# EXTENDED SUDDEN APPROXIMATION FOR HIGH ENERGY NUCLEON REMOVAL

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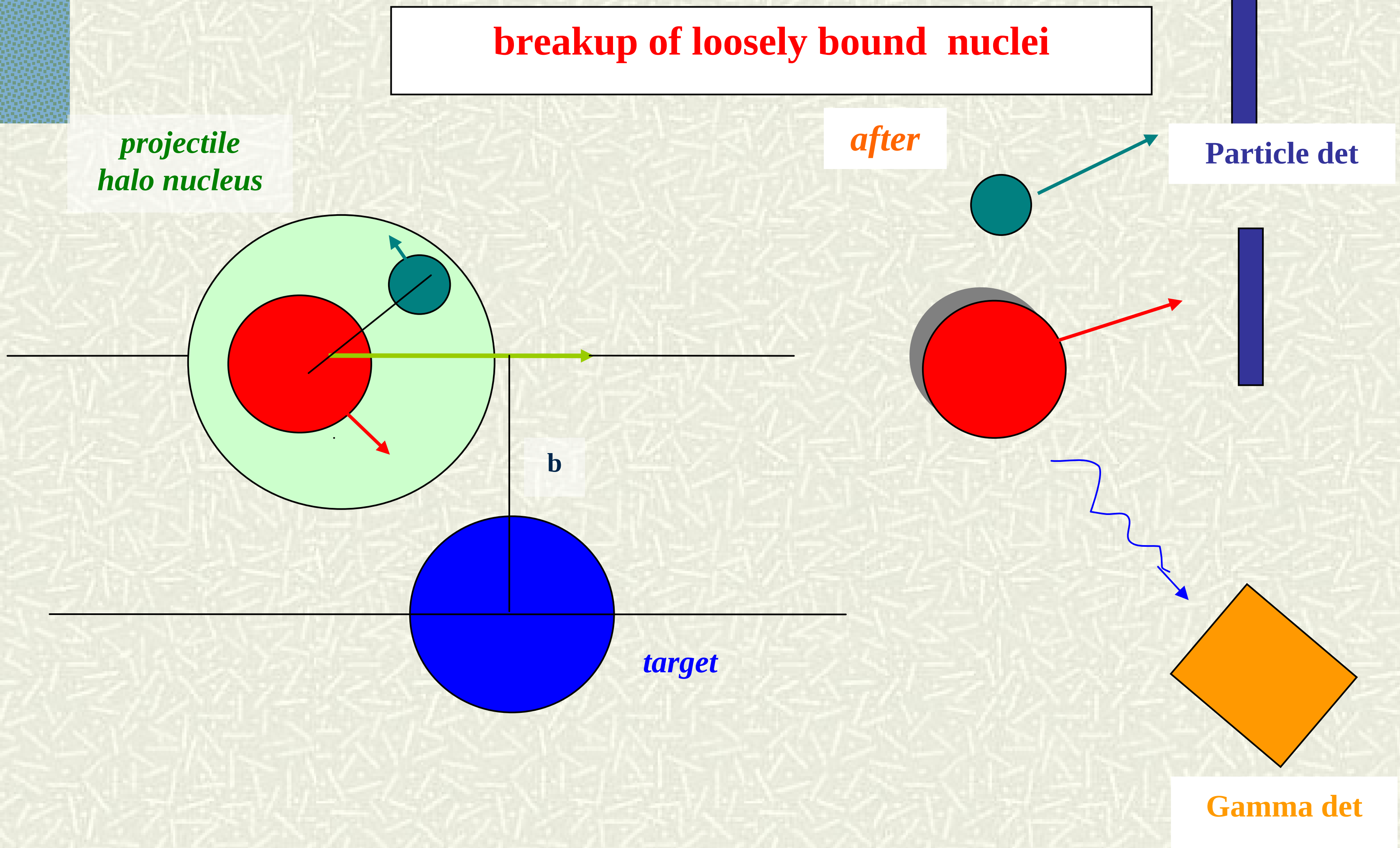
## *Summary*

1. INTRODUCTION
2. BASIC ASSUMPTIONS
3. BREAKUP PROBABILITIES
4. MOMENTUM DISTRIBUTIONS
5. COULOMB DISSOCIATION
6. RESULTS

# Breakup

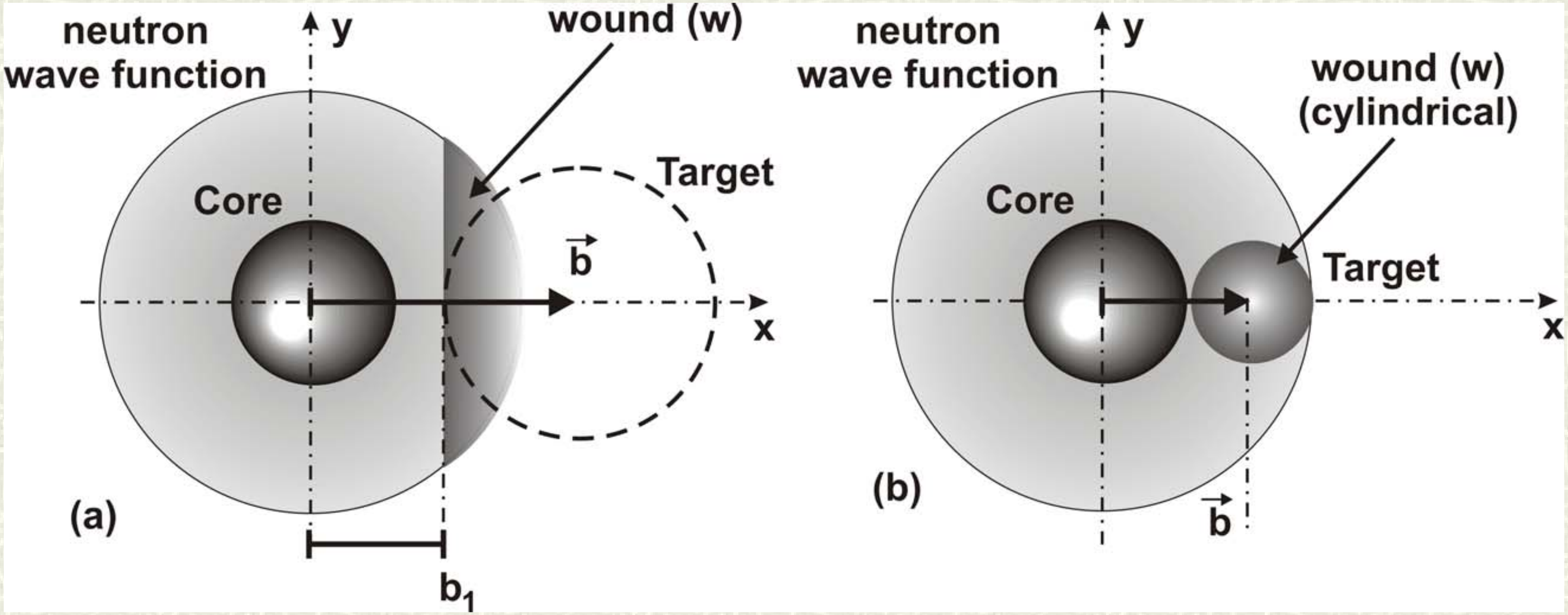


breakup of loosely bound nuclei
projectile
halo nucleus
after
Particle det
b
target
Gamma det

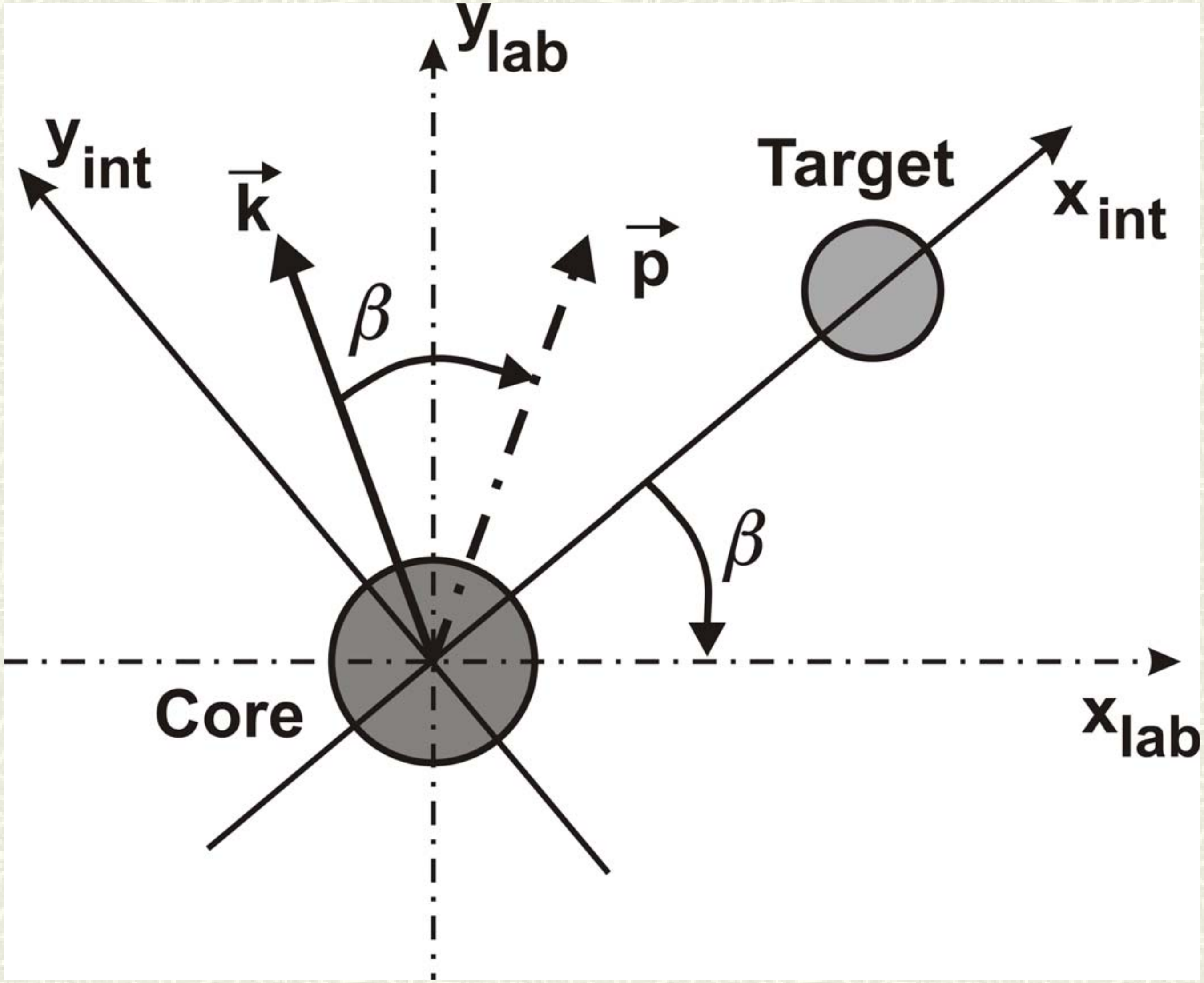
# *2. Basic assumptions of the model*

- The reaction proceeds by instantaneous removal of a nucleon from the projectile without disturbing the remaining nucleons
- High energy regime. The intrinsic velocity of the valence nucleon is much smaller than the projectile velocity.
- The projectile and the fragment follow straight line trajectories.
- Final state interactions are neglected.
- Target is a black disk. The absorbed nucleon is not observed.
- One bound state. The transition probabilities to the continuum are calculated via sum rules.
- Only the transverse component of the momentum transfer generated by Coulomb interaction is retained.

# *Schematic layout*



# Coordinates



# 3. Breakup probabilities

The ground state of the projectile

$$|J^\pi> = [I_c^\pi \otimes nlj]^{J^\pi}$$

$$\sigma_{-1n}(I_c^\pi) = \sum_{nlj} C^2 S(I_c^\pi, nlj)\, \sigma_{sp}(nlj, S_n^{eff}).$$

The removed part of the wave function is

$$\delta\psi(\vec{r}) = \begin{cases} \psi_0(x,y,z) & \text{if } (x,y,z) \in (\mathrm{w}) \\ 0 & \text{otherwise.} \end{cases}$$

The complement ($\bar{\psi}$)

$$\psi_0 = \bar{\psi} + \delta\psi$$

$$\int d\vec{r}\bar{\psi}^* \delta\psi = \int d\vec{r}\bar{\psi}\delta\psi^* = 0$$

The stripping (absorption)probability

$$P_a(b) = \int d\vec{r} |\delta\psi|^2$$

The wave function after collision

$$\psi(\vec{r}) = e^{iq\vec{r}}(\psi_0 - \delta\psi) = e^{iq\vec{r}}\bar{\psi}$$

The elastic content

$$\gamma_{el} = \int d\vec{r}\psi\psi_0^*(\vec{r})$$

The decaying state ($\psi_d(\vec{r})$),

$$\psi_d(\vec{r}) = \psi_0(\vec{r}) - \delta\psi(\vec{r}) - \gamma_{el} e^{-iq\vec{r}}\psi_0(\vec{r})$$

The elastic probability

$$P_{el}(b) = 1 - P_a(b) - |\gamma_{el}(b)|^2$$

## I. ELASTIC PROBABILITY

The elastic probability defined by,

$$\gamma_{el} = \int d\vec{r}\,\psi_0^*(\vec{r})e^{i\vec{q}\vec{r}}(\psi_0 - \delta\psi) \equiv \gamma_C - \gamma_{C+N}$$

$$|\gamma_{C+N}|^2 = \hat{\rho}_0^2 \frac{4\pi^2 R_t^2}{q^2} J_1^2(qR_t)$$

# 5. Coulomb dissociation in sudden approximation

$$\vec{R}(t) = \vec{b} + vt\hat{z}$$

$$V_2(\vec{r},t) = V_{nt}(\vec{r} + \vec{R}(t)) + V_{dip}(\vec{r},t),$$

$$V_{dip}(\vec{r},t) = \frac{Z_c Z_t e^2}{A_p} \, \frac{\vec{r}\vec{R}(t)}{R^3(t)}.$$

The TC breakup amplitude,

$$g_{lm}(\vec{k},\vec{b}) = \frac{1}{i\hbar}\int_{-\infty}^{\infty} dt < \phi^f | V_2(\vec{r},t) | \phi^i_{lm} >$$

$$g_{lm}(\vec{k},\vec{b}) = \frac{1}{i\hbar}\int d\vec{r}\int dt e^{-i\vec{k}\vec{r}+i\omega t} e^{\frac{1}{i\hbar}\int_t^{\infty} dt' V_2(\vec{r},t')} V_2(\vec{r},t)\phi_{lm}(\vec{r}) \equiv < \vec{k} | I(\omega) | lm >$$

$$I_C(\omega) = \frac{1}{i\hbar}\int_{-\infty}^{\infty} dt e^{i\omega t} e^{\frac{1}{i\hbar}\int_t^{\infty} dt' V_{dip}(t')} V_{dip}(t).$$

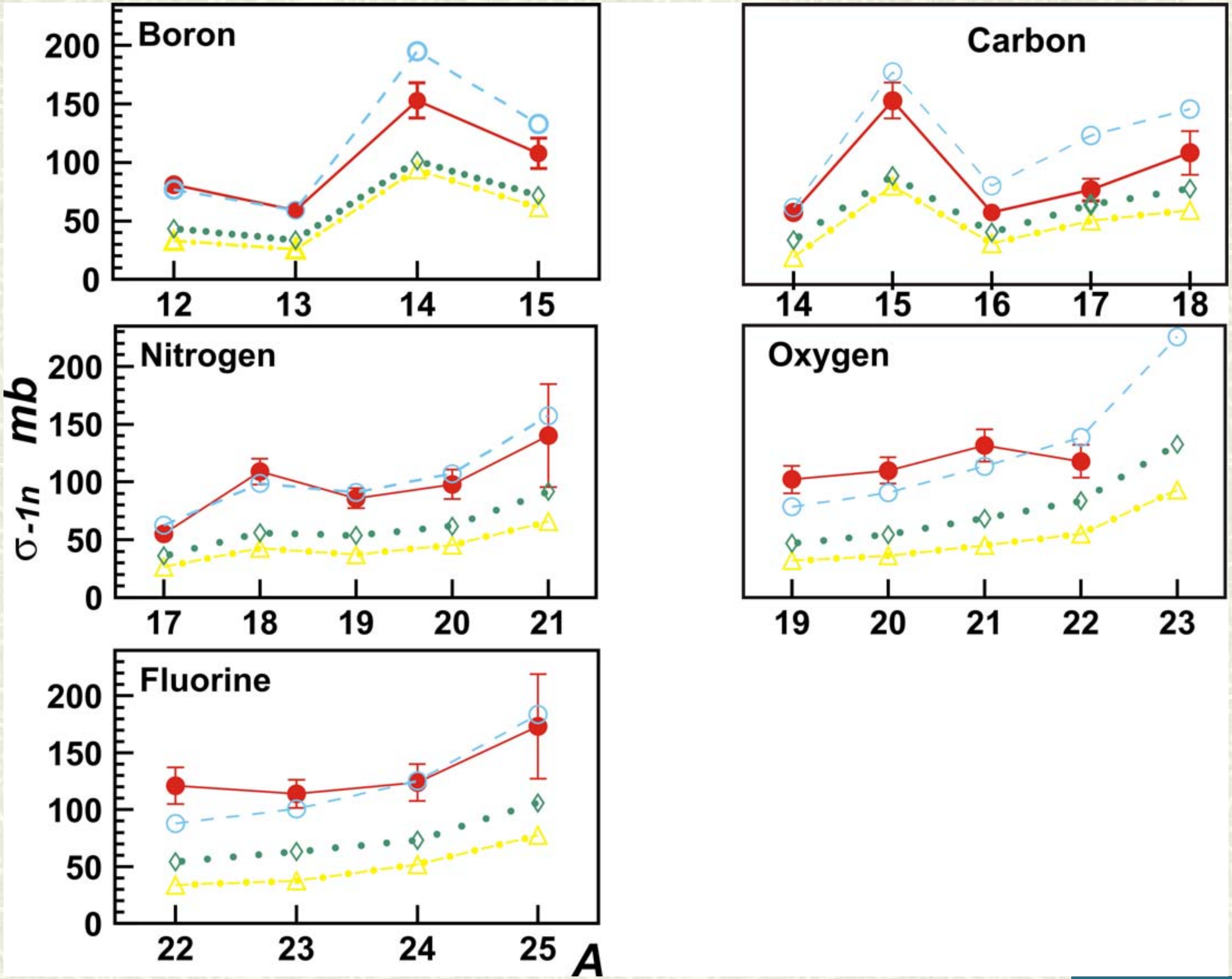
$$I_C^{sa} = e^{-i\chi_C} - 1$$

with,

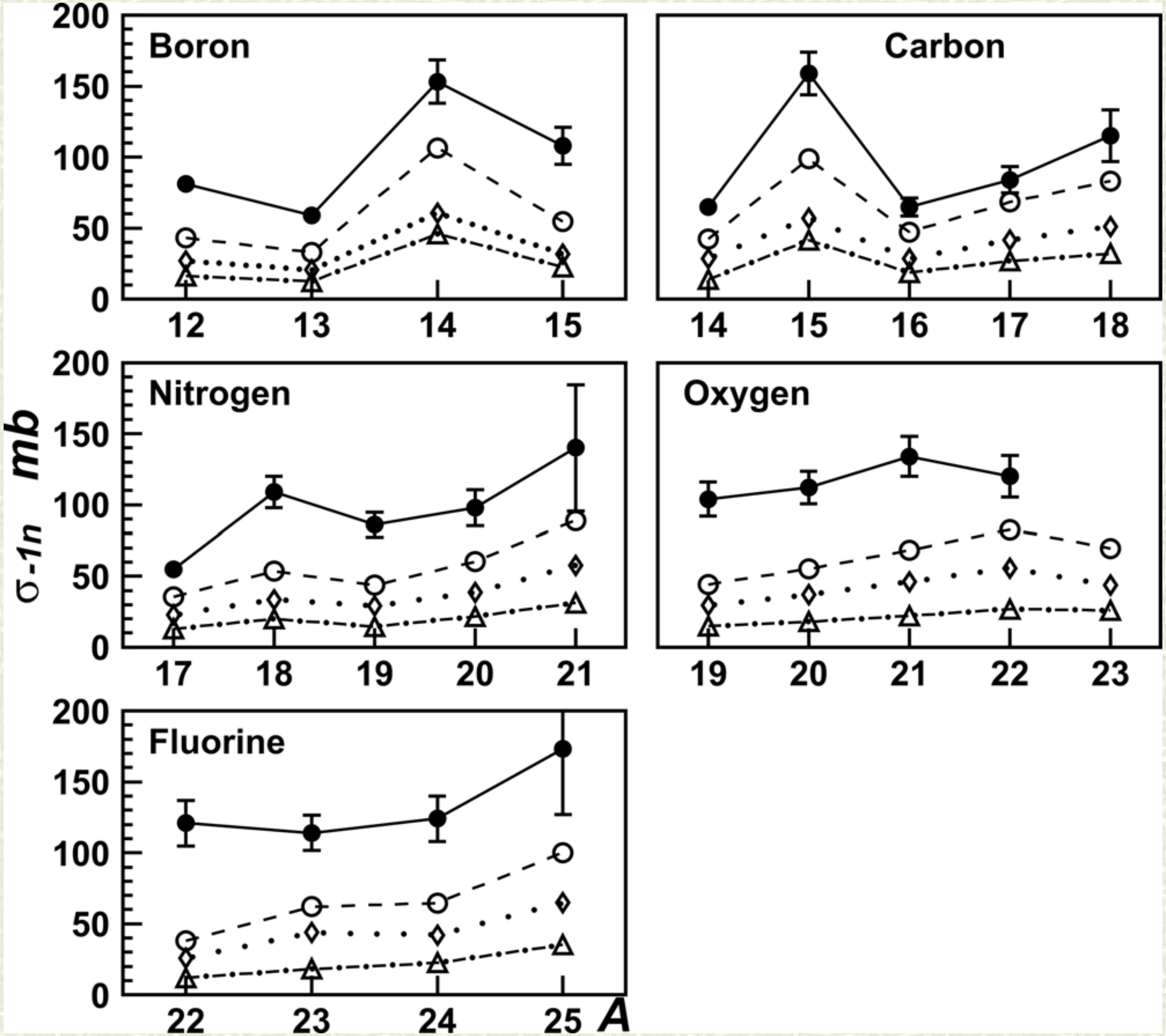
$$\chi_C = \frac{1}{\hbar}\int_{-\infty}^{\infty} dt V_{dip}(t) = \frac{1}{\hbar}\int_{-\infty}^{\infty} dt \frac{Z_c Z_t e^2}{A_p} \, \frac{\vec{s}\vec{b} + zvt}{(b^2 + v^2 t^2)^{3/2}} = \frac{2 Z_c Z_t e^2}{A_p} \, \frac{\vec{s}\vec{b}}{\hbar v b^2}$$

$$e^{i\chi_c} \equiv e^{i\vec{q}\vec{r}}$$

# *One neutron-removal cross sections in the planar cut-off approximation*



# One neutron-removal cross sections in the cylindrical wound approximation

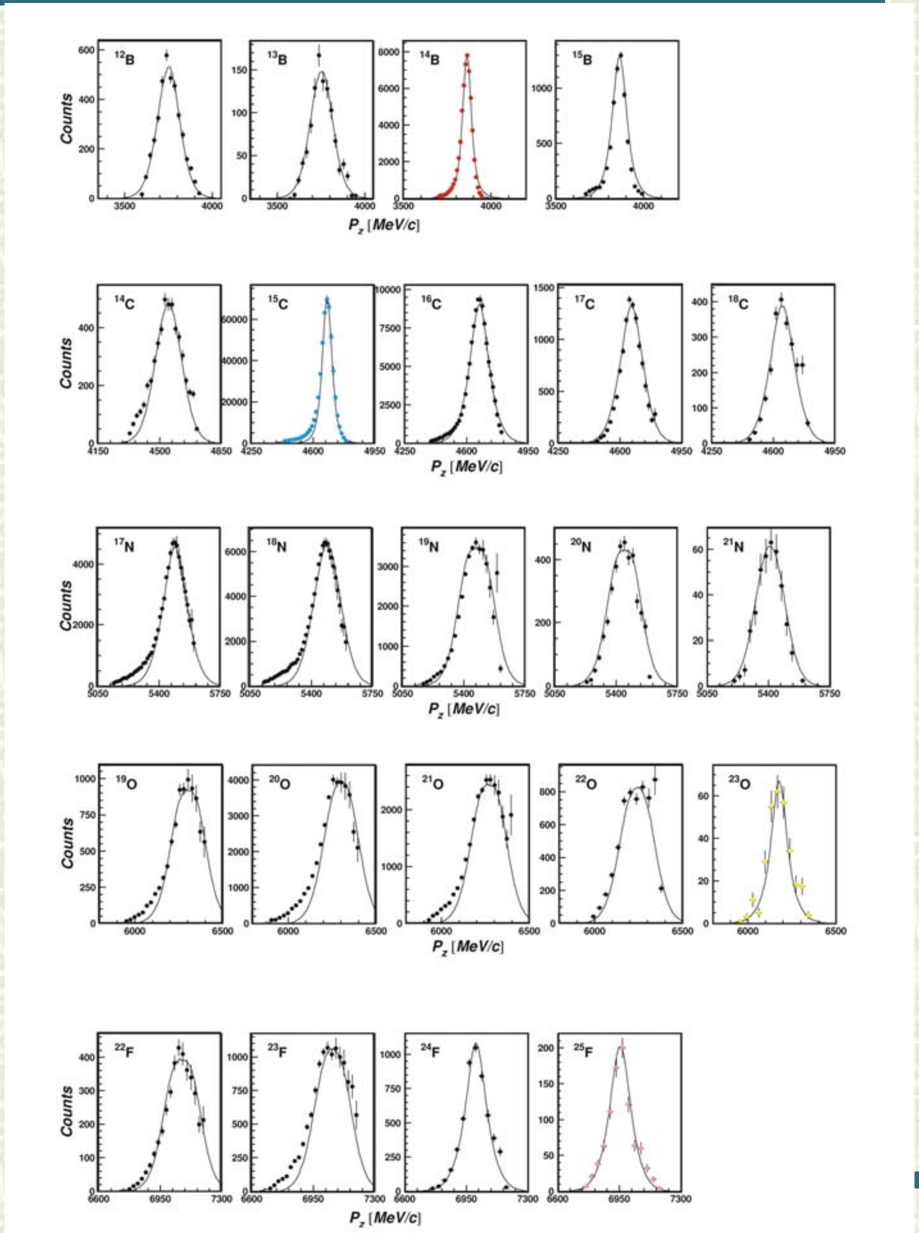


# 4. *Parallel momentum distributions*

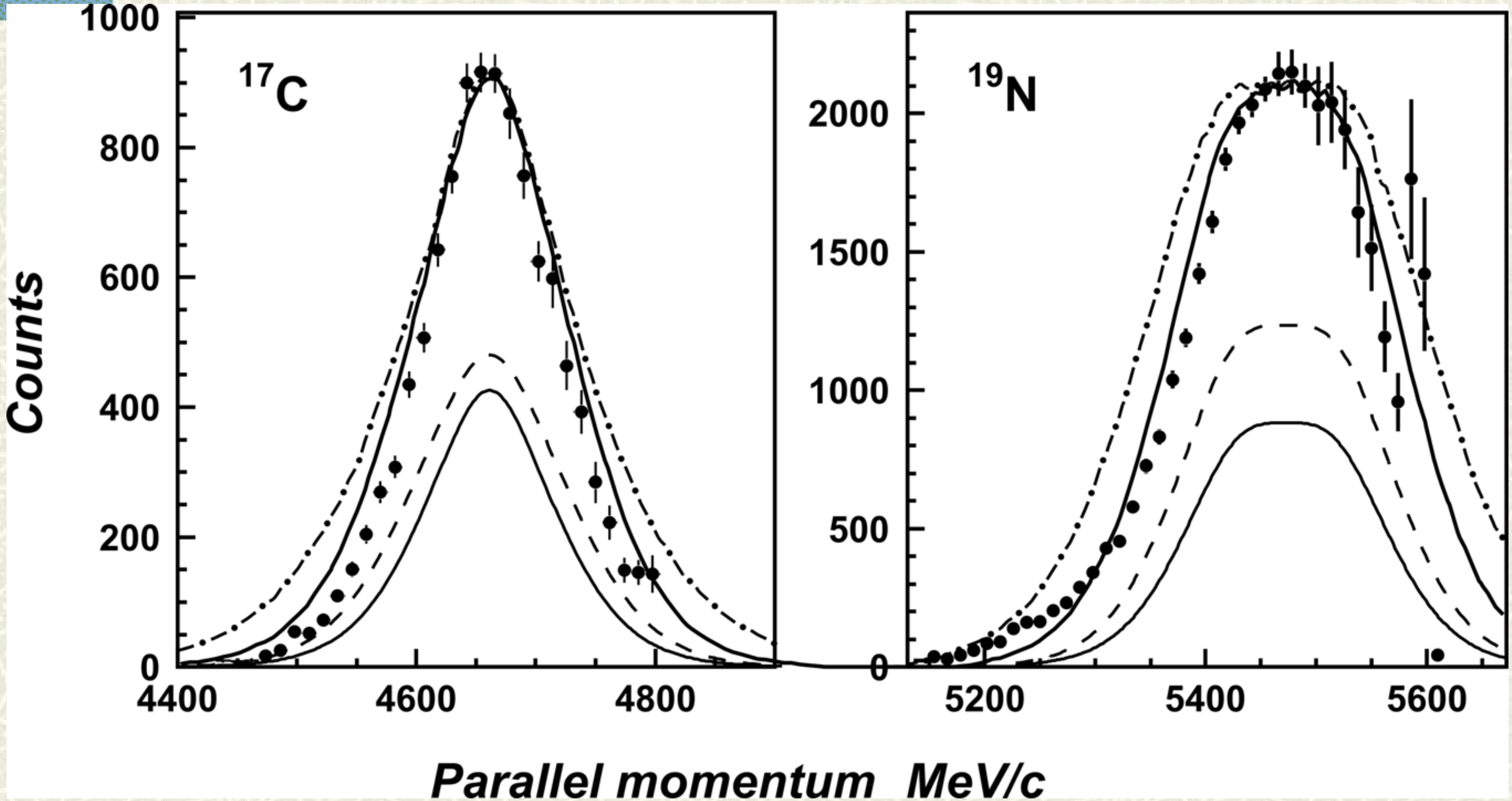
- **One neutron-removal reactions for nuclei in psd-shells E/A=40-60 MeV/u**

**Data from:**

**E. Sauvan et al., Phys Rev C 69 (2004), in press**



# Sudden approx vs Extended Glauber



# *Transverse momentum distributions*

- **Another result:** **One neutron-removal reactions for nuclei in psd-shells E/A=40-60 MeV/u**

**Data from:**

**E. Sauvan et al., Phys Rev C 69 (2004), in press**

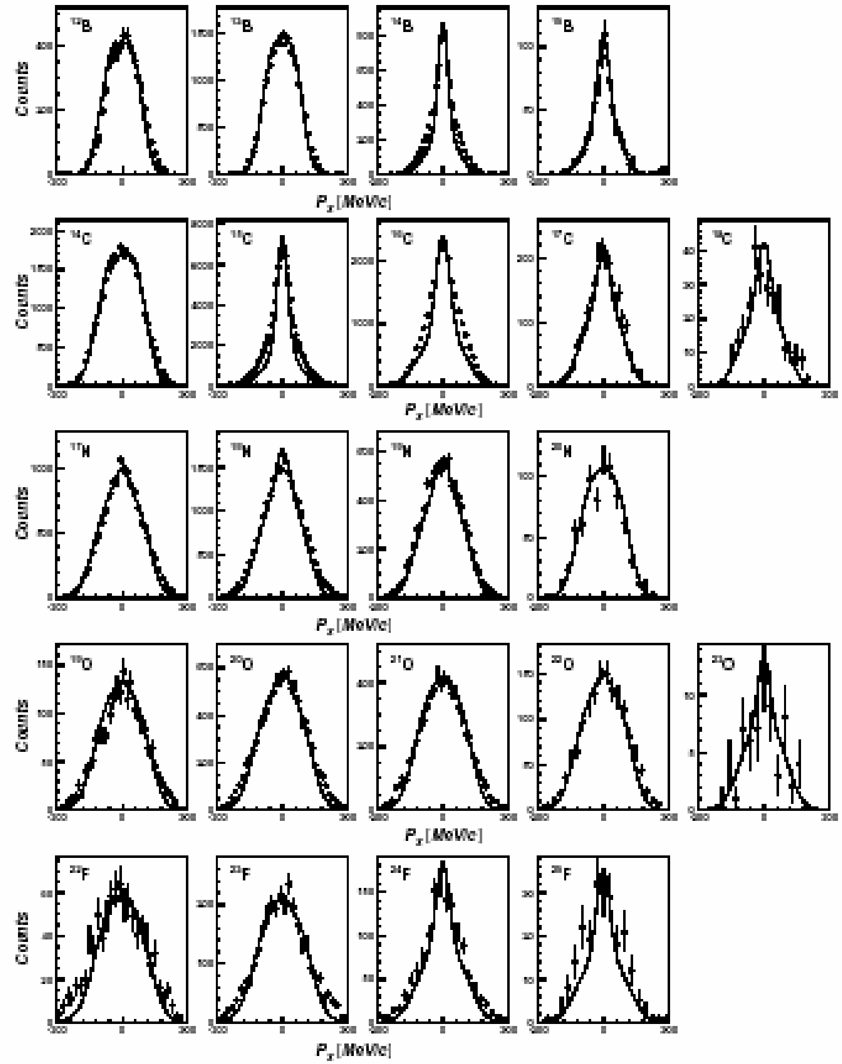
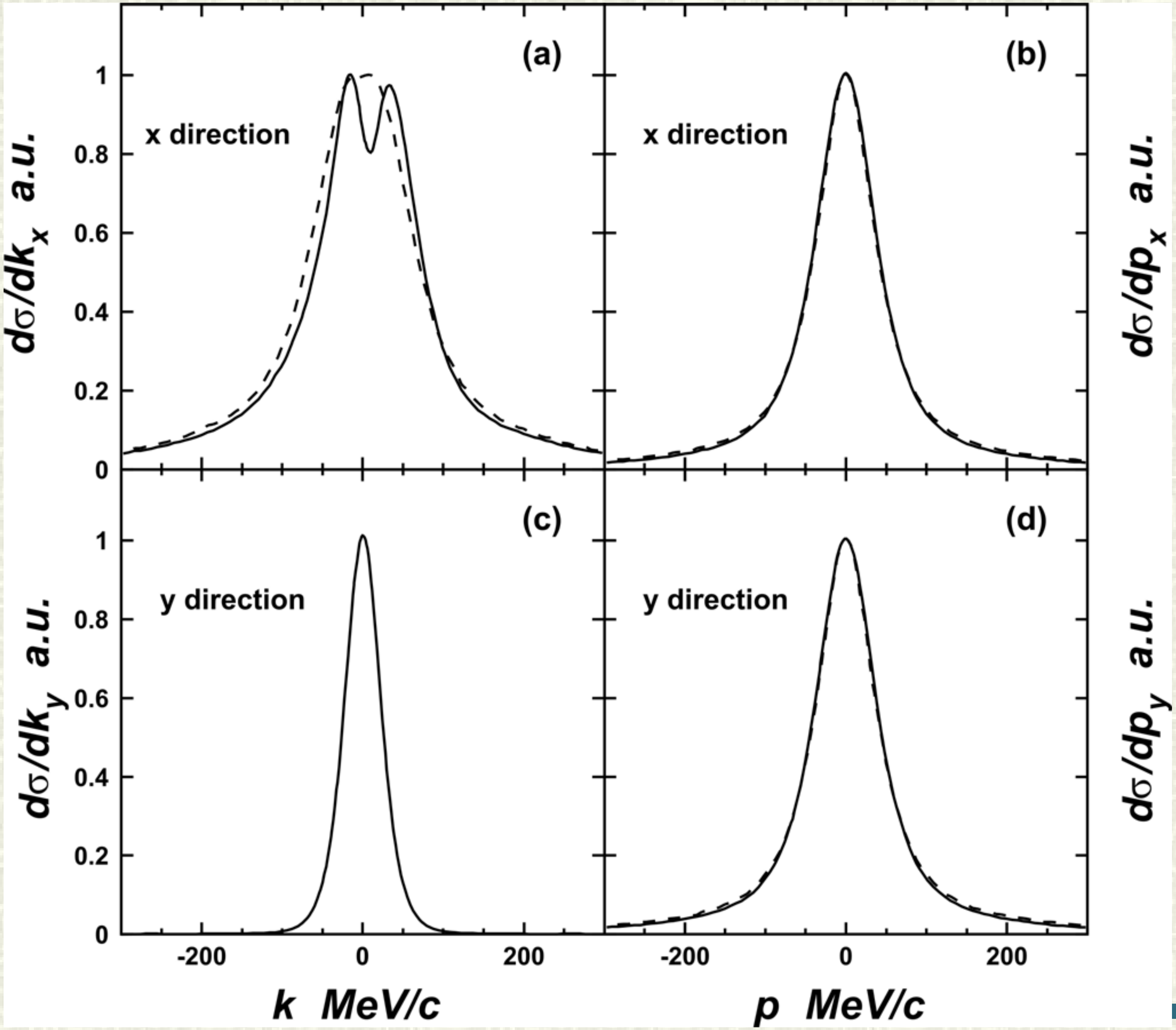
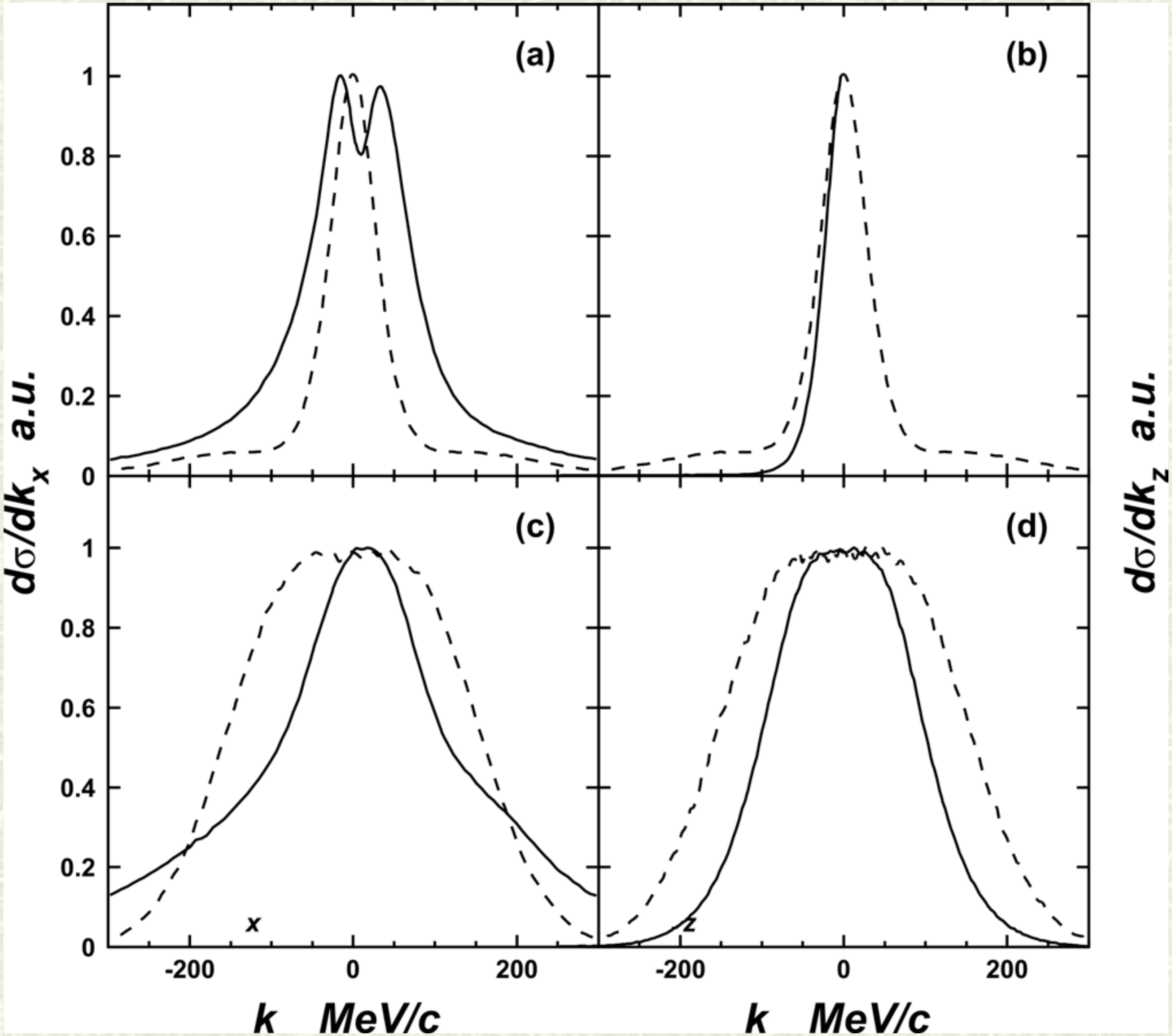



FIG. 1. Comparison of experimental core fragment transverse momentum distributions ($p_x$) on carbon target and Glauber model calculations (plain line).

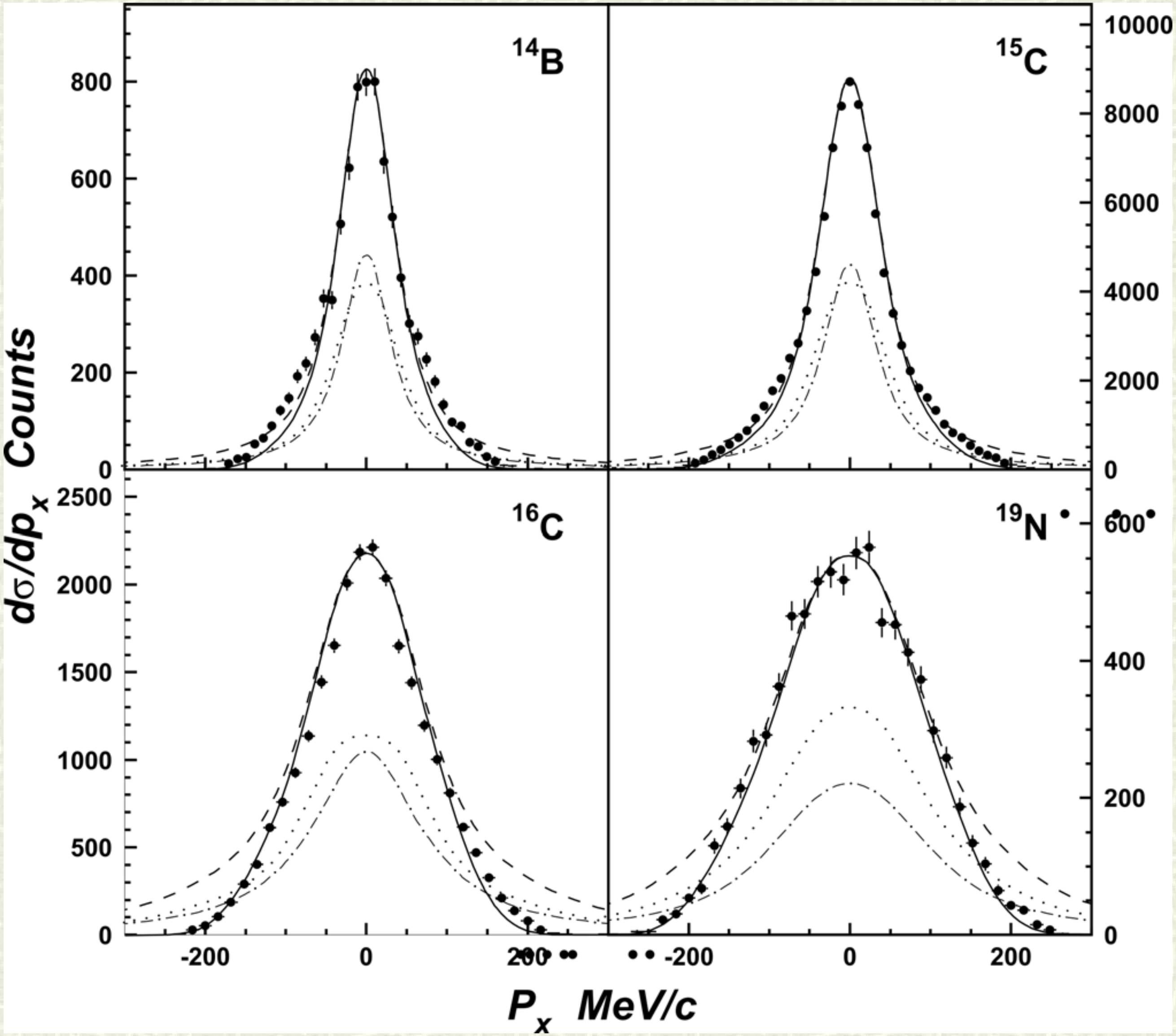
# Rest frame and lab system distibutions



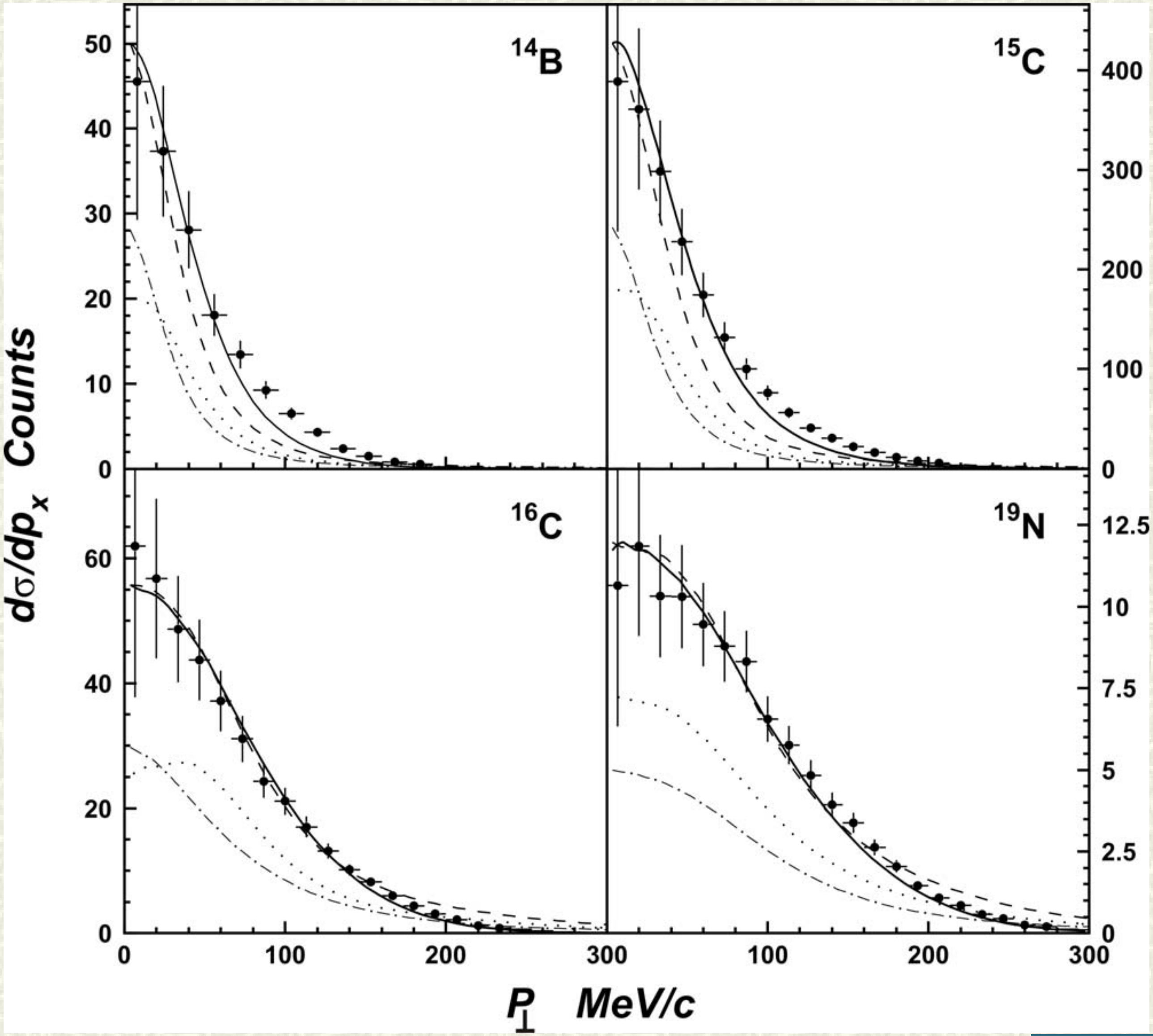
# Reaction model effects on the shape of distributions



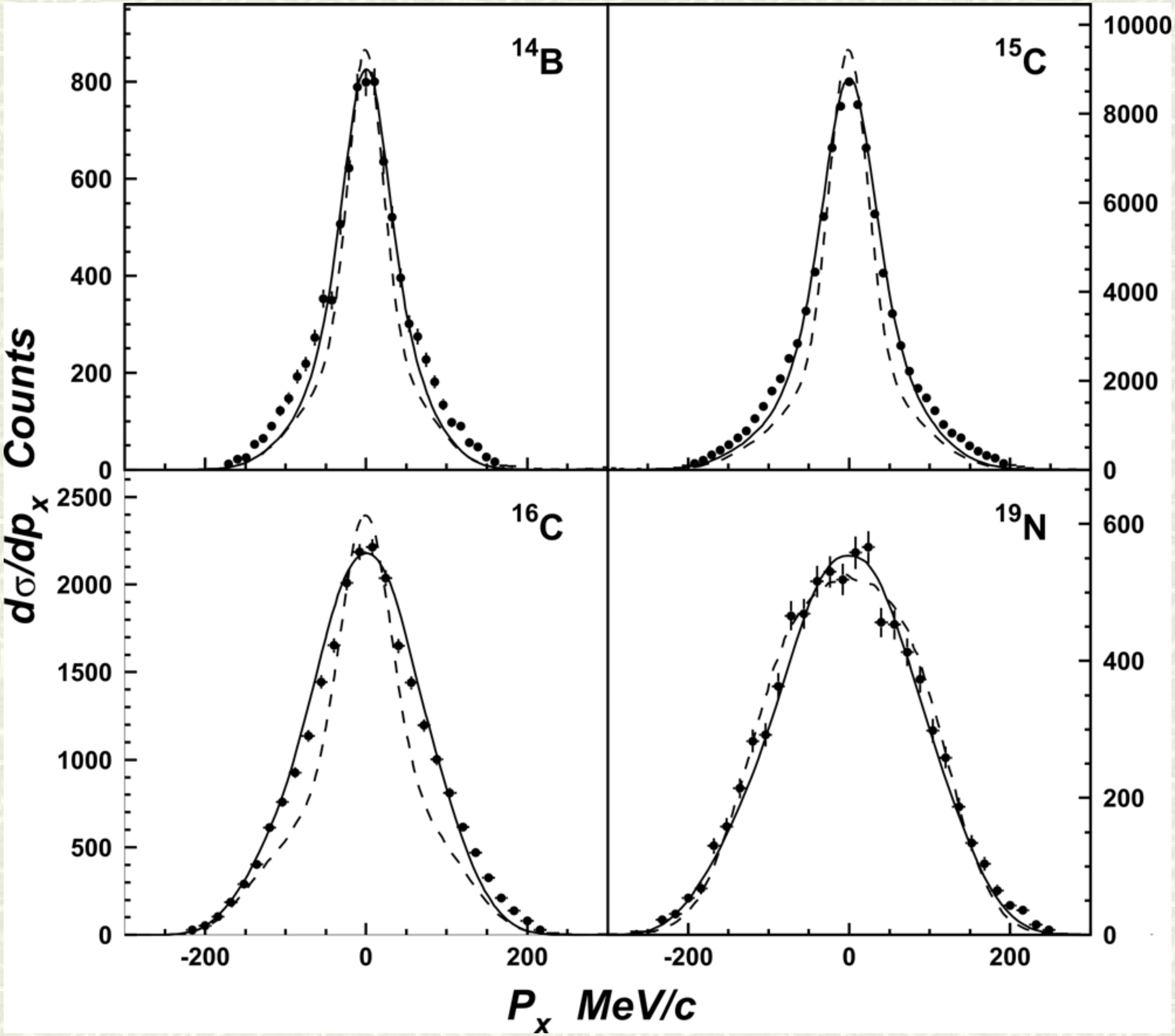
# Transverse momentum distributions



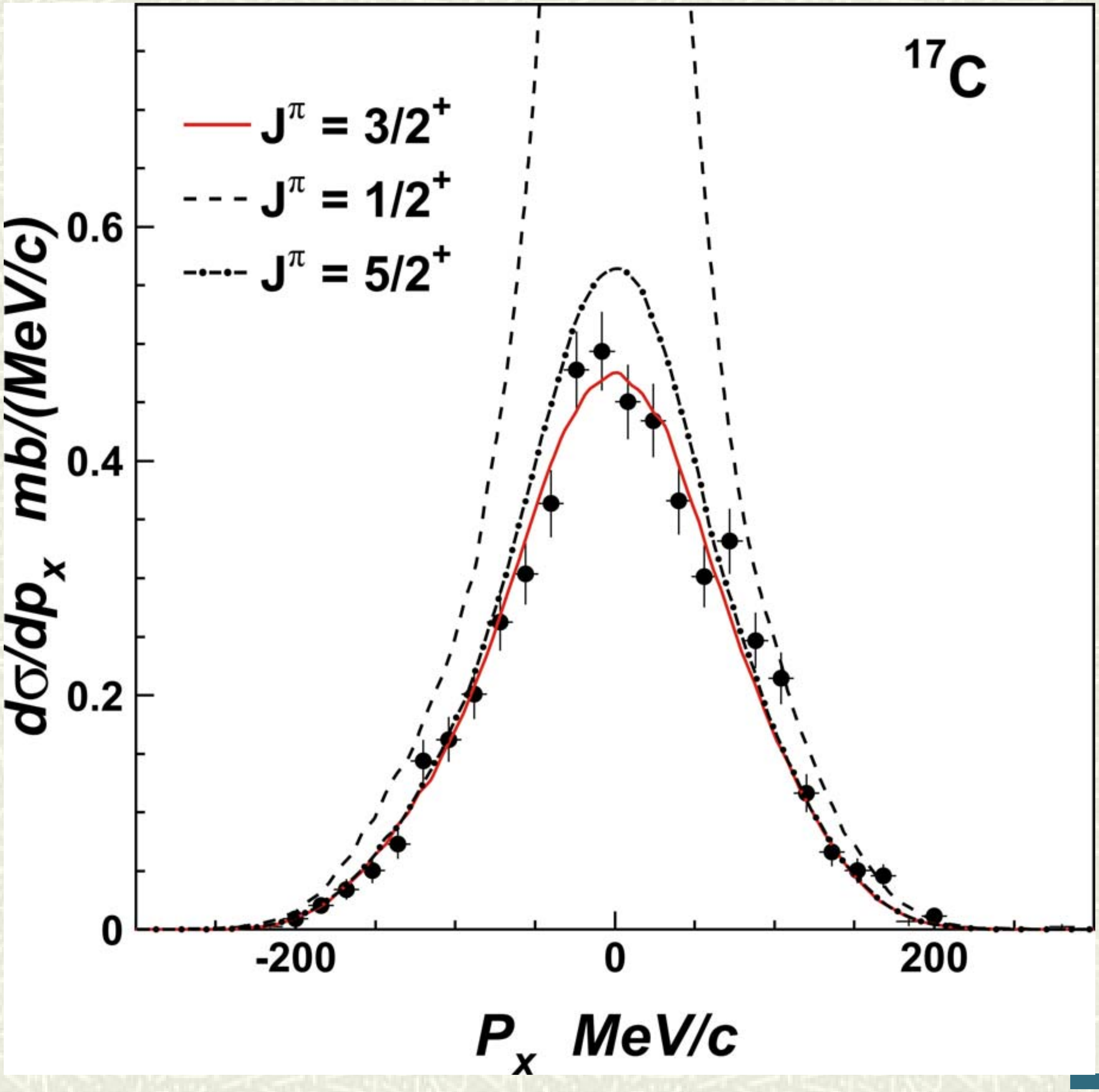
# *Perpendicular momentum distributions*



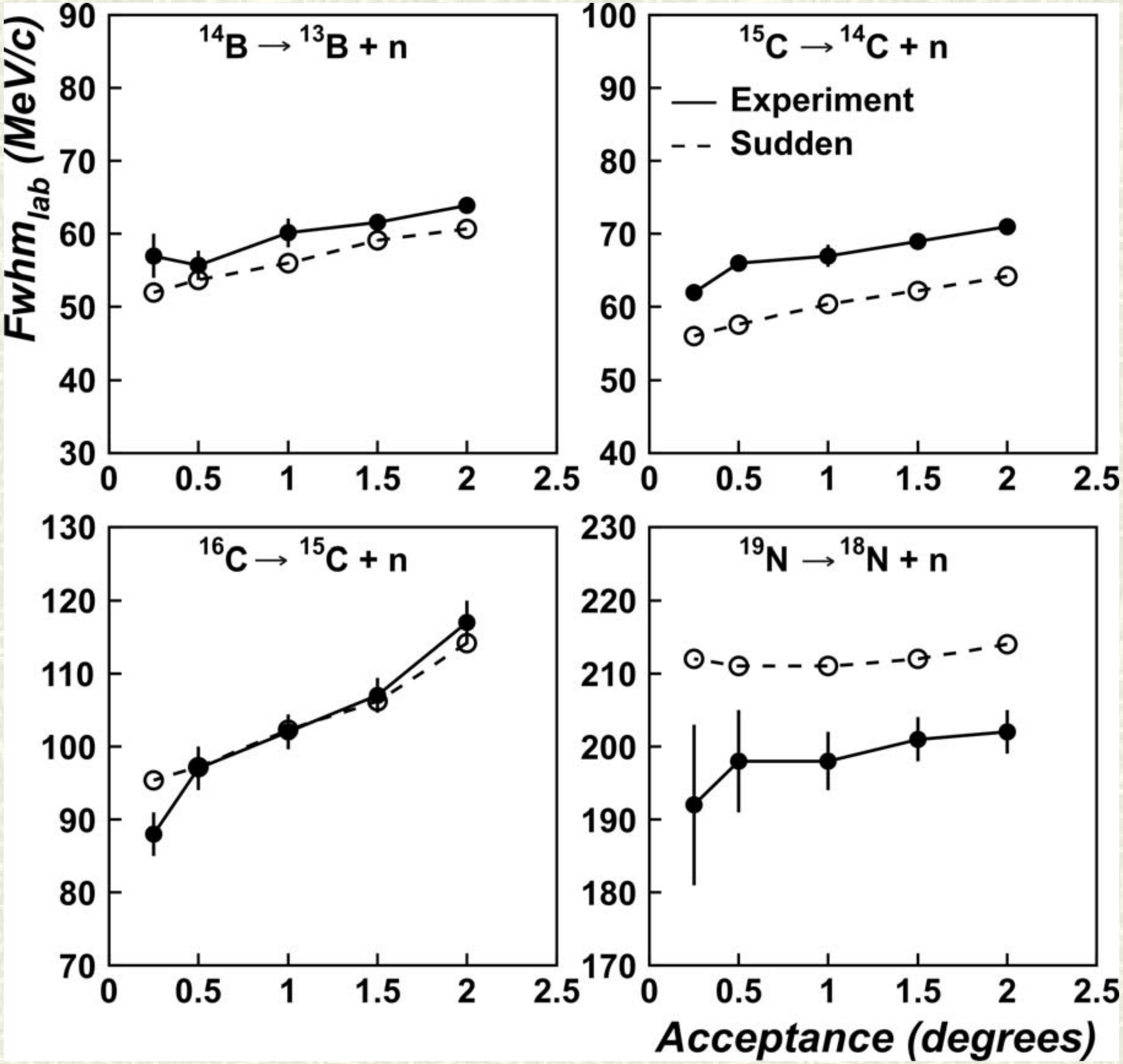
# Sudden vs Glauber – transverse mom distributions



# *Transverse mom distrib as spectroscopic tool*

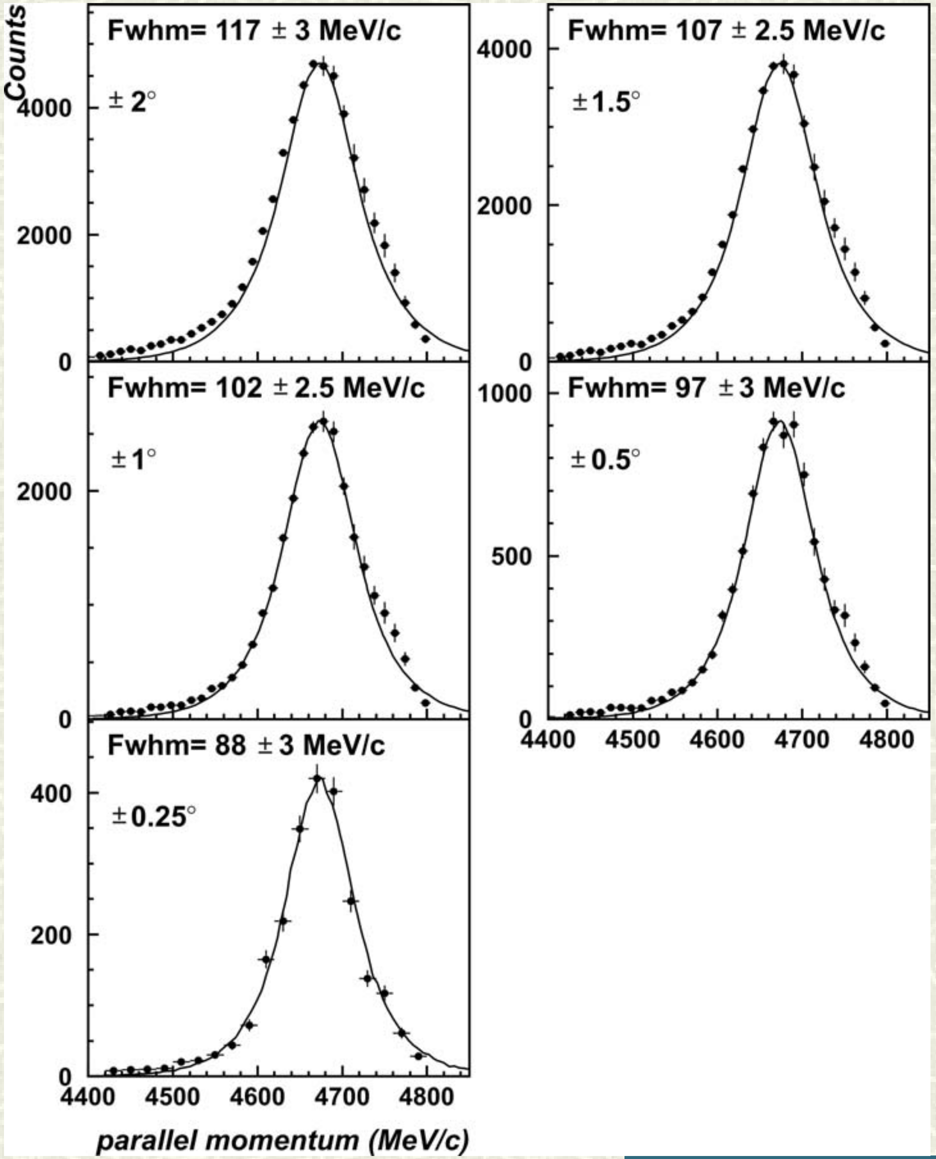


# *Parallel distrib widths vs spectr acceptance*



# $^{16}C$ case

- $^{16}C$ one neutron-removal parallel mom distrib vs spectrometer acceptance



# $^{19}$N case

- $^{19}$N one neutron-removal parallel mom distrib vs spectrometer acceptance