MPS/DL - Note 69-19
25.6.1969

NOTES ON AN INFORMAL TALK ON THE AGS SLOW EJECTION

(June 24, 1969)

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1. BEAM EMITTANCE MEASUREMENTS

The emittance determination is based on the beam profile measurement with a 12 slit .05" wide (~ 1 mm) venetian blind Aluminium SEC. The emittance is deducted from 3 profile measurements with 3 values of the current in a set of quadrupoles upstream in the beam.

The results are the following :

	Announced at '69 Wash. Conference	Calculated in report AADD 131	Adiabatic damping based on AGS aperture	Measured in May-june 1969
ϵ_V (inch. mrad)	.09	.035	.017	.03
ϵ_H (inch. mrad)	.036	.015	.011	?

The beam emittance system is connected on a PDP-8 computer which can take up data corresponding to 20 settings. The technique consists in measuring a beam profile - Draw the best fitting curve - Take the width of the distribution (at $\frac{1}{e^2} \sim \frac{1}{10}$ the peak amplitude) and plot this as a function of the quadrupole strength. One can then use the least square fit to find the transform matrix coefficients and from there compute the emittance. For the moment the profile width is measured manually, one hopes to educate the computer to do this operation in order to achieve an automatic emittance measurement.

The emittance sampling is done in 1 msec.

PS/7294

A new detector array is under construction to improve the resolution especially for the radial emittance, by making narrower slits (.02 or .03 " ?).

In the 1/3 integer resonance of the AGS slow extraction the stop-band is very narrow ($\Delta Q = .003$) but the separatrix changes more with momentum than in the CPS integer resonance. The horizontal emittance is therefore larger but the resonance is easier to control because the equilibrium orbit does not "wobble around" so much. If one goes faster than 100 ms through the resonance there is an appreciable part of the beam which is not ejected.

2. EFFICIENCY

It is still a very unclear problem.

It is determined by activation of the Carbon in Polyethylene foils; the latest SEB (Slow Ejected Beam) efficiency measurement was :

$$\epsilon_{SEB} = \frac{\text{foil}}{\text{circulating beam monitor}} = .071$$

with a 300 ms spill and a large momentum spread (.5%).

The fast beam efficiency was :

$$\epsilon_{FEB} = \frac{\text{foil}}{\text{circulating beam monitor}} = .086$$

The relative slow ejection efficiency is : $\frac{\epsilon_{SEB}}{\epsilon_{FEB}} = .83$.

It is however believed that the fast ejection is more efficient (around 95%) and that the real SEB efficiency is somewhere between 80 and 85%.

One source of loss has already been located and will be suppressed. It is the $3\lambda/2$ orbit bump which will be cured by having only a $\lambda/2$ bump.

3. SEPTUM MAGNETS

The SE uses now 2 septum magnets a .03" thin septum in F5 and a .$\frac{1}{4}$" thick septum in F10. A 1 mil , 1.5 m long electrostatic septum will be installed after the shut down.

A 30-40 cm model has been tested successfully in the external beam for a few hours. Two types were tested: tungsten wires wound on form and a 2 mil foil. The voltage was 100 kV over a 1 cm gap. No current was detected during the beam traversal, there was no arc. The pressure was $2.5 \cdot 10^{-6}$ Torr. The septum location is not yet fixed. If put in E 10 the effective thickness would be 2.5 mil and the expected efficiency 99%.

Improvements foreseen on the magnetic septa consist in changing many small mechanical details.

The insulation performed by Norton Abrasive Co. is quite satisfactory. It is a white ceramic coating, Alumina-like, but the exact manufacturing process is unknown.

The only radiation sensitive component left is the epoxy used for the steel insulation.

4. HIGH FREQUENCY STRUCTURE

The high frequency structure was observed with a HP 8552 spectrum analyser. One found the revolution frequency and its multiples. The 12th harmonic (acceleration frequency) was not higher than the other components. However, the measurement was made with a hole in the beam due to a previous fast extraction.

Before flat top the momentum spread is .5 to 1‰ . A 160° phase jump is performed for 2 ms before turning the RF off. The momentum spread is increased to 5 ‰. The radial spread in equilibrium orbit is . 3" and the tune spread $\Delta Q_H = .08$. The cavity is then run down to injection frequency. There is little voltage left on the cavities during the spill.

In the absence of this momentum spreading one observes after about 100 ms a rebunching on the 12 and 24 harmonic of the revolution frequency. This gets worse with high intensity but is cured by momentum spread. This phenomenon is not understood.

5. LOW FREQUENCY STRUCTURE

The major component left is 120 c/s. It can be reduced at best to 30 to 40% modulation of the SEB intensity by feeding an auxiliary quadrupole with the ripple frequency to act on the machine tune (This has mainly reduced the 360 c/s component). In operation one has often close to 100% modulation. The modulation comes from a combination of the main magnet and of the quadrupole supply ripple. An improvement is expected by introducing better power supplies after the shut down.

A strange phenomenon is the presence of a 120 c/s ripple on the sum signal and 60 c/s on the difference signal of the SEB position electrodes.

The normal spill length is 300 ms. One is trying to go to 500 ms. The limitation is then due to the septum magnet duty factor.

6. FAST SLOW SPILL

Several methods were tried but with little success :

a) use of fast kicker. 200 µs spill - extraction of 1 bunch every
3 revolution,

b) rapid beam deflector - 3 msec spill but not efficient,

c)"inverted B spike"(at the beginning of magnetic field decrease).
5 msec unefficient spill of triangular shape,

d) the use of RF Ko is now envisaged.

7. SHARING WITH INTERNAL TARGET

The process consists in setting up the slow beam in F10 and then moving in radially a target at the standard G10 location.

Moving the target in radius by 2 mm changes the percentage from 0 to 50%.

The radial control stabilisation is therefore very critical.

The target is located between the beam and the transformed in G10 of the F5 septum. The target must be very near the unstable fixed point and the particles do traverse it many many times. The target support is in the radial plane but is only traversed a few times by particles performing larger amplitude jumps.

In order not to destroy the secondary beam optics the target is stationary and the rate of sharing is varied by using a $\lambda/2$ orbit bump. The bump coil supply is controlled by the target spill counter adjusted for the desired sharing percentage; while the SEB is controlled by feeding its monitor signal in the main magnet supply $\dot{B}$ control to keep the SEB intensity constant. The two servos are independent. One must of course adjust the SEB servo reference level to a lower value to have a spill of the desired length when sharing.

When 75% of the beam is used on an internal target the vertical emittance is increased by a factor 1.6. This factor is 1.4 for 50% sharing.

Multiple scattering plays an important role in this sharing process. The closed orbit inward motion due to energy loss after target traversal ($\Delta r \sim 10$ μ inch/target passage) is probably offset by the betatron amplitude increase, but these effects are submerged in the multiple scattering and in the resonance process.

There is little increase in horizontal emittance.

The process is very sensitive to coupling.

In fact the whole AGS slow ejection is sensitive to coupling and when working above 25 GeV it is necessary to use quadrupoles to shift the working point away from coupling resonances.

Sharing works well up to 75% (on the target) But a deterioration of the SEB quality appears above 60%.

Sharing worked to the user's satisfaction for two days. However, there was a large low frequency structure both on the target burst and on the low beam; but it was not much worse than in normal SEB operation.

8. CONVERSION PROGRAMME AND FUTURE PLANS

- No second slow beam and therefore no sharing between two slow ejections is envisaged.
- The intensity on the G 10 targets will be limited to 20%.
- There will be one slow beam in F10.
- The two small bubble chambers fed by the E20 target will be removed elsewhere.
- The B10 and I10 fast extraction points will be suppressed.
- All fast extractions (including neutrino experiments) will be done from a single fast extraction in H10.

External beam sharing is envisaged. A cryogenic aluminium splitter (at liquid N_2 or even H_2 temperature) is studied. The aluminium must contain less than $1/10^6$ impurity. Radiation will probably damage it but annealing is possible. A .2 mm thickness seems possible.

Work goes on on 40-60 kG superconductor magnets for synchrotrons.

O. Barbalat

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