Charm production with jets at H1

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DESY

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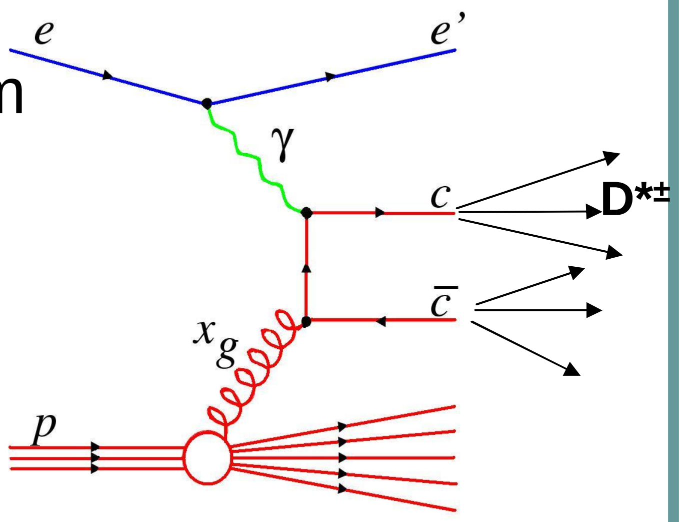
- Motivation
- D* tagging
- Models
- Inclusive cross sections (DIS/γp)
- Jet cross sections (DIS/γp)
- Conclusion

Coverage:
DESY-2006-110
DESY-2006-240

Motivation!

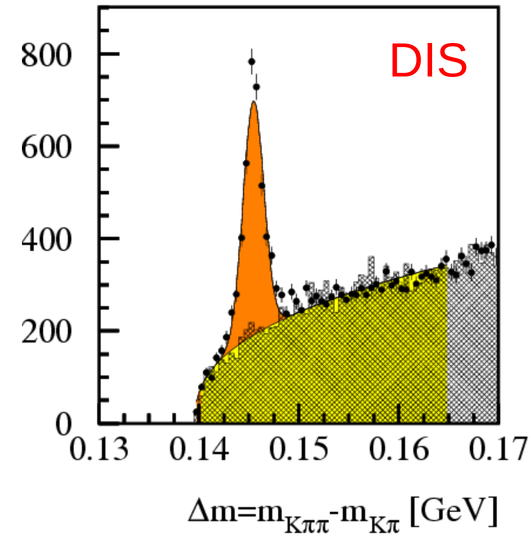
- Heavy quarks provide hard scale for pQCD → QCD tests!
- **Boson gluon fusion (BGF)** dominant production mechanism
- Tagging of charm by **$D^{*\pm}$ mesons**
- Complete understanding only if **both** hard partons are detected
- **Jets**: experimental signature of the partons
- → Study events with **$D^{*\pm}$ meson and jets**

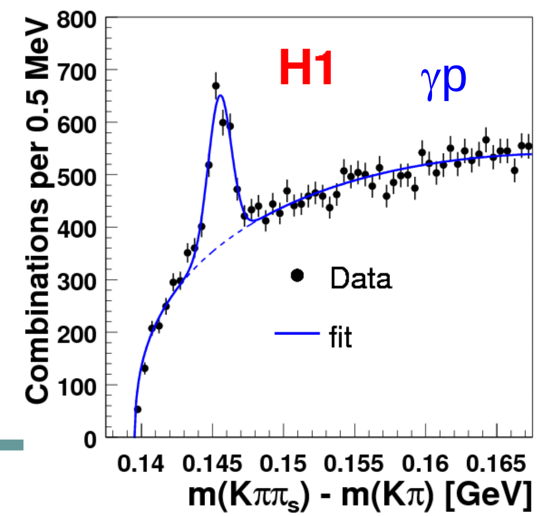


D*± tagging

- **Kinematical range**
  - **DIS:** 2 GeV^2 < Q^2 < 100 GeV^2 und 0.05 < y < 0.7
  - **γp:** Q^2<0.01 GeV^2 and 171 < $W_{\gamma p}$ < 256 GeV
- Selection of **D*± meson candidates** in DIS (γp)
  - Scattered electron in backward calorimeter (e-tagger)
  - Golden decay channel
  - Visible range: p_t(D*)>1,5 GeV (p_t(D*)>2,0 GeV), |η(D*)|<1,5
- **Signal extraction**
  - Fit: Gauß + background
  - N_{D^*} = 2684 ± 78 (1166 ± 82) D*± mesons
  - Data set: e+ 99/2000, $\mathcal{L}$ = 47 pb^{-1} (51.1 pb^{-1})
- **Dominating experimental errors**
  - Track reconstruction efficiency, signal extraction
  - γp: e-tagger efficiency/ trigger efficieny

$$\eta = -\ln \tan\left(\frac{\theta}{2}\right)$$





Models

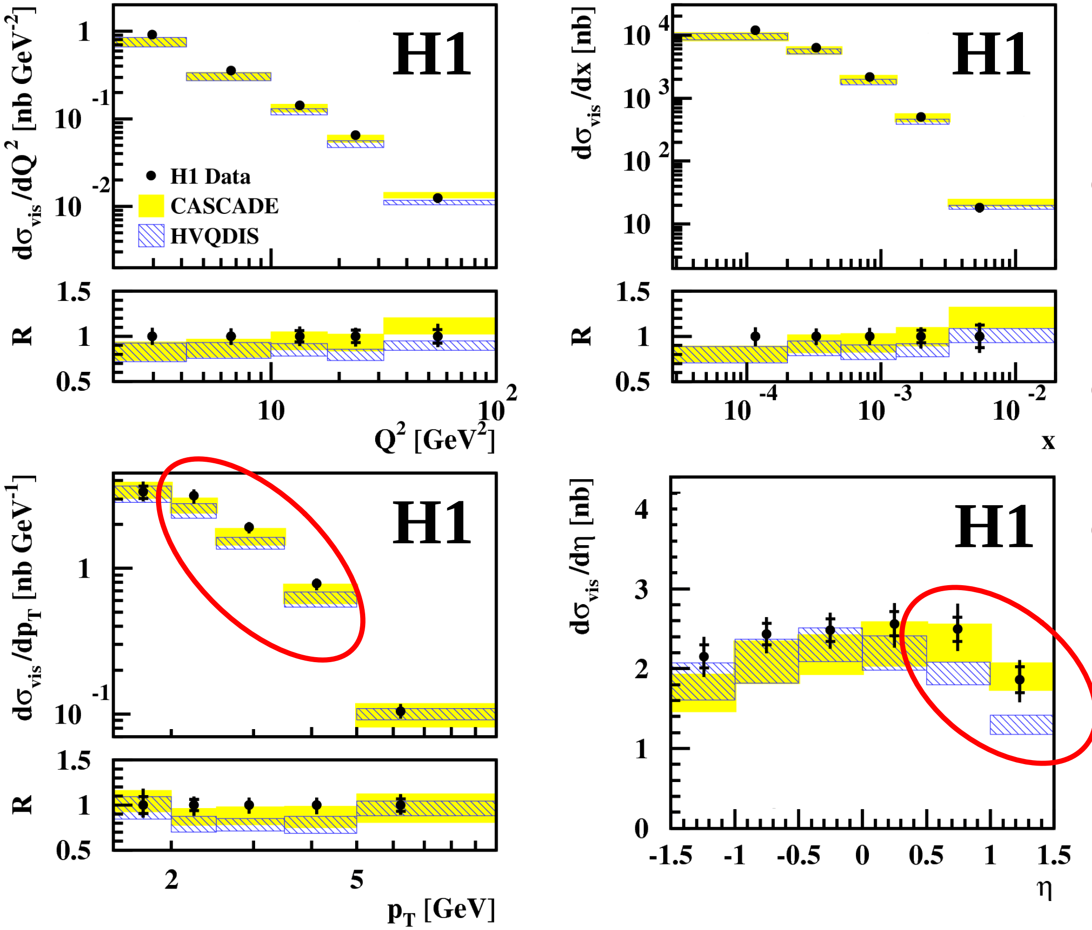
	DIS	photoproduction
NLO DGLAP massive	HVQDIS (Kartvelishvili α=2.5-3.5)	FNMR (Peterson (value for NLO): ε=0.035)
massive + mass less		GM-VFNS (only for inclusive $D^{*\pm}$)
mass less	ZM-VFNS (only for inclusive $D^{*\pm}$)	ZM-VFNS (for $D^{*\pm}$ + jets)
DGLAP+PS	Rapgap (Bowler (BELLE) a=0.22,b=0.56)	Pythia (Peterson: ε=0.04)
CCFM	CASCADE	CASCADE
m_c	1.5±0.1 GeV	1.5±0.2 GeV
variations	Added quadratically	Maximum of variations
beauty	1.5 (± 0.5) × prediction	1.0 × prediction

Scale dependent FF

Peterson ε=0.025-0.060 (HERA)

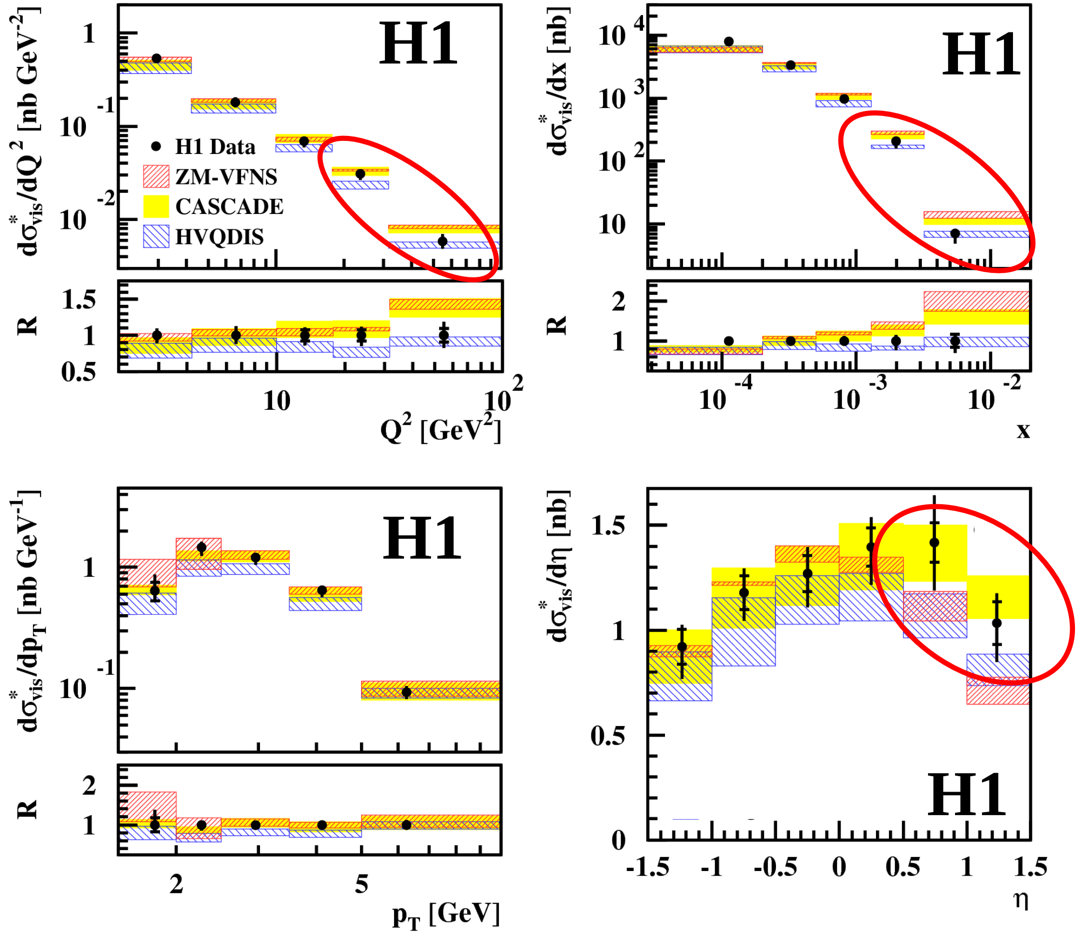
Scale variations 0.5 – 2 where appropriate.

Inclusive D*± cross sections DIS



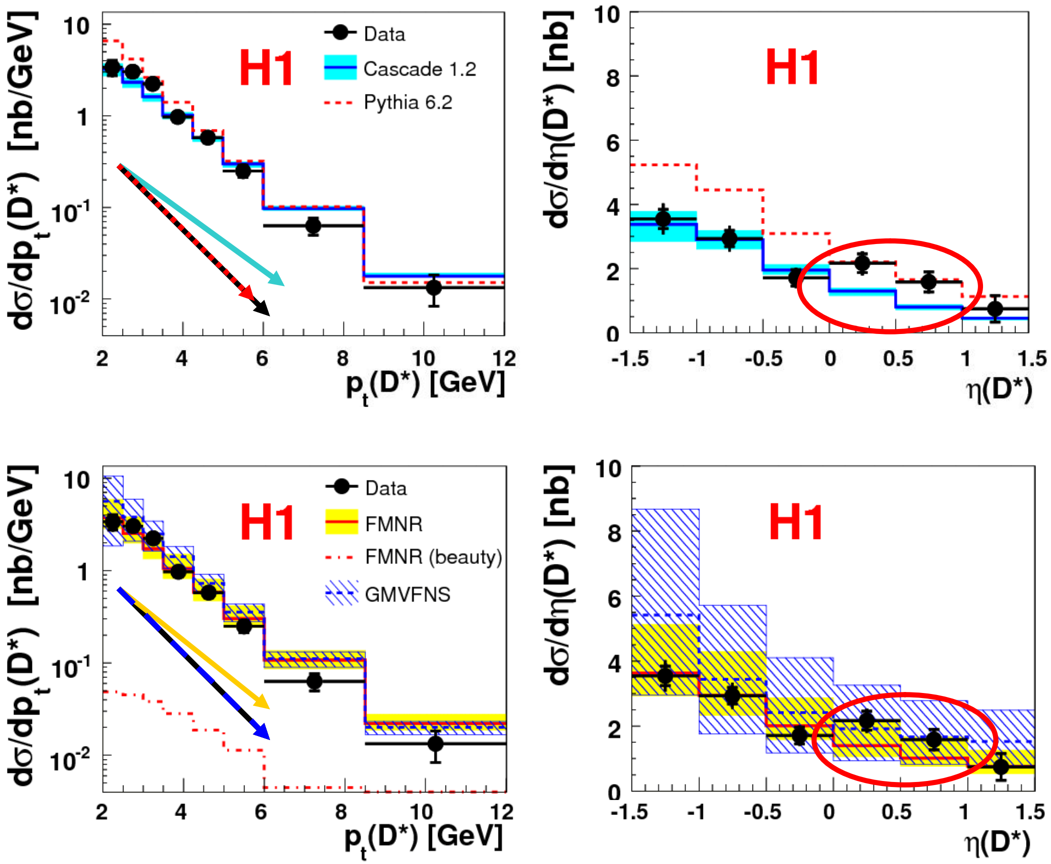
- Good description by CASCADE and HVQDIS
- Deviation for large η (forward!)
- Confirms previous H1 analysis

Inclusive D*± cross sections DIS



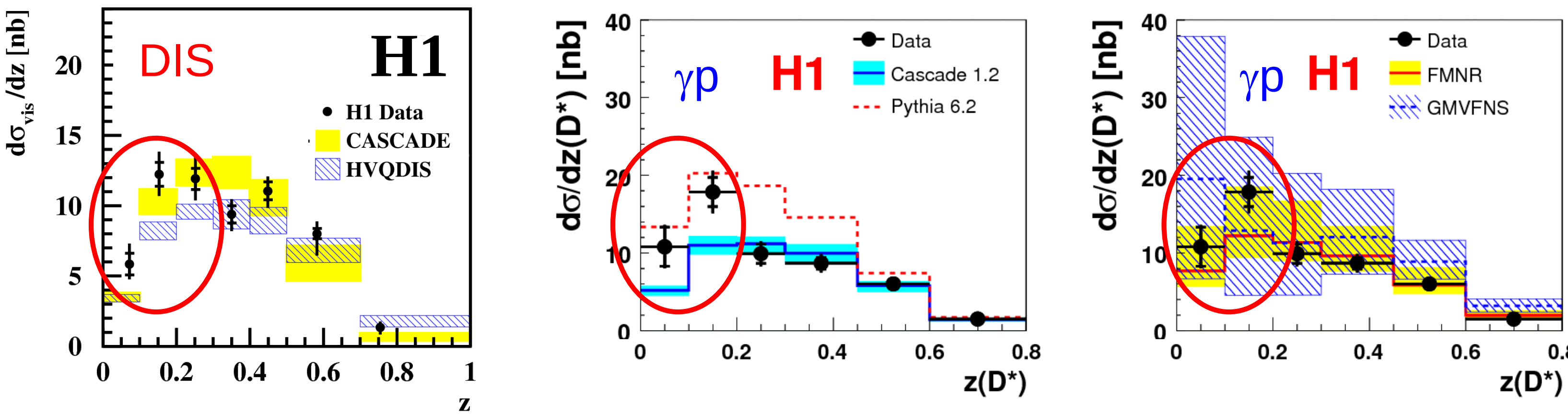
- First comparison with ZM-VFNS calculations in DIS
- Additional cut p_T*> 2.0 GeV needed to ensure validity of calculations

Inclusive D*$^{\pm}$ cross sections γp



- Slope of p_t(D*) not described
- Discrepancy in forward (η(D*)>0) direction

Inclusive $D^{*\pm}$ cross sections

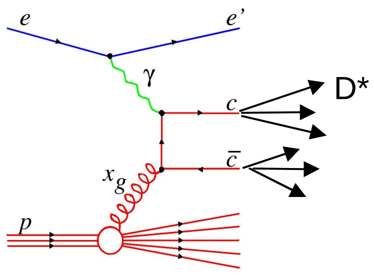


- z = inelasticity
- Low z range not described

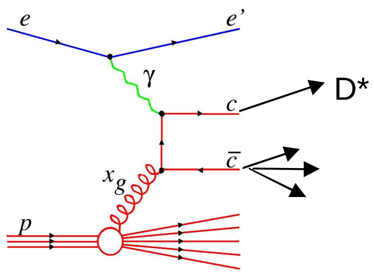
$$z = \frac{P \cdot p(D^*)}{P \cdot q}$$

Jets

- Different jet selections are applied for **DIS** and **γp**
- Jet algorithm: **k_t cluster** algorithm in the **Breit (laboratory)** frame with **E (pt) recombination scheme**
- Relatively low jet energies in charm events
- **DIS selection** (and γp selection for x_γ)
  - **Both** hard partons are approximated by jets
  - $E_{T,Breit(Lab)}^{jet\ 1} > 4$ GeV, $E_{T,Breit(Lab)}^{jet\ 2} > 3$ GeV
  - $D^{*\pm}$ is normally part of one of the jets

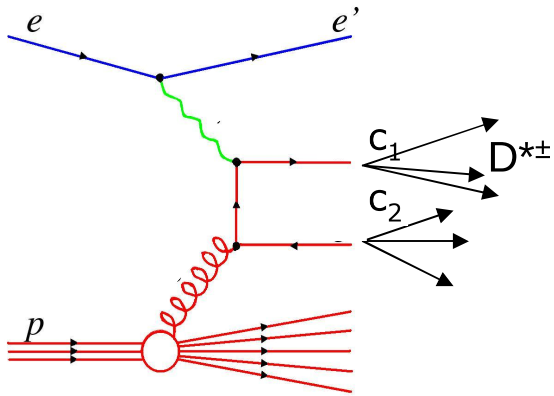


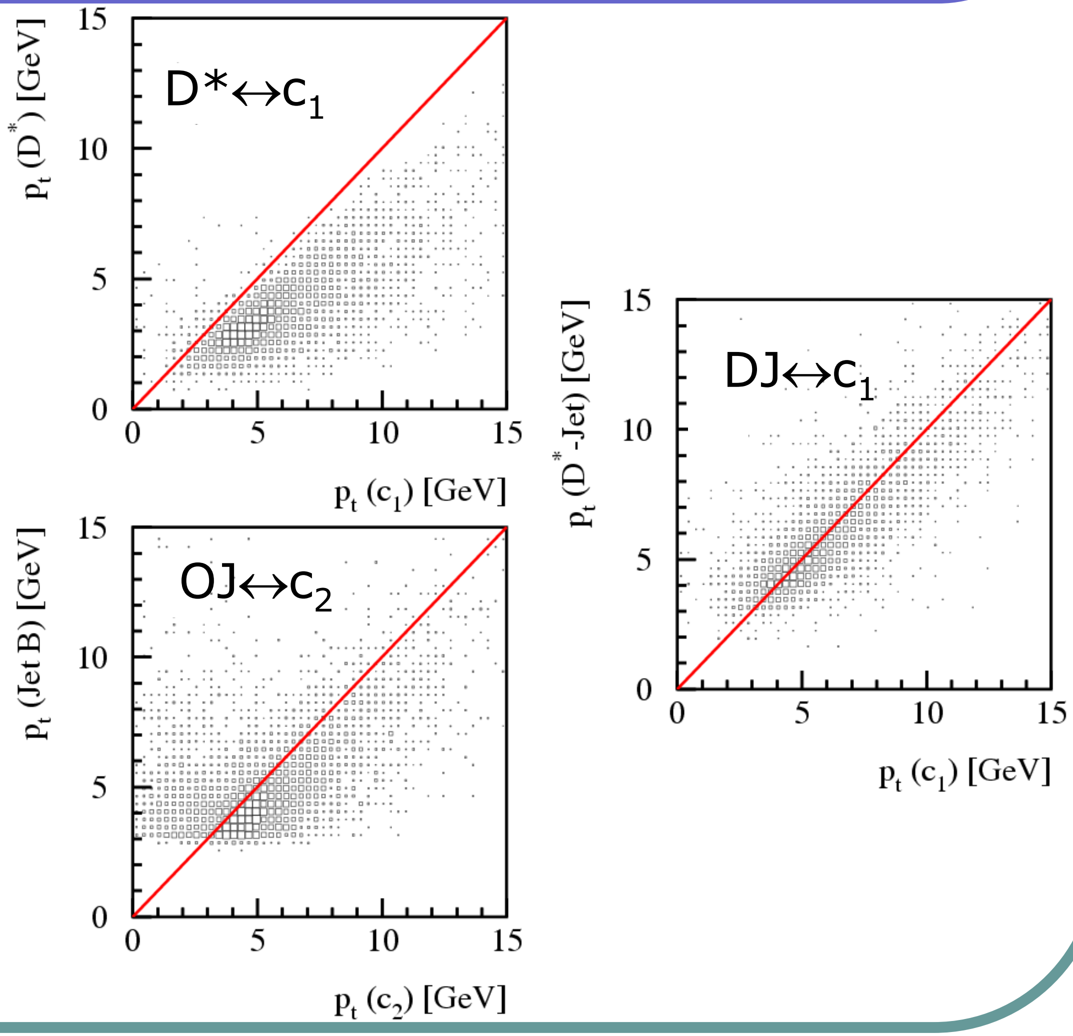
- **γp** standard **selection**
  - **One** charm is approximated by the $D^{*\pm}$ meson, the other parton by a jet
  - $E_{T,lab}^{jet\ 1} > 3$ GeV
  - $D^{*\pm}$ is not part of the jet



- Jets in the central calorimeter: -1 (-1.5) < η_{lab}^{jets} < 2,5 (1.5)

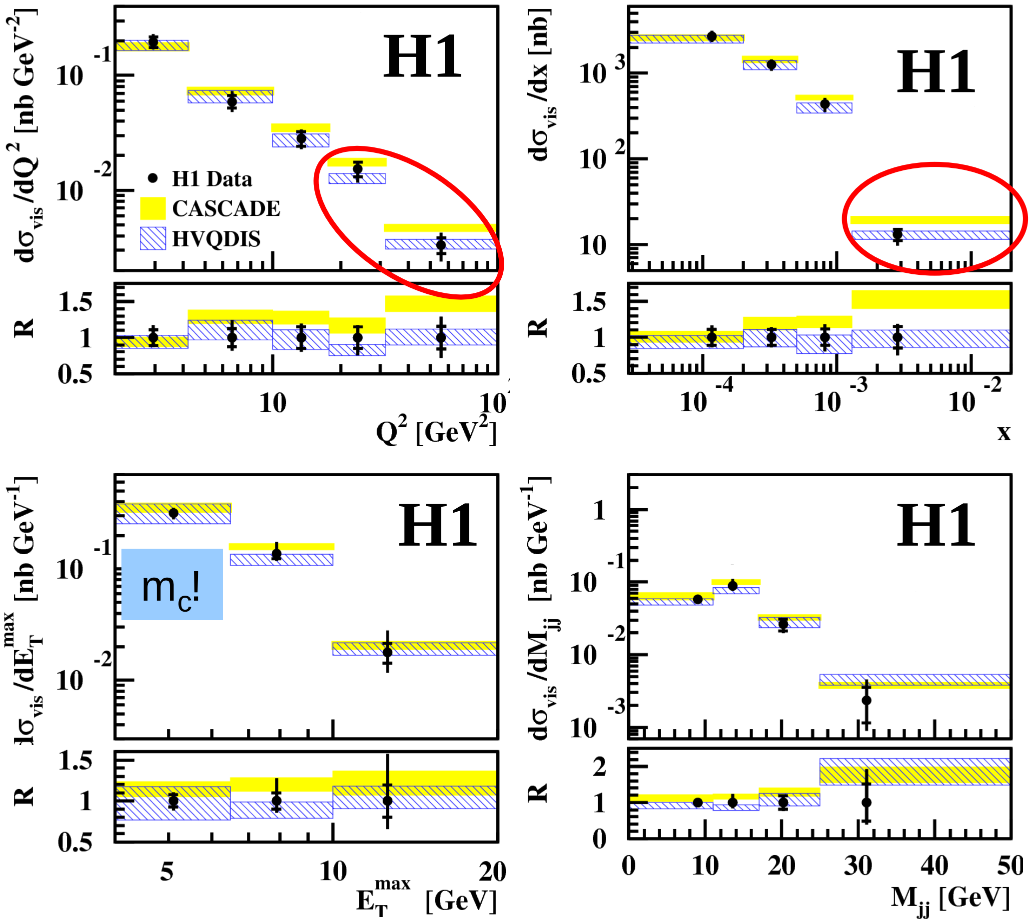
Correlations between jets and partons





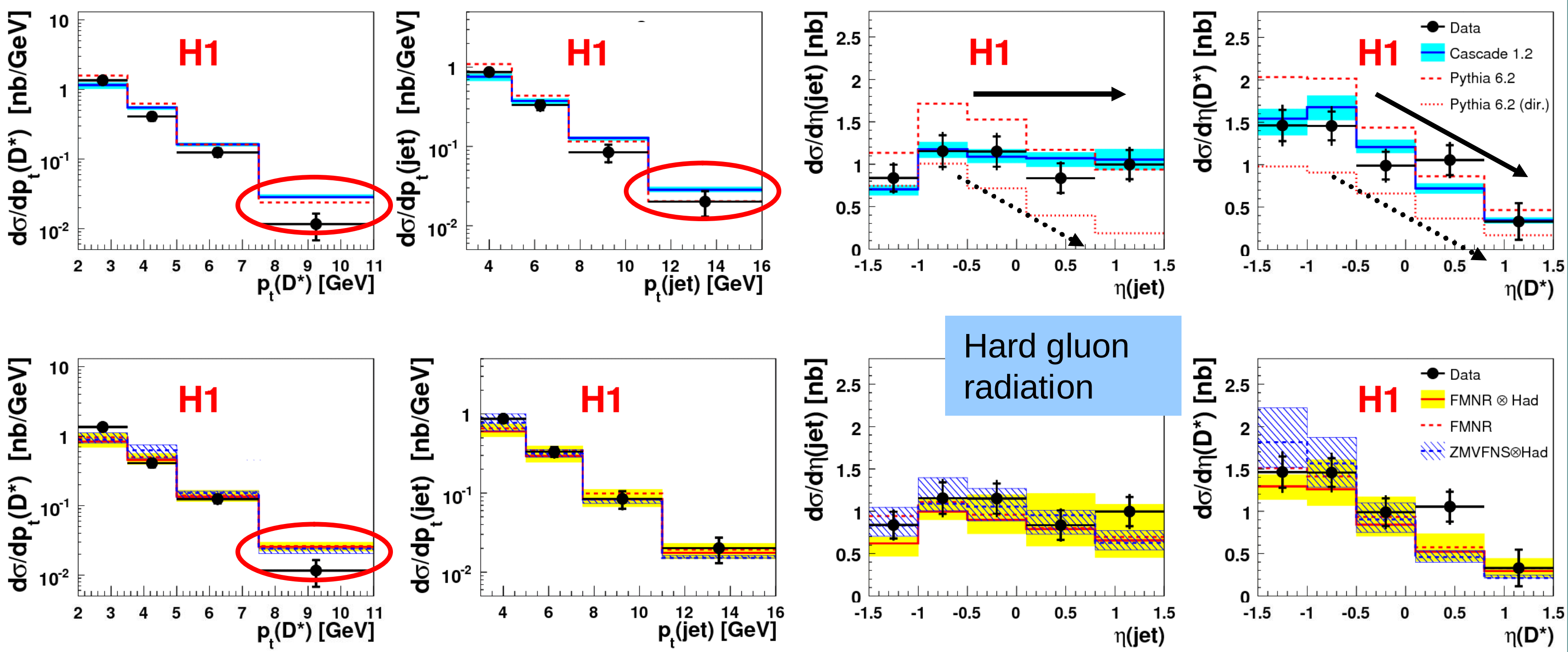
- $D^{*\pm}$ meson ↔ c_1
- Jet with $D^{*\pm}$ meson
  → **„D* jet“ (DJ)**
  → DJ ↔ c_1
- Leading jet in central detector without $D^{*\pm}$
  → **„other jet“ (OJ)**
  → OJ ↔ c_2

$D^{*\pm}$ + jets cross sections DIS



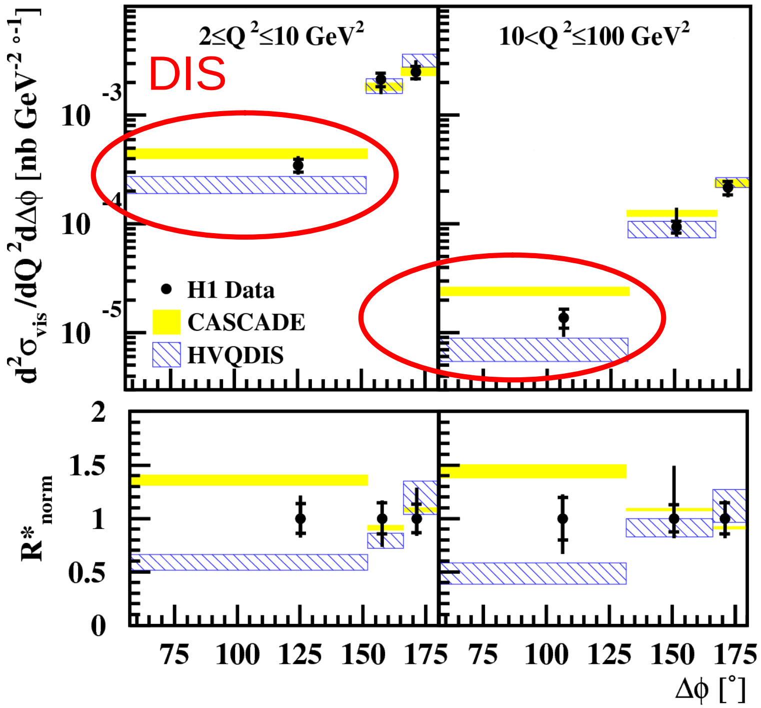
- Description of Q^2 and x distributions by CASCADE worse than for inclusive $D^{*\pm}$ cross sections
- E_T^{max} (transverse energy of leading jet) and M_{jj} (invariant mass of dijet system) well described

D*± + jet cross sections γp

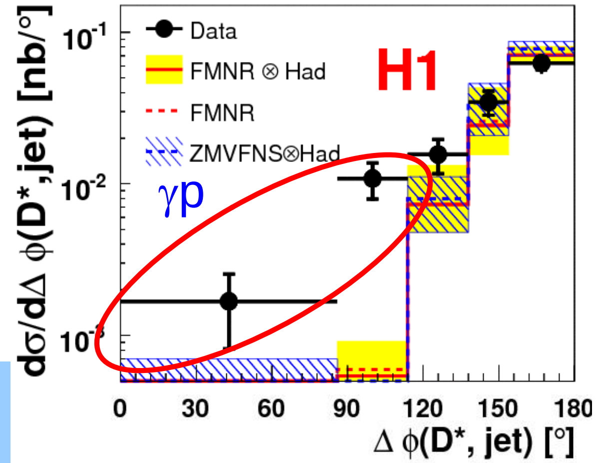


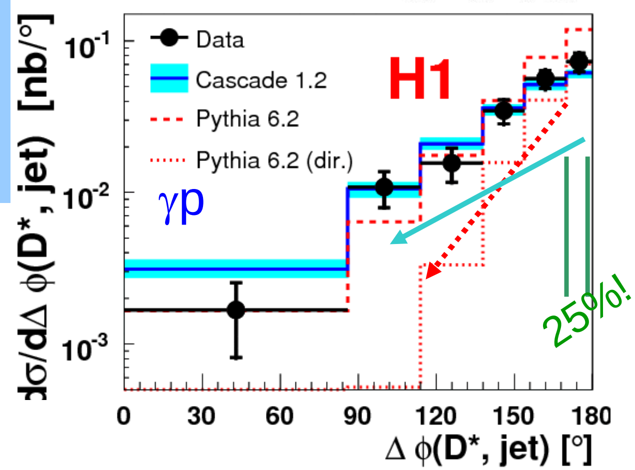
- Jet cross sections better described than inclusive D*± cross sections
- High $p_t(D^*)$ overestimated by all models
- High $p_t(\text{jet})$ overestimated by CASCADE

D*± + jet cross sections (DIS and γp)



Ratios norma-
lized in bins 2+3





- Δφ: difference in the azimuthal angle
- Large higher order contributions
- CASCADE too broad
- Some contribution missing for HVQDIS beyond NLO

x_g und x_γ

- **x_g**: part of the proton momentum which participates in the hard interaction
- **x_γ**: part of the photon momentum which participates in the hard interaction

- Unambiguous definition only in leading order: „obs“

$$x_g^{obs} = \frac{E^*_{t,c1}\exp(\eta^*_{c1}) + E^*_{t,c2}\exp(\eta^*_{c2})}{2E^*_p}$$

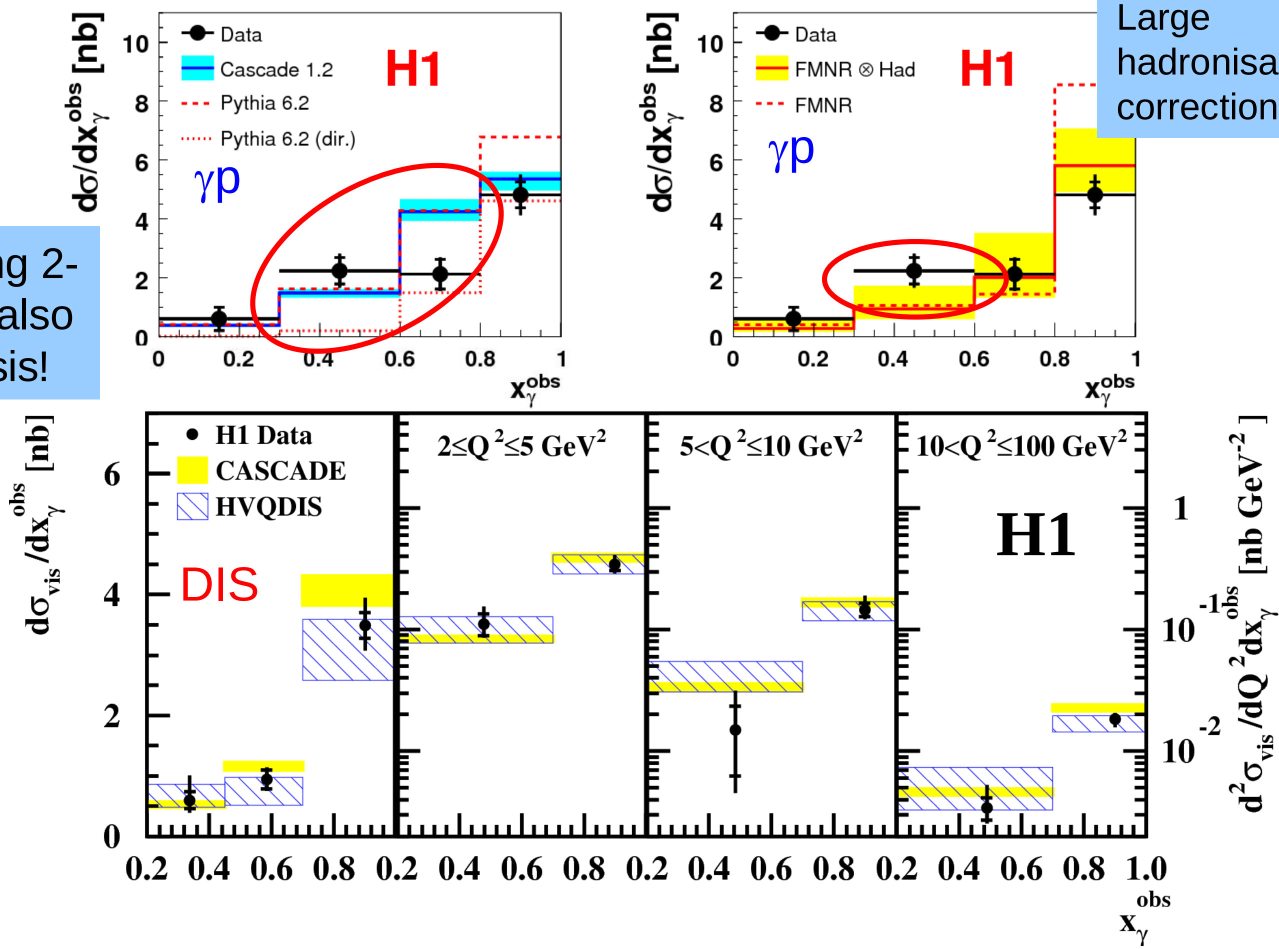
$$x_\gamma^{obs} = \frac{E^*_{t,c1}\exp(-\eta^*_{c1}) + E^*_{t,c2}\exp(-\eta^*_{c2})}{2yE'^*_e}$$

- Usage of jets instead of the partons

$$x_\gamma^{obs} = \frac{\sum_{jet\,1}(E - p_z)^* + \sum_{jet\,2}(E - p_z)^*}{\sum_{had}(E - p_z)^*}$$

- $\rightarrow$ Access **gluon density** in the proton
- $\rightarrow$ Access **resolved processes** for the production of charm

x_γ (DIS and γp)

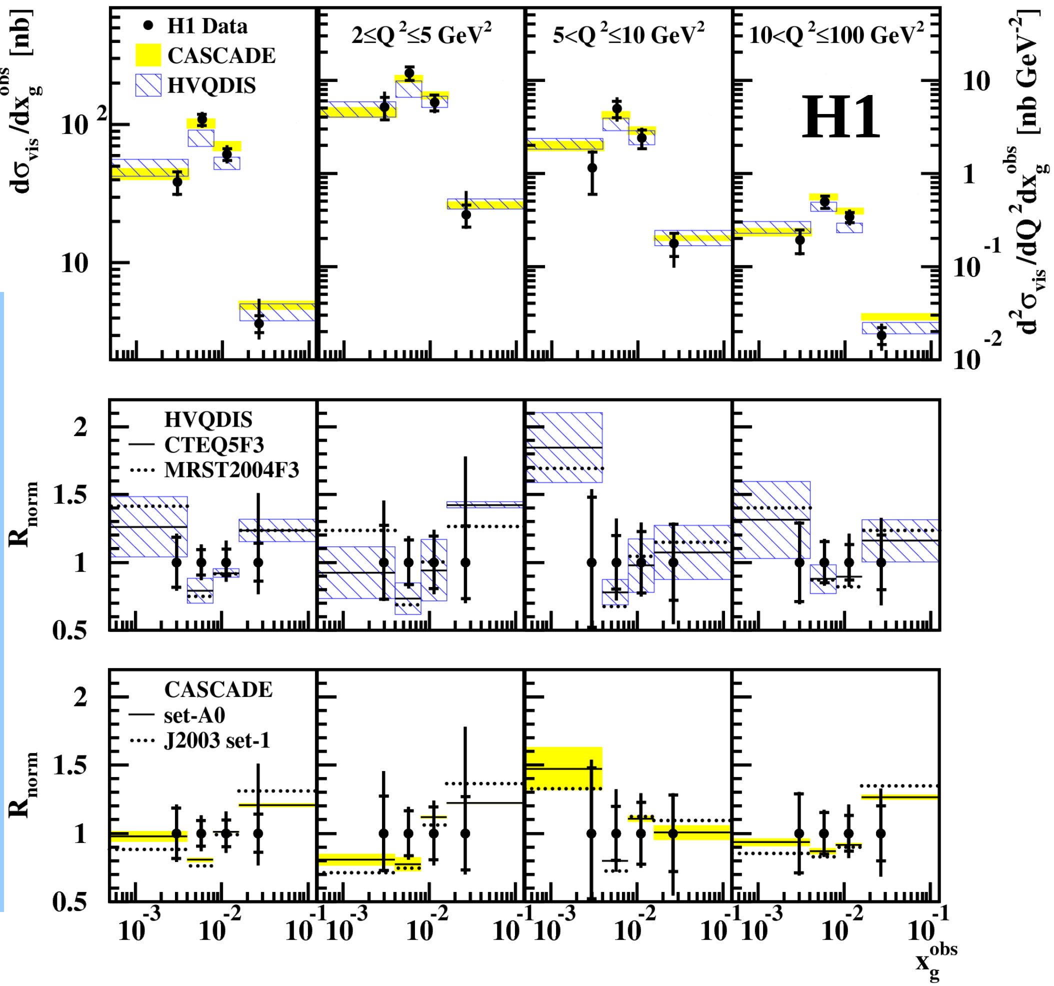


Large hadronisation corrections

For x_γ: Using 2-jet-sample also in γp analysis!

x_g (DIS)

Normalised ratios of data and theory



- x_g described well for all Q^2 bins
- Due to size of experimental and theoretical errors not (yet!) possible to separate between current PDFs
- As example: CTEQ5F3 vs. MRST2004F3 and set-A0 vs. J2003 set-1
- HERA II ?!

Conclusions

- **$D^{*\pm}$ meson production** cross sections measured by **H1** for HERA I data sets in **DIS** and **photoproduction**
- Comparisons with different theoretical approaches: **CASCADE, HVQDIS/FFNS** and (where available) **ZM-VFNS** and **GM-VFNS**
- Small deviations between data and theory for DIS, larger discrepancies for photoproduction
- **Jets associated with $D^{*\pm}$ mesons** have been studied
- In general good description by theory (but x_γ, $\Delta\varphi$!)
- HERA II data still to come!