CERN TECHNOLOGY NOTE

B31 SECONDARY EMISSION DEVICES FOR MONITORING THE CPS EJECTED BEAMS

Ejected Beams

Two different types of high intensity and high density ejected proton beams exist around the CERN Proton Synchrotron.

Fast Ejected Beam

1) The fast ejected proton beam, in which all the 20 circulating proton bunches, or some of them, are ejected within the revolution period of the PS (∿ 2 μsec).

Slow Ejected Beam

2) The slow ejected proton beam, in which all the circulating debunched protons, or part of them, are ejected during a few hundred thousand revolution periods, giving what we call "long-spill" beams.

Monitoring Needs

The setting up and operation of both fast and slow ejected proton beams require a number of monitors for measuring beam intensity, beam position, and beam intensity distribution at a number of points along their transport channels.

These monitors must have the following features: reliability, reproducibility, high resistance to radiation, linearity without saturation, and they should be non-destructive, or cause negligible interference with the beam.

The intensity measurement of the fast ejected beam is measured by a "charge transformer", i.e. a special version of the Beam Current Transformer described in Technology Note B21. However, the sensitivity of this completely non-destructive beam monitor does not permit measurement of intensity of the slow ejected beam.

The intensity of the "long spill" burst of the slow ejected beam is measured by a method based on the secondary emission phenomenon. Fortunately this device can measure as well the intensity of the fast ejected beam. This means that intercalibration tests with the charge transformer are possible.

The measurement of the beam position and beam intensity distribution of all ejected beams is also based on devices using the secondary emission phenomenon.

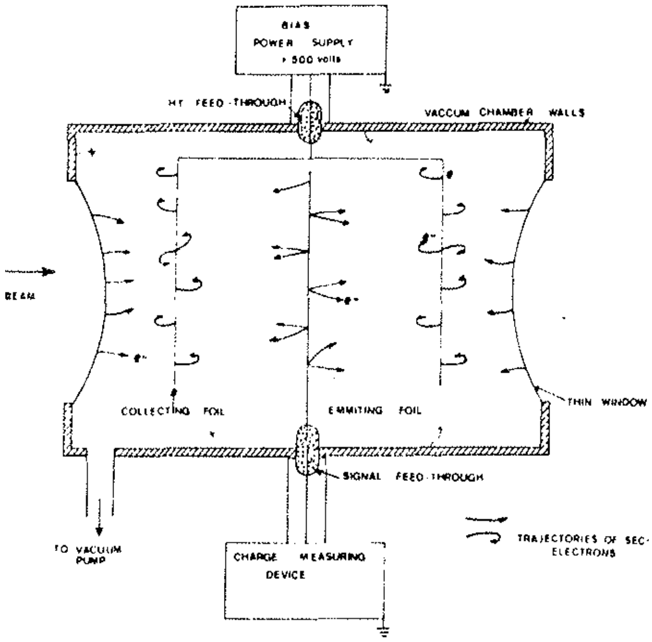


Figure 1 illustrates the principles of operation of a device using the secondary emission phenomenon.

The secondary emission phenomenon

When a charged particle (e.g. high energy proton) passes through a thin foil of metal it interacts through its accompanying electromagnetic field with the electrons of the foil giving enough energy to some of them to be emitted from the foil surfaces. The majority of these emitted electrons have kinetic energies of the order of a few electron-volts. This means that these electrons can easily be collected by applying weak electric fields perpendicular to the foil surfaces. In our applications the emitting foil is in the middle of two other foils which are positively biased. These bias foils collect the electrons of the emitting foil as well as those emitted from the bias foils themselves.

The secondary emission coefficient

The secondary emission coefficient is defined as follows

$$p = \frac{\text{number of emitted electrons per emitting foil}}{\text{number of charge particles traversing the foil}} \times 100\%$$

depending on the nature of the charged particle, its energy and the foil material.

In Table I, some secondary emission coefficients are cited for aluminium foils traversed by high energy protons.

TABLE I

Proton momentum in GeV/c	Secondary emission coefficient for 2,5 microns thick aluminium foil in %	
8	3,90	± 0.7 %
12	4,01	
16	4,13	
20	4,19	
24	4,30	
28	4,36	

Knowing the secondary emission coefficient, an accurate measurement of the number of emitted electrons will give a good measurement of the proton intensity.

The secondary emission coefficient is rather independent of the foil thickness (up to 1mm). However, in practice very thin aluminium foils (a few microns thick) are used so that they are almost invisible to the high energy proton beam which traverses them, causing negligible deterioration in beam quality due to scattering.

The secondary emission chamber

The secondary emission phenomenon is reproducible and linear only if a very high and clean vacuum exists around the foils. These conditions do not exist in the transport channel of the slow ejected beams. Consequently, for these beams the foils are enclosed in a 10^{-8} Torr vacuum chamber with very thin end windows (25 micron stainless steel). This assembly is called the Secondary Emission Chamber (SEC).

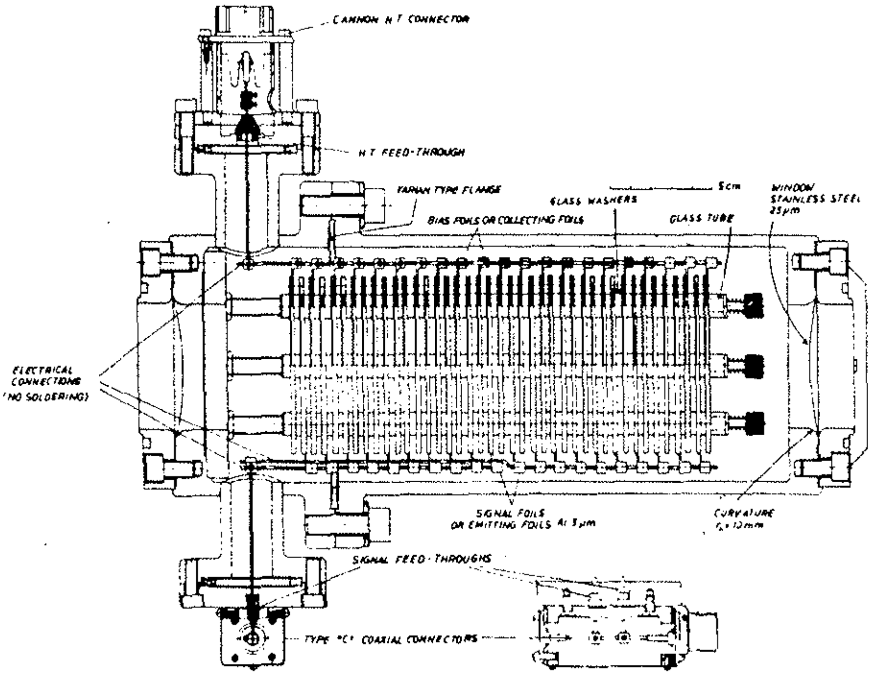


Figure 2 A schematic drawing of a secondary emission chamber. Half of the foils are used for beam intensity measurement; the other half has a circular central aperture and serves for beam diagnostics by giving signals only when the beam is not well focused.

Toposcope: beam distribution monitor

Measurements of the beam position and beam intensity distributions can also be made with secondary emission devices. One emitting foil can be divided into several strips, electrically insulated from one another. Then the signals of these strips give the beam position as well as the projected intensity distribution of the beam in the plane of the strips. Such a device has been given the name of "Toposcope". Elsewhere at CERN similar devices are called SEM grids (Technology Notes B25 & B29).

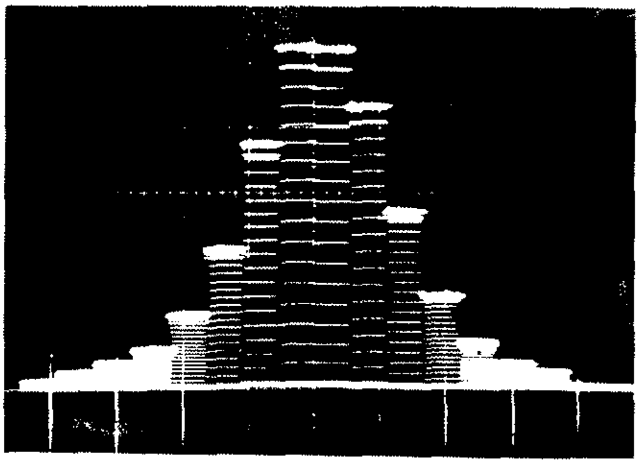
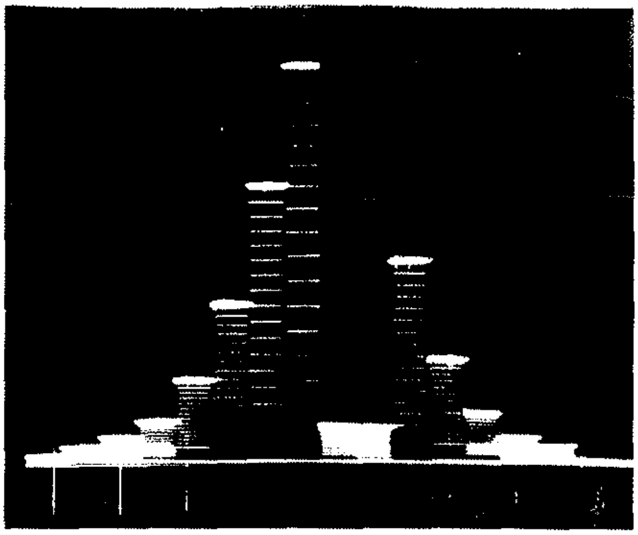


Figure 3 Two oscilloscope displays of a 16-strip toposcope placed in the e_9 slow ejected beam in front of the second septum magnet.



The first display shows the intensity distribution of this beam in the vertical plane with the first septum magnet out of the beam. The second display is with the first septum inside the beam and energized. Electronic settings : 50 scans per second, each column = 1 cm space.

References

1. Secondary emission chambers for monitoring the CPS ejected beams, Proceedings Daresbury Symposium on Beam Intensity Measurement. 1969

2. Secondary emission chambers (SEC) CERN courier april 1969 vol. 9 No4 page 103.

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