Outline: Deep-inelastic heavy-ion collisions

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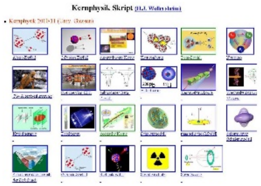
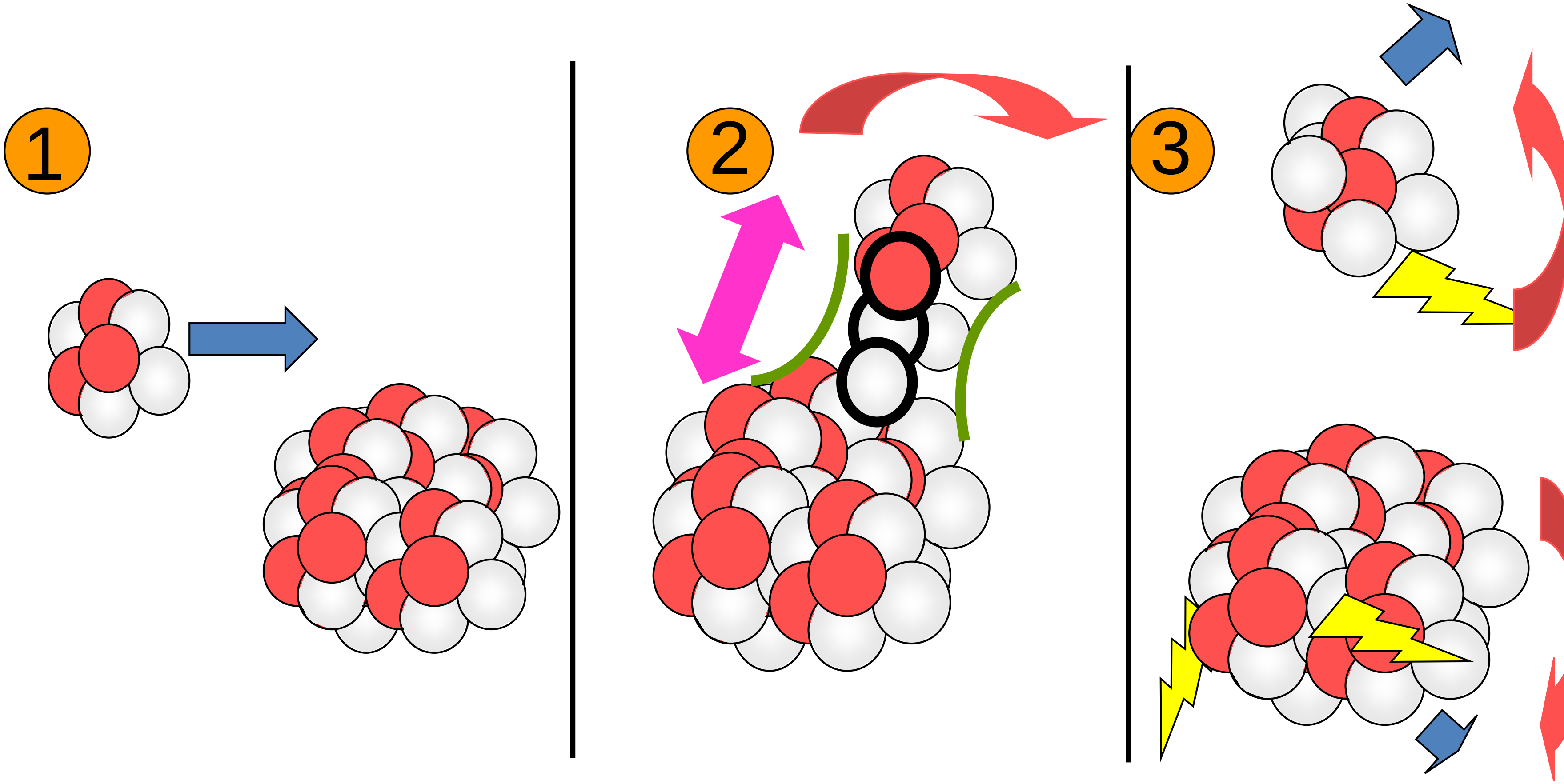
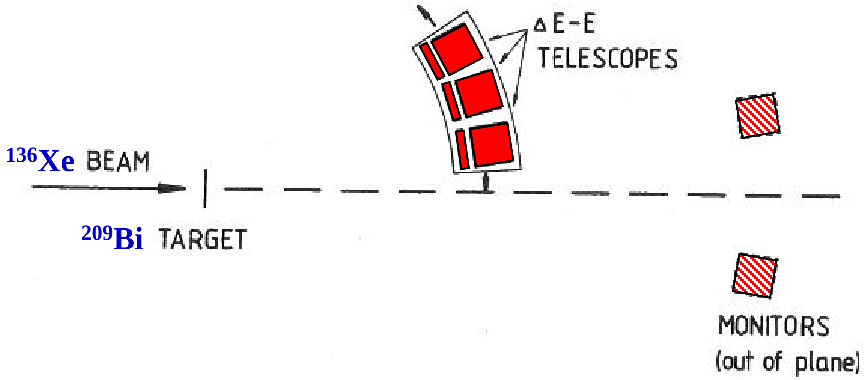
web-page: https://web-docs.gsi.de/~wolle/ and click on 

1. elastic scattering
2. deep-inelastic heavy-ion collisions
3. correlations of experimental observables

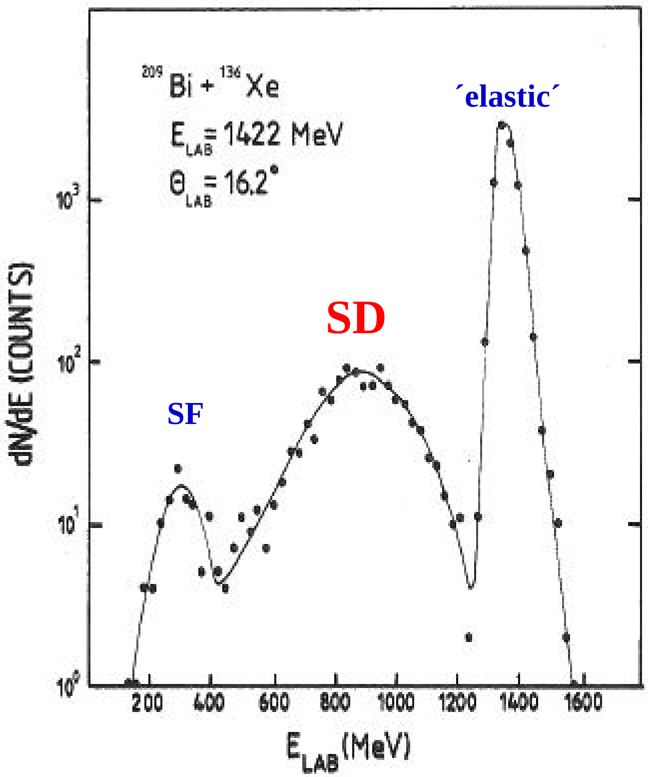
N/Z equilibration



Deep-inelastic or strongly damped heavy-ion collisions

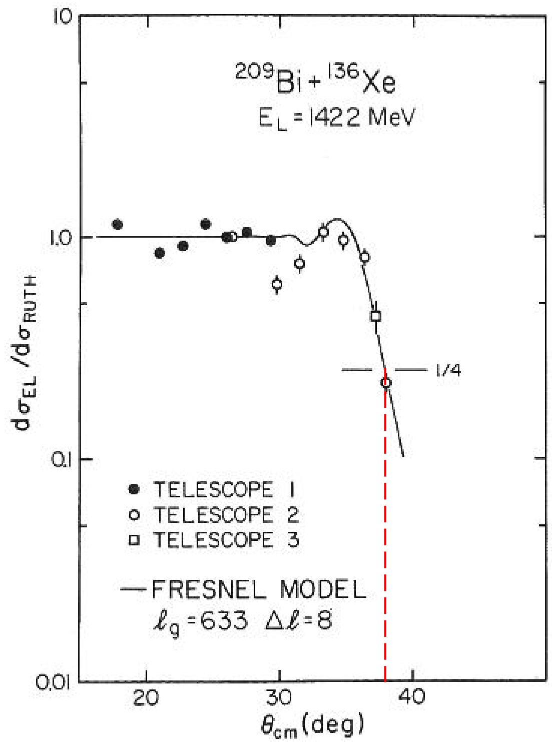


- measured angular range: $\theta_{lab}=11^0$-30^0
- energy resolution 4.5% FWHM for elastic scattering



H.J. Wollersheim; Phys.Rev.C 24 (1981), 2114

Elastic scattering



electromagnetic interaction:

$$R_{int} = a \cdot \left[\sin^{-1}\left(\frac{\theta_{1/4}}{2}\right) + 1 \right] = 15.2 \text{ fm}$$

$$\ell_g = \eta \cdot cot\left(\frac{\theta_{1/4}}{2}\right) = 633\ \hbar$$

^{209}Bi (^{136}Xe, HI); E_{lab}= 940, 1130, 1422 MeV

reaction parameters:

$$R_{int} = C_T + C_P + 4.5 - \frac{C_T + C_P}{6.35} = 15.14 \text{ fm}$$

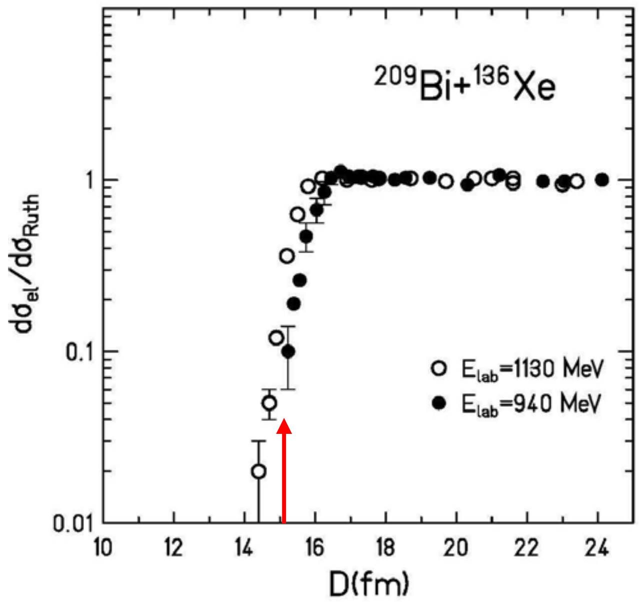
$$\sigma_R = \pi \cdot \Delta^2 \cdot \left[(\ell_g + 1/2)^2 + 2 \cdot \Delta \cdot (\ell_g + 1/2) + (\pi^2/3) \cdot \Delta^2\right]$$

^{209}Bi (^{136}Xe, HI); E_{lab}= 1422 MeV

$$\sigma_R = (3.8 \pm 0.2)\ b$$

H.J. Wollersheim; Phys.Rev.C 24 (1981), 2114

W.W. Wilcke; At. Data & Nucl. Data Tables 25 (1980), 389



electromagnetic interaction:

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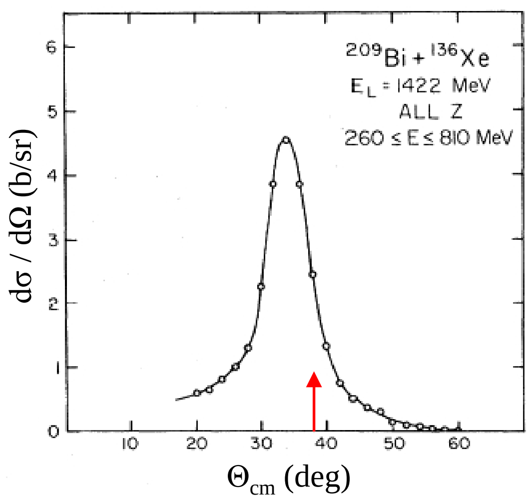
$$\sigma_R = \pi \cdot R_{int}^2 \cdot \left[1 - \frac{V_C(R_{int})}{E_{cm}} \right]$$

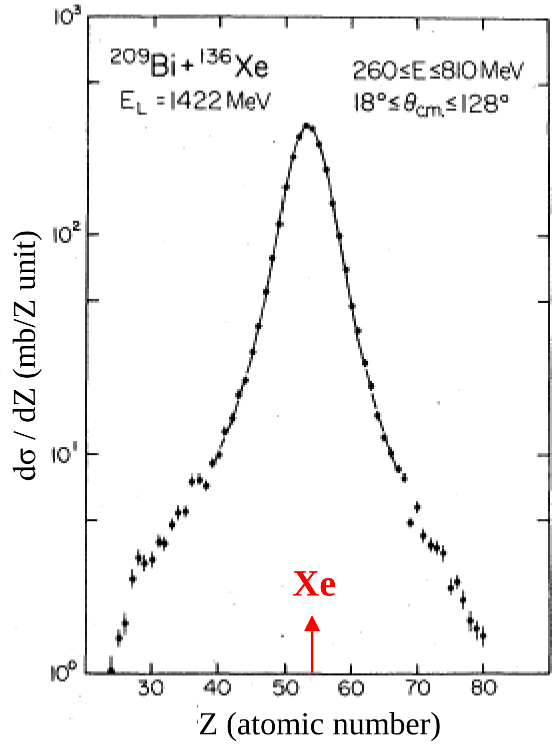
^{209}Bi (^{136}Xe, HI); E_{lab}= 1422 MeV

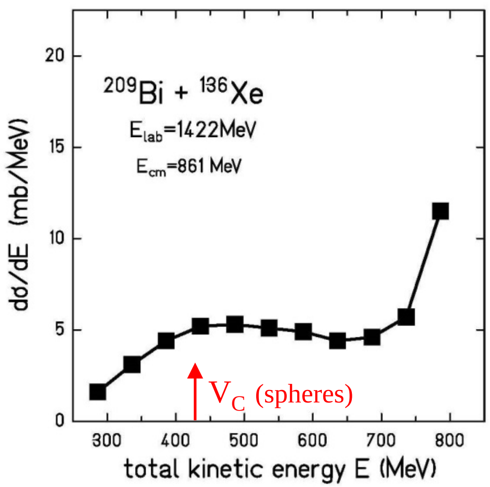
$$\sigma_R = (3.8 \pm 0.2)\ b$$

H.J. Wollersheim; Phys.Rev.C 24 (1981), 2114 *W.W. Wilcke; At. Data & Nucl. Data Tables 25 (1980), 389*

Deep-inelastic or strongly damped heavy-ion collisions







- cross section focused into a narrow angular region close to the grazing angle ($\theta_{gr}=38^0$) (similar to peripheral collision)

σ_{SD} = (3.1±0.4) b ~ σ_R

- maximum of Z-distribution remains centered at Z of the projectile (**Z=54**)

- **But** a large amount of kinetic energy is dissipated

(V_C (R_{int}) = 426 MeV is the initially available energy)

E_{min}= (270±30) MeV

(nuclei in the exit channel can be deformed)

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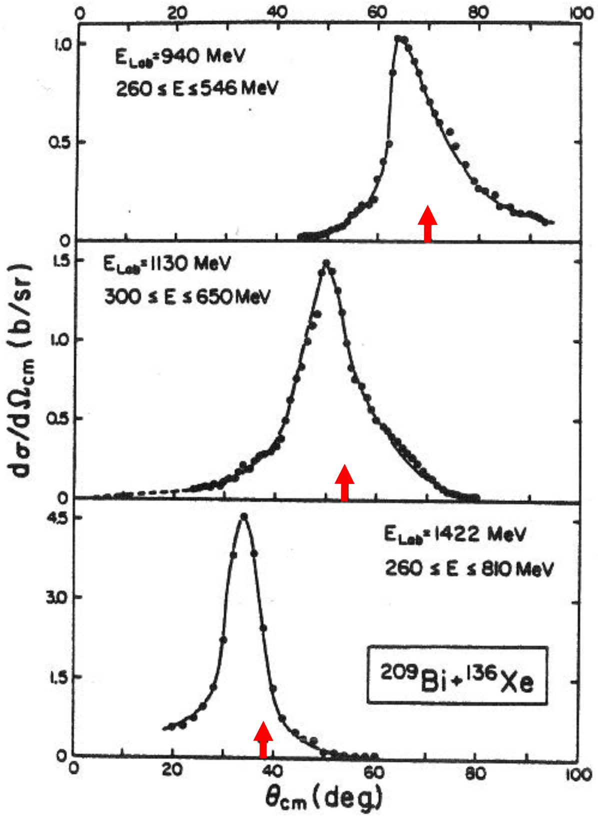
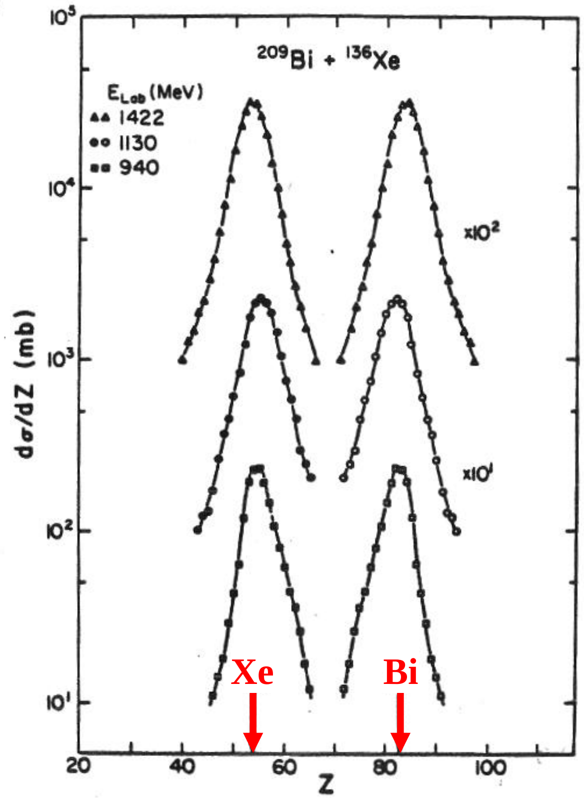
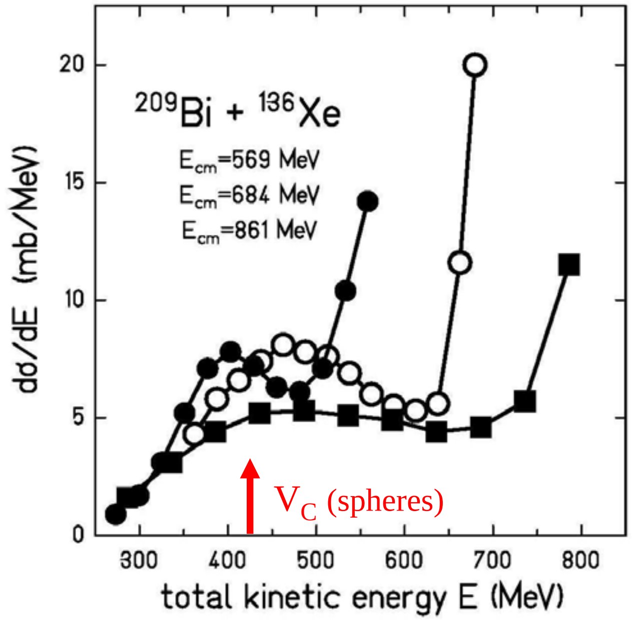
Deep-inelastic or strongly damped heavy-ion collisions







❖ cross section focused into a narrow angular region close to the grazing angle
(similar to peripheral collision)

❖ maximum of Z-distribution remains centered at Z of the projectile (**Z=54**)

❖ a large amount of kinetic energy is dissipated
(V_C (R_{int}) = 426 MeV is the initially available energy)

E_{min}= (270±30) MeV
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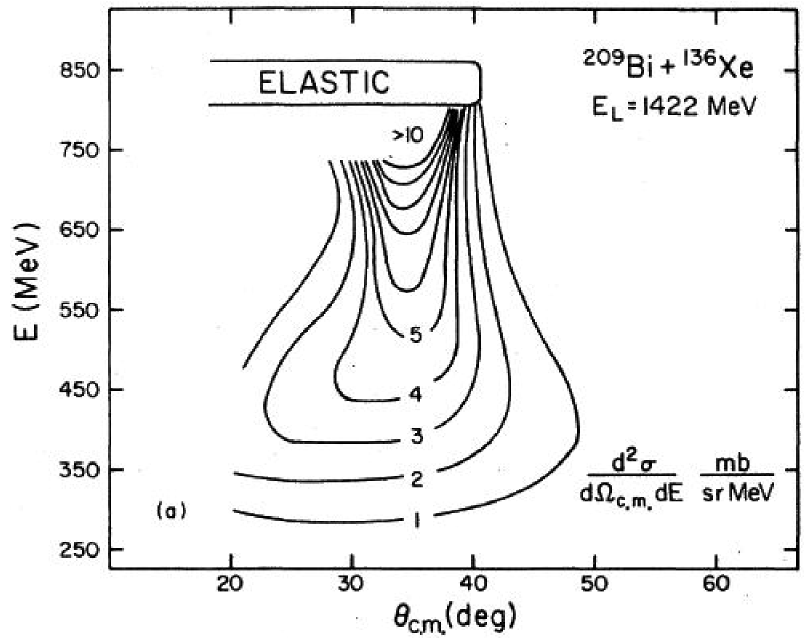
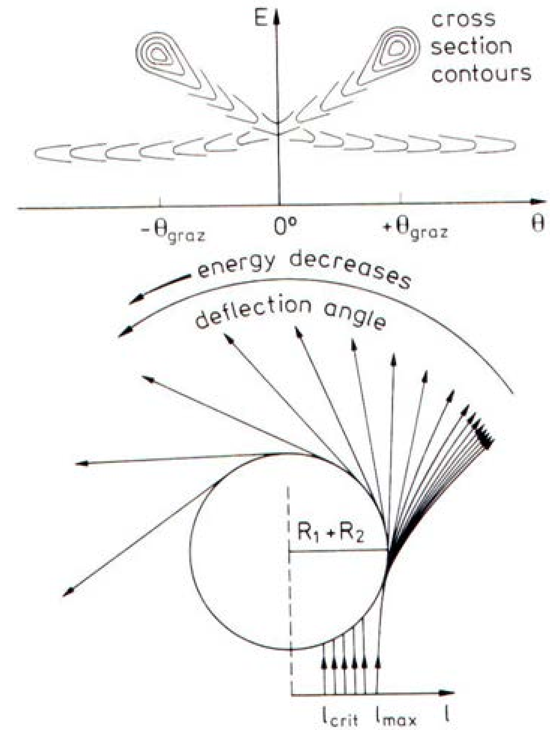
H.J. Wollersheim; Phys.Rev.C 24 (1981), 2114 *W.W. Wilcke; Phys.Rev.C 22 (1980), 128* *W.U. Schröder; Phys.Rep.45 (1978), 301*

Correlations of experimental observables





modified Coulomb parameter:

$$\eta' = Z_P \cdot Z_T \cdot e^2 / \hbar \cdot v' = 0.157 \cdot Z_P \cdot Z_T \left[\mu / (E_{cm} - V_C)\right]^{1/2}$$

$0 < \eta' < 150$	orbiting trajectory (see left)
$250 < \eta' < 400$	strong focussing effect
$500 < \eta'$	Coulomb-like trajectory

$\eta' = 306$ for ^{209}Bi (^{136}Xe, HI); $E_{lab} = 1422$ MeV

Wilczynski plot ($0 < \eta' < 150$)

(Phys. Lett. 47B (1973) 484)

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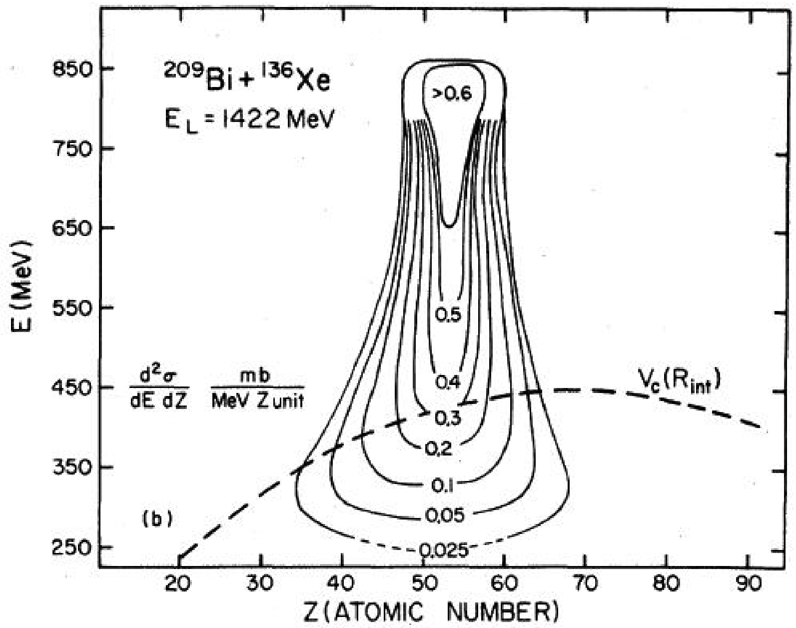
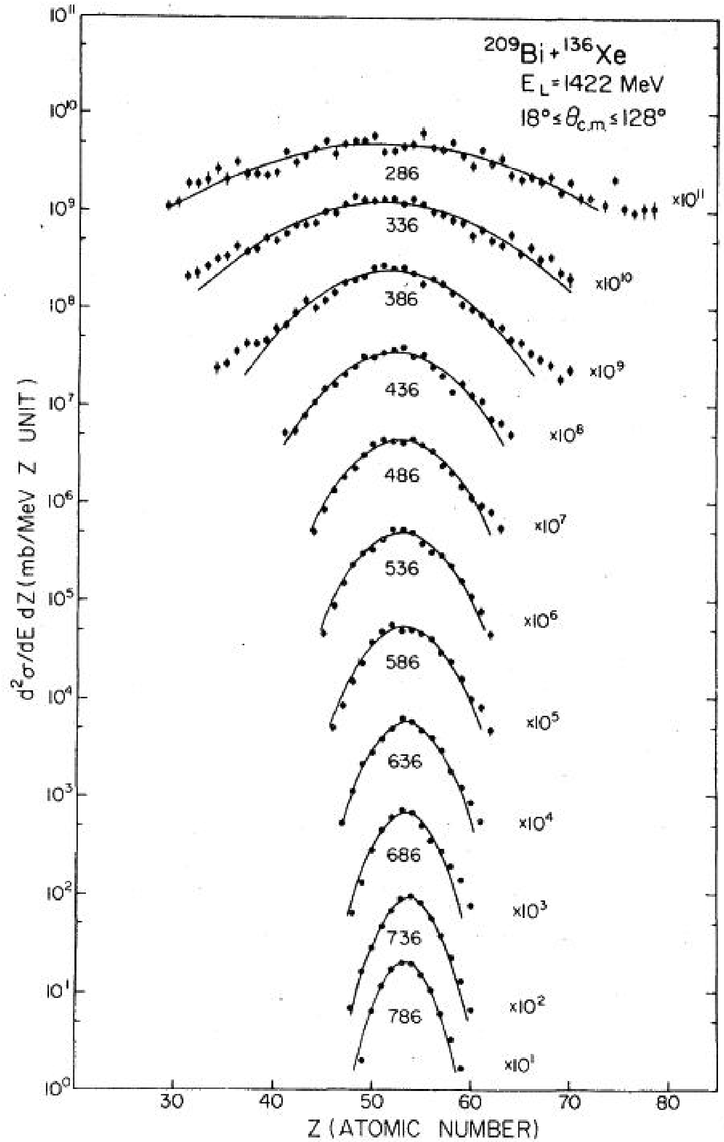
Correlations of experimental observables





❖ **Gaussian Z-distribution:**

$$\frac{d\sigma^2}{dE\,dZ} = \frac{d\sigma}{dE} \cdot \frac{1}{\sqrt{2 \cdot \pi \cdot \sigma_Z^2}} \cdot e^{-\frac{(Z-Z_0)^2}{2\cdot\sigma_Z^2}}$$

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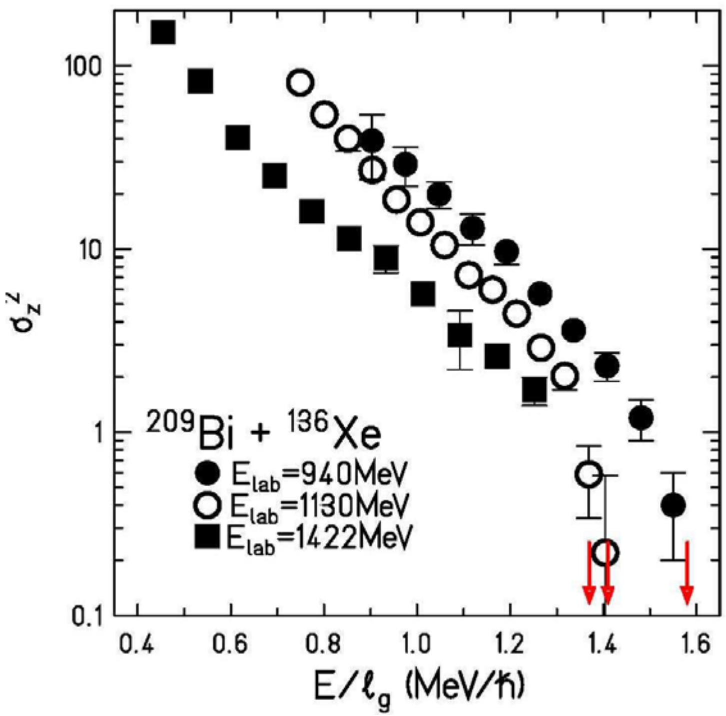
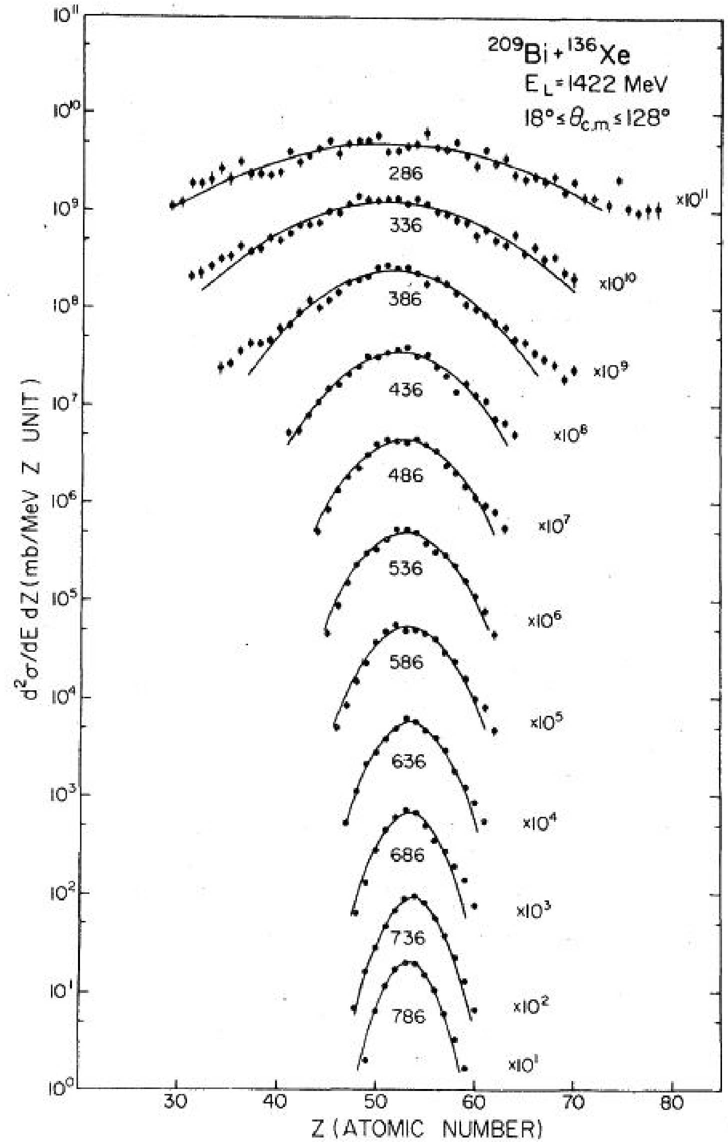
Correlations of experimental observables





❖ **common slope dependence:**

$$\ln \sigma_Z^2 = -6.07 \cdot \left[\left(E/\ell_g\right) + c(x) - 1\right]$$

with $1 - c(x) = 1.393 \cdot E_0/\ell_g - 0.651$

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H.J. Wollersheim; Phys.RevC25 (1982), 338