

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

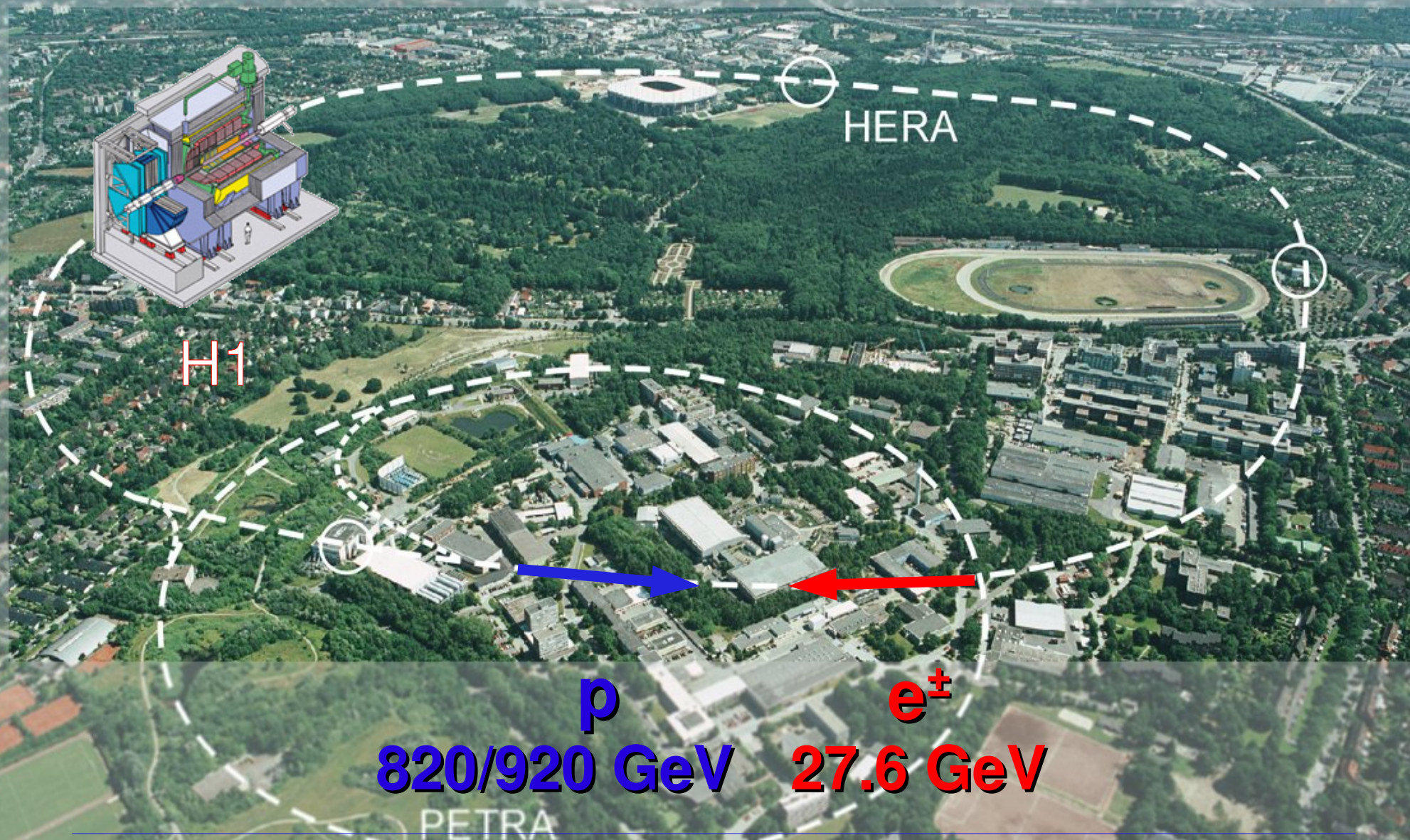
DIS08 Workshop, London, 7-11. April 2008



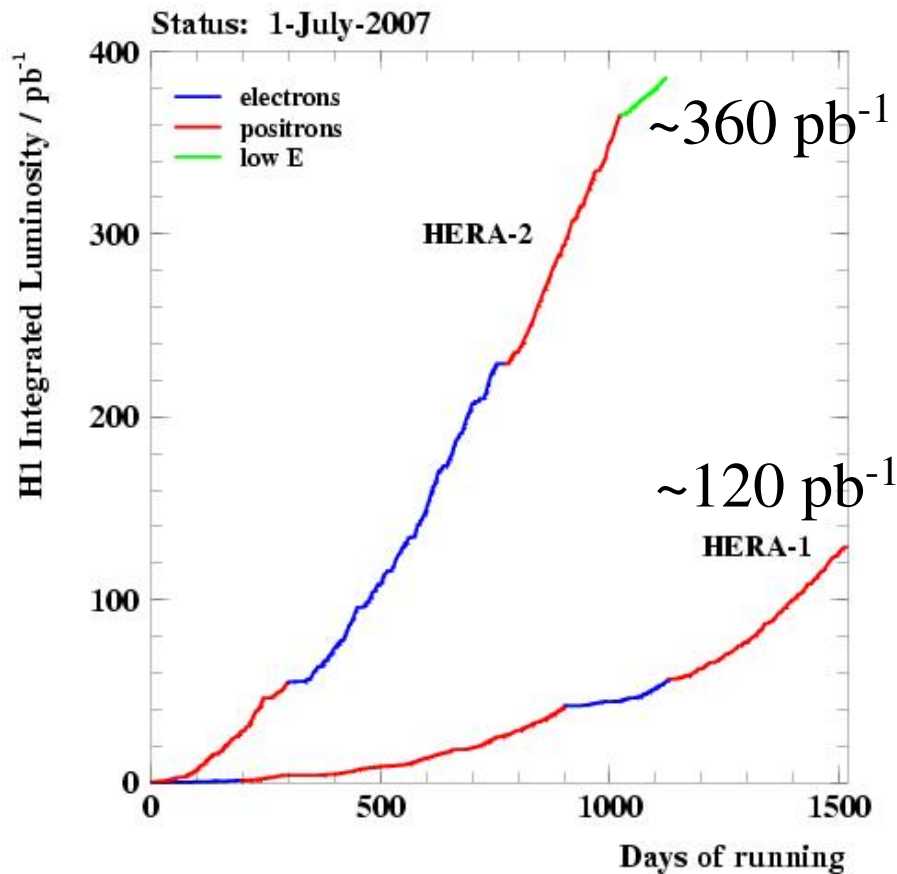
- Motivation
- Selection
- D^*p Mass Distribution



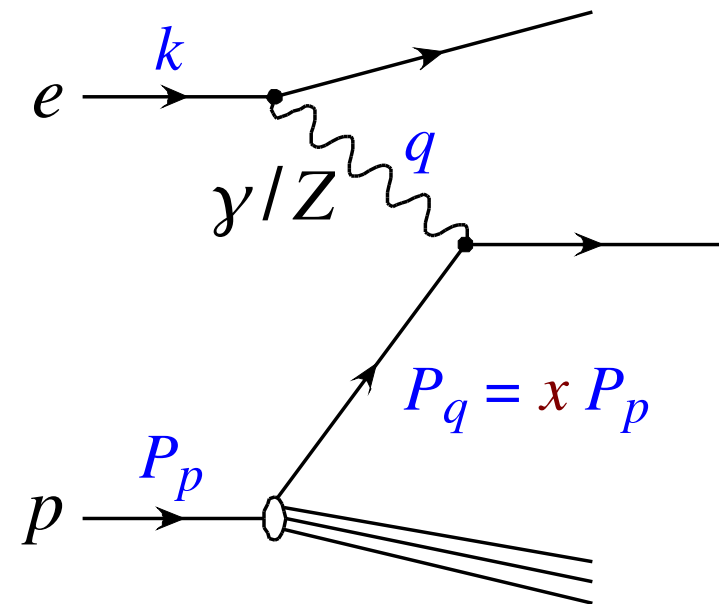
Electron-Proton-Collisions at HERA



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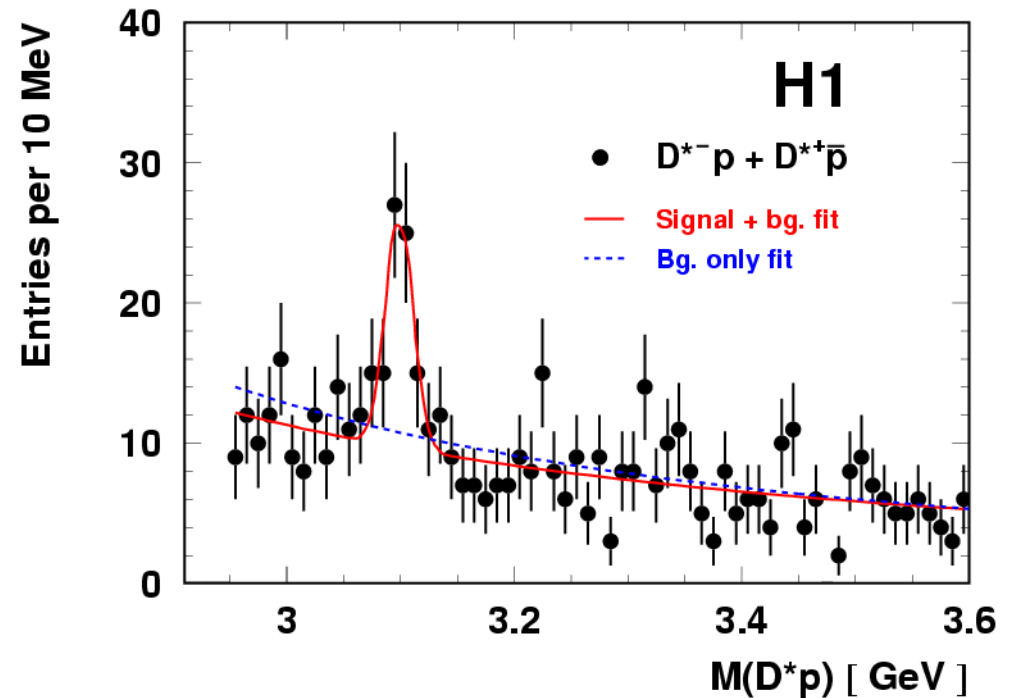
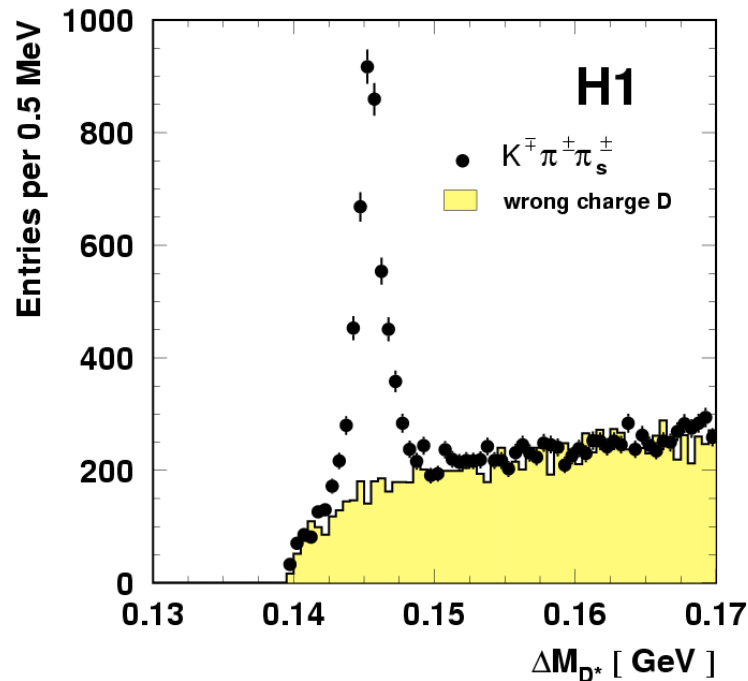
kinematics:



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

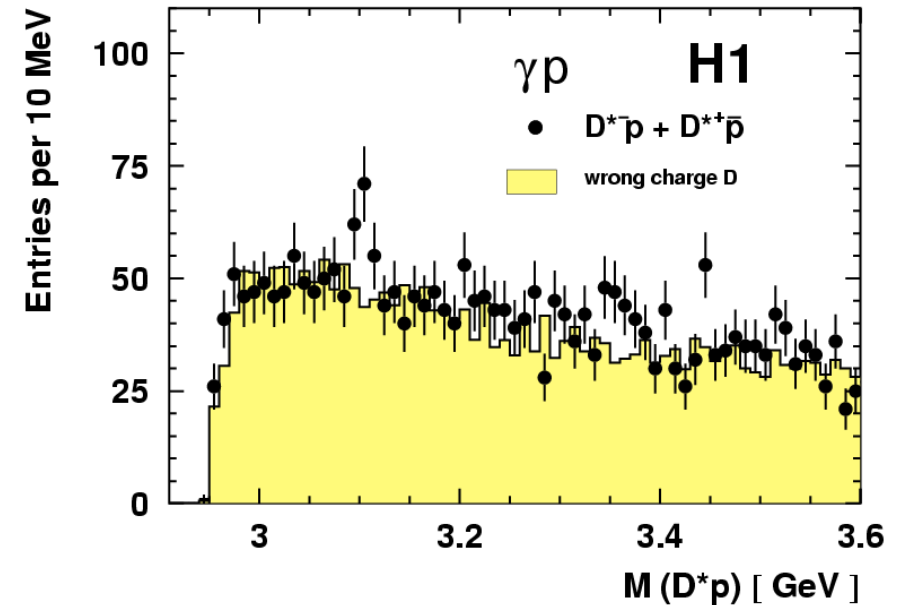
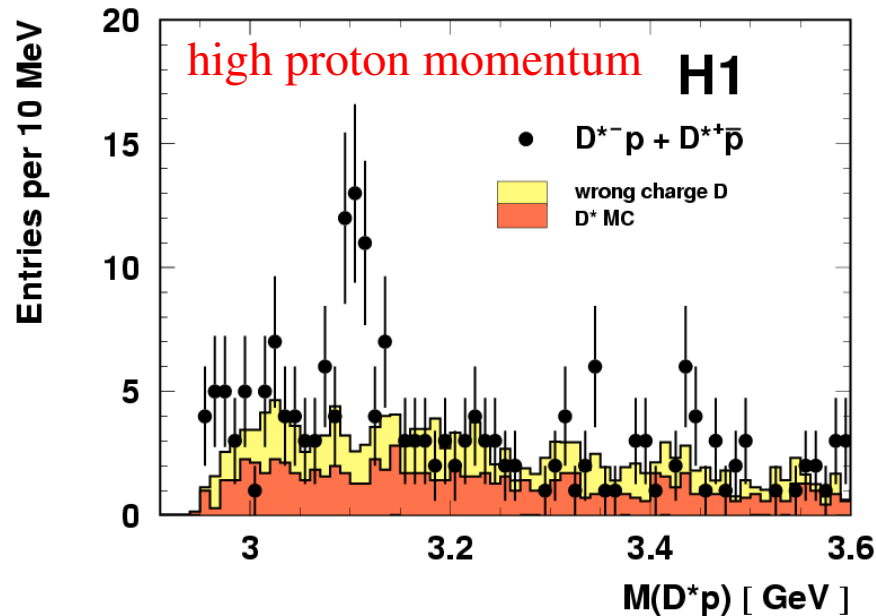
$$y = \frac{q \cdot P_p}{k \cdot P_p}$$

Motivation



- analysis of HERA I data (75 pb^{-1}): peak in D^*p spectrum at 3.1 GeV
- based on reconstructed ~ 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

Motivation

- 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 γ 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

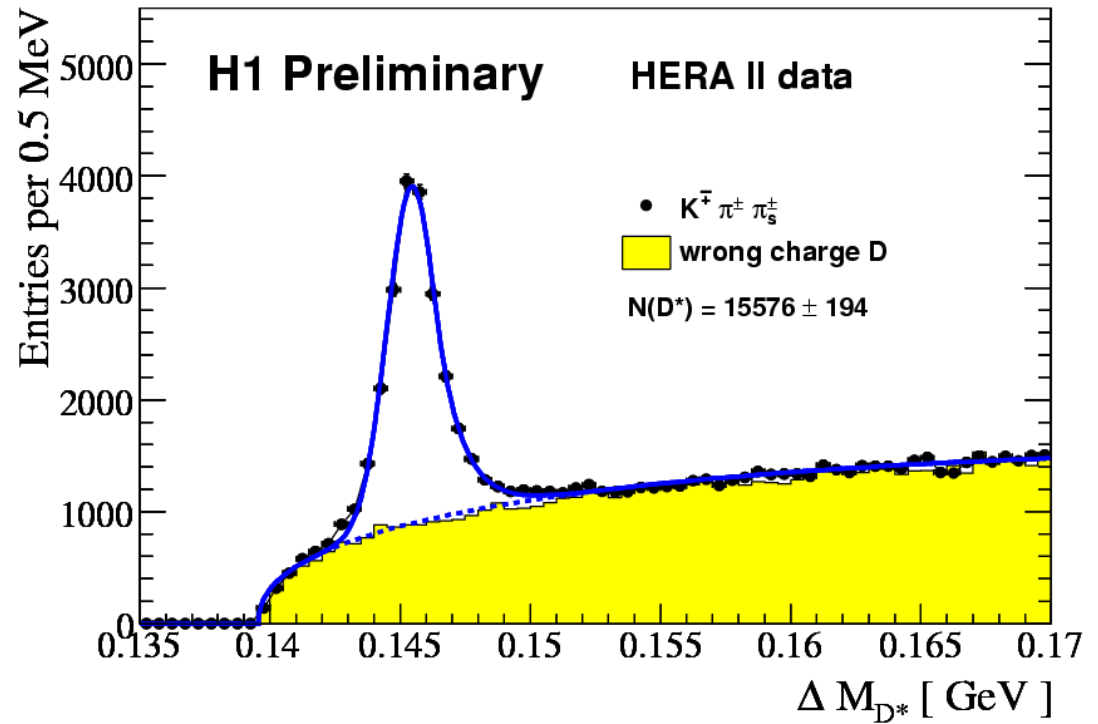
- full HERA II data, 348 pb⁻¹
- HERA II analysis:
 - $0.05 < y_e < 0.7$
 - $2 < Q^2 < 100 \text{ GeV}^2$
 - $E'_e > 10 \text{ GeV}$
 - $\theta_e < 3.09$
 - radius cut: $r > 12 \text{ cm}$
(center shifted)
- $-1.5 < \eta(D^*) < 1.0$, $p_t(D^*) > 1.5 \text{ GeV}$, $z(D^*) > 0.2$,
 $p_t(K) > 0.5 \text{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

D* Signal

- D* selection in „golden channel“

$$D^{*\pm} \rightarrow D^0 \pi^\pm \rightarrow K^\mp \pi^\pm \pi^\pm$$

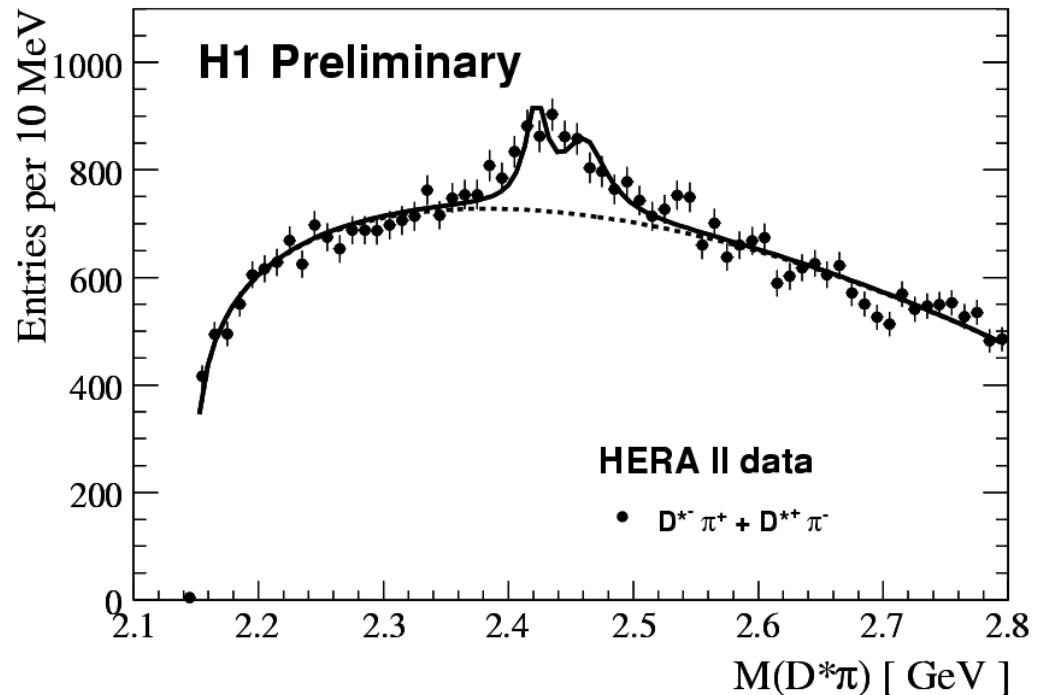
- restricted $\eta(D^*)$ region and $z(D^*)$ cut to reduce background
- 15576 ± 194 D*s in HERA II data
- less than increase in luminosity compared to HERA I data due to different phase space



Cross Check: Higher Mass D Mesons

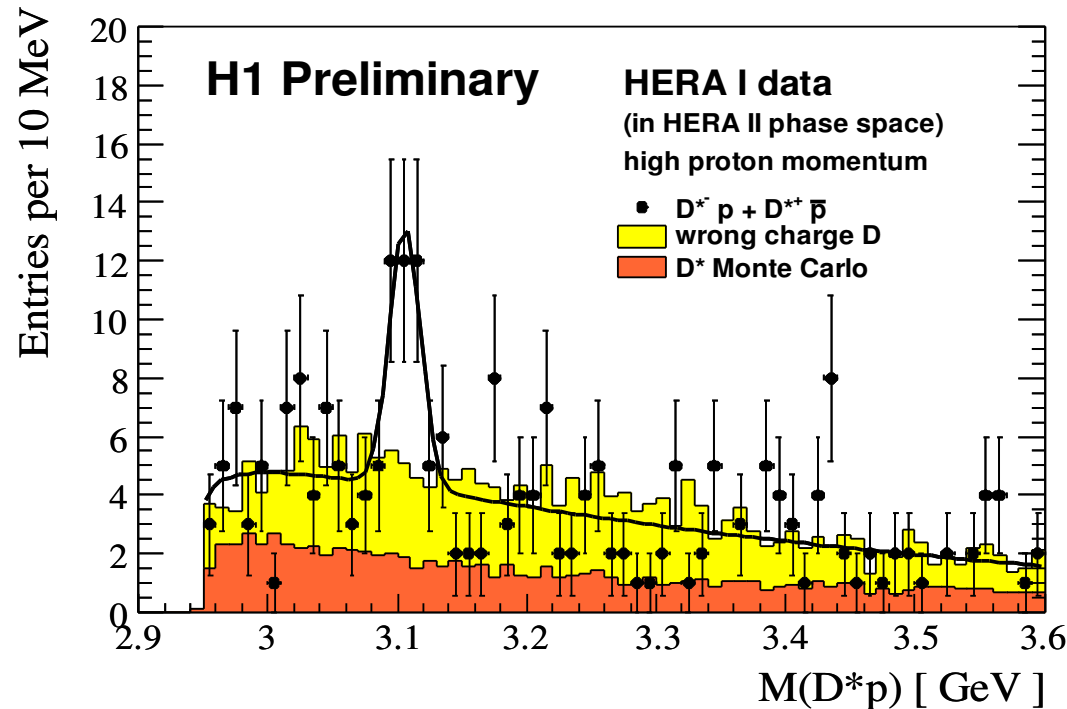
- look for $D_1(2420)^0$
and $D_2^*(2460)^0$
 $\rightarrow D^* \pi$

- same D^* selection,
use π mass for
additional track



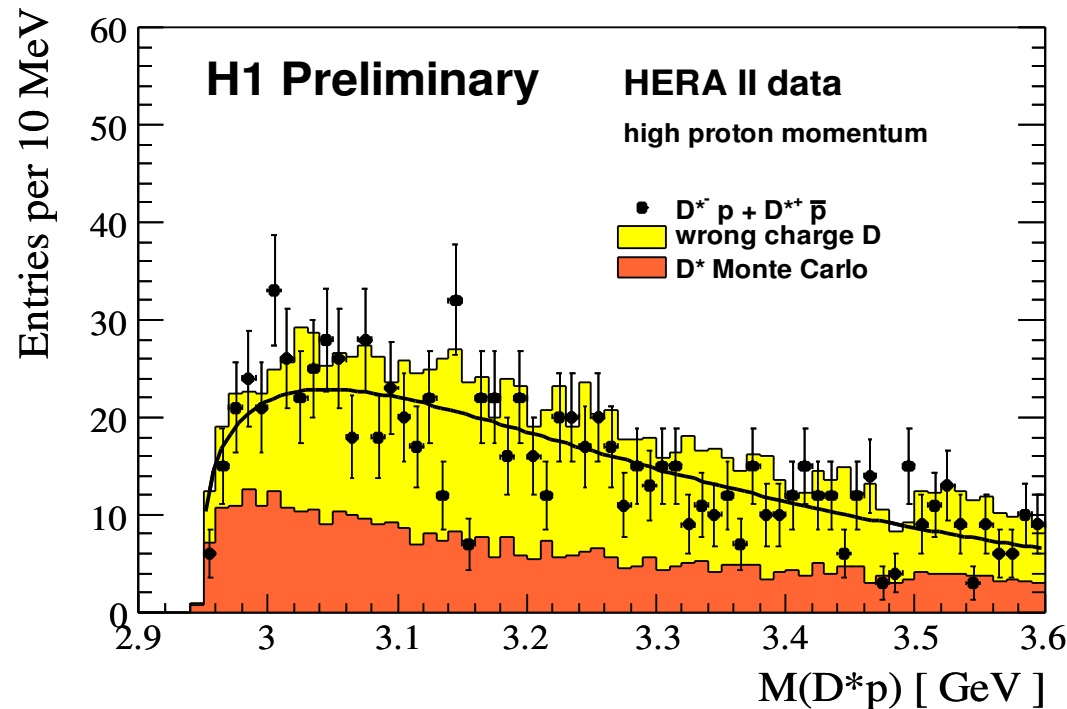
- ΔM technique: $M(D^* \pi) = m(K \pi \pi_s \pi) - m(K \pi \pi_s) + M_{D^*}$
- clear excess at expected positions
masses & widths of Breit-Wigners fixed to PDG values
- we are sensitive to this kind of decays

HERA I data in HERA II phase space



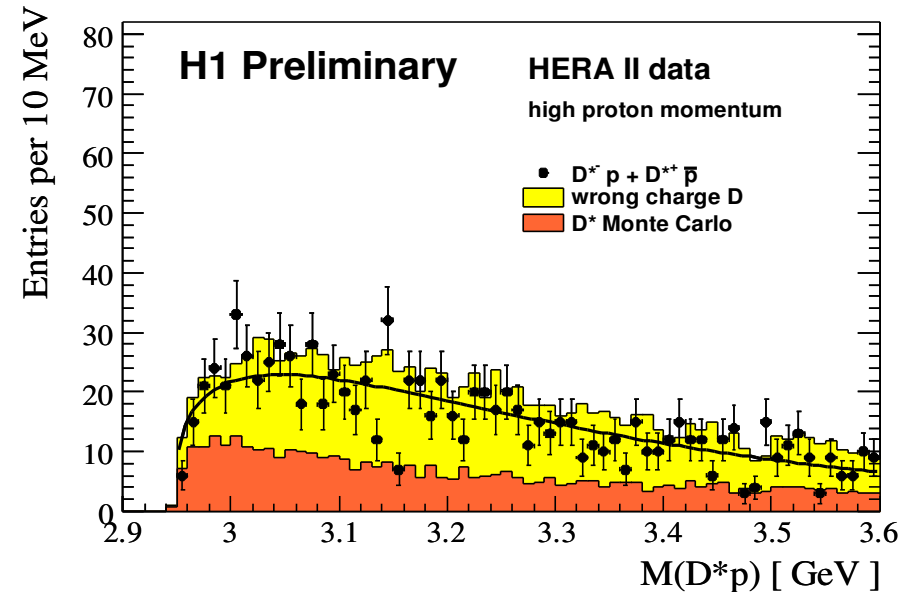
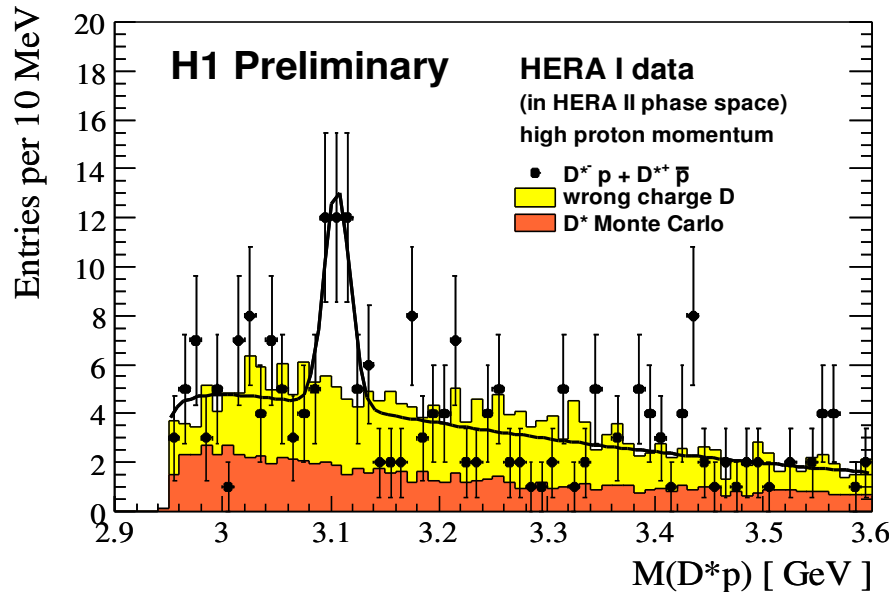
- structure at 3.1 GeV in HERA I data also for this selection
- D* MC (normalised to number of D*) + wrong charge D (from data) gives reasonable description away from 3.1 GeV
- ratio $N(D^*p)/N(D^*) = 0.8 \pm 0.2 \%$

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



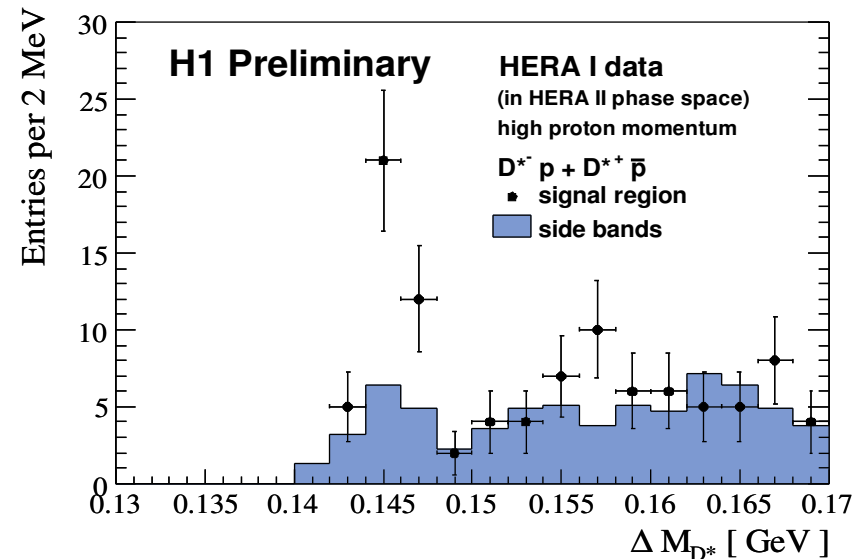
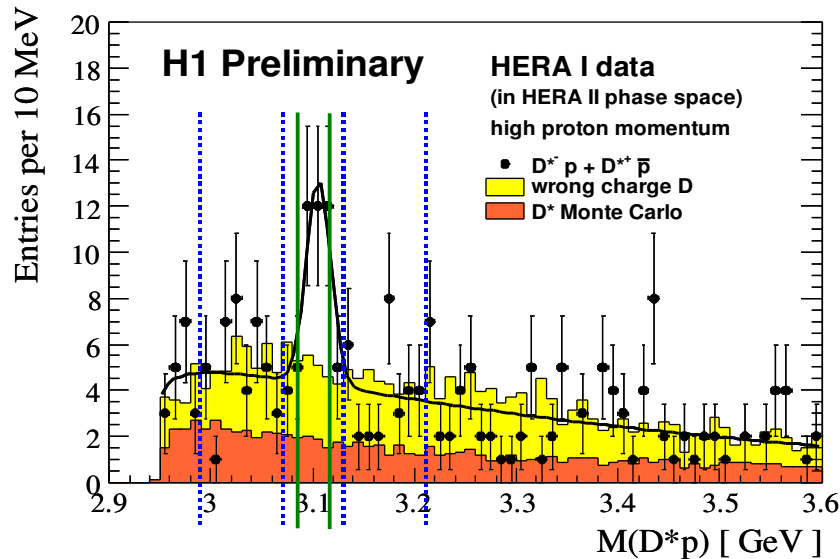
y axes scaled roughly to luminosity

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

Limit

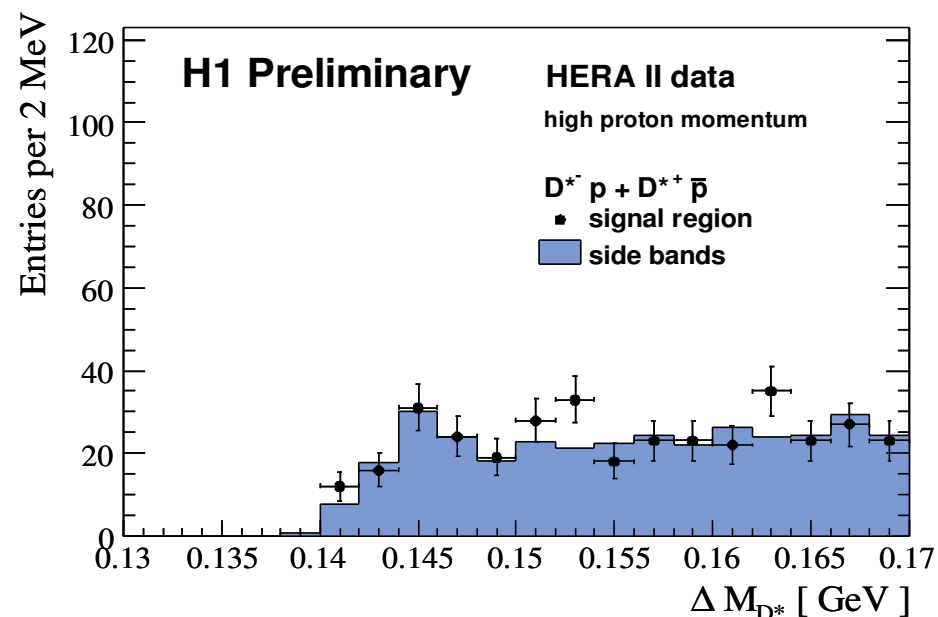
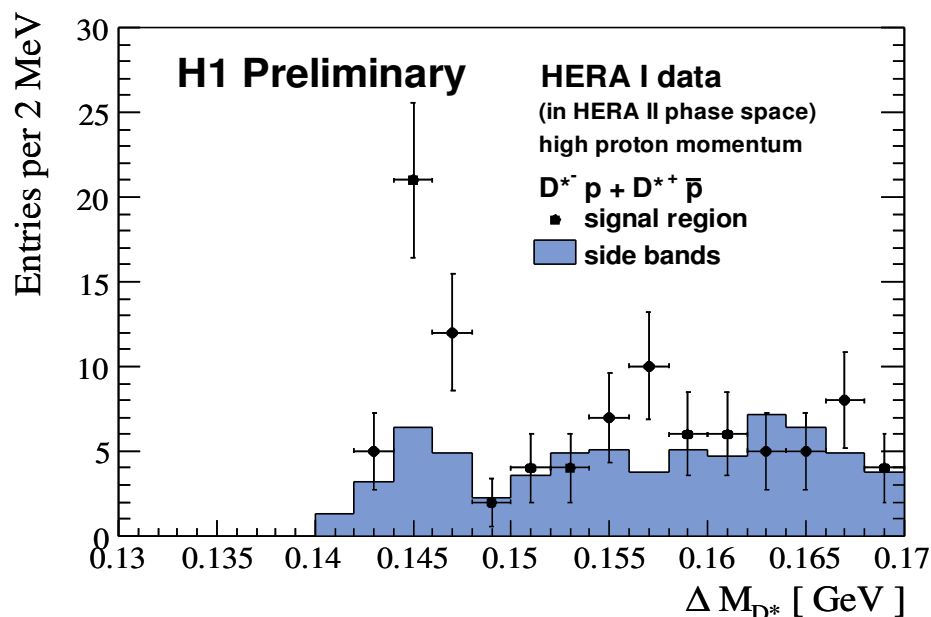
- limit determined with HERA II data only
- background function:
$$p_0 * (x - M_{D^*} - M_p)^{p_1} * e^{p_2 * (x - M_{D^*} - M_p)}$$
- signal: assumed 12 MeV mass resolution (from HERA I publication, compatible with 0 MeV natural width)
- 95% confidence level limit on N(D*p) at 3.1 GeV:
16.3 events
-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

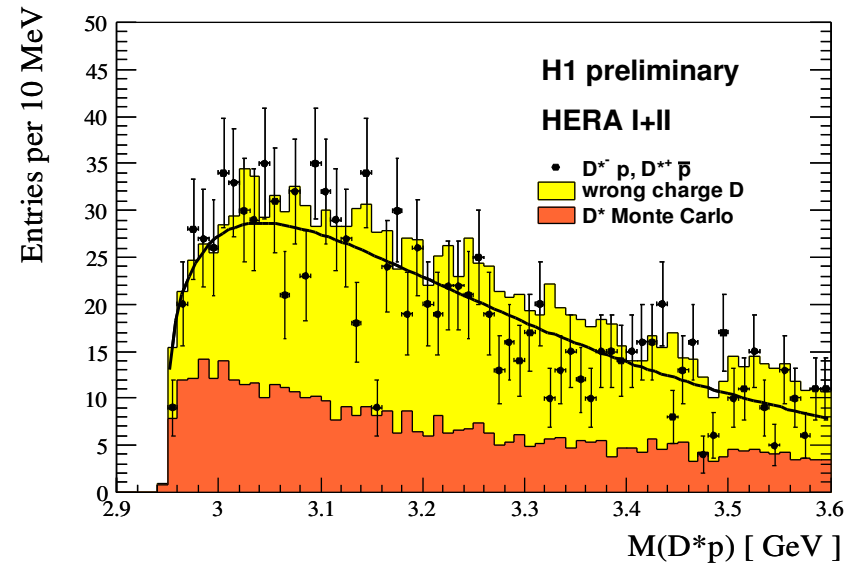
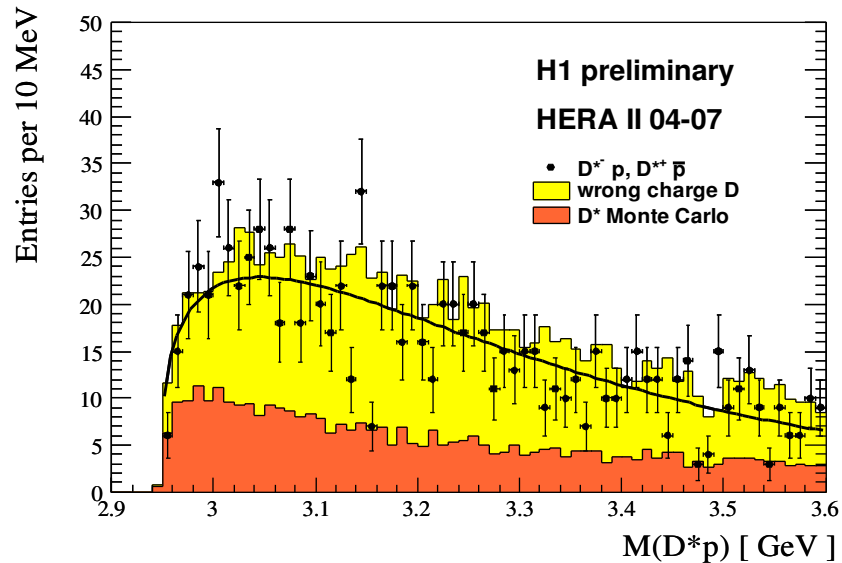


- no excess in HERA II data in **signal sample** compared to **side bands**

Conclusions

- 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