The laser ion source as a tool for physics at Eurisol

Resonant laser ionisation

Isomeric beams

In-source spectroscopy

Doppler free two photon resonance

Search for the Giant Pairing Vibration at Eurisol

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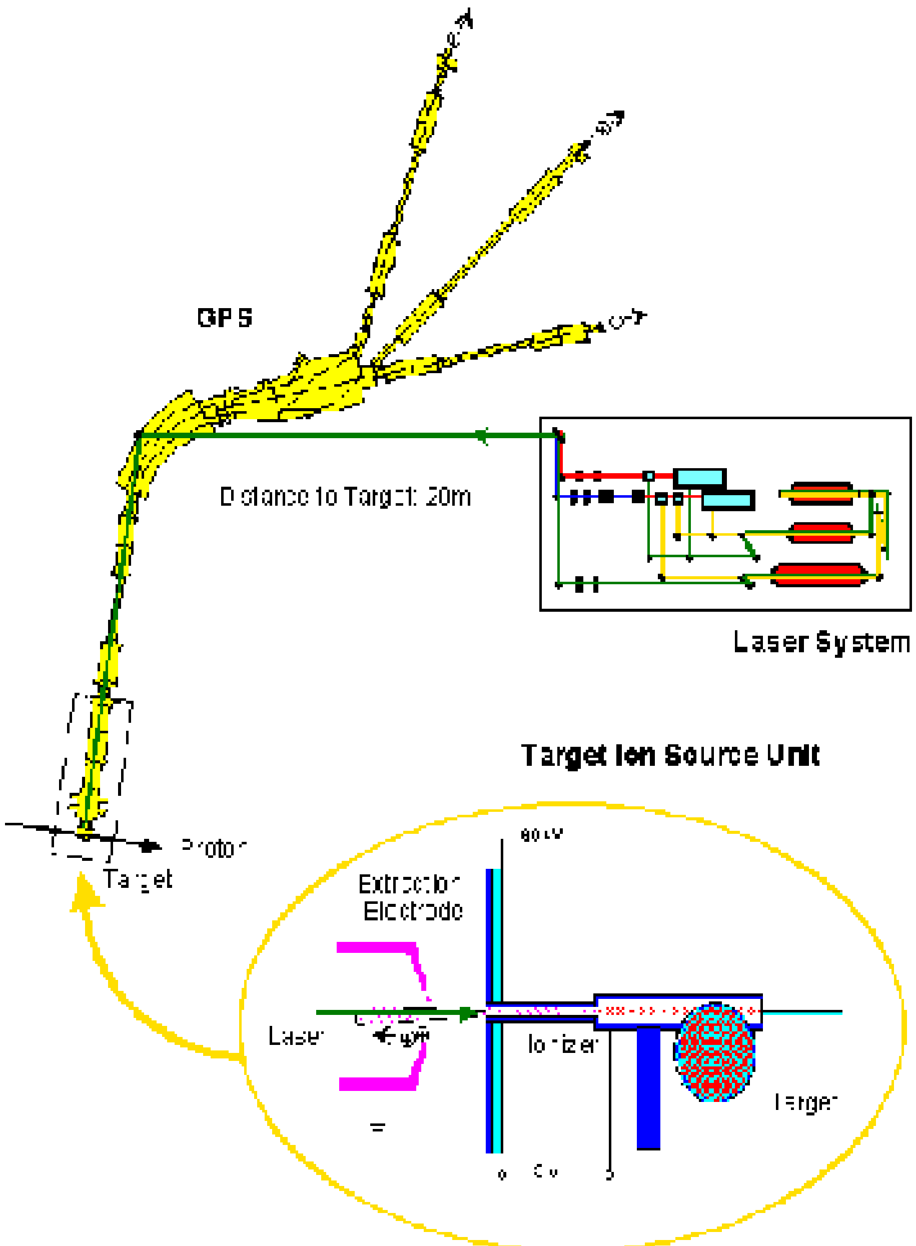
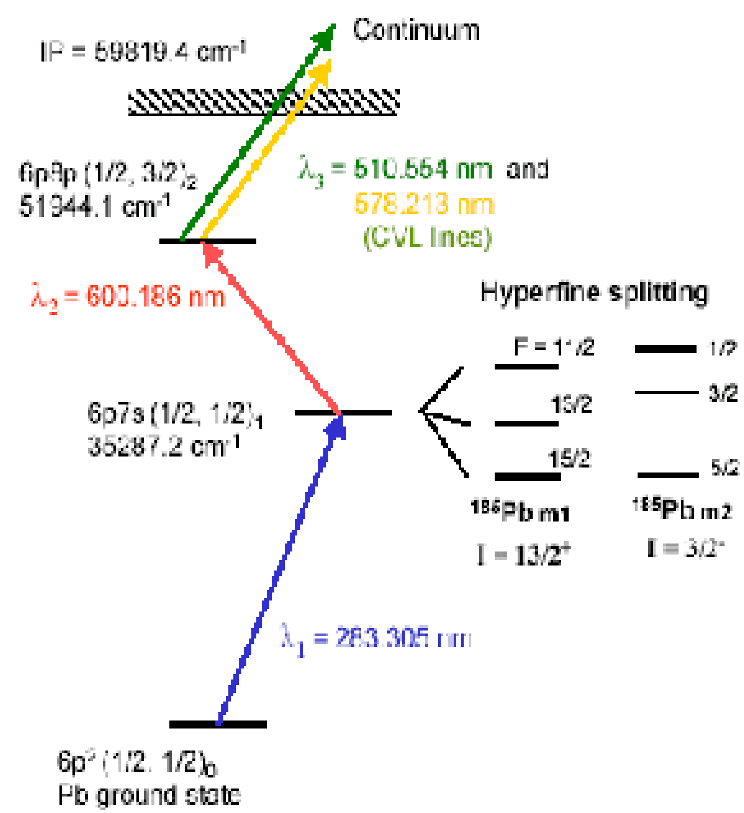
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Resonant laser ionisation

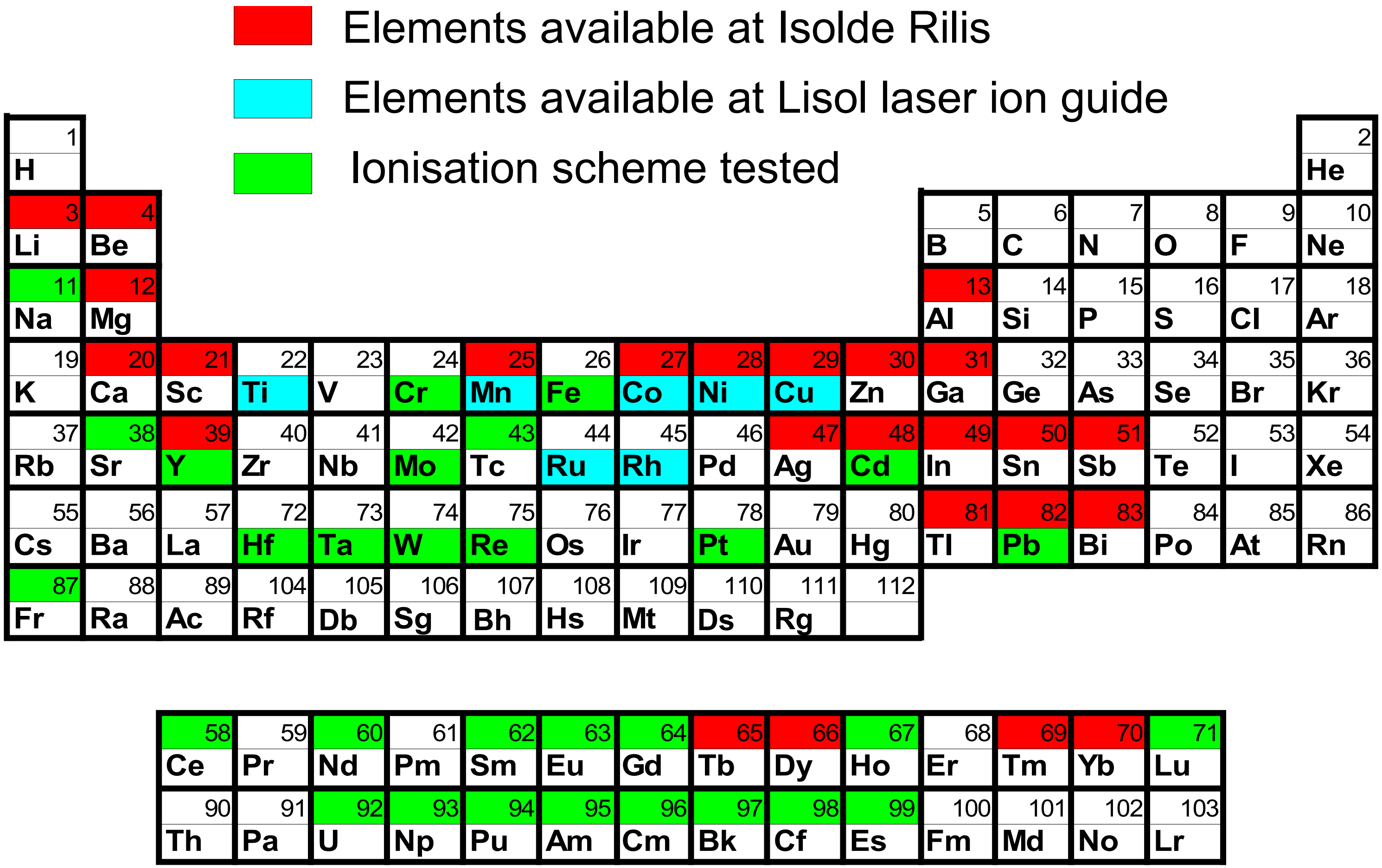


V. Fedoseyev et al., HI 127 409 (2000)



management of radioactive inventory

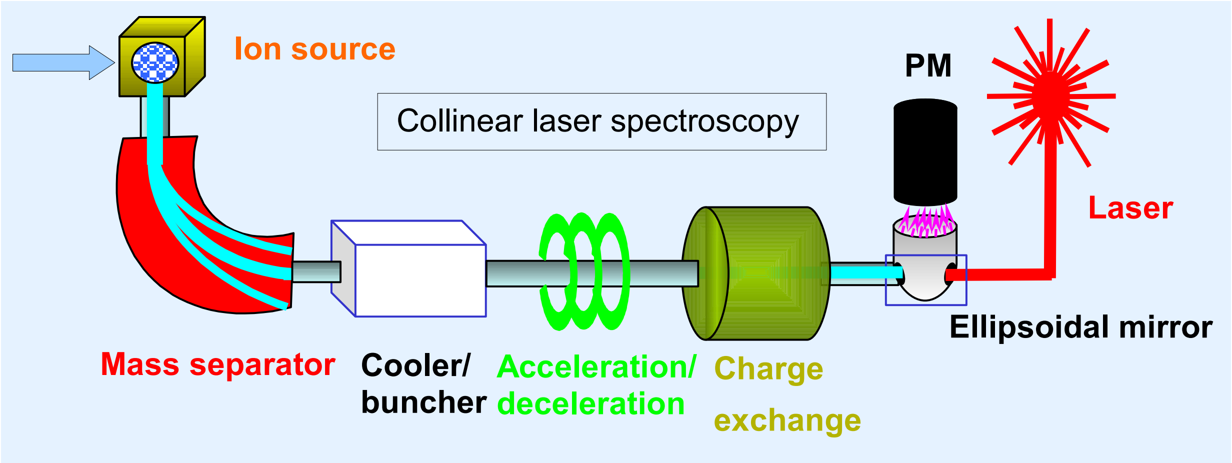
Resonant laser ionisation

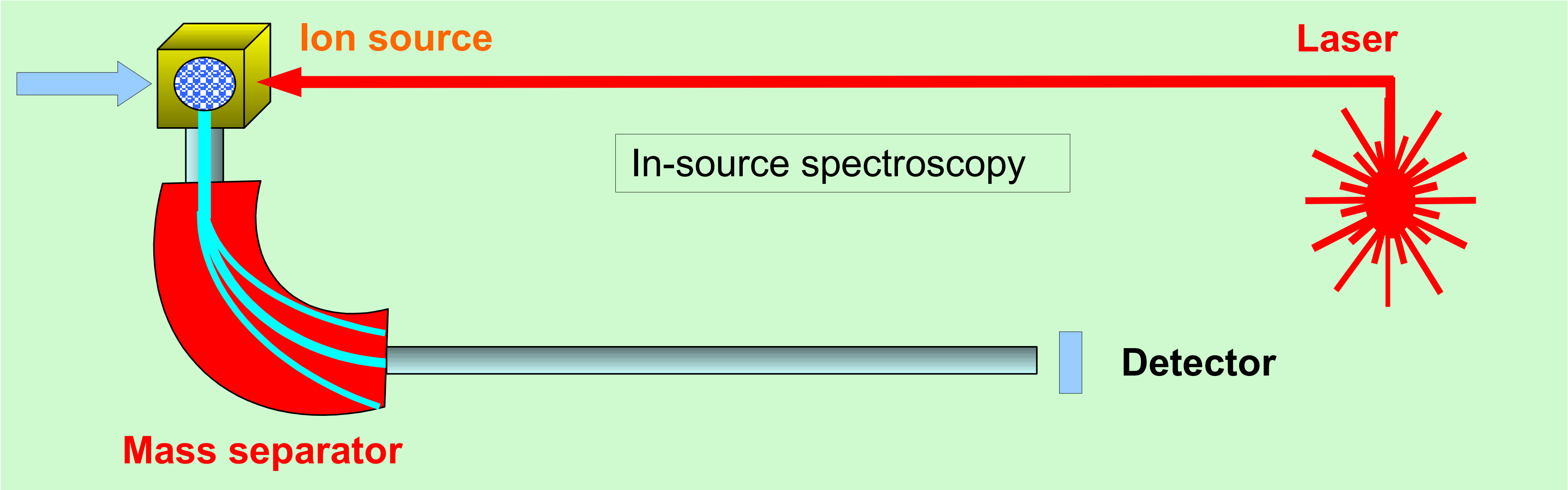


large range of extracted beams

U. Köster et al., NIM B 204 347 (2003)
V. Fedosseev et al., NIM B 204 353 (2003)
K. Wendt, NIM B204 325 (2003)

In-source spectroscopy

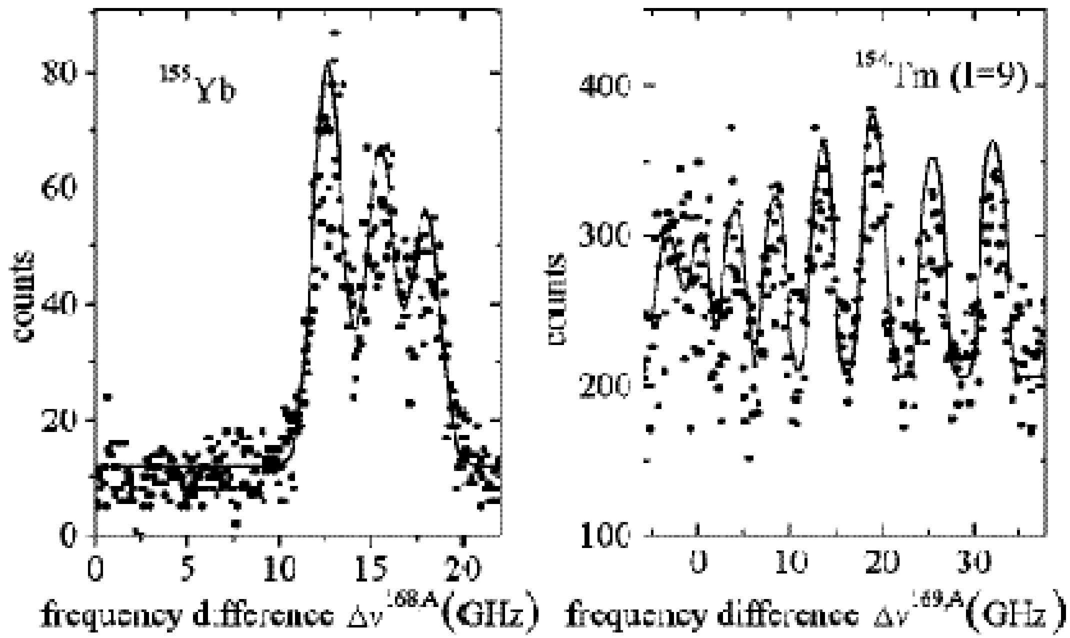


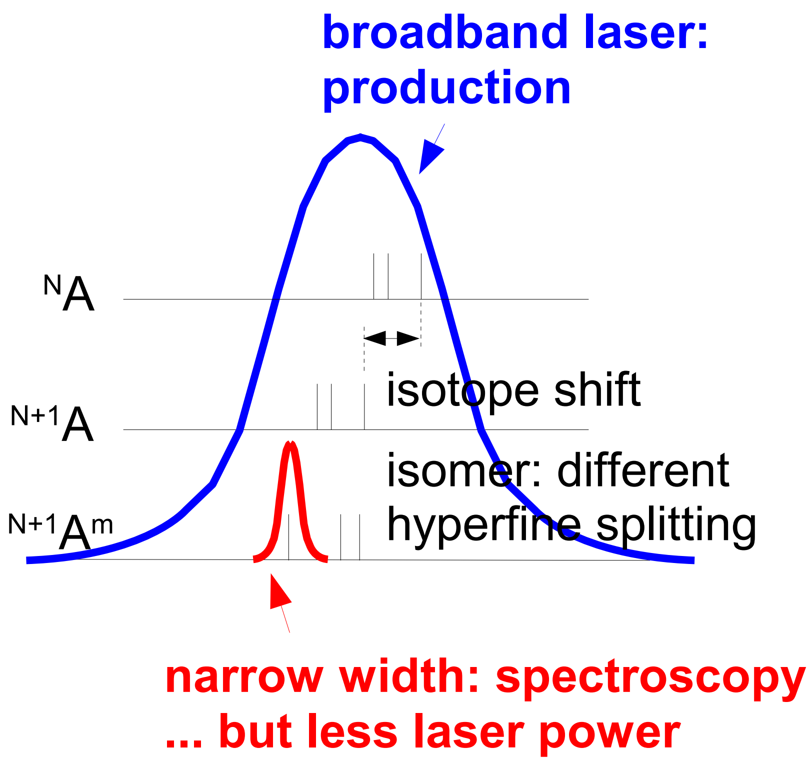


Petersburg NPI:

^{155}Yb, $^{153\text{-}154}$Tm
1-1.7 GHz bandwidth dye laser
(total linewidth 2.5-3 GHz)

G. Alkhazov et al., NIM B69 517 (1992)
A. Barzakh et al., PRC 61 034304 (2000)





Isolde:

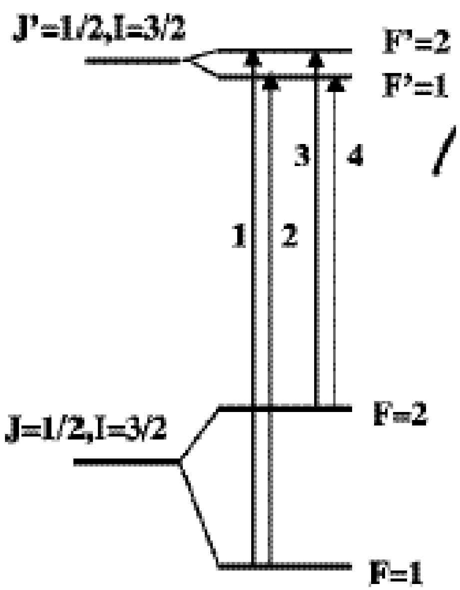
$^{7...14}$Be, $^{122...129}$Ag
12 GHz bandwidth dye laser

V. Sebastian et al., Enam-2 126 (1998)
V. Fedoseyev et al., HI 127 409 (2000)
U. Köster et al., HI 127 417 (2000)

$^{68,70}Cu$

1.2 GHz bandwidth dye laser at 11 kHz repetition rate
Doppler broadening = **3.8** GHz

L Weissman et al, PRC 65 024315 (2002)



$$E = A\frac{C}{2} + B\frac{\frac{3}{4}C(C+1) - I(I+1)J(J+1)}{2(2I-1)(2J-1)IJ}$$

$$C = F(F+1) - I(I+1) - J(J+1)$$

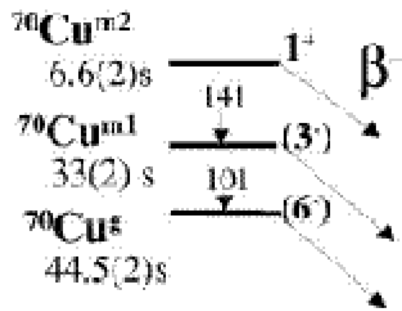
$$A = \frac{\mu_I B_J}{IJ} \qquad B = e\,Q_s\,V_{JJ}$$

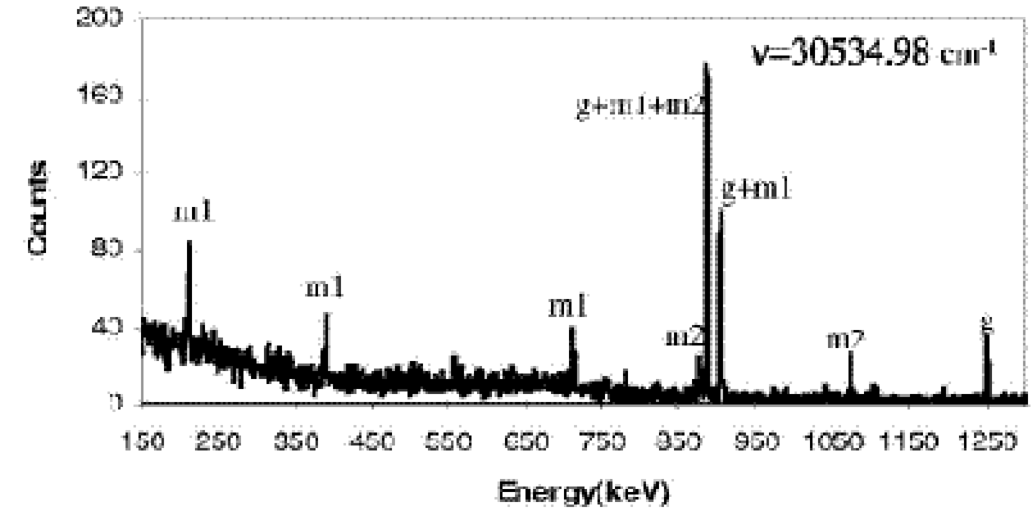
$$\delta v^{AA'} = \left(\frac{A'-A}{AA'}\right)(N+S) + F k\, \delta\langle r^2\rangle^{AA'}$$

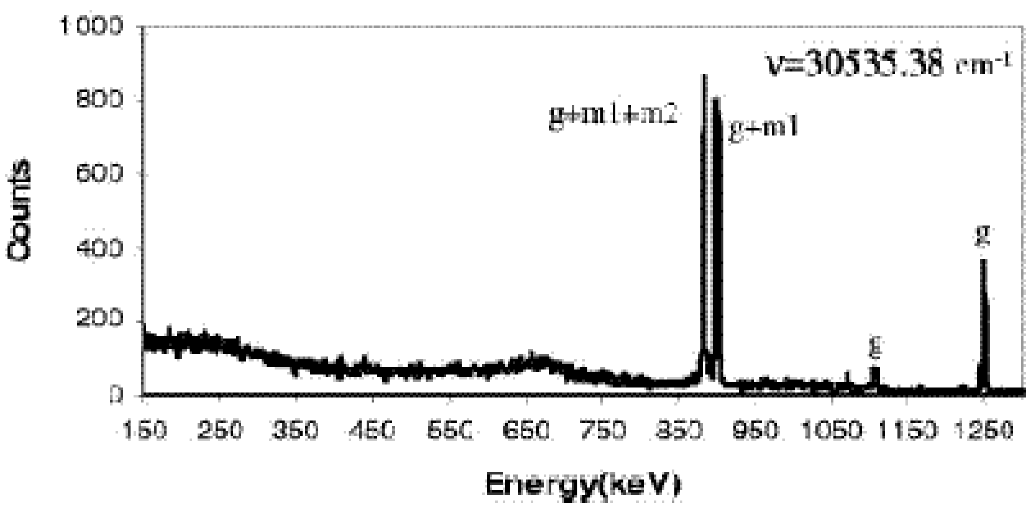
normal & specific mass shift

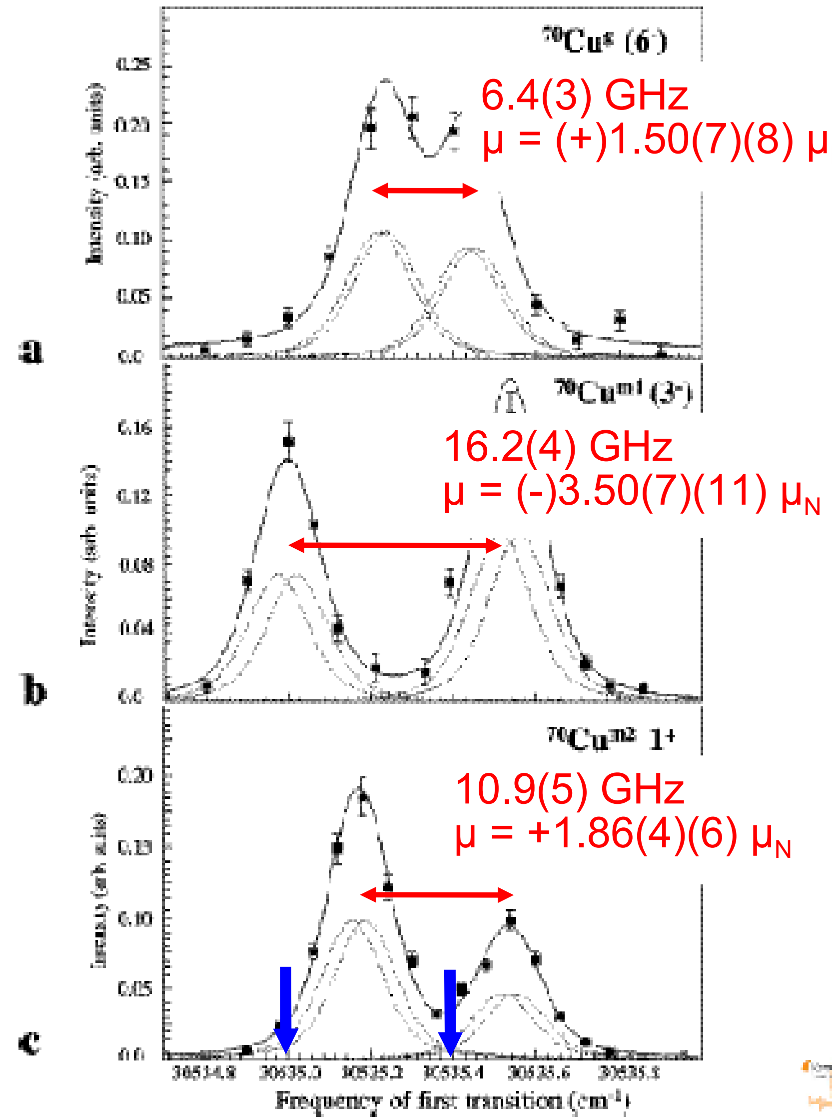
field shift
deformation
(Brix & Kopfermann)

In-source spectroscopy

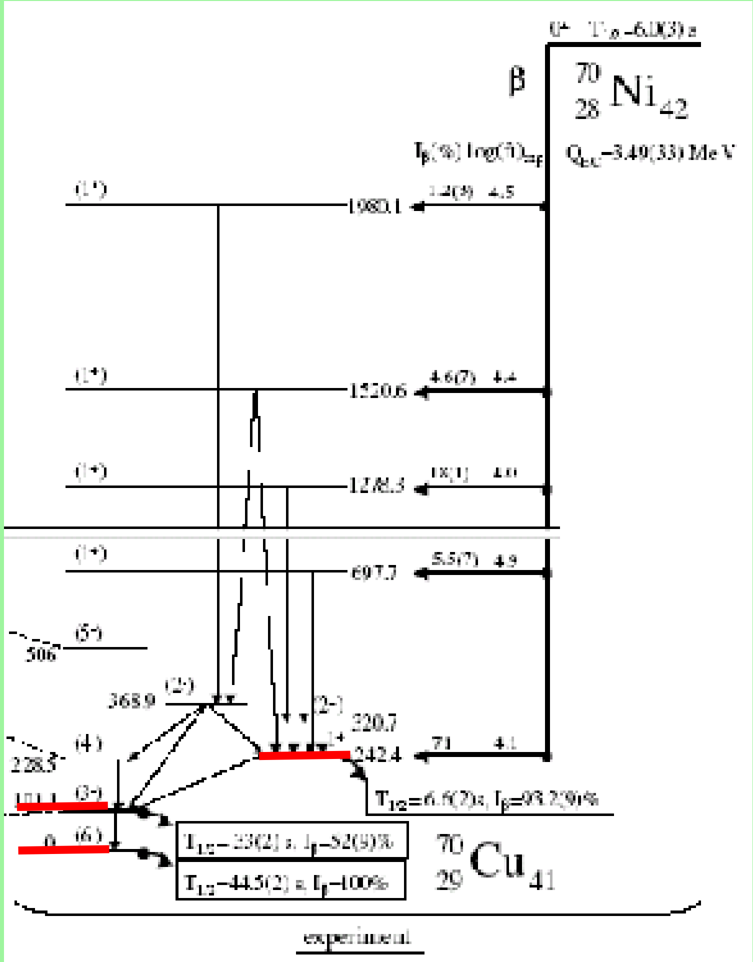








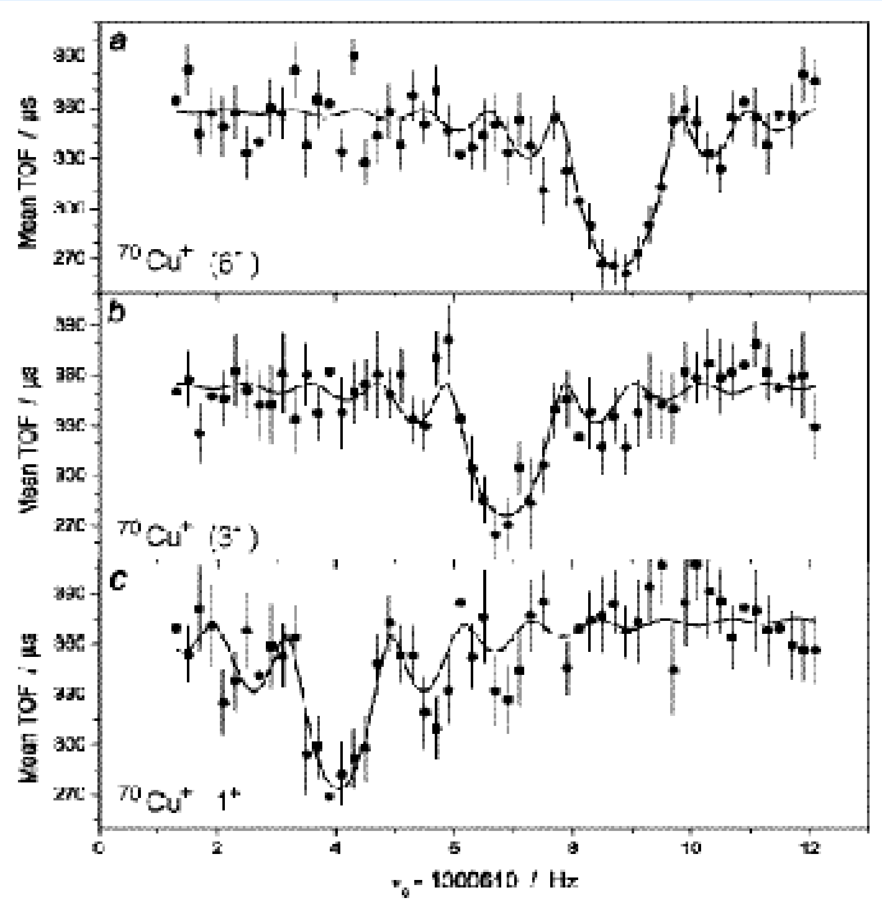
In-source spectroscopy



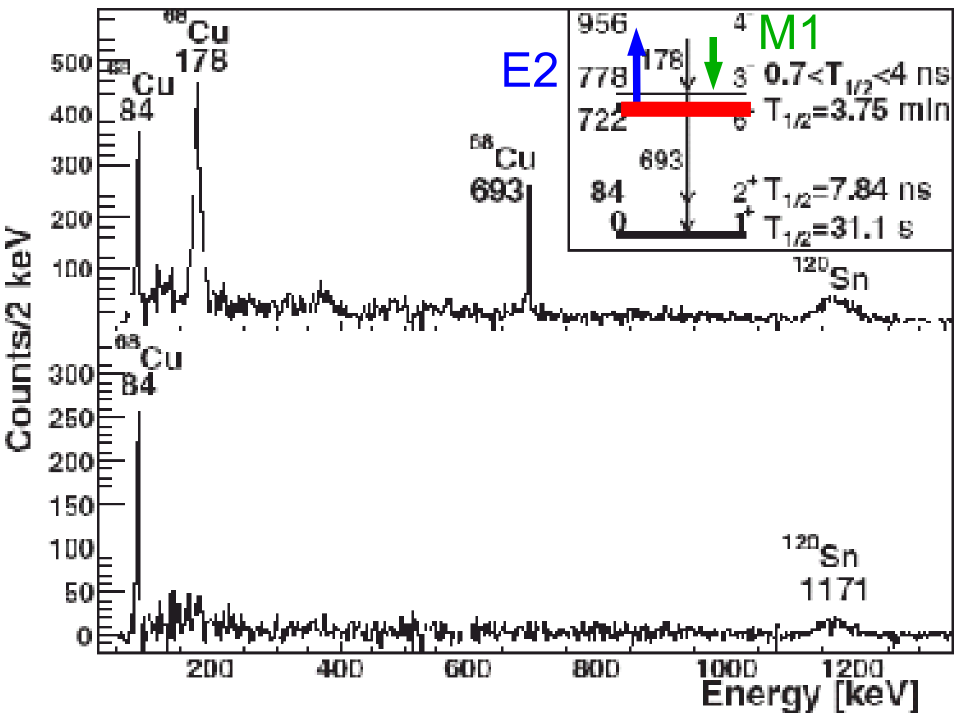
J. Van Roosbroeck et al.,
PRL 92 112501 (2004)

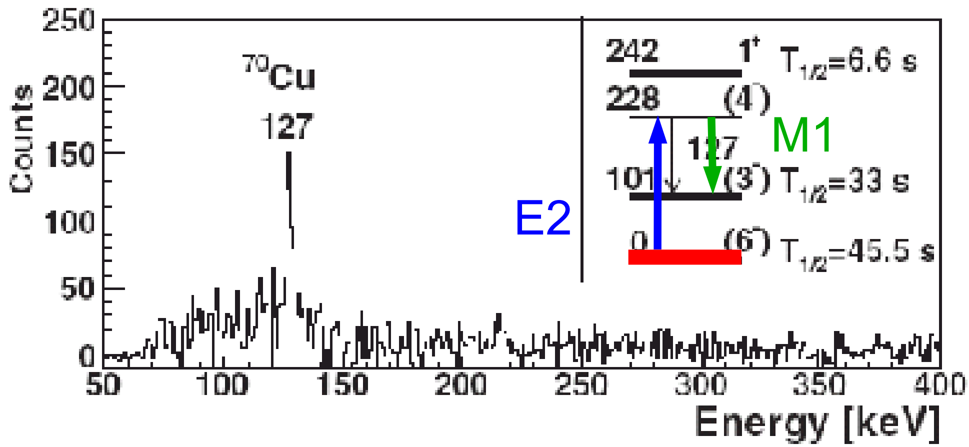
Isoltrap

G. Bollen, K. Blaum, H.-J. Kluge et al.



powerful technique to disentangle isomers!





Offshoot:
isomeric beams for postacceleration

Coulex of odd-odd $^{68,70m}Cu$ at Rex-Isolde
2.83 MeV/n Cu + 2.3 mg/cm^2 ^{120}Sn

At Miniball
3 10^5 pps $^{68}Cu(6-)$ 86(3)%
5 10^4 pps $^{70}Cu(6-)$ 85(5)%
$^{70}Cu(3-, 1+)$ each 7%

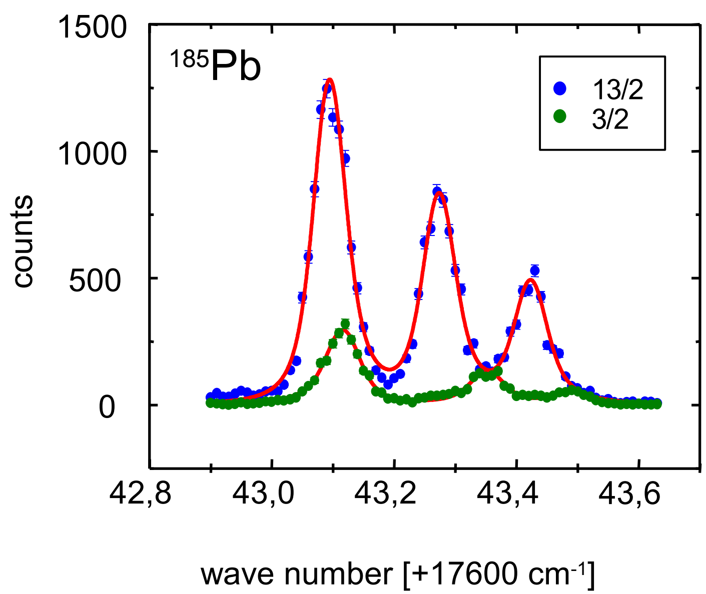
I Stefanescu, G Georgiev et al,
PRL98, 122701 (2007)

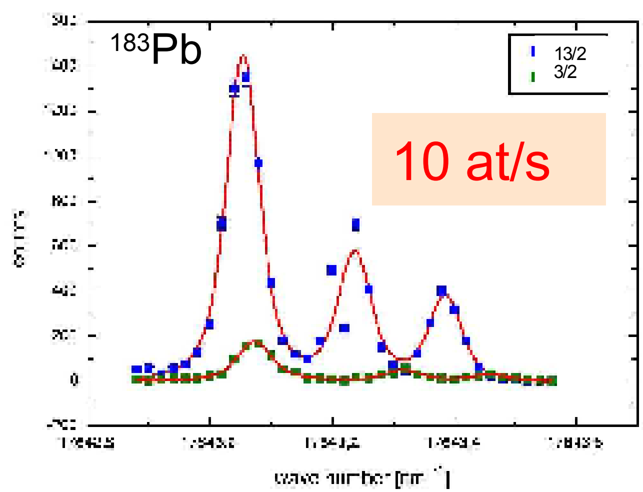
transfer on isomeric beams:
HIE Isolde, Spiral 2, Eurisol

In-source spectroscopy

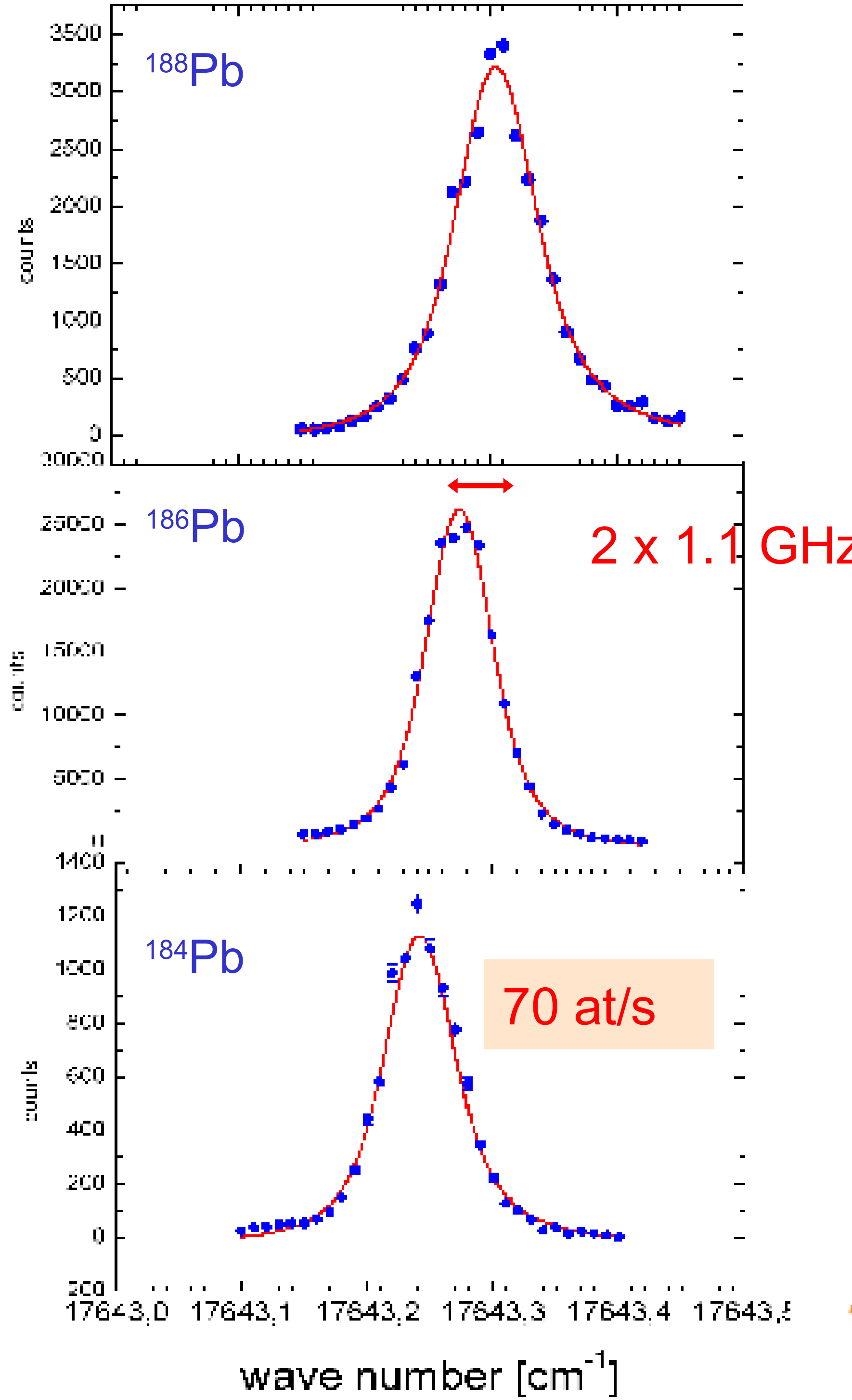
$\delta\nu^{AA'} = (A'-A)/AA' (N+S) + F\, k\, \delta\langle r^2\rangle^{AA'}$

$F(Pb, 283\ nm) = 20.26(18)\ GHz/fm^2,\ k=0.93$

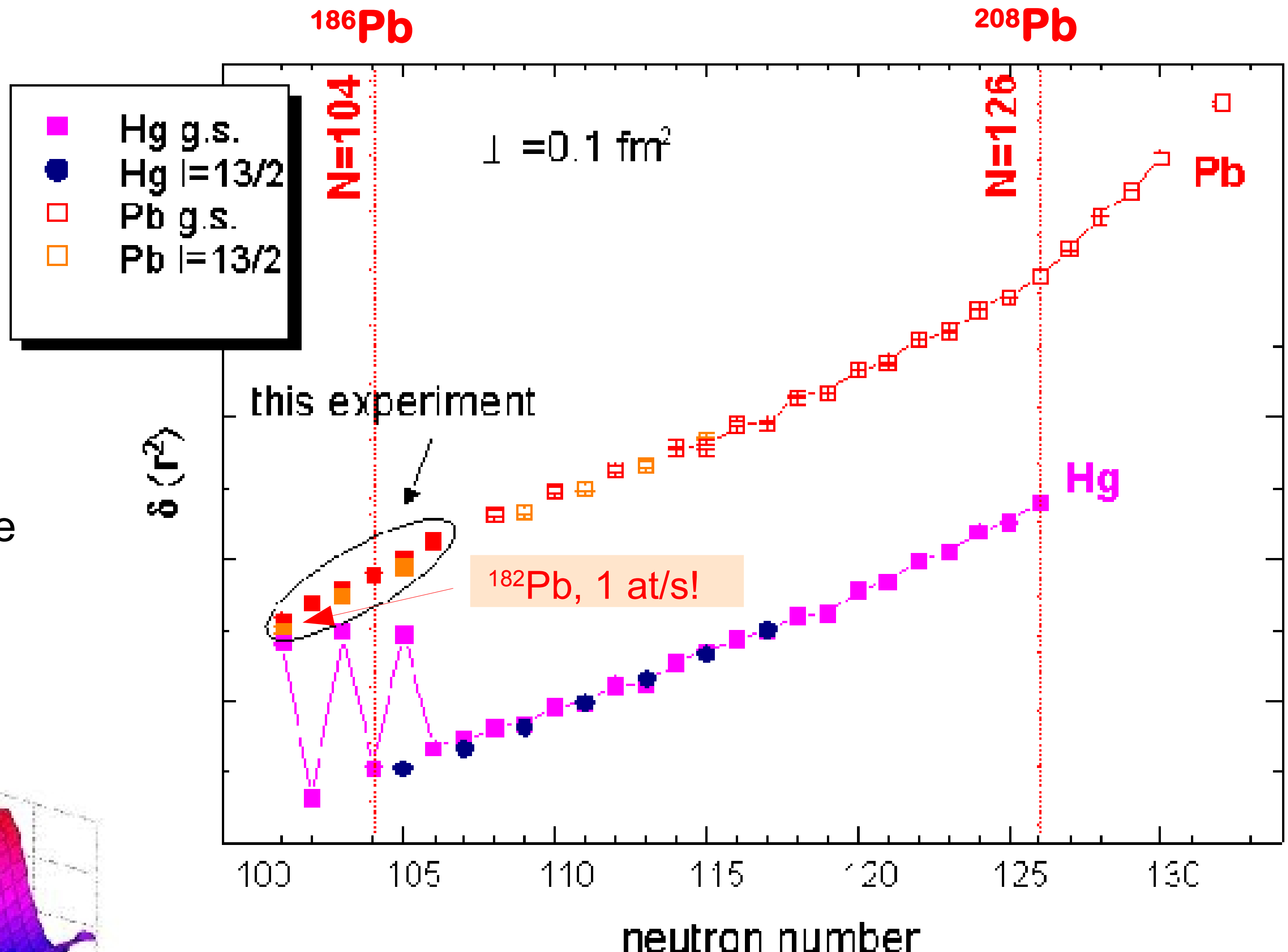




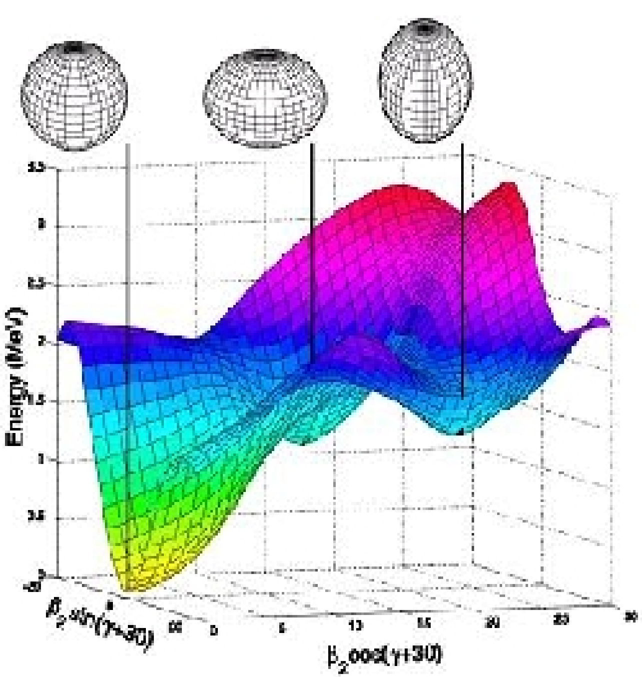
$\Delta\nu_B = 1.2\ GHz,\ \Delta\nu_D = 2\ GHz$



In-source spectroscopy



^{186}Pb shape coexistence
A. Andreyev et al,
Nature 405 (2000) 430



No mixing of deformed 0^+ into ground state
H. De Witte et al, PRL 98, 112502 (2007)

2007: $^{193...}$Po
T. Cocolios, Isolde Workshop December 2007

Electronic F factors of selected transitions in GHz/fm^2

E. Otten, Treatise on Heavy Ion Science, vol. 8 p. 517 (1989)

$$F = \frac{\pi a_0^3}{Z} \Delta|\psi(0)|^2 f(z)$$

11	Na		-0.047	63	Eu	ss-sp	-6.55
19	K		-0.128	66	Dy	421	-7.26
37	Rb	780	-0.650	67	Ho	592	-8.41
38	Sr	407	-1.582(49)	68	Er	583	-8.08
47	Ag	547	**-12.070(966)**	69	Tm	597	**-10.3**
48	Cd	326	3.91(46)	70	Yb	555	**-11.8**
49	In		2.070(10)	78	Pt	266	**-28**
50	Sn	286	3.3(5)	79	Au	268	**-43.07**
54	Xe	823	-2.32	80	Hg	254	**-55.36**
55	Cs	852	-2.313	82	Pb	283	**20.26(18)**
56	Ba	455	-5.120	86	Rn	745	**-22.1**
60	Nd	588	-5.50	88	Ra	468	**-49.6**
62	Sm	600	-5.5				

large F factors for heavy elements only!

Limitations

- laser band width
  1.2 GHz at Isolde
  600 MHz with seeding

- power broadening
  $\Delta\nu_{Power} = \Omega_{Rabi} / \pi = 10^7 I^{1/2}$ [Hz (cm²/W)^{1/2}]
  1 MHz for 1 W/mm²

- pressure broadening
  $\Delta\nu_{Pressure} = 10^{-3} P$ [cm⁻¹/mbar]
  negligible unless gas cell

- **Doppler broadening**
  $\Delta\nu_{Doppler} = 7.16 \times 10^{-7} \nu_0 (T/M)^{1/2}$ [cm⁻¹ (amu/K)^{1/2}]
  2 GHz for Cu at Isolde (2300 K)

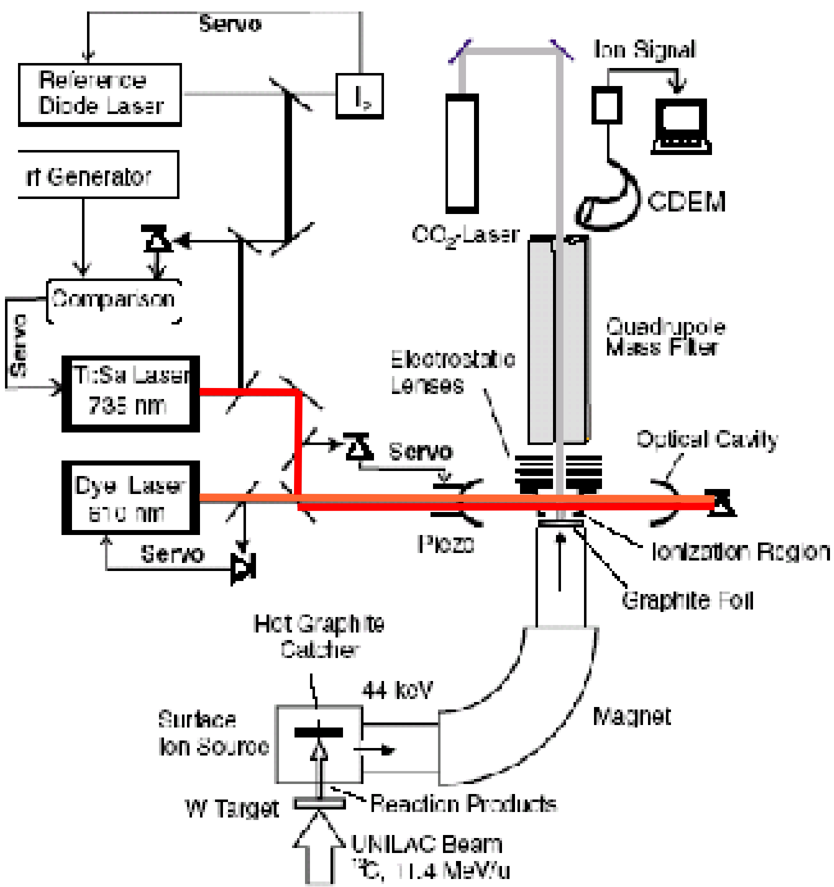
Y. Kudryavtsev et al., NIM B 114 350 (1996)
V. Fedoseyev et al., NIM B 204 353 (2003)

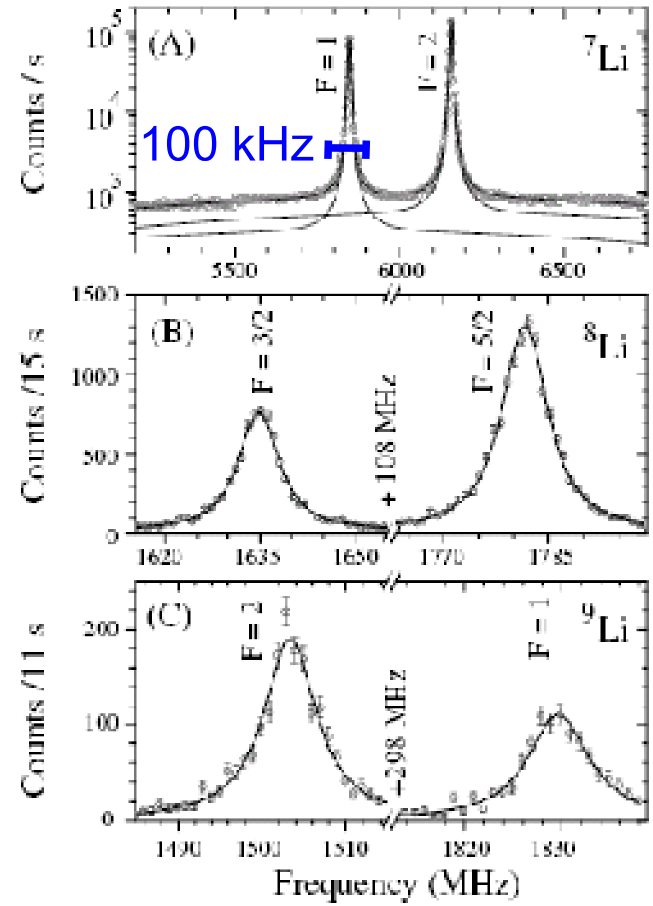
development of laser cavities at low temperature !

Doppler free two photon resonance

$h\nu = h\nu/2 + h\nu/2$

Doppler free

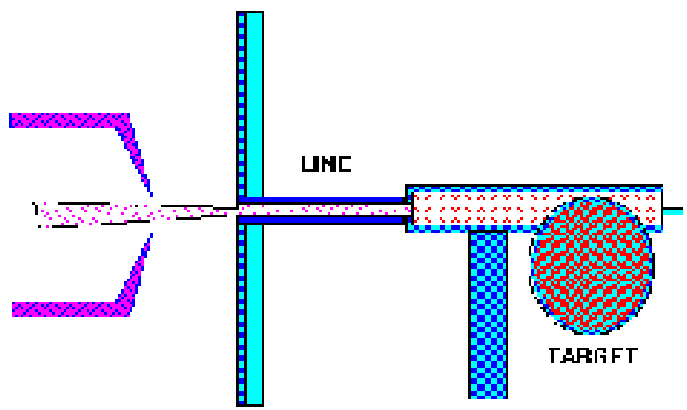




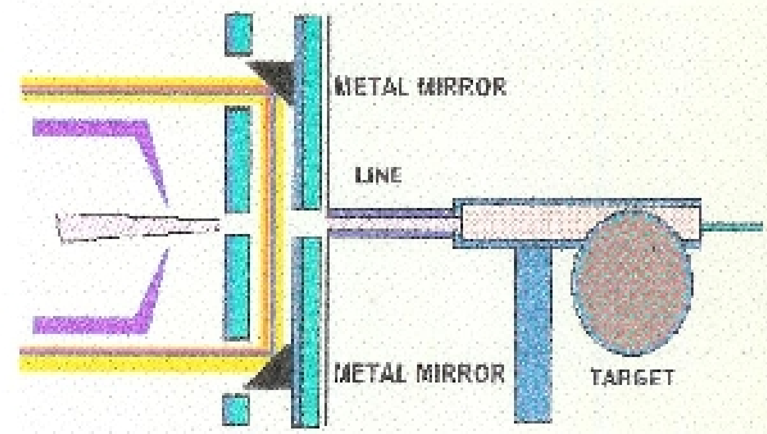
G Ewald et al, PRL94, 039901 (2005)
W Nörtershäuser et al, HI 162, 93 (2005) & EPJA 25 S1, 199 (2005)

Two photon laser spectoscopy in the ion source!

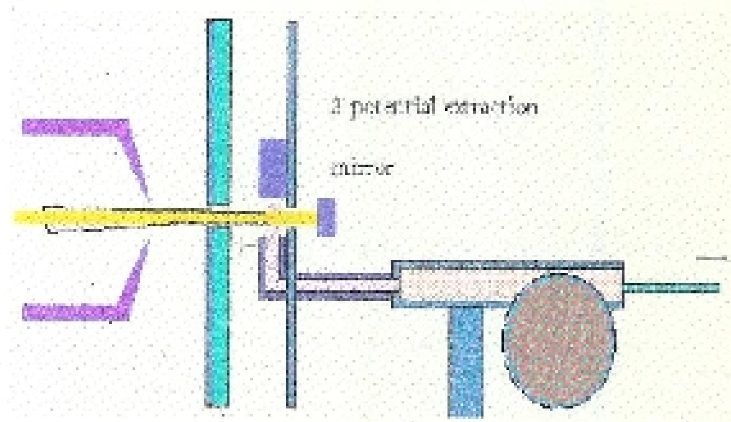
conventional laser ion source



cavity with metal mirrors



90° extraction



G Huber, H Ravn's 60th birthday symposium
& January 2006 LOI at Alto

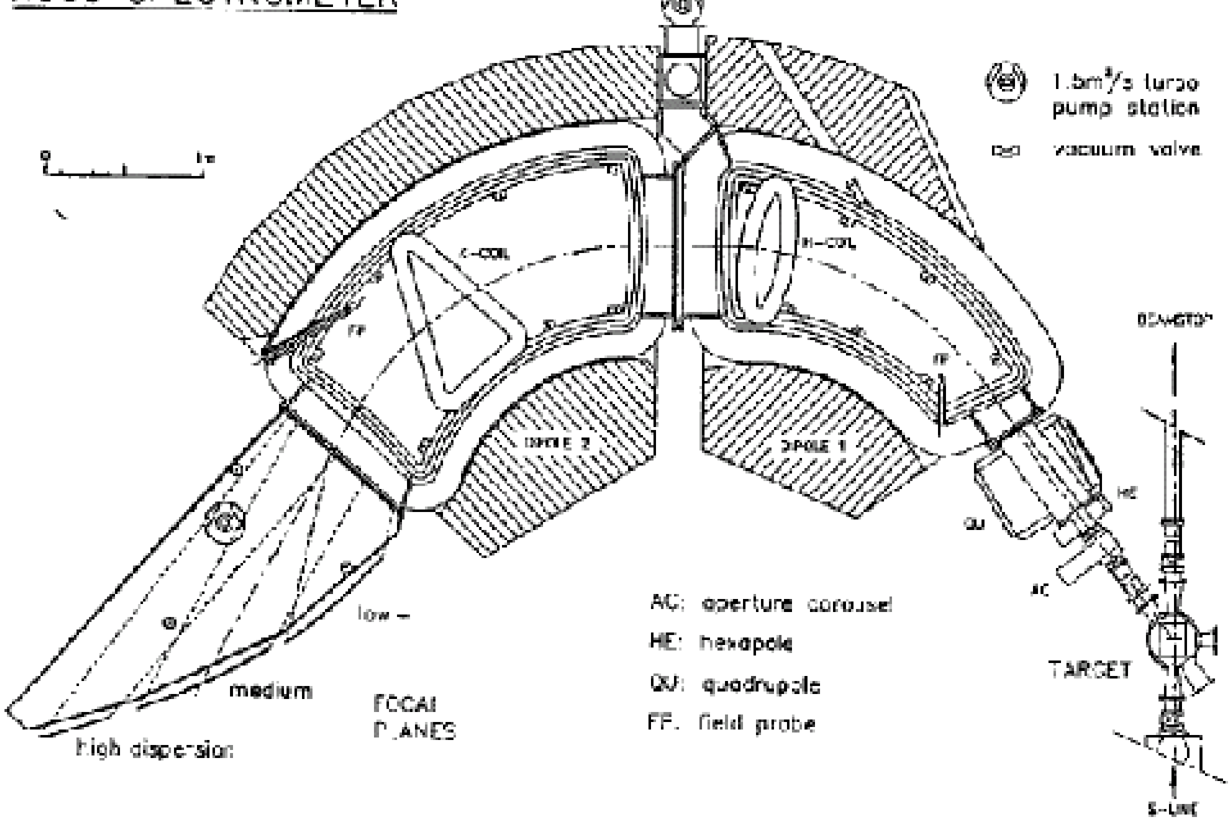
stable probe: $^{208}Pb(p,t)^{206}Pb$ at iThemba

Q= -5.62 MeV
intensity 10-15 nA = 10^{11} pps

GPV L=0 pairing mode
spectrometer at 7° but no GPV seen

2008: modification for 0° mode

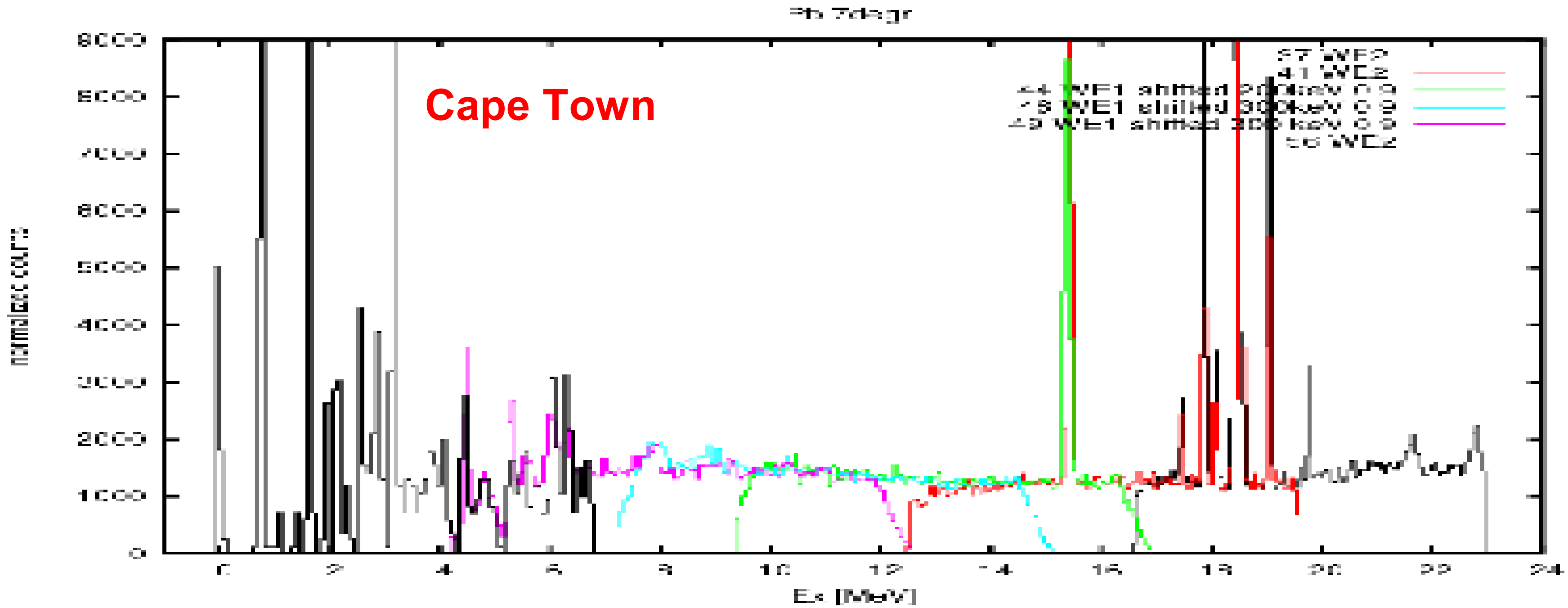
K600 SPECTROMETER

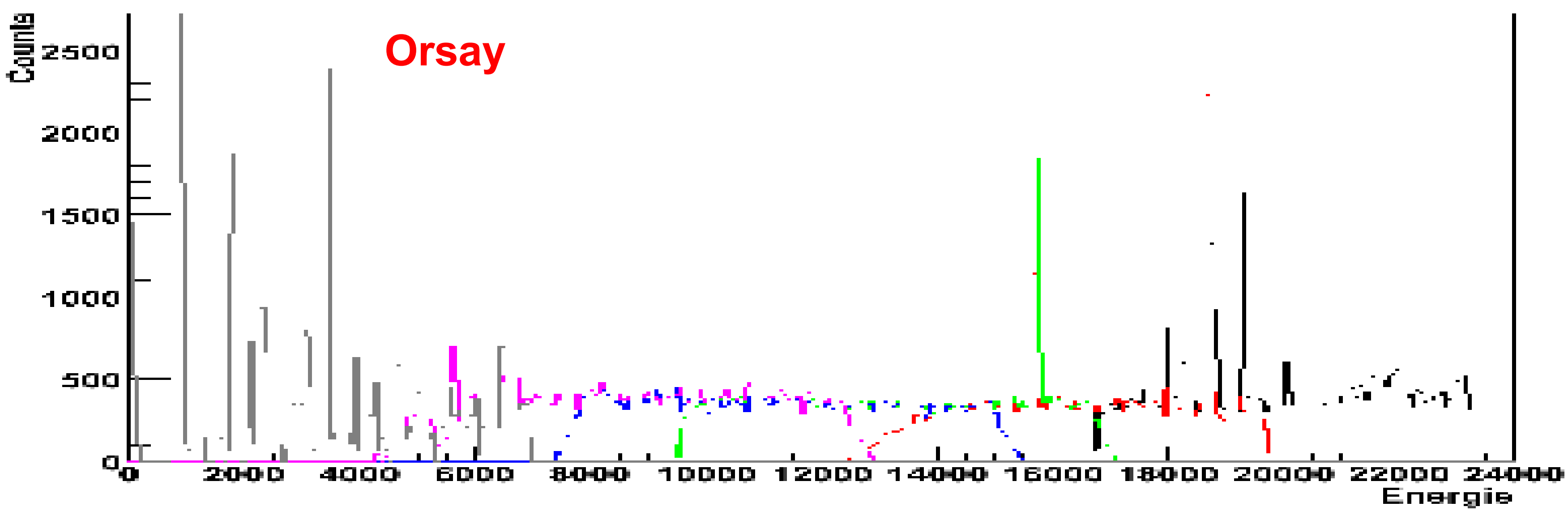


E. Khan, B. Mouginot
IPN Orsay

R. Neveling
iThemba

GPV: iThemba





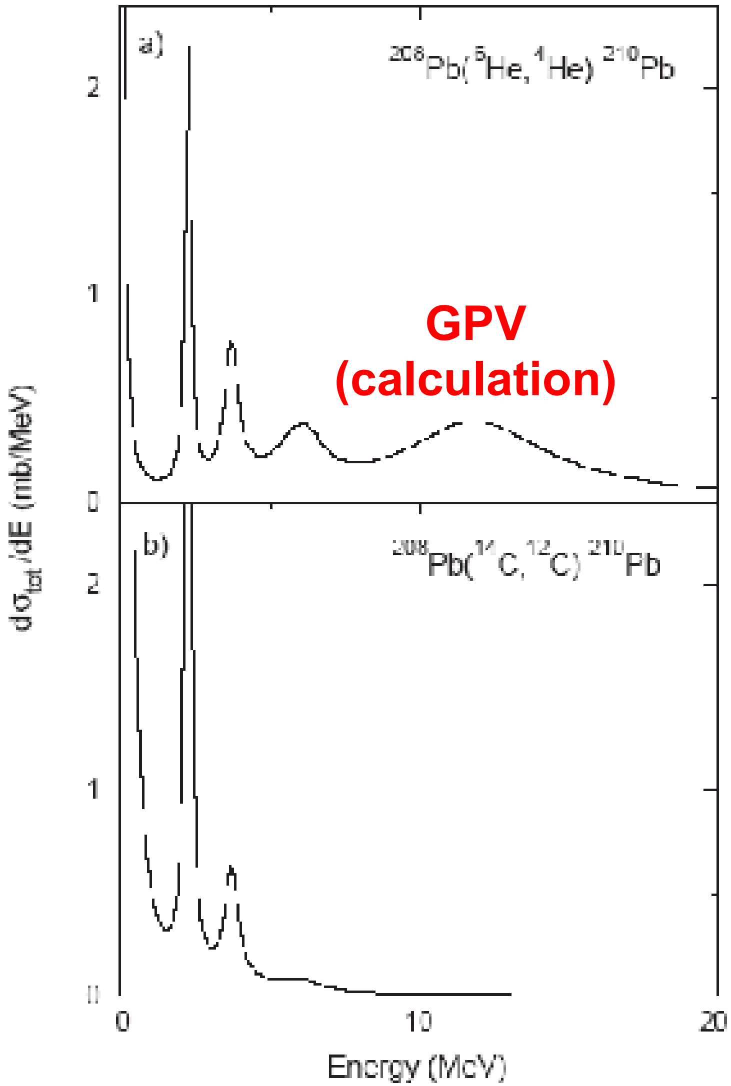
no GPV seen (yet) since not at 0°

^{6}He radioactive probe

better energy matching:
large Q value +8.15 MeV

RPA+DWBA: 1 mb cross section

cross section (^{6}He,^{4}He) probe high if dineutron configuration really exists!

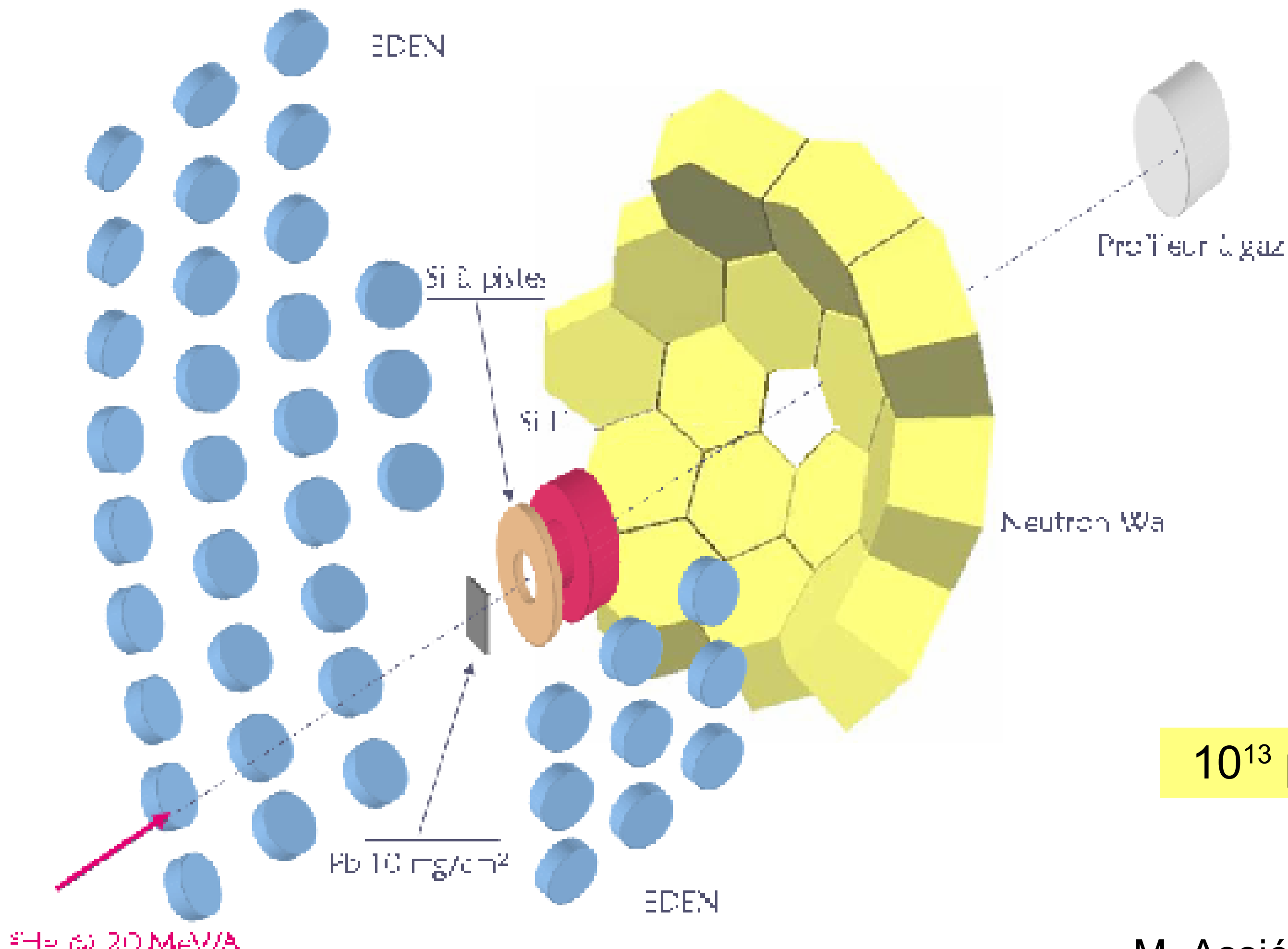


L Fortunato et al, EPJA 14, 37 (2002)

GPV: radioactive probe

radioactive probe: $^{208}Pb(^{6}He,^{4}He)^{210}Pb$ at Ganil
10^{6}-10^{7} pps ^{6}He at 20 MeV/u + 10 mg/cm^{2} ^{208}Pb

No GPV seen...



10^{13} pps ^{6}He at Eurisol!

M. Assié, JA Scarpaci, IPN Orsay

Conclusions

Laser ion source

production of RIB
management of radioactive inventory

Isomeric beams
Lasers at Eurisol for In Source spectroscopy
    sensitivity of 10 atoms/s at resonance
    Doppler free two photon spectroscopy
    modify design of laser ion source

Giant pairing vibration

searched for since thirty years
better energy matching with radioactive probe
Eurisol intensity x 10^6

Reed Elsevier:
Stop organising
Arms Fairs