

U261

X-ray Fingerprinting of E115 Decay Chains

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on behalf of the TASCA/TASISPEC collaboration

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Main Aim: Discriminate Z of Neutron-rich SHE

Year 2010: Mere confirmation less important – the question is: what are Z and A ?

Statistically significant X-ray fingerprinting of SHE

IDEA:

Alpha decay into low-lying excited states:

Common(!) for all heavy odd- A and odd-odd nuclei:
The odd nucleon acts as a spectator and ends up in an excited (Nilsson) state in the daughter!

Hit highly-converted transition(s):

M1 at 200 keV: K-conversion coefficient $\sim 10!$

K X-rays: ~ 150 keV

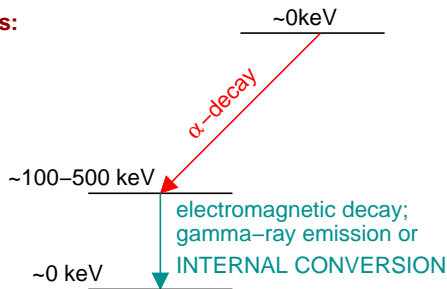
E2 at 100 keV: L-conversion coefficient $\sim 50!$

L X-rays: ~ 30 keV

Odd-odd nuclei are 'nuclear structure nightmares'

Preference: odd- A nuclei/chains!

NEEDED: Long decay chains and high production and detection probability!



followed by K and/or L X-rays

Main Aim: Discriminate Z of Neutron-rich SHE

Year 2010: Mere confirmation less important – the question is: what are Z and A ?

Statistically significant X-ray fingerprinting of SHE using the 5-step decay chains of 287–115.

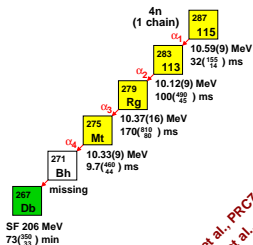
12 chains provide $5 \times 12 = 60$ opportunities

$^{243}\text{Am}(48\text{Ca},4n)^{287}\text{115}$

(Comparatively)

- easy beam
- easy target

in terms of availability and radiation safety as well as decent cross section: ~ 1.5 pb.



Yu. T. Oganessian et al., PRC72, 034611 (2009)
Yu. T. Oganessian et al., JPG 34, R165 (2007)

NEEDED: Long decay chains and high production and detection probability!

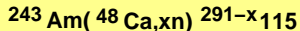


Secondary Aims: Spectroscopy and Confirmation

Year 2010: Mere confirmation less important – the question is: what are Z and A?

Statistically significant X-ray fingerprinting of SHE using the 5–step decay chains of 287–115.

12 chains provide $5 \times 12 = 60$ opportunities



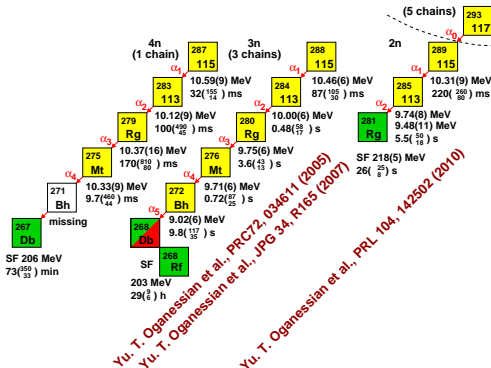
Alpha–gamma coincidence spectroscopy near $Z=114$; nuclear structure of low-lying excited states in the heaviest elements.

30 chains provide 150 opportunities

By default:

Confirmation of E115 (and possibly E117) decay chains claimed by Dubna.

NEEDED: Long decay chains and high production and detection probability!

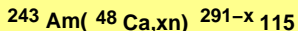


Alpha Fine Structure in 293-117 Chains

Year 2010: Mere confirmation less important – the question is: what are Z and A?

Statistically significant X-ray fingerprinting of SHE using the 5-step decay chains of 287–115.

12 chains provide $5 \times 12 = 60$ opportunities



Alpha-gamma coincidence spectroscopy near $Z=114$; nuclear structure of low-lying excited states in the heaviest elements.

30 chains provide 150 opportunities

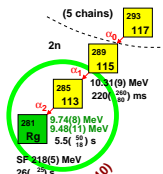
Explicit wish of ORNL collaborators:
Search for daughter chains of 293–117!

By default:

Confirmation of Dubna E115 decay chains

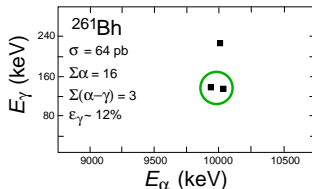
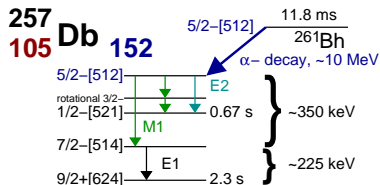
NEEDED: Long decay chains and high production and detection probability!

9.74(8) MeV
9.48(11) MeV
0.26(14) MeV



Yu. T. Oganessian et al., PRL 104, 142502 (2010)

K X-ray No. 1: Step 5 — $^{271}\text{Bh} \rightarrow ^{267}\text{Db}$



Two K_{α}
 $Z = 105$
 observed!

F.P. Hessberger et al., EPJA 43, 175 (2010)

N=152 and **N=162** are predicted and experimentally established shell closures at prolate deformation (~ 0.2):

\Rightarrow Proton single-particle spectrum must be (merely) the same for

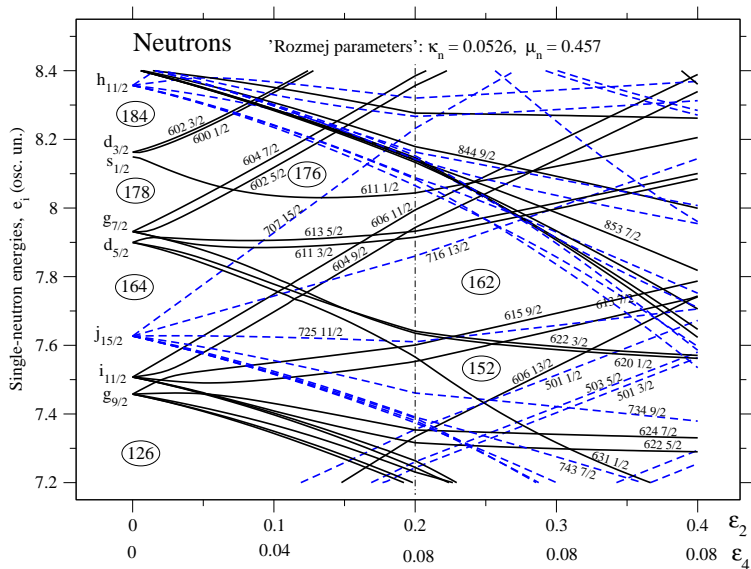
$^{257}_{105}\text{Db}_{152}$ and $^{267}_{105}\text{Db}_{162}$

\Rightarrow **Safe bet for K X-rays for this (last) step!**

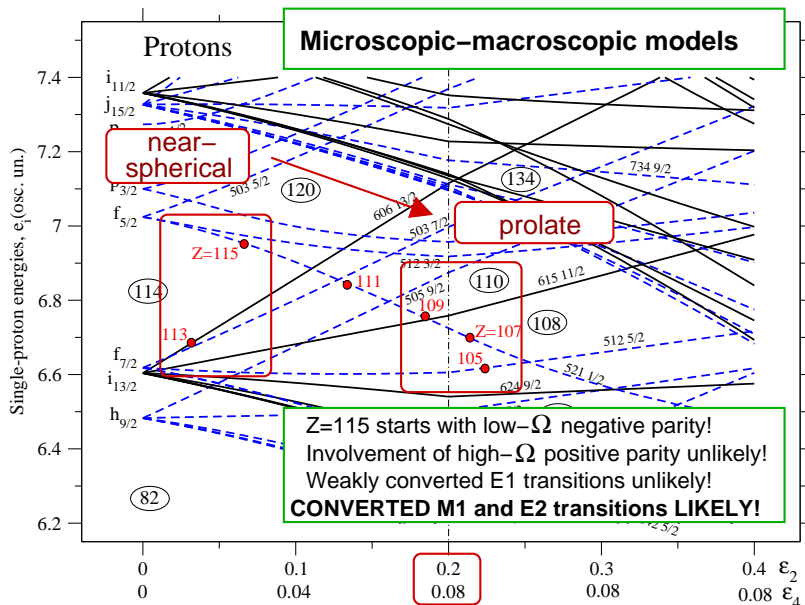
(independent of detailed interpretation/involved Nilsson orbitals)



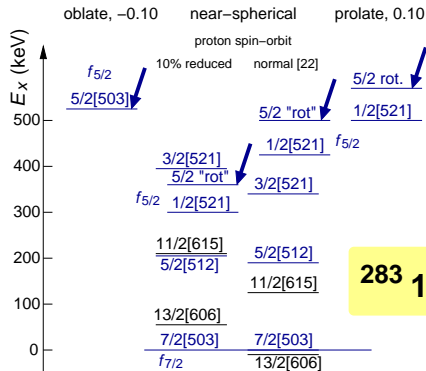
Neutron single-particle energies



Are there K X-rays? A Scenario



K X-ray No. 2: Step 1 — $^{287}\text{115} \rightarrow ^{283}\text{113}$



E115 predicted near-spherical or weakly oblate or weakly prolate.

E113 predicted spherical.

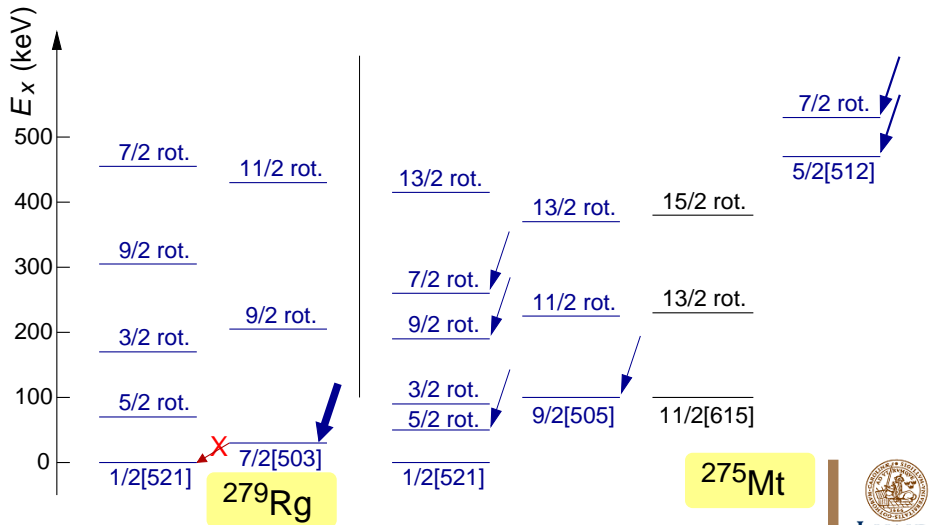
$\Rightarrow f_{5/2} \longrightarrow f_{5/2}$ decay
into excited states!

(independent of E115 shape)

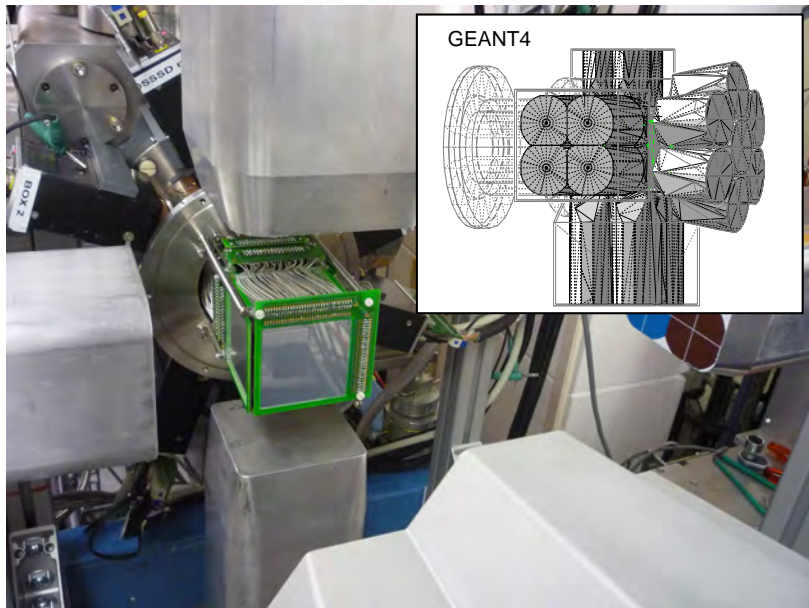
\Rightarrow (pretty) safe bet for
K X-rays in this step!

Positive-parity $i_{13/2}$ orbitals are bypassed!
E1 transitions unlikely!!

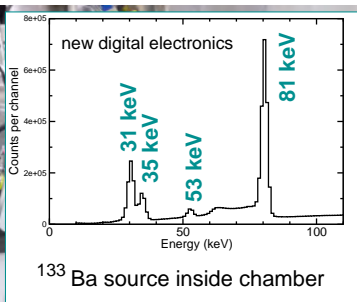
Decay Sequence $^{283}_{113} \rightarrow ^{279}\text{Rg} \rightarrow ^{275}\text{Mt}$



Tasca Small Image mode SPECTroscopy



Tasca Small Image mode SPECTroscopy



23 Ge crystals in 5 detectors:
4 Clovers and 1 EB Cluster

1

4

60mm x 60mm cube
of Si-strip detectors
 $\epsilon_{\alpha} = 80(2)\%$
"Transparent" for
 γ -rays and X-rays

2

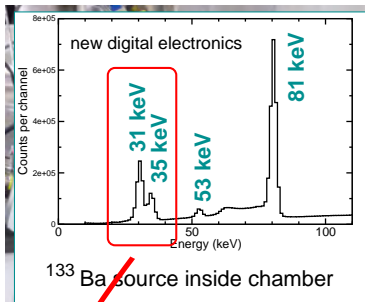
3

Cluster



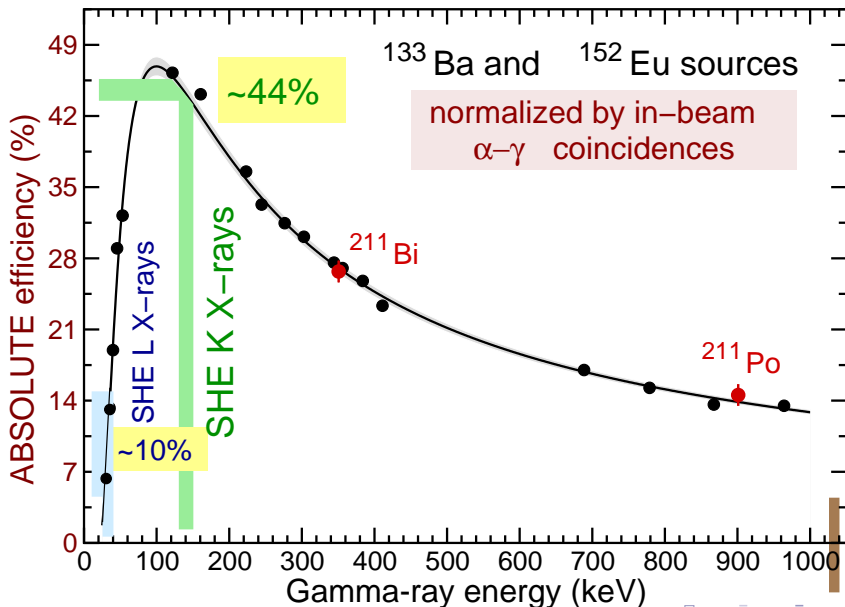
LUND
UNIVERSITY

Tasca Small Image mode SPECTroscopy

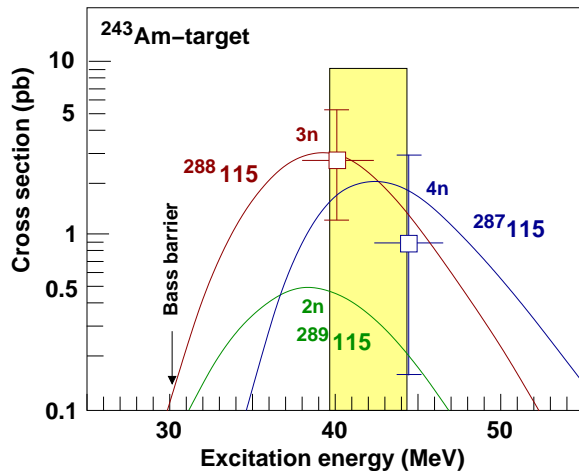


Ba K X-rays \triangleq E113 L X-rays !!

TASISPEC Efficiency (U225 4/2010)



Cross sections



Yuri Oganessian, JPG34, R165 (2007).

V. Zagrebaev, NPA734, 164 (2004).

Rates and Anticipated Significance

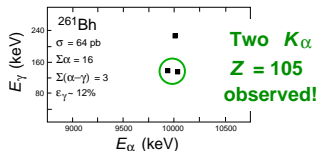
About 1 K–X–ray per 287–115 chain being DETECTED!

Extrapolating from Bh experiment (SHIP)

Extrapolating from E114 experiment (TASCA)

} ~1 week/chain

(using known Dubna cross-sections, transmissions, targets, beam intensities etc.)



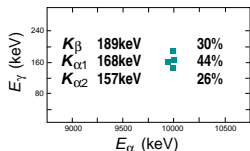
3x α -X matrices

115 \rightarrow 113

Rg \rightarrow Mt

Bh \rightarrow Db

N~4 per matrix



F.P. Hessberger et al., EPJA 43, 175 (2010)

12 weeks

2–3 decay chains of 2n–channel 289–115 (E117 daughter)
good chance for 1 coincidence between K and L X–rays



Readiness & Feasibility: Electronics & DAQ

Ge: 23 channels SIS3302 sampling ADC (U225, 2010)

Box-DSSSD: 128 channels multiplexed (E114, 2009)

Imp-DSSSD: 32+32 channels read-out (U225, 2010)

New, faster ADCs existing/ordered

19/11/2010:

All electronics collected in Lund to optimize MBS and DAQ software including beam shut-off upon chain ID.

TASISPEC Commissioning 2008:

$^{244}\text{Pu}(^{48}\text{Ca}, xn)^{292-x}\text{114}$

~500/s background rate during beam-on for E115.



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Readiness & Feasibility: Personnel

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