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Comment on RHIC-PG-52 "Electron Trappings In RHIC From A Debunched Proton Beam"

G. R. Young

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Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy
USDOE Office of Science (SC)

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RHIC-PG-55

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B N L

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"Electron Trapping in RHIC from a Debunched Proton beam"

The following drift distances are quoted in RHIC-PG-52 for electrons moving for a time $t = \eta \tau_e$, where η is the allowable charge neutralization coefficient for a betatron tune depression $\Delta\nu = 0.0025$ and τ_e is the production time for one electron per proton. Values are $\eta = 0.0005$ and $\tau_e = 1.21$ sec.

The drift velocities are

free $v_e \sim 1 \times 10^7$ cm/sec

dipole trapping $v_D = 3.5 \times 10^5$ cm/sec

quadrupole trapping $v_Q = 6.8 \times 10^6$ cm/sec.

The drift lengths $v \eta \tau_e$ quoted were

$l_D = 212$ m

$l_Q = 4119$ m

These should be

$l_D = 2.12$ m

$l_Q = 41.19$ m

The dipole term dominates; it is less than the length of the proposed CBA dipoles. Thus these electrons cannot be cleared; one must use less beam or go to bunched proton operation.

In CBA there was even more current, but the vacuum was much better notably in the dipoles 10^{-11} warm, not cold. Half the problem at present comes from CO in the warm region at an assumed pressure of 10^{-9} torr.

A solution to the problem would be to drop the warm pressure to 10^{-11} torr and ensure ~~bak~~ bakeout of all gas except H_2 which is always there.

Then one gets the following gas composition (see RHIC-PG-51)

warm 25% of circumference
Equivalent Nitrogen pressure 10^{-11} torr
100% H_2 300°K

cold 75% of circumference
Equivalent Nitrogen pressure 10^{-11} torr
50% He, 50% H_2, 4.2°K

Gauge efficiency 100% CO, 50% H_2, 50% He

in warm $(0.5)\, n_{H_2} = n_{N_2}$

in cold $(0.5)\, n_{H_2} + (0.5)\, n_{He} = n_{N_2}$

and $n_{H_2} = n_{He}$

By Definition $n_{N_2} = 2.687\; 10^{19}\, \frac{P_{torr}}{760} \cdot \frac{273.16}{T_{°K}}$

so

$n_{N_2} = 3.22\; 10^{5}/cm^3$ warm

$2.30\; 10^{7}/cm^3$ cold

Densities	warm (25%)	cold (75%)
H_2	$6.44\; 10^{5}/cm^3$	$2.3\times10^{7}/cm^3$
He	—	$2.3\times10^{7}/cm^3$

Then the electron production rates are $\frac{dn}{dt} =$ ~~[struck out]~~ $c\sigma n$
where $\sigma = 1.8 \times 10^{-19} Z_{target}$ cm^2 for relativistic protons ionizing residual gas

H_2^+	.188 /s/proton
He^+	.186
total e^-	.374 /s/proton

or a time between electron productions of 2.67 sec which is 2.2 times longer than before.

This gives a dipole drift length of $l_D = 4.68$ m

which is tantalizingly close to the length of 5 m dipoles. Clearing electrodes could then handle the electron load.

Better cold region vacuum would solve this