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Simple and hybrid parallelizations for GPU clusters in a nutshell

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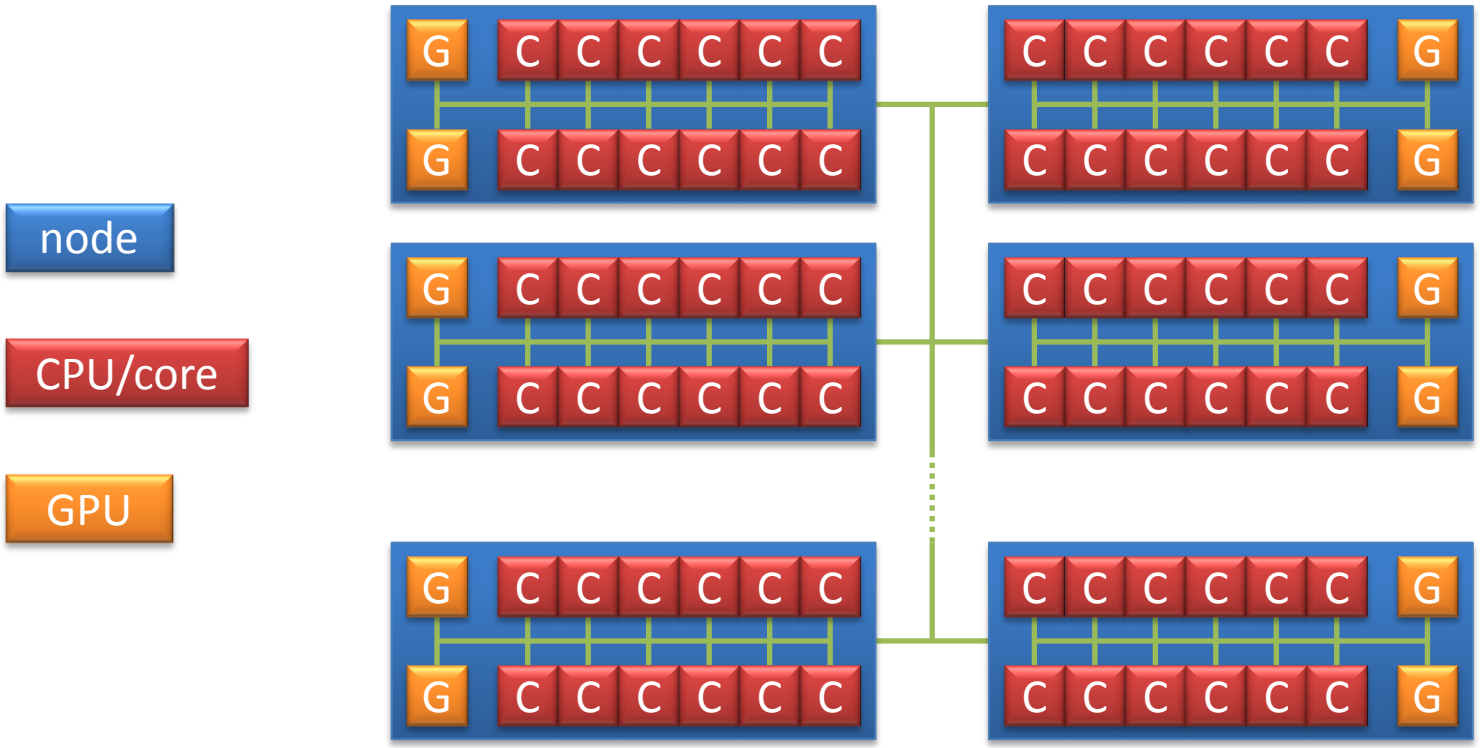
GPU cluster



Use cases

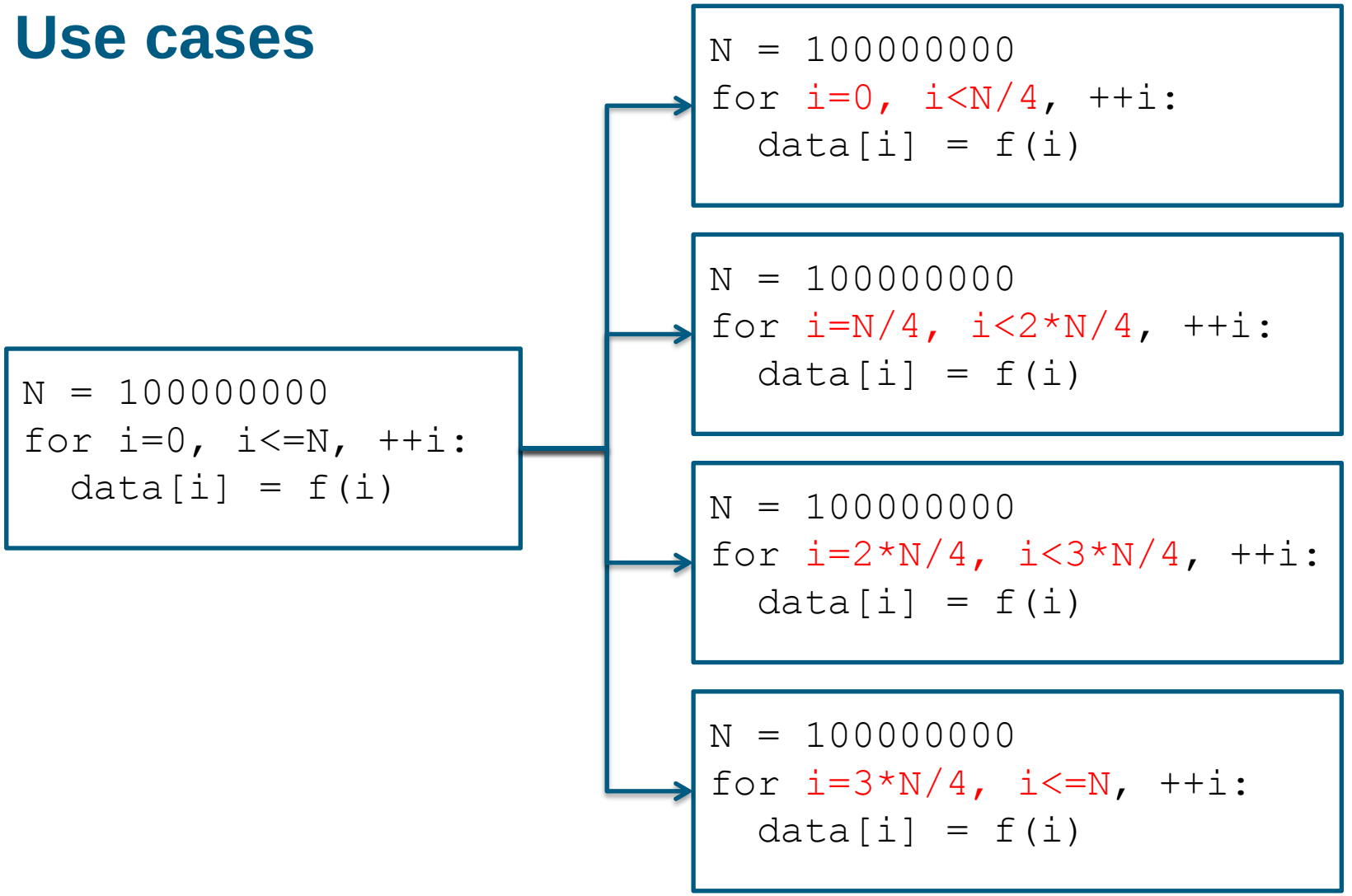
- Data-parallel (parts of) algorithms
- Example:
  - Loop with many iterations
  - Iterations independently processable
    - → Order of iterations may be changed
    - → Iterations distributable to processing units

```
N = 100000000
for i=0, i<=N, ++i:
  data[i] = f(i)
```

→

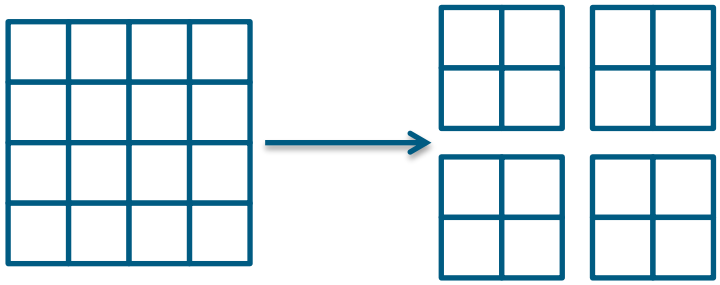
```
N = 100000000
for i=N, i>=0, --i:
  data[i] = f(i)
```

Use cases

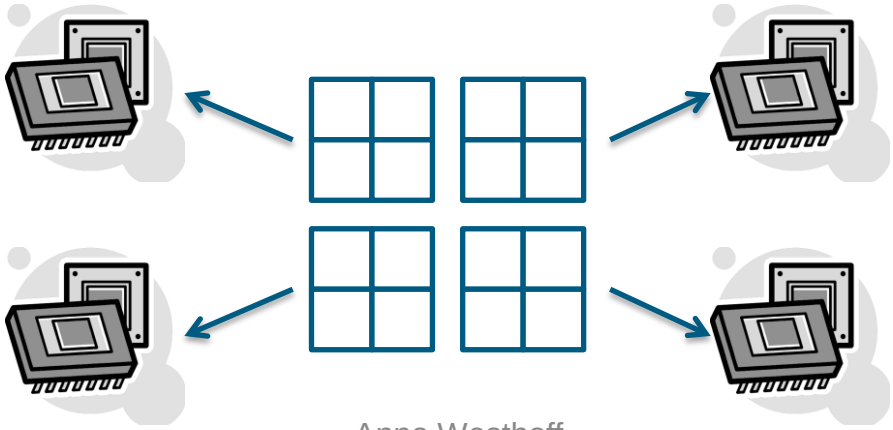


How to use a GPU cluster – basic principle

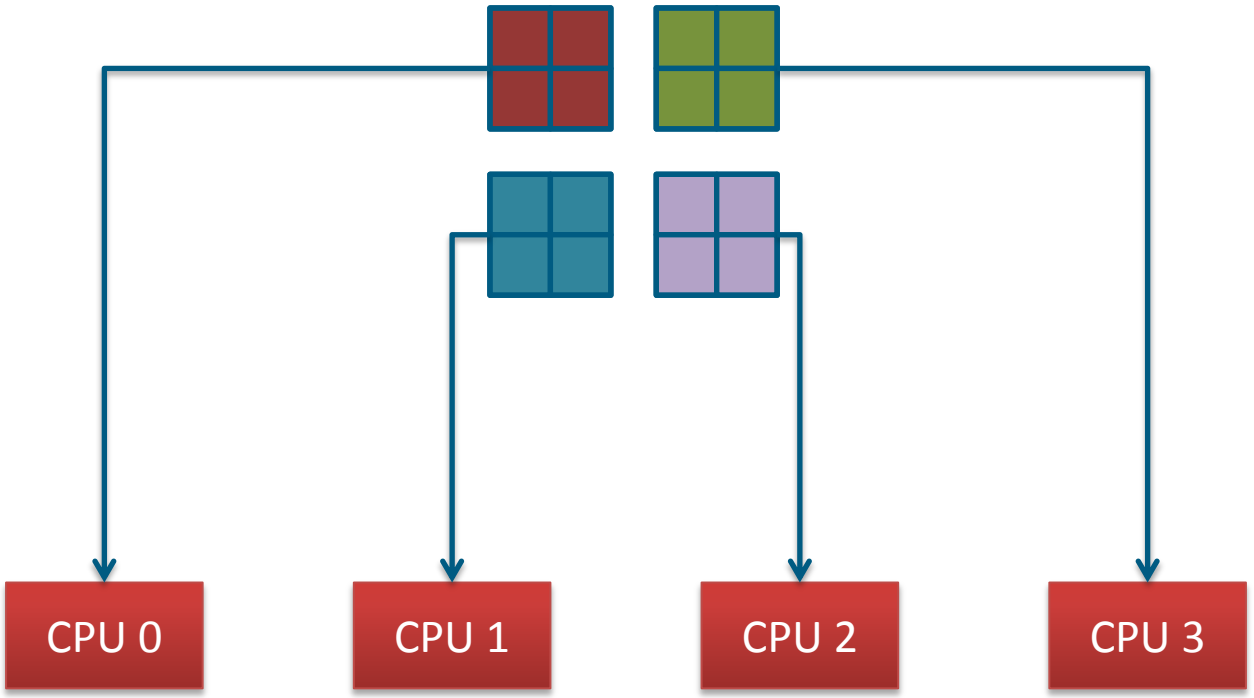
- Split data-parallel task into sub-tasks



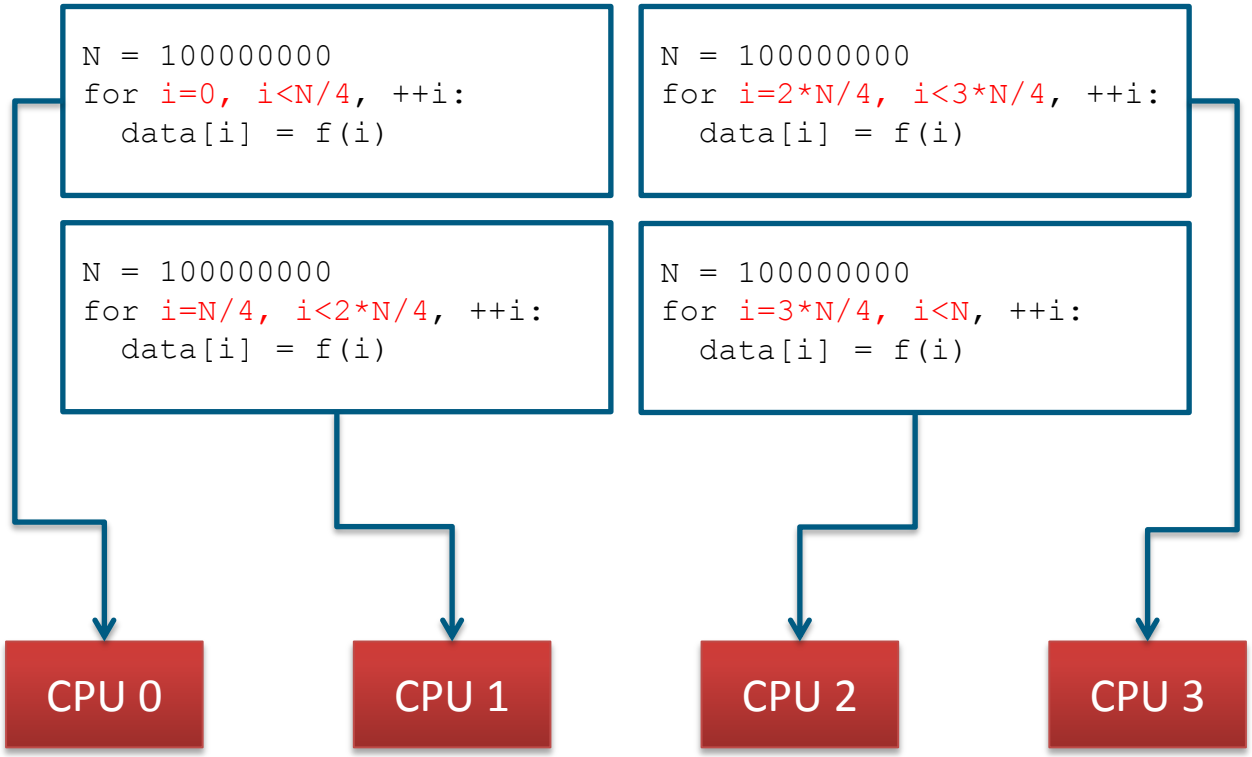
- Distribute sub-tasks to the available processing units



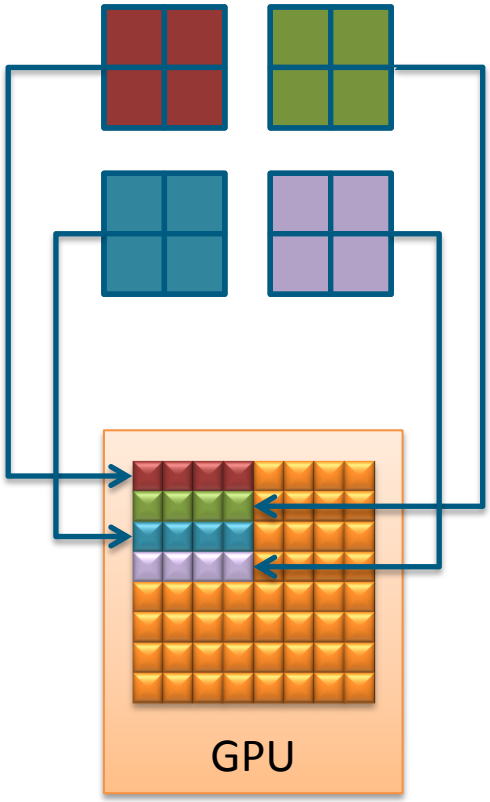
On a supercomputer



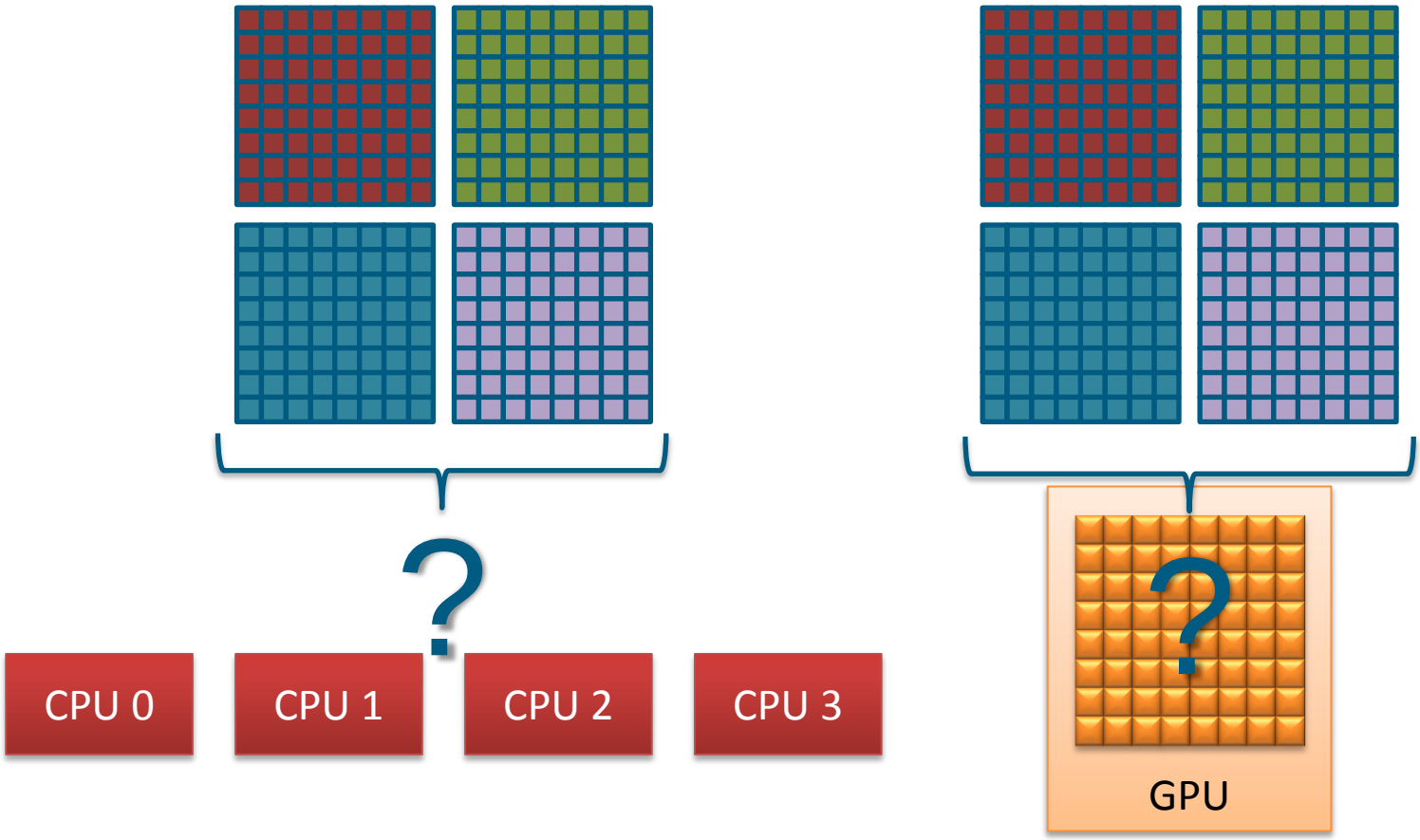
On a supercomputer



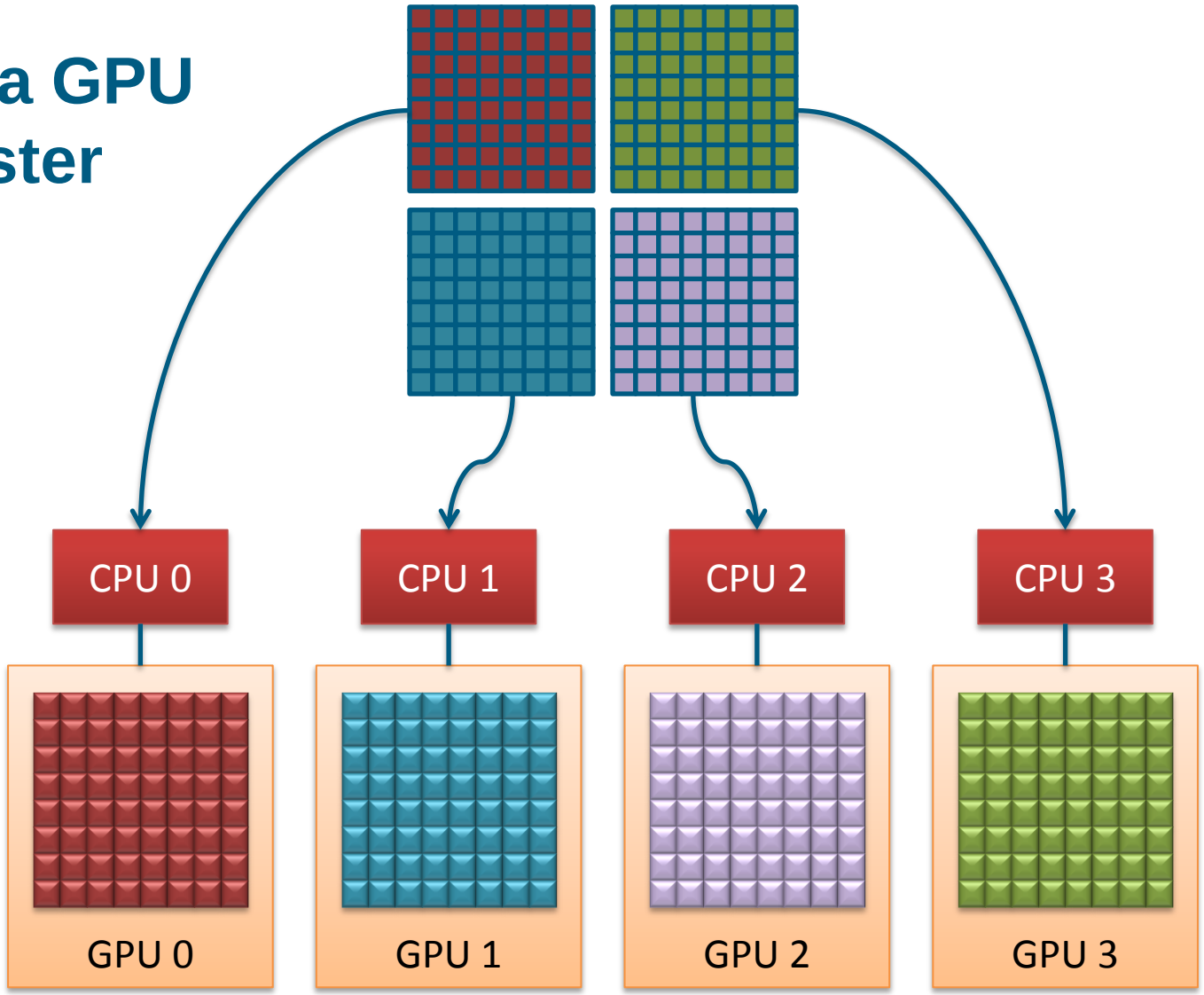
On a workstation with GPU



… and if the data is too big?!



On a GPU cluster



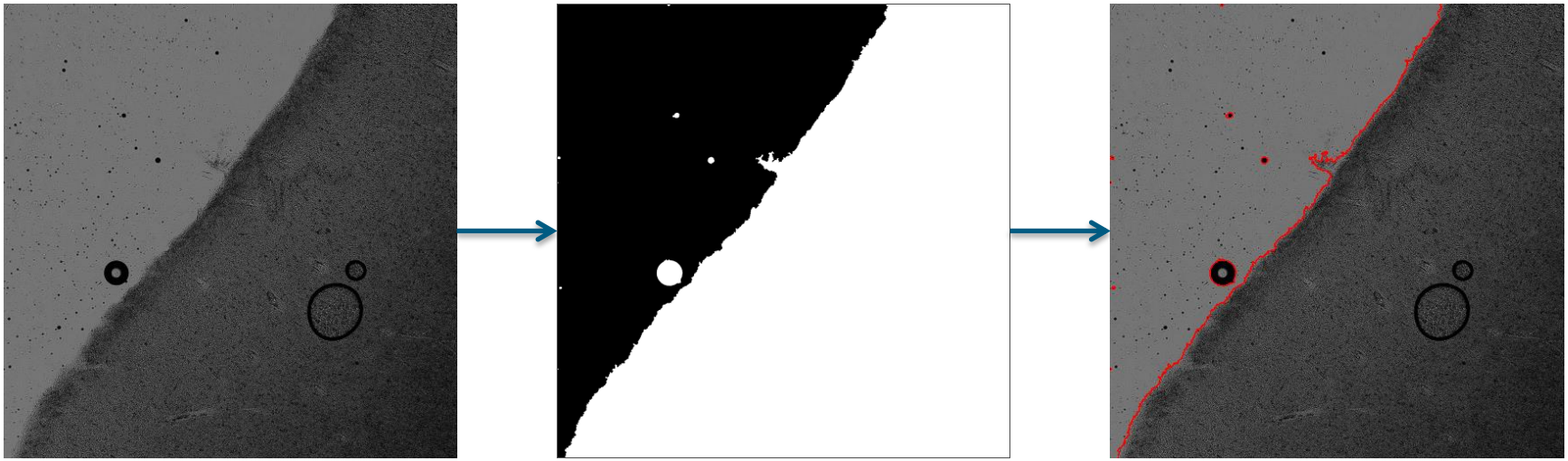
Example: PLI image segmentation

- Polarized Light Imaging (PLI): imaging technique developed at INM-1, Forschungszentrum Jülich
- Aim: extracting the course of single nerve fibers

- Sections of postmortem human brain
- Imaging of the sections under polarized light
- ~1500 sections/brain
- 30x30 tiles/section
- 2048x2048 pixels/tile

Example: PLI image segmentation

- 3D reconstruction needed
- Requires a segmentation:
  differentiation between brain and background



Example: PLI image segmentation

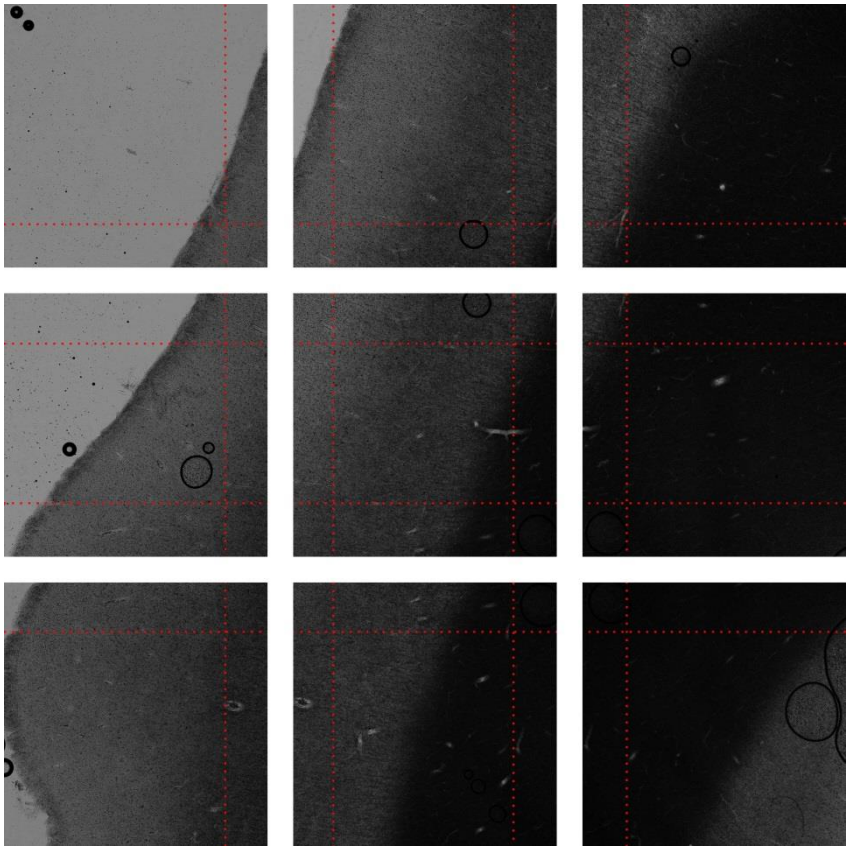
- Tiles captured with large overlapping

→ independently processable

- Loops iterating over all pixels

→ Distribute to processing units

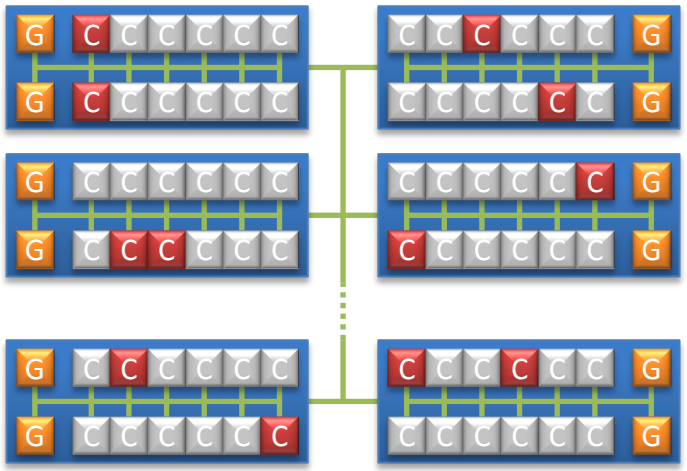
→ Do it on a GPU cluster!



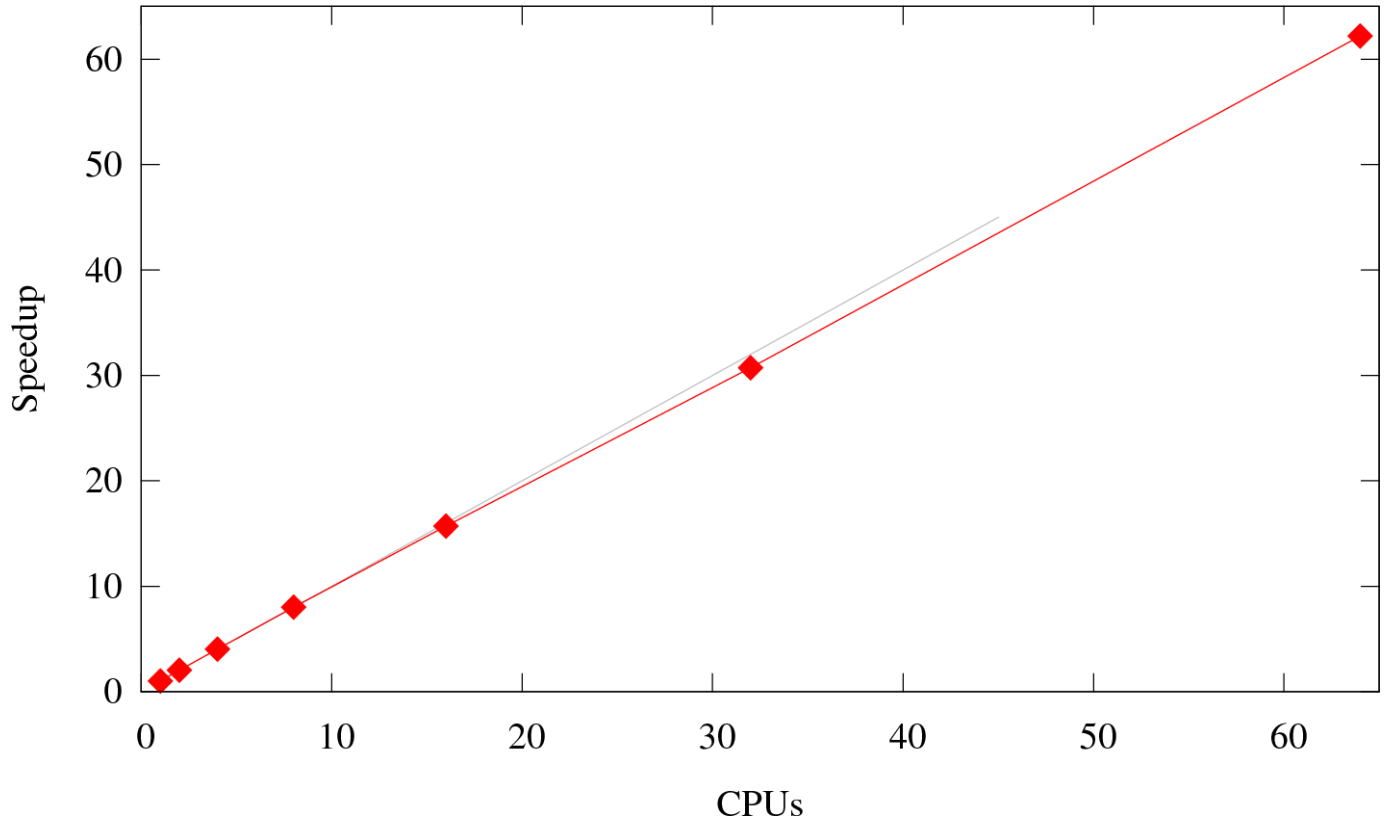
Example: PLI image segmentation

- Hybrid MPI-CUDA parallelization on GPU cluster JUDGE
- 1:1 assignment of CPUs and GPUs

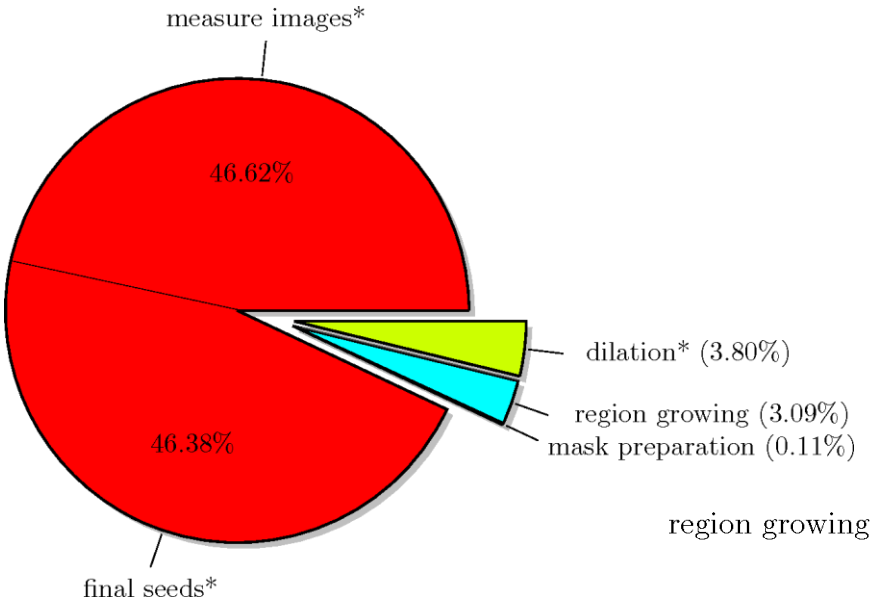
1. Distribute tiles of a section to the CPUs
2. Compute data-parallel loops on the GPUs



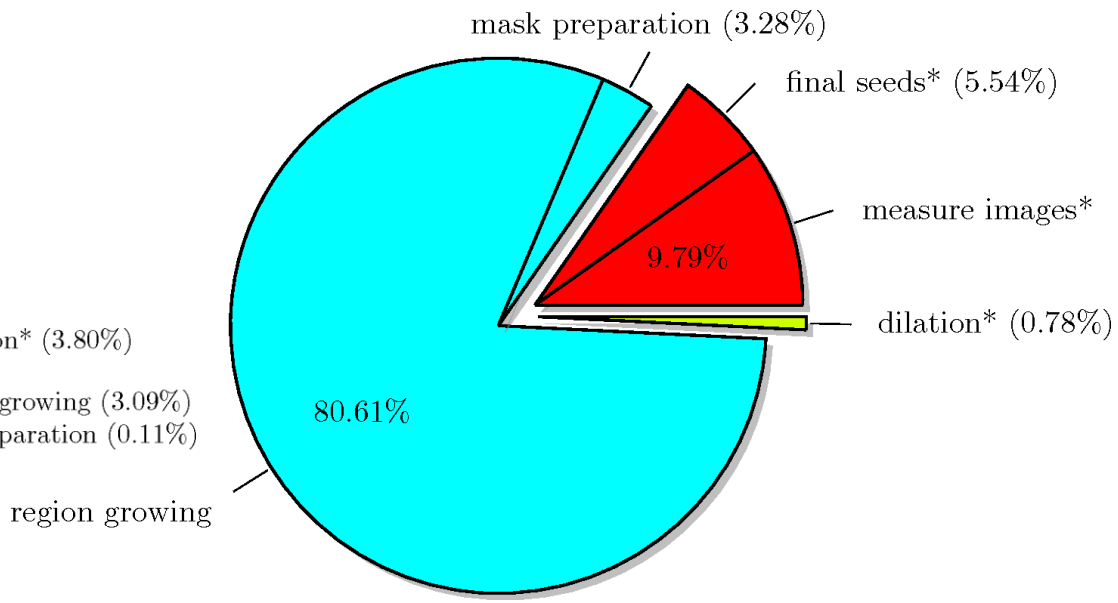
Example: PLI image segmentation



Example: PLI image segmentation



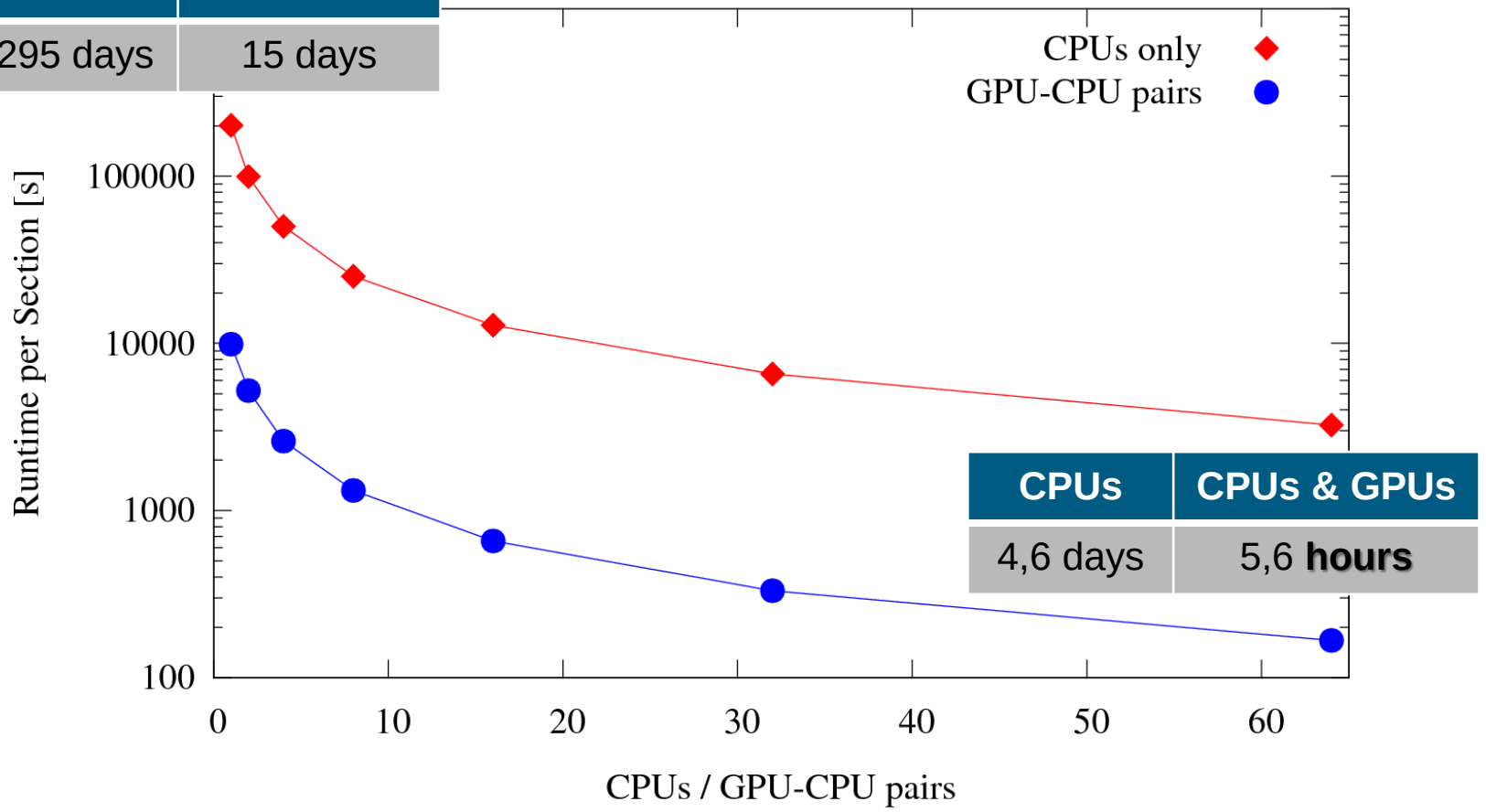
Only CPUs



Hybrid: CPUs & GPUs

Example: PLI image segmentation

CPU	CPU & GPU
295 days	15 days



CPUs	CPUs & GPUs
4,6 days	5,6 **hours**