Contribution ID: **290** Type: **Invited Talk**

Simulation of ionisation-based tracking

Thursday 18 February 2010 14:00 (50 minutes)

Precision tracking of charged particles in high-energy physics experiments often relies on ionisation. There are several reasons for that:

```
* ionisation electrons are closely-spaced, even in light media such as gases;
* ionisation electrons are produced in the vicinity of the path of the charged particle;
* low-energy ionisation electrons are comparatively easy to measure;
* the energy losses associated with ionisation are small compared with the energy of high-energy physics partic
```

Despite its intrinsic qualities, taking best advantage of ionisation as a tracking principle remains a challenge. Traditionally, this is less of an issue for semi-conductor tracking: even when not exploited to the limits, the spatial resolution is usually adequate. With gas as active medium, current detectors achieve a resolution below 50 μm, but this is the fruit of numerous prototype tests and careful optimisation.

Early gas-based detectors were designed without help of computers, but simulation has played a role since the 1970s. Many of the techniques are significantly older. For instance, from approximately 1972, George Erskine used analytic methods to solve the electrostatic fields in a range of wire chamber configurations. The finite element method, since the 1990s widely used for small-scale devices, had already been pioneered in engineering in 1956. Simulation of ionisation energy losses goes back to 1960s and reached its present state around the year 2000 with models that accurately describe the distance between ionisation electrons and the track, relaxation of excited states and absorption of high energy electrons and photons. Also electron transport in gases has a long history. A.V. Phelps and colleagues solved the Boltzmann equation numerically already in 1962. Both the technique and the cross section data that are used as input have been refined ever since.

The present generation of gas-based detectors shows a marked trend towards miniaturisation. In particular, the electron mean free path in such devices is not much smaller than the smallest structural elements and the traditional decoupling of electrostatics and transport no longer applies. The miniaturisation also reduces the amount of active material and hence the number of ionisations available for tracking. This needs to be compensated by improving the single-electron efficiency, which calls for a deeper understanding of avalanche processes, and in particular of avalanche statistics, excitation-ionisation energy transfer processes and space charge. Along the same lines, medical imaging and dark matter detectors are using photons along with ionisation electrons to achieve higher efficiency and resolution.

Interestingly, many of the methods that have been developed, and are being developed, are applicable to semi-conductor devices. This not only holds for the simulation of ionisation patterns, but also for new field calculation techniques in which dynamic space charge is more easily incorporated.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

Not required (Invited Talk)

Primary author: Dr VEENHOF, Rob (CERN)

Presenter: Dr VEENHOF, Rob (CERN)

Session Classification: Particle ID 3