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SEB Beam Size vs. Intensity

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Subject SEB Beam Size vs. Intensity

OBSERVATIONS AND CONCLUSION

The SEB beam size was measured with plunging SWIC's CW039, CW100 and CW223 for various settings of matching quads CQ1-4. The corrected beam widths were compared with predictions of a model of the SEB, as discussed in References 1 and 2. The model is characterized by parameters E^{V}_{rms} and Δ that are related to the vertical emittance and the horizontal beam divergence at F5. In each case the spiral pitch at F5 is measured with the F5 flag, and fed into the model. Values measured two years ago and given in Reference 1 are

$$E^{V}_{rms} = 0.009\ \pi \text{ in-mrad and } \Delta = 0.07 \text{ mrad.}$$

These values are consistent with the assumed emittance used in the design of the new SEB Switchyard (Reference 3).

New measurements were first made at high intensity (7.5×10^{12} protons per pulse), yielding

$$E^{V}_{rms} = 0.009\ \pi \text{ in-mrad and } \Delta = 0.14 \text{ mrad.}$$

These values confirm the measurements made in December of last year and given in Reference 4. The beam size is as expected in the vertical plane and much larger than expected horizontally. The horizontal emittance is too large for efficient Switchyard operation.

The problem in the horizontal plane could come either from the AGS internal emittance being too large (by a factor of 4) or from problems during extraction that blow up the beam size in the horizontal plane.

Measurements were then made at low intensity (2.5×10^{12} protons per pulse) and the beam was found to be considerably smaller:

$$E^{v}_{rms} = 0.003\ \pi \text{ in-mrad and } \Delta = 0.07 \text{ mrad.}$$

The low intensity was obtained by reducing Linac pulse width.

If the beam size is not blown up during extraction, and the internal beam shape is Gaussian, then the horizontal emittance is related to Δ by

$$E_x^{rms} = \left(9\beta_{F5}/\sqrt{3}\right)\ \Delta^2$$

Also, the normalized emittance at, for example, 95 percent of phase space area, is related to the unnormalized rms emittance used here by

$$\beta\gamma\pi\varepsilon^{95\%} = -2\ \ln\ (1-0.95)\ \beta\gamma E^{rms}$$

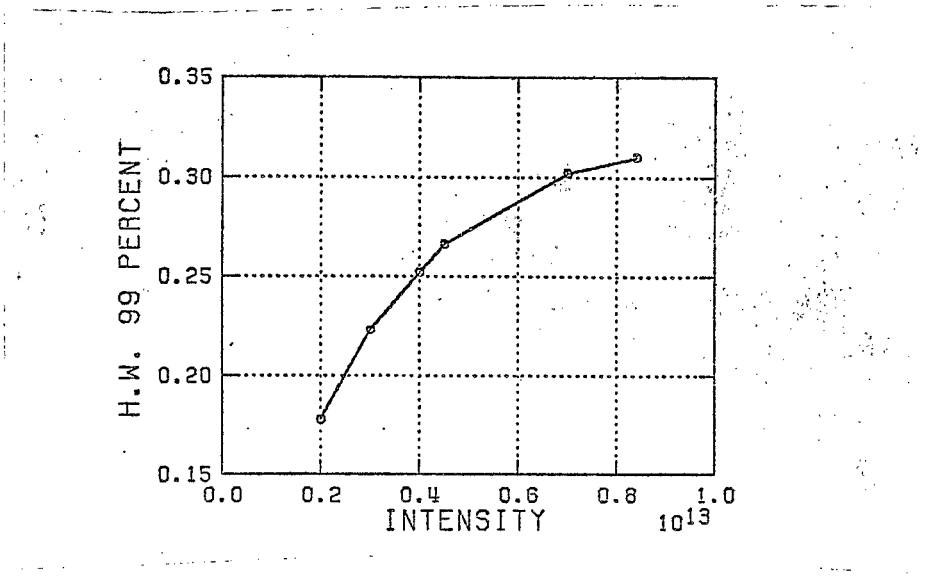
Our measured extracted beam sizes then translate into values of $\beta\gamma\pi\varepsilon^{95\%}$ in mm-mrad that can be compared with other estimates of internal emittance:

Intensity, Protons/Pulse	H	V
7.5×10^{12}	130π	42π
2.5×10^{12}	35π	14π

The estimated measurement error for these values is ± 25%.

These are reasonable values for the vertical plane, but much too large for the horizontal.

A set of measurements was made, at different intensities, of horizontal beam size at CW100 (where it is most sensitive to internal emittance). The result is shown on the next page. The reason was to search for an intensity threshold; none was seen.



Finally, the horizontal beam size at CW100 was studied at 2.5×10^{12} protons per pulse for various kinds of injection tuning, with the results given below, expressed as half-width at 99% in inches.

Intensity	Injection Detuning	H	V
7.5×10^{12}	--	0.39	0.46
2.5×10^{12}	Linac Pulse Width	0.20	0.20
" "	Vertical Steering	0.29	0.38
" "	Vertical ν Quads	0.17	0.32
" "	Manual Phase	0.25	0.33

These measurements show that, at low intensity, the AGS beam remembers all the way through acceleration and extraction how big it was and what shape it had at injection. During these tests no attempt was made to go clearly through phase transition.

A good measurement of internal horizontal beam size is needed to determine whether the SEB problem is with internal emittance or with extraction.

References

1. H. Weisberg, Improved Measurements of Slow-Extracted Beam Emittance, Nuclear Instruments and Methods 169, 11 (1980).

2. H. Weisberg, SEB Emittance Measurements, AGS Division Technical Note No. 155, October 1979.

3. H. Brown, et al, The AGS Slow External Beam Switchyard, BNL 24508R, December 1979.

4. H. Weisberg, More SEB Emittance Measurements, AGS Division Technical Note No. 168, February 1981.