Design and Engineering of Modern Beam Diagnostics

Other Transverse Profilers Homework

1A: The Dune neutrino experiment at FNAL has a final transfer line that will supply 3 x 10^{14} protons per second at 120 GeV. Let's say we put Tungsten wire SEMs along the transfer line. Assume the wires are square cross section of 10 μm and 75 mm long. The beam size will be approximated as a uniform density 4 mm x 4 mm square. The dE/dx for 120 GeV protons in Tungsten is ~39 MeV/cm. How much energy is deposited in a wire per second at the center of the beam? Using the heat capacity of Tungsten, and assuming the entire wire is heated uniformly (use the whole wire for the volume of material), how fast does the temperature rise assuming no loss of heat from the wire? How fast does the temperature rise if the heating is only over a 10 mm long section of the wire? Is there a risk of it melting?

1B: Determine the secondary emission yield from the plot in the lecture (120 GeV protons). The units are per proton per surface, and the wire has two surfaces (entry and exit). How many secondaries per second are emitted from a wire located at the center of the beam?

2A: In the Booster at FNAL, we have 8 GeV protons. The vacuum pressure is ~10^{-8} mbar (torr). We wish to use an IPM to measure the profile, how many ionizations do we get over a length of 10 cm with a single pass of a 10 nC bunch? We will assume the residual gas is N_2 at room temperature which has an average ionization energy, w_i, of 35 eV. The dE/dx for 8 GeV protons through N_2 is ~2 MeV cm^2/g.