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Expected precision in the M_ρ–measurement as a function of target length.

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Abstract

Using Monte Carlo simulations, we have investigated the different sources of uncertainties, including multiple scattering and ionization loss, in the measurement of the ρ^0 mass, under the conditions discribed in the proposal [1]. To answer the question about which target length to use, the simulations has been done for varies values of lenght.
These results were presented at a video conference 7th of August at CERN with Aarhus and South Africa, except for ionization loss, which hadn't been analyzed at the time.

1 Short introduction

In order to measure the degree of polarization, both in the case of linear and circular polarization, one looks at the angular distribution of the $\pi^+ \pi^-$ pairs originating from ρ^0 photo-production in the Be target.
Uncertainties in the ρ^0 mass resolution reflects directly upon the measurement of $cos\theta$ i.e. the degree of polarization, and so one would for obvious reasons like to have a good mass resolution. This also makes it possible to reduces the background from $e^+ e^-$ pairs, though this elimination is limited by the broadness of the ρ^0 resonance (full width 150 MeV /citePPbook).

2 Sources of uncertainty and their influence

There are several sources of uncertainty in the ρ^0 mass measurement. The most significant ones are listed below:

- *Multiple scattering and Ionization loss in target.* The multiple scattering smears the momentum in transvers direction and is approximately gaussian with a width of 3.5 MeV for the pion energies considered here (from [2] p. 184). The energy loss due to ionization is about 4 MeV/cm target (from [2] p. 180), and so it is a flat distribution, which makes the error assymetric.

- *Finite resolution in the three drift chambers.* The resolution in x–direction of each drift chamber is expected to be 100 μm ([1] p. 9).

- *Uncertainty in the vertex position.* This gives rise to errors, since the vertex is used in the reconstruction. The only known vertex component is the x–position, which from the proportional chambers is known within 290 μm[1)].

How these uncertainties influences on the ρ^0 mass measurement was investigated using a Monte Carlo simulation on a realistic beam, i.e. a 40 mm radius peaked beam with an angular divergens of 3.7 $mrad$.
The simulation was done with each source of uncertainty turned on seperately in order to estimate their seperate influence (see figure 1). Under the assumption, that the different sources are independant, one should be able to add them up in quadrature and get the final result, which can then be checked. It should also be mentioned that in the calculations there was a width of 1.2 MeV due to numerical effects, which has been subtracted from the below results, which were done for a target length of 5 cm:

- *Multiple scattering & Ionization loss*.. 4.1 MeV.

- *Drift chambers*.. 20.2 MeV.

- *Vertex position total*... 39.5 MeV.
  x-vertex............39.1 MeV
  y-vertex..............1.0 MeV
  z-vertex..............5.8 MeV

1) The number arises from the 3.7 $mrad$ beam divergens times the lenght 78 m to target.

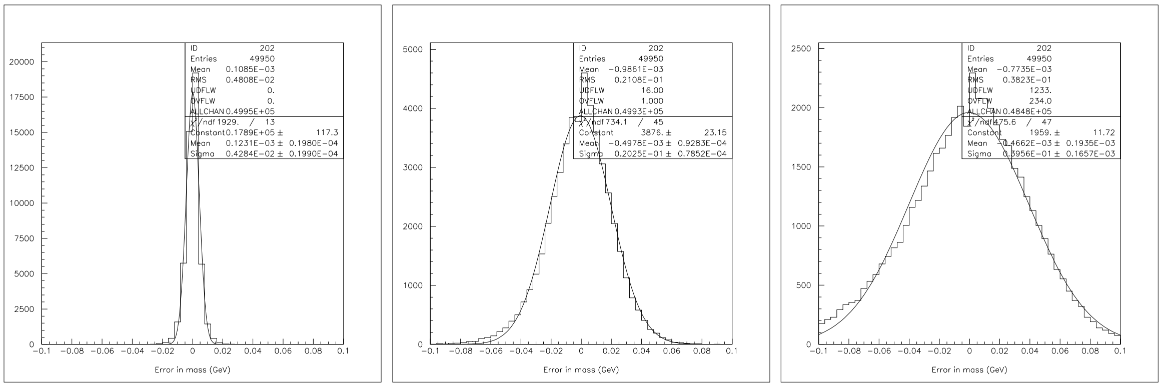

Figure 1: Different effects giving rise to uncertainties (calculated for a target length of 5 cm). The plots shows the differences between the true and the reconstructed values for: a) Multiple scattering & Ionization loss. b) Finite drift chamber resolution. c) Uncertainty in vertex position.

When added in quadrature, this adds up to a total width of $44.6 \pm 0.2\ MeV$, while the value with all sources of uncertainties in effect was $44.0 \pm 0.2\ MeV$ (see figure 2a). The small inconsistency comes from the correlation between effects and from the slight non–gaussian shape of the error made, when reconstructing.
It is seen, that the dominant source of uncertainty is the error in the x-vertex, which is used for reconstructing the momentum. One realistic way to improve this, is to double the resolution of the proportional chambers. The result is a reduction of the total width to $29.9 \pm 0.2\ MeV$ (see figure 2b).

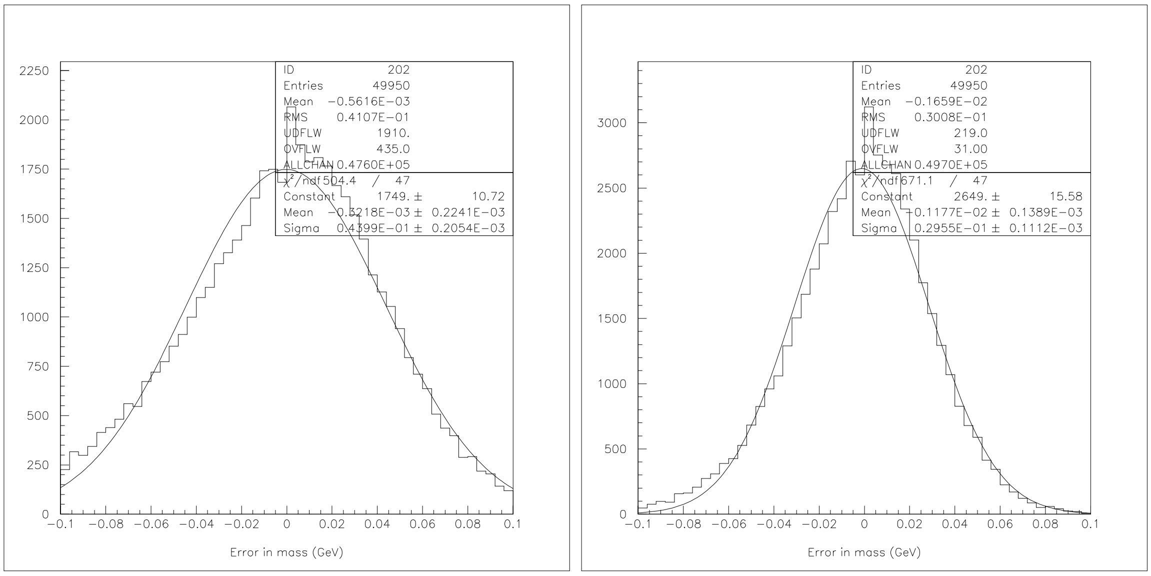

Figure 2: a) The total uncertainty of the M_ρ–measurement with a target length of 5 cm. b) The same plot as before, but with the resolution of the proportional drift chambers doubled.

3 Dependence on target length

The targets length influences on the size of the multiple scattering, the ionization loss and the uncertainty in z-vertex. The width of the ρ^0 mass measurement therefore increases with target, but since non of the three sources of uncertainty are dominant, the increase should be moderate, and indeed it is. Figure 3 below shows the total width of the ρ^0 mass measurement as a funtion of target length.

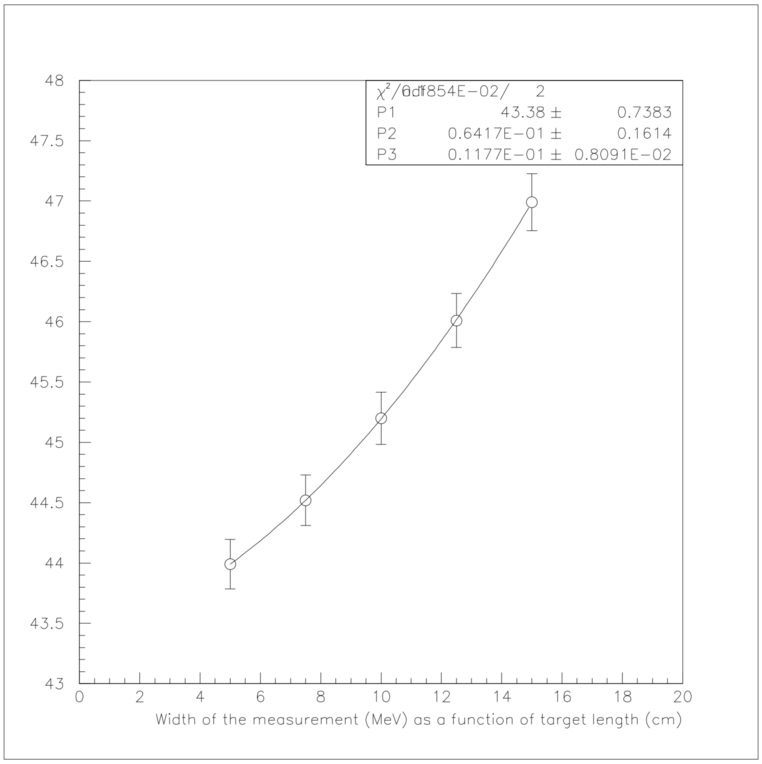

Figure 3: The width of the M_ρ–measurement as a function of target lenght. The fit is done to a second degree polynomium, consistent with expectance.

The fit is made to a second degree polynomial, which should include the eccential features of the curve. The low χ^2/N suggests, that the error bars, which are taken from the gaussian fit to the width, are somewhat overestimated. This is also the reason for the large errors on the fit, which however, are much smaller (about a factor of 20) than indicated on the fit.

References

[1] E. Uggerhøj, M. Velasco *et al.*, CERN/SPSC 98-17, SPSC/P308 (1998).
[2] Particle Physics Booklet, Springer, July 1998.