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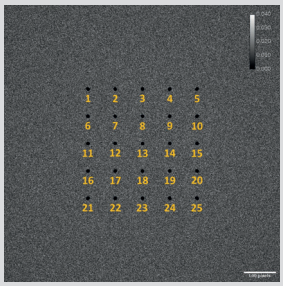
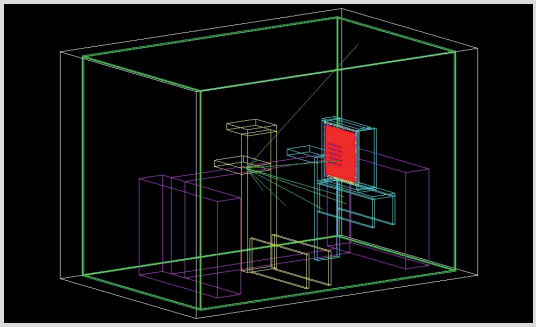
Bachelor-Thesis Medizintechnik

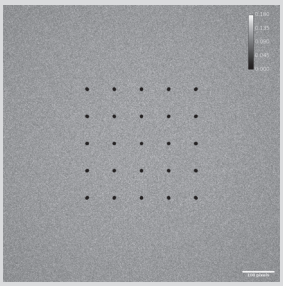
Simulation and Measurement of Scattered Radiation



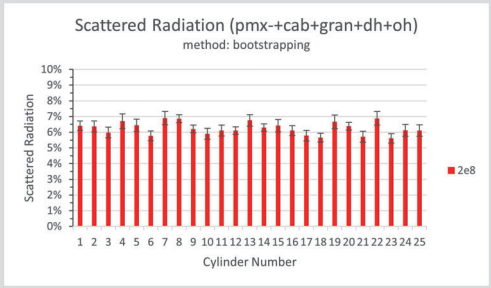
Simulation CT—image
CT image from 1 simulation with 2e8 primary particles and the 5 by 5 scatter grid.



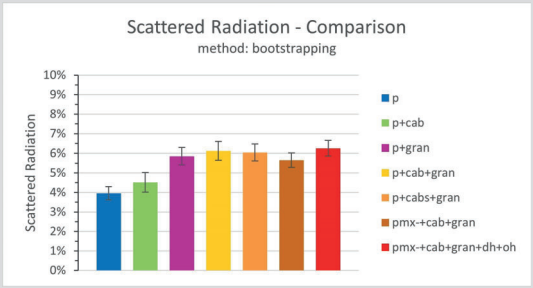
Simulation system setup
System setup containing all parts from which specific ones can be chosen for different configurations.
detector (red), phantom (blue), cabinet (green), granite blocks (magenta), detector holder (cyan), object holder (yellow)



Simulation CT—image
CT image of 8 simulations added up with 2e8 primary particles and the 5 by 5 scatter grid.



Scattered radiation—full setup
Mean and standard deviation of the scattered radiation of all 25 individual cylinders for the full system setup, simulated with 2e8 primary particles.



Scattered radiation—configuration comparison
Mean and standard deviation over all 25 individual cylinders means per configuration.
Phantom centred (p), phantom actual position (pmx-), 1-layer cabinet (cab), sandwich cabinet (cabs), granite blocks (gran), detector holder (dh) object holder (oh)

Background

X-ray computed tomography (CT) is an imaging technology increasingly used in the industry for inspection, evaluation and analysis owing to the fact that it offers a non-destructive testing technique. Scattered radiation within such a system is an important deteriorating factor regarding the accuracy of reconstruction of a measured object. Hence, the reduction of scattered radiation is essential for high-quality CT images. To achieve this objective, the form and amount of scattered radiation must be analysed and quantified.

Methods

There are two main strategies to analyse scattered radiation: firstly, scattered radiation can be estimated experimentally by taking specific measurements while using phantoms; secondly, simulation programmes can be used to estimate its effects. The focus of this thesis lies on the latter.
The Monte Carlo method is a reliable tool for the simulation of scattered radiation as research has shown. GATE, a tool implementing the before mentioned method was used for the simulations. It is based on GEANT4, a toolkit used for the simulation of the passage of particles through matter.

A virtual simulation setup of LuCi (Lucerne Ct Imaging) was developed by representation of the most prominent parts. The scattered radiation was simulated for different system configurations with a cone beam source with a source spectrum generated for a 160kV acceleration voltage and a 6.5 µm thick tungsten target. As a phantom a scatter grid with a 5 by 5 cylinder distribution was used.

Results

The generated images were analysed and the scattered radiation of the individual cylinders calculated with two different methods. Either the simulations per configuration were split into 2-datasets or a method called bootstrapping was used for the calculation of the mean and standard deviation. Additionally, the mean and standard deviation of the means of the 25 individual cylinders was calculated to facilitate comparison of the configurations.

The biggest contributors to the scattered radiation are the granite blocks with a contribution of 1.89% The detector holder's and object holder's contribution is smaller with 0.60% and followed by 0.56% contribiuted by the cabinet. The scattered radiation simulated for the full setup (phantom, cabinet, granite blocks, detector holder and object holder) is 6.25±0.40%.

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