

HERA-B

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Outline

- Latest news from commissioning:
 - Status of detector components.
 - Status of First Level Trigger.
- Analysis of 2000 data.
- Physics program for 2002.
- Summary.



Status of detector components.

- HERA-B detector **operational in 2000 run.**
- Improvements during 2001 shutdown:
 - **Noise reduction** (improved grounding):
 - increased efficiency.
 - improved resolutions.
 - Dead **detector modules repaired.**

| | Status & actions during 2001 shutdown |
|-------------|---|
| VDS | Fully operational in 2000. Detector modules repaired. |
| ITR | Dead chambers repaired. Noise reduction (improved grounding). Installation of missing chambers. |
| OTR | Dead HV groups repaired. Noise reduction → Higher efficiency due to lower threshold cut. |
| RICH | Fully operational in 2000. |
| ECAL | Reduction of common noise (grounding improved) → better E resolution. |
| MUON | Dead channels repaired. Noise reduction → lower threshold, higher efficiency. |



Status of First Level Trigger

The First Level trigger was **not fully commissioned in 2000**.
Low efficiency from detector and trigger performances.

Analysis of 2000 data finished:

single track muon efficiency ~ 20%. (expected ~50% in 2002.)

single track electron efficiency ~ 50%. (expected ~80% in 2002.)

Vector test successful: download MC event into the hardware for **bit wise comparison** between the hardware and simulation outputs.
Independent confirmation of previous results.

Many improvements in hardware, algorithm, & simulation,
... implemented in 2001

Large improvement in performance expected for 2002.



Analysis of 2000 data.

2000 ANALYSIS TOPICS

*Different trigger
conditions.*

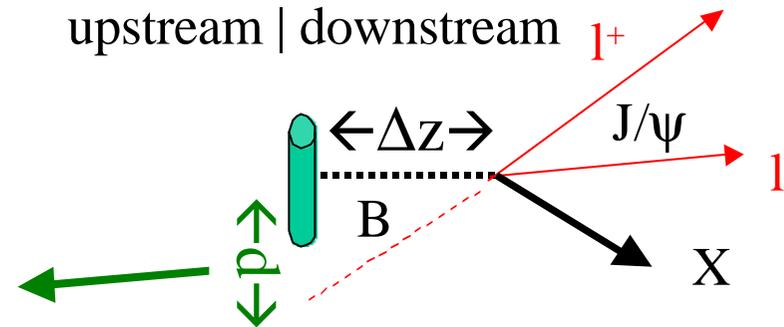
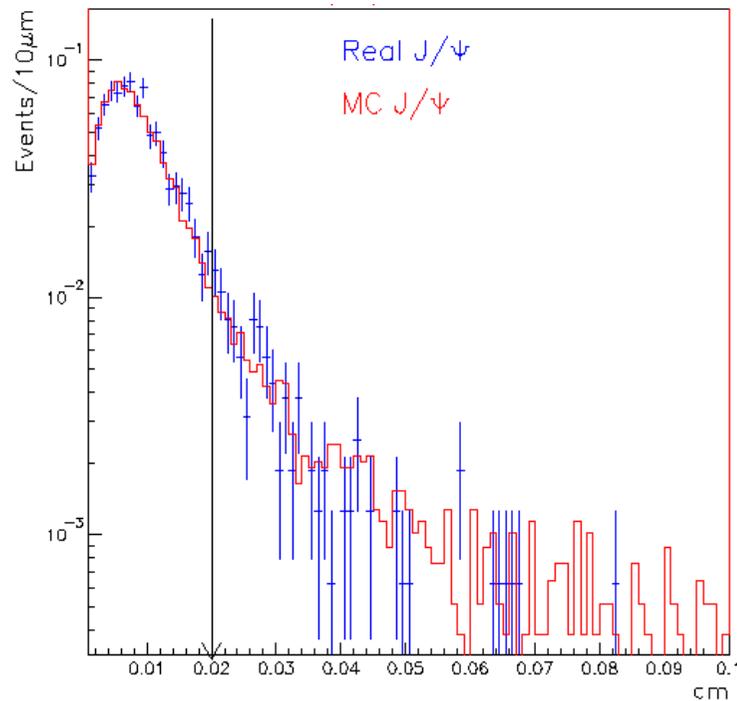
- **Minimum Bias:** (No trigger)
 - K_s^0 & Λ production cross section.
 - Inclusive particle productions.
 - Λ polarisation.
- $e^+ e^-$ pair (ECAL E_t trigger seed and tracking)
- $\mu^+ \mu^-$ pair (MUON track seed and tracking)
 - σ_{bb} production cross section.
 - J/ψ production cross section.
 - x_f and p_t inclusive J/ψ distributions.
 - Fraction of J/ψ from χ_c .
 - J/ψ suppression in different target materials.
- **Single lepton** (electron and muon trigger).
 - Open charm production cross-section.



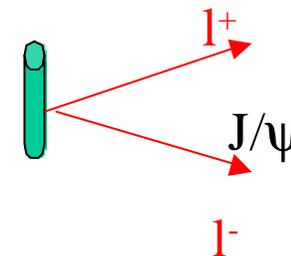
$pA \rightarrow bb$ cross section (σ_{bb})

Principle of the measurement

Look at the production chain: $pA \rightarrow b b \rightarrow B \rightarrow J/\psi X$ via detached J/ψ vertices.



and normalized to the inclusive J/ψ (prompt) cross section.



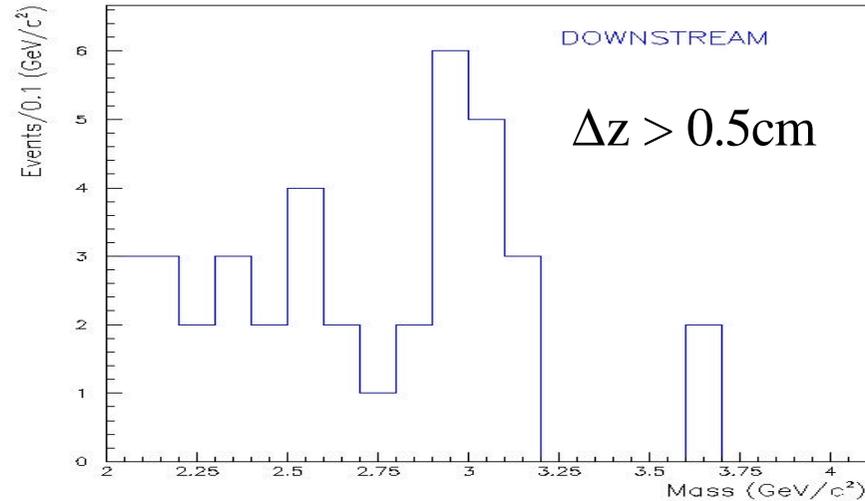
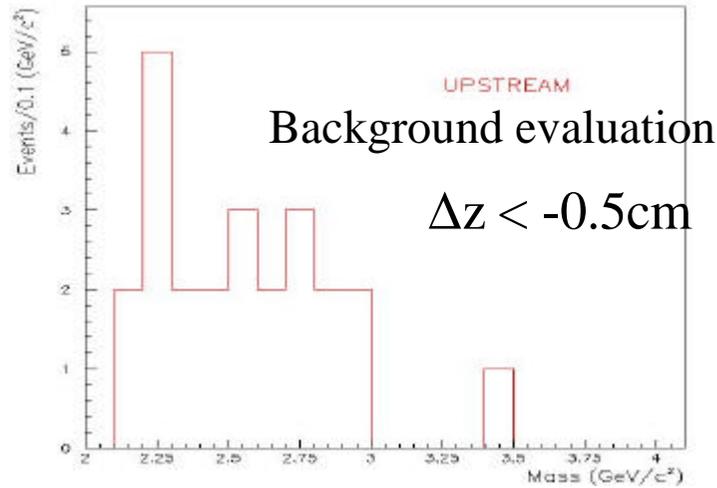
Comparison of lepton impact parameter between Data and MC for prompt J/ψ .



$pA \rightarrow bb$ cross section (σ_{bb})

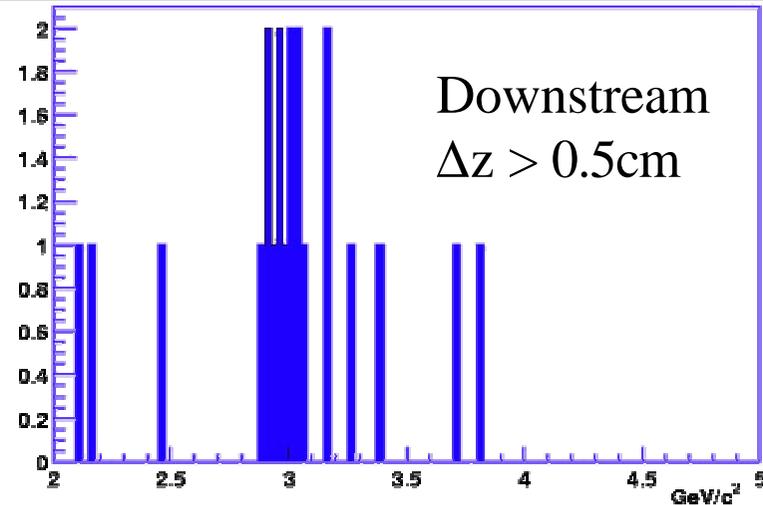
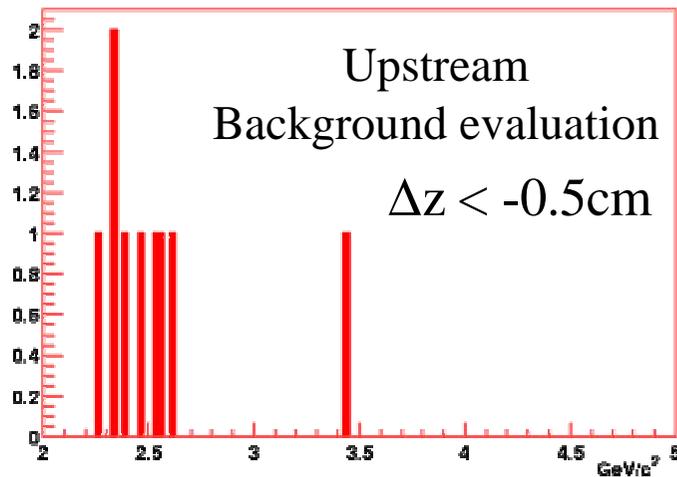
Excess of J/ψ downstream
 \rightarrow indication of B decays.

Event by event J/ψ vtx. to primary vertex.



$J/\psi \rightarrow e^+e^-$

Alternative method using the **average target wire position** \rightarrow reduced primary error



$J/\psi \rightarrow e^+e^-$



$pA \rightarrow bb$ cross section (σ_{bb})

$J/\Psi \rightarrow e^+ e^-$

Method 1 $\sigma_{bb} = 60 \pm 19$ nb

Method 2 $\sigma_{bb} = 55 \pm 22$ nb

$J/\Psi \rightarrow \mu^+ \mu^-$

Similar analysis gives upper limit:

$\sigma_{bb} < 98$ nb @ 90% C.L.

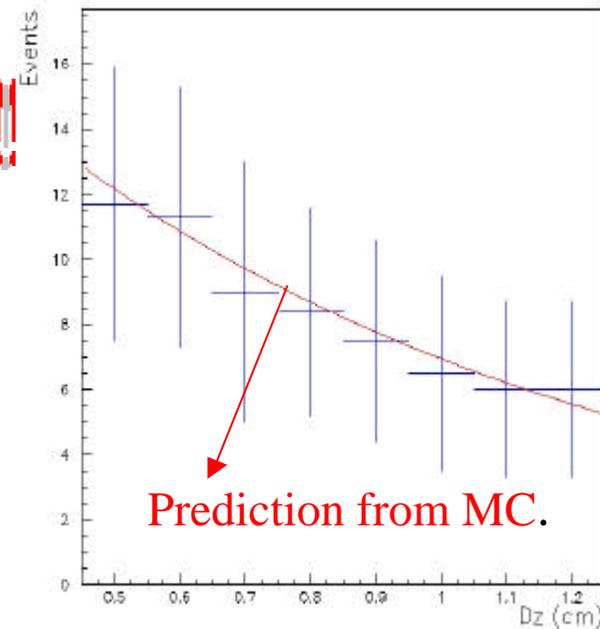
Published values (800 GeV):

E789: $5.7 \pm 1.5 \pm 1.3$ nb

E771: $43^{+27}_{-17} \pm 7$ nb

**Accumulated detached \mathbf{Y} vs.
distance J/\mathbf{Y} vertex to primary.**

Very preliminary!!!



HERA-B sees B mesons with low statistics.

HERA-B will be able to measure σ_{bb} in 2002:

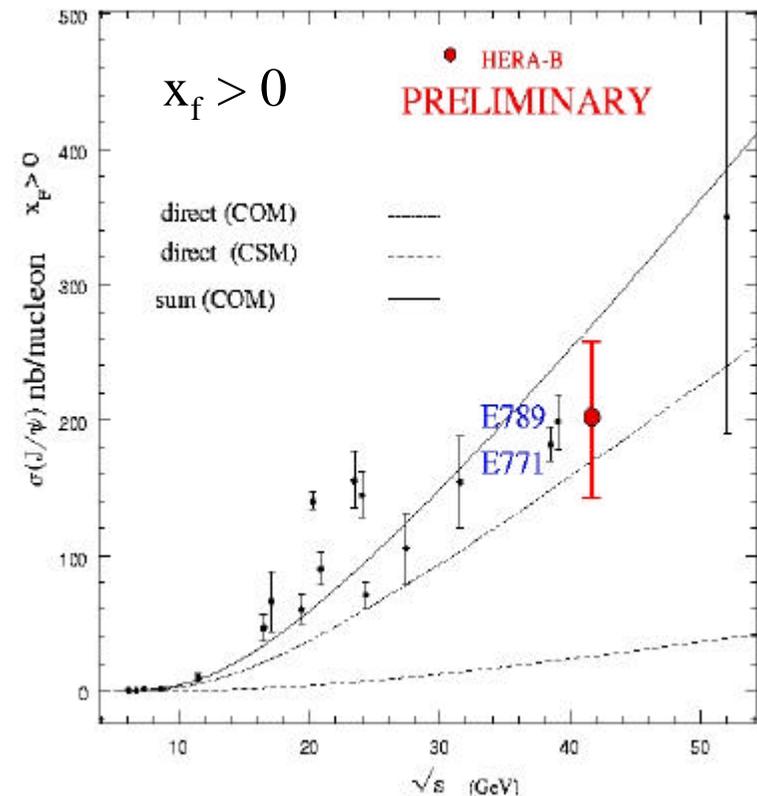
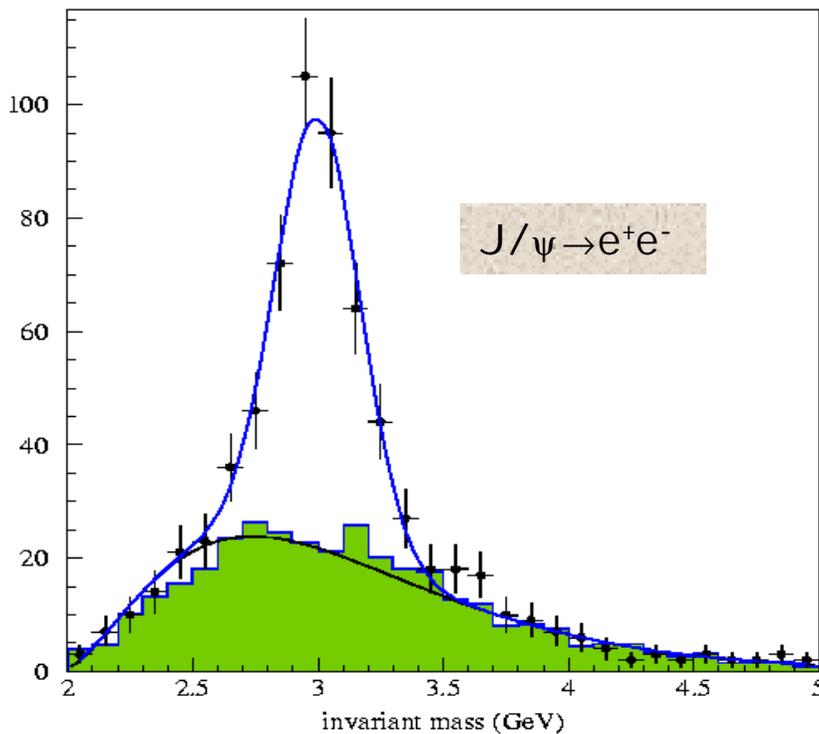
- expected error **limited by J/ψ direct cross section** (20%).
- possibility of measuring **cross section vs. material nuclear mass (A)(NEW!).**



Absolute J/ψ cross section

HERA-B is able to measure an **absolute cross-section** comparable to previous experiments.

Trigger efficiency & Luminosity determination (from reference minimum bias) can be controlled.



J/Ψ P_t and x_f spectra.

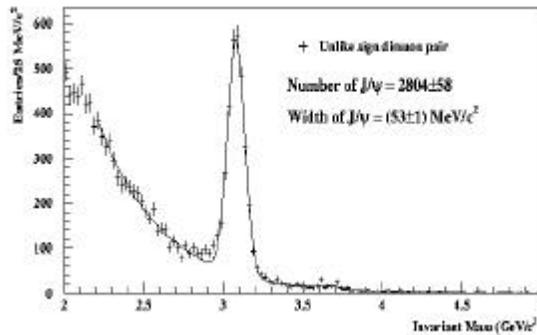
$$\frac{dN}{dx_f} = A(1 - |x_f|)^c$$

Phenomenological dependency.

x_f

J/Ψ → μ⁺ μ⁻

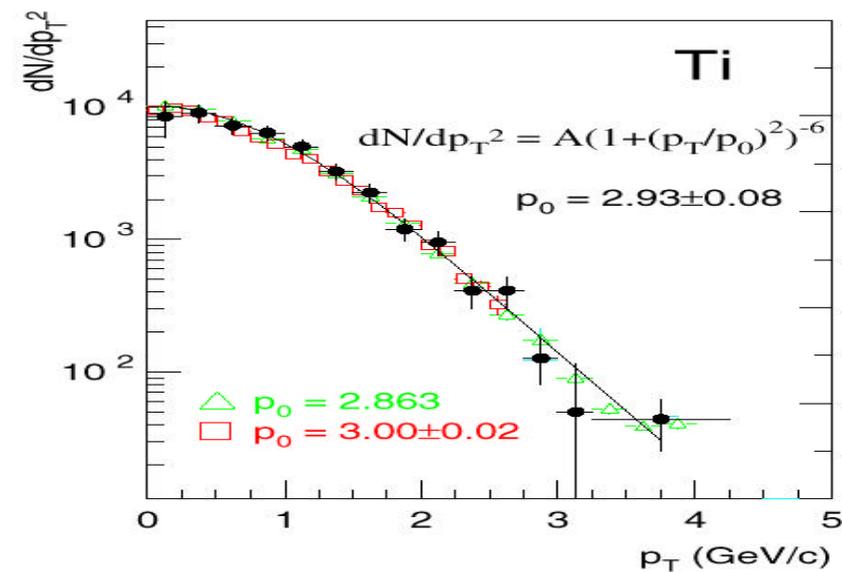
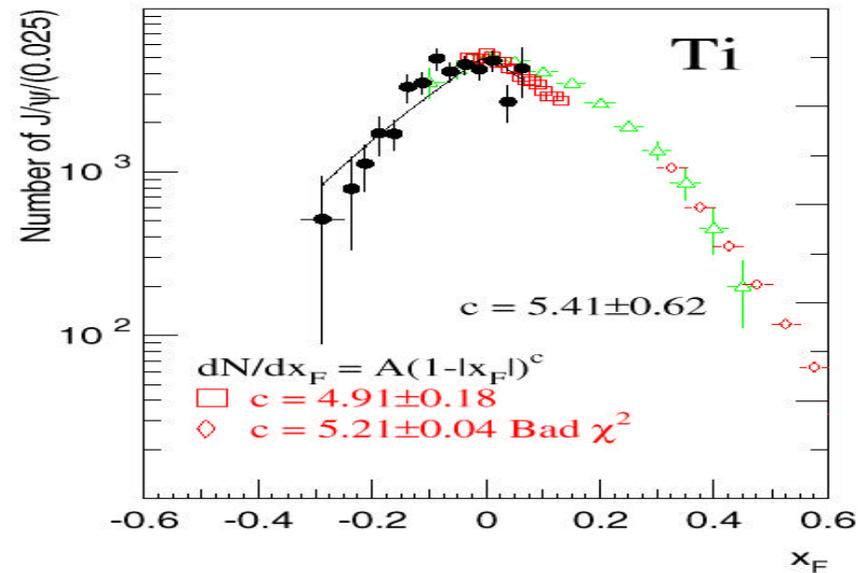
Samples for C and Ti.



Phenomenological dependency.

p_t

$$\frac{dN}{dp_t^2} = A(1 + (p_t / p_0)^2)^{-6}$$



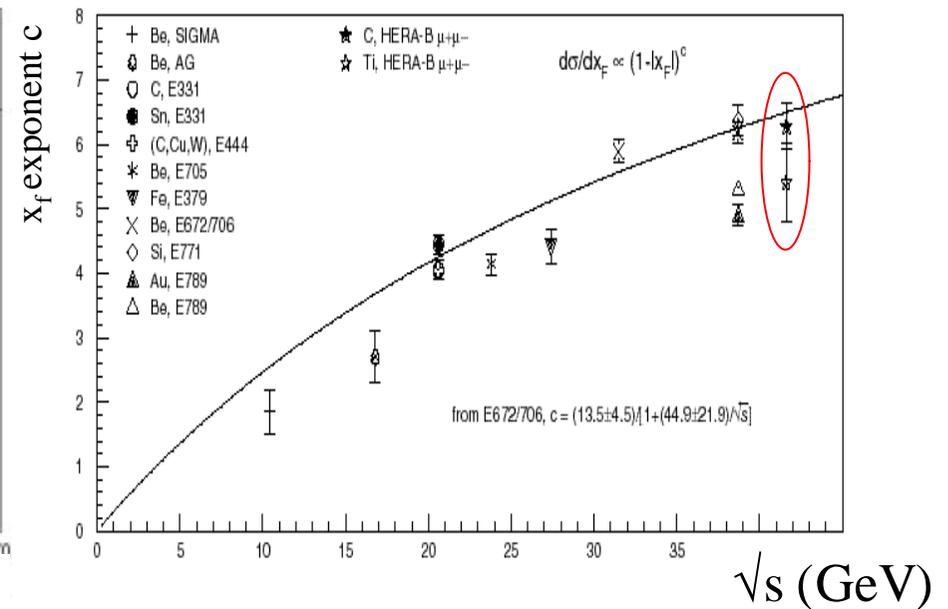
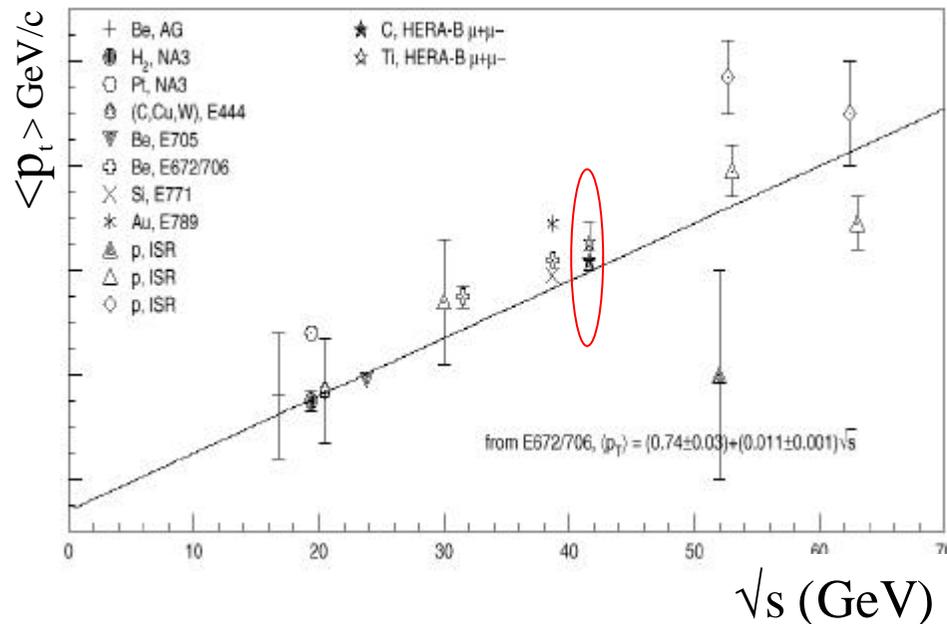
J/ψ P_t and x_f spectra.

HERA-B will be able to measure the p_t and x_f spectra in 2002 with comparable precision to the existing data.

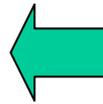
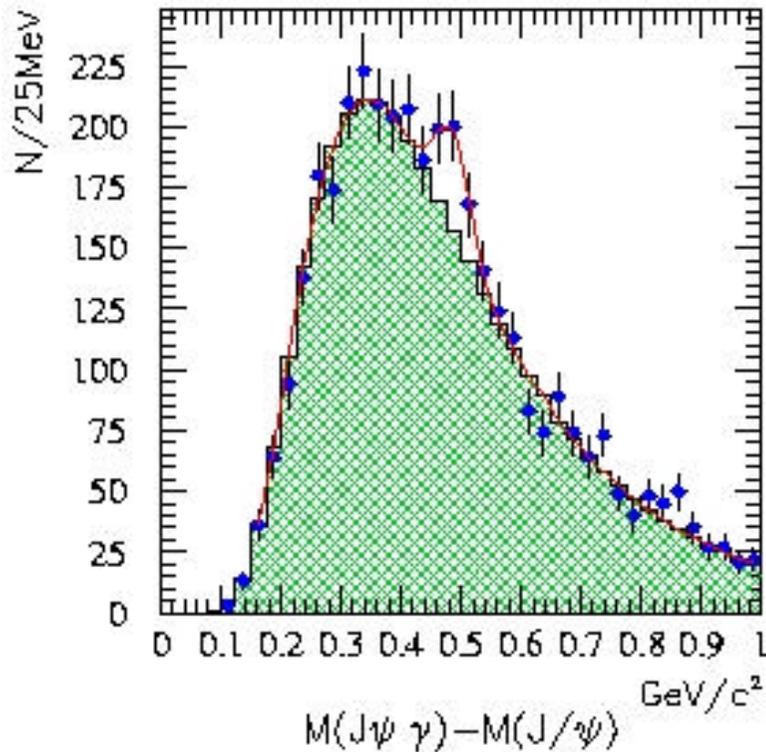
It will extend for the first time data to the negative Feynman x.

Errors will be limited by the modelling of trigger and detector acceptance.

Comparison with previous experiments

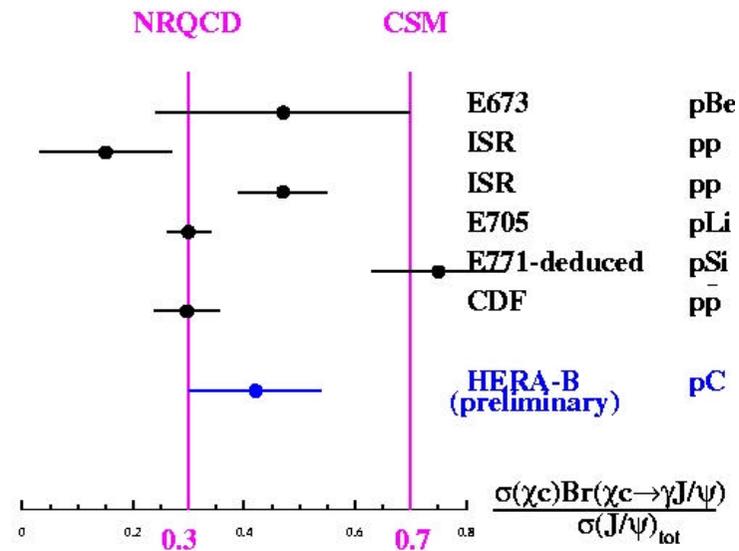


Fraction of J/ψ from χ_c



$\chi_c \rightarrow J/\psi \gamma$ (sum of $e\bar{e}\gamma$ and $\mu\bar{\mu}\gamma$)

Background model from mixed events.



HERA-B spectrometer allows to look at more than the dileptons.
 HERA-B will be able to reconstruct a large sample of χ_c in 2002:

- first measurement of suppression in nuclear matter.
- study of production ratios between J/ψ , χ_c and Ψ' .



Physics program for 2002

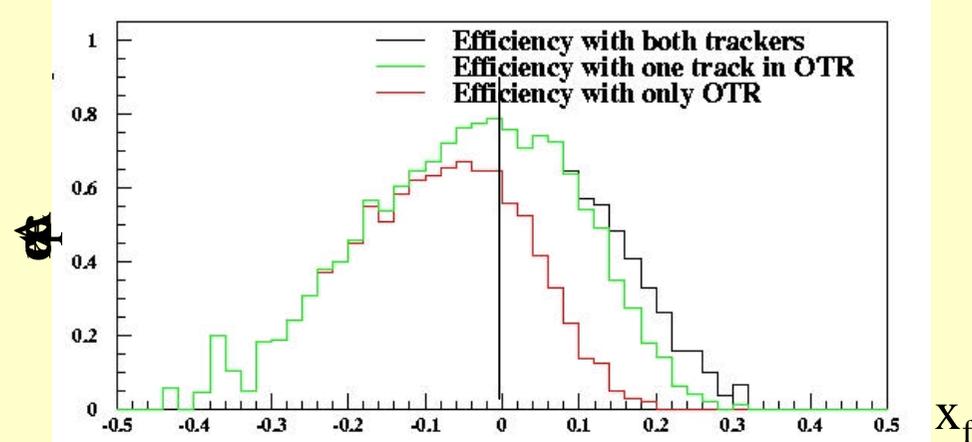
- Next year HERA-B will run a **dilepton trigger** (μ & e).
- Expected number of events:

| | 2002 | 2000 |
|------------------------------------|---------------------|---------------------|
| J/ψ (μ channel) | $\sim 2 \cdot 10^6$ | $\sim 4 \cdot 10^3$ |
| $\chi_c \rightarrow J/\psi \gamma$ | $\sim 2 \cdot 10^5$ | $\sim 1 \cdot 10^2$ |
| Ψ' | $\sim 3 \cdot 10^4$ | $\sim 2 \cdot 10^1$ |

Distributed over different target materials: **C, Ti and W.** (possibly Al & Pd)

With a large acceptance into the **negative Feynman x** $[-0.4, 0.3]$.

Acceptance
from MC



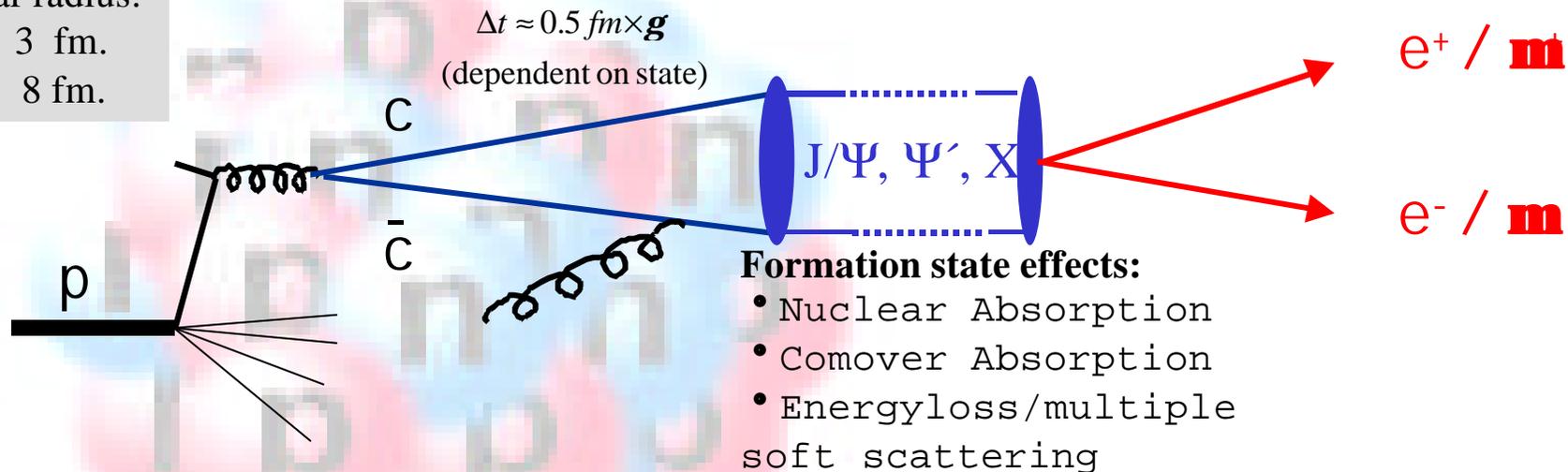
Physics program for 2002

Study of charmonium suppression

x_f measures the distance the ccg state travels before charmonium formation.

| X_f | Dist. |
|-------|-------|
| 0.2 | 15fm |
| 0.0 | 5fm |
| -0.2 | 1.5fm |

Nuclear radius:
 $C \sim 3$ fm.
 $W \sim 8$ fm.



Initial state effects:

- Shadowing
- Parton energy loss
- Intrinsic charm

Formation state effects:

- Nuclear Absorption
- Comover Absorption
- Energy loss/multiple soft scattering

- Positive $x_f \rightarrow$ ccg abandons the nucleus before it forms a bound state.
- Negative $x_f \rightarrow$ charmonium is formed before leaving the nucleus.



Physics program for 2002

Study of charmonium suppression

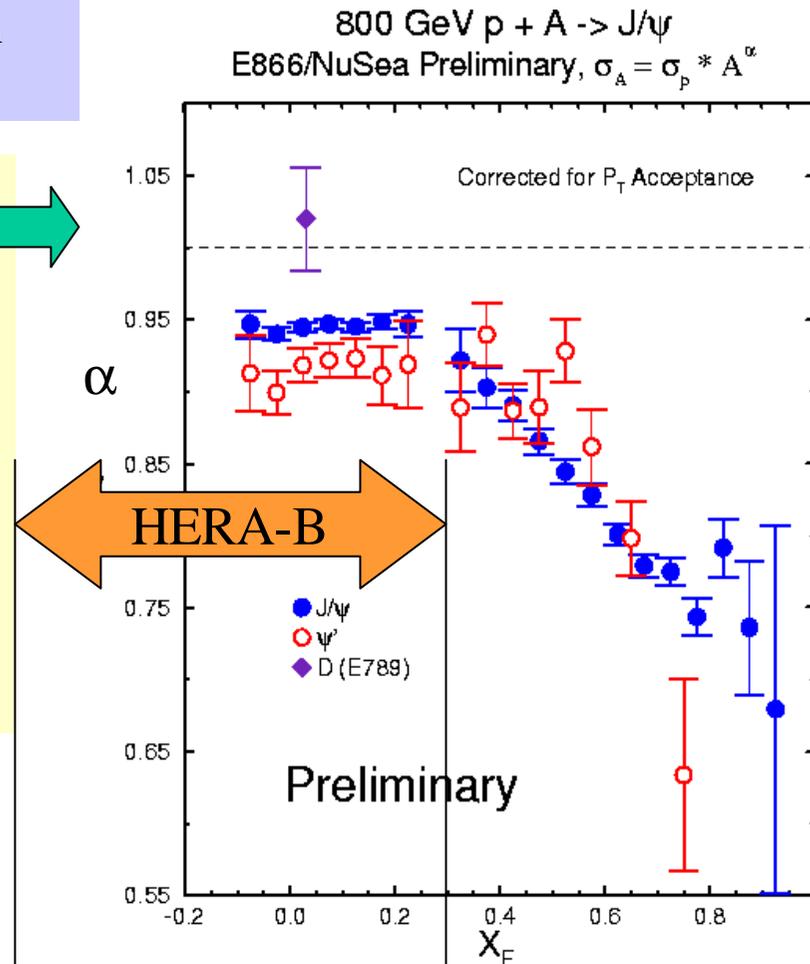
The charmonium cross section versus nuclear mass:

$$\sigma = \sigma_0 A^{\alpha(x_f)}$$

$\alpha(x_f)$ measures the charmonium suppression in nuclear matter. ($\alpha=1 \rightarrow$ no suppression)

- **E-866** has measured the suppression in nuclear matter for **positive** x_f .
- **HERA-B** will measure the charmonium suppression in the **negative** x_f region.
- HERA-B explores the charmonium-N cross-section for J/ψ and Ψ' .
- HERA-B will measure the suppression of χ_c in nuclear matter for the first time.

Expected precision similar to existing data in the common x_f range.



Summary

- First analysis of 2000 data shows the capabilities of the detector to provide interesting physics.
- Improved performance of the HERA-B spectrometer for 2002.
- HERA-B will cover an unexplored area of proton-nucleus collisions with $x_f < 0$.
- Large statistics of charmonium states expected for year 2002. (factor of ~60 increase of production rate)



Summary (physics program)

Base line physics program for 2002

- Charmonium suppression.
- bb production cross section.

Possible extensions

- Drell-Yan (e.g. angular distribution).
- Direct photon production at high p_t .
- Limit on $\text{Br}(D^0 \rightarrow \mu^+ \mu^-)$.
- Open charm production.
- Minimum bias (e.g. Inclusive particle production).



Summary

HERA-B is anxiously waiting for the new data to come.

