The Exascale Challenge: are tools the key to success?

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Motivation

What are ‘tools’?

- Debuggers
  - Performance analysers
    - Code analysers
      - Simulators
        - Emulators
          - Benchmarks
            - Power monitors
              - …

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What are ‘tools’?

- Debuggers
  - Pe
    -

anything thats helps the
user/developer/sysadmin/…
understand the behaviour of
application X on
system Y

  - Power monitors
    - …

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The Exascale Challenge

- unprecedented levels of parallelism
  - vast core counts
    - reliability concerns
      - I/O and communication bottlenecks
        - heterogeneity
          - power budgets
            - algorithmic limitations
              - …

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The Exascale Challenge

- unprecedented levels of parallelism
  - va
    - algorithmic limitations
    - …

users/developers/sysadmins/…
need more in-depth understanding of the behaviour of **application X** on **system Y** **than ever before**

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CREST

Collaborative **R**esearch into **E**xascale **S**ystemware, **T**ools and **A**pplications

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The CRESTA project

- Focus on software co-design
- Leading European **HPC** centres
  - ➡ EPCC (UK), HLRS (Germany), CSC (Finland), KTH (Sweden)
- A world leading **vendor**
  - ➡ Cray UK
- World leading **tools** providers
  - ➡ TUD (Germany), Allinea (UK)
- Exascale **application** owners and specialists
  - ➡ Abo Akademi University & Jyvaskylan Yliopisto (Finland), UCL & ECMWF (UK), Ecole Central Paris (France), DLR & University of Stuttgart (Germany)

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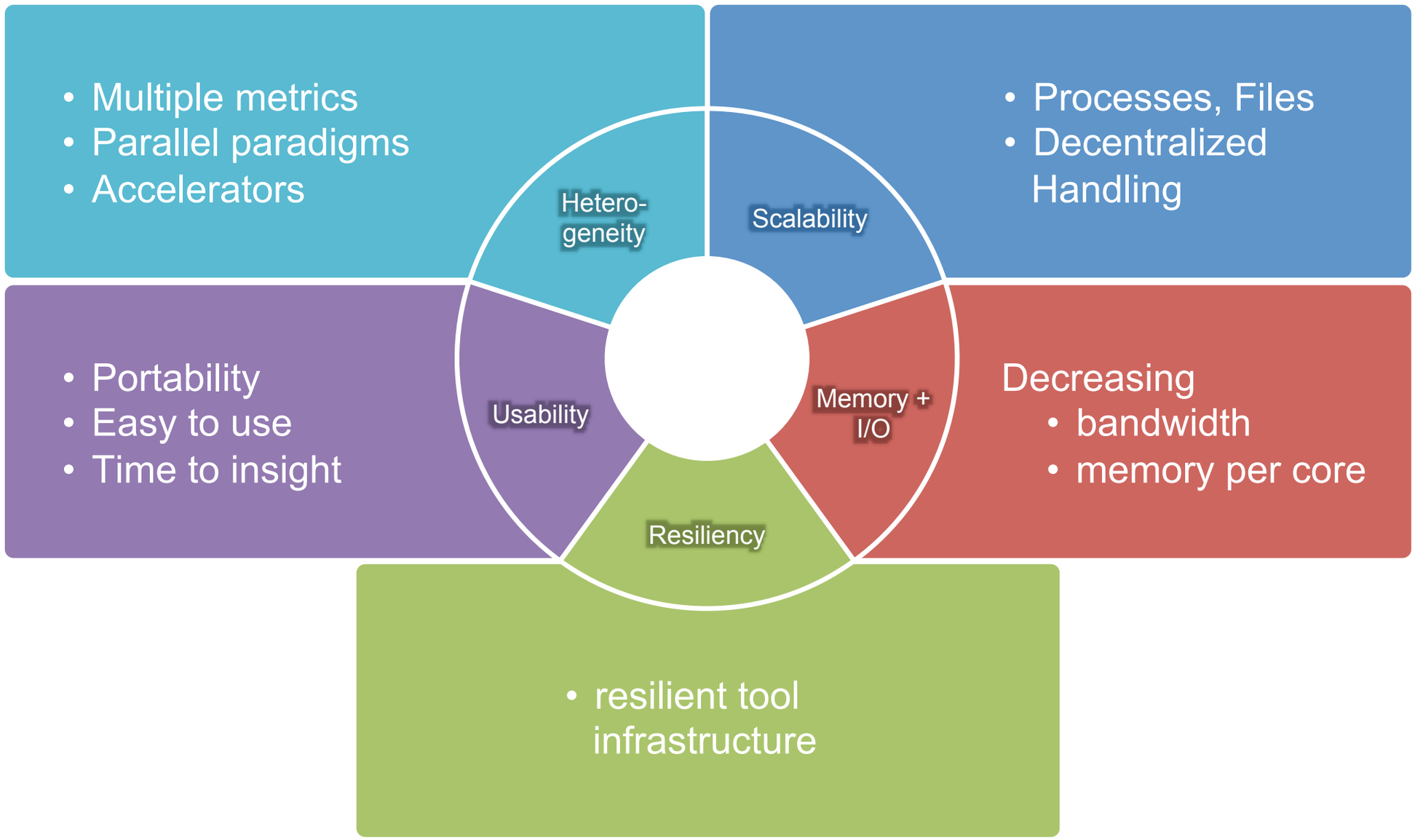
Key principles

- Co-design is at the heart of the project. Co-design applications:
  - provide guidance and feedback to the systemware development process
  - integrate and benefit from this development in a cyclical process
- Employing both incremental and disruptive solutions
  - Exascale requires both approaches
  - Particularly true for applications at the limit of scaling today
  - Solutions will also help codes scale at the peta- and tera-scales

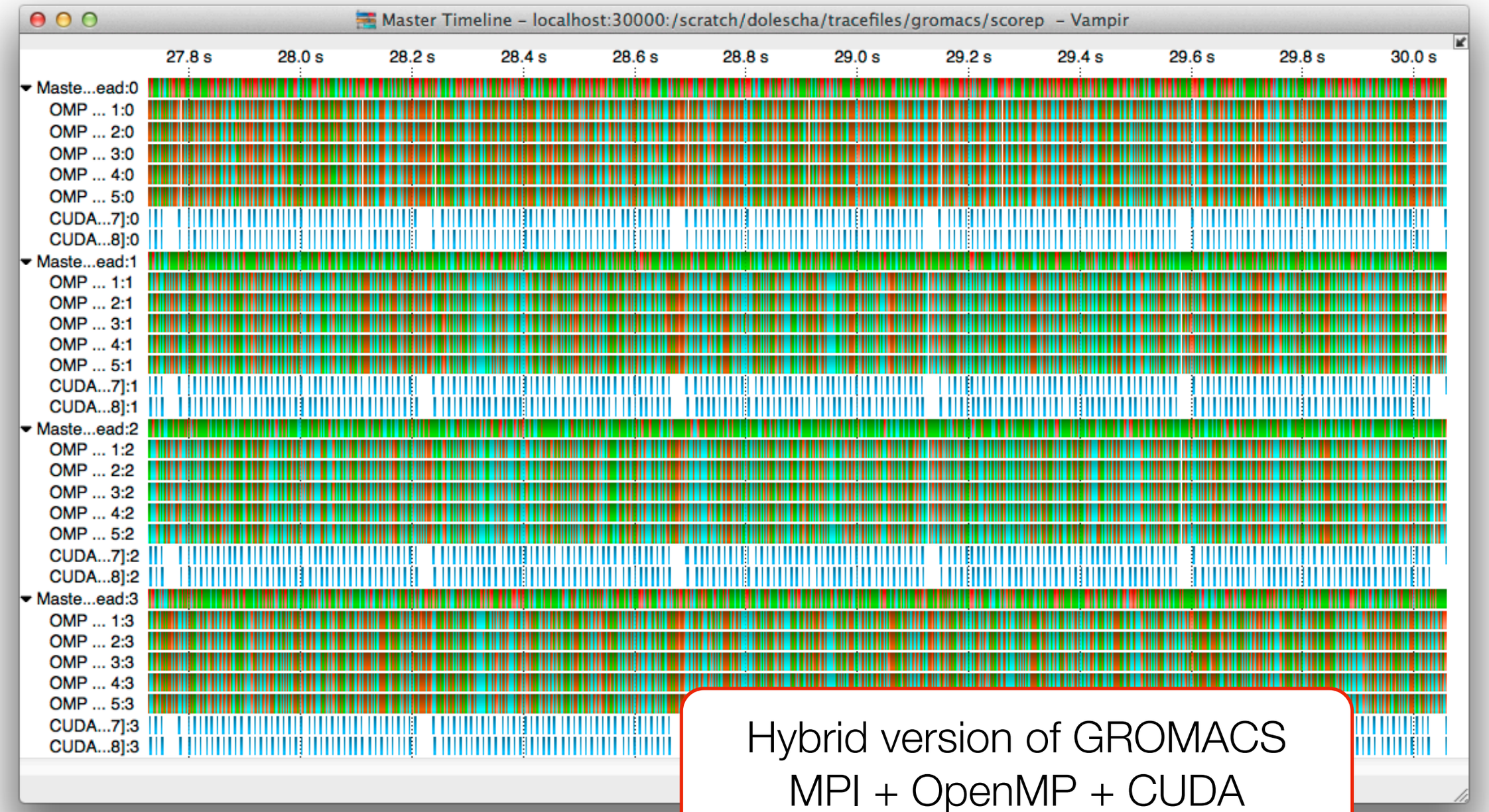
Tools in CRESTA

- investigated performance analysis, debugging at a massive scale, power usage monitoring and data visualisation
- focussed development on confirmed **user needs**
  - in co-design process with application owners

Exascale challenges for tools

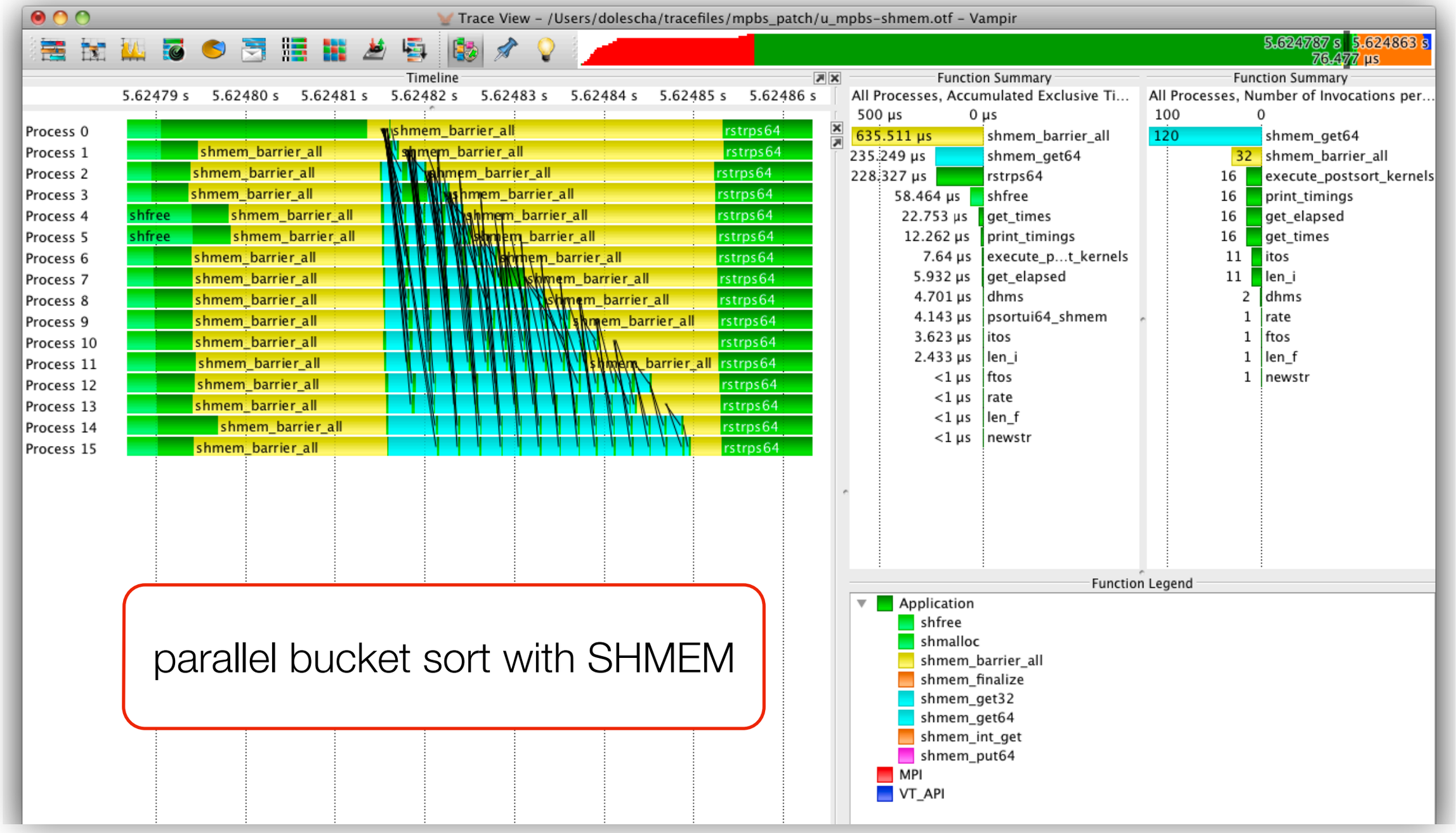


Support for heterogeneity

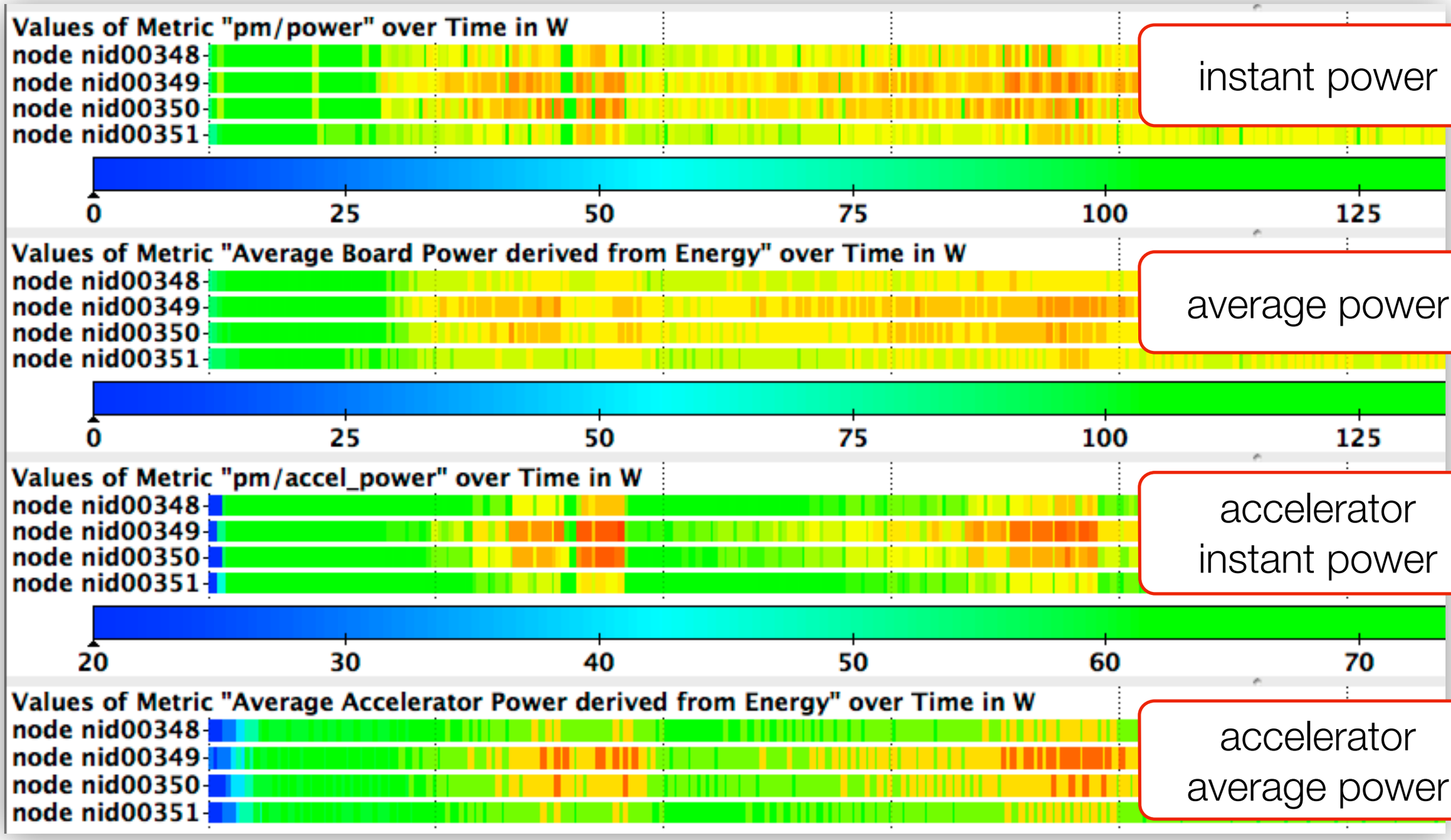


Hybrid version of GROMACS
MPI + OpenMP + CUDA

Support for PGAS



Support for power



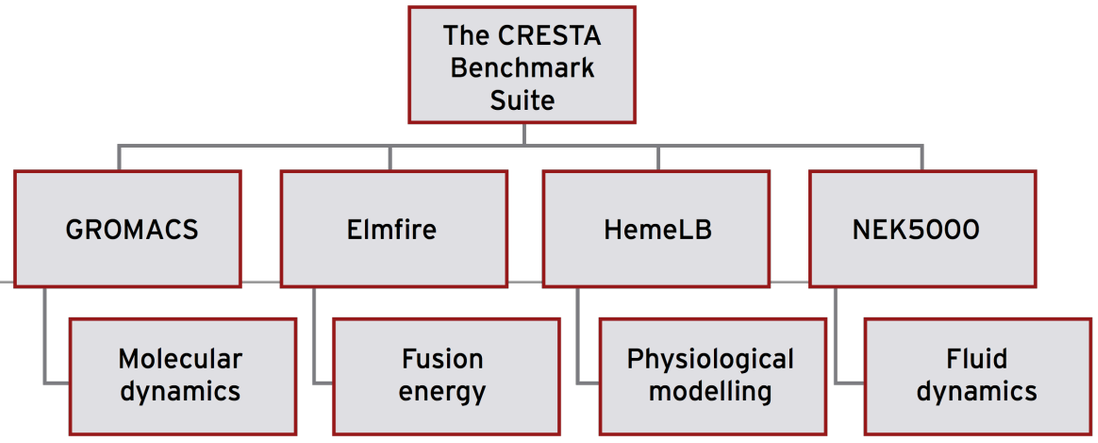
instant power

average power

accelerator instant power

accelerator average power

Benchmark Suite



- collection of CRESTA co-design applications
- test cases are ***scientifically representative*** of problems that will require Exascale computing
- simple to use benchmarking framework
  - built-in verification of results
  - easy to extend to support new test cases, platforms

➡ will be available from www.cresta-project.eu

Addressing **E**nergy in **P**arallel **T**echnologies

The Adept project

- 3-year project, started 1st September 2013
- consortium of universities and industry
- HPC **and** Embedded

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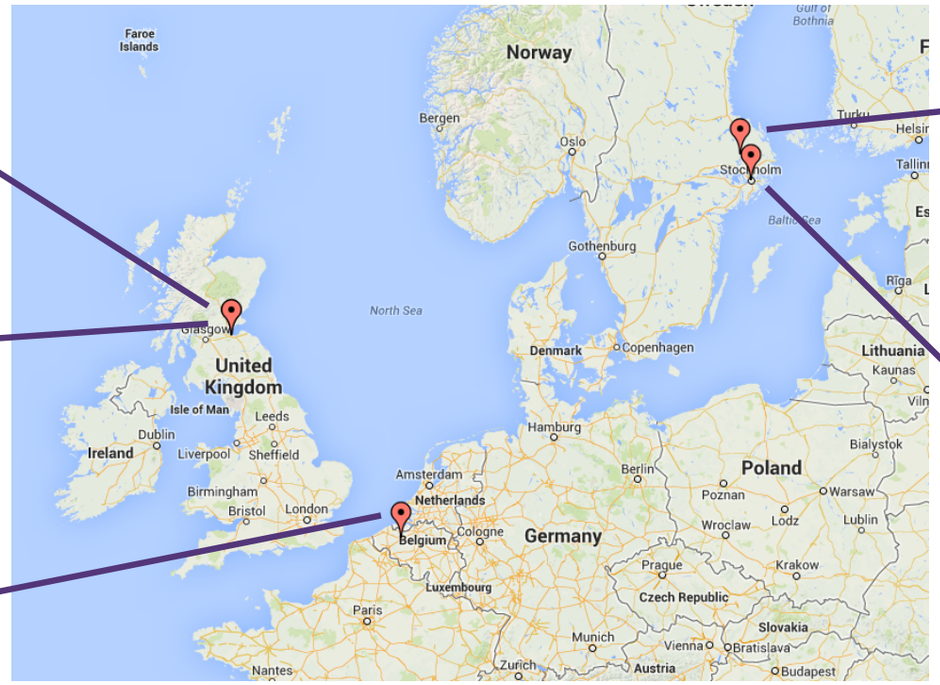
ALPHA DATA

UNIVERSITEIT GENT



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Objectives

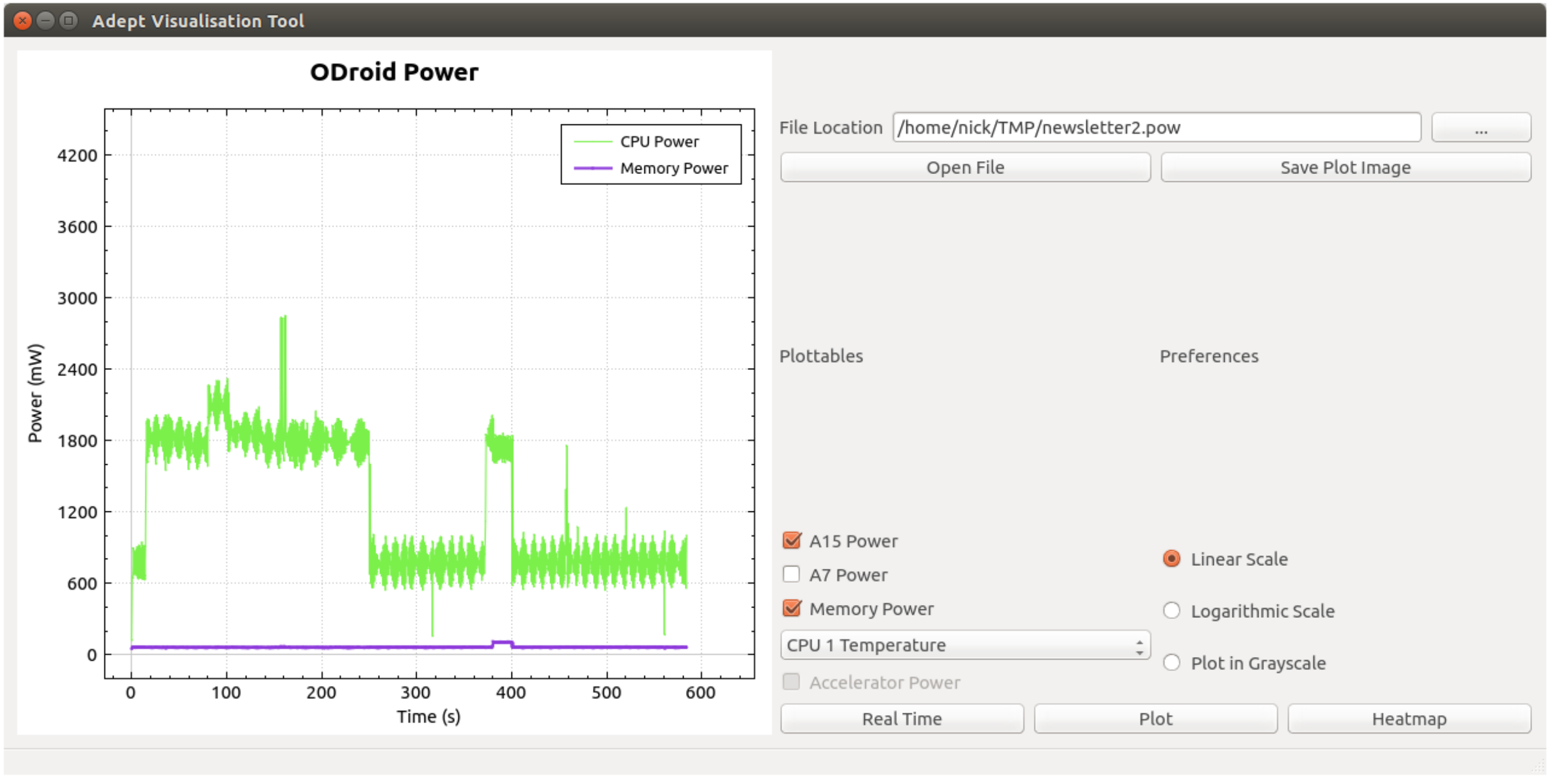
- **advance understanding** of energy usage in parallel software and hardware technologies
- develop a modelling tool to **predict** the **power** consumption and **performance** of parallel software
- influence **architecture selection** and guide **software design decisions**

Power benchmarks

- necessary to get in-depth understanding of behaviour of parallel software on parallel hardware
- developed a set of benchmark, from nano (single instructions and operations) to micro & kernel (e.g. memory operations, stencils) to applications (e.g. BFS)

Michèle Weiland and Nick Johnson. "**Benchmarking for power consumption monitoring**". Springer Computer Science – Research and Development, 2014. DOI: 10.1007/s00450-014-0260-1.

Visualisation tool



Power & performance prediction

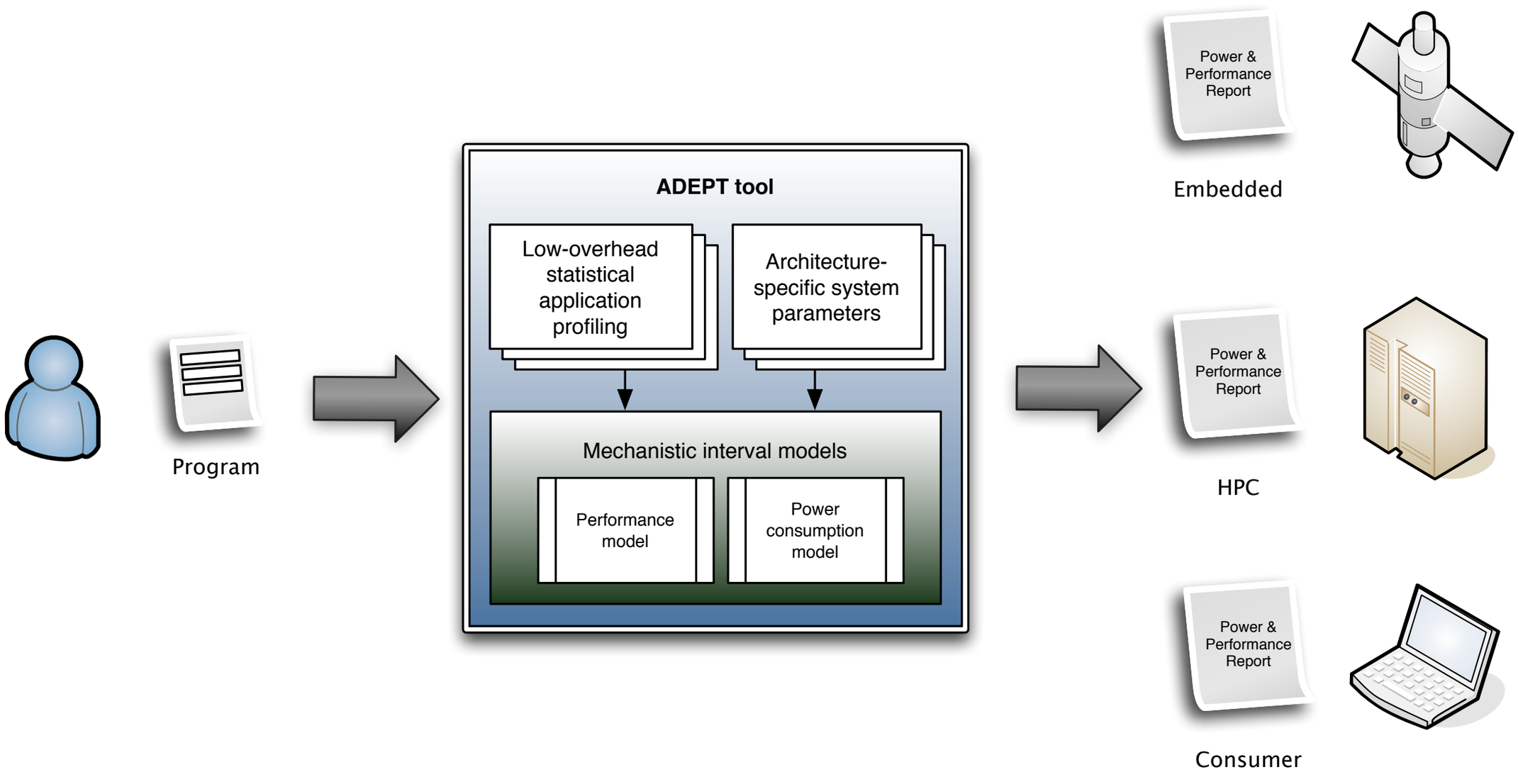
information from single execution

micro-architecture independent

performance and power

low-overhead, fast

Basic concept



Prototype tool

- first prototype being tested internally
  - currently limited to single-threaded applications
- multi-threaded applications targeted next
  - correct modelling of shared components crucial
- early results exist, but cannot be shown here… paper currently under review

User perspective on status of tools

- often still difficult to use, and support for new features does not make this easier
- tools are (rightly) specialised, thus users need well equipped **toolbox** to tackle a range of problems
- vast amounts of data which are difficult to handle even at current scale
- similarly vast amounts of information need to be navigated and nuggets of valuable knowledge extracted

Conclusions

- projects like CRESTA help a great deal with usability and features
  - tools providers work directly with users and implement features that users want and will use
- projects like Adept explore a new space for tools
  - prediction for rapid design space exploration
  - as part of **both** hardware and software design processes

- the Exascale challenge means users will have to rely more than ever before on a wide range of tools

Thanks go to…

Jens Doleschal and **Tobias Hilbrich** from TUD

Stijn Eyerman from Ghent University

…and everyone else in the **Adept** and **CRESTA** projects!

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Please come and speak to us

EPCC - Booth #3445

European Exascale Projects - Booth #1039

Tuesday 18th November 10:00am
Erik Lindahl from the KTH Royal Institute of Technology will be present to describe the key outcomes for the GROMACS code.

Tuesday 18th November 12:00 noon
Harvey Richardson from Cray UK will be discussing auto-tuning technology in combination with a directive-based GPU programming approach to tune the Nek5000 fluid-dynamics solver.

Tuesday 18th November 3:00pm
Tobias Hilbrich from The Center for Information Services and High Performance Computing (ZIH) at TU Dresden (TUD) will share insights into Exascale enabled tools for performance and correctness analysis. He will showcase them with the Vampir performance optimization tool suite.

Wednesday 19th November 11:00am
Achim Basermann from DLR, Germany's national research center for aeronautics and space, will be present to discuss the pre- and post-processing as well as remote hybrid rendering tools developed to support exascale applications.

Wednesday 19th November 3:00pm
Michele Weiland from EPCC at the University of Edinburgh will be available to discuss the CRESTA benchmark suite, a suite designed to collate CRESTA's co-design applications into a unified framework to automate compilation, executions, results gathering and verification.

Thursday 20th November 11:00am
Mark O'Connor from Allinea will be present to showcase Allinea's DDT, their global standard for high-impact debugging. He will be able to provide insight into the developments required debugging at the Exascale.

ESPT workshop @SC14, 17th November 2014

EXASCALE APPLICATIONS AND SOFTWARE CONFERENCE

EDINBURGH, UK, 21ST-23RD APRIL 2015

ORGANISED BY EPCC AT THE UNIVERSITY OF EDINBURGH, IN COOPERATION WITH SIGHPC

www.easc2015.ed.ac.uk

The aim of this conference is to bring together all of the stakeholders involved in solving the software challenges of the exascale. The following keynote presentations have been confirmed:

- **Mark Taylor**, Head of CFD at McLaren Racing, will discuss the use of **HPC in Formula 1 racing** and the challenges faced in this industrial area as we head towards the exascale.
- **Simon Portegies Zwart**, Professor of Computational Astrophysics at Leiden University will present **massively parallel GPU-accelerated galaxy simulations** which have been nominated for the 2014 Gordon Bell prize.
- **Pete Beckman**, Director of the Exascale Technology and Computing Institute at Argonne National Laboratory, will provide an update on recent progress in the US with a particular focus on **software for the exascale.**
- **Xue-feng Yuan**, Director of The National Supercomputer Centre at Guangzhou, will describe the experience of **managing Tianhe-2, the world's largest supercomputer.**
- **Cynthia McIntyre**, Senior Vice President, Council on Competitiveness, will focus on the **value of HPC engagement with industry.**

The conference seeks contributions in the form of an abstract on relevant topics.

Please see www.easc2015.ed.ac.uk for further details.

acm In-Cooperation

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Questions?

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