



**Supplementary Figure 1** Results of a Monte Carlo model of the effect of ATONA baseline length on accuracy of a measured ratio (e.g.  $^{206}\text{Pb}/^{205}\text{Pb}$ ) acquired with a limiting intensity  $< 1$  mV (relative to  $10^{11} \Omega$  amplifier).  $^{205}\text{Pb}$  intensity is fixed at 2 mV,  $^{206}\text{Pb}$  intensity varies between 0.1–1 mV. Random samples of populations of real baseline measurements from Fig. 3B at 300–3000 s (10–100 cycles of 30 s) were applied to both intensities, generating a distribution of measured  $^{206}\text{Pb}/^{205}\text{Pb}$  ratios. The figure displays 1 SD bounds of the expected offset from the true  $^{206}\text{Pb}/^{205}\text{Pb}$ , illustrating the necessity of long baseline acquisition times when beams  $< 1$  mV are analysed.