Status and Physics Opportunities at the Frascati Φ-Factory

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The current status of the KLOE experiment at the Frascati Φ-factory, DAΦNE, is reviewed. In June 2001 DAΦNE succeeded in delivering 1.3 pb^{-1} per day : with this performance KLOE will integrate $\sim$ 200 pb^{-1} by the end of the year, corresponding to 6×10^8 Φ decays. New results on the Φ radiative decays, on the K_S^0 semileptonic decays, with the largest sample selected so far of 600 events, and the perspectives for the measurement of the hadronic cross section below 1 GeV are discussed.

1. Introduction

DAΦNE [1], realized to achieve a yield of 1,500 Φ mesons per second, at present is delivering 2 pb^{-1} per day, working at 6% of the design luminosity. At the end of year 2001 the KLOE experiment (KLOng Experiment) will integrate $\sim$ 200 pb^{-1}, a statistics suited to provide new results, among the others, on the Φ radiative decays ($f_0\gamma$, $a_0\gamma$, $\eta\gamma$, $\eta'\gamma$), on the ρ-meson parameters, on the K_S^0 semileptonic decays, on the $K_L \to \gamma\gamma$ branching ratio, and on the upper limit of the CP violating decay $K_S \to \pi^0\pi^0\pi^0$.

2. The KLOE Detector

The KLOE detector[2] consists of a large tracking chamber, an electromagnetic calorimeter and a superconducting magnet providing a solenoidal field of $\sim$ 6 KGauss. The large tracking volume, 2 m radius and 3.3 m long, is instrumented by a drift chamber (DC)[2] operating with a low-Z gas mixture, enclosed by Carbon-fiber/Epoxy walls. The light materials optimize the chamber resolution and reduce both the photon conversion and the $K_L^0 \to K_S^0$ regeneration. The DC resolution is $\sigma_{r\phi} \le 200\ \mu$m, while the $K_S^0 \to \pi^+\pi^-$ vertex resolution is $\sigma_{x,y} \le 500\ \mu$m, $\sigma_z \le$ 1-2 mm.
The electromagnetic calorimeter (EmC)[2] is a sampling calorimeter made from lead and scintillating fiber layers, 15 X_0 thick. Its hermeticity is ensured by barrel modules surrounding the drift chamber and by modules of the two endcaps, which are bent outwards to reduce dead zones in the overlap region between barrel and endcap. The calorimeters provide time and energy for photons of energy as low as 20 MeV, with resolutions of 54 ps/$\sqrt{E} \oplus$ 147 ps (E in GeV) in time and 5.7%/$\sqrt{E}$ in energy[3].
The trigger system[2] has been designed to be fully efficient with respect to CP-violating channels and to retain all the Φ decays. It collects the interesting channels for physics as well as those for the self-calibration and the monitoring of the detector. The architecture of the KLOE Data Acquisition[2] has been conceived to work with a sustained throughput of 50 Mbytes per second.

3. Φ radiative decays.

3.1. Scalar mesons.

Φ radiative decays provide the opportunity to study different aspects of chiral dynamics[4]. The $\Phi \to \pi^0\pi^0\gamma$ and $\Phi \to \eta\pi^0\gamma$, forbidden at tree level, can proceed via kaonic loops involving creation of $f_0(980)$ and $a_0(980)$ resonances. The accurate measurement of their branching ratios, together with the analyses of the shape of the $\pi\pi$ and $\eta\pi$ mass spectra provide the way to

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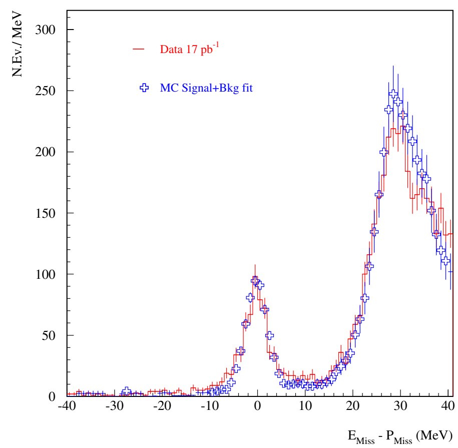

Figure 1: E_{miss}-P_{miss} distribution for the $K_S \to \pi e \nu$ events : peak centered at 0 refers to the signal, and the rest to the separated $K^0_S \to \pi^+\pi^-$ decays. The points represent fit results, assuming the distribution shape predicted by Monte Carlo.

disentangle different models for these particles. Data analyses [5] so far, with a sample of 17 pb^{-1} of integrated luminosity give Br($\Phi \to f_0\gamma \to \pi^0\pi^0\gamma$) = (0.79 ± 0.02) 10^{-4} based on an integrated excess in the proper mass region of 1960 ± 56 events, and Br($\Phi \to a_0\gamma \to \eta\pi^0\gamma$) = (0.58 ± 0.05) 10^{-4}. Systematic errors, not exceeding 10% and dominated by background subtraction, are currently under study. The $\Phi \to f_0\gamma \to \pi^+\pi^-\gamma$ is also being analyzed but the signal extraction is made more difficult by the concurrent $\pi^+\pi^-$ production accompanied by final state radiation, including the interference term whose phase is unknown. A detailed generator [6] for the $\pi\pi\gamma$ processes is being used to simulate, under various hypotheses, mass spectra for data comparison.

3.2. Pseudoscalar mesons.

New measurements of $\Phi \to \eta\gamma$, $\Phi \to \eta'\gamma$ decays include the ratio of the branching ratios, providing the η-η' mixing angle [7], and the Br($\Phi \to \eta'\gamma$), a probe of the gluonium content of the η' meson. With year 2000 data sample (17 pb^{-1}), the KLOE new measurement [8] of Br($\Phi \to \eta'\gamma$) = (6.9 ± 0.6 ± 0.5) 10^{-5} disfavours models with large gluonium content of the η' meson. η-η' mixing angle turns out to be θ_p = (-14.7 ± 1.6)°.

4. The $K_S \to \pi e \nu$ decays.

Semileptonic decays of the K^0_S have been measured by CMD-2 experiment with a statistics of 75 events[9]. In year 2000 KLOE [10] selected 627 events, corresponding to Br($K_S \to \pi e \nu$) = (6.80 ± 0.30)10^{-4}, to compare with the expectation obtained assuming Γ_S (π e ν) = Γ_L (π e ν) : Br($K_S \to \pi e \nu$) = (6.70 ± 0.07)10^{-4}.

Background rejection of $K^0_S \to \pi^+\pi^-$ channel proceeds, in the clean Φ factory environment, cutting on $m_{\pi\pi}$ and total momentum of the particle pairs pointing back to the interaction region. The K^0_S tagging, requiring a Kaon visible interaction in the calorimeter, and the high-resolution time-of-flight measurement of the particles impinging the calorimeter, requiring one electron and one pion on the calorimeter surface, reduce the $K^0_S \to \pi^+\pi^-$ background down to 3% level. Selected sample is shown in fig. 1, where the peak centered at 0 in the E_{miss}-P_{miss} variable is due to the $K_S \to \pi e \nu$ events, and the rest refers to the $K^0_S \to \pi^+\pi^-$ decays. Systematics, of order of percent, are being evaluating.

5. Hadronic cross section below 1 GeV.

The interest for improving the measurement of hadronic cross section below 1 GeV increased recently with new results from the BNL g-2 experiment[11]. At KLOE we are investigating[12] the radiative return method to obtain the $\sigma(\mathrm{e}^+\mathrm{e}^- \to \pi^+\pi^-)$ via the measurement of the differential cross section $\mathrm{d}(\sigma)/\mathrm{d}\,\mathrm{M}^2_{hadr}$, using the knowledge of the radiator function H. The muon anomalous moment is related to the $\sigma(\mathrm{e}^+\mathrm{e}^- \to \pi^+\pi^-)$ via the dispersion integral and the ρ resonance region ($\sqrt{s} \sim 0.75$ GeV), that can be measured at KLOE, represents 65% of the whole integral[13]. Moreover KLOE can study the hadronic cross section just above the threshold , eventually confirming the results obtained using in this region τ decays and assuming isospin invariance. Preliminary analyses of the $\pi\pi\gamma$ events demonstrate the actual applicability of the method to the KLOE environment, and we expect to provide soon the $\sigma(\mathrm{e}^+\mathrm{e}^- \to \pi^+\pi^-)$ at percent level of accuracy.

6. Perspectives.

DAΦNE plans in the year 2002 include major hardware modifications [14] (installation of octupoles, of a third-harmonic RF, wiggler upgrade, and the upgrade of both the KLOE and the Finuda Interaction Regions) which, starting from the present 2 pb^{-1} per day would eventually provide the improvement to achieve the luminosity needed for the CP and CPT studies[15].

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