# Study of Hyperon and Antihyperon Production in Deep Inelastic Muon Scattering

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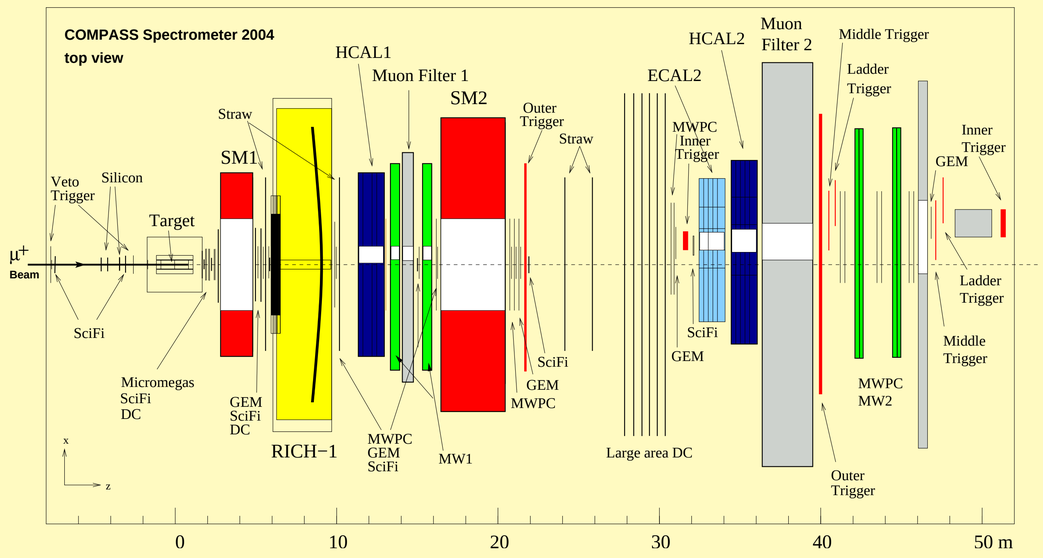
## Abstract

The yields of heavy hyperons and antihyperons have been studied in deep inelastic scattering at the COMPASS experiment at CERN. The relative yields of $\Sigma(1385)^+$, $\Sigma(1385)^-$, $\bar{\Sigma}(1385)^-$, $\bar{\Sigma}(1385)^+$, $\Xi(1321)^-$, and $\bar{\Xi}(1321)^+$ hyperons decaying into $\Lambda(\bar{\Lambda})\pi$ were measured. The ratios of $\Sigma^{\pm}/\Lambda$, $\bar{\Sigma}^{\pm}/\bar{\Lambda}$, $\Xi^-/\Lambda$ and $\bar{\Xi}^+/\bar{\Lambda}$ were determined. The measured yields were used to tune the parameters of the LEPTO generator simulating the DIS events.


## Motivation

- Understanding of the mechanism of heavy hyperons and antihyperons production in DIS. No measurements of the heavy antihyperon yields were existing before.
- Role of heavy hyperons decays in the production and polarization of $\Lambda$ and $\bar{\Lambda}$. Indirect $\Lambda$ (from heavy hyperons decays) is about 40 %. What about $\bar{\Lambda}$?
- Possible dependence of heavy hyperons production on $Q^2$.
- Testing and tuning the existing MC generator ($\Sigma^{\pm}(1385)/\Lambda$, $\bar{\Sigma}^{\pm}(1385)/\bar{\Lambda}$, $\Xi^-(1321)/\Lambda$, $\bar{\Xi}^+(1321)/\bar{\Lambda}$).

## COMPASS setup




**Muon beam**
160 $GeV/c$ $\mu^+$
$2\cdot 10^8 \mu/16.8s$
Target material $^6$LiD

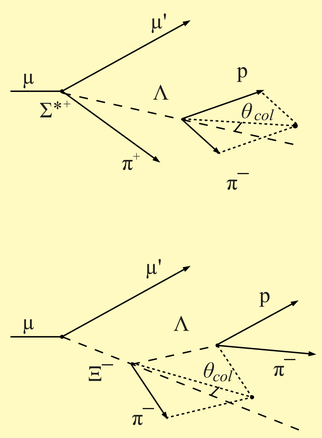
**Spectrometer**
Two magnets (1 Tm, 4.4 Tm)
Traking (p>0.5 GeV/$c$)
SciFi, Silicon, MicroMega, GEM, MWPC, Drift, Straws, Drifttubes
PID: $\pi, K, p$ (RICH)
ECAL, HCAL, muon filter

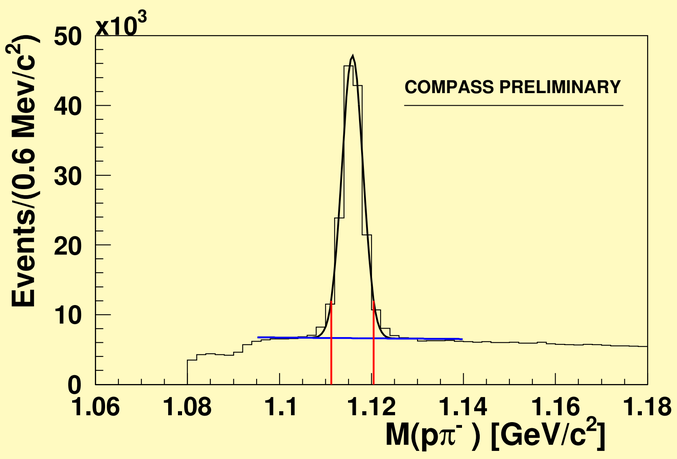
## Yields of $\Lambda$ and $\bar{\Lambda}$ hyperons

2003 - 2004 data were used for this analysis.

$\mu^+ + d \to \mu^+ + \Lambda(\bar{\Lambda}) + X$
$\mu^+ + d \to \mu^+ + \Sigma(1385) + X$
$\mu^+ + d \to \mu^+ + \Xi(1321) + X$

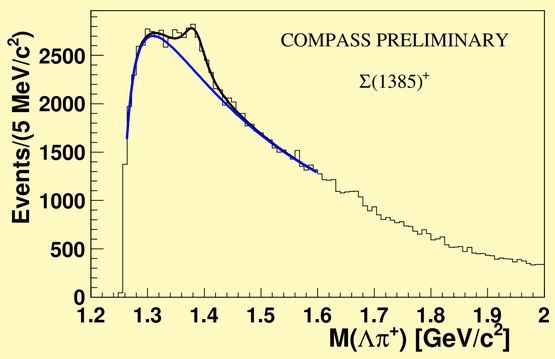
DIS cuts:
$Q^2 > 1\ (\mathrm{GeV}/c)^2$
$0.2 < y < 0.9$



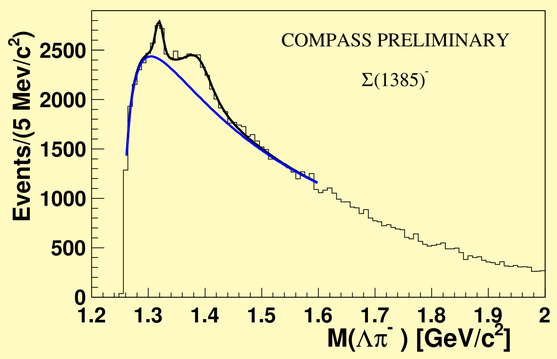




| | $N(\Lambda)$ | $N(\bar{\Lambda})$ |
|---|---|---|
| E665 | 750 | 650 |
| NOMAD | 8087 | 649 |
| HERMES | 26714 | 3610 |
| RHIC | 30000 | 24000 |
| COMPASS | 112000 | 67000 |

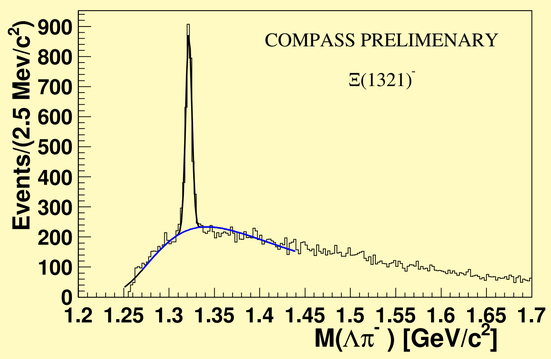
## Yields of heavy hyperons and antihyperons




DIS cuts: $N(\Sigma^+)3600 \pm 330$
no DIS cuts: $N(\Sigma^+) = 40000 \pm 1250$



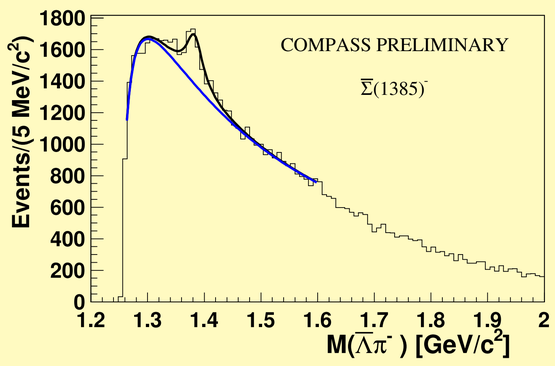

$N(\Sigma^-) = 3000 \pm 500$
$N(\Sigma^-) = 35200 \pm 1500$



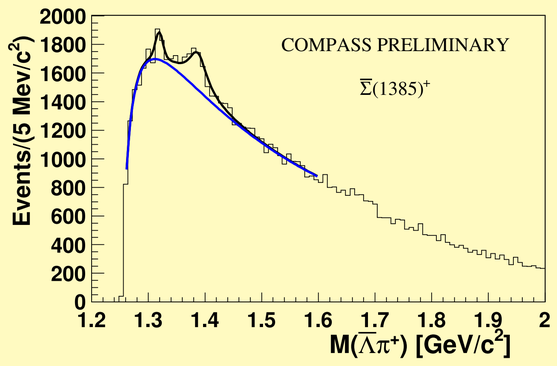

$N(\Xi^-) = 1600 \pm 50$
$N(\Xi^-) = 20500 \pm 170$

The heavy hyperons to $\Lambda$ and antihyperon to $\bar{\Lambda}$ yield ratios in lepton DIS:

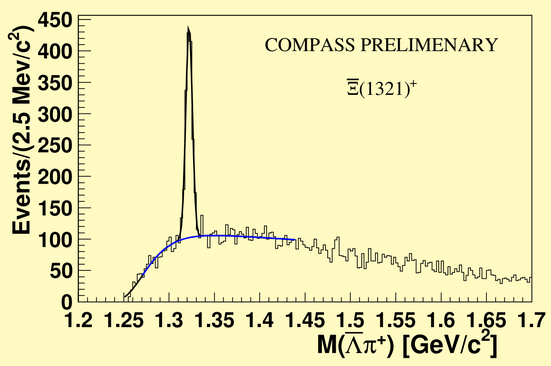
$\Sigma^{*+}/\Lambda = 0.055 \pm 0.005(stat) \pm 0.005(syst)$
$\bar{\Sigma}^{*-}/\bar{\Lambda} = 0.047 \pm 0.006(stat) \pm 0.006(syst)$
$\Sigma^{*-}/\Lambda = 0.056 \pm 0.009(stat) \pm 0.007(syst)$
$\bar{\Sigma}^{*+}/\bar{\Lambda} = 0.039 \pm 0.006(stat) \pm 0.006(syst)$
$\Xi^-/\Lambda = 0.038 \pm 0.003(stat) \pm 0.002(syst)$
$\bar{\Xi}^+/\bar{\Lambda} = 0.043 \pm 0.004(stat) \pm 0.002(syst)$




DIS cuts: $N(\bar{\Sigma}^-) = 2200 \pm 220$
no DIS cuts: $N(\bar{\Sigma}^-) = 20000 \pm 850$




$N(\bar{\Sigma}^+) = 1900 \pm 260$
$N(\bar{\Sigma}^+) = 19500 \pm 1200$




$N(\bar{\Xi}^+) = 1050 \pm 40$
$N(\bar{\Xi}^+) = 11500 \pm 130$

| Ratios | COMPASS | NOMAD |
|---|---|---|
| $\Sigma^+(1385)/\Lambda$ | $0.055 \pm 0.005$ | $0.025 \pm 0.019$ |
| $\bar{\Sigma}^-(1385)/\bar{\Lambda}$ | $0.047 \pm 0.006$ | – |
| $\Sigma^-(1385)/\Lambda$ | $0.056 \pm 0.009$ | $0.037 \pm 0.015$ |
| $\bar{\Sigma}^+(1385)/\bar{\Lambda}$ | $0.039 \pm 0.006$ | – |
| $\Xi^-(1321)/\Lambda$ | $0.038 \pm 0.003$ | $0.007 \pm 0.007$ |
| $\bar{\Xi}^+(1321)/\bar{\Lambda}$ | $0.043 \pm 0.004$ | – |

## Tuning the Monte Carlo

| Ratios | LEPTO Default | DATA COMPASS | LEPTO COMPASS |
|---|---|---|---|
| $\Lambda/\bar{\Lambda}$ | $1.22 \pm 0.01$ | $1.71 \pm 0.02$ | $1.72 \pm 0.01$ |
| $K/\Lambda$ | $6.06 \pm 0.01$ | $6.21 \pm 0.05$ | $6.22 \pm 0.01$ |
| $\Sigma^+/\Lambda$ | $0.082 \pm 0.001$ | $0.055 \pm 0.005$ | $0.052 \pm 0.001$ |
| $\bar{\Sigma}^-/\bar{\Lambda}$ | $0.074 \pm 0.001$ | $0.047 \pm 0.006$ | $0.038 \pm 0.001$ |
| $\Sigma^-/\Lambda$ | $0.084 \pm 0.001$ | $0.056 \pm 0.009$ | $0.067 \pm 0.001$ |
| $\bar{\Sigma}^+/\bar{\Lambda}$ | $0.060 \pm 0.001$ | $0.039 \pm 0.006$ | $0.037 \pm 0.001$ |
| $\Xi^-/\Lambda$ | $0.051 \pm 0.0008$ | $0.038 \pm 0.003$ | $0.029 \pm 0.001$ |
| $\bar{\Xi}^+/\bar{\Lambda}$ | $0.056 \pm 0.0008$ | $0.043 \pm 0.004$ | $0.040 \pm 0.001$ |

## Conclusions

- The yields of heavy (anti-)hyperons in DIS were measured.
- The relative yields of indirect $\Lambda$ and $\bar{\Lambda}$ production are similar
- The ratios $\Sigma/\Lambda$, $\Xi/\Lambda$ do not dependent on $Q^2$ (DIS cuts)
- The LEPTO generator parameters have been tuned to reproduce the yields
- The influence of indirect $\Lambda$ production on the measurement of $\Lambda$ polarisation is weak.