Method of the absolute beam momentum determination

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The uncertainty of the determination of the proton orbit length in the COSY ring implies that the absolute beam momentum is known with an accuracy of only about ± 0.1%. For measurements at a reaction threshold this uncertainty has rather serious consequences. For example, in case of the $pp \to pp\eta\prime$ reaction at the beam momentum of 10 MeV/c above threshold the corresponding uncertainty of the total cross section amounts to about ± 40%. This strong dependence of the beam momentum on the cross section is due to the steep cross section increase with increasing excess energy at threshold.
In the first order one can assume that very close to threshold, in case of $pp \to pp\eta$ or $pp \to pp\eta\prime$ reactions, the energy dependence of the cross section is given by the kinematical factors only [?]. Thus, one obtains cross sections proportional to the fourth power of the maximum momentum of the produced meson in the center of mass system, which, further is proportional to the second power of the beam momentum above threshold. Figure 1 shows, the expected production rate of the $pp \to pp\eta\prime$ reaction versus the beam momentum above threshold, calculated as a convolution of the cross section, the COSY - 11 detection system acceptance, the target density distribution and the beam momentum spread. The computations were performed under the assumption that i) the beam-target overlap region has dimensions of 1.2 cm x 1.2 cm x 1.2 cm, and ii) that the beam momentum has the gaussian distribution with $\sigma = 3 MeV/c$ (open circles), and $\sigma = 0$ (pluses). For the momentum range from about 6 MeV/c to about 20 MeV/c above threshold the number of registered events is approximately a linear function of the beam momentum *independently* of the beam momentum spread. The extrapolation of this dependence towards the momentum axis gives an absolute momentum value equal to about 1.5 MeV/c, with the error depending only on the statistical errors of the measured points. Thus for reactions measured with sufficient statistics this method could give an absolute momentum determination with an error less than 1 MeV/c.

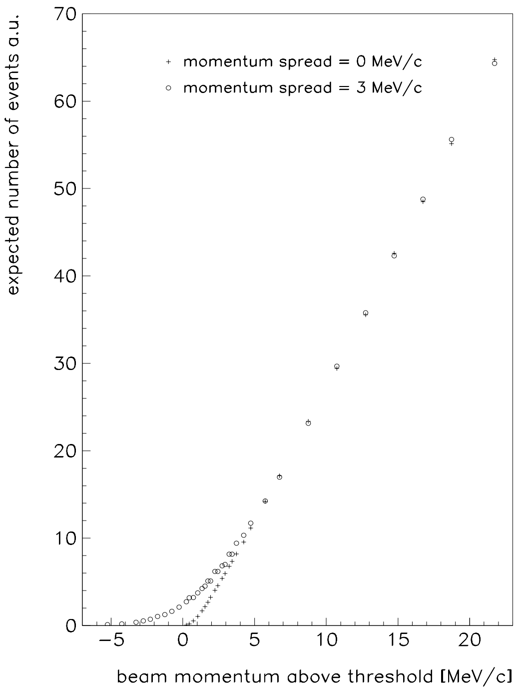

Figure 1: Expected number of registered events from the $pp \to pp\eta\prime$ reaction versus beam momentum, calculated according to assumptions described in the text. Open circles correspond to a beam momentum spread of 3 MeV/c, and pluses to no beam momentum spread.

References

[1] Ulf Schuberth *The Reaction $pp \to pp\eta$ Close to Threshold* Ph.D. thesis, Uppsala 1995