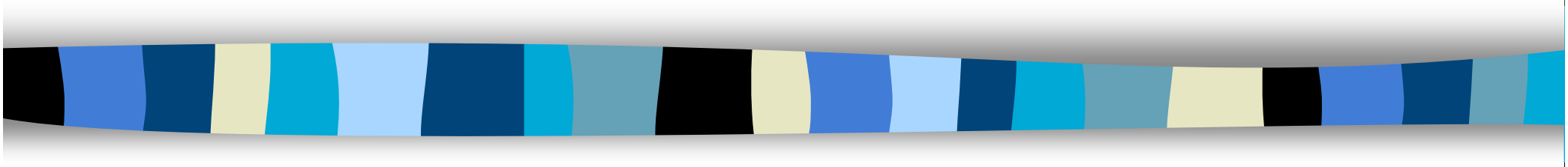
Frühjahrstagung der Deutschen Physikalischen Gesellschaft

Mainz, March 29–April 1, 2004

Charmonium Production at HERA-B



Ulrich Husemann

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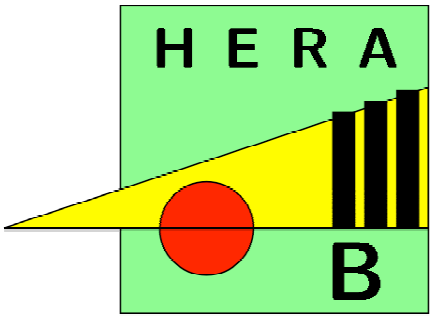
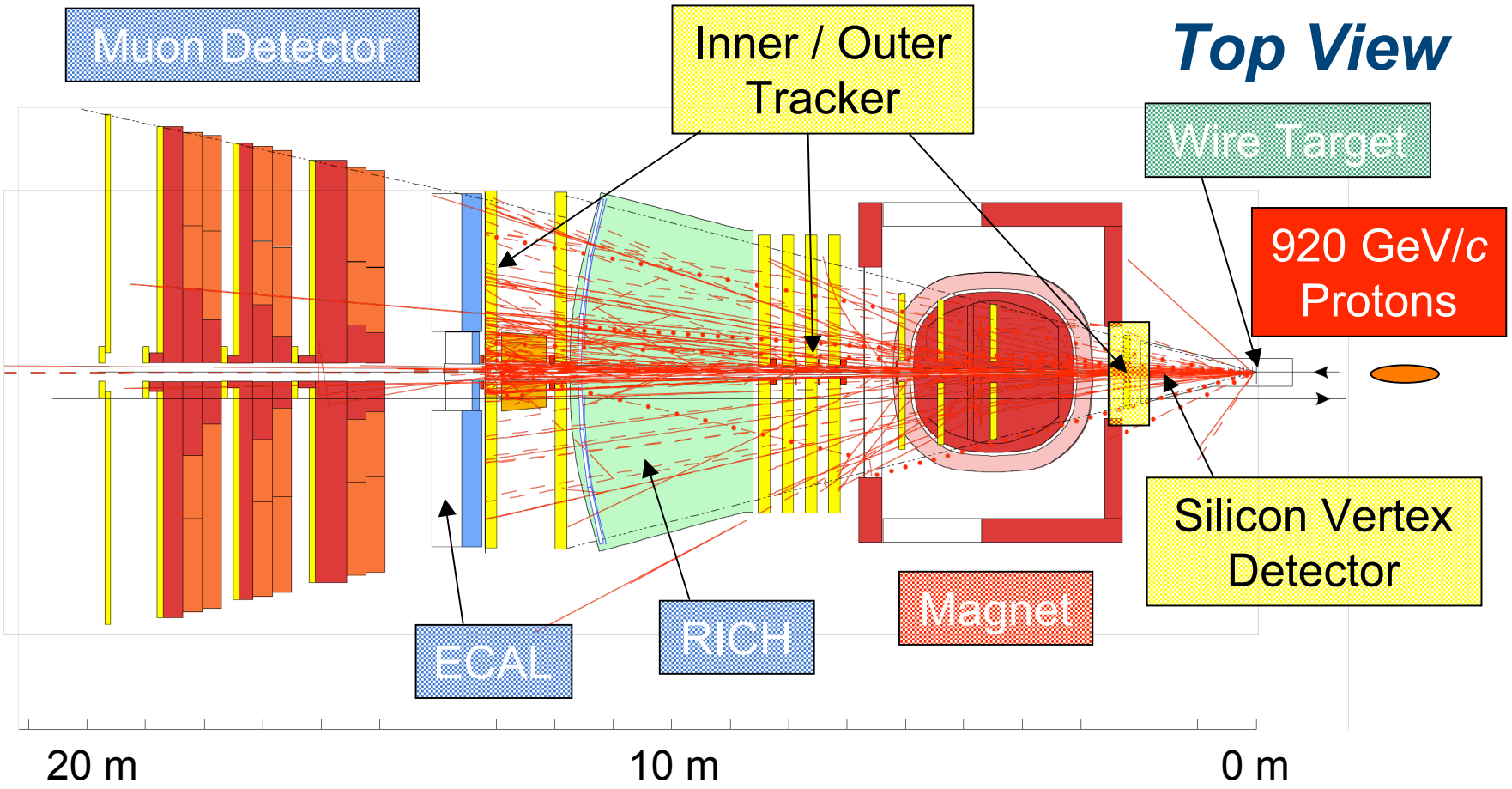
Experimentelle Teilchenphysik

Universität Siegen



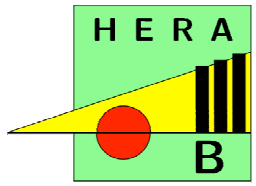
The HERA-B Detector



Data Sample

- Data-taking period: October 2002–March 2003
- HERA-B's main trigger setup: di-lepton trigger
  → ≥ 2 electrons or muons, e.g. sensitive to $J/\psi \rightarrow \mu^+\mu^-$
- Charmonium sample (electron & muon trigger):
  300,000 J/ψ
  15,000 χ_c
  5,000 ψ'
- Most runs use 2 target wires of different atomic mass number *A* (^{12}C, ^{48}Ti, ^{184}W) simultaneously
  → measurement of nuclear effects
  (systematic effects cancel to first order)

Why Charmonia Production?



- Test of current framework for charmonium production models: nonrelativistic QCD
  (perturbative expansion in relative quark velocities)
- Modification of models via nuclear effects
  - Initial state effects, e.g. shadowing, energy loss
  - Final state effects, e.g. absorption in nuclear matter
  - Parametrization: power law with exponent $\alpha = \alpha(x_F, p_T)$

$$\sigma_{pA} = \sigma_{pN} \cdot A^{\alpha}$$

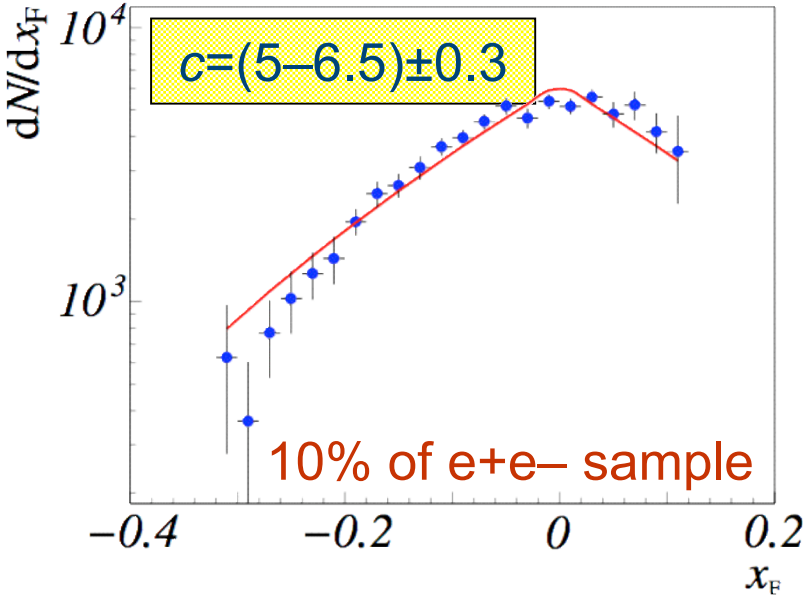
α is measure of A-depencence, $\alpha<1$: charmonium suppression (anomalous suppression: signature for quark-gluon plasma, e.g. RHIC)

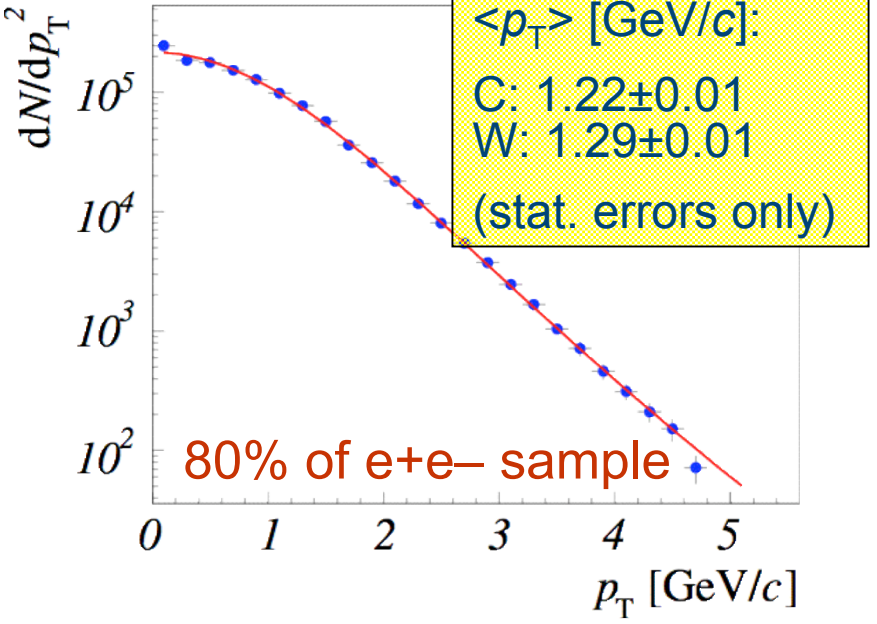
J/ψ Differential Distributions

- Parametrizations:

$$\frac{d\sigma}{dx_F} = A \cdot (1 - |x_F|)^c$$

$$\frac{d\sigma}{dp_T} = A \cdot \left[1 + \left(\frac{35\pi \cdot p_T}{256\langle p_T \rangle}\right)^2\right]^{-6}$$

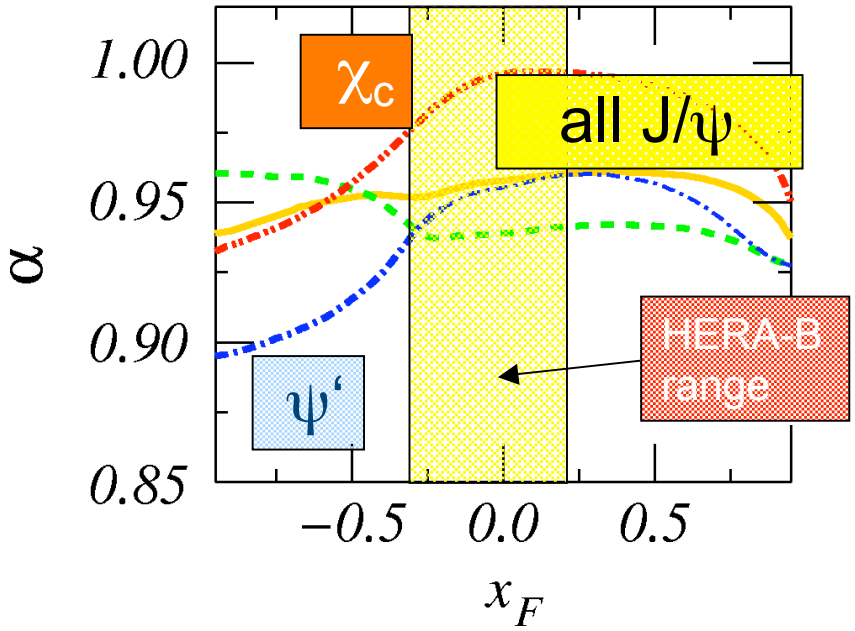




- Work on systematics ongoing
- HERA-B: access to negative x_F ($x_F = p_L^{cms}/p_{L,max}^{cms}$)

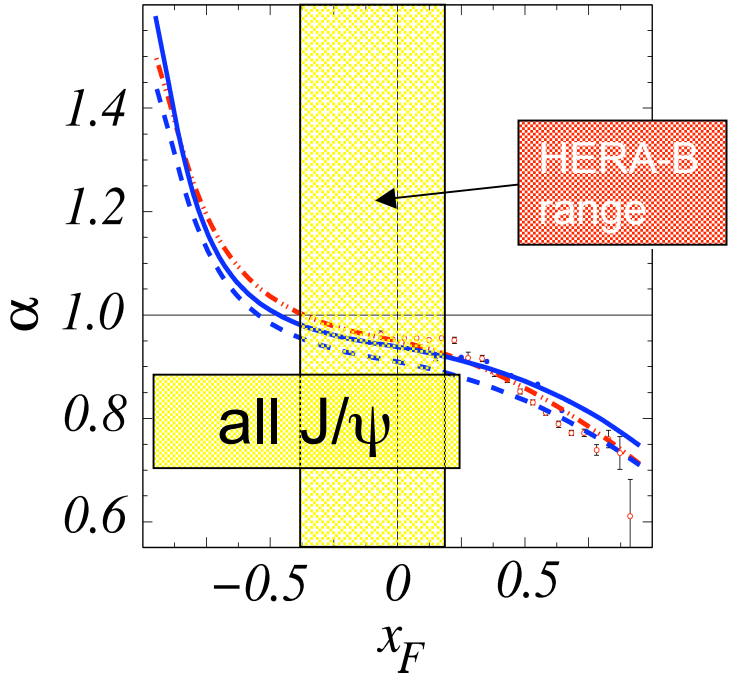
A-Dependence: Theory

- Prediction 1: NRQCD + nuclear absorption



R. Vogt,
Nucl. Phys. **A700** (2002) 539

- Prediction 2: BCKT (Reggeon-based)

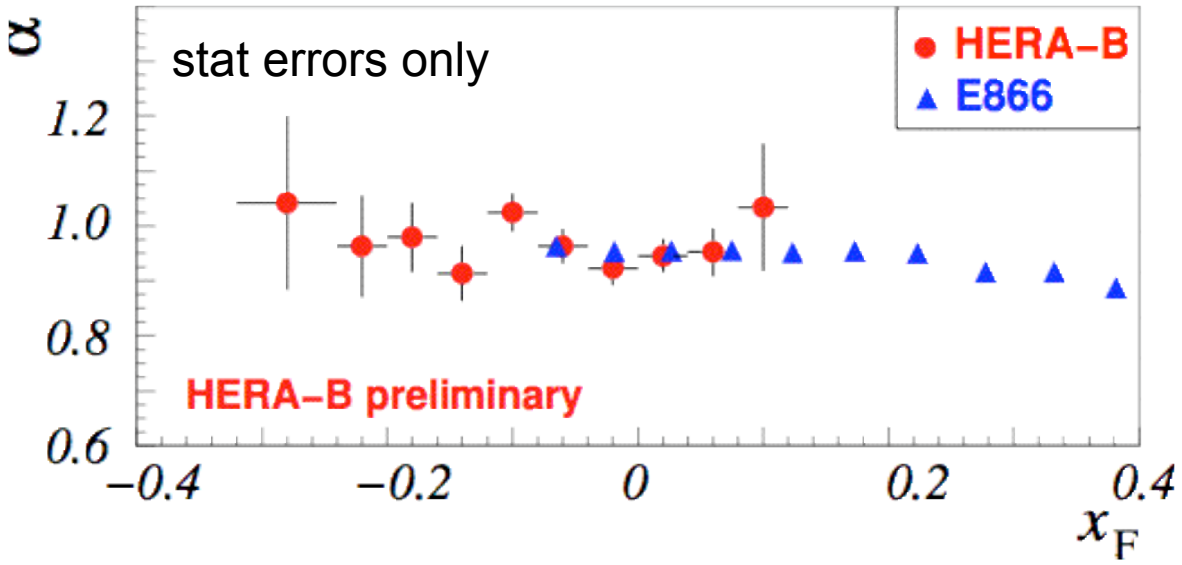


K.G. Boreskov, A.B. Kaidalov,
JETP Lett. **77** (2003) 599

J/ψ A-Dependence

- Parametrization: $\sigma_{pA} = \sigma_{pN} \cdot A^{\alpha}, \qquad \sigma = N / \varepsilon L$
  → extract α from runs with two target wires (C, W)

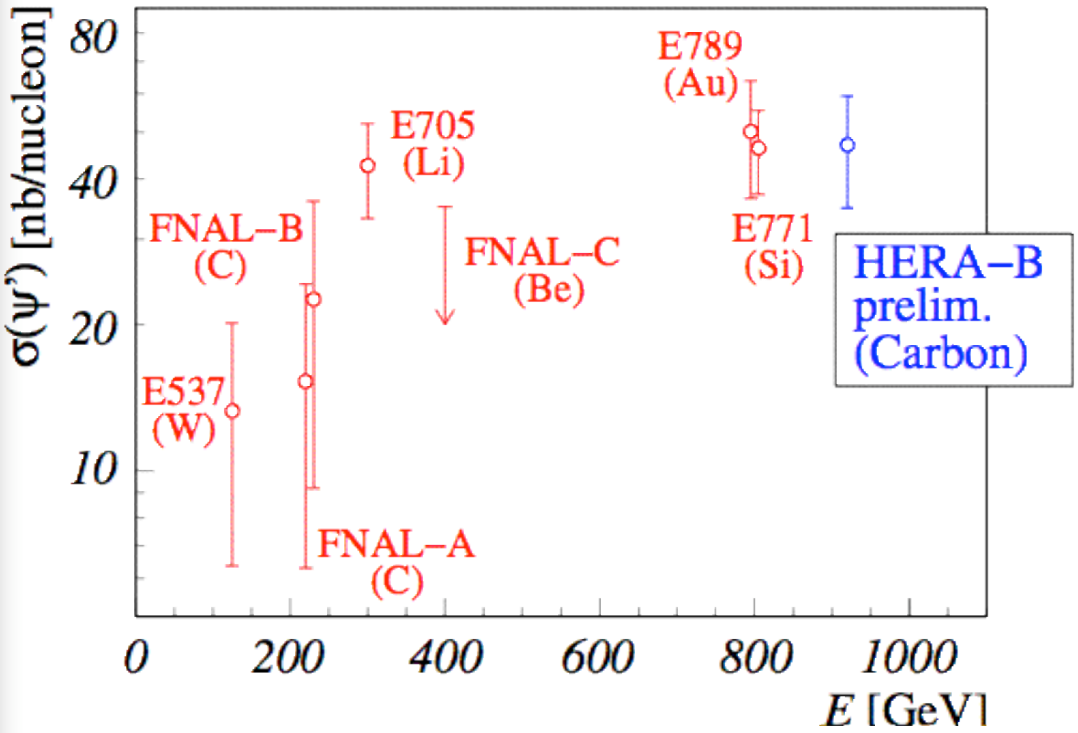
$$\alpha = \frac{1}{\log\left(A_2 / A_1\right)} \log\left(\frac{N_1}{N_2} \frac{L_2}{L_1} \frac{\varepsilon_2}{\varepsilon_1} \right)$$



- 25% of full e^+e^- sample
- Efficiency ratio: full detector & trigger simulation
- Luminosities: norm. to E866

Production Ratio: ψ‘ to J/ψ

$$\sigma_{\psi'} = \sigma_{J/\psi} \cdot \frac{N_{\psi'}}{N_{J/\psi}} \cdot \frac{\mathrm{BR}(J/\psi \to l^+l^-)}{\mathrm{BR}(\psi' \to l^+l^-)} \cdot \frac{\varepsilon_{J/\psi}}{\varepsilon_{\psi'}}$$

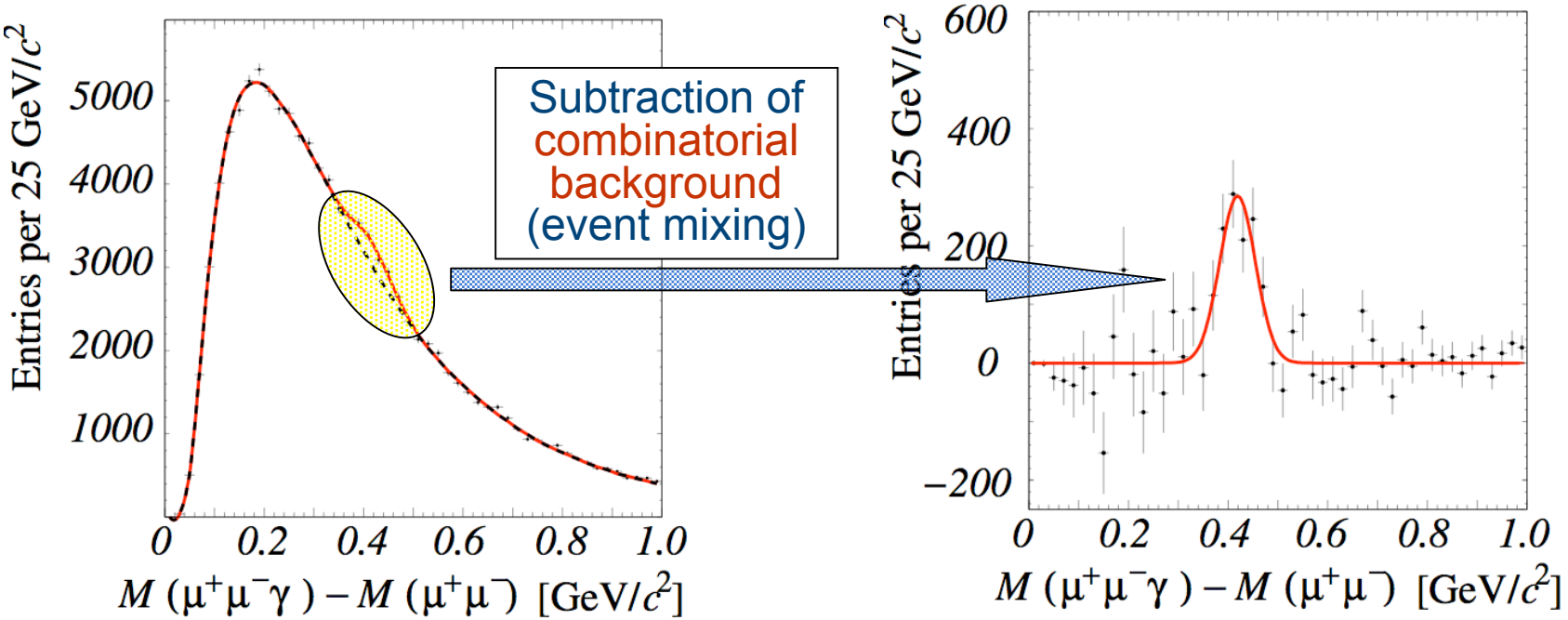


- Measure ψ‘ cross-section relative to J/ψ → reduce systematic uncertainties
- $\varepsilon_{J/\psi}/\varepsilon_{\psi'}$= 0.72 (from MC)
- J/ψ cross-section from FNAL E771 & E789: (357±8±25) nb/nucl.
- Preliminary result (electrons, carbon targets only):

$\sigma_{\psi'}$ = (46±12) nb/nucl.

Production Ratios: $R(\chi_c)$

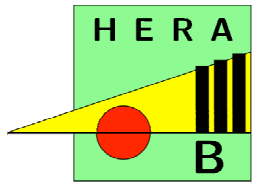
- Test of charmonium production models: fraction $R(\chi_c)$ of J/ψ from radiative decays $\chi_c \rightarrow J/\psi\,\gamma$



- Preliminary (15% of $\mu^+\mu^-$ stat.): $R(\chi_c)=0.21\pm0.05(\text{stat.})$

  2000 publication: $R(\chi_c) = 0.32\pm0.06(\text{stat.})\pm0.04(\text{syst.})$

Summary & Outlook



- HERA-B has finished data-taking
- Large sample of charmonia acquired: 300,000 J/ψ
- Charmonium production: preliminary results for
  - Differential distributions
  - *A*-dependence of J/ψ production for $x_F<0$
  - Production ratios: ψ‘ to J/ψ, χ_c to J/ψ
- Outlook:
  - First results of 2002/2003 run to be published soon
  - More careful studies needed for charmonium analyses
  - Stay tuned – many interesting results to come

Thanks to the HERA-B Charmonium Working Group