

GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung



UNIVERSITÄT **BONN**

Subject Area D

Cost- and energy-efficient use of computing resources

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Overview of Area D

Lösungsansätze können auf verschiedenen Ebenen gefunden werden. Im Rahmen dieses Teilprojekts stehen insbesondere die Entwicklung **alternativer Algorithmen** (z.B. *Cellular Automaton*-basierte Ansätze statt Kombinatorischer Kalman Filter), **bessere Software Codes**, die z.B. größere **Datenlokalität** und **single instruction, multiple data** (SIMD) Optimierungen möglich machen, und alternative Software-Architekturen (z.B. GPUs) zusammen mit einem grösseren Maß an **Parallelisierung** im Mittelpunkt. Um angesichts des erforderlichen Expertentums auch die Personalressourcen optimal zu nutzen, sollten die Entwicklungen möglichst in **gemeinsam genutzten Bibliotheken gebündelt** werden und Beispielanwendungen zum besseren Verständnis zur Verfügung stehen. Der größte Teil der Entwicklungen, die im Rahmen dieses Projekts angestrebt werden, wird daher mit Hilfe von ACTS (**A Common Tracking Software**) angebunden.

~~Three~~ **Two** work packages:

1. Novel Algorithms for track reconstruction
2. Common tools to determine optimal track parameters
3. ~~Event reconstruction at neutrino experiments~~

AP D2: Common tools for tracking



<http://acts.web.cern.ch>

- Instead of each experiment writing their own tracking algorithms

Often algorithms are not optimised for CPU usage and small runtimes

→ pool resources and expertise

- **ACTS** (“A common tracking software”) is an attempt to create such a common library, which implements many of the often used algorithms;

many implemented algorithms much faster than what experiments currently are using

- **Goal:** Help to extend ACTS to become fully usable by energy and intensity frontier experiments

Add missing features, evaluate how aspects of the library can be used to improve the current track finding and fitting.

AP D2: Common tools for tracking



<http://acts.web.cern.ch>

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Often algorithms are not optimised for CPU usage and small runtimes

→ pool resources and expertise

ACTS developers are very open to engage in new collaborations and to find contributors (or for people to test their code for their application)

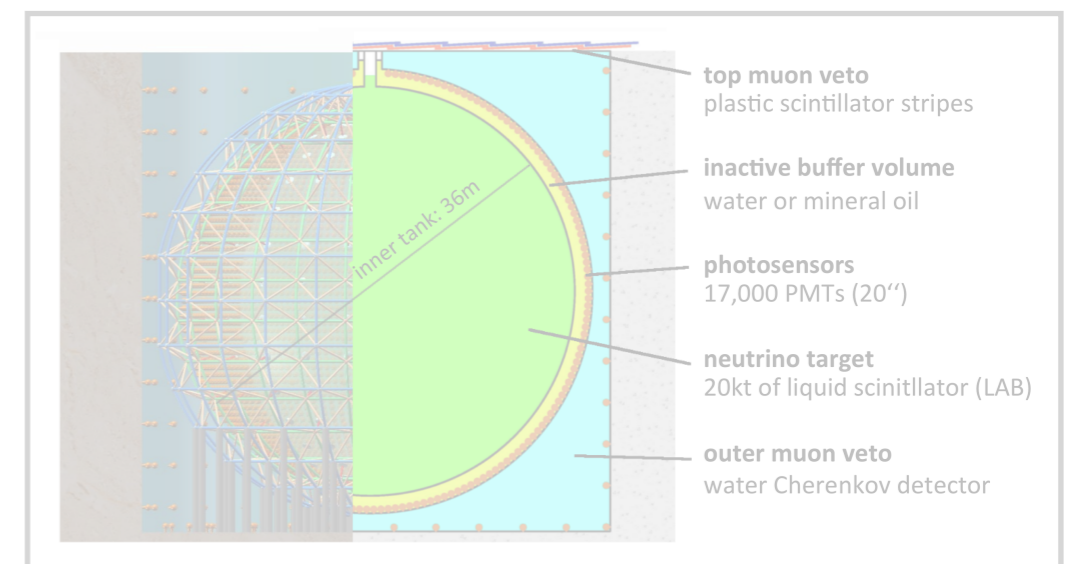
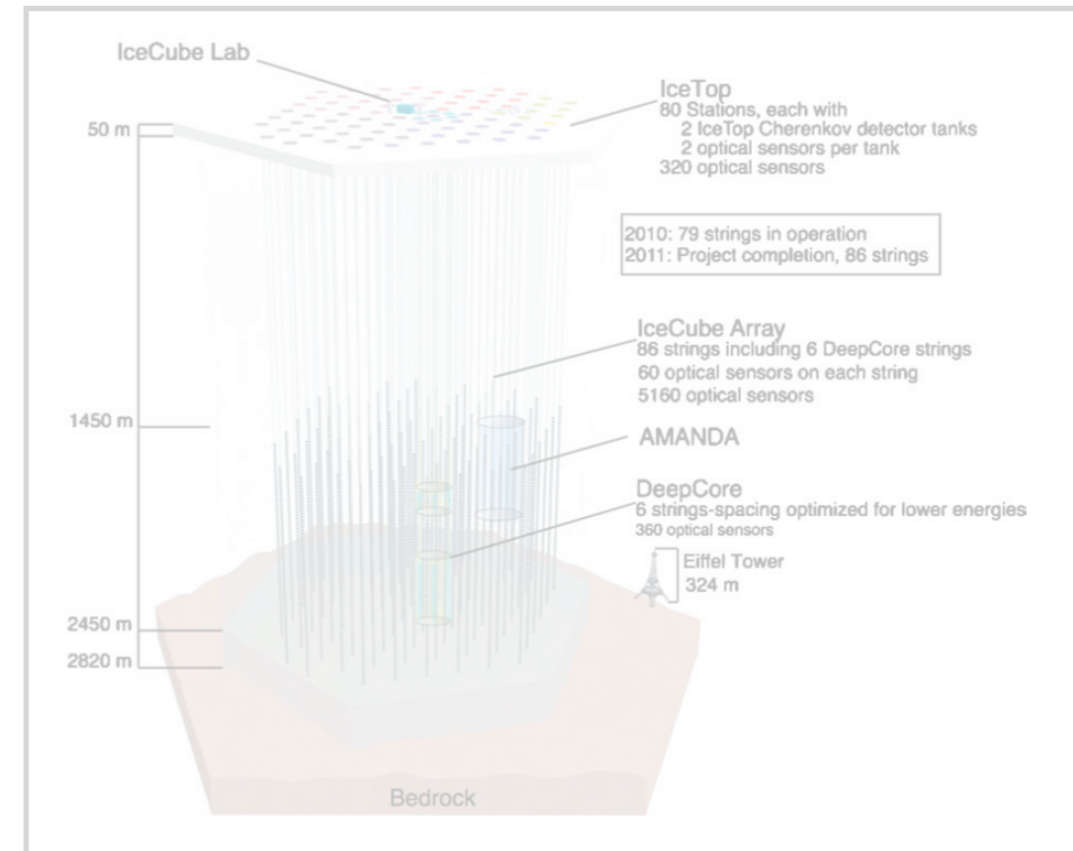
Feel free to contact Markus Elsing and Andreas Salzburger if you want to help.

- **Goal:** Help to extend ACTS to become fully usable by energy and intensity frontier experiments

Add missing features, evaluate how aspects of the library can be used to improve the current track finding and fitting.

AP D3: Event reconstruction at neutrino experiments

- Neutrino experiments have unique challenges:
 - Huge detector volumes; sparse sensors that observe signals from a distance
 - Inclusion of time-information important to make sense of detector signals
 - Signatures typically have multiple components: e.g. Muon and hadronic recoil in CC-scattering of muon neutrinos **No resources allocated**
 - Immense amount of information that needs to be processed: e.g. JUNO uses $O(17k)$ PMT signals to reconstruct a single muon track. A single fit to do this can take $O(1h)$



Manpower

- KIT → Bonn (Florian Bernlochner): 1 FTE
 - Filled, but rotation imminent
 - Started interviewing PhD students to continue work
 - 2 Students, one focussing on general ACTS development, one on Belle II integration
- Aachen (Alexander Schmidt): 0.5 FTE
 - PhD student will soon be hired, hence nothing yet to report
- Frankfurt (Ivan Kisel): 0.5 FTE
 - PhD student hired since August, first ACTS related work started (see next slide)

Frankfurt: on A Common Tracking Software (ACTS) Project

The ACTS project provides a framework- and experiment-independent toolkit for track reconstruction tasks.



Basic packages installed:

- **acts-framework** - Test framework for ACTS development with a lightweight structure.
- **acts-core** - detector and framework independent Tools, geometry and event data classes for the ACTS track reconstruction toolkit.
- **acts-data** - static data files for ACTS, e.g. magnetic field maps.
- **acts-fatras** - Fast ATLAS Track Simulation extension to ACTS.

Additional software installed:

- ROOT 6.18, boost 1.71, Eigen 3.2.3, DD4hep 1.10

Standard examples launched successfully in multi-thread mode:

```
./ACTFWHelloWorldExample
12:27:35 Sequencer INFO Added algorithm 'HelloLogger'
12:27:35 Sequencer INFO Added algorithm 'HelloRandom'
12:27:35 Sequencer INFO Added algorithm 'HelloWhiteBoard'
12:27:35 Sequencer INFO Added service 'HelloService'
12:27:35 Sequencer INFO Starting event loop with 40 threads
12:27:35 Sequencer INFO 1 services
12:27:35 Sequencer INFO 0 context decorators
12:27:35 Sequencer INFO 0 readers
12:27:35 Sequencer INFO 3 algorithms
12:27:35 Sequencer INFO 0 writers
12:27:35 HelloLogger INFO Hello World! (from event=0, block=0)
12:27:35 HelloRandom INFO Running random number generation
12:27:35 HelloRandom INFO 5000 draws per event will be done
. . .
12:27:35 Sequencer INFO finished event 3
12:27:35 Sequencer INFO Processed 10 events in 22.145476 ms
12:27:35 Sequencer INFO Average time per event: 14.006023 ms/event
```


Parallel Program Tomorrow

09:00 → 13:00	Areas C+D: Parallel Session	Hörsaal - R 140
	Remote Connection RemoteConnection...	
09:00	Progress on DL applications for CBM physics and data analysis at FIAS ¶ Speaker: Jan Steinheimer (Frankfurt Institute for Advanced Studies)	15m Hörsaal - R 140
09:15	Progress on DL applications for CBM physics and data analysis at FIAS Speaker: Kai Zhou (FIAS)	15m Hörsaal - R 140
09:30	PXD background generation Speaker: Pascal Schmolz	15m Hörsaal - R 140
09:45	Implementation of deep neural networks on FPGAs Speaker: Christian Schmitt (Uni Mainz)	15m Hörsaal - R 140
10:00	TBA Speaker: Thomas Pfeiffer	10m Hörsaal - R 140
10:10	TBA Speaker: Gregor Kasieczka (Uni Hamburg)	10m Hörsaal - R 140
10:30	Coffee Break	30m Foyer (Steinbuch Centre for C...)
11:00	ACTS Overview Speaker: Mr Paul Gessinger-Befurt (CERN / JGU Mainz)	25m Hörsaal - R 140
11:25	ACTS at Belle II Speaker: Braun Nils	15m Hörsaal - R 140
11:40	Progress on DL applications for fast calo simulations ¶ Speaker: Jubna Jabbar	15m Hörsaal - R 140
11:55	Progress on DL applications for atmospheric shower sim Speaker: Marcel Köpke	15m Hörsaal - R 140
12:10	FastSim with DL Speaker: James Kahn (KIT)	15m Hörsaal - R 140

ATLAS tracking software (Athena)

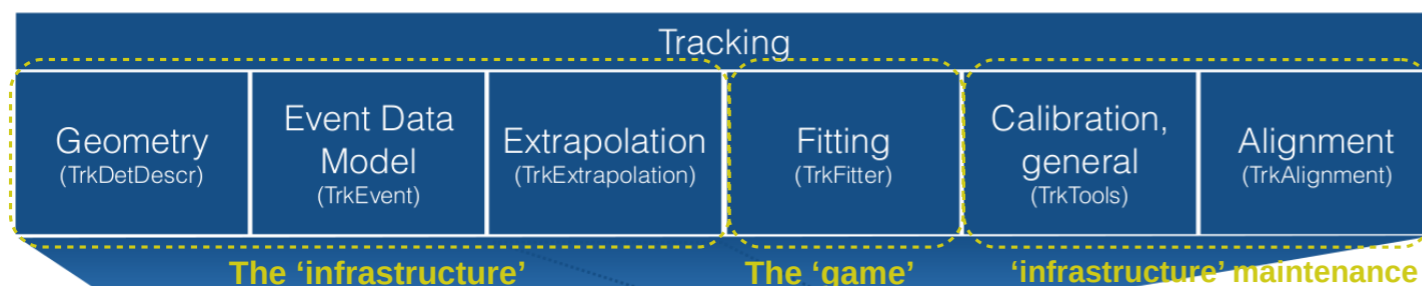
- Performance tested and known
- Hard to maintain after > 15 years
- Design not thread-safe

Acts

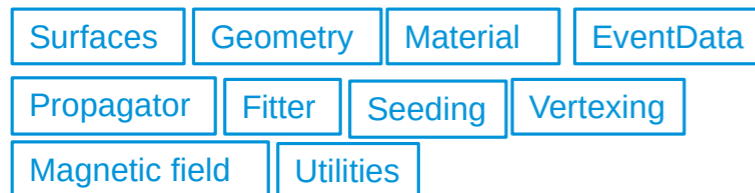
- Preserve and improve ATLAS tracking code
- Modern C++ 17 concepts
- Facilitate usability and maintenance
- Thread-safe design
- Minimal dependencies to simplify integration with software framework

ATLAS Tracking modules

Most figures from [A. Salzburger's slides](#)



acts-core



acts-fatras

Simulate particle trajectories through detector with simplified material effects



acts-framework

A light-weight Gaudi style framework for integration and concurrency test

Still much functionality missing, e.g. CKF but active progress is being made on filling the gaps.

ACTS - Framework für Spurrekonstruktion

- ACTS ist Basis für Tracking Machine Learning Challenge
 - ➔ Datensatz für Referenz-Detektor generiert mit ACTS schneller Spur-Simulation

➔ "Accuracy Phase" auf:

kaggle

➔ "Throughput Phase" auf:

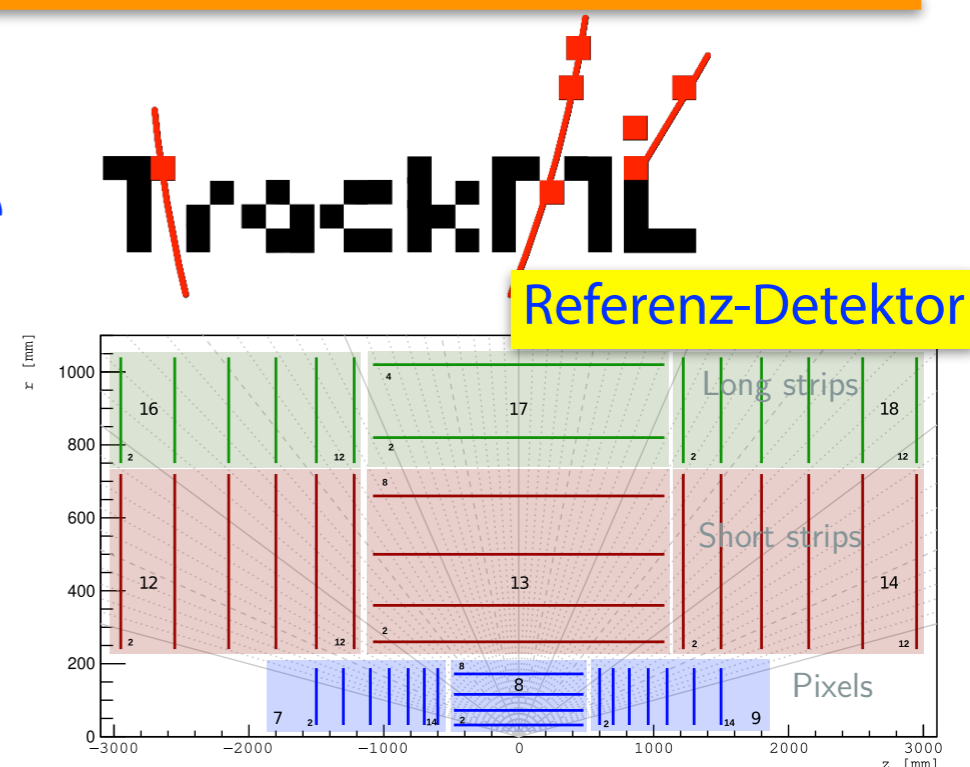
CodaLab

- neuer Release des Referenz-Datensatzes auf

opendata
CERN

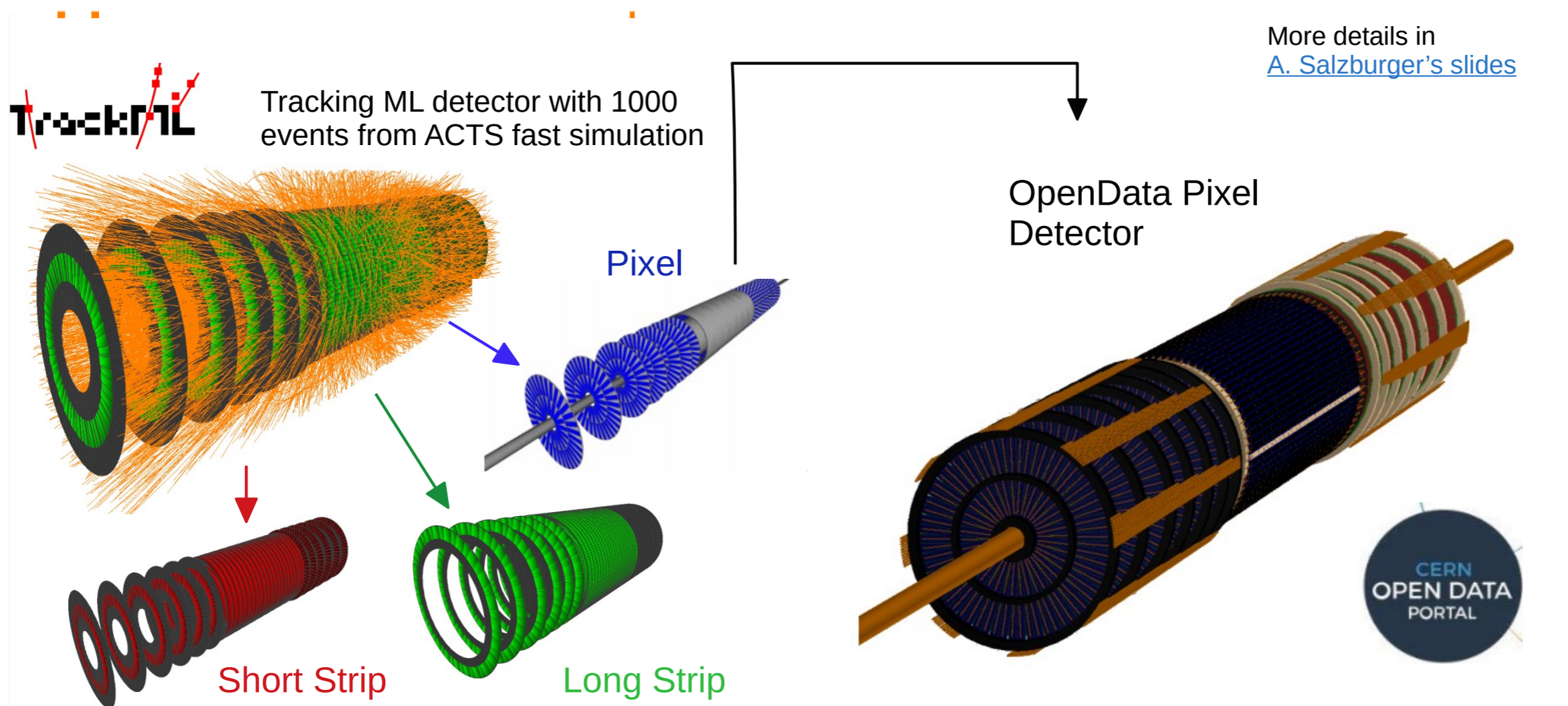
➔ Experiment unabhängiger Datensatz

➔ ermöglicht Entwicklung von neuen Algorithmen über Experimente hinweg



OpenData Detector

Slides: Curtesy of
Xiacong Ai (DPF 2019)
& Andreas Salzburger

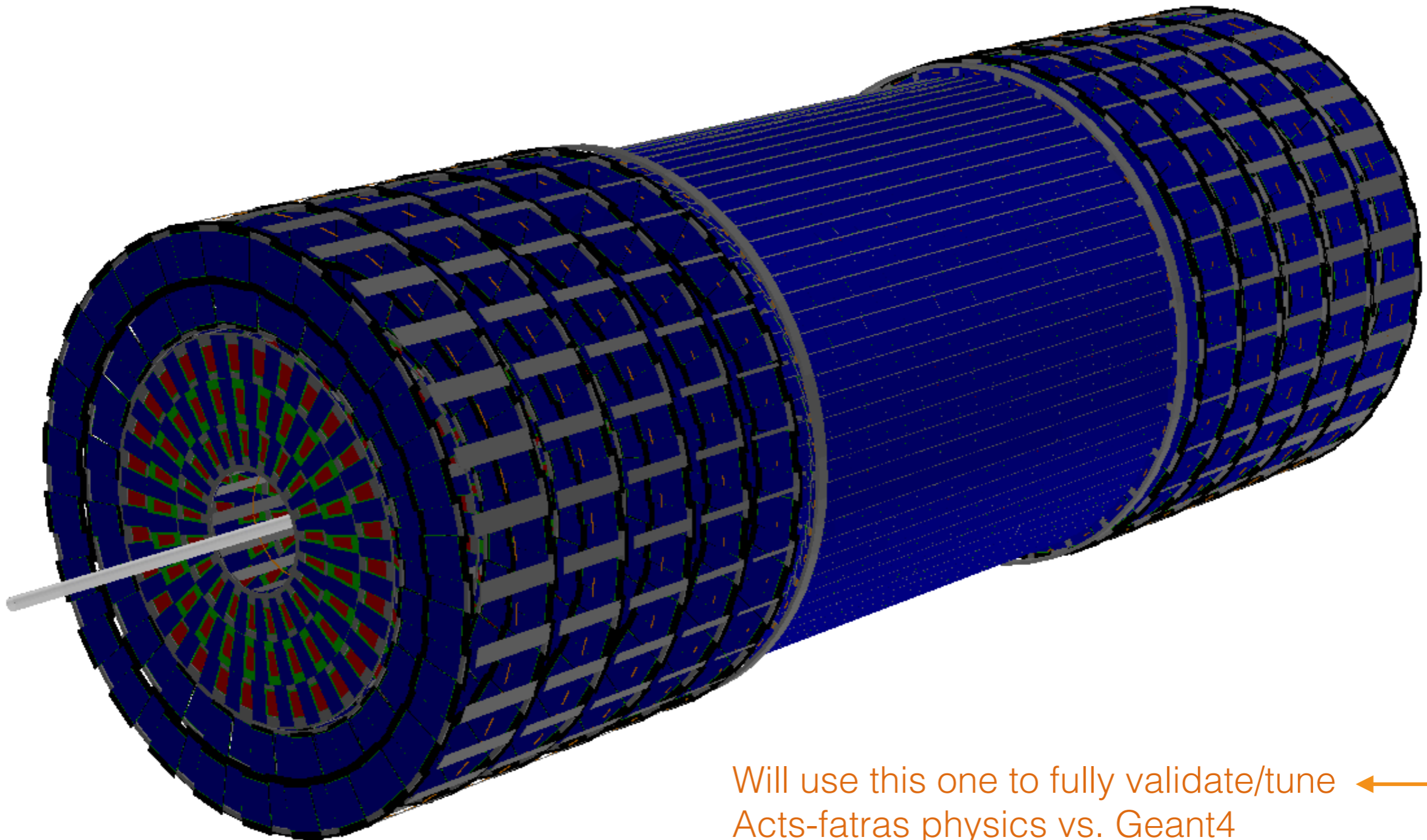


- Dataset is simulated with ACTS fast simulation
 - Includes multiple scattering, energy loss and hadronic interactions (no particle decay)
 - Not enough material
- TrackML dataset is also used for other projects:
 - e.g. [Hep.TrkX & Exa.TrkX project](#) (talk by X. Ju later today)

- Simulating a realistic detector
 - Realistic material description
 - Full material interaction
- Large benchmark dataset to be released as CERN OpenData

OpenDataDectector

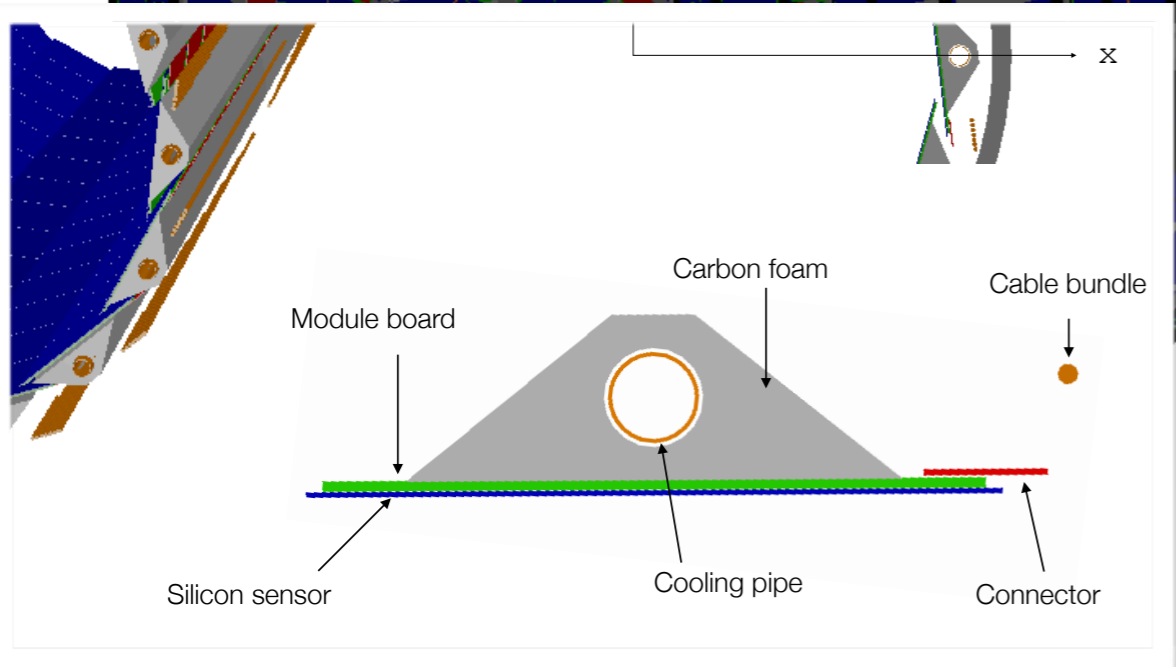
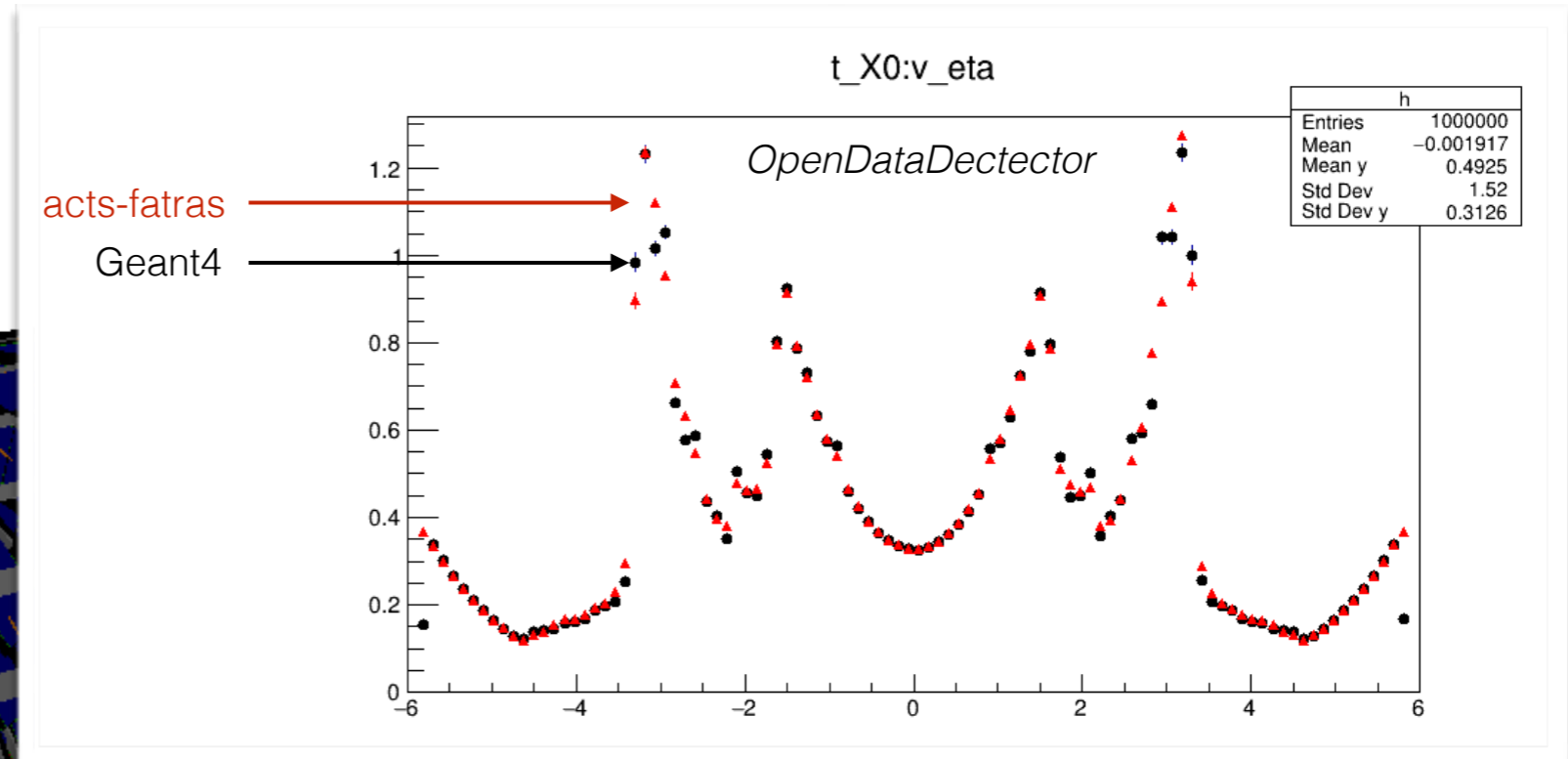
- realistic full simulation detector with mixture of material, etc.



Will use this one to fully validate/tune Acts-fatras physics vs. Geant4

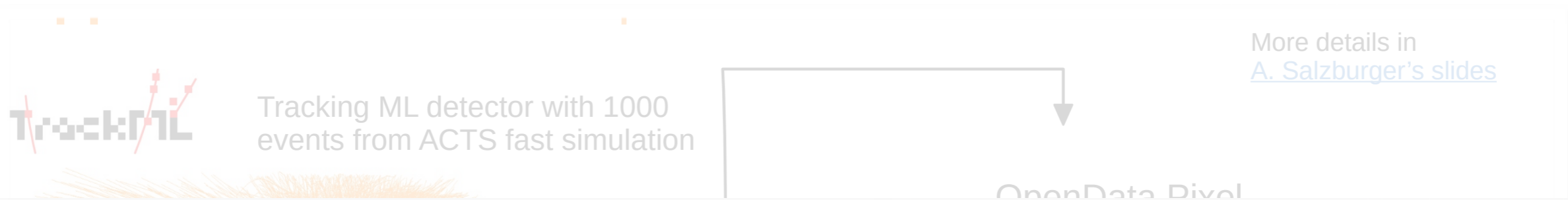
OpenDataDectector

- realistic full simulation detector with mixture of material, etc.



“TrackML detector on steroids”

Will use this one to fully validate/tune Acts-fatras physics vs. Geant4



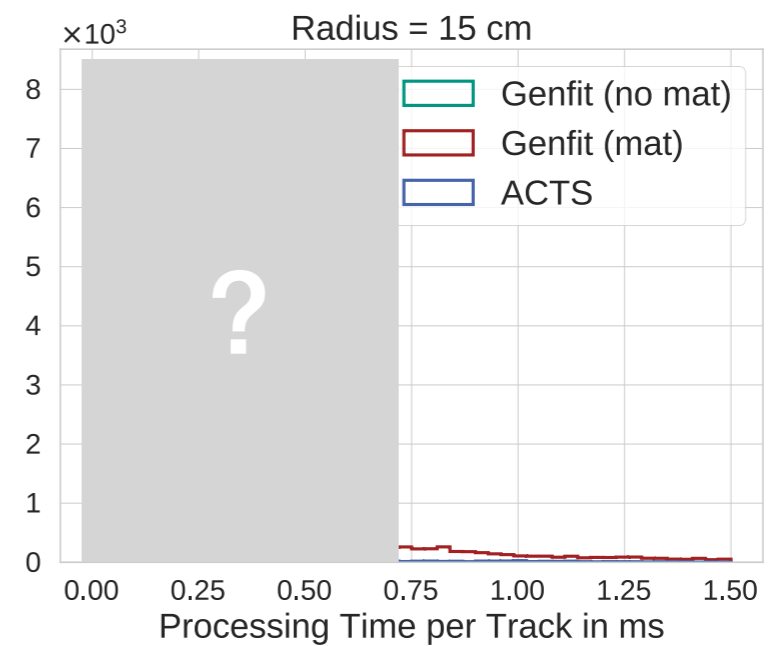
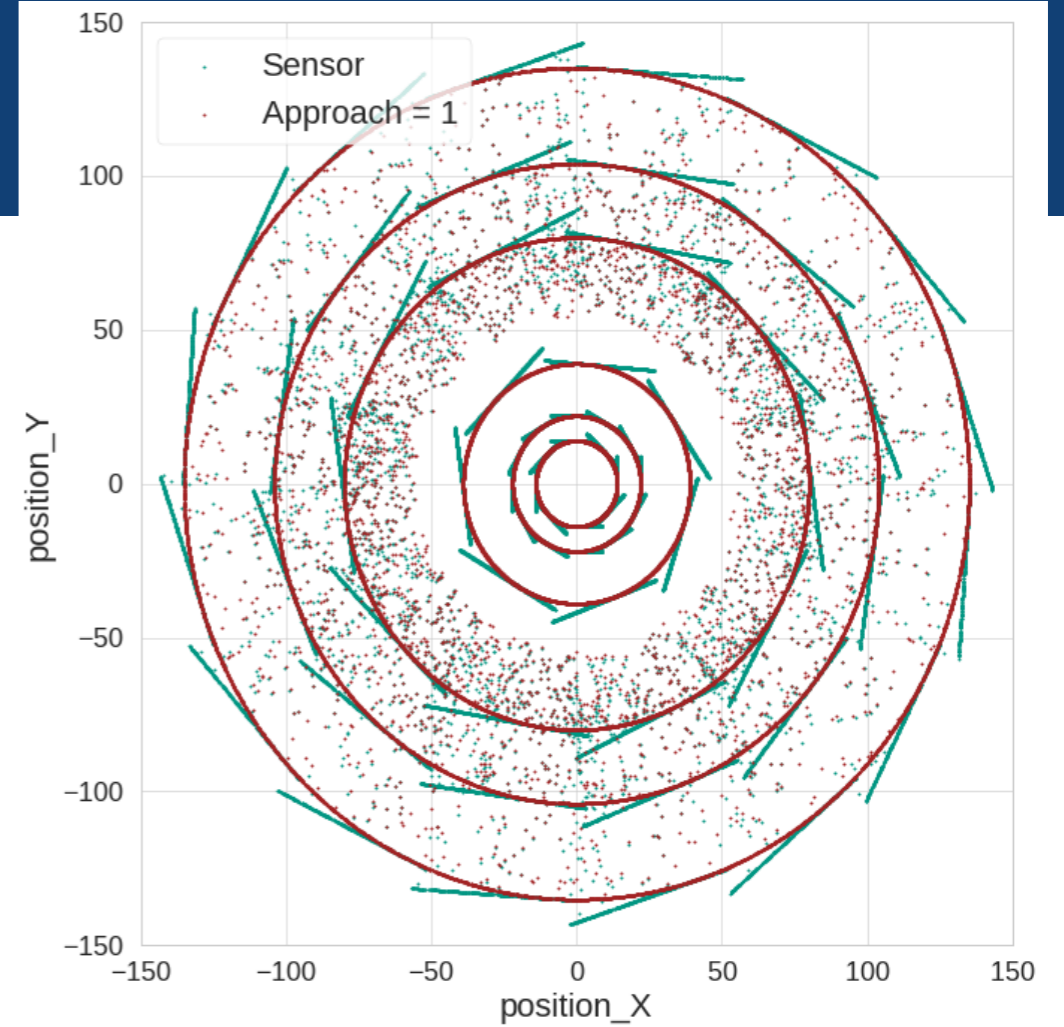
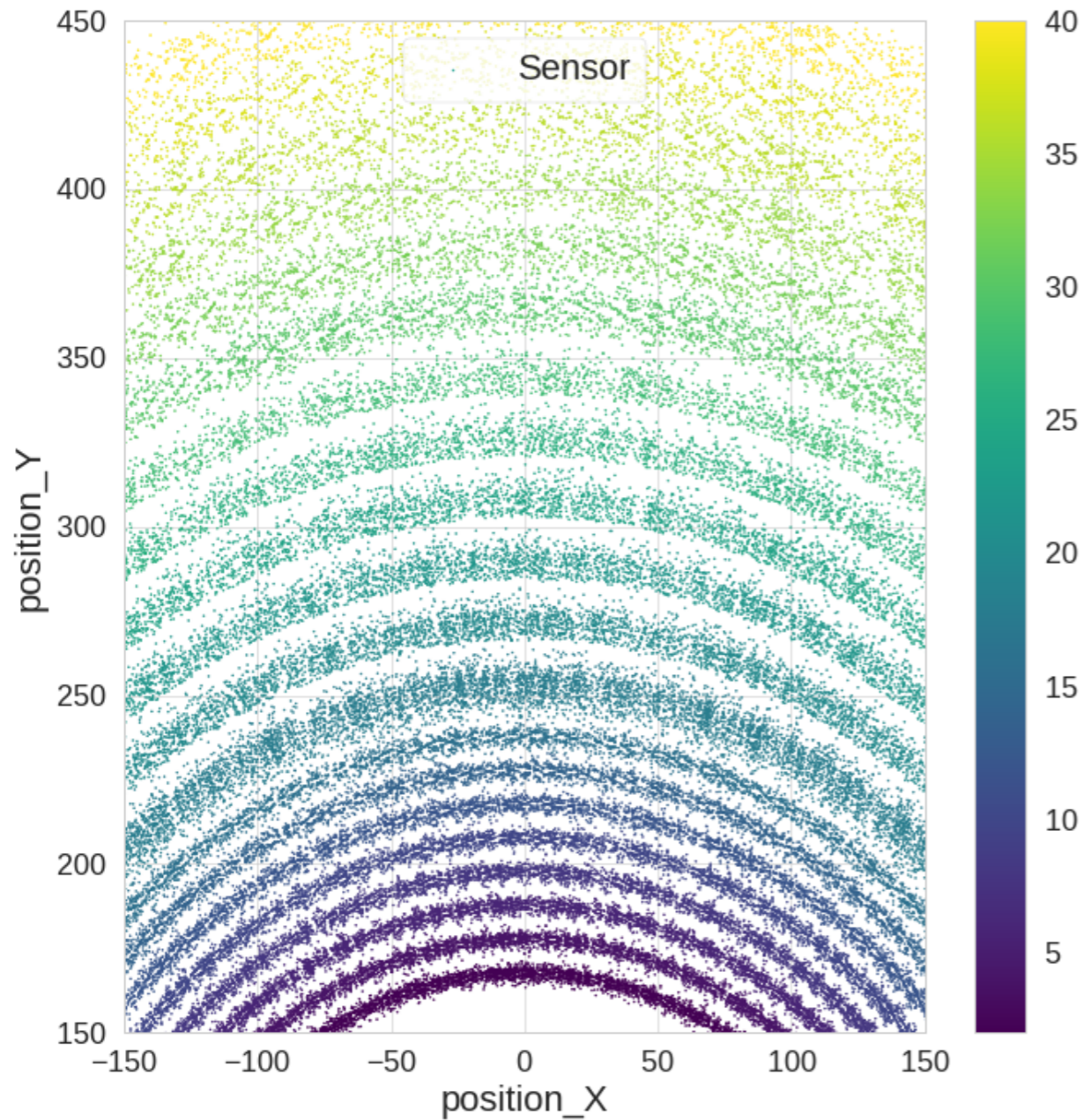
Status

- Propagation, single Kalman Filter, seed finder developed and usable
- Time propagation implemented and tested
- So far: tests mostly standalone
- Tests of ATLAS geometry (ID + first tests for calorimeter modeling and navigation)
- Demonstrated multi-threaded execution with alignment

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 - Includes multiple scattering, energy loss and hadronic interactions (no particle decay)
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- Simulating a realistic detector
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More tomorrow in Paul's ACTS overview talk

ACTS & Belle II



More results: Nil's talk tomorrow

Follow WS to “Tracking Workshop for HEP 2019”

- 22 Participants from various experiments
 - **2 ACTS experts:** Dr. Moritz Kiehn und Paul Gessinger
 - Members from **ATLAS, Belle II, and Mu2e**
- Diverse 5 day program
 - Mix of **tutorials** from Moritz and Paul;
 - Talks from Belle II (Dr. Nils Braun), ATLAS (Dr. Nick Styles), Mu2e (Dr. Dave Brown) tracking challenges
 - A lot of **Hackathon** time to kick-start projects



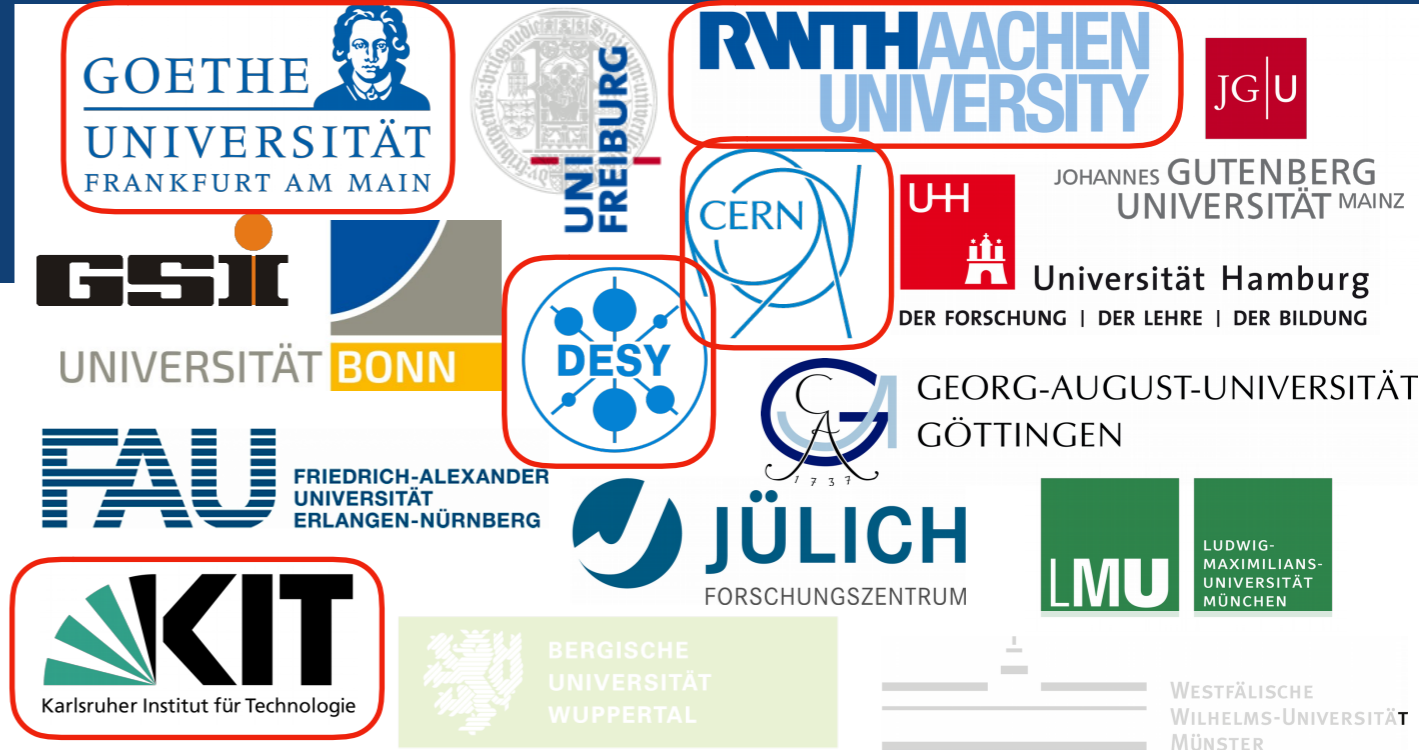
Are still planing a follow-up workshop for next year either at **DESY, Bonn, or CERN**

Outlook

- **ACTS** is on its way to become a complete and mature package
 - Full overview tomorrow in Paul's talk
- **First studies** on how to integrate **ACTS** into **Belle II** have been carried out
 - Easy things are done, the next steps will be harder (more on that tomorrow)
- Plan to organize a follow-up workshop/hackathon to bring ACTS developers or people interested in the package at DESY
- Other work packages in research area will have more to report next time.

Backup

Involved Groups



Standort	PI	FTE	Experiment	AP D1	AP D2	AP D3
Aachen	Schmidt	0.5	CMS	X		
Aachen	Stahl	-	ν-Exp.			X
Frankfurt	Kisel	0.5	CBM	X		
KIT	Bernlochner	1	Belle II		X	
Assoziiert						
CERN(ATL/SFT)	Elsing/Hegner	-	ATLAS	X	X	
DESY	Gaede	-	ILC		X	
FZJ	Prencipe	-	Panda		X	