SuSi : A Monte Carlo model of a novel proton CT Scanner using Geant4

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PRaVDA & Proton CT

- Proton Computerized Tomography (pCT) uses high energy proton beams to image a patient
- Will measure stopping power of body tissues directly and reduce uncertainties in proton radiotherapy treatments
- Need to measure each individual proton
- PRaVDA are designing, building and testing the world's first fully solid state pCT device
- One of the most complicated imaging devices ever built and contains enough silicon for 20,000 iPhone cameras

SuSi: An Overview

- Comprehensive Geant4 Monte Carlo code to fully model the PRaVDA pCT device
- Incorporates all aspects of device: tracking sensors, CMOS range telescope sensors and phantoms
- Contains true to life models of iThemba and UoB cyclotron beam lines for correct input parameters
- Performs realistic charge spreading and signal generation in both the tracking and CMOS sensors
- Used to optimise design parameters: sensor positions, phantom choices, etc.
- Models the radiation field around the proton beam
- Allows the testing of a novel CT reconstruction algorithm specifically written for pCT by PRaVDA

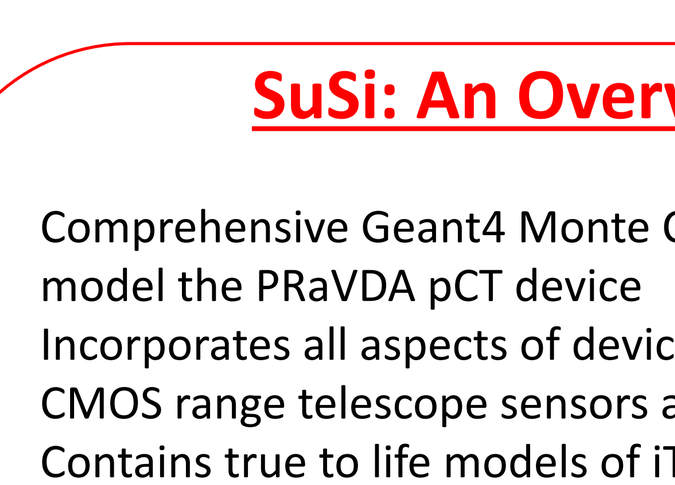

Figure 1: Visualisation of PRaVDA device using the iThemba beam line model. Also shown are protons passing through the detectors and spherical phantom

Results

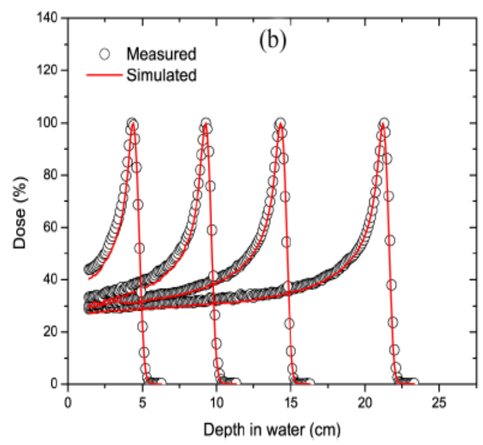

Figure 2: Depth dose profiles for the iThemba beam line for various proton energies.

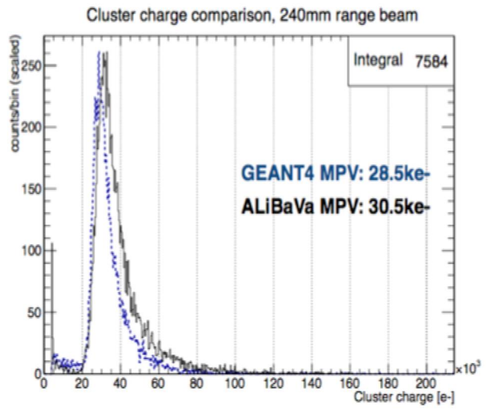

Figure 3: Signal size in tracking sensor for 191 MeV protons compared with predicted values from SuSi

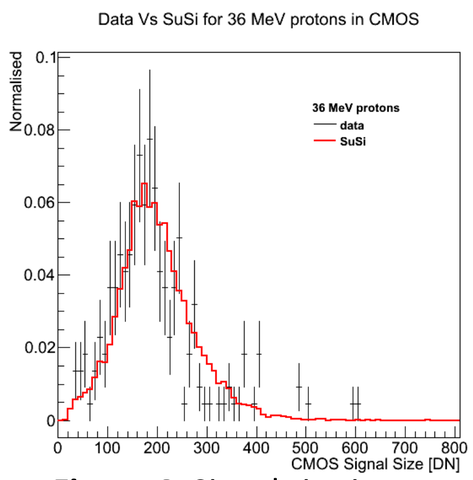

Figure 4: Signal size in CMOS sensors for 36 MeV protons compared with predicted values from SuSi.

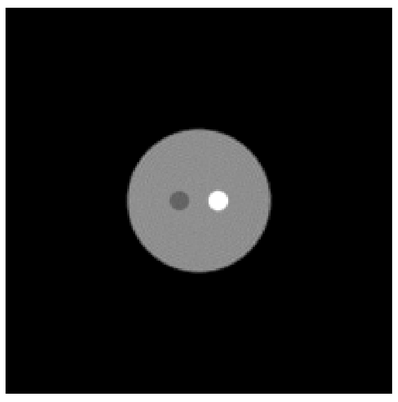

Figure 5: Reconstructed phantom slice using SuSi truth data to test PRaVDA reconstruction algorithm.

Run Time Statistics

- 180 different angles needed for each reconstruction.
- Figure 5 shows reconstruction with just 1/10th of the protons required in final system
- Each angle
  - 2,000,000 generated protons
  - Used 12 CPU hours
  - Produced 4.6 GB of raw data
  - 250 MB of processed data for proton tracking
- All made possible in just 3 days using BlueBEAR!!!

PRaVDA
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