Baryon Spectroscopy at COMPASS

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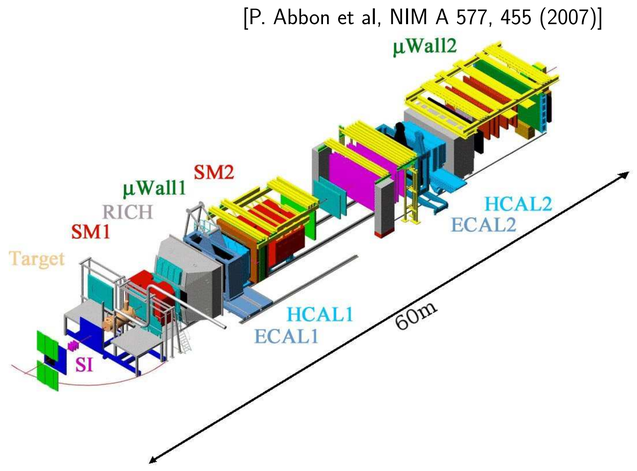
COMPASS

COmmon Muon and Proton Apparatus for Structure and Spectroscopy

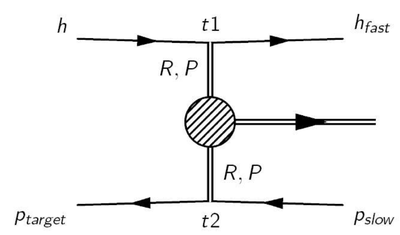
- Fixed target experiment
- Located at CERN SPS
- Data taking since 2002
- Physics objectives:
  - Hadron spectroscopy
  - Nucleon spin structure
- 2 types of beam
  - 190 GeV/c secondary hadron beams (p, π^+ or π^-, K^-)
  - 160 GeV/c tertiary muon beams (μ^+ or μ^-)

[P. Abbon et al, NIM A 577, 455 (2007)]

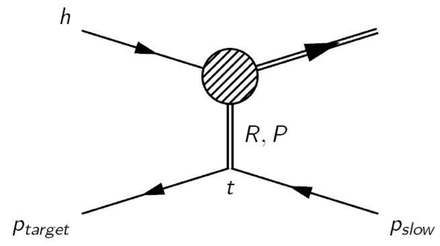


Hadron Spectroscopy

Central Production:

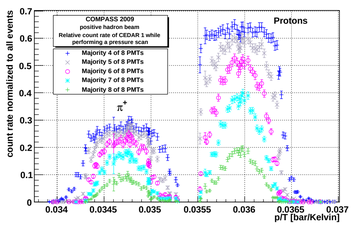


Diffractive Dissociation:



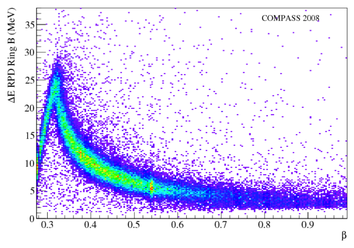
- Liquid hydrogen target
- Trigger on recoil proton → no bias on forward kinematics
- Production of non-$q\bar{q}$-mesons (Glue Balls, Hybrids) at central rapidities enhanced with proton beam
- Diffractive excitation of proton beam → **Baryon Spectroscopy**
- In analogy to diffractive dissociation of pion beam [→ Meson Spectroscopy at COMPASS, F.Nerling]

Beam Proton Identification



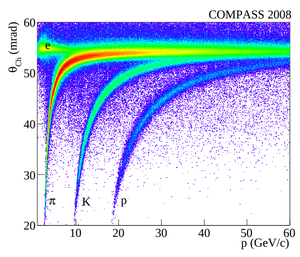
Beam composition:
75% p, 24% π^+, 1% K^+
→ CEDAR detector
(ChErenkov Differential counter with Achromatic Ring focus)

Recoil Proton Identification



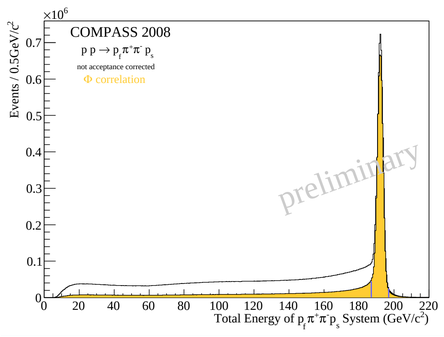
- Energy loss of particle in recoil detector
- Clean proton signal

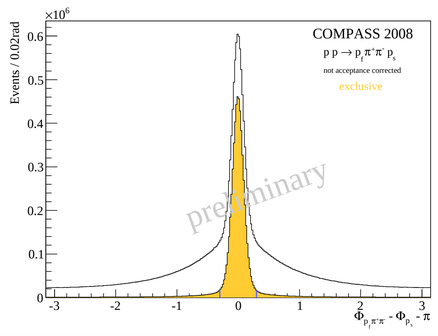
Final State Particle Identification



- Distinction between 2 positively charged particles in forward direction
  → RICH (Ring Imaging CHerenkov) detector
- Direct proton identification not effective in this kinematic range
- π^+/K^+ identification below 50 GeV/c
- K^+ identification above 9 GeV/c

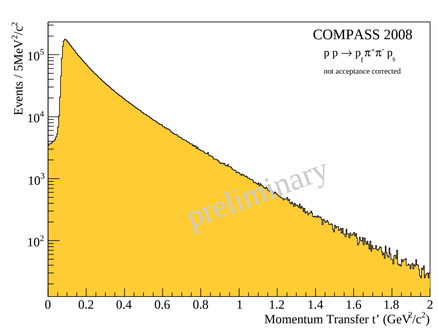
Selection of Exclusive Events





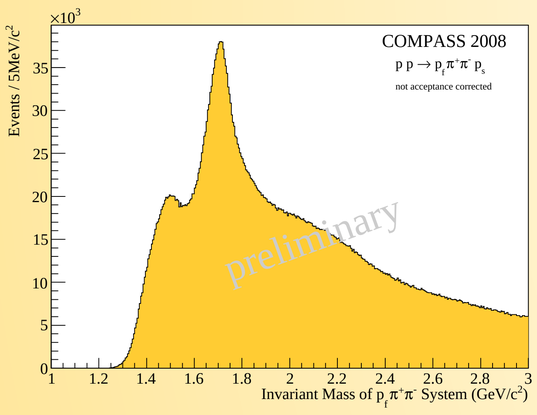
- Energy sum of the 4 final-state particles
- Φ-correlation between forward-going three-particle system and recoil proton
- Very low background

4-Momentum Transfer



- Slope consistent with diffraction on nucleon
- Recoil proton detector acceptance $t' > 0.07\,\mathrm{GeV}^2/c^2$

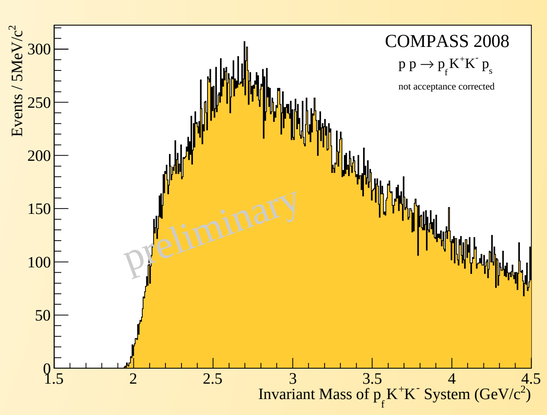
$p\,p \to p_f\,\pi^+\pi^-\,p_s$

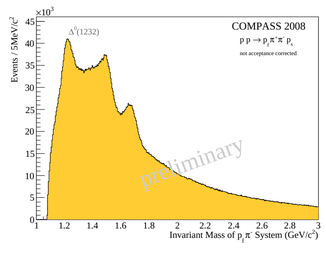


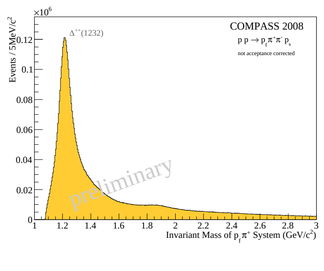
Baryon Spectroscopy

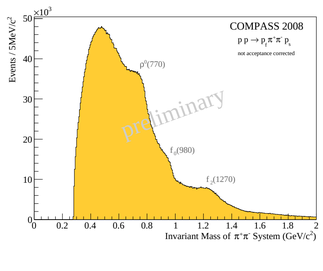
- **Hadro-production** complementary to existing photo- and electro-production experiments (CLAS, CBELSA, ..)
- High resolution spectrometer with flat acceptance
  → Baryon spectrum accessible in **great detail**
- Presented histograms represent only 10% of complete data sample
  → **Large data set**
- High mass and high angular momentum states poorly known

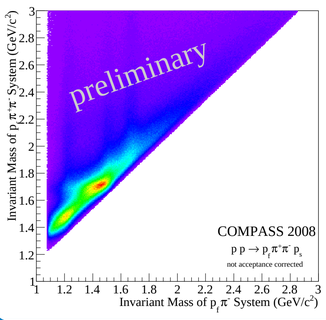
$p\,p \to p_f\,K^+K^-\,p_s$

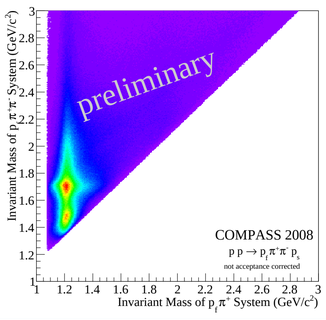


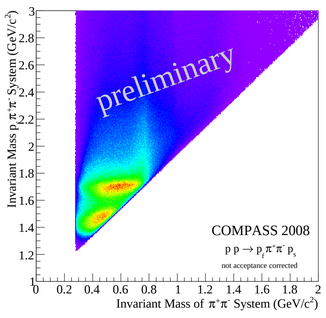






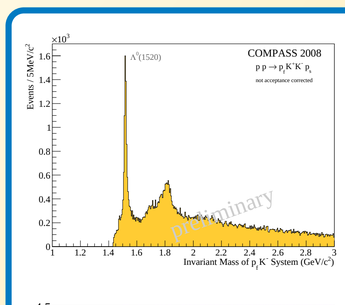


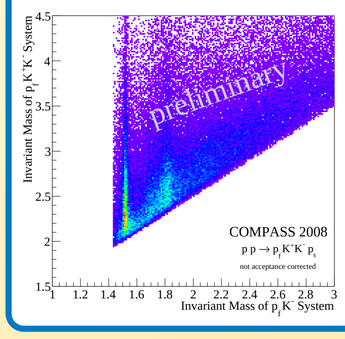


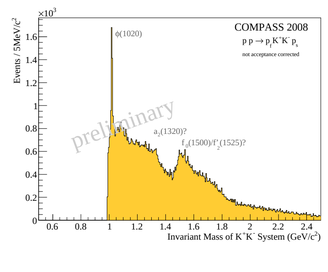


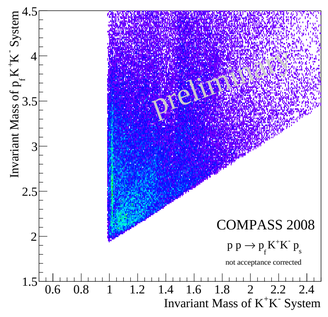
Two-Particle Sub-Systems:

- Resonances both in $N\pi$ and $\pi\pi$ modes
- Distinct excited baryon spectrum







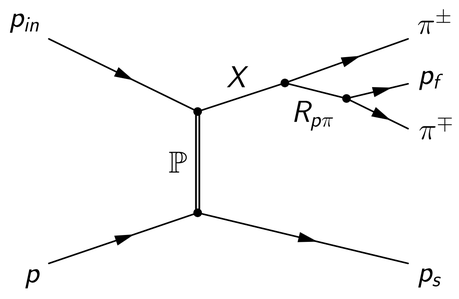


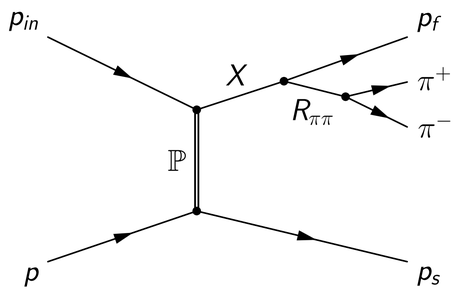
Two-Particle Sub-Systems:

- Resonances both in NK and KK modes
- Baryons with strangeness

Analysis Technique

- Target proton remains intact
- Pomeron exchange dominates at high energies
- **Partial-wave analysis** with isobar model
  → subsequent two-body decays
- Final-state interactions not modelled
- 2 different decay topologies
- Both mesons and baryons as intermediate states, e.g.:
  - $R_{\pi\pi}$: $(\pi\pi)_S$, $\rho^0(770)$, $f_0(980)$, $f_2(1270)$, ..
  - $R_{p\pi^-}$: $\Delta^0(1232)P_{33}$, $N(1440)P_{11}$, $N(1650)S_{11}$, $\Delta(1700)D_{33}$, ..
  - $R_{p\pi^+}$: $\Delta^{++}(1232)P_{33}$, ..





Partial-waves characterised by

$$I\ J^P\ M\ R_1\ \begin{bmatrix} L \\ S \end{bmatrix}\ R_2$$

- I: Isospin
- J: Spin and P: Parity
- M: Spin projection on z-axis
- R_1: Isobar
- R_2: Bachelor particle (p_f or $\pi^{\pm}$)
- S: Spin of R_1
- L: Relative orbital angular momentum between R_1 and R_2

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