New HERMES Results on Baryon Production

The photoproduction cross sections of $\Lambda(1520)$ and $\bar{\Lambda}(1520)$

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On behalf of the HERMES collaboration

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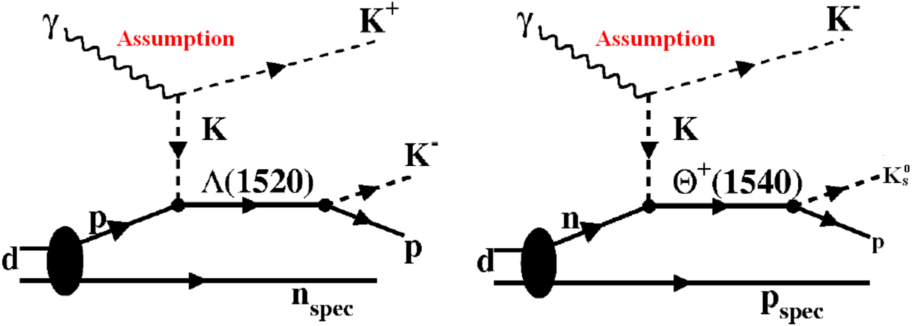
Outline

For Penta-quark Searching

Assumption: Same production mechanism for $\Lambda(1520)$ and Θ^+

- HERMES: evidence Θ^+ seen, $\bar{\Theta}^+$ not (Numbers: $59 \pm 16/3 \pm 6$)
- Also saw $\Lambda(1520)$, how about the $\bar{\Lambda}(1520)$? $\sigma_{\bar{\Lambda}(1520)} =?$ $\sigma_{\Lambda(1520)} =?$



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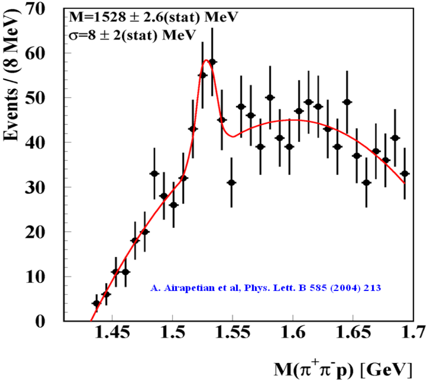
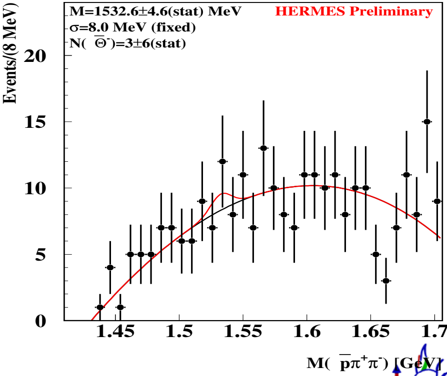


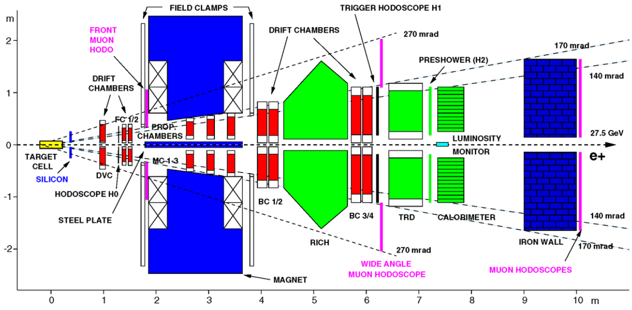


Location of HERMES

HERMES in beautiful Hamburg,Germany:

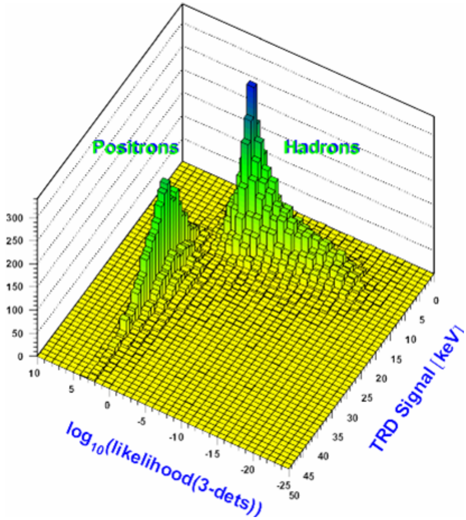
- Investigating: the quark-gluon structure of matter
- Seeking: how overall nucleon spin of 1/2 is constructed by its constituents

Spectrometer

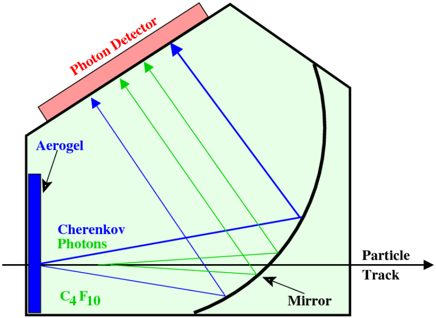


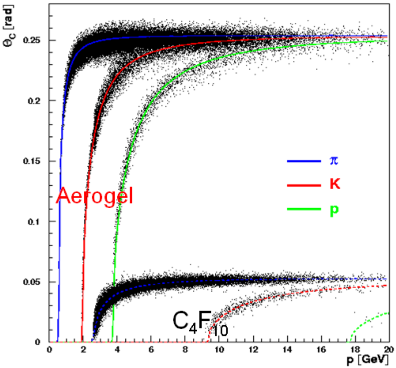
- Beam: 27.5 GeV e^+/e^-
- Target: D target, Luminosity $209pb^{-1}$
- Forward spectrometer: $\theta_x \leq 175mrad$, $40mrad \leq \theta_y \leq 140mrad$
- Reconstruction: $\Delta p/p$: $1.0 \sim 2.0\%$ and $\Delta\theta \leq 0.6mrad$
- Particle ID:
  - **RICH, TRD, Preshower, Calorimeter** (hadron/lepton)
  - Dual radiator **RICH** (π, K, p)

Leptons $\rightleftharpoons$ Hadrons Separation:



Hadrons⇒ $\pi/K/p$ (RICH)





Dual Radiator RICH:

- Silica Aerogel: $n = 1.0304$
- C_4F_{10} : $n = 1.0014$

Particle Identification:

- Cherenkov angle: $\cos\theta_C = \frac{1}{\beta n}$
- $P = \frac{m\beta c}{\sqrt{1-\beta^2}}$

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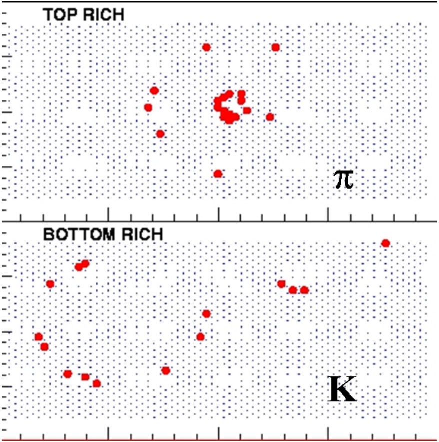
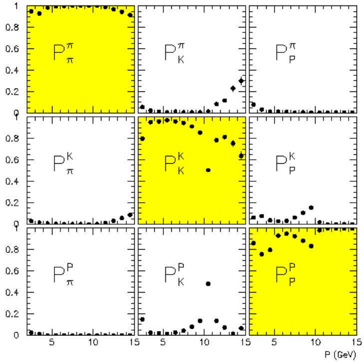
Hadrons$\Rightarrow \pi/K/p$ (RICH)





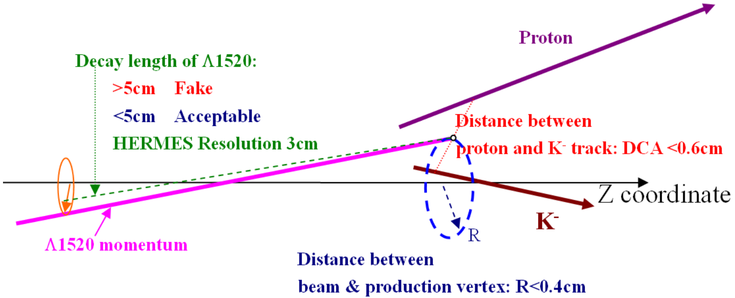
Detection Efficiencies:

- Diagonal: Identified
- Off-Diagonal: Mis-Identified

Reconstruction of $\Lambda(1520)$ and $\bar{\Lambda}(1520)$

$e + D \rightarrow \Lambda(1520) + X \rightarrow pK^- + X$

$e + D \rightarrow \bar{\Lambda}(1520) + X \rightarrow \bar{p}K^+ + X$



Topology of $\Lambda(1520)$ ($c\tau \approx 12.6 fm$)

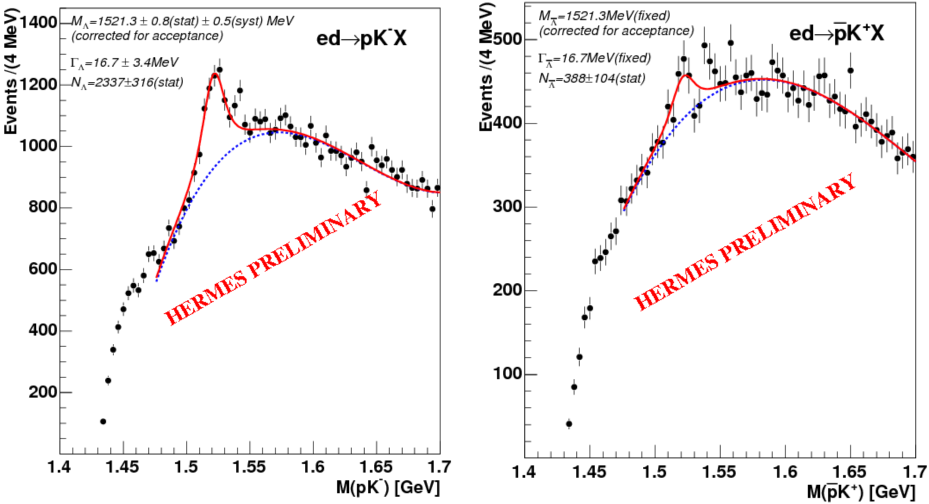
- p and K from one vertex $DCA < 0.6$ cm
- $\Lambda(1520)$ decayed from Beam $R < 0.4$ cm
- Decayed inside target cell $|Z < 18cm|$
- $\Lambda(1520)$ decay Length < 5 cm(Resolution along z: 3cm)

to Fit:

Unbinned Maximum Likelihood Fit

- With $\frac{1}{(x-M)^2+\frac{1}{4}\Gamma^2} \otimes \exp\left(-\frac{x^2}{2\sigma^2}\right) + \left(a_0 + a_1 x + a_2 x^2 + a_3 x^3\right)$
  - Breit-Wigner Function: Γ for intrinsic width
  - Gaussian Function: $\sigma = 4MeV$ for HERMES resolution(MC)
  - Polynomial function for baseline
- Steps to get $N_{\Lambda(1520)}$ and $N_{\bar{\Lambda}(1520)}$:
  1. With Fix $\sigma = 4MeV$ fit M(pK^-) spectrum and get M, Γ and $N_\Lambda(1520)$
  2. Fix $\sigma = 4MeV$, take the M and Γ from $\Lambda(1520)$ to get $N_{\bar{\Lambda}(1520)}$ on $\bar{p}K^+$ spectrum

$\Lambda(1520)$ and $\bar{\Lambda}(1520)$ Spectra



Partial Cross Sections($P_z > 6$ GeV) & Ratio

Calculated with the acceptance of HERMES spectrometer(MC) and integrated luminosity, partial cross sections are:

Partial cross sections of $\bar{\Lambda}(1520)$ and $\Lambda(1520)$ & ratio

$\sigma_{\bar{\Lambda}(1520)}$ $9.8 \pm 2.6(stat) \pm 0.9(syst)$ nb

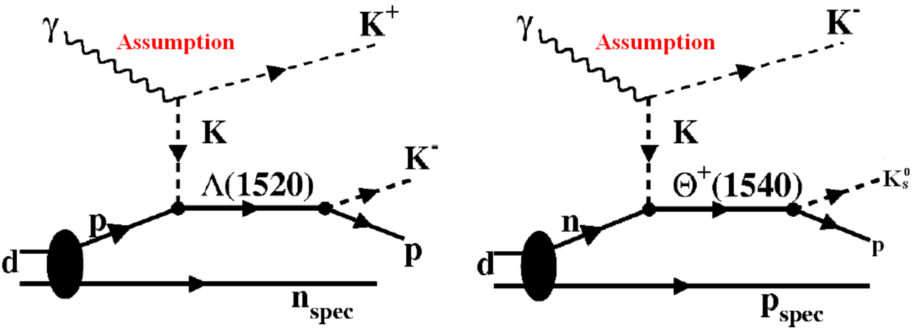
$\sigma_{\Lambda(1520)}$ $65.3 \pm 8.8(stat) \pm 6.9(syst)$ nb

$\frac{\sigma_{\bar{\Lambda}(1520)}}{\sigma_{\Lambda(1520)}}$ $0.15 \pm 0.05(stat) \pm 0.02(syst)$

Systematic Errors:

- Effect on acceptance from difference of the initial momentum distributions

Estimate of $N_{\bar{\Theta}^+}$ in HERMES



Base on the assumption of same production mechanism for $\Lambda(1520)$ and Θ^+, and also assumption of $\frac{N_{\bar{\Theta}^+}}{N_{\Theta^+}} = \frac{N_{\bar{\Lambda}}}{N_{\Lambda}}$, $N_{\bar{\Theta}^+}$ estimated as

1. $N_{\bar{\Theta}^+} = \frac{N_{\bar{\Lambda}}}{N_{\Lambda}} N_{\Theta^+} \approx 10 \pm 4$ should be seen
2. $N_{\bar{\Theta}^+} = 3 \pm 6$ has been seen

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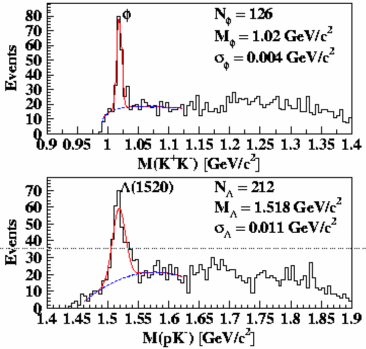
Summary

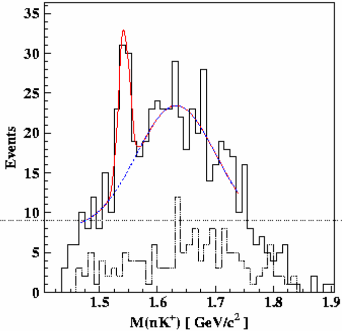
1. The cross sections of the $\Lambda(1520)$ and $\bar{\Lambda}(1520)$ were presented
2. The number of $\bar{\Theta}^+$ candidates that HERMES should see was given according to the assumption of $\frac{N_{\bar{\Theta}^+}}{N_{\Theta^+}} = \frac{N_{\bar{\Lambda}}}{N_{\Lambda}}$ and number of Θ^+ candidates seen at HERMES
3. Nucleons like the universe: at HERMES energy, it can easily produce $\Lambda(1520)$ but not easily create a $\bar{\Lambda}(1520)$ from the sea. It will be interesting to see how the ratios of particle and antiparticle for hyperons change with invariant mass.

BACKUP SLIDES

The Θ^+ resonance from CLAS



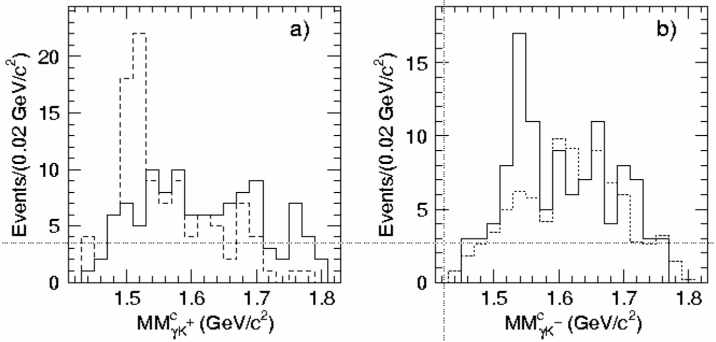
- Production of ϕ and $\Lambda(1520)$ in the reaction $\gamma d \rightarrow pK^+K^-n$
  They are removed in the analysis.



- solid histogram: final M(nK^+)
  solid line: arbitrary fit + bkgd
  dashed histogram: $\Lambda(1520)$ events

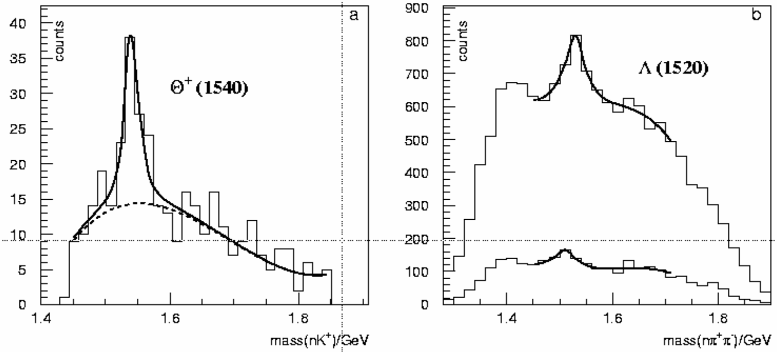
- Conclusion: M=1542±5 MeV, FWHM=21 Mev, σ=5.3±0.5

The Θ^+ resonance from LEPS



- a) solid histogram: K^-n missing mass (no res. expected)
  dashed histogram: K^-p missing mass ($\Lambda(1520)$ expected)
- b) solid histogram: K^+n missing mass (Θ^+ expected ?)
  dashed histogram: LH_2 spectrum of K^+p (no res. expected)
- Conclusion: M=1540 $\pm$ 10 MeV, Γ <25 MeV, $\sigma = \frac{N_s}{\sqrt{N_b}}$ = 4.6 ± 1.

The Θ^+ resonance from SAPHIR



- a) K^+n Missing Mass with the cut $\Theta_{K_s}^{cm} > 0.5$
- b) $\pi^+\pi^-n$ Missing Mass with (lower histogram) without (upper histogram) $\Theta_{K_s}^{cm} > 0.5$ cut
- Conclusion: M=1540$\pm 4 \pm 2$MeV, $\Gamma < 25$MeV, σ=4.8