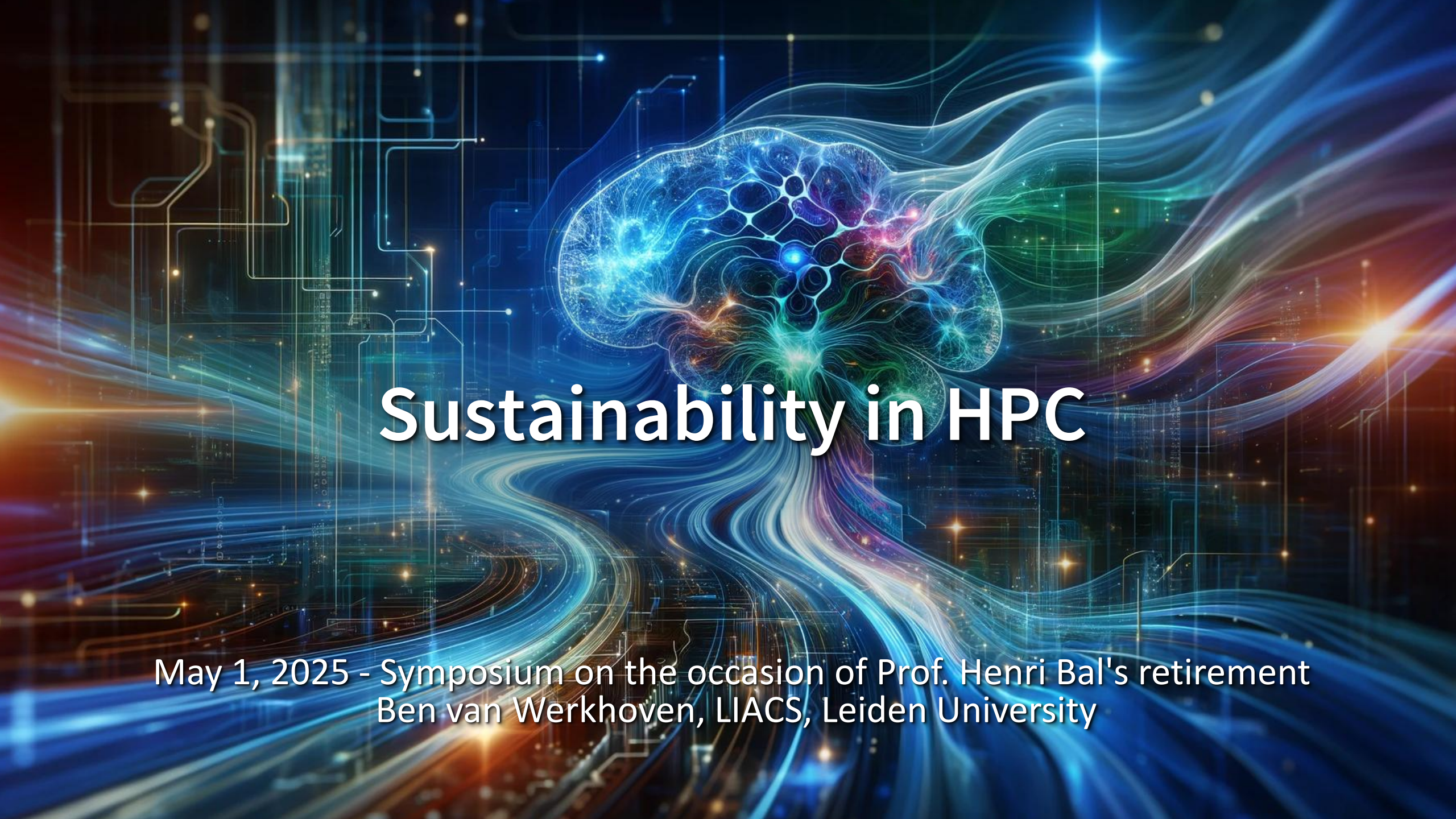
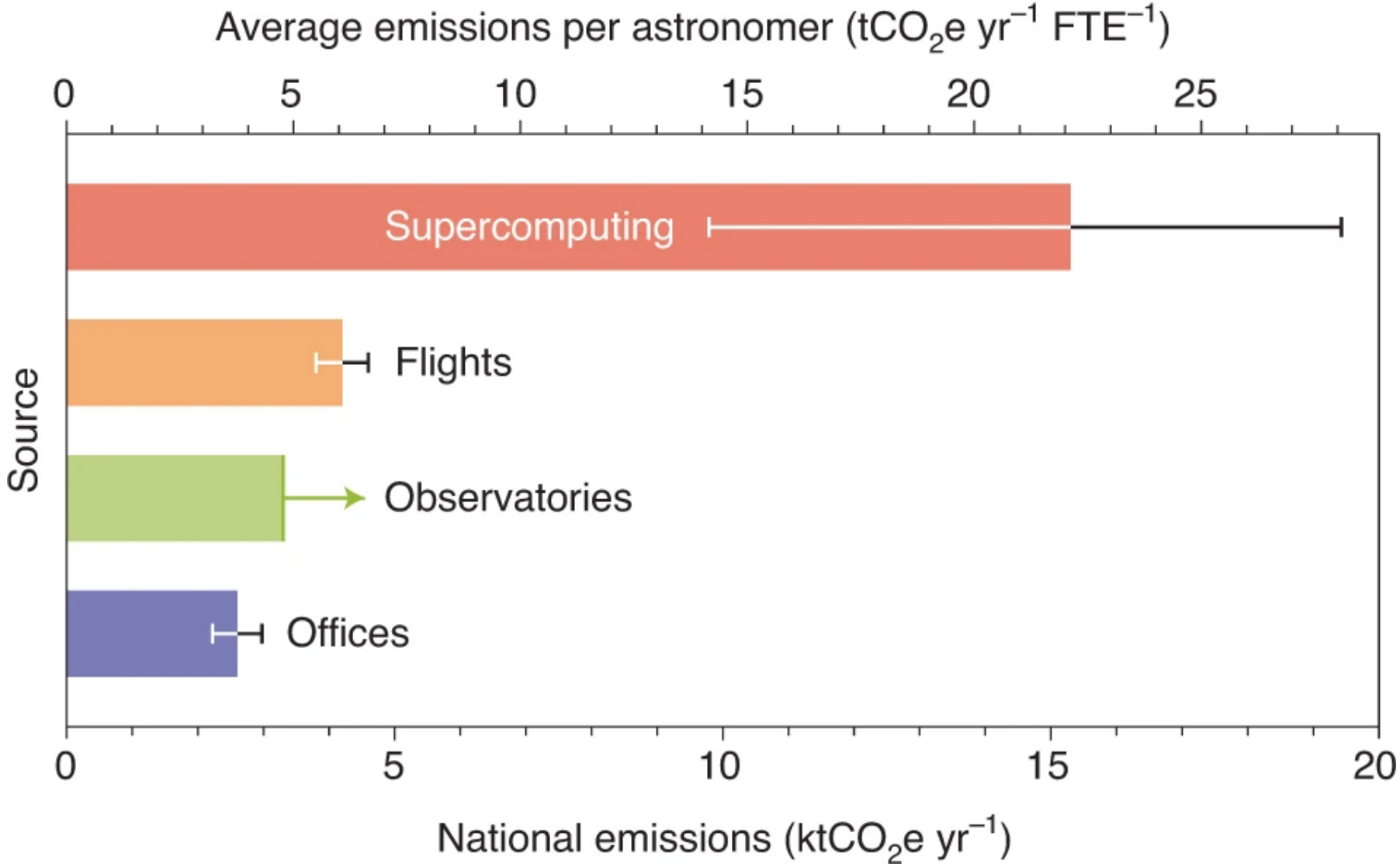


Sustainability in HPC

May 1, 2025 - Symposium on the occasion of Prof. Henri Bal's retirement

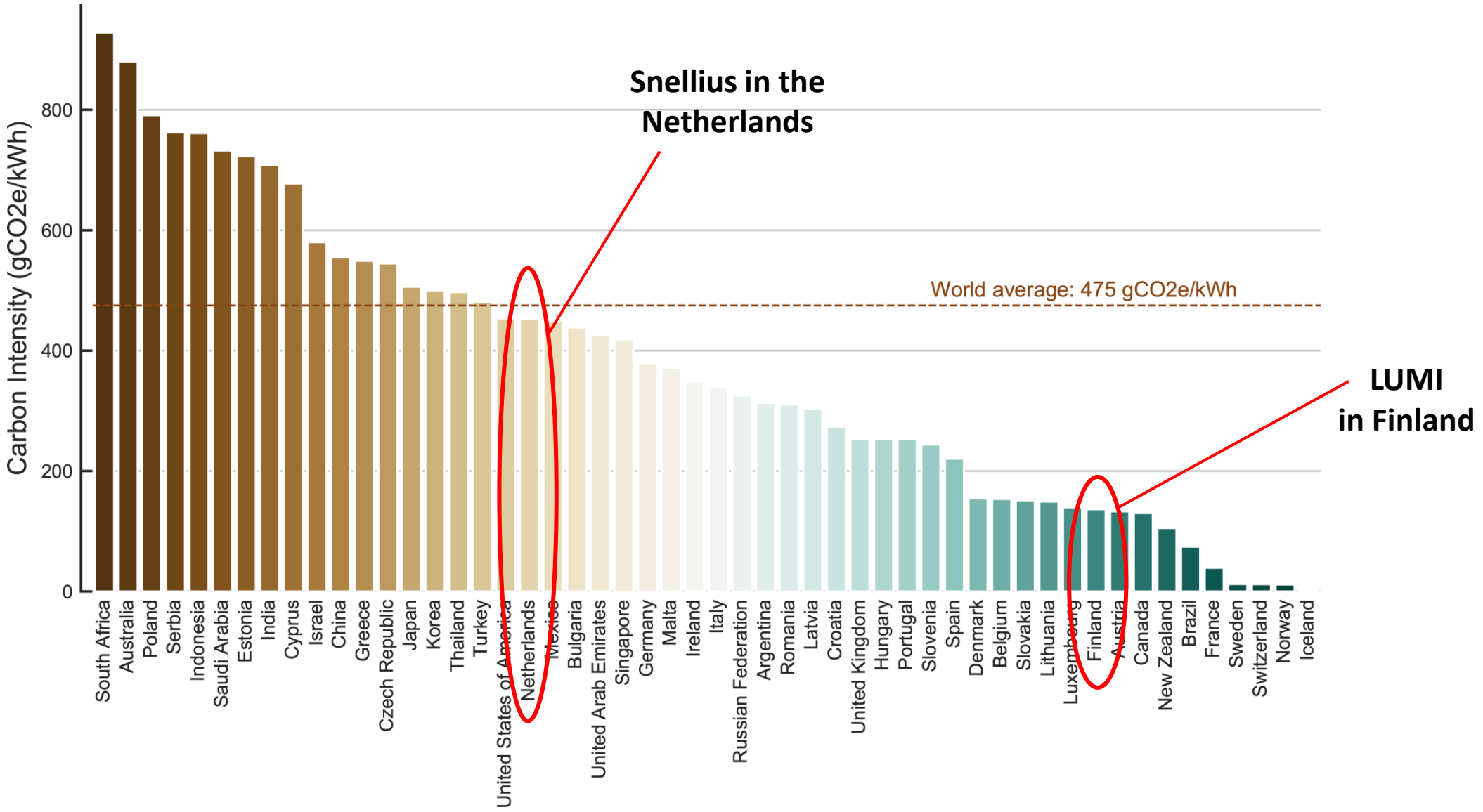
Ben van Werkhoven, LIACS, Leiden University

Computing might cost more than you think



The imperative to reduce carbon emissions in astronomy
A.R.H Stevens et al. Nature Astronomy 2020

Select your supercomputer

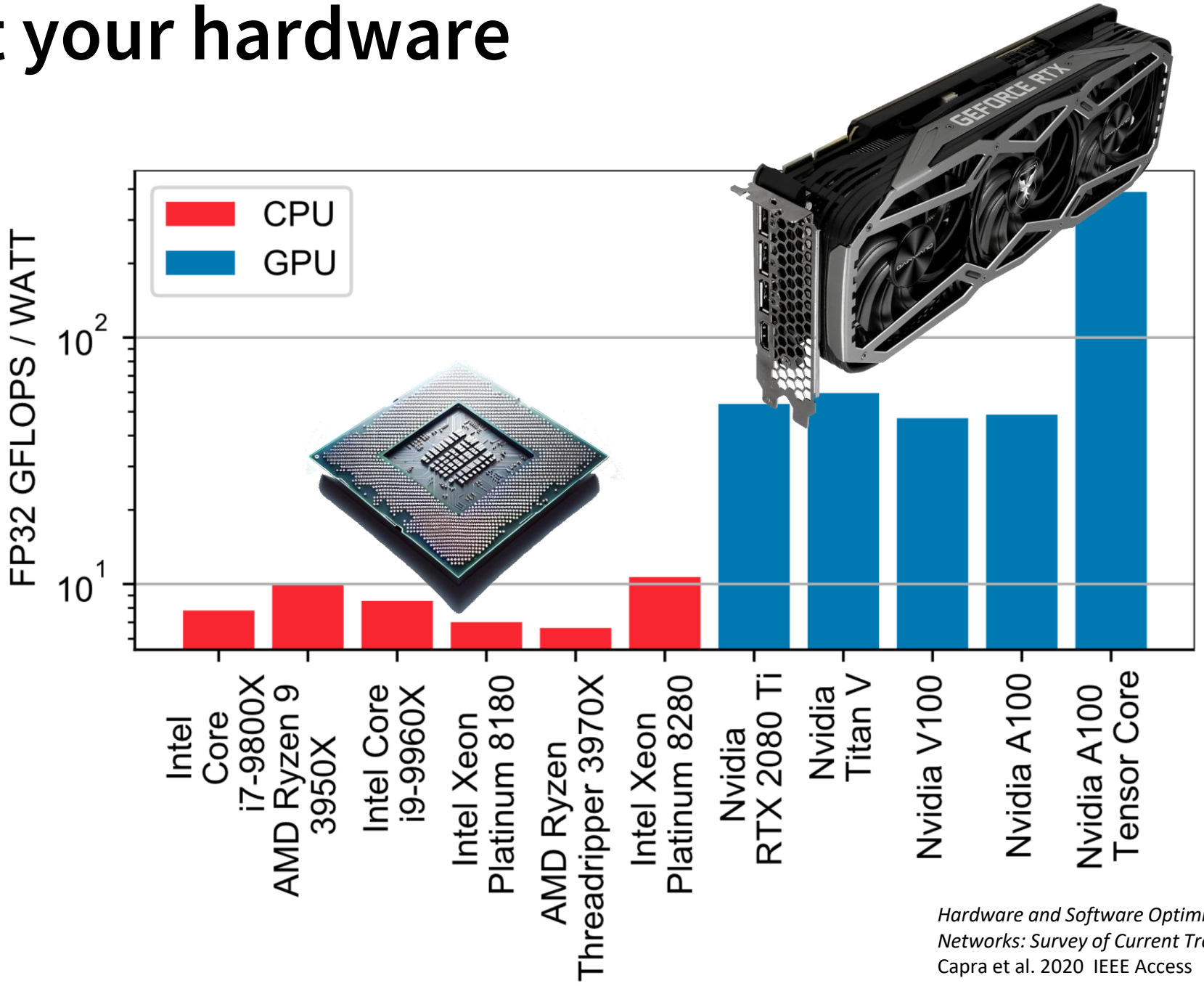


https://doi.org/10.1371/journal.pcbi.1009324.g001

Select your hardware

Graphics Processing Unit (GPU)

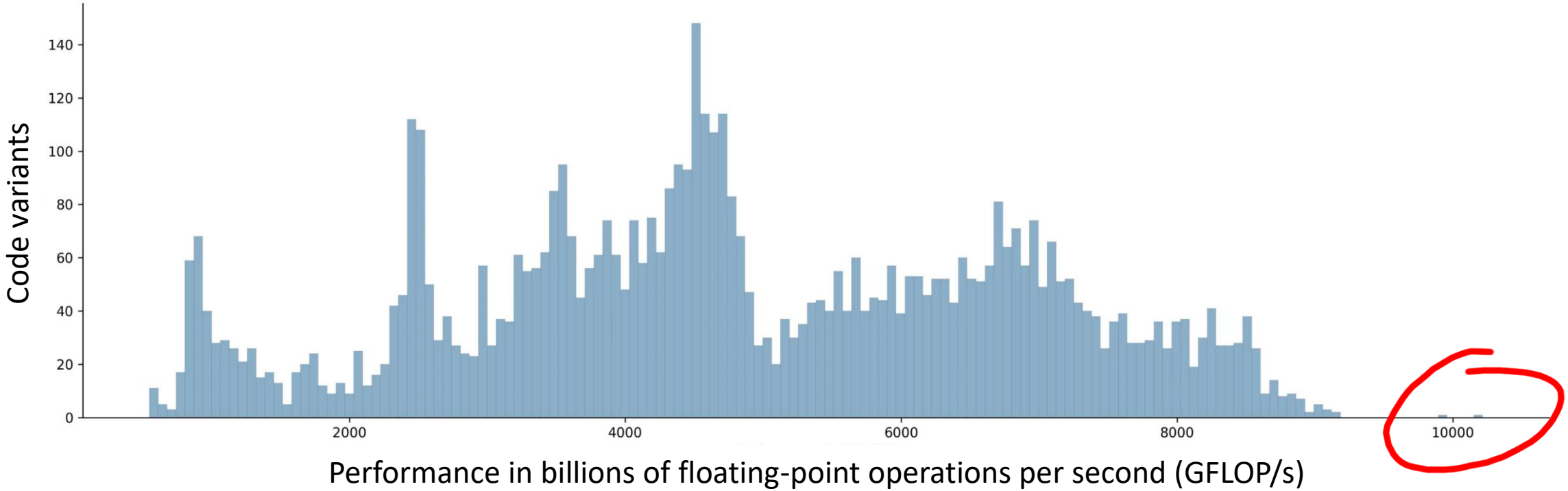
Energy Efficiency



Hardware and Software Optimizations for Accelerating Deep Neural Networks: Survey of Current Trends, Challenges, and the Road Ahead
Capra et al. 2020 IEEE Access

Optimize software to the underlying hardware

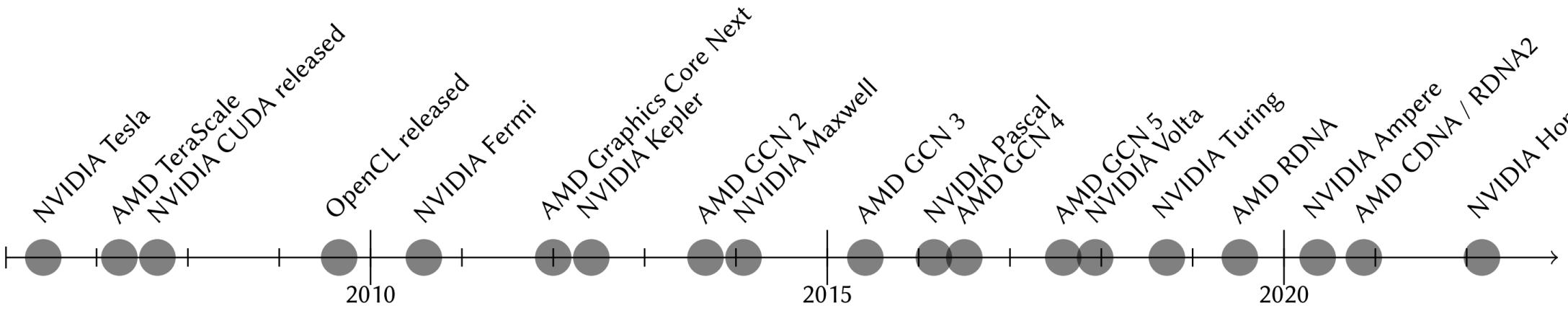
Different versions of a convolution program on an Nvidia A100 GPU



Kernel Tuner

https://github.com/KernelTuner/kernel_tuner

GPU architecture lifetimes



Average lifetime: 1.96 years

Optimization Techniques for GPU Programming
Pieter Hijma, Stijn Heldens, Alessio Sclocco, Ben van Werkhoven, and Henri E. Bal
ACM Computing surveys 2022 https://doi.org/10.1145/3570638

HPC Sustainability challenges

The three Ps:

- **P**roductivity
  - Software cannot keep up with constantly changing hardware
  - (Re)writing architecture specific code over and over is not sustainable

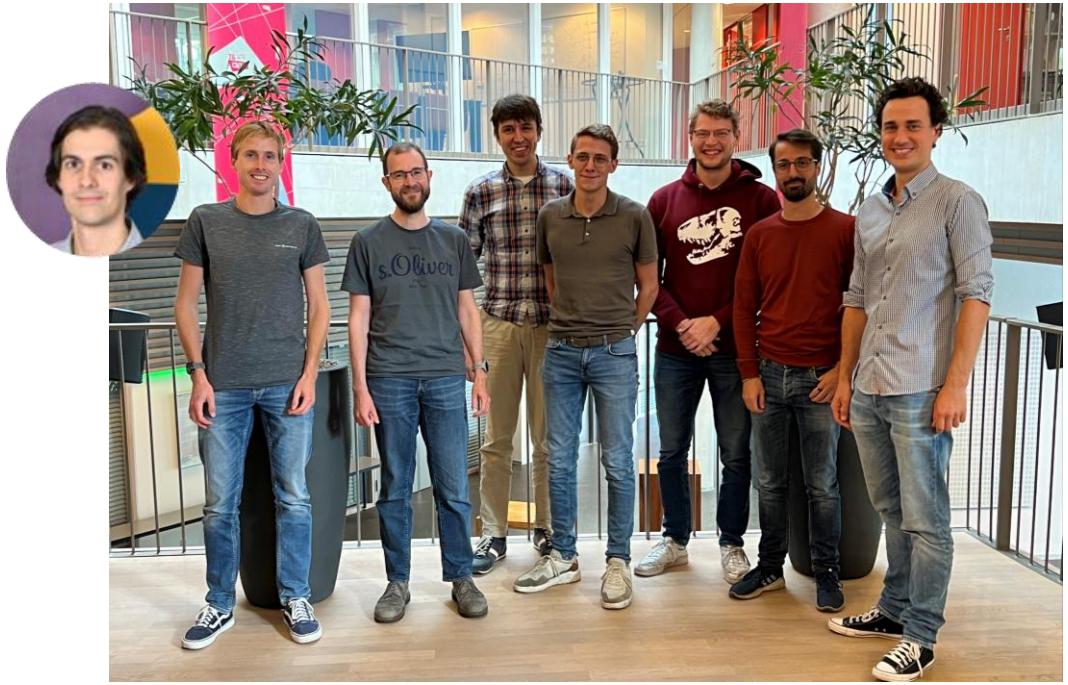
- **P**rogrammability
  - Programming models should ideally provide (performance) portability
  - Writing software that can be auto-tuned is remains challenging

- **P**erformance
  - We need tools to automate software optimization, e.g. Kernel Tuner
  - Tools to measure energy consumption, e.g. PowerSensor3

Kernel Tuner

A tool for automatic performance tuning of GPU kernels

- Developed open source (Apache 2.0)
- Funded by several national and European projects
- Used by 10+ universities & organizations
- Supports:
  - CUDA, HIP, OpenCL, C++, Fortran, OpenACC
  - 20+ search optimization algorithms
  - Energy measurement of GPU kernels
  - Many different use cases



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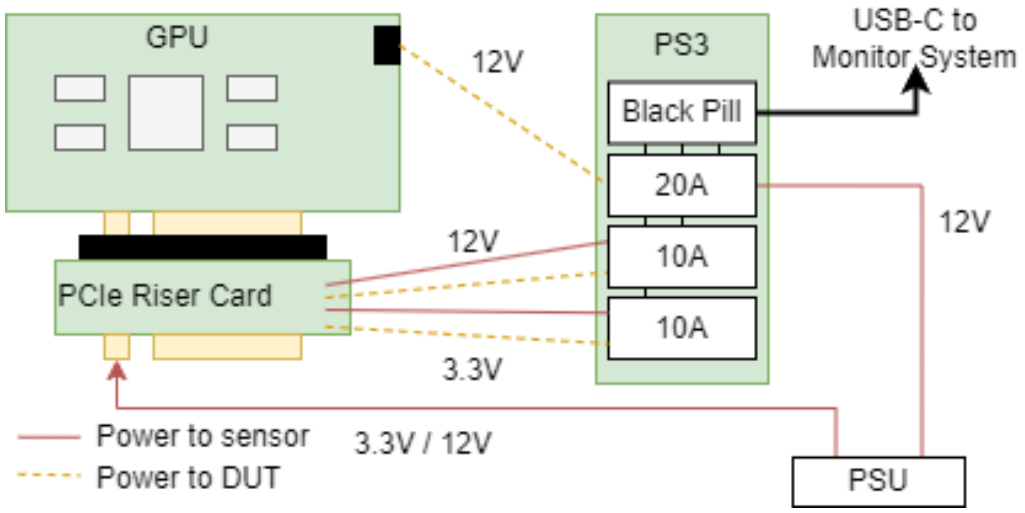
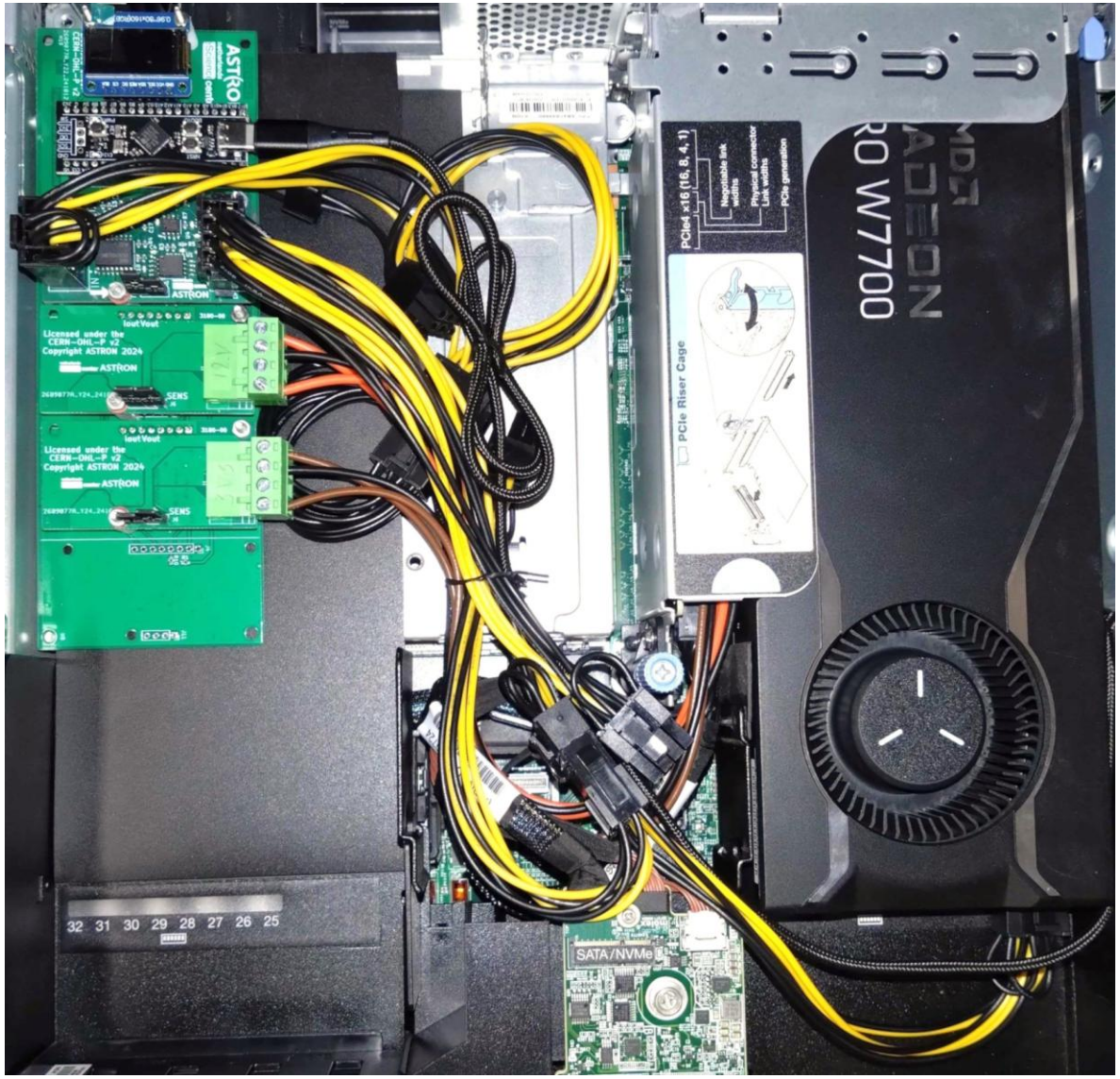
https://github.com/KernelTuner/kernel_tuner

PowerSensor3

- Fast and accurate power measurement for GPUs and other PCIe devices

- Supported within Kernel Tuner





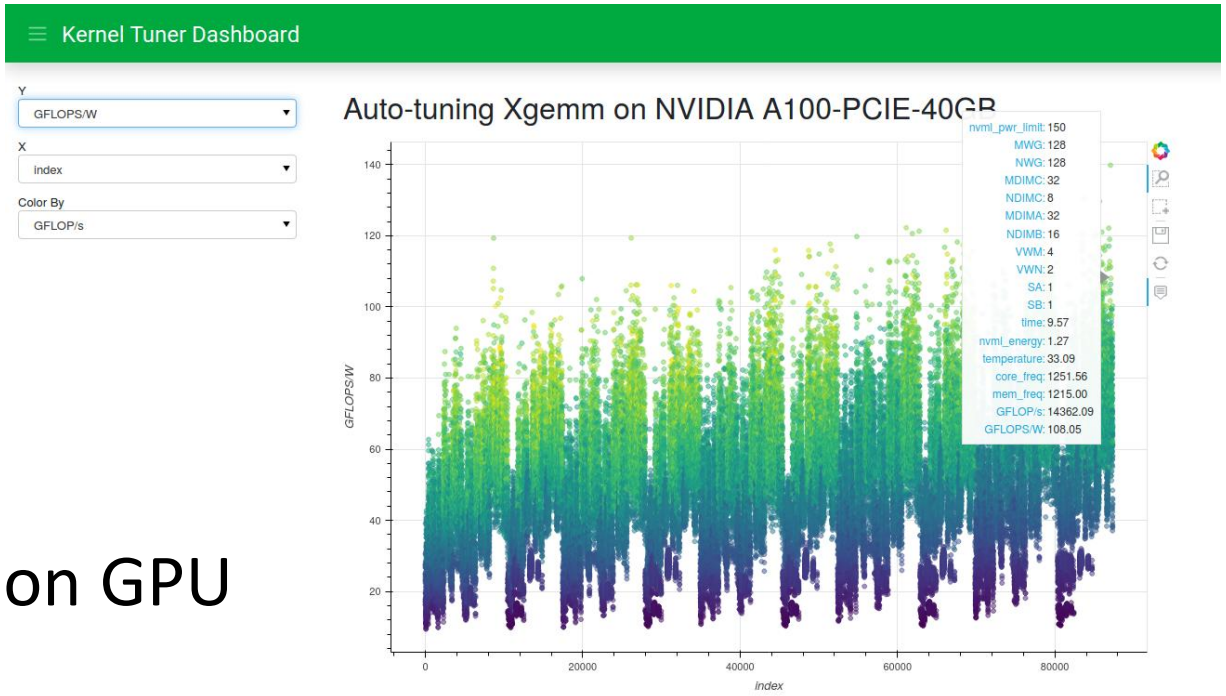
PowerSensor3: A Fast and Accurate Open Source Power Measurement Tool
S. van der Vlugt, L. Oostrum, G. Schoonderbeek, B. van Werkhoven, B. Veenboer, K. Doekemeijer, J. W. Romein. ISPASS 2025. https://arxiv.org/abs/2504.17883

Kernel Tuner ecosystem

Kernel Launcher

C++ magic to integrate auto-tuned kernels into C++ applications

Kernel Dashboard



Kernel Float

Data types for mixed-precision GPU kernel programming

https://github.com/KernelTuner/