Charm Fragmentation Function with D*

Shuangshi Fang (DESY)
Matthew Wing (UCL/DESY/UHH)
(Sanjay Padhi (McGill))

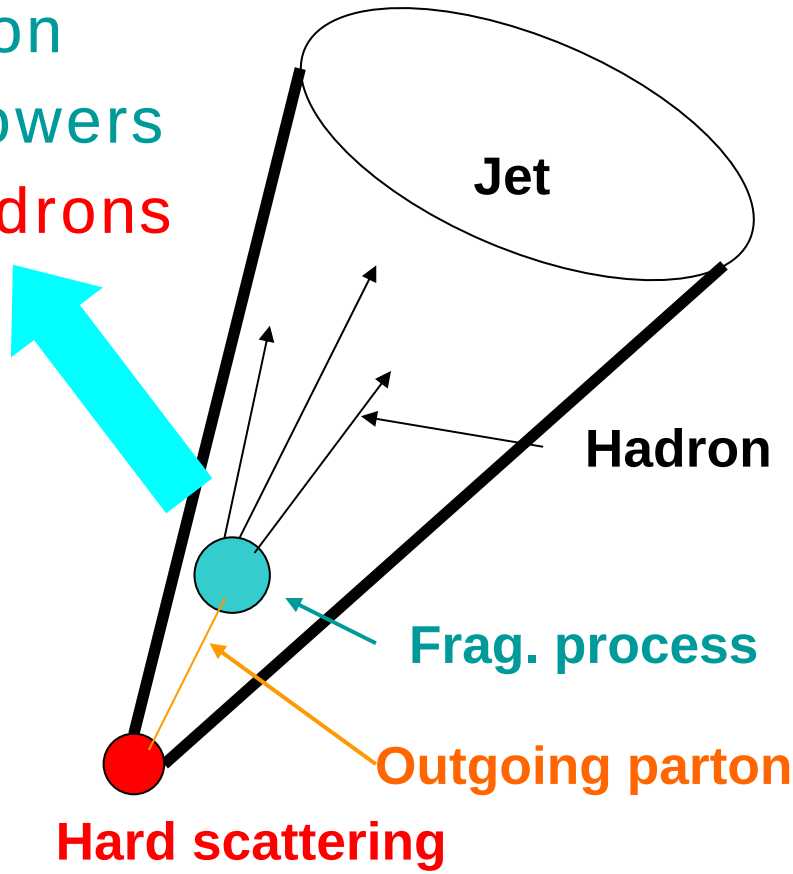
Experiment-Theory Meeting on Charms, 8th August,2008

Outline

- Motivation
- Fragmentation models
- Event selection
- Fragmentation function
- Summary

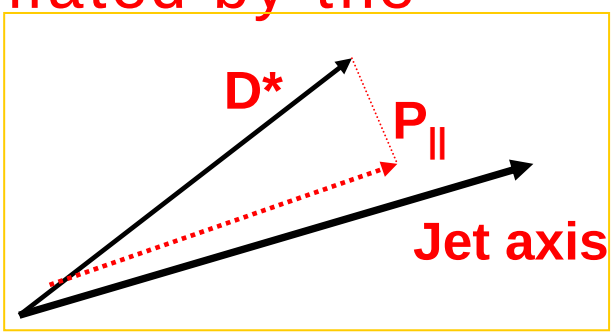
Motivation

- 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

- 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 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

$$f(z) \propto \frac{1}{z^{1+r_Q b m_Q^2}}(1-z)^a \exp(\frac{-bm_\perp^2}{z})$$

Event Selection

- Data:1996-2000, 120pb^{-1}
- Trigger

  FLT 42(1996-1997)/FLT42 or FLT 59(1998-2000)
  HPP01(1996-1997)/HFL01(1998-2000)
  DST 27
- No scattered electron in CAL

$$130 < W_{\gamma p} < 280 \text{ GeV}, \; Q^2 < 1 \text{ GeV}^2$$

Event Selection

$D^{*\pm}$ selection

- $P_T(\pi_s)>0.12$ GeV, $P_T(\pi,K)>0.5$ GeV
- $|\eta(\pi_s,K,\pi)|<1.75$
- $1.83 < M(D^0) < 1.9$ GeV
- $P_T(D^*)/E_{\perp}^{\ \theta>10^\circ} > 0.1$
- $0.1435 < M(D^*)-M(D^0) < 0.1475$ GeV

$P_T(D^*)>2$GeV, $|\eta_{D^*}|<1.5$

Event Selection

Jet Selection

- k_T algorithm
- E_T^{jet} >9 GeV
- $|\eta^{jet}|<2.4$
- $\sqrt{(\eta_{D^*}-\eta_{jet})^2+(\phi_{D^*}-\phi_{jet})^2}<0.6$
- Matching at hadron-level with k_T algorithm

- Remove daughters of D*
- D* was sent as input to KT algorithm
- D* was traced until the final formation of jet
- Pick up the jet which contains D*

Event Selection

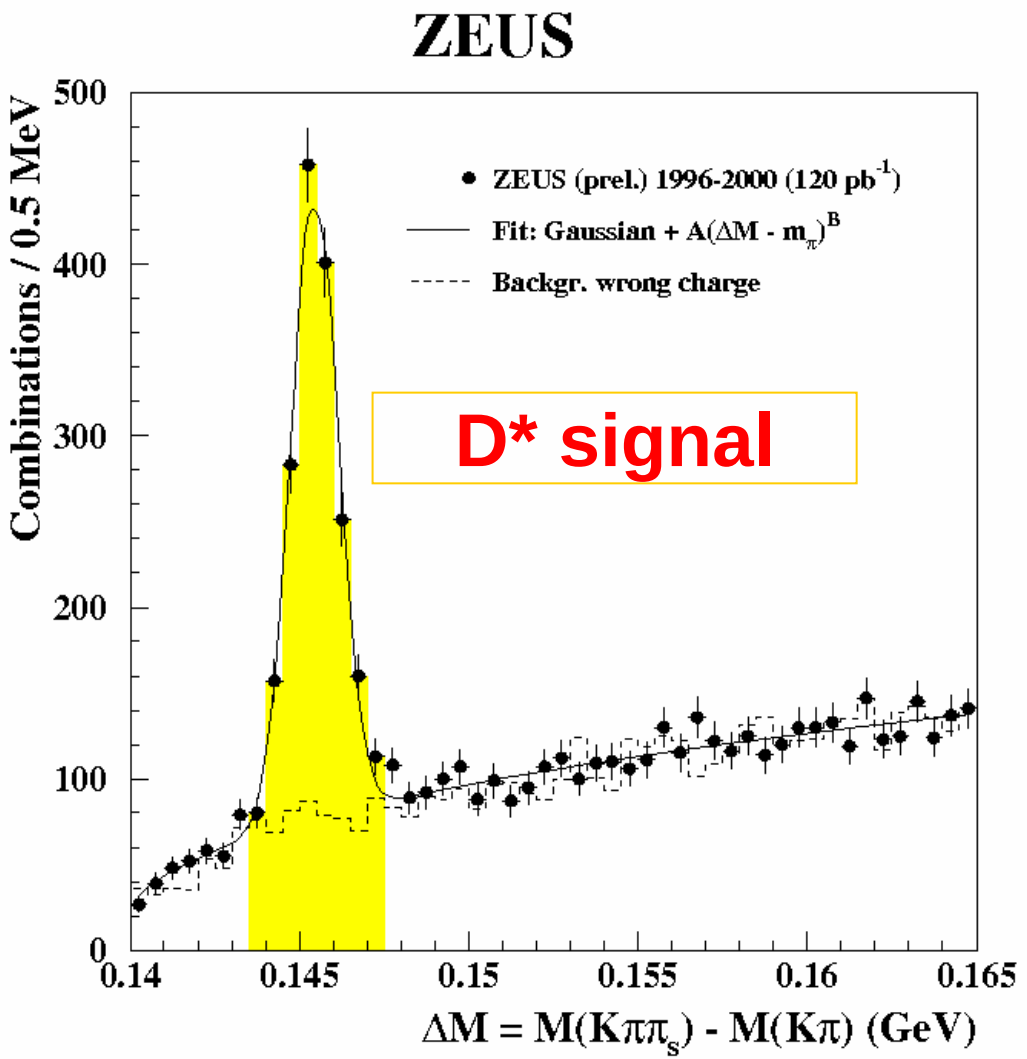
- Cuts on $P_T(D^*)>2GeV$ and ETjet >9 GeV can lead to a bias in the fragmentation observable as $z \sim p(D^*)/ E_{jet}$
- As high as possible for E_T^{jet}
- As low as possible for $P_T(D^*)$
- z distribution is unbiased above 0.22

MC fragmentation models

- **PYTHIA: the Lund string model modified to Bowler for heavy quarks (default)**
- **PYTHIA: the Peterson fragmentation function**
- **HERWIG: a cluster model**

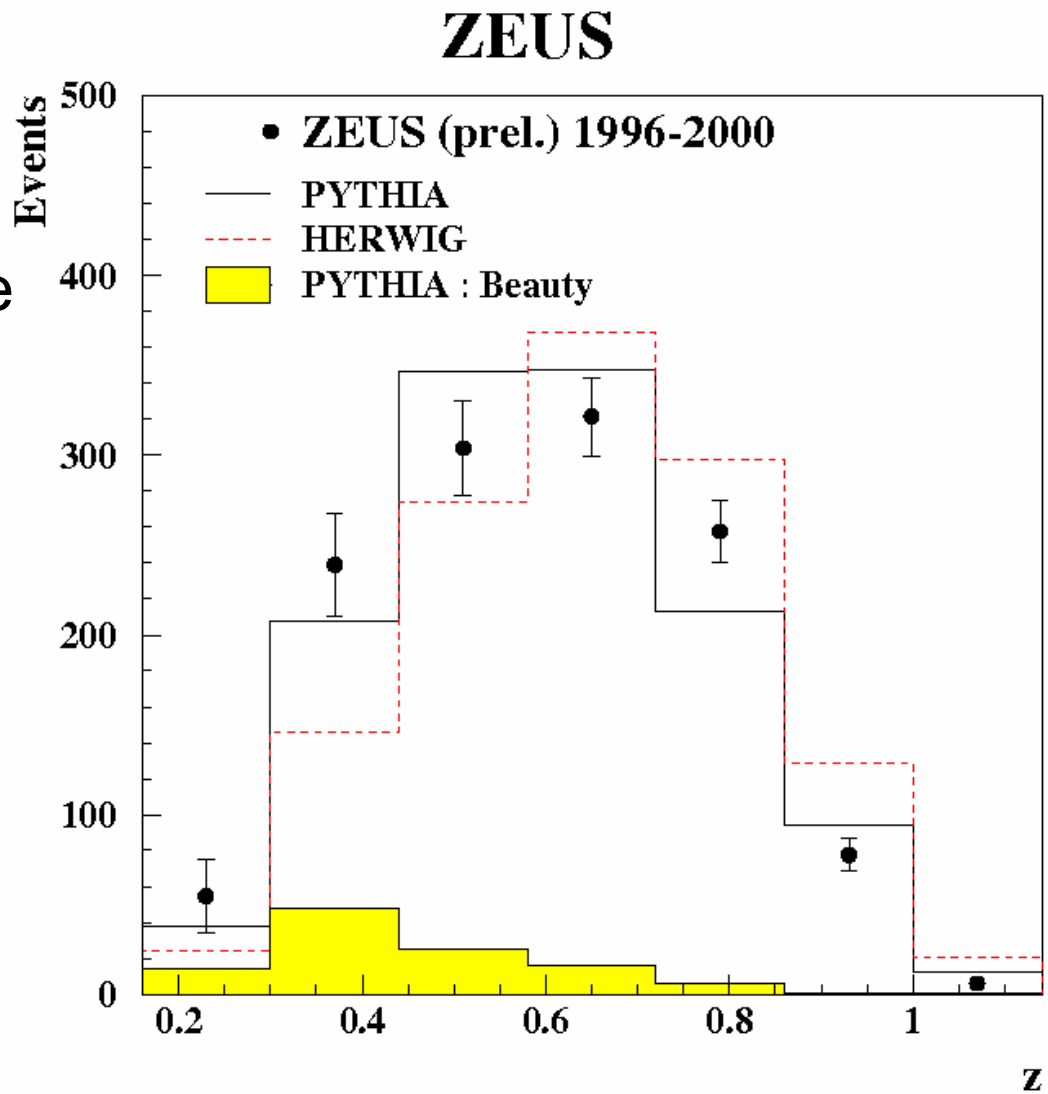
D* Signal

- $N_{D^*} = 1268 \pm 56$



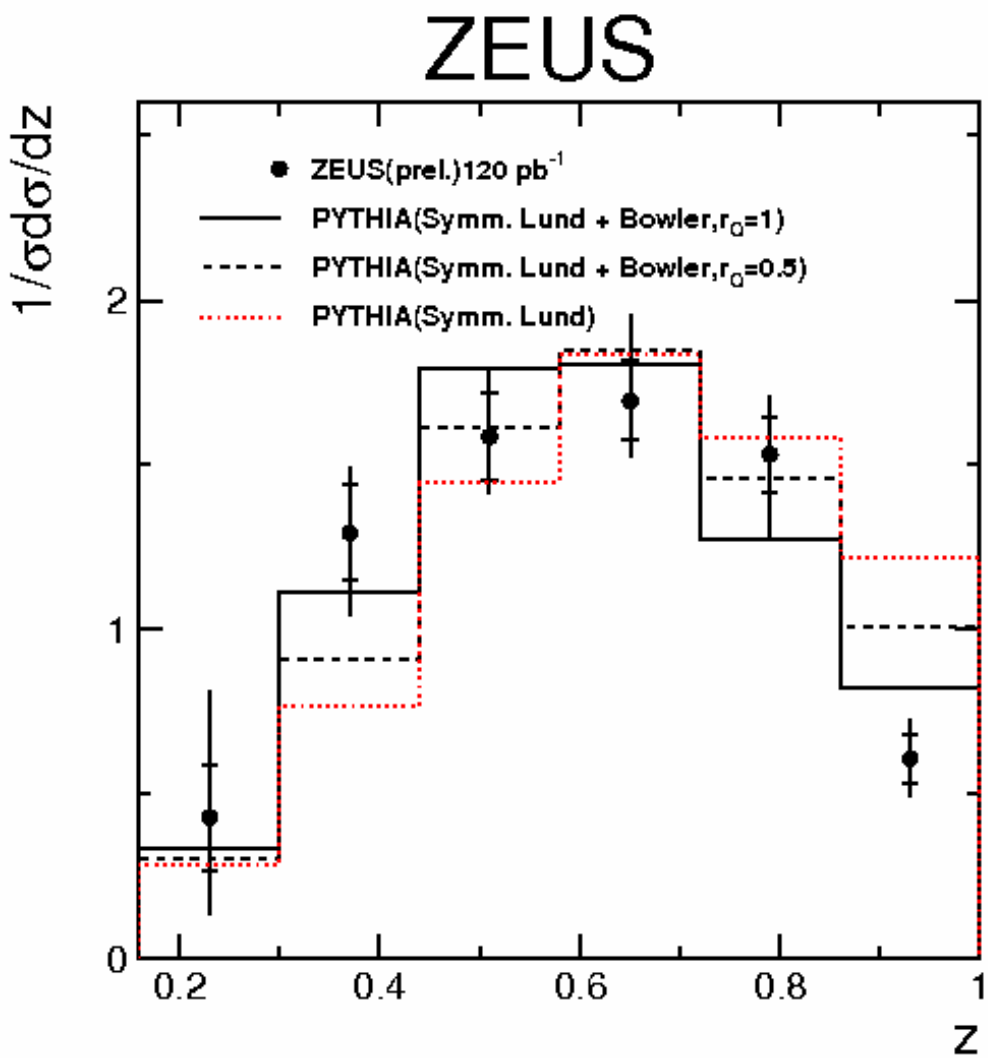
Fragmentation Function

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



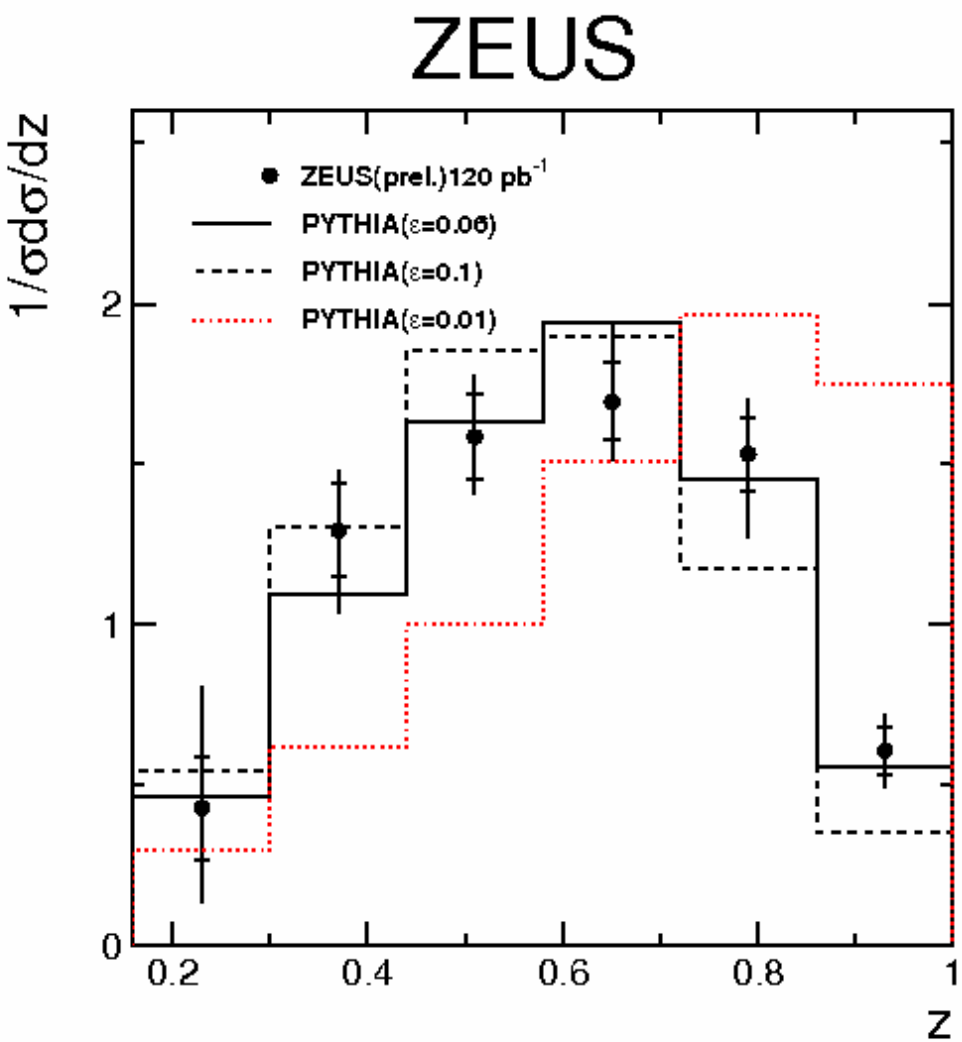
Comparison with PYTHIA simulation

- 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 PYTHIA simulation

- 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



Comparison with NLO QCD

- NLO QCD prediction is a fixed-order calculation from FMNR
- Renormalization and factorization scale:

$$m_T = \sqrt{<(p_T^c)^2> + m_c^2}$$

- Parton density function: CTEQ5M1
- Photon parton density function: AFG-HO
- To compare with data, NLO QCD calculation at parton level were corrected for effects of hadronization
- Hadronization correction factor:

$$C_{had} = d\sigma_{MC}^{hardrons} / d\sigma_{MC}^{partons}$$

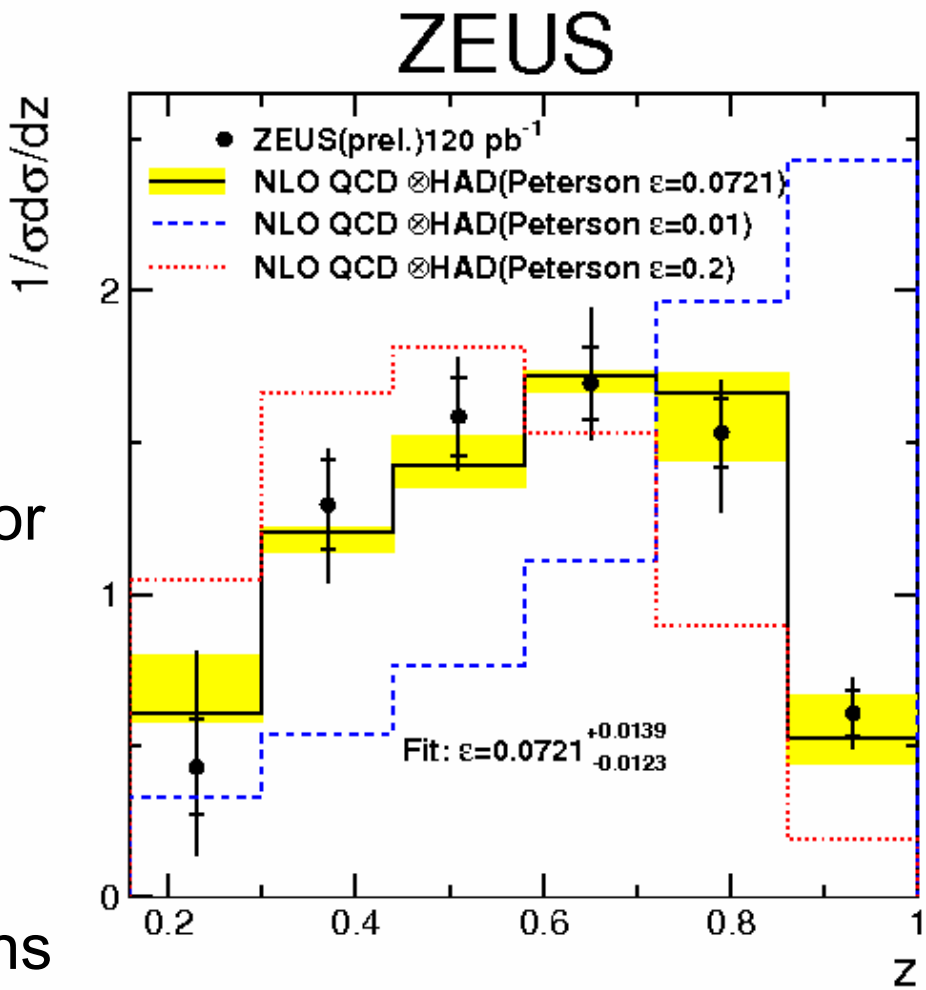
Comparison with NLO QCD

- Parton(NLO calculation) to hadron corrections
- Different hadronisation models used

Bin	(PYTHIA+HERWIG)/2
0.16-0.30	1.70±0.15
0.30-0.44	1.42±0.28
0.44-0.58	1.18±0.18
0.58-0.72	1.05±0.09
0.72-0.86	0.97±0.04
0.86-1	1.20±0.01

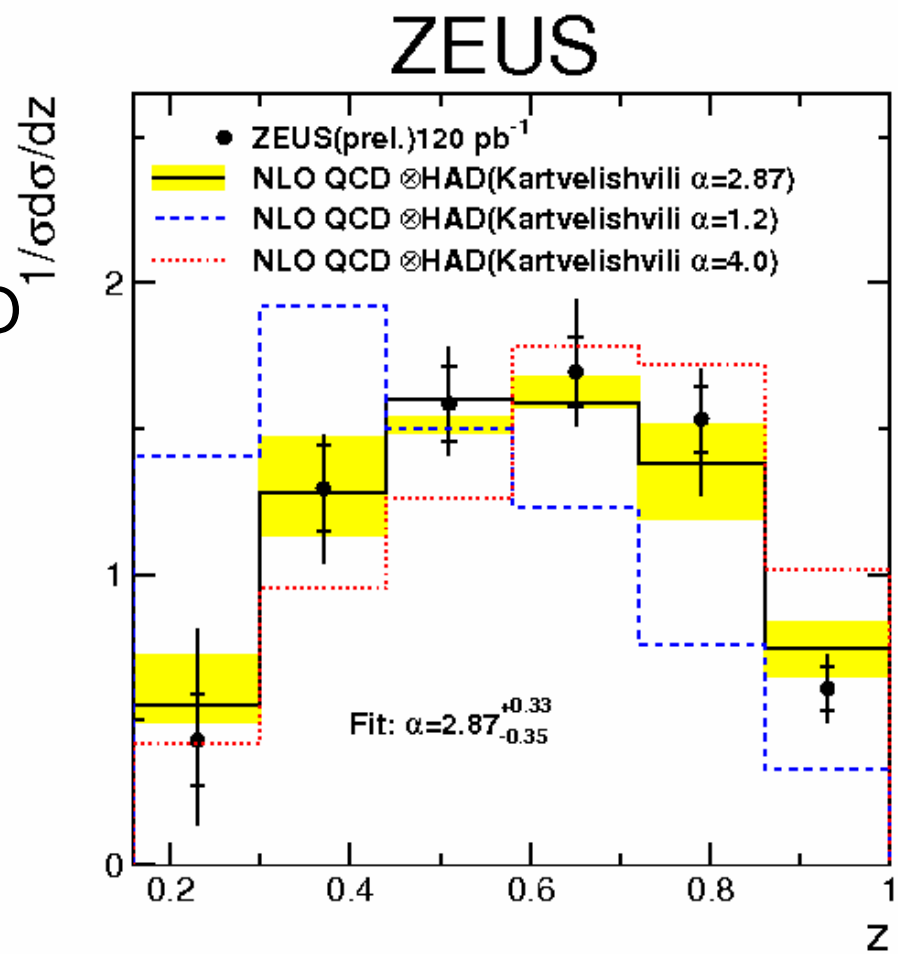
Comparison with NLO QCD

- 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
- Be used in future predictions

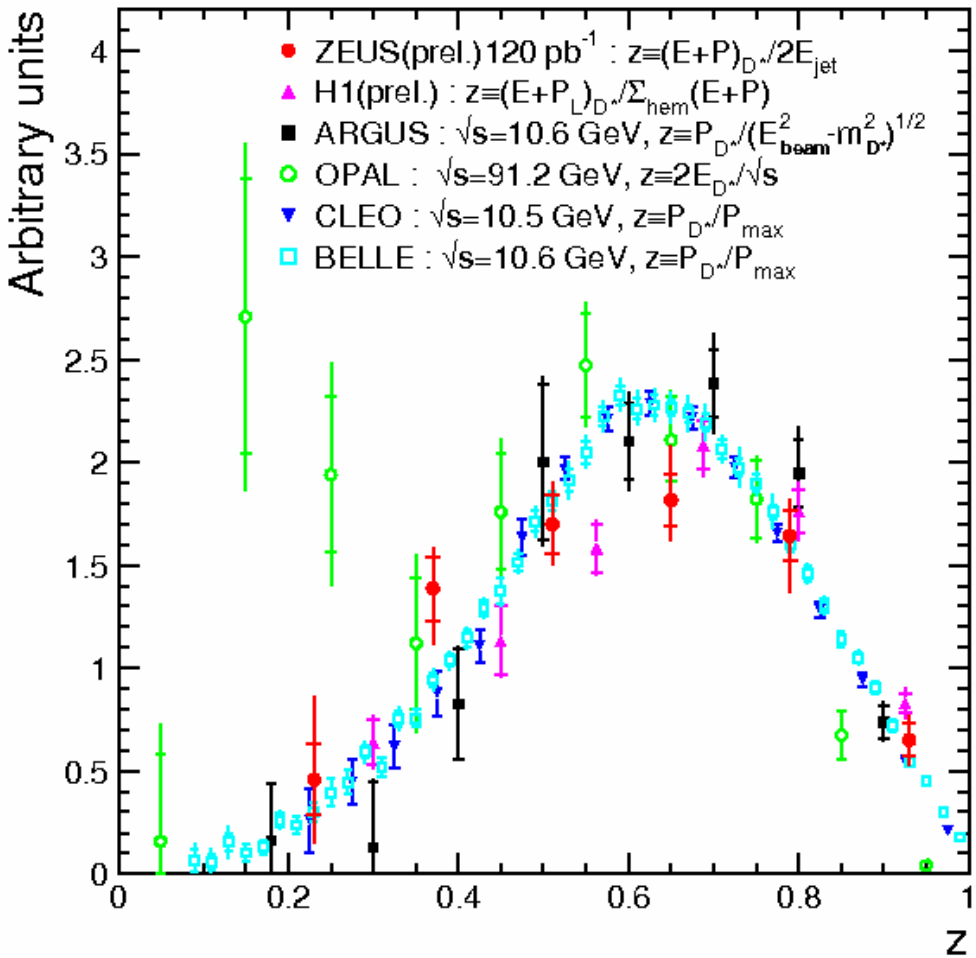


Comparison with NLO QCD

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



Comparison with other experiments



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

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

Beijing Olympics Opening Ceremony

- Starts at 14:00, Germany time
- TV: EuroSport, ARD
- One World, one Dream!

Dirk Werner Nowitzki

China National Stadium

National Aquatics Center

Thank you !