Diffractive pion dissociation into $(K\bar{K}\pi)^0\,\pi^-$ final states

Johannes Bernhard (*) & Frank Nerling (#)
on behalf of the COMPASS Collaboration

1. Motivation

Constituent quark model:

- color neutral $q\bar{q}$ systems, Quantum numbers $I^G J^{PC}$
- $P = (-1)^{L+1}$ $C = (-1)^{L+S}$ $G = (-1)^{I+L+1}$
- J^{PC} multiplets: 0^{++}, 0^{+-}, 1^{--}, 1^{+-}, 1^{++}, 2^{++},…
- Forbidden: 0^{--}, 0^{+-}, 1^{-+}, 2^{+-}, 3^{-+},…

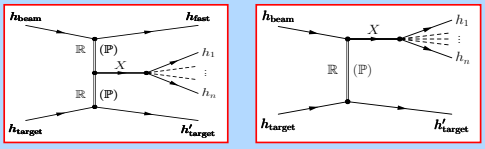
QCD: meson states beyond

- Glueballs: gg, ggg
- Hybrids: $q\bar{q}g$
- Tetraquarks: $(q\bar{q})(q\bar{q})$

Experimental observation:
=> Fundamental confirmation of QCD

Different production mechanisms:

Central production | Diffractive production



Hybrid candidates (1.3 - 2.2 GeV/c²):
lightest hybrid predicted: exotic $J^{PC} = 1^{-+}$

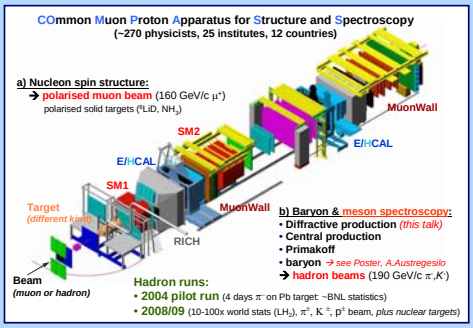
- $\pi_1(1400)$: *VES, E852, Crystal Barrel* –> $\eta\pi$
- $\pi_1(1600)$: *E852, VES* –> $\rho\pi$, $\eta'\pi$, $f_1\pi$, $b_1\pi$
- $\pi_1(2000)$: *E852* –> $f_1(1285)\,\pi$, $b_1(1235)\,\pi$

…. *still controversal* → **COMPASS**

2. The COMPASS experiment

- two stage spectrometer
- high resolution, large acceptance
- ~250 000 read-out channels, ~1 PB / year

[hep-ex/0703049, NIM A 577, 455 (2007)]



Experimental set-up 2008/09:

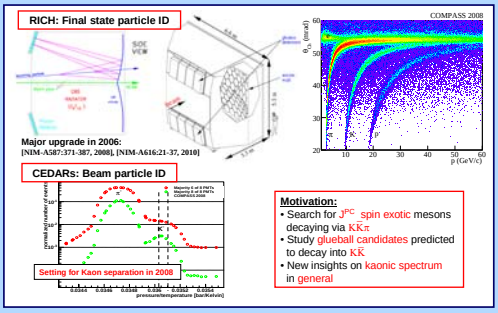
- 190 GeV/c beam ($\pi^\pm$, $K^\pm$, p), liquid H_2 target
- new recoil proton detector (exclusive trigger)
- 2 CEDARs (beam particle PID)
- Calorimetry in both stages – upgraded 2008/09
- RICH in 1st stage – upgraded in 2006
  [NIM-A587:371-387, 2008], [NIM-A616:21-37, 2010]

[Hadron set-up 08/09, NIM A, in preparation (2011)]

3. Event selection

Two event topologies:

Final state a): $\pi^- p \to K_s K^+ \pi^- \pi^- p$
Final state b): $\pi^- p \to K_s K^- \pi^+ \pi^- p$



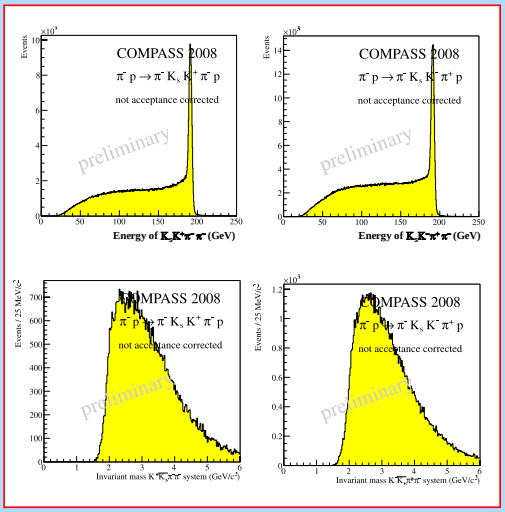
Main aspects of selection:

- Beam kaon anti-tagged by CEDARs
- Final state kaon identified by V0 vertex (K_s) or by RICH (K^+K^-)

Event Type separation using RICH-1:

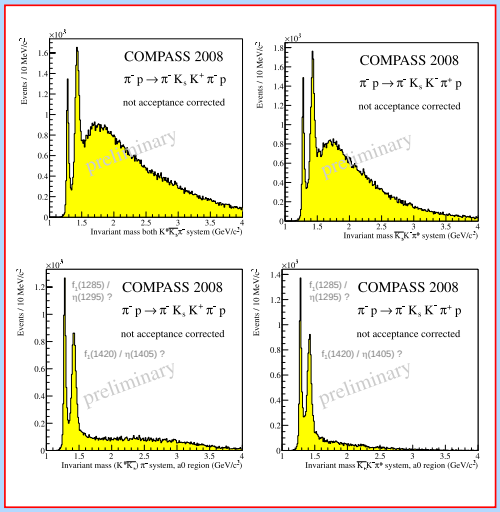
- Positive identification of the $K^\pm$ and π assumption
  => separation of the two event types

4. Exclusivity & $(K\bar{K}\pi)^0\,\pi^-$ systems



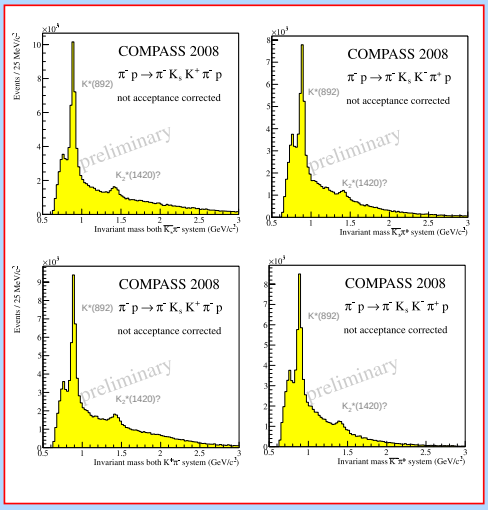
Top: Energy balance of 4-body forward system, peaks at beam energy, cut to select exclusive events
Bottom: 4-body system after cuts

5. $(K\bar{K}\pi)^0$ subsystems



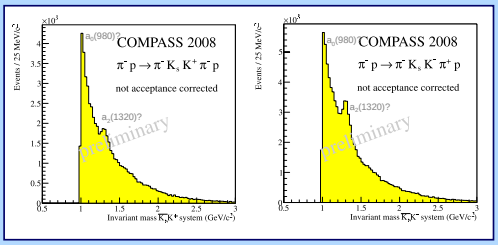
Top: $(K\bar{K}\pi)^0$ subsystem featuring $f_1(1285)$ and $f_1(1420)$
Bottom: Restricting $(K\bar{K})$ inv. mass to $a_0(980)$ mass

6. $(K_s\pi)^\pm$ & $(K\pi)^0$ subsystems

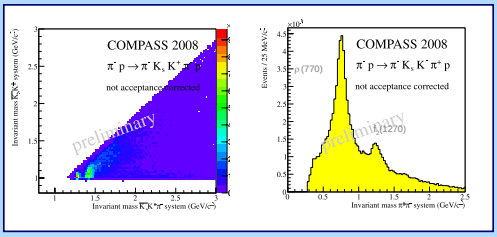


Top: $(K_s\pi)^\pm$ subsystems featuring $K^*(892)$
Bottom: $(K_s\pi)^0$ subsystems featuring $K^*(892)$

7. $(K\bar{K})$ subsystems

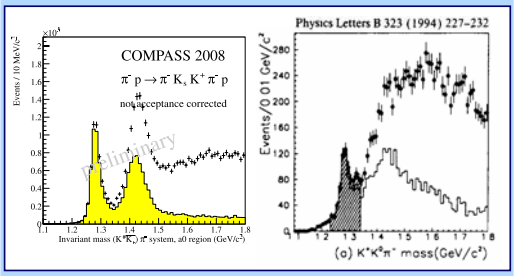


$(K\bar{K})$ subsystems showing strong $a_0(980)$ at threshold



Left: $f_1(1285)$, $f_1(1420)$ dominantly decaying via $a_0(980)$
Right: Strong $\rho(770)$ contribution in $\pi^+\pi^-$

8. Comparison to previous measurement



$(K\bar{K}\pi)^0$ subsystem featuring $f_1(1285)$, $f_1(1420)$, with and without $a_0(980)$ cut, comparison to BNL measurement [1]

Comparison to BNL E852 shows 10x (20 x incl. 2009 data) more statistics and less background

List of isobars to be included (from 5.–7.):

- $f_1(1285)$, $f_1(1420)$, $a_0(980)$, $a_2(1320)$, $K_1^*(892)$, $K_{0,2}^*(1430)$, $K_0^*(800)$ or κ
- final state b) only: $\rho(770)$, $f_2(1270)$, $f_0(600)$ or σ

… t.b.c.

9. Summary & outlook

COMPASS:

- ✓ High potential for Hadron Spectroscopy
- ✓ 2004 data: Exotic J^{PC} → $\pi_1(1600)$, see [2]
- ✓ 2008/09: High statistics *(10-100x world statistics)*
- ✓ measures neutral & charged channels, see e.g. [3]

→ *and kaonic final states!*

Feasibility study for $(K\bar{K}\pi)^0\pi^-$:

- $(K\bar{K}\pi)^0$ in: $K_sK^{+/-}\pi^{-/+}\pi^-$ final states
- low background, suifficient statistics,
- higher masses *(>2 GeV)*
- initial list of isobars obvious from study of subsystems
- might to be completed

Outlook:

- First PWA started with initial list of isobars, quite promising
- Goal: PWA of $f_1(1285)\pi$ & $f_1(1420)\pi$ *(never done before!)*
  → *completing list of channels for spin-exotic search*

→ *more news soon …*

Further kaonic channels under study at COMPASS:

- ✓ $(K\bar{K}\pi)^-\,\pi^- p \to \pi^- K_s K_s p$ *vs.* $\pi^- p \to \pi^- K^+ K^- p$, see [4]
- ✓ Kaon diffraction: $K^- p \to K^-\pi^+\pi^- p$, see [5]

References:
[1] J.H. Lee et al., Phys. Lett. B 323 (1994) 227
[2] M. Alekseev et al., COMPASS collab., PRL 104 (2010) 241803
[3] F. Nerling, AIP Conf. Proc., Hadron09 (2010)
[4] T. Schlüter AIP Conf. Proc., Hadron09 (2010)
[5] P. Jasinski, EPJ Conf. Proc., SpinPraha09 (2010)

(*) Johannes.Bernhard@cern.ch, KPH, Johannes-Gutenberg-Universität Mainz
(#) Frank.Nerling@cern.ch, Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

Hadron2011 – Munich

bmbf - Förderschwerpunkt COMPASS Großgeräte der physikalischen Grundlagenforschung