SPA6309 Mid-term Feedback

General points

1. Some people were confused between the interaction of charged particles, where dE/dx data from Figure 1 was required, and photons where the key data was contained in Figure 2 (photon mass attenuation length)
2. Quite a few careless errors in simple arithmetic (conversion of mm to cm, dividing powers of 10 for example) and in many cases no units given (or the wrong units) given in the answers.
3. Some very poor sketches with no axis labels and no numerical magnitudes. Easy marks thrown away, please take care to provide proper graphs.
4. Some appreciation of plausible order-of-magnitude values would have helped many of you spot errors in arithmetic. Shielding questions are never going to have answers which are < 1 atom thick for example. Similarly charge collection times in silicon strip diode sensors are in tens of ns not µs let alone seconds.

Question specific

Question A1 (both papers)

IMPORTANT: I noted during marking that in Q1(b) you need the value of the electronic charge *e*. I inadvertently left this off the list of physical constants. Following a discussion with our Director of Education it has been decided to ignore Q1(b) and thus mark out of a total of 34 rather than 40.

For any student (there were a couple only) who by this process received a *lower* percentage the *original higher* percentage (including mark for A1(b) and a total of 40 for the paper) was retained – the principle of “no detriment”. Nearly all students have benefitted from this adjustment, no one has lost out.

A1(a) was not generally answered well. Many people did not appreciate the avalanche gain near the anode and that most of the signal is caused by the movement of the positive ions back to the cathode.

Question A2 (First sitting)

Bragg peak seemed to cause some confusion; it is the peak in the energy loss per unit length (dE/dx). The “range” is the point at which no particles continue to penetrate the material (all their original kinetic energy having been lost primarily through ionisation). Water (H_2O) is best approximated as carbon, but I did not deduct marks if values appropriate to H_2(l) was used.

Question A2 (Second sitting)

(a) Making assumptions that dE/dx does NOT vary with energy is the quick and simple way to solve this problem. Of course it over-estimates the range and the better way (which I did not expect anyone to do) would be to use the dE/dx in bins of 25 MeV/c decreasing down from 600 MeV/c until 400 MeV/c

(b) Lack of collimation is due to single and multiple scattering; this leads to different path lengths and that provides part of the spread in energy. In addition dE/dx in figure 1 is (as shown by the <>) an *average* quantity subject to fluctuations about the mean even neglecting any scattering.

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Question A3 (both papers)

Identical, essentially, to one of the tutorial questions I set prior to the class test. Where many people made an error was in calculating the whole sensor volume rather than just the volume under one strip.

Question A4 (both papers)

(a) Almost no one remembered the order of magnitude of the cross-sections. A typical low Z material (example carbon which I used in my lectures) has a cross-section of about 10 kb @ 1keV and about 1 b at 1 GeV. For lead it is about 1 Mb and 10 b at these photon energies. This was a question where a neat sketch with labelled axes and the three regions indicated would have given you rather straightforwardly 4 marks from 5.

(b) Here there was confusion in some answers between a 1/1000 reduction in “strength” and a 1/1000 reduction in photon energy. Of course once photons interact they very often generate lower energy photons by Compton scattering but that isn’t what the question is asking. Several people got significantly wrong answers by not correctly rearranging $1/(\mu/\lambda)$. This was a question where an appreciation of order-of-magnitude thickness would have helped many people spot errors.