Possibility of rare decay K_{e2} measurement by the FINUDA detector.

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The FINUDA (FIsica NUcleare at DAΦne) experiment will be operational at DAΦNE, the new Φ Factory of the INFN Laboratory of Frascati, at the end of 2000. The main physics goals of the experiment are: fine spectroscopy of $\Lambda-$ hypernuclei, study of non mesonic decay of hypernuclei and search for neutron rich hypernuclei. With the designed luminosity of $5 \cdot 10^{32}$ FINUDA will collect a very abundant statistics of hypernuclear events and a high statistics of K^+ decays into $K_{\mu 2}$ and K_{e2} following the relative branching ratios. So, in principle, with the FINUDA Detector it's possible to measure the branching ratio $\Gamma(K^+ \rightarrow e^+\nu_e)/\Gamma(K^+ \rightarrow \mu^+\nu_\mu)$ with a statistics by at least a factor 3 more than the previous experiment carried out about 20 years ago.

1. INTRODUCTION

The FINUDA Experiment [1] will run at the end of 2000 at DAΦNE [2], the new e^+e^- Collider located at the INFN Laboratory of Frascati, near Rome. The main physics aim is the Hypernuclear Physics. The first step is a systematic study of $\Lambda-$ hypernuclei production and decay. By means of the low energy K^- ($\approx$ 16 MeV) from Φ decay at rest, and through the reaction,

$$K^-_{stop} + {}^AX_z \rightarrow {}^A_\Lambda X_z + \pi^-$$

which is one of the more efficient hypernuclei production reactions, it's possible to produce the ${}^A_\Lambda X_z$ hypernucleus. We designed the FINUDA apparatus in order to stop the K^-'s in a thin nuclear target placed around the beam pipe. In fact FINUDA is the first example of a Nuclear Physics Experiment, which is inherently fixed target physics, carried out at a Collider. The hypernuclei identification will be obtained by means of high resolution magnetic spectrometry of $\pi^{-\prime}$s produced following the K^- interaction at rest in the nuclear target. The decay products will be measured with the same high angular acceptance apparatus. The properties of the K^- beam, nearly monochromatic ($p \approx 128$ MeV/c), no contamination of other charged particles, very low energy and consequently very low range ($\simeq 1$ g/cm^2) and straggling on range ($\simeq 50$ mg/cm^2, about 100 μm FWHM in Carbon) and the possibility of tagging by means of K^+, represent an ideal tool and a unique opportunity for high resolution hypernuclear physics, with stopped K^-. We designed the FINUDA Detector in order to reach the highest momentum resolution ($\Delta p/p \leq 0.3\%$, FWHM) and, with a magnetic field of 1.1 T and a pion momentum ranging in the 220 $\div$ 270 MeV/c interval, the corresponding energy resolution is $\Delta T = 700$ KeV. In the table

1 the performances of FINUDA are showed in comparison with analogous experiments in Hypernuclear Physics.

Table 1
FINUDA features compared to analogous ones for other facilities

Detector	Events/h	Energy resolution
FINUDA	$\simeq 400$ (MC simulation)	700 KeV
KEK SKS	10	1.5 MeV
TJNAF	5	350 KeV

2. THE APPARATUS

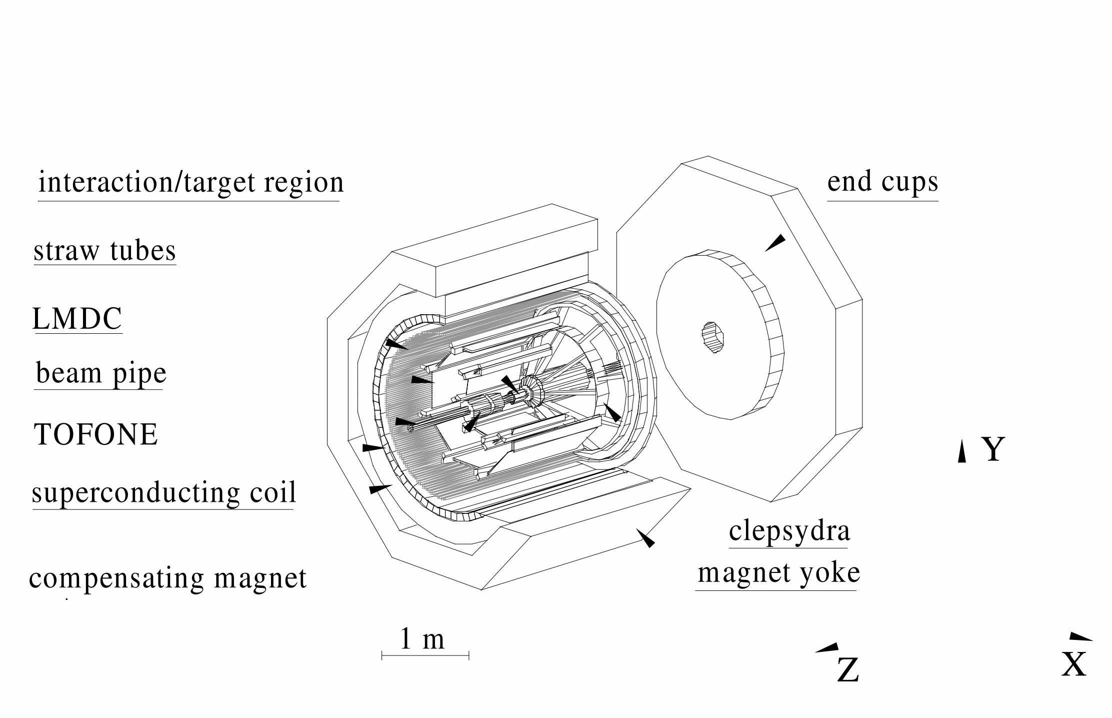

Figure 1. A pictorial view of the FINUDA apparatus.

The FINUDA Apparatus (fig. 1) has the following features: cylindrical geometry, large solid angle, large momentum acceptance (from 200 to 300 MeV/c), capability of detecting neutrons from non mesonic decay of hypernuclei. The apparatus has been optimized in order to reach the highest momentum resolution for $\pi's$ of momentum about 270 MeV/c. Taking into account the function of each subdetector and its operation we can divide basically the apparatus in three parts that, starting from the beam line, are: 1) an interaction/target region; 2) a compound tracking system; 3) an outer scintillator array.

The inner part of the apparatus is formed essentially by three layers of subdetectors. Starting from the beam line, around the beryllium beam pipe (400 μm thick), there are: a cylindrical array of thin scintillators (the TOFINO); an inner octagonal array and an outer decagonal array of Si microstrips detectors (called ISIM and the OSIM respectively). Between ISIM and OSIM there is a cylindrical array of eight planar thin nuclear targets.

The external tracking device is built up by two cylindrical arrays each of eight drift chambers and a cylindrical array of straw tubes, arranged in three superlayers of about 800 tubes each. The last two ones are tilted by an angle of + 15° and − 15° respectively (more details are in [1]) for z-coordinate determination.

The subdetectors, above mentioned, are supported by a mechanical structure that, due to its shape, is named Clepsydra.

The outer scintillator array has a cylindrical geometry and the slabs are about 2.5 m long and with a section of trapezoidal shape, with a side of about 10 cm.

2.1. Activity in the 1998-1999

In the 1998 we made the following operations on the apparatus: 1) cosmic ray tests with all the tracking subdetectors mounted on the clepsydra in the Astra building (laboratory area for tests end subdetectors assembly); 2) helium bag finishing in the Astra building; 3) off-line reconstruction program finalization; 3) on-line analysis program completion; 4) superconductor magnet installation in the DAΦNE building; 5) infrastructure installation in the experimental area.

2.2. Foreseen activity in the 2000

Next year we will be engaged in the final activities before data taking: 1) cool down and energization of the superconducting magnet; 2) installation of the apparatus in the experimental area; 3) final mechanical alignments and subdetector calibrations; 4) global apparatus calibrations and operations; 5) first tests with the beam (triggers, backgrounds, ...); 6) data taking.

3. THE FINUDA PHYSICS

The main Physics goals of the FINUDA experiment are:

- high resolution $\Lambda-$ hypernuclei spectroscopy,
- $\Lambda-$ hypernuclei lifetime,
- study of hypernuclei decays and possible evidence for a violation of the $\Delta I = 1/2$ rule,
- production of $\Lambda-$ hypernuclei, with a neutron excess.

With the final luminosity of DAΦNE of $5 \cdot 10^{32}$ FINUDA will collect a very abundant statistics of new hypernuclear events, very interesting for traditional Nuclear Physics (single particle states) and for Fundamental Physics (weak interaction with 4 baryons). But with the K^+, used as a tagging particle, it could be possible to make some additional measurements. The K^+'s, from the Φ decay, stop in the nuclear target and decay following the relative branching ratios. The most abundant $K_{\mu 2}$ decay will be recorded to calibrate the apparatus and to optimize the reconstruction software. But more than 30 events per day, from the K_{e2} decay, will be recorded too. So, in principle, with the FINUDA detector it's possible to measure the branching ratio $\Gamma(K^+ \to e^+\nu_e)/\Gamma(K^+ \to \mu^+\nu_\mu)$, measured more than 20 years ago [3] [4] [5], with a higher statistics (by at least a factor 3). We made a M.C. simulation and the result is shown in the figure 2 a) that represents the $K_{\mu 2}$ and K_{e2} peaks, very well separated, assuming equal decay branching ratio of K^+, and figure 2 b) that shows the μ^+ events reconstructed under the e^+ peak. The contamination of these events is of the order of a few 10^{-5} , i.e. comparable to the signal.

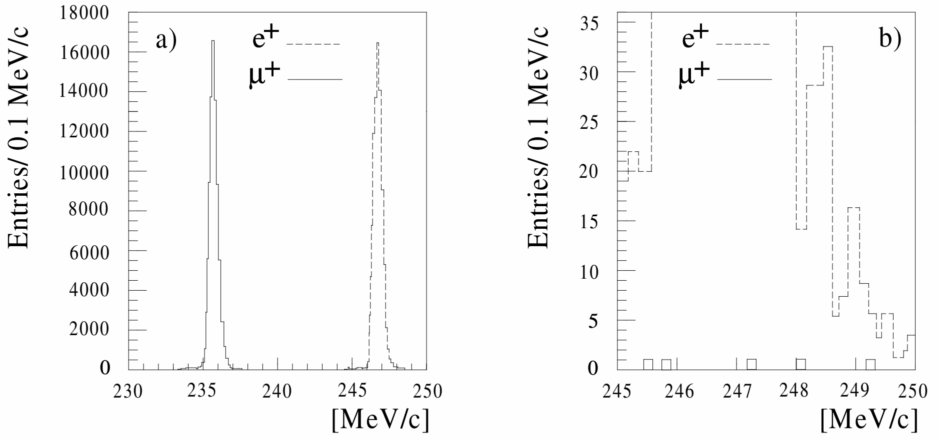

Figure 2. M. C. simulation of μ^+ and e^+ events as reconstructed by the FINUDA apparatus from simulated $K_{\mu 2}$ and K_{e2} decays.

4. CONCLUSION

The FINUDA apparatus can't be modified to implement the μ^+ and e^+ particle identification from stopped K^+ decays, but a possible way of lowering the background events, due to large angle scattering in the material of the tracking system, is that of using only events with four hits of good quality. Furthermore, by reconstructing the momentum of the particle with different combinations of three over four hits and by requiring that the differences of these measured momenta are less than 2 MeV/c, it could be possible to improve considerably the rejection of the background events. Of course this improvement will be paid in terms of number of events.

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