The TICL reconstruction at the CMS Phase-2 High Granularity Calorimeter Endcap

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On behalf of the CMS collaboration

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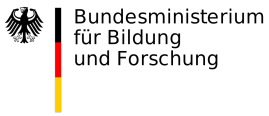
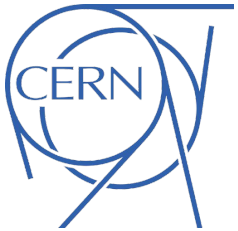
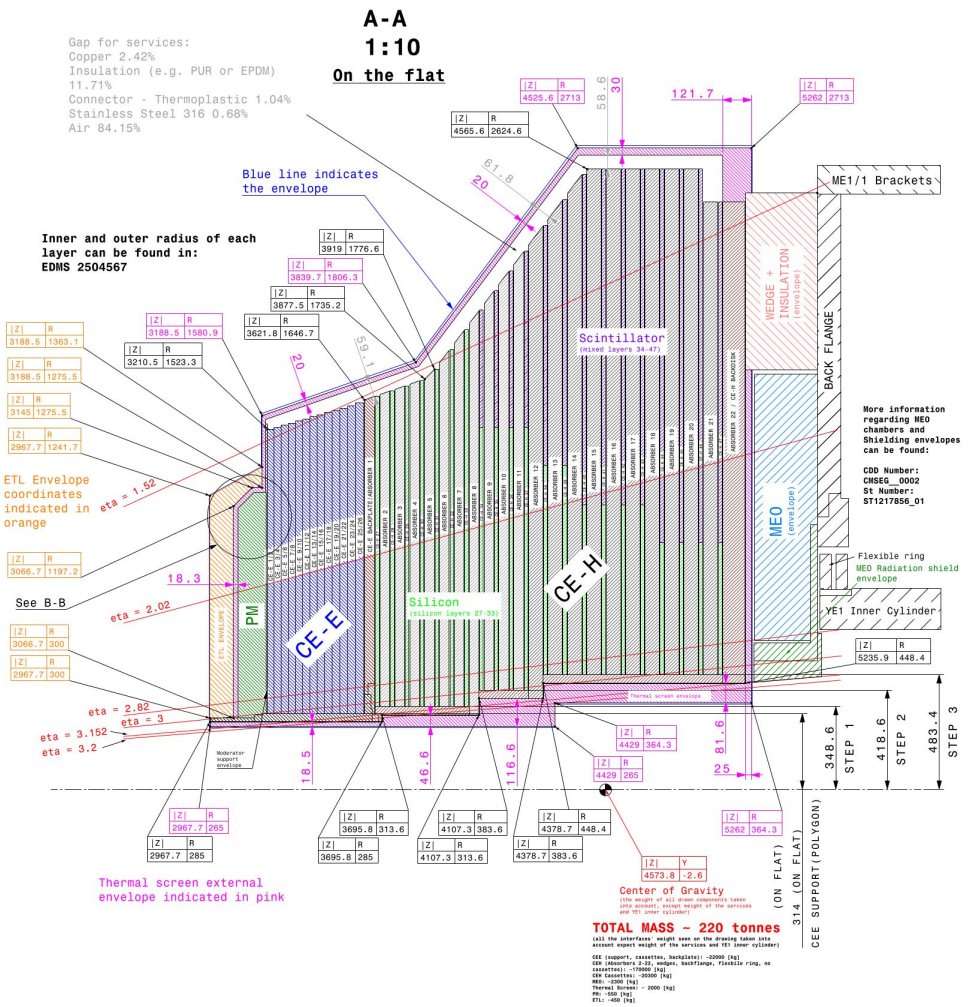


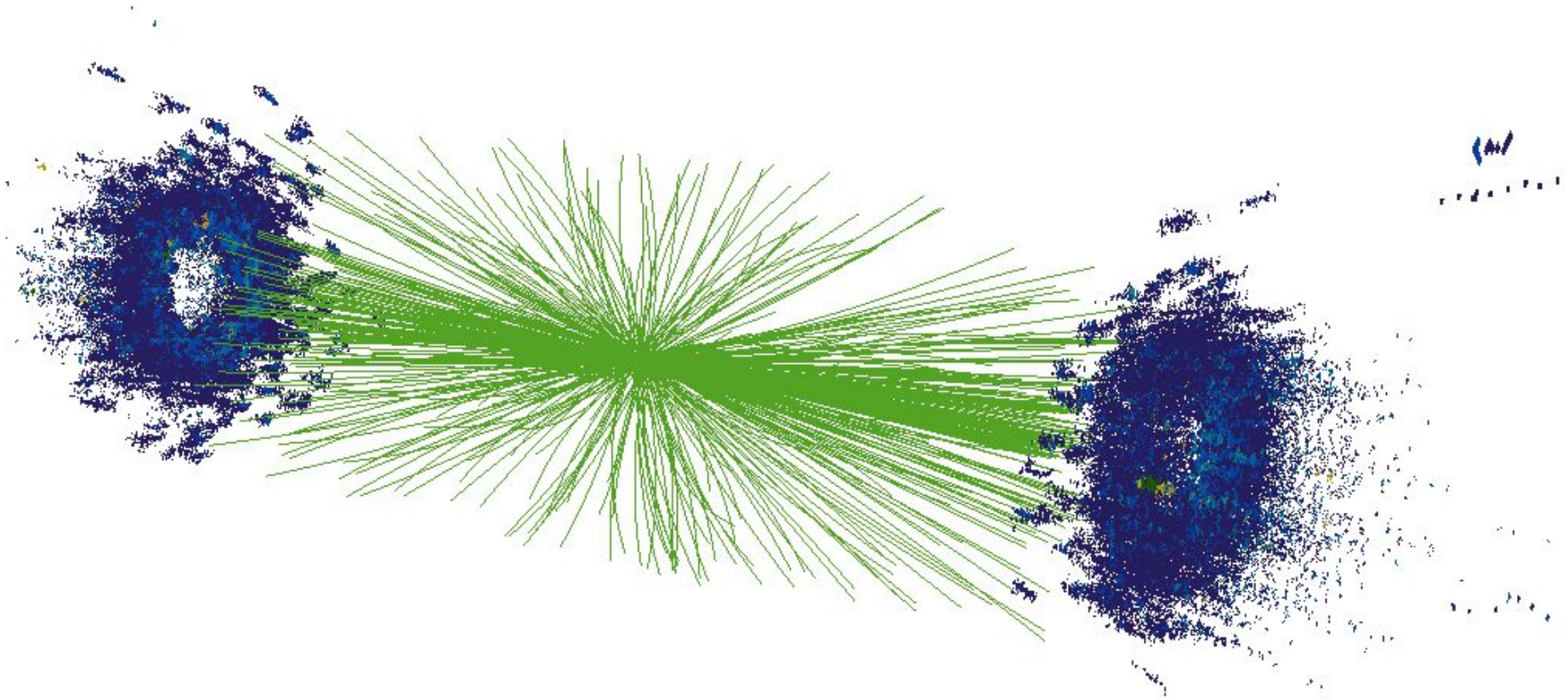


HGCAL Detector

- High granularity sampling calorimeter
- ~50 layers of silicon + scintillators
- Cu/CuW/Pb absorbers

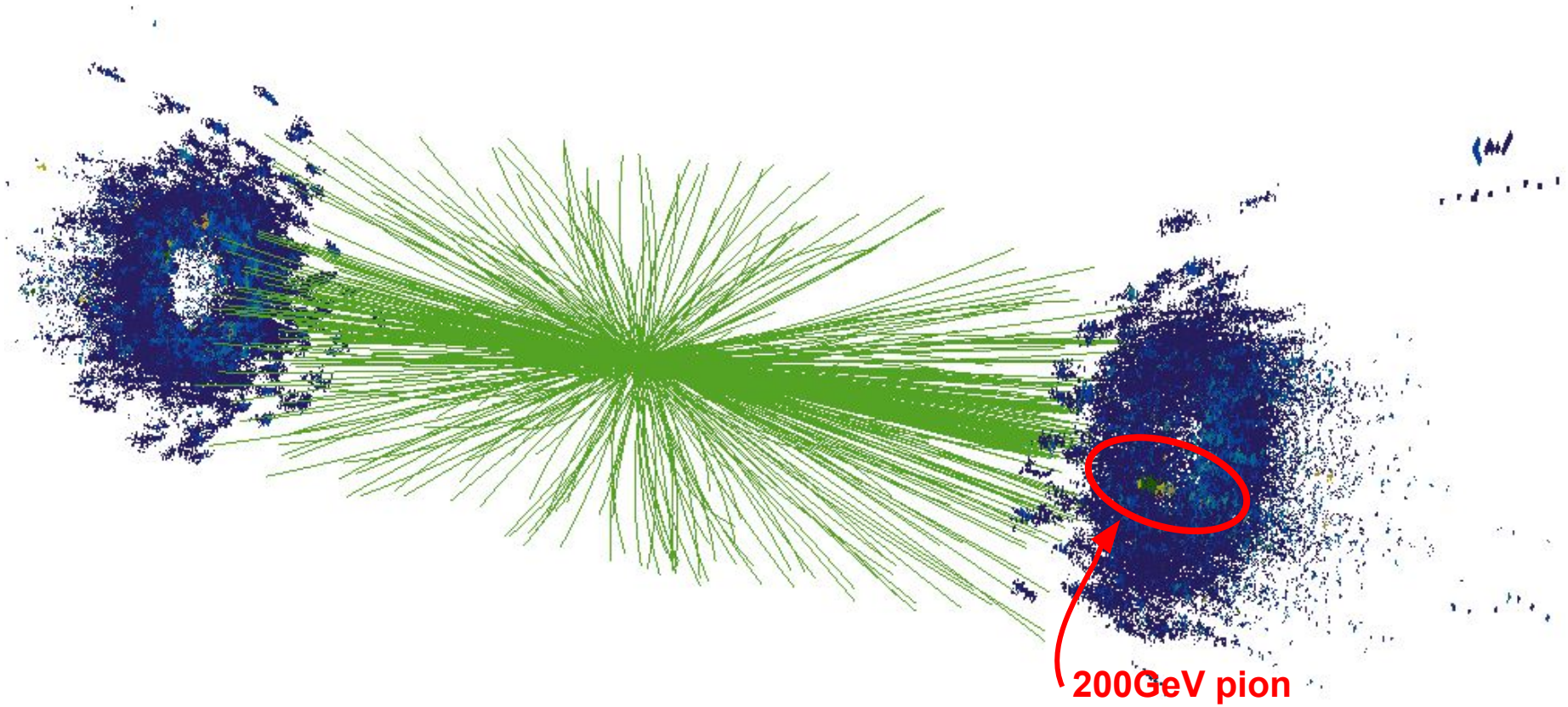


The challenge



- 6M channels
- 500k hits per event
  - (x,y,z,E,t)
- Extremely granular

The challenge



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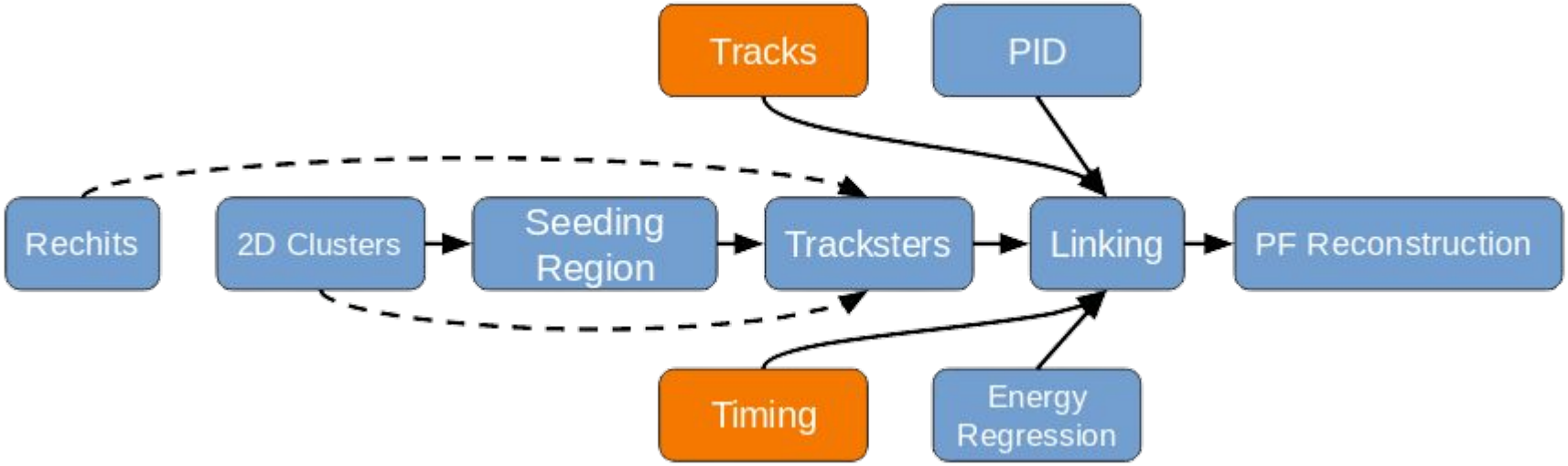
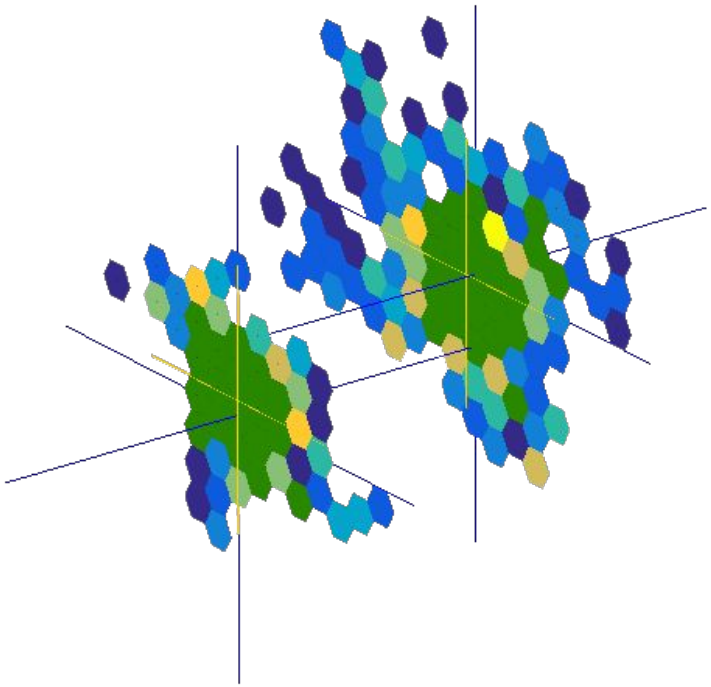
TICL - The Iterative Clustering Framework

- **Modular** framework developed within CMSSW
- Takes in account different detectors
- **Full reconstruction** starting from Rechits, up to full particles with global event interpretation
- Built with **Heterogeneous Computing** in mind
- Developed first in the context of HGCAL, extend to full detector next



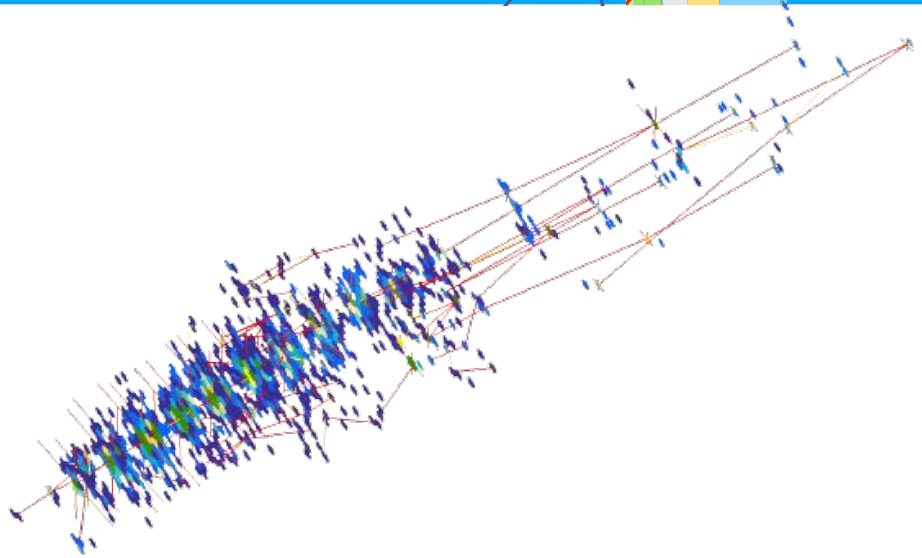
- Energy based clustering algorithm
- Reduces problem size of **one order of magnitude**
- **Highly Parallelizable**
  - Already on GPU
  - CUDA, Alpaka, SYCL
- Produces 2D Clusters - **Layer Clusters**

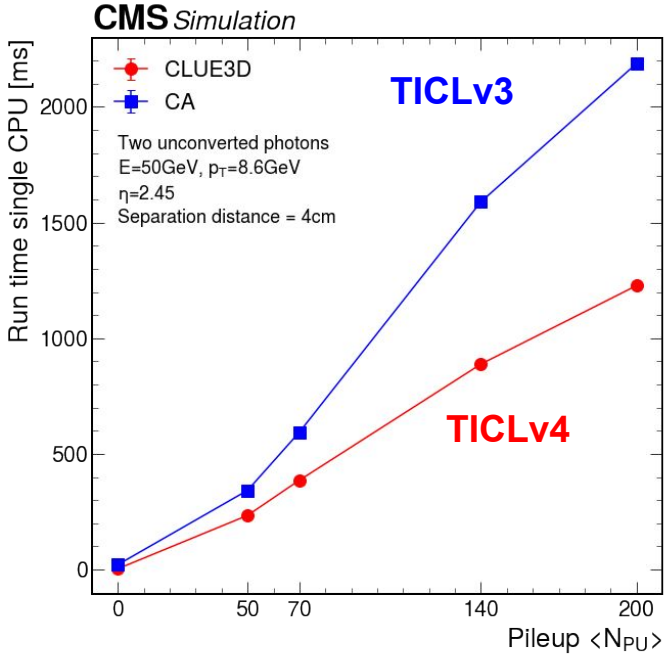


CLUE: A Fast Parallel Clustering Algorithm for High Granularity Calorimeters in High Energy Physics

Pattern recognition by

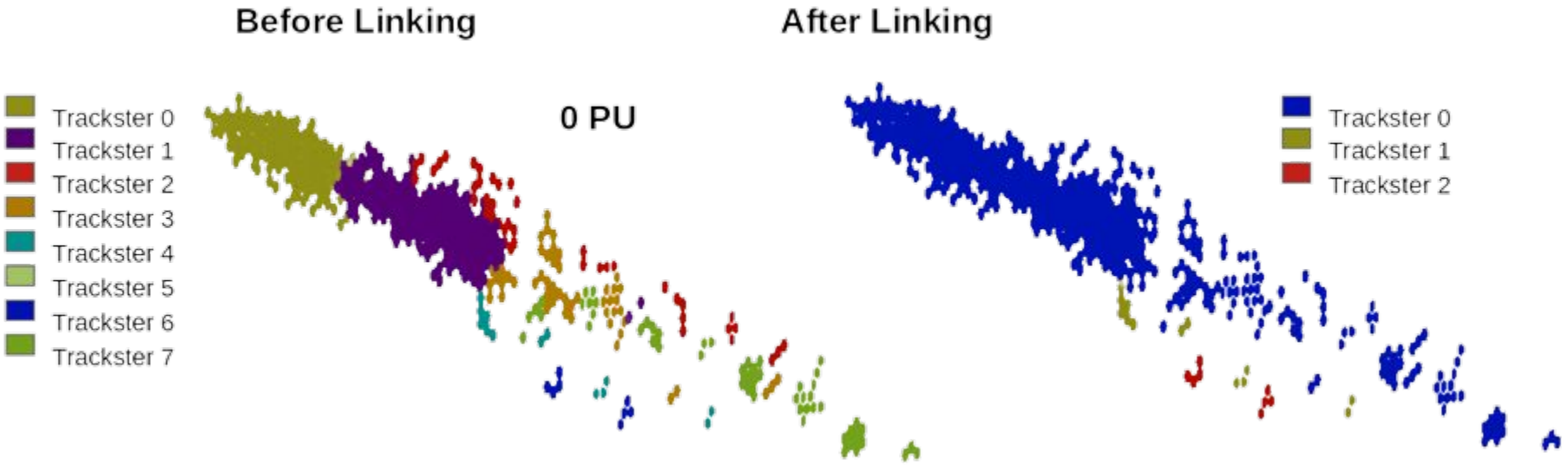
- **Pattern recognition** is the core of the TICL framework
- Currently uses **CLUE3D**
  - Starts from 2D Layer Clusters
  - Follows the energy flow
- Builds graphs of layer clusters; **Tracksters**
- Reduces, again, problem size by one order of magnitude
- **Already on GPU**
  - With alpaka
- Excellent computing performance on a single core CPU
  - < 1.5s in 200PU
  - scales linearly with number of threads
  - scales linearly with pileup





Particle Flow reconstruction
Linking

- Further step to link CLUE3D Tracksters together
- Link final Tracksters with Tracks
- Build the final TICLCandidates
  - Assign PDG ID and apply energy regression



Conclusions and Future Perspectives

- TICL is a modular framework, candidate as Particle Flow framework for Phase-2
  - New algorithms and techniques can be easily plugged in
- First use case of TICL with the HGCAL reconstruction
- Full chain of reconstruction starting from rechits up to Particle Flow reconstruction and interpretation
- Extremely fast
  - Most of the modules already on GPU
- Extremely fun
  - development of pattern recognition algorithms in a challenging environment, optimized C++, heterogeneous computing, performance portability and fast neural network inference

- More work to enhance clustering performance
- More work to enhance Linking performance and exploit non-HGCAL objects
- Extend TICL to the barrel
  - Uniformize Particle Flow reconstruction over the whole detector

Thank you!

Poster