SVD Simulation Status

Peter Kvasnička
Charles University, Prague

F2F Tracking Group meeting
3 February 2018

Why we refactor SVD simulation

Signal simulation in time

We want to have a proper simulation of signal waveforms

- Time of signal formation ~ 10 ns for electrons, 25 ns for holes, comparable to sampling period of 31.44 ns.
- This requires calculation of the weighting field
- We can also improve the representation of E-field while we're at it.

Noise simulation, bad strips

We need a better model for strip noise

- Currently, we add gaussian samples to simulated strip signals + we generate some random digits from Gaussian tail distribution
  - Generation of random digits is currently turned off, since it overestimates the number of noise strip signals
  - I find noise in fitted waveforms different from strip noise.
- We need better understanding
- So far learning from real data..

Why we refactor (cont'd)

Strip-wise parameterization

We want to simulate the variability of strip parameters and bad strips.

- Use calibration data for runs as input
  - SVD hardware test data are usable for simulation
- Parameterized variation of strip parameters
  - Better control of various effects than calibration data

Better structure

We need to increase clarity of simulation

- With time, some aspects of simulation become increasingly complicated
  - Timing (latency, trigger jitter, trigger bins etc.) - too many shifts in time
- Increasing amount of calibrations (and we don't have them all)
  - Strip parameters
  - Lorentz shifts

Why we refactor (cont'd)

Documentation and validation

We want to make demonstrably clear what the simulation is doing

- Documentation
- Prototype (precise) simulation
  - With step-by-step documentation
  - Base for approximations in SVDDigitizer module and validation

Time simulation

Generation of strip signals by charge carrier movement in the sensor

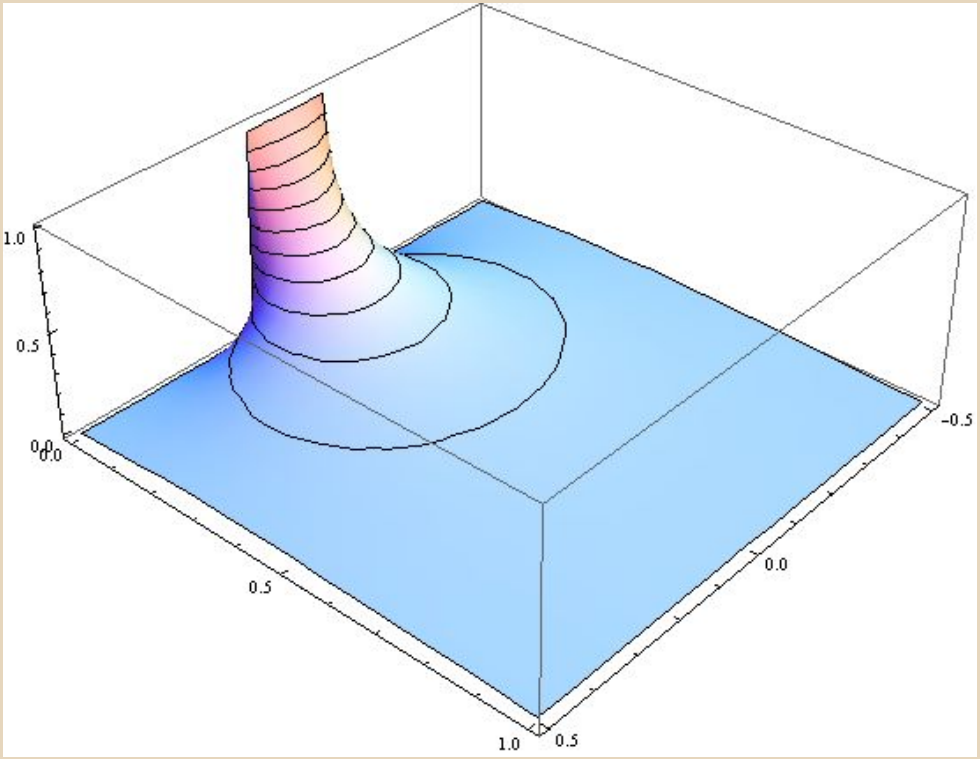
Currently:

- Electrons and holes move in the E+B field towards the respective sensor face
- Strip signals are generated based on the amount of charge that arrived to a specific strip area
- The time of charge arrival to sensor face is assigned to the generated signal
  - This has been modified to half that time recently as a rough improvement

Desired:

- Electrons and holes move in the E+B field.
- Strip signal is calculated from weighting field and transport velocity along charge trajectory

Time simulation

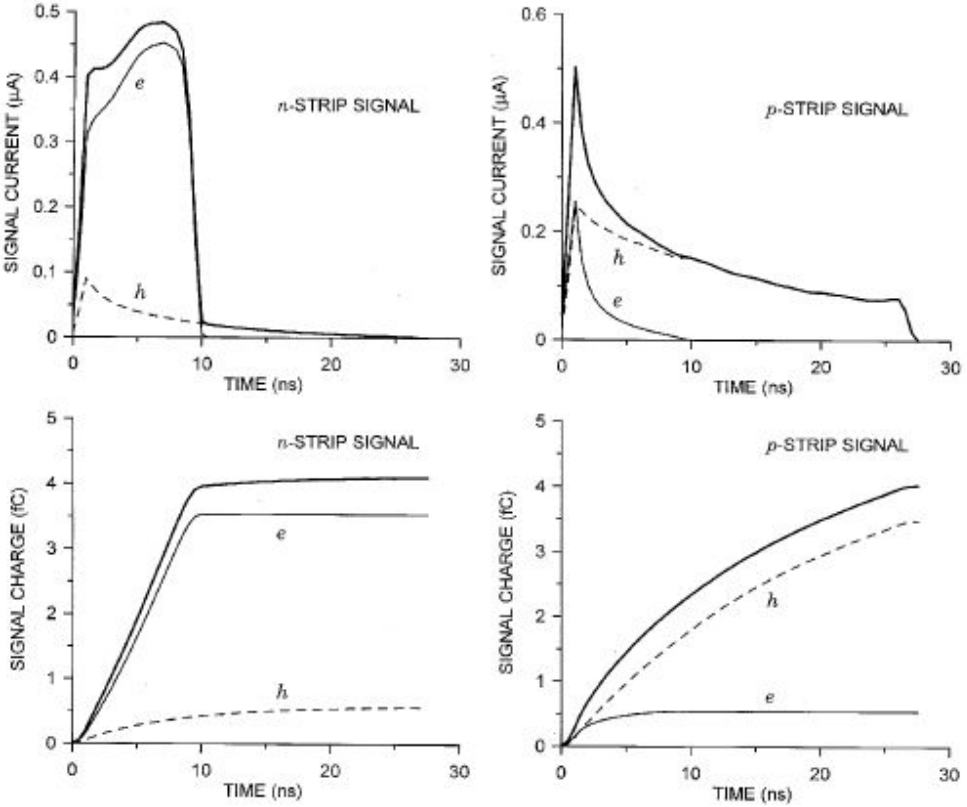


Weighting field

1. Strip-by-stirp, solve Laplace equation by putting that strip to potential 1 and all other strips to potential 0.
2. Charge on the strip induced by a particle moving from A to B is W(B) - W(A)
3. Current is $v.\nabla W$
4. We have to have a more precise electric field map as well to make this work reasonably (currently uniform in xy).

(illustration: analytical solution for a simple situation, slide by Peter Fischer)

Time simulation



Weighting field: when things get combined

Charges induced by a particle track

1. Electrons and holes move with a different velocities
2. Time scale of 10 ns and 25 ns, so we can expect a corresponding broadening of waveforms compared to calibration - not exactly observed in testbeam!!!

(Plots from Helmut Spieler lecture slides)

Time simulation

Notes:

1. Current simulation is basically correct as regards charge distribution (modulo strip capacitances that have to be set properly)
2. The weighting field simulation will be more complicated and the trick is to find a crude approximation that works
   - That's why we need a detailed simulation
3. The benefits of proper timing simulation:
   - Correct transformation of signal waveforms (shift + width increase), can be tested on real data
   - Little inverse inference, the effect is poor in features and noisy
4. We need a better E-field simulation, too, with the same mesh representation as the weighting field.
5. Parameterization:
   - Lorentz effect - use Hall factor as calibration parameter?
   - Parameters of W and E field approximations for tuning

Prototype simulation

Python - Jupyter notebook (?)

- Detailed simulation of electric field and weighting field within a small number of sensor cells, PDE solver
- Input of realistic particle energy depositions from SVDSimHits/TrueHits
- We want high detail at reasonable execution speed (interactivity)
- Easy use outside of basf2

Status:

- In construction
  - PDE solver
  - Simple approximation using analytic solution
  - Plots

Plan:

- February.

Stripwise parameterization: 2 modes

Calibration data

We want to simulate data using detector properties at a specific moment in time

- Bad strips
- Strip gains
- Waveform parameters

Artificial variation

We need to understand the effects of strip parameter variation. For that, we need control over the size of variation.

- Take mean values and variances from calibration
- Generate random strip parameters based on these parameters
- Look at correlations
- Bad strips: assign randomly

Strip-wise parameterization

Status

This is a straightforward task, but so far nothing has been done

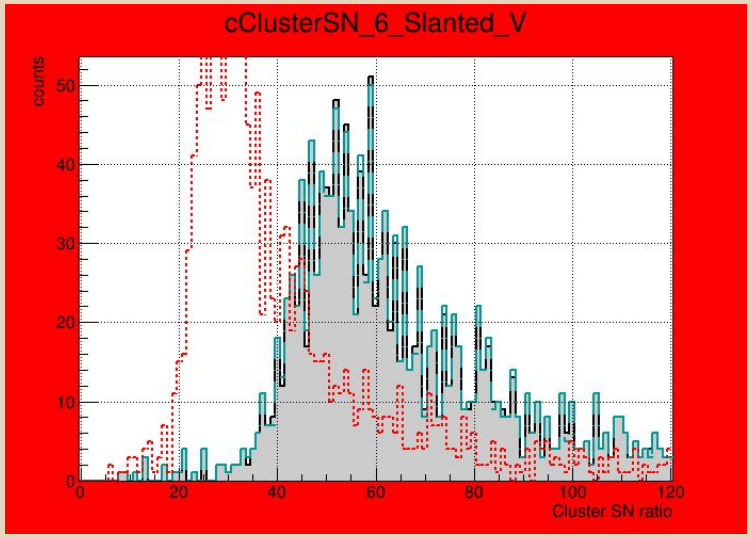
Plan

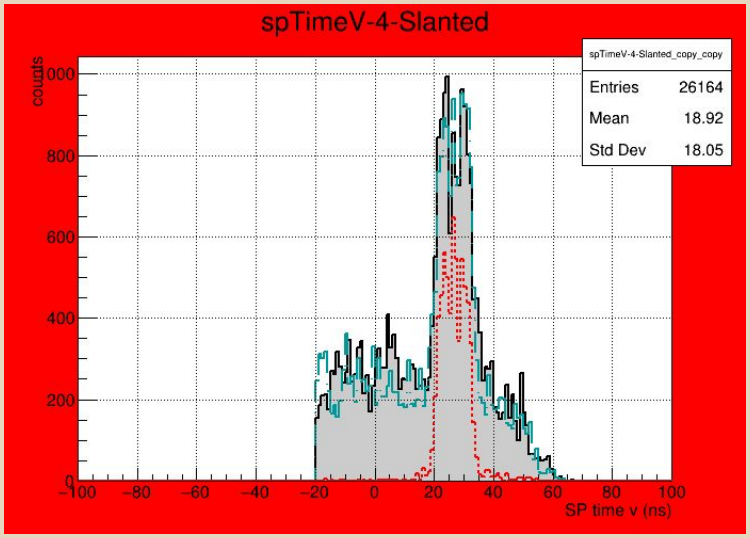
February

Current status of simulation

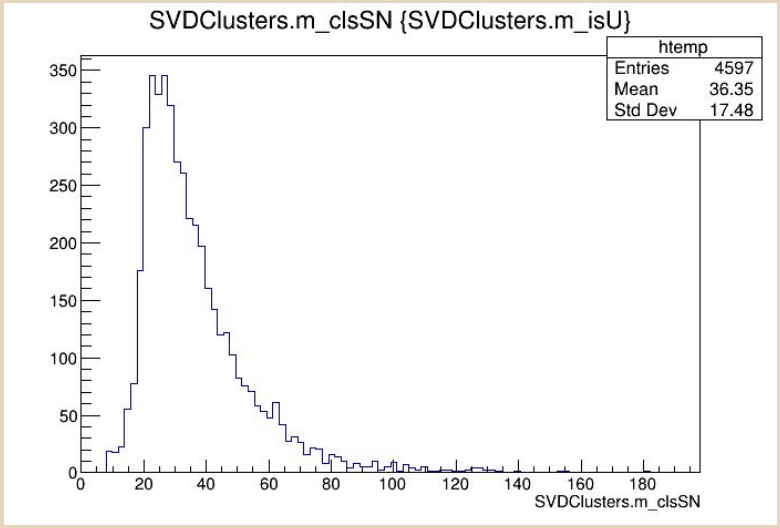
Shift of cluster SN peak

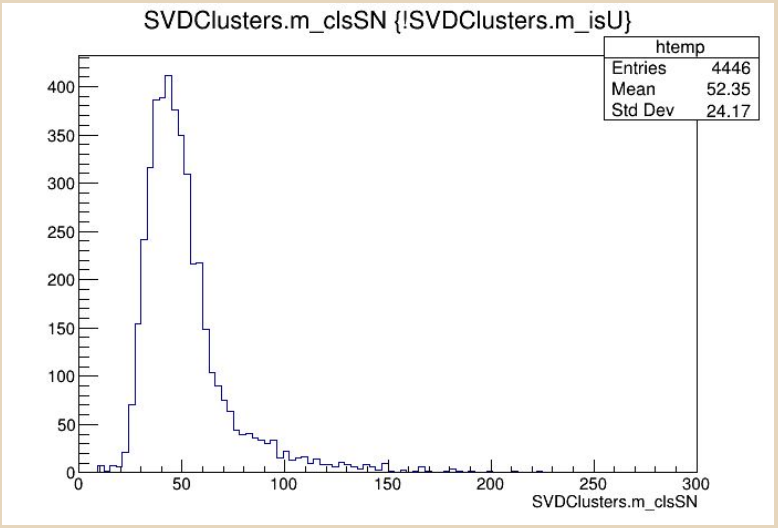
1. Appeared in late January
2. **Origin still under investigation**
3. At the same time, only small changes in validation plots showing simulation data
4. Large changes in spacepoint time distribution.

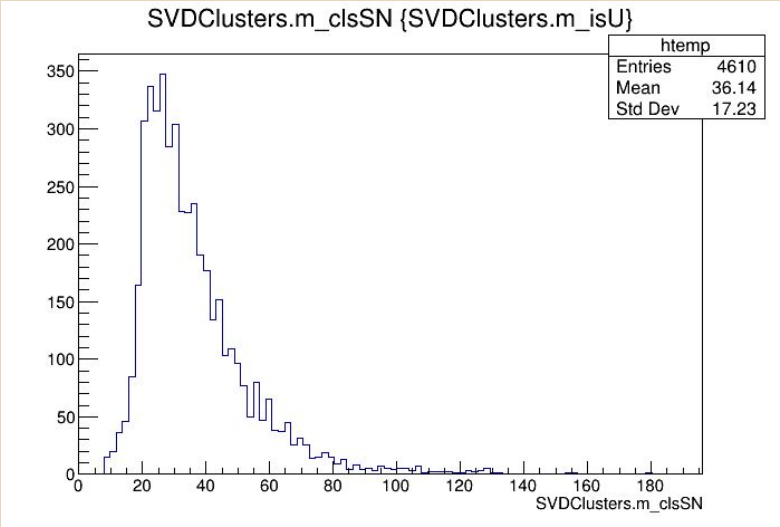


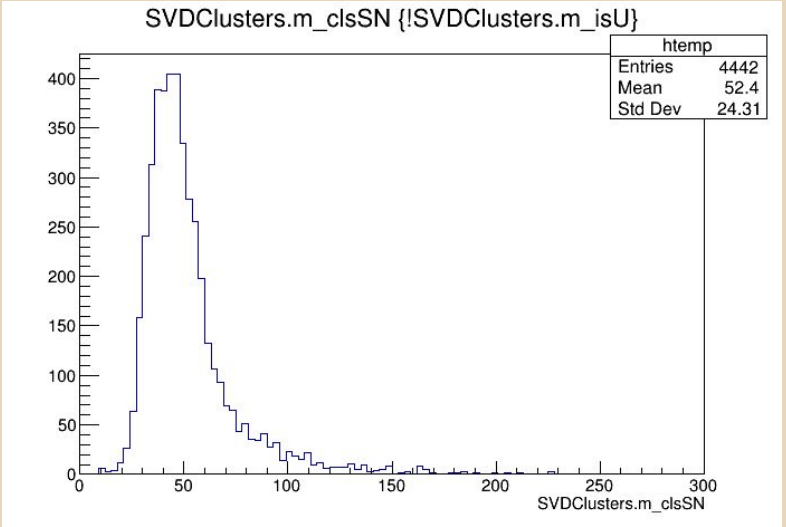


Current status of simulation









Conclusions

Status

1. Basf2 approximation to be tested with testbeam and Phase-2 data, February
2. Strip noise: requires more time to settle
3. Strip-wise parameterization next week