Summary of the DESY meeting
Part 2: Experiment

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Talks covered here:

- b production with JetWeb (O. Gutsche)
- Charm fragmentation in hadronic enviroment (M. Wing)
- Bottom fragmentation in hadronic enviroment (M. C.)
- HQ fragmentation in Pythia at LHC (R. Guernane)
- Higgs to $\tau^+\tau^-$ signatures from $b\bar{b}$ fusion (Z. Was)

\+ some consideration...

b production with JetWeb (O. Gutsche)

JetWeb

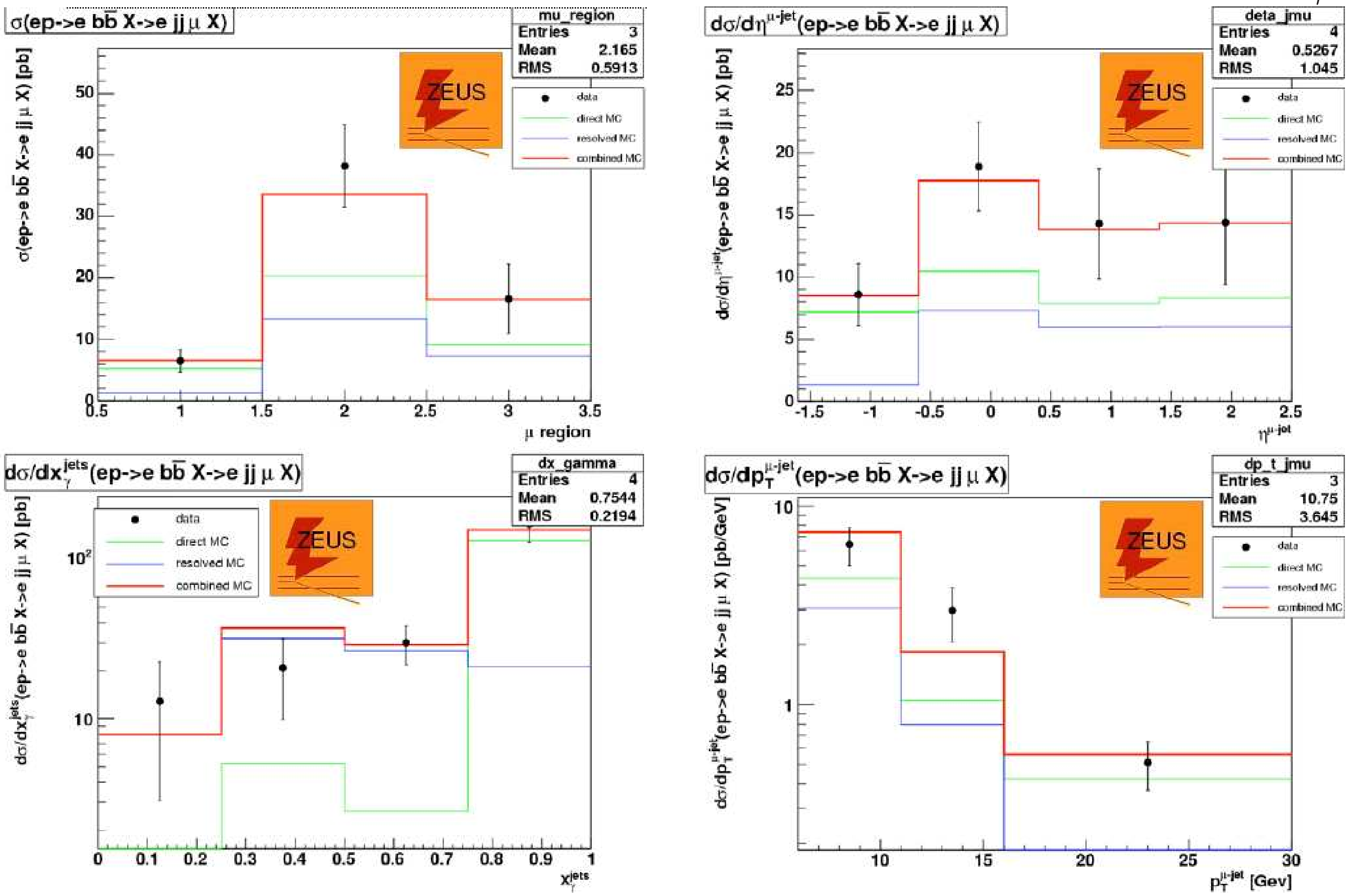
- Tool to compare public experimental results to MC
- Many experimental measurements with their definition are coded in HZTOOL routines
- Interfaced to Pythia and Herwig
- The user can submit to `http://jetweb.ucl.ac.uk/` a request for a specific MC model and settings and get the comparison with the available measurements after a while

b production with JetWeb (O. Gutsche)

- **b production measurements implemented in HZTOOL:**
  - **UA1:** b **cross sections from single** μ **and dimuons,** $\Delta\phi_{\mu\mu}$
  - **D0:** b **cross sections from single** μ
  - **ZEUS:** b **cross sections from 2 jets** $+$ μ **photoproduction**

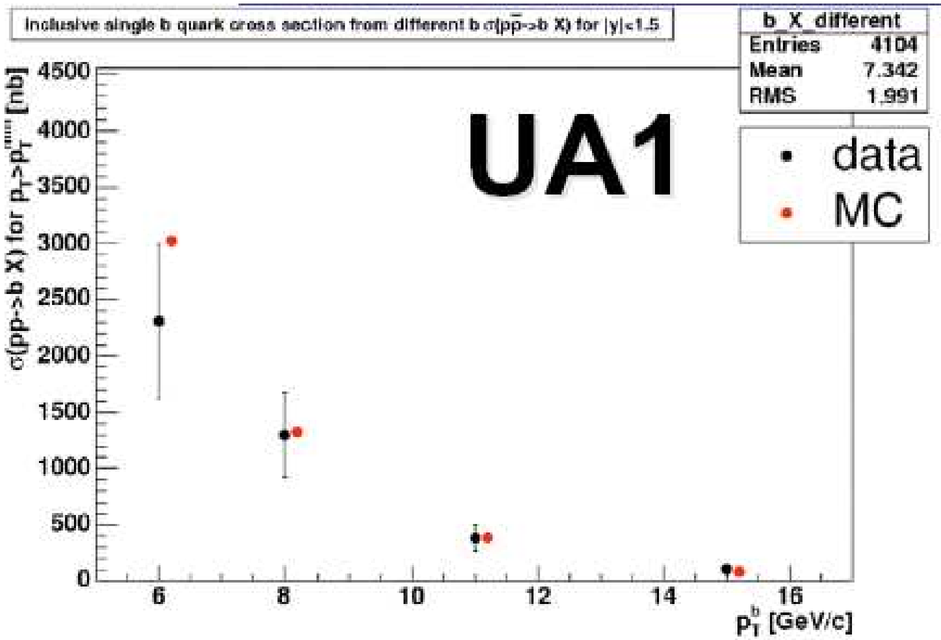
- **Compared to Herwig and Pythia:**
  - **inclusive mode with b from massless matrix elements**
  - **PDFs: CTEQ5L (p) and GRV LO** (γ)
  - $p_T^{\mathrm{MIN}} = 3$**GeV**
  - **MC normalization fixed from High** E_T **jets at HERA (1.45/1.7 for Pythia/Herwig)**

Pythia describes ZEUS data well, including x_γ

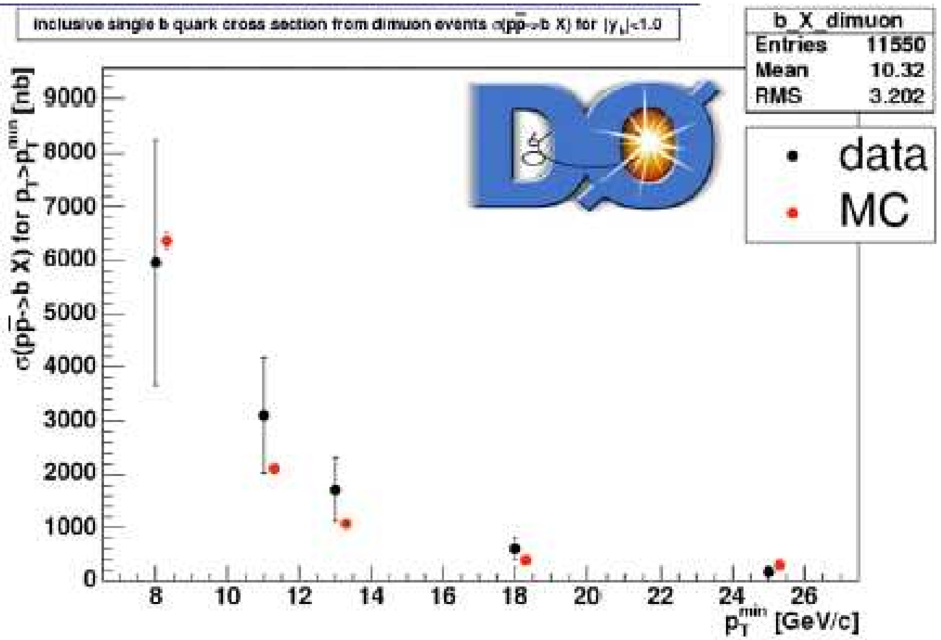


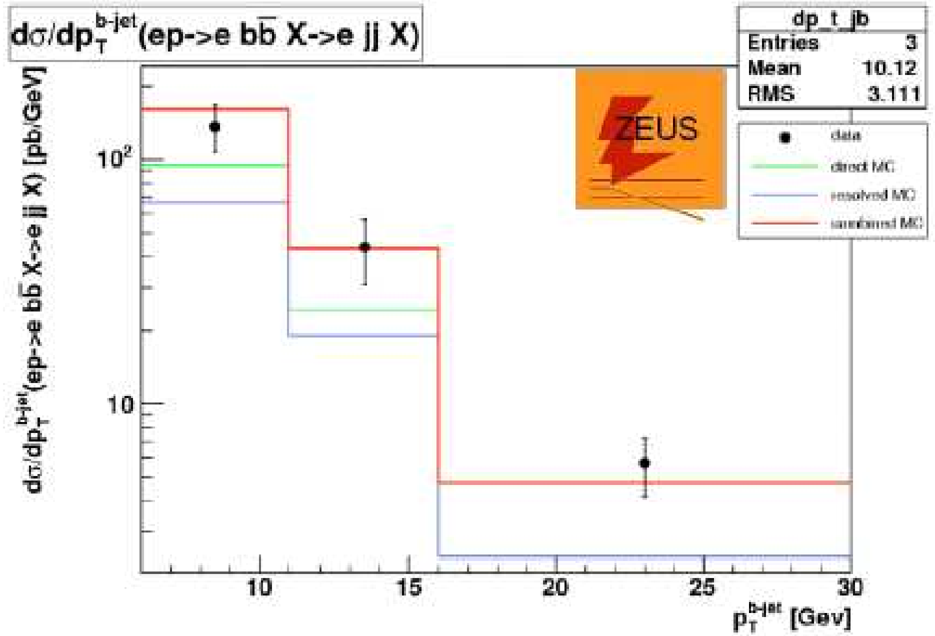
UA1 and D0 data reasonably well described by Pythia Herwig too low

UA1, D0, ZEUS data described by a Pythia with the same parameters

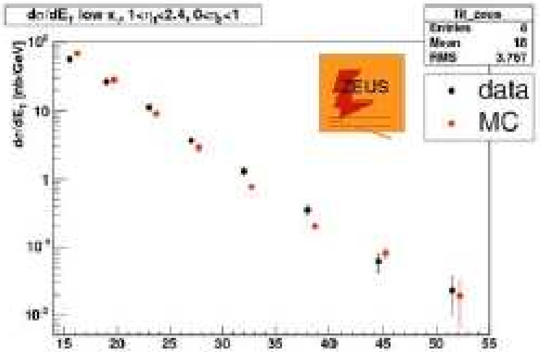


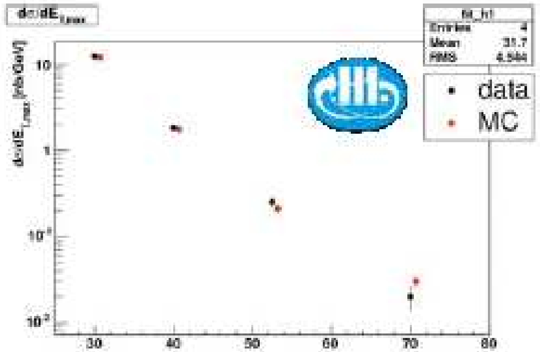
PYTHIA





- good simultaneous description of UA1 and D0 results and HERA-jet cross sections





Possible extensions for this Workshop

JetWeb:

- **Add other measurements**
- **Interface to other theoretical predictions (NLO ?)**

The same Pythia tuning gives a good description of b production at HERA/Tevatron/$Sp\bar{p}S$

- **what are the predictions for LHC ?**
- **how this tuning compares with Pythia tunes used by LHC collaborations ?**

Fragmentation of c and b, the experimental side

Fragmentation is a key ingredient for HQ calculations at HERA and LHC (see M. Cacciari's talk)

How can we understand it better and reduce uncertainties ?

- **Use e^+e^- data to get the best knowledge (fits)**
- **Evaluate uncertainties from fragmentation**
- **Check universality of HQ fragmentation by measuring it at HERA (and LHC ?)**

Charm fragmentation (M. Wing)

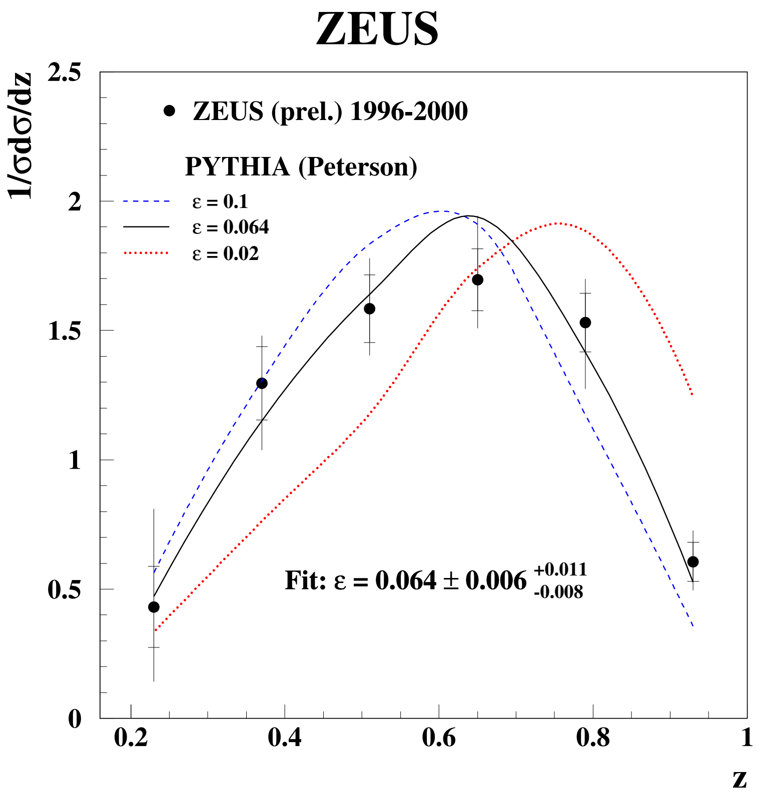
Existing measurements (corrected to hadron level)

Experiment	$\sqrt{s}$ (GeV)	corrected?
ARGUS	10.6	YES
CLEO	10.55	YES
OPAL	91	NO
ALEPH	91	NO
TPC	29	YES
DELCO*	29	(YES)
TASSO	$28 \to 46.8$	YES
HRS	29	YES
JADE	$29.9 \to 38.7$	YES
ZEUS	> 18 (~ 30)	YES

Possible program: Use e^+e^- data to

- Check consistency of data sets within Pythia, fit best parameters in Pythia
- Try NLL theory
- Measurement at HERA possible (see next page)

Charm fragmentation at HERA



ZEUS measurement:
D^*+jet photoproduction

measure $z = \frac{(E-P_{\rm par})_D}{(E-P)_{\rm jet}}$

Compare to MC with different fragmentation models and parameter

Compare also with NLO ?
needs hadronization correction

Jets introduces typical jet uncertainties: hadronization, energy scale etc.

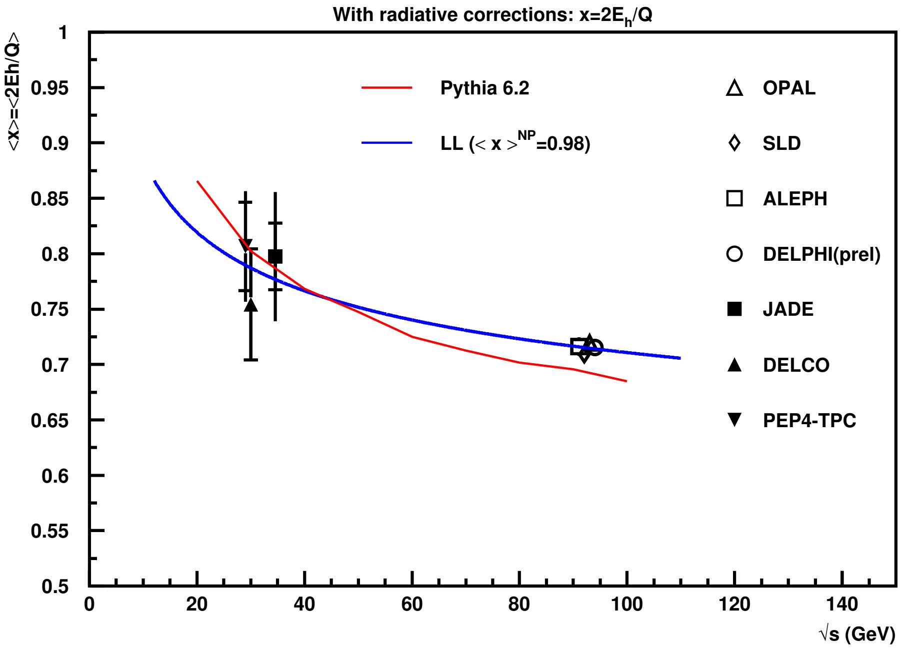
Alternative: semi-inclusive observables in DIS

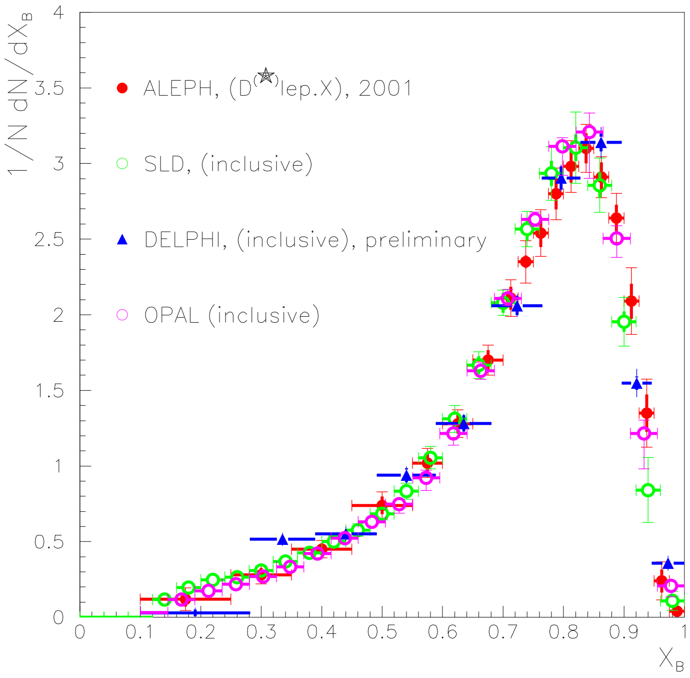
$$z' = \frac{p_D \cdot P}{q \cdot P} = \frac{(E - P_z)_D}{2yE_e}$$

quark-parton-model: $z' = E_D/E_c$ in the proton rest frame
equivalent to $x_E = 2E_D/E_{\rm beam}$ in e^+e^- at $\mathcal{O}(\alpha_S^0)$, no jet involved
Directly comparable to NLO (FONLL ?) calculations.

Beauty fragmentation (M.C.)

Beauty data from e^+e^-: $\langle x_E \rangle$ from low energy, $f(x_E)$ from LEP/SLD





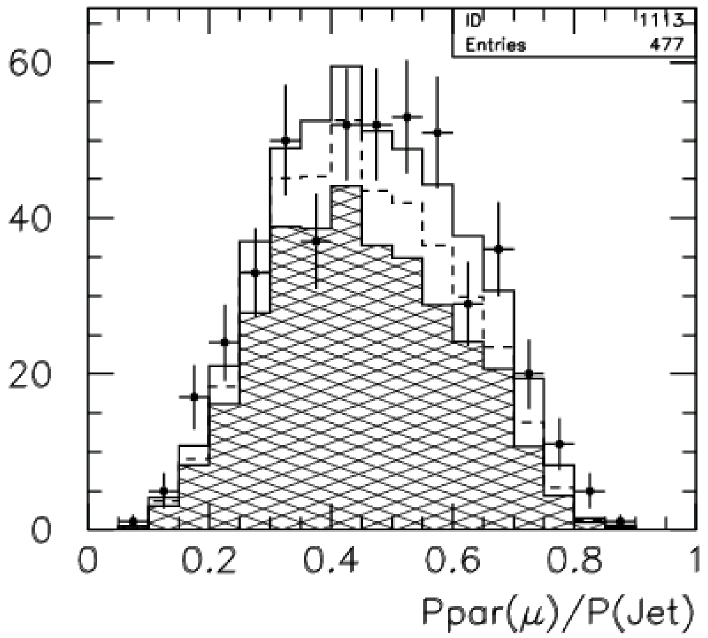
what can be done:

- **Global Fit of all the e^+e^- data with Pythia and NLL theory**
- **Can it be measured at HERA ?**
- **Study the dependence of HERA/LHC observables on fragmentation**

Beauty fragmentation from HERA ?

Possible techniques:

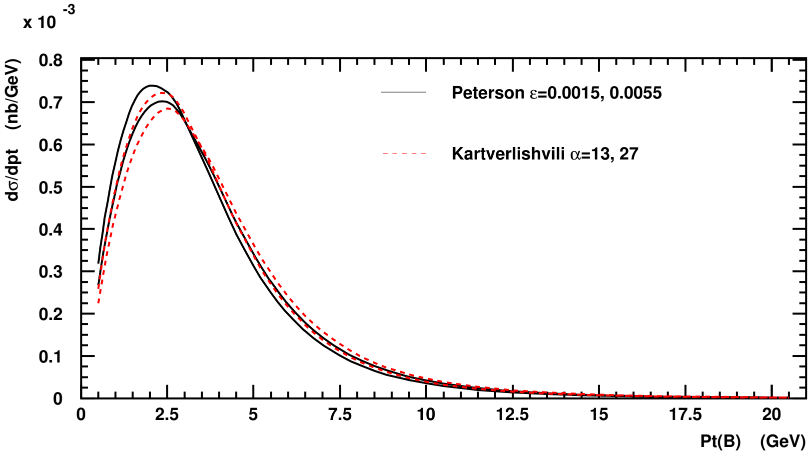
1. **From leptons:**
   Measuring $z = P_\mu / P_{\rm jet}$ in b events with a muon and a jet.
   Feasible but not very sensitive, $f(x)$ smeared by $b \to lX$ decay
   Probably only an estimate of $\langle z \rangle$ within a given model
2. **From reconstructed B hadrons (a la ALEPH):**
   probably not enough statistics
3. **From inclusive B hadron tagged with secondary vertices (a la OPAL/SLD/DELPHI):**
   need high-energy jets (high-Q^2 ?) to get sufficient boost
   not obvious, feasibility needs to be studied

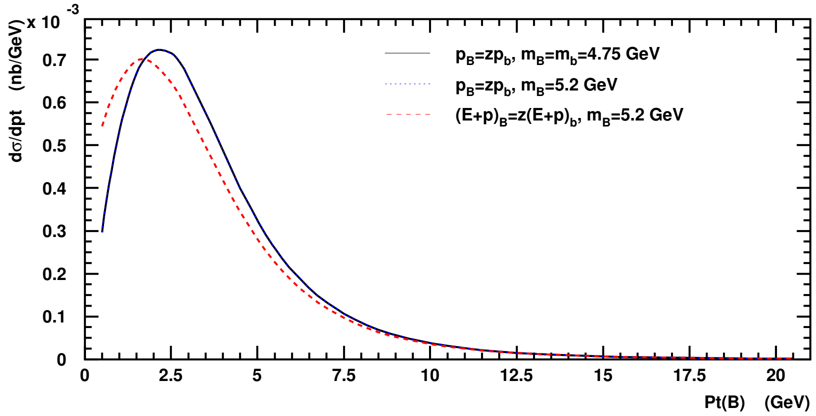


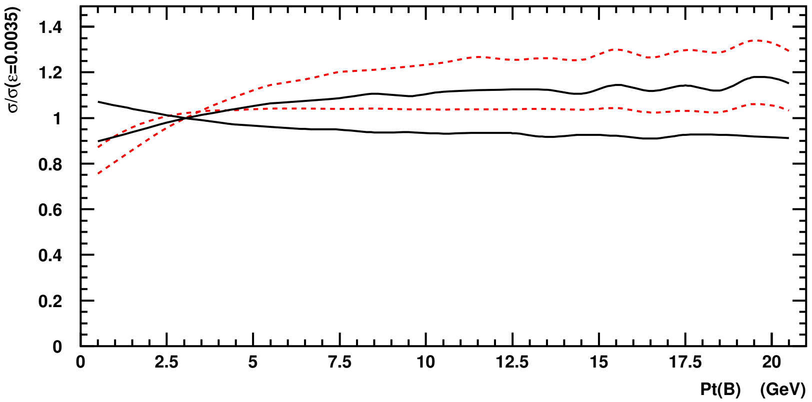
$z = P_{par}(\mu)/P(jet)$ **for dijet+μ events**
110 pb^{-1}
$p_T^\mu > 2.5$ **GeV**
$p_T^{\rm jet} > 6,7$ **GeV,** $p_T^{\rm rel} > 2$ **GeV**
Histogram=Pythia
(shaded = b)

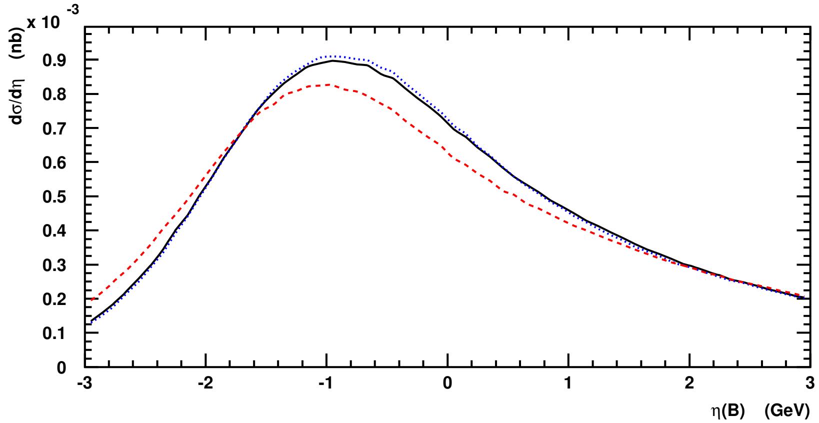
Uncertainty from b fragmentation

NLO prediction for HERA (FMNR)









different choices of fragmentation effects of up to $\sim 20\%$ at large p_T

different choices of z variable:

-$z = (E - p_{par})_H / p_Q$

-$z = p_{had}/p_Q$ in a particular frame

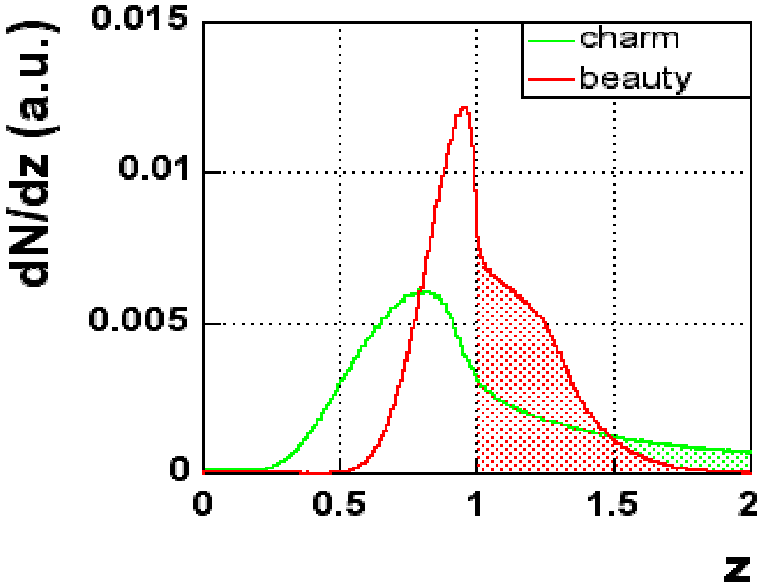
large differences at low P_T

Non perturbative effects may be large!

Beauty fragmentation at Alice (G. Guernane)

- Alice forward muon spectrometer covers
  $2.5 < y < 4$ and low p_T
  Region very sensitive to non-perturbative effects!

Fragmentation in Pythia $z > 1$ due to beam-drag effect:

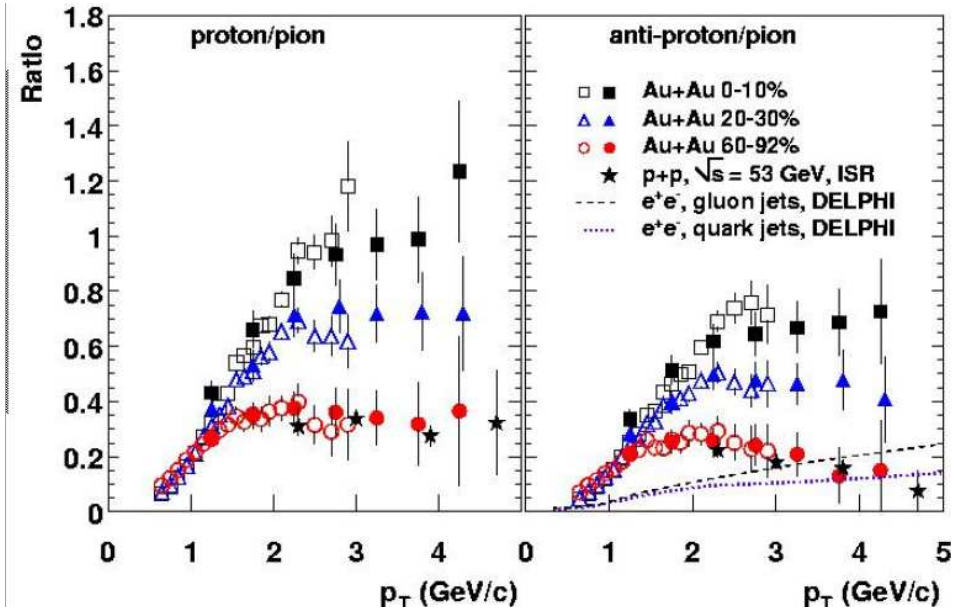


Can this be measured experimentally ?

Beauty fragmentation at Alice: Heavy Ions

- **Nuclear corrections to PDFs**
- **Energy loss in nuclear matter**
- **Screening effects on quarkonia**
- **Hadronization via coalescence**

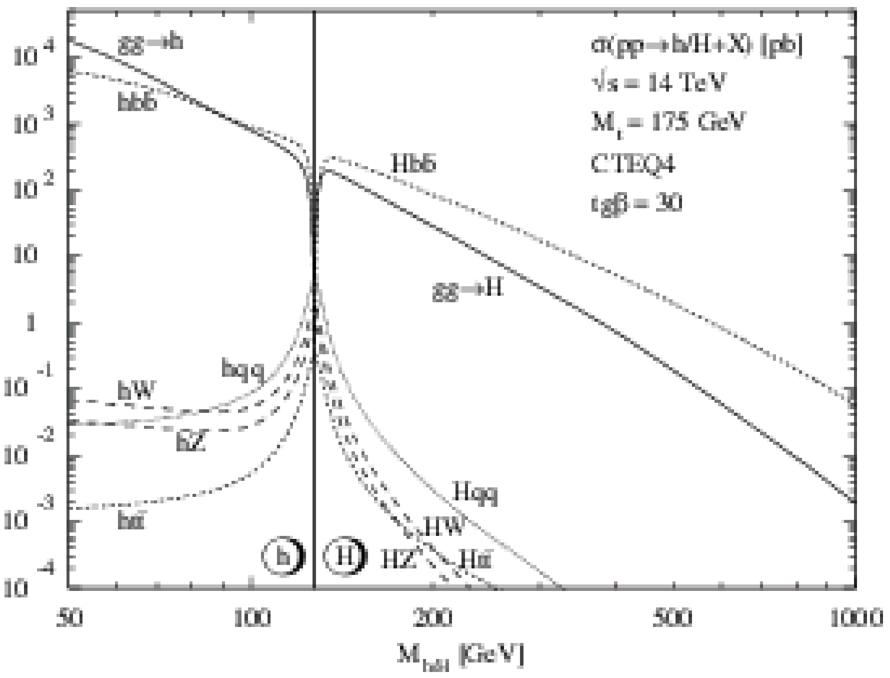
Anomalous ratio $p/\pi \sim 1$ at RHIC:

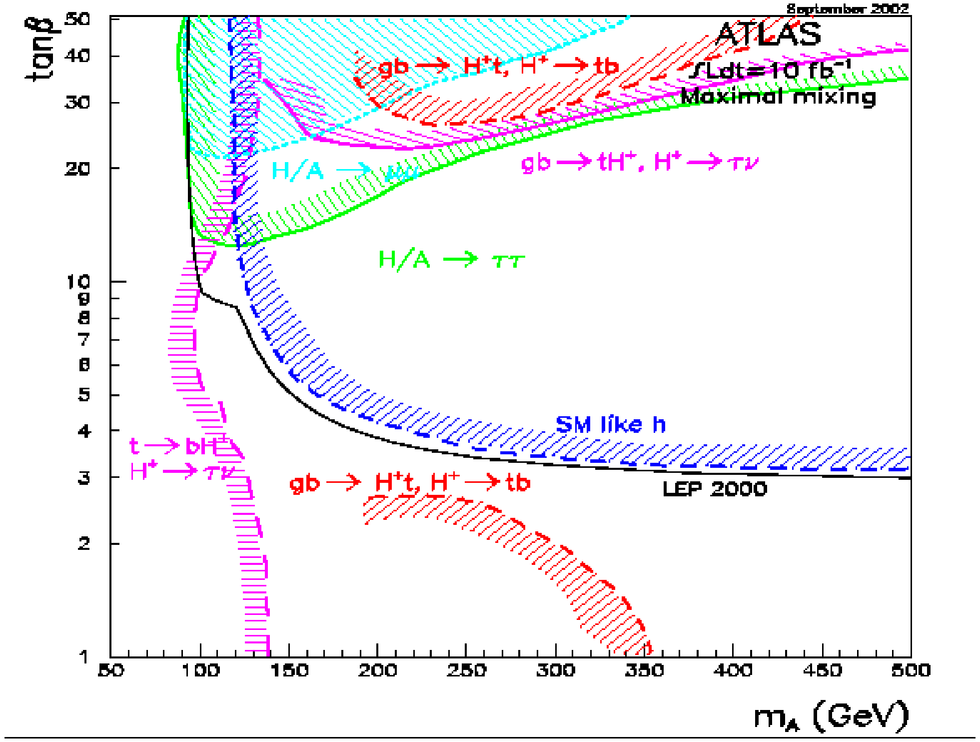


$H \to \tau^+\tau^-$ from $Hb\bar{b}$ (Z. Was)

MSSM:

for large $\tan\beta$ Higgs produced mainly via $gg \to H/Ab\bar{b}$ and decays into $H/A \to \tau^+\tau^-$





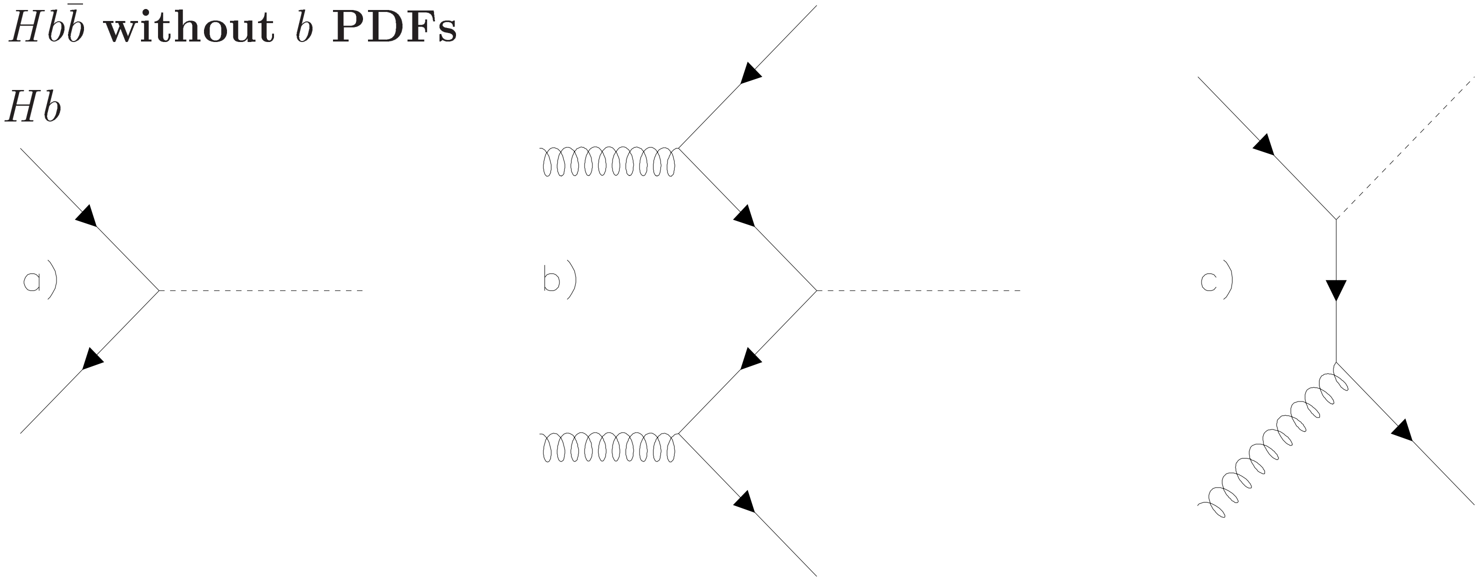
$H \to \tau^+\tau^-$ from $Hb\bar{b}$

$hb\bar{b}$ **production can be calculated using different approaches:**

a) $b\bar{b} \to H$ **using** b **PDFs**

b) $gg \to Hb\bar{b}$ **without** b **PDFs**

c) $gb \to Hb$



Total cross section for $gg \to hb\bar{b}$ **(at NLO) and** $b\bar{b} \to h$ **(at NNLO) in agreement (see F. Maltoni's talk).**

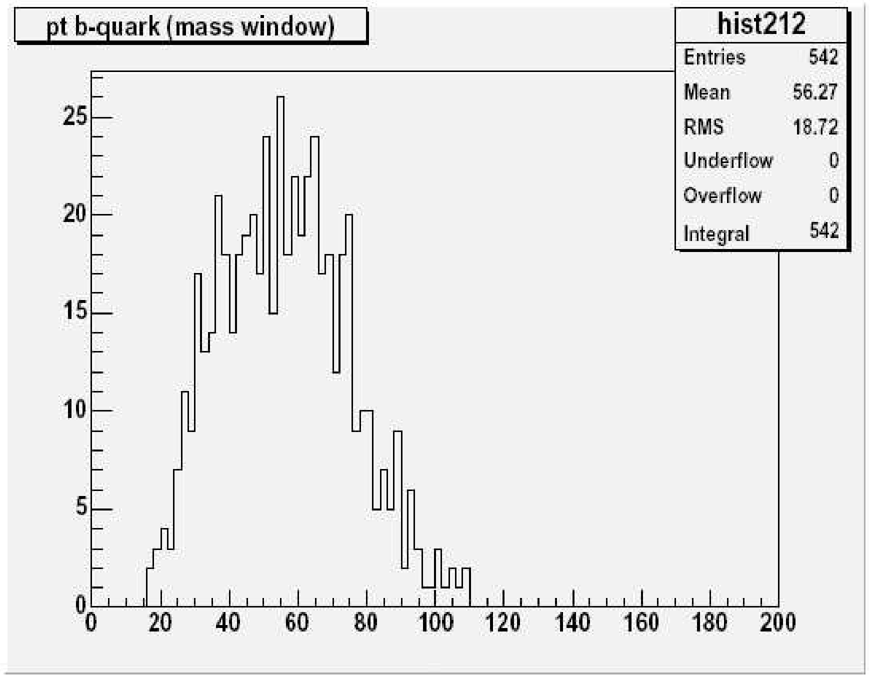
BUT
Experimental acceptances depend on details of the event topology . . .

Study based on PYTHIA+TAUOLA+AcerDET (Z.Was)

Selection	$b\bar{b} \to H$	$gb \to bH$	$gg \to b\bar{b}H$	$gg \to H$	$--$
1 iso ℓ, $p_T^{\ell} > 20$ GeV 1 τ-jet, $p_T^{\tau-jet} > 30$ GeV	$19.5 \cdot 10^{-2}$	$19.3 \cdot 10^{-2}$	$19.7 \cdot 10^{-2}$	$19.5 \cdot 10^{-2}$	
PARTICLE level					
resolved neutrinos	$16.6 \cdot 10^{-2}$	$16.6 \cdot 10^{-2}$	$16.9 \cdot 10^{-2}$	$16.9 \cdot 10^{-2}$	A
$\lvert sin(\Delta\phi_{\ell\ \tau-jet})\rvert > 0.2$	$9.4 \cdot 10^{-2}$	$10.4 \cdot 10^{-2}$	$9.4 \cdot 10^{-2}$	$10.4 \cdot 10^{-2}$	
$m_T^{\ell,miss} < 50$ GeV	$8.9 \cdot 10^{-2}$	$9.7 \cdot 10^{-2}$	$8.9 \cdot 10^{-2}$	$9.8 \cdot 10^{-2}$	
Additional selection					
$p_T^{miss} > 30$ GeV	$1.3 \cdot 10^{-2}$	$2.6 \cdot 10^{-2}$	$1.8 \cdot 10^{-2}$	$3.5 \cdot 10^{-2}$	
$cos(\Delta\phi_{\ell\ \tau-jet}) > -0.9$	$8.5 \cdot 10^{-3}$	$2.2 \cdot 10^{-2}$	$1.4 \cdot 10^{-2}$	$3.1 \cdot 10^{-2}$	
$R_{\ell\ \tau-jet} < 2.8$	$6.1 \cdot 10^{-3}$	$1.9 \cdot 10^{-2}$	$1.2 \cdot 10^{-2}$	$2.6 \cdot 10^{-2}$	B
DETECTOR level					
resolved neutrinos	$11.0 \cdot 10^{-2}$	$11.6 \cdot 10^{-2}$	$11.1 \cdot 10^{-2}$	$12.5 \cdot 10^{-2}$	C
$\lvert sin(\Delta\phi_{\ell\ \tau-jet})\rvert > 0.2$	$5.9 \cdot 10^{-2}$	$7.1 \cdot 10^{-2}$	$6.5 \cdot 10^{-2}$	$8.2 \cdot 10^{-2}$	
$m_T^{\ell,miss} < 50$ GeV	$5.5 \cdot 10^{-2}$	$6.6 \cdot 10^{-2}$	$6.2 \cdot 10^{-2}$	$7.6 \cdot 10^{-2}$	
Additional selection					
$p_T^{miss} > 30$ GeV	$9.1 \cdot 10^{-3}$	$2.1 \cdot 10^{-3}$	$1.4 \cdot 10^{-2}$	$3.0 \cdot 10^{-2}$	
$cos(\Delta\phi_{\ell\ \tau-jet}) > -0.9$	$6.5 \cdot 10^{-3}$	$1.8 \cdot 10^{-2}$	$1.1 \cdot 10^{-2}$	$2.7 \cdot 10^{-2}$	
$R_{\ell\ \tau-jet} < 2.8$	$4.9 \cdot 10^{-3}$	$1.5 \cdot 10^{-2}$	$9.3 \cdot 10^{-3}$	$2.3 \cdot 10^{-2}$	D

Acceptances in $\tau^+\tau^-$ channel depend strongly on the kind of process: Higgs can be well reconstructed only with some p_T

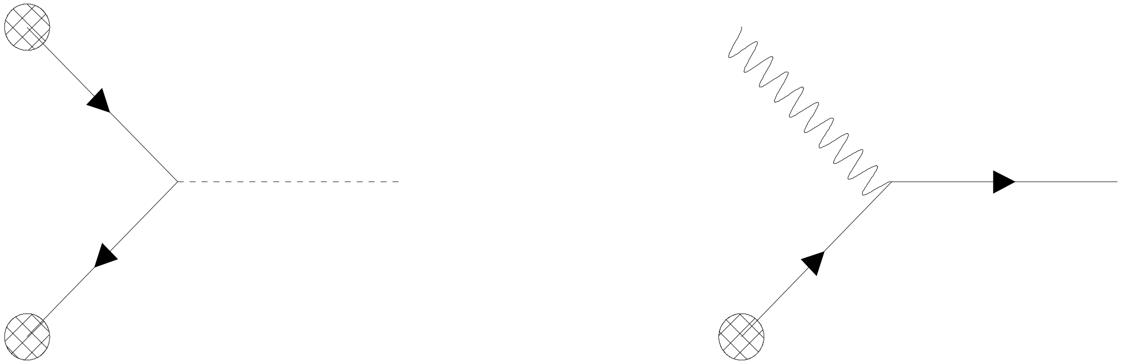
- p_T for a single b (of higher p_T) entering the hard process $b\bar{b} \to H$.



Incoming b p_T spectrum from Pythia is it reliable ?

How to get it right ?

Can Heavy Quark production in DIS at HERA help ?
e.g. tune Pythia to get the p_T^c spectrum in DIS from the process $\gamma^* c \to c$?.



Tentative Conclusion