S. Simon

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CALIBRATION OF THE EFFECTIVE BEAM HEIGHT IN THE ISR

by

S. van der Meer

Geneva - Switzerland

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For the evaluation of absolute cross-sections with the ISR, the effective beam height, as defined by Darriulat and Rubbia[1] has to be determined. It is equal to

$$h_{eff} = \frac{\int S_1(z)dz . \int S_2(z)dz}{\int S_1(z) . S_2(z)dz}$$

where $S_1(z)$ and $S_2(z)$ are the densities in the two beams as a function of the vertical coordinate z.

For determining this quantity, a simple method that is probably less precise than the "wire method" proposed in [1] and[2], but that does not require any equipment mounted in the ISR vacuum chamber, will be described.

For this method, a monitoring counter system is needed with a counting rate proportional to the rate of beam-beam interactions. For the moment, it will be supposed that the background in this monitor due to beam-gas interactions is small.

One of the two beams is displaced vertically with respect to the other one, and the counting rate in the monitor is plotted versus displacement. A bell-shaped curve will result with its maximum at zero displacement. It will now be shown that, irrespective of beam shape, h_{eff} is equal to the area under this curve, divided by the ordinate for zero displacement.

If we call the displacement h, the counting rate is equal to

$$A. \int S_1(z) . S_2(z-h)dz$$

where A is an unknown constant. The procedure outlined above results in the quantity

$$h^{*} = \frac{\int\left[A.\int S_1(z).S_2(z-h)dz\right]dh}{A.\int S_1(z).S_2(z)dz} = \frac{\int\left[S_1(z).\int S_2(z-h)dh\right]dz}{\int S_1(z).\ S_2(z)dz}$$

Since the integrals are taken over the entire region where the integrands are not zero, we have

$$\int S_2(z-h)dh = \int S_2(z)dz$$

Therefore

$$h^{*} = \frac{\int\left[S_1(z).\int S_2(z)dz\right]dz}{\int S_1(z).\ S_2(z)dz} = \frac{\int S_2(z)dz.\int S_1(z)dz}{\int S_1(z).S_2(z)dz} = h_{eff}$$

A reasonable amount of background due to beam-gas interactions does not affect the measurement, provided the background is independent of h. In this case, it will only increase the counting rate by a fixed amount that can be subtracted. The monitor geometry should therefore be such that background from the beam that is being displaced is minimized. On the other hand, the counting rate due to beam-beam interactions should be as high as possible in order to reduce the time needed for the measurement.

Establishing the counting rate versus h may be replaced by measuring the total number of monitor counts during a continuous linear sweep at known speed of one of the beams. The beam-gas background must then be determined separately at fixed, large h.

The counting rate for zero displacement can be determined at leisure during the performance of the experiment for which the calibration is needed.

Of course, this method suffers from all the disadvantages connected with beam displacements outlined in ref.[1]. On the other hand, it might be suitable for somewhat less precise measurements in cases where the experiment requires that the intersection region remains without the obstructions inherent to the wire method.

REFERENCES

1) P. Darriulat, C. Rubbia, CERN internal document 68/340/5 SIS/si.

2) W. Schnell, CERN internal document PS/6513.