

# Spectroscopic Measurements Using the H1 and ZEUS Detectors

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DESY

on behalf of the H1 and ZEUS Collaborations

XXXXth Rencontres de Moriond on QCD and High Energy Hadron  
Interactions

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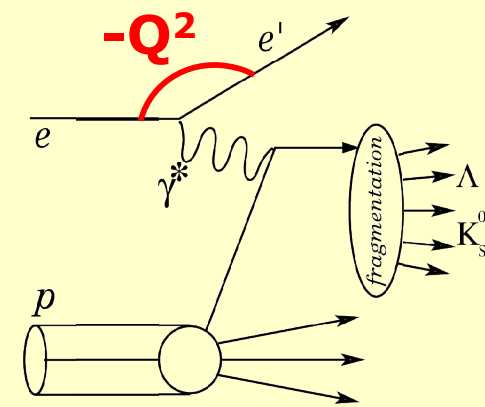


# The HERA Collider



- Two colliding experiments:  
H1, ZEUS
- HERA I data sample: 1994-2000  
 $L \approx 120 \text{ pb}^{-1}$  for each experiment
- HERA II data taking since 2002

$Q^2$ : virtuality of exchanged boson  
 $Q^2 \approx 0 \text{ GeV}^2$ :  
 photoproduction  
 $Q^2 > 1 \text{ GeV}^2$ :  
 deep inelastic scattering (DIS)



# Motivation for Measurements

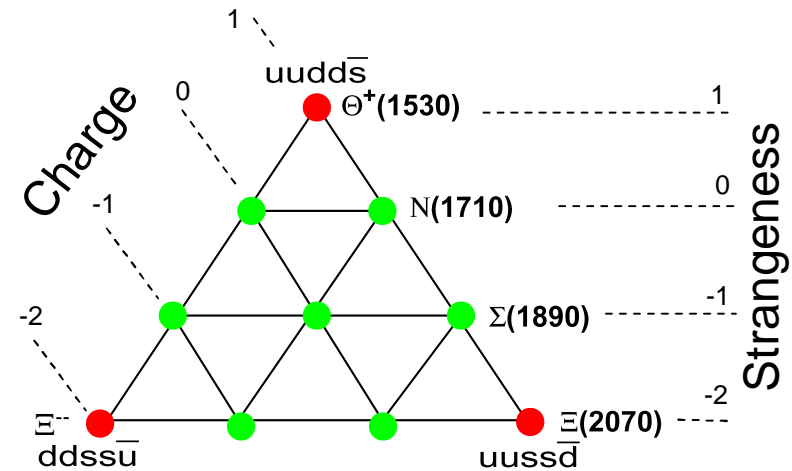
Strange Pentaquark anti-dekuplet (Diakonov, Petrov, Polyakov, 1997)

**At the corners:**

- baryons with exotic quantum numbers
- can not be explained by 3 quarks

Recently:

Many positive/negative results at different experiments



ZEUS: Evidence for a narrow baryonic state decaying to  $K_s^0$ - (anti)proton in DIS at HERA

ZEUS: Search for Pentaquarks Decaying to  $\Xi\pi$  in DIS at HERA



# Evidence for a narrow baryonic state decaying to $K_S^0 p$ in DIS



Search for  $\theta^+ \rightarrow p K_S^0$ ,  $\theta^- \rightarrow \bar{p} K_S^0$

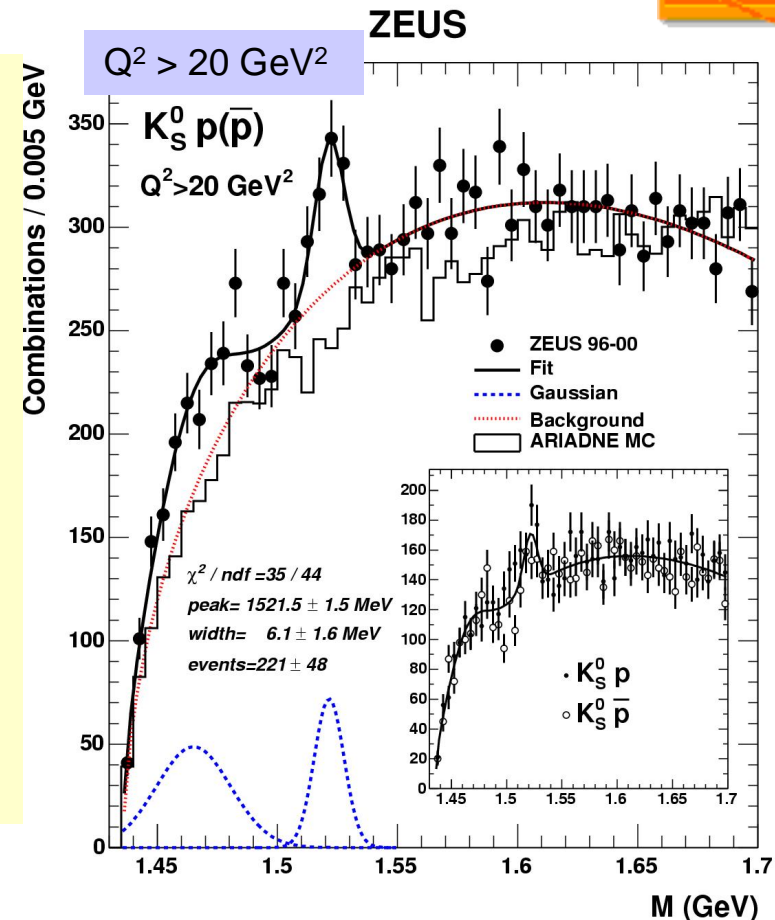
Selection

- DIS sample ( $Q^2 > 1 \text{ GeV}^2$ )
- Identify  $K_S^0 \rightarrow \pi^+ \pi^-$  (secondary vertex)
- Identify (anti-)proton (dE/dx)

Peak observed at

- Mass  $1521.5 \pm 1.5(\text{stat}) + 2.8 - 1.7(\text{syst}) \text{ MeV}$
- Significance:  $3.9 - 4.6 \sigma$
- Width:  $8 \pm 4 \text{ MeV}$

Signal seen in both charges



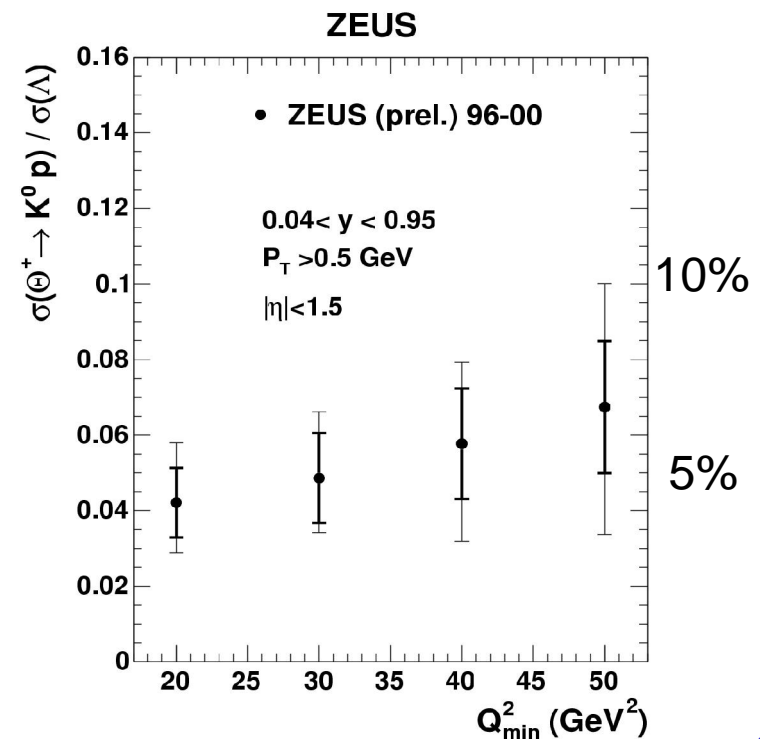
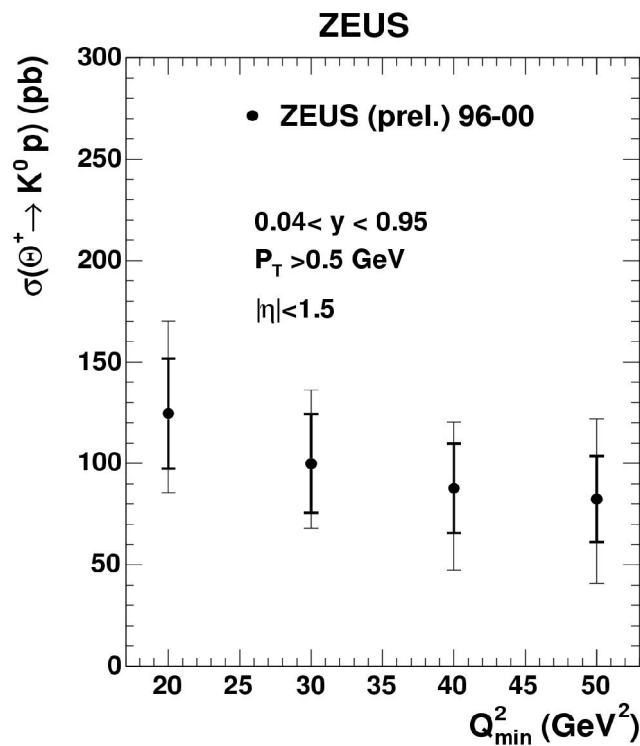
# Evidence for a narrow baryonic state decaying to $K^0_s p$ in DIS



Cross sections measured as function of  $Q^2_{\min}$ :

$$\sigma(\theta^+ \rightarrow K^0 p) \text{ (pb)}$$

$$\sigma(\theta^+ \rightarrow K^0 p) / \sigma(\Lambda)$$



# Search for Pentaquarks Decaying to $\Xi\pi$ in DIS



NA49:

Search for  $\Xi_{3/2}^- \rightarrow \Xi^- \pi^-$

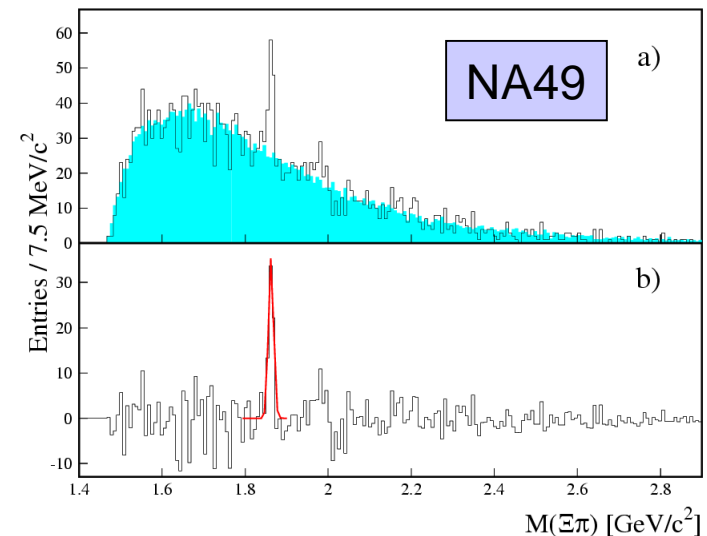
- Identify  $\Xi^- \rightarrow \Lambda^0 \pi^-$  (secondary vertex)
- Identify  $\Lambda^0 \rightarrow p \pi^-$  (tertiary vertex)

Peak at

- $M = 1862 \pm 2 \text{ MeV}$
- Significance  $\approx 4\sigma$



Analysis repeated by ZEUS



# Search for Pentaquarks Decaying to $\Xi\pi$ in DIS



Clean  $\Xi^0(1530)$  signal

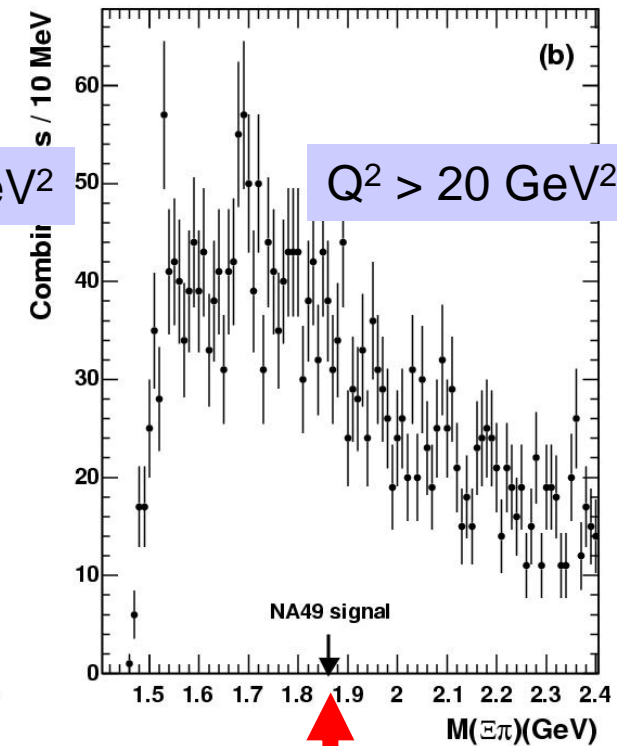
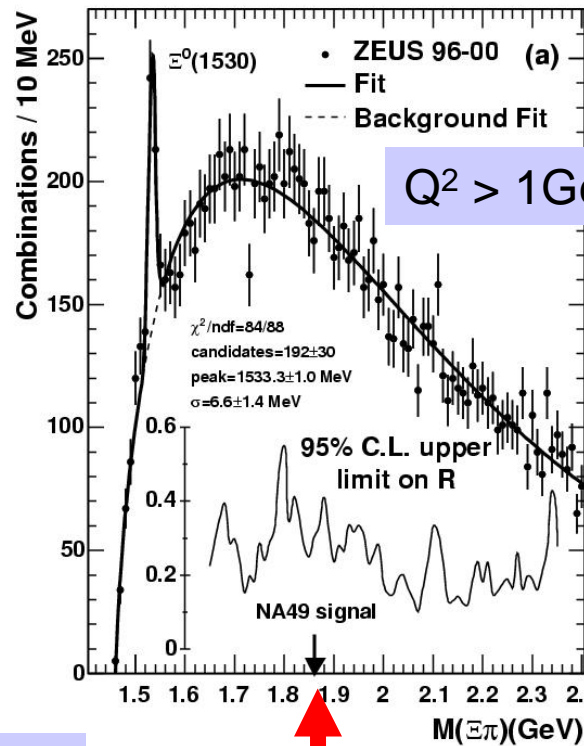
but

No pentaquark signal!



Different production  
mechanism?

ZEUS



NA49 signal

# Charm Pentaquark

What about  $uudd\bar{c}$ ?

Recent theoretical predictions give a mass between 2704 – 2997 MeV, width  $\approx$  20 MeV

Experimentally best suited decay channel:  $\theta_c^0 \rightarrow D^{*-}p$



- H1: Evidence for a Narrow Anti-Charmed Baryon State
- ZEUS: Search for a narrow charmed baryon state decaying to  $D^{*-}p$  in ep collisions at HERA



# Evidence for a Narrow Anti-Charmed Baryon State



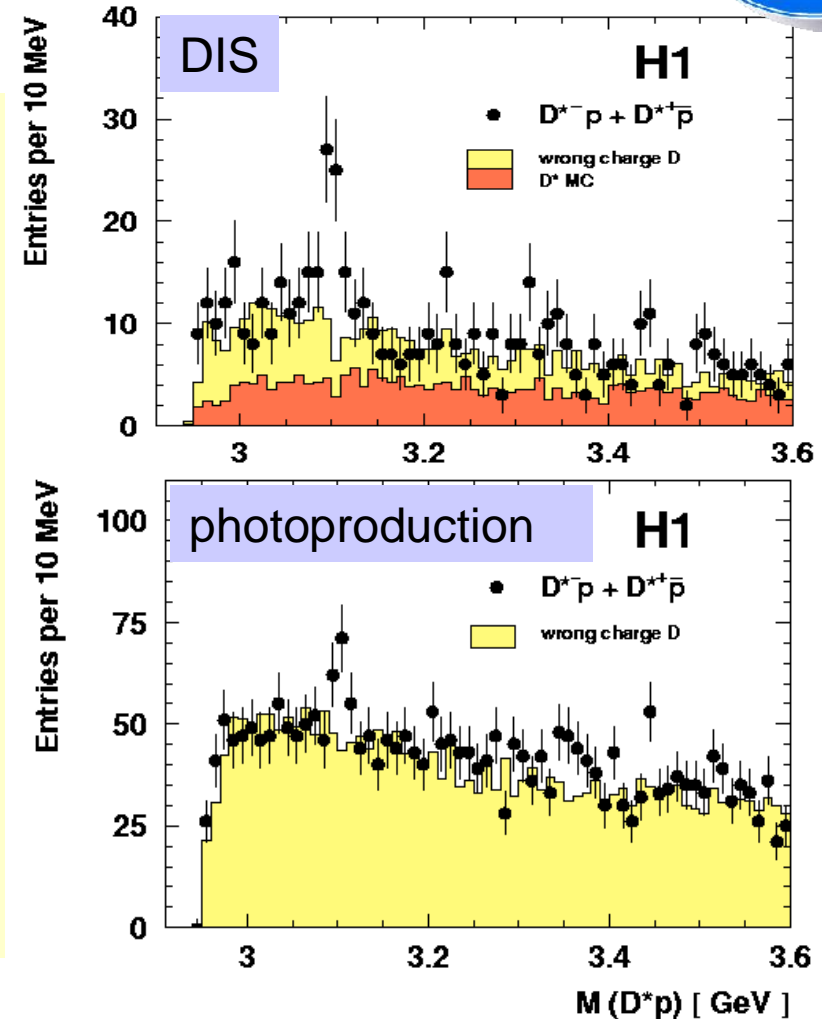
Search for  $\theta_c^0 \rightarrow D^{*-}p + \text{c.c.}$

Selection:

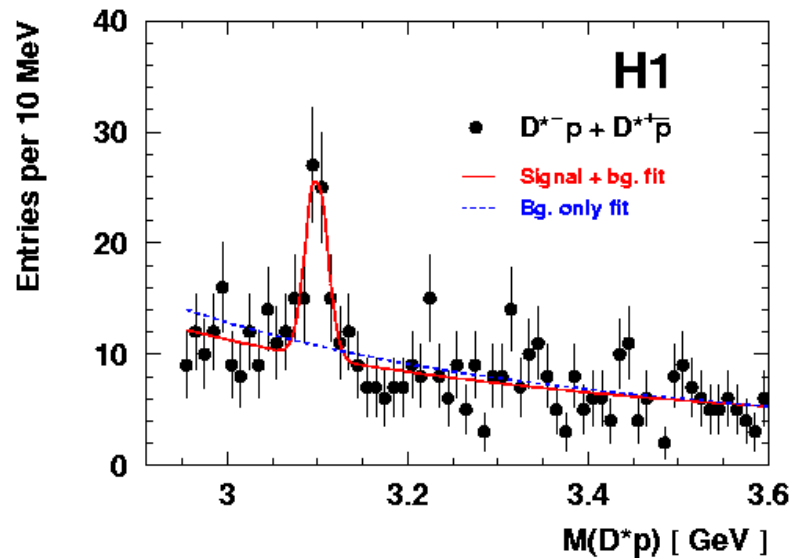
- Identify  $D^{*-} \rightarrow D^0\pi^- \rightarrow (K^+\pi^-)\pi^-$  ( $\Delta m$  method)
- Identify (anti-)proton with  $dE/dx$

Signal observed at approx. 3.1 GeV in DIS and photoproduction sample

Good description of background



# Evidence for a Narrow Anti-Charmed Baryon State: significance estimation

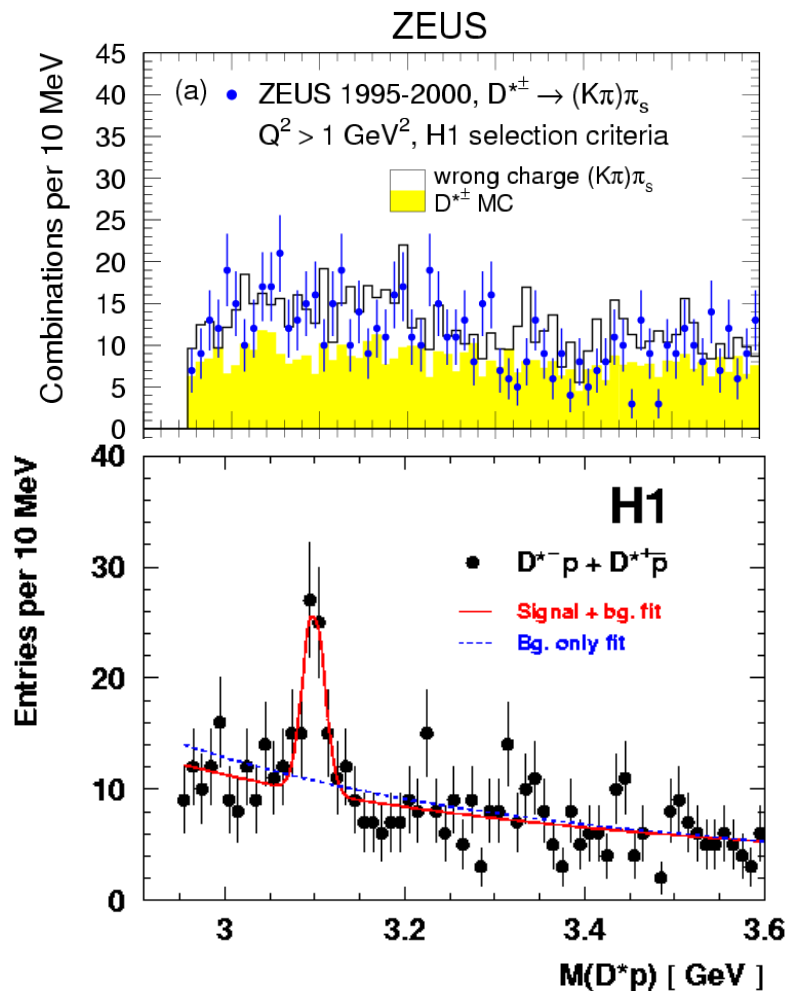


- $N_s = 50.6 \pm 11.2$  from **background + signal hypothesis**
- Mass  $3099 \pm 3$  (stat.)  $\pm 5$  (syst.) MeV
- Width  $12 \pm 3$  (stat.) MeV
- $N_s + N_b = 95$   $D^*p$  candidates within  $2\sigma$
- $N_b = 51.7 \pm 2.7$  from **background only hypothesis**

- Significance estimate based on the **background only hypothesis**

Background fluctuation probability  $4 \times 10^{-8}$  (**Poisson**)  $\equiv 5.4 \sigma$  (**Gauss**)

# Search for a narrow charmed baryon state decaying to $D^{*-}p$



H1 analysis repeated by ZEUS in similar region of phase space



No observation of  $\theta_c^0$  signal in DIS (and photoproduction) sample



Observations of H1 and ZEUS are **not** compatible

$N_\theta/N_{D^*}$	
H1	ZEUS
$1.46 \pm 0.32\%$	$< 0.35\%$ (95% C.L.)

# Observation of $K_S^0 K_S^0$ Resonances in DIS



Selection:

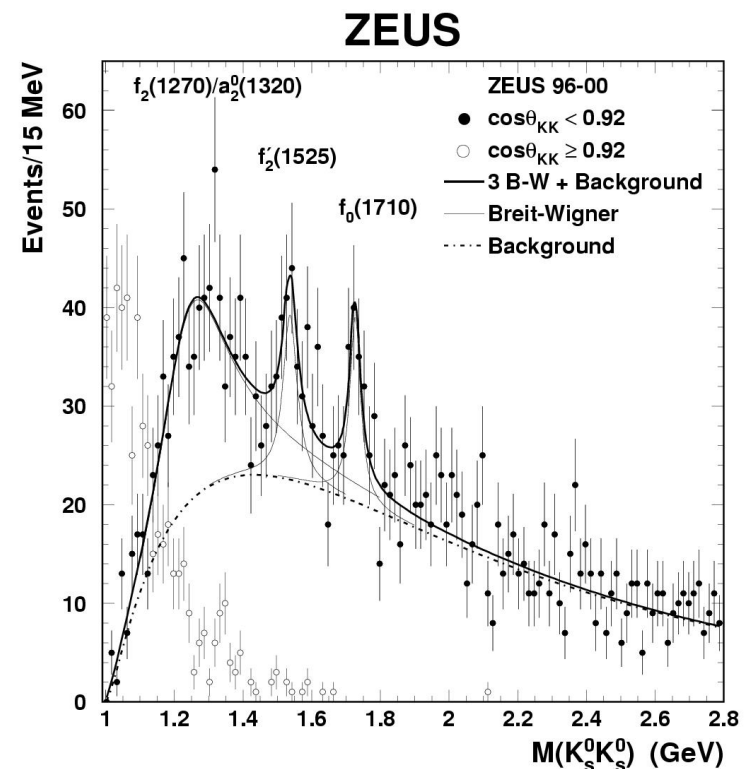
- DIS sample
- Identify  $K_S^0 \rightarrow \pi^+ \pi^-$  (secondary vertex)
- $\cos \theta_{KK} < 0.92$

Two states observed:

- $M = 1537^{+9}_{-8}$  MeV
- width =  $50^{+34}_{-22}$  MeV
- consistent with  $f'_2(1525)$
  
- $M = 1726 \pm 7$  MeV
- width =  $38^{+20}_{-14}$  MeV
- mass consistent with glueball candidate  $f_0(1710)$ , but narrower than observed by previous experiments



First observation, at an ep collider, of  $K_S^0 K_S^0$  final states  $f'_2(1525)$ ,  $f_0(1710)$



# Conclusions

- $\theta^+(1530)$ : evidence for narrow baryonic state decaying to  $K^0_S p$  at  $M=1521.5$  GeV seen by ZEUS
- $\Xi^{--}(1860)$ : no evidence from ZEUS for a state decaying to  $\Xi^-\pi^-$  seen
- $\theta^0_c(3100)$ : evidence seen by H1, not confirmed by ZEUS
- First observation, at an ep collider, of  $K^0_S K^0_S$  final states  $f'_2(1525)$ ,  $f_0(1710)$  by ZEUS



- In general no consistent picture yet
- HERA 2 data will provide higher statistics