The Search for Exotic Baryons at HERMES

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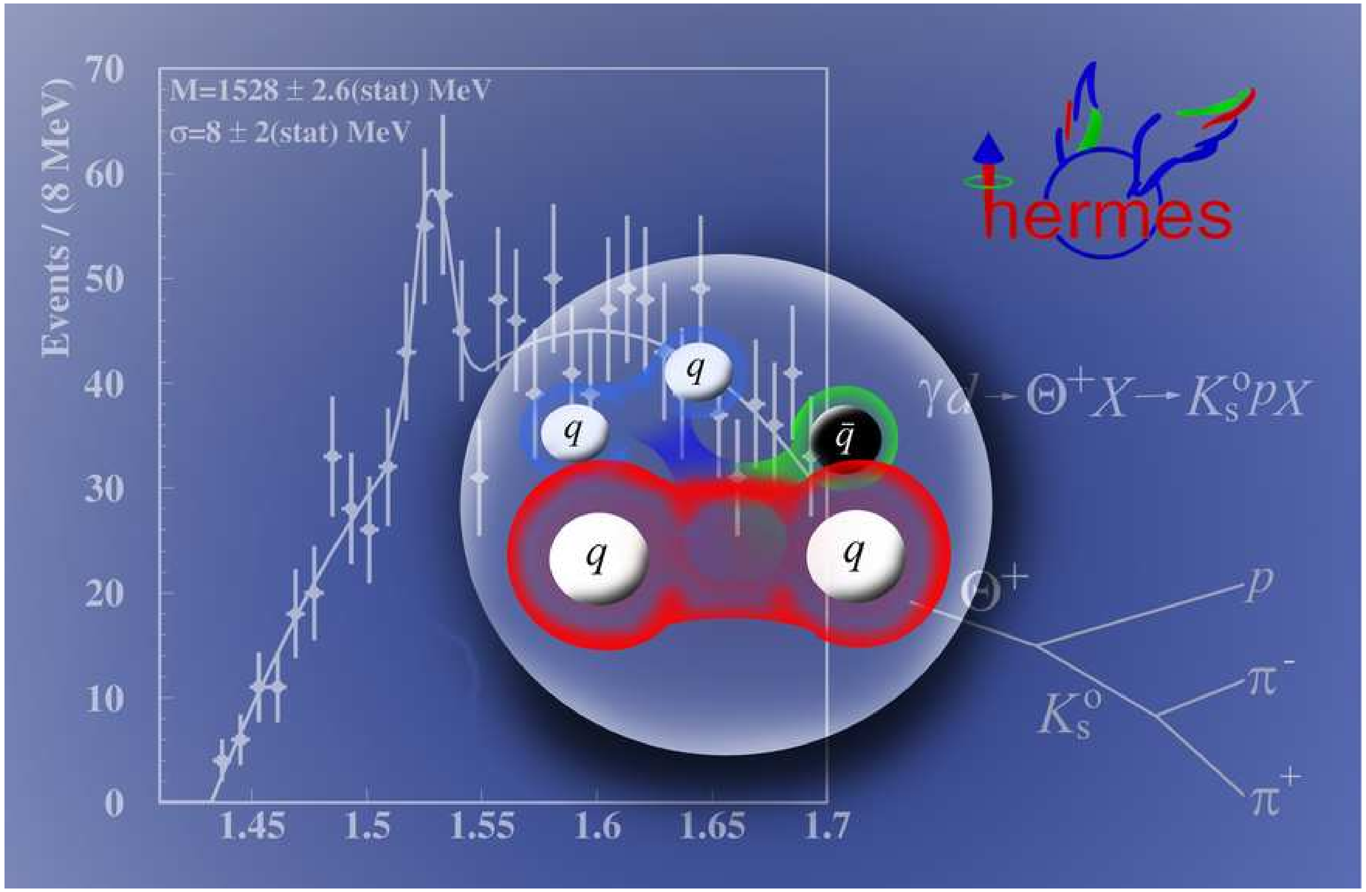
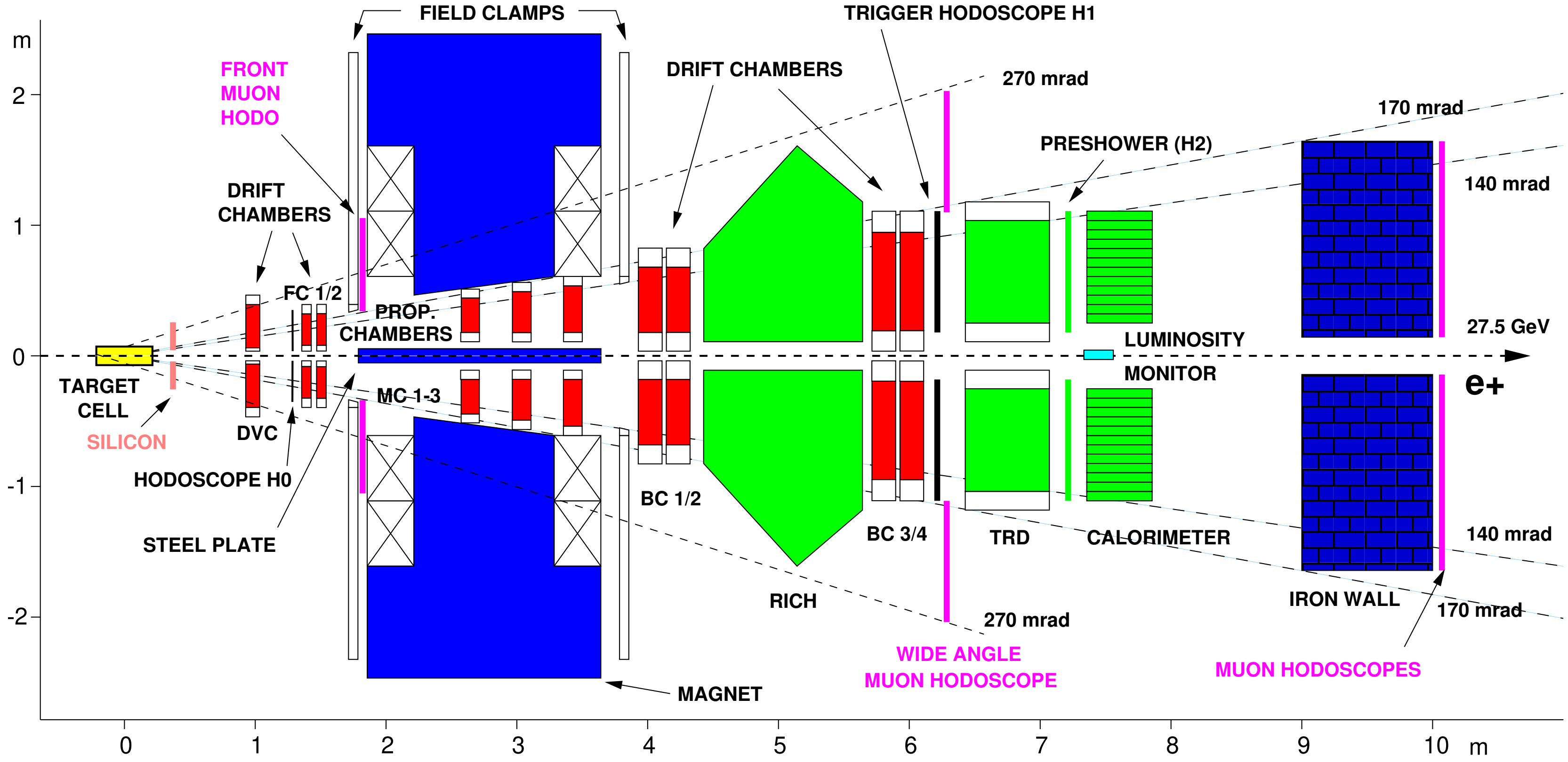
The HERMES Collaboration



Overview

- The HERMES Spectrometer
- Particle Identification and Event Reconstruction
- Results for Θ^+
- Search for Ξ^{--}
- Conclusion and Outlook

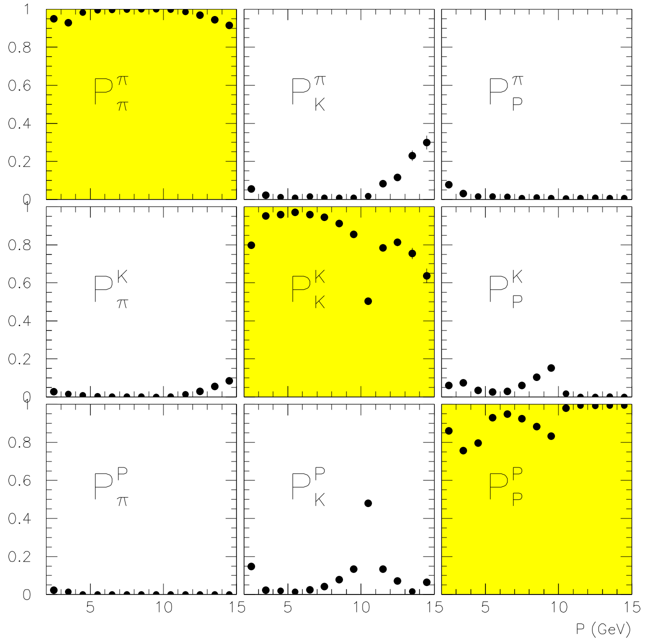
The HERMES Spectrometer



- 27.5 GeV e^+ beam from HERA
- Target: H↑, He↑, **D**↑ or unpolarized H_2, D_2, He,. . .
- Magnet and Tracking Chambers:
  $\frac{\Delta p}{p}$ = 1.4 – 2.5% and $\Delta\theta \lesssim 0.6$ mrad
- RICH: hadron identification (π, K, p)
- TRD, Calorimeter and Preshower:
  hadron/lepton separation

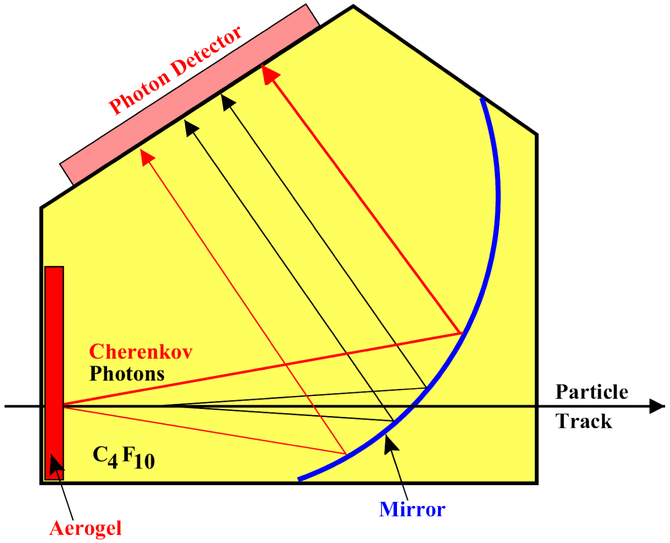
Particle Identification

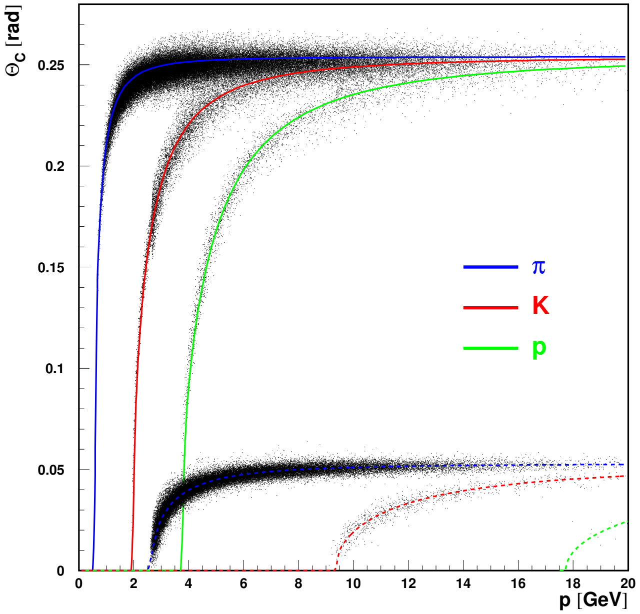
- RICH: dual radiator, separation of π, K, p
- Particle identification relies heavily on RICH
  $\longrightarrow$ determine contaminations (P-matrix)



Contamination negligible if momentum

- p: between 4 and 9 GeV
- π: between 1 and 15 GeV

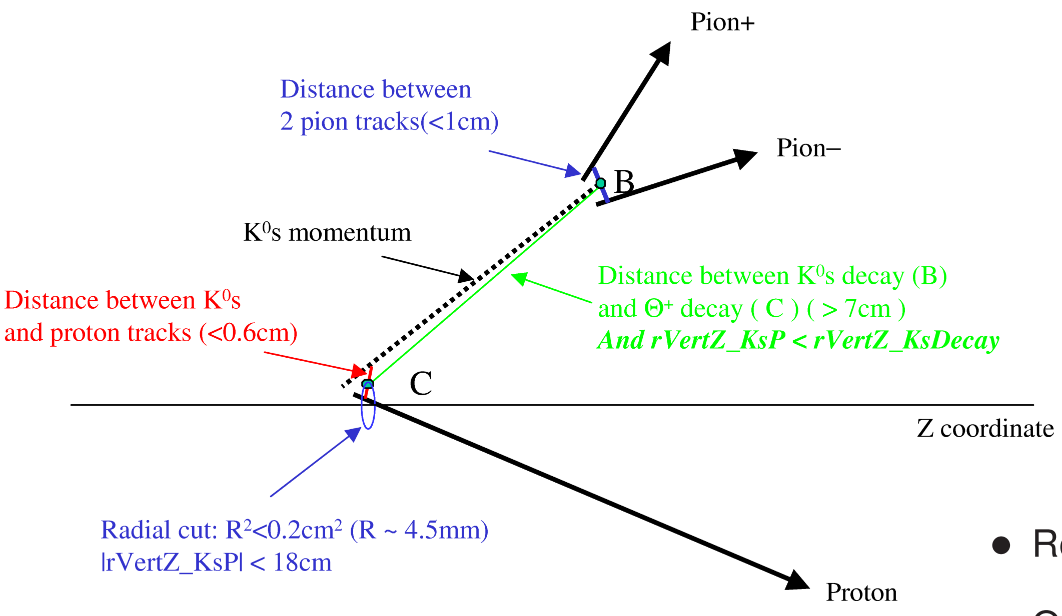


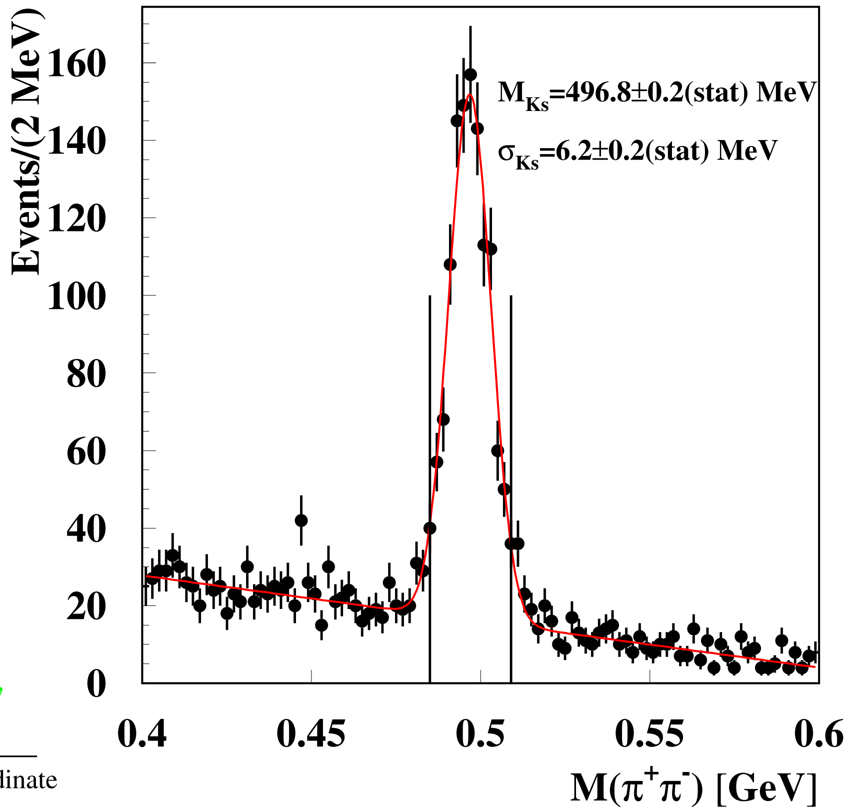


Event Reconstruction

Quasi-real photoproduction:

$$e^+ + \mathrm{D} \;\rightarrow\; \Theta^+ + \mathrm{X}$$
$$\rightarrow\; K^0_S + p + \mathrm{X}$$
$$\rightarrow\; \pi^+ + \pi^- + p + \mathrm{X}$$





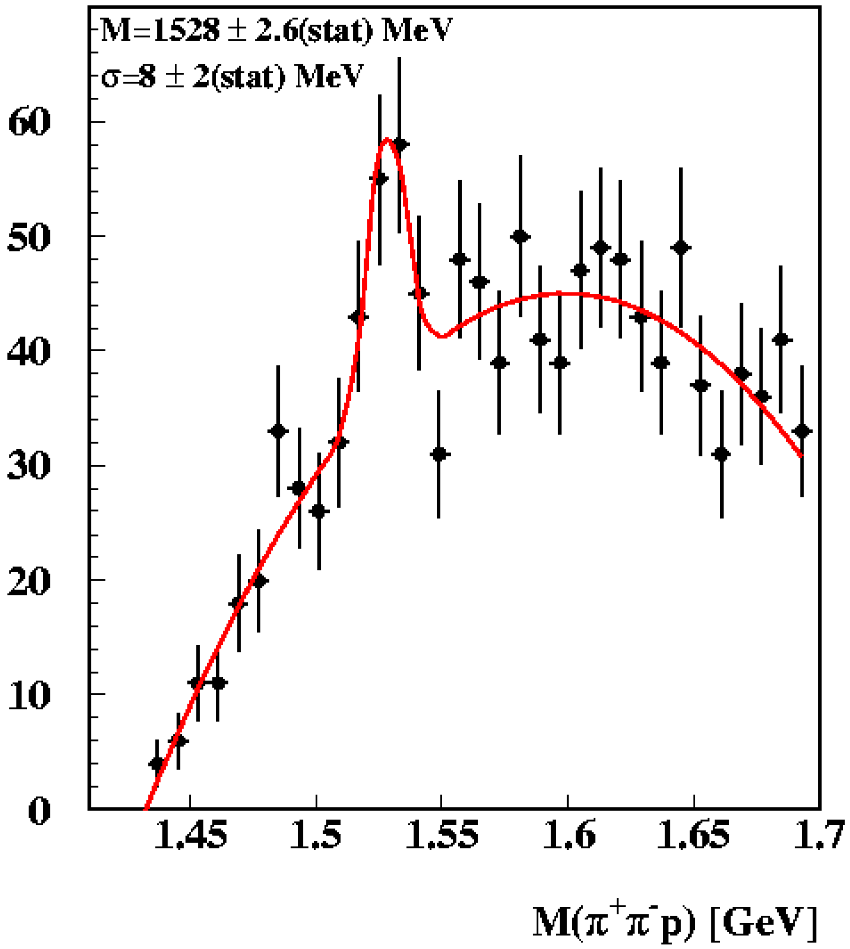
- Rejection of events within $\pm\,2\,\sigma$ of M_Λ
- Only events with $M_{\pi^+\pi^-}$ within $\pm\,2\,\sigma$ of $M_{K^0_S}$

Results

Fit with 3rd order polynomial:

- M_{Θ^+} = 1528 $\pm$ 2.6(stat) MeV
- Γ_{Θ^+} = 19 $\pm$ 5 MeV (σ_{Θ^+} = 8 $\pm$ 2 MeV)
- Significance:

$$N_s/\sqrt{N_b} = 4.7\,\sigma \text{ (naive)}$$
$$N_s/\delta N_s = 3.7\,\sigma \text{ (true)}$$



Toy MC model:

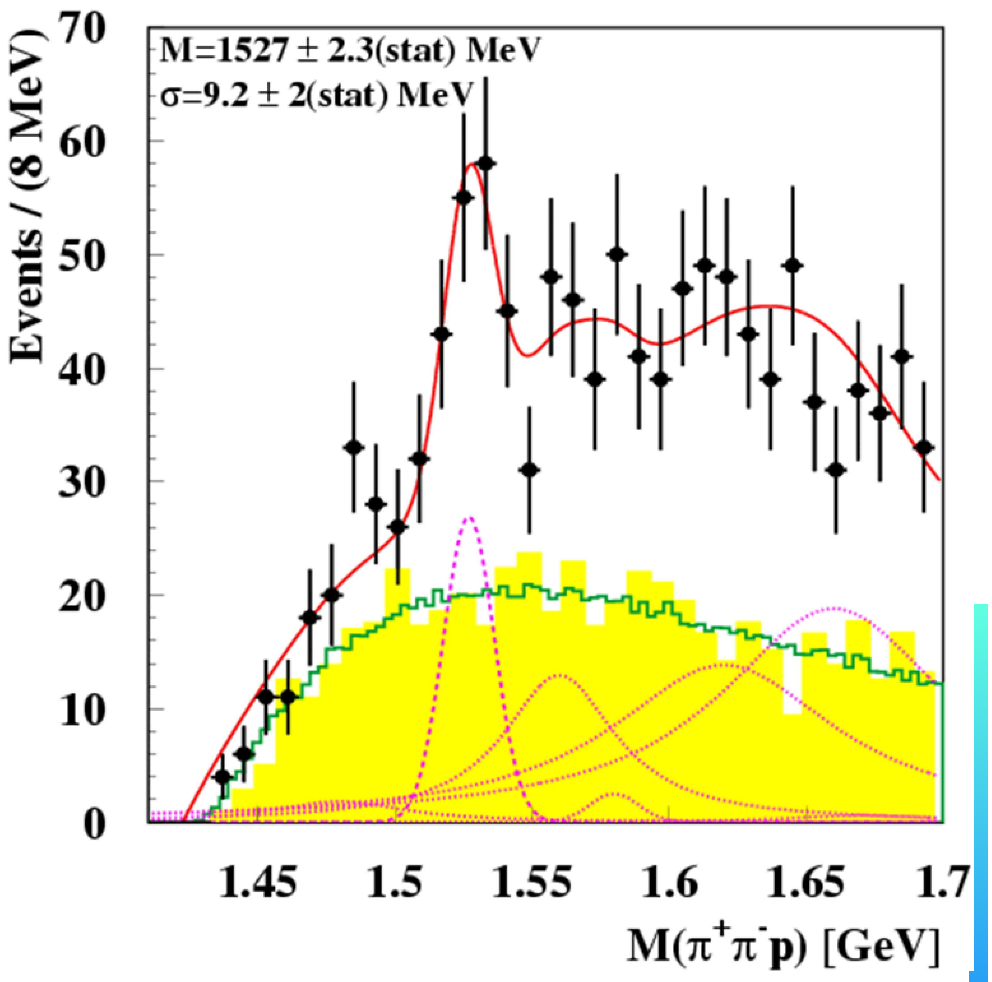
- spectrometer resolution: 6.2 MeV

$\Rightarrow$ σ_{Θ^+} is somewhat larger than resolution of spectrometer

Unbinned fit: result does not depend on binsize and starting point

Understanding the Background

- Three models for background:
  - 3rd order polynomial (Chebyshev)
  - PYTHIA6 tuned to HERMES kinematics
  - Mixed events
- Non-resonant background (PYTHIA6, confirmed by mixed events technique) plus six known Σ^{*+} resonances
  - M_{Θ^+} = 1527 $\pm$ 2.3(stat) MeV
  - Γ_{Θ^+} = 22 $\pm$ 5 MeV
  - Significance: 6.1 σ (naive) or 4.3 σ (true)



Results: Isospin

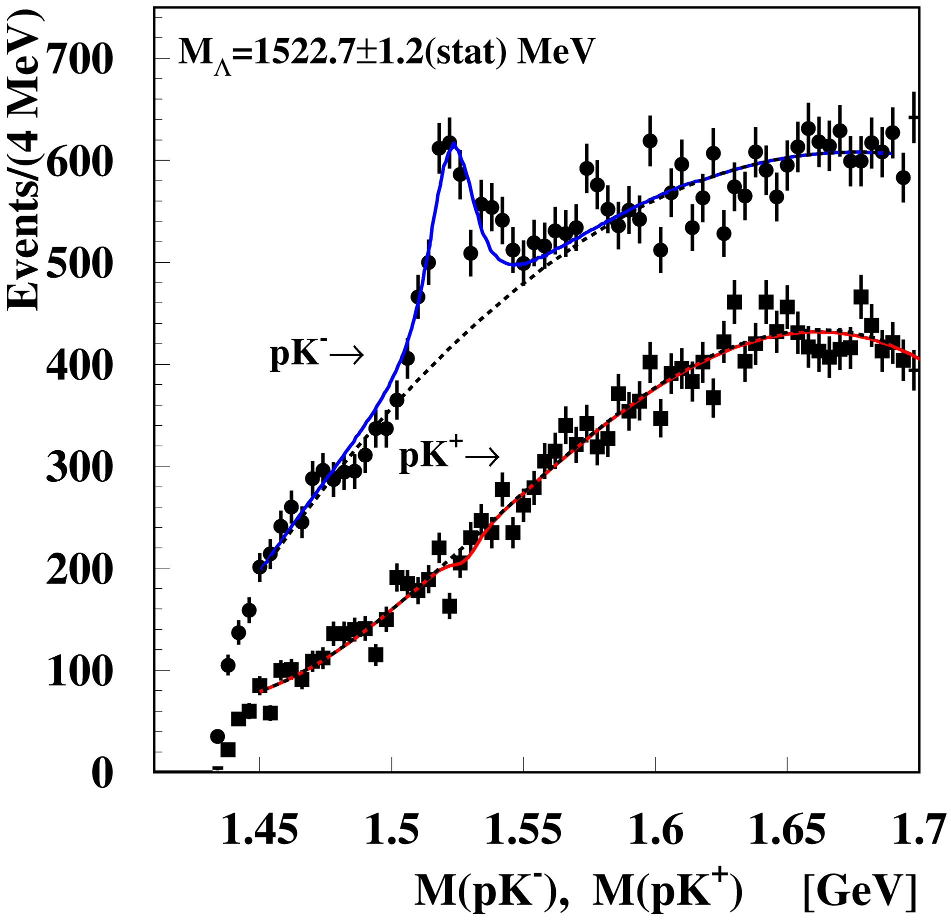
In the decay channels:

- $\rightarrow p\,K^-$: Clear Λ peak at 1522.7 MeV
- $\rightarrow p\,K^+$: no peak structure

  zero counts at 91 % CL

$\Rightarrow \Theta^+$ is not an isotensor

probably isosinglet



Production Cross-Section

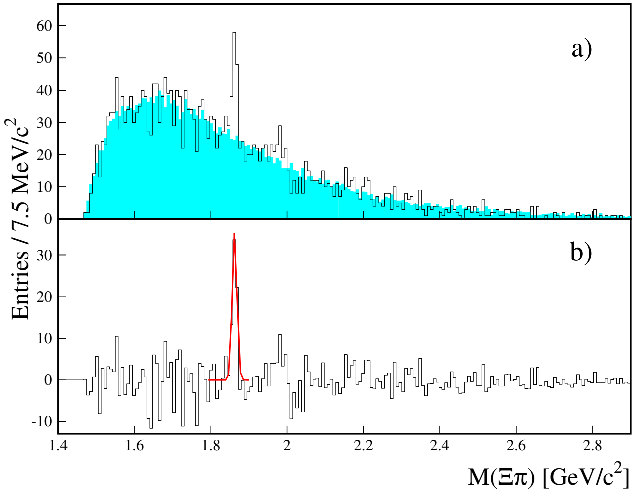
- Integrated luminosity $\mathcal{L}T$ = 250 pb^{-1}
- Toy MC model:
  - M_{Θ^+} = 1540 MeV, Γ_{Θ^+} = 2 MeV
  - Full detector simulation
  - Same set of cuts
- Toy model: acceptance 1.5% for Λ(1520) and 0.05% for Θ^+
- Branching ratio to pK^0_S is $\frac{1}{4}$

$\Rightarrow$ Estimate: $\sigma(\Theta^+)$ = (100 – 220) nb $\pm$ 25%(stat)

Search for Ξ^{--}

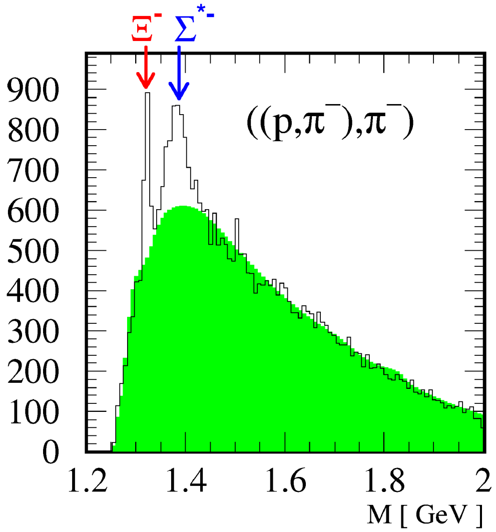
NA49:

- $M_{\Xi^{--}}$ = 1862 $\pm$ 2 MeV (significance 4 σ)
- Not confirmed by: Aleph
  Zeus
  CDF



HERMES:

- $\Xi^-\pi^- \rightarrow (\Lambda^0\pi^-)\pi^- \rightarrow ((p\pi^-)\pi^-)\pi^-$
- Results for Ξ^- (mixed events)
  - $M_{\Xi^-} = 1321.5 \pm 0.3$ MeV
  - $M_{\Sigma^{*-}} = 1381.1 \pm 1.5$ MeV
- $\Xi^{--}\ldots$



Conclusion and Outlook

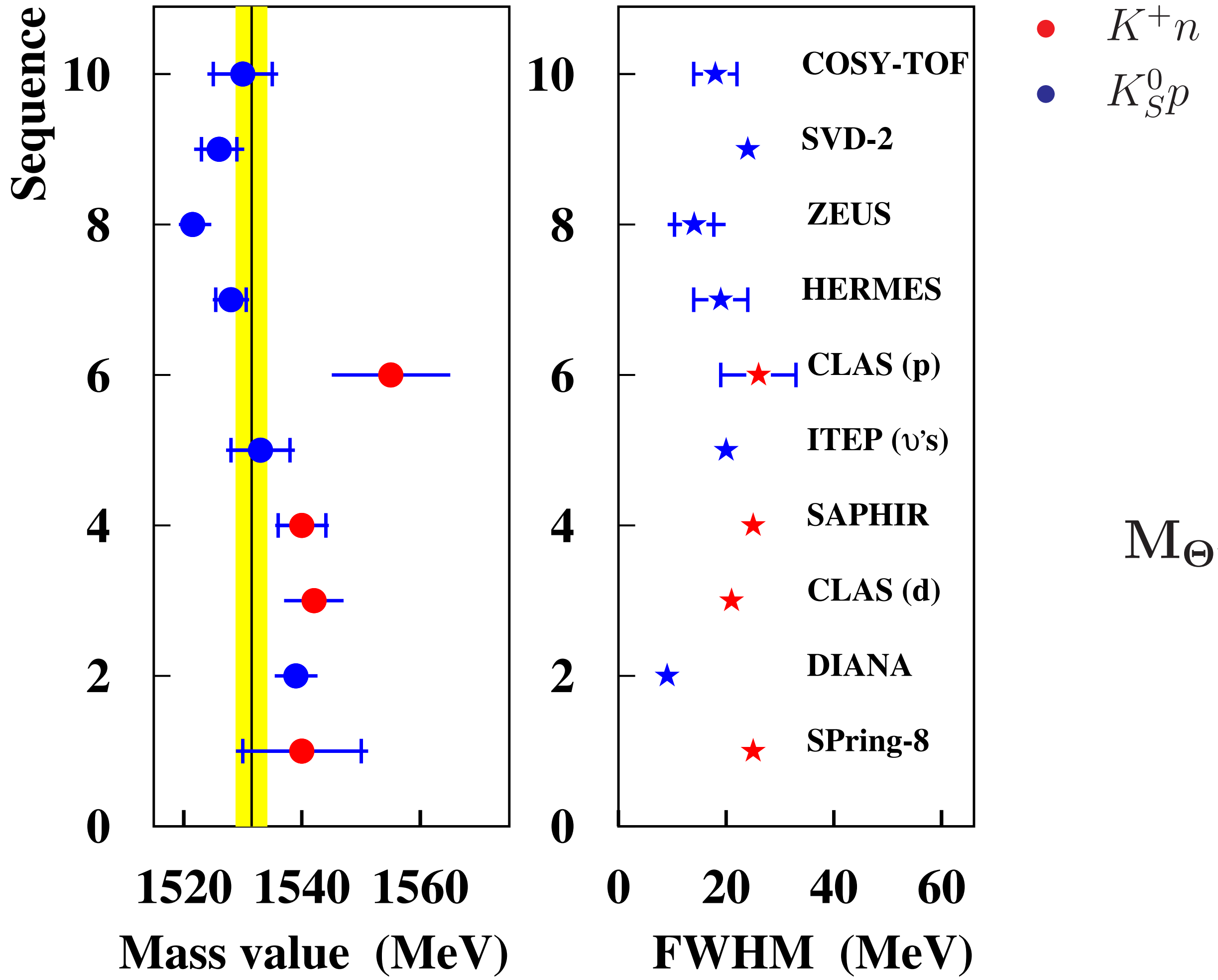
- Reaction channel e + D $\longrightarrow \Theta^+$ + X $\longrightarrow p$ + K^0_S + X
  - M_{Θ^+} = 1528 $\pm$ 2.6(stat) $\pm$ 2.1(syst) MeV
  - Γ_{Θ^+} = 17 $\pm$ 9(stat) $\pm$ 3(syst) MeV
- Significance: 4.2 σ – 6.3 σ (naive) and 3.4 σ – 4.3 σ (true)

  (depending on the background model)
- Θ^+ is not an isotensor

  probably an isosinglet
- Analysis of Ξ^{--} on the way
- Continue taking data with improved trigger for high density running

  $\longrightarrow$ increase statistics by about a factor 3 by this summer

Other Experiments



$M_{\Theta^+} = 1531.5 \pm 2.6$ **MeV**