Development of an X-ray radiograph simulator: from STL file to grey scale image

Lars Körner[1], Rong Su[1], Simon Lawes[1], Nicola Senin[1,2] and Richard Leach[1]

[1]Manufacturing Metrology Team, University of Nottingham, Nottingham, UK; [2]Department of Engineering, University of Perugia, Italy

Email: Lars.Korner@nottingham.ac.uk

Introduction

- X-ray computed tomography (XCT) is currently transitioning into the metrology market
- In radiography alone a large range of settings and influencing factors exists

⇒ Making uncertainty assessments and setting up a scan problematic

A simulation tool of radiographs is presented to assist the metrological evaluation of scan settings and the exploration of factors influencing uncertainty

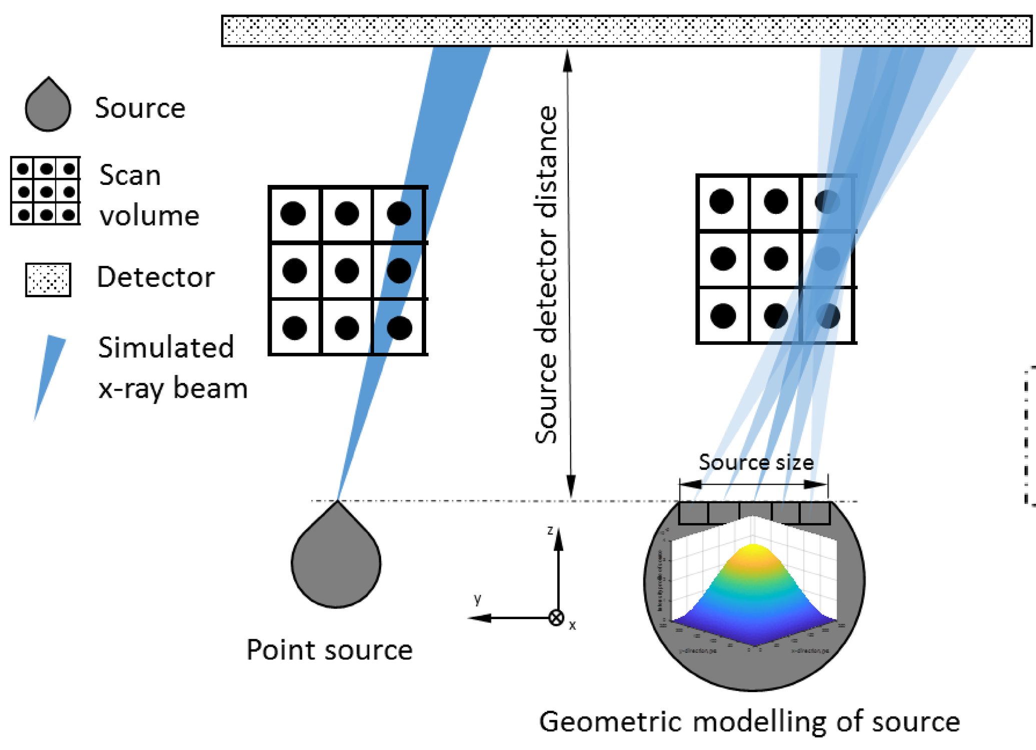

Figure 1: Geometrical modelling of the focal spot vs. a point source assumption during simulation

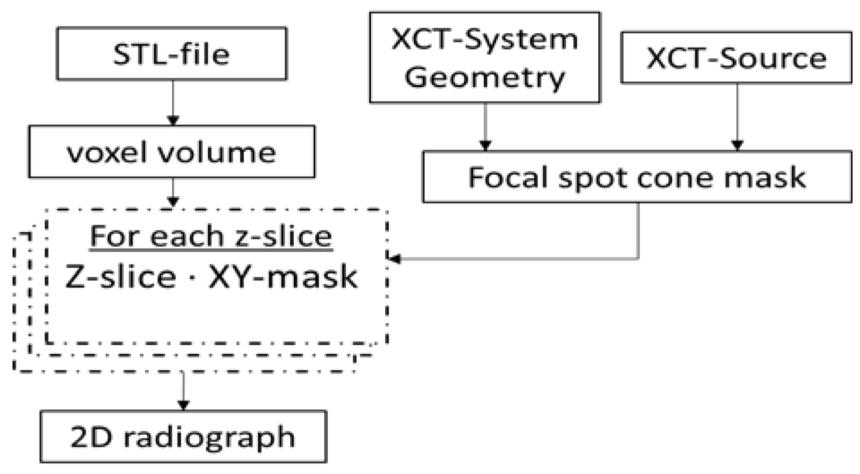

Figure 2: A simplified schematic of the data flow of the presented software

Geometric modelling of the system

- Geometric modelling has been utilised in forward projectors of iterative reconstruction algorithms [1]
- Focal spot issues become of significance if the projected penumbra is large in terms of detector pixel size, see Figure 1
- Figure 3 shows simulation results

Software architecture:

1. STL file is ray traced into a voxel volume, compare to Figure 2
2. The Cone mask is derived from the cone beam geometry and the focal spot geometry
3. Voxel volume is multiplied with a matrix describing the focal spot cone mask to obtain the final 2D descriptor
4. The material model is applied to simulate the X-ray behaviour

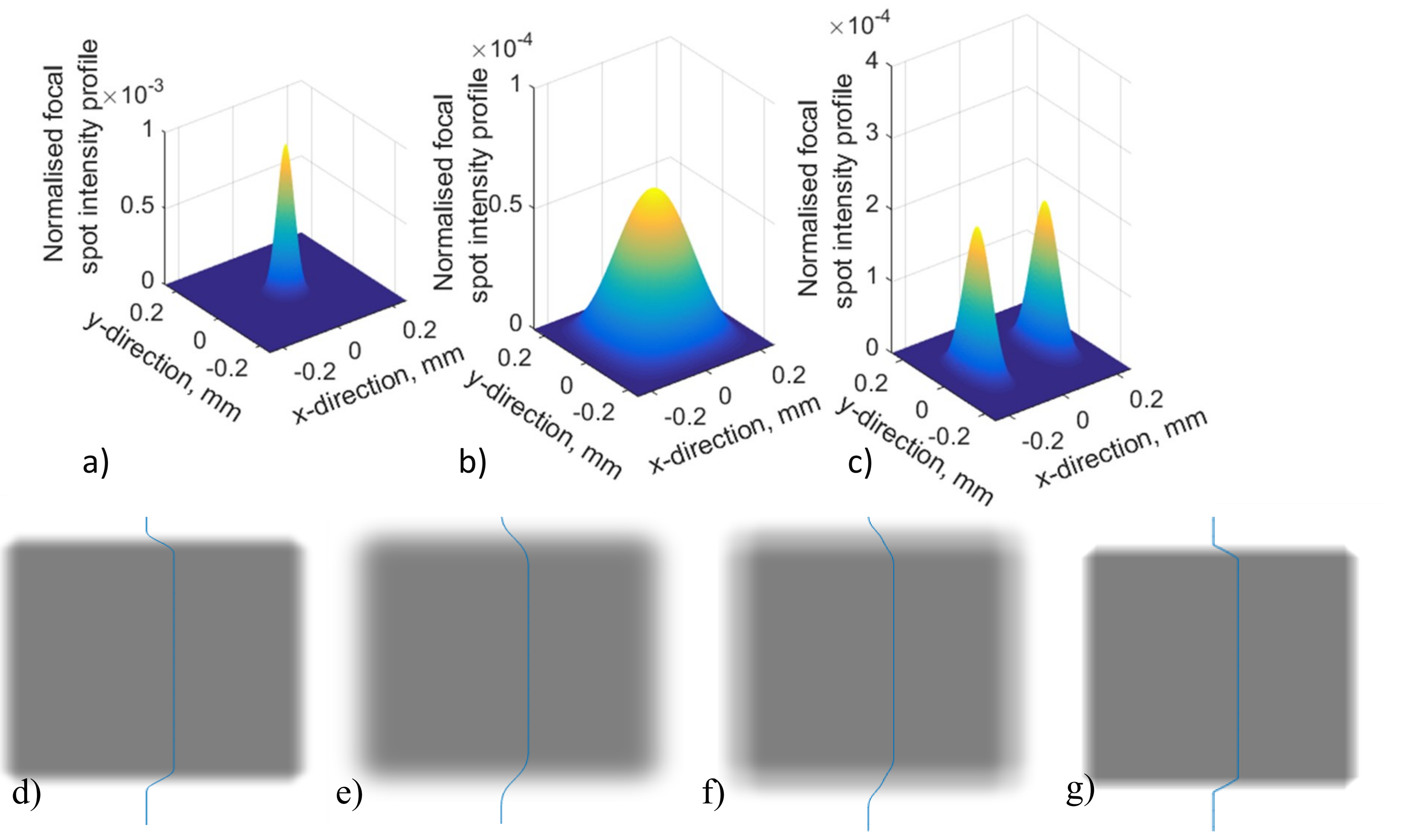

Figure 3: a), b) and c) show simulated focal spots with different distributions. d), e) and f) show corresponding projections of an aluminium piece with a thickness of 3 mm. g) shows the simulation result of a point source. The projected pixel size is 4 µm, and the representation grid of the focal spot has an increment of 2 µm.

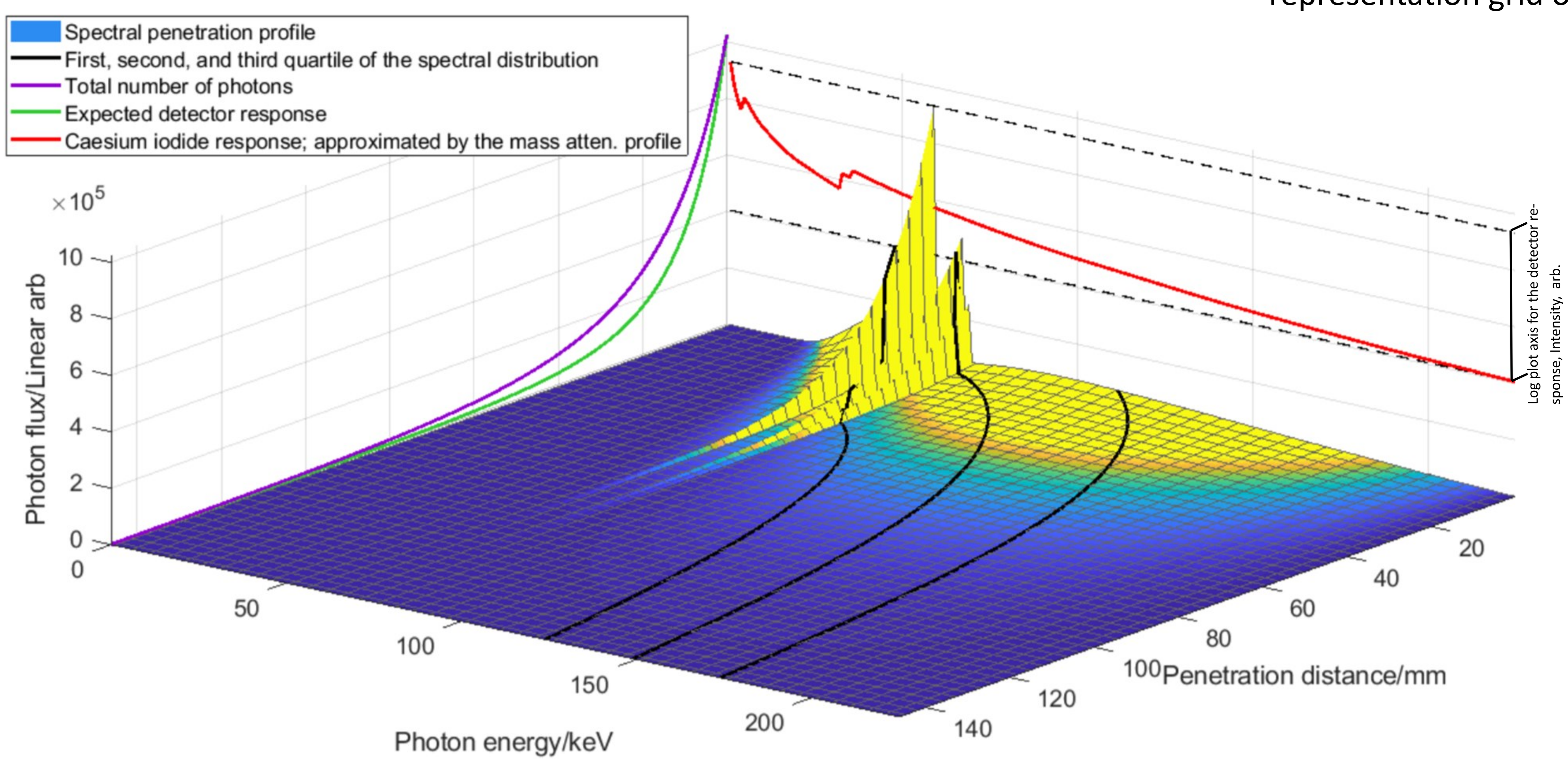

Figure 4: Spectral simulation of aluminium by an X-ray spectrum produced from a 225 kV accelerating voltage and a tungsten target.

Material modelling

X-ray attenuation is well studied in physics, this simulation tools allows for:

- Tungsten source spectrum based on [2]
- Filtering
- Spectral resolving of the detector response
- Models material behaviour based on NIST data base [3]
- Scatter is currently not preliminary implementation

Future work

- Evaluation through comparison to real radiographs.
- System specific calibration to include exposure time and x-ray flux
- Migration to complied code
- Scatter modelling is undergoing preliminary implementation

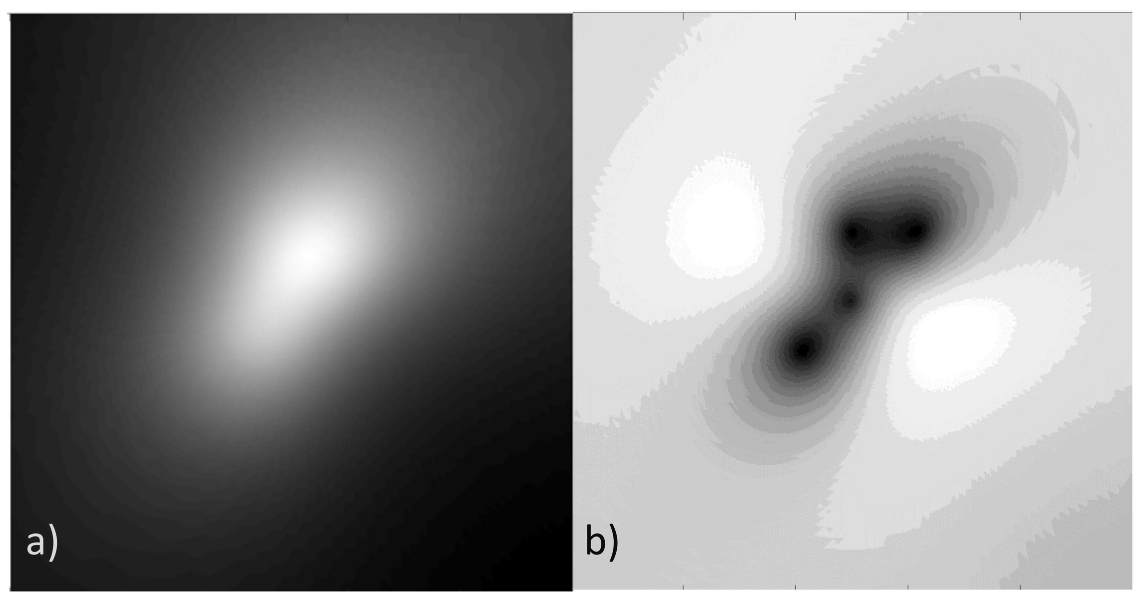

Figure 5: Preliminary implementation of a first order scatter simulations :
a) Compton, &
b) Rayleigh
scattering of an aluminium part

References

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[2] Boone J M, Fewell T R and Jennings R J 1997 Molybdenum, rhodium, and tungsten anode spectral models using interpolating polynomials Med. Phys. 24 1863–74

[3] Hubbell J H and Seltzer S M 2004 X-Ray Mass Attenuation Coefficients NIST

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