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Latin American Strategy Forum for Research Infrastructures for HECAP
LASF4RI—HECAP

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Introduction

LHC – largest pp dataset at highest energies

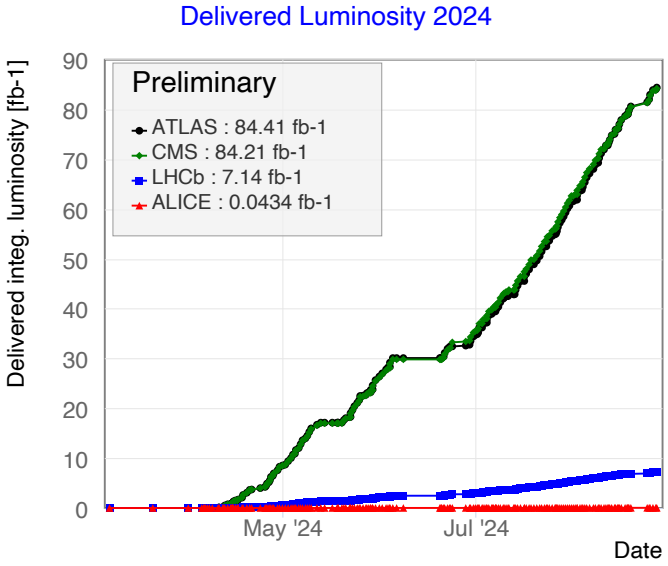
- Run 1 (2010—2012): 6/fb at 7 TeV and 20/fb at 8 TeV
- Run 2: (2015—2018): 160/fb at 13 TeV
- Run 3: (2022—2025?): 140+/fb at 13.6 TeV
- pPb and PbPb datasets also available

Next step: The High-Luminosity LHC (HL-LHC)

- Reach 4000/fb by the end of operation
- Dominate the field of collider HEP up to the 2040s

Projects beyond the HL-LHC

- EIC: approved for operations starting 2030
- CEPC, ILC, CLIC, FCC: in design process



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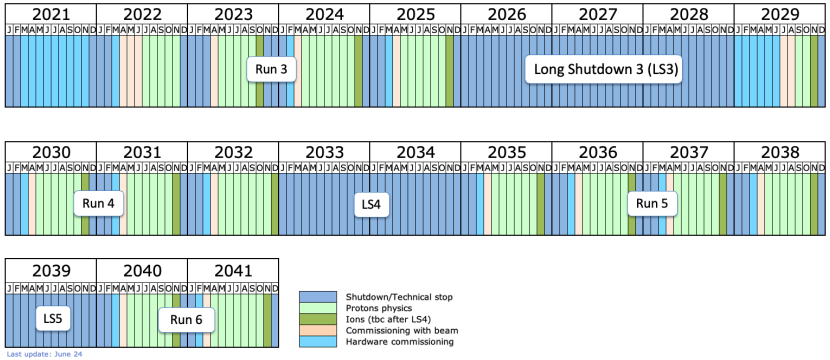

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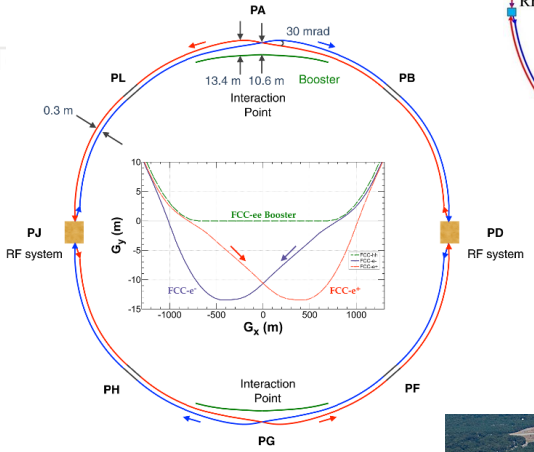

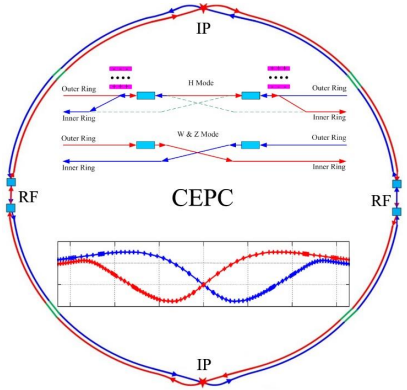

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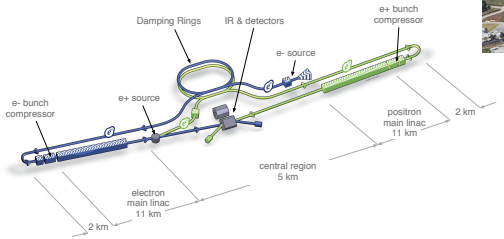

Scenario Changes Since Last Report

INCT CERN Brasil

- Organised around **technologies** instead of collaborations
- Double goal: advances in detector R&D and Brazilian consolidation in CERN experiments
- See yesterday's talk by M. Munhoz

Brazil as an Associate member of CERN

- New, transversal collaborations within HEP community
- New, synergistic interactions with industry
- Funding goals: researchers' mobility and **predictability of calls by the Funding Agencies**

DoE green light for the Electron-Ion Collider at BNL

- Interest by Brazilian groups in joining the Collaborations

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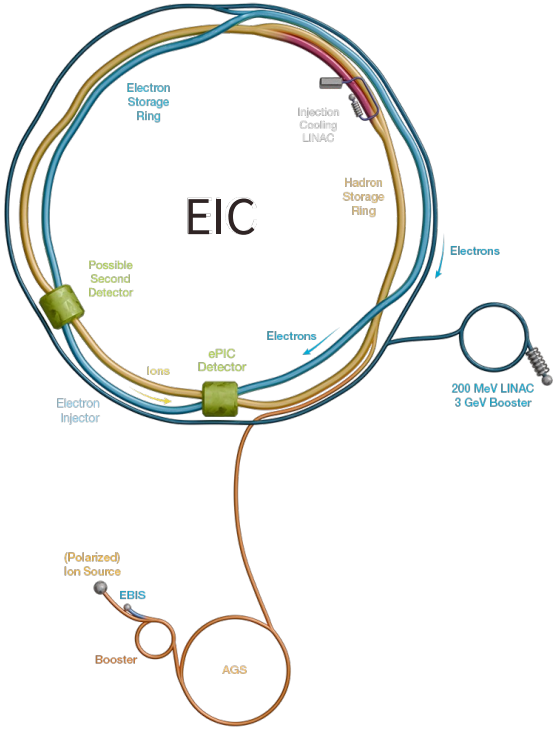

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Highlights of Current Activities

Disclaimer: this is just a **small subset** of the activities being developed by the Brazilian community!

Highlights of Current Activities

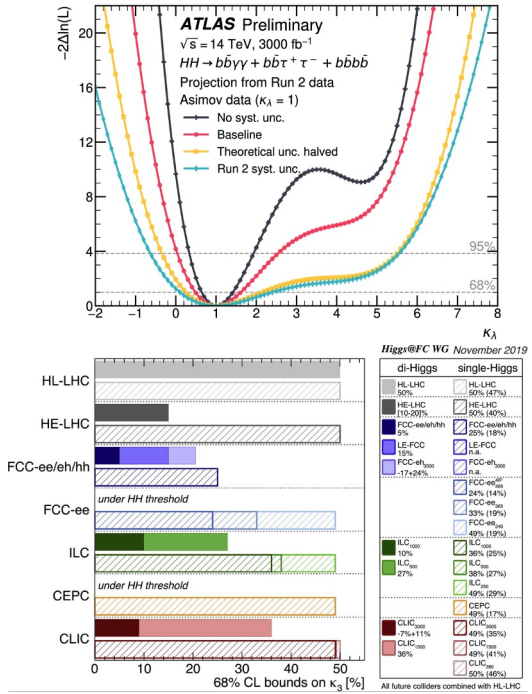
Please see our full paper and our colleagues' talks in this conference.

H self-interaction, HH production

Higgs boson self-interaction λ_{HHH}

- Primary goal in the reach of the HL-LHC
- Parameterized by the coupling strength $\lambda_{HHH} = m_H^2/2v$
- Direct measurement would provide constraints on the shape of the Higgs potential and the verification of the EWSB mechanism of the SM
- Presence of new dynamics at higher energy scales could modify the measured value of λ_{HHH} with respect to the SM prediction
- HH production cross-section:
  1000 x smaller than that of single Higgs!
- Maximal sensitivity: combination of complete HL-LHC datasets (ATLAS and CMS)

ATLAS projection studies combining bbγγ, bbττ and bbbb channels



HL-LHC on κ_λ will have unsurpassed precision for a long time

Heavy Ions physics challenges

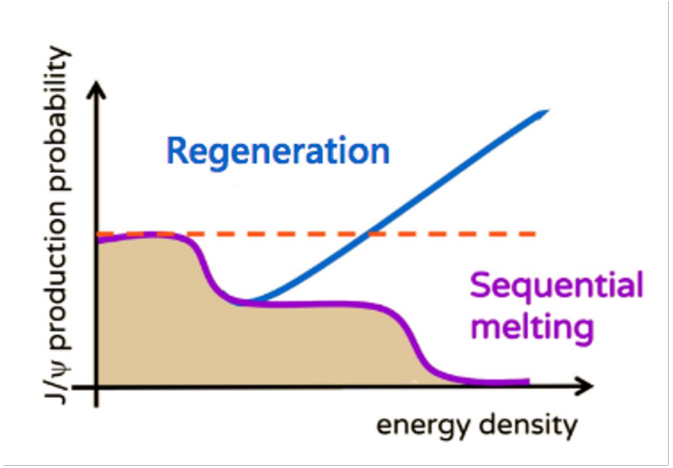
Four LHC experiments involved

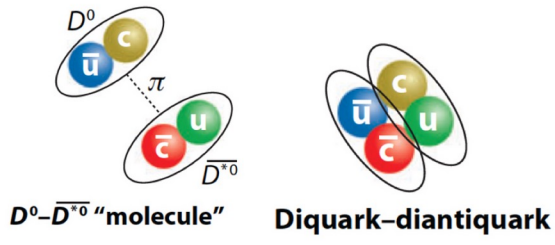
- QCD, QED, and BSM physics

Few examples of topics expected to receive important inputs

- Search for the onset of parton saturation
- Search for the onset of the collective effects in small colliding systems
  - Is the quark-gluon plasma (QGP) produced in such colliding systems (like pp, pPb)?
- Physics involving ultra-peripheral heavy ion collisions
  - Search for physics beyond standard model
  - Heavy-flavour production
  - Parton shower improvements
- Usage of novel tools to study jet quenching
- Study of 3D proton/nucleus structure using Multiple Parton Interactions (MPI) observables

Quarkonia states in HI collisions





Quarkonia production mechanisms inside the QGP – regeneration vs melting

- Melting: due to Debye screening in a QGP
- Regeneration: possibility of charmonium creation on a statistical basis

Measurements:

- J/ψ nuclear modification factor
- ψ(2S) cross section at midrapidity
- X(3872): production may increase via coalescence or decrease due to dissociation.
  - Processes depend on spatial configuration: tetraquark or molecular state?
  - ML algorithms development for background suppression

Heavy Ions + ECAL

Triple Parton Scattering in CMS pPb collisions

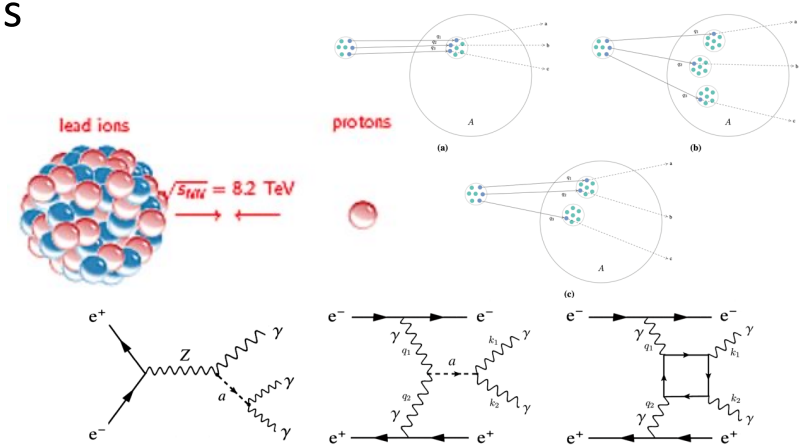
- Signature: triple bbbar, ccbar pairs
- pPb CMS data available, MC in development, analysis code in progress

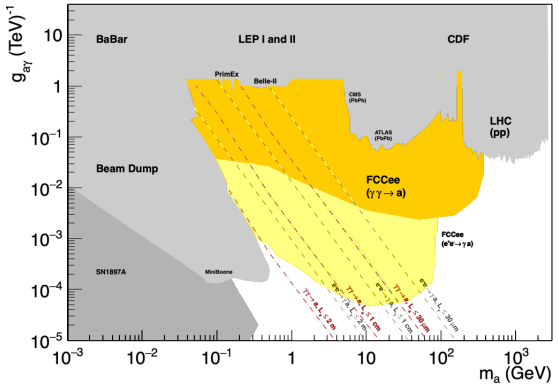
Machine Learning for ALPs at the FCCee

- Low-mass ALPs → collimated photons
- Reuse CMS ML tools → precise photon ID and better precision in m_{yy}

ALP and Gravitons at the FCChh

- Extension of FCCee analysis + addition of gravitons. MC samples ready
- FCC ALP Collider Weizsacker-William adapted to quasi-real ALP flux





LHCb Upgrade II

HL-LHC increase in instantaneous luminosity

- Remodelling the detector
- Adapt individual subsystems keeping or improving performances

Intense and attractive R&D program ongoing

- Great opportunity for new technologies in HEP and uncharted scenarios

First approval steps fulfilled

- Following a clear strategy laid by the LHCC:
  PID enhancement TDR, DAQ enhancement TDR

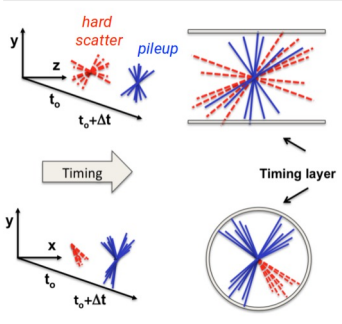
Scoping Document under preparation for submission to the LHCC in 09/2024

- Three detector scenarios: 1) FTDR-baseline, 2) reduced luminosity, 3) no new sub-detectors
- Impact on physics when deviating from FTDR-baseline
- Detailed cost estimate of all scenarios

High Granularity Timing Detector

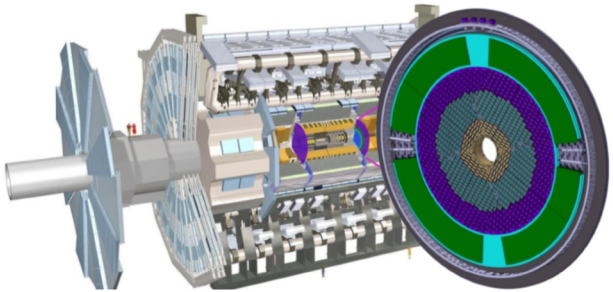
4th dimension (time) in the spatial track reconstruction

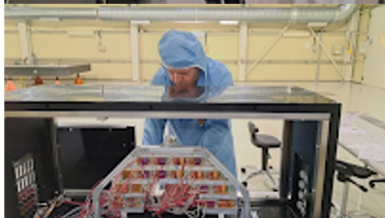
- Capable of < 30 ps timing resolution
- High segmentation for track association



High Granularity Timing Detector

- 8 layers of ultrafast semiconductor sensors
- 16000 15x15 sensor arrays in 3 rings (3.4M channels)
- Total thickness ~ 12cm, total radius ~ 1.1m
- Very radiation hard
- Very thin, very high timing resolution sensors

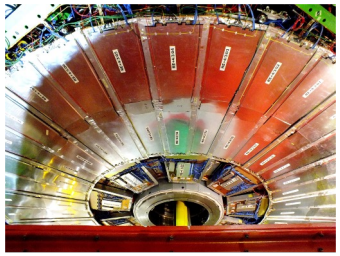




Contribution to sensors, construction and commissioning

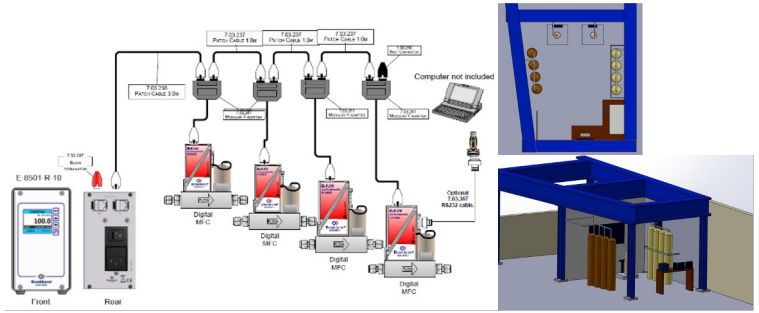
Developments on RPCs

Developments for MARTA-RPC on Auger



Developments for CMS-RPC system

Gas Mixture Laboratory



Studies for CMS-RPC Upgrade

Exploring new electrode materials

Study of electrical signal formation

Investigate eco-friendly gas mixtures

Develop a gas regeneration system

Active participation in CMS, Pierre Auger, and DRD1 collaborations

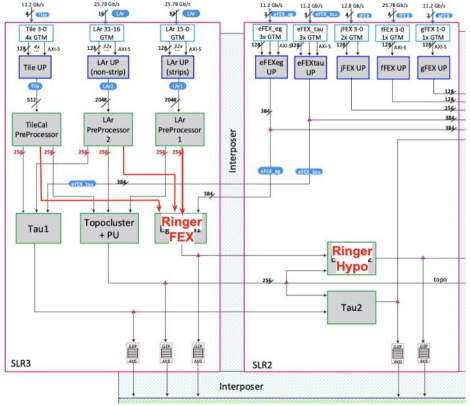
Trigger and Energy Estimation

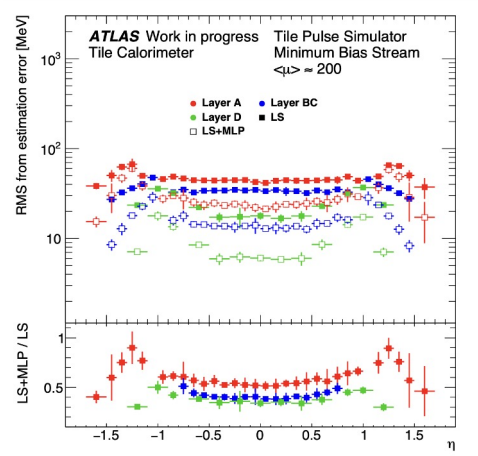
NeuralRinger

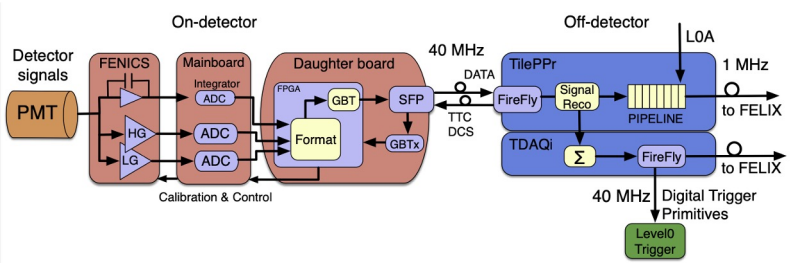
- NN for electron and photon identification
- Developed for FPGA operation (L0 Global Trigger) in HL-LHC conditions
- Integration and development of firmware in the Global Event Processor (GEP) framework

New Energy Reconstruction Methods for Calorimetry

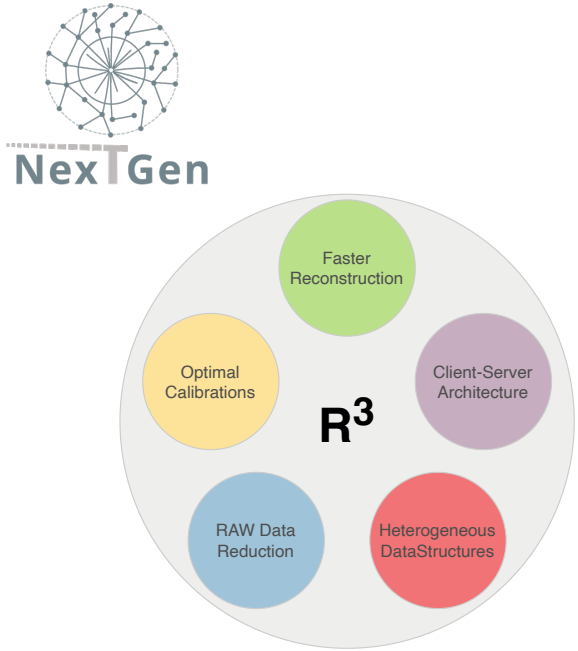
- Linear filter designed
- Significant improvement in the performance of all calorimeter cells for the HL-LHC conditions
- Preliminary results: improvement of up to 20% with the Optimal Filter

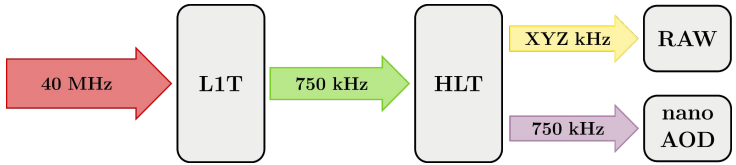






Next-Generation Triggers





Enhanced triggers of HL-LHC era ATLAS and CMS **beyond the currently projected scope**

- Beyond the TDR specifics (*e.g.* CMS-TDR-022)

Accelerate the evaluation and introduction of novel computing, engineering and scientific ideas

- Demonstrators for Run III, focus on HL-LHC

Critical insight to develop data flows for the **even more ambitious objectives** of a future collider

In CMS, focus on High-Level Trigger – achieve a **Real-time Reconstruction Revolution R3**

- Speed-up online reconstruction matching offline quality
  - Heterogeneous compute resources
  - Data-oriented programming
  - Advanced AI-based techniques

Next Steps and Conclusions

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Strong participation of Brazilian community in the next-generation of collider experiments

- Upgrades for ATLAS, CMS, ALICE and LHCb
- Participation in FCC working groups
- Expression of interest in the BNL-EIC

As usual, one of the main challenges is the funding situation

- Not only amount of resources -- flexibility and predictability
- INCT CERN Brasil shows a possible way forward – inter-collaboration projects
- But INCT is a medium-term project (5 years)

We must go beyond the medium-term horizon

- A possible next milestone – a National Laboratory
- Possible models: INFN (Italy), National Scientific User Facilities (USA-DoE), CNPEM

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