Photoproduction of D* and Jets at H1

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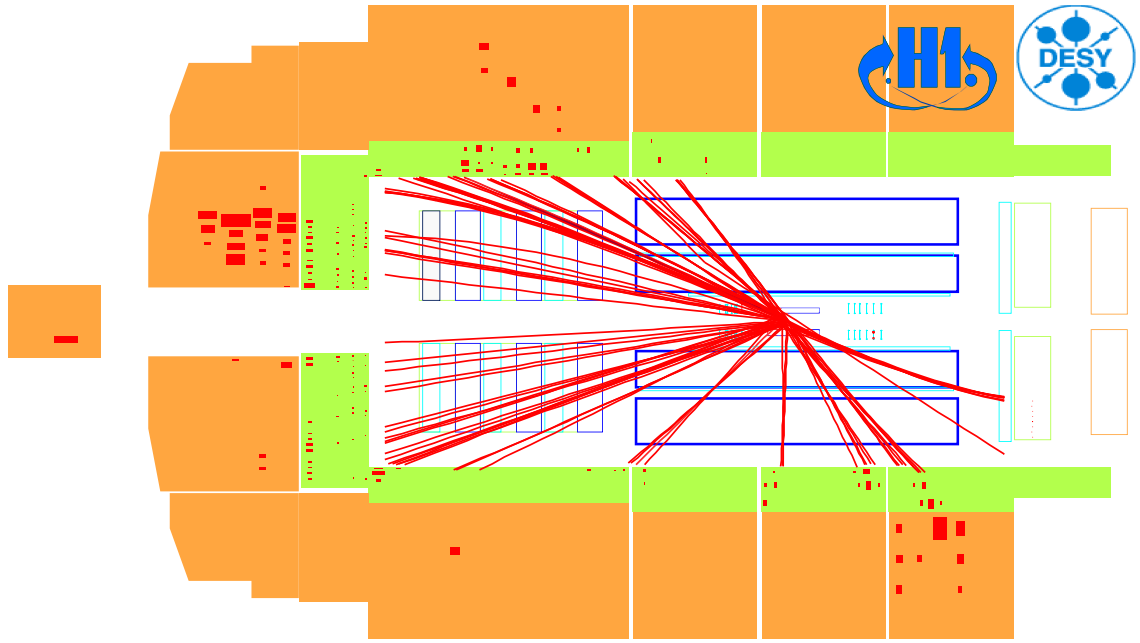
for the H1 Collaboration

DESY Hamburg

DIS 2010
Florence, Italy

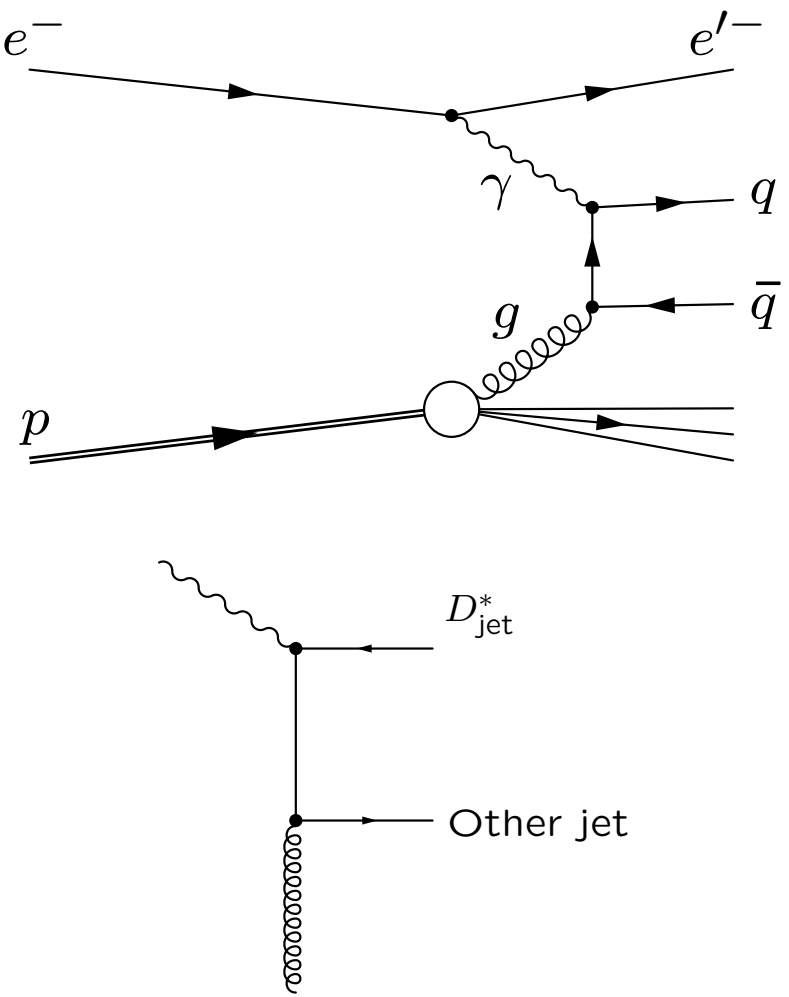


Outline

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

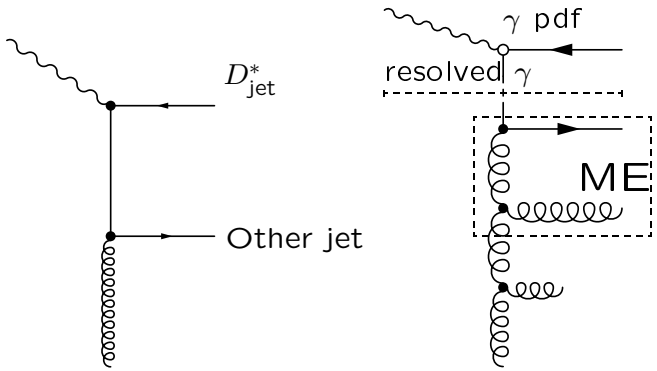
Photoproduction of Charm Quarks

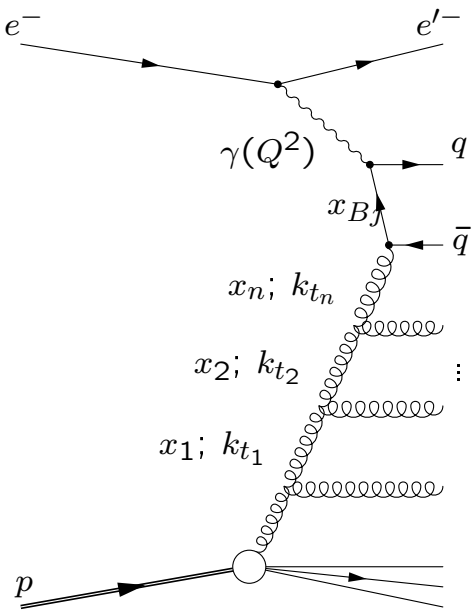
- In γp $Q^2 \approx 0$, a suitable scale for pQCD is $m_c \gg \Lambda_{QCD}$
- Dominant process Boson Gluon Fusion $\Longrightarrow$ highly sensitive to the incoming gluon
  - Use D* meson to tag the charm
  - Use jets to tag the second hard parton in the event



Motivation

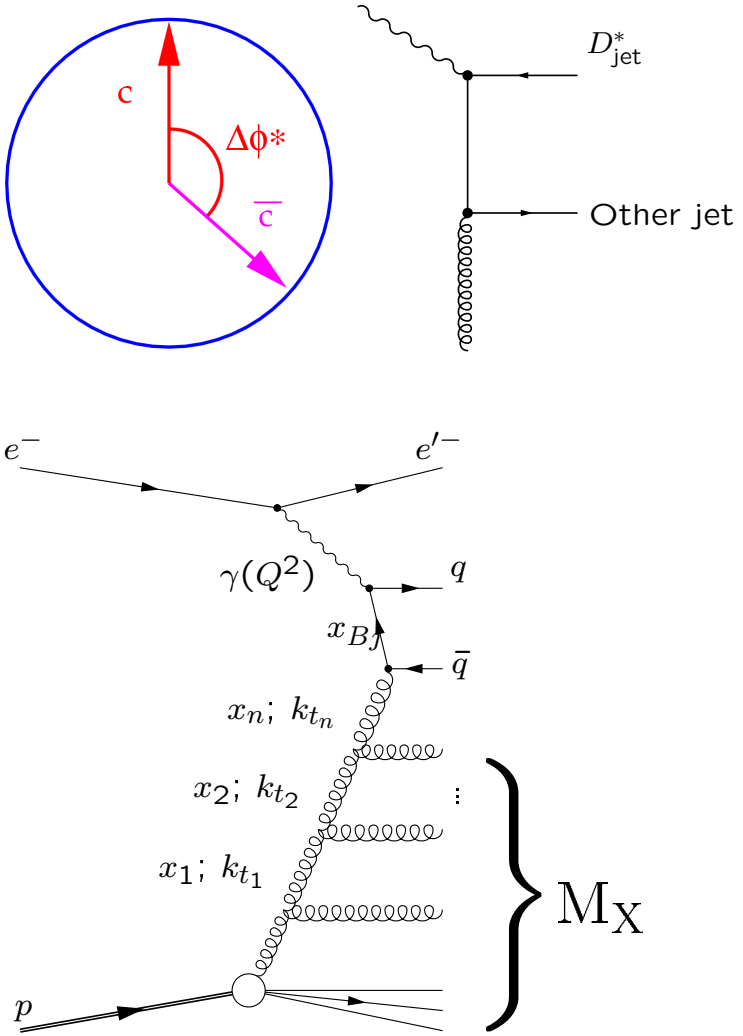
- Sensitivity to the incoming gluon
- Parton evolution models:
  - DGLAP: ordered in k_t
  - CCFM: ordered in emission angles
- Resolved γp, the photon exhibits hadron like structure:
  - Shifts the matrix elements lower in the cascade such that higher p_t emission are possible closer to the proton side





Definitions of the Observables

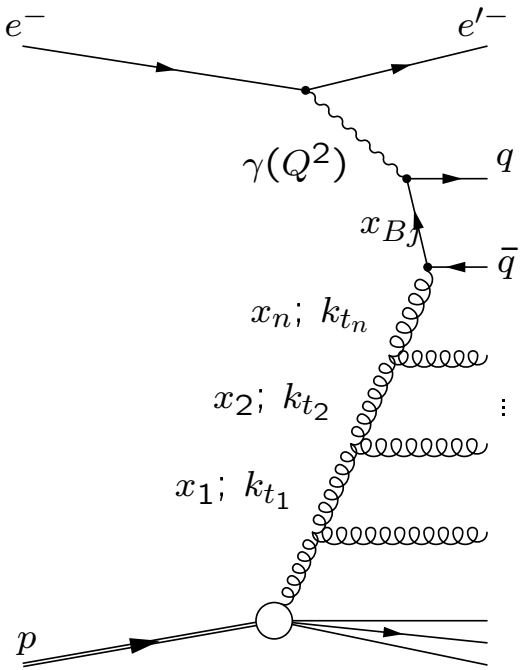
- $\Delta\varphi = |\varphi_{D^*_{jet}} - \varphi_{Other\ jet}|$ and p_t^{jj} highly sensitive to the k_t of the incoming gluon
- $M_X^2 = (p + q - (p_{D^*_{jet}} + p_{Other\ jet}))^2$ the invariant mass of the remnant:
  - Sensitive to the history of the partonic cascade from both sides, proton and 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

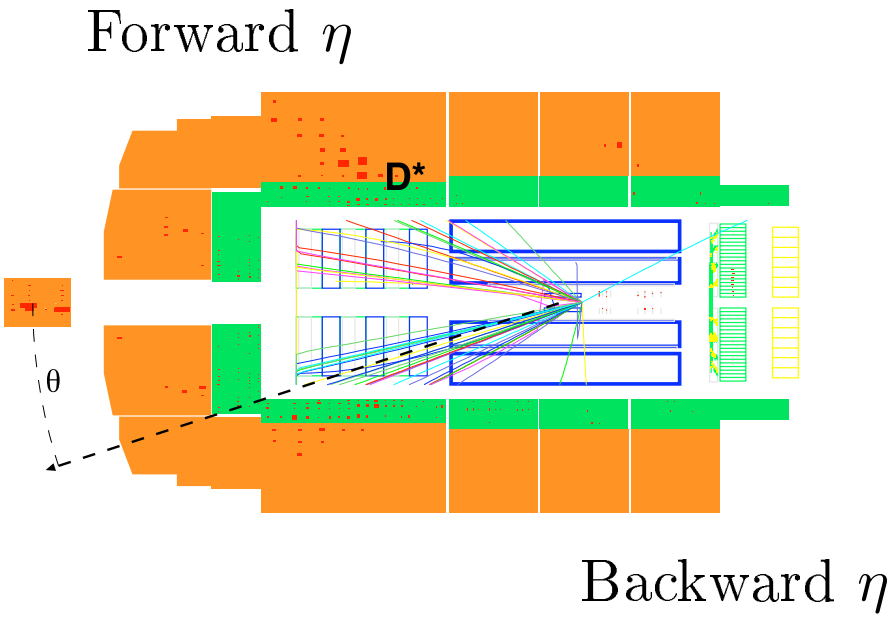
- Pythia based on the DGLAP evolution, partons ordered in p_t, highest p_t in the quark box. Includes direct photoproduction and resolved processes
- Cascade based on the CCFM evolution, partons ordered in emission angle, allows higher p_t emissions closer to the proton side
- MC@NLO: full next-to-leading 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

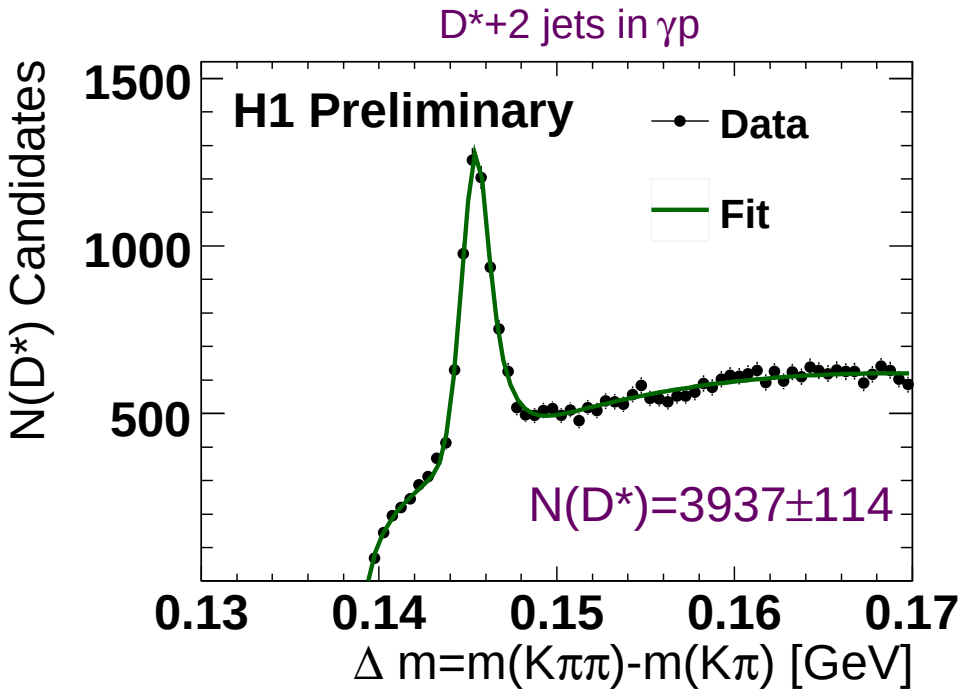
- H1, HERA II data, $\mathcal{L} = 93.4\,\mathrm{pb}^{-1}$
- Untagged Photoproduction ($Q^2 < 2\,\mathrm{GeV}^2$)
  - D^* reconstructed in the golden decay channel $D^{*\pm} \to D^0\pi^\pm \to (K^\mp\pi^\pm)\pi^\pm$
  - Events triggered by Fast Track Trigger
  - $p_t(D^*) > 2.1\,\mathrm{GeV}$ in $|\eta|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



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

Number of Particles Determination

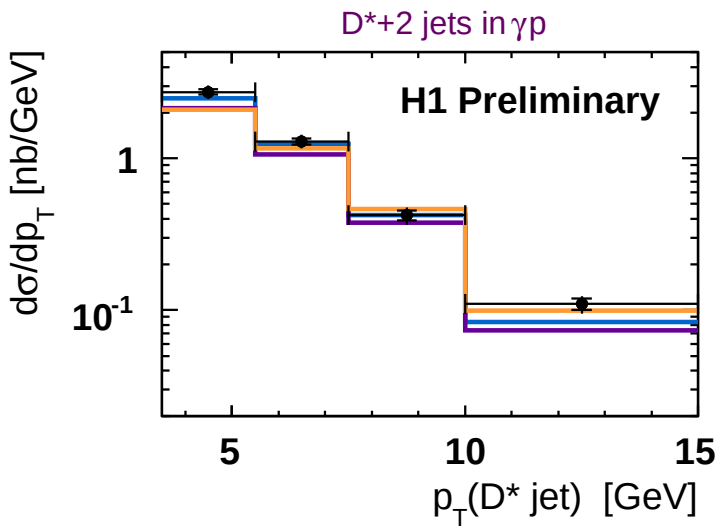
- The number of D^* particles was determined from a fit to the Δm distribution
  - The mass difference $\Delta m = m(K\pi\pi) - m(K\pi)$ is formed for each three tracks fulfilling the charge and selection criteria
- The asymmetric signal Crystal Ball function was used

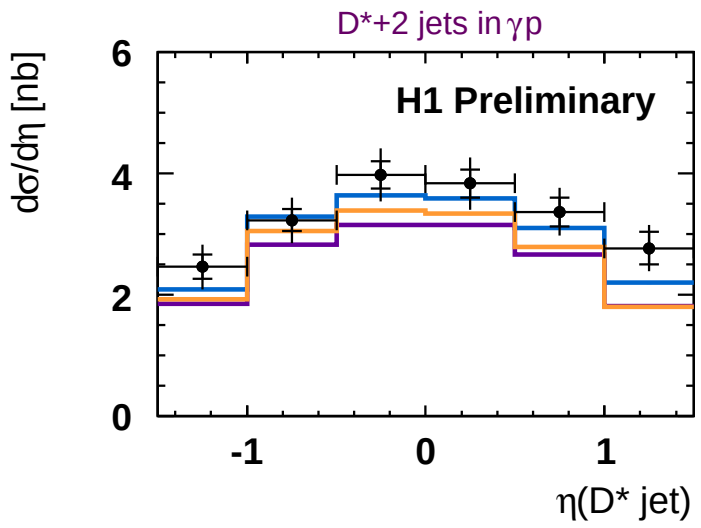


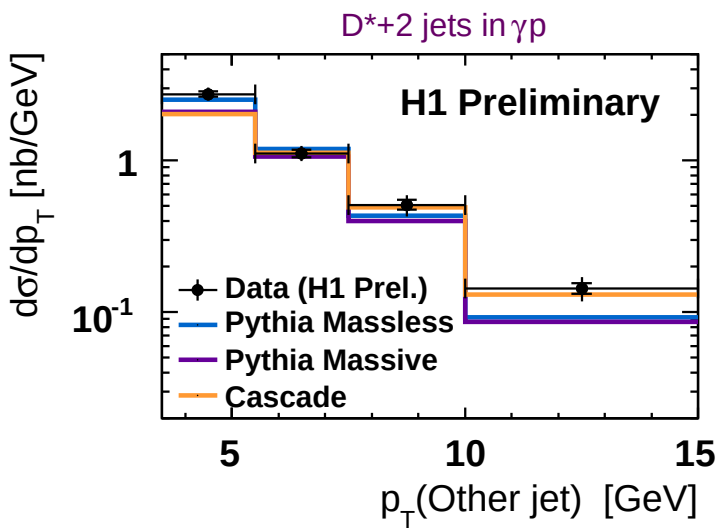
- 8 times more D^* than H1 HERA I [Eur.Phys.J.C50:251-26]

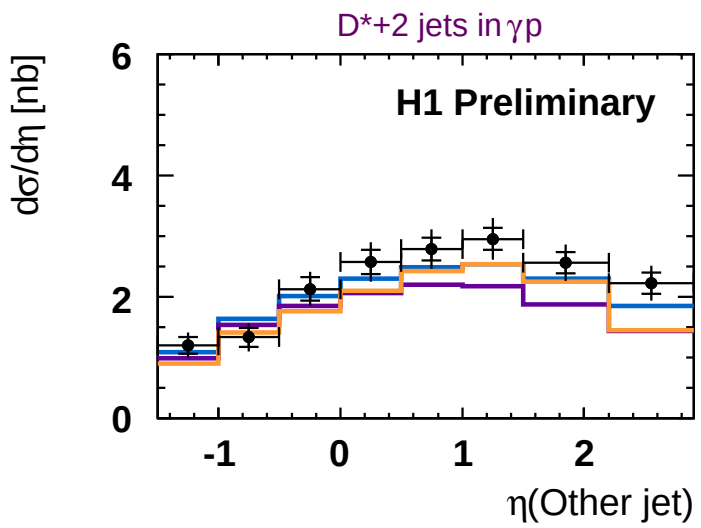
Results

Differential Cross Sections



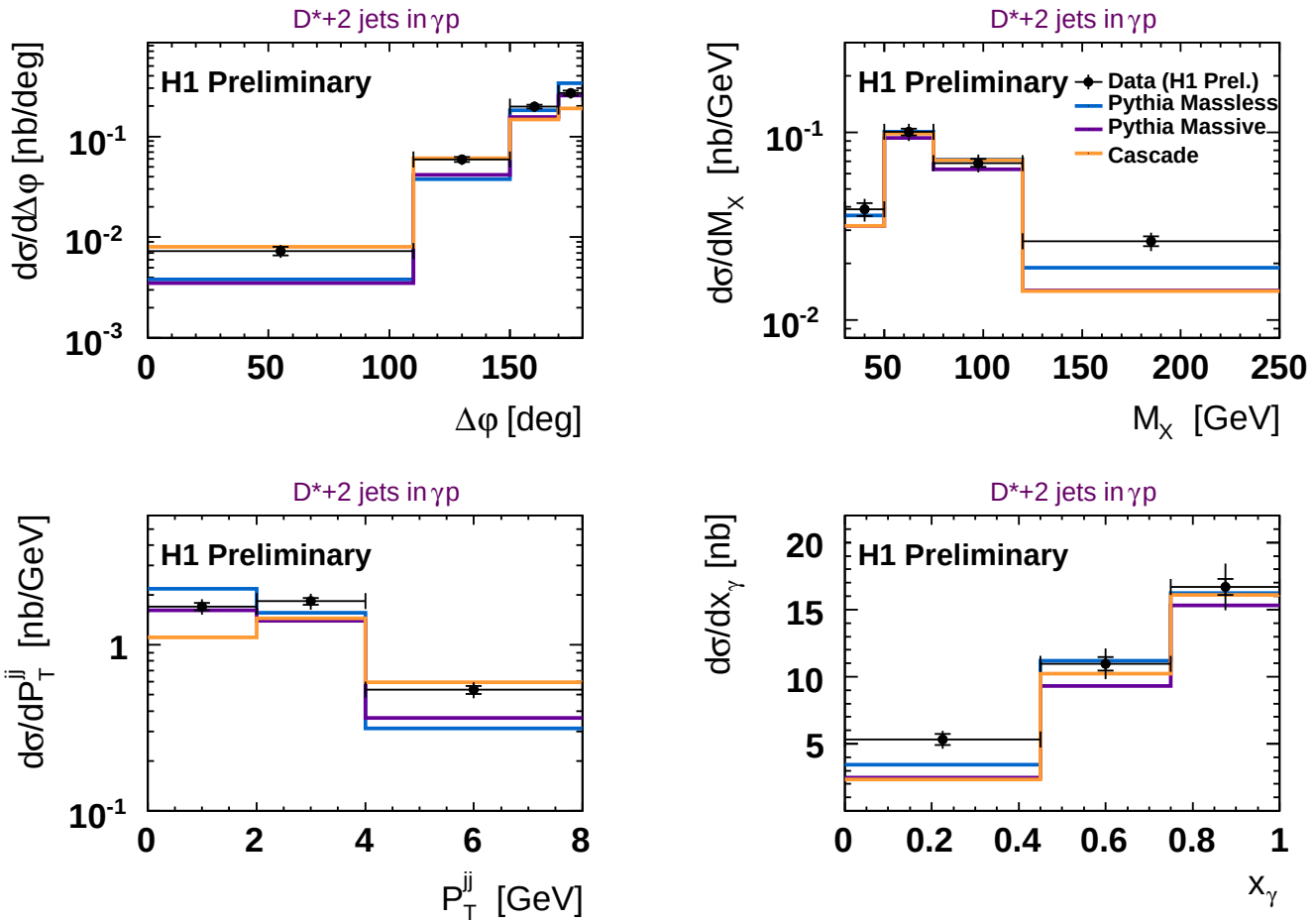






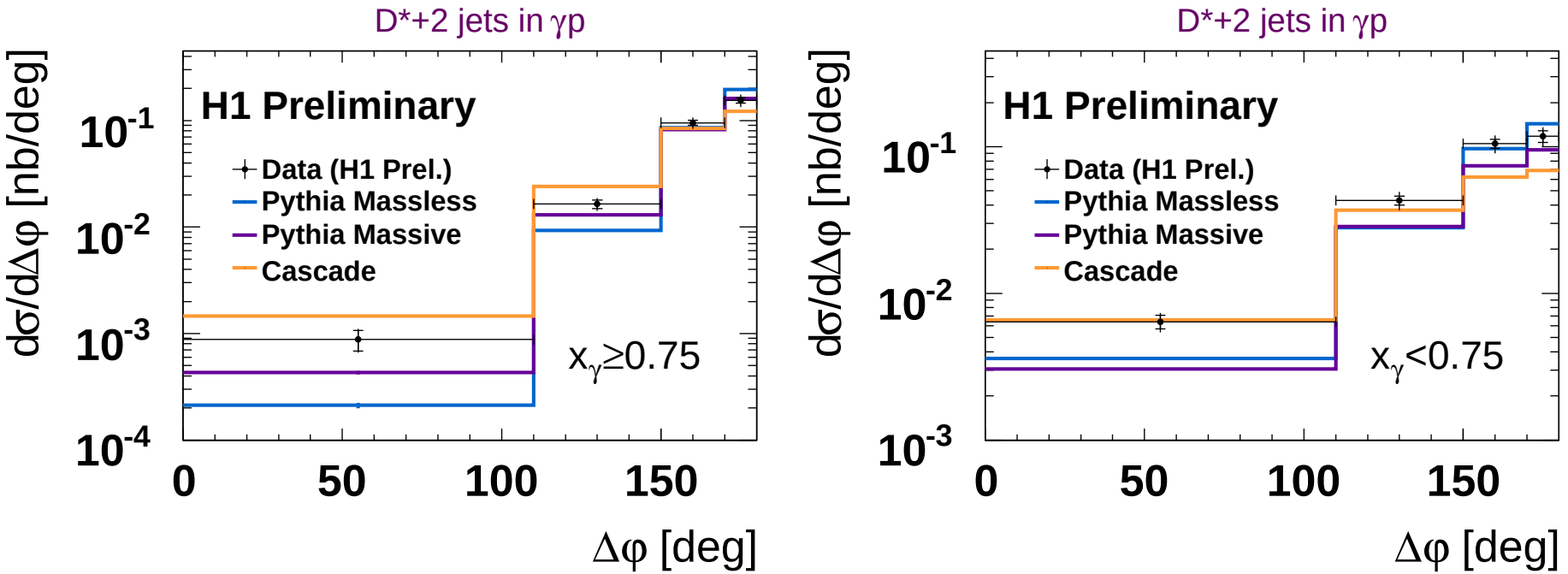
- Reasonable description of the data

Differential Cross Sections



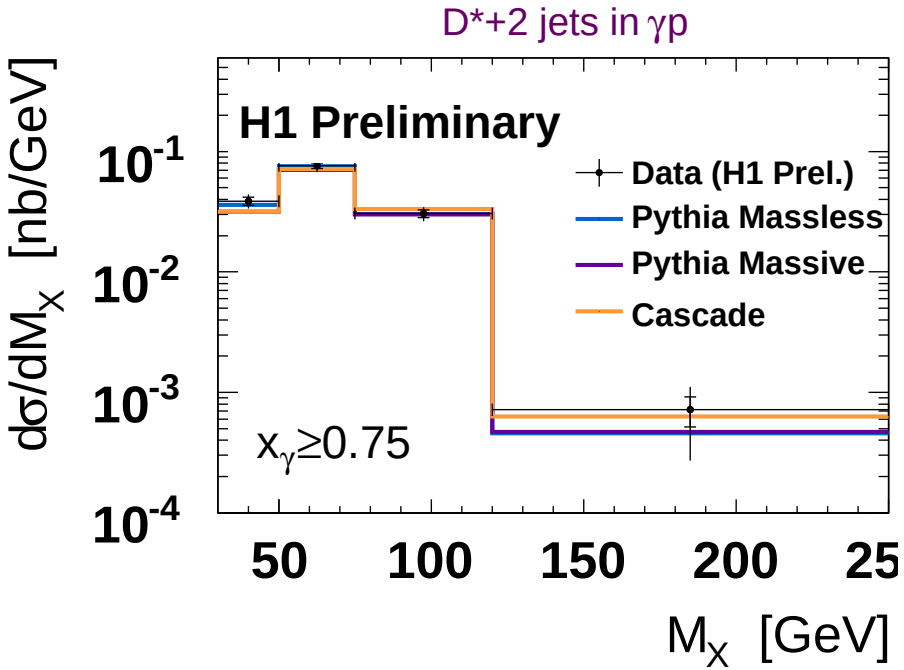
- Back-to-back region is well model by Pythia, while at small $\Delta\varphi$ (large p_t^{jj}) Cascade provides good description
- The lowest x_γ bin is not described by any of the models

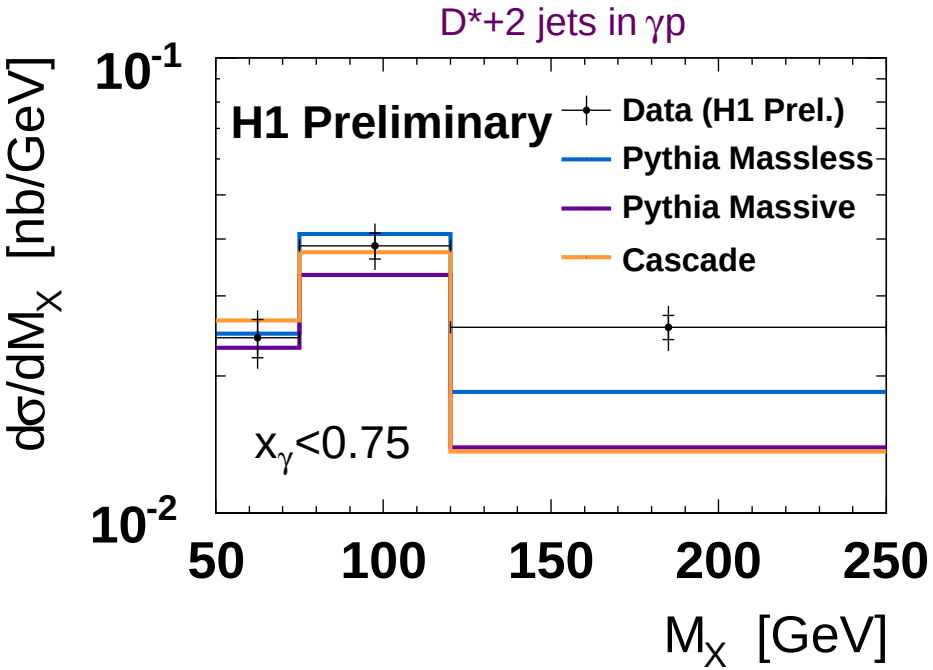
$\Delta\varphi$ in Bins of x_γ



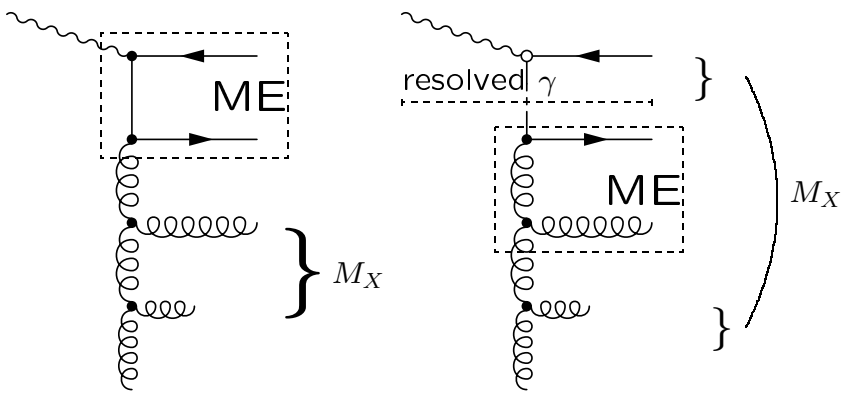
- Cascade undershoots the data at the high $\Delta\varphi$ but provides perfect description for the low $\Delta\varphi$
- Pythia describes the data at the back-to-back region and fails at low $\Delta\varphi$

M_X in bins of x_γ

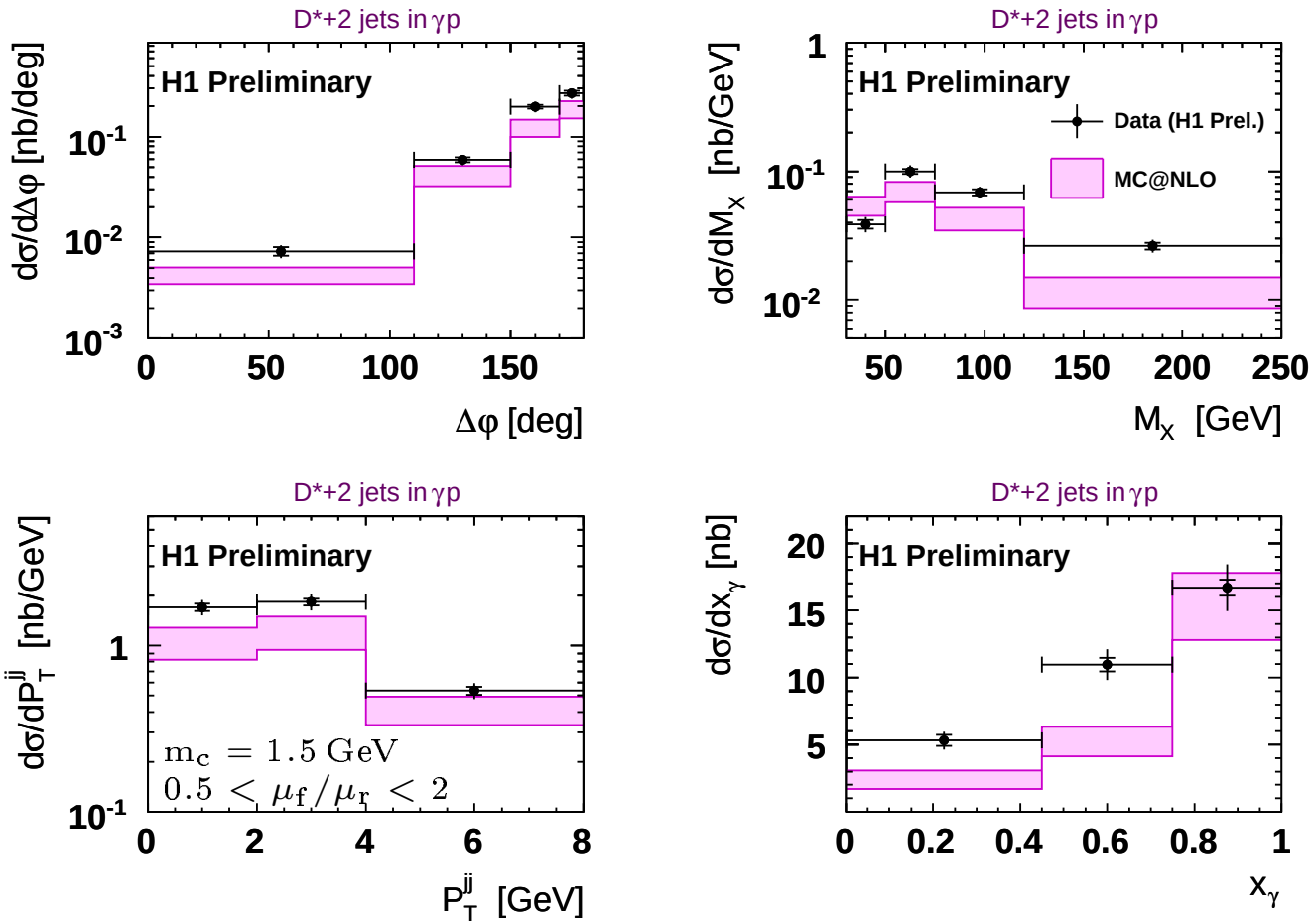




- In the high x_γ region, the data are perfectly described by all three models
- Different shapes for the three MCs, not described high M_X in the resolved case

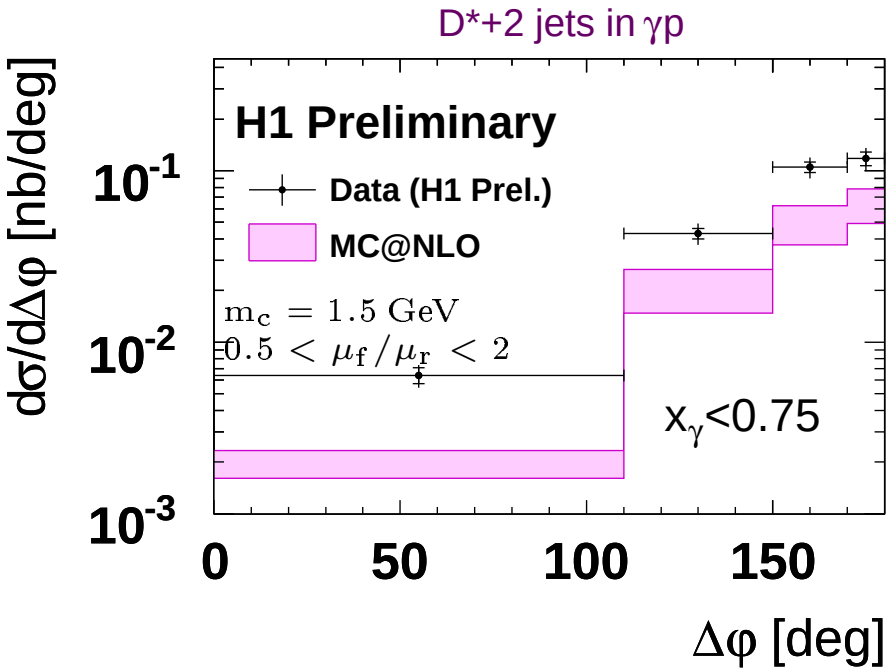


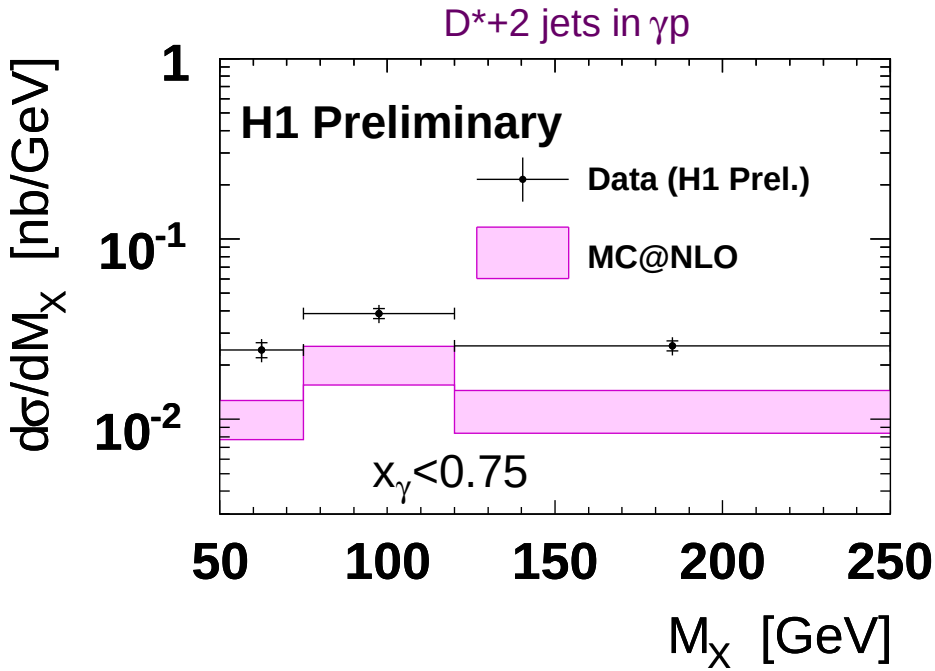
Comparison to MC@NLO



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

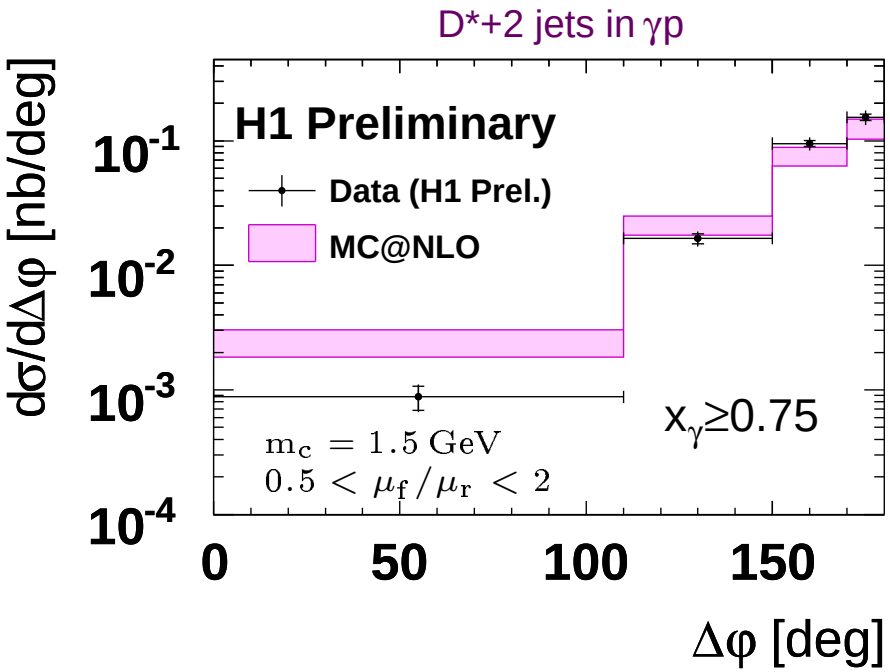
Comparison to MC@NLO: Low x_γ

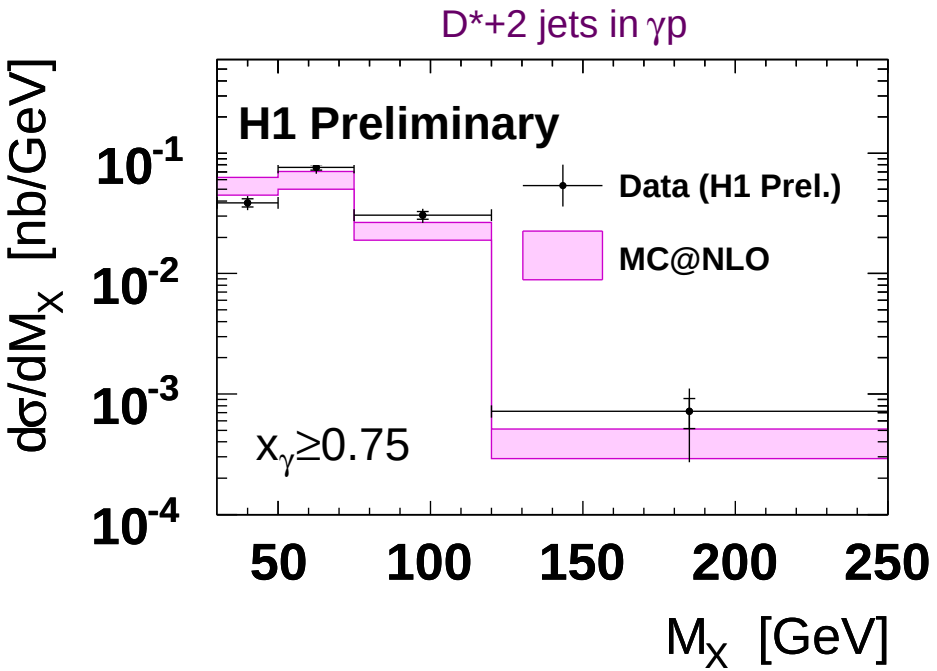




- Well described shape, too long cross sections

Comparison to MC@NLO: High x_γ





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

Conclusions

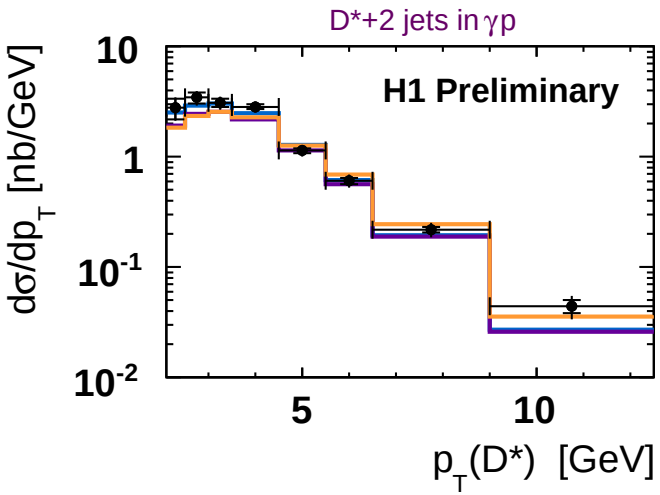
- The differential cross sections for ep $\longrightarrow$ $D^* + 2 -$jets were measured in an extended phase space:
  - New variables (p_t^{jj} and M_X) were presented
- Comparison to Pythia/Cascademodels:
  - Well described transverse momenta and rapidities
  - M_X perfectly reproduced in the high 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

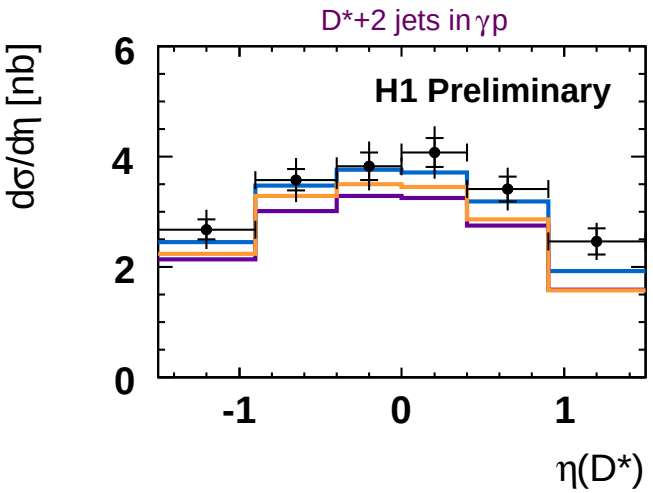
Back up Slides

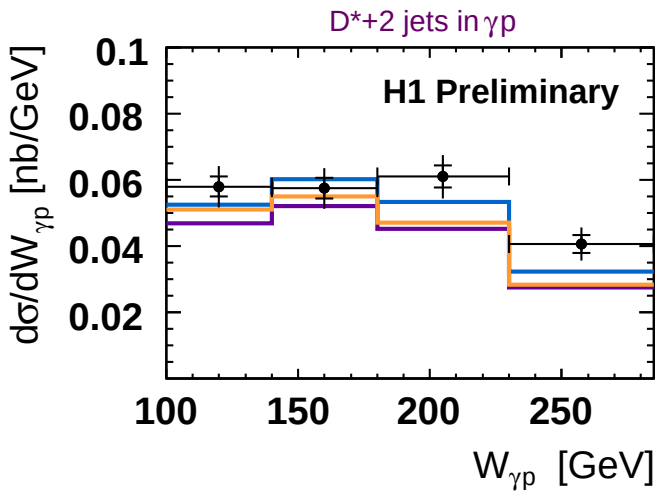
Phase Space Definition

$$0.1 < y_h < 0.8$$
$$Q^2 < 2.\,\mathrm{GeV}^2$$
$$2.1\,\mathrm{GeV} < p_t(D^*) < 12.5\,\mathrm{GeV}$$
$$|\eta(D^*)| < 1.5$$
$$3.5\,\mathrm{GeV} < p_t(D^*_{jet}, \text{Other jet}) < 15.\,\mathrm{GeV}$$
$$\left|\eta(D^*_{jet})\right| < 1.5$$
$$-1.5 < \eta(\text{Other jet}) < 2.9$$
$$M_{jj} > 6\,\mathrm{GeV}$$

Differential Cross Sections

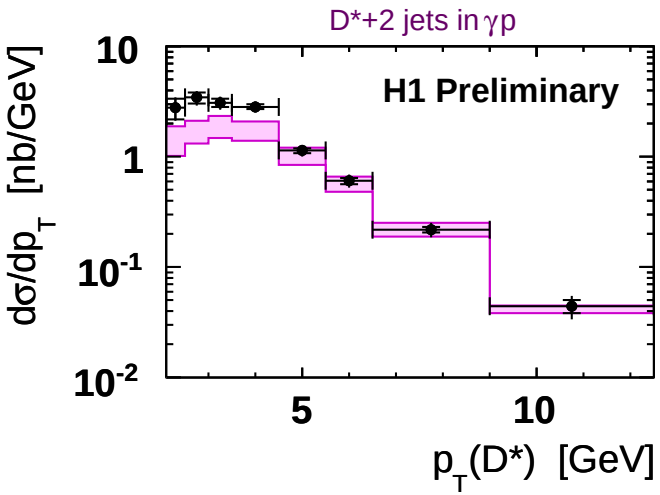


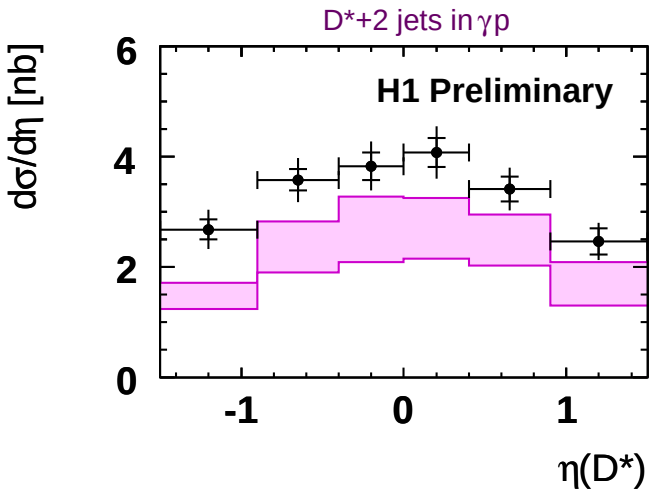


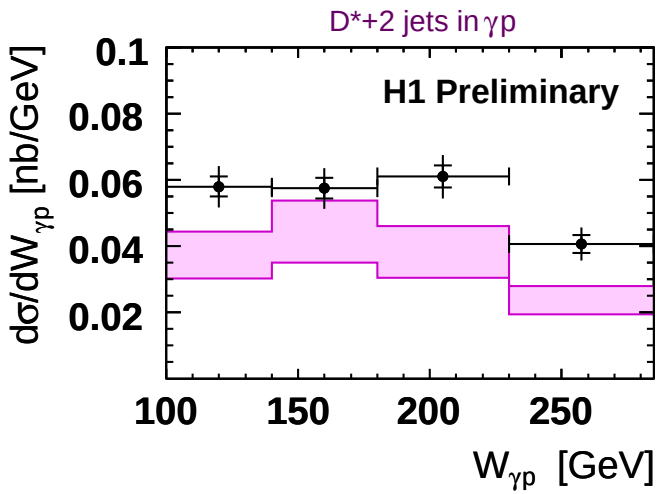


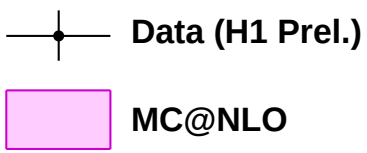
Data (H1 Prel.)
Pythia Massless
Pythia Massive
Cascade

MC@NLO

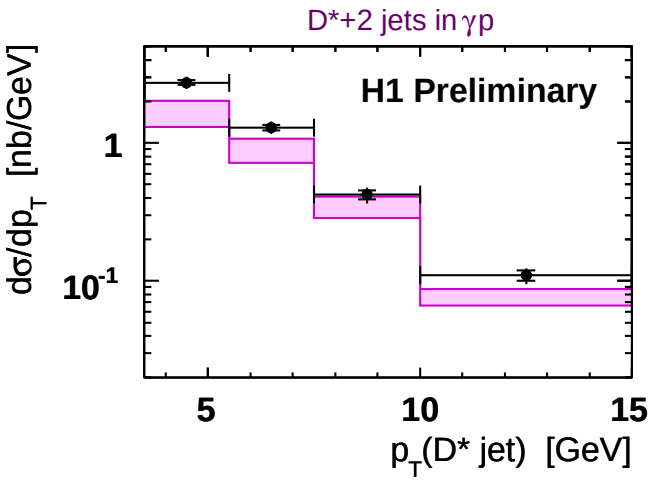

D*+2 jets in γp
H1 Preliminary
dσ/dp_T [nb/GeV]
p_T(D*) [GeV]

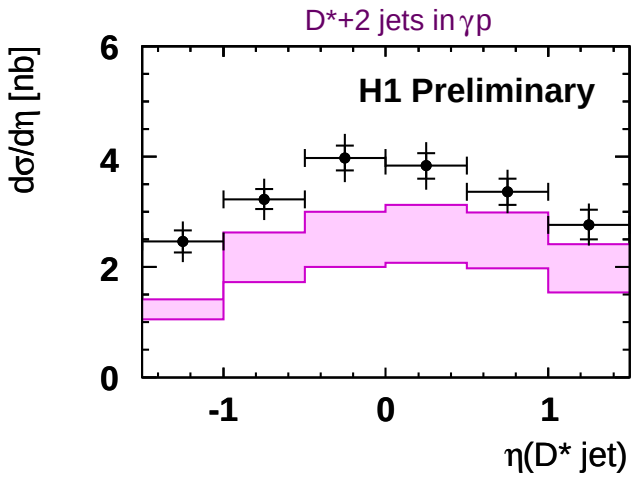

D*+2 jets in γp
H1 Preliminary
dσ/dη [nb]
η(D*)

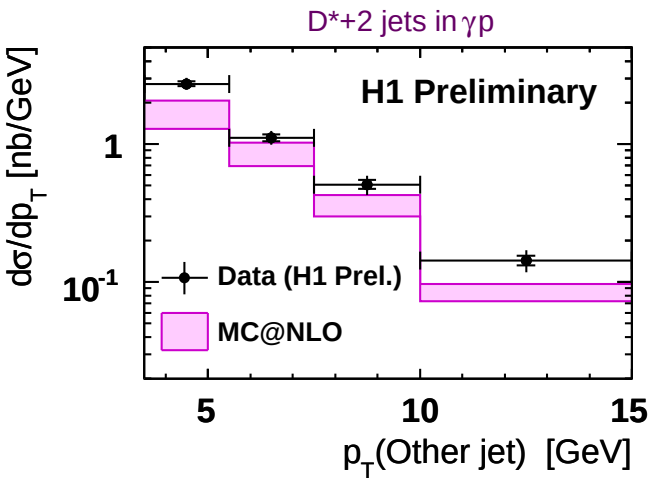

D*+2 jets in γp
H1 Preliminary
dσ/dW_γp [nb/GeV]
W_γp [GeV]

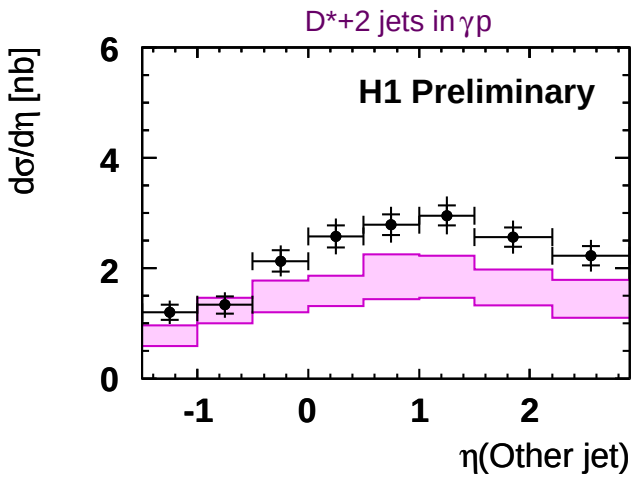

Data (H1 Prel.)
MC@NLO

MC@NLO


D*+2 jets in γp
H1 Preliminary
dσ/dp_T [nb/GeV]
1
10^-1
5
10
15
p_T(D* jet) [GeV]


D*+2 jets in γp
H1 Preliminary
dσ/dη [nb]
6
4
2
0
-1
0
1
η(D* jet)


D*+2 jets in γp
H1 Preliminary
dσ/dp_T [nb/GeV]
1
10^-1
Data (H1 Prel.)
MC@NLO
5
10
15
p_T(Other jet) [GeV]


D*+2 jets in γp
H1 Preliminary
dσ/dη [nb]
6
4
2
0
-1
0
1
2
η(Other jet)