

## SUMMARY - MEETING VII BEVATRON RESEARCH CONFERENCE

November 17, 1953

4 PM Auditorium, Bldg. 50

Clyde Wiegand: Counting Equipment for the Bevatron

General

This discussion will review the results of a survey of present plans for the Bevatron counting equipment. Proposed counting facilities, tentative specifications for desired counting equipment, a view of past counting techniques, and some of the later associated circuits will be considered. The committee consisted of: Lofgren, Wiegand, Mack, Harris, Madey, Bandtel, Farnsworth, Deuser, Constantian.

Counting Facilities

Counting Area - Counting equipment and power supplies will be located in the space adjacent to the main Bevatron control room. Cable runs will connect this area to the experimental area by the west tangent tank.

General Facilities - The following electronic facilities will be available at start up:

1. 115 volt power (10 KVA) electronically regulated and supplied from a specially shielded isolation transformer. This transformer will be isolated from the Bevatron power lines and will have the secondary ground at one point to the main Bevatron grounding system.
2. Low voltage power supplies will include: 6-300 volt, 300 milliamperere electronically regulated power supplies. 2-150 volt, 200 milliamperere regulated power supplies, 4-2 KV, 12 milliamperere regulated supplies which will feed 4 high voltage metering panels. These panels will allow approximately 20 percent downward variation in supply voltage. An electrostatic voltmeter will be permanently installed which can be switched directly to any high voltage output cable. This will allow accurate resetting of photomultiplier voltages when experiments are interrupted.
3. Two delay boxes of 197 ohm impedance cable will be available. These will contain fixed delays of .2, .5, and  $1 \times 10^{-8}$  sec.
4. One mercury pulser will provide output pulses up to about one hundred volts with a rise time of approximately  $5 \times 10^{-9}$  sec.

Cables to Experimental Area - Interconnecting cables between the experimental and counting areas will include the following:

Signal Cables: 12-125 ohm, 6-197 ohm, 6-50 ohm

Power Cables: 18 H.V. cables to supply photomultipliers; 300 V, 150 V DC, and 115 V AC power cables.

Necessary precautions will be taken in shielding cables leading to the experimental area to minimize pick up due to transients produced by the Ignitrons of the Bevatron magnet power supply. All racks of experimental equipment in the counting room will be connected together and bonded to the central grounding system of the Bevatron at one point. The cable runs will be contained in conduit insulated from ground except at the counting room end and will terminate in insulated panels at the experimental area. Timing signals in the Bevatron current marking system will be available for gating electronic equipment at specified times during the acceleration cycle.

Desired Counting Equipment

Experimenters using the Bevatron beam will probably ask for equipment with

characteristics as follows:

Particle Detectors - Response time of  $10^{-9}$  to  $10^{-10}$  sec, and output currents of the order of tenths of amperes.

Coincidence Circuits - Resolving time approximately  $10^{-9}$  sec. These should respond reliably for various pulse amplitudes and should withstand large single pulses without feed through. One would like to have multiple inputs and multiple outputs to provide for coincidence and anti-coincidence work.

Scalers - Scaling equipment having a time resolution of  $10^{-8}$  sec to count the pulses from the coincidence equipment.

#### Equipment in Sight and State of Availability

Some of the desired counting equipment specifications can be met with existing standard equipment when accompanied by certain new designs.

Detectors. The time spread associated with the electronic avalanche of the photomultiplier constitutes a major limitation in fast counting techniques. For 1P21's and 5819's this is of the order of  $5 \times 10^{-9}$  sec. Organic scintillators approach this limitation whereas Cerenkov counters produce light pulses of about  $10^{-10}$  sec duration. The output of photomultipliers can be amplified directly by means of distributed amplifiers, e.g., Hewlett-Packard 460 series which have a rise time of  $2.6 \times 10^{-9}$  sec per amplifier. One would like to eliminate the amplifiers, and the recent development of a production model of a 16 stage photomultiplier (RCA 4646) should allow this. The 4646 is expected to give an output of several tenths of an ampere. A few of these are now being made by RCA; and according to Hugh Bradner, some are being tested successfully at Brookhaven. Others are being tested by Louis Wouters at Livermore.

Connectors: 50 ohm cables are desirable for signal cables because of the availability of constant impedance connectors. Unless there are serious objections, 50 ohm cables rather than 75 ohm cables (for which there are also constant impedance connectors) will be installed for use with the new high current output photomultipliers. Other cables can be installed at a later date if desired.

Coincidence and Anti-Coincidence Circuits. There are existing circuits for coincidence and anti-coincidence techniques which have resolving times comparable to that of the particle detectors. A satisfactory circuit in terms of resolving time and reliability is that described by Garwin.<sup>(1)</sup>

In this circuit, negative pulses are fed to the grids of conducting pentode tubes (6AHG) the plates of which are connected in parallel. About  $2/3$  of the plate current is supplied through one or more G7A germanium diodes in series with a resistance from  $B^+$ . The plate of the diode is held fixed in potential by a capacitance to ground. The remaining  $1/3$  plate current is supplied through a resistance alone. The G7A has a forward resistance of a few ohms; therefore, the voltage across it varies only slightly if the plate current decreases by one or more tubes being cut off. However, if all the tubes are cut off simultaneously the voltage across the diode reverses and a pulse appears at the pentode plates. The circuit is relatively insensitive to large single pulses due to the effective grid to plate shielding of the conducting pentodes. A natural development of this circuit, which has been followed by Brookhaven, is to effectively cancel the tube plate capacitances by the use of distributed amplifier techniques. Gangs of coincidence and anti-coincidence circuits of this type can be fed to a conventional mixer circuit and have been found to be reliable to 1 part in 1000 in actual counting experiments.

(1) R. L. Garwin, R.S.I. 24, 618, 1953

Scalers: It would be desirable to count up to  $10^3$  particles per beam pulse. For an assumed average beam time of  $10^{-3}$  sec, the average counting rate to be recorded will be  $10^6$  counts per second. Our standard laboratory scalers have a recording time of  $2 \times 10^{-6}$  sec. Therefore they must be preceded by a scaler with a resolving time of about  $10^{-8}$  sec. A suitable scale of 10 circuit has been developed by John Marshall of the University of Chicago. (2) This circuit, which utilizes EFP 60 secondary emission tubes, consists of a binary stage and a ring of five and has a counting time of about  $10^{-8}$  sec. A test model constructed at this laboratory has been found to have a recording time of 3 to  $4 \times 10^{-8}$  sec and appears to be quite practical. Using this equipment and assuming a beam of  $10^6$  particles per sec, the average counting loss would be 4 percent. The Marshall scale of 10 can be used as a pre-scaler to the Radiation Laboratory units which, owing to their 2 microsec resolving time, would contribute negligibly to the counting losses.

Secondary Emission Tube Amplifiers: Dick Madey and Paul Nikonenko have utilized the principle of amplifying negative pulses with EFP 60 tubes to produce a gain of 40 in 3 stages with a rise time of approximately  $10^{-8}$  sec. The amplifier has good non-over load characteristics and is suitable for amplifying output pulses of fast coincidence circuits.

Summaries: Harry Hoard  
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(2) Presented at 1953 Convention of I.R.E.