Future Experiments at Dafne, the Frascati Phi Factory

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Abstract

An important machine experiment is being performed at $DA\Phi N E$, the $\phi$ -factory collider of the Frascati Laboratory of INFN. The goal is to achieve a luminosity exceeding $5 \times 10^{32} \text{cm}^{-2}\text{s}^{-1}$, that would allow starting a new data taking campaign with upgraded detectors.

Key words:

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1. Introduction

The Laboratori Nazionali di Frascati of INFN, is a multi-purpose laboratory whose interests span over a wide range of activities, from synchrotron light physics to gravitational waves searches. The central facility of the laboratory is $DA\Phi N E$, a $\phi$-factory $e^+e^-$ collider, which has started operations in year 1999. After 8 years of operation, the first phase of $DA\Phi N E$ has come to the end. Between years 2000 and 2007 the machine has delivered about 4 fb-1 of collision data around the $\phi(1020)$ peak to three different experiments: KLOE [1], a multipurpose experiment, devoted mainly to the study of CP and CPT violation in the kaon system, to the precise determination of the CKM matrix element $V_{us}$ and to several studies in hadronic physics and low energy QCD; FINUDA [2], devoted to detailed studies of hypernuclear spectroscopy; DEAR [3], for the observation and study of kaonic atoms. The performance of $DA\Phi N E$ has been steadily increasing as a function of time. It has reached a peak luminosity of $1.5 \times 10^{32}\text{cm}^{-2}\text{s}^{-1}$ and already in the course of 2005 it was delivering steadily about $200\text{pb}^{-1}/\text{month}$. Using this data $\simeq 50$ papers have been published by the three collaborations on international physics journals so far.
2. **DAΦNE: the present and the future**

In 2006 P. Raimondi and collaborators have proposed the idea of implementing a new interaction scheme in the present collider, which should provide an increase of the luminosity of a factor between 3 and 10, at the price of minimal changes in the hardware setup [5]. It combines the use of a larger crossing angle with a proper rotation of the optical functions of the beams at the interaction point, the so-called "crabbed waist" scheme. Detailed independent simulations, performed at Frascati, KEK and Novosibirsk, have demonstrated the potential advantages of this option, confirming the foreseen increase in luminosity. A non trivial bonus of the scheme is also a better control of the beam-beam effects, making the machine more stable. For the above reasons the Laboratory has decided to start the implementation of the crabbed waist scheme already in the course of the data taking of the latest approved experiment, SIDDHARTA [6], an improved version of DEAR. All the needed hardware intervention was performed between July and November 2007. Essentially, only the two interaction regions have been changed. In the main interaction region (IP1) the focusing quadrupoles have been moved inward and the crab sextupoles have been inserted. On the other side (IP2) instead, the two beams are kept physically separate, to minimize beam-beam effects. The first beams have circulated in **DAΦNE** in December 2007. The beneficial effect of the use of the crab sextupoles has been clearly demonstrated in the DEAR data taking: peak luminosities up to $\simeq 4 \times 10^{32} \text{cm}^{-2}\text{s}^{-1}$ have been measured, with beam currents similar to those used in the previous **DAΦNE** runs, and even more important, integrated daily luminosity of the order of $12 - 13 \text{pb}^{-1}$ are steadily achieved. No saturation effect in the dependence of the luminosity with currents has been observed so far, which means that one can hope to reach a record $\simeq 8 \times 10^{32} \text{cm}^{-2}\text{s}^{-1}$ when injecting the currents design value. Of course this improvement is likely to be obtained after some time, by slowly but continuously improving the control of several small systematic effects. At present, the **DAΦNE** team is working hard to improve the beams lifetimes, which are still lower than the desired value.

Since the luminosity request of SIDDHARTA is relatively modest, this means that, at the today rate of delivered luminosity, in at the end of 2009 there will be room for new experiments.

3. **New experiments on a new machine**

This new exciting perspective has triggered several experimental groups to apply for the use of the new **DAΦNE**. Three proposals have been put forward. FINUDA has proposed to roll back in with the same detector, but maybe with newer targets to continue their program of hypernuclear spectroscopy. The only required detector upgrade implies a revision of the trigger and DAQ systems, to cope with the higher data rates. A second proposal was the use of the KLOE detector for the search of the so-called "deeply bound kaonic states", whose existence is under debate in the nuclear physics community. This scheme foresees the insertion a cryogenic target in the KLOE inner part. On paper this seems feasible and the newly born AMADEUS Collaboration is studying the possible technical implementation of such idea [7]. An important issue about these searches is the capability of the KLOE calorimeter in detecting neutrons; this efficiency has been
measured in the framework of the so-called KLONE project. [8]. The Frascati Laboratory Scientific Committee has however given the priority in the collider time schedule to a third project: many KLOE members together with several new collaborators have proposed the continuation of the KLOE physics program, with an upgraded detector: KLOE-2 [9]

4. the KLOE-2 experiment

The new KLOE-2 collaboration foresees the insertion of new subdetectors
- An inner ‘vertex’ chamber is being developed in Frascati, based on a brand new technology, the cylindrical GEM, in the inner part of KLOE, between the beryllium beam pipe and the inner wall of the drift chamber. Five layer of providing each spatial hits are foreseen. This new device will increase the vertex resolution on the decays nearby the IP and will increase the reconstruction efficiency on the low momentum track emitted by IP.
- A crystal calorimeter will be inserted in front of the machine focusing quadrupoles, to help catching the photons emitted at very low polar angle, helping the kinematical closure of the events and the rejection of machine background.
- A silicon-scintillator tagger for the electrons scattered in $\gamma\gamma$ interactions will be embedded in the machine optic at $\approx 5m$ from the IP. This device, together with a dedicated section of the quad calorimeter will give information on the $\gamma\gamma$ physics.

The new KLOE-2 setup is an ambitious project, which requires a few years of preparation. After this period few years of data taken at the improved machine will be needed to gather a luminosity of the order of $20 fb^{-1}$ by year 2014. This huge data set and the improved detector capability will open nice physics perspective to this enterprise in the field of quantum interferometry, $K_S$ decay, $\eta, \eta'$ and $\gamma\gamma$ physics.

References

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