Forward jets at HERA and Mueller Navelet jets at Tevatron/LHC

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- Fit to H1 $d\sigma/dx$ data
- Prediction for the H1 triple differential cross section
- Prediction for Mueller Navelet jets at the Tevatron/LHC
- Effect of energy conservation on BFKL equation

Work done in collaboration with O. Kepka, C. Marquet, R. Peschanski

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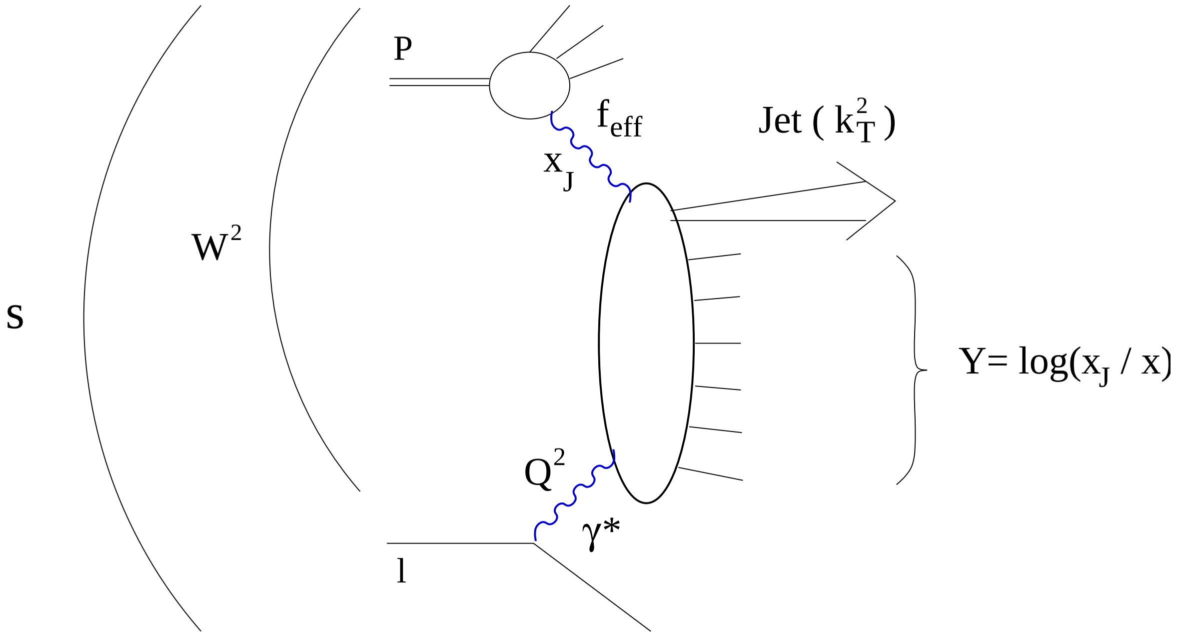
Forward jet measurement at HERA



- Typical kinematical domain where BFKL effects are supposed to appear with respect to DGLAP: $k_T^2 \sim Q^2$, and Q^2 not too large
- LL BFKL forward jet cross section: 2 parameters α_S, normalisation
- NLL BFKL cross section: one single parameter: normalisation (α_S running via RGE)

BFKL NLL calculation

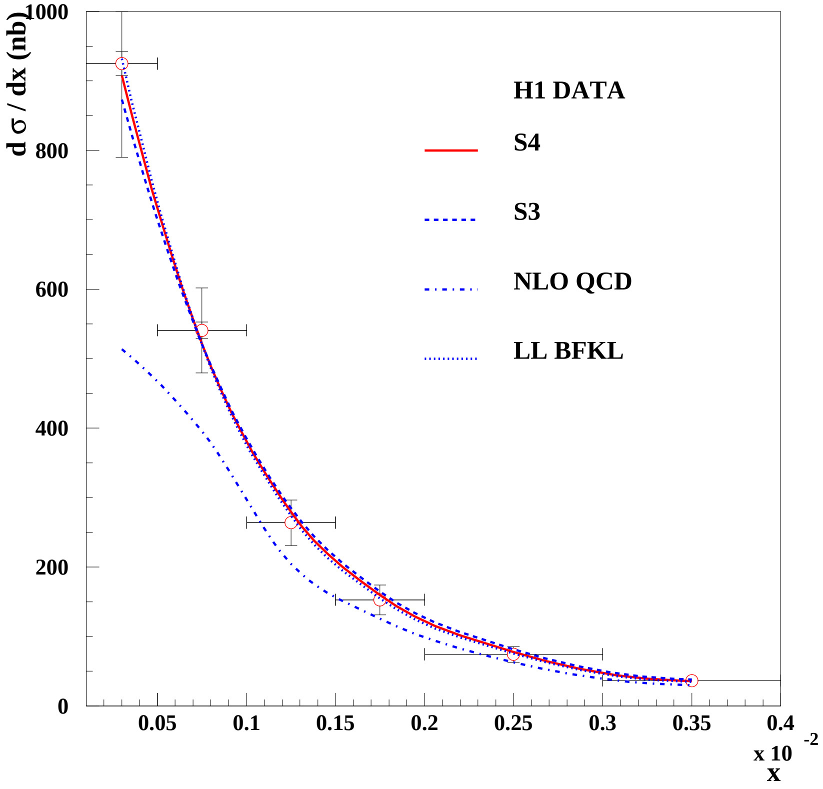
- Full BFKL NLL calculation used for the BFKL kernel, available in S3 and S4 resummation schemes to remove the spurious singularities (modulo the impact factors taken at LL)
- Equation:

$$\frac{d\sigma_{T,L}^{\gamma^* p \to JX}}{dx_J dk_T^2} = \frac{\alpha_s(k_T^2)\alpha_s(Q^2)}{k_T^2 Q^2} \ f_{eff}(x_J, k_T^2)$$
$$\int \frac{d\gamma}{2i\pi} \left(\frac{Q^2}{k_T^2}\right)^{\gamma} \phi_{T,L}^{\gamma}(\gamma) \ e^{\bar{\alpha}(k_T Q)\chi_{eff}[\gamma,\bar{\alpha}(k_T Q)]Y}$$

- Implicit equation: $\chi_{eff}(\gamma, \alpha) = \chi_{NLL}(\gamma, \alpha, \chi_{eff}(\gamma, \alpha))$ solved numerically

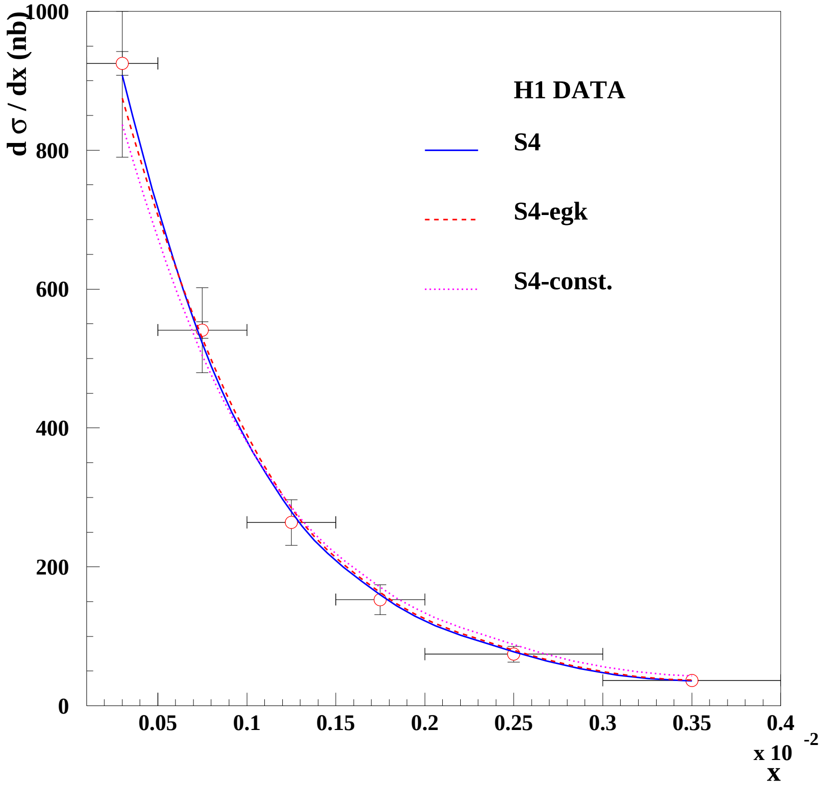
Fit results

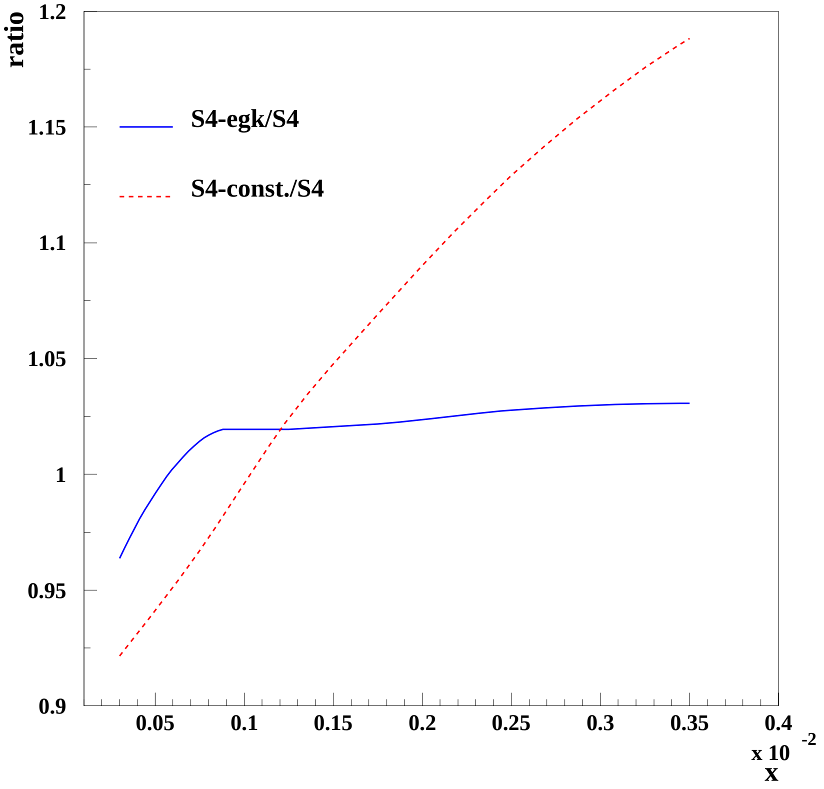
- Fit of NLL BFKL calculation to the H1 $d\sigma/dx$ data: one single parameter, normalisation of cross section
- χ^2 for S3: 29.5 (1.15), S4: 10.0 (0.48)
- Good description of H1 data using BFKL LO and BFKL NLL formalism, DGLAP-NLO fails to describe the data
- Scale dependence: variation of the scale between $2Qk_T$, $Qk_T/2$, Q^2, k_T^2: $\sim 20\%$ difference
- BFKL higher corrections found to be small (We are in the BFKL-LO region, cut on $0.5 < k_T^2/Q^2 < 5$)



Dependence on impact factor

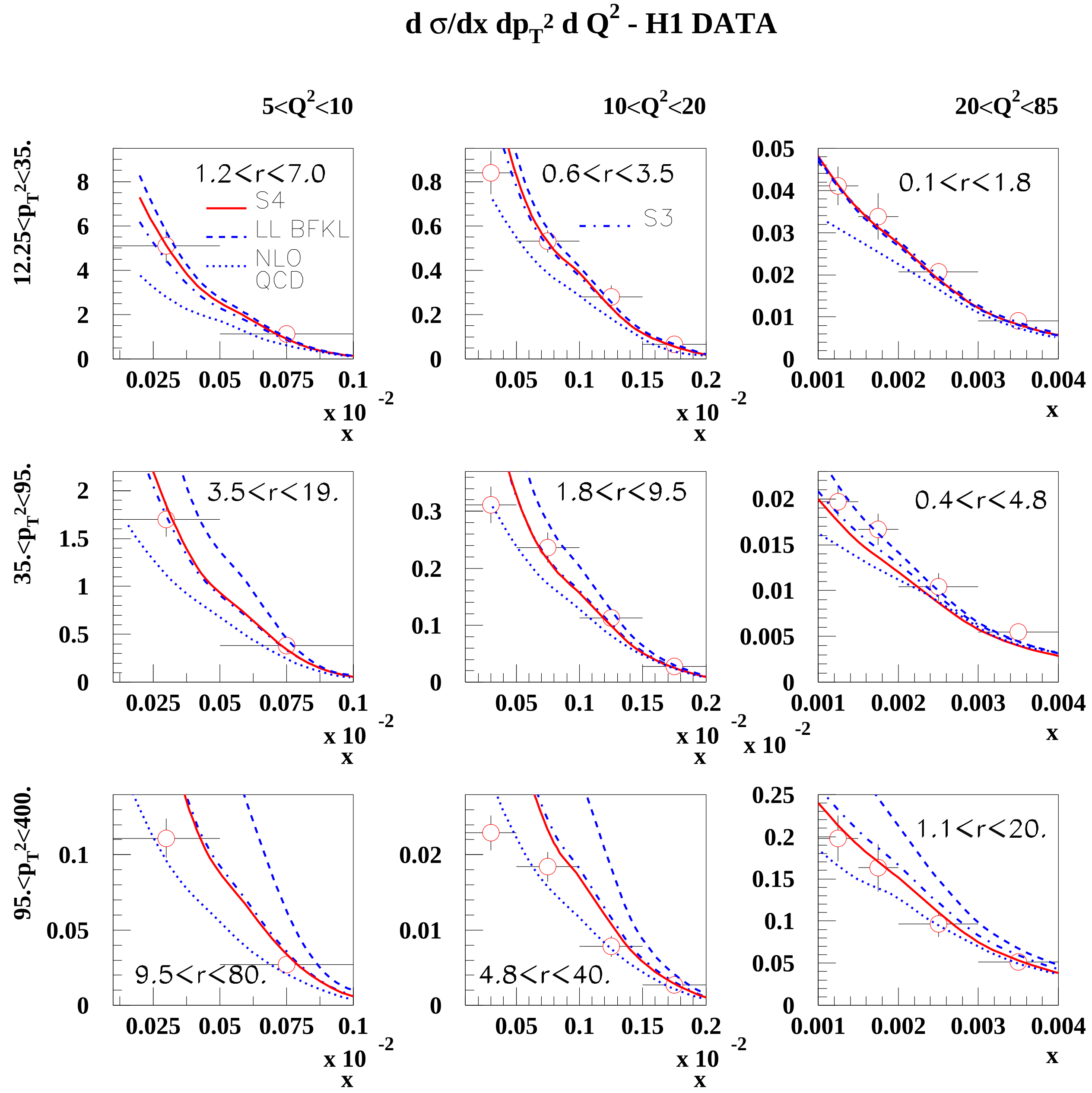
- Impact factor not yet fully known at NLL
- Variation of impact factor, 3 studies: $h_T,\ h_L(\gamma)$ at LO; $h_T,\ h_L(1/2)$ constant; implement the higher-order corrections in the impact factor due to exact gluon kinematics in the $\gamma^* \longrightarrow q\bar{q}$ transition (see C.D. White, R. Peschanski, R.S. Thorne, Phys. Lett. B 639 (2006) 652)





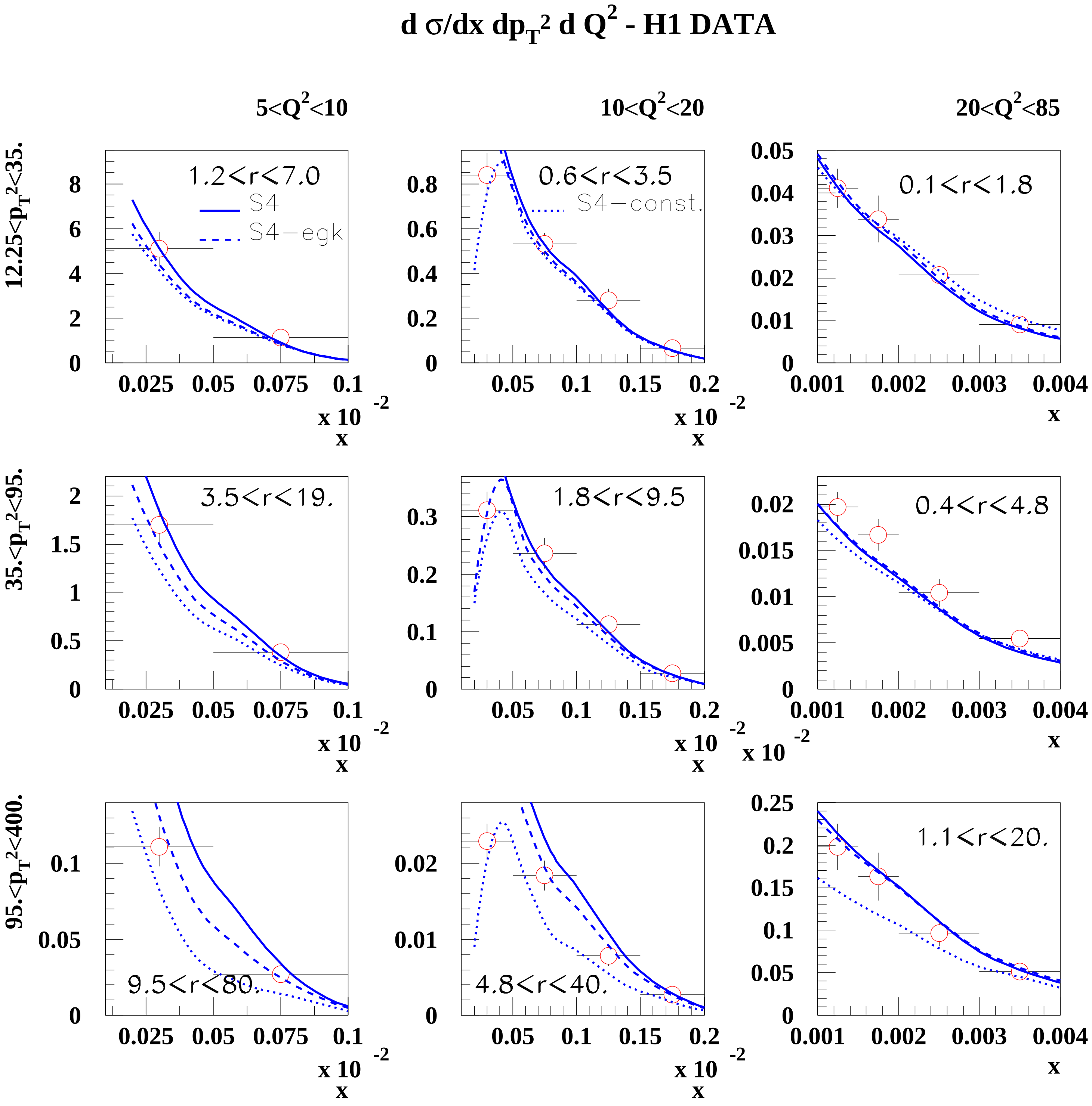
Comparison with H1 triple differential data

- Triple differential cross section: Keep the normalisation from the fit to $d\sigma/dx$ and predict the triple differential cross section
- Good description over the full range



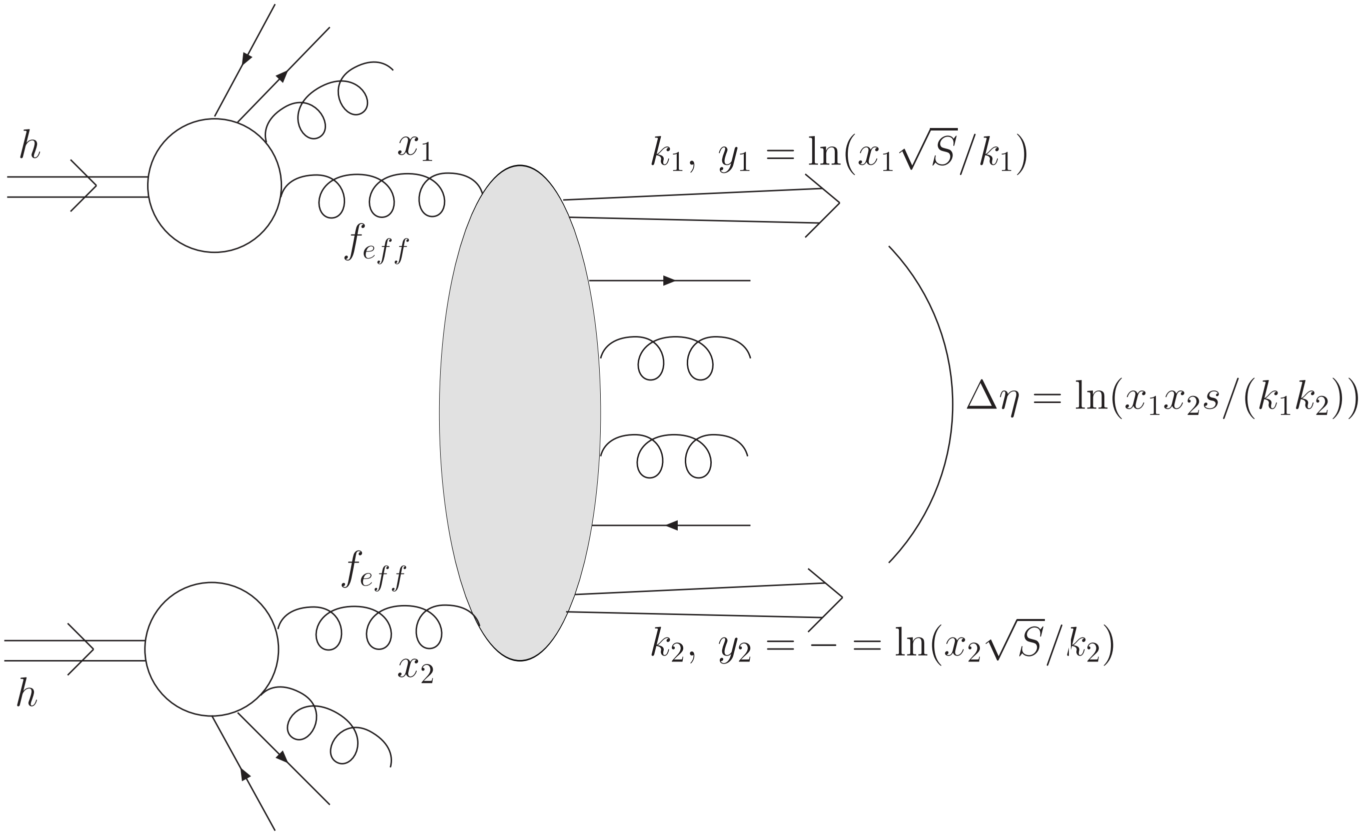
Comparison with H1 triple differential data

Study of dependence on impact factor



Mueller Navelet jets

Same kind of processes at the Tevatron and the LHC



- Same kind of processes at the Tevatron and the LHC: Mueller Navelet jets
- Study the $\Delta\Phi$ between jets dependence of the cross section:

Mueller Navelet jets: $\Delta\Phi$ dependence

- Study the $\Delta\Phi$ dependence of the relative cross section
- Relevant variables:

$$\begin{aligned}\Delta\eta &= y_1 - y_2\\ y &= (y_1+y_2)/2\\ Q &= \sqrt{k_1 k_2}\\ R &= k_2/k_1\end{aligned}$$

- Azimuthal correlation of dijets:

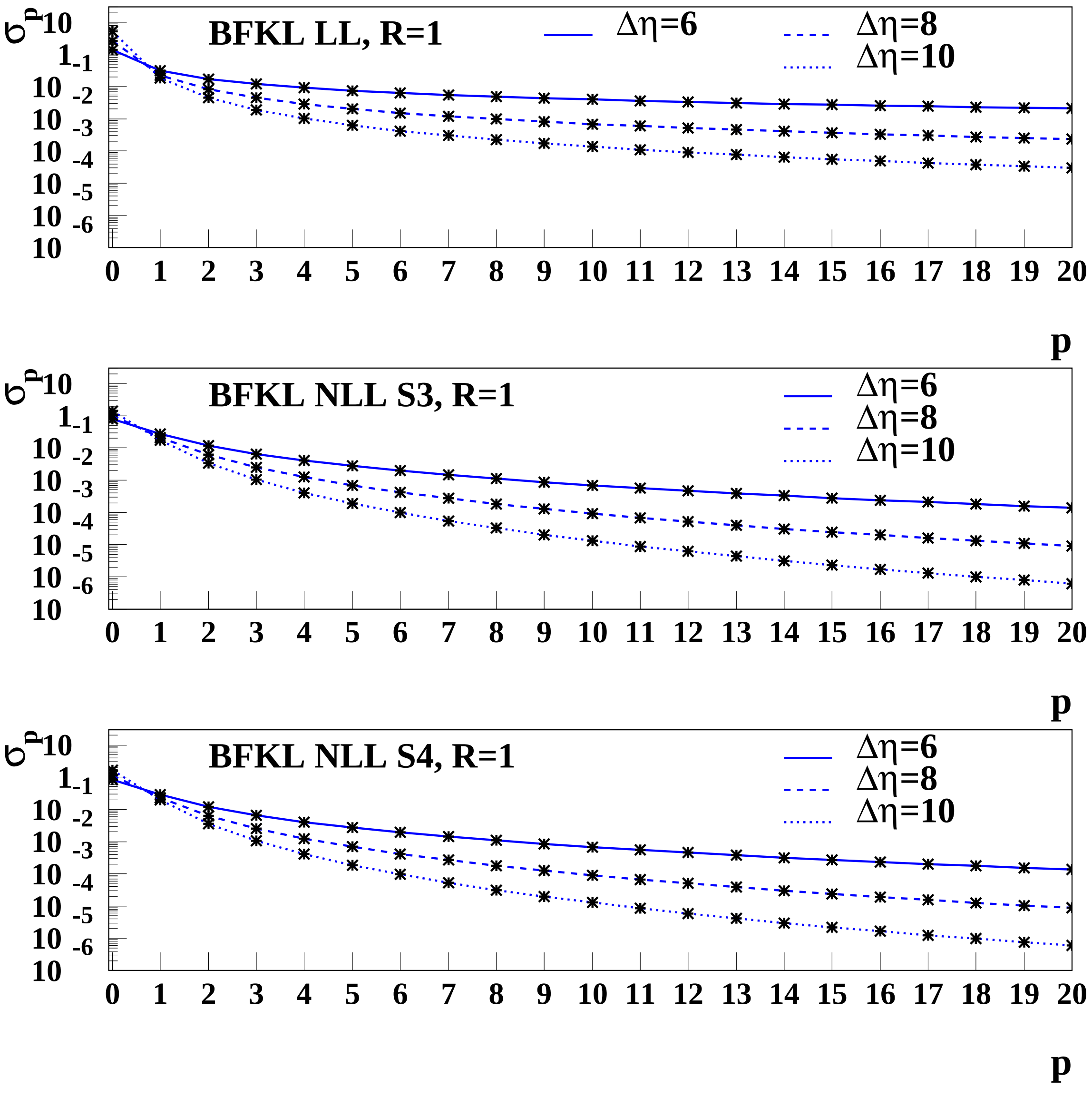
$$2\pi \, \frac{d\sigma}{d\Delta\eta dR d\Delta\Phi} \bigg/ \frac{d\sigma}{d\Delta\eta dR} = 1 + \frac{2}{\sigma_0(\Delta\eta, R)} \sum_{p=1}^{\infty} \sigma_p(\Delta\eta, R) \cos(p\Delta\Phi)$$

where

$$\sigma_p = \int_{E_T}^{\infty} \frac{dQ}{Q^3} \alpha_s(Q^2/R)\alpha_s(Q^2 R) \left(\int_{y_<}^{y_>} dy x_1 f_{eff}(x_1, Q^2/R) x_2 f_{eff}(x_2, Q^2 R) \right) \int_{1/2-\infty}^{1/2+\infty} \frac{d\gamma}{2i\pi} R^{-2\gamma} \; e^{\bar{\alpha}(Q^2)\chi_{eff}(p)\Delta\eta}$$

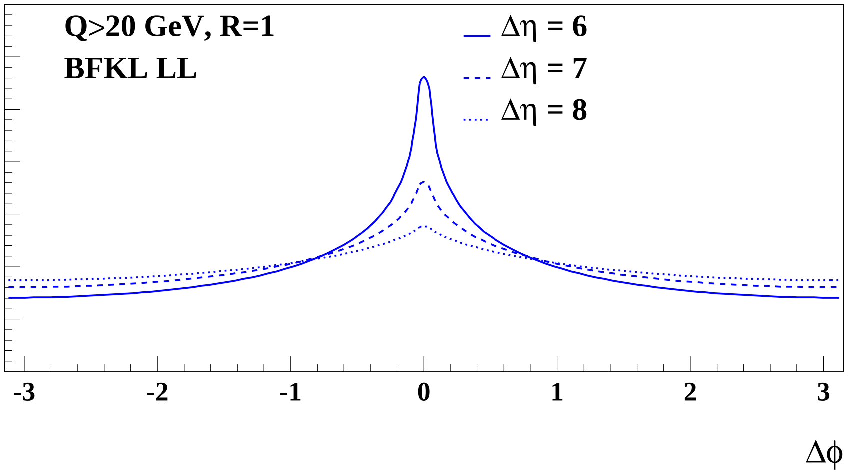
Different conformal spin components

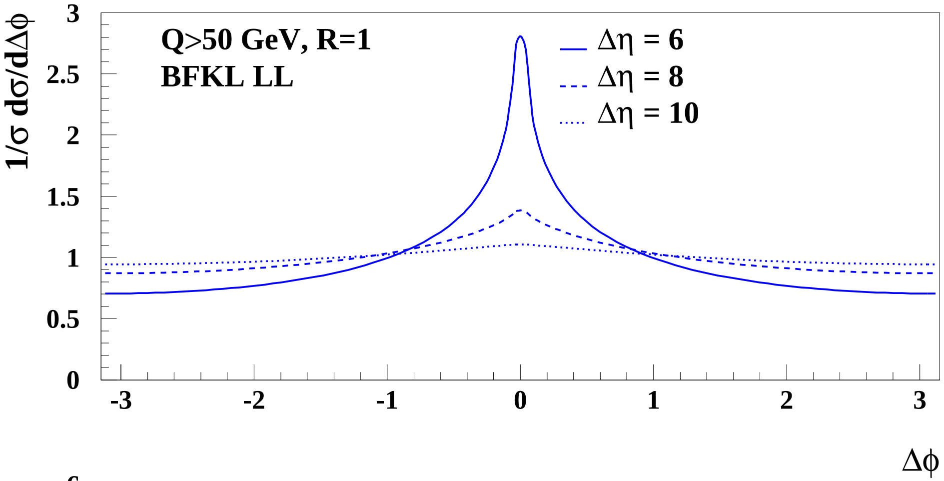
Values of σ_i entering into the $\Delta\Phi$ spectrum for BFKL NLL for different intervals in rapidity → Resummation needed

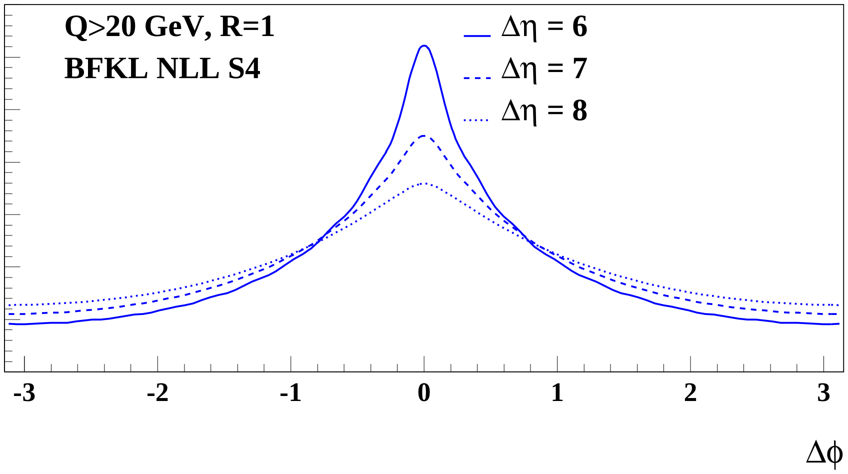


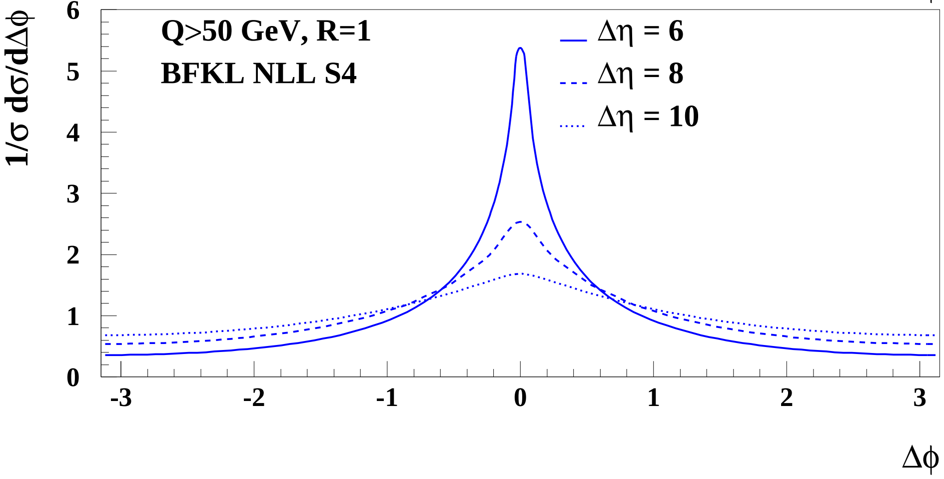
Mueller Navelet jets: $\Delta\Phi$ dependence

- $1/\sigma d\sigma/d\Delta\Phi$ spectrum for BFKL LL and BFKL NLL as a function of $\Delta\Phi$ for different values of $\Delta\eta$
- Measurement being done at CDF, to be performed at LHC



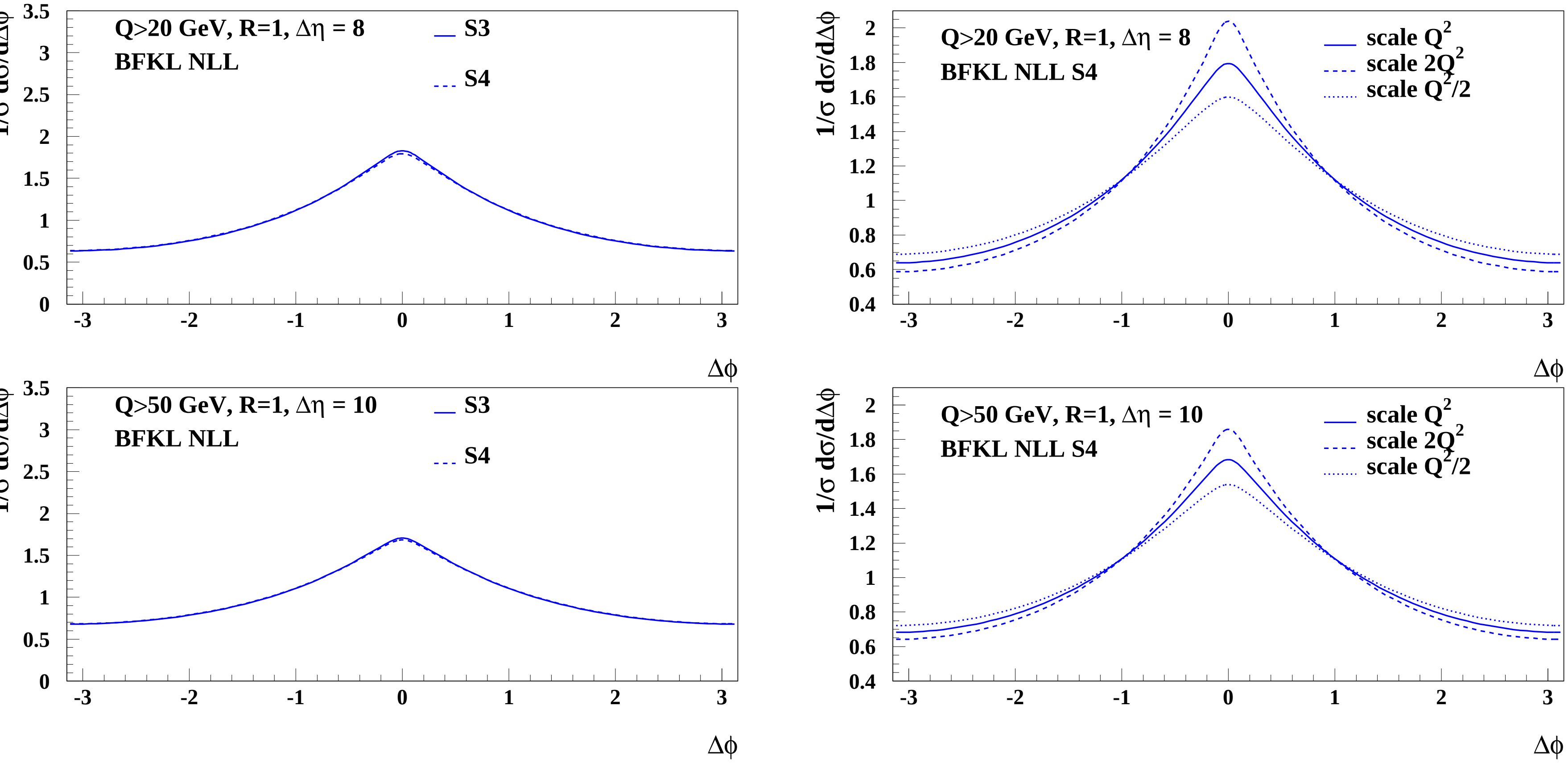






Mueller Navelet jets: S3 and S4, scale dependence

- No difference between S3 and S4 schemes (as an example for LHC)
- Weak scale dependence (given as an example for the LHC): $Q^2/2$, Q^2, $2Q^2$



Effect of energy conservation on BFKL equation

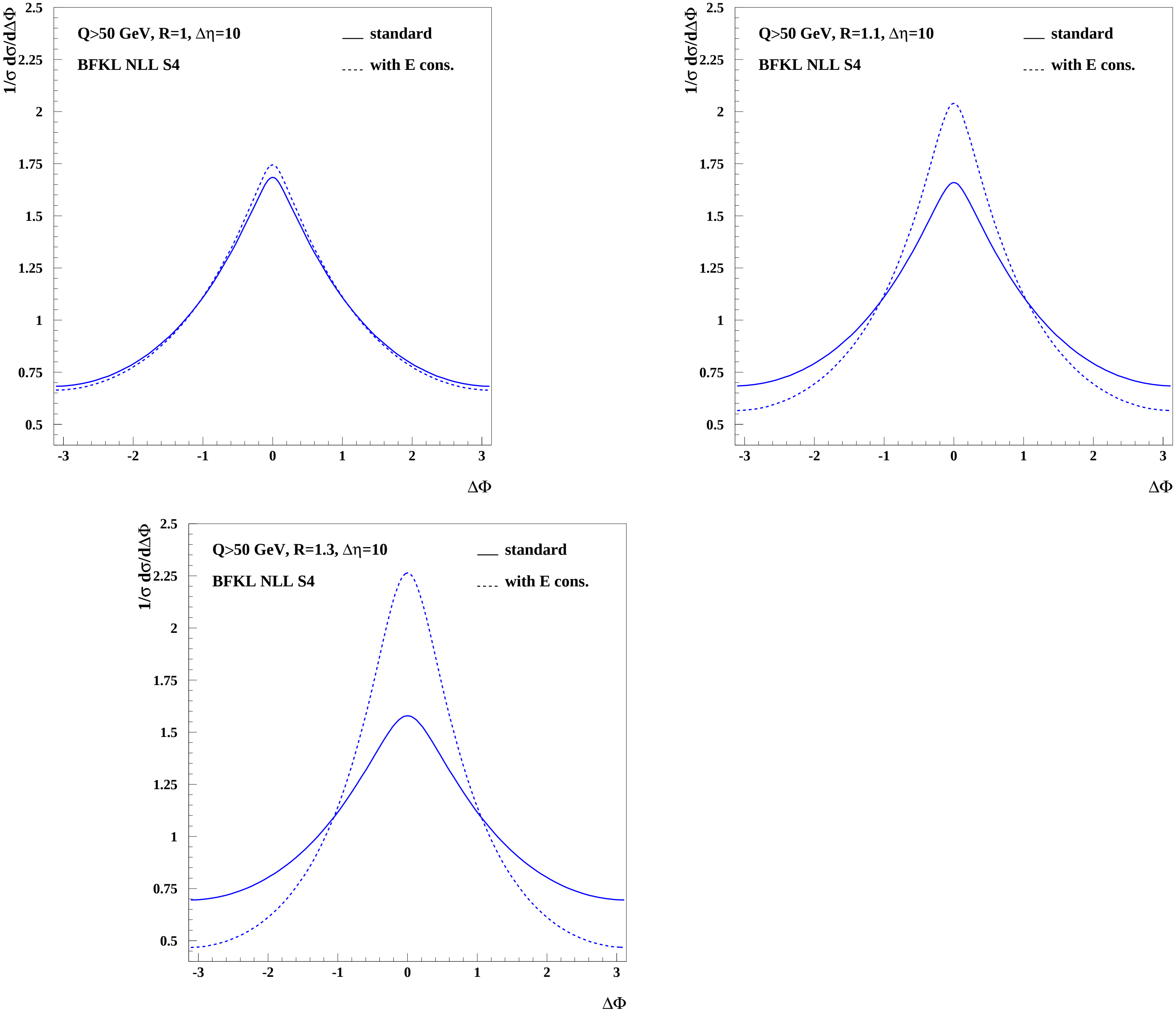
- BFKL cross section lacks energy-momentum conservation since these effects are higher order corrections
- Following Del Duca-Schmidt, we substitute $\Delta\eta$ by an effective rapidity interval y_{eff}

$$y_{eff} = \Delta\eta \left(\int d\phi \cos(p\phi) \frac{d\sigma^{O(\alpha_s^3)}}{d\Delta\eta dy dQ dR d\Delta\Phi} \right)^{-1} \int d\phi \cos(p\phi) \frac{d\sigma^{LL-BFKL}}{d\Delta\eta dy dQ dR d\Delta\Phi}$$

where $d\sigma^{O(\alpha_s^3)}$ is the exact $2 \rightarrow 3$ contribution to the $hh \rightarrow JXJ$ cross-section at order α_s^3, and $d\sigma^{LL-BFKL}$ is the LL-BFKL result

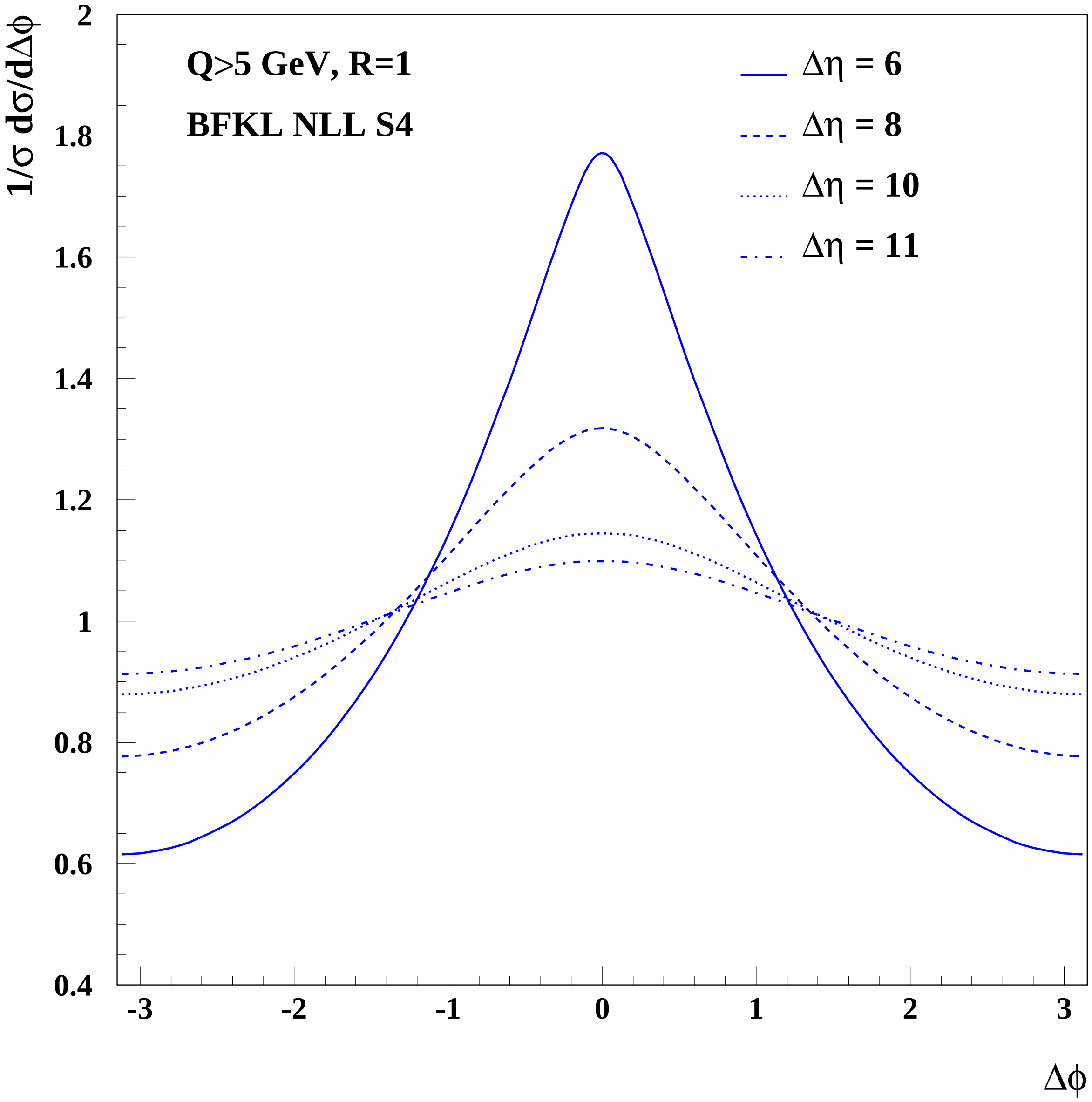
- To compute $d\sigma^{O(\alpha_s^3)}$, we use the standard jet cone size $R_{cut} = 0.5$ when integrating over the third particle's momentum

Effect of energy conservation on BFKL equation



Mueller Navelet jets in CDF

Possibility to measure $\Delta\Phi$ distribution in CDF for large $\Delta\eta$ and low jet p_T ($p_T > 5$ GeV) using the CDF miniPLUG calorimeter



Conclusion

- DGLAP NLO fails to describe forward jet data
- BFKL NLL description of H1 and ZEUS forward jet data: very good description using full BFKL-NLL kernel and LO impact factors
- Study scale dependence and also dependence on assumption of impact factor: typically $\sim$ 20% uncertainty, larger at high p_T
- Mueller Navelet jets: Full calculation available using S3 and S4 schemes
- Mueller Navelet jets $\Delta\Phi$ dependence: weak dependence even after NLL corrections, little sensitivity to chosen scale
- Effet of energy conservation in BFKL equation: negligible if R close to 1, large effect if R further away from 1
- Mueller Navelet jets: Very nice measurement to be performed at the Tevatron/LHC, special use of CDF forward miniPLUG calorimeter which gives a good acceptance at large η and small p_T for jets