

# Fission of $^{194}\text{Hg}$

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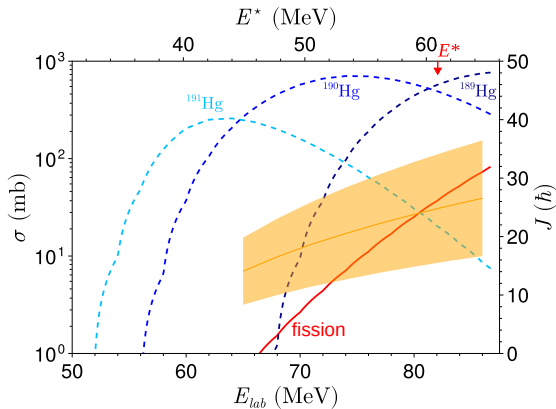
# Experiment at ALTO - $\nu$ -ball-2 campaign

- 24 Clover detectors
- 1  $\times$  LaBr<sub>3</sub>
- (-) 64  $\times$  PARIS modules
- (-) Warsaw DSSD
- $^{12}\text{C} + ^{182}\text{W} \longrightarrow ^{194}\text{Hg}$
- Stable 3 nA beam, 87.5 MeV
- Thick target ( $\approx 100\mu\text{m}$ ) prepared on Faculty of Chemistry, University of Warsaw



# $^{12}\text{C} + ^{182}\text{W}$ reaction

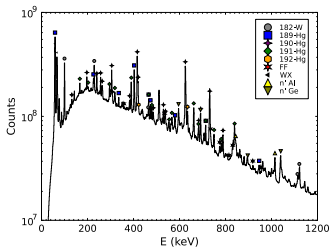
- Calculations with HIVAP, PACE and SRIM



- Excitation energy for fission  $E^* = 60.9 \pm 3.9$  MeV
- Angular momentum  $\langle J \rangle = 23 \pm 3\hbar$
- Fission barrier 14-18 MeV,  $E_{rot} \approx 4$  MeV

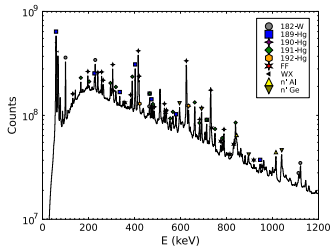
# Fragment yield analysis

- Gamma singles are dominated by fusion-evaporation and Coulomb excitation lines

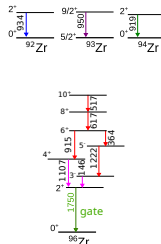
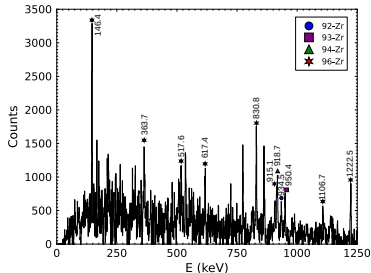


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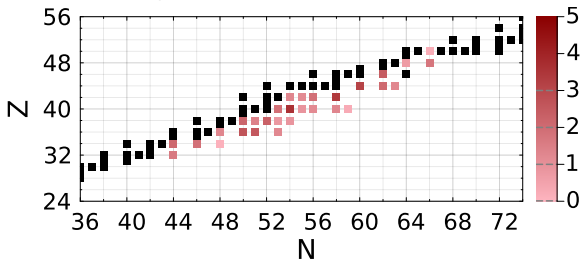


- Fission fragment yield based on analysis of all  $\gamma - \gamma$  leading to the g.s. of a given isotope



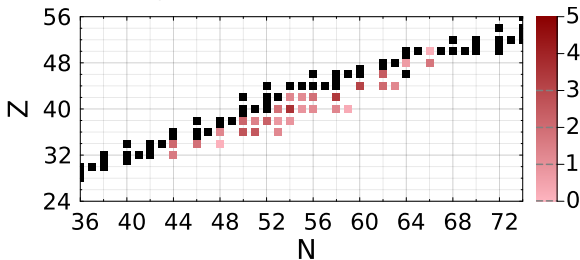
# MLE method

- In total:
  - 30 fission fragments (21 even-even, 9 odd)
  - 26 transitions in fission partners

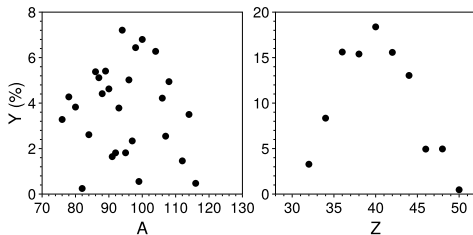


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- Projections on  $A$  or  $Z$  result in losing information, and are distorted due to missing isotopes.



# MLE method

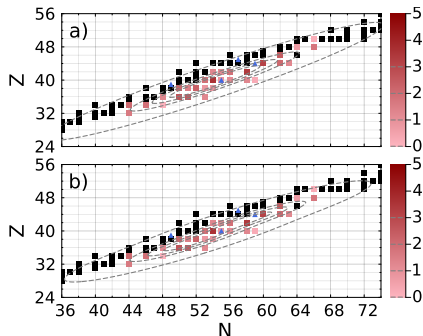
- 2D normal distribution (a) and sum of two 2D normal distributions (b) was fitted with the maximum likelihood method

$$f(N, Z) = \frac{1}{2\pi\sigma_N\sigma_Z\sqrt{1-\rho^2}} \exp \left\{ -\frac{1}{2(1-\rho^2)} \left[ \left( \frac{N-\mu_N}{\sigma_N} \right)^2 - 2\rho \frac{(N-\mu_N)(Z-\mu_Z)}{\sigma_N\sigma_Z} + \left( \frac{Z-\mu_Z}{\sigma_Z} \right)^2 \right] \right\}$$

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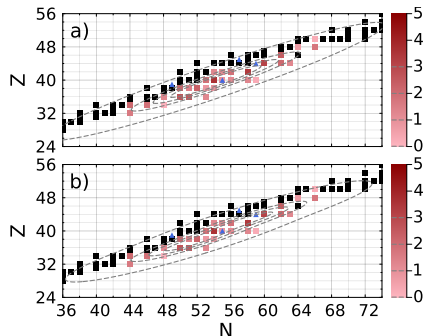


Parameter	Model	
	(a)	(b)
$\mu_{ZL}$	39.8	37.0
$\mu_{ZH}$	–	42.8
$\sigma_Z$	4.05	2.83
$\mu_{NL}$	54.4	50.8
$\mu_{NH}$	–	58.3
$\sigma_N$	5.75	4.40
$\rho$	0.957	0.930
$\ln(\mathcal{L}_{max}^i)$	-141.9	-141.5
$AIC_i$	293.8	297.0

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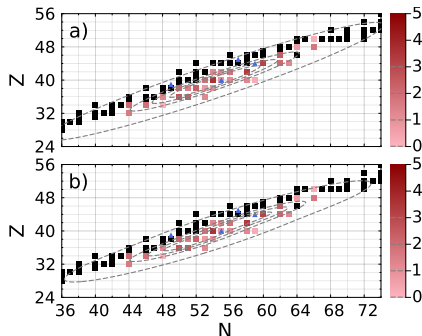
- Likelihood function and Akaike Information Criterion

$$AIC_i = 2k_i - 2 \ln(\mathcal{L}_{max}^i).$$

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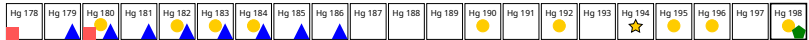


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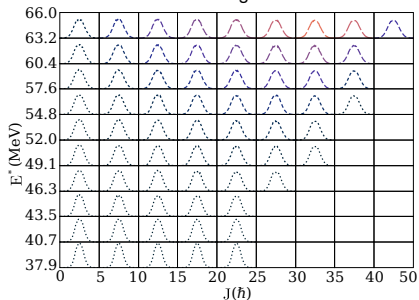
# Comparison with systematics and theory



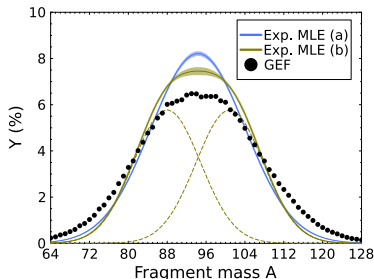


# Comparison with the GEF model

- Distribution of fragments was calculated for a range of  $E^*$  and  $J$  with the GEF model

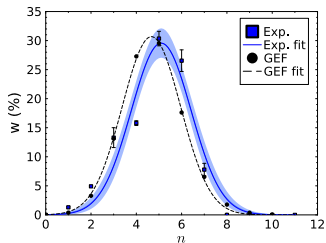


- Projection of 2D distribution on  $A$



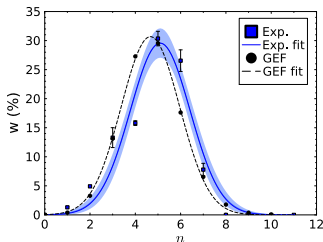
# Fission partners and angular momentum

- From transitions in fission partners, the number of emitted neutrons can be calculated

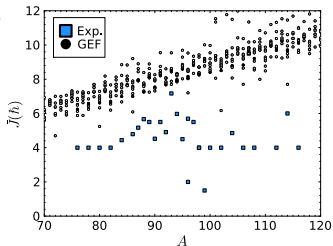
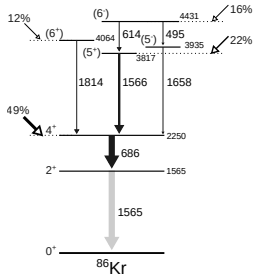


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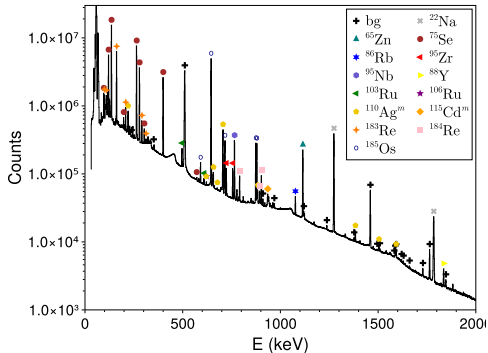
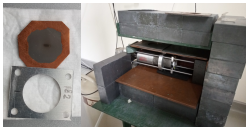


- Angular momentum of fragments was derived with the Manchester method



# Residual activity

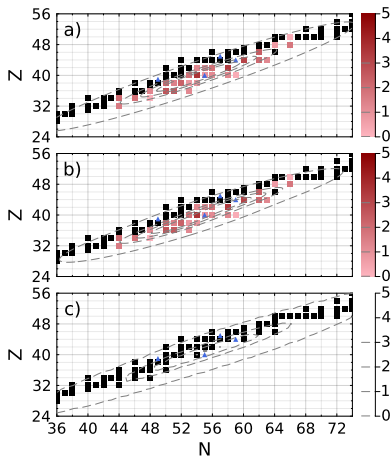
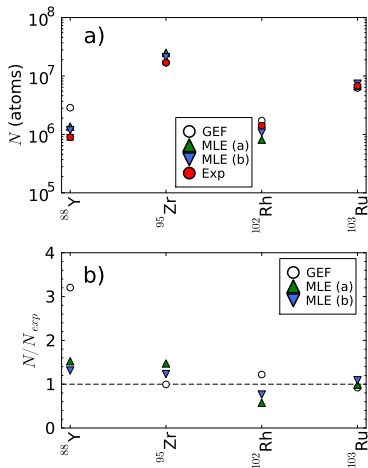
- After 171 days the target was placed in a low-background hut and residual activity was measured with a HPGe detector.



- More details in [P. Garczyński talk this evening](#)

# Residual activity

- Results were compared with calculations starting from fission yields (GEF, MLE) using beam intensity, half-lives, delayed neutron branching and  $\beta^+/\beta^-$  BR



- Independent confirmation of the prompt radiation analysis!

# Summary

- Unknown before fission of  $^{194}\text{Hg}$  was measured
- Independent fission yield was obtained by the MLE method
- Charge distribution fits systematics in the region and show peak at  $Z = 37$
- Results were confirmed by the residual activity measurement
- $\gamma$ -spectroscopy proves a valuable method
- Work is submitted to PRC

## Thanks for all the collaborators

P. Garczyński, A. Korgul, J.N. Wilson, A. Algora, M. Chotkowski, S. Czajkowski, N. Dzysiuk, L. M. Fraile, C. Hiver, T. Kurtukian-Nieto, K. Komuda, M. Lebois, A. Lopez-Martens, J. Ljungvall, L. Mathieu, J. A. B. Monago, G. Pasqualato, W. Poklepa, P. Polczyński, H. A. Rösch-Kabadayi, K. Solak, I. Tsekhanovich, S. Zajda