LHC Physics: P2IO Projects

from LHC analyses to new developments in theory and detectors

P2IO
Physique des 2 Infinis et des Origines

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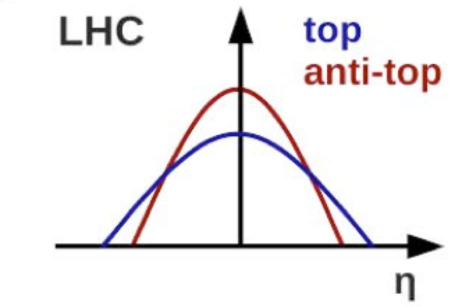
LHC

- Run 1 (2011-2012):
  - ➔ 7 - 8 TeV, 5 - 21 fb^{-1}
- Run 2 (2015-2018):
  - ➔ 13 TeV, ~ 100 fb^{-1} expected
- LHC physics:
  - ➔ heart of P2IO lab activities
  - ➔ P2IO support: from data analyses to new developments in theory and detection

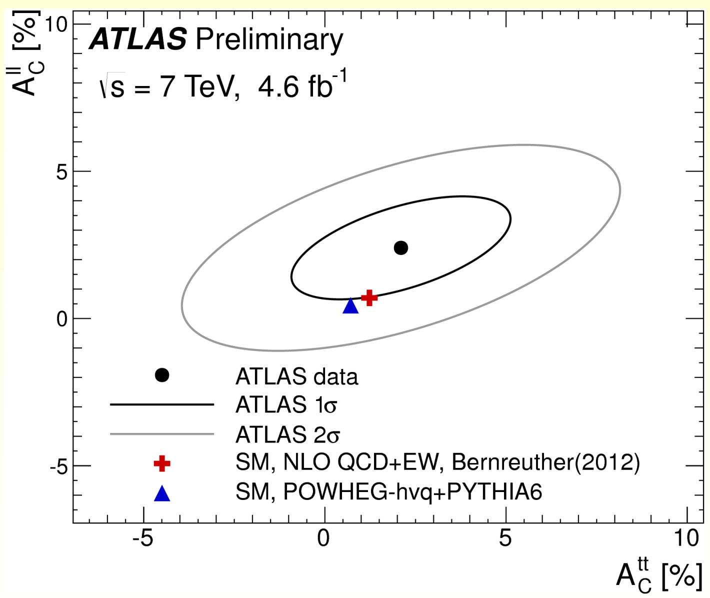
Data analyses

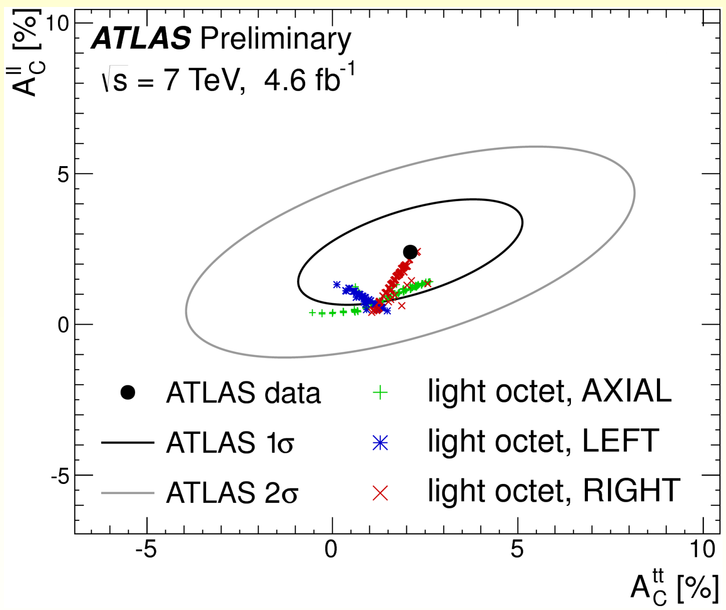
- ATLAS
  - ➔ 2012-2014: measurement of the charge asymmetry and polarization of top quarks
- CMS
  - ➔ 2013-2015: measurement of parity and couplings of the Higgs boson in the diphoton final state

Measurement of charge asymmetry in top quark pairs



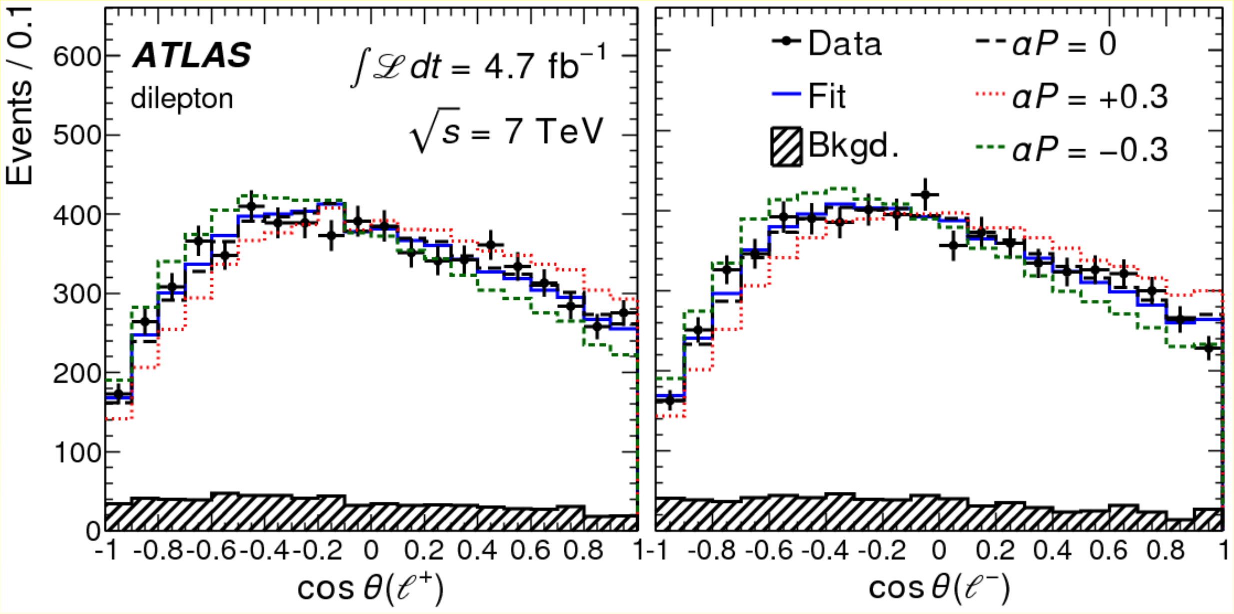
- top-antitop charge asymmetry
  - ➔ QCD predicts that top quarks are emitted preferentially backward/forward while antitops are rather central at the LHC
  - ➔ several measurements of this asymmetry at the Tevatron were larger than the standard model prediction
- $t\bar{t}$ asymmetry measurement in the dileptonic channel in ATLAS at 7 TeV
  - ➔ $t\bar{t}$ asymmetry (need the final state reconstruction) or from the leptons coming from the top decays (diluted asymmetry)
  - ➔ « unfolding » of reconstructed distributions to get partonic informations to be comparer with theory predictions
- result:
  - ➔ first measurement in 2D at LHC
  - ➔ limited by statistical error
  - ➔ in agreement with standard model prediction





Measurement of top quark polarisation

- top quark polarisation
  - ➔ in the standard model, the top quark is produced with a almost vanishing polarisation
  - ➔ models that could explain a large asymmetry at the Tevatron can also induce a top quark polarisation
- measurement of the top quark polarisation in ATLAS at 7 TeV
  - ➔ fit the distribution of polar angle from the top quark decay products
  - ➔ first measurement at the LHC : measured polarisation compatible with 0

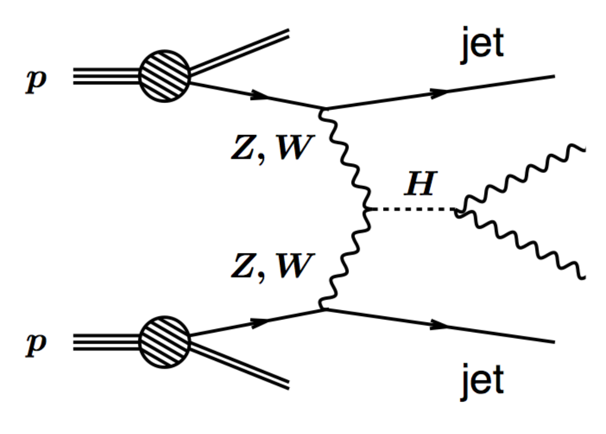


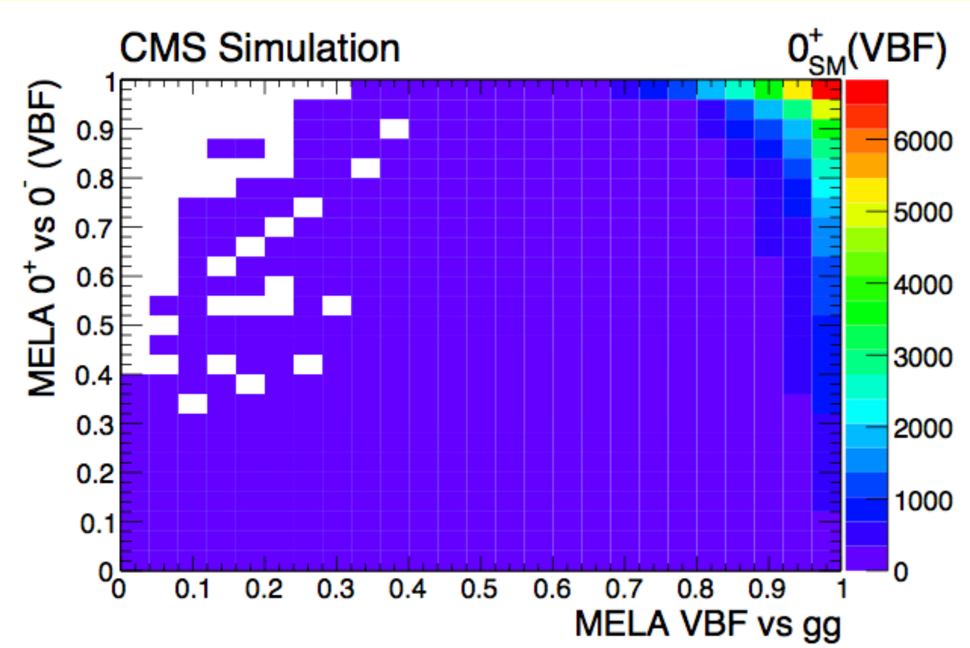
PRL 111, 232002 (2013)

- P2IO added value
  - ➔ work in collaboration between experimentalists and theorists (Saclay-LPT)
  - ➔ visibility of experimentalists on hot topics

Measurement of Higgs boson parity and couplings in the diphoton final state

- Higgs boson :
  - ➔ discovered in 2012, highlight of LHC Run 1
  - ➔ important goal of Run 2: measurements of its properties to establish the nature of this new particle
- measurements of the Higgs boson couplings to the W and Z in CMS
  - ➔ use the vector boson fusion mechanism (VBF)
  - ➔ search for Higgs boson decaying into two photons:
    small branching ratio, clear signature
  - ➔ sensitivity study at 8 TeV:
    likelihood fit to separate signal from background and the different hypotheses for Higgs boson parity





- P2IO added value
  - ➔ new analyse in CMS complementary to the H→ZZ final state
  - ➔ visibility of experimentalists on hot topics

New theory developments

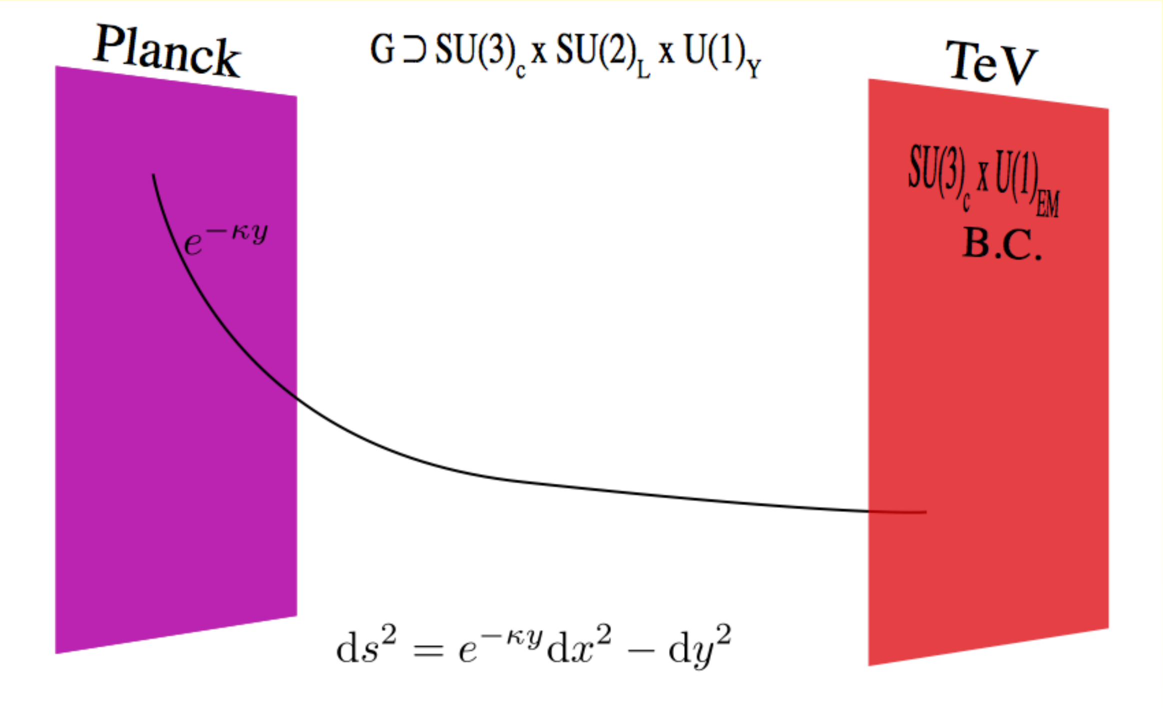
- LPT-Orsay
  - ➔ 2012-2014: the Higgs boson problem located on a brane

The Higgs boson problem located on a brane

- the hierarchy problem
  - ➔ The Higgs boson was discovered but the electroweak symmetry breaking mechanism is still to be understood: electroweak scale << Planck scale, hierarchy between the fermion masses
  - ➔ several models could overcome these weaknesses like extradimension models
- extradimension models implication on Higgs physics
  - ➔ influence of the Kaluza-Klein fermions on the pp→H→VV production
  - ➔ implementation of the Yukawa terms in lagrangiens to solve the equations of motion
  - ➔ 2 computations in 4D lead to different results

    non commutativity: Higgs localisation on the brane vs infinite sum of the KK levels

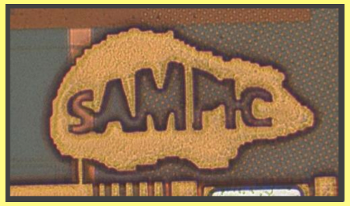
arXiv:1408.1852



- P2IO added value
  - ➔ join together a group of experts in extradimension to work on this difficult paradox

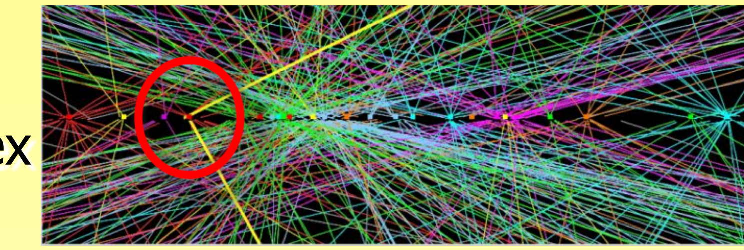
detector R&D

- SAMPIC
  - → 2012-2014: development of an electronic system for absolute time measurement based on a new chip
- ATLAS
  - → 2013-2014: upgrade of the ATLAS electromagnetic calorimeter L1 trigger

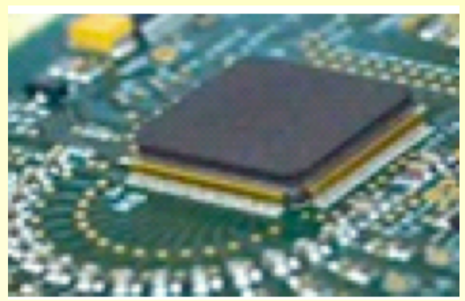


Chip to measure absolute timing at the picosecond level

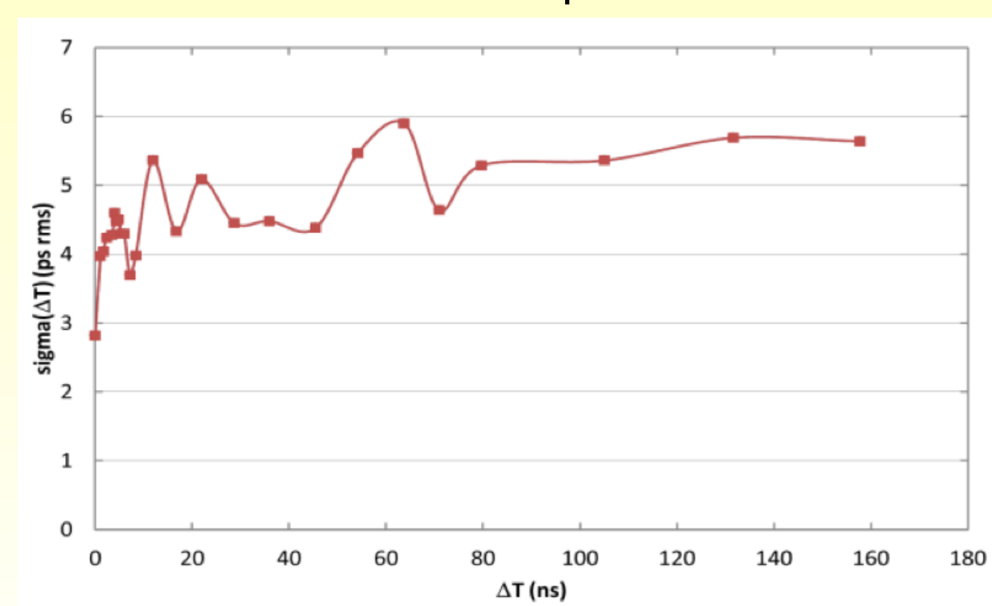
- flight time measurement at the picosecond level in particle physics
  - ➔ study of diffractive protons at small angles (a few mm from the beam)
  - ➔ a few ps resolution to reject background and link the event to the right vertex



- SamPic: Sampler for Picosecond time pick-off
  - ➔ based on CMOS
  - ➔ principle: threshold detection, sampling and time estimate, analog-digital conversion and readout of the region of interest
  - ➔ excellent results of the chip prototype



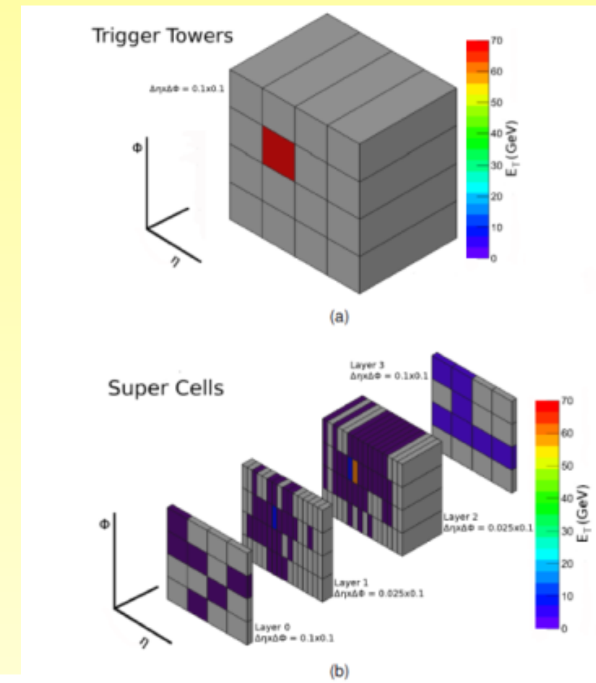
resolution on the time difference between 2 pulses of 0,85 ns length as a fonction of their time separation

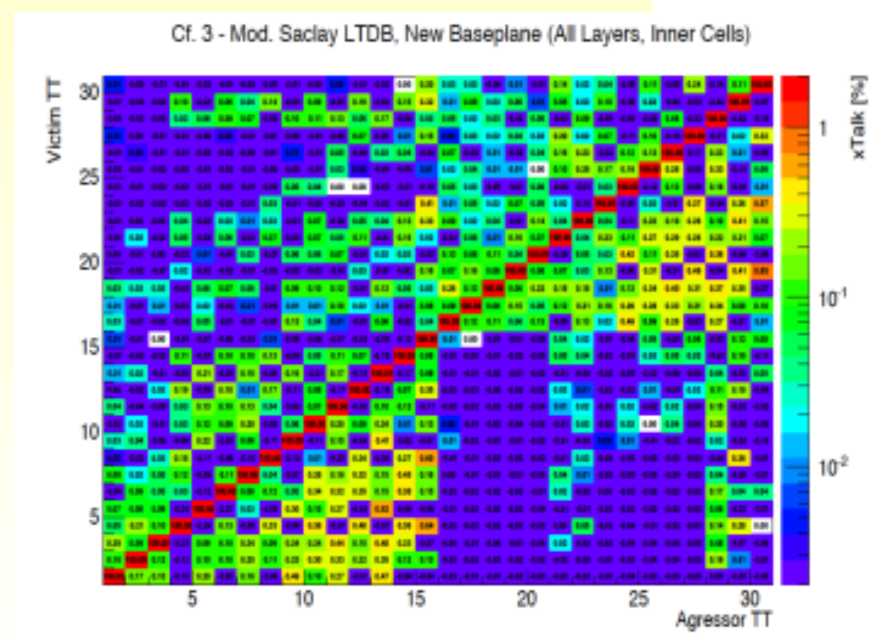


- P2IO added value
  - ➔ projet hardly doable without P2IO support
  - ➔ collaboration Saclay-LAL

Upgrade of the ATLAS electromagnetic calorimeter L1 trigger

- LHC Run 3 (2019-2021):
  - ➔ high luminosity phase: 2 10^{-34} cm^{-2} s^{-1} , 300 fb^{-1} expected, trigger EM: 20 kHz
  - ➔ with the current L1 trigger: thresholds on electrons/photons: 40-45 GeV (inacceptable efficiency loss)
- Upgrade of the ATLAS L1 trigger
  - ➔ increase granularity (isolation and shower shape optimisation)
  - ➔ compatibility between the old and new system (analog part - digital part)
  - ➔ prototype successfully integrated in ATLAS last summer ready to take data: analog and digital parts validated (noise, cross-talk, linearity)





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Conclusion

- P2IO and LHC physics
  - ➔ P2IO supports/supported several LHC projets:
    physics analysis, theory developments, detector R&D
  - ➔ within large international collaborations, P2IO support allows significant progress led by labs from the Labex

- LHC Run 2 will open new perspectives