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A MULTIWIRE SECONDARY EMISSION PROFILE MONITOR FOR SMALL EMITTANCE BEAMS

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SUMMARY

A secondary emission monitor using two multiwire grids separated by a positively biased collector has been constructed and tested with a 1 GeV electron beam at the Orsay Linac. The monitor installed just before the electron-positron converter has 8 gold-plated-tungsten wires of 0.1 mm diameter equally spaced 0.2 mm apart in each plane. Each wire is connected with an integrator using a low-bias current operational amplifier. The wire planes and the collector are moved into the beam by a stepping motor : that allows beam-position verification. We measured narrow profiles for 1 Amp peak current pulses of 30 nanoseconds width. Profiles are displayed on a scope and allow emittance determination by the three gradient method. Such a monitor is very useful to control the electron beam position and dimensions on the converter, because the positron source dimensions are rather bigger than those of the incident beam and the geometrical acceptance of the positron Linac is limited.

CONSTRUCTION OF THE MONITOR

The profile monitor uses two grids of 8 goldplated tungsten wires. The 0.1 mm diameter wires are equally spaced 0.2 mm apart. Each signal plane is fixed on a Radiation Resistant Optical Glass (BK7 G25). Each wire passes on an eccentric guide-pulley and is fixed on a screw. Electric contact is precisely obtained on that screws. The tension on the wire is about 450 grams. Opening for beam crossing is about 15 mm diameter. A wire set is shown on Fig. 1.

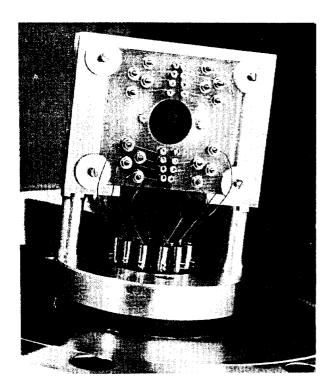


Fig. 1 - The profile monitor : a wire set

Between the two signal planes equally spaced from each one, a positively biased collector made up of a 0.1 mm thick aluminium foil, is fixed. Typical collector voltages are less than 100 volts.

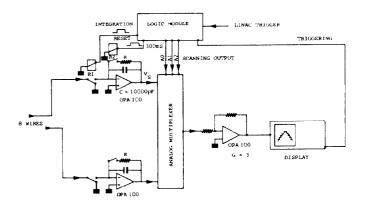
The overall width of the assembly is about 20 mm. Lateral dimensions of the isolating support are of $55 \text{ mm} \times 55 \text{ mm}$. The aluminium frame is fixed on a movable piece driven by a stepping motor. Exact position of the wire sets is attainable having a step displacement of 0.002 mm and a total travel of 45 mm. Taking into account the beam dimensions to be measured, such a travel is widely enough to avoid beam damages on the isolating support.

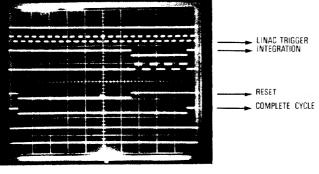
The wire sets are under vacuum and 200 mm before the positron converter.

SIGNAL AND ELECTRONICS CONSIDERATIONS

The monitor is based on secondary electron emission from the wires as the incident electron beam impiges on them. The number of secondaries is proportional to the primaries ; so we obtain on the set of wires a true image of the primary beam. The secondary emission coefficient has been measured with electron incident beams having energies between 30 MeV and 1000 MeV : yields of 3 to 3.5 % have been obtained. With a gaussian beam, a wire placed in the center of the distribution intercepts 9.5 % of a 1.7 mm diameter beam, whereas the one placed at two standard deviations intercepts 1.2 % of the beam. Measurements made using the stepping motor agree quite well with the estimations.

The positive charges obtained on each wire are integrated on a Miller integrator using the OPA 100 Burr Brown operational amplifier with low bias current -better than 1 pA at normal temperature- and high input impedance. A good stability with temperature variations was observed. The integrating capacitor is of 10 000 pF. The drift voltage values observed were less than 0.2 mV/S. The reset, integration and reading sequences are provided by two relays having a high leak impedance. The integrated signals for each plane are connected with analog multiplexers. The cutput of the multiplexer is then amplified by a factor of 5 before display on a scope. A scheme of the electronic system is presented in Fig. 2.





The timing sequences are given in Fig. 3. The timing

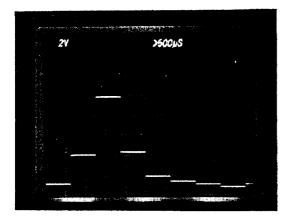
Fig. 3 - Timing sequence ; scale 40 ms/div.

schedule as the operating mode is chosen by means of a logic module. Two modes are used : the first one consists of a permanent cycle : reset, integration, reading, reset... and the second one of a single cycle.

The number of beam pulses to be integrated may be chosen from 2 to 256 representing roughly a maximum of 5 seconds duration. That possibility is useful for a beam dynamic range of more than two orders of magnitude. Usual intensities were of 1 Amp. peak current for 25 to 30 nanoseconds duration with a repetition rate of 50 Hz.

PROFILE MEASUREMENTS

Display of the signal obtained on horizontal and vertical planes is shown on Fig. 4. The beam position



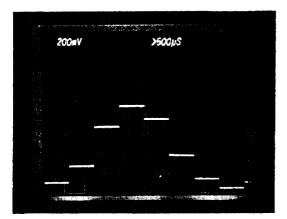


Fig. 4 - Beam profiles

and the beam width can be controlled in this manner. Beam widthes as small as 0.3 mm diameter were observed. The geometrical acceptance for the positron beam being limited at 3 mm diameter on the converter plane, it is necessary to obtain on the entry face of the converter an electron beam spot of no more than 2 mm diameter for a tungsten converter.

EMITTANCE DETERMINATION

Profile measurements allow emittance determination by the three gradient method. More than three profile measurements are usually made in each plane to calculate the three coefficients of the beam emittance ellipses by a least square fitting. Using Brown formulation¹) one may write for the emittance equation in the (x, ∂) plane for instance :

$$\sigma_{22}(0) \mathbf{x}^2 - 2\sigma_{21}(0) \mathbf{x}^0 + \sigma_{11}(0) \theta^2 = \varepsilon^2$$
 (1)

where σ_{ij} (o) represents the coefficient of the beam matrix in the (o) plane where we wish to know the emittance and ε the emittance area value.

Beam width variation on the monitor is obtained by varying the gradients in a quadrupole triplet situated 3 meters before the monitor. If R represents the transform matrix from the entry of the quadrupole triplet -where we have to know the emittance- to the monitor one may write for the width of the beam at the monitor $\sqrt{\sigma_{11}}$ (1) -for the x plane- :

$$\sigma_{11}(1) = R_{11}^{2} \sigma_{11}(0) + 2R_{11}R_{12}\sigma_{21}(0) + R_{12}^{2}\sigma_{22}(0)$$
(2)

where R $_{\mbox{ij}}$ represents the coefficient of that matrix R.

Example of such determination is given for both planes on Fig. 5. The measured emittance area is of ϵ = 0.4 mm mrad at 1 GeV.

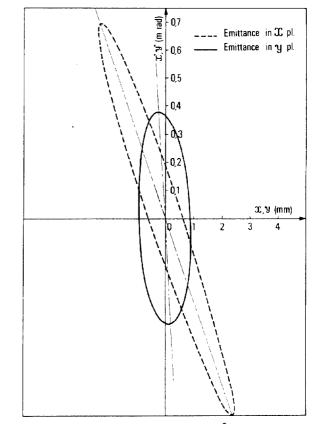


Fig. 5 - Emittance ellipses - E = 1 GeV - I = 1 Amp - τ = 25 ns

SOME COMMENTS

The situation of the monitor is near the converter where many back scattered particles coming back in the monitor direction contribute to noise generation. For a 1 GeV electron beam and a tungsten target of 3Xo thickness we have roughly 0.08 of backward electrons (e⁻ and e⁺) and 0.30 of photons for one incident electron²). That kind of noise was completely avoided retracting the positron converter.

REFERENCES

- (1) : K.L. Brown, D.C. Carey, Ch. Iselin and F. Rothacker Transport - CERN 80/04 (1980)
- (2) D. Crawford, H. Messel Electron-Photon Shower distribution function Pergamon Press (1970)

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