GPU BASED HOUGH TRACK FINDER

15.06.2021 I PANDA COLLABORATION MEETING | ANNA ALICKE

WHY USING GPUS?

Intention

- tracking: most computing intensive part of event reconstruction
- high event rate in panda: 20 mio events/s

→ tracking algorithm: must be really fast to reduce the amount of data

→ test if GPUs can deliver the speed up we need

WHY USING GPUS?

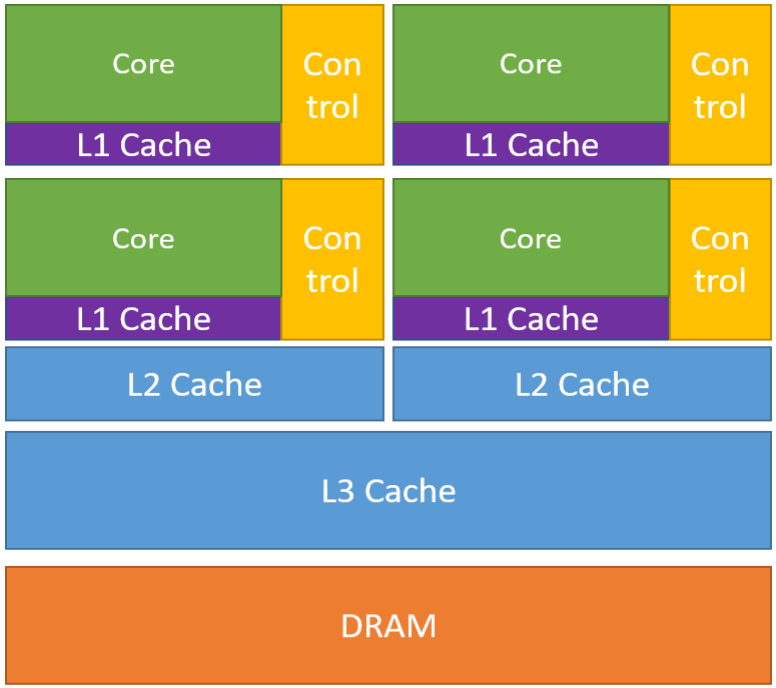
Architectural differences: CPU vs GPU

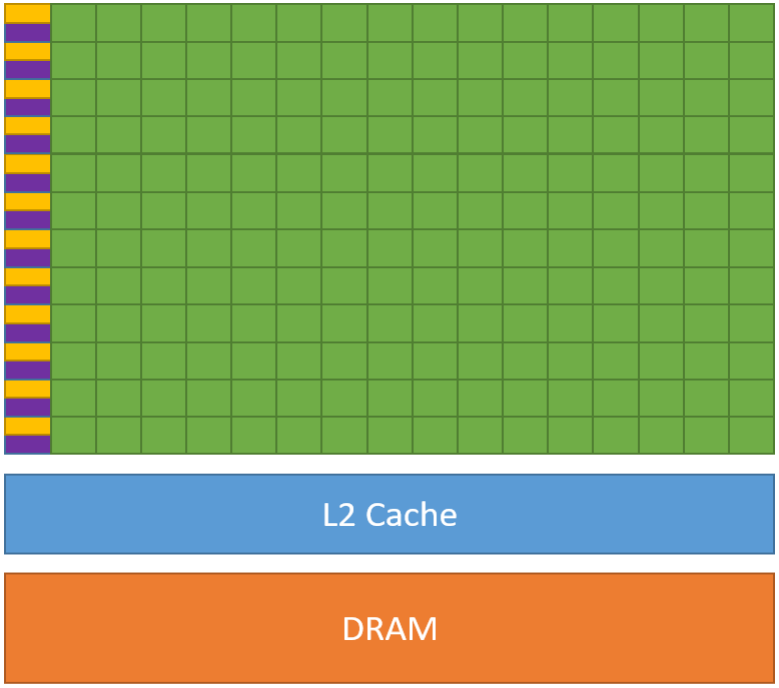
CPU

- Large cache and controlling
  → fast handling of complex sequential calculations

GPU

- Small cache and controlling
  → many small calculations in parallel with less memory accesses





Taken from: NVIDIA Corporation (2021), 'NVIDIA CUDA C++ Programming Guide' , Version 11.2 .1.

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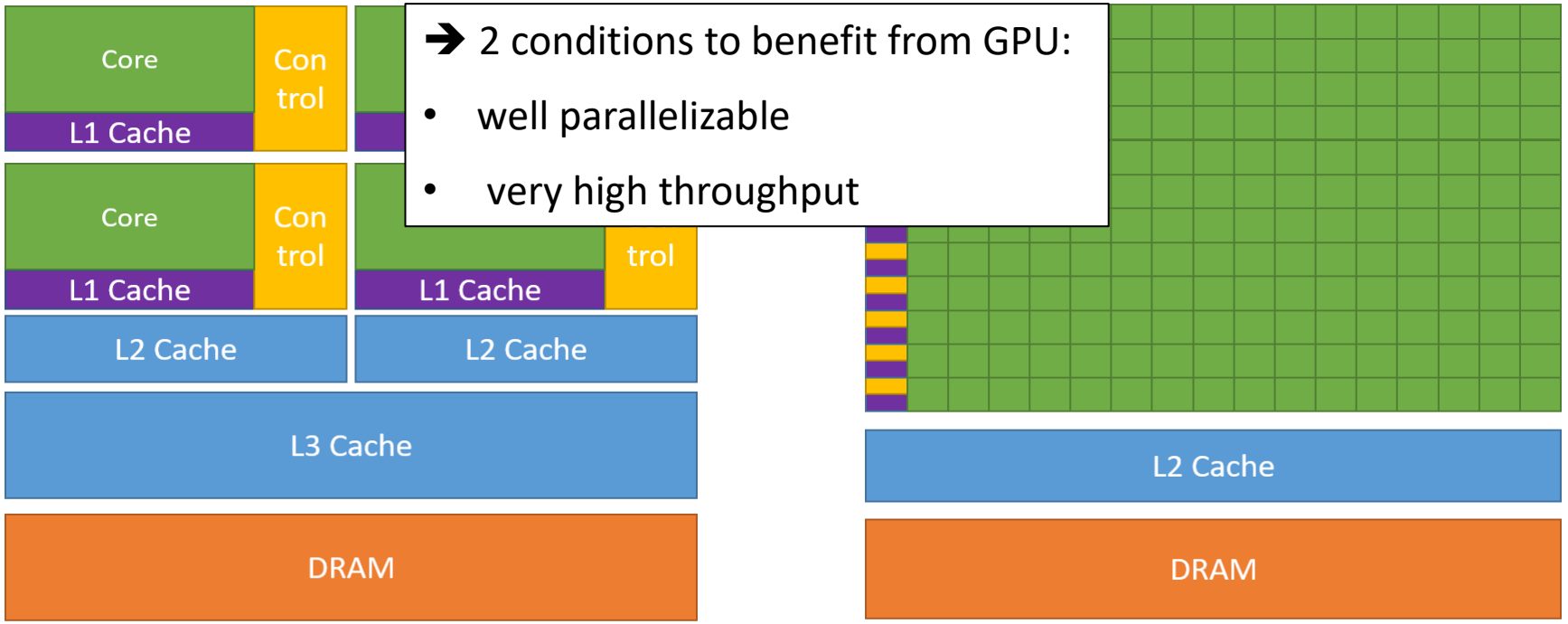

➔ 2 conditions to benefit from GPU:

- well parallelizable
- very high throughput

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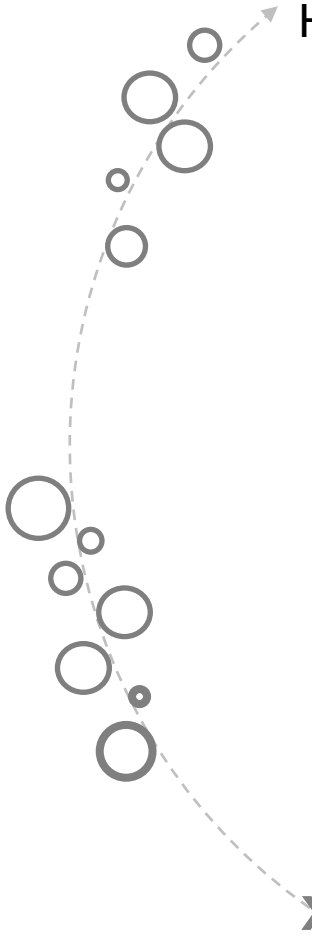
Does the HoughTrackFinder fulfill the conditions?

Hough transformation + Apollonius problem



X interaction point (IP)

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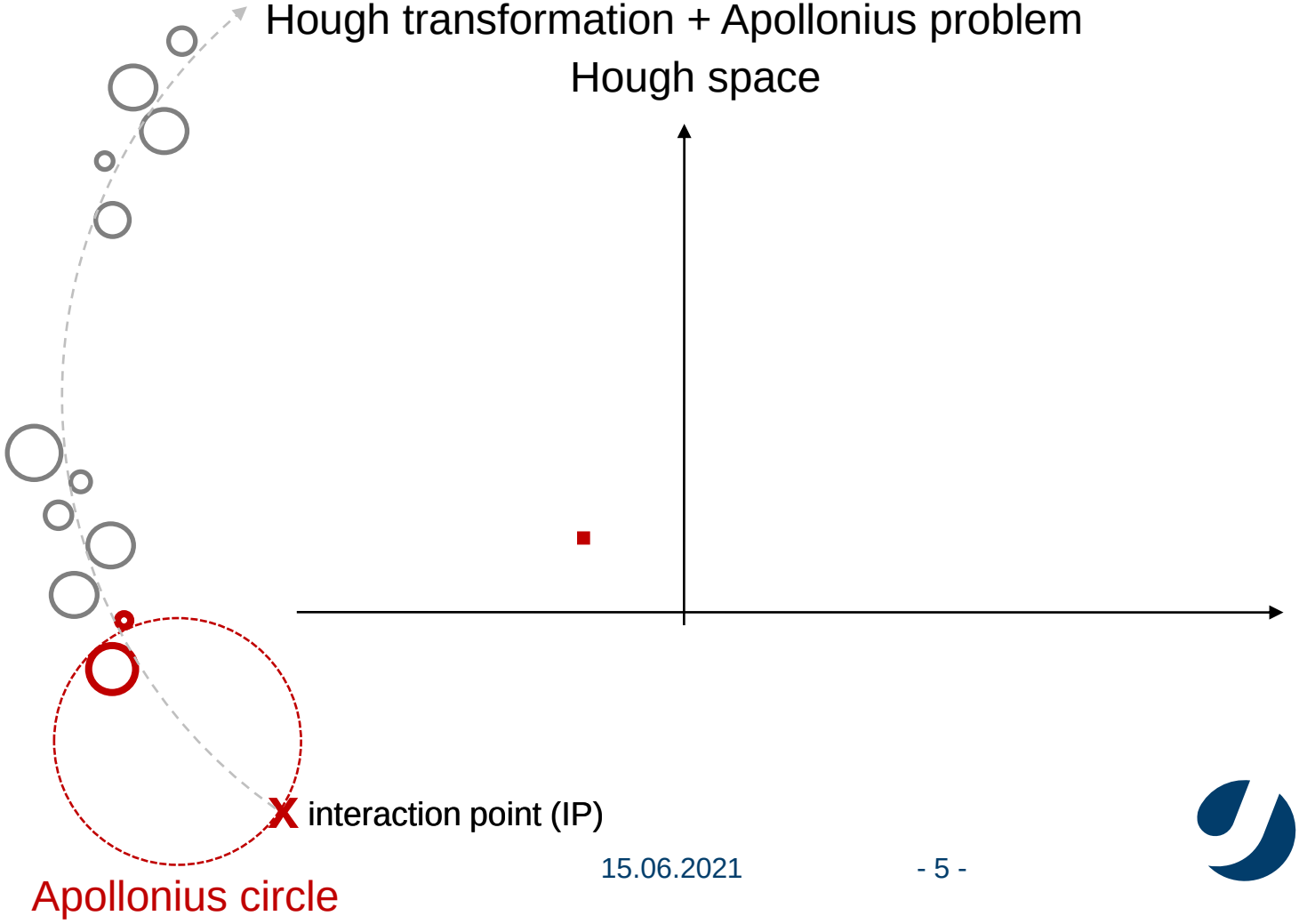

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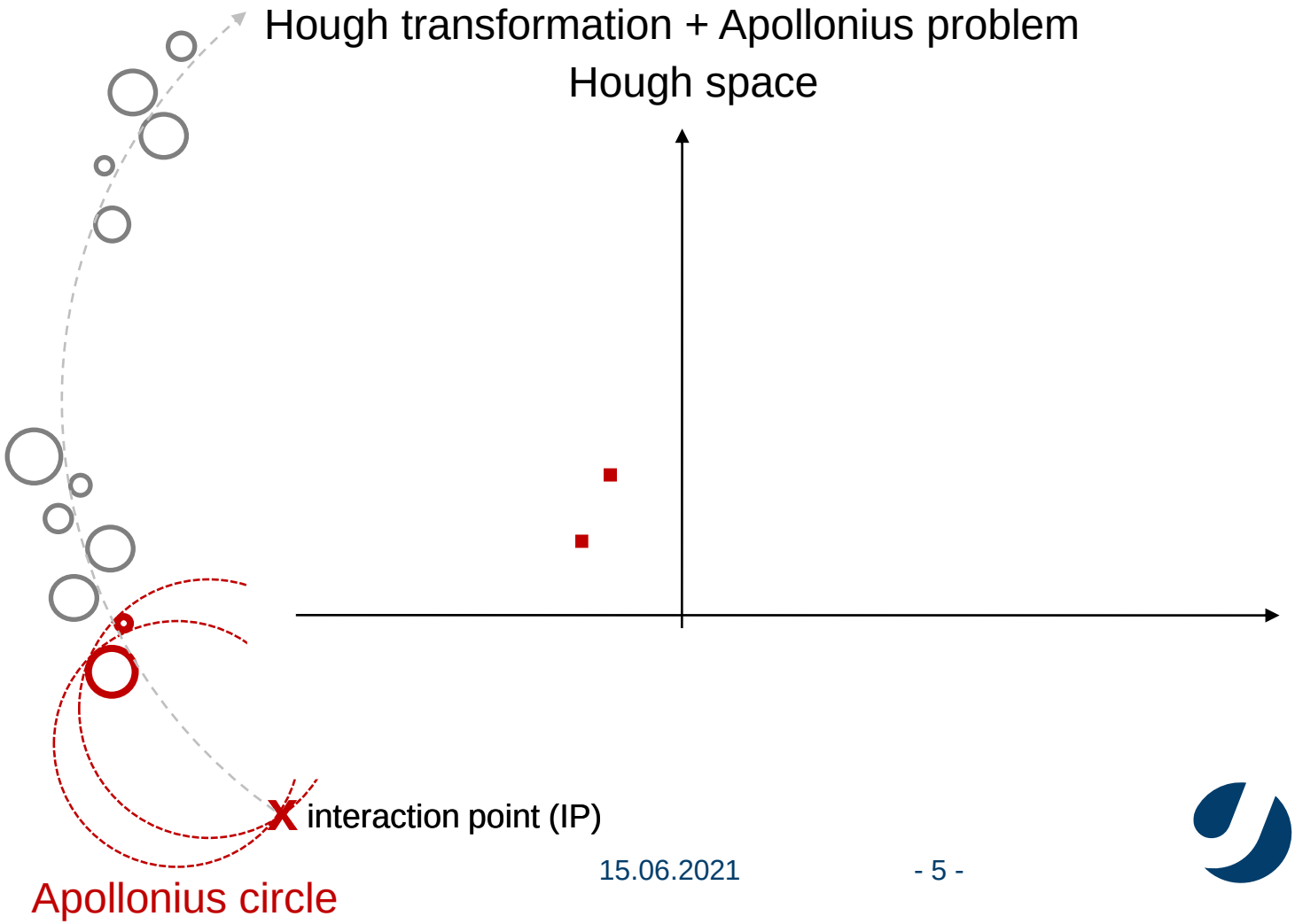

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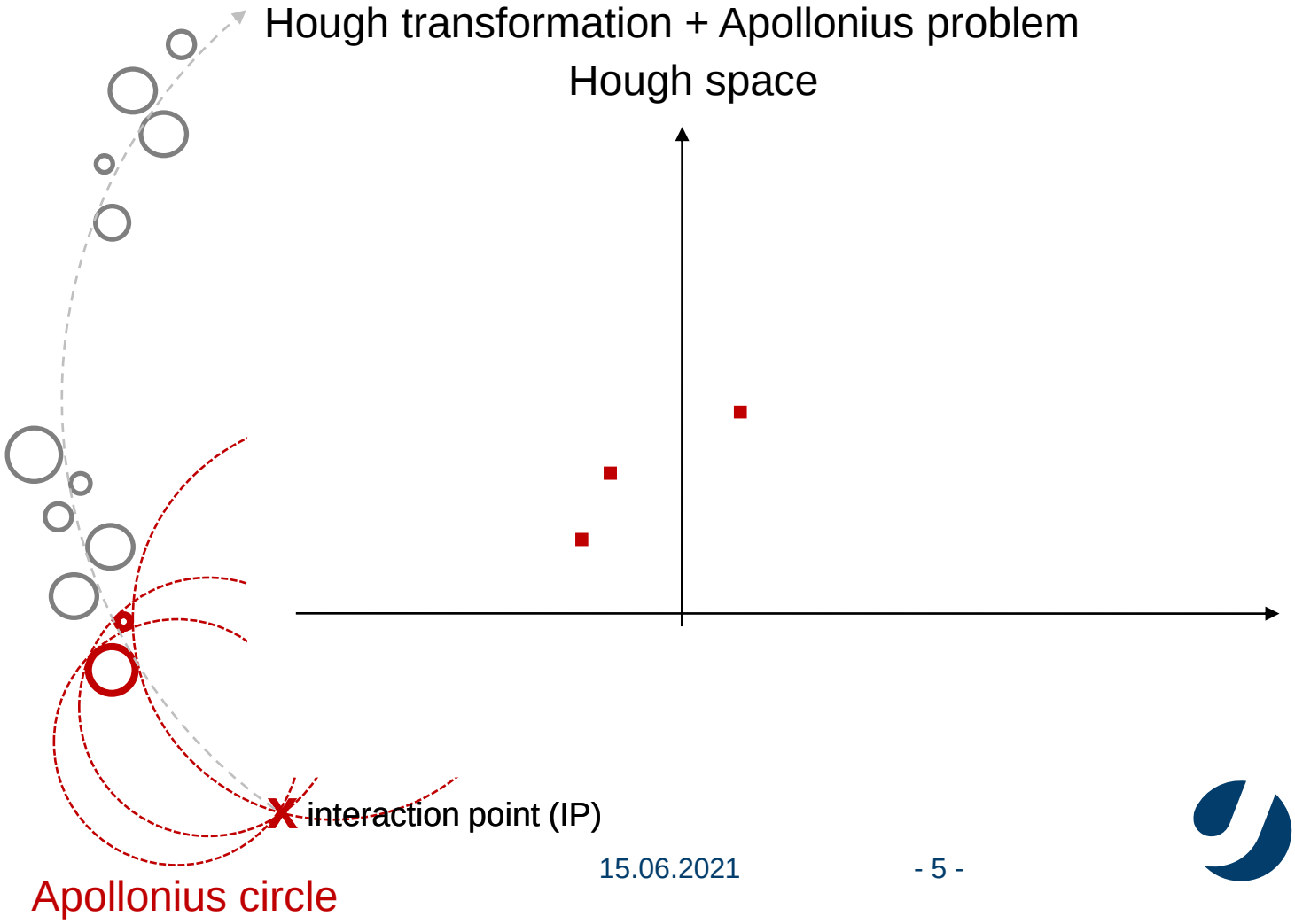

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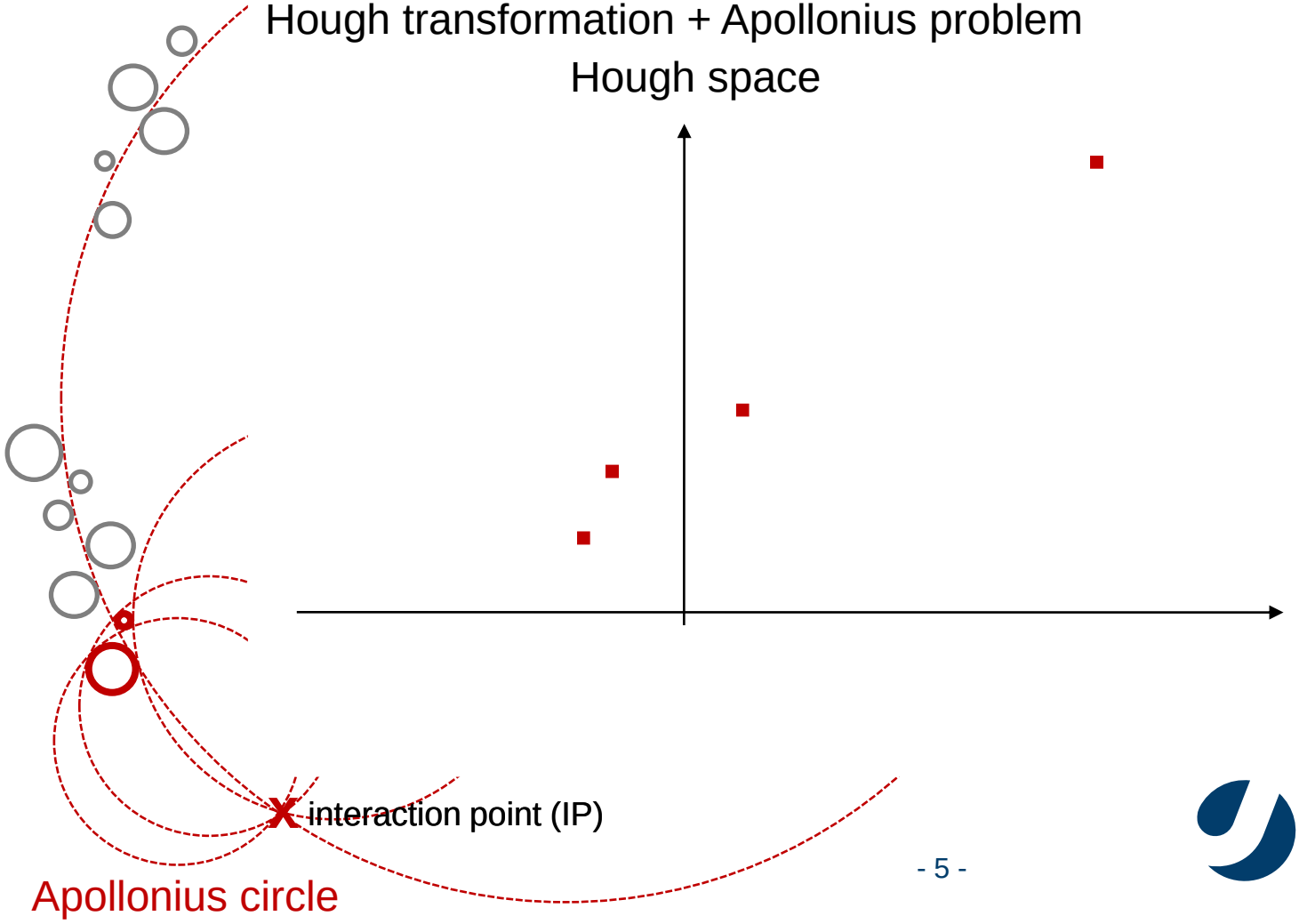

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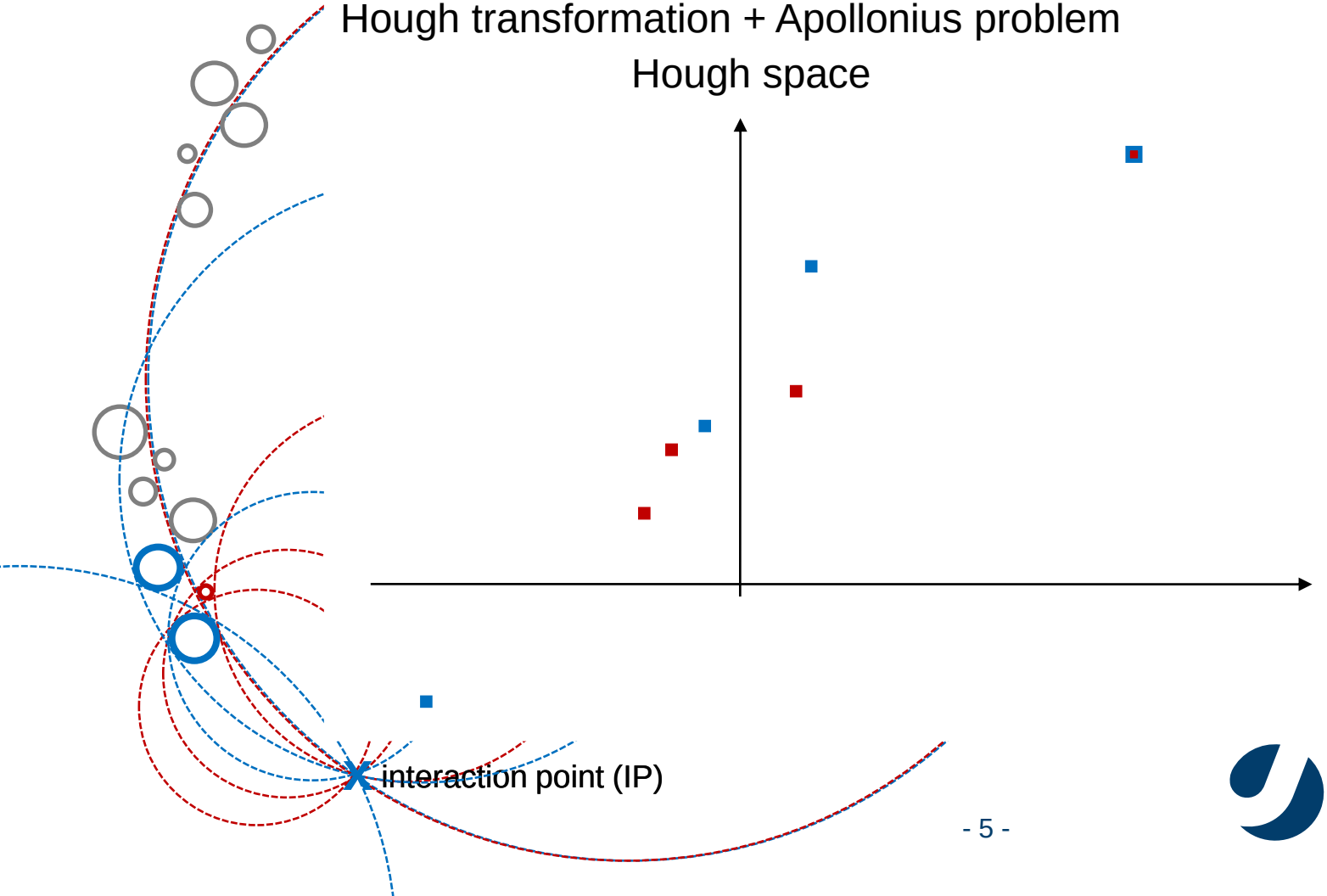

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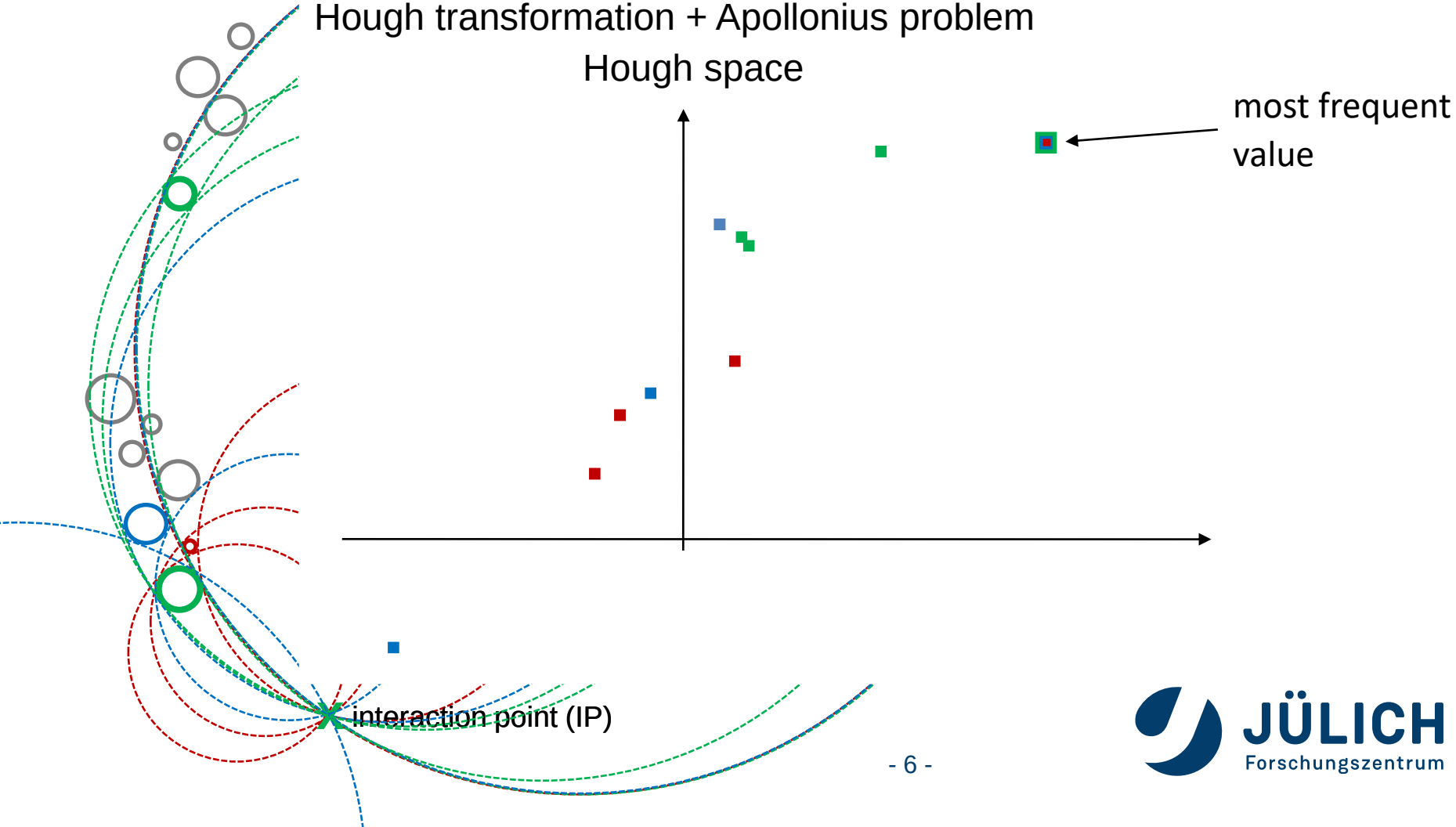

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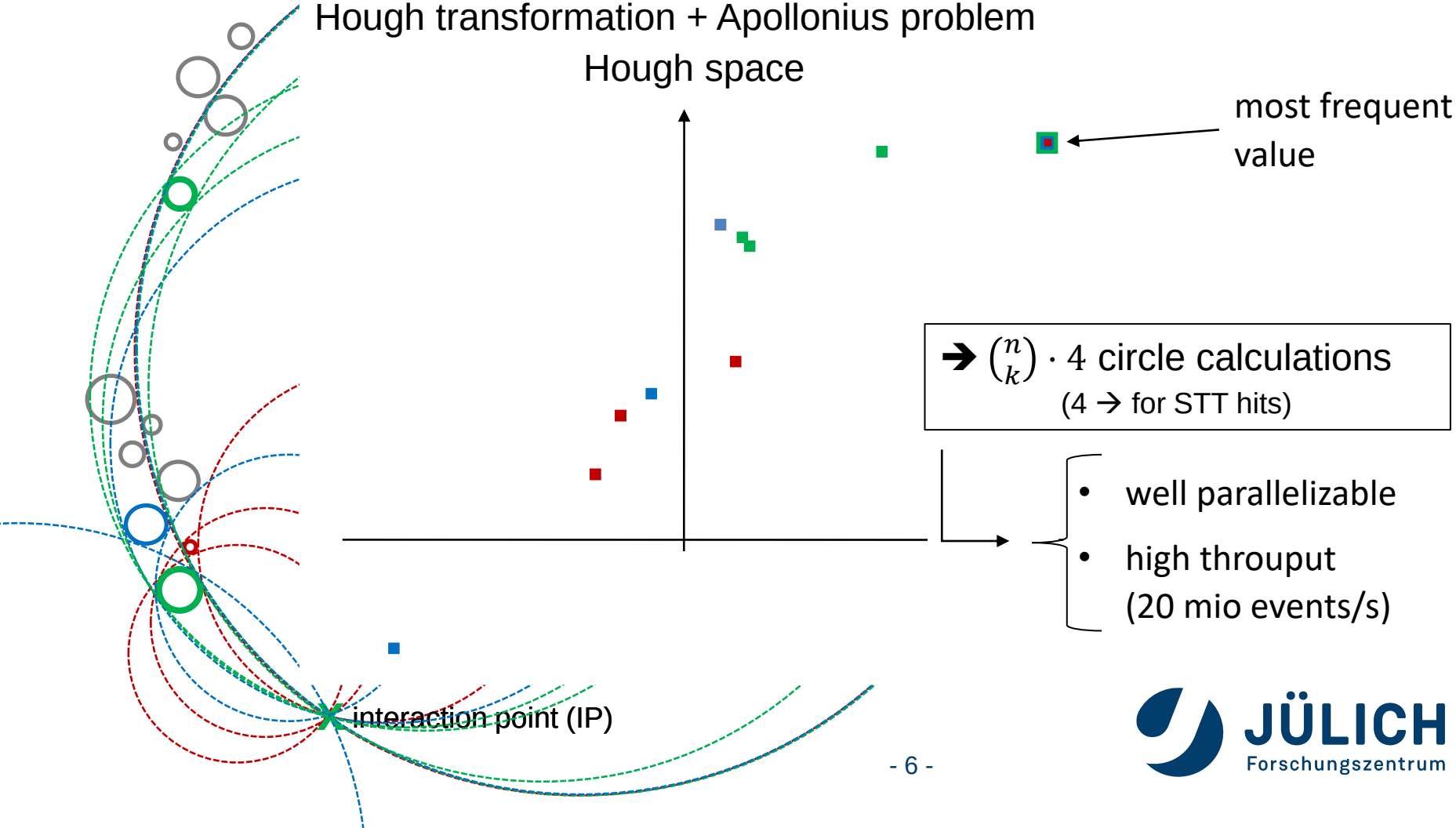
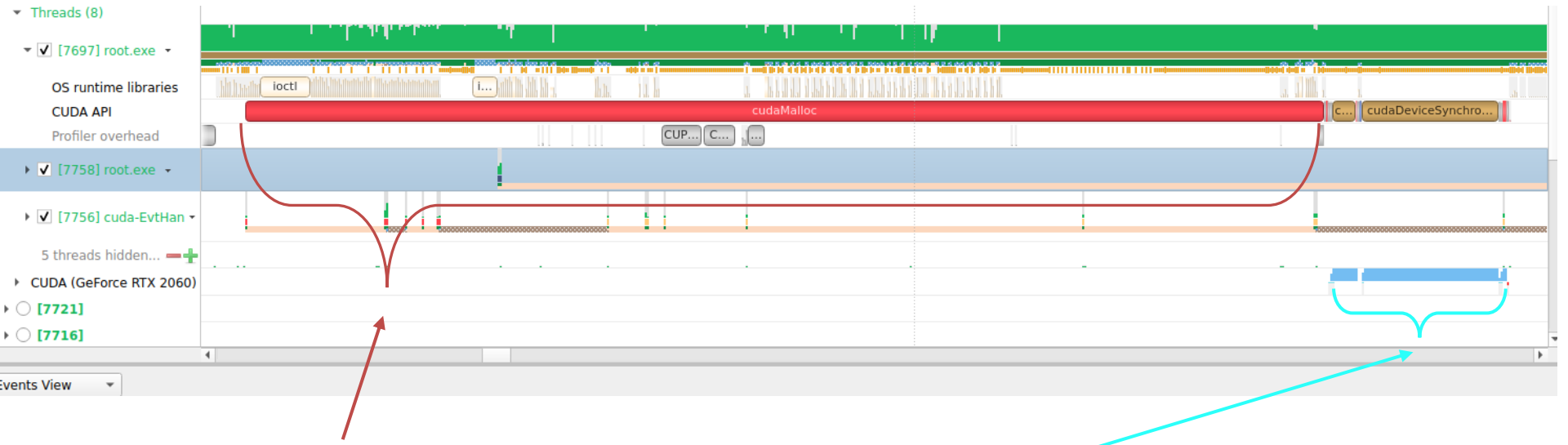


GPU PROGRAMMING CHALLENGES

- Allocate memory and copy data to GPU is time intensive

→ Main aims:

  - Reduce amount of data that have to be copied or allocated
  - Increase computing time of GPU
  - Increase occupancy of GPU



Allocate memory on GPU

Computing time on GPU

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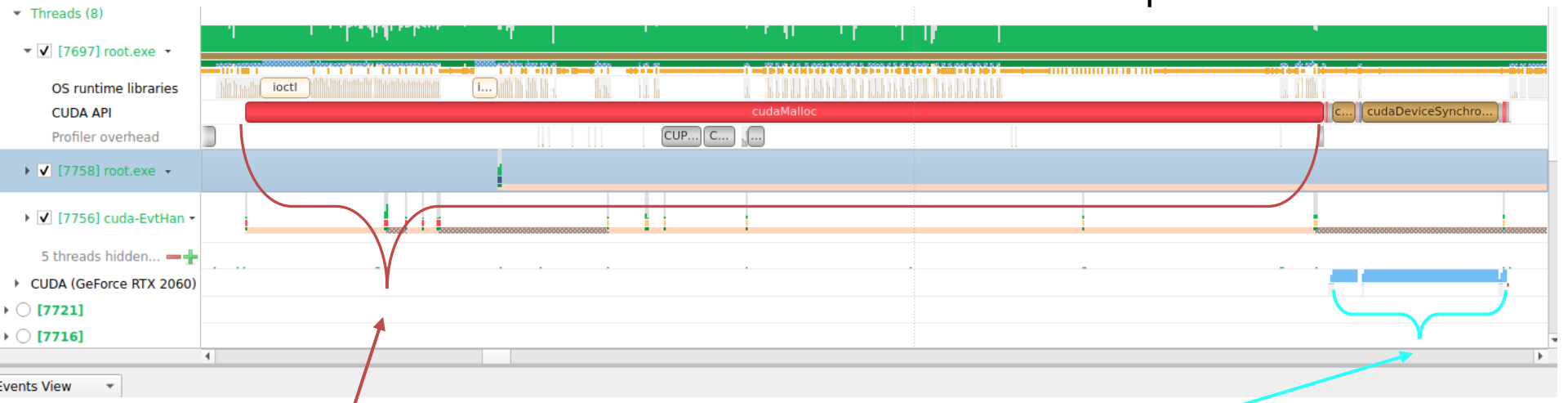
} Many events have to be calculated in parallel



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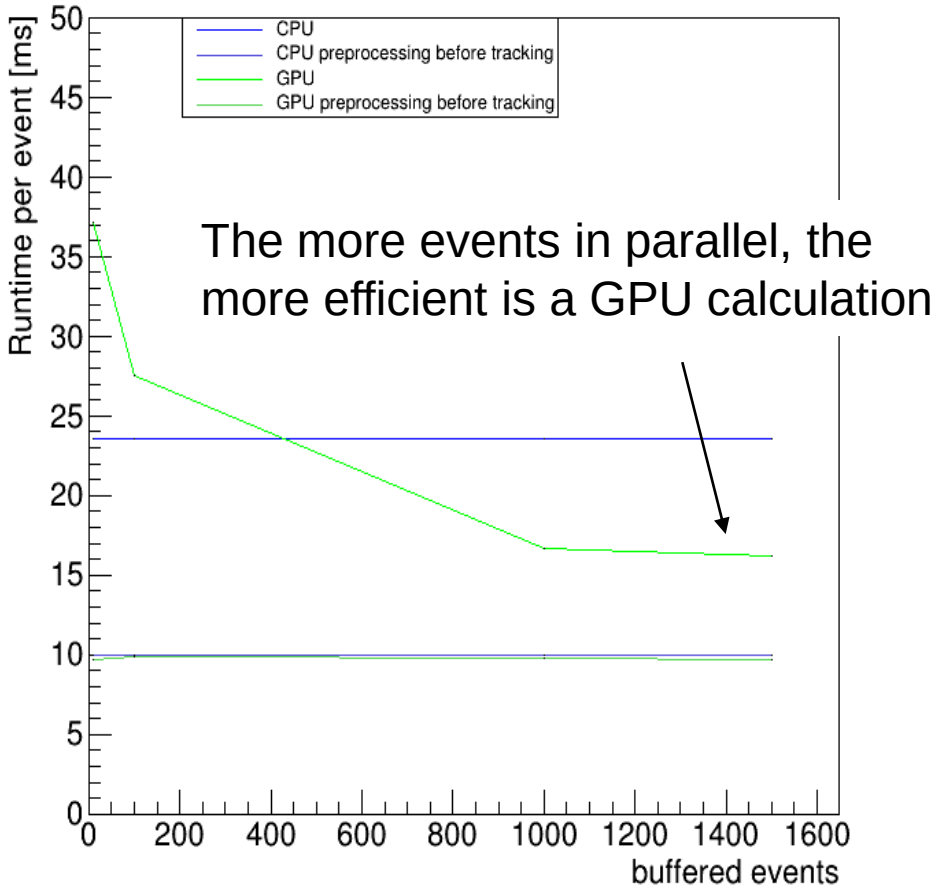
COMPARISON CPU VS GPU

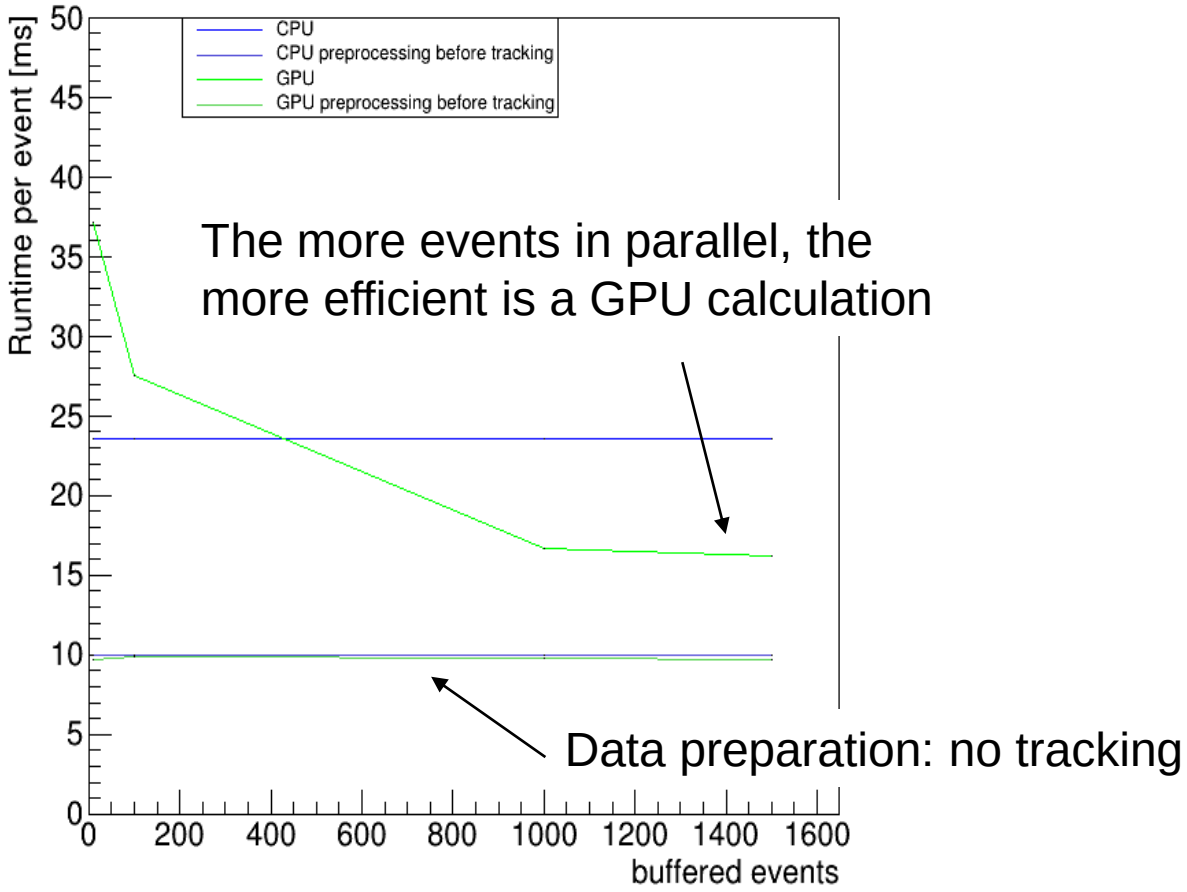
- Buffered events: events calculated in parallel



The more events in parallel, the more efficient is a GPU calculation

COMPARISON CPU VS GPU

- Buffered events: events calculated in parallel
- Before tracking data have to bee collected.
  → Software specific, different for real detector



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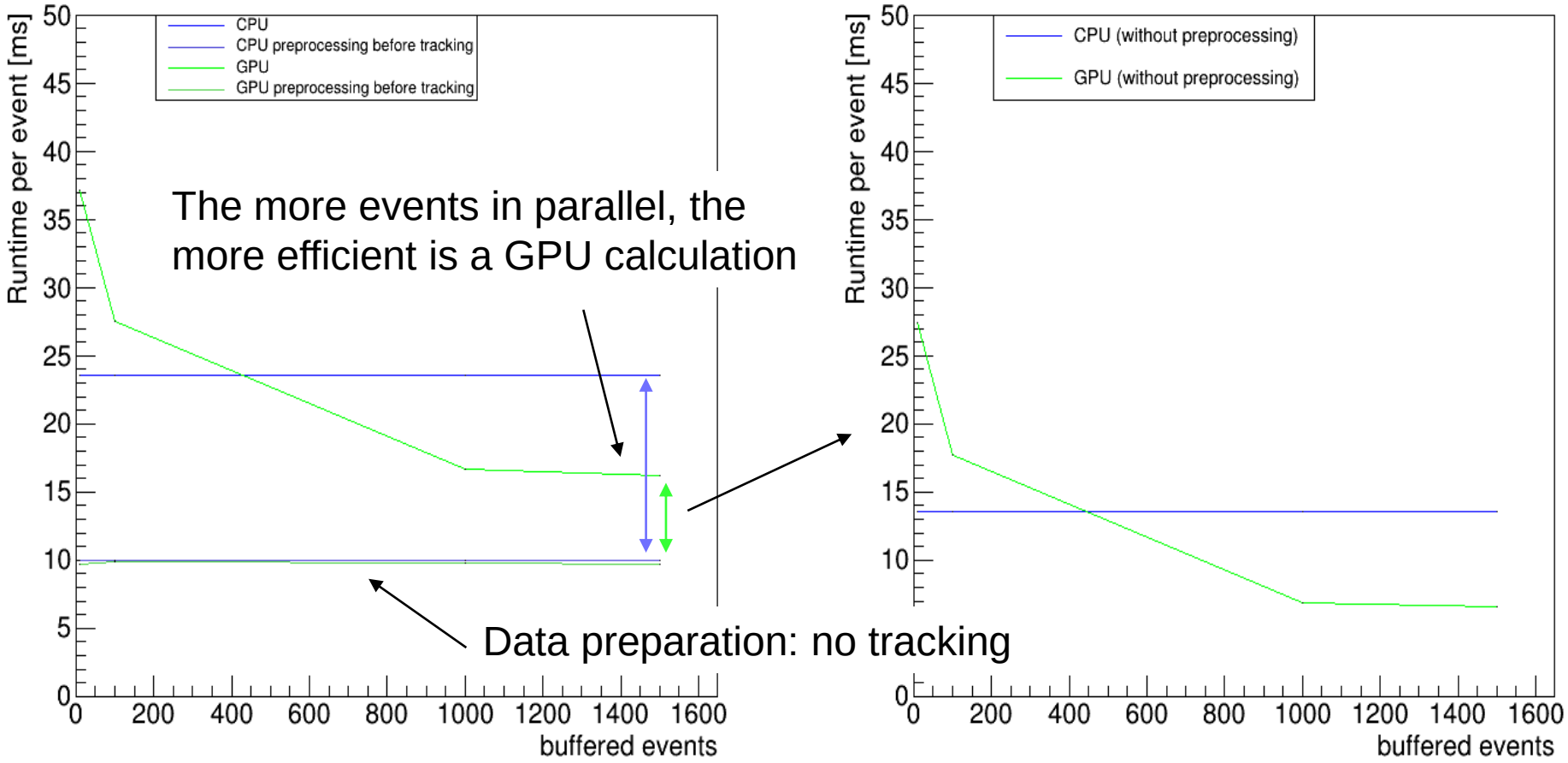

RESULTS

10,000 events, 7 GeV/c beam momentum, FTF background

	CPU time [ms/event]	GPU Time [ms/event]	Speed up
Apollonius calculation	4.25	0.05	85
Hough Space	7.27	2.35	3
Hough transformation (Maximum Finding)	8.37	3.19	2.6
With merging	12.54	4.88	2.5

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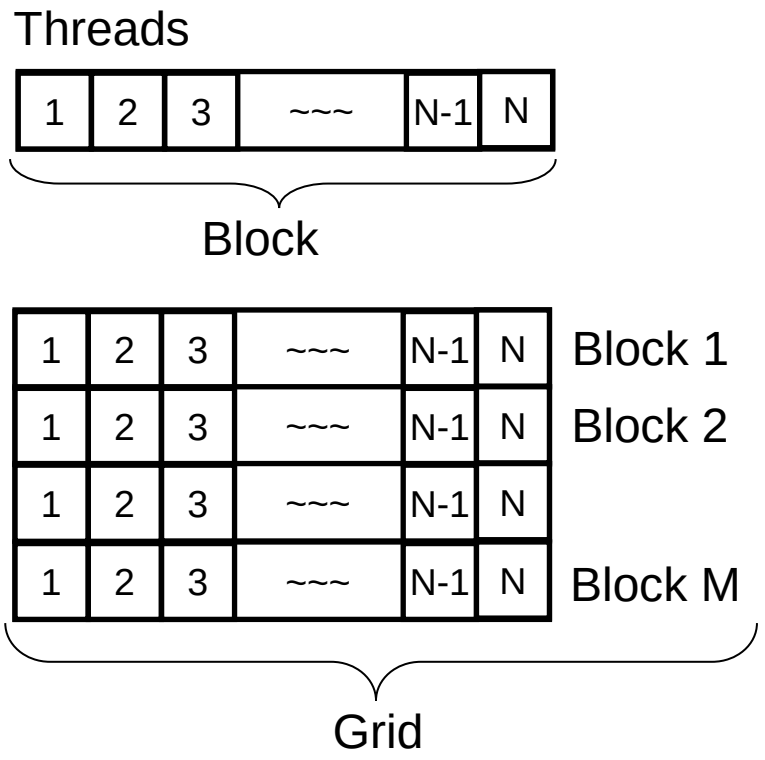

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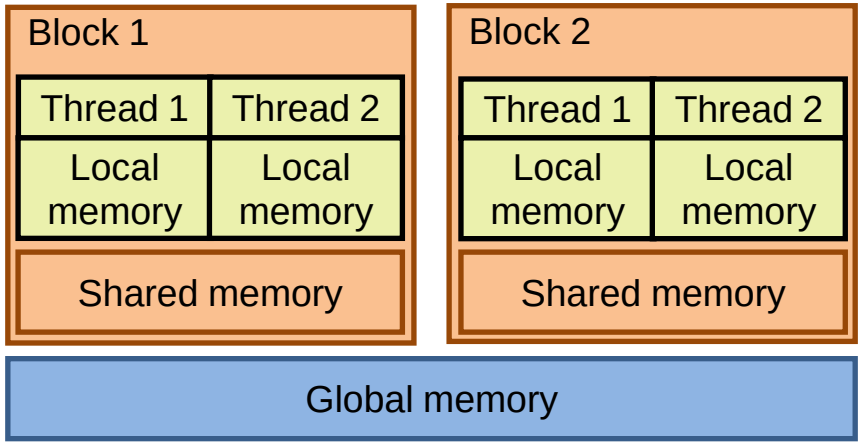
→ Slow global memory accesses



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A whole method per thread

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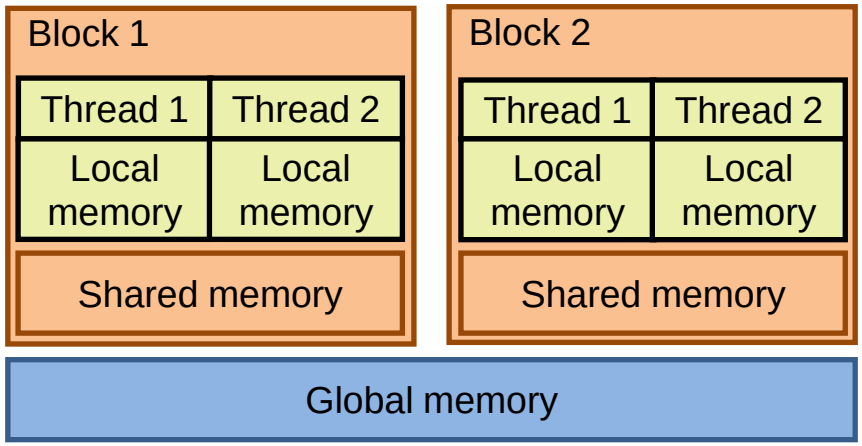


1 Apollonius Circle per thread

RESULTS

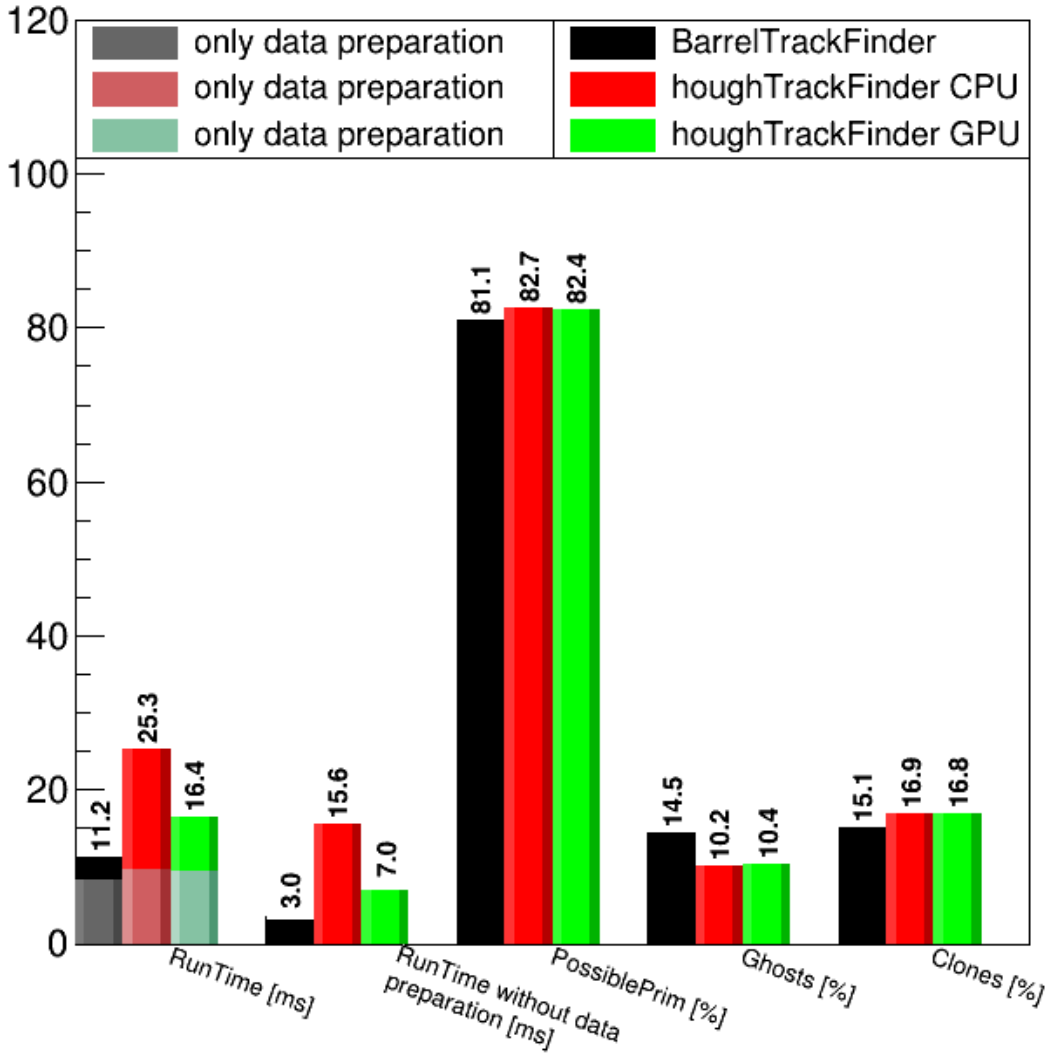
10,000 events, 7 GeV/c beam momentum, FTF background

	CPU time [ms/event]	GPU Time [ms/event]	Speed up	Memory usage [GB]	Buffer Size	Blocks * Threads
Apollonius calculation	4.25	0.05	85	2	10000	393812 * 256
Hough Space	7.27	2.35	3	4	4000	125 * 256
Hough transformation (Maximum Finding)	8.37	3.19	2.6	4	4000	125 * 256
With merging	12.54	4.88	2.5	4	2000	8 * 256

→ Bad GPU occupancy

→ Potential for improvement

QUALITY + RUNTIME COMPARISON



- GPU version is a bit faster
- Still too slow
- Potential for development

SUMMARY & OUTLOOK

Summary

- GPU version of HoughTrackFinder is implemented
- → Large speed up only for one part of the algorithm
- Speed up in total: ~2

Outlook

- Speed: Potential for development
  - → memory problem: allocate all Hough spaces for all tracklets
  - → better method has to be found
- Secondaries: as new improvement for tracking in PANDA

Thank you for your attention!