First Results from HERA-*B*

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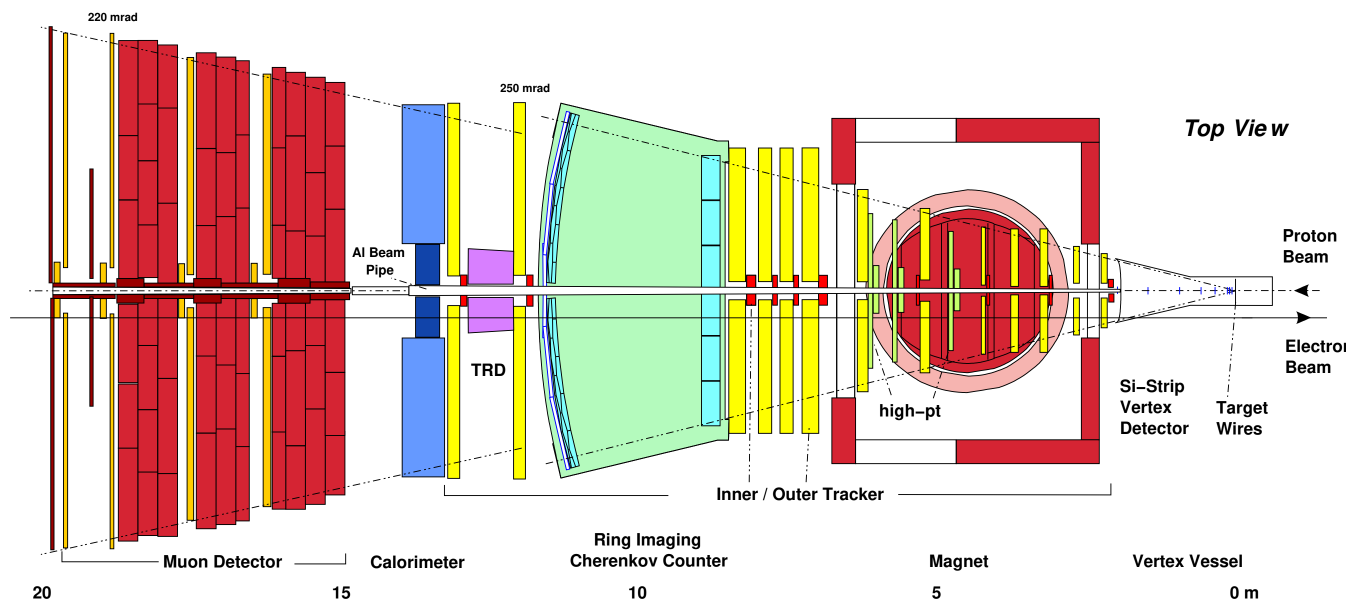
Overview

- The HERA-B Detector
- Topics of Run 2000 Analysis
- First Results
- Outlook: 2002/2003 Physics Program

The HERA-B Detector at DESY

- Fixed target experiment at HERA's proton beam
- Centre-of-mass energy: $\sqrt{s} = 41.6\,\mathrm{GeV}$
- 8 thin target wires in the beam halo,
  made of different materials (C, Al, Ti, Pd, W)
- Magnetic forward spectrometer with vertex detector and particle identification covering central region of particle production: $-0.4 \leq x_{\mathrm{F}} \leq 0.3$



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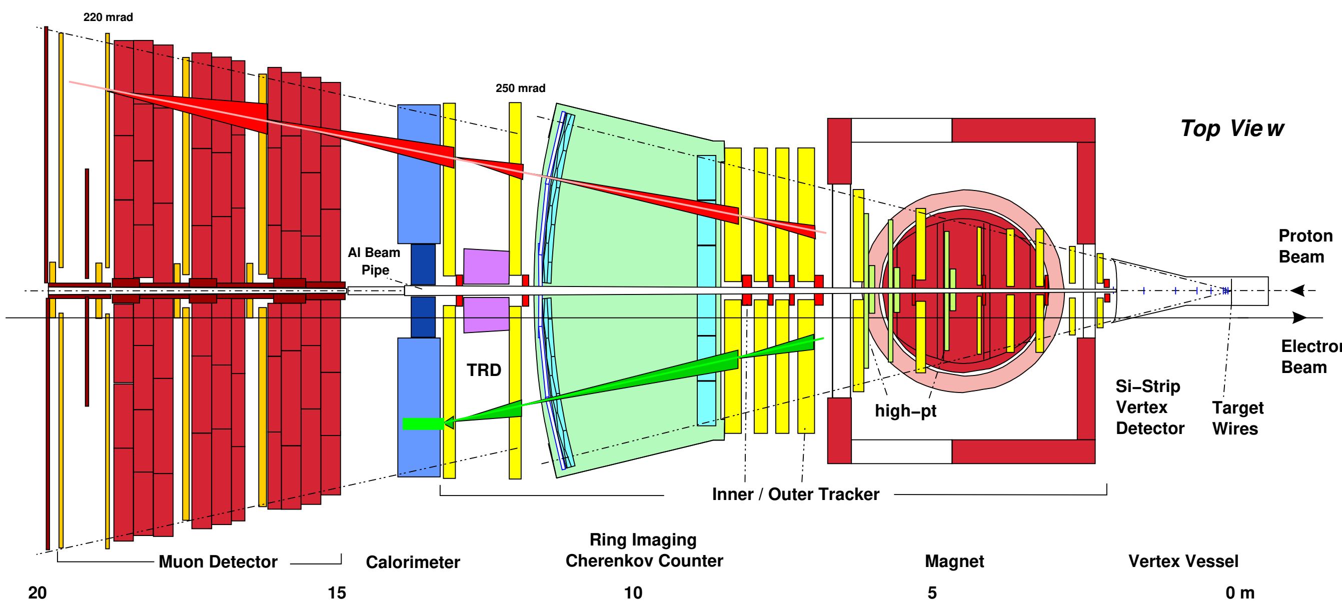


Conditions of Run 2000

- Detector and trigger commissioning
- Small amount of running time devoted to physics data taking
- No triggers from the inner detector
  ➠ acceptance loss in forward region

Statistics available for analysis:

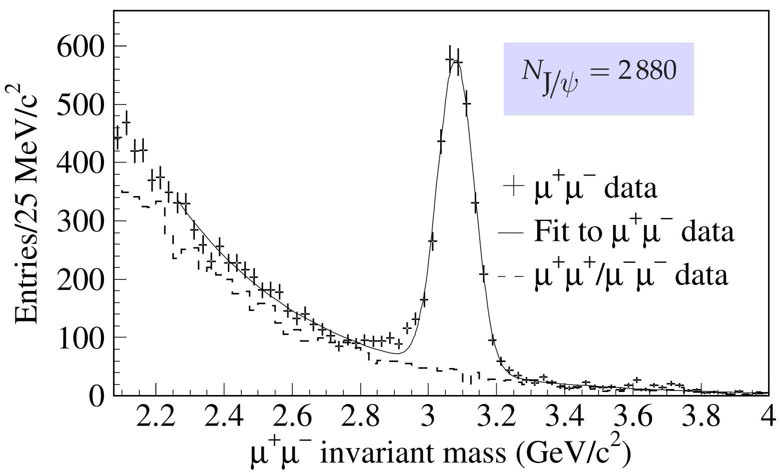
- Minimum bias: 2 million events (C, Al, Ti, W targets)
- Di-lepton triggers:
  0.45 million events di-muon
  0.90 million events di-electron
  (mostly C target, some Ti)

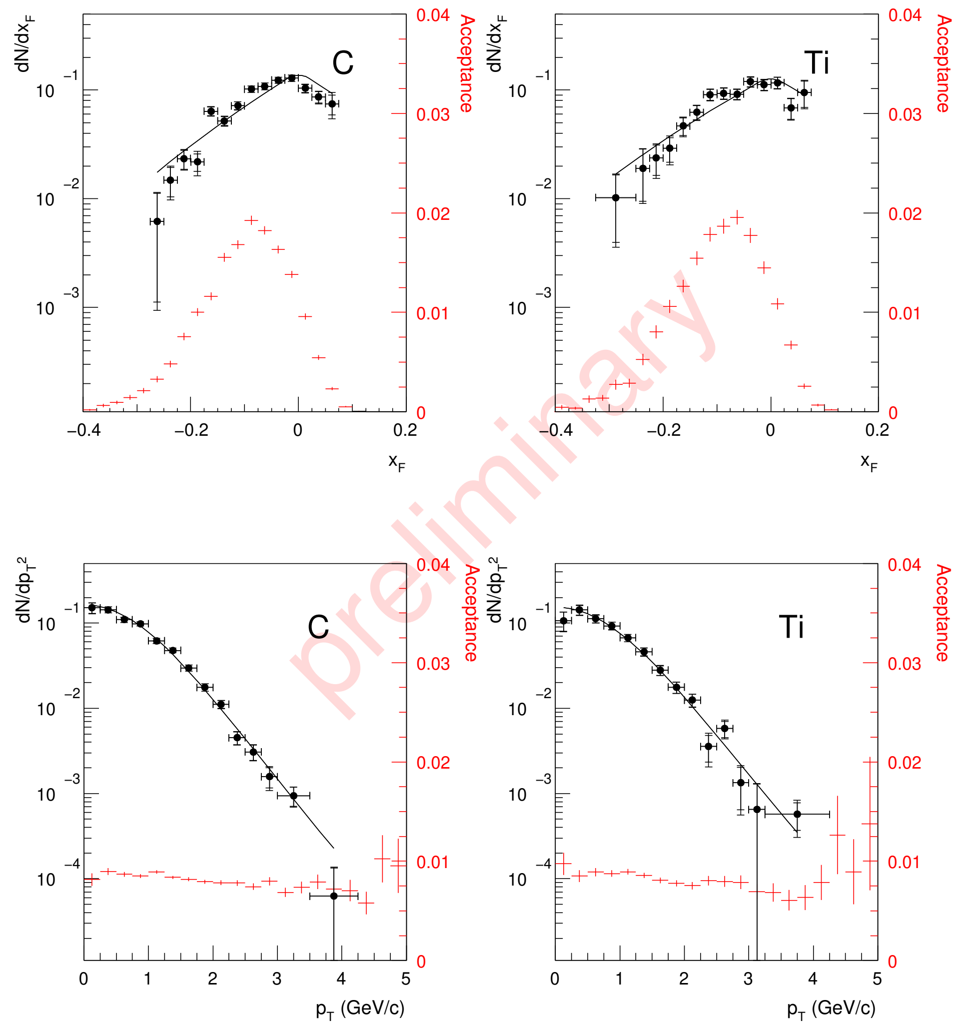
Run 2000 Analysis Topics

Trigger	Topic
Minimum Bias (no trigger)	◆ K_S^0 and Λ production cross section ◆ Inclusive particle production
Lepton Pair $e^+ e^-$ ECAL pretrigger $\mu^+ \mu^-$ Muon pretrigger + SLT tracking	◆ $b\bar{b}$ production cross section ◆ Production ratio of χ_c to J/ψ ◆ J/ψ: Inclusive x_{F} and p_{T} distributions

Spectra of Prompt J/ψ: Muon channel

Di-Muon trigger tracks, PID confirmed by MUON and RICH



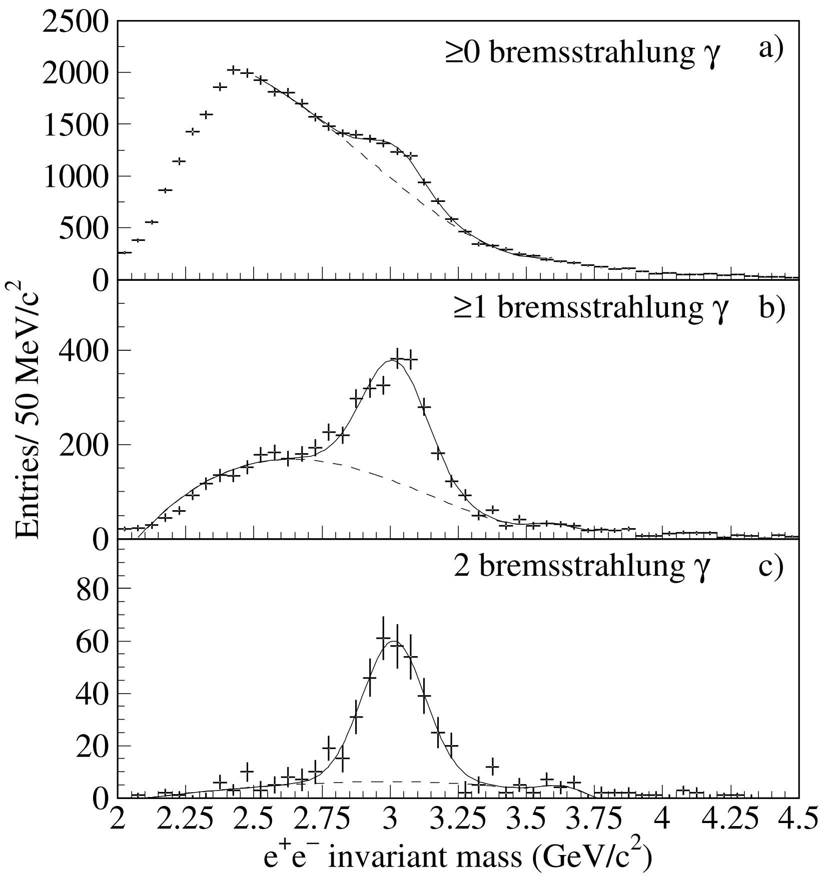


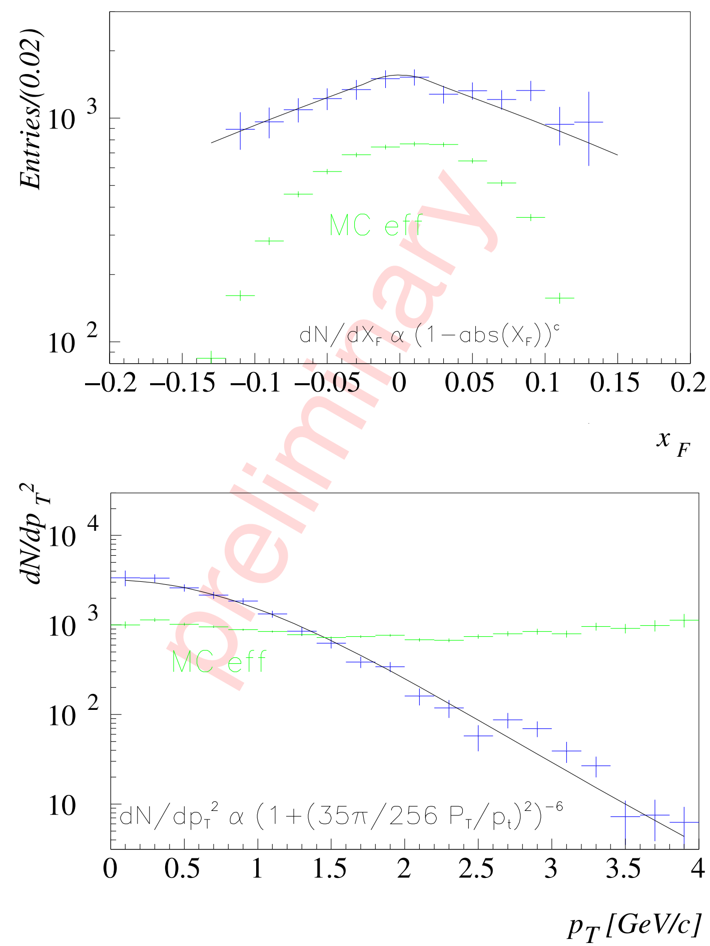
$$x_F: \quad \frac{dN}{dx_F} = A\left(1 - |x_F|\right)^c$$

$$p_T: \quad \frac{dN}{dp_T^2} = A\left(1 + \left(\frac{p_T}{p_0}\right)^2\right)^{-6}$$

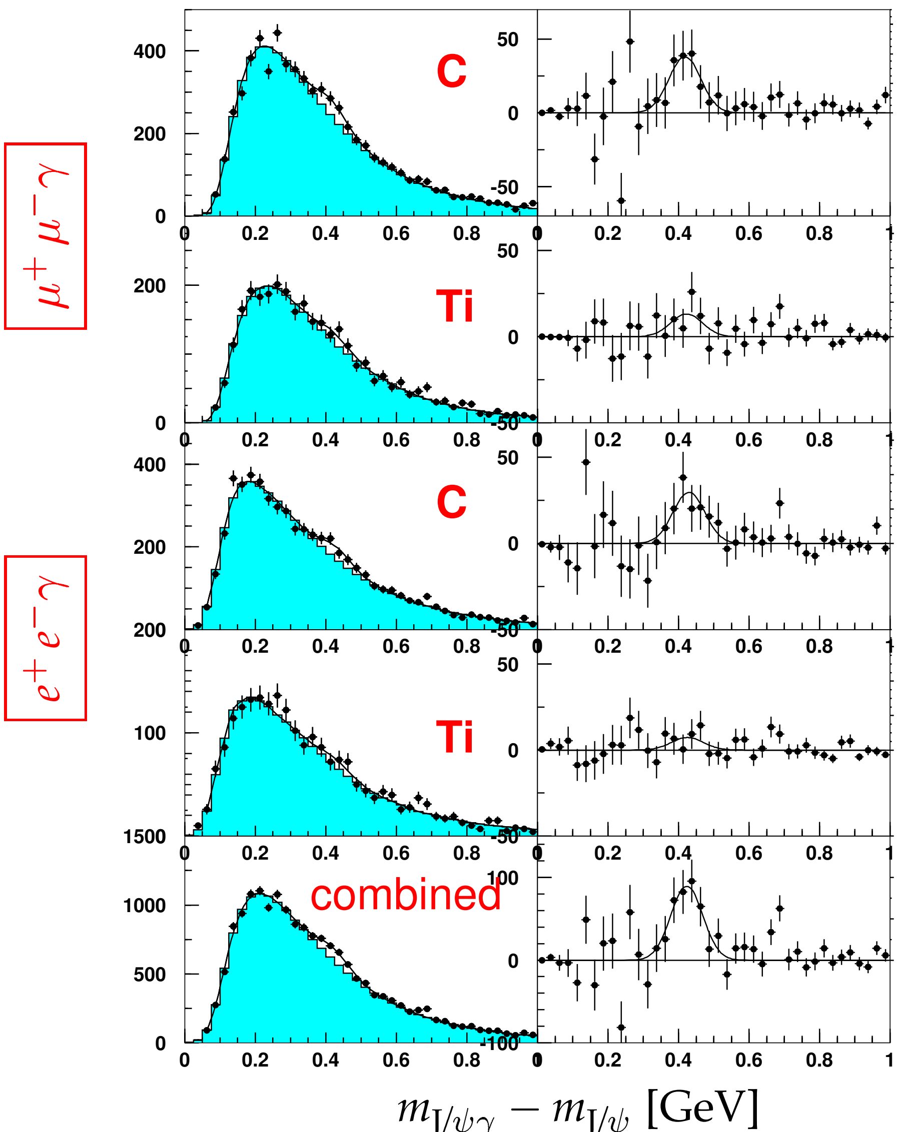
Spectra of Prompt J/ψ: Electron channel

Confirm trigger tracks by reconstruction
Particle ID by E/P and bremsstrahlung ($\varepsilon_{BR} = 0.34 \pm 0.02$)





Fraction of J/ψ from χ_c



Decay channel: $\chi_c \to J/\psi\,\gamma \to \ell^+\,\ell^-\gamma$

$$R_{\chi_c} = \frac{\sigma(\chi_c)\,\mathrm{Br}(\chi_c \to J/\psi\,\gamma)}{\sigma(J/\psi)}$$

Preliminary result for Carbon:

$$R_{\chi_c} = 0.351 \pm 0.077 \pm 0.037$$

consistent with previous measurements

Run 2002:

- First measurement of χ_c suppression in nuclear matter
- Disentangle $\chi_{c,1}$ and $\chi_{c,2}$?

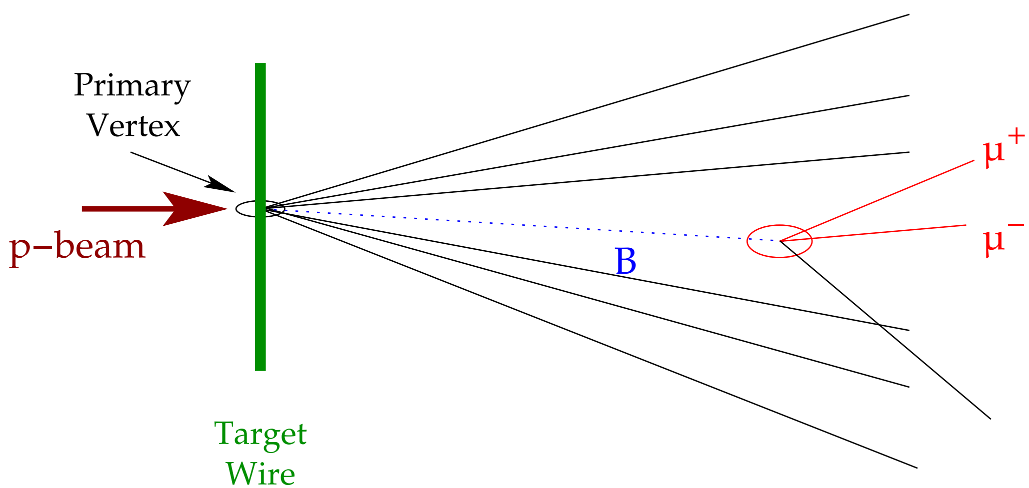
Measurement of $\sigma(b\bar{b})$

- Identify b-hadrons by their decay length, using decay chain

$$pN \to b\bar{b}\,X \to \mathrm{J}/\psi\,XY \;\begin{array}{l} \to \; e^+ e^- XY \\ \searrow \; \mu^+ \mu^- XY \end{array}$$

trigger on lepton pair from J/ψ decay
and search for displaced secondary vertex

average decay length of B mesons at HERA-B: ≈ 8 mm



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

- Measure *relative to* prompt J/ψ production:

$$\sigma^{A}_{b\bar{b}} = \sigma^{A}_{\mathrm{J}/\psi}\,\frac{N_b}{N_{\mathrm{J}/\psi}}\,\frac{1}{\varepsilon_R\,\varepsilon^{b}_{\Delta z}\,\mathrm{Br}(b\bar{b}\to \mathrm{J}/\psi)}$$

$\sigma^{A}_{\mathrm{J}/\psi}$	$357 \pm 8 \pm 27$ nb/nucleon	E789, E771
$\varepsilon_R\,\varepsilon^{b}_{\Delta z}$	$\approx 40\%$	Monte Carlo Simulation
$\mathrm{Br}(b\bar{b}\to \mathrm{J}/\psi)$	(2.32 ± 0.20) %	LEP 1

Avoid absolute measurement of luminosity
Most systematic errors (acceptance, trigger efficiencies, . . .) cancel
Total uncertainty attainable with this method: ≈ 15 %
Compare:

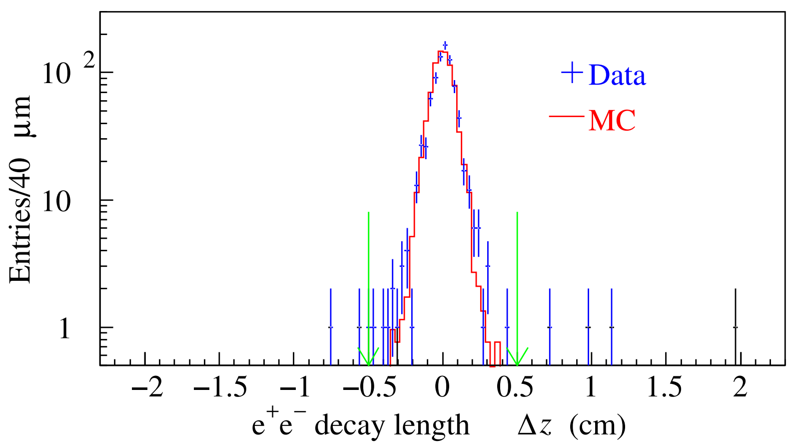
E789: 26 %(stat) $\oplus$ 23 %(sys)

E771: $^{+63}_{-40}$ %(stat) $\oplus$ 16 %(sys)

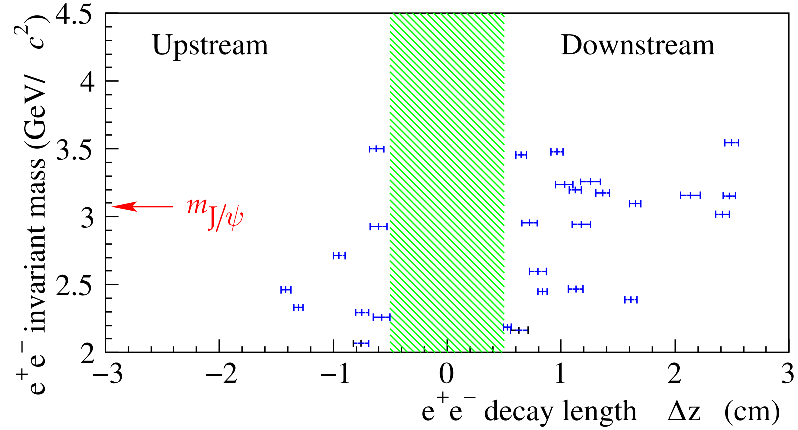
Measurement of $\sigma(b\bar{b})$

Decay length of $e^+ e^-$

data compared to prompt J/ψ MC



$m_{e^+ e^-}$ vs. decay length



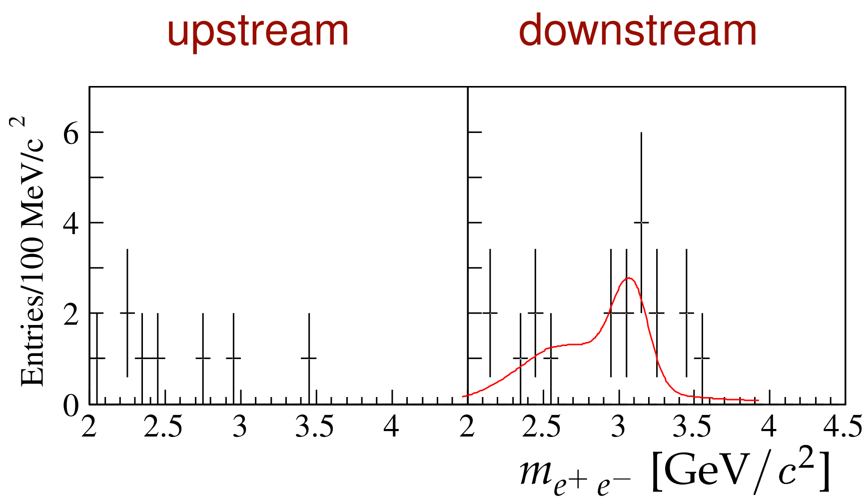
good agreement: MC describes target and vertex resolution sufficiently well

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

Electron channel:

$\Delta z \geq 0.5$ cm

$I_w(e^{\pm}) > 200\ \mu$m

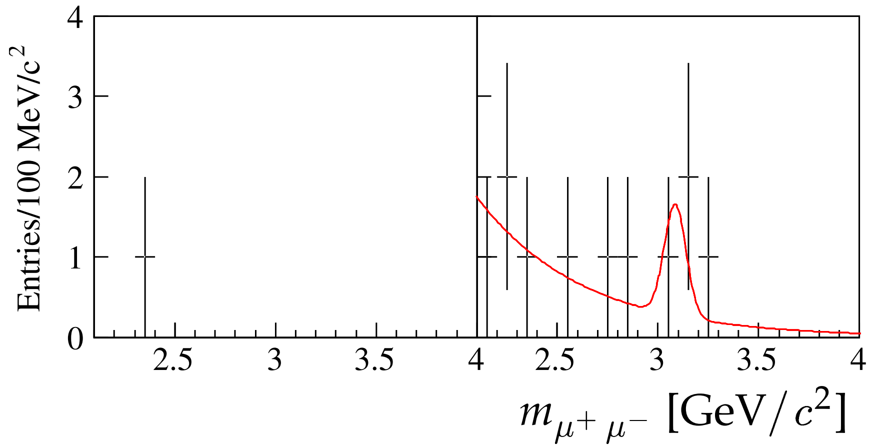


$$n_B = 8.6^{+3.9}_{-3.2}$$

Muon channel:

$\Delta z \geq 7.5\sigma_z$

$I_p(\mu^{\pm}) > 160\ \mu$m

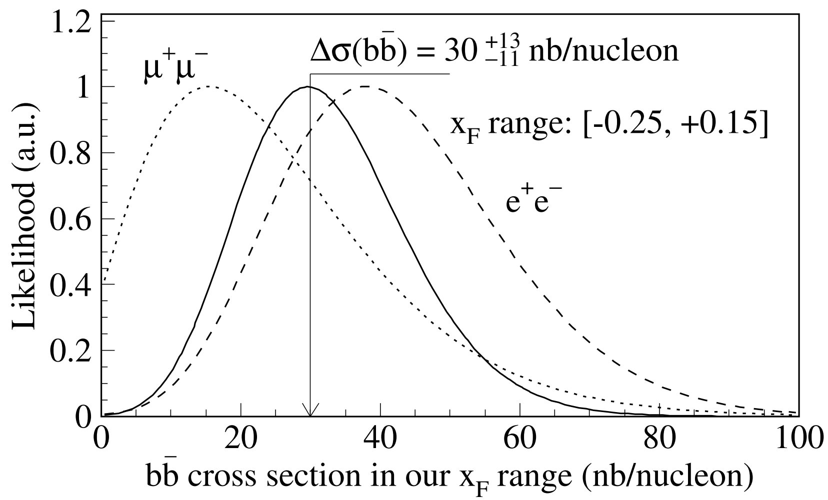


$$n_B = 1.9^{+2.2}_{-1.5}$$

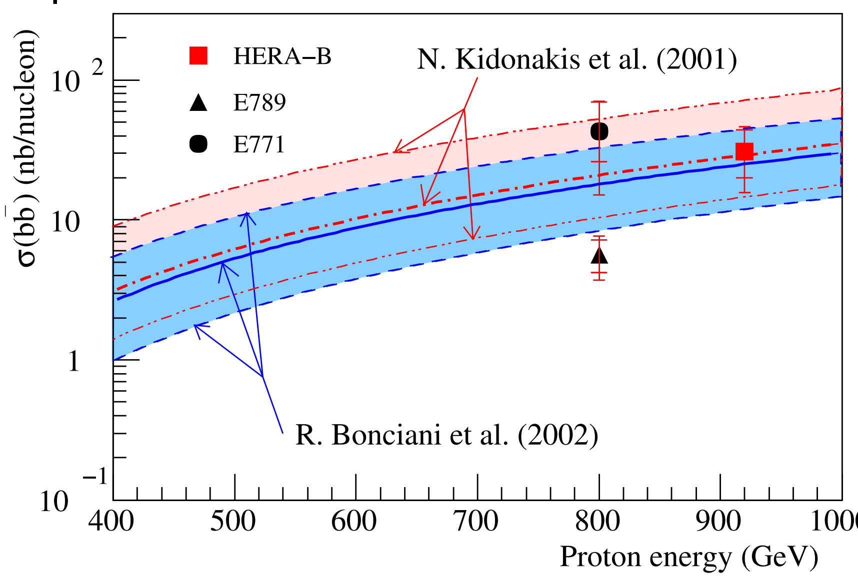
use unbinned likelihood fit with fixed shapes for signal (MC) and background (data)

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

Fit e^+e^- and $\mu^+\mu^-$ data simultaneously:



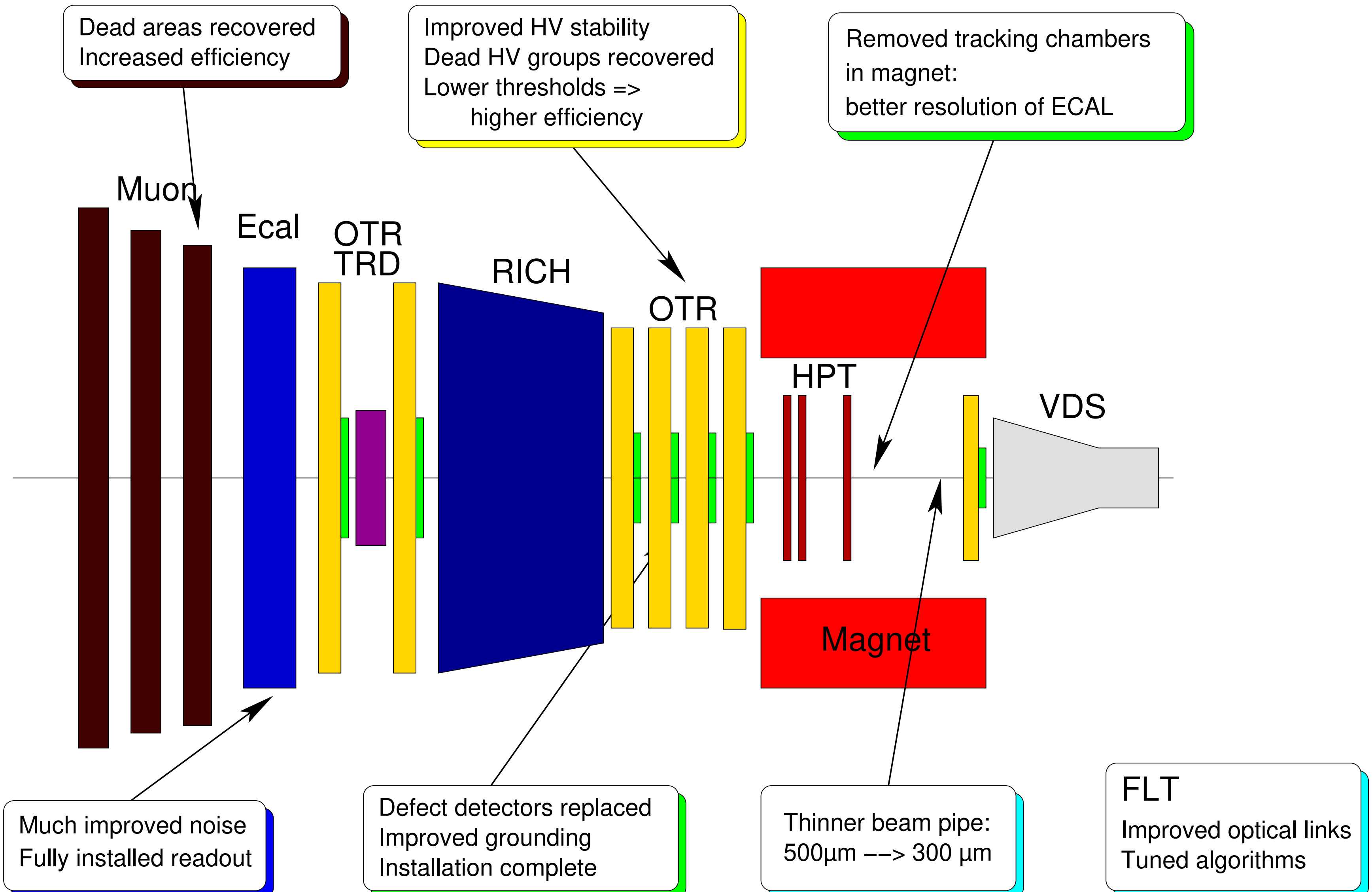
Compare to QCD calculations and previous experimental results:



extrapolate to full phase space:

$$\boxed{\sigma_{\text{tot}}(b\bar{b}) = 32\,^{+14}_{-12}(\text{stat})\,^{+6}_{-7}(\text{syst})\ \text{nb/nucleon}}$$

Detector Improvements for 2002



2002/3 Physics Program

- Nuclear dependence of charmonium production
  - Extend existing measurements for J/ψ and ψ' to negative x_F
  - First measurement for χ_c
  - Measure production ratios of J/ψ, ψ' and χ_c
- Improve measurement of $b\bar{b}$ cross section
  - Uncertainty limit of $\approx 15\%$ due to systematic errors
  - Cross section from fully reconstructed B decays
- Expected event yields (assume 8 months of running):

	2000	2002/3
J/ψ ($\mu^+\mu^-$ and e^+e^-)	1×10^4	4×10^6
$\chi_c \to \mathrm{J}/\psi\,\gamma$	1×10^2	3×10^5
ψ'	4×10^1	1×10^5

Summary

- First physics results from HERA-B:
  $\sigma_{b\bar{b}}$ [hep-ex/0205106]
  R_{χ_c}
  x_F- and p_T-spectra of J/ψ
- Detector upgrade: improve performance of spectrometer
  improve understanding of trigger
- Run 2002/3: expect very large statistics of various charmonium states
- Eagerly waiting for new data