Barrier distribution for fusion to synthesize superheavy elements: role of static deformation of a target nucleus

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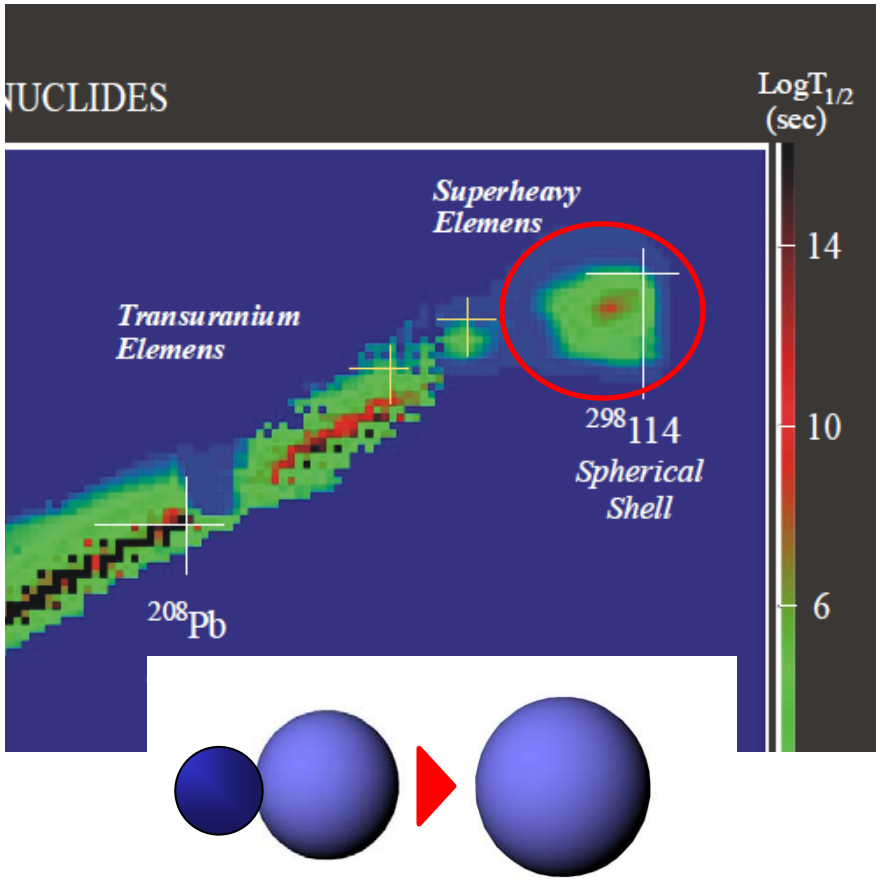
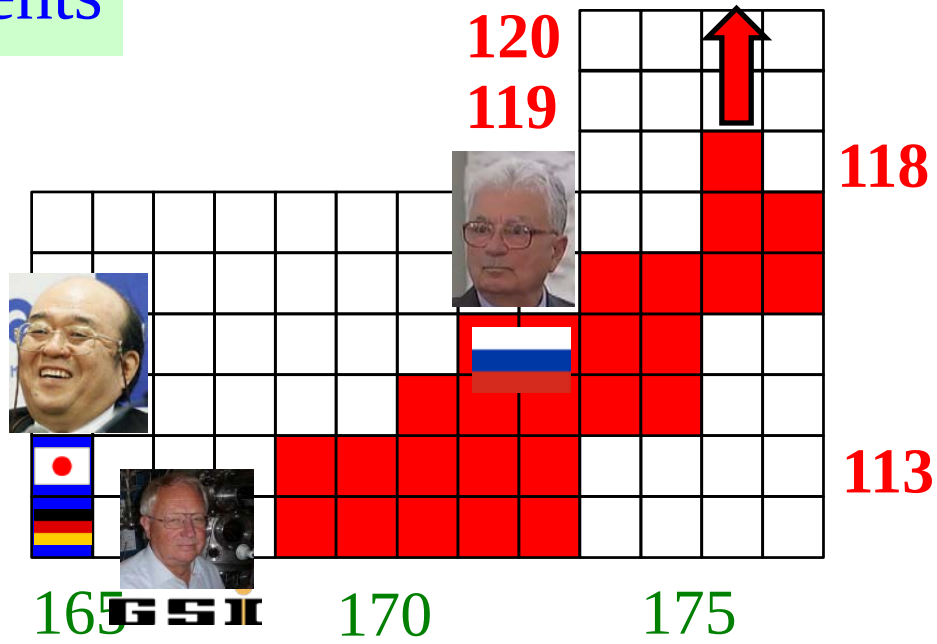
1. Hot fusion reactions for superheavy elements
2. Nuclear deformation and barrier distribution
3. Extended Fusion-by-diffusion model
4. Summary

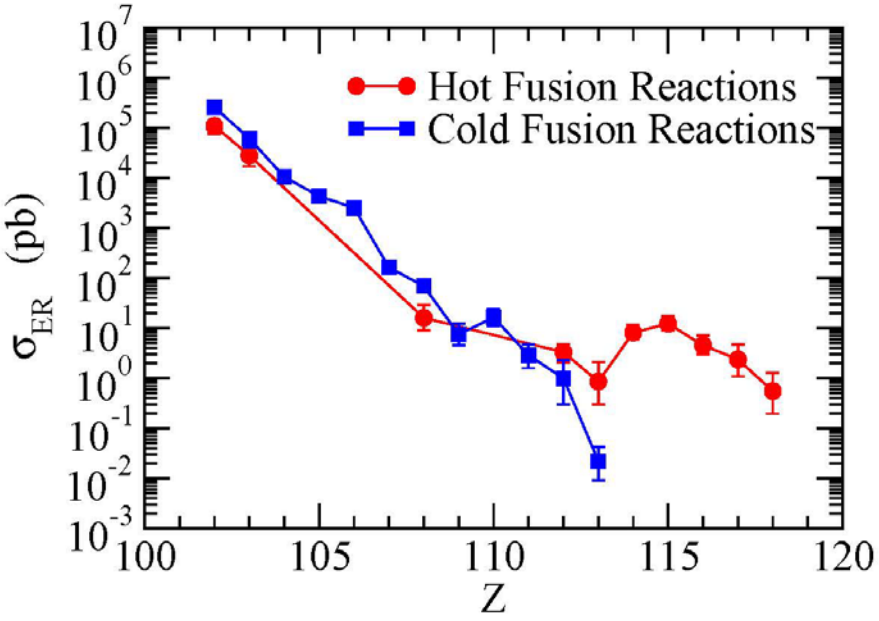
The NN2018, Dec. 4-8, 2018, Omiya, Japan

Introduction: superheavy elements

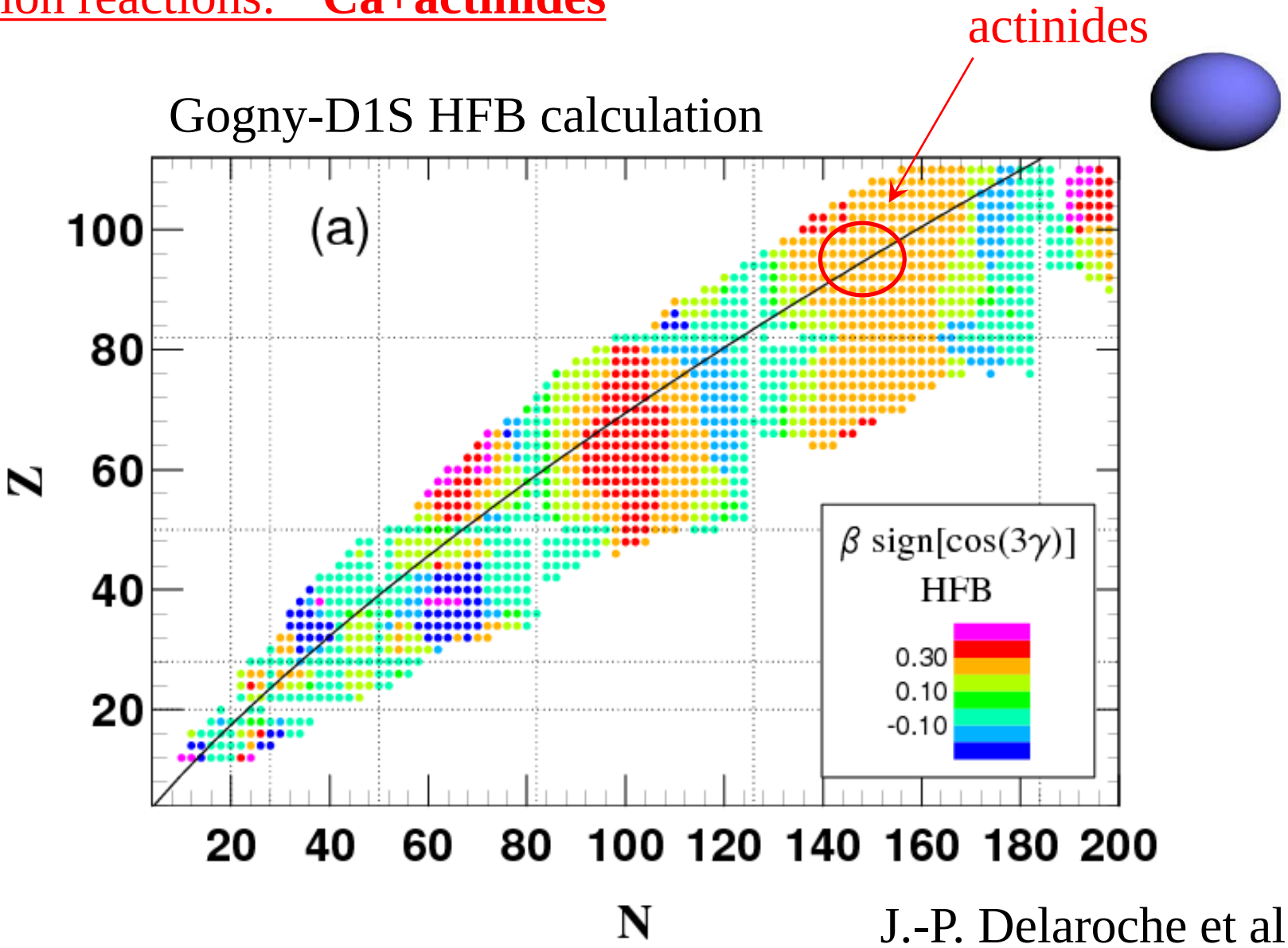


fusion reaction





Hot fusion reactions: ^{48}Ca+actinides



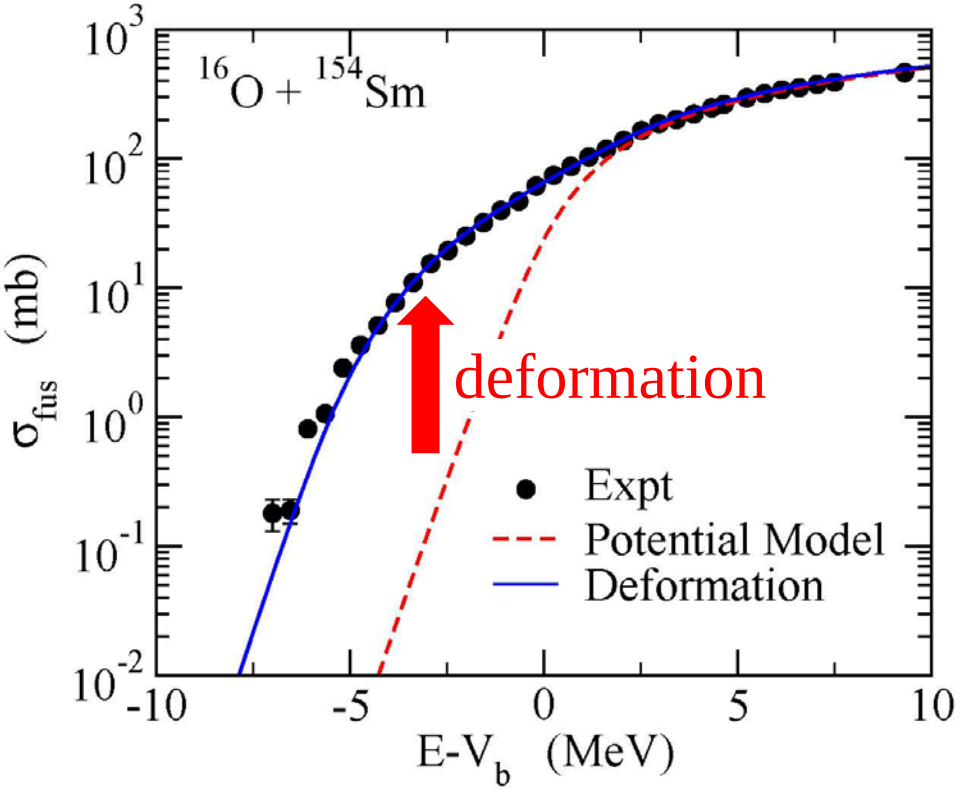
J.-P. Delaroche et al., PRC81 (‘10) 014303

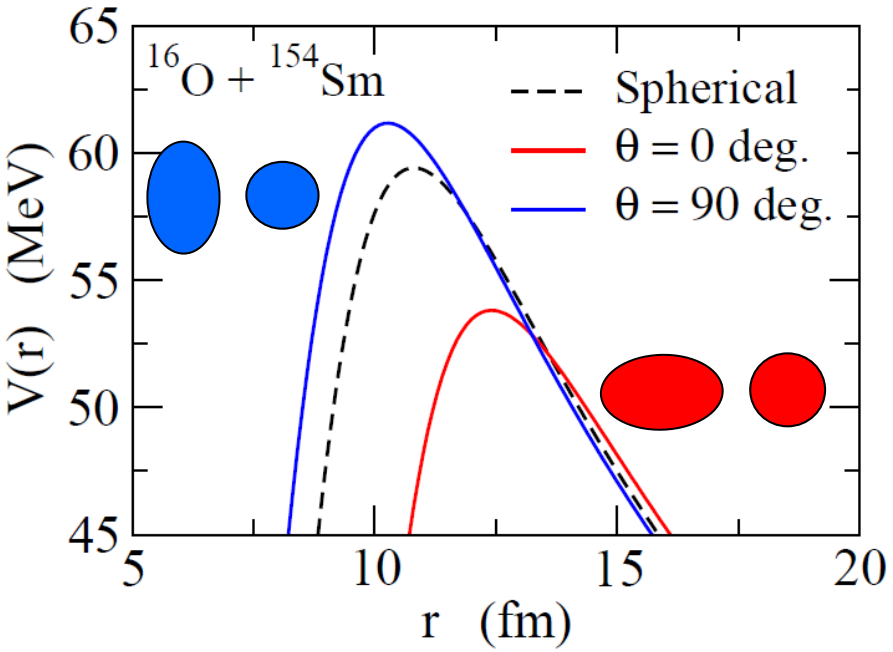
What is the role of deformation in fusion?

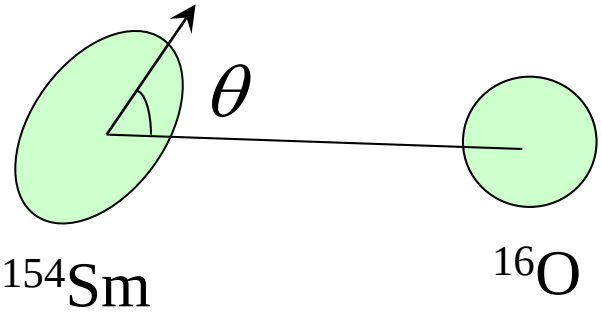
Nuclear deformation and barrier distribution

fusion in the medium-heavy region: a large sub-barrier enhancement

$^{16}O+^{154}Sm$



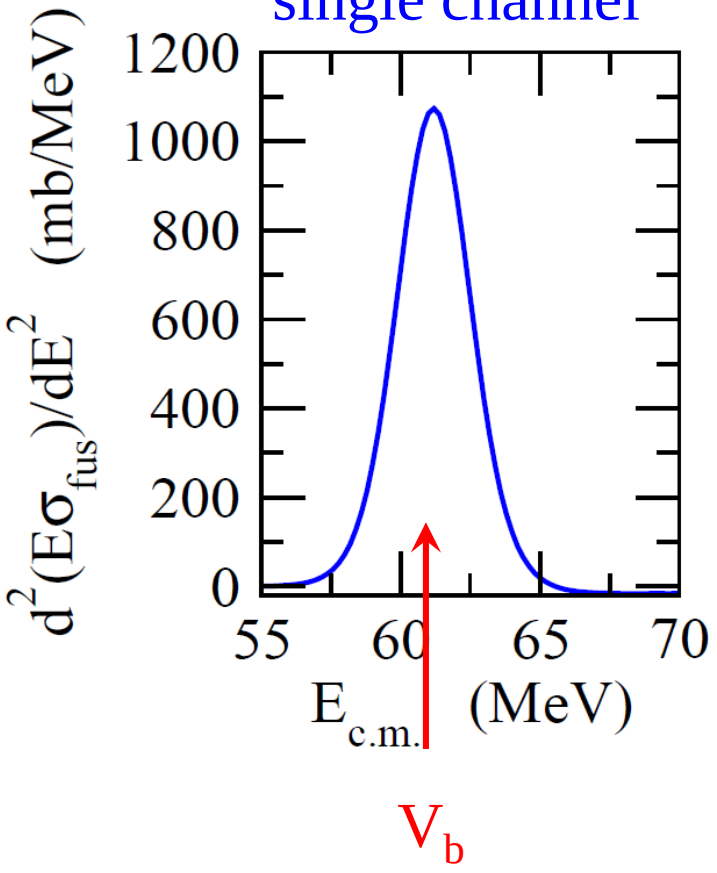


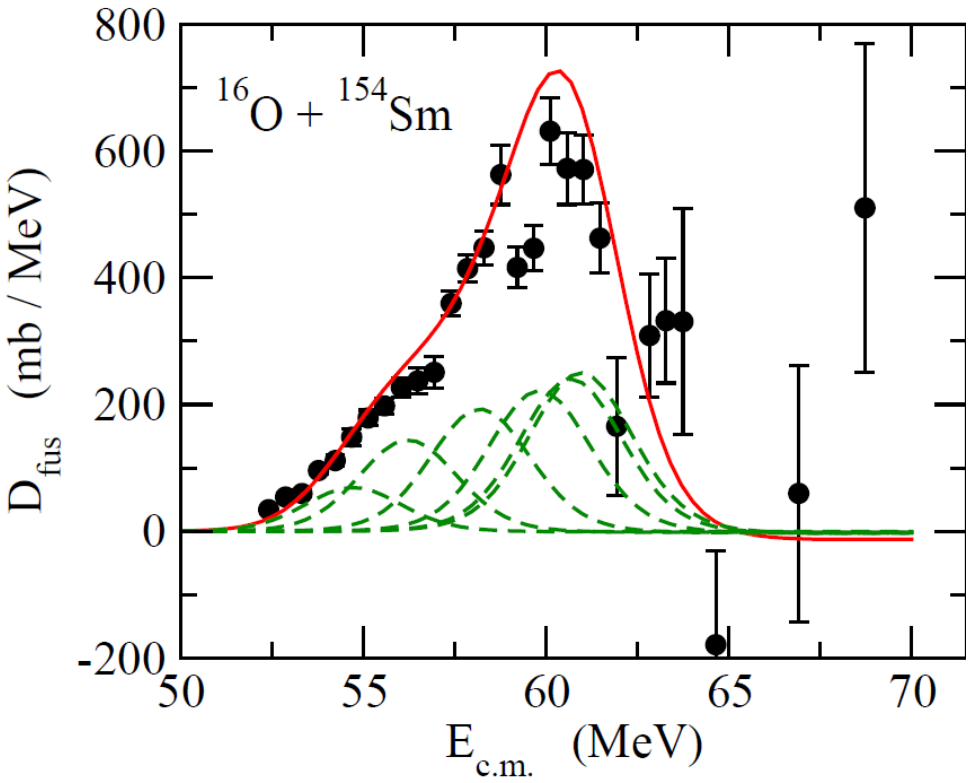


Fusion barrier distribution [Rowley, Satchler, Stelson, PLB254('91)]

$$D_{\rm fus}(E) = \frac{d^2(E\sigma_{\rm fus})}{dE^2} \propto \frac{dP_{l=0}}{dE}$$

single channel

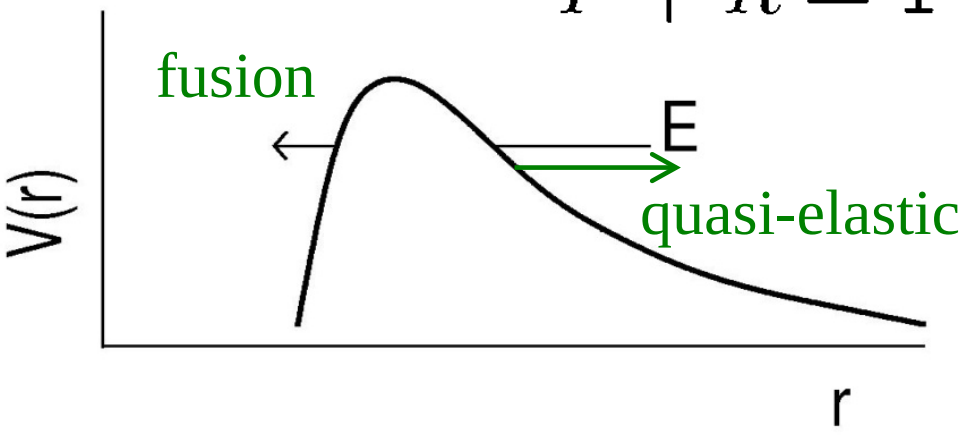




K.H., N. Takigawa, PTP128 ('12) 1061

Quasi-elastic barrier distribution

$$P + R = 1$$

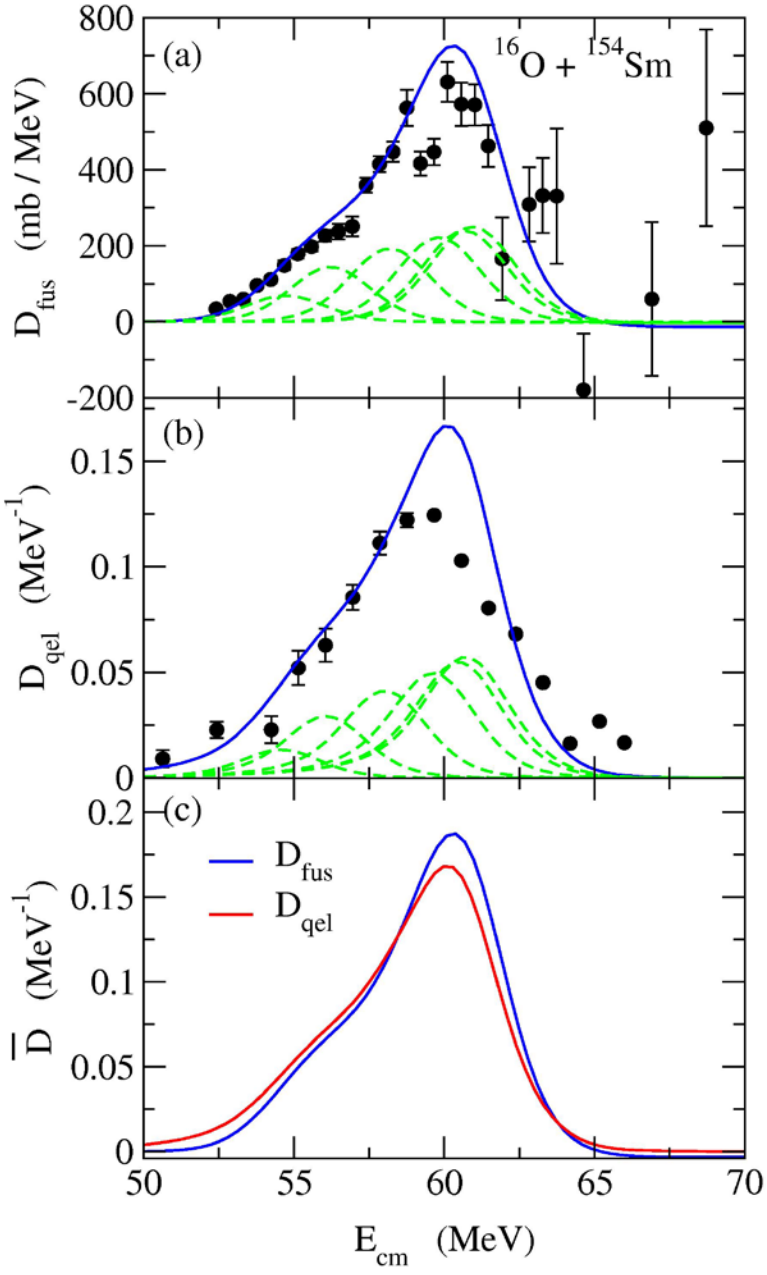


$$\sigma_{\mathrm{qel}} = \sigma_{\mathrm{el}} + \sigma_{\mathrm{inel}} + \sigma_{\mathrm{trans}}$$

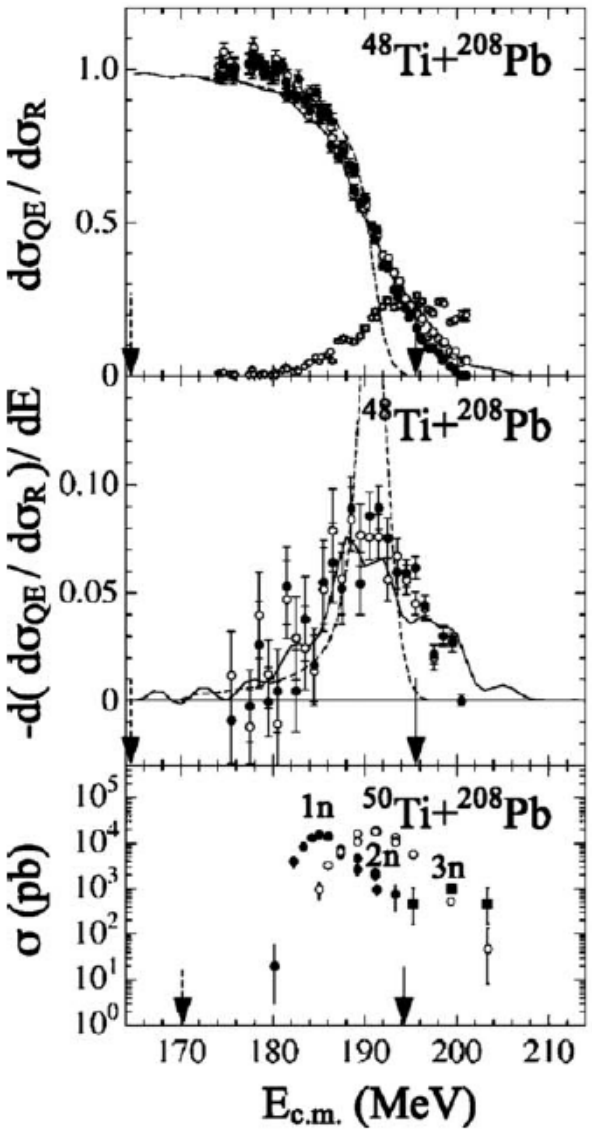
Quasi-elastic barrier distribution

$$D_{\mathrm{qel}}(E) = -\frac{d}{dE}\left(\frac{\sigma_{\mathrm{qel}}(E,\pi)}{\sigma_R(E,\pi)}\right)$$

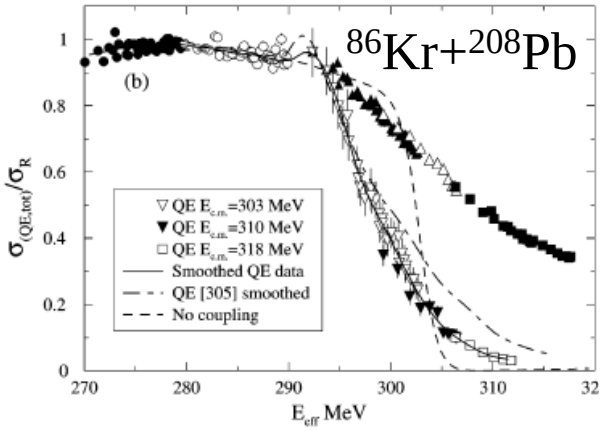
H. Timmers et al., NPA584('95)190
K.H. and N. Rowley, PRC69('04)054610



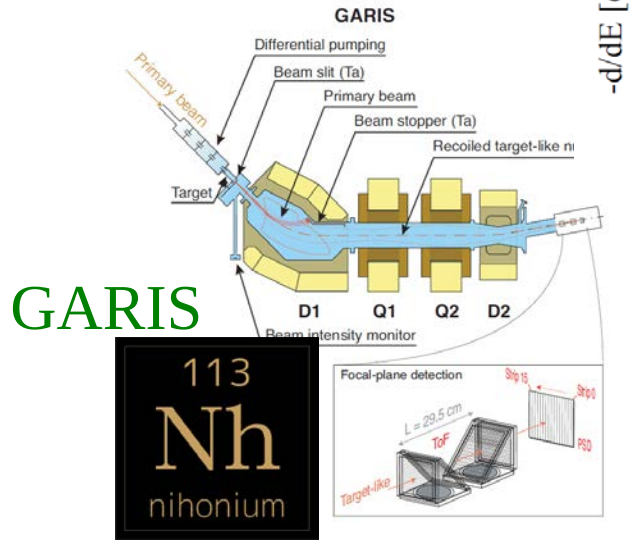
Application to fusion for superheavy elements



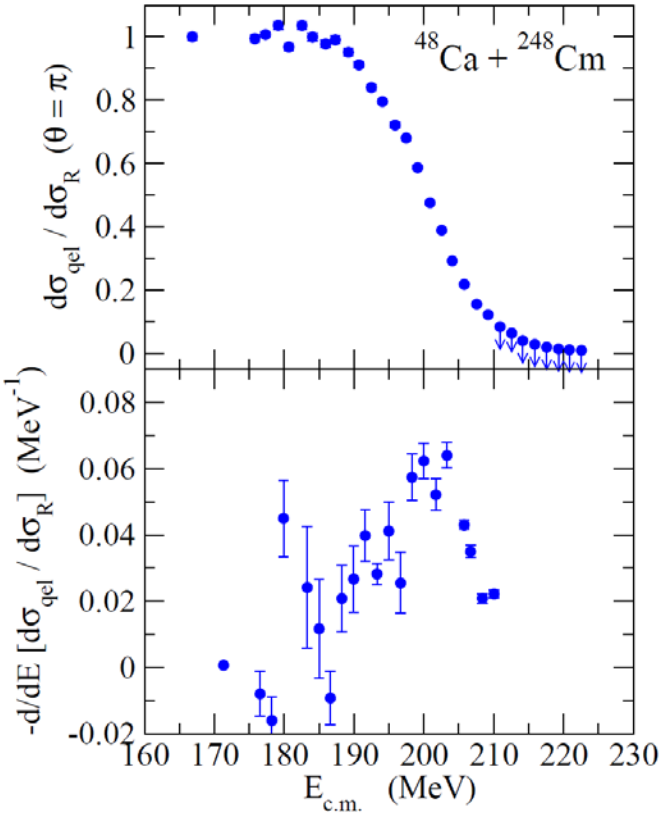
S. Mitsuoka et al.,
PRL99 (‘07) 182701



S.S. Ntshangase et al.,
PLB651 (‘07) 27



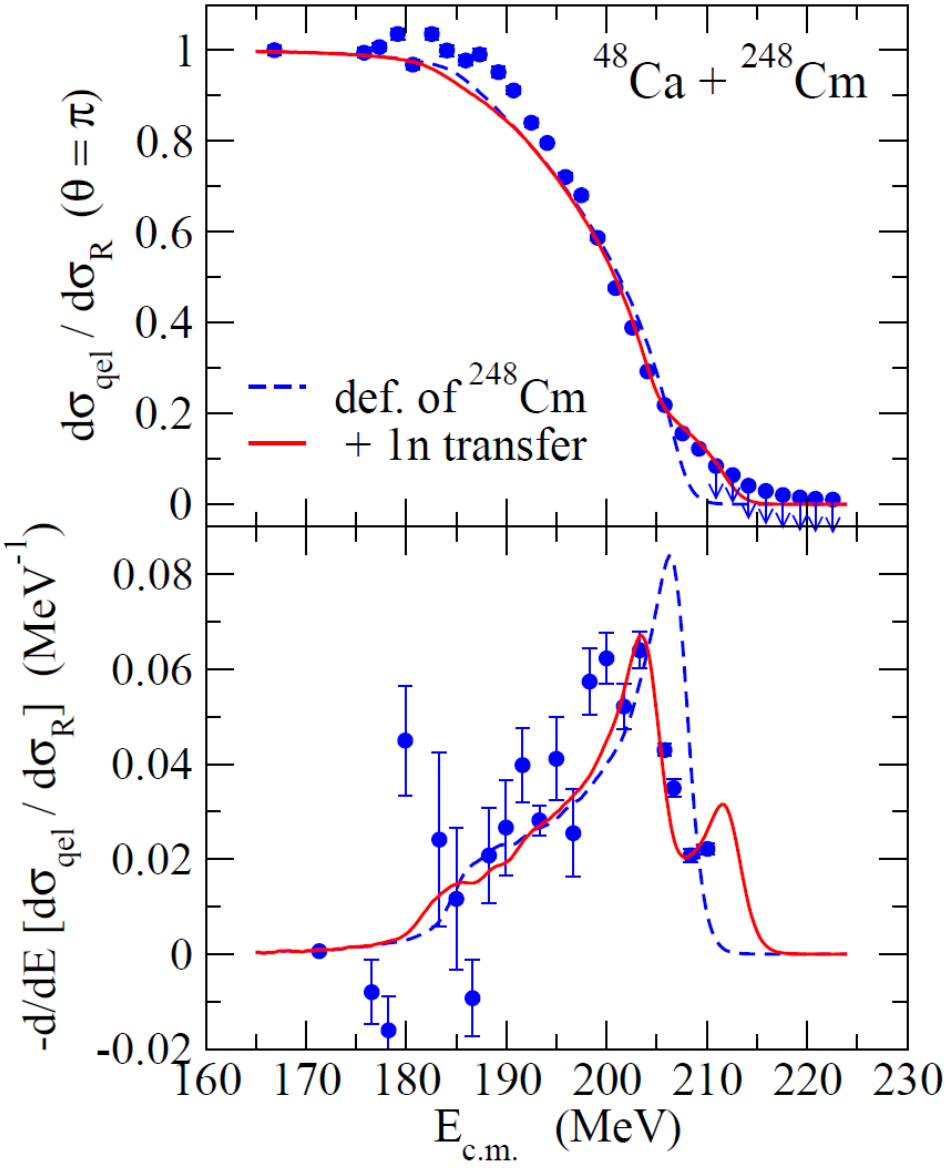
GARIS

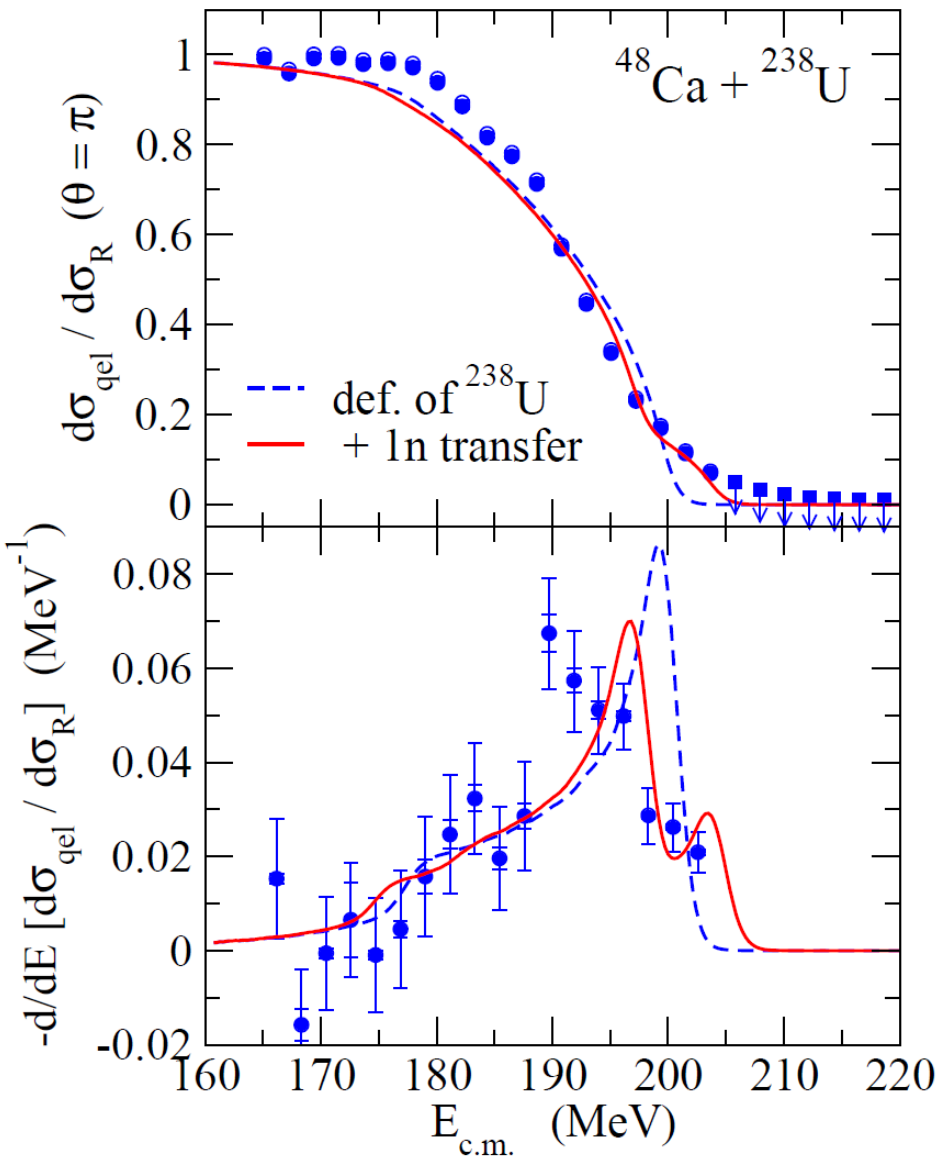


T. Tanaka et al.,
JPSJ 87 (‘18) 014201

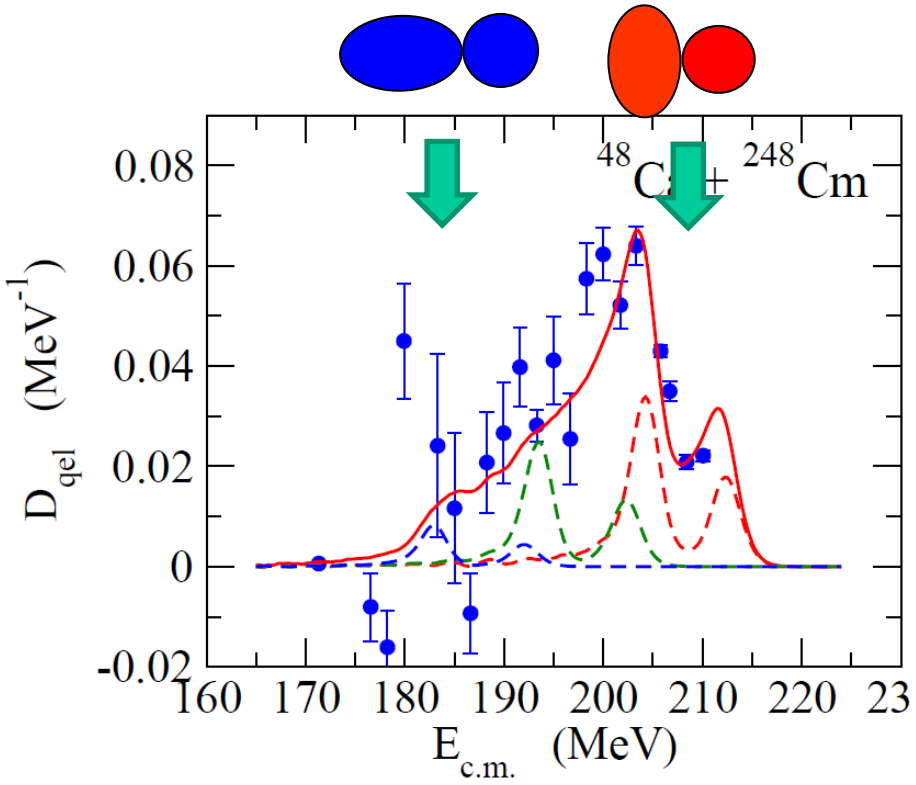
Coupled-channels calculations (K.H. and T. Tanaka)

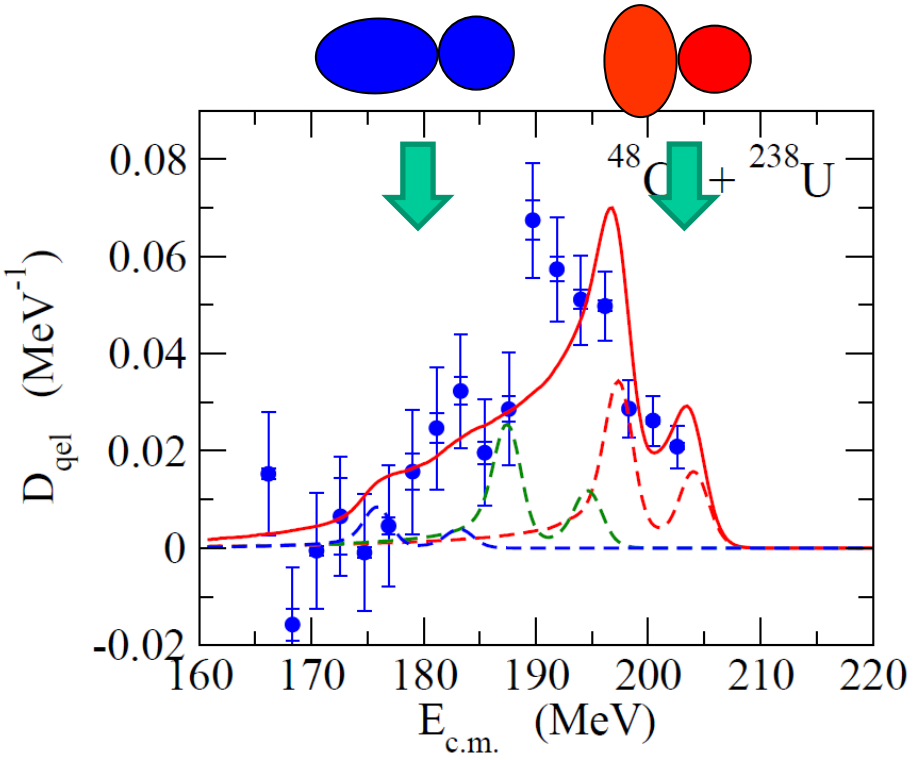
* Experimental details with more data: the next talk by Tanaka





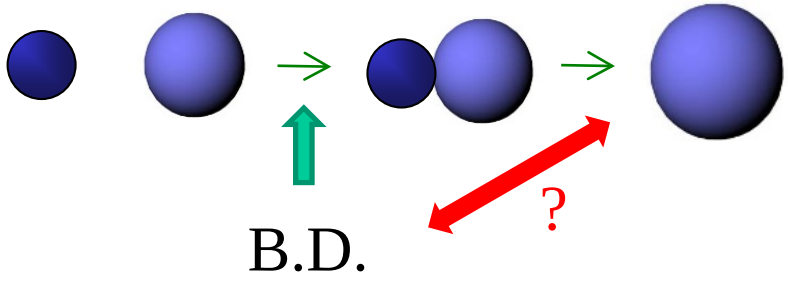
Coupled-channels calculations (K.H. and T. Tanaka)



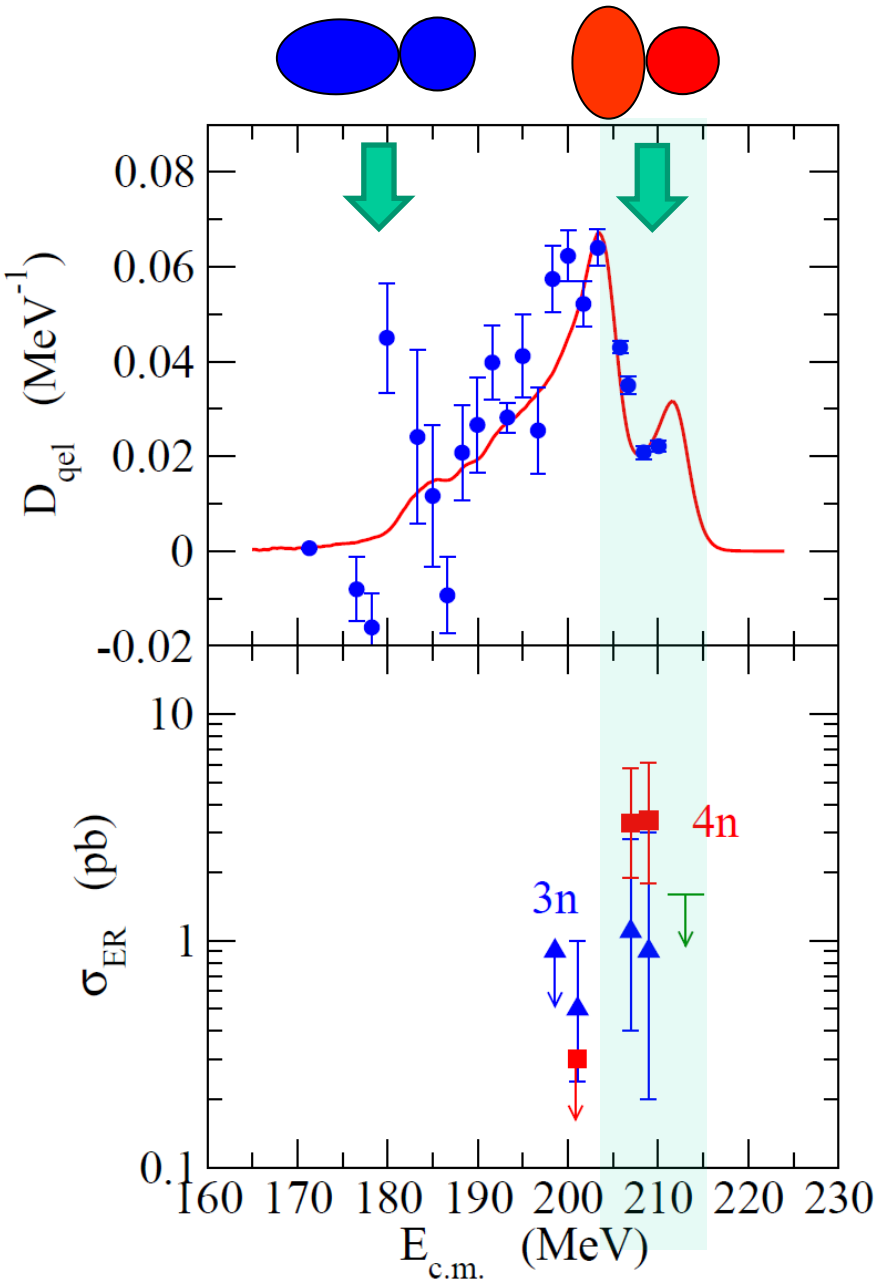


$$\frac{d\sigma_{qel}}{d\Omega} = \int_0^1 d(\cos\theta)\,\frac{d\sigma_{el}}{d\Omega}(\theta)$$

the next question:

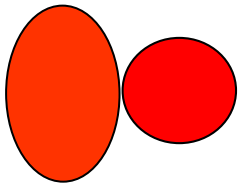


Connection to the ER cross sections

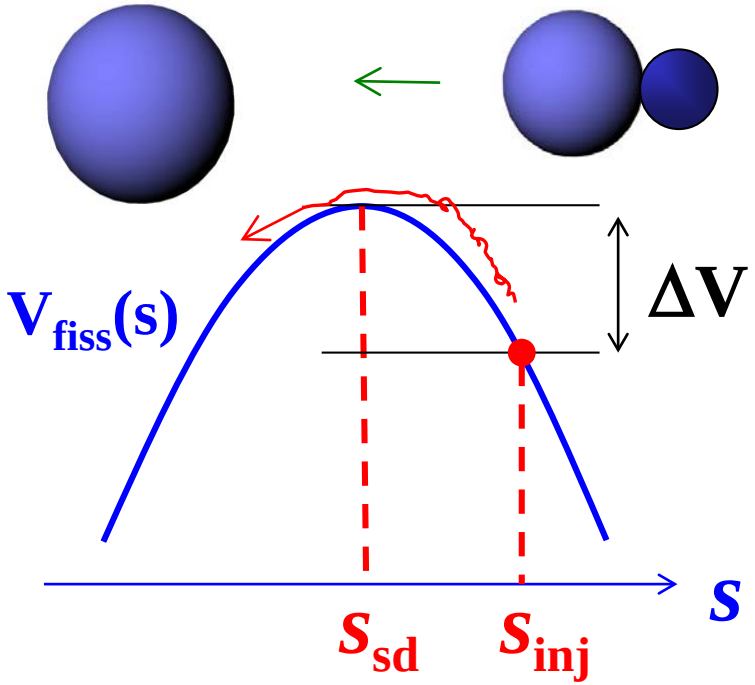


$^{48}Ca + {}^{248}Cm \rightarrow {}^{296}_{116}Lv^{*}$

notion of compactness:
D.J. Hinde et al., PRL74 (‘95) 1295



→ more compact at the touching
→ favorable for CN



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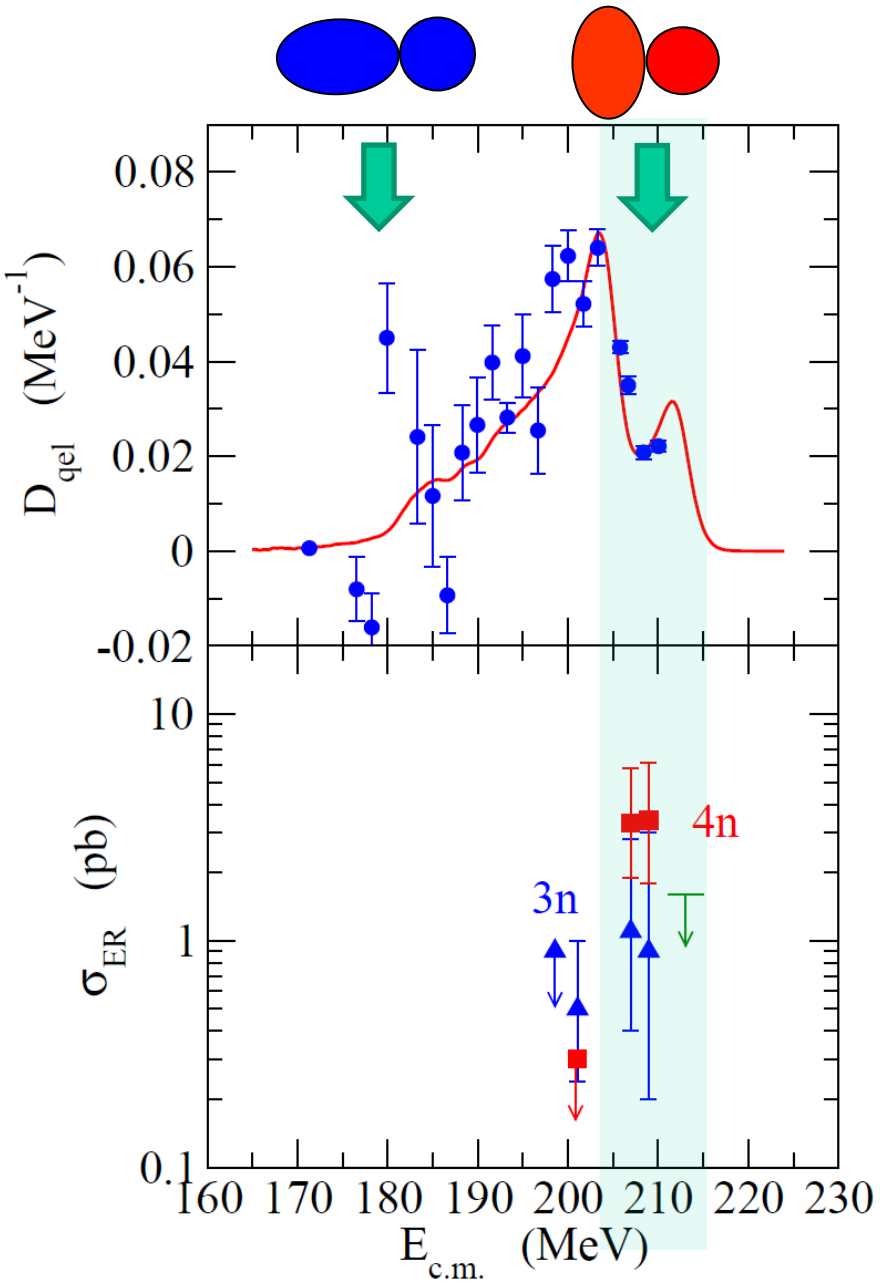

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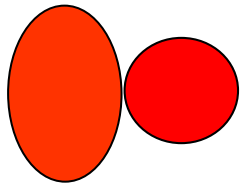

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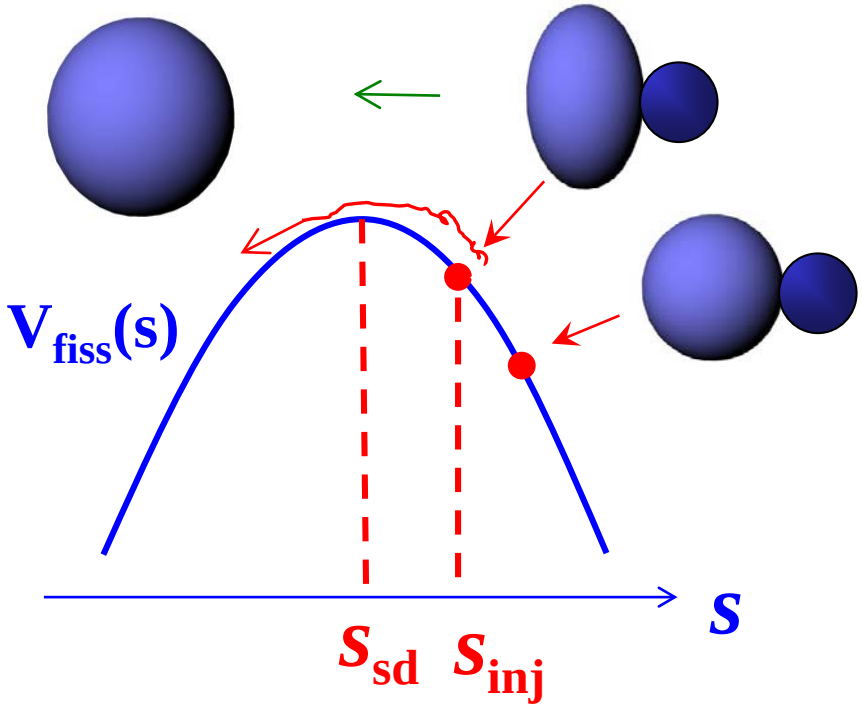
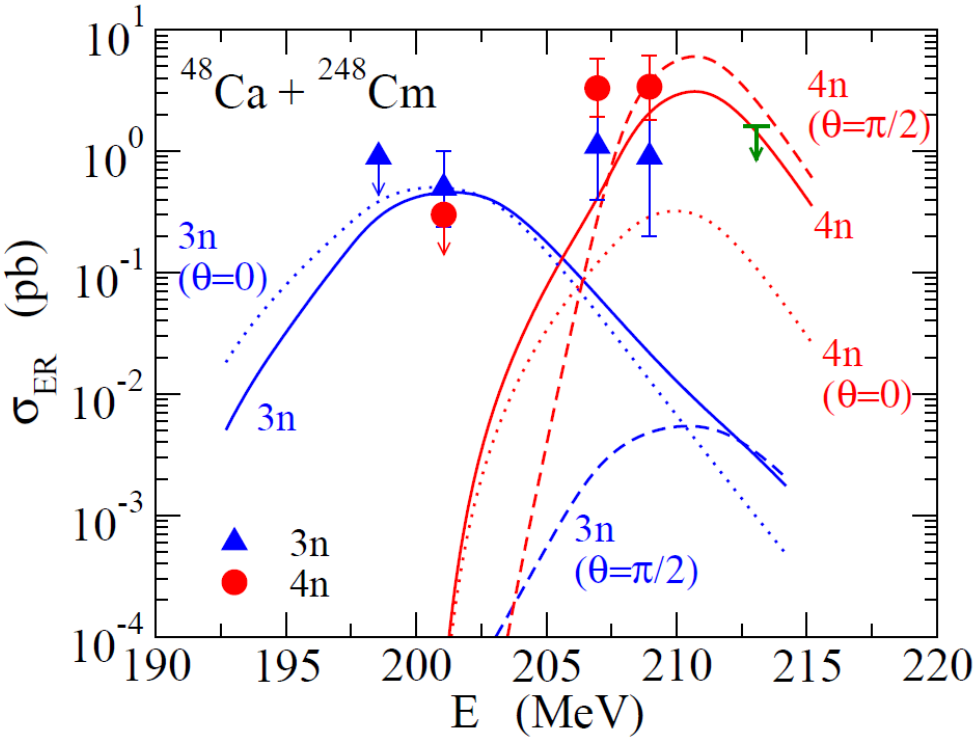
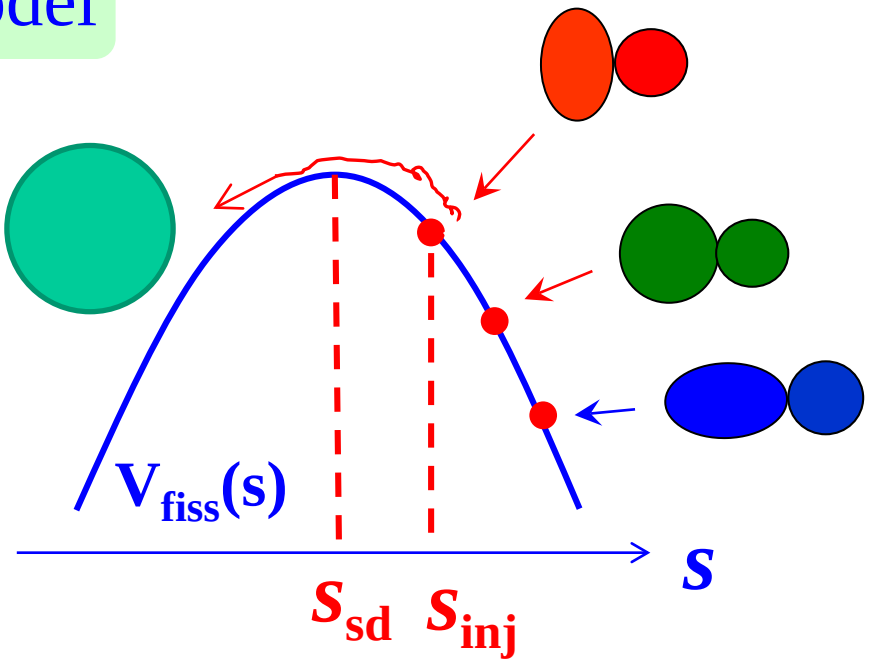


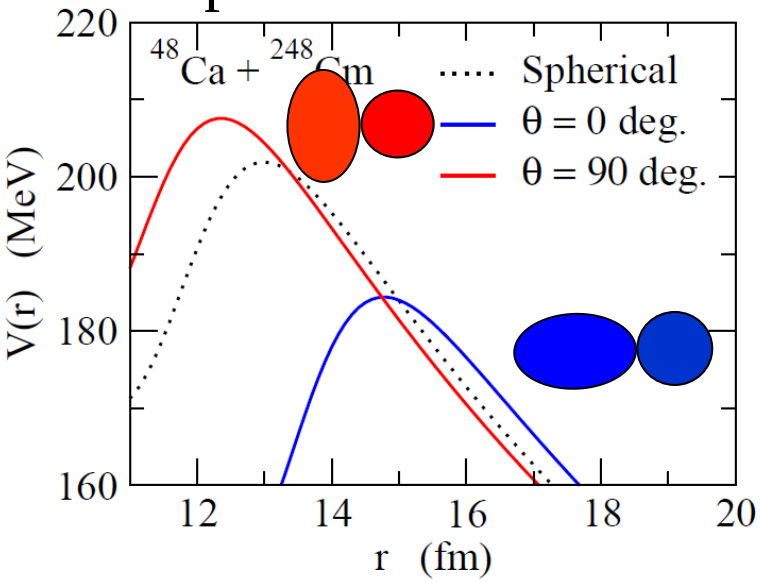
Extended fusion-by-diffusion model

K.H., PRC98 (‘18) 014607





capture barrier:



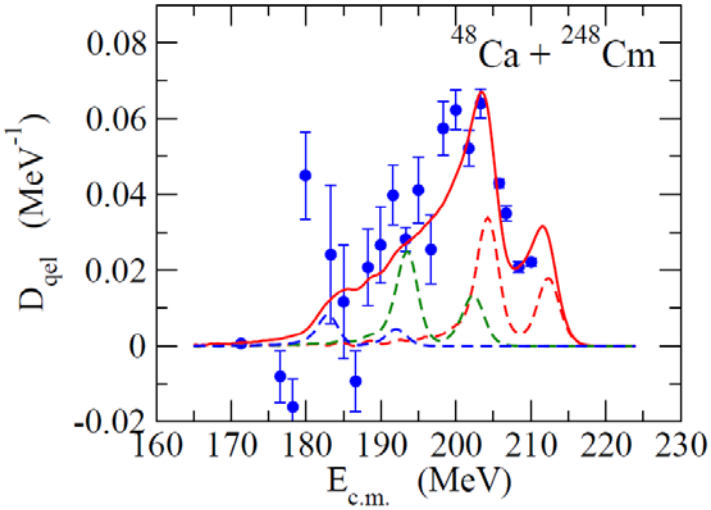
Summary

Reaction dynamics for hot fusion reactions to synthesize SHE

- Recent measurements of QEL barrier distributions with GARIS
  - ✓ $^{48}Ca + ^{248}Cm$, ^{238}U
  - ✓ coupled-channels analysis
  - ✓ notion of compactness: ER formation with side collisions

    more data coming soon

    cf. the next talk by T. Tanaka



- ✓ extended fusion-by-diffusion model: role of deformation

- Z=119 and 120 with hot fusion reactions