

QCD results from the Tevatron

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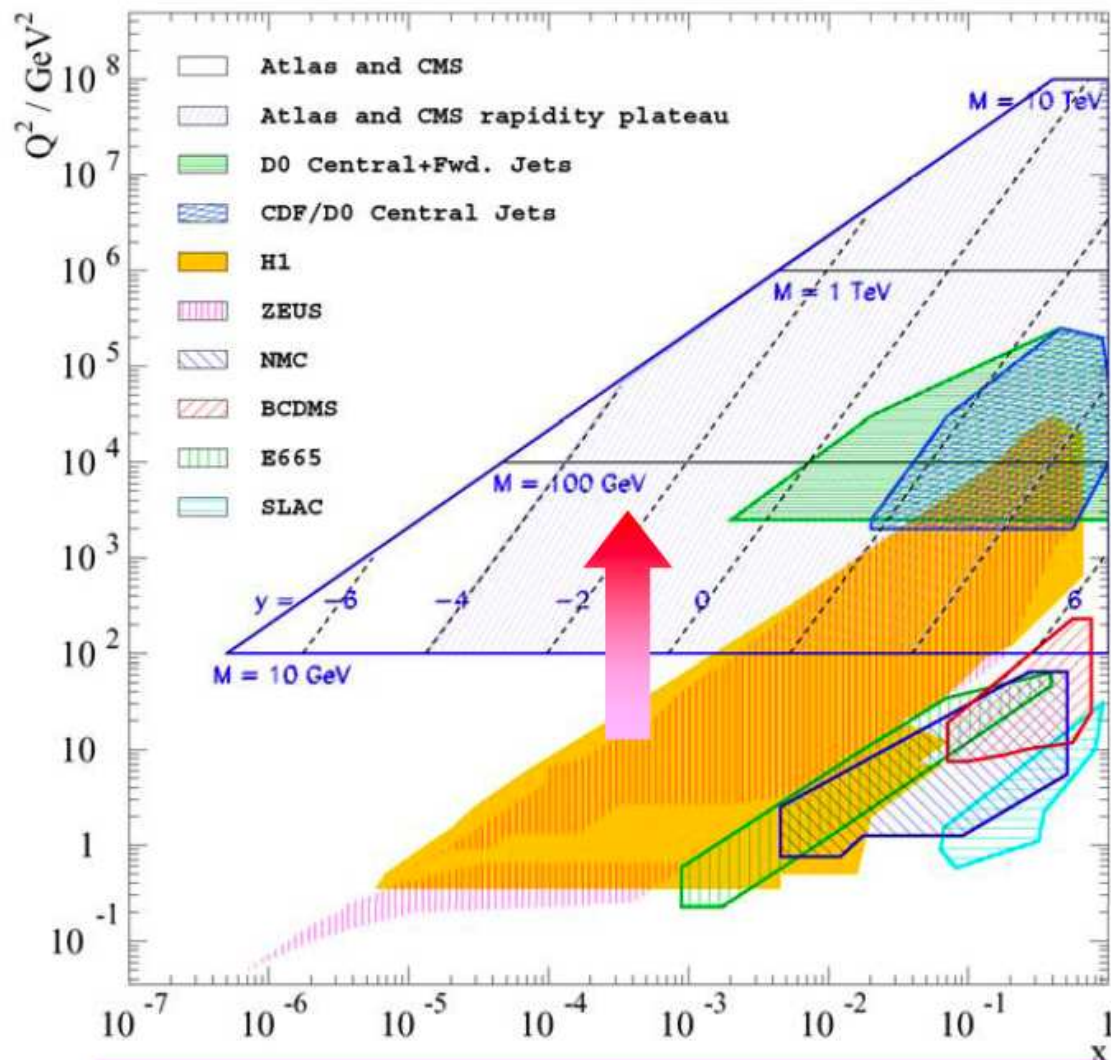
D0 France, Paris, October 13 2008

Contents:

- Jet inclusive p_T cross section
- Dijet angular distributions
- Study of underlying events
- Diffractive exclusive events
- List of D0 France students and post-docs:
 - Alexander Kupčo (Prague/Saclay): dijet mass and inclusive jet p_T cross section (2002 and post-doc in 2003-2004)
 - Pavel Demine (Saclay): dijet mass (post-doc 2003-2004)
 - Jean-Laurent Agram (Strasbourg/Saclay): Inclusive jet p_T cross section (2004)
 - Mikko Voutilainen (Helsinki/Saclay): Inclusive jet p_T cross section (2008)

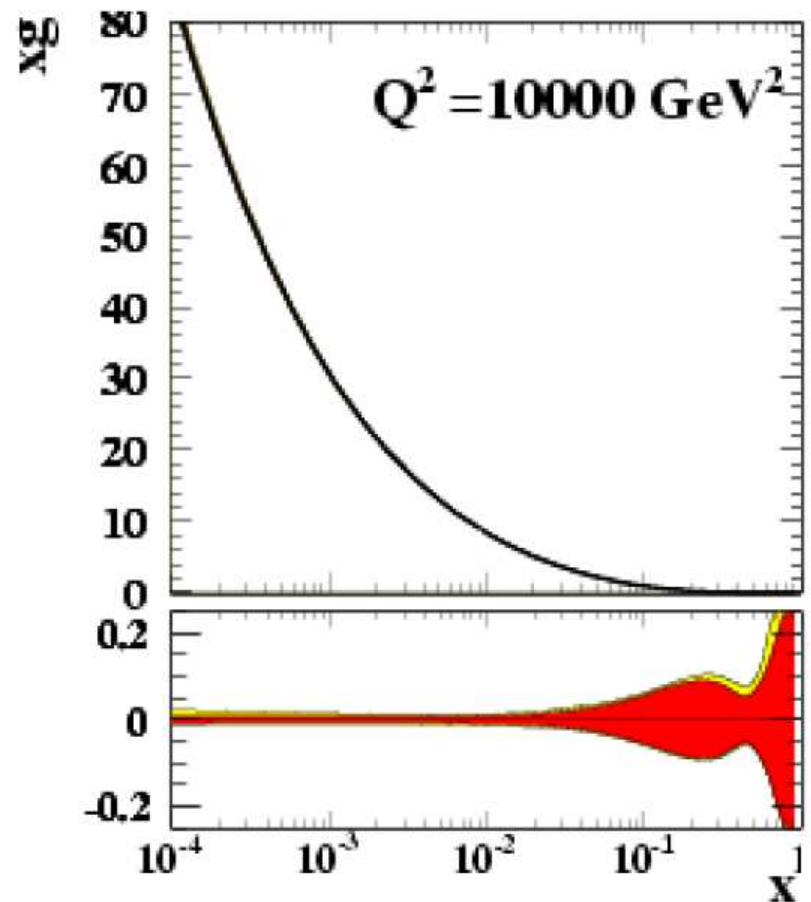
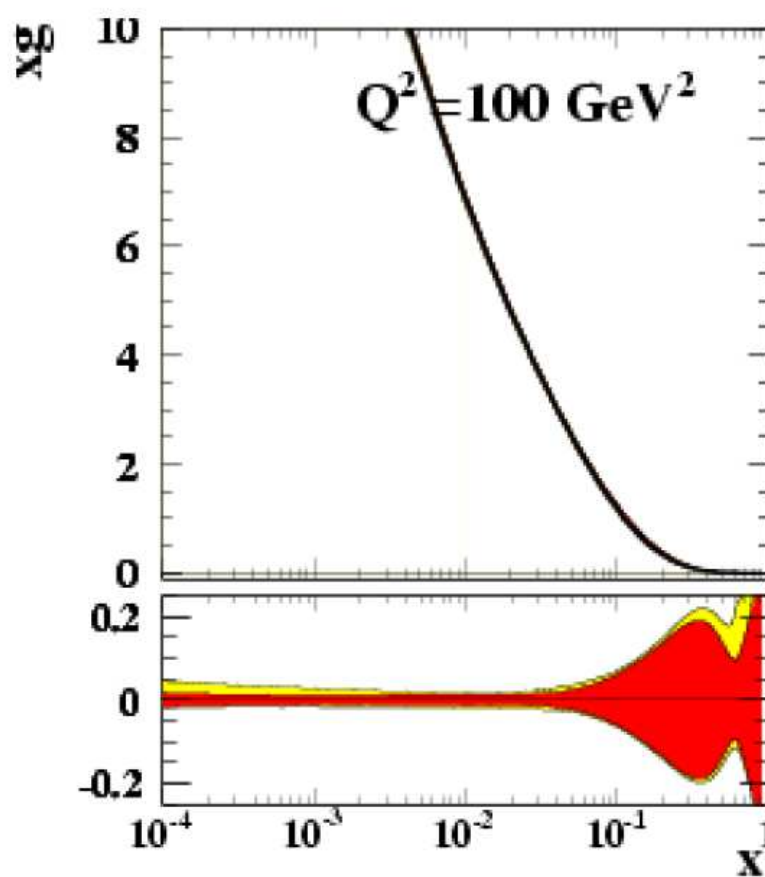
HERA, Tevatron and LHC kinematical planes

- Kinematical plane at HERA, Tevatron and LHC in (x, Q^2) compared to fixed target experiments
- HERA and Tevatron are complementary to constrain PDFs



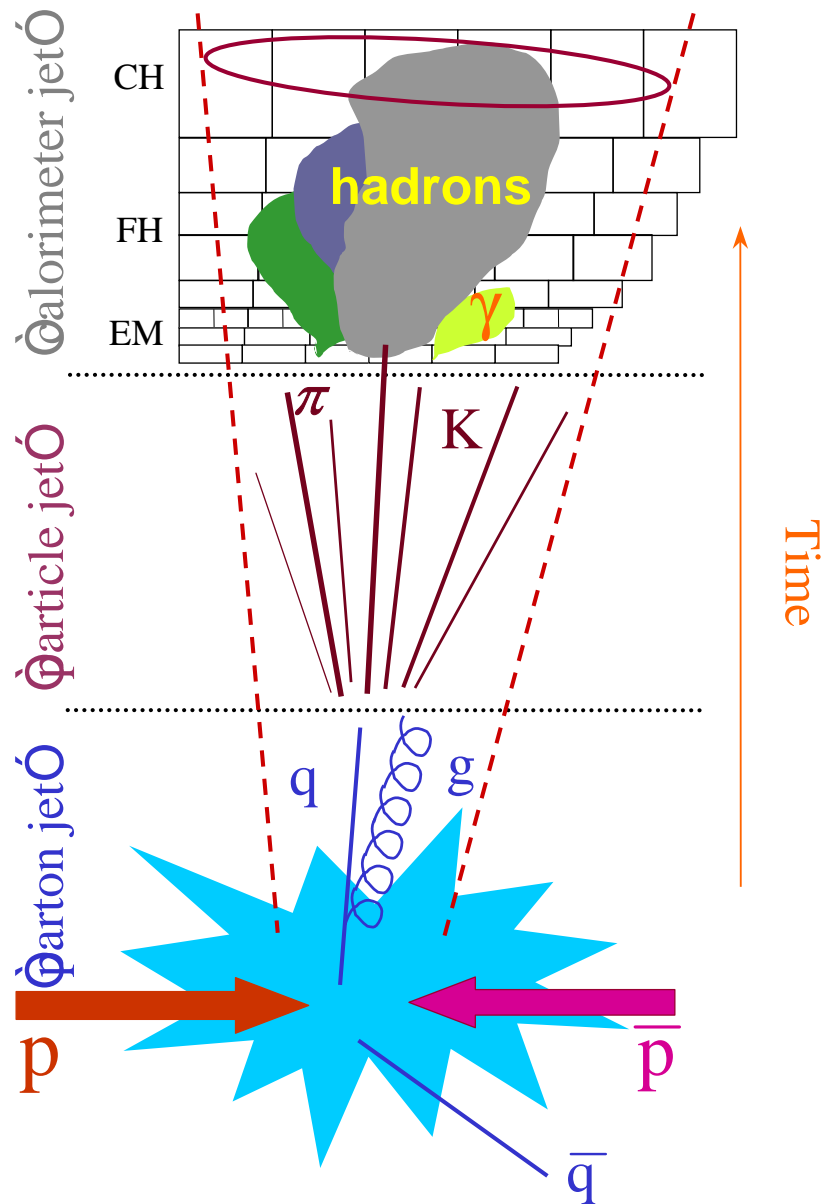
Uncertainty on gluon density

- Large uncertainties on the gluon density measured at HERA at high x : Important for searches at the LHC in jet channels
- Can Tevatron (and then LHC) constrain further the PDFs at high x ?



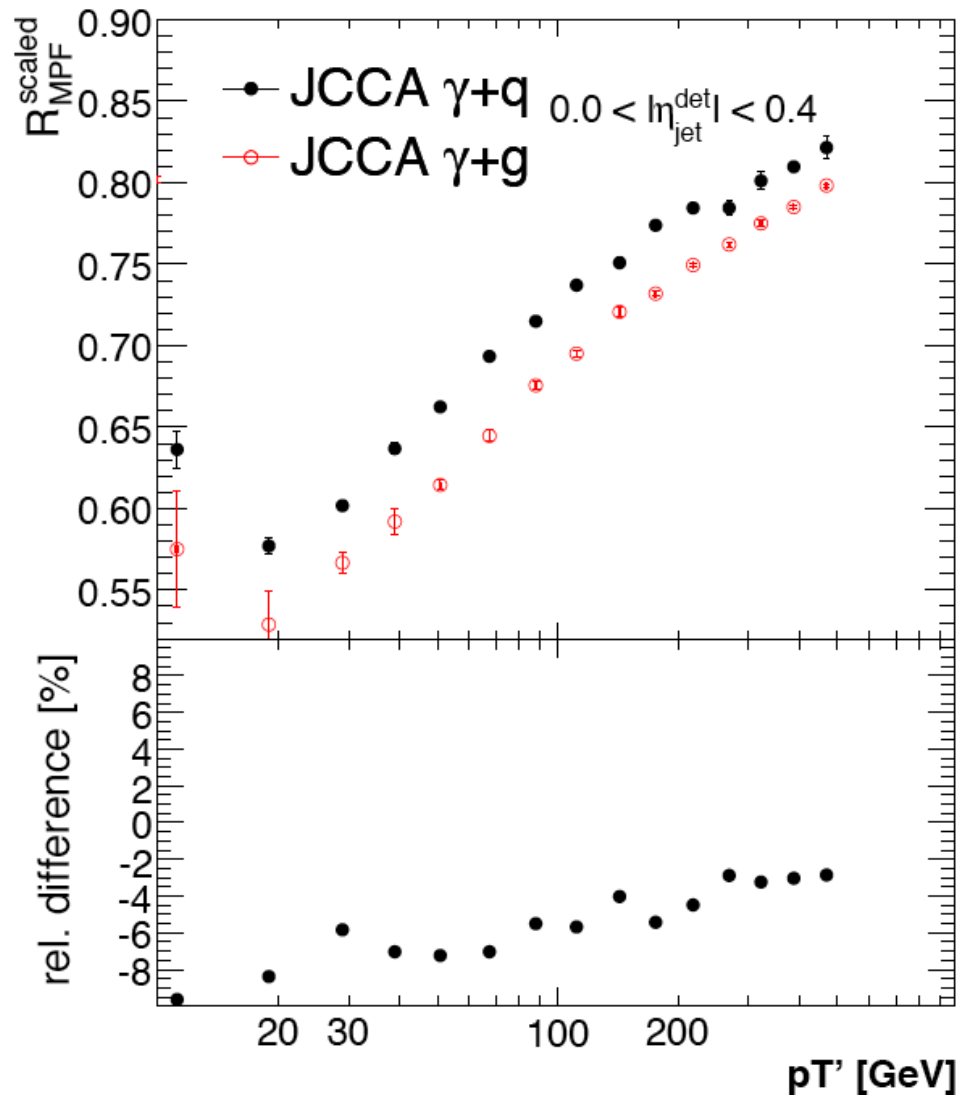
Jets at the Tevatron (and the LHC)

Dominant uncertainty: Determination of jet energy scale in calorimeter: use γ +jet at Tevatron, Z +jets at LHC



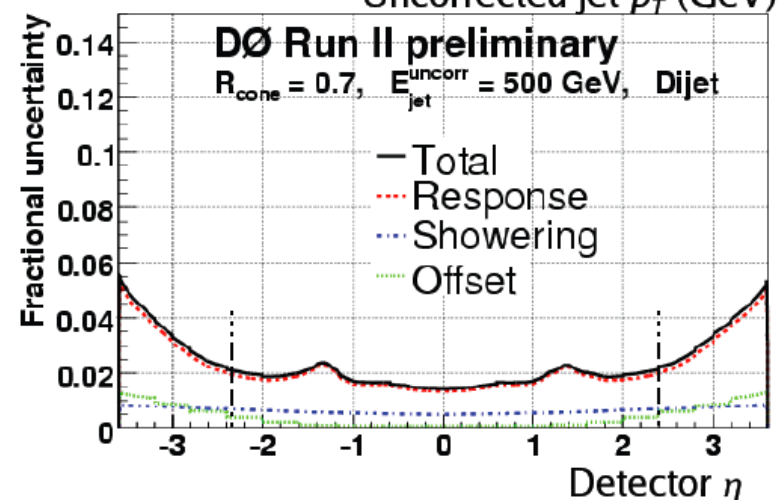
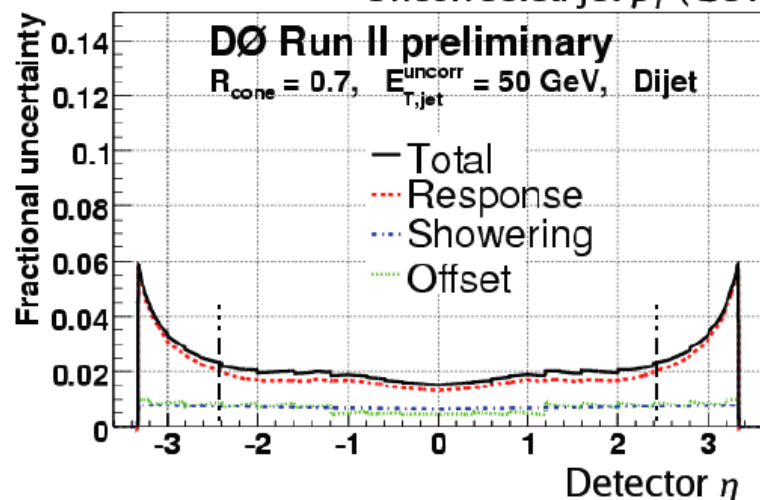
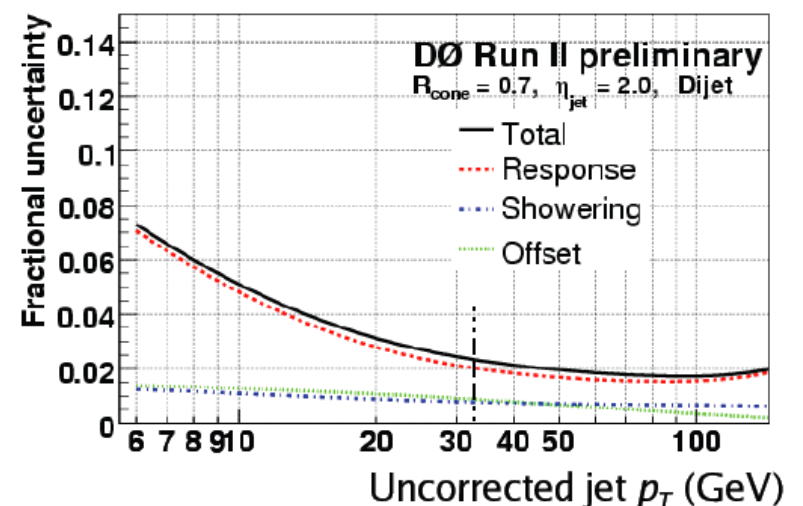
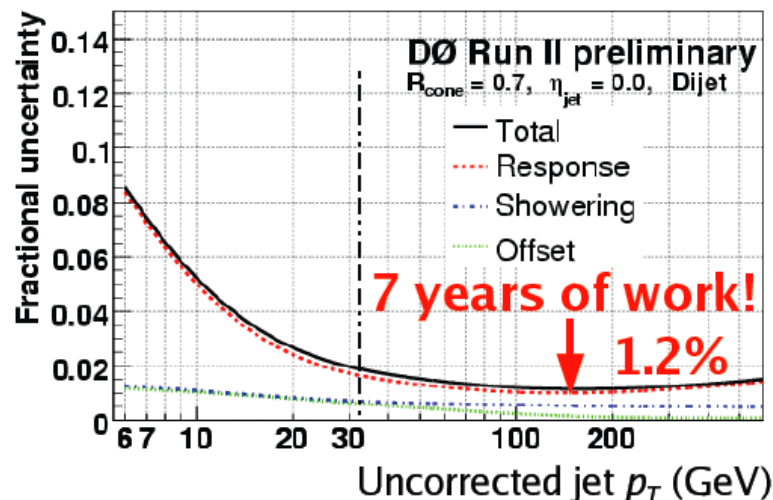
Differences between quark and gluon responses

- Different quark and gluon jet responses (studied in response between quark and gluon using the γ +jet and inclusive jet samples)
- Means different corrections depending on physics: QCD jets (gluon dominated), $t\bar{t}$ events (quark dominated)...



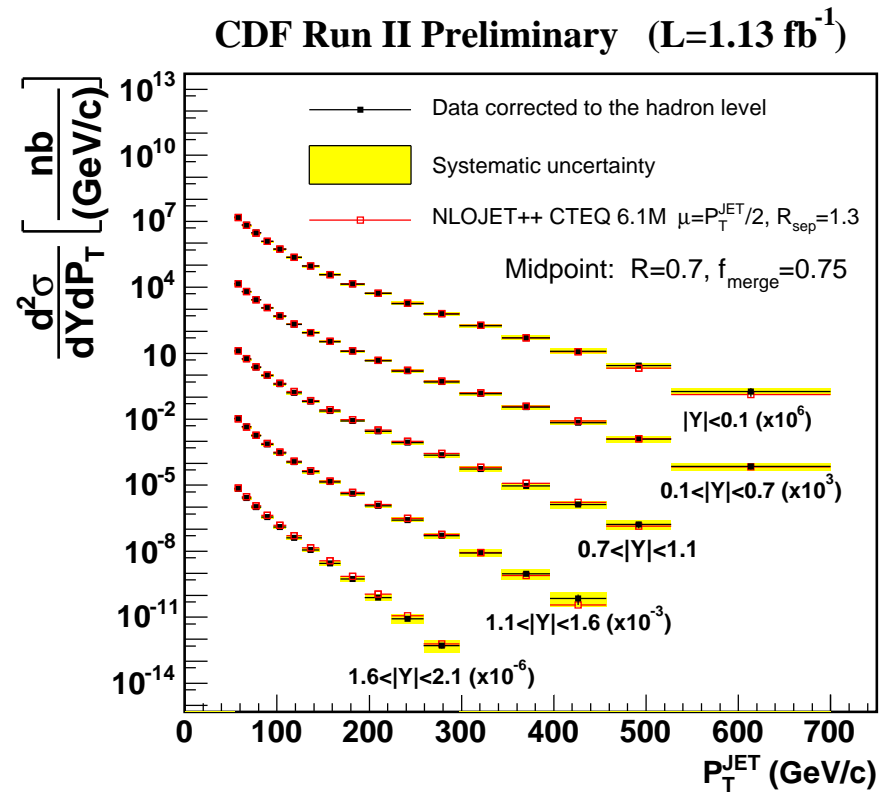
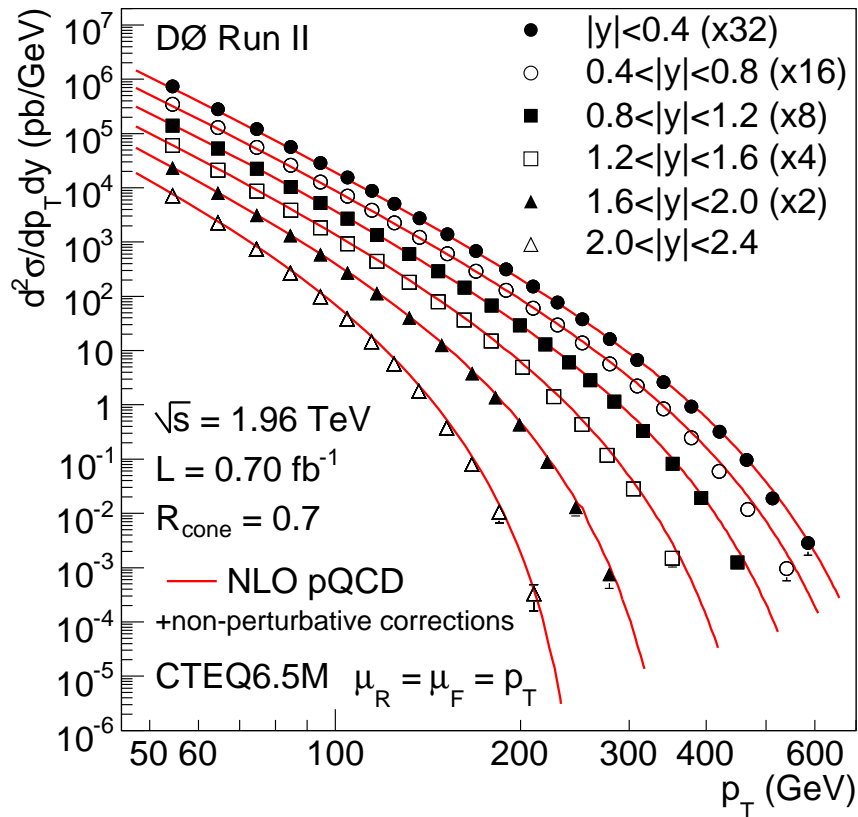
Jet Energy Scale

- “Standard” JES determined using γ +jet
- Corrections for JES for QCD jets obtained using inclusive jet sample and p_T balance between dijets
- Uncertainties of the order of 1.2% for central jets and $p_T \sim 100$ GeV
- Many post-docs/PhD associated to France: Alexander Kupco (Saclay/Prague), Pavel Demine (Saclay), Jean-Laurent Agram (Strasbourg), Mikko Voutilainen (Saclay/Helsinki), Nikola Makovec (Orsay), Christophe Ochando (Orsay)...



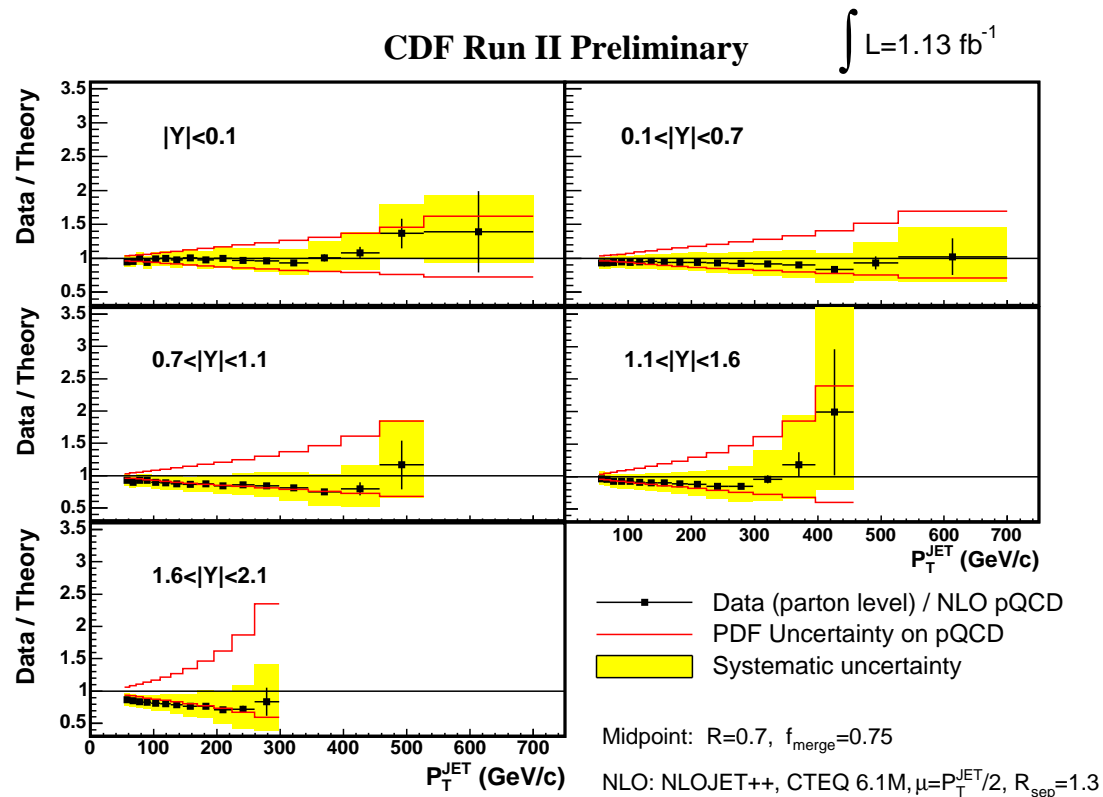
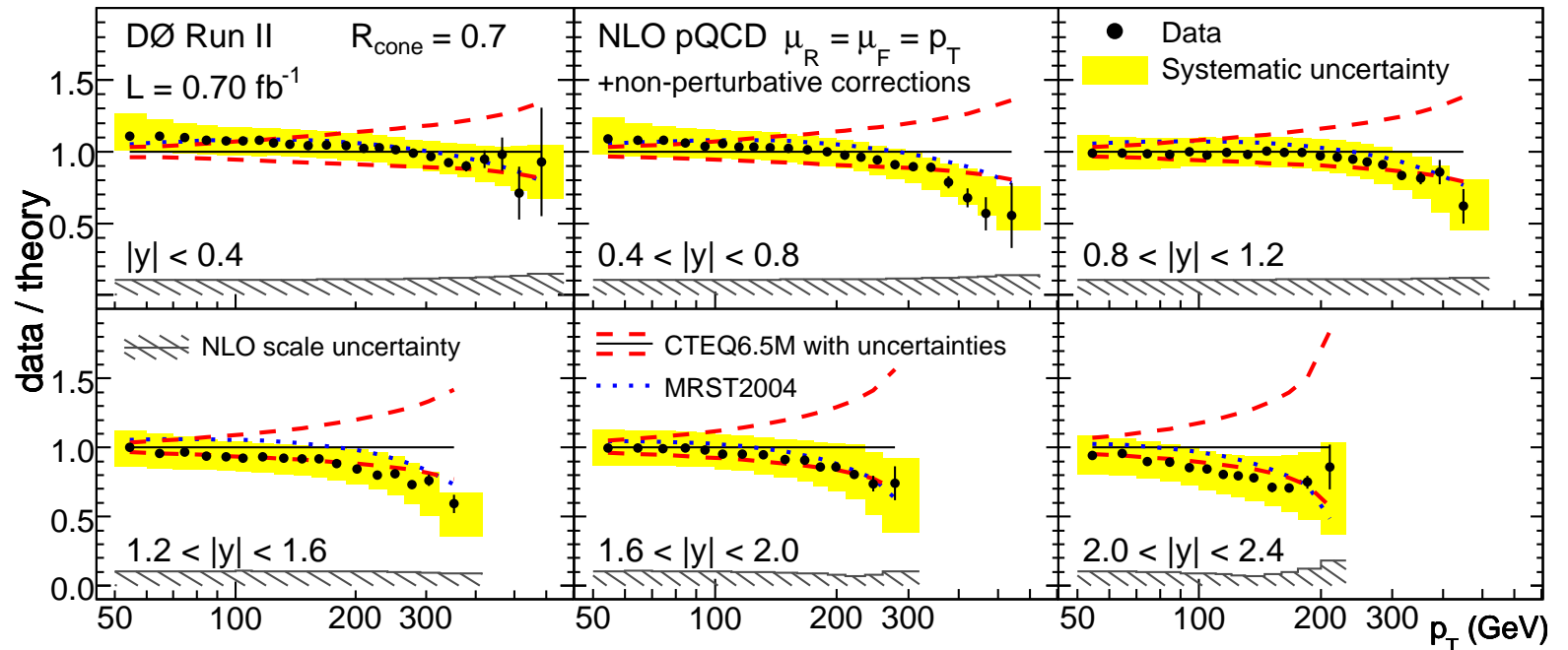
Jet inclusive p_T cross section

- Measurement of the inclusive jet cross section using 0.7 cone algorithm in a p_T range 50-700 GeV and a rapidity up to 2.4
- Corrections up to hadron level
- Comparison with NLO QCD calculation (CTEQ6.5M parametrisation) (CTEQ6.1 for CDF with uncertainties \sim two times larger): **Good agreement over six orders of magnitude**



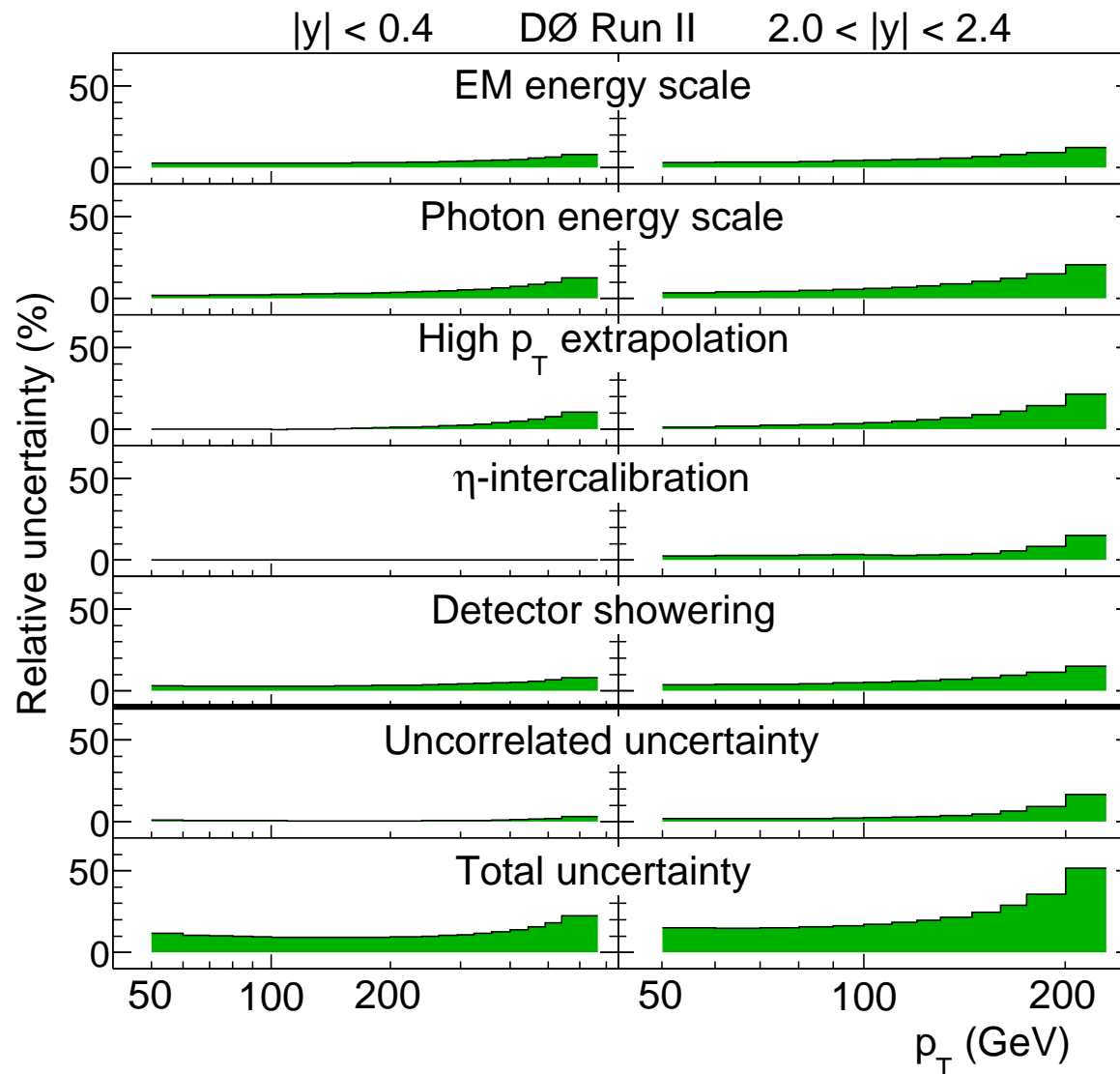
Data/Theory for inclusive jet cross section

- Good agreement between NLO QCD and measurement
- Data used by CTEQ and MRST for new PDFs: DIS2008



Correlation studies for jet inclusive p_T cross section

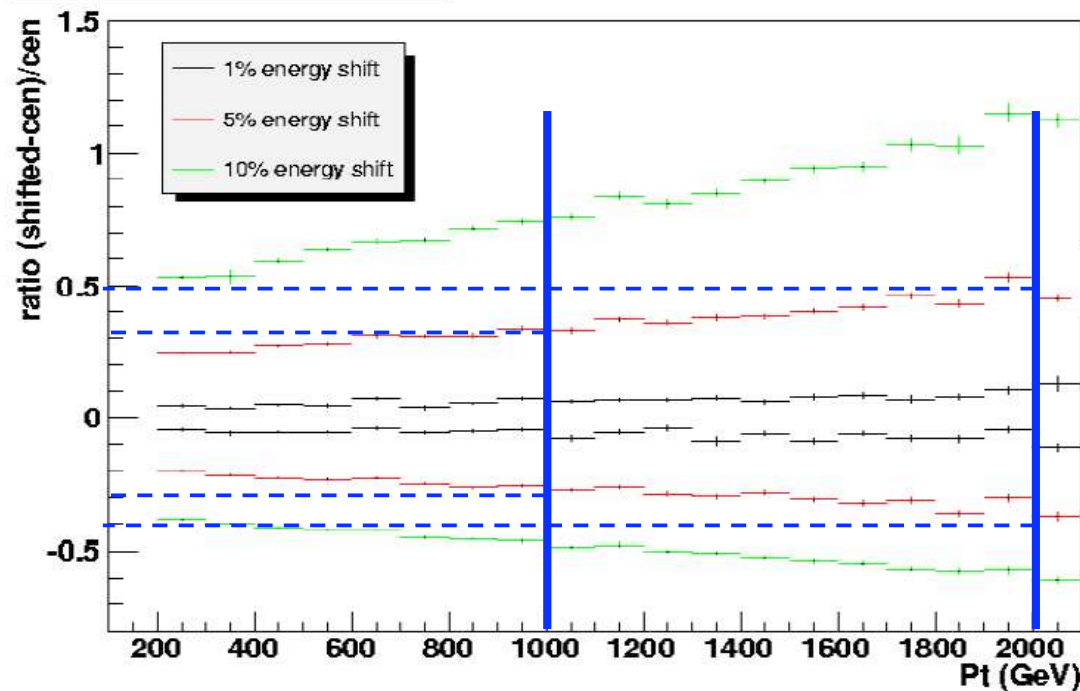
- Full correlation studies: give the effects of 24 sources of systematics in data
- Possibility to constrain further PDFs using correlation matrices
- Published in PRL 101 no 6 (2008), see Mikko Voutilainen's PhD



Can PDF be further constrained at the LHC

- Can PDFs be further constrained using jet inclusive measurements at the LHC?
- PDF uncertainties of the order of 15% at 1 TeV, 25% at 2 TeV for $1 < |\eta_{jet}| < 2$ (without taking into account new Tevatron measurements)
- Need very good control of JES to improve knowledge of gluon at high x

Jet Energy Scale Errors



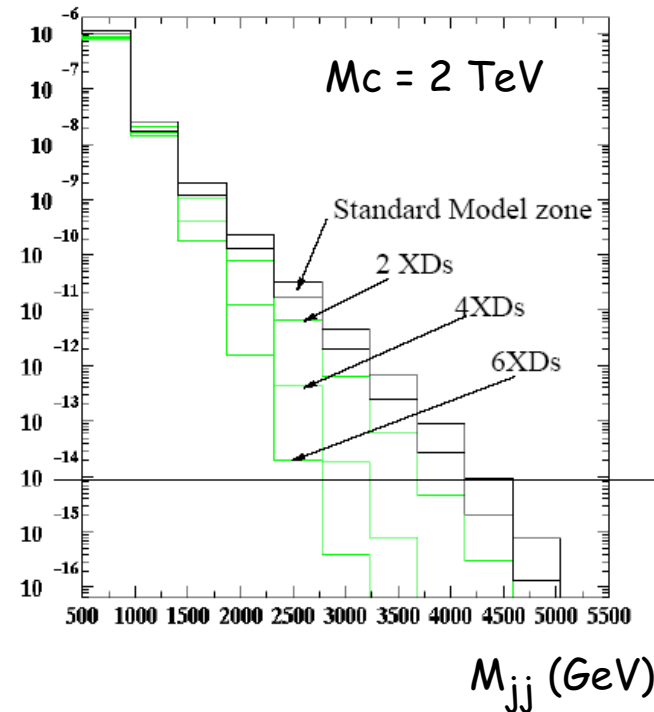
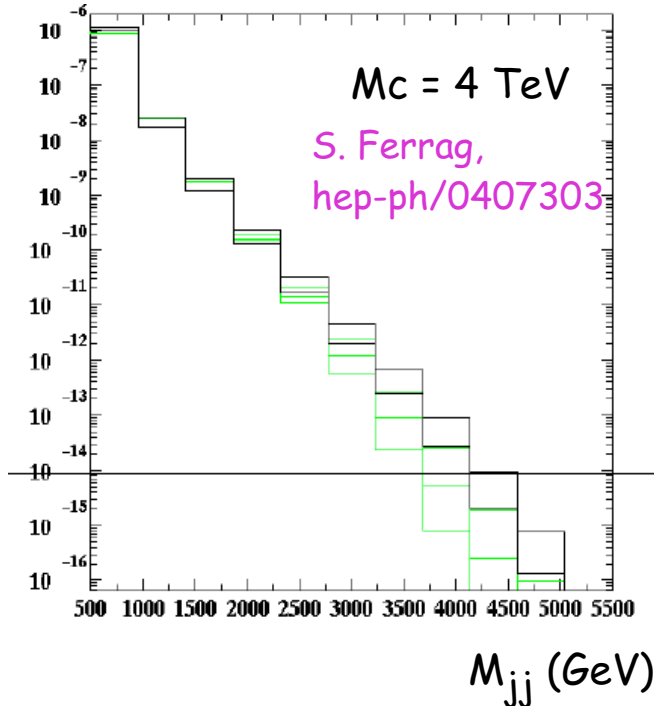
10% JES \rightarrow 60% on σ

5% JES \rightarrow 30% on σ

1% JES \rightarrow 6% on σ

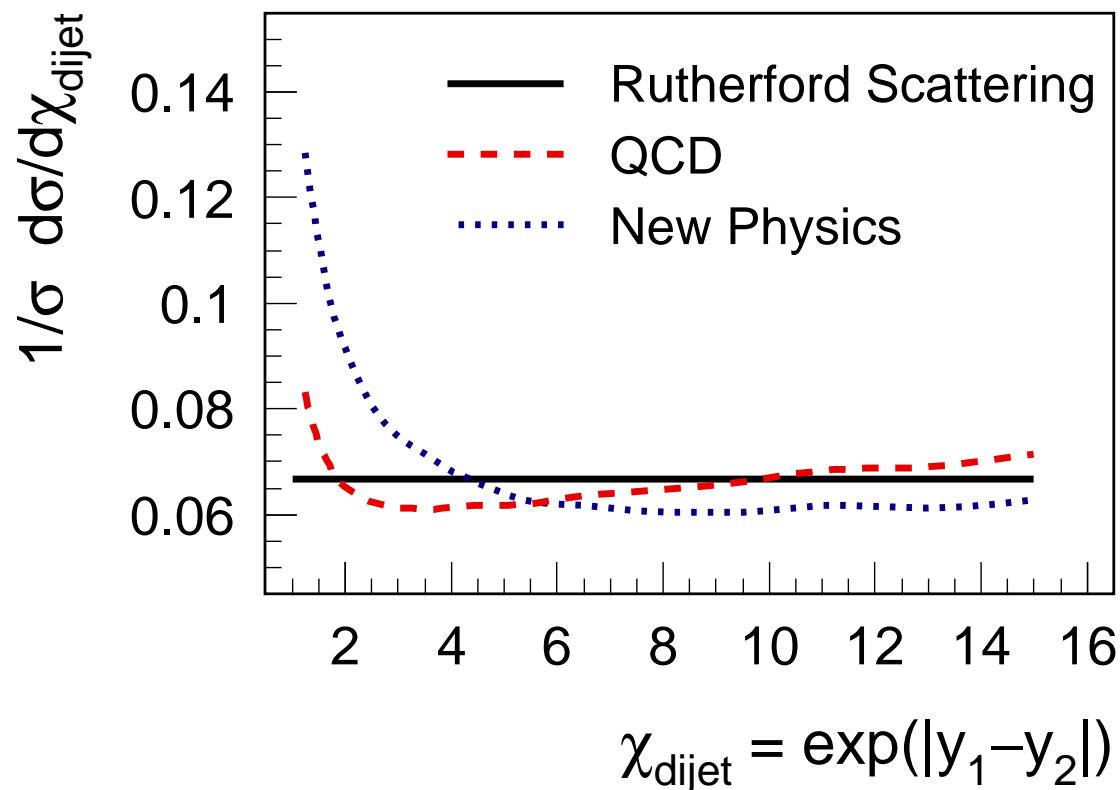
How do PDF uncertainties affect LHC potential?

- How do PDF uncertainties affect LHC discovery potential on Higgs boson as an example?
- Cross sections (signal and background) are known within 10%, no strong impact on cross section calculation to produce heavy object (Higgs)
- Higher uncertainties due to NLO calculation: for example, for Higgs events at 120 GeV, NNLO effects are of the order of 9% (for Z^0 , 4%)
- Search for extra dimensions in the dijet spectrum: effect of the same order as PDF uncertainties



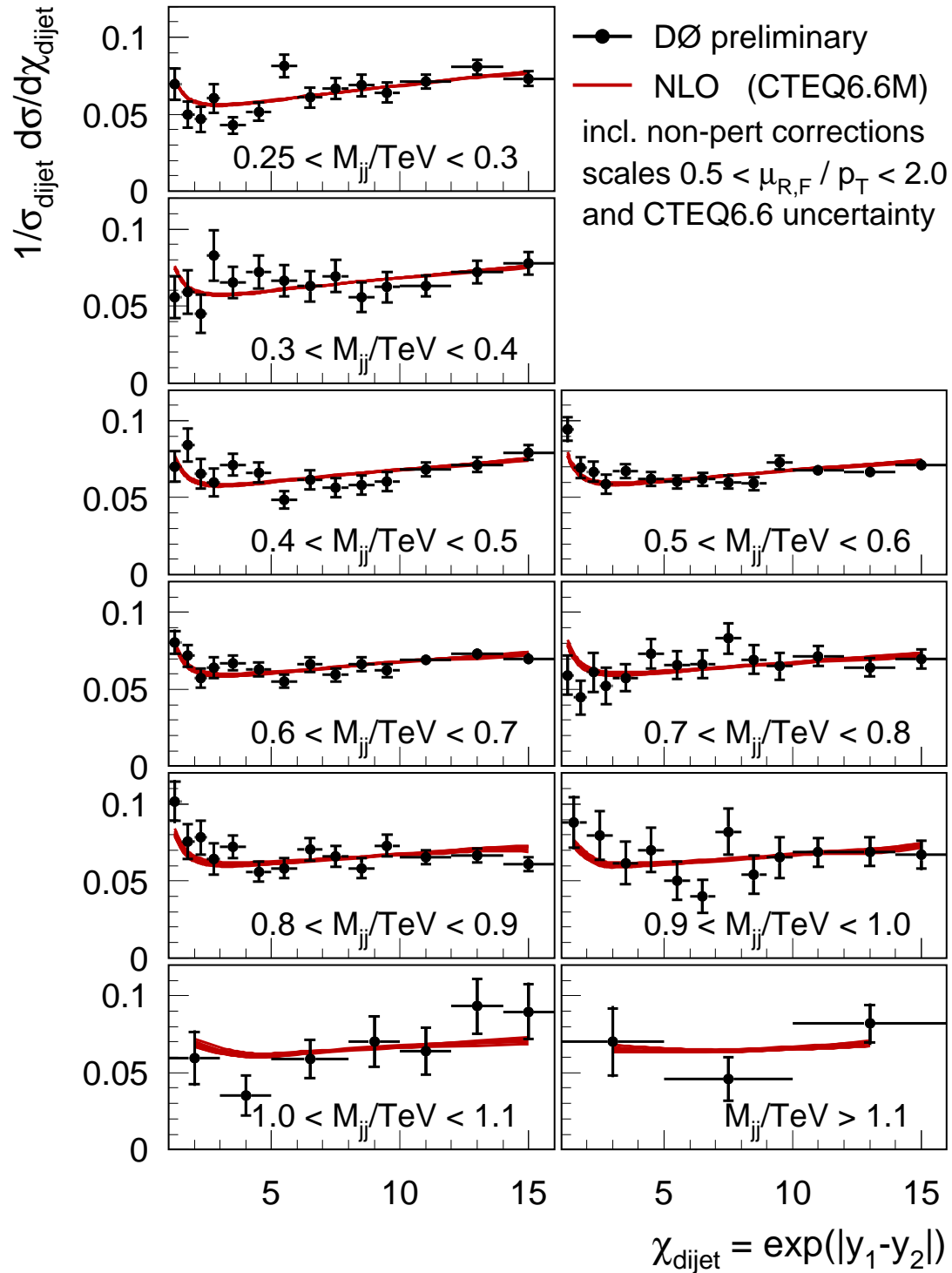
Dijet angular distribution

- $\chi_{dijet} = \exp(|y_1 - y_2|)$, related to CM scattering angle at LO:
 $\chi_{dijet} = (1 + \cos\theta^*)/(1 - \cos\theta^*)$
- Flat for Rutherford scattering, different shape for QCD, strong enhancement at low values for quark compositeness, large extra dimensions...
- Measurement of the dijet cross section in bins of χ and M_{JJ}
- Measurement of $y_{boost} = 0.5|y_1 + y_2|$



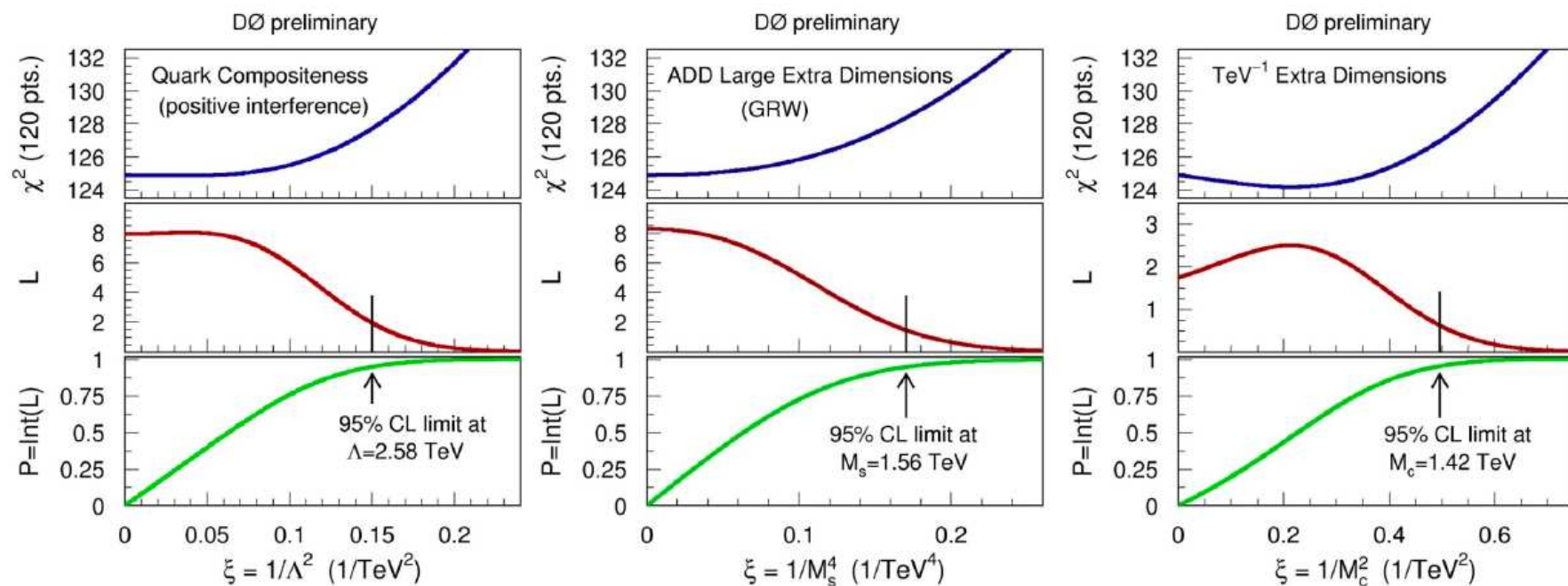
Dijet angular distribution: comparison with QCD

Comparison with NLO QCD: good agreement → Limits on new physics



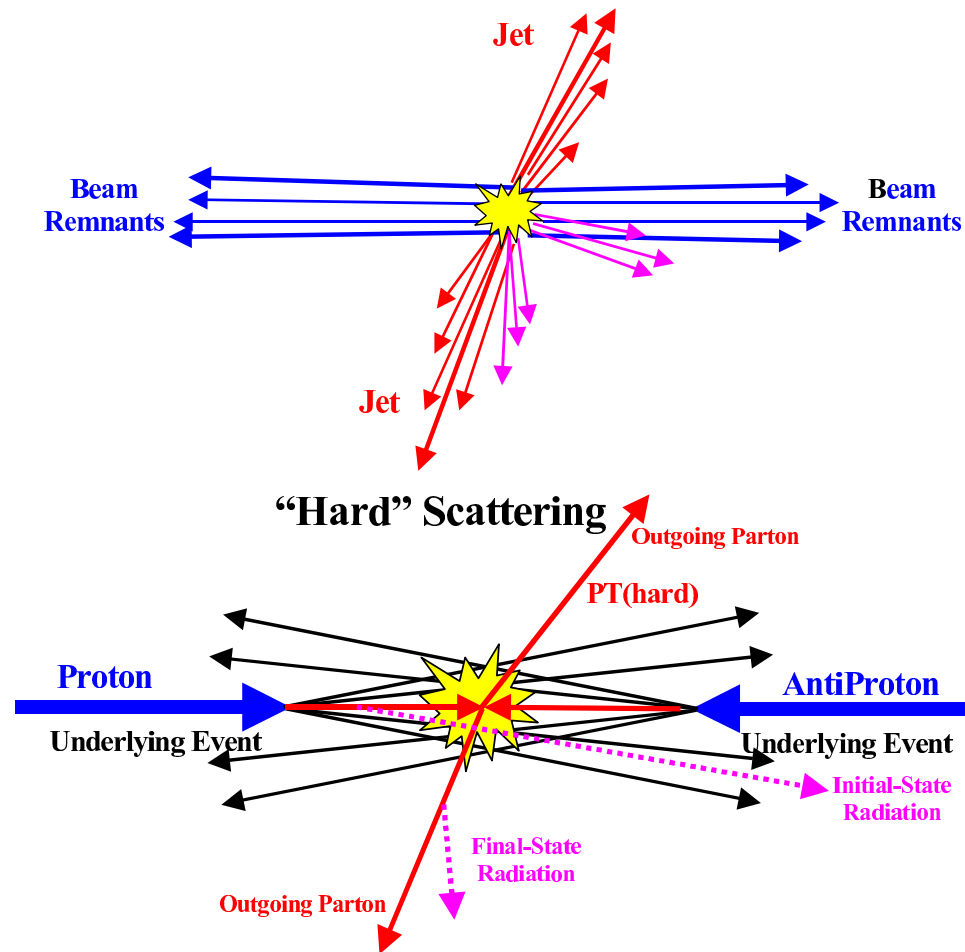
Dijet angular distributions: limits

Limits on different new physics models: best limits on quark compositeness
(2.58 TeV)



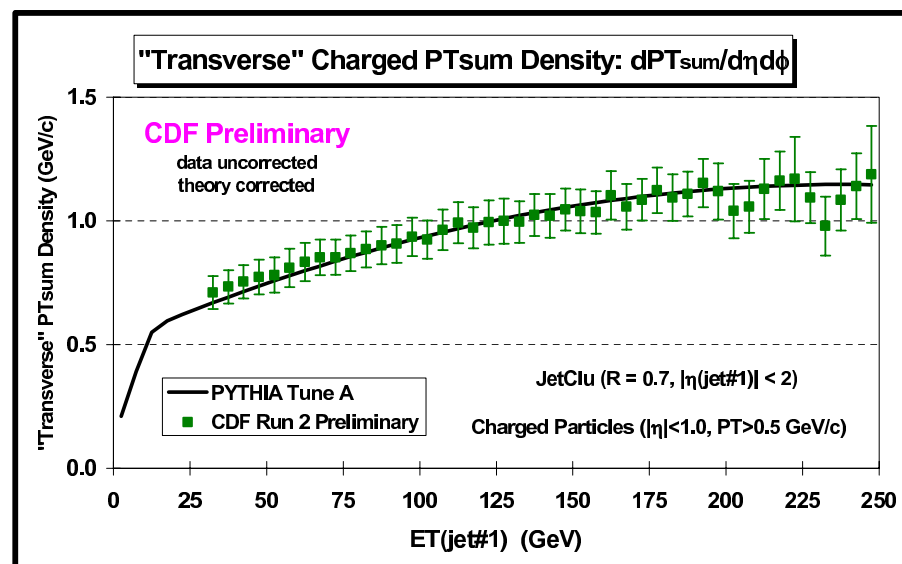
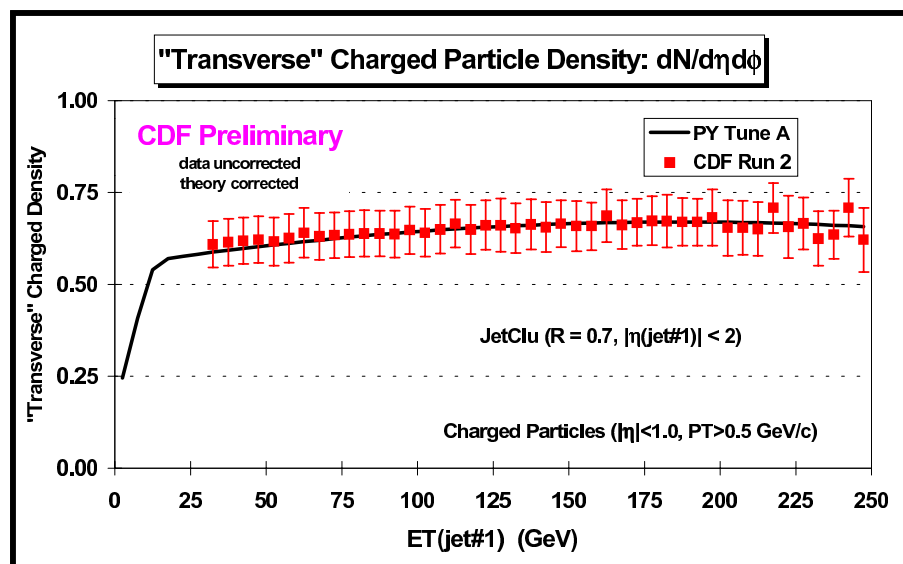
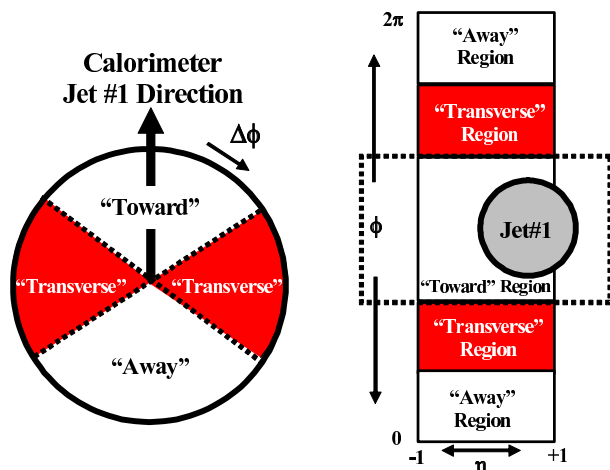
A parenthesis: underlying events at Tev./LHC

Study of underlying events at the Tevatron

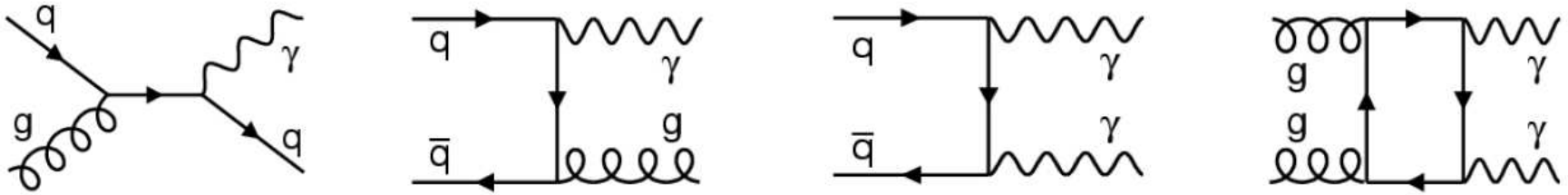


A parenthesis: underlying events at Tev./LHC

Idea: study the energy in the transverse region ($60 < \Delta\Phi < 120$ degrees)



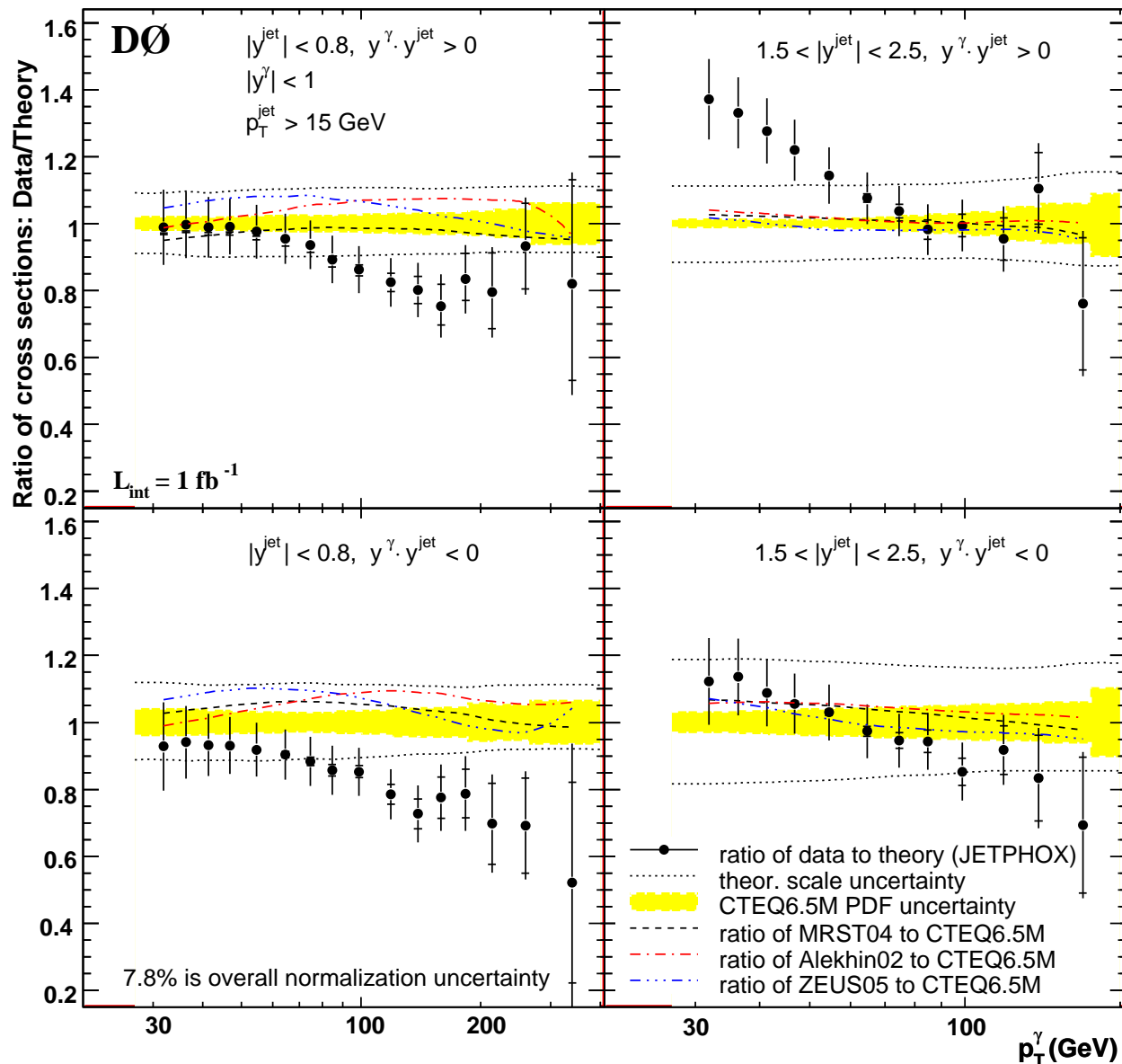
Measurement of photon + jet cross section



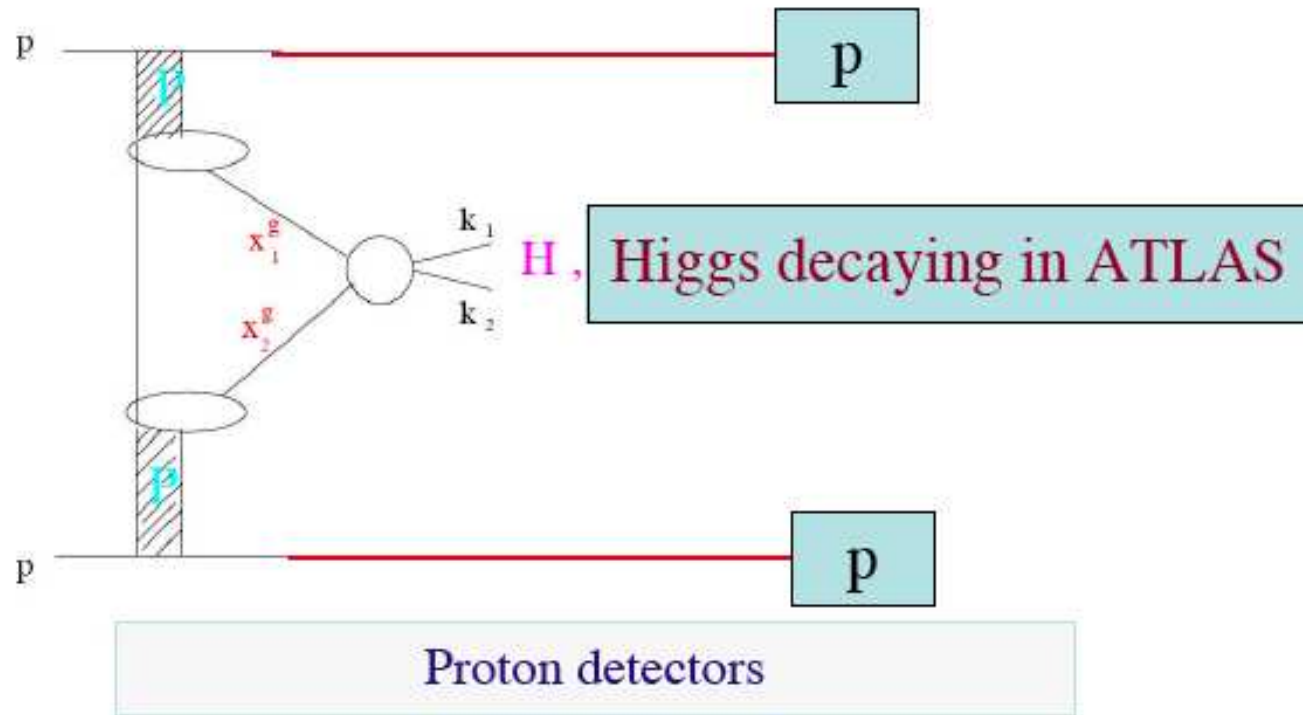
- Direct photons: direct probe of hard scattering dynamics
- test of NLO QCD, sensitivity to gluon PDFs if theory works
- Fragmentation contribution quark into photon: suppressed by isolation criterion

Measurement of photon + jet cross section

- Measurement of inclusive production cross section of isolated photons + jet in different detector regions (central photon, central or forward jets)
- Cross section in disagreement with NLO QCD both in shape and normalisation: reason unclear, higher order corrections? resummation?



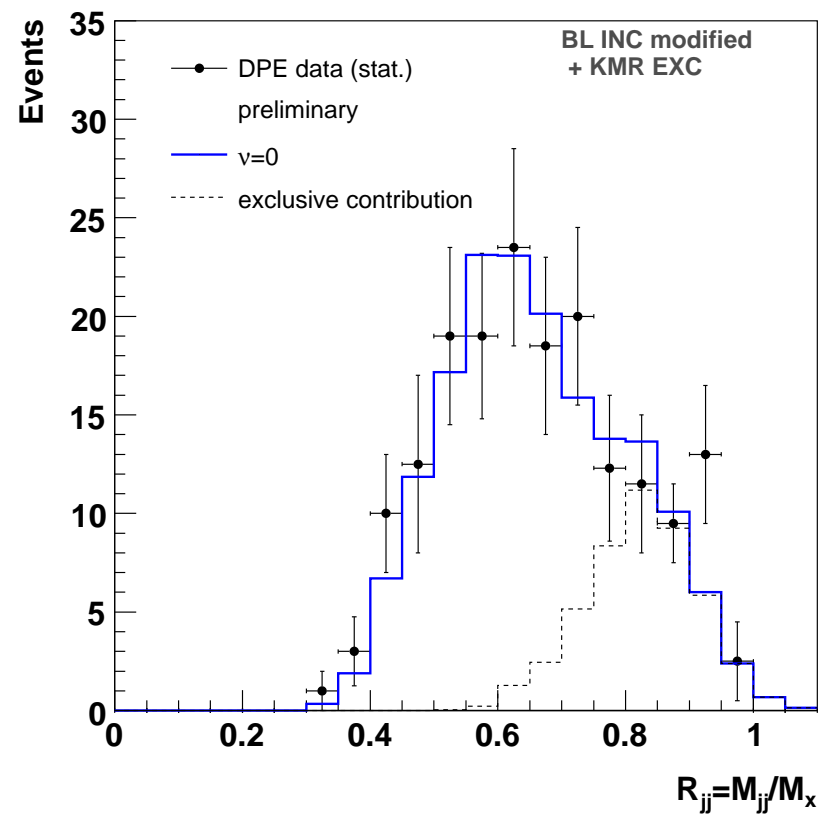
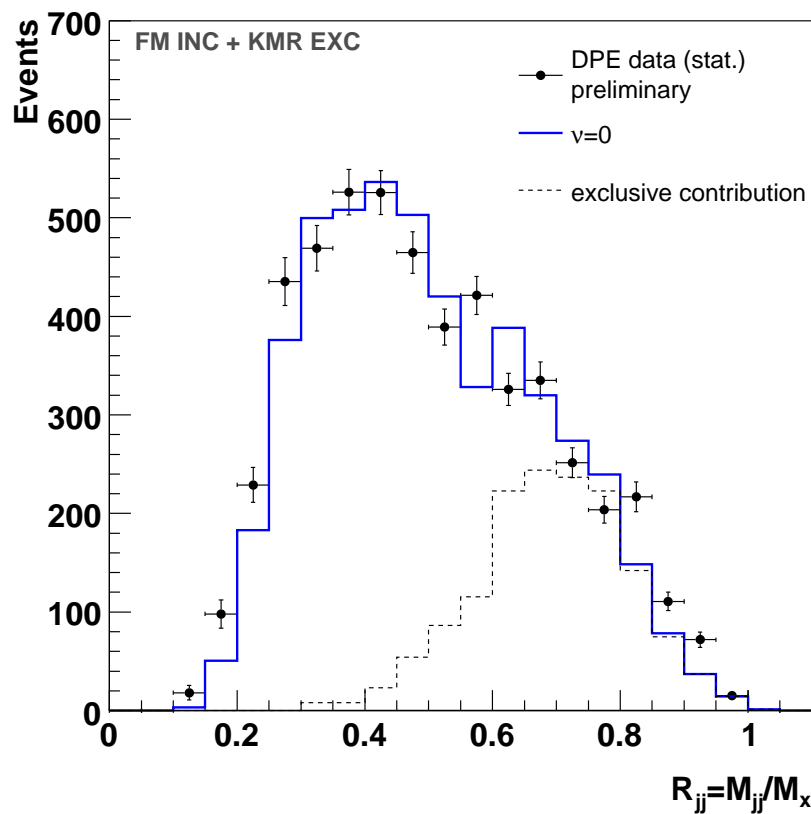
What is Diffractive exclusive production?



- All the energy is used to produce the heavy object (Higgs, dijets....), namely $xG \sim \delta$
- Possibility to reconstruct the Higgs boson properties from the tagged proton: system completely constrained
- See papers by Khoze, Martin, Ryskin; Boonekamp, Peschanski, Royon...

Search for exclusive events in CDF

- Inclusive diffraction cannot explain CDF measurement of dijet mass fraction
- Other measurements by CDF: χ_C , exclusive diphoton production, exclusive b jets...
- Measurements compatible with inclusive and exclusive diffraction added



Conclusion

- Many new results from the D0 and CDF QCD groups
- Inclusive jet p_T cross section: High precision reached due to high precision of JES
- Allows other studies to be performed: Dijet angular distributions...
- γ + jet cross section measurements: differences with NLO QCD calculations in shape and normalisation
- Underlying events: PYTHIA generator tuning, need to be redone with the first LHC data
- Exclusive diffraction: Look for exclusive events, important for LHC
- Many other results not quoted: W + jets, Z + jets, jet shape, b -jet cross sections, Mueller Navelet jets, measurement of $\Delta\Phi$ between jets...
- Many new results expected in the future: Dijet mass cross section in D0, Ratio of 3 jet to 2 jet cross sections (sensitive to α_S), elastic cross section, search for exclusive events in diffraction in D0...