MENU 2007
11th International Conference
on Meson-Nucleon Physics and
the Structure of the Nucleon
September10-14, 2007
IKP, Forschungzentrum Jülich, Germany

# First results on pion polarizabilities @ COMPASS

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**Abstract**

The COMPASS experiment at SPS/CERN investigates a variety of reactions related to the structure and spectroscopy of hadrons. First data with hadron beams have been collected at the end of 2004. This initial run has been devoted mostly to the measurement of the pion electric ($\overline{\alpha_\pi}$) and magnetic ($\overline{\beta_\pi}$) polarizabilities via the inverse Compton scattering. The preliminary results of $\overline{\alpha_\pi}$ and $\overline{\beta_\pi}$ from the 2004 pion beam data taking are presented.

## 1 Introduction

The electric ($\overline{\alpha}$) and magnetic ($\overline{\beta}$) polarizabilities characterize the induced dipole moment of hadrons subjected to an external electromagnetic field. They are a measure of the rigidity of the internal structure of a particle. We concentrate here on the $\pi$-meson polarizabilities due to the relative simplicity of the $q\overline{q}$ system and its small mass. For this case the Chiral Perturbation Theory ($\chi PT$) [1] provides rigorous predictions giving the value:

$$(\overline{\alpha_\pi} - \overline{\beta_\pi}) \ = (5.7 \pm 1.0) \cdot 10^{-4} fm^3. \text{ [2]}$$

Other models predict different values for $\overline{\alpha_\pi}$ and $\overline{\beta_\pi}$ (for a review see [3]), but all agree on the fact that $(\overline{\alpha_\pi} + \overline{\beta_\pi})$ is zero or compatible with zero.

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## 2 The measurement @ COMPASS

$\overline{\alpha}$ and $\overline{\beta}$ can be obtained from the deviation of the measured Compton cross section from the known behaviour of a point-like particle. The real data can be collected via the Primakoff reaction, i.e. a scattering of a pion beam in the Coulomb field of an heavy nuclear target $\pi + Z \rightarrow \pi + Z + \gamma$.

In 2004, COMPASS took data with a 190 GeV/c beam of both pions and muons. Lead, carbon and copper targets were used. The largest statistics was collected with the lead target. A detailed description of the COMPASS setup can be found elsewhere [4].

In order to select the Primakoff reaction is necessary to reconstruct completely the final state. For this purpose only events with an outgoing pion and a photon detected in the downstream calorimeter were considered. Additional requests were the primary vertex inside the target and a momentum transfer lower than 0.0075 $(\mathrm{GeV/c})^2$.

The geometrical acceptance for the data collected with the two beams were found to be similar, the Monte-Carlo simulations are reported in fig. 1a. In fig. 1b the measured $Q^2$ dependence for pions and muons data is shown. Here, we clearly see the strong diffractive contribution present as background to the pion data that is absent in the muon case. Additional correction were applied in the pion case for the background contributions coming from the $K^-$ (beam contamination) and $\rho^-$ (pion excitation) decay.

The polarizability value was determined under the assumption of $(\overline{\alpha} + \overline{\beta}) = 0$ fitting the $\omega$ ($\omega = E_\gamma / E_{beam}$) dependence of the ratio R ($R = \sigma_{measured}/\sigma_{point-like}$).

As a cross-check, from the analysis of the muon data, a value of the muon polarizability compatible with zero was found, as expected. This is illustrated in fig. 2a. The preliminary value (see fig. 2b) for the pion magnetic polarizability $\overline{\beta_\pi}$ was found to be:

$$\overline{\beta_\pi} = (-2.5 \pm 1.7_{stat} \pm 0.6_{syst}) \cdot 10^{-4} fm^3.$$

To obtain this result radiative corrections were applied.

The $Z^2$ dependence for the cross-section [7] was checked comparing lead data to those of other target C, Cu, as reported in fig. 2a. The cross sections as a function of $Q^2$ for the three targets are shown in fig. 3b.

The overall statistics considered here correspond to only three days of beam time.

In fig. 4 the current world data on $\overline{\alpha}_\pi = -\overline{\beta}_\pi$ are reported together with the $\chi PT$ prediction. The preliminary value measured at COMPASS agrees with the $\chi PT$ prediction and is lower than the values measured by the A2 collaboration at MAMI [5] and the previous measurement performed

at Serpukhov [6]. The values given here are still preliminary. In particular MC simulations are running to refine the estimation of the systematic errors from the $Q^2$ cuts.

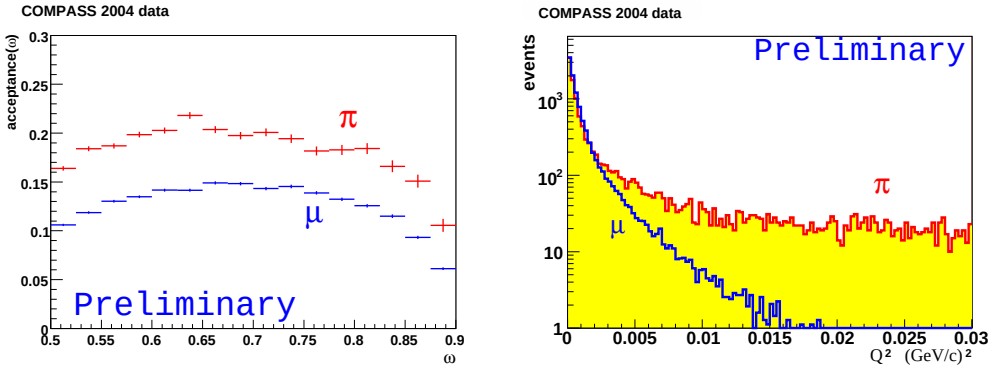


Figure 1: MonteCarlo acceptance for muon and pion as function of $\omega = E_\gamma/E_{beam}$ on the left $Q^2$ dependence for pion and muon real data on the right.

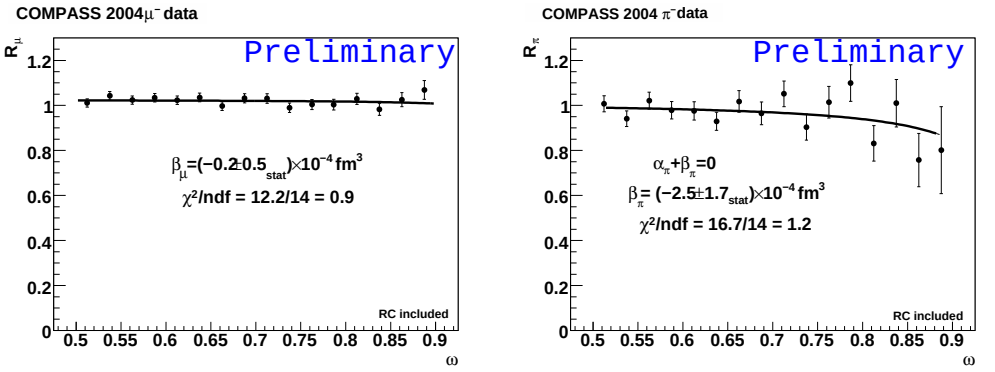


Figure 2: Fitted results for muon (on the left) and pion (on the right). magnetic polarizability.

# Acknowledgments

This work has been supported by the University of Piemonte Orientale and Istituto Nazionale di Fisica Nucleare Sezione di Torino (INFN-To)

# References

[1] J. Gasser, H. Leutwyler, Annals Phys. **158**, 142 (1984)
J. Gasser, H. Leutwyler Nucl.Phys. **B250**, 465 (1985)
S. Weinberg, Physica **A96**, 327 (1979)

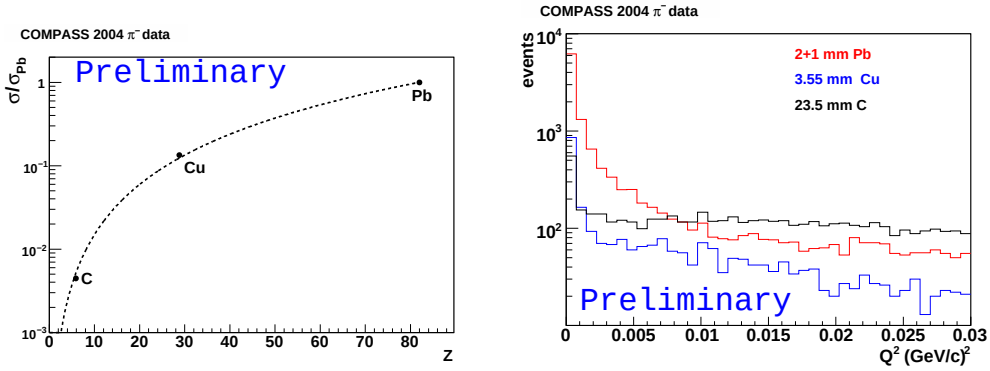


Figure 3: $Z^2$-dependence of the cross-section on the left $Q^2$-dependence for the C, Cu, Pb target on the right.

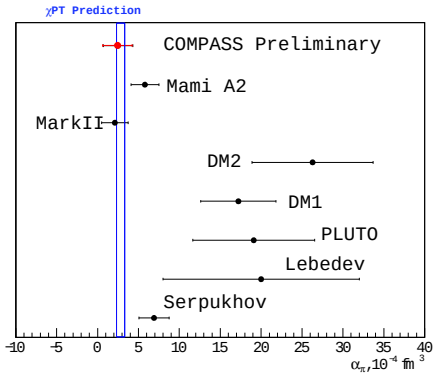


Figure 4: Overview of all pion polarizability measurement together with the $\chi PT$ prediction. The statistical and systematical errors are summed in quadrature

[2] J. Gasser et al., Nucl. Phys. Rev **B745**, 84 (2006).

[3] J. Portoles, M.R. Pennington, *The second DaΦne Physics Handbook* v.2, 579 (1999), hep-ph/9407295
C.A. Wilmot, R.H. Lemmer, Phy. Rev. **C65**, 035206 (2002)

[4] P. Abbon et al., Nucl. Inst. Meth. **A577**, 455 (2007)

[5] J. Ahrens et al., Eur. Phys. J. **A23**, 113 (2005)

[6] Yu.M. Antipov et al., Phys. Lett. **B121**, 445 (1983)

[7] M. Buenerd, Nucl. Inst. Meth. **A361**, 111 (1997)

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