

# LAWSCHEP 2019

## Software & Computing Projects for HEP

### Live Document

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

*Initial version: March 10th., 2020*

#### **Authors:**

Workshop participants and members of the LAWSCHEP 2019 Scientific Organizing Committee

#### **Editors:**

Rodrigo Castro (Universidad de Buenos Aires, Argentina), Daniel Elvira (Fermilab, USA)

- Workshop page: <https://indico.cern.ch/e/LAWSCHEP2019>
- LAWSCHEP 2019 White Paper: [Link here](#)
- **You can keep adding project ideas and your name as an interested researcher in the list below**

# 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](mailto:ljf26@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto: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](mailto:ljf26@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto:daniel@fnal.gov)) - Rodrigo Castro - Universidad de Buenos Aires ([rcastro@dc.uba.ar](mailto: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](mailto:rcastro@dc.uba.ar)), Matti Kortelainen - Fermilab ([matti@fnal.gov](mailto:matti@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto: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](mailto:rcastro@dc.uba.ar)), Ernesto Kofman - Universidad Nacional de Rosario ([ekofman@gmail.com](mailto: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](mailto:rcastro@dc.uba.ar)), Wainer Vandelli - CERN ([wainer.vandelli@cern.ch](mailto: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](mailto:pcanal@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto:daniel@fnal.gov)), Andrei Gheata - CERN ([andrei.gheata@cern.ch](mailto:andrei.gheata@cern.ch)), Guilherme Amadio - CERN ([guilherme.amadio@cern.ch](mailto:guilherme.amadio@cern.ch))
7. **Modernisation of Geant4 to achieve a 'stateless' transport prototype.** The goal is to demonstrating 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](mailto:witold.pokorski@cern.ch)), Andrei Gheata - CERN ([andrei.gheata@cern.ch](mailto: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](mailto:pedrok@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto:daniel@fnal.gov)), Thiago Tomei - São Paulo Research and Analysis Center ([Thiago.Tomei@cern.ch](mailto:Thiago.Tomei@cern.ch)), Sérgio Novaes - São Paulo Research and Analysis Center ([Sergio.Novaes@cern.ch](mailto:Sergio.Novaes@cern.ch)) - Rodrigo Castro - Universidad de Buenos Aires ([rcastro@dc.uba.ar](mailto: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](mailto:genser@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto:daniel@fnal.gov)), Andrei Gheata - CERN ([andrei.gheata@cern.ch](mailto:andrei.gheata@cern.ch)), Guilherme Amadio - CERN ([guilherme.amadio@cern.ch](mailto: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](mailto:cerati@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto:daniel@fnal.gov)), Thiago Tomei - São Paulo Research and Analysis Center ([Thiago.Tomei@cern.ch](mailto:Thiago.Tomei@cern.ch)), Sérgio Novaes - São Paulo Research and Analysis Center ([Sergio.Novaes@cern.ch](mailto: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](mailto:ntran@fnal.gov)), Lindsey Gray - Fermilab ([lagray@fnal.gov](mailto:lagray@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto: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](mailto: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](mailto:ntran@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto: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](mailto:perdue@fnal.gov)), Daniel Elvira - Fermilab ([daniel@fnal.gov](mailto: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: Jokob Blomer - CERN ([jokob.blomer@cern.ch](mailto:jokob.blomer@cern.ch)), Axel Naumann - CERN ([axel@naumann](mailto: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](mailto:xavier.espinal@cern.ch)), Rodrigo Castro - Universidad de Buenos Aires ([rcastro@dc.uba.ar](mailto: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](mailto:carlos.sandoval@uan.edu.co)), Javier Solano, Universidad Nacional de Ingeniería ([jsolano@uni.edu.pe](mailto: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](mailto:sudhir.malik@upr.edu))