

Workshop on Ultimate Precision at Hadron Colliders

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Workshop site (in progress)

<https://www.universite-paris-saclay.fr/fr/precision-electroweak-and-higgs-physics-at-the-lhc>

Scientific objectives

- In short, estimate how far the LHC, its upgrades and companion machines, and low-energy data can push the exploration of Electroweak symmetry breaking by ~2035.
Provide a sound benchmark against which the larger future projects can be evaluated
- To be (re-)discussed:
 - QCD precision : perturbative QCD developments; PDFs
 - Measurement precision of traditional EW parameters
 - Inputs from low-energy experiments
 - Higgs boson properties in relation with TeV-scale vector boson scattering
 - Global interpretation
- Context
 - HL-LHC
 - DIS : eIC ; LHeC (a fundamental component for precision in pp)
 - HE-LHC (relevant for vector boson scattering, for example)

Themes

The proton structure – ultimate reach in PDF precision?

critical review of HL-LHC and LHeC prospects. What are the limitations to be overcome to achieve the advertised precision? Relevance of eIC?

EW precision observables

W&Z mass, weak mixing angle, top mass and properties in relation with electroweak symmetry breaking. Correlation between measurements and impact on their interpretation.

Higgs boson properties and TeV-scale vector boson scattering

Limiting systematic uncertainties in Higgs physics (not an exhaustive review), in particular related to PDFs and theoretical predictions. Diboson and VBS measurements.

Low-energy probes

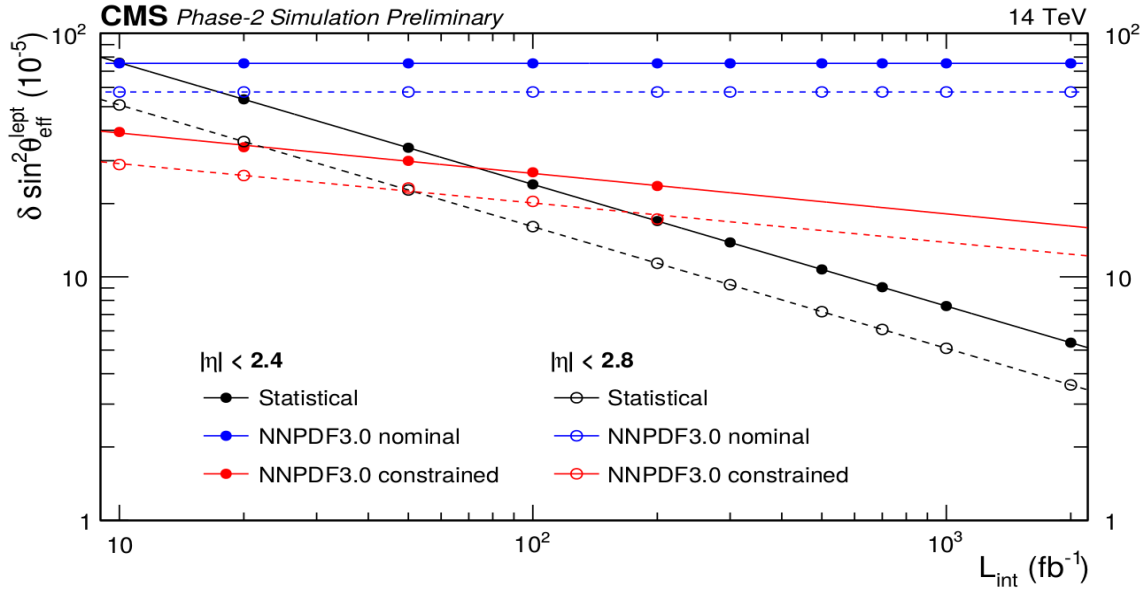
Prospects for $g-2$; $\Delta\alpha_{\text{had}}$; $\sin^2\theta_W$ in ep scattering. Lepton and meson decays rates and branching fraction. Other low-energy measurements relevant for EWSB?

Global interpretation

Workshop objectives (ambitious proposal)

- Define, in advance, a limited number of “money plots”, to be discussed at the workshop. For example:
 - PDF uncertainties
 - m_W vs $\sin^2\theta$, experimental precision including correlations.
 - Higgs coupling overview. Self-coupling?
 - Expected knowledge of $g-2$, $\Delta\alpha_{\text{had}}$, etc
 - VBS cross sections; and implications on Higgs couplings to vector bosons
 - Interpretation : EW fit, S/T/U, SMEFT
- **Where relevant, compare : LHC / HL-LHC / HL-LHC+LHeC (or EIC) / HE-LHC**
- Goal : summarize the precision we can hope for by the end of the HL-LHC, to be used as a benchmark to evaluate the larger future projects
- If we manage, draft conclusions in a compact document with a clear message.

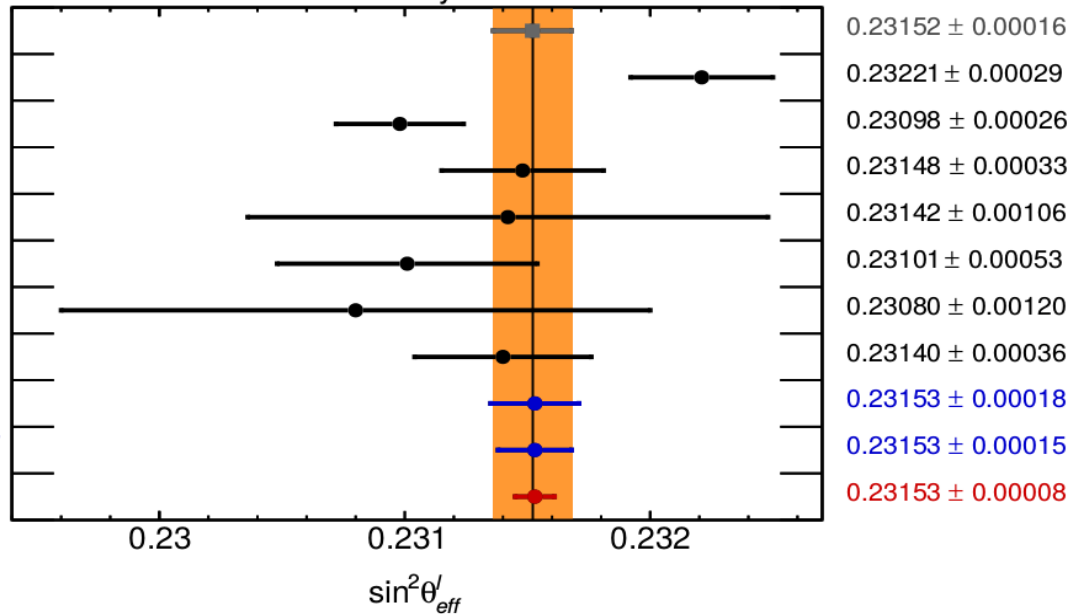
Examples (HL-LHC Yellow Reports)



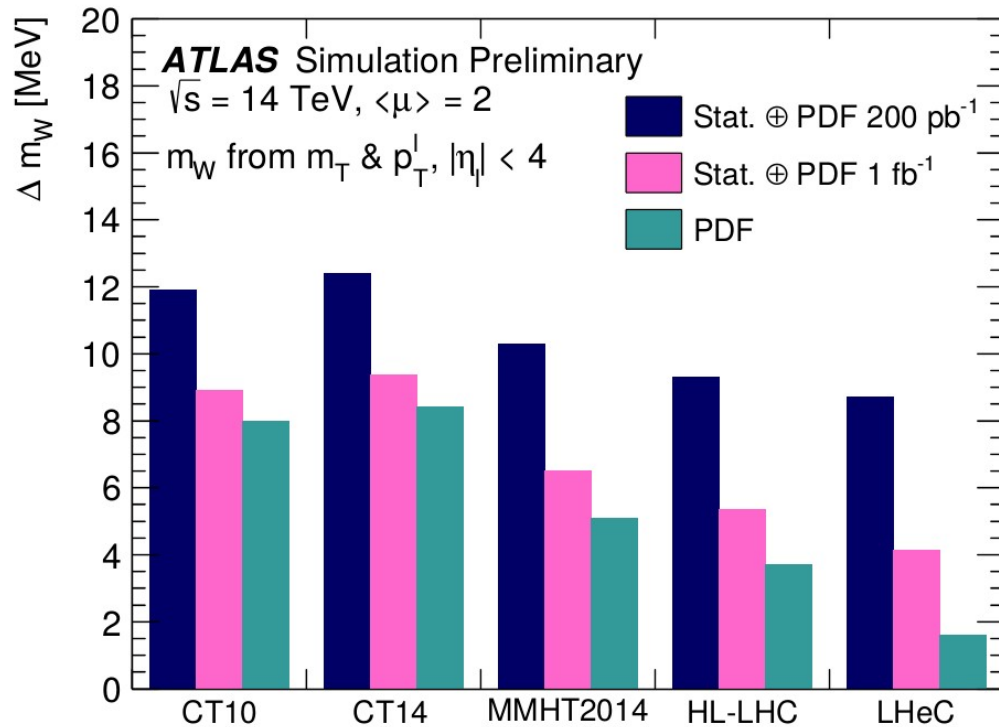
$\delta \sin^2 \theta_W \sim 10^{-4}$ reachable at the HL-LHC, even better with LHeC PDFs

- LEP-1 and SLD: Z-pole average
- LEP-1 and SLD: $A_{FB}^{0,b}$
- SLD: A_1
- Tevatron
- LHCb: 7+8 TeV
- CMS: 8 TeV
- ATLAS: 7 TeV
- ATLAS Preliminary: 8 TeV
- HL-LHC ATLAS CT14: 14 TeV
- HL-LHC ATLAS PDF4LHC15_{HL-LHC}: 14 TeV
- HL-LHC ATLAS PDFLHeC: 14 TeV

ATLAS Simulation Preliminary



Examples (HL-LHC Yellow Reports)



- $\delta m_W[\text{PDF}] :$

6-8 MeV with “std” LHC PDFs,
 <2 with LHeC

Objectives of workshop :

consolidate these prospects (critical review of HL-LHC and LHeC PDFs ; impact of eIC?
 extend to Higgs and other theory-limited measurements
 impact on global interpretation

Relation with existing working groups

- We would like this workshop to work as a joint meeting of the relevant existing working groups, dedicated to future prospects at the LHC
 - **LPCC** : EW precision & Multiboson working groups ; Higgs Cross-section WG
 - **PDF4LHC**
 - **VBSCan**
- Announcements to be sent out asap. We hope to involve everyone interested!

Provisional agenda

<https://indico.cern.ch/event/830120/timetable/?view=atlas>

- 1st week
 - proton structure – ultimate reach in PDF precision (two days)
 - EW precision observables (two days)
 - Low-energy probes (one day)
- 2nd week
 - Higgs boson properties and TeV-scale vector boson scattering (two days)
 - Summaries & global interpretation (three days)
- Idea :
 - alternate long in-depth talks (~1 hour) with discussion, and shorter topical talks
 - Ample time foreseen for informal discussions