

Evidence for exotic baryon decaying to K_S^0 - (anti)proton



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for the ZEUS Collaboration

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Motivation

- ⇒ Significant interest in baryon spectroscopy triggered by recent observations of possible pentaquark at **1530 MeV and width <15 MeV**, predicted by D.Diakonov, V.Petrov and M. Polyakov;
- ⇒ In this study, we attempt to find such a state by reconstructing K^0 -(anti)proton invariant mass;
- ⇒ We use the ZEUS central tracking region, where the particle production is dominated by fragmentation.

Event selection

- 121 pb^{-1} , 1996-2000, e^+p , e^-p collisions, CM energy of 300-318 GeV;
- $Q^2 > 1 \text{ GeV}^2$.

K^0_S selection

- CTD tracks, $p_T > 150 \text{ MeV}$, $-1.75 < \eta < 1.75$;
- K^0_S reconstructed from secondary-vertex tracks;
- Photon conversions removed: $M(e^+e^-) < 50 \text{ MeV}$;
- Λ 's removed $M(\pi p) < 1.121 \text{ GeV}$;
- $p_T(K^0) > 300 \text{ MeV}$;
- $|\eta(K^0)| < 1.5$.

Resolution for $M(K^0_S - (\text{anti})\text{proton})$ masses $\sim 5 \pm 2 \text{ MeV}$

K^0_s mass peak

Double Gaussian +
linear background
for the fit

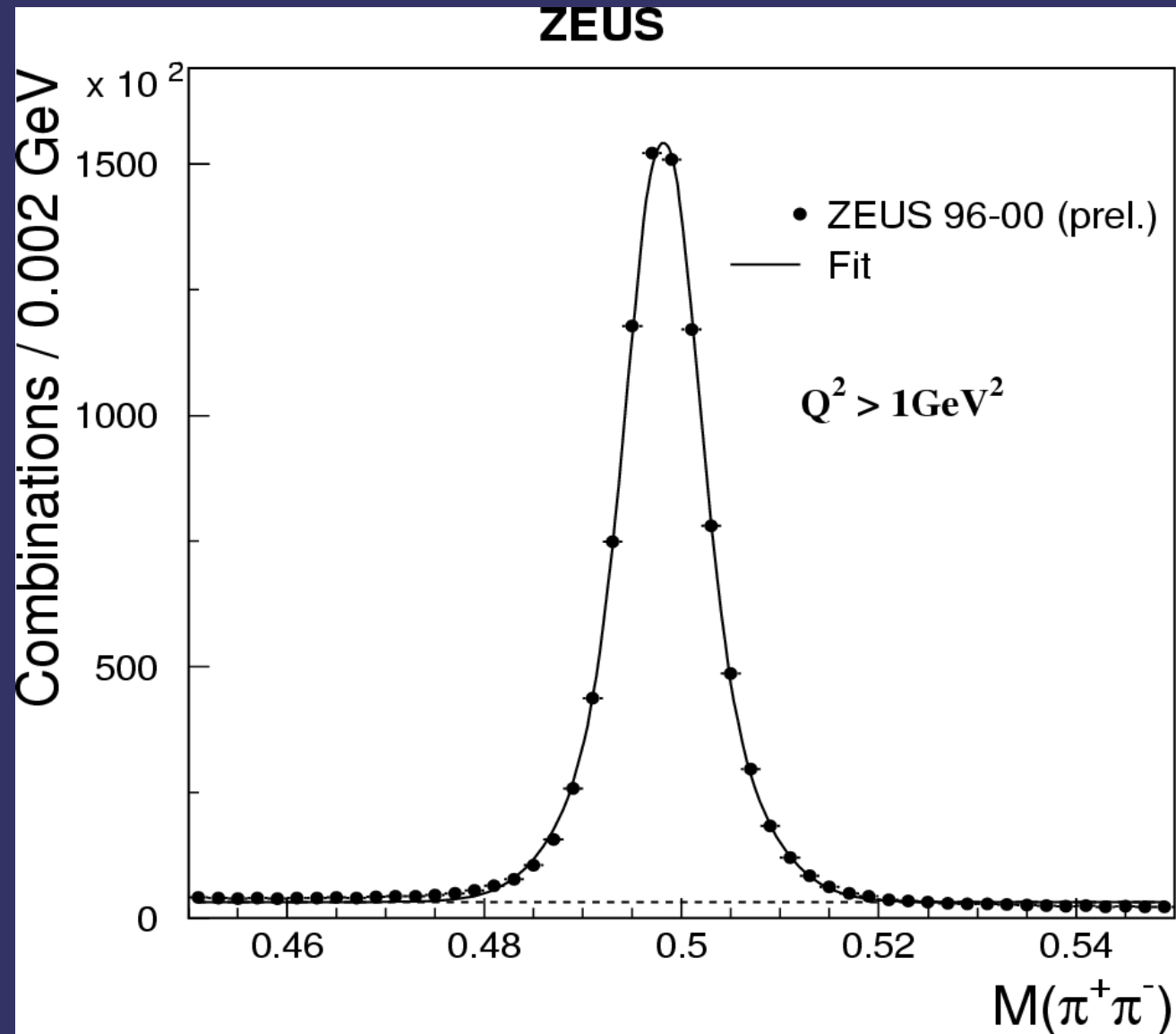
869690 \pm 1016 candidates

3222 background (0.37%)

Peak at:

498.12 \pm 0.01 (stat) MeV

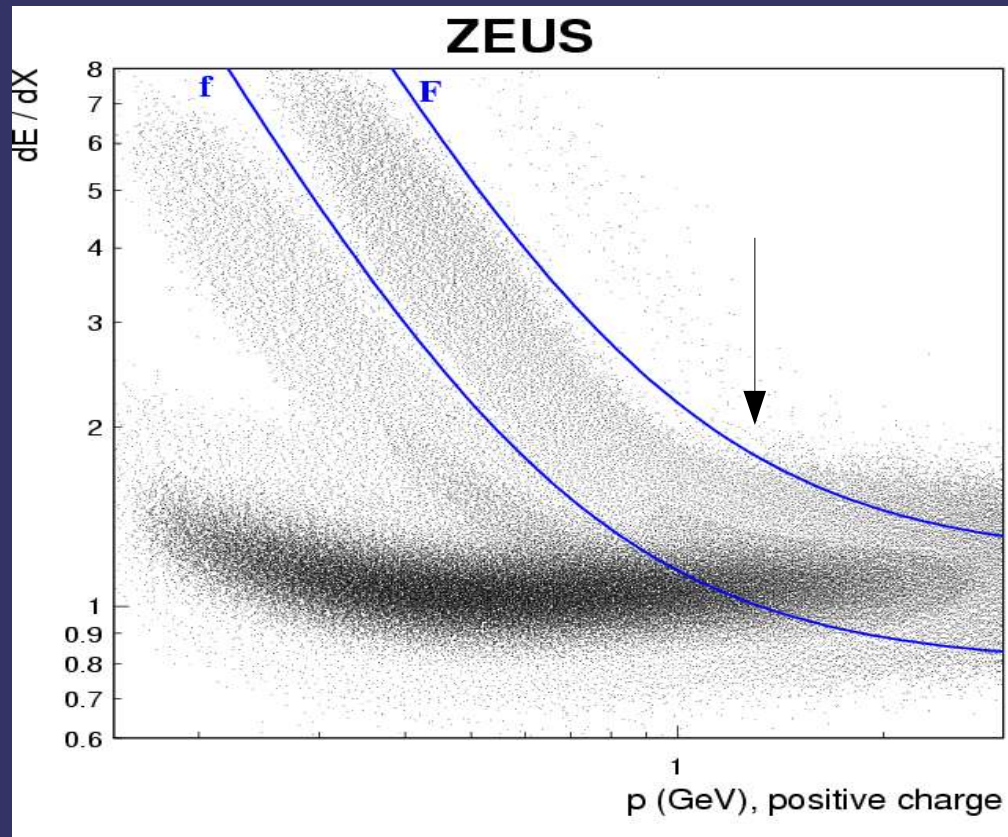
Shift by +0.8 MeV
from the PDG value



Proton and antiproton selection

Only primary tracks are taken with: $f < dE/dX < F$

- ◆ found from a visual examination of dE/dX
- ◆ verified using a sample with reconstructed Λ
- ◆ (anti)protons from ARIADNE have a similar band

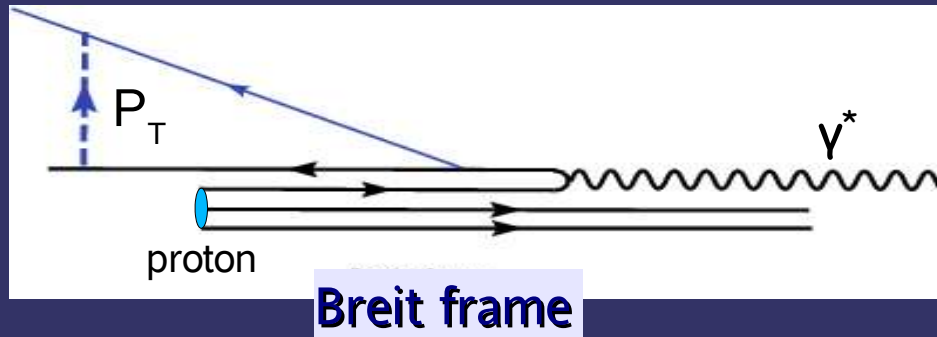


Proton and antiproton selection

Most protons are concentrated in the region $p \sim 0.8-2 \text{ GeV}$:

☞ Large pion background

- Reject tracks with $p > 1.3 \text{ GeV}$ inside the dE/dX band;
- Assign pion mass to proton candidate, reconstruct $K^0\pi$ mass, rejects pions from K^* : $800 < M(K^0\pi) < 980 \text{ MeV}$;
- $E(\text{proton}) > E(K^0)$;
- $P_T > 0.5 \text{ GeV}$ in the Breit frame to look at gluon-rich DIS region;

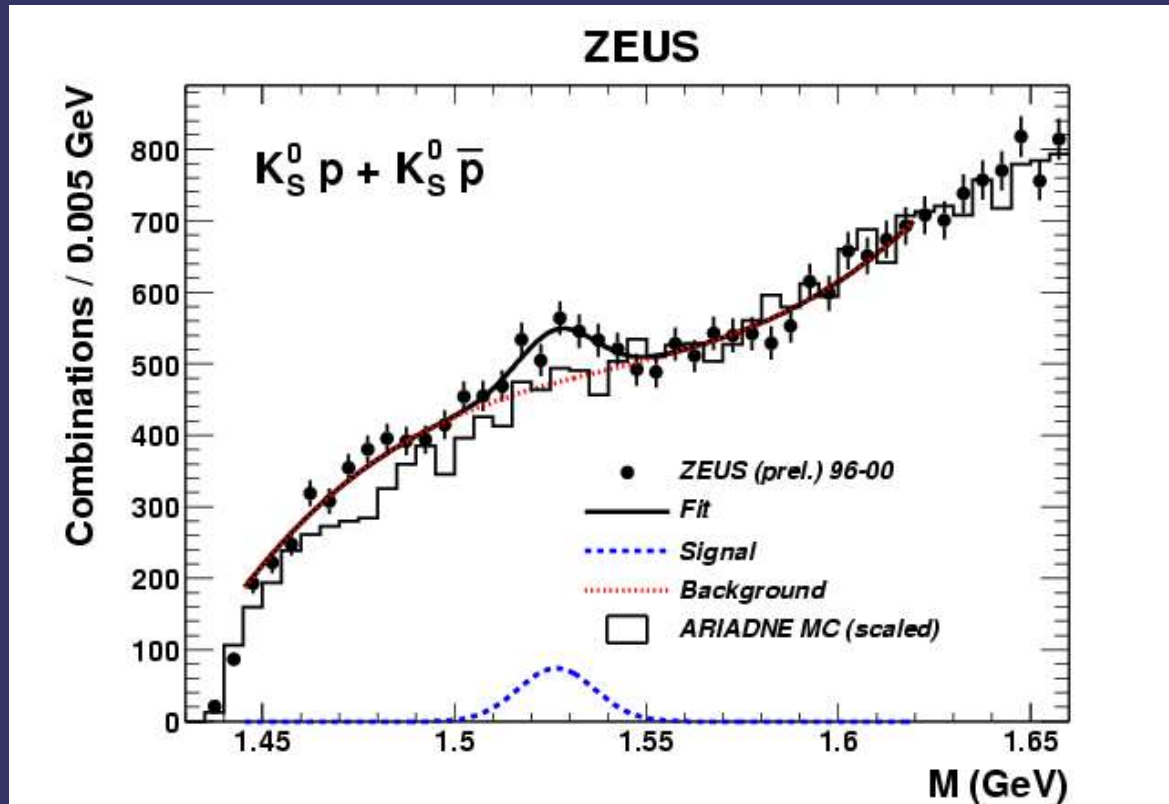


Possible reflections from known resonances

- Plenty of weakly decaying resonances cannot be reflected to narrow peaks;
- Narrow decays from charmed/bottom mesons cannot give reflections due to their large masses;
- MC contains reflections from known decays or possible misreconstruction.

ZEUS preliminary results

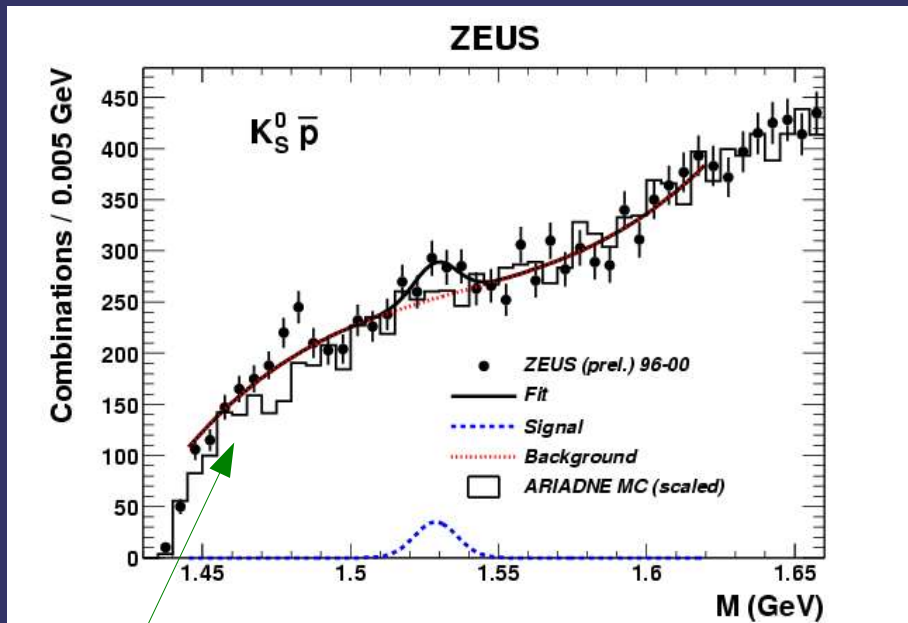
Fit: Gaussian + P3 (free parameters)



Combined sample: 372 ± 75 candidates
peak = $1527 \pm 2(\text{stat})$ MeV, $W = 10 \pm 2(\text{stat})$ MeV

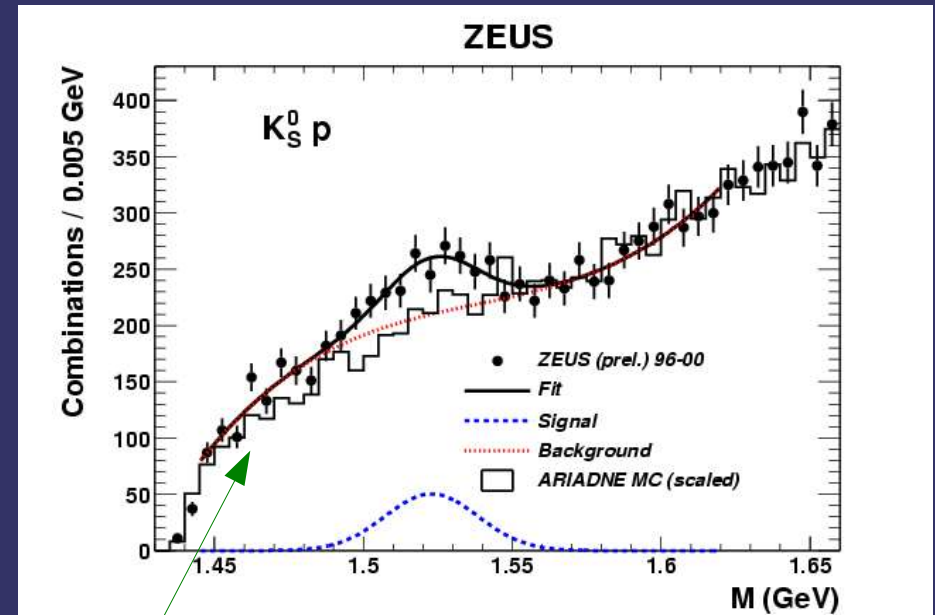
ZEUS preliminary results

Fit: Gaussian + P3 (free parameters)



$\Sigma(1480)$ bump?

K^0 -antiprotons: 126 ± 50 candidates
peak = 1529 ± 3 (stat) MeV, $W = 7 \pm 3$ MeV (stat)



$\Sigma(1480)$ bump?

K^0 -protons: 393 ± 86 candidates
peak = 1523 ± 3 (stat) MeV, $W = 16 \pm 3$ (stat) MeV

Systematic study

- Several systematic checks were performed:
 - ✓ Momentum cut varied within 1.1-1.7 GeV;
 - ✓ Q^2 raised to 20 GeV²;
 - ✓ K^* cut removed;
 - ✓ P_T in Breit frame removed (decreases the signals by $\sim 0.8 \sigma$);
 - ✓ Fit done with Breit-Wigner (instead of Gaussian) + different order polynomials.

Peak position found to be robust

- Most convincing check: combine K^0 with tracks from region $dE/dX < 1.2$ and $p < 0.9$ GeV, where all particles except for (anti)protons can contribute to mass spectra:
 - NO 1527 MeV PEAK!

Summary

- A signal at $1527_{\pm 2}(\text{stat.})$ MeV, with a Gaussian width of $10_{\pm 2}$ MeV:
 - ✓ $\sim 4\text{-}5 \sigma$ statistical significance (from Gaussian fit);
 - ✓ exists for both K^0 -protons and K^0 -antiproton channels (antipentaquark);
 - ✓ consistent with the predicted pentaquark (1530 MeV, <15 MeV width);
 - ✓ Possible systematic shift for the peak is within ~ 1 MeV (from K^0_S , Λ and K^* measurements), but full systematics need to be estimated.
- First measurement in HEP colliding experiment.

