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ACCELERATOR DEPARTMENT
Informal Report

SOME COMMENTS ON AGS BUNCH AREAS

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Abstract

Recently, Fainberg and Kalogeropoulos have measured the bunch width in a bunched extracted beam. This width is probably less than that of the internal beam. Application of their method to the internal beam is possible.

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In a recent note, Fainberg and Kalogeropoulos⁽¹⁾ describe measurements of the width of bunches in an external beam extracted via the usual resonant extraction system but with full rf bunching in the ACS. They report a bunch width of ≤ 4 nsec FWHM after correction for their counter resolution. The bunch shape fits a distribution function of $\exp(-|t - 220|/1.7)$. With this function, the FWHM is actually 2.4 nsec and 95% of the beam is contained in a base width of 10 nsec.

For ISABELLE, the bunch area is an important parameter. This area can be deduced from the bunch width by the expression

$$A = \pi \frac{\chi^2}{f_o} \left[2^{-h} \left(\frac{\cos \varphi_s}{|\eta|} \right) eV E \right]^{1/2}.$$

Here f_o is the rotation frequency, h the harmonic number, φ_s the stable phase angle, $\eta = \frac{1}{\gamma^2} - \frac{1}{\gamma_\tau^2}$ where γ_τ is the transition energy, eV is the peak rf energy gain per turn, and E the total energy. χ is the half width of the bunch in units of the circumference of the machine. This expression is strictly true only for small oscillations about φ_s . Using

$$f_o = 3.7 \times 10^5 \text{ Hz}$$

$$h = 12$$

$$\cos \varphi_s = 1$$

$$eV = 3.00 \times 10^5 \text{ eV}$$

$$E = 30 \times 10^9 \text{ eV}$$

$$\eta = \frac{1}{30^2} - \frac{1}{(8.75)^2} = 0.01195$$

$$\chi = 5 \times 10^{-9} \text{ sec} \times 3.7 \times 10^5 \text{ sec} = 1.85 \times 10^{-3}$$

we find

$$A \sim 0.2 \text{ eV sec.}$$

This is smaller than the 0.36 eV sec used for the ISABELLE design⁽²⁾ which was assumed attainable only for lower intensity beams.

Clearly it is of great interest to know this area. Unfortunately, the bunch width measured in the external beam is probably smaller than what circulates in the machine. The mechanism for this difference is as follows:
We picture the bunch in the machine as in the sketch

occupying a region in momentum and x space. The vertical axis can also be labelled as v because of the chromaticity of the machine. For the extraction process, the bunch is moved vertically to the resonance line. Clearly the ellipse containing the particles remaining touches the resonance line at one point and, with this simplified picture, a zero width beam is extracted. Actually, the exact v value for resonance extraction depends on the betatron phase space and, therefore, a finite band of particles comes from the top of the ellipse resulting in a pulse width greater than zero but still less than the total width inside the machine. The details of the width can only be worked out if the distributions in the (p, x) and horizontal betatron phase spaces are known along with many parameters of the machine.

This model suggests several comments:

1. If this bunch structure is used for time of flight physics, other parameters of the machine in addition to obvious rf parameters may need to be controlled and monitored to keep the bunch width stable.
2. Some parameters such as chromaticity can possibly be adjusted to provide further narrowing of the width to enhance the applicability of this method to time of flight applications.

3. The bunch width results measured externally should not be used to infer the internal bunch structure.

4. The internal bunch structure could be derived from use of this technique with counters looking at an internal target which is slowly moved vertically into the beam. This target would sample the (p, χ) space uniformly and avoid the narrowing which occurs in the extraction process. The method is basically sound and simple with corrections for counter resolution that are no worse than the corrections for bandwidth normally needed for wide band pickup electrodes.

5. Comparison of internal beam and external beam pulse widths might conceivably be of value to study aspects of the extraction process.

References

1. The AGS Beam Structure, A. Fainberg and T.E. Kalogeropoulos, BNL Informal Report 18938 (unpublished) 1974.
2. A Proposal for Construction of a Proton-Proton Storage Accelerator Facility - ISABELLE, BNL 18891 (unpublished) 1974, p. 34.