Baryon Spectroscopy at COMPASS

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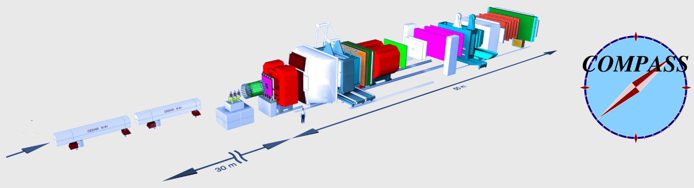
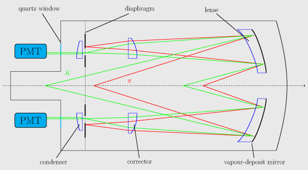
The COMPASS experiment

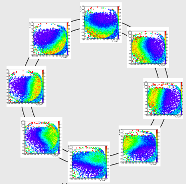
The COMPASS (COmmon Muon and Proton Apparatus for Structure and Spectroscopy) experiment at CERN is a fixed-target experiment at the Super Proton Synchrotron (SPS) covering a broad spectrum of physics topics. The experimental setup consists of two magnetic spectrometers extending over a length of 50 m downstream of the target. These are the large angle spectrometer and the small angle spectrometer, respectively. In addition the trajectory of each incoming beam particle is measured in front of the target using a high resolution silicon detector telescope. Particle identification is performed using electromagnetic and hadron calorimeters as well as a ring imaging Čerenkov detector (RICH).



Beam Particle Identification at COMPASS

The COMPASS negative hadron beam used in 2008 and 2009 mainly consists of pions but also of 2.4% kaons. These kaons have to be identified to allow background free analyses of pion induced reactions (e.g. $\pi^- p \to \pi^-\pi^+\pi^- p$). In addition a identification of the beam kaons allows to study kaon induced processes (e.g. $K^- p \to K^-\pi^+\pi^- p$).





For the identification of beam particles at COMPASS two Čerenkov detectors of the CEDAR (ČErenkov Differential counter with Achromatic Ring focus) type are used. By choosing the correct pressure inside of the detector the Čerenkov ring for kaons is guided through a diaphrgm and collected by eight photomultipliers. This principle only works well for particles crossing the detector parallel to the beam axis. For particles with a certain angle the Čerenkov rings are shifted and the kaon ring is no longer detected by the photomultipliers. Thus a simple cut on the number of responding photomultipliers is not very efficient. Therefore, a new method was developed using Bayes' theorem and the response of the photomultipliers using pure kaon and pion samples.
This new method improves the kaon identification efficiency by a factor of 2 with a misidentification rate that is comparable to a multiplicity cut.

Baryon Spectroscopy

The spectrum of baryons is still not fully understood. On the one hand many states found by different experiments do not fit into theoretical calculations, on the other hand many states predicted by theory are still not found in the available data. Thus further experiments are needed to clarify the situation.
For six weeks in 2009 COMPASS took data using a 190 GeV/c positive hadron beam impinging on a liquid hydrogen target. The beam consists of 75% protons and thus allows the study of light baryon resonances in the $pp \to p_{\text{recoil}} B^+ \to p_{\text{recoil}} X^0 p_{\text{fast}}$ process, with a baryonic resonance B^+ and a mesonic state X^0. As COMPASS measures charged as well as neutral final state particles with high accuracy several possibilities for X^0 are accessible. Therefore, different channels are investigated:

- $pp \to p\pi^0 p$
- $pp \to p\eta' p$
- $pp \to p\pi^+\pi^- p$
- $pp \to pK^+K^- p$
- $pp \to p\eta p$
- $pp \to p\omega p$
- $pp \to p\pi^0\pi^0 p$
- $pp \to pK^0K^0 p$

Here we present some first results for the $\pi^0 p$, ηp, $\pi^+\pi^- p$ and $K^+K^- p$ final state.

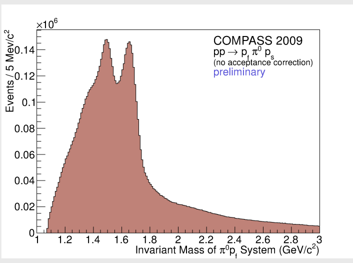
$pp \to p\pi^0 p$ and $pp \to p\eta p$

Event Selection

- 1 primary vertex in the target
- incoming proton identified
- recoil proton + 1 outgoing charged track + 2 photons
- 2 photons from π^0/η decay
- exclusive event

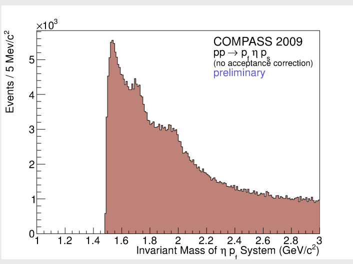
The final data set comprehends about 9M events for $\pi^0 p$ and 400k events for ηp.

$pp \to p\pi^0 p$



The invariant mass spectrum of $p\pi^0$ shows two clear peaklike structures around 1500 MeV and around 1700 MeV, which could be explained by a number of candidates in the PDG but also might result from a overlap of several states.

$pp \to p\eta p$



The invariant mass spectrum of $p\eta$ also shows two peaklike structures around 1700 MeV and 2000 MeV. Especially in the region of the second structure no established states are available in the PDG listings.

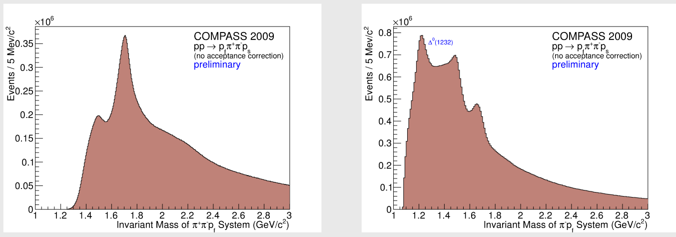
$pp \to p\pi^+\pi^- p$ and $pp \to pK^+K^- p$

Event selection

- 1 primary vertex in the target
- incoming proton identified
- recoil proton + 3 outgoing charged tracks
- positive meson identified by RICH
- exclusive event

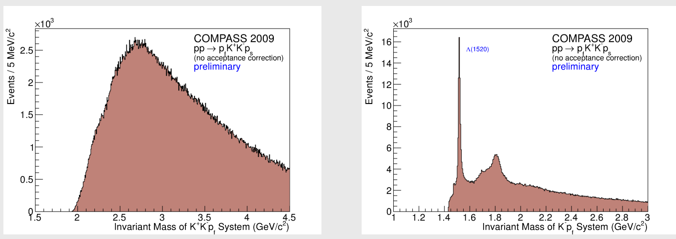
The data set contains about 56M events for $\pi^+\pi^- p$ and 900k events for $K^+K^- p$.

$pp \to p\pi^+\pi^- p$



In the invariant mass spectrum of $\pi^+\pi^- p$ a large structure is observed around 1700 MeV. In addition also in the $\pi^- p$ mass spectrum several structures – including the $\Delta^0(1232)$ – can be observed.

$pp \to pK^+K^- p$



The invariant mass spectrum of $K^+K^- p$ shows no clear structures. For this channel the different subspectra are of larger interest, e.g. the $K^- p$ spectrum which shows rich structures beyond a sharp $\Lambda(1520)$ peak.

Outlook

To decompose the strucures found in the invariant mass distributions a partial wave analysis (PWA) will be performed. In addition further channels will be investigated and analysed.