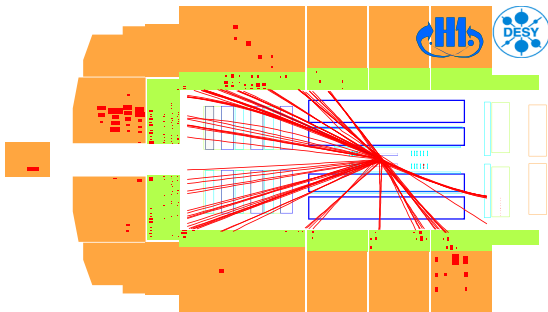


Photoproduction of D^* and Jets at H1

Zlatka Staykova
for the H1 Collaboration

DESY Hamburg

DIS 2010
Florence, Italy

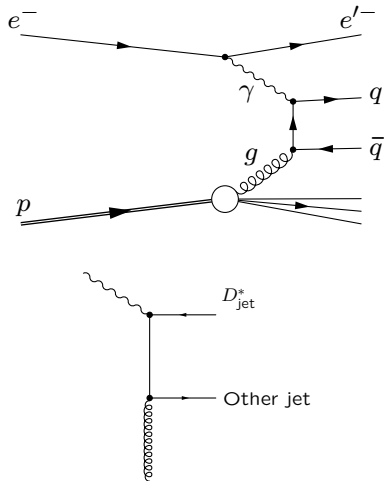


Outline

- ▶ Motivation
- ▶ Monte Carlo Models
- ▶ Data selection and analysis strategy
- ▶ Differential cross sections

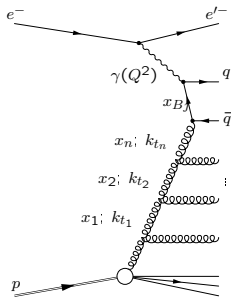
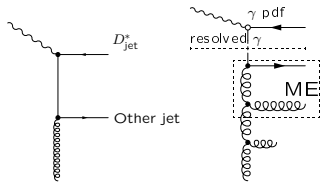
Photoproduction of Charm Quarks

- ▶ In γp $Q^2 \approx 0$, a suitable scale for pQCD is $m_c \gg \Lambda_{\text{QCD}}$
- ▶ Dominant process Boson Gluon Fusion \implies highly sensitive to the incoming gluon
 - ▶ Use D^* meson to tag the charm
 - ▶ Use jets to tag the second hard parton in the event



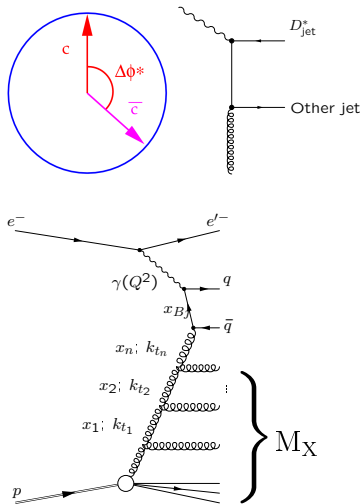
Motivation

- ▶ Sensitivity to the incoming gluon
- ▶ Parton evolution models:
 - ▷ DGLAP: ordered in k_t
 - ▷ CCFM: ordered in emission angles
- ▶ Resolved γp , the photon exhibits hadron like structure:
 - ▷ Shifts the matrix elements lower in the cascade such that higher p_t emission are possible closer to the proton side



Definitions of the Observables

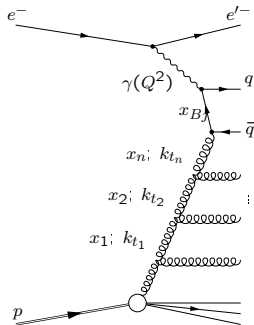
- ▶ $\Delta\varphi = |\varphi_{D_{\text{jet}}^*} - \varphi_{\text{Other jet}}|$ and p_{t}^{jj} highly sensitive to the k_{t} of the incoming gluon
- ▶ $M_{\text{X}}^2 = (p + q - (p_{D_{\text{jet}}^*} + p_{\text{Other jet}}))^2$ the invariant mass of the remnant:
 - ▶ Sensitive to the history of the partonic cascade from both sides, proton and photon
- ▶ The longitudinal momentum fraction of the photon carried by the jets:
 - ▶ Small x_{γ} ($x_{\gamma} < 0.75$): Significant contribution of resolved photons
 - ▶ Large x_{γ} ($x_{\gamma} \geq 0.75$): Direct photon enhanced sample



MC Models

- ▶ Pythia based on the DGLAP evolution, partons ordered in p_t , highest p_t in the quark box. Includes direct photoproduction and resolved processes
- ▶ Cascade based on the CCFM evolution, partons ordered in emission angle, allows higher p_t emissions closer to the proton side
- ▶ MC@NLO: full next-to-leading order ME calculation matched with parton showers (Herwig) (calculations, thanks to [Tobias Toll](#))

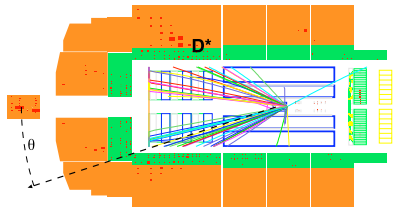
| generator | proton (u)pdfs | photon pdfs |
|-----------------|----------------|-------------|
| Pythia massive | CTEQ 6M NLO | SAS 2D LO |
| Pythia massless | CTEQ 6L LO | GRV-G LO |
| Cascade | Set A0 | — |
| MC@NLO | CTEQ 6.6 | GRV |



Experimental Setup

- ▶ H1, HERA II data, $\mathcal{L} = 93.4 \text{ pb}^{-1}$
- ▶ Untagged Photoproduction ($Q^2 < 2 \text{ GeV}^2$)
 - ▶ D^* reconstructed in the golden decay channel
 $D^{*\pm} \rightarrow D^0 \pi^\pm \rightarrow (K^\mp \pi^\pm) \pi^\pm$
 - ▶ Events triggered by **Fast Track Trigger**
 - ▶ $p_t(D^*) > 2.1 \text{ GeV}$ in $|\eta| < 1.5$

Forward η

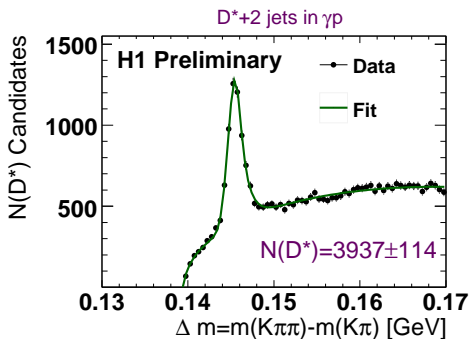


Backward η

- ▶ Jets with inclusive k_t , $R = 1$ and $p_t(\text{jet}) > 3.5 \text{ GeV}$
- ▶ D_{jet}^* found in $|\eta(\text{jet})| < 1.5$, highest p_t besides the D_{jet}^* selected in $-1.5 < \eta(\text{jet}) < 2.9$ and referred as **other jet**

Number of Particles Determination

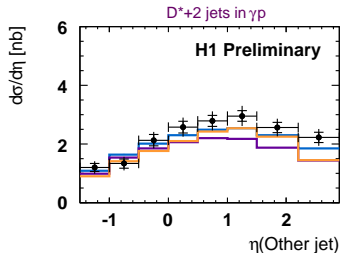
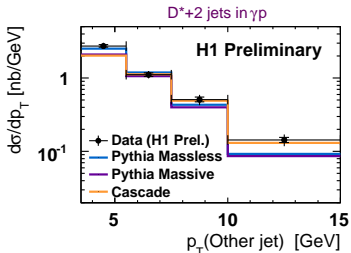
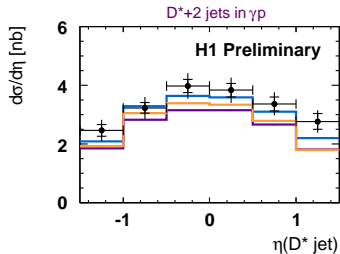
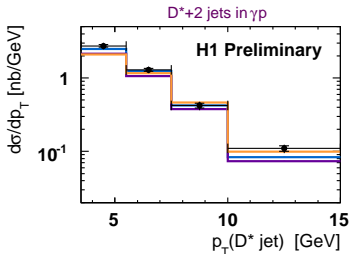
- ▶ The number of D^* particles was determined from a fit to the Δm distribution
 - ▶ The mass difference $\Delta m = m(K\pi\pi) - m(K\pi)$ is formed for each three tracks fulfilling the charge and selection criteria
- ▶ The asymmetric signal **Crystal Ball** function was used



- ▶ 8 times more D^* than H1 HERA I [Eur.Phys.J.C50:251-26]

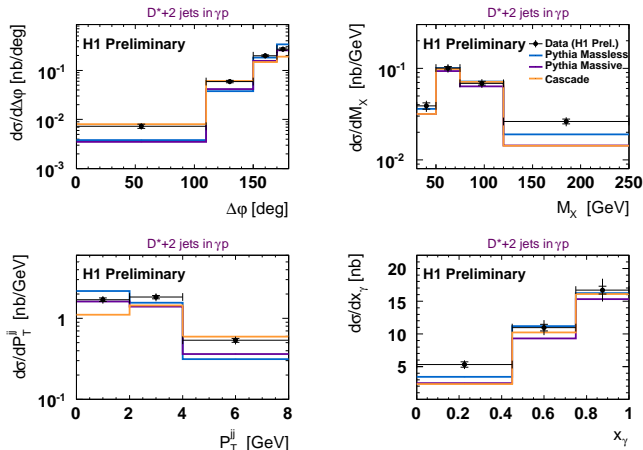
Results

Differential Cross Sections



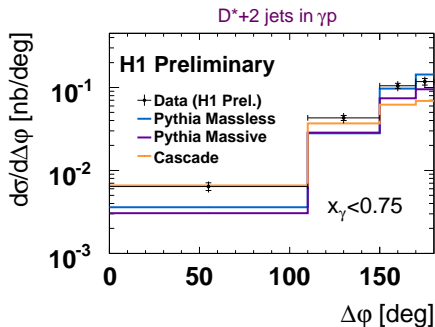
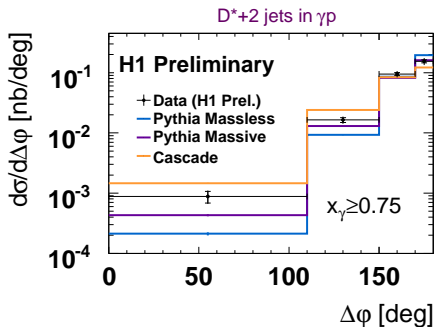
► Reasonable description of the data

Differential Cross Sections



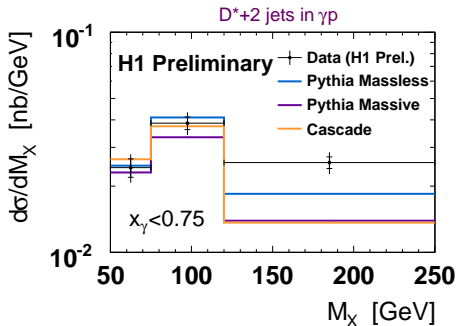
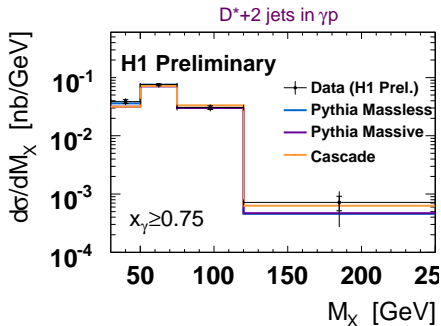
- ▶ Back-to-back region is well model by Pythia, while at small $\Delta\phi$ (large p_t^{jj}) Cascade provides good description
- ▶ The lowest x_γ bin is not described by any of the models

$\Delta\varphi$ in Bins of x_γ

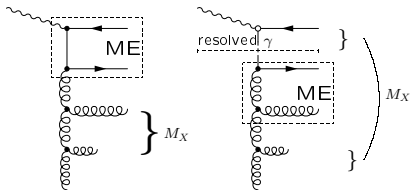


- ▶ Cascade undershoots the data at the high $\Delta\varphi$ but provides perfect description for the low $\Delta\varphi$
- ▶ Pythia describes the data at the back-to-back region and fails at low $\Delta\varphi$

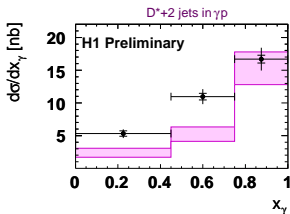
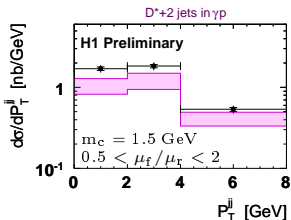
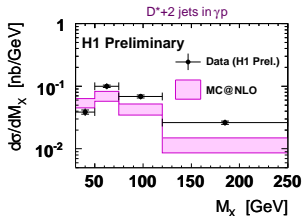
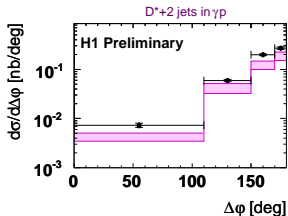
M_X in bins of x_γ



- ▶ In the high x_γ region, the data are perfectly described by all three models
- ▶ Different shapes for the three MCs, not described high M_X in the resolved case

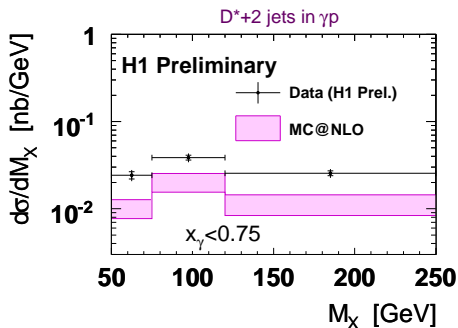
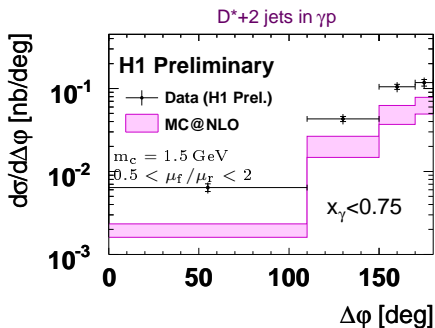


Comparison to MC@NLO



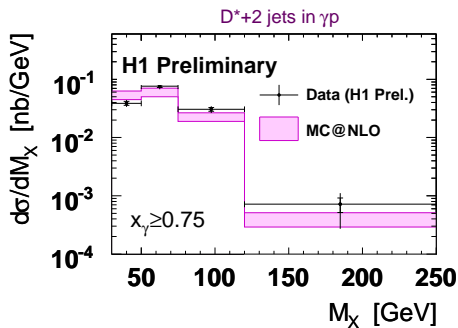
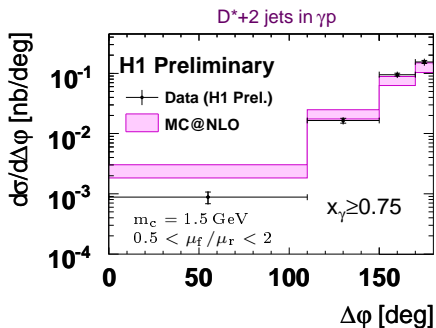
- ▶ Uncertainty band estimated with scale variations
- ▶ Well described shapes except x_γ

Comparison to MC@NLO: Low x_γ



- ▶ Well described shape, too long cross sections

Comparison to MC@NLO: High x_γ



- ▶ Cross sections agree for $x_\gamma \geq 0.75$, very well described $\Delta\phi$ and M_X

Conclusions

- ▶ The differential cross sections for $ep \rightarrow D^* + 2\text{-jets}$ were measured in an extended phase space:
 - ▶ New variables (p_t^{jj} and M_X) were presented
- ▶ Comparison to Pythia/Cascademodels:
 - ▶ Well described transverse momenta and rapidities
 - ▶ M_X perfectly reproduced in the high x_γ region, lack of contribution at high M_X for the resolved part
 - ▶ Very different shapes for $\Delta\varphi$
- ▶ MC@NLO:
 - ▶ Well reproduced shapes but wrong normalization for in small x_γ
- ▶ The precision of the measurement is good enough to differentiate between the models

Back up Slides

Phase Space Definition

$$0.1 < y_h < 0.8$$

$$Q^2 < 2. \text{ GeV}^2$$

$$2.1 \text{ GeV} < p_t(D^*) < 12.5 \text{ GeV}$$

$$|\eta(D^*)| < 1.5$$

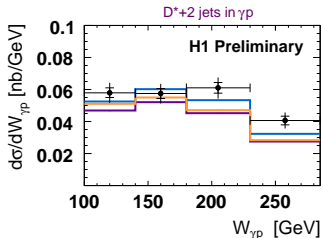
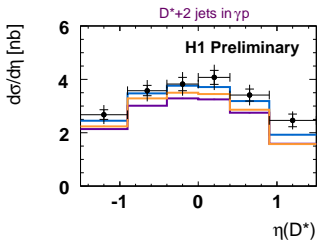
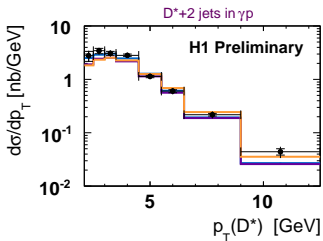
$$3.5 \text{ GeV} < p_t(D_{\text{jet}}^*, \text{Other jet}) < 15. \text{ GeV}$$

$$|\eta(D_{\text{jet}}^*)| < 1.5$$

$$-1.5 < \eta(\text{Other jet}) < 2.9$$

$$M_{jj} > 6 \text{ GeV}$$

Differential Cross Sections



- + Data (H1 Prel.)
- Pythia Massless
- Pythia Massive
- Cascade

