DIS2006

XIV International Workshop on Deep Inelastic Scattering

20/April/2006 - 24/April/2006

Heavy stable-particle production in NC DIS with the ZEUS detector

Takahiro Matsumoto, KEK

For the ZEUS collaboration

Motivation

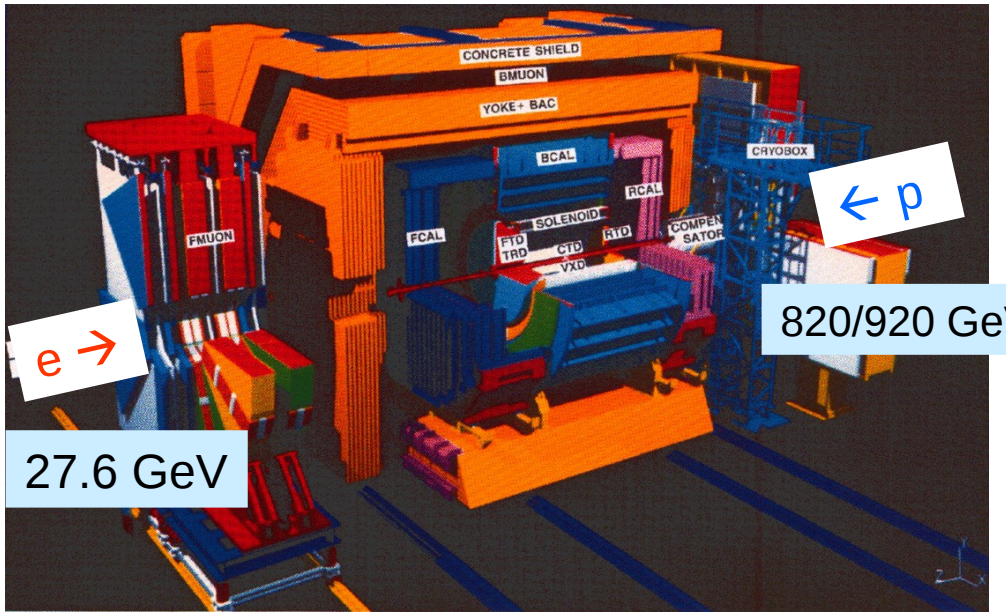
- Light nuclei production is interesting topics in heavy ion collisions
  - Possible to test how neuclei are produced in the early of universe
    - Fireball is created by collision (~a few μs after Big Bang)
    - Light neuclei is produced in the thermal freeze out stage
  - Coalescence model can be applied for formation
- However, still few measurements in elementary collision

  Some results on antideuteron
  - ARGUS ($e^+e^- \rightarrow \gamma^* \rightarrow q\bar{q}$); < 1.7 x 10^{-5} anti-d/evt
  - OPAL ($e^+e^- \rightarrow Z^0$) ; < 0.8 x 10^{-5} anti-d/evt
  - ALEPH ($e^+e^- \rightarrow Z^0$) ; 0.6 x 10^{-5} anti-d/evt; *hep-ex/0604023* *New!*
  - ARGUS ($e^+e^- \rightarrow \Upsilon(1S,2S)$); 6×10^{-5} anti-d/evt, $\bar{d}/p \sim 3 \times 10^{-4}$ (19 anti-d's)
  - H1 (Photoproduction) ; $\bar{d}/p \sim 5 \times 10^{-4}$ (45 anti-d's)

  Different production mechanism among processes?

  → *We searched for heavy stable-particles in NC DIS (first results)*
- Possible relations between antideuteron and pentaquarks are recently discussed
  - Both are multi-quark states, formed with coalescence model, hard to observe in e^+e^- process

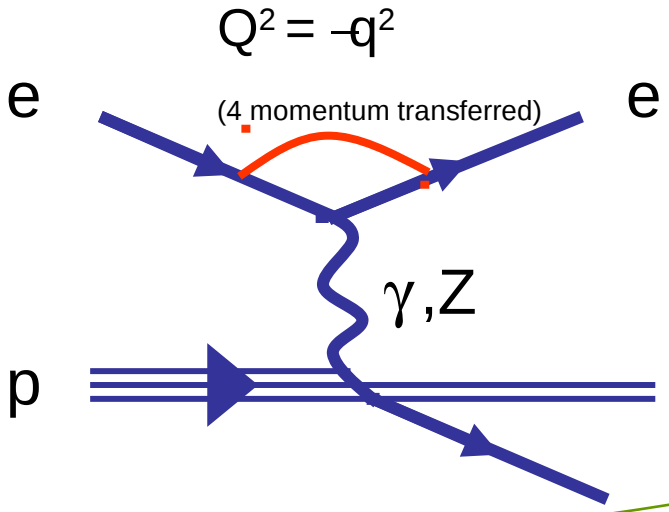
Data sample



- HERA-I (1996-2000)
- L = 120/pb
  - e^+p ($\sqrt{s}$=300 GeV); 39/pb
  - e^+p ($\sqrt{s}$=318 GeV); 64/pb
  - e^-p ($\sqrt{s}$=318 GeV); 17/pb

- *DIS selection*
  - $Q^2 > 1$ GeV^2
  - $E_e > 8.5$ GeV
  - $35 < E - P_Z < 65$ GeV
  - $|Z_{vertex}| < 40$ cm

$N_{DIS} = 2.68 \times 10^7$ (0.22 μb)

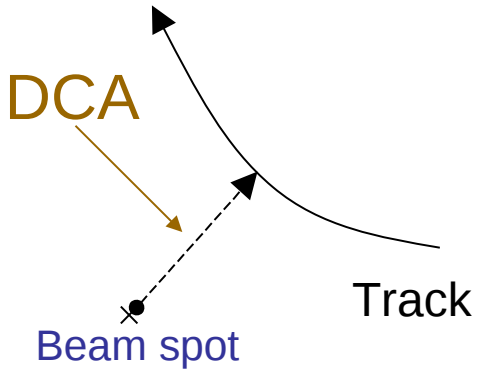


Selection of heavy stable-particles

- Good reconstructed charged tracks with CTD
  - p_T>0.15 GeV/c
  - Started from 1st layer
  - More than 40 CTD hits
- Particle identification with dE/dx

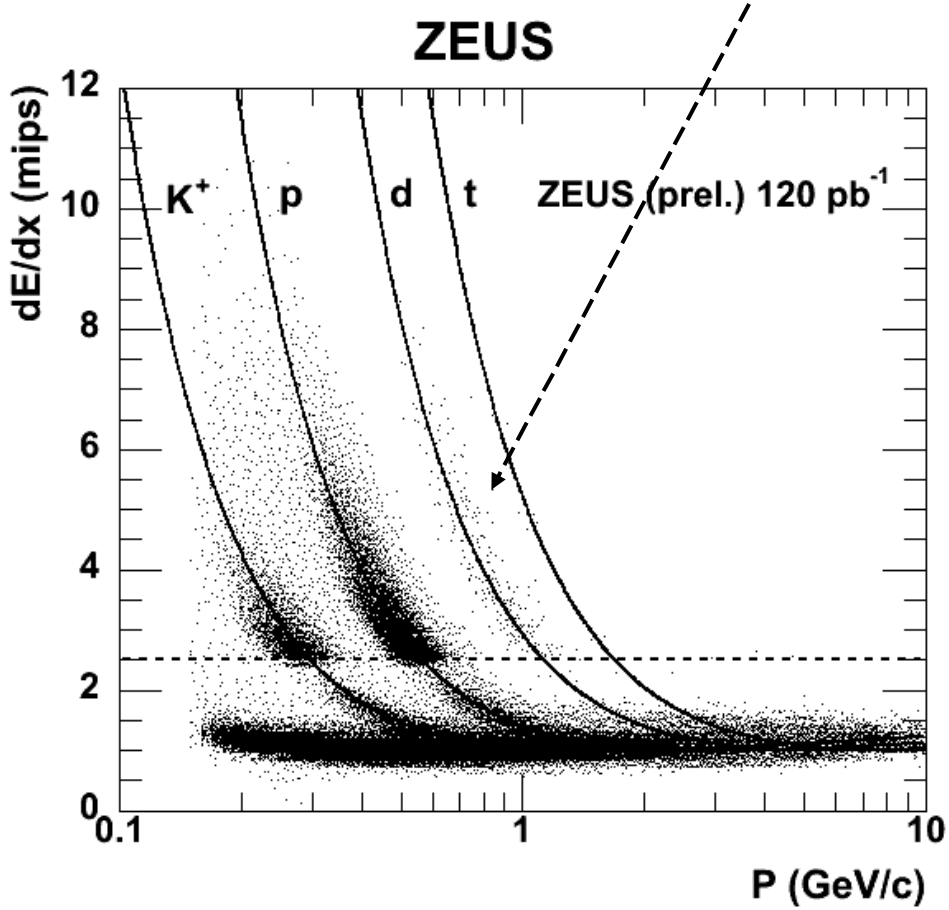
  σ(dE/dx)/dE/dx ~ 10%
- Originated from primary vertex

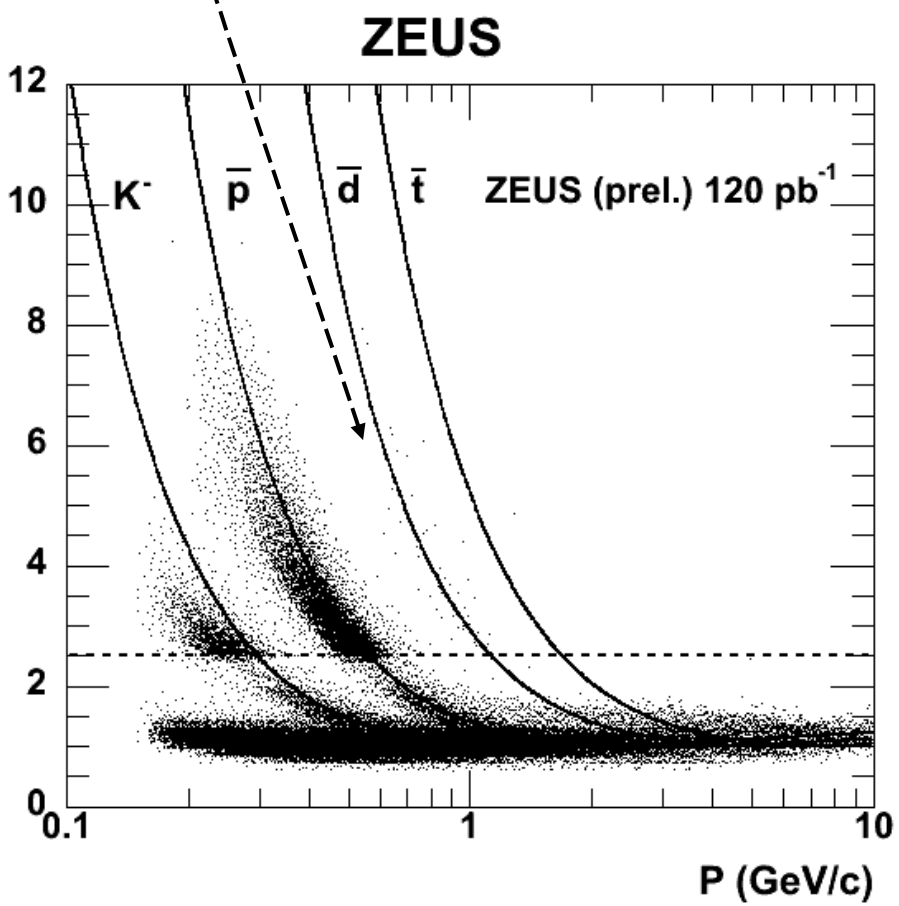
  ΔZ (= $Z_{track} - Z_{vertex}$)
  - $|\Delta Z| < 2$ cm for p
  - $|\Delta Z| < 1$ cm for d, t
  - DCA : distance of closest approach from beam spot (on rϕ plane)
    - |DCA| < 1.5 cm for p
    - |DCA| < 0.5 cm for d, t



dE/dx

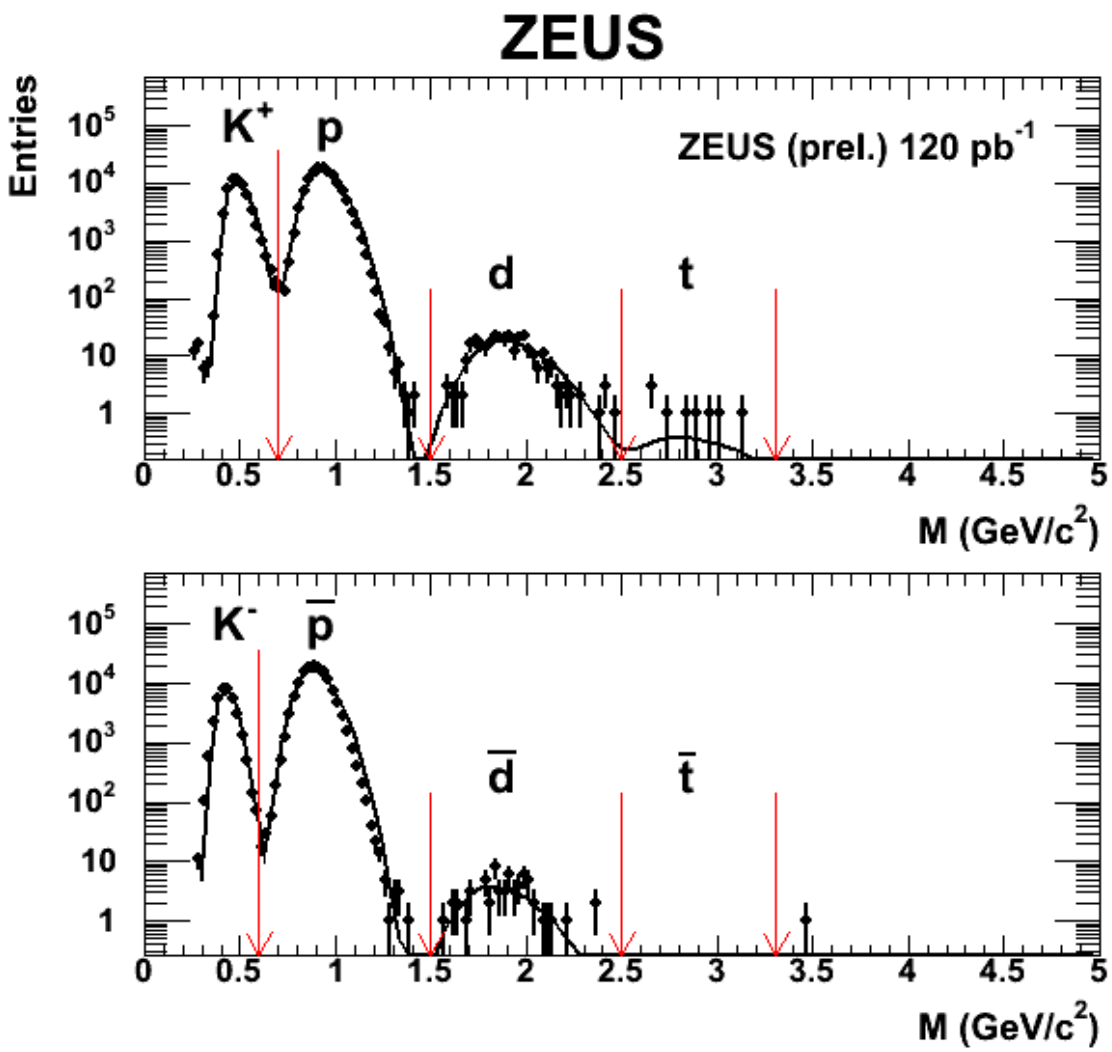
Significant deuteron and antideuteron events !





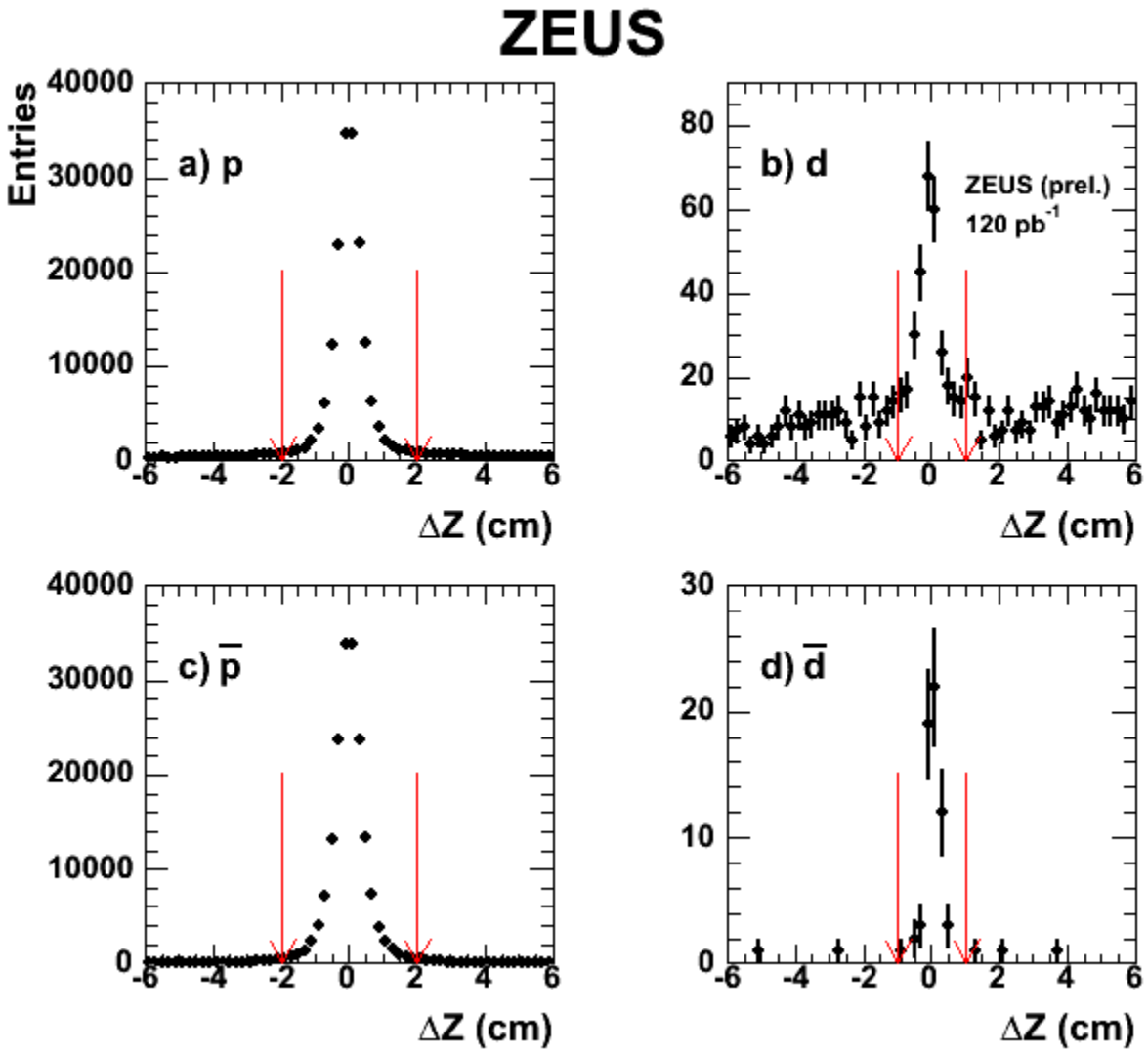
- Plotted if at least one track satisfies dE/dx(mips) >2.5
- Also cuts: $|\Delta Z|<1$ cm, $|DCA|<0.5$ cm

Mass distribution



- Mass is calculated from dE/dx and momentum (For dE/dx > 2.5)
- Resolution
  $\Delta M/M \sim +11/-7\ \%$
  → Good separation
- 309 deuteron and 62 antideuteron candidate (Contributions from non-primary tracks are not subtracted yet)
- No antitriton and 9 triton candidates (But consistent with BKG)

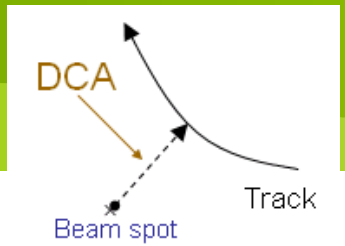
ΔZ distributions

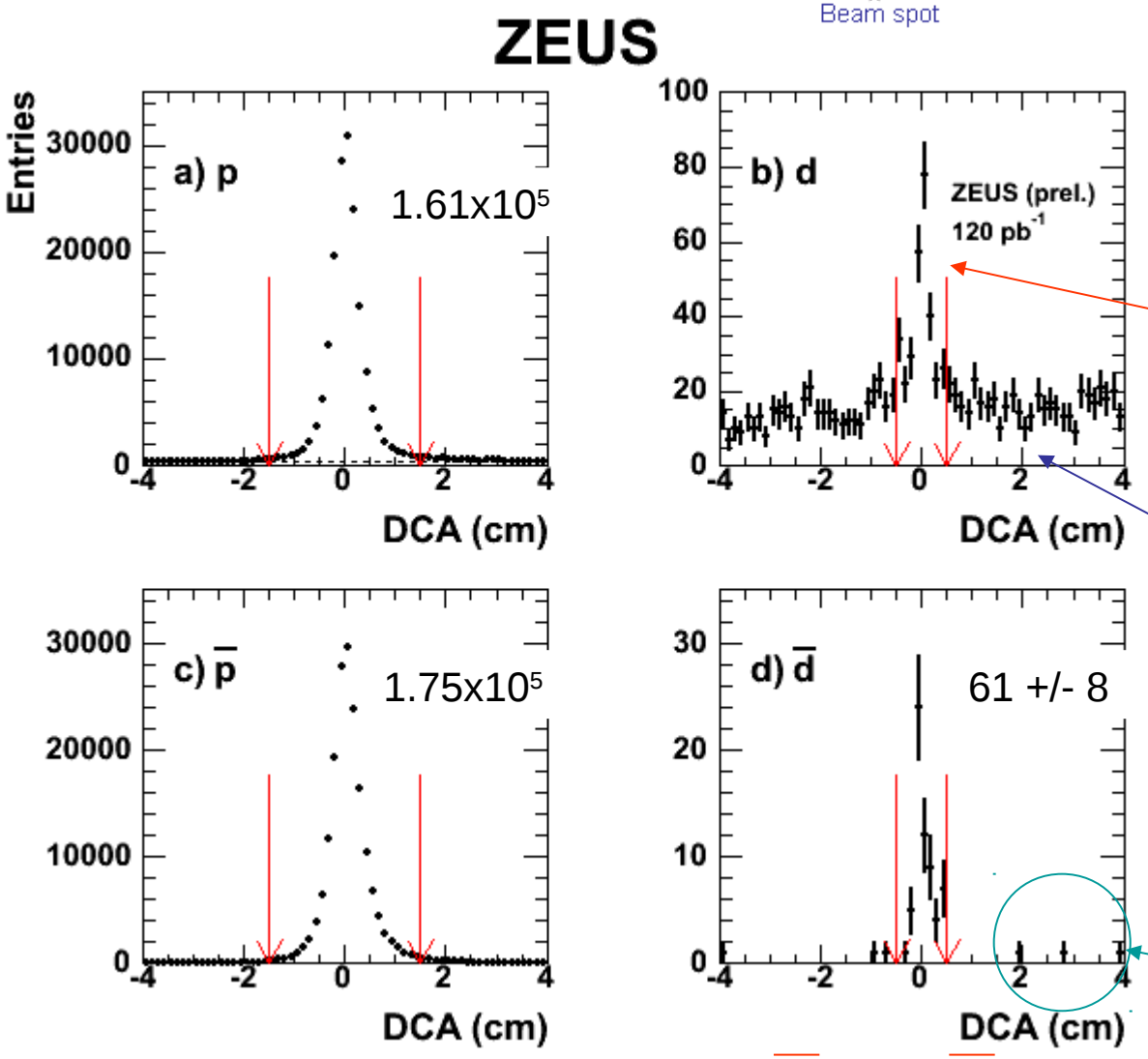


- Tracks are required to originate from interaction point in Z and rϕ
- ∀ $\Delta Z = Z_{trk} - Z_{vertex}$ has clear peak for primary

(plots after DCA cuts are shown)

DCA distributions





- Backgrounds are estimated using DCA to beam spot after ΔZ cut

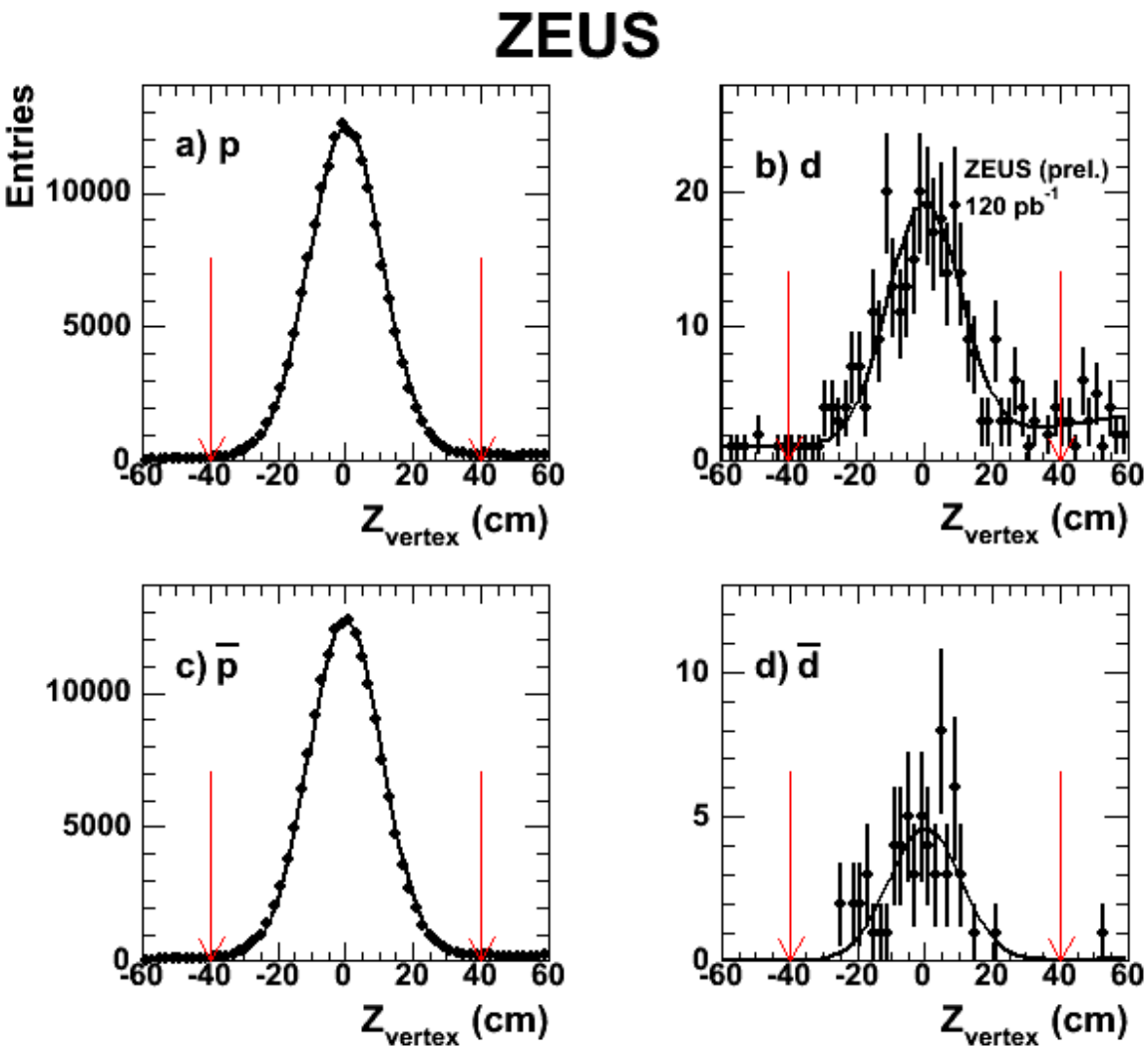
Clear peaks are from primary tracks (also from BKG, difficulty in estimation for d)

Flat distribution in side band is from secondary (used to estimate backgrounds in the signal region)

Small events from back-scattered deuteron

Clean peaks in p, p and d

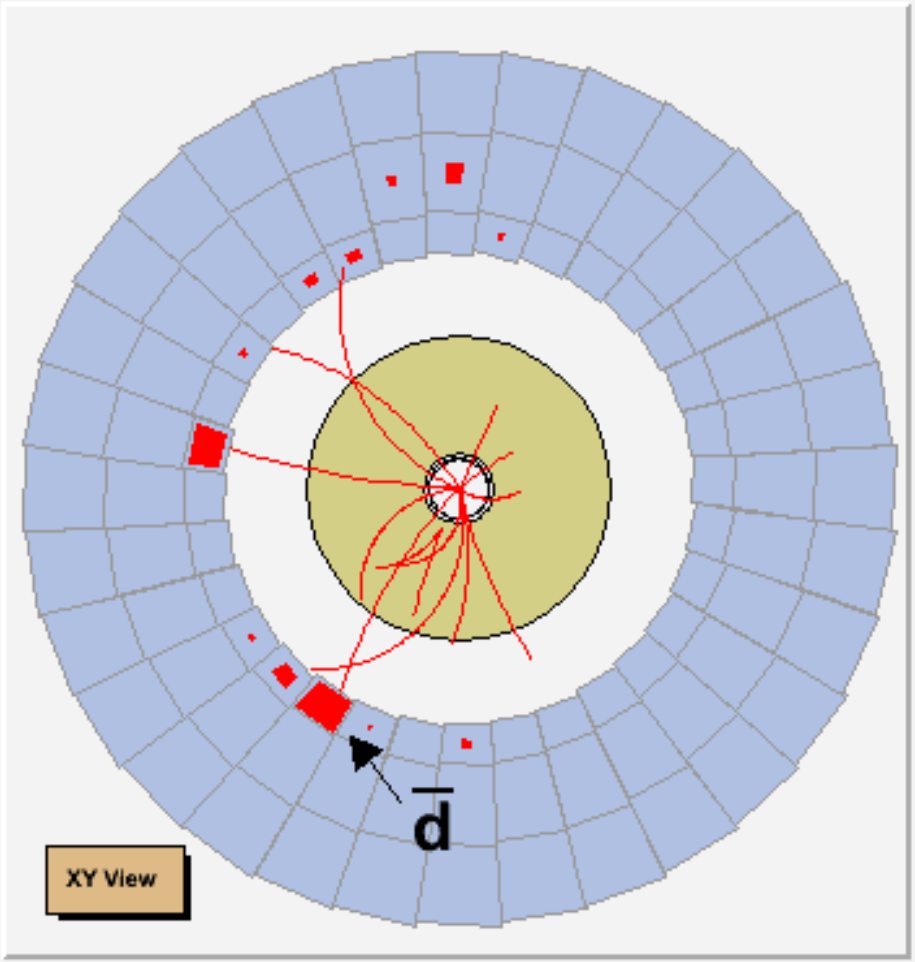
Z_{vertex} distributions

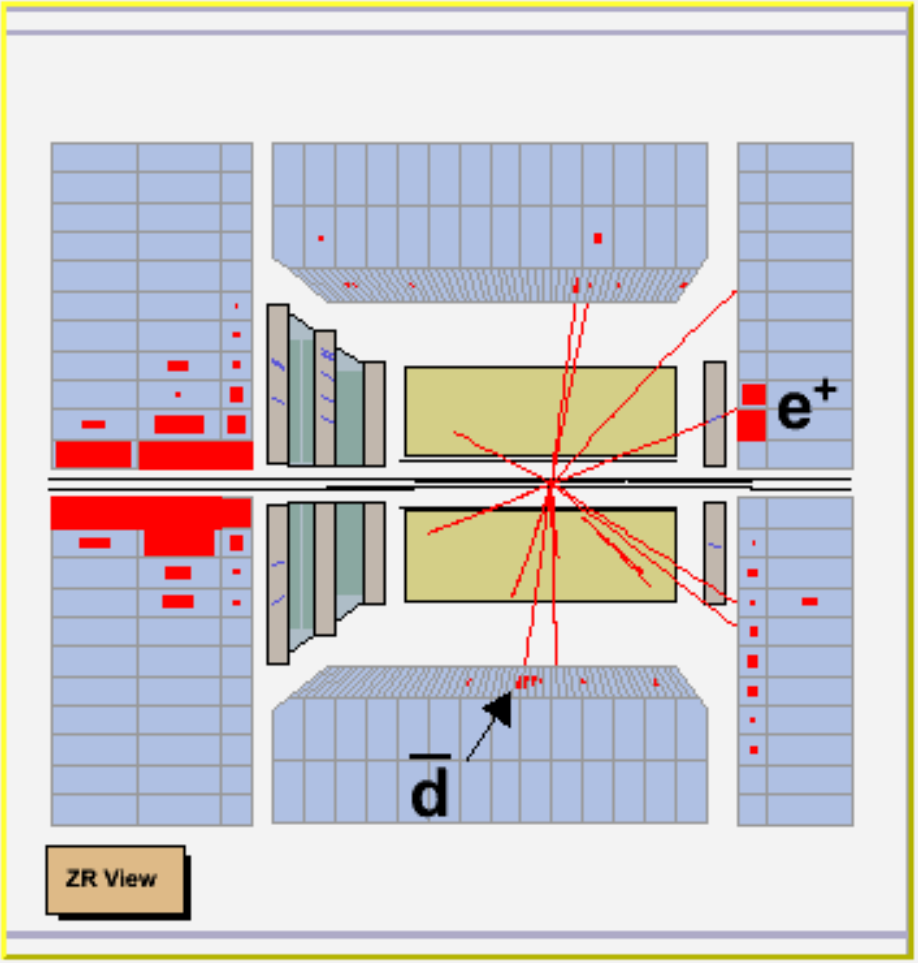


- Clean DIS events with scattered electron

  → Events are consistent with DIS
- Beam gas backgrounds are small enough for p, ~~$\bar{p}$~~ and ~~$\bar{d}$~~

Event display of antideuteron



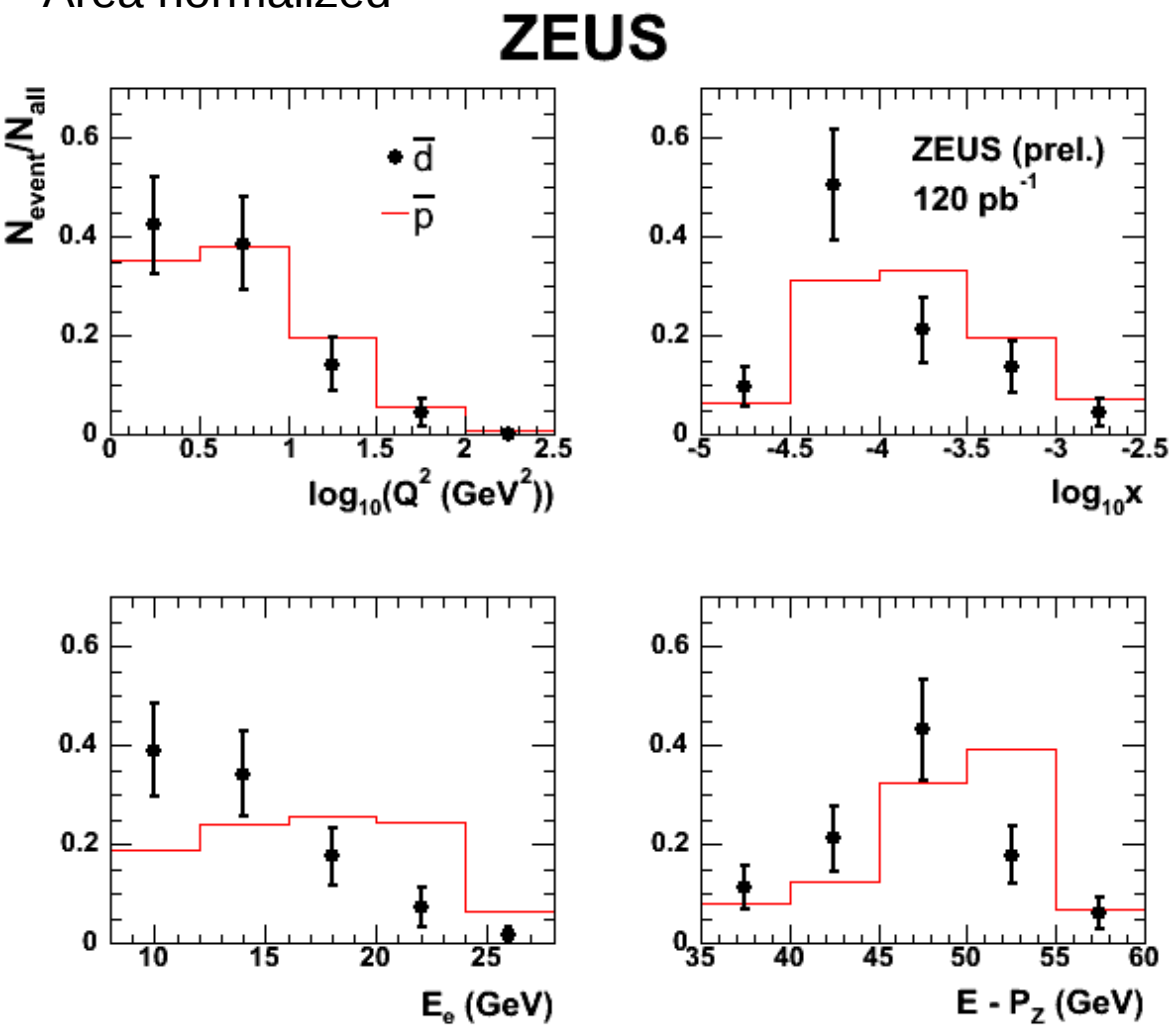


Q^2 = 45.5 GeV^2, E_e = 14.2 GeV

antideuteron; P = 1.1 GeV/c, dE/dx(mips) = 2.7, E_{CAL} = 3.2 GeV

DIS variables of antideuteron

Area normalized



* Distributions are not corrected

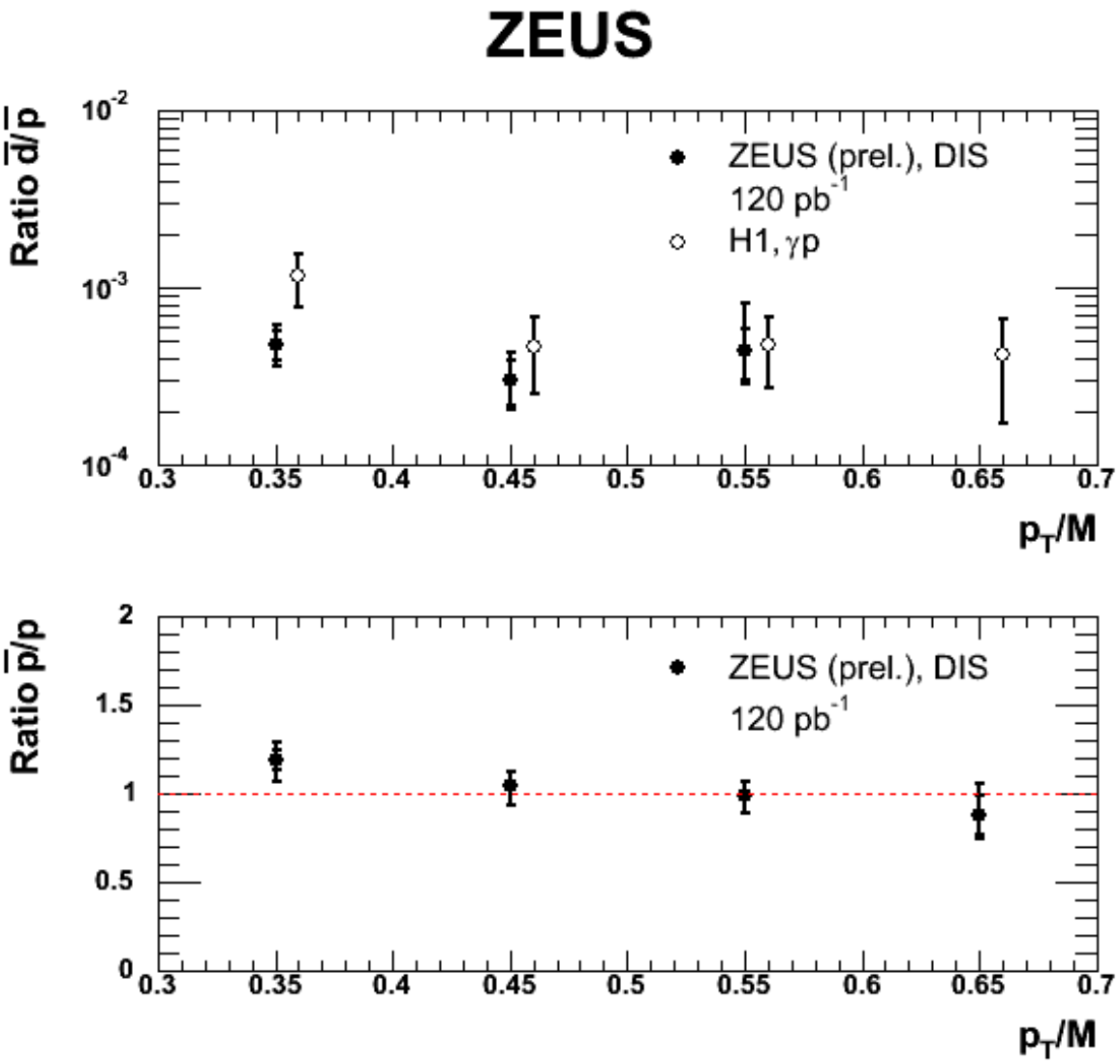
- Similar Q^2 distribution with antiproton
- But lower x, higher y (lower E_e)

Are there any hints of production mechanism?

Ratio extraction

- We measure ratios, $\bar{d}/\bar{p}$, $\bar{p}/p$
  - Ratios including d are not extracted due to difficulty in the non ep backgrounds estimation
- Yields extraction
  - $0.3 < p_T/M < 0.7$ with 4 bin, $|y| < 0.4$
    - Yields are extracted from DCA distribution for each bin
  - p_T is normalized with mass to match the kinematic region between p and d
- Efficiency correction
  - Need to correct following:
  - Tracking efficiency ; Estimated from MC
  - eff. of dE/dx cut ; Estimated from MC and $\Lambda \rightarrow p\,\pi$ in Data
- Decay proton subtraction
  - Some protons from $\Lambda \rightarrow p\pi$ are not separated with DCA. Subtract contribution 21% by using Monte Carlo

Ratios



- $\bar{d}/\bar{p} \sim 5 \times 10^{-4}$
  - Agrees with H1 results in γp
- No asymmetry between proton and antiproton

Summary

- Antideuterons are observed in DIS for the first time
  - $\bar{d}/\bar{p}$ ratio, ~ 5×10^{-4} is found to be similar between DIS (ZEUS) and Photoproduction (H1)
  - No asymmetry between proton and antiproton
  - Triton and antitriton are not observed
- Possible to provide new aspects on nuclear production from comparison with the heavy ion collisions