ABSTRACT

The operation of wire grids and wire scanners as beam profile monitors, both in terms of measurement accuracy and wire integrity, can be heavily affected by the thermal response of the wires to the energy deposited by the charged particles. A comprehensive model to describe such interaction has been implemented including beam induced heating, all relevant cooling processes and the various phenomena contributing to the wire signal such as secondary emission and 6-electron scattering. The output from this model provides a prediction of the wire signal and temperature evolution under different beam conditions. The model has thus been applied to the wire grids of the CERN LINAC4 160 MeV HE beam and compared to experimental measurements. This successful benchmarking allowed the model to be used to review the beam power limits for operating wire grids in LINAC4.

Simulation Model

Intensity Model:

The charge generated in the wire per incident particle can be summarized by the following equation:

\[ \frac{d e}{d\text{proj}} = Q_{\text{dep}} + Q_{\text{SE}} + Q_{\text{Th}} \]

The term \( Q_{\text{dep}} \) refers to the charge generated in the wire due to charge deposition of the incident particle, \( Q_{\text{Th}} \) refers to the charge generated due to the effect of secondary particle emission. \( Q_{\text{SE}} \) refers to charge generated due to thermionic emission.

Thermal Model:

During operation, the beam of particles deposits some energy on the wire material, which is translated into a temperature increase \( \Delta T_{\text{Tot}} \). For this model, the considered cooling mechanisms were Radiative Cooling \( \Delta T_{\text{Rd}} \), Thermionic Cooling \( \Delta T_{\text{Th}} \), Conductive Cooling \( \Delta T_{\text{Con}} \) and Sublimation Cooling \( \Delta T_{\text{Sub}} \). The temperature variation of the wires for each time step can be written as follows:

\[ \Delta T_{\text{Tot}} = \Delta T_{\text{Rd}} - \Delta T_{\text{Th}} - \Delta T_{\text{Con}} - \Delta T_{\text{Sub}} \]

Model Applicability: LINAC4 power limits.

LINAC4 beam power limits were calculated, to minimize the risk of overheating and damaging the tungsten wires. The temperature limit set for tungsten wires at LINAC4 was 1400 K due to the gold coating of the wires.

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