

# Baryon Spectroscopy at COMPASS

HK 77.2

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bmb+f - Förderschwerpunkt  
**COMPASS**  
Großgeräte der physikalischen  
Grundlagenforschung



Symmetry  
**Breaking**

# Introduction

## Why study baryons?

- ▶ 3-quark bound states  
⇒ excellent probe to study QCD
- ▶ baryon spectrum only poorly known
  - ▶ many states with \* or \*\* in PDG listings
  - ▶ many missing states



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## How to study baryons?

- ▶  $\pi N$  scattering
  - ▶ no new data available
  - ▶ still dominates PDG listings
- ▶  $\gamma N$  scattering
  - ▶ MAMI, ELSA (HK 84.2), ...
- ▶  $J/\psi$  decays
  - ▶ BESIII (HK 61.1)
- ▶  $NN$  scattering
  - ▶ HADES (HK 1.2)
  - ▶ COMPASS

# Introduction

## What do we measure at COMPASS?

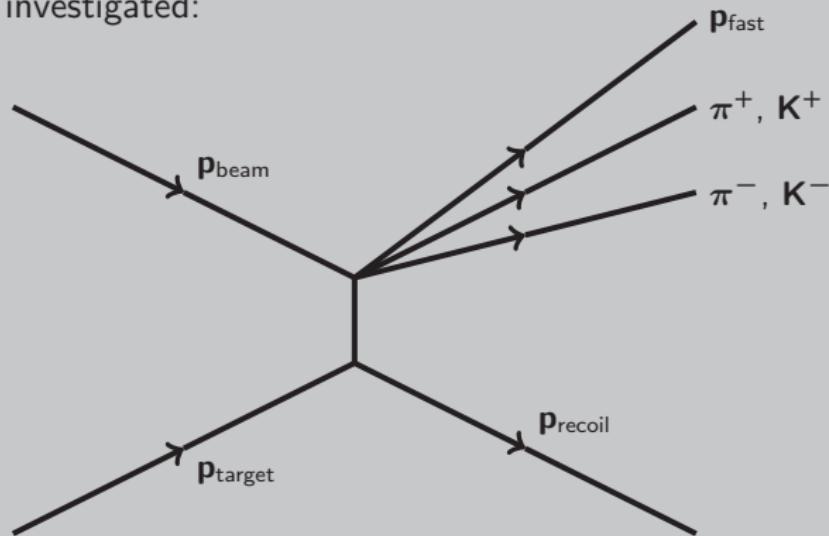
- ▶ 2009 data taking
- ▶ 190 GeV/c proton beam on liquid hydrogen target
- ▶ So far only two channels investigated:
  - ▶  $p\bar{p} \rightarrow p_f \pi^+ \pi^- p_{\text{recoil}}$
  - ▶  $p\bar{p} \rightarrow p_f K^+ K^- p_{\text{recoil}}$

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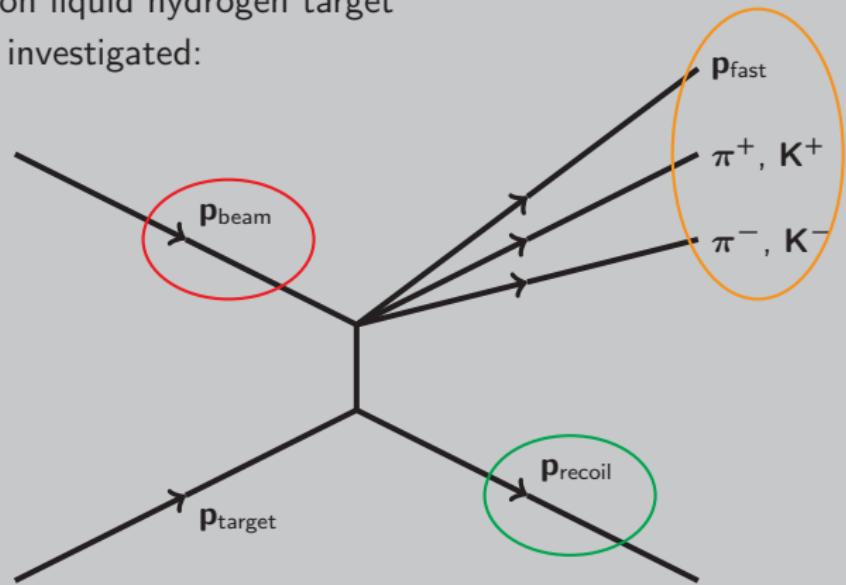
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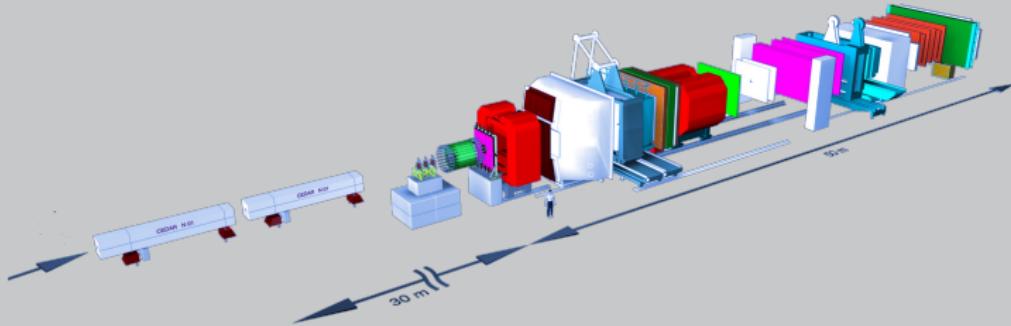
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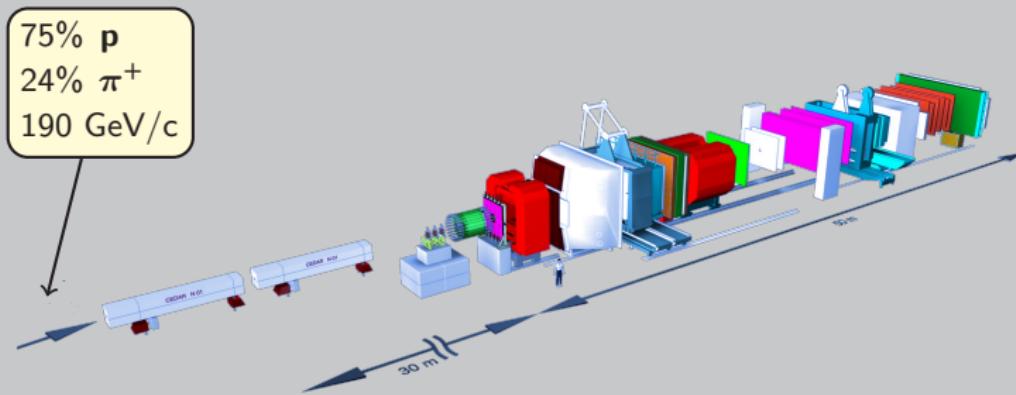
# The COMPASS Experiment

- ▶ COmmon Muon and Proton Apparatus for Structure and Spectroscopy
- ▶ Located at SPS at CERN



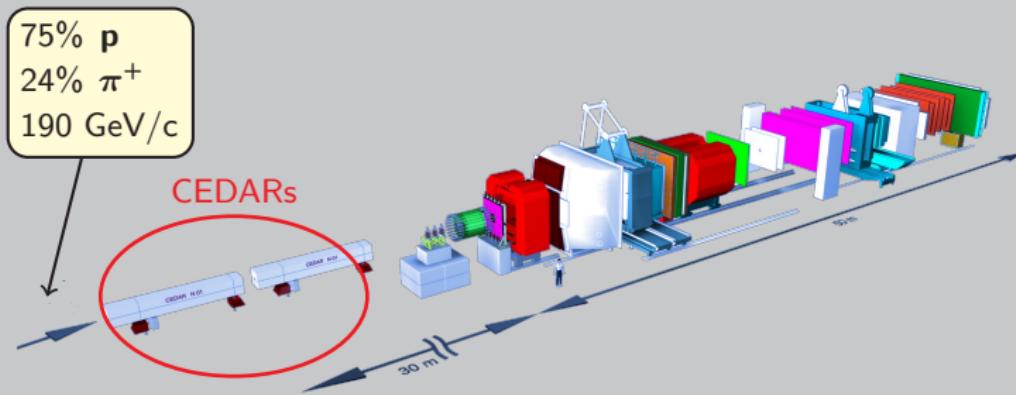
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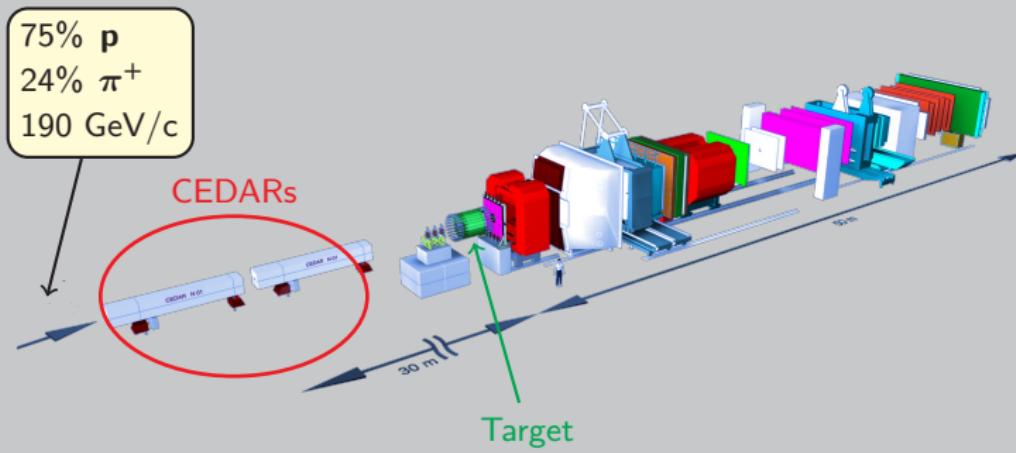
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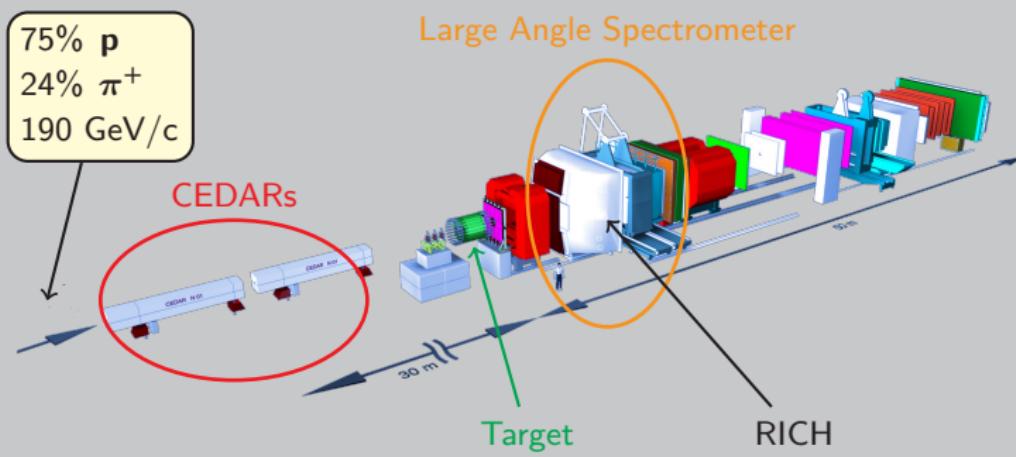
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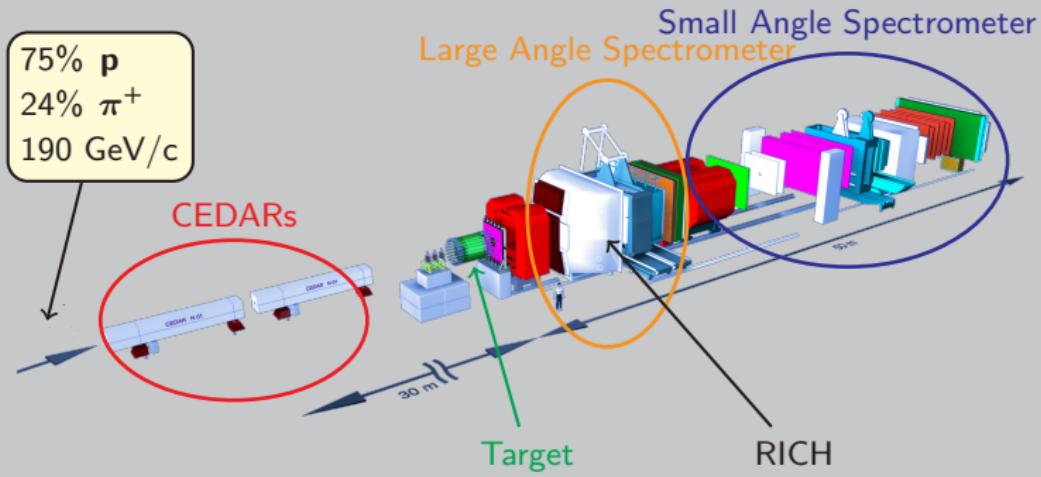
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## Cuts

- ▶ minimum bias trigger
  - ▶ incoming beam + recoiling proton
- ▶ exactly 1 primary vertex reconstructed inside the target
- ▶ identified incoming proton
- ▶ 1 reconstructed recoil proton
- ▶ 3 outgoing charged particles
  - ▶  $\sum Q = +1$
- ▶ outgoing  $\pi^+$  or  $K^+$  identified by RICH



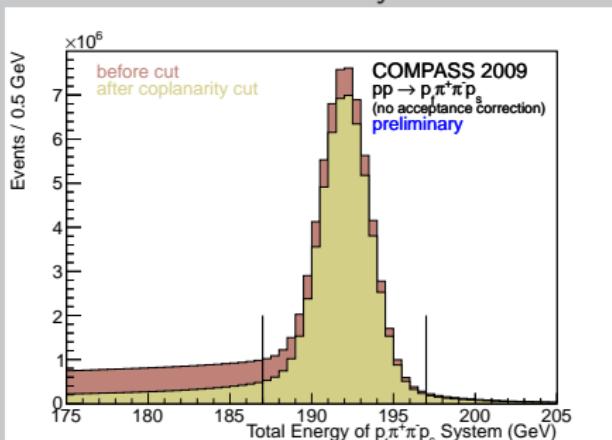


## Exclusivity and Coplanarity

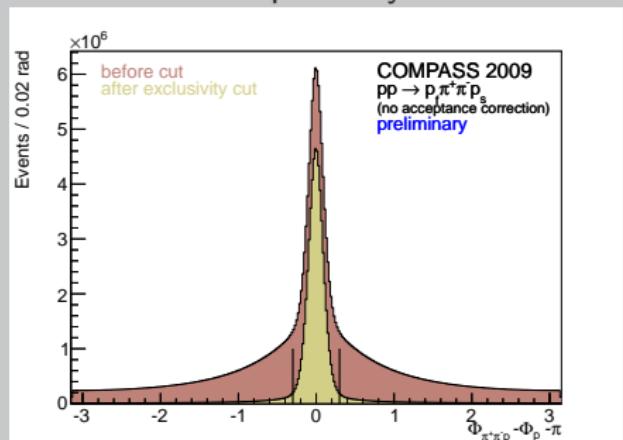
Exclusive events selected by 2 cuts:

- ▶ energy sum of outgoing system around peak value (exclusivity)
- ▶ azimuthal angles of outgoing system and recoil proton differ by  $\pi$  (coplanarity)

Exclusivity

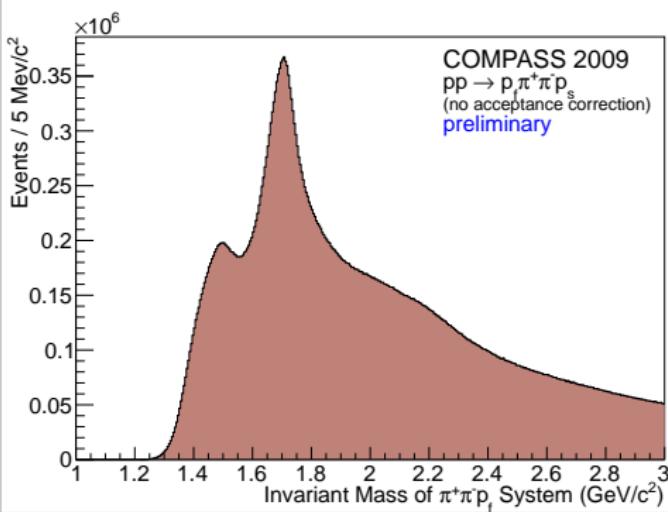


Coplanarity





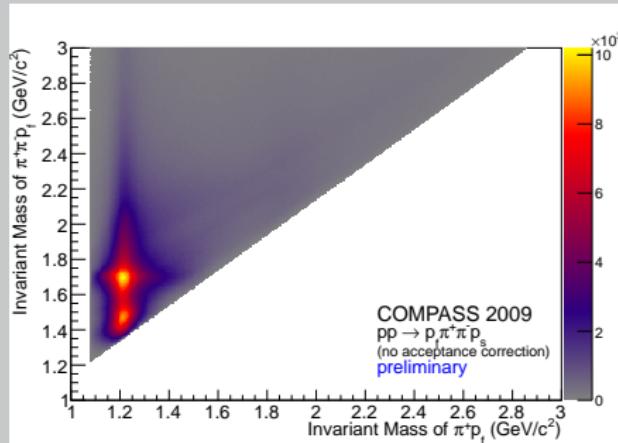
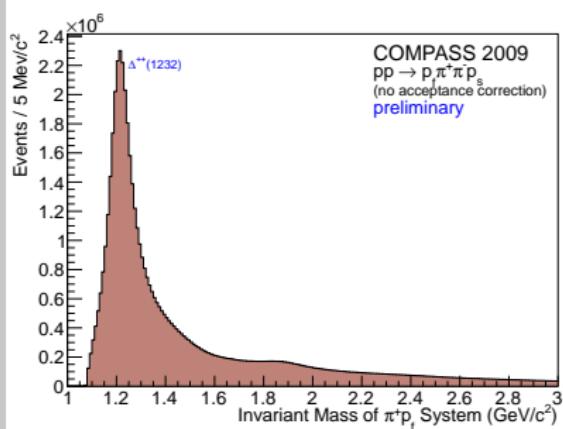
## Invariant Mass of $\pi^+ \pi^- p_f$



- ▶ more than 56M events
- ▶ small structure at  $\approx 1450 \text{ MeV}$
- ▶ dominant structure at  $\approx 1700 \text{ MeV}$   
possible candidates:
  - ▶  $N(1700)^{3/2}^-$  (\*\*\*)
  - ▶  $\Delta(1700)^{3/2}^-$  (\*\*\*\*)
  - ▶  $N(1710)^{1/2}^+$  (\*\*\*)
  - ▶  $N(1720)^{3/2}^+$  (\*\*\*\*)
- ▶ shoulder at  $\approx 2200 \text{ MeV}$



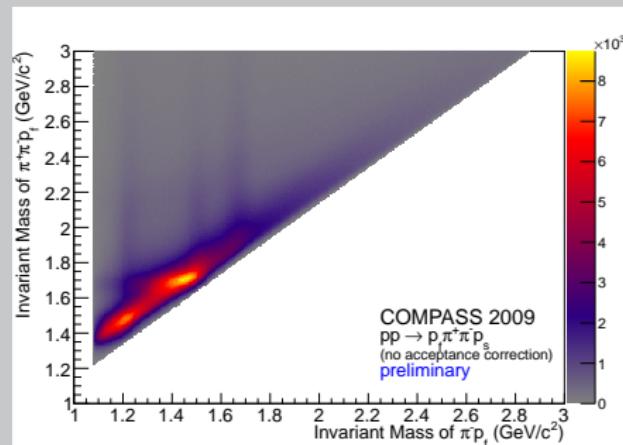
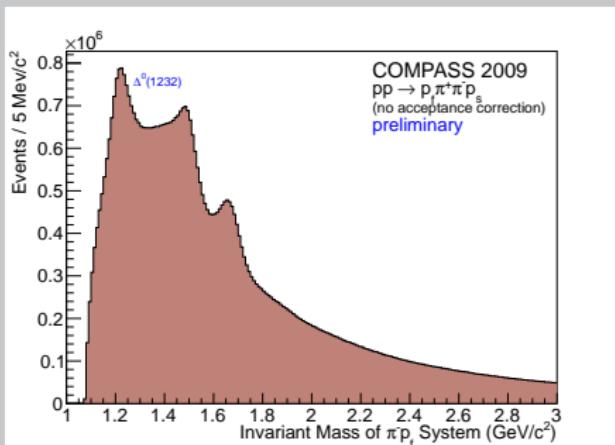
## Invariant Mass of $\pi^+ p_f$ -subsystem



- ▶  $\Delta^{++}(1232)$  dominates
- ▶ small shoulder at  $\approx 1900$  MeV



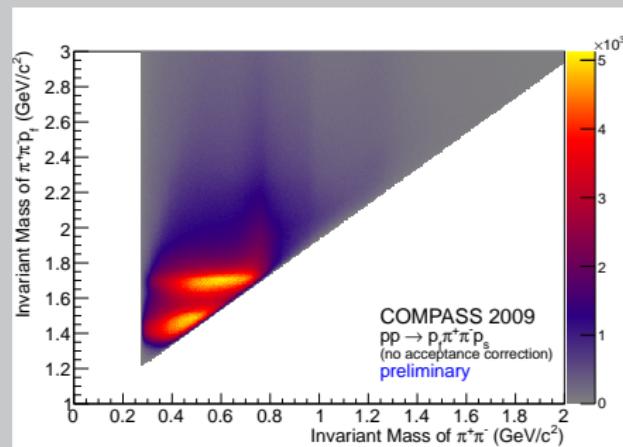
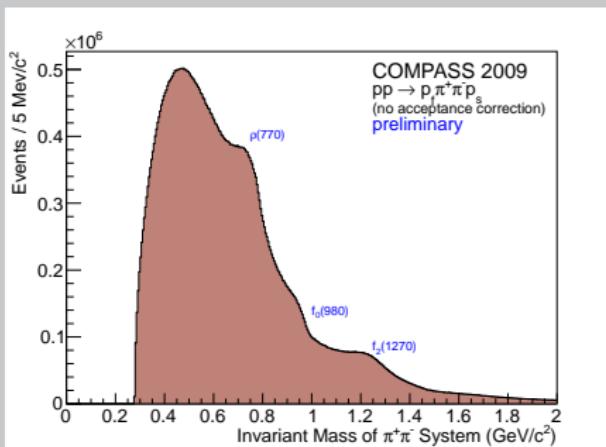
## Invariant Mass of $\pi^- p_f$ -subsystem



- ▶  $\Delta^0(1232)$
- ▶  $N(15??) \leftarrow$  dominant decay mode of 1700 MeV structure
- ▶  $N(16??), \Delta(16??)$



## Invariant Mass of $\pi^+ \pi^-$ -subsystem

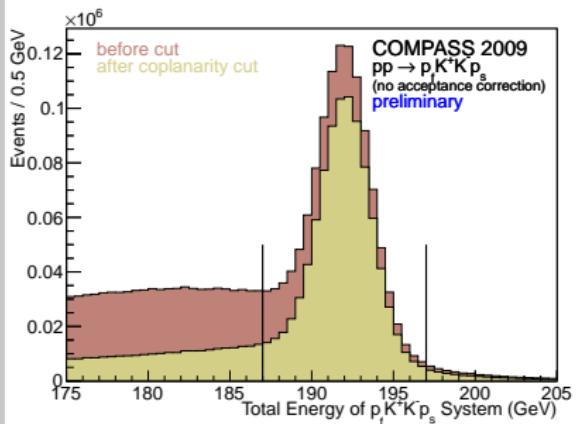


- ▶  $\rho(770)$
- ▶  $f_0(980)$
- ▶  $f_2(1270)$

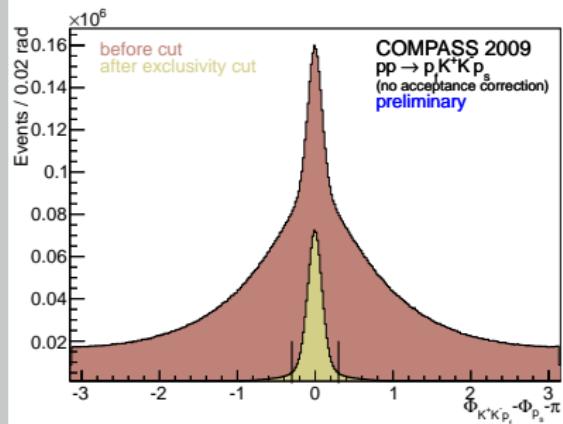


## Cuts

### Exclusivity

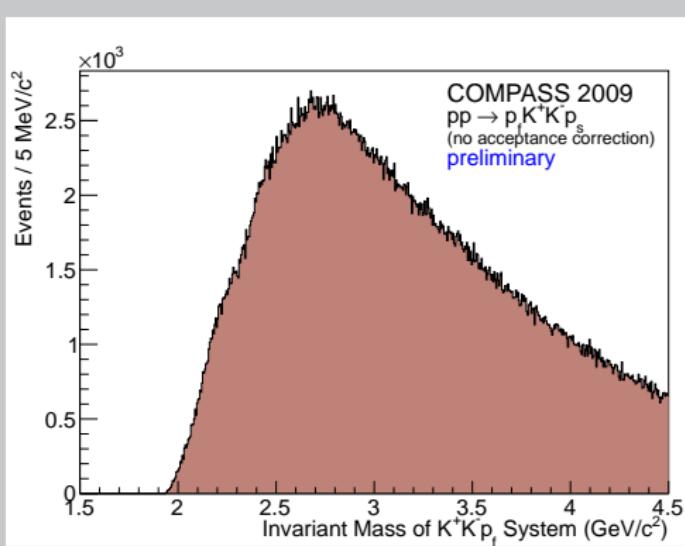


### Coplanarity





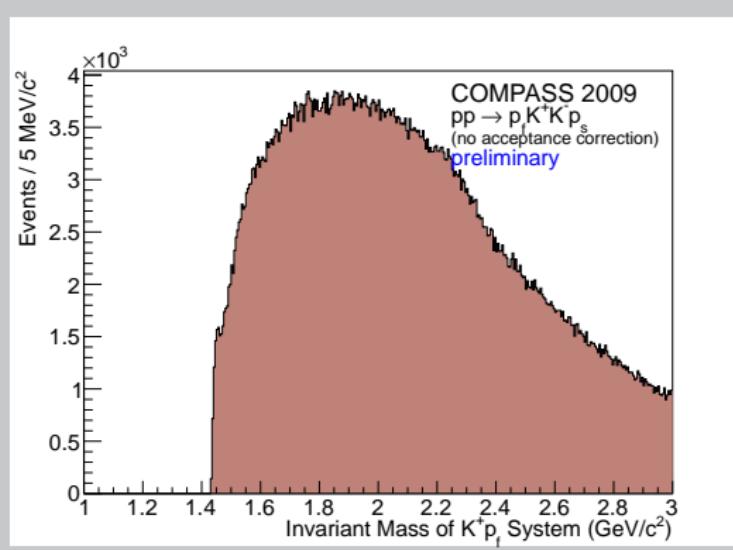
## Invariant Mass of $K^+ K^- p_f$



- ▶ more than 900k events
  - ▶ no clear structures seen
  - ▶ some pion contributions still visible
- ⇒ RICH selection still to be optimised



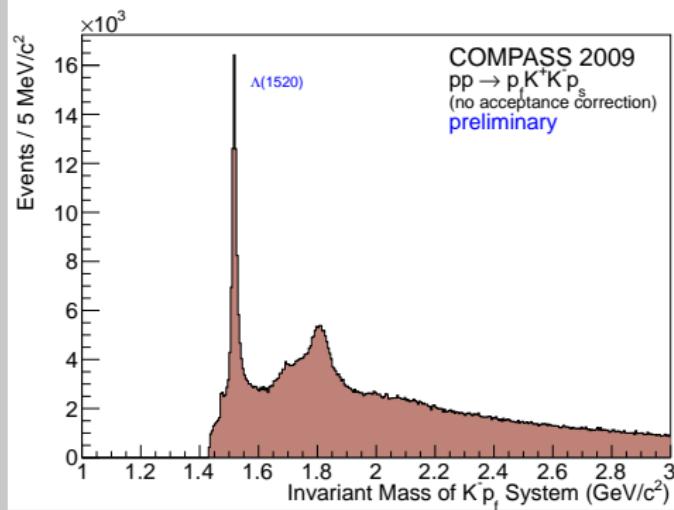
## Invariant Mass of $K^+ p_f$ -subsystem



- ▶ no resonances expected for  $q = +2$  and  $s = +1$
- ▶ no structures seen



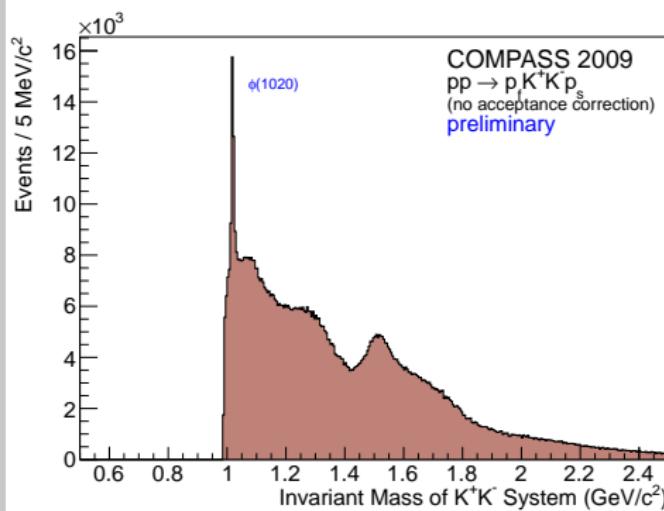
## Invariant Mass of $K^- p_f$ -subsystem



- ▶ clear  $\Lambda(1520)$  contribution
  - ▶ good resolution
- ▶ further structure at  
 $\approx 1800$  MeV ( $\Lambda(18??)$ )?



## Invariant Mass of $K^+K^-$ -subsystem



- ▶ clear  $\phi(1020)$  contribution
  - ▶ good resolution
- ▶ shoulder by  $a_2(1320)$ ?
- ▶ structure at  $\approx 1500$  MeV ( $f_0(1500)$ ?  $f'_2(1525)$ ?)

PWA of centrally produced system performed by A. Austregesilo (HK 2.5)

# Conclusion and Outlook

- ▶ COMPASS has large datasets for baryon spectroscopy in **p p** scattering
- ▶ so far **p p** → **p π<sup>+</sup>π<sup>-</sup> p** and **p p** → **p K<sup>+</sup>K<sup>-</sup> p** analysed
- ▶ rich structures visible in most mass spectra



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- ▶ rich structures visible in most mass spectra

Next steps:

- ▶ Extend to further channels
  - ▶ p $\pi^0\pi^0p$ , pK<sup>0</sup> $\bar{K}^0p$
  - ▶ p $\pi^0p$ , p $\eta p$ , p $\omega p$ ,  $\Lambda K^+p$ , ...
- ▶ start of partial wave analysis (PWA)



# Thank you for your attention

