# 4th Allpix Squared User Workshop

Monday, 22 May 2023 - Tuesday, 23 May 2023

DESY, Hamburg, Germany

# Book of Abstracts

# Contents

**Applications and studies / 1**

## Reconstruction of high track density beams in beam tests

**Author:** Christopher Krause[1]

[1] *Technische Universitaet Dortmund (DE)*

**Corresponding Author:** christopher.krause@cern.ch

The Inner Tracker of the ATLAS experiment requires the optimal performance of its pixel sensors. To test their efficiency, a reliable track reconstruction and analysis for testbeam data is necessary to ensure the precise detection of particles. The quality of data from testbeam campaigns are influenced by many factors, including high beam densities, which can impair the track reconstruction.
To analyse and evaluate the data taken at beam tests, the track reconstruction software Corryvreckan is used.
The reconstruction of particle tracks with too many hits becomes increasingly difficult due to the ambiguity of track fits. In order to differentiate between false and true reconstructed tracks, a machine learner is implemented, which is trained on simulated testbeam data, generated by the Allpix Squared software.
This talk presents results of the track reconstruction of high track density using Corryvreckan and the performance of a machine learner for true track tagging.
Both simulated data and real testbeam data is investigated.

**Applications and studies / 2**

## The 100μPET project: Simulation of the next generation PET scanner with monolithic silicon pixel sensors

**Author:** Jihad Saidi[1]

**Co-authors:** Andrea Pizarro Medina ; Antonio Picardi [1]; Carlo Alberto Fenoglio ; Didier Ferrere [1]; Frank Raphael Cadoux [1]; Fulvio Martinelli [1]; Giuseppe Iacobucci [1]; Jorge Andres Sabater Iglesias [1]; Lorenzo Paolozzi [2]; Luca Iodice [3]; Mateus Vicente Barreto Pinto [1]; Roberto Cardella [1]; Sergio Gonzalez Sevilla [1]; Stefano Zambito [4]; Thanushan Kugathasan [2]

[1] *Universite de Geneve (CH)*

[2] *CERN*

[3] *Universita degli Studi di Napoli Federico II (IT)*

[4] *University of Geneva*

**Corresponding Author:** jihad.saidi@cern.ch

The 100μPET project, led by the University of Geneva, the University of Luzern, and the École Polytechnique Fédérale de Lausanne, aims at the development of a small-animal positron emission tomography (PET) scanner with ultra-high-resolution molecular imaging capabilities.

This is achieved with compact and modular stacks of multiple thin monolithic pixel detectors bonded to flexible printed circuits (FPC) via flip-chip, thus resulting in unprecedented scanner depth-of-interaction and volumetric granularity.

Simulations performed with the Allpix$^2$ framework allowed the optimisation of the scanner sensitivity by analysing effects of different design choices such as, for example, the specifications of the Si layers and the impact of adding high-Z photon conversion layers, the thickness of the FPCs or cooling blocks. Simulations were also done to generate realistic scanner data for imaging reconstruction. Very large datasets with billions of events were produced with different source phantoms. A

point-spread-function of 0.2 mm was found, free of parallax effect, resulting in a volumetric spatial resolution of ˜ 0.015 mm$^3$ - one order of magnitude better than modern scanners.

The work developed within the Allpix$^2$ framework, including the PetAnalysis module and improvements for faster data generation, will be presented in this contribution.

**Welcome and Allpix Squared overview / 3**

## Overview: Allpix Squared 2.x Releases

**Author:** Simon Spannagel[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** simon.spannagel@cern.ch

This contribution will summarize the new features released in 2022/2023 in the v2.x release series of Allpix Squared.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 4**

## Development and simulation of a new preshower detector for the FASER experiment at the LHC

**Author:** Rafaella Eleni Kotitsa[1]

[1] *CERN*

**Corresponding Author:** rafaella.eleni.kotitsa@cern.ch

The design of a new high-granularity pre-shower detector for the FASER experiment at LHC is in progress, with the purpose of measuring and discriminating electromagnetic showers generated by photons with O(TeV) energies and separation down to 200 µm. The new pre-shower will comprise six planes of monolithic silicon pixel detectors with hexagonal pixels of 65 µm side.
The detector simulation was implemented in Allpix Squared to drive the design of the pre-shower layout and the production of the shower reconstruction algorithms. New modules were developed for the integration of the hexagonal pixel matrix and the simulation of the ASIC charge measurement and digitization circuit. The update of the simulations will be presented, as well as the implementation of the new module for the studies of the background of our experiment.

**Will the talk be given in person or remotely?**:

In person

**Applications, studies, and developments / 5**

## Simulation of laser-TCT experiments with Allpix$^2$

**Author:** Daniil Rastorguev[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** daniil.rastorguev@cern.ch

The Transient Current Technique (TCT) is a powerful yet flexible laboratory characterization technique for silicon sensors. By precisely injecting charges with laser pulses and analyzing waveforms, produced as deposited charge drifts in the sensor bulk, one may experimentally study different charge collection features of the sensor under test.

With the development of novel types of silicon sensors with complex internal structures, experimental results can be challenging to interpret. To investigate possible outcomes of such experiments and understand these in detail, computer simulations are often used.

This work focuses on Monte-Carlo simulations of TCT experiments, performed with the Allpix$^2$ framework.
A dedicated Allpix$^2$ module, modeling absorption of laser light in silicon sensors, was developed to build a full pipeline that simulates processes occuring in a real experiment.
An overview of the simulation technique is presented, as well as first simulation results and its comparison to experimental data.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 6**

## A look to Charge carrier properties in single-crystal diamonds using the Allpix-squared simulation framework

**Author:** Faiz Ishaqzai[1]

**Co-authors:** Tobias Bisanz [2]; Christopher Krause [2]; Kevin Kroeninger [2]; Jens Weingarten [2]

[1] *TU Dortmund, DEU Izmir, Kabul University*

[2] *TU Dortmund*

**Corresponding Author:** faiz.ishaqzai@tu-dortmund.de

Allpix-Squard is Geant4 based modular framework that was initially designed for the simulation of silicon detectors in high-energy physics but now its sensor material capability and applicability have been extended. My work is intended to check the validity of the implementation of Diamond material in Allpix-squared. Diamond sensors have specific applications in high-energy physic because of their faster signal generation, thermal properties, and ability to operate in harsh conditions. To test the implementation, the basic charge carrier properties e.g. low field mobility, saturation velocities, and drift velocities of pure single-crystal diamond material are obtained at different applied voltages via simulation and compared with the standard literature data. From our initial results, it is concluded that diamond implementation is not valid in Allpix-squared, and in the first step, new parameter values for the Caughy mobility model have been added for diamond sensors. Further investigations are necessary in the case of polycrystalline diamond sensors and their operation in high-radiation environments. The full implementation of Diamond sensor material will significantly contribute to the task of R&D of Diamond sensors by making the simulated prototype simply possible. I will present the ongoing status of the implementation of the diamond as detector material in Allpix Squared.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 7**

## Time Resolution Simulations for 4H-SiC PiN Detectors

**Authors:** Andreas Gsponer[1]; Paul Sommerer[2]

[1] *Austrian Academy of Sciences (AT)*

[2] *Austrian Academy of Sciences*

**Corresponding Author:** andreas.gsponer@cern.ch

Silicon Carbide (SiC) is a wide-bandgap semiconductor that has recently become a topic of intensified interest in the HEP instrumentation community due to the availability of high-quality wafers from the power electronics industry. SiC features multiple advantageous material properties over silicon. It is insensitive to visible light, hypothesized to be more radiation hard, and has much lower leakage currents, even after irradiation. As the impact ionization coefficient for electrons is larger than for holes in SiC, this would enable a Low Gain Avalanche Diode (LGAD) based on electron multiplication, suitable for high precision timing applications.

Using the transient current technique (TCT), which uses an ultra-violet LASER to induce electron-hole pairs, we investigated 4H-SiC samples in terms of charge collection and timing performance. Due to the deterministic nature of TCT measurements, they can serve as a basis for validating detector simulations.

In order to reproduce the measurements, an AllPix² simulation has been performed. The extended Canali model has been used to describe the charge carrier mobility, and electric and weighting fields have been imported from Synopsys Sentaurus TCAD. Transients waveforms were obtained by using the CSADigitizer module together with a measured transfer function of the front-end electronics. The simulation results are compared to measurements, and finally, some challenges specific to simulating transient waveforms and non-silicon detector materials are highlighted.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 8**

## Assessing the Impact of Miscalibrating the RD53B-CMS Front End for the HL-LHC CMS Inner Tracker

**Author:** Andreas Mastronikolis[1]

[1] *University of Manchester (GB)*

**Corresponding Author:** andreas.mastronikolis@cern.ch

In this work, we present a framework, wrapped around Allpix$^2$, that can be used to optimize the performance of the HL-LHC CMS Inner Tracker. The framework uses minimum-bias events, generated at a pileup of 200, and simulates their transversal through silicon pixel sensors with Allpix$^2$. The behavior of the Inner Tracker front-end (RD53B-CMS, i.e. CROC), for processing pixel hits, has been defined outside of Allpix, with standalone code. With a clustering and a position reconstruction scheme, the framework can compute how various quantities of interest vary with respect

to the parameters of the CROC digital and analog front end. As an illustrative example, the variation of spatial resolution of a specific Inner Tracker module can be determined with respect to the Krummenacher feedback current set on its respective readout chip.

The presentation of this work will review the present status and capabilities of this framework and outline future directions.

**Will the talk be given in person or remotely?**:

Remotely

**Applications, studies, and developments / 9**

## Test beam simulations of the ATLAS ITk Strip End-Cap detectors

**Author:** Radek Privara[1]

[1] *Palacky University (CZ)*

**Corresponding Author:** radek.privara@cern.ch

The Allpix-Squared simulation toolkit has long been used by the ATLAS Collaboration to perform simulations of silicon pixel and strip detectors, developed for future deployment in the upgraded central detector called the ATLAS Inner Tracker (ITk). Lately, the focus has shifted towards a particular class of strip detectors featuring radial geometry of strips, so-called ITk Strip End-Cap detectors, and for several years, prototypes of such detectors have been tested extensively at the DESY II Test Beam Facility.

Full simulations of the experimental test beam setup of the DURANTA telescope at the DESY-II Test Beam Facility have been performed in Allpix-Squared. Two strip End-Cap detectors were simulated as the device-under-test (DUT), the ATLAS ITk Strip R2 and R4. Additional efforts were spent to explore the effects of the particle beam impacting the DUTs under a non-perpendicular angle. The resulting simulation output has been reconstructed and analysed using the Corryvreckan framework, which has also been used by the ATLAS ITk Strip and Test Beam Group for reconstruction of test beam data.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 10**

## Deconvolution of Spectra of High-Flux Mixed Radiation Fields with Dosepix

**Author:** Florian Beißer[1]

**Co-authors:** Dennis Haag [1]; Leonie Ullmann [1]; Thilo Michel [1]

[1] *Erlangen Centre for Astroparticle Physics*

**Corresponding Author:** florian.beisser@fau.de

Radiation therapy is commonly used for cancer treatment. However, not only tumor tissue is affected by ionizing radiation, but also healthy tissue is damaged [1]. The ratio of tumor control with respect to healthy tissue damage needs to be optimised by choosing suitable particle types, energies, and dose rates. Healthy tissue is less affected if dose is applied with very high dose rates, i.e. short pulse duration, while tumor control is approximately independent of dose rate (FLASH effect) [2]. Therefore, high dose rate treatments might allow for larger treatment windows and better tumor regulation.
There is no detector at the time of this abstract (April 2023) that is capable of correctly reconstructing spectra of the radiation fields occuring in FLASH applications. In this abstract, simulations of a prototype of a spectrometer based on the hybrid photon-counting energy-resolving pixel detector Dosepix are presented [3]. Dosepix has been developed by a collaboration of Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) and the European Organisation for Nuclear Research (CERN). A 300 µm thick silicon sensor layer is attached to Dosepix ASIC. Deposited energies are sorted into a histogram of 16 energy bins by the individual pixel electronics.
Ten Dosepix detectors are aligned behind each other. Filters of different materials and thicknesses are positioned between the detectors. Therefore, information about the particle type and energy is accessible from its absorption behaviour, i.e. the ratios of registered events in the individual Dosepix detectors. Read-out electronics is taken into account by the utilised Allpix-Squared simulation only in terms of its scattering behaviour. The novel CSADigitizer-Module is used to receive information about the detector behaviour under ultra-high dose rates. Spectral reconstruction is currently performed via deconvolution similar to the procedure described in [4]. Exhaustive simulation data is hereby crucial to determine the response of each energy-channel of Dosepix in each layer. In the future, a different analysis approach utilising a neural network is going to be compared to the classical deconvolution.

[1] K. Lindberg et al: J Thoracic Oncol Journal of Thoracic Oncology, Volume 12, Issue 1, Supplement, 2017, Page S340, ISSN 1556-0864,
[2] A. Schüller et al: Physica Medica 80, 2020, Page 134–150
[3] W. Wong et al: Radiation Measurements, 2011, vol. 46, no. 12, Page 1619–1623
[4] R. Behrens: PTB-Dos-44: ISBN 978-3-86509-002-7

**Will the talk be given in person or remotely?**:

In person

**Applications, studies, and developments / 11**

## Deep learning for sub-micron UCN position resolution using CMOS sensor

**Author:** Shanny Lin[None]

**Corresponding Author:** shannylin@lanl.gov

**Authors:** S. Lin[1] , Z.Wang[1], W. Li[1], S. M. Clayton[1], J. K. Baldwin[1], S. A. Currie[1], M. A. Hoffbauer[1], T. M. Ito[1], M. Makela[1], C. L. Morris[1], C. O'Shaughnessy[1], M. Singh[1], Z. Tang[1], W. Uhrich[1], P. L. Walstrom[1], B. Wolfe[1], H. Zhu[2], N. B. Callahan[3], M. Blatnik[4], B. Filippone[4], E. M. Fries[4], K. P. Hickerson[4], S. Slutsky[4], V. Su[4], X. Sun[4], C. Swank[4], W. Wei[4], A. Komives[5], R. W. Pattie Jr.[6], L. Blokland[7], M. Dawid[7], W. Fox[7], D. J. Salvat[7], W. M. Snow[7], J. Vanderwerp[7], P. Geltenbort[8], E. I. Sharapov[9], T. Bailey[10], J. H. Choi[10], C. Cude-Woods[10], E. B. Dees[10], L. Hayen[10], R. Musedinovic[10], A. R. Young[10], L. J. Broussard[11], F. Gonzalez[11], J. Ramsey[11], A. Saunders[11], L. Chapman[12], C. Hasting[12], A. T. Holley[12], E. Upton[12], C. Shepherd[12], C.-Y. Liu[13], S. Spannagel[14]

[1]Los Alamos National Laboratory, Los Alamos, NM 87545, USA
[2]Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX 78712, USA
[3]Argonne National Laboratory, Lemont, IL 60439, USA
[4]Kellog Radiation Laboratory, California Institute of Technology, Pasadena, CA 91125, USA

[5]DePauw University, Greencastle, IN 46135, USA
[6]East Tennessee State University, Johnson City, TN 37614, USA
[7]Center for Exploration of Energy and Matter, Indiana University, Bloomington, IN 47405, USA
[8]Institut Laue-Langevin, CS 20156, 38042 Grenoble Cedex 9, France
[9]Joint Institute for Nuclear Research, 141980 Dubna, Russia
[10]Department of Physics, North Carolina State University, Raleigh, NC 27695, USA
[11]Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
[12]Tennessee Technological University, Cookeville, TN 38505, USA
[13]Department of Physics, University of Urbana-Champaign, Urbana, IL 161801, USA
[14]Deutsches Elektronen-Synchrotron, Notkestraβe 85, 22607 Hamburg, Germany

(For the 4 th Allpix Squared User Workshop, DESY, Hamburg, Germany; May 22-23, 2023)

High spatial resolution for ultracold neutron (UCN) measurement is highly desired for several UCN experiments such as UCN spectrometers, polarimeters, quantum physics, and quantum gravity. We describe the experimental UCN capture method using a room-temperature CMOS sensor and the nuclear reaction with boron-10. To obtain sub-micron position resolution, we explore the use of the open-source software Allpix Squared for data generation and deep learning for position prediction, and demonstrated sub-pixel and sub-micron resolution [1]. The automated analysis for sub-micron position resolution in UCN detection combined with the fast data rates of current and next generation UCN sources will enable improved precision for all modern UCN studies.

[1] X. Yue, et al., "Ultrafast CMOS image sensors and data-enabled super-resolution for multimodal radiographic imaging and tomography,"arXiv preprint arXiv:2301.11865 (2023).

LA-UR-23-23695

**Will the talk be given in person or remotely?**:

Remotely

**Applications and studies** / **12**

## Simulation of sapphire micro-strip detectors with Allpix Squared for the LUXE's Gamma Beam Profiler detector

**Author:** Pietro Grutta[None]

**Corresponding Author:** pietro.grutta@cern.ch

LUXE (Laser Und Xfel Experiment) is a new experiment proposed at DESY to investigate the strong-field regime of QED, with the main aims (a) to measure the interactions of real photons with $e^-/e^+$ at field strengths where the coupling to charges becomes non-perturbative; (b) to make precision measurements of the $e^-\gamma$ and $\gamma\gamma$ interactions in a transition from perturbative to non-perturbative QED; and (c) to exploit strong-field QED processes to search for new particles beyond the SM coupling to photons. This is achieved by using the European XFEL electron beam and an high-power 40TW laser. Two modes of operation are envisaged: e-laser mode, where electrons scatter photons in the focused laser beam at the interaction point (IP); and a gamma-laser mode, where the electron is first converted to high-energy gamma and then collided with the laser field. For the e-laser interactions, important information is contained in the energy spectrum and angular distribution of photons produced at the IP. Also, the ellipticity of the photon beam is a direct measure of the laser intensity experienced by the electrons.
The Gamma Beam Profiler (GBP) detector is part of LUXE's photon detection system. Its purpose is to measure the transverse profile of such an high-energy photon beam at about 11m downstream the IP. Such a detector operates in presence of a very intense high-energy gamma ray flux, calling for a radiation-hard material, and it has target 5um profile reconstruction accuracy goal. A micro-strip detector made of artificial optical-grade sapphire is envisaged for this task. This material has an extremely low leakage current at room temperature, remaining stable under high irradiation, therefore

representing a promising low-cost alternative to the well known diamond detectors often used in such beam monitor applications.

This talk focuses on the efforts to parametrically simulate a sapphire micro-strip detector using the Allpix Squared framework and only open-source software - e.g. Salome (CAD), ELMER (finite-element field solver) and Paraview (visualization). First, the key steps of simulation development are briefly summarized. Also, a first validation of the tool with data in the literature is presented. Second, recent experimental data from test beams is used to fine-tune the simulation to the GBP case. Last, the tools is used to evaluate the expected detector performance in profile reconstruction when the front-end response is taken into account.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 13**

# Beam Telescope Simulations in Allpix Squared

**Author:** Sara Ruiz Daza[1]

**Co-authors:** Håkan Wennlöf [1]; Simon Spannagel [1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** sara.ruiz.daza@cern.ch

Beam telescopes are used to investigate future particle detector prototypes, and to do this efficiently they must provide excellent position and time resolution at the device under test location. One of the goals of the Tangerine Project is to develop a beam telescope based on sensors created in a 65 nm CMOS imaging process. In order to study the tracking performance and optimize the best geometry configuration, simulations are needed.

This contribution will focus on the steps needed for a realistic beam telescope simulation using the Allpix Squared framework. Moreover, the talk will cover the integration of Allpix Square with Corryvreckan, a framework dedicated to reconstructing and analyzing test beam data. The analysis chain will be explained, using a beam telescope made up of sensors based on work carried out in the Tangerine project as an example.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 14**

# A Timepix3 front-end simulator plugin for Allpix2

**Authors:** Lukas Tlustos[1]; Pinelopi Christodoulou[1]

[1] *Czech Technical University in Prague (CZ)*

**Corresponding Author:** pinelopi.christodoulou@cern.ch

The talk will present the latest implementation of the Timepix3 front-end simulator. The front-end electronics channel is modelled using an integrator stage and parallel low-pass filtered feedback loops with individually configurable time constants. The system noise is implemented using independent bandwidth limited noise channels for pre-amplifier, feedback and threshold noise. The Timepix3 time of arrival (ToA) and time over threshold (ToT) measurement is computed using a discriminator model with independent rise and fall time constants and separate clock frequencies for the ToA and ToT time-stamping. The measured dependence of the ToT on the pre-amplifier input charge using test-pulses of a Timepix3 assembly is correctly reproduced by this model for a wide range of discriminator threshold settings. Simulated data will be compared to measurements using radioactive sources. The model does however not cover all aspects of the Timepix3 front-end and its limitations will be discussed.

**Will the talk be given in person or remotely?**:

Remotely

**Applications and studies / 15**

# Simulation of hybrid pixels using precise TCAD simulations

**Authors:** Keerthi Nakkalil[1]; Marco Bomben[2]

[1] *APC,CNRS/IN2P3 and Université'de Paris*

[2] *APC & Université Paris Cité, Paris (FR)*

**Corresponding Author:** keerthi.nakkalil@cern.ch

In preparation for the High Luminosity LHC phase, the ATLAS collaboration is developing a new all-silicon tracking detector called the Inner Tracker (ITk). At the core of the new tracker will be 5 barrel layers equipped with hybrid pixel detectors with a fine pitch of either 50x50 or 25x100 µm. The new detector will need to withstand radiation damage levels up to 10 times greater than the current tracker, making it important to predict its performance after accumulating such a large radiation damage fluence. To do this, Allpix-squared will be used in combination with inputs from TCAD tools such as the electric field and weighting potential. This contribution will present the first lookup tables for an irradiated 100-µm-thick n-on-p sensor for collected charge, charge deflection, and free path, based on Allpix-squared simulations prepared using TCAD files from Silvaco tools. The plan is to use these lookup tables to correct cluster shapes and charges of ATLAS MC pixel-simulated events.

**Will the talk be given in person or remotely?**:

Remotely

**Applications and studies / 16**

# Hexagonal silicon pixel simulations

**Authors:** Adriana Simancas[1]; Håkan Wennlöf[1]; Larissa Mendes[None]; Simon Spannagel[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** h.wennlof@cern.ch

Hexagonal pixels can be beneficial compared to rectangular geometries. By using a hexagonal pixel grid, the amount of shared charge in pixel corners is reduced, allowing for efficient operation over a larger threshold range for small signals. The pixel corners also have a larger opening angle compared to rectangular pixels, significantly impacting the electric field in this regions. A hexagonal grid also

has a smaller distance between the pixel borders and the collection electrodes which allows for smaller low-field regions and faster charge collection.
This contribution will describe simulation of hexagonal pixels in Allpix Squared. Examples will be given using both simple field approximations in the framework, and simulation and inclusion of TCAD fields in the context of the Tangerine project. The simulations will be described in detail, and comparisons between rectangular and hexagonal pixel simulation results shown.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 17**

## Transient Simulations: Weighting Potentials through Technology Computer-Aided Design

**Author:** Manuel Alejandro Del Rio Viera[1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Author:** manuel.alejandro.del.rio.viera@cern.ch

The principle of signal formation in every ionization detector can be understood using the Shockley-Ramo Theorem. This simple but useful theorem states that the induced current in an electrode is proportional to the movements of the charges along the direction of a field called the Weighting Field. As such, this special field, or its potential called Weighting Potential are required to calculate the response of a sensor.

In order to obtain these fields, Technology Computer-Aided Design (TCAD) simulations were used. By applying a voltage to an electrode of interest, while all others are kept grounded, and repeating this process by increasing the voltage by a small amount, the electrostatic potential of both configurations is obtained. With a simple calculation of these potentials, we can compute the weighting potential. And finally, by importing this potential into the Allpix Squared framework and using the TransientPropagation module, the signal induced in a sensor can be obtained.

In this contribution, the process and calculations to obtain the Weighting potential as well as the signals obtained in simulations will be presented.

**Will the talk be given in person or remotely?**:

In person

**New features and developments / 18**

## Allpix Squared Website & Documentation

**Author:** Stephan Lachnit[1]

**Co-author:** Simon Spannagel [1]

[1] *Deutsches Elektronen-Synchrotron (DE)*

**Corresponding Authors:** simon.spannagel@cern.ch, stephan.lachnit@cern.ch

Allpix Squared has been using LaTeX to create its documentation. While this results in an excellent looking PDF, the documentation on the website had issues with displaying certain math and code blocks nicely. Thus it was decided to change the documentation format, using Markdown for the source and Docsy for the website.

This talk will present the now deployed website, some of the technical details of the process and changes since the last Workshop. A brief introduction in Markdown is given as well to get the audience familiar with the new format.

**Will the talk be given in person or remotely?**:

**Welcome and Allpix Squared overview / 19**

## Welcome from the workshop organisers

**Corresponding Author:** h.wennlof@cern.ch

**New features and developments / 21**

## New features in Allpix Squared 3.0

**Corresponding Author:** paul.schuetze@desy.de

**Will the talk be given in person or remotely?**:

**New features and developments / 22**

## Upcoming features and current developments

**Corresponding Authors:** simon.spannagel@cern.ch, paul.schuetze@desy.de

**Will the talk be given in person or remotely?**:

**Applications, studies, and developments / 23**

## Simulation of Radial Strips for Comic Ray Studies

**Author:** Maximilian Caspar[1]

**Co-author:** Radek Privara [2]

[1] *DESY*

[2] *Palacky University (CZ)*

**Corresponding Author:** maximilian.caspar@cern.ch

The ATLAS Inner Detector (ID) will be replaced with a new all-silicon tracker (ITk) for LHCs high luminosity phase. ITk will consist of a pixel and a strip subdetector, both of which subdivide into barrel and endcap sections. The endcap strip modules use a radial strip geometry that resembles a polar coordinate system. Groups of these modules are then placed on a common support structure (petals) which are arranged in discs to form two endcaps of the detector. Additionally, an 1/8 slice of one endcap (called "System Test") is being commissioned at DESY. Among many characterisation measurements, it is also planned to take cosmic ray data with this setup to verify tracking and overall detector performance.

A new implementation of both the radial strips geometry and cosmic rays was developed for the simulation framework Allpix2. Additionally, an effort to implement this geometry also in the Corryvreckan framework to allow for tracking is currently ongoing. This talk will cover the simulation of the radial strips geometry used in the ALTAS ITk Strips Endcap modules R0 - R5 in the context of Cosmic Ray studies to be performed with the Endcap System Test.

**Will the talk be given in person or remotely?**:

In person

**Applications and studies / 24**

## Simulating monolithic active pixel sensors using generic doping profiles

**Corresponding Author:** adriana.simancas@cern.ch

Optimisation of the sensitive region of CMOS sensors with nonlinear electric fields requires precise simulations, which can be achieved by a combination of finite-element electrostatic field simulations and Monte Carlo methods. Exact predictions of the behaviour of monolithic active pixel sensors produced using commercial CMOS imaging processes are difficult to make, as the detailed electric field configuration in the sensitive material is highly dependent on the extent and concentration of different doping regions in the silicon, which may be proprietary information.
This talk aims to demonstrate that by making basic assumptions and performing simulations based on the fundamental principles of silicon detectors and using generic doping profiles, performance parameters of MAPS can be inferred and compared for different sensor geometries. A procedure for this utilising Sentaurus TCAD and Allpix Squared will be described, serving as a toolbox for performing sensor response simulations without detailed knowledge of the sensor doping concentrations and manufacturing process.

**Will the talk be given in person or remotely?**: