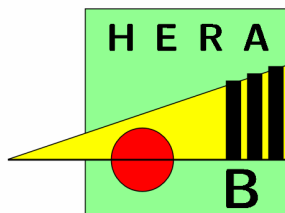


VietNam 2004 - 5th Rencontres du Vietnam
Particle Physics and Astrophysics - New Views in Particle Physics
Hanoi, August 5 - 11, 2004

RECENT RESULTS FROM THE HERA-B EXPERIMENT



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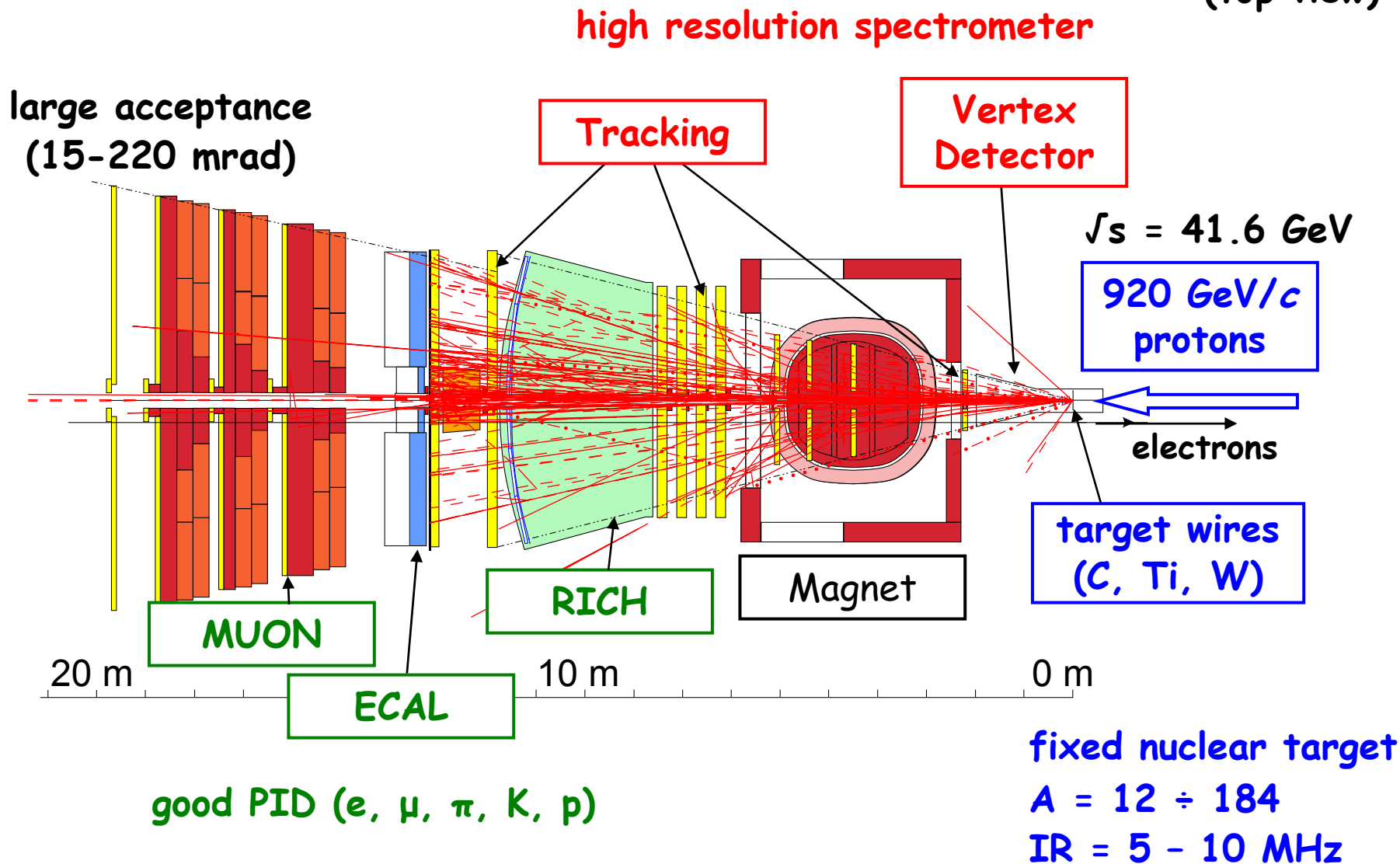
for the HERA-B Collaboration



- Outline:
- detector and data
 - charm and charmonium
 - beauty and bottonium

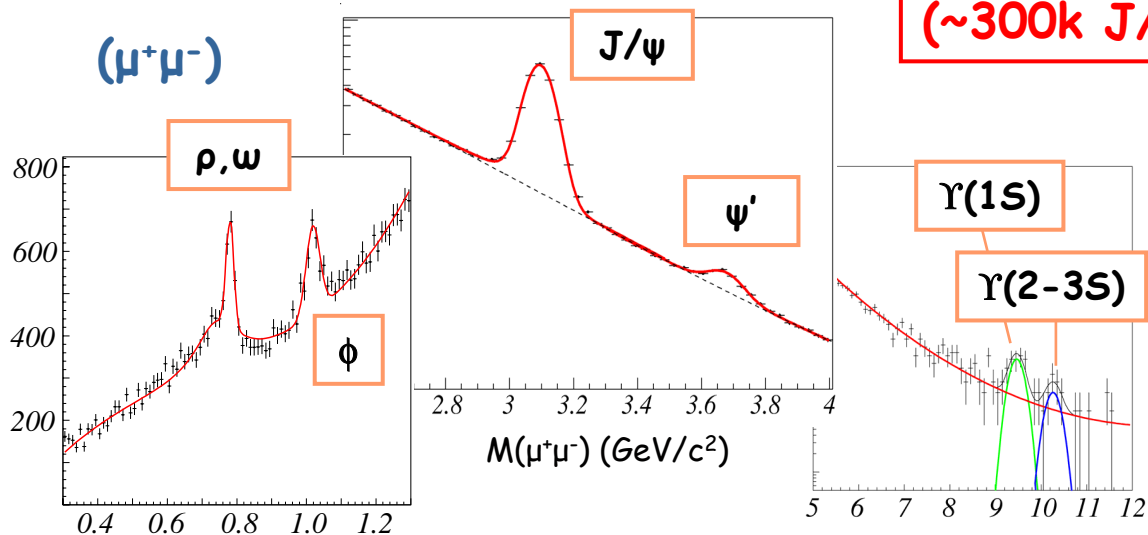
The HERA-B detector

(top view)



Acquired data samples

$\sim 150 \cdot 10^6$ events using dilepton trigger



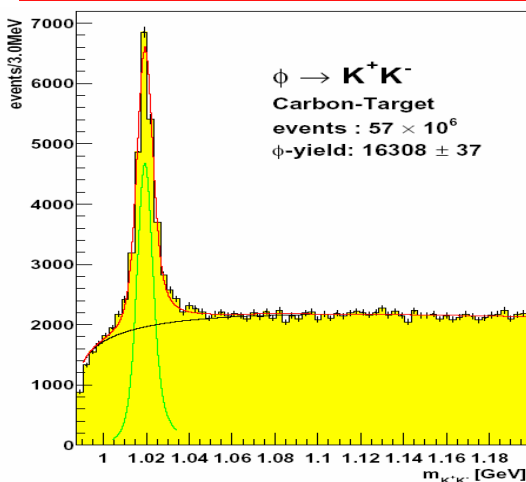
($\sim 300\text{k } J/\psi$)

studies on

- charmonium ($J/\psi, \chi_c, \psi'$), with A-dependence
- FCNC: $D^0 \rightarrow \mu^+\mu^-$
- inclusive b production
- $\Upsilon, \phi, \rho/\omega$ production

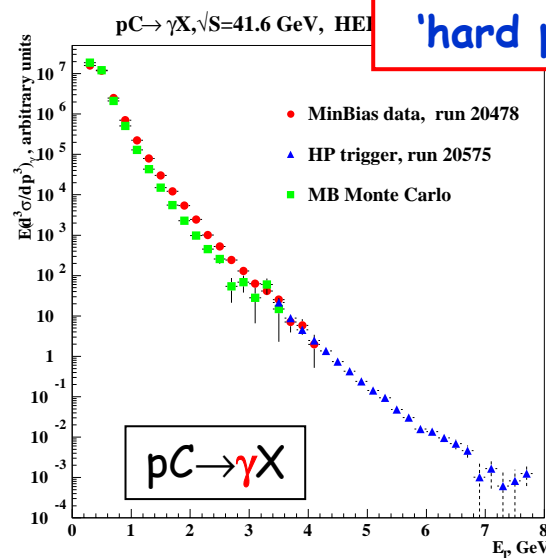
two independent channels ($e^+e^-, \mu^+\mu^-$)

$\sim 210 \cdot 10^6$ minimum bias events



- $D^0, D^+, D^{*+}, K_s, \Lambda, \phi, K^*, \Xi^{\pm+}$
- pentaquark

$\sim 35 \cdot 10^6$ events using 'hard photon' trigger



- $pA \rightarrow \gamma X$
- $pA \rightarrow \pi^0 X$
- $pA \rightarrow \eta X$

large p_T & rapidity acceptances, different (heavy) nuclei

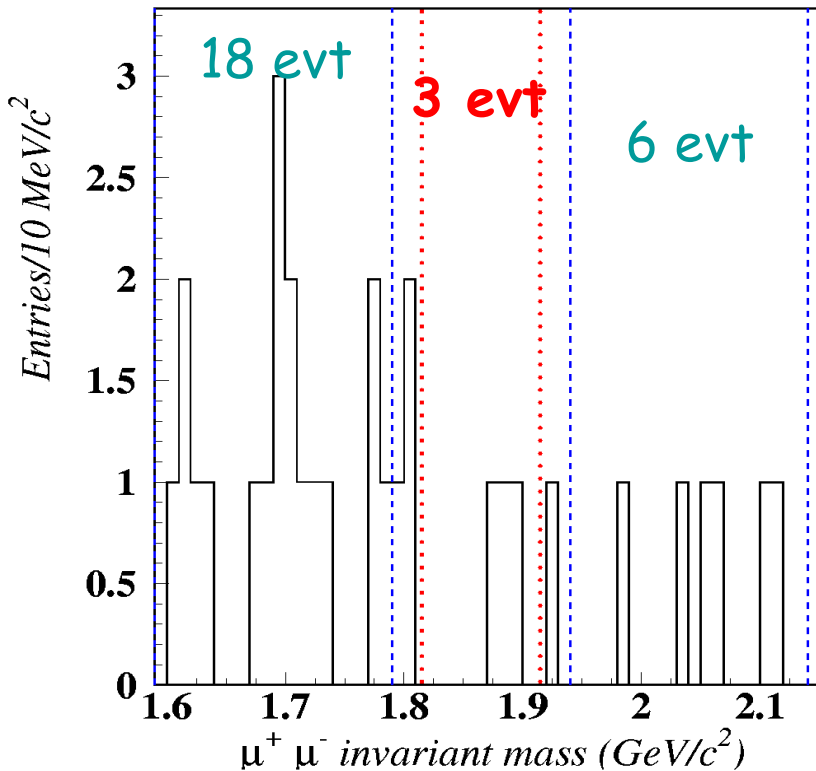
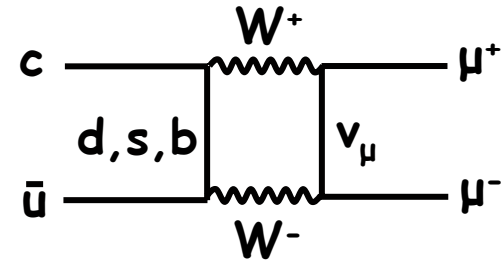
$$D^0 \rightarrow \mu^+ \mu^-$$

$$BR(D^0 \rightarrow \mu^+ \mu^-)$$

FCNC process:

Standard Model $\sim 10^{-19}$

supersymmetric models $\rightarrow \sim 10^{-7}$



first HERA-B result using
2002/2003 data

Phys. Lett. B 596, 173 (2004)

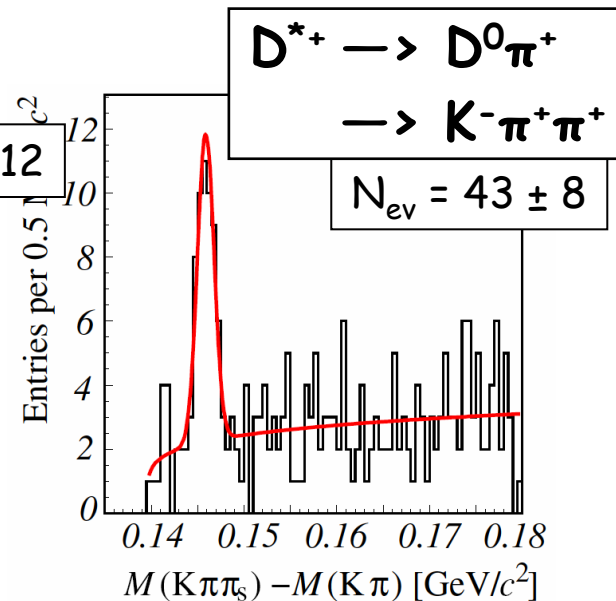
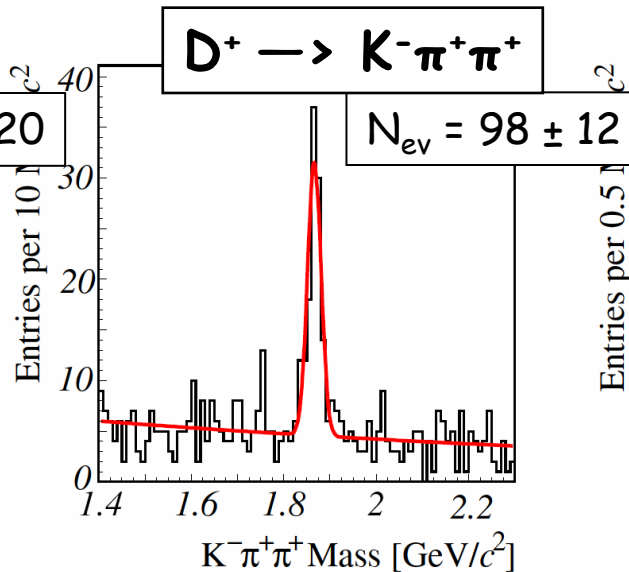
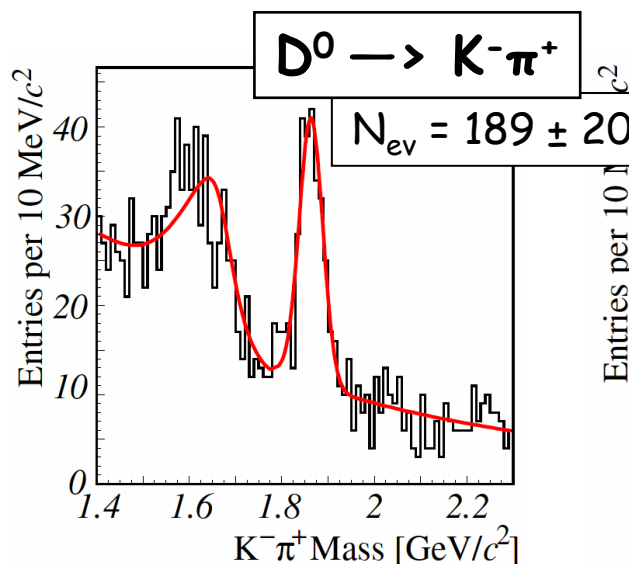
$$BR(D^0 \rightarrow \mu^+ \mu^-) < 2.0 \times 10^{-6} \text{ (90\% cl)}$$

Currently the best experimental limit

(CDF 2003: $BR < 2.5 \times 10^{-6}$)

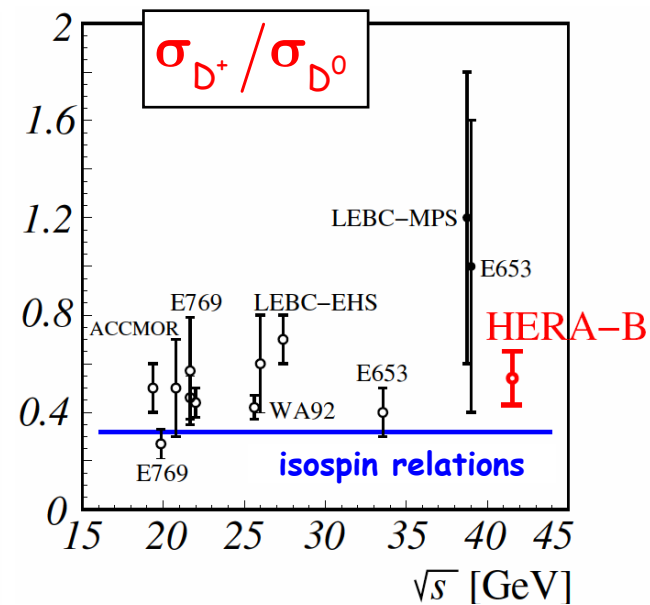
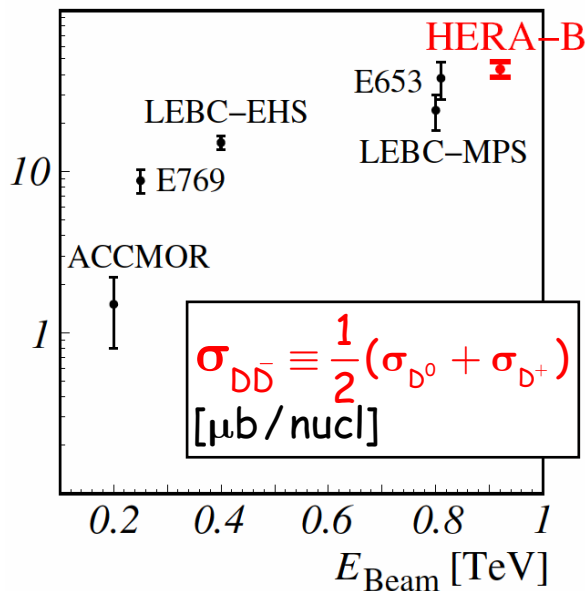
Open charm production

signals in MB data (c.c. included):



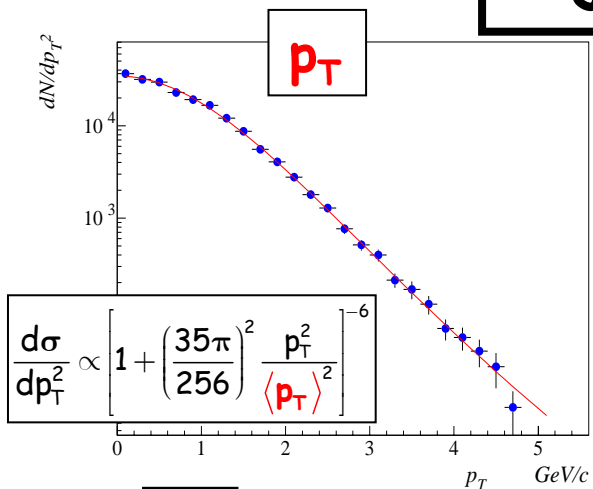
preliminary results

$\sigma(D^0)$	$56.3 \pm 8.5 \pm 9.5$
$\sigma(D^+)$ [$\mu\text{b}/\text{nucl}$]	$30.2 \pm 4.5 \pm 5.8$
$\sigma(D^{*+})$	$27.8 \pm 5.2 \pm 3.9$
$\sigma(D^+)/\sigma(D^0)$	$0.54 \pm 0.11 \pm 0.14$
$\sigma(D^{*+})/\sigma(D^0)$	$0.49 \pm 0.12 \pm 0.10$



J/ψ differential cross-sections

preliminary results (15% of the e⁺e⁻ sample)

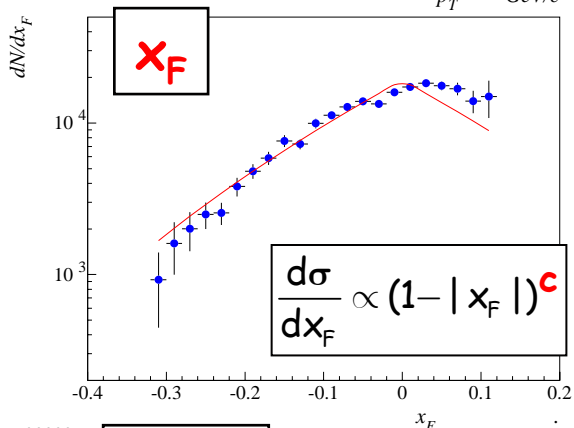


$$\langle p_T \rangle = \begin{cases} 1.24 \pm 0.01 \text{ (C)} \\ 1.29 \pm 0.01 \text{ (W)} \end{cases} \text{ (GeV/c)}$$

$p_T < 4.5 \text{ GeV/c}$

- wide p_T coverage
- results consistent: A-dependence?

exp.	target	Range (GeV/c)	$\langle p_T \rangle$ (GeV/c)
E771	p-Si	< 3.4	1.20 ± 0.01
E789	p-Au	< 2.6	1.29 ± 0.01

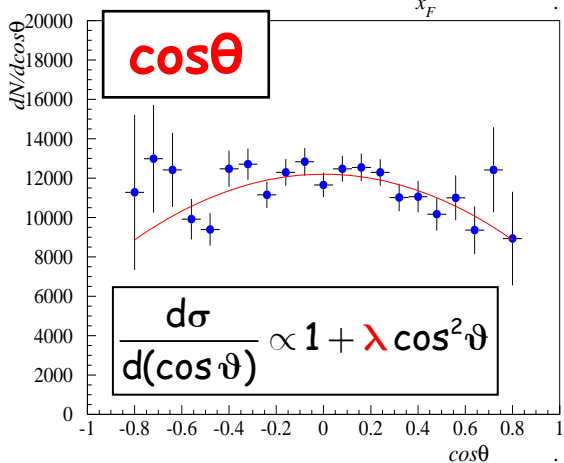


$$c = 5 \div 6.5 \text{ (stat } \pm 0.2)$$

$-0.35 < x_F < 0.15$

exp.	target	x_F range	c
E672/E706	p-Be	0.0 ÷ 0.6	6.18 ± 0.16
E789	p-Be	0.30 ÷ 0.95	5.32 ± 0.05
E771	p-Si	$-0.05 \div 0.25$	6.54 ± 0.23
E789	p-Cu	0.30 ÷ 0.95	5.21 ± 0.04
E789	p-Au	$-0.035 \div 0.135$	4.91 ± 0.18

negative- x_F region significantly extended



$$\lambda = -0.5 \div 0.1 \text{ (stat } \pm 0.1)$$

exp.	target	λ
E672/E706	p-Be	-0.11 ± 0.15
E771	p-Si	-0.09 ± 0.12

possible first measurement of a (longitudinal) polarization?

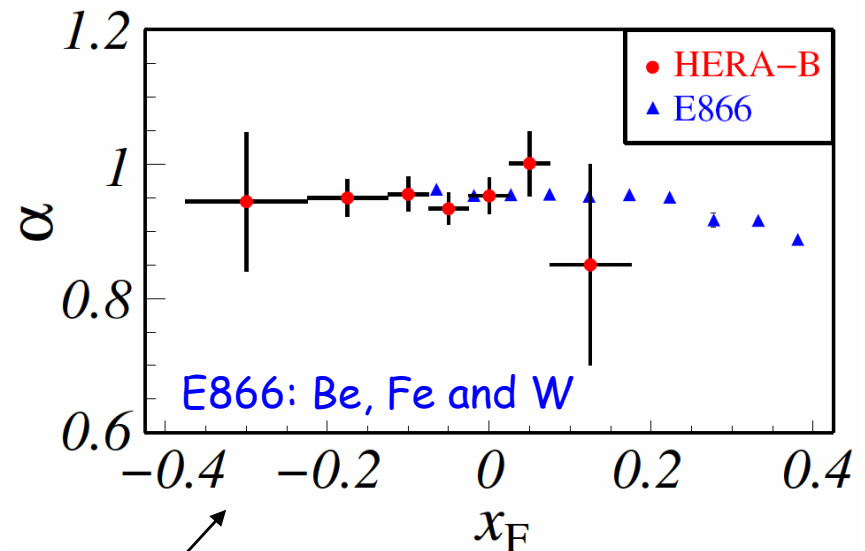
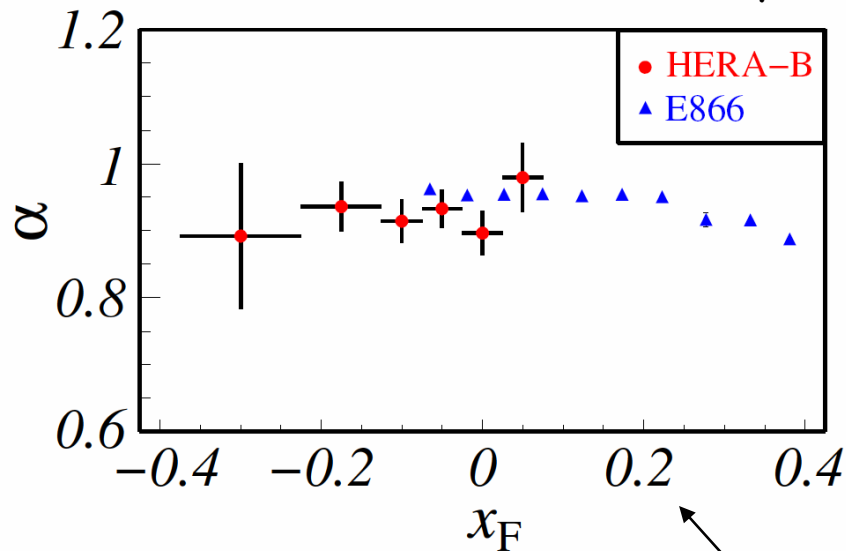
A-dependence of J/ψ production

parameterization: $\sigma_{pA} = \sigma_{pN} \cdot A^\alpha$ where $\sigma = \frac{N}{\epsilon \cdot L}$

α extracted from two-target runs [carbon ($A = 12$) & tungsten ($A = 184$)]

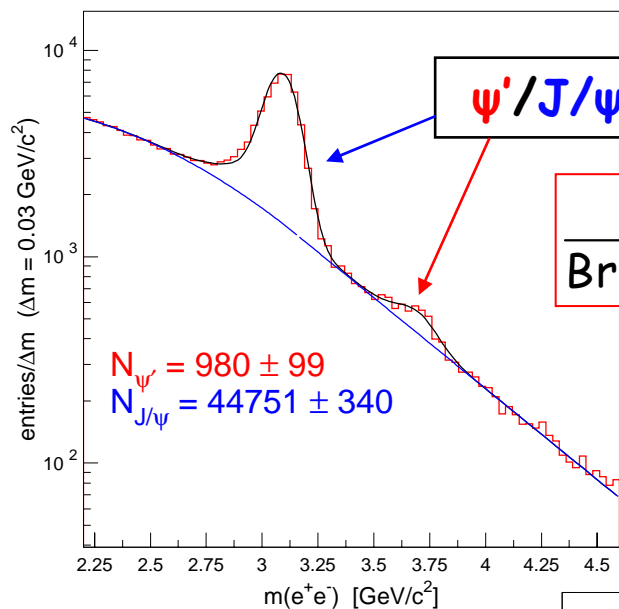
$$\alpha = \frac{1}{\ln(A_W / A_C)} \cdot \ln \left(\frac{N_W}{N_C} \cdot \frac{L_C}{L_W} \cdot \frac{\epsilon_C}{\epsilon_W} \right)$$

- Preliminary result from 10% of the full $\mu^+\mu^-$ sample, statistical uncertainties only



- Two different combinations of carbon and tungsten wires (different acceptances): consistent results

ψ' production



$\psi'/J/\psi$ ratio

$$\frac{\text{Br}(\psi' \rightarrow l^+l^-) \cdot \sigma(\psi')}{\text{Br}(J/\psi \rightarrow l^+l^-) \cdot \sigma(J/\psi)} = \begin{cases} (1.6 \pm 0.2_{\text{stat}})\% & \mathbf{C} \\ (1.8 \pm 0.4_{\text{stat}})\% & \mathbf{W} \end{cases}$$

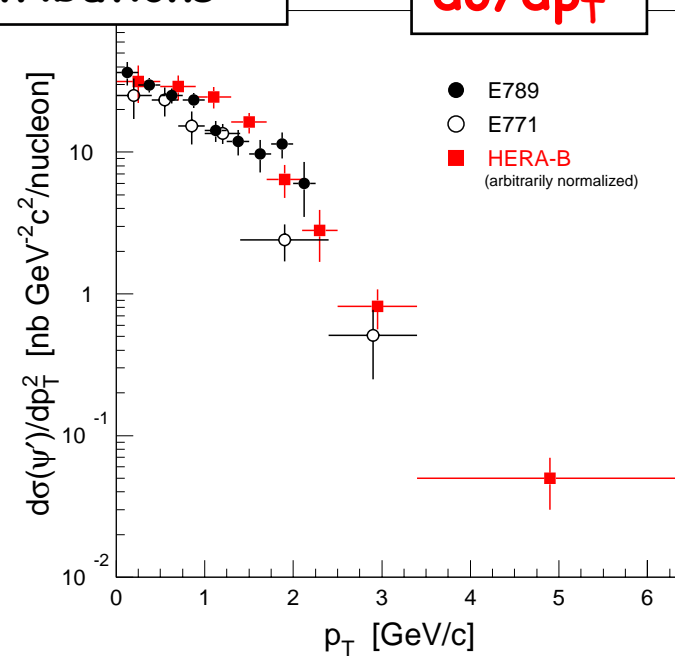
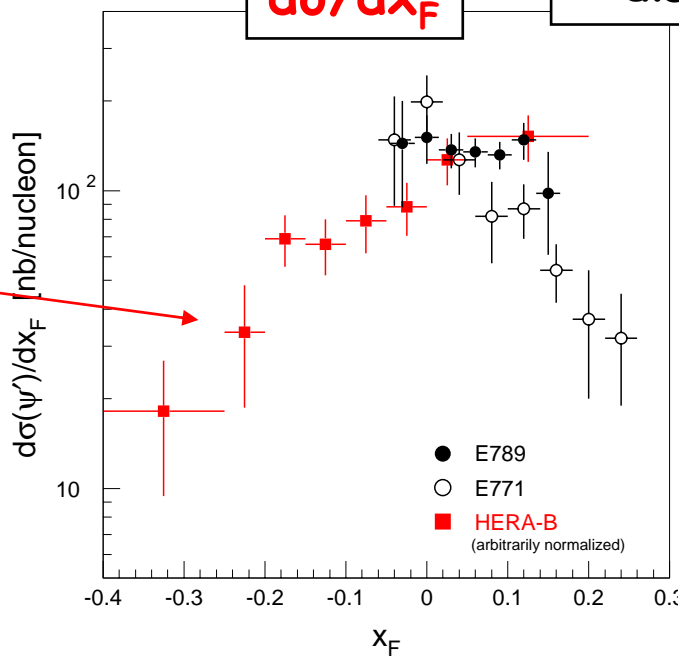
preliminary
(e^+e^- sample only)

$d\sigma/dx_F$

differential distributions

$d\sigma/dp_T^2$

$x_F < 0$



χ_c production

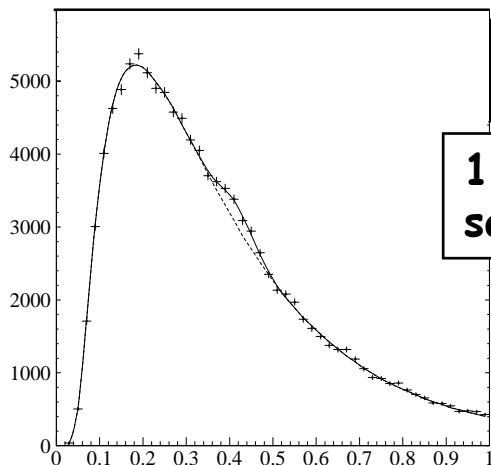
$$\chi_c \rightarrow J/\psi \gamma \rightarrow \mu^+\mu^- \gamma$$

$$e^+e^- \gamma$$

- χ_{c1} and χ_{c2} not resolved ($\Delta M = 46 \text{ MeV}/c^2$)
- χ_{c0} neglected (small br)

$$R_{\chi_c} = \frac{\sum_{i=1}^2 \sigma(\chi_{ci}) \cdot \text{Br}(\chi_{ci} \rightarrow J/\psi \gamma)}{\sigma(J/\psi)} = \frac{N(\chi_c)}{N(J/\psi)} \cdot \frac{\epsilon_{J/\psi}}{\epsilon_{\chi \rightarrow J/\psi} \epsilon_{\gamma}}$$

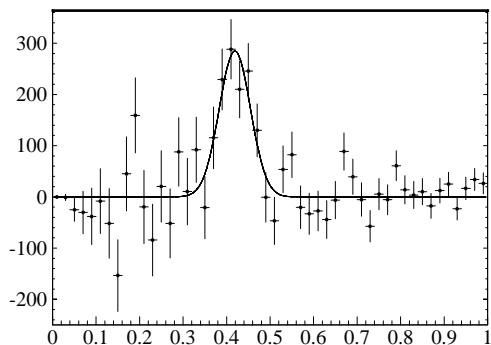
$\epsilon_{J/\psi} \approx 1$
 $\epsilon_{\gamma} \approx 0.4$



15% of the $\mu^+\mu^-$ sample ($\approx 1300 \chi_c$)

$$R_{\chi_c} = 0.21 \pm 0.05$$

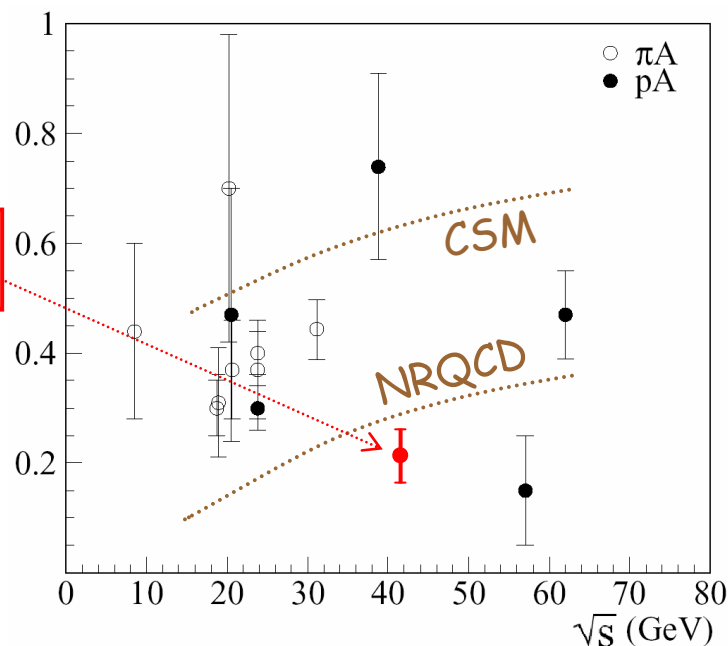
preliminary



$M(\mu^+\mu^- \gamma) - M(\mu^+\mu^-) \text{ (GeV}/c^2\text{)}$

2000 data
[Phys. Lett. B561, 61
(2003)]:
 $N(\chi_c) = 370 \pm 74$
($\mu^+\mu^- + e^+e^-$)

$$R_{\chi_c} = 0.32 \pm 0.06 \pm 0.04$$



previous experimental results:

IHEP140, WA11, E610, E673,
E369, E705, E672/706, E771, ISR

$\sigma(b\bar{b})$: inclusive b-hadron production

$$pA \rightarrow b\bar{b} X$$

$$b \rightarrow J/\psi Y \rightarrow e^+e^-/\mu^+\mu^- Y$$

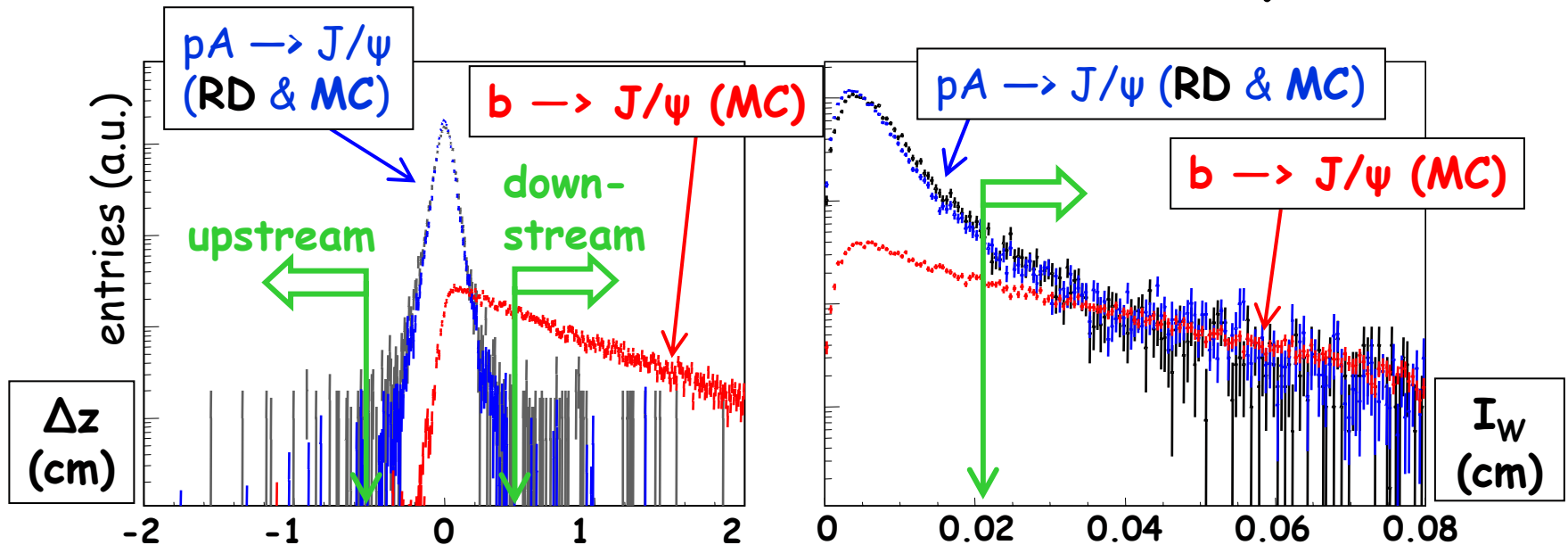
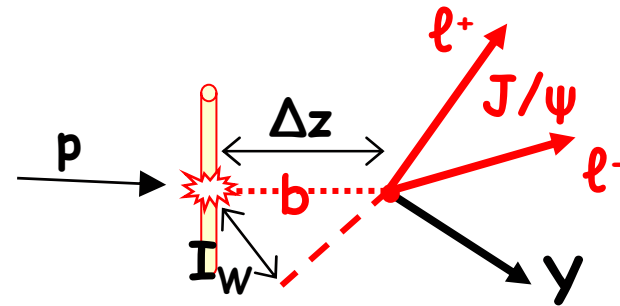
Normalized with respect to the direct J/ψ production:

$$\frac{\sigma(pA \rightarrow b\bar{b})}{\sigma(pA \rightarrow J/\psi)} \sim \frac{N(b \rightarrow J/\psi)}{N(J/\psi)} \cdot \frac{1}{B(b\bar{b} \rightarrow J/\psi)}$$

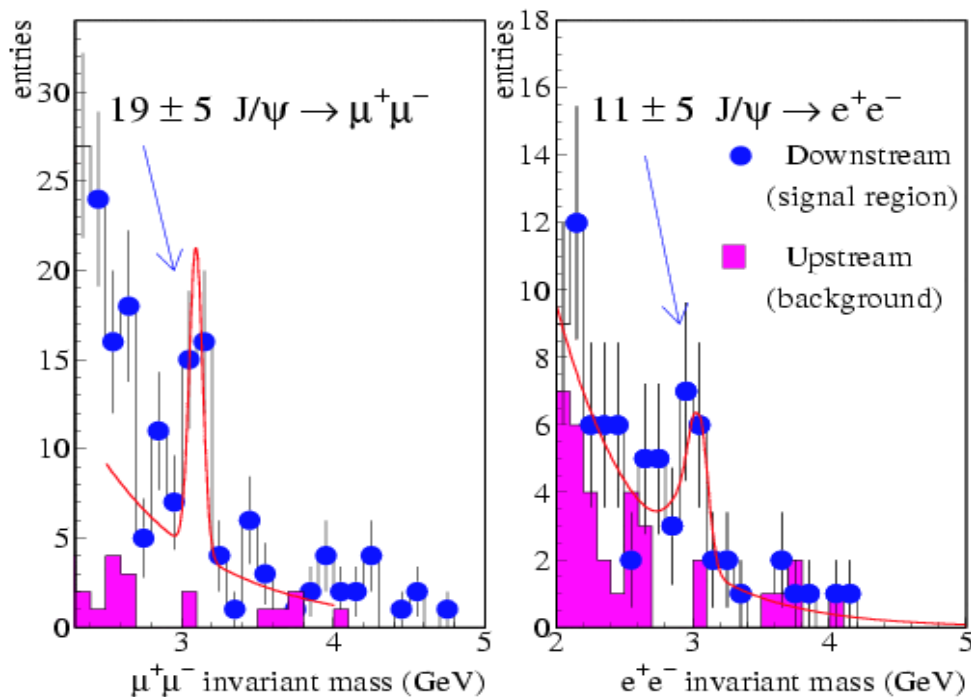
direct J/ψ
($pA \rightarrow J/\psi$)

J/ψ from b
($b \rightarrow J/\psi$)

selection of detached vertices



$\sigma(b\bar{b})$

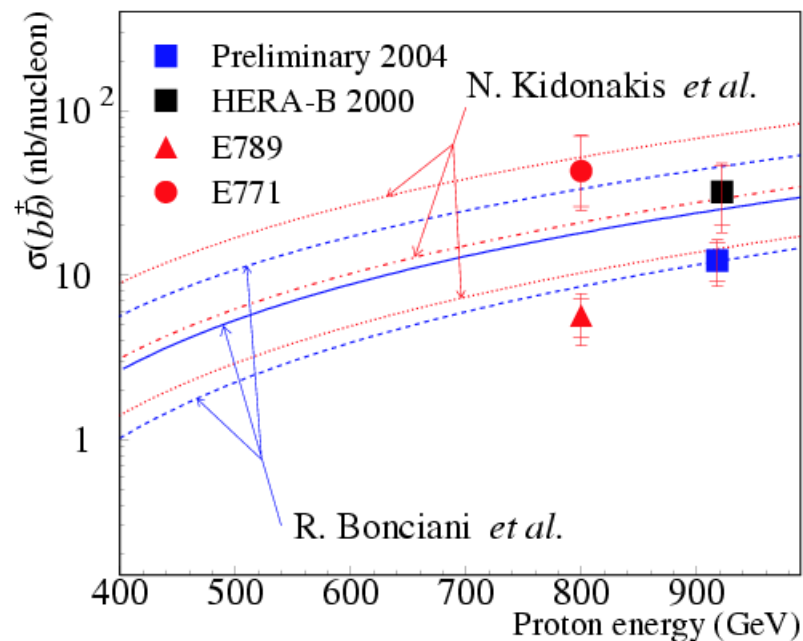


Preliminary result using 35% of the 2002/3 statistics (~ 30 J/ψ)

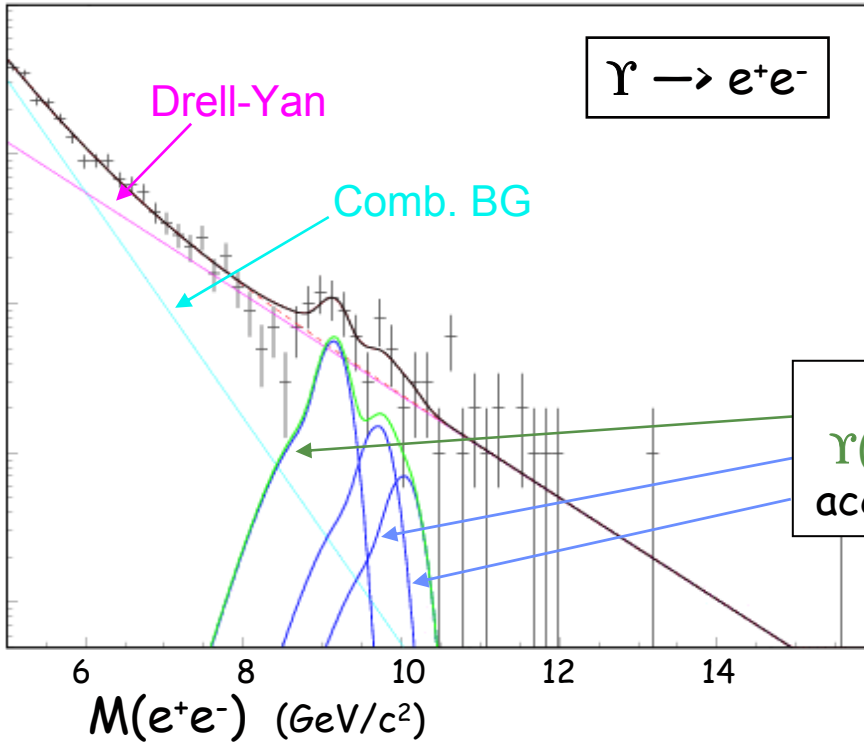
$$\sigma(b\bar{b}) = 12.3^{+3.5}_{-3.2} \text{ nb/N}$$

Expected ~ 100 J/ψ
from full statistics

2000 result (~ 10 J/ψ)
[Eur. Phys. J. C26, 345 (2003)]:
 $\sigma(b\bar{b}) = 32^{+14+6}_{-12-7} \text{ nb/N}$



Υ production



$$\Upsilon \rightarrow e^+e^-$$

$$pA \rightarrow \Upsilon X$$

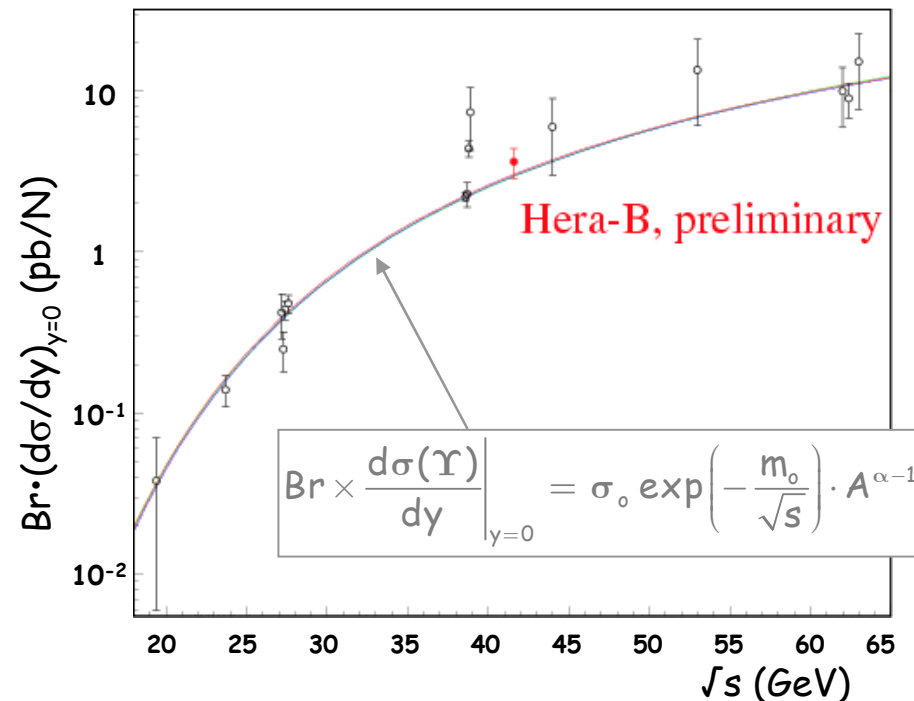
$$\Upsilon \rightarrow e^+e^-/\mu^+\mu^-$$

$$\frac{\sigma(\Upsilon)}{\sigma(J/\psi)} = \frac{N(\Upsilon)}{N(J/\psi)} \cdot \frac{\text{Br}(J/\psi \rightarrow l^+l^-)}{\text{Br}(\Upsilon \rightarrow l^+l^-)} \cdot \frac{\epsilon(J/\psi)}{\epsilon(\Upsilon)}$$

relative production of $\Upsilon(1S)/\Upsilon(2S)/\Upsilon(3S)$ fixed according to E605 results

preliminary	$\text{Br} \cdot (d\sigma/dy)_{y=0}$
$\mu^+\mu^- (33 \pm 7)$	$3.9 \pm 1.1 \text{ pb/N}$
$e^+e^- (31 \pm 10)$	$2.9 \pm 1.2 \text{ pb/N}$
combined	$3.4 \pm 0.8 \text{ pb/N}$

C and W data (150 M evts)
combined using $\alpha=0.99\pm 0.05$



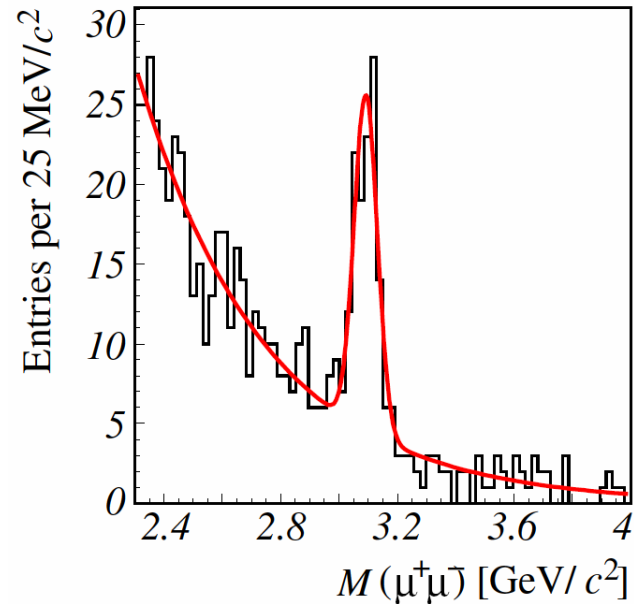
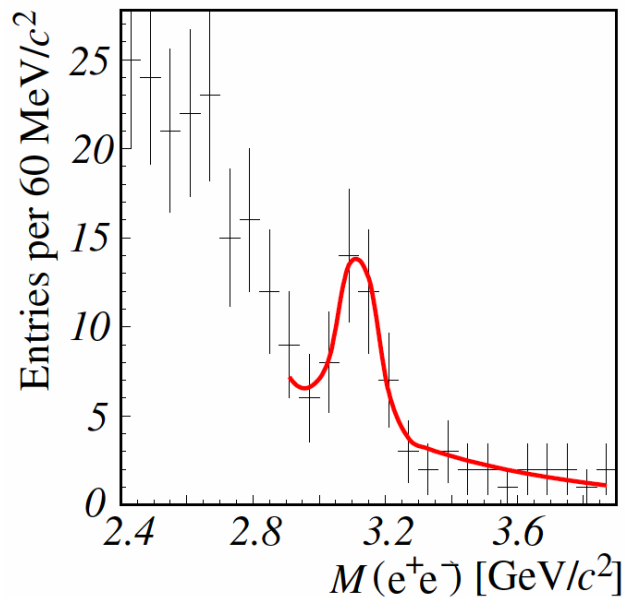
Summary

- Data taking concluded, several analyses in progress
 - large statistics, clear signals, wide kinematical range
 - results and ongoing analyses on
 - charm:
 - new limit on the FCNC decay $D^0 \rightarrow \mu^+\mu^-$
 - production cross sections and ratios of $D^0, D^\pm, D^{*\pm}$
 - J/ψ differential distributions: wide p_T range, $x_F < 0$, polarization
 - A -dependence
 - ψ' to J/ψ ratio, ψ' differential distributions
 - χ_c to J/ψ ratio
 - beauty:
 - inclusive b-hadron production
 - Υ production
- competitive results, first publications to appear soon

Backup

J/ψ production cross-section

- J/ψ → e⁺e⁻/μ⁺μ⁻ signals observed in minimum bias data

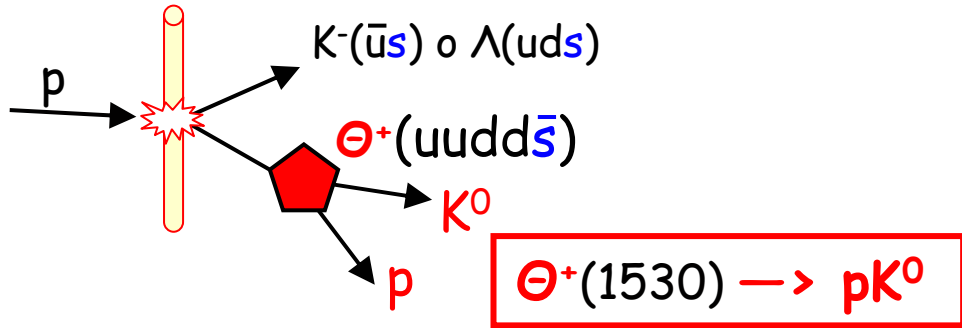


- Determination of J/ψ cross section without trigger bias

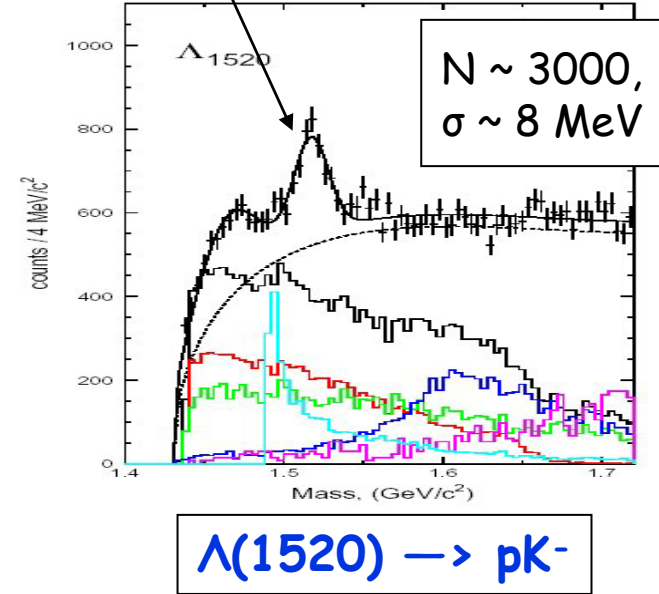
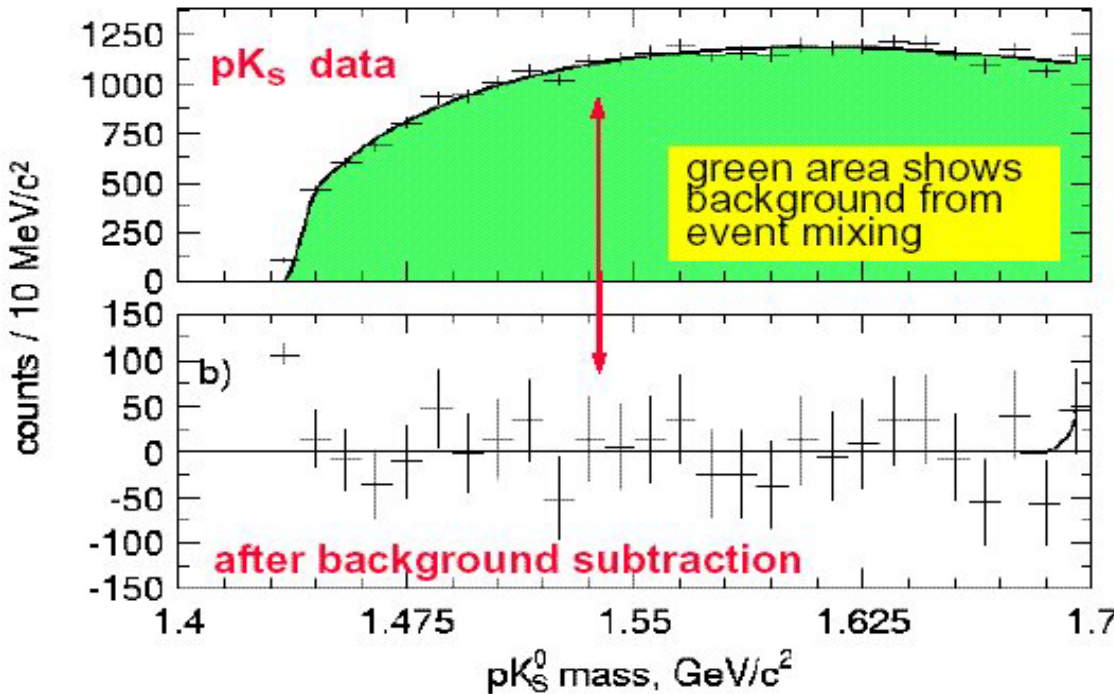
$$\sigma_0^{J/\psi} = \frac{N_{J/\psi}}{\text{BR}(J/\psi \rightarrow l^+l^-) \cdot \sum_i \epsilon_i A_i^\alpha L_i}$$

(systematic effects currently under study)

Search of "pentaquark" states into pK



- high statistics: $\sim 5 \times 10^6 K_S$!
- excellent PiD from RICH

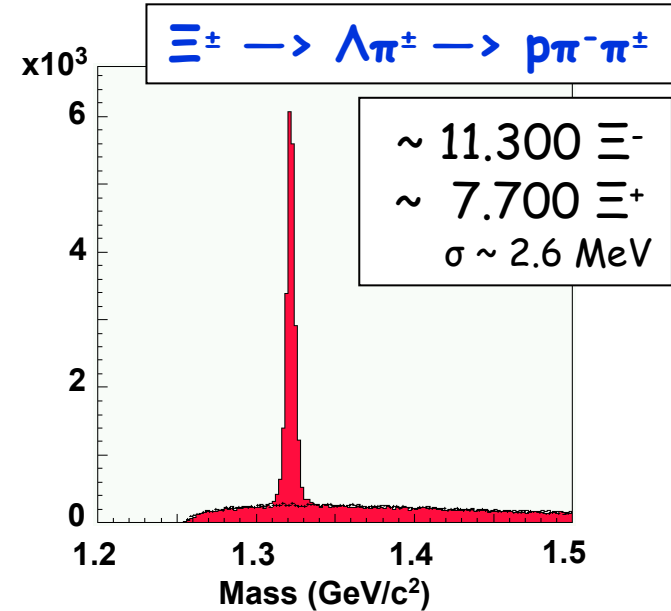
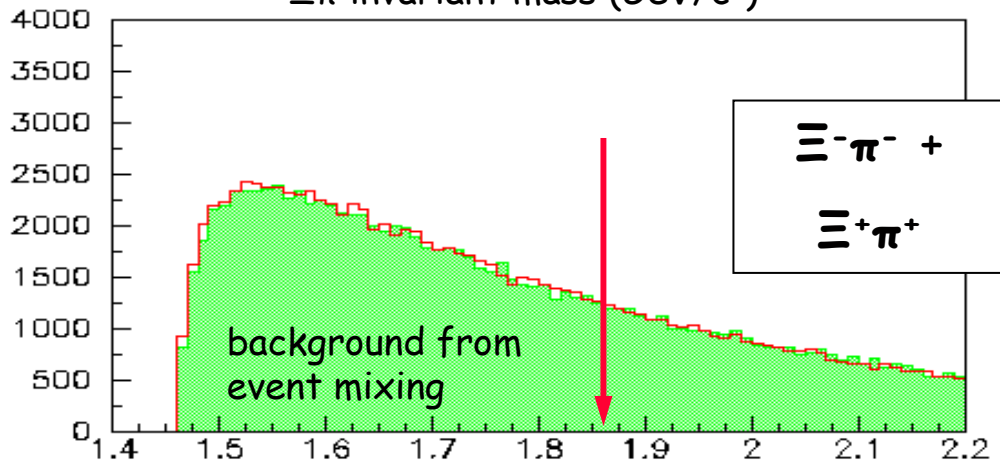
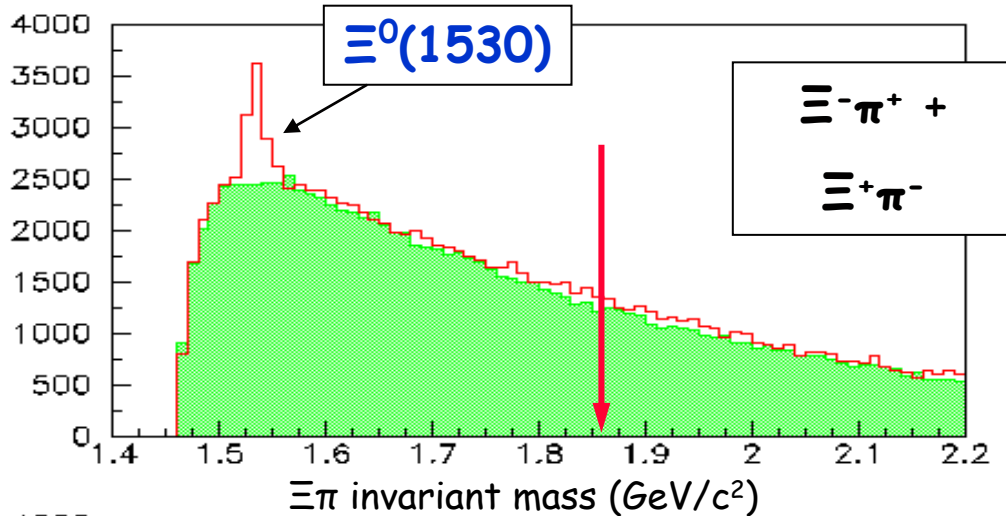


- No evidence of resonances where expected
 Upper limit: $\Theta^+/\Lambda_{1520} < 0.02$ (95% cl) (Hermes: $\sim 1.6 \div 3.5$)
- Evaluation of cross section upper limit in progress

Search of "pentaquark" states into $\Xi\pi$

$\Xi^{--}(1862) \rightarrow \Xi^-\pi^- \rightarrow \Lambda\pi^-\pi^-$

$ddss\bar{u}$



- No evidence of resonances
- Upper limit (95% cl):
 $\Xi^{--}/\Xi^0(1530) < 0.08$
- Evaluation of cross section
 upper limit in progress