

Performance study of Traccc on ATLAS ITK samples

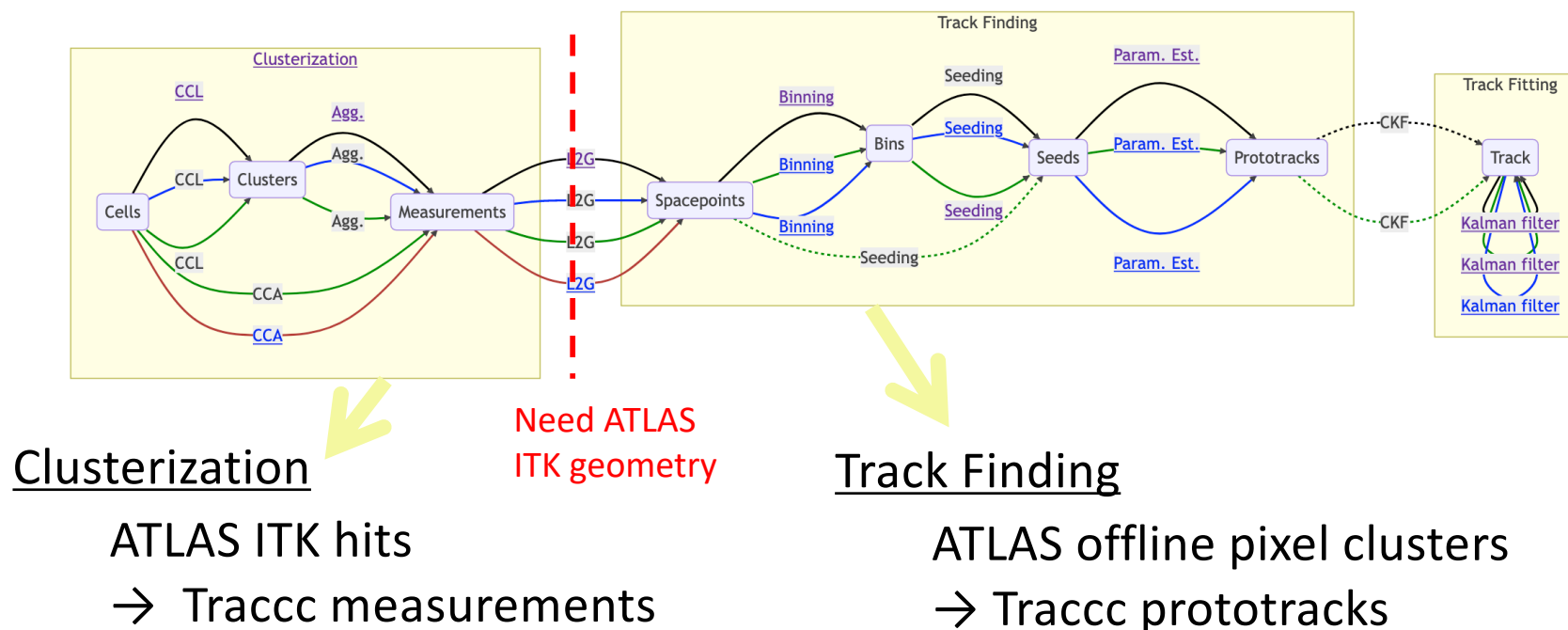
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ACTS Parallelization meeting 16 Jun. 2023

Several Traccc updates are now coming this week.
My slides today are based on the version before.

Introduction

- ◆ Test of Tracc performance using ATLAS ITK samples.
 - Effort started in a context of tracking trigger (ATLAS EFtrack).
- ◆ Preparation of the ATLAS ITK geometry for Tracc is ongoing.
 - (Not my topic, but proceeding as ACTS ITK geometry -> Detray -> Tracc)
 - = Local <-> Global coordinate conversion is not possible yet.
- ◆ Test is started for each Tracc block.

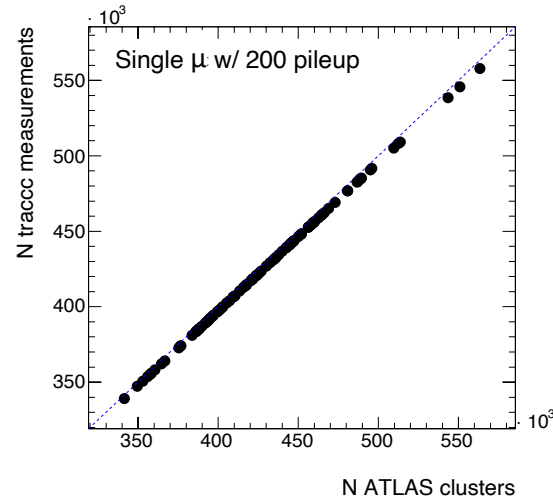
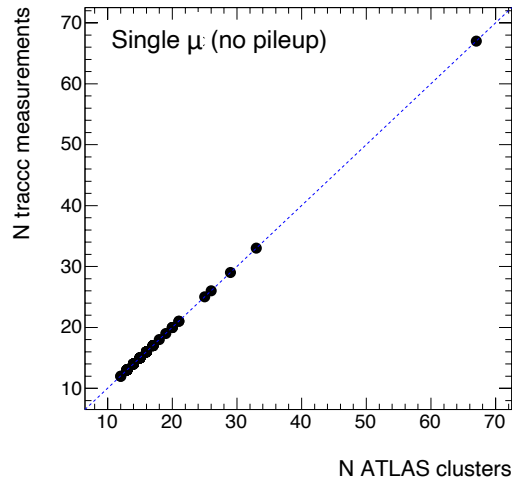


Tracc clusterization on ATLAS ITK hits

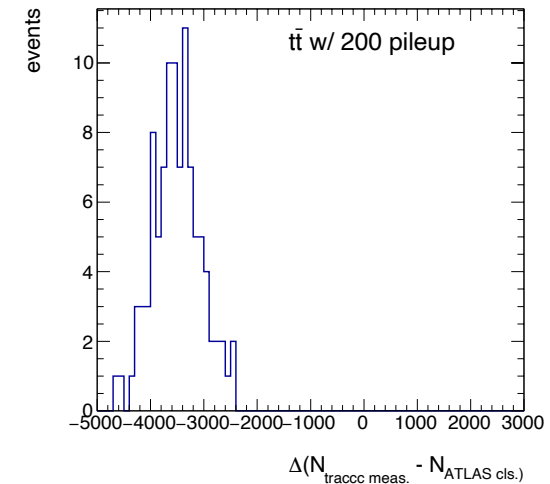
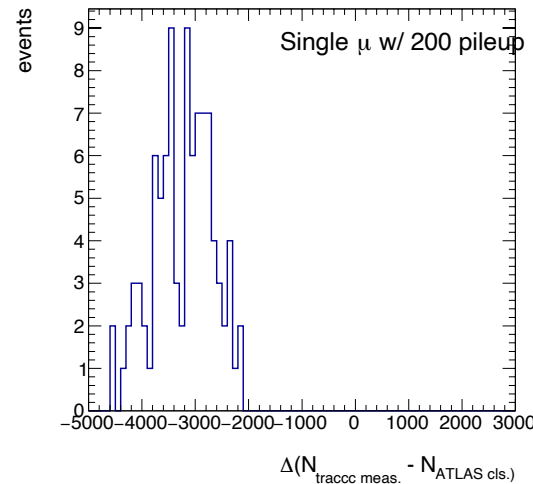
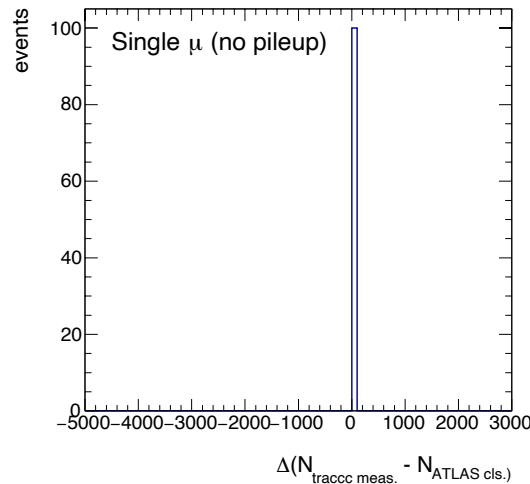
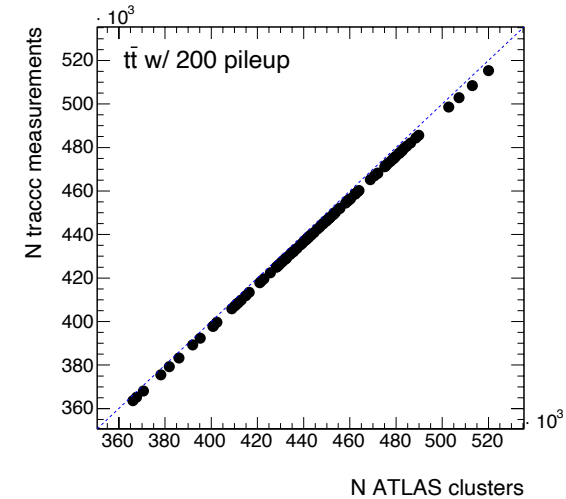
- ◆ Tracc default detector (tml detector)
 - Pitch: 0.05mm x 0.05mm, 0.08mm x 1.2mm, 0.12mm x 10.4mm
 - ◆ Application on ATLAS ITK sample:
 - Inputs: ITK hits
 - Assigning dummy Tracc tml detector IDs to ATLAS hits
 - Pixel hits: IDs of tml 0.05mm x 0.05mm modules
 - Strip hits: IDs of other tml modules
 - Their pitch is overwritten as 0.0755 mm x 24.1mm before processing the clusterization in tracc.
- ➔ Tracc clusterization (**CPU**) works w/o error.
- Due to the difference in the position definition (Tracc: local, ATLAS clusters: global) , only their numbers are compared.

Number of ATLAS clusters vs Tracc measurements

- ◆ 100 events are checked, for 3 samples.



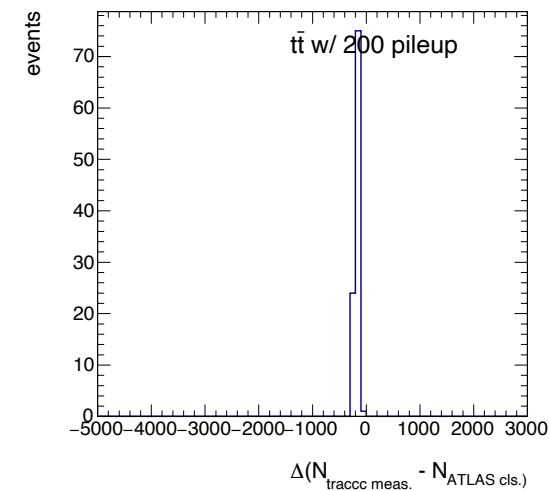
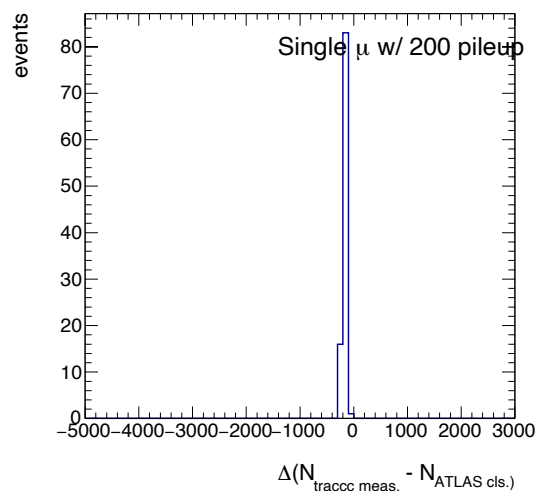
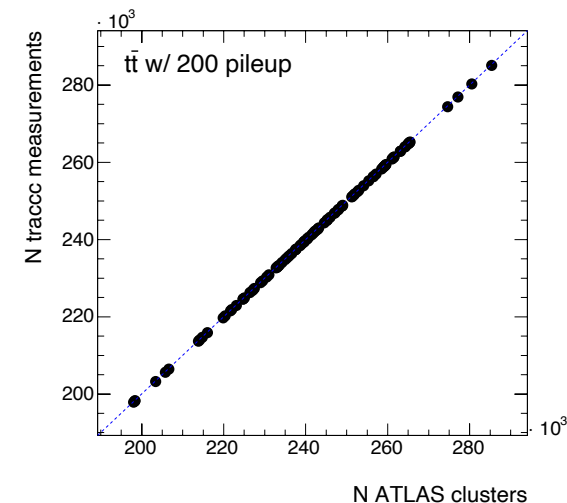
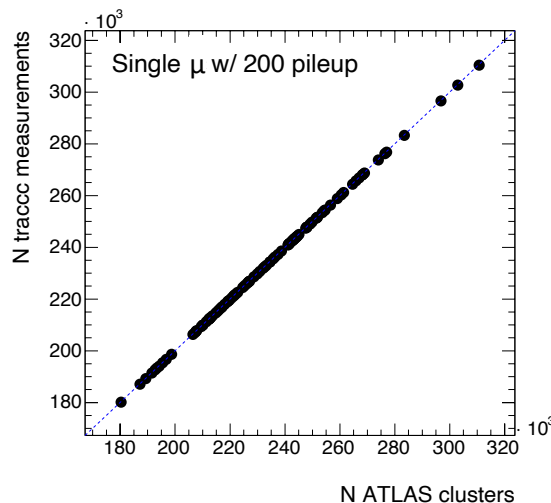
Single μ : $0.1 < \eta < 0.3$, $0.3 < \phi < 0.5$



- Perfect agreement for single μ with no pileup.
- In dense environment, tracc creates less clusters than ATLAS clusters.

Pixel hits only

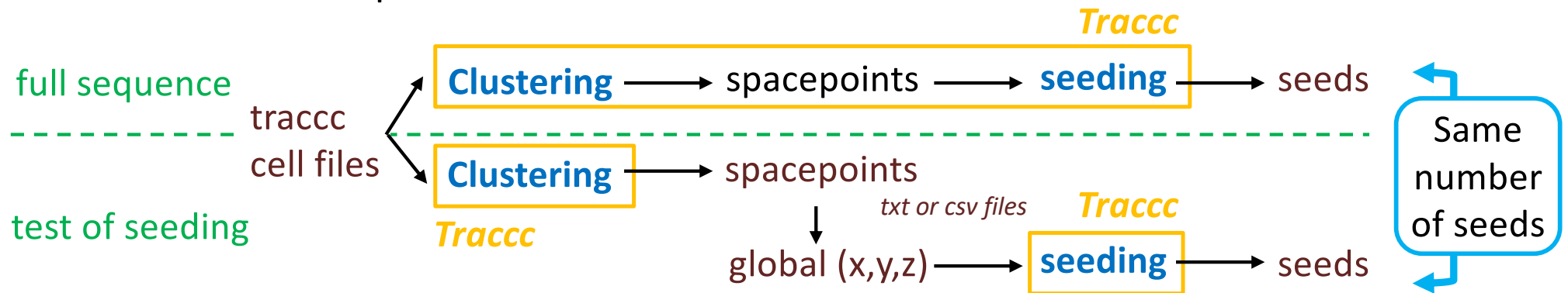
- ◆ Much less difference between ATLAS and Traccc.
i.e. Most of difference on the previous page come from strip hits.
- ◆ Still, there are some difference, even for Pixel hits.
Reasonable to have smaller numbers for ATLAS clusters.
In ATLAS, cluster separation runs after CCL clusterization.



The comparison looks reasonable.

Traccc seeding on ATLAS offline clusters

- ◆ Idea is to use the global coordinates of ATLAS offline clusters as spacepoints.
- ◆ Validation of the procedure:



- ◆ Application on ATLAS offline clusters
 - Inputs: **ATLAS offline pixel clusters**
 - Seeding configuration is loosened to cover the ATLAS ITK geometry.
 - Traccc seeding and track parameter estimation are applied.

Parameters modified from the traccc default

```
scalar zMin = -1500 * Acts::UnitConstants::mm;
scalar zMax = 1500 * Acts::UnitConstants::mm;
scalar rMax = 1100 * Acts::UnitConstants::mm;
```

```
int maxSeedsPerSpM = 10
unsigned int maxSeedsPerSpM = 10;
size_t max_triplets_per_spM = 10;
```

```
scalar deltaRMax = 200 * Acts::UnitConstants::mm;
```

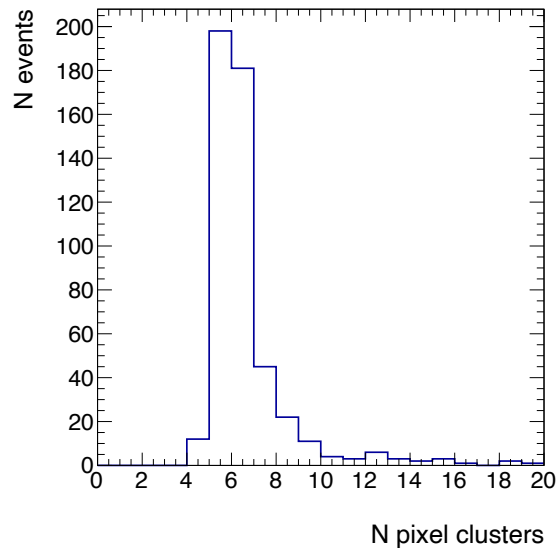
```
scalar spB_min_radius = 33. * Acts::UnitConstants::mm;
```

Tracc on ATLAS single muon events

- ◆ Tracc seeding runs over 500 ATLAS single muon events.

Single μ : $0.1 < \eta < 0.3$, $0.3 < \phi < 0.5$

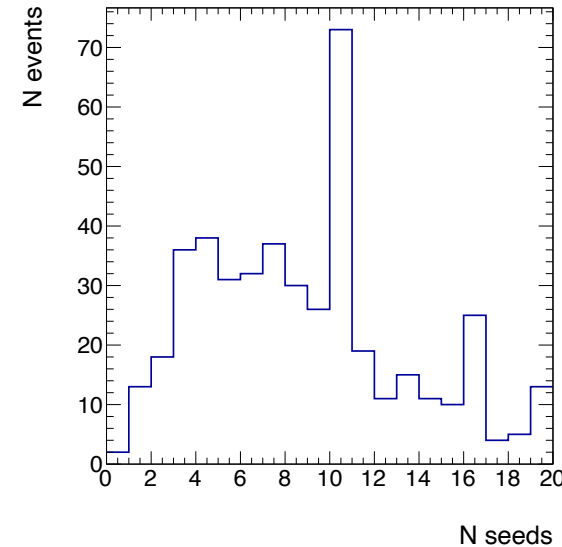
Number of the ATLAS offline pixel clusters per event



Tracc seeding



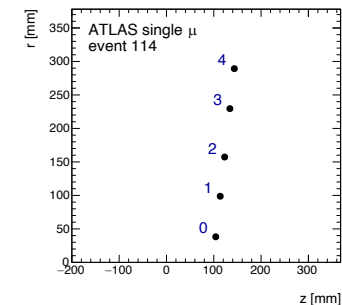
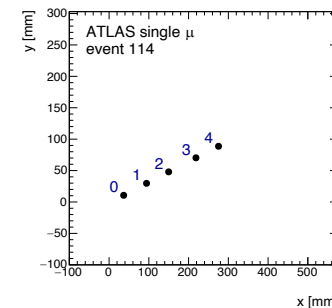
Number of the created Tracc seeds per event



- 5 clusters \rightarrow 10 seeds. Reasonable to have a peak at 10 seeds.
- 2 events fail to have a seed.
 - No triplet is created.
 - They have similar geometrical topology. \rightarrow Looked into by Beom-Ki Yeo

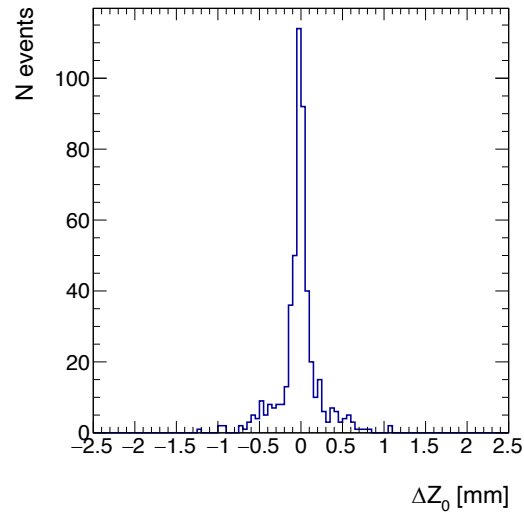
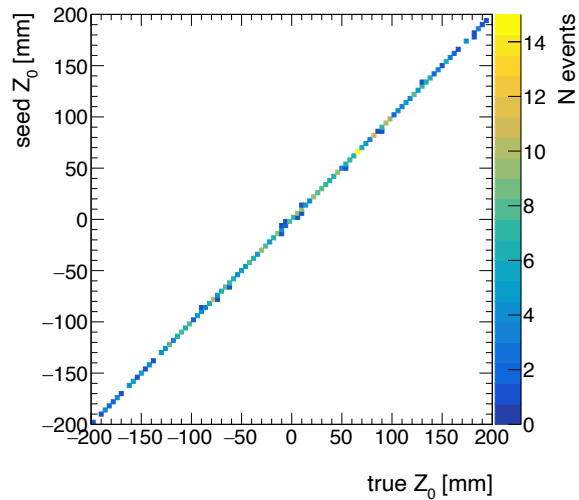
(tracc [issue 413](#), [PR 416](#))

Cluster position in event 114 (x vs y, r vs z)

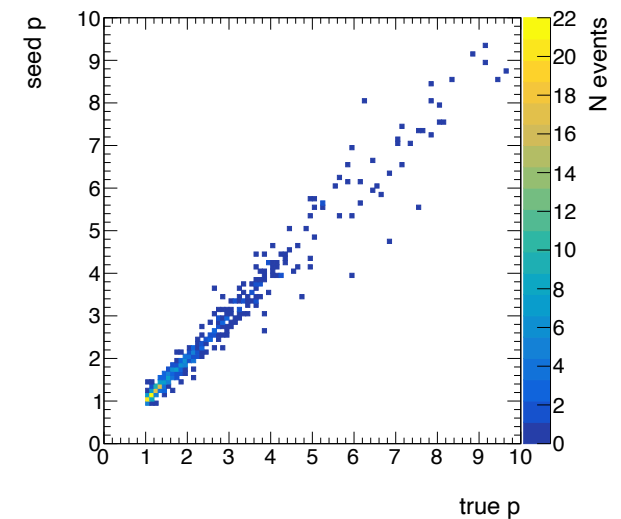
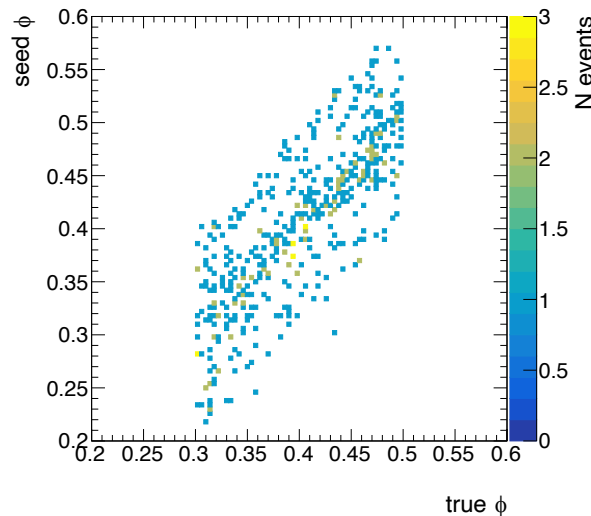
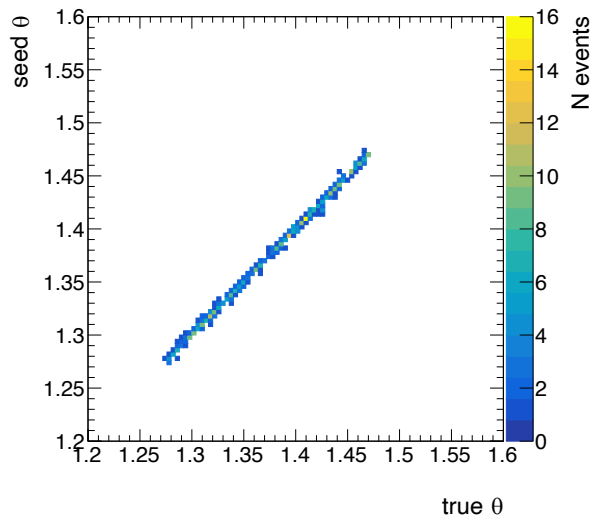


Comparison to truth muon track

- ◆ The seed with the highest weight in each event is compared to the truth track.

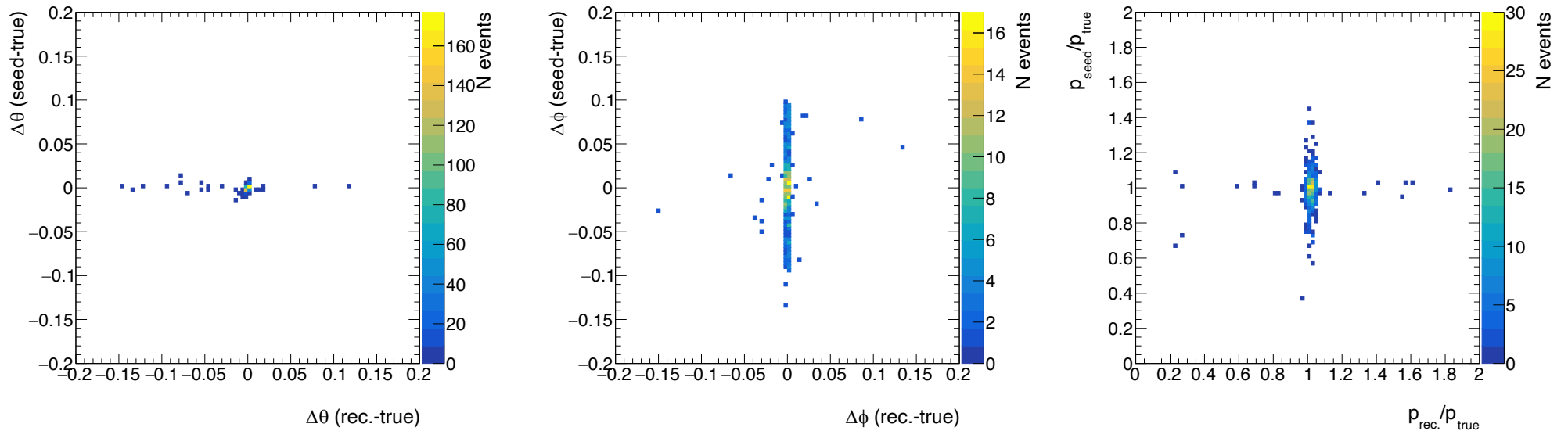


- Good correlation in Z_0 , θ , and p .
- Seeds have spread in ϕ .



Comparison to offline reconstruction

- ◆ Differences wrt the truth track are compared between seeds and ATLAS offline tracks.



- Seeds have spreads in ϕ and momentum.
- For a few events, offline tracks have larger deviation than seeds.

CUDA-based Traccc

- ◆ Got an error on the 2 events with 0 triplets. (see slide 7)

i.e. Traccc throws an error and stops.

```
CUDAassert: invalid configuration argument  
/afs/cern.ch/work/s/shima/eftrack/traccc/device/cuda/src/seedfinding/seed_finding.cu 298
```

→ Traccc [issue 414](#), [PR 415](#).

(These 2 events are skipped to process other events in my study.)

- ◆ Traccc CUDA vs CPU Comparator tells:

- All events have 100% matching rate at 1% uncertainty.
- 19 / 498 events has non-100% matching rate at 0.01% uncertainty.
- 4 / 498 events has non-100% matching rate at 0.1% uncertainty.

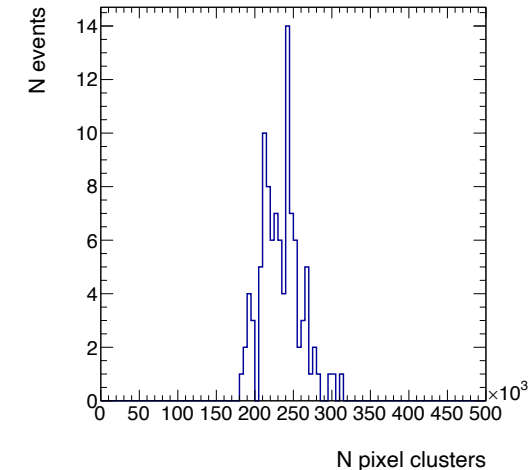
They all have >0.01 % difference only in q/p values.
Largest difference=0.5% ($q/p_{\text{CPU}}=0.000546$ vs $q/p_{\text{CUDA}}=0.000549$)

Probably due to the calculation accuracy.

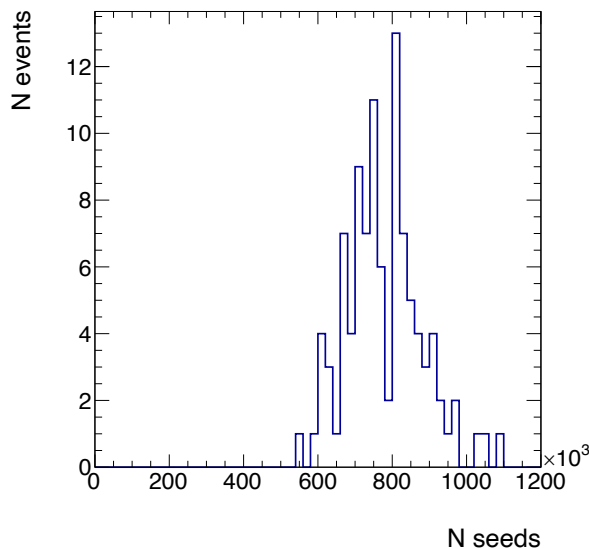
Ongoing: Tracc seeding on ATLAS pileup events

- ◆ 100 single muon events w/ 200 pileup are processed.
 - Huge number of pixel clusters in an event.
 - Truth information in ATLAS offline clusters allows to identify muon-origin clusters.
- ◆ Tracc creates $10^5 \sim 10^6$ seeds per event.
 - ~ 100 seeds contain muon-origin clusters.

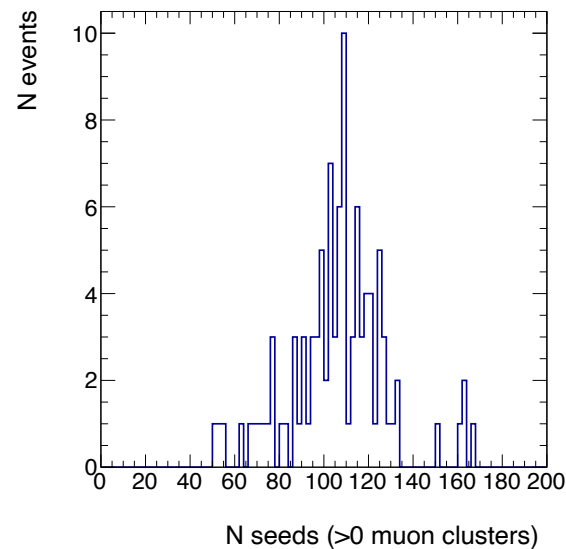
Number of pixel clusters



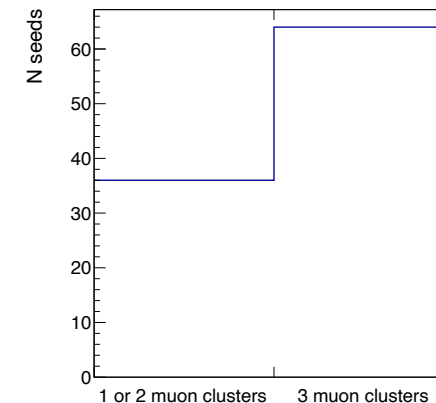
N of created seeds



N of created seeds incl. muon-origin clusters



If we look at that with the highest weight, $\sim 35\%$ contain pileup clusters.



Study is ongoing... Looking into more plots.

Summary and To-do

- ◆ Traccc is tested using ATLAS ITK samples.
 - So far, clusterization look reasonable for ATLAS pixel hits
 - Seeding is checked using single muon sample.
 - Looks reasonable, if the phi spread is ok.
- ◆ Next steps:
 - Performance study using single muon with pileup events.
 - Study is ongoing. More plots will come.
 - Comparison/understanding of Traccc seed filtering configuration, wrt ATLAS ACTS seed filtering configuration.
 - Re-check the traccc seeding after including recent Traccc updates.