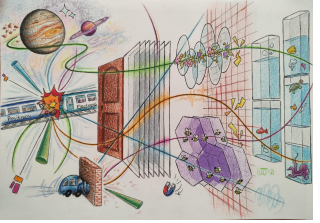


WP4 - MC simulations

Proposal for work plan and milestones

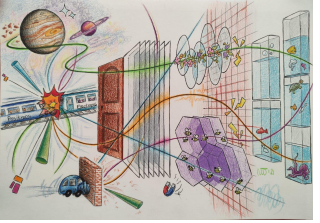
S. Spannagel, J. Schwandt

on behalf of the WP4 preparation/proposal group



Semiconductor Detector MC Simulations DRD3

- Complexity of detectors increases, more and more technologies available, different approaches combined (e.g. monolithic + LGAD)
 - Necessity of MC simulations growing
 - Some sensors / setups impractical to simulate in TCAD (time limitation, stochastics)
 - Community needs *common* flexible, tested & supported MC simulation tools
- Using Monte Carlo methods to describe detector response is not new
- Creation & proliferation of many different codes for detector simulation
 - Experiment-specific
 - Specialized on specific detectors
 - Inclusion only of effects relevant to that one simulation
 - Written as part of a PhD thesis, abandoned afterwards
- Would be great to collate features in commonly maintained software (->SM)
 - Having several tools is valuable as testbed for algorithms
 - Well-maintained & supported common software will significantly ease use in community



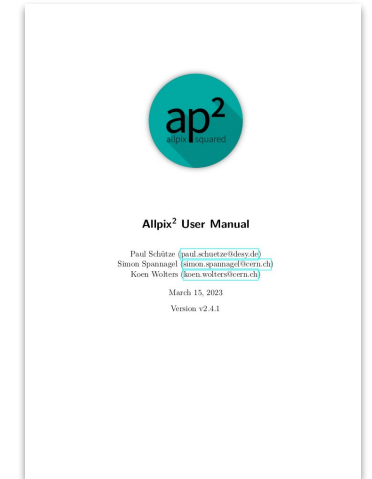
Development of Common Frameworks

DRD3

- **Development of Allpix² Framework**

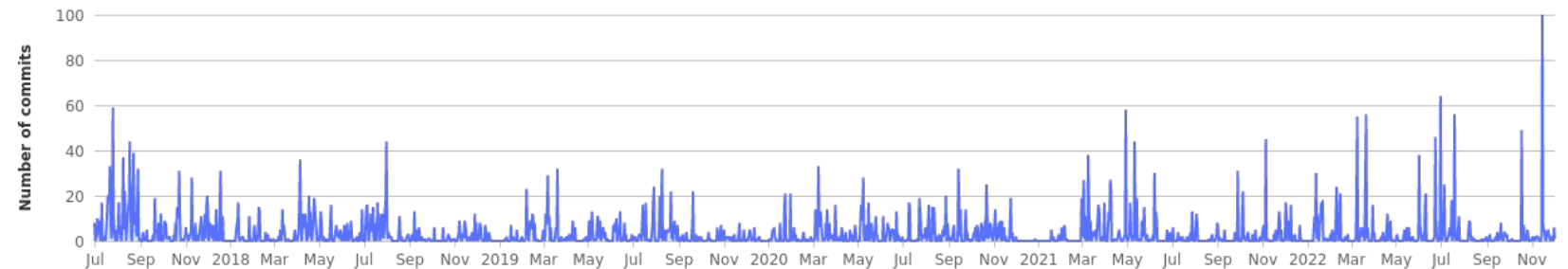
- Development started within **CLICdp Collaboration** 6 years ago
- 46 releases, current version 2.4.1
- 3 user workshops, > 50 code contributors, extensive documentation

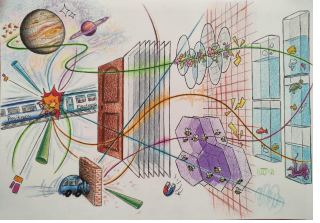
<https://indico.cern.ch/e/apsqws4>



- **Current state of the development**

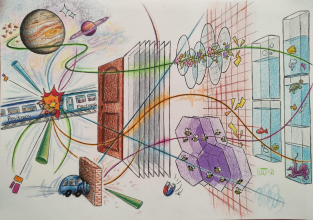
- Integrates with Geant4, automatic geometry generation, tuned physics list / cuts setup
- Provides field conversion tools for TCAD (Synopsys, Silvaco)
- Algorithms with different simulation complexity (projection, charge collection, induction)
- Many models available (mobility models, trapping, recombination, ...)
- Fully parallel for multi/many-core simulation runs





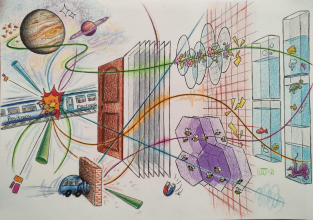
MC Simulations: Input from Community DRD3

- In many cases MC is not explicitly mentioned, but rather an implicit part of larger R&D project, accompanies sensor testing/development
 - e.g. "developing of novel monolithic CMOS sensors"
- We should differentiate between:
 - model building, development of simulation tools, understanding of sensor effects
 - application of common simulation tools in sensor R&D projects
- Strong interest by many institutes on CMOS sensor simulations
 - TCAD mentioned often, but full understanding also requires MC!
 - As community, we have to overcome issues with missing sensor production information
- Interest by many institutes to work on radiation damage models, both TCAD & MC
- Explicit interest by several institutes to simulate & understand non-Si materials
- Interest to build new models to describe e.g. gain screening effects in LGADs



Future Directions & Developments DRD3

- **Development & extension of common Monte Carlo tools**
 - Continue development of flexible, universal framework for semiconductor MC simulations
 - Validation of algorithms / models
- **Model building for adaptive electric fields**
 - LGADs - gain screening
 - Plasma effects - high local charge densities, heavy ions, high gamma fluxes
 - Dynamic trapping/de-trapping models
- **Time-weighted simulation approach - dynamic weighting field**
- **Development of commonly-used front-end circuit models**
 - Hit digitization modeling, possibility of tuning towards specific applications
 - Interface to SPICE simulators
- **Continue documentation & training effort**
 - User workshops & tutorials / trainings
 - Providing reference manual with models, simulation flow description, ...



Milestones, Deliverables & Resources

DRD3

Short term (S-) / mid term (M-) milestones (-M) and deliverables (-D):

- SM - Validate current impact ionization modeling
- SD - Develop algorithm to include adaptive e-fields (brute-force)
- SM - Collate solutions from different MC tools
- MM/D - Investigate possible ways to simulate front-end responses
- MD - Pre-defined digitization models for different devices / front-ends

Long term (L-)

- LD - Build model to approximate space charge effects (computat. efficient)

Resources

- Model building requires dedicated resources
 - Should take into account that model validation requires (pre-analyzed!) data
- Support, training, dissemination requires dedicated resources
 - Should investigate if sensible to combine with TCAD training
- Estimate of ~ 5 FTE for MC simulation tools development & training