Probing the Stability of Superheavy Nuclei with Radioactive Ion Beams

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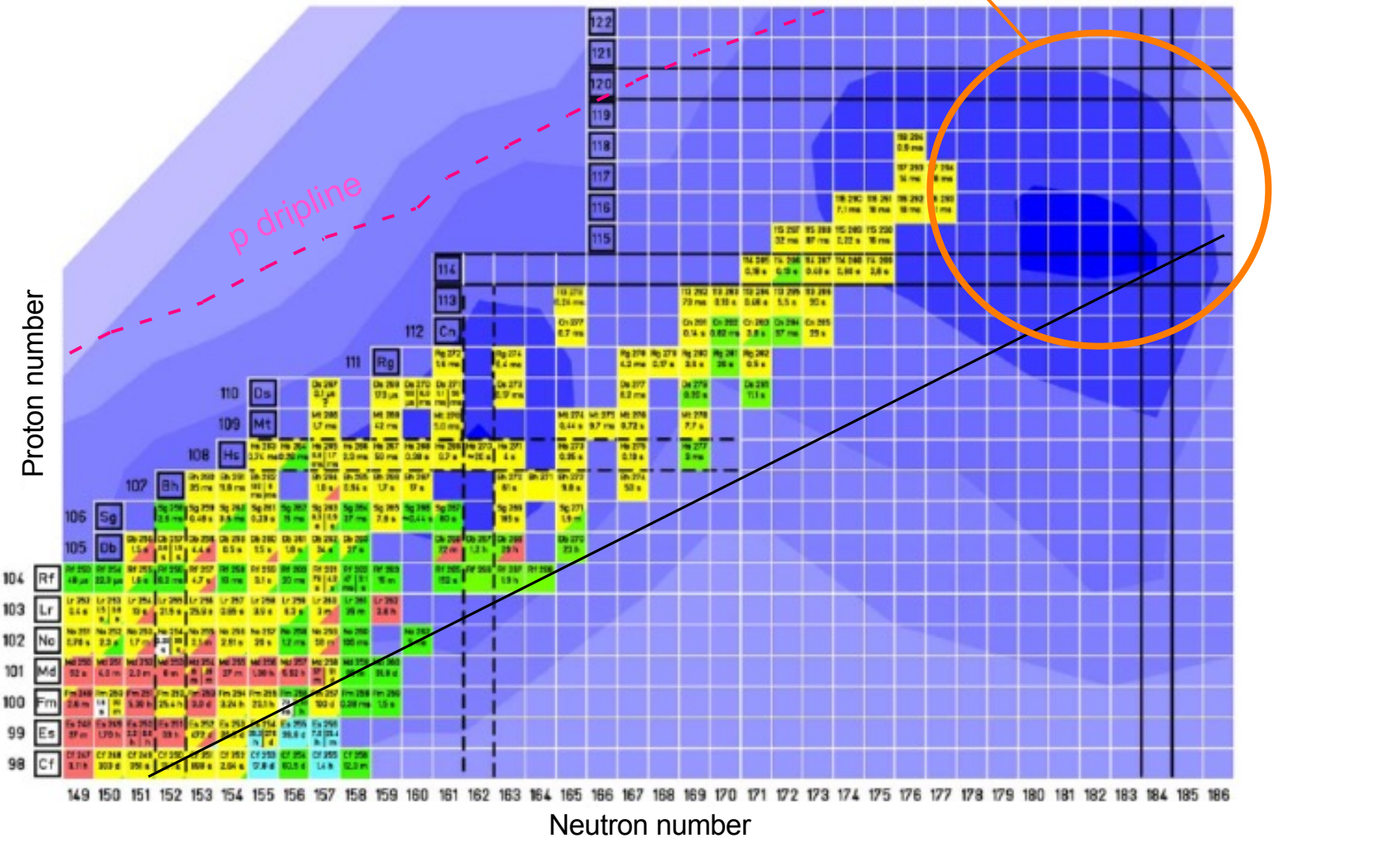
How to Access the N=184 region?

can be reached with n-rich RIBs, <u>but</u>:

- ♦ small ER cross-sections
- ♦ small RIB intensities

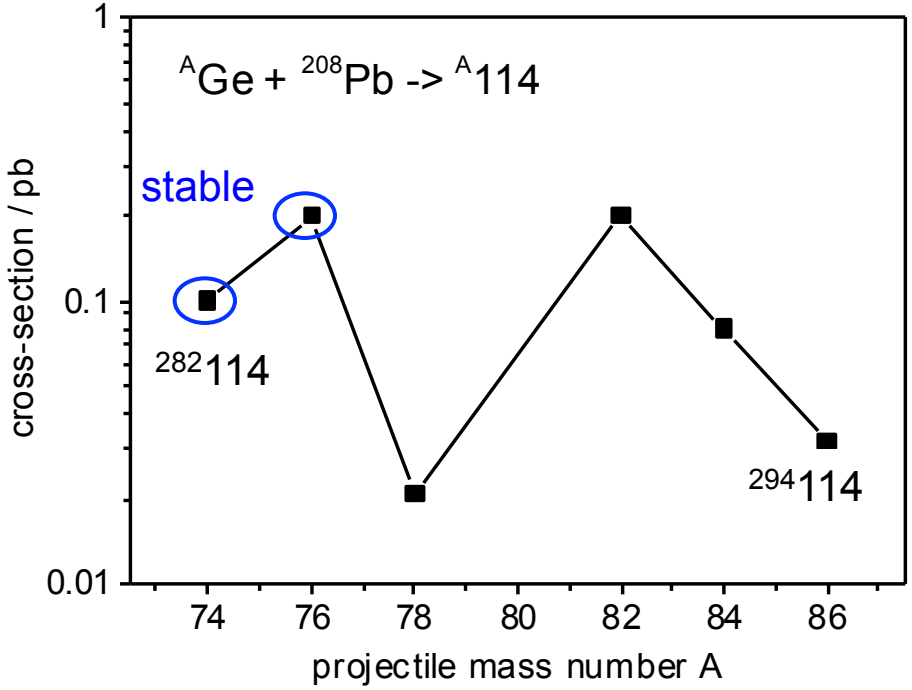


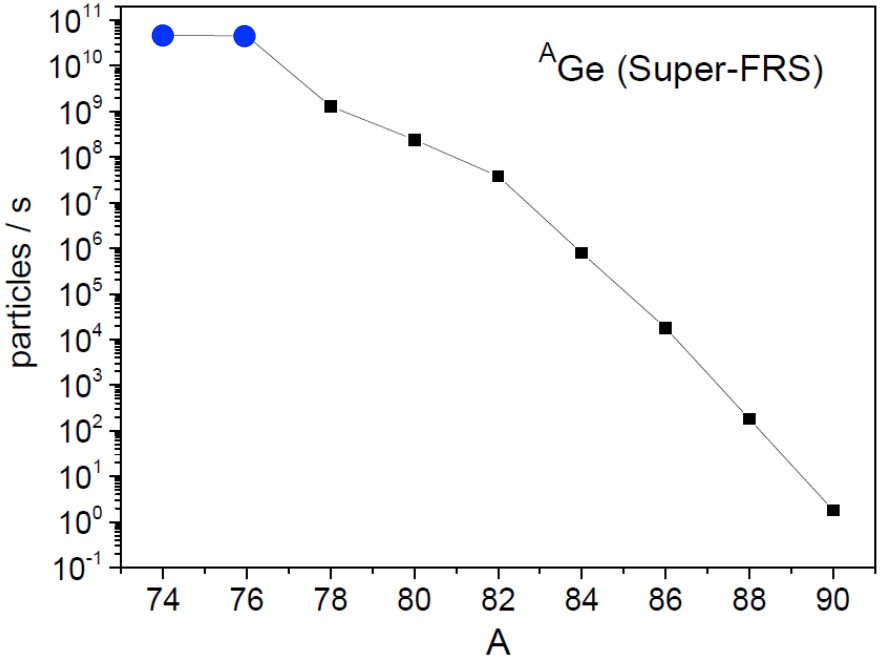
Synthesis of Neutron-rich Isotopes with RIBs?

More neutrons does not mean larger fusion residue cross-sections.

example: ^{A}Ge + ^{208}Pb → ^{A}114*

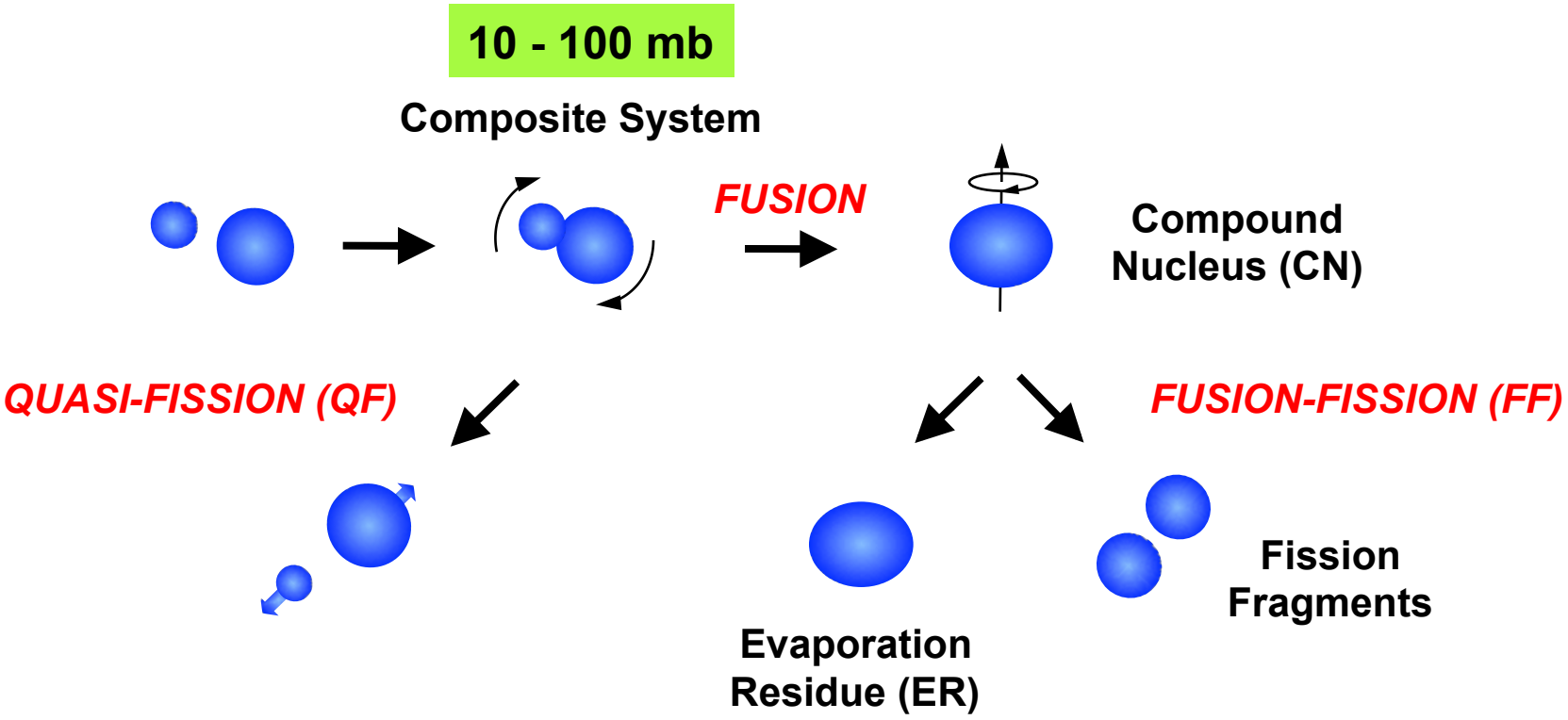
(Theorie: G. Adamian, N. Antonenko, W. Scheid, DNS model)





expected yields for σ = 0.1 pb and 10^{9} proj./s: 1 event in 300 years

The Fusion Process in Heavy Systems



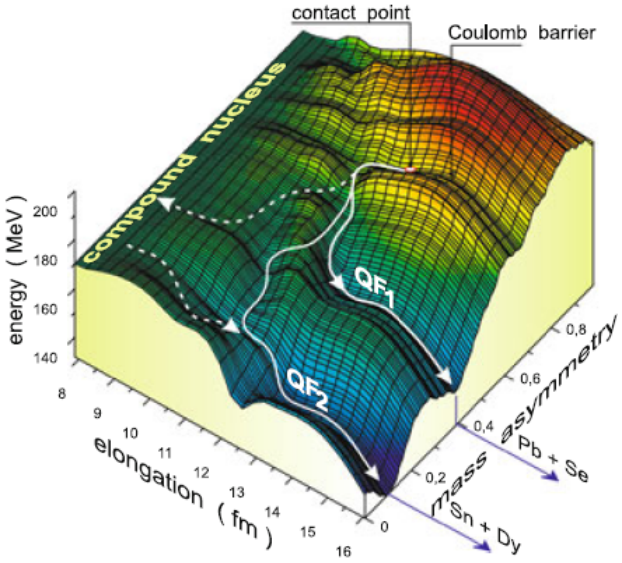
$$\sigma_{ER} = \sigma_{capture} \cdot P_{CN} \cdot P_{survival}$$

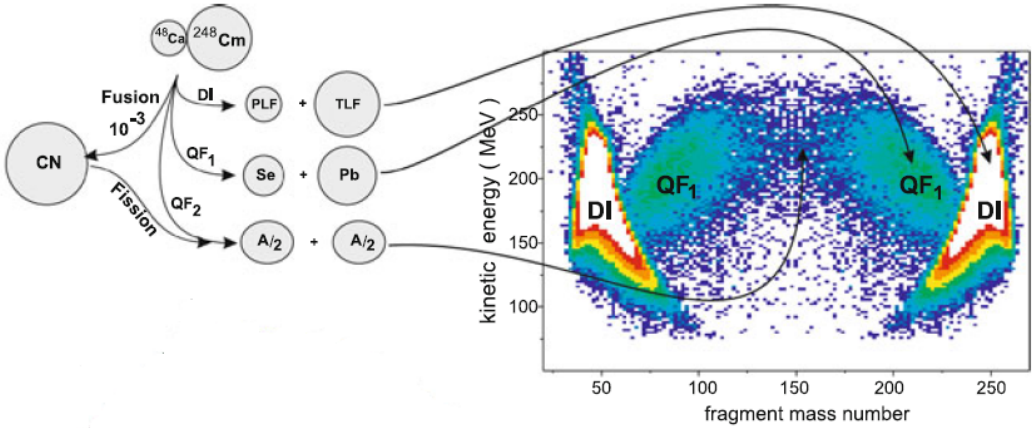
Superheavy systems: $\sigma_{ER} << \sigma_{capture} \longrightarrow \sigma_{capture} \approx \sigma_{QF} + \sigma_{FF} = 10 - 100$ mb

The Fusion Process in Heavy Systems

Movement of the nuclear system on the potential energy surface

example: 48Ca + 248Cm





V. Zagrebaev and W. Greiner

- Study of QF and FF allows the „mapping“ of the potential energy surface
- expected yields for σ = 100 mb and 10^6 proj. / s: ~300 / hour
- experiments are possible in very near future at HIE-ISOLDE, CERN

The HIE-ISOLDE Project at CERN

HIE-ISOLDE: an energy, intensity and quality upgrade

ISOLDE (since 1967) **REX-ISOLDE (2001)** **HIE-ISOLDE (2015)**

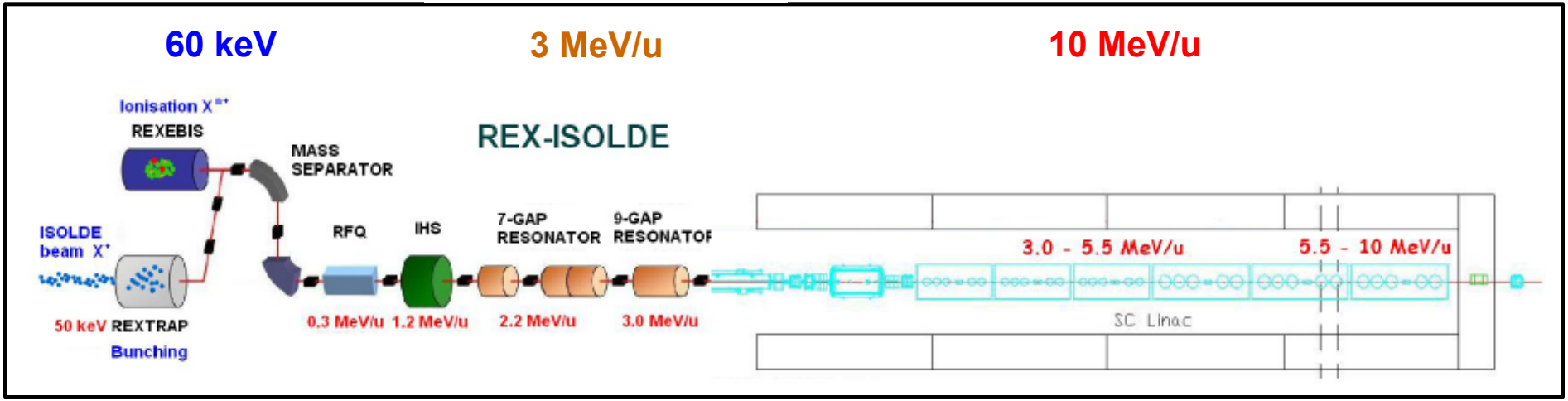


figure: CERN web page

Timeline:

- 2015: installation of LINAC stage 1 + beamlines; first beam in October 2015 (up to 5.5 MeV/u)
- 2016: LINAC stage 2 and 3: beam energies up to 10 MeV/u

Our first experiment at HIE-ISOLDE

The reaction ^{A}Rb + ^{209}Bi → ^{A}120*

- Rb beams are available in a broad range of N and with high intensities
- With ^{95}Rb the N = 184 shell can be reached

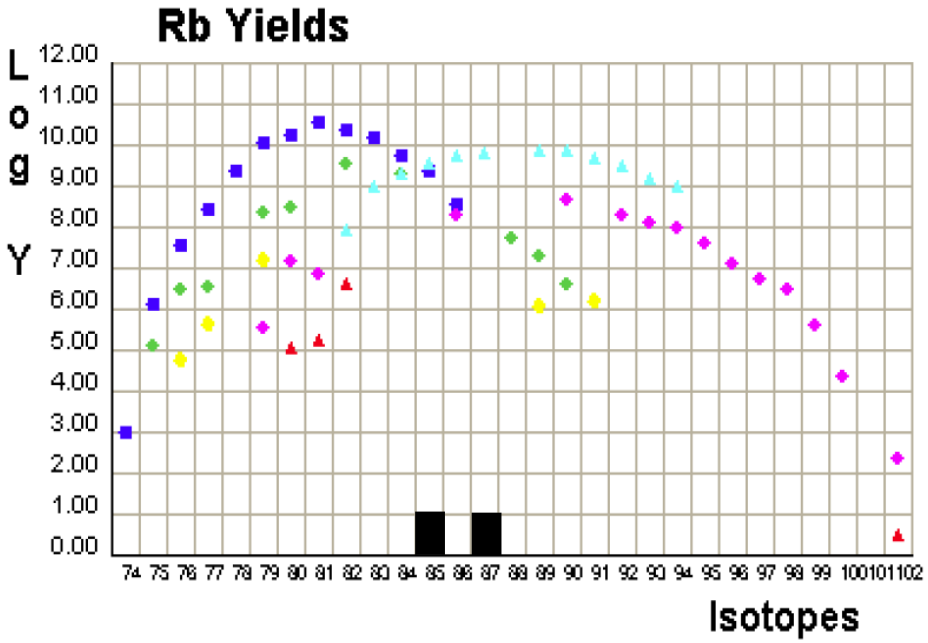
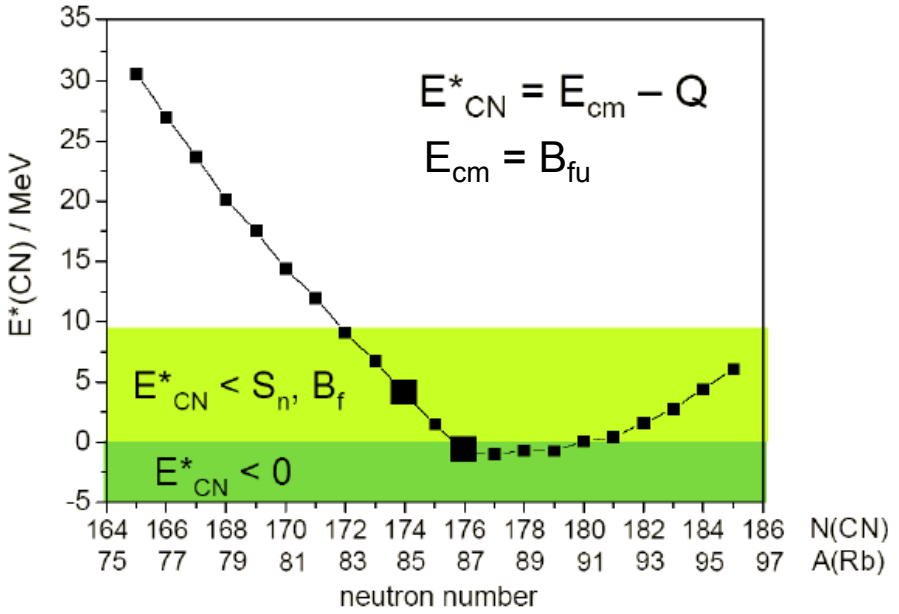


figure: CERN web page



$E^*_{CN} < S_n \approx 10$ MeV → no neutron evaporation
$E^*_{CN} < B_f \approx 5$ MeV → no CN fission
$E^*_{CN} < 0$ → no CN formation

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Study of the Di-nuclear System ^{A}Rb + ^{209}Bi ($Z_1 + Z_2 = 120$)

October 1, 2012

S. Heinz[1,2], E. Kozulin[3], C. Beck[4], O. Beliuskina[1], T. Dickel[2], H. Geissel[1,2], S. Hofmann[1], M. Itkis[3], Y. Itkis[3], D. Kamanin[3], B. Kindler[1], G. Knyazheva[3], T. Loktev[3], B. Lommel[1], J. Maurer[1], A. Di Nitto[5], W. Plass[2], W. Trazska[6], E. Vardaci[5], L. Vayshnene[8]

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[2] Justus-Liebig-Universität Gießen, 35392 Gießen, Germany
[3] Joint Institute of Nuclear Research, 141980 Dubna, Russia
[4] IPHC Department RS, Strasbourg, France
[5] Dipartimento di Scienze Fisiche del'Universita di Napoli, 80126 Napoli, Italy
[6] Department of Physics, University of Jyväskylä, FI 40500, Finland

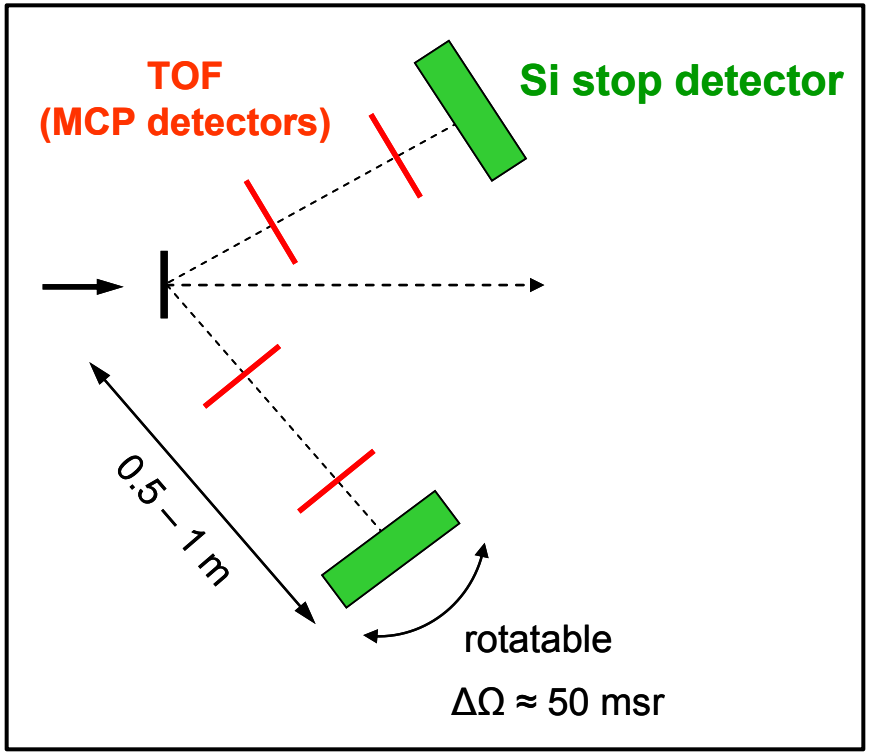
Spokespersons: Sophie Heinz (s.heinz@gsi.de), Eduard Kozulin (kozulin@jinr.ru)

Decision of the CERN INTC, December 2012:

„ … formation of the capture probability. The two-arm CORSET setup providing mass- and energy information will be employed at 3 different ^{95}Rb beam energies. The proposal is very interesting and will initiate a new program at ISOLDE. It was requested that stable Rb beam be used for … “

Experimental Setup for the Study of ^{A}Rb + ^{209}Bi

CORSET detection system, Dubna (E. Kozulin et al.)



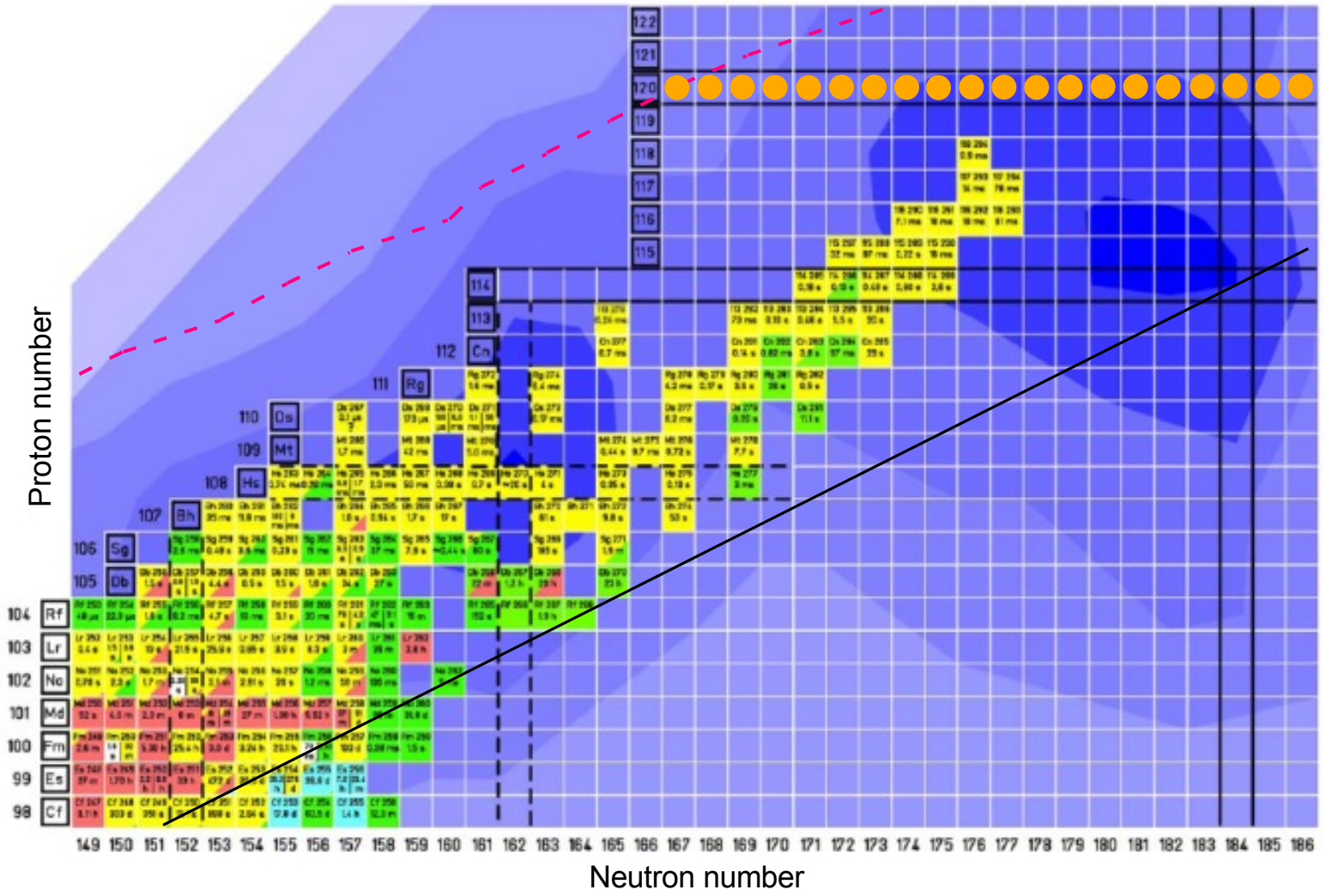
TOF, E → A, TKE

Experimental program:

Measurement of A -TKE distributions of as a function of projectile neutron number and beam energy

The Heaviest Known Nuclei

- ^{A}Rb + ^{209}Bi composite systems reachable Rb RIBs of intensity > 5 ·10^{6} / spill



Summary

- The N=184 shell cannot be reached on mid-term time scale in fusion-evaporation reactions with RIBs

- But: QF and FF appear with large cross-sections of ~100 mb and allow the probing of the PES → possible with RIB intensities ≥ 10^6 part. / s

- RIBs with energies up to >5 MeV/u available at HIE-ISOLDE (CERN) starting from late 2015