

Spectroscopy of Heavy Elements at Dubna

Olivier DORVAUX

on behalf of the GABRIELA collaboration

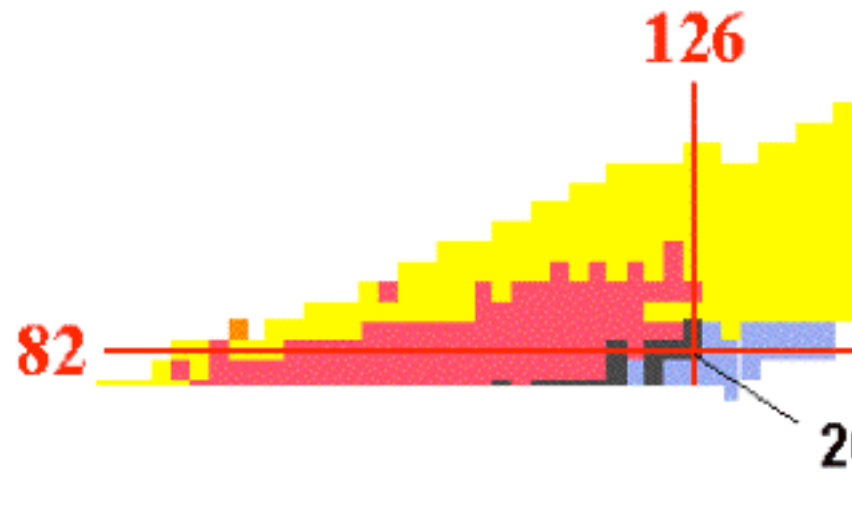
Institut Pluridisciplinaire Hubert Curie

Université Louis Pasteur de Strasbourg

Attractive Interaction = analytical description?

Time limit = mass

Existence of Super-Heavy Elements (SHE : $Z=108$) in nature?



Island of stability
consensus in the
analytical predictions

$Z=114, 120$ or 126 ?

$Z=172$ or 184 ?

What is the contribution of the

M. Bender et al, PL B515 (2001)

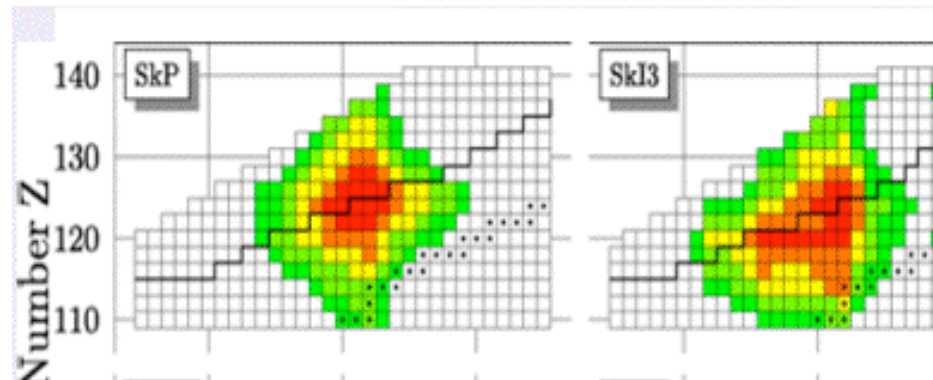
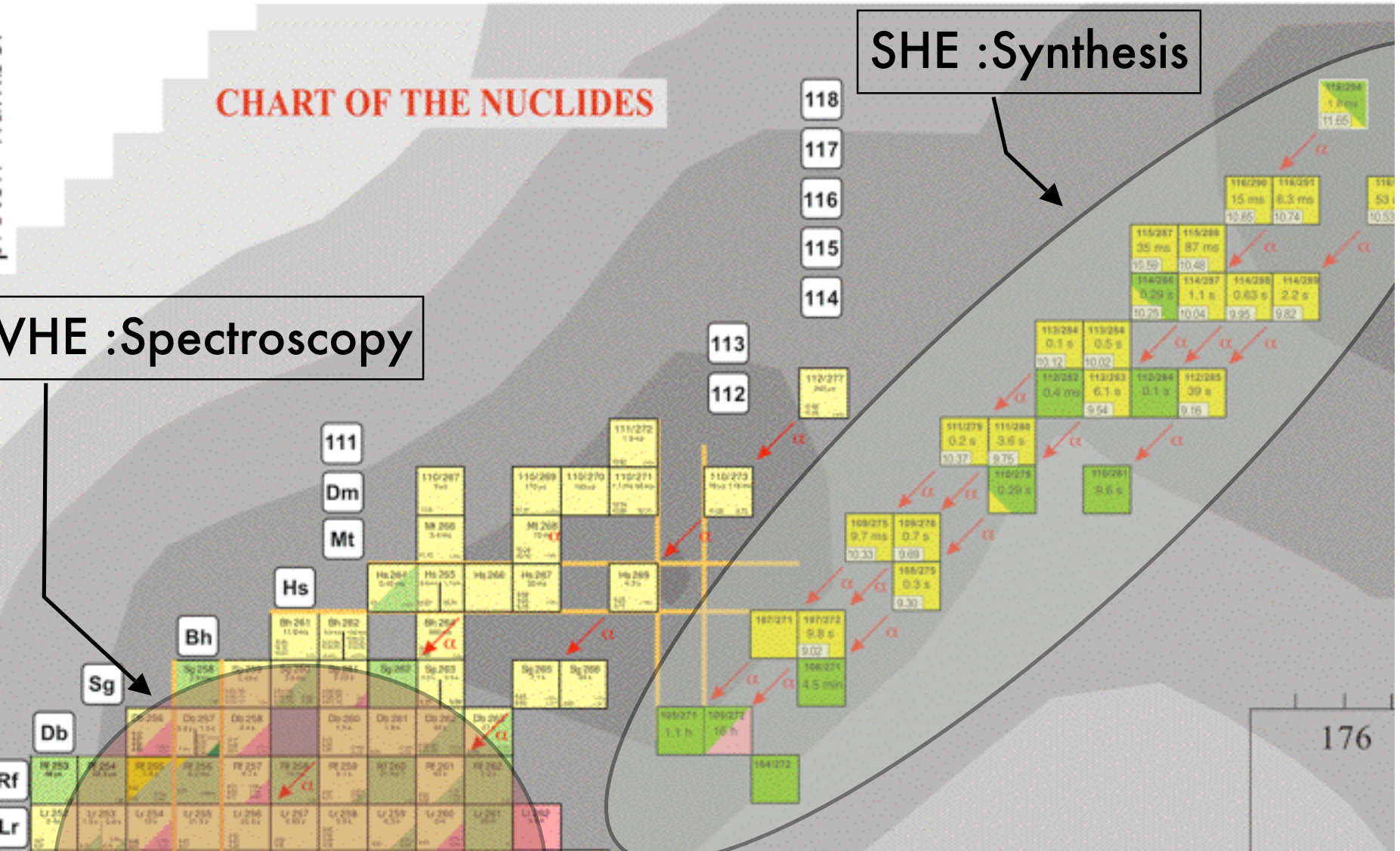


CHART OF THE NUCLIDES

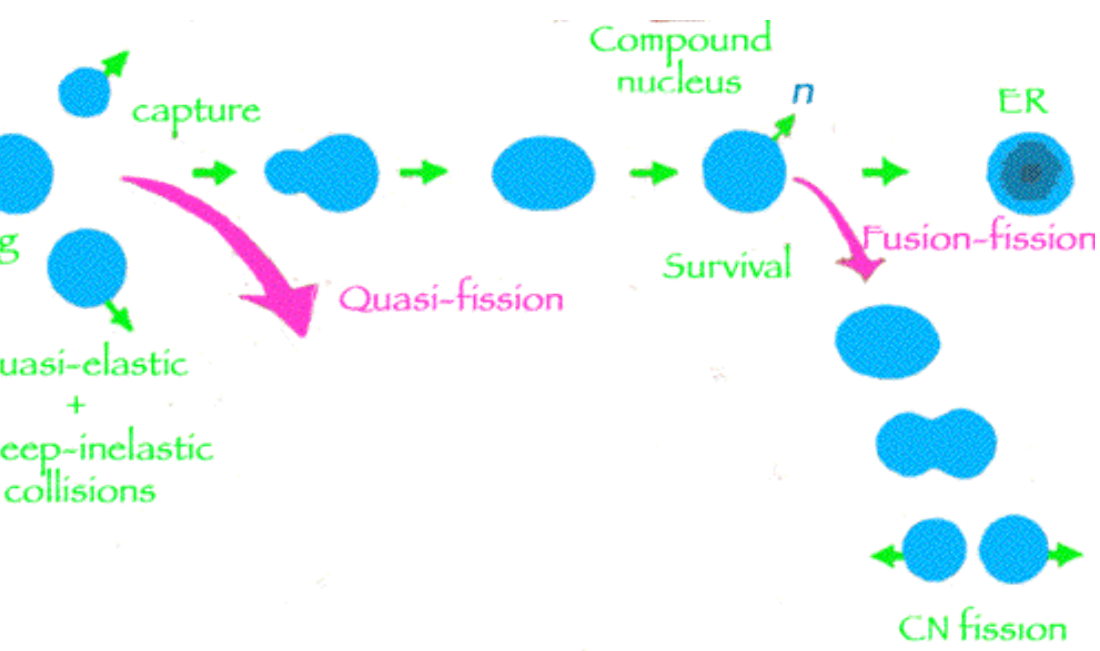
SHE :Synthesis

VHE :Spectroscopy

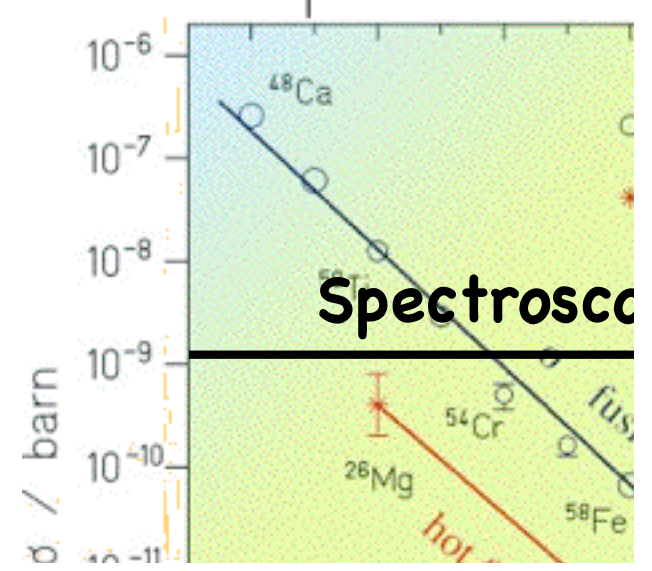


176

domination of the fission processes



Very low σ



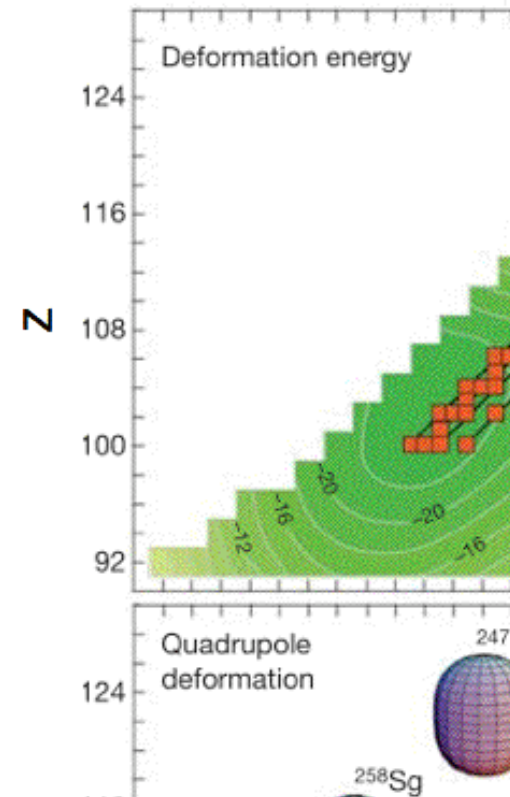
- Probe of the extreme states of the nuclear matter
- Many parameters are interpolated...when they diverge by

ps are strongly correlated with the spin-
t interaction

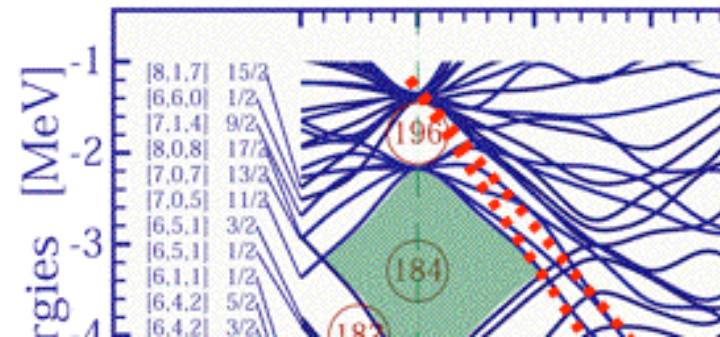
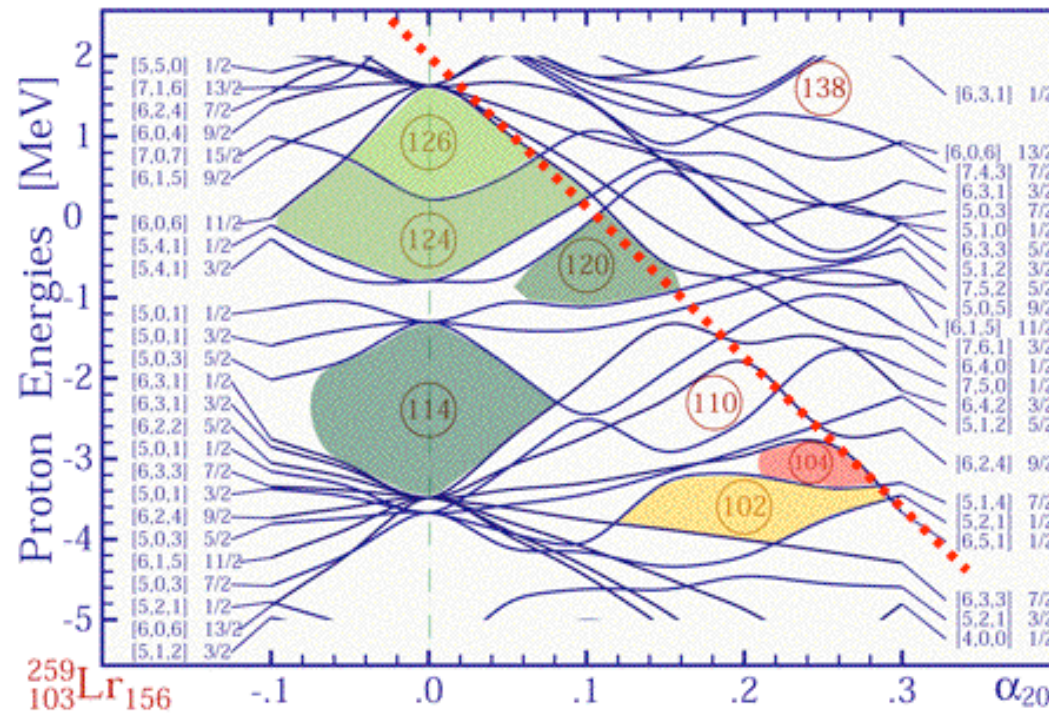
importance of the nucleus deformation ?

the SHE gap spherical ?

what is the real Coulomb effect ?



presence of high angular
 momentum orbitals?
 two-particle states
 originating from levels above
 and below the potential
 spherical Z=114 shell closure
 close to the Fermi energy
 in the deformed ground
 states of SHE in the Z~100
 A~150 region" (M. Bender)



Dubna Alpha Beta Recoil Investigation at the Electrostatic separator

<http://www.csnsn.in2p3.fr/groupes/strucnuc/gabriela.html>

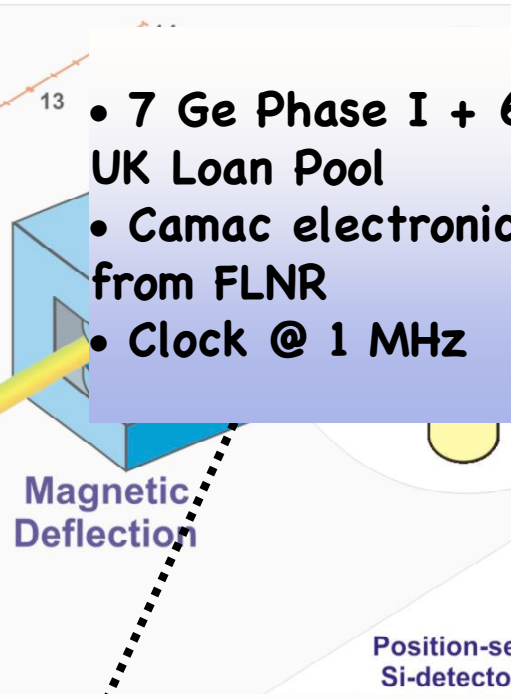
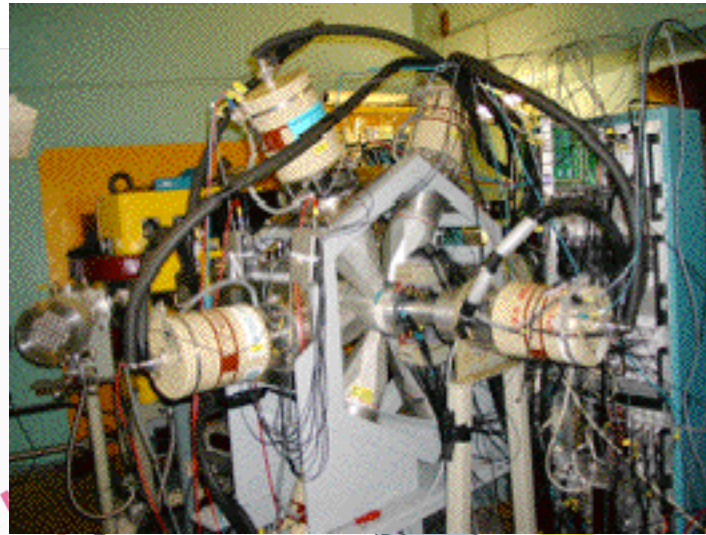
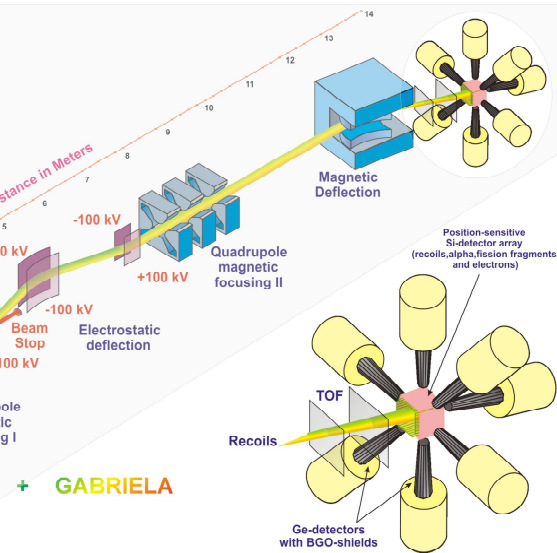
Project launched by a French (CSNSM and IPHC) - Russian (FLN) project dedicated to spectroscopy studies of Transfermium elements (using radioactive targets)

Project approved by the SC of the IN2P3 in Dec. 2003

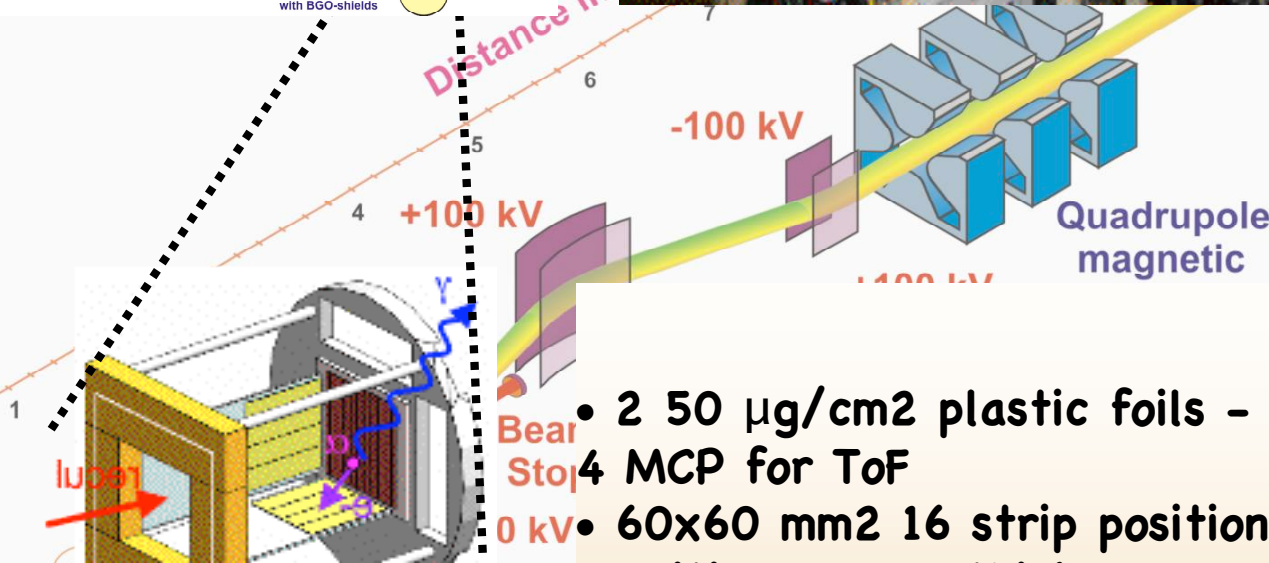
Project approved by the SC of JINR Dubna in Jan. 2004

First results presented at the EXOTAG Workshop at JYFL in J



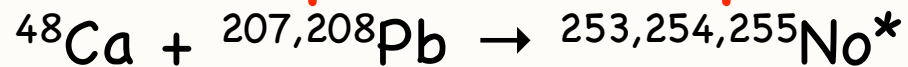


- 7 Ge Phase I + (UK Loan Pool
- Camac electronics from FLNR
- Clock @ 1 MHz

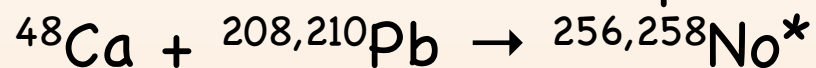
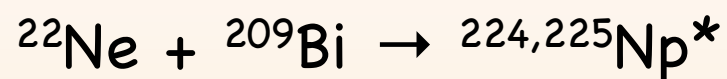
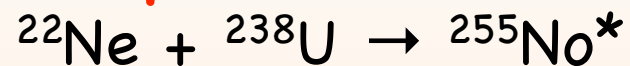


- Improvements :**
- γ detection :
 - modification of crystal-front face

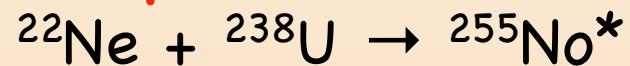
first full scale experiment : September 23 - October 25 2004



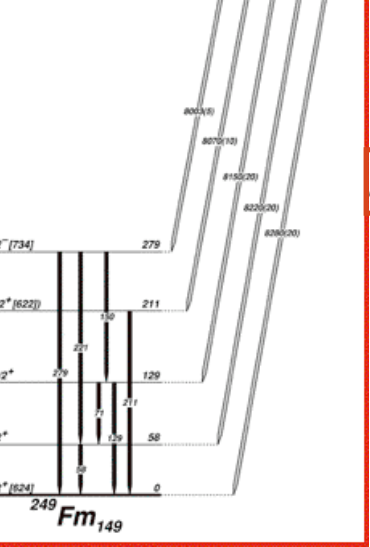
full scale experiment : October 3 - November 9 2005, 36 days



full scale experiment : October 30 - December 4 2006, 35 days



A. Lopez-Martens et al., PRC 74 (2006) 044303



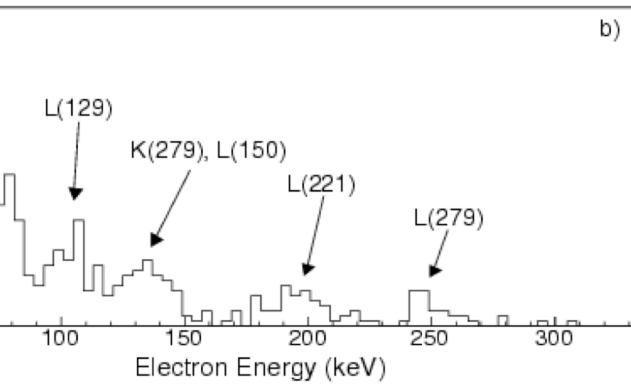
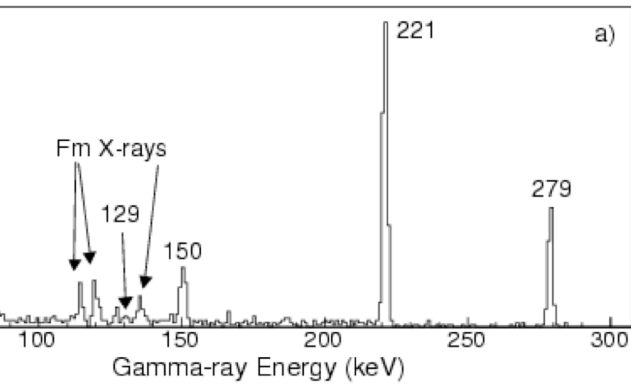
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103Lr								Lr252	Lr253	Lr254	Lr255	Lr256	Lr257	Lr258	Lr259
102No						No250	No251	No252	No253	No254	No255	No256	No257	No258	
101Md	Md245	Md246	Md247	Md248	Md249	Md250	Md251	Md252	Md253	Md254	Md255	Md256	Md257		
100Fm	Fm242	Fm243	Fm244	Fm245	Fm246	Fm247	Fm248	Fm249	Fm250	Fm251	Fm252	Fm253	Fm254	Fm255	Fm256

ia, in preparation

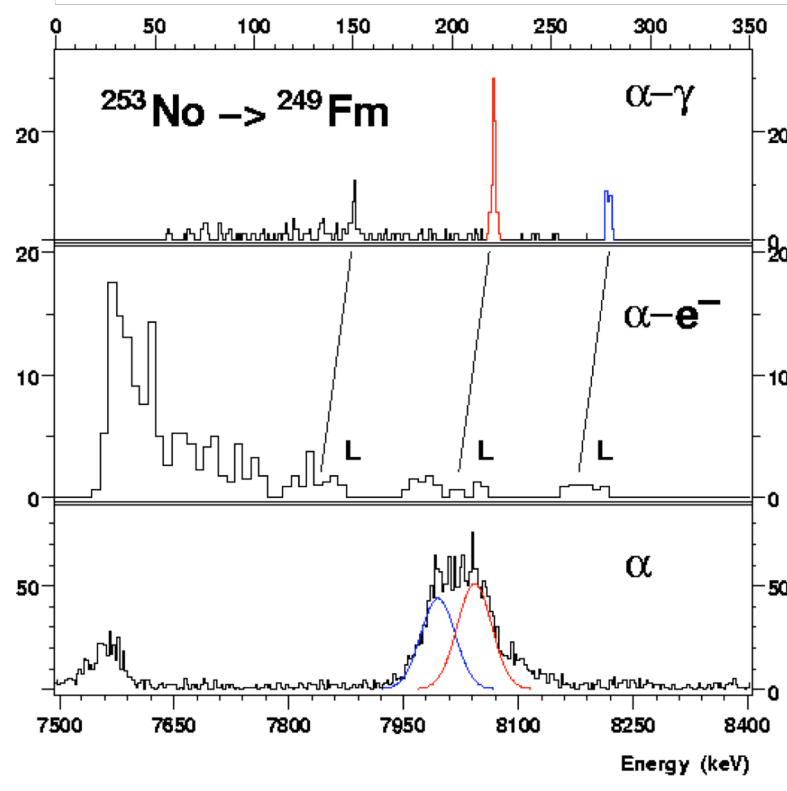
93Np								Np224	Np225	Np226	Np226	Np227	Np228	Np229	
92U	U217	U218	U219	U220	U221	U222	U223	U224	U225	U226	U227	U228	U229		
91Pa	Pa215	Pa216	Pa217	Pa218	Pa219	Pa220	Pa221	Pa222	Pa223	Pa224	Pa225	Pa226	Pa227	Pa228	
90Th	Th213	Th214	Th215	Th216	Th217	Th218	Th219	Th220	Th221	Th222	Th223	Th224	Th225	Th226	Th227

A. Lopez-Martens et al., PRC 74 (2006) 044303

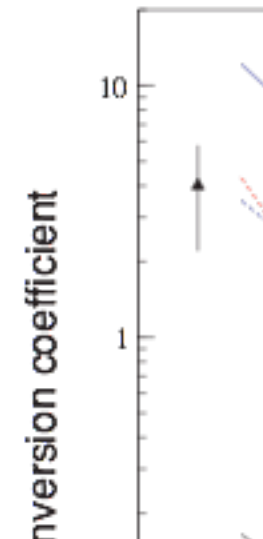
This work



R-D. Herzberg et al.,
J. Phys G30 R123 (2004)

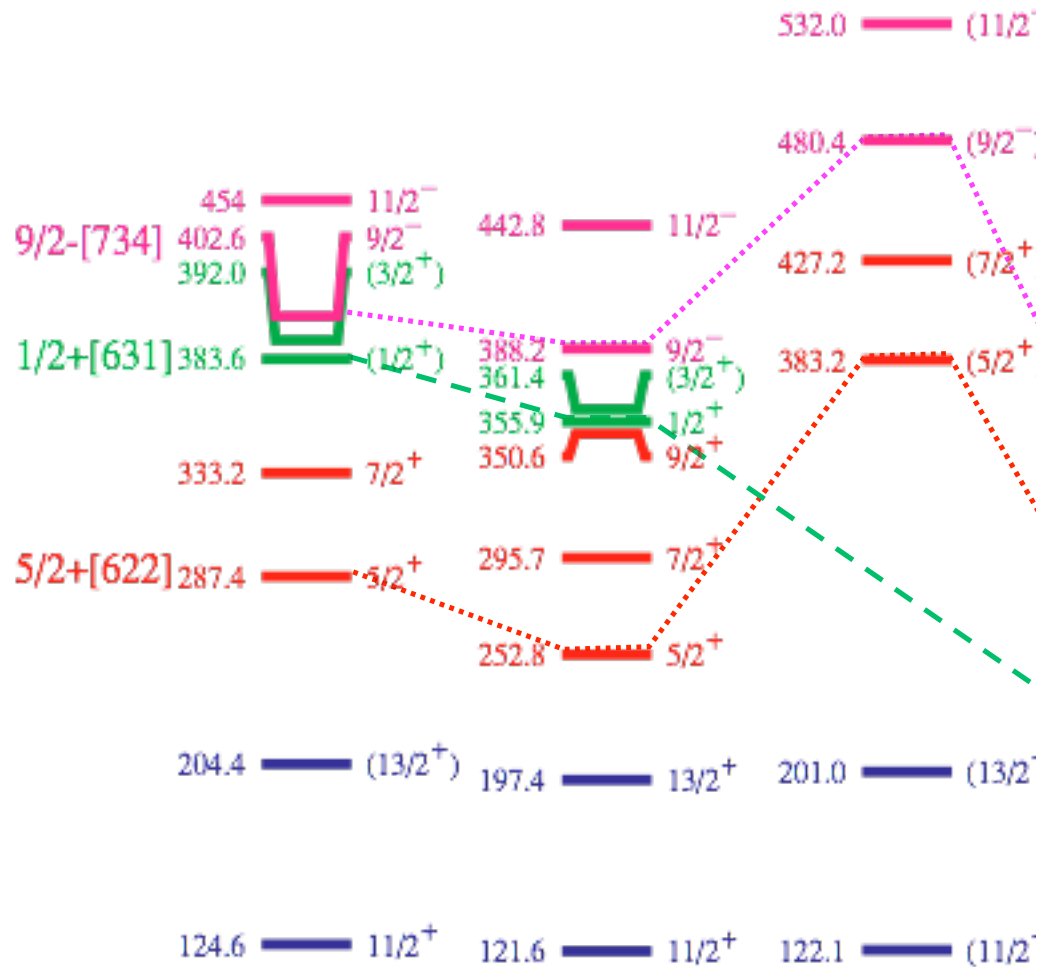
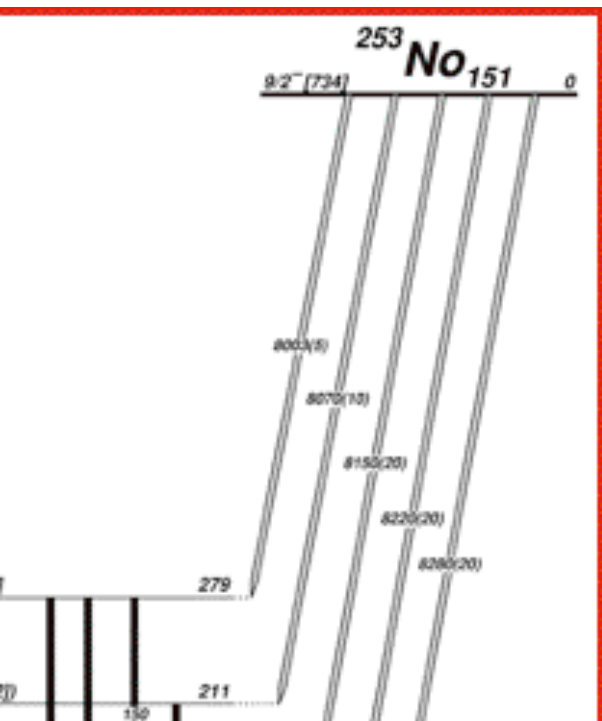


2
0.7 p
10500



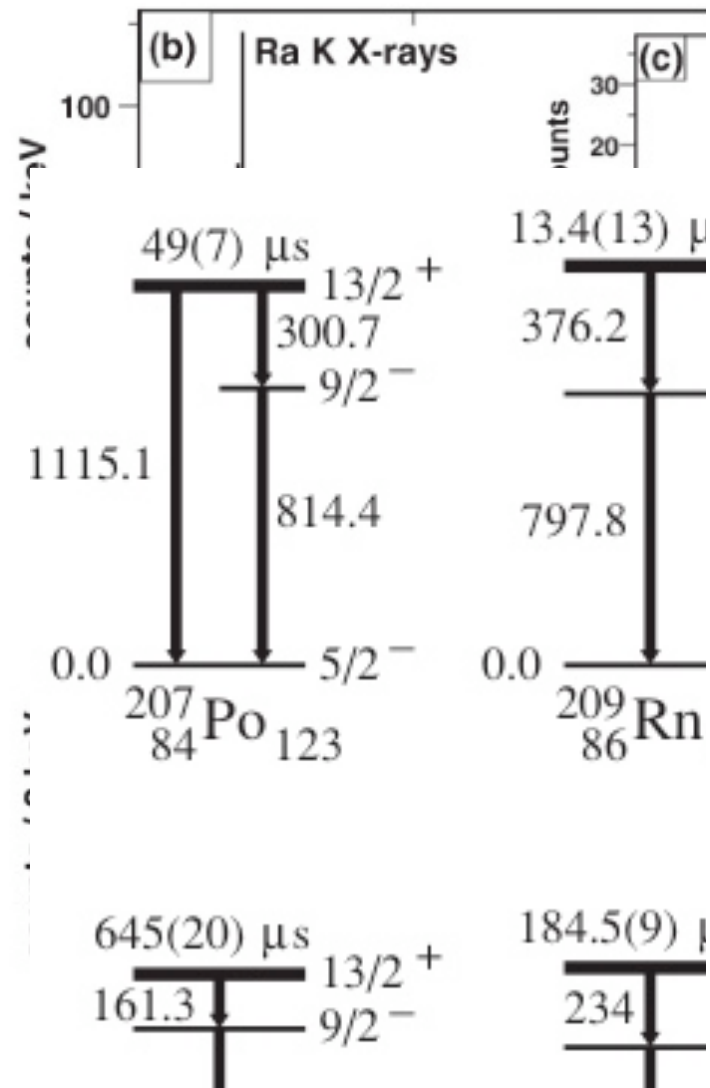
A. Lopez-Martens et al., PRC 74 (2006) 044303

berger et al., EPJ A22 (2004) 417
 erzberg et al., J. Phys G30 R123 (2004)
 ork



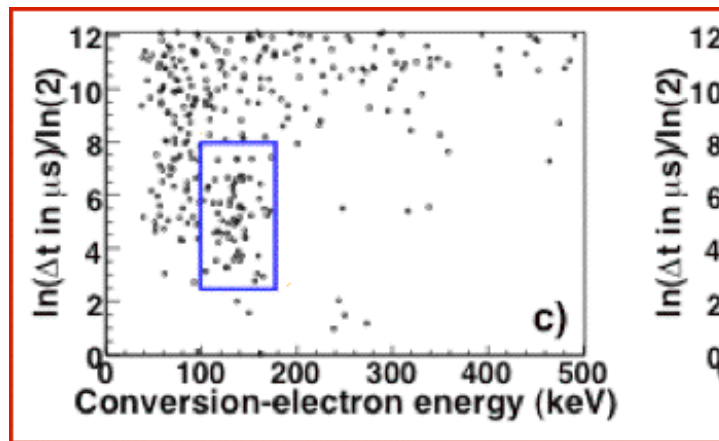
^{40}Ar , 5n) ^{209}Ra
 10 MeV beam energy with
 intensity of 0.6 μA
 alphas of $^{209,210}\text{Ra}$

New isomer observed in ^{209}Ra
 measured to be 117(5) μs
 $^{209}\text{Ra}^m$ state assigned to
 $+v(i13/2)-1$ excitation.



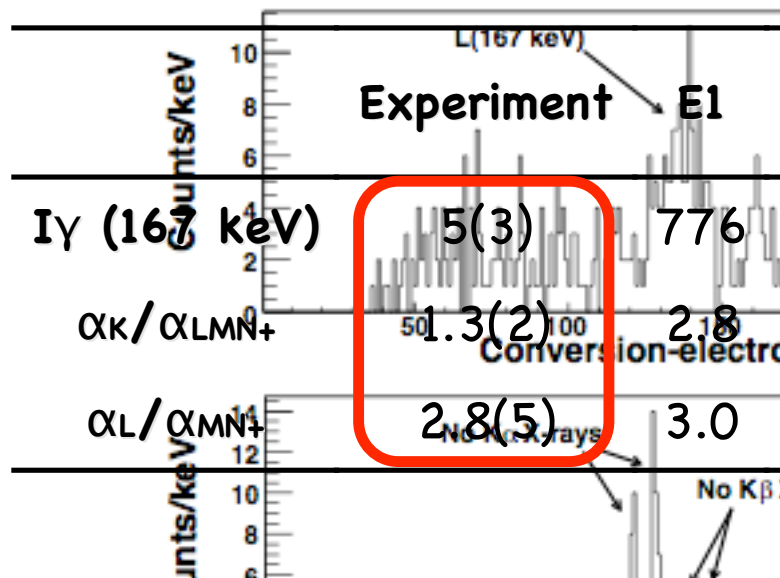
A. Lopez-Martens et al., EPJ A32 (2007) 245

$^{48}\text{Ca}, 2n) ^{253}\text{No}$
 10 MeV beam energy with
 intensity of 0.7 μA
 detection of alphas of $^{253,254}\text{No}$



lifetime Measurement

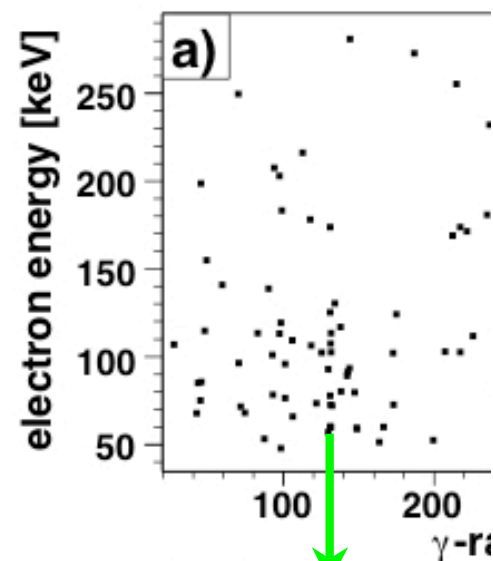
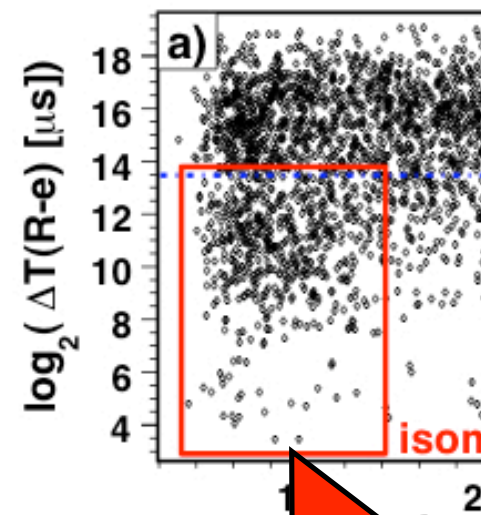
1/2 + 18201



K. Hauschild et al., submitted

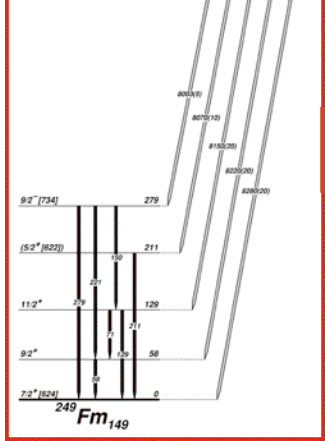
$(^{48}\text{Ca}, 2n) ^{255}\text{Lr}$
MeV beam energy with
intensity of 0.7 pμA

New isomer observed in ^{255}Lr of 1.4 ms
lifetime
Energy limit @ 720 keV (assuming LM
conversion)
Search for K-isomer 3qp states but not enough
microscopic information

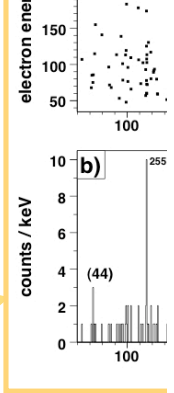


GABRIELA Summary

A. Lopez-Martens et al., PRC 74 (2006) 044303



104Rf	Rf253	Rf254	Rf255	Rf256	Rf257	Rf258	Rf259	Rf260							
103Lr	Lr252	Lr253	Lr254	Lr255	Lr256	Lr257	Lr258	Lr259							
102No	No250	No251	No252	No253	No254	No255	No256	No257	No258						
101Md	Md245	Md246	Md247	Md248	Md249	Md250	Md251	Md252	Md253	Md254	Md255	Md256	Md257		
100Fm	Fm242	Fm243	Fm244	Fm245	Fm246	Fm247	Fm248	Fm249	Fm250	Fm251	Fm252	Fm253	Fm254	Fm255	Fm256

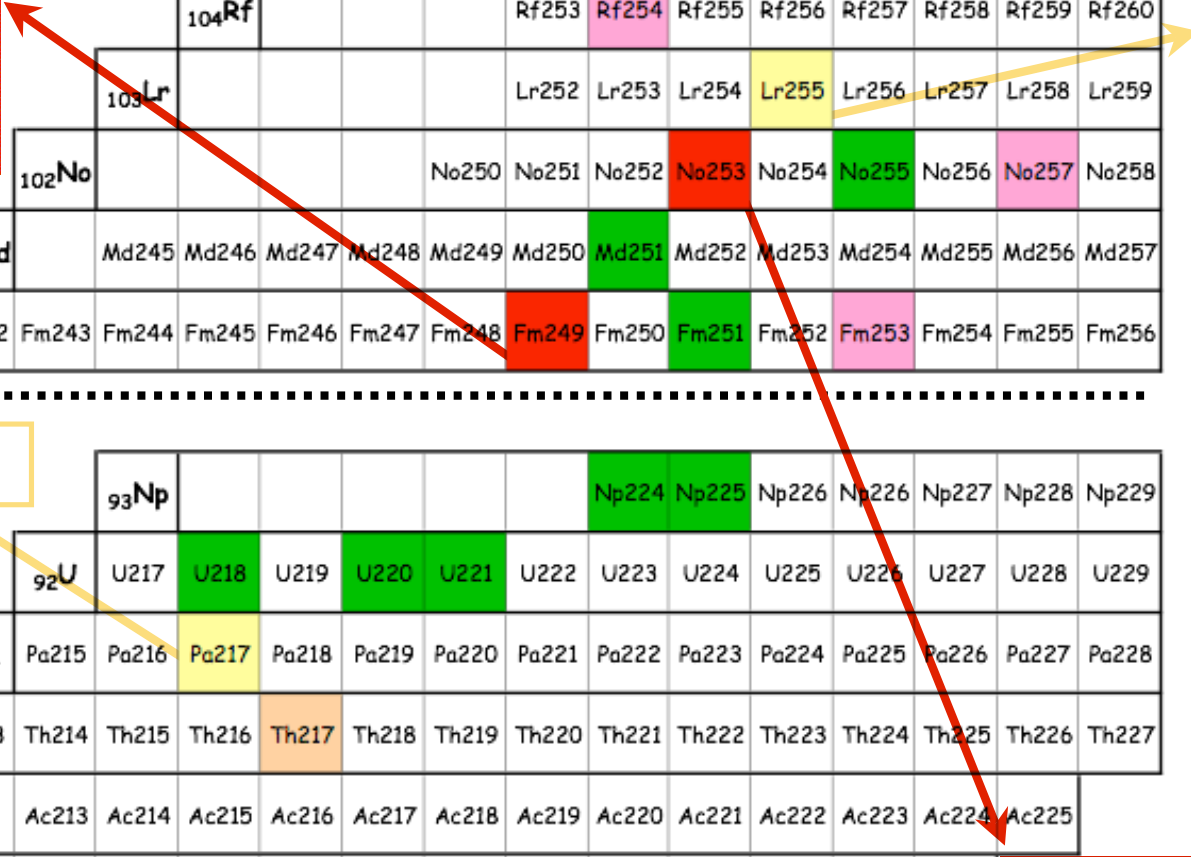
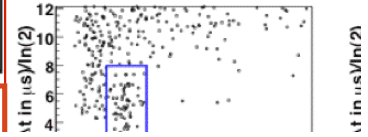


K. Hauschi

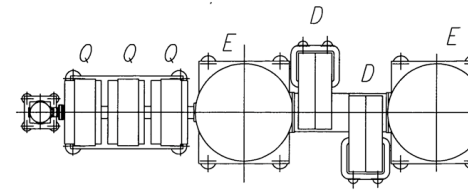
- Pub
- In
- In
- Fail

A. Khouaja, in preparation

93Np	Np224	Np225	Np226	Np226	Np227	Np228	Np229								
92U	U217	U218	U219	U220	U221	U222	U223	U224	U225	U226	U227	U228	U229		
91Pa	Pa215	Pa216	Pa217	Pa218	Pa219	Pa220	Pa221	Pa222	Pa223	Pa224	Pa225	Pa226	Pa227	Pa228	
90Th	Th213	Th214	Th215	Th216	Th217	Th218	Th219	Th220	Th221	Th222	Th223	Th224	Th225	Th226	Th227
89Ac	Ac213	Ac214	Ac215	Ac216	Ac217	Ac218	Ac219	Ac220	Ac221	Ac222	Ac223	Ac224	Ac225		
88Ra	Ra209	Ra210	Ra211	Ra212	Ra213	Ra214	Ra215	Ra216	Ra217	Ra218	Ra219	Ra220	Ra221	Ra222	Ra223



mass separator (see A. POPEKO's talk)



Dedicated to Transfermium spectroscopy elements using radioacti
 Need test efficiency for lighter beams (^{18}O , ^{12}C , ...)
 Estimated transmission efficiency for asymmetric reactions using ac
 ch as $^{22}\text{Ne} + ^{238}\text{U}$: >5% (instead of 1%)
 Optimization for symmetric reactions such as $\text{Xe} + \text{Xe}$

A

sensitivity to low energy EC (new amplifiers/digital electronics)
 v 1 mm thick electron Si detectors
 v Si implantation detectors: DSSD

ORS/IN₂P₃, Strasbourg, France

ervaux, A. Khouaja, D. Curien, B. Gall, F. Khalfallah, J. Piot, M. Rousseau, N. Stuttgart

/IN₂P₃, Orsay, France

pez-Martens, K. Hauschild, Ch. Briançon, P. Désesquelles, A. Korichi ... and

JINR, Dubna, Russia

eremin, A.V. Belozеров, M.L. Chelnokov, V.I. Chepigin, V.A. Gorshkov, A.P. Kev, Yu. Ts. Oganessian, A.G. Popeko, R.N. Sagaidak, A.V. Shutov, A.I.Svirikhin

University, Norway

formsen, A.C. Larsen, S. Siem, N.U.H. Syed

IFIN-HH, Bucharest, Romania

D. Pantelica, R. Borcea, V. Z

