Synthesis of superheavy nuclei: A search for new production reactions

- **“Cold” fusion reactions**
- **“Hot” fusion reactions (beyond ^{48}Ca)**
- **Fusion of accelerated fission fragments**
- **Radioactive ion beams**
- **Summary**

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for TASCA-2009, Darmstadt, October 14, 2009

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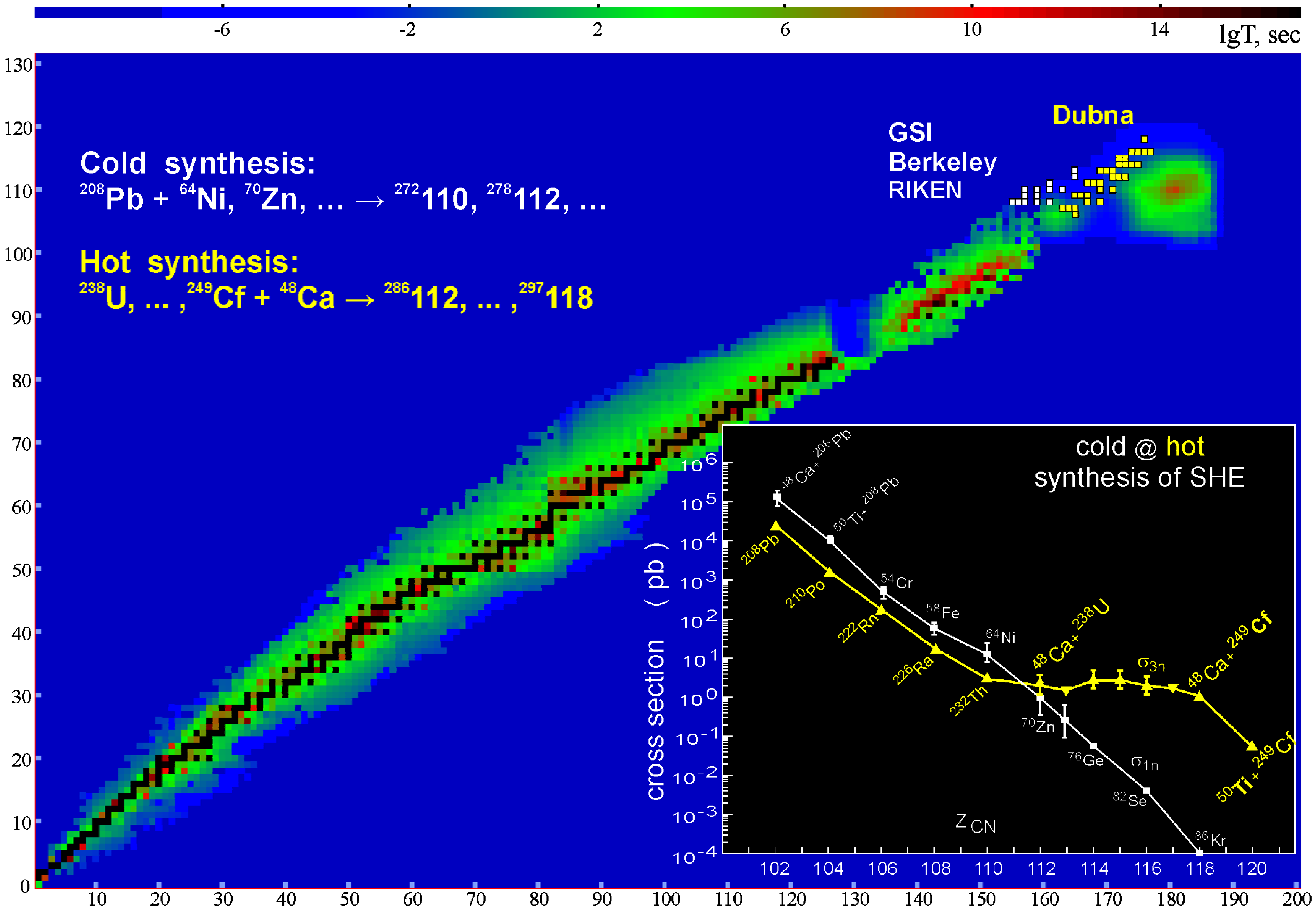
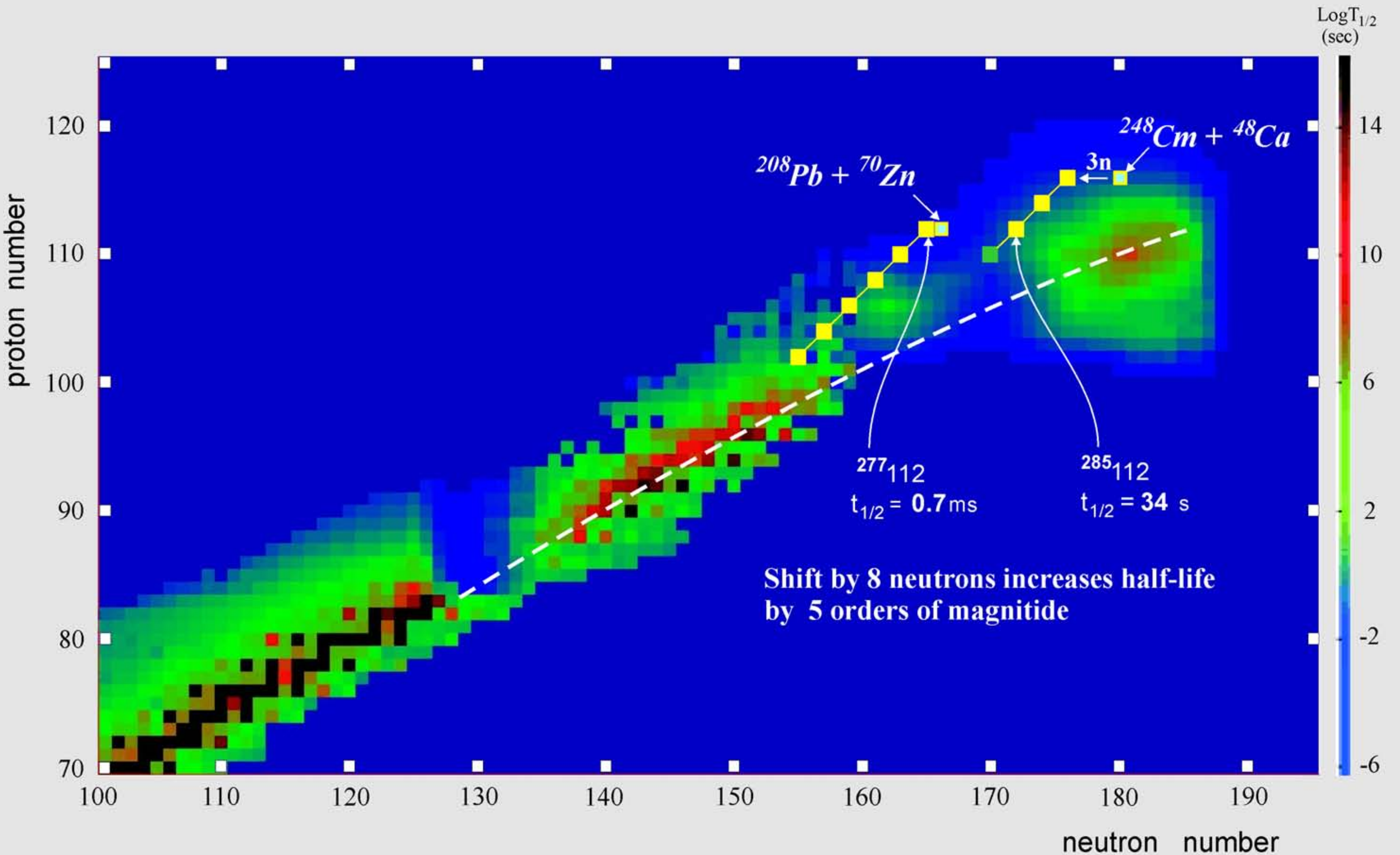
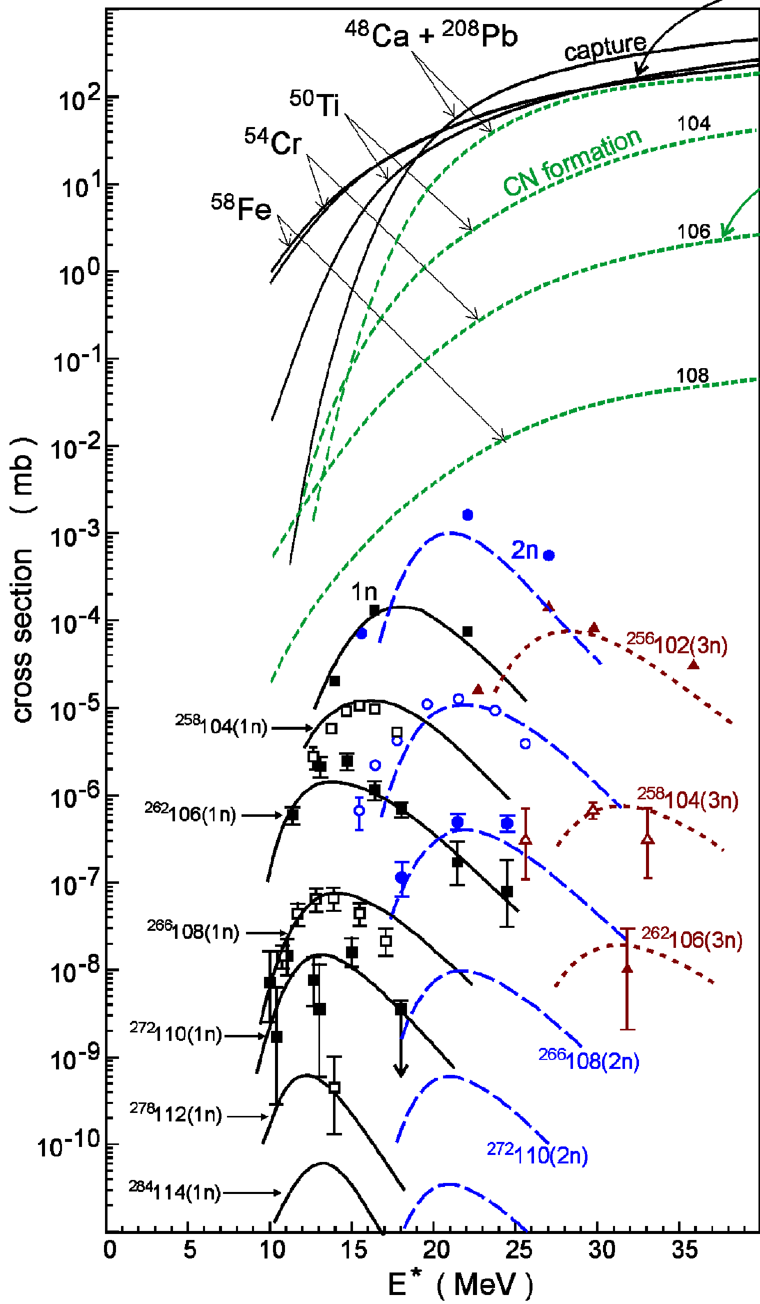
Synthesis of superheavy elements (cold and hot fusion)



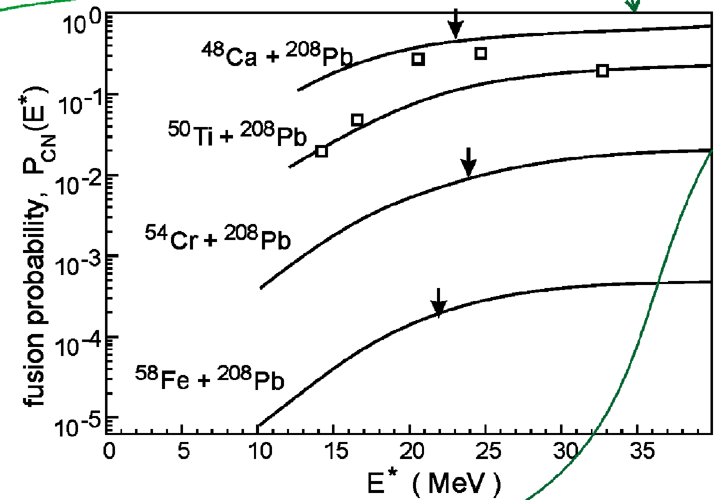
We are still far from the line of stability



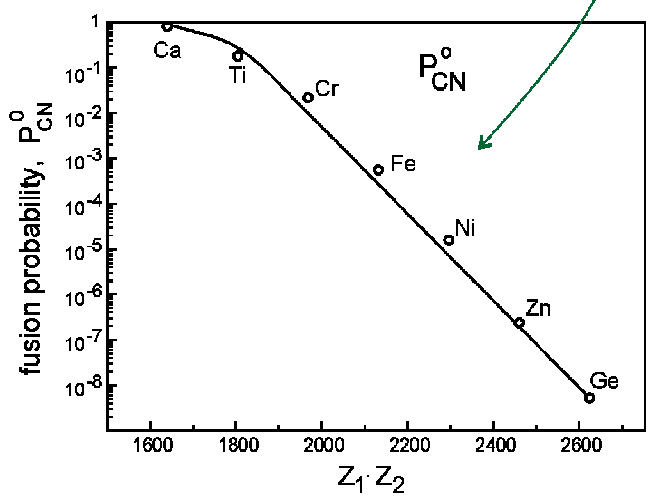
"Cold" synthesis of SHE



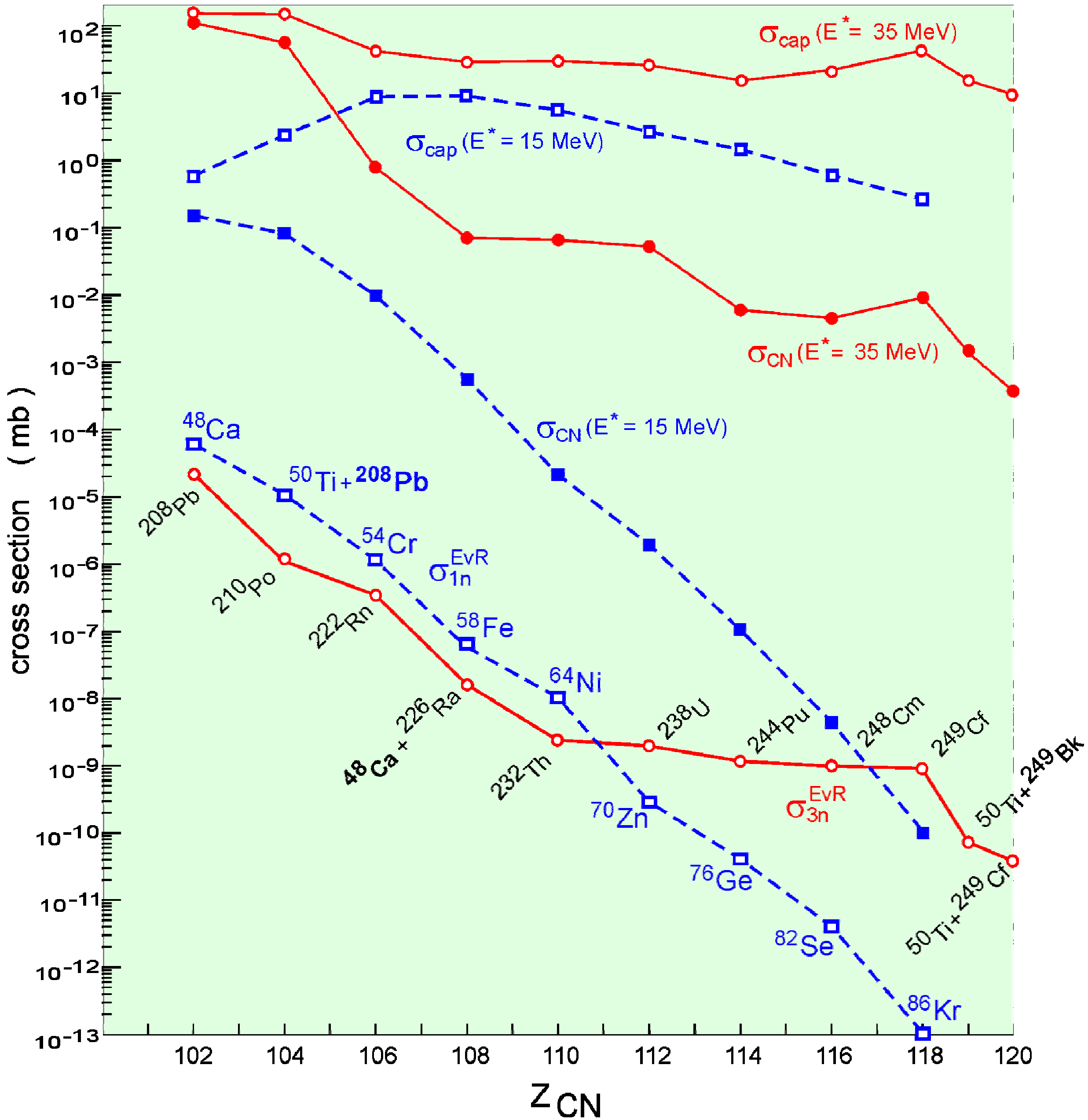
$$\sigma_{ER}^{xn}(E) = \frac{\pi}{k^2}\sum_{\ell=0}^{\infty}(2\ell+1)\cdot P_{cont}(E,\ell)\cdot P_{CN}(E^*,\ell)\cdot P_{xn}(E^*,\ell)$$



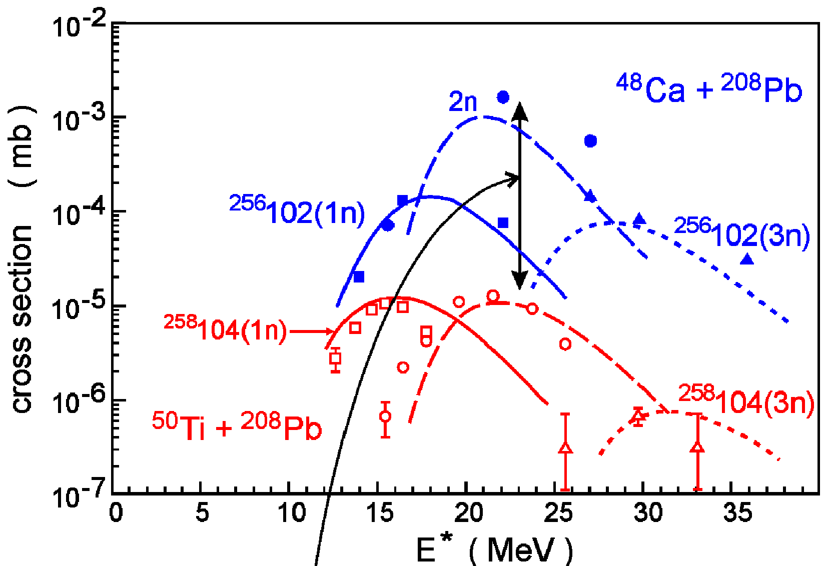
$$P_{CN}(E^*,\ell) = \frac{P_{CN}^{0}}{1 + \exp\left[\frac{E_B^* - E_{int}^*(\ell)}{\Delta}\right]}$$



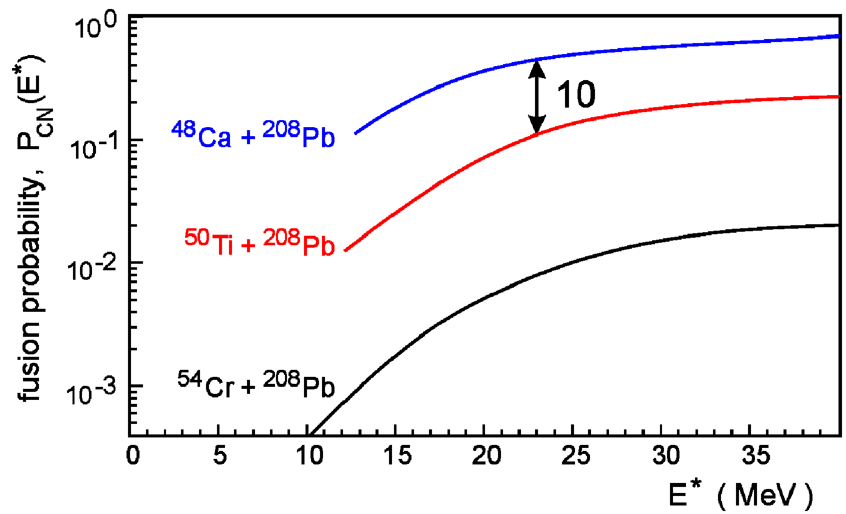
“Cold” and “Hot” synthesis of SHE

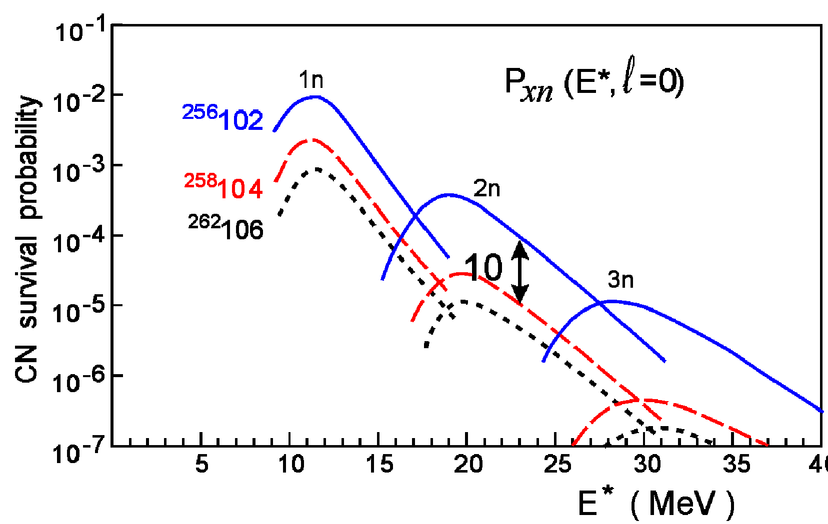


Beyond ^{48}Ca: How much ^{50}Ti is worse ?



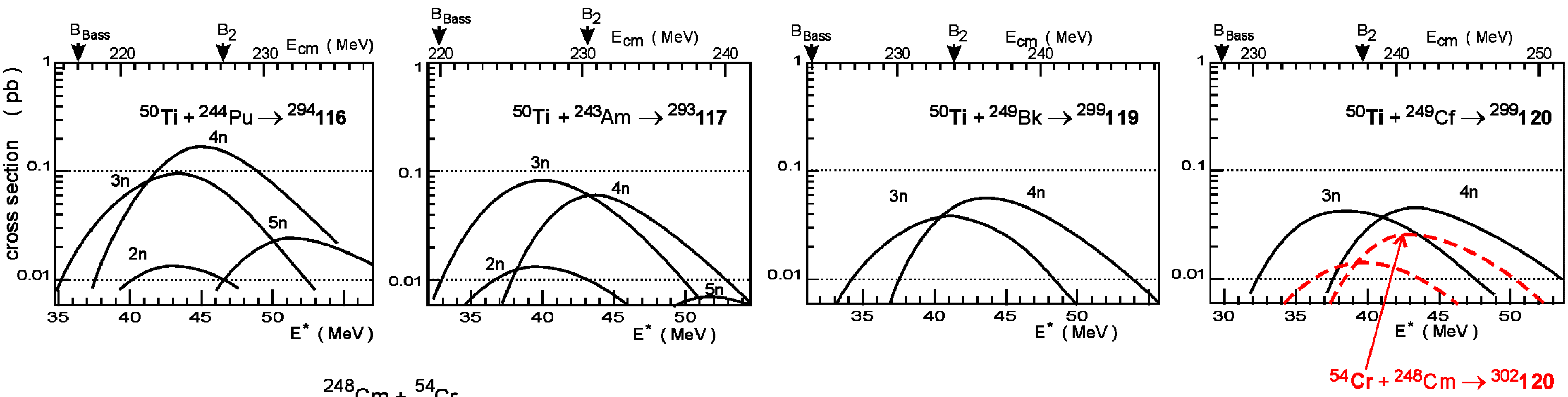
$\dfrac{\sigma(^{48}\mathrm{Ca})}{\sigma(^{50}\mathrm{Ti})}$ two orders of magnitude

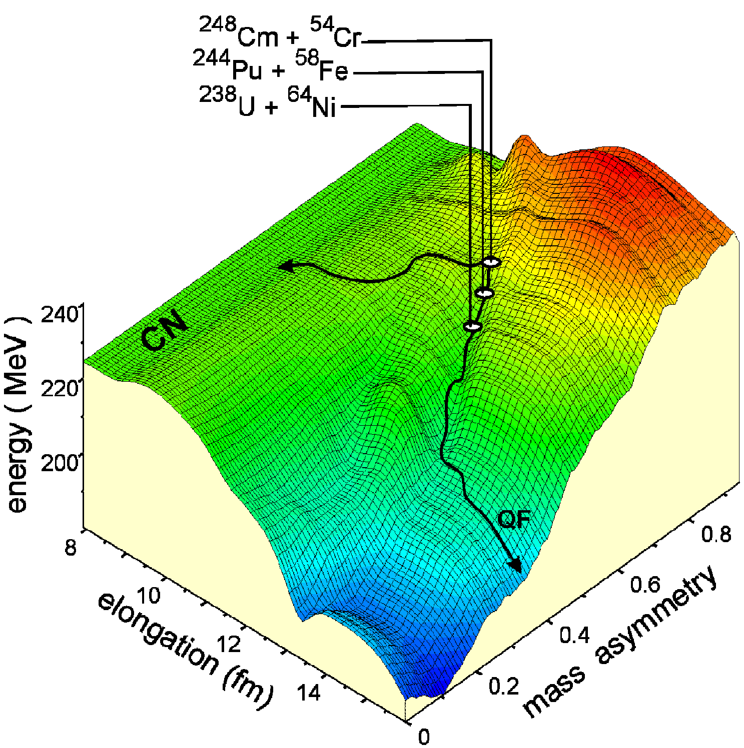


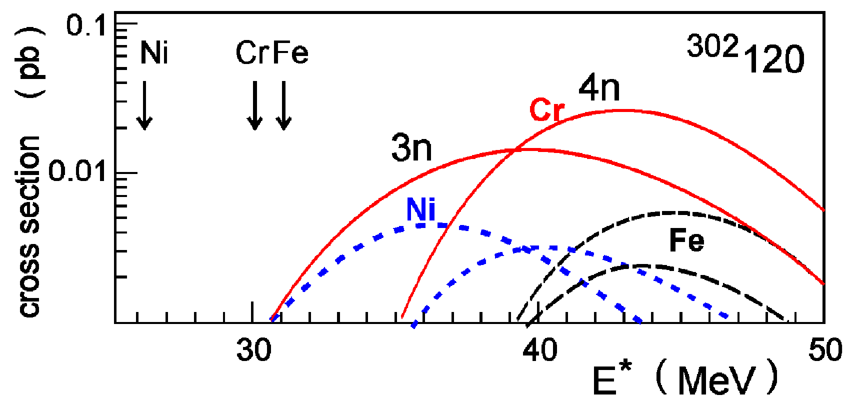


	B_{LD}	δW	B_f	E_n
^{256}102	1.26	4.48	**5.7**	**7.1**
^{258}104	0.77	4.49	**5.3**	**7.6**

Beyond ^{48}Ca: ^{50}Ti - induced fusion reactions

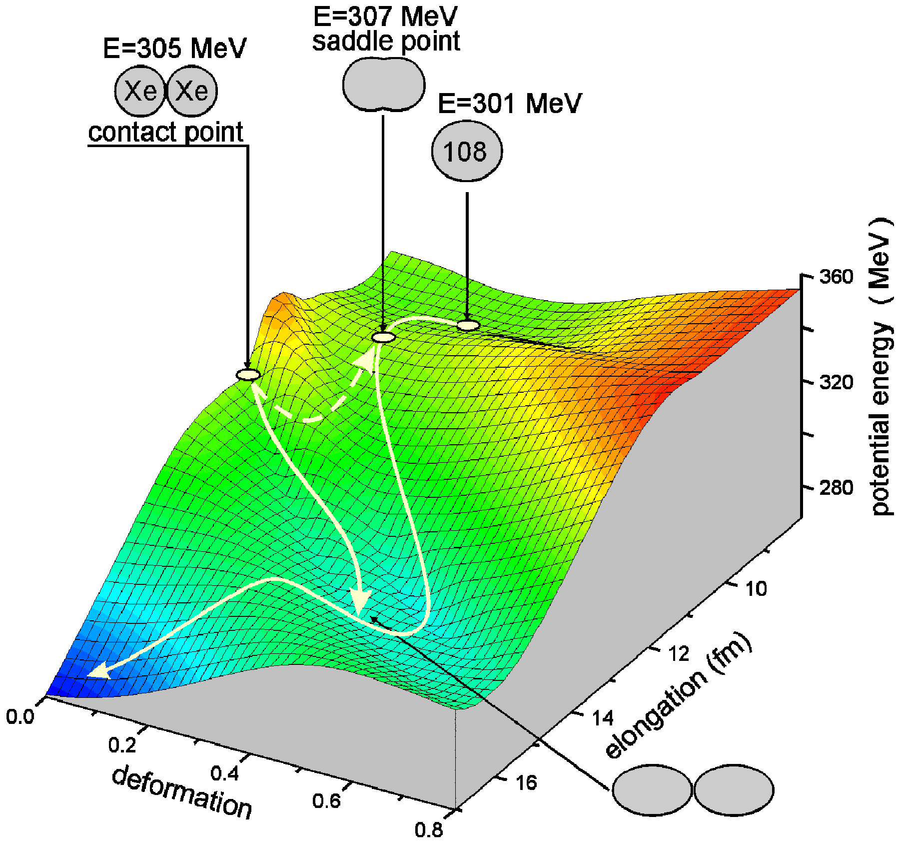


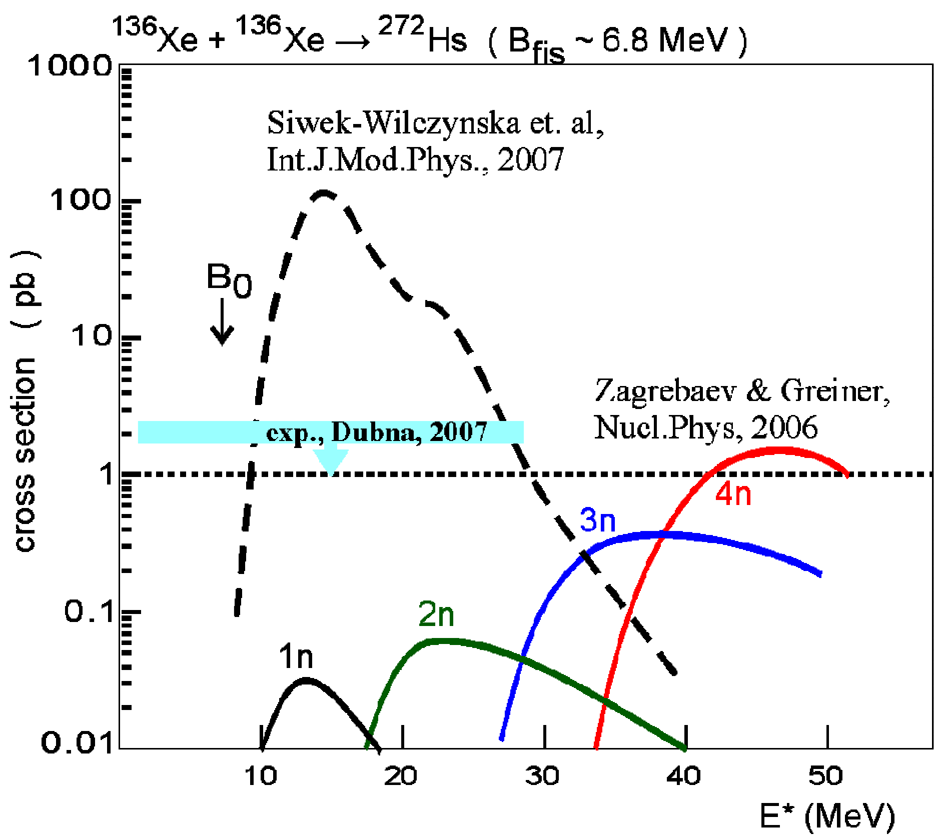




Fusion of "fission fragments": $^{136}Xe + ^{136}Xe \rightarrow {}^{272}108$

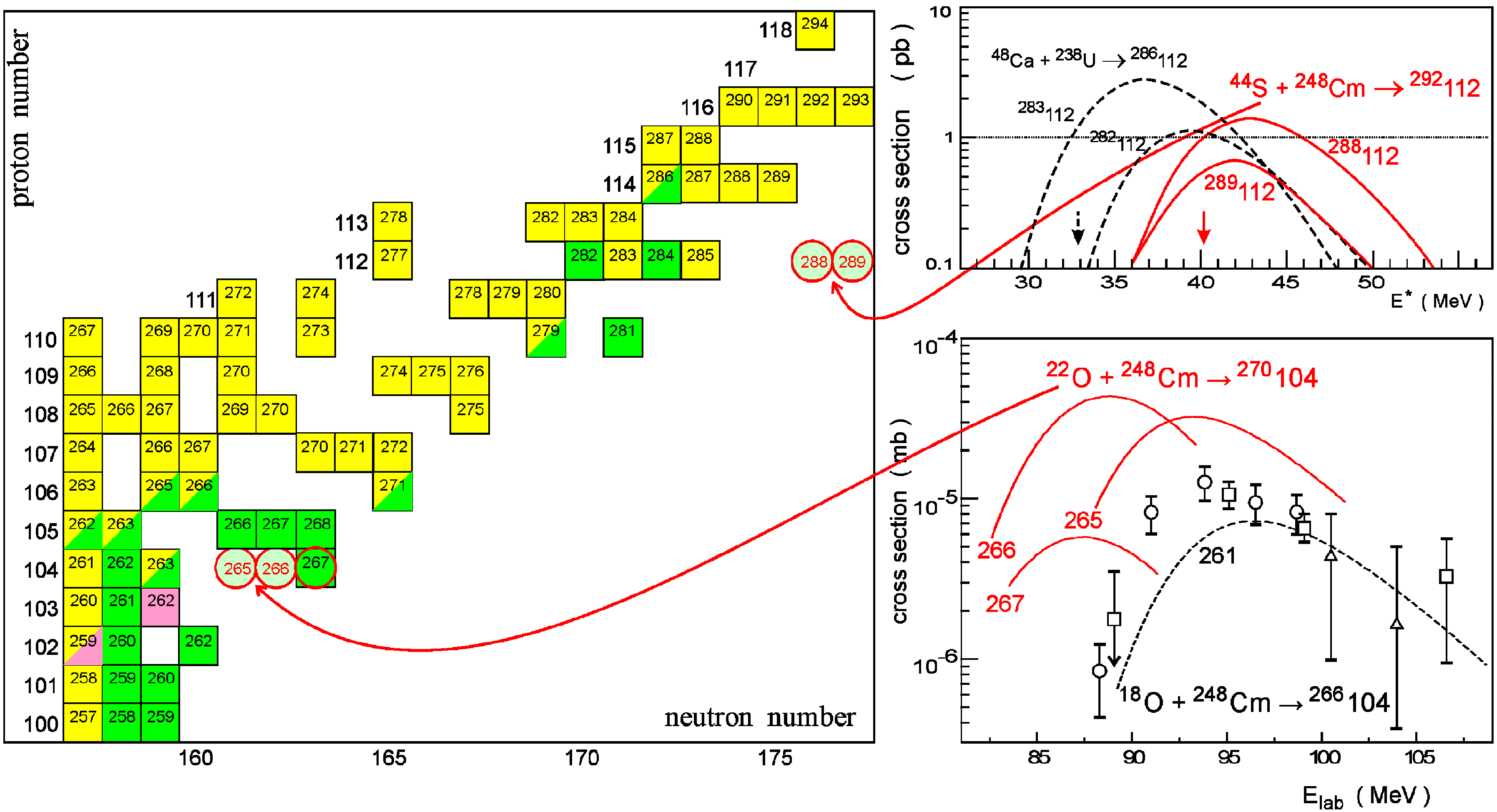
if OK then $^{132}Sn + ^{176}Yb \rightarrow {}^{308}120$



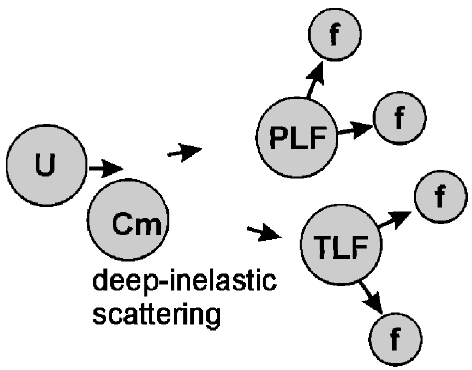


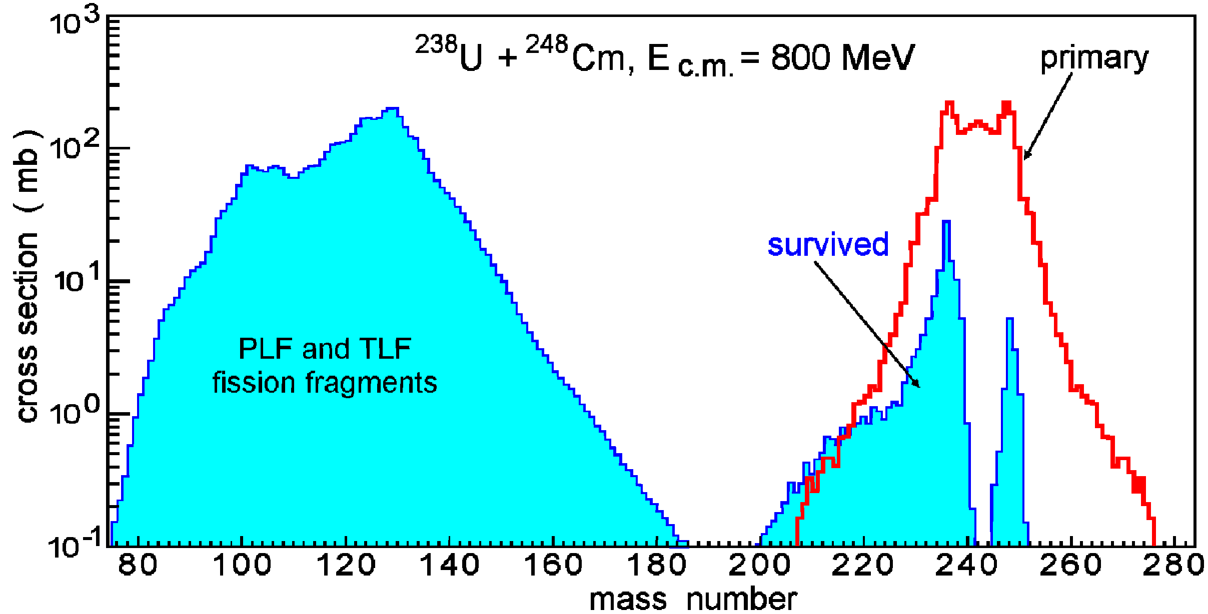
Accelerated fission fragments
hardly may be used
for production of SH nuclei

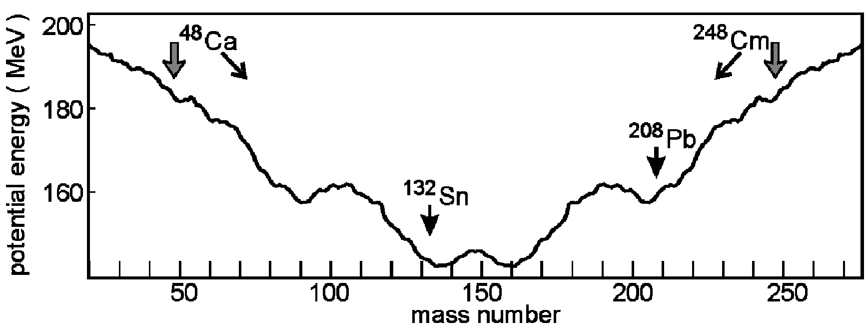
Radioactive Ion Beams
for the production of neutron rich superheavy nuclei



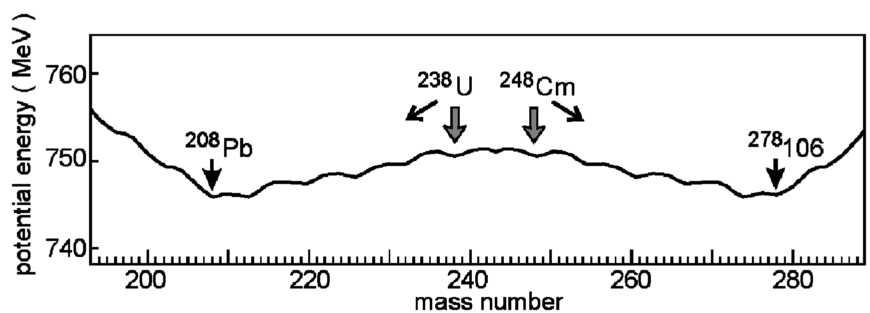
Transfer reactions in damped collision of very heavy nuclei ?





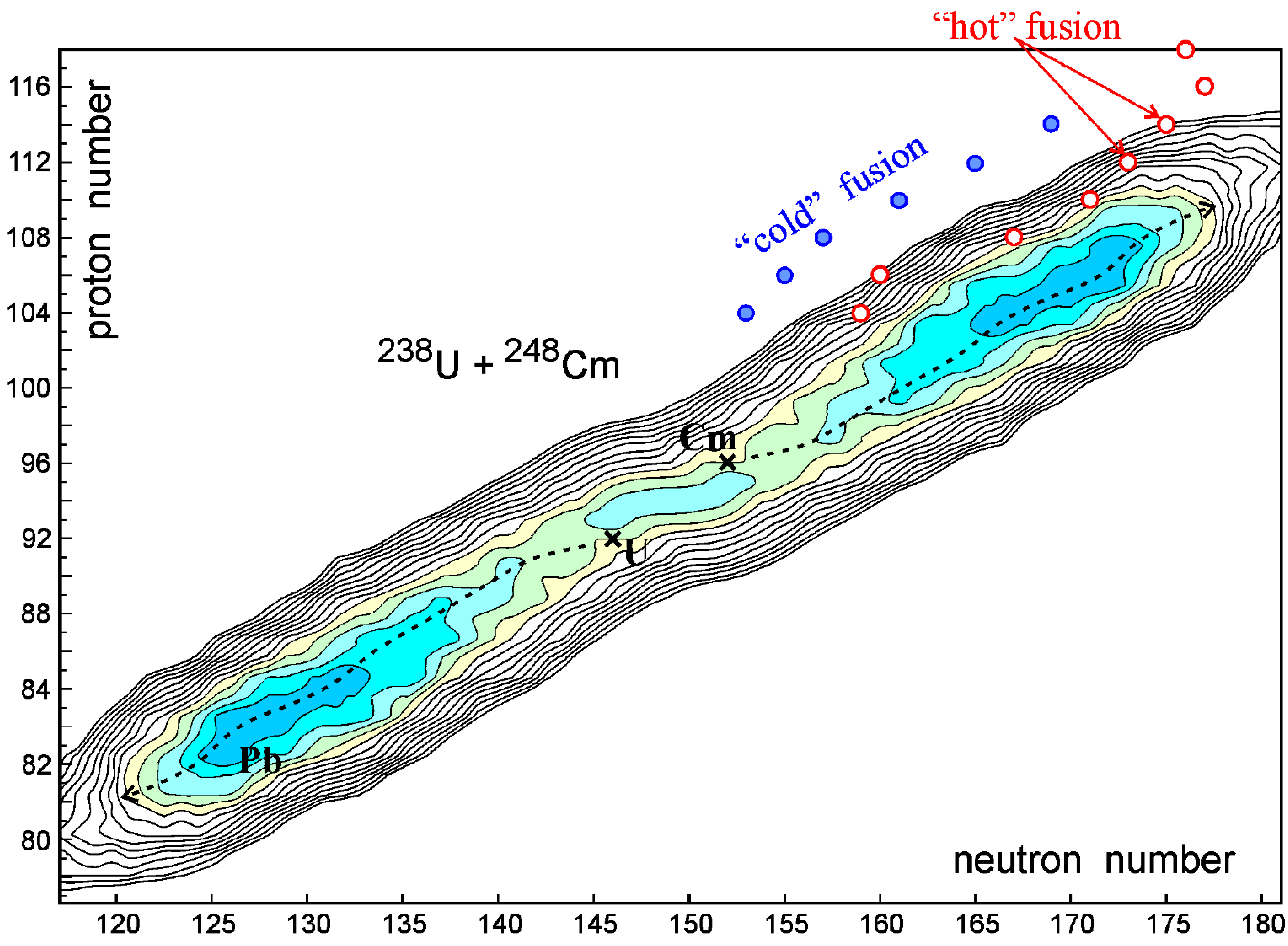


ordinary (symmetrizing) quasi-fission

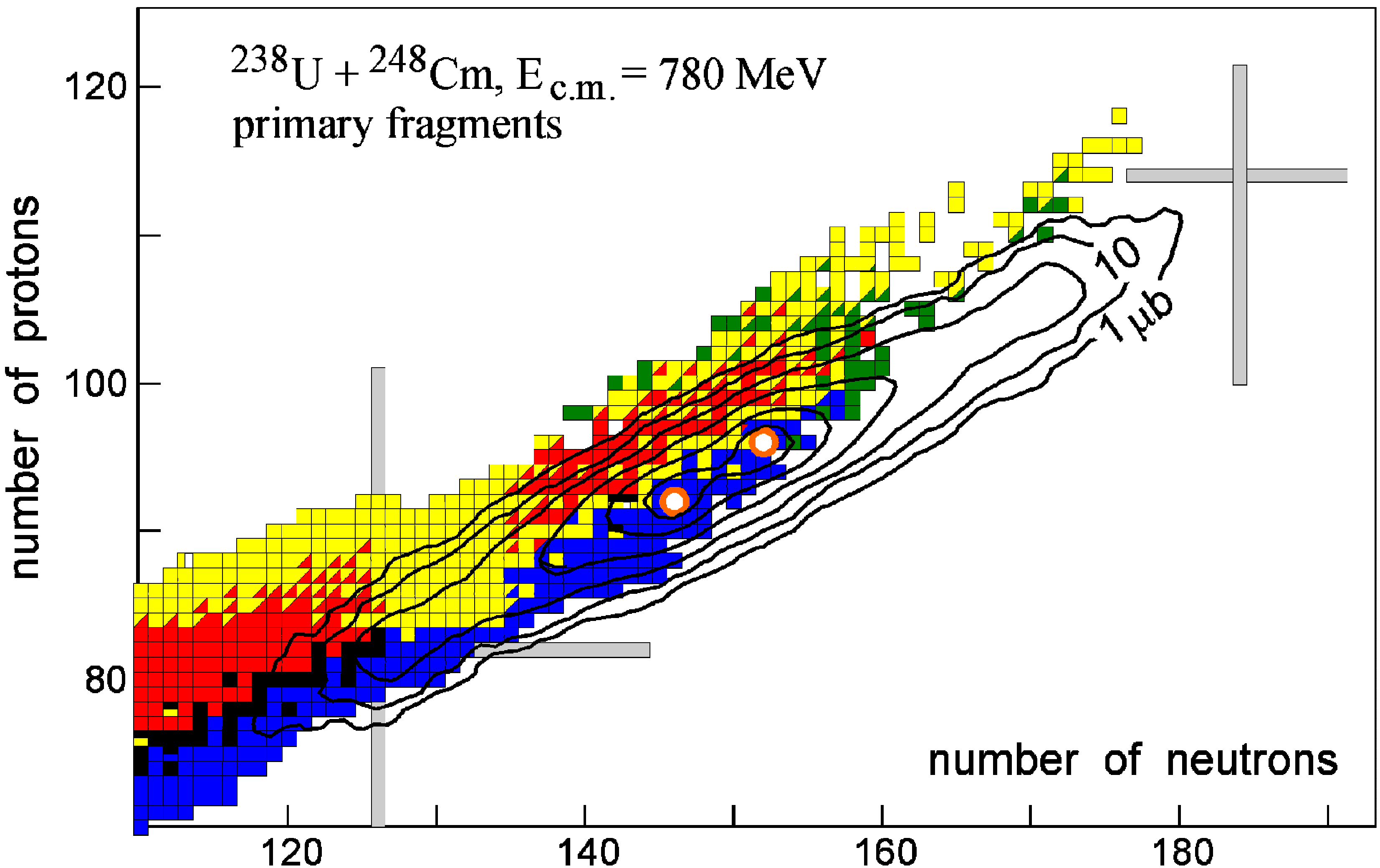


anti-symmetrizing quasi-fission

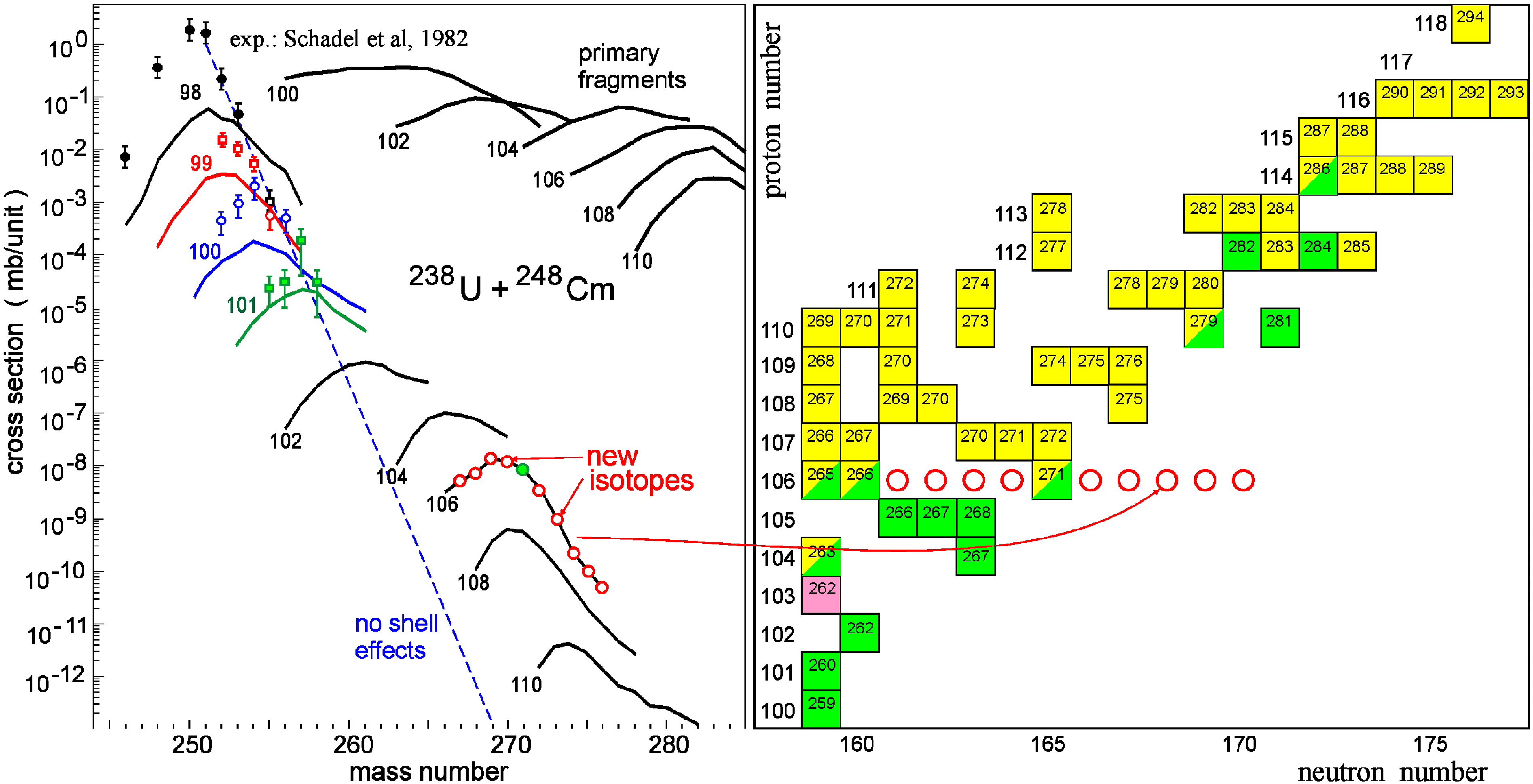
Production of SHE along the stability line in low-energy collisions of actinide nuclei



238U + 248Cm. Primary fragments



Production of neutron-rich SHE in low-energy collisions of heavy actinide nuclei



Summary

- **Resources of the cold synthesis (with Pb and Bi targets) seems to be exhausted.**
- **The production of SH elements in fusion reactions with accelerated fission fragments does not look very encouraging. Only if an extremely high beam intensity were to be attained would the chances increase.**
- **The use of light and medium-mass neutron-rich radioactive beams may help us to obtain and explore SH neutron-rich nuclei in the region of 102<Z<112.**
- **In the hot fusion reactions of ^{50}Ti and ^{54}Cr with actinide targets the SH elements Z=120-122 might be synthesized with the cross sections of 10-50 fb**
- **SH neutron-rich nuclei close to the island of stability can be produced in low-energy damped collisions of actinide nuclei (U +Cm).**
- **Low-energy multi-nucleon transfer reactions allow us to fill and explore also the “blank spot” at the north-east part of the nuclear map (important for astrophysics investigations)**