

Future Higgs Physics at Electron-Proton Colliders

LHeC Higgs Study Group^{1,‡}

Abstract. The Higgs boson and its physics have become a central topic of modern particle physics and a key parameter in the evaluation of future high energy collider projects. This paper provides a summary and overview on the potential of future luminous, energy frontier electron-proton colliders, especially the LHeC, the HE-LHC and the FCC-eh, for precision Standard Model measurements of the properties of the Higgs boson in deep inelastic scattering. Detailed analyses are presented on the prospects for accurate measurements of the Higgs boson decays into pairs of bottom and charm quarks. An extended study is performed for estimating the precision on the Higgs couplings in the most abundant decay channels, based on measurements in the charged and weak neutral current DIS reactions. The addition of ep information to the expected HL-LHC Higgs coupling measurements is demonstrated to lead to major improvements on the Higgs results one can expect to come from the LHC facility at large.

The ECFA Higgs Working Group expects this by the end of March, 19..

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Max + Uta Klein + Masahiro Kuze - Higgs WG Meeting, 11.3.2019

1. Introduction

All began when we had the CDR [1].

2. Prospects for Electron-Proton Scattering at CERN

3. Higgs in ep

3.1. Cross Sections and Kinematics

3.2. Detector Concept

4. Higgs Decay into Bottom and Charm Quarks

4.1. Signal and Background Event Simulations

4.2. Boosted Decision Tree Analysis

5. Accessing Further Decay Channels

6. Further Prospects

6.1. The $t\bar{t}H$ Coupling

6.2. Higgs Decay into Invisible

7. Coupling Analyses

7.1. LHeC Results

7.2. Joint Fits: LHeC and HL-LHC

7.3. HE-LHC and FCC-eh Prospects

8. Summary

The main part of the paper should be the explanation of the signal strength analyses for the 7 most frequent decay channels, for LHeC/HE-LHC/FCC-eh

We decided today to not include any BSM Higgs here in order to be able to converge on time and since much of BSM Higgs is published.

The main result of the paper

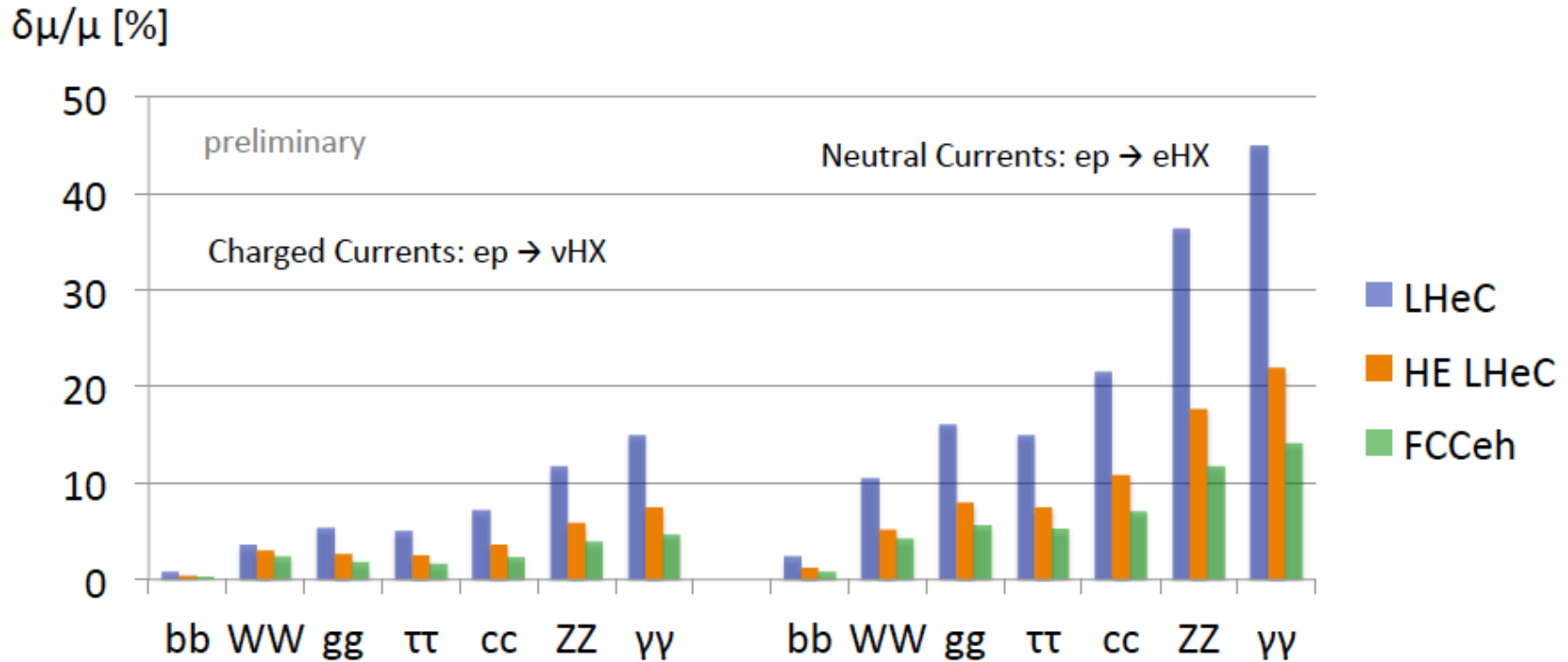


Figure 1. Uncertainties of signal strength determinations in the seven most abundant SM Higgs decay channels for the FCC-eh (green, 2 ab^{-1}), the HE LHeC (brown, 2 ab^{-1}) and LHeC (blue, 1 ab^{-1}), in charged and neutral current DIS production.

Combination with HL LHC

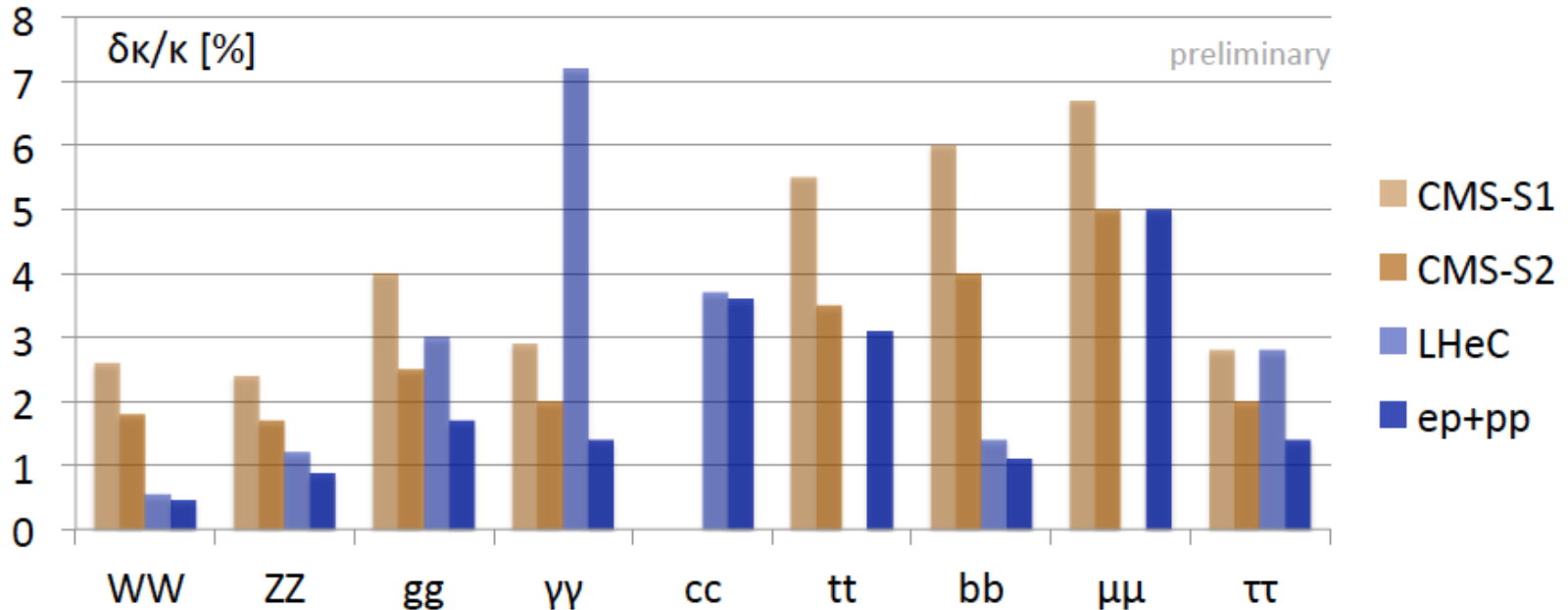


Figure 3: Determination of the κ scaling parameter uncertainties with SM width: Brown (light/dark): CMS with systematic error assumption S1/S2 [30]; Light Blue: LHeC; Dark Blue: Joint κ fit to CMS (S2) and LHeC H decay signal strengths. Note that LHC has no significant charm result, while LHeC has no precise results for very rare processes, as $H \rightarrow \mu\mu$.

In December only CMS had released the signal strength. Now also ATLAS, Jorge de Blas just sent a first joint fit: ep+ATLAS+CMS. This looks very similar as CMS has been most optimistic

Timeline

Monday 18.3. First Draft

Monday 25.3. Second Draft

Monday 1.4 out to ECFA WG

Monday 8.4. out to ArXiv [beginning of DIS in Torino]

We have all results, presented them for a year without major change or addition
It is necessary that we now write these up, for the whole ep Higgs working group