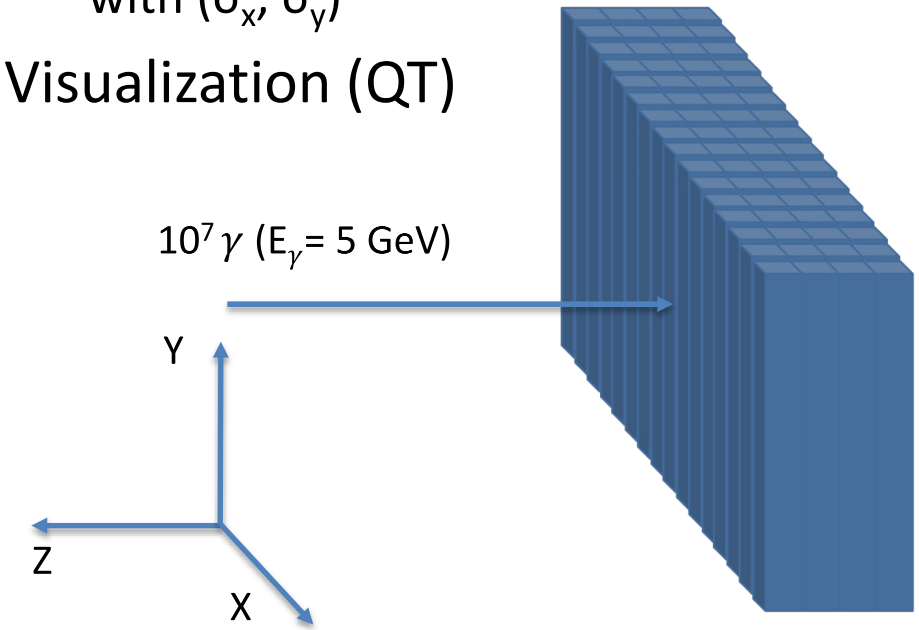
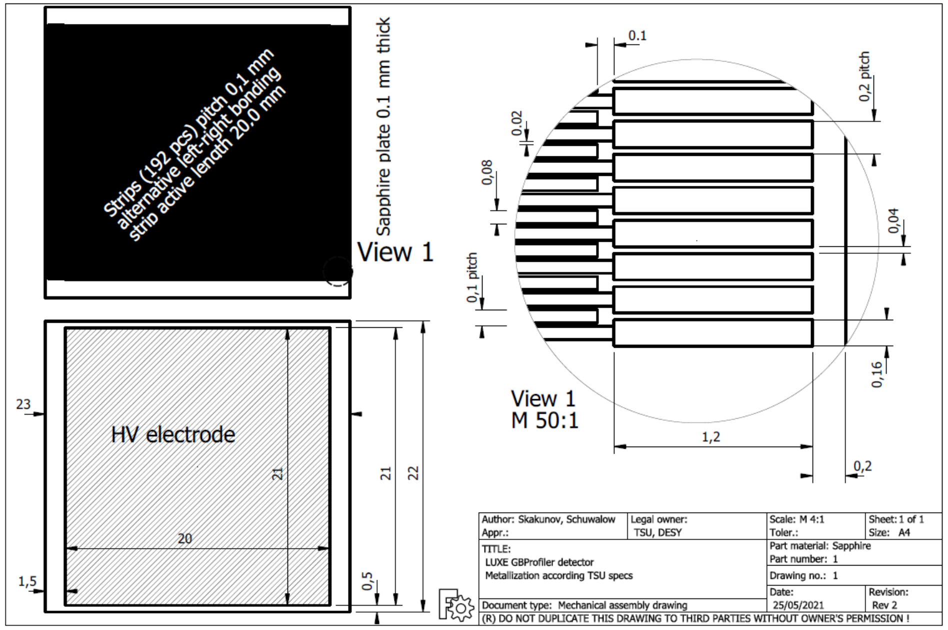
Standalone MC for LUXE GBP

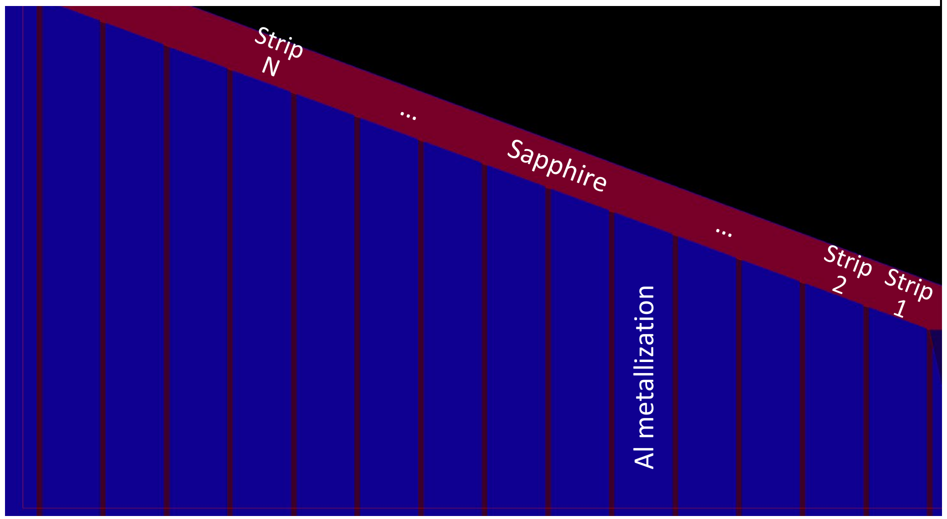
some updates

Current status of the ‘Standalone MC’

- Latest detector geometry was implemented
  - Front/rear metallization
  - Strip spacing
- Initial γ beam
  - It is directed along -z, gaussian distributed in the xy-plane with (σ_x, σ_y)
- Visualization (QT)

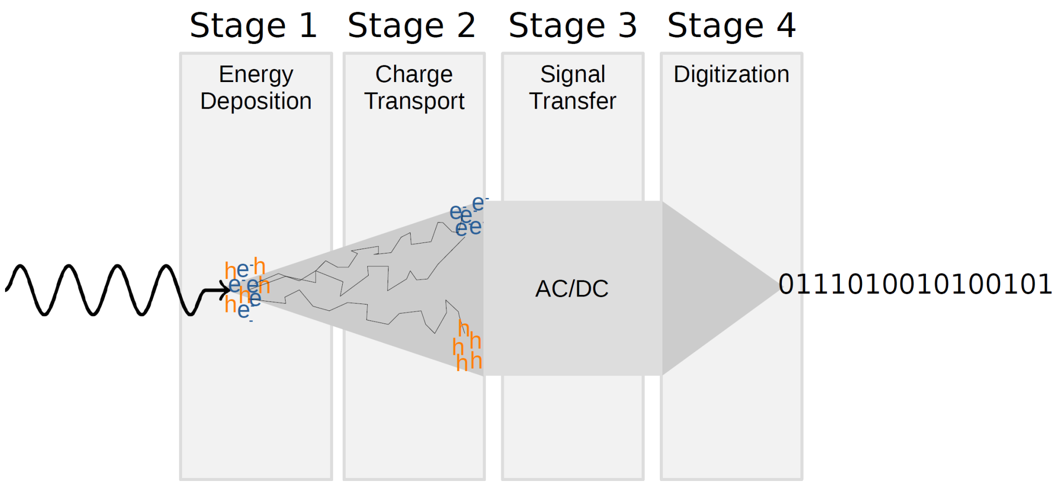






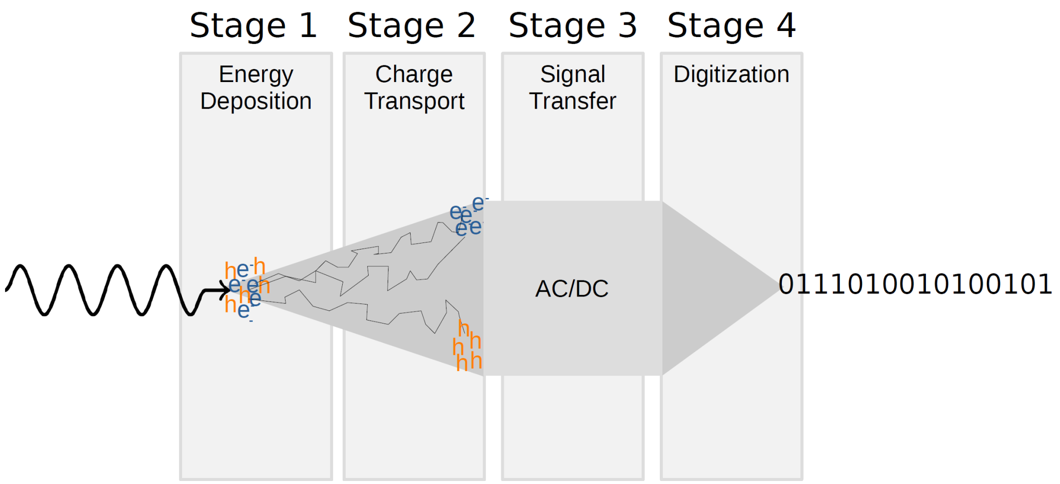
What is next?

- The bare GEANT4 analysis allows to estimate the expected bare detector performance, for instance analysing energy deposits and charge particle production within the sensitive volumes.
- However, it is a priority to simulate the signal formation at the electrodes in order
  - to estimate the collection efficiency the detector;
  - to build a MC expectation for the experimental detector characterization data;
  - to optimize detector design.
- There are 3 steps leading to ‘The Waveform’
  - Energy deposition
  - Charge transport
  - Signal transfer



Strategies and working plan

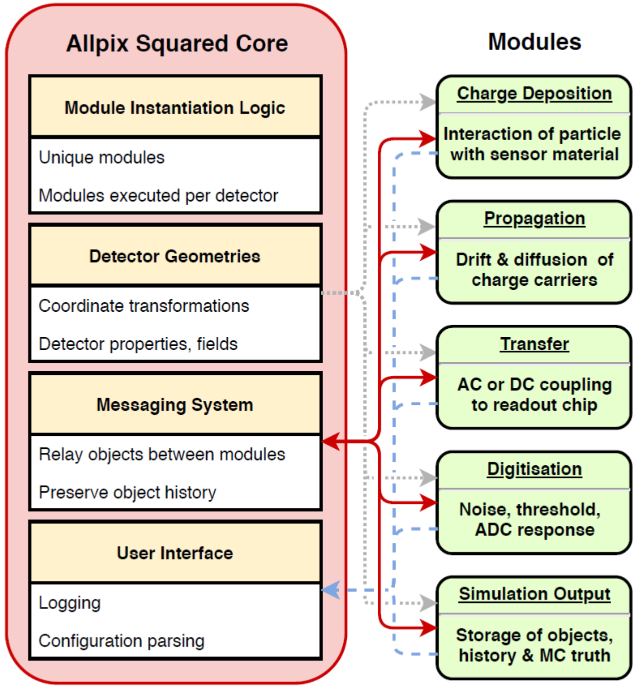
- There are several options to address this problem. They are divided in the two classes: the deterministic (or semideterministic) approach and the stochastic one.
- All the simulation frameworks considered are best suited for semiconductor detectors.
- Synopsys TCAD is considered the reference standard for silicon-based detector simulations. It solves the Poisson's equation using doping information, and it provides detailed information of the field configuration.
- On the other hand, Monte Carlo approaches
  - account stochastic effects;
  - can be inspected in every step;
  - the processes can be 'layered' in complexity;
  - the implementation of physical processes is clear and customizable in every line of code;
  - realistic performance with GEANT4 integration.



Strategies and working plan

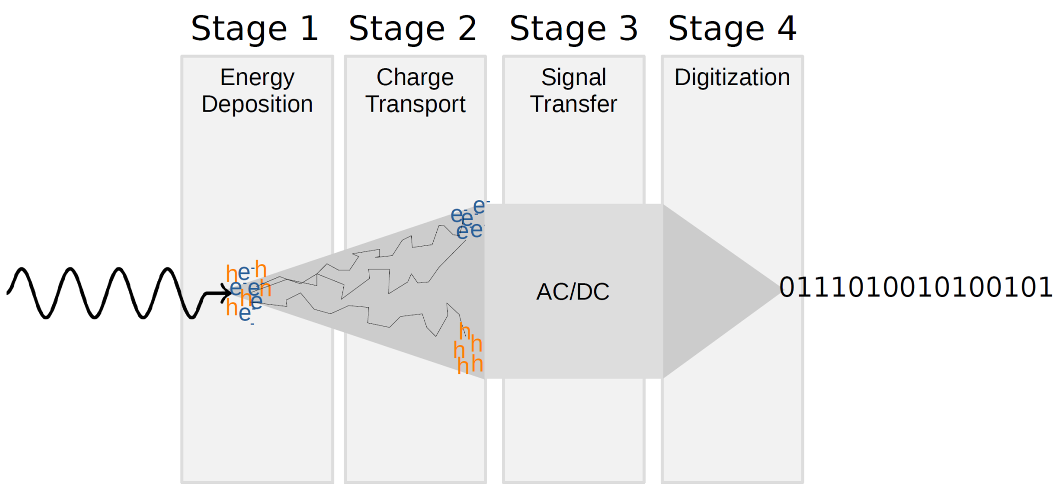
- The MC approach seems simpler, less time-demanding and easily integrable with other simulation frameworks (like GEANT4) by means of ROOT messengers.
- PixelAV, KdetSim, Garfield++, Weightfield2, AllPix1 are examples of packages for the charge transport / signal transfer.
- The candidate under consideration is AllPix^2 in combination with Weightfield2.

> AllPix^2 is a generic, open-source software framework for the simulation of silicon pixel detectors. Its goal is to ease the implementation of detailed simulations for both single detectors and more complex setups such as beam telescopes *from incident radiation to the digitised detector response.*



Why AllPix^2?

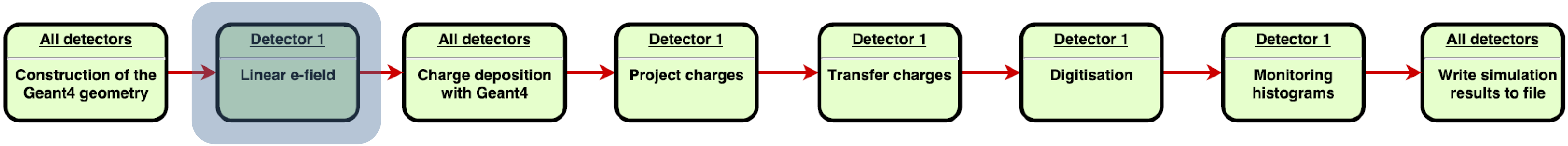
- Open code & multithread-ready
- Extremely easy GEANT and ROOT integrations
- Paul Schütze (DESY) is one of the authors
- Well documented manual (180 pp.)
- All the 4 steps are encompassed by a unique framework



- Many built-in physical processes for charge carrier mobility. Some models depend of the electric field strength to parametrize the mobility, others on the doping concentration of the device.
  - Jacoboni-Canali
  - Canali
  - Hamburg
  - Hamburg (2.5 keV/cm)
  - Masetti
  - Arora
  - Extended Canali
- Possibility to simulate finite charge carriers lifetimes as a function of local doping concentration via non-radiative recombination processes (Shockley-Read-Hall, Auger, both)

What about Weightfield2?

- AllPix² default electric/magnetic field is zero. There are two presents for uniform fields.



- This approximation can be improved by a calculating the actual field configuration for a given geometry. This is the primary task of *Weightfield2*
  - Actual GEANT4 geometry is passed to Allpix2, and the weighfield2 code for evaluating the E field will be implemented as a module.

Conclusions

- AllPix^2 seems the best candidate for the signal reconstruction.
  - Physical processes can be inferred precisely from the code
  - Ready-to-use GEANT4 geometries/data can be passed without any integrations
  - **ProjectionPropagation** module calculates the total drift time for each set of charge carriers by an analytical approx. of the mobility integral. Also, it applies a randomised lateral diffusion
  - **GenericPropagation** module allows for a more detailed transportation model by parametrisation of charge mobility.
  - **CapacitiveTransfer** module simulate crosscoupling between different pixels in order to emulate the behaviour of the assembly.