Charm Fragmentation Function and Fragmentation Fractions of Charm Mesons at ZEUS

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(on behalf of the ZEUS Collaboration)

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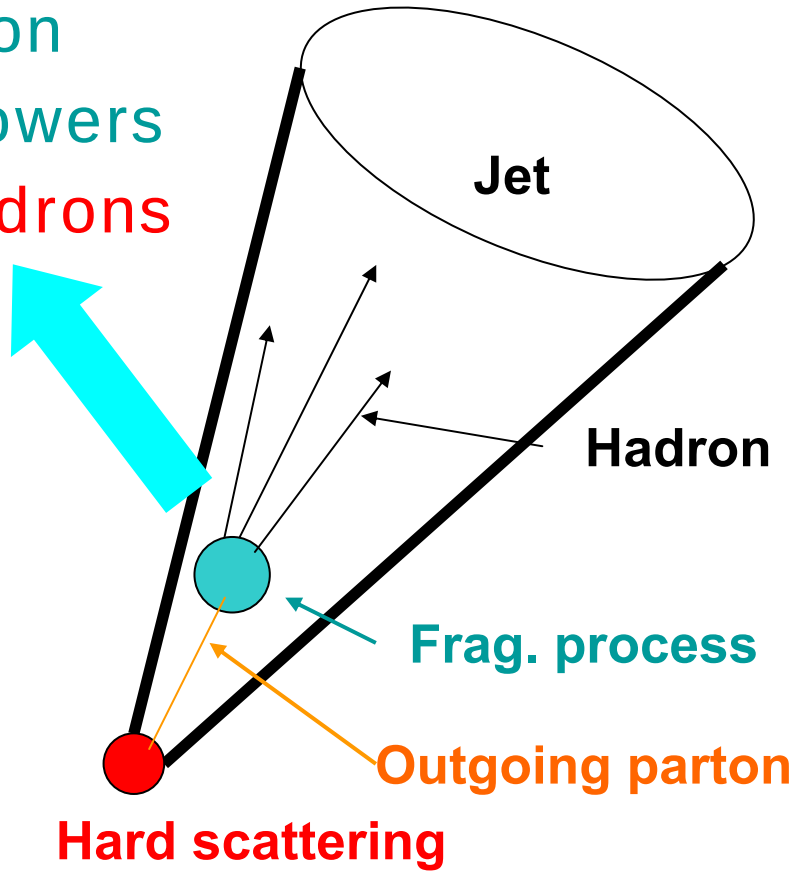
Outline

- Motivation
- Fragmentation function
- Fragmentation fractions
- Summary

Motivation

- Charm production
  - Charm quark pair production
  - Development of parton showers
  - Transition of partons to hadrons
  - Unstable hadrons decay
- Why fragmentation ?
  - Non-perturbative process
  - phenomenological model
  - needs experimental study



Motivation

- Fragmentation function

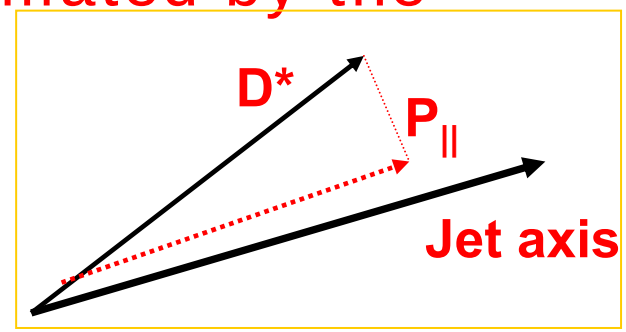
  the energy fraction of c-quark taken by charmed meson

- Fragmentation fractions

  the probability of c-quark to hadronize into particular charm mesons

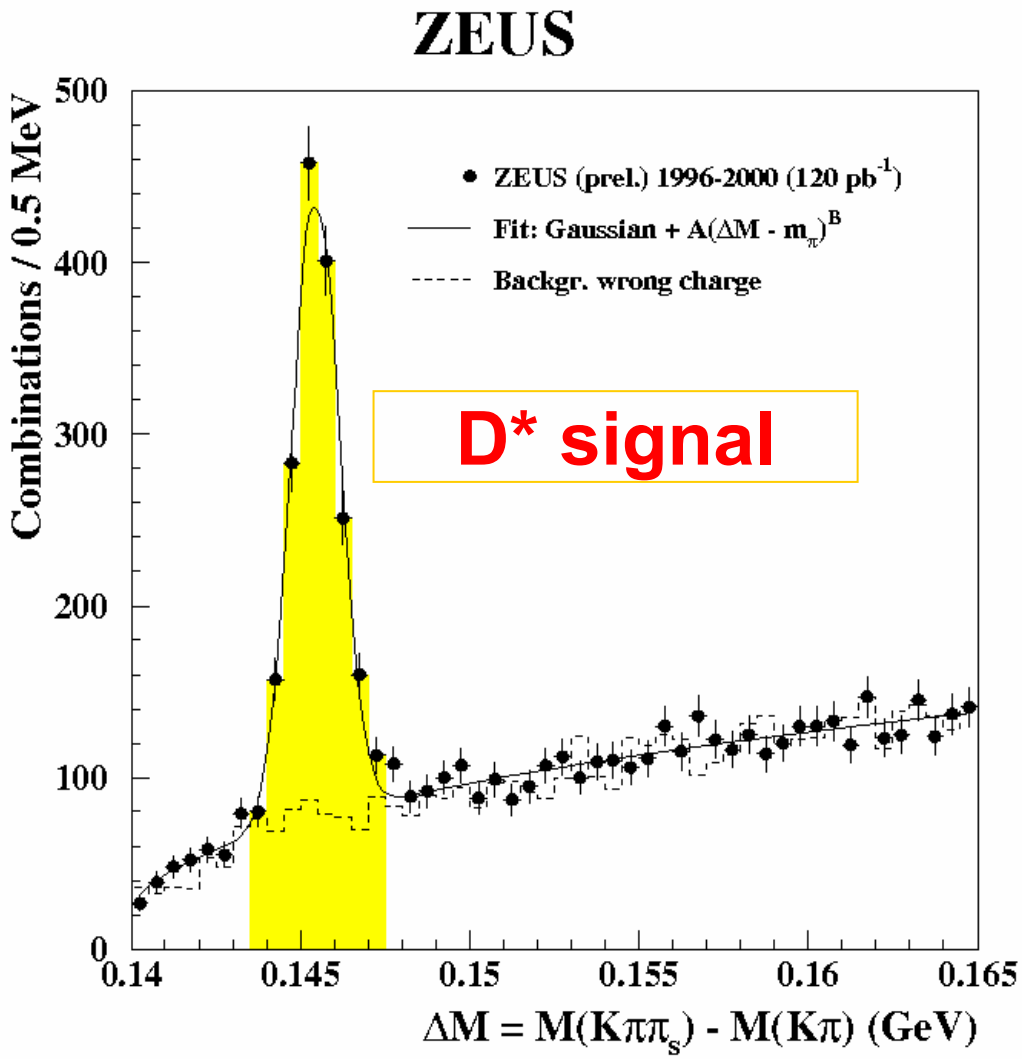
Fragmentation Function

- It describes the energy transferred from quark to a given meson
- e^+e^- collisions
  - $z = E_{D^*} / E_{beam}$
- ep collisions
  - the definition is not so simple
  - IPS contributions, different kinematics
  - the energy of c-quark is approximated by the energy of the reconstructed D* jet
  - $z = (E+P_{||})_{D^*} / 2E_{jet}$



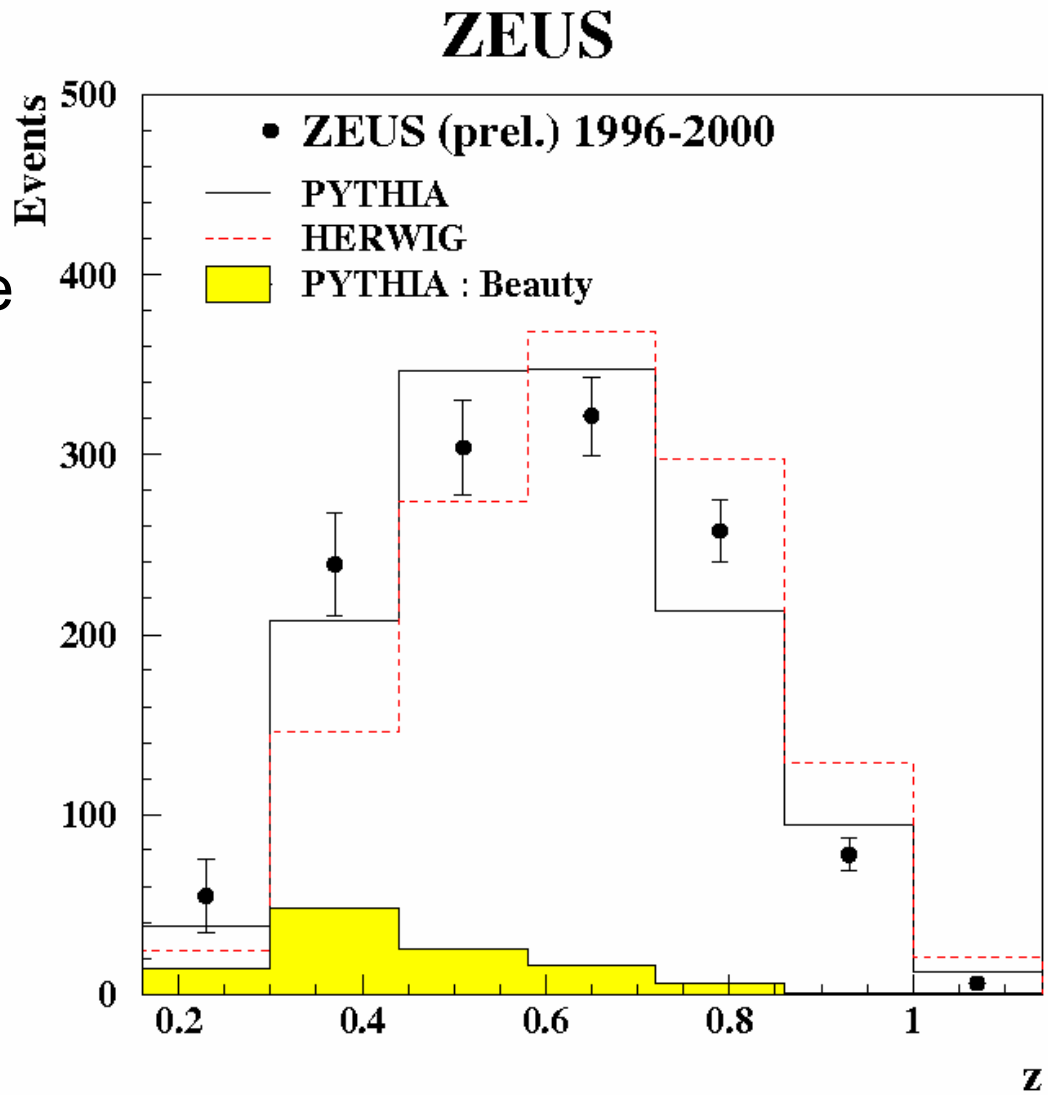
Fragmentation Function

- Data: 1996-2000, 120pb^{-1}
- Golden channel
  $D^{*\pm} \rightarrow D^0 \pi^{\pm}_s \rightarrow K^- \pi^+ \pi^+_s$ + c.c.
- Kinematic range (PHP)
  Q^2<1GeV^2, 130<Wγp<280GeV^2
  $P_T(D^*)$>2GeV, $|\eta(D^*)|$<1.5
  E_T^{jet} >9 GeV, $|\eta^{jet}|$<2.4
- N_{D^*} = 1268±56



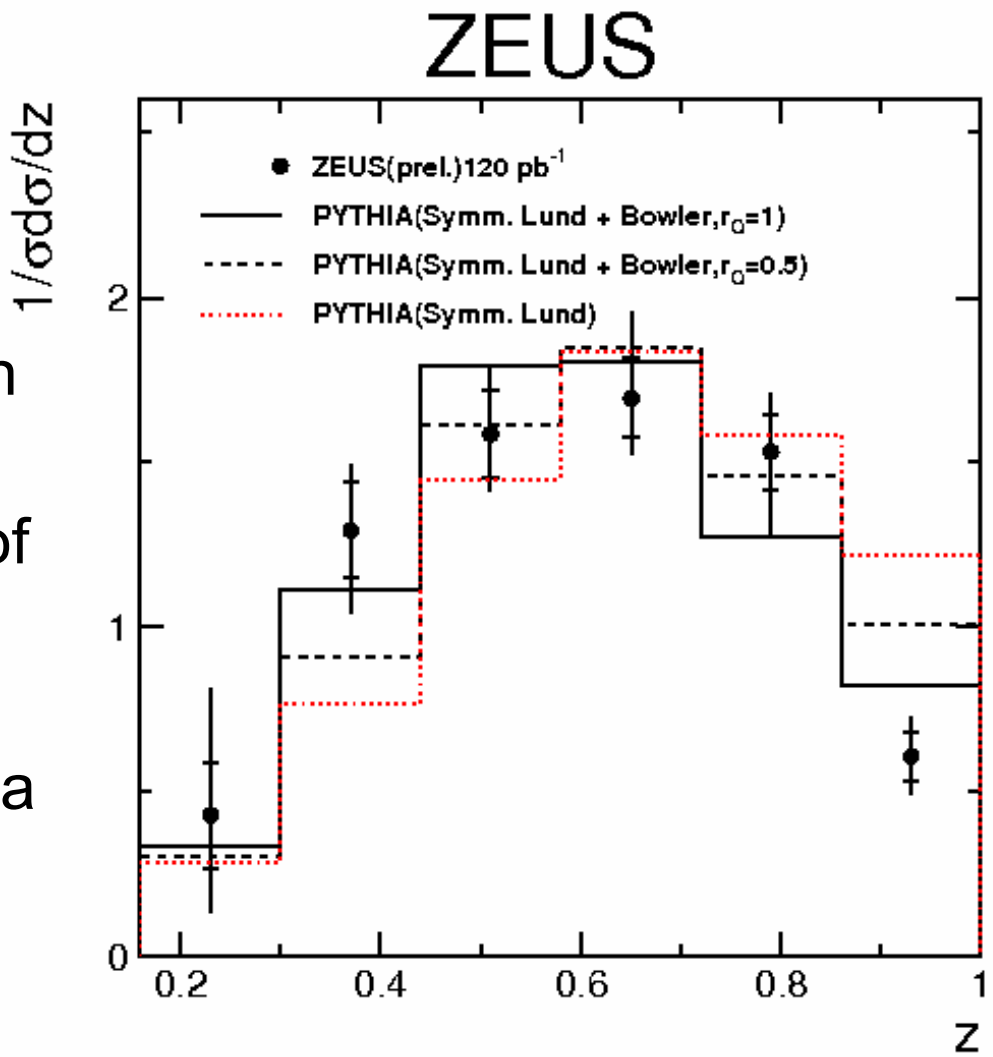
Fragmentation Function

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



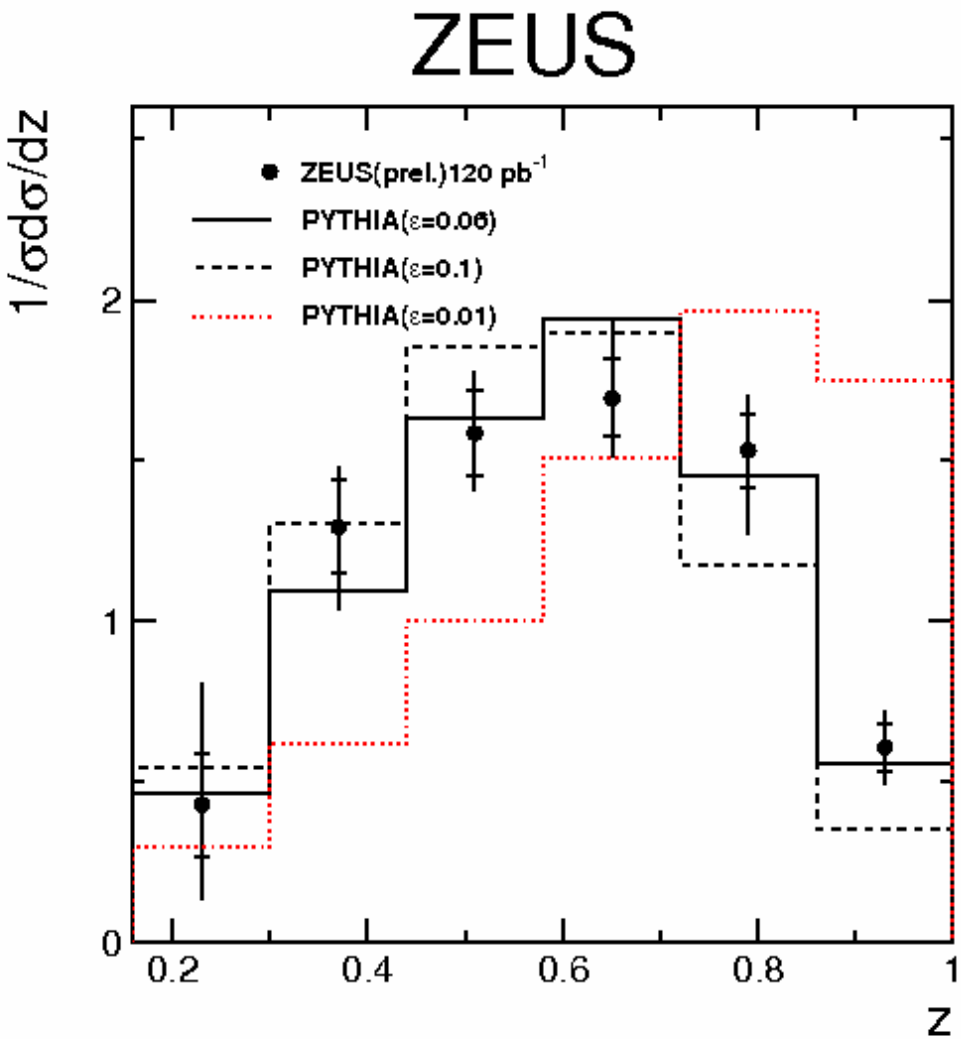
Fragmentation Function

- 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



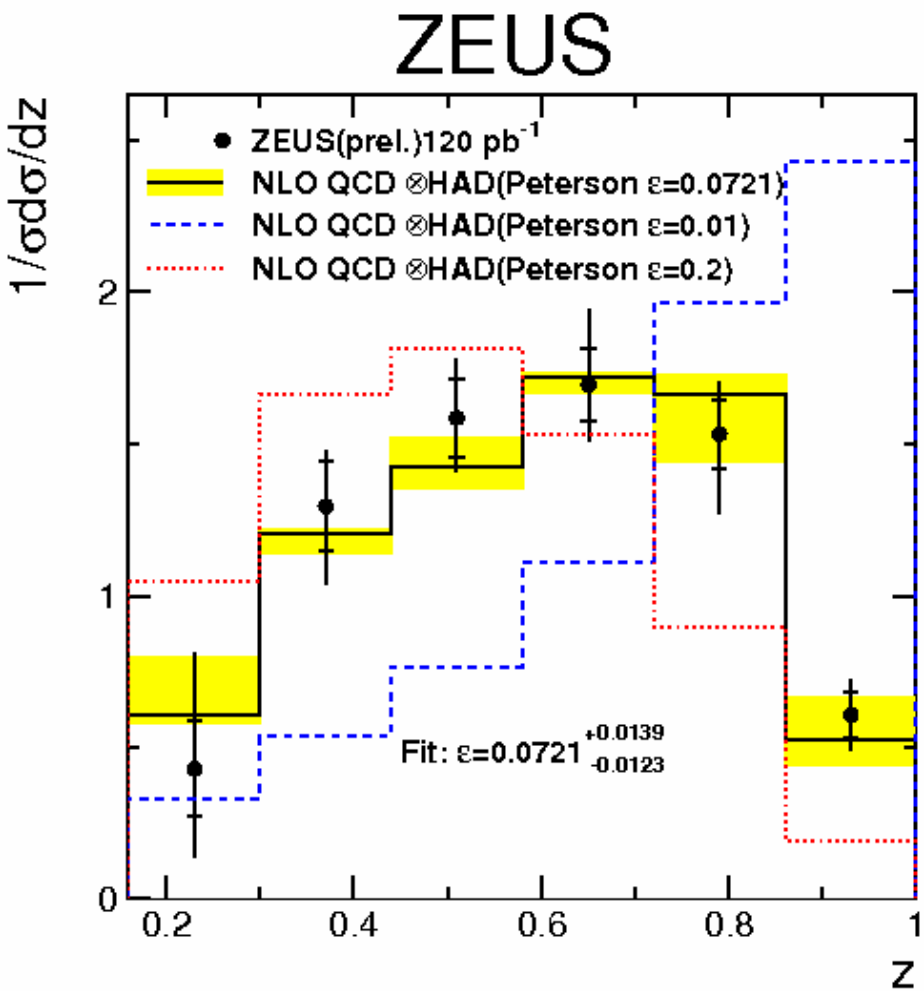
Fragmentation Function

- Extract parameter of Peterson in PYTHIA with minimum χ^2 method
- $\varepsilon = 0.064 \pm 0.006^{+0.011}_{-0.008}$
- The best value from fit is slightly larger than the default value 0.05



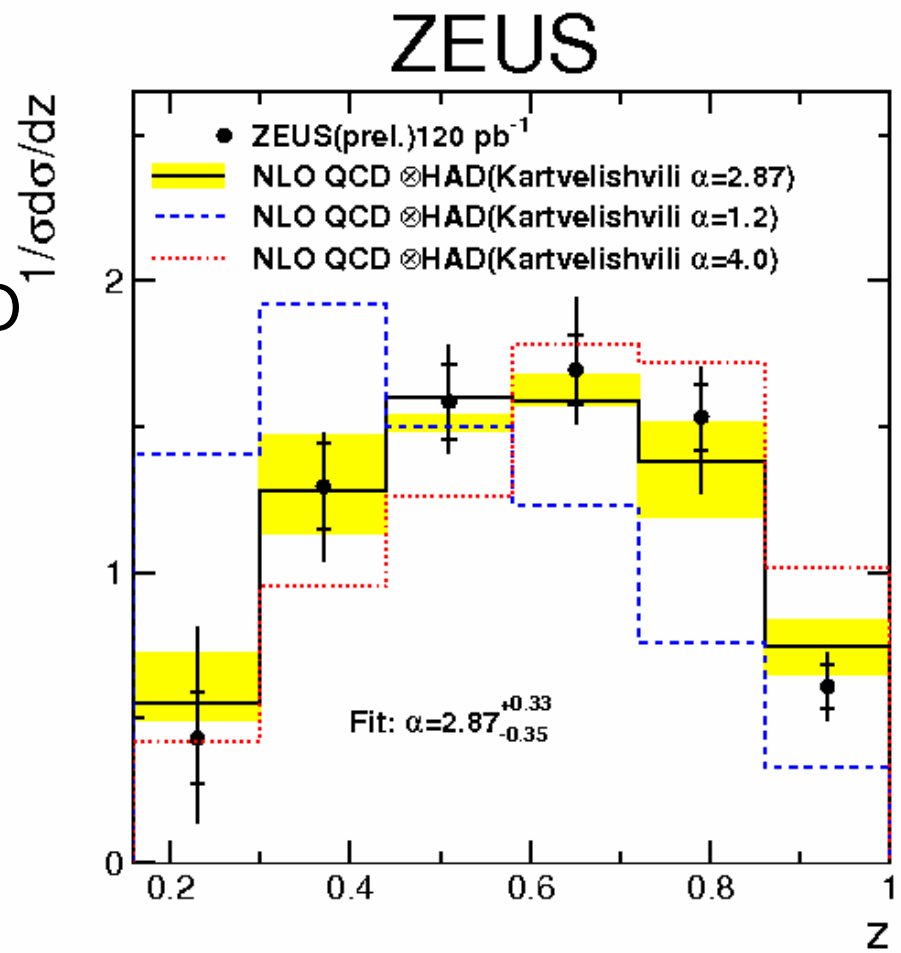
Fragmentation Function

- Extract parameter of Peterson function in NLO QCD calculation (FMNR)
- Hadronization correction for jet done
- $\varepsilon = 0.0721^{+0.0139}_{-0.0123}$
- The default value 0.035 is below the measured one

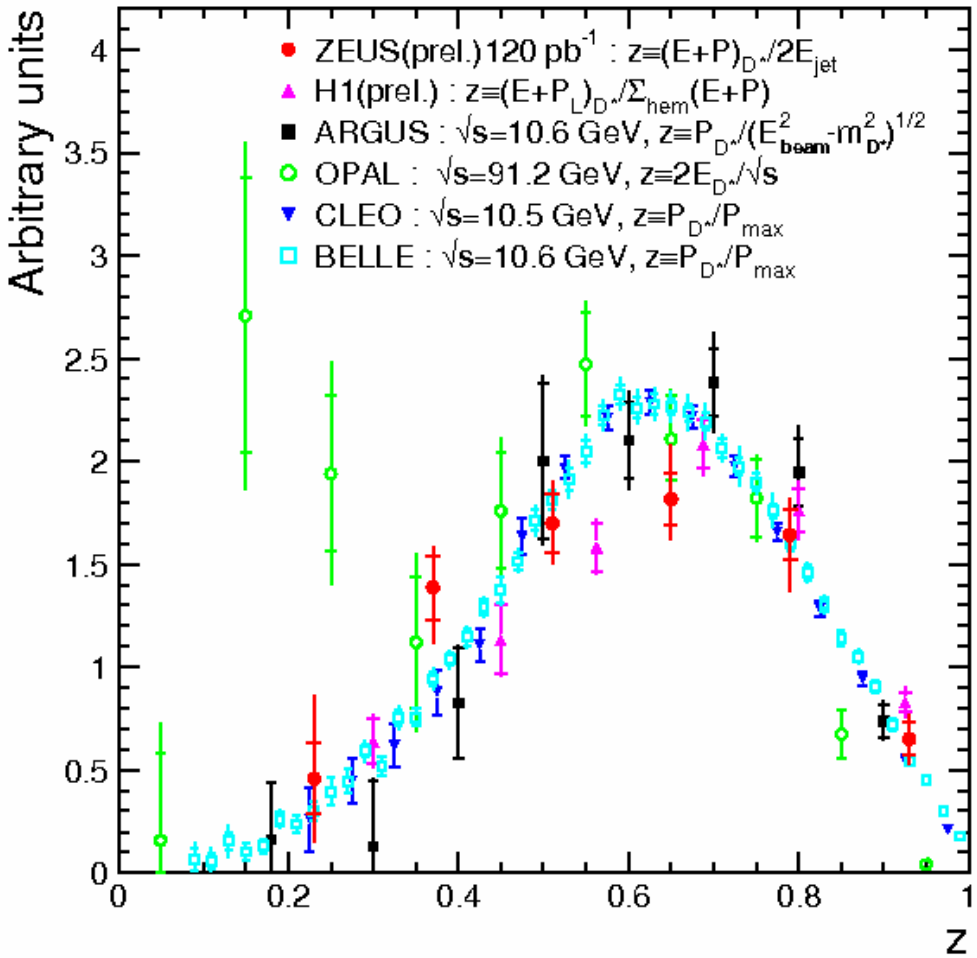


Fragmentation Function

- Extract parameter of Kartvelishvili function in NLO QCD calculation (FMNR)
- Hadronization correction for jet done
- $\alpha = 2.87^{+0.33}_{-0.35}$



Fragmentation Function



ZEUS $z = (E+P_{||})/2E_{jet}$

H1 $z = (E+P_L)/\Sigma_{hem}(E+P)$

ARGUS $\sqrt{s}$ =10.6 GeV

$z=P_{D^*}/(E^2_{beam}-m^2_{D^*})^{1/2}$

OPAL $\sqrt{s}$ =91.2 GeV

$z = E_{D^*}/2\sqrt{s}$

CLEO $\sqrt{s}$ =10.5 GeV

$z = P_{D^*}/P_{max}$

BELLE $\sqrt{s}$ =10.6 GeV

$z = P_{D^*}/P_{max}$

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

Fragmentation Fractions

- **Data: 1998-2000, 82pb^{-1}**
- **Kinematic range (DIS)**

  $1.5<Q^2<1000\ GeV^2$,$0.02<y<0.7$

  $P_T(D)>3GeV, |\eta(D)|<1.6$

- **Measurements of charm-meson cross sections**
- **Fragmentation fractions**

  The fraction of the production cross section for the meson to the cross section of c-quark

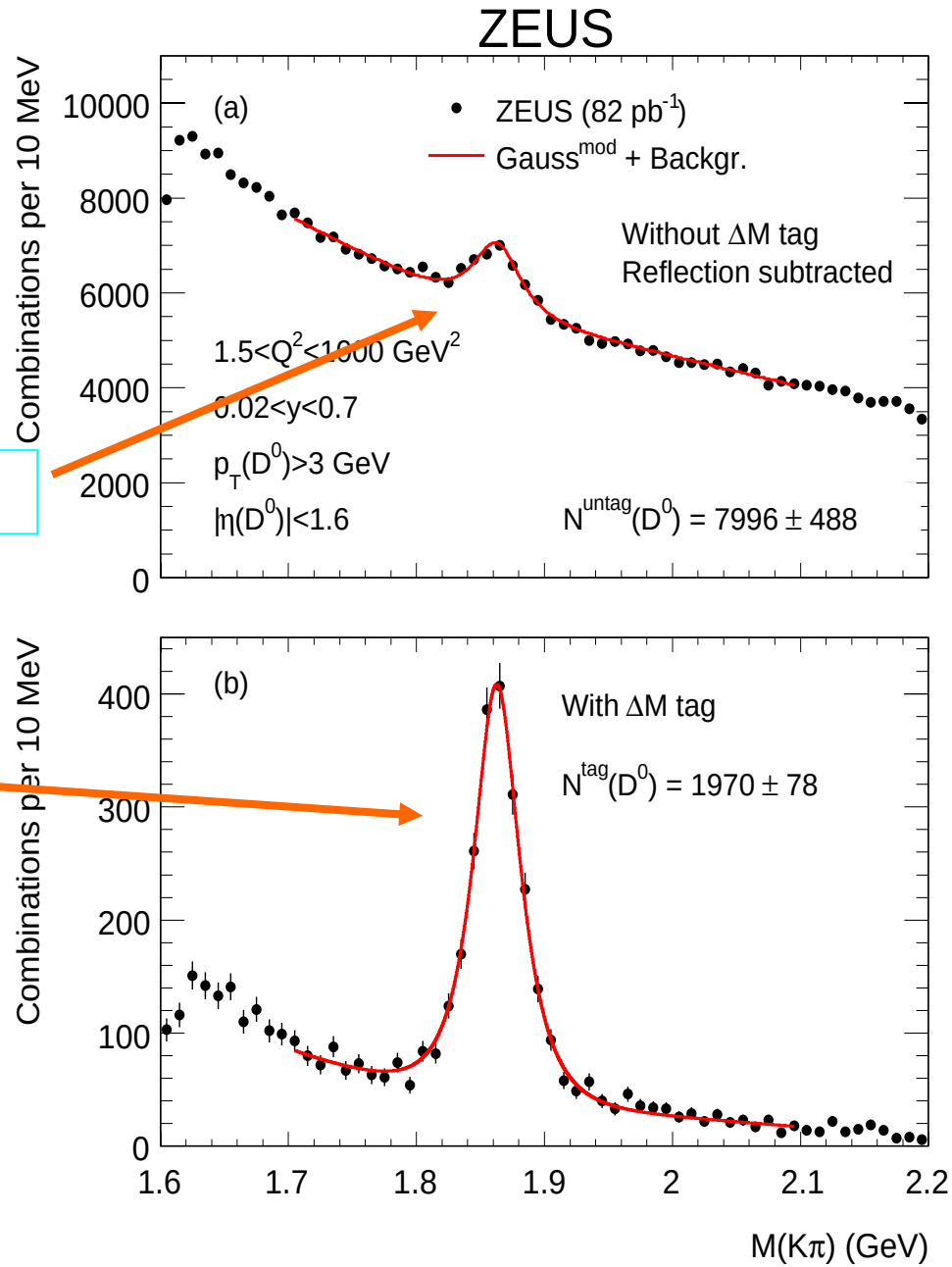
- **Fragmentation ratios**
  - The ratio of neutral to charged D-meson production rates($R_{u/d}$)
  - The fraction of charmed D mesons produced in a vector state (P^d_v)
  - The strangeness-suppression factor in charm fragmentation(γ_s)

Fragmentation Fractions

$D^0 \rightarrow K^+\pi^-$+c.c.

Untagged D^0 :without π_s from D^*

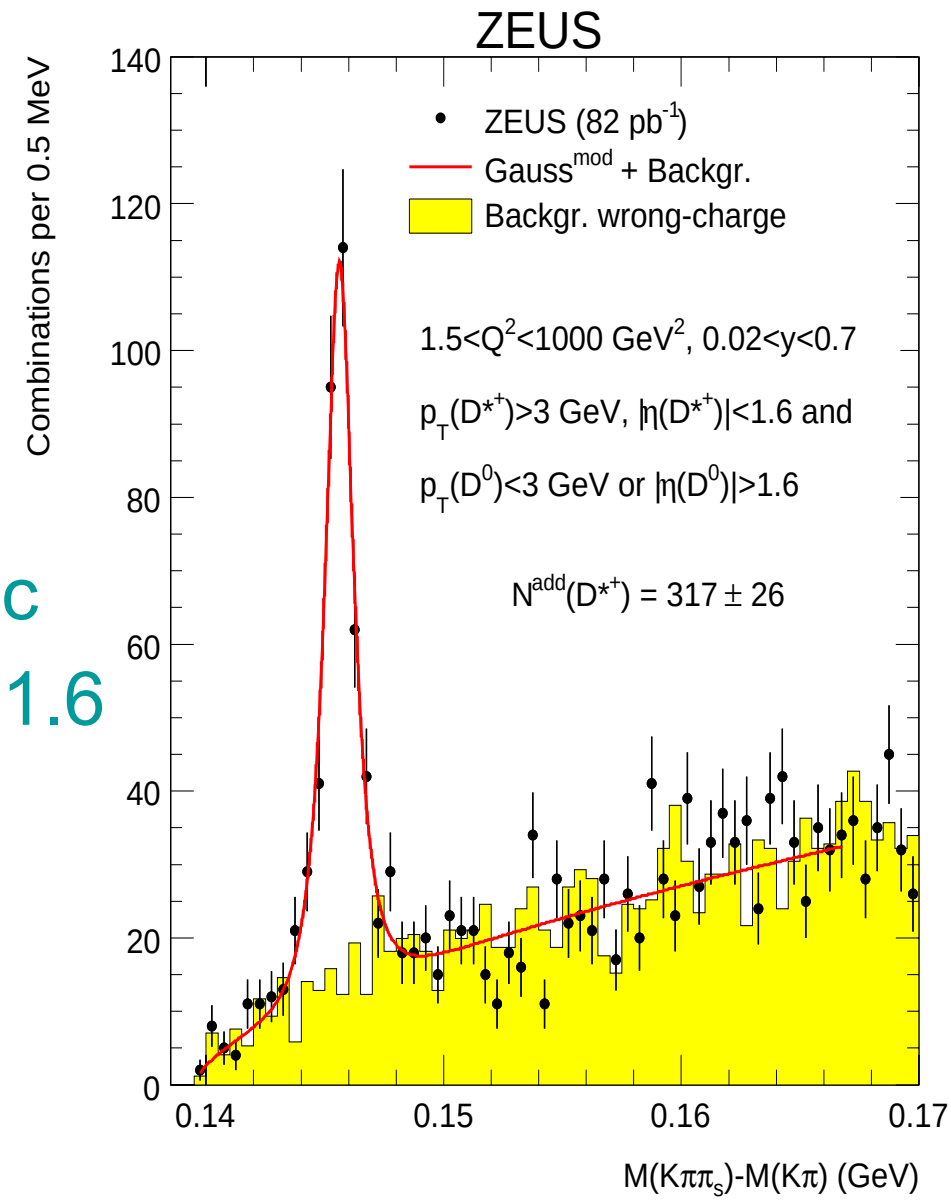
Tagged D^0 : with π_s from D^*



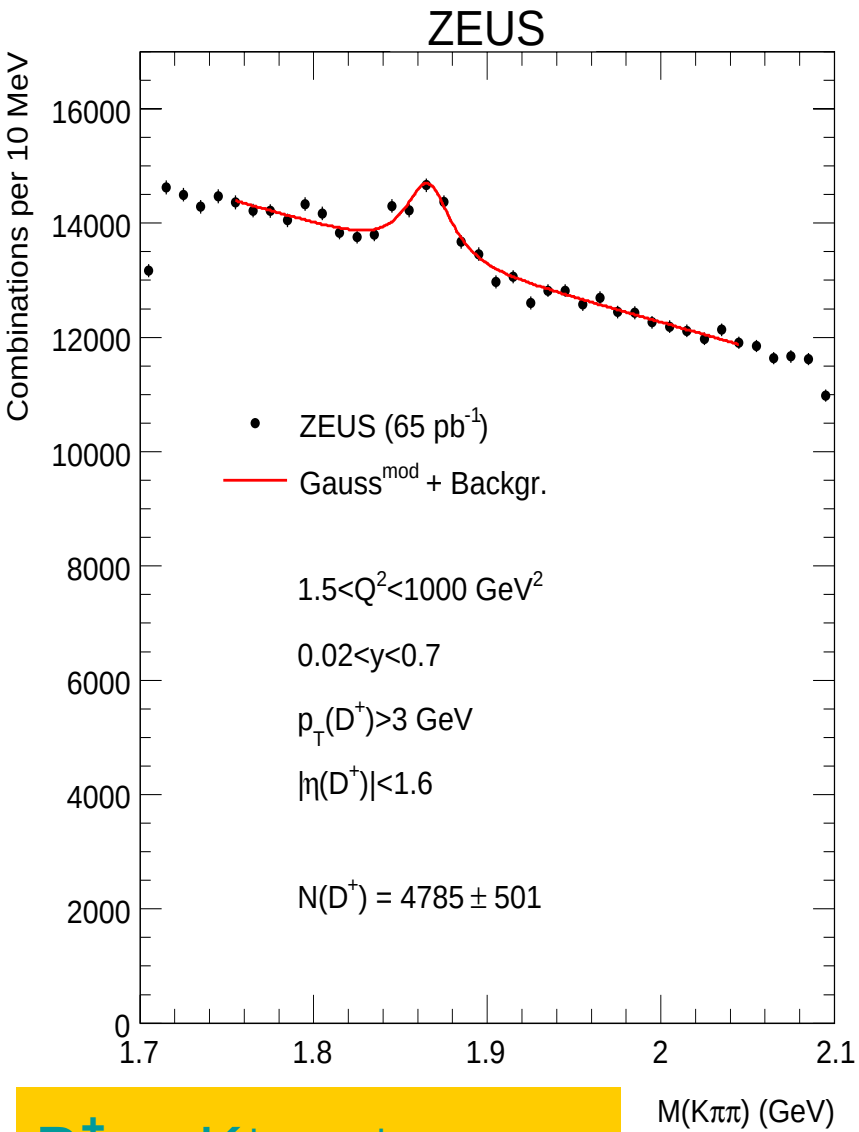
Fragmentation Fractions

$D^{*\pm} \rightarrow D^0 \pi^{\pm}_s \rightarrow K^- \pi^+ \pi^+_s + c.c.$

- "additional" D*
- without D^0 in its kinematic range, i.e. :PT>3GeV, |η|<1.6

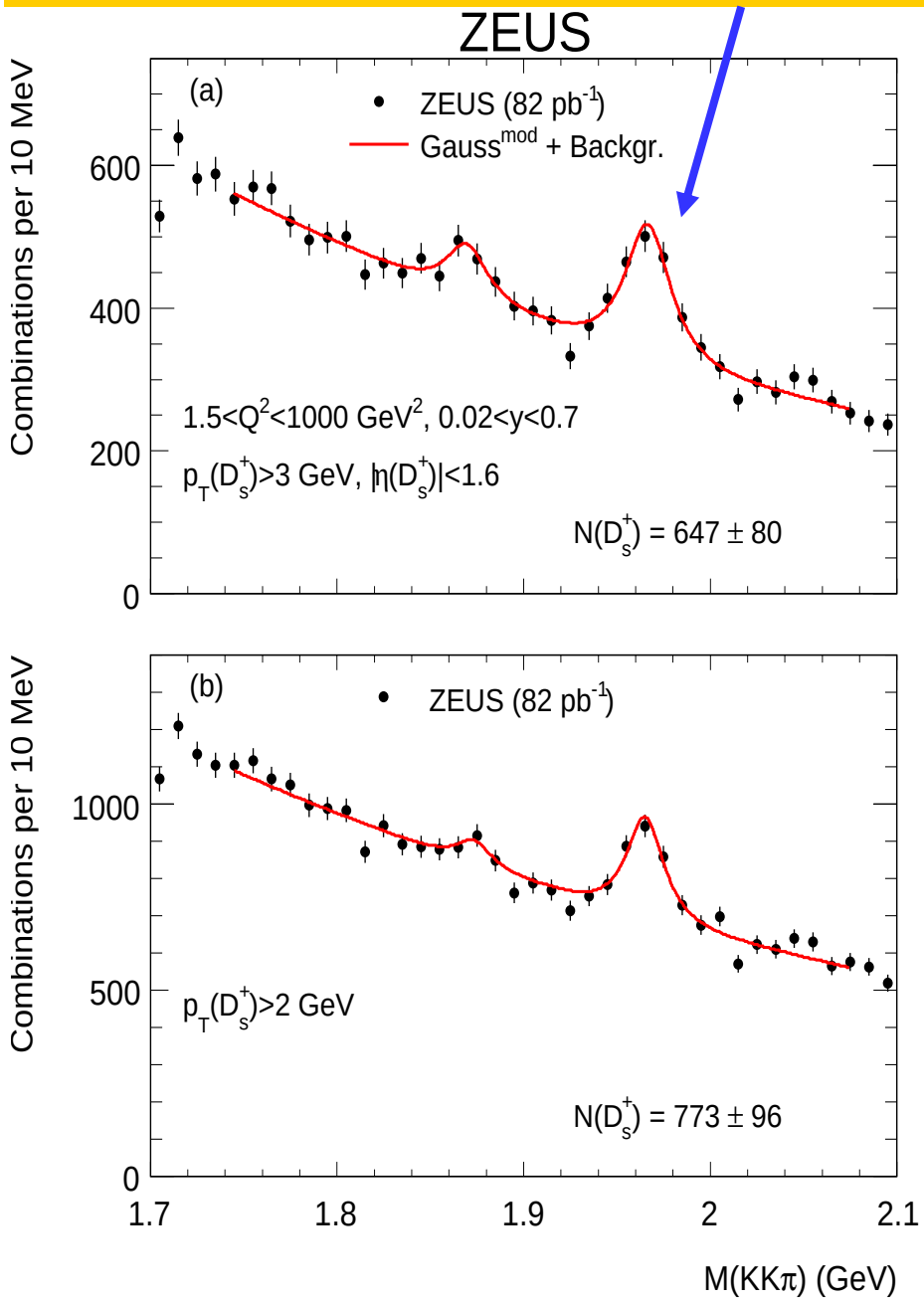


Fragmentation Fractions



$D^{\pm} \rightarrow K^{+}\pi^{-}\pi^{+}$ +c.c.

$D^{\pm}_{S} \rightarrow \Phi\pi^{\pm} \rightarrow K^{+}K^{-}\pi^{+}$ + c.c.

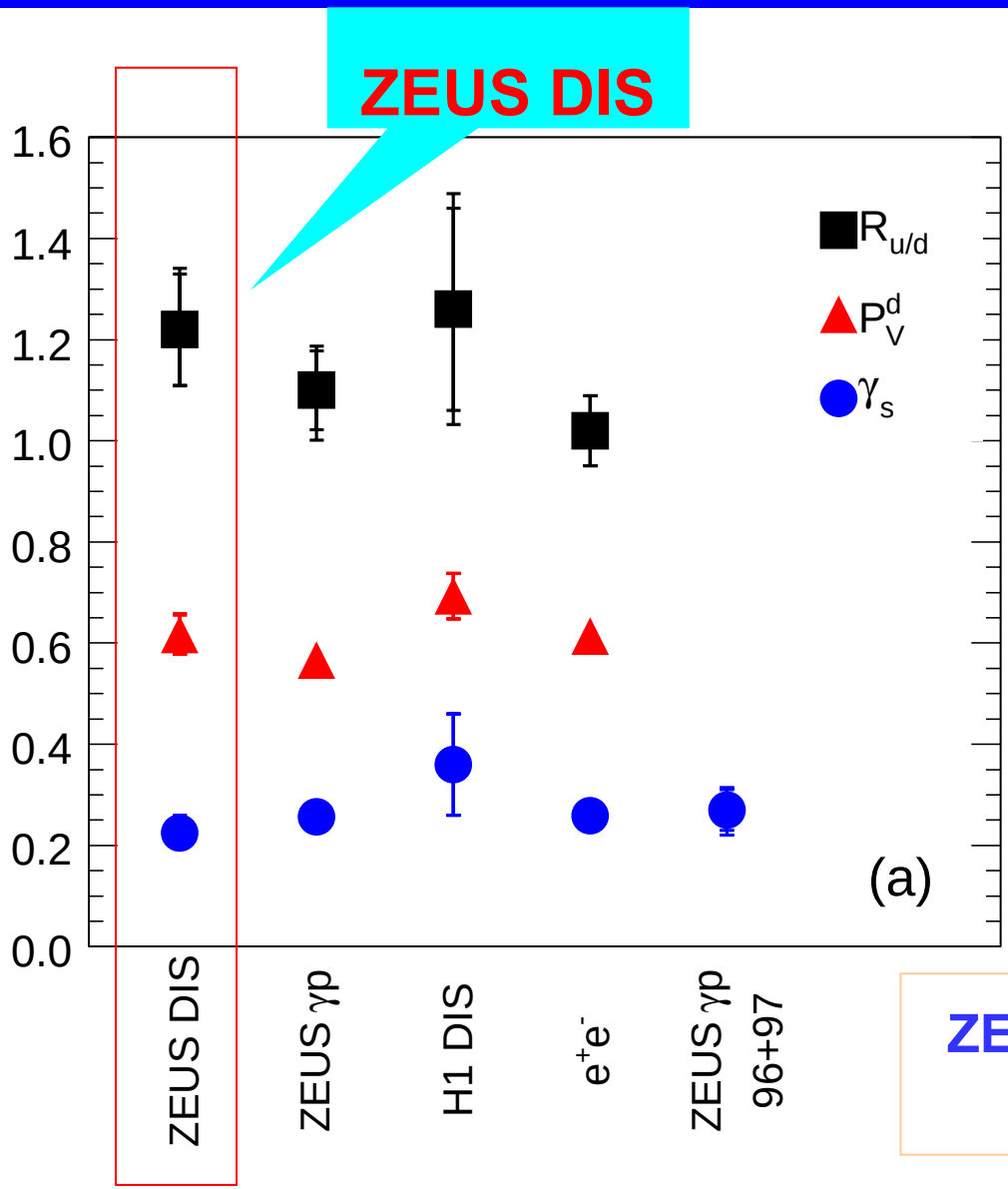


Fragmentation Fractions

Charm-meson production cross sections

	Cross sections
Untagged D^0	$5.56 \pm 0.35(\text{stat.}) \,^{+0.32}_{-0.26}(\text{syst.}) \pm 0.10(\text{br.})$ nb
Tagged D^0	$1.78 \pm 0.08(\text{stat.}) \,^{+0.12}_{-0.10}(\text{syst.}) \pm 0.03(\text{br.})$ nb
Additional $D^{*\pm}$	$0.518 \pm 0.046(\text{stat.}) \,^{+0.051}_{-0.046}(\text{syst.}) \pm 0.01(\text{br.})$ nb
$D^{\pm}$	$2.80 \pm 0.30(\text{stat.}) \,^{+0.18}_{-0.14}(\text{syst.}) \pm 0.10(\text{br.})$ nb
$D^{\pm}_s$	$1.27 \pm 0.16(\text{stat.}) \,^{+0.11}_{-0.06}(\text{syst.}) \,^{+0.19}_{-0.15}(\text{br.})$ nb

Fragmentation Fractions



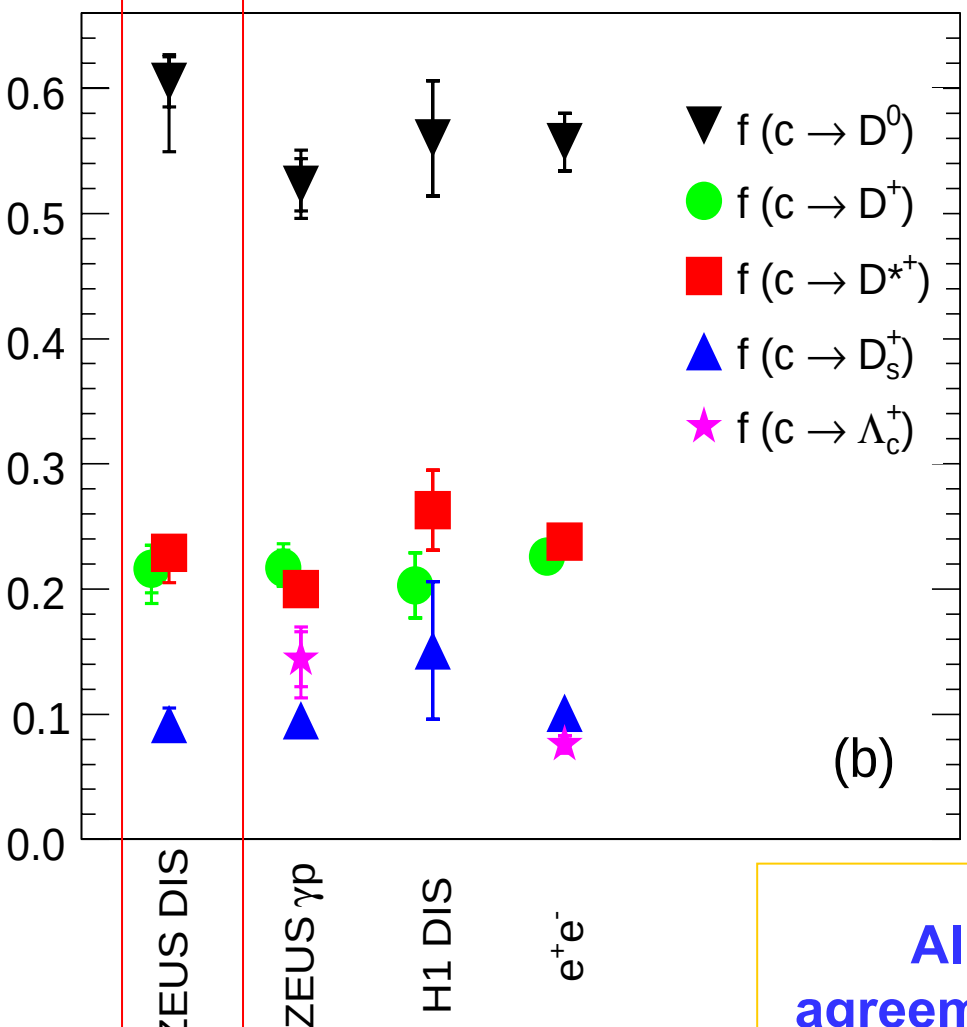
$$R_{u/d} = 1.22 \pm 0.11\,^{+0.05}_{-0.02} \pm 0.03$$

$$P^d_v = 0.617 \pm 0.038\,^{+0.017}_{-0.009} \pm 0.017$$

$$\gamma_s = 0.225 \pm 0.030\,^{+0.018+0.034}_{-0.007\ -0.026}$$

ZEUS results in DIS agree with previous measurements

Fragmentation Fractions



$f(c \to D^0) = 0.605 \pm 0.020\,^{+0.009+0.015}_{-0.052-0.023}$

$f(c \to D^+) = 0.216 \pm 0.019\,^{+0.002+0.008}_{-0.020-0.010}$

$f(c \to D^{*+}) = 0.229 \pm 0.011\,^{+0.006+0.007}_{-0.021-0.010}$

$f(c \to D^+_s) = 0.092 \pm 0.011\,^{+0.007+0.012}_{-0.008-0.010}$

ZEUS DIS

All fragmentation fractions are in agreement with each other and consistent with assumption of universality

Summary

- Fragmentation function for D* was measured in photoproduction regime
- Parameters of Peterson and Kartvelishvili functions were extracted
- Both of the fragmentation functions provide a reasonable description of data
- Although definitions are different, spectra similar in shape
- Fragmentation ratios and fractions were measured in DIS regime
- Extracted fragmentation ratios and fractions are consistent with assumption of universality

Backup

Fragmentation Fractions

- **Fragmentation fractions**

  $f(c \rightarrow h) = \sigma(h)/\sigma(c)$

- **Fragmentation ratios**

  $R_{u/d} = \sigma^{untag}(D^0)/[\sigma(D^+) + \sigma^{tag}(D^0)]$

  $\gamma_s = 2\sigma(D^+_s)/[\sigma(D^+) + \sigma^{untag}(D^0) + \sigma^{tag}(D^0) + \sigma^{add}(D^{*+})(1+R_{u/d})]$

  $P^d_v = [\sigma^{tag}(D^0)/B(D^* \rightarrow D^0\pi) + \sigma^{add}(D^{*+})]/[\sigma(D^+) + \sigma^{tag}(D^0) + \sigma^{add}(D^{*+})]$