Argentina Experimental HEP Input

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on behalf of La Plata and Buenos Aires HEP groups

II Latin American Strategy Forum for Research Infrastructure:
an Open Symposium for HECAP

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Argentina Experimental HEP Input

Contribution from Buenos Aires and La Plata groups to the Latin American Strategy Forum for Research Infrastructure

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La Plata: F. Alonso, M.T. Dova, F. Monticelli, H. Wahlberg

This document is sent on behalf of the academic faculty members and researchers of the High Energy Physics (HEP) Groups at Universidad de Buenos Aires (UBA-CONICET) and Universidad Nacional de La Plata (UNLP-CONICET). The main goal of these HEP groups is the search for new physics by a synergy of theoretical exploration and experimental innovation in the framework of the ATLAS experiment at the Large Hadron Collider (LHC) in the current phase, and in the approved High Luminosity Large Hadron Collider (HL-LHC), as well as in experiments of future colliders in the field.

LHC/HL-LHC

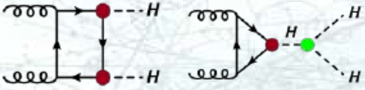
- 2019 - 2020 is LS2 to get ready for Run3: 14 TeV and higher inst luminosities → Phase-I
- The HL-LHC project is planned to begin collisions by 2026
- ATLAS will collect an integrated luminosity of 3000-4000 fb^{-1} in 10 years
- HL-LHC upgrades will happen during Long Shutdown 3 (2024-2026)

Physics Motivations

HL-LHC will be a Higgs Factory!

Facility	LHC	HL-LHC	ILC	ILC LumiUP	CLIC	TLEP (4 IPs)
Energy (GeV)	14,000	14,000	250+500+1000	250+500+1000	350+1400+3000	240+350
$\int \mathcal{L}dt$ (fb^{-1})	300/expt	3000/expt	250+500+1000	1150+1600+2500	500+1500+2000	10000+1400
N_H ($\times 10^6$)	17	170	0.37	1.05	2.2	3.2

Higgs Self couplings



Higgs-fermion Yukawa coupling

Higgs boson self-coupling

- First opportunity to measure Higgs boson trilinear self-coupling λ_{HHH} strictly connected to the form of the Higgs potential.
- Expected precision is investigated for several direct searches.

- HH→ $bb\gamma\gamma$; HH→ *bbbb*

Higgs rare decays

- H→ $J/\Psi(\mu\mu)\gamma$
- H→ $\mu\mu$

Beyond Standard Model

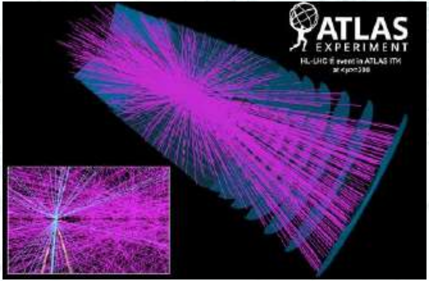
- Direct stop production
- Direct stau production

New interactions

- Z′→ *tt*

Challenges for ATLAS @HL-LHC

- Stand the 5-7 $10^{34}/cm^2/s$ instantaneous luminosity is beyond the capabilities of the current detectors
- Replace several parts (like full inner detector!) to achieve a robuster, faster, radiation harder and lighter detector.
- Goal : have the same-or better-performances in HL-LHC harsh conditions than in Run2
- Upgrade: fruit of permanent feedback between physics requirements and detectors' component design



- Protect against high fluencies. Needs more radiation hard eletronics design.
- Mitigate pileup rates and occupancy
- Keep low p_T requirements for main triggers
- Guarantee precise measurements up to large rapidity
- Lighten the detector, dropping material

Motivations to upgrade TDAQ

- More data needs to be collected → Trigger and Data Acquisition (TDAQ) of ATLAS needs to be upgraded too!

- Full details in TDR – > ATLAS-TDR-029.pdf < –

TDAQ Phase-II upgrade

Many complex analysis on real time at hardware trigger

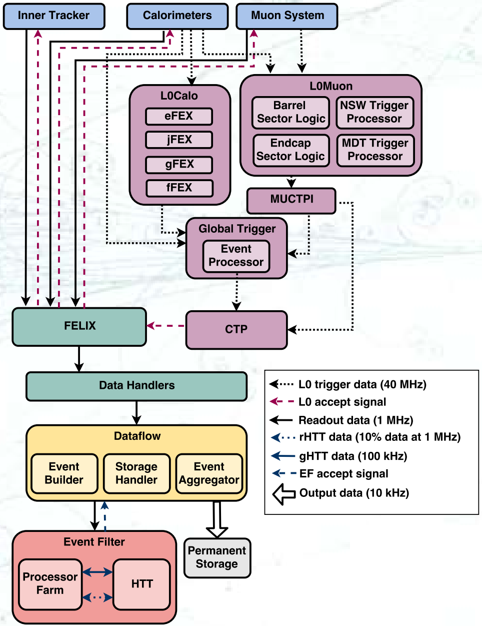
Among other aspects

- L0 Calo will include electron FeatureExtractor (eFEX), jet (jFEX), global (gFEX) and forward jet (fFEX), all implemented in FPGA hardware
- Global trigger will replace current L1-Topo, get inputs from L0 Calo and muons to make a decision
- Common hardware, specialized firmware
- Access to full calorimeter data

Not just TDAQ needs to be updated

Upgrade of LAr electronics

- The LAr calorimeters themselves are expected to operate reliably during the HL-LHC data-taking period
- But the current electronics is not compatible with operations at HL-LHC
- All front-end and back-end electronics will be replaced



Argentina involved in Hardware for ATLAS

Global trigger

- A complex system, implemented in hardware which runs algorithms currently executed at software Trigger (HLT)
- The Global Trigger has 3 main components:
  - Multiplexer processors (MUX),
  - Global Event Processors (GEP)
  - Global-to-CentralTriggerProcesor demultiplexer (CTP interface),
- all implemented in identical hardware based on FPGAs with several transcievers of several Gb/s

Responsibilities included in signed MoU

- Contribute to the design of various Global Trigger module:

  * 23% of modules production will be done in Argentina,

  * including tests of modules before deployment in ATLAS. Tests wil be don in our Lab, usin gone of the demonstrators being built in Germany
- Firmware and Software developments
- Design of Rear Transition Modules, (RTM)

  * 90% of such modules will be produced in local industry.

MoU

MOU signed on July 2, 2019

- For CERN: Eckhard Elsen (Director for Research)
- For Argenitina: Lino Barañao (Secretario de Ciencia y Tecnología)

ATLAS COLLABORATION CERN-MoU-2019-017

Work Responsibilities:

1.1.6.1	Common Module	Buenos Aires, La Plata, Rio de Janeiro UF, Juiz de Fora UF, Heidelberg KIP, Mainz, Tel Aviv, Nikhef, Nijmegen, Krakow IFJ PAN, Krakow AGU-UST, Birmingham, Cambridge, London QMUL, RAL, Argonne, Brookhaven BNL, Chicago, Indiana, Michigan SU, Oregon, Pittsburgh
1.1.6.2	Production Firmware Deployment Module (PFM)	Mainz
1.1.6.3	Infrastructure	Buenos Aires, La Plata, Nikhef, Nijmegen, Krakow IFJ PAN, Krakow AGU-UST

ATLAS COLLABORATION CERN-MoU-2019-017

Contribution by Funding Agency:

Argentina	Design, production and testing of Common modules; Development of algorithmic firmware and software. Design, production, testing, installation and commissioning of Rear Transition Modules (RTM); Design, production, testing, installation and commissioning of Fibre Management; Procurement of ATCA infrastructure.
Brazil	Development of algorithmic firmware and software.
Germany BMBF	Financial contribution to the procurement of interface components to Tile Calorimeter Pre-Processors; Design, production and testing of Common modules; Development of algorithmic firmware and software. Design, production, testing, installation and commissioning of PFM; Development of associated firmware and software.
Israel	Development of algorithmic firmware and software.
Netherlands	Contribution to production of Common modules; Development of algorithmic firmware and software. Financial contribution to the procurement of ATCA infrastructure.
Poland	Financial contribution to the procurement of both MUX and GEP modules; Development of algorithmic firmware and software. Financial contribution to the procurement of ATCA infrastructure.
United Kingdom	Overall system development including design, production, testing, installation and commissioning of Common modules for both MUX and GEP modules; Development of firmware and software associated; Development of algorithmic firmware and software.
USA DOE	Overall system development including design, production, testing, installation and commissioning of Common modules for both MUX and GEP modules; Development of firmware and software associated.
USA NSF	Development of algorithmic firmware and software.

LAE@IFLP: Laboratorio de Altas Energías

Lab and equipment

- Lab being equiped aiming to fulfill our responsabilities with the PHase-II project
- When done, we will have equipments to test, evaluate, develop, and research on very high speed signal processing and Data Acquisition
- We have ATCA shelf, FPGA kits, high performance computer, fast arbitrary signal generators, multi channel osciloscope, SMD soldering station.
- In proces to aqcuire remaining items such as high speed fibers and optical transcievers and very high speed Osciloscope

Know how

- Our Engineer is being trained ring now at CERN
- Involved in a Phase-I project, upgrading a key piece of the L1 trigger, implemented in FPGAs
- This knowledge is critical for our commitment for Phase-II but it open doors for any application and development in our lab Towards High speed signal processing

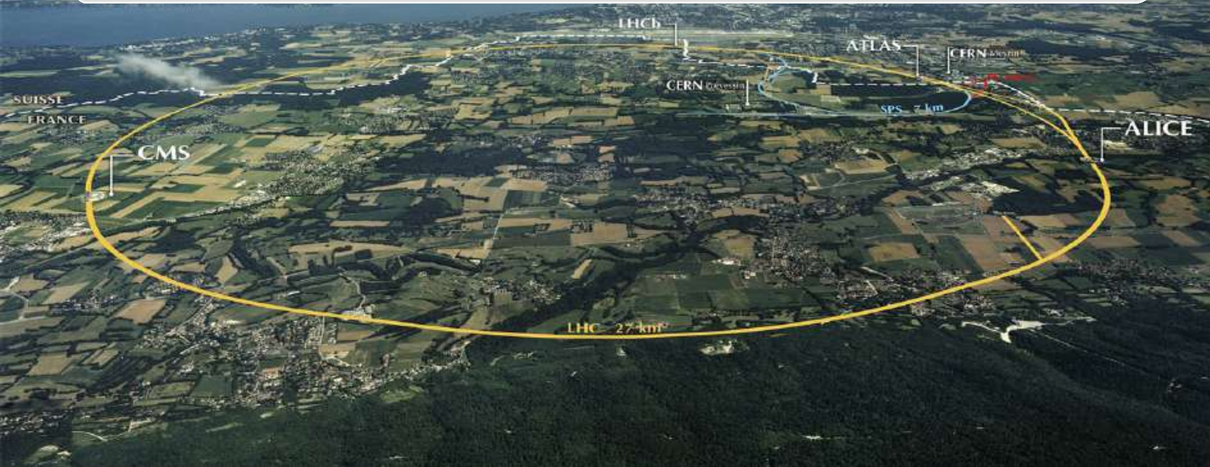
Implications of having this kind of facility

- This kind of facility allows to research, develop and prototype hardware for Trigger, Data Acquisition and data processing of experiments hosted in LA
- Know how and collaboration we are buildin, along with the infraestructiure is a key component for hardware development and prototyping needed for HEP experiments.
- Also, the interaction with industry makes the know how to be transferred to and from private partners

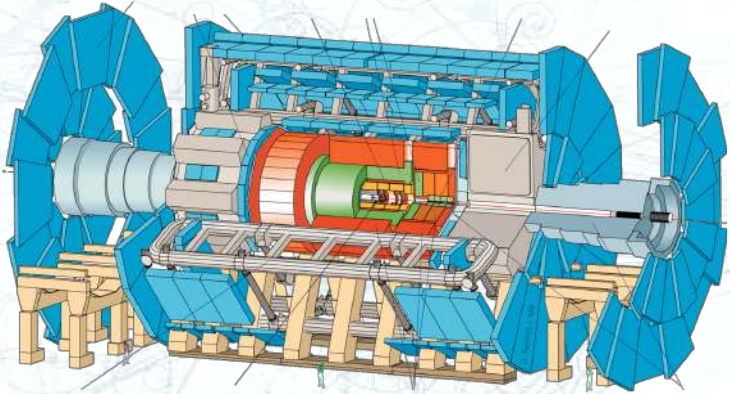
BACKUP

Large Hadron Collider

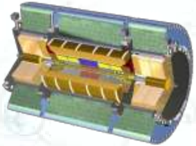
- Acelerador de protones 27 km de circunferencia 100m bajo tierra
- Energía de centro de masa = 14 TeV (corriendo a 13 TeV entre 2015-2018)
- Imanes superconductores, 8T, enfriados a 1.9^{o}K $\rightarrow$ -271^{o}C
- Todo el acelerador al vacío



El detector ATLAS

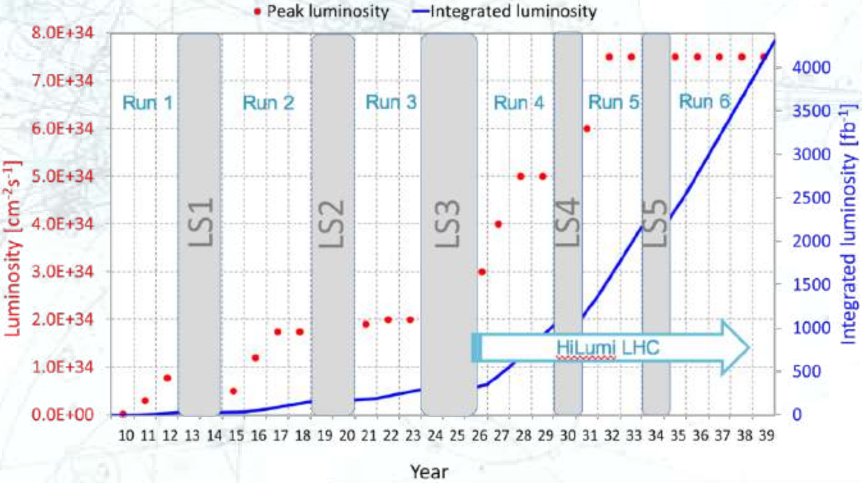


- Detector multipropósito
- 46m largo x 25m diámetro x 7000 Tons (100 Boeing 747)
- 100 m bajo tierra en el LHC



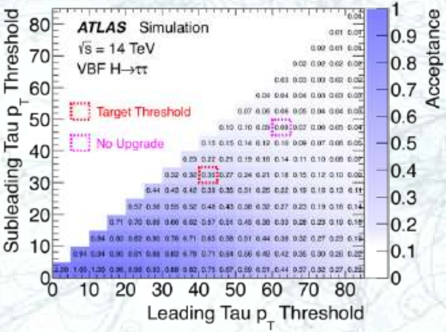
HL-LHC collisions plans

Ultimate scenario 7.5 10^{34}: 320 fb^{-1}/y for 160 days
ions collisions end at LS4
Physics days: 160 Run4 → 200 Run5→ 220 Run6



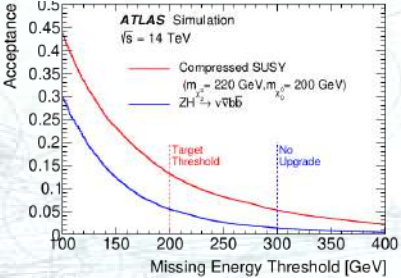
Some examples

Tau Higgs decay



(a) *VBF* $H \rightarrow \tau\tau$ *acceptance using* $\tau\tau$ *triggers where both* τ*s decay hadronically. The acceptance at the target is 30% and the acceptance in the no-upgrade scenario is 8%*

SUSY searches with MET



Double Higgs production