Description of the Parameterized Charge Deposition Model

M. Gold  
*University of New Mexico*

**Abstract**

The parameterized model for silicon charge deposition is briefly described. Further details and preliminary evaluation of the model relative to a GEANT-based calculation of the underlying physics can be found in references [1, 2].

1 **Introduction**

The idea of a parameterized charge deposition model grows out of the Run I silicon experience. For Run I, a parameterized cluster model was used. The motivation for a new algorithm were first, that the Run I model did not generalize to double-sided silicon taking into account the charge correlations; and second, that the Run I model which parameterized clusters rather than charge on strips folded in the effects of Run I noise. Therefore it was decided to parameterize charge on strips taking into account double-sided correlations, and adding in noise separately which could be easily be modified to track the detector.

2 **Algorithm**

The algorithm is as follows:

1. path length in the silicon is calculated;
2. the mean, restricted energy loss is calculated corresponding to a minimum δ-ray energy of 30 KeV;

3. the energy loss is chosen from a Gaussian distribution;

4. the charge is put on the strips, taking in account diffusion and the magnetic field;

5. a number of δ-rays are generated;

6. for each δ-ray:
   a) an energy is chosen;
   b) the energy is converted into a mean range;
   c) the range is converted into a lateral range (in the plane of the silicon) including a fluctuation about the mean according to Gaussians with mean-dependent widths;
   d) a lateral ionization loss profile is chosen according to the range;
   e) the charge, distributed according to the profile is put on the strips;

7. a fraction of the charge is shared between strips, taking into account capacitive coupling between readout strips;

8. noise is added.

If the model works perfectly, then the only tuning required would be adjustment of the capacitive sharing (nominal 10%) and noise. Only comparison with the data will tell, but it seems highly likely that additional ad-hoc tuning will be required.

3 Implementation

The code is part of the "SvxSim" package. It is written in Fortran-77 and interfaced to the C++ code via the header Svxmc2.hh and the Fortran routine umap_svxmc2.F. This Fortran wrapper calls the main routine svxchg2. This main routine then does the following:
• call dedxr (elosr.F)
  This calculates the restricted energy loss.

• call qstrip (qstrip.F)
  This puts the charge on the strips.

• call ndray (qdray.F)
  This adds the δ-rays.

• call chshare (chshare.F)
  This adds the capacitive sharing.

• call addnoise2 (addnoise2.F)
  This adds noise.

An important aspect of the algorithm is the routine called qstrip that
takes into account the diffusion of the ionization charge in the presence of the
magnetic field (Figures 1,2). The other major piece of the algorithm is the
call to ndray. The number of δ-rays are chosen according to the distribution
in Figure 3. The δ-rays are handled for each δ-ray with a call to qdray (also
in qdray.F).

• Pick the δ-ray energy according to the distribution in Figure 4.
• Call rang (rang.F) to convert this into a mean range (Figure 5).

• Call frang (frang.F) to convert this mean into a fluctuated lateral
  range, where lateral means in the plane of the silicon (Figure 6).

• Distribute the charge according to the appropriate (for that range)
  charge profile (Figure 7).

• Put the charge on the strips using qdray.

An additional complication is that when the lateral range is calculated,
there is a certain fraction of δ-rays that will exit the silicon. This is hand-
dled with a call to frexit (frexit.F), and a special lateral charge profile in
svxmc2_block_data.inc (not shown here).
Figure 1: The charge diffusion profile used by qstrip for phi or small angle strips. The horizontal scale is a half-strip width, with zero the midpoint between strips. The effect of the magnetic field is apparent. These numbers are in the arrays proxm,proxp in the include file *svzmc2_block_data.inc*.

References


Figure 2: The charge diffusion profile used by qstrip for orthogonal Z strips. The horizontal scale is a half-strip width, with zero the midpoint between strips. These numbers are in the array proxx0 in the include file swmc2_block_data.inc
Figure 3: The δ-ray multiplicity distribution. These numbers are in the array nv3100 in the include file suzmc2_block_data.inc
Figure 4: The $\delta$-ray energy distribution. These numbers are in the array nv3106 in the include file suzmc2_block_data.inc
Figure 5: The energy to mean range conversion curve. These points are in the include file range.inc.
Figure 6: The mean fractional lateral range (in the plane of the silicon) as a function of $\delta$-ray range. The error bars correspond to the approximately Gaussian widths of these distributions. The lateral range is chosen from the means according to the Gaussian distributions. These points are in the subroutine frang in the file frang.F.
Figure 7: Lateral $\delta$-ray ionization loss profiles in different range bins. These profiles take into account the rapid energy loss near the $\delta$-ray's endpoint (Bragg peak). The range has been scaled to the corresponding mean. These profiles are in the include file dhisto.inc.