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Interactive comment on "Technical note: On the reliability of laboratory beta-source calibration for luminescence dating" *by* Barbara Mauz et al.

Anonymous Referee #1

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The manuscript presents new data on systematic effects encountered with regard to beta source calibration in luminescence dating. As the authors claim, source calibration is a central part in obtaining reliable luminescence dating results and systematic errors should be avoided whenever possible. While in the past 40 years numerous papers on that topic were published, the authors draw particular attention to the aliquot size and its impact on the calibration results, an aspect that has not been considered previously.

The dataset compiled by the authors on three different luminescence readers with various source geometries, grain sizes and aliquot sizes supports the conclusions drawn, as well as do the results of GEANT4 modelling in general. There are some slight discrepancies between experimental and modelled data that remain unexplained though. The same is true for the "edge effect" that the authors think to be the reason for the

observed dose rate dependence on aliquot size, but any details on underlying mechanisms are not provided. However, given the scope of the submission ("technical note") it would probably go too far to ask the authors for more in-depth analyses of related physical processes. In that sense, the study represents a valuable contribution for all luminescence practitioners and hopefully entails an enduring effect on how the sources will be calibrated in luminescence laboratories. I recommend publication after the issues detailed below have been taken into account.

Another aspect of the paper, which is rather mentioned on the fly, is the use of several gamma doses for beta source calibration and then taking the regression of a plot of gamma dose vs. recovered beta dose to derive the dose rate of the beta source. This is an approach that should certainly be promoted, and hence deserves a bit more weight in the manuscript (currently it is mainly mentioned at the end of the discussion), although the idea is not new (Bos et al., 2006, as correctly stated by the authors).

The manuscript is well written and logically structured, although some aspects of data presentation should be improved, as outlined below. I found some formal inconsistencies and oversights that need streamlining, such as the use of the terms "beta source" vs "beta-source" or the erroneous use of the unit "mm" instead of "μm". This can be easily done with a thorough round of proof-reading. Also, it seems that a wrong plot has been uploaded as Fig. 4; the authors should check this carefully. Some of the references in the bibliography are incomplete and should be checked also.

Specific comments

l. 22: What do you mean with "geometrical function"? Maybe just replace by "irradiation geometry"?

l. 39: What is meant with the "interplay between sample and sample carrier"? Please be a bit more specific here.

l. 75 (Table 1 caption): it should read "... are derived from MC simulation".

l. 79: I feel that the calibration quartz from Freiberg needs to be described regarding its main properties (origin, preparation, treatment before giving the gamma dose). While readers can look up in Hansen et al. (2015) for the DTU quartz, nothing is written here about the Freiberg quartz.

l. 87 (Fig. 1): The font size for most of the information contained in the figure is too small. On a print-out the letters can hardly be read. Please increase the font size.

l. 99 (Table 2 caption): Which stimulation power density was used for which aliquot size and why? Please provide the reasoning why you chose this approach.

Table 2, last row: it should be "R108_4", I guess.

l. 108: Does "depth of dose rate" mean "dose rate as a function of depth"? Consider re-phrasing.

l. 109: The units given for the simulated layers of the sample "cylinder" should be μm instead of mm, I would think (same in the caption to Fig. 2).

l. 130: Does this statement in brackets mean that the dose is registered in Gy for each starting particle, i.e. particle emitted from the source? In general, for readers not so familiar with simulation of irradiation, it would be beneficial to write one or two additional sentences on the specific purposes of the GEANT4 and MCNP6 codes, i.e. which code was used for which part of the simulation. In the current version of the text, this is not very obvious.

Table 3: Are the uncertainties for the dose rate given at 1-sigma CI (68%)? If yes, please add this information. It would further add the immediate comprehension of the table if an additional column with the "sample code" would be added. This information is provided in Table 2, but if given here as well correlations between the calibration results and the types of calibration samples could be established much easier. Finally, please homogenise the number of significant digits for the reported dose rates.

l. 157: How does the "total uncertainty of experimental data" of 5-8% relate to the

dose rate results shown in Table 3 (where the 1-sigma (?) uncertainty is in the range 2.0-3.4%)?

l. 165: It should read "... quoted at 95% confidence level...".

Table 4: I suggest expressing the difference in dose rate between different grain size fractions not in percent, but as a ratio, because in this way the direction of deviation is also indicated (similar to Table 3).

Fig. 3: Please mind the consistency of axis labelling (Dose Rate vs. Dose rate).

Fig. 4: This figure seems to be identical with Fig. 3a. Please check and update.

Fig. 5: Black and red dots in the caption (legend to plot) should be swapped.

Fig. 6: Why are the GEANT4 simulations skipped for grain sizes >250 μm, while they were carried out for the MCNP6 simulation?

Fig. 7: What is the purpose and meaning of the simulation without sample holder? Can inferences be made about the role/magnitude of electron backscatter from the sample holder? Maybe this aspect should be shortly discussed in the manuscript.

Fig. 8: If the dose rate is shown normalized to the 10 μm large aliquot simulations, why do the data start at $\sim$108% in the center of the sample carrier?

l. 236: It should read "linearly".

l. 234-242: Even after reading the paragraph several times, I must admit that I do not fully understand the logic behind it. Maybe it should be mentioned that the surface of a grain is approximated here as a 2D spherical plane, and not as understood as the real surface of a 3D spherical grain (if I got it right...). Probably this paragraph needs re-phrasing to clarify what you mean with the "edge effect". This affects also the discussion (l. 270-274), which should be adapted/expanded to add some explanations on the edge effect. Additionally, in line 239, it should be a reduction of absorbed dose by $\sim$3-5% (as compared to Fig. 8).

l. 249: “. . . of an individual beta source results from . . .”

l. 265: Consider writing “geometry” instead of “geometrical function”.

l. 278: Figure reference correct? There is no Fig. 4A (and Fig. 4 is probably the wrong one. . .).

l. 288: What is “purpose-prepared sample material”?

l. 293: Replace “Des” by “De values”.

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