中間エネルギーにおける反応断面積と核子密度分布

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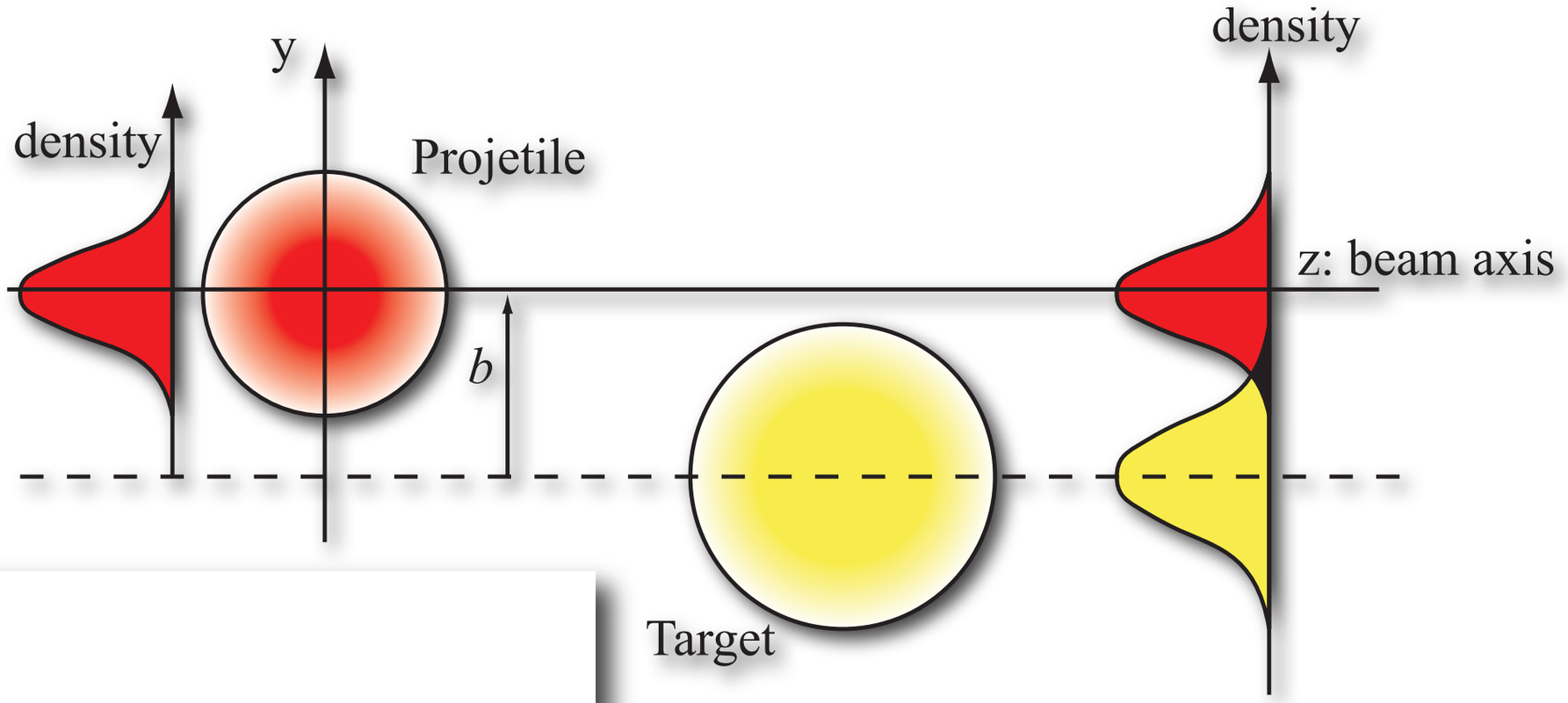
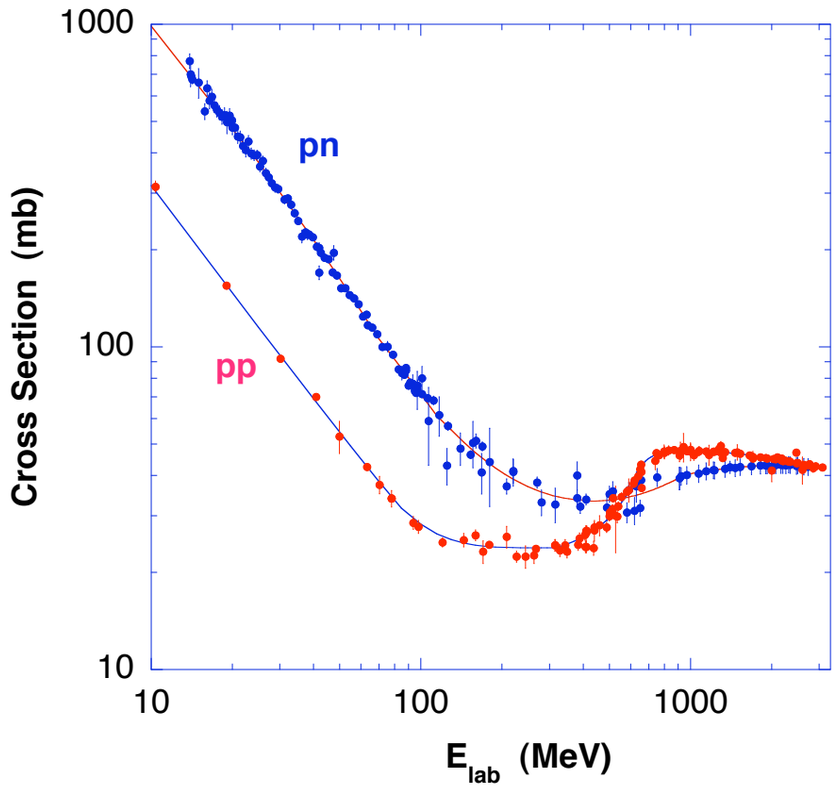
内容

- 反応断面積と核子密度分布
- 問題点
- 安定核の反応断面積
  @中間エネルギー
- 応用





反応断面積

Glauber計算
(optical limit)

核子密度分布

Glauber calculation

Nuclear Collision → sum of individual nucleon-nucleon scatterings

$$\sigma_R = \int \mathrm{d}\boldsymbol{b}\left[1-\exp\left(-\int d^2\boldsymbol{r}\sum_{i,j}\sigma_{ij}(E)\,\rho_z^{P_i}(\boldsymbol{r})\,\rho_z^{T_j}(\boldsymbol{r}-\boldsymbol{b})\right)\right]C(E)$$

Projectile

Target

個々の核子-核子散乱

σ_{NN}

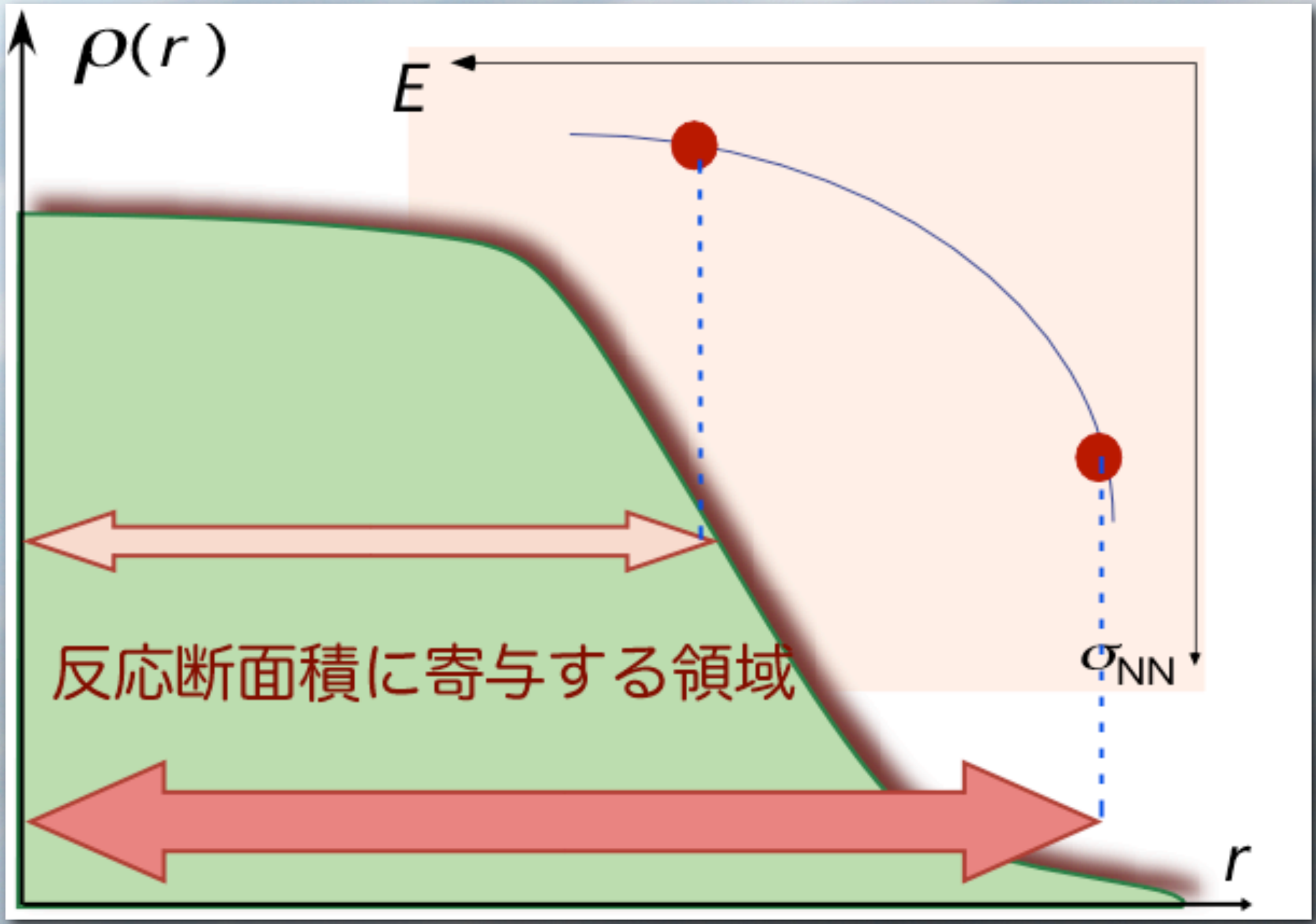
σ_R

Glauber calc.
(optical limit)

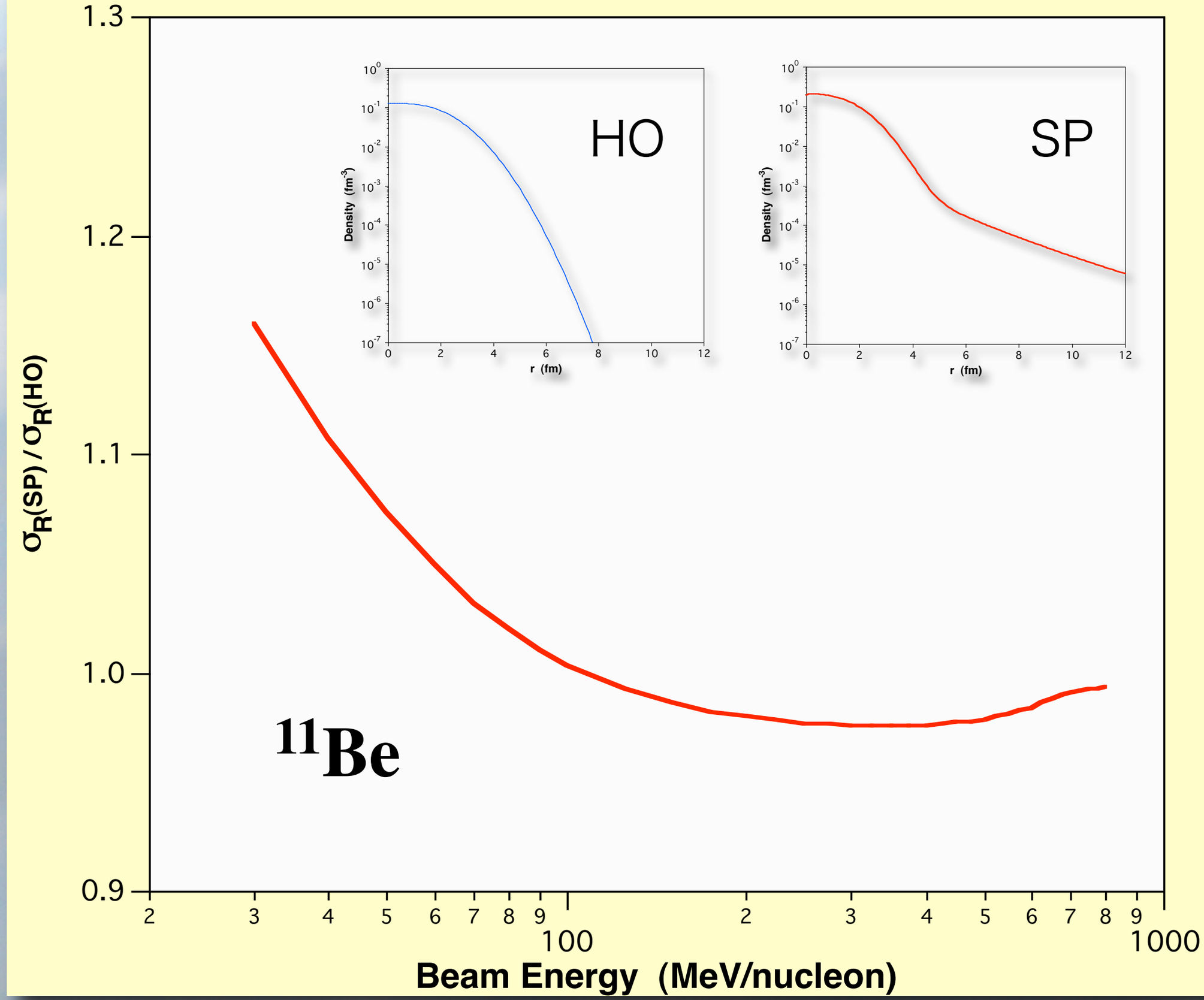
$\rho(r)$

核子密度分布 $\rho(r)$

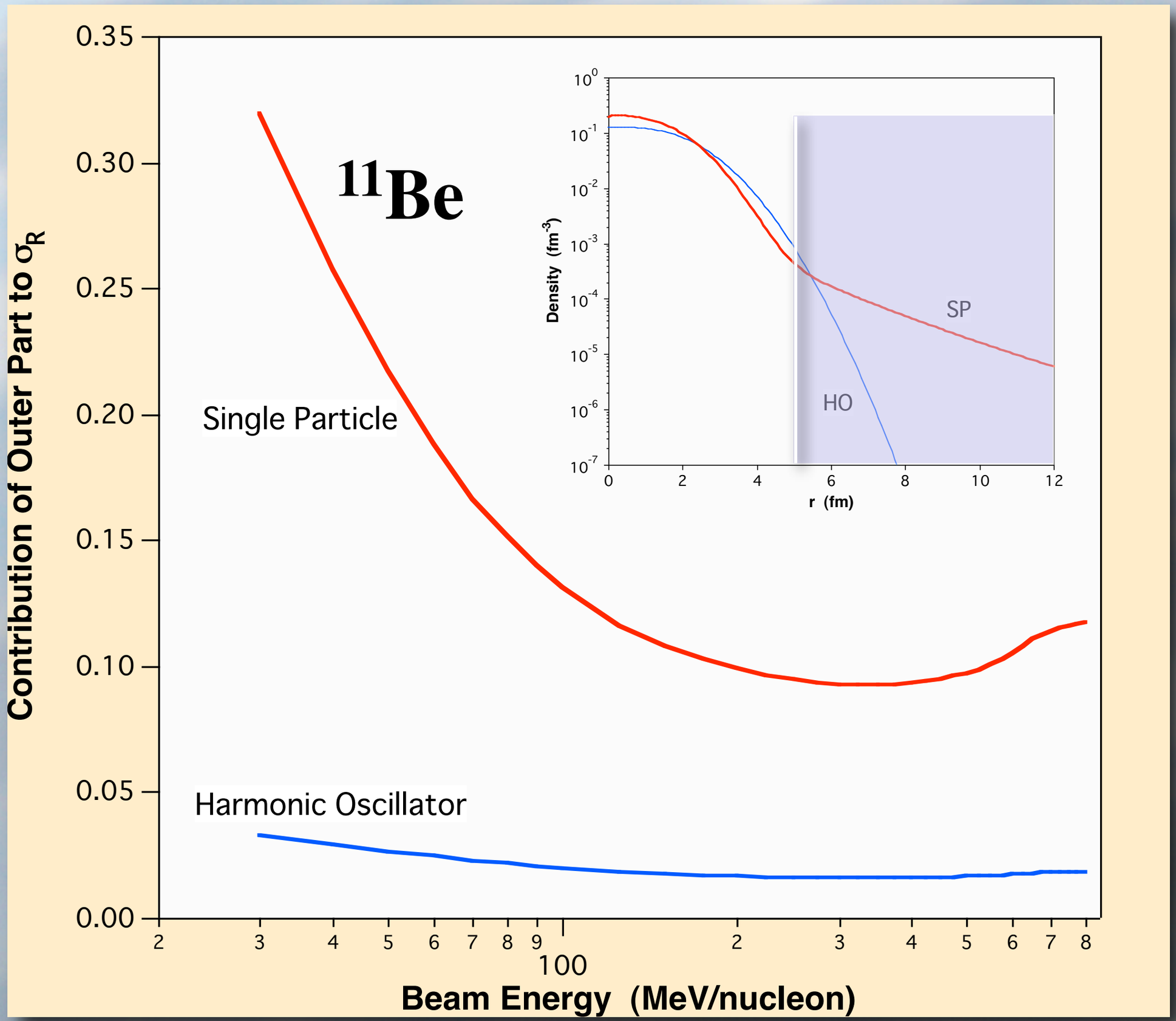
反応断面積のエネルギー依存性と核子密度分布



Energy Dependence of σ_R



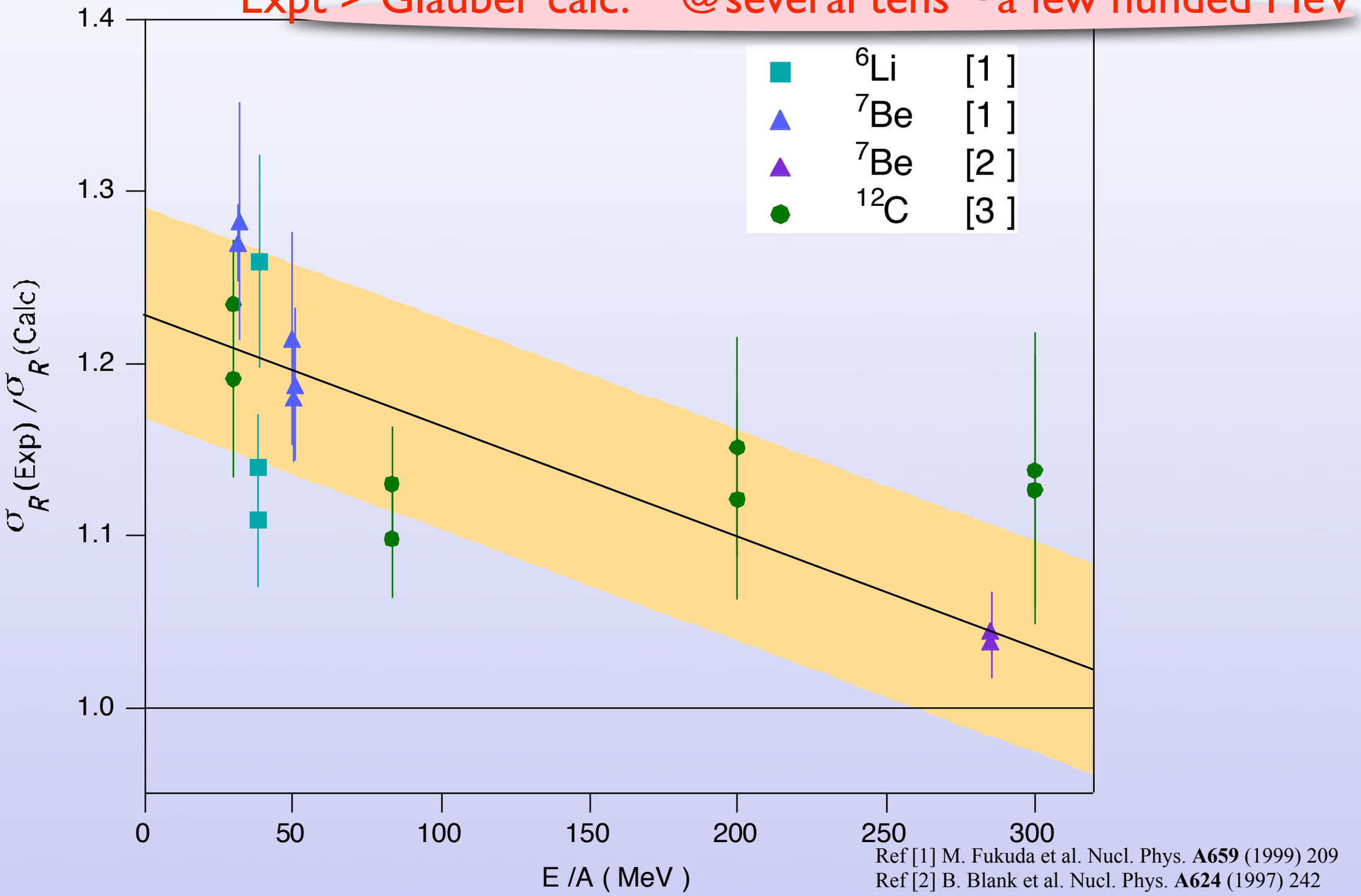
Sensitivity to Halo



Problem at Intermediate Energies

Expt ≈ Glauber calc. @～1 GeV

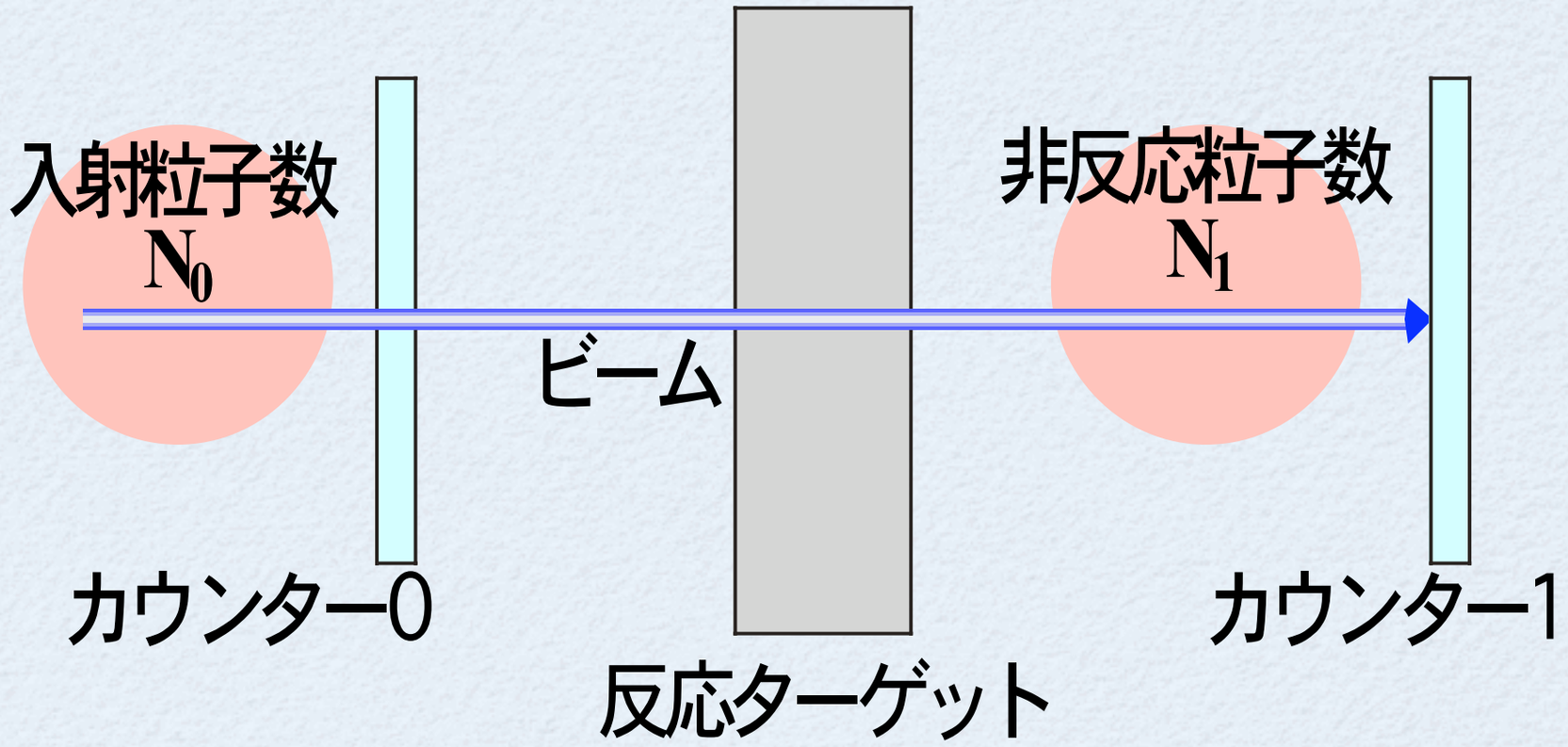
Expt > Glauber calc. @several tens～a few hunded MeV



Ref [1] M. Fukuda et al. Nucl. Phys. **A659** (1999) 209
Ref [2] B. Blank et al. Nucl. Phys. **A624** (1997) 242
Ref [1] S. Kox et al. Phys. Rev. **C35** (1987) 1678

反応断面積の測定

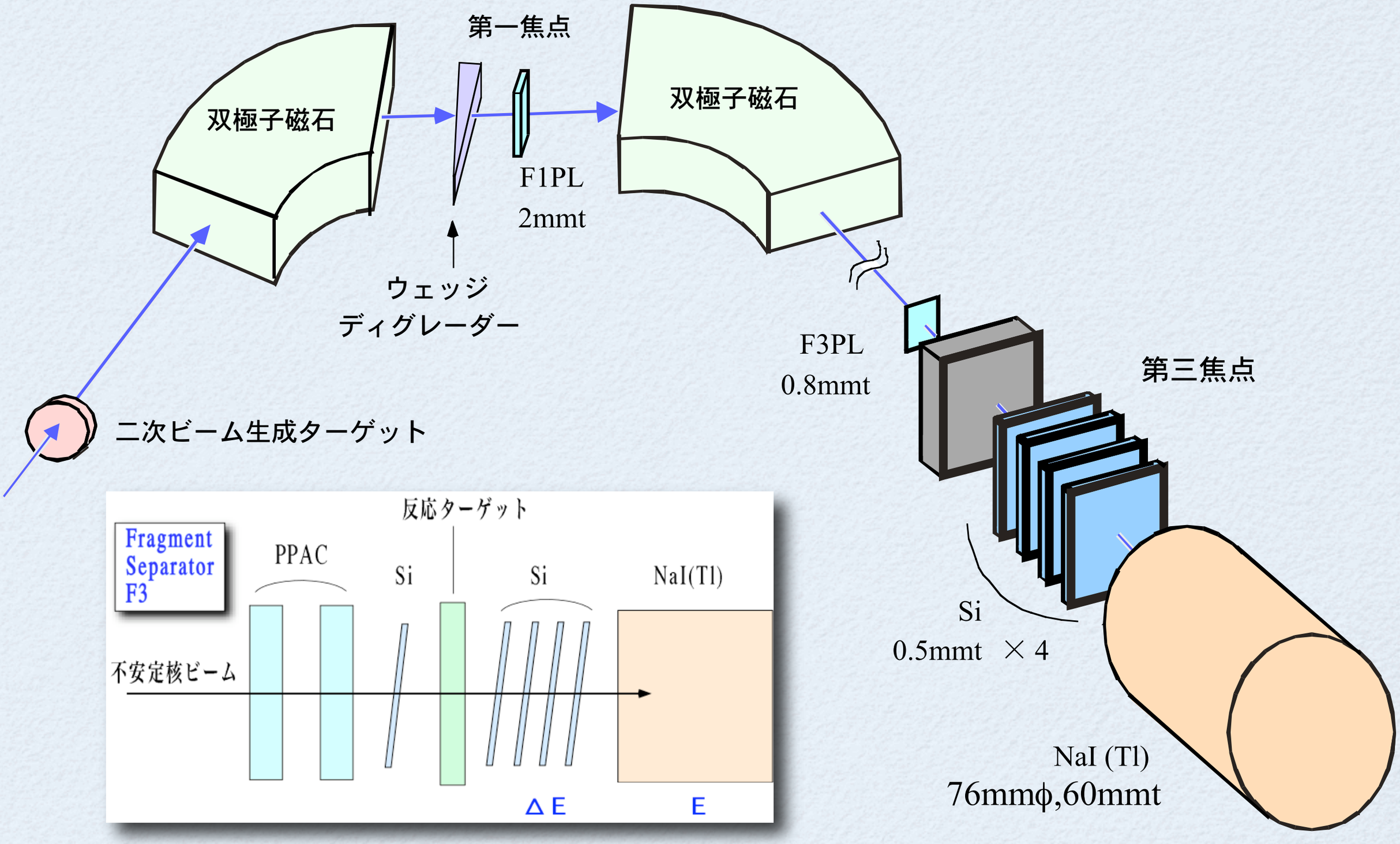
透過法 (transmission or beam attenuation method)



$$\sigma_R = -\frac{1}{t}\ln\left(\frac{N_1}{N_0}\right)$$

t ： 反応ターゲットの厚さ

実験セットアップの例 (HIMAC)



安定核(^{12}C)の反応断面積

ρ_P, ρ_T がよくわかっているもの(安定核)

入射核

^{12}C

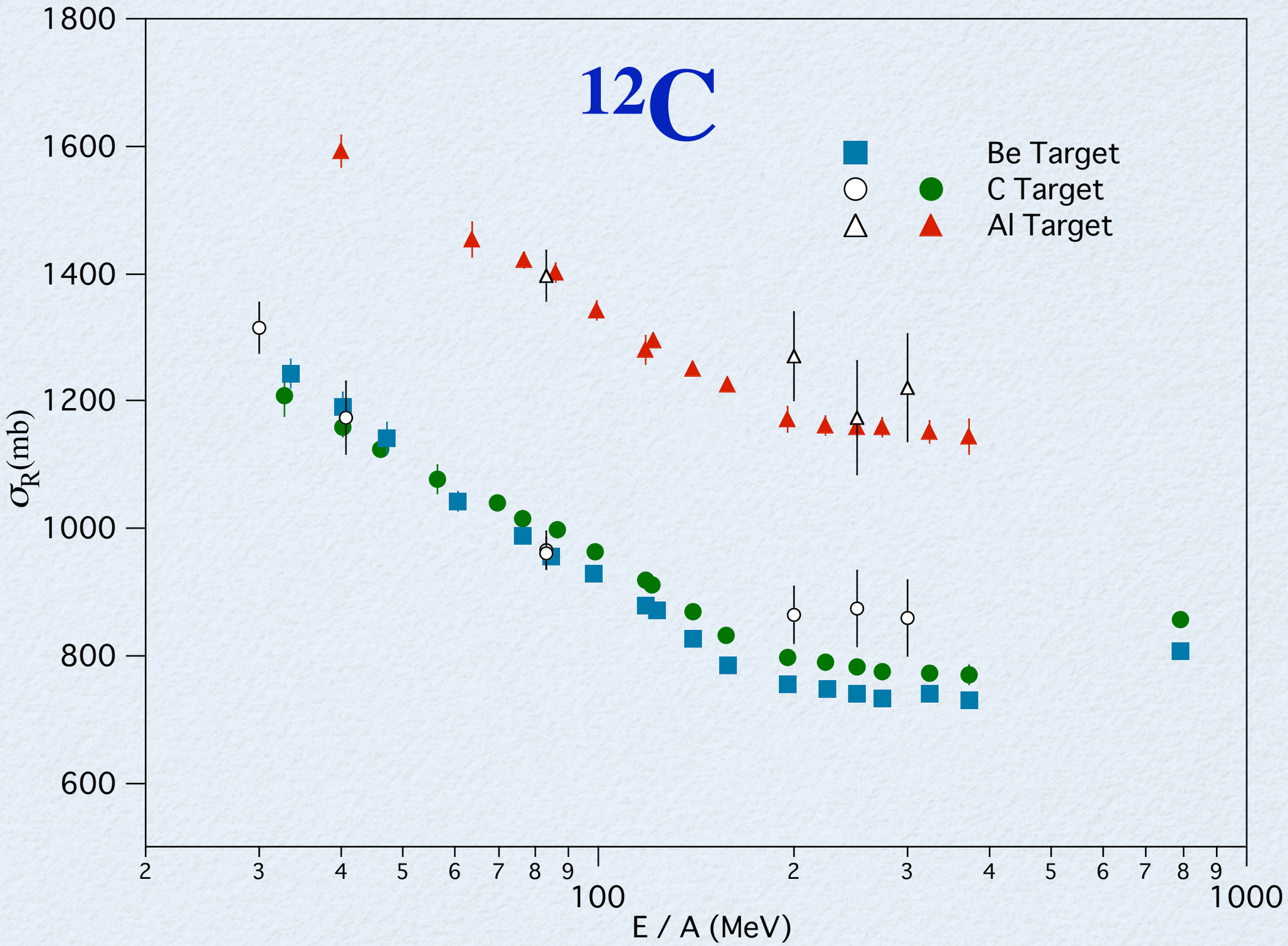
標的核

^{9}Be

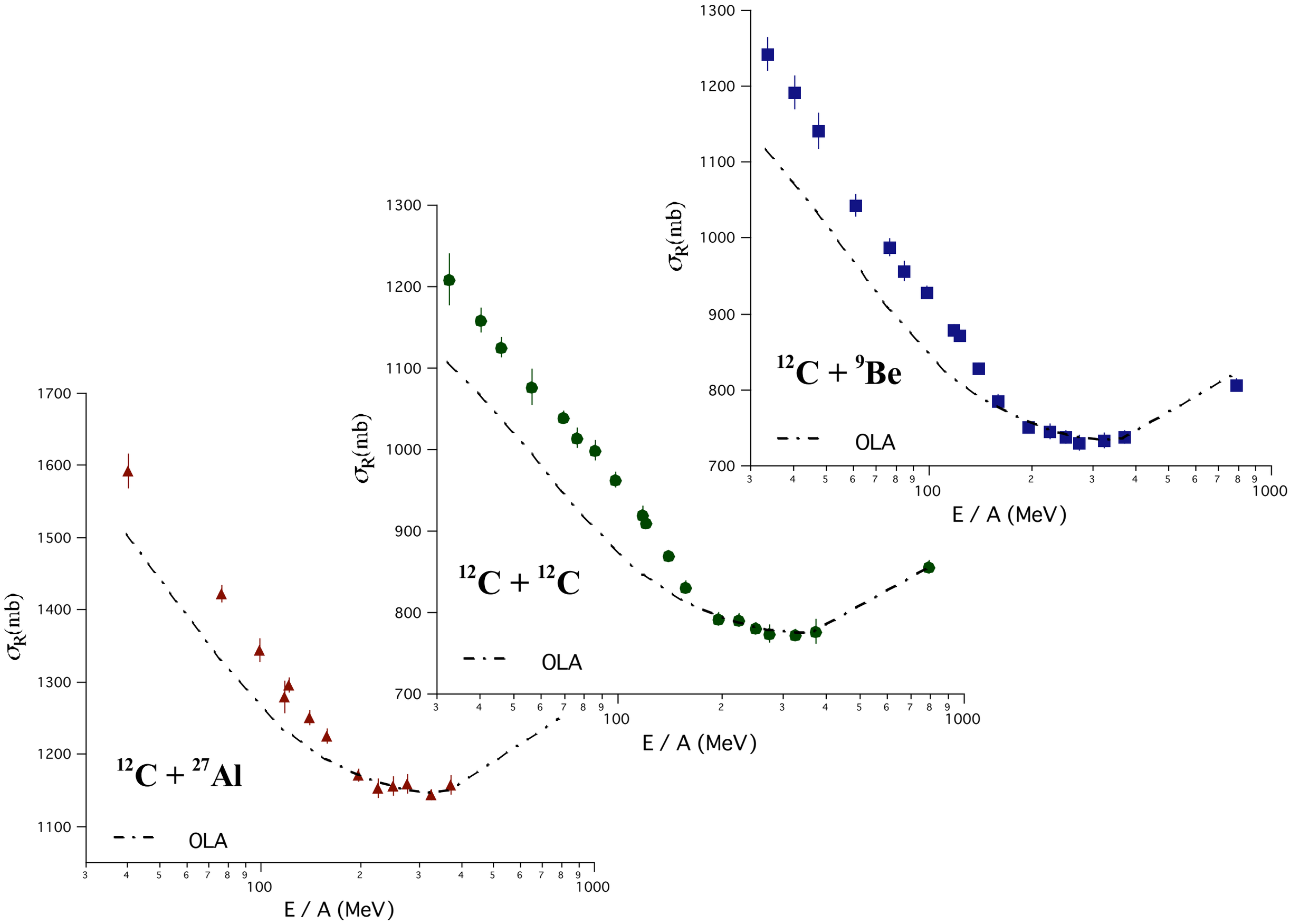
^{12}C

^{27}Al

安定核の反応断面積

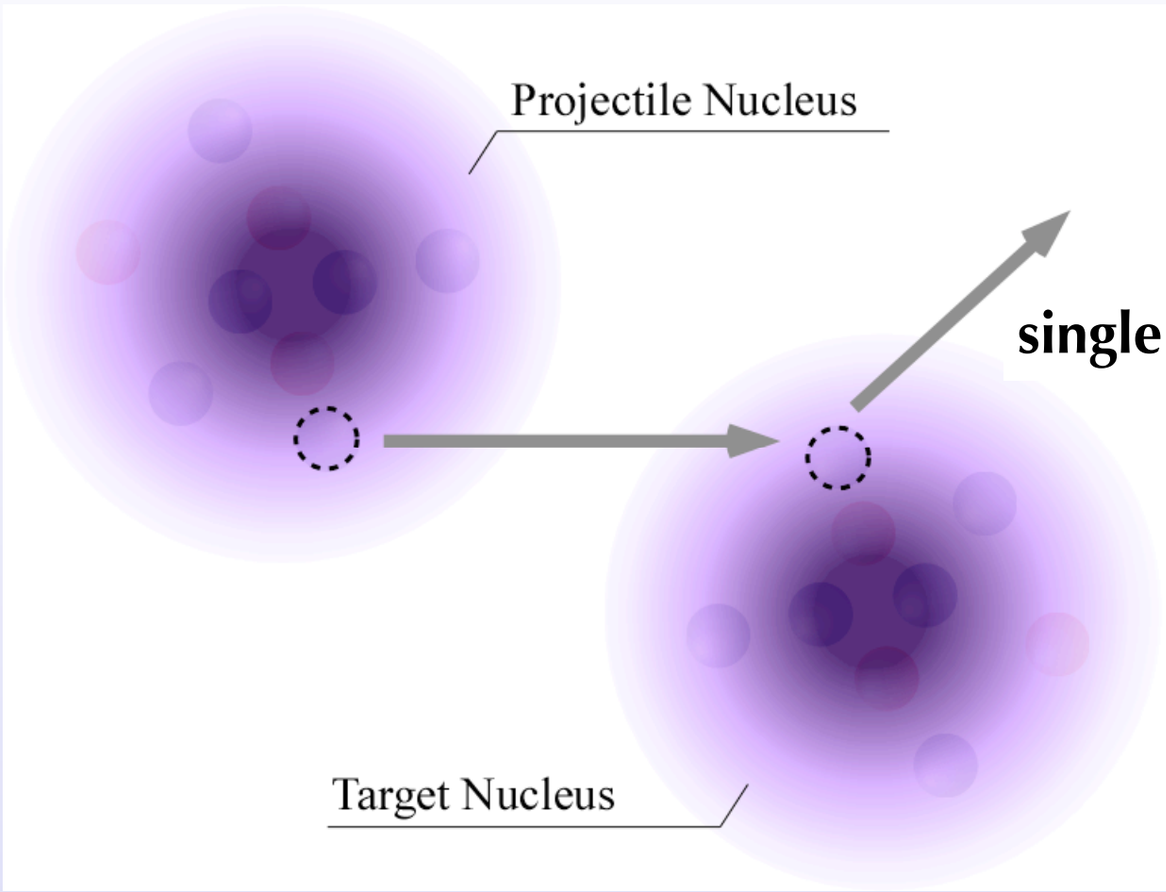

12C
Be Target
C Target
Al Target
σR(mb)
1800
1600
1400
1200
1000
800
600
2
3
4
5
6
7
8
9
100
2
3
4
5
6
7
8
9
1000
E / A (MeV)

Comparison with Glauber calc.



Multiple Scattering (Few-Body) Effect

OLA **Optical Limit**



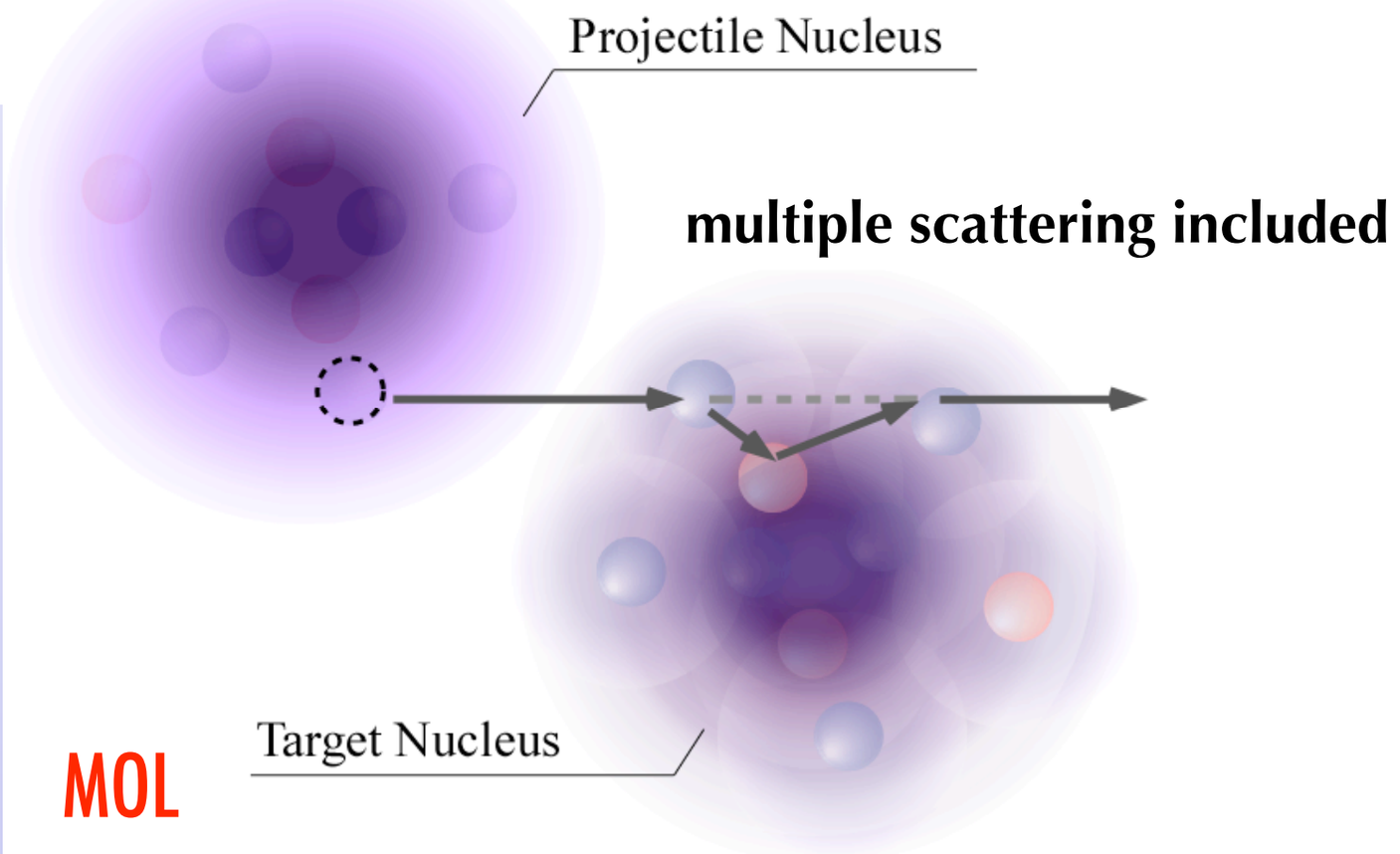
single scattering only

$\sigma_R(OL) > \sigma_R(MS)$

by Y. Suzuki et al.

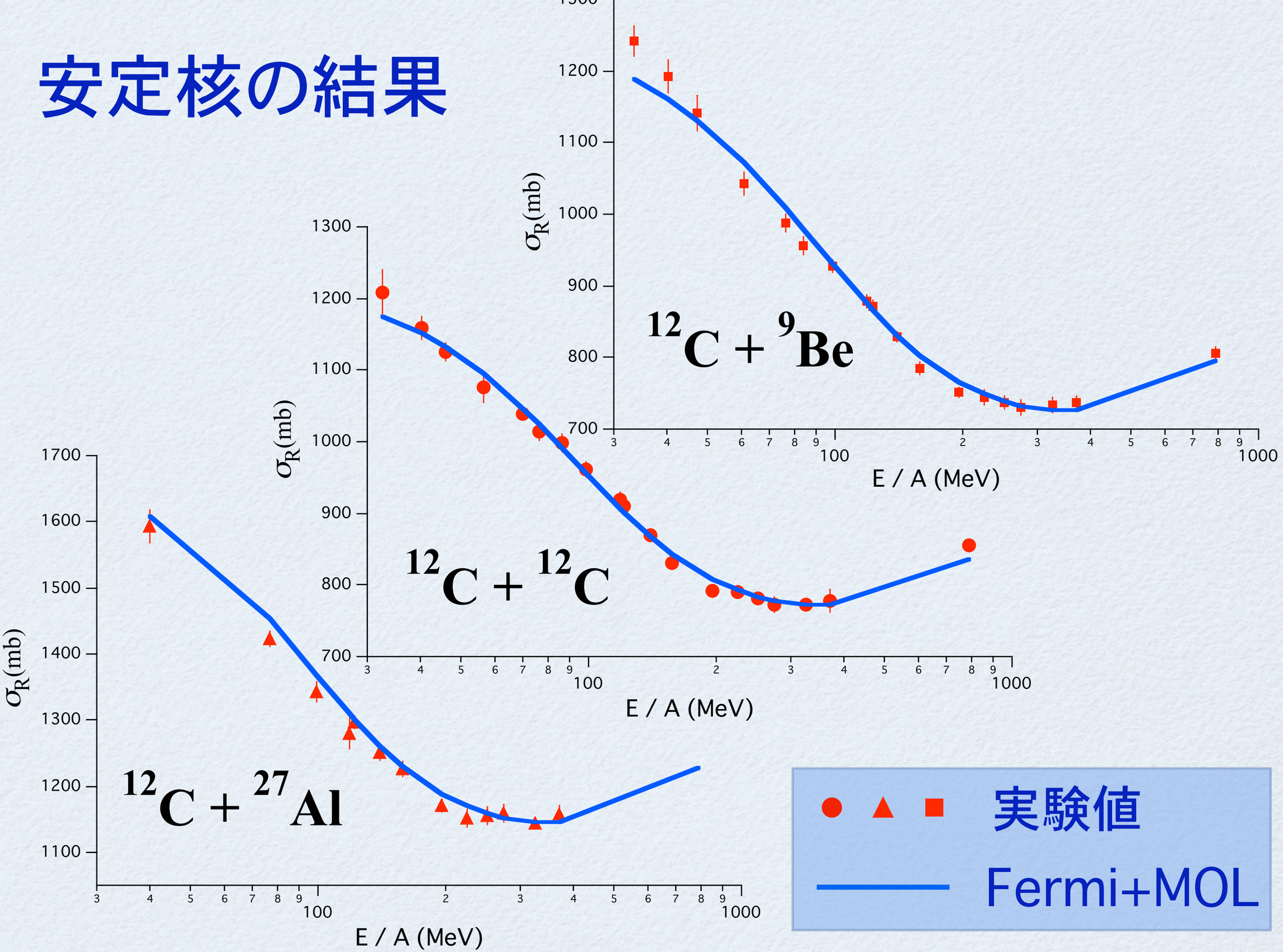
Multiple Scattering

MOL



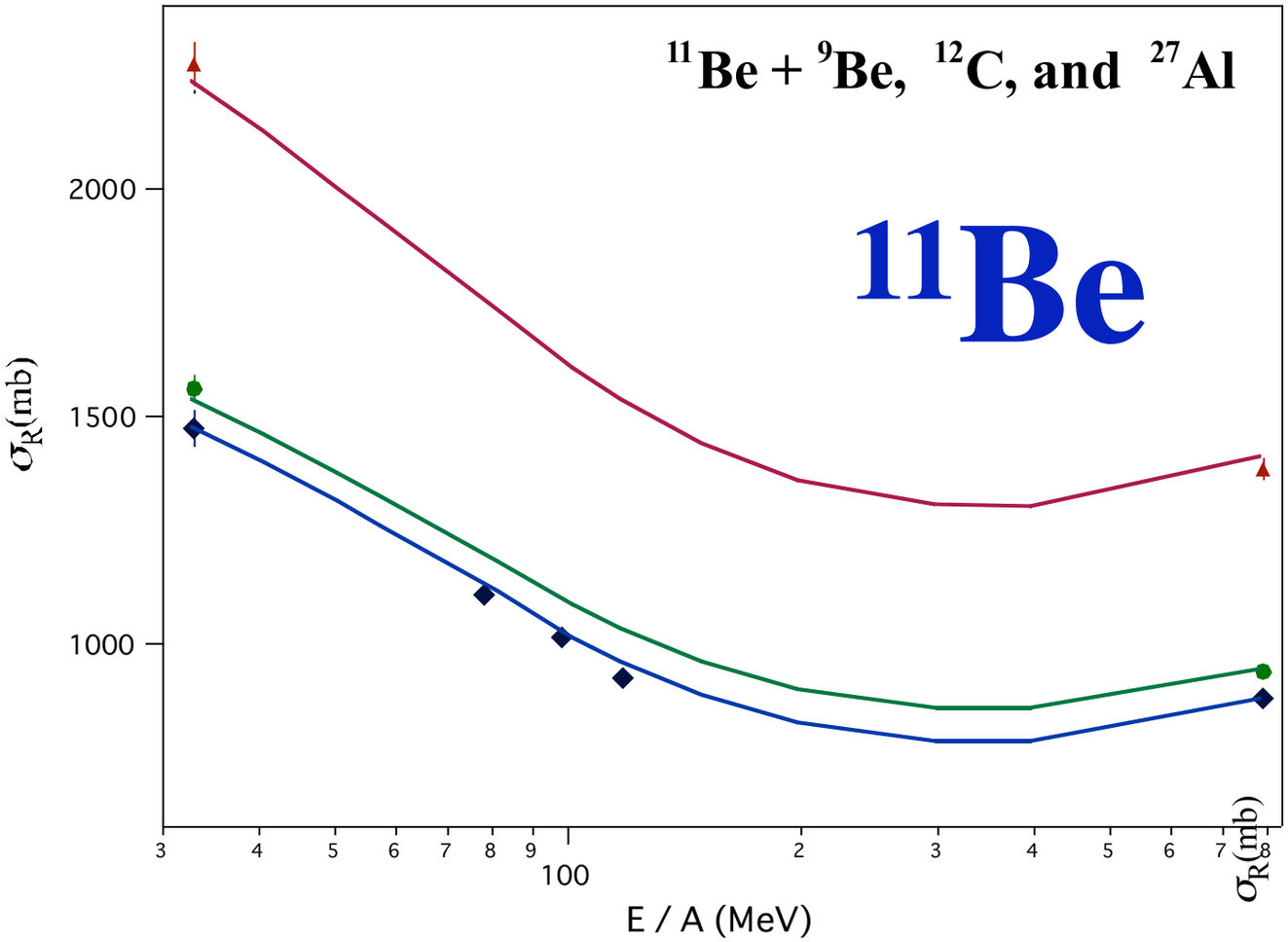
multiple scattering included

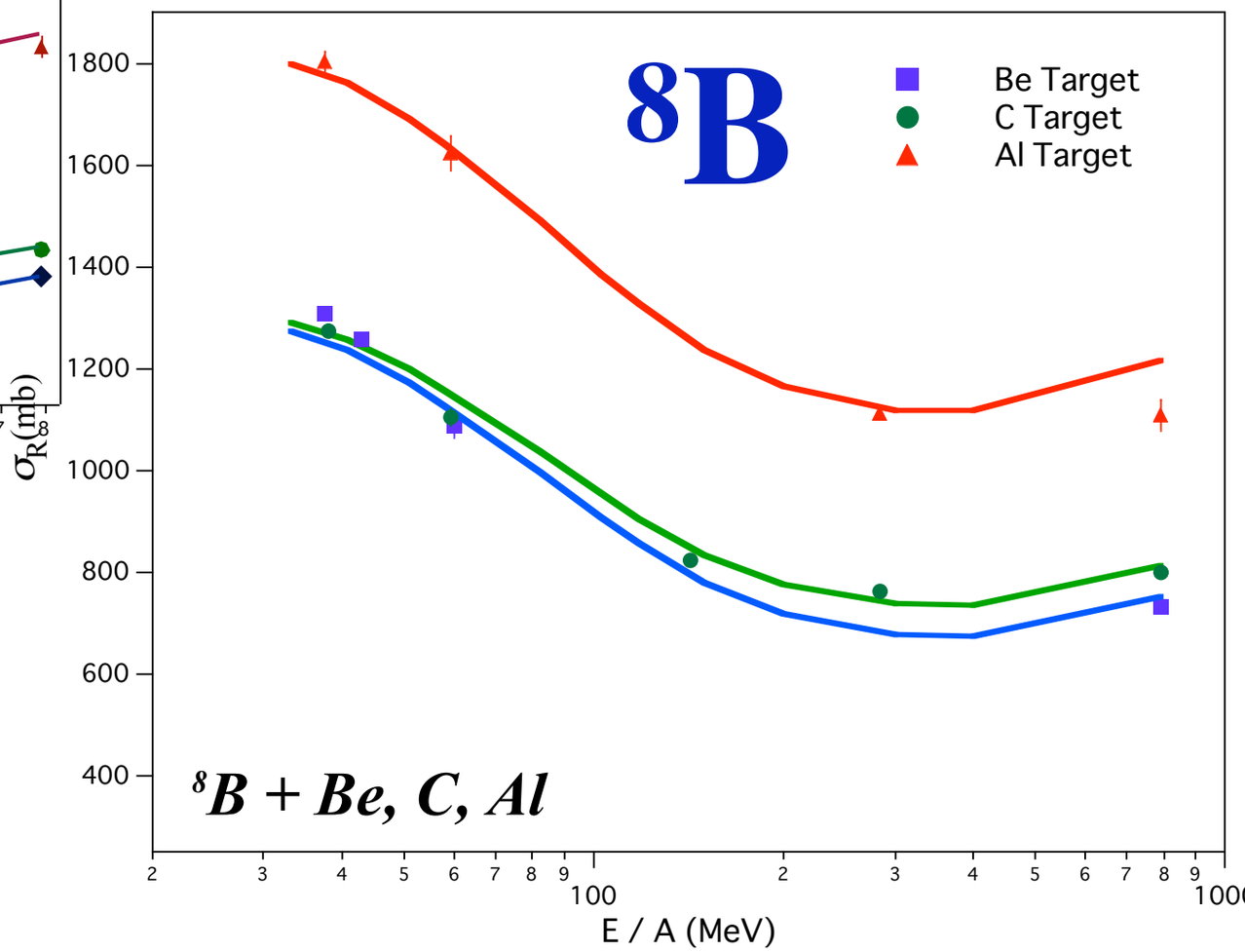
安定核の結果



不安定核 σ_R との比較

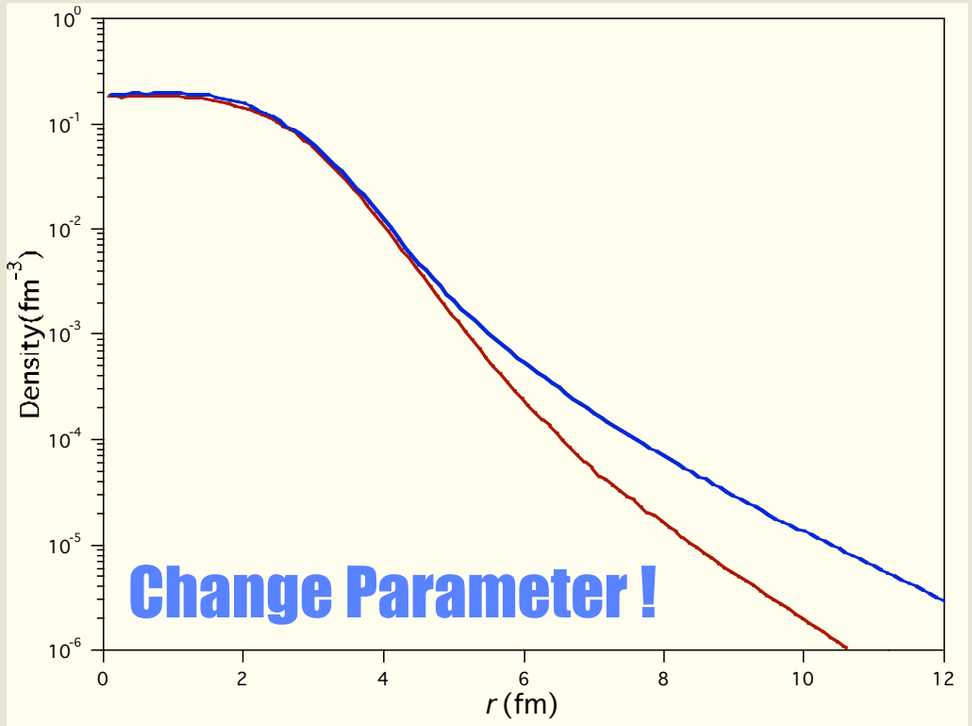
ρが比較的よくわかっている ^{11}Be, ^{8}B

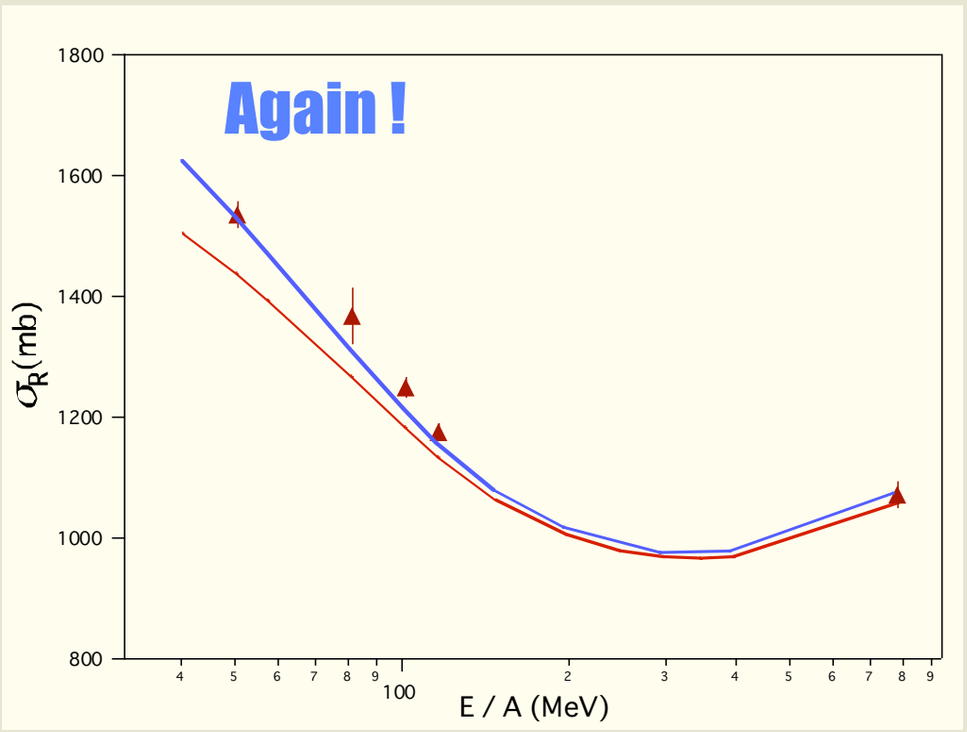




How to Deduce Nucleon Density

~ χ^2 fitting procedure ~





$\rho(r)$

$\rho(r)$: Model Density

Glauber Calculatio

σ_R(Calc.)

Compare

σ_R(Expt.)

Model Density

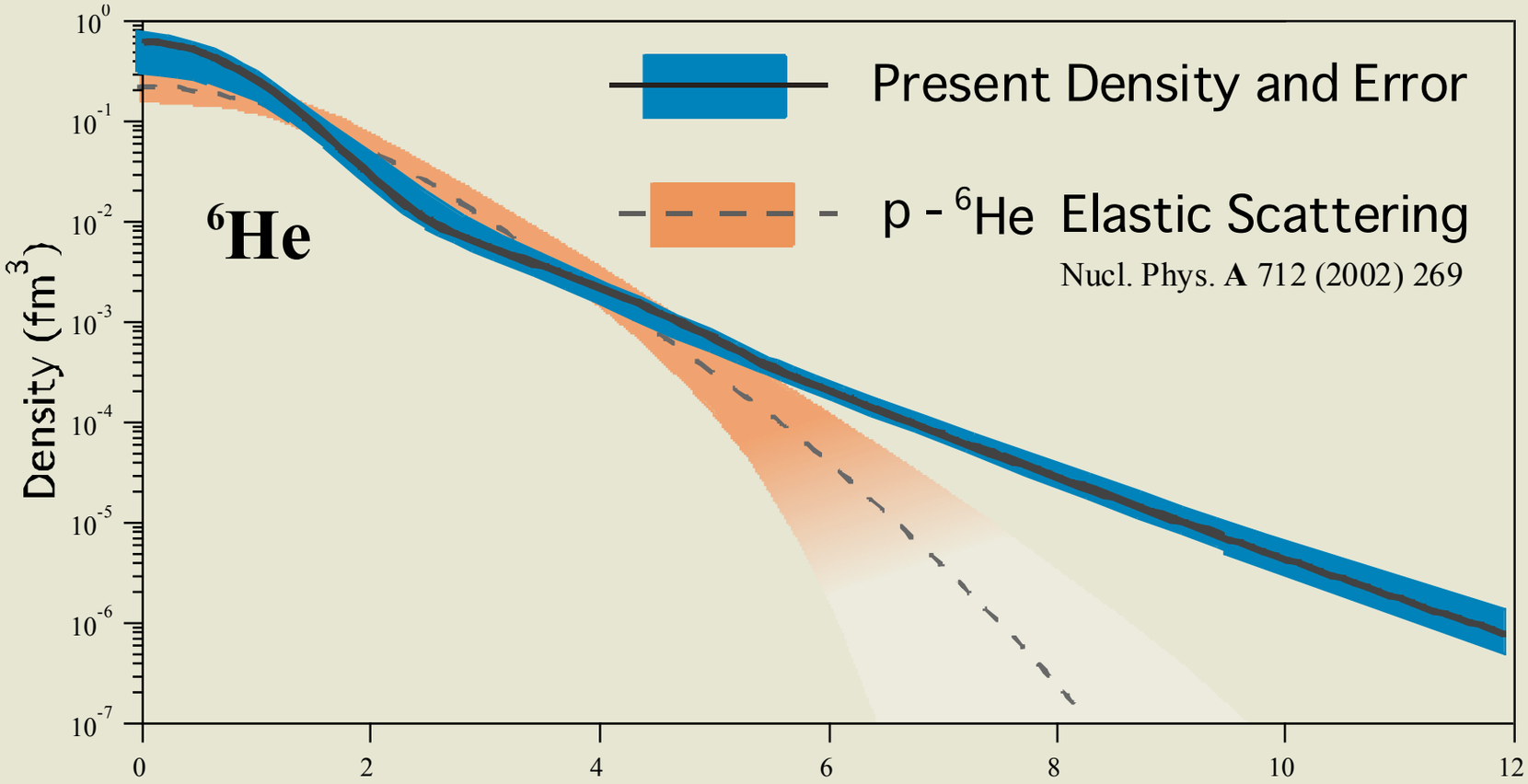
^{6}He : ^{4}He + 2n Model

^{8}He : ^{4}He + 4n Model

Core : Gaussian

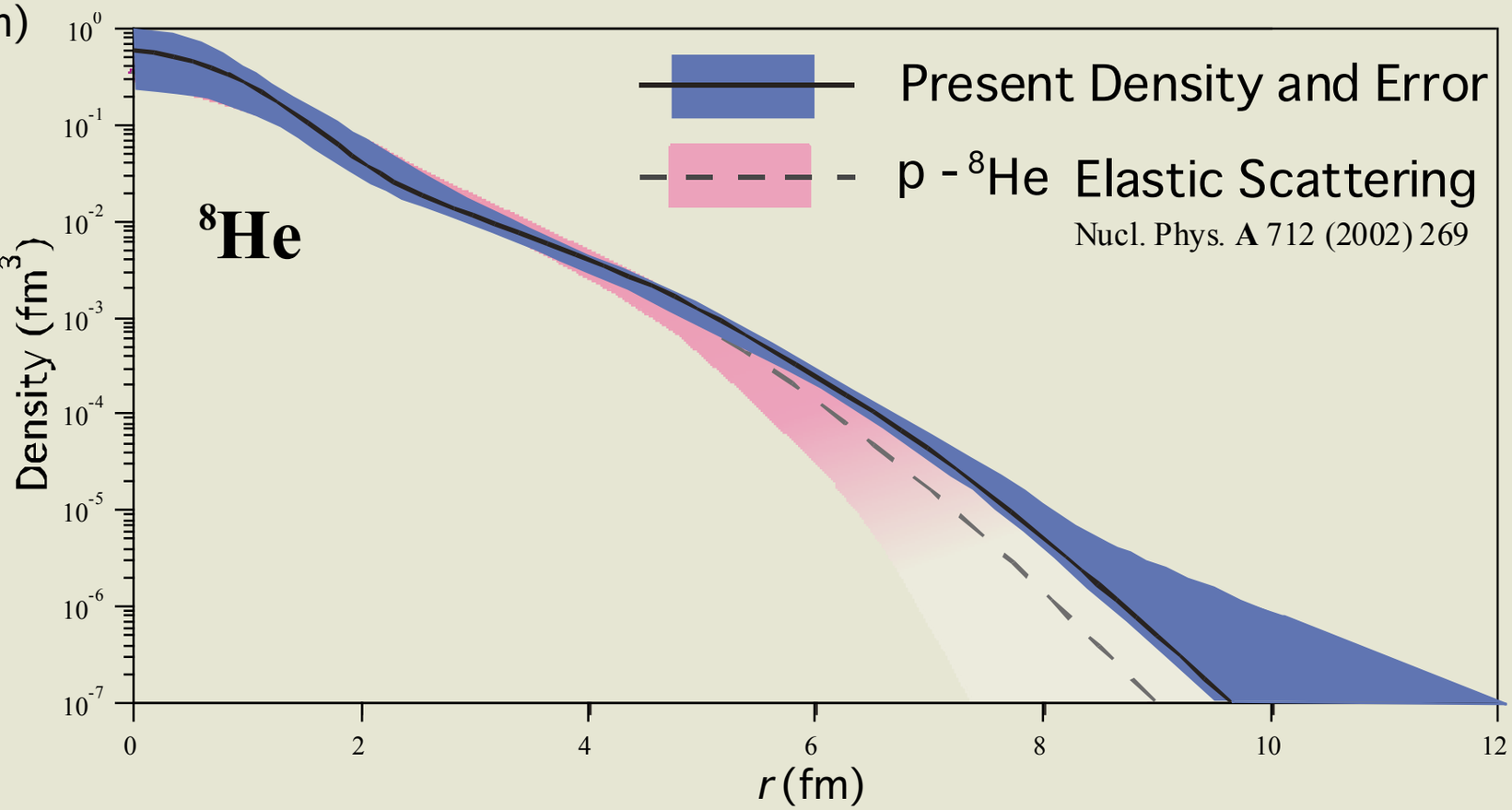
Valence : Gaussian + Yukawa

Density Distributions



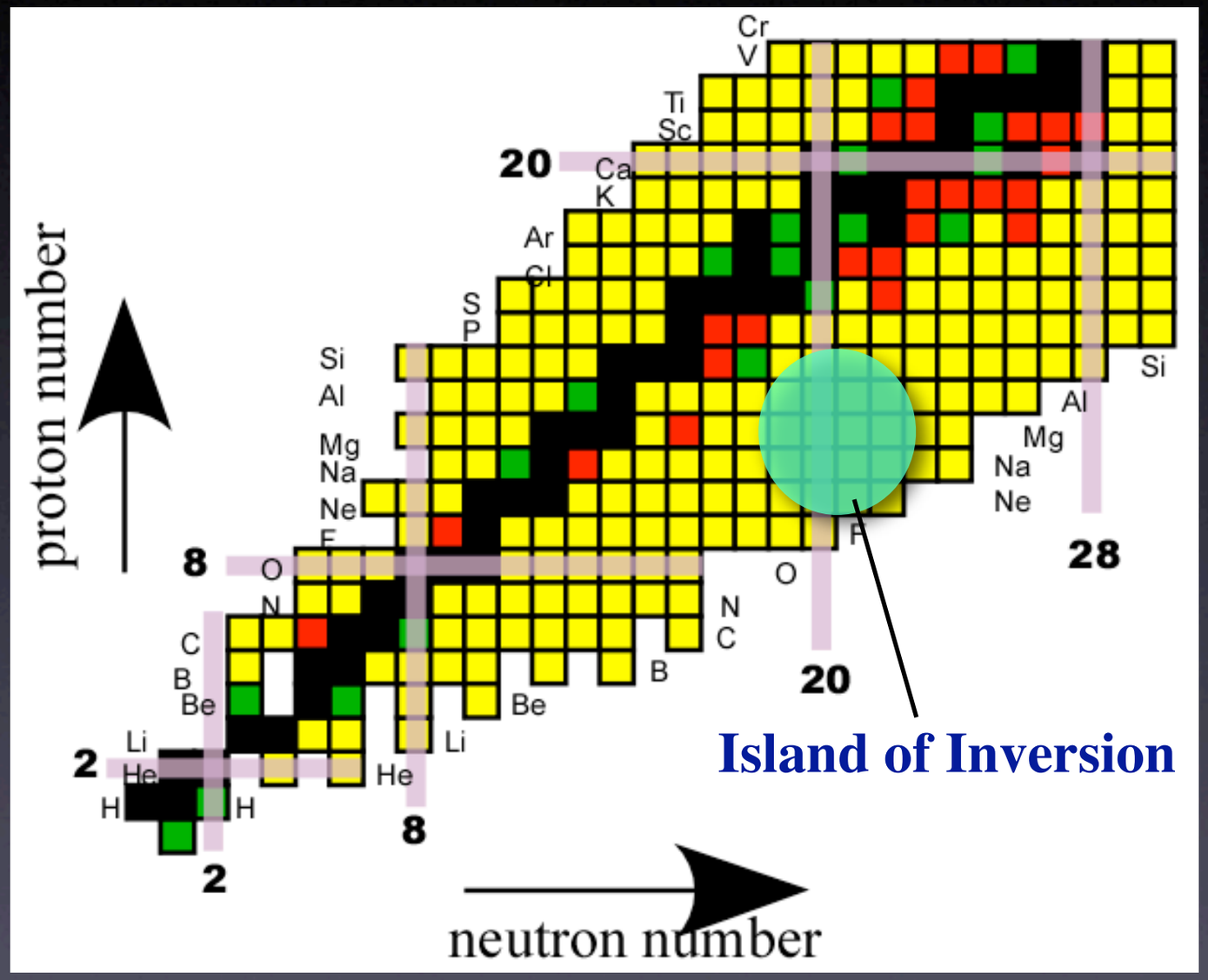
Halo Tail

Skin-Type Density



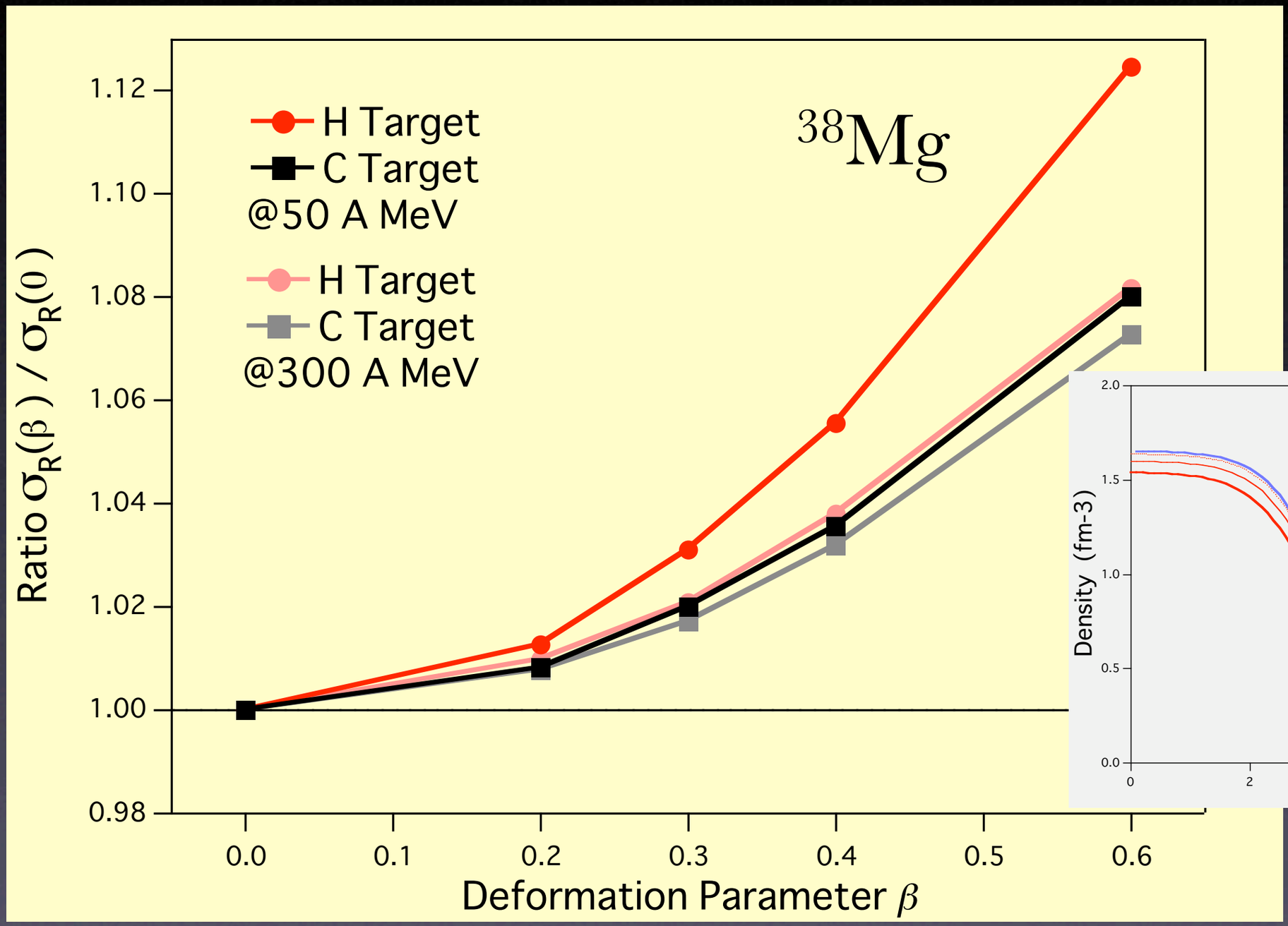
Z = 10–14 region

- **Island of Inversion**



$\beta_2 \sim 0.4 - 0.7$ ⟸ γ-ray spectroscopy
Coulomb excitation

deformation ⇔ σ_R



optical-limit Glauber calculation

まとめ

- 中間エネルギーで反応断面積と核子密度分布を関係づけることに成功
- →軽核の核子密度分布を求められる
- 変形やハローの探索(Iland of Inversion)
- 核整列と反応断面積
- 中性子スキン　→EOS, 宇宙物理

Main Collaborators

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