Compton Electron Tracking: Project Kick-Off Meeting

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| 16/04/13 10:30-12:00 | Daresbury, T27. |
| Attendees: Ian Lazarus, Marc Labiche, Andrew Boston , Helen Boston , Amina Patel, Laura Harkness, Matt Wilson. | |
| Apologies: Daniel Judson | |

# Meeting Notes

Matt presented the motivation and plan for the project; explained the CfI project aim to test the feasibility of tracking the electron with the aim of generating a larger funded project to build a system in the future. Need to quantify the benefits of tracking the electron (w.r.t state of art), to what accuracy we would need to track the electron, determine if a detector could be made and identify stakeholders/applications/users/funding for the future.

Marc presented GEANT 4 simulations of the interactions of 140keV, 511keV and 662keV photons from an isotropic source 3cm from the centre of a 400µm thick 3x10cm Si detector. The Compton electrons were discussed. It was clear that the 140keV case was the most challenging and the headline results from this were that:

* 1.5% of 140keV photons incident on the Si resulted in a Compton event.
* The Compton electrons had energies up to ~50keV resulting in most electrons having a range of ~10-50µm. *This doesn’t include any effects of the E field in the detector on the electrons but it is expected this would be a small effect.*
* The ToF of the electrons was 10ps.
* The higher energy photons had ranges a wide distribution of electron energies and ranges from ~10µm to ~0.5mm.

Marc noted that there is a discrepancy in electron ranges calculated by GEANT4 in versions earlier than 9.5.

Laura and Andy said discussed some of the studies they had conducted in the past. From this they expect that the critical factors in being able to track the electron will be the noise floor of the system (3keV previously seen as a limit) and the position resolution. The reconstructions will also depend on the energy resolution and timing resolution will be needed too. It was noted that there will be a trade off in a camera design in having multiple thin scattering detectors to increase the Compton interaction probability and reducing the number of single-single events and reducing the field of view. The scattering detector could be Si (monolithic or stacks), Si(Li) (thick) or if needed Ge (very thick). Liverpool would suggest using GAMOS (GEANT 4 v?) for the simulation of the photon interactions and electron paths. A detector response will be simulated by a simple diffusion, drift time analytical calculation that can be verified by TCAD and/or COMSOL. The output of the simulations in E, x, y, z; with/out electron track information and uncertainties can be used to reconstruct images with an analytical reconstruction that Dan uses. This final output will allow us to be able to quantify and image quality with/out the tracking information and with different levels of uncertainty in the track measurement.

Potential applications, stakeholders and funding were discussed. The points of note were:

* Brian Hutton at UCLH would be a good stakeholder for medical applications. He has shown interest in Compton Cameras for SPECT but noted the need for electron tracking to improve efficiency.
* Nuclear decommissioning could be a potential application. Liverpool have links in this area that could be explored in the future.
* Tony Bird at Southampton University could be interested in a technology for astrohphysics.
* GSI have a technology development plan with European wide project to be allocated for an instrument planned for 2020 – *Andy or Ian, could you please provide some more details on this?*
* STFC PRD funding is available for April 2014. There is a £1.2M pot for a few projects to demonstrate new technologies with a few to further funding for their implementation. The call closes on the 9th of July. <http://www.stfc.ac.uk/Our+Research/4621.aspx>

All were happy to discuss the project with other people but some simulation results would be needed to make direct approaches to people to become stakeholders in the project and form collaborations for funding applications.

The options of simulations were discussed and narrowed down to give a manageable number of variations. It was agreed that the first simulations would look at:

* Energies:
  + 141keV (Tc-99m) for SPECT applications – most challenging case.
  + 662keV (Cs-137) for Nuclear Decommissioning.
  + 1332keV (Co-60) for Nuclear Science.
* Detector: Si would be the starting point:
  + 4x4cm chosen as it would be maximum of 2x2 bump bonded ASICS and will give better figures of merit than a single 2x2cm piece.
  + Thicknesses of 100µm, 300µm, 750µm and 1mm of Si.
  + Single monolithic pieces as starting point. Multiple layers to be simulated too.
* Readout:
  + The effect of bump bonding the ASIC to a pixelated detector will be investigated by simulating 120µm and 50µm thick Si and a 20µm thick layer of uniform In to represent the bump bonds. This will determine if pixels can be used or if strips need to be used.
* Segmentation:
  + Pixels with a pitch of 50, 100 and 200µm will be investigated first.
  + If strips are needed then these pitches will also be reviewed.

# Actions

Marc will simulate the effect of the ASIC and In layer. The negative impact will come from photons that Compton scatter in the Si detector subsequently interacting with the Si ASIC and In interconnect layer. This will be reported at the next meeting.

Andy and Ian to circulate information about GSI application.

# Next Meeting

The next meeting has been scheduled for the 14th of June.

We will discuss:

* The impact of the ASIC layer and plan the transfer of the GEANT 4 code to GAMOS.
* Plans for simulations at Liverpool.
* Any other relevant work.
* Funding, including the PRD call.