Cross section for quasi-real photo-production of $h^{\pm}$ with high p_T in μ-d scattering at COMPASS

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Rencontres de Moriond, QCD and High Energy Interactions
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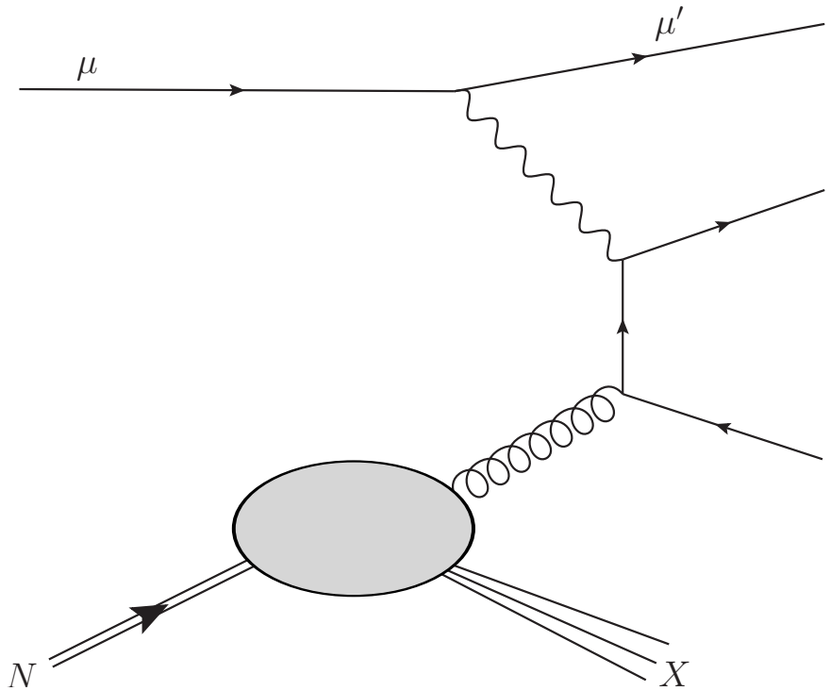
Outline

- Motivation for hadron production cross section measurement
- The COMPASS experiment at CERN
- Luminosity determination, check with structure function F_2
- Cross section for high-p_T hadrons at low Q^2
- Conclusion and outlook

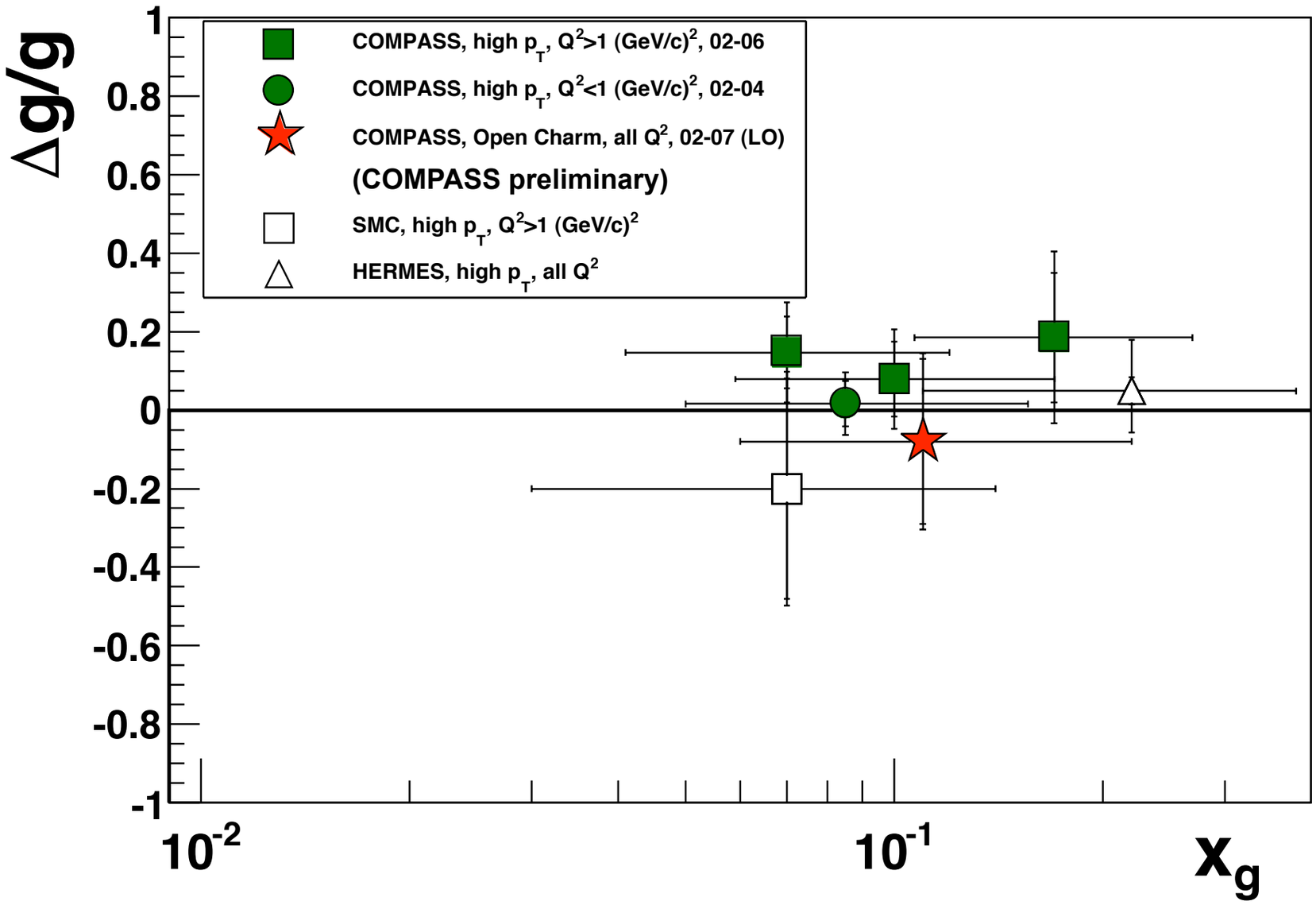
Measuring gluon polarization in DIS

- Photon-gluon fusion



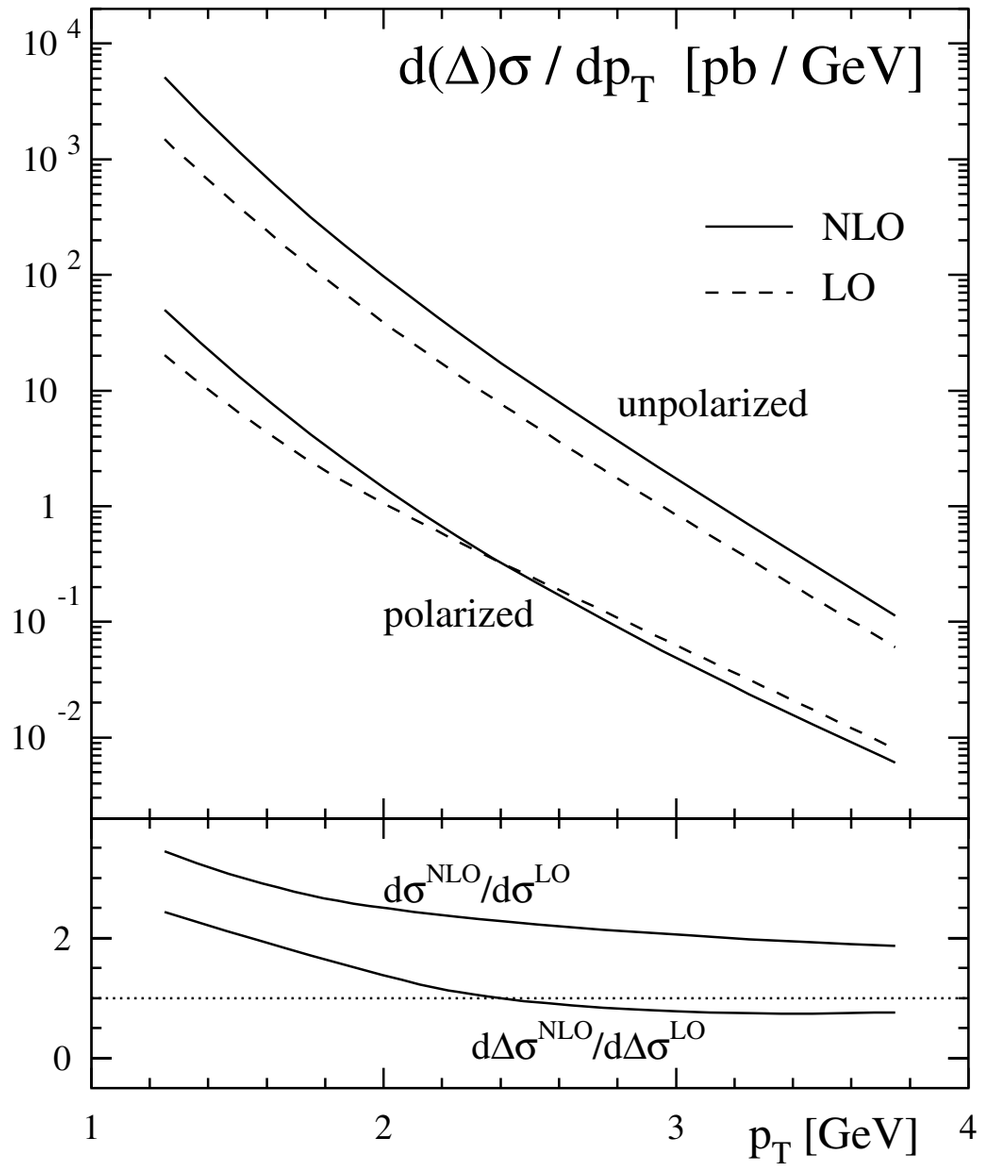
- Dominates cross section for open-charm production
- Considerable contribution to inclusive production of high-p_T hadrons or hadron pairs
- Double spin asymmetries of these processes should be sensitive to gluon polarization

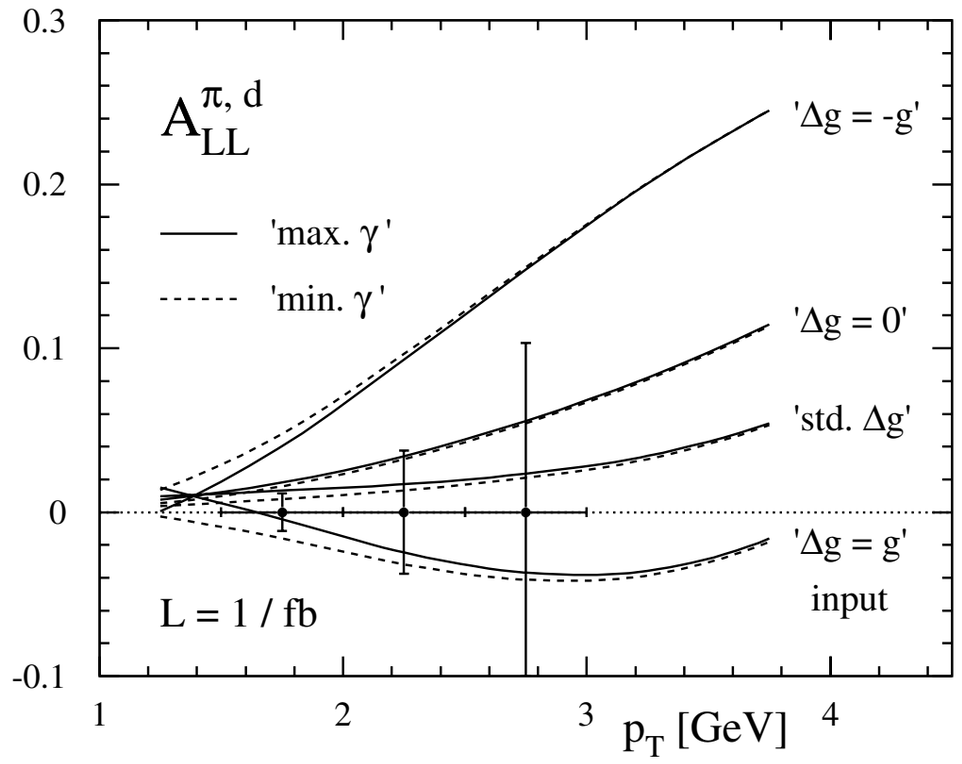
Δg/g from DIS



- Δg/g is small (in the probed x_g range)

Gluon polarization from quasi-real photo-production of inclusive high-p_T hadrons at COMPASS

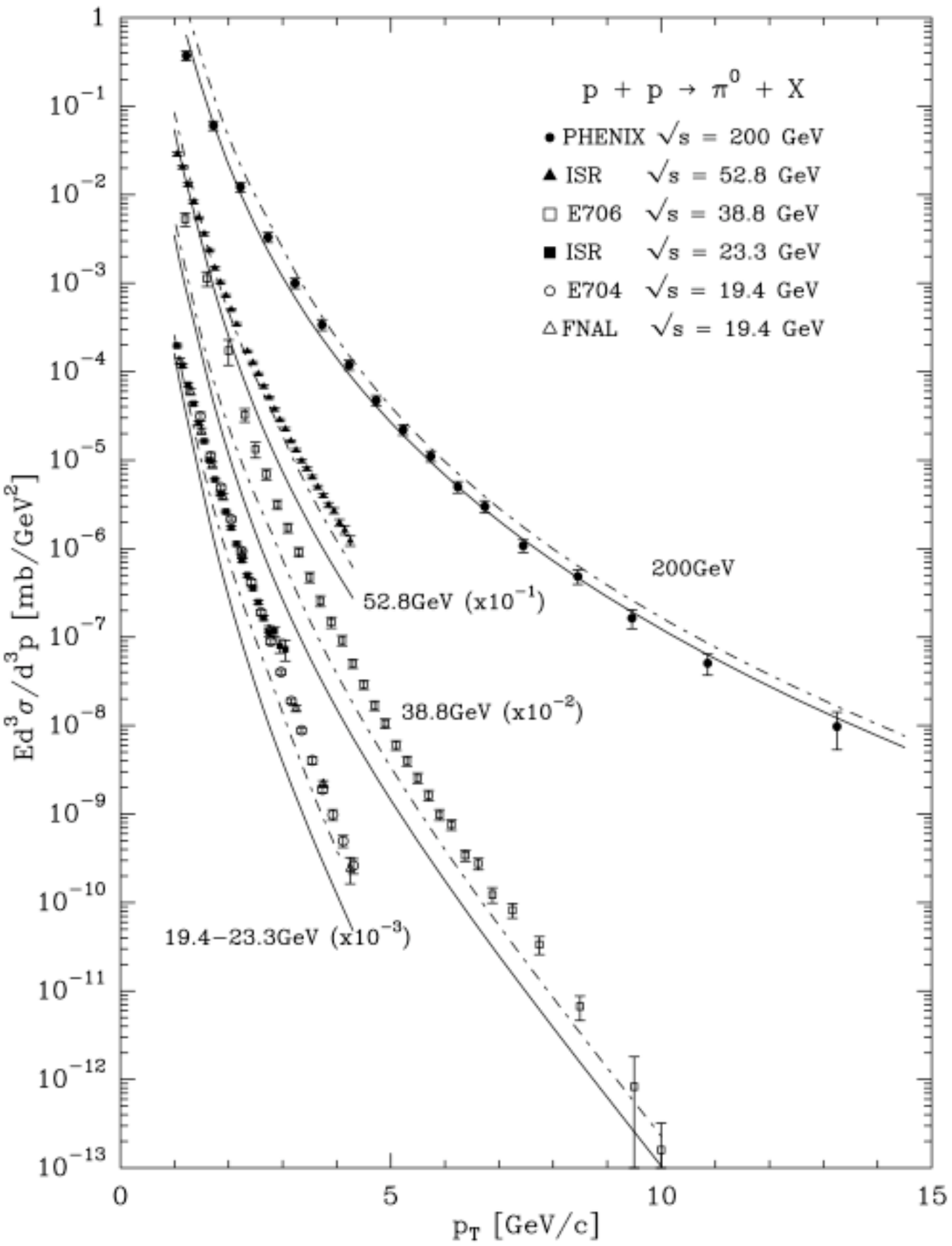




B. Jäger et al., Eur. Phys. J. C **44,** (2005) 533

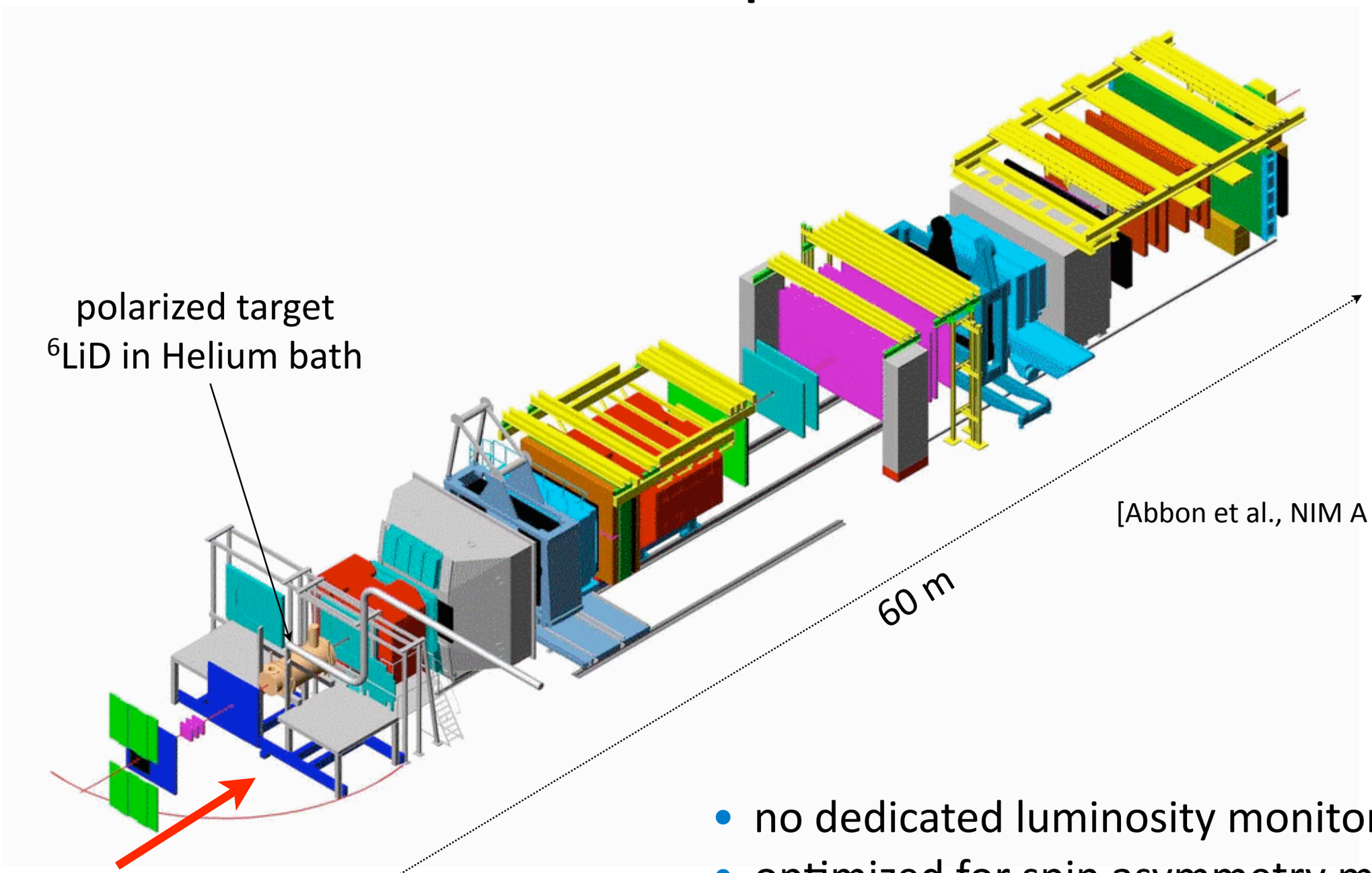
Cross sections as benchmarks for pQCD

- Before spin observables can be extracted from polarized cross sections with confidence, theory has to correctly reproduce unpolarized cross section
- Unpolarized PDFs are much better known
- At collider energies (RHIC p-p) benchmark works well
- Concept is still to be proven at fixed target energies
- Does it work for quasi-real photo-production in lepton-nucleon scattering?



C. Bourrely & J. Soffer, Eur. Phys. J. C **36,** (2004) 371

The COMPASS Experiment at CERN SPS

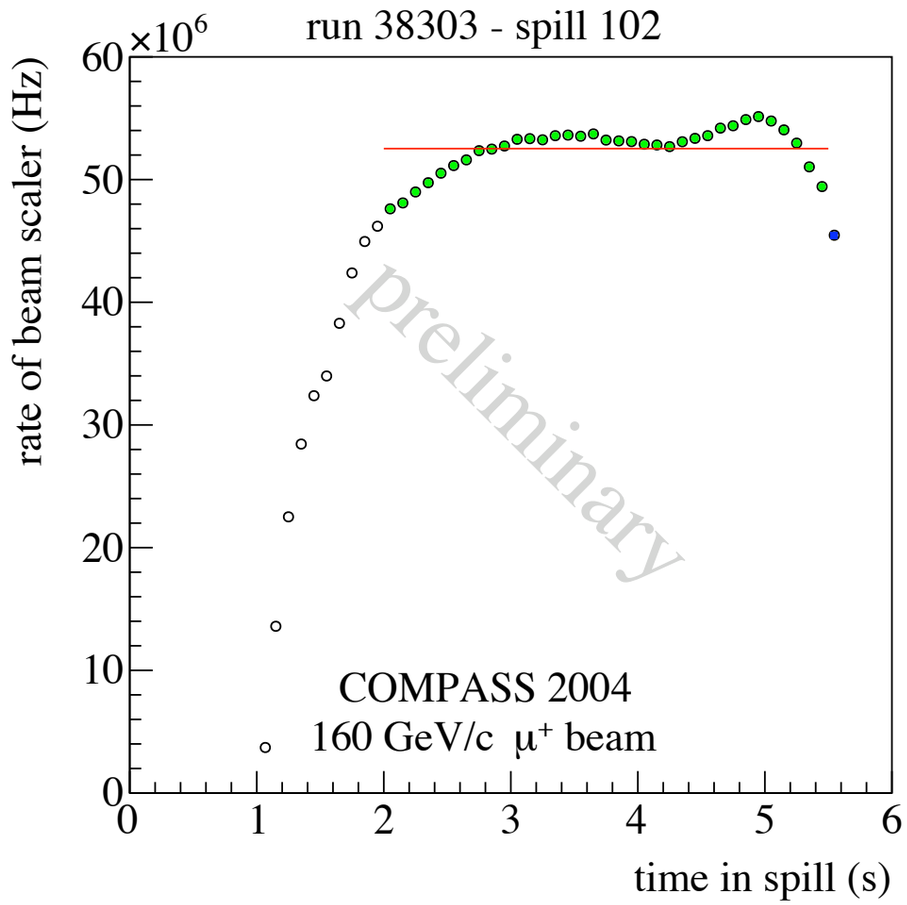


[Abbon et al., NIM A 577 (2007), 455-518]

- no dedicated luminosity monitor
- optimized for spin asymmetry measurements

Luminosity Determination

- Select good spills
  (54624 of 73591 spills retained)
- Select flat top of the beam in each spill
- Determine beam flux on target:
  - scaler on a beam counter
  - counting reconstructed beam tracks in random trigger events



- Take into account rate dependent dead times of DAQ (max. 9%) and the veto system of the trigger (max. 20%) on a spill by spill basis.
- 50% of presented data set recorded with half beam intensity
- Integrated luminosity (corrected for all dead times) of the presented data set is 142.4 pbarn^{-1} ±10% sys.

Check of luminosity - F_2

- Need a well-known reference cross section that can be measured with COMPASS: Inclusive muon scattering or structure function F_2

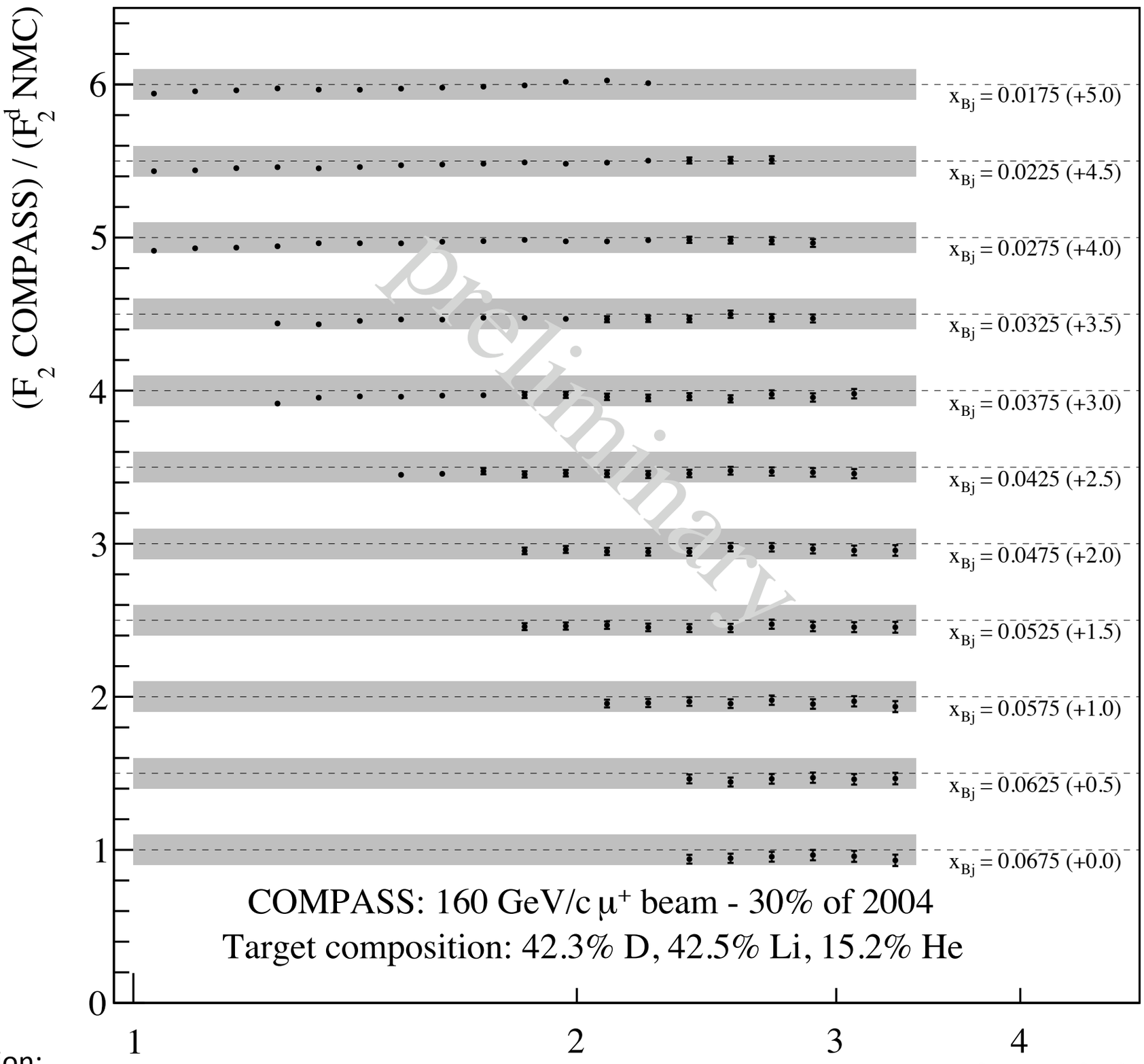
$$F_2 = \frac{\mathrm{d}^2\sigma}{\mathrm{d}Q^2\mathrm{d}x_{\mathrm{Bj}}} \times C(Q^2, x_{\mathrm{Bj}}, E)$$

- Selected kinematics for check: $Q^2 > 1$ (GeV/c)^2, $x_{Bj} \in [0.015, 0.07]$, $y < 0.5$
- Nuclear effects (EMC effect) negligible
- Radiative corrections are applied (but are < 15%)

$$y = \frac{E - E'}{E} = \frac{\nu}{E}$$

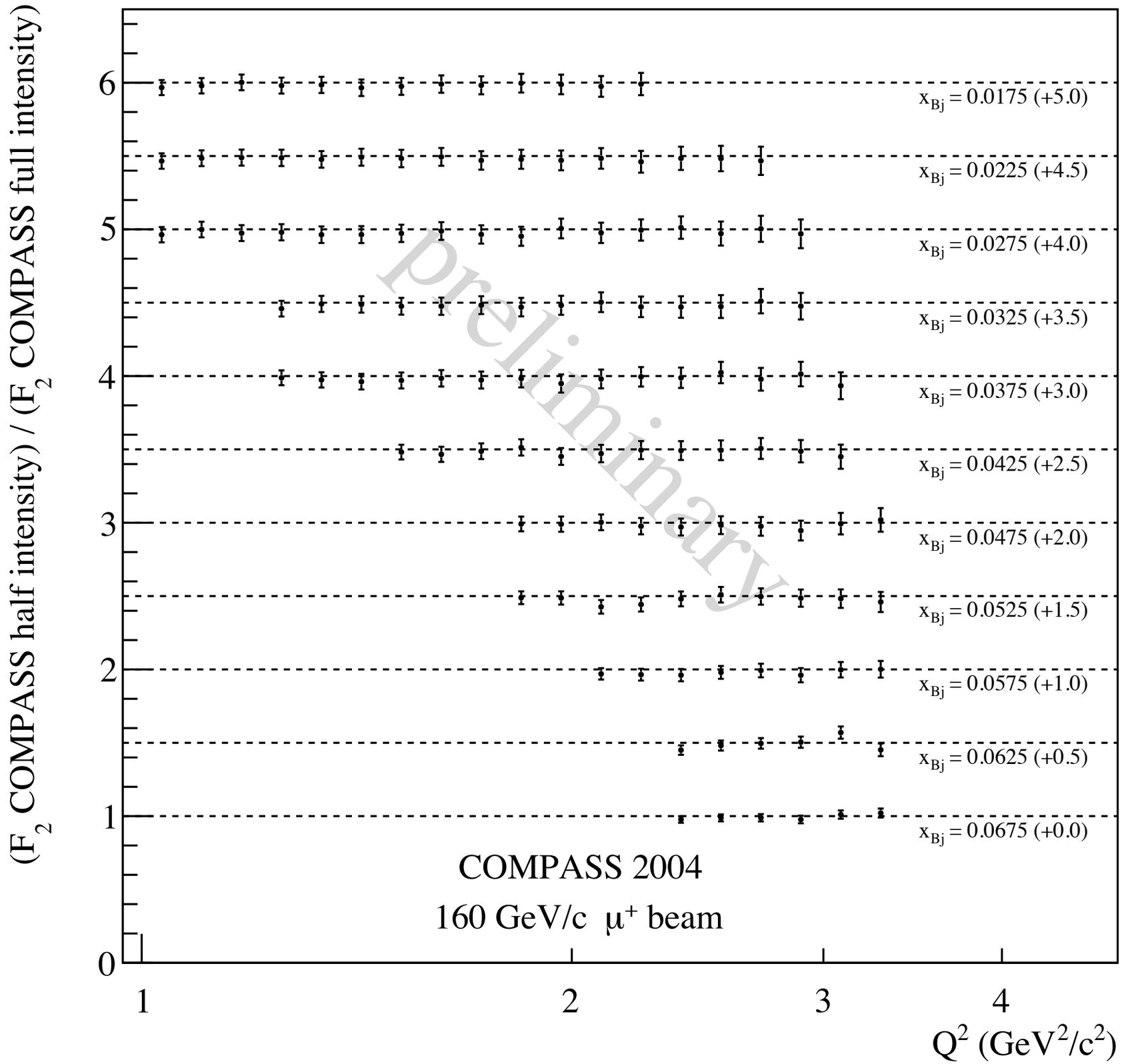
- Acceptance correction for inclusive muon scattering:
  Full MC simulation of inclusive muon scattering
  in COMPASS (LEPTO, GEANT3, COMPASS event reconstruction)

F_2 Comparison with Literature



NMC paramtrization:
M. Arneodo et al. (NMC Collaboration), Physics Letters B **364,** (1995) 107

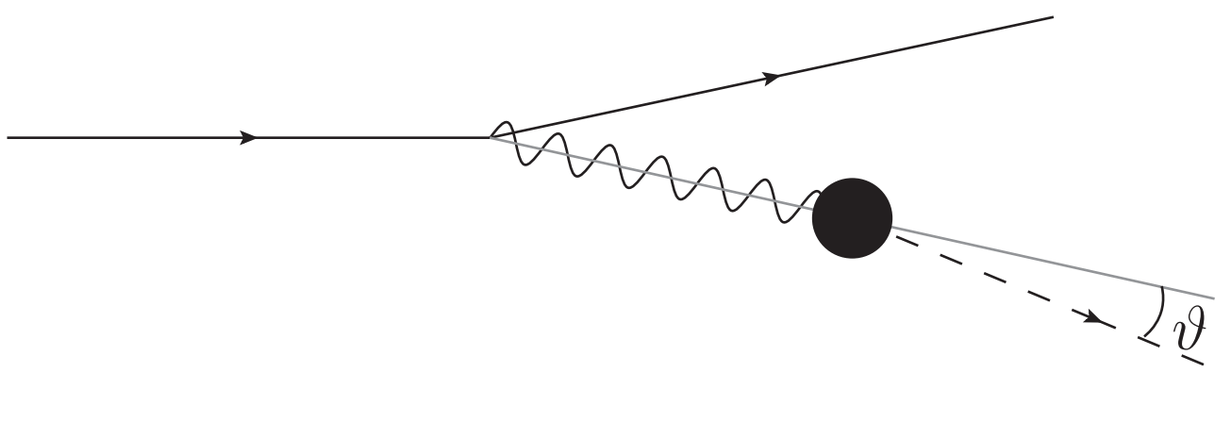
F_2 - Different Intensities



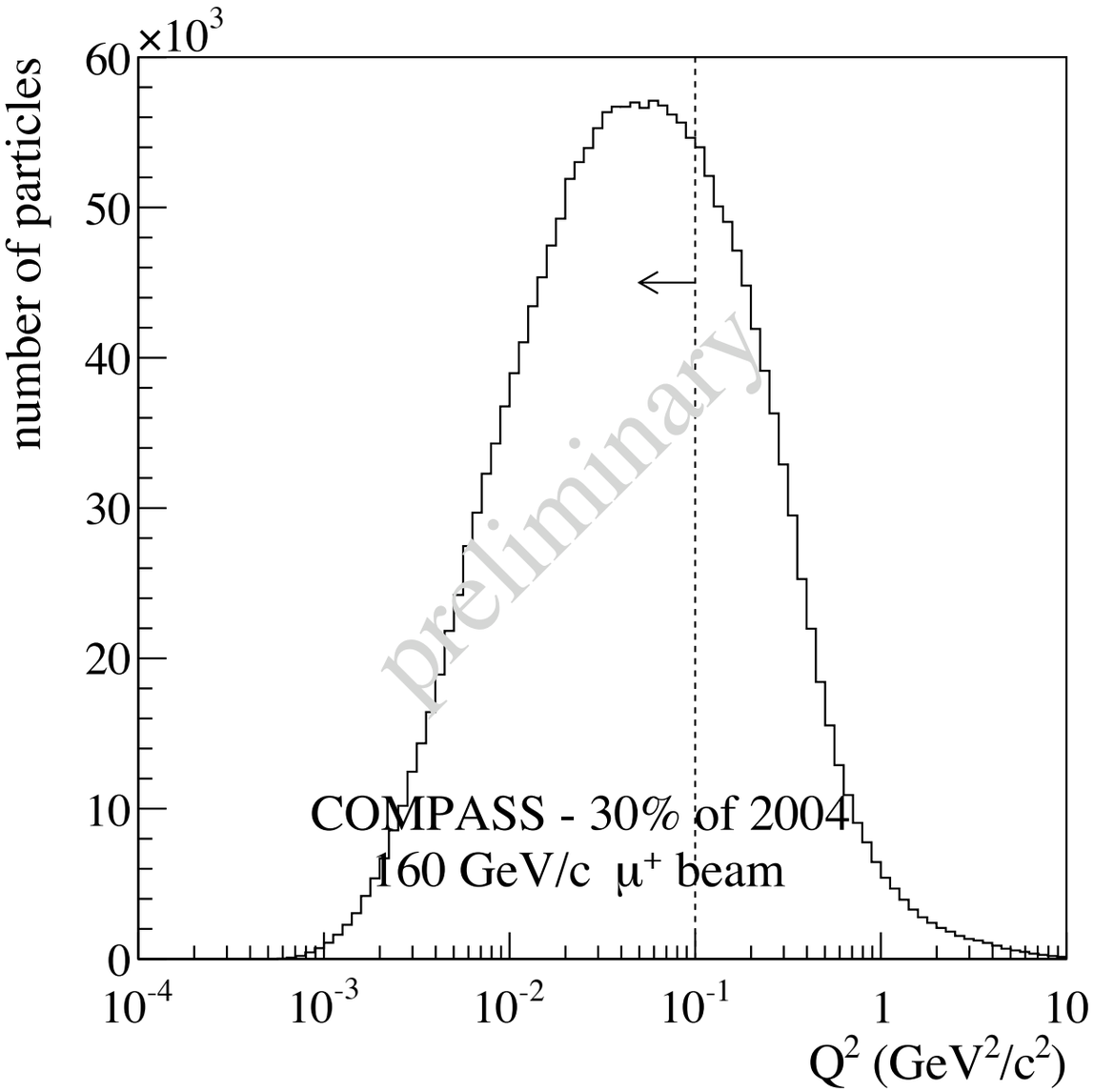
High-p_T hadron production cross section

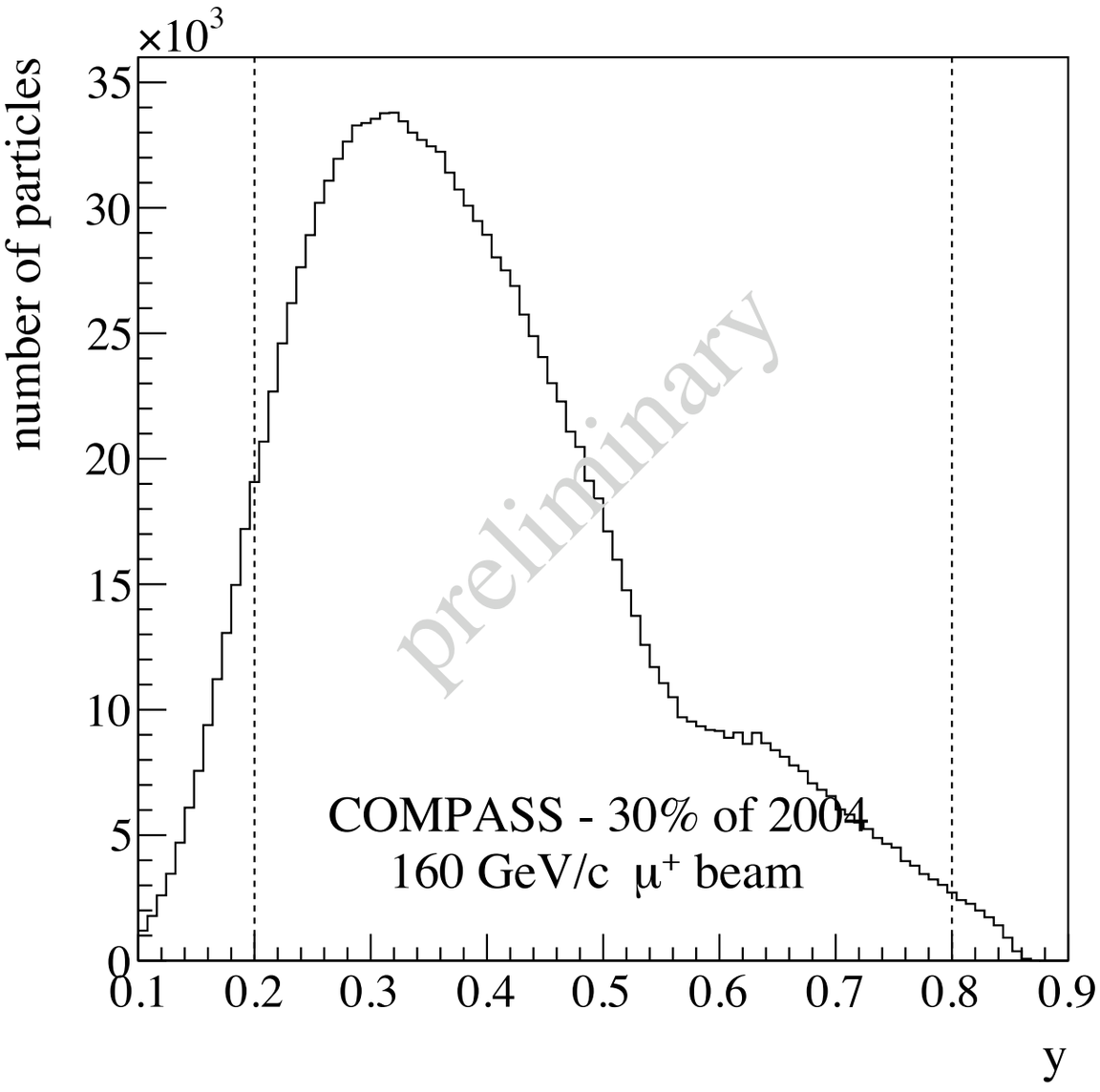
Experimental cuts

- Two low Q^2 triggers: Energy loss of muon and energy deposit in HCAL
- Primary vertex in fiducial target volume (as used for luminosity)
- *$Q^2 < 0.1$ (GeV/c)^2*
- *$y \in [0.2,0.8]$* $\qquad y = \frac{E - E'}{E} = \frac{\nu}{E}$
- Hadron candidate cuts:
  - must hit hadronic calorimeter and *$p > 15$ GeV/c*
  - *$z \in [0.2,0.8]$,* $(z=E_h/\nu)$
  - *$\vartheta \in [20$ mrad, 120 mrad$]$*



Kinematical distributions





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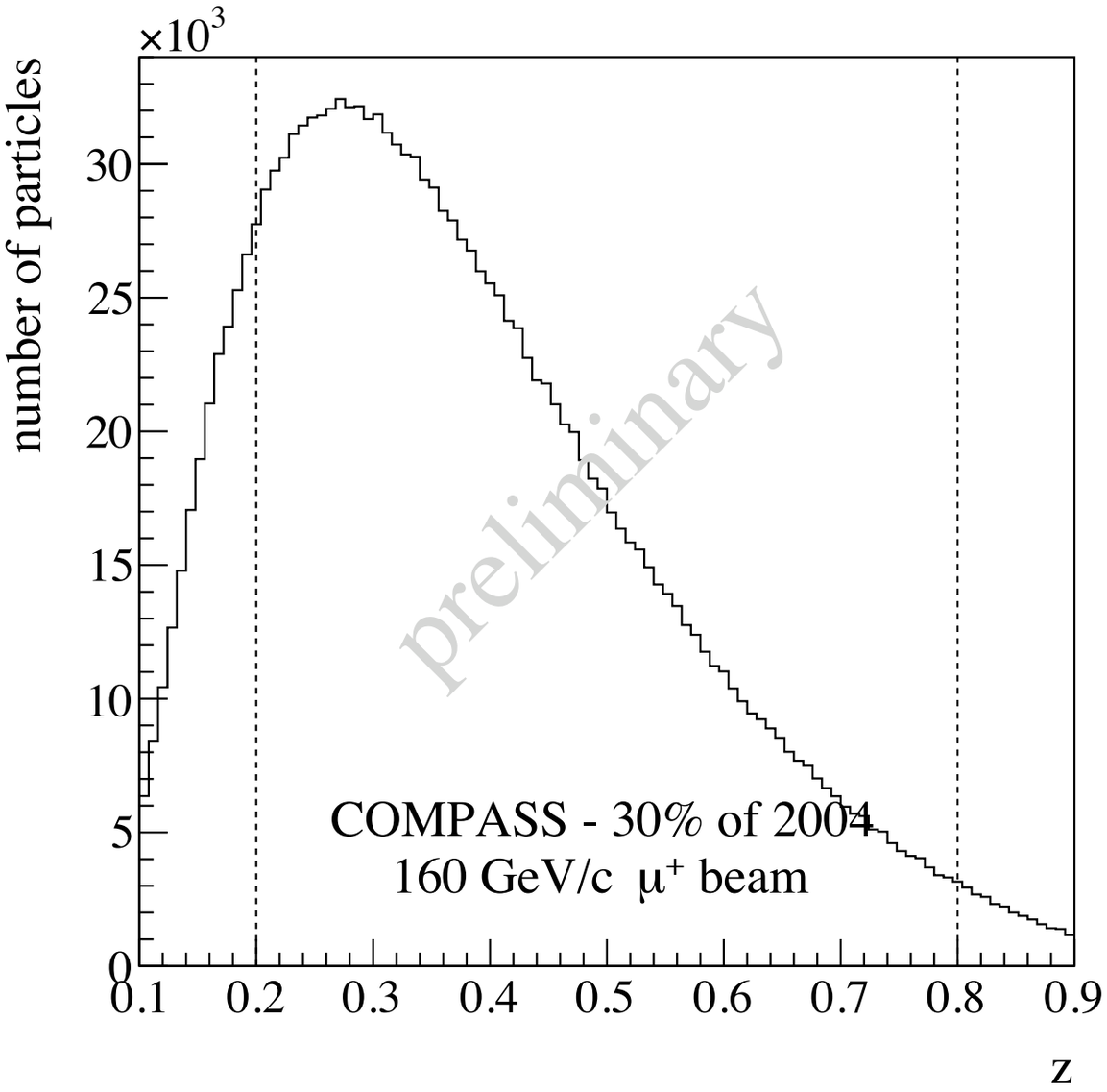
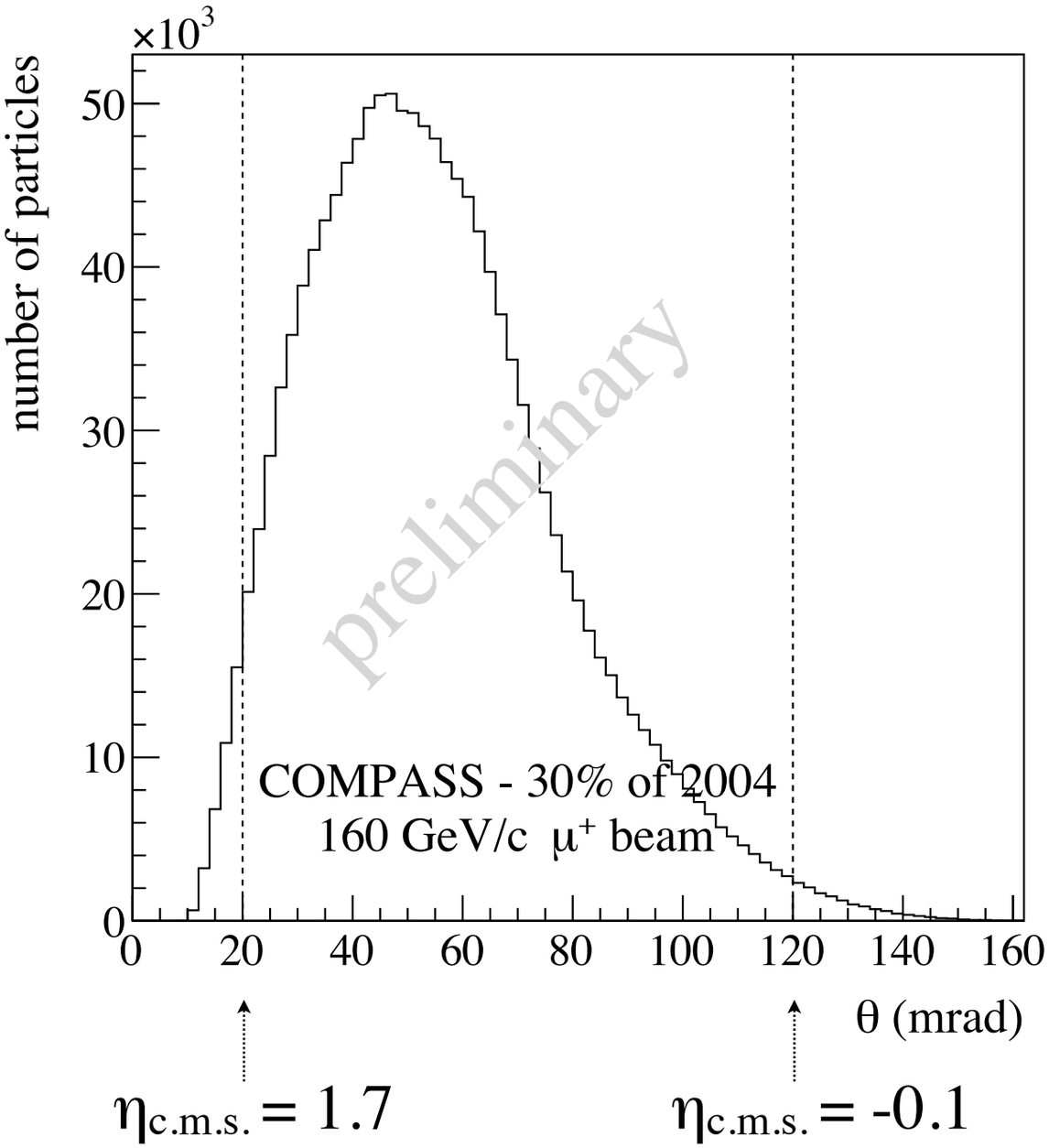
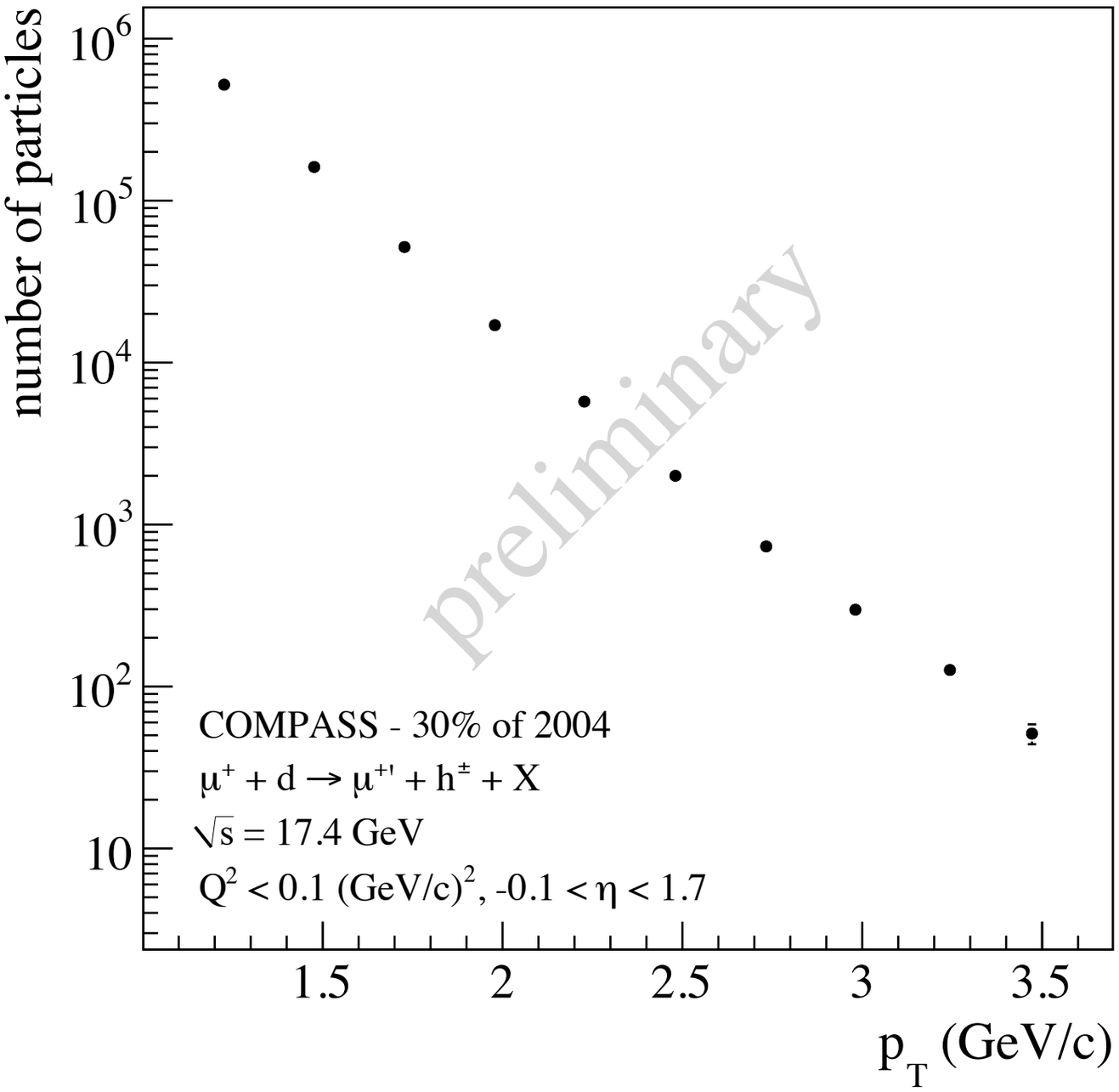




High-p_T yield



From yield to cross section

- Acceptance correction:
  - Obtained from MC simulation:
    PYTHIA6, GEANT3, COMPASS event reconstruction
  - trigger & detection efficiency
  - kinematical smearing
- Challenge: Hadronic interactions in the 1.2 m solid state target
  -> different simulation models under investigation
- Systematic error estimation of acceptance correction is still ongoing
- Production of large MC sample (several 10^8 events) will still
  take few weeks/months
- No cross section result can be shown yet :(

Conclusion and Outlook

- Measurements of single-inclusive particle production cross sections provide an important benchmark for pQCD methods
  (especially at fixed-target energies)

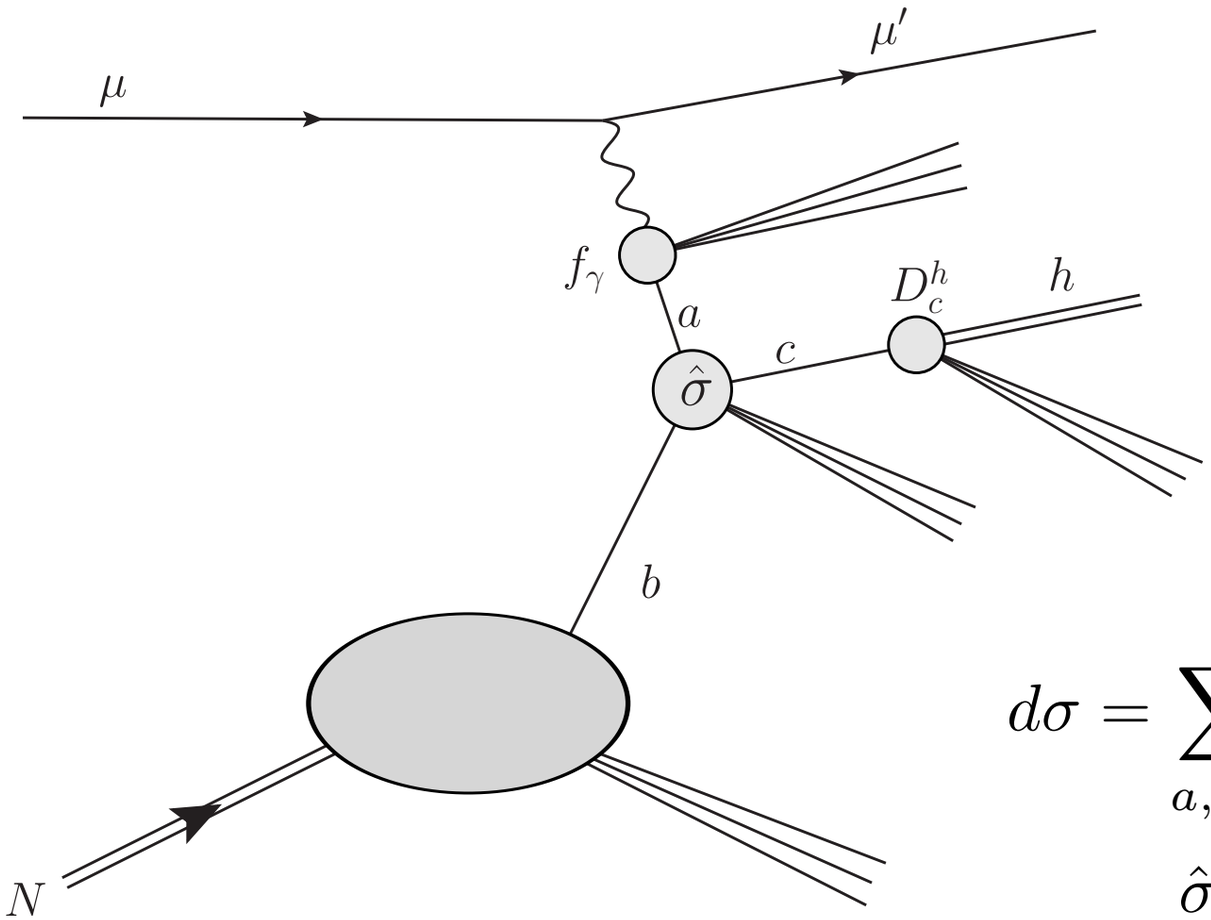
- Luminosity for part of COMPASS muon-deuteron scattering data set has been determined and checked by comparison with F_2

- Unpolarized cross section for quasi-real photo-production
  of high-pT charged hadrons will be published very soon

- Polarized high-pT hadron production cross section at low Q^2 has potential to constrain gluon polarization

Extra Slides

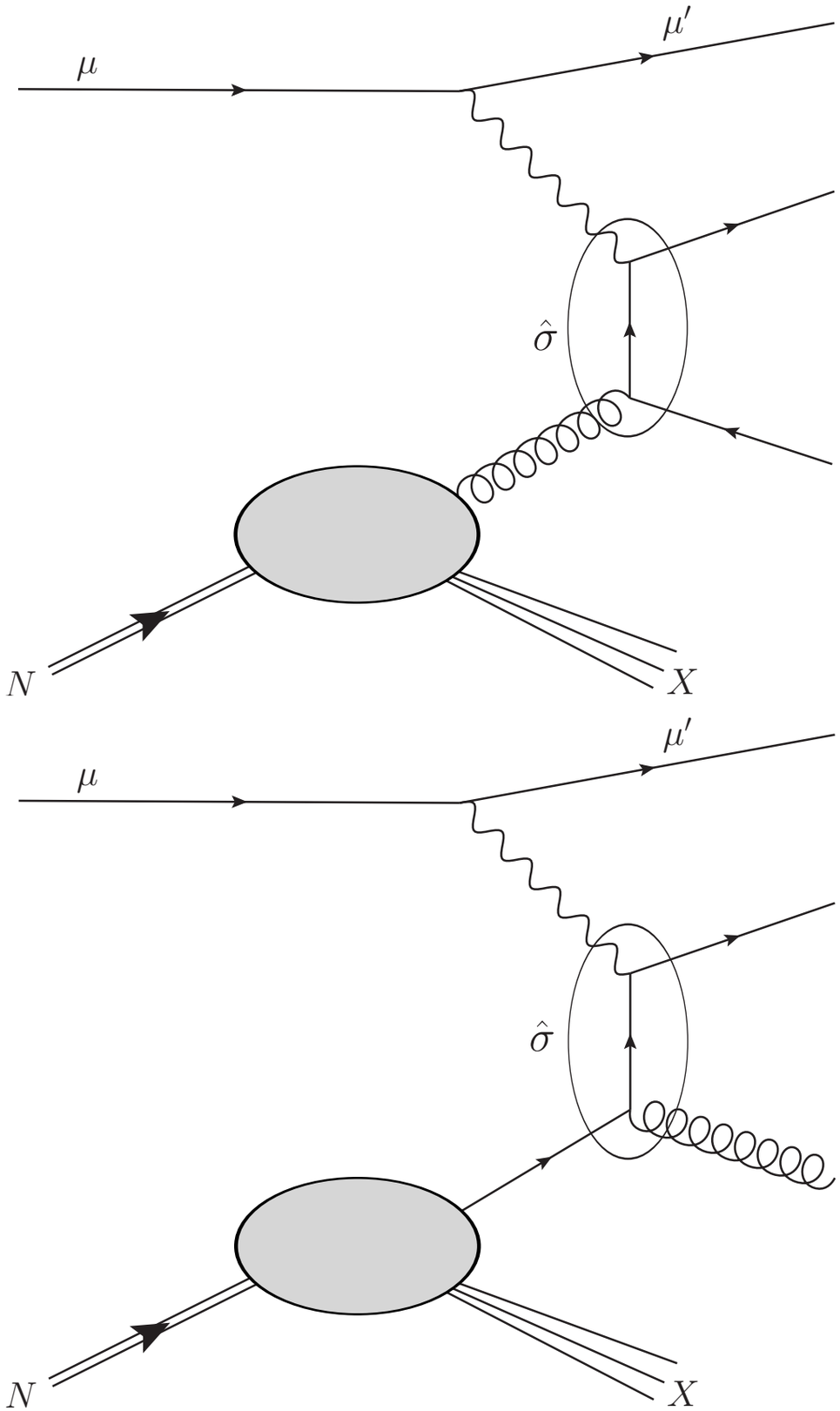
pQCD factorization of hadron production cross section

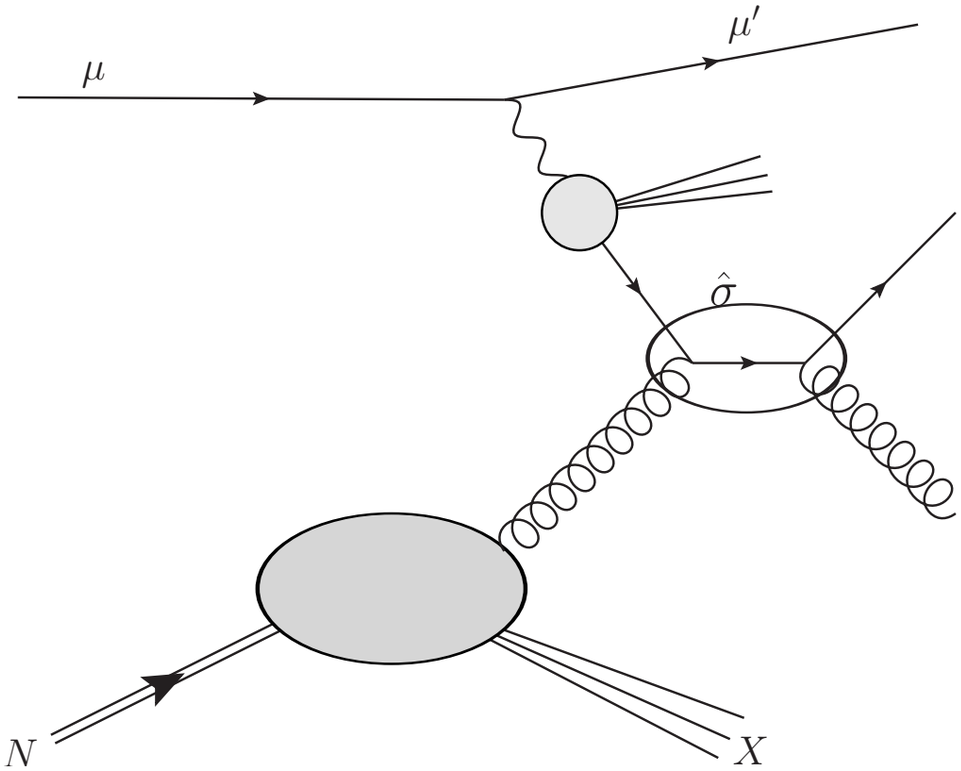
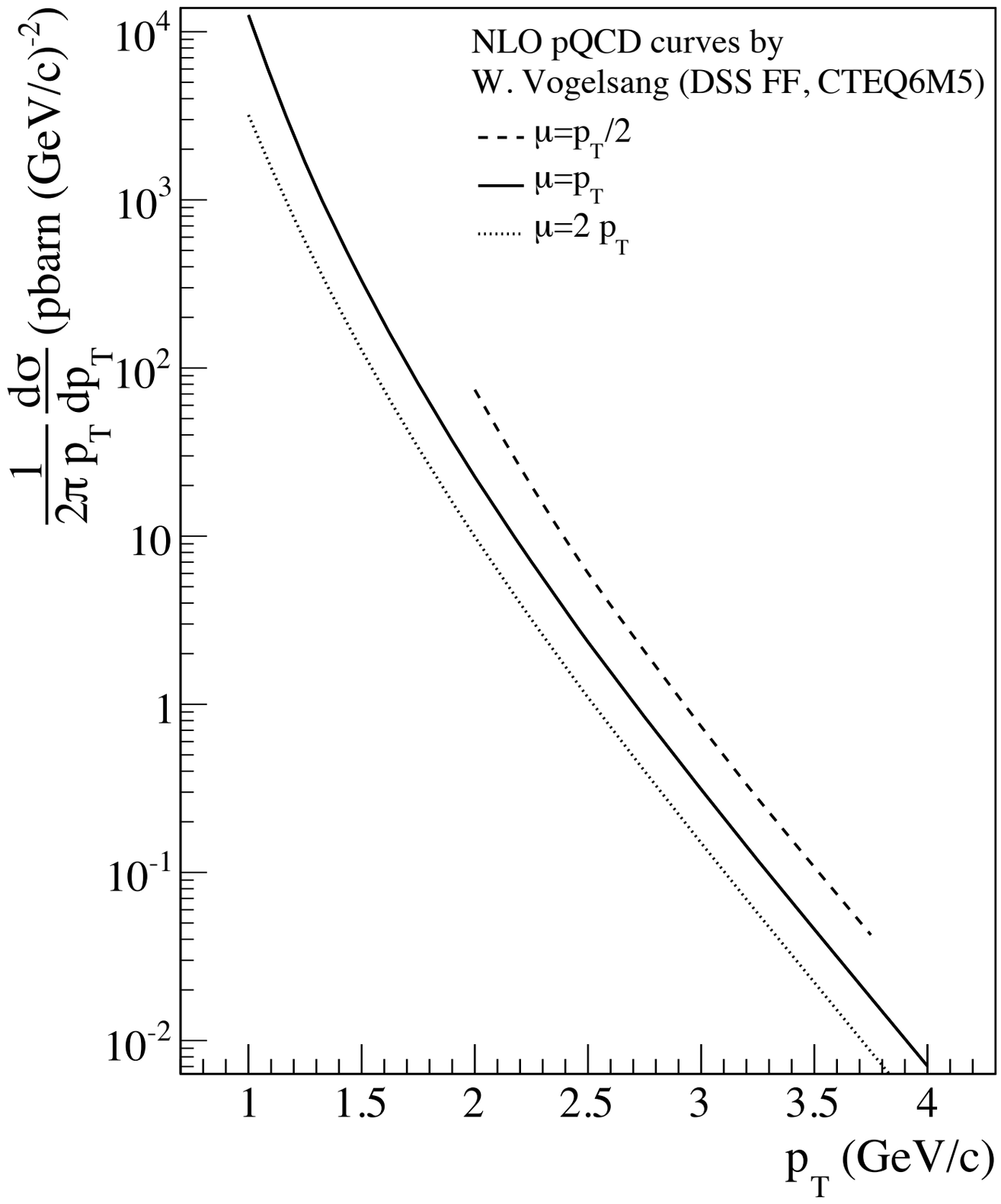


$$d\sigma = \sum_{a,b,c} \int dx_a dx_b dz_c f_a^l(x_a, \mu_f) f_b^N(x_b, \mu_f) \times$$
$$\hat{\sigma}(S, x_a, x_b, P_h/z_c, \mu_r, \mu_f, \mu'_f) D_c^h(z_c, \mu'_f)$$

$$f_a(x_a, \mu_f) = \int_{x_a}^1 \frac{dy}{y} P_{\gamma l}(y) f_a^\gamma(x_\gamma = \frac{x_a}{y}, \mu_f)$$

Examples for high-p_T production





Recent pQCD results on cross section