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Muon Detector

(Calibration)

- the first part -

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Abstract

The main aspects of the results regarding the spatial corrections of the muon hit distributions due to the multiple scattering effect in the iron absorber and in the materials before the muon detector have been discussed in this note. The procedure of time correction to align signals from slabs have been explained too.

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Contents

1 Physical considerations

In order to check the precise prediction of low energy QDC the DIRAC double arm spectrometer has been designed and successfully put in the operation [1]. Thereby, the DIRAC experiment at PS-CERN allows the observation of πK atoms [2] and permits to measure simultaneously the lifetime of $\pi^+\pi^-(A_{2\pi})$[3] and $\pi^\pm K^\mp(A_{\pi K})$ atoms [4]. The electrons and muons can contaminate the $\pi^+\pi^-$, π^+K^- and $K^+\pi^-$ low relative momentum events produced in the target area. On purpose to eliminate these fake events the muon upgraded detector setup (MU) has been comprised the setup aperture increasing by adding scintillator counters and absorbers. A complete description of the new muon detector has been done elsewhere [5]. We remember here just to the end that to improve the time resolution, the muon hodoscope consists of two layers of scintillator counters. The first layer is composed from 28 (before upgrading)+4 (internal)+2 (external) scintillators with light guides and photomultipliers toggled mainly vertically on top. The second layer has the same structure, but the light guides and photomultipliers are mainly placed on the bottom. From reason of space 20 photomultipliers of external bottom scintillators among the scintillation counters used before upgrading are placed horizontally. Also all the photomultipliers of additional internal and external scintillators are placed horizontally. The volume of each scintillator slab used before upgrading, and which is included also in the new setup is $755 \times 120 \times 5\ mm^3$, while the volume of each of additional internal and external scintillator slabs is $800 \times 120 \times 10\ mm^3$. The sensitive area, together with the gaps of one hodoscope is near upon $3,121\ m^2$.

In the off-line analysis only the events with muon counter hits, which have corespondent hits in the preshower detector [6] and which are correlated in time with those of other detectors are tagged as muon events, and thus rejected. The results [7] show a fraction of such events containing at least one muon near to 10%.

2 The muon slabs location and their corrections due to the multiple scattering effect

For this analysis three 2009 runs were used: 8930, 8931 and 8933. The evens were selected from a data sample of good evens with 1+1 drift chambers tracks and one muon hit per arm with proper time. In the detector data file all time delays and coordinate shifts were reset to 0. The Figure 1 presents the hit distributions for muon arm 1 slab 17 and muon arm 2 slab 51, achieved by muon finder procedure which involves: the signals from vertical hodoscopes which define a time reference for TDC counters; the signals from horizontal hodoscopes used by the coplanarity trigger; the signals from drift chambers which give the positions of the particles, essentials in the tracks reconstruction act and the signals from preshower detector which in this case ensure us that particles associated with the reconstructed tracks reach the iron absorber. On the other hand, the Figure 2 presents the same distributions obtainded before but with additional conditions imposed, namely: the time interval between the signals delivered by the muon TDC and time mark provided by vertical hodoscopes TDC is selected to be lower than 5 ns and also $|x^{'}_{\mathrm{tr}}$ - $x^{'\,exp}_{\mathrm{center\ slab}}| \leq$18cm. $x^{'}_{\mathrm{tr}}$ represents the particle trajectory coordinate in the horisontal direction and $x^{'\,exp}_{\mathrm{center\ slab}}$ means the experimental observed center slab position which due to multiple scattering effect differs little bit to the physical center slab $x^{'}_{\mathrm{center\ slab}}$.

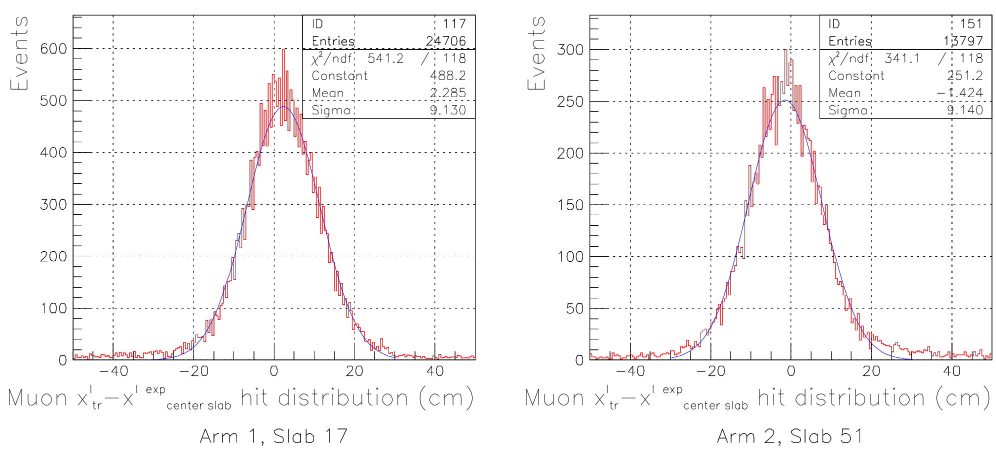

Figure 1: The ($x^{'}_{\mathrm{tr}}$ - $x^{'\,exp}_{\mathrm{center\ slab}}$) distributions for muon arm 1 slab 17 and arm 2 slab 51.

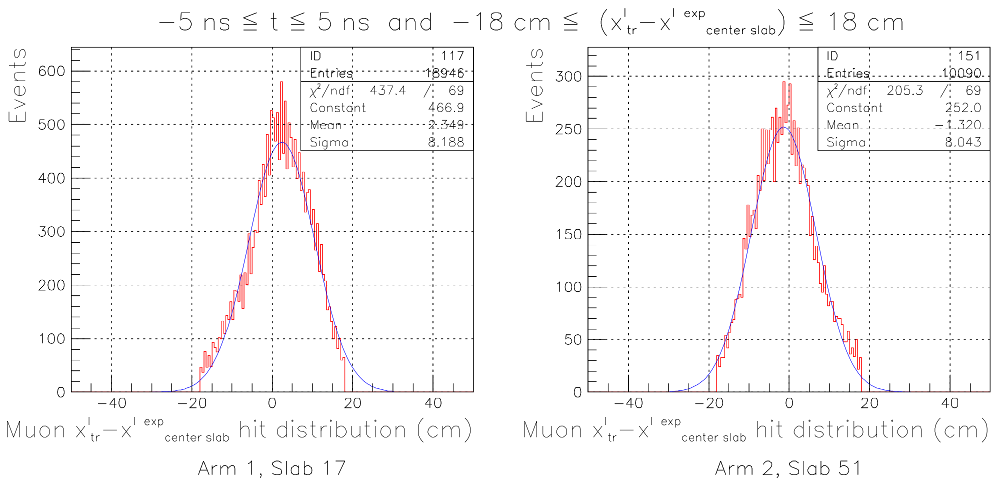

Figure 2: The same distributions presented in the figure preceding but with special conditions imposed ($|\Delta T| \leq 5\,ns$ and $|x'_{\rm tr}$ - $x'^{exp}_{\rm center\ slab}| \leq 18\,cm$).

As we can observe undoubtedly in the Figures 1 and 2, due to multiple Coulomb scattering deflection the particle trajectories are strongly affected, such than the distributions are not centered at zero. Just for the sake of clarity, we emphasise the fact that for each one of the slab, zero in the corresponding hit distribution denotes the particle tracks which hit the muon detector in the experiment observed center of the respective slab. With a view to center the hit distributions musts be introduced small corrections in the detector.dat file. These corrections represent the disagreements between $x'_{\rm center\ slab}$ values and the experimentally observed positions of the muon center slabs $x'^{exp}_{\rm center\ slab}$. The above mentioned corrections due to multiple scattering effects for each slab of each muon detector arm are given in the Table 1 and displayed in the Figure 3. These values have been obtained for all muon slabs with the constraints described upper and represented in Figure 2.

Table 1: *Multipe scattering effect corections:* x'_{tr} - $x'^{\,exp}_{\mathrm{center\ slab}}$

Left Arm Slabs [no]	Values [cm]	Right Arm Slabs [no]	Values [cm]
1	6.7	1	-6.3
2	4.7	2	-3.3
3	2.1	3	-0.8
4	0.9	4	-1.4
5	-0.6	5	-0.6
6	-1.2	6	0.3
7	0.2	7	0.7
8	0.5	8	0.7
9	0.6	9	0.4
10	-0.9	10	1.5
11	-0.7	11	1.2
12	-1.2	12	1.8
13	-1.3	13	2.4
14	-1.1	14	1.8
15	-1.3	15	1.4
16	-1.0	16	1.1
17	-1.3	17	2.4
18	-0.9	18	1.2
19	-2.1	19	2.9
20	-1.4	20	2.1
21	-2.4	21	3.1
22	-1.3	22	2.9
23	-1.3	23	3.0
24	-1.4	24	2.5
25	-3.9	25	4.9
26	-2.5	26	5.2
27	-2.9	22	5.0
28	-3.5	28	5.2
29	-3.3	29	5.7
30	-2.9	30	6.3
31	-3.3	31	7.9
32	-6.7	32	0.0
33	-8.4	33	9.5
34	-11.7	34	8.9

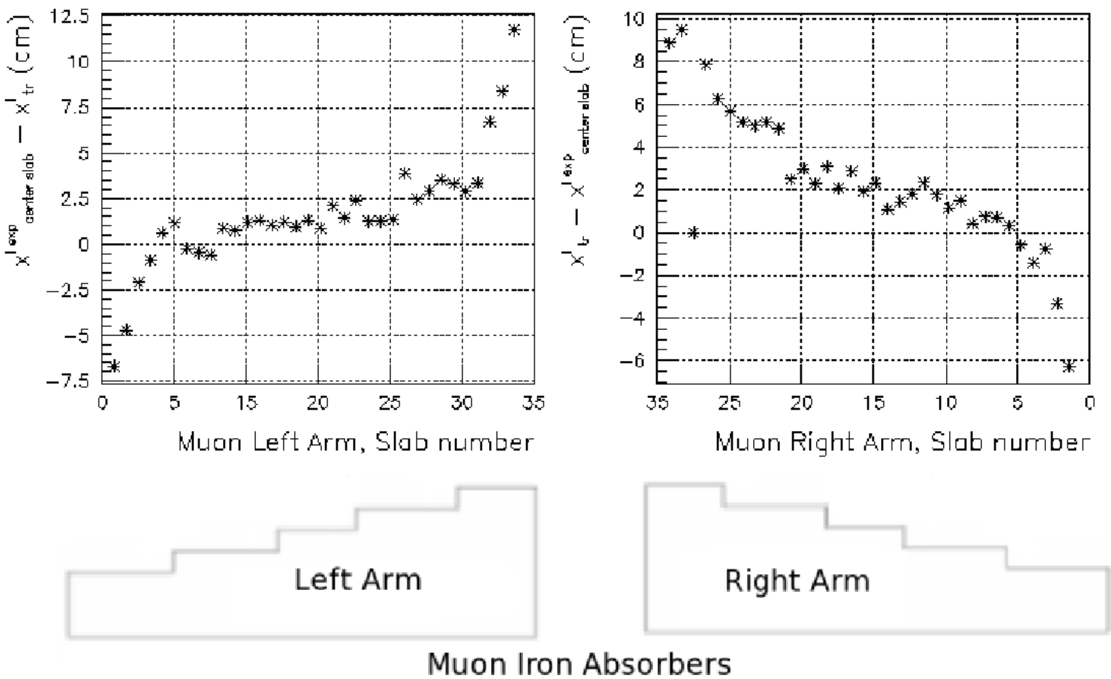

Figure 3: The differences $x'_{\mathrm{tr}} - x'^{exp}_{\text{center slab}}$.

3 The muon time alignment

In the left side of Figures 4 and 5 are represented the time distributions of time channel 17 arm 1 and respectively channel 51 arm 2, obtained with the same selection criterion which was already presented in the precedent section. The individual slab time hit distribution must be fitted with a Gaussian. In order to apply the Gaussian fit for a large number of runs and a large number of time channels (64 for each run) we have chosen a more restrictive fit criteria. Namely, have been selected from muon time hit distributions just the hits with have been accomplished the next requirement: MEAN-0.5*RMS$<$t$<$MEAN+0.6*RMS, where MEAN is mean value of time hit distribution, RMS is the root mean square of the same distribution, and t is muon time. The resulting 'cuts' of the muon time distributions with corresponding Gaussian fits for slab 17 arm 1 and slab 51 arm 2 are giving in the right side of Figures 3 and respectively 4. As we can observe in the Figures 4 and 5 the muon time distributions are not centered to zero. On order to bring 'in time' the signals from the particles which have hits in the muon detector with corresponding signals in vertical hodoscopes, in the detector.dat we have been introduced small corrections for each muon slab.

In other words, these corrections represent the corresponding deviations of each Gaussian centroid of each time muon distribution vis a vis to time zero marked by the corresponding time in vertical hodoscopes.

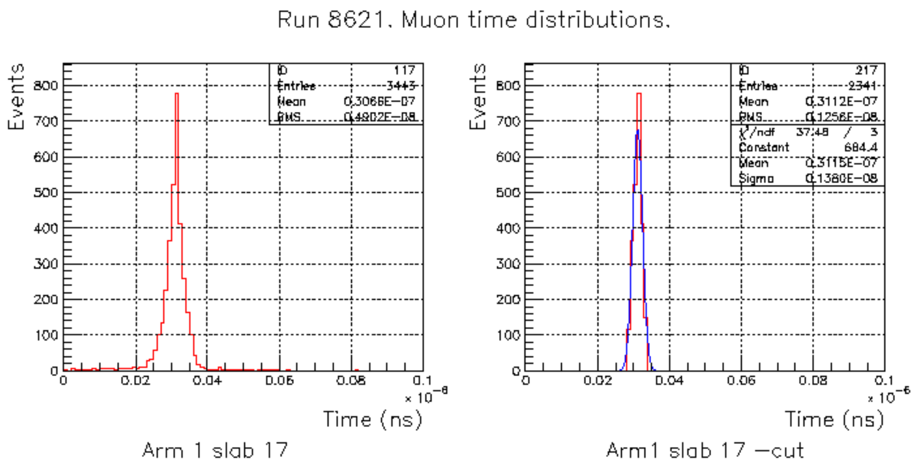

Figure 4: The muon time hit distribution for slab 17 arm 1 (left side). Fit Gaussian of the same distribution (right side) but after have performed a cut imposed by the automatic peak finding procedure.

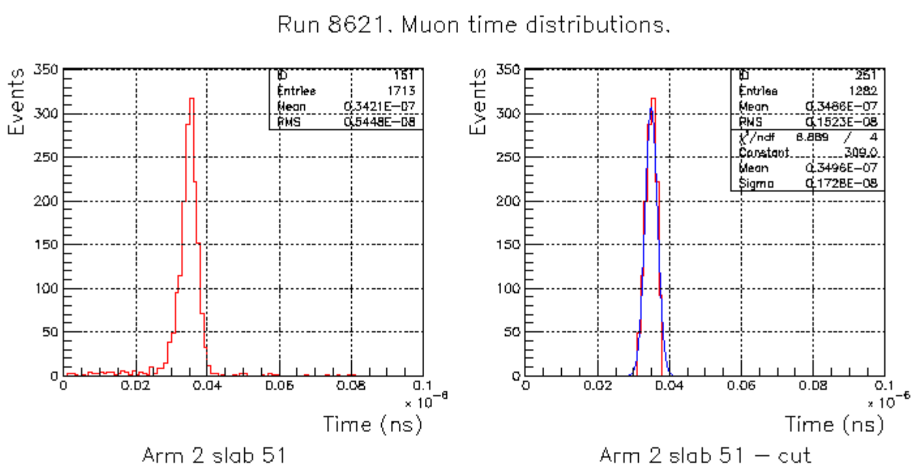

Figure 5: The muon time hit distribution for slab 51 arm 2 (left side). Fit Gaussian of the same distribution (right side) but after have performed a cut imposed by the automatic peak finding procedure.

For the runs interval 8621- 9201 have been done the time alignment of 32 + 32 + 4 TDC L3377 time data channels. A case in point are the time alignment results obtained for run 8621 and presented in the Table 2.

The run 8621 was considered as being a standard run. Certainly, the centroid values of hit distributions should be introduced in the detector.dat file for time

Table 2: *Muon time alignment*

Left Arm Slabs [no]	Values [ns]	Right Arm Slabs [no]	Values [ns]
1	0.2396E-07	1	0.2581E-07
2	0.2433E-07	2	0.2446E-07
3	0.2411E-07	3	0.2526E-07
4	0.2408E-07	4	0.2515E-07
5	0.2477E-07	5	0.2889E-07
6	0.2471E-07	6	0.2770E-07
7	0.2820E-07	7	0.2848E-07
8	0.2709E-07	8	0.2594E-07
9	0.2809E-07	9	0.2726E-07
10	0.2881E-07	10	0.2769E-07
11	0.2973E-07	11	0.2863E-07
12	0.2695E-07	12	0.2877E-07
13	0.2768E-07	13	0.2729E-07
14	0.2764E-07	14	0.2964E-07
15	0.2652E-07	15	0.2931E-07
16	0.2691E-07	16	0.2815E-07
17	0.3115E-07	17	0.3496E-07
18	0.3049E-07	18	0.3213E-07
19	0.3146E-07	19	0.3210E-07
20	0.2993E-07	20	0.3383E-07
21	0.3143E-07	21	0.3472E-07
22	0.3407E-07	22	0.3314E-07
23	0.3260E-07	23	0.3464E-07
24	0.3175E-07	24	0.3385E-07
25	0.3301E-07	25	0.3527E-07
26	0.3137E-07	26	0.3456E-07
27	0.3207E-07	22	0.3367E-07
28	0.3207E-07	28	0.3720E-07
29	0.3032E-07	29	0.3549E-07
30	0.3300E-07	30	0.3453E-07
31	0.2875E-07	31	0.3525E-07
32	0.2849E-07	32	0.3532E-07
33	0.3296E-07	33	0.3660E-07
34	0.3294E-07	34	0.3678E-07

alignment corrections. By token, for the following runs, if any centroid position of muon hit distribution for any slab is with more than 1 ns different from the corresponding value of this standard run, then a Fortran subroutine save automatically the all mean values of slab distributions of the respective run in a file which can be ulterior utilized for time alignment corrections in detector.dat file.

4 Conclusions

The trajectory deviations of the particles from the expected hit positions in the muon detector due to multiple scattering effect in the iron absorber and materials before this have been investigated and evaluated in this note. We have found values for these spatial corrections enclosed between zero and few centimeters depending mainly to the iron absorber thickness. Also, the time alignment corrections of the Muon TDC signals vis-a-vis to the corresponding signals provided by the vertical hodoscopes TDC have been investigated and reported here.

References

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