PROCEEDINGS OF SCIENCE

The KLOE-2 experiment at DAΦNE

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The KLOE-2 Collaboration succesfully ended its data-taking period, collecting 5.5 fb^{-1} of data at the peak of the ϕ resonance at the DAΦNE collider of the Frascati LNF. New detectors have been added to the preexisting KLOE apparatus to improve its performance. By adding this sample to the data of the previous KLOE data-taking, a total of about 8 fb^{-1} has been collected. The measurement program of KLOE-2 includes precision studies on kaon and light meson physics, hadronic cross-section, and dark force searches.

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1. Introduction

On March 30, 2018, the KLOE-2 Collaboration ended its data-taking phase at the DAΦNE ϕ-factory of the Laboratori Nazionali di Frascati of INFN. A total integrated luminosity of 5.5 fb^{-1} has been collected since November 2014 at the peak of the $\phi(1020)$ resonance. KLOE-2 is the continuation, with an upgraded detector, of the KLOE experiment, which collected about 2.5 fb^{-1} of data from 1999 to 2006. For this new data-taking phase the DAΦNE collider has been also upgraded with the implementation of a new interaction region based on the concept of the crab-waist collision scheme, wich allowed to increase the machine luminosity and to reach a peak value of 2.4×10^{32} cm^{-2} s^{-1}(Fig.1), and a daily integrated luminosity of 14 pb^{-1}. For

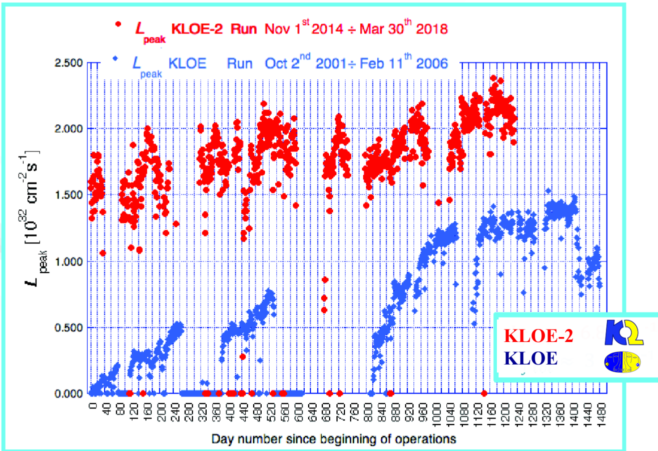

Figure 1: Comparison of the DAΦNE peak luminosity for KLOE and KLOE-2 data-taking.

the KLOE-2 data-taking, new subdetectors have been added to the preexisting KLOE detector to improve its performances and to increase the physics reach: an Inner Tracker around the DAΦNE Interaction Point (IP) to improve tracking and vertexing, new small angle calorimeters to increase the acceptance for low polar angle particles, and taggers for the detection of $e^{\pm}$ scattered in $\gamma\gamma$ processes. With this data, together with the old KLOE data set, a total of 8 fb^{-1} luminosity has been collected, allowing KLOE-2 to continue the high precision investigation of light hadron physics[1].

2. The KLOE detector

The KLOE detector consists of a large volume Drift Chamber surrounded by a Calorimeter, both immersed in an axial magnetic field of 0.52 T. The Drift Chamber (DC), filled with a gas mixture of He - isobutane, provided a momentum resolution $\sigma_{p_t}/p_t = 0.4\%$ and a space resolution of 150 μm in the plane transverse to the beam line, and 2 cm along the beam direction.
The Calorimeter (EMC), made of Pb-scintillating fibers, was covering 98% of the whole solid angle, with resolutions $\sigma_E/E = 5.7\%/\sqrt{E(GeV)}$ (energy) and $\sigma_t = 55\text{ps}/\sqrt{E(GeV)} \oplus 100\text{ps}$. The performances of the DC and of the EMC were very stable in time, for almost 20 years since the

collection of the first events, taking into account also the different machine background condition of the KLOE-2 run with respect to the KLOE one.

3. The Inner Tracker

For the KLOE-2 data-taking an Inner Tracker (IT)[2], has been installed between the beam pipe and the inner wall of the DC, 25 cm far from the IP. It is based on the cylindrical GEM technology, and it is the first detector of this kind operated in a high energy experiment. It is composed of four layers of triple-GEM detectors. Each layer is made of five electrodes: the cathode, three GEM foils for electron multiplication, and the anode, acting also as redout circuit. Anode with XV readout has been developed for this detector: longitudinal X strips, and pads conected through internal vias to form V strips, at a stereo angle of $25^o \div 27^o$ for a total of 30000 FEE channels. The total material budget is about 2% of radiation length.
Starting from tracks reconstructed in the DC, the information from the IT is added with the Kalman filter technique, and the track parameters are then updated. In Fig.2 the improvement in the vertical (Y) coordinate of the vertex position, which is not sentitive to beam size effects, is shown for different processes. For $\phi \to \pi^+\pi^-\pi^0$ events the vertex resolutions is $\sigma_{IT+DC} = 4.4$ mm with

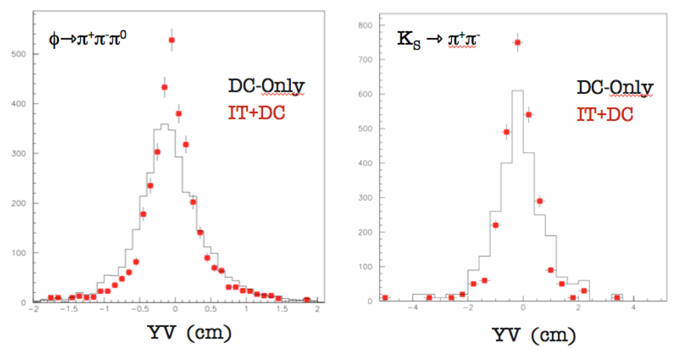

Figure 2: Y coordinate of the vertex: comparison between DC and the integrated IT + DC tracking.

IT+DC compared to $\sigma_{DC} = 5.5$ mm when tracks are reconstructed with the DC only. For vertices from $K_s \to \pi^+\pi^-$ the resolution improves from $\sigma_{DC} = 10.6$ mm to $\sigma_{IT+DC} = 7.4$ mm. Further improvements are expected by using more refined alignment and calibration of the IT.

4. Taggers for $\gamma\gamma$ physics

In $\gamma\gamma$ processes, $e^+e^- \to \gamma^\star\gamma^\star \to e^+e^-X$ hadronic states with even charge conjugation are produced. At the DAΦNE energies the single π^0 production is interesting to measure the two photon width $\Gamma(\pi^0 \to \gamma\gamma)$ which has been measured with an uncertainty of 2.8% by the PrimEx

Collaboration, and is known with 1.4% from theory. The Transition Form Factor $F_{\pi\gamma\gamma^\star}(q^2,0)$ can also be measured at very low space-like q^2, to constrain the Hadronic Light-by-Light contribution to the more than 3 σ's discrepancy between the experimental and the theoretical value of $g_\mu - 2$. Since DAΦNE is operated at the peak of the ϕ resonance, a tagging system for scattered electrons is needed to reject the huge background from ϕ decays. Two detectors have been installed for the KLOE-2 data-taking: the Low Energy Tagger[3], made of two LYSO crystal calorimeters readout by SiPM, placed 1 m far from the IP, and the High Energy Tagger (HET)[4], which is crucial for the detection of single π^0's. The bending dipoles of DAΦNE act as spectrometers for scattered electrons and positrons resulting in a strong correlation between the particle energy and trajectory. Then the HET consists of two scintillator hodoscopes readout by PMTs placed 11 m far from the IP, inserted in roman pots to be close to the beam line. The HET counting rate is dominated by Bhabha scattering. The analysis of the events in which either a single HET station is fired (Single Arm) or both HET stations are in coincidence (Double Arm) is in progress, with a multivariate analysis technique, using the Ekhara 2.1 Monte Carlo to simulate $e^+e^- \to e^+e^-\pi^0$ events.

5. Single Photon Trigger

In last years the existence of particles belonging to a dark sector have been proprosed. The simplest scenario consists in an additional gauge symmetry associated to a light vector boson, the dark photon, that couples through kinetic mixing to particles of the Standard Model. At an e^+e^- collider the dark photon (U) can be produced in processs like $e^+e^- \to U\gamma$. The signature of the decay of the U-boson into dark sector particles would be a single monochromatic photon. At a ϕ-factory the cross-section scales as $1/s$, about 100 times greater than at the B-factories, compensating for the lower integrated luminosity. In the second part of the KLOE-2 data-taking a new Single Photon Trigger (SPT) has been implemented, by requiring a cluster of at least $E > 350$ MeV in the barrel part of the EMC. This trigger can also be exploited for the search of the Axion Like Particles (ALPs). If a long living ALP (a) is produced ($e^+e^- \to \gamma^\star \to a\gamma$), the signature will also be a single monochromatic photon. A total luminosity of 2.7 fb^{-1} has been collected with the SPT, allowing to explore the region of masses below 600 MeV.

References

[1] G. Amelino-Camelia et al., *Physics with the KLOE-2 experiment at the upgraded DAϕNE*, Eur. Phys. J. **C68** (2010) 619–681, [1003.3868].

[2] A. Balla, G. Bencivenni, P. Branchini, P. Ciambrone, E. Czerwinski, E. De Lucia et al., *The KLOE-2 Inner Tracker: Detector commissioning and operation*, Nucl. Instrum. Meth. **A845** (2017) 266–268.

[3] D. Babusci et al., *The Low Energy Tagger for the KLOE-2 experiment*, Nucl. Instrum. Meth. **A617** (2010) 81–84, [0906.0875].

[4] F. Archilli, D. Babusci, D. Badoni, M. Beretta, F. Gonnella, L. Iafolla et al., *Gamma-gamma tagging system for KLOE2 experiment*, Nucl. Instrum. Meth. **A617** (2010) 266–268.