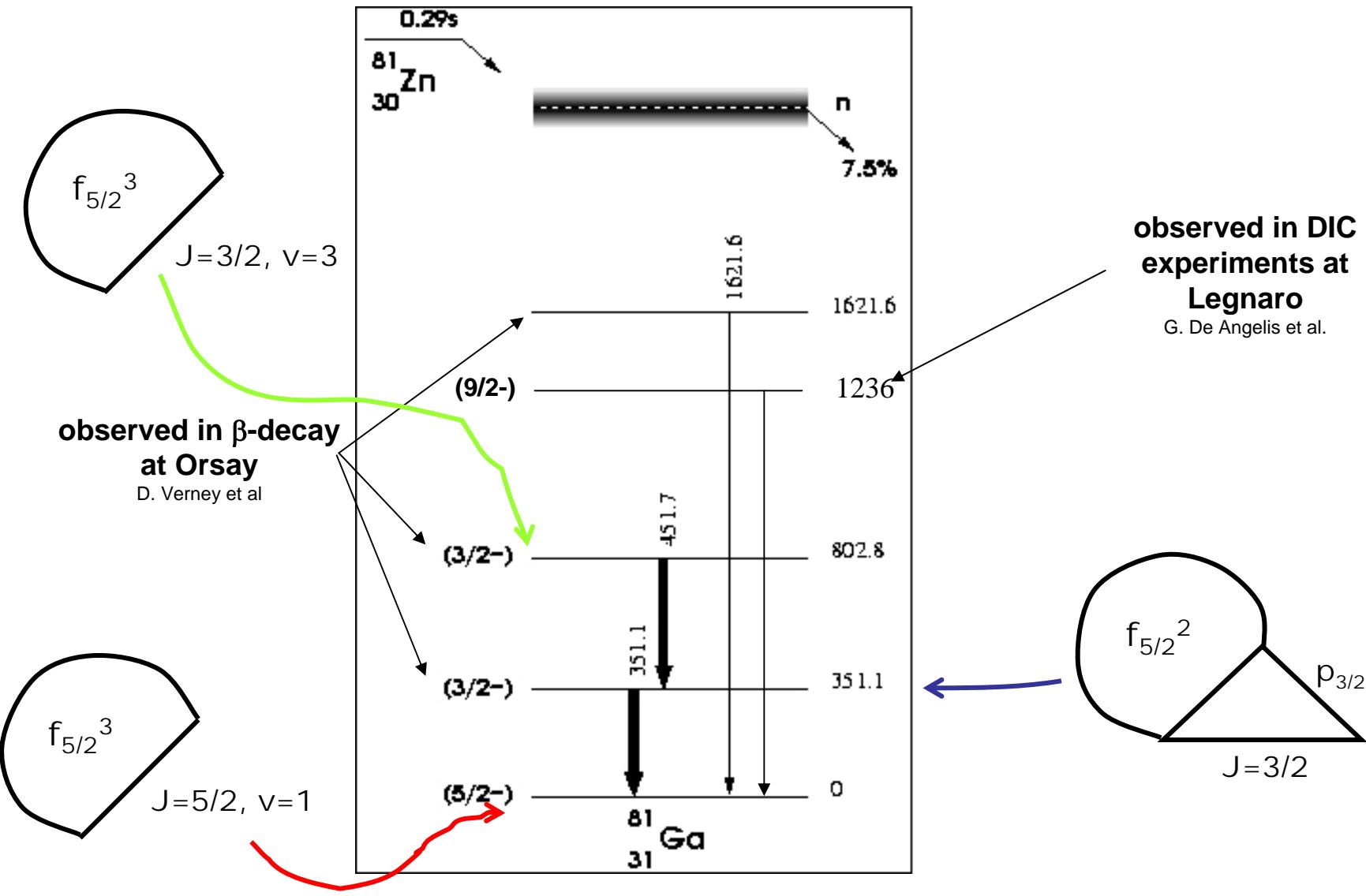
${}^{81}\text{Ga} \rightarrow {}^{81}\text{Ge}$ (37.4%)

Unknown !

451.7 keV



Proposed level scheme for ^{81}Ga : persistence of N=50 shell closure



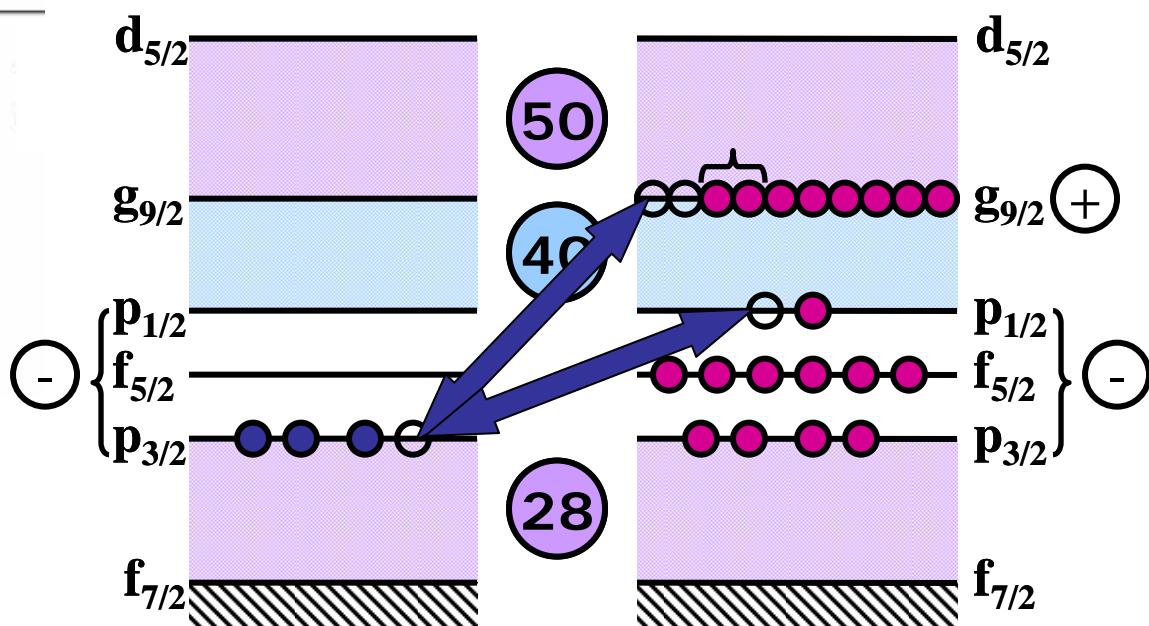
Importance of conversion electron measurements

Study of the N=40 « gap » versus pairing in g_{9/2}

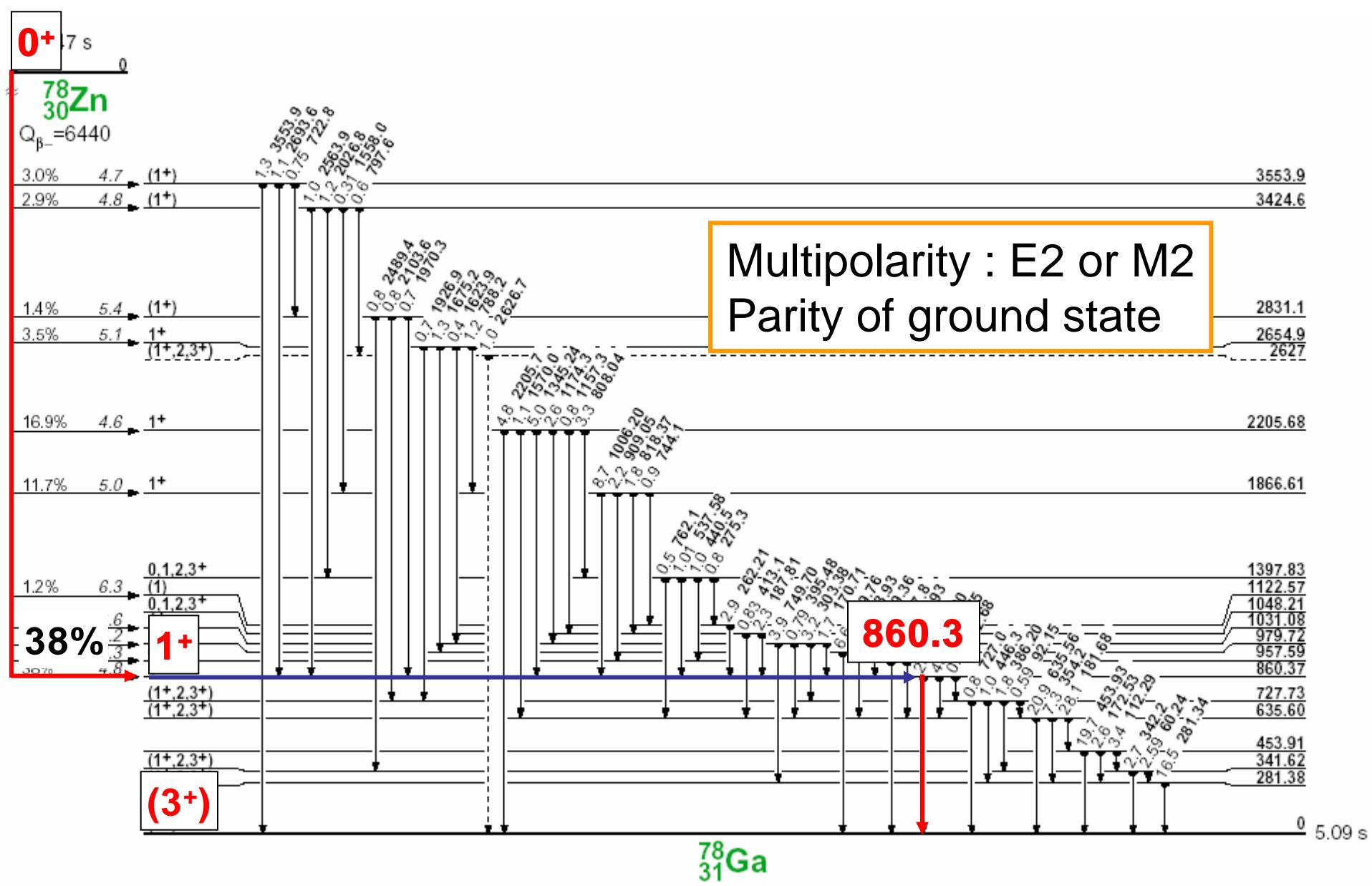
Ge78 88.0 m 0+	Ge79 18.98 s (1/2)-*	Ge80 29.5 s 0+	Ge81 7.6 s (9/2+)*	Ge82 4.60 s 0+	Ge83 1.85 s (5/2+)	Ge84 966 ms 0+	Ge85 535 ms 0+	Ge86 0+
β^-	β^-	β^-	β^-	β^-	β^-	β^-n	β^-n	
Ga77 13.2 s (3/2-)	78Ga 78Ga	Ga79 2.847 s (3/2-)	Ga80 1.697 s (3)	Ga81 1.217 s (5/2-)	Ga82 0.599 s (1,2,3)	Ga83 0.31 s	Ga84 85 ms	
β^-		β^-n	β^-n	β^-n	β^-n	β^-n	β^-n	
Zn76 5.7 s 0+	Zn77 2.08 s (7/2+)*	78Zn 78Zn	Zn79 995 ms (9/2+)	Zn80 0.545 s 0+	Zn81 0.29 s	Zn82 0+		
β^-	β^-		β^-n	β^-n	β^-n	β^-m		
Cu75 1.224 s	Cu76 0.641 s	Cu77 469 ms	Cu78 342 ms	Cu79 188 ms	Cu80			
β^-n	β^-n	*	β^-n	β^-	β^-n			
Ni74 1.1 s 0+	Ni75	Ni76 0+	Ni77	Ni78 0+				
β^-								

46 48 50

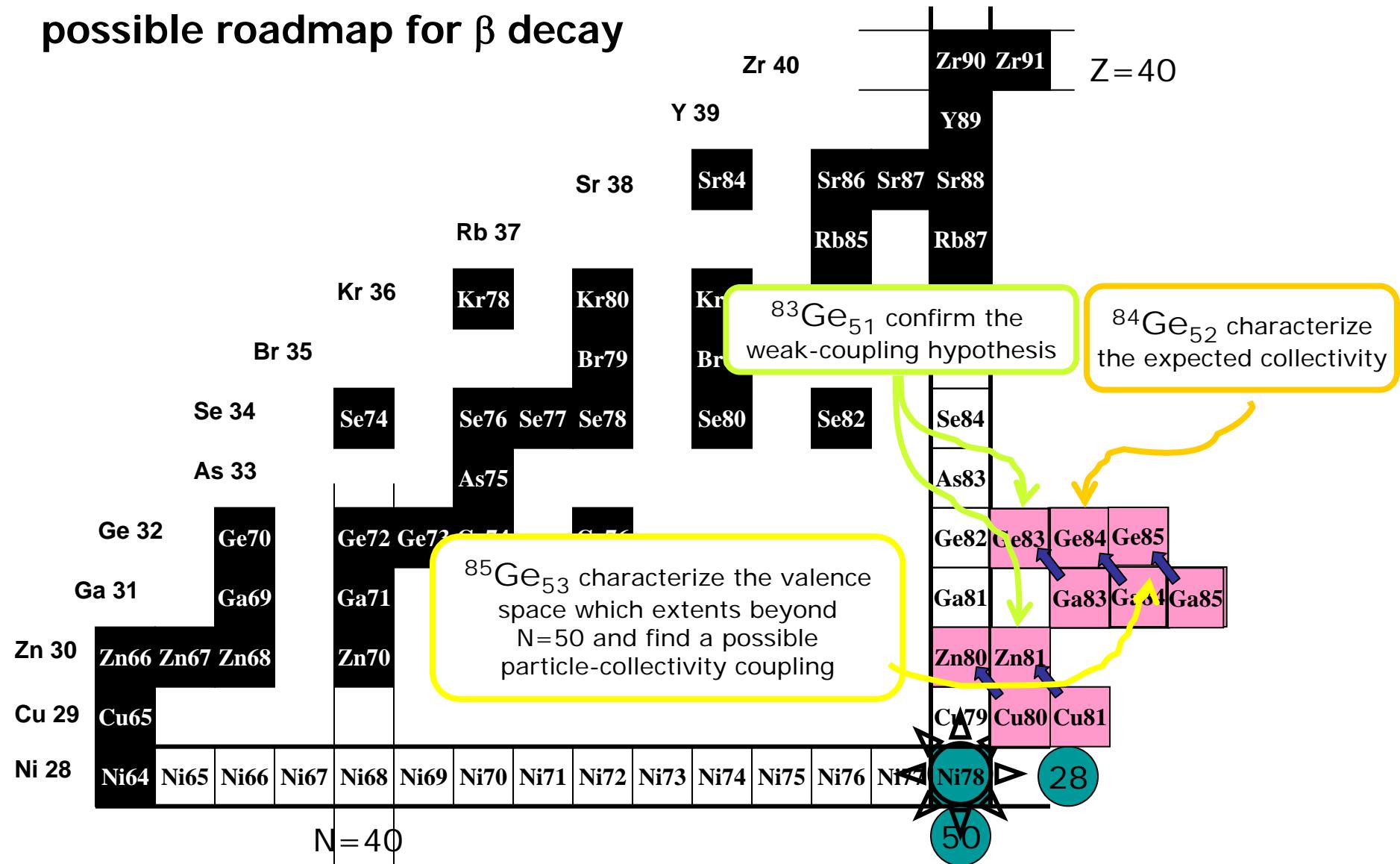
Parity of
⁷⁸Ga ground state?



N=40 gap weaker than pairing in g_{9/2}?

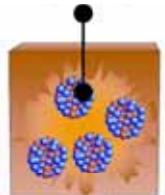


possible roadmap for β decay



Collinear laser spectroscopy

Ion source



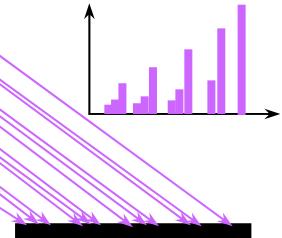
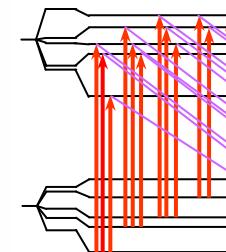
Charge exchange cell

lenses

separator

Separated beam

PM

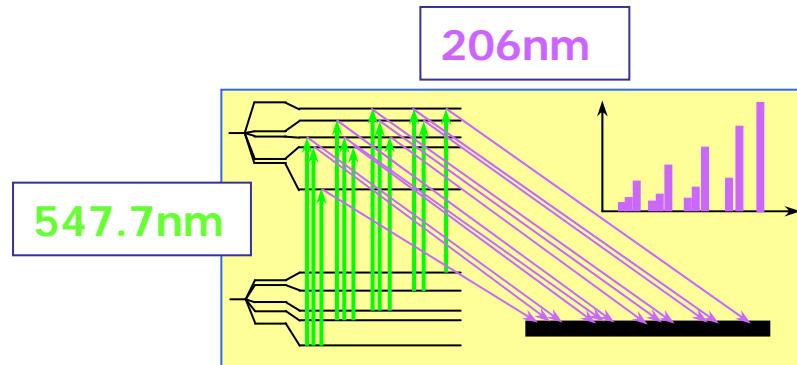


mirror

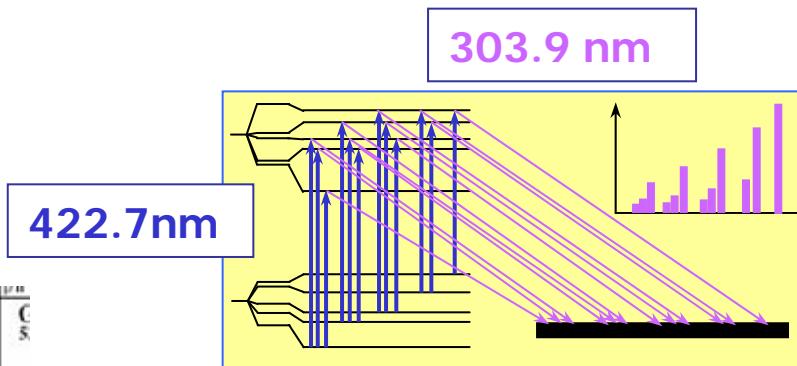
Pulsed laser



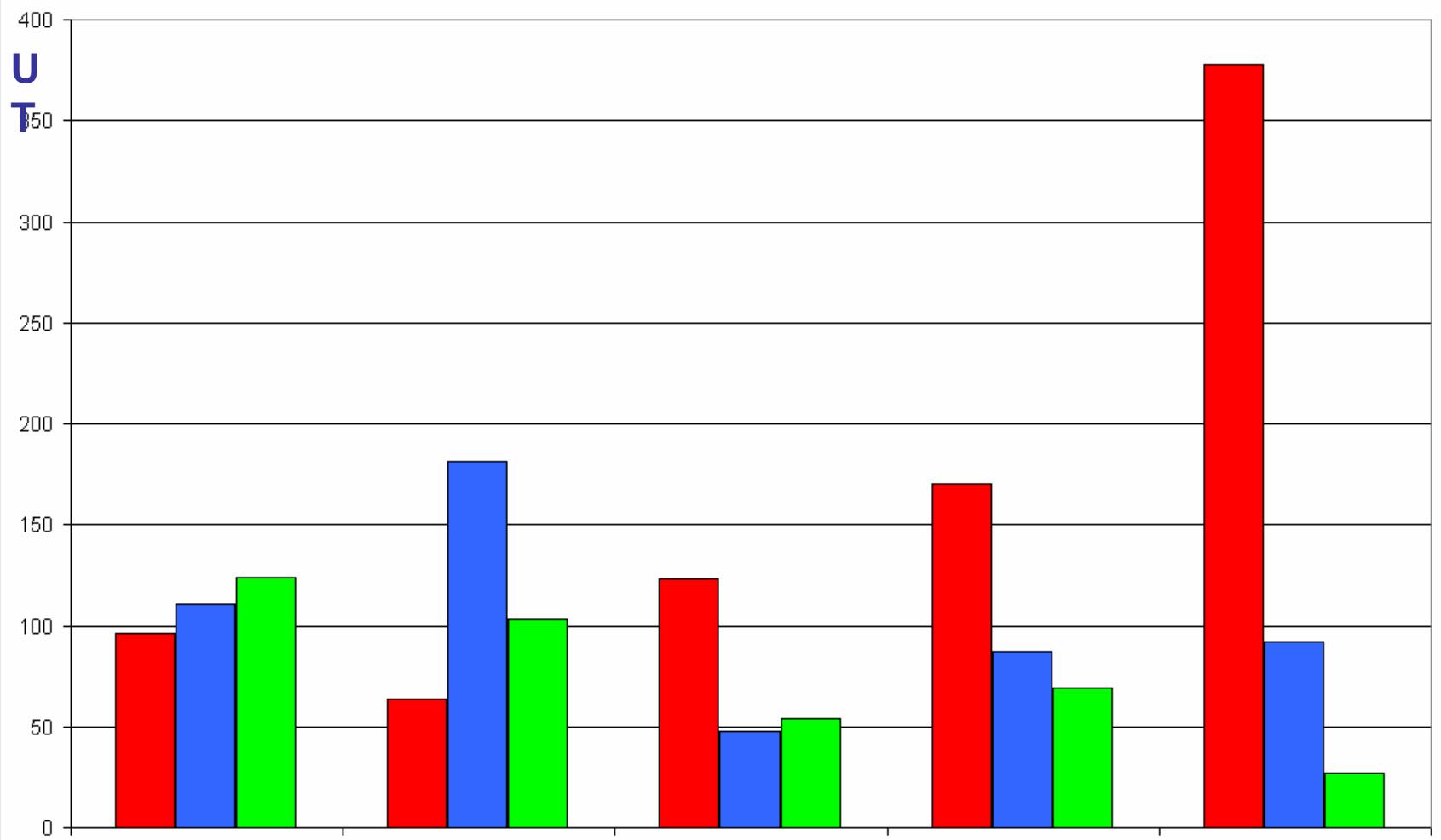
Ag (Z=47)
de A=111 à A=123



Ge ($Z=32$) de $A=77$ à $A=83$



N=50



Nuclear
physics

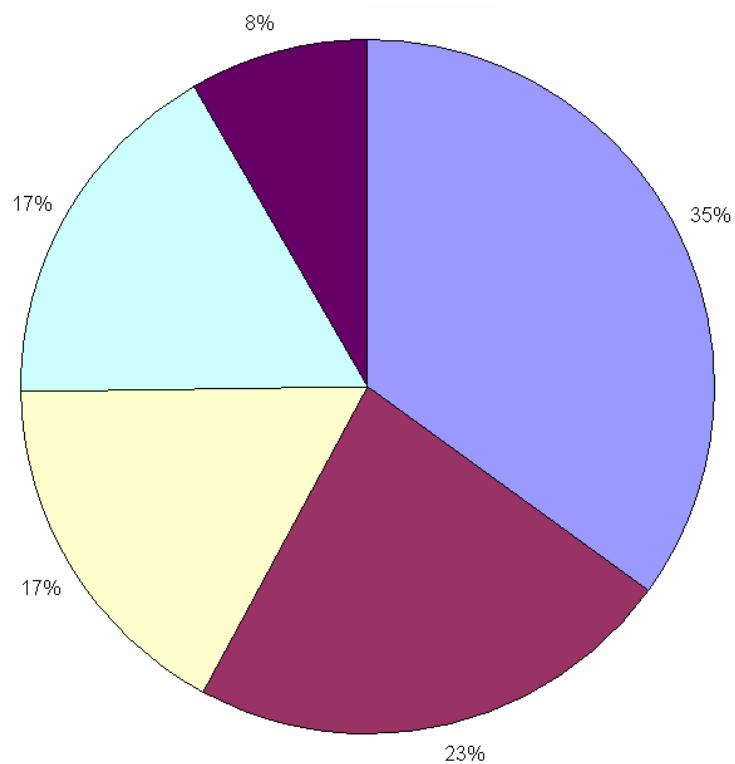


Ion Matter
interactions

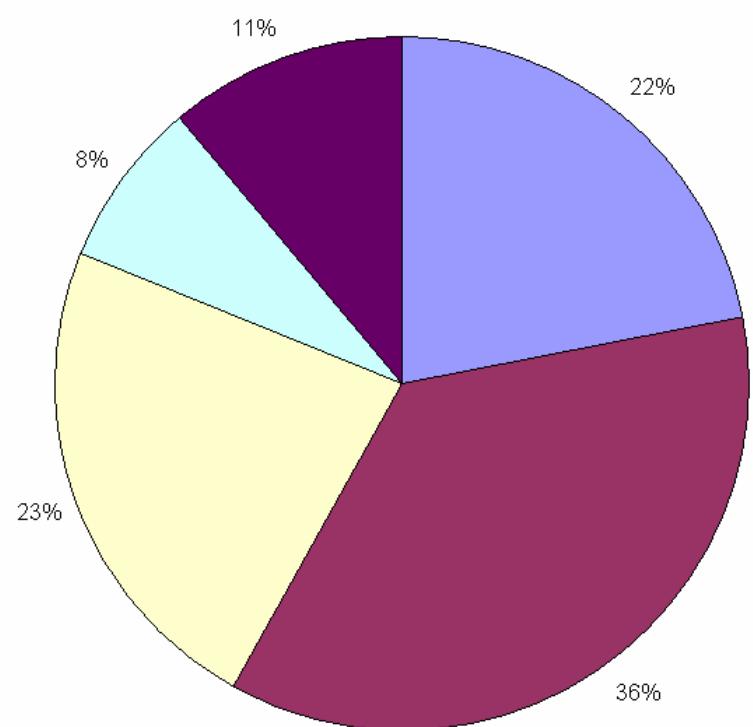


Instrumentation

2005



2006



- Available
- Projects



History of the project... present and future

