

LAWSCHEP 2019: Conclusion and Outlook

Latin American Workshop on Software and Computing (S&C) Challenges
in High-Energy Particle Physics (HEP)

March 10th., 2020

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Introduction

Under the auspices of the HEP Software Foundation (HSF) and with support from the Institute for Research & Innovation in Software for HEP (IRIS-HEP), the [“Latin American Workshop on Software and Computing \(S&C\) Challenges in High-Energy Particle Physics \(HEP\)”](#) brought together Latin American HEP groups to discuss opportunities for collaboration in topics of S&C within the region and with the international community at large.

The HEP community has an ambitious and broad experimental program for the coming decades. This program requires large investments in detector hardware, either to build new facilities and experiments, or to upgrade existing ones. It also needs a commensurate investment in software R&D to manage, process, and analyze the sheer amounts of experimental and simulated data to be acquired and produced.

Over the past decades, HEP groups experienced considerable growth in Latin America (LA) and contributed in effective and significant ways to the domestic and international scientific programs. The workshop agenda focuses on the intersection between the S&C challenges recently summarized in “A Roadmap for HEP Software and Computing R&D for the 2020’s” (Comput. Softw. Big Sci., 2019, 3: 7, <https://doi.org/10.1007/s41781-018-0018-8>) and the experience and interest of Latin American groups. The roadmap paper describes S&C topics of research to address the needs of future experiments in the areas of physics and detector simulation, event reconstruction, data storage, transfer, and analysis. Future solutions will require exploring novel software paradigms and advanced algorithmic techniques in fields such as hybrid modeling and simulation, fine-grained parallelism, efficient use of accelerators in High Performance Computing (HPC), as well as methods for Artificial Intelligence (AI) and data science.

LAWSCHEP 2019 offered the opportunity to leverage the growth and the vast computing experience and capabilities of Latin American groups, strengthening the region’s impact through collaboration.

The LAWSCHEP 2019 Workshop

The workshop consisted of presentations and discussions on the challenges to be addressed within the next decade, analysis of success stories, status reports on current activities by participating institutions, and the opportunity for young researchers to present their work. A discussion session during the last day revolved around topics such as the S&C areas of strength and common interest within Latin America, the associated technologies and skills, opportunities for integration of Latin American researchers to international community organizations such as the HSF, as well as ideas for scientific or educational events, fora for exchanging information and present project status, and regional centers or other vehicles to communicate and foster activity and collaboration within the different institutes.

The present document summarizes the ideas and action items that emerged from the workshop, and is also the mechanism we chose to communicate the participant’s interests to the Latin American Strategy Forum for Research Infrastructure (LASF4RI) process.

(<https://www.ictp-saifr.org/workshop-on-the-latin-american-strategy-forum-for-research-infrastructure/>)

One of the action items emerging from the presentations and the discussion session was the commitment to build and maintain a curated database with the following information:

- HEP experiments with participation of LA countries, including their responsibilities within the experiments
- Past and current partnerships on S&C projects within HEP between LA institutions, and between LA and international institutions
- Current and future S&C areas of interest of LA institutions, related experience and skills
- Computing centers in LA that support HEP-oriented research
- Funding programs for multi-country collaboration (LA-LA and LA-other)
- Courses and training on S&C topics offered at LA institutions and by LA-based researchers visiting other LA institutions.

This information will be used to foster increased levels of interaction among LA groups. For example, one outcome of LAWSCHEP is the idea to establish a program to incubate S&C projects that bring together researchers from two or more LA countries to work together on identified common goals, including stays at the experiment sites, both within Latin America and abroad. These projects would then continue and develop within Latin American countries with support from domestic institutions. As a start, LAWSCHEP participants composed a list of S&C projects aligned with their interests and the community needs, which offer opportunities for collaboration among LA groups, as well as with international institutions.

S&C projects

1. **Modernization of the GENIE neutrino generator.** This includes Improving physics models and framework infrastructure in the GENIE neutrino event generator, and expanding and generalizing event generator interfaces in LArSoft.
Interested researchers: Laura Fields - Fermilab (ljf26@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov)
2. **Neutrino beam simulation.** Development of the DUNE neutrino beam simulation and other long-baseline experiments based on hadron production physics, including participation in projects like EMPHATIC.
Interested researchers: Laura Fields - Fermilab (ljf26@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov) - Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar)
3. **Performance portability.** Find procedures for performance portability to revamp vast amounts of legacy code designed specifically to CPU in order to make it run with increased performance in hybrid CPU/GPU/FPGA hardware.
Interested researchers: Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar), Matti Kortelainen - Fermilab (matti@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov)

4. **Particle tracking simulation with ML.** ParticleBoost the performance of particle tracking simulation by leveraging knowledge about the structure of governing equations and ML techniques to run coarse-grained fast simulations.
Interested researchers: Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar), Ernesto Kofman - Universidad Nacional de Rosario (ekofman@gmail.com)
5. **Modeling and Simulation-based analysis (performance, scalability, resilience) of candidate software/hardware architectures.** Assist the design of future dataflows in data-acquisition systems.
Interested researchers: Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar), Wainer Vandelli - CERN (wainer.vandelli@cern.ch)
6. **Adaptation of Geant4 for efficient use of accelerators and HPCs.** This project targets applications to experiments scheduled to start in the late 2020's and early 2030's.
Interested researchers: Philippe Canal - Fermilab (pcanal@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov), Andrei Gheata - CERN (andrei.gheata@cern.ch), Guilherme Amadio - CERN (guilherme.amadio@cern.ch)
7. **Modernisation of Geant4 to achieve a 'stateless' transport prototype.** The goal is to demonstrate some form of code locality (multiple tracks to a single kernel). This is also a step towards more code modularity, cutting code dependencies and enabling a functional programming approach.
Interested researchers: Witold Pokorski - CERN (witold.pokorski@cern.ch), Andrei Gheata - CERN (andrei.gheata@cern.ch)
8. **De-noising of Geant4 using ML.** The goal is to develop a fast simulation option based on running Geant4 with loose parameter values and then improve the physics fidelity through ML de-noising techniques similar to those used to sharpen images.
Interested researchers: Kevin Pedro - Fermilab (pedrok@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov), Thiago Tomei - São Paulo Research and Analysis Center (Thiago.Tomei@cern.ch), Sérgio Novaes - São Paulo Research and Analysis Center (Sergio.Novaes@cern.ch) - Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar)
9. **Integration of Opticks (optical photons package) to Geant4.** This project targets liquid argonne experiments. Opticks runs on GPU and this would allow for better physics and improved computing performance (speedup).
Interested researchers: Krzysztof Genser - Fermilab (genser@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov), Andrei Gheata - CERN (andrei.gheata@cern.ch), Guilherme Amadio - CERN (guilherme.amadio@cern.ch)

10. **Reconstruction algorithms for parallel architectures.** Modernization of conventional algorithms (CMS tracking, LArTPC signal processing) for efficient usage on parallel architectures.
Interested researchers: Giuseppe Cerati - Fermilab (cerati@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov), Thiago Tomei - São Paulo Research and Analysis Center (Thiago.Tomei@cern.ch), Sérgio Novaes - São Paulo Research and Analysis Center (Sergio.Novaes@cern.ch)
11. **Graph NN for CMS High Granularity and LArTPC reconstruction.** Application of Graph Neural Networks for 3D Space Point reconstruction in LArTPC experiments and reconstruction in High Granularity Calorimeters in CMS.
Interested researchers: Nhan Tran - Fermilab (ntran@fnal.gov), Lindsey Gray - Fermilab (lgray@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov)
12. **ML algorithms for particle triggering and identifications in FPGAs.** Development and integration of machine learning algorithms to run on FPGA cards to perform online tasks such as particle identification and triggering to optimize data acquisition and analysis towards the HL-LHC era.
Interested researchers: Alfredo Castañeda - Universidad de Sonora (castaned@cern.ch)
13. **Develop computing architectures to integrate heterogeneous hardware (GPU, FPGA, ASIC) into the HEP computing model to accelerate machine learning algorithms.**
Interested researchers: Nhan Tran - Fermilab (ntran@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov)
14. **Infrastructure work for fast inference and distributed training coupled to algorithmic work on uncertainty quantification in AI.**
Interested researchers: Gabe Perdue - Fermilab (perdue@fnal.gov), Daniel Elvira - Fermilab (daniel@fnal.gov)
15. **Development of RNTuple (for n-tuple and nested tuple), an evolution of the ROOT TTree columnar data storage.** RNTuple introduces new interfaces that aim to be more robust and optimal storage performance for HEP data in terms of speed and size.
Interested researchers: Jakob Blomer - CERN (jakob.blomer@cern.ch), Axel Naumann - CERN (axel@naumann)
16. **New models in data management and data processing.** The LHC computing grid is evolving towards an evolution of the current grid to face the High-Luminosity requirements. Also non-HEP experiments are entering into a new dimension in computing, astrophysics, cosmology and neutrino physics (e.g. DUNE, SKA, CTA, LSST, ...) The new model is based on a datalake concept and content delivery network.
Interested researchers: Xavier Espinal - CERN (xavier.espinal@cern.ch), Rodrigo Castro - Universidad de Buenos Aires (rcastro@dc.uba.ar)

17. **LA-CoNGA education initiative.** This is an European Union funded program to develop an educational platform with tools and content to be included in masters programs in 8 different universities in LA (Colombia, Ecuador, Peru and Venezuela). The program aims at modernizing education in the region, through the development of a series of courses in particle physics, instrumentation, and computing with emphasis in data analysis, supported by a network of partners in Europe (CERN, DESY, ICTP, University of Paris, University of Toulouse, University of Dresden). Students will work together with their counterparts in the different LA countries on projects and will also have an internship at either one of the partners in Europe or one of the Universities in LA.

Interested researchers: Carlos Sandoval - Universidad Antonio Nariño (carlos.sandoval@uan.edu.co), Javier Solano, Universidad Nacional de Ingeniería (jsolano@uni.edu.pe)

18. **Training for S&C R&D projects.** Create an environment in Latin America for a systematic training program for HEP graduate students and researchers to develop the software and computing skills necessary to make high-impact contributions to current and future R&D projects.

Interested researchers: Sudhir Malik - Universidad de Puerto Rico (sudhir.malik@upr.edu)

Outlook

The community built around LAWSCHep has the potential to improve communication and expand collaboration within LA on topics of S&C in HEP, by leveraging a rich history of successful partnerships with international laboratories. LAWSCHep is the first step towards constructing an identity among scholars doing research in S&C for HEP in Latin America.

The goal towards the future is to strengthen and create new opportunities for collaboration around the S&C topics of interest discussed during the workshop and listed in this document. LAWSCHep could eventually become an annual or bi-annual workshop bringing together the Latin American HEP S&C community to discuss technical progress, bolster local knowledge and expertise, and develop common strategies and visions. The addition to the LAWSCHep program of a series of lectures or a school on S&C tools and techniques would satisfy the training needs of LA groups as they grow and diversify, and would motivate young scientists and students to participate.

A more ambitious initiative, with a scope larger than that of LAWSCHep, would be to create a Latin American HEP panel, in the same spirit of the Particle Physics Project Prioritization Panel (P5) in US or the European Strategy for Particle Physics. Its purpose would be to identify the particle physics priorities within Latin America and provide a long-term strategy for HEP based on the history, experience, and interests of LA institutions. This grass roots community panel would encourage Latin American funding agencies to work together to establish a global funding plan for HEP across the whole Latin America which would guide funding allocation within each country.