Evolution of Collectivity in the Vicinity of Pb-208:

PRESPEC-AGATA Campaign at GSI 2012

L.G. Sarmiento on behalf of the S429 collaboration.

Lund University

NSP13, Palazzo del Bo', Padova, Italy
June 2013

Overview

1. Aim of the experiment
2. The experimental setup
3. Data analysis
4. Preliminary results

The S429 collaboration

L.G. Sarmiento, T. Alexander, M.L. Cortes, J. Gerl, Zs. Podolyák, D. Rudolph,
F. Ameil, D. Bazzacco, P. Boutachkov, B.G. Carlsson, A. Gadea, P. Golubev, M. Górska,
I. Kojouharov, N. Kurz, E. Merchán, S. Pietri, D. Ralet, M. Reese, H. Schaffner, P. Singh, T. Arici,
Ch. Bauer, M.A. Bentley, A. Blazhev, M. Bowry, C. Fahlander, J. Gellanki, A. Givechev, N. Goel,
A. Gottardo, E. Gregor, G. Guastalla, T. Habermann, M. Hackstein, A. Jungclaus, W. Korten,
S. Kumar, M. Lettmann, C. Lisarazo, S. Mandal, Th. Möller, K. Moschner, Z. Patel, N. Pietralla,
P. Reiter, P.H. Regan, Ch. Stahl, R. Stegmann, O. Stézowski, P. Thoele, A. Wendt, O. Wieland,
E. Wilson, H.-J. Wollersheim, R. Wood

Background

PHYSICAL REVIEW C **84**, 044313 (2011)

Isomeric states observed in heavy neutron-rich nuclei populated in the fragmentation of a ^{208}Pb beam

S. J. Steer,[1] Zs. Podolyák,[1,*] S. Pietri,[1] M. Górska,[2] H. Grawe,[2] K. H. Maier,[3,4] P. H. Regan,[1] D. Rudolph,[5]
A. B. Garnsworthy,[1,6] R. Hoischen,[5] J. Gerl,[2] H. J. Wollersheim,[2] F. Becker,[2] P. Bednarczyk,[2,4] L. Cáceres,[2,7] P. Doornenbal,[2,8]
H. Geissel,[2] J. Grebosz,[2,4] A. Kelic,[2] I. Kojouharov,[2] N. Kurz,[2] F. Montes,[2] W. Prokopowicz,[2] T. Saito,[2] H. Schaffner,[2]

…nal of Physics G: Nuclear and Particle Physics

doi:10.1088/0954-3899/38/3/035104

Isomeric mirror states as probes for effective charges in the lower pf shell

…Ma[1,3], P Montuenga[1], M Hellström[1],
…man[4], A B Garnsworthy[4,5,12],

PHYSICAL REVIEW C **78**, 061302(R) (2008)

Single-particle behavior at $N = 126$: Isomeric decays in neutron-rich ^{204}Pt

S. J. Steer,[1,*] Zs. Podolyák,[1] S. Pietri,[1] M. Górska,[2] P. H. Regan,[1] D. Rudolph,[3] E. Werner-Malento,[2] A. B. Garnsworthy,[1,4]
R. Hoischen,[3] J. Gerl,[2] H. J. Wollersheim,[2] K. H. Maier,[5,6] H. Grawe,[2] F. Becker,[2] P. Bednarczyk,[2,6] L. Cáceres,[2,7]
P. Doornenbal,[2,8] H. Geissel,[2] J. Grębosz,[2,6] A. Kelic,[2] I. Kojouharov,[2] N. Kurz,[2] F. Montes,[2] W. Prokopowicz,[2] T. Saito,[2]
H. Schaffner,[2] S. Tashenov,[2] A. Heinz,[4] M. Pfützner,[9] T. Kurtukian-Nieto,[10] G. Benzoni,[11] A. Jungclaus,[7]
D. L. Balabanski,[12,13] C. Brandau,[1] B. A. Brown,[1,14] A. M. Bruce,[15] W. N. Catford,[1] I. J. Cullen,[1] Zs. Dombrádi,[16]
M. E. Estevez,[17] W. Gelletly,[1] G. Ilie,[8,18] J. Jolie,[8] G. A. Jones,[1] M. Kmiecik,[6] F. G. Kondev,[19] R. Krücken,[20]
S. Lalkovski,[15,21] Z. Liu,[1] A. Maj,[6] S. Myalski,[6] S. Schwertel,[20]
T. Shizuma,[1,22] P. M. Walker,[1] and O. Wieland[11]

…305(R) (2009)

…ctures in $^{198}_{76}$Os$_{122}$

…n,[1] D. Rudolph,[3] A. B. Garnsworthy,[1,4] R. Hoischen,[3,5]

…with Materials & Atoms

…hysics Research B 261 (2007) 1079–1083

www.elsevier.com/locate/nimb

…on isomer spectroscopy with rising

S. Pietri [a,*], P.H. Regan [a], Zs. Podolyák [a], D. Rudolph [b], S. Steer [a], A.B. Garnsworthy [a,c],

---

High angular momentum states populated in fragment…

Eur. Phys. J. A **42**, 489–493 (2009)
DOI 10.1140/epja/i2009-10794-5

THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Experimental Physics

Structure of neutron-rich nuclei around the N = 126 closed shell; the yrast structure of ^{205}Au$_{126}$ up to spin-parity $I^{\pi} = (19/2^{+})$

Zs. Podolyák[1,a], S.J. Steer[1], S. Pietri[1], M. Górska[2], P.H. Regan[1], D. Rudolph[3], A.B. Garnsworthy[1,4], R. Hoischen[3],
J. Gerl[2], H.J. Wollersheim[2], H. Grawe[2], K.H. Maier[5,6], F. Becker[2], P. Bednarczyk[2,5], L. Cáceres[2,7], P. Doornenbal[2,8],

---

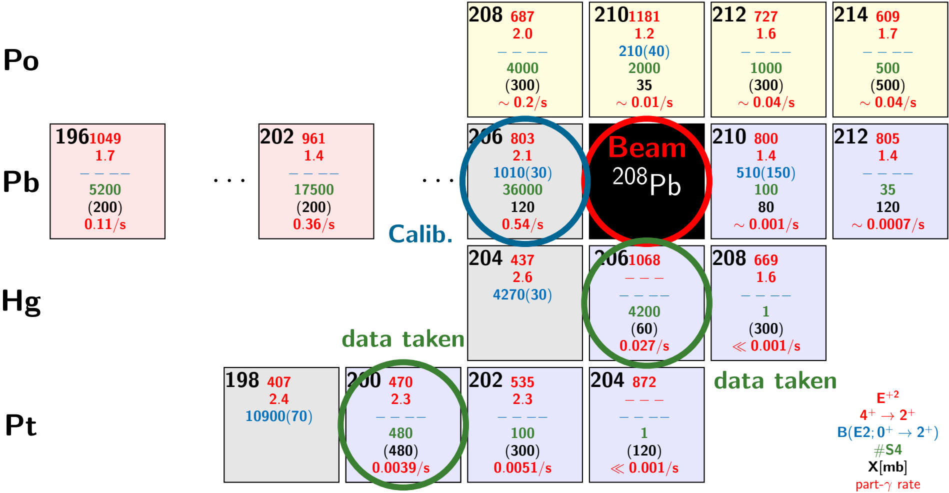
PHYSICAL REVIEW C **78**, 021301(R) (2008)

…in symmetry and proton decay: Identification of the 10^{+} isomer in ^{54}Ni

…oischen,[1,2] M. Hellström,[1] S. Pietri,[3] Zs. Podolyák,[3] P. H. Regan,[3] A. B. Garnsworthy,[3,4] S. J. Steer,[3]
…rczyk,[2,5] L. Cáceres,[2,6] P. Doornenbal,[2,7,‡] J. Gerl,[2] M. Górska,[2] J. Grębosz,[2,5] I. Kojouharov,[2] N. Kur…
…Schaffner,[2] H. J. Wollersheim,[2] L.-L. Andersson,[1] L. Atanasova,[8] D. L. Balabanski,[8,9] M. A. Bentley…
…C. Brandau,[2,3] J. R. Brown,[10] C. Fahlander,[1] E. K. Johansson,[1] A. Jungclaus,[6] and S. M. Lenzi[11]
[1]Department of Physics, Lund University, S-22100 Lund, Sweden

Experiment S429 @ GSI

^{208}Pb beam; $B(E2;0^+\rightarrow 2^+)$ of ^{200}Pt , ^{206}Hg , ^{198,200,202}Pb



Po					**208** 687 2.0 — — —— 4000 (300) ∼ 0.2/s	**210** 1181 1.2 210(40) 2000 35 ∼ 0.01/s	**212** 727 1.6 — — —— 1000 (300) ∼ 0.04/s	**214** 609 1.7 — — —— 500 (500) ∼ 0.04/s
Pb	**196** 1049 1.7 — — —— 5200 (200) 0.11/s	· · ·	**202** 961 1.4 — — —— 17500 (200) 0.36/s	· · ·	**206** 803 2.1 1010(30) 36000 120 0.54/s	**Beam** ^{208}Pb	**210** 800 1.4 510(150) 100 80 ∼ 0.001/s	**212** 805 1.4 — — —— 35 120 ∼ 0.0007/s
Hg					**204** 437 2.6 4270(30)	**206** 1068 — — — — — —— 4200 (60) 0.027/s	**208** 669 1.6 — — —— 1 (300) ≪ 0.001/s	
Pt			**198** 407 2.4 10900(70)	**200** 470 2.3 — — —— 480 (480) 0.0039/s	**202** 535 2.3 — — —— 100 (300) 0.0051/s	**204** 872 — — — — — —— 1 (120) ≪ 0.001/s		

Calib.

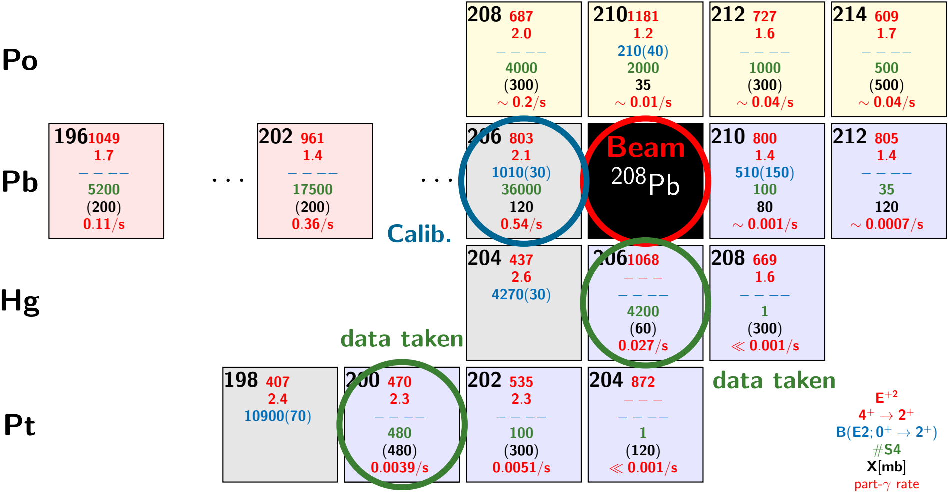
data taken

data taken

E^{+2}
$4^+ \rightarrow 2^+$
$B(E2;0^+ \rightarrow 2^+)$
#S4
X[mb]
part-γ rate

Experiment S429 @ GSI

^{208}**Pb [1 GeV/u]**$\rightarrow$ ^{9}**Be (2.5 g/cm^2)**$\rightarrow$**Au(0.5 g/cm^2)[$\sim$ 140 MeV/u]**



Po					208 687 2.0 – – – – 4000 (300) ~ 0.2/s	210 1181 1.2 210(40) 2000 35 ~ 0.01/s	212 727 1.6 – – – – 1000 (300) ~ 0.04/s	214 609 1.7 – – – – 500 (500) ~ 0.04/s
Pb	196 1049 1.7 – – – – 5200 (200) 0.11/s	. . .	202 961 1.4 – – – – 17500 (200) 0.36/s	. . .	206 803 2.1 1010(30) 36000 120 0.54/s	Beam ^{208}Pb	210 800 1.4 510(150) 100 80 ~ 0.001/s	212 805 1.4 – – – – 35 120 ~ 0.0007/s
Hg					204 437 2.6 4270(30)	206 1068 – – – – – – – 4200 (60) 0.027/s	208 669 1.6 – – – – 1 (300) ≪ 0.001/s	
Pt			198 407 2.4 10900(70)	200 470 2.3 – – – – 480 (480) 0.0039/s	202 535 2.3 – – – – 100 (300) 0.0051/s	204 872 – – – – – – – 1 (120) ≪ 0.001/s		

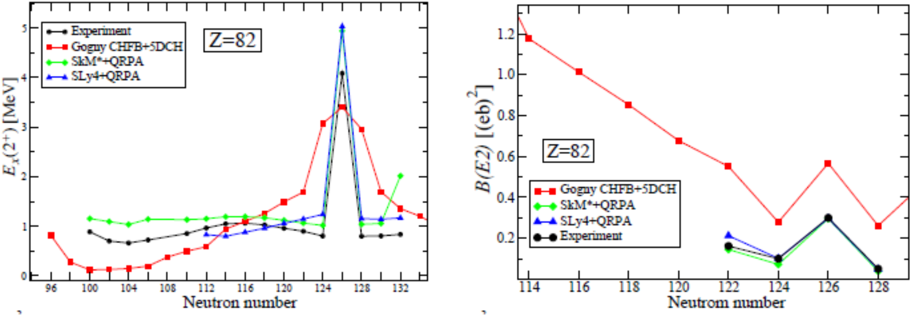
Calib.

data taken

data taken

E^{+2}
$4^+ \rightarrow 2^+$
B(E2; $0^+ \rightarrow 2^+$)
#S4
X[mb]
part-γ rate

What collectivity?



[1]

$$\tau(1+\alpha) = \tau_\gamma = 40.81 \cdot 10^{13} \frac{E_\gamma^{-5}[\text{keV}]}{B(E2)[e^2 b^2]}$$

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[1] [Delaroche, J. -P et al. Phys. Rev. C **81**, 014303 (2010), Sabbey, B. et al. Phys. Rev. C **75**, 044305 (2007), Terasaki, J. and Engel, J. Phys. Rev. C **82**, 034326 (2010)]

Why?

Spectroscopic data on the heaviest known doubly-magic nucleus ^{208}Pb and nearby neighbours . . .

- . . . serve as sources and act as constraints on shell-model parametrizations;
- . . . provide anchor points for (global) parametrizations of nuclear structure DFT models (including QRPA or GCM or other "collective" methods);
- . . . provide a basis for shell structure extrapolations towards the SHE regime.

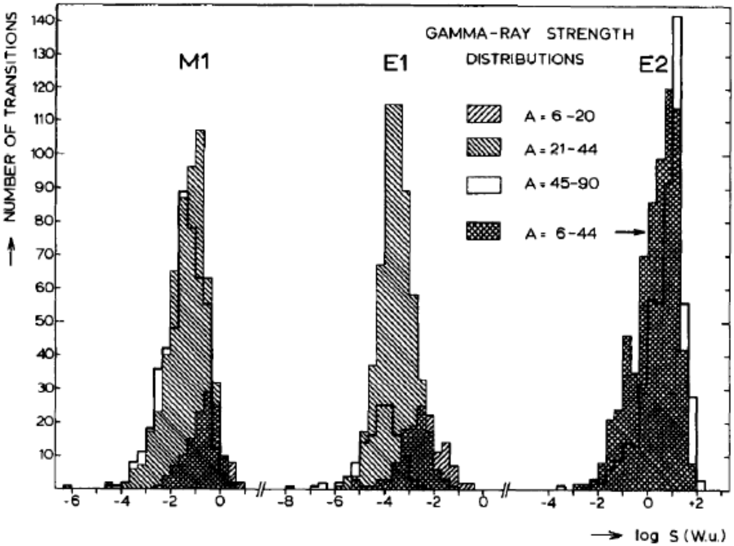
One numerical example: ^{206}Hg

$$B(E2; 0^+ \rightarrow 2^+) = 0.09 e^2 b^2 (\text{Gogny-IBM})$$

$$B(E2; 0^+ \rightarrow 2^+) = 0.19 e^2 b^2 (\text{SM})$$

$$B(E2; 0^+ \rightarrow 2^+) = 0.41 e^2 b^2 (\text{Gogny-5DCH})$$

*E*2: Collectivity?



[2]

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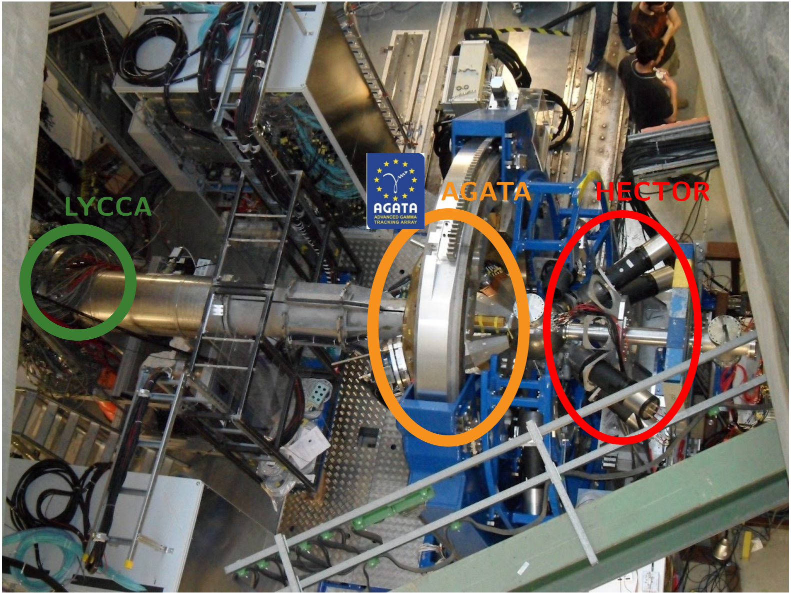
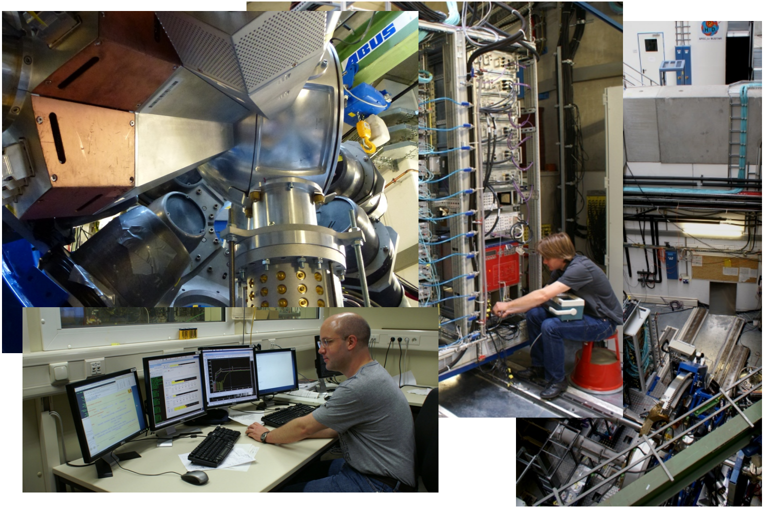
[2] [Endt, P. M. At. Data Nucl. Data Tables, 23(6):548 (1979)]

Experimental setup



AGATA campaign


[3]

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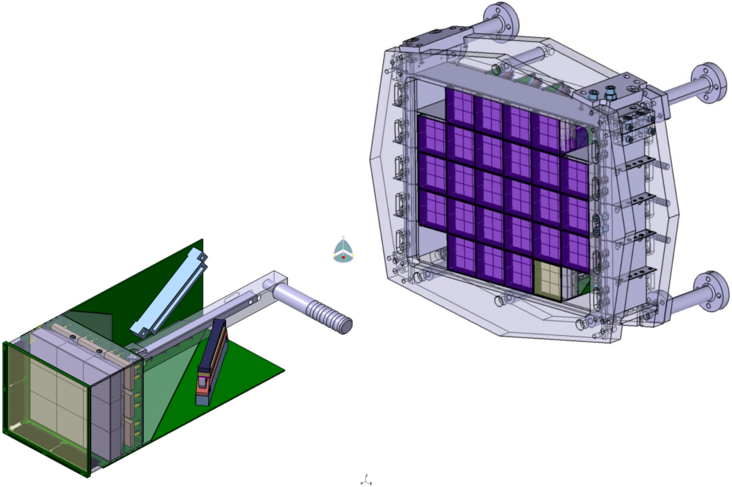
[3] S. Pietri and D. Ralet

LYCCA



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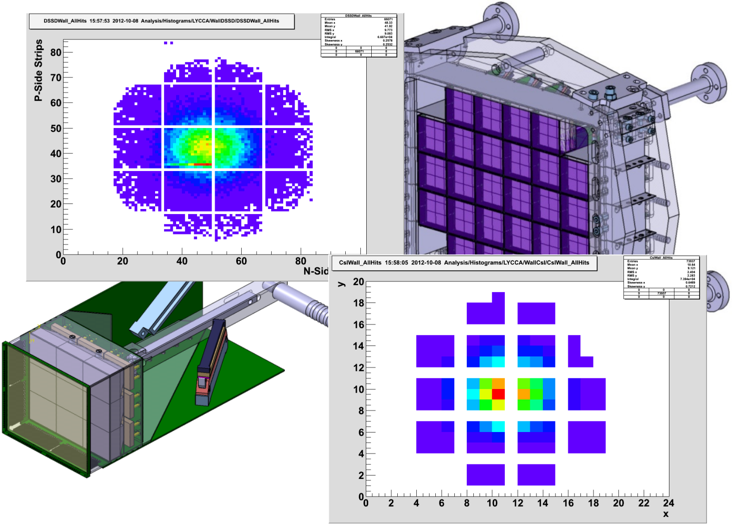
[4] P. Golubev et al. Nucl. Instrum. Methods Phys. Res., Sect. **A723** (2013) 55

LYCCA



4

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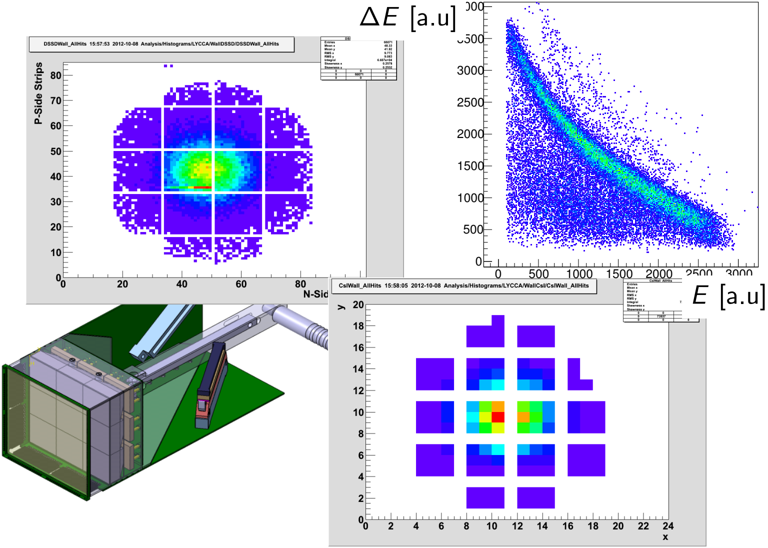
[4] P. Golubev et al. Nucl. Instrum. Methods Phys. Res., Sect. **A723** (2013) 55

LYCCA



[4]

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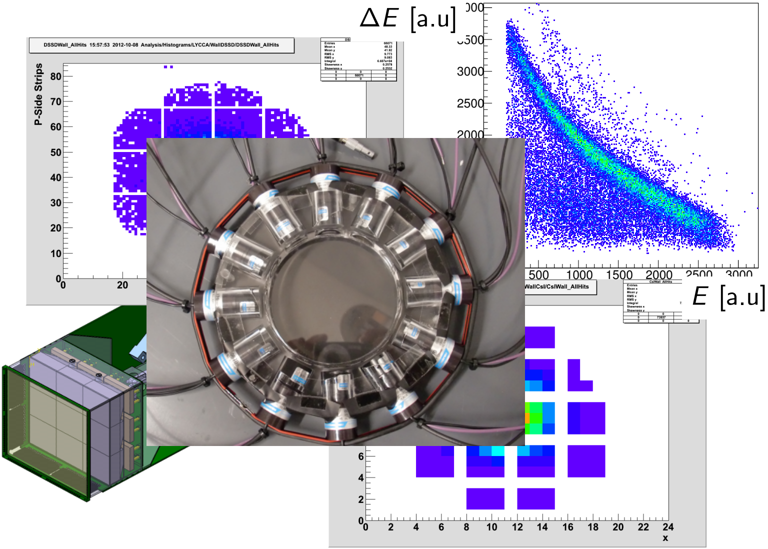
[4] P. Golubev et al. Nucl. Instrum. Methods Phys. Res., Sect. **A723** (2013) 55

LYCCA



[4]

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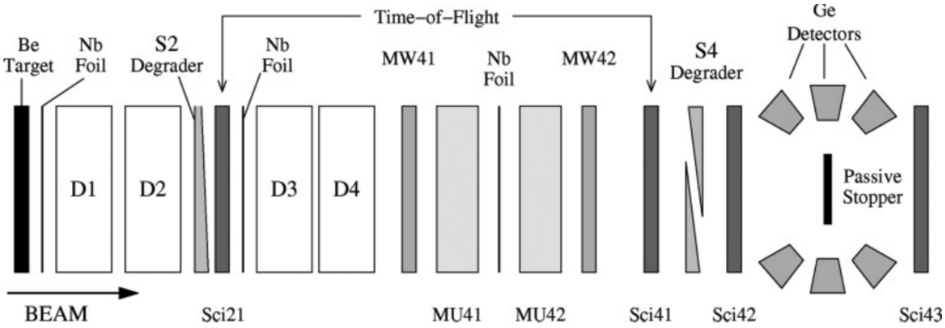
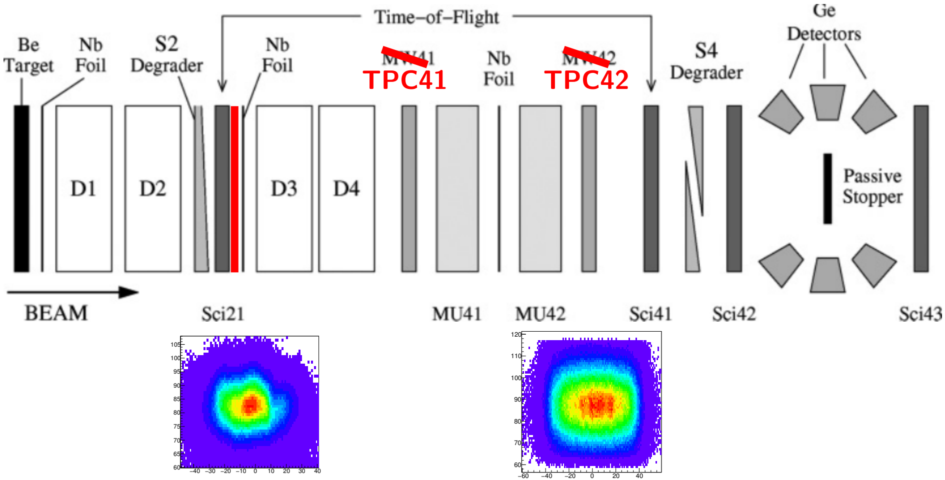
[4] P. Golubev et al. Nucl. Instrum. Methods Phys. Res., Sect. **A723** (2013) 55

Before Coulomb ...



Before Coulomb ...

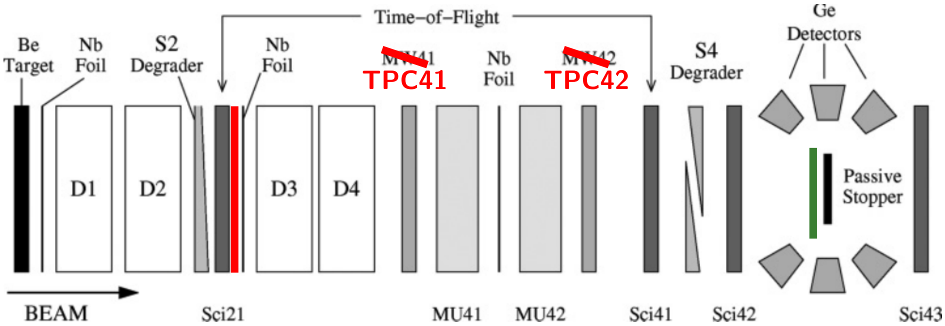
Finger detector, TPC21, TPC22

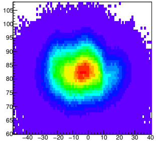


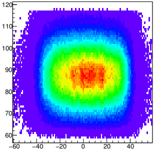
Before Coulomb ...

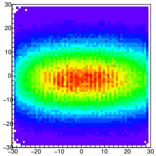
LYCCA
Target DSSSD

Finger detector, TPC21, TPC22





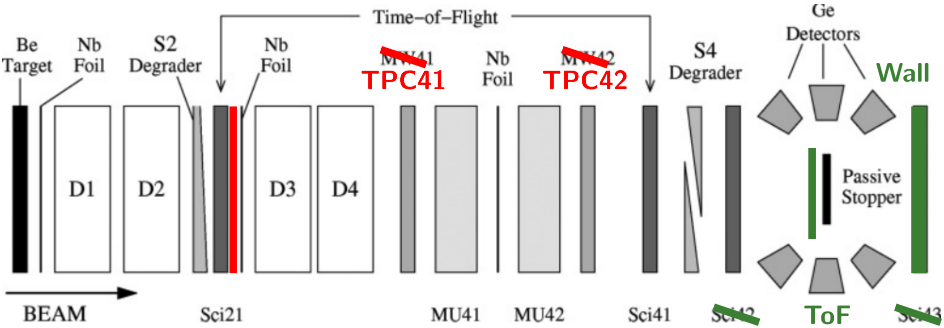




Before Coulomb ...

LYCCA
Target DSSSD

Finger detector, TPC21, TPC22

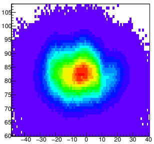


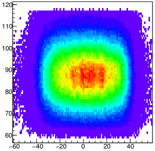
TPC41

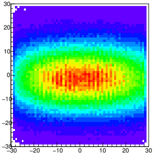
TPC42

Wall

ToF





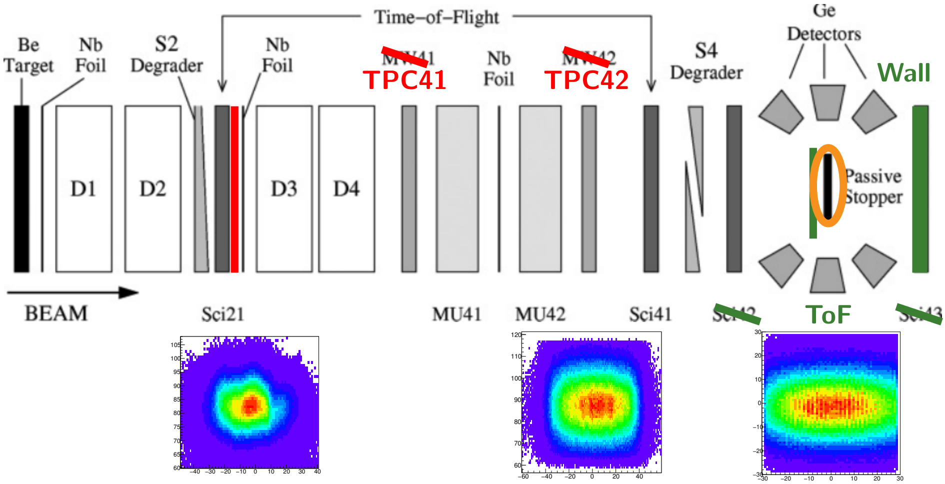


Before Coulomb ...

LYCCA
Target DSSSD

Finger detector, TPC21, TPC22

Target



Finger detector

[6]

The finger detector is basically a series of scintillating detectors that are read in overlapping pairs of two. The segmentation of the detector allows for a higher counting rate by means of reduced pile-up.

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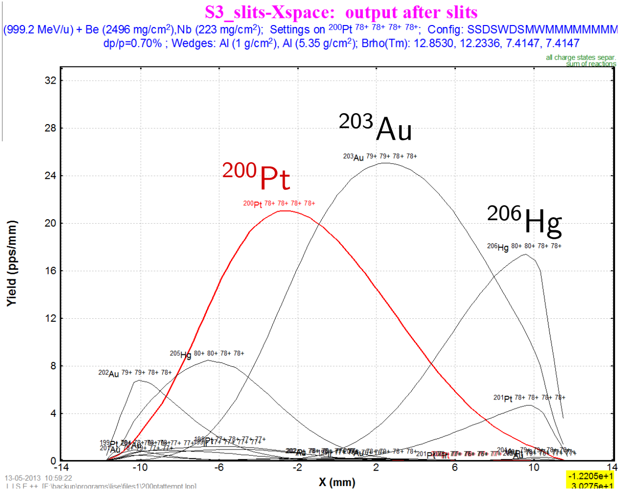
[6] 15 strips, $13 \times 80 \times 1\,\mathrm{mm}^3$. F.Ameil (GSI), M. Danchev (Sofia University).

What does LISE say? ^{200}Pt settings



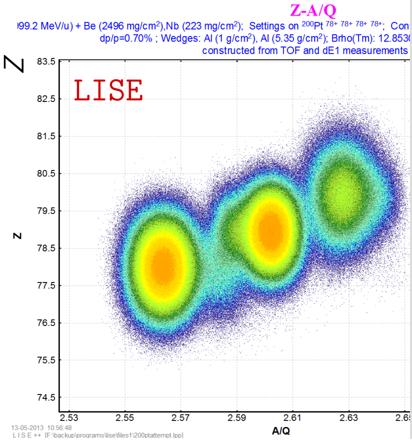
[7]

The optimization is based on the ^{200}Pt settings since they are the most demanding.

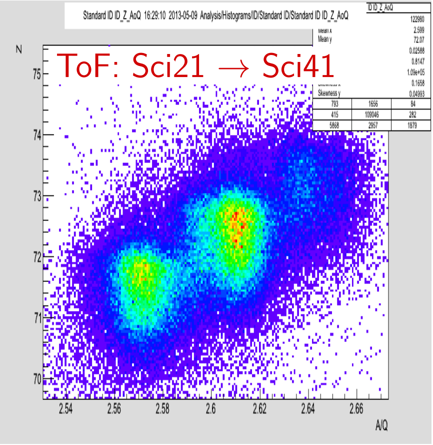
---

[7] T. Alexander, priv. comm.

FRS ID ^{200}Pt settings



A/Q



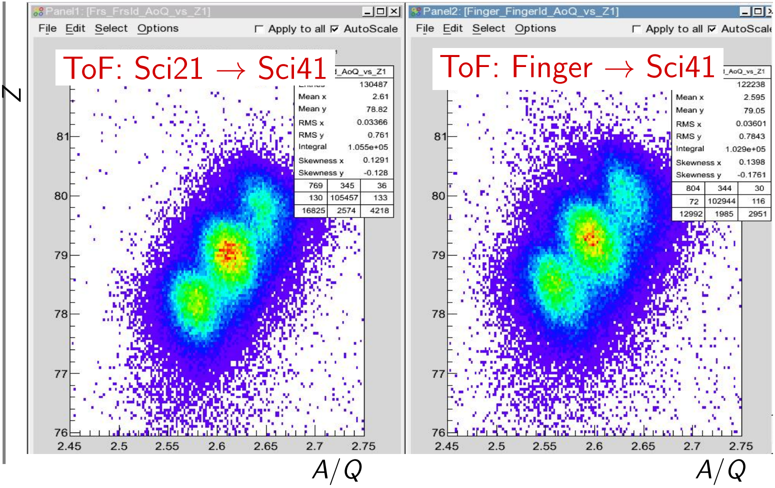
A/Q [8]

Although the *blobs* are there, the intensities can be improved to match what `LISE` says.

---

[8] T. Alexander, priv. comm.

Whatever works best



ToF: Sci21 → Sci41

_AoQ_vs_Z1	
	130487
Mean x	2.61
Mean y	78.82
RMS x	0.03366
RMS y	0.761
Integral	1.055e+05
Skewness x	0.1291
Skewness y	-0.128

769	345	36
130	105457	133
16825	2574	4218

ToF: Finger → Sci41

_AoQ_vs_Z1	
	122238
Mean x	2.595
Mean y	79.05
RMS x	0.03601
RMS y	0.7843
Integral	1.029e+05
Skewness x	0.1398
Skewness y	-0.1761

804	344	30
72	102944	116
12992	1985	2951

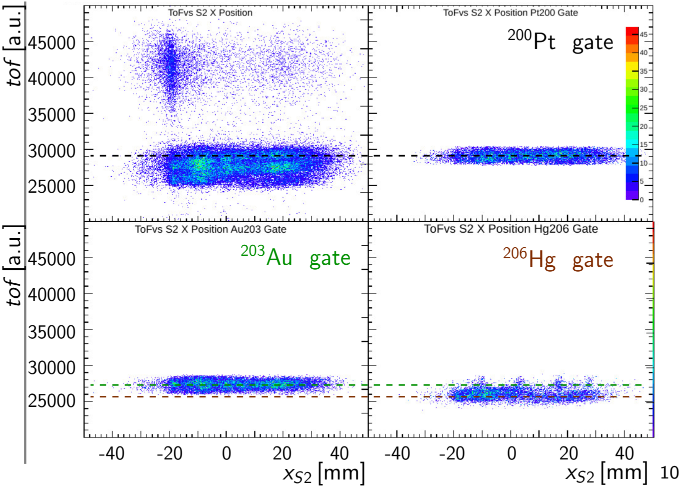
[9]

The Lund/GSI analysis software seems improved compared to the Surrey one. The finger detector does not seem to help anyway.

---

[9] M.L. Cortes, priv. comm

Whatever works best



10

[Too] many possibilities for selection/analysis of the secondary beam!!
ToF vs x_{S2} position seems like a viable alternative ...

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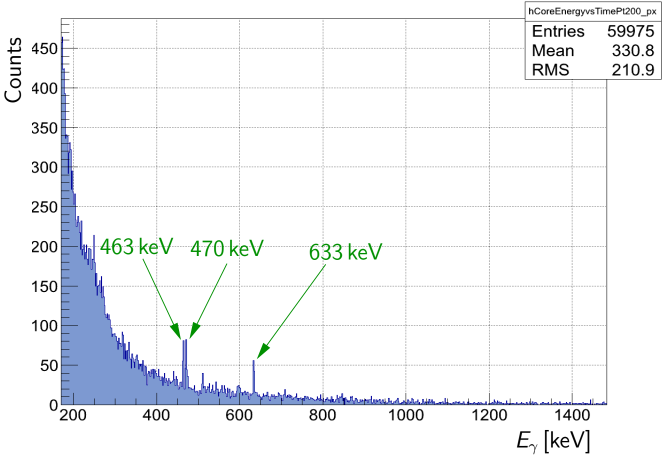
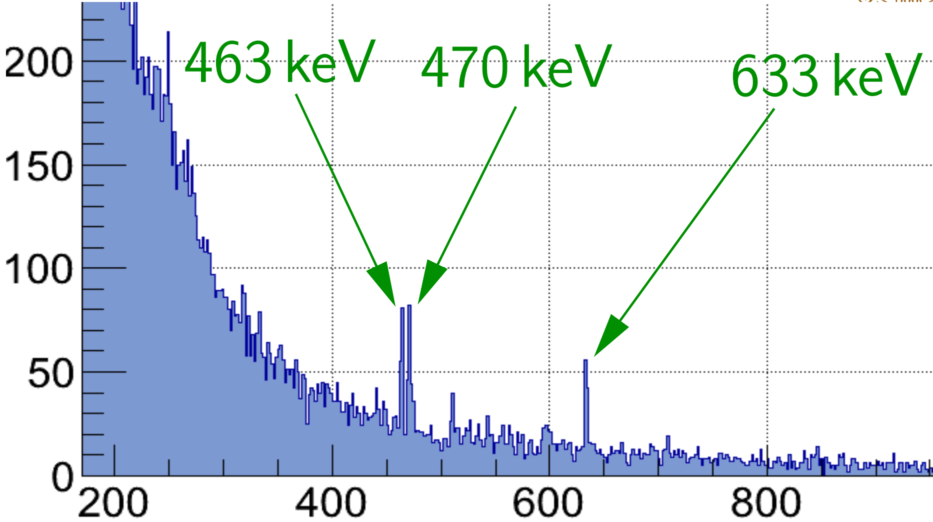
[10] T. Alexander, priv. comm.

^{200}Pt isomeric state



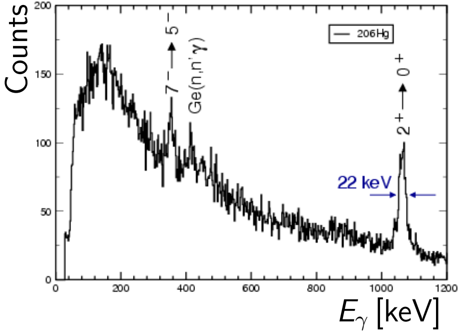
The tracking algorithm in AGATA seems to be OK given that the peak at stop are resolved.

^{200}Pt isomeric state

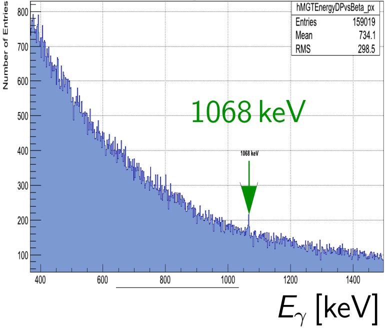


Preliminary results (^{206}Hg)

Simulation



Experiment



[11]

The expected Coulomb excitation peak *is there* for the isotope with lowest cross-section. However more work need to be done to enhance its Doppler correction and peak-to-background ratio.

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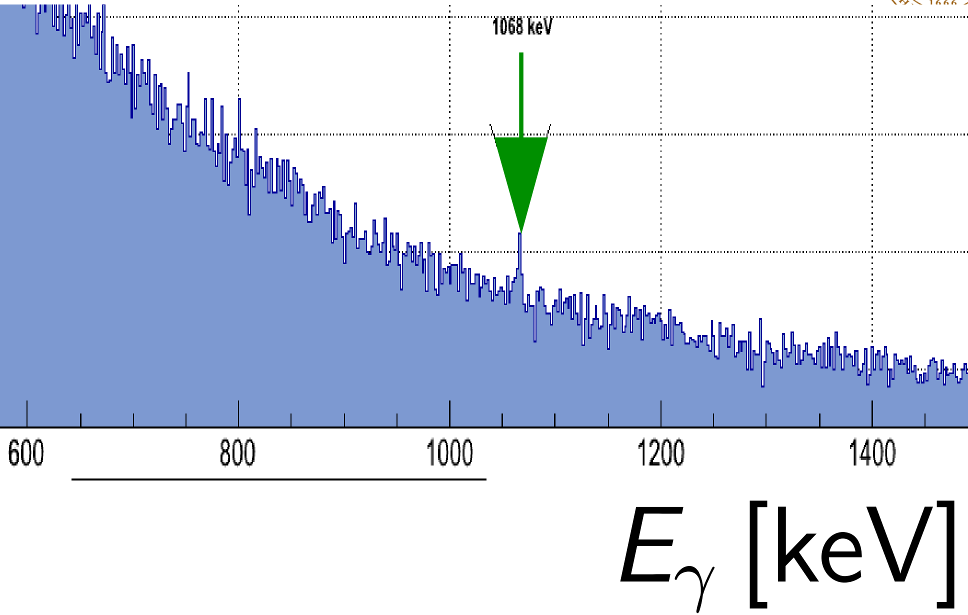
[11] M. Reese, T. Alexander, priv. comm.

Preliminary results (^{206}Hg)



Key Takeaways

- The experiment S429 was successfully carried out in October 2012.
- The data analysis is currently ongoing at Lund University, University of Surrey, and at GSI/TU Darmstadt.
- Using a recently developed -and still evolving- more generic software [M. Reese, M.L. Cortes, L.G. Sarmiento et al.]
- The secondary beam is characterized, i.e., FRS and its many components are under control.
- LYCCA and in particular AGATA have still to be included (full scale).
- but ... Coulex peaks in AGATA spectra require all components "at their best".
- Only when **all** the pieces of the puzzle are ready the -properly Doppler corrected- peaks will arise in full glory.
- ... stay tuned

THANK YOU

for your attention