



# **LAWSCHep 2019 – Opportunities for growth through collaboration in HEP S&C**

V. Daniel Elvira for the LAWSCHep scientific organizing committee

LASF4RI Symposium, Sao Paulo, Brazil, July 6<sup>th</sup> 2020

# Latin American workshop on S&C challenges in HEP

- Learn from each other on the status of HEP Software and Computing (S&C) in Latin America and the international community
  - Computing infrastructure, expertise, past and current contributions, interests, plans
- Identify topics of common interest, particularly among LA institutions
- Explore partnership and funding opportunities between Latin American Institutions and with international labs
  - Includes strengthening existing collaborative efforts and creating new ones
- Composed a document at the end of the workshop
  - Summarizing all of the above
  - Establishing mechanisms for communication and follow up

**No time today for details on S&C in LA or detailed content of LAWSCHep**

- Instead focus on S&C challenges in HEP and the LAWSCHep final document

# LAWSCHEP 2019 – Mexico City, November 20-23, 2019



## Local Organizing Committee

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Jun Takahashi (UNICAMP, Brasil)

Participants from  
Argentina, Brazil,  
Colombia, Ecuador,  
Mexico, Peru, as well as  
Europe and USA  
(CERN, FNAL, IRIS-  
HEP)

Contributions from  
Chile, Paraguay,  
Venezuela

Indico agenda at <https://indico.cern.ch/event/813325/>

From there, follow the link to the **Final Document** (summary & conclusions)  
and the live document on **S&C Projects** (propose new ones or join existing ones!)

# The context is the HEP physics program in the 2020's

International HEP community – ambitious physics programs in Europe and the US

- Largest ever neutrino experiment to start in 2026 (DUNE)
- HL-LHC physics run to start in 2027 (ATLAS, CMS, ALICE, LHCb)

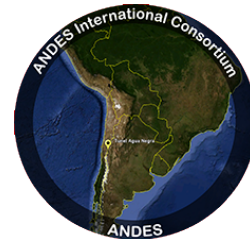
Complex detectors, large data sets to collect, reconstruct, analyze, simulate

Latin American experimental particle and astro-particle physics programs – significant growth since the 1990's

- Significant contributions to Fermilab experiments (Minerva, Nova, DUNE, ...), and CERN experiments (ATLAS, CMS, LHCb, ALICE, ...)
- Growing domestic program

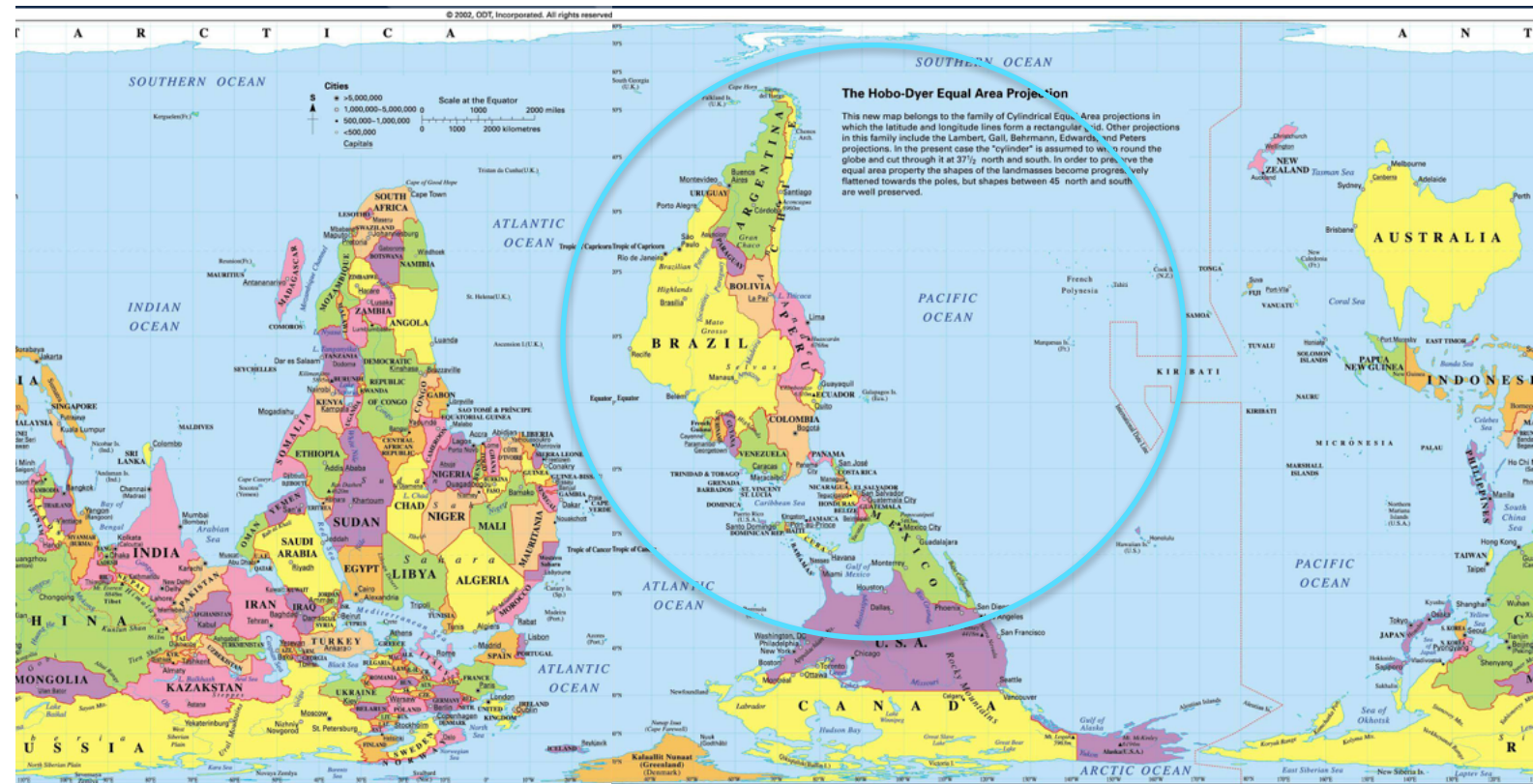


The Latin American Giant Observatory (LAGO)





# LA benefits from a very central location



# HEP Software and Computing

LHC uses 1M CPU cores/hr/day, ~1 TB of data with 100 PB of data transfers per year

- Need 10-100 more computing resources in the HL-LHC era (CPU, storage)

Moore's law sort of holds (# transistors/vol.)

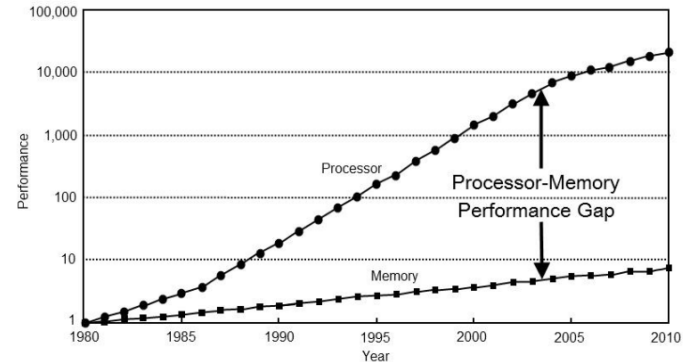
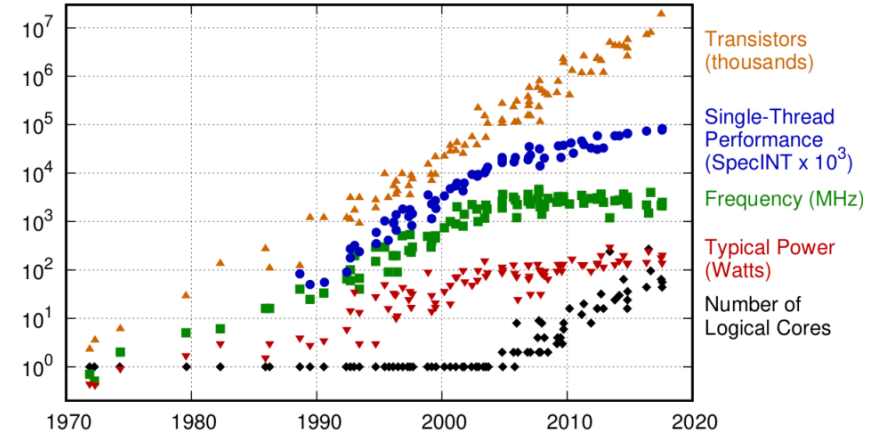
- Doubling time is lengthening (> 2 years)

Dennard scaling (dissipated power/volume independence with the # transistors)

- Breaks down at ~3 GHz clock speeds (Power Wall driven by heat and cost)

We can not count on the performance of a CPU chip to double every 18 months, and we have a flat S&C budget

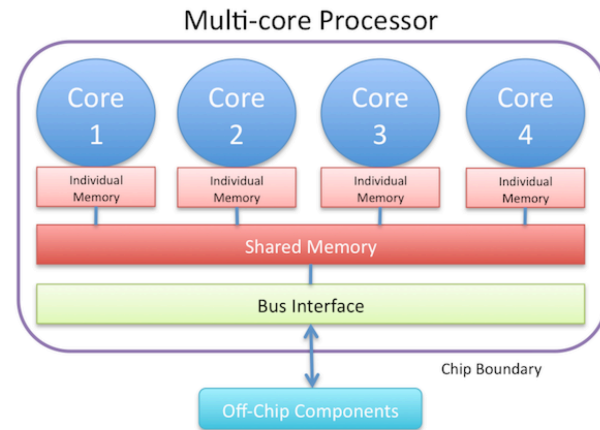
42 Years of Microprocessor Trend Data [K Rupp](#)



# The brave new world

Solution for the shortage in HEP computing resources will have to leverage growth in:

- Core count (multi-core machines)
  - Concurrency and parallelism
  - Multithreading, vectorization – SIMD
- Co-processors also called accelerators
  - GPU: matrix operations, FPGA: configurable through software, ASIC: application specific
- Artificial intelligence techniques and hardware (TPU)
  - Based on software algorithms: training, inference



Community solutions – avoid duplication => HEP Software Foundation (HSF)

- White paper entitled “A Roadmap for HEP Software and Computing R&D for the 2020s”
- Massive community engagement: 310 authors from 124 institutes, 14 chapters
- Published in Computing and Software for Big Science, <https://doi.org/10.1007/s41781-018-0018-8> (and on [arXiv](https://arxiv.org/abs/1808.07449))

# The LAWSCHEP final document

**Introduction** – Goals, S&C challenges in the next decade, pointer to community documentation

## **Workshop presentations**

- Challenges and on-going R&D projects in the areas of physics generators, simulation, analysis tools, software development/validation/verification, trigger/DAC, distributed computing/data management, education/training
- Computing infrastructure, S&C contributions and interests of individual LA countries
- Feature presentations on emerging technologies such as accelerators (GPUs, FPGAs, ASICs), High Performance Computing (HPC), Artificial Intelligence (AI)
- A presentation about LASF4RI, poster sessions (students)

## **Discussions, ideas, action items**

- Integration of LA to the HEP S&C international community, educational/training events, fora/regional centers for communication and information exchange, curated database (experiments, interests, experience/skills, funding opportunities, S&C training)
  - Incubator projects bringing together two or more LA countries to work on a common topic
  - Visitor programs within LA and with international institutions



# The LAWSCHEP final document (cont')

Projects – proposed by the participants [everyone is welcomed to add his/her name in the live document]

- Generators
  - Modernization of GENIE neutrino generator, Pythia collider generator
- Simulation
  - Neutrino beam modeling for neutrino experiments, modernization of Geant4 to achieve a stateless transport prototype, G4 adaptation to run efficiently on GPUs, integration of the Opticks package (optical photons on GPUs) to G4, G4 de-noising using ML, modeling and analysis of software/hardware architectures, particle tracking simulation in ML
- Trigger, reconstruction, particle identification
  - ML algorithms for triggering and particle identification in FPGAs, modernization of tracking algorithms for efficient use in parallel architectures, Graph NN for reconstruction in high-granularity detectors
- Analysis tools
  - Evolution of the ROOT columnar data storage

# The LAWSCHEP final document (cont')

- Performance portability
  - Adapt legacy code using performance portability libraries (KOKKOS, ALPAKA, SYCL) to run on hybrid computing architectures including HPCs
- Machine Learning
  - Computing architectures to integrate heterogeneous hardware into HEP computing to accelerate ML algorithms, infrastructure work for fast inference and distributed training coupled to algorithmic work on uncertainty quantification in AI
- Data management and processing
  - Models based on a data-lake concept and content delivery network
- Education and training
  - LA-CoNGA education initiative to develop an educational platform with tools and content to be included in masters programs in 8 different universities in LA
  - Create an environment in LA for a systematic training program for HEP graduate students and researchers to develop S&C skills necessary for high-impact contributions

# Conclusion and outlook

- HEP experiments are highly data intensive and require high-quality S&C
- The landscape for software is becoming ever more challenging
  - Mostly due to the break down of *Dennard Scaling*
    - Concurrency and parallelism, AI algorithms, heterogeneous HPC facilities
- Latin America's computing infrastructure for science growing fast
  - Large computer clusters serve as Tier 2, 3 centers within major experiments
  - Heterogeneous computing taking root: GPUs, ASIC chips for specific applications
  - SC laboratories and HPC facilities serve a broad range of scientific disciplines including HEP (mainly in Brazil and Mexico)
  - Artificial intelligence initiatives popping up in many countries
- Perfect time for Latin America to strengthen involvement in HEP S&C R&D
  - Broader impact of the region in the domestic and international HEP program
  - Development of human resources in heterogeneous computing and AI