

Experimental data

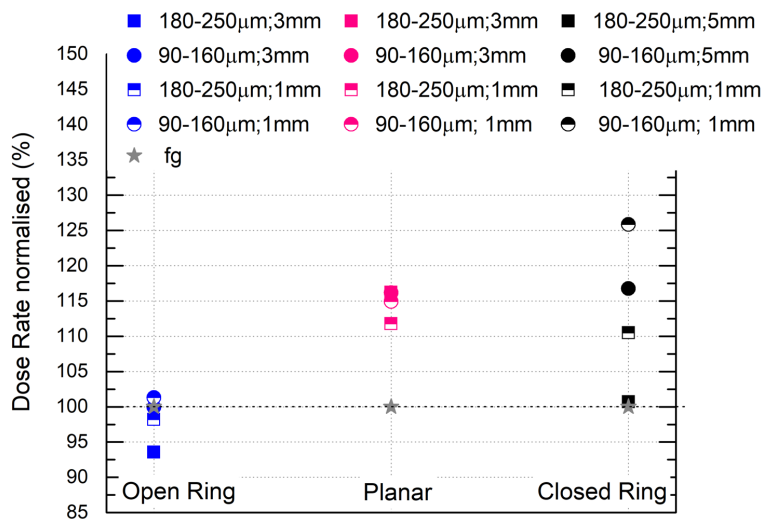


Fig. S1. Dose rate normalised to the respective fine grain (fg)-value versus beta source shape. Aliquot sizes are 3 mm and 1 mm for the open-ring (blue) and planar (pink) sources; they are 5 mm and 1 mm for the closed-ring (black) source. For the sake of clarity error bars are not plotted.

MCNP6.2 simulation

Detailed information provided by the manufacturer (A Richter, pers. com., May 2020) was used to design the irradiation geometry as realistic as possible (Fig. S2). Standard data for material composition and density were taken from Williams et al. (2006). The spectra of the $^{90}\text{Sr}/^{90}\text{Y}$ beta source were simulated using reference nuclear data tables (Chisté, 2005; Chisté and Bé, 2005). The MCNP simulation used the F6 tally designed to estimate the energy deposition (MeV/g) averaged over the target cell using atomic and mass (g) densities and heating response (MeV). The F6 tally includes all reactions and scores the corresponding quantities (e.g., number of tracks, see Table S1).

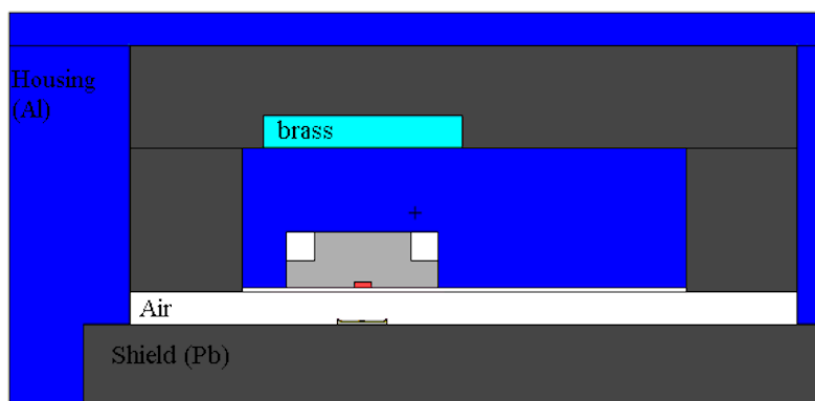


Fig. S2. Irradiation geometry of the lexsys *SMART* planar beta source (red) used in the *MCNP6.2* simulation.

Backscatter

Backscatter is the result of interaction between electrons and matter where the atomic nucleus of the matter generates deflections, hence scattering. The physics of the interaction is comprehensively described by Autzen et al. (2017). Disentangling the various interaction mechanisms (Table S1) shows that photon production through bremsstrahlung decreases with increasing grain size and aliquot size (Figs S3 and S5). The same trend exists for the electron production through knock-on (Figs S4 and S6). The trend is well-known (i.e., grain-size dependent backscatter effect; Wintle and Aitken 1977; Autzen et al., 2017). However, our data do not confirm the trend for the 1 mm aliquot as for this geometry the number of photons and electrons remains almost constant (Fig. S7).

Details of the MCNP6.2 simulation results

A table (print table 110 of the simulation output file) records the number of tracks induced by the various interaction mechanisms of a particle (electron or photon) with the material. The interactions are listed in Table S1. For each simulation run aliquot size (with a defined thickness and diameter made of SiO₂) was changed while everything else (e.g., irradiation geometry, number of initial particles) was kept constant.

Table S1. Summary of the number of tracks plots extracted from the MCNP output files of the simulations. nps = number of initial particles. See Figs S3-8 for graphical display of data.

nps= 1·10 ⁸	Interaction mechanism	Number of tracks (order of magnitude)	Trend of number of tracks plots with increasing aliquot size	Trend of number of track plots with increasing grain size
photon production	bremsstrahlung	≈8·10 ⁷	↘	↗ (10 and 50 μm) ↘ (others)
	p-annihilation	≈1·10 ⁴	↕	↕
	electron x-ray	≈1·10 ⁷	↗	↗ (others) ↔ (10 μm)
	1st fluorescence	≈2·10 ⁷	↘	↗ (10 and 50 μm) ↔ (100 μm) ↘ (others)
	2nd fluorescence	≈2·10 ⁶	↕ (1 mm) ↘ (others)	↗ (10 and 50 μm) ↔ (100 μm) ↘ (others)
electron production	pair production	≈1·10 ⁴	↕	↕
	compton recoil	≈1·10 ⁷	↕ (1 mm) ↘ (others)	↗ (10 and 50 μm) ↔ (100 μm) ↘ (others)
	photo-electric	≈1·10 ⁸	↘	↗ (10 and 50 μm) ↔ (100 μm) ↘ (others)
	photon auger	≈4·10 ⁶	↘	↘
	electron auger	≈1·10 ⁸	↗	↗
	knock-on	≈1·10 ¹⁰	↘	↗ (10 μm) ↔ (50 μm) ↘ (others)

Trend symbols:

- ↗ increasing
- ↘ decreasing
- ↕ increasing and decreasing (not systematic)
- ↔ stable

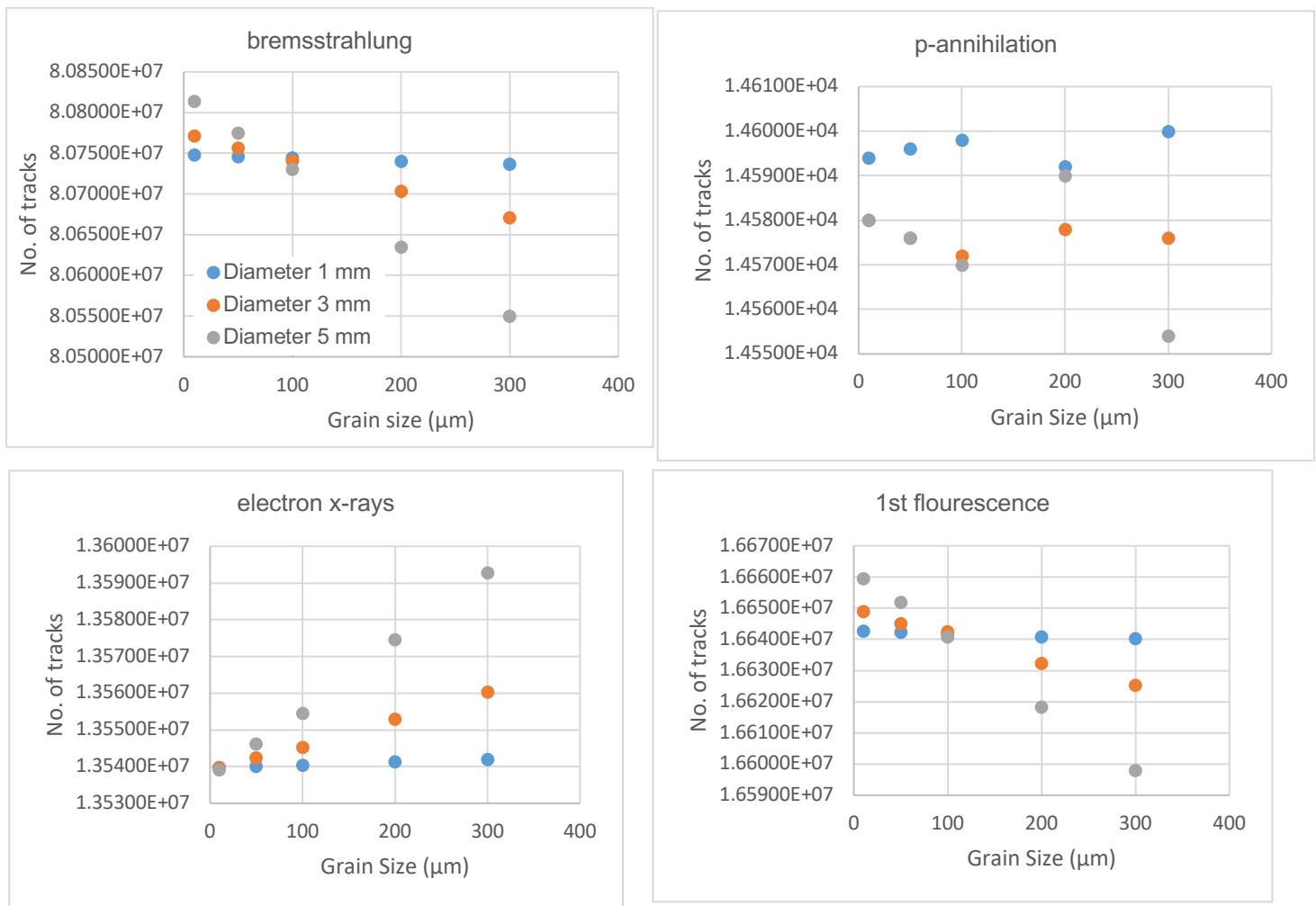


Fig. S3. Gamma production (no of tracks) as a function of grain size for three aliquot sizes. For key of symbols see top left panel.

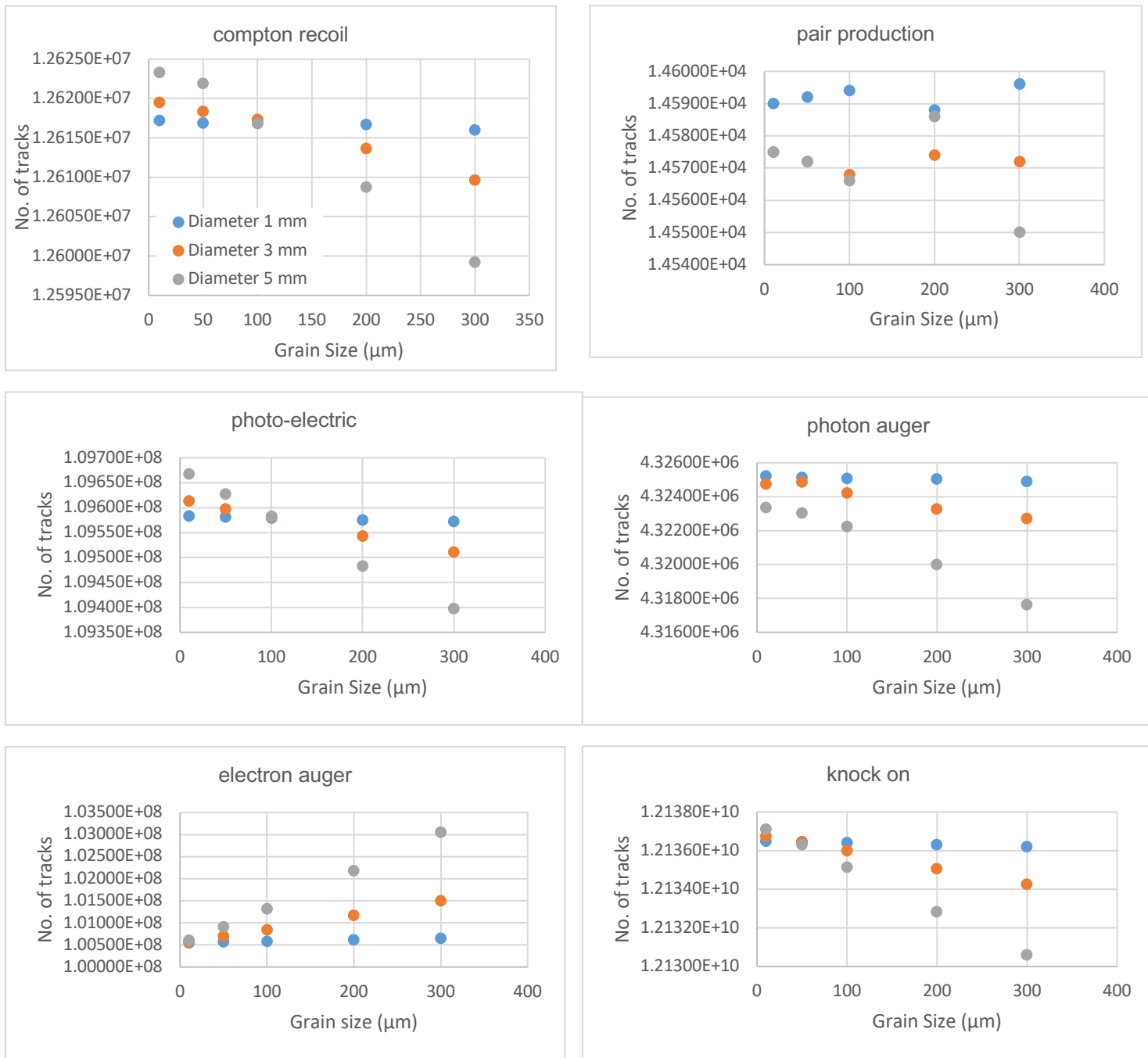


Fig. S4. Electron production (no of tracks) as a function of grain size for three aliquot sizes. For key of symbols see top left panel.

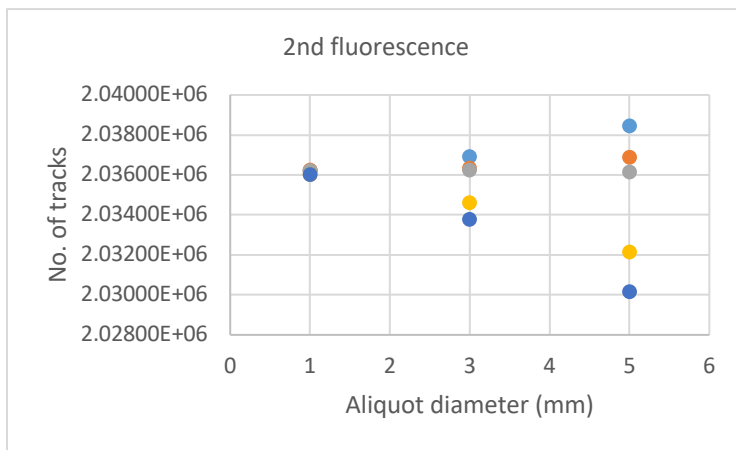
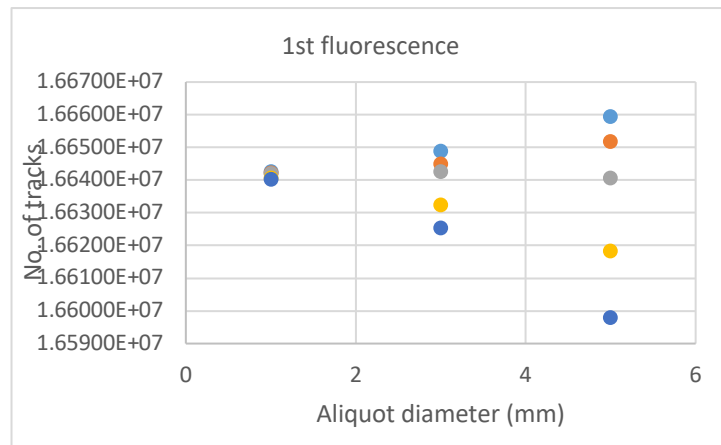
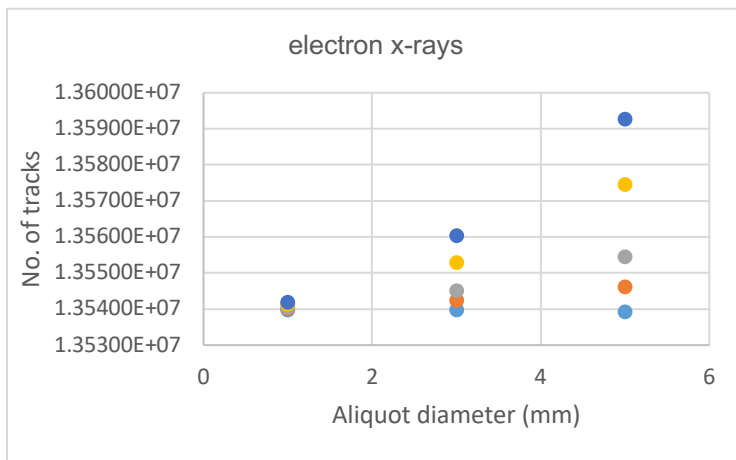
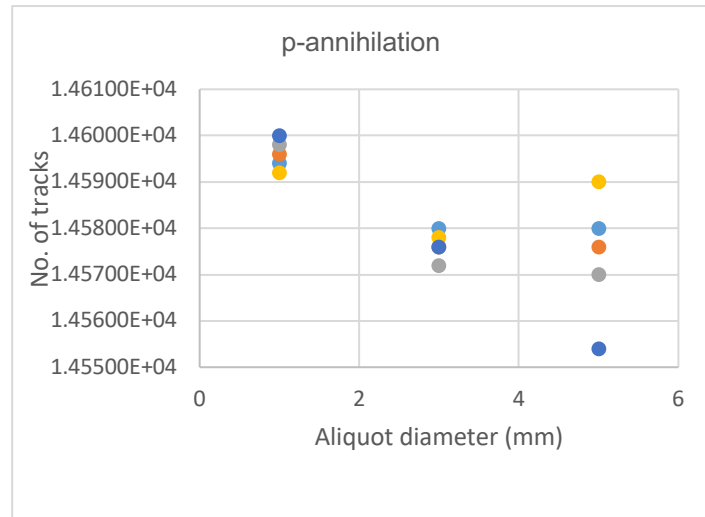
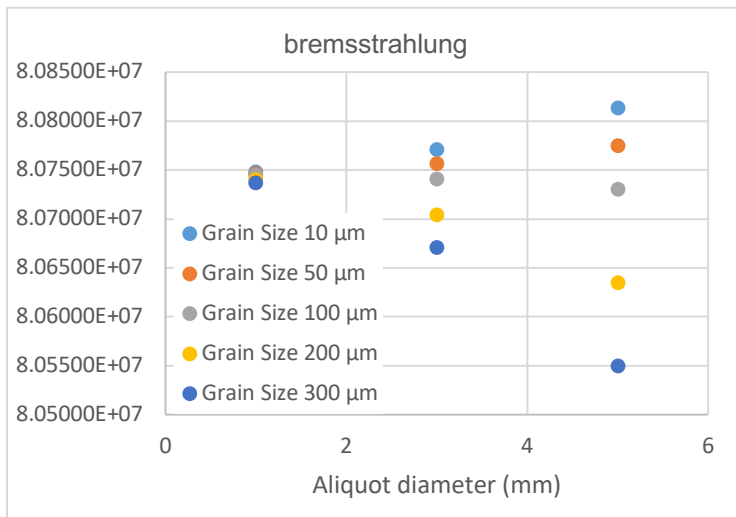


Fig. S5. Gamma production (no. of tracks vs. aliquot diameter) in grains of 10 μm to 300 μm in small, medium and large aliquots. For key of symbols see top left panel.

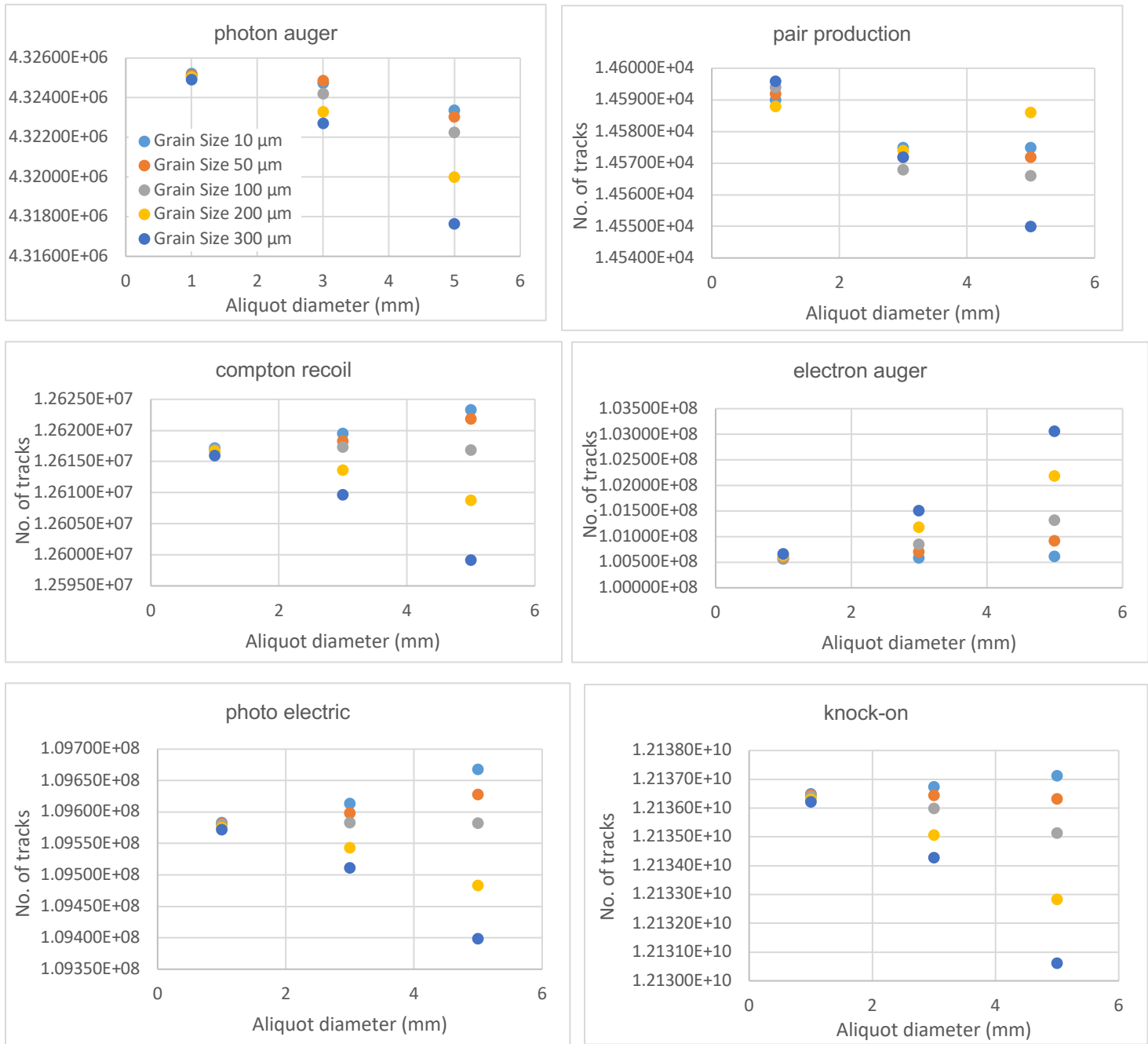


Fig. S6. Electron production (no. of tracks vs. aliquot size) in grains of 10 μm to 300 μm in small, medium and large aliquots. For key of symbols see top left panel.

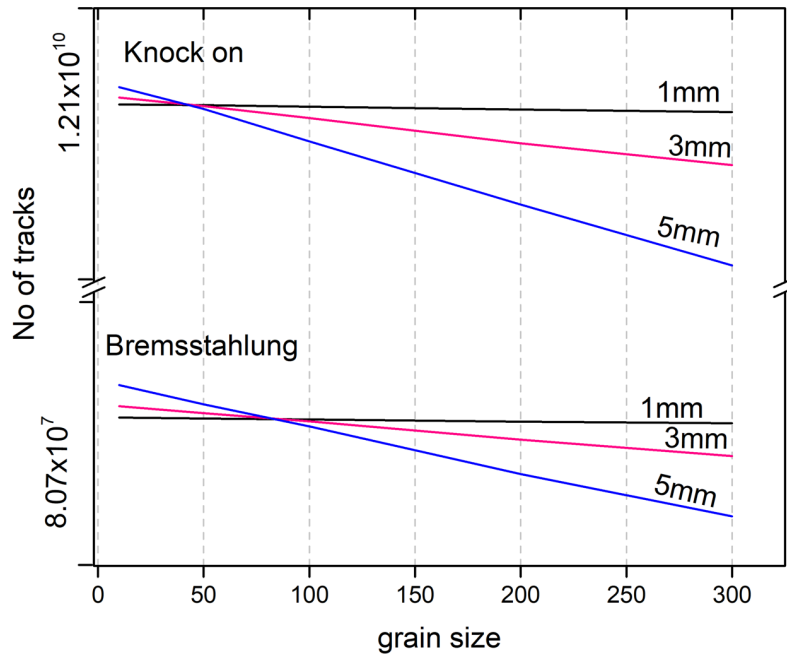


Fig. S7. Result from MCNP6 simulation: The two major interaction mechanisms for electron and photon production with regard to grain size and aliquot size. The decrease of interactions with increasing grain- and aliquot size is noticeable, but it remains within the same order of magnitude for each mechanism.

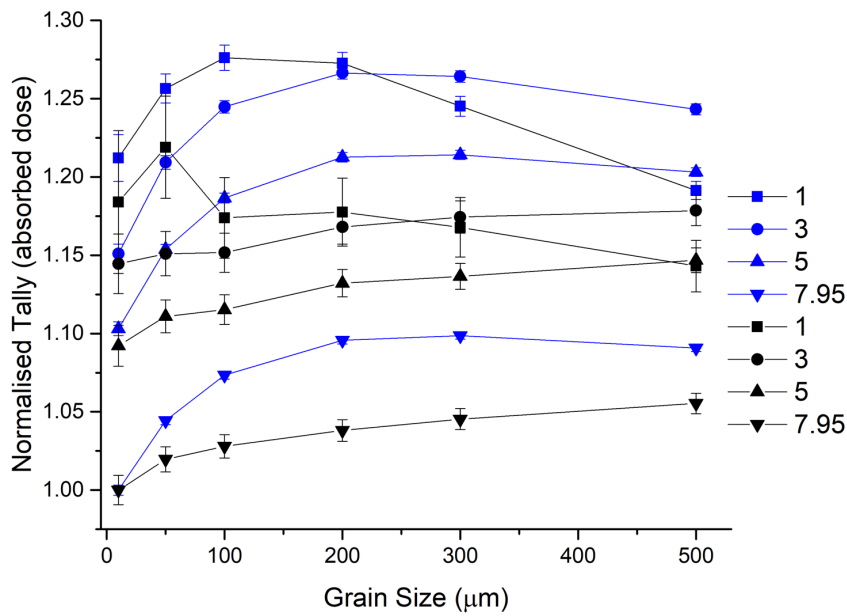


Fig. S8. Result from MCNP6 simulation: absorbed dose in grains of 10-500 μm size for electrons (blue) and photons (black) in small, medium and large aliquots. Numbers in key indicate aliquot size (mm).

References

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- Chisté, V., 2005. LNE-LNHB/CEA - Table de Radionucléides, Laboratoire National Henri Becquerel. Available from: http://www.lnhb.fr/nuclides/Sr-90_tables.pdf (28th September 2020).
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