Studies of the Cronin Effect in pA collisions at RHIC

Y. Zhang[1], G. Barnaföldi[2],
P. Lévai[2],G. Papp[3], G. Fai[1]

[1] *Kent State University, Kent, OH, USA*
[2] *RMKI Budapest, Hungary*
[3] *Eötvös University, Budapest, Hungary*

- pp collisions: intrinsic transverse momentum
- pA collisions: width enhancement
- AB collisions at RHIC

Reference: Phys. Rev. C **61**, 021902(R) 2000.

Cronin Effect

- Hard particle production in pA collisions

  $\sqrt{s} \geq 20$ GeV

  3 GeV/c $\leq p_T \leq 6$ GeV/c

  γ,π,K,$\cdots$

- Cronin effect:

  Particle production in pA collisions shows an enhancement (in a certain p_T range), which goes with A^α compared to pp collisions:

  $$\frac{\sigma^{pA}}{\sigma^{pp}} \sim A^\alpha, \; \alpha > 1$$

  D. Antreasyan *et al.* PRD **19**, 764 (1979)
  C.N. Brown *et al.* PRC **54**, 3195 (1996)

Transverse Momentum Degree of Freedom

- Observed width of distribution (proton)

$$\langle k_T^2 \rangle \approx 1 \text{ GeV}^2$$

M.D. Corcoran *et al.* Phys. Lett. B **259**, 209 (1991)

- Incorporate transverse momentum into pQCD calculation:

$$dx\ f_{a/p}(x,Q^2) \longrightarrow dx\ d^2k_T\ g(\vec{k}_T)\ f_{a/p}(x,Q^2)$$

$$g(\vec{k}_T) = \frac{\exp(-k_T^2/\langle k_T^2 \rangle)}{\pi \langle k_T^2 \rangle}$$

$\langle k_T^2 \rangle$: 2D width of the k_T distribution

$\langle k_T^2 \rangle$: $= 4\langle k_T \rangle^2/\pi$

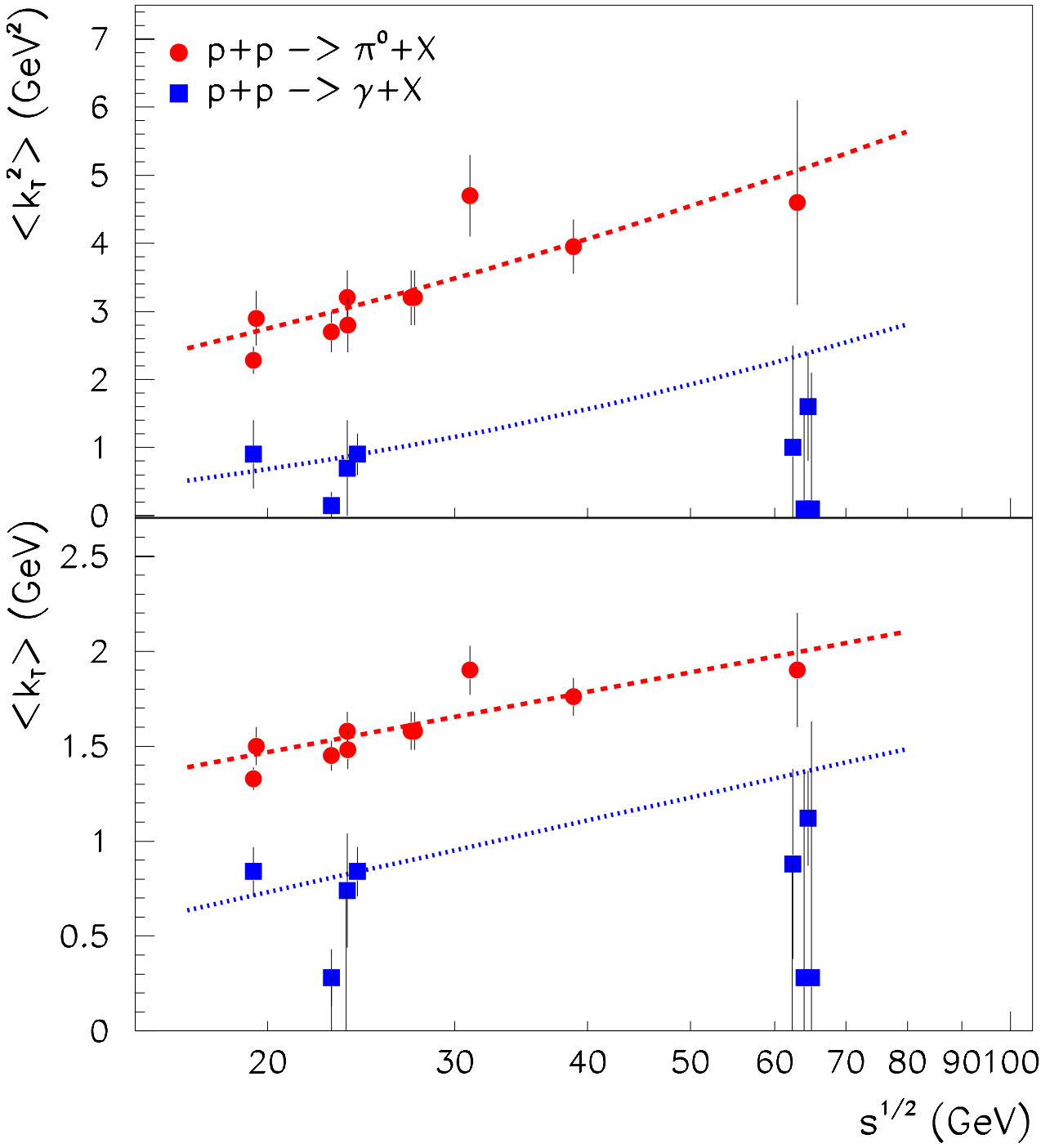

Figure 1: The best fit values of $\langle k_T^2 \rangle$ in $pp \to \pi^0 X$ reactions (upper panel), and a calculated $\langle k_T \rangle$ (lower panel).

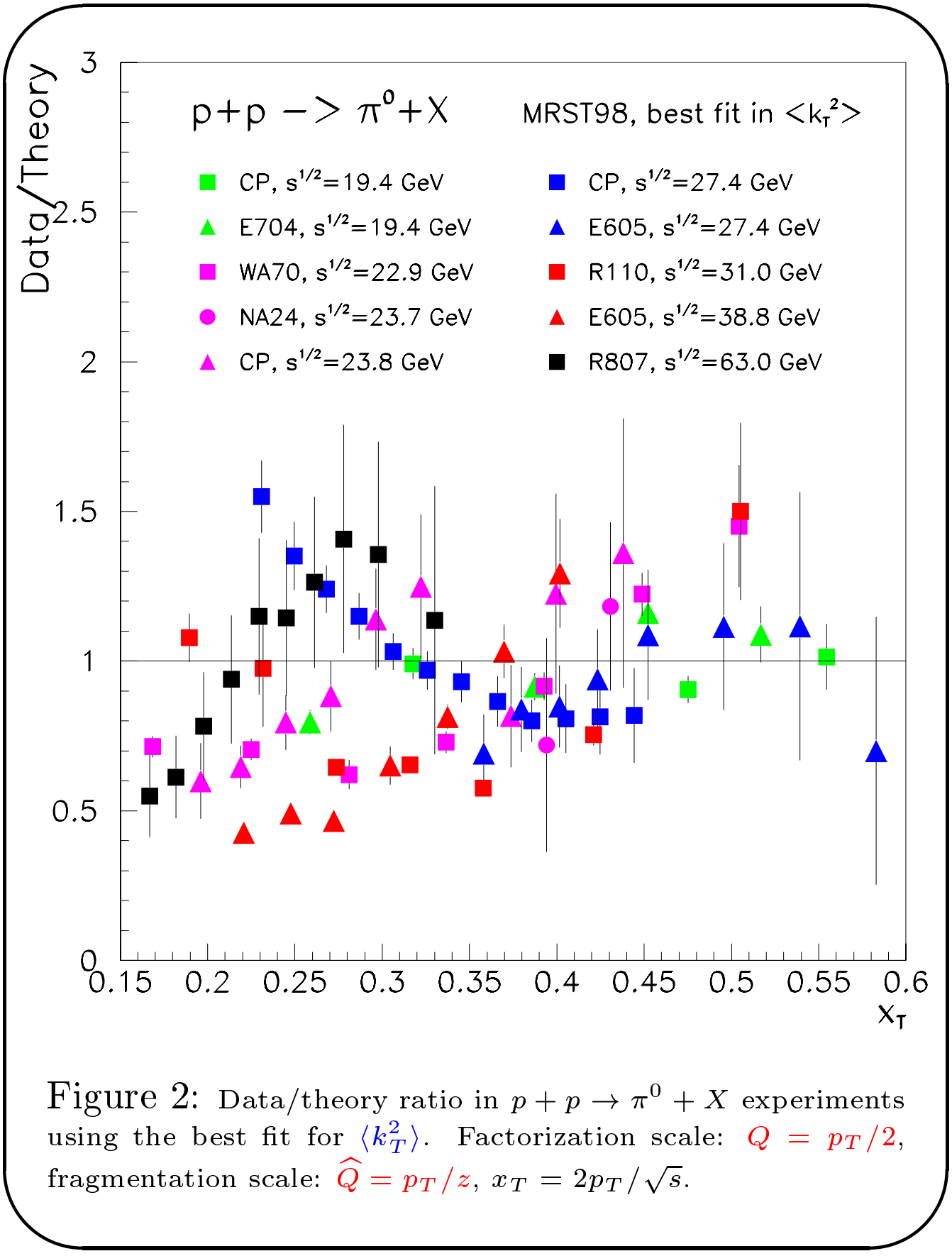

Figure 2: Data/theory ratio in $p + p \to \pi^0 + X$ experiments using the best fit for $\langle k_T^2 \rangle$. Factorization scale: $Q = p_T/2$, fragmentation scale: $\widehat{Q} = p_T/z$, $x_T = 2p_T/\sqrt{s}$.

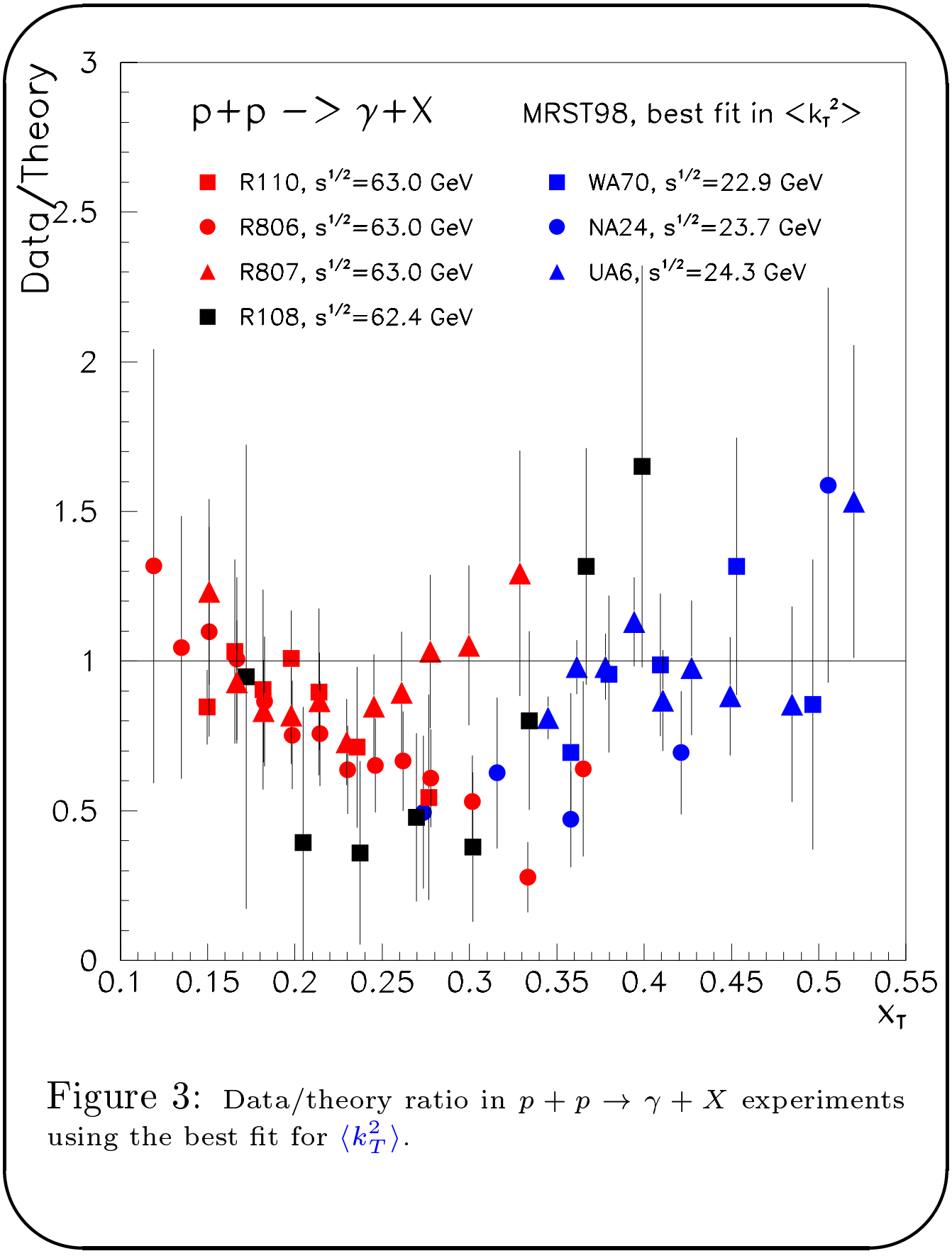

Figure 3: Data/theory ratio in $p + p \to \gamma + X$ experiments using the best fit for $\langle k_T^2 \rangle$.

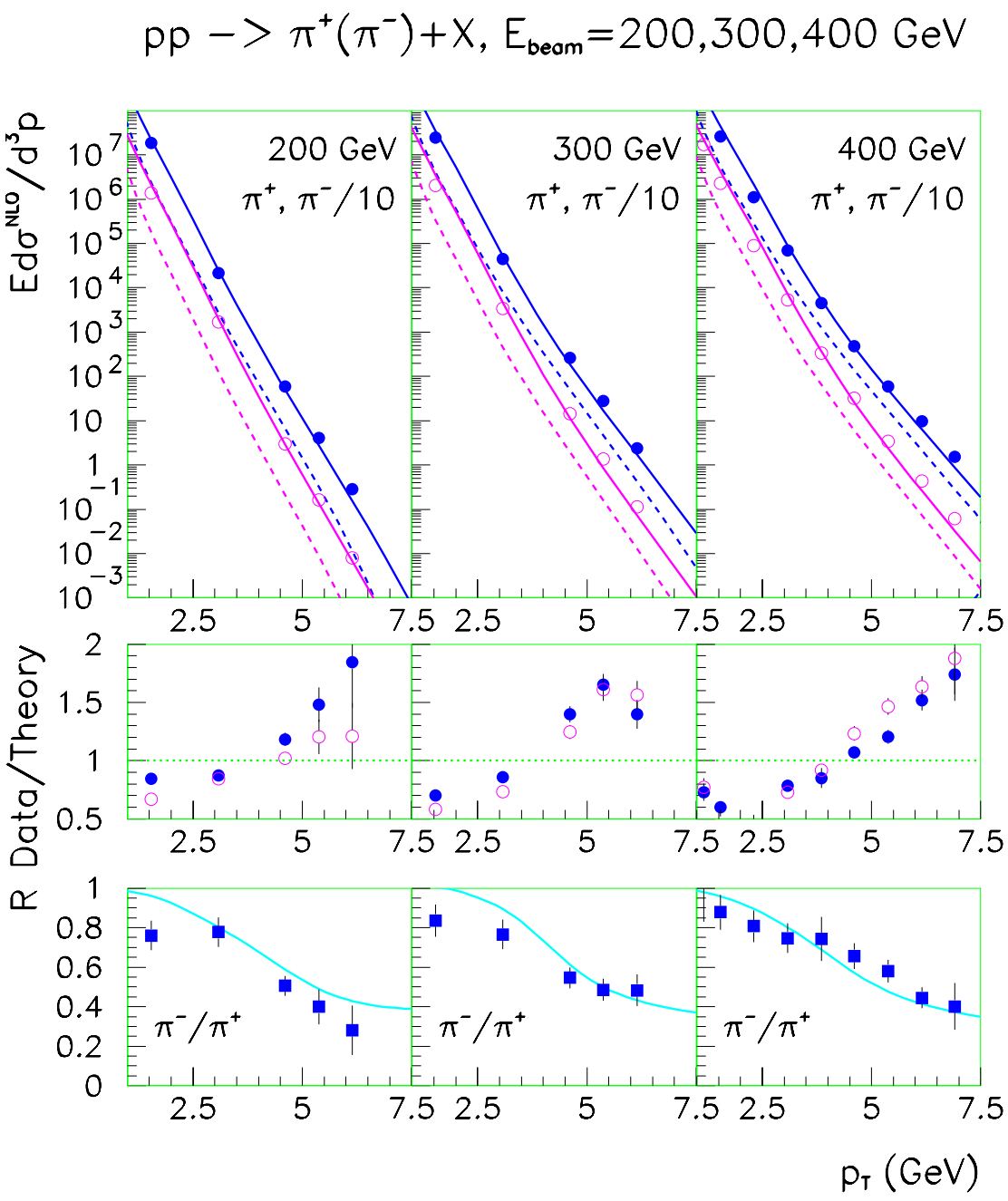

Figure 4: $\pi^+(\pi^-)$ spectra and π^-/π^+ ratio

✔ Enhanced width for $\langle k_T^2 \rangle$ distribution

C.Y. Wong *et al.* PRC **58**, 376 (1998)
X-N. Wang PRC **61** 064910 (2000)

✎ Our assumption:

$$\langle k_T^2 \rangle_{pA} = \langle k_T^2 \rangle_{pp} + C\ h_{pA}(b)$$

$h(b)$: number of effective collisions at impact parameter b

C : average squared transverse-momentum transfer per collision

Saturation:

$$h_{pA}^{sat}(b) = \begin{cases} 0 & \text{if } \nu_A(b) < 1 \\ \nu_A(b) - 1 & \text{if } 1 \le \nu_A(b) < 2 \\ 1 & \text{if } 2 \le \nu_A(b) \end{cases}$$

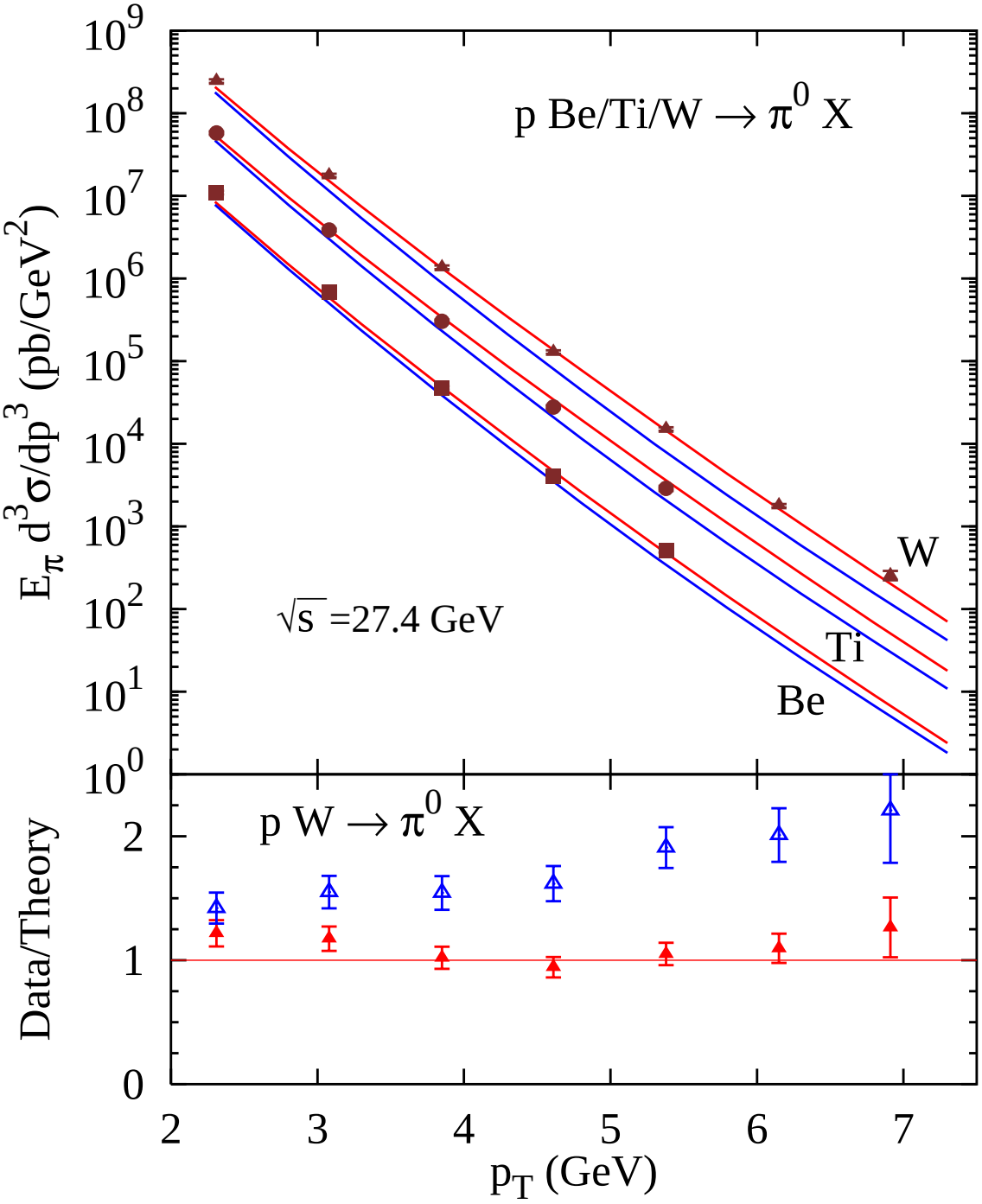

Figure 5: Cross section per nucleon in $pA \to \pi^0 X$ reactions ($A = Be, Ti, W$) with $C^{sat} = 1.2$ GeV^2 (red) and $C^{sat} = 0$ (blue). The lower panel displays the data to theory ratio on a linear scale for the pW collision.

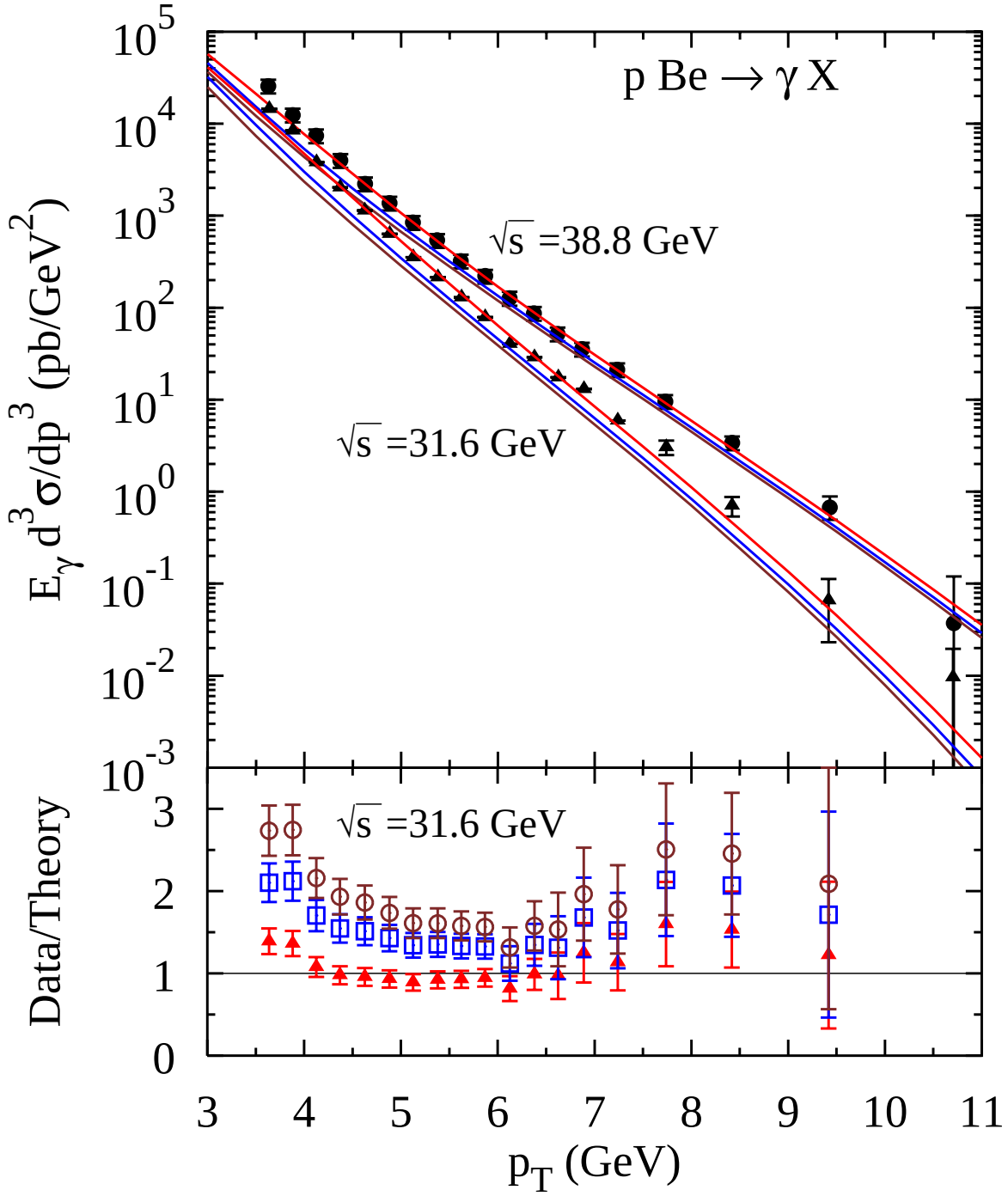

Figure 6: Cross section per nucleon in the $pBe \to \gamma X$ reaction at $\sqrt{s} = 38.8$ GeV (dots) and at $\sqrt{s} = 31.6$ GeV (triangles). Brown lines indicate no intrinsic transverse momenta, blue $C^{sat} = 0$, red $C^{sat} = 1.2$ GeV^2. Lower panel shows data/theory at $\sqrt{s} = 31.6$ GeV. Data from $E706$.

At present:

No data on π, K, γ production in

1. pp collisions at 60 GeV $\leq \sqrt{s} \leq$ 200 GeV
2. pA collisions, except $\sqrt{s} \approx 30$ GeV

However:

pp and pA data in a wide energy range are essential to understand Cronin effect

$\Longrightarrow$ implications on other observables