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Shift and width of momentum distribution of projectile-like fragments produced at 290MeV/u

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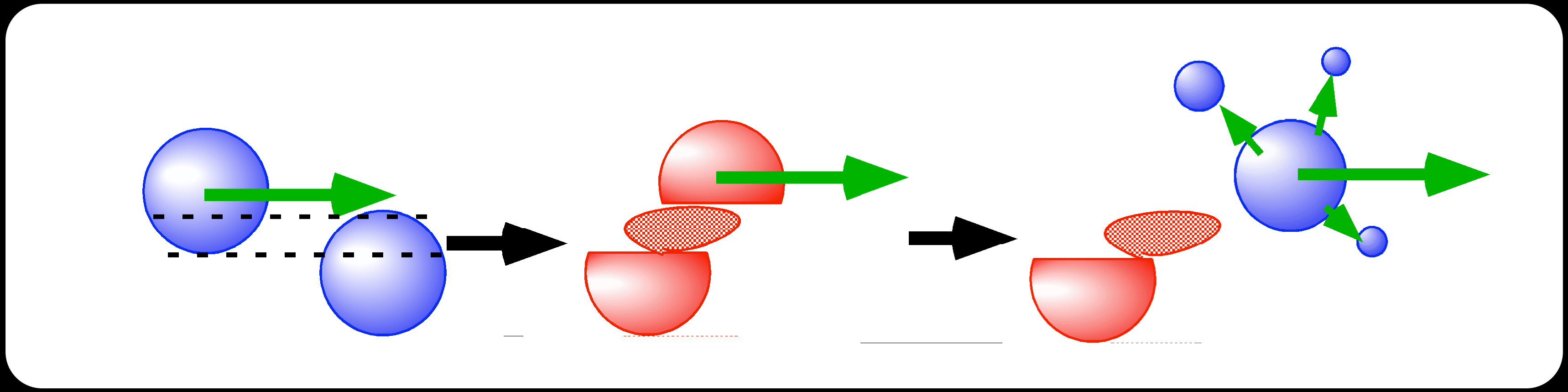
Projectile fragmentation process

- Powerful process to produce RNB
  - →Structure/reaction of unstable nuclei
  - →Tools/probes applied to various fields



- Momentum distribution
  - Interaction acting in production process
  - Production cross-sections ($\sigma_{Prod.}$) of PLFs

P_L distribution of PLFs

Exp. / Simple model / Parameterization

- Width : σ_L
  - +Fermi momentum in nucleus — Goldhaber(1974)
  - +Sequential evaporation — Morrissey(1989)
  - +Universal parametrization — Tarasov(2004)
  - +Analyzed by asymmetric func. — Notani(2004), Mocko(2007)

- Shift (deceleration) : $-\Delta P_L$
  - +Linear dep. on σ_L — Greiner(1975)
    - ΔA — Kaufman(1982), Morrissey(1989)
  - +E_B of removed nucleons — Borrel(1983)
  - +N_{Pair} of nucleons — Notani(2004)

P_T distribution of PLFs

Exp. / Simple model / Parameterization

- Width : $\sigma_T^2 = \sigma_L^2 + ...$

  + Orbital deflection due to interaction with target

    Bibber(1979)

  + Coulomb final state interaction

    Wong(1982)

- Shift (deflection) : ΔP_L

  + Empirical consideration of nuclear and Coulomb force

    Giacomelli(2004)

  + Observation with Ar + Nb, Tb, Au @ 290MeV/u

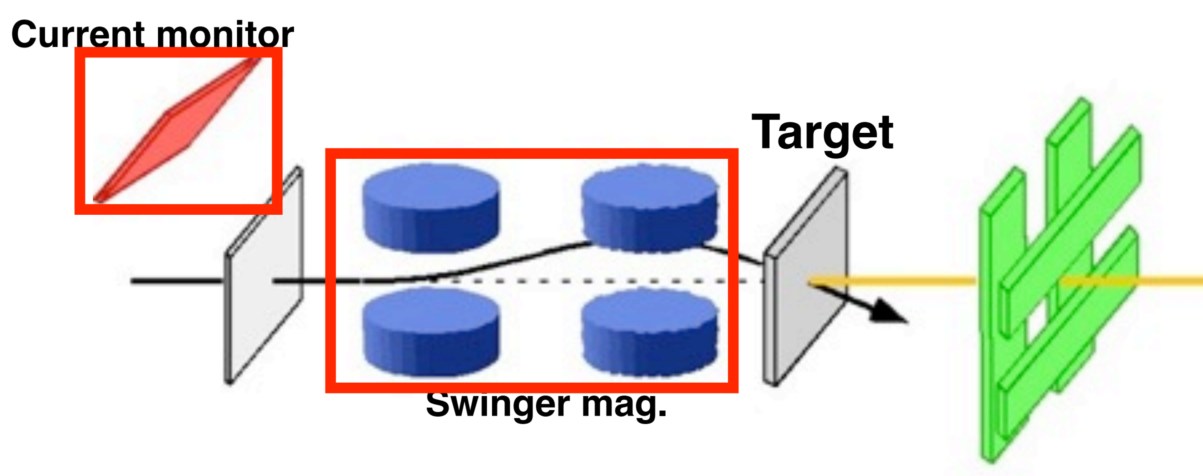
    Momota(2007)

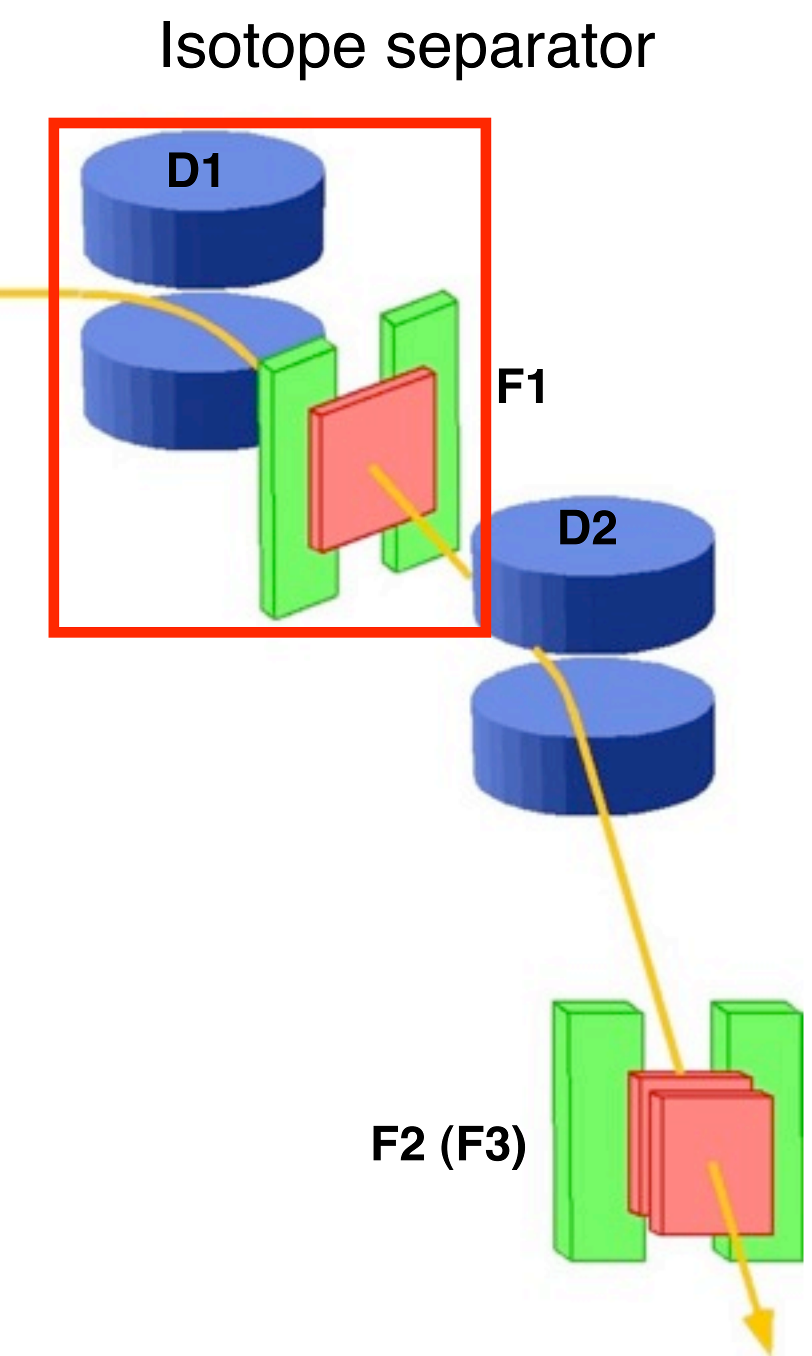
Object of this talk

- Systematic measurements of P distributions of PLFs at 290 MeV/u
  1. P_L : asymmetric Gaussian functions
  2. P_T : off-centered Gaussian functions
  3. Systematics

Reliable $\sigma_{Prod.}$ of PLFs
Simulation of heavy ion transport phenomena

Experimental setup





A. Identification of fragments
TOF : F1 - F2 or F1-F3
ΔE : F2 (or F3)

B. P_L distribution
D1, F1-slit

C. P_T distribution
Deflection by swinger mag., 4D-slit

D. Monitor of beam current
Charged particle emitted from thin foil

Reaction/Meas. parameters

Beam : ^{40}Ar, ^{84}Kr 290 MeV/u

Target : ^{12}C, ^{27}Al, ^{93}Nb, ^{159}Tb, ^{197}Au

1.0 0.8 0.5 0.5 0.333 mm

Acceptance of ISOL :

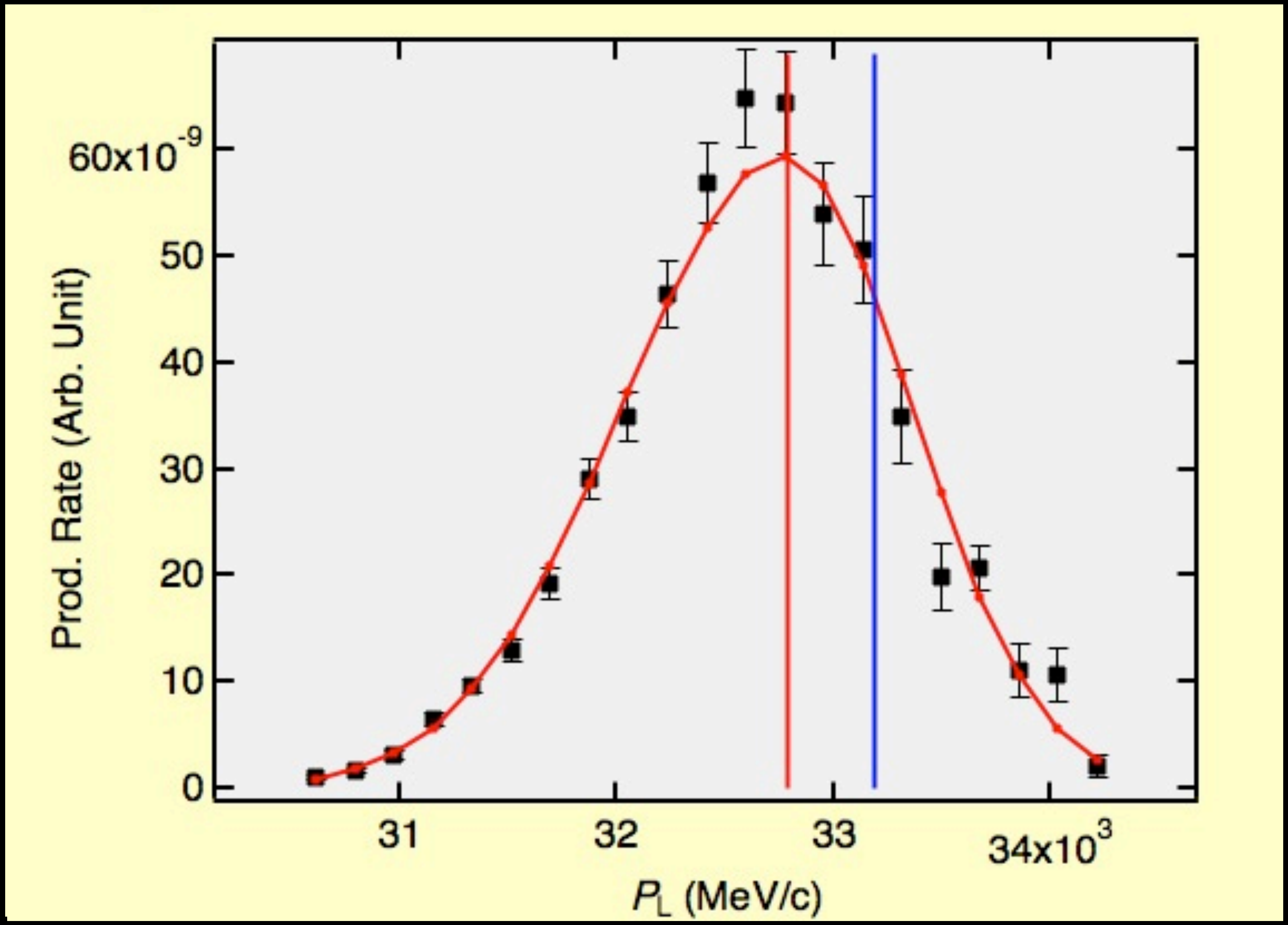
$\Delta P/P0$ = 1.0% (Ar) / 0.5% (Kr)

$\Delta\theta_x = \Delta\theta_y$ = 26 mrad P_L dist.

8 mrad P_T dist.

P_L distribution

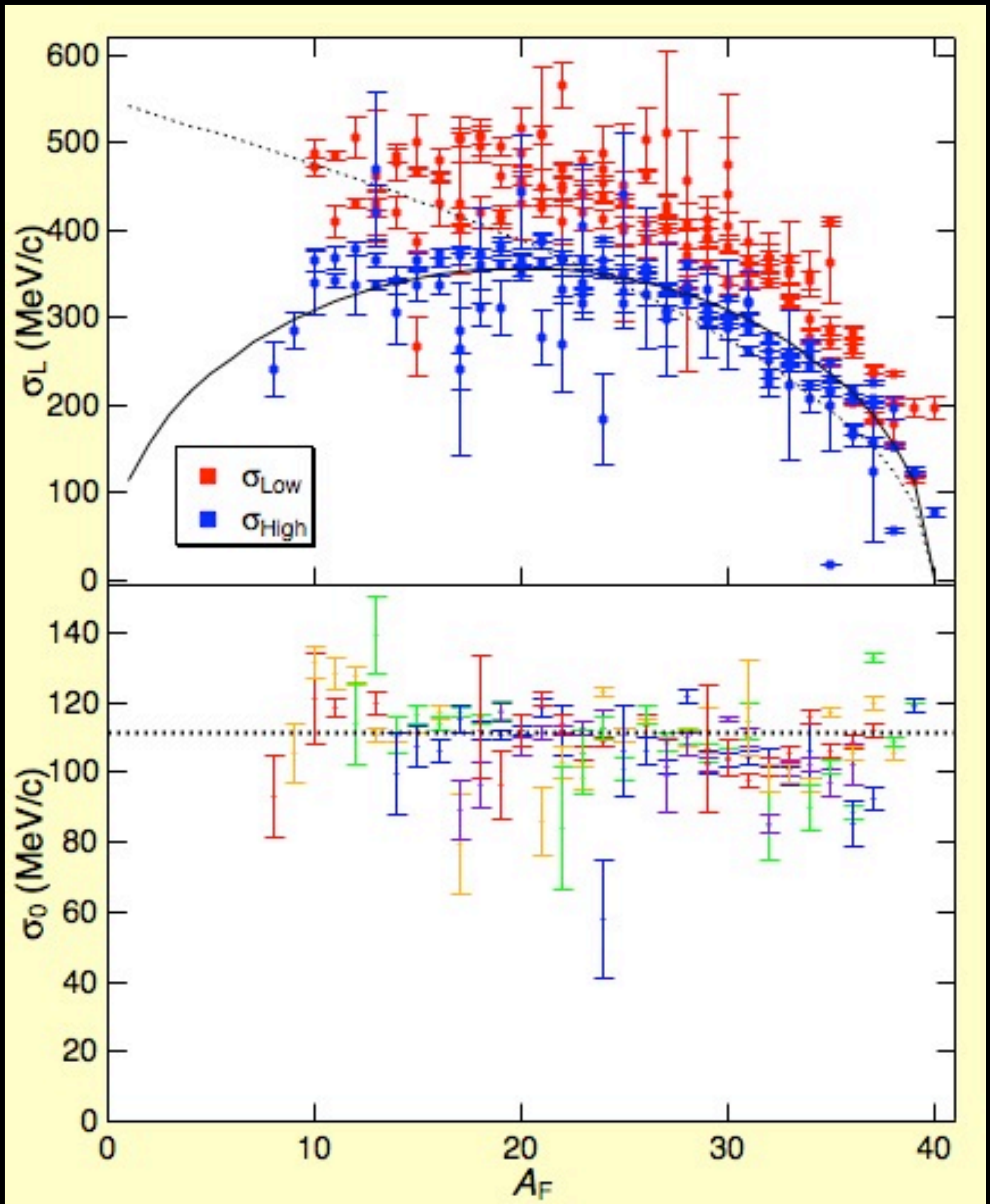
^{484}AKr + NCb → ^{430}CNae + X



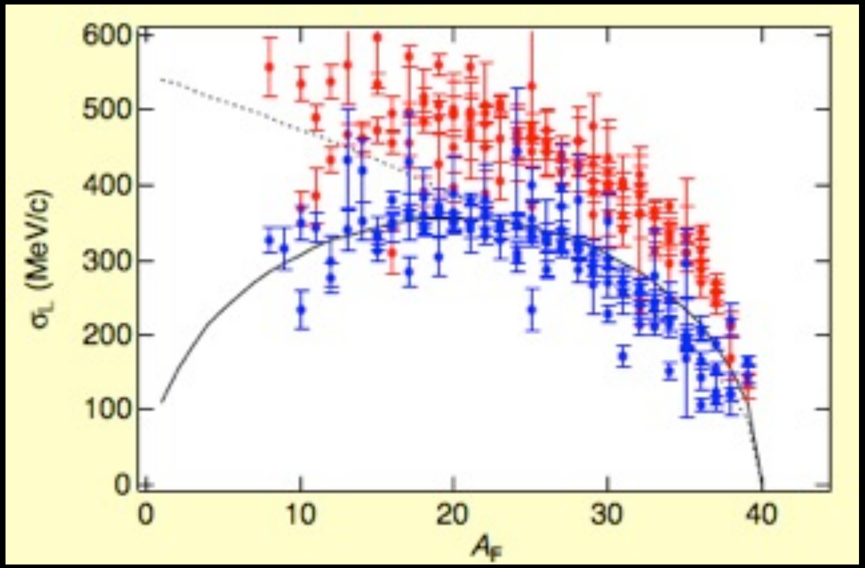
Analyzed by asymmetric Gaussian functions

Width of P_L distribution : Ar

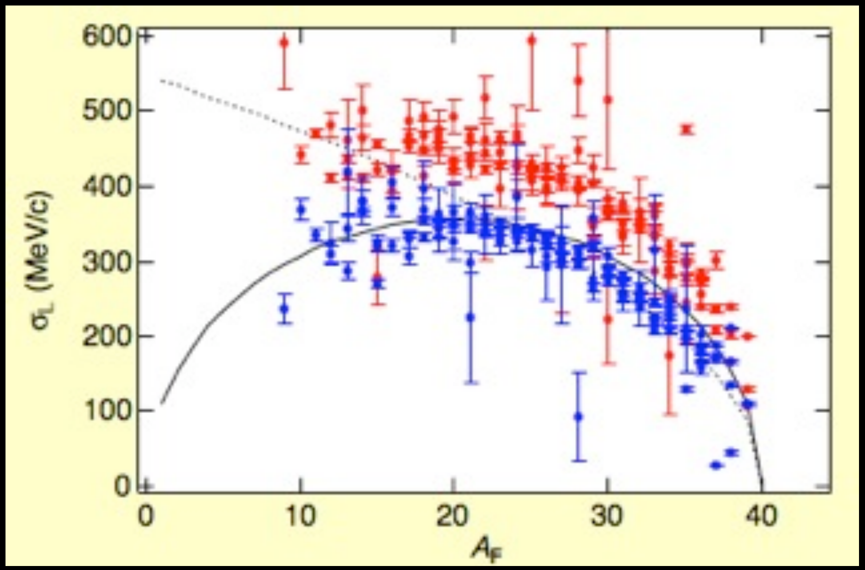
^{40}Ar + Nb → ^{A}Z + X



^{40}Ar + C → ^{A}Z + X

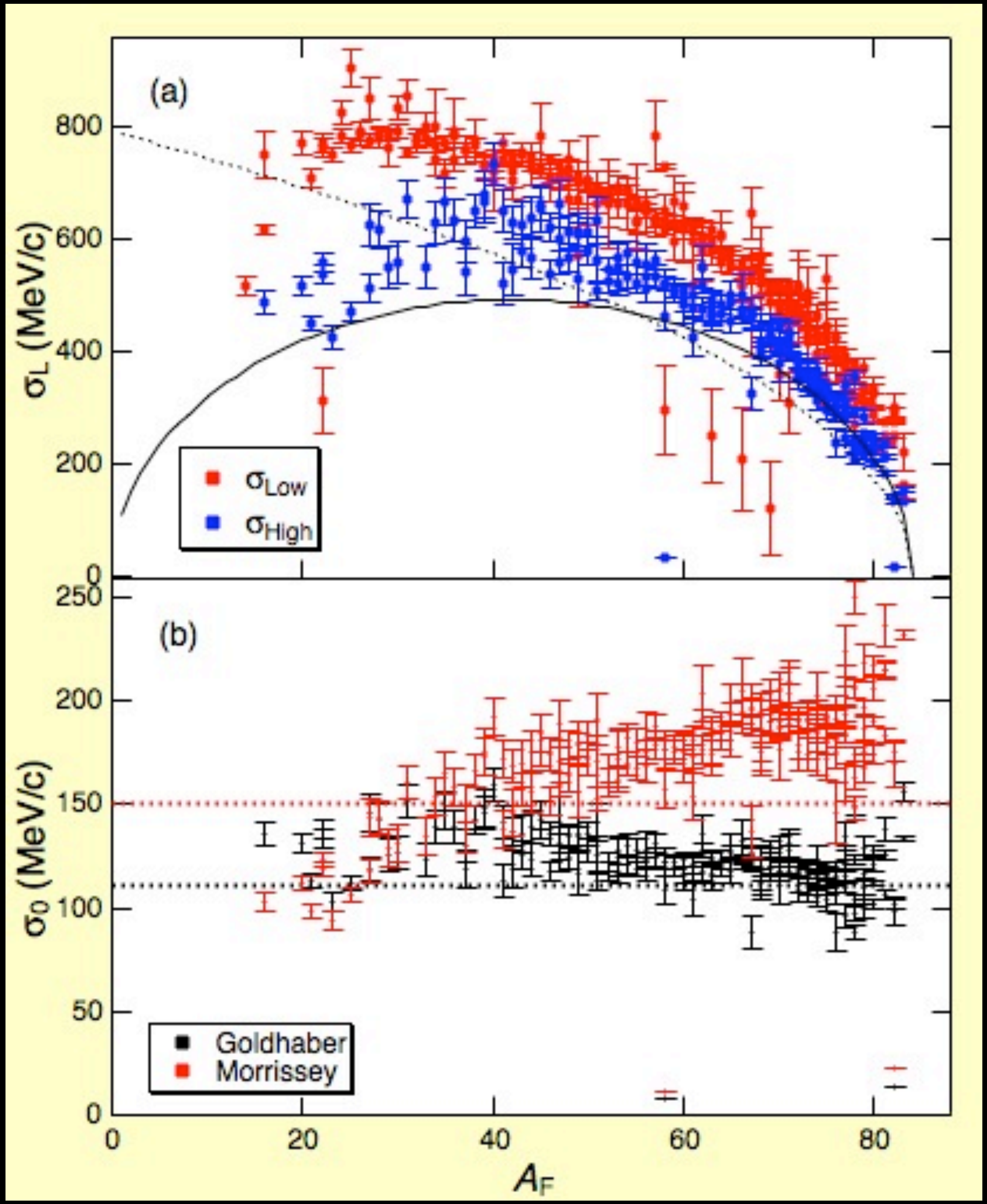


^{40}Ar + Au → ^{A}Z + X



Width of P_L distribution : Kr

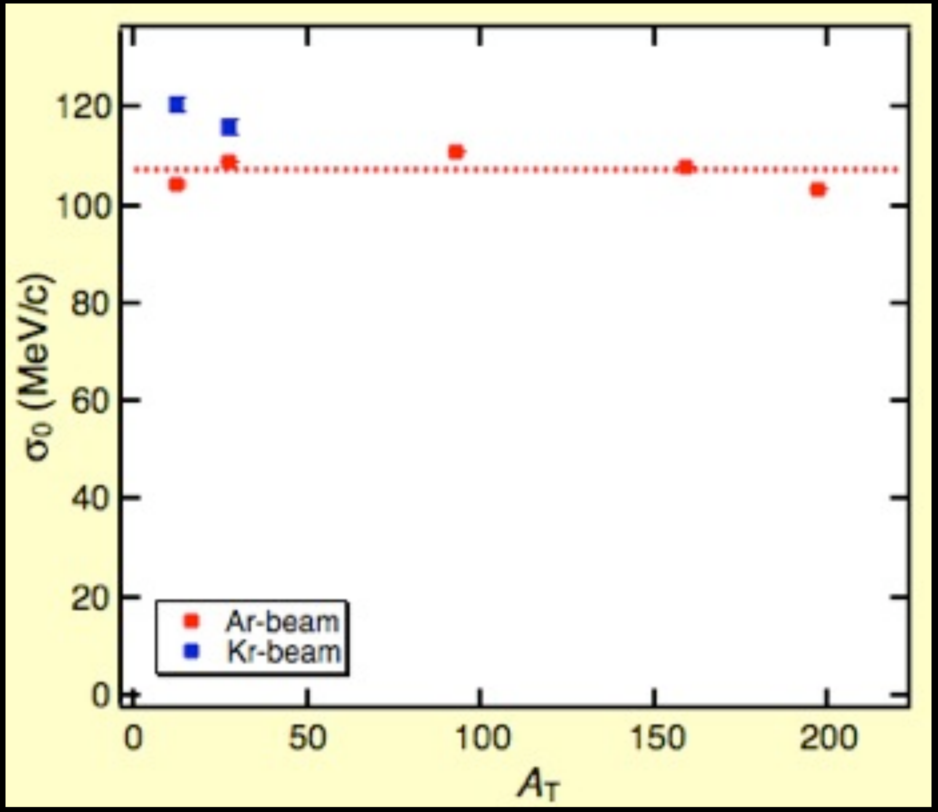
$^{84}Kr + C \rightarrow {}^{A}Z + X$



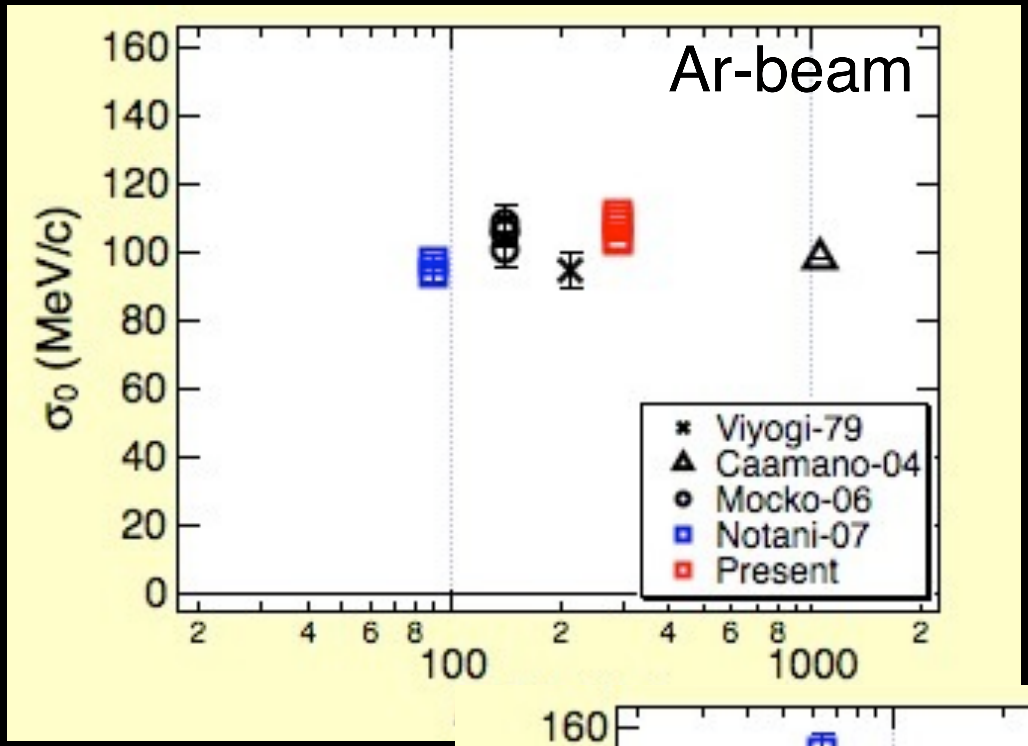
- GH model is probable for $A_F < 50$.
- σ_0 (Kr) > σ_0 (Ar)

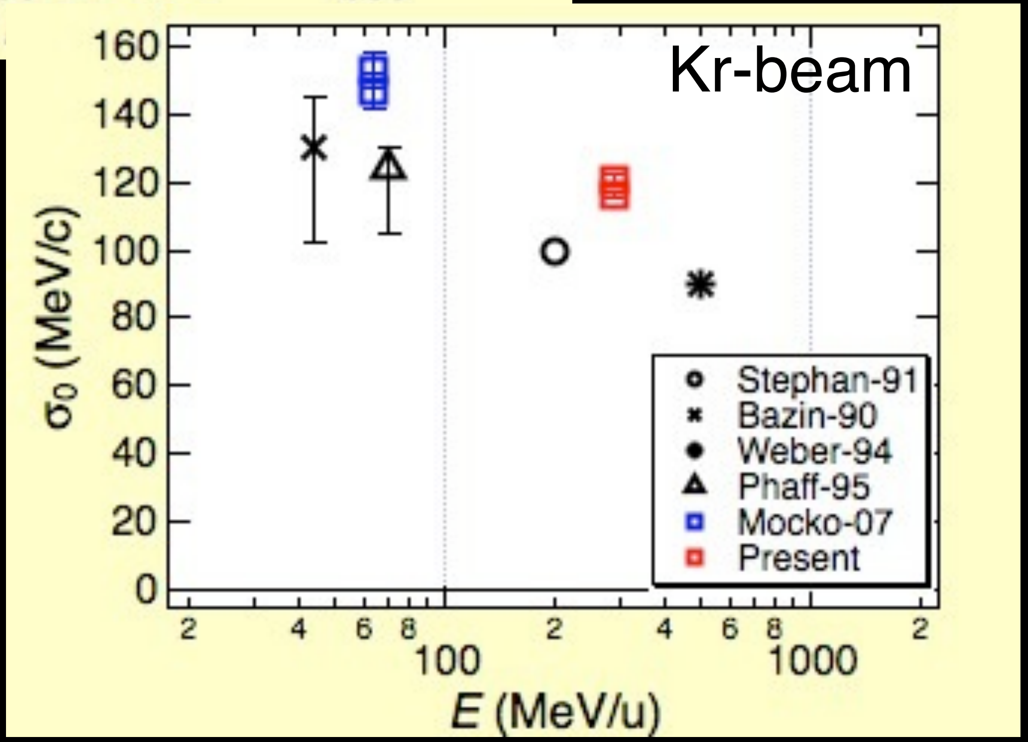
Reduced momentum width

Target&Beam Dep.

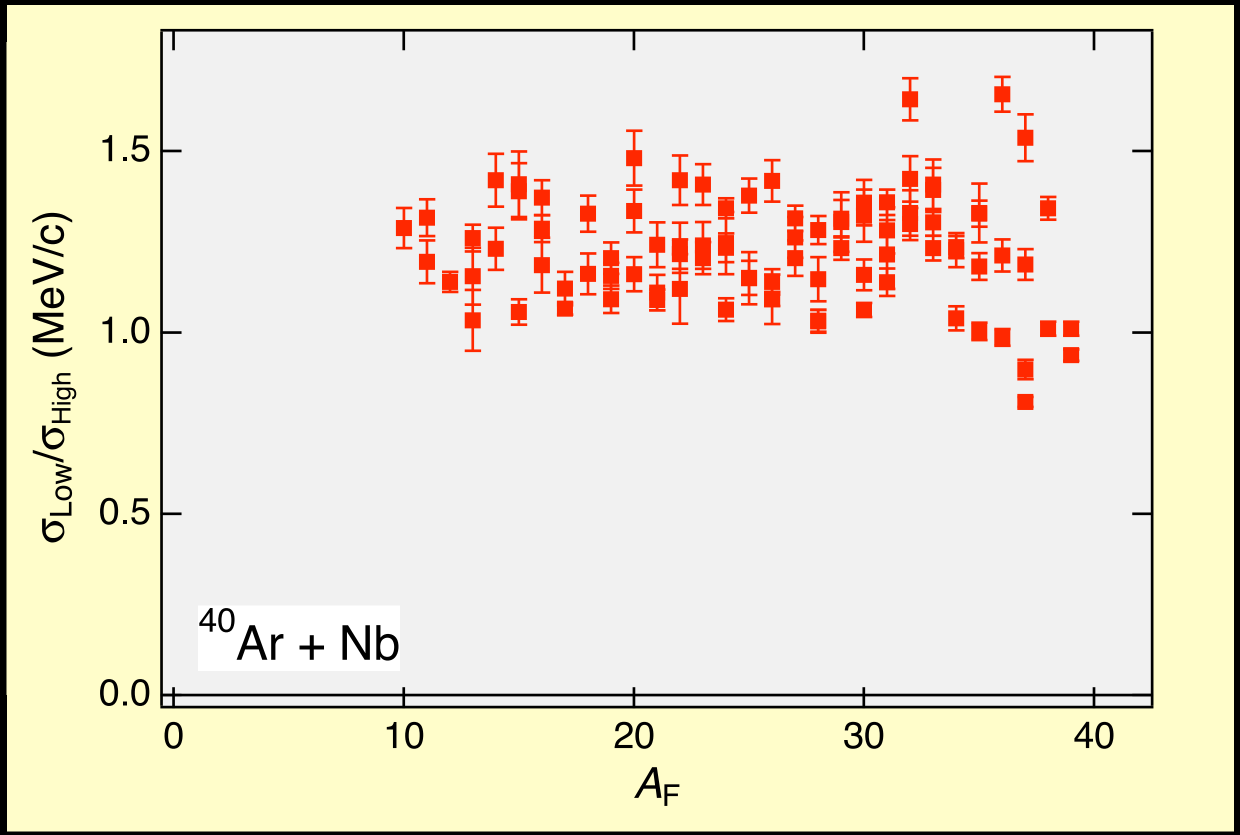


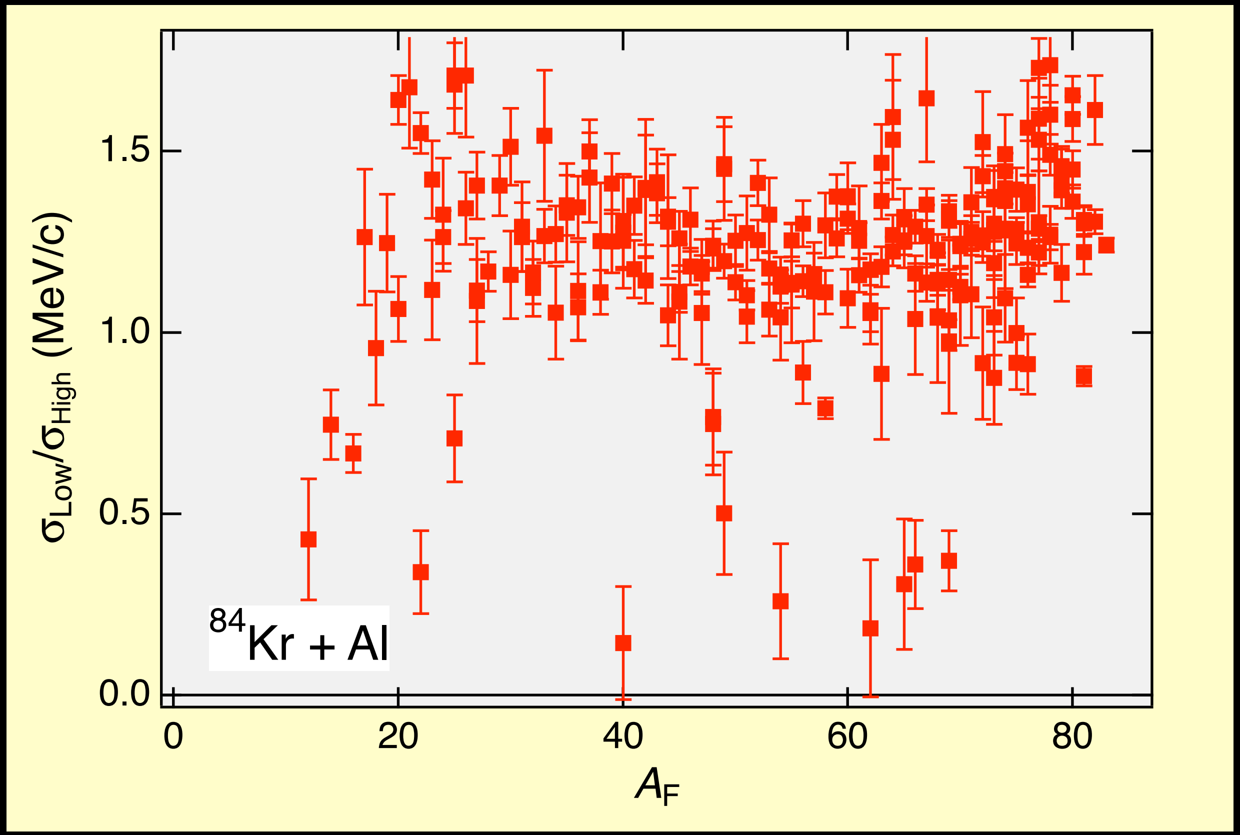
Energy Dep.





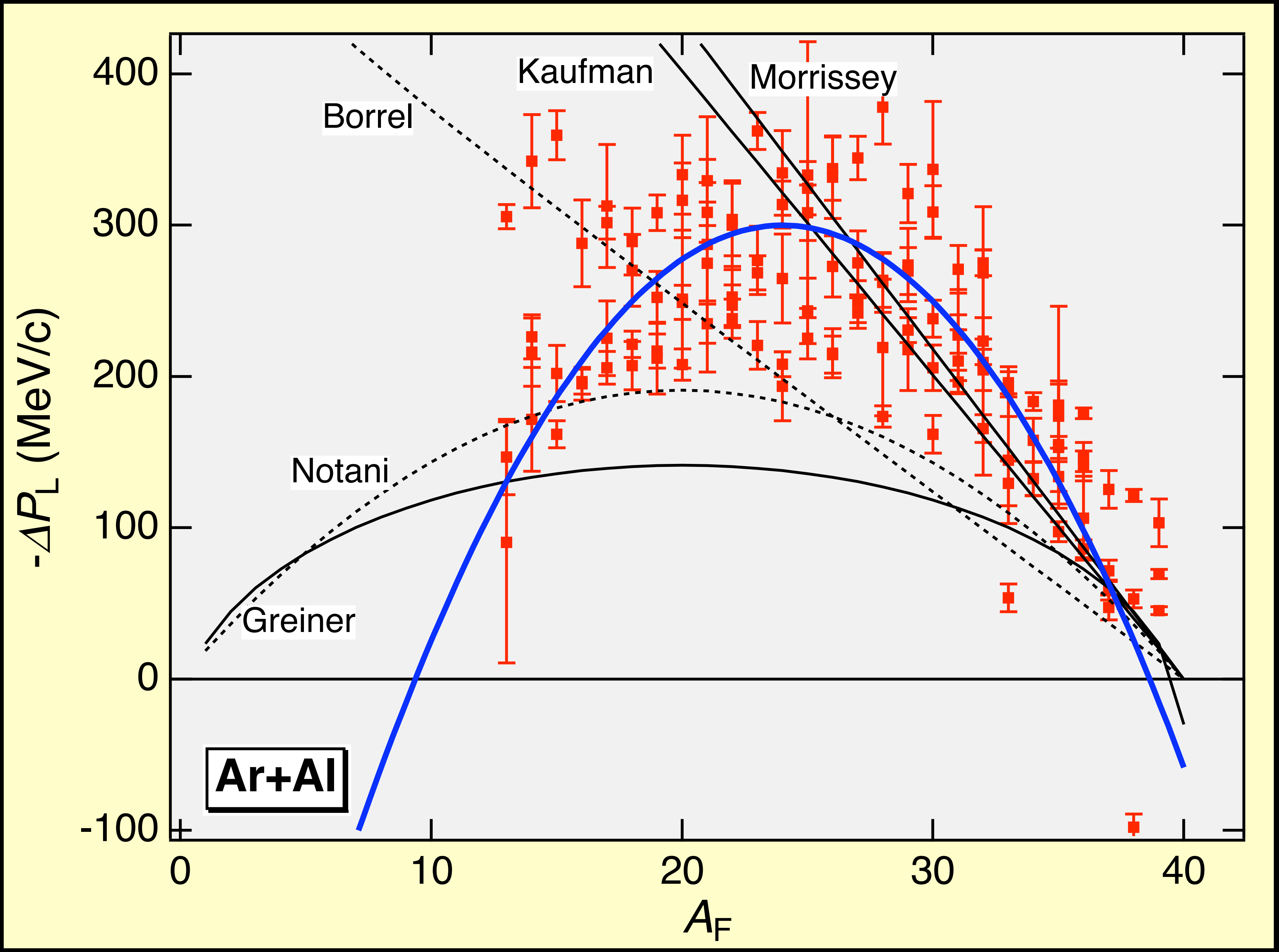
Asymmetric width of P_L



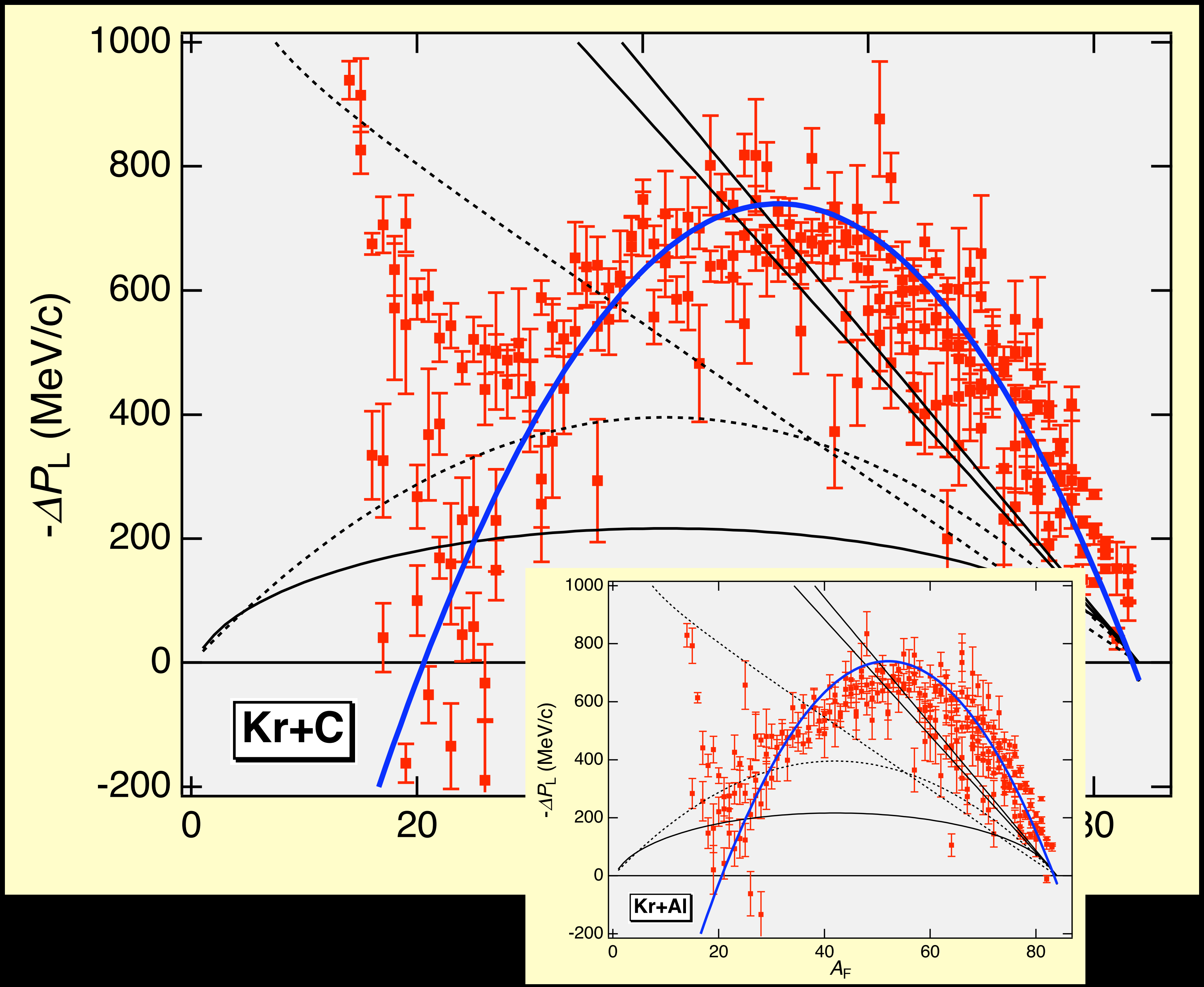


$\sigma_{Low}/\sigma_{High}$: Universal parameter at 290 MeV/u

Shift of P_L distribution : Ar

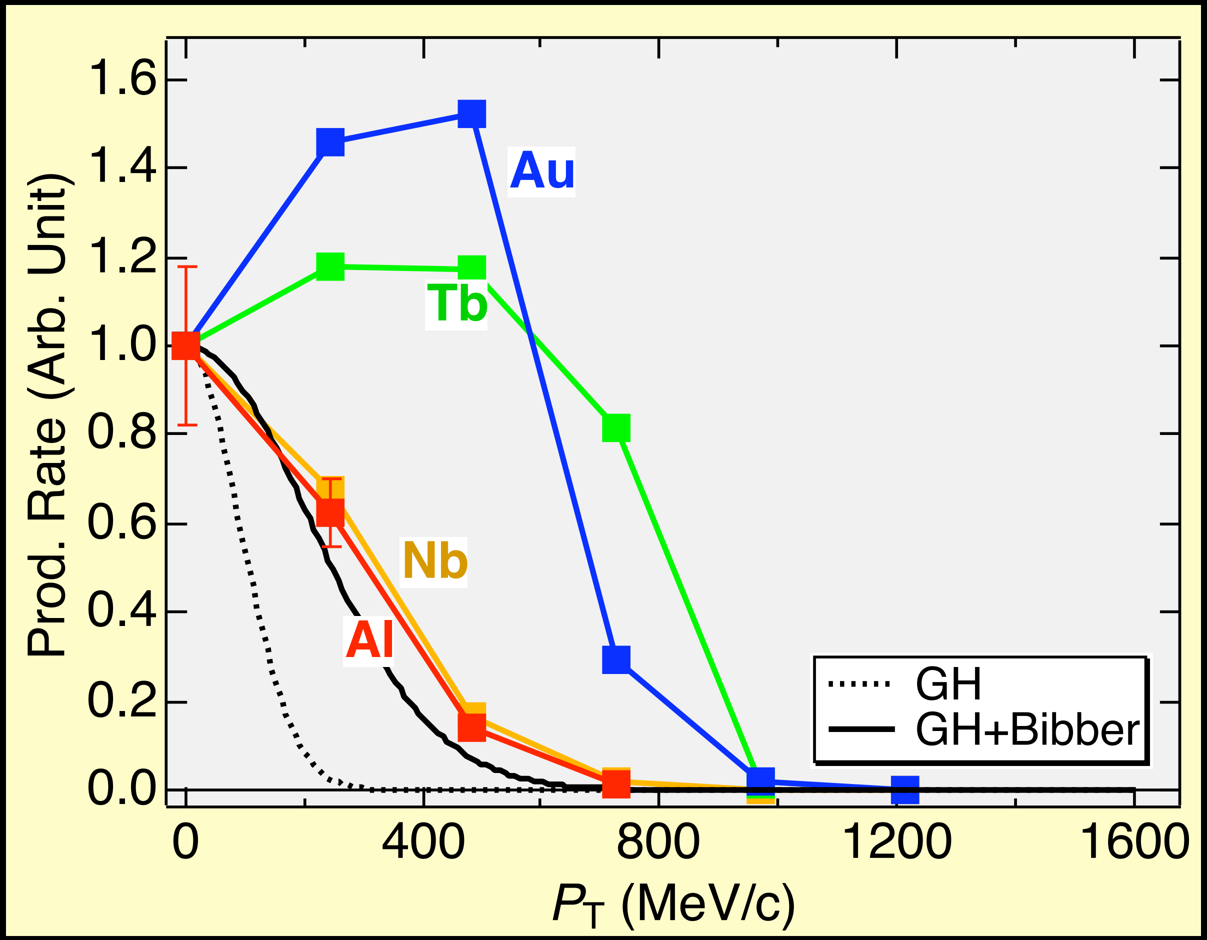


Shift of P_L distribution : Kr

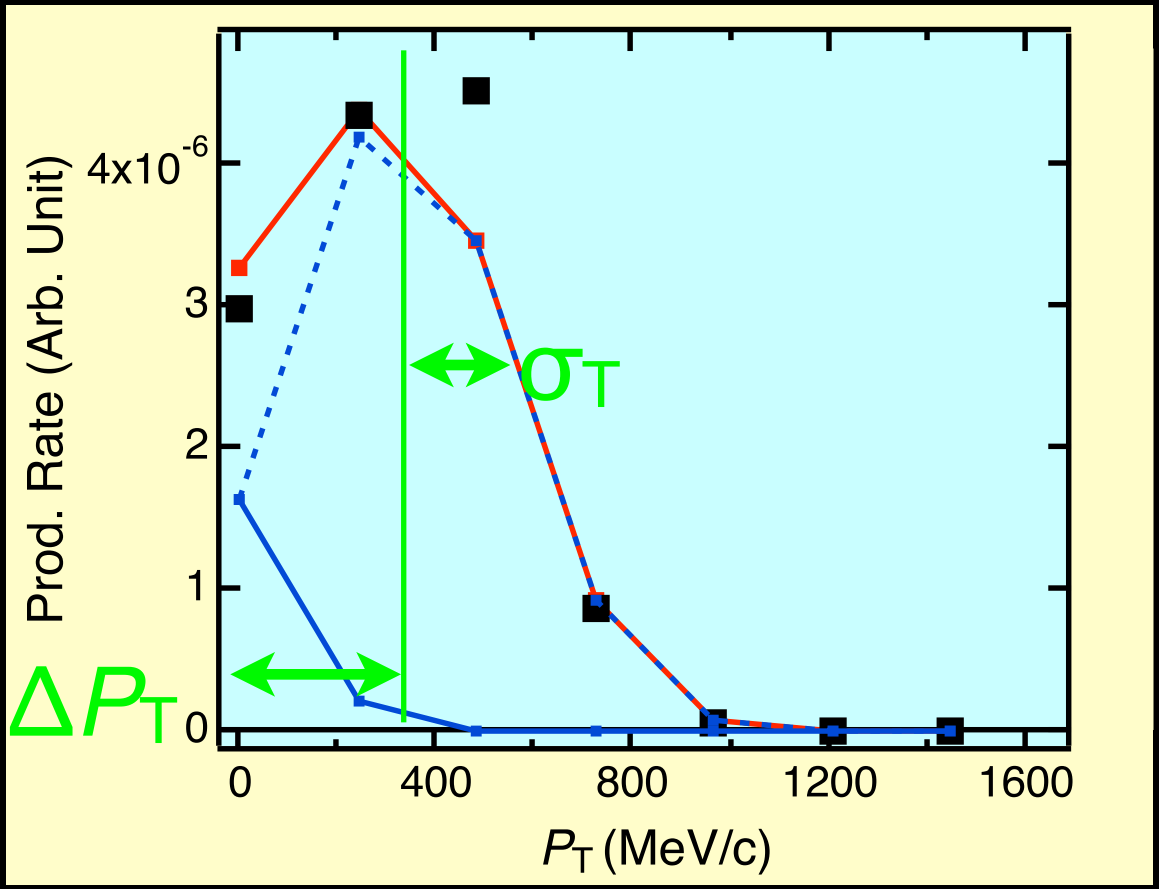


P_T distribution : Ar

^{40}Ar+Target → ^{39}Cl + X



Function fitting

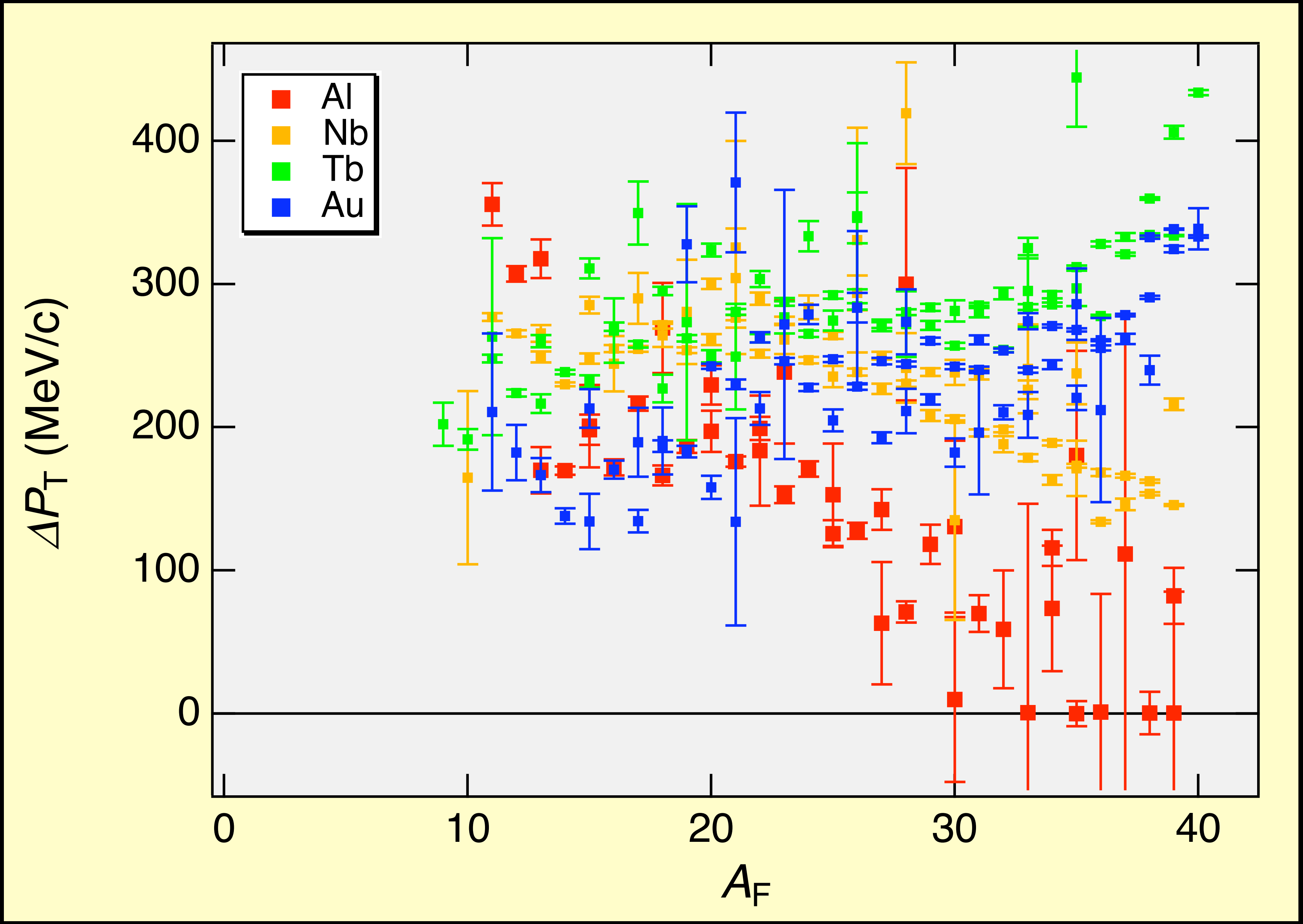


Off-centered Gaussian functions

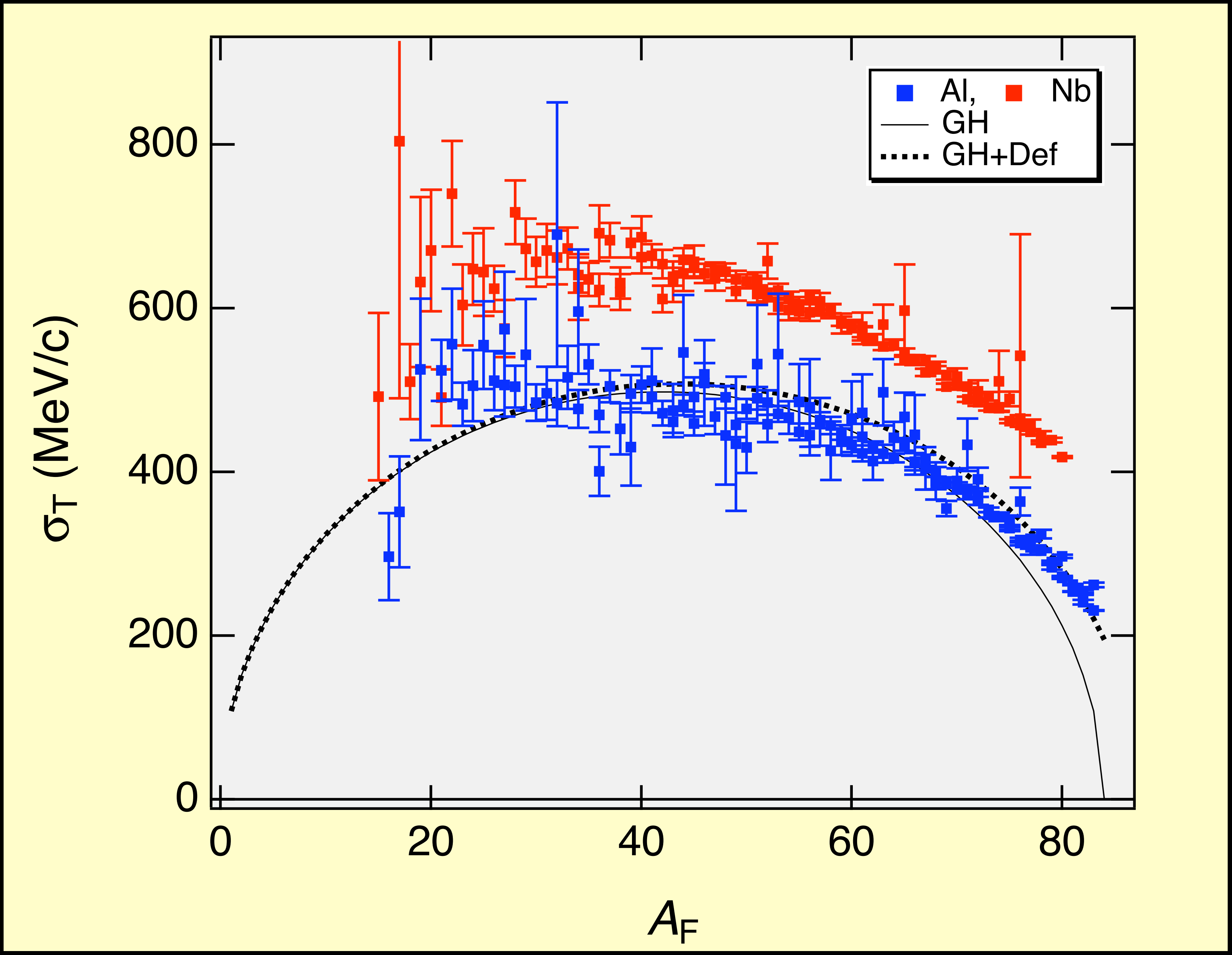
$$f(P_T) = k\left\{\exp\left(-\frac{(P_T - \Delta P_T)^2}{2\sigma_T^2}\right) + \exp\left(-\frac{(P_T + \Delta P_T)^2}{2\sigma_T^2}\right)\right\}$$

σ_T is fixed.

Width of P_T distribution : Ar



Width of P_T distribution : Kr



Summary

- P_L distribution

  Contribution of multiple-step processes

  $\sigma_{Low} / \sigma_{High} = 1.2 \sim 1.3$

  less than E = 90 MeV/u

  Reduced momentum width (100 ~ 1000 GeV/u)

  decreases with *E* for Kr-beam

  Momentum shift

  maximum at $A_F \sim 25$ (Ar), 50 (Kr)

- P_T distribution

  Deflection of orbit caused by Coulomb force

  Systematics?

  Reliable $\sigma_{Prod.}$ produced from heavy target