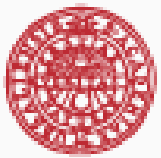

UPPSALA
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Prototype of an online track and event reconstruction scheme for the $\overline{\text{P}}$ANDA experiment at FAIR

Project in Computational Science (10 weeks)

Björn Andersson Johan Nordström
Supervisors: Michael Papenbrock, Karin Schönning

March 6, 2017

Uppsala University

Table of contents

1. Project introduction
2. Event reconstruction algorithms
3. Implementation details
4. Performance analysis
5. Summary and outlook

Project introduction

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- $\overline{\text{P}}$ANDA experiment: event rates up to 20MHz, event size 10kB

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- Data rate: 200GB/s
- Reduce data rate with a completely software based trigger

Background

- **Project goal**: Prototype of an online track and event reconstruction scheme for the $\overline{\text{P}}$ANDA experiment.

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  - Scalable

Methodology

- Generation of semi-realistic data

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- Prototype event reconstruction algorithms

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- Prototype event reconstruction algorithms
- Benchmarking of algorithms

Relevant sub-detectors

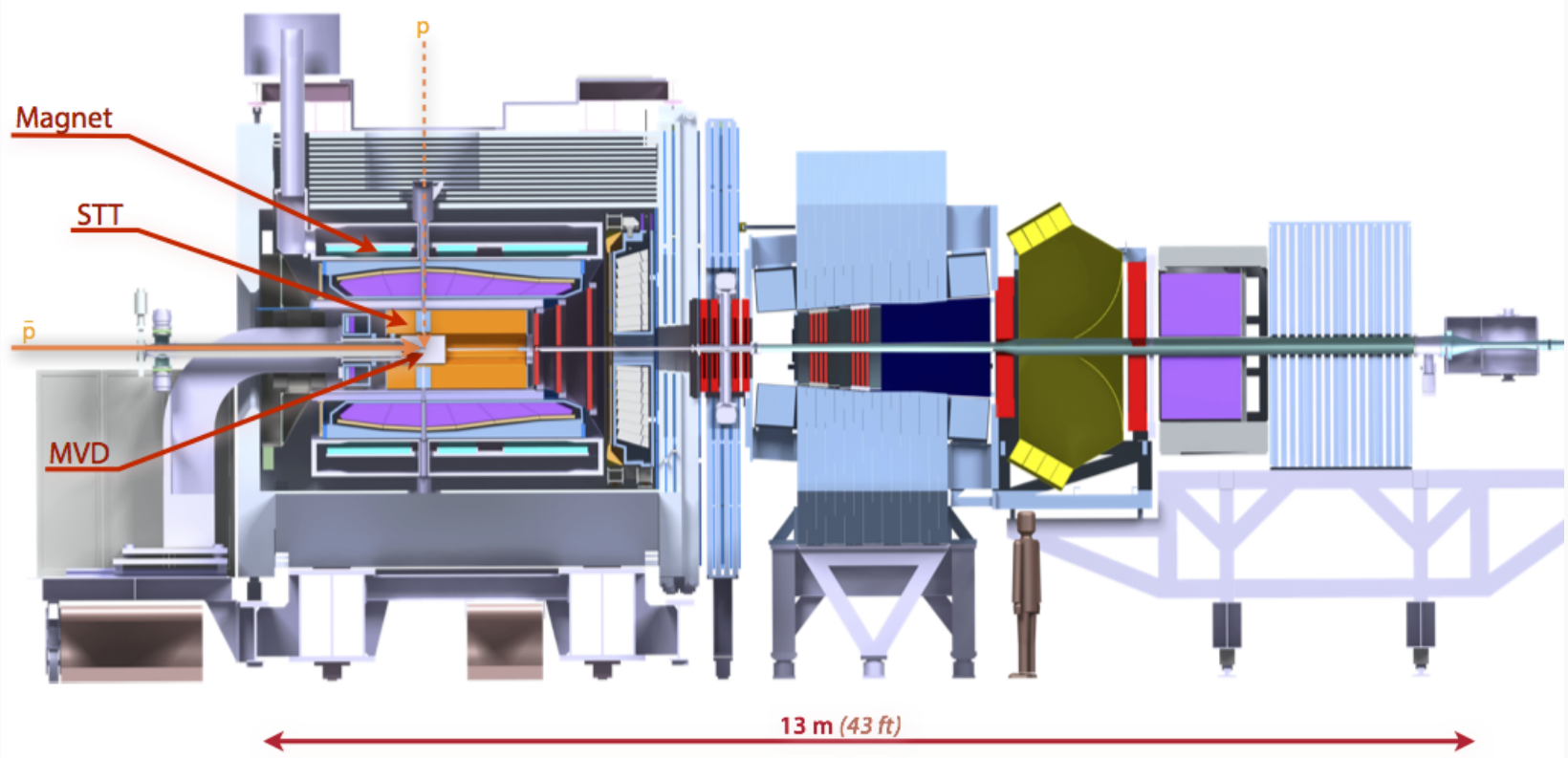

Figure 1: The $\overline{\text{P}}$ANDA Detector

Straw Tube Tracker

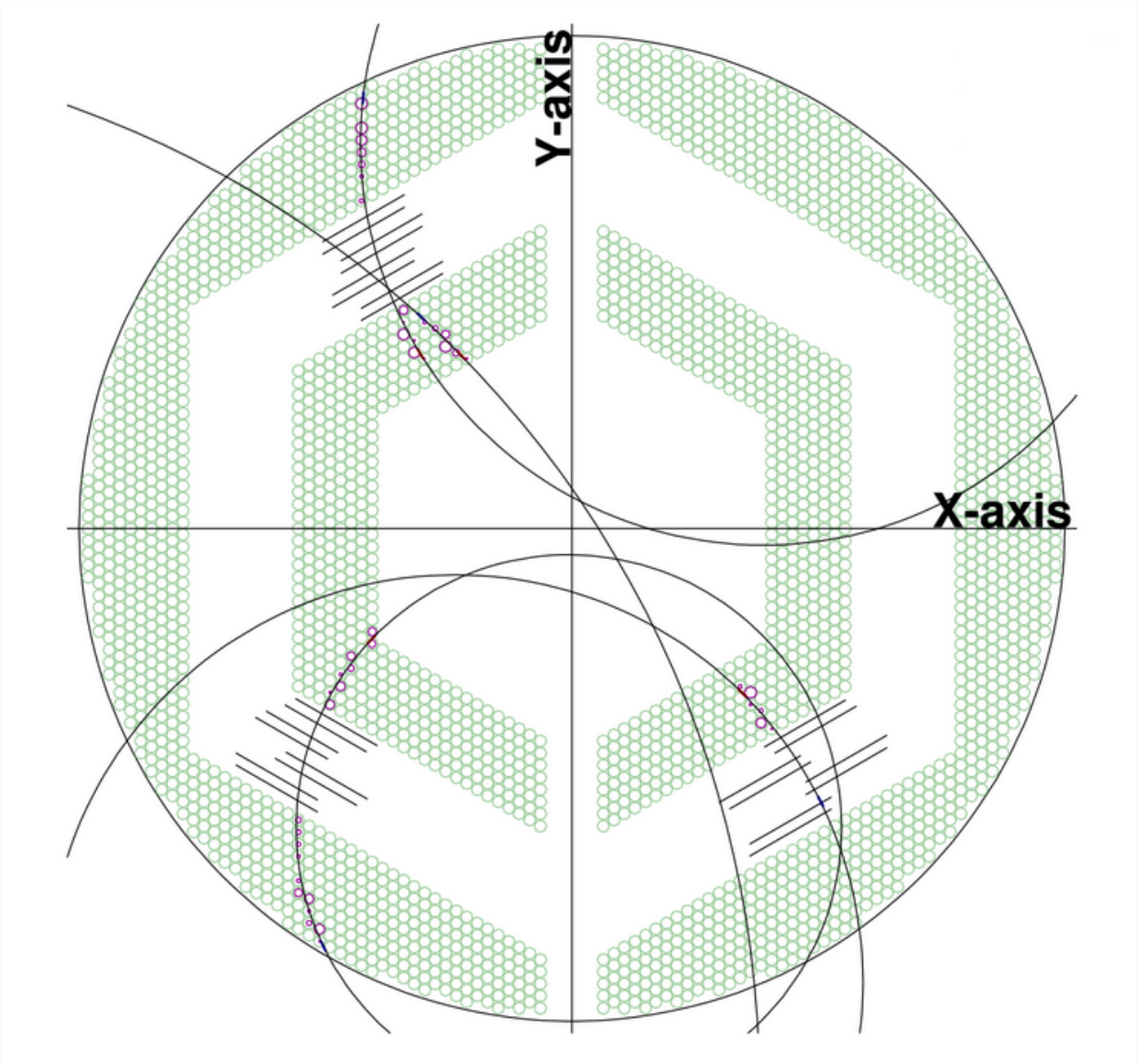

Figure 2: Cross section of STT with trajectories

Generated data structure

- Sequence of STT hits

```
class Hit {
        int strawID;
        float timeStamp;
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```

- Hyperons $\rightarrow$ displaced vertices
- Hits generated in lines and V-shapes
- Additional noise hits.

Event intermixing

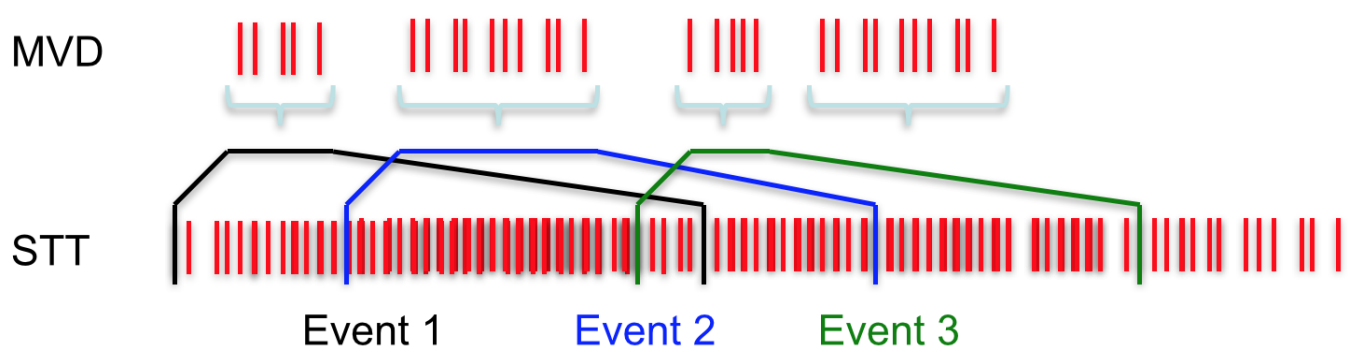

Figure 3: Illustration by T. Stockmanns.

Event intermixing is simulated by incrementing the timestamps with:

$t \rightarrow t + \Delta t + \xi, \quad \xi \sim \mathcal{N}(0, \sigma^2).$

Displaced vertices

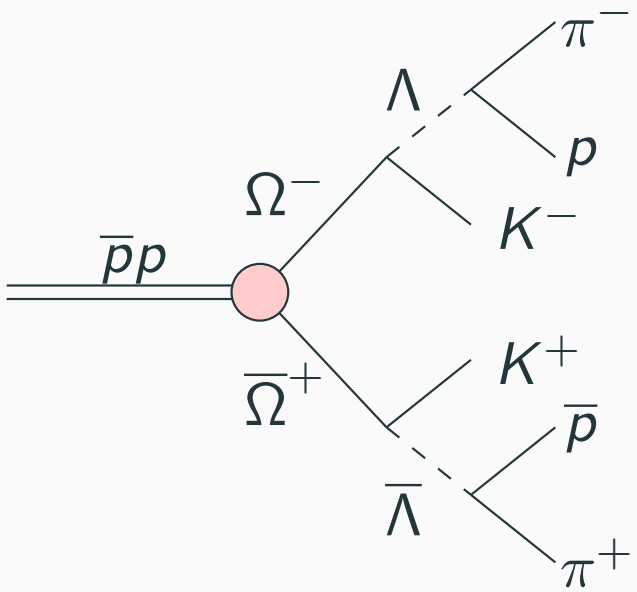

Figure 4: Proton Anti-proton reaction.

Event reconstruction algorithms

Event reconstruction

- Three different algorithms
  - Clustering of STT hits based on position in space and time

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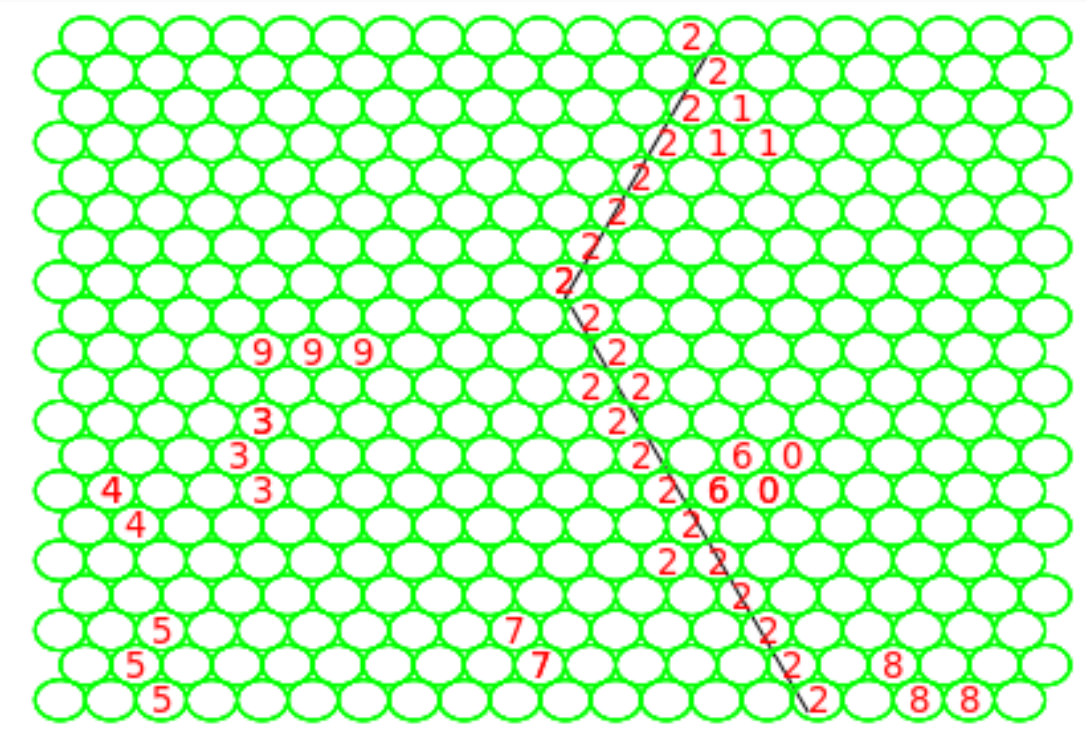
  - Displaced vertex detection (at clustering stage)

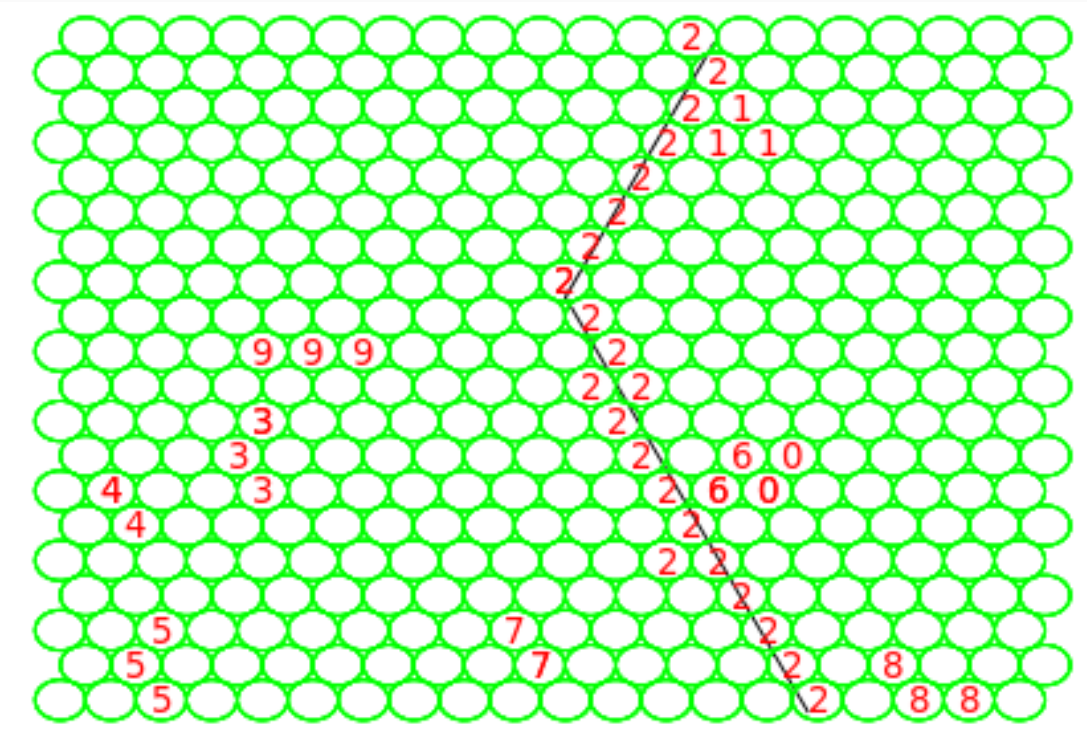
Clustering

- Neighbourhood relation in both space and time



Clustering

- Neighbourhood relation in both space and time
- Clustering N elements $\rightarrow$ time consuming for large N.



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- Assumption (*):
  - Time difference between two STT hits in the same event can not exceed STT response time ($\approx$ 250 ns)
- Place STT hits in multiple different bins so that (*) holds.

Track reconstruction

- Track reconstruction through modified version of STTCellTrackFinder (Schumann, FZ Jülich)

Track reconstruction

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- Simplification: Straight particle trajectories (Line fitting)

Cellular automaton

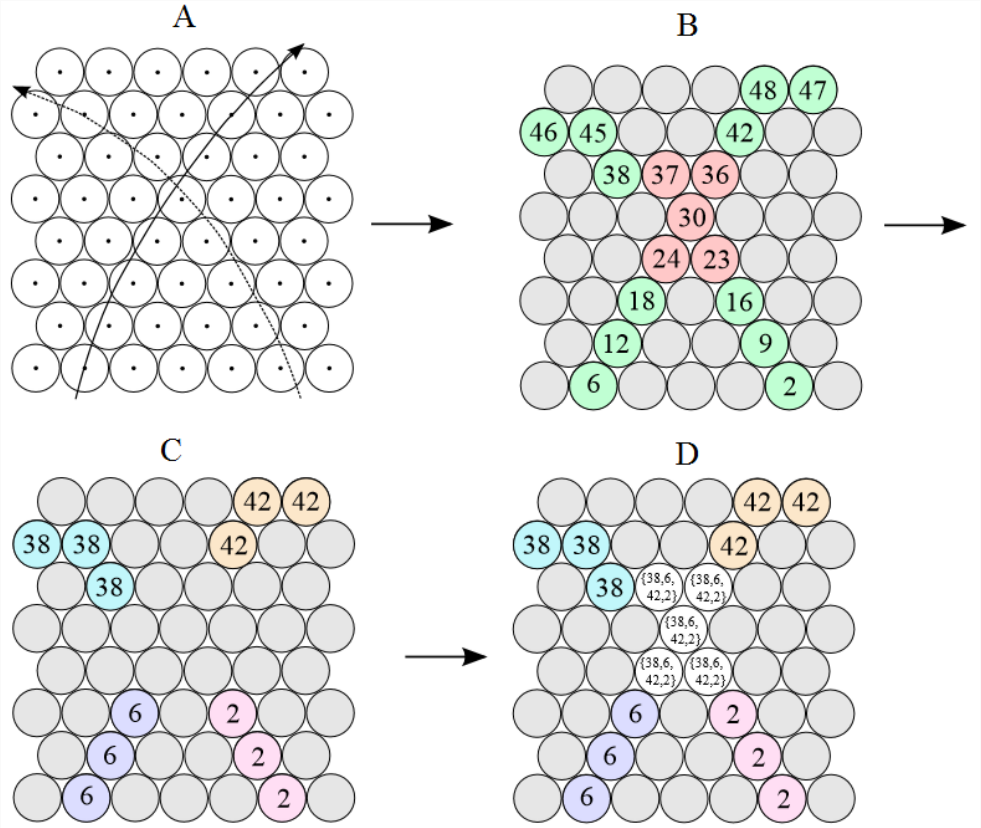
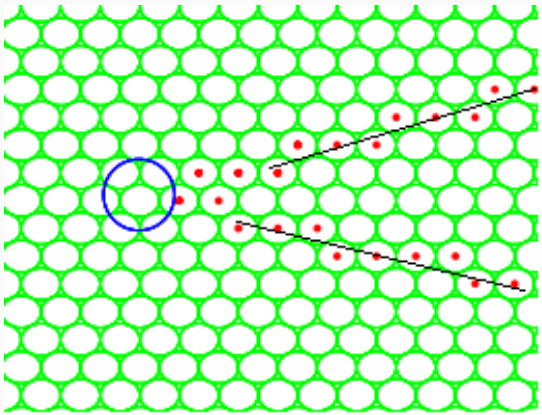


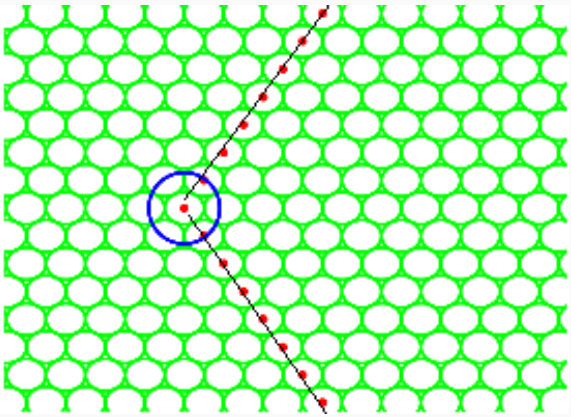
Figure 5: Illustration showing four steps in the track finding cellular automaton.

Displaced vertex detection

Two cases:

- An ambiguous node with exactly two possible IDs





Displaced vertex detection

Two cases:

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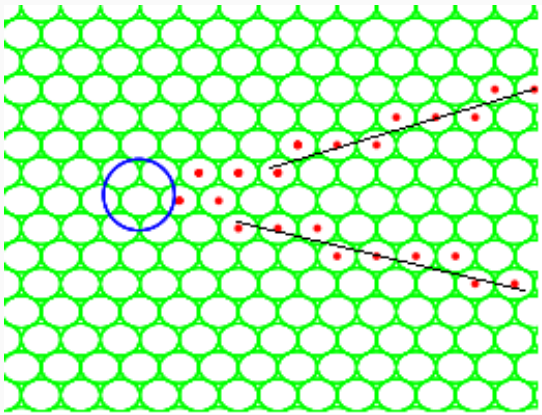
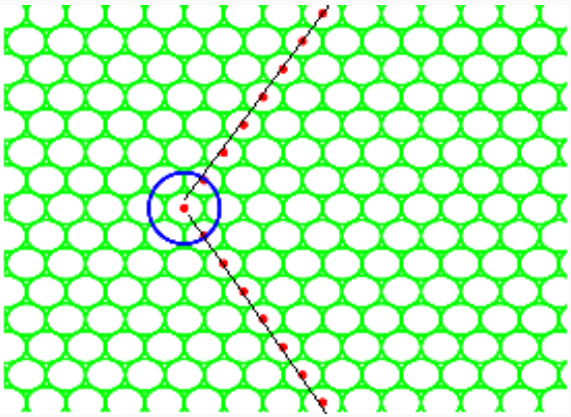
- A tracklet with a high mean square error to the curve fit





Implementation details

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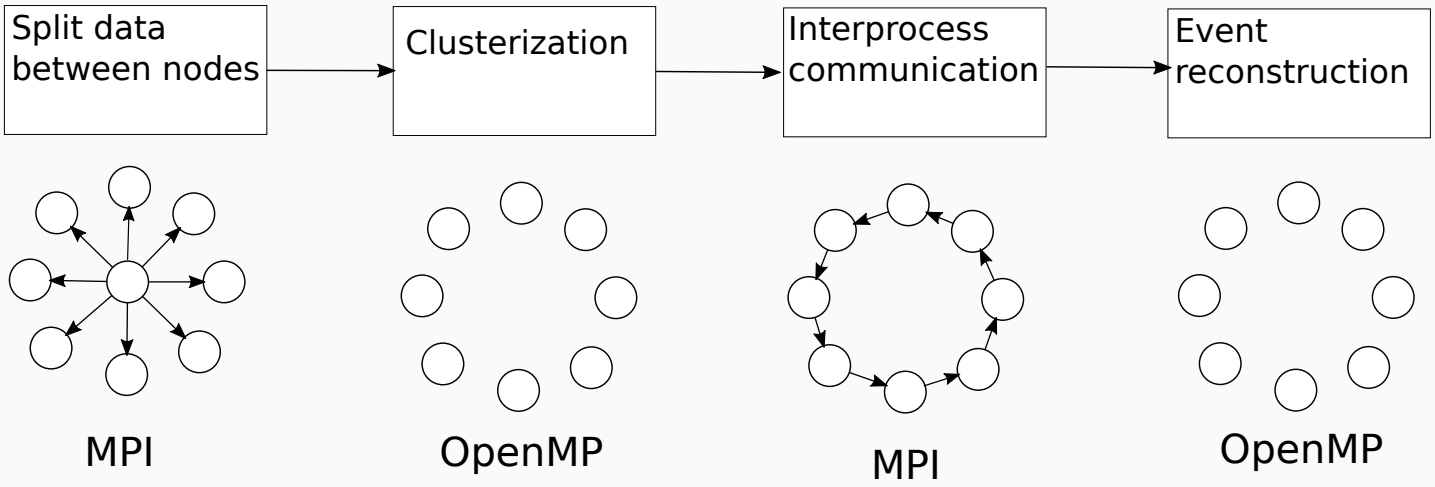

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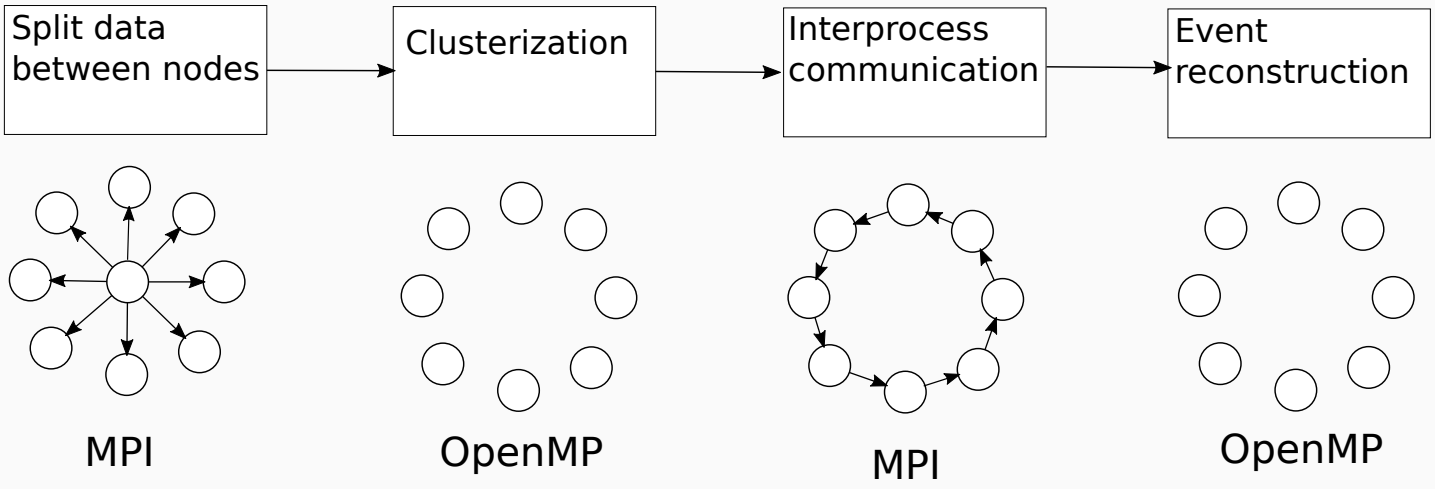
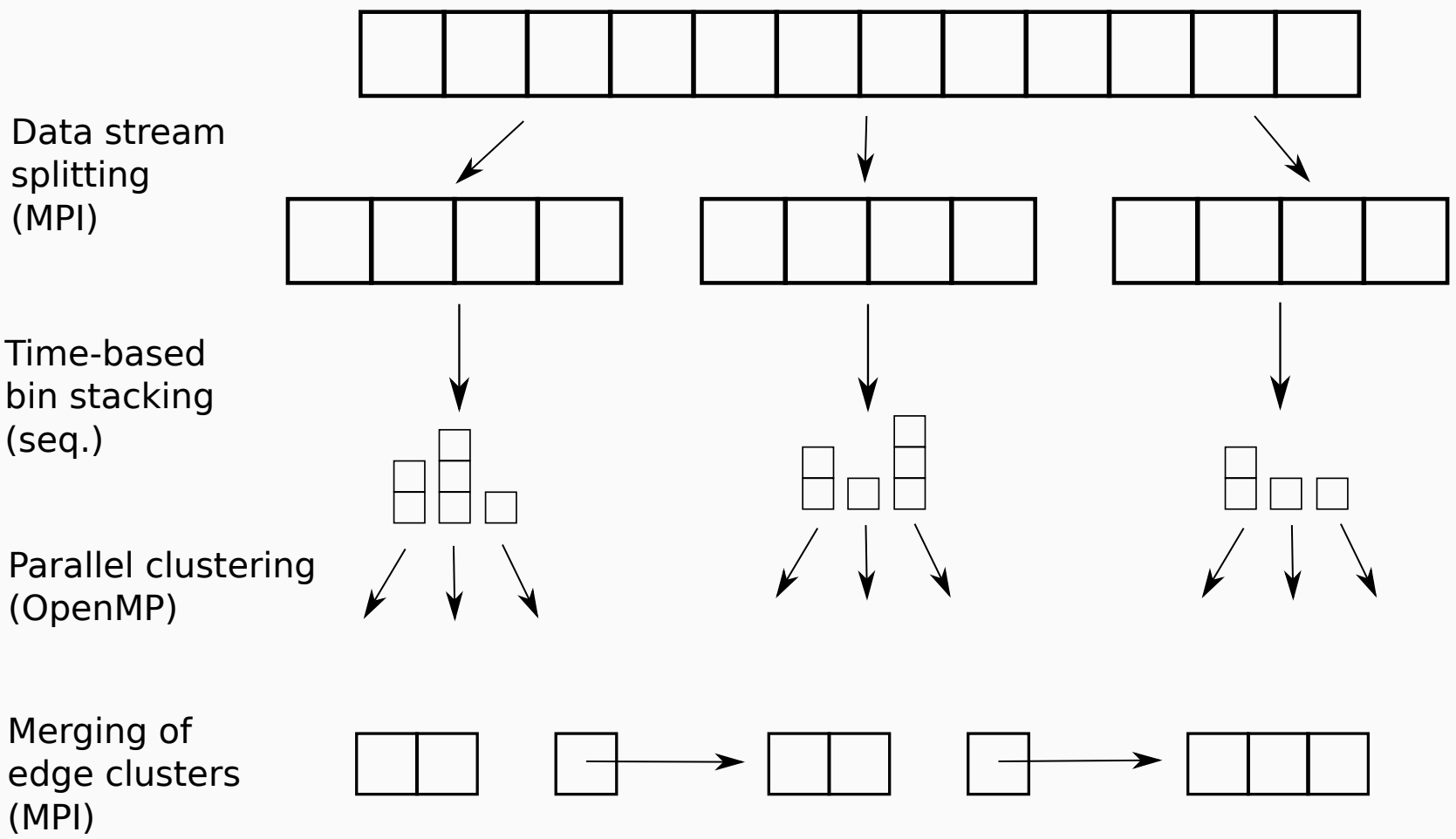


- Load balancing by master/slave model

Parallel clustering pipeline



Performance analysis

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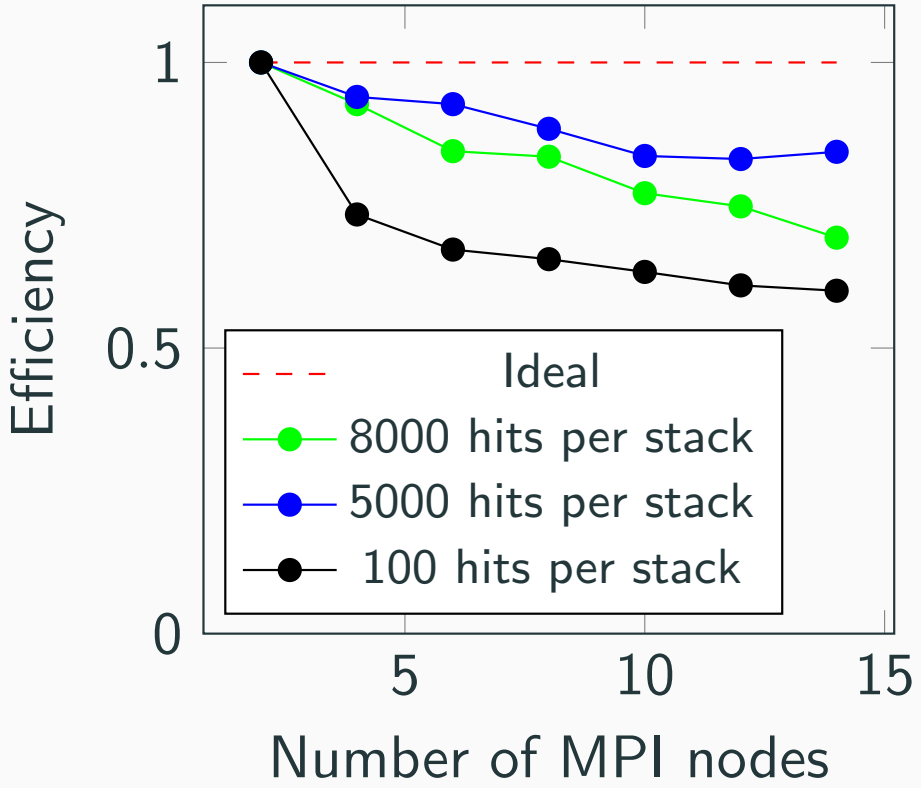
  - τ_1 and τ_N are the execution times using 1 and N computing nodes respectively for a fixed problem size.

Non-shared memory efficiency (MPI)

- 5000 STT hits per stack
  $\rightarrow$ optimal efficiency



Non-shared memory efficiency (MPI)

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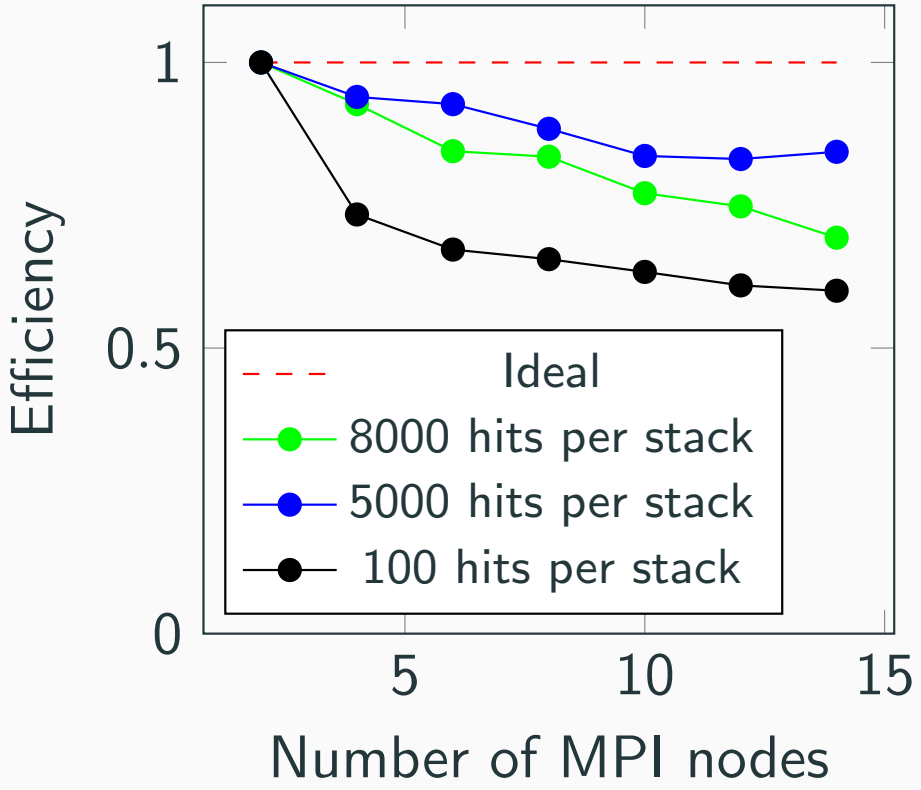
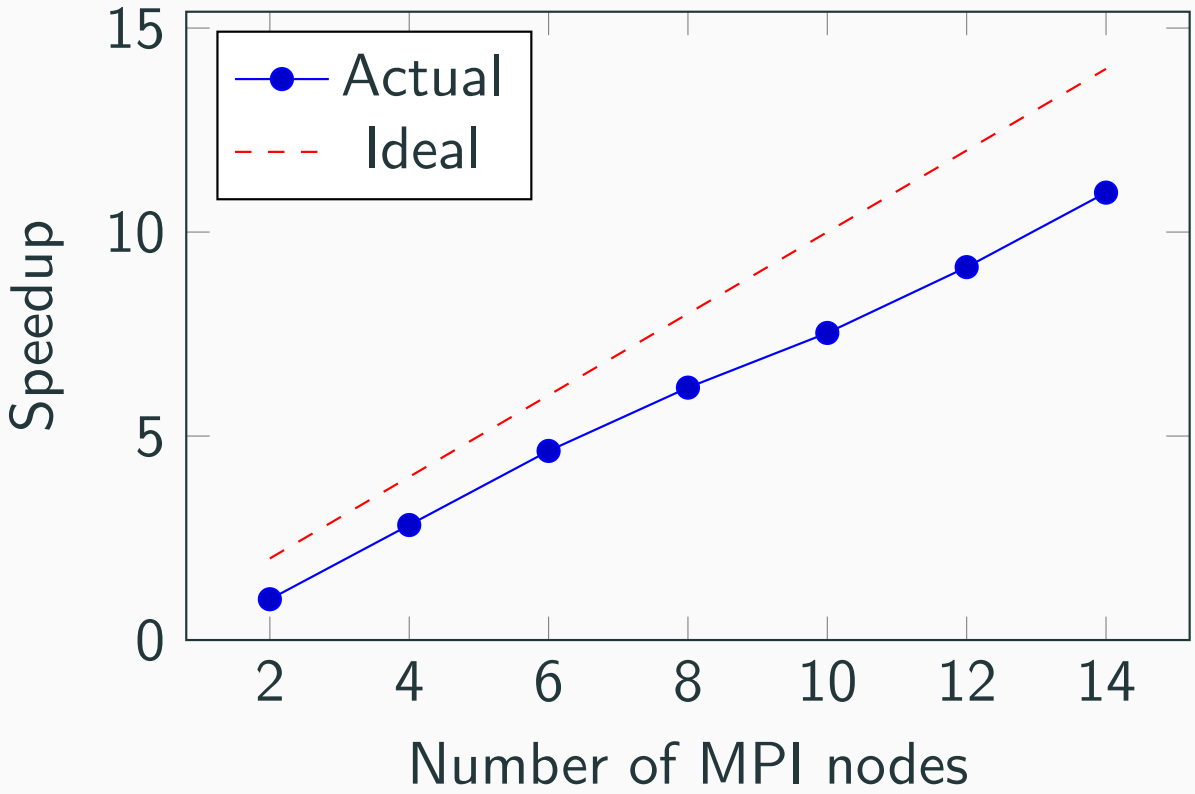
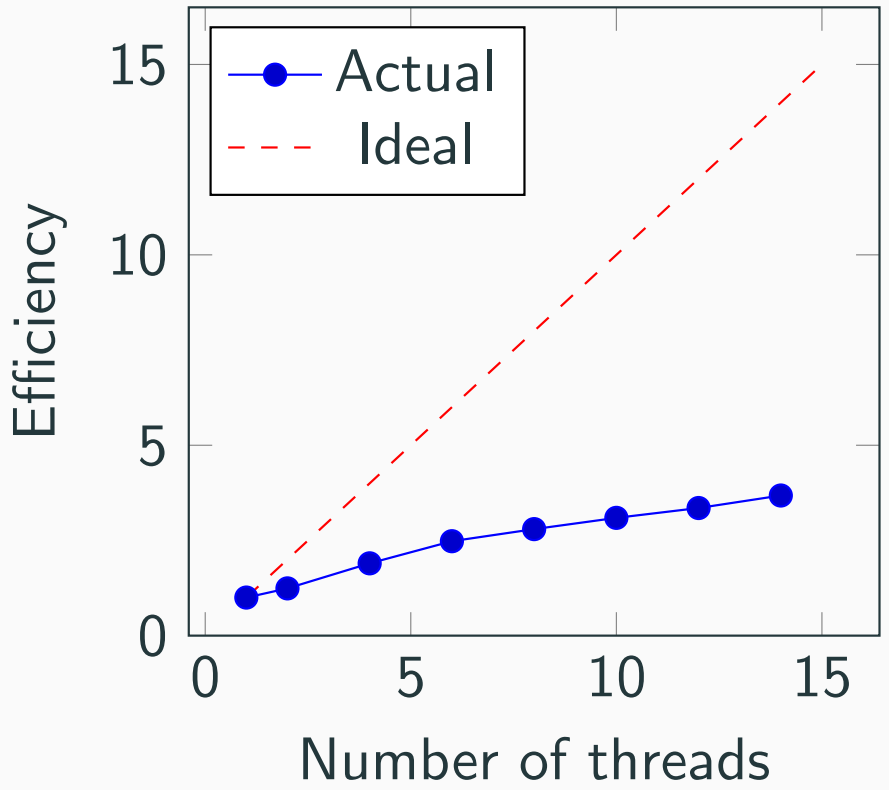


Non-shared memory speedup (MPI)



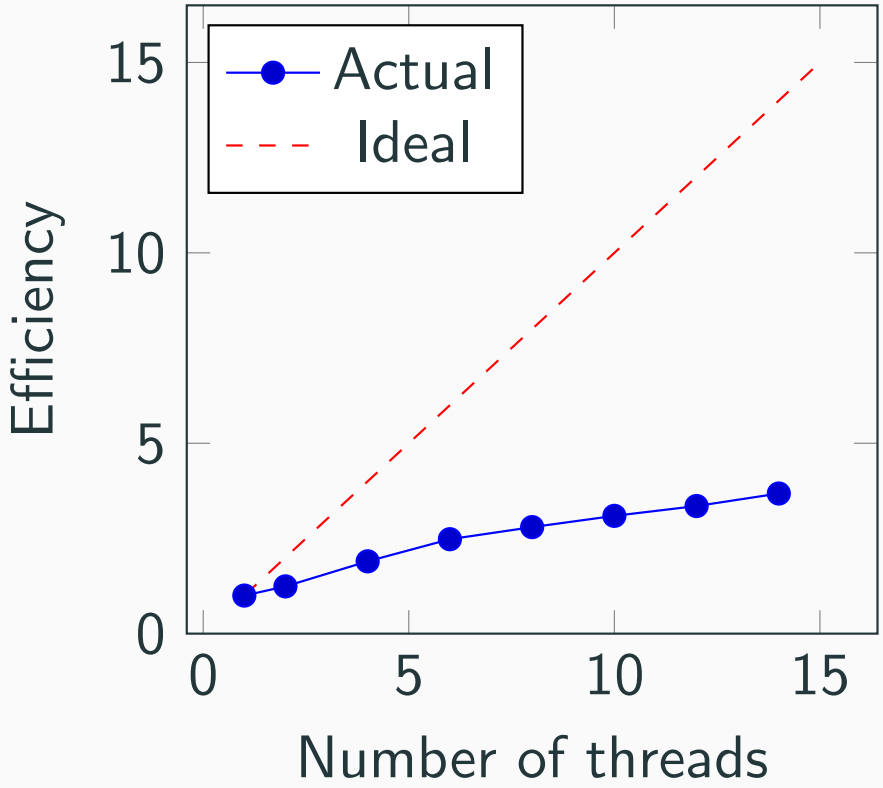
Shared memory speedup (OpenMP)

- Quite low speedup



Shared memory speedup (OpenMP)

- Quite low speedup
- Will improve with more realistic algorithms.



Parallel clustering run time

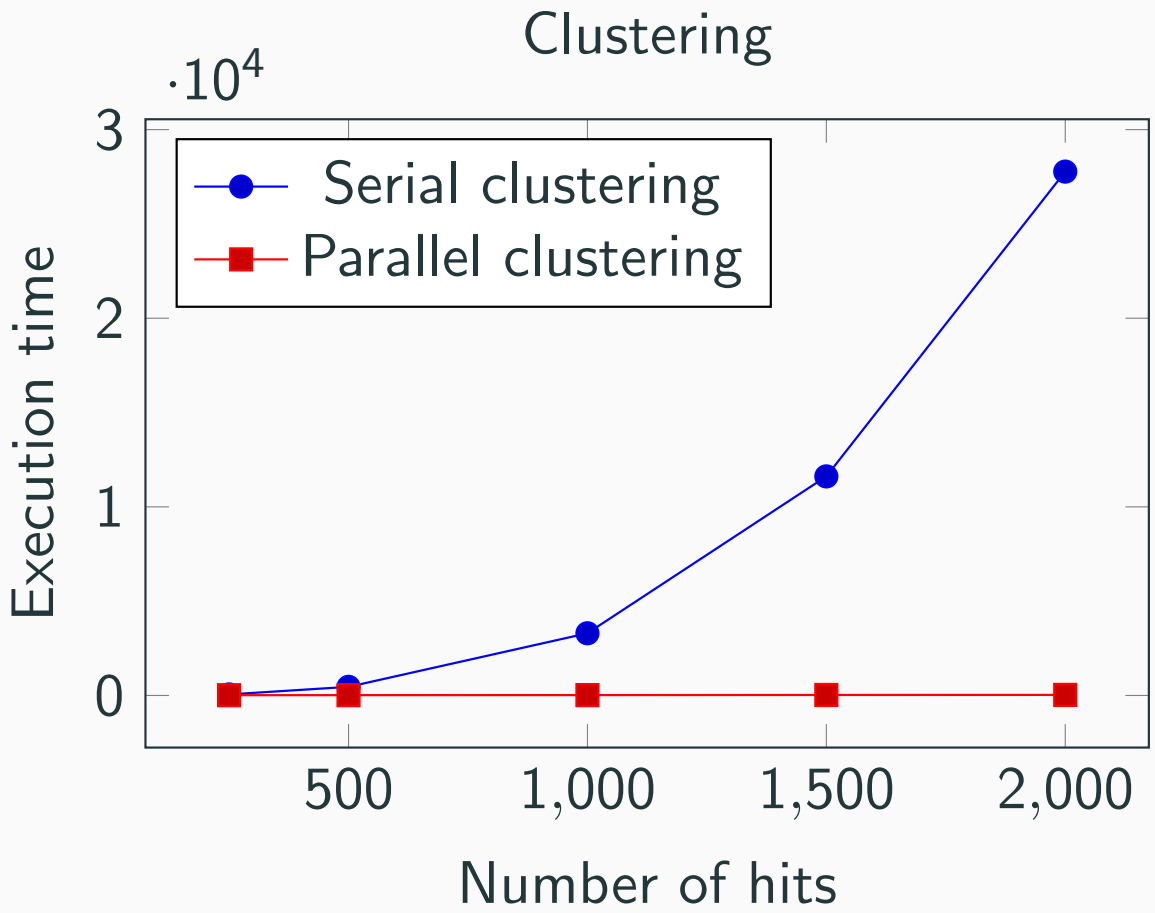


Figure 6: Execution time of the clustering algorithms.

Summary and outlook

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- The report is available as an internal $\overline{\text{P}}$ANDA document.

Questions

Questions?

Inter-process communication

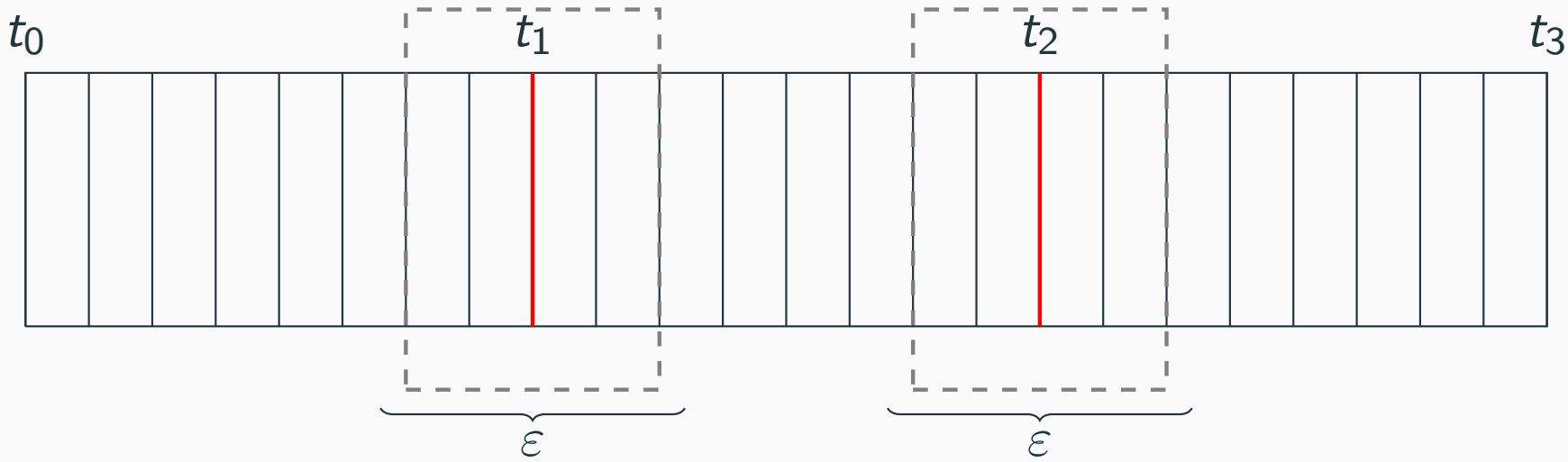

Figure 7: Ordered hit sequence by time.

- Stacks in different nodes $\rightarrow$ need interprocess-communication.
- Can be ignored if one allows to throw away a proportion of events.