

# The Search for Exotic Baryons at HERMES

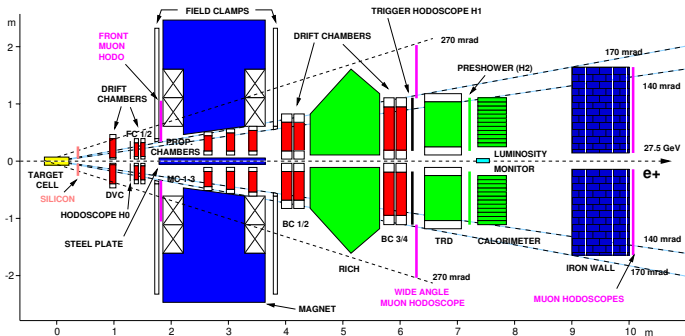
Wouter Deconinck



# Overview

- ▶ The HERMES Spectrometer
- ▶ Analysis of  $\Theta^+$ 
  - ▶ Particle Identification
  - ▶ Is  $\Theta^+$  Peak a  $\Sigma^+$  Resonance?
  - ▶  $\Theta^+$  with an extra hadron
- ▶ Analysis of  $\Xi^{--}$
- ▶ Conclusion

# The HERMES Spectrometer

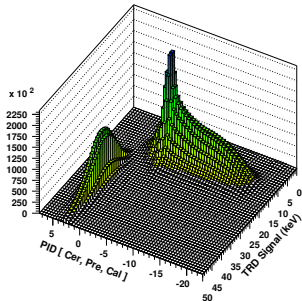


- ▶ 27.6 GeV  $e^\pm$  HERA beam on  $\vec{H}$ ,  $\vec{He}$ ,  $\vec{D}$  or  $H_2$ ,  $D_2$ ,  $He, \dots$
- ▶ Resolution:  $\frac{\Delta p}{p} = 1.4 - 2.5\%$ ,  $\Delta\vartheta \lesssim 0.6$  mrad
- ▶ **RICH**: hadron identification ( $p$ ,  $\pi$ ,  $K$ )
- ▶ **TRD**, **Calorimeter** and **Preshower**: hadron/lepton separation

# The HERMES Spectrometer

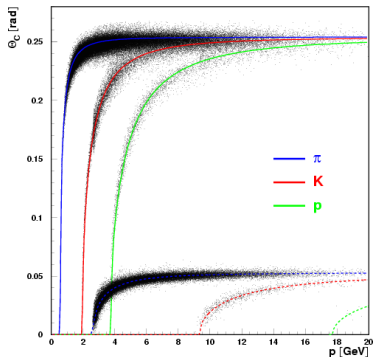
▶ **hadron/lepton separation:**  
combination of

- ▶ TRD
- ▶ Calorimeter
- ▶ Preshower
- ▶ RICH

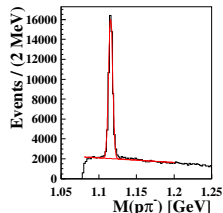
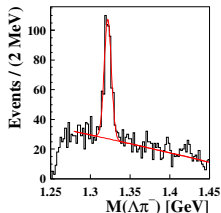
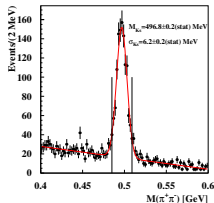
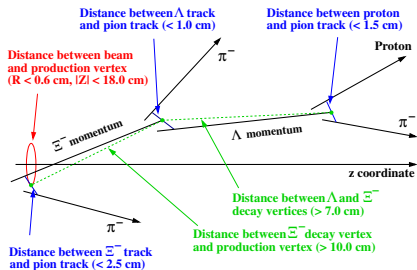
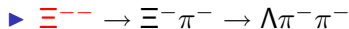
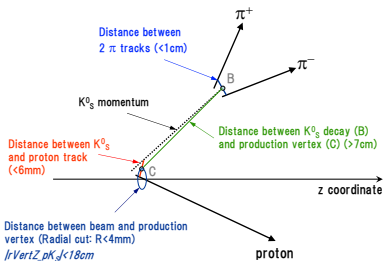
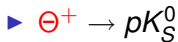


▶ **hadron identification:**  
dual radiator RICH

- ▶ aerogel:  $n = 1.03$
- ▶  $C_4F_{10}$  gas:  $n = 1.0014$

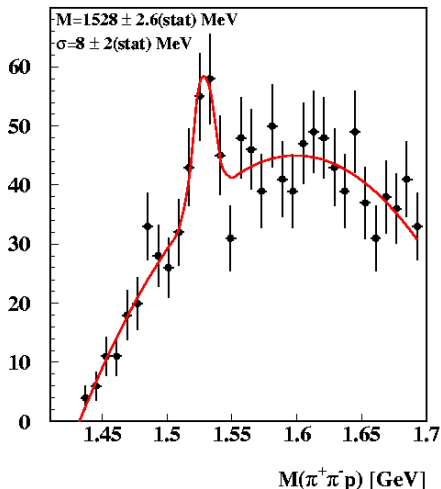


# Event Selection



# $\Theta^+$ Spectrum

## ► Spectrum with polynomial fit

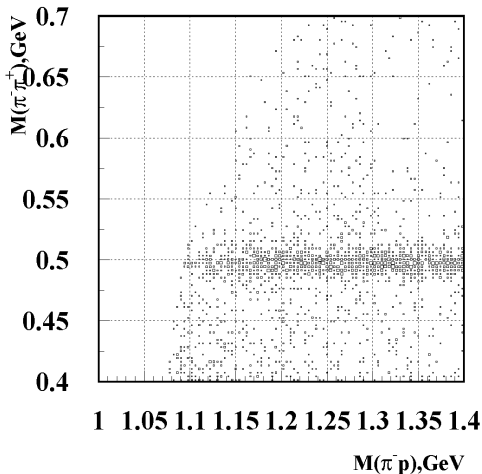


- Unbinned fit (red) with sum polynomial and Gaussian
- $\Theta^+$  peak
  - $M = 1528 \pm 2.6 \text{ MeV}$
  - $\sigma = 8 \pm 2 \text{ MeV}$
- Significance  $3.7 \sigma$

Ref.: Phys. Lett. B585 (2004) 213

# Particle Identification

## ▶ Correlation $M_{\pi\pi}$ vs. $M_{p\pi}$



## ▶ Ghost tracks

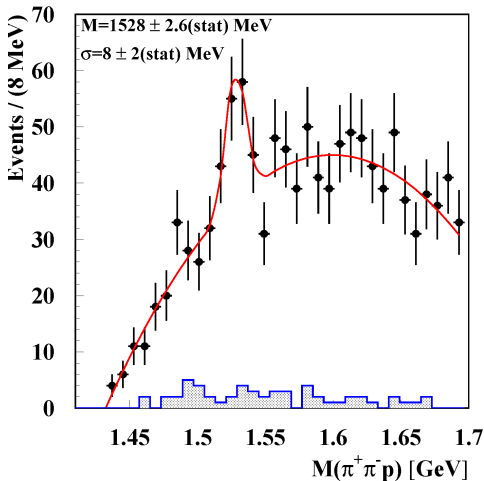
- ▶ No correlations
- ▶ Examined data files
- ▶ **No ghost tracks!**

## ▶ PID leaks

- ▶  $\pi^+$  is actually  $p$  (mis-ID)
- ▶  $K_S$  combination is a  $\Lambda$
- ▶  $\Lambda$  peak at  $M_\Lambda = 1116$  MeV not seen
- ▶ **No significant mis-ID of  $p$  tracks as  $\pi^+$ !**

# Particle Identification

## ▶ Contribution $\Lambda(1116)$

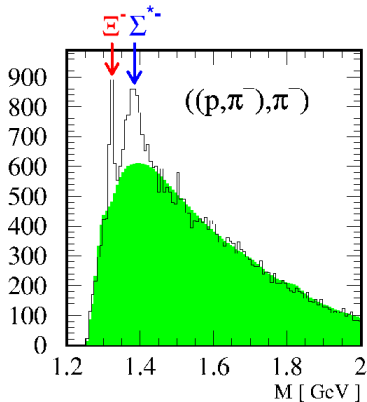
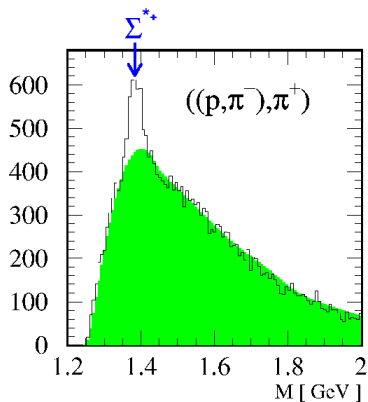


- ▶  $\Lambda(1116)$  events already cut out
- ▶ Cut may be inefficient. . .
  - ▶ How many  $\Lambda$  events cut away?
  - ▶ Events from  $\Lambda$  decay (blue)
- ▶ Peak not from  $\Lambda$ !

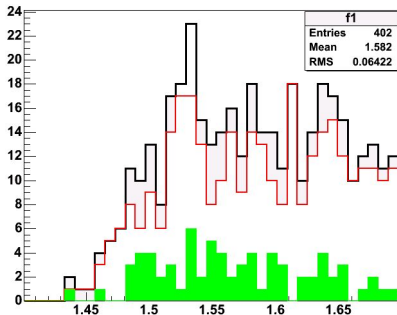


## Is $\Theta^+$ Peak a $\Sigma^{*+}$ Resonance?

- ▶  $\Sigma^{*+}$  would decay to  $\Lambda\pi^+$  with  $Br(\Lambda\pi^+)/Br(K_S^0\pi) = 3/2$



- ▶ **No peak** in  $\Lambda\pi^+$  spectrum at 1530 MeV (mixed events in green)
- ▶ Known  $\Xi^-$ ,  $\Sigma^{*-}$ ,  $\Sigma^{*+}$  clearly seen

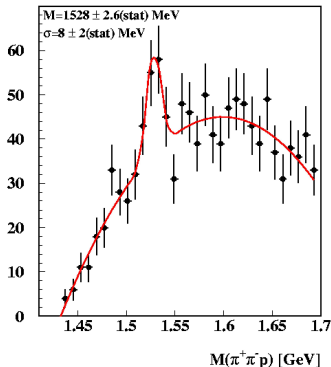
$\Theta^+$  with an Extra Hadron

- ▶ With 4th hadron (black)
- ▶ 4th hadron =  $\pi$  (red)
- ▶ 4th hadron  $\neq \pi$  (green)

- ▶ Require extra  $\pi$ 
  - ▶ Decreases background from  $p\phi \rightarrow pK_S^0 K_L^0 \rightarrow p\pi^+\pi^-(K_L^0)$
  - ▶ Signal stays
- ▶ Additionally
  - ▶ Remove  $K^{*\pm}$  from  $K^{*\pm} \rightarrow K_S\pi^\pm \rightarrow \pi^+\pi^-\pi^\pm$
  - ▶ Remove  $\Lambda \rightarrow p\pi_4$  from  $K_S^0\Lambda \rightarrow p\pi\pi\pi$

# Summary $\Theta^+$ Search

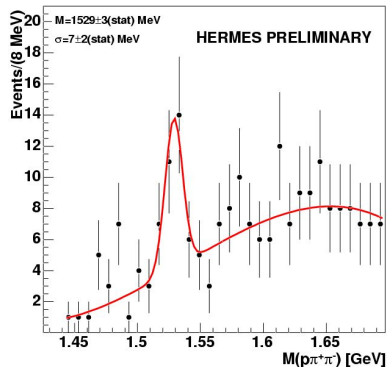
## ▶ Signature $p\pi\pi$



▶  $M = 1528 \pm 2.6 \text{ MeV}$

▶  $\sigma = 8 \pm 2 \text{ MeV}$

## ▶ Extra $\pi$ : signature $p\pi\pi\pi$

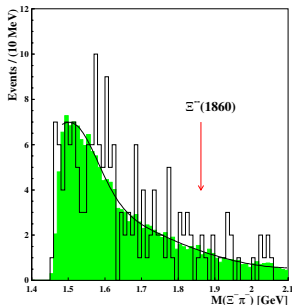


▶ Signal over background

**1 : 3  $\rightarrow$  2 : 1**

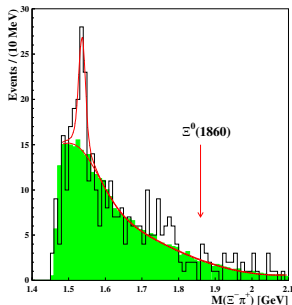
# Summary $\Xi^{--}$ Search

## ▶ $\Xi^{--}$ spectrum



- ▶ No  $\Xi^{--}(1860)$  peak!
- ▶ Upper limit  $\sigma_{\Xi^{--}}^{90\%} = 1.0 - 2.1$  nb

## ▶ $\Xi^0$ spectrum



- ▶ No  $\Xi^0(1860)$  peak!
- ▶ Upper limit  $\sigma_{\Xi^0}^{90\%} = 1.2 - 2.5$  nb
- ▶  $\sigma_{\Xi^0}(1530) = 8.8 - 24$  nb

Ref.: Phys. Rev. D71 (2005) 032004

# Conclusions

Experimental status:

- ▶  $\Theta^+$ : about 15 sightings, about 15 null results
- ▶  $\Xi^{--}$ : 1 sighting, several null results

Contributions of HERMES (in 2004 – 2005):

- ▶ Confirmation of  $\Theta^+$  (results carefully checked)
- ▶ No peak in  $\Theta^{++} \rightarrow pK^+$ : probably isoscalar
- ▶ Third  $\pi$  improves signal  $\rightarrow$  production mechanism?
- ▶  $\Xi^{--}$  is not seen  $\rightarrow \sigma_{\Xi^{--}} < 2.1$  nb (90% C.L.)

Outlook: analyzing new data. . .