Charm Fragmentation into D* at HERA

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on behalf of the ZEUS and H1 Collaborations

OUTLINE

Introduction

Fragmentation function in photoproduction

Fragmentation function in DIS

Summary

HEP 2009, July 16-22, Krakow, Poland

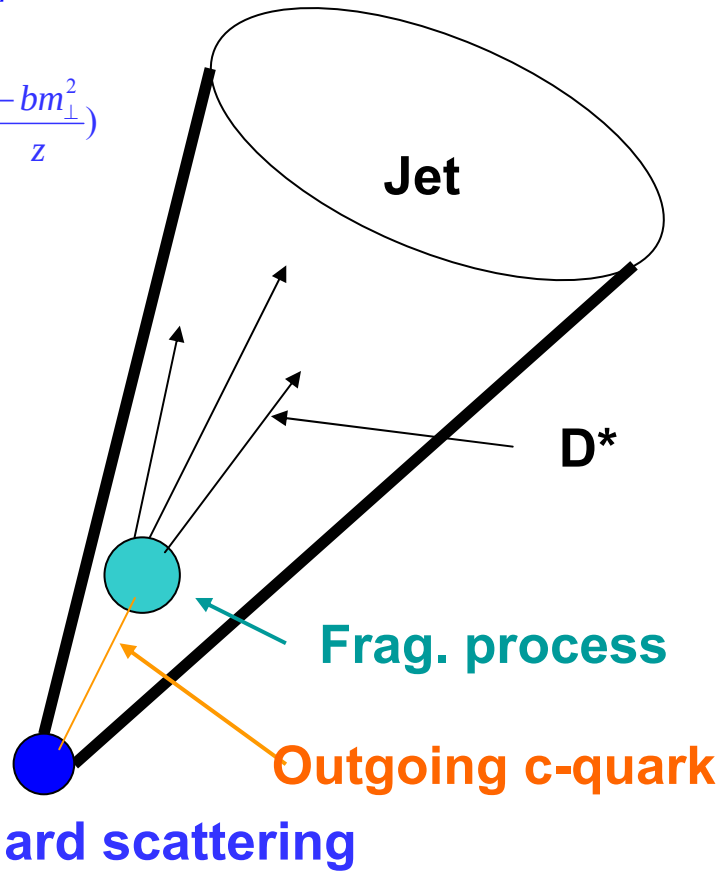
Introduction

- Why fragmentation ?
  - non-perturbative process
  - phenomenological models

    Peterson function: $f(z) \propto \frac{1}{[z(1-1/z-\varepsilon/(1-z))^2]}$

    Kartvelishivili function: $f(z) \propto z^{\alpha}(1-z)$

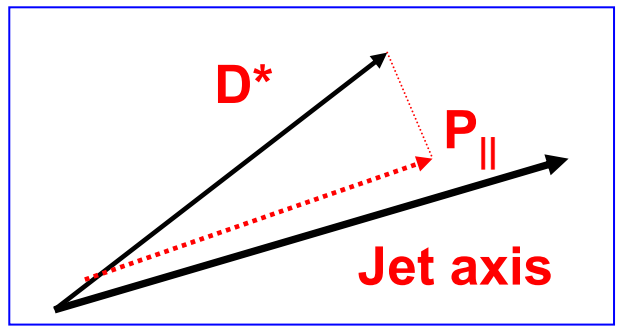
    Bowler function: $f(z) \propto \frac{1}{z^{1+r_Q bm_Q^2}}(1-z)^a \exp(\frac{-bm_\perp^2}{z})$
  - needs experimental study
  - check fragmentation universality
- e^+e^- collisions: $z \sim E_{D^*}/E_{beam}$
- ep collisions
  - the definition of z is not unique
  - two methods used at HERA



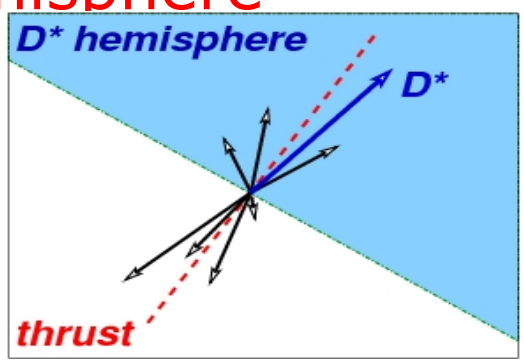
Experimental Definitions at HERA

- Jet method(ZEUS,H1)
  - energy of c-quark is approximated by the energy of the reconstructed D* jet

$z = (E+p_{||})_{D^*} / (E+p)_{jet}$



- Hemisphere method(H1)
  - energy of c-quark is approximated by the energy of reconstructed D*-hemisphere
  - $z = (E+p_{||})_{D^*} / \Sigma(E+p)_i$



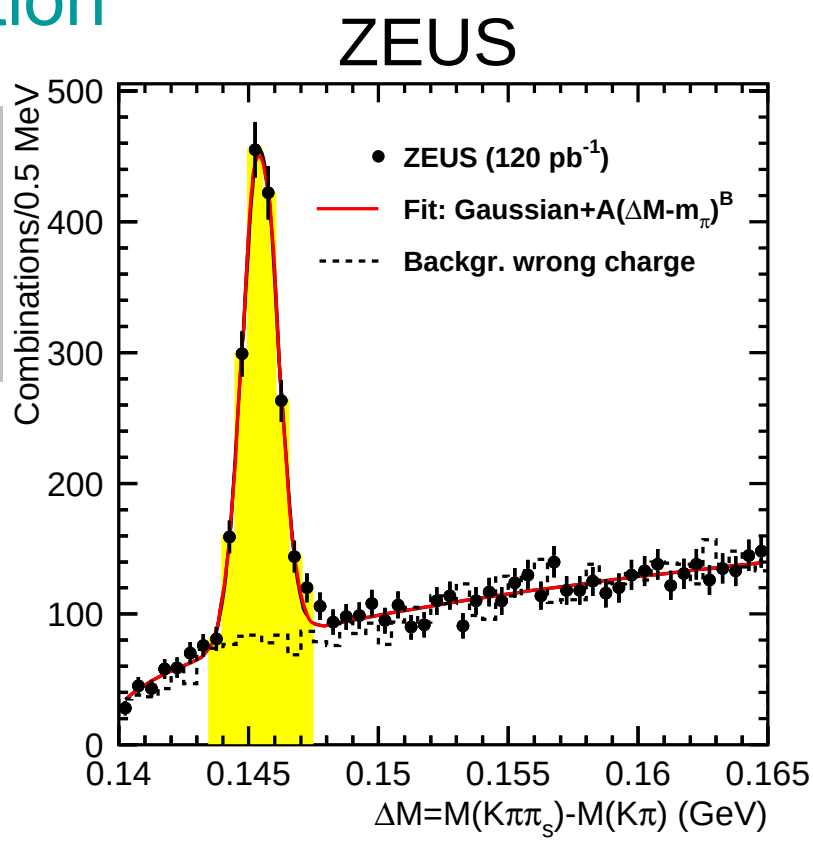
Charm Fragmentation in Photoproduction

JHEP 0904:082,2009

- HERA I data:1996-2000, 120pb^{-1}
- Golden channel: $D^* \rightarrow D^0 \pi_s \rightarrow K\pi\pi_s$
- D* selection in photoproduction

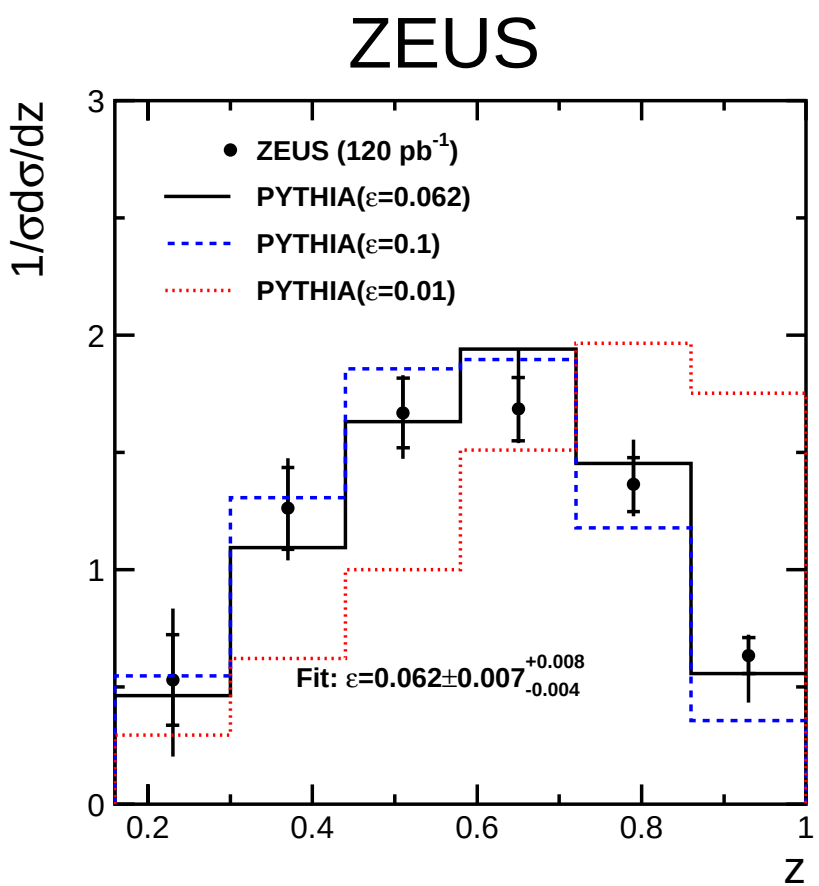
- Q^2<1 GeV^2 ,130<$W_{\gamma p}$<280 GeV
- $P_T(D^*)$>2GeV, $|\eta_{D^*}|$<1.75
- E_T(jet)>9 GeV

- N(D*)=1307±53



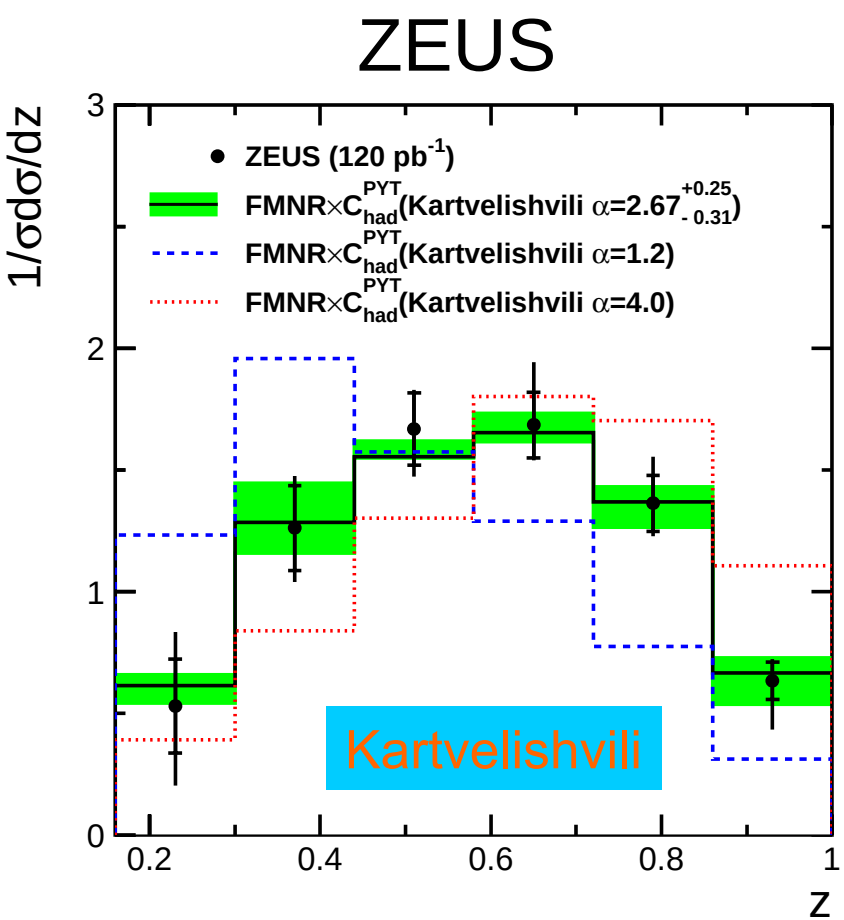
Fit to PYTHIA simulation

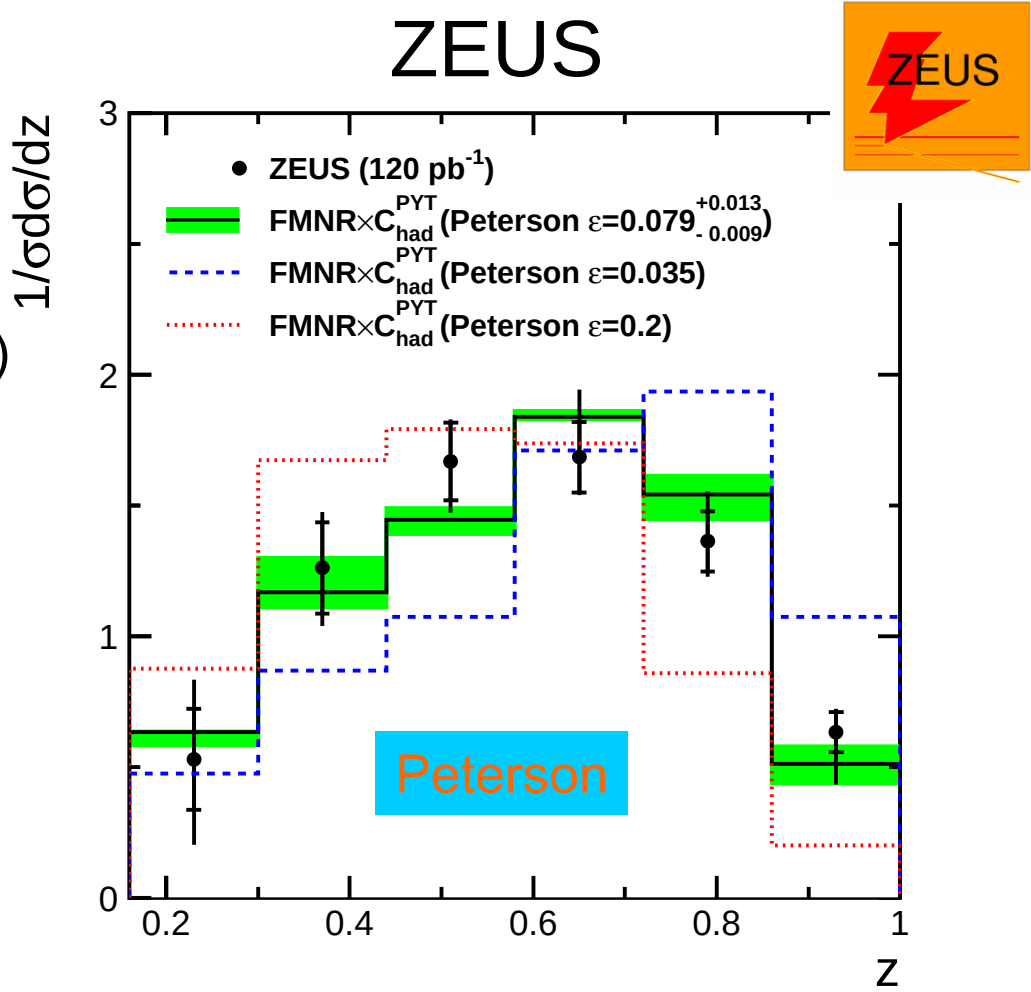
- Extract parameter of Peterson function in PYTHIA with minimum χ^2 method
- $\varepsilon = 0.062 \pm 0.007\ ^{+0.008}_{-0.004}$
- The best value from fit is consistent with the default value 0.05 obtained from fit to e^+e^- experiment



Fit to NLO QCD

- NLO QCD calculation : FMNR corrected for hadronization (PYTHIA)





- **parameters of Peterson and Kartvelishvili function**

- $\varepsilon = 0.079^{+0.013}_{-0.009}$
- $\alpha = 2.67^{+0.25}_{-0.31}$

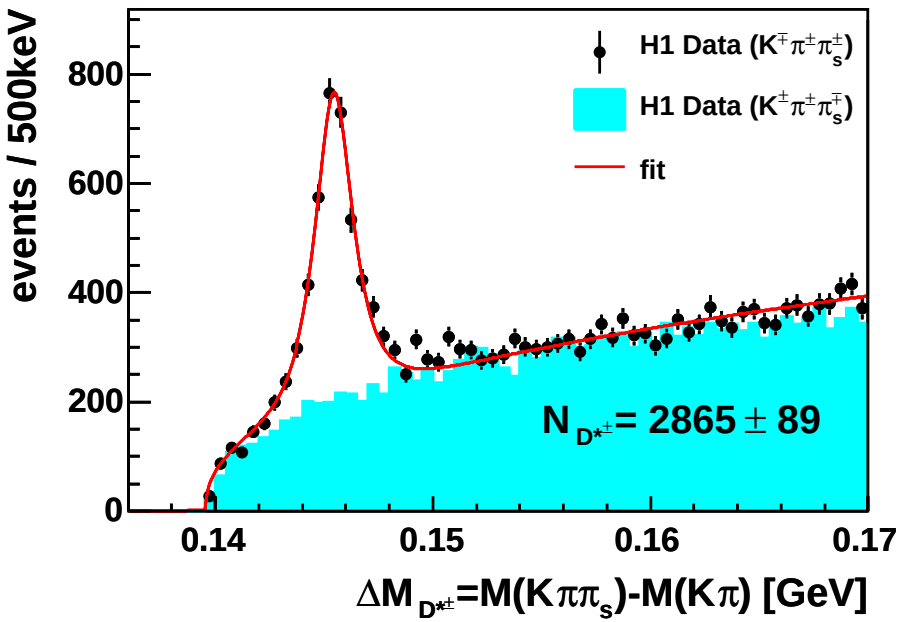
Charm Fragmentation in DIS

Eur. Phys.J. C59:589,2009

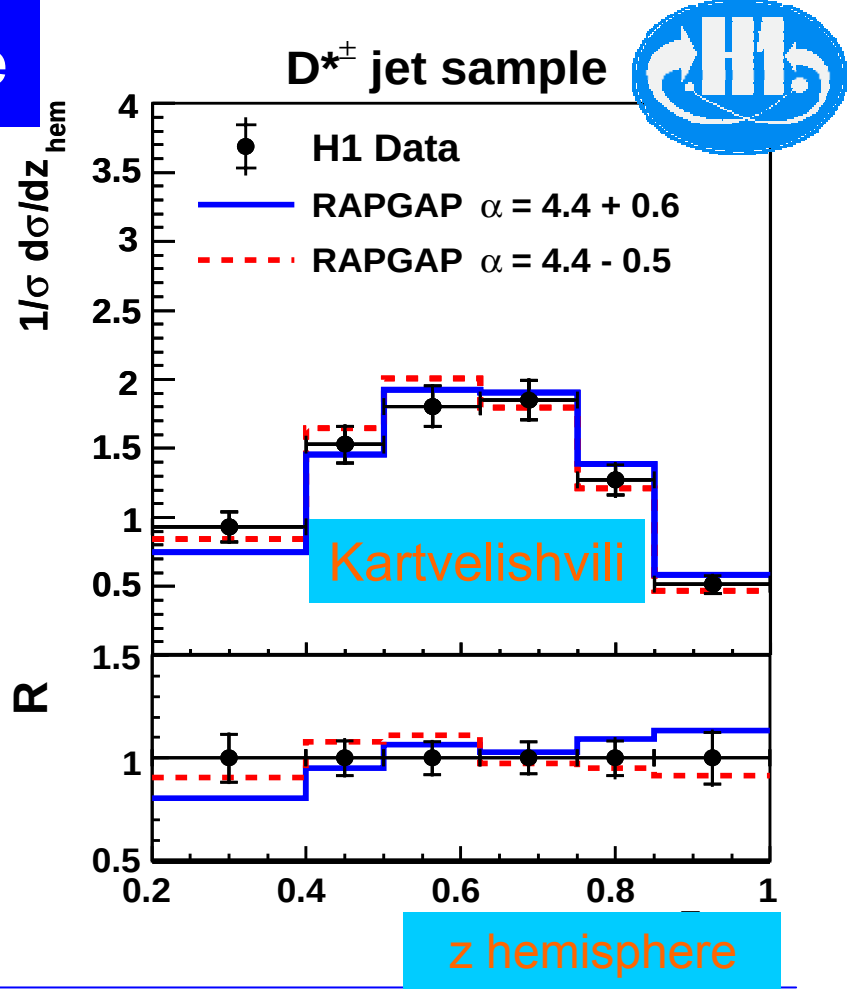
- HERA I data:1999-2000, 47pb^{-1}
- Golden channel: $D^* \rightarrow D^0 \pi_s \rightarrow K\pi\pi_s$
- D* selection in DIS
  - $2 < Q^2 < 100$ GeV^2
  - $1.5 < P_T(D^*) < 15$GeV
  - $|\eta_{D^*}| < 1.5$
- Jet sample, $E_T(\text{jet}) > 3$ GeV,

  N(D*)=1508±68
- No jet sample,

  N(D*)=1363±54



Fit to RAPGAP simulation: jet sample



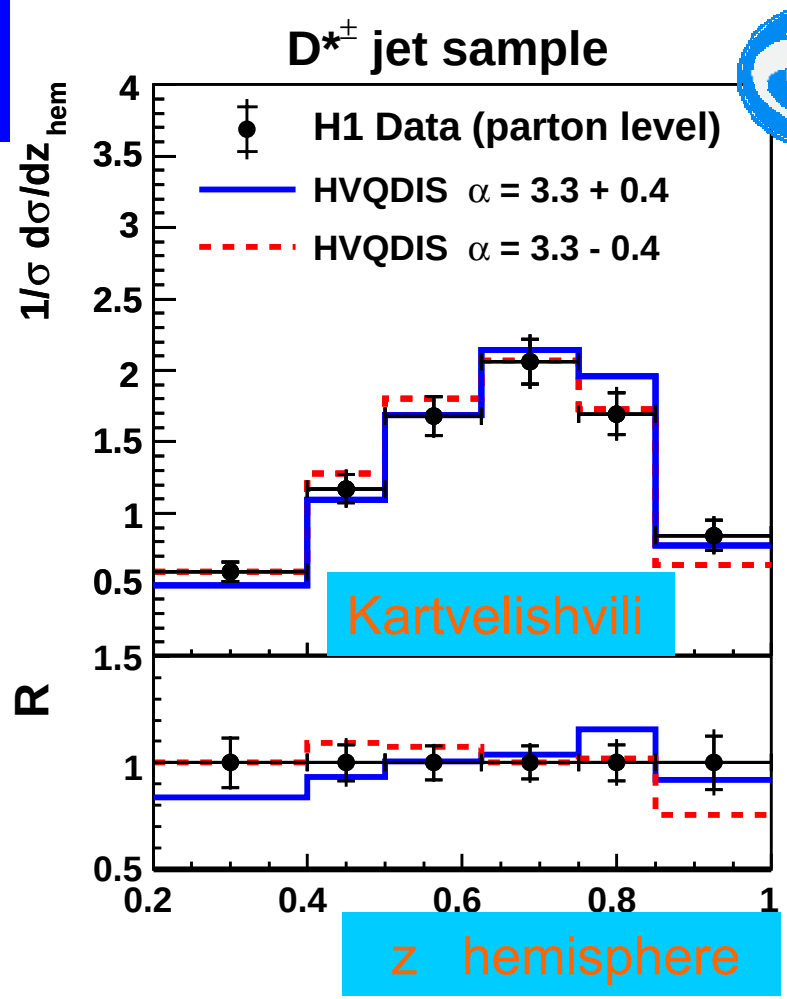
- Two methods used:
  - Jet method
  - Hemisphere method
- RAPGAP contains higher resonances (Aleph tune) as opposed to the ZEUS analysis: the fragmentation parameters can not be directly compared

	Kartvelishvili(α)	Peterson(ε)
Jet method:	$4.3^{+0.5}_{-0.4}$	$0.035^{+0.007}_{-0.006}$
Hemisphere method:	$4.4^{+0.6}_{-0.5}$	$0.030^{+0.007}_{-0.006}$

both methods give consistent results

Fit to NLO QCD: jet sample

- NLO QCD: HVQDIS
- data corrected to parton level
- compared with NLO partonic cross sections

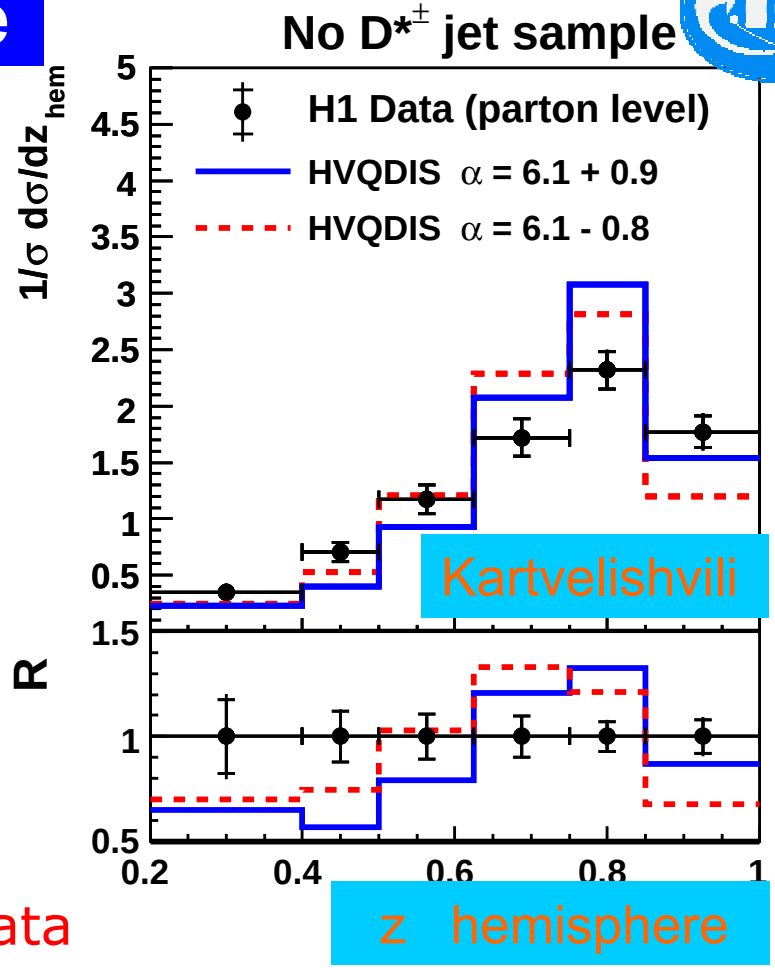


	Kartvelishvili(α)	Peterson(ε)
Jet method:	3.8±0.3	$0.034^{+0.004}_{-0.004}$
Hemisphere method:	3.3±0.4	$0.068^{+0.015}_{-0.013}$

Fit to NLO QCD: no jet sample

- NLO QCD: HVQDIS
- Investigation of the threshold region
- events not fulfilling hard scale cut $E_T(jet)>3GeV$
- compared with NLO partonic cross sections
- models describing the jet data are not able to describe the no-jet data with the same set of parameters.

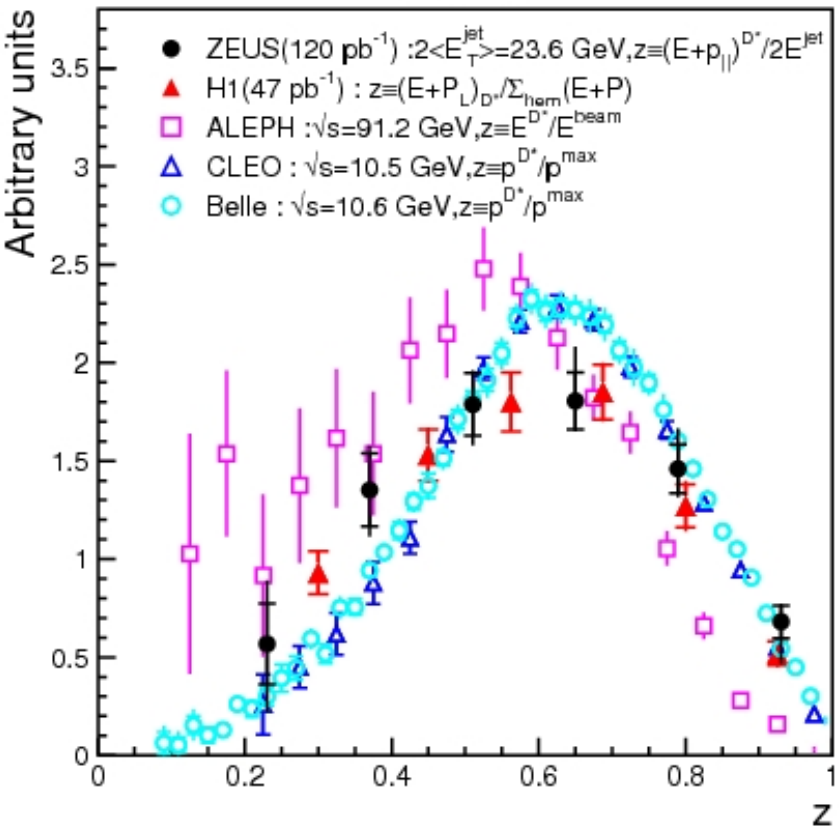
Observation confirmed with RAPGAP data



	Kart.(α)	Peterson(ε)
Hemisphere method	$6.1^{+0.9}_{-0.8}$	$0.007^{+0.001}_{-0.001}$

Comparison with e^+e^- experiments

ZEUS $z = (E+P_{||})/2E_{jet}$
H1 $z = (E+P_{||})/\Sigma_{hem}(E+P)$ Hemisphere
ALEPH $\sqrt{s}$ =91.2 GeV, $z = E_{D*}/E_{beam}$
CLEO $\sqrt{s}$ =10.5 GeV, $z = P_{D*}/P_{max}$
Belle $\sqrt{s}$ =10.6 GeV, $z = P_{D*}/P_{max}$



- z mean

$$< z >= \sum_i^n z_i \bullet (\frac{d\sigma}{dz})_i$$

- <z>=0.588 $\pm$ 0.024 ± 0.028 (ZEUS)
- <z>=0.4878 ± 0.0046 ± 0.0061 (ALEPH)
- <z>=0.6122 ± 0.0004 ± 0.0014 (Belle)
- <z>=0.611± 0.007 ± 0.004 (CLEO)
- z mean from ALEPH is a little lower due to gluon emission

- **The data sets were normalized to 1/(bin width) for z>0.3**
- **Although different definitions, spectra similar in shape**

Summary

- Fragmentation function for D* was measured in photoproduction and DIS regime
- Parameters of Peterson and Kartvelishvili functions were extracted
- Both of the fragmentation functions provide a reasonable description of data
- Fragmentation seems universal within PYTHIA, far away from the production threshold
- Different experimental methods yield compatible results within same kinematic region
- Results in threshold region differ from results at high p_T

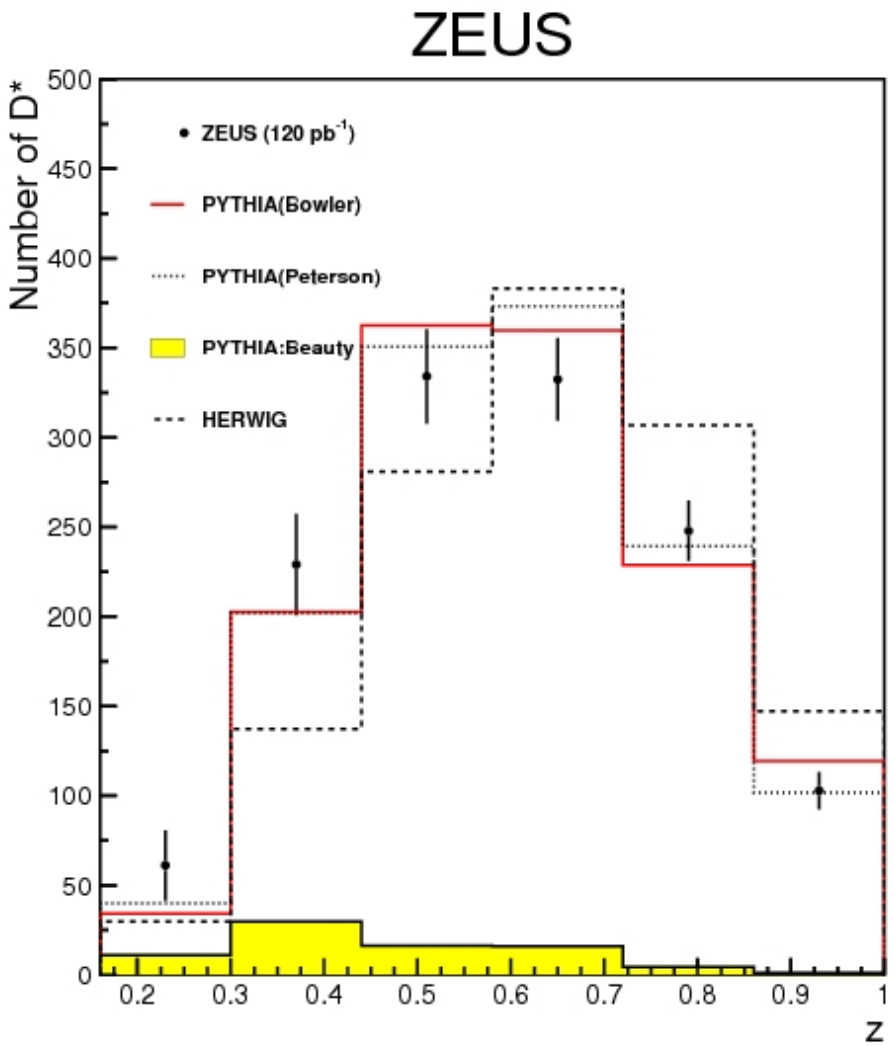
  → more refined theoretical treatment needed!

Thank you !

Backup

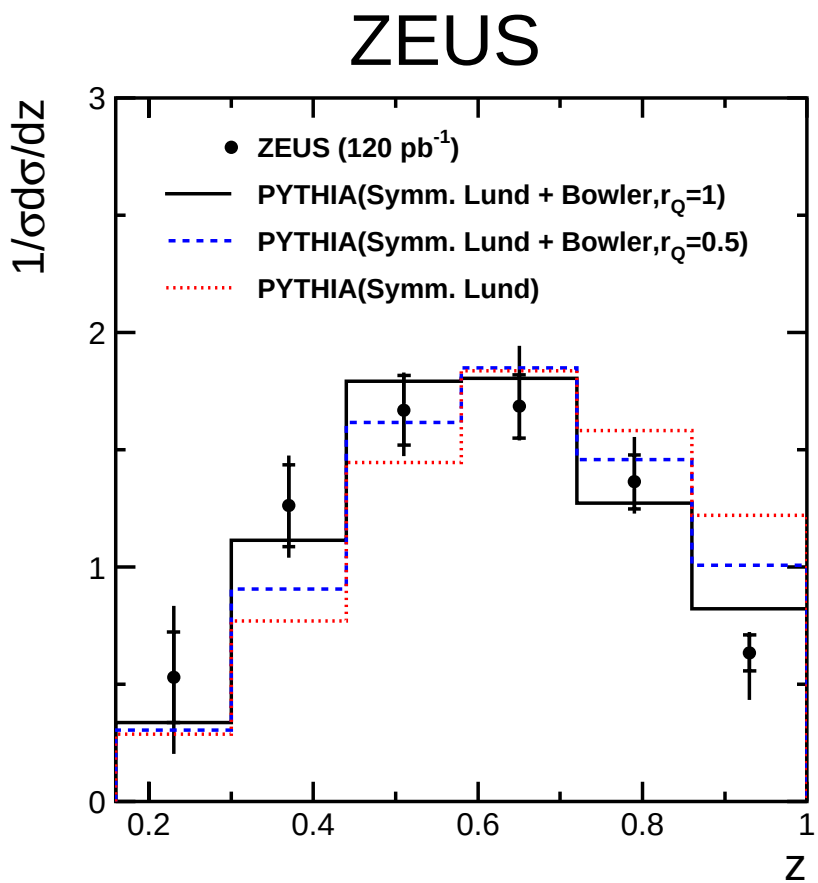
Comparison with MC predictions

- Fragmentation observable distribution
- PYTHIA6.1 seems to be better in describing data

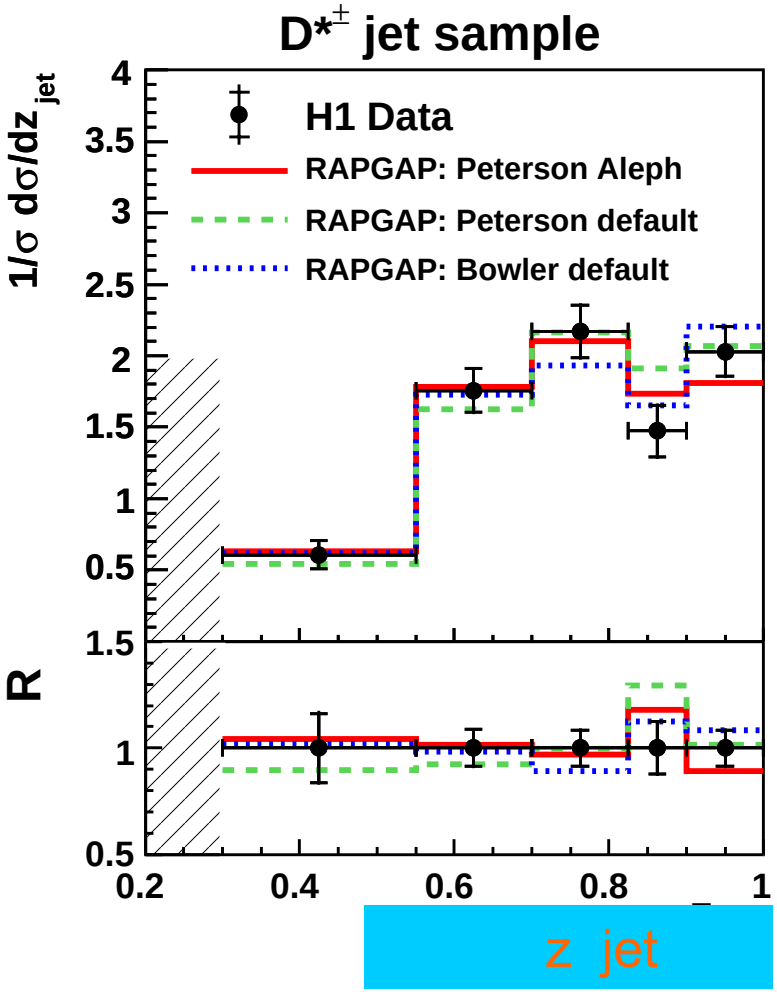


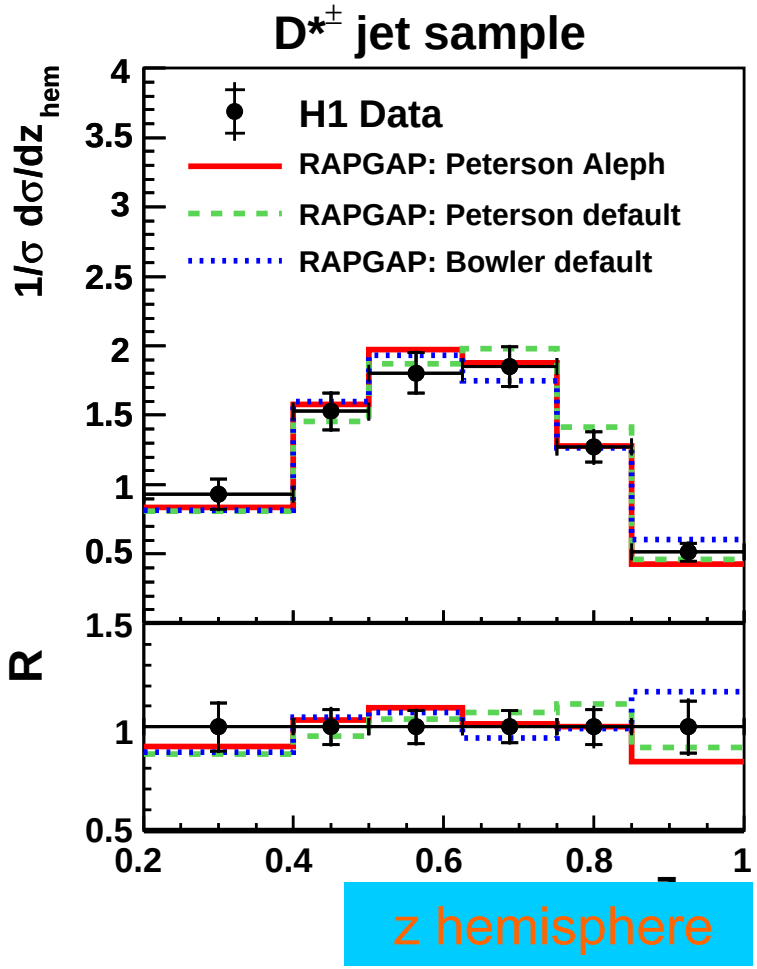
Comparison with PYTHIA simulation

- Compared with Symm. Lund + Bowler model
- The default value,r_Q=1,in PYTHIA gives a reasonable description of data
- The prediction deviates more and more from data as r_Q decreases

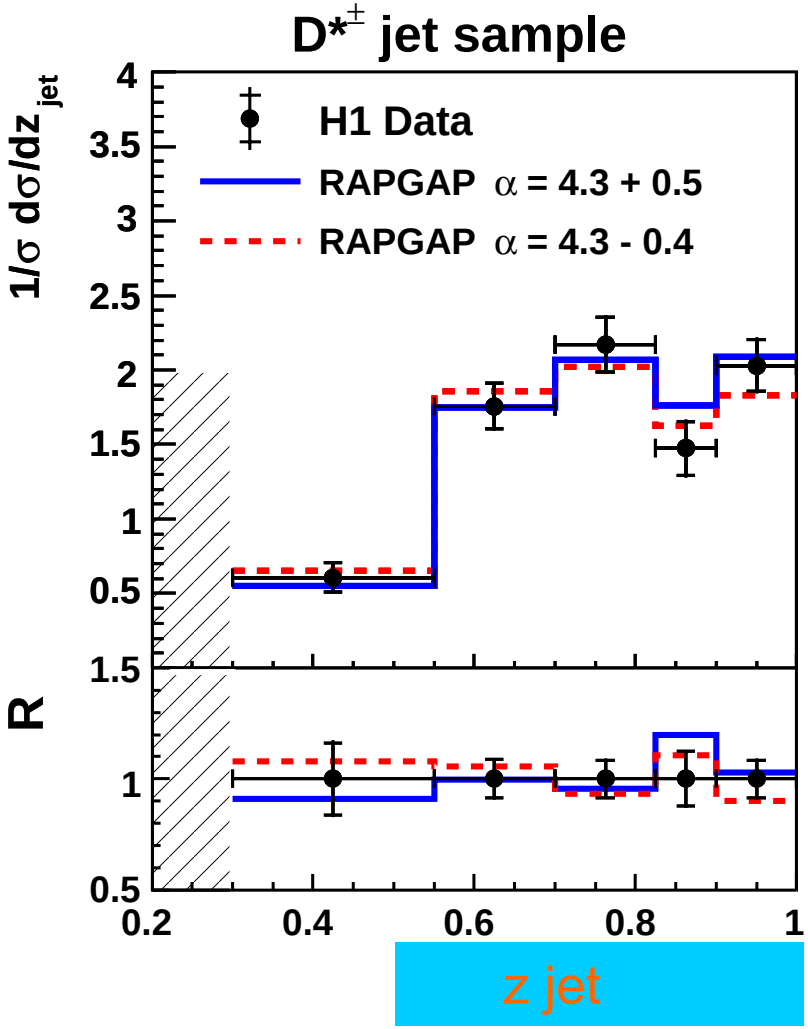


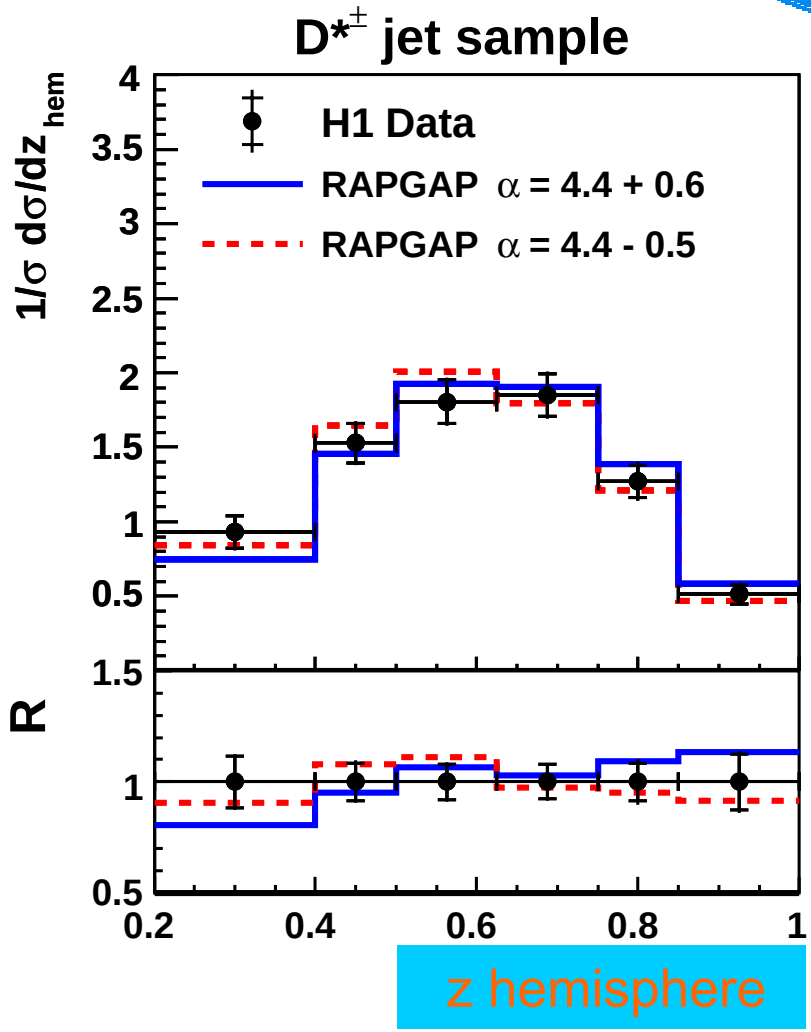
Comparison with RAPGAP: jet sample





Fit to RAPGAP simulation: jet sample





Fit to NLO QCD: jet sample