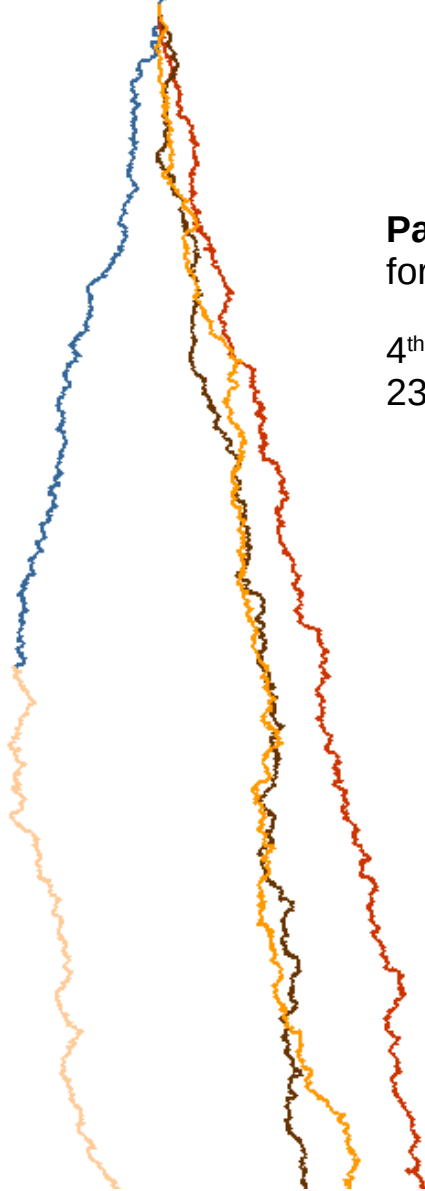


# Allpix Squared

## The Show Must Go On



**Paul Schütze, Simon Spannagel**  
for the Allpix Squared Authors

4<sup>th</sup> Allpix Squared User Workshop  
23<sup>rd</sup> May 2023

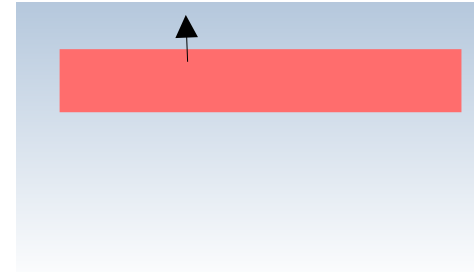


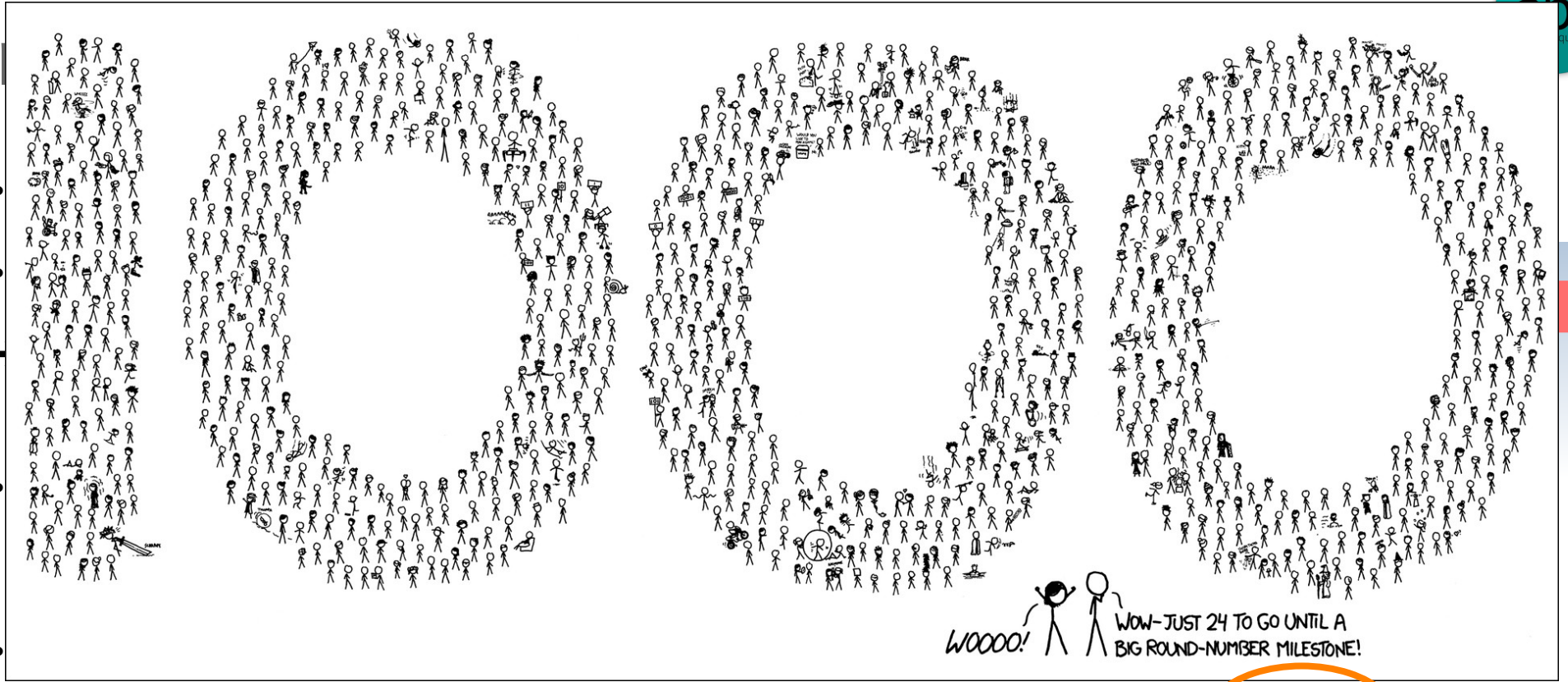
# Allpix Squared Development

- Version 3.0 has just been released
  - *Completed* several long-standing developments in preparation to this
- As always, there's more ...
- Some things under development, discussions ongoing and ideas forming, ...

# Impact Ionization – Precision

- Field used for per-step local gain determination:  $(E_{pre} + E_{post})/2$
- LGADs: high electric field slopes at the borders of the gain layer
- ➔ Propagation steps into and out of gain layer lack precision due to non-linear dependency of gain on electric field
- Reduction in step size would be valid for the whole sensor → computing time!
- Several ideas for improvements: in case of large field differences, ...
  - calculate position of threshold (or 50%) field and scale gain, see [!1000](#)
  - perform sub-sampling and integration of gain





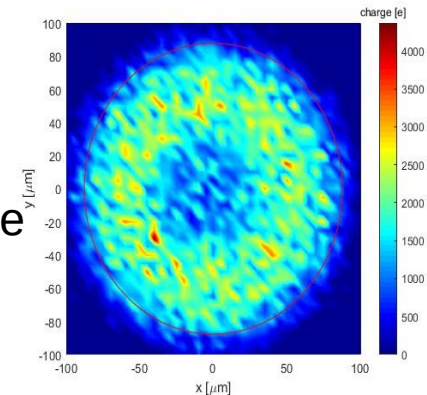
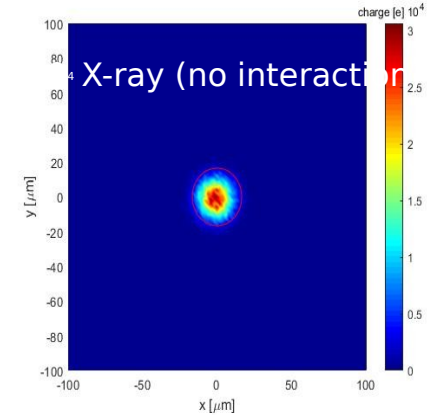
- calculate position of threshold (or 50%) field and scale gain, see **!1000**
- perform sub-sampling and integration of gain

# Impact Ionization – Gain Reduction

- For large gains or high ionisation density, secondary charge carriers can generate a counter field in the gain layer
  - Gain reduction
  
- Several simulation strategies possible:
  - Calculation of (counter-) field per-step
    - See following slide
  - Surrogate models – discussions ongoing

# High Charge Density Effects

- Current simulation modules based on simplification:  
No interaction between charge carriers
  - Very good approximation for low charge densities
  - Very fast since carriers can be transported individually
- Breaks down with high charge densities:  
we need Coulomb field contribution to external field
- Many applications (X-ray imaging/diffraction,  $\alpha$  measurements, UCN imaging, anti proton annihilation, ...)
- ➔ Working on new propagation module including interaction between charge carriers
- Still early state, investigating possibilities for reducing computational load



# Circuit Simulations

- Front-end simulations in Allpix Squared are still generic
  - Amplifier simulation & ToA/ToT determination
- Circuit simulations are usually standalone and lack realistic, fluctuating sensor signals
- Goal: provide an interface towards device simulations
- ➔ Efforts on bridging the gap: dedicated PhD position @IPHC
- ➔ Import of CADENCE data – see [talk by Rafaella](#)

# Readout Architecture Implementation

- Goal: make Allpix Squared capable of studying readout architectures
  - Simulate buffers
  - Implement readout bandwidth
- ➔ Idea: implement sequential module with local event buffers
- ➔ Interface to implement different readout architectures



# This & That

- Sapphire as sensor material → see [talk by Pietro](#)
- Simulating the sensor edge → see [forum entry by Peilin](#)
- More flexibility in matrix layout – inhomogeneous pixel layouts → see [talk by Florian](#)
- Charge injection into front-end similar to [Andreas' solution](#) → separate module?

# Allpix Squared & the ECFA Detector R&D Roadmap

## Monte Carlo Simulations in DRD3 – Solid State Detectors

- Complexity of detectors increases, many 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
- Proposal in **DRD3 / WG4 (Simulations)** to establish Allpix Squared as **commonly maintained MC simulation software**
  - Development & extension of flexible, universal framework for semiconductor MC simulations
  - Model building for adaptive electric fields
    - 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, interface to SPICE simulators
  - Continue documentation & training effort: User workshops & tutorials / trainings, reference manual

# DRD3

ECFA

European Committee for Future Accelerators

# Summary

ap<sup>2</sup>  
allpix | squared

# Summary

- Despite the recent release of v3.0, there's a lot of ideas, discussions and code in progress
- We tried to give you a glimpse into things in progress
- We're happy for help!
- Contact us in case you ...
  - ... have code that could potentially be useful for others → share it
  - ... are in doubt how to implement features sustainably → we can help
  - ... use analysis macros that make use of Allpix Squared objects
- Merge requests, forum posts, mail, mattermost ...

# Allpix Squared Resources



Website

<https://cern.ch/allpix-squared>



Repository

<https://gitlab.cern.ch/allpix-squared/allpix-squared>



Docker Images

[https://gitlab.cern.ch/allpix-squared/allpix-squared/container\\_registry](https://gitlab.cern.ch/allpix-squared/allpix-squared/container_registry)



User Forum:

<https://cern.ch/allpix-squared-forum/>



Mailing Lists:

allpix-squared-users <https://e-groups.cern.ch/e-groups/Egroup.do?egroupId=10262858>

allpix-squared-developers <https://e-groups.cern.ch/e-groups/Egroup.do?egroupId=10273730>



User Manual:

<https://cern.ch/allpix-squared/usermanual/allpix-manual.pdf>



Mattermost