BNL-104528-2014-TECH

AGS/AD/Tech Note No. 96;BNL-104528-2014-IR

# THE E20 WIDE BAND PICK-UP ELECTRODE

E. C. Raka

June 1972

Collider Accelerator Department

**Brookhaven National Laboratory**

**U.S. Department of Energy**

USDOE Office of Science (SC)

## DISCLAIMER

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

AGS DIVISION TECHNICAL NOTE

No. 96

E.C. Raka
June 26, 1972

# THE E20 WIDE BAND PICK-UP ELECTRODE

This electrode is a 7-1/2 in. diameter, 12 in. long cylinder located in the forward half of the upstream chamber at E20. External connection is made by a feed through located in a re-entrant cylinder of ≈ 4 in. in diameter that penetrates to within 2 cm of the center of the electrode. Previously the electrode was connected to an 8233 tube which drove about 400 ft of type C-3T transradio cable ($Z_o$ = 196 Ω). See drawing D06-E139.

This cable had an attenuation of 1.9 dB/100 ft at 100 Mc which represented the primary bandwidth limitation (see AGS Internal Report HH/HJH-1, 9/28/61). Another limitation of the old system was that of saturation in the neighborhood of transition as the AGS peak intensity increased. This can be seen as follows; the voltage induced on the electrode is given by

$$V = \lambda \ell / C$$

where $\lambda$ is the charge per unit length, $\ell$ the effective length of the electrode and C its capacity to ground. It is assumed that $\ell$ is small compared to the bunch length. If we assume $10^{12}$ protons/bunch and a 20:1 peak to average charge density at transition the peak line charge density will be $3 \times 10^{11}$ protons/meter. Taking $\ell$ = 1/3 meter and C = 50 μμf we obtain a peak signal of 320 volts for $1.2 \times 10^{13}$ protons or 32 volts at $1.2 \times 10^{12}$. Even if the maximum bunching ratio is 15 instead of 20 we would have 24 volts peak at $1.2 \times 10^{12}$ which is enough to overdrive the circuit shown in D06-E139.

In order to minimize the bandwidth limitation due to the signal cable 75 ohm alumifoam (Times Wire and Cable AM7578PJ) cable was run in several years ago but never used. This cable has an attenuation of .53 dB/100 ft at 100 Mc and 400 ft of it would give 3 dB loss at about 175 Mc. It was not clear how to best make use of this increased bandwidth since another limitation of the tube circuit aside from the saturation effect were the problems inherent in obtaining a clean wide band response.[1,2] The scheme of G. Schneider[3] was also considered with the idea of putting the electronics at the end of the 400 ft of cable rather than only a few meters away.

Finally, however, a completely passive method was tried out. Since the induced signal is quite large in the region of interest (transition and beyond) and a Hewlett Packard 183 scope with 250 Mc of bandwidth at 10 mV/cm was available for wide band observation, a simple RC compensated attenuator was constructed to drive the 75 ohm cable. This consists of a 10 K 1/4 watt carbon film resistor forming the lead from the PUE to the vacuum feed through. Immediately outside the vacuum a 75 ohm resistor paralled with a 56 $\mu\mu$f fixed and a 4-30 $\mu\mu$f variable capacitor were connected to the feed through. Also affixed to the latter was a 75 ohm type N connector. The nominal attenuation here is 267:1 with the stray capacity across the 10 K resistor being compensated with the variable capacitor. This was adjusted using a Hewlett Packard vector voltmeter and driving the electrode directly up to 50 Mc.

Since the input impedance of the 183 is 50 $\Omega$ one must put 25 $\Omega$ in series with the scope to match the cable. Peak signals at transition of 250 mV at $3 \times 10^{12}$ have been observed. It should also be pointed out that with this method one has quite adequate low frequency response since the RC is $10^4 \times 5 \times 10^{-11} = .5\ \mu s$ or $f_{LF} \simeq 320$ Kc. The maximum rotation frequency being 371 Kc and the bunch frequency $12\ f_o = 4.45$ Mc.

The increased bandwidth capability of this system was immediately apparent when the signal was observed in the neighborhood of transition. A strong ringing at 500 Mc was seen along with a weaker resonance at 250 Mc which seems to be present from the neighborhood of transition to the end of the acceleration cycle. It was relatively easy to remove the 500 Mc ringing from the observed signal by using a 200 Mc low pass filter borrowed from the Linac Group. However, its attenuation at 250 Mc is not sufficient to suppress that component and this reduces the present usefulness of the wide band electrode signal.

It is planned to obtain a 176 Mc low pass Tschebyeff filter which has at least 40 dB attenuation at 250 Mc. Also during the winter shutdown the chamber will be removed and the nature of the resonances studied.

References

1. H.H. Umstatter, "On the Transmission of Signals by the Wide Band Pick-Up Station," CERN, MPS/Int. SR 68-2.

2. H.H. Umstatter, "The Miminum Length and Shape of Proton Bunches at Transition at High and Low Beam Intensity," CERN, MPS/SR Note 69-11.

3. G. Schneider, "Method For Ultra Wide Band Pick-Up Signal Tranmission Without Active Electronic Elements Near the Capacitive Electrodes," CERN MPS/ Int. SR 69-1.

Distr. Dept. Admin.
AGS Division Physicists & Engineers