Superciężkie pierwiastki

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NATIONAL CENTRE FOR NUCLEAR RESEARCH
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PTF Seminar
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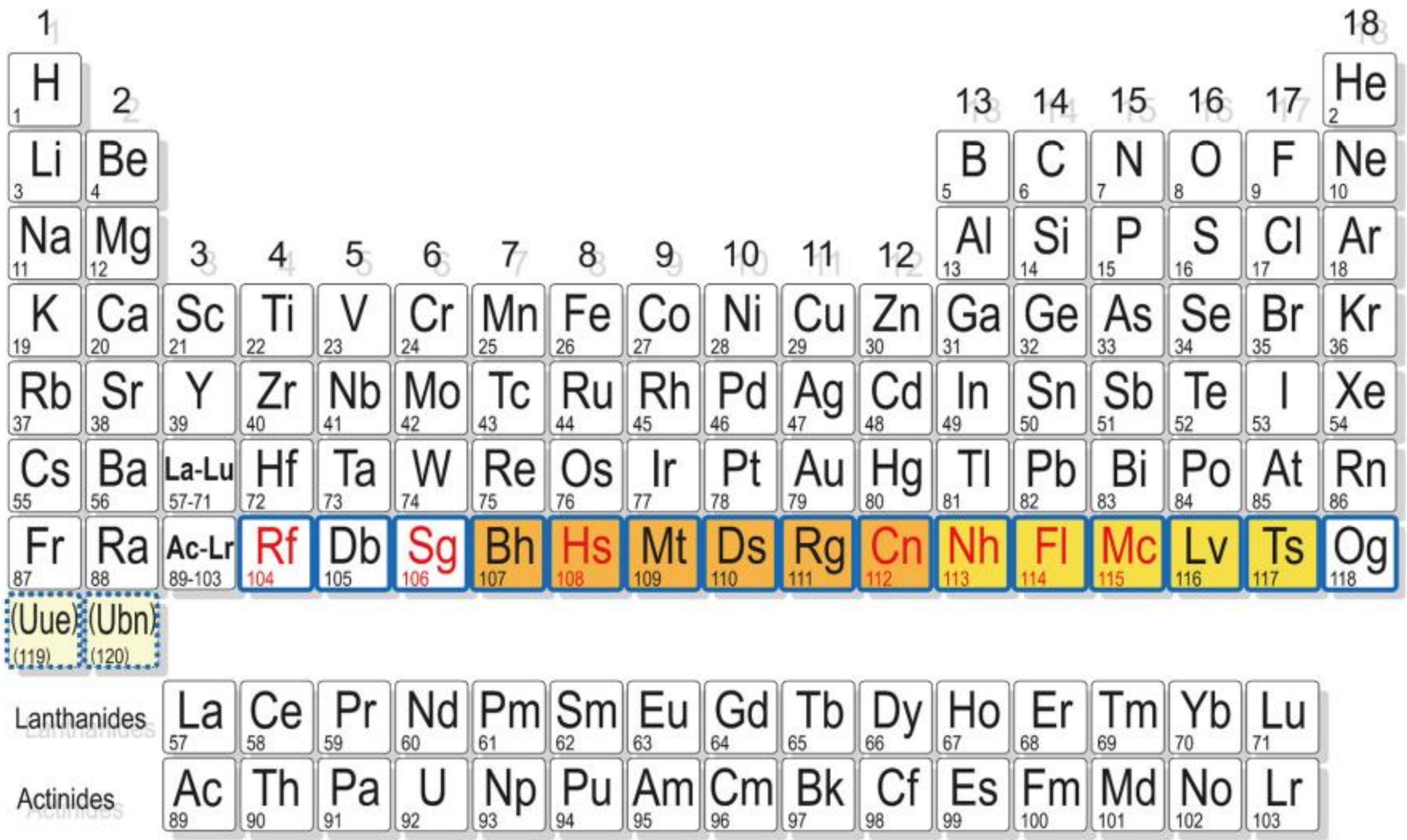
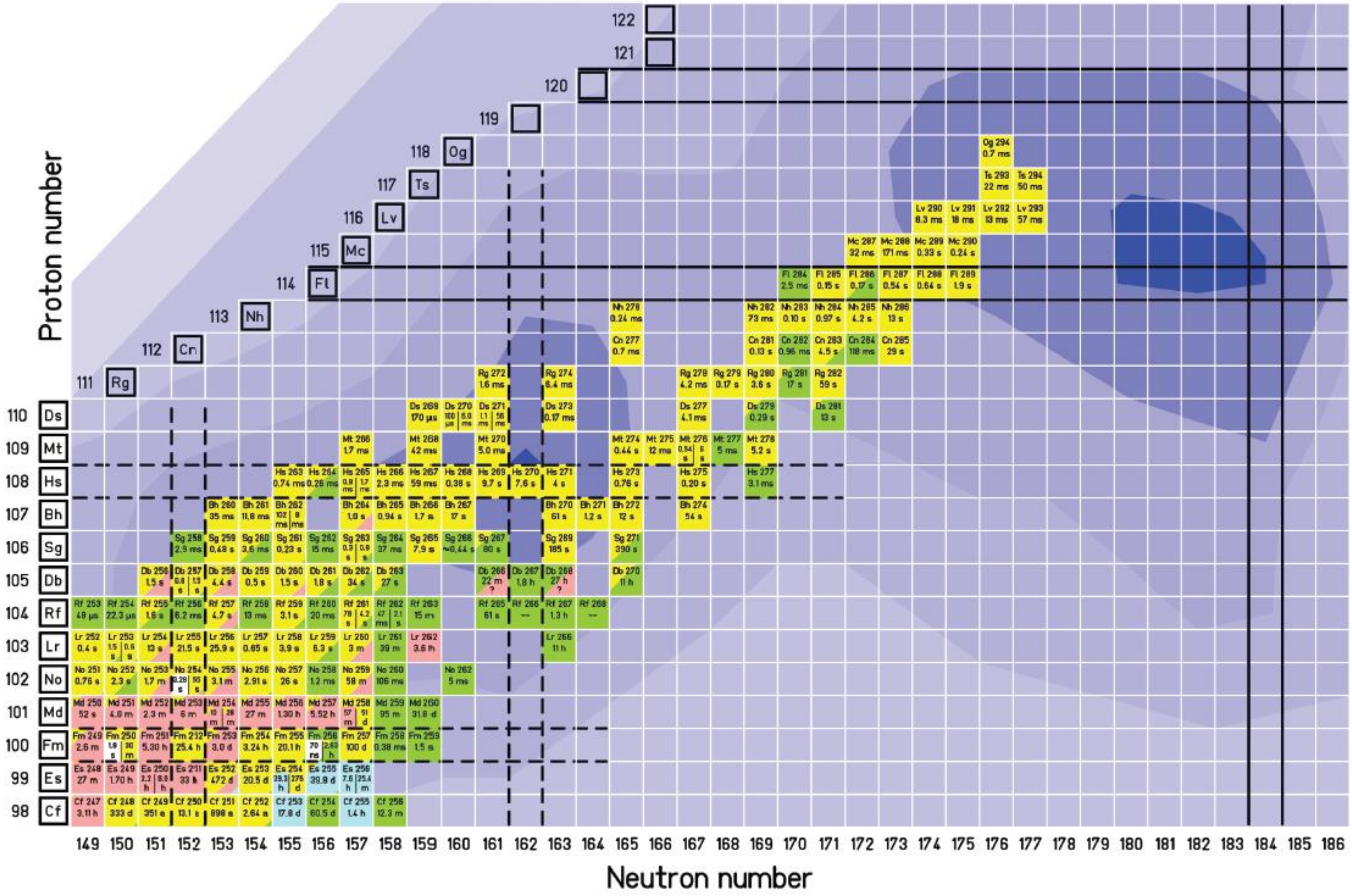


‘Discovery of a chemical element is the experimental demonstration, beyond reasonable doubt, of the existence of a nuclide with an atomic number Z not identified before, existing for at least 10^{-14} s.



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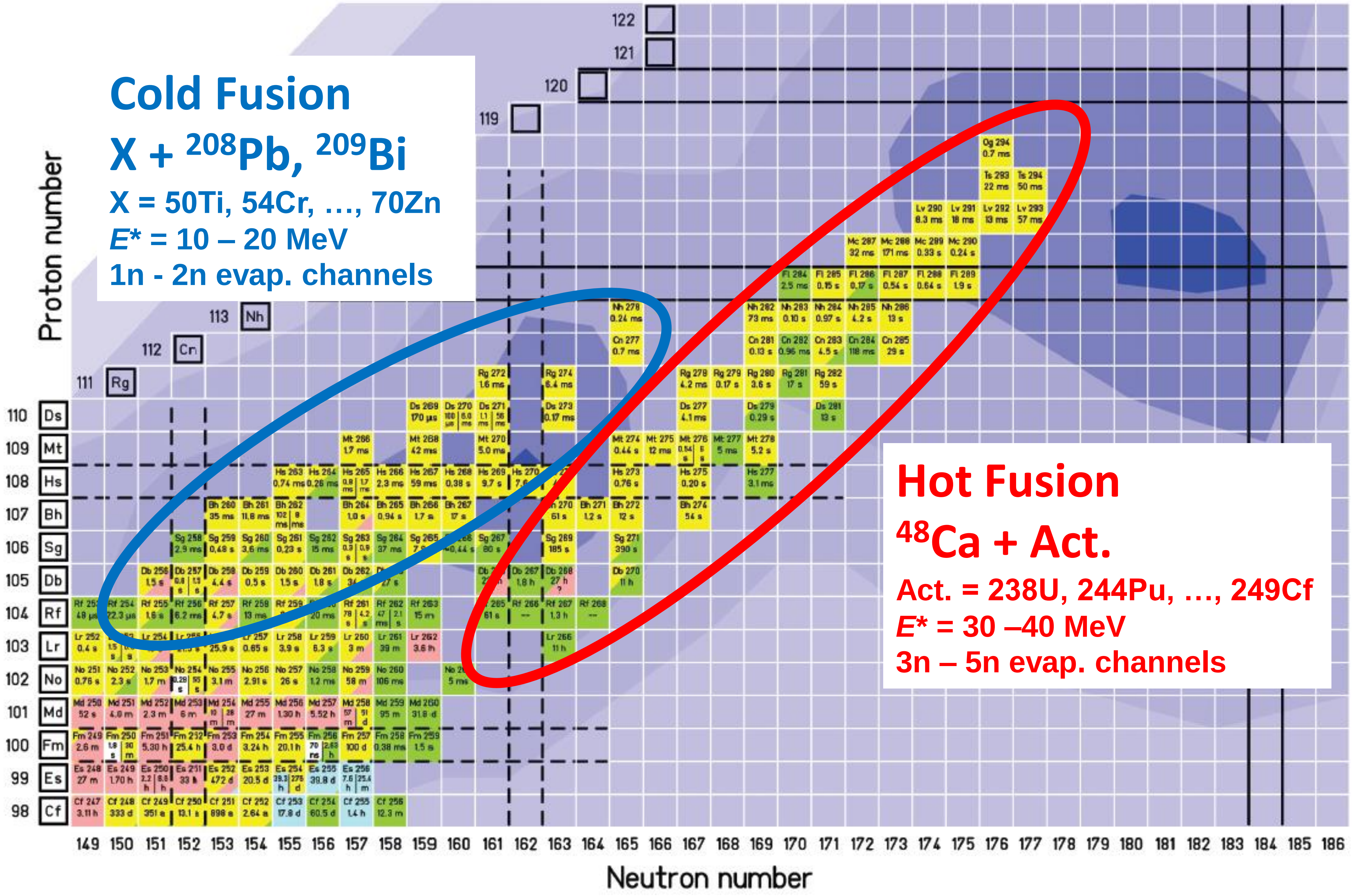
Cold Fusion

X + ^{208}Pb, ^{209}Bi

X = 50Ti, 54Cr, …, 70Zn

*E** = 10 – 20 MeV

1n - 2n evap. channels



Hot Fusion

^{48}Ca + Act.

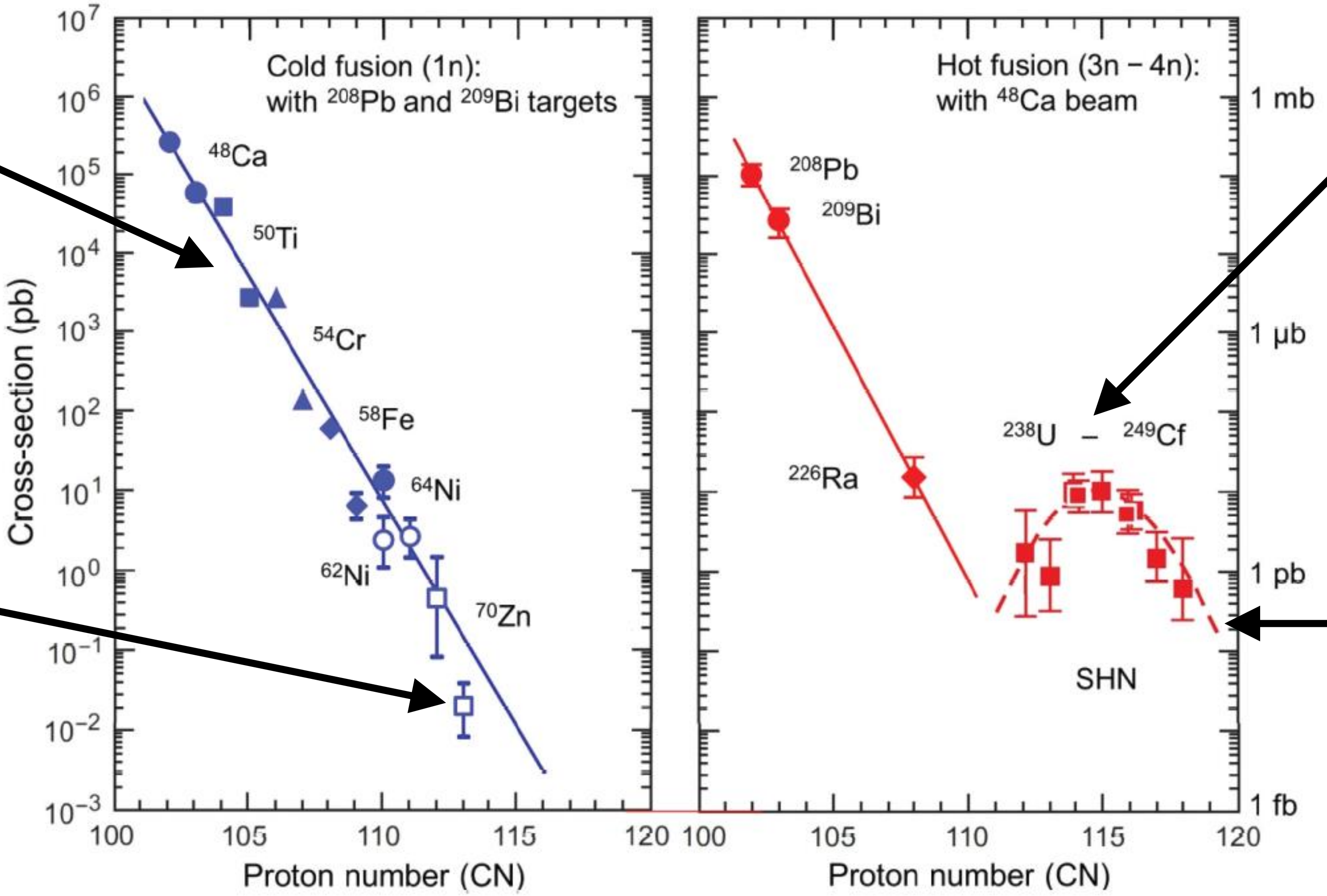
Act. = 238U, 244Pu, …, 249Cf

*E** = 30 –40 MeV

3n – 5n evap. channels

Cross section drops **7** orders of magnitude with the change from Ca to Zn.

Z=113, 22 fb, only 3 atoms in 576 days of irradiation

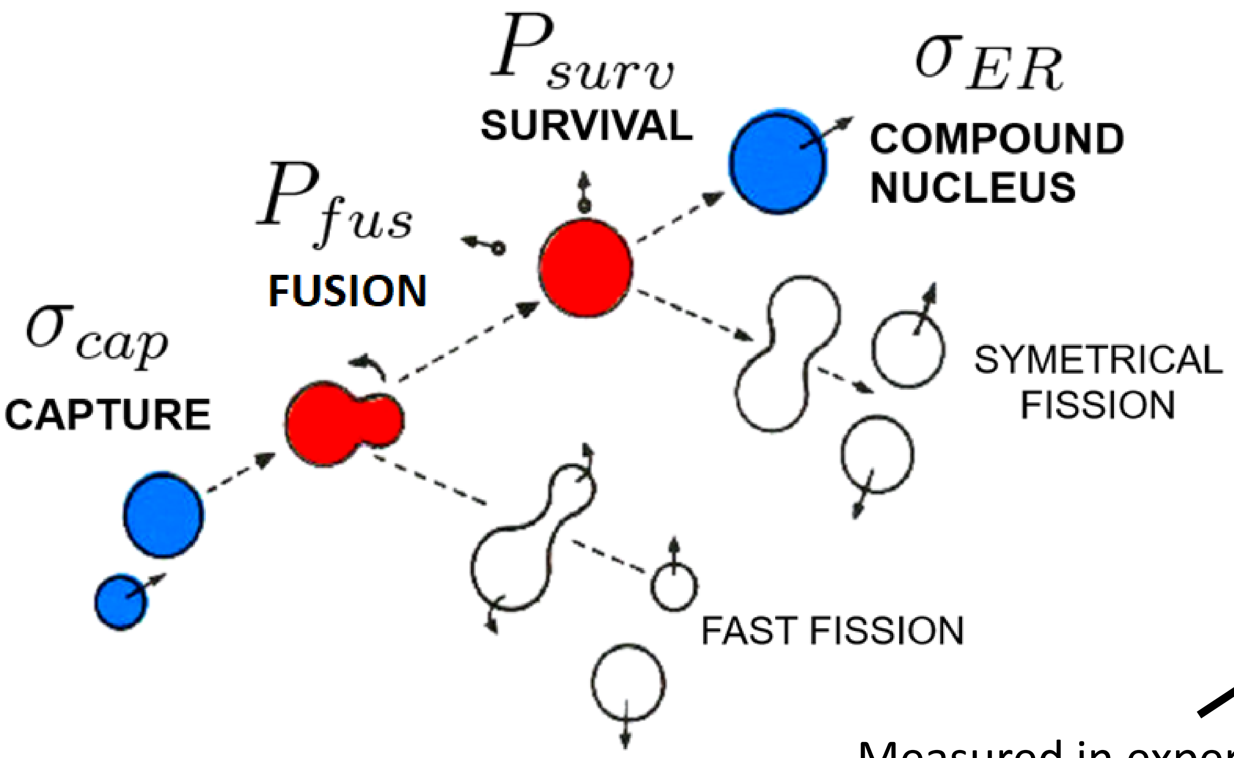


No heavier target than Cf (*Z*=98) is available.

Es (*Z*=99) is too radioactive but can possibly be used.

Experiments with 50Ti, 54Cr, 58Fe and 64Ni beams have not succeeded so far.

Sigurd Hofmann, Sergey N. Dmitriev, Claes Fahlander, Jacklyn M. Gates, James B. Roberto and Hideyuki Sakai
Report of the 2017 Joint Working Group of IUPAC and IUPAP, Pure Appl. Chem. 2020; 92(9): 1387–1446



FBD (fusion-by-diffusion)

Synthesis of SHN can be described as a **3** step process:

$$\sigma_{\mathrm{ER}} = \sigma_{\mathrm{cap}} \times P_{\mathrm{fus}} \times P_{\mathrm{surv}}$$

σ_{cap}: Measured in experiments, can be calculated using various models ← **Diffussed barrier formula (Entrance channel barrier is given by a Gaussian distribution)**

P_{fus}: Not measured directly, difficult to calculate ← **Smoluchowski Diffusion Equation**

P_{surv}: Well established theory and formulas Monte Carlo Statistical model ← **masses, fission barriers, deformations from Warsaw Micro-Macro model**

W. J. Świątecki, K. Siwek-Wilczyńska, J. Wilczyński, **PRC 2005**

T. Cap et al., **PRC 2011**
K. Siwek-Wilczyńska et al. **PRC 2012**
T. Cap et al., **PRC 2013**
K. Siwek-Wilczyńska et al. **PRC 2019**
T. Cap et al. **EPJ 2022**

Atomic Data and Nuclear Data Tables 138 (2021) 101393

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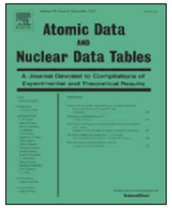

Properties of heaviest nuclei with $98 \leq Z \leq 126$ and $134 \leq N \leq 192$

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Ground-state and saddle-point shapes and masses for 1305 heavy and superheavy nuclei including odd-A and odd–odd systems. Static fission barrier heights, one- and two-nucleon separation energies, and Qα values.

Microscopic–macroscopic method with the deformed Woods–Saxon single-particle potential and the Yukawa-plus-exponential macroscopic energy taken as the smooth part.

Ground-state shapes and energies are found by the minimization over seven axially-symmetric deformations.
A search for saddle-points was performed by using the "imaginary water flow" method in three consecutive stages, using five- (for nonaxial shapes) and seven-dimensional (for reflection-asymmetric shapes) deformation spaces.

Good agreement with the experimental data for actinides.

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Dlaczego zająłem się fizyką jądrową?

- Ludzie i atmosfera w zakładzie (ZFJA@FUW)
- Badania podstawowe - superciężkie pierwiastki są na granicy naszego poznania i łączą elementy fizyki, chemii, astrofizyki, inżynierii, …
- Możliwości wyjazdów zagranicznych na eksperymenty

Fizyka jądrowa jest tematyką rozpoznawalną i istotną dla społeczeństwa, znajduje zastosowania w energetyce, medycynie, sztuce, datowaniu, sterylizacji żywności, szukaniu złóż ropy, itd.

Każdy znajdzie coś dla siebie (teoria, eksperymenty, praca z materiałami promieniotwórczymi, analiza danych, modelowanie, budowanie detektorów, elektroniki, itd.)

Thank you for your attention

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