Hadron Spectroscopy with COMPASS at CERN

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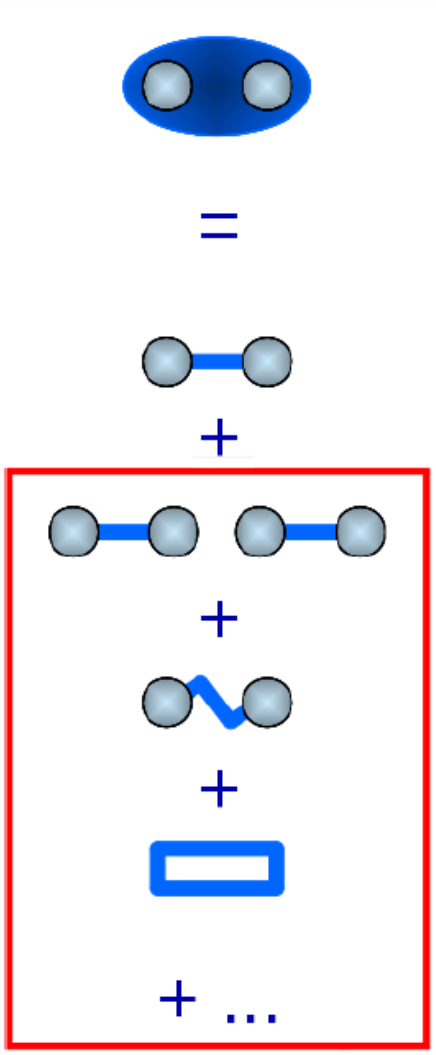
Outline

- Introduction
- The COMPASS experiment
- Diffractive Dissociation of pions
- Coulomb production of pions
- Final states with strangeness
- COMPASS physics with proton beam

Introduction

Meson Spectroscopy:

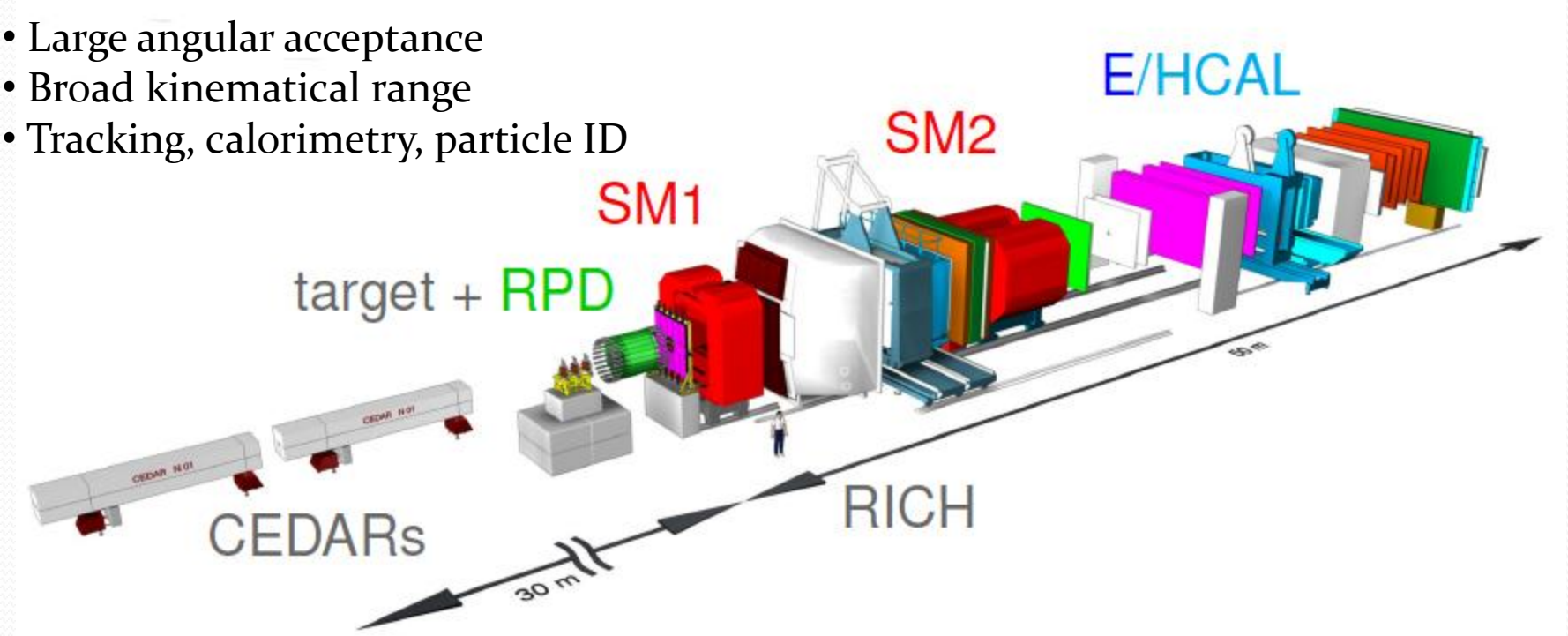
Study the meson spectrum and search for states other than conventional quark-antiquark pairs. For example *multiquarks*, *glueballs* and *hybrids*.



The COMPASS experiment

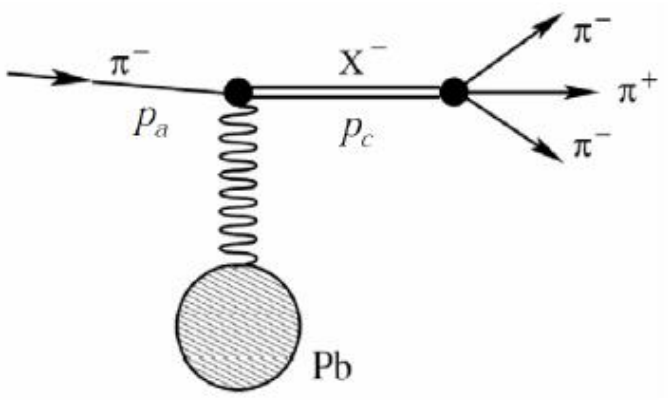
Two-stage magnetic spectrometer:

- Large angular acceptance
- Broad kinematical range
- Tracking, calorimetry, particle ID



Beam: 190 GeV positive (p, π^+, K^+) or negative (π^-, K^-) hadron beam.
Targets: Liquid H_2, Nuclear targets (Pb, Ni, W).
Final states: charged ($\pi^\pm$, p, ...), neutral (π^0, η, η', ...),
kaonic ($K^\pm$, K_S, ...)

Diffractive Dissociation of pions



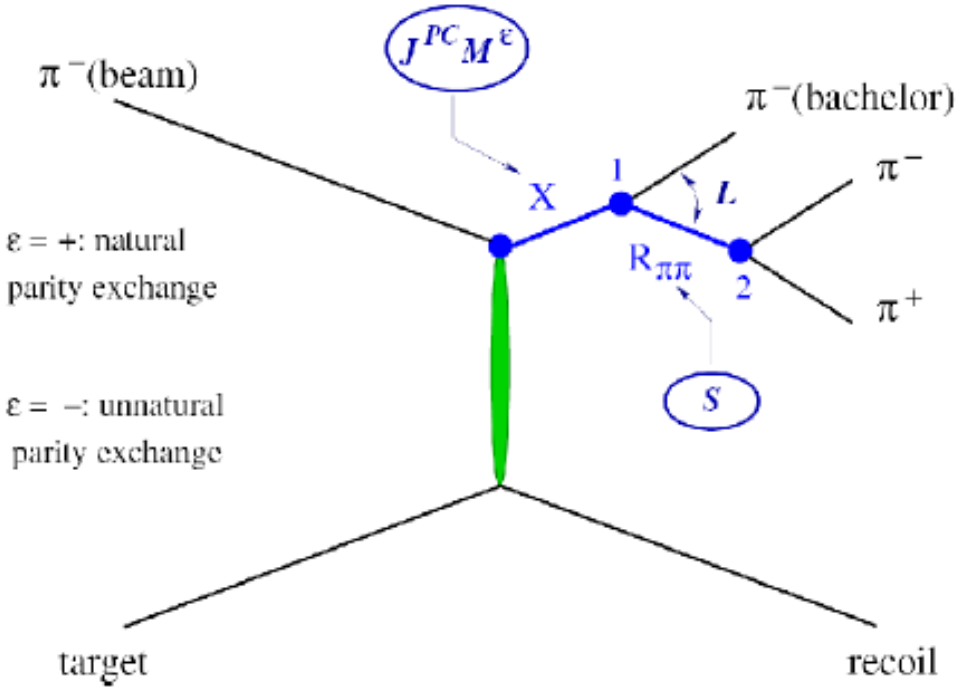
π^- Pb → $\pi^-\pi^+\pi^-$ Pb

- Data from 2004
- 190 GeV/c π^- on Pb
- Momentum transfer $0.1 < t' < 1$ (GeV/c)²

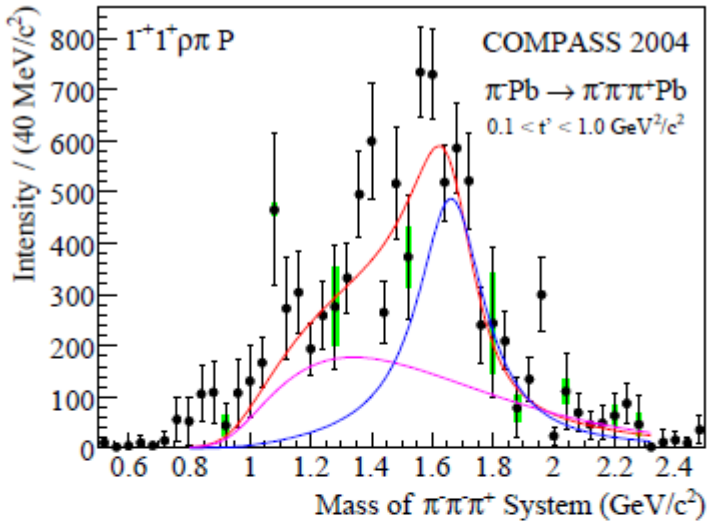
→ quasi-free nucleons in Pb

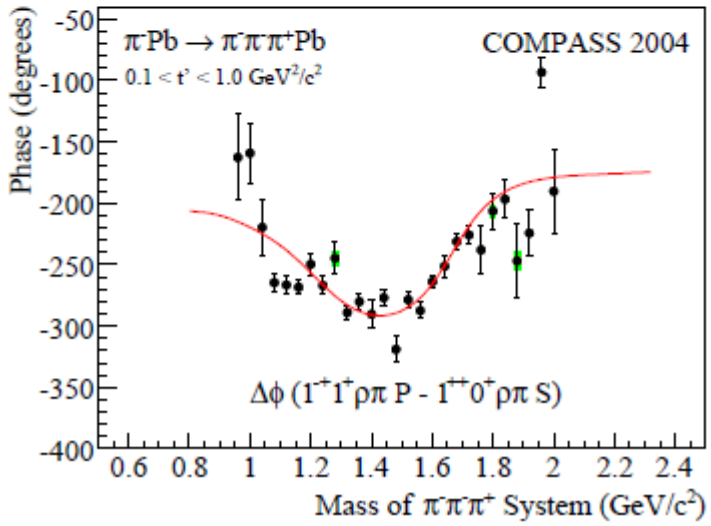
Partial Wave Analysis (PWA) Model:

- *t*-channel Reggeon exchange
- Isobar model
- Reflectivity basis



Diffractive dissociation of pions



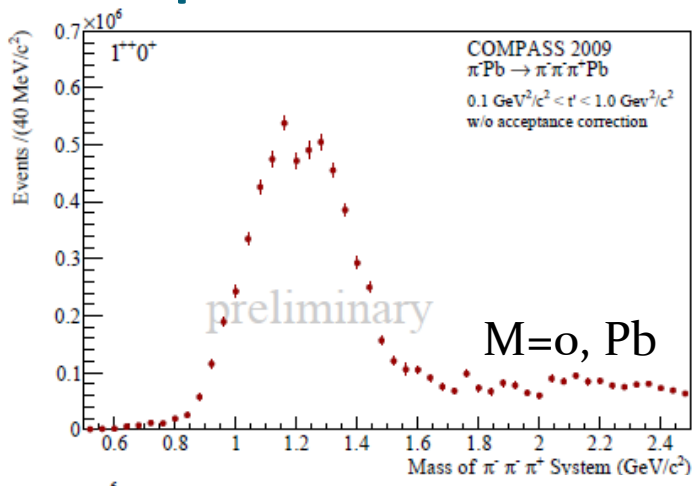


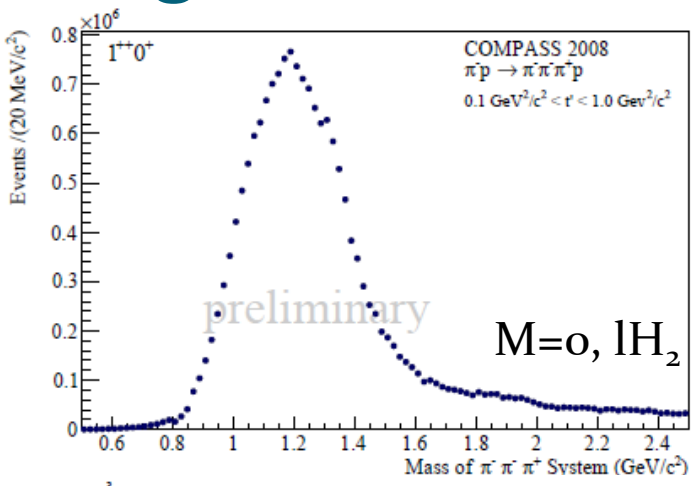
Significant spin exotic $J^{PC} = 1^{-+}$ wave [1]

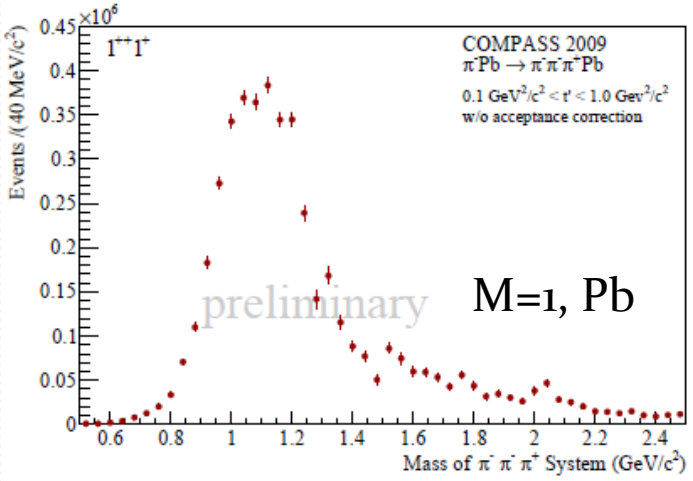
- $M = 1660 \pm 10^{+0}_{-64}$ MeV/c^2
  $\Gamma = 269 \pm 21^{+42}_{-64}$ MeV/c^2
- consistent with $\pi_1(1600)$
- Neglible leakage from other waves

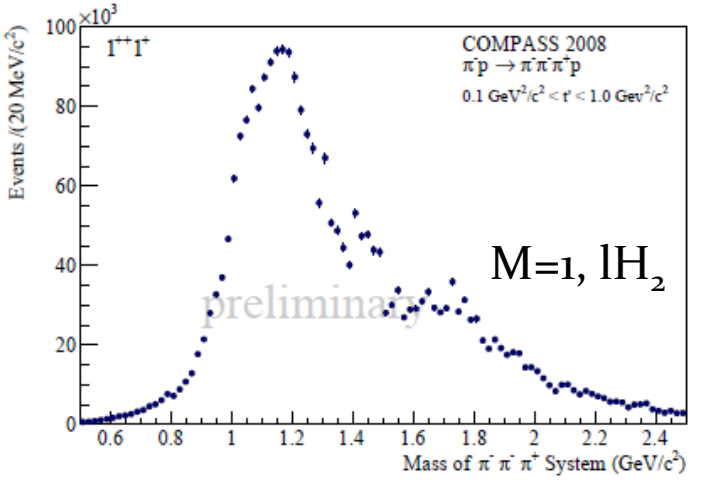
[1] COMPASS, Phys. Rev. Lett. 104 (2010) 241803

Dependence of M on target material





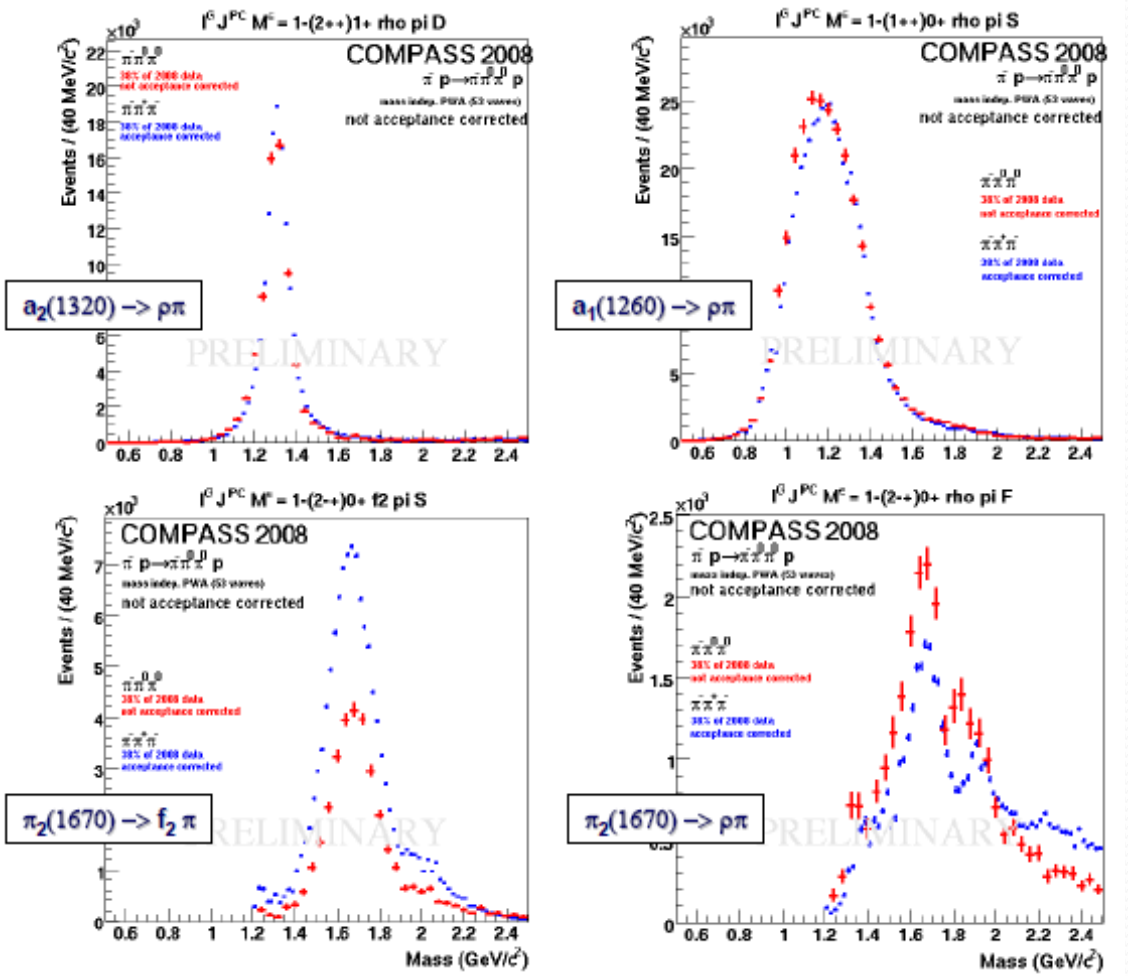




Pb (2009) vs. H_2 (2008) target

- Normalised to $a_2(1320)$
- Different intensity of spin projections, i.e. of $J^{PC} = 1^{++}$
- On Pb: M = 1 enhanced, M = 0 suppressed

Search for exotics in $\pi^- p \rightarrow p(3\pi)^- $ and $\pi^- p \rightarrow p\,\pi^-\eta/\eta'$

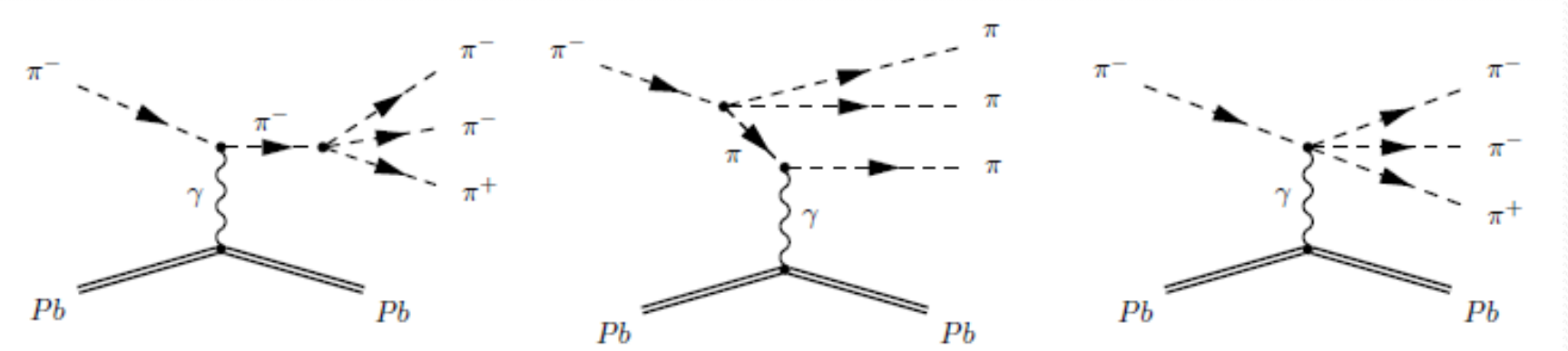


- Data collected during 2008/9.
- Hydrogen and nuclear targets.
- Statistics will outnumber previous experiments.
- Charged and neutral channels available.
- Comparison between $\pi^-\,\pi^+\,\pi^-\,p$ and $\pi^-\,\pi^o\,\pi^o\,p$ promising.
- Excellent potential also in $\pi^- p \rightarrow p\,\pi^-\eta/\eta'$

Isospin symmetry: neutral / charged mode

- X^- decaying into $\rho\,\pi$: 1/1 intensity expected
- X^- decaying into $f_2\,\pi$: 1/2 intensity expected

Coulomb production of pions

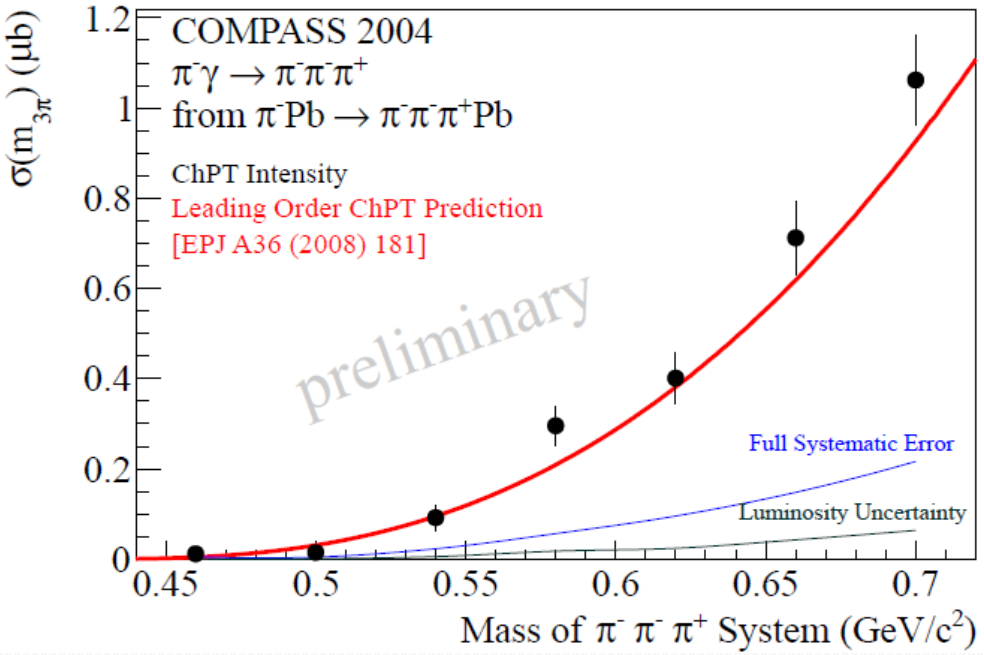


Low momentum transfer:

Contribution from photon exchange.

Low masses:

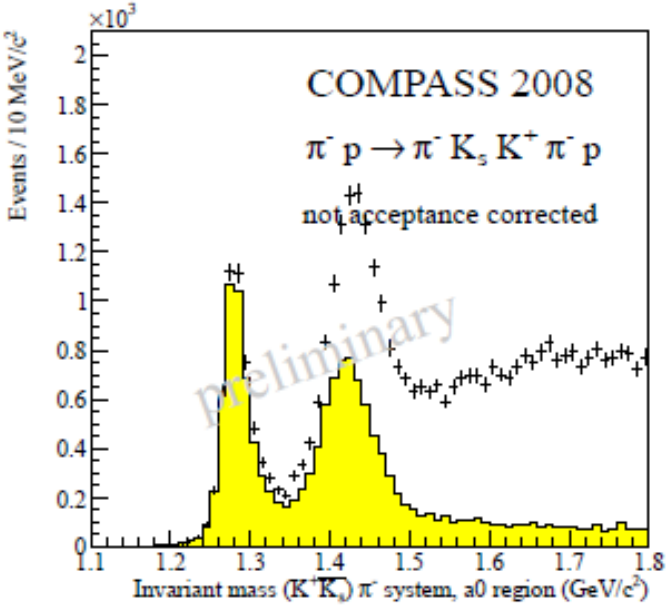
Only pions produced → ChPT test.
Results compared to LO ChPT predictions from EPJA 36 (2008) 181.

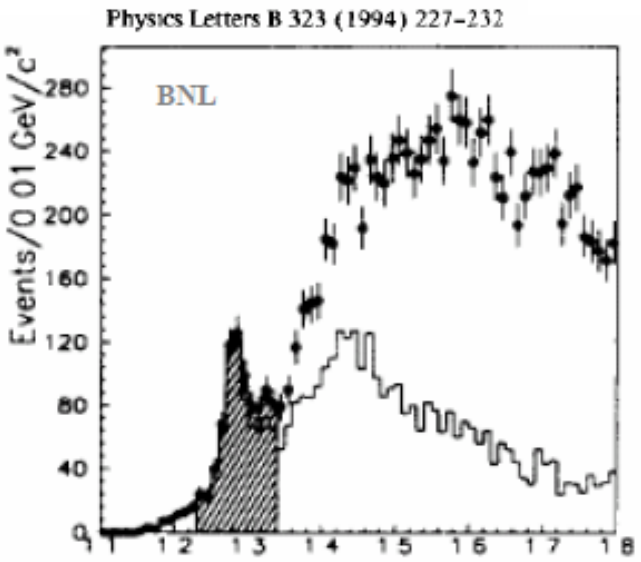


Final states with strangeness

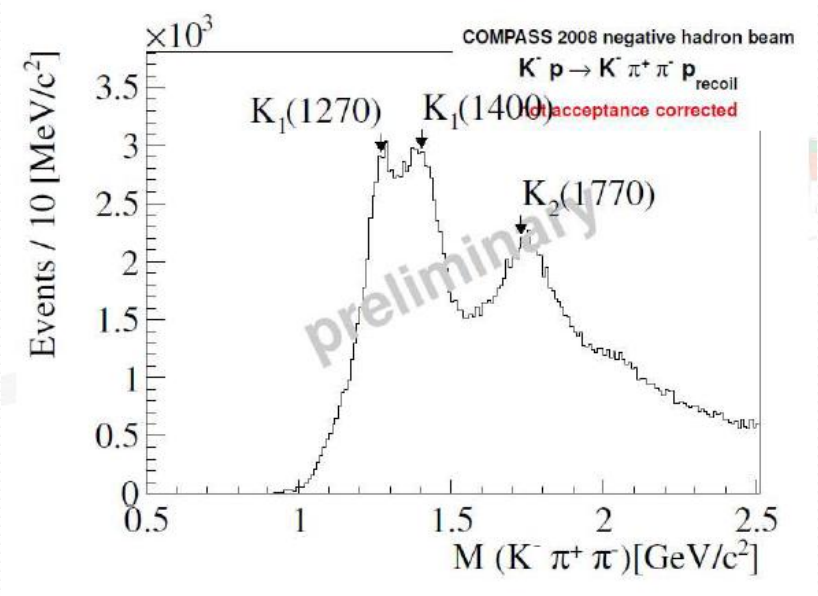
$$\pi^- p \rightarrow K\bar{K}\pi\pi\, p$$

- exotic signals can be observed in various decay channels, *e.g.* $f_1(1285)$ mode.
- The $(K\bar{K}\pi\pi)$ system reaches higher mass ranges .
- $f_1(1420)\pi$ system never studied before.
- COMPASS 2008 data contain 10 times higher statistics than BNL.





Final states with strangeness

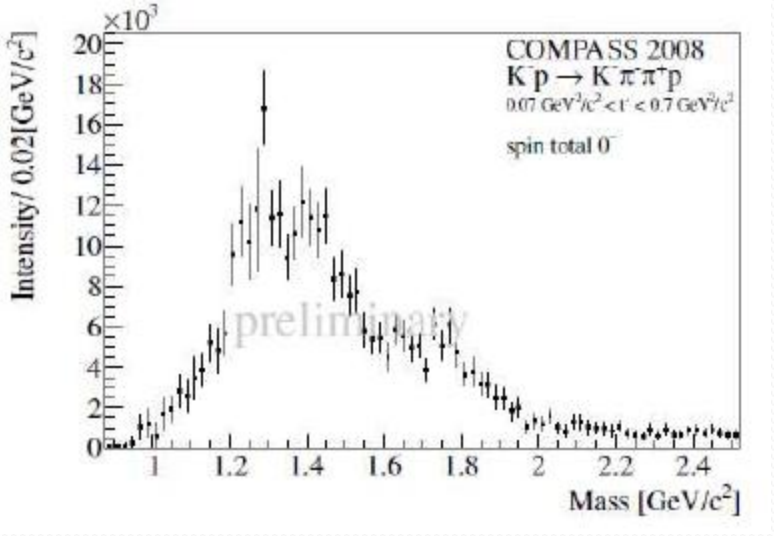


$K^- p \to K^- \pi^+ \pi^- p$

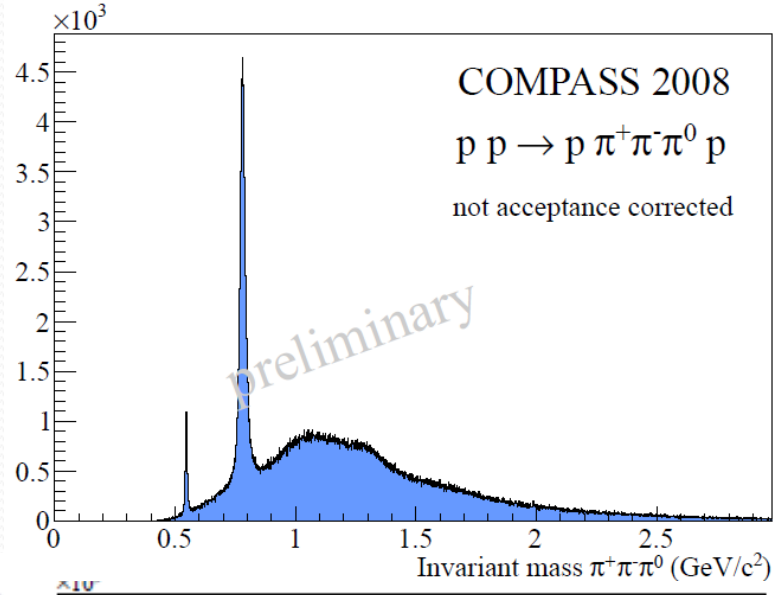
- Tagging incoming beam kaon.
- Many debated states need confirmation
- Most results from mass independent PWA agree with previous results from WA03.
- States consistent with $q\bar{q}$ with isospin ½.

Observed intensity in the 0^- wave near the mass of the debated K(1460).

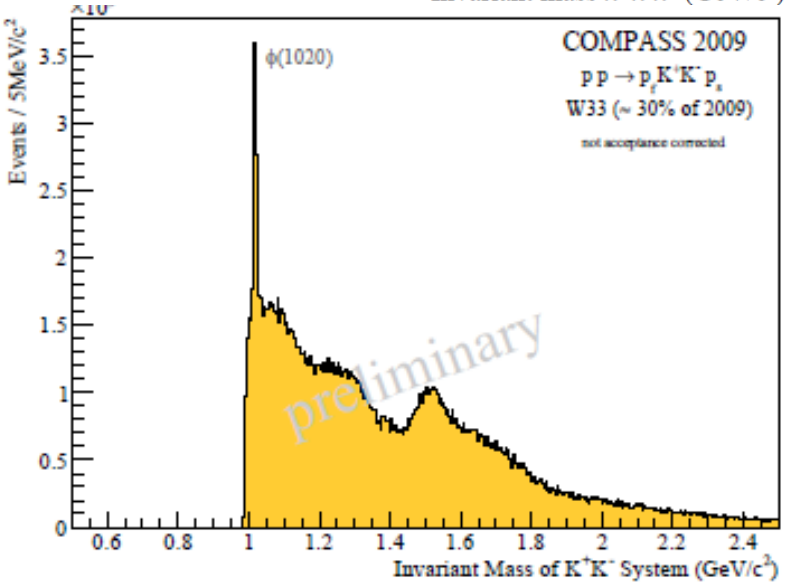
Leakage studies and mass dependent fit needed for more definite conclusions.

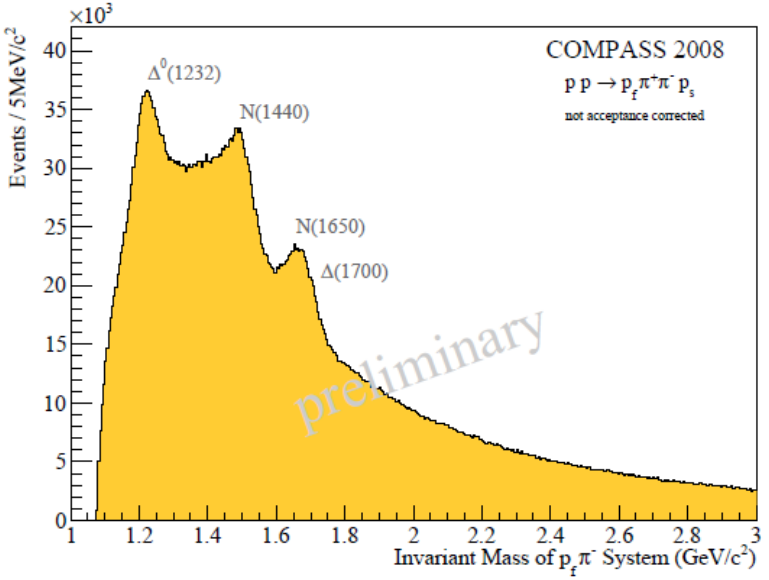


Physics with proton beam



- Search for glueballs in central *pp* collisions
- Baryon spectroscopy
- Precise OZI tests
- Spin alignment of vector mesons





Summary

- Evidence for QCD allowed states like multiquarks, glueballs and hybrids still not beyond doubt.
- COMPASS has excellent potential to contribute:
  - Already observed the spin exotic wave $\pi_1(1600)$ in data from 2004 pilot run.
  - A large amount of data were collected with hadron beam in 2008/2009 (10 – 100 times world statistics).
- COMPASS measures charged and neutral channels:
  - Independent consistency check.
- COMPASS measures kaonic final states.
- COMPASS has access to 3 production mechanisms:
  - Diffractive dissociation
  - Central production
  - Coulomb production
- COMPASS also offers excellent opportunities to measure
  - Baryon spectroscopy
  - OZI tests
  - Spin alignment measurements