Shape coexistence in the neutron-deficient Hg isotopes studied via lifetime measurements

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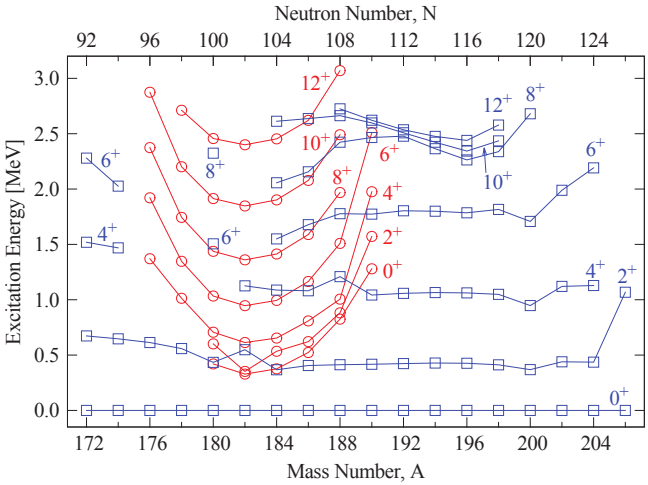
September 13, 2016

The neutron-deficient isotopes around $N \approx 104$

- Intruder bands observed for $^{176-190}$Hg
- Different deformation:
  - ground state band oblate deformed
  - Intruder band prolate deformed

K. Heyde and J.L. Wood, Rev. Mod. Phys. 83 (2011)



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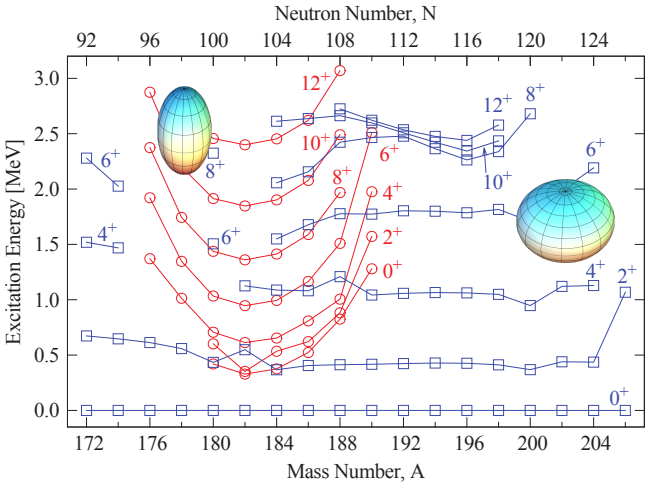

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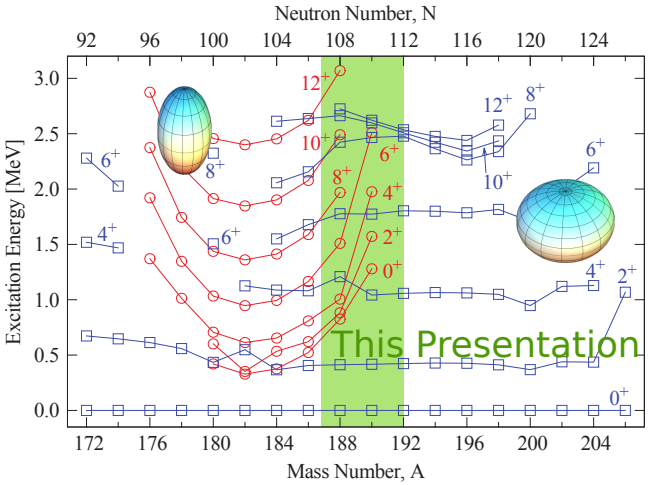
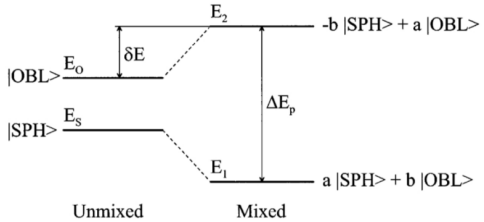


Two state configuration mixing

- Two state configuration mixing model: observed states are a mixture between these two unperturbed intrinsic states $|J_o\rangle, |J_p\rangle$:

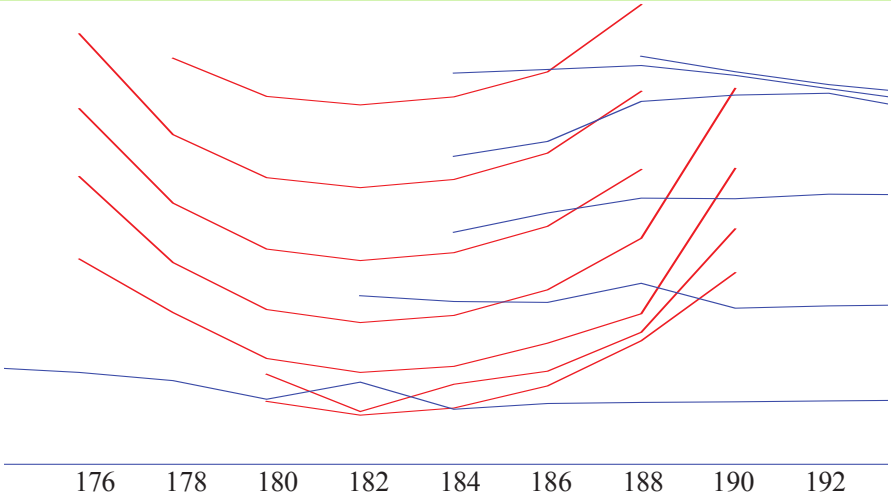
$$|J_a\rangle = \alpha_1 |J_p\rangle + \alpha_2 |J_o\rangle$$
$$|J_b\rangle = -\alpha_2 |J_p\rangle + \alpha_1 |J_o\rangle$$



- Changing contribution as a function of neutron number
- Transition prolate deformed $\rightarrow$ mixing $\rightarrow$ oblate deformation
- Maximum mixing in the 2_1^+ state for ^{184}Hg

K. Heyde and J.L. Wood, Rev. Mod. Phys. 83 (2011)

What we know about this region



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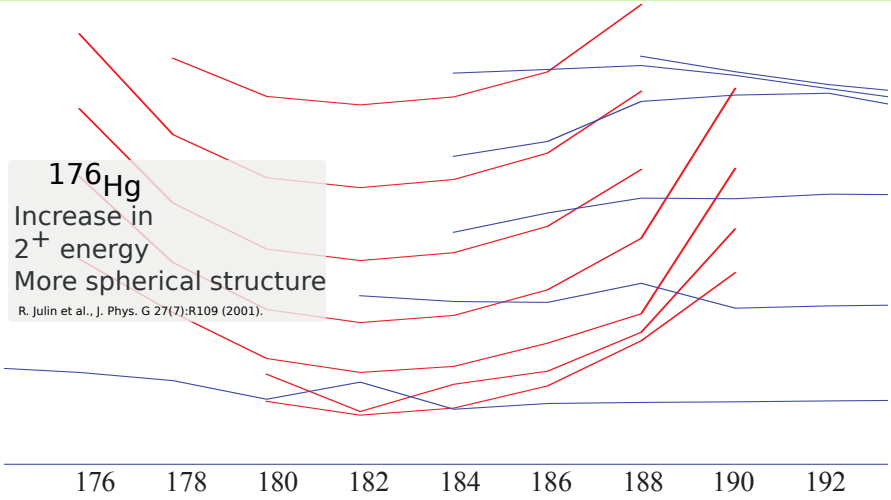

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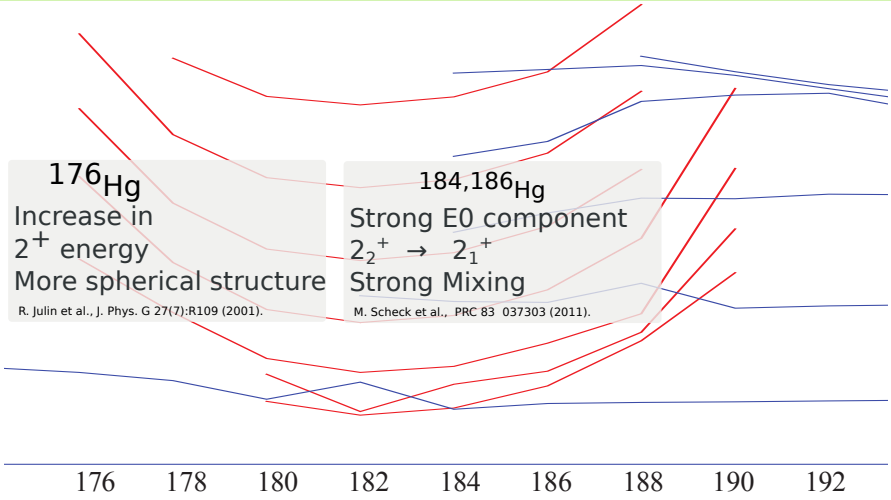

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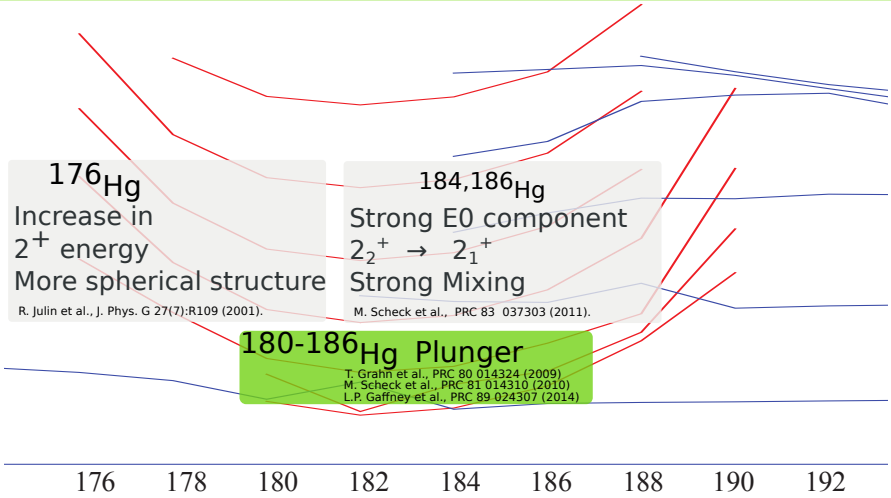

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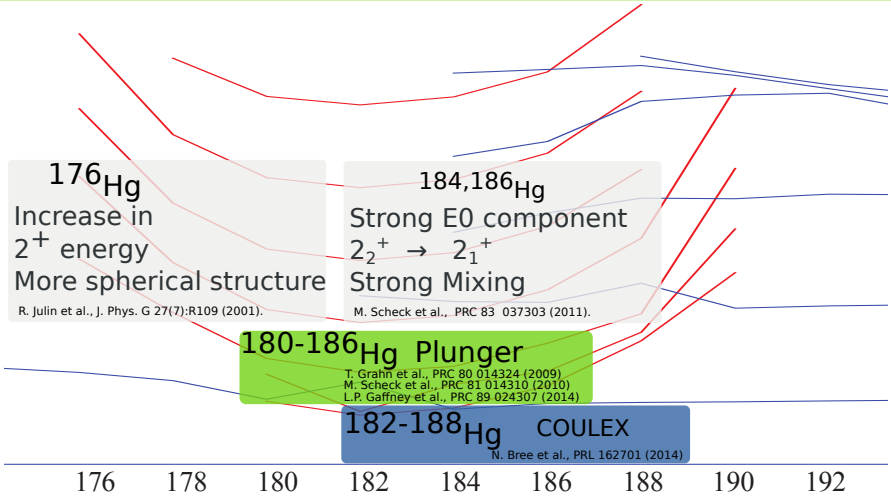

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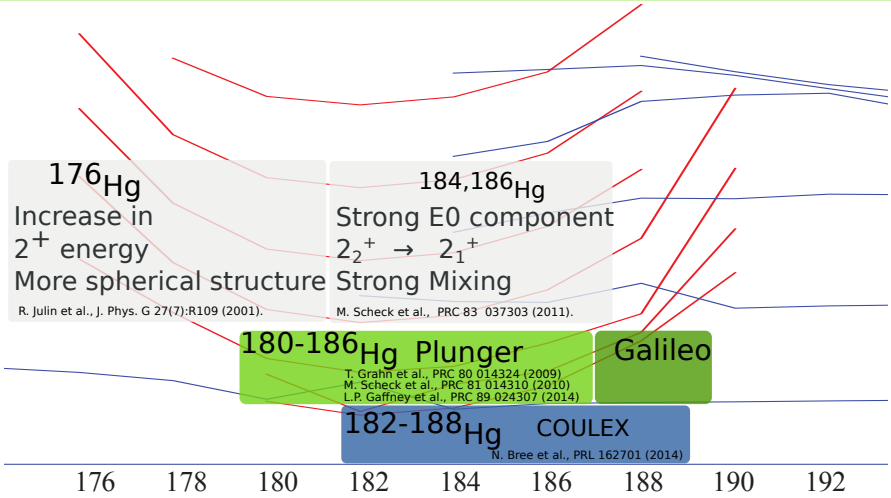
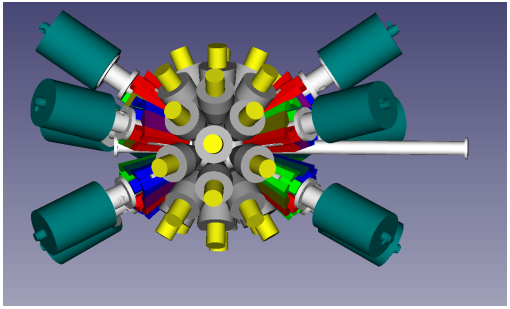


GALILEO a new 4π γray spectrometer

- takes advantage of the developments made for AGATA
  - preamplifiers
  - digital sampling
  - preprocessing
  - DAQ
- uses the EUROBALL cluster detectors capsules
  - improved efficiency
  - development of a new cluster detector with 3 capsules



- 30 GASP detectors
- 10 triple cluster detectors

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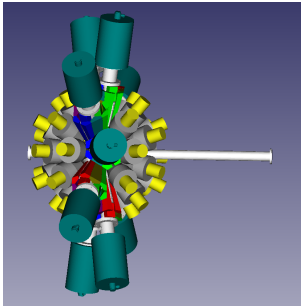

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GALILEO NeutronWall campaign

- γ-array
  - 25 HPGe Compton-suppressed GASP detectors
  - 4 angular groups
- Neutron Wall
  - 50 liquid scintillator detectors
  - n-γ discrimination via TOF and ZCO
  - Analog electronics
  - **for these experiments digital NeutronWall**

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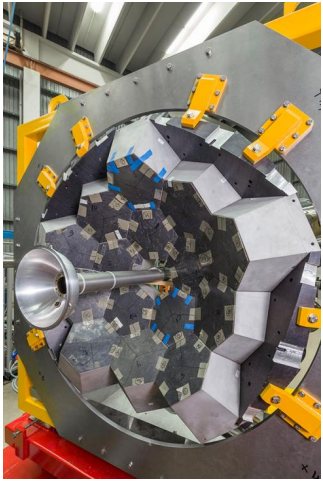
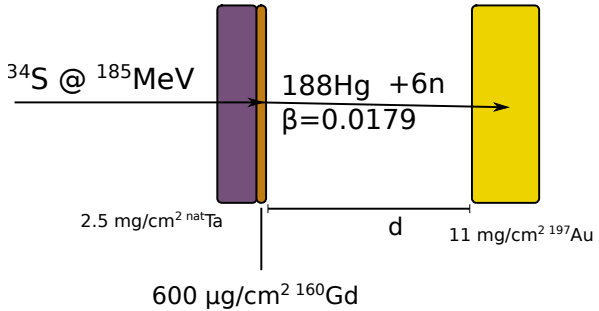


Experiments using Galileo (+NeutronWall)



- $^{34}S + {}^{160}Gd \Rightarrow {}^{188}Hg + 6\,n$

- Main evaporation residual ^{190,188}Hg $> 50\%$ of total ER
- For the 6n channel: probability of detecting at least 1n very high

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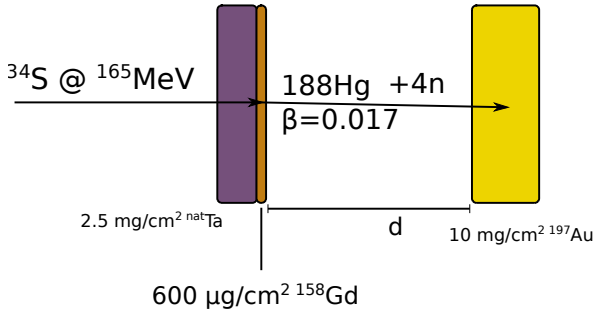

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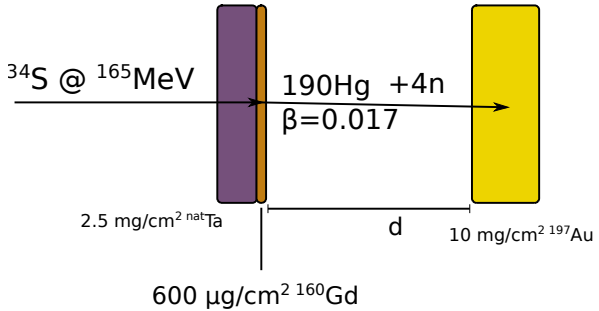

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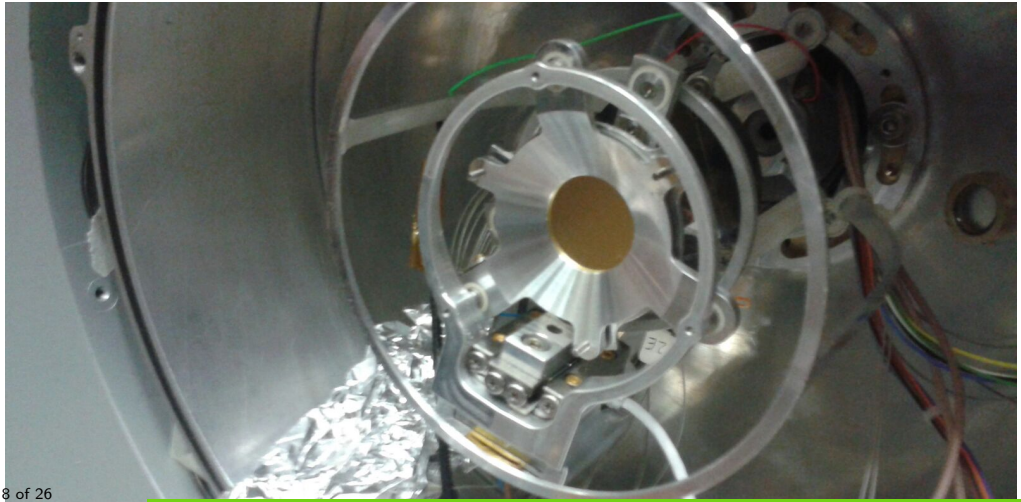

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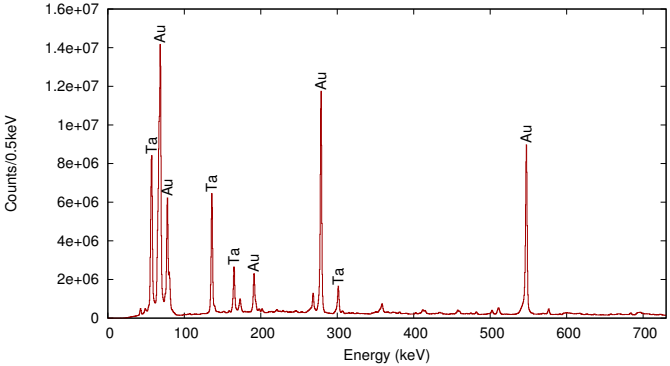

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- Background from Coulex $\Rightarrow$ Reduced by condition $1n > 1$

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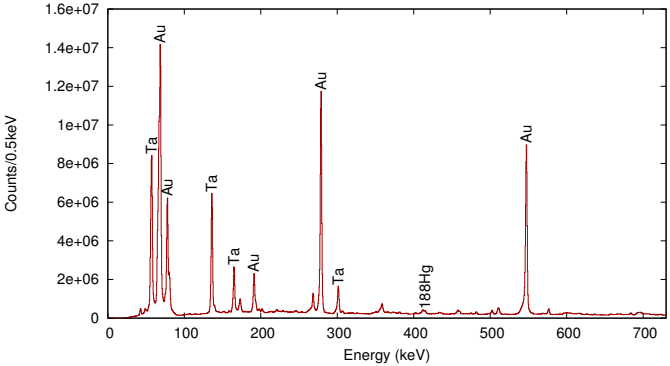

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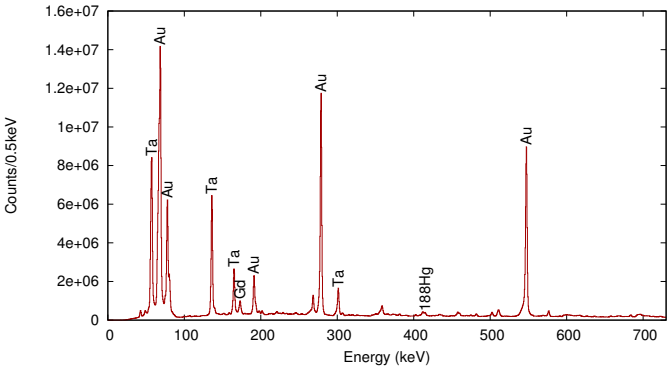

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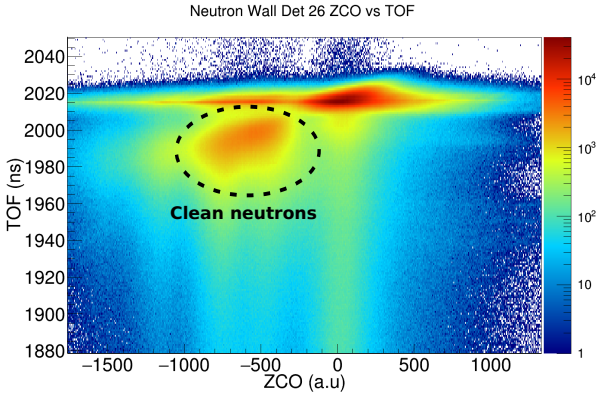
(Ab)Using for suppressing Coulex

- First time completely digital NeutronWall
- Very “dirty” selection of neutrons
- Fast online selection of ZCO in order to reduce data rate
- Nearly dead-time free



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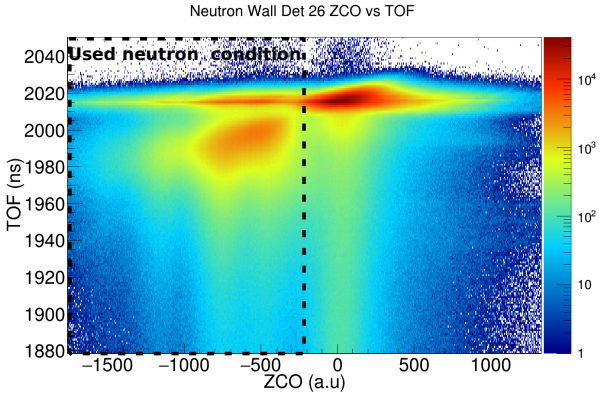

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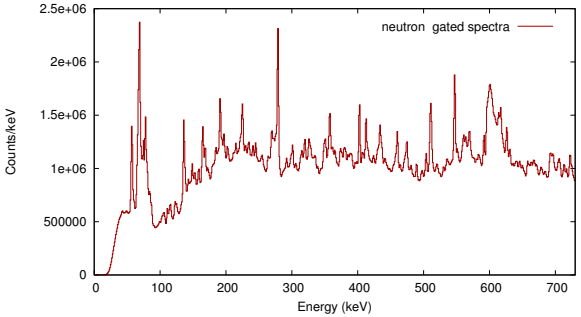
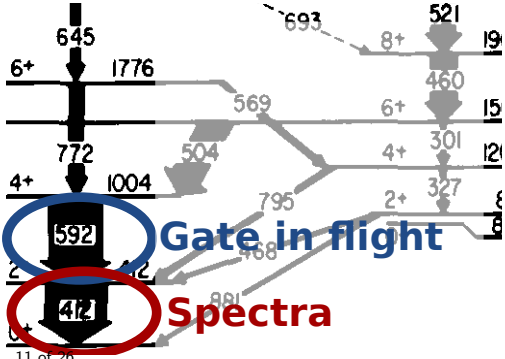


Preliminary results

$2_1^+ \Rightarrow 0_{gs}^+$ transition @ 152°

- Experiment split in two parts
- Analysis is still in progress



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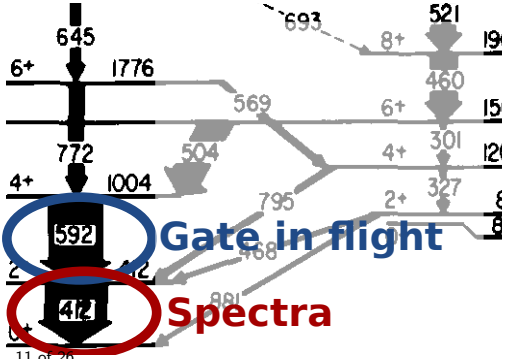

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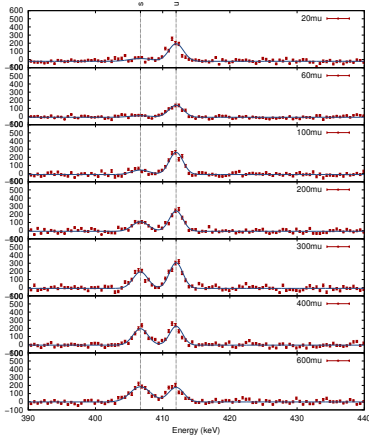

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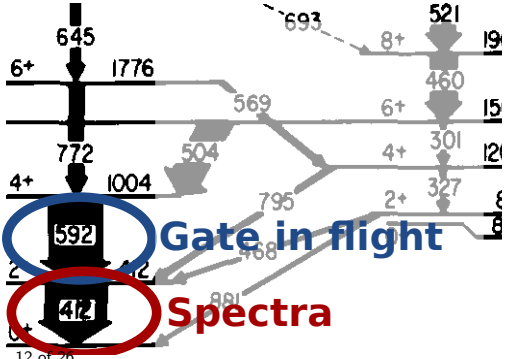
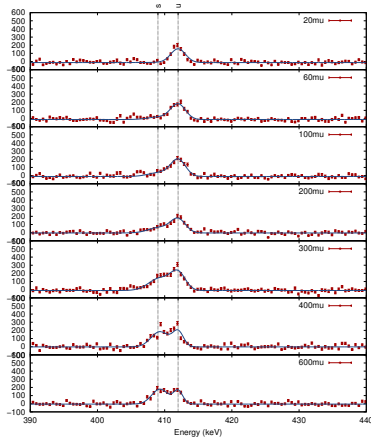
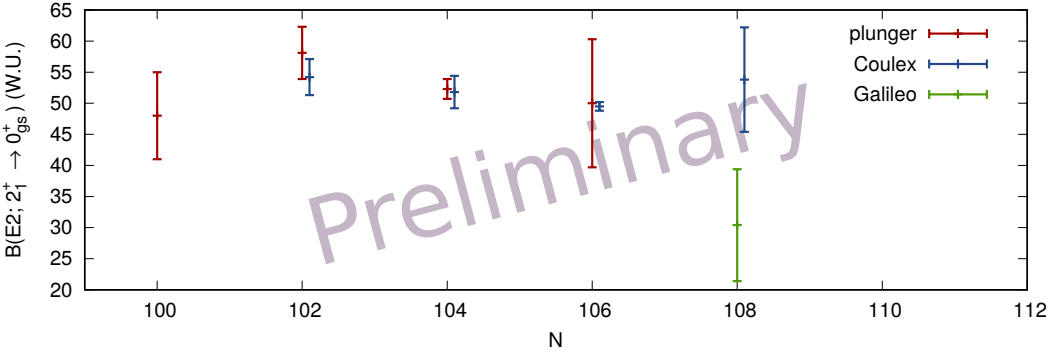


$2_1^+ \Rightarrow 0_{gs}^+$ transition @ 119°

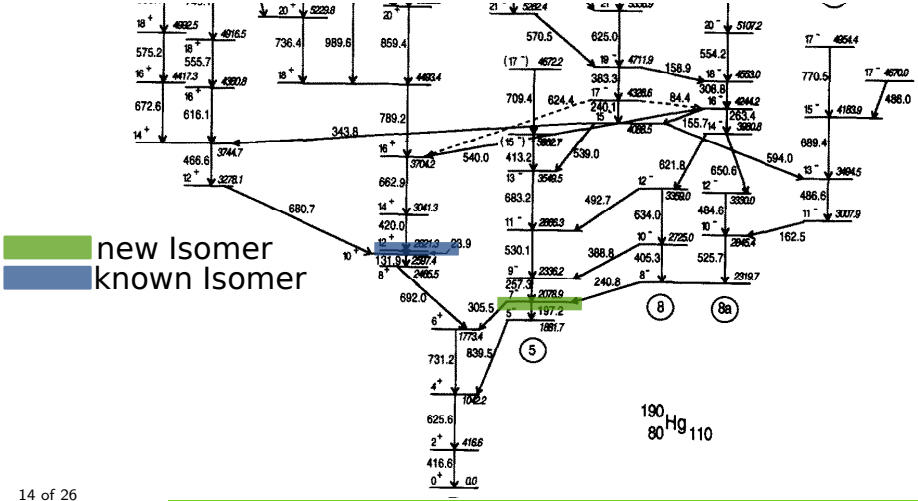


Systematics of the even-even mercury isotopes

- $T_{1/2} = 25\,(3)$ ps $\Rightarrow$, preliminary
- From Coulex: $T_{1/2} = 19.0(26)$ ps *N. Bree et al., Phys. Rev. Let. 112:162701 (2014).*



New Isomeric state in ^{190}Hg



Outlook and future perspective

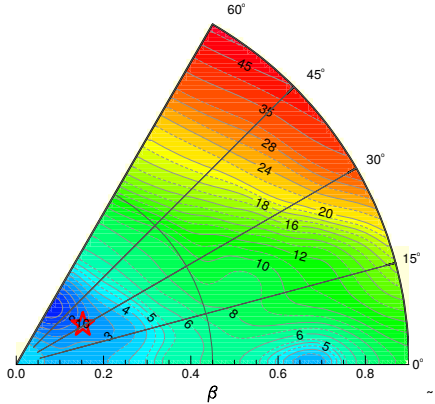
- Promising data and great performance of the system, Plunger stable up-to 7 pnA
- Accelerator problems during the experiment $\Rightarrow$ Experiment split in two parts
- Finish to analysis of half-lives of the isomeric states in ^{190}Hg

Thank you for your attention

Also special thanks to M. Loriggiola for the targets

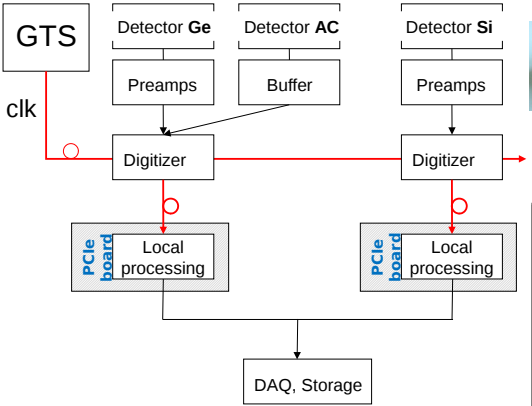
^{190}Hg – a γ-soft nucleus?

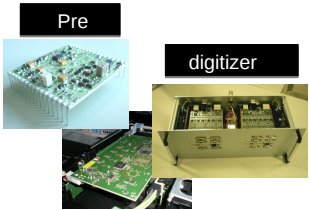
- Transition between shape coexistence and single minimum
- Change in configuration
- Signs of γ-softness
  J.P. Delaroche et al., Phys. Rev. C 50:2332, (1994).
- Dipole bands with $\pi(2p4h)$ configuration observed
  A.N. Wilson et al., Phys. Let. B 81, B 505(1):614, (2001).
- Super deformed band observed
  A.N. Wilson et al., PRL 104, 162501 (2010).



Adapted from J.-P Delaroche et al., Phys. Rev. C 81, 014303 (2010)

GALILEO electronics

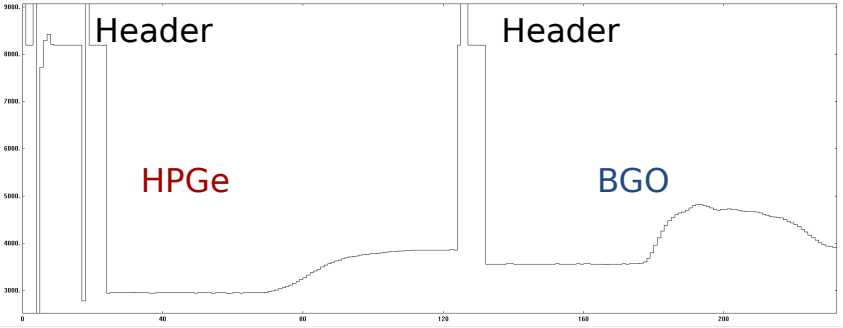




- **HPGe,AC, Anc. digitized**
- **Branches are sync by GTS.**
- **Trigger-less operation**
- **240 channels available**
- **Typical rate ~ 20 kHz/det**
- **Max rate ~ 50 kHz/det**

GALILEO electronics

- Local processing of the data recorded
- Online Pulse Shape Analysis
- Agata style Local processing



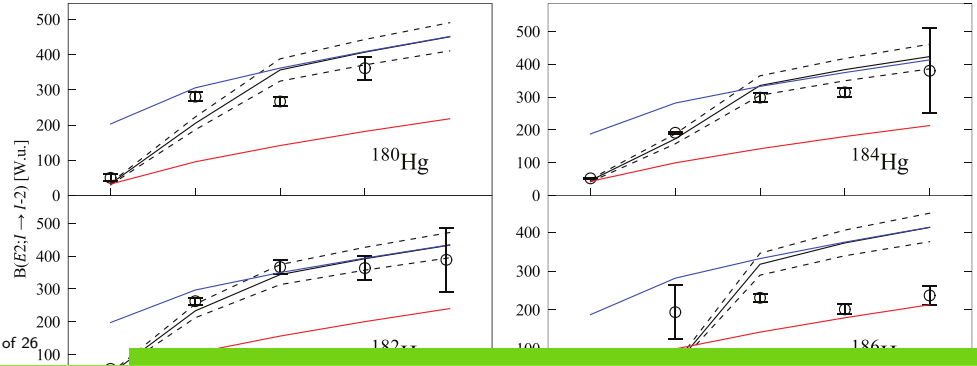
GALILEO electronics

- Local processing of the data recorded
- Online Pulse Shape Analysis
- Agata style Local processing

Shape coexistence and lifetime measurements

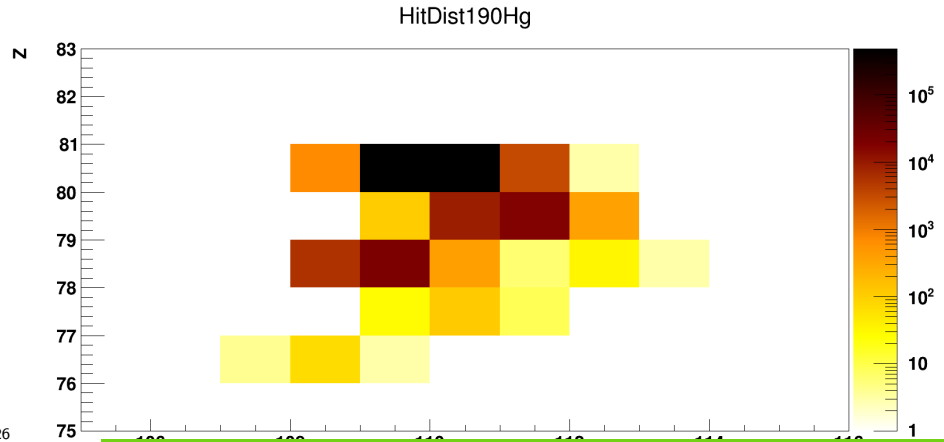
- Transition strengths very sensitive to the wave functions
- Huge change in nuclear structure, but $B(E2; 2_1^+ \rightarrow 0_{gs}^+) \approx 50\,\text{W.U.}$
- Change in major contribution with higher spins

L.P. Gaffney et al., Phys. Rev. C 89, 024307 (2014)



Cross section estimate ^{190}Hg

- Gemini



Cross section estimate ^{188}Hg

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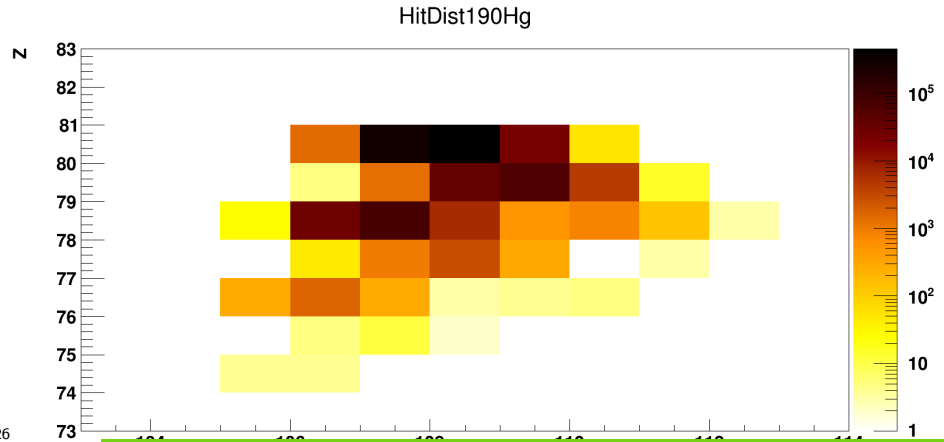

Fission ^{190}Hg

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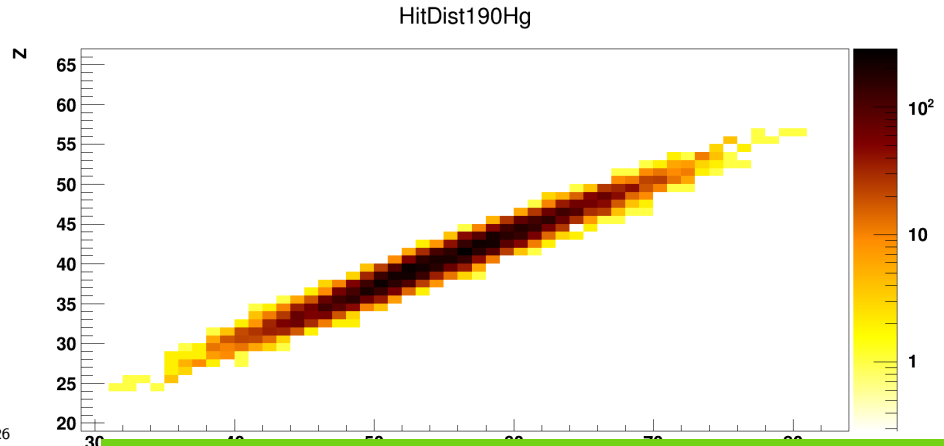

Fission ^{188}Hg

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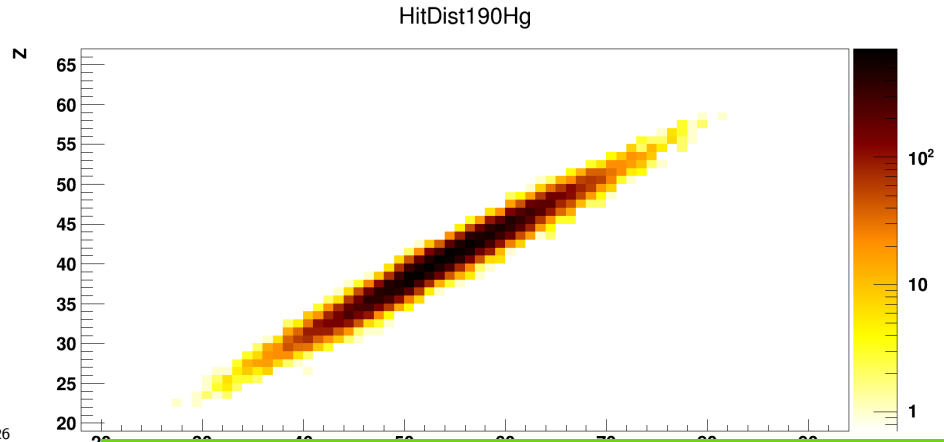

Proposed experiment (alternative)

- Setup **Galileo + Cologne Plunger** *(+ Euclides as veto)*
- Reaction ^{40}Ar + ^{154}Sm and ^{152}Sm (500 μg/cm^2 evaporated on 1.2 mg/cm^2 ^{181}Ta) 1 pnA
- Reaction channel $-4n$ for ^{188}Hg and ^{190}Hg
- 12 target-stopper distances between 10 μm and 1200 μm each 4 h
- Energy lower $\Rightarrow$ less contribution of fission

Energy	Channel	$\sigma_{\text{-xn}}$	Fraction	$\gamma-\gamma$-coinc./h $2^+/4^+$
172 MeV	$-4n$ ^{190}Hg	13 mbarn	55.4%	900
178 MeV	$-4n$ ^{188}Hg	19 mbarn	72%	1200

+ 1 day for change of energy + calibration

$\Rightarrow$ **5 days of beam time**

^{190}Hg a γ-soft nucleus