International Europhysics Conference on High Energy Physics
Lisboa, Portugal, July 21st – 27th, 2005

Charmed pentaquark searches at HERA

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Representing
the H1 and ZEUS
collaborations

O U T L I N E:

Introduction

Searches for the charmed pentaquark in D^*p decay mode

Details of the H1 signal

Summary

Charm pentaquark Θ_c^0

Search for the charm pentaquark was inspired by the observation of the strange pentaquark with the quark content ($uudd\bar{s}$). The existence of a strange pentaquark implies that a heavy pentaquarks, with the quark content ($uudd\bar{c}$) , could also exist.

Several Theoretical Predictions for pentaquark with the charm quark:

Jaffe,Wilzek [hep-ph/0307341]; Wu,Ma [hep-ph/0402244] :

$M(\Theta_c^0) \approx 2700$ ($< (M(p) + M(D^-))$) - cannot decay to D-mesons

hence weak decay to $\Theta^+\pi^-$

Karliner, Lipkin [hep-ph/0307343)]:

$M(\Theta_c^0) = 2985 \pm 50$ MeV and width ~ 21 MeV

Cheung [hep-ph/0308176] :

$M(\Theta_c^0) = 2938 - 2997$ MeV and the dominant decay modes D^-p^+ and D^0n

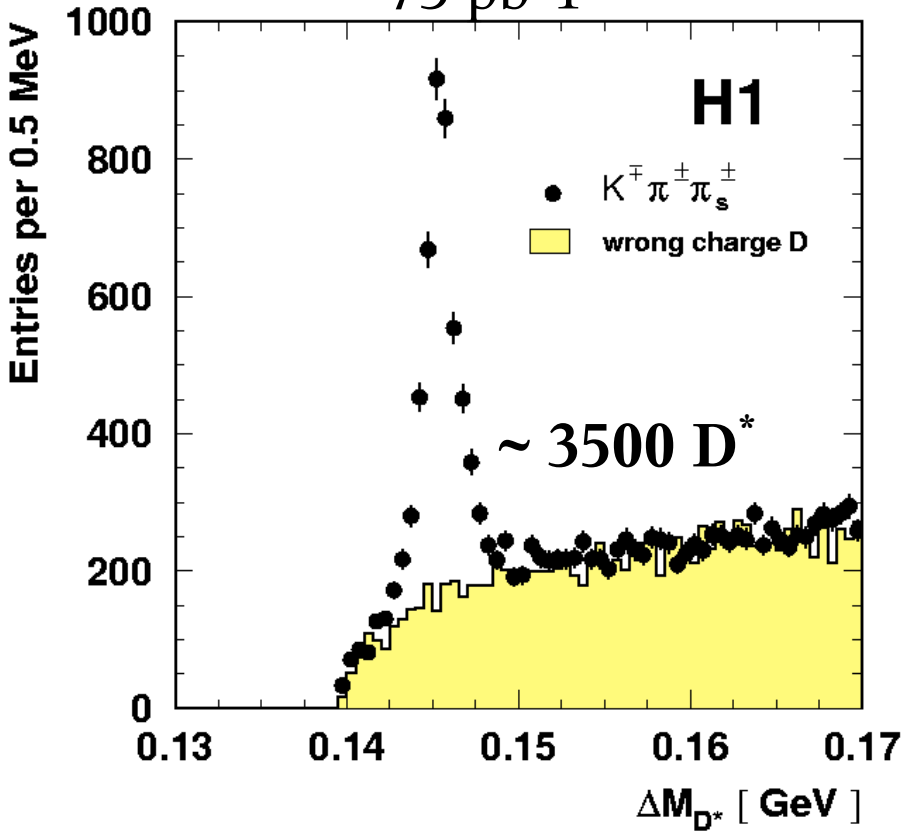
If mass of the charm pentaquark > $M(D^{*\pm}) + M(p)$ (=2948 MeV)

Θ_c^0 can decay to $D^{*\pm}p$

H1 and ZEUS D* in DIS for golden decay channel.

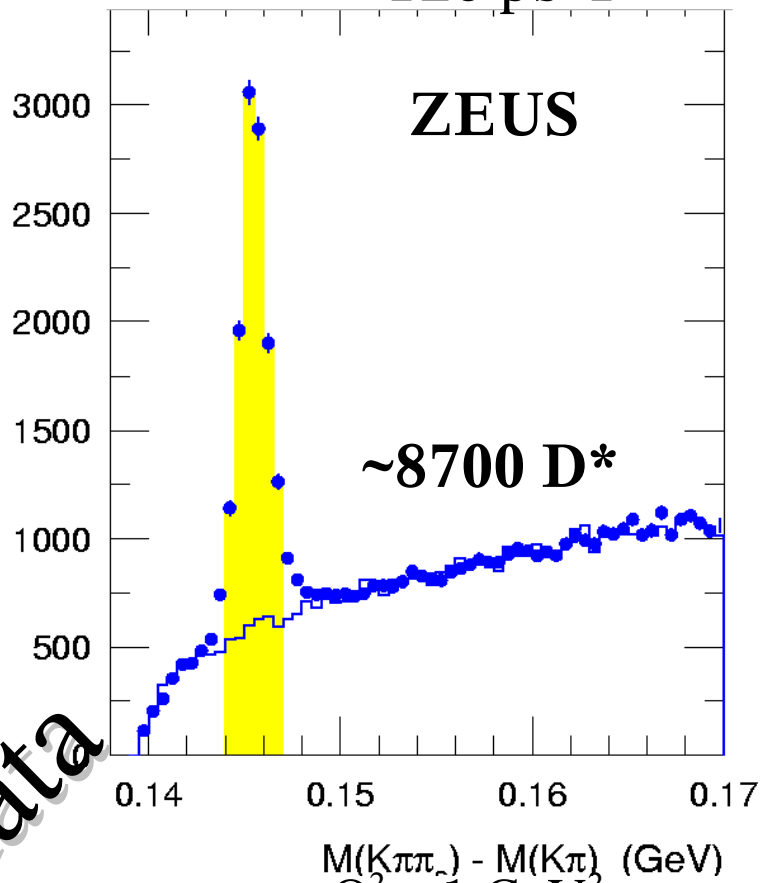
$$D^{*+} \rightarrow D^0 \pi_s^+ \rightarrow (K^- \pi^+) \pi_s^+$$

75 pb-1



$1 < Q^2 < 100$ GeV^2
$0.05 < y < 0.7$
$P_T(D^*) > 1.5$ GeV
$-1.5 < \eta(D^*) < 1$
$z(D^*) > 0.2$

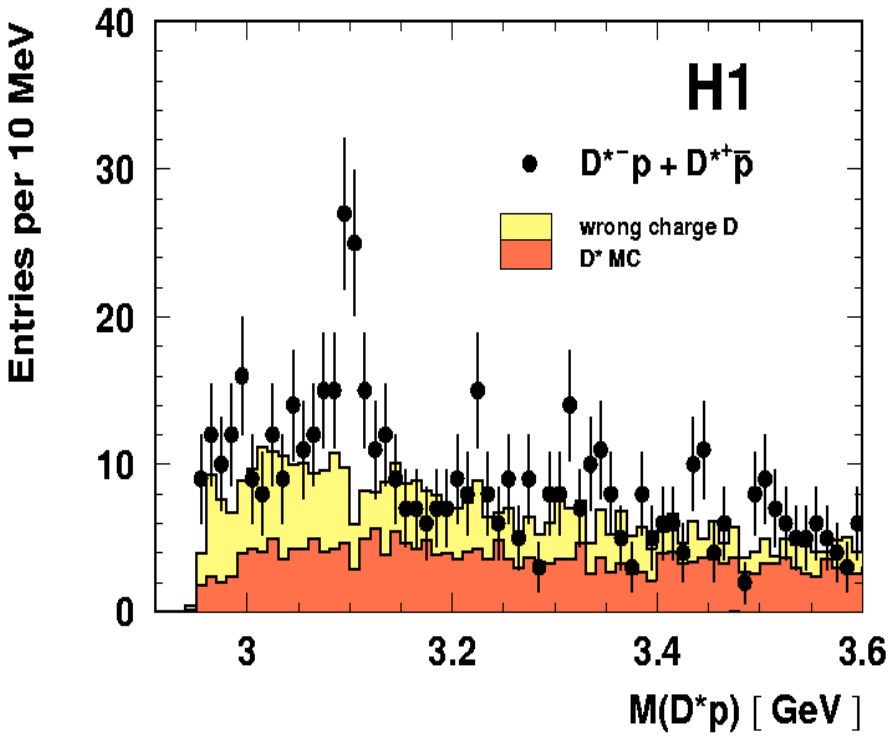
126 pb-1

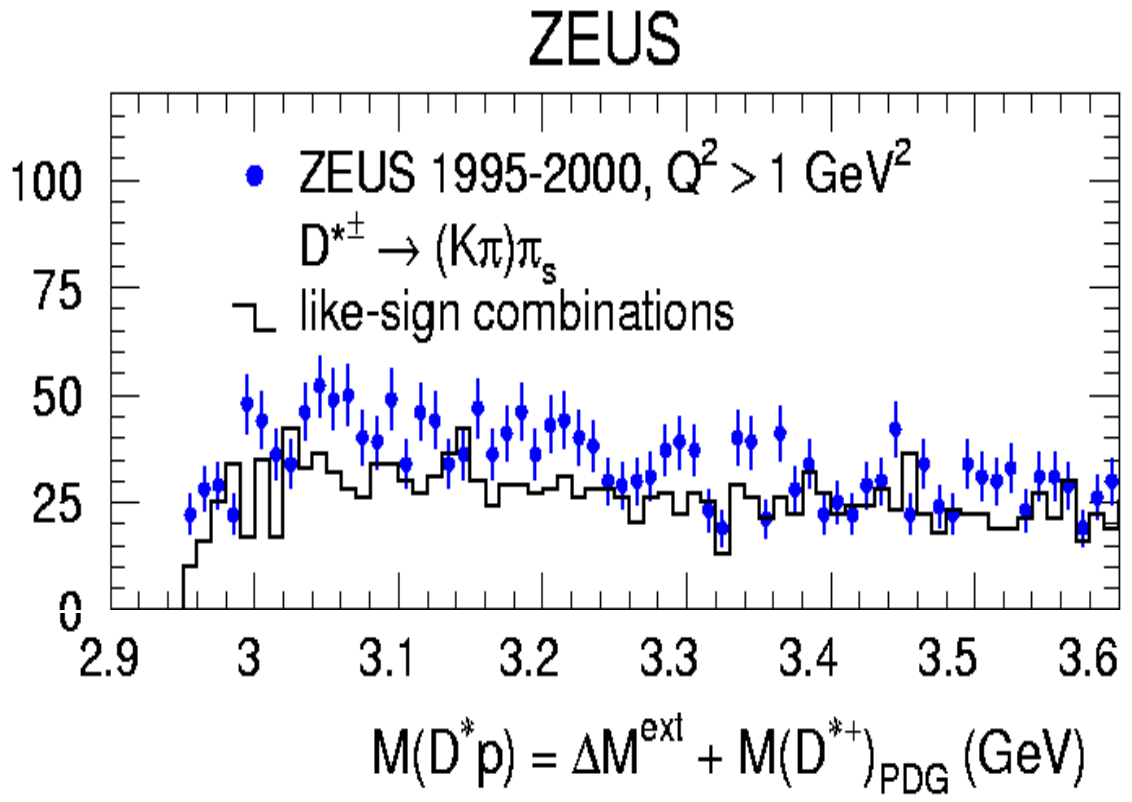


$Q^2 > 1$ GeV^2
$y < 0.95$
$P_T(D^*) > 1.35$ GeV
$-1.6 < \eta(D^*) < 1.6$
$P_T(D^*)/E_T^{\Theta>10} > 0.2$

HERA I data

M(D*p) spectra in DIS





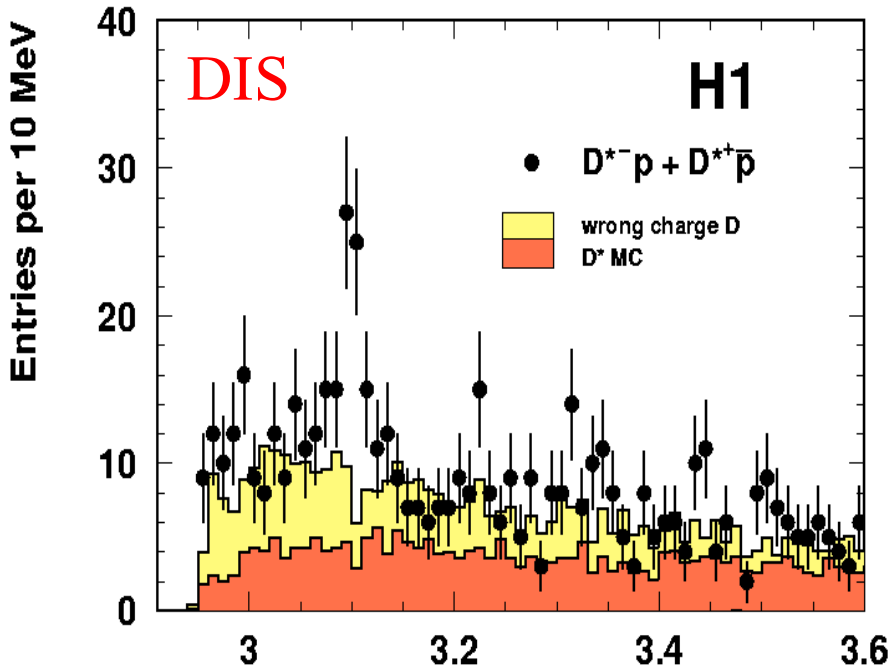
<u>H1 observed narrow resonance at a mass 3099 ± 3(stat) ± 5(syst) MeV</u>

Width is 12 ± 3(stat) MeV (consistent with the exp. resolution 7 ± 2MeV)

The signal consists of 50.6 ± 11.2 events

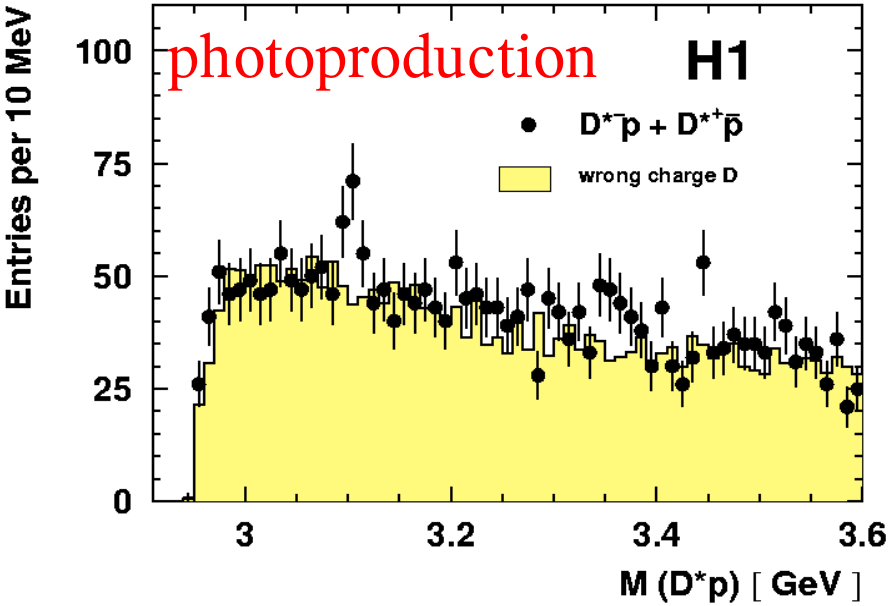
Background fluctuation probability : 4×10^{-8} (Poisson) (5.4 σ Gauss)

<u>ZEUS : no evidence for a signal at 3100 MeV</u>

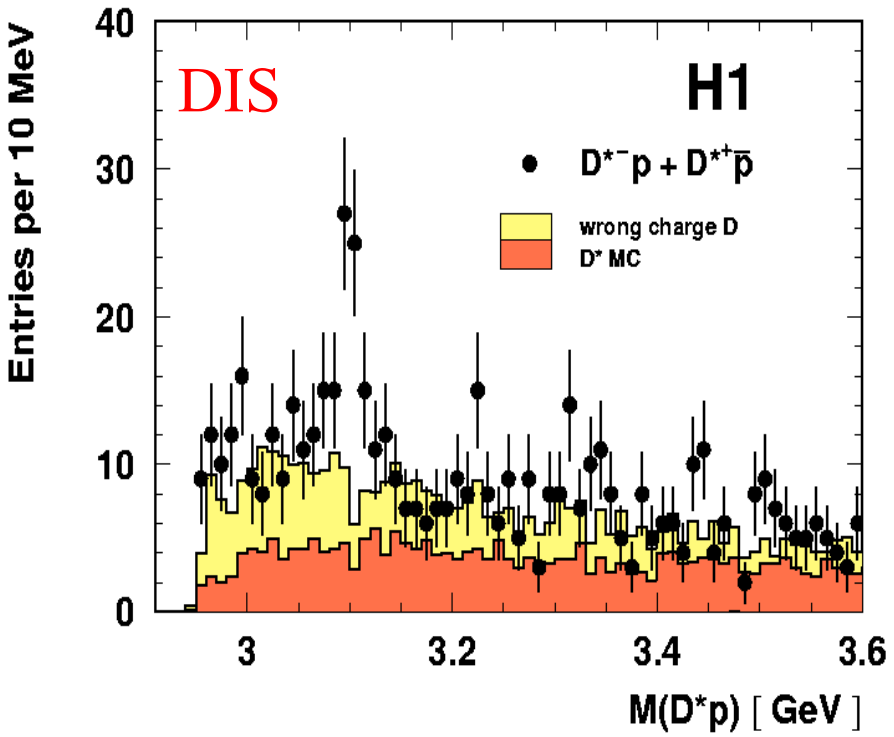


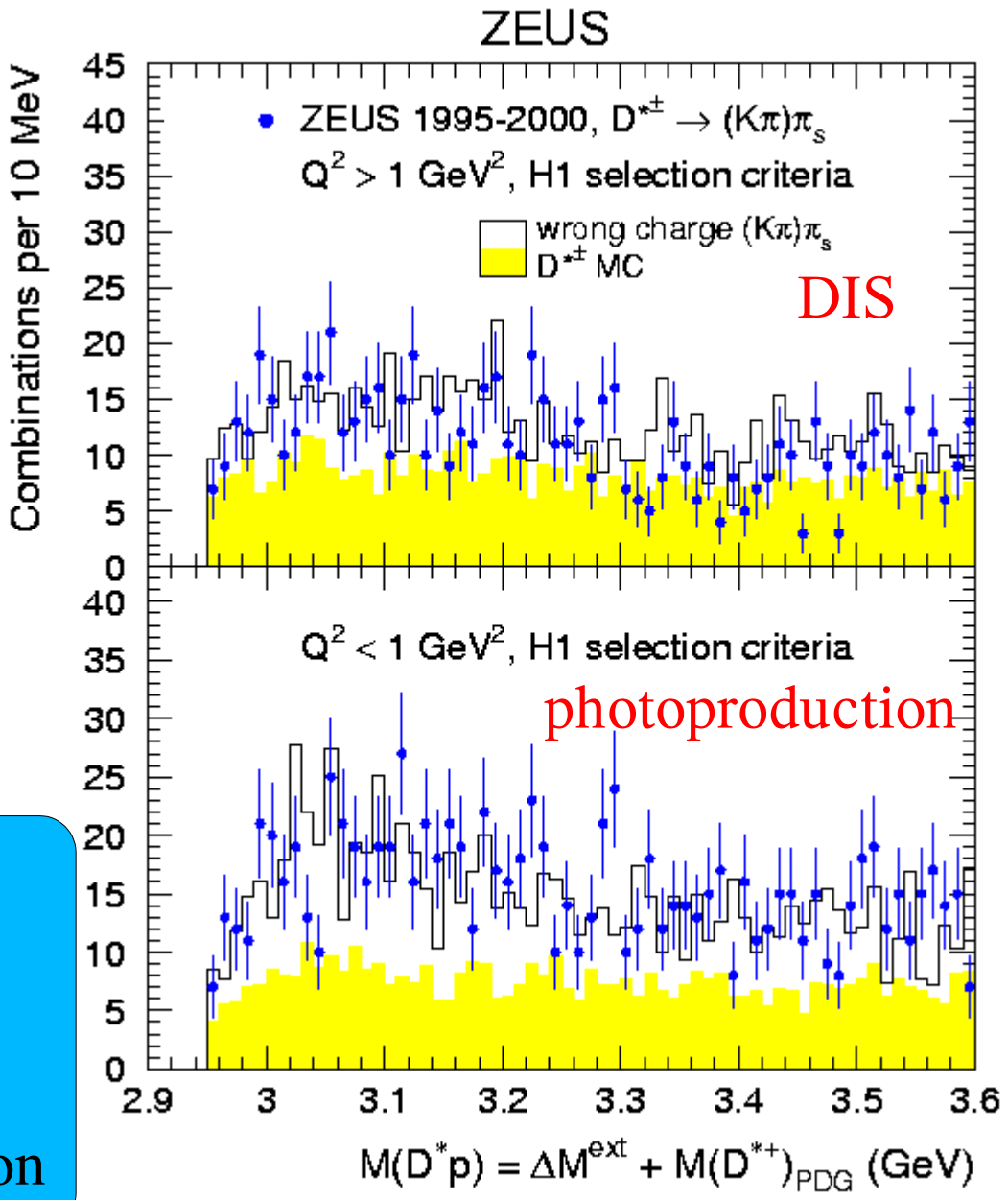
All events from the D*p distribution were visually scanned and no anomalies are observed in the events or the candidate tracks (no multiple hypothesis)

Different kinematic and reflection hypothesis were tested :
D*p(3100) resonance hypothesis survived.



Signal at 3.1 GeV is present also in the photoproduction $Q^2 < 1$ GeV^2 sample. (~4900 D* mesons)

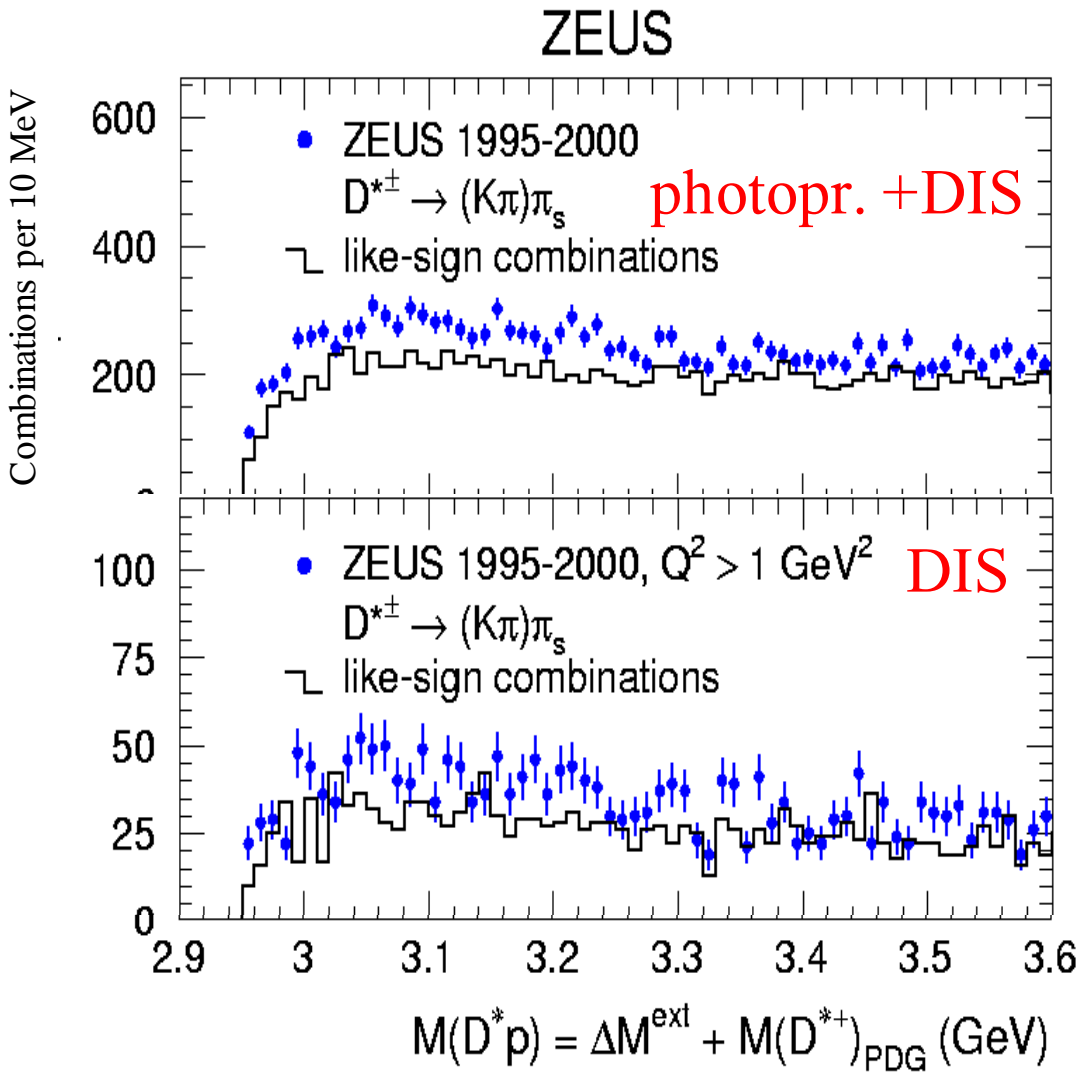


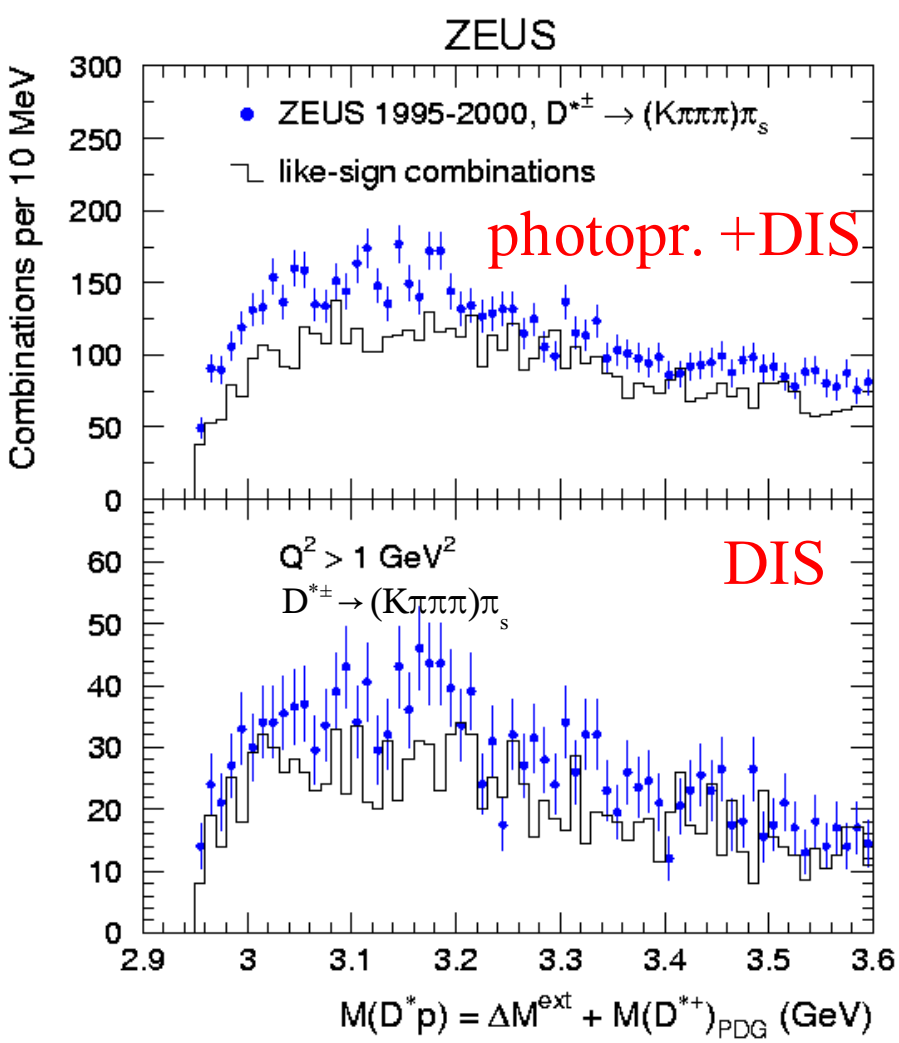


ZEUS

analysis repeated with very similar cuts to H1

No signal in DIS and photoproduction





ZEUS : add D*'s with the decay channel of $D^{*+} \rightarrow D^0\pi_s^+ \rightarrow (K^-\pi^+\pi^+\pi^-)\pi_s^+$

No hint for the signal observed by H1 at 3099 MeV

Acceptance corrected $R_{cor}(D^*p(3100)/D^*)$

H1 : kinematic region $1 < Q^2 < 100\ GeV^2$ & $0.05 < y < 0.7$

in the visible D^*p range : $P_T(D^*p) > 1.5$ GeV, $-1.5 < \eta(D^*p) < 1.0$

and visible D^* range : $P_T(D^*p) > 1.5$ GeV, $-1.5 < \eta(D^*p) < 1.0$, $z(D^*) > 0.2$

$$R_{cor}(D^*p(3100)/D^*) = (1.59 \pm 0.33^{+0.33}_{-0.45})\% \text{ (preliminary)}$$

ZEUS : kinematic region $Q^2 > 1\ GeV^2$ & $y < 0.95$

phase space : $P_T(D^*) > 1.35$ GeV, $-1.6 < \eta(D^*) < 1.6$, $P_T(D^*)/E_T^{\Theta>10} > 0.2$

95% C.L. upper limit:

$R_{cor}(D^*p(3100)/D^*) < 0.59$ % (< 0.51 % for both D^0-decay channels)

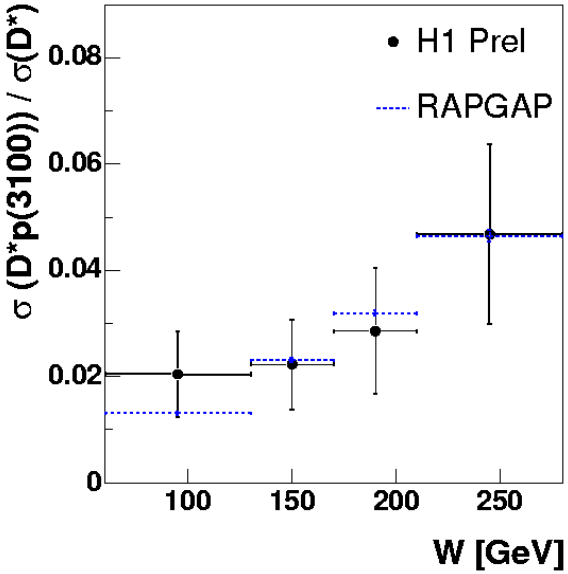
ZEUS: full kinematic region (DIS + photoproduction)

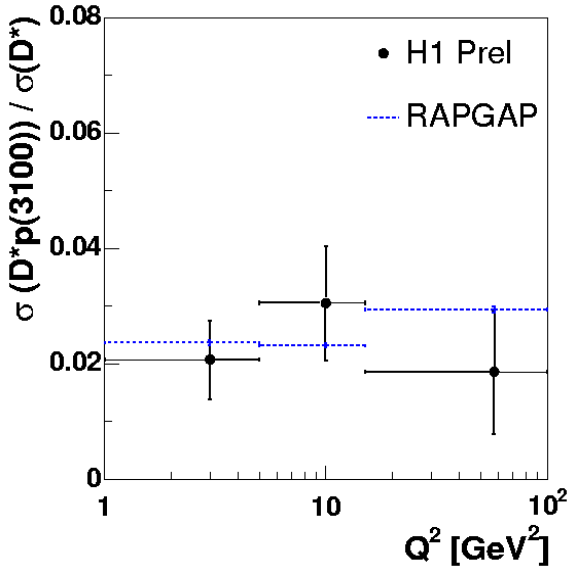
95% C.L. upper limit:

$R_{cor}(D^*p(3100)/D^*) < 0.47$ % (< 0.37 % for both D^0-decay channels)

$\sigma(D^* p(3100))/\sigma(D^*)$ vs. event kinematical variables

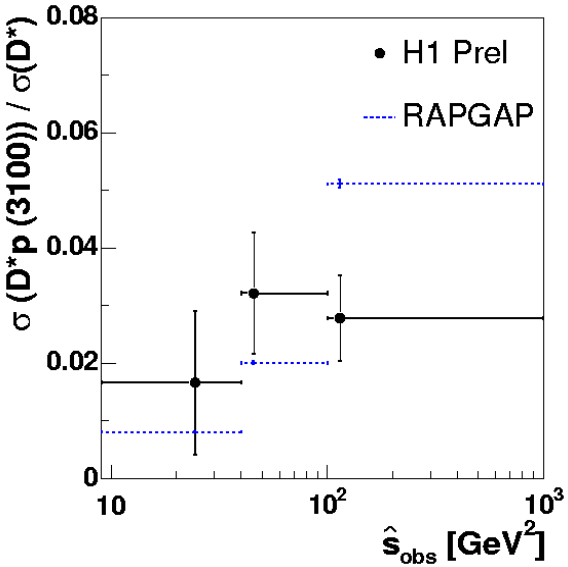
MC used for the acceptance correction and comparison:
RAPGAP 3.1 MC,
mimic $D^* p(3100)$
by the appropriate modification
of mass and decay
of $D_1(2420)$ and $D_2(2460)$
(isotropic decay)





W and Q^2 distributions well described by MC

The model prediction
is normalised
to the observed
$\sigma(D^* p(3100))/\sigma(D^*)$ ratio
$2.48 \pm 0.52^{+0.85}_{-0.64}$ %



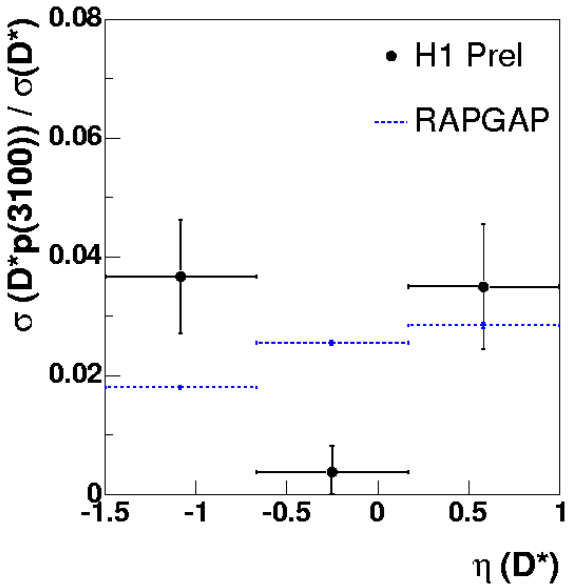
$\hat{s}_{obs} - invariant\ mass\ of\ (c\,\bar{c})\ system$

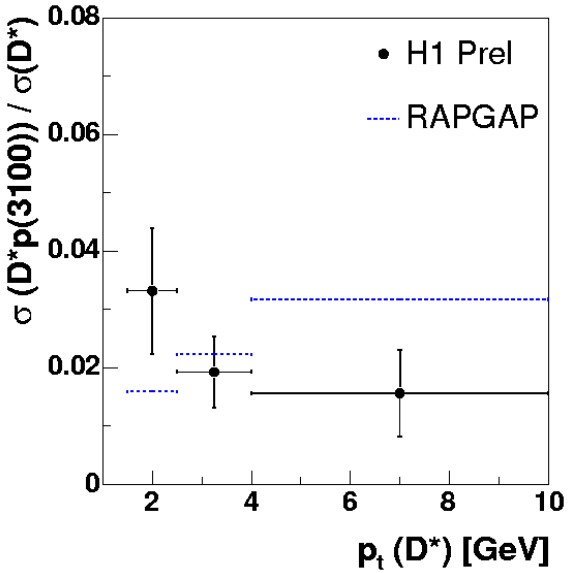
Different behavior of $\hat{s}_{obs}$ for data and MC

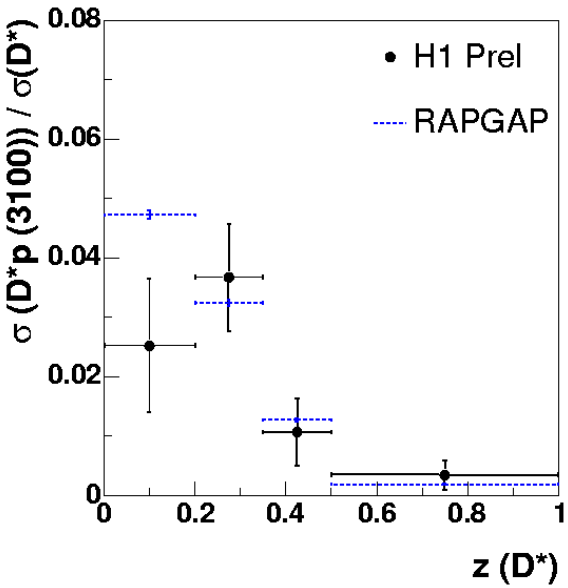
Statistical errors only on the plots

$\sigma(D^*p(3100))/\sigma(D^*)$ as a function of D^* variables

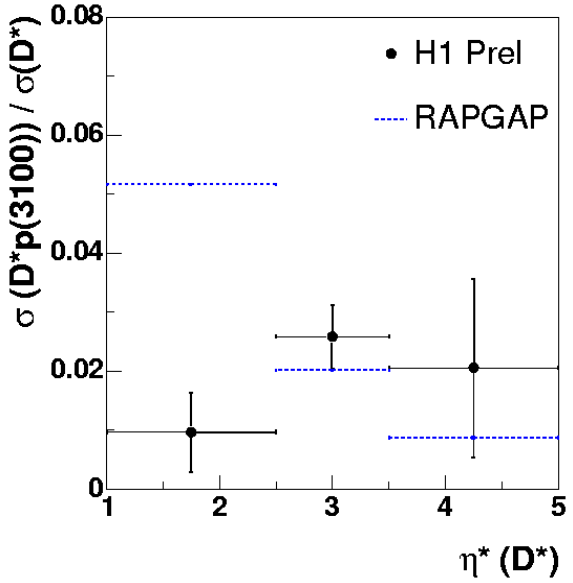
Lab. frame







γp frame



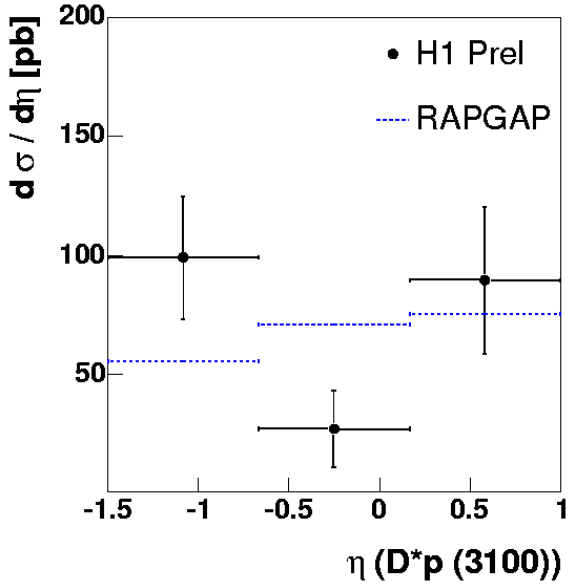
Production of D^*p is suppressed for central η both in the lab and γp frames

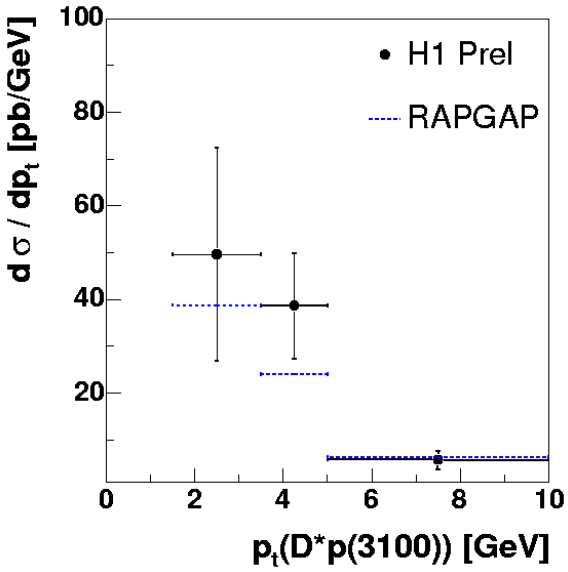
D^* from the decay of D^*p are significantly softer in $P_T(D^*)$ and $z(D^*)$ compared to the inclusive D^*

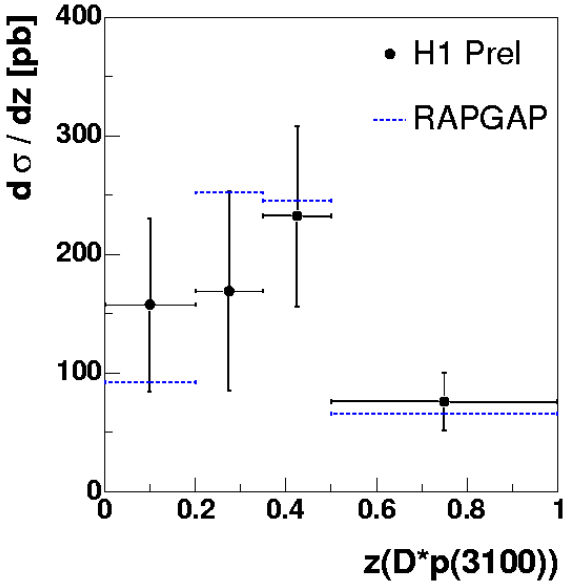
Statistical errors only on the plots

σ(D*p(3100)) as a function of (D*p) variables

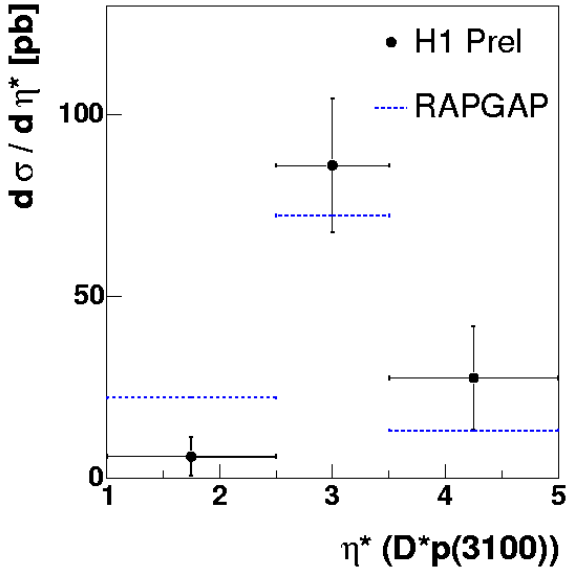
Lab. frame







γp frame

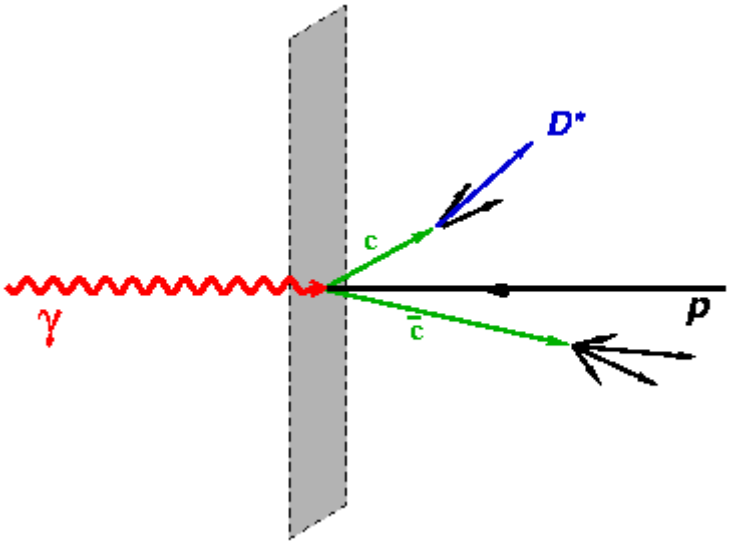


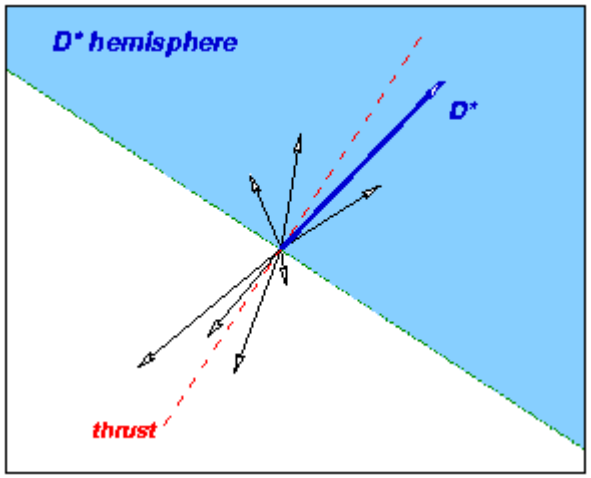
Features of D*p production:

- Suppressed for central η in the lab and γp frames
- MC describes well P_T and z distributions

Statistical errors only on the plots

Fragmentation functions of $D^*p(3100)$ and D^*



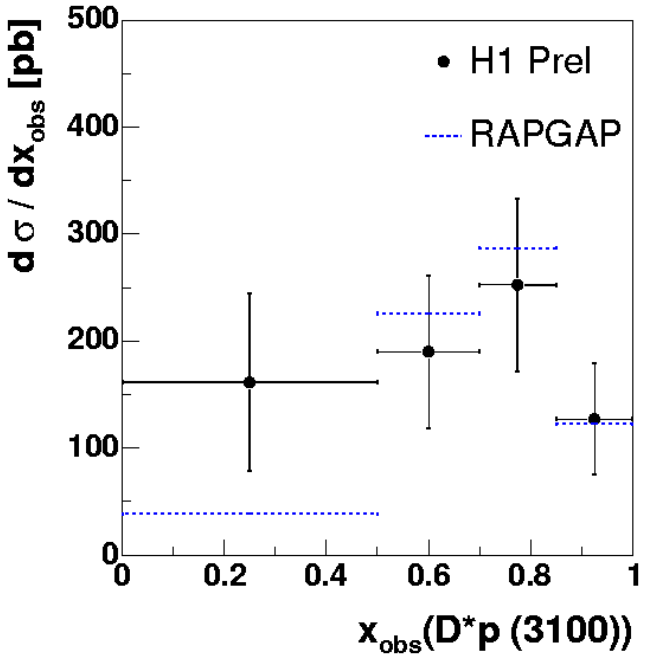


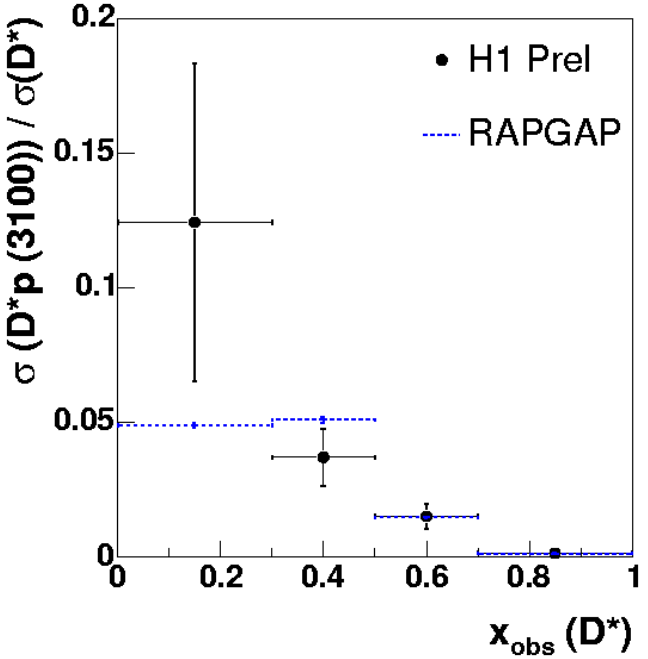
Particles in the $D^*(D^*p)$ hemisphere are used to estimate $(E\text{-}p_z)$ of the charm quark.

$$x_{obs}(D^*p, D^*) = \frac{(E-p_z)_{lab}(D^*p, D^*)}{\Sigma_{hemisphere}(E-p_z)_{lab}}$$

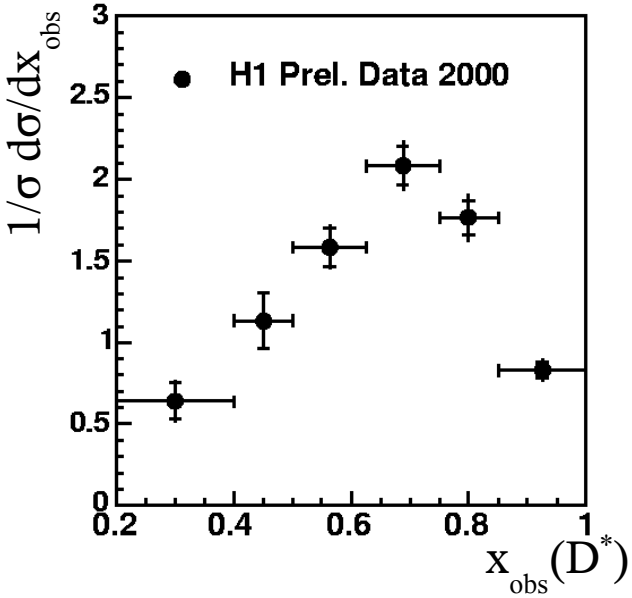
x_{obs} can be compared to the fragmentation variable in e^+e^-

Fragmentation functions of $D^*p(3100)$ and D^*





For comparison, x_{obs} distributions for the inclusive D* :



See Jurai Bracinik talk (Hard QCD session)

$D^*p(3100)$ fragmentation is hard and similar to the fragmentation of charm hadrons

D^* from $D^*p(3100)$ gets very little energy from c-quark

Statistical errors only on the plots

Summary

- H1 and ZEUS performed a search for a D^*p resonance.
  - H1 observed a narrow resonance at 3099 MeV

$$R_{cor}(D^*p(3100)/D^*) = 1.59 \pm 0.33^{+0.33}_{-0.45}\ \%\ \text{(H1 preliminary)}$$

  - ZEUS does not see this signal

$$R_{cor}(D^*p(3100)/D^*) < 0.59\% \qquad 95\ \text{C.L. (ZEUS)}$$

- H1 presented studies of the phase space for the observed signal:
  - Suppression of $D^*p(3100)$ at central rapidity in lab. / γp frames is found
  - $D^*p(3100)$ fragmentation is hard and similar to the charmed hadrons from c-quark fragmentation
  - D^* from the $D^*p(3100)$ decay are significantly softer than inclusive D^*

Higher statistics HERA II data will help to resolve current discrepancy between the H1 and ZEUS results.