

# Investigation of the $D^*p$ Resonance in the 3 GeV Region with HERA II Data at H1

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for the H1 Collaboration



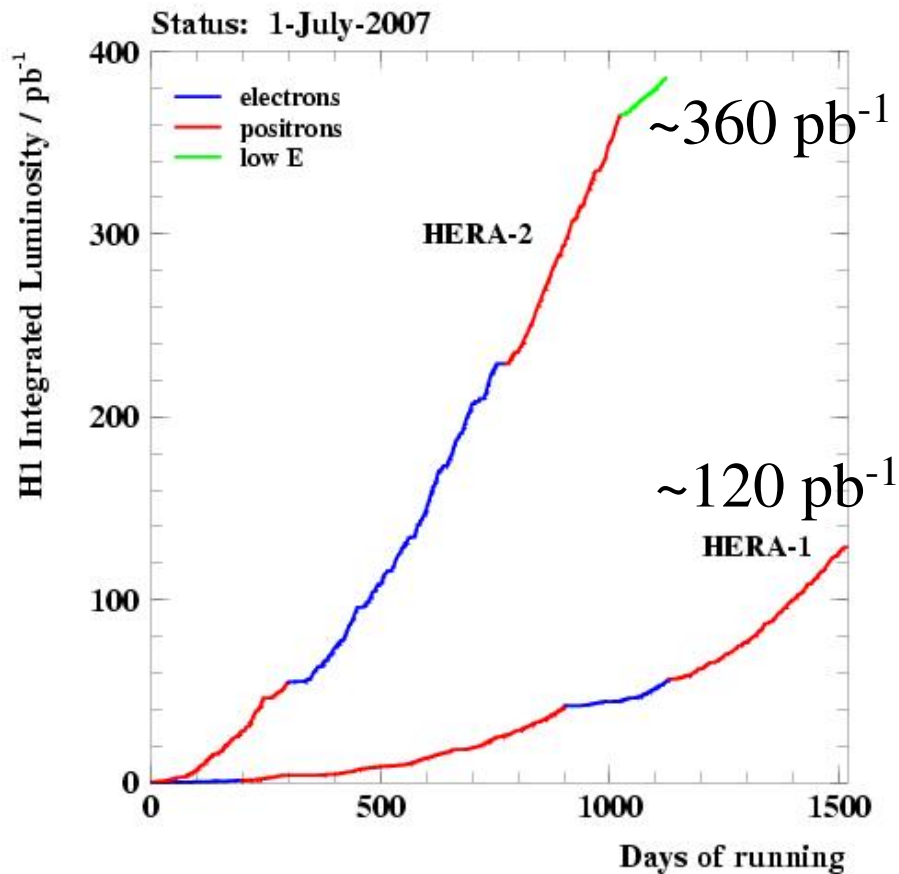
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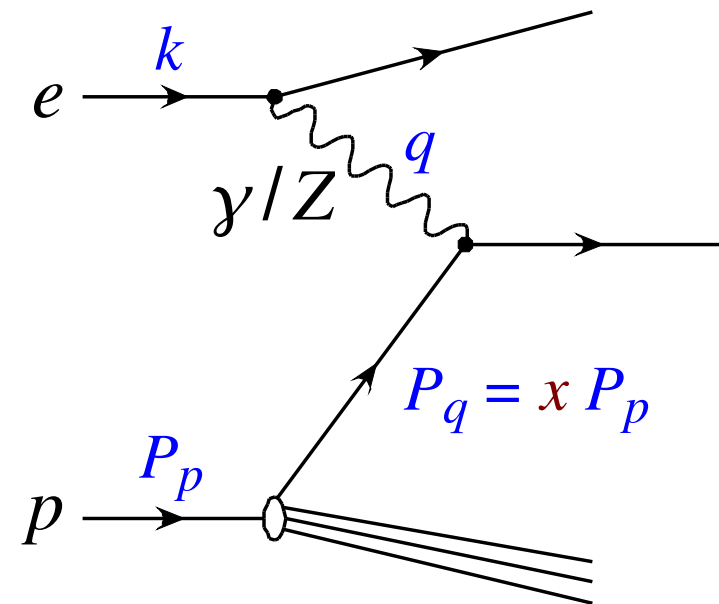
- Motivation
- Selection
- $D^*p$  Mass Distribution



# Electron-Proton-Collisions at HERA



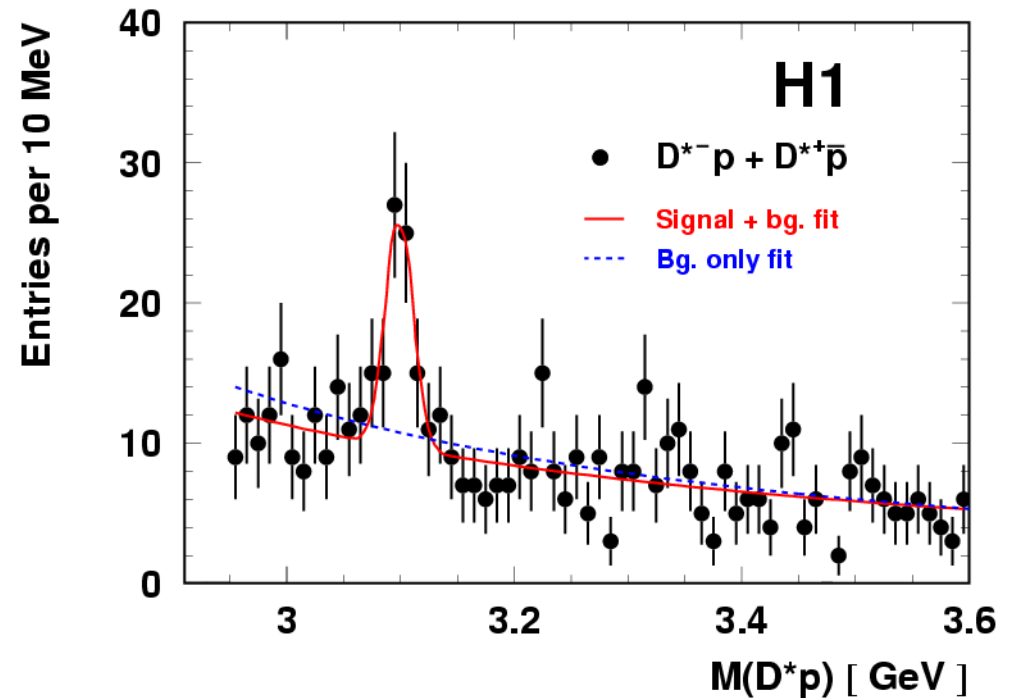
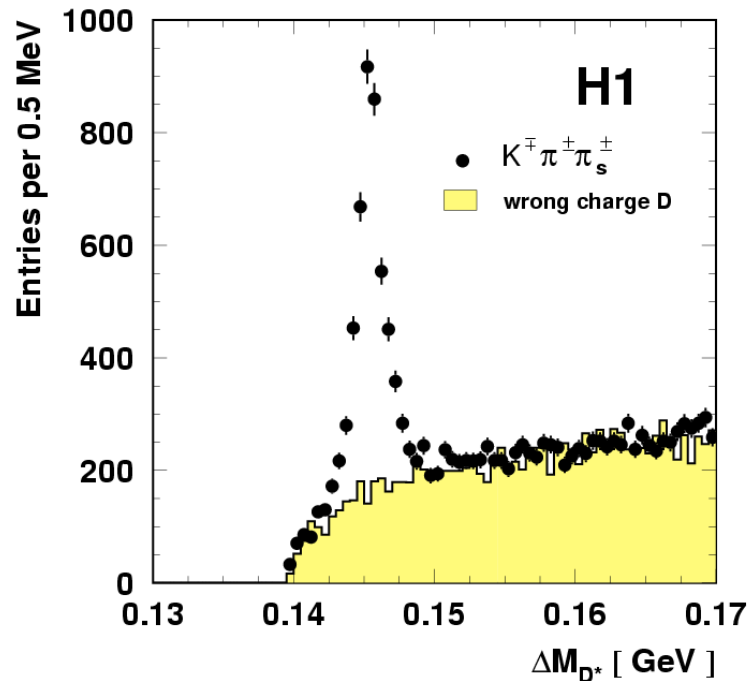
kinematics:



$$Q^2 = -q^2$$

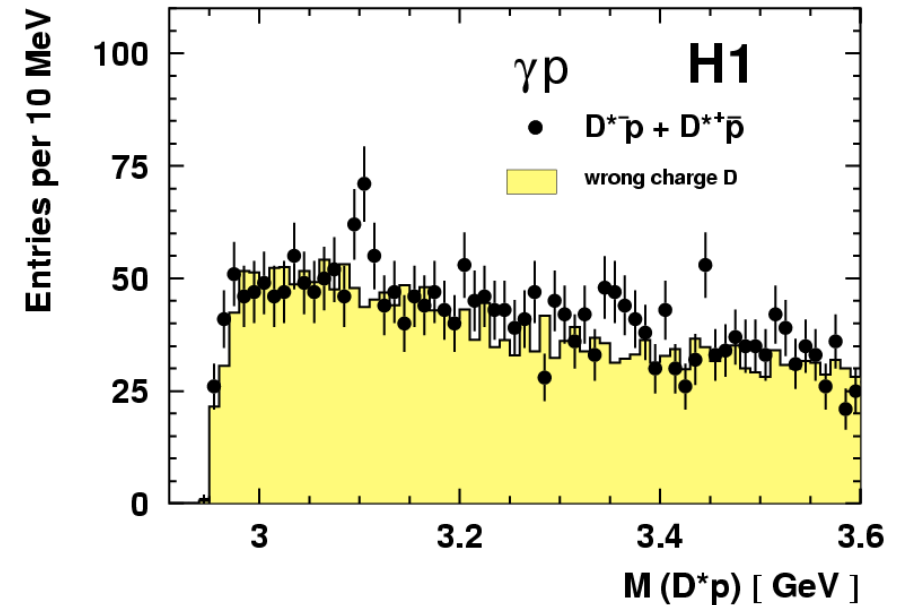
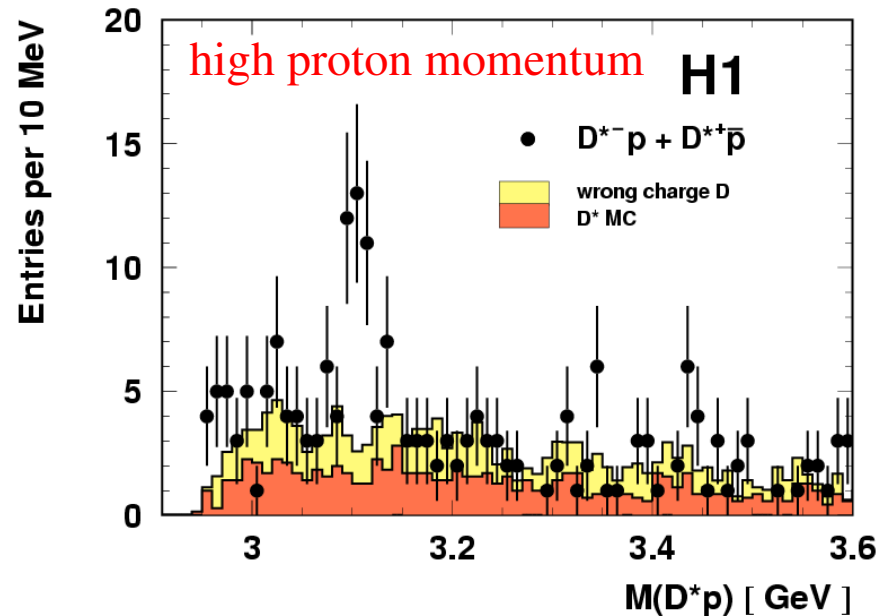
$$y = \frac{q \cdot P_p}{k \cdot P_p}$$

# Motivation



- analysis of HERA I data ( $75 \text{ pb}^{-1}$ ): peak in  $D^*p$  spectrum at 3.1 GeV
- based on reconstructed  $\sim 4000$   $D^*$  mesons
- minimum quark content:  $uudd\bar{c}$

# Motivation



- standard selection: DIS, protons identified by  $dE/dx$
- cross checks with different selections:
  - DIS, high proton momentum (no  $dE/dx$  cuts)
  - photoproduction ( $Q^2 \approx 0$ )

# Motivation

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- excess in  $D^*p$  mass not confirmed by other experiments
  - ZEUS:  $\sim 63\,000$   $D^*$  ( $\sim 13\,500$  in DIS)
  - BaBar:  $> 750\,000$   $D^*$  in B decays
  - CDF:  $540\,000$   $D^*$  in  $p\bar{p}$  collisions
  - ALEPH:  $\sim 5\,000$   $D^*$  in Z decays
  - FOCUS:  $\sim 35\,000$   $D^*$  in  $\gamma$  collisions with fixed target
- possible differences: kinematics / cuts / prod. mechanism / ...?
- HERA II data offer the chance to study an independent data sample with the same detector
- look at HERA II data with (nearly) same cuts

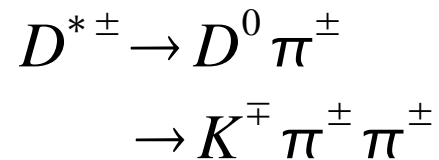
# Selection

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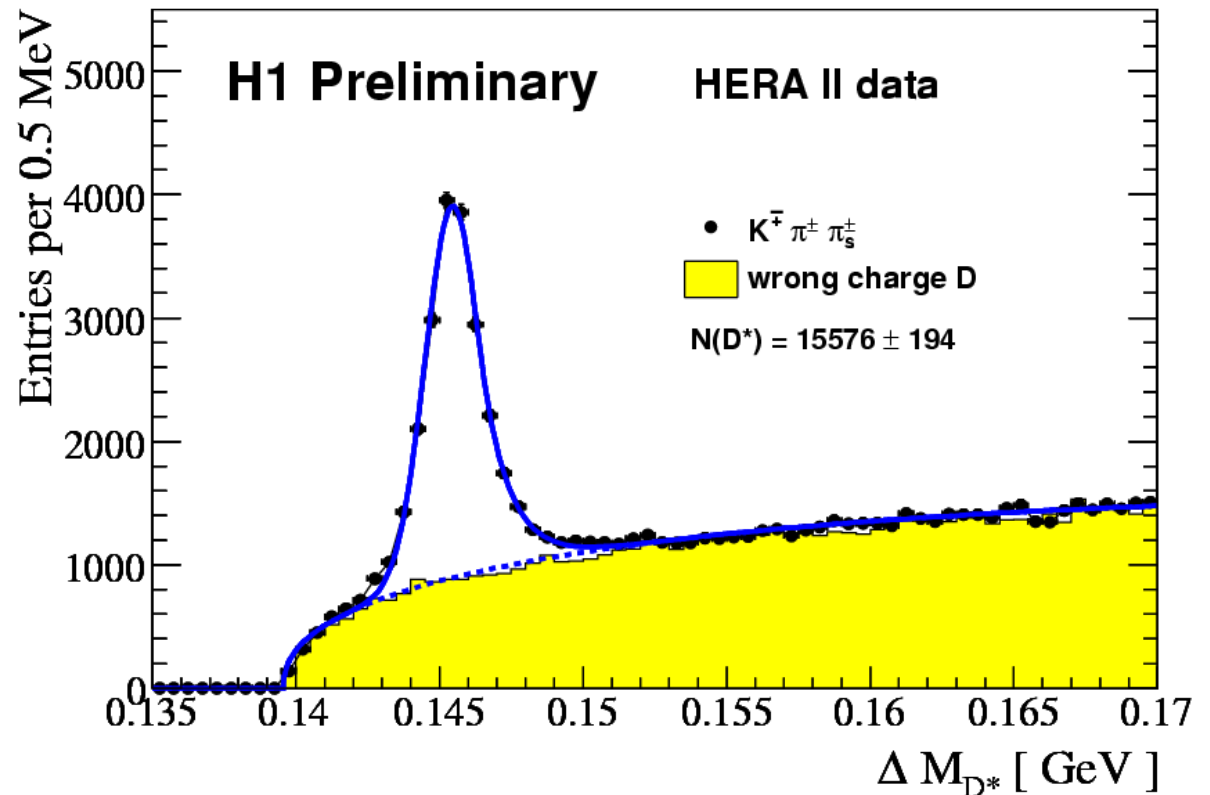
- full HERA II data, 348 pb<sup>-1</sup>
- HERA II analysis:
  - $0.05 < y_e < 0.7$
  - $2 < Q^2 < 100 \text{ GeV}^2$
  - $E'_e > 10 \text{ GeV}$
  - $\theta_e < 3.09$
  - radius cut:  $r > 12 \text{ cm}$   
(center shifted)
- HERA I publication:
  - $0.05 < y_e < 0.7$
  - $1 < Q^2 < 100 \text{ GeV}^2$
  - $E'_e > 8 \text{ GeV}$
  - (no cut)
  - radius cut:  $r > 8.7 \text{ cm}$
- $-1.5 < \eta(D^*) < 1.0$ ,  $p_t(D^*) > 1.5 \text{ GeV}$ ,  $z(D^*) > 0.2$ ,  
 $p_t(K) > 0.5 \text{ GeV}$ ,  $p_t(\pi) > 0.25 \text{ GeV}$ ,  $p_t(\pi_s)$ ,  $p_t(p) > 0.12 \text{ GeV}$
- use „high proton momentum“ ( $p(p) > 2 \text{ GeV}$ ) selection,  
no dE/dx cuts

# D\* Signal

- D\* selection in „golden channel“



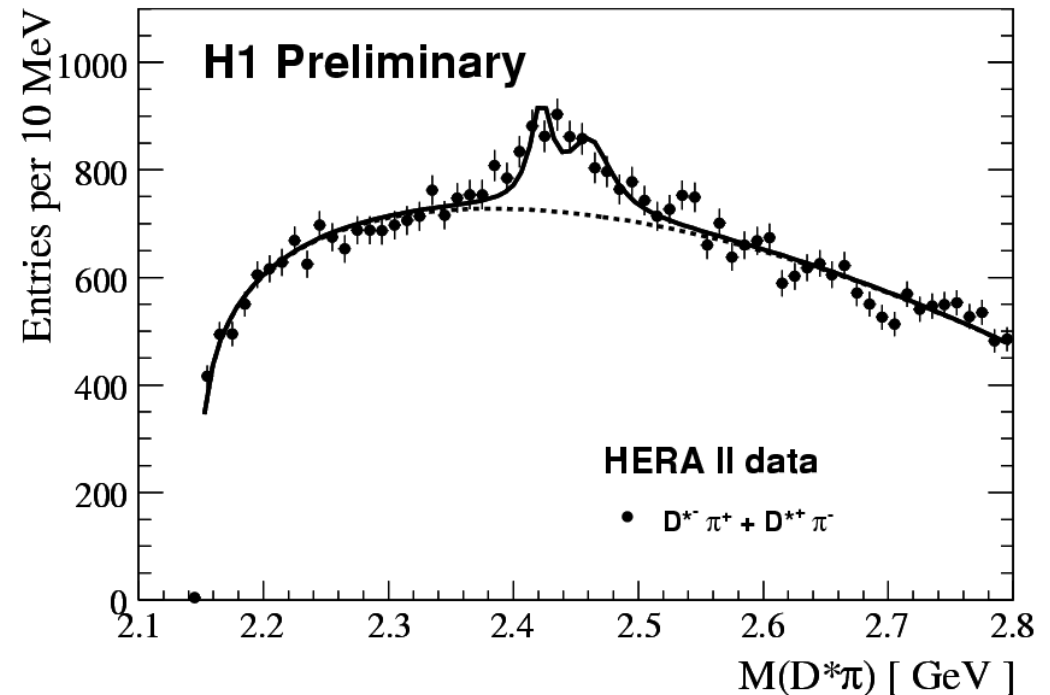
- $15576 \pm 194$  D\*s in HERA II data



- less than increase in luminosity compared to HERA I data due to different phase space

# Cross Check: Higher Mass D Mesons

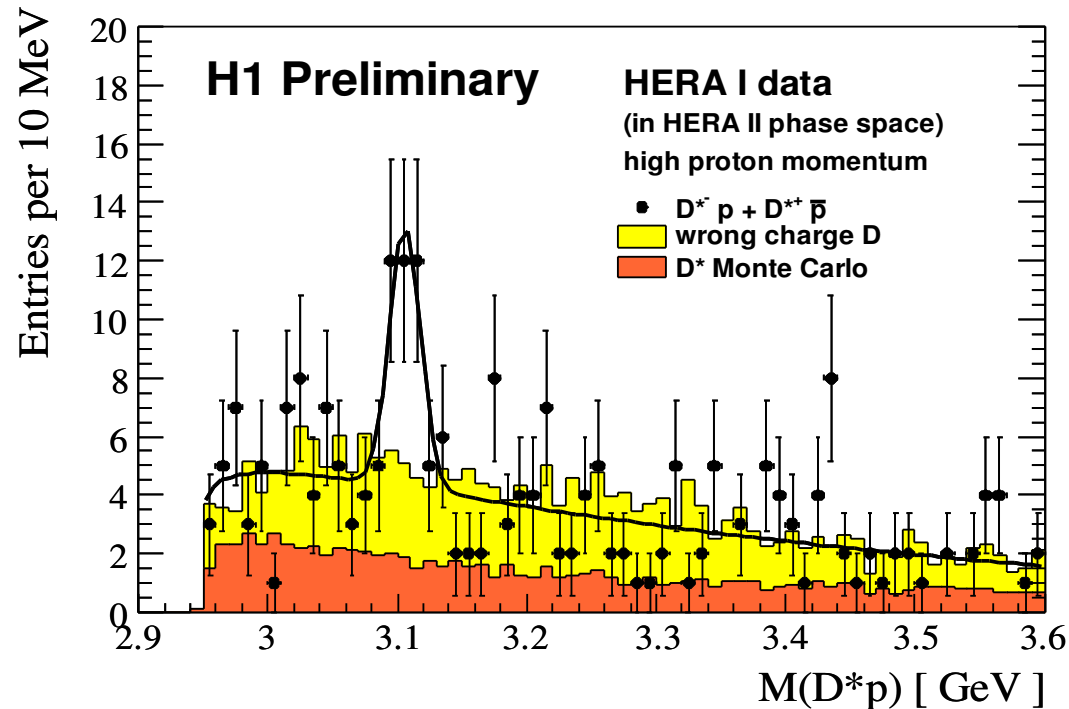
- look for  $D_1(2420)^0$  and  $D_2^*(2460)^0$   
→  $D^* \pi$
- same  $D^*$  selection, use  $\pi$  mass for additional track



- $\Delta M$  technique:  $M(D^* \pi) = m(K \pi \pi_s \pi) - m(K \pi \pi_s) + M_{D^*}$
- clear excess at expected positions  
masses & widths of Breit-Wigners fixed to PDG values
- sensitivity to this kind of decays

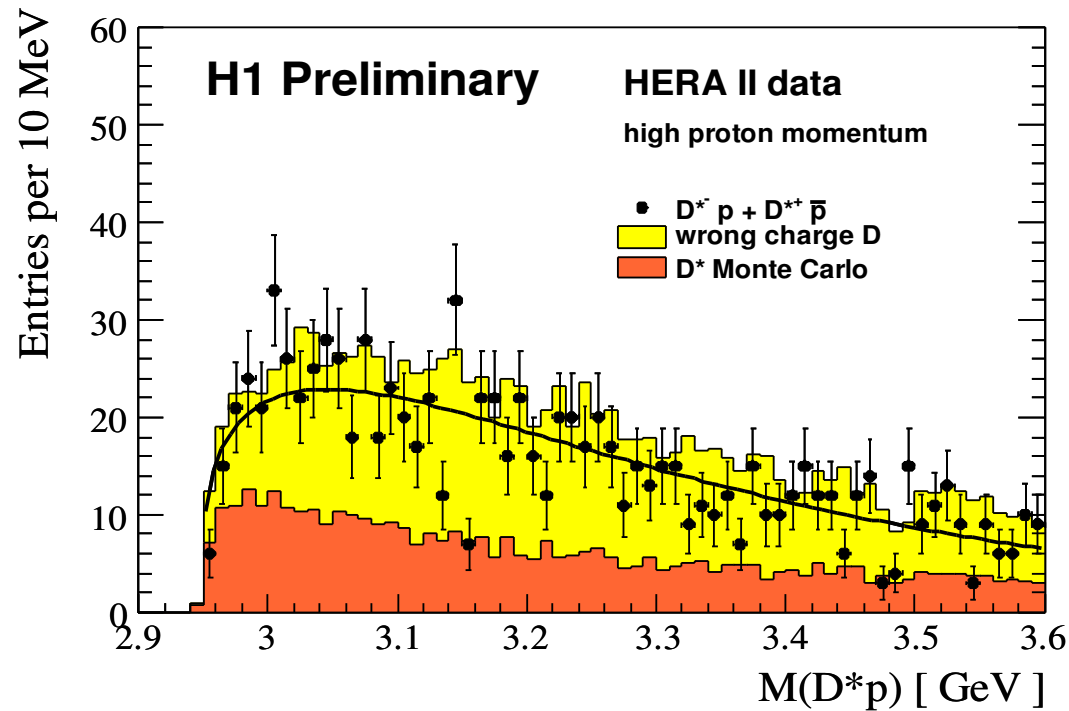


# HERA I data in HERA II phase space



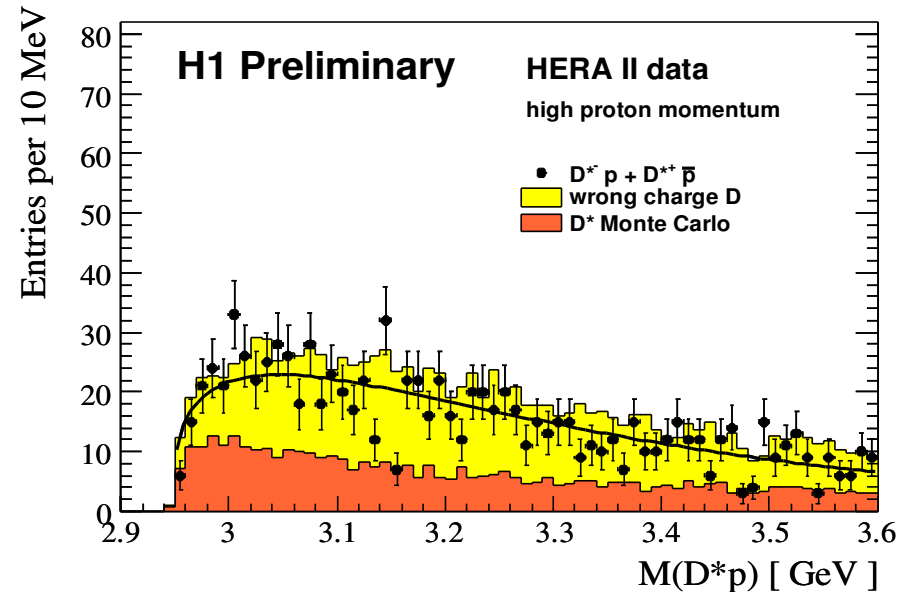
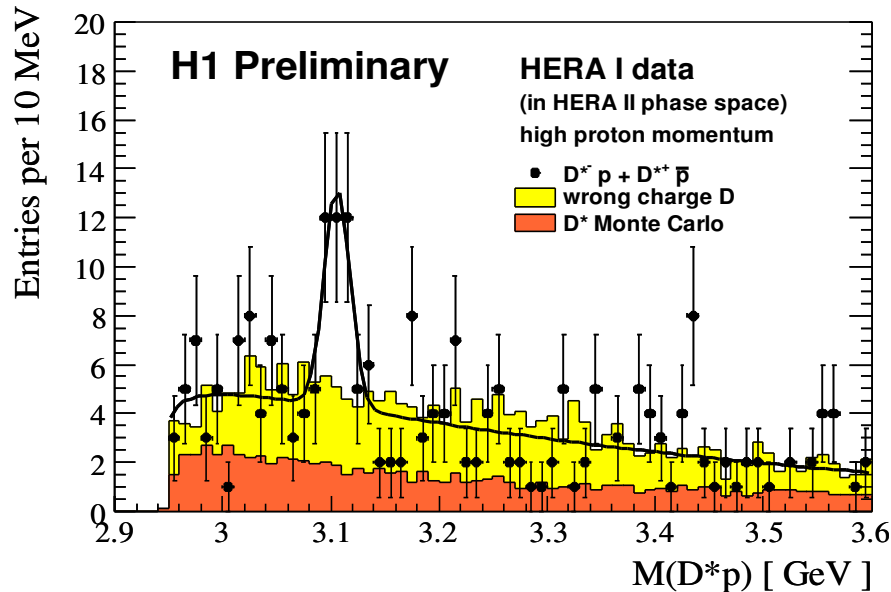
- structure at 3.1 GeV in HERA I data also for this selection
- $D^*$  MC (normalised to number of  $D^*$ ) + wrong charge D (from data) gives reasonable description away from 3.1 GeV
- ratio  $N(D^*p)/N(D^*) = 0.8 \pm 0.2 \%$

# HERA II $D^*p$ Mass Spectrum



- no peak structure around 3.1 GeV
- $D^*$  MC (normalised to number of  $D^*$ ) + wrong charge D (from data) gives reasonable description

# Comparison HERA I and HERA II



y axes scaled roughly to luminosity

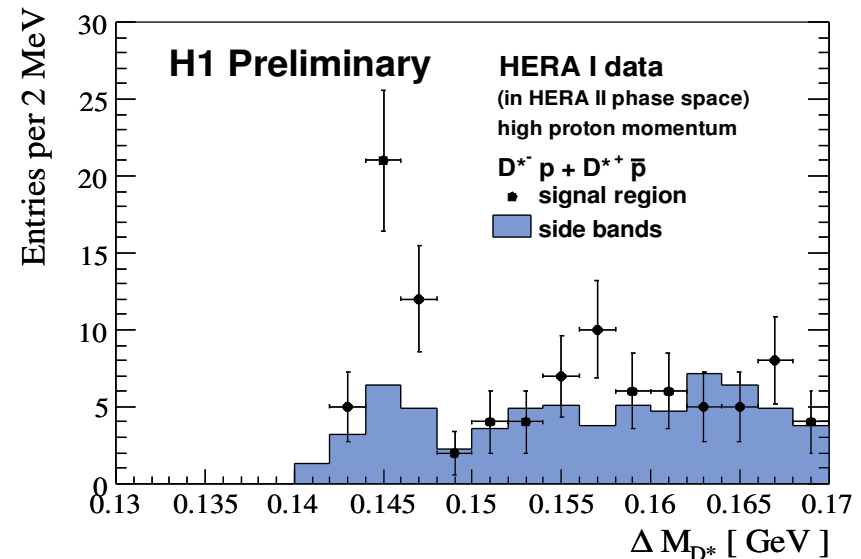
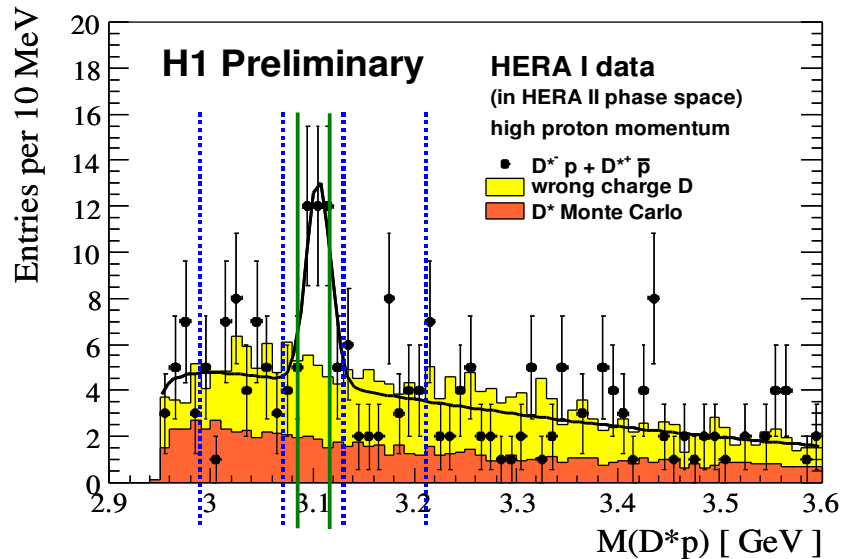
- excess corresponding to the HERA I rate should be visible in the HERA II data
- expected excess not there

# Limit

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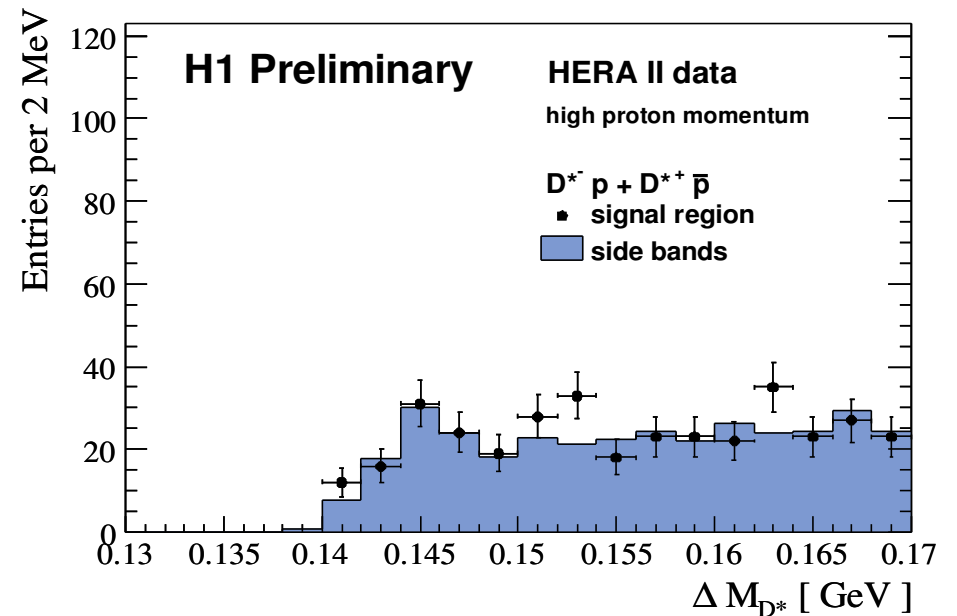
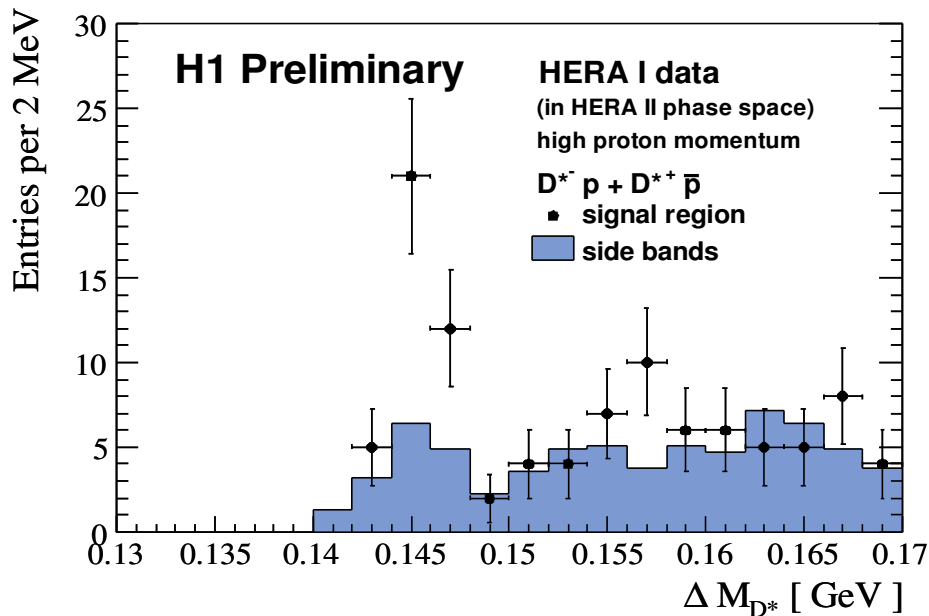
- limit determined with HERA II data only
- background function:  
$$p_0 * (x - M_{D^*} - M_p)^{p_1} * e^{p_2 * (x - M_{D^*} - M_p)}$$
- signal: assumed 12 MeV mass resolution (from HERA I publication, compatible with 0 MeV natural width)
- 95% confidence level limit on N(D\*p) at 3.1 GeV:  
**16.3 events**
- HERA II limit on **ratio N(D\*p)/N(D\*)**: **0.1 %**  
HERA I data: **0.8 ± 0.2 %**

# „Backward Analysis“



- study  $D^*$  mass in **signal region** (3.085 to 3.115) and **side bands** (2.990-3.070 and 3.130-3.210 GeV, scaled by 3/16) of  $D^*p$  distribution
- excess at nominal value in HERA I data in **signal sample** compared to **side bands**
- **signal sample** is charm enriched

# „Backward Analysis“



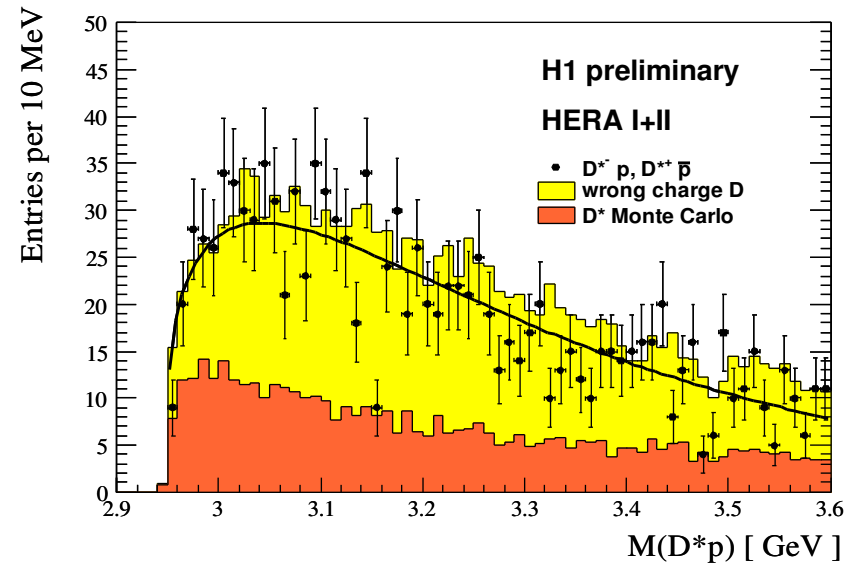
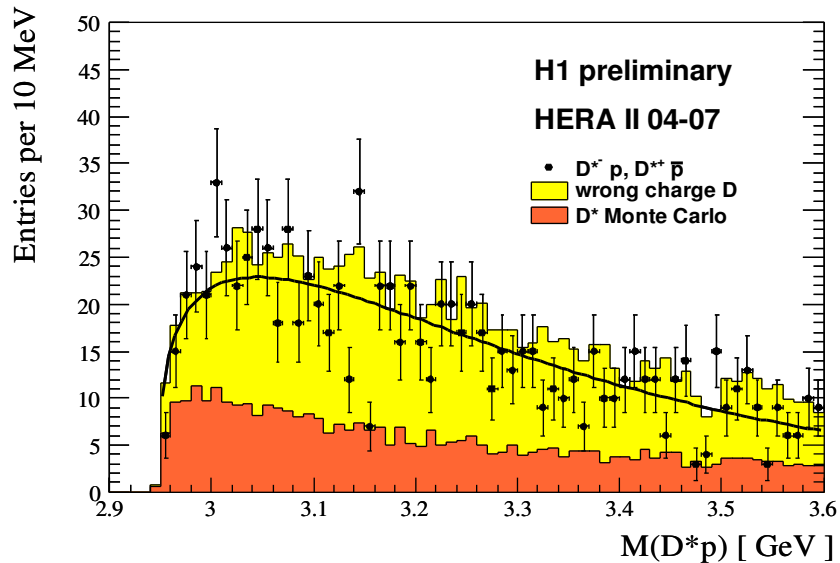
- no excess in HERA II data in **signal sample** compared to **side bands**

# Conclusions

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- excess at 3.1 GeV in the  $D^*p$  mass distribution in HERA I data also in the phase space of the HERA II analysis
- no excess in HERA II data for high proton momentum
- 95% CL limits from HERA II data:
  - $N(D^*p, 3.1 \text{ GeV}) < 16.3$  events
  - $N(D^*p)/N(D^*) < 0.1 \%$

# Sum of HERAI and HERAII



- sum of HERAI and HERAII shows no signal