Mask Scattering Modelling with Geant4

March 8, 2010

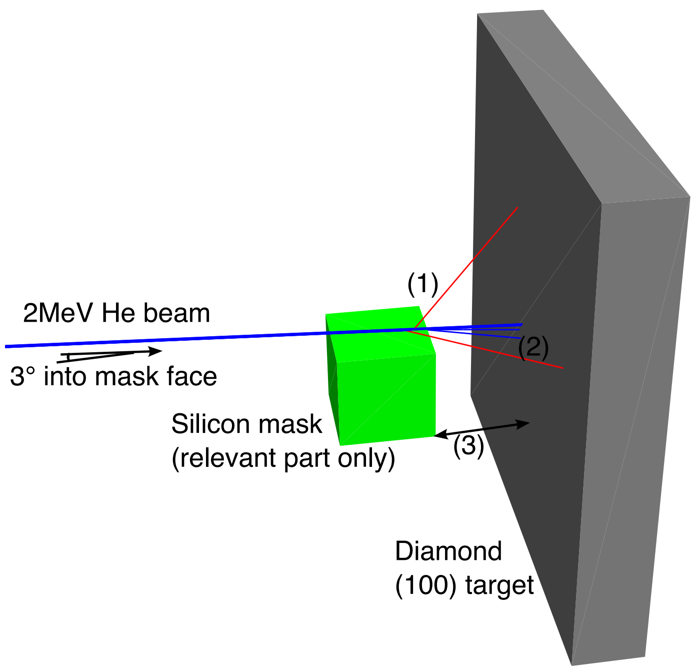


Figure 1: Diagram of experimental setup. The 2MeV He beam (blue) is directed at a 3° into the edge of a cleaved silicon mask. (1) He ions clip the edge of the silicon mask and are absorbed or scattered, also producing secondary electrons (red). Ions that don't hit the mask are not simulated. (2) Scattered ions hit the diamond target and come to rest. (3) The mask-target spacing is varied during the simulation (by moving the target).

I spoke to Babs, and her best guess for the mask-sample spacing was anything less than 30um. A large flux will still produce scattering out to 50um at this spacing (as found in the experiment).

Figure 5 shows that ions that are scattered through a larger angle come to rest at a shallower depth. Most of the damage an ion causes is localised near the end of its range. This means that plotting the final positions of the ions gives a good indication of where damage occurs. At larger mask spacings, there is a wide area of low damage. The width of the lightly-damaged region can be controlled by varying the mask spacing. The damage profile is reversed in this lightly damaged region - the surface receives between 5-20x more damage than the 3.5um end-of-range depth of unscattered ions.

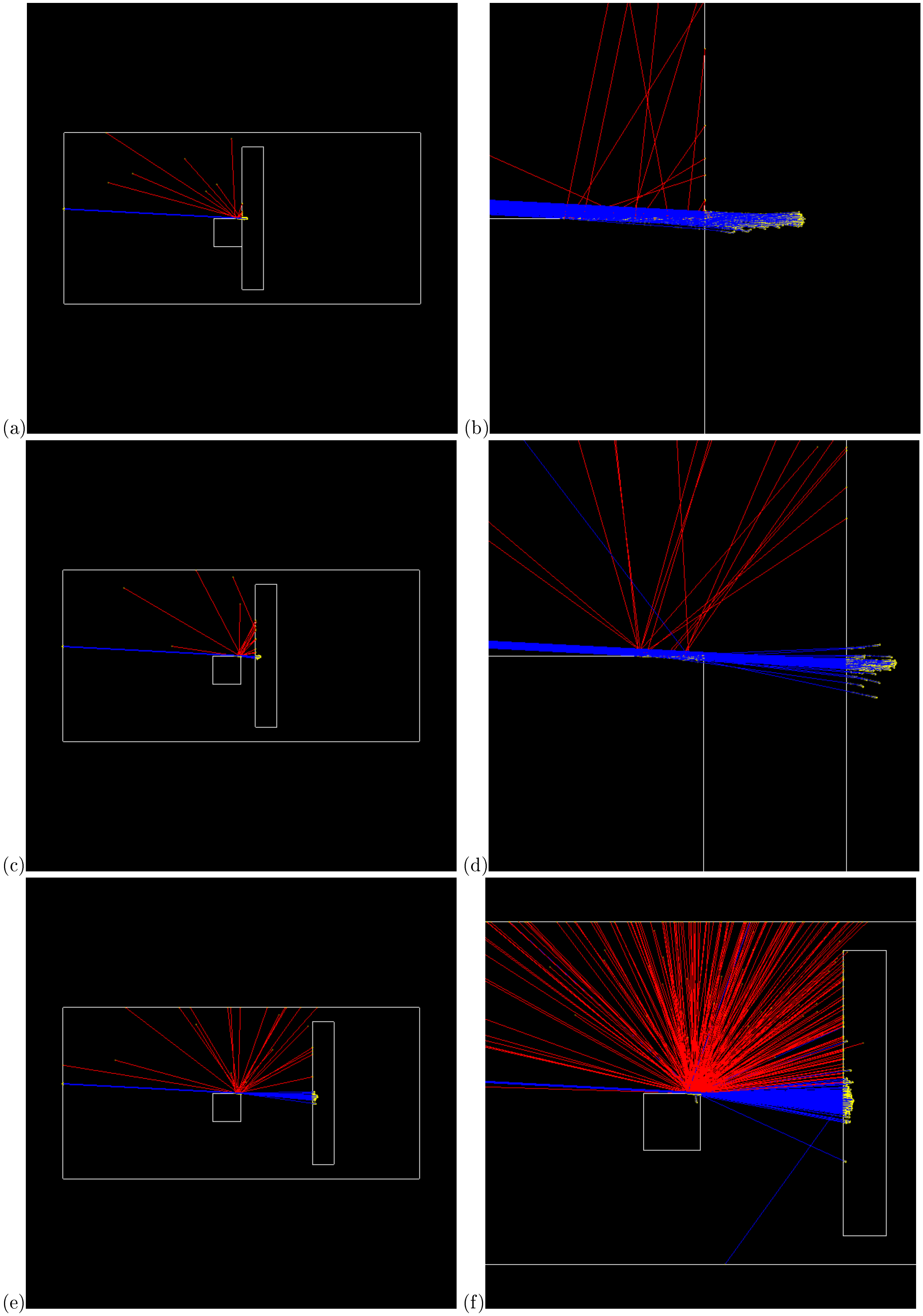
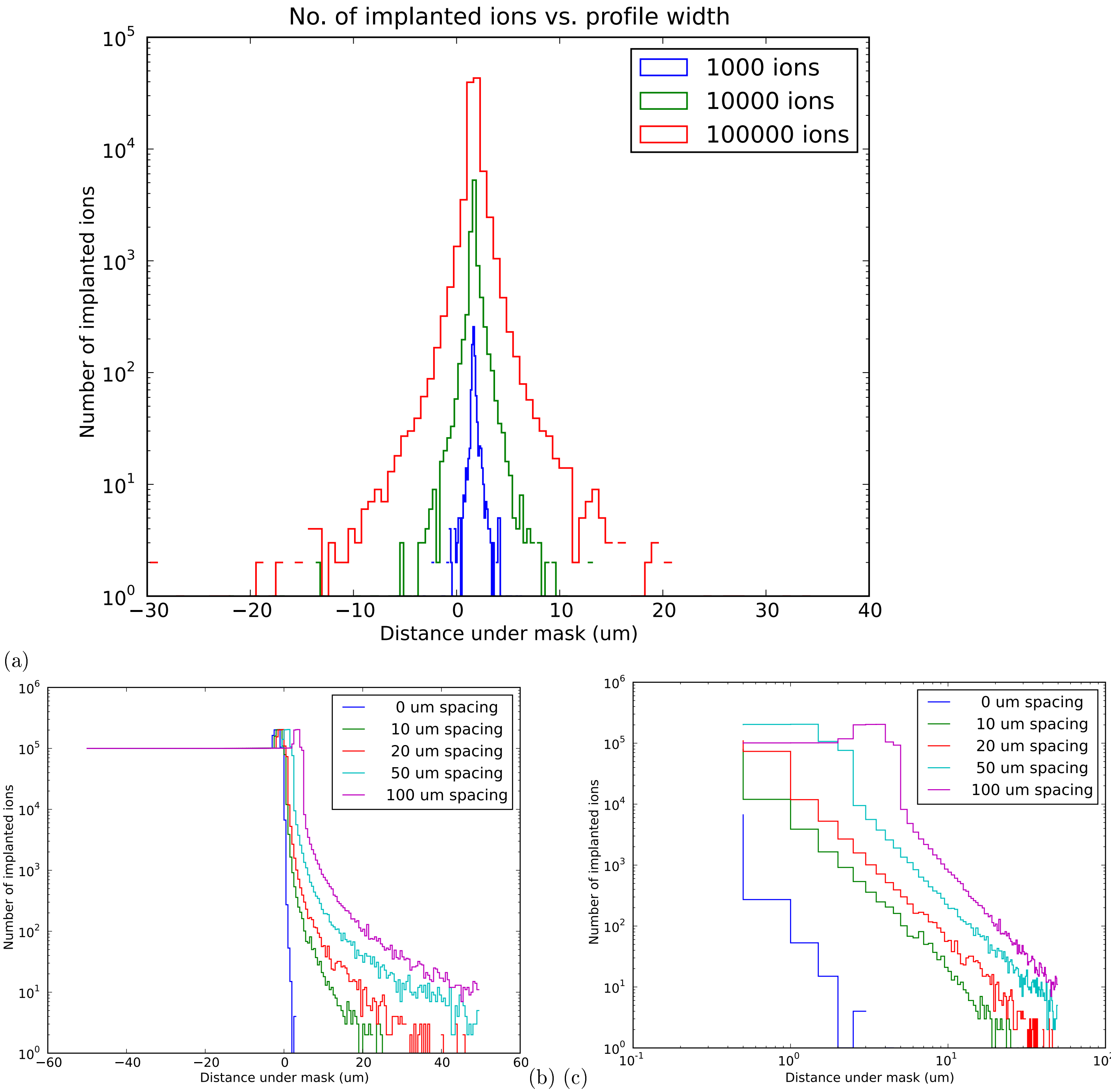
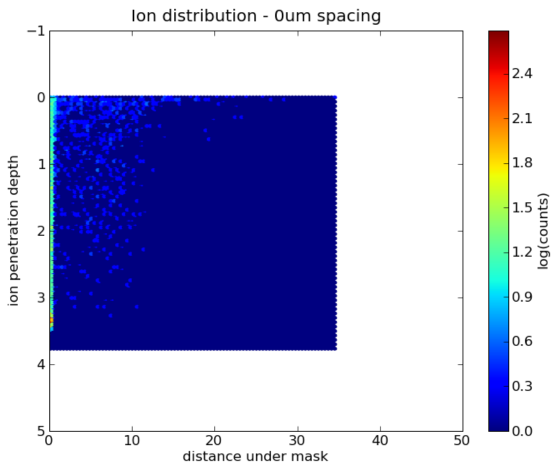


Figure 2: Various screenshots of simulations. Blue lines are ion tracks; red scattered electrons; yellow dots are energy deposits. (a) 0um gap. (b) Closeup of 0um gap impact site. (c-d) 10um gap. (e) 50um gap. (f) 50um gap closeup, with 1000 ions to show a high angle scattered ion (and also a reflected ion).

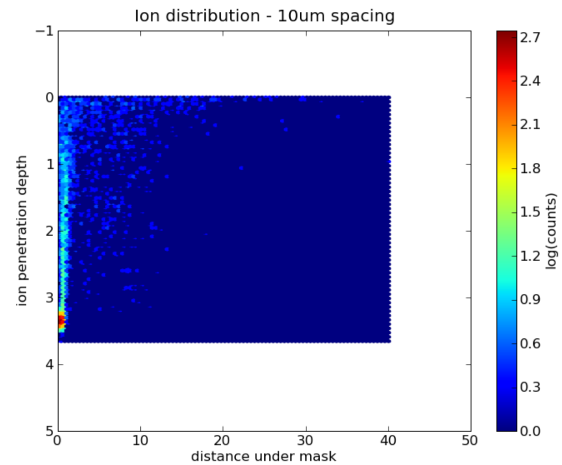


(a) (b) (c)

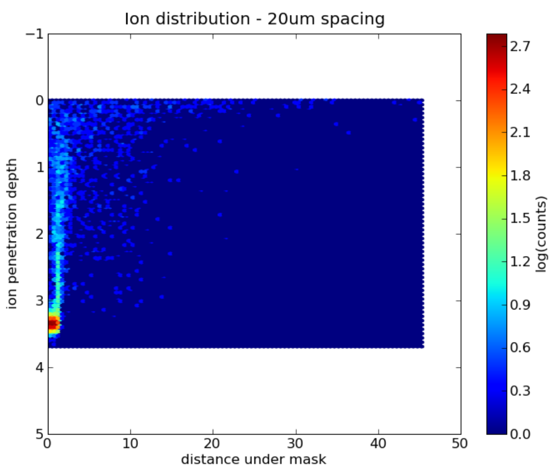
Figure 3: Distribution of ions by how far they travelled laterally under the mask. (a) Variation with the number of simulated ions (flux). As more ions are implanted, it is more likely that some will scatter out at higher angles. (b) Variation with mask separation distance. Ions not touching the mask were calculated statistically (not simulated) due to time constraints. Larger distances allow ions to travel further under the mask before hitting the target. (c) Same as (b) but with a logarithmic lateral axis.



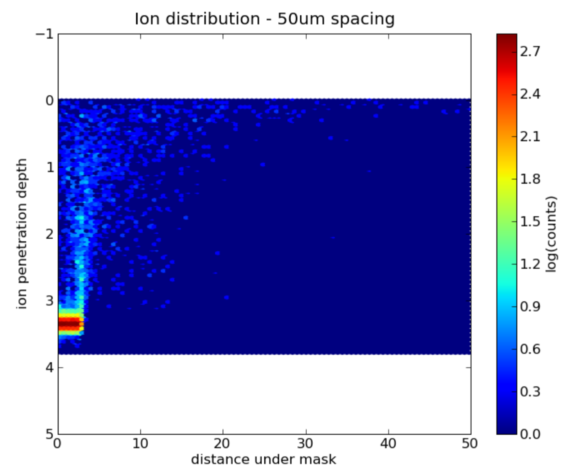
(a)



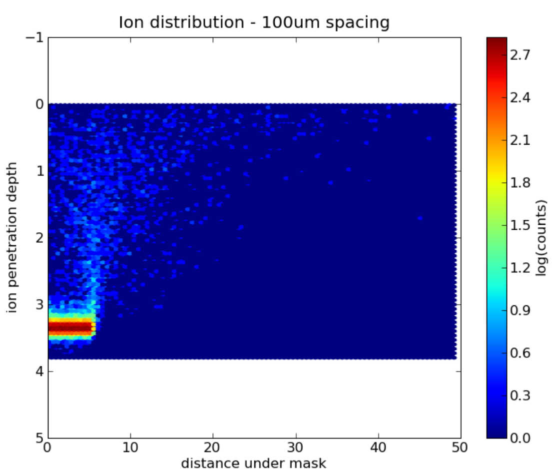
(b)



(c)



(d)



(e)

Figure 4: Ion distributions for various separations with a wide beam. A wide beam was used here so not many ions impacted the mask. (~50 000 ions are visible in these plots)

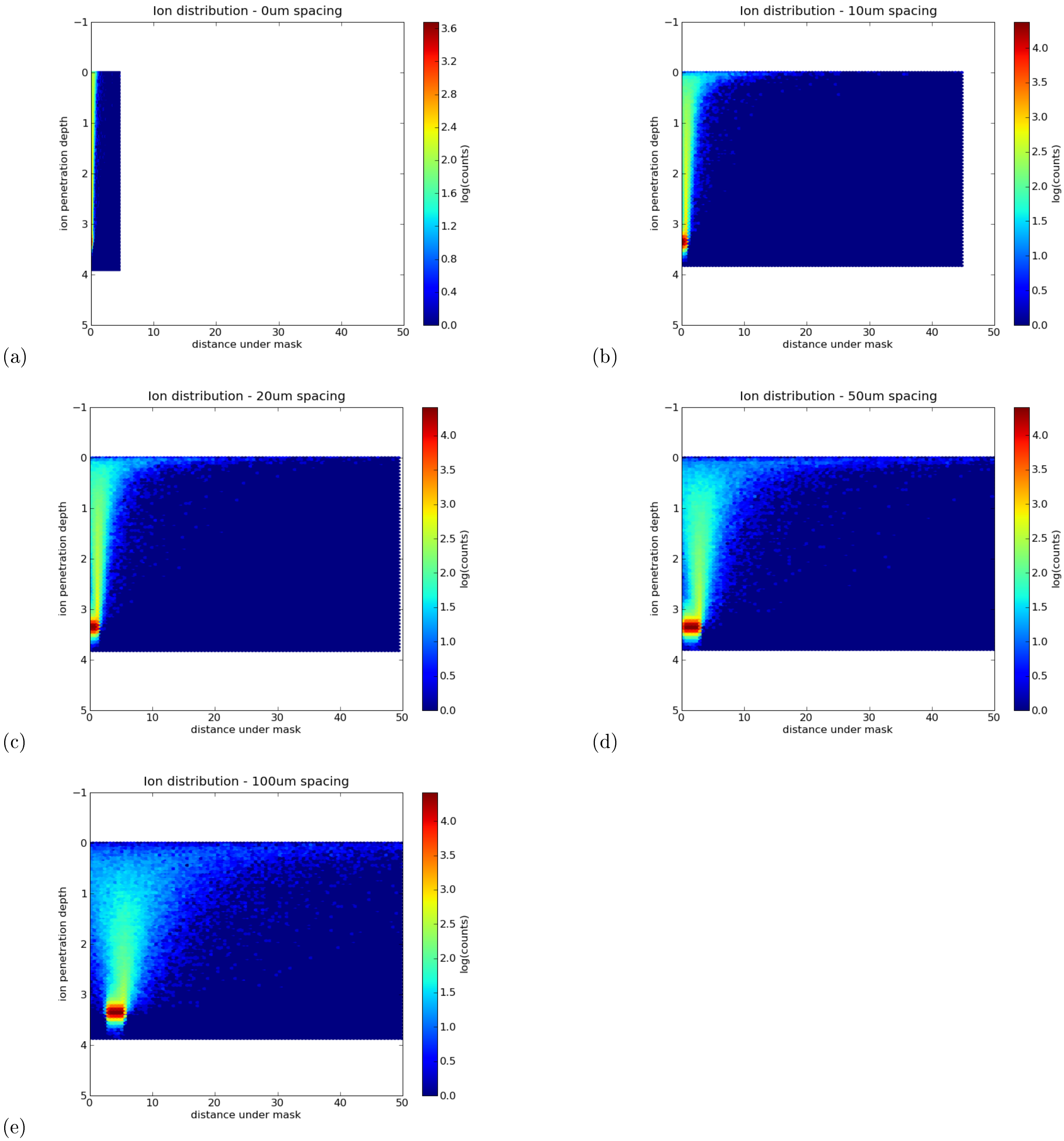


Figure 5: Ion distributions for various mask-target spacings with a narrow beam. Here a sharp beam was used to give more scattering from the mask, with the side effect that not many ions are recorded further out from underneath the mask (as the beam did not cover that area). (∼500 000 ions are visible in these plots)