
# Parallel EEG processing on GPULab, a GPU-enabled container-based distributed system in the SLICES EU research infrastructure

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# Content outline

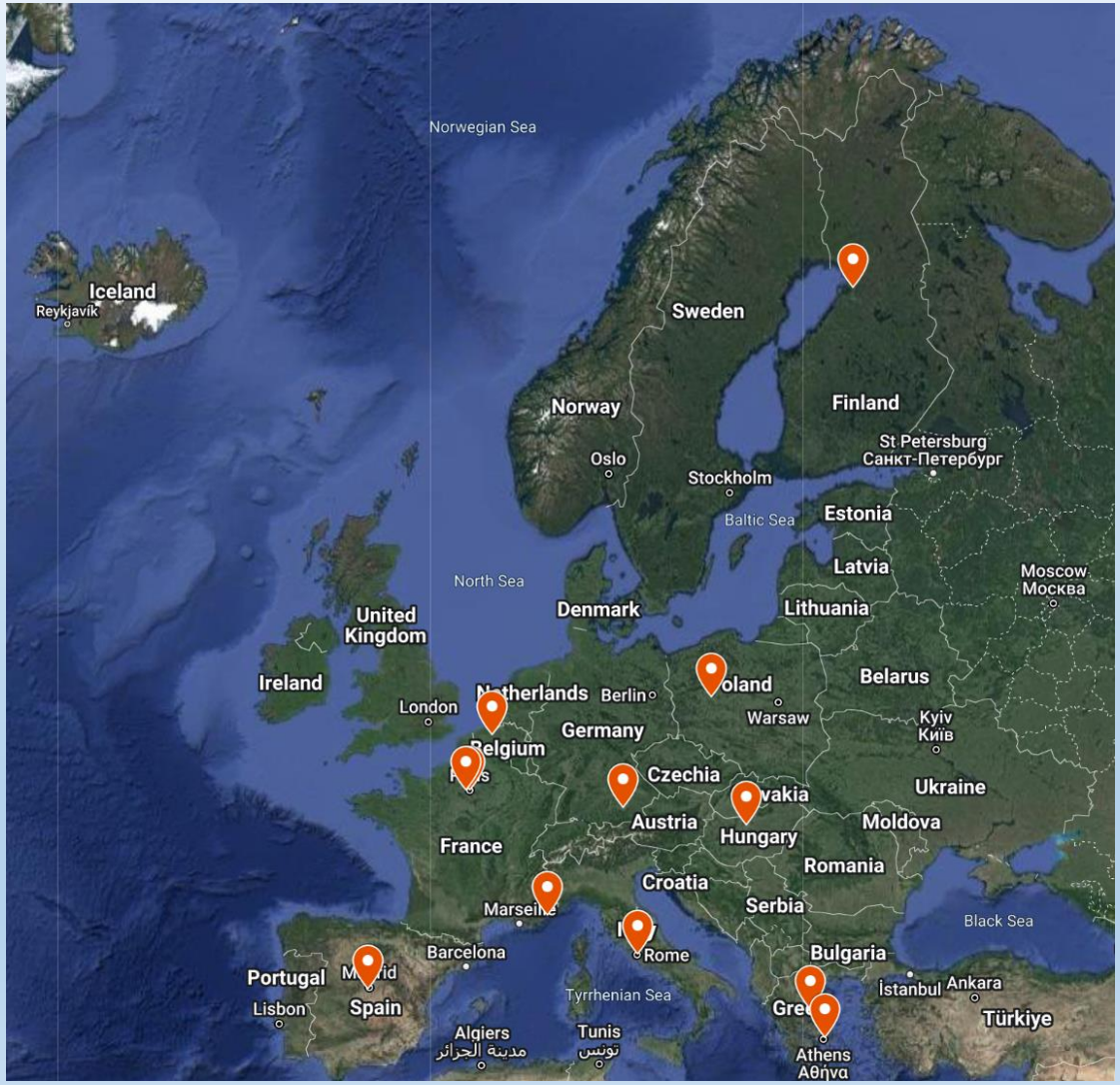
# 1.1 About the SLICES

Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies (**SLICES**)

SLICES-RI (Research Infrastructure)
SLICES-DS (Design Study)
**SLICES-SC (Starting Community)**
SLICES-PP (Preparatory Phase)

**SLICES-SC (Starting Community)**

1. Consiglio Nazionale Delle Ricerche (IT)
2. SZTAKI (HU)
3. **Imec (BE)**
4. University of Thessaly (GR)
5. Sorbonne Universite (FR)
6. French Institute for Research in Computer Science (FR)
7. Eurecom (FR)
8. University of Oulu (FI)
9. Poznan Supercomputing and Networking Center (PL)
10. IMDEA Networks Institute (ES)
11. Cosmote (GR)
12. Technische Universitat Munchen (DE)



# imec iLab.t testbed

**Virtual Wall**

Perform large networking and cloud experiments

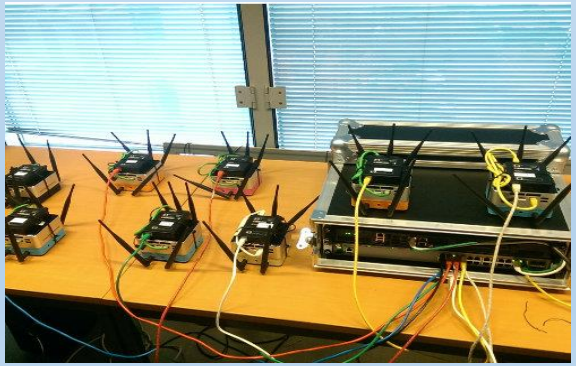
**W-iLab.t testbeds**

Wireless Testbed and Officelab

**GPULab**

Batch system for GPU-enabled docker containers

**Portable testbed**



A testbed which can be deployed in the wild

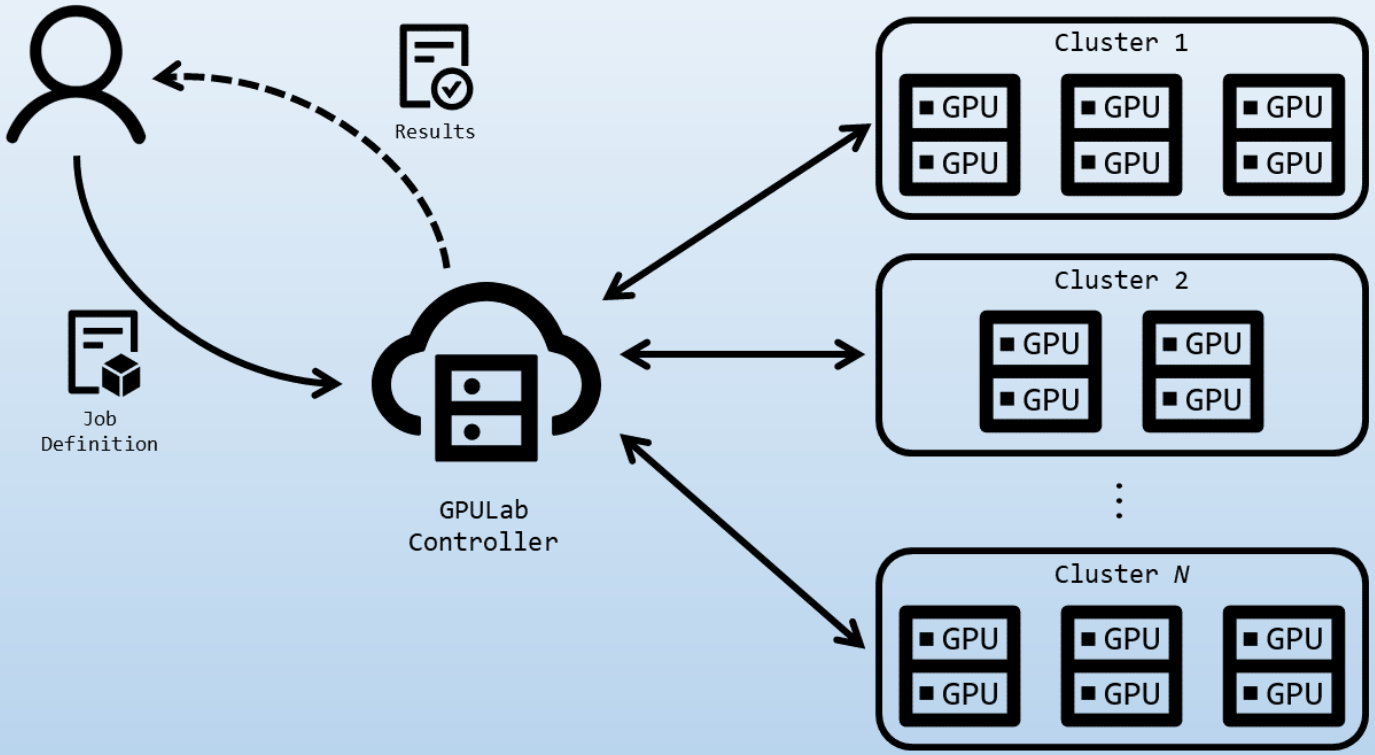
**CityLab testbed**

City of Things smart cities FIRE testbed

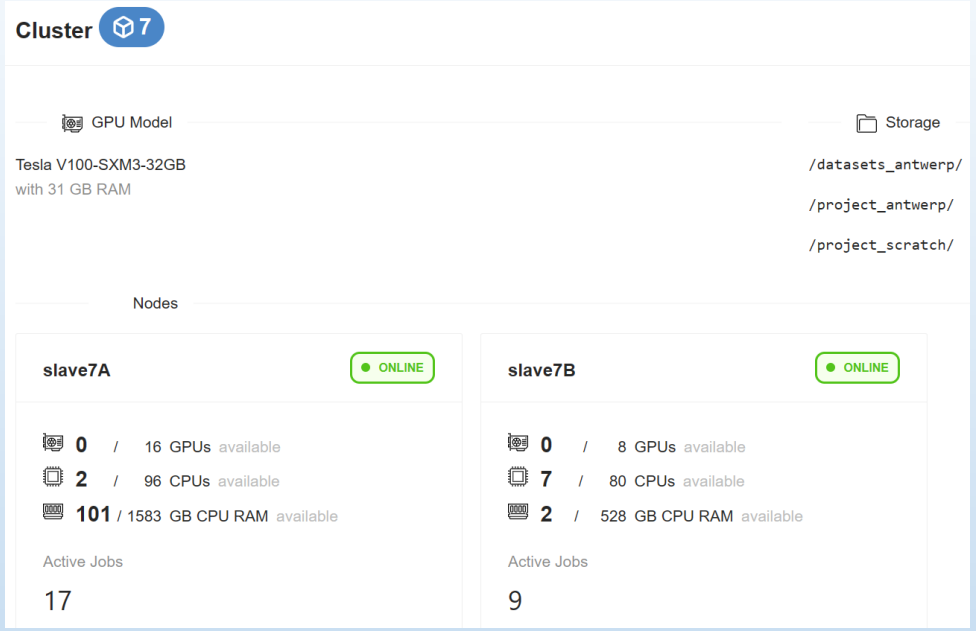
**HomeLab**

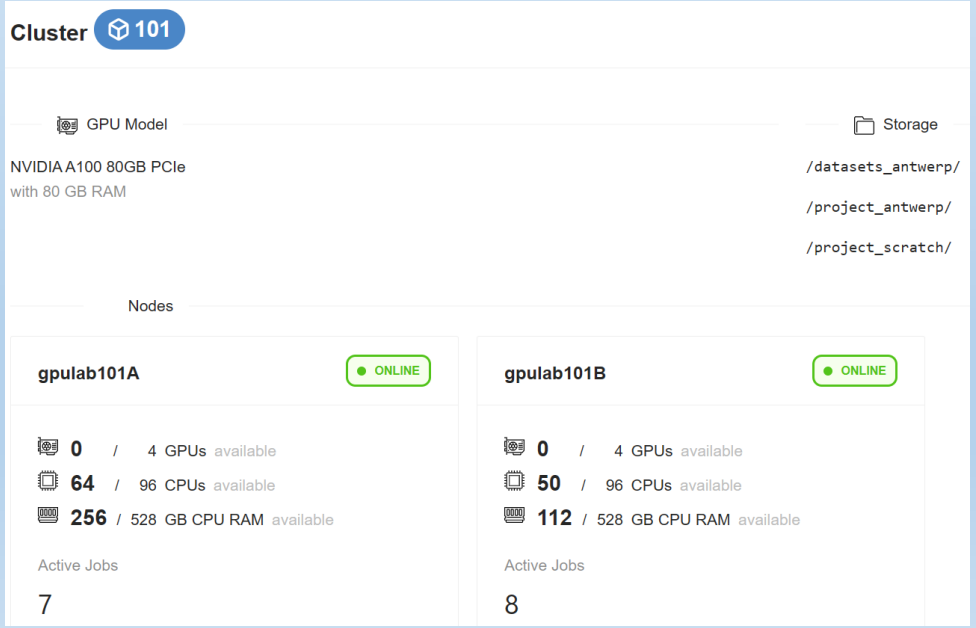
HomeLab test environment

# GPULab architecture



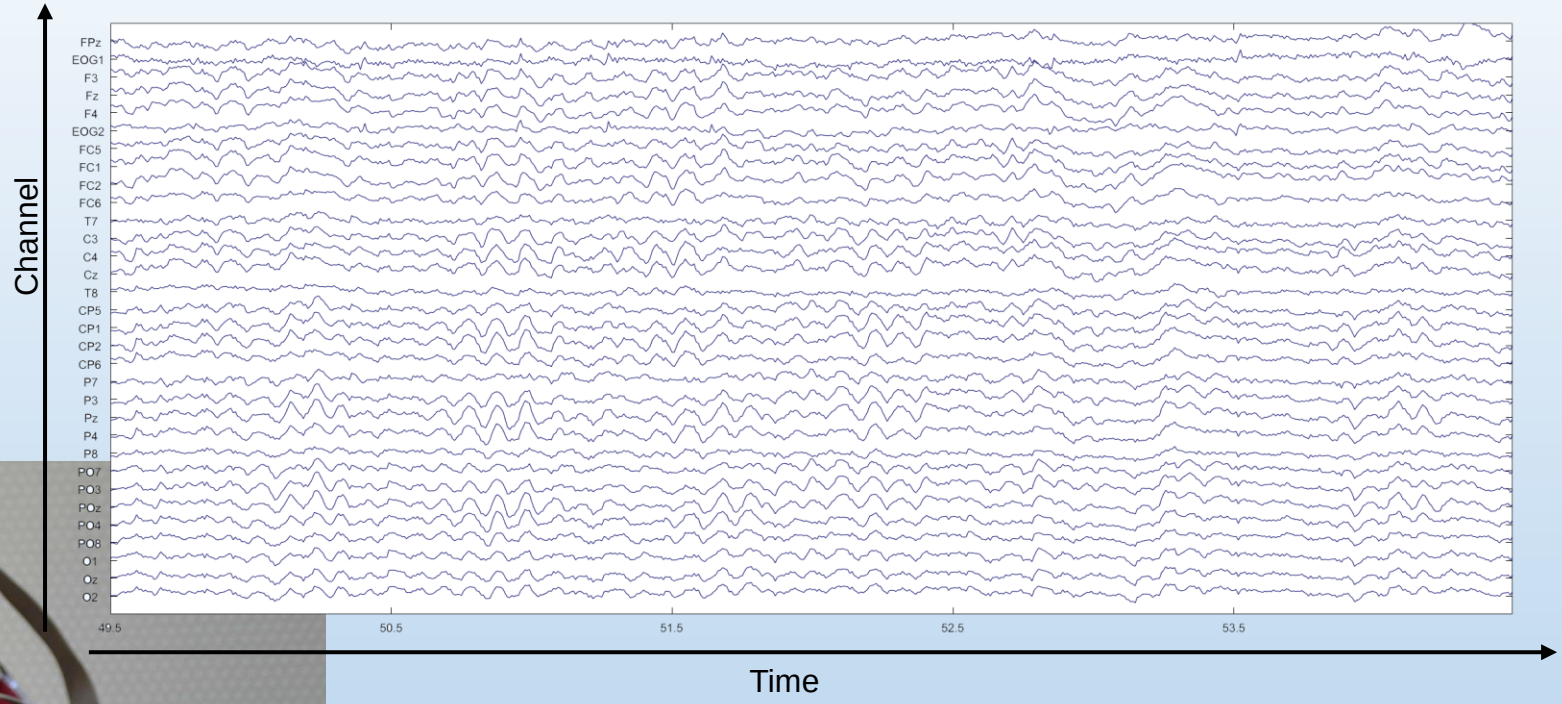

GPULab is a distributed system for running jobs in GPU-enabled Docker-containers.



# 1.2 About EEG processing

- The brain is the most complex system known to human
- EEG contains physiological and pathological information of brain activity.




- Time-frequency analysis
- Connectivity analysis
- Source localization analysis
- Signal decomposition analysis
- Resting state and task-related analysis

……

# 1.3 HPC requirements for EEG processing

**High computational workload factors:**

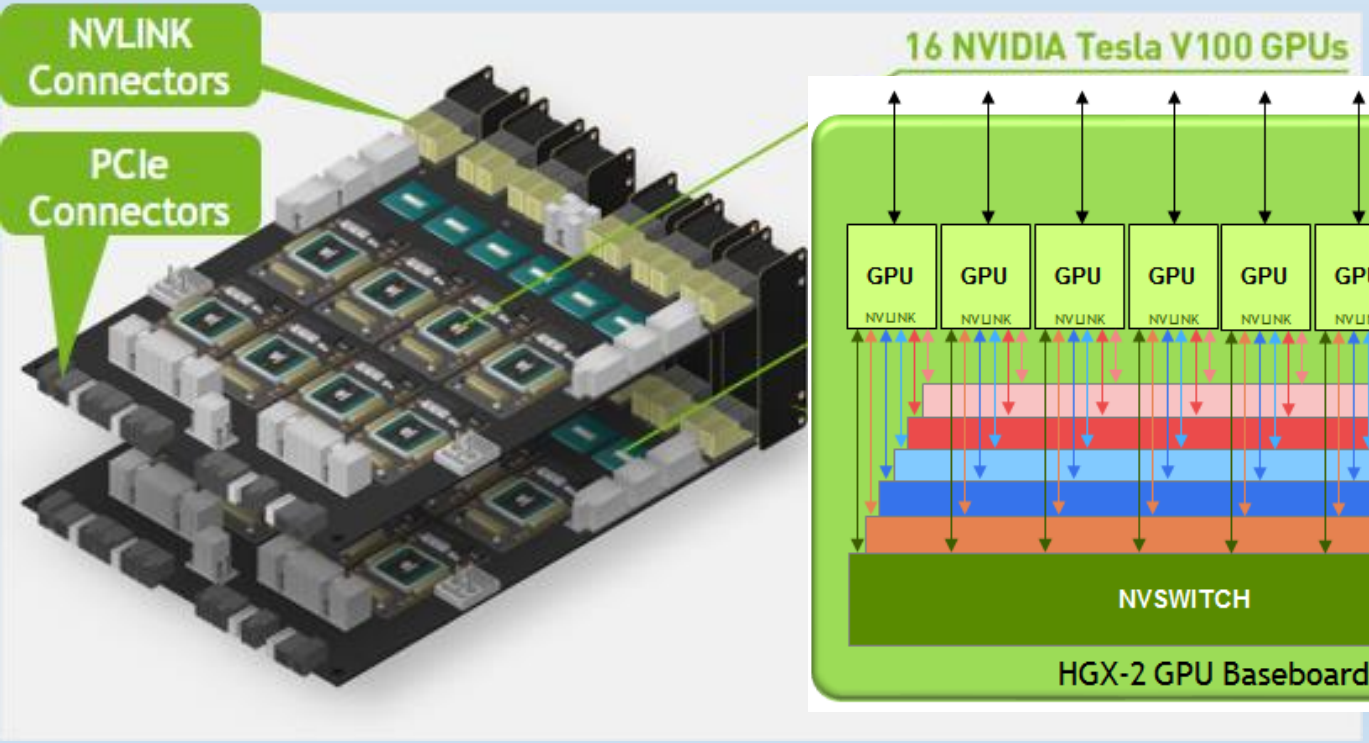
- High temporal resolution
  - 1024Hz, 2048Hz
- High electrode density
  - 128, 256 channels
- Long record
  - Minutes to half hour
- Large number of subject
  - Start from 20 subjects usually
- MATLAB based processing script
  - Low execution efficiency
- Complex processing algorithms
  - ICA EMD

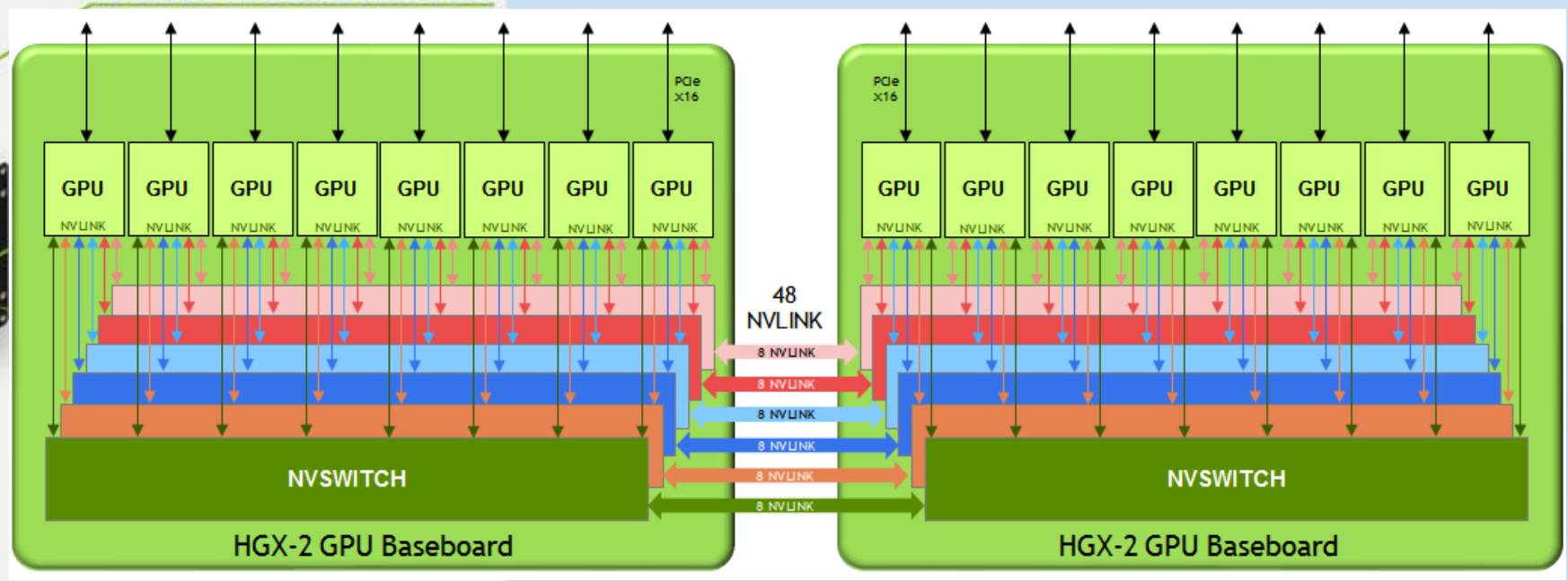
**Compromise solutions:**

- Down sampling
  - 1024Hz, 2048Hz → 256Hz, 128Hz
- Reduce spatial resolution
  - 128, 256 → 32, 16 channels
- Segmentation
  - Minutes → epoch in seconds
- Limited number of subjects
  - 20 → less than 10
- C based processing program
  - Low → high efficiency
- Algorithm optimization
  - Time/space complexity: high → low

# 2.1 Hardware infrastructure of GPULab

- Several GPU clusters with different types of GPU cards
- We take Cluster 6 as an example:
  - NVIDIA HGX-2 with **16 Tesla V100 GPUs**, 96 2.7Ghz vCPU cores with 1.5TB RAM
  - NVLink switch connection fabric



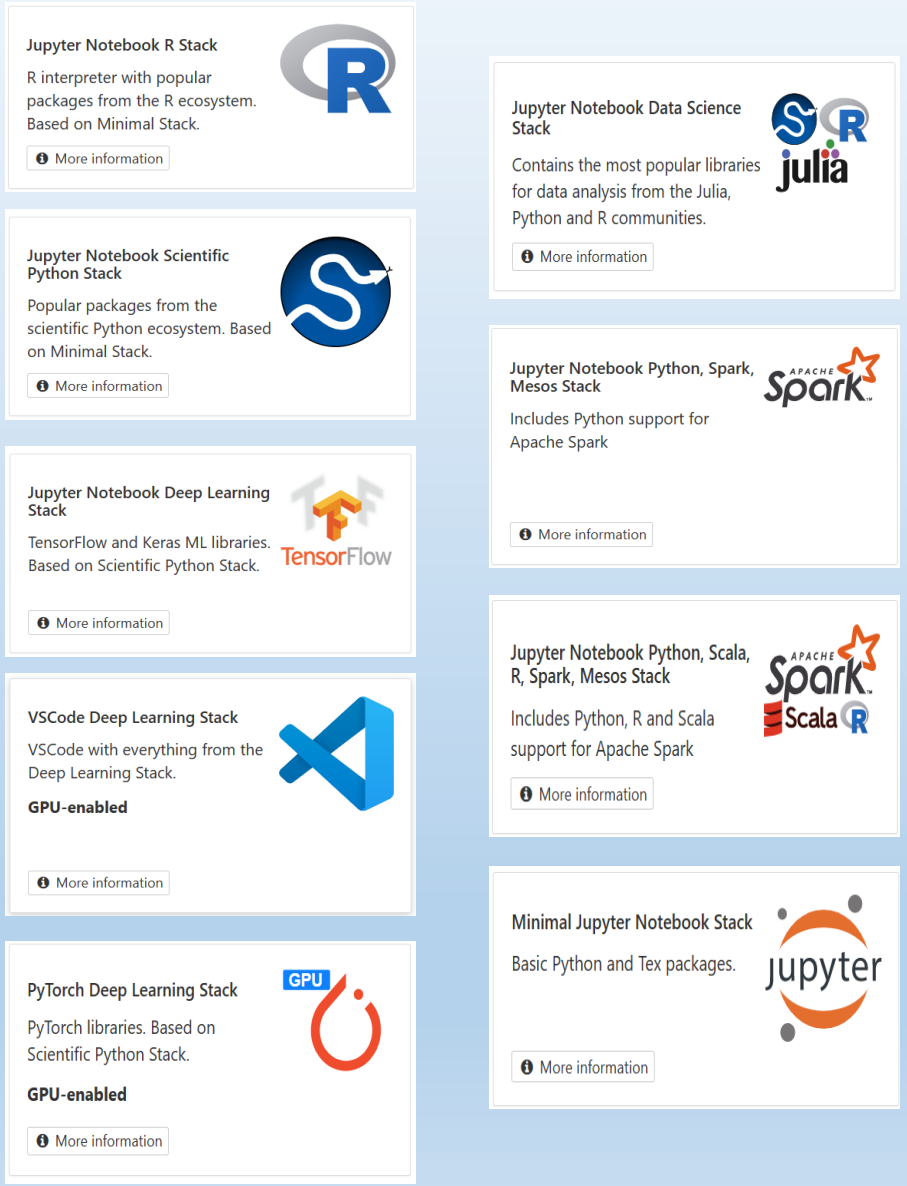



# 2.2 Access modes of GPULab

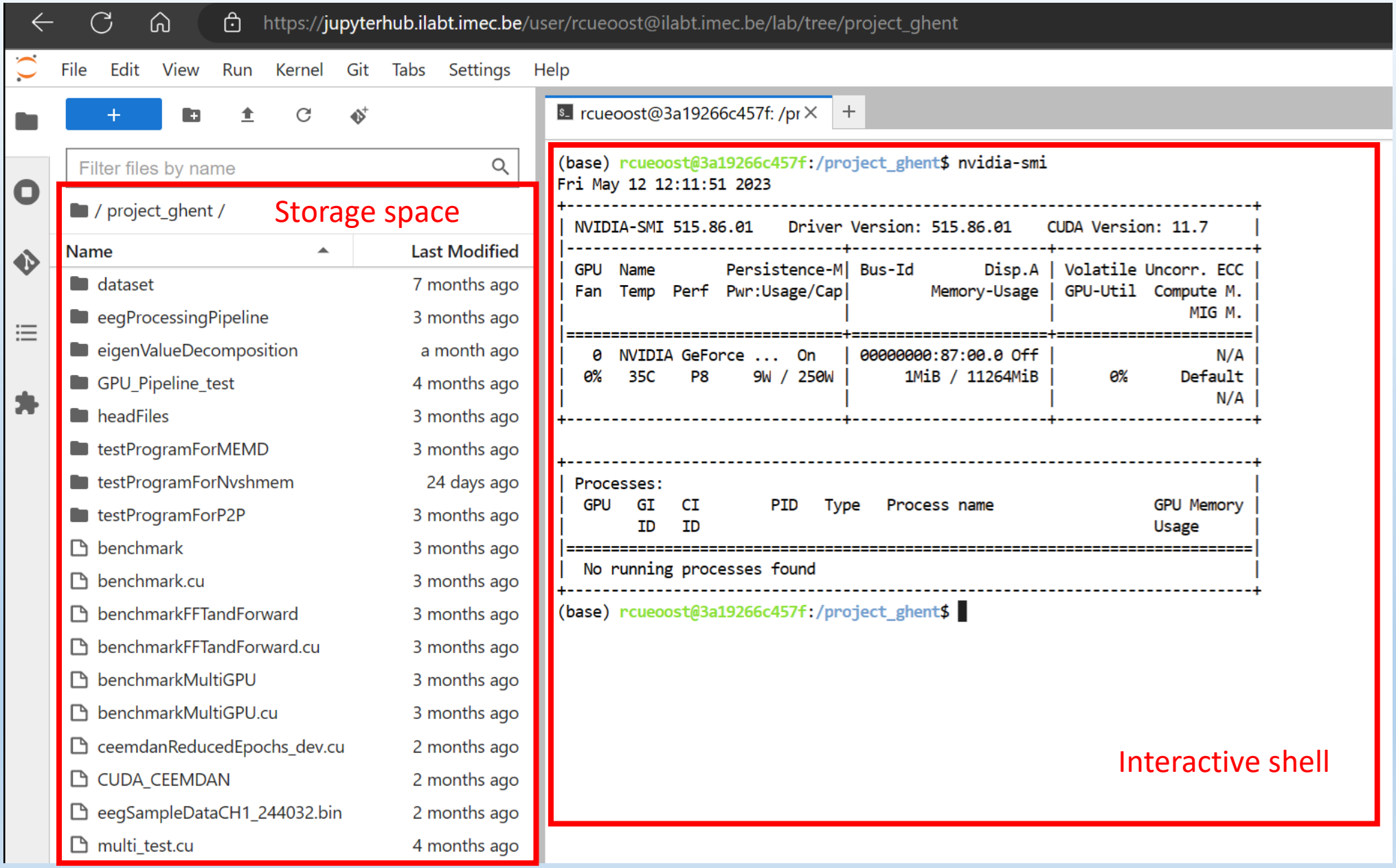
Everything runs in containers

- Interactive mode
- CLI batch mode

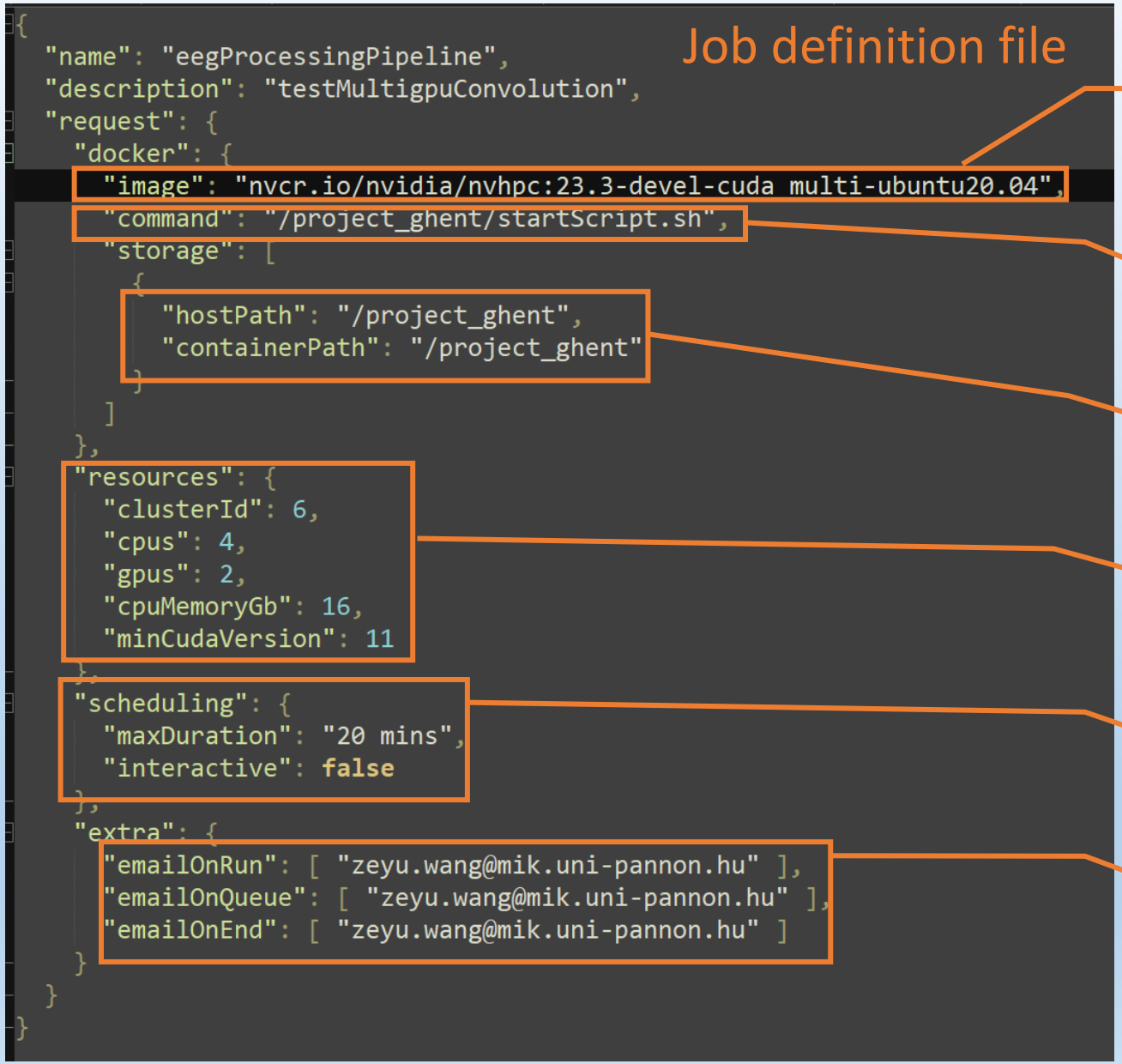
## Default container images:



# JupyterHub based interactive mode



# CLI batch mode




Container image files

Customized containers are available

Batch script

Storage path specification

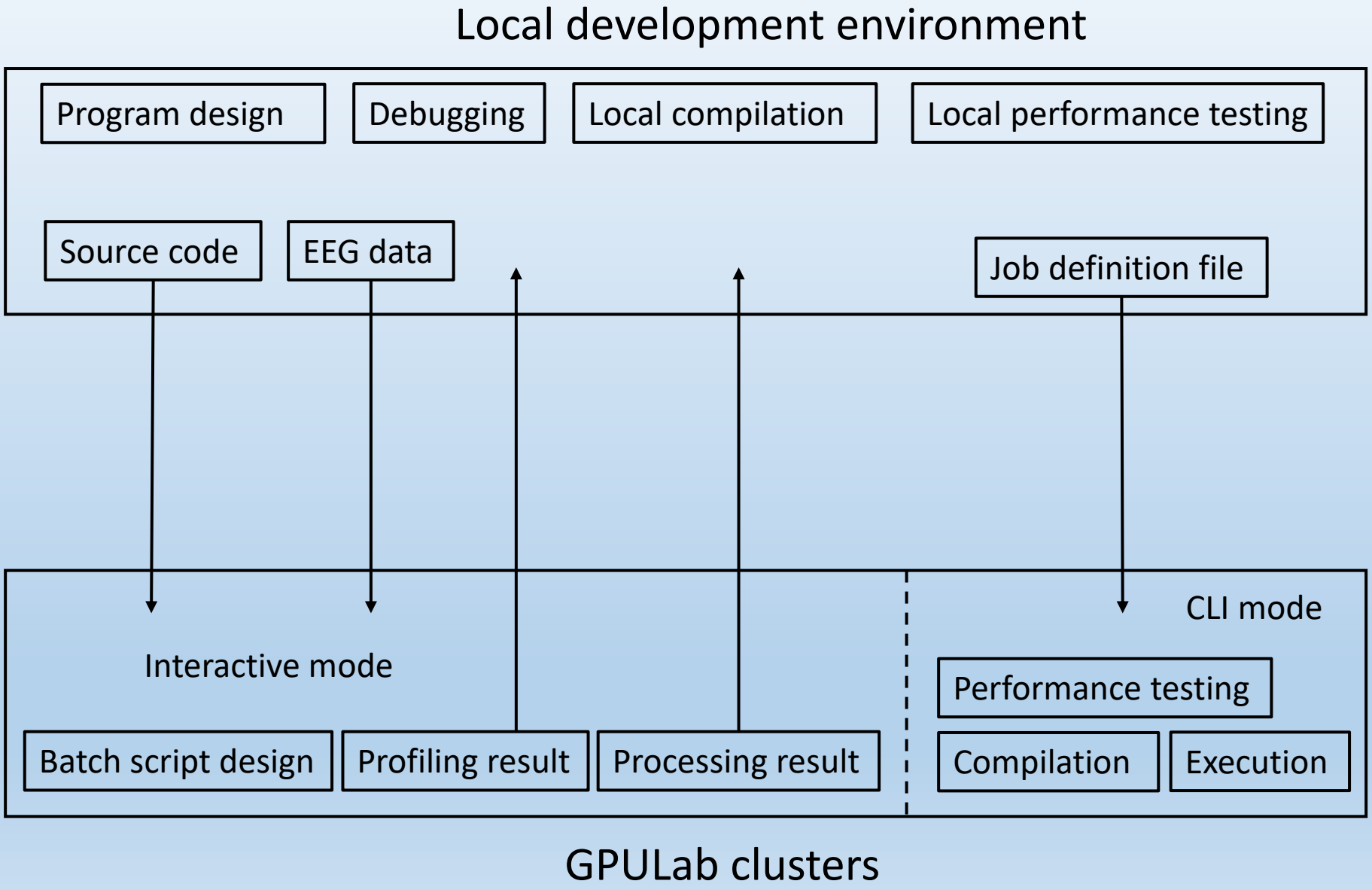
Hardware resource specification

Scheduling info

Notification config

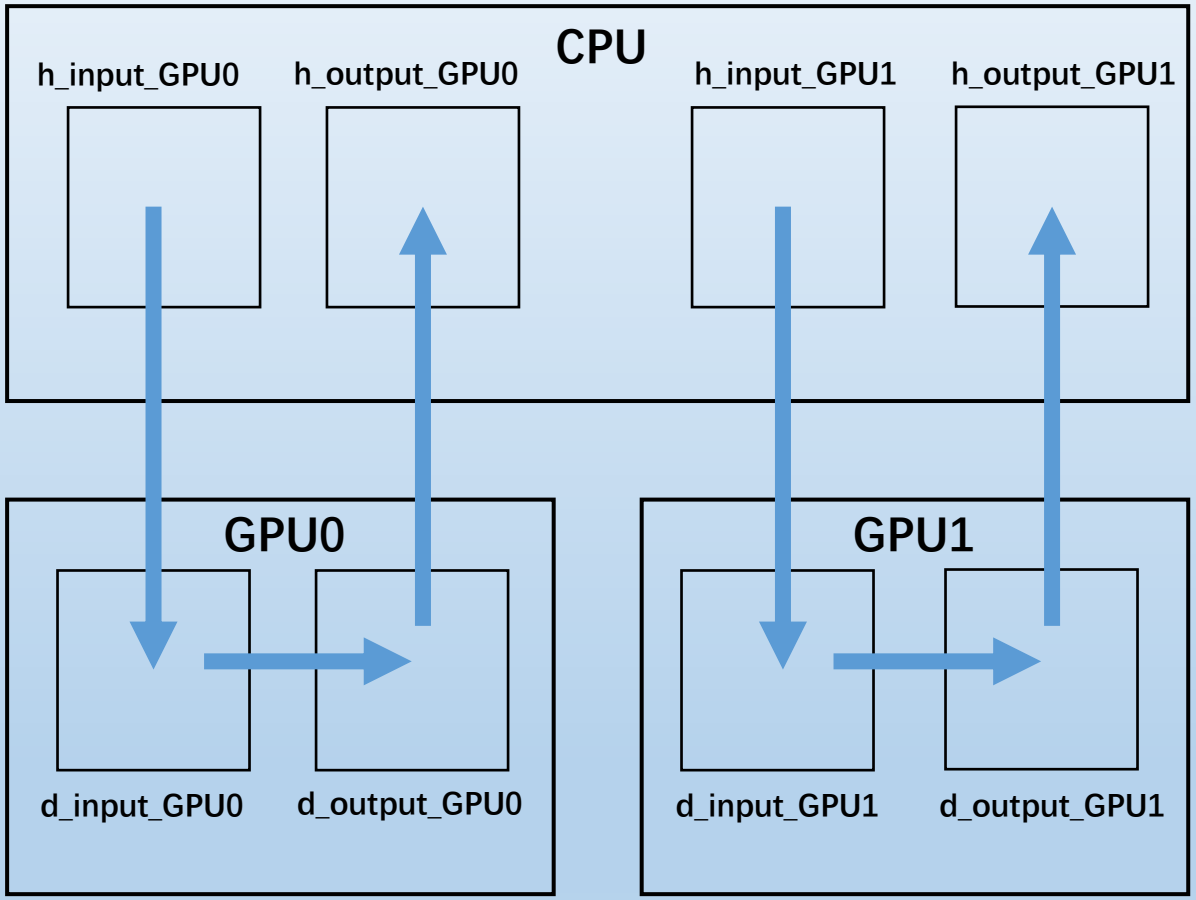
**“gpulab-cli submit jobDefinition.json”**

# 2.3 Our workflow with GPULab



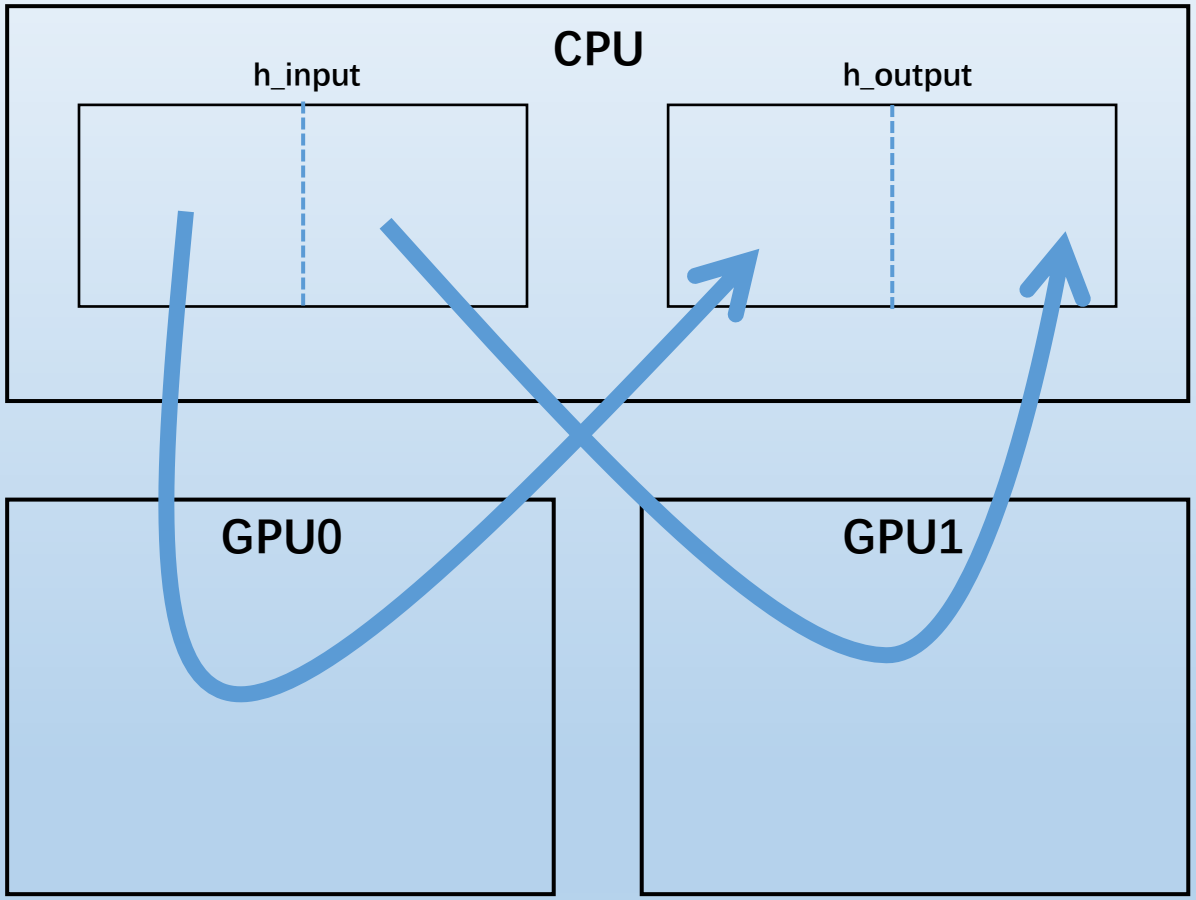
# 3 Multi-GPU access test

Case 1



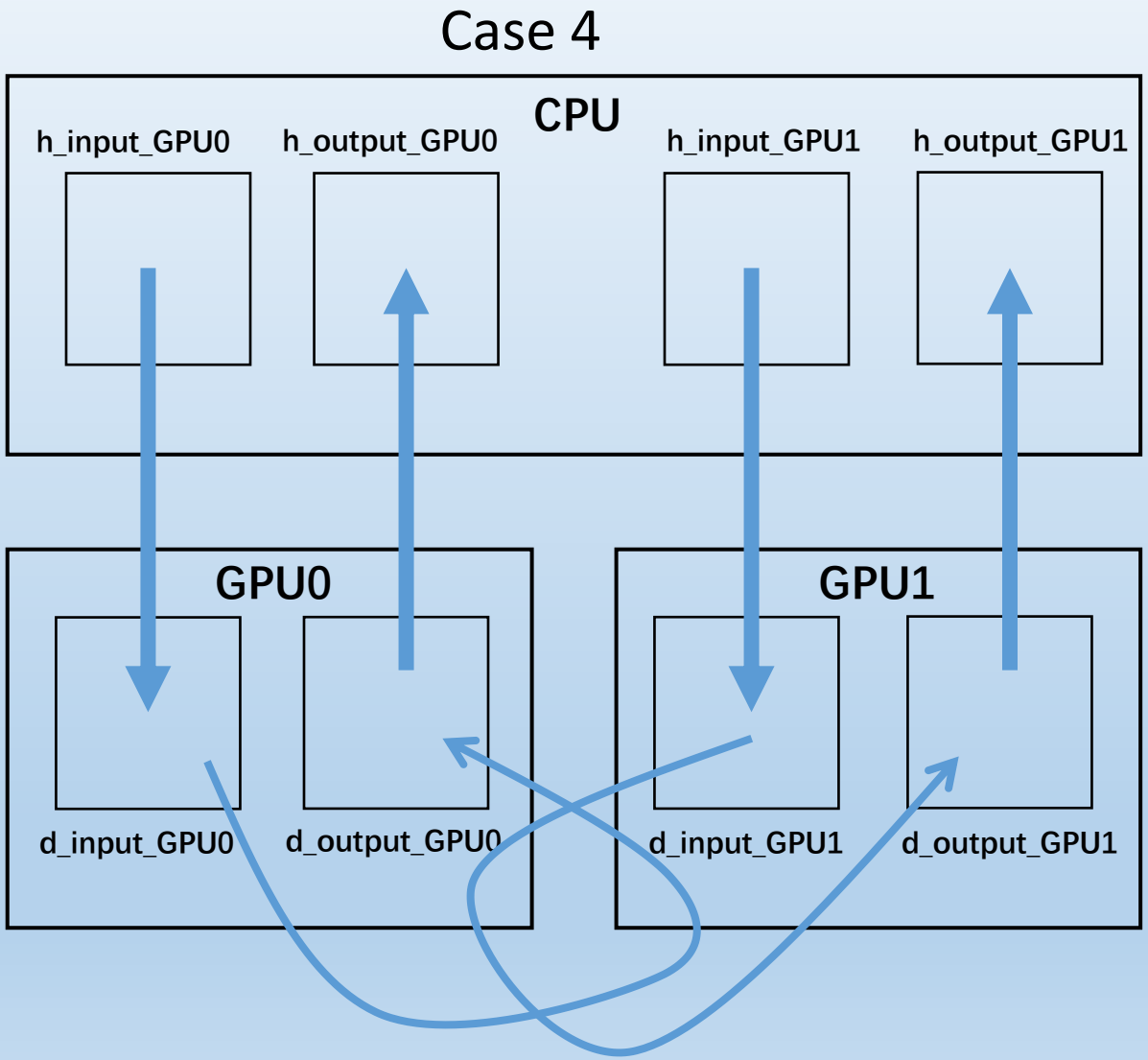

Naïve pattern

Case 2 & 3




Unified Memory & Unified Virtual Address

# 3 Multi-GPU access test




- Input signal is processed by 2 GPUs
- Different lengths with same SR (2048 Hz)
- Kernel: multiplication and addition
- Hardware:  HGX-2
- 50 repetitions

| | 512s | 1024s |
|---|---|---|
| Case1 | 4.28 | 69.99 |
| Case2 | 7.47 | 43.14 |
| Case3 | 0.93 | 6.41 |
| Case4 | 0.79 | 5.79 |

Execution time in microseconds

# 4 Future works

- Several single-GPU EEG processing algorithms have bee developed
  - Empirical Mode Decomposition (EMD) and its several variants
  - Independent Component Analysis (ICA)
  - Source localization
  - ……
- Single-GPU algorithm optimization
- **Multi-GPU-based EEG processing algorithm development**
- Extend the EEG pre-processing pipeline to multi-GPU system
  - filtering, mean removal, averaging, artifacts removal, statistical analysis ……
- Research on the scalability of multi-GPU signal processing algorithm