Beam blow-up due to intra-beam scattering

Beam blow-up rates for vertical and horizontal beam size, as well as momentum blow-up rates have been tabulated for various conditions by K. Hübner. The results are given in ref. 1. Figure 1 has been reproduced from the same report. The graph in Fig. 2 comes from table X of this report. Both figures refer to 31 GeV/c stacks with 3% momentum spread. It is obvious from these curves that the radial blow-up is about an order of magnitude greater than the vertical blow-up.

In fig. 3 I have sketched the evolution of h and $E_x$ for 4 different starting conditions, where condition A is a good approximation for 31 GeV/c physics runs.

Some conclusions can be drawn from this.

1) For small $E_{x0}$ one has an enormous blow-up rate (20%!) for the radial emittance so that $E_x = 1 \pi \mu radm$ is in any case reached in a few hours. So for long runs one very soon has the condition of $E_x > 1 \pi \mu radm$ which thus makes $\dot{h}$ independent of $E_x$.

2) Smaller $h_{eff}$ yields higher $\dot{h}_{eff}$ which is well known. However, the expected blow-up rates of around only 1%/hour make a small initial $h_{eff}$ always worthwhile.

Note: The evolution of radial emittances of stacks which are to be found in ref. 2 indicates that the observed radial blow-up at 22 and 26 GeV/c for 15 Amps is compatible with intra-beam scattering.

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References:

1. ISR-TH/KH/amb 17.1.1975
2. ISR-OP/LV/svw 14.10.1974
$\frac{1}{x^2} \cdot \frac{1}{h^2}$

$Y = 33.529$

$\frac{\Delta P}{P} = 3.2$

$E_x = 25 \text{ kPa/m}$

$6 \text{ mm} \cdot 0.1 \text{ in}$

FIG. 2.