

Toward Flerovium Spectroscopy and Lundium

Anton Såmark-Roth

*Knut och Alice
Wallenbergs
Stiftelse*

On behalf of the
Lundium collaboration

Oct. 17, 2018



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Outline

1 Toward Fl-spectroscopy

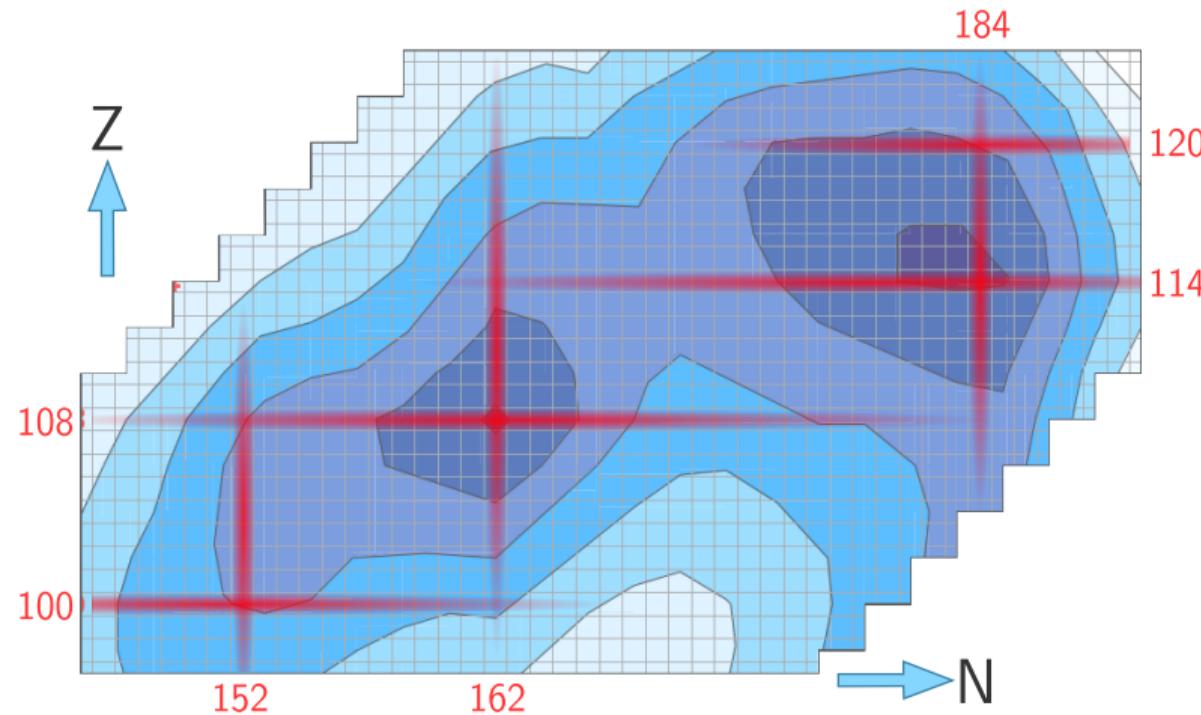
- Superheavy Nuclei
- Future Experiment

2 Toward Lundium

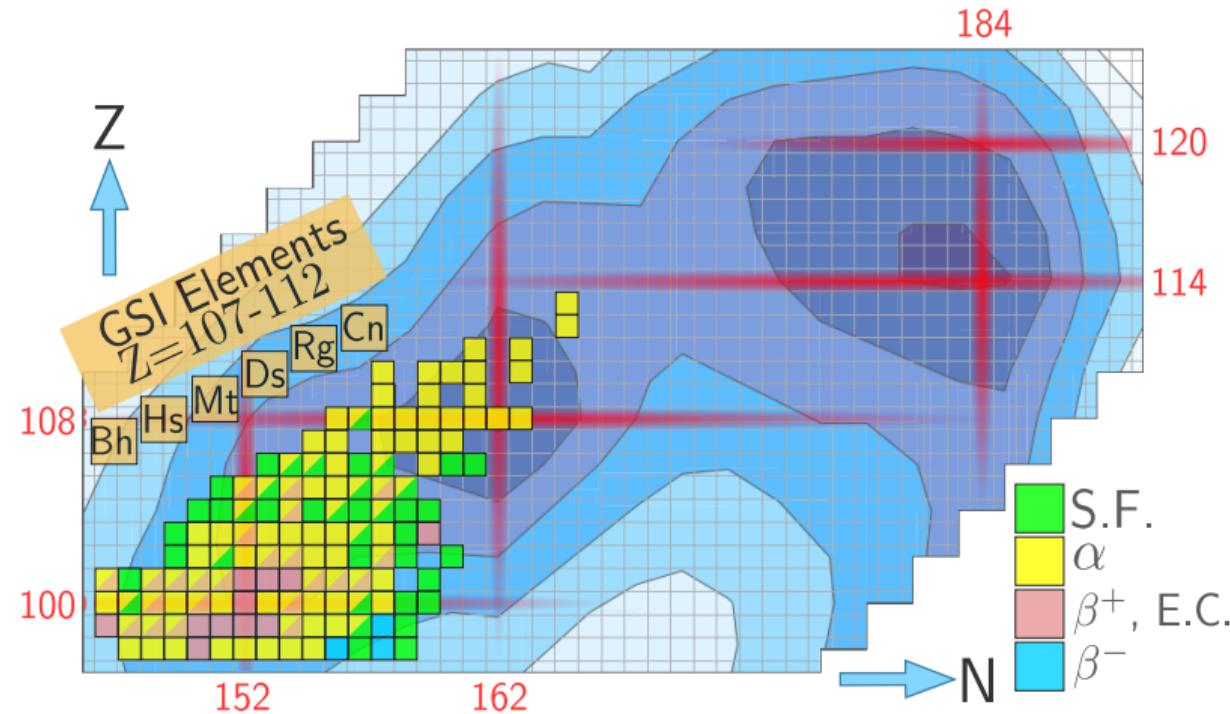
- Decay Station
- Status



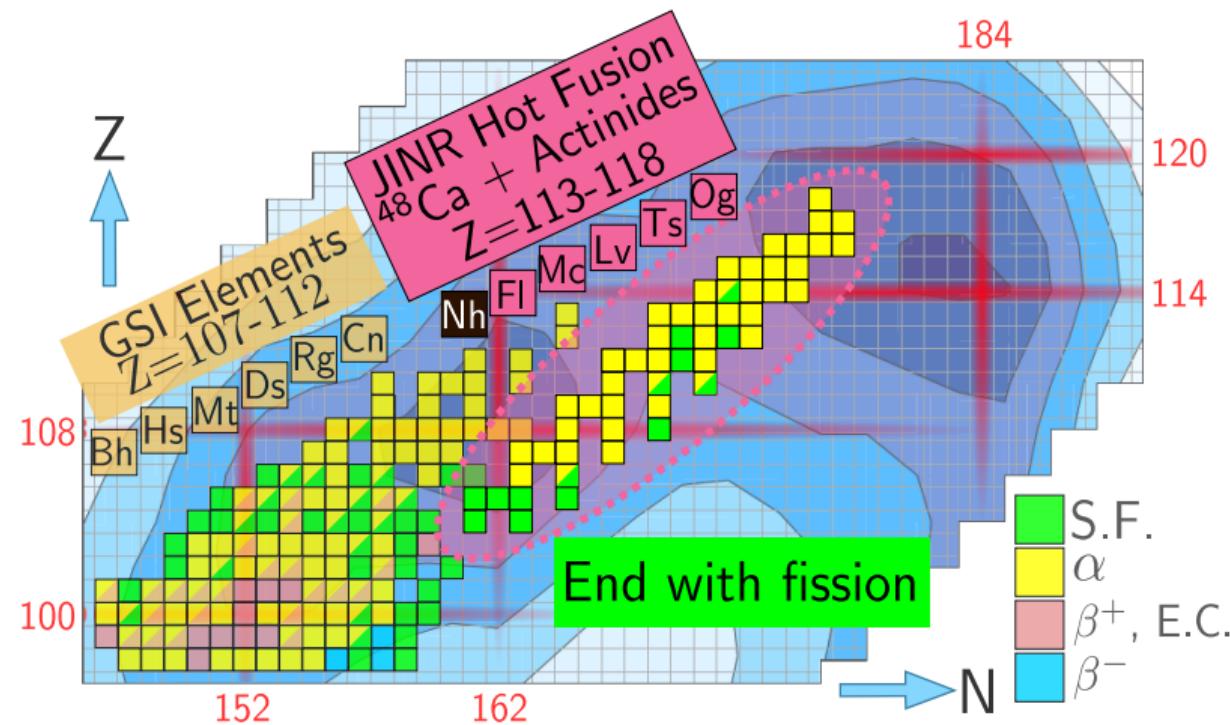
Superheavy Nuclei $Z \geq 104$ (Rf)



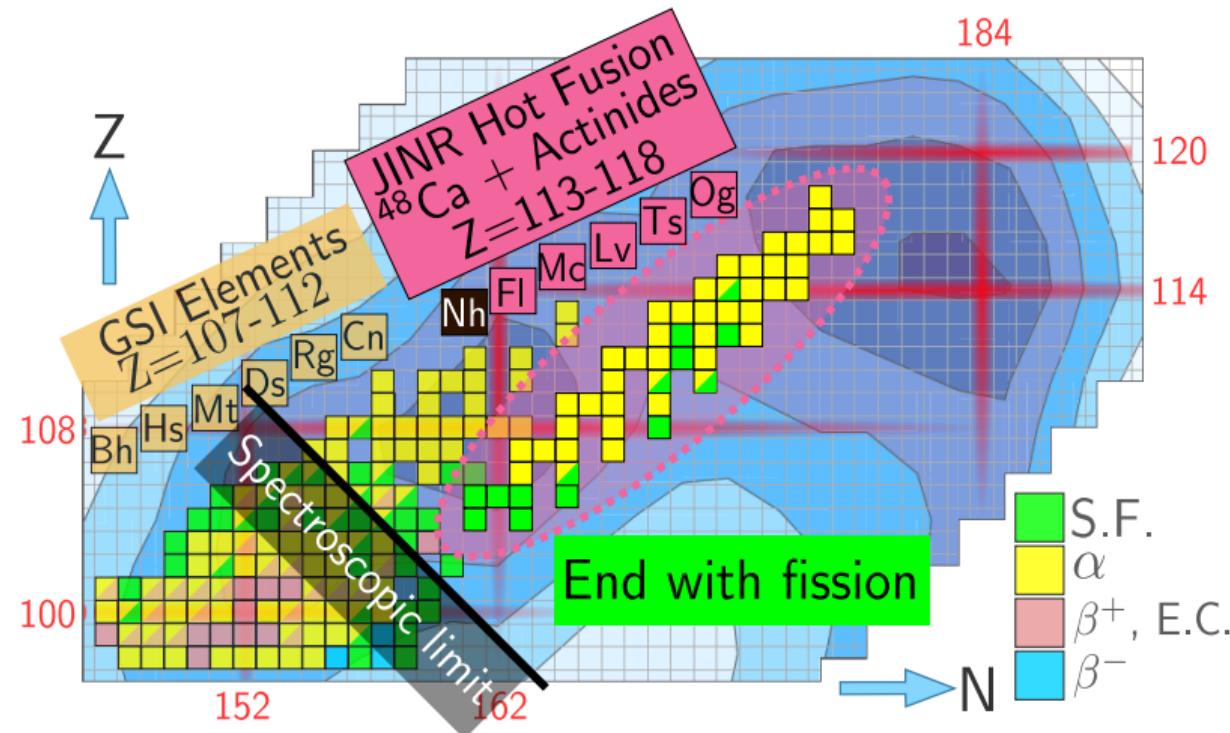
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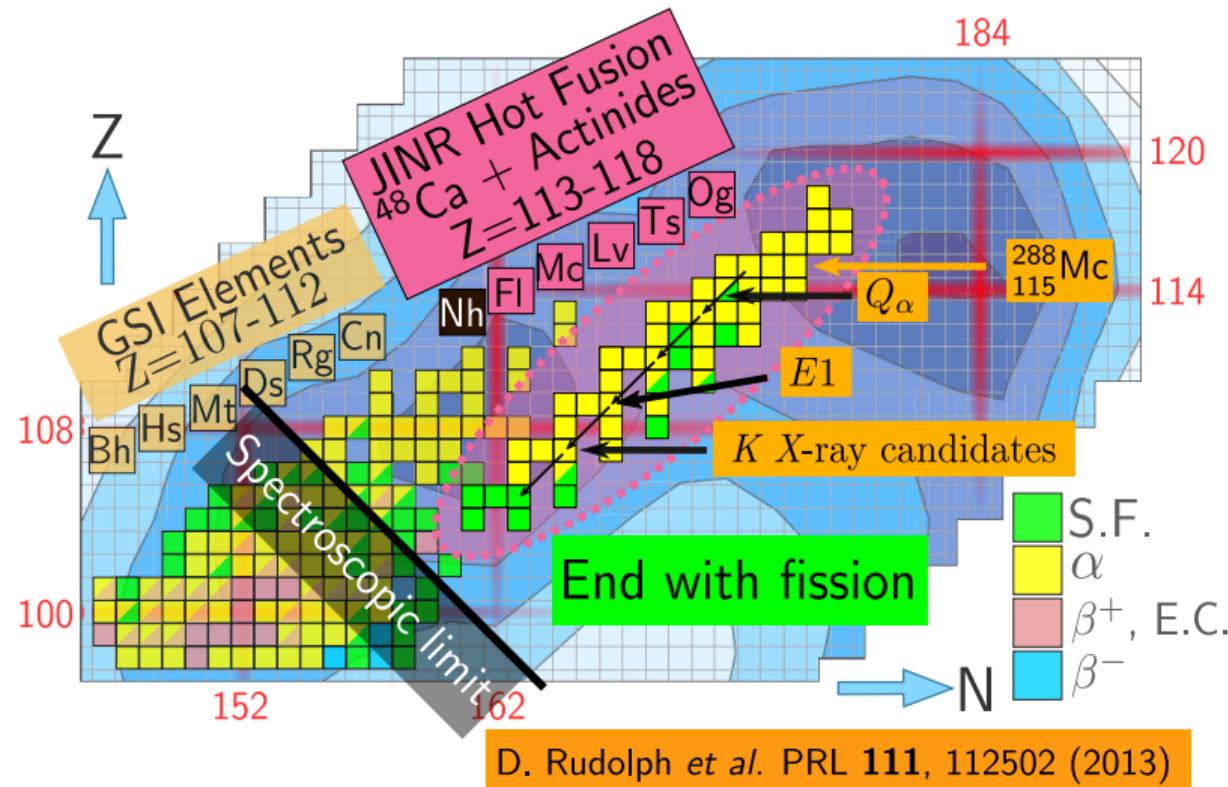
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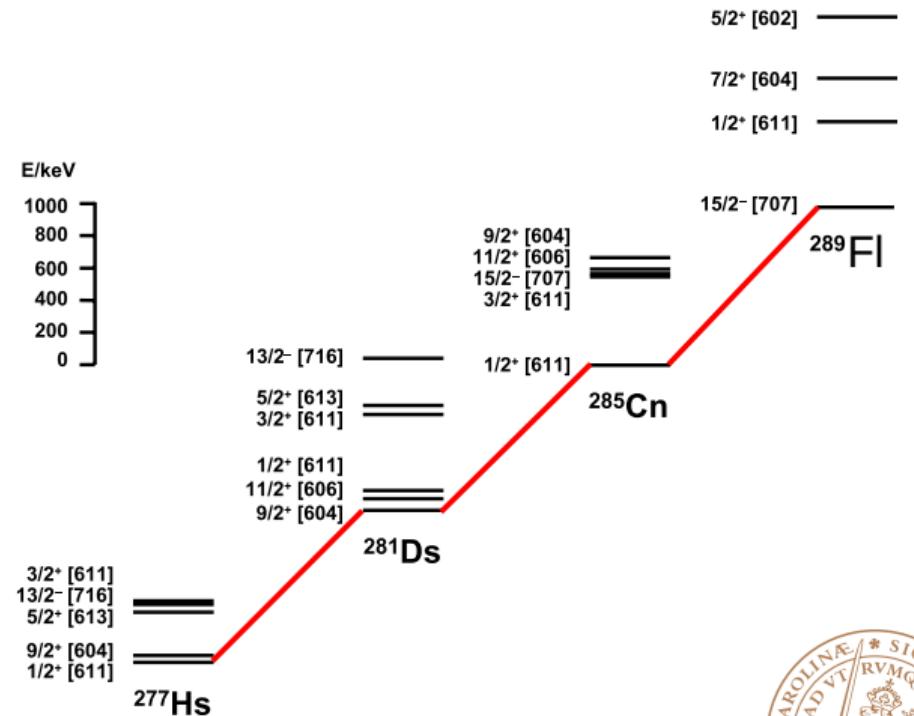
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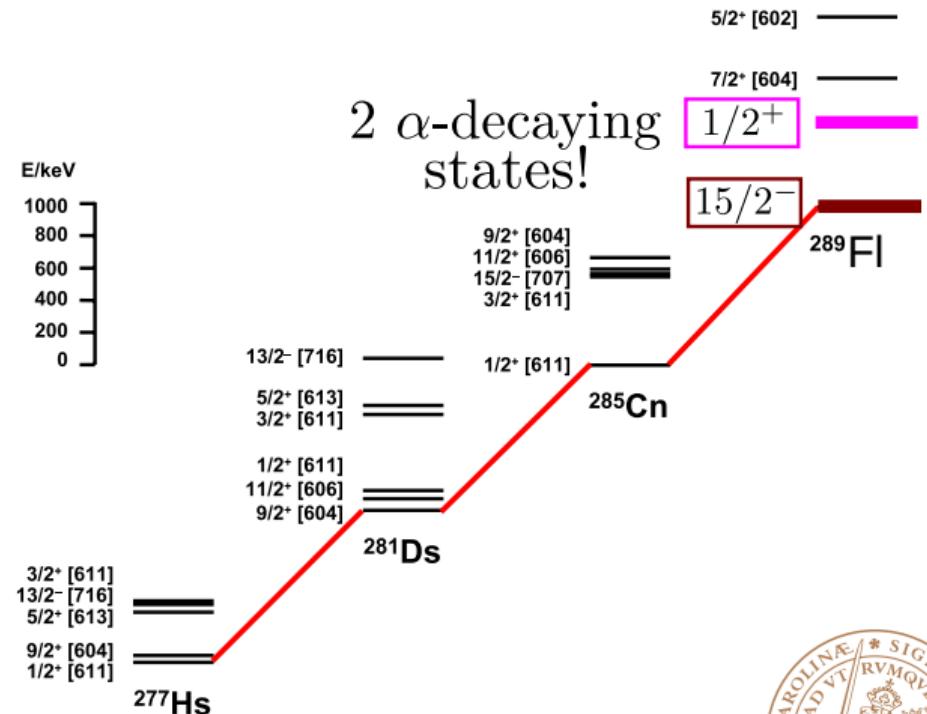
Future Experiment - Flerovium Spectroscopy



S. Hofmann, *et al.*. Eur. Phys. J. A (2012) 48:62



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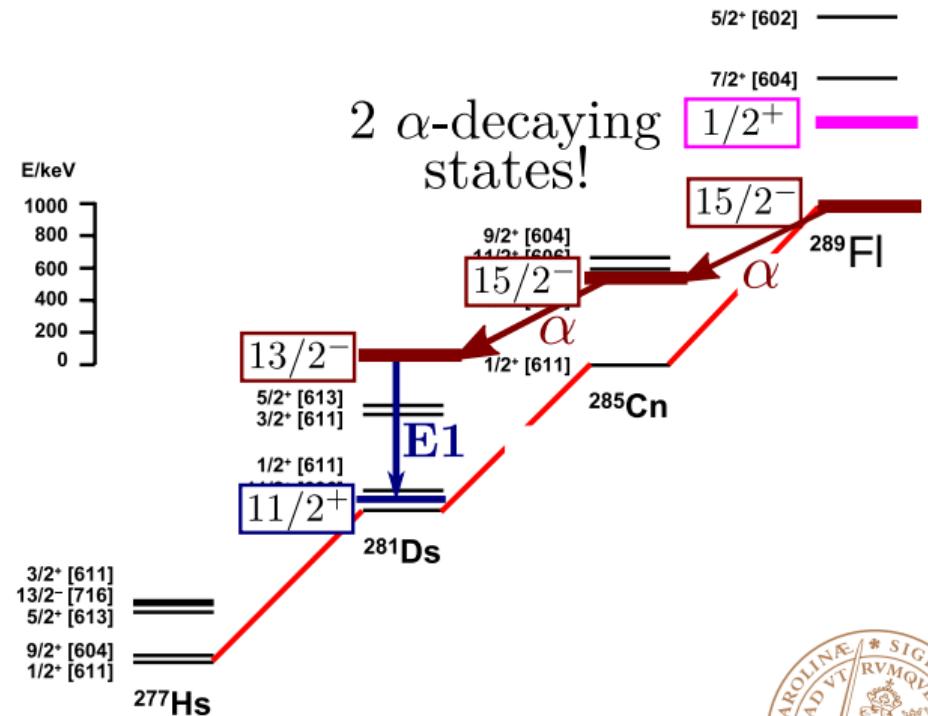


2 α -decaying states!

S. Hofmann, *et al.*, Eur. Phys. J. A (2012) 48:62



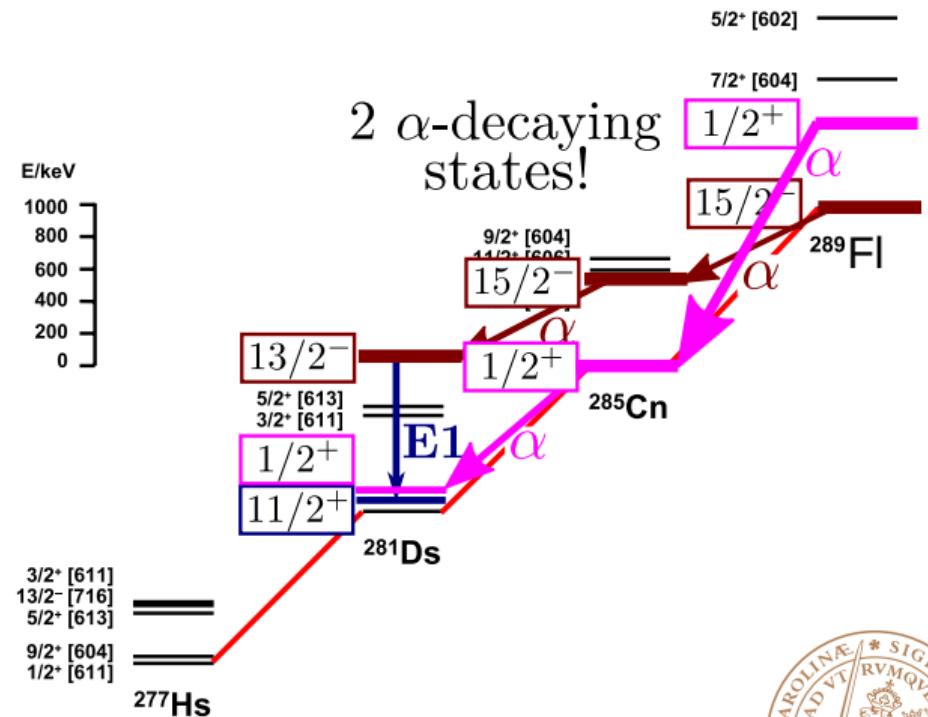
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Future Experiment - Flerovium Spectroscopy



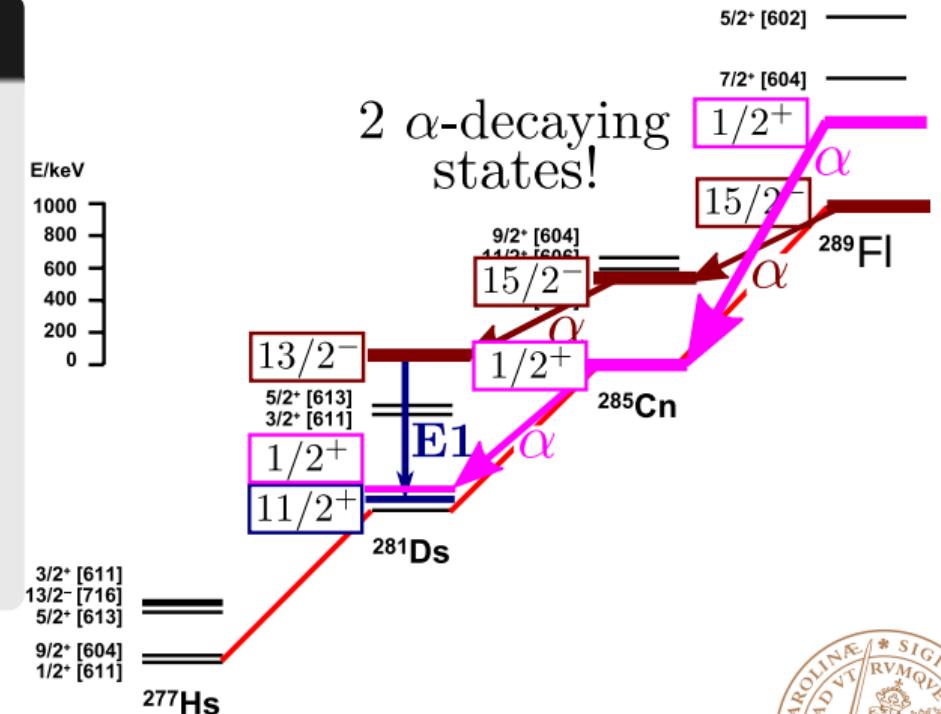
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Future Experiment - Flerovium Spectroscopy

$^{287,289}\text{Fl}$ -decay chains

- This is just one prediction, however this pattern is **model independent**.
- Therefore, all odd-A decay chains ($Z=114-117$) should reveal at least 2 independent decay chains!
- Where are they?



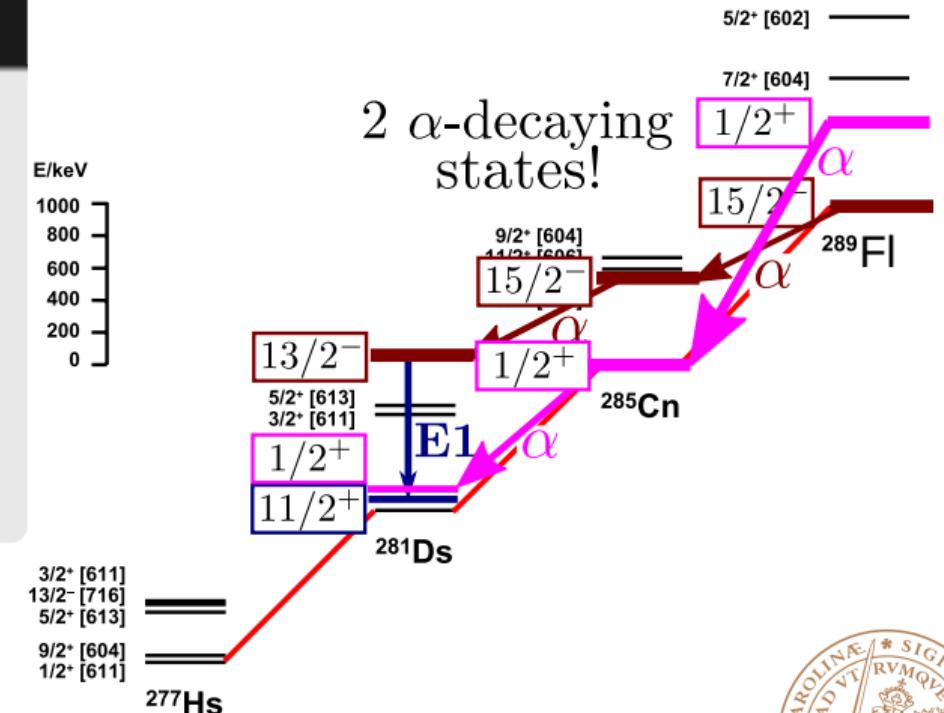
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Future Experiment - Flerovium Spectroscopy

$^{287,289}\text{Fl}$ -decay chains

- Precise Q_α values.
- Search for/discriminate E1 γ transitions and K X rays from highly converted transitions.
- Beam time approved (2016) and scheduled (2017) for August 2018.

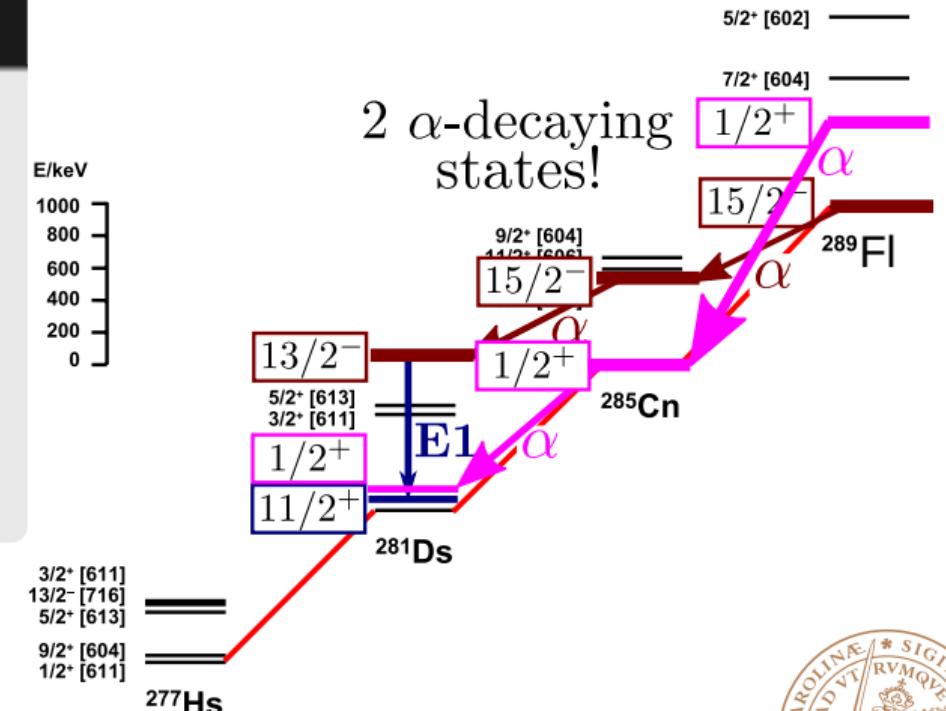


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Characterisation of New Superheavy Elements

ChaSE Lundium

38.3 MSEK \sim 4 M€ (2016-2020)

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Stiftelse*

D. Rudolph, Division of Nuclear Physics, Faculty of Science.

B.G. Carlsson & S. Åberg, Division of Nuclear Physics, LTH.

Ch.E. Düllmann, University of Mainz & GSI, Darmstadt.

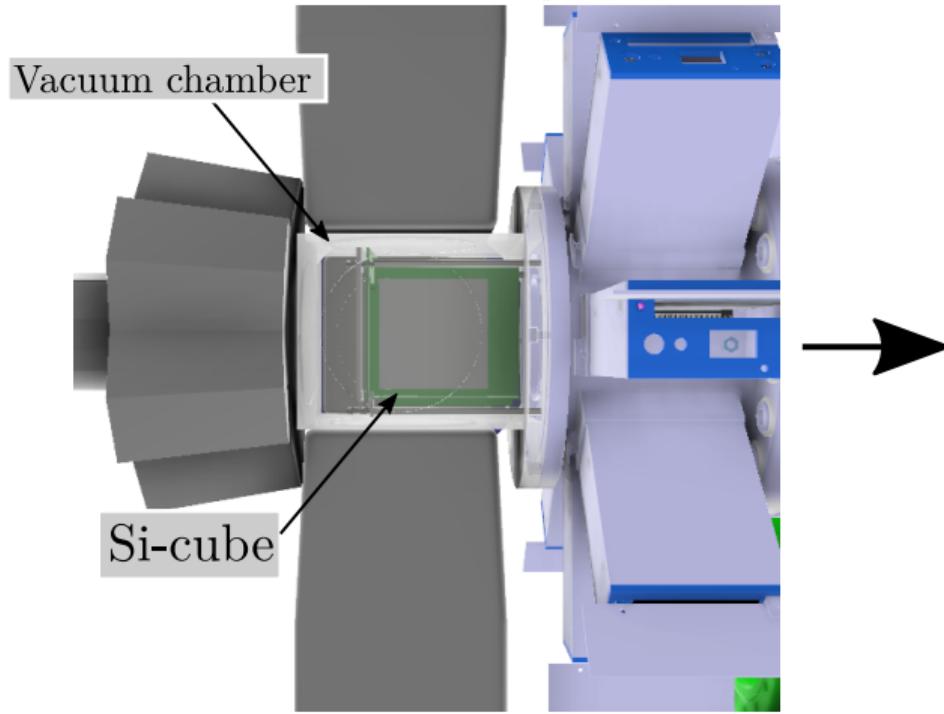
Experiment & Theory (Nuclear Structure)

From TASISpec to Lundium (Decay Station)

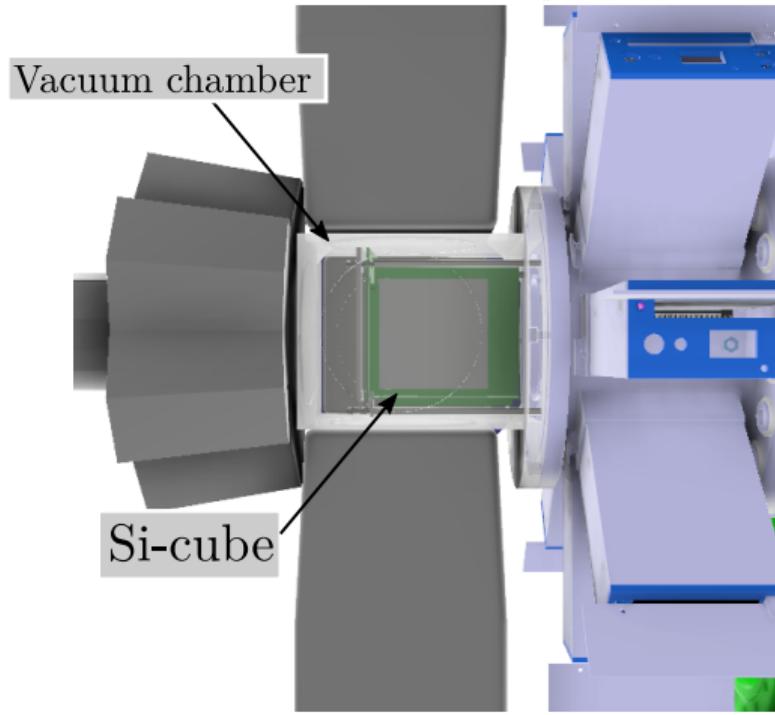




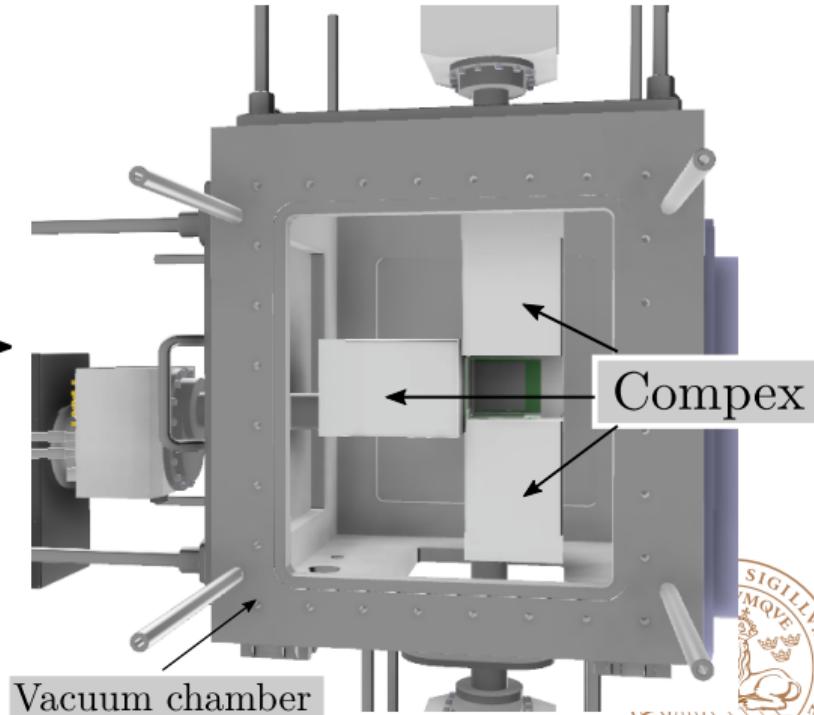
TASISpec

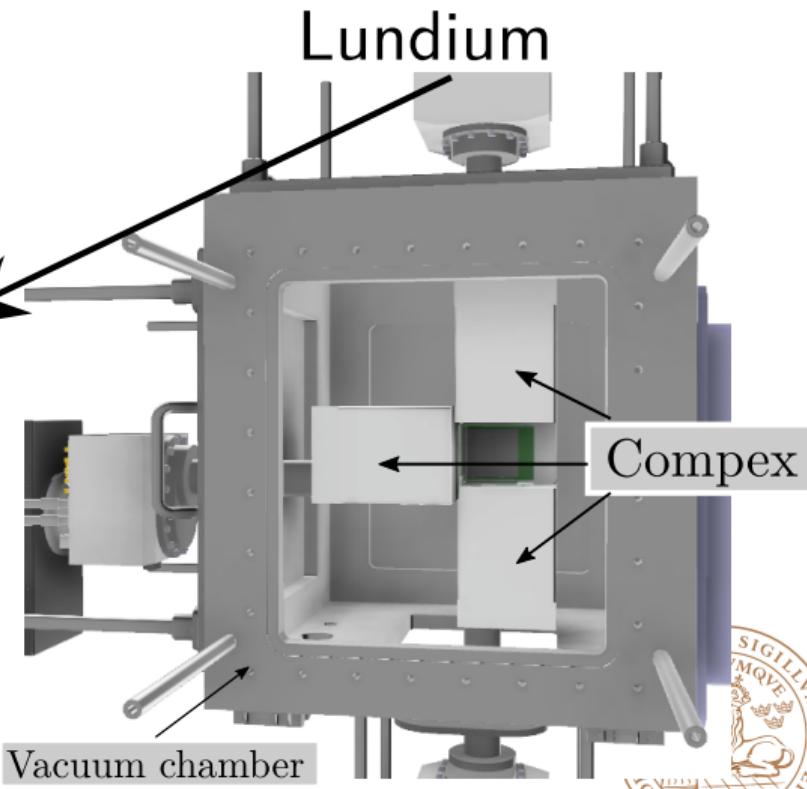
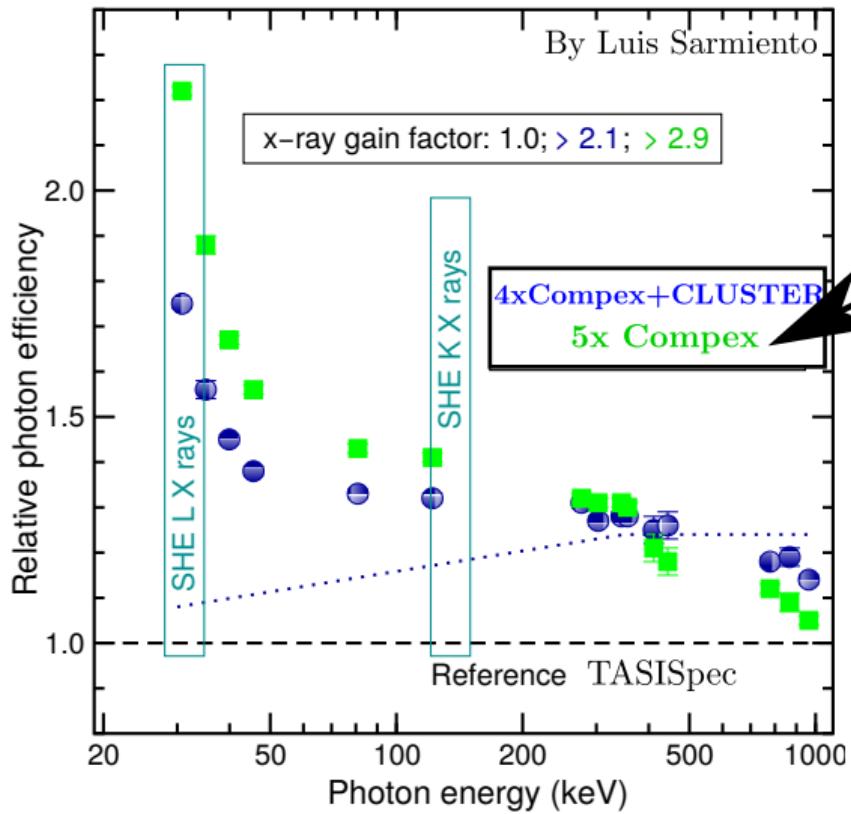


TASISpec



Lundium

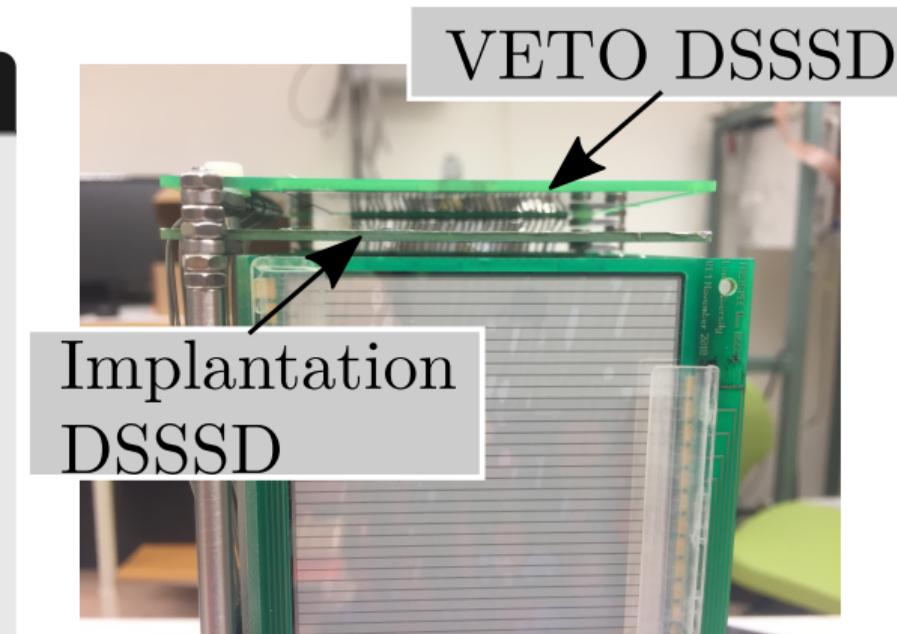




Toward Lundium

Si-upgrades

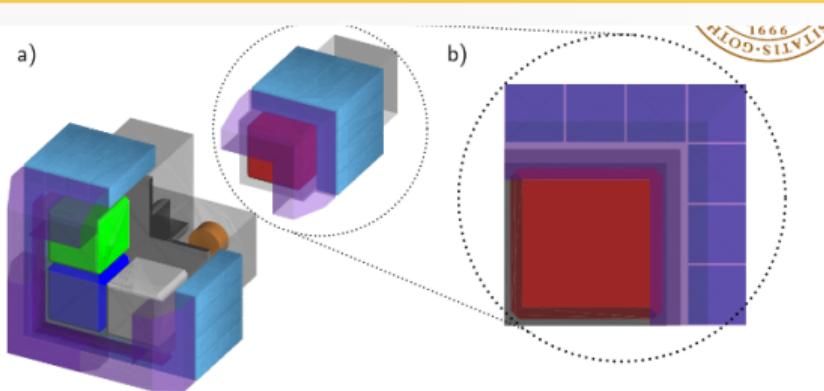
- Implantation detector: 1.8 mm → 1.0 mm pitch (32x32 → 58x58 strips).
 - 10x 0.3 mm thick = in Lund.
- Box detectors: 3.6 mm → 1.8 mm pitch (16x16 → 32x32 strips).
 - Trying to get 1 mm thick
- VETO DSSSD to distinguish escaping α :s from and electrons (installed by Daniel Cox & Pavel Golubev).



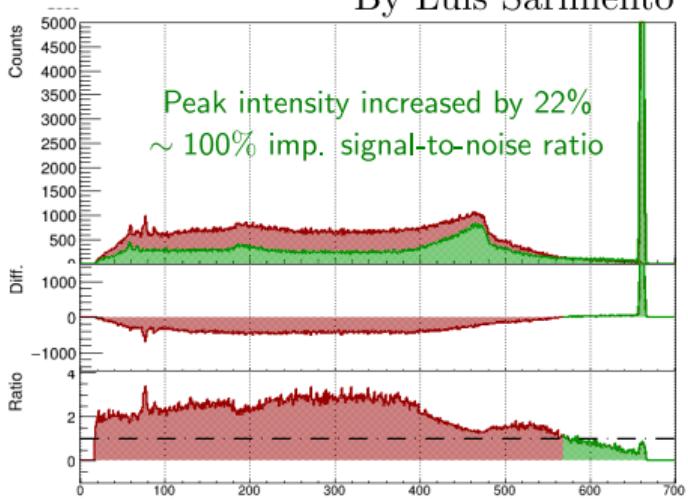
Toward Lundium

Passive and active shielding

- High signal-to-noise-ratio →
- Anti-Compton shield - Detectors and PhD position funded (Luis Sarmiento).
- Plastic+Lead shield in 'pre-chamber' (planned).
- New concrete wall at TASCA (installed).

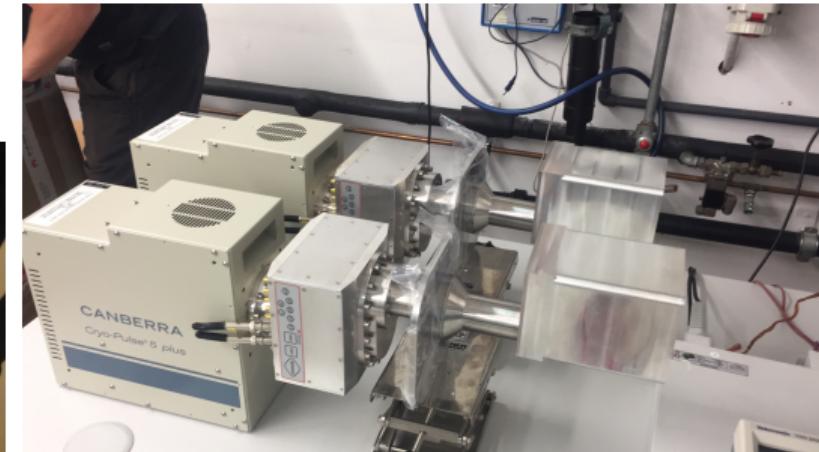
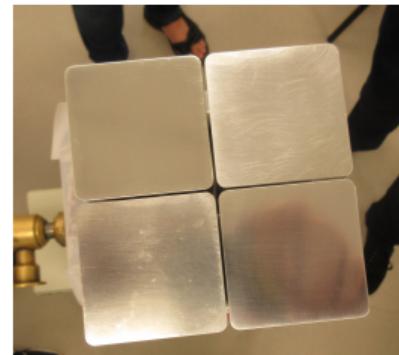
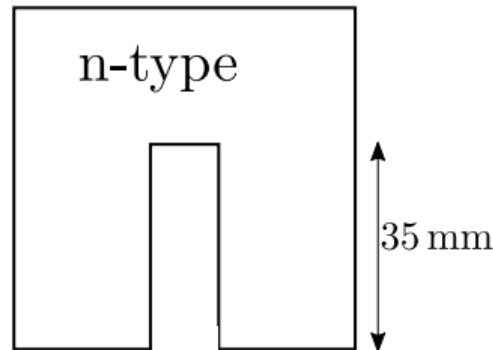


By Luis Sarmiento



Complex

50x50x50 mm³

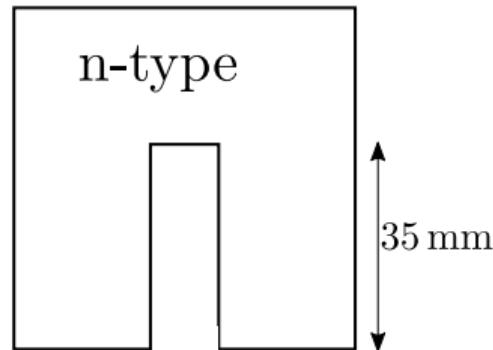


'Cubic' encapsulated crystals

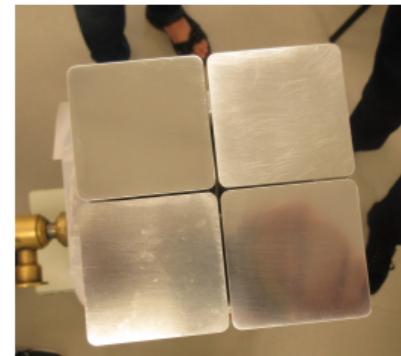


Complex

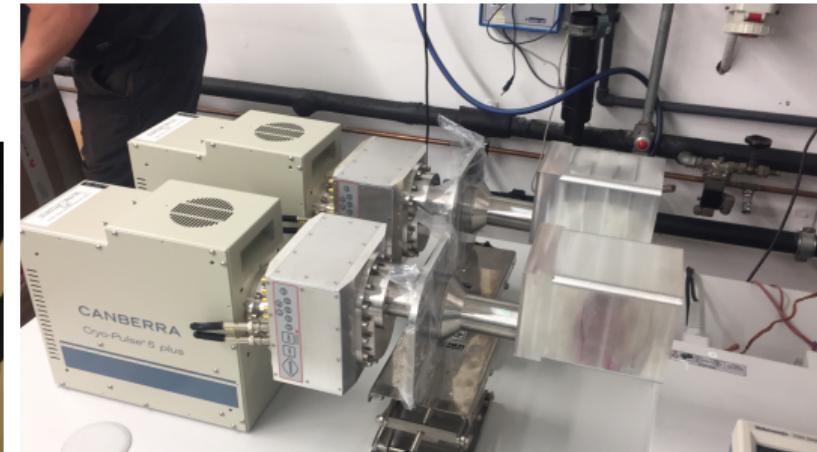
50x50x50 mm³



'Cubic' encapsulated
crystals



4 crystals in a
common cryostat



Mechanical cooling, $T \sim -160^\circ\text{C}$

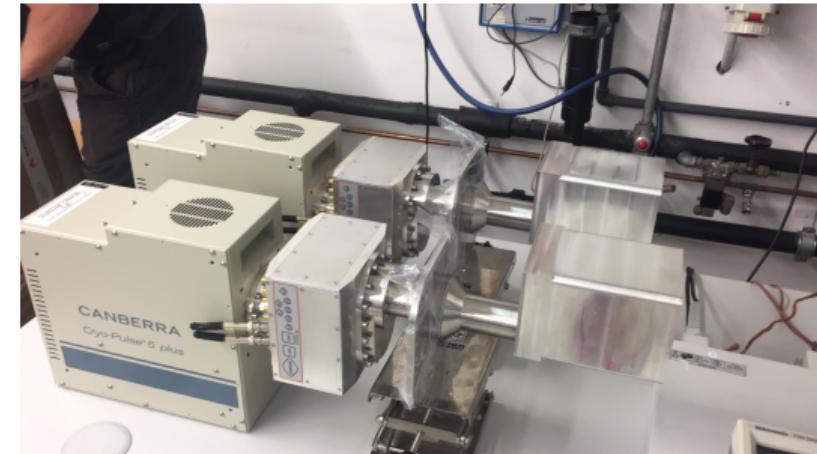
Typical resolutions:
1.9 keV @ 1.33 MeV
0.8 keV @ 122 keV



Compex

Status

- Maintenance training: outgassing, annealing and replacing a crystal.
- 2 detectors delivered in July.
- 2 Compex to be delivered by Nov. 2018.
- Segmented Compex to be delivered 2019?



Mechanical cooling, $T \sim -160^\circ\text{C}$

Typical resolutions:

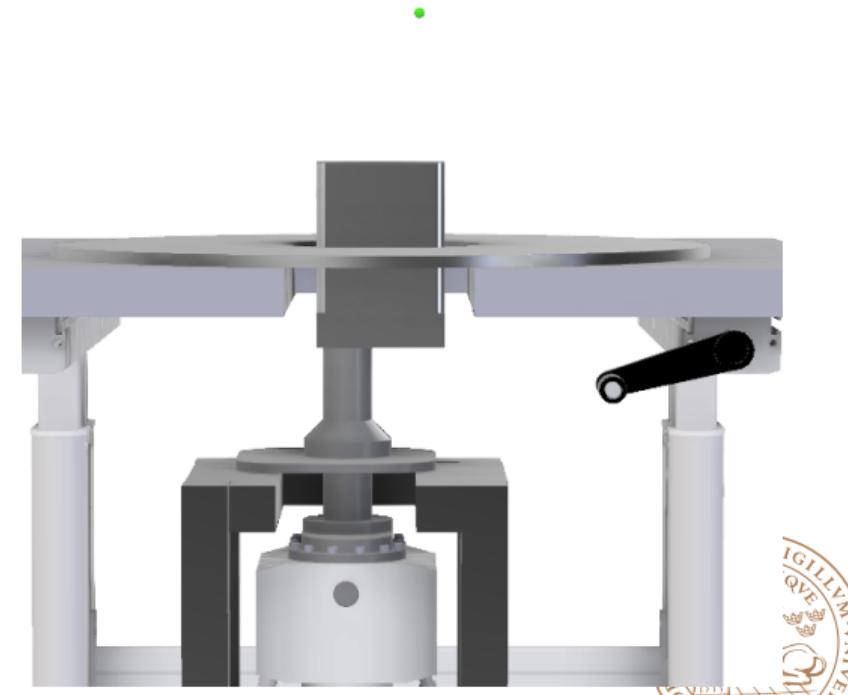
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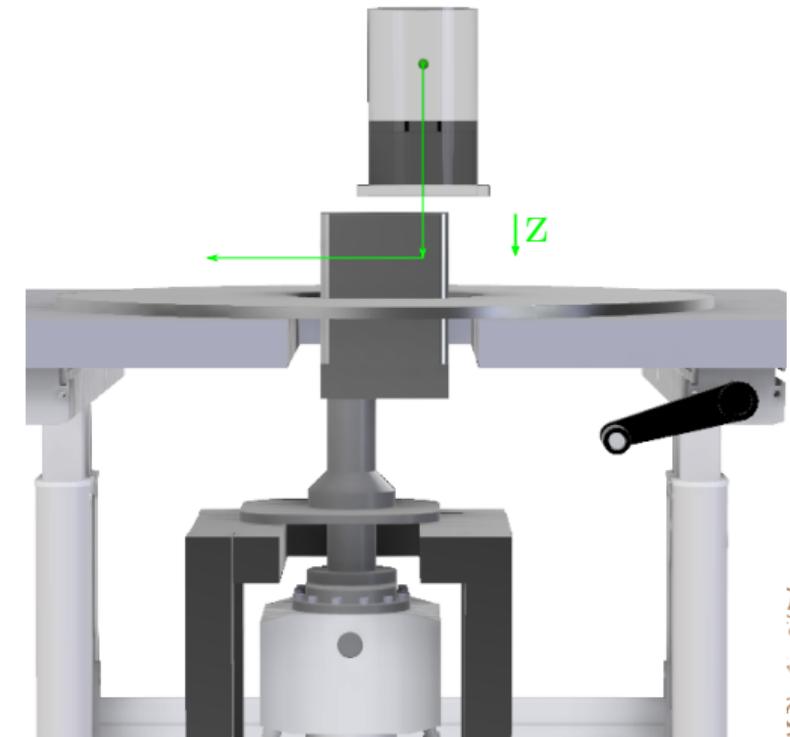
Complex characterisation

- New type of Germanium detector - How does it perform in comparison to existing detectors?
 - New shape.
 - Different cooling principle.
- Knowing our detector in detail, can we improve its performance?
- Energy response as a function of the (x, y, z) interaction point in the crystal.



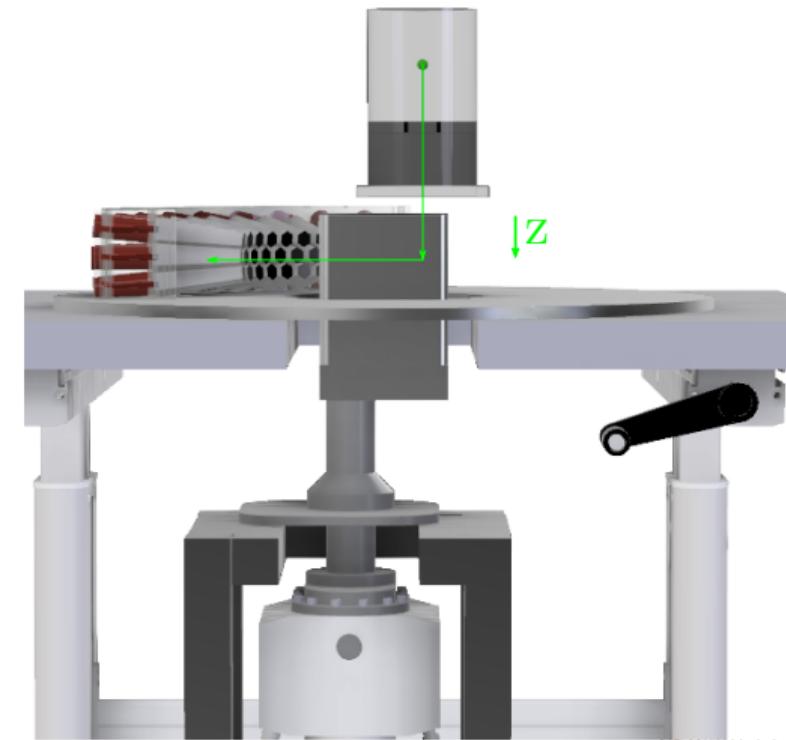
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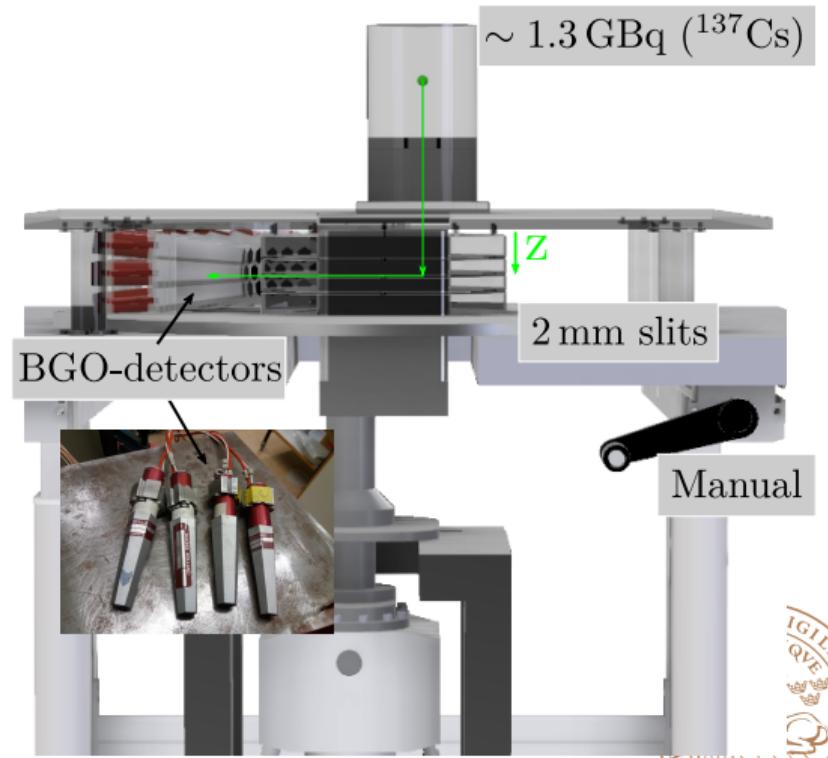
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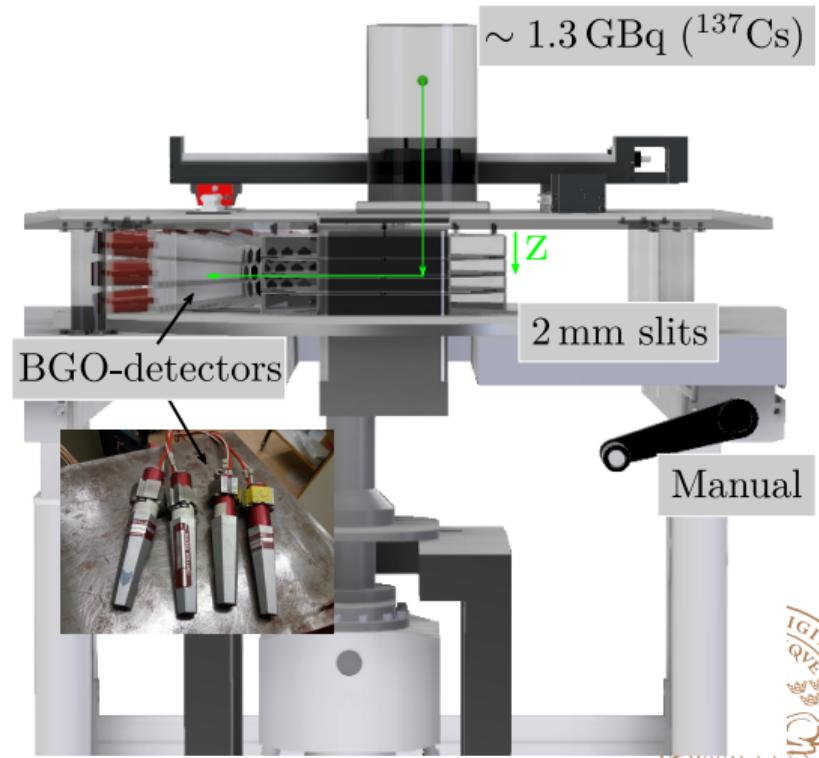
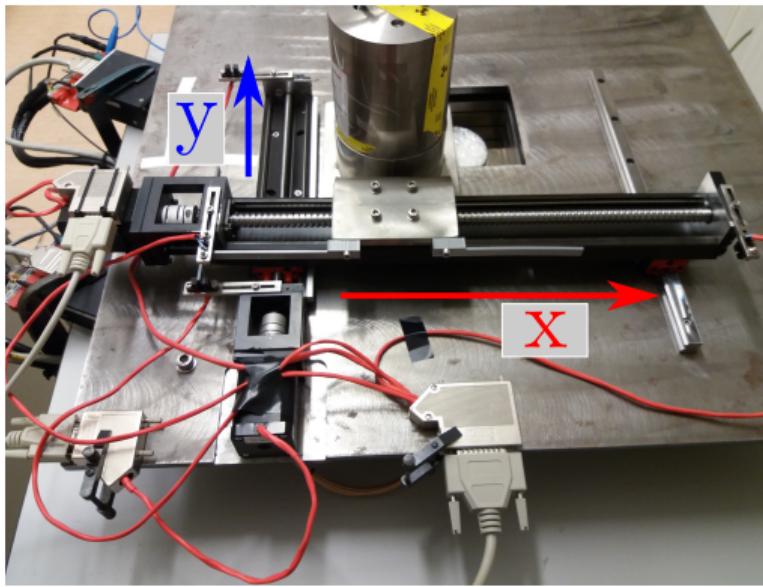


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Complex characterisation



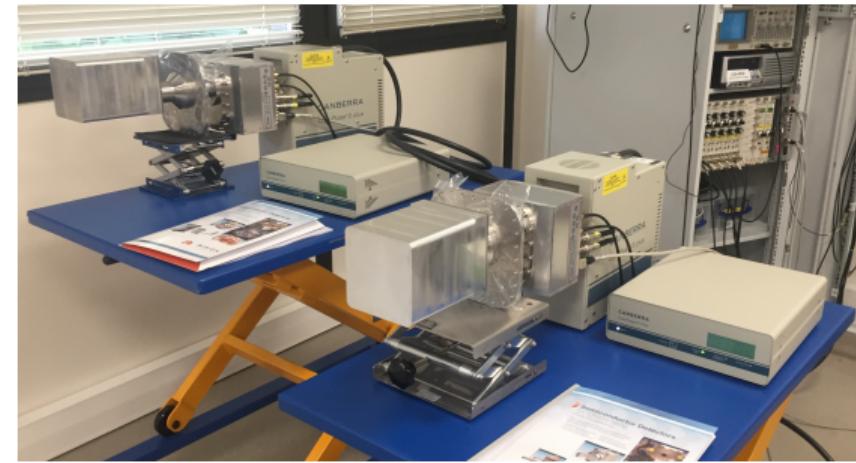
Summary

- Experiment on $^{287,289}\text{Fl}$ spectroscopy in 2019?
- Upgrade to Lundium!
- Characterisation of Compex detectors!



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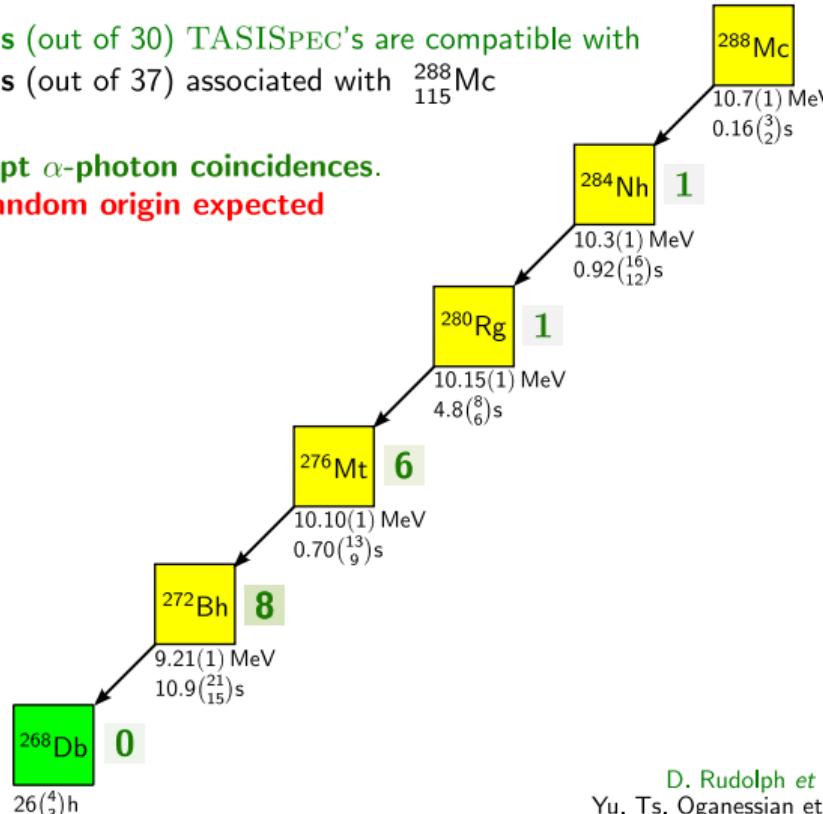
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α -photon spectroscopy along decay chains of ^{288}Mc

22 chains (out of 30) TASISPEC's are compatible with
 31 chains (out of 37) associated with $^{288}_{115}\text{Mc}$

16 prompt α -photon coincidences.
 2-3 of random origin expected



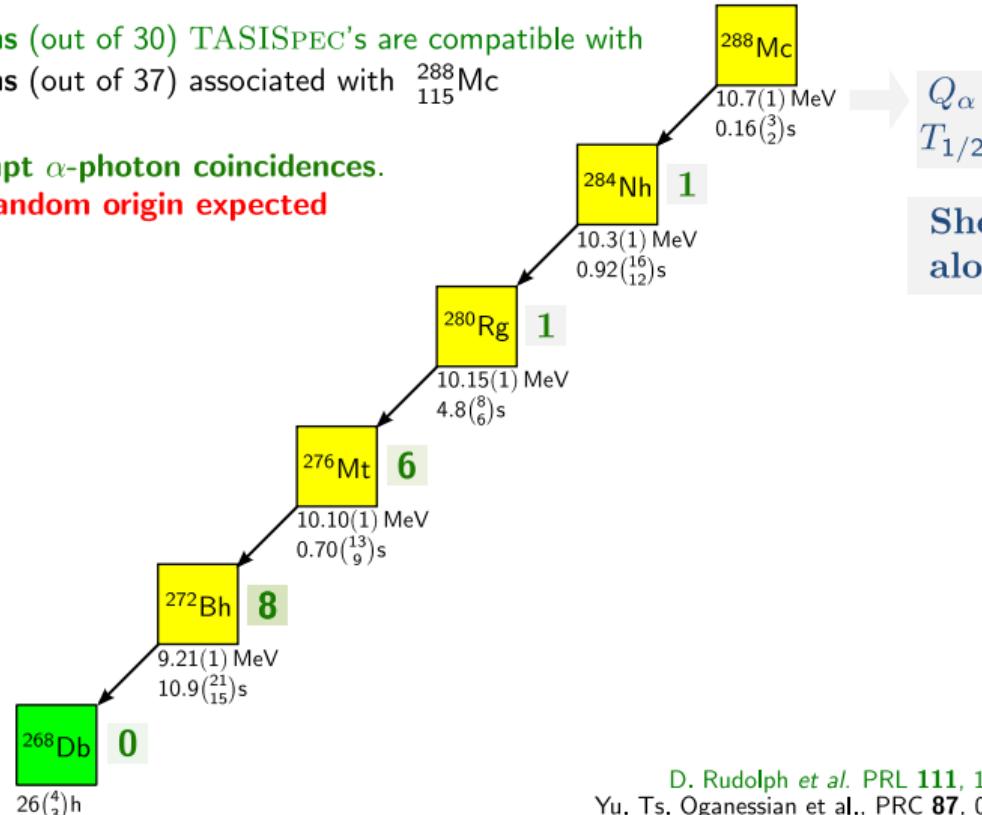
D. Rudolph et al., PRL 111, 112502 (2013)
 Yu. Ts. Oganessian et al., PRC 87, 014302 (2013)



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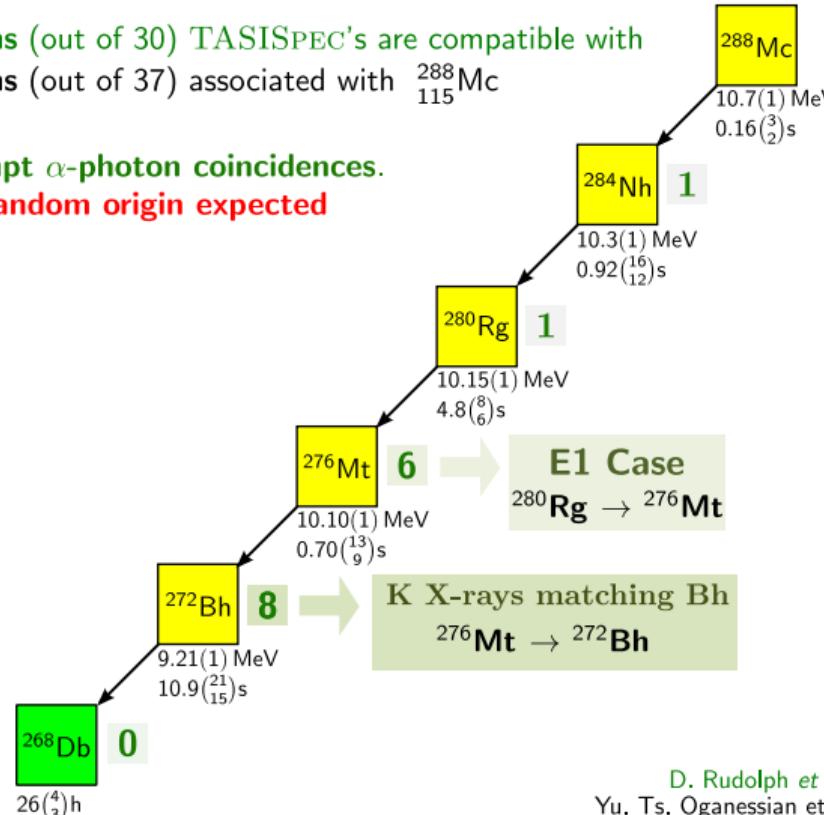
Shell stability
along $Z = 114$



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α -photon spectroscopy along decay chains of ^{288}Mc

43 chains (out of 46) BGS+BNL's are compatible with

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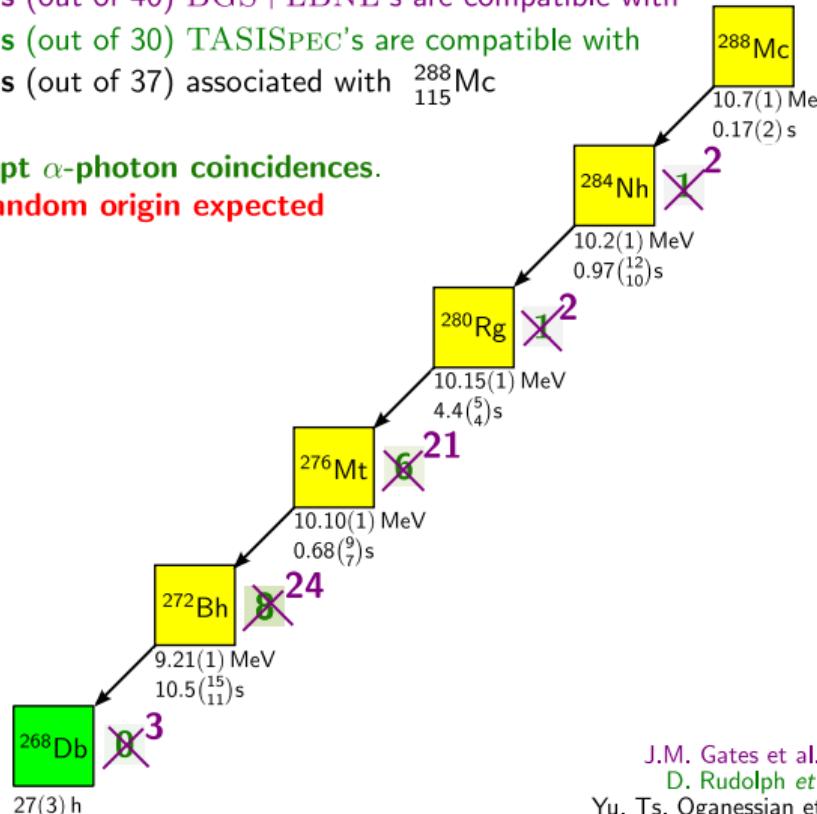
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52

16 prompt α -photon coincidences.

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~ 8



J.M. Gates et al., PRC **92**, 021301(R) (2015)

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α -photon spectroscopy along decay chains of $^{288}\text{Mc}_{115}$

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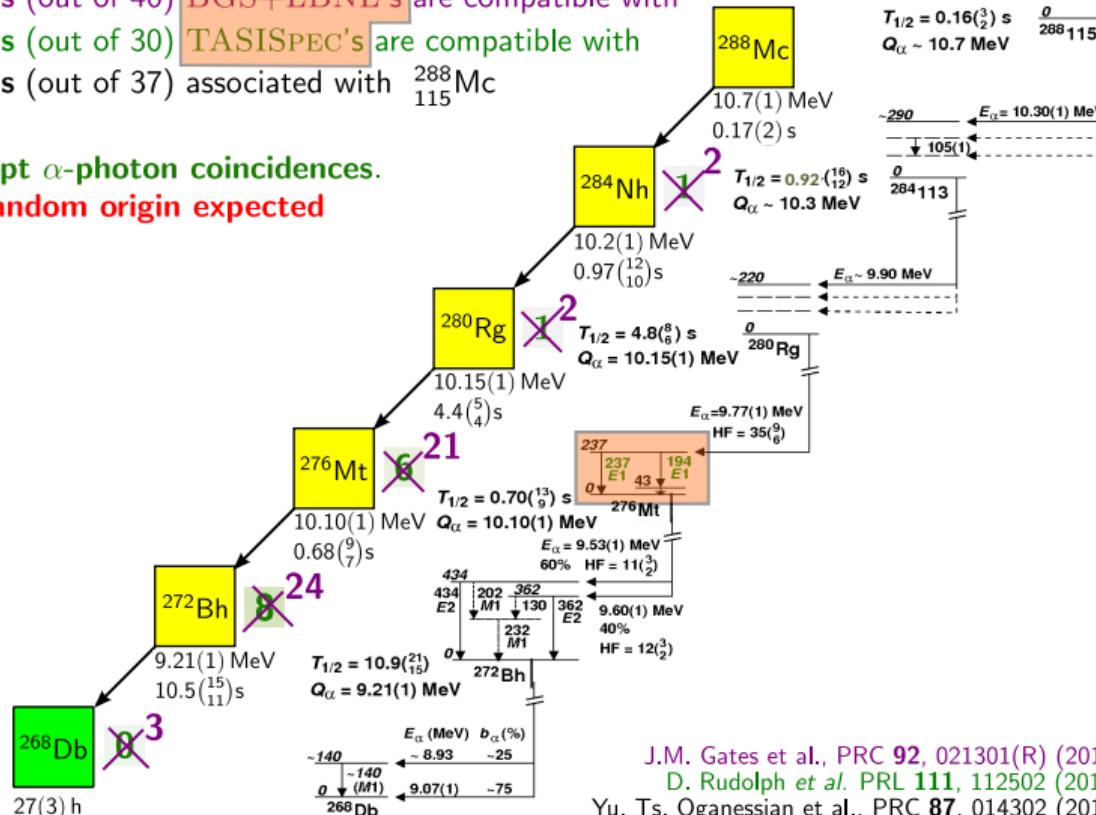
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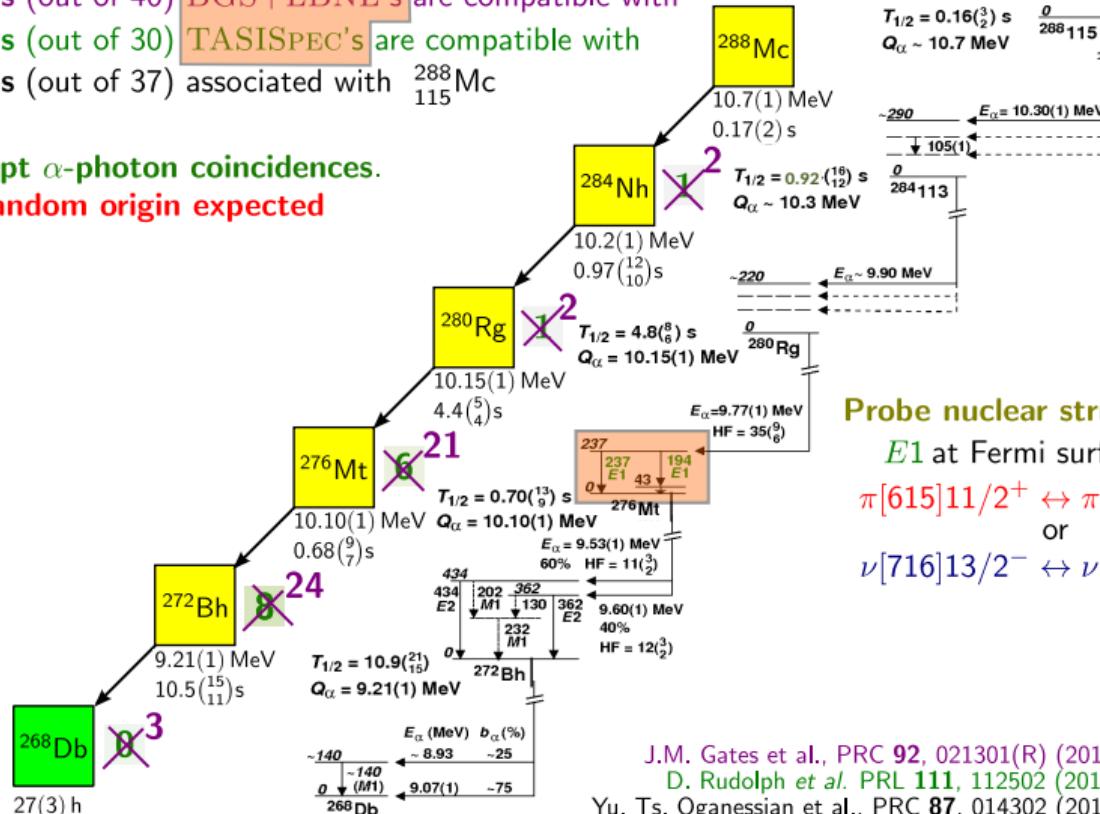
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Probe nuclear structure theory (!)

$E1$ at Fermi surface

$$\pi[615]11/2^+ \leftrightarrow \pi[505]9/2^-$$

or

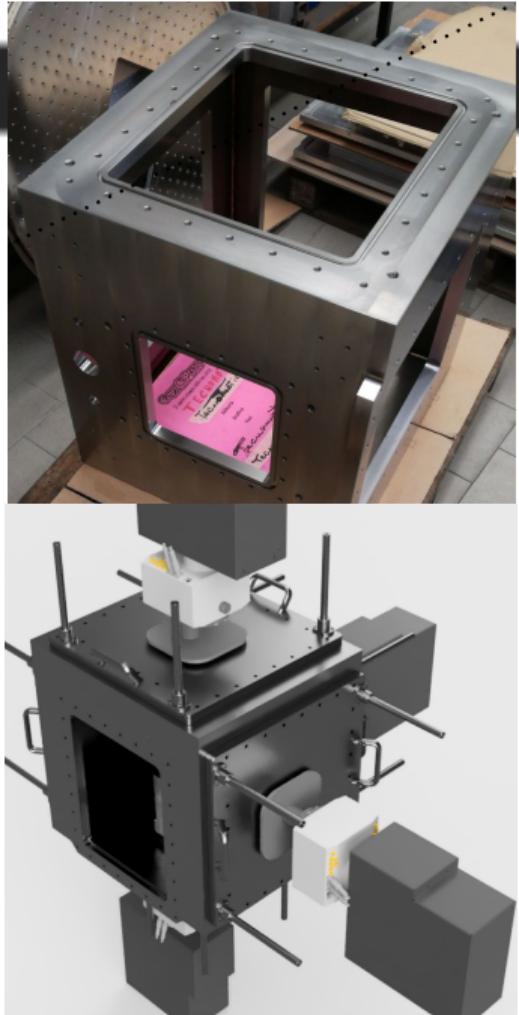
$$\nu[716]13/2^- \leftrightarrow \nu[606]11/2^+$$



Toward Lundium

Vacuum chamber

- Move into TASCA nominal focal plane (Done for the TASISpec chamber).
- Chamber : Frame in Lund, waiting for vacuum pump.
- Wagon to move the entire Lundium chamber (in Lund).
- Rail system to 'roll' chamber into position at TASCA (ordered).
- Rods with ball bearing to set side-plates with detectors into position (planned).
- Engineering : how to set it up (thinking remains).



Toward Lundium

DAQ-upgrades

- All Si-detectors read with FEBEX (in use since 2015).
- Improved beam shutoff routine to preserve low-background environment triggered by SHN-decay-like signals (Done).
 - Pixelised correlated implant- α_1 events optimised on the 2012 data.
 - Beam shutoff signal sent from FEBEX I/O unit.
- Go fully FEBEX, i.e. SIS3302→FEBEX4 for germanium readout. (Ordered).

