

Recent results from the COMPASS experiment

Muon & Hadron physics -- a selected overview



Frank Nerling

Universität Freiburg, Physikalisches Institut
for the COMPASS Collaboration

DPG Frühjahrstagung 2012, Mainz, Germany, 19th-23rd March

Outline:

• Introduction

- COMPASS physics addressed
- The COMPASS experiment

• First results using hadron beams (2008/09 proton target data, π^- , K^- , p beams)

- PWA method (*using published results 2004 data*)
- Search for spin-exotic mesons (*diffractive production: $\rho\pi$, $\eta\pi^-$, $f_1\pi$, ..., PWA*)
- Search for glueballs (*central production: $(2\pi)^0$, $(KK)^0$..., PWA*)
- Further measurements (*Primakoff, photo-production, OZI violation ...*)

• Results using muon beam (2002-06 deuteron, 2007/10 proton target data)

- Longitudinal & transverse spin structure of the nucleon (*DIS, SIDIS*)

• Summary & outlook



bmb+f - Förderschwerpunkt
COMPASS
Großgeräte der physikalischen
Grundlagenforschung



COMPASS: The facility to study QCD

Physics with Muon & Hadron beams



The goal:

- Study **non-perturbative** regime of **QCD** & Probe **structure** and **dynamics** of **hadrons**
- complementary **methods**:

Large Q^2 :

Nucleon structure:

- Helicity, transversity PDFs
- Generalised PDFs (future)

Low Q^2 :

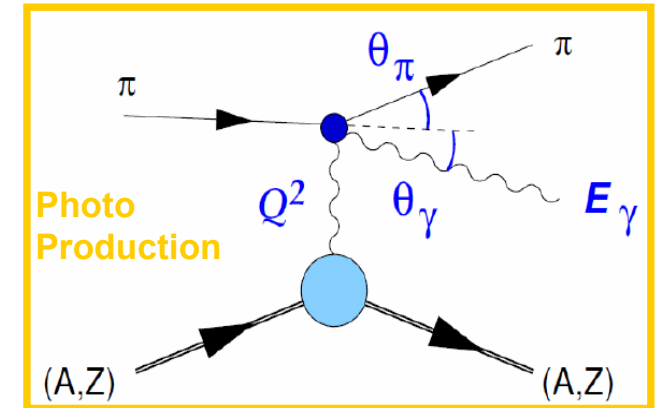
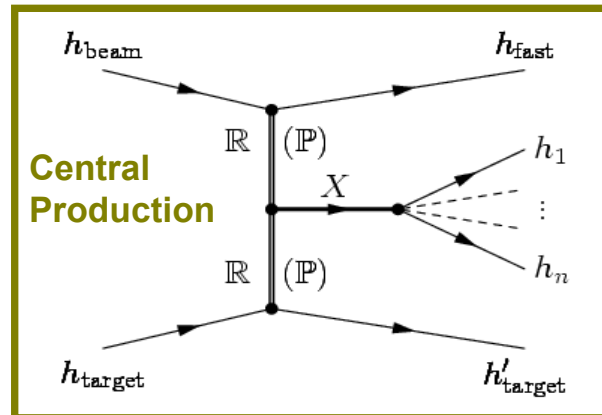
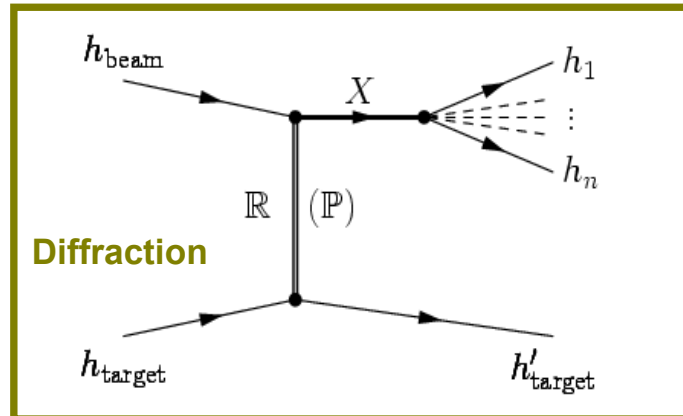
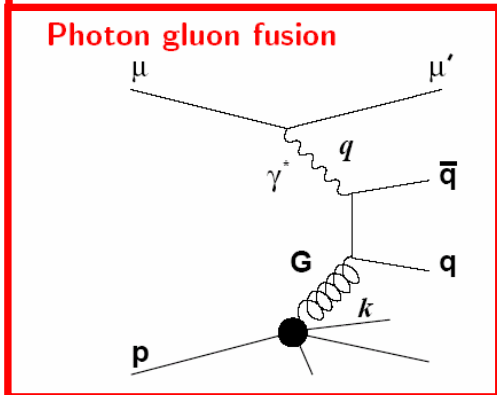
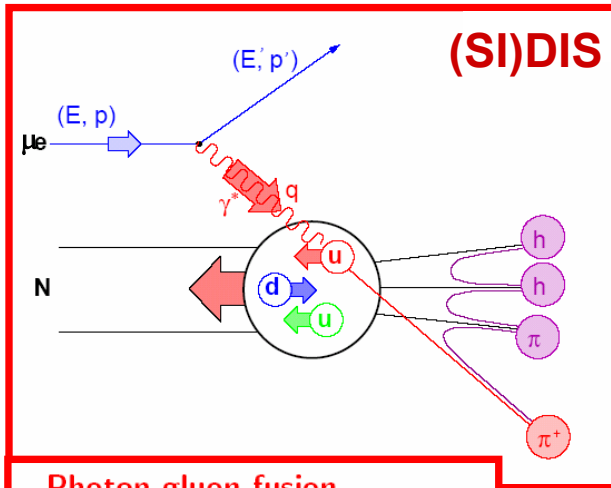
Spectroscopy

- Mass spectrum of hadrons
- Gluonic excitations (spin-exotics)

Very low Q^2 :

Chiral dynamics

- Pion, Kaon polarisabilities
- Chiral Anomaly $F_{3\pi}$ (future)





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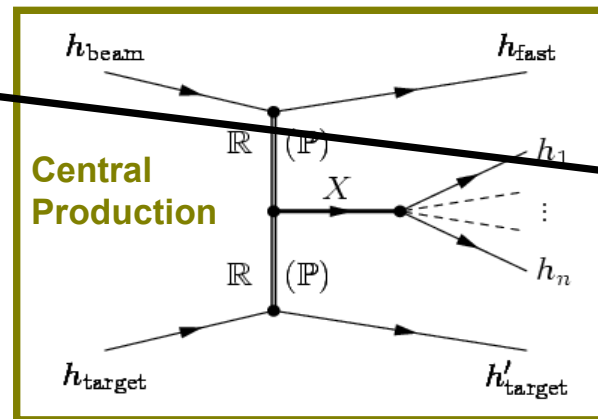
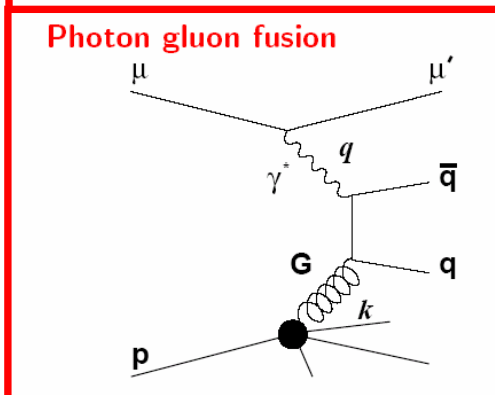
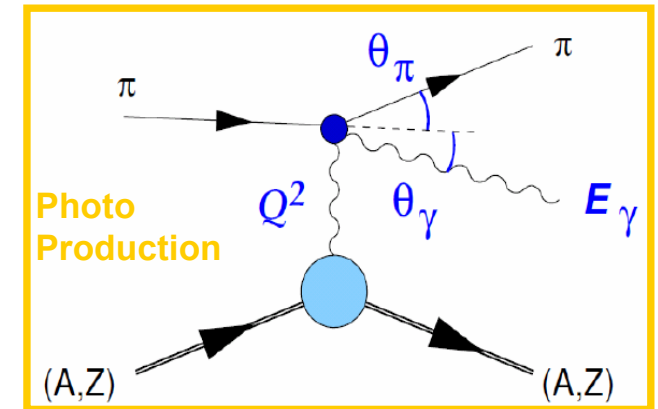
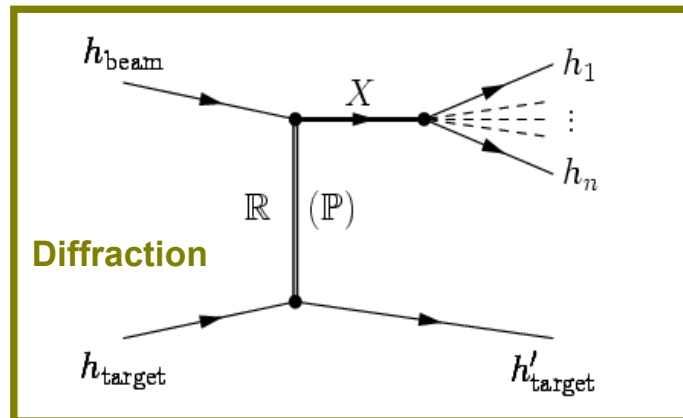
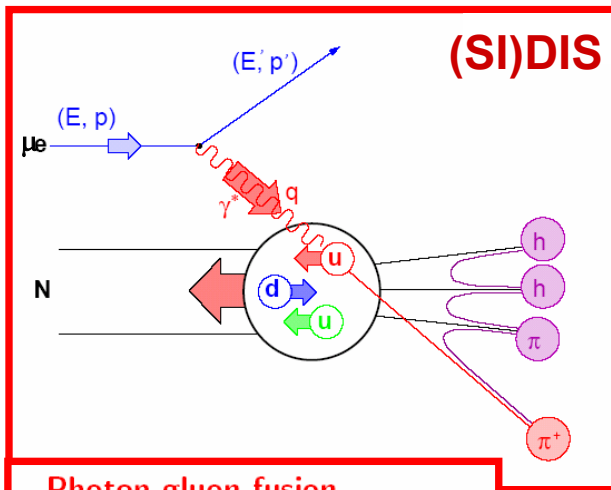
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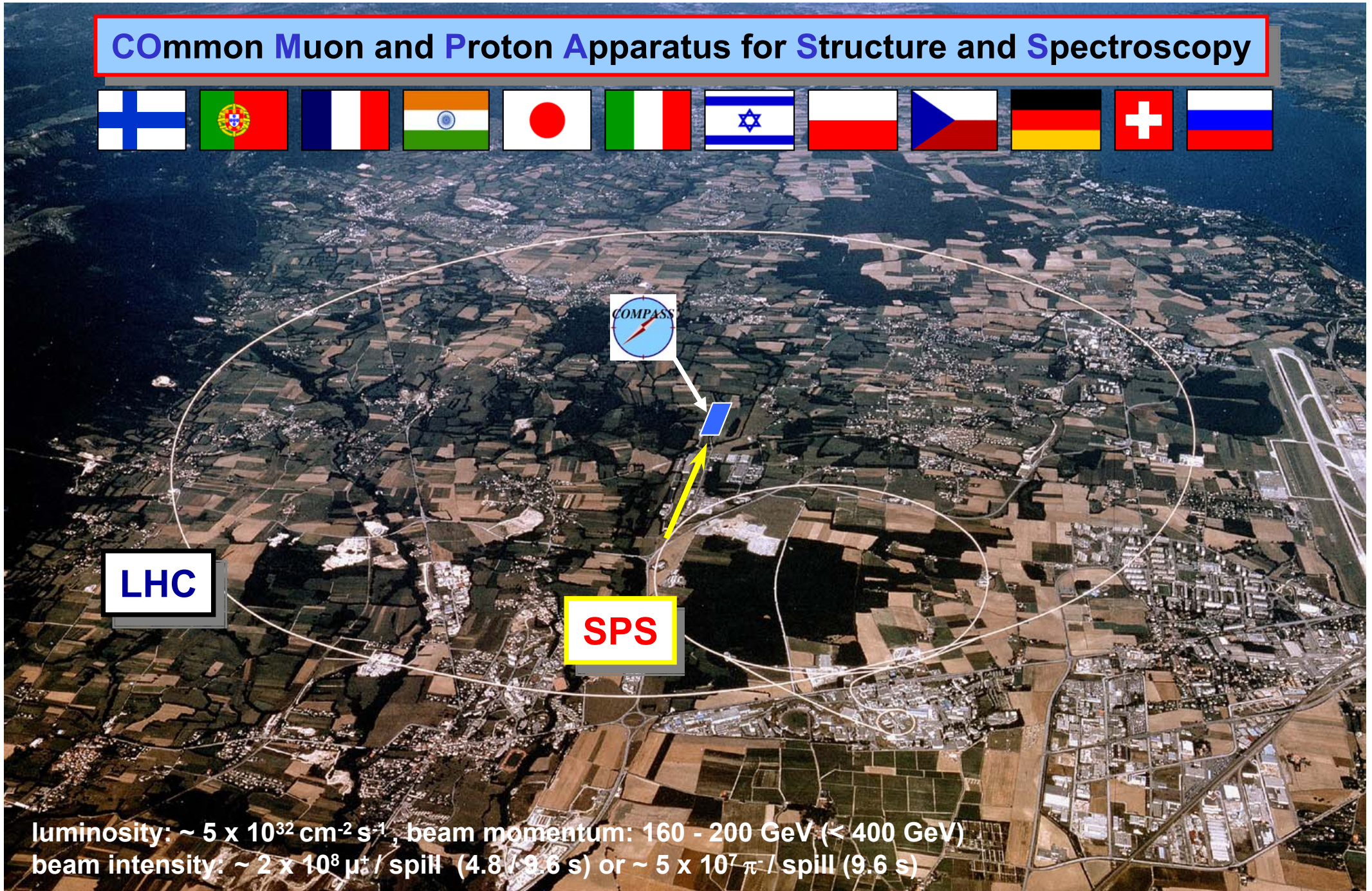
- Main focus in this talk
- Diffractive dissociation
 - Longit. & Transversity



The COMPASS Experiment at CERN



COmmon Muon and Proton Apparatus for Structure and Spectroscopy



luminosity: $\sim 5 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$, beam momentum: 160 - 200 GeV (< 400 GeV)
beam intensity: $\sim 2 \times 10^8 \mu^+ / \text{spill}$ (4.8 / 9.6 s) or $\sim 5 \times 10^7 \pi^- / \text{spill}$ (9.6 s)



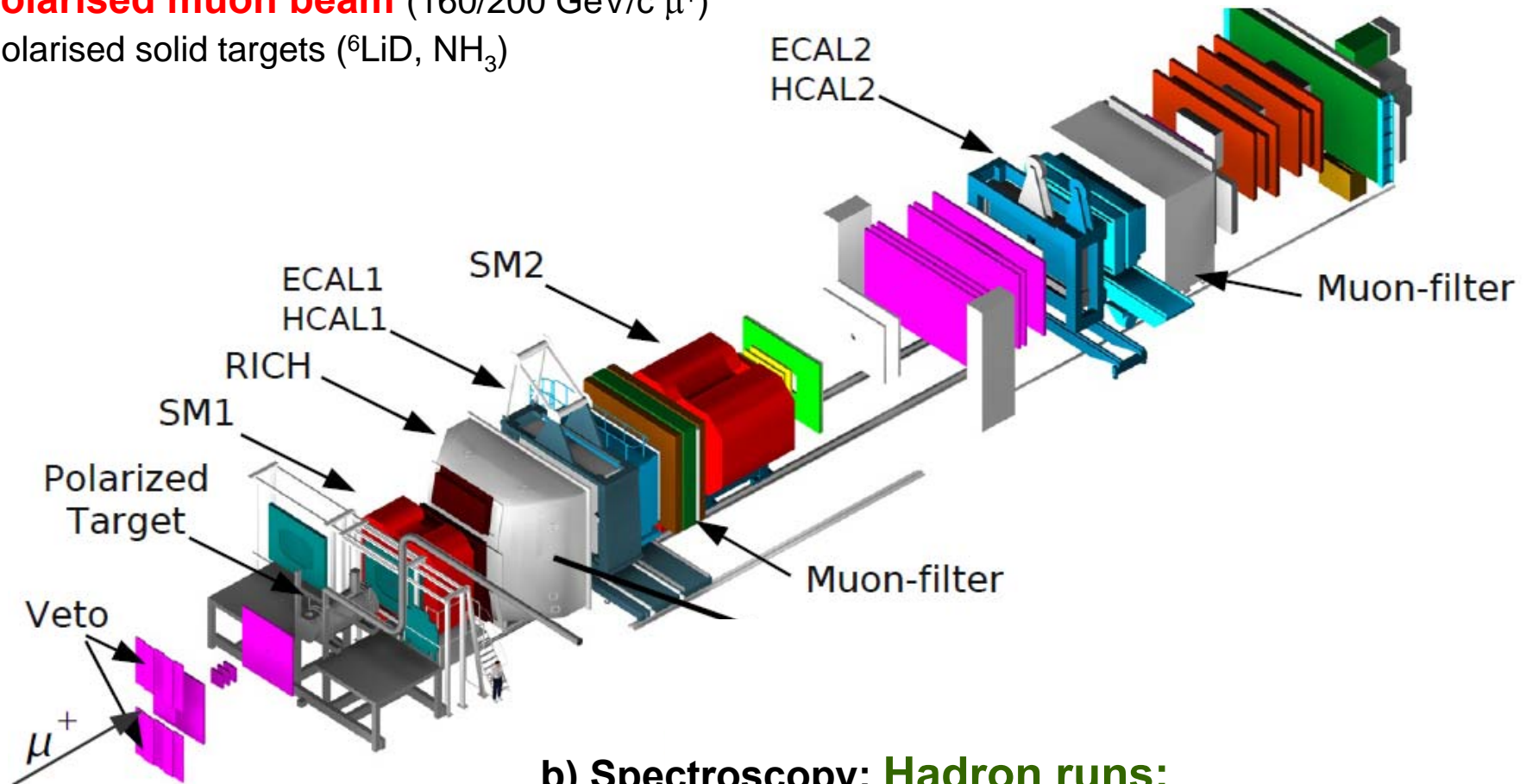
COMPASS spectrometer: Muon setup (2002-07, 2010/11)



a) Nucleon spin structure:

→ **polarised muon beam** (160/200 GeV/c μ^+)

polarised solid targets (${}^6\text{LiD}$, NH_3)



b) Spectroscopy: Hadron runs:

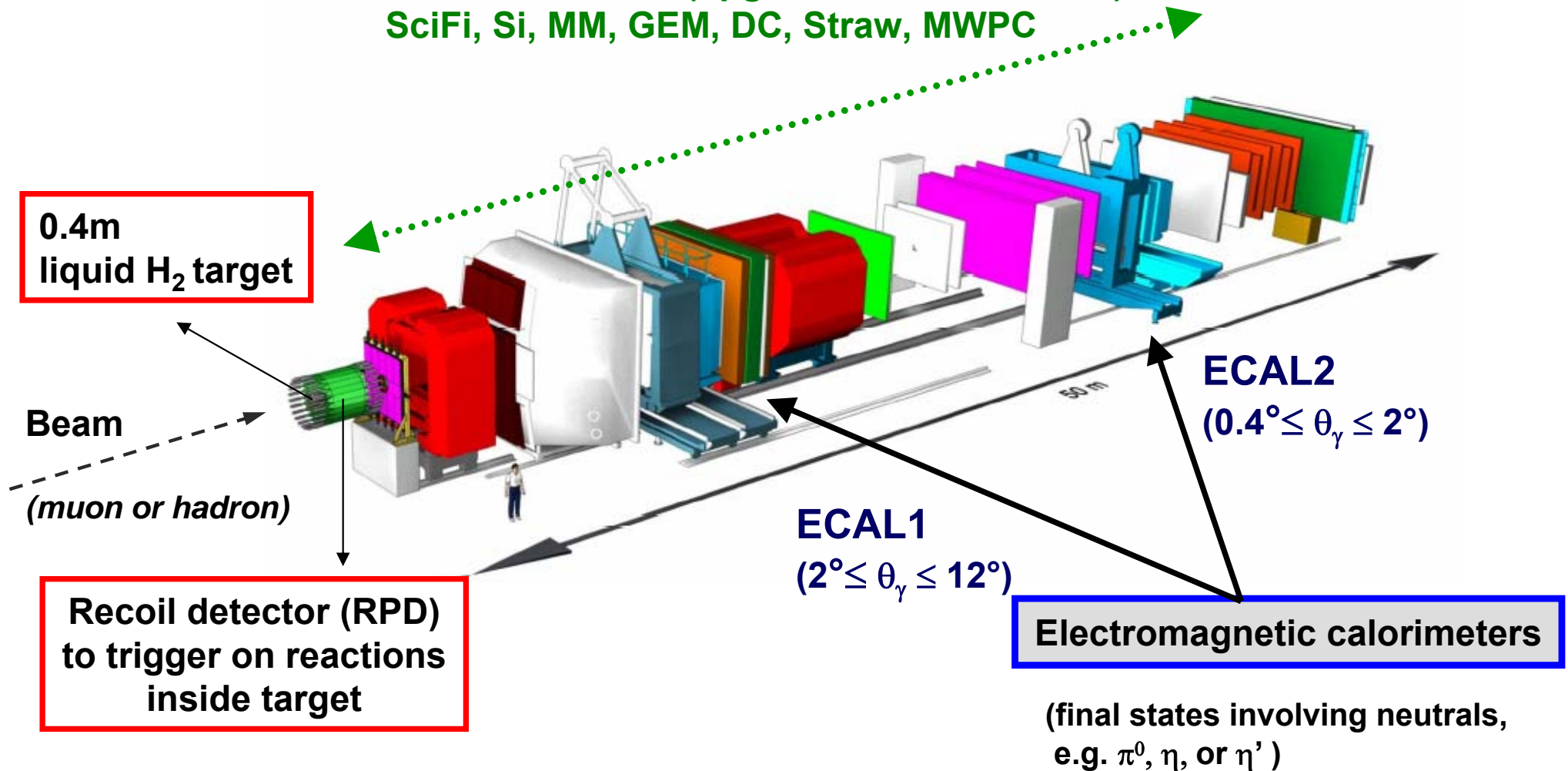
- **2004 pilot run** (4 days 190 GeV/c π^- , Pb target: ~BNL stats.)
- **2008/09** (large statistics, 190 GeV/c LH_2 target, π^\pm , K^\pm , p^\pm beam, and some data on nuclear targets)



COMPASS spectrometer: Hadron setup (2008/09) -- main changes w.r.t. muon setup



All COMPASS trackers (upgraded close to beam):
SciFi, Si, MM, GEM, DC, Straw, MWPC





Mesons and Spin Exotic States



Constituent quark model

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

Hybrid candidates (1.3 - 2.2 GeV/c²):

lightest hybrid predicted: exotic $J^{PC} = 1^{-+}$

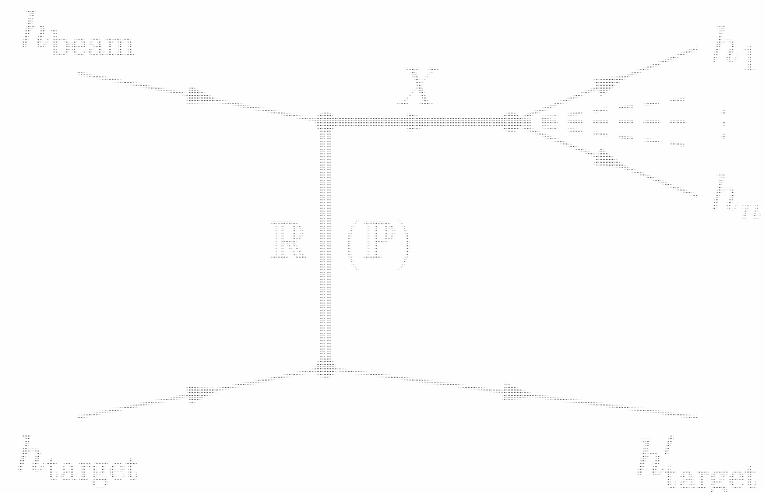
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- $\pi_1(2000)$: E852 $\rightarrow f_1(1285)\pi, b_1(1235)\pi$
- ... still controversial \rightarrow COMPASS

QCD: meson states beyond

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

Diffractive scattering

- study of J^{PC} exotic mesons
- t-channel Reggeon exchange
- forward kinematics, target stays intact
- small momentum transfer





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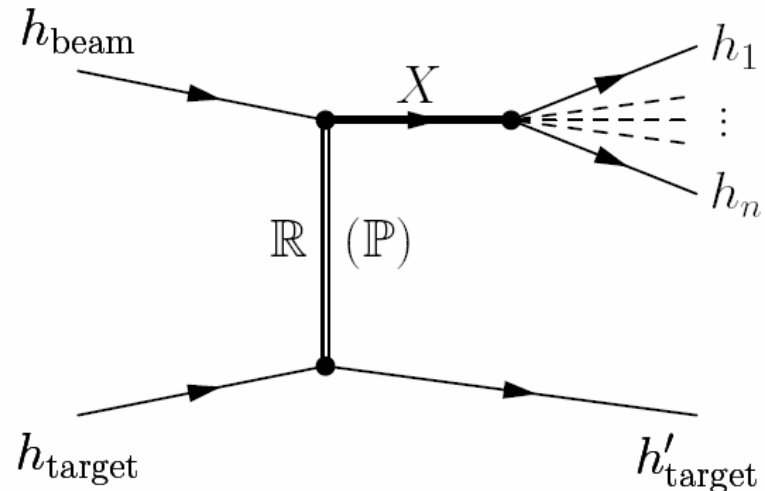
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COMPASS (2004 pilot run)

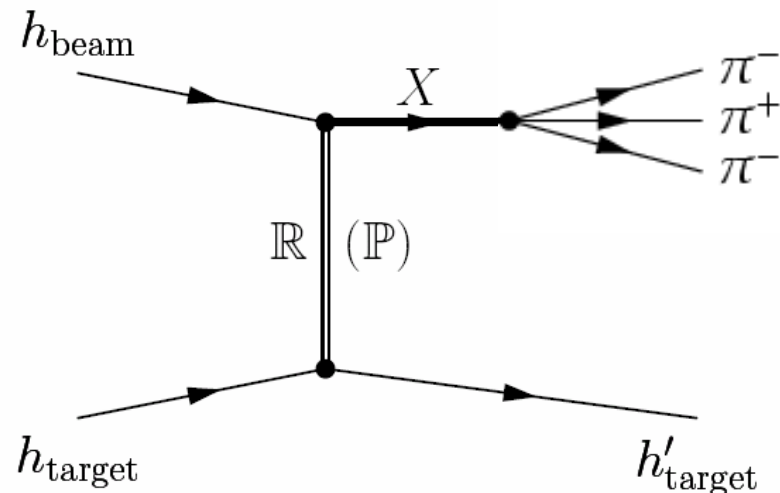
- 190 GeV π^- beam (Pb target)
- studied $\rho\pi$ decay channel via
 $\pi^- \text{ Pb} \rightarrow \pi^- \pi^+ \pi^- \text{ Pb}$

QCD: meson states beyond

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Diffractive pion dissociation

- incoming π^- excited to resonance X^-
- X^- decays into final state, e.g. $(3\pi)^-$





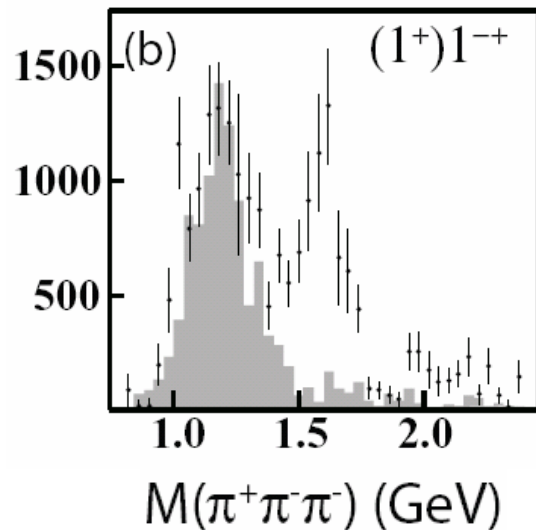
The $\pi_1(1600)$ in the 1^-+ partial-wave controversy -- some history



$\pi_1(1600)$: E852, VES $\rightarrow \rho\pi, \eta'\pi, f_1\pi, b_1\pi$
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BNL/E852:

- 250k events (charged), 18 GeV/c², 21 waves



[G.S. Adams et al., E852, PRL 81, 5760 (1998)]



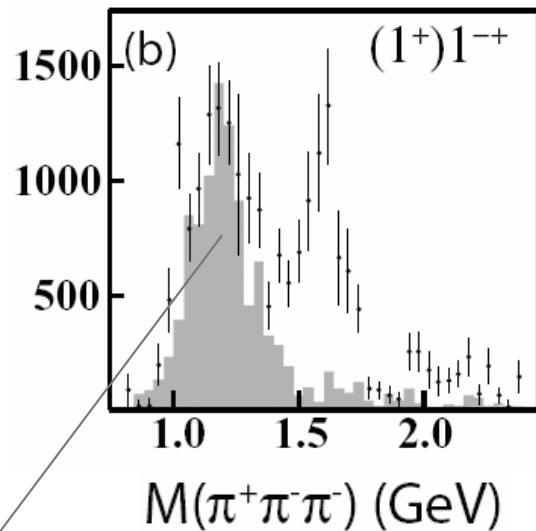
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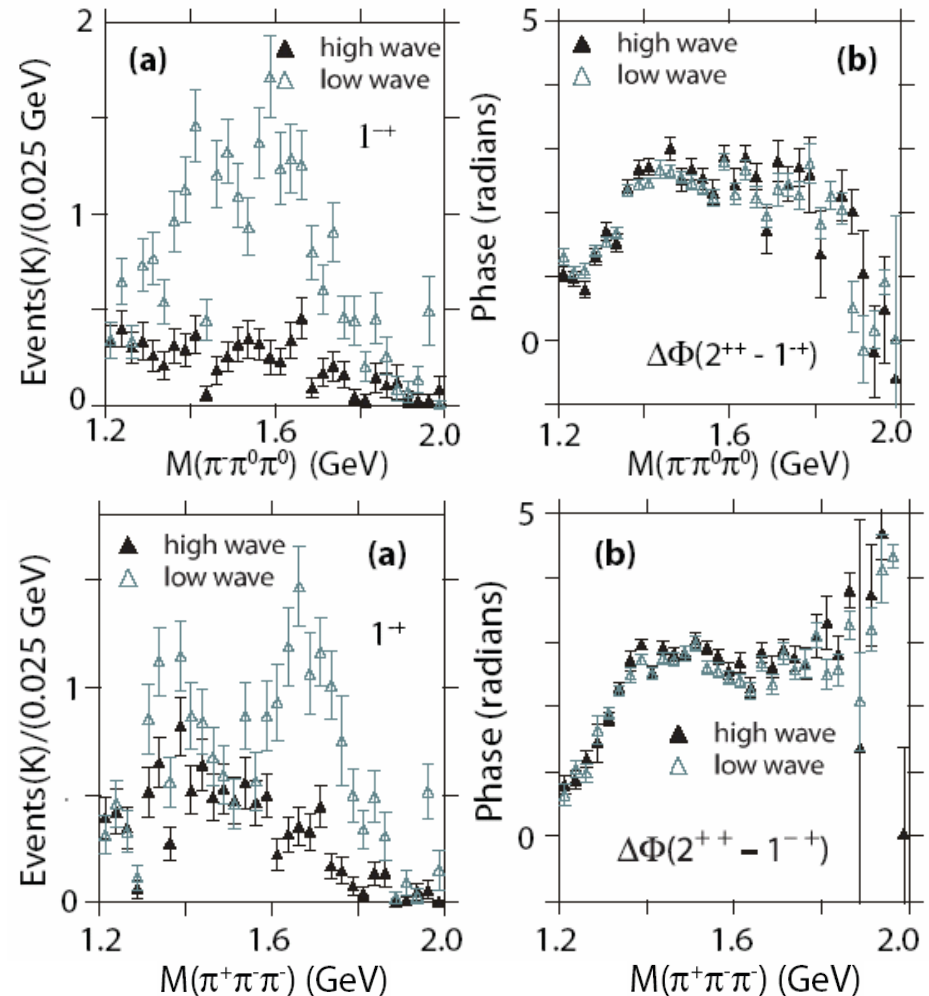
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validated to be leakage from $a_2(1320)$

E852-IU re-analysis:

- higher statistics: 3M & 2.6M (neutral & charged)
- extended wave-set (35 waves) $\Rightarrow 1^-+$ object vanished



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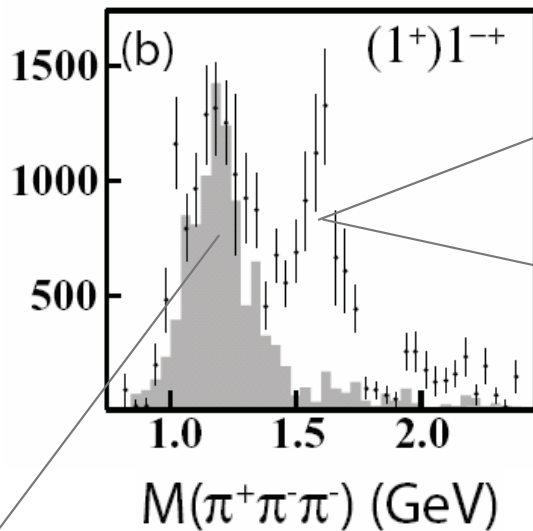
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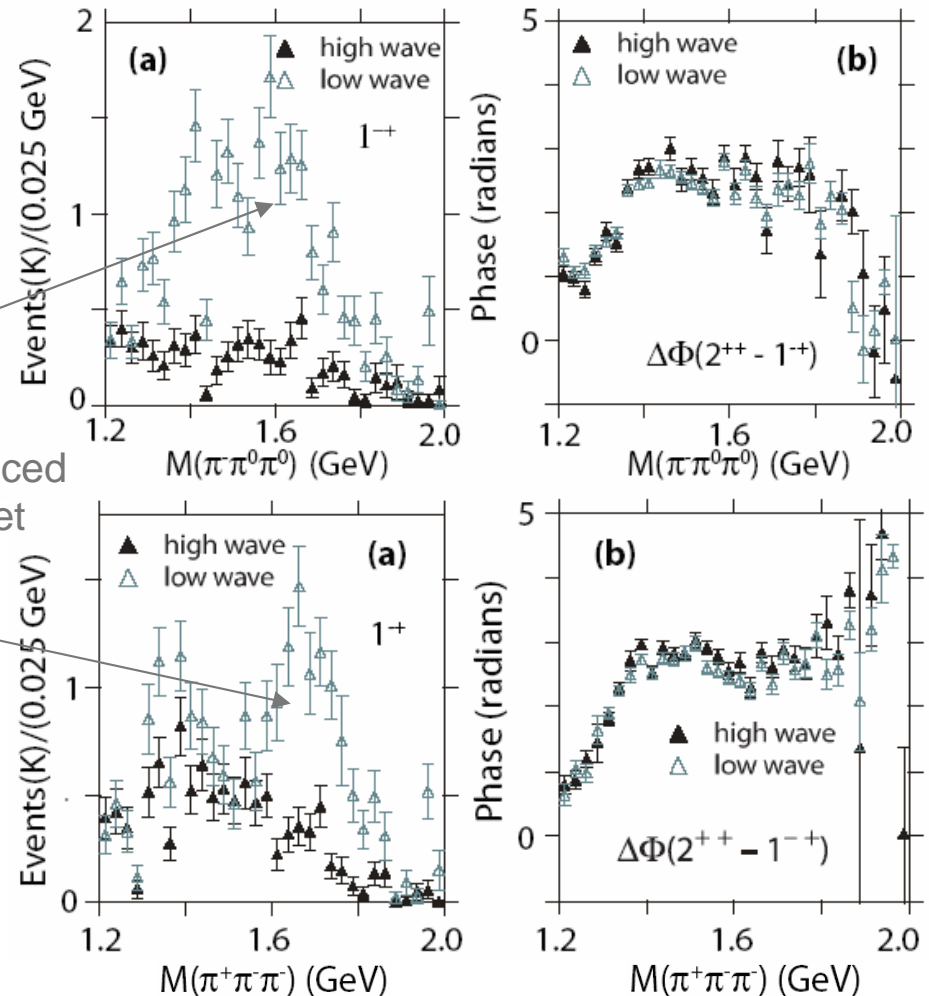


1⁺ object reproduced using low wave-set

validated to be leakage from a₂(1320)

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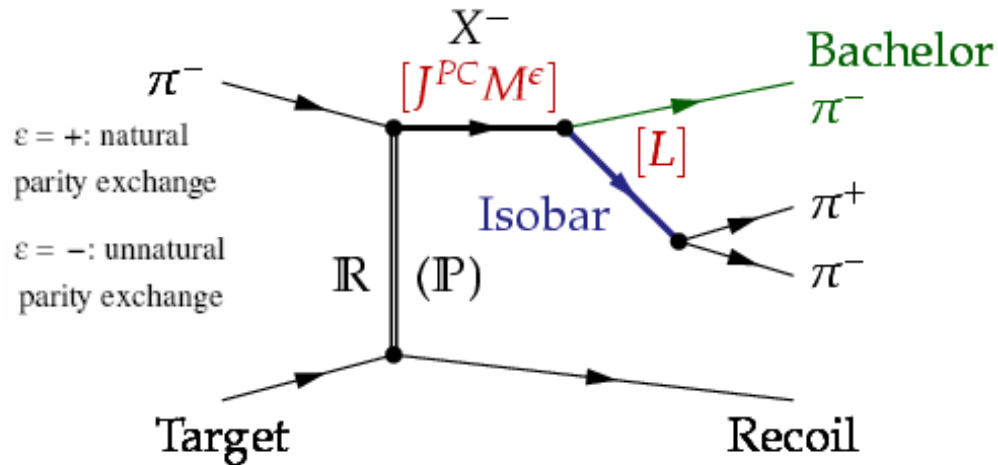


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COMPASS PWA method



X^- decay described using isobar model:

- Intermediate di-pion resonance (isobar)
 - *Spin S and rel. orbital angular momentum L w.r.t bachelor π*
 - *$L+S$ couple to J*
- Partial waves (reflectivity basis): $J^{PC} M^\varepsilon$ [isobar] L

Partial wave analysis:

- **Isobars:** All possible, needed isobars
- **Acceptance:** corrections included (normalisation integrals)

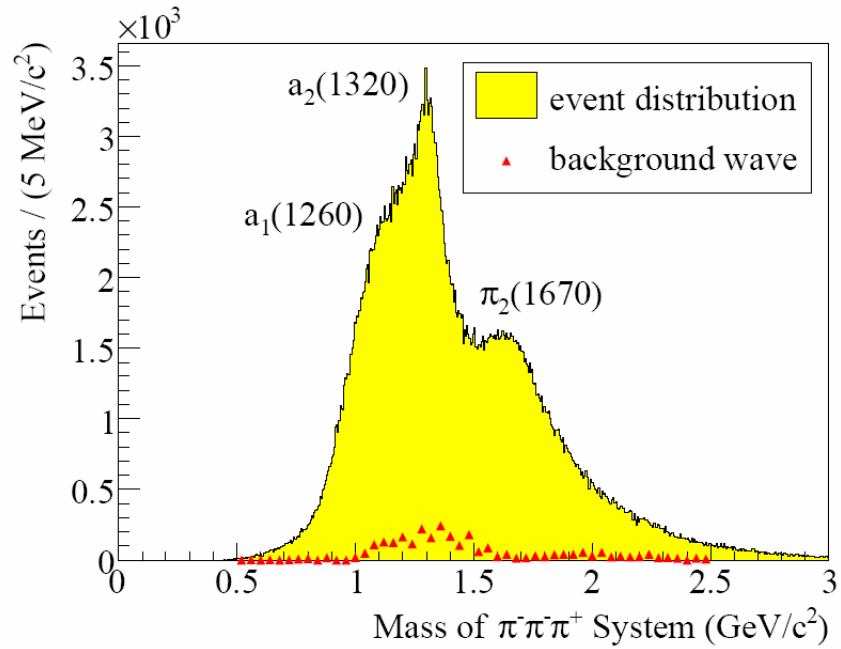
Step 1) Mass independent PWA:

Step 2) Mass dependent χ^2 fit: (to mass independent result)

- Main **partial waves chosen**, parameterised by Breit-Wigner
- Non-resonant **background** for some waves

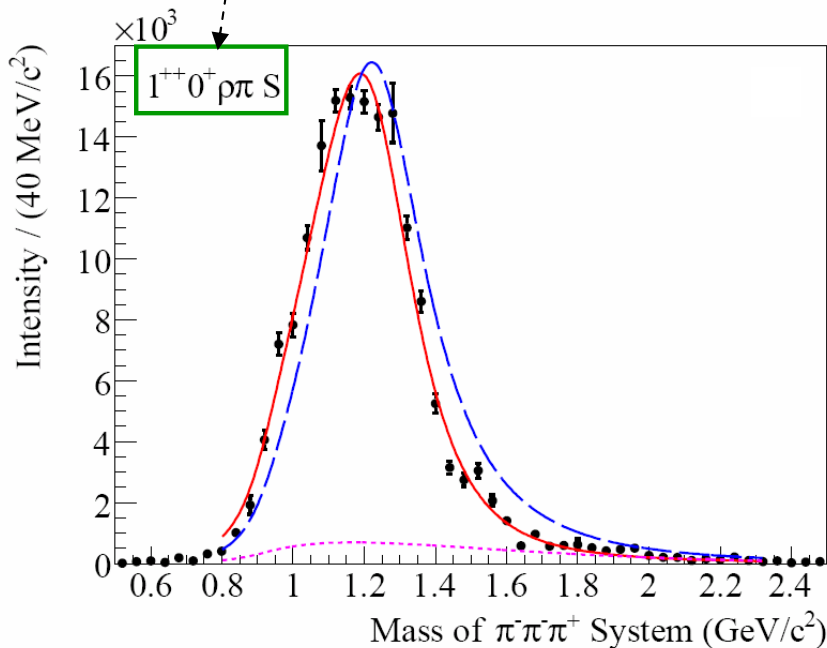
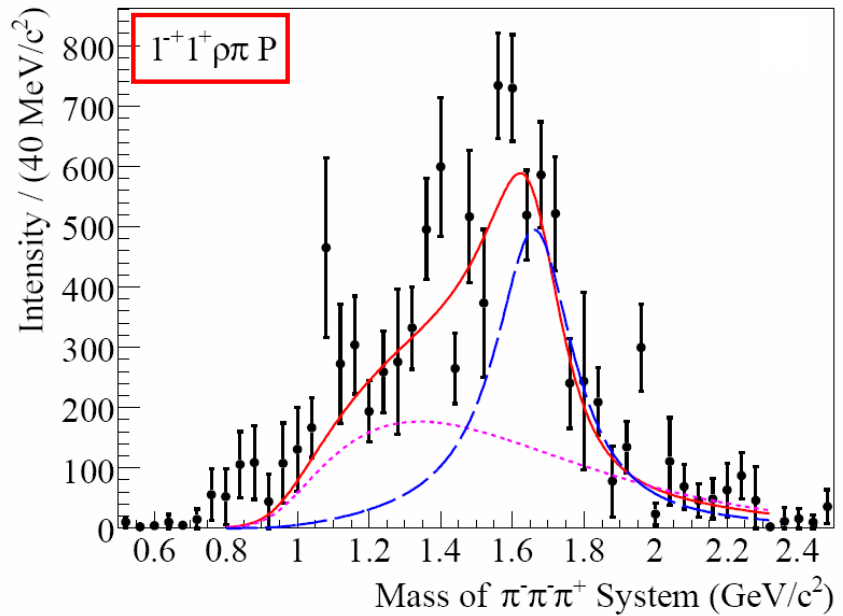
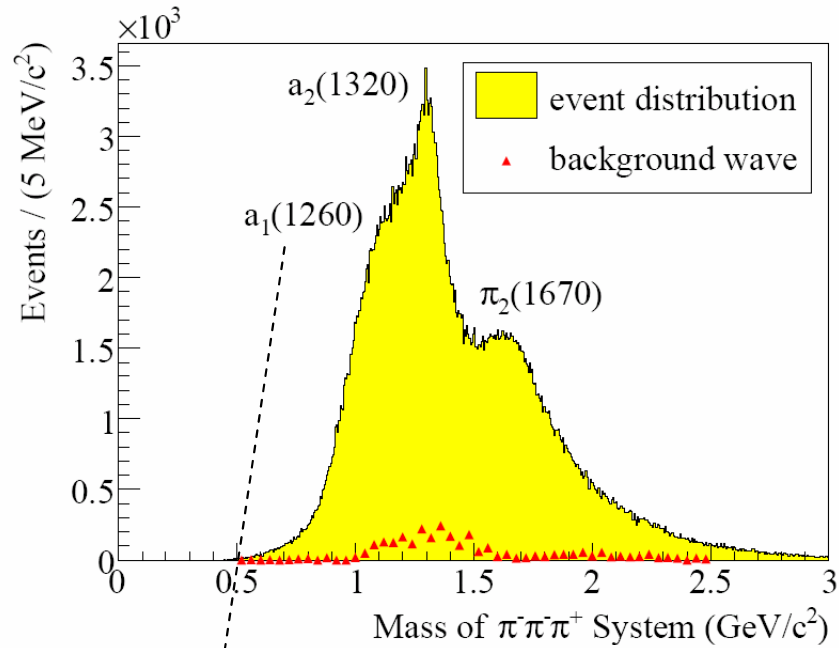


Diffraction dissociation into 3π final states (2004 data, Pb target) [PRL 104 (2010) 241803]



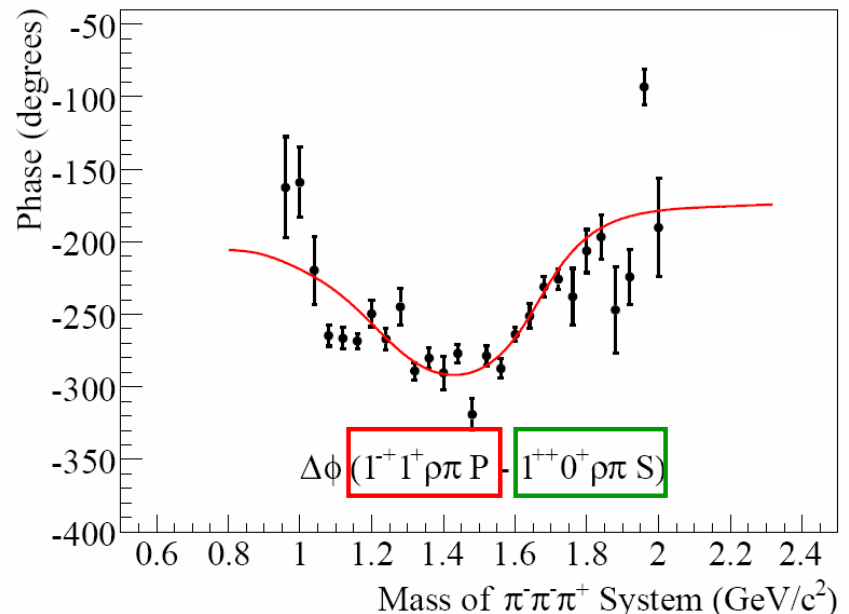
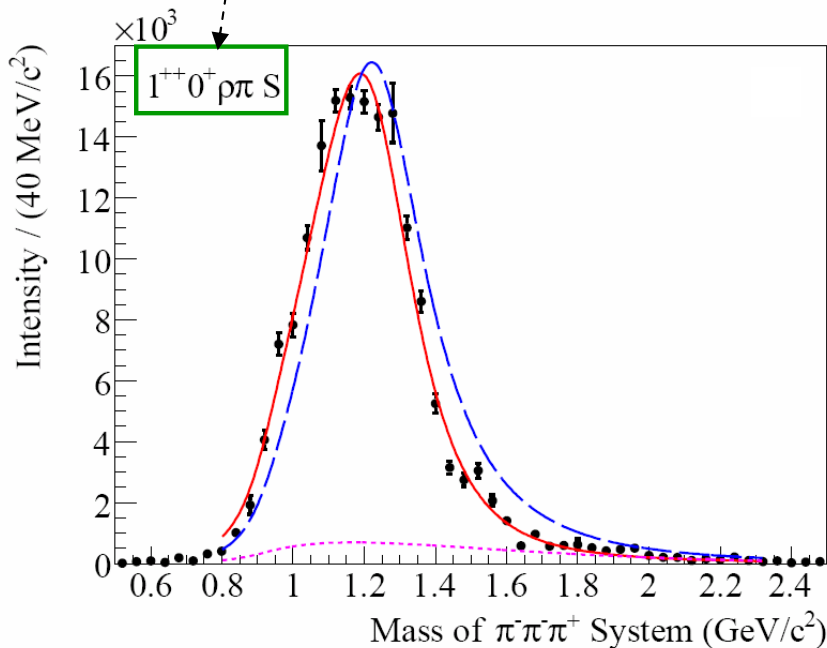
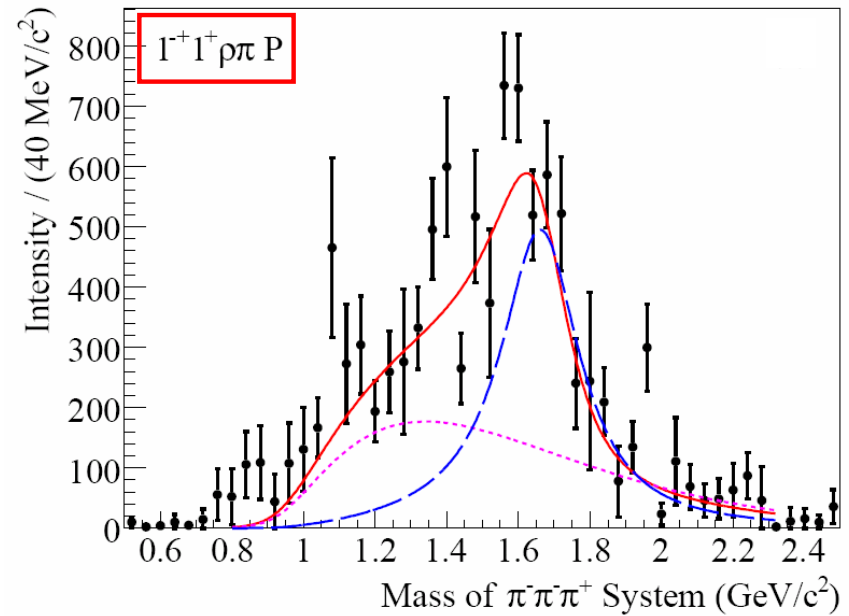
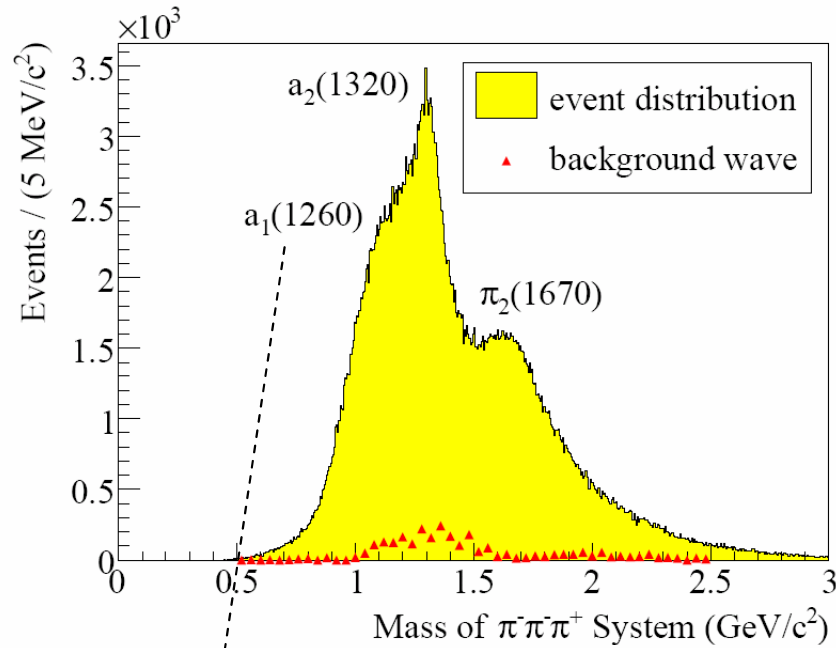


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Study of the exotic 1^{-+} wave

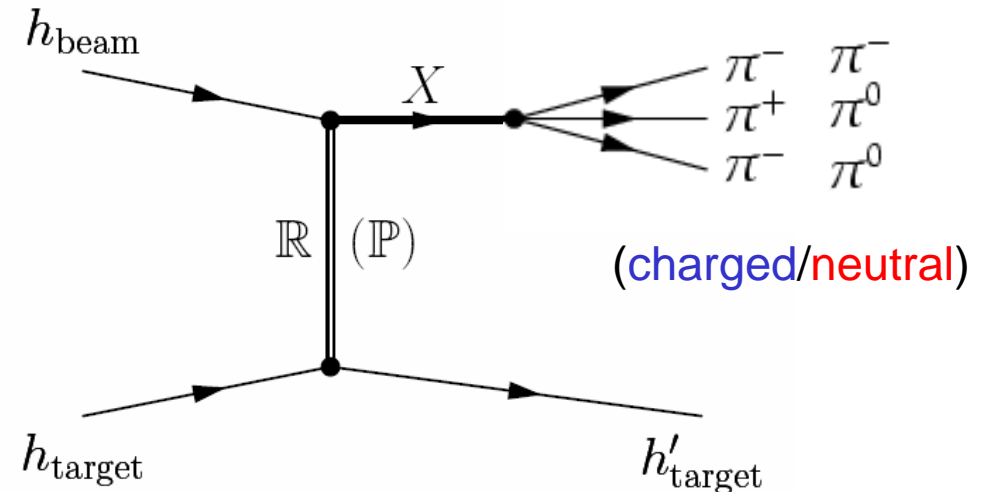
-- different decay channels ...

Hybrid candidates (1.3 - 2.2 GeV/c²):

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\rightarrow access to *all decay channels*, spin-exotics were *reported in* so far ..



COMPASS (2008/09 data), lets focus on:

- 190 GeV π^- beam (proton target)
- study of $\rho\pi$ decay channel via:
 - a) $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$ (charged mode)
 - b) $\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$ (neutral mode)



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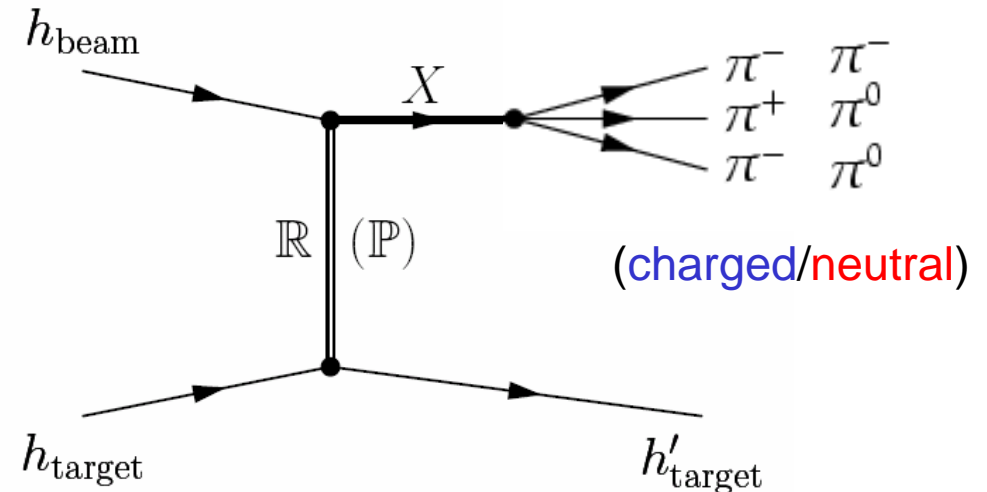
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... and further decay channels:

- study of $\eta'\pi, \eta\pi$ decay channel via:
 - a) $\pi^- p \rightarrow \pi^- \eta p$
 - b) $\pi^- p \rightarrow \pi^- \eta' p$
- study of $f_1\pi$ decay channel via:
 - a) $\pi^- p \rightarrow K\bar{K}\pi\pi^- p$ (two modes)

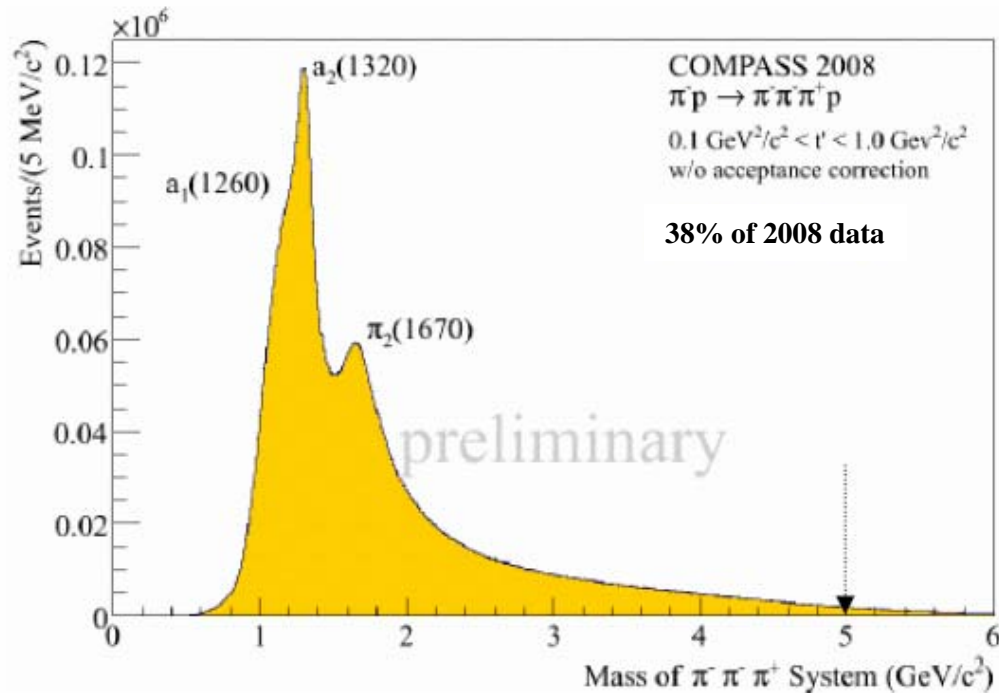


Diffractive dissociation into 3π final states (2008 data, proton target)

search for $\pi_1(1600)$

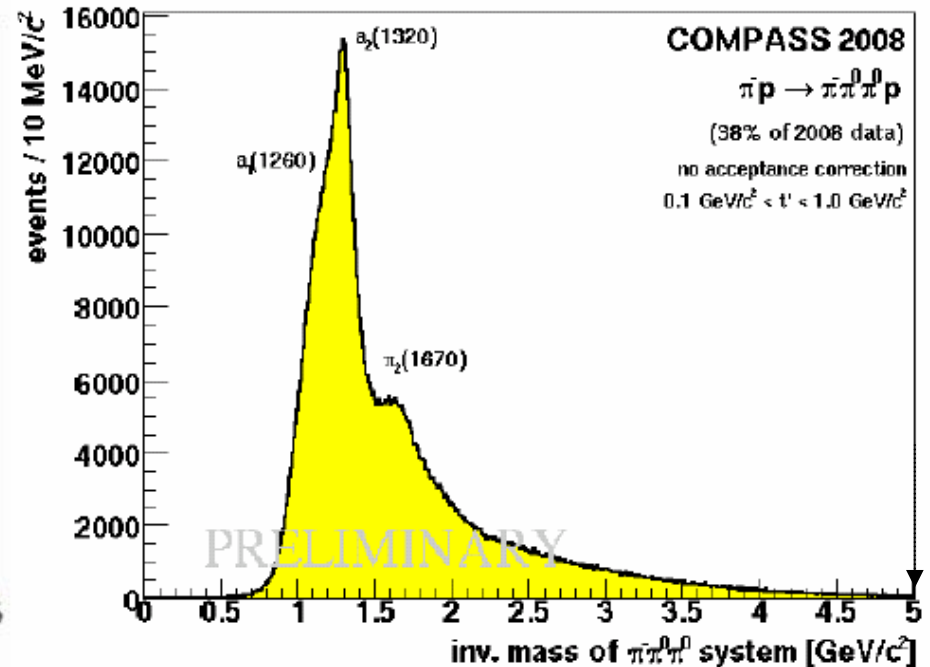
Mass of outgoing 3π system – **charged**
mode: $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$

Mass of outgoing 3π system – **neutral**
mode: $\pi^- p \rightarrow \pi^- \pi^0 \pi^0 p$



PWA: ~ 24M events

HK 23.3



PWA: ~ 1M events

HK 8.3



Comparison: Neutral vs. charged mode

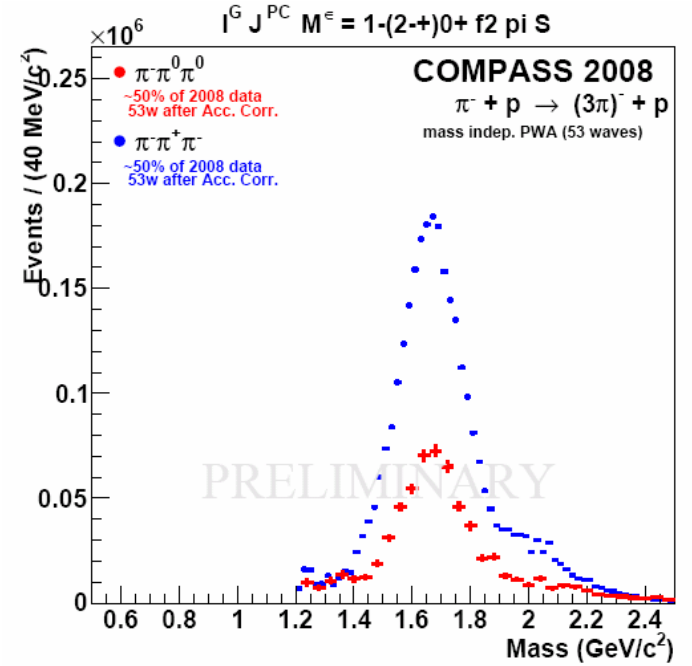
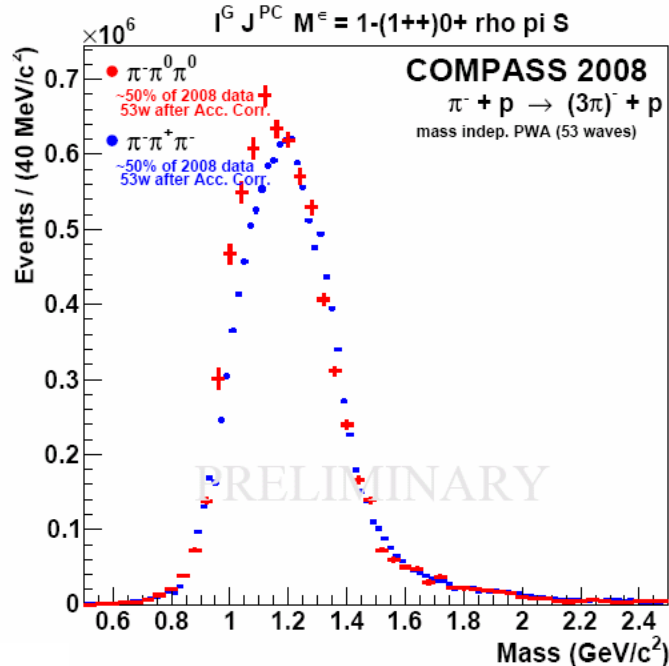
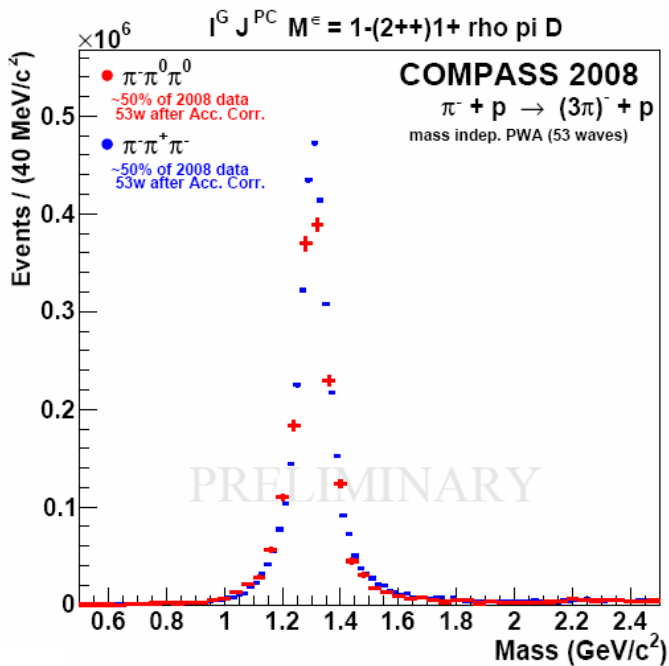
The 3 prominent resonances -- Consistency of isospin partners

search for $\pi_1(1600)$

$a_2(1320) \rightarrow \rho\pi$

$a_1(1260) \rightarrow \rho\pi$

$\pi_2(1670) \rightarrow f_2\pi$



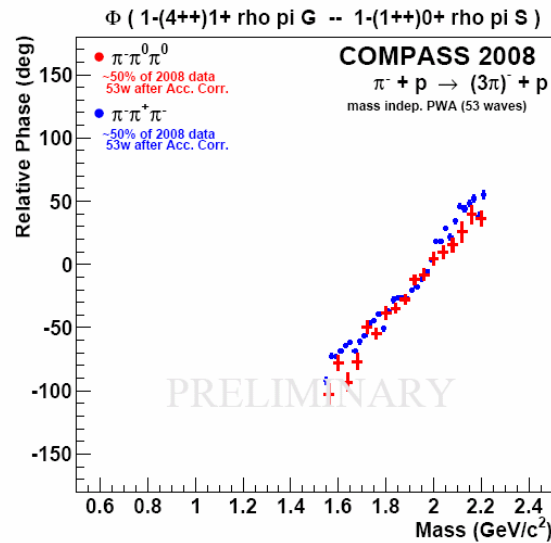
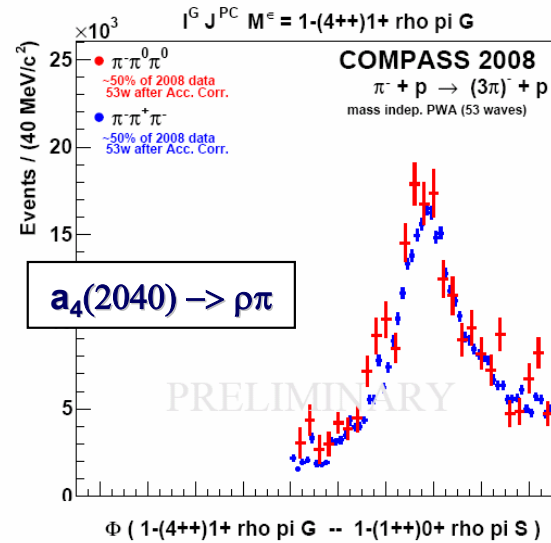
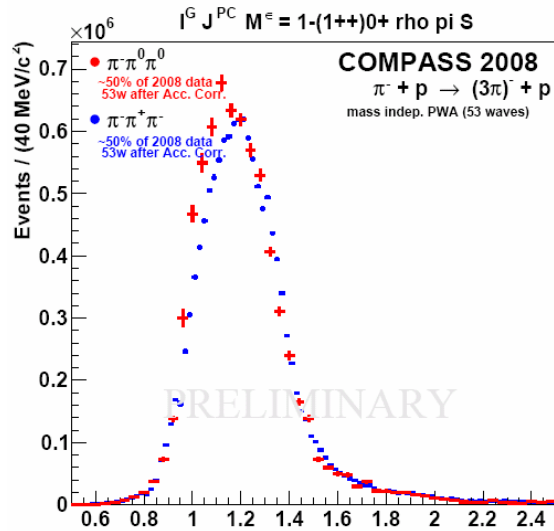
Isospin symmetry: neutral / charge mode

- X^- decaying into $\rho\pi$: 1/1 intensity expected (*isovector*)
- X^- decaying into $f_2\pi$: 1/2 intensity expected (*isoscalar*)



First AccCorr PWA results of $\pi^-\pi^0\pi^0$ final states

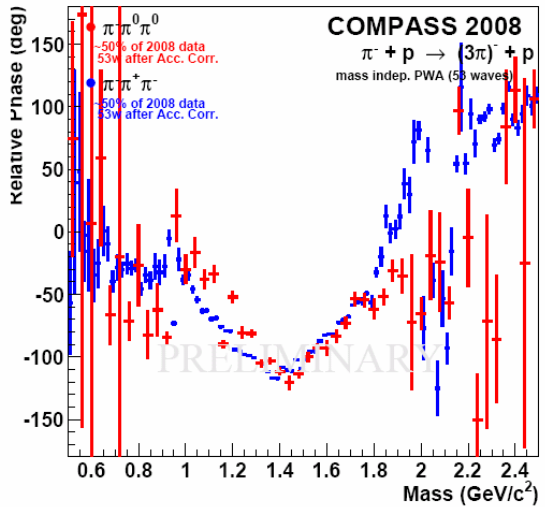
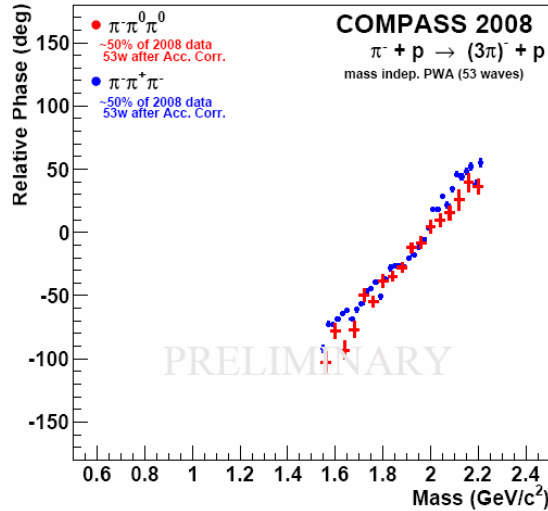
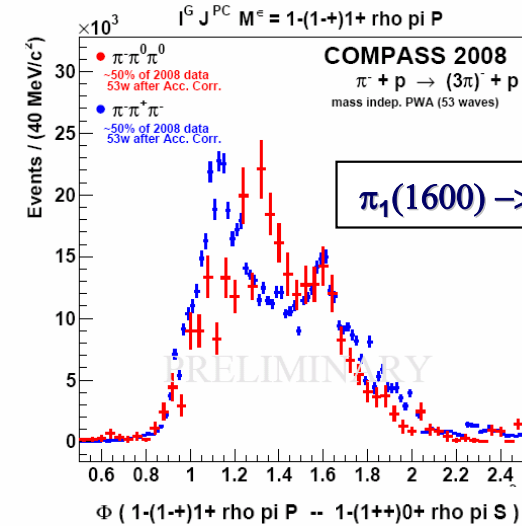
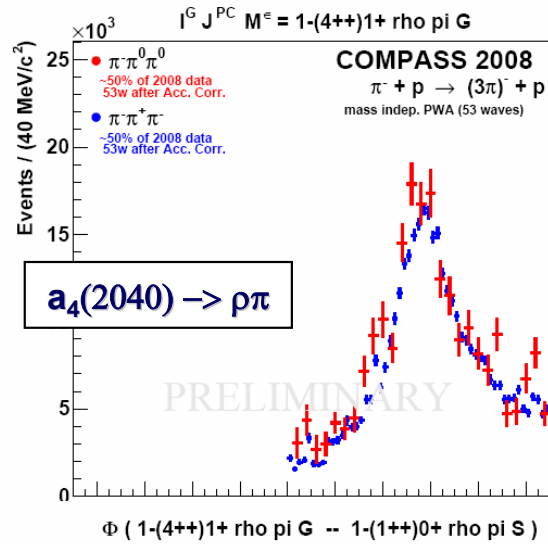
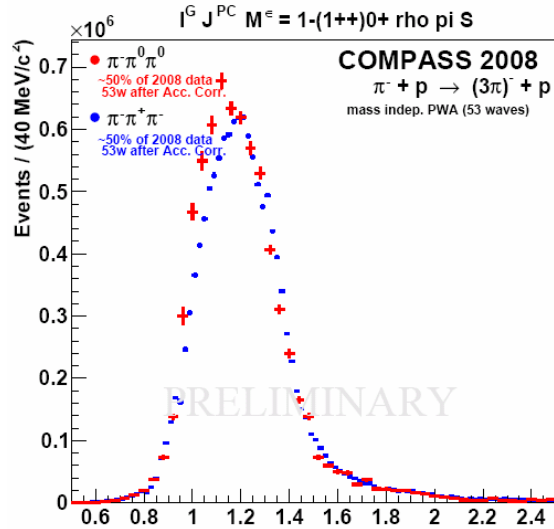
Intensities and relative phase -- small waves





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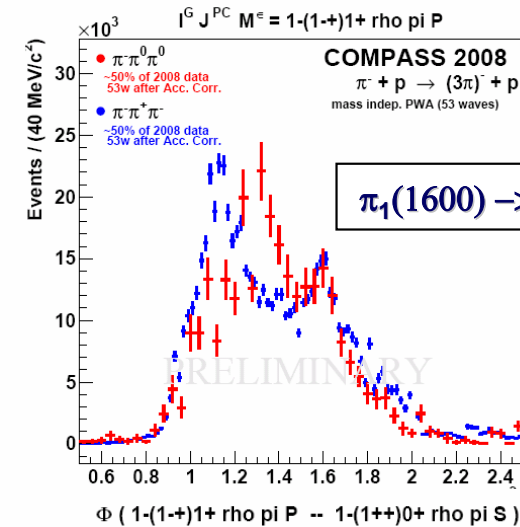
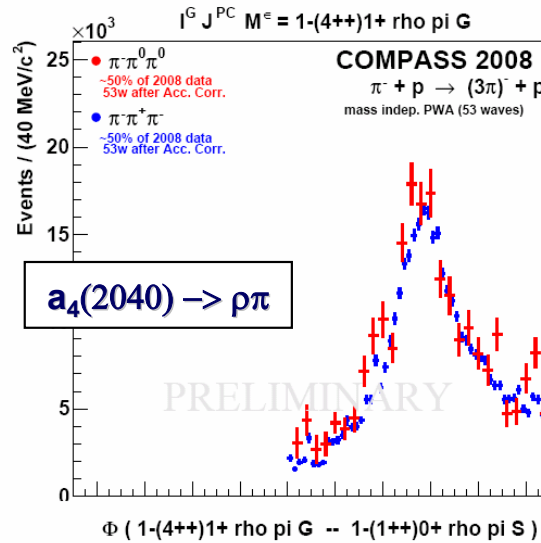
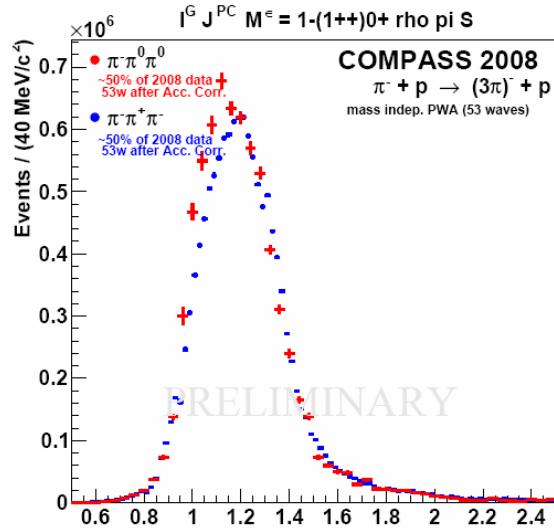
Intensities and relative phase -- small waves





First AccCorr PWA results of $\pi^- \pi^0 \pi^0$ final states

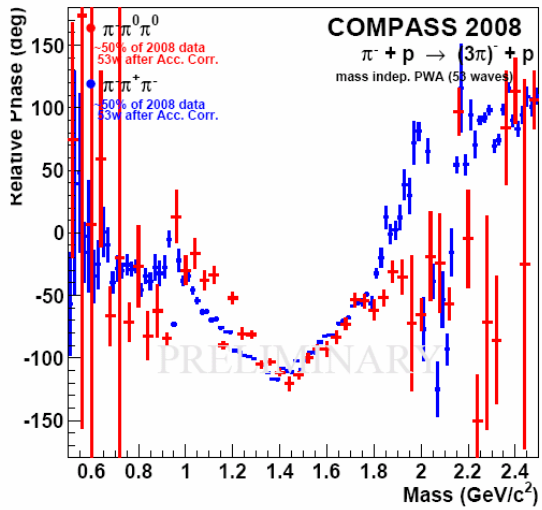
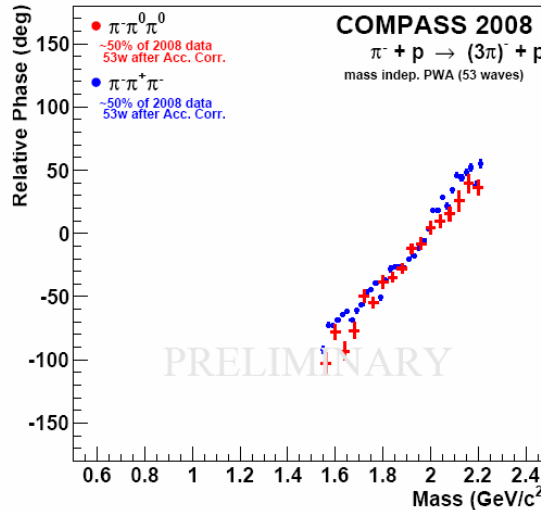
Intensities and relative phase -- small waves



$\pi_1(1600) \rightarrow \rho \pi ???$

Before any strong conclusion:

- More systematic studies (Leakage, Deck, thresholds)
- Mass-dependent fit





Study of the exotic 1^{-+} wave

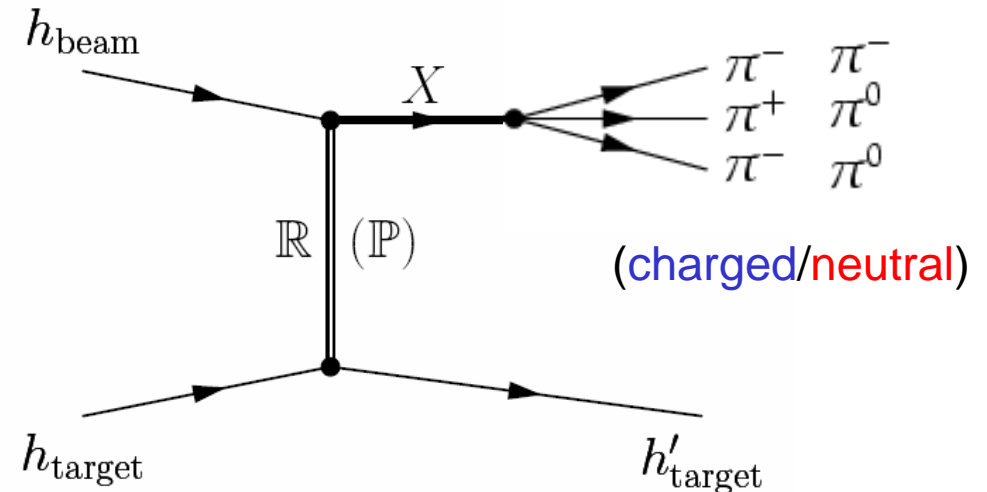
-- different decay channels ...

Hybrid candidates (1.3 - 2.2 GeV/c²):

lightest hybrid predicted: exotic $J^{PC} = 1^{-+}$

- $\pi_1(1400)$: VES, E852, Crystal Barrel $\rightarrow \eta\pi$
 - $\pi_1(1600)$: E852, VES $\rightarrow \rho\pi, \eta'\pi, f_1\pi, b_1\pi$
 - $\pi_1(2000)$: E852 $\rightarrow f_1(1285)\pi, b_1(1235)\pi$
- still controversial \rightarrow COMPASS

\rightarrow access to *all decay channels*, spin-exotics were *reported in* so far ..



COMPASS (2008/09 data), lets focus on:

- 190 GeV π^- beam (proton target)
- study of $\rho\pi$ decay channel via:
 - $\pi^- p \rightarrow \pi^+ \pi^- \pi^- p$ (charged mode)
 - $\pi^- p \rightarrow \pi^+ \pi^0 \pi^0 p$ (neutral mode)

... and further decay channels:

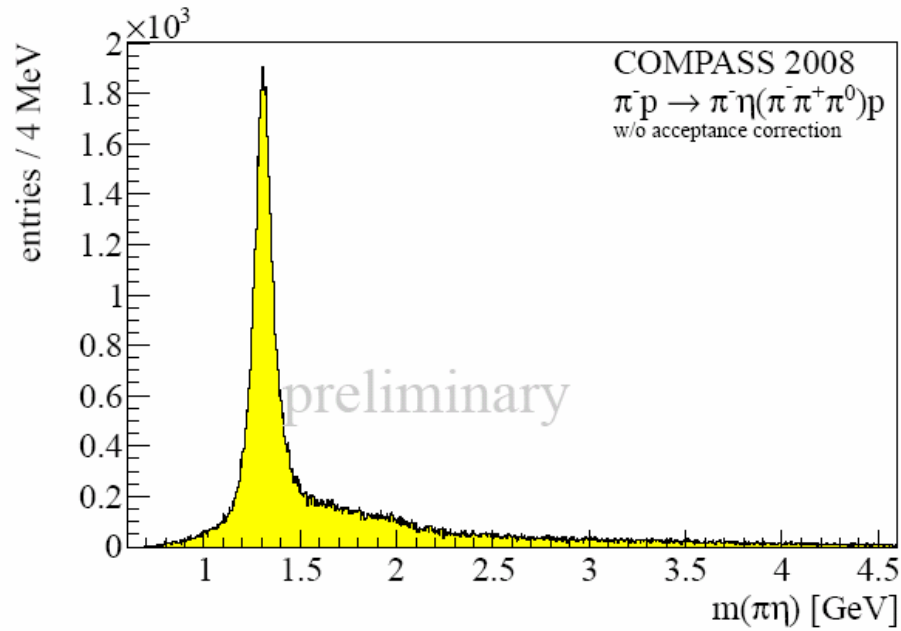
- study of $\eta'\pi, \eta\pi$ decay channel via:
 - $\pi^- p \rightarrow \pi^- \eta p$
 - $\pi^- p \rightarrow \pi^- \eta' p$
- study of $f_1\pi$ decay channel via:
 - $\pi^- p \rightarrow K \bar{K} \pi \pi^- p$ (two modes)



Different channel for the search: $\pi^- + p \rightarrow \pi^- \eta + p$



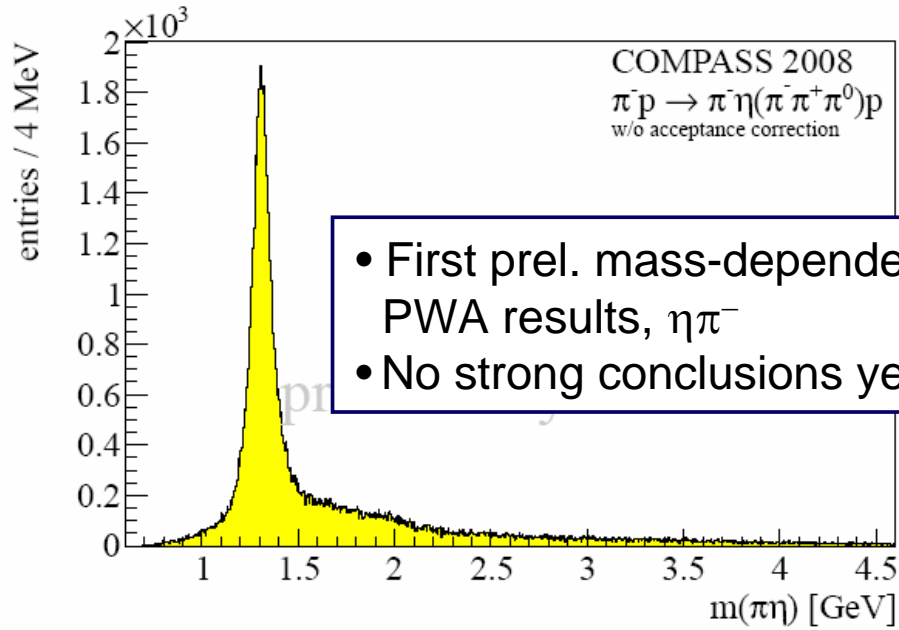
search for $\pi_1(1600)$



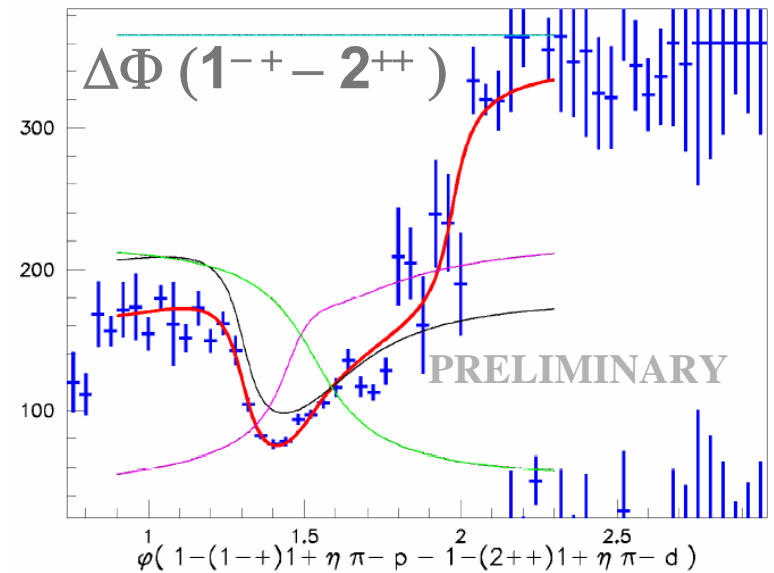
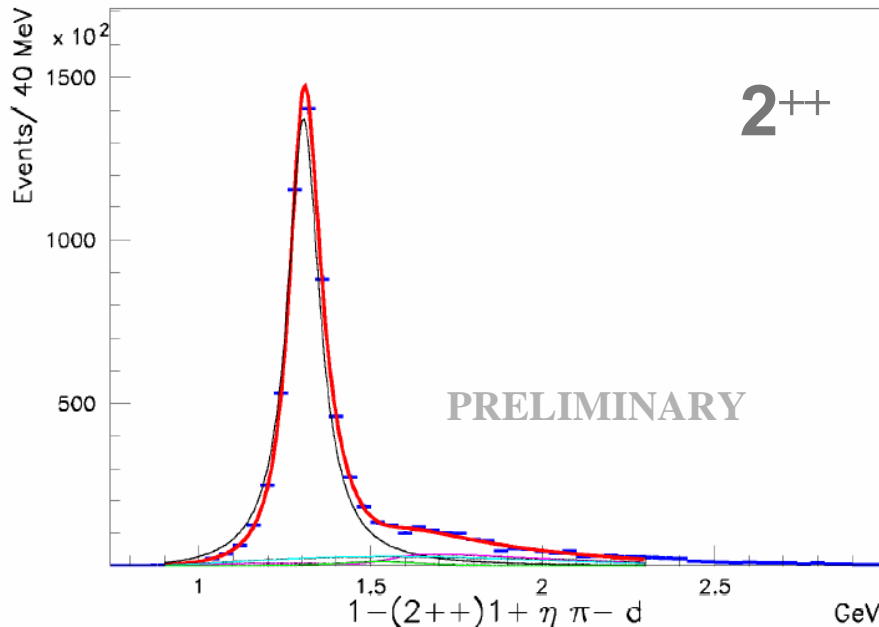
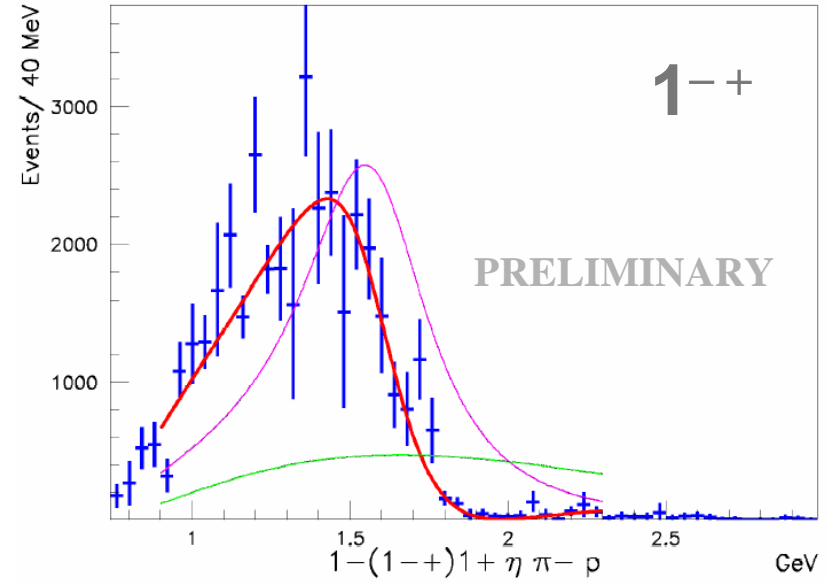


Different channel for the search: $\pi^- + p \rightarrow \pi^- \eta + p$

search for $\pi_1(1600)$



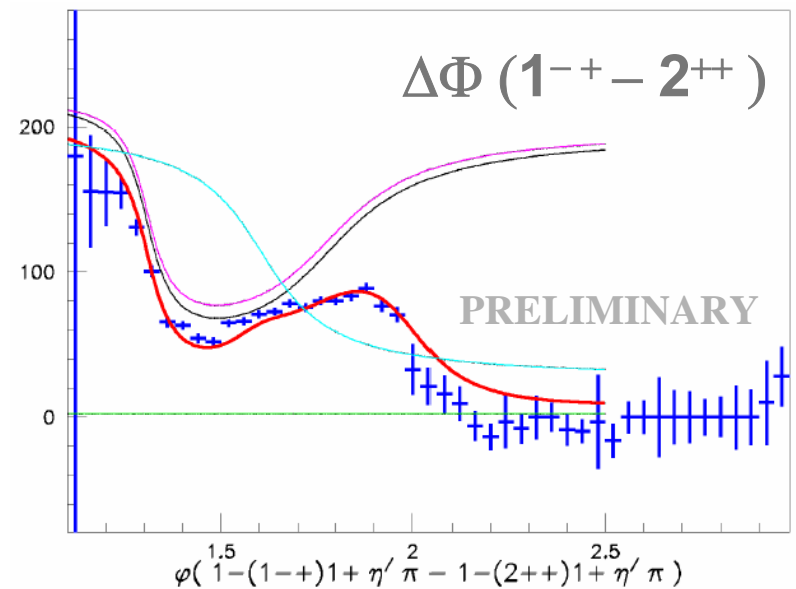
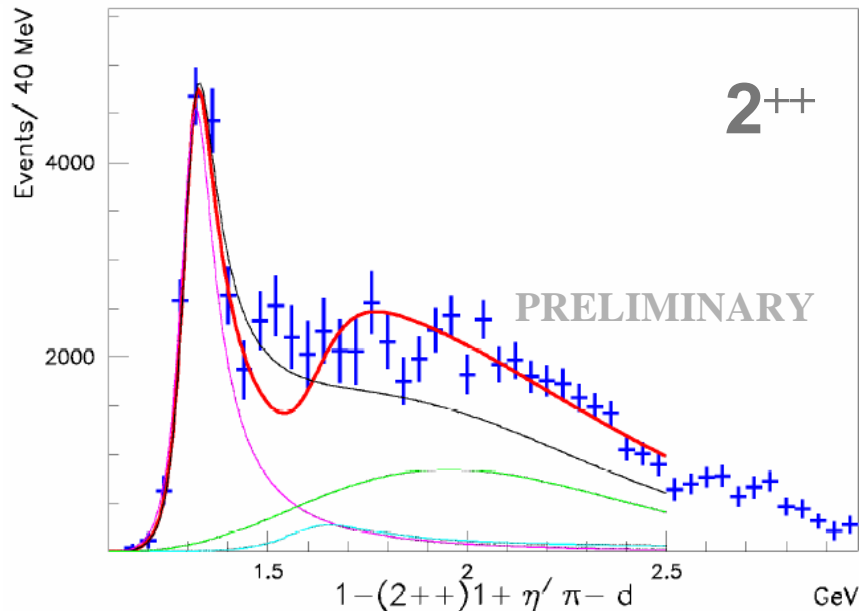
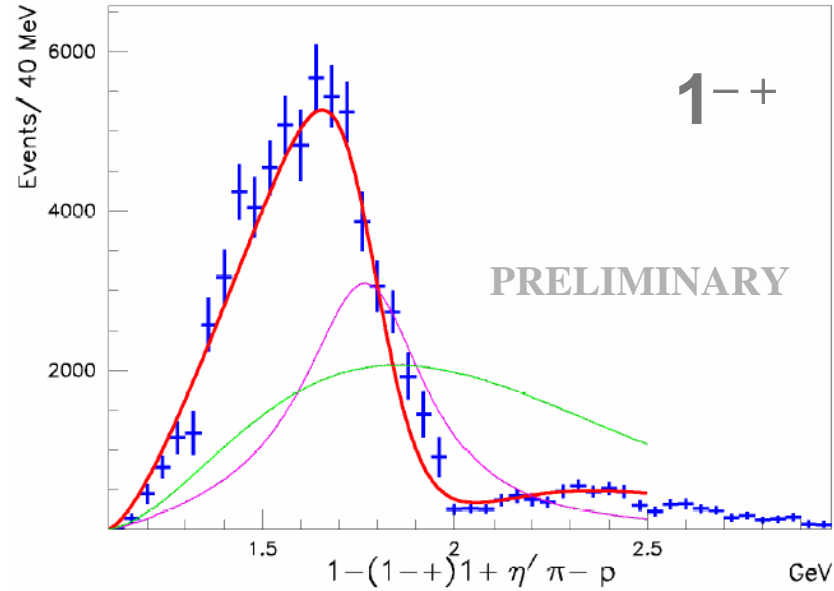
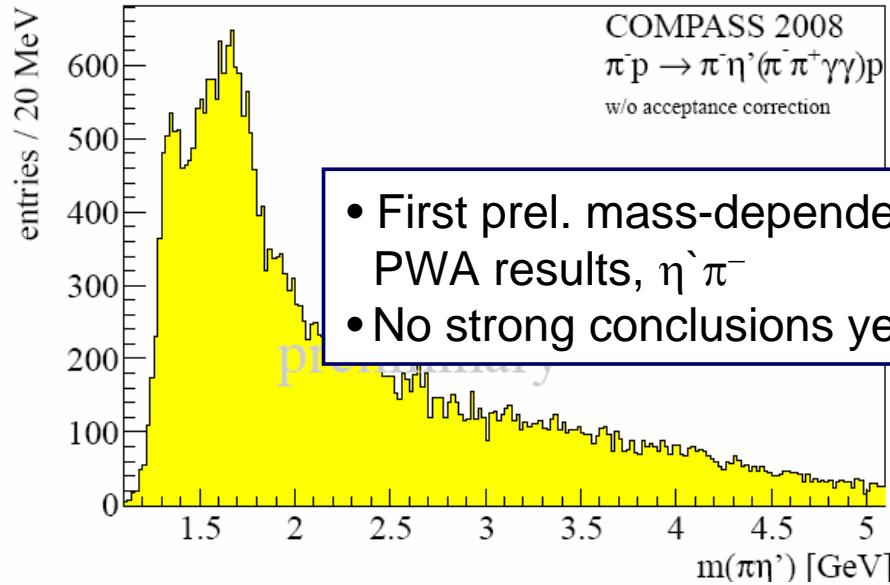
- First prel. mass-dependent PWA results, $\eta \pi^-$
- No strong conclusions yet





Different channel for the search: $\pi^- + p \rightarrow \pi^- \eta' + p$

search for $\pi_1(1600)$





Different channel for the search: First studies of $K\bar{K}\pi\pi$ final states



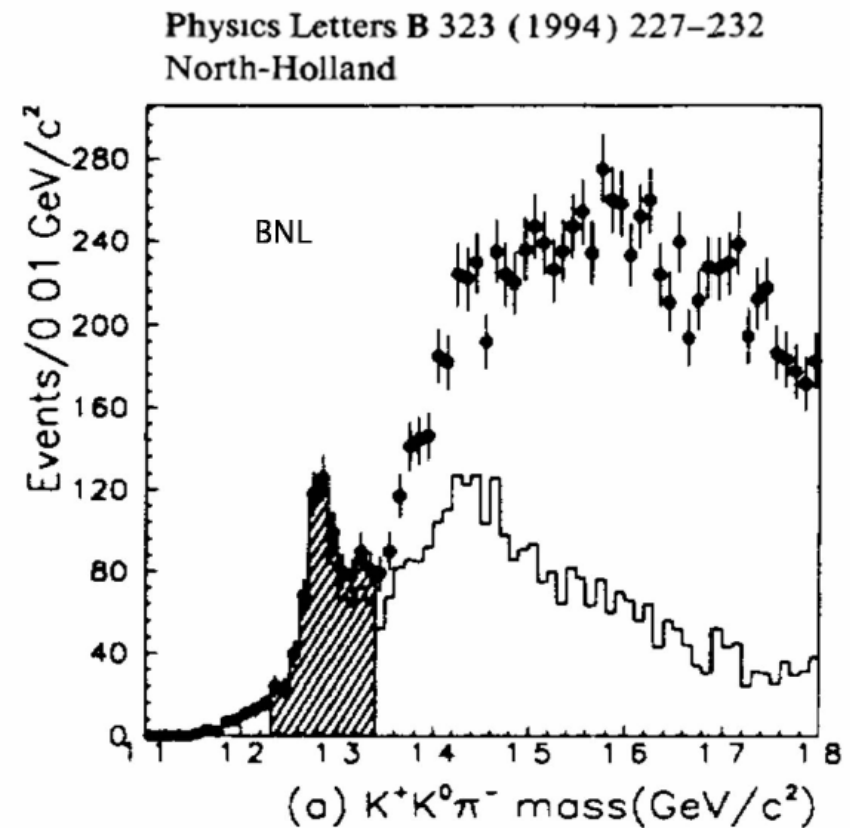
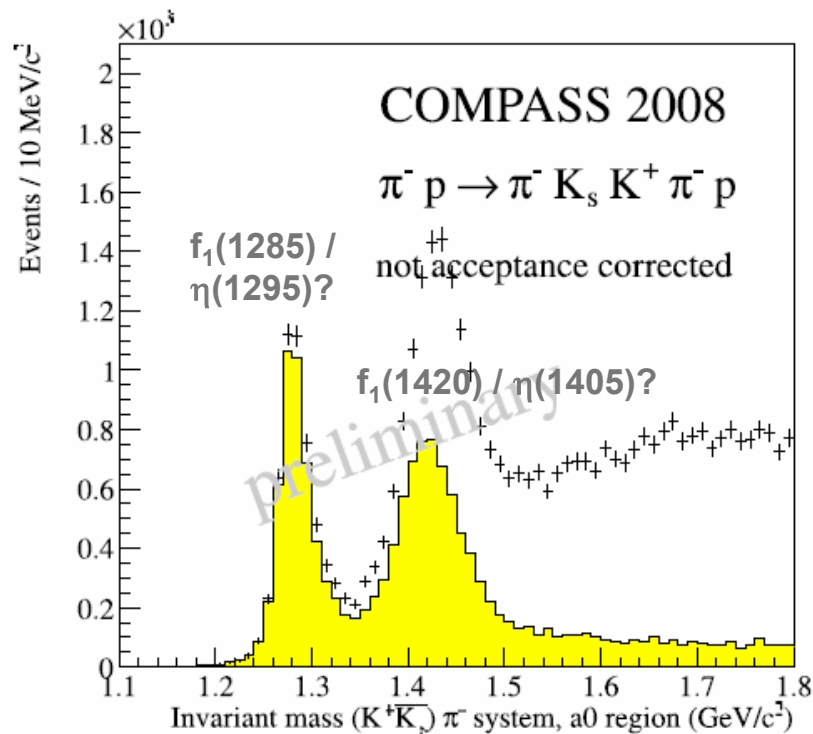
Physics channel: $\pi^- p \rightarrow K\bar{K}\pi\pi^- p$ (two modes)

Motivation: Search for diffr. X^- coupling to $s\bar{s}$ final states

search for $\pi_1(1600)$, $\pi_1(2000)$

First preliminary PWA started: $\bar{K}^0 K^+ \pi^- \pi^-$

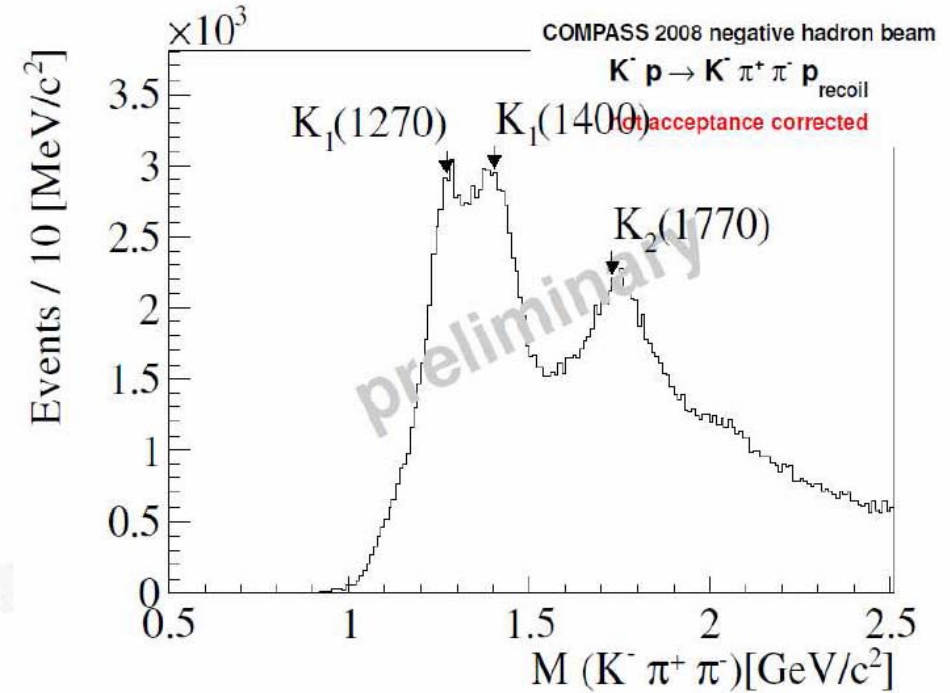
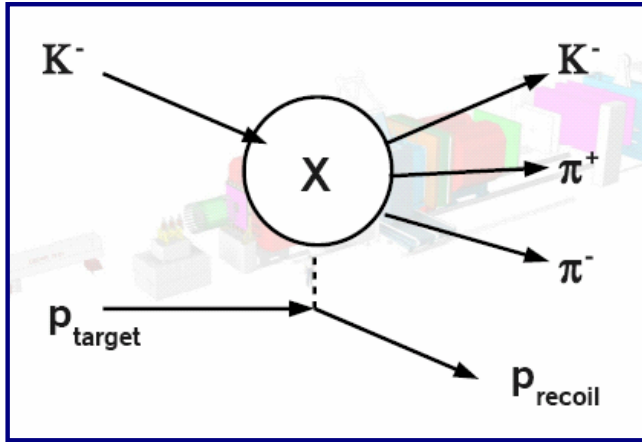
$(K\bar{K}\pi)^0$ subsystem:



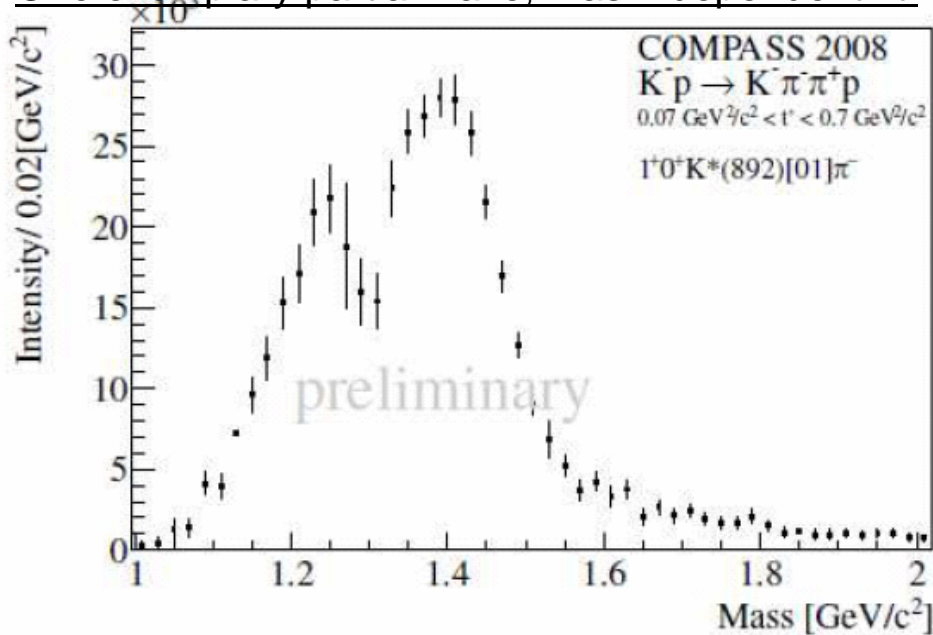
Statistics: **2008 data** => ~ factor 10 w.r.t. BNL (~20 for 2008/09)



Physics with the kaon beam: Kaon diffraction



One exemplary partial wave, mas-independent fit:

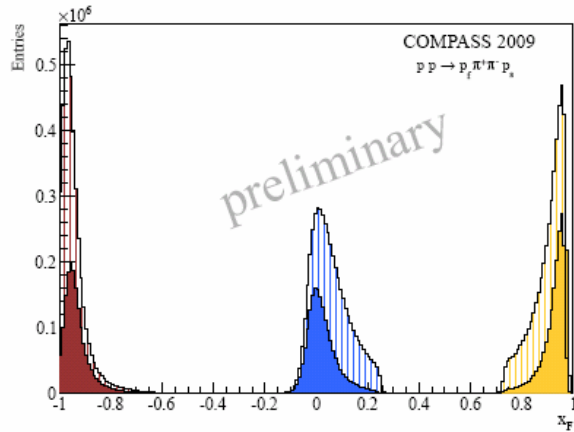


- Statistics ~5 more than WA03
- Several states need confirmation, \rightarrow e.g. the $K(1460)$
- Kaon physics will be an interesting option for future measurements!



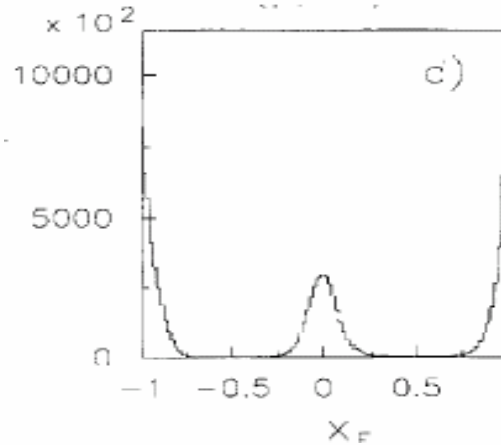
First studies of Central Production of $(\pi\pi)^0$

COMPASS

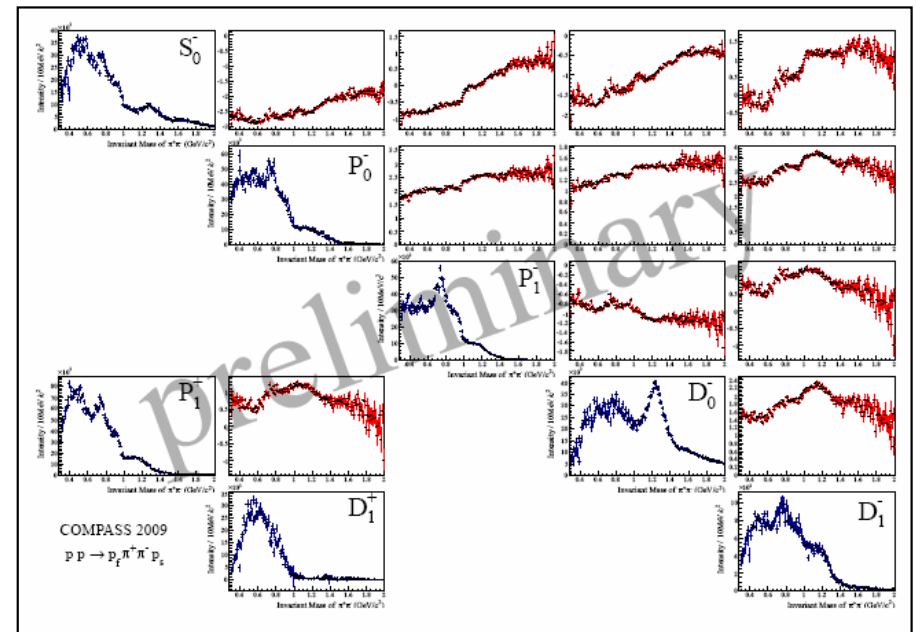
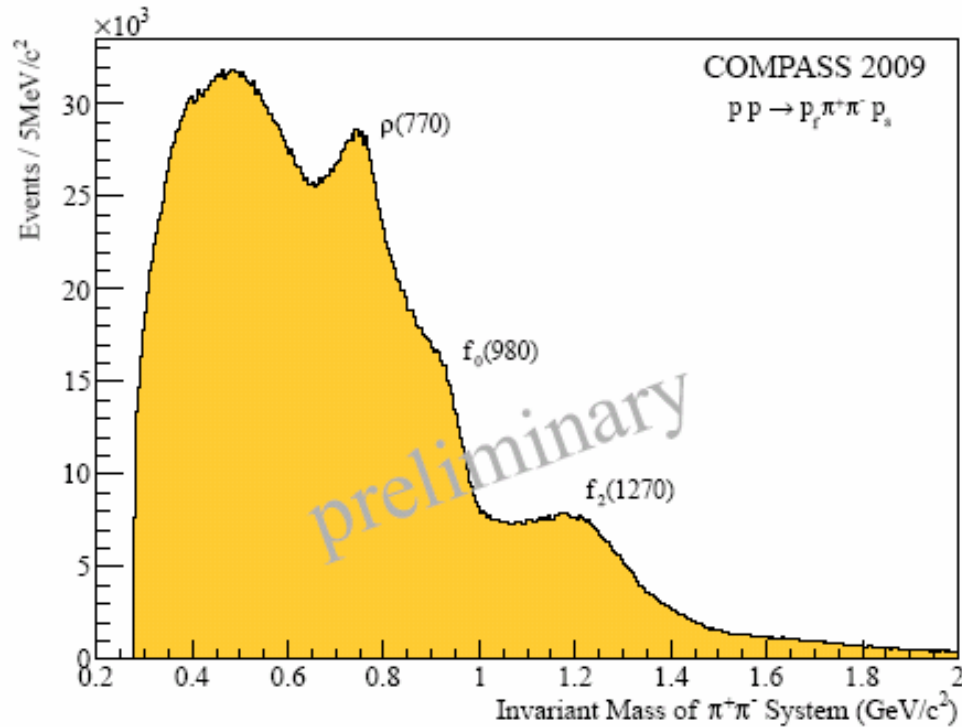


WA102

[Barberis et al. PL B 453 (1999)]



Search for resonances, CP



HK 22.3



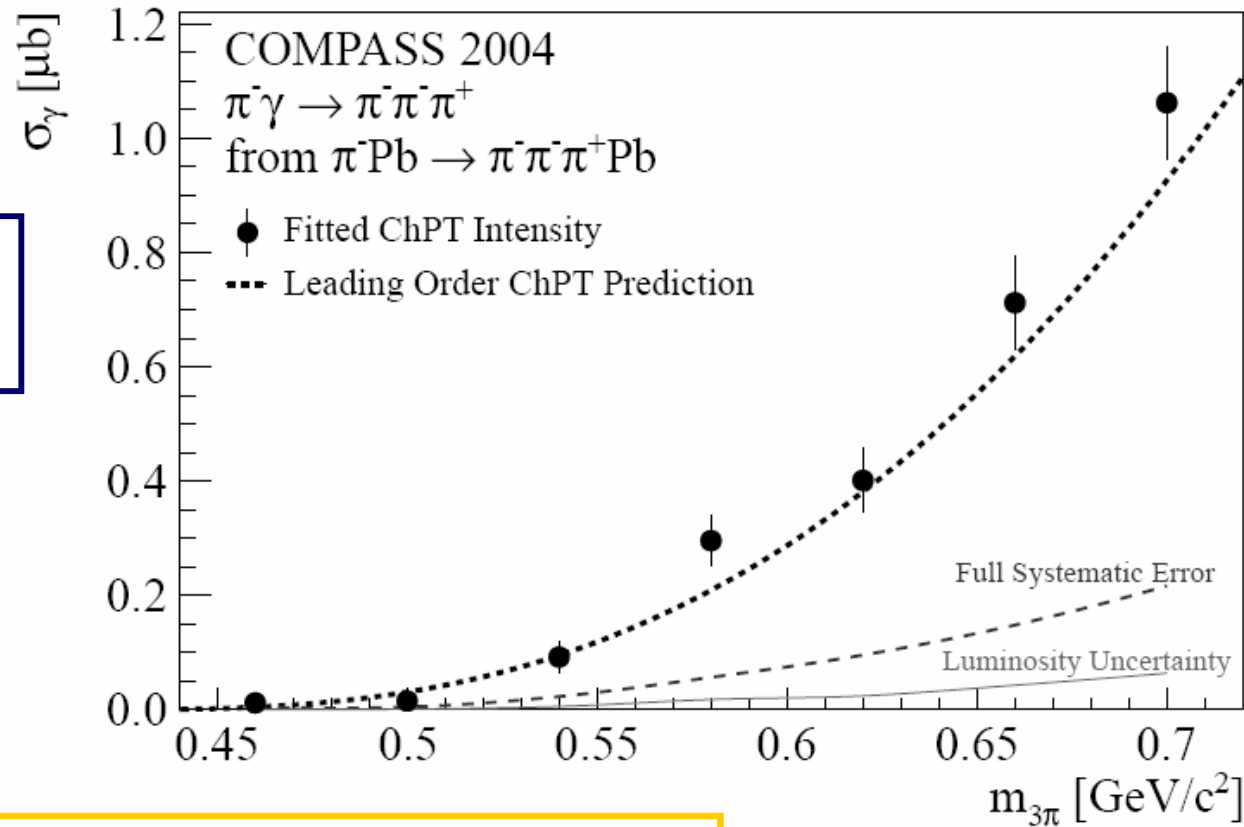
Measurement of Chiral dynamics in 3π final states (low t' in Coulomb region)



Go to very low Q^2 :

[hep/ex/1111.5954, PRL accepted (2012)]

PWA including amplitude from ChPT calculations substituting isobaric waves at low masses



First measurement of cross-section in this range:

Reaction $\pi^- Pb \rightarrow \pi^- \pi^- \pi^+ Pb$

- Results in agreement with **LO ChPT** calculations
- **More data available** from 2009 run (Pb target)



Nucleon Spin Structure

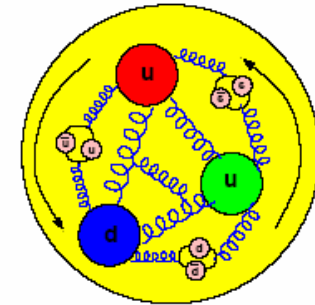


The spin of the nucleon

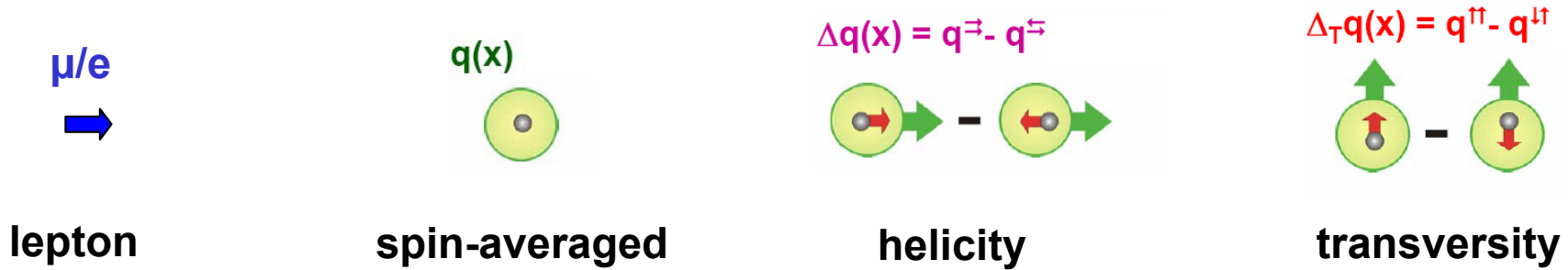
$$S_N = \frac{1}{2} = \frac{1}{2} \Delta\Sigma + \Delta G + L_q + L_g$$

accessible via

$\Delta\Sigma, \Delta s$	} inclusive DIS semi-inclusive DIS PGF in DIS DVCS
$\Delta u, \Delta d, \Delta s$	
ΔG	
L_q	

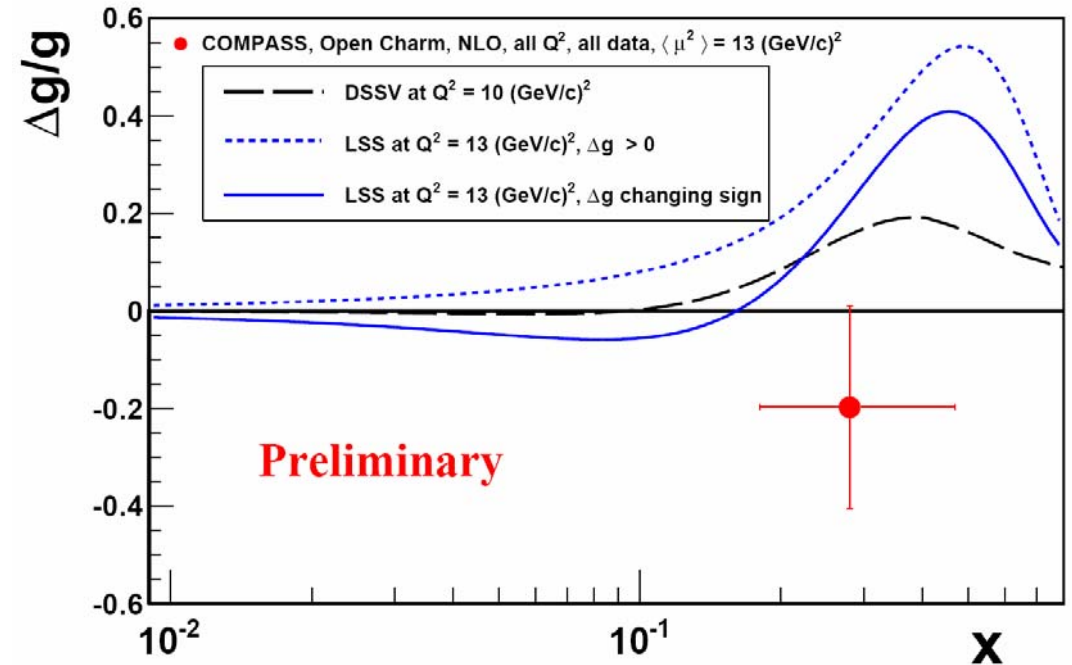
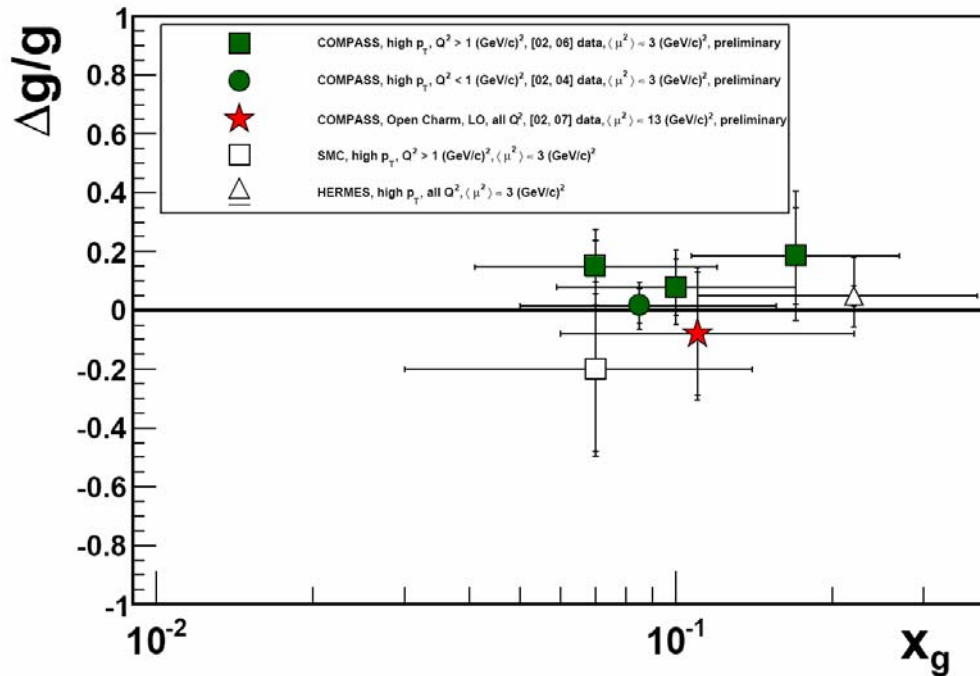


studied using
Parton distribution functions:





Results for $\Delta G/G$



[subm. PLB]

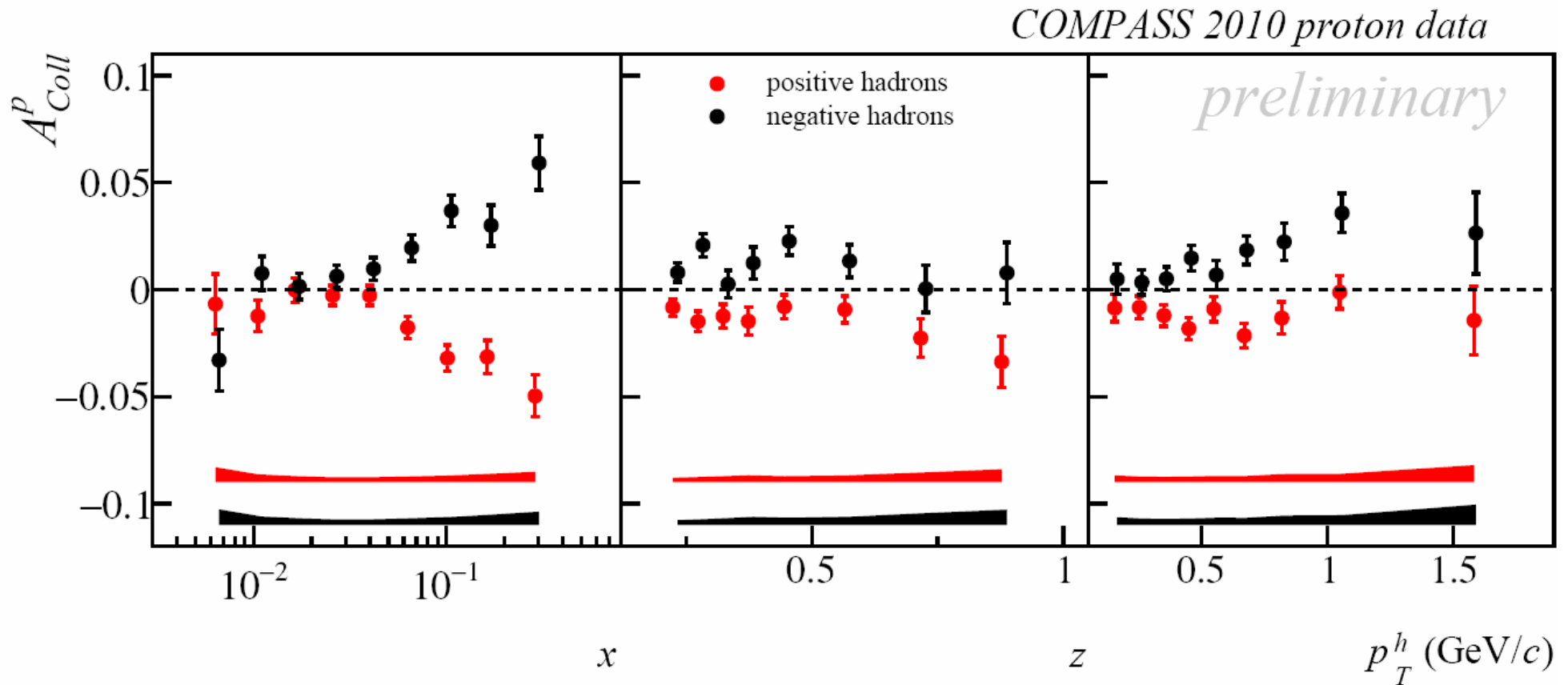
$$\Delta g/g^{\text{NLO}} = -0.20 \pm 0.21 \text{ (stat.)}$$

$\Delta g/g$:

- **LO** results, **high p_T** hadrons (SMC, HERMES, COMPASS) and **open charm**
- **NLO** result, **open charm** (COMPASS) \rightarrow syst. errors still under investigation
- $\Delta g/g$ **small** around $x_g \approx 0.1$, node not excluded



Results Transversity: Collins asymmetry



- significant signal observed on proton (was compatible with zero on deuteron)
- confirm at better statistics 2007 data result ($\sigma_{\text{sys.}} = 0.5 \sigma_{\text{stat.}}$)

$$A_{Coll} \approx \frac{\sum_q e_q^2 \Delta_T q \otimes A_T^0 D_q^h}{\sum_q e_q^2 q \otimes D_q^h}$$

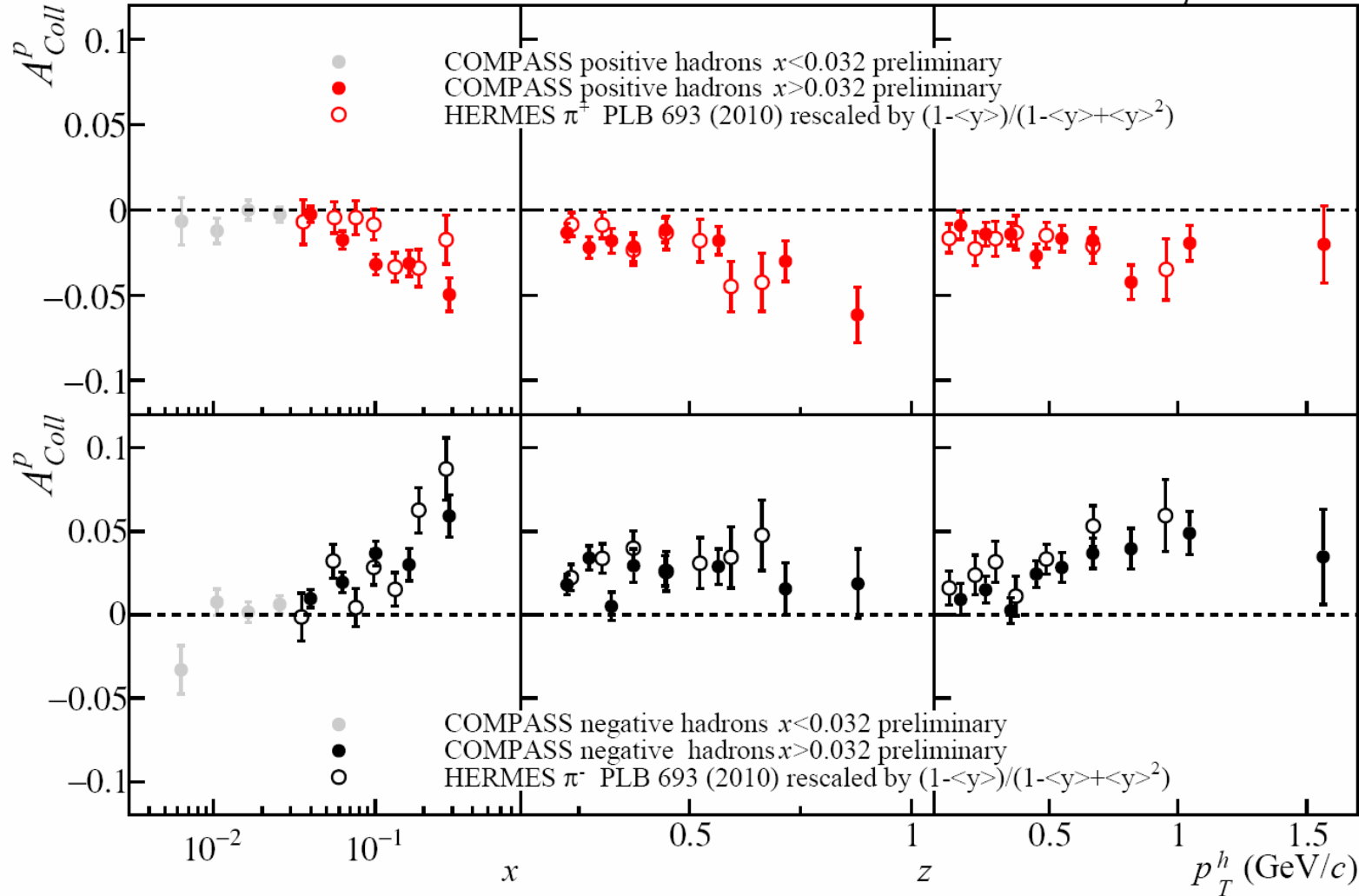


Results Transversity: Collins asymmetry



x > 0.032 region – for comparison with HERMES

COMPASS 2010 proton data

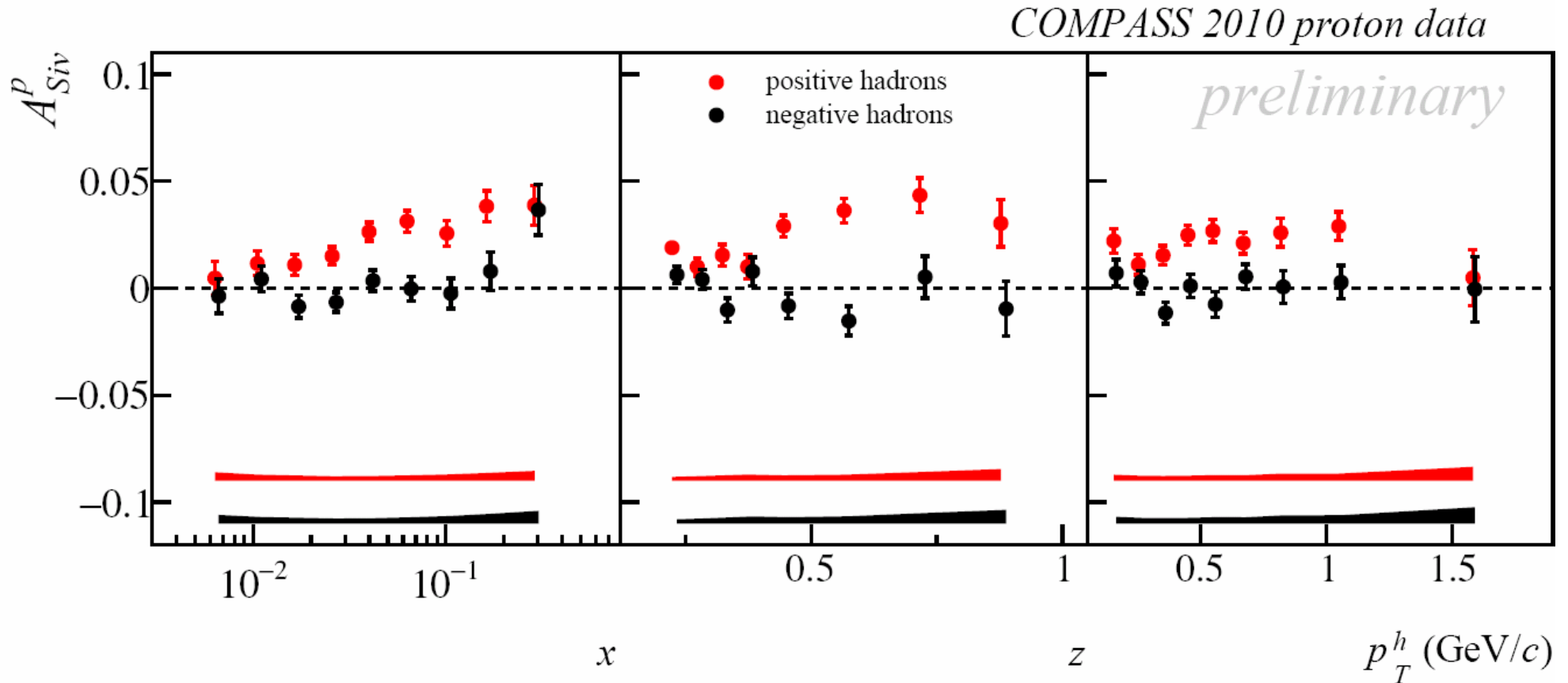


→ result also compatible with HERMES (at same quality)

$$A_{Coll} \approx \frac{\sum_q e_q^2 \Delta_T q \otimes A_T^q D_q^h}{\sum_q e_q^2 q \otimes D_q^h}$$



Results transv. pol. data: Sivers asymmetry

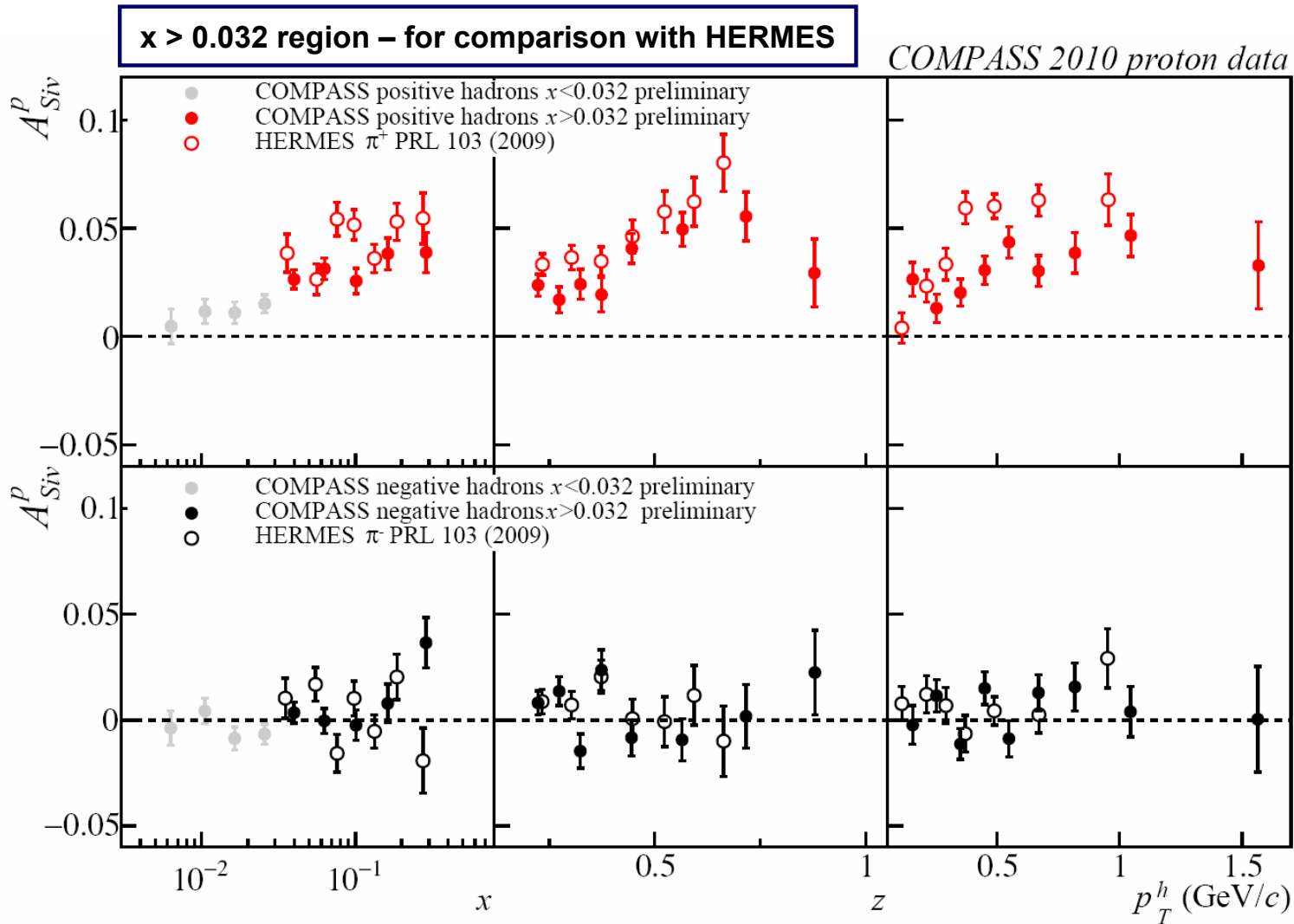


- confirm positive signal for positive hadrons first found by HERMES (was compatible with zero on deuteron)
- confirm at better statistics 2007 data result ($\sigma_{\text{sys.}} = 0.5 \sigma_{\text{stat.}}$ in 2010)

$$A_{Siv} = \frac{\sum_q e_q^2 f_{1T}^{\perp q} \otimes D_1^q}{\sum_q e_q^2 f_1 \otimes D_1^q} \frac{F_{UT}^{\sin(\phi_h - \phi_S)}}{F_{UU}}$$



Results transv. pol. data: Sivers asymmetry



→ result compatible with HERMES for neg. hadrons, but smaller effects for pos. hadrons (*at same quality*)
 → under study ...

$$A_{Siv} = \frac{\sum_q e_q^2 f_{1T}^{\perp q} \otimes D_1^q}{\sum_q e_q^2 f_1 \otimes D_1^q} \frac{F_{UT}^{\sin(\phi_h - \phi_S)}}{F_{UU}}$$



Future: COMPASS II



- **Primakoff:**

- **Measurement of fundamental pion / kaon polarisability**

- ✓ **scheduled for 2012** (*1 year of data taking*)

- => *experimentally demanding, systematics precisely to be controlled*

- **Drell-Yan**

- **Theor. expectation that Sivers fctn. has opposite sign as in SIDIS**

- ✓ **scheduled for 2014** (*1 year of data taking*)

- => *few, very basic assumptions only*

- **GPDs**

- **Complete picture of nucleon structure, from 2D to 3D picture**

- ✓ **scheduled for 2015/16** (*2 year of data taking*)

- => *accessible via hard exclusive reaction (DVCS, HEMP)*

COMPASS II proposal:

submitted in May 2010 for 5 years of data taking in the first phase
approved in December 2010 for initially 3 years of data taking



Summary & conclusions

- **COMPASS: high potential for spin-exotic search**
 - ✓ **2008/09: Very high statistics taken** (*hadron beams, proton & nuclear targets*)
 - ✓ **COMPASS measures Neutral & Charged channels**
 - => *all relevant channels for spin-exotic search feasible*
 - => *and many other analysis topics (OZI, ChPT, Baryon spectroscopy ...)*
- **Nucleon spin structure, traditional PDFs nearly finished**
 - ✓ **Longitudinal** (*quark & gluon helicities*)
 - ✓ **Transversity** (*Collins & Sivers*)
 - ✓ **Unpolarised physics** (*fragm. fctns. from multiplicites*)
 - => *analysis of new 2011 longitudinal data, extension to NLO calculations*
- **COMPASS II (outlook)**
 - **Primakoff** (*polarisibilities*)
 - **Drell Yan** (*fundamental check of Sievers fctn.*)
 - **GPDs** (*2D → 3D picture of the nucleon*)

**Many results already, more to come soon,
very active in the fields involved ...**



COMPASS very active, much more contributions (μ /hadron.physics & hardware) than possible to cover / refer to in this overview ...

- Di, 09:30 PV 3.1 Recent Results from the COMPASS Experiment — •FRANK NERLING
- Mo, 16:30 HK 8.1 Hadron Spectroscopy with COMPASS — •BORIS GRUBE
- Mo, 17:00 HK 8.2 bold Resonanzen der Systeme $\pi^- \eta$ und $\pi^- \eta'$ in der Reaktion $\pi^- p \rightarrow \pi^- \eta^0 p_{\text{slow}}$ bei COMPASS — •TOBIAS SCHLÜTER, WOLFGANG DÜNNWEBER und MARTIN FAESSLER
- Mo, 17:15 HK 8.3 Spin-exotic search in the $\rho\pi$ decay channel:
First results on $\pi^- \pi^0 \pi^0$ in comparison to $\pi^- \pi^+ \pi^-$ final states (diffractively produced on proton) — •FRANK NERLING
- Mo, 17:30 HK 8.4 Search for Resonances in the Diffractively Produced 5 Pion System at COMPASS — •SEBASTIAN NEUBERT
- Mo, 17:45 HK 8.5 Analysis of diffractive dissociation of exclusive $K^- \pi^+ \pi^-$ events in the high energetic hadron beam of the COMPASS-experiment — •PROMETEUSZ JASINSKI and FOR THE COMPASS COLLABORATION
- Mo, 17:45 HK 12.5 Development of a Deadtime Measurement System for the COMPASS experiment using FPGA technology — •OLIVER FREYERMUTH
- Di, 18:30 HK 19.8 Charakterisierung von Spiegeln für den RICH-Detektor von CBM — •SASCHA REINECKE
- Mi, 14:45 HK 22.3 Partial-Wave Analysis of the Centrally Produced $\pi^+ \pi^-$ System in pp Reactions at COMPASS — •ALEXANDER AUSTREGESILO, BORIS GRUBE, STEPHAN PAUL, and TOBIAS SCHLÜTER
- Mi, 14:00 HK 23.1 Messungen zu den Meson-Polarisierbarkeiten und zu chiraler Dynamik in Pion-Photon-Reaktionen an COMPASS — •JAN FRIEDRICH

List cnts. next page



- Mi, 14:30 HK 23.2 [Cross section for quasi-real photo-production of charged hadrons with high transverse momenta in muon-deuteron scattering](#) — •CHRISTIAN HÖPPNER
- Mi, 14:45 HK 23.3 [Diffractive Dissociation into 3 Pion Final States at COMPASS](#) — •FLORIAN HAAS
- Mi, 15:00 HK 23.4 [Single-Hadron transverse target spin asymmetries at COMPASS](#) — •CHRISTOPH ADOLPH
- Mi, 15:15 HK 23.5 [OZI rule violation and spin alignments in vector meson production at COMPASS](#) — •JOHANNES BERNHARD
- Mi, 15:30 HK 23.6 [COMPASS results on transverse spin asymmetries in two-hadron production in SIDIS](#) — •CHRISTOPHER BRAUN
- Mi, 15:45 HK 23.7 [Hard exclusive \$\rho^0\$ production to constrain generalized parton distributions](#) — •KATHARINA SCHMIDT, STEFFEN BAUER, HORST FISCHER, TILLMANN GUTHÖRL, KAY KÖNIGSMANN, FRANK NERLING, CHRISTIAN SCHILL, STEFAN SIRTIL, and JOHANNES TER WOLBEEK
- Mi, 14:45 HK 27.3 [Neue Ansätze bei der Strahlteilchenidentifikation im COMPASS Experiment](#) — •TOBIAS WEISROCK
- Mi, 15:00 HK 27.4 [Production and behavior studies of the new ammonia target for the COMPASS experiment](#) — •ALEXANDER BERLIN, SONJA KUNKEL, STEFAN RUNKEL, JONAS HERICK, CHRISTIAN HESS, WERNER MEYER, and GERHARD REICHERZ
- Mi, 18:00 HK 35.6 [Zeitdiskrete Pulsformanalyse von Detektorsignalen in Echtzeit](#) — TOBIAS BAUMANN, MAXIMILIAN BÜCHELE, HORST FISCHER, MATTHIAS GORZELLIK, FLORIAN HERRMANN, •PHILIPP JÖRG, KAY KÖNIGSMANN, TOBIAS KUNZ, CHRISTOPH MICHALSKI, CHRISTIAN SCHILL, SEBASTIAN SCHOPFERER und TOBIAS SZAMEITAT
- Do, 14:00 HK 53.8 [GANDALF Framework - Auslese und Triggereinheit für den CAMERA Detektor](#) — TOBIAS BAUMANN, MAXIMILIAN BÜCHELE, HORST FISCHER, MATTHIAS GORZELLIK, •FLORIAN HERRMANN, PHILIPP JÖRG, KAY KÖNIGSMANN, TOBIAS KUNZ, CHRISTOPH MICHALSKI, CHRISTIAN SCHILL, SEBASTIAN SCHOPFERER und TOBIAS SZAMEITAT
- Fr, 14:30 HK 61.2 [Luminosity determination at COMPASS](#) — •NICOLAS DU FRESNE VON HOHENESCHE



- Mi, 14:30 HK 23.2 Cross section for quasi-real photo-production of charged hadrons with high transverse momenta in muon-deuteron scattering — •CHRISTIAN HÖPPNER
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Stay tuned for more interesting COMPASS results ...

- Mi, 15:45 HK 23.7 Hard exclusive p p → p p π⁰ production at COMPASS — •KATHARINA SCHMIDT, STEFFEN BAUER, KÖNIGSMANN, FRANK NERLING, CHRISTIAN SCHILL, STEFAN WOLBEEK
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- Mi, 15:00 HK 27.4 Production and behavior studies of the new ammonia target for the COMPASS experiment — •ALEXANDER BERLIN, SONJA KUNKEL, STEFAN RUNKEL, JONAS HERICK, CHRISTIAN HESS, WERNER MEYER, and GERHARD REICHERZ

Thanks for your attention!

- Mi, 18:00 HK 35 •TOBIAS BAUMANN, AN HERRMANN, •PHILIPP JÖRG, KAY KÖNIGSMANN, TOBIAS KUNZ, CHRISTOPH MICHALSKI, CHRISTIAN SCHILL, SEBASTIAN SCHOPFERER und TOBIAS SZAMEITAT
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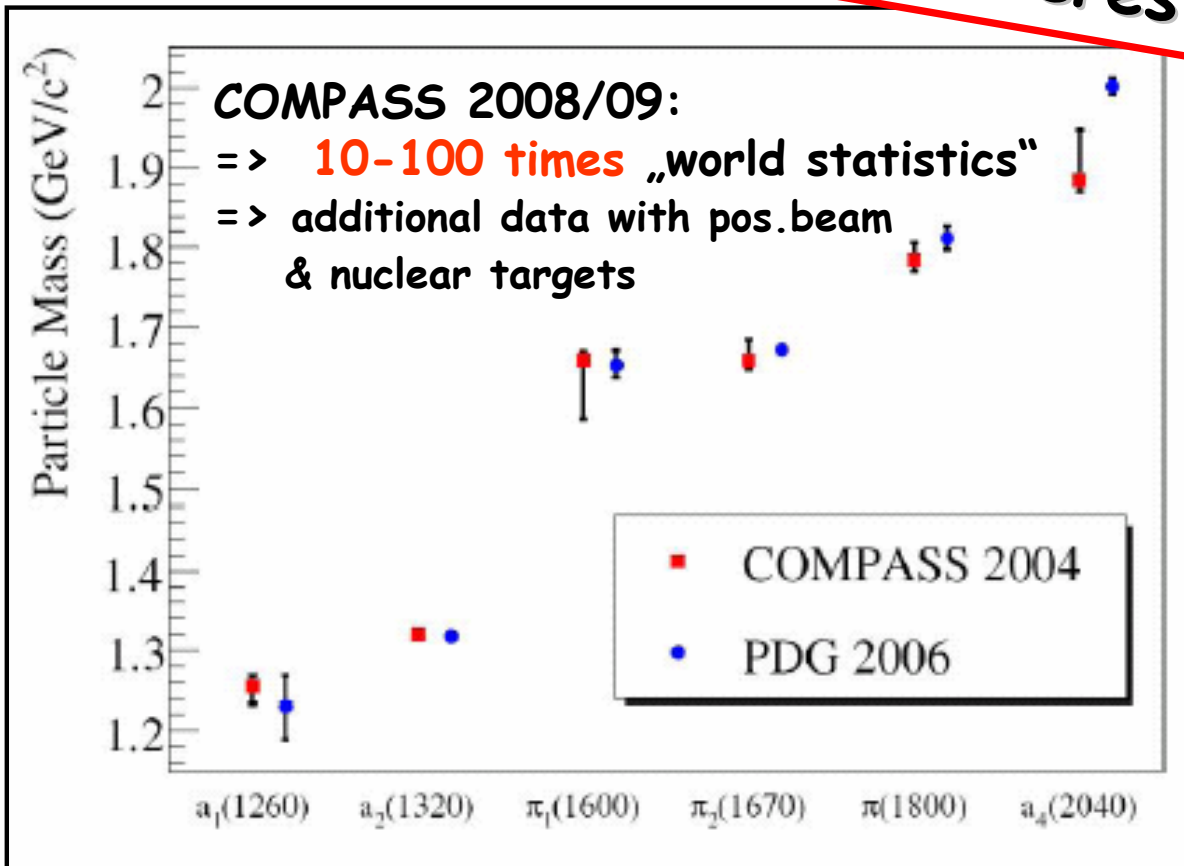


Additional material



Summary & conclusions

Stay tuned for more interesting COMPASS results ...



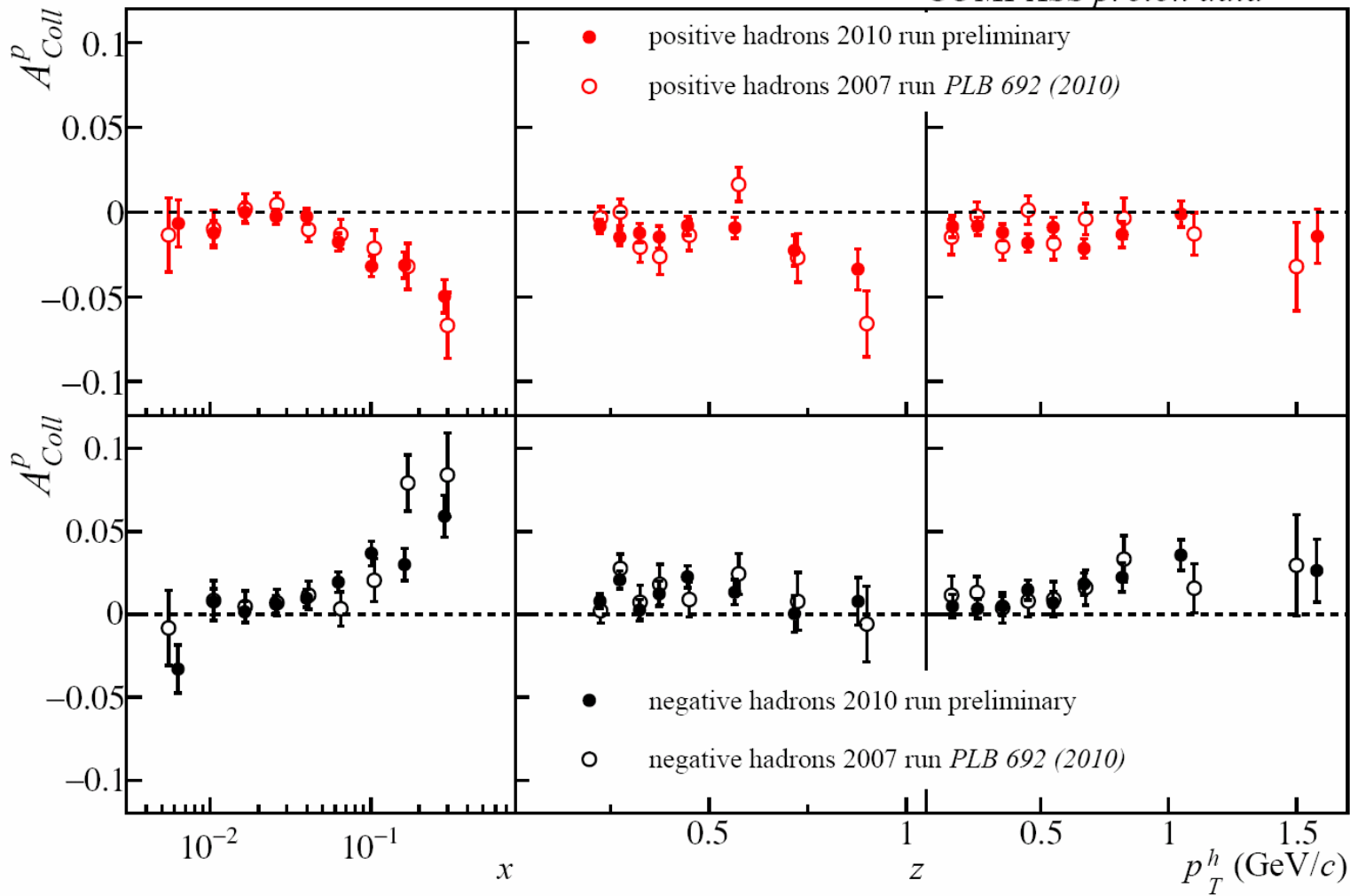
THANK YOU !!!



Results Transversity: Collins asymmetry



COMPASS proton data



- significant signal observed on proton (was compatible with zero on deuteron)
- confirm at better statistics 2007 data result ($\sigma_{\text{sys.}} = 0.5 \sigma_{\text{stat.}}$)

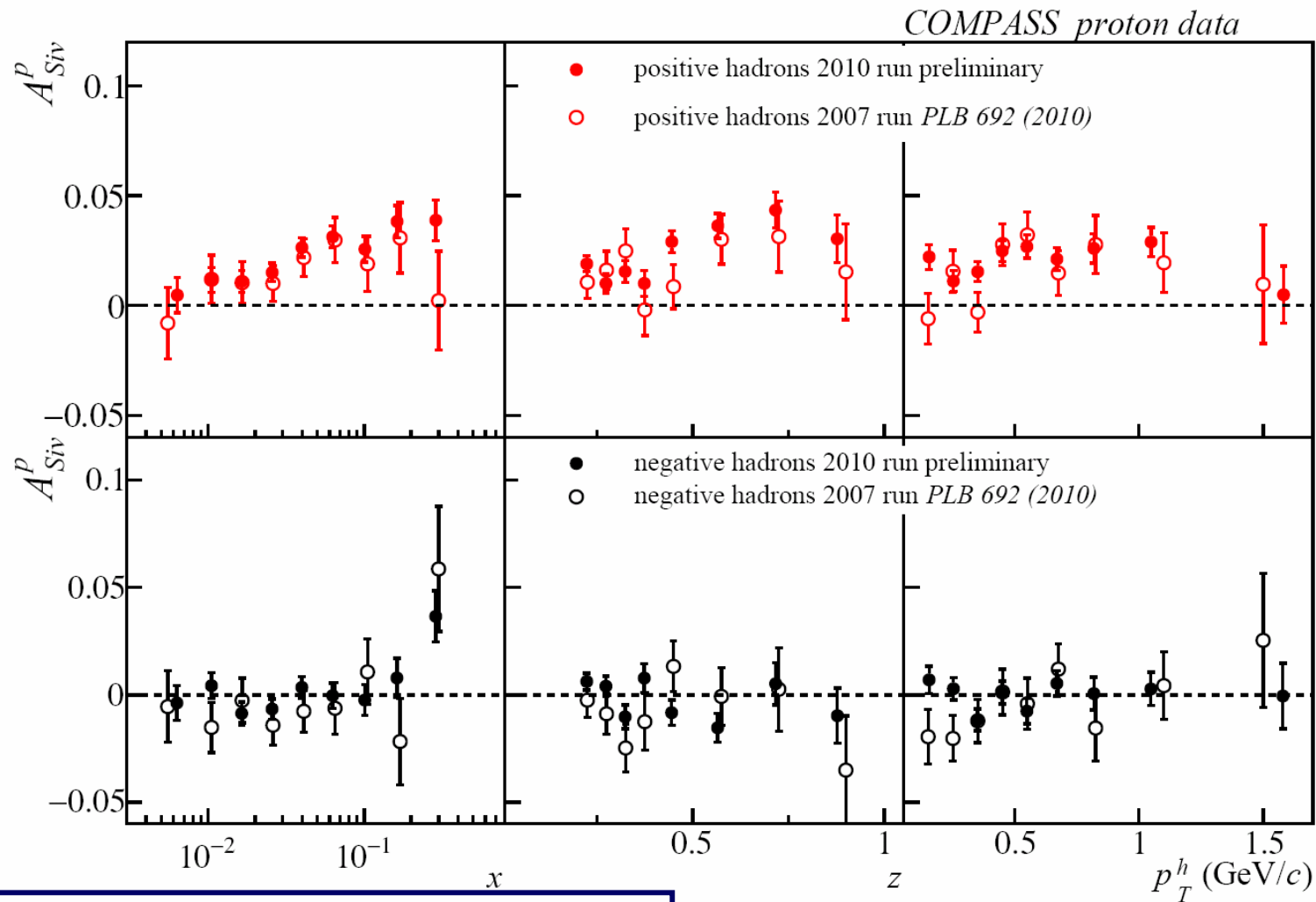
HK 23.4

HK 23.6

$$A_{\text{Coll}} \approx \frac{\sum_q e_q^2 \Delta_T^q \otimes A_T^0 D_q^h}{\sum_q e_q^2 q \otimes D_q^h}$$



Results transv. pol. data: Sivers asymmetry



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$$\frac{F_{UT}^{\sin(\phi_h - \phi_s)}}{F_{UU}}$$



Results unpolarised: Quasi real photoproduction of hadrons (PGF)



- independent cross-check of leading order calculations
 - high pt (unpolarised) cross-section measurement, compared to pQCD prediction
 - shapes already fine, but offset still to be improved
 - as soon as improved, NLO possible, and can trust also unpol. physics
- Asymm. using single hadrons

