Experimental data

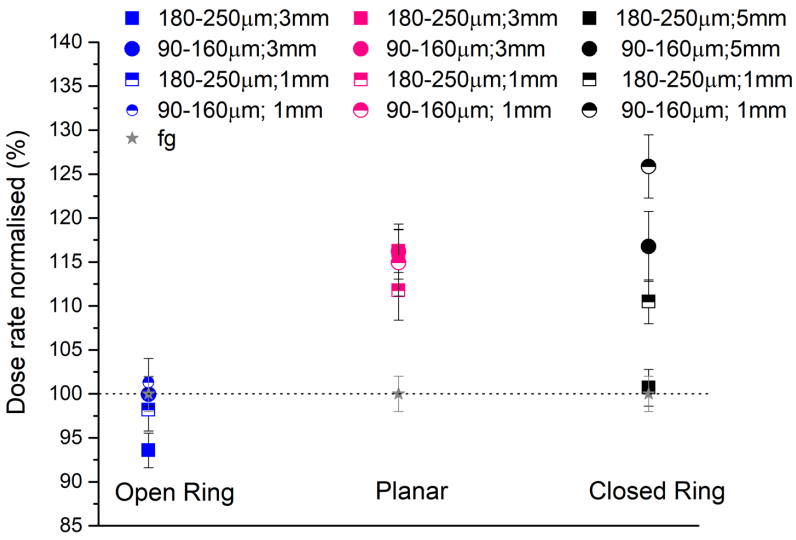


Fig. S1. Dose rate normalised to the respective fine grain (fg)-value versus beta source shape. Aliquot sizes are 3 mm and 1 mm for the open-ring (blue) and planar (pink) sources; they are 5 mm and 1 mm for the closed-ring (black) source.

***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}Sr/^{90}Y beta source were simulated using reference nuclear data tables (Chisté, 2005; Chisté and Bé, 2005).

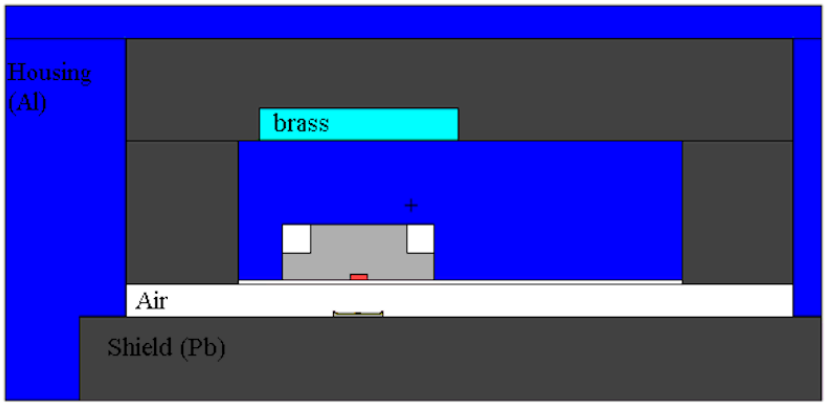


Fig. S2. Irradiation geometry of the lexsyg *SMART* planar beta source (red) used in the *MCNP6.2* simulation.

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 trends are well-known (i.e., grain-size dependent backscatter effect; Wintle and Aitken 1977; Autzen et al., 2017) with the exception of the one of the 1 mm aliquot where 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 and/or diameter of the cylindrical target (with a defined thickness and diameter made of SiO_2) 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= $1 \cdot 10^8$	**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	$\approx 8 \cdot 10^7$	↘	↗ (10 and 50 µm) ↘ (others)
	p-annihilation	$\approx 1 \cdot 10^4$	↕	↕
	electron x-ray	$\approx 1 \cdot 10^7$	↗	↗ (others) ↔ (10 µm)
	1st fluorescence	$\approx 2 \cdot 10^7$	↘	↗ (10 and 50 µm) ↔ (100 µm) ↘ (others)
	2nd fluorescence	$\approx 2 \cdot 10^6$	↕ (1 mm) ↘ (others)	↗ (10 and 50 µm) ↔ (100 µm) ↘ (others)
electron production	pair production	$\approx 1 \cdot 10^4$	↕	↕
	compton recoil	$\approx 1 \cdot 10^7$	↕ (1 mm) ↘ (others)	↗ (10 and 50 µm) ↔ (100 µm) ↘ (others)
	photo-electric	$\approx 1 \cdot 10^8$	↘	↗ (10 and 50 µm) ↔ (100 µm) ↘ (others)
	photon auger	$\approx 4 \cdot 10^6$	↘	↘
	electron auger	$\approx 1 \cdot 10^8$	↗	↗
	knock-on	$\approx 1 \cdot 10^{10}$	↘	↗ (10 µm) ↔ (50 µm) ↘ (others)

Trend symbols:

↗ increasing

↘ decreasing

↕ increasing and decreasing (not systematic)

↔ stable

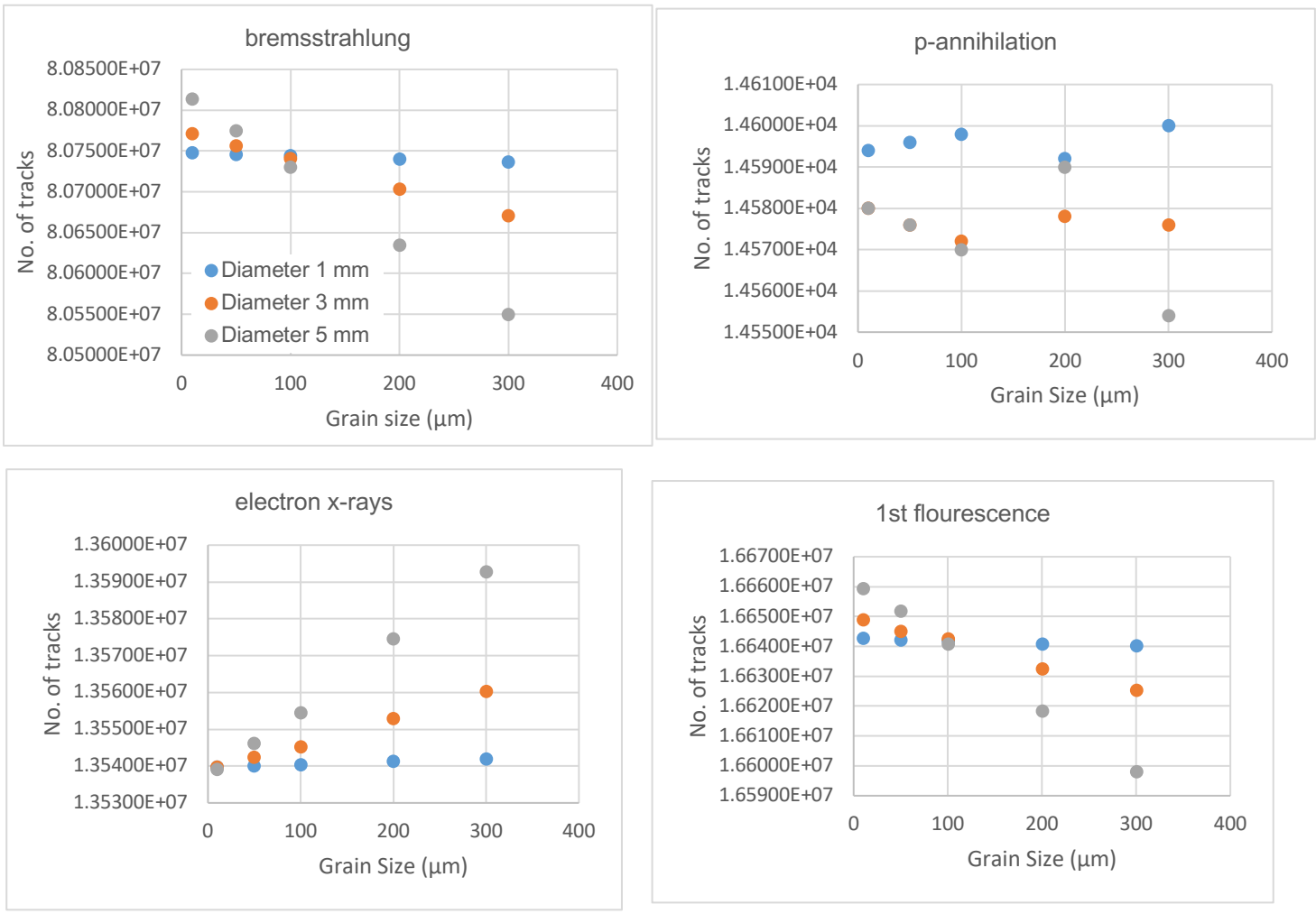
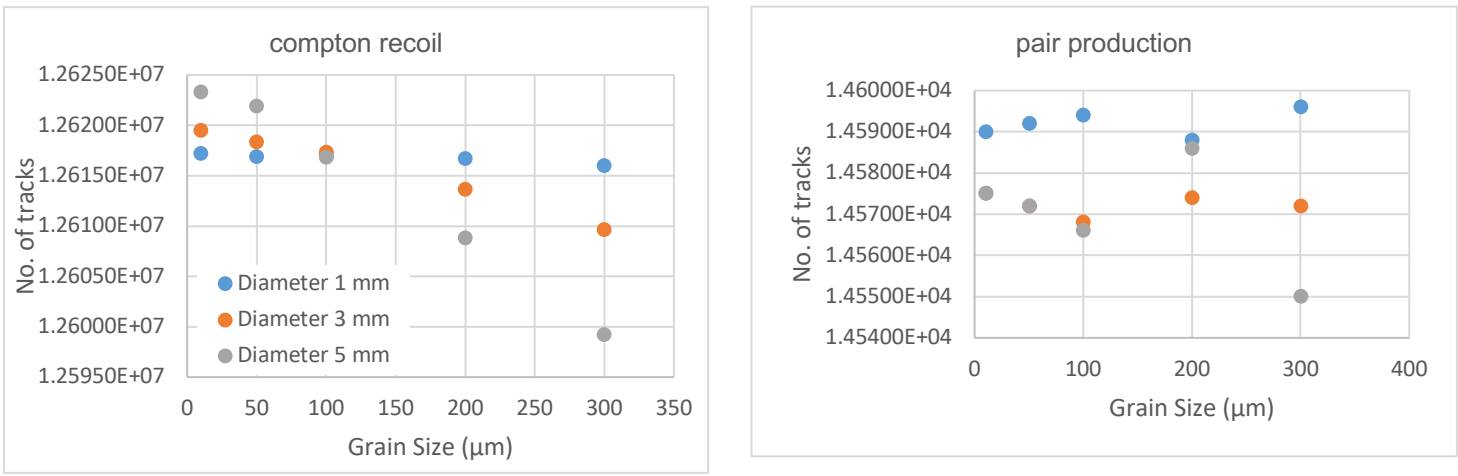


Fig. S3. Gamma production (no of tracks) as a function of grain size for three aliquot sizes. For key of symbols see top left panel.



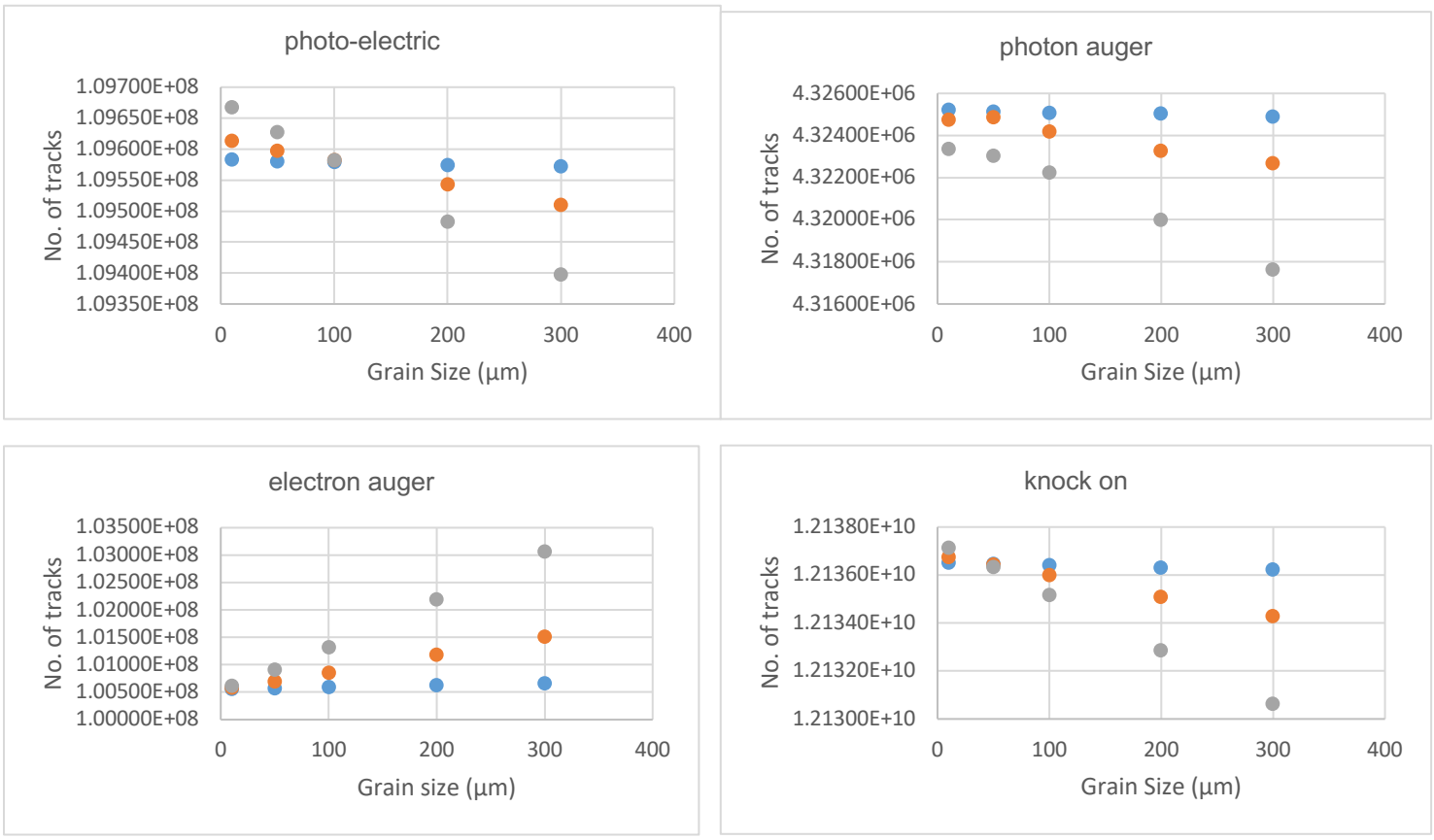
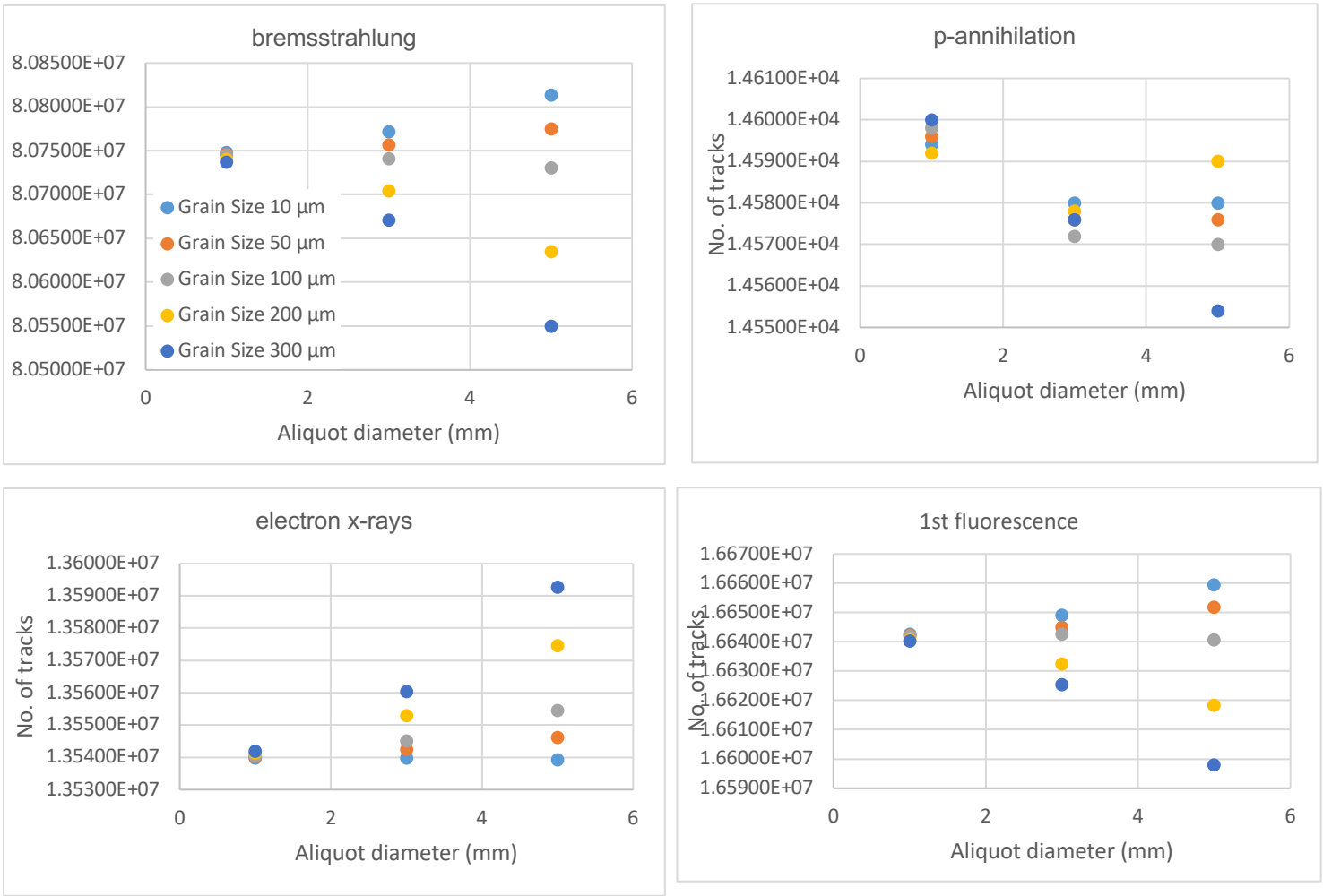


Fig. S4. Electron production (no of tracks) as a function of grain size for three aliquot sizes. For key of symbols see top left panel.



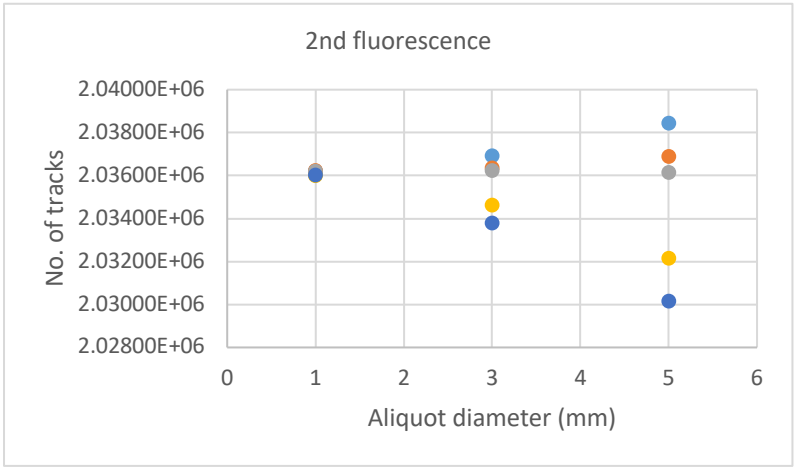
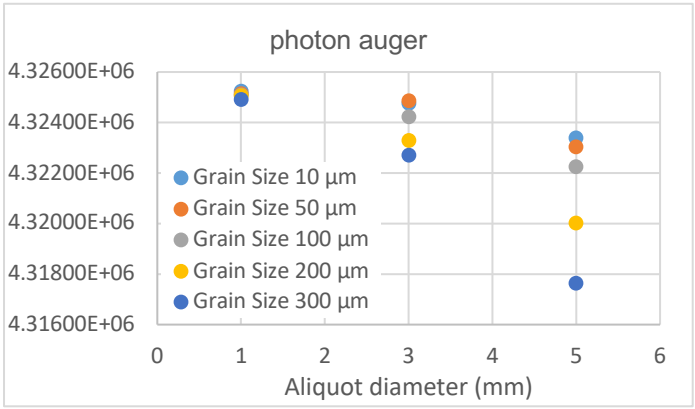
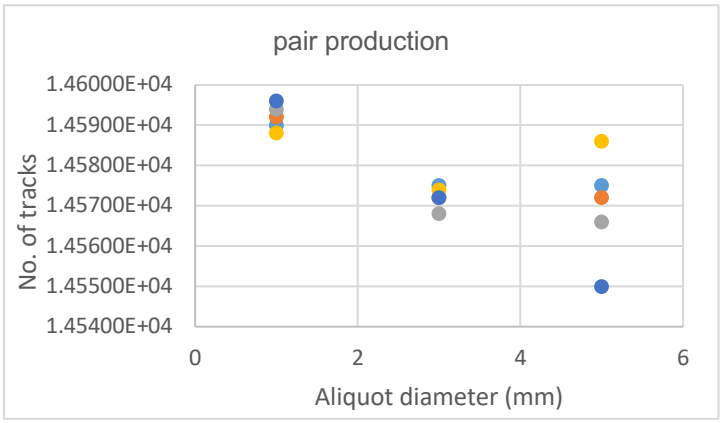
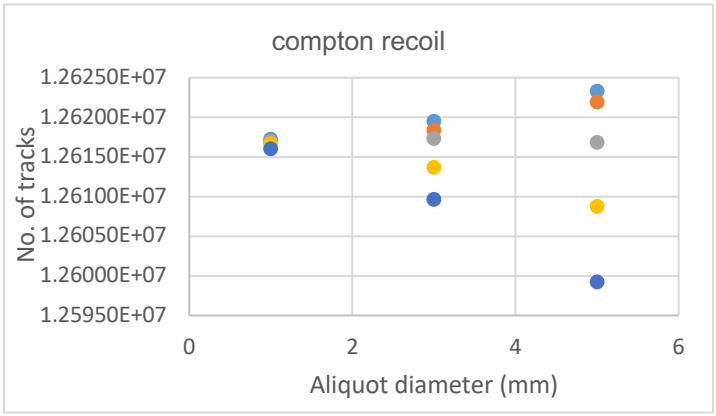
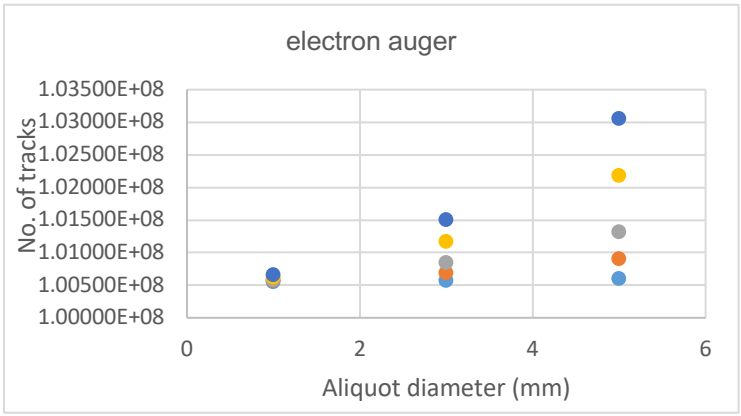


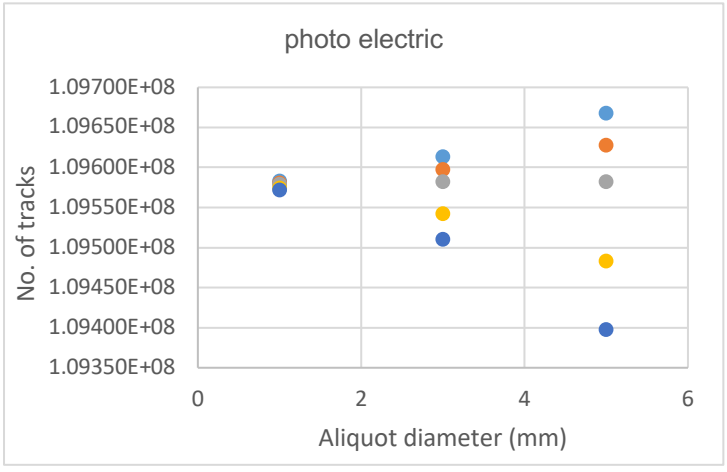
Fig. S5. Gamma production (no. of tracks vs. aliquot diameter) in grains of 10 µm to 300 µm in small, medium and large aliquots. For key of symbols see top left panel.











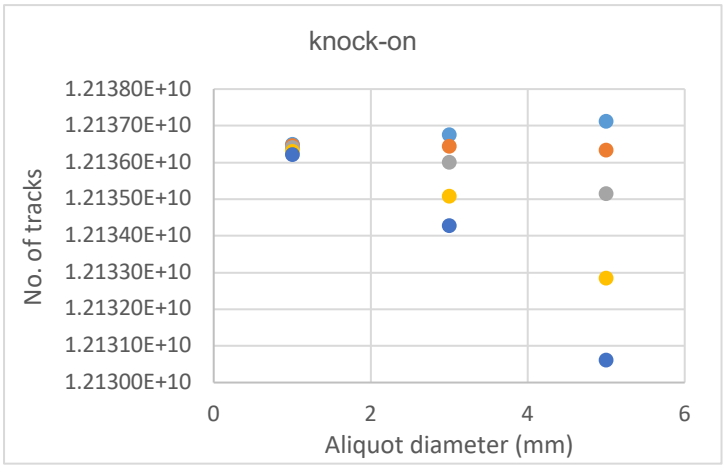


Fig. S6. Electron production (no. of tracks vs. aliquot size) in grains of 10 µm to 300 µm in small, medium and large aliquots. For key of symbols see top left panel.

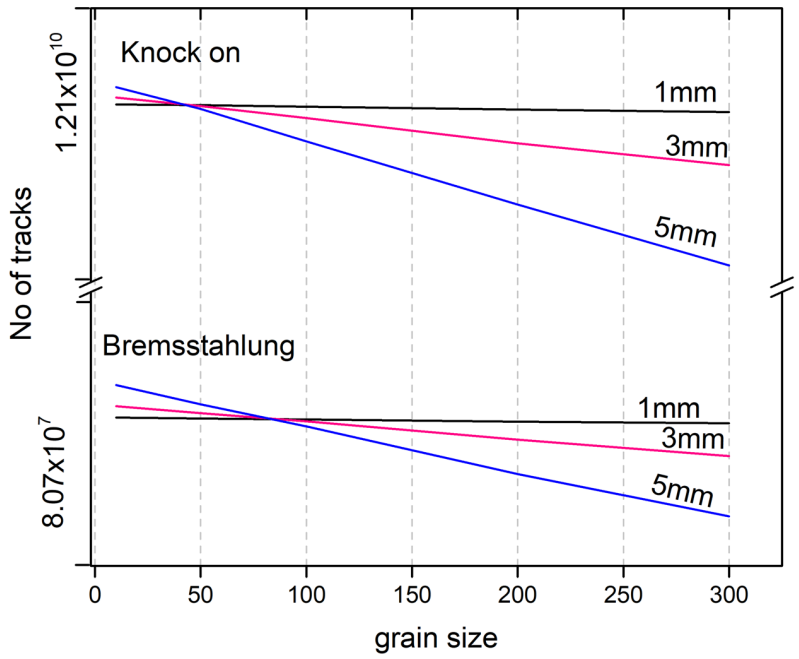


Fig. S7. Result from MCNP6 simulation: The two major interaction mechanisms for electron and photon production with regard to grain size and aliquot size. The decrease of interactions with increasing grain- and aliquot size is noticeable, but it remains within the same order of magnitude for each mechanism.

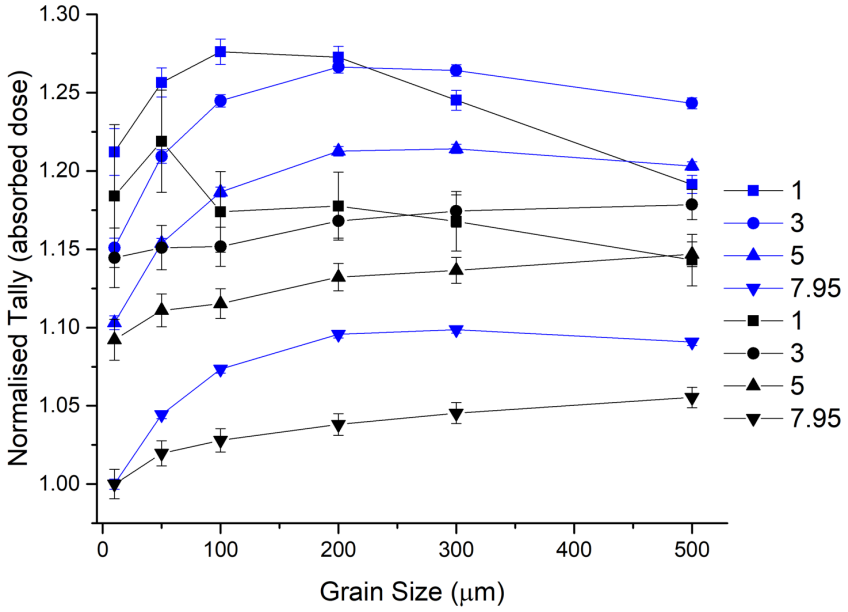


Fig. S8. Result from *MCNP6* simulation: absorbed dose in grains of 10-500 µm size for electrons (blue) and photons (black) in small, medium and large aliquots. Numbers in key indicate aliquot size (mm).

References

Browne, E., 2003. NM - CEA/LNHB - Table de Radionucléides, Laboratoire National Henri Becquerel. Available from: http://www.nucleide.org/DDEP_WG/Nuclides/Ir-192_tables.pdf (10.September 2016).

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

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

Williams, R.G., Gesh, C.J., Pagh, R.T., 2006. Compendium of Material Composition Data for Radiation Transport Modeling. PNNL-15870.