Weightfield 2 – Basic user's guide

Weightfield 2 allows to simulate quickly silicon and diamond solid state detectors with or without charge multiplication. The program solves Poisson's equation iteratively from depletion voltage.
Note: the program does not manage doping concentrations, only depletion voltage.

Downloadable at the page weightfield2.web.cern.ch

Further information on the program structure can be found at http://www.hephy.at/fileadmin/user_upload/Fachbereiche/Halbleiter/weightfield/Report_Weightfield.pdf

Installation

- Download and uncompress the .zip/.tar.gz file from weightfield2.web.cern.ch
- Make sure you have istalled ROOT 5.34 (root.cern.ch)
- Compile and execute by typing from shell

```
make
./weightfield
```

Graphical interface

1. Control panel

a. Precision: allows to perform a faster simulation by tracking only 1 particle out of n (n is user selectable, from 1 to 10). The global effect is given by multiplying the effect of a single charge by n

b. Sampling: manages sampling rate

c. File name: when this option is on, the program writes an output file with the following format “Time, Total Current, Partial currents, Electronics (Oscilloscope, Broad Band and CSA output voltages, optional)”

d. Batch: performs a loop of a selectable number of events. When “rand” is on, the point along x where particle hits the detector is random

e. Select particles:
I. “MIP: uniform Q, Qtot=75*height”: ideal case of a minimum ionizing particle producing 75 e-h pairs per micron
II. “MIP: non uniform Q, Qtot=75*height”: MIP with non uniform charge deposition (Landau distributed), but total charge fixed to 75*(detector height)
III. “MIP: non uniform, Qtot=Landau”: MIP with non uniform charge deposition and total amount of charge randomly extracted from a Landau
IV. “MIP: uniform Q, Q/micron”: MIP producing constant charge deposition of a user selectable number of e-h pairs per micron
V-VI. “Alpha from top/bottom”: 5 MeV alpha particles, impinging from top/bottom. Range is selectable
VII. “Current pulse”: current pulse with selectable duration (ns) to test the effect of electronics

f. Plot settings: controls plots displayment on the left panel.
I. “Draw electric field”: draws field lines on the drift potential canvas
II-III. “No 1D plots”, “No 1D & 2D”: select these options to perform a simulation without showing plots.

g. Currents:
I. “B field”: accounts for the effect of magnetic field (Lorentz drift) with selectable B-field value in Tesla
II. “Diffusion”: adds thermal diffusion

Set button: sets parameters.
Calculate potentials button: performs electric and weighting potentials calculation according to the geometry defined in “Detector properties”.

2. Detector properties

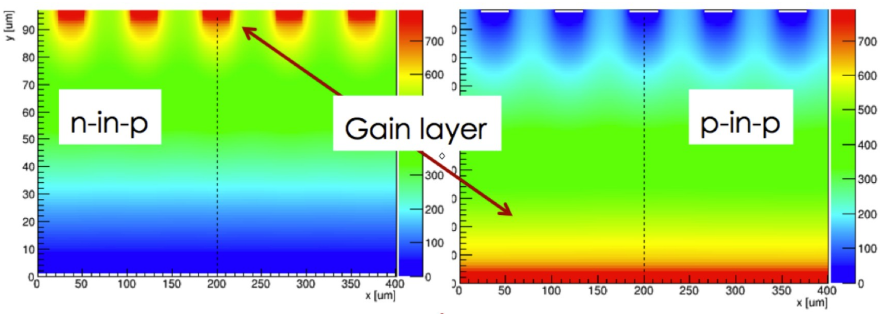
a. Type: allows to select the type of bulk (silicon, diamond).
Note: up to now, “free” is exactly like silicon.

b. Doping type: selects the doping type of electrodes and bulk (p or n)

c. Dimensions: geometrical features such as number of strips, thickness (along y), strips width and pitch in microns.
Note: for proper calculation, the number of strips MUST be an ODD number

d.Gain:
I. Gain: defined as the ratio (number of collected partickes)/(number of initial particles). If charge multiplication is not present, the proper value is 1
II. Force fixed gain: neglects gain fluctuations and forces the gain ratio
III. H/e gain ratio: accounts for hole multiplication. Charge multiplication is much weaker for holes, the ratio should be lower than 1
IV. Gain recess: gain layer can be narrower than a strip. This number controls the difference of width between the strip and the additional implant which produces charge multiplication (gain layer)

Note: gain layer is always placed at the junction. By changing doping type the program will place it properly at the top or bottom (see figure)



e. Voltage: selectable bias and depletion voltages

3. Electronics

When electronics is on, the effect of detector capacitance and signal shaping by oscilloscope and/or amplifier are added to the current calculation.

a. Detector capacitance: adds a detector capacitance value in pF

b. Oscilloscope: behaves like a RC filter with t=1/BW. BW is the oscilloscope bandwidth in GigaHertz

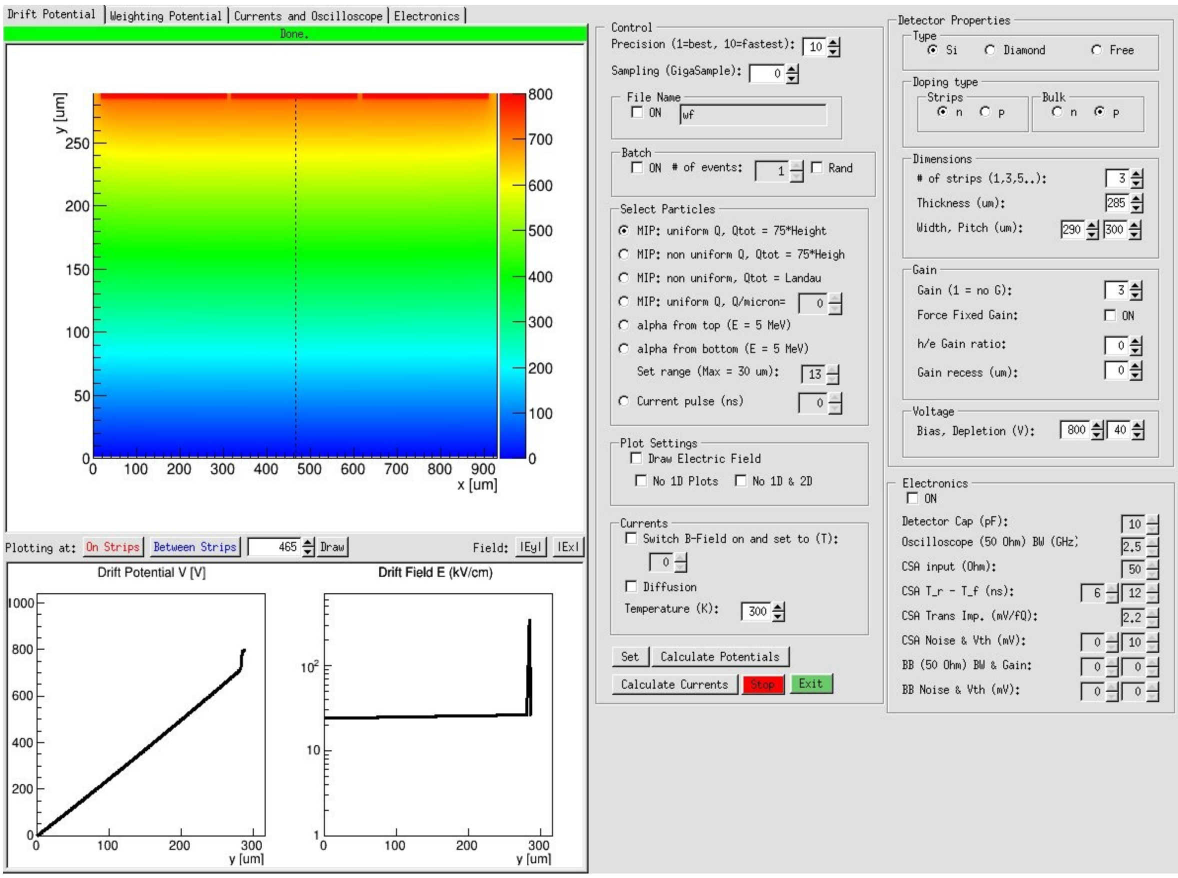
c. CSA: performs signal integration and shaping by a charge sensitive amplifier. Requires an input impedance in Ohm, rise time and fall time in ns (T_r, T_f), gain (CSA Trans. Imp.) in mV/fQ, noise and threshold voltage. Returns a voltage output in the output file and on the related tab “Electronics”

d. BB: simulatesa a broad band amplifier with input impedance of 50 Ohm, selectable bandwidth, gain, noise and threshold voltage. Returns a voltage output in the output file and on the related tab “Electronics”.

<u>Simulation step by step</u>

Single simulation mode

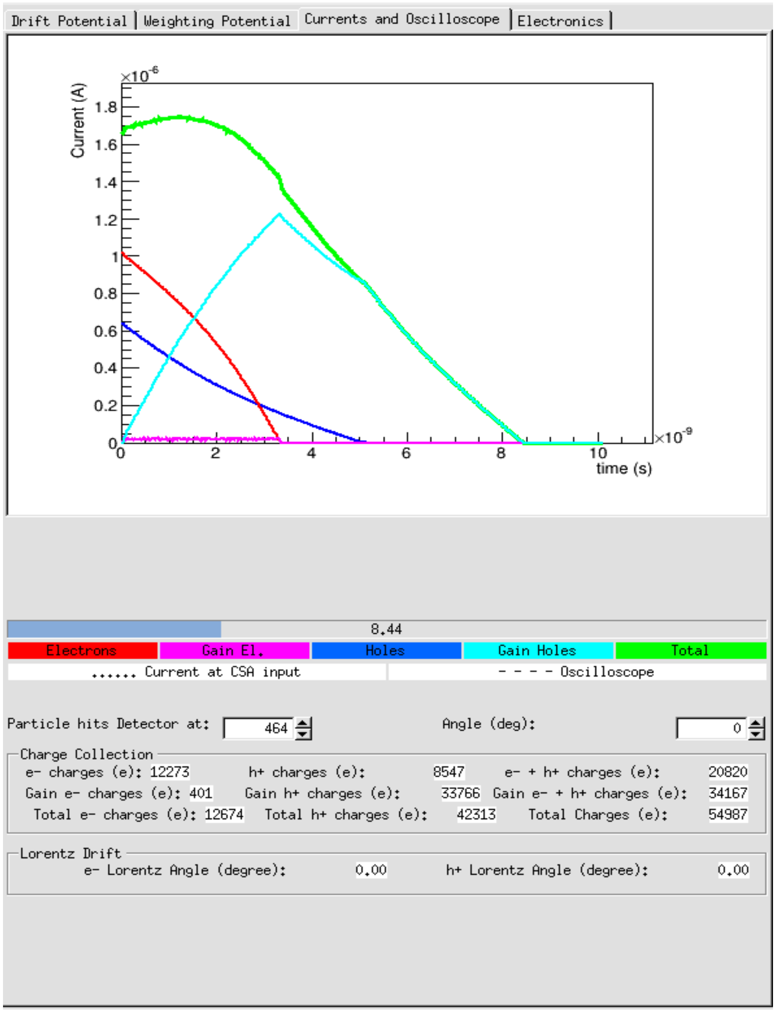
1. Select the bulk type from “Detector properties”, as well as the doping type of bulk and electrodes.
2. Select an odd number of strips and geometrical features.
3. Select gain value, depletion and bias voltage
4. Select the type of incident particle
5. (Optional) select precision, file name, electronics, thermal diffusion and magnetic field
6. Click “Set” and “Calculate potentials”: the program plots drift and weighting potential on the left part of the GUI (see figure)



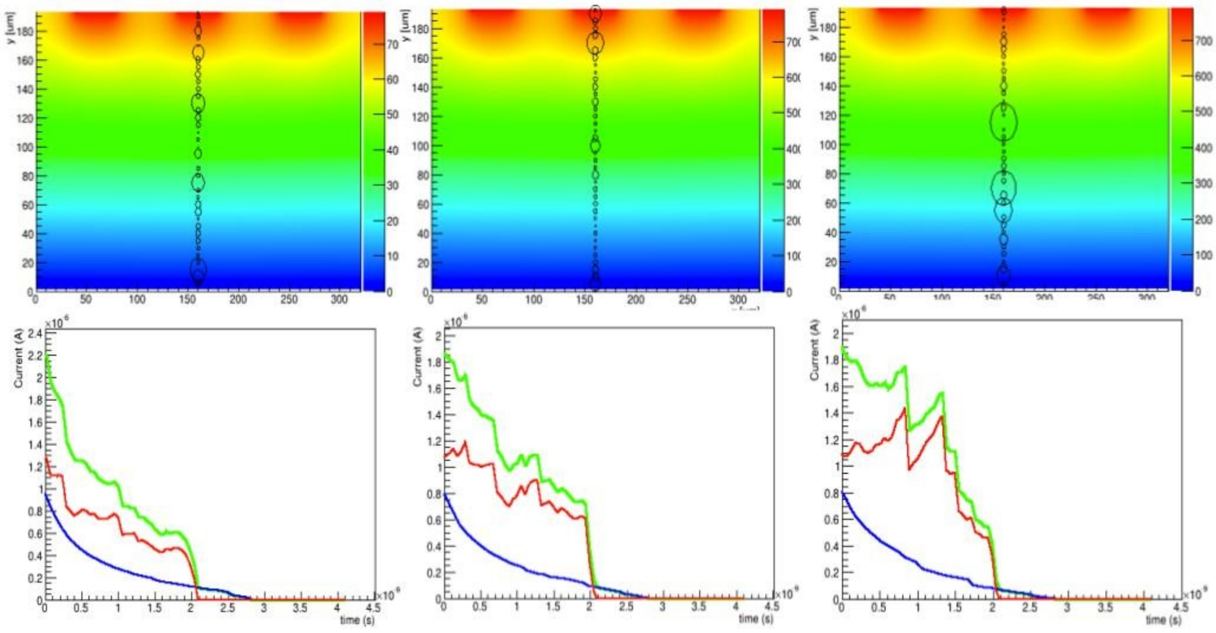
The two plots at the bottom of the "Drift potential" tab show:
a. drift potential along the y coordinate (calculated on strips or between strips, according to the option "Plotting at". By default it is calculated at the middle of the central electrode, but is selectable from number entry);
b. drift field along y or x

Note: the total detector width is given by multiplying strip pitch times the number of strips.
Selected parameters are written on the shell.

7. Particle hit coordinate along x and incindent angle are selectable from "Currents and oscilloscope" tab.
8. Click "Calculate Currents".
Currents are displayed on "Currents and oscilloscope" tab.
The blue bar shows the charge collecting time.



The program displays small ellipses on the drift potential plot, whose radius is proportional to the released charge. In case of non uniform charge deposition, ellipses have variable radius. The case MIP-Landau introduces variability in the total released charge value (see figure)



y [um]
Current (A)
time (s)