Status of the HERA-B Analysis

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- Data samples
- Physics topics
- Selected topics:
  - J/ψ cross section
  - ψ(2S) production
  - A-dependence of J/ψ production
  - χ_c production
- Summary

Data samples

Analysis of data taken from Oct. 2002 to Feb. 2003

- 150 M di-lepton trigger events

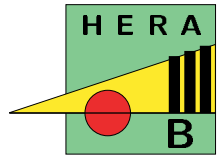
$\Rightarrow$ 300 000 J/ψ: $e^+e^- + \mu^+\mu^-$

- 210 M minimum bias events
- 35 M hard photon trigger events
- 60 M “glueball” trigger events

Different target wires, mainly **C, Ti, W**

proton-nucleon CM energy: $\sqrt{s} = 41.6\,\mathrm{GeV}$

Analysis Topics



- Upper limit on BR(Do $\rightarrow \mu+\mu-$) [Phys.Lett.B596:173-183,2004]
- Pentaquark limits (pK_S, $\Xi\pi$) [Phys.Rev.Lett. 93 (2004) 212003]

published (2002/03 only)

- *bb* production cross section
- Υ production cross section
- Production of ϕ and K* mesons
- J/ψ production cross section

needs J/ψ ref. cross section

draft stage

- D^+/D^o production ratio
- Production ratio ψ(2S) / J/ψ

analysis note in preparation

- J/ψ differential distributions
- Charmonium production A-dependence
- χ_c production, A dependence
- high-p_t photons
- Λ polarization

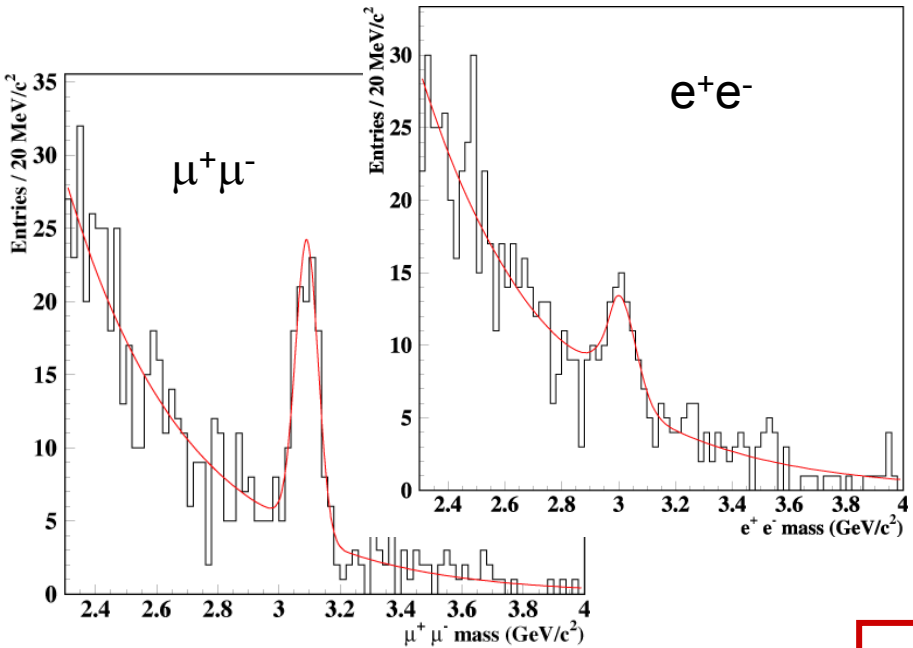
preliminary results available

- V^o differential and total cross section
- Hyperon production
- Deuteron/anti-deuteron production
- Bose-Einstein correlations
- Jet production

needs more work

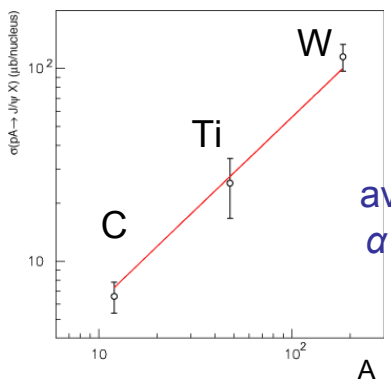
J/ψ Cross Section from Min. Bias Data

relatively low statistics, but no trigger uncertainty



$$\sigma^{A}_{J/\psi} = \frac{N_{J/\psi}}{\varepsilon_{J/\psi} \cdot BR(J/\psi \to \mu^+\mu^-) \cdot L^A}$$

A lot of work for lumi studies;
publication in preparation



average over A with
α = 0.96±0.01 fixed

$$\sigma_{J/\psi} = (605 \pm 67 \pm 43)\ \text{nb/nucleon}$$

(prelim.)

HERA-B ~1.7 x higher **than E771 / 789**
extrapolated to this energy region (!?)

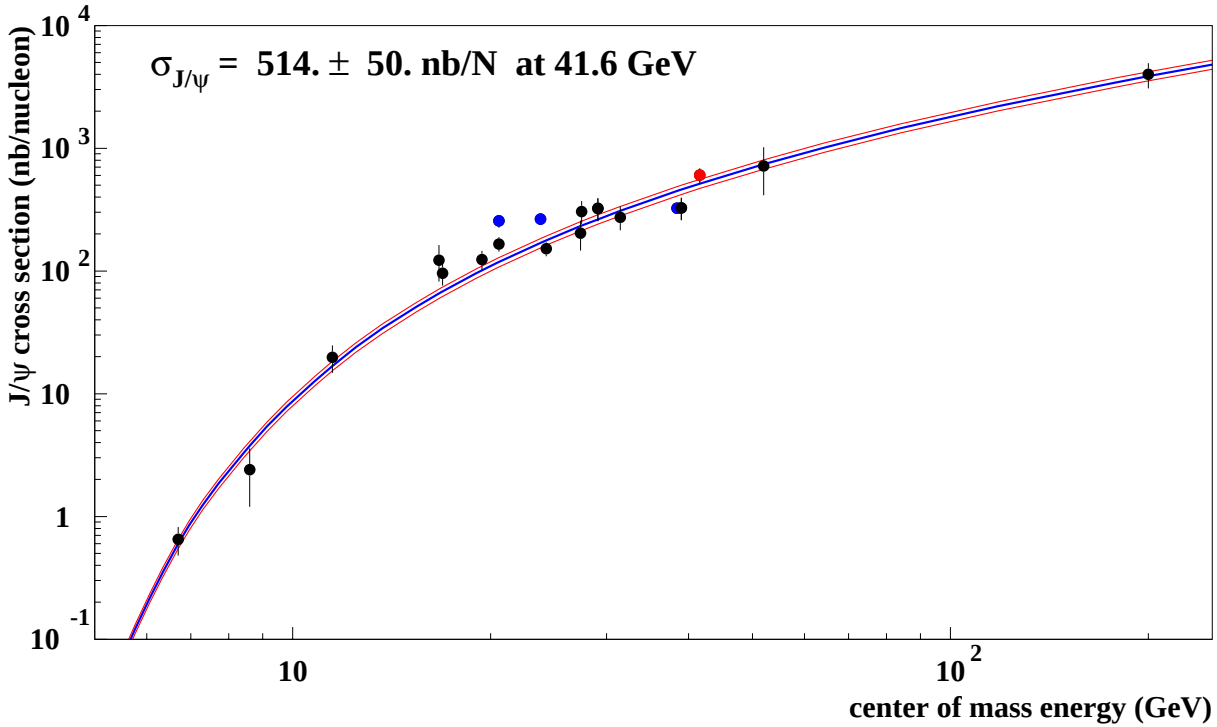
Important for cross section normalization of di-lepton triggered data

Study of J/ψ Cross Section Parametrisations

Fit of cross section data currently studied with F.Maltoni using NRQCD model

Fits rather stable w.r.t. changes in model input (PDF's, ME's, ..)

Biggest problem: inconsistent exp.data



Our new reference cross section : $\sigma_{J/\psi} = (514 \pm 50)$ nb/nucleon

(previously from E771 and E789: (357 ± 8 ± 27) nb/nucleon)

× 1.44

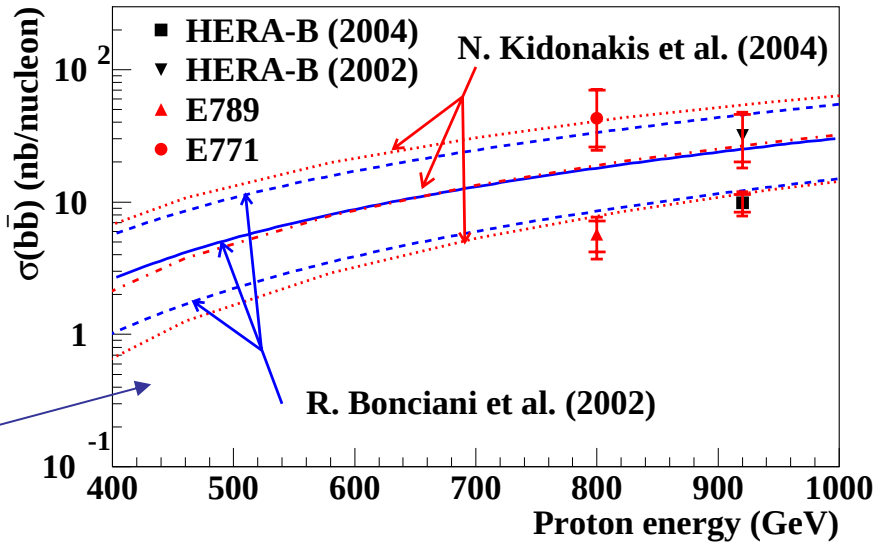
(prelim., study ongoing)

Results for Beauty Cross Sections

have to be scaled by new J/ψ reference cross section

$$\frac{\sigma_{b\bar{b}}}{\sigma_{J/\psi}} = 0.033 \pm 0.005 \pm 0.004$$

(prelim.)

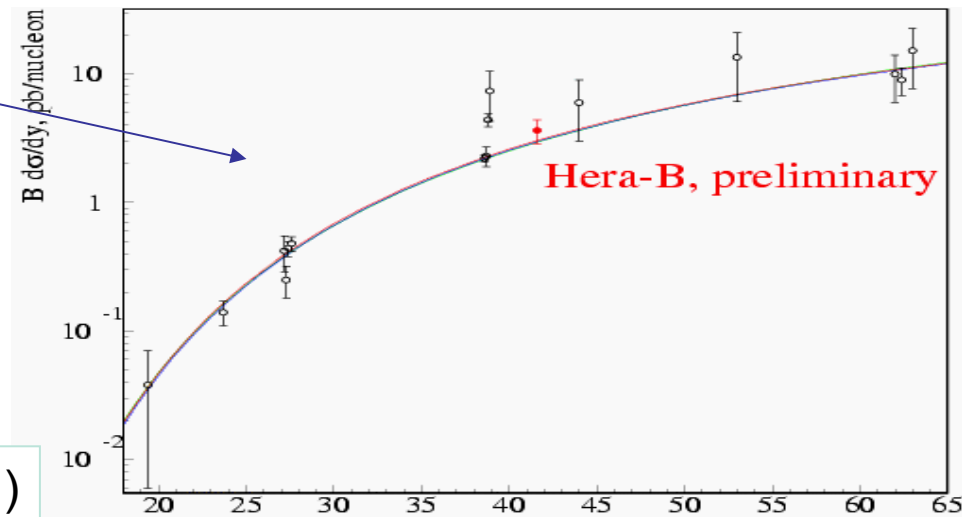


Plots still normalized to $\sigma_{J/\psi}$ from E771 and E789

will change by ~ ×1.4

$$\frac{B(l^+l^-)\cdot \left.\frac{d\sigma_\Upsilon}{dy}\right|_{y=0}}{\sigma_{J/\psi}} = (10.0 \pm 2.1)\cdot 10^{-6}$$

(prelim.)

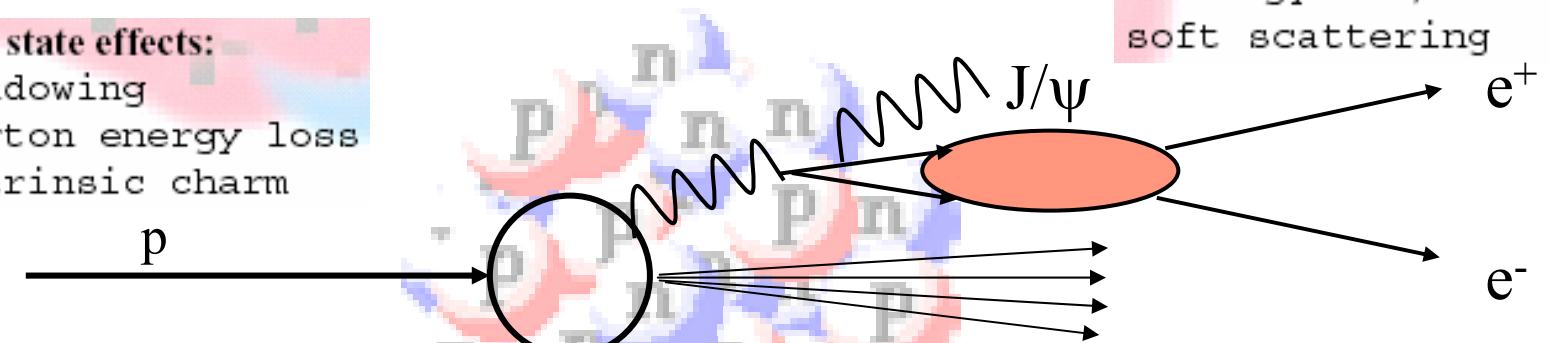


Study of Charmonium Suppression
as input for QGP searches in heavy ion collisions

Kinematical distributions (x_F, p_T, polarization) derived from:
- NRQCD for nucleon-nucleon reactions
- models for nuclear effects in pA reactions

Initial state effects:
- Shadowing
- Parton energy loss
- Intrinsic charm

Formation state effects:
- Nuclear Absorption
- Comover Absorption
- Energyloss/multiple soft scattering



x_F measures the **formation length** of the **ccg state:**

$L_f \approx 0.3$ fm $\cdot \gamma_\psi$

x_F	L_f [fm]
0.2	20
0.0	7
-0.2	2

Nuclear radius:
C ~ 3 fm.
W ~ 8 fm.

- $x_F > 0$: ccg forms a bound state **outside** the nucleus
- $x_F < 0$: ccg forms a bound state **inside** the nucleus

$$\sigma_{cc} = \sigma_0 \cdot A^{\alpha}$$

$\alpha \neq 1 \Rightarrow$ "suppression"

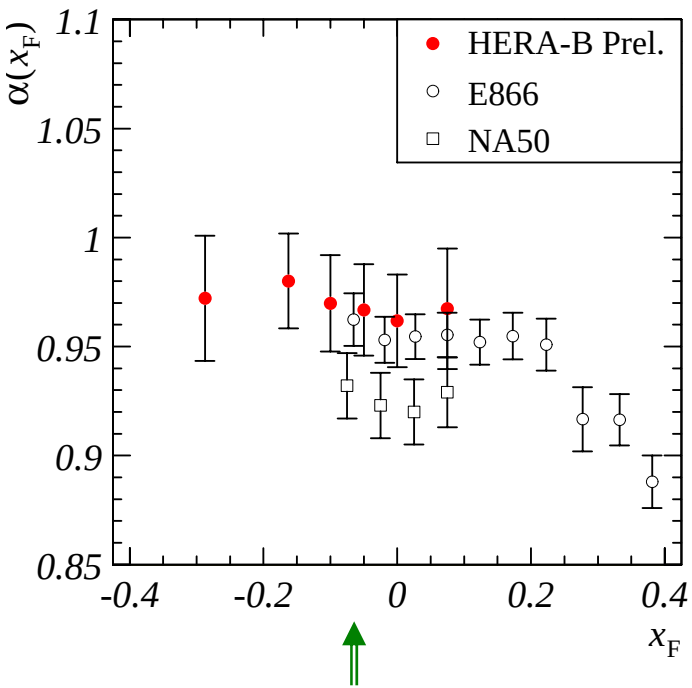
A dependence of J/ψ Production : $\alpha(x_F)$, $\alpha(p_T)$

$$\sigma_{pA} = \sigma_{pN} \cdot A^{\alpha}; \quad \sigma = \mathrm{N}/(\varepsilon \cdot L)$$

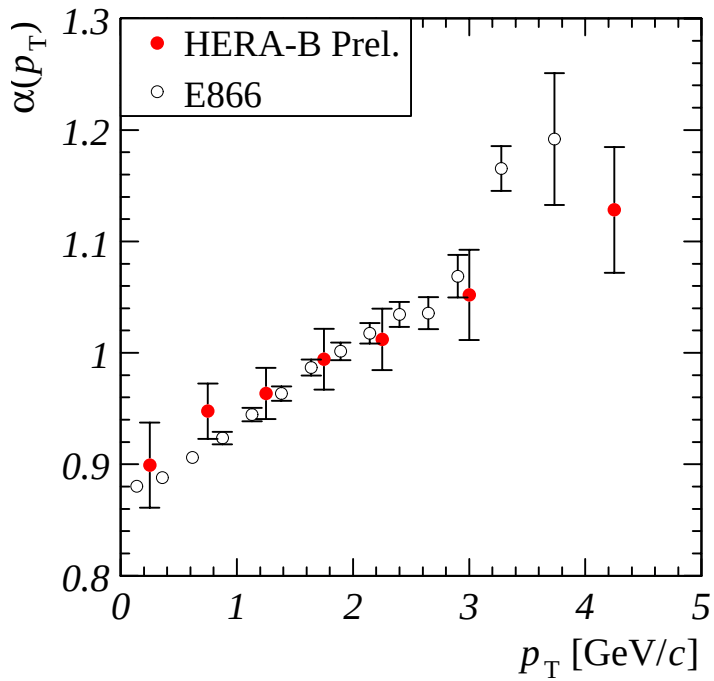
$$\alpha = \frac{1}{\ln(A_W / A_C)} \cdot \ln\left(\frac{\mathrm{N}_W}{\mathrm{N}_C} \frac{L_C}{L_W} \frac{\varepsilon_C}{\varepsilon_W} \right)$$

dominant syst.: "wire sharing"; ~2% decrease to ~1% (?)

2-wire runs (C, W), $\mu^+\mu^-$ data:



HERA-B now absolutely normalized

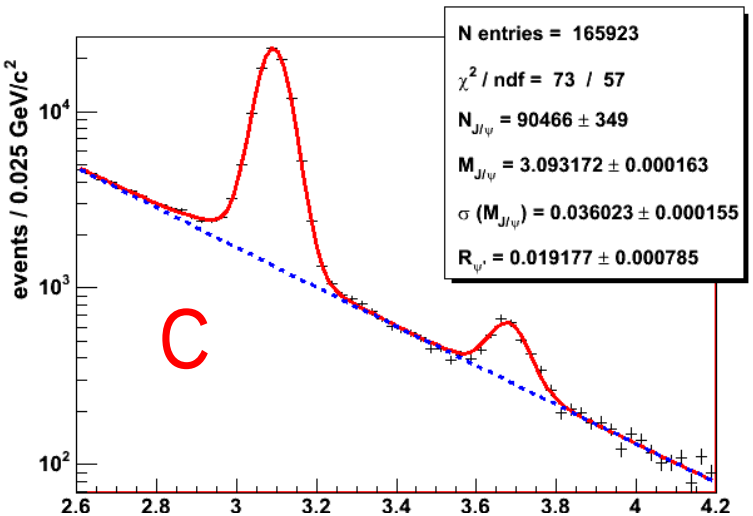


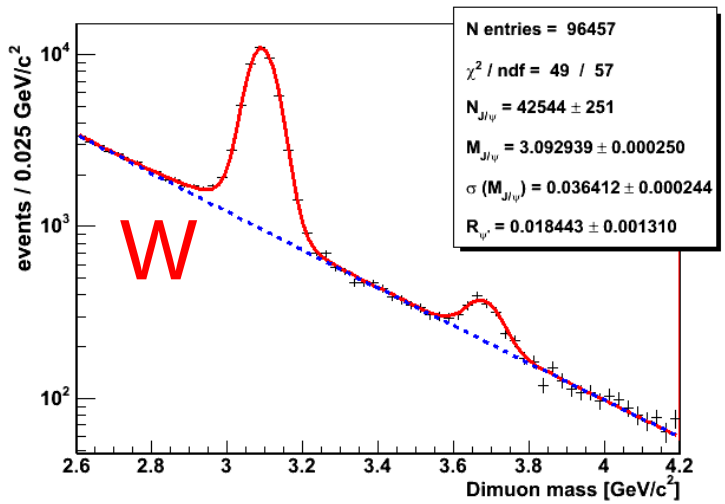
extending the range of measurements to $x_F = -0.35$

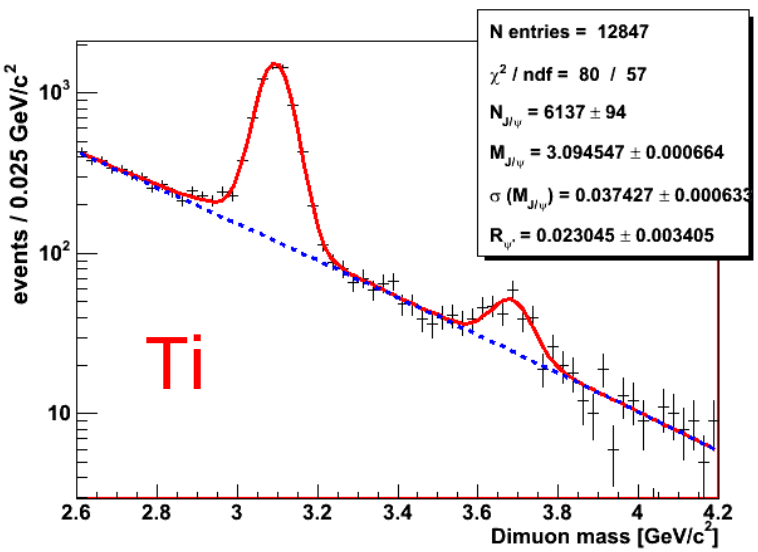
- Systematic studies ongoing
- electron channel being finalized

ψ(2S) Production: σ(ψ(2S)) / σ(J/ψ)

$\mu^+\mu^-$ data:

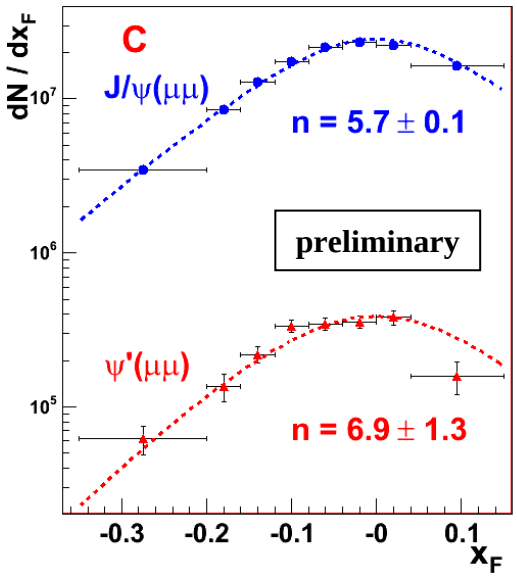


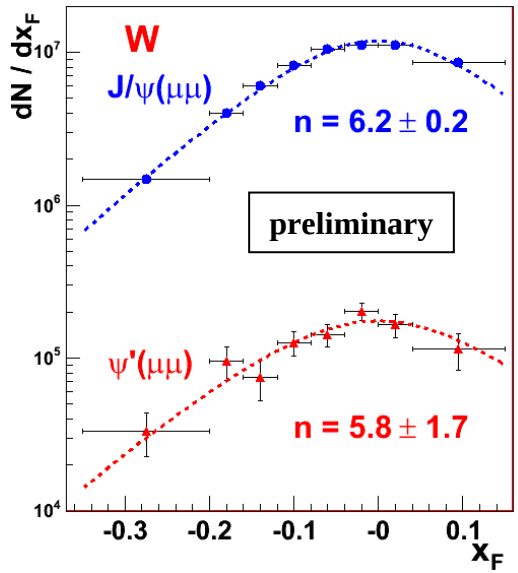


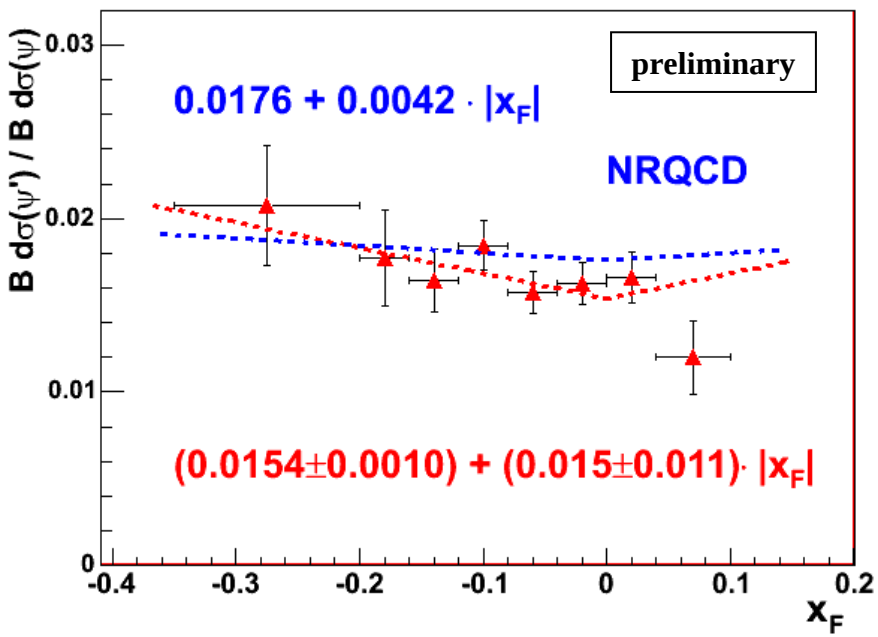


$$\frac{B(\psi(2S)\to l^+l^-)\cdot\sigma_{\psi(2S)}}{B(J/\psi\to l^+l^-)\cdot\sigma_{J/\psi}} = \frac{N_{\psi(2S)}}{N_{J/\psi}}\frac{\varepsilon_{J/\psi}}{\varepsilon_{\psi(2S)}}$$

x_F distributions





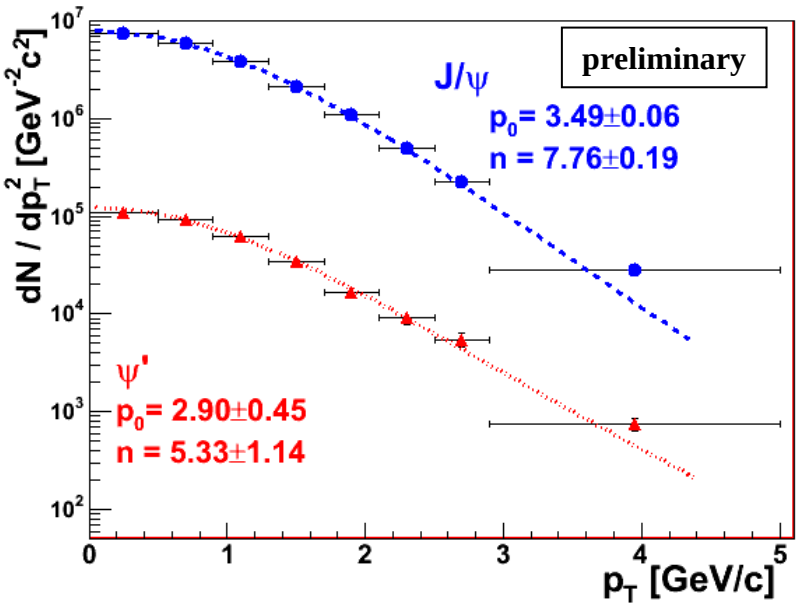


Ratio:

- In agreement with NRQCD
- almost constant vs xF

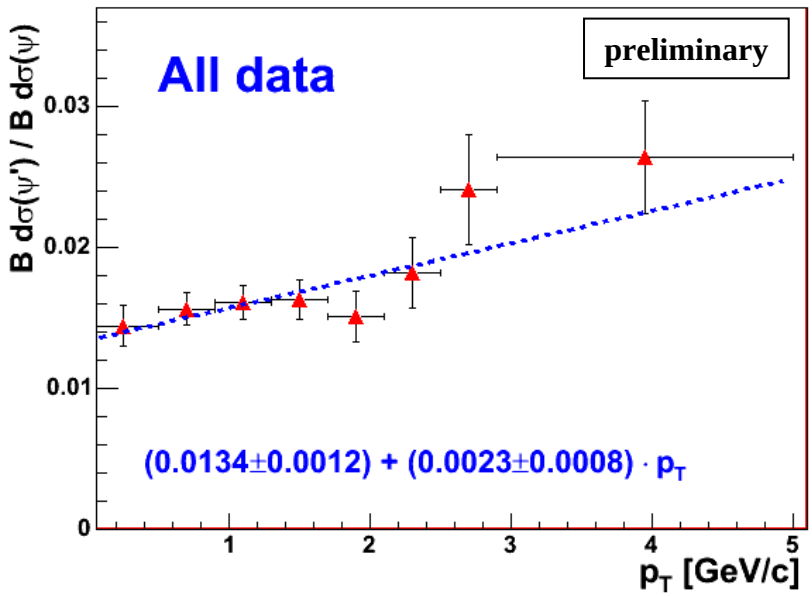
← fitted by $a + b \cdot |x_F|$

Dependence on p_T



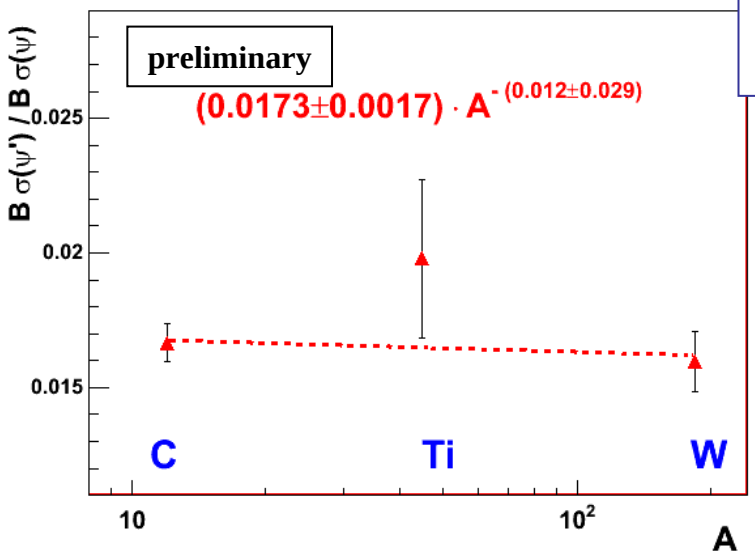
Power-low is suitable for the fitting

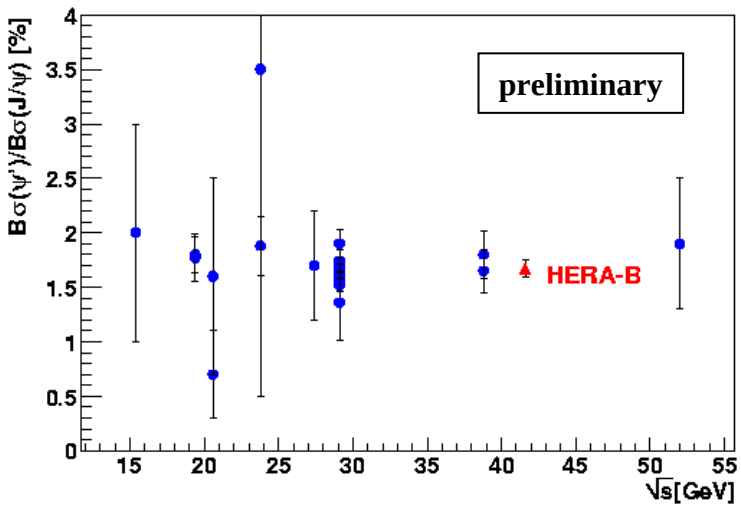
$$\frac{d\sigma}{dp_T^2} = A\left[1+\left(\frac{p_T}{p_0}\right)^2\right]^{-n}$$



ψ(2S) appears to have a wider p_T distribution
⇒ nuclear effects different for radial excitation?

A- and s-Dependence of $\sigma(\psi'(2S)) / \sigma(J/\psi)$





Agrees with E866 value:
$\alpha(\psi(2S)) - \alpha(J/\psi) = -0.026 \pm 0.005$

Results from $\mu^+\mu^-$ data:

prelim.

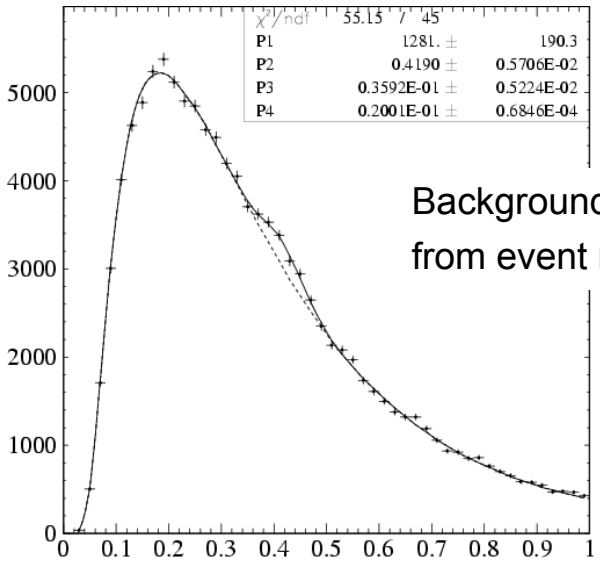
$$R = B\,\Delta\sigma(\psi(2S)) / B\,\Delta\sigma(J/\psi)$$

C :	(1.667 +/- 0.069) %
W:	(1.596 +/- 0.114) %
Ti:	(1.979 +/- 0.293) %
All:	(1.659 +/- 0.058) % ,

(as one sample, A-dep. from E866)

Similar results from e^+e^- data

χ_c / J/ψ production ratio



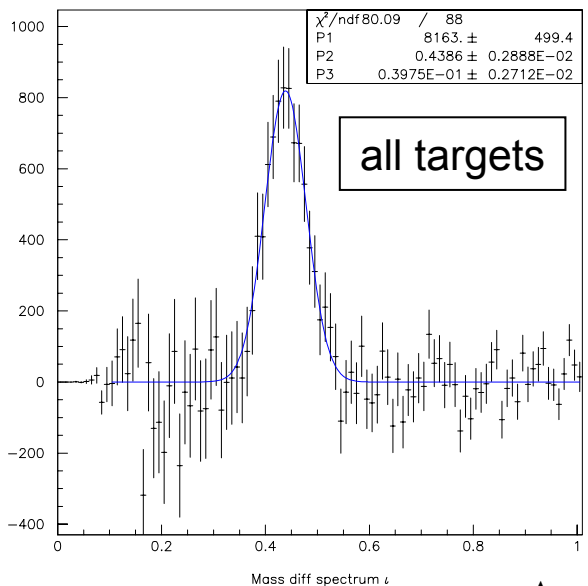
Background shape from event mixing

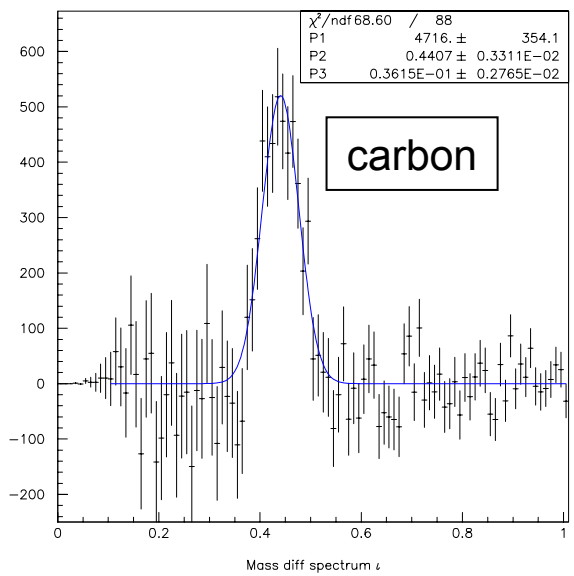
observed in radiative decay

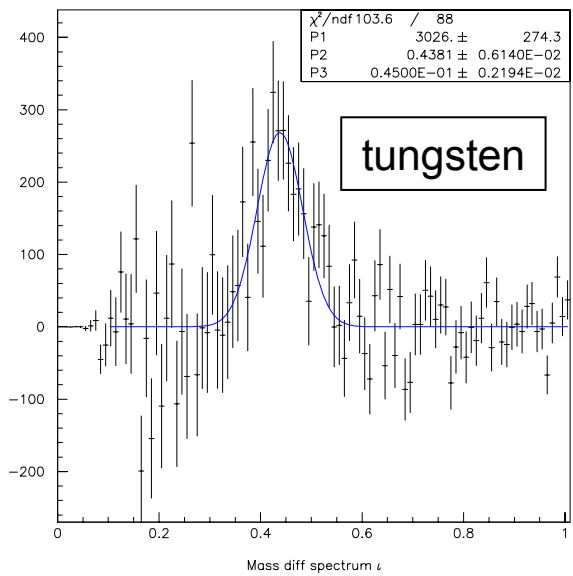
$$\chi_c \to J/\psi\gamma \to l^+l^-\gamma$$

$$R_{\chi_c} = \frac{\sum_{i=1}^{2}\sigma_{\chi_{ci}} \cdot BR(\chi_{ci} \to J/\psi\gamma)}{\sigma_{J/\psi}} = \frac{N_{\chi_c}}{N_{J/\psi}} \cdot \frac{\varepsilon_{J/\psi}}{\varepsilon_{\chi_c}\varepsilon_{\gamma}}$$

μ+μ- channel, results from full data set now available







$\Delta m = m(l^+l^-\gamma) - m(l^+l^-)$ [GeV/c^2]

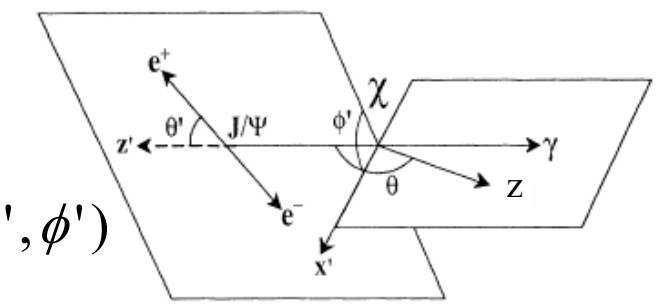
χ_c production: results

$R(\chi_c) = 0.21 \pm 0.05$ (prel.)

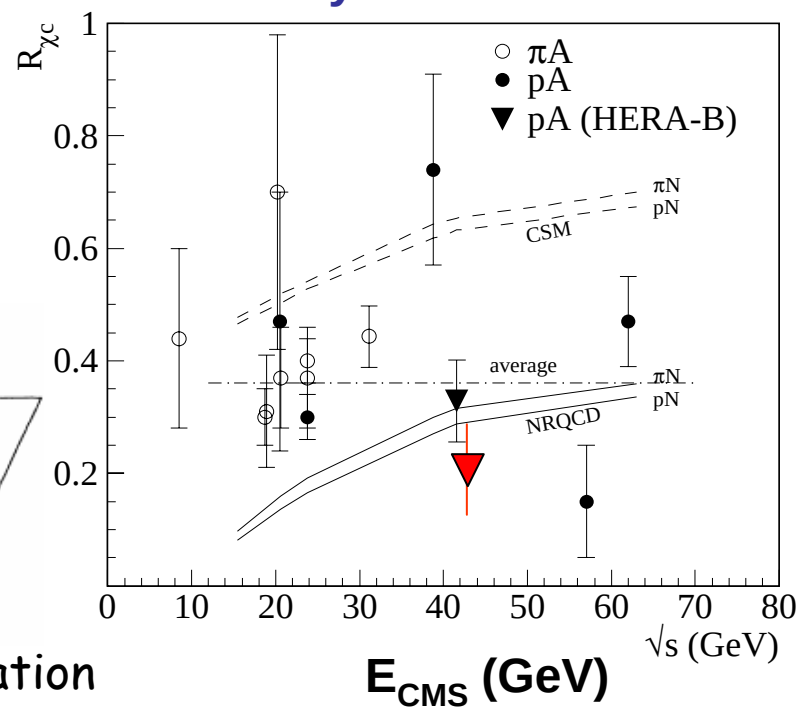
from only 10% of 2002/03 data

Systematic studies ongoing

- **background determination**
- **γ efficiency**
- electron channel (similar results)
- **dependence on polarization**



$$W^{J,M}(\theta,\theta',\phi')$$



The efficiencies for all possible polarization states have been calculated and differ by less than 10%.

Conclusion

- HERA-B has a considerable list of interesting topics under study which should be published.
- The number of active collaboration members is decreasing as expected but the main analysis topics should be reasonably covered.
- The goal is to produce draft publications by end of this year for most of the topics (O(10), for sure 4 publications this summer)