H1 search for a narrow baryonic resonance decaying to K^0_s p($\bar{p}$)

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on behalf of the H1 collaboration

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Outline:

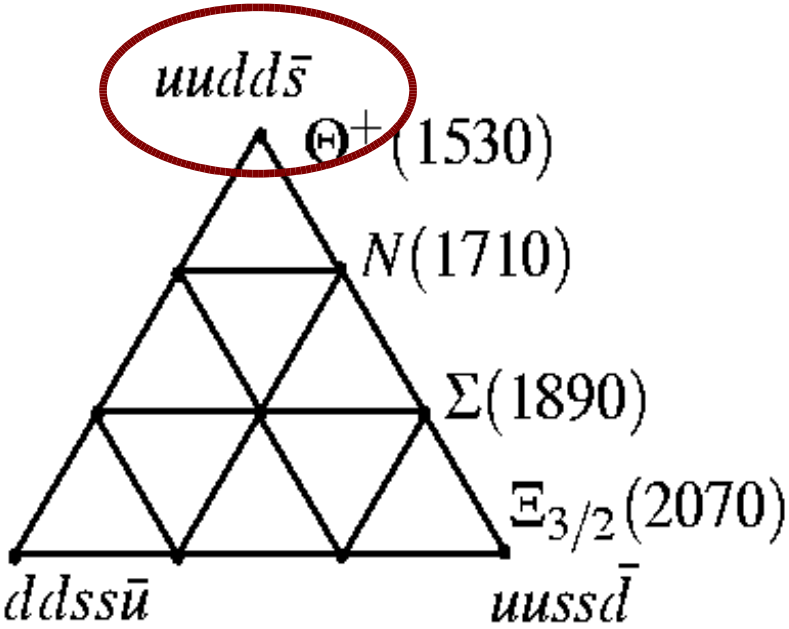
- Introduction
- Reconstruction of K^0_s p
- Results
- Summary

Pentaquarks

- many observations of baryonic resonances in K+n (exotic) and also in K^0_s p channel
- interpreted as pentaquarks
- also many non-observations

Θ+ -> K+ n exotic

Θ+ -> K^0s p maybe exotic

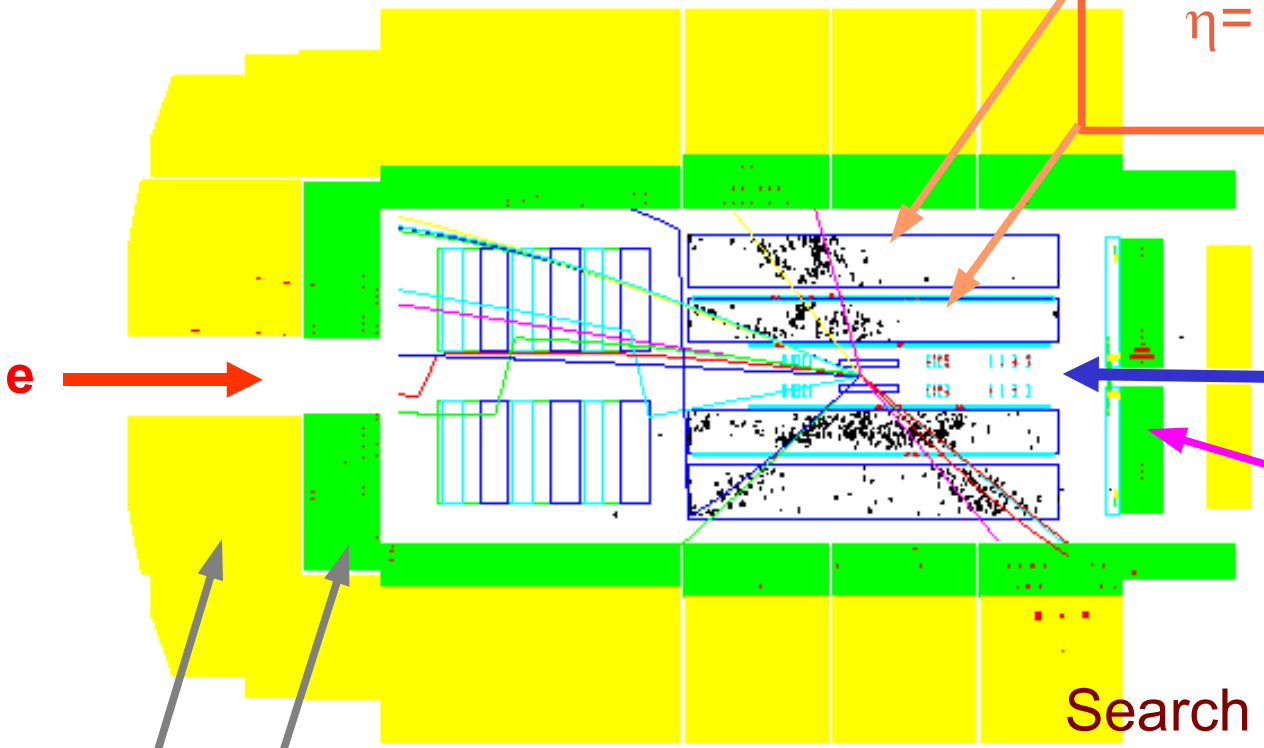


antidecuplet

H1 detector at HERA

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

Search for state decaying to K^0_s p($\bar{p}$)

- H1 data, 96-00, 75 pb^{-1}
  DIS events, $5 < Q^2 < 100$ GeV^2,
  $0.1 < y < 0.6$

K^0_s reconstruction

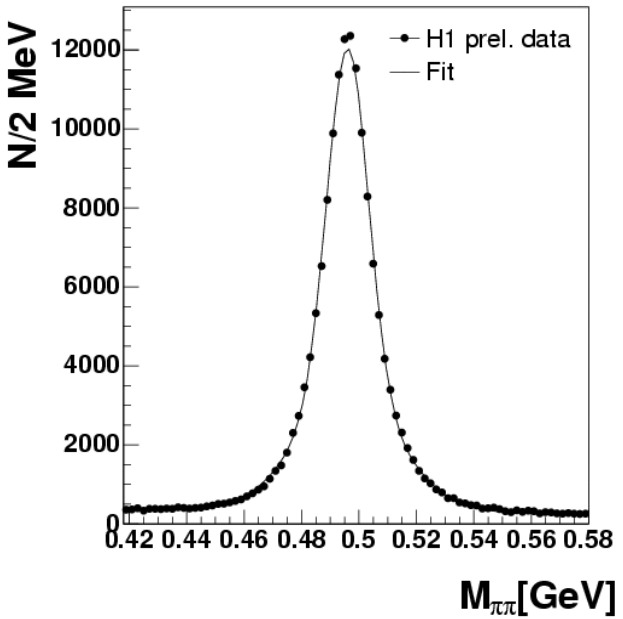
K^0_s selection $K^0_s \rightarrow \pi^+\pi^-$

secondary vertices : combinations of oppositely charged tracks

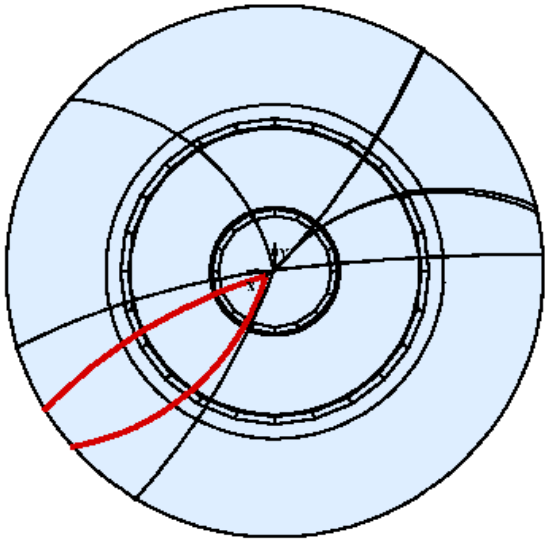
$p_T(K^0s)>0.3$ GeV, $|\eta| < 1.5$

remove combinatorial background and contaminations from Λ decays, photon conversions

Inclusive K^0_s signal $Q^2>5GeV^2$



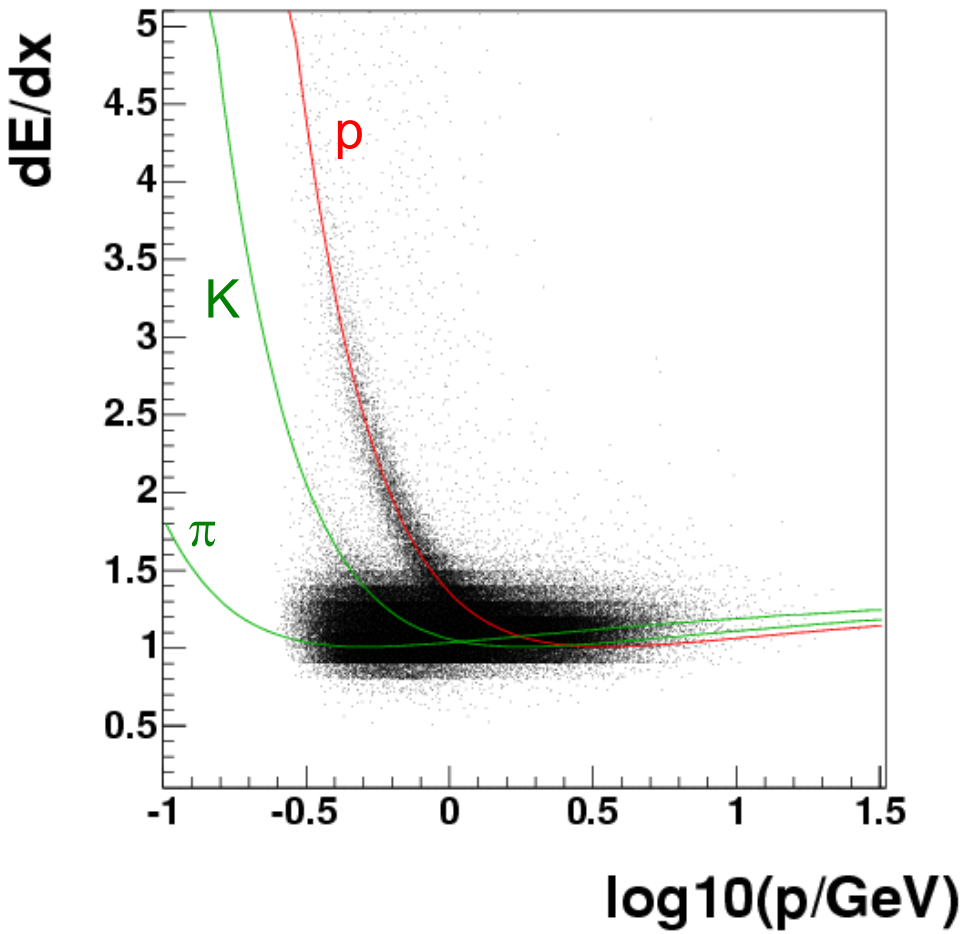
K0s in the central jet chamber



from fit:
$N(K^0_s) \approx 140\,000$

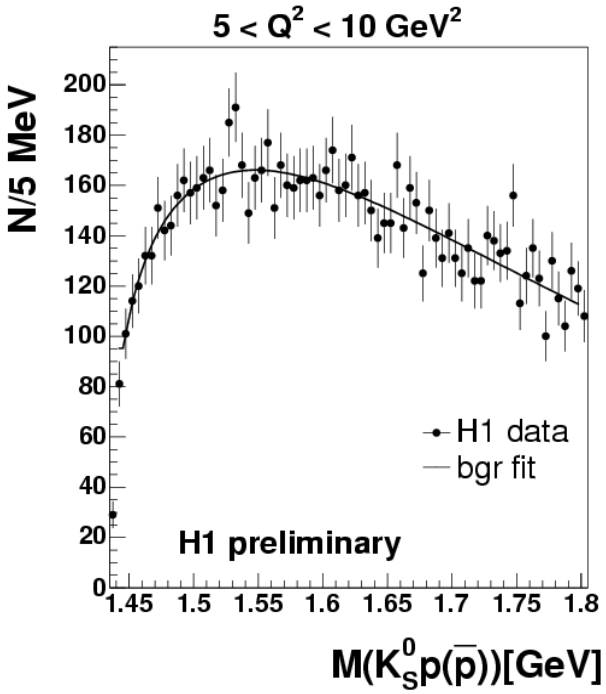
Proton selection via energy loss dE/dx

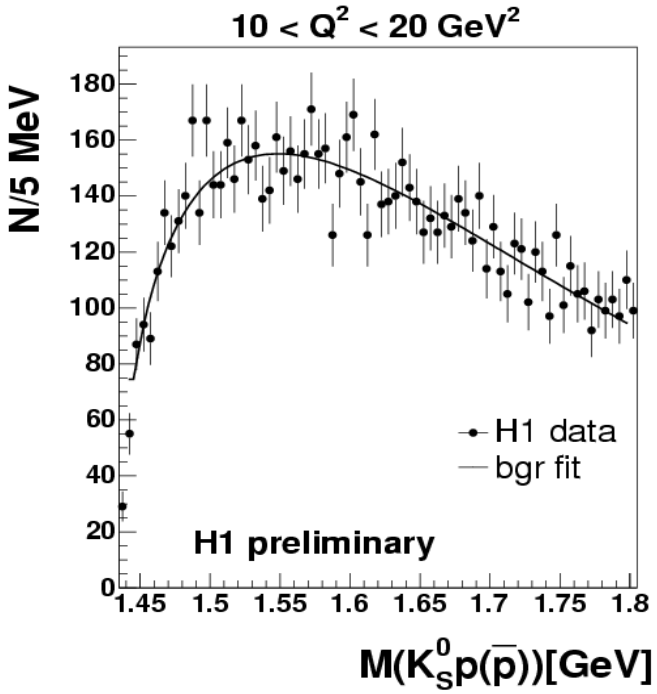
- resolution for mininal ionizing particles ~8%
- most probable dE/dx: phenomen. parameterisation (Bethe Bloch)
- use likelihoods for separation of protons and π large momentum range
- average proton efficiency ~90%
- π-suppression probability
  86%
  96 % at low momenta (p<1.5 GeV)

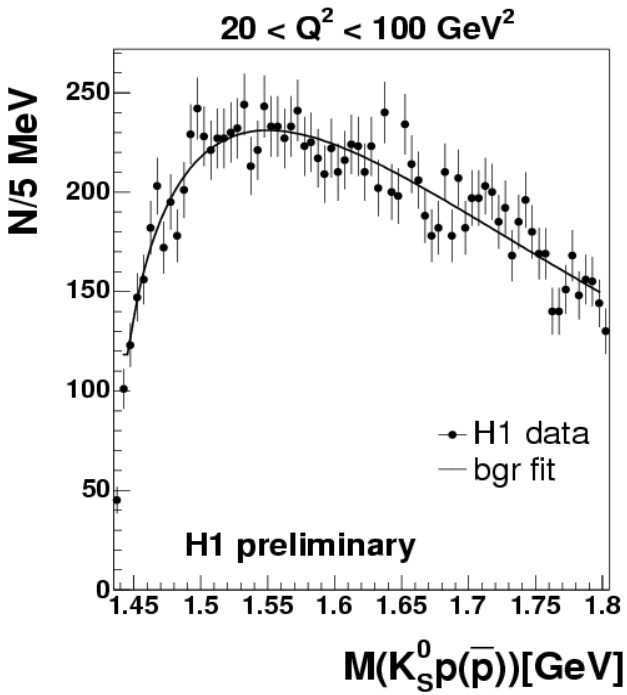


Invariant K^0_s p($\bar{p}$) mass

visible range : $p_T(K^0_s p) > 0.5$, $|\eta(K^0_s p)|<1.5$







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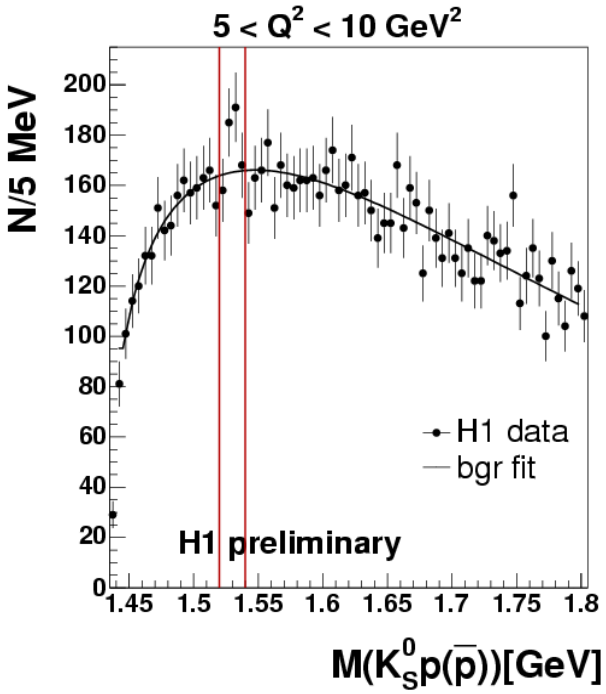
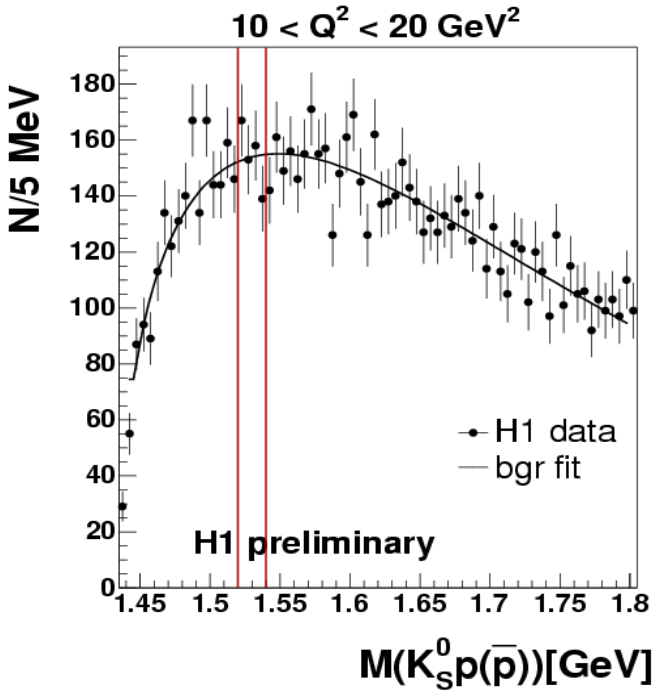
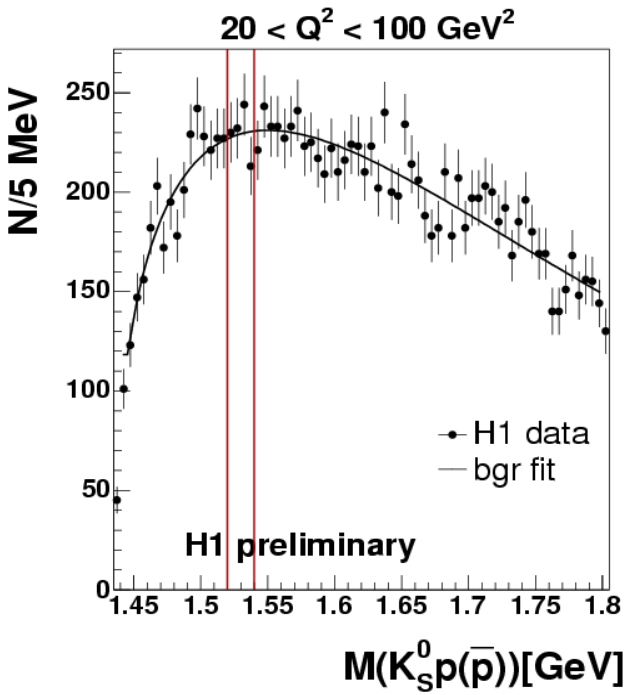
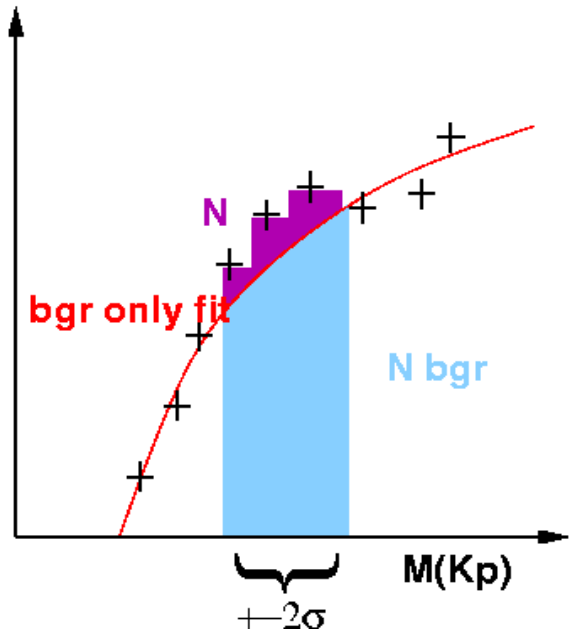






no significant signal in the interesing mass range 1.52 to 1.54 GeV

Extracting Upper Limits on θ+ production



- fit background
- background subtraction in integration window
  M ± 10 MeV, ±16 MeV
  corr. to 2σ assuming a resolution of 5(8) MeV
- scan M in the range 1.48 to 1.7 GeV
- upper limit on N(θ+) (95% C.L.)

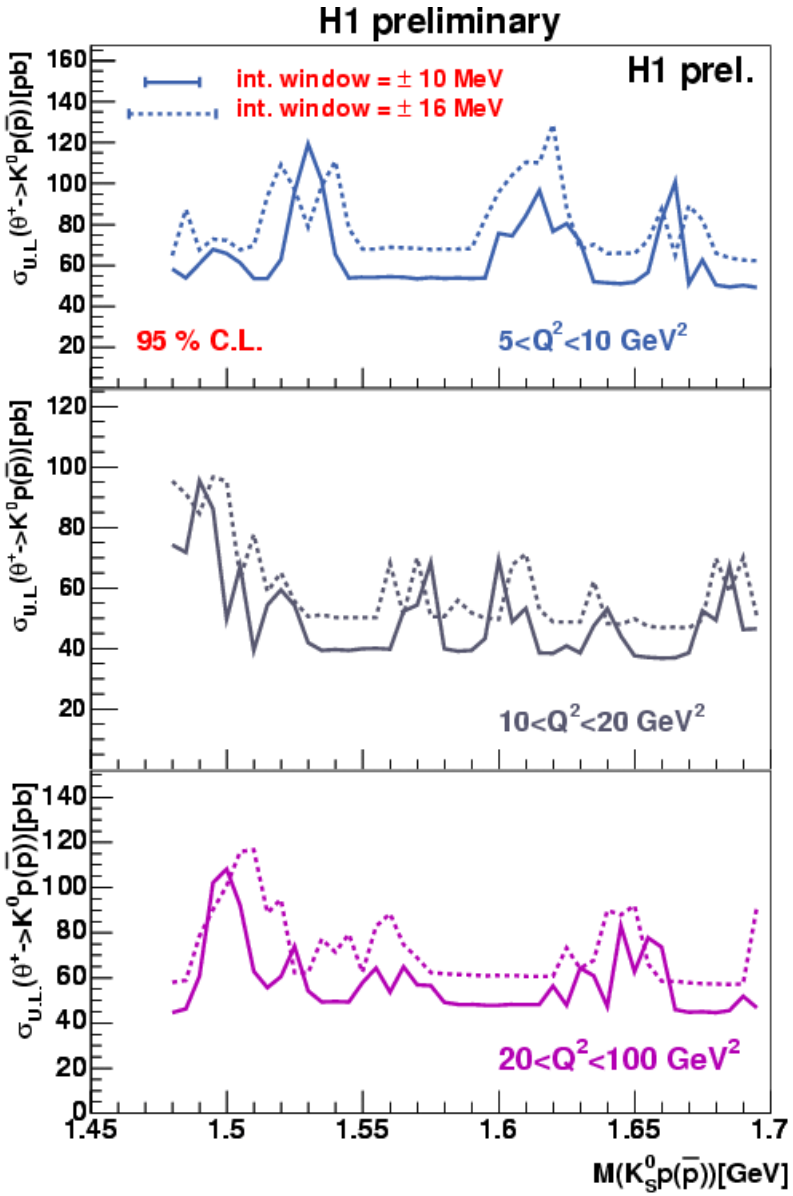
$$\sigma_{U.L.}(\theta^+ \to K^0 p) = \frac{N_{u.l.}(\theta^+ \to K^0_s p)}{BR * \varepsilon * L}$$

- $BR(K^0_s \to \pi^+ \pi^-) * BR(K^0 \to K^0_s) = 0.343$
- $L = 75\ pb^{-1}$

Signal Monte Carlo

- RAPGAP 3.1
  change decay properties of Σ*
  to M=1.52(1.54), σ=0
- detector resolution ~ 5MeV
- acceptance $\varepsilon \approx 5\ \%$

Upper Limit (95%C.L.) on σ(ep-> eθ X-> e$K^0p(\bar{p})X$)



- $5<Q^2<100$ GeV^2, $0.1 < y < 0.6$
- visible range :
  $p_T(K^0_s p) > 0.5$, $|\eta(K^0_s p)|<1.5$
- different fluctuations in Q^2 bins
- 95% C.L. upper limit on cross section
  $\sigma_{U.L.}(ep \rightarrow e\,\theta\, X \rightarrow e\, K^0 p(\bar{p})\, X) \sim 40\text{-}120$ pb

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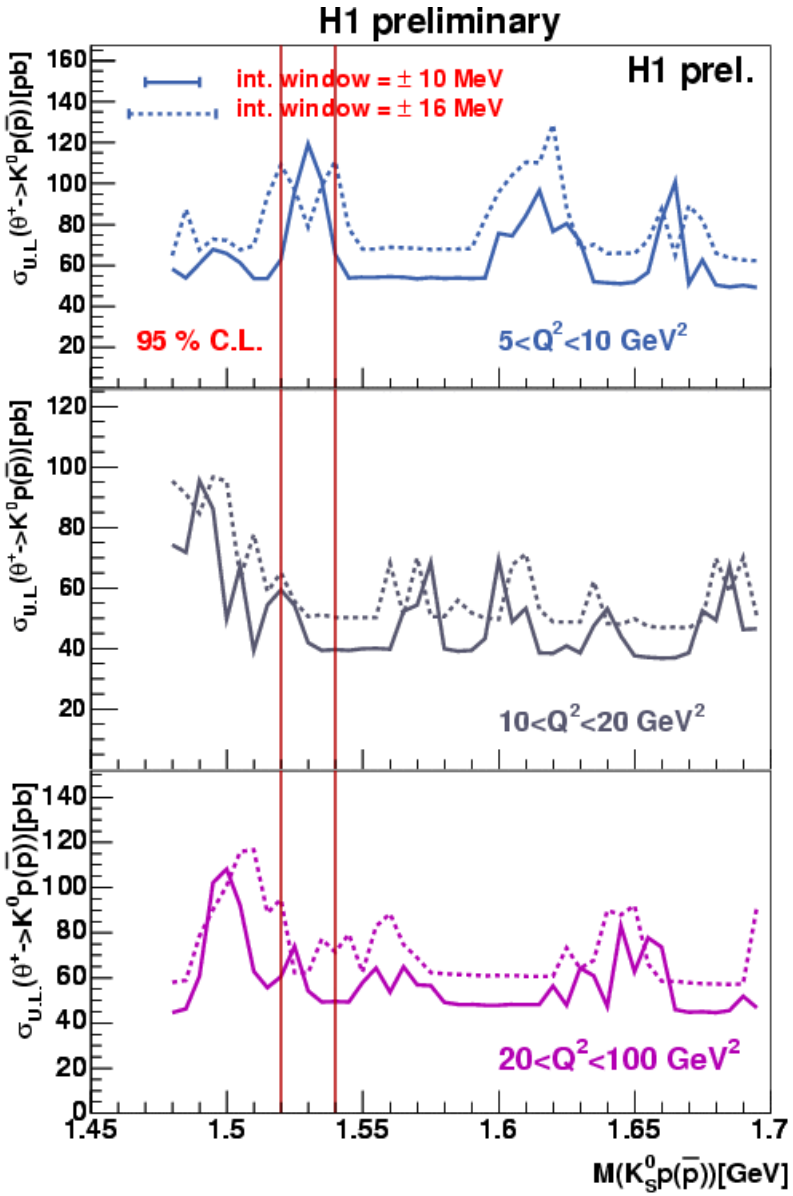

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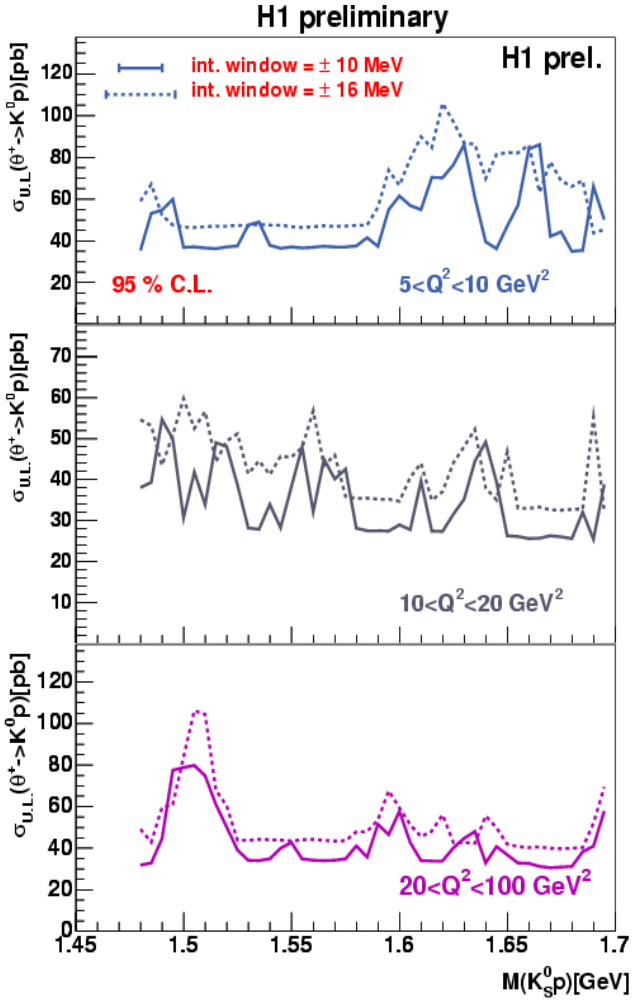
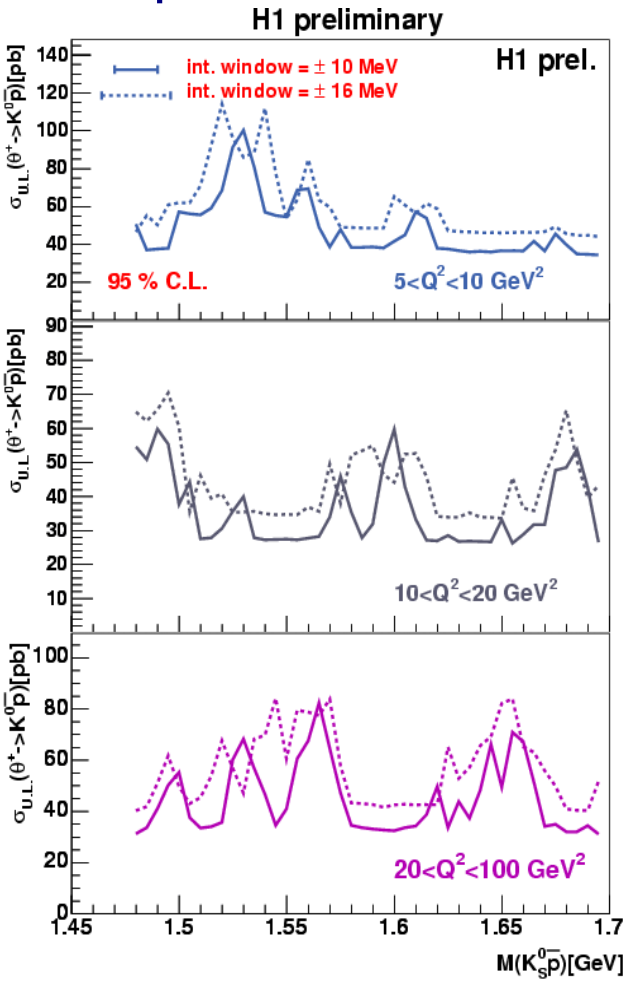
Upper Limit (95%C.L.) on σ(ep-> eθ X-> eK^{0}p($\bar{p}$)X): charges

protons



antiprotons



- limits for $K^0_s p$ and $K^0_s \bar{p}$ compatible
- fluctuations at different masses for p and $\bar{p}$

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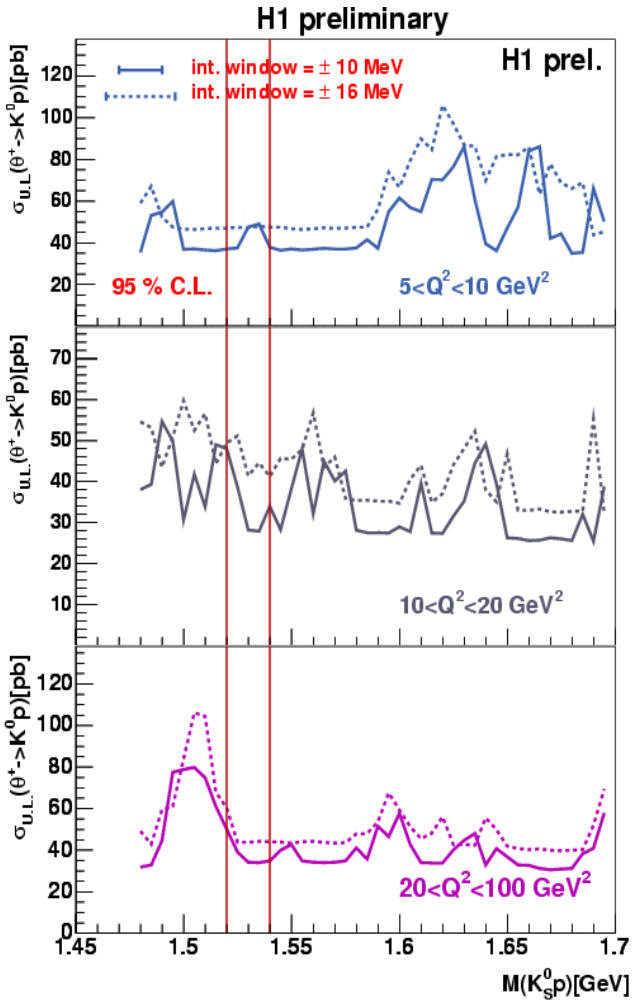

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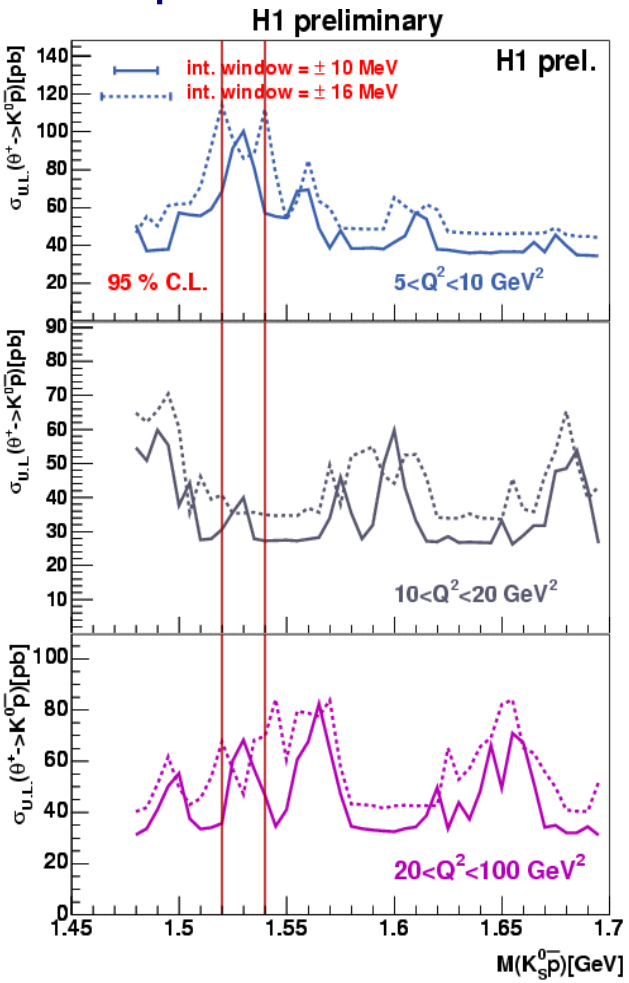


- limits for $K^0_s p$ and $K^0_s \bar{p}$ compatible
- fluctuations at different masses for p and $\bar{p}$

Comparison with ZEUS

ZEUS: signal at 1.522 GeV observed

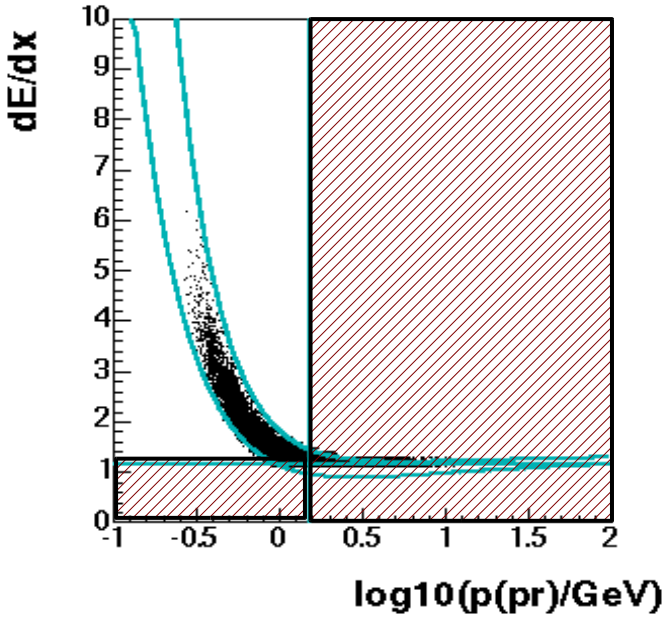
$Q^2>20$ GeV^2, $0.04 < y < 0.95$, $p_T>0.5$, $|\eta|<1.5$

$\sigma(ep \to e\,\theta\, X \to eK^0pX)=125 \pm 27(\text{stat}) +36\ -28\ (\text{syst.})$ pb (prel.)

dE/dx selection, p(pr) < 1.5 GeV

low-momentum dE/dx selection:

- use visual selection of bands in dE/dx, momentum
- dE/dx > 1.15
- proton momentum < 1.5 GeV



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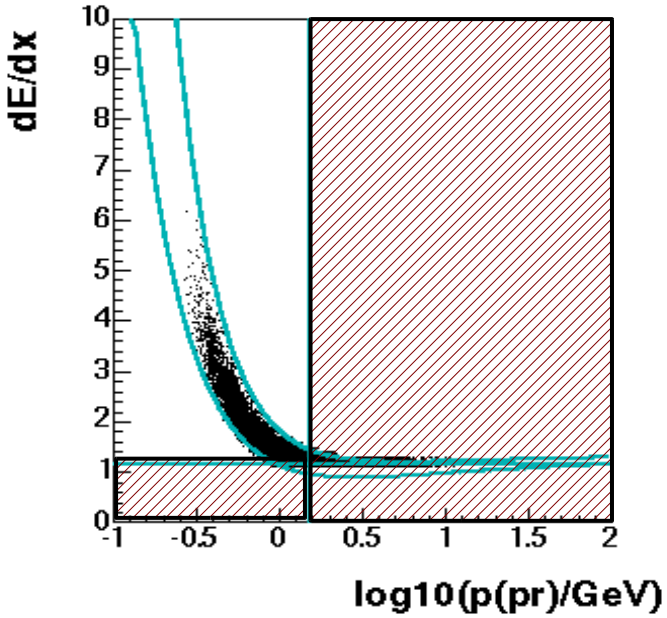

20<Q^2<100 GeV^2

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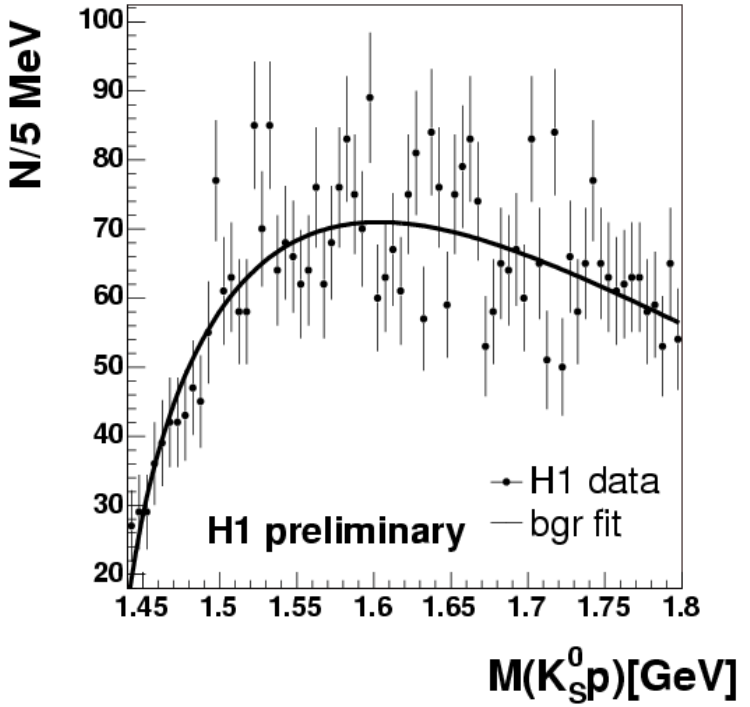

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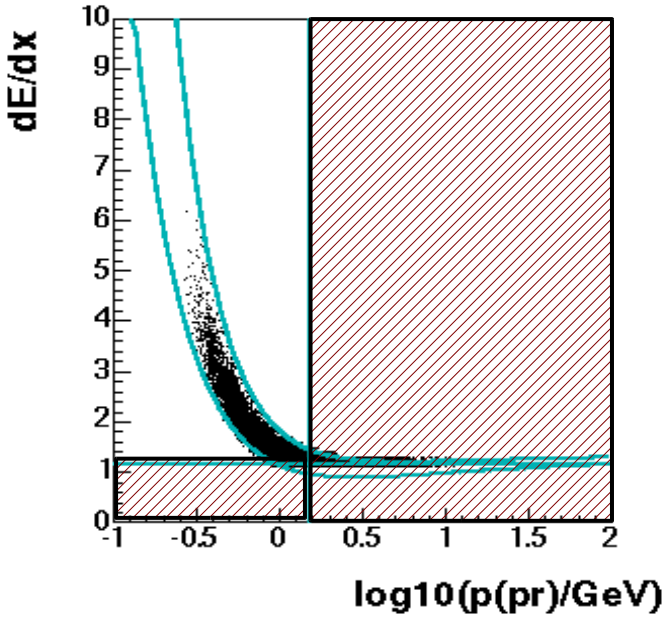

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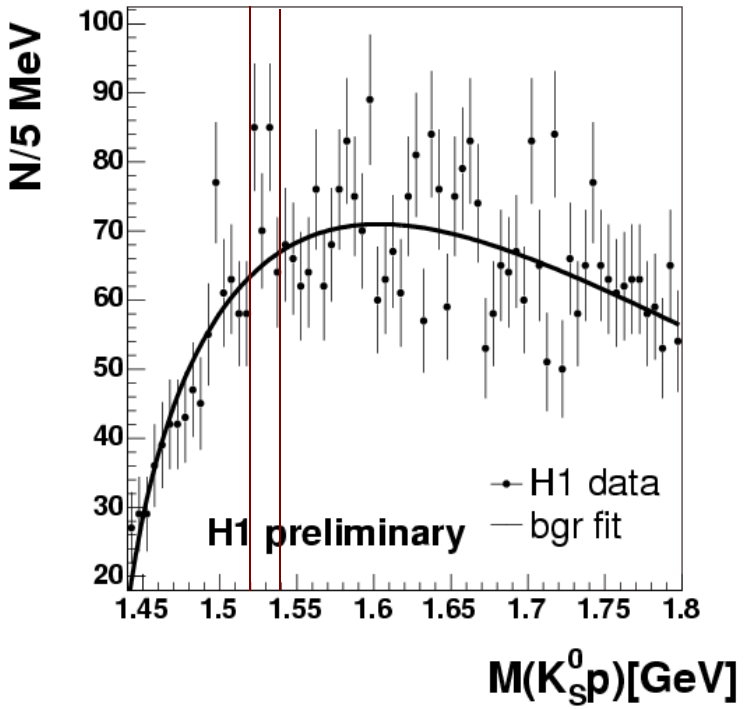

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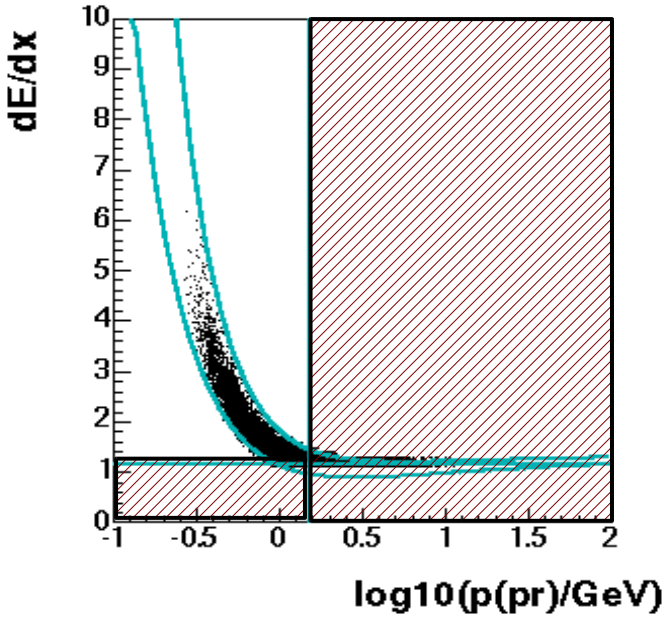
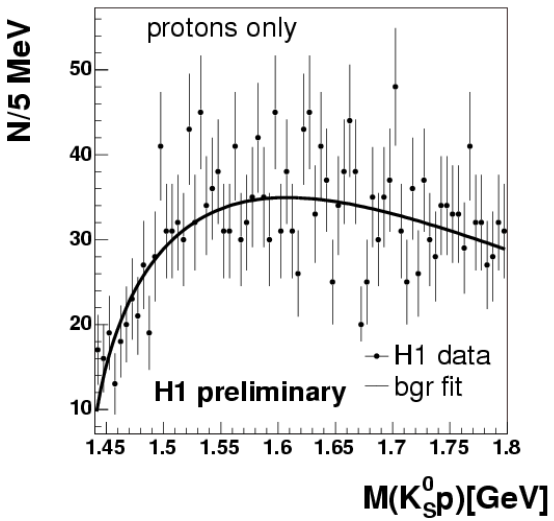


20<Q^2<100 GeV^2

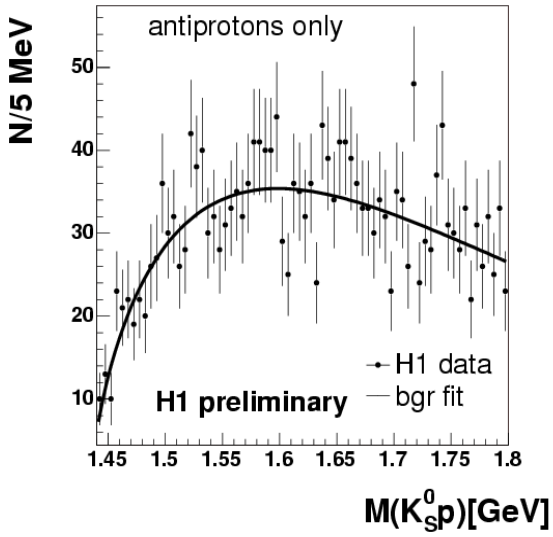
0.1 < y < 0.6

separate charges:

invariant K^0s p mass



invariant K^0s $\bar{p}$



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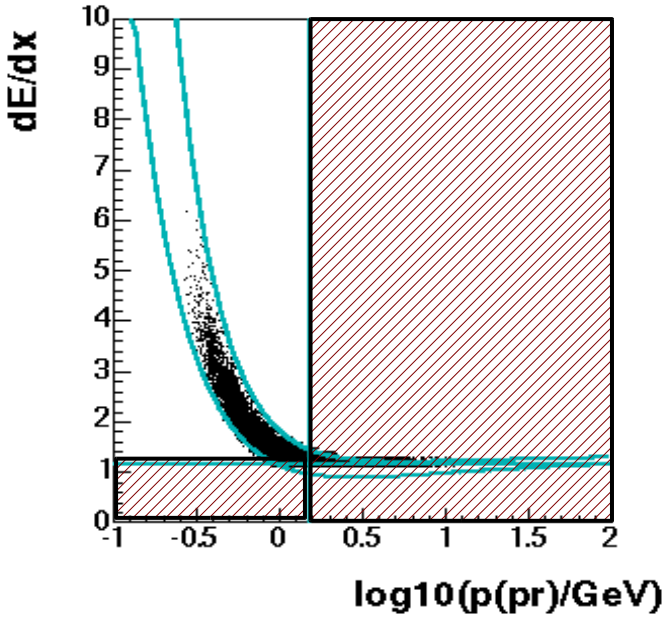

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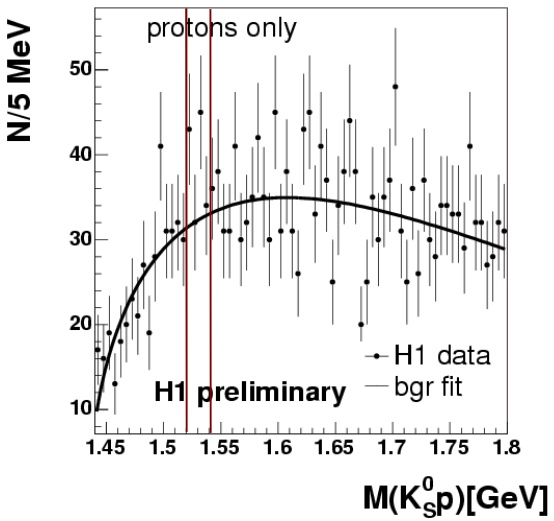
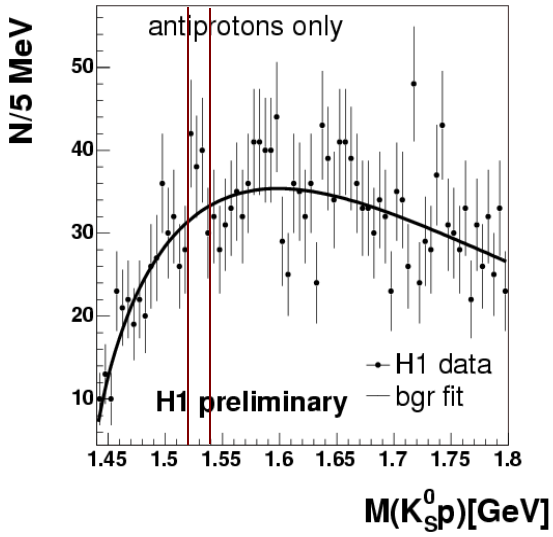


invariant K^0s $\bar{p}$



Upper Limit (95%C.L.) on σ(ep-> eθX ->e $K^0 p(\bar{p})X$): low p selection

low-momentum dE/dx selection
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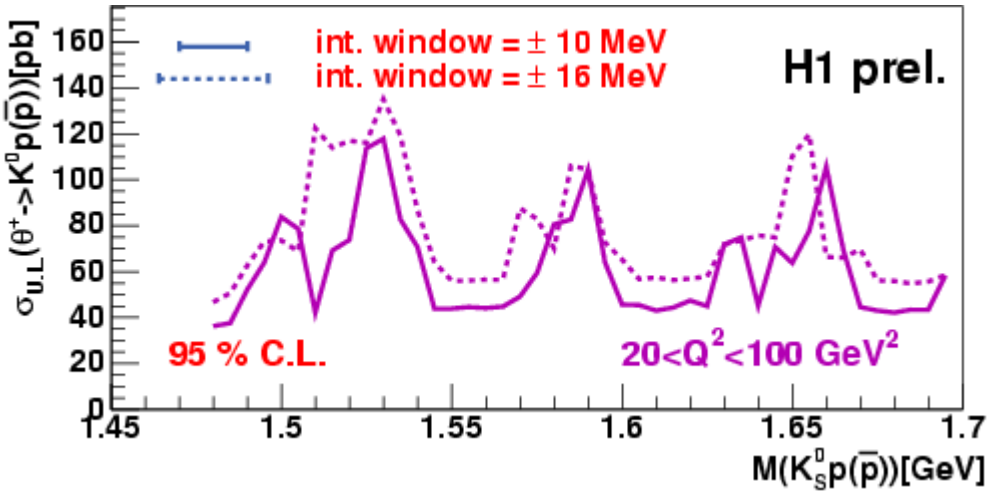
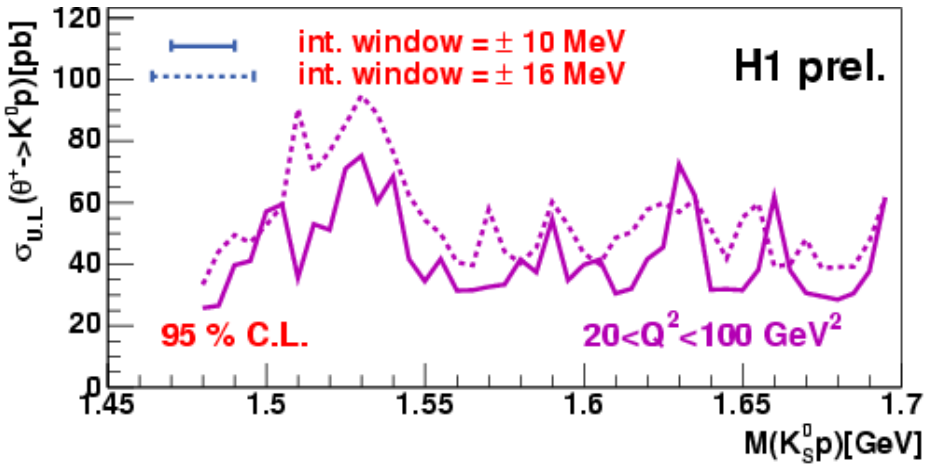
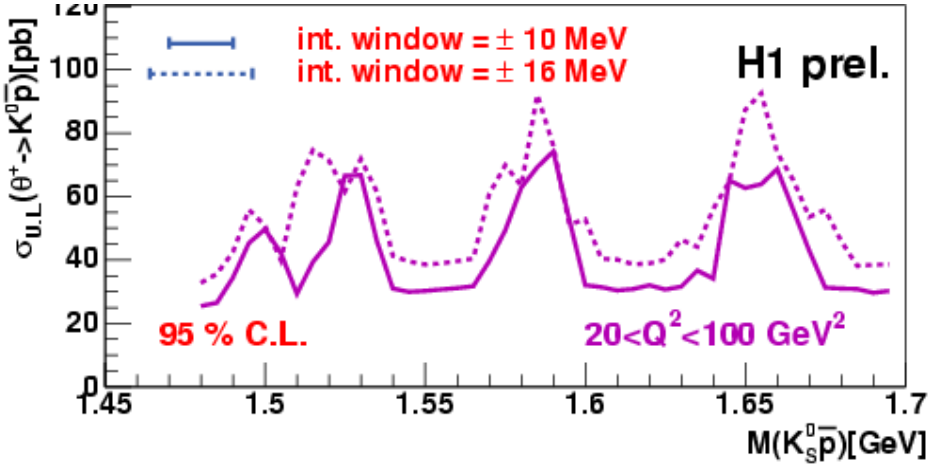
$0.1 < y < 0.6$



protons



antiprotons



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low-momentum dE/dx selection
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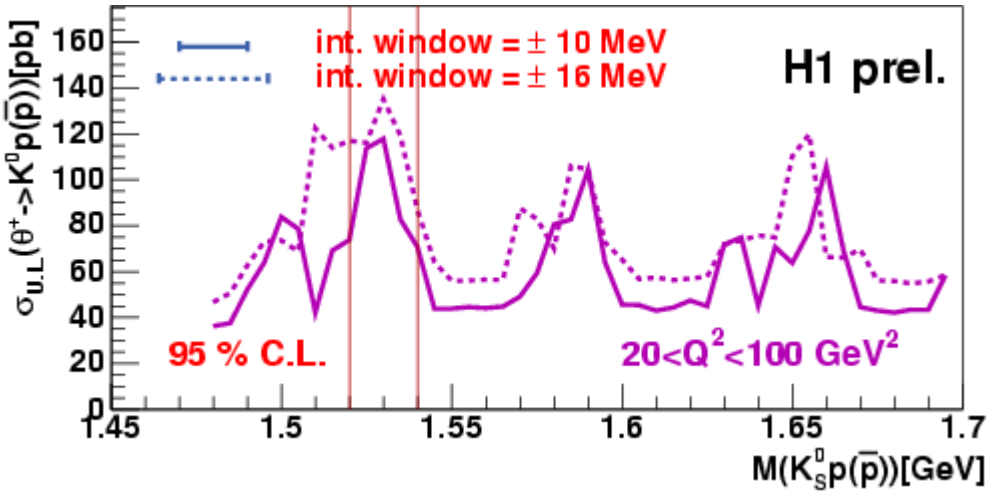
M=1.52 GeV $\sigma_{U.L.}$~ 100 pb



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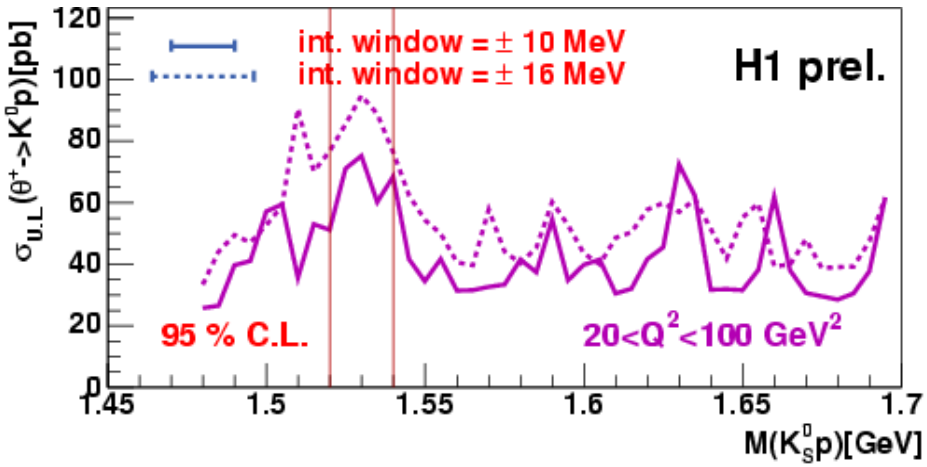

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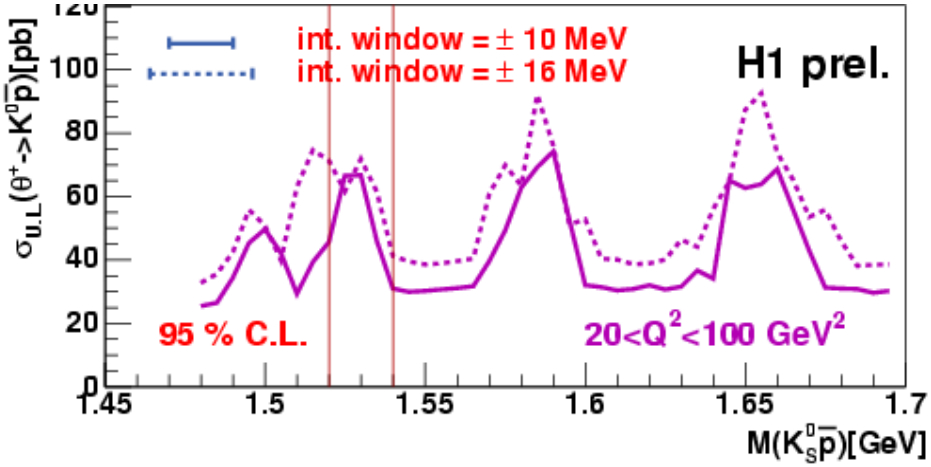

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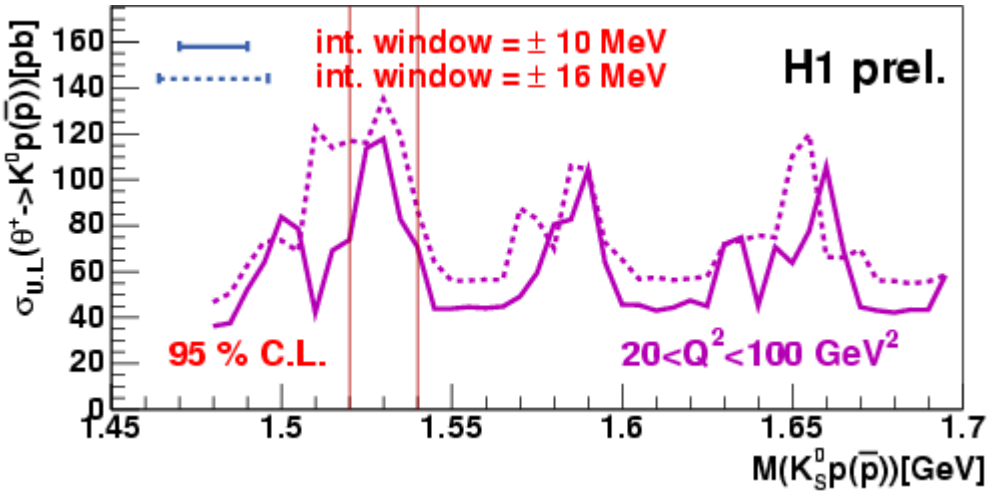

ZEUS observation:
Q2>20 GeV2, $0.04 < y < 0.95$, $p_T>0.5$, $|\eta|<1.5$
$\sigma(ep->e\ +X->eK^0pX)=125 \pm 27(stat) +36 -28$ (syst.) pb (prel.)

$\sigma_{U.L.}$ ~ 100 pb not in contradiction with ZEUS measured cross section

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* at M=1.522 GeV assuming a resolution of 5 (8) MeV
$\sigma_{U.L.}$ = 89.6 (116.3) pb

Summary

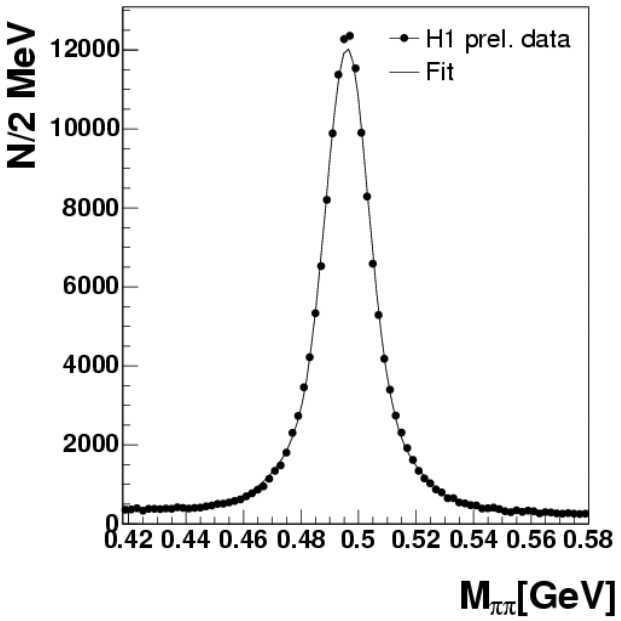
- search for a baryonic resonance decaying to $K^0_s p(\bar{p})$ performed
- no significant signal observed

- 95% C.L. upper limit on cross section in different Q^2 ranges
  visible range: $p_T(K^0_s p) > 0.5$, $|\eta(K^0_s p)|<1.5$
  $\sigma_{U.L.}(ep \rightarrow \theta X \rightarrow K^0 p(\bar{p})X) \sim 40$ -120 pb for M= 1.48 – 1.7 GeV

- similar selection and phase space as for the ZEUS analysis
  - no significant signal observed
  upper limit on cross section compatible with the preliminary ZEUS cross section

Backup Slides

K^0_s Signal



Q2>5GeV2

Result from fit: (bgr function + 2 gaussians)

N= 142505 ± 430

M= 496.08 ± 0.03 MeV

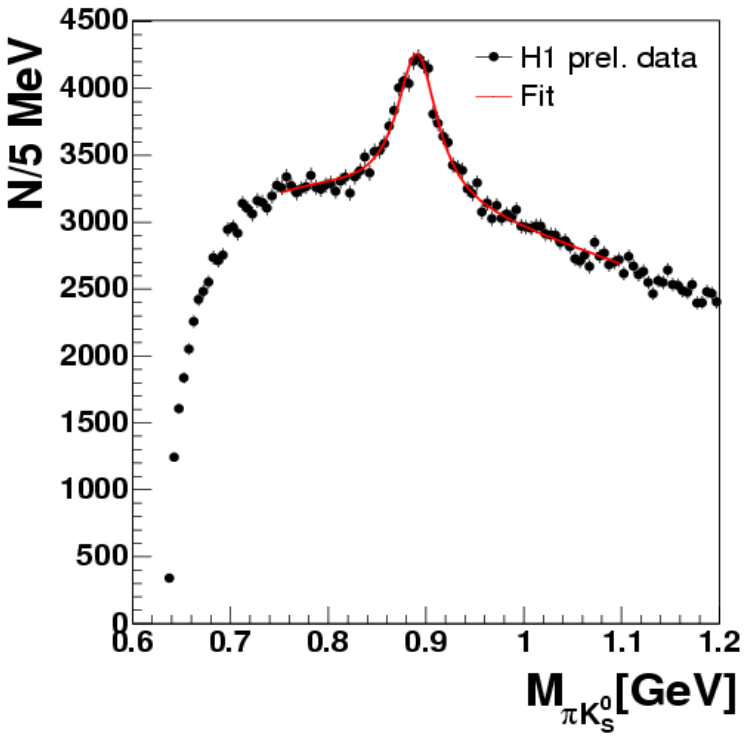
σ1=7.06 ± 0.07 MeV

σ2=17.47 ± 0.02 MeV

Invariant $K^0_s \pi$ mass

- combine K^0_s with primary tracks
- no dE/dx requirement

K^* signal



result from fit: (conv. B.W. and gaussian)

M= 891 ± 1 MeV

(PDG M = 891.66 ± 0.26 MeV)

N= 18939 ± 844 (stat.)

Γ= 50.8 MeV (fixed)

(PDG Γ=50.8 ± 0.9 MeV)

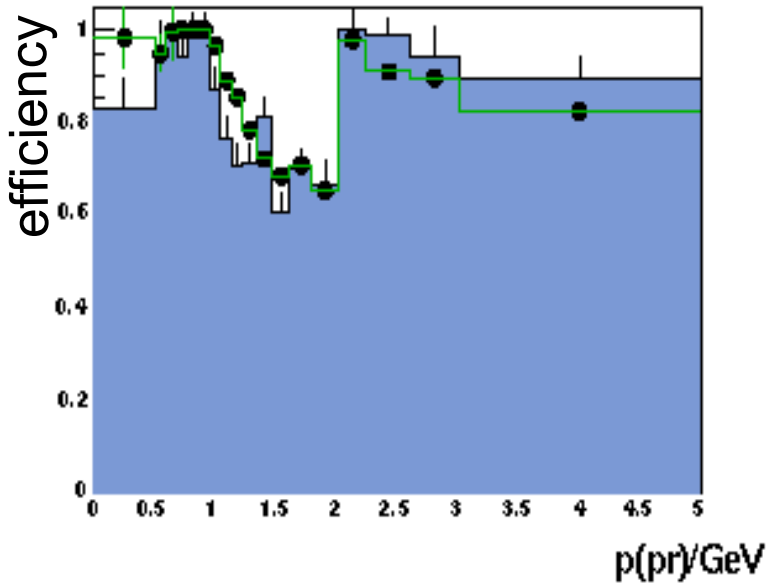
σ = 7.79 ± 2.34 MeV

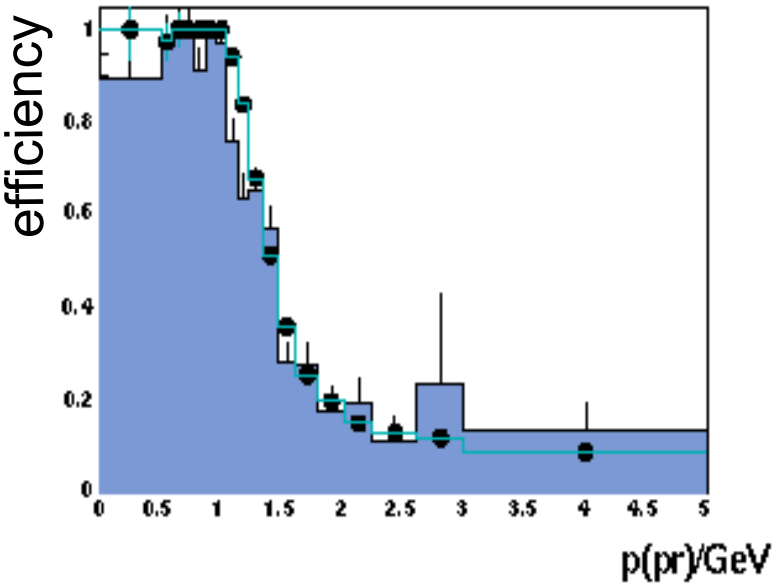
mass and width
agree with expectations

Proton selection efficiency

- momentum dependent cut on Likelihoods
- p <= 2GeV : >25hits, LH>30%
- p > 2GeV : >15 hits, LH>10%

- like ZEUS - bands
- without cut p(pr)<1.5



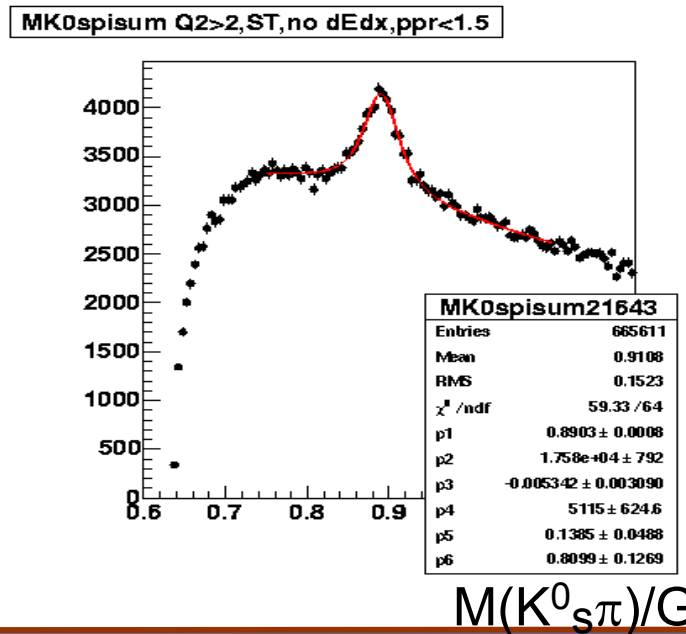


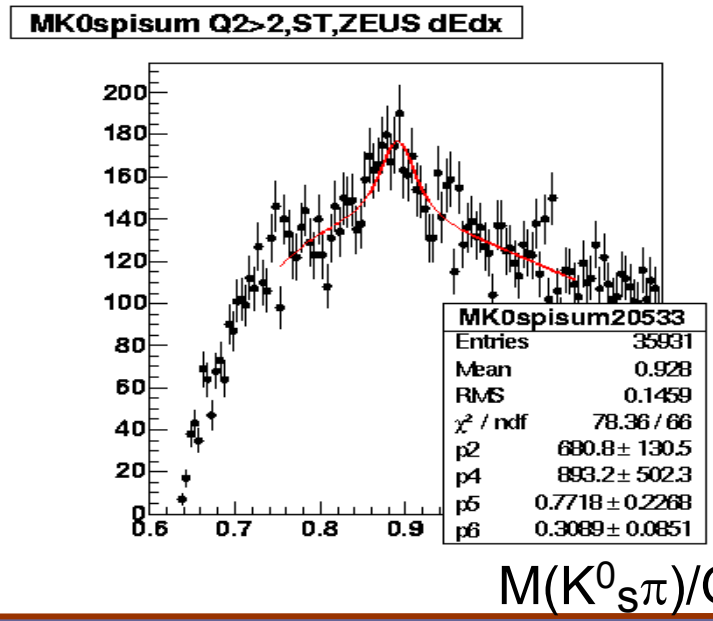
dE/dx efficiency described by MC within ~5%
possible differences in pt and η distribution of protons from Λ or θ+
contribution to systematic uncercainty: +- 10%

Proton selection efficiency

- N(K*) before and after dE/dx selection:
  20975 +- 841 K* and 3064 +- 207 K*
  14 % of pions survive dE/dx cut
- N(K*) before and after low momentum dE/dx selection, p(pr) <1.5 GeV:
  17581 +- 792 K* 681 +- 131 K*
  3.8% of pions survive dE/dx cut

Invariant M(K0sπ) , p(pr)<1.5 GeV before and after dE/dx selection:





Limit Extraction

- Fitting procedure: 3 different hypothesis
  1) bgr only:
     $f(M)= a*(M- (m_K+m_p))^b * \exp(- (M - (m_K+m_p)*c)$
  2) exclude signal region from fit
  3) bgr + gaussian signal

- upper limit on N (95 % C.L)
  $N + 1.64*\sqrt{N}$
- upper limit on N(θ+) (95% C.L.) :

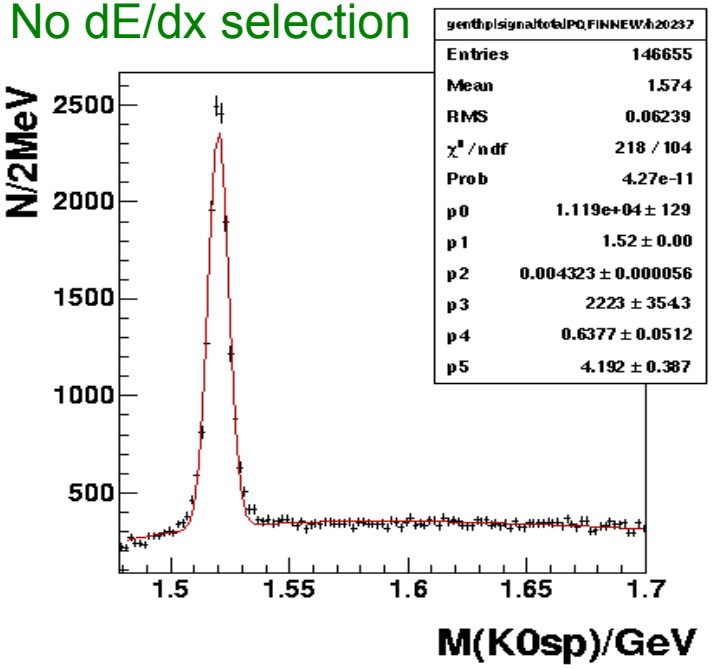
$$(max(N - Nbgr, 0) + 1.64*\sqrt{N}) / 0.95$$

95%C.L.

extrapol from 2σ

Detector resolution estimated from Signal MC

No dE/dx selection



RAPGAP3.1
changed decay properties of Σ^*
$\theta+ \rightarrow K^0_s$ p at M=1540 MeV and M=1520 MeV

Fit Result: M=1520MeV
M=1519.5 +- 0.1 MeV
σ=4.323 +- 0.056 MeV

Fit Result: M=1540 MeV
M=1539.7 +- 0.1 MeV
σ=4.839 +- 0.084 MeV

- detector resolution ~ 5 MeV

Acceptances (before proton ID) :

	$5<Q^2<10$	$10<Q^2<20$	$20<Q^2<100$ GeV^2
M=1520	6.52 %	7.82 %	7.3%
M=1540	6.77 %	7.9 %	7.64%

(contribution to systematic error 3%)

Systematic uncertainties

Different fit methods

- bgr function only, full mass range
- bgr function, exclude signal region M+-2σ
- fit bgr + signal (fixed width)

Differences small ~2% always use most conservative

averaging weights

- average weight in Q2 bins (from fit) +- 4%

dE/dx

- efficiency described within 5% +- 10 %

Triggerefficienies S2/S61 (corrected by using MC)

- discrepancy of up to 8% +- 8%

Tracking

- single tracks: 1.8% uncertainty, 3 tracks ~6% +- 6%

e reconstruction

- +- 10%

Model dependece

- difference between signal MC M=1520 and M=1540 +- 3%

Lumi

+- 1.5 %

Total increase upper limit by 18.1 %

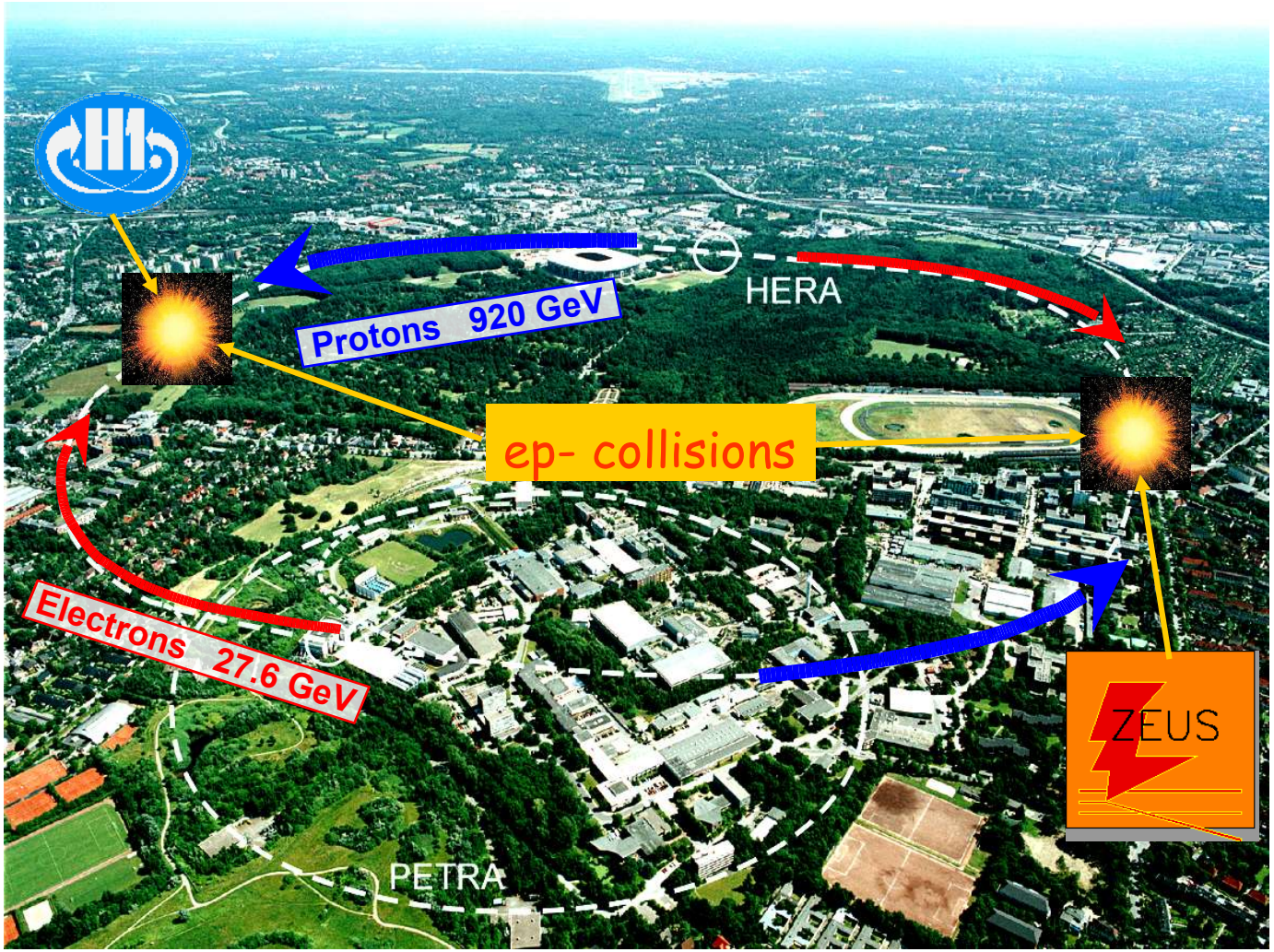
The HERA accelerator

E_e = 27.6 GeV

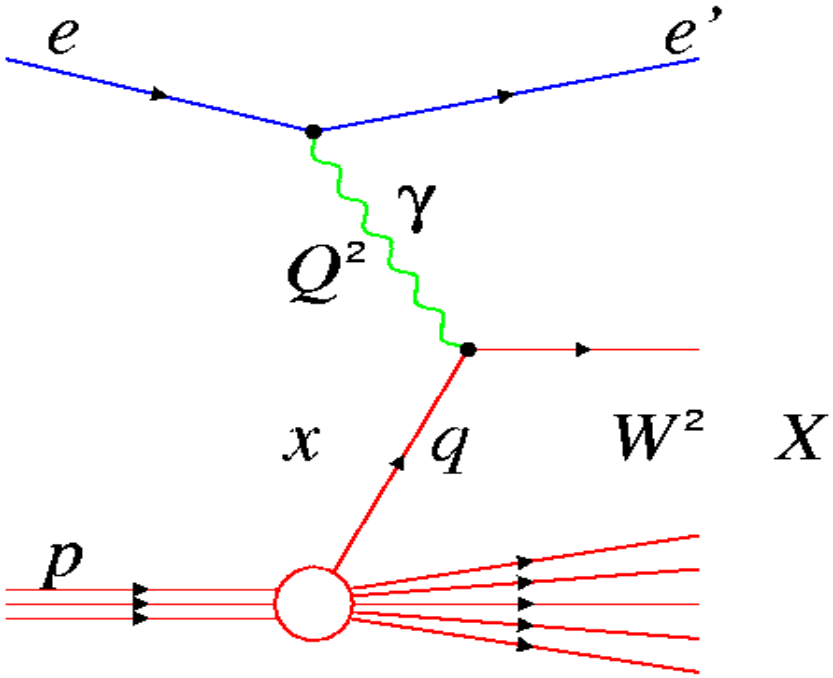
E_p= 920 (820) GeV

ep collisions at $\sqrt{s}$ ≈300-320 GeV

DESY
Hamburg
Germany



Deep-inelastic scattering (DIS) kinematics



E_e=27.6 GeV

E_p=920 (820) GeV

$\sqrt{s}$ ≈300-320 GeV

kinematics:

pairs of Lorentz invariants:

- 4-momentum transfer squared
  $Q^2 = -q^2$
- Bjorken scaling variable: momentum fraction of proton carried by quark
  $x = Q^2/(2\,q\,P)$
- inelasticity $y = qP/kP$
- mass of the hadronic system
  $W^2 = (P + q)^2$

Kinematic regimes:

- **$Q^2 > 1$ GeV^2 : DIS** **scattered e in detector**