Status report of FINUDA data taking

FINUDA Collaboration

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Abstract

A survey of the status of the FINUDA data taking, as of end of February 2007, is reported, with focus on the detector behavior, and on the quality of data over the run period. A particular care has been dedicated to understand the possible worsening effects of the data quality due to changes of the experimental working conditions.

Contents

Chapter 1

Status of Data Taking

1.1 Collected statistics and general features of the data taking

After the machine tuning the systematic data taking of FINUDA started on Nov. 20, 2006. Since this day, until Dec. 22 morning, the data taking with colliding beams was continuously and smoothly carried on, with the scheduled interruptions for machine development. During the LNF winter shutdown (from Dec. 22 to Jan. 2, 2007) the magnetic field was switched off and straight cosmic ray data were taken, to be used for geometric alignment of the apparatus, as agreed during the last Committee meeting. As soon as DAΦNE restarted, on Jan. 3, 2007, the data taking with colliding beams resumed and ran continuously until Feb. 12. From Feb. 12 to Feb. 14, due to a failure of the cryogenic system of the machine, cosmic rays without magnetic field were taken; from Feb. 14 until Feb. 22 the data taking was suspended to allow for scheduled and contingent maintenances both of DAΦNE and FINUDA (caring mostly for He chamber problems and for a few silicon detector modules).

The summary of the collected data and integrated luminosity is summarized in Tab. 1.1, updated as of Feb. 22.

The luminosity delivered by the machine was continuously improved since the beginning of the data taking, reaching a daily integrated value of about 7 pb^{-1}. After a first period of tuning in which the machine induced background level was quite sizeable, it was soon reduced to the level of the last data taking, even with a twice as large available luminosity. The recovery of the working machine conditions after short interruptions was excellent and usually fast.

The improvement of the machine performances in luminosity could be fully exploited by the new DAQ system of FINUDA, thanks to the complete re-design of the architecture, which has reduced the dead time of a factor over four, and its excellent stability over long time data taking. Also all the subdetectors showed a very satisfactory stability, continuously monitored online with instrumental and physical calibrations, and offered a prompt recovery in case of (rare) failures,

		2006-2007	2003-2004
Total collected luminosity		300 pb^{-1}	200 pb^{-1}
HYPE pure trigger		46.6×10^6	29.7×10^6
BHABHA pure trigger		10.4×10^6	–
prescaled triggers	HYP 1 or BHA 1	2.5×10^6	7.5×10^6
	HYP 1 or BHA 4	7.6×10^6	–
	HYP 1 or BHA 6	9.7×10^6	–
cosmic ray data	B=0	4.2×10^6	5.5×10^6
	B=1	1.6×10^6	1.8×10^6

Table 1.1: Statistics collected in the present data taking, updated as of Feb. 22, 2007, compared to the 2003-2004 data taking (running from Dec. 1, 2003 to Mar. 23, 2004 with a 8 days interruption for the winter shutdown). Differently from the previous data taking, in which HYPE and BHABHA triggers were collected together asking for both of them simultaneously, in the present data taking several choices for mixed trigger were made (roughly, the ratio between the HYPE and BHABHA trigger rates is 0.4). Most of the data have been collected asking for a pure HYPE and BHABHA trigger; smaller amounts of data have been taken requiring mixed triggers with a different ratio between the HYPE and BHABHA rates (namely, as reported in the table: 1:1, 1:1/4, 1:1/6). The total amount of HYPE triggers available so far is 62.8×10^6 events.

mostly due to beam structure imperfections.

1.2 Status of He Chamber

As already presented at the last Committee meeting the He chamber suffered a leakage probably due to a compression damage occurred during the first end-caps closure, at the end of July 2006. The damage could be recovered only partially during a four week intervention in Sep. 2006. The average air content inside the chamber, at the beginning of the present data taking on Nov. 20, 2006, was about 18%.

It was verified, by Montecarlo calculations, that up to an air level of 25% inside the chamber the quality of the data can be considered as not meaningfully affected (with particular concern to the hypernuclear spectroscopy which requires the highest resolution).

The oxygen content is continuously monitored during the data taking with dedicated gauges and a continuous slight increase, up to 21%, had been recorded until Jan. 18, 2007. Suddenly, on this day, a jump of 4% was observed, leading to an average content of air inside the chamber of 25%. After this episode, however, the amount of air remained constant and fixed to this level. Taking advantage of a scheduled machine shutdown (Feb. 12-21) the endcaps of the magnet were opened and a careful external inspection was performed on the He chamber walls finding only minor leakages, that were healed lowering the air concentration to an average value of 24%.

The effect of the presence of air inside the tracking medium was studied looking at the events that could be affected by such a tiny effect. To this purpose the momentum spectra of monochromatic μ^+ from the K^+ decay at rest, abundantly recorded during the data taking, were checked, studying in particular their resolution for tracks taken in well defined time intervals and space volumes. Since at present the subdetectors have not been aligned yet, just a first survey was made trying to reduce distortion effects by applying strong geometric selections on the volume spanned by the tracks. Therefore the analysis was limited to particles following well defined "roads" inside the apparatus. As show in Fig. 1.1, a "road" is defined by a fixed set of subdetectors and a given target.

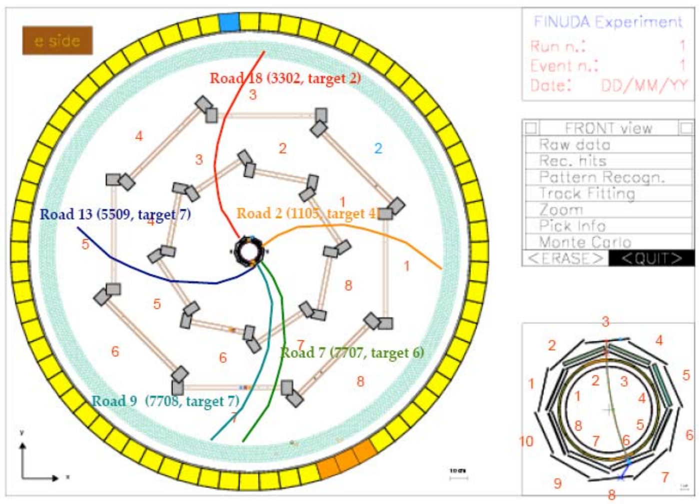


Figure 1.1: Typical layout of the FINUDA tracking region with a few examples of selectable "roads" for the study of detector subvolumes.

Thanks to the huge statistics available so far, strong geometric cuts can be applied without loosing statistical significance, and the effect of misalignments can be sizeably reduced. Examples of spectra obtained under these conditions are shown in Fig. 1.2. The offsets in the values of the means from the fit with respect to the reference value (0.2355 MeV/c) are mostly due to misalignment effects.

For positive particles (for which, we remind, the apparatus geometry is *not* optimized), at least 20 different roads can be selected. Dividing the available statistics in homogeneous and enough populated groups, of at least 300 runs each taken in consecutive time intervals, a survey over the features of about 200 spectra could be made as a function of time. From them, a first information

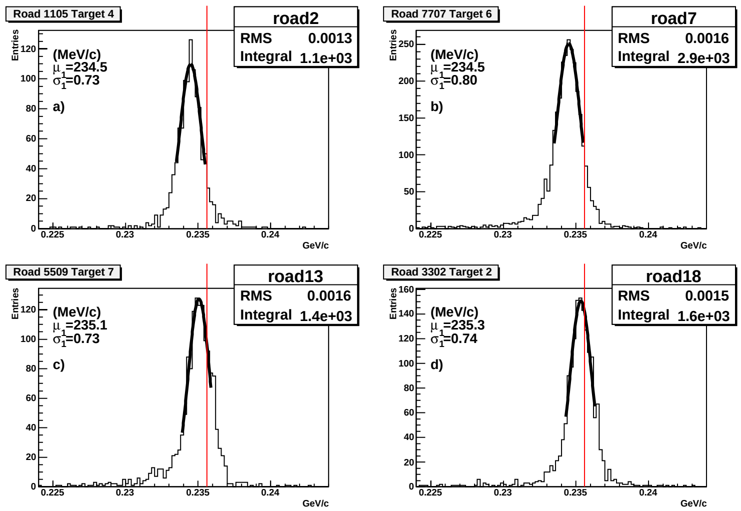
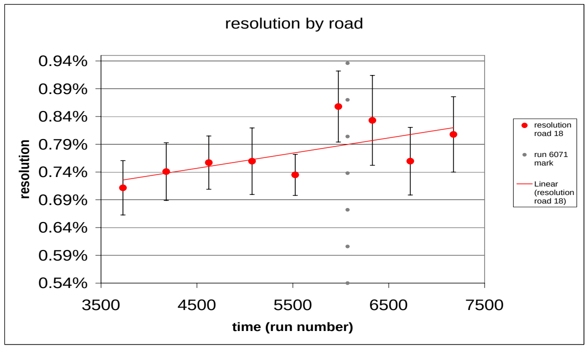


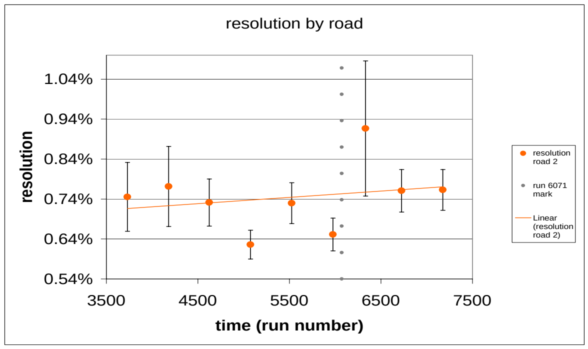
Figure 1.2: Distribution of the μ^+ momentum for tracks selected along different roads in the apparatus, for a sample of about 500 runs. Top left a): road 2, spanning the right part of the apparatus (with a resolution 0.73%); Top right, b): road 7, spanning the bottom part of the apparatus (with a resolution 0.80%); Bottom left c): road 13, spanning the left part of the apparatus (with a resolution 0.73%); Bottom right d): road 18, spanning the upper part of the apparatus (with a resolution 0.74%).

about the best resolution achieved so far could be extracted. At present it can be fixed around $(0.65 \div 0.7)\%$, to be compared to the 0.58% value obtained in the last data taking after full alignment. This means that the momentum resolution is already close to the one we'll achieve after the final alignment.

Fig. 1.3 shows, as an example, the variation of the momentum resolution as a function of time. In all the analyzed spectra no significant worsening related to the increase of the air content can be reported. The slight increasing trend that can be noticed is compatible with the experimental conditions.

Standing the present situation for the rest of the data taking, without further major breakdowns, what has been observed so far hints that the data taking can be continued without spoiling dramatically the data quality even for hypernuclear spectroscopy studies, which are the most sensitive to the momentum resolution.





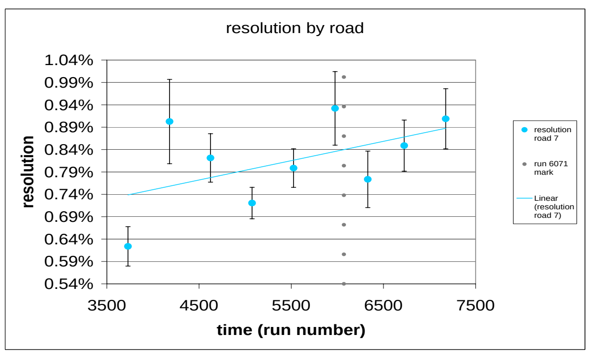


Figure 1.3: Typical trends of resolutions for μ^+ tracks as a function of time for three selected roads: n. 18, spanning the top side of the apparatus (top figure, red points); n. 2, spanning the right side of the apparatus (central figure, orange points); n. 7, spanning the bottom side of the apparatus (bottom figure, light blue points). The sudden worsening of the He chamber working conditions occurred at run 6017 (marked in the plots by the dotted vertical line): no evident effect of the trend may be observed.

Chapter 2

New data quality and comparison with previous data taking

In the following a first survey of some selected topics will be shown, concerning items for which a direct comparison with the previous data taking can be made – namely, spectra collected from the same targets. We focus, in particular, on the two ^{6}Li targets, present in both data takings (even if in different positions, therefore exhibiting a different stopping efficiency to the incoming kaons). The integrated luminosity analysed so far is roughly similar to the total luminosity collected in the past data taking: the number of events in the spectra are comparable, showing that the apparatus exhibits roughly the same efficiency, in spite of the lack of fine calibrations and alignments. The latter affect most sensitively the shape of some of the spectra shown in the following.

As far as the π^- spectra analysis is concerned, the first results obtained on brand new targets, namely ^{16}O and ^{13}C, are reported here as well.

2.1 π^- momentum spectra. Comparison and new results.

Fig. 2.1 shows a comparison of the π^- spectra following K^- capture on ^{6}Li corresponding to equivalent integrated luminosities collected in the 2003-2004 run (a) and in the present one (b). One can appreciate that, apart from the resolution which still has to be improved pending a tuning of the subdetectors calibrations and alignments, the spectra look very similar and with comparable statistics. We remind that the ^{6}Li spectrum shouldn't exhibit any peak structure due to the instability of the $^{6}_{\Lambda}$Li hypernucleus, but a signal of activity due to the formation of hyperfragments ($^{5}_{\Lambda}$He, ...) is expected beyond the quasi-free Λ production threshold.

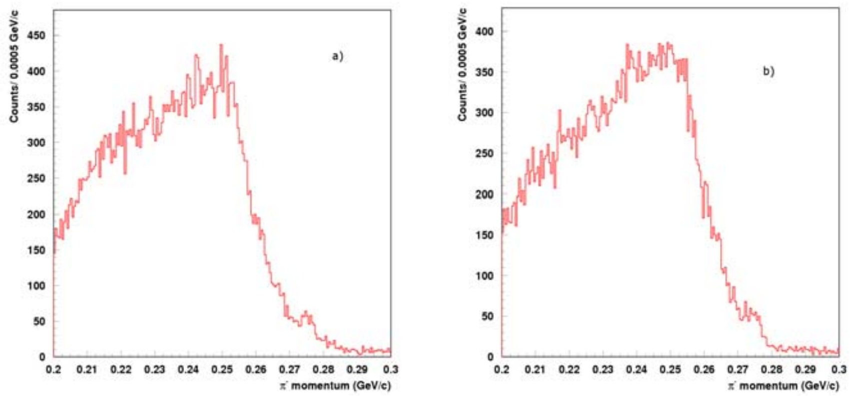


Figure 2.1: Momentum spectrum of π^- emerging from the ^{6}Li targets, for the old data taking (left figure, a)), and for the present one (right figure, b)).

Figs. 2.2 and 2.3 show very preliminary π^- spectra from the new ^{13}C and ^{16}O targets, that should present clear peaks due to the production of well defined final hypernuclear states. They were never observed extensively in K^-_{stop} reactions, and most of all they were never published before. Even with the present coarse resolution hints for well defined peaks in the interesting momentum region may be singled out.

In ^{13}C the peak at $B_\Lambda = -3.91$ MeV (labelled as n. 5 in Ref. [1]) can be observed.

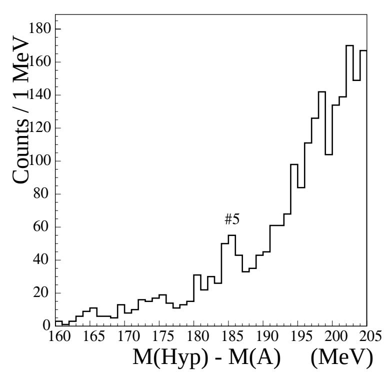


Figure 2.2: Experimental $M_{HYP} - M_A$ spectrum of $^{13}_{\Lambda}$C: see text for explanation of the labelled peak

For ^{16}O some hints for at least three hypernuclear states can be suggested (labelled as in the description of Ref. [1]): n. 2 ($B_\Lambda = 5.82$ MeV), n. 3

($B_\Lambda = 1.76$ MeV) and n. 4 ($B_\Lambda = -4.17$ MeV).

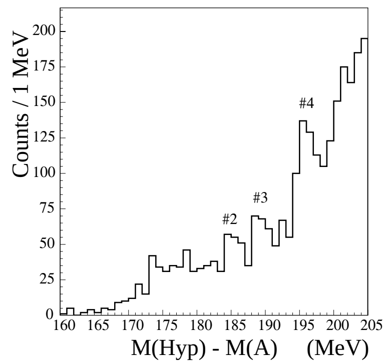


Figure 2.3: $M_{HYP} - M_A$ spectrum of ${}^{16}_{\Lambda}$O (from the D_2O target): see text for explanation of the labelled peaks.

2.2 Proton momentum spectra from ^{6}Li

Fig. 2.4 shows a comparison of the proton spectrum from ^{6}Li targets asking for a coincidence with a π^- having a momentum larger than 275 MeV/c. The signature for the two nucleon absorption reaction $K^- +$ "d" $\to \Sigma^- p$ appears clearly, as the proton momentum in this reaction is expected at about 505 MeV/c (smeared due to the Fermi momentum of the quasi-deuteron).

This reaction is most favorably observed in ^{6}Li, as its nuclear structure foresees the presence of two distinguishable clusters, a "quasi"-deuteron and a "quasi"-^{4}He systems.

The present results (b) are compared with the analogous spectrum obtained in the previous data taking (left picture) [2]. The collected number of events in the two histograms is comparable (700 events for the new plot vs. about 500 for the old one), and the shape as well, as in this case the resolution is not a crucial requirement.

2.3 Λ invariant mass spectra from ^{6}Li targets

Fig. 2.5 shows the invariant mass spectrum of the ($\pi^- p$) system obtained using the data of the present run (b) and those of the previous one (a), for tracks coming from the ^{6}Li targets only. The resolution is obviously worse (the width is almost twice as large), since in this case the effects of misalignments weigh for both the tracks involved in the Λ identification, but, as can be deduced by the background level, the number of events collected so far is comparable to what we had in the first data taking from targets of the same composition.

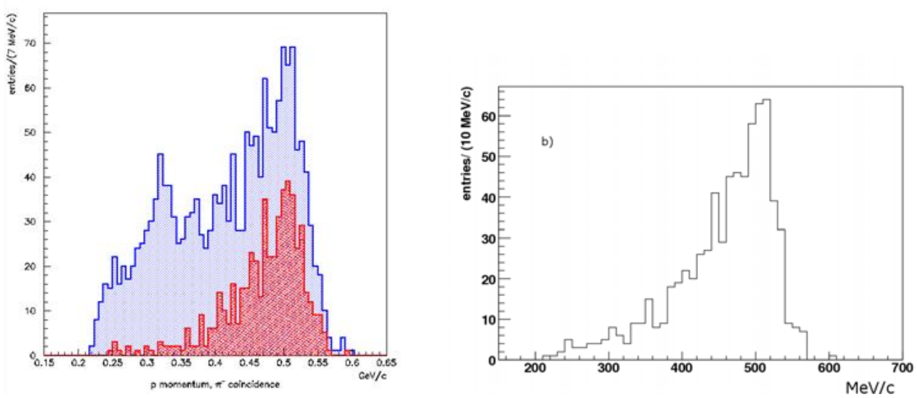


Figure 2.4: Momentum spectrum of the protons emerging from the ^{6}Li targets selected in coincidence with π^-'s faster than 275 MeV/c, for the old data taking (left figure, a) red spectrum – the blue one refers to the full momentum spectrum with a π^- coincidence, without cuts on momentum), and for the present one (right figure, b)).

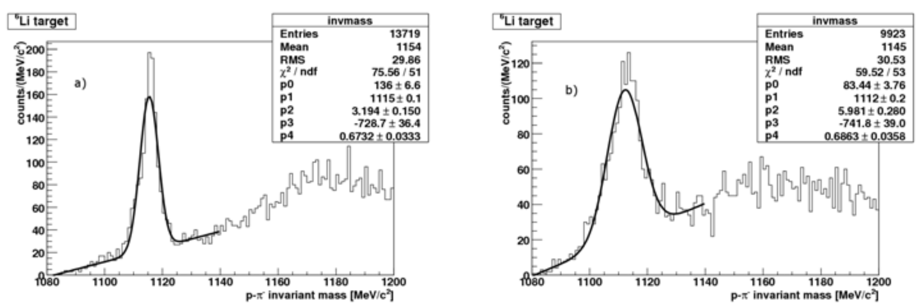


Figure 2.5: Invariant mass of the $(\pi^- p)$ system for tracks emerging from the ^{6}Li targets, for the whole statistics collected in 2003-2004 (left figure, a), and for the statistics collected so far (right figure, b). In spite of the present coarse alignments and calibrations, the Λ peak can be already clearly identified in the new data, with good statistics.

Chapter 3

Conclusions

From the previous studies we ask for a continuation of the data taking in the present conditions, until an integrated luminosity of 1 fb^{-1} is reached. The data collected so far are of very good quality and we expect to improve it further with the inclusion of final alignments and calibrations, about which the work is currently in progress.

Bibliography

[1] *Plans for FINUDA 2006-2007 data taking*, M. Agnello *et al.*, Report presented to the Scientific Committee for the Nov. 2007 Meeting, Nov. 2, 2006

[2] FINUDA Collaboration, M. Agnello *et al.*, *Nucl. Phys.* **A775** (2006), 35