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Calibration of the Stripped Electron Collector--Status Report

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Subject Calibration of the Stripped Electron Collector--Status Report

Introduction/Summary

H^- particles injected into the AGS ring are stripped of their two electrons within the B1 magnet. These electrons spiral on to a plate mounted perpendicular to the stripping foil. The plate itself is connected to the center conductor of a coaxial cable which is terminated in MCR. The efficiency of this collection is the subject of this report. If all electrons were collected, and the coax were terminated in 100 Ω, every milliamp of H^- current would generate 2 mA x 100 Ω of voltage in MCR. The effective resistance of the stripped electron collector would be 200 Ω ($V_{observedMCR}/R_{eff}$ = proton current). Historically, use of this ideal calibration has resulted in an apparent inefficiency between the current measured in HEBT and in the stripping foil. Further, this inefficiency qualitatively agreed with the observed injection inefficiency, leading to the conclusion that local loss at the very end of HEBT upstream of the stripping foil was a significant contributor to the inefficiency. The present calibration disagrees with this, and suggests little loss in entering the ring.

The calibration concentrates on the B5 (downstream end of B5 magnet) current transformer, a relative newcomer to the ring instrumentation. The calibration of B5 is checked with and without beam, and the B5 is used to set an upper limit on the beam current coming through the stripping foil. In fact, this current agrees with the current measured upstream of the foil in the downstream end of the HEBT implying the same current is present at the foil, which then calibrates the stripped foil collector.

Procedure

The calibrations make use of as much redundancy as possible. The monitors involved are (1) stripped electron monitor (SE); (2) B5 current transformer (B5) at gain setting medium (high and low settings are also available); (3) the L20 "CERN" slow current transformer (L20S); and (4) the L20 intermediate current transformer (L20I). B5 and L20S have calibration turns included in their construction. Two beam shapes are also used. The basic calibration uses a long single turn, with the beam intentionally wiped off after passing the device being calibrated. A stacked beam involving many turns allows a cross calibration between B5 and the less sensitive (L20S and L20I) monitors. The cross check is weakened due to the different rise and fall times of the devices, and the fact that the signal being measured is changing with time--beam is being lost.

Results

The B5 current transformer with medium gain is calibrated using its calibration winding giving sensitivities on a terminated cable in the Main Control Room of 5.9 ± 0.1 Ω using a 10 mA pulse and 6.15 ± 0.05 Ω using a 100 mA pulse. The L20S has a sensitivity of 5 Ω (which in this note means a 1 Amp proton beam gives 5 Volts of signal at the MCR).

A cross calibration between B5 and L20I is motivated by Figure 1 showing the similar wave forms for B5 and L20I for stacked beam. L20I does not have a calibration winding, but L20S does. Figure 2 shows L20I and L20S. The initial shapes differ due to different rise times. An estimate of relative sensitivity is possible away from the front edge yielding an effective resistance for L20I of 1.19 ± 0.02 Ω. This can be combined with Figure 1 to give an independent estimate for B5 of 6.03 ± 0.3 Ω consistent with the internal calibrations.

Finally, Figure 3 shows B5 and SE for a long single turn. Using the above sensitivity, B5 yields 22 ± 2 mA. The HEBT current transformers reported 22-23 mA. If then 22 mA is present at SE (physically located between HEBT and B5), the sensitivity of SE is 175 ± 15 Ω instead of the ideal 200 Ω.

Summary of Measurements

Internal Calibration

	10 mA Pulse	100 mA Pulse
B5 H	59 ± 1 Ω	---
M	5.9 ± 0.1 Ω	6.15 ± 0.05 Ω
L	---	2.35 ± 0.05 Ω
L20S	5 Ω	

Stacking

$$\frac{\text{Voltage (L20S)}}{\text{Voltage (L20I)}} = 4.2 \pm 0.05$$

$$\left.\frac{\text{Voltage (B5M)}}{\text{Voltage (L20I)}}\right|_{\text{measured at the peak}} = \frac{3.55 \pm 0.05)\ \text{V}}{(0.70 \pm 0.01)\ \text{V}} = 5.07 \pm 0.15$$

Single Turn

SE	3.8 ± 0.1 V
B5M	130 ± 5 mV
HEBT IX	22-23 mA

Conclusions

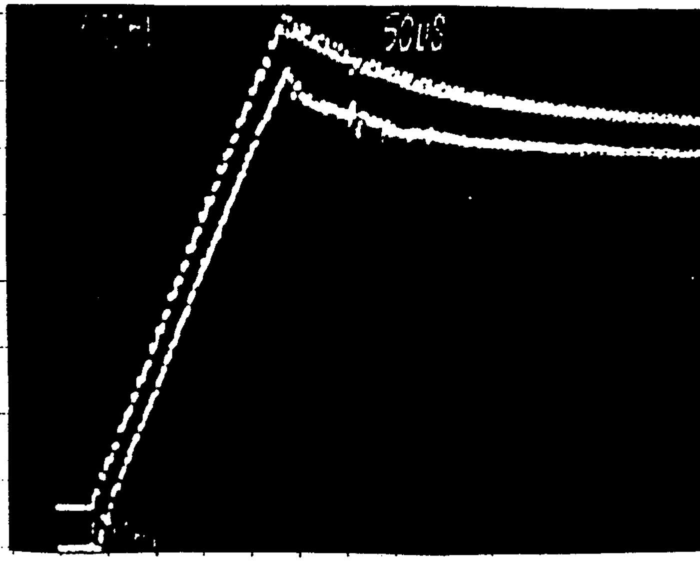
The B5 current transformer sees no first turn injection loss and requires an effective resistance for SE of 175 ± 15 Ω instead of the ideal 200 Ω. It should be stressed that the quoted errors are nearly as large as the loss being considered. Perhaps the techniques can be refined to reduce these. It has been pointed out (D. Barton) that L20I could probably be included in the single turn cross calibration measurement by wiping the beam off using the A13 injection magnet. Finally, if the SE efficiency for collecting electrons is only 175/200 = 88%, this efficiency may depend on the injected beam position relative to the collecting plate and such an effect which has not been seen in casual past work would be worth searching for.

Fig 1

stacking

B5 (M) +

L20I



← B5 (M) 500mV

← L20I 100mV

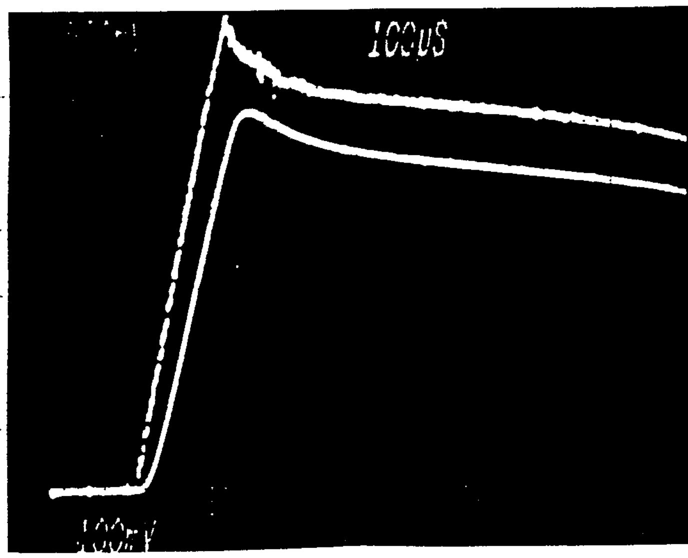
(50 μs)

Fig 2

stacking

L20I +

L20S



← L20I 100mV

← L20S 500mV

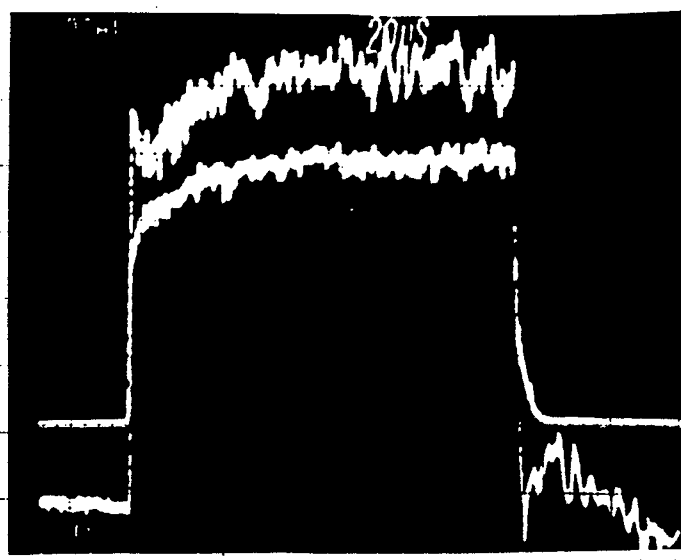
(100 μs)

Fig 3

single turn

SE +

B5 (M)



← B5M (20mV)

← SE (1V)

(20 μs)

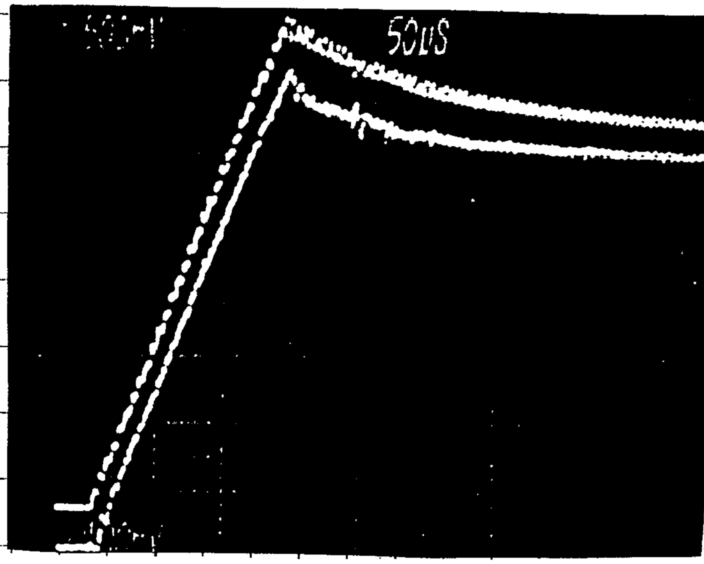
← SE

← B5M

Fig 1

stacking

B5 (M) +
L20I



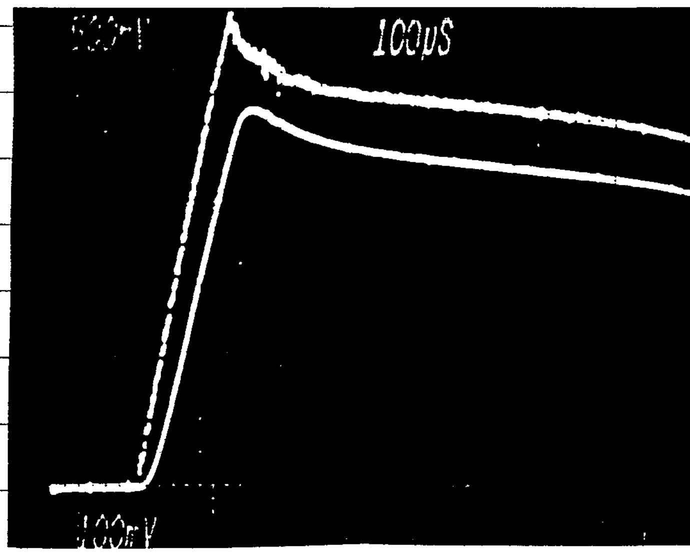
← B5 (M) 500mV
← L20I 100mV

(50 µs)

Fig 2

stacking

L20I +
L20S



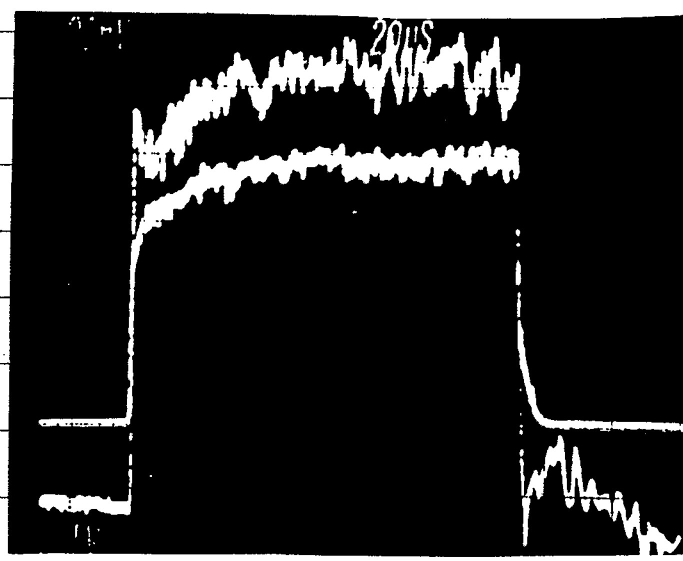
← L20I 100mV
← L20S 500mV

(100 µs)

Fig 3

single turn

SE +
B5 (M)



← B5M (20mV)
← SE (1V)

(20 µs)

← SE
← B5M