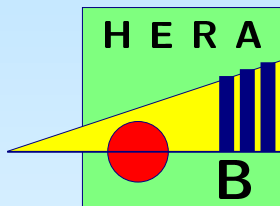
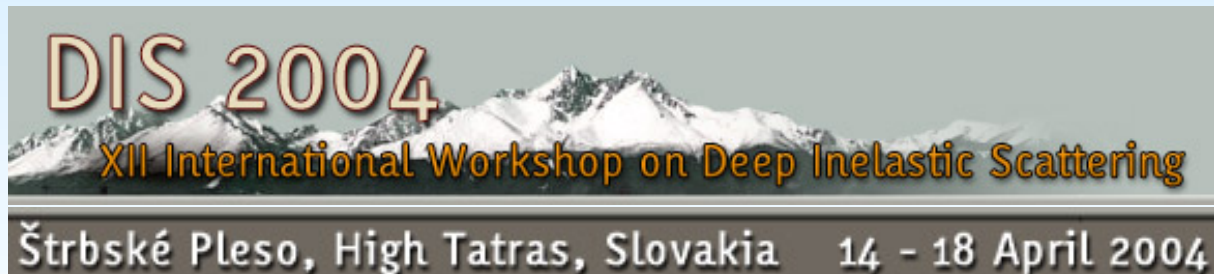
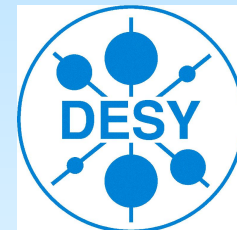


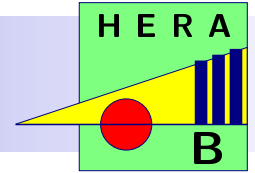
Hidden and Open Beauty Production in 920 GeV p-N interactions



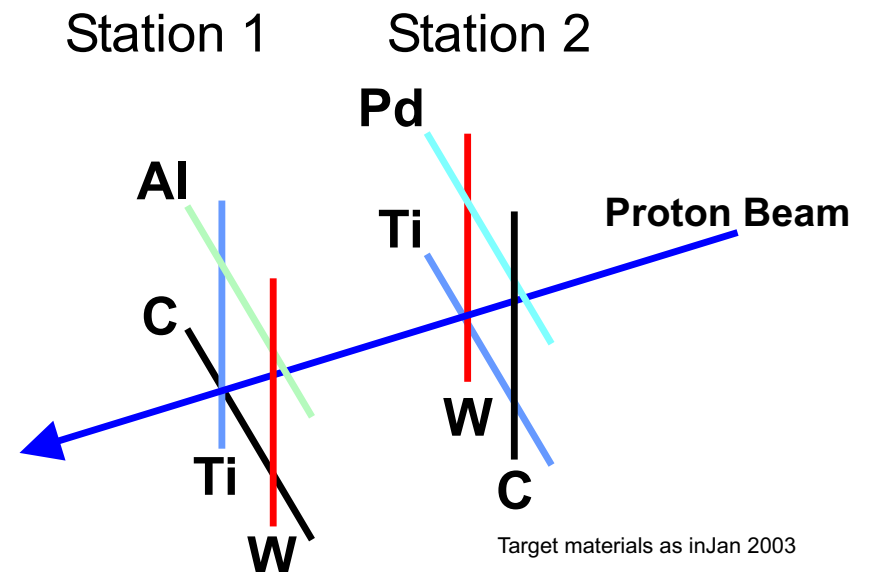
Silvia Masciocchi
DESY Hamburg
April 15th 2004



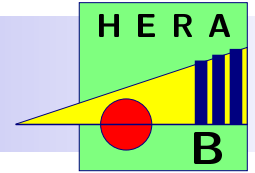
The Hera-B Experiment



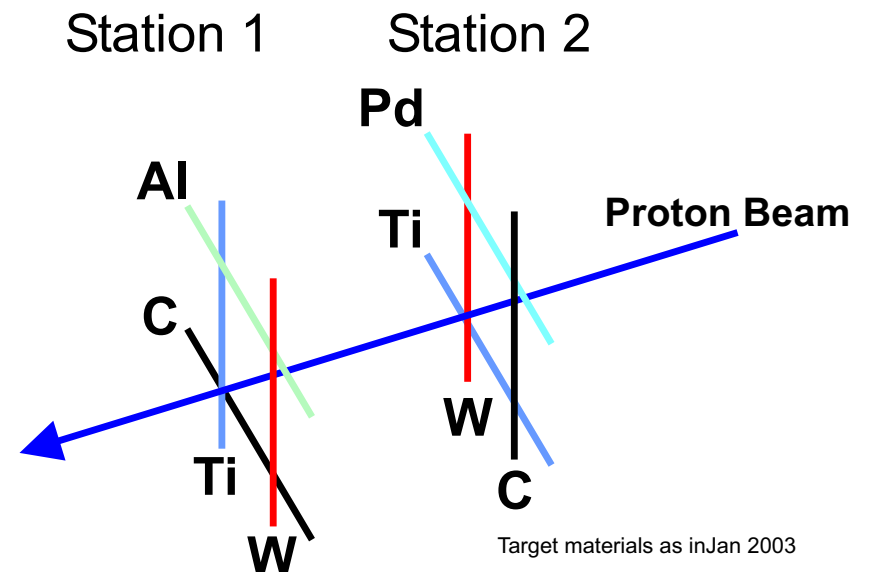
- Fixed target detector at e-p ring HERA, DESY
- High rate forward spectrometer (<40 MHz interaction rate)
- Proton beam at 920 GeV/c ($\sqrt{s}=41.6$ GeV)
- Wire targets in proton halo
 - eight wires (50-500 μm)
 - different materials with atomic number A from 12 (C) to 184 (W)
 - target steering (transversally)
 - tunable interaction rate
 - in 2002-3 usually 2 wires operated simultaneously, ≈ 10 MHz



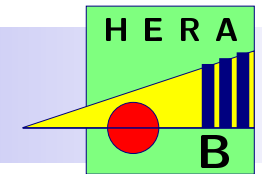
The Hera-B Experiment



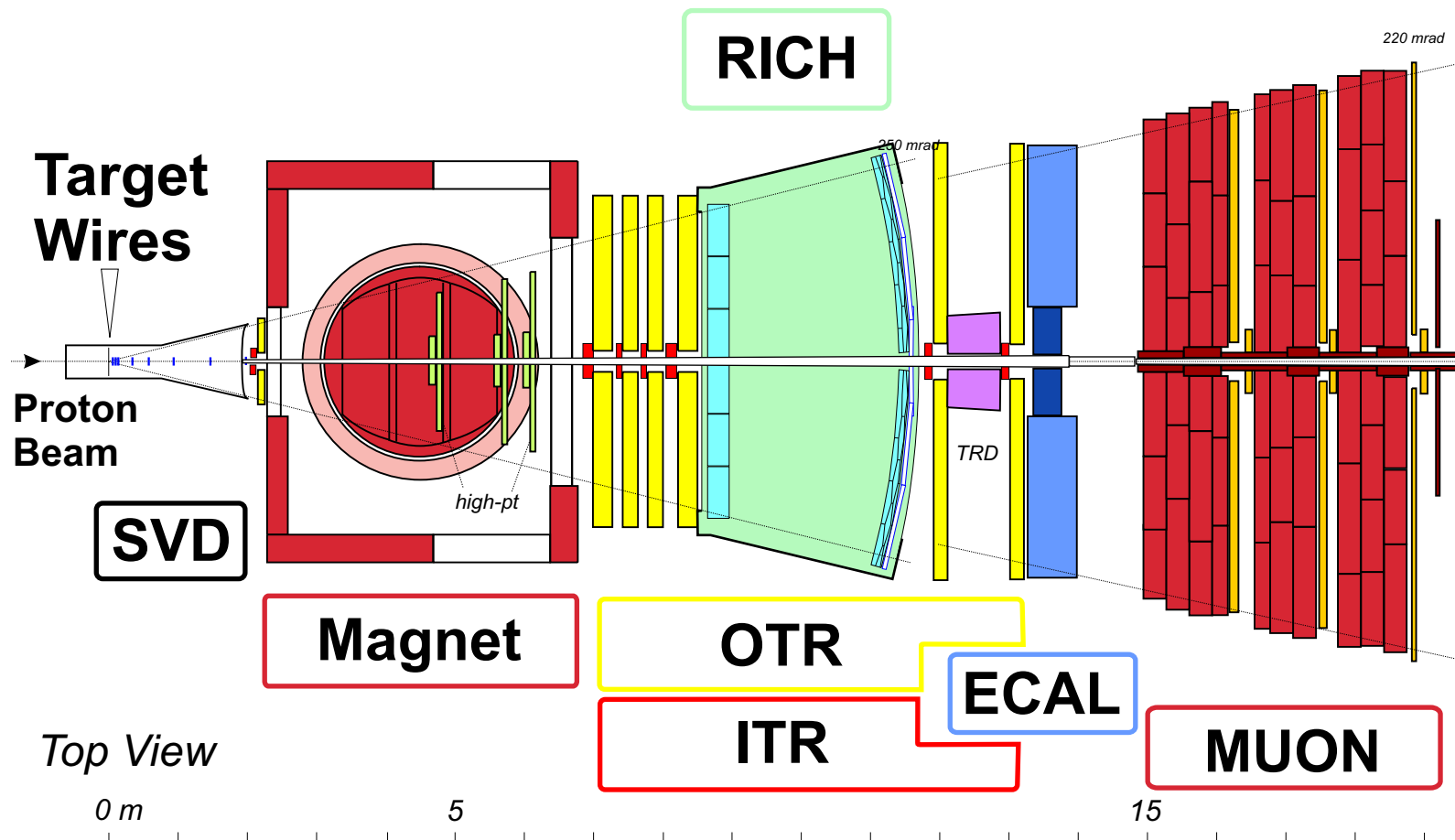
- Fixed target detector at e-p ring HERA, DESY
- High rate forward spectrometer (<40 MHz interaction rate)
- Proton beam at 920 GeV/c
($\sqrt{s}=41.6$ GeV)
- Wire targets in proton halo
- Hardware track trigger for lepton pairs ($ee, \mu\mu$)
- Multiple trigger levels
(electron and muon pretriggers, hardware first level trigger, software second level trigger)
- On-line event reconstruction



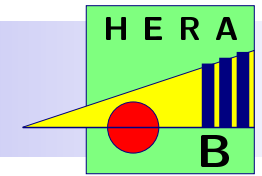
The Hera-B Detector



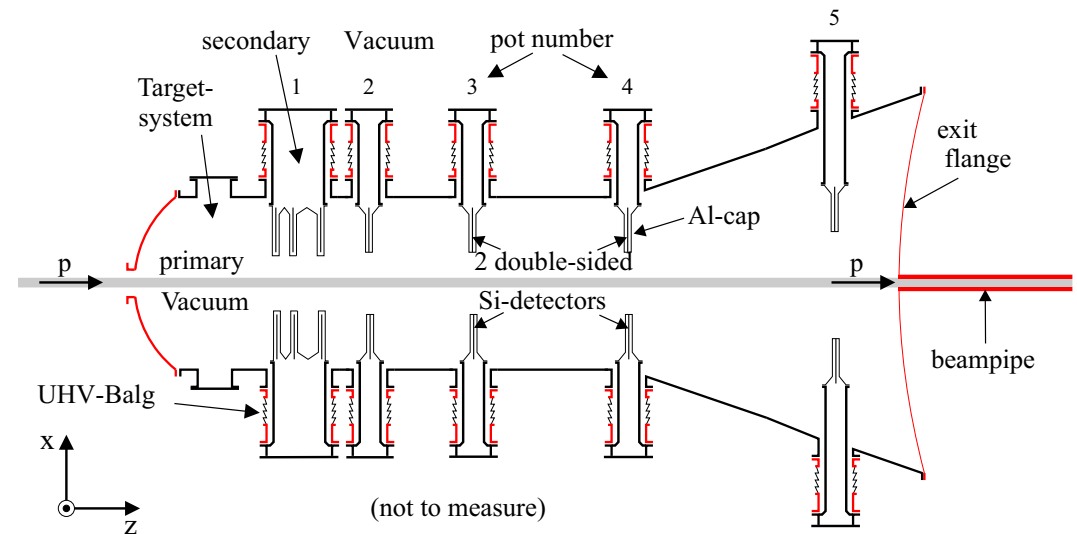
- Angular coverage: 15-220 mrad in bending plane, 15-160 mrad in vertical plane
- High resolution silicon vertex detector →
- Good particle identification (e, μ , π , K, p)



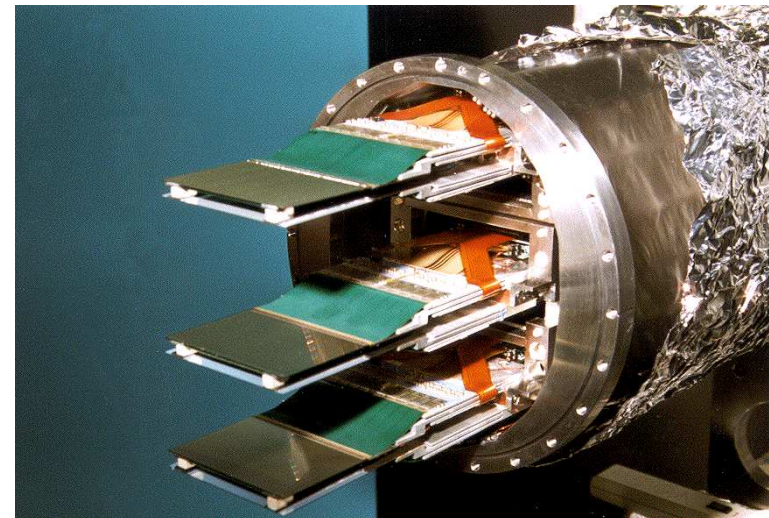
The Vertex Detector



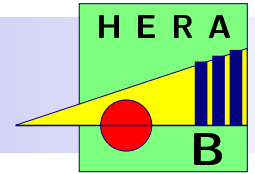
- Roman pot system with double sided silicon microstrip detectors
- 64 detectors, 150 k readout channels at 50 μm readout pitch, 4 projections
- 10-250 mrad acceptance
→ independent tracking and vertexing



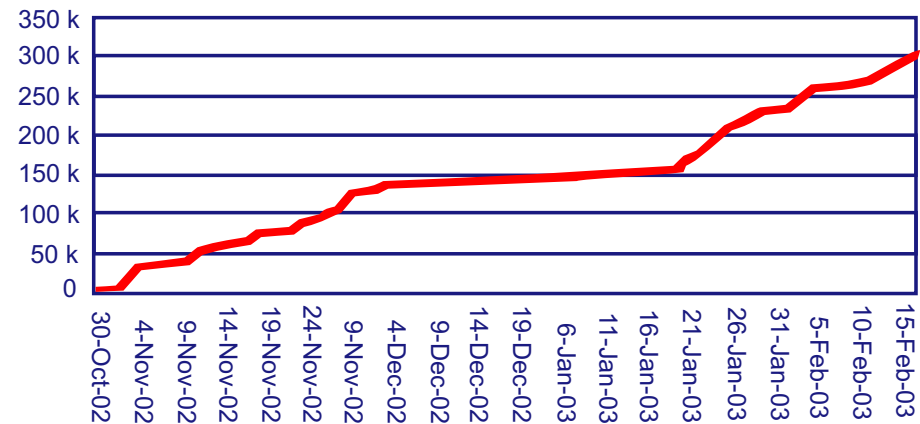
- Tracking efficiency $> 95\%$
- Excellent resolution in vertex reconstruction
- Primary vertices: $\epsilon > 99\%$
in the beam direction $\approx 450\ \mu\text{m}$
longitudinally $\approx 40\ \mu\text{m}$
- Dilepton vertices:
in the beam direction $\approx 500\ \mu\text{m}$
longitudinally $\approx 50\ \mu\text{m}$



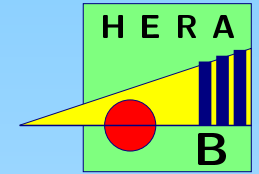
2002-2003 Data Taking



- Data taking: 30 Oct 2002 - 3 Mar 2003
- Running time: ≈ 480 h
- 4 wire materials used: C, Ti, (Pd,) W
- $210 \cdot 10^6$ minimum bias events
- $150 \cdot 10^6$ dilepton triggered events
- Achieved J/ψ rates: ≈ 1000 /hour
- Total sample of $\approx 300,000$ J/ψ
- $10 \cdot 10^6$ hard photon trigger events
- $60 \cdot 10^6$ “glueball” trigger events



BEAUTY PRODUCTION



in p-nucleus interactions at $\sqrt{s}=41.6$ GeV

- Few existing measurements
- Large uncertainties in theoretical descriptions

HIDDEN BEAUTY: $pA \rightarrow \Upsilon + X$

OPEN BEAUTY: $pA \rightarrow b\bar{b} + X$

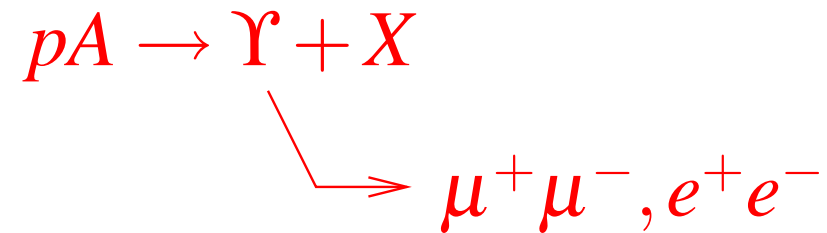
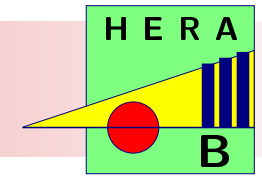
Both cross section measurements are done relative to the prompt J/ψ production:
less sensitive to systematic effects on luminosity or MC efficiency evaluation

$$\Delta\sigma_{b\bar{b}} = \Delta\sigma_{J/\psi} \cdot \frac{n_B}{n_P} \cdot \frac{\epsilon_{J/\psi}^{pr}}{\epsilon_B^{pr}} \cdot \frac{1}{\epsilon_B^{det} \cdot BR(b\bar{b} \rightarrow J/\psi X)}$$

$\Delta\sigma$: in Hera-B x_F acc.

Prompt J/ψ cross section taken from E771 and E789.

Hidden Beauty Production

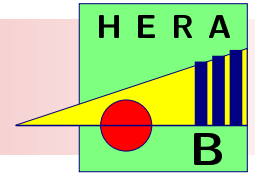


Measurement of:

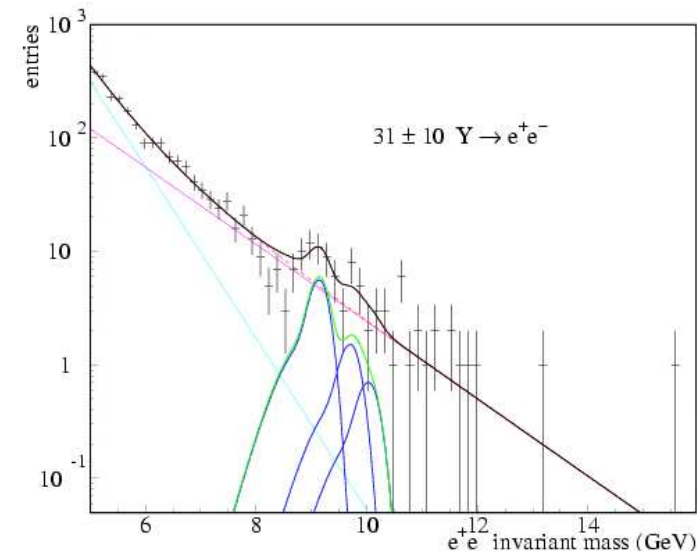
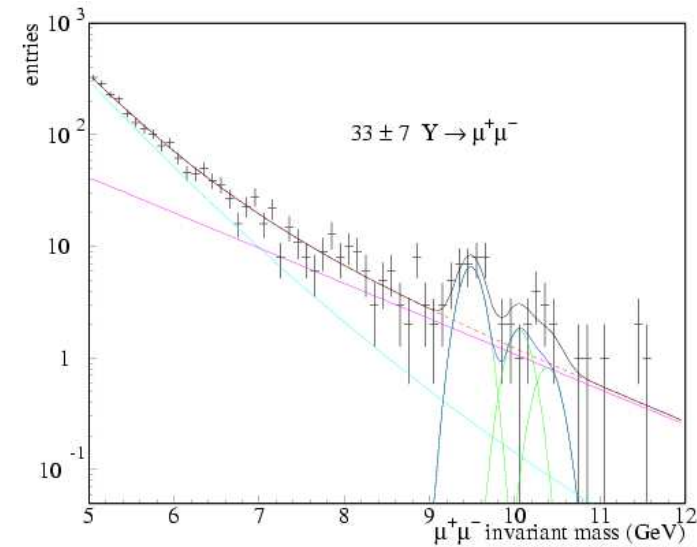
$$Br(\Upsilon \rightarrow \ell^+ \ell^-) \times \left. \frac{d\sigma_{\Upsilon}}{dy} \right|_{y=0}$$

- Measurement relative to the prompt J/ψ
- DATA SAMPLE: full 2002-3 dilepton triggered data (150 MeV events)
- Used targets: 50% Carbon (A=12)
50% Tungsten (A=184)
- Prompt J/ψ sample: ≈ 141 k $J/\psi \rightarrow \mu^+ \mu^-$
 ≈ 78 k $J/\psi \rightarrow e^+ e^-$
- Electrons identified with E/p and a bremsstrahlung tag

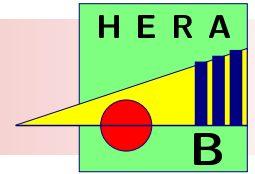
Υ Signals



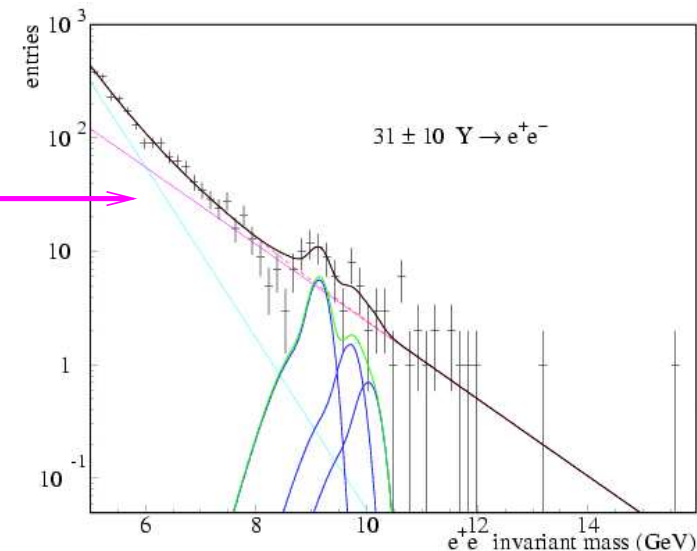
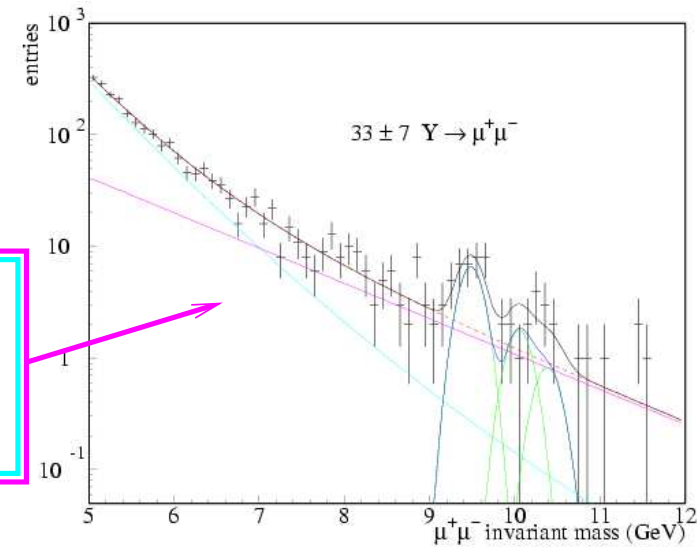
- Mass resolution between 140 and 160 MeV
- Background shapes from even pair leptons or combinatorial combinations (blue) and Drell-Yan events (purple)
- $\Upsilon(1S)/\Upsilon(2S)/\Upsilon(3S)$ relative production fixed on E605 data
- Υ shapes taken from MC
- Stable results with respect to changes in the selection and in the background description



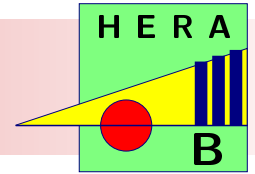
Υ Signals



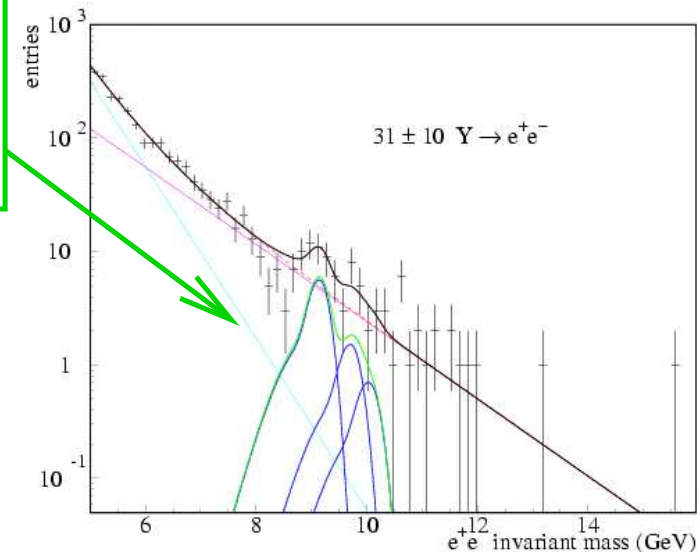
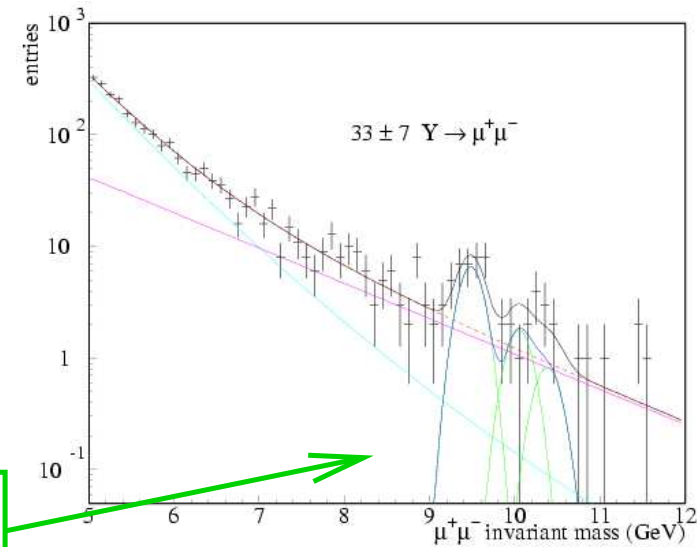
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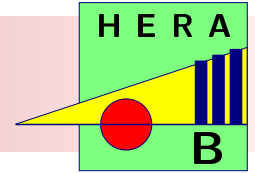
Υ Signals



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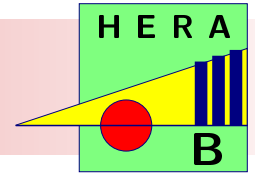
Preliminary Results Υ



$$\begin{aligned} Br \times \frac{d\sigma_{\Upsilon}}{dy} \Big|_{y=0}(\sqrt{s}) &= (3.9 \pm 1.1_{stat}) \text{ pb/nucleon } (\mu^+\mu^-) \\ &= (2.9 \pm 1.2_{stat}) \text{ pb/nucleon } (e^+e^-) \\ &= (3.4 \pm 0.8_{stat}) \text{ pb/nucleon (combined)} \end{aligned}$$

- Good sample compatibility
- Drell-Yan yields compatible with recent measurements (E866)
- Υ cross section compatible with the lower measurements performed at 800 GeV proton momentum

Modified Craigie parametrization

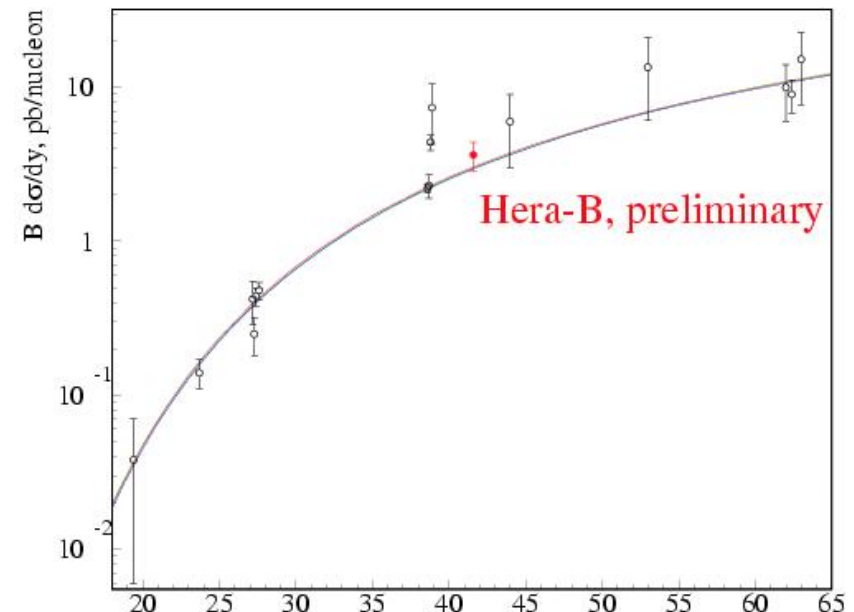


Craigie parametrization modified to account for possible nuclear suppression:

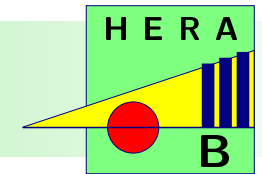
$$Br \times \left. \frac{d\sigma_Y}{dy} \right|_{y=0}(\sqrt{s}) = \sigma_0 \cdot e^{-\frac{m_0}{\sqrt{s}}} \cdot A^{\alpha-1}$$

where $\sigma_0 = 144 \pm 28$ pb/nucleon and $m_0 = 161 \pm 9$ GeV.

- Good fit to all experimental data
- High value at $\sqrt{s}=38$ GeV excluded
- Data compatible with no nuclear suppression: $\alpha = 0.99 \pm 0.05$



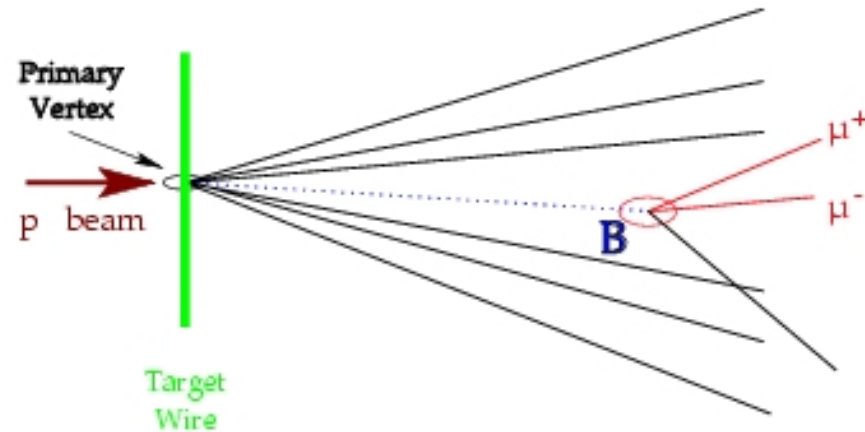
Open Beauty Production



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

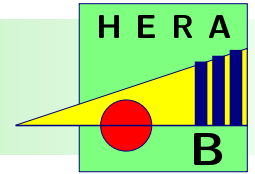
$$b(\bar{b}) \rightarrow B \rightarrow J/\psi + Y$$

$$\rightarrow \mu^+\mu^-, e^+e^-$$

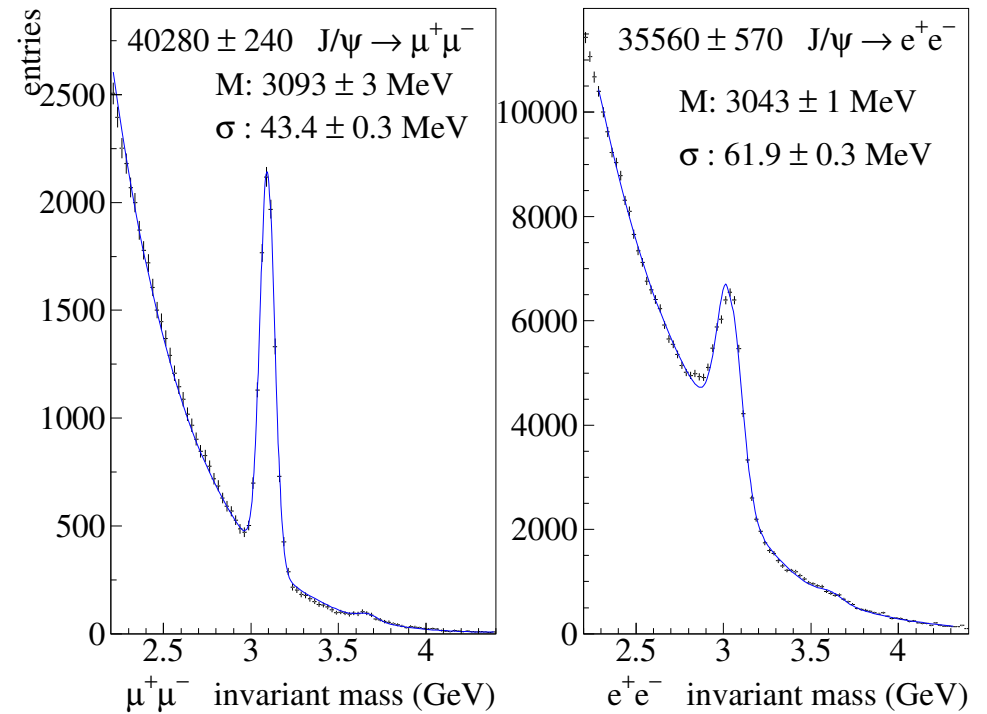


- Relative measurement to the prompt J/ψ
- DATA SAMPLE: $\approx 35\%$ of 2002-3 dilepton triggered data (50 MeV events)
- Used targets: 75% Carbon ($A=12$)
25% Tungsten ($A=184$)
- Simple J/ψ selection
- $b\bar{b}$ events identified via **DETACHED VERTEX ANALYSIS**
- Average decay length ≈ 7 mm, to be compared with a dilepton vertex resolution of ≈ 0.5 mm

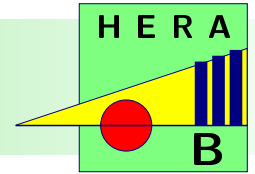
Prompt Analysis



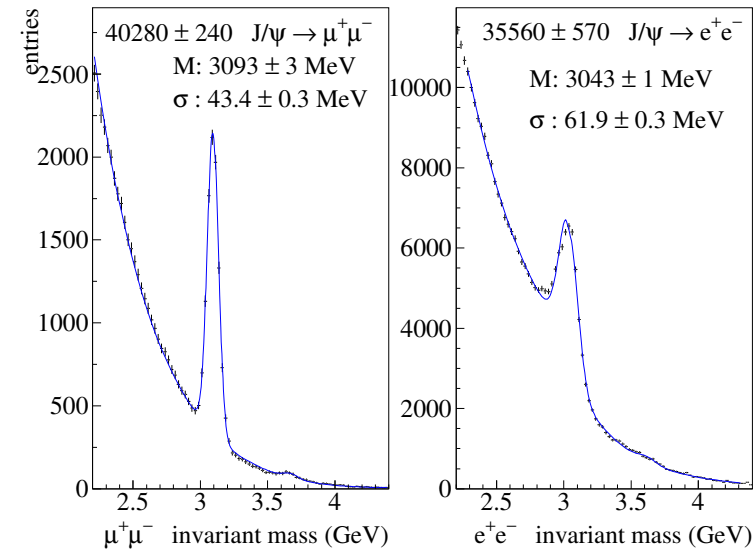
- Simple J/ψ selection:
 - dilepton vertex quality
 - PID (μ likelihood, E/p)
- Acceptance: $-0.35 < x_F < 0.15$
- Prompt J/ψ sample:
 - $\approx 40 \text{ k } J/\psi \rightarrow \mu^+ \mu^-$
 - $\approx 36 \text{ k } J/\psi \rightarrow e^+ e^-$



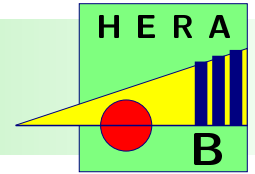
Prompt Analysis



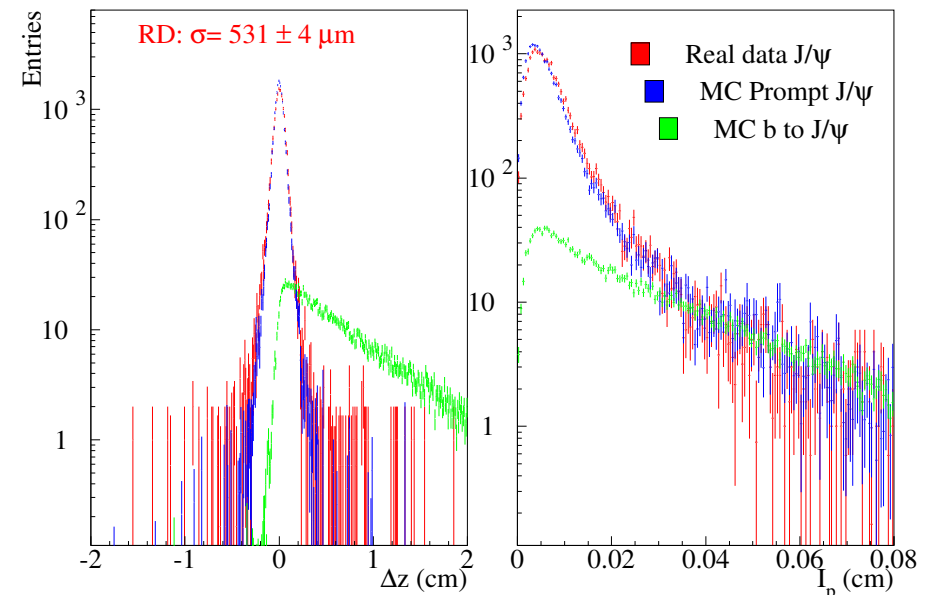
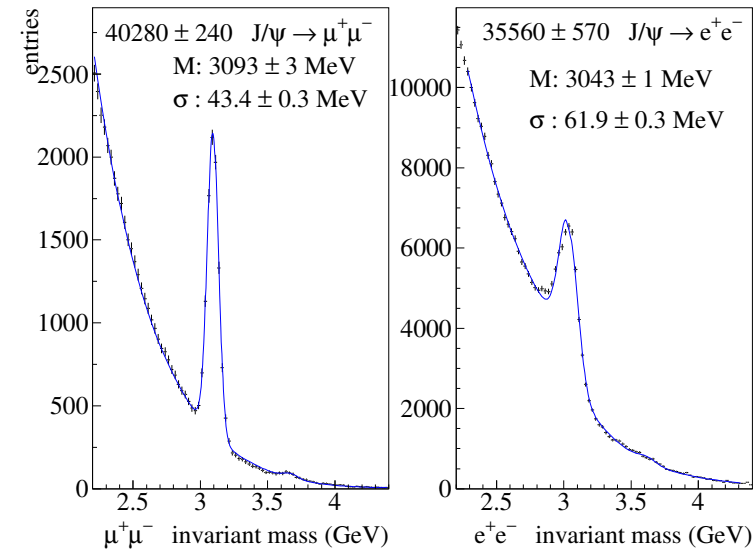
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 - $\approx 40 \text{ k } J/\psi \rightarrow \mu^+ \mu^-$
 - $\approx 36 \text{ k } J/\psi \rightarrow e^+ e^-$
- Dilepton vertices are associated to wires and to primary vertices on the base of geometrical considerations
- Only unambiguous associations are kept



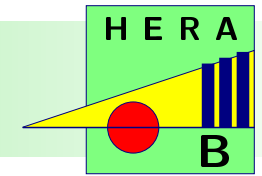
Prompt Analysis



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 - $\approx 36 \text{ k } J/\psi \rightarrow e^+ e^-$
- Dilepton vertices are associated to wires and to primary vertices on the base of geometrical considerations
- Only unambiguous associations are kept
- MC tuned to match experimental distributions
- Afterward a blind analysis can be performed

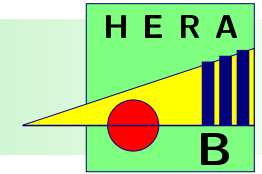


Detached Analysis

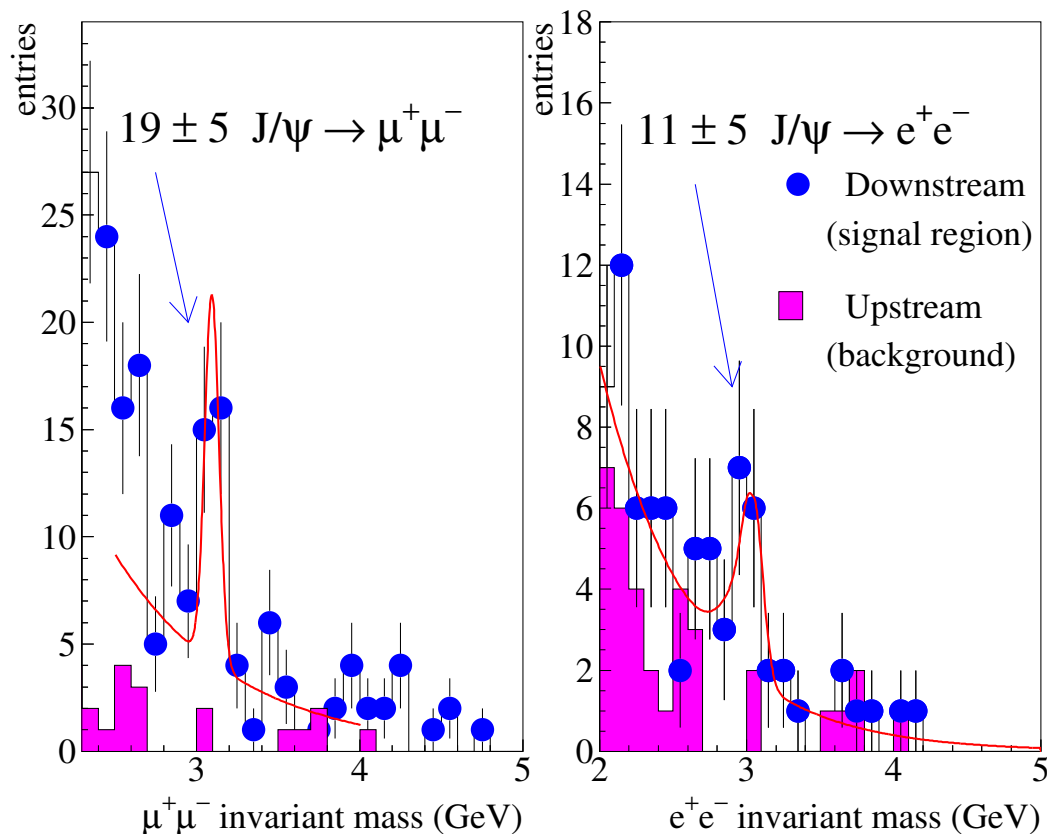


BLIND ANALYSIS: Detachment cuts (type and value) are optimized “blindly” using: **SIGNAL** from MC ($B \rightarrow J/\psi + X$)
BACKGROUND from
MC (prompt J/ψ , background channels)
DATA (same sign pairs, event mixing)

Detached Analysis



BLIND ANALYSIS: Detachment cuts (type and value) are optimized “blindly” using: **SIGNAL** from MC ($B \rightarrow J/\psi + X$)
BACKGROUND from MC and data



SELECTED CUTS:

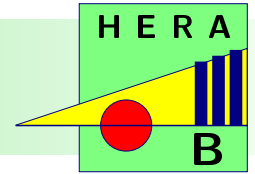
- dilepton separation in z from wire
- J/ψ impact parameter to wire
- lepton impact parameter to wire
- lepton CDA to primary

MC efficiency: 30-45 %

CROSS SECTION ESTIMATE:

$$\mu^+\mu^- : \sigma(b\bar{b}) = 12.7^{+4.1}_{-3.6^{stat}} \text{ nb/nucleon}$$
$$e^+e^- : \sigma(b\bar{b}) = 11.5^{+5.3}_{-4.5^{stat}} \text{ nb/nucleon}$$

Preliminary Results

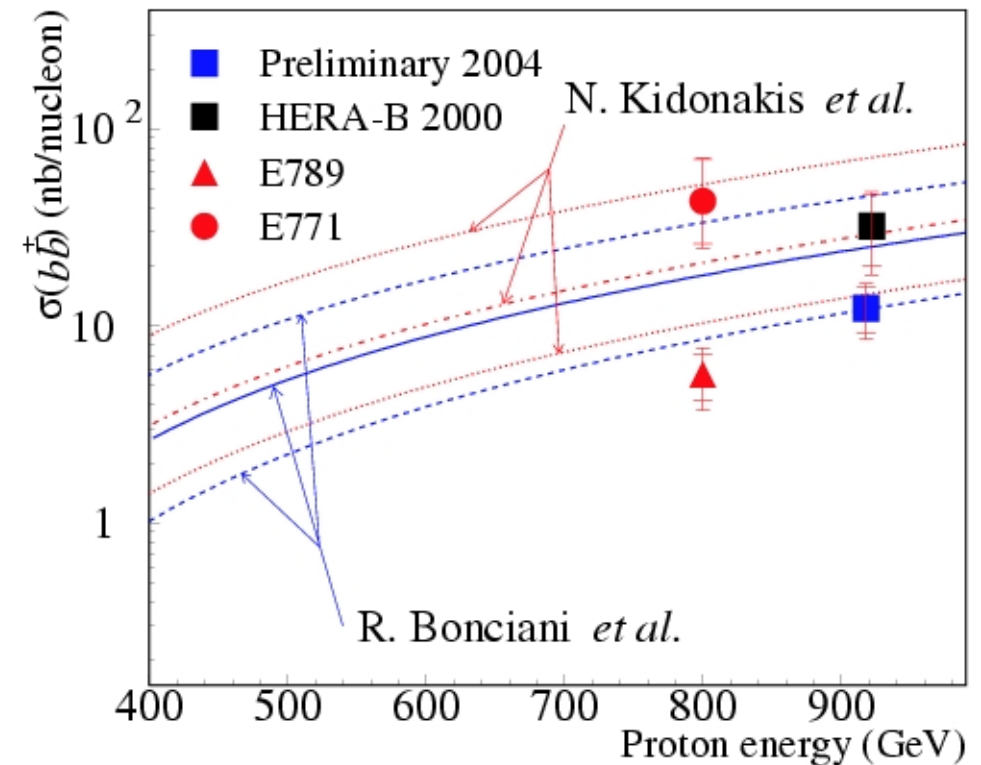


- Good compatibility of two samples

- Combined result:

$$\sigma(b\bar{b}) = 12.3^{+3.5}_{-3.2^{stat}}$$

- Current systematic error: $\approx 25-30\%$



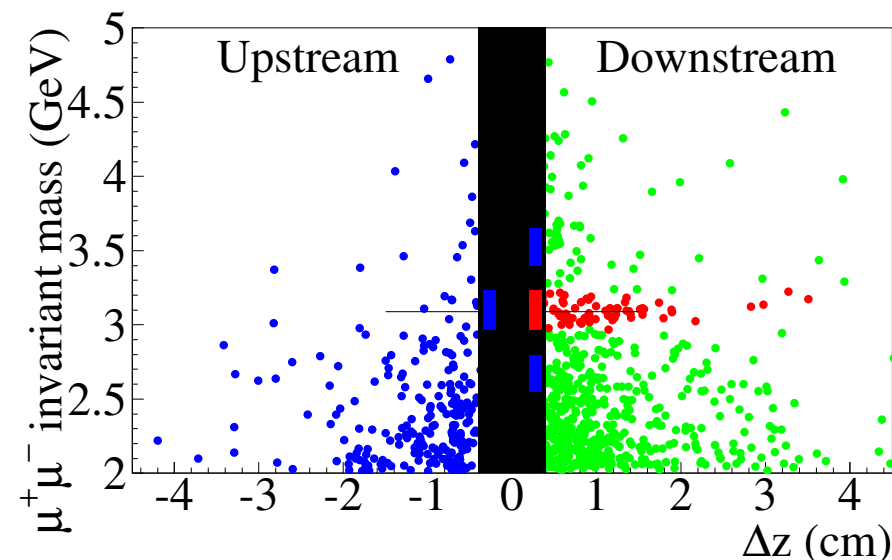
Previous Hera-B result (based on limited statistics collected in 2000):

$$\sigma(b\bar{b}) = 32^{+15}_{-12} \pm 8_{sys} \text{ nb/nucleon}$$

(Eur.Phys.J. C26(2003) 345)

The new result is 1.3σ lower.

- The full 2002-3 statistics is a factor 3 larger
- A new reprocessing just finished
- We expect ≈ 95 b candidates in the muon channel, and ≈ 80 in the electron channel
- We can reduce the statistical error to **15-18 %**
- Lifetime of candidate b events is compatible with MC expectations



- We will obtain a number of candidate b events **one order of magnitude larger** than previous fixed target experiments
- Ongoing additional analysis: **exclusive decay channels**
double semileptonic b decays

Conclusions

- Events from hidden and open beauty production have been observed in the 2002-3 data sample of the Hera-B experiment
→ preliminary measurement of the $b\bar{b}$ production cross section
- The complete Hera-B beauty candidate sample will be one order of magnitude larger than previous fixed target experiments
- Additional measurements with exclusive decay channels and double semileptonic b decays possible
- Good improvement of statistical errors and systematic uncertainties in reach

