2nd preliminary request for

Measurement of beauty production from dimuon events at HERA II

A. Geiser, N. Stefaniuk, I. Bloch

ZEUS meeting 2.7.2018

- only minor changes with respect to 1st preliminary presentation:

- tentative extra 15% systematic uncertainty on total cross sections removed as decided at 1st preliminary presentation
- figure cosmetics kindly updated by Iris
- systematics very slightly streamlined (all quoted uncertainties taken from already public sources: theses N. Stefaniuk or D. Bot, or HERA I paper; cross section numbers unchanged)
- writeup provided (ZEUS-prel-18-006)

- answers to questions by E. Lohrmann, P. Bussey, et al.

Visible beauty cross sections

visible phase space:

$1^{st}\ \mu$: p_T > 1.5 GeV
$2^{nd}\ \mu$: (p > 1.8 GeV for $\eta < 0.6$
p > 2.5 *or* p_T > 1.5 GeV for $\eta > 0.6$)
and p_T > 0.75 GeV
both μ: -2.2 < η < 2.5

Visible cross section: using lumi + MC acceptance + corrections

- Ingo/HERA I paper:

  σ_{vis} **ep→bbX→μμX' = 55 ± 7 (stat.) $^{+14}_{-15}$ (syst.) pb**

- Nazar/HERA II thesis: **-> preliminary request**

  σ_{vis} **ep→bbX→μμX' = 43 ± 3 (stat.) $^{+13}_{-11}$ (syst.) pb**

NLO QCD (same as HERA I paper):

σ_{vis} **ep→bbX→μμX' = 33 $^{+14}_{-8}$ (NLO) $^{+5}_{-3}$ (frag+Br) pb**

Total beauty cross sections

Total cross section: using MC cross section x scale factor + corrections

- Ingo/HERA I paper:

  $\sigma_{b\ tot}$ **ep→bbX (318 GeV) = 13.1 ± 1.5 (stat.) $^{+\ 4.0}_{-\ 4.3}$ (syst.) pb**

- Nazar/HERA II thesis: **-> preliminary request**

  $\sigma_{b\ tot}$ **ep→bbX (318 GeV) = 11.4 ± 0.8 (stat.) $^{+\ 3.5}_{-\ 2.9}$ (syst.) nb**

NLO QCD predictions (same as HERA I paper):

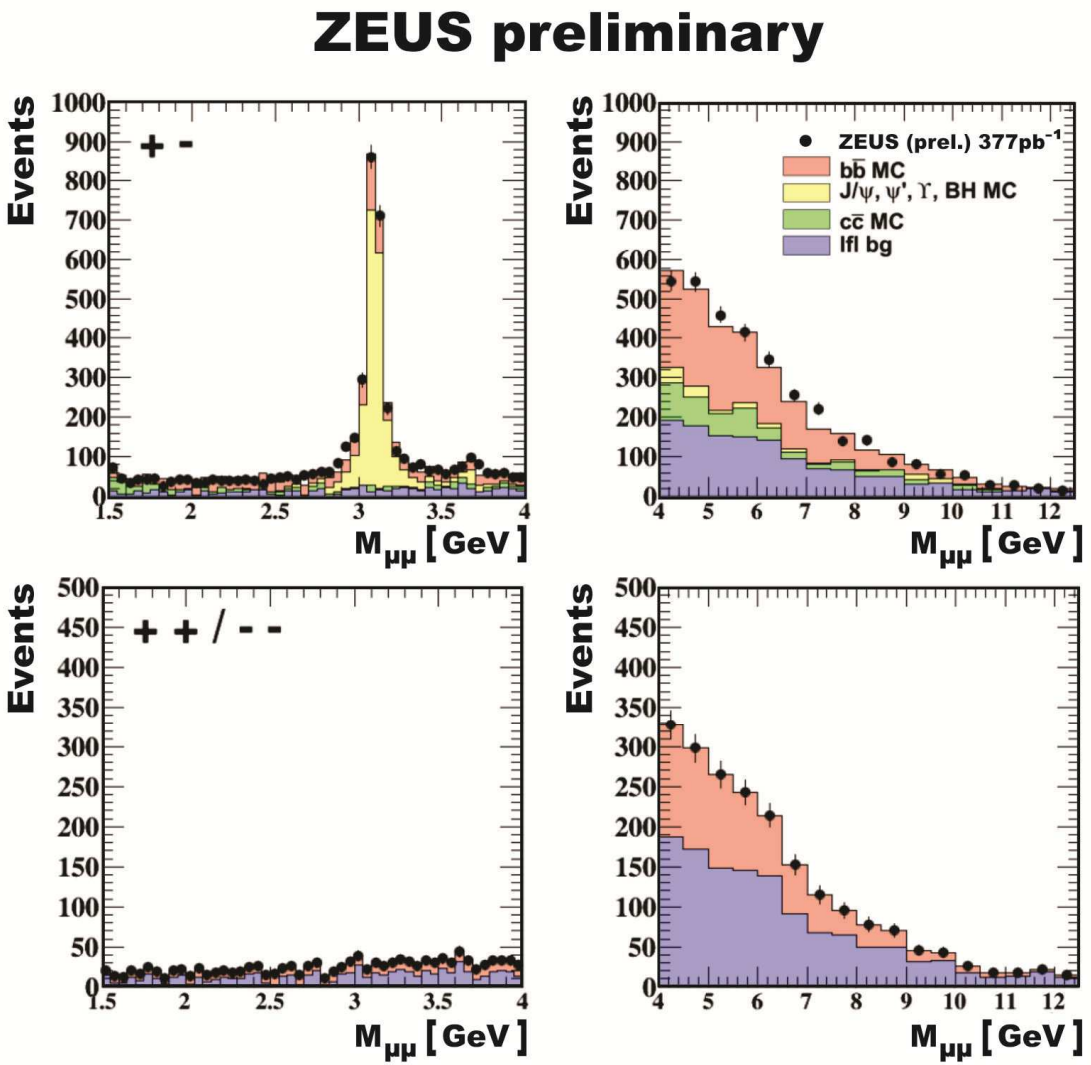
FMNR+HVQDIS $7.5\ ^{+\ 4.5}_{-\ 2.1}$ **nb**

Summary of systematic uncertainties (visible cross section)

	Nazar/Danny	paper	HERA I
Muon efficiency correction:			
Use BRMUON only or BAC only; Trigger	**+20% -18%;**	**+-5%**	**+-15%; +-5%**
Dimuon isolation; vary cut by 500 MeV (data and MC):	**+-3%** Nazar/Danny		**+-2%**
CAL ET; vary cut by 1 GeV (data and MC):	**+-3%** Nazar/Danny		**+-2%**
Bethe Heitler and Quarkonia contributions;			
change normalisation of nonisolated fraction by +-50%:	Nazar **+10% -3%**		**+-10%**
Charm contribution; vary by +-20%:	Danny **+6% -10%**		**+-12%**
Charm and beauty spectral shape;			
Variation of direct and nondirect fractions			
charm:	**+-2%** Nazar/Danny		**+0/-4%**
beauty:	**+-12%**		**+4/-12%**
BBbar oscillations; other b model uncertainties	**+-4%;** paper	**+-10%**	**+-4%; +-10%**
Variation of like/unlike sign light flavour ratio by 3%:	Nazar/Danny **+3% -1%**		**+-3%**
Luminosity:	**+-2%** Nazar/Danny		**+-2%**
	-------		**---------**
	+30% -26%		**+25% -28%**
	Nazar		

part of preliminary request

Dimuon mass distributions

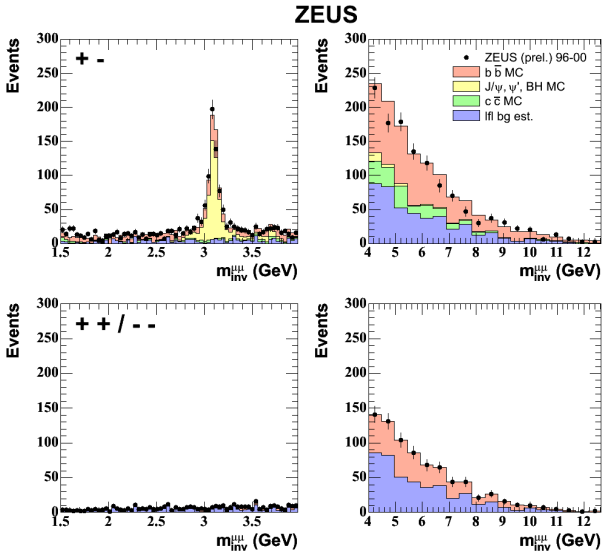


requested preliminary plot

data well described by MC.

beauty contribution:
~5200 events

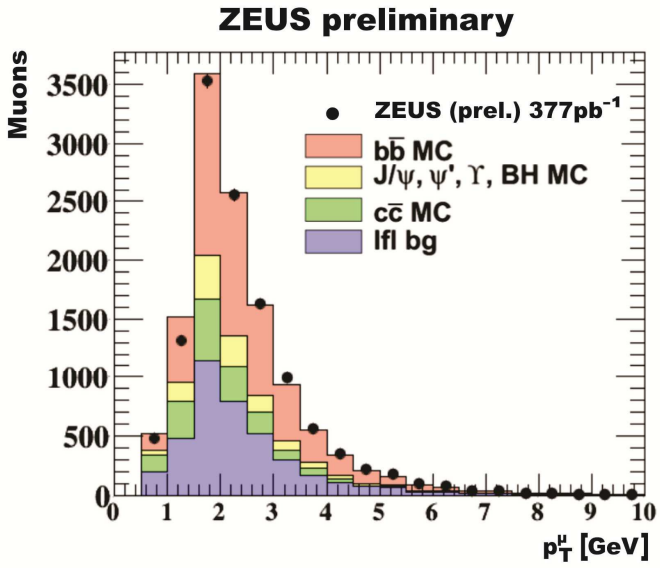
(Hera I: 1900 ± 210 events)

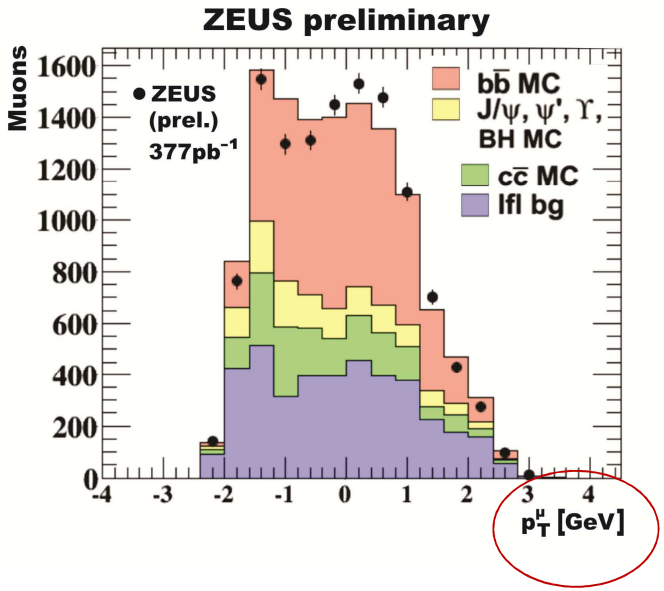


Muon p_T and η distributions

nonisolated unlike sign muon pairs

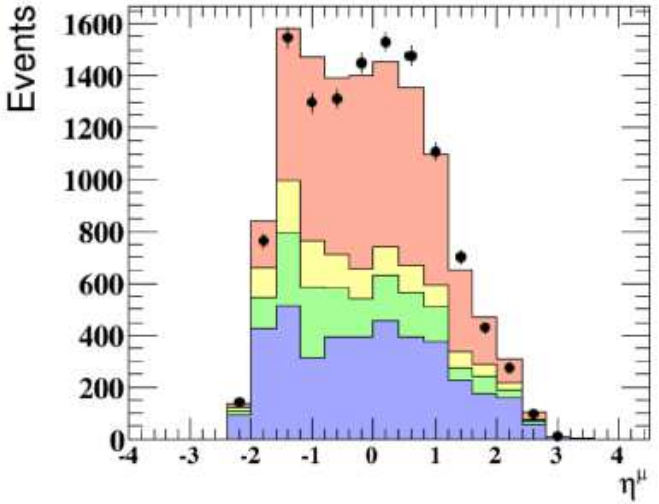
requested preliminary plots





needs fix

Nazar's plot
(not for preliminary)



acceptance down to **very low p_T**

very **large η range** (-2.2 to +2.5)

b MC (x 1.85) **agrees with data**

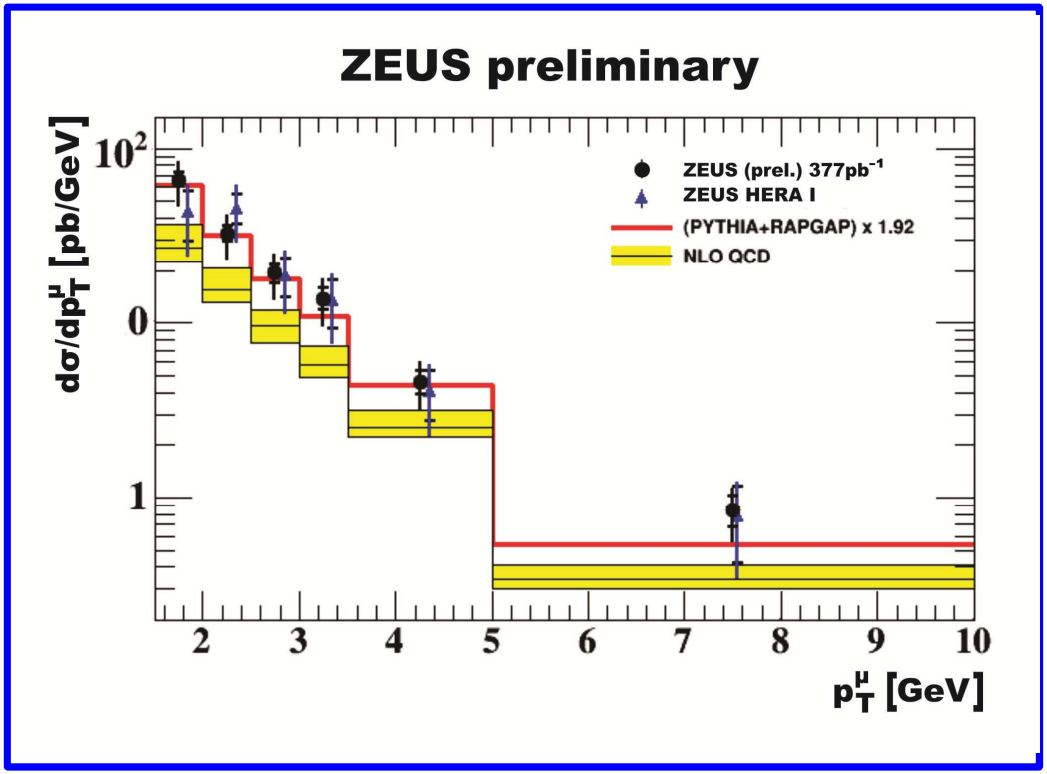
Muon differential cross sections - p_T^{μ}

- restrict both μ to
  $p_T^{\mu} > 1.5$ GeV
  and $-2.2 < \eta^{\mu} < 2.5$
  -> average factor $S_b = 1.92$

- extract b signal bin-by-bin
  from unlike vs. like sign contributions:

→ **cross section in p_T^{μ}**

Very good description of the p_T shape by the LO+PS MC and NLO (FMNR+PYTHIA)



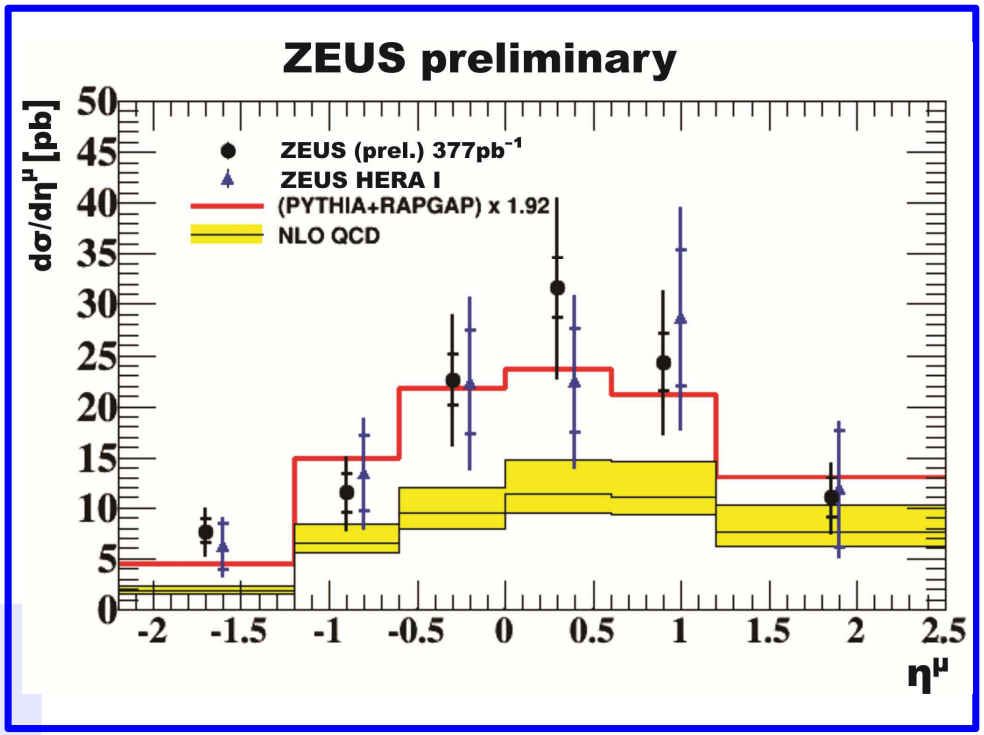
requested prel. plot

Muon differential cross sections - η^{μ}

- restrict both μ to
  $p_T^{\mu} > 1.5$ GeV
  and $-2.2 < \eta^{\mu} < 2.5$

- extract b signal bin-by-bin
  from unlike vs. like sign contributions:

→ **cross section in η^{μ}**

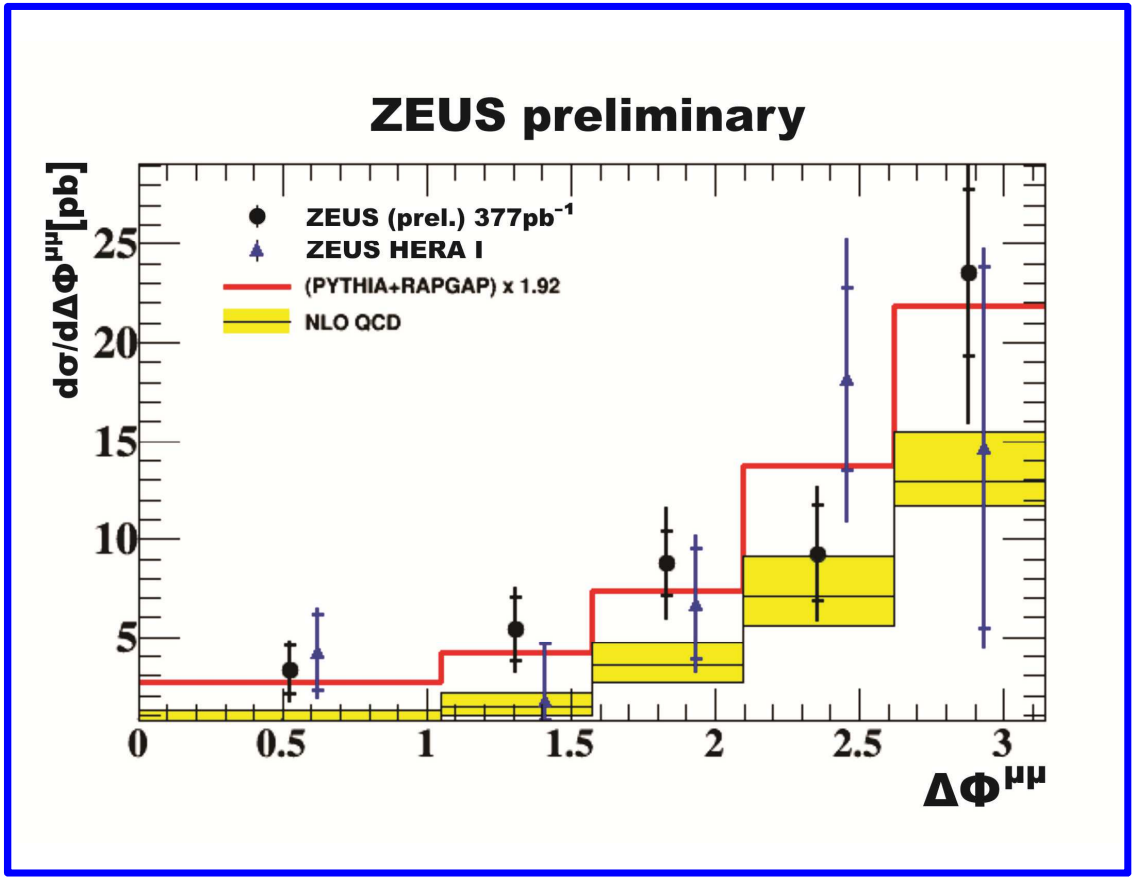


Very good description in shape by the LO+PS MC and NLO in full η and p_T range. NLO low but consistent.

requested prel. plot

Muon angular correlations - $\Delta\phi^{\mu\mu}$

- restrict both μ to
  $p_T^{\mu} > 1.5$ GeV
  and $-2.2 < \eta^{\mu} < 2.5$



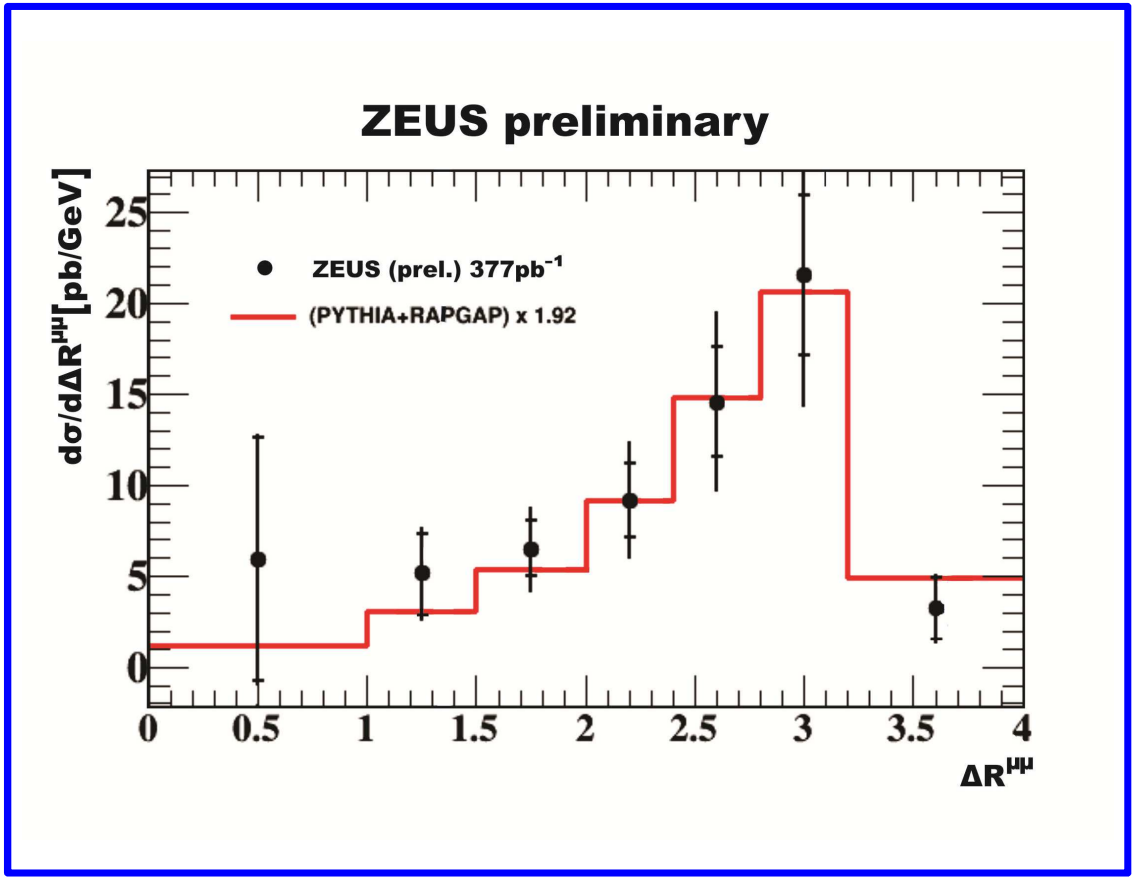
requested preliminary plot

→ **cross section in $\Delta\phi^{\mu\mu}$ for muons from diff. b**

reasonable agreement within large errors

Muon angular correlations - $\Delta R^{\mu\mu}$

- restrict both μ to
  $p_T^{\mu} > 1.5$ GeV
  and $-2.2 < \eta^{\mu} < 2.5$



→ cross section in $\Delta R^{\mu\mu}$ for muons from diff. b

requested prel. plot

was not published previously (statistics)
-> NLO prediction was not calculated

Answers to Erich

- Suggestion for title of writeup:
  Measurement of beauty production from ep interactions at HERA
  (to indirectly hint that it is both DIS and PHP)

  Current title (same as HERA I paper):
  Measurement of beauty production from dimuon events at HERA

  My compromise suggestion:
  Measurement of beauty production from dimuon events **in ep interactions** at HERA

  (or keep present title)

Answers to Erich

- Suggestion for abstract and/or introduction:
  mention that the paper is about both photoproduction and DIS

Potential corresponding change of abstract:
… almost the full phase space for beauty production, **including both deep ineleastic scattering and photoproduction.**
(long sentence, a bit clumsy)

In any case, **add full sentence to introduction**

My compromise suggestion: Keep abstract, add sentence to introduction

Answers to Erich

- Suggestion for text:

  split HERA references according to photoproduction and DIS **-> will do**

  give more details on how DIS/PHP transition region is treated in MC
  would require whole pragraph;
  suggestion: not in preliminary, but **do for paper**

  add comparison to HERA I total cross section result explicitly **-> will do**

  Table 1: explain table inscriptions better
  compromise suggestion for preliminary: **remove table here and instead refer to HERA I paper, where it is published**
  Alternative: keep table and give reference to paper for more detail

  Fig. 1: interchange b) and c) in caption **-> will do**

  Fig. 2b: fix abscissa P_T -> eta **-> will do** (need Iris …)

Answers to Peter

- Question:

  Why are the FMNR theoretical uncertainties so much worse in the total cross section than in the differential cross sections?
  That at least is the appearance from the plots.

  Answer:

  The theoretical uncertainties are indeed a bit smaller for the differential than for the total cross sections (but not dramatically so).
  The differential cross sections have tighter muon P_T cuts, which removes part of the threshold region.
  The Delta-phi and Delta-R distributions only refer to muons from different b's.
  The statement that 90% of the cross section is 'visible' applies to the total cross section, not the differential ones.
  All NLO predictions are identical to the ones in the published HERA I paper.
  Details to be followed up for the paper.

Conclusion

- Measured **Beauty cross sections with**
  - **large acceptance** (extended η^{μ} and p_T^{μ} range) / **low extrapolation**
  - **sensitive to very low p_T^b**
  - **high beauty purity of ~ 50%**
- Confirmation of measurement of **total beauty cross section** at HERA
- **Differential cross sections**
  - good agreement in shape **with LO+PS and HERA I, smaller uncertainties**
- **Reasonable agreement with NLO**, generally slightly lower than data
  - no particular trend in p_T or η (as before)
- New distribution: Delta R (not enough statistics in HERA I)
- **Request preliminary release**