International Journal of Modern Physics A
Vol. 26, Nos. 3 & 4 (2011) 529–532

DOI: 10.1142/S0217751X11051949

PROSPECTS FOR KLOE-2

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FOR THE KLOE-2 COLLABORATION*

The basic motivation of the KLOE-2 experiment is the test of fundamental symmetries and Quantum Mechanics coherence of the neutral kaon system, and the search for phenomena beyond the Standard Model in the hadronic and leptonic decays of ground-state mesons. Perspectives for experimentation by means of the KLOE-2 apparatus equipped with the inner tracker, new scintillation calorimeters, and the $\gamma\gamma$ taggers at the DAΦNE electron-positron collider upgraded in luminosity and energy are presented.

Keywords: Electron-positron annihilation; ϕ-factory; kaon interferometry; discrete symmetries; $\gamma\gamma$ physics; scalar spectroscopy; hadronic cross sections; g-2; α_{em}.

PACS numbers: 11.30.Er, 12.15.Ji, 13.66.Bc, 13.66.Jn, 14.40.Be, 14.40.Df

1. Introduction

The KLOE-2 experimental setup[1,2] is a successor of KLOE,[3–6] which is at present being upgraded by new components in order to improve its tracking and clustering capabilities as well as in order to tag $\gamma\gamma$ fusion processes. The basic motivation of the KLOE-2 experiment is the test of fundamental symmetries and Quantum Mechanics coherence of the neutral kaon system, and the search for phenomena beyond the Standard Model.[1,7–9] Thanks to the luminosity upgrade of DAΦNE,[10–12] as well as the installation of new detectors, KLOE-2 will be able to improve the accuracy of the measurement of the K_S mesons and to study the time evolution of the entangled pairs of neutral kaons with an unprecedented precision. It is worth mentioning that at present KLOE-2 is a unique facility for testing novel ideas on the kaonic quantum

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eraser.[13,14] KLOE-2 aims at the significant improvement of the sensitivity of the tests of the discrete symmetries in the decays of K, η and η' mesons beyond the presently achieved limits. In some cases like e.g. the tests of P, C, or CP symmetries an improvement by more than one order of magnitude is expected with an integrated luminosity of 20 fb^{-1} to be achieved within 3-4 years of data taking. Among other issues the KLOE-2 physics program will include investigations of (i) universality of the weak interaction of leptons and quarks, (ii) lepton universality, (iii) the structure of the scalar mesons, (iv) the meson production via $\gamma\gamma$ interaction, (v) the muon anomalous magnetic moment, (vi) the evolution of the fine structure constant, (vii) the narrow di-lepton resonances in context of the hidden dark matter sector.

Hereafter the upgrade of the detector system will be briefly presented and for the comprehensive discussion of all of the above mentioned physics issues the interested reader is referred to the recent publication describing in details the physics program of KLOE-2 at the upgraded DAΦNE collider.[1]

2. Upgrade of Instrumentation

The Accelerator Division of the INFN Frascati Laboratory has successfuly commissioned the new electron-positron interaction region, based on large Piwinski angle, small beam sizes at the crossing point, and *Crabbed Waist* compensation of the beam-beam interaction.[10–12] This new solution allowed to increase the collider luminosity by a factor of three with respect to the performance reached before the upgrade, and DAΦNE will deliver up to 15 pb^{-1} per day giving possibility to achieve about 20 fb^{-1} within the next 3-4 years of data taking by means of the KLOE-2 detector. The detector, shown schematically in the left panel of Fig. 1 consits of a $\sim$ 3.5 m long cylindrical drift chamber with a diameter of about 4 m surrounded by the sampling electromagnetic calorimeter.[4–6] Both these detectors are immersed in the axial magnetic field provided by the superconducting solenoid. Their functioning and properties have been widely described in previous publications e.g. Refs. 3-6. Therefore, hereafter we will only briefly discuss the main new components of the KLOE-2 setup.

Exclusive measurements of the $\gamma\gamma$ reactions will be enabled by the low and high energy taggers[21] allowing for registration of electrons and positrons originating from $e^+e^- \to e^+e^-\gamma^*\gamma^* \to e^+e^-X$ reaction. Right panel of Fig. 1 shows the scheme of the DAΦNE rings with position of taggers indicated by arrows.

First commissioning runs with KLOE-2 will start next month and, after collection of statistics corresponding to the integrated luminosity of about 5 fb^{-1}, the next phase of installation of new detectors shall commence by the end of the year 2011. This stage will include (i) installation of inner tracker[15–17] in order to improve the kaons decay vertex reconstruction and to increase the geometrical acceptance for registration of low momentum charged particles and (ii) installation of the scintillation calorimeters[18–20] in order to increase acceptance for registration of very forward electrons and photons outgoing from the interaction region as well as

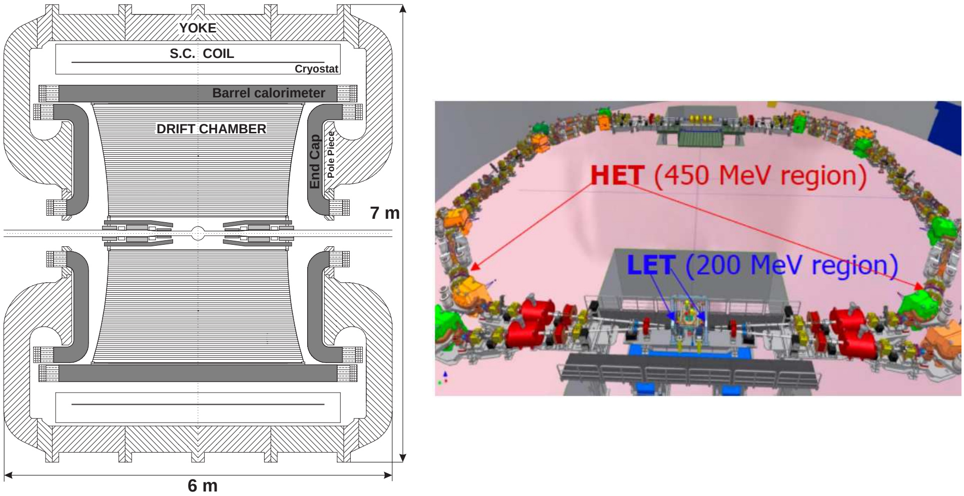

Fig. 1. (Left) Cross section of the KLOE detecor. (Right) Scheme of the DAΦNE collider with positions of Low Energy Taggers (LET) and High Energy Taggers (HET) indicated by arrows. The average energy of electrons and positrons covered is also shown.

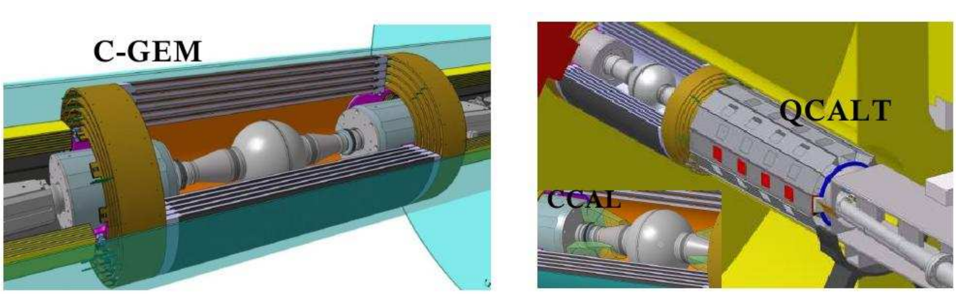

Fig. 2. Illustration of new detectors which will be installed for the second stage of the KLOE-2 experiment. (Left) Inner tracker consisting of four cylindrical layers build out of four gas electron multipliers foils (C-GEM). (Right) Quadrupole Tile Calorimeters (QCALT) and Crystal Calorimeters (CCAL).

photons originating from the K_L decays inside the drift chamber. The new detecors will be placed between beam pipe and the drift chamber as it is indicated in Fig 2. The CCAL calorimeters will be mounted between the spherical beam-pipe and the quadrupole closest to the interaction region whereas the QCALT detectors will sorround the inner quadrupoles. These extra calorimeters will improve the capabilities of the KLOE-2 apparatus e.g. for the search of the rare neutral decays of kaons.

In addition to the above mentioned detector upgrades, as described in the recent proposal,[22] we intend also to extend the research towards higher electron-positron energies possibly up to 2.5 GeV. An appropriate upgrade of the DAΦNE collider in energy would allow a precise scan of the multihadronic cross sections in the energy region where these cross sections are poorly known, and hence it would improve significantly the accuracy of tests of the Standard Model through a precise determination of the anomalous magnetic moment of the muon and the effective fine-structure constant at the M_Z scale. It would enable also tests of QCD and effective theories by investigations of the production of all ground state mesons and search for exotics states in the $\gamma\gamma$ interaction.

Acknowledgements

The author is grateful to the KLOE-2 Colleagues for the kind help in the preparation of the talk for the MESON2010 workshop, and appreciates corrections of the manuscript by Caterina Bloise, Fabio Bossi and Antonio Di Domenico. The author acknowledges also support by INFN and Polish Ministry of Science and Higher Education through the Grant No. 0469/B/H03/2009/37.

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