

Allpix Squared

Recent Developments

Paul Schütze for the
Allpix Squared Developers

CLICdp Collaboration Meeting
29.08.2018

HELMHOLTZ RESEARCH FOR
GRAND CHALLENGES



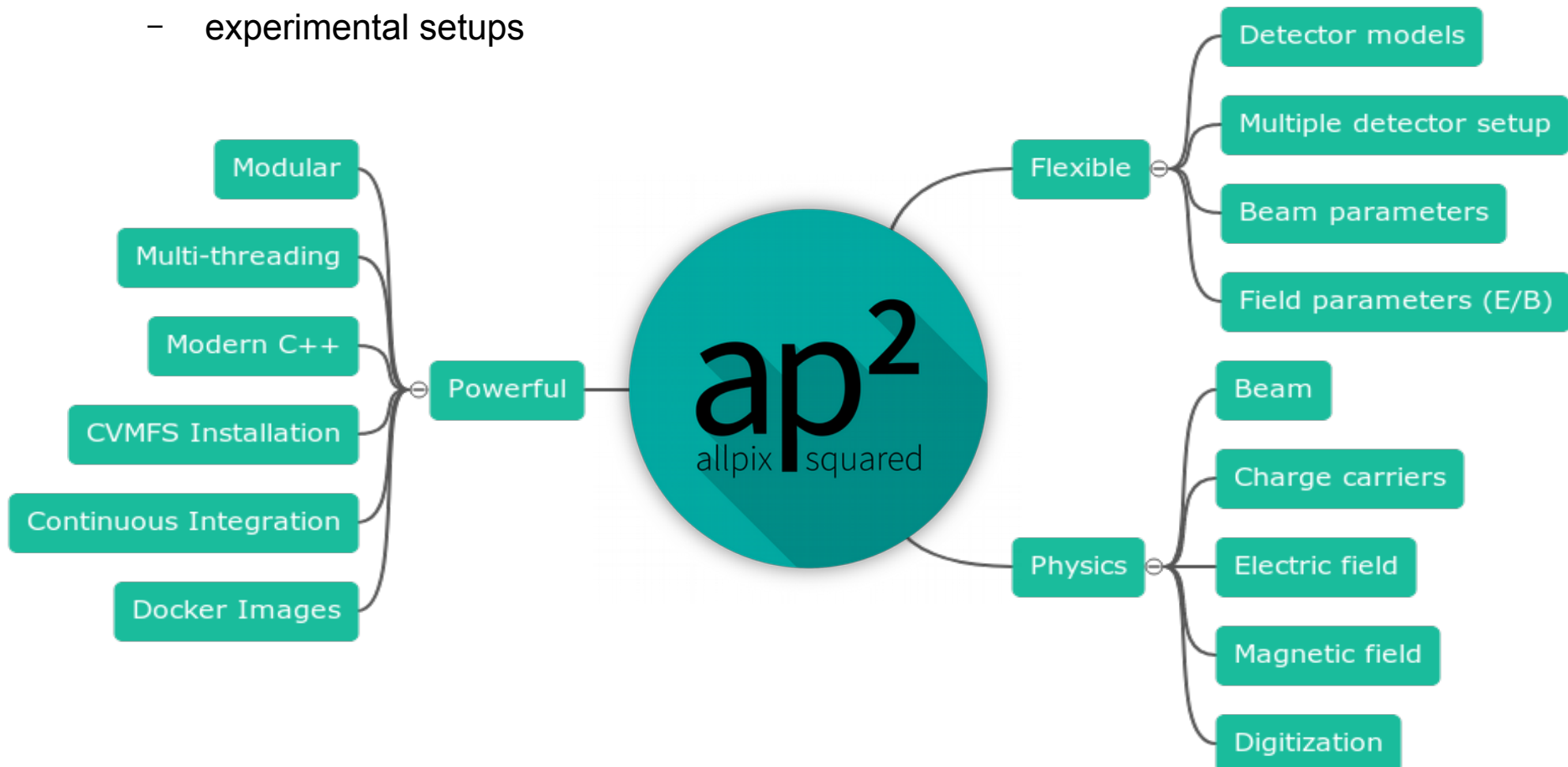
Allpix Squared

The Framework



A Generic Pixel Detector Simulation Framework

- **Goal:** Simulation of pixel detector responses for testing and the parametrization of ...
 - simulation models
 - detector/sensor models
 - experimental setups



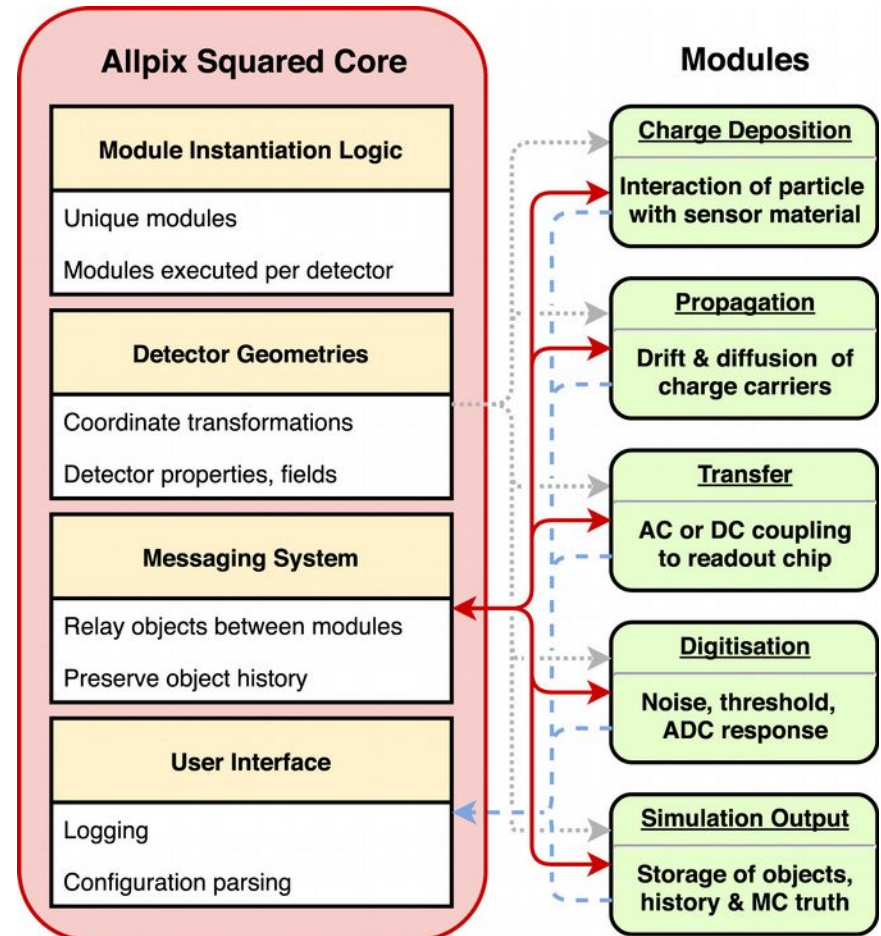
A Generic Pixel Detector Simulation Framework

- **Goal:** Simulation of pixel detector responses for testing and the parametrization of ...
 - simulation models
 - detector/sensor models
 - experimental setups
- Developed within the **CLICdp collaboration**
 - Simulation of sensor prototypes
 - Design optimization
- Increasing number of developers ...
 - implementing **new features**
 - increasing the range of possible **applications**
 - fixing bugs

v 1.0	September 2017
v 1.1	January 2018
v 1.2	June 2018
v 2.0	???

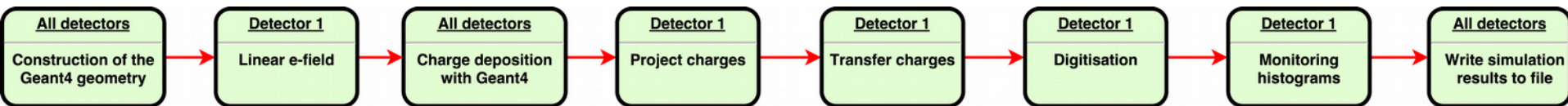
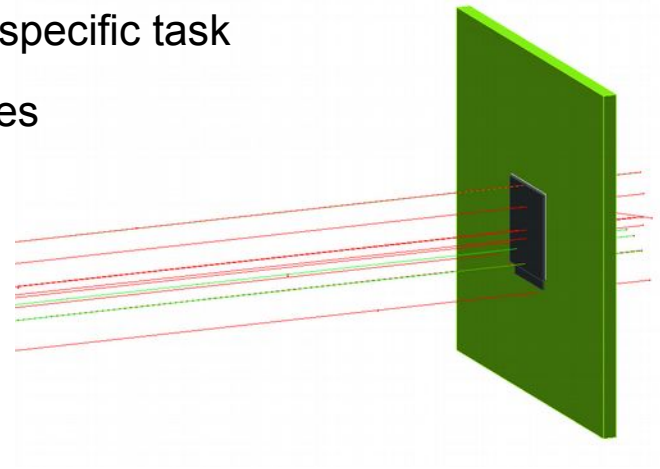
The Framework

- Core
 - Internal Logic
 - Geometry definition
 - Initialization of modules
 - Communication between modules
- Modules
 - Small part of the simulation chain
 - or
 - Definition and distribution of global or local properties
- Objects
 - Results of single modules
 - Passed on between modules as messages



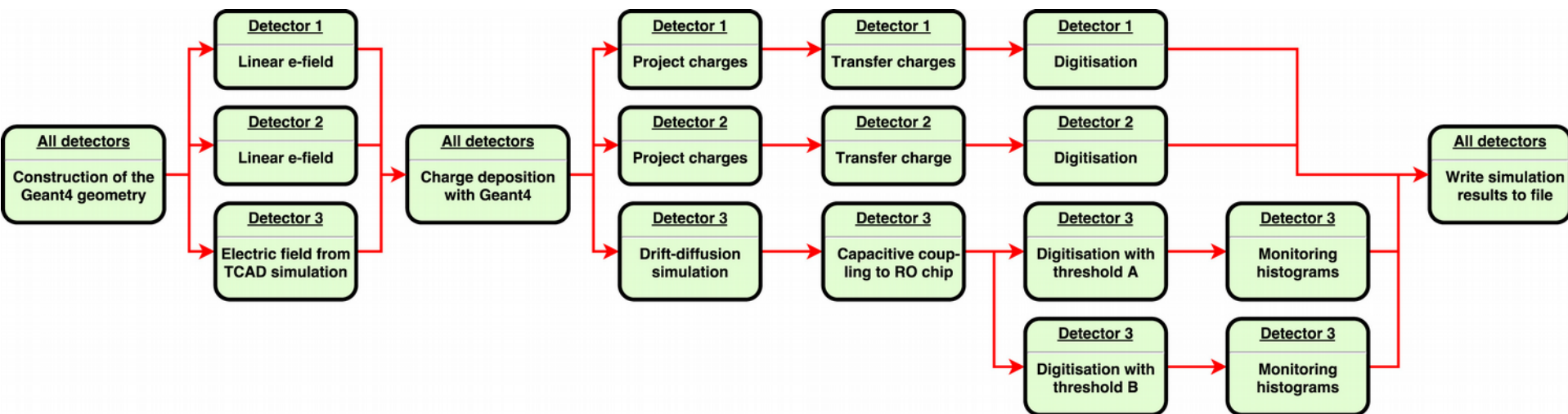
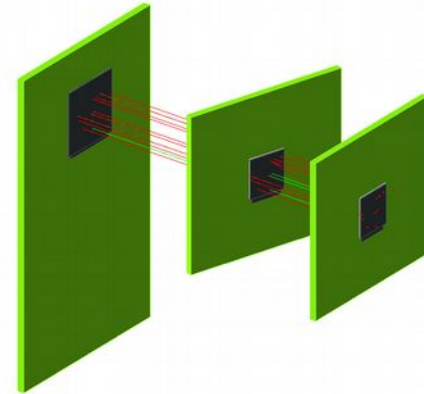
Simulation Workflow

- The workflow is configurable by the user via the configuration file
- Modules are executed sequentially, each performing one specific task
 - Triggered by messages received from other modules
- Simple examples available in the repository



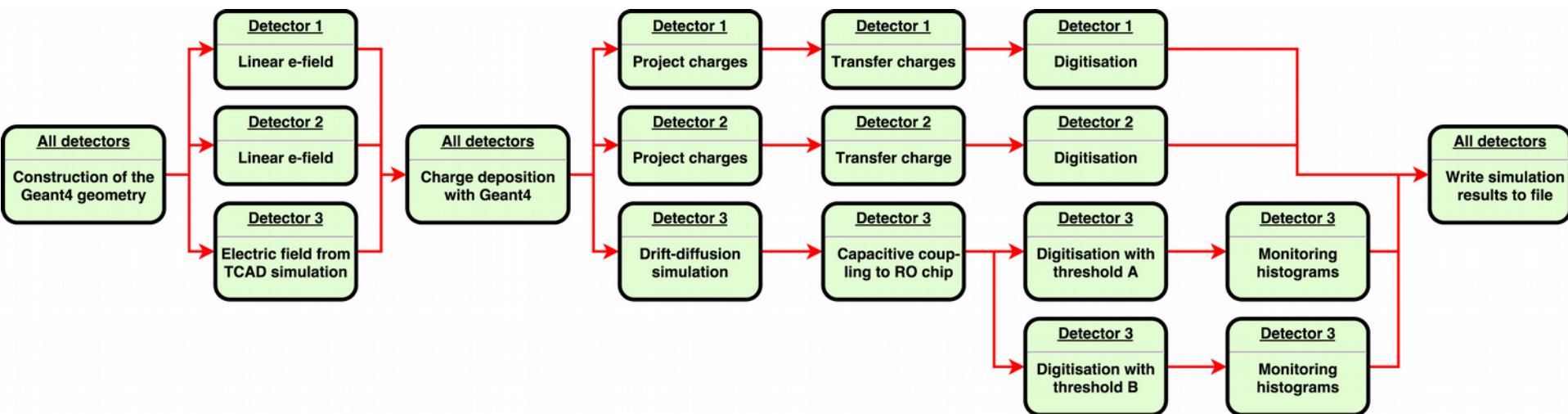
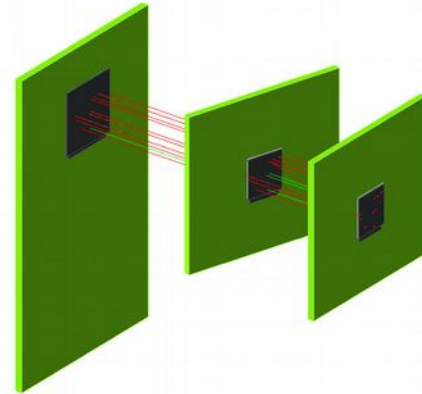
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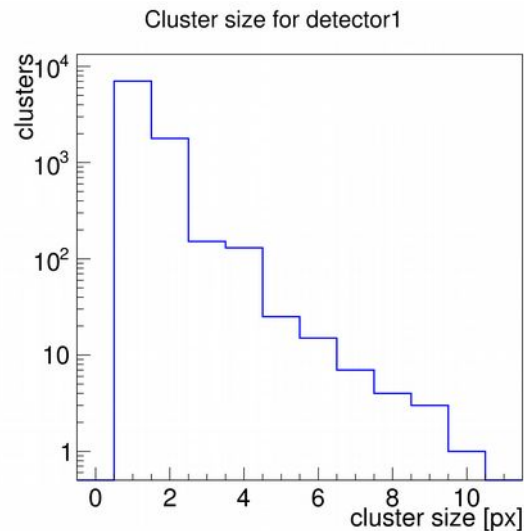
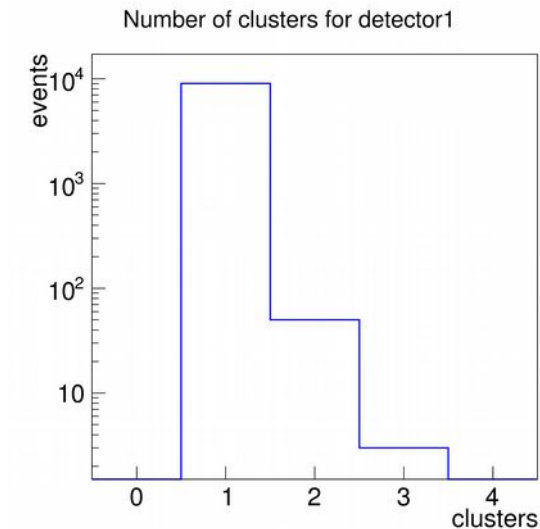
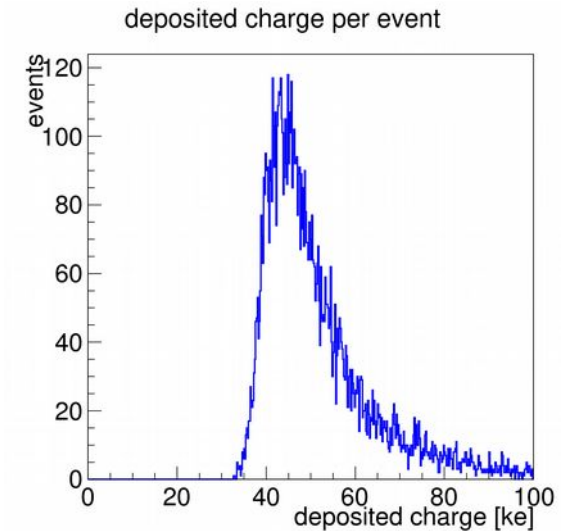
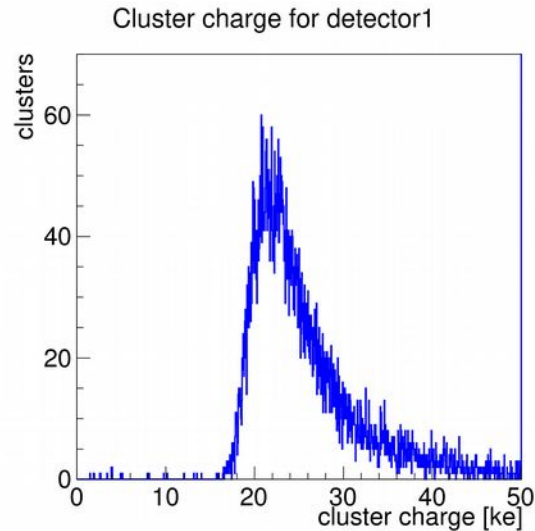
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- Every object can be stored as a ROOT for a replay of partial simulation chains



Simulation Results

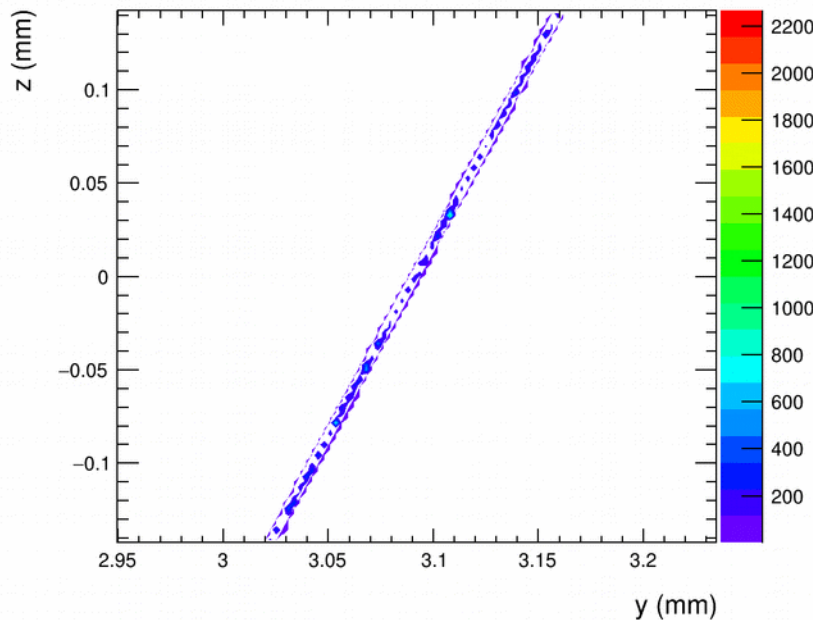
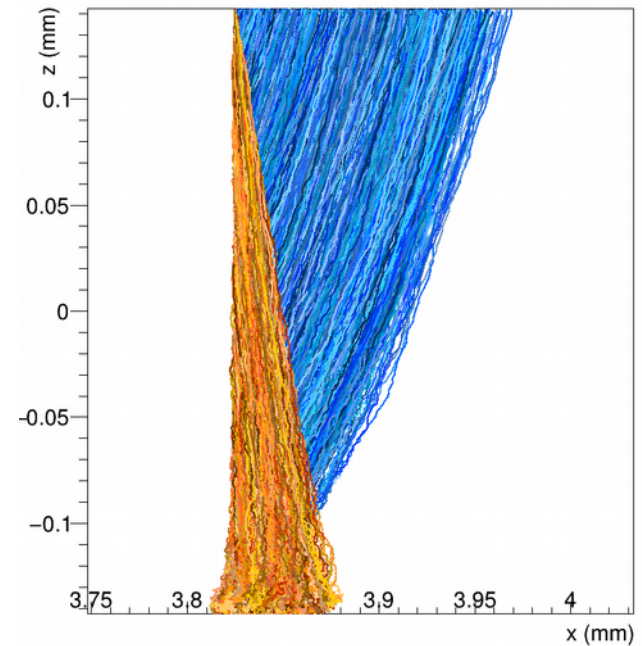
- Detector output distributions



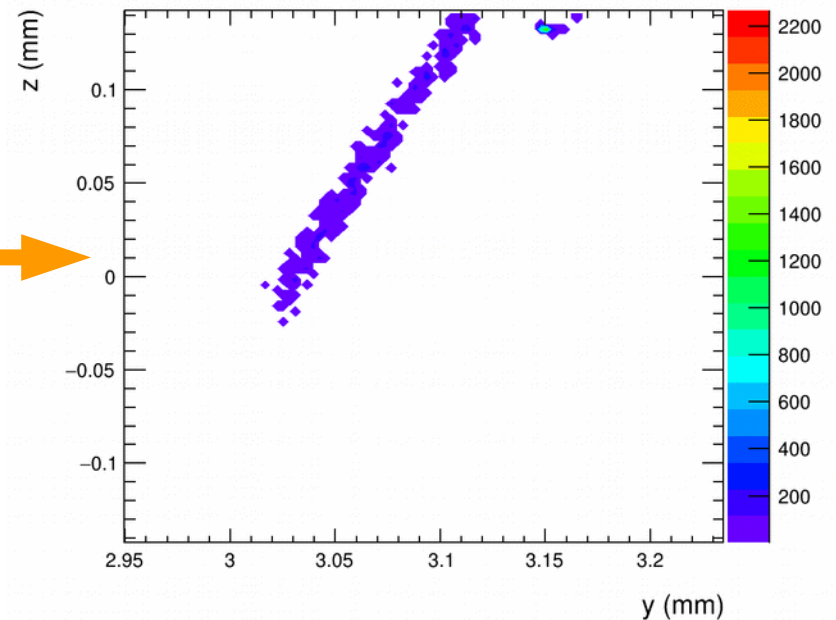
and many more...

Simulation Results

- Detector output distributions
- Information on charge carrier drift

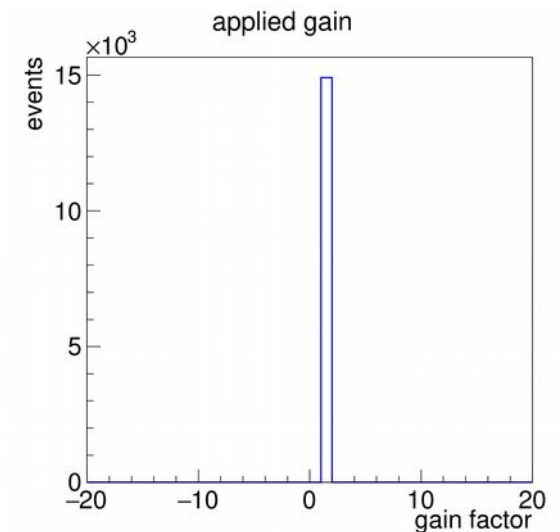
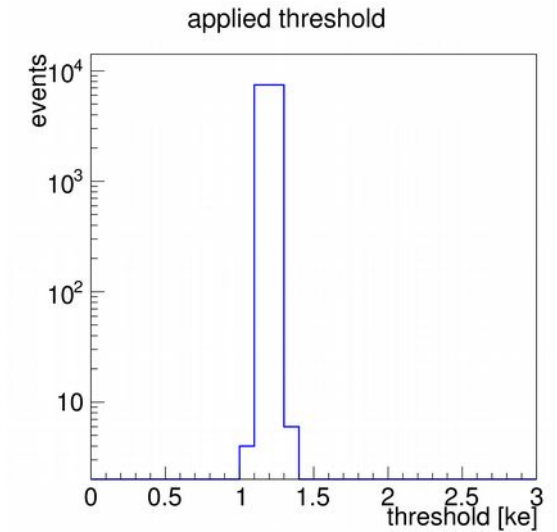
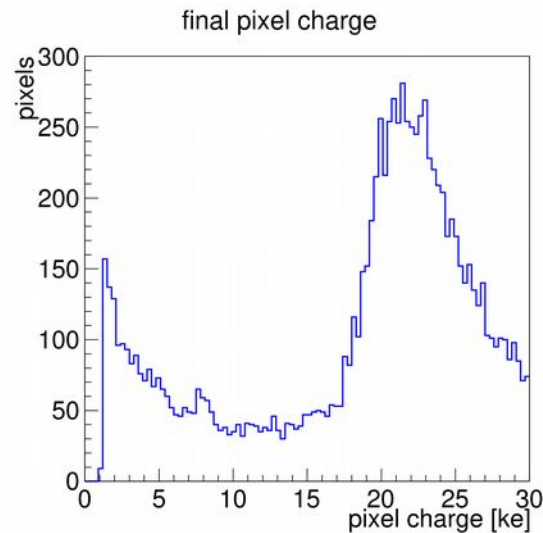
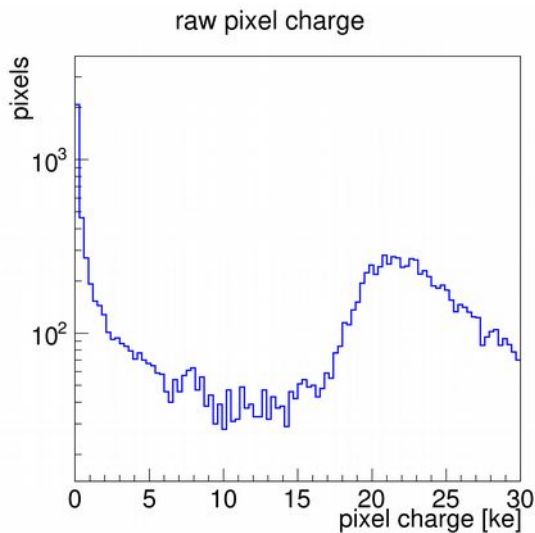


Drift



Simulation Results

- Detector output distributions
- Information on charge carrier drift
- Information on digitization process



Simulation Results

- Detector output distributions
- Information on charge carrier drift
- Information on digitization process
- Information on performance (resolution / efficiency) can be derived from higher level output, including the MC Truth information, supporting ...
 - ROOT
 - ASCII
 - LCIO (→ EUTelescope Analysis Framework)
 - Corryvreckan (→ Test Beam Analysis Framework developed @CLICdp)
 - RCE (→ Proteus Telescope Reconstruction Framework)
 - ➔ Use Test Beam Analysis software for reconstructing Allpix Squared data!

Allpix Squared

Recent Developments



CapacitiveTransfer Module

- Mapping of **propagated charges** to **readout pixels**
- New module, alternative to *SimpleTransfer*
- Includes capacitive **cross-coupling** between pixels
- Cross-coupling defined as either as a matrix or from ROOT graphs

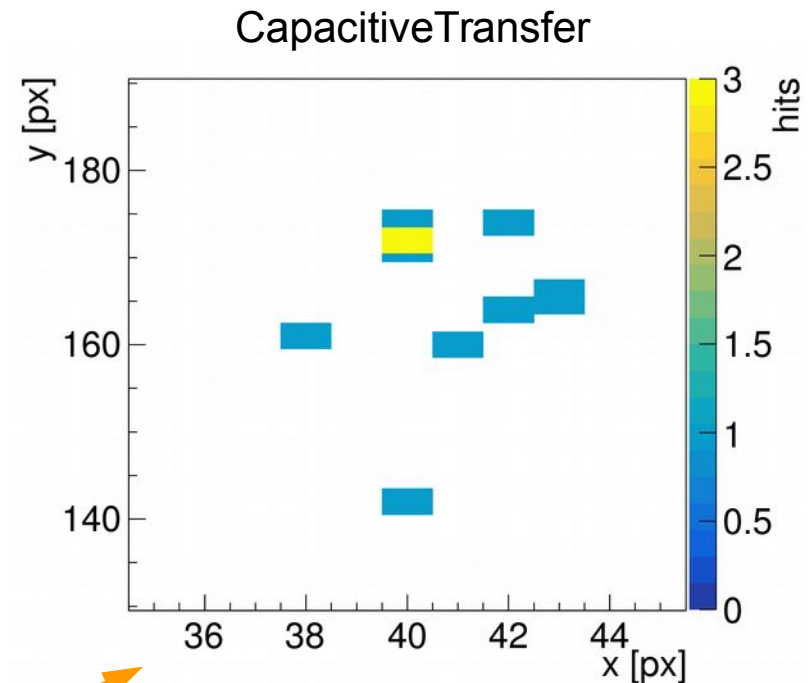
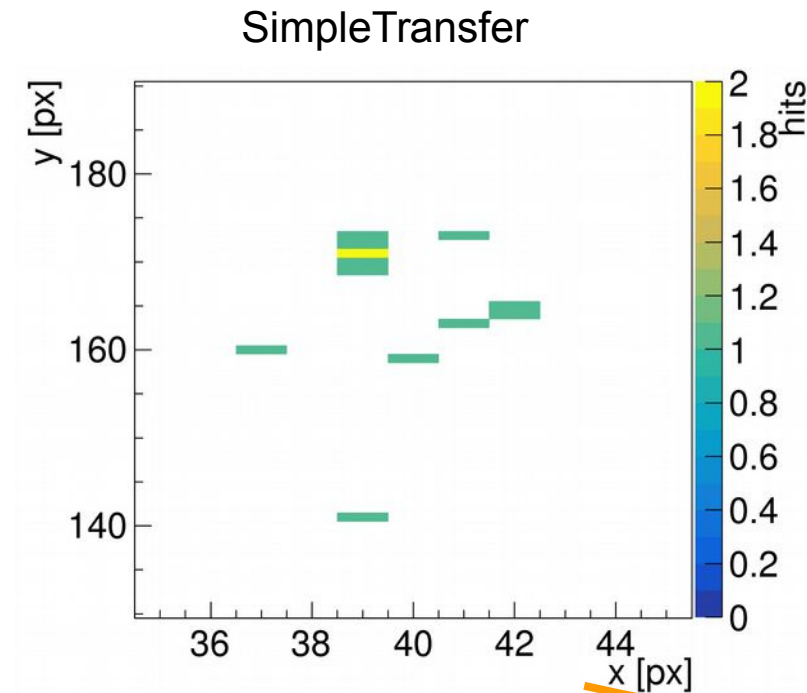


0.000	0.023	0.000
0.004	1.000	0.006
0.001	0.037	0.001

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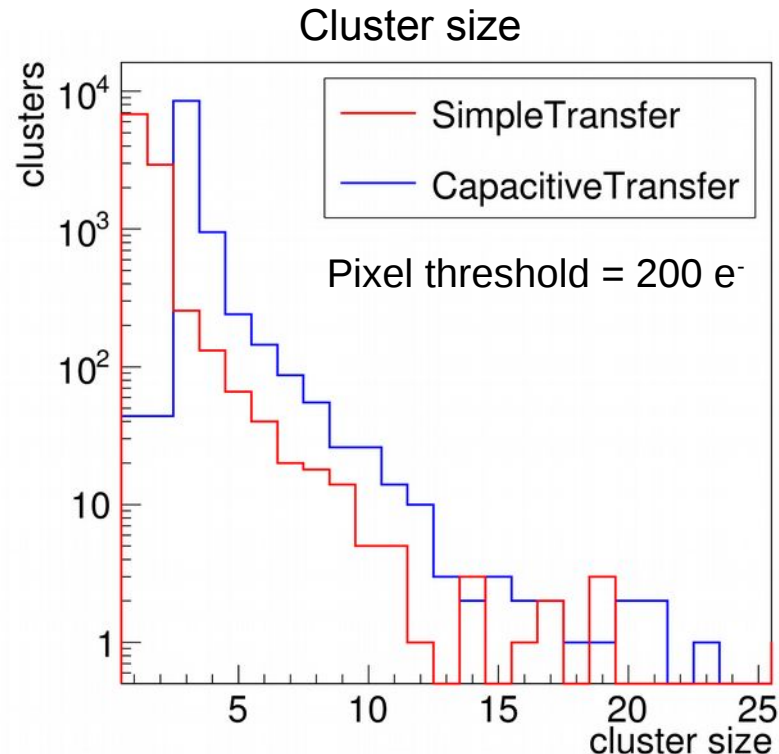
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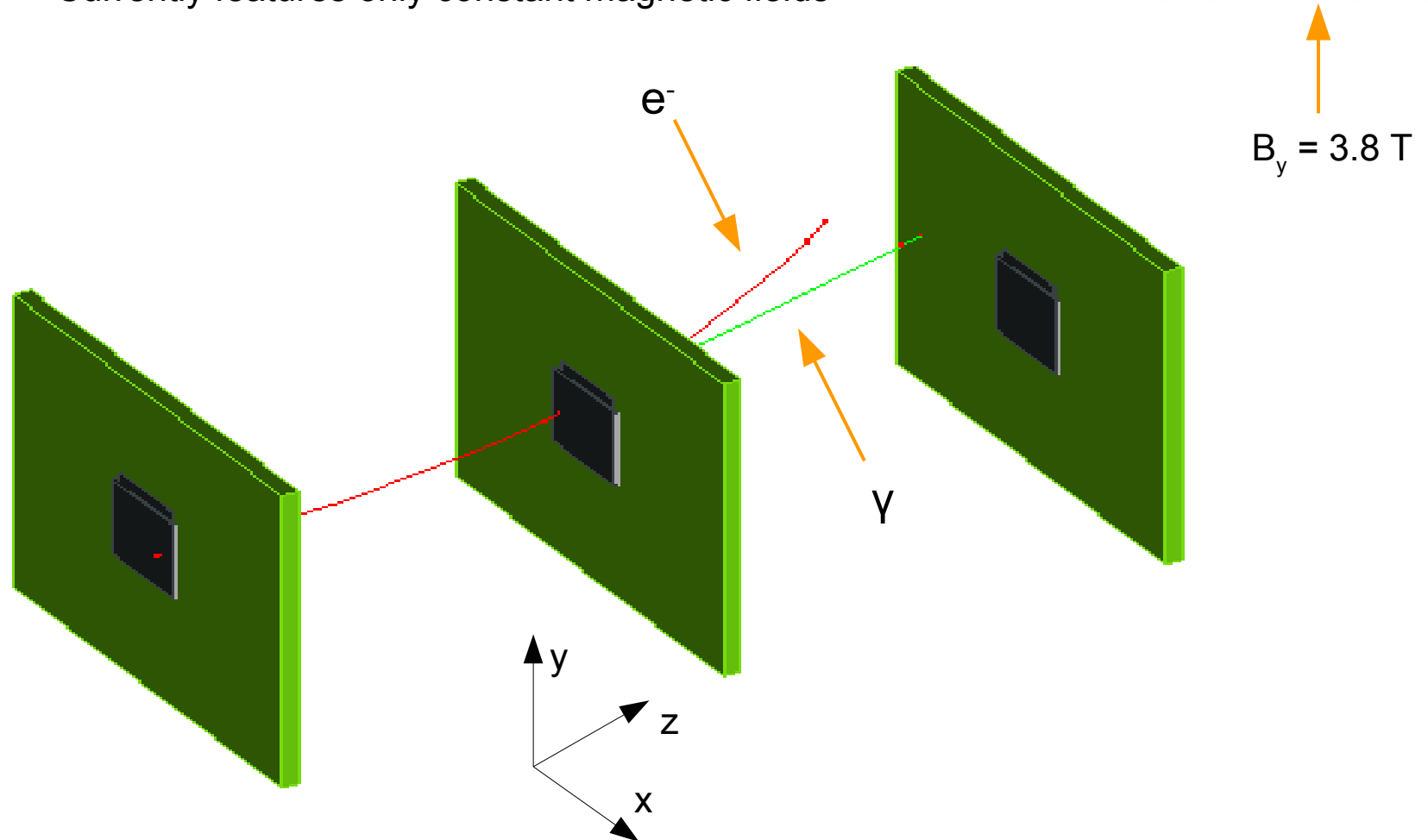
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Magnetic Field / Lorentz Drift

- New module *MagneticFieldReader*
 - Currently features only constant magnetic fields

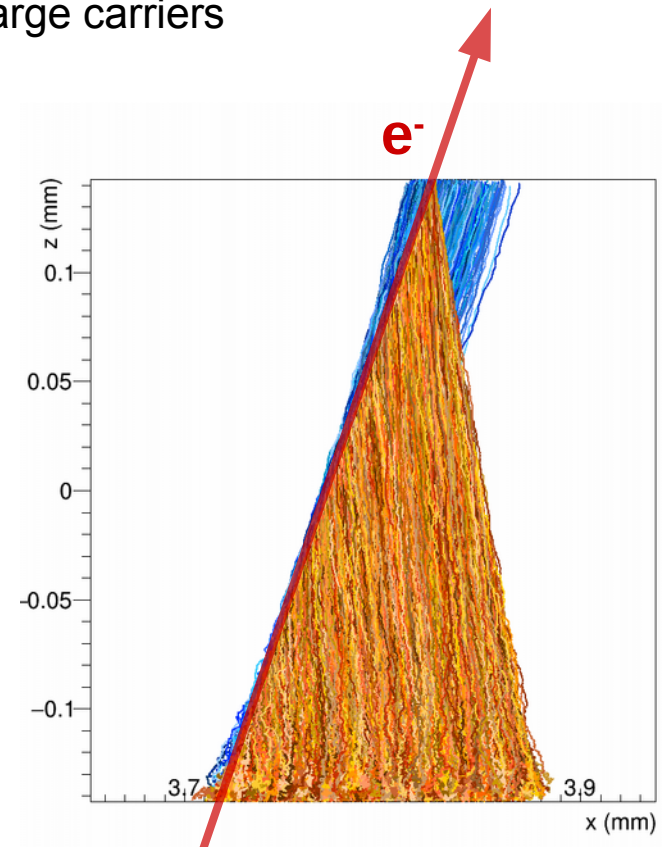
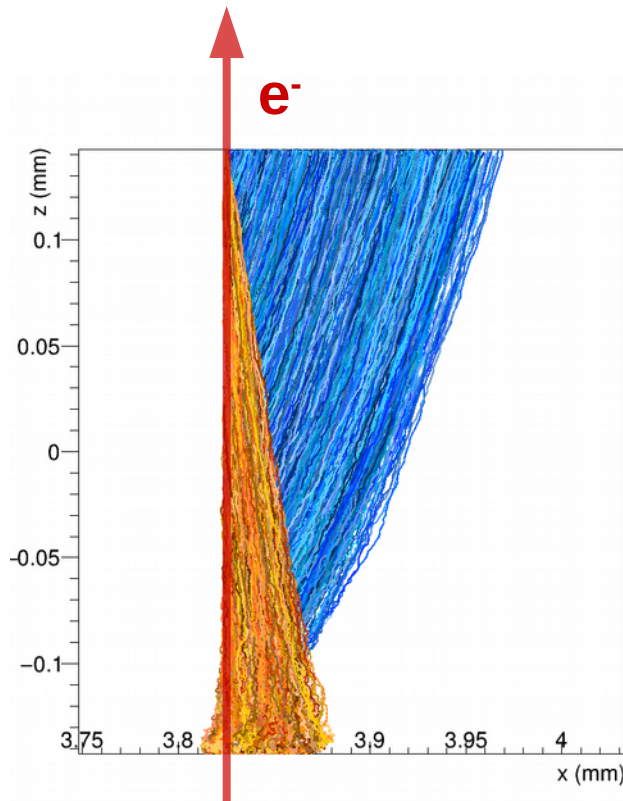
```
[MagneticFieldReader]  
model="constant"  
magnetic_field = 0mT 3.8T 0T
```



Magnetic Field / Lorentz Drift

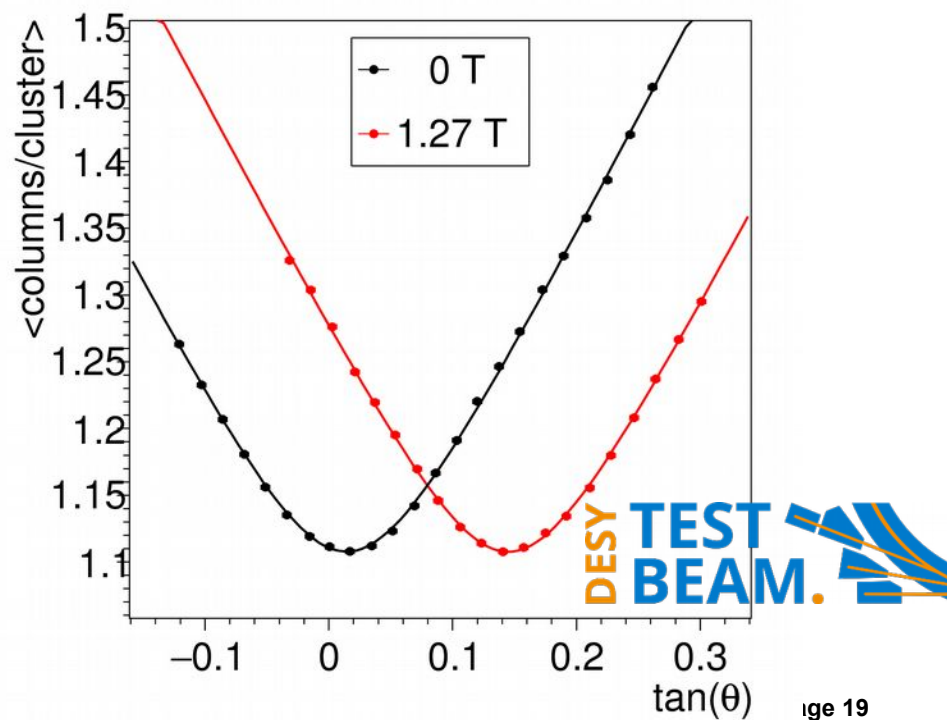
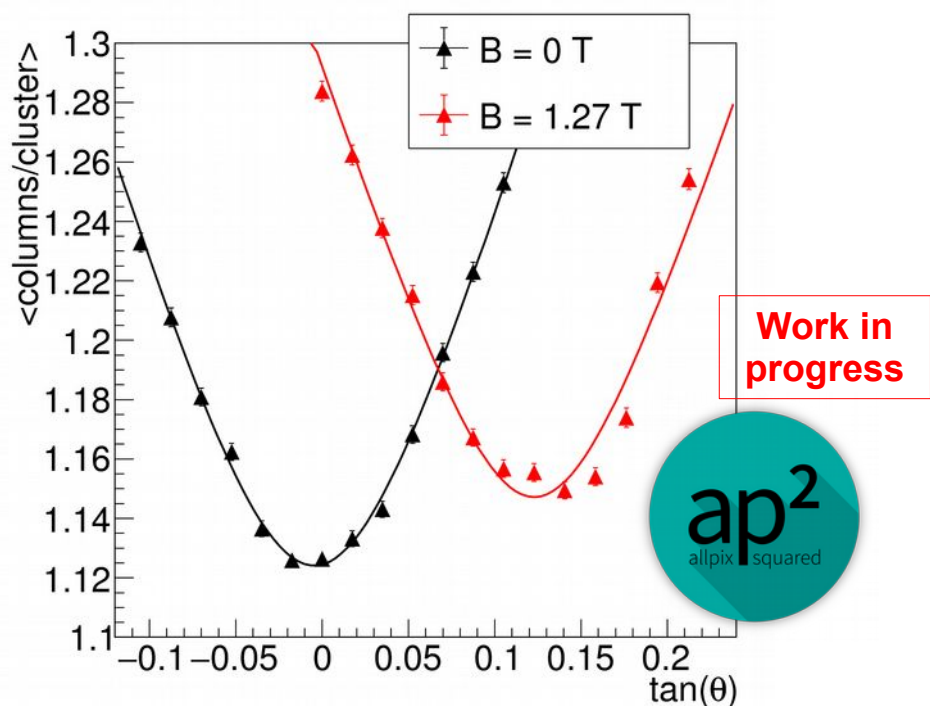
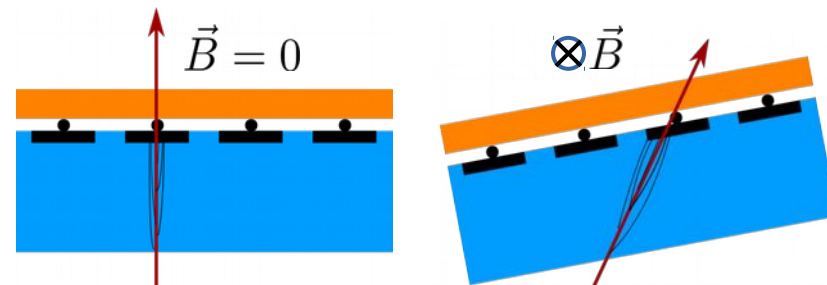
- New module *MagneticFieldReader*
 - Currently features only constant magnetic fields
- Updated *GenericPropagation* module
 - Lorentz Drift - deflection of the drifting charge carriers

```
[MagneticFieldReader]  
model="constant"  
magnetic_field = 0mT 3.8T 0T
```



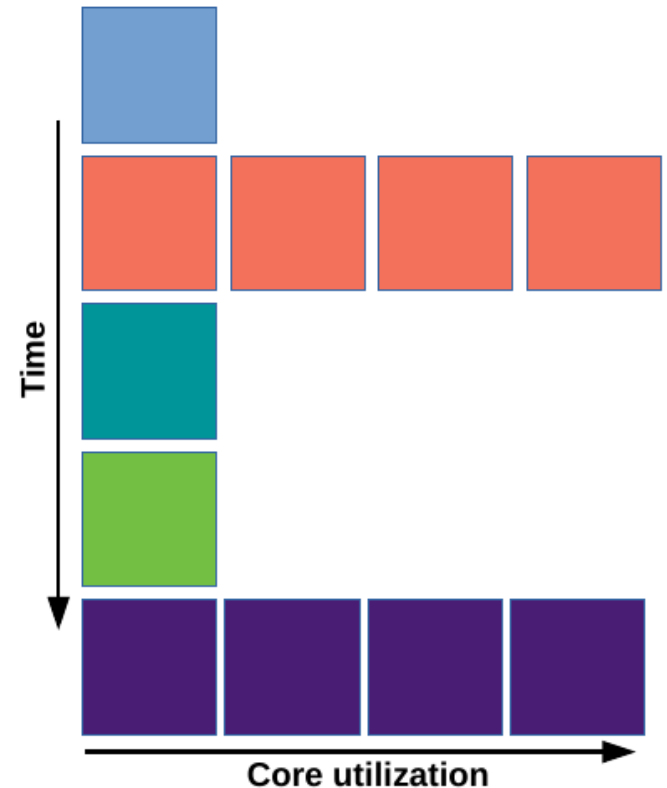
Magnetic Field / Lorentz Drift – Use Case

- Simulate the measurement of the Lorentz Angle in silicon hybrid detectors
- Different magnetic fields / incidence angles
 - For a certain magnetic field, the cluster size is minimal, when the detector is rotated by the Lorentz angle



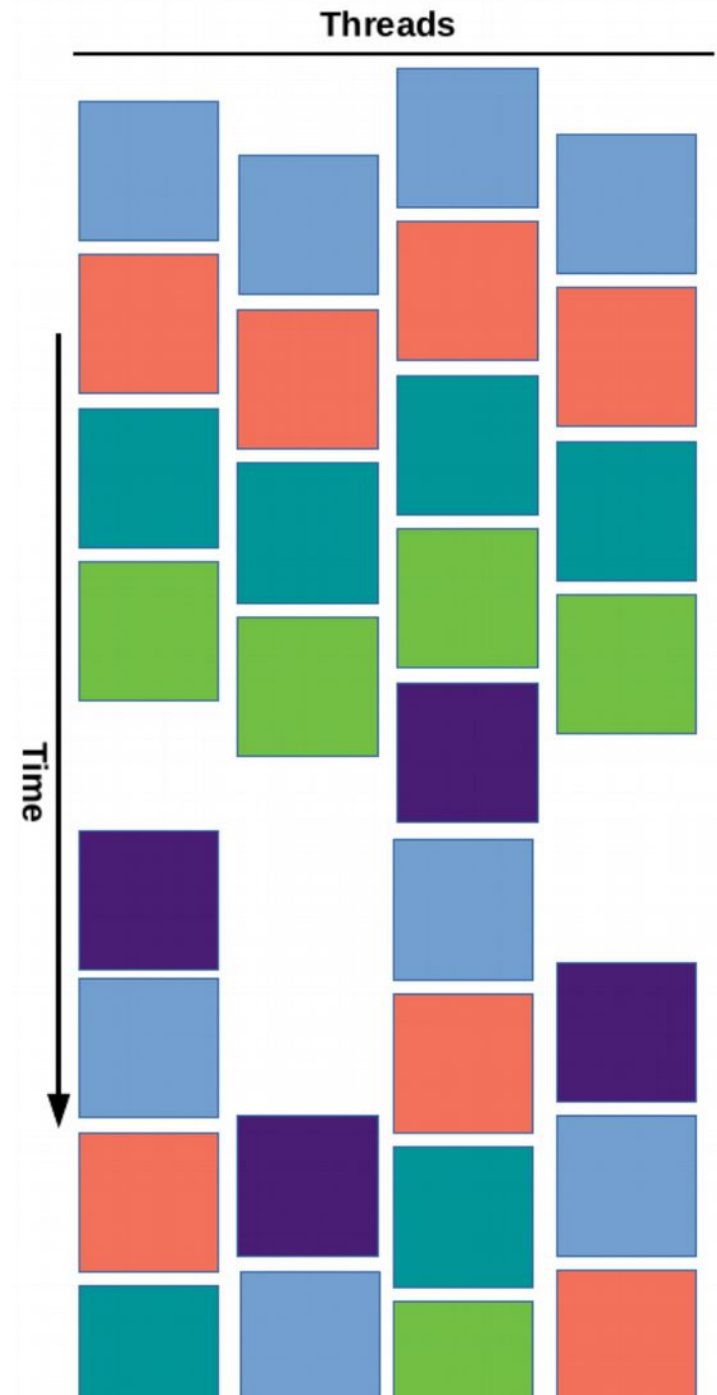
Multi-Threading

- Developed within a Google Summer of Code project
 - 12 week mentored student project
- Before:
 - All events were run sequentially
 - Single modules allowed for parallelization



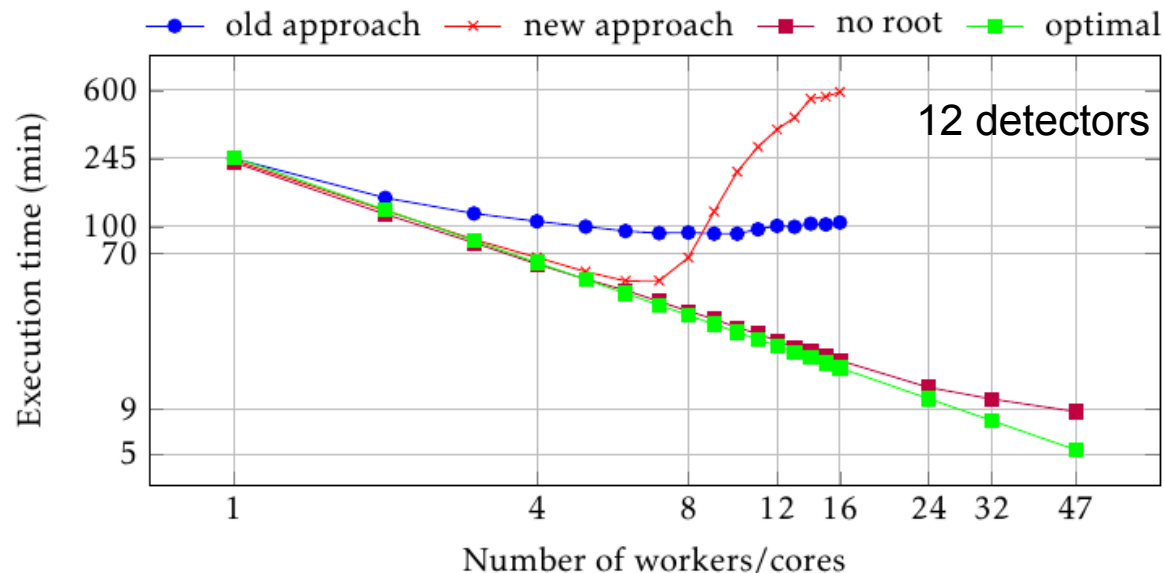
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- Developed within a Google Summer of Code project
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- Before:
 - All events were run sequentially
 - Single modules allowed for parallelization
- After:
 - All modules allow for parallelization
 - Events can overlap
 - Several restrictions have to be met when writing/reading files or depend on messages



Multi-Threading

- Rework of the event handling and messaging system, random number generation
- Merge Request under internal review
- Geant4 and ROOT as showstoppers? Not necessarily...
 - Geant4 features an internal parallelization → problematic for the ap^2 implementation
 - Dialogue with Geant4 developers
 - Several ROOT classes show ill behaviour for a large number of cores
- Execution time already reduced drastically



... and many more

- Unit tests (CI):
 - Before integrating Merge Requests, Unit Tests verify that simulation results are unaltered
- Geometry:
 - Enable automatic, randomized misalignment of components for realistic detector setups
- Monte Carlo Truth:
 - New *MCTrack* object, combining the information on all *MCParticles*
 - Output of MC Truth to the LCIO file format is now possible

... and many more

- G4 Particle Source:
 - New source shapes available
- New module *TextWriter*:
 - Possible output of all ap^2 objects to ASCII
- CVMFS Installation available:

```
# For CERN CentOS7:  
source /cvmfs/clicdp.cern.ch/software/allpix-squared  
/1.2.1/x86_64-centos7-gcc7-opt/setup.sh  
# For CERN Scientific Linux 6:  
source /cvmfs/clicdp.cern.ch/software/allpix-squared  
/1.2.1/x86_64-slc6-gcc7-opt/setup.sh
```

- ... and even more!

Summary & Outlook

- Allpix Squared is facing great acceptance by the Detector R&D community
- Growing framework with an increasing number of developers
- **Version 1.2** released with major improvements and new features
- Working on **Version 2.0** with improved multi-threading capabilities
- Follow us: <https://cern.ch/allpix-squared>

Many thanks to all developers!