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IEEE Transactions on Nuclear Science, Vol. NS-28, No. 3, June 1981

A FAST BEAM PROTECTION SYSTEM

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Summary

The MEA 500 MeV high duty factor electron linac has been designed to accelerate electrons eventually on a pulse-to-pulse base. Each beam pulse may have a different current and/or energy and may serve one or several experimental beam lines. The usual beam protection systems impose limitations on this multi-user scheme. Due to good emittance of the electron beam, a very fine beam spot may be focussed accidentally on an unwanted place, causing damage within 50 microsec. Therefore a system has been developped which provides reliable beam shut-off within less than 10 microsec. Copper protection collimators positioned at crucial places will intercept a faulty beam. The gamma rays produced will then induce current in a special downstream compton battery, which is part of the emergency injector stop-line. More than 50 units have been installed to protect beam lines, vacuum valves, beam monitors, etc.

System description

The blockdiagram is shown in fig. 1.

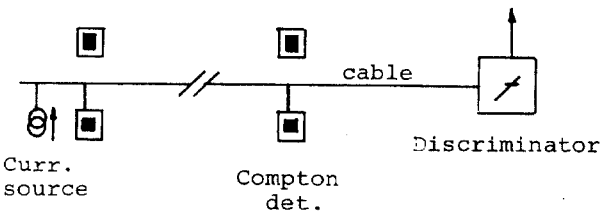

Fig. 1 Block diagram

The actual protection system consists of:
a. Compton detectors which act as current sources connected in parallel to a coaxial cable. They will be described later.
b. A semi-rigid coaxial cable of approximately 250 m long mounted along the accelerator.
c. A DC current source necessary to protect the system against open and short circuit cable faults.
d. A discriminator, which detects the currents from the current source and the compton detectors.

The time required to shut off the gun depends on the detector current, cable capacitance and delay, and discriminator triplevel.. Missteering a beam peak current of 50 mA causes beam shut-off within 10 µsec.

Compton detector prototype tests

Experiments had been performed with the old 85 MeV EVA linac, using a peak beam current of 100 mA, beam pulse length of 4 µsec. and a repetition rate of 25 pps. The beam energy was varied from 30 up to 70 MeV. The experimental setup is shown in fig. 2.

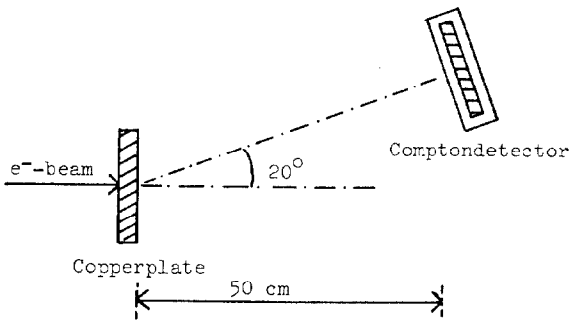

Fig. 2 Experimental setup

A copper collimator was simulated by a copper plate. The compton detector was made of a aluminum box containing a removable insulated lead absorber and a removable front scatterer. The output current of the detector had been measured as a function of thickness of the copper plate, aliminum scatterer and the leadabsorber. The front scatterer surface was kept constant (50 cm^2). The output current was measured across a 50 ohm load. Sample test results are shown in fig. 3. Results were strongly dependent on the geometry of the test setup and the focussing properties of the beam. Calculations indicate [1] that 5 cm leadabsorber is sufficient to capture most compton electrons. The results (fig. 3) indicate a 2 mm aluminum scatterer will be sufficient.

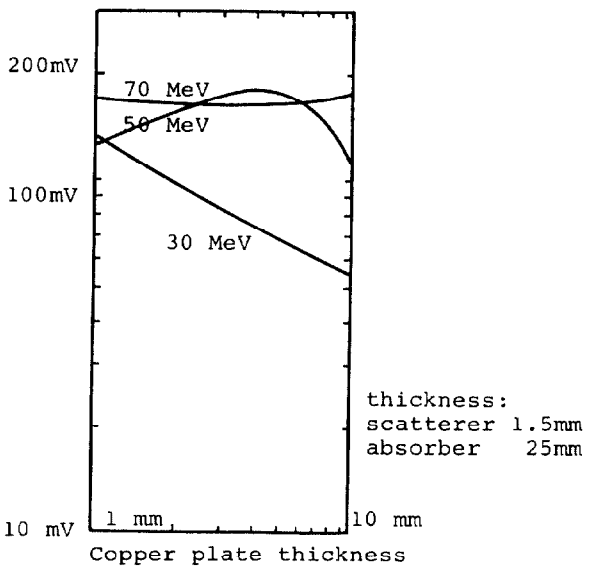

Fig. 3a Test results

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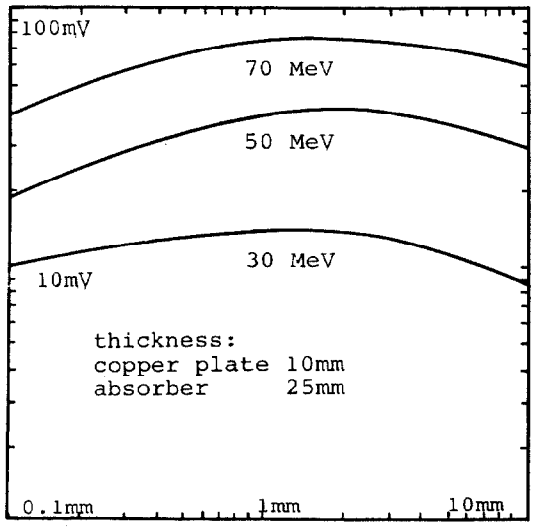

Al. scatterer thickness

Fig. 3b

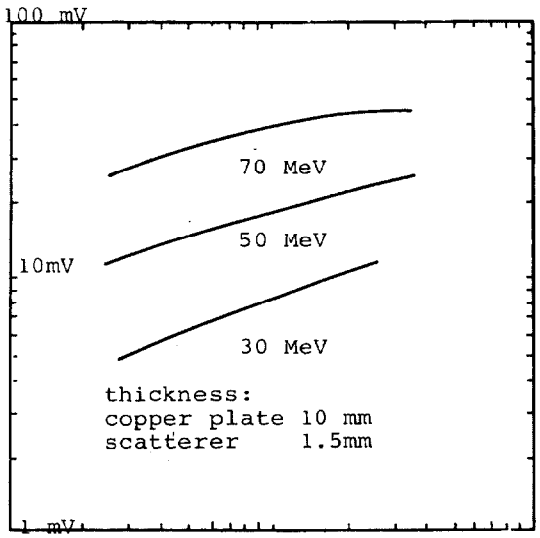

Fig. 3c

The compton detector construction

The compton battery consists of two separate detectors mounted in one aluminum box.
One detector is used for the beam protection system, the other is available for beam analysis.

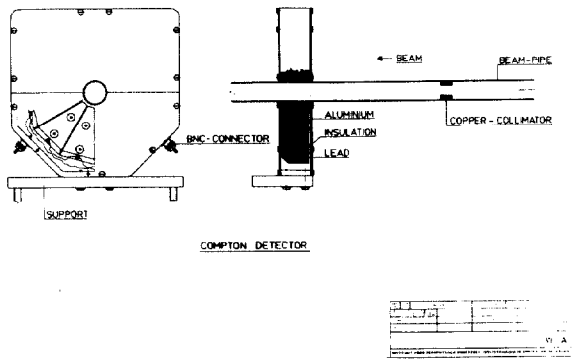

Fig. 4 Compton detector construction

Fig. 4 shows the construction of the compton detector. The front side of the aluminum box is used as scatterer. The absorber consists of lead wavers insulated from the box and each other. To obtain two similar detectors, the wavers are interleaved.

Conclusion

A system containing approx. 50 detectors are now in use. Several models have been adapted to geometric constraint of some beam lines. Initial operation with beams in the low energy halls (140 MeV) was very succesfull. Discriminator voltage levels are in the order of a few millivolts. Due to these low voltage levels special attention has to be given to avoid noise problems.

Acknowledgement

The work described in this paper is part of the research program of the National Institute for Nuclear and High Energy Physics, section Nuclear Physics (NIKHEF-K), made possible by financial support from the Foundation for Fundamental Research on Matter (F.O.M.) and the Netherlands Organization for the Advancement of Pure Research (Z.W.O.).

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