PHYSICS SOFTWARE ENGINEERING

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Physics Software Engineering: Functional overview

The Physics Software Engineering Section works on novel software engineering concepts and computing hardware performance aspects of commonly used algorithmic data processing applications in high energy physics (HEP) and provides support and opportunities for skills development and visibility of software engineers and computing experts in relevant activities.

Frontier Technologies and Initiatives

- Collaborations and Partnerships
- **Physics Software Engineering**
- Computing and Data Science
- Technology Infrastructures
- Communications and Outreach
- Learning and Education

KEY ROLES & RESPONSIBILITIES

- Improve the performance of software applications commonly used in the HEP community by adopting new computing hardware architectures and engineering techniques
- Investigate and evaluate innovative computing architectures and software engineering concepts for their usability in the domain of physics data processing
- Measure and enhance the sustainability of HEP software at the level of the individual application on current and future heterogeneous computing architectures
- Boost the career paths of research software engineers and scientists via specialised training and recognition of their work in the field

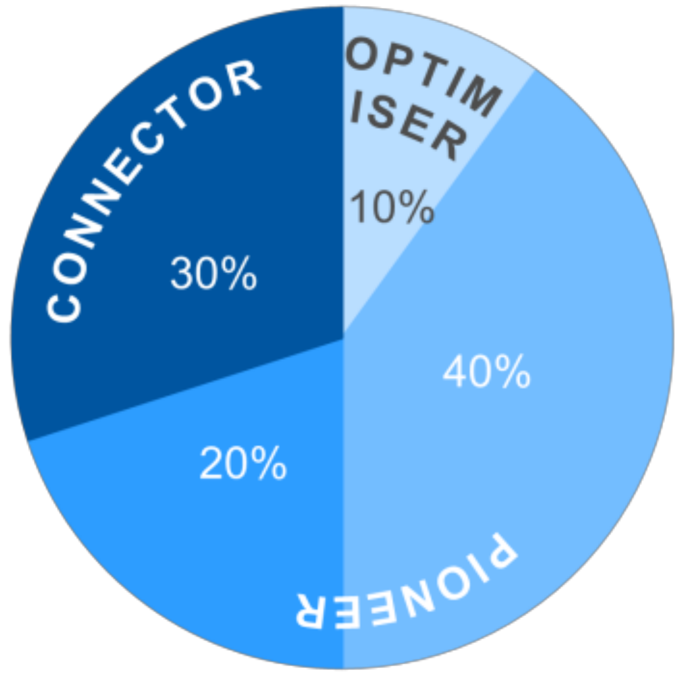
MEASURES OF SUCCESS

- Adoption of software packages within the HEP community, in particular the LHC experiments and their usage on novel computing hardware platforms
- Improvements in data processing challenges of forthcoming data taking periods based on solutions provided by the Section
- Increased adoption of novel software engineering techniques, tools and platforms within the physics software engineering community
- Improved skills development, especially students and early career researchers, training resources and recognition mechanisms

KEY CAPABILITIES

- Technology Assessment
- Collaboration
- Innovation
- Training and Recognition
- Impact on physics data processing

ROLES FRAMEWORK



GOVERNANCE STRUCTURES

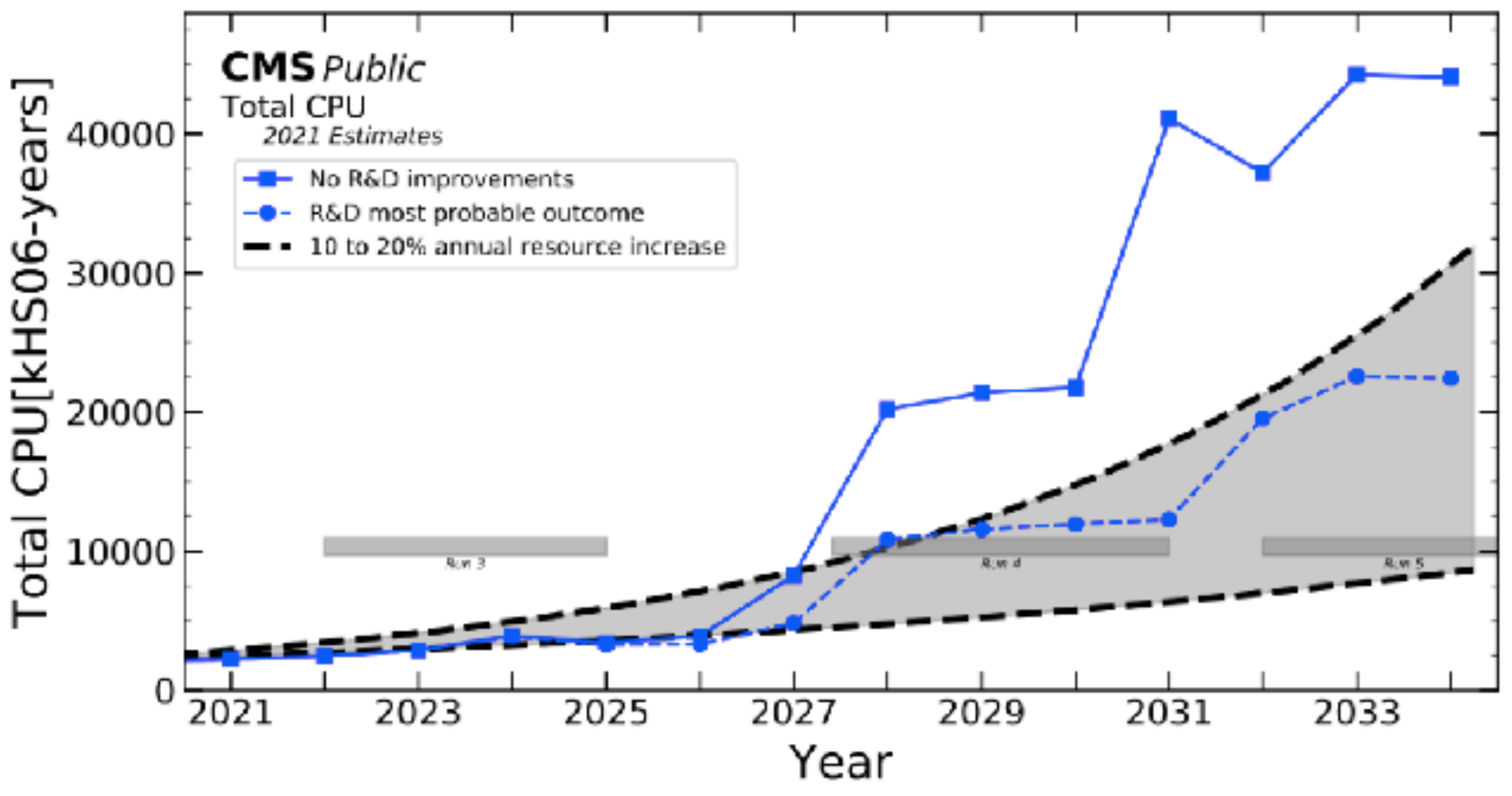
- Bi-weekly Section leaders meetings
- Weekly section meetings to assess status and plans
- Regular meetings with projects and collaborations (CERN EP + TH, NGT, LHC MC WG, MCNet, HSF, ICFA, JENA, EIROforum, EVERSE, SYCLOPS, …)

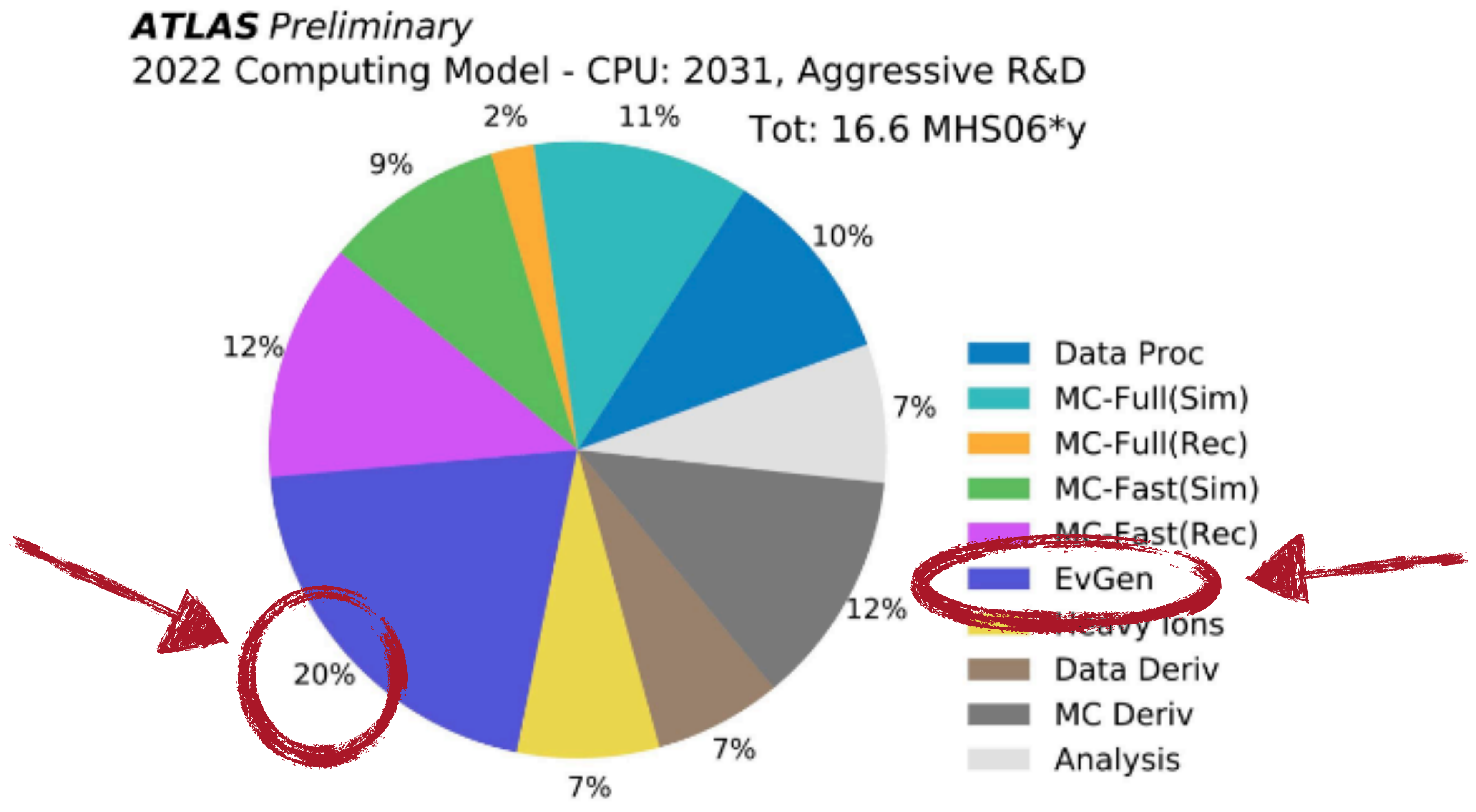
PAIN POINTS ADDRESSED

- Communicating the role CERN IT plays in fostering a culture of continuous improvement and cutting-edge solutions more clearly
- Improve integration and exchanges across the RCS sector on software engineering and code development for physics

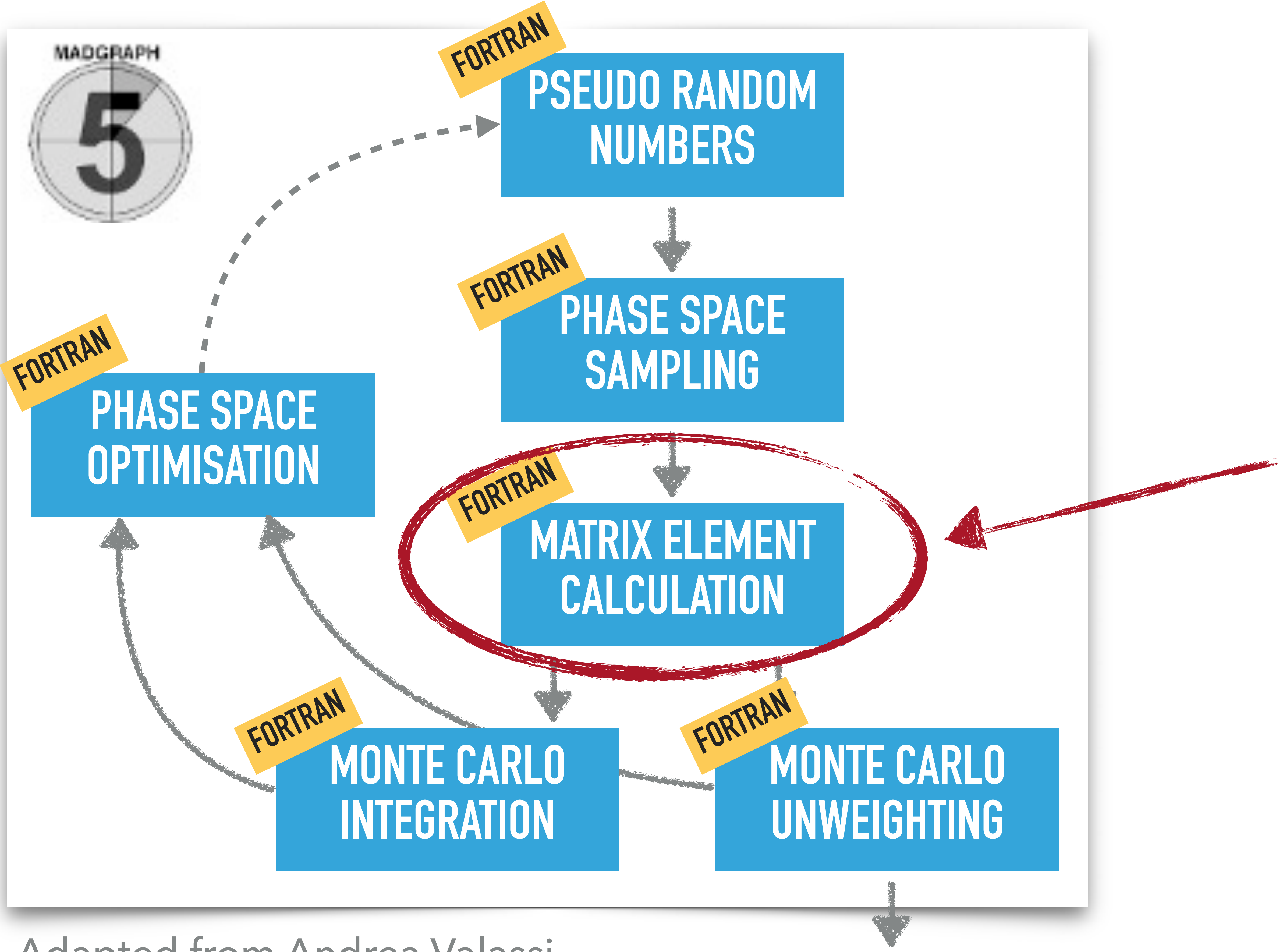
HARDWARE ACCELERATION OF PHYSICS SOFTWARE APPLICATIONS

- Monte Carlo Event Generation will use considerable compute resources during HL-LHC, due to
  - increased number of simulated events
  - higher precision of calculations
- Strategy: overcome shortcomings by hardware acceleration
  - Via vector instructions on CPUs (SIMD)
  - Parallel execution on GPUs (SIMT)
- Status: A hardware accelerated release for leading-order calculations of Madgraph5_aMC@NLO is available for use by the experiments





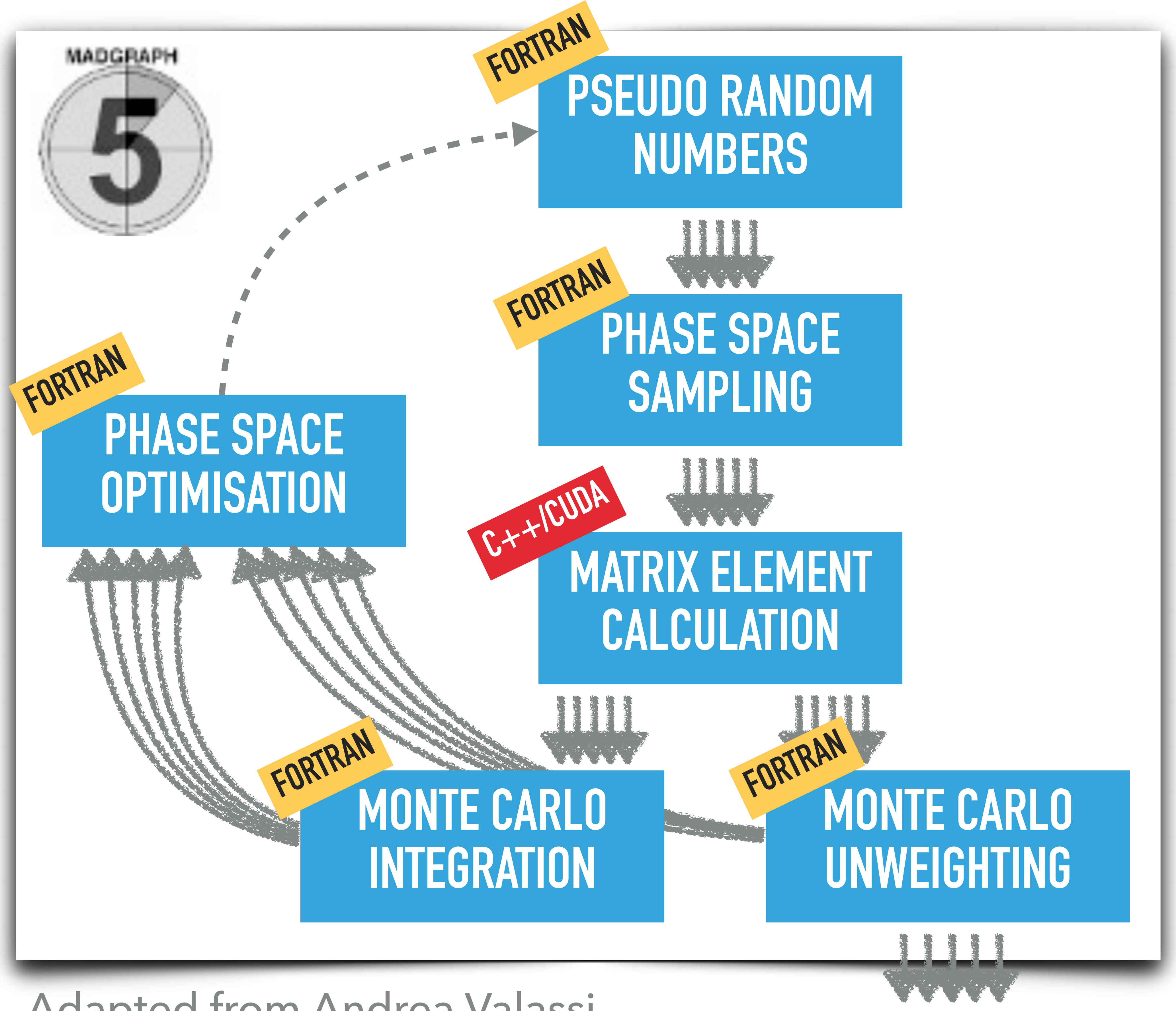
MADGRAPH5_AMC@NLO



Adapted from Andrea Valassi

up to 99% of CPU time

MADGRAPH5_AMC@NLO



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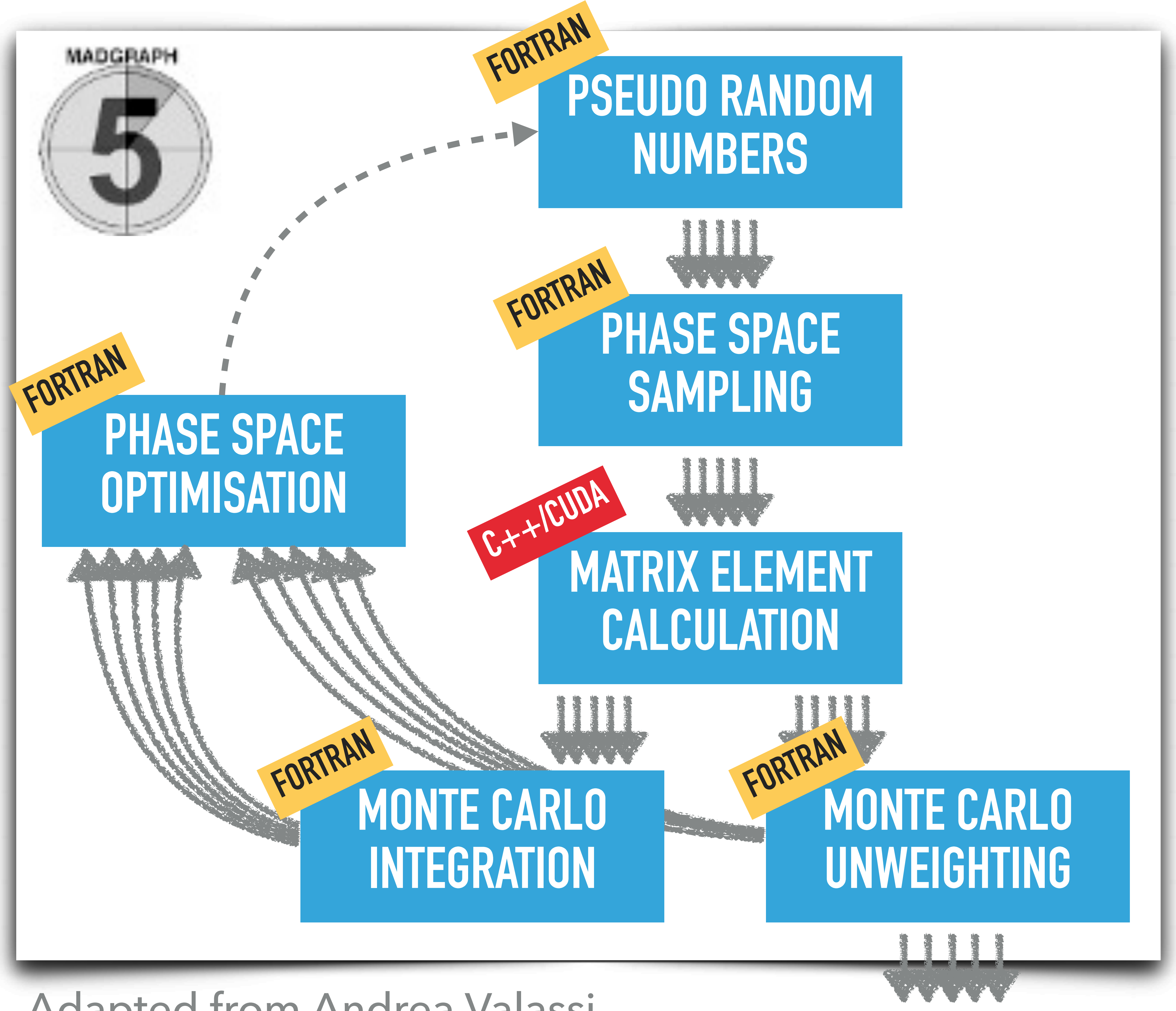

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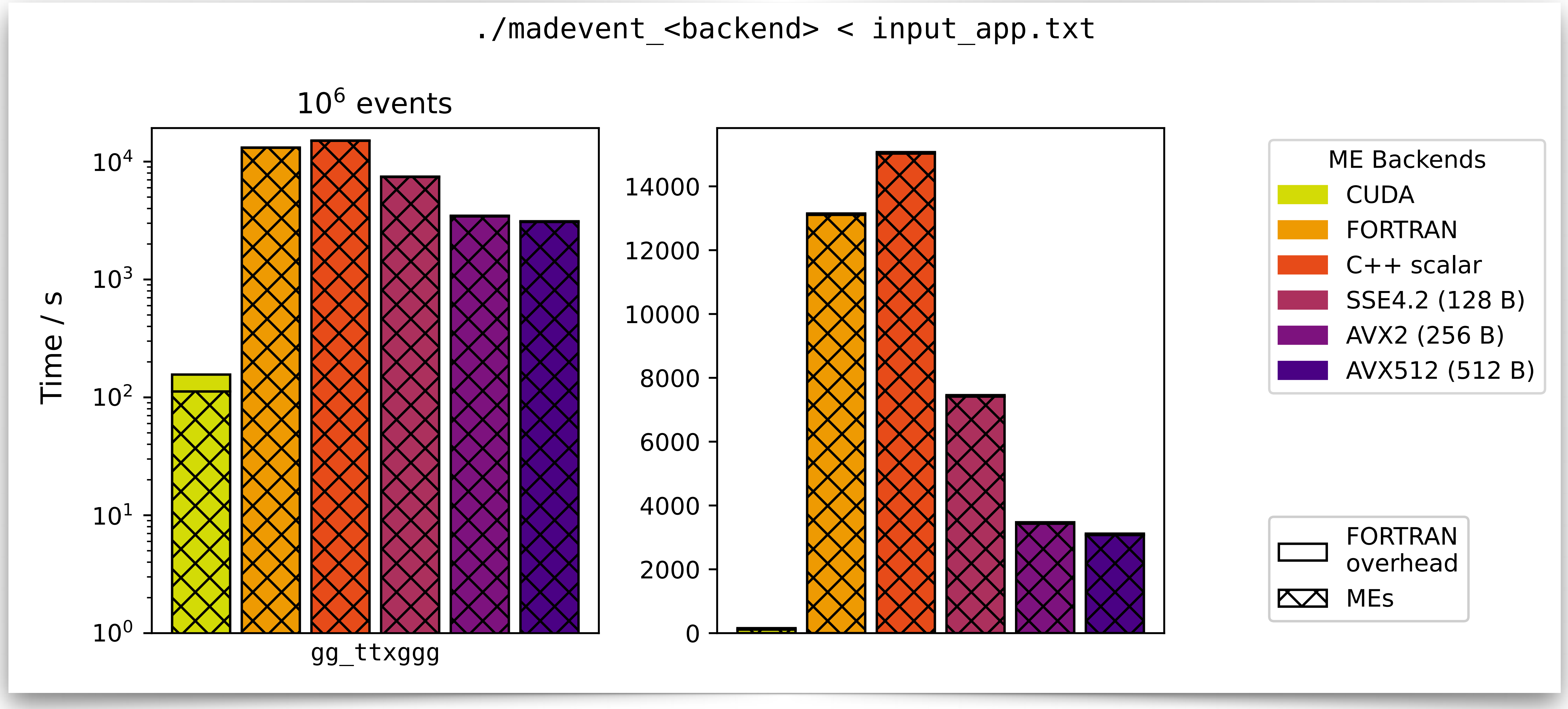
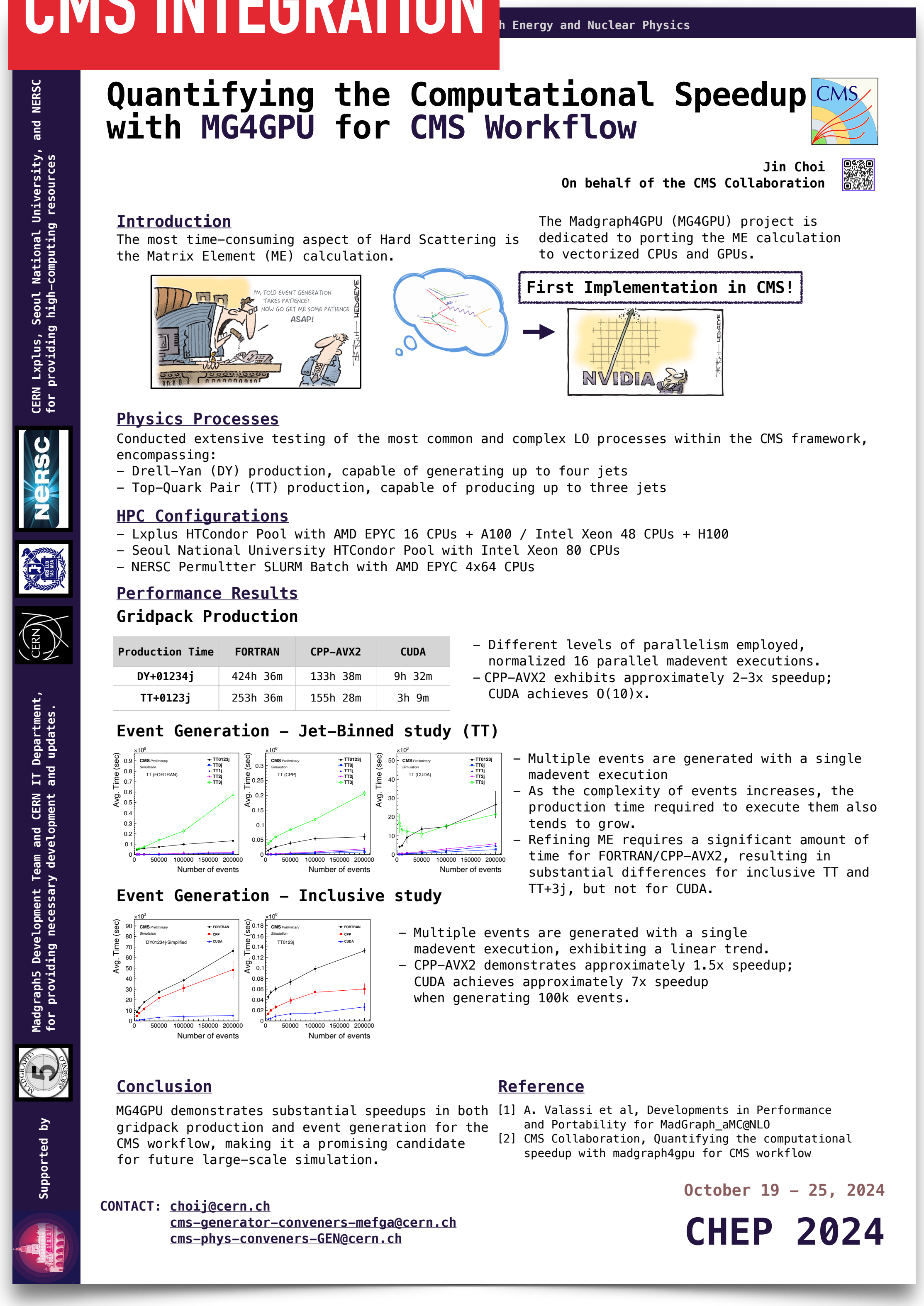


Daniele Massaro

(RE-)USE OF WORK ON MADGRAPH HARDWARE ACCELERATION

CMS INTEGRATION

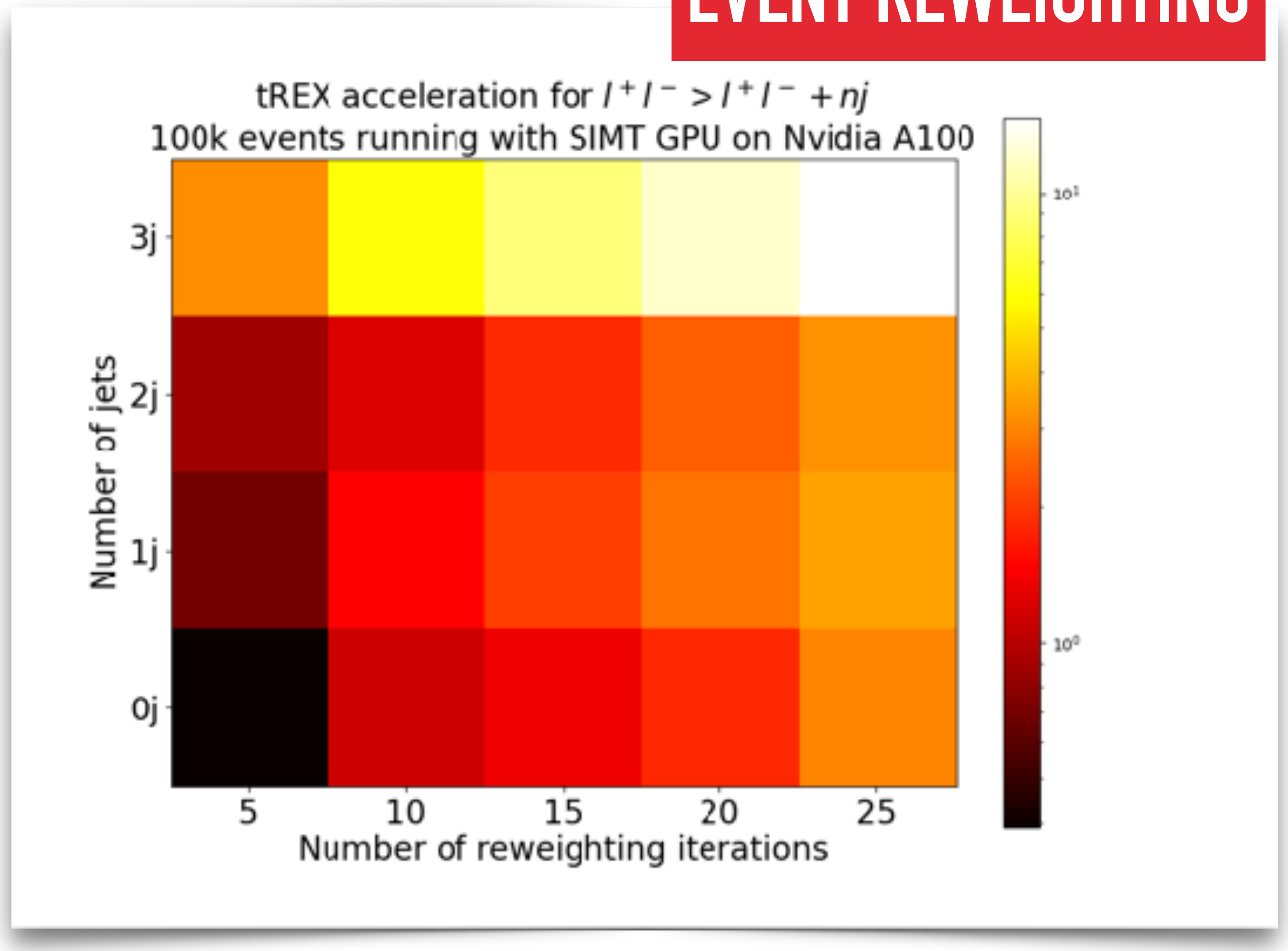


CHEP 2025, Krakow
J Choi, S Bhattacharya (CMS)

QUANTUM ALOGORITHMS
IBM, SOFIA, MICHELE

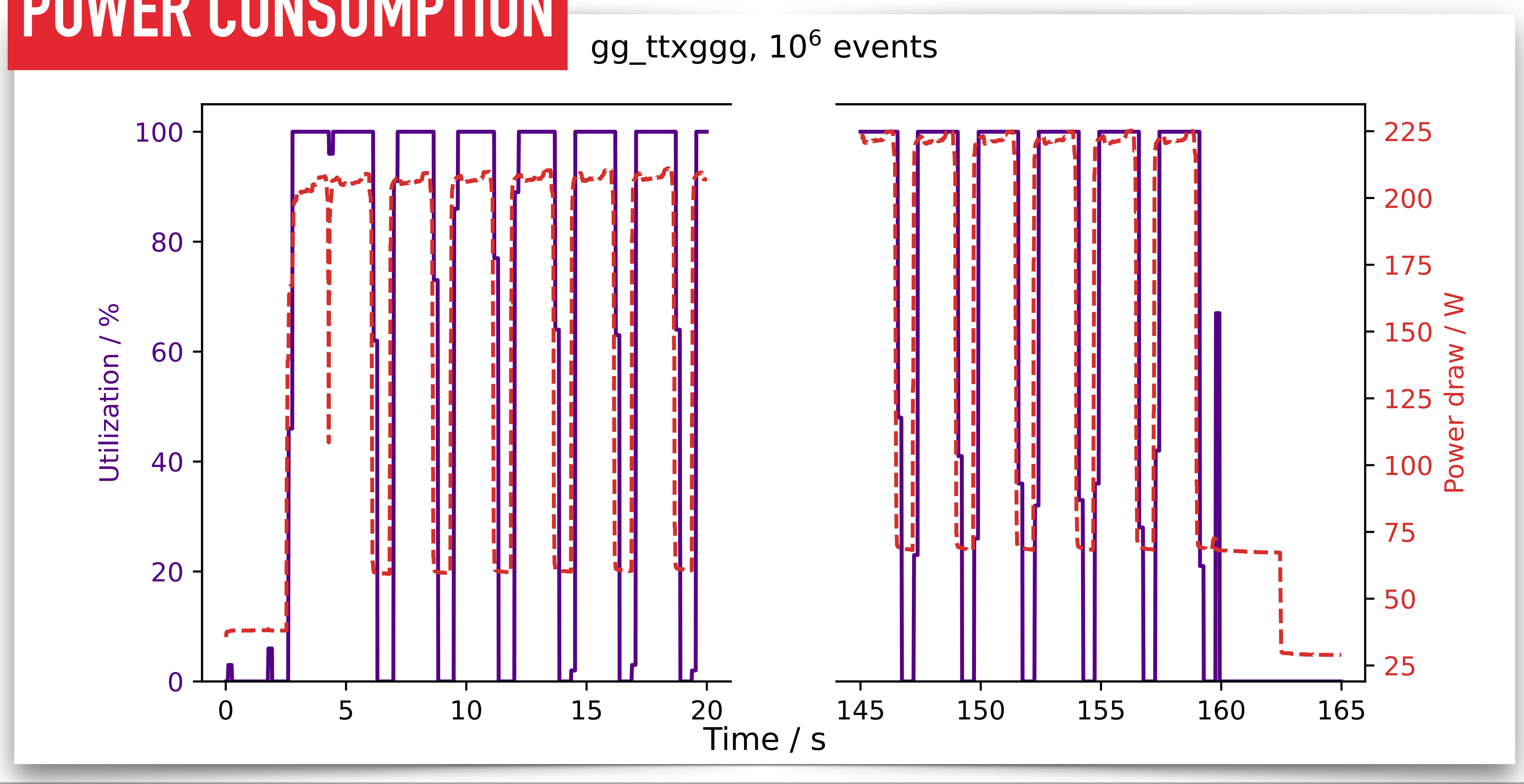
RE-USING MATRIX ELEMENTS
POWHEG COLLABORATION

EVENT REWEIGHTING

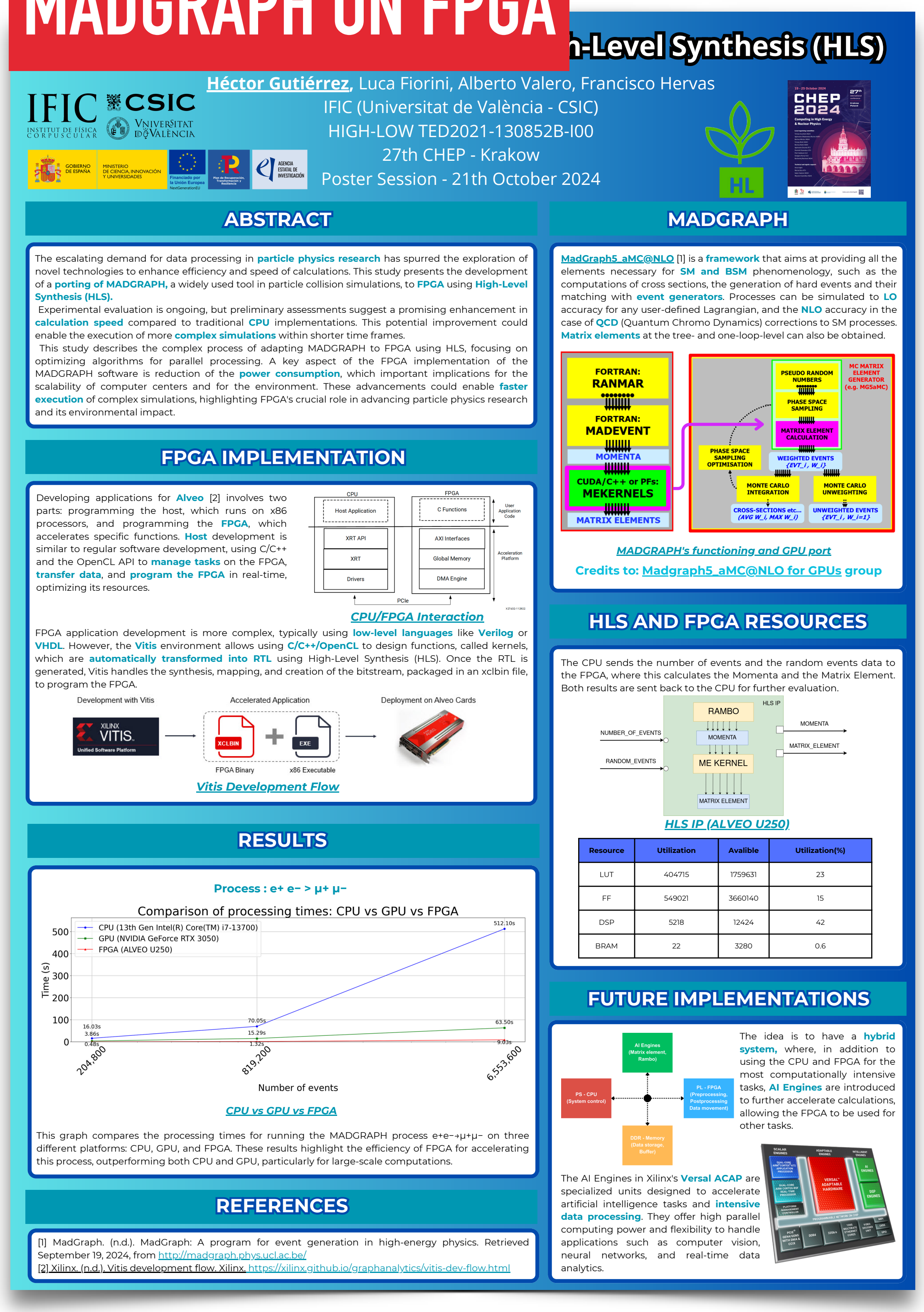


Zenny Wettersten

POWER CONSUMPTION



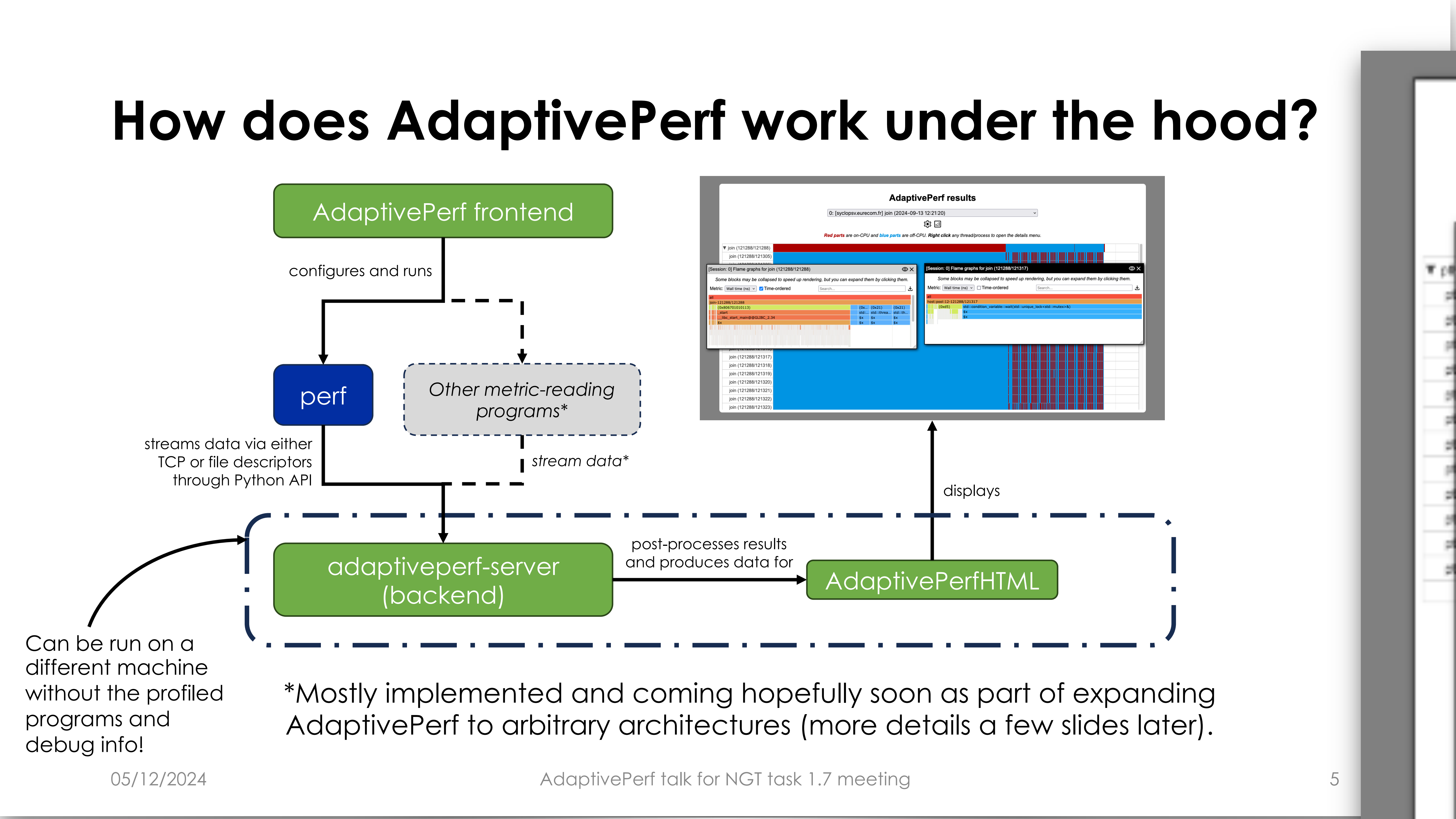
MADGRAPH ON FPGA



CHEP 2025, Krakow
Héctor Gutiérrez et al. (Valencia)

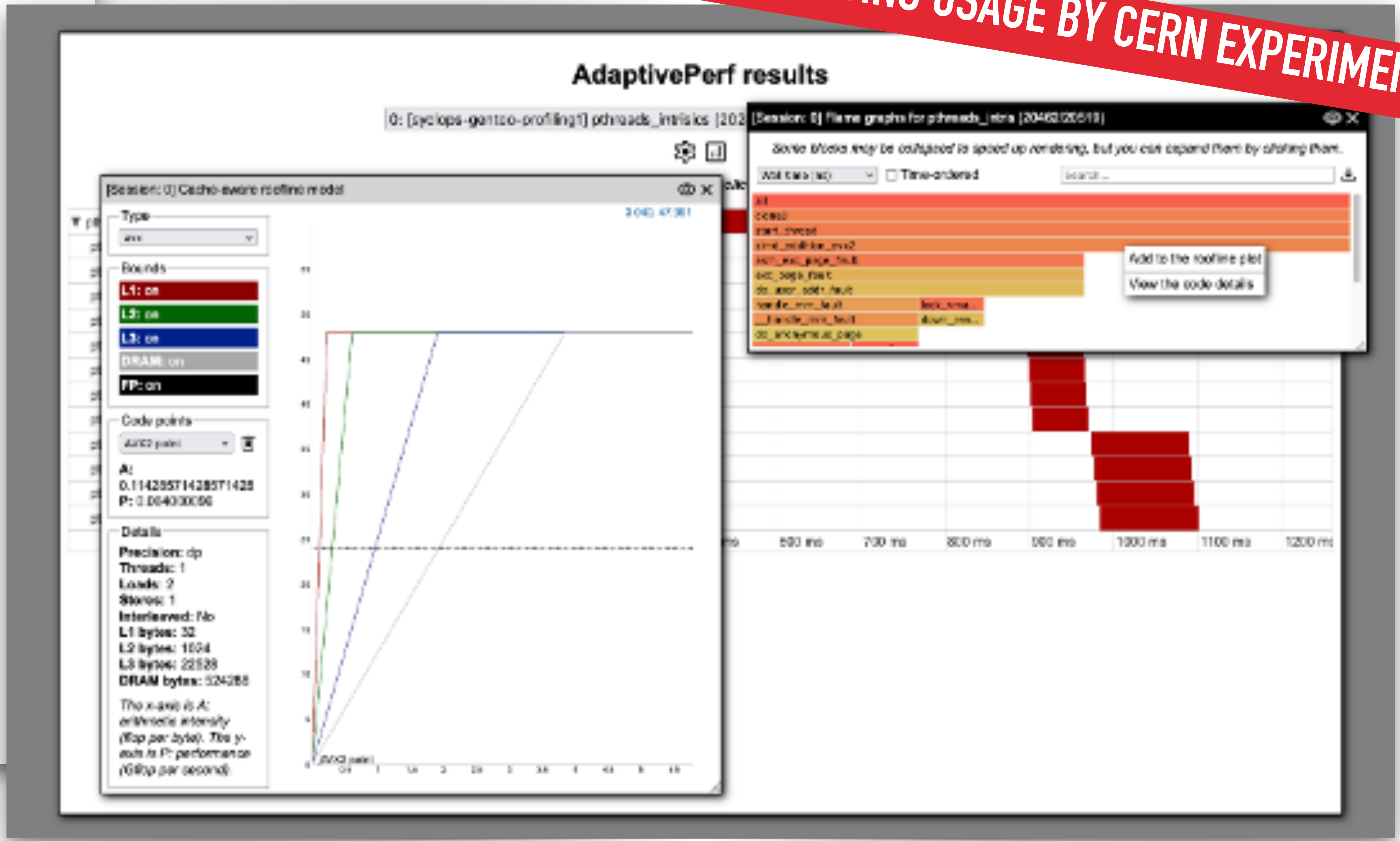
SYCLOPS

- Project on hardware acceleration with open standards, based on SYCL and RISC-V
- Involvement in work package on performance profiling and integration



Maks Graczyk

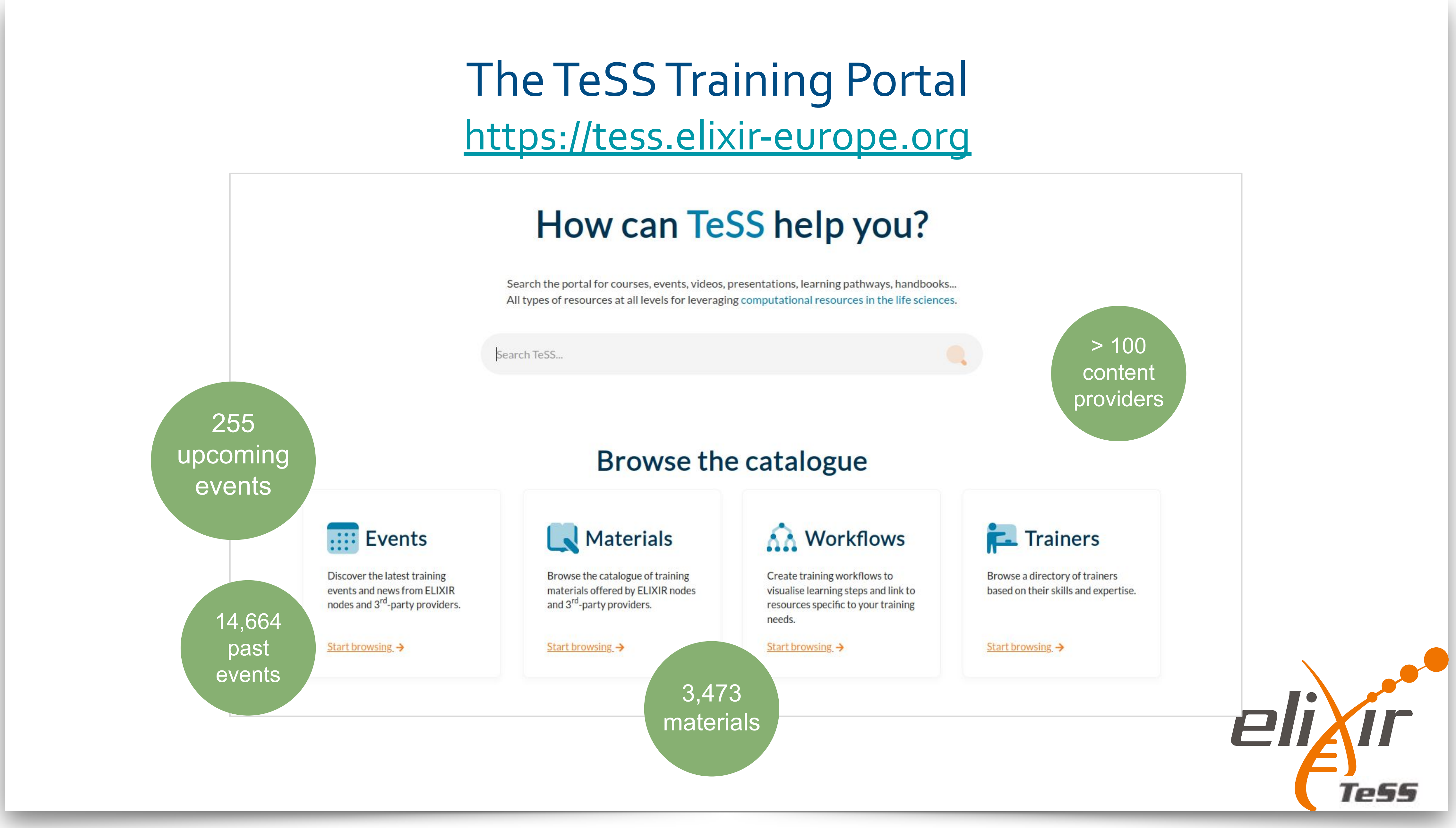
DISCUSSING USAGE BY CERN EXPERIMENTS

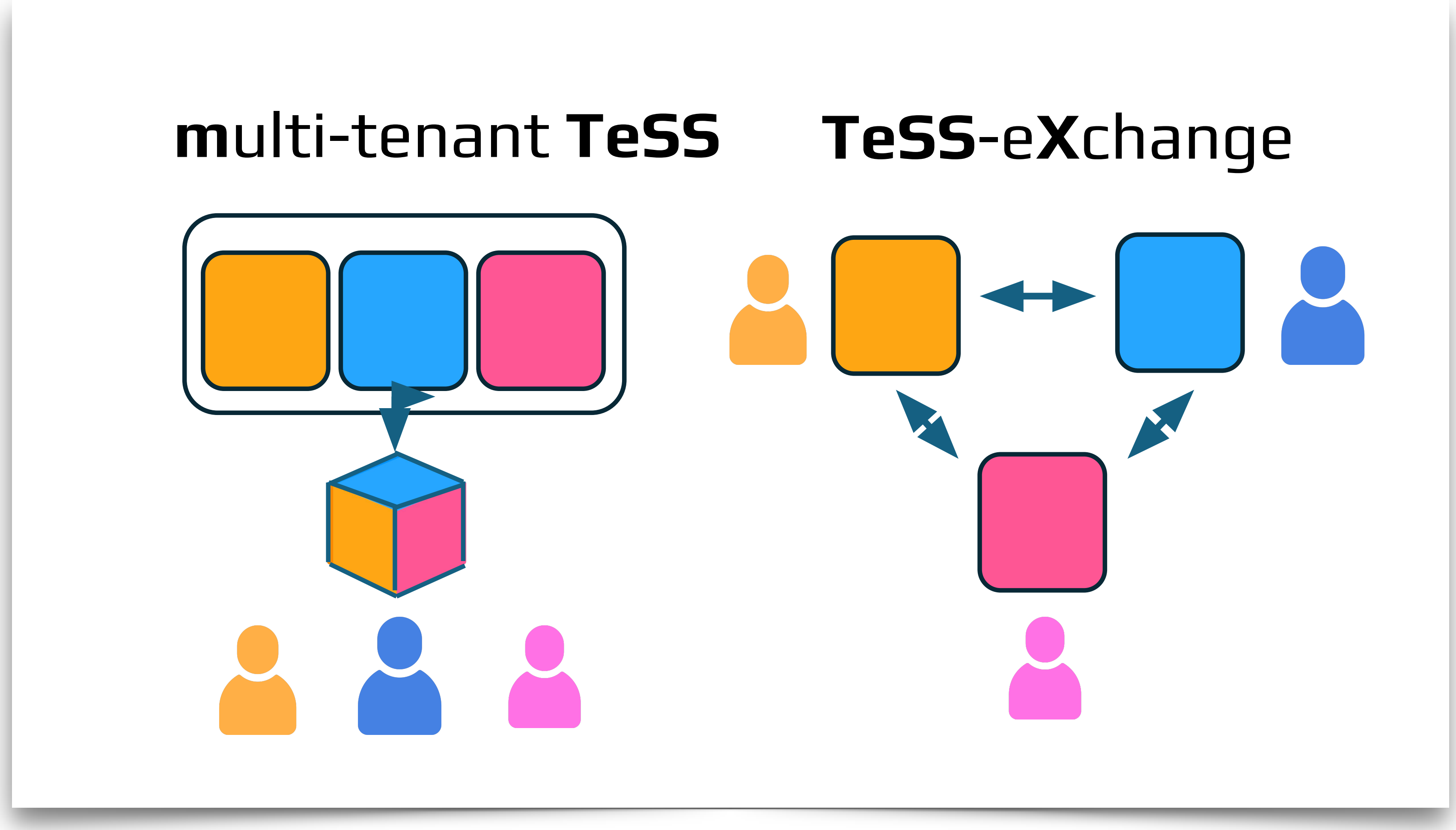


Maks Graczyk

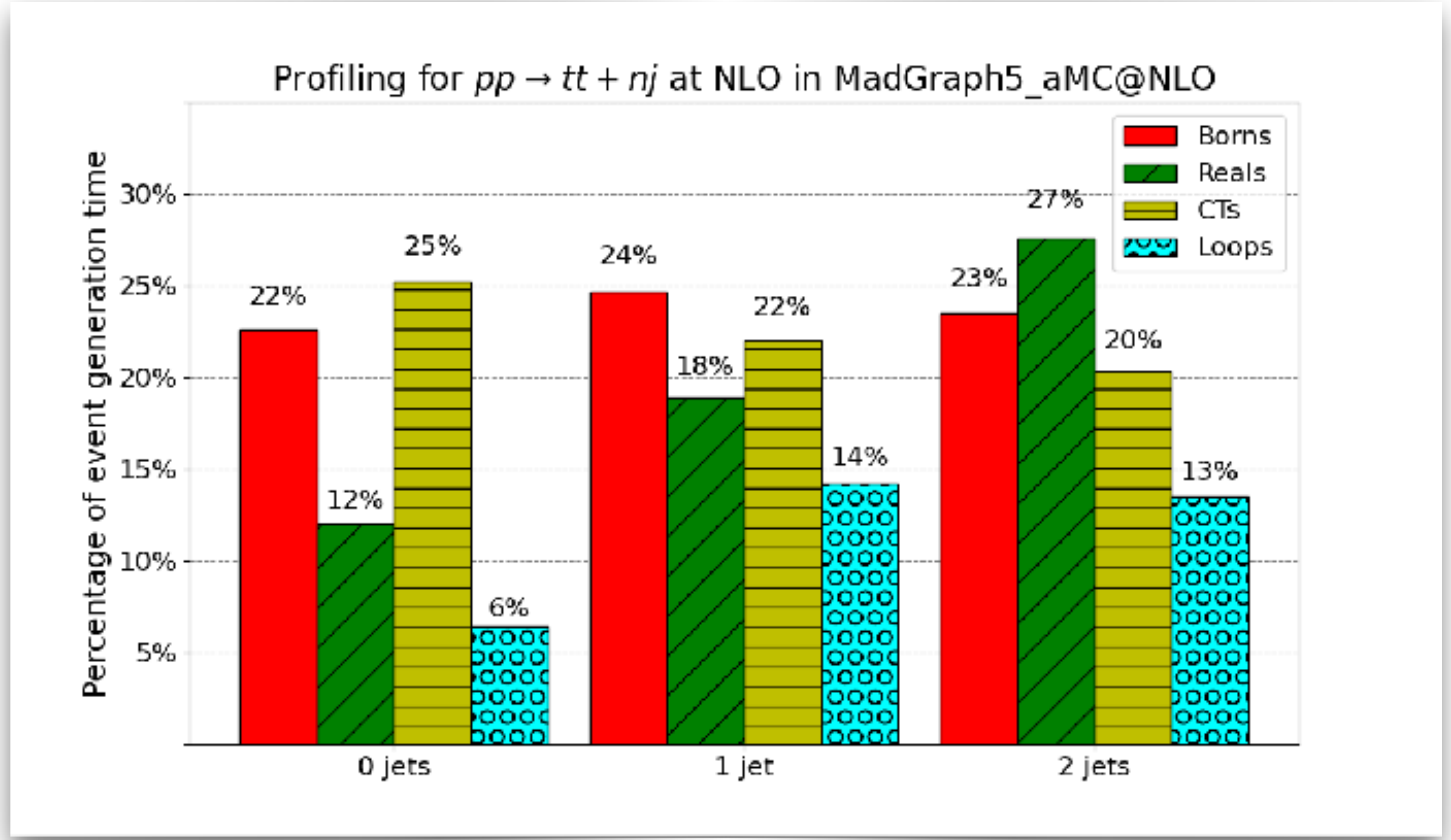
eosc | EVERSE

- Build a virtual institute to promote best practices in research software engineering
- Lead WP “capacity building & recognition”





WHAT'S NEXT?



Zenny Wettersten

- MC event generation
  - Deployment of leading-order for experiments
  - Develop a prototype for next-to-leading-order calculations
  - Expand the realm of projects with Sherpa/Pepper
- Development of new AdatpivePerf features and its usability by CERN experiments
- Create instance of a training catalogue, usable from within HEP and connect it to other sciences