Scorza Questions (email 12/5/2014)

1. We calculate radiogenic neutron spectra for the following material: copper, stainless steel, poly, titanium and borosilicate glass. Are they enough? Is there any material of better interest? If so, which one?
   ANSWERS:
   Dongming: It looks to me what you have done is sufficient. If you would like to do do one more, it may be Teflon, though the results may be similar to that of poly.
   Kimberly: We should add teflon, PTFE as I mentioned because of the import of fluorine in the alpha-n production in the TPCs. By species it is 1/3 C, 2/3 F , or .76 F by mass and .24 C by mass. I believe that the flourine will cause a significant difference from plastics that lack it, but that is quite anecdotal.
   Marco: I definitely think it would be good to add PTFE (because of F) and also Ceramic , which is present is the stem of some PMTs used in liquid noble detectors. The chemical composition can be either (Al_2 O_3) or (Ti_2 O_3). Aluminum in particular can be dangerous for neutron production.

2. Neutron spectra calculations assume secular equilibrium of U and Th decay chains. But, secular equilibrium might be broken: do we want to present a spectra comparison for the single isotope daughters in the U/Th decay chains? Maybe it is not needed for the paper goal, but we might want to say something about that.
   ANSWERS:
   Dongming: This is a good point. In general, due to migration differently, the long-lived isotopes, 226Ra, 222Rn, 210Po, 228Ra, 228Th and the associated the decay daughters should be calculated separately.
   Kimberly: This is a very good point. Instead of fully presenting spectra by isotope, can we say anything qualitative, or simply bound the error based on a realistic scenario of being out of equilibrium?
   Marco: I think we suggested this possible study at the beginning. But my understanding was that for the USD code it is not possible (at least not from the web tool) to have the neutron production separately for each alpha decay, so we gave it up. If DongMing and Chao can comment on this point and they say that it is feasible, I think it is very much relevant to add this study. In SOURCES it is quite easy to have the separate contribution. Even if we don't want to have the single alpha decays, we can anyway simply split the Th and U chains in two or three sub-chains: Th : from Th232 till Th 228, then from Th228 to the end. (even if this is not so relevant, as the first part of the chain will produce a negligible amount of neutrons) More important is to consider it for U238: from U238 till Ra226 and from Ra226 till Pb210 (or till the end) In particular the first part is relevant since it is very difficult to estimate its contamination using gamma spectroscopy.
   Another point: what about U235 ? Is there any possibility to study its neutron production with the USD code ?

3. Concerning the cross section comparison, I would show only Cu63, Cu65 - do you agree? Cross section study of the targets listed in section 2 http://www.physics.smu.edu/cooley/aarm/webpage.html is between EMPIRE (SOURCES) and TENDL. Hang, did you make the comparison of EMPIRE against the cross section Chao sent us? https://skydrive.live.com/#cid=97567B2787A2C828&id=97567B2787A2C828%21226
   ANSWERS:
   Dongming: Well, it would be good to show more and the cross-sections can be different for other materials.
   Kimberly: In my head we can go two ways. With our reasonably limited number of studies right now we could probably have a large appendix to the paper that covers everything. But the alternative of pointing to the webpage at http://www.physics.smu.edu/cooley/aarm/webpage.html and then there expanding the studies as needed or desired is a good one too. And probably far easier for us.
   Hang: For the differential cross section part, SOURCES4 (or EMPIRE) doesn't have corresponding numbers so we can't make a direct comparison on this part. For the total cross section files, I did do a comparison by using the USD numbers as the SOURCES4 inputs earlier this year. The spectra are shown in the attachment. They look smooth, so that's why we got the conclusion that the difference in

the spectra shapes might come from different calculation methods.

4. Differential vs total cross section: how to address it in the paper? Chao and/or Dongming would you mind to briefly remind me how the cross section libraries are implemented in your code? When we used your cross-section as input of SOURCES we used the nprod.tot63 /65 if I remember correctly (we only tested Cu).
   ANSWERS:
   Chao: we are using the differential cross section data to calculate the final neutron spectrum instead of total cross section data you used for SOURCES.
   Difference:
   Differencial cross section data: fixed alpha energy + target -> number of neutrons in different energy Bin (unit: barn).
   Total cross section data: fixed alpha energy + target -> number of total neutrons (unit: barn).
   I am not sure how SOURCES code convert the total cross section data into number of neutrons in different energy bins. That's something you need to find it out.