SFB 676, Project Section B6

STRONG INTERACTIONS AND NEW PHYSICS AT THE LHC

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BACKGROUND

> Title: Strong Interactions and New Physics at the LHC

> Background and aim:

- Strong interaction least well understood building block of Standard Model.
- Still good progress recently by experimental (HERA) and theoretical efforts.
- In-depth understanding of strong force particularly important for search and interpretation of new physics at the LHC.
  → understand better the strong force and implement knowledge in LHC data analysis and interpretation
- Fruitful collaboration of experimentalists and theorists expected.

> People involved in the project section:

- Project leaders J. Bartels (theory) and R. Klanner (experiment)
- Theory: L. Motyka (PostDoc), F. Schwennsen (PhD)
- Experiment: J. Sztuk (PostDoc), TSS (PostDoc), T. Theedt (PhD), A. Bonato (PhD), several diploma students
- Expecting input and contributions from other interested theorists and experimentalists from DESY, CERN, …

WORK PLAN

(i) Precision measurement of the parton distributions in the proton including a reliable estimation of its uncertainties.

(ii) ~~Experimental and theoretical studies of the QCD radiation in the domain of high parton densities at low parton momenta.~~

(iii) Understanding of final states with large rapdity gaps.

(iv) Study of the impact of multiple (secondary) interactions and of underlying events.

(v) ~~Study of jet algorithms at high transverse energies optimizing the information from the tracking detectors and the calorimeter.~~

PRECISION MEASUREMENTS OF PDFs

> HERA: PDFs (with uncertainties) typically from structure function F_2:

– Large uncertainties at high gluon-x > 0.1; correlation between α_S and gluon.

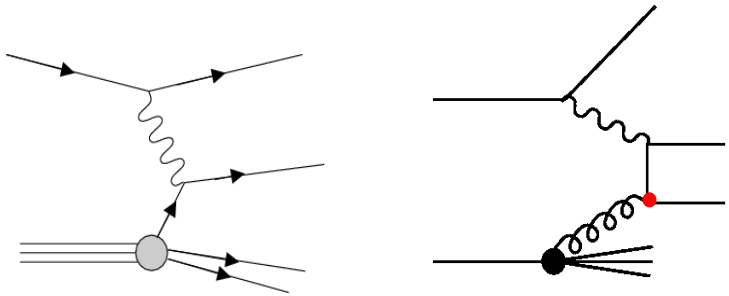
$$\frac{\partial F_2(x,Q^2)}{\partial \ln Q^2} \approx \alpha_s(Q^2) g(x,Q^2)$$

> Use of jet events (DIS and γp)

– would allow decoupling of α_S and gluon;

– allows access to different x ranges;

– allows direct access to gluon density.



> Last ZEUS NLO QCD fit (DESY-05-050) reduced gluon errors significantly.

– see next slide.

> Next steps: Input more final states data:

– Charm and beauty data (heavy flavour structure functions F_2^{cc}, F_2^{bb}, directly sensitive to gluon density),

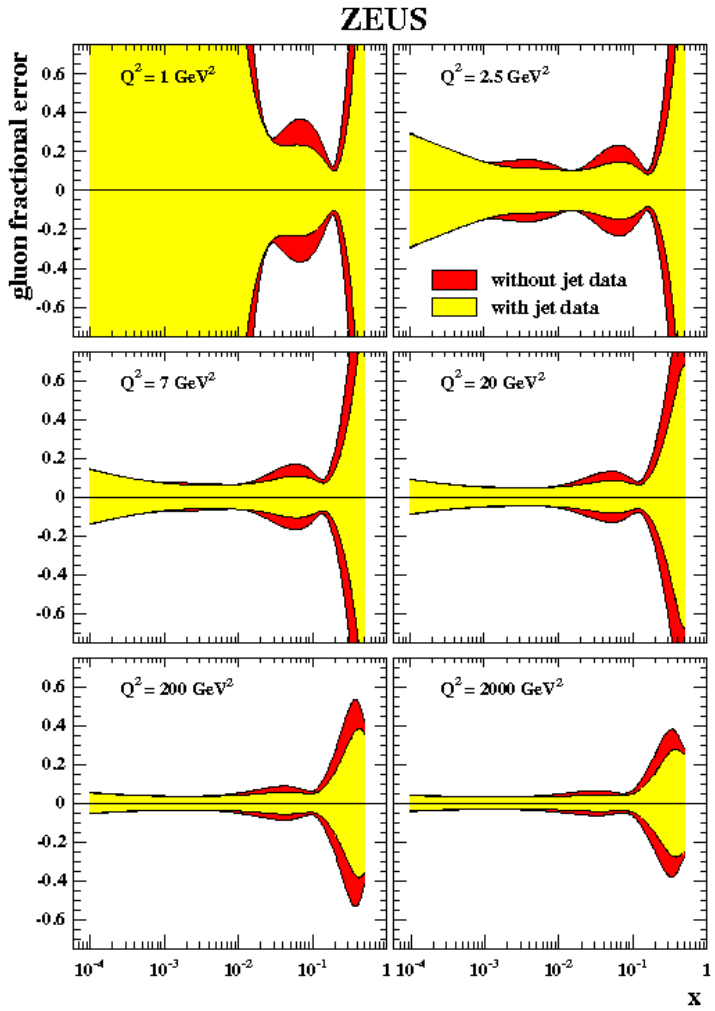
– more and multidifferential jet data,

– charged current data with polarized $e^{\pm}$ beam (also full HERA-II statistics for NC),

– F_L at HERA, W,Z at LHC (next slide)

PRECISION MEASUREMENTS OF PDFs

> ZEUS NLO QCD Fit with(out) jets:
  – fractional gluon uncertainty

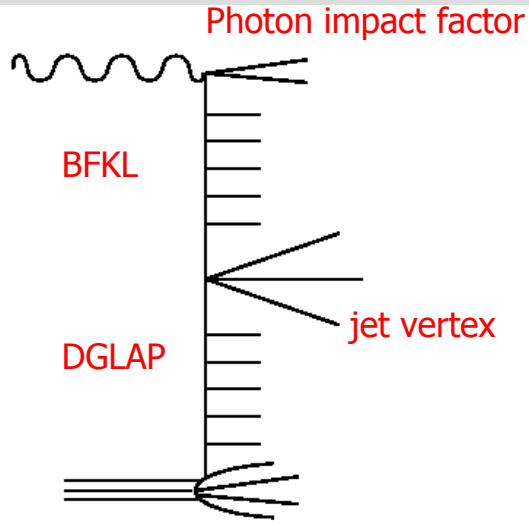


> F_L at HERA
  – longitudinal structure function directly sensitive to QCD effects
  – F_L measurement will be performed at end of HERA running in 2007.

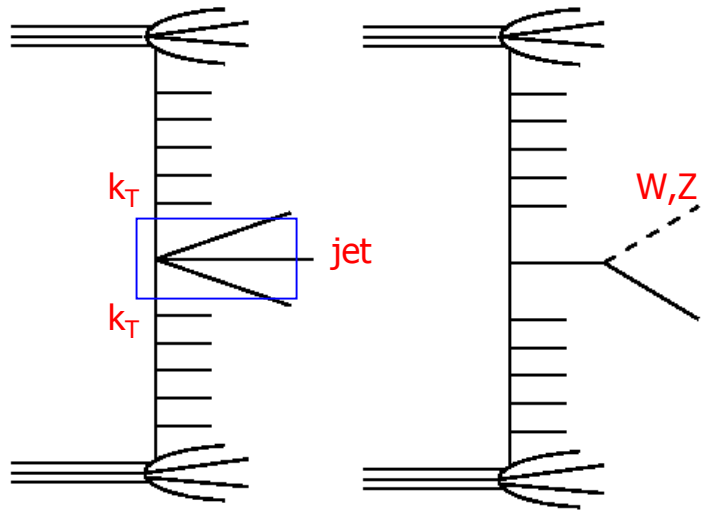
> W,Z at the LHC
  – Cross-sections for W, Z production are among the most precise measurements at the LHC.
  – Also theo. predictions quite precise, and sensitive to proton PDFs.
  – Using cross-section ratios might help reduce unsertainties.

PRECISION MEASUREMENTS OF PDFs

> "Forward jets" and parton dynamics in the proton
  - Deviation from collinear factorisation observed in HERA data; but theoretical situation unsatisfactory: BFKL, resolved photons, higher orders, …?
  - New theory approach based on NLO BFKL evolution; theorists working on combination of ingredients (cast everything into Monte Carlo?)
  - Preparing more studies in HERA-II data.



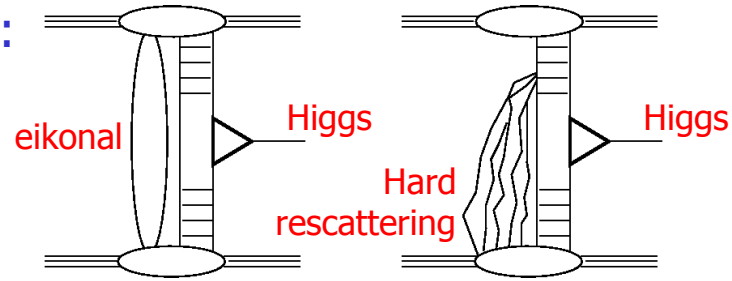
> NLO k_T factorisation at the LHC
  - regions at HERA where k_T factorisation seems advantageous.
  - at LHC jets at smallish k_T and x test case.
  - Also W,Z production interesting (will be needed for detector calibration)
  - Currently being worked on (F. Schwennsen).



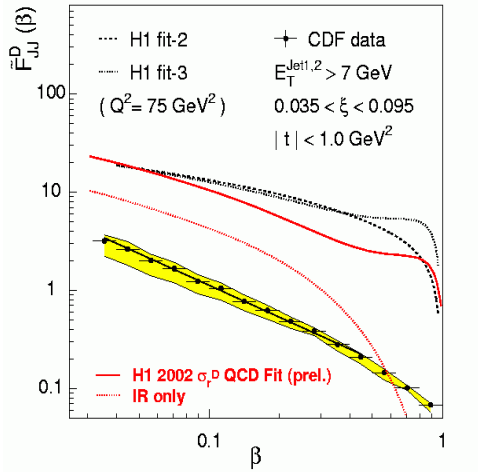
LARGE RAPIDITY GAPS

> Hot issue: LHC double-diffractive Higgs production:
- Tagging of protons would allow precise Higgs mass determination (MeV!).
- Durham: Eikonal model for treatment of soft rescattering.
- But dynamics not accurately modelled?

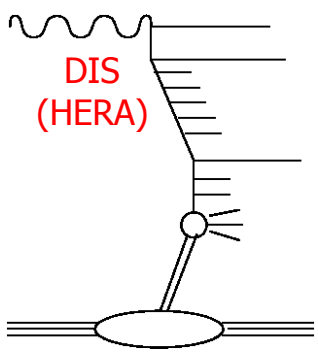
→ try more complete "hard rescattering"
→ better estimate of (small) Higgs Xsection?

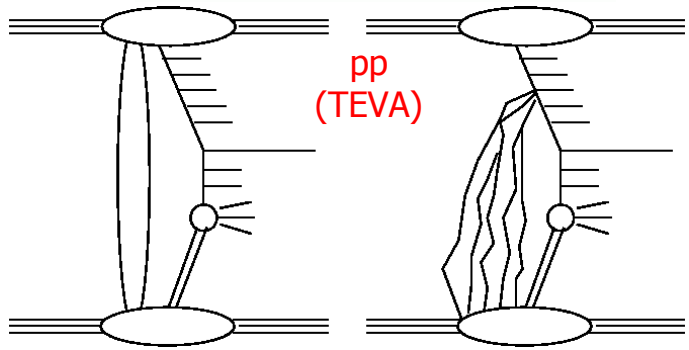


> Evidence: large factor between HERA and TEVATRON diffractive dijets:
- Factor 5-10 needed to bring data to agreement.
- Shape of distributions in agreement?



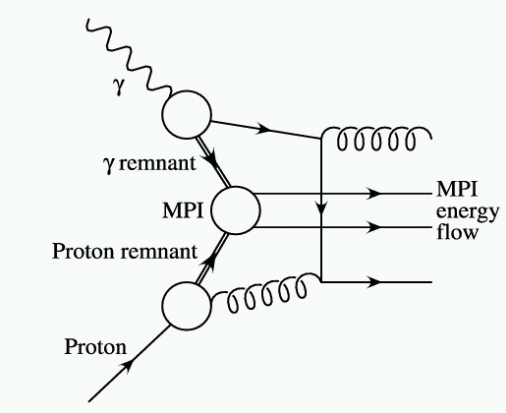
> Possible approach:
- study dPDFs at HERA and LHC
- using for example dijets
- H1 has published dPDFs.
- ZEUS measurement in publication process.

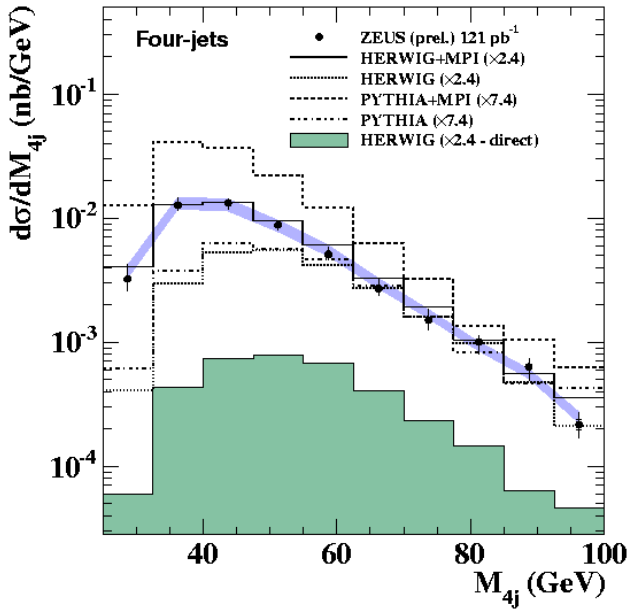




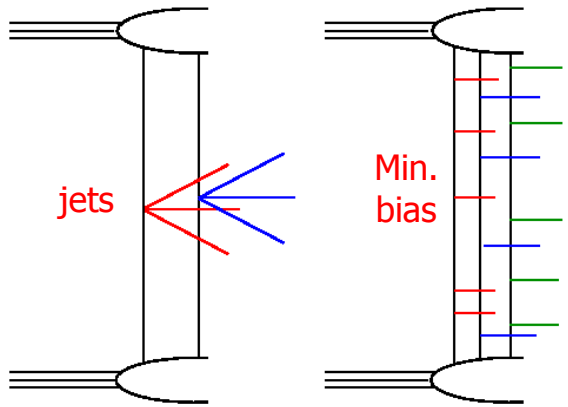
MULTIPLE INTERACTIONS AT HERA+LHC

> Multiple interactions, the underlying event (UE)
- will play major role in many analysis at the LHC
- at HERA: jets in photoproduction, diffraction





> Expected at the LHC (and partly tested at TEVATRON):
- Underlying event in minimum-bias events
- Effect on jets: partons from different interactions?
- Effects on Drell-Yan events, etc.
- Background to new physics (6 b jets events …)



> Activities:
- Measurements of MPI and UE at ZEUS and CMS
- Theory: - Handling of parton-jet relation? Modelling?
  - Deliver constraints to MC builders.

PROJECT SECTION PLANS (SUMMARY)

> Precision measurements of PDFs, understanding of parton dynamics (i):

- Large progress in measurements for x values up to 0.1.
- Now using final states (jets, charm, F_L, CC, W,Z at LHC) to reduce errors.
- forward jets at HERA: deviations from coll. factorisation? BFKL? MC at NLO?
- k_T factorisation in NLO at LHC: jets? W,Z → detector calibration?

> Large Rapidity Gaps (LRG) (iii):

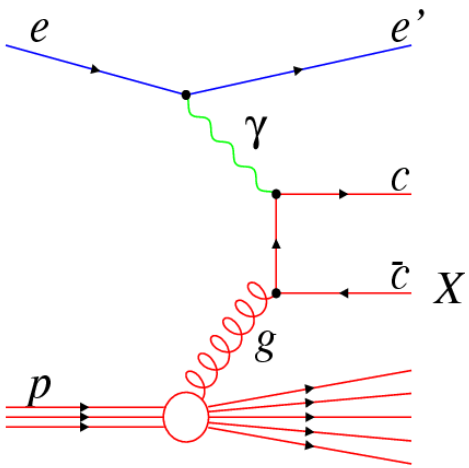
- Eikonal model for double-diffractive Higgs production at LHC receives large attention; alternative approach based on hard rescattering by project members.
- Evidence for necessity: Factor 5-10 between HERA and Tevatron diffractive dijets!
- Study dPDFs at HERA and LHC with different approaches.

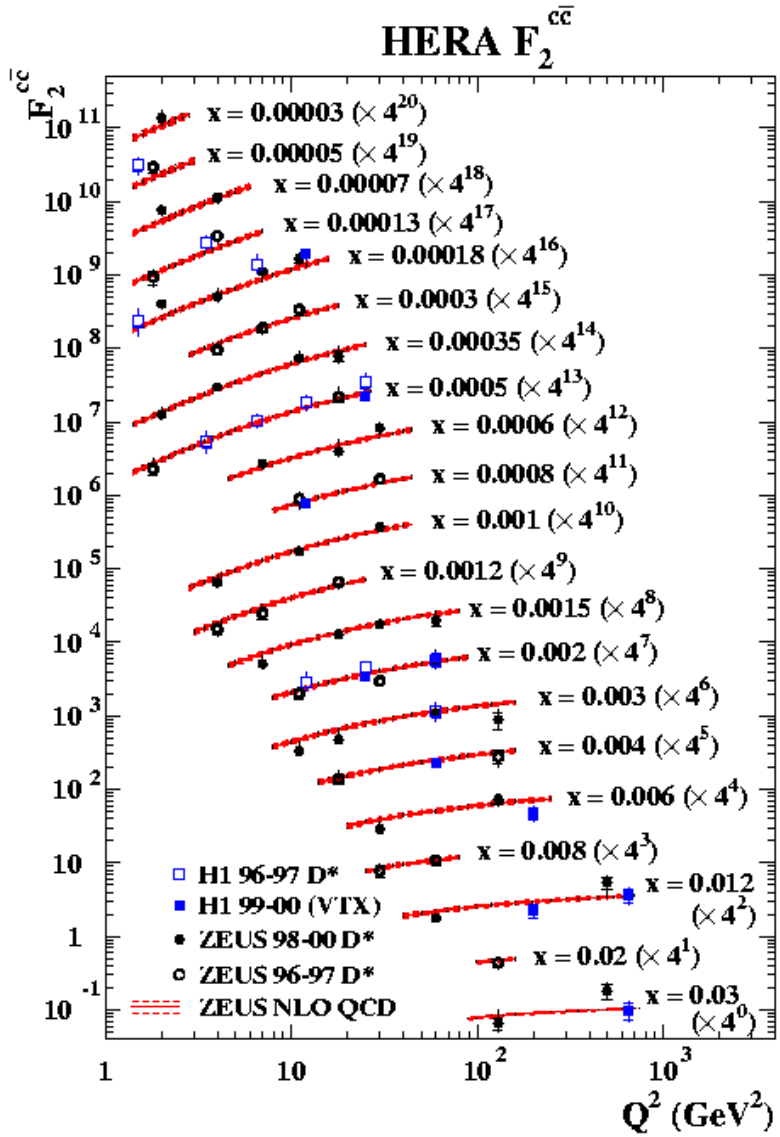
> Multiple Interactions and the "Underlying Event" (iv):

- Multiple interactions are an important issue for many physics processes at LHC.
- Evidence at HERA: Jets in γp, diffractive final states.
- Expected at the LHC: underlying events, jets from multiple interactions, … Question of modelling in MC programs.

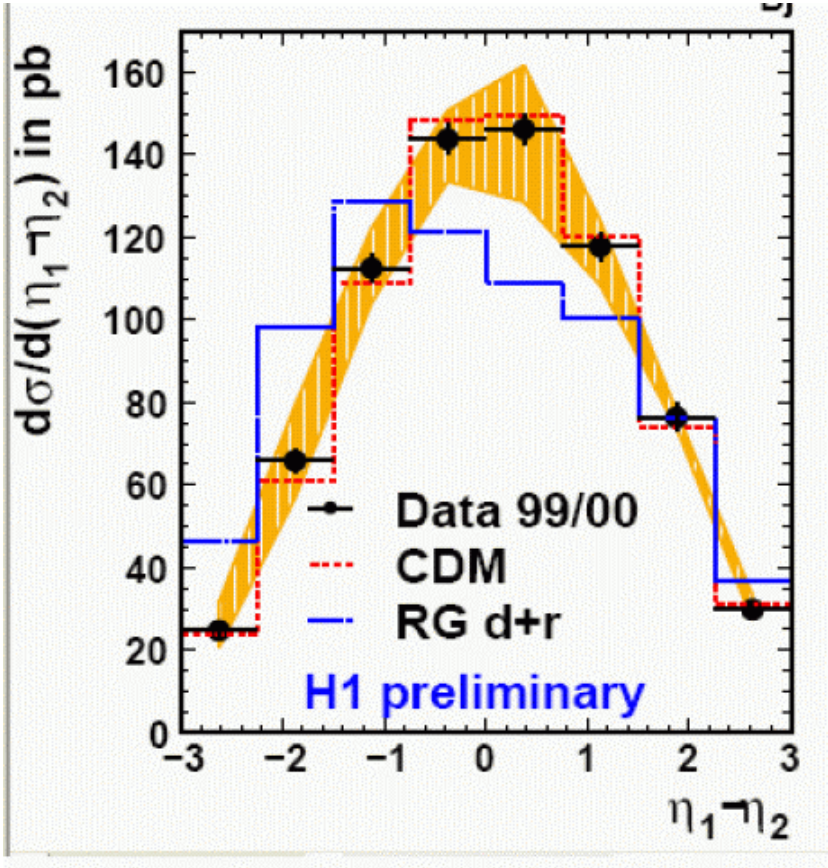
BACKUP

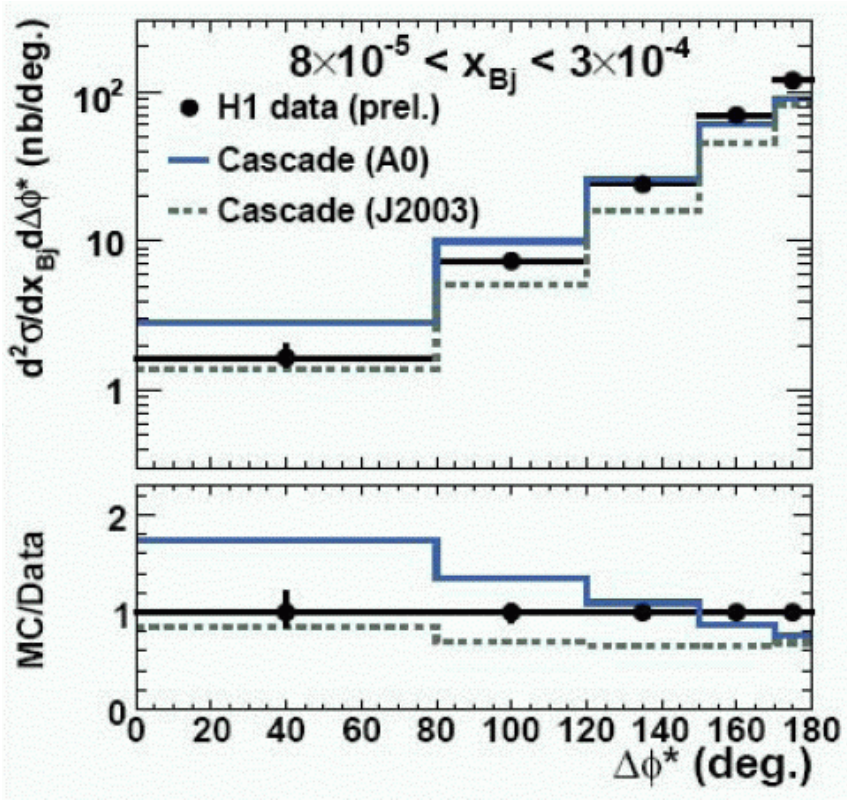
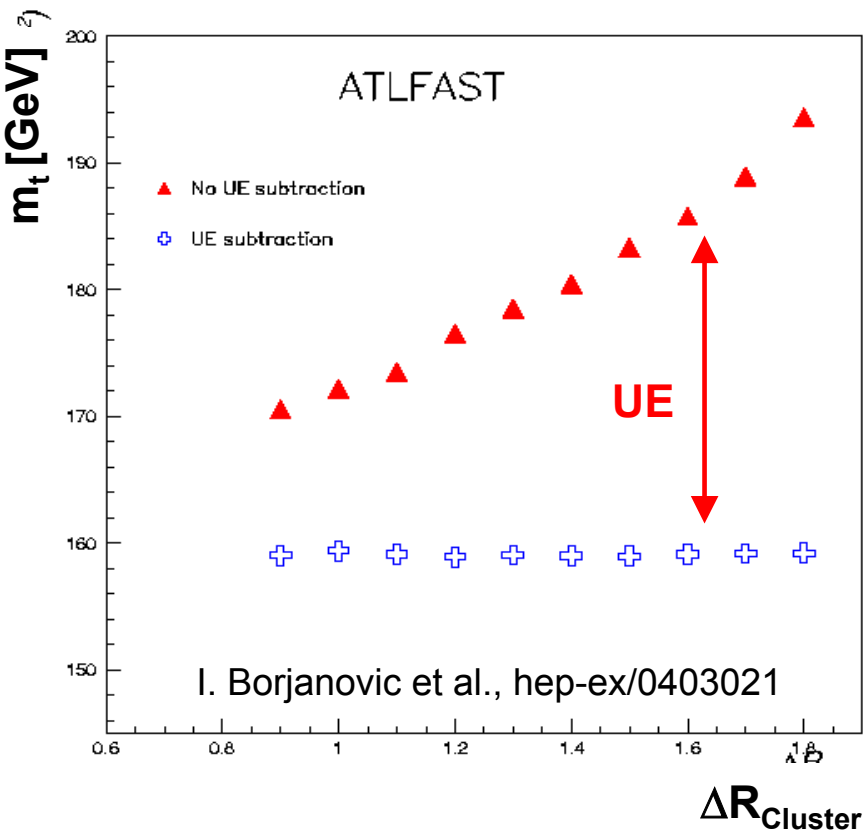
F_2^{cc} AND F_2^{bb}





k_T FAKTORISATION AT HERA





UNDERLYING EVENT AND MPI