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H1 search for a Narrow Baryonic Resonance Decaying to $K^0_s p$ ($K^0_s \bar{p}$)

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On behalf of the H1 Collaboration

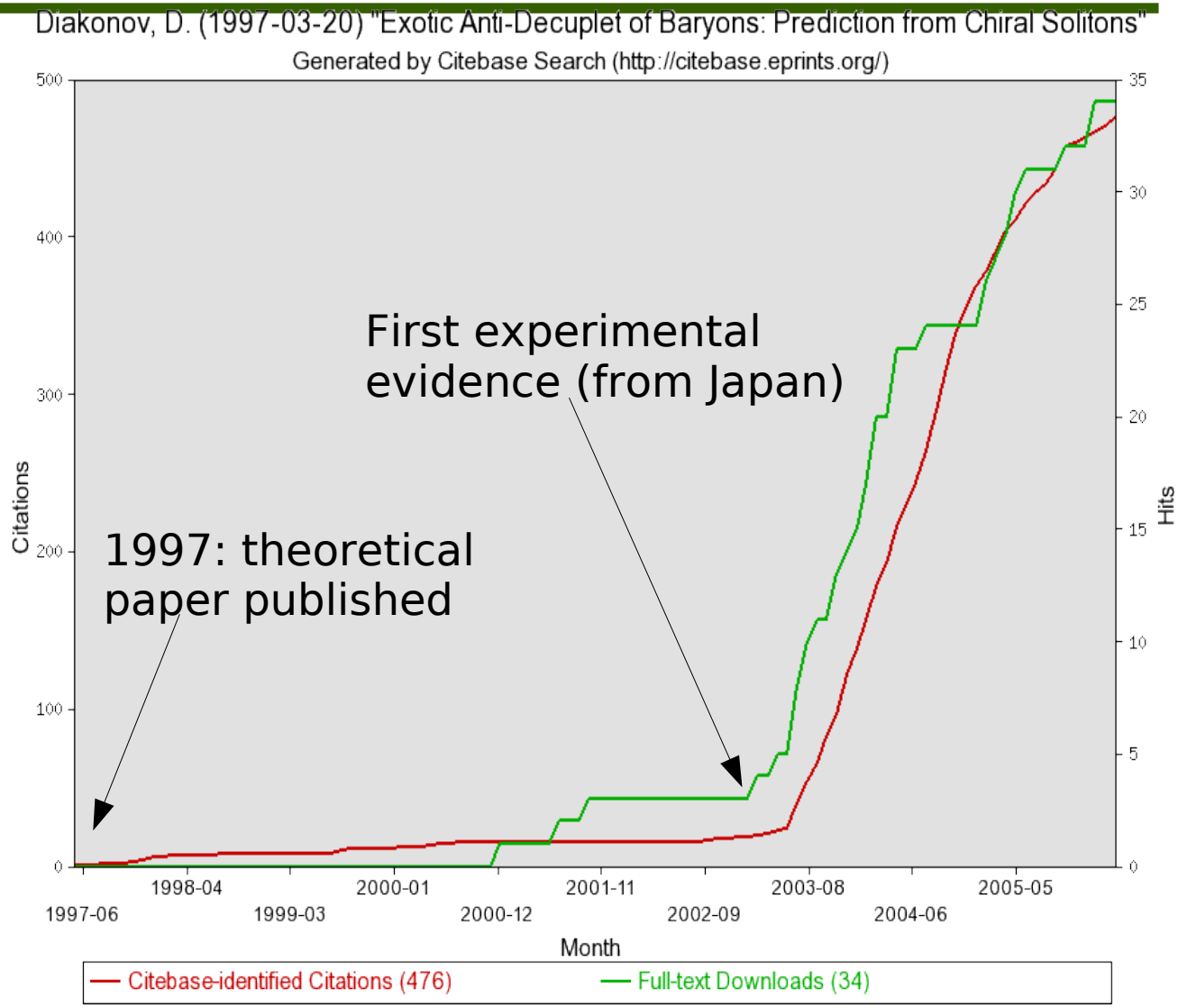
- Introduction
- Event selection and K^0_s / proton reconstruction
- Results
- Summary

Introduction I

Theoretical paper from 1997: prediction for a 5-quark state at a certain mass and with a narrow width.

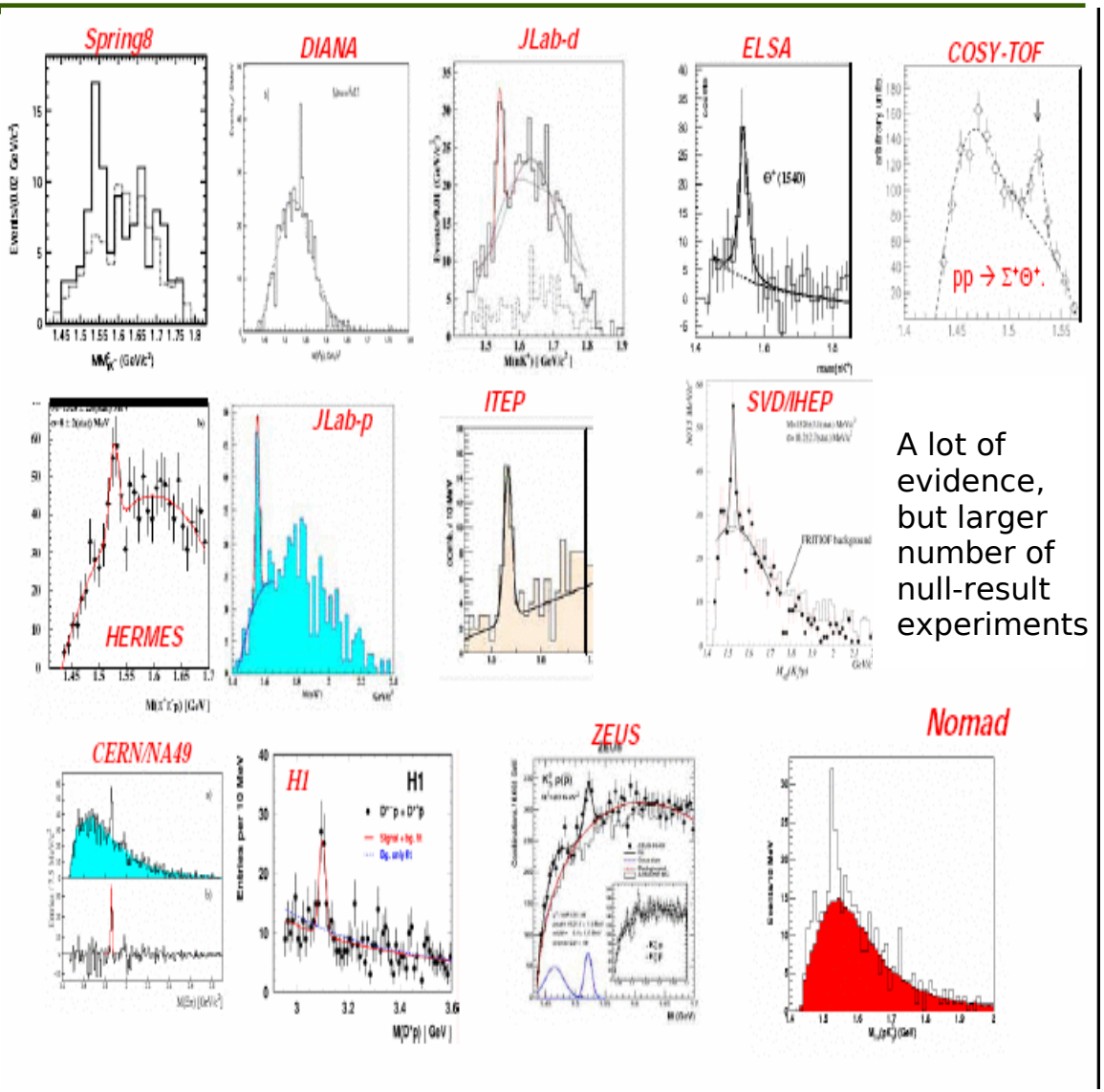
$uudd\bar{s}$ -quark state with possible decays to K^+n (known strangeness) and $K^0_s p$.

The experimental evidence in 2003 for such state triggers a lot of experimental and theoretical activities.



Introduction II

- A lot of evidence, but not a discovery, since the statistics is low.
- Several similar experiments gave null results.
- High statistics experiments from e^+e^- and hadron accelerators gave null results.



A lot of evidence, but larger number of null-result experiments

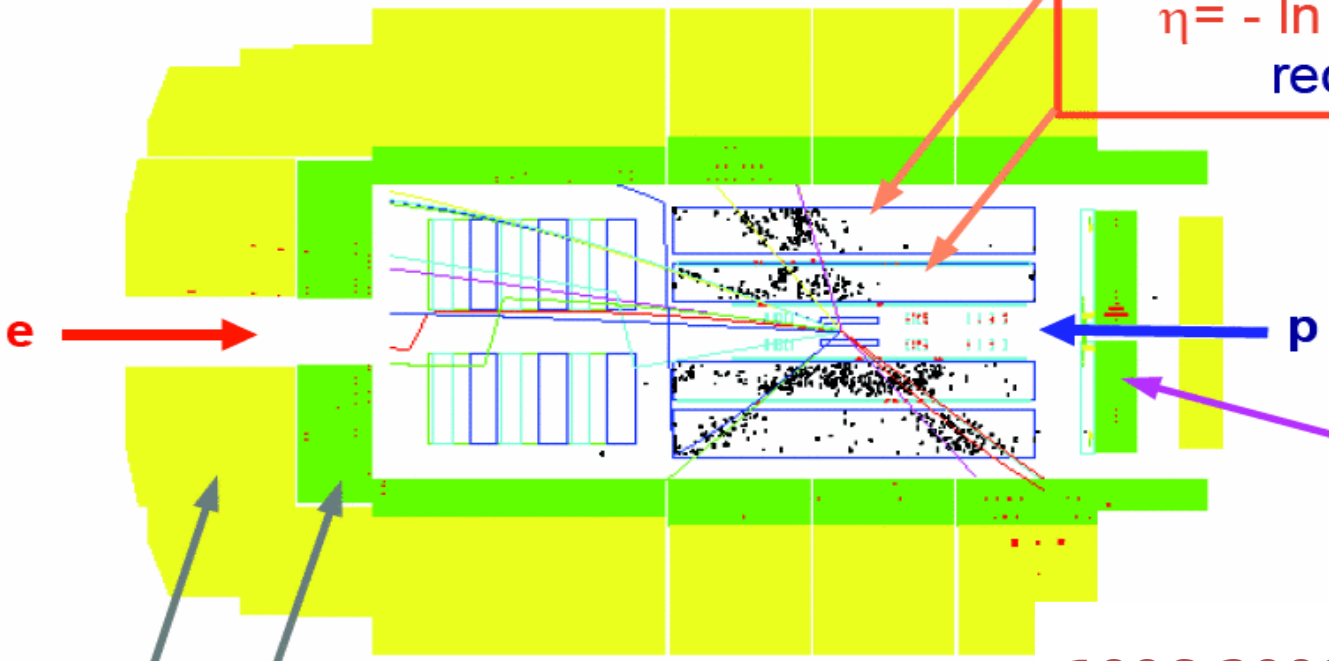
The question of existence of pentaquark state is still open.

Clarification can only come with additional experimental data.

Selection of events with the H1 detector

E_e=27.6 GeV
E_p=920 (820) GeV
$\sqrt{s}$ ≈300-320 GeV

Central jet chamber CJC
tracking, particle ID via dE/dx
acceptance $-1.75 < \eta < 1.75$
$\eta = -\ln \tan \theta/2$
rec. of K^0_s, protons



backward
electromagnetic
calorimeter SpaCal
rec. of scattered e

Lar Calorimeter

1996-2000 year, 74 pb^{-1}

DIS events, $5 < Q^2 < 100$ GeV^2,
$0.1 < y < 0.6$

K^0_s selection

Identification of K^0_s through it's decay to two charged pions. $K^0_s \rightarrow \pi^+\pi^-$

Search for secondary vertex, made by two oppositely charged tracks.

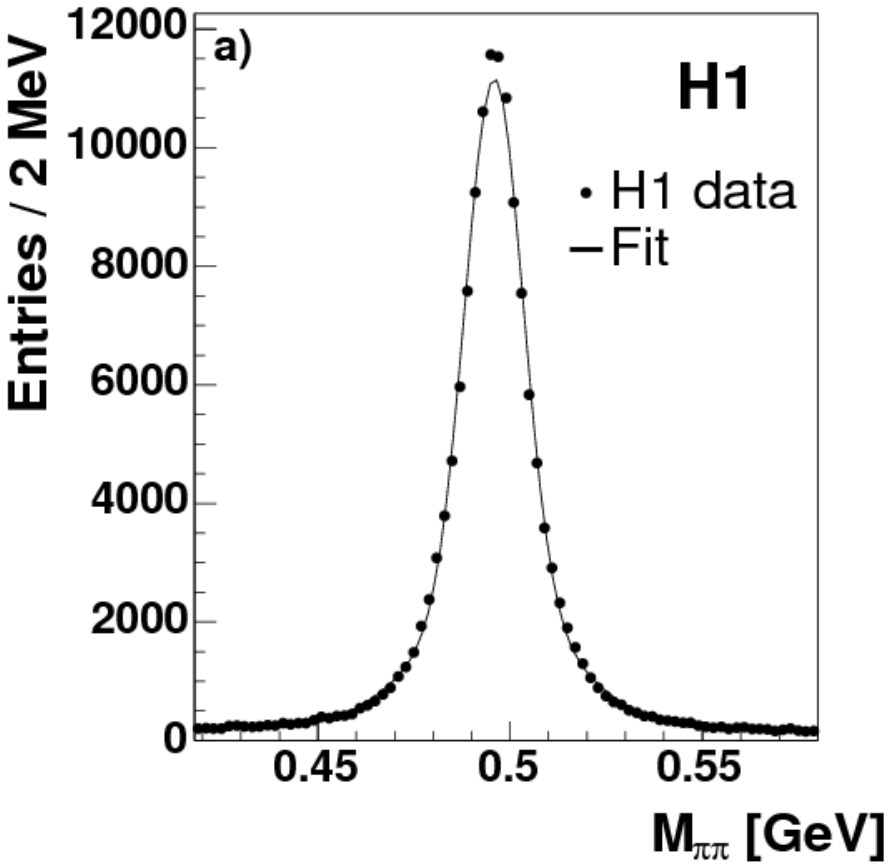
$P_T(K^0_s) > 0.3$ GeV, $|\eta| < 1.5$

Combinatorial background from the Λ and γ-conversion is removed.

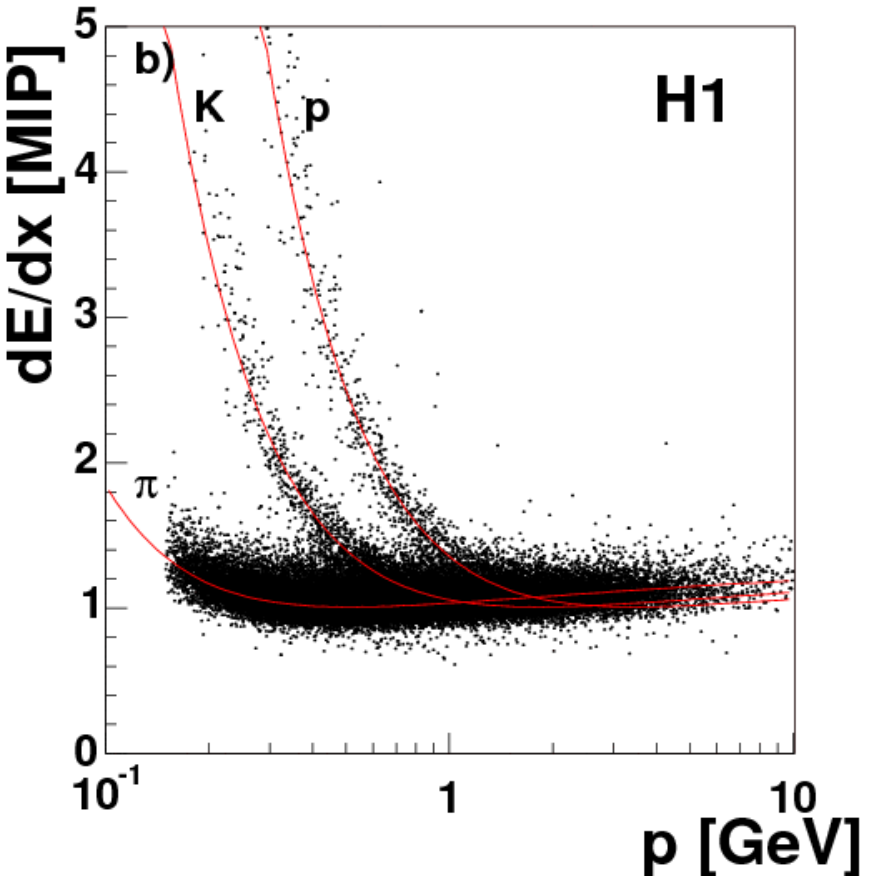
Large and clean K^0_s sample (132,000 K^0_s from the fit with the 3% background contamination)

Inclusive K^0_s sample

$5 < Q^2 < 100$ GeV^2



Identification of the protons



Resolution for the dE/dx ~ 8%

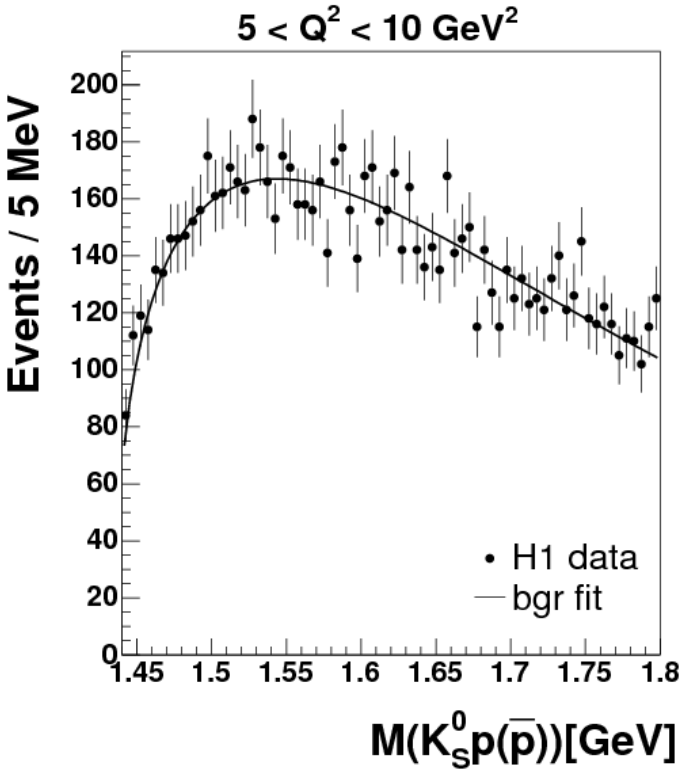
Most probable dE/dx values for different particles: phenomenological parametrisation.

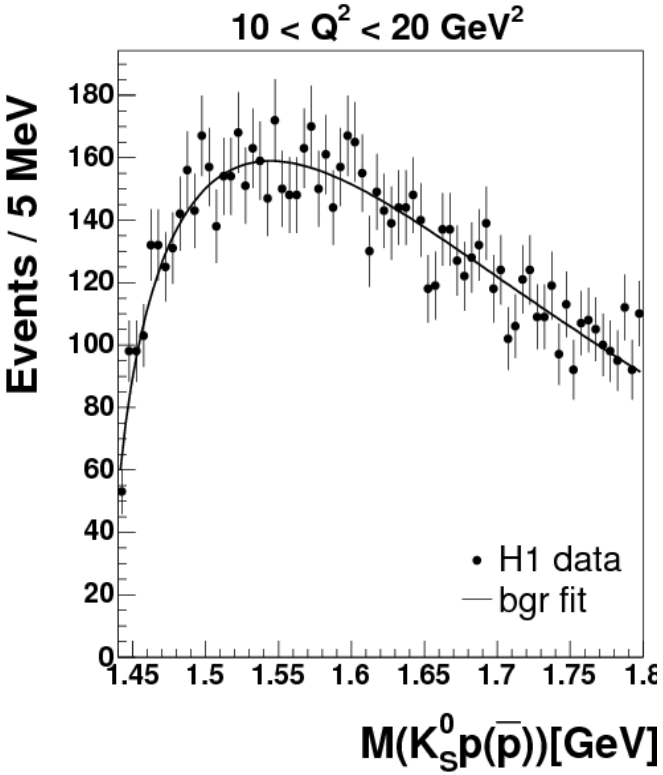
Likelihood approach is used to separate protons from other particles.

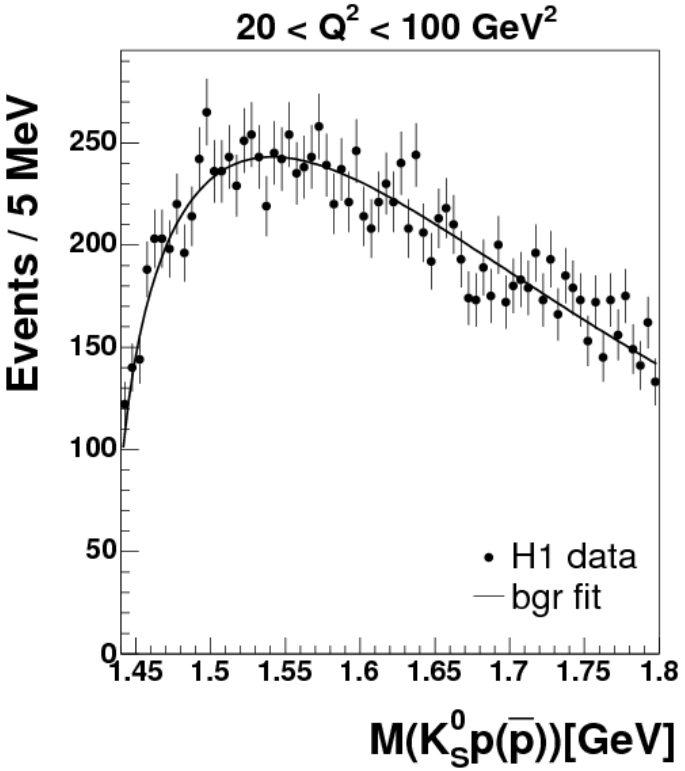
Efficiency varies between 65% and 100%.
MC describes the efficiency within the 5%

Invariant $K^0_s p(K^0_s \bar{p})$ mass

Visible kinematic range : $P_T(K^0_s p) > 0.3$ GeV, $|\eta| < 1.5$







$$background = \alpha (M - M_{thr})^{\beta} \exp(-(M - M_{thr})\gamma),\ M_{thr} = M_p + M_{K^0_s}$$

No significant signal is observed in any of the Q^2 bins

MC Simulation of Θ

The production mechanism for the Θ is unknown.

From the assumption that the production of Θ is similar to that of the strange baryons – a modified MC is used to estimate acceptance. The Σ^{*+} baryon was forced to decay to $K^0_s p$ and to be on mass shell.

The Θ signal was approximated as a Gaussian with width (as extracted from MC) varying with the mass (4.8 MeV@M=1.48 GeV , 11.3 MeV@M=1.7 GeV)

Use of the modified frequentist approach based on likelihood ratios, which takes the statistical and systematic uncertainties into account.

The systematic uncertainties are 11 % for the signal (efficiency, lumi calculation, event selection..) and 2 % for the background determination.

The upper limit is given for the process $ep \to e\,\theta(\bar{\theta})\,X \to e\,K^0\,p(\bar{K}^0\,\bar{p})\,X$

Calculation of upper limit on cross section

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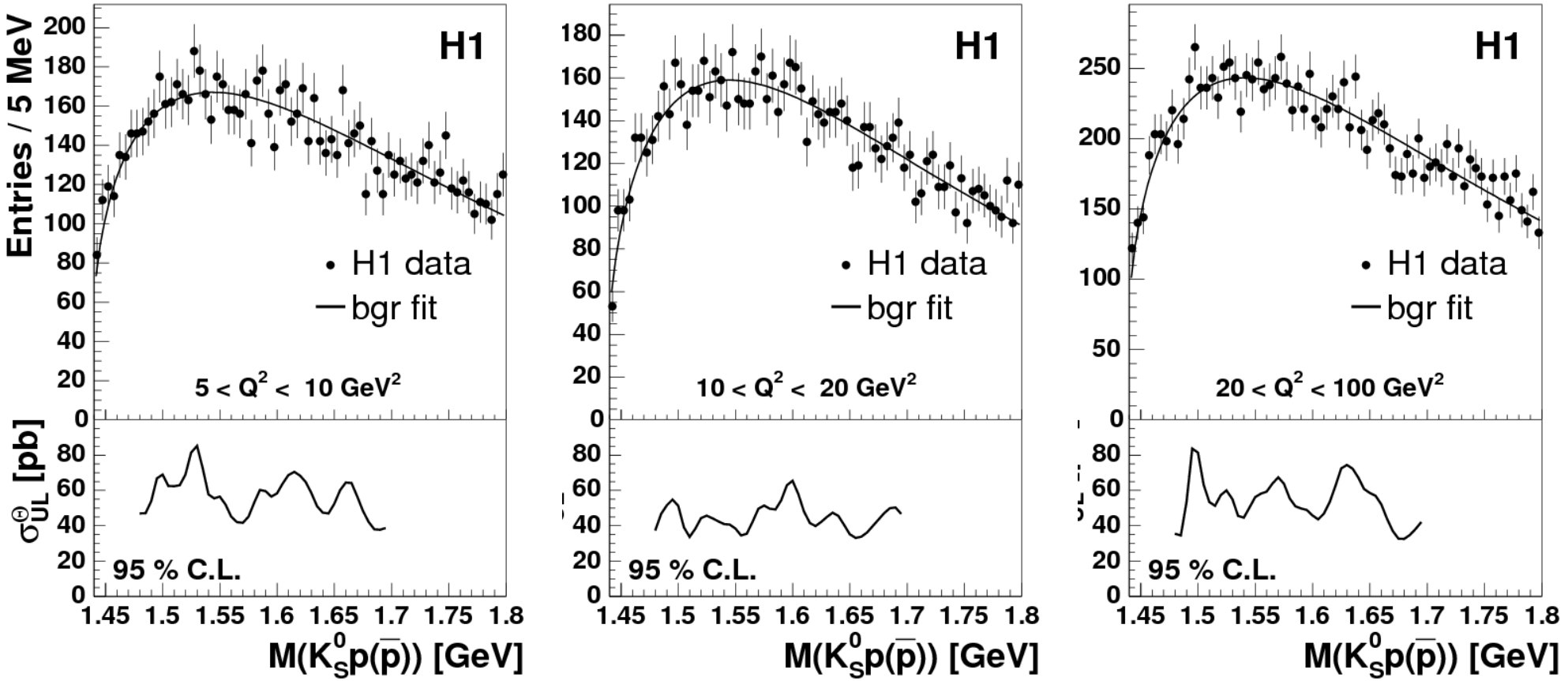
upper limit on the cross section



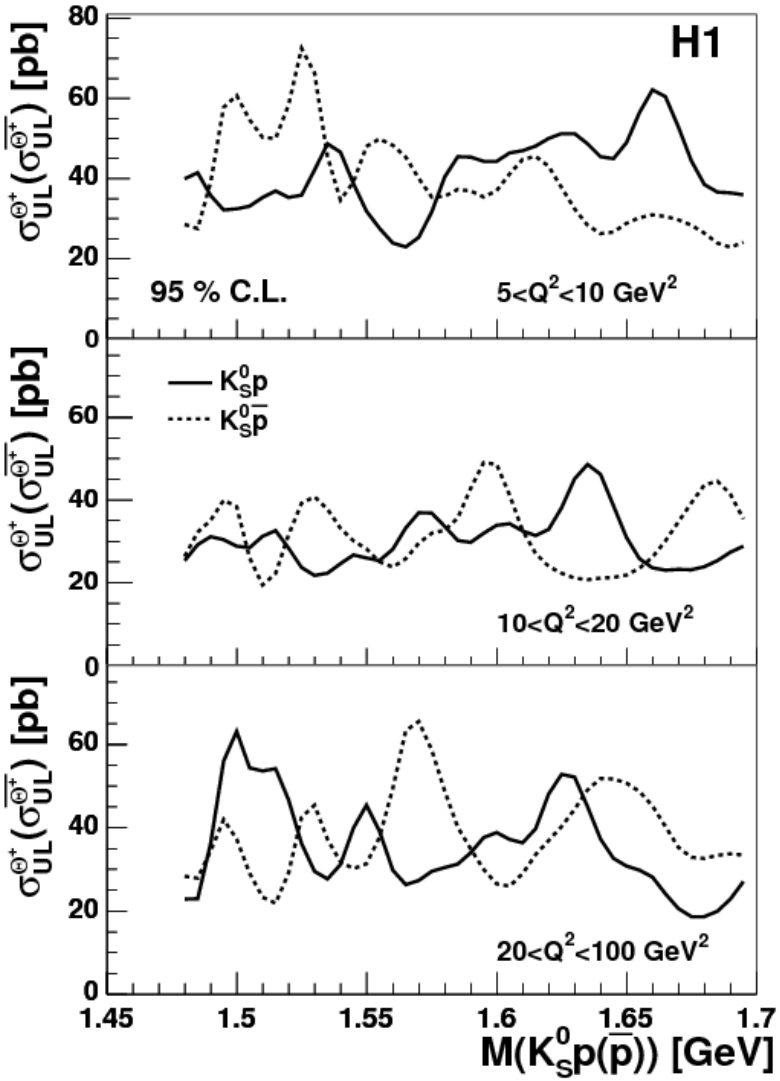
No fluctuation at the same mass in different Q^2 bins

upper limit on the cross section: baryon/anti-baryon case

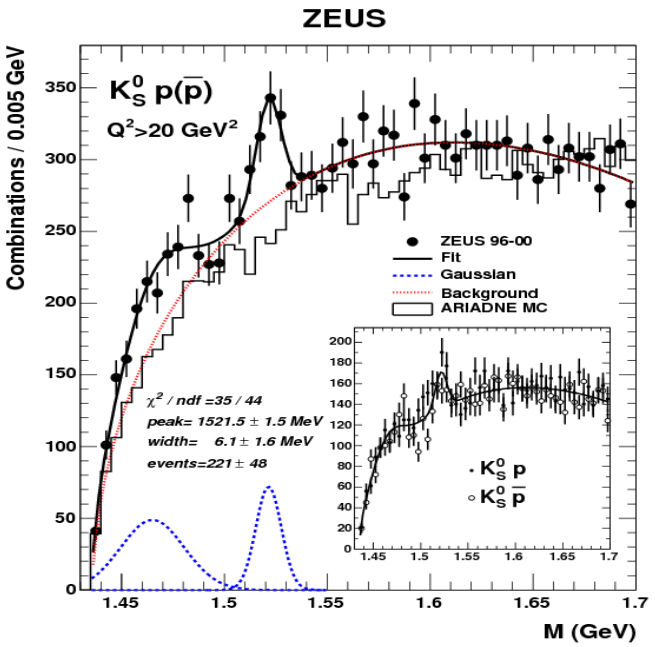
The limits for the $\theta/\bar{\theta}$ (decay involving proton or anti-proton) are comparable in size.

No narrow resonance is observed.

No fluctuation is present at the same mass for particle or anti-particle in different Q^2 bins.

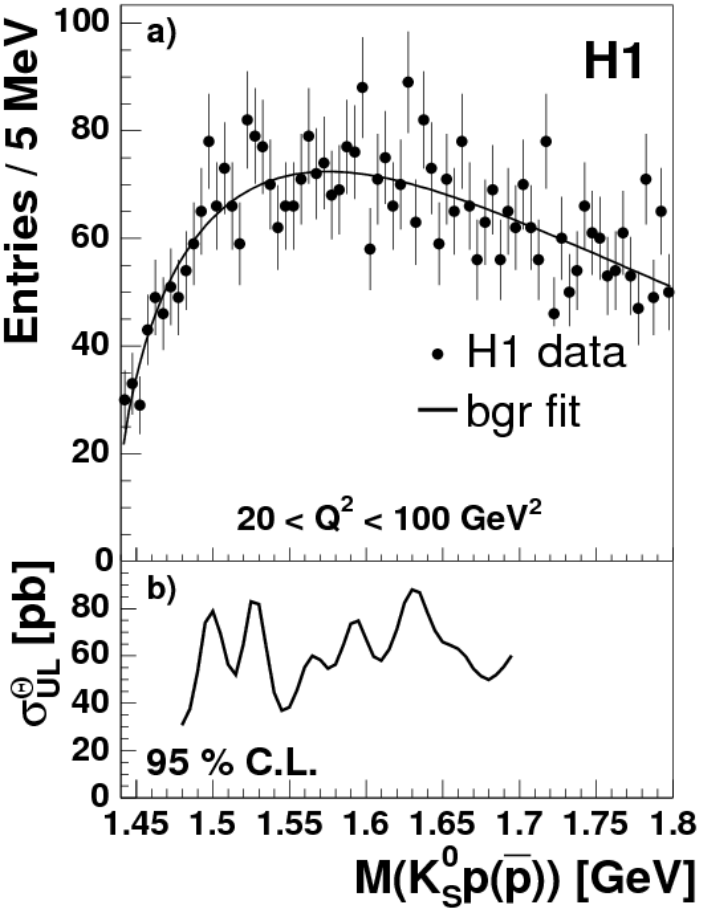


Comparison with the ZEUS signal I



H1 analysis, restricted to $Q^2 > 20.0$ GeV^2 and to low momentum ($P(p) < 1.5$ GeV) :

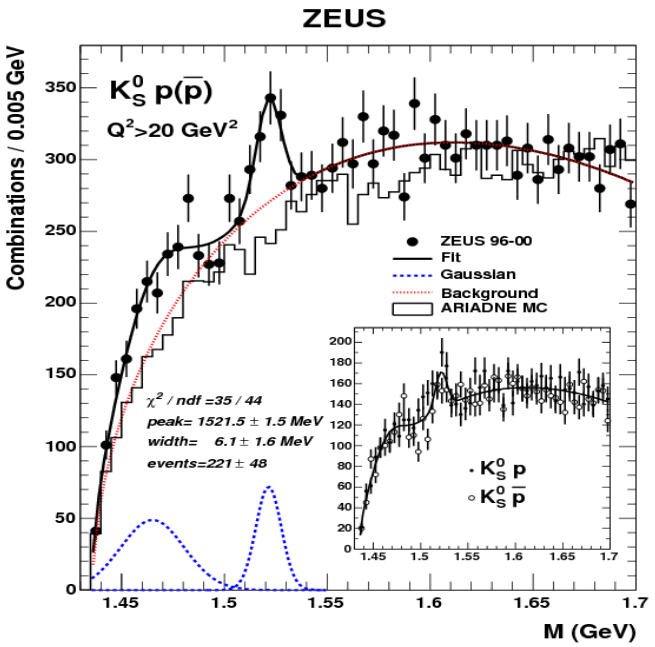
no significant signal is observed.



signal at $Q^2 > 20.0$ GeV^2
$0.04 < y < 0.95$,
narrow width, M=1.522 GeV

band selection (proton) :
$P(p) < 1.5$ GeV

Comparison with the ZEUS signal II

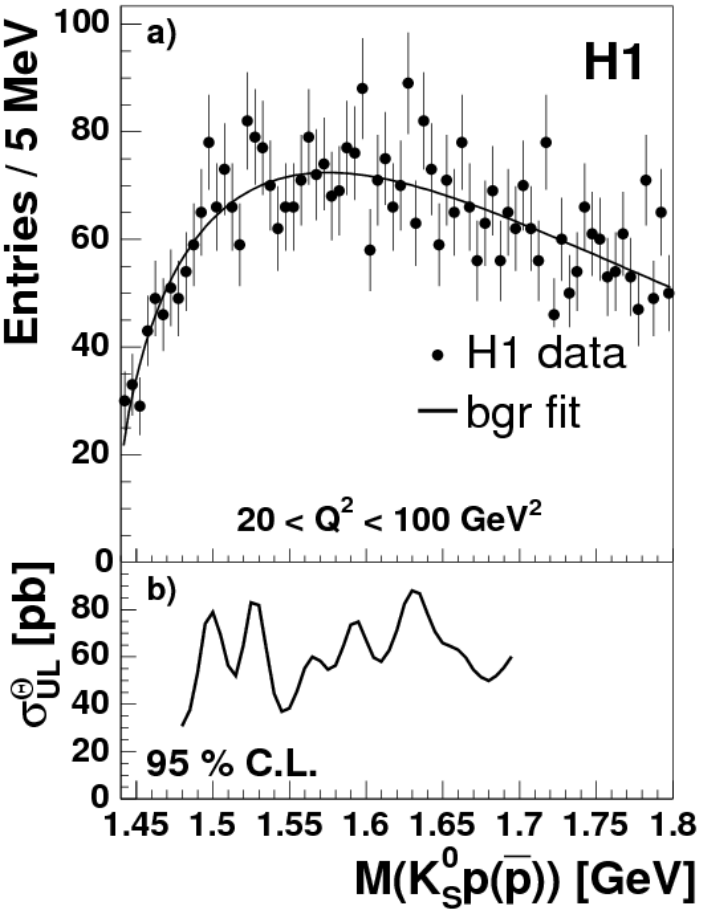


H1:
$20.0 < Q^2 < 100.0$ GeV^2
$0.1 < y < 0.6$

$$\sigma(M=1.52) < 72\ pb\ (95\ C.L.)$$

(interpolated to ZEUS y-region):

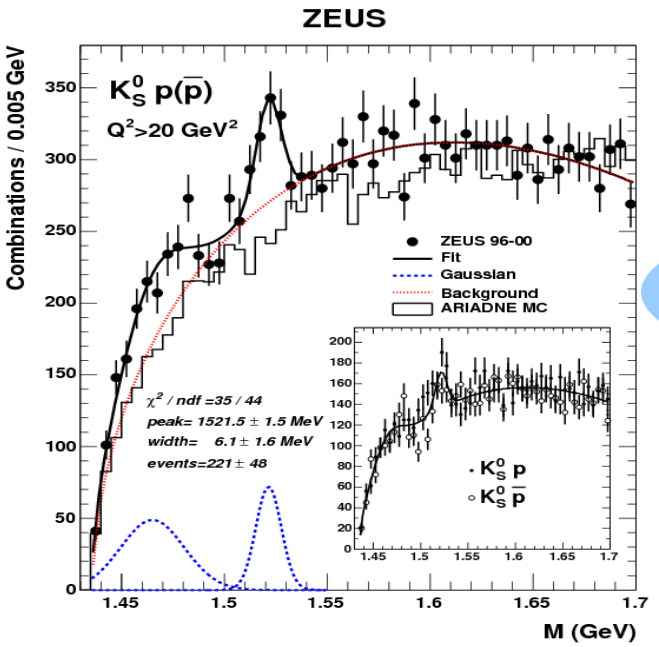
$$\sigma(M=1.52) < 100\ pb\ (95\ C.L.)$$



ZEUS : preliminary result (DIS 2005)
$Q^2 > 20.0$ GeV^2, $0.04 < y < 0.95$

$$\sigma(e\,p \to e\,\theta\,X \to e\,K^0\,p\,X) = 125 \pm 27\,(stat)^{+38}_{-28}\,(syst)\ pb$$

Comparison with the ZEUS signal III

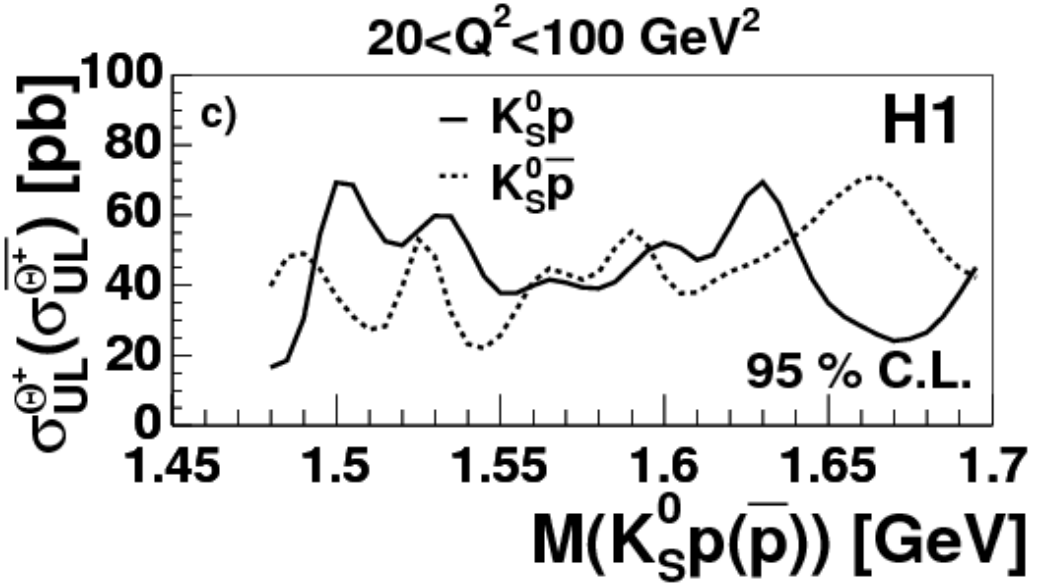


signal at Q^2>20.0 GeV^2
0.04 < y < 0.95,
narrow width, M=1.522 GeV

band selection (proton):
P(p) < 1.5 GeV

H1 analysis,
restricted to Q^2 > 20.0 GeV^2
and to low momentum
(P(p) < 1.5 GeV)

No significant signal is observed in $K^0_s p / K^0_s \bar{p}$ combinations



Summary

- H1 performed a search in DIS for a narrow resonance decaying to $K^0_s p / K^0_s \bar{p}$
- No significant signal observed in the Q^2 region between 5 and 100 GeV^2

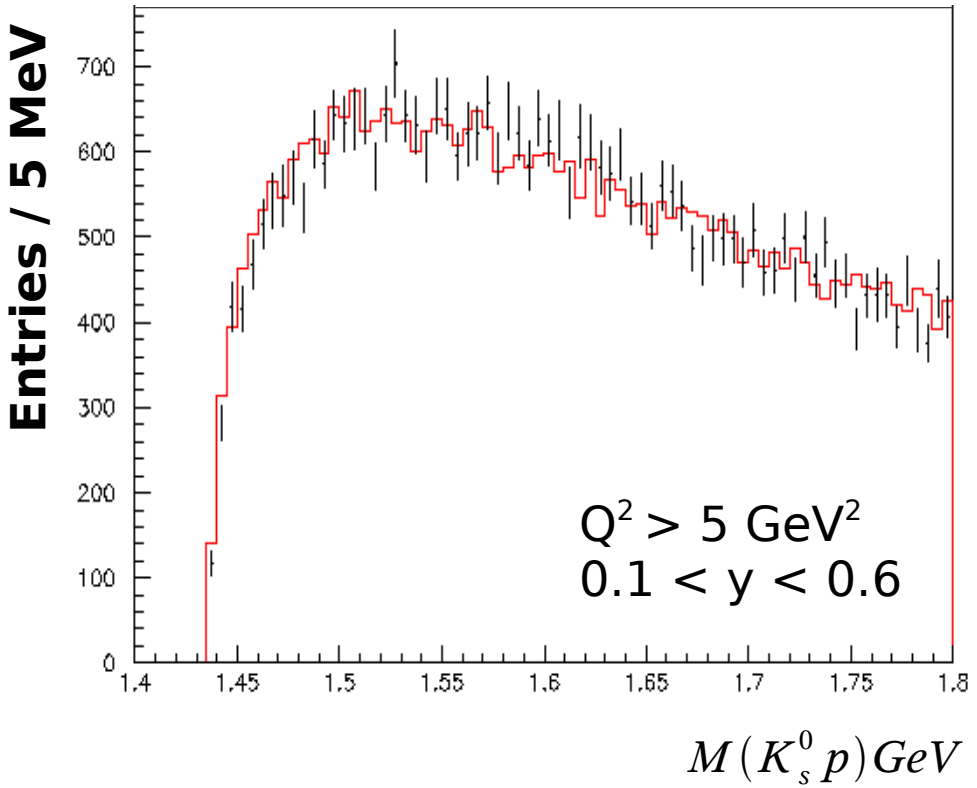
- Assuming that in the fragmentation region the production of the pentaquark is similar to that of strange baryons, the mass dependent limits at 95% C.L. on the cross section are derived.

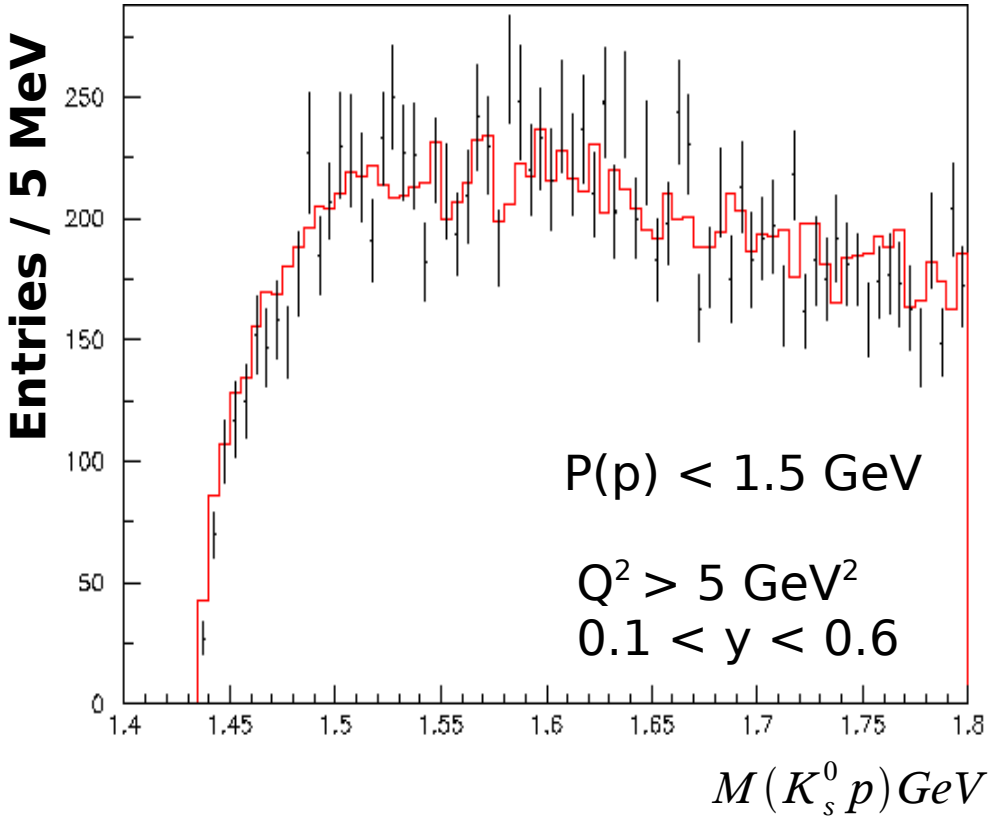
95% C.L. $\sigma(ep \to e\theta(\bar{\theta})X \to eK^0 p(\bar{K}^0 \bar{p})X) < 30-90\,pb$ for Θ mass = 1.48 - 1.7 GeV

- With similar selection and phase space as in the ZEUS analysis:
  no significant signal observed
  H1 does not support the ZEUS evidence,
  as expressed in their preliminary cross section

BACKUP SLIDES

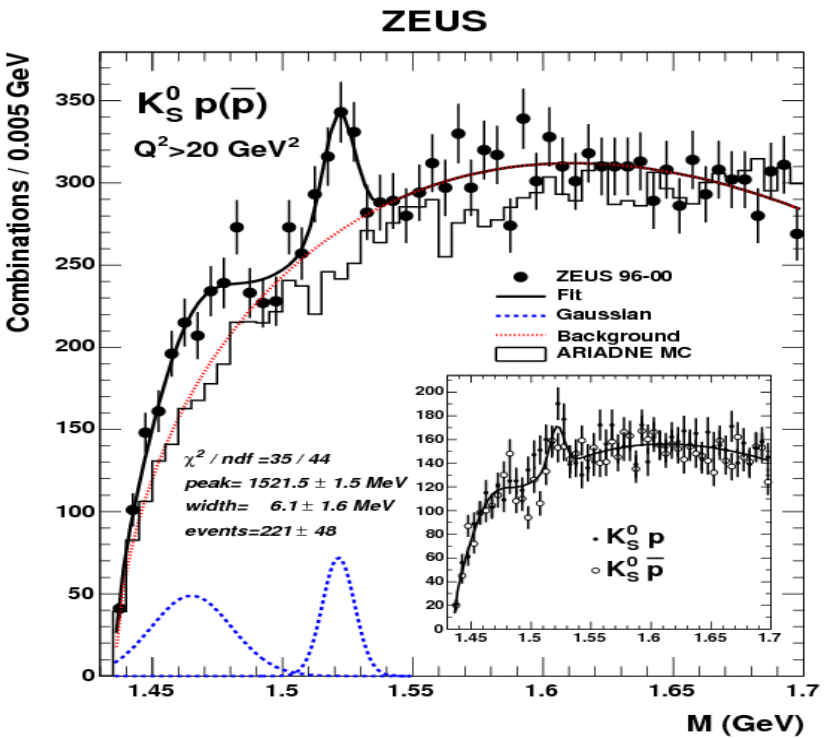
MC description

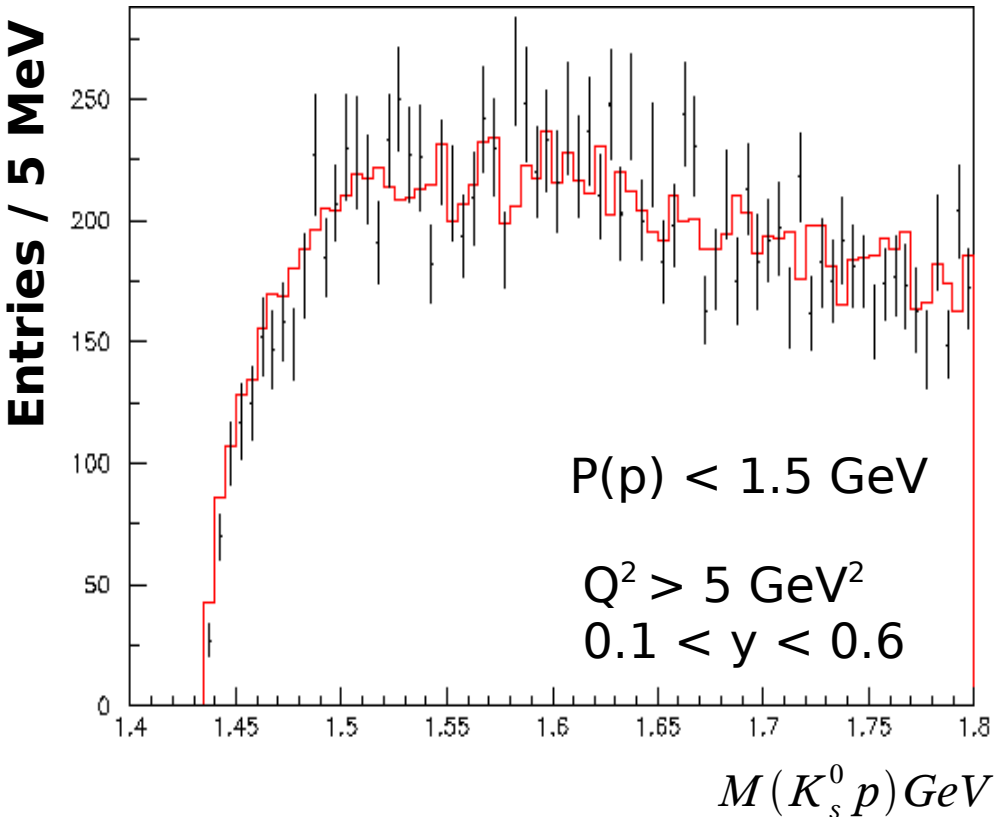




Good description of the shape of the M(K0sp) distribution by the inclusive MC

MC description





Compare the MC description of the shape of $K^0_s p$ combinations for ZEUS (Q^2>20 GeV^2 case) and H1 (Q^2 > 5 GeV^2 case)