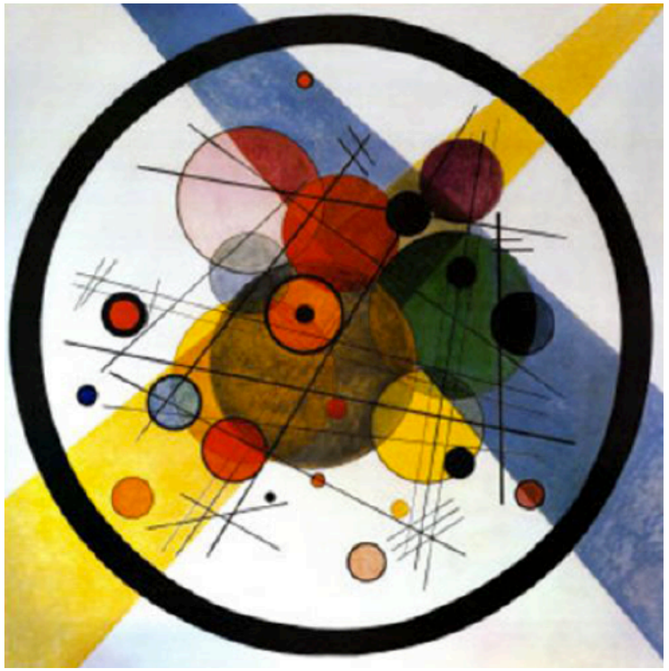
Physics prospects at the Large Hadron electron Collider



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Motivation

- Complementarity of the three kind of collisions for our understanding of the interaction of matter at TeV-scale

- Primary physics cases for LHeC:

  ☞ Proton structure at $\sim 10^{-20}$ m

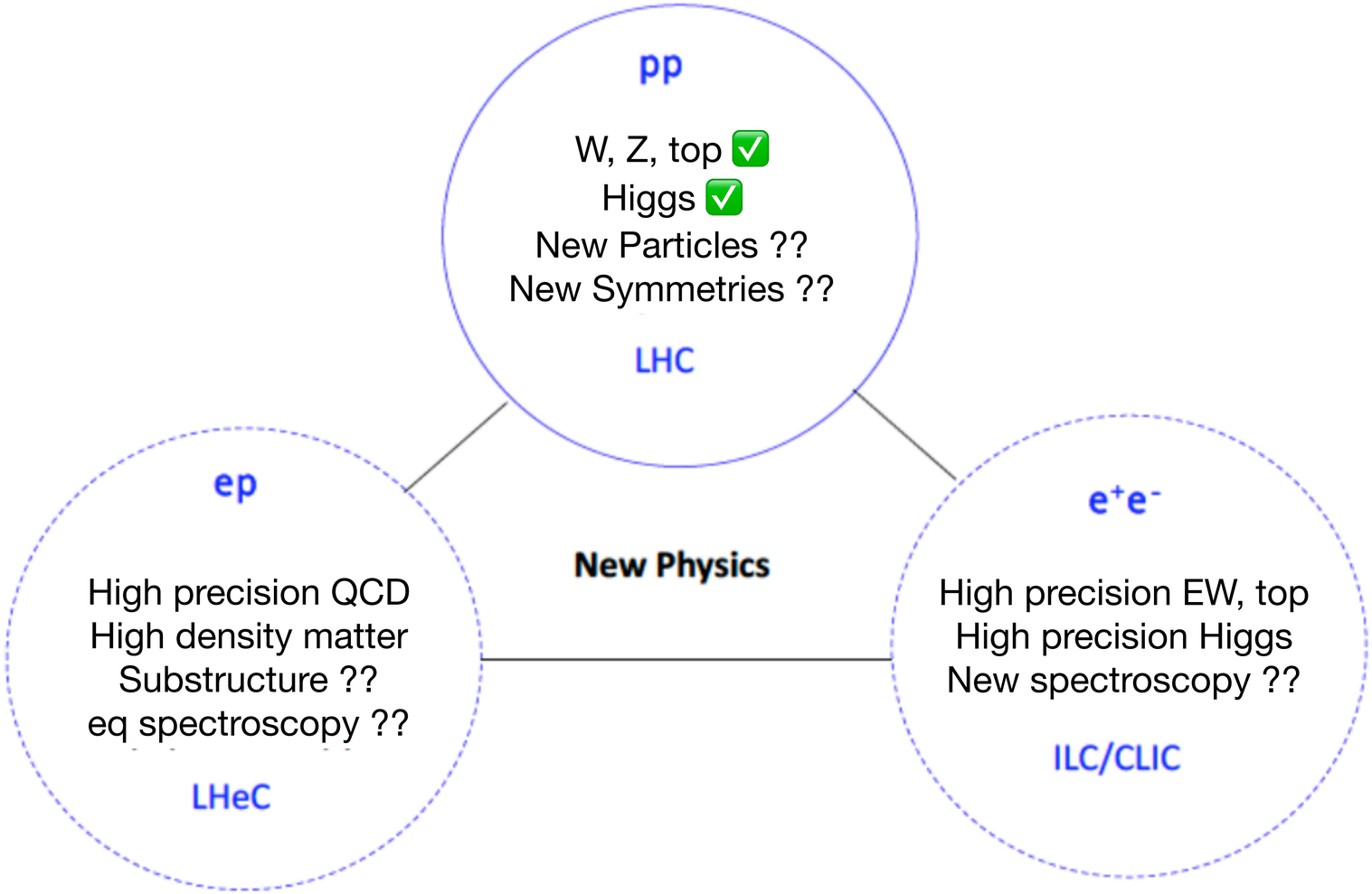
  ☞ Precision QCD and EW physics

  ☞ Probing high mass frontier for

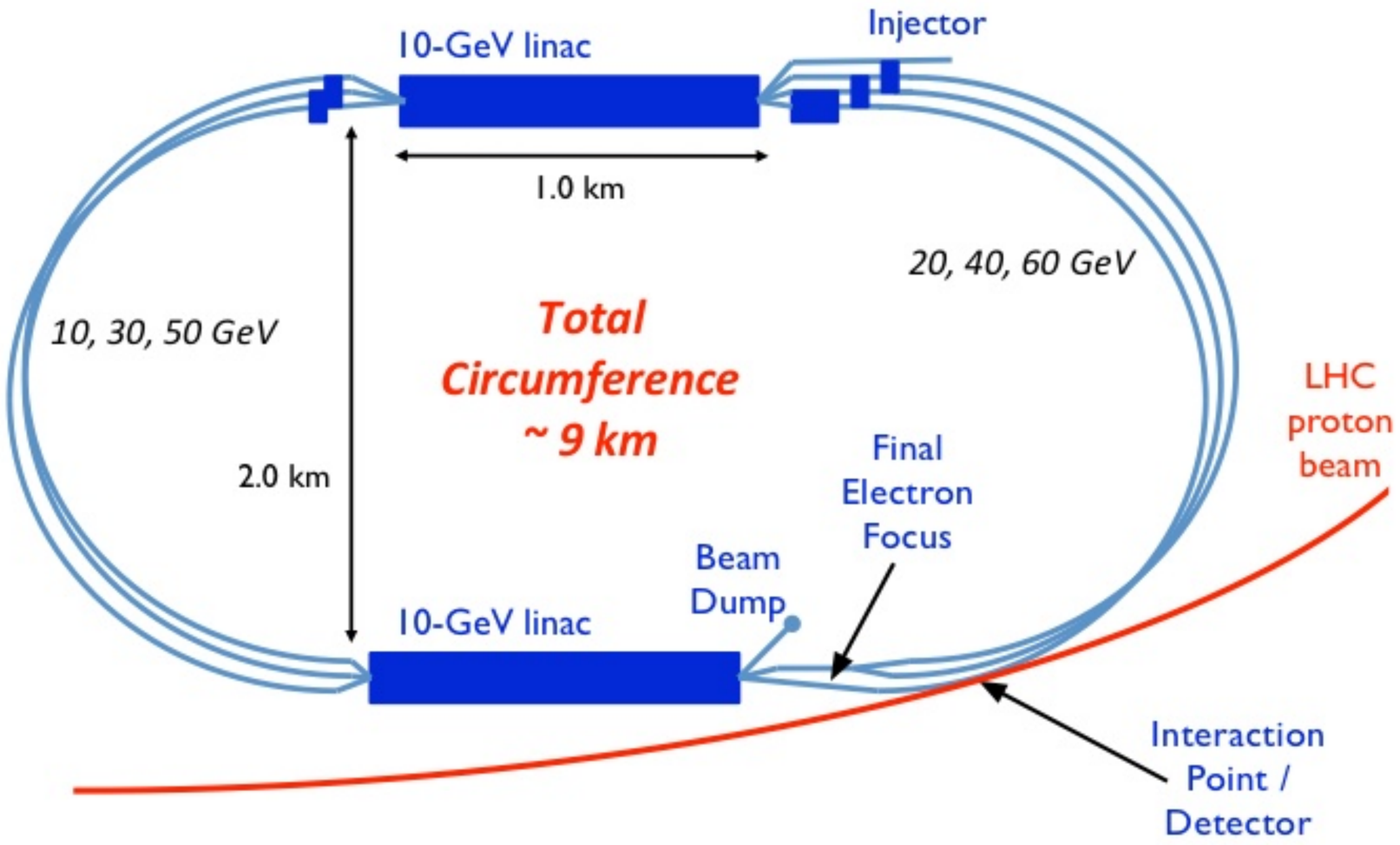
  BSM signature such as ALPs, Z′, LQ etc.

  ☞ Substructure/parton dynamics

  inside nuclei with strong QGP implications



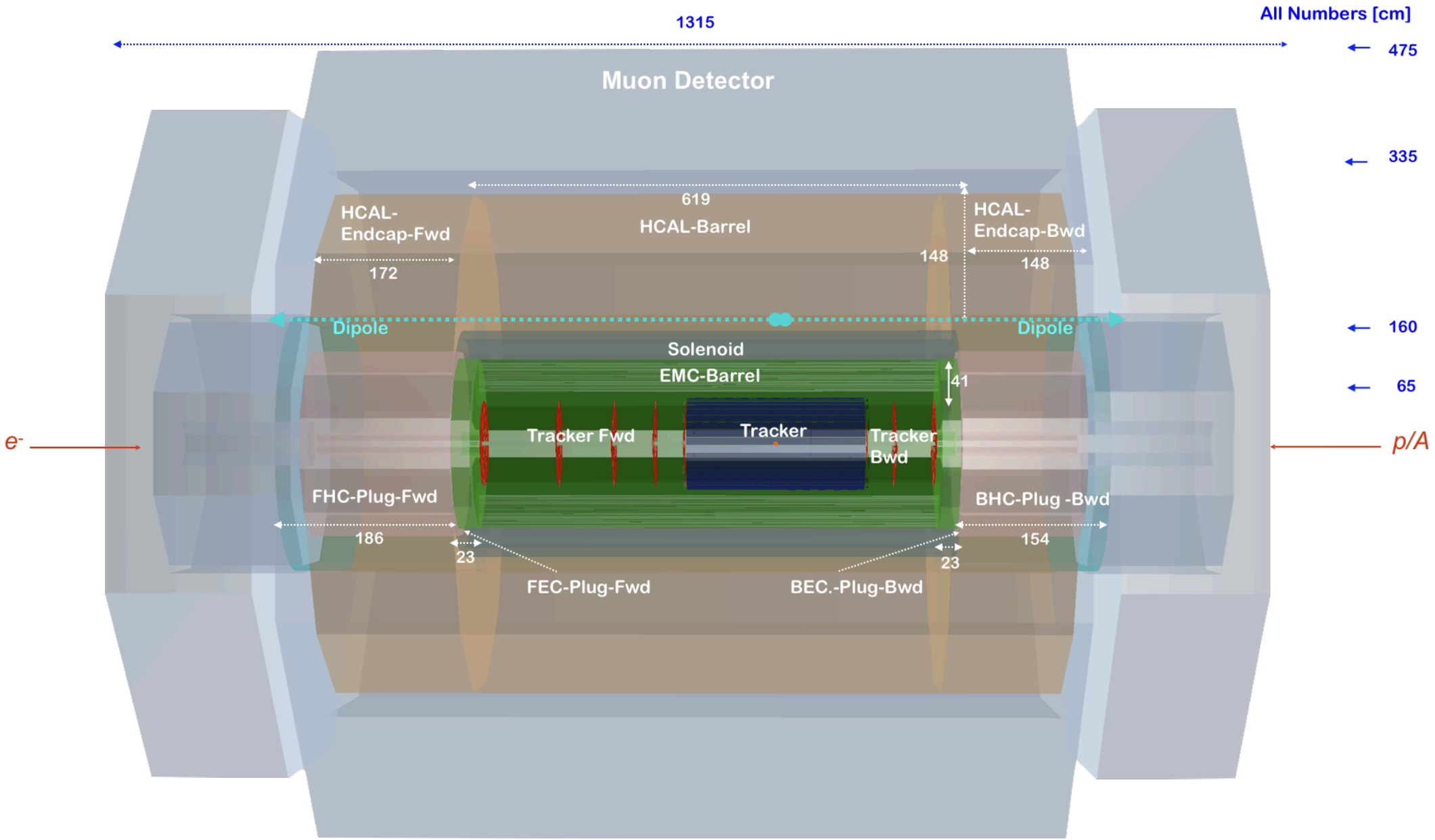
LHeC facility



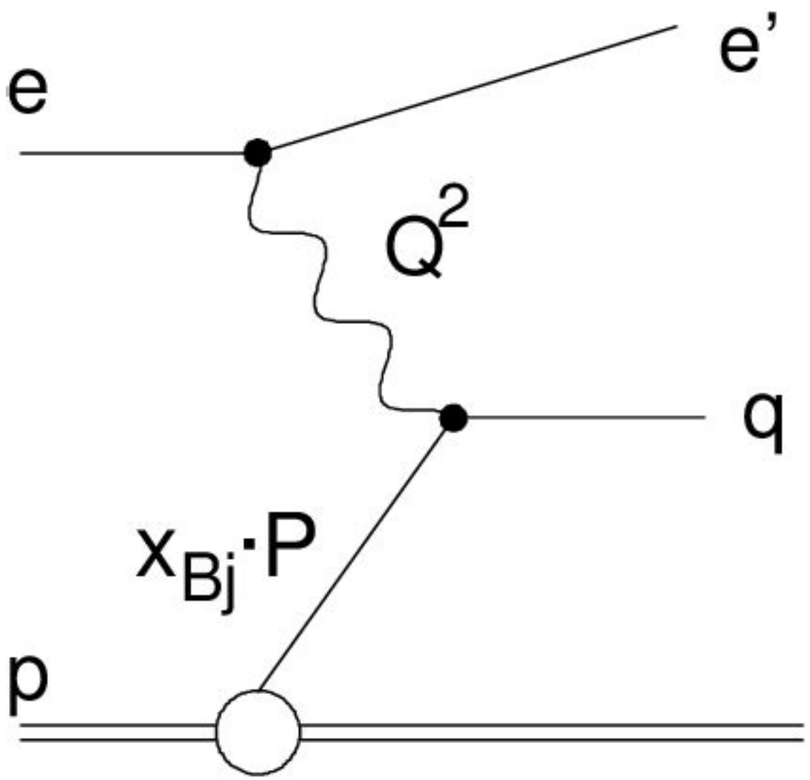
- E_e = 60 GeV, E_p = 7 TeV
- CM energy: $\sqrt{s}$ = 1.3 TeV
- ± 80 - 90% polarized e beam
- High luminosity : 10^{34} cm^{-2} s^{-1} ➔ O(10^3) more compared to HERA
- Large acceptance: 1-179 deg.

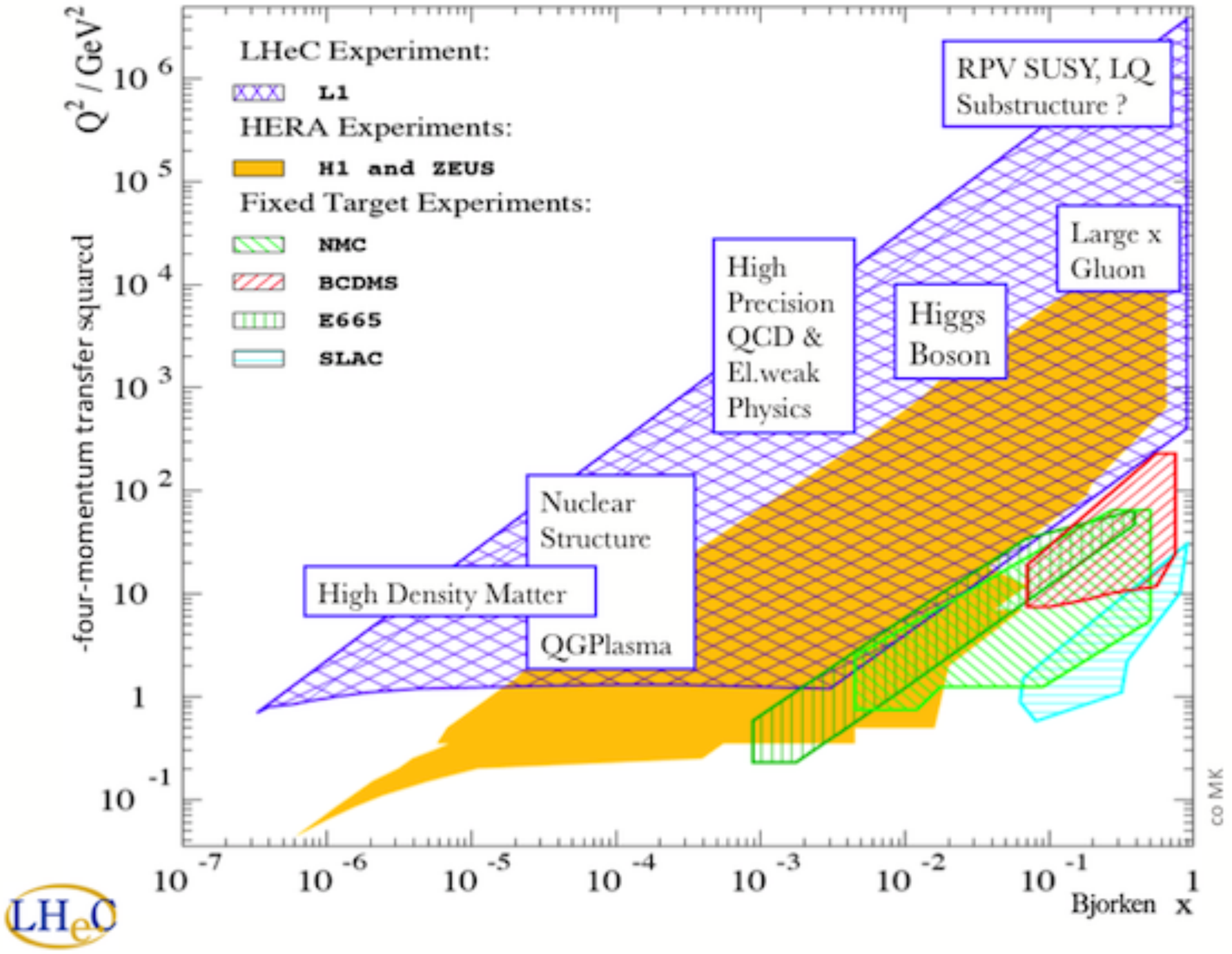
- In this talk, I focus only on *ep* scattering
- Dedicated eA scattering studies are also available in the latest *Conceptual Design Report* of LHeC

A prototype LHeC detector



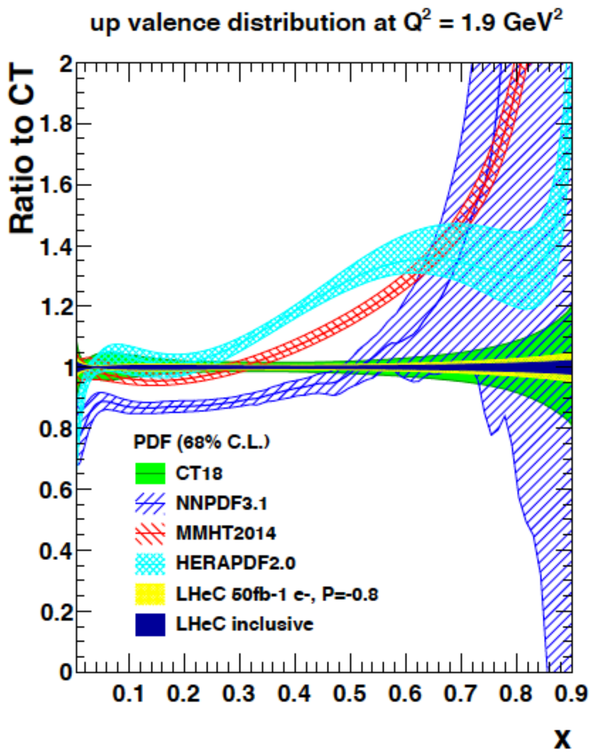
Accessible kinematic range



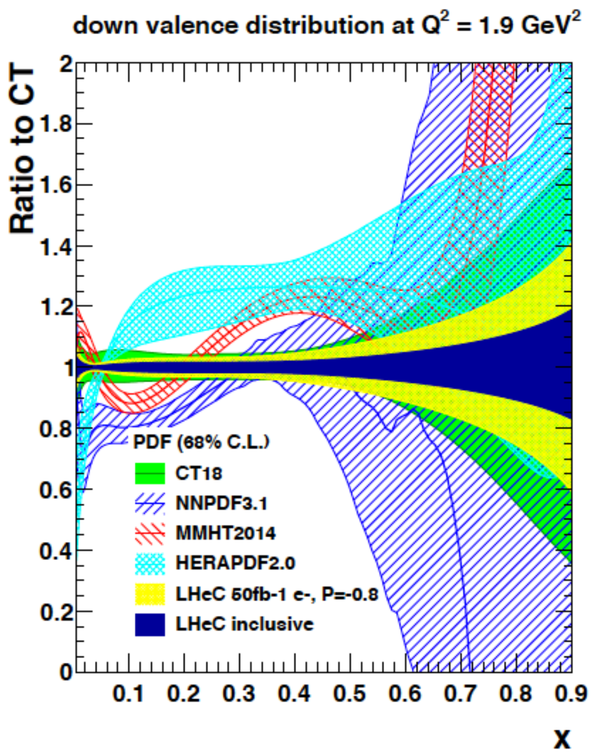


Proton PDFs

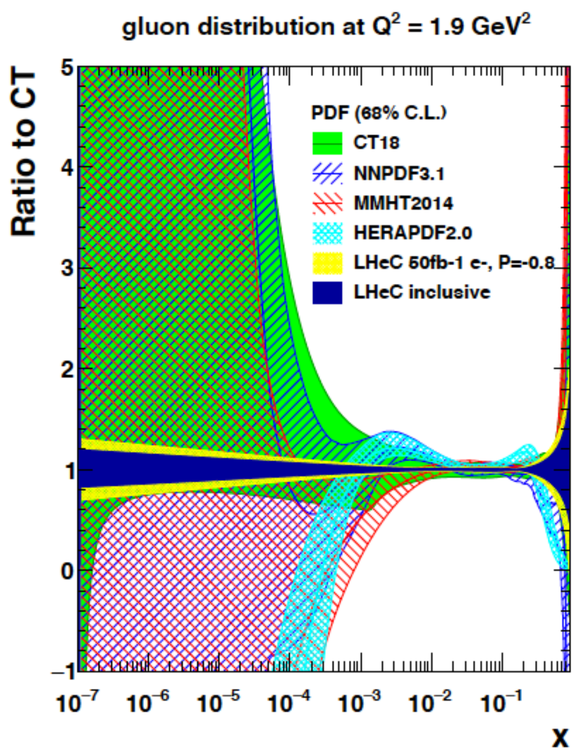
u-quark

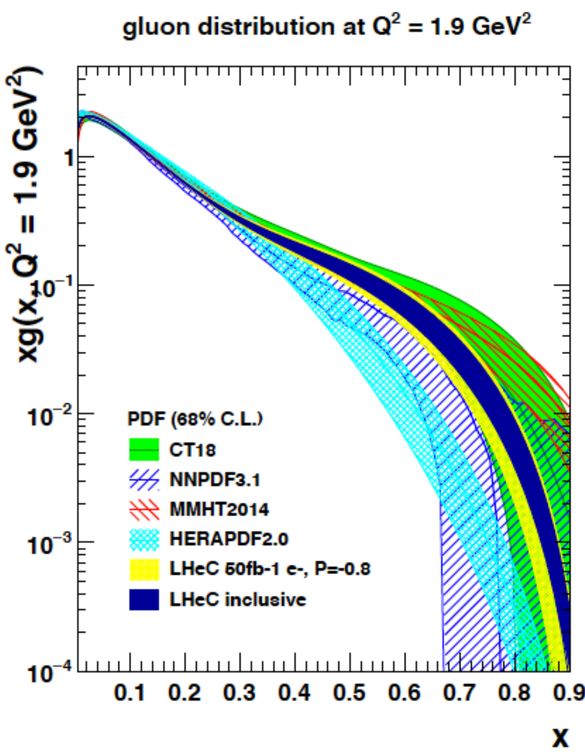


d-quark



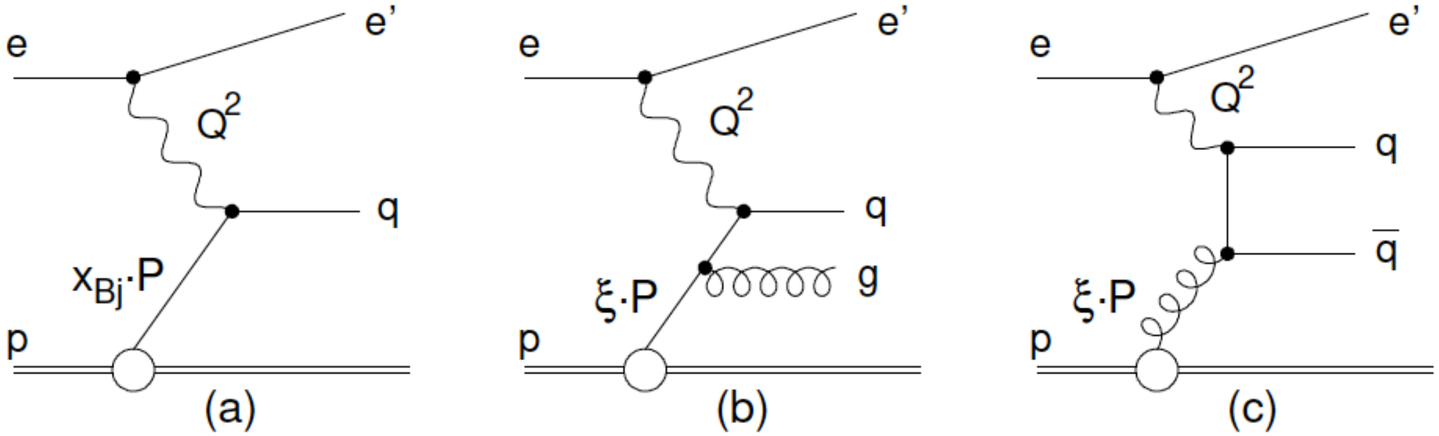
gluons

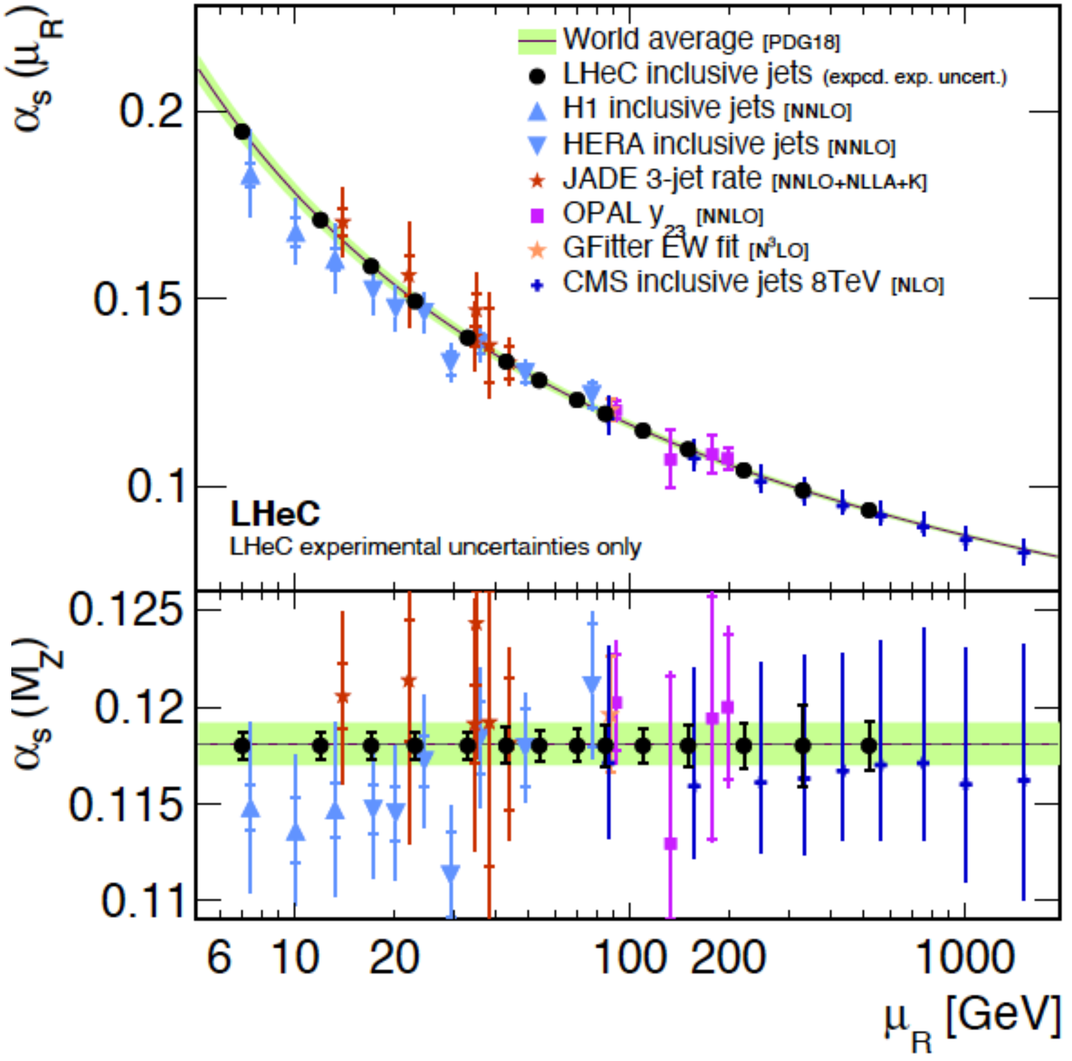




α_s Running

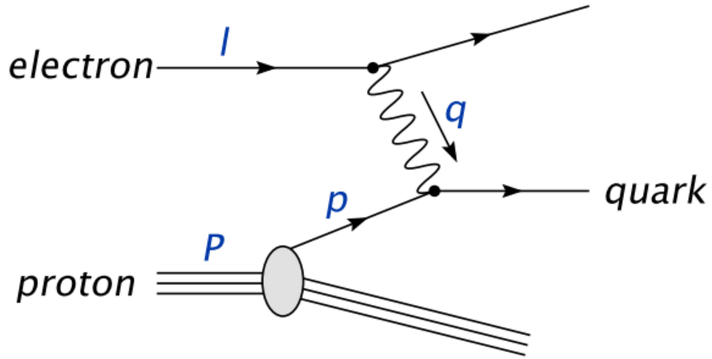
- Jet production cross section used for extracting strong coupling

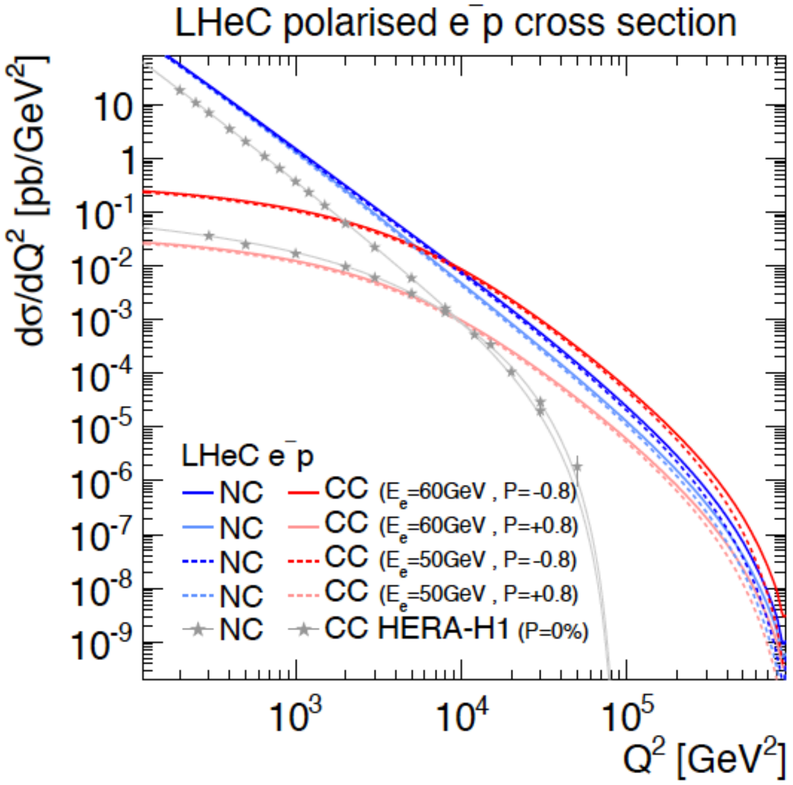


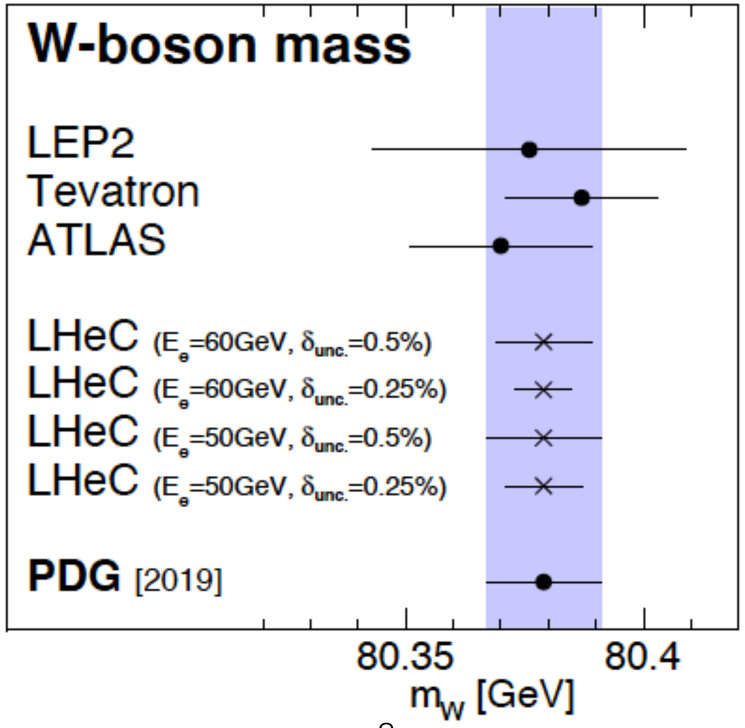


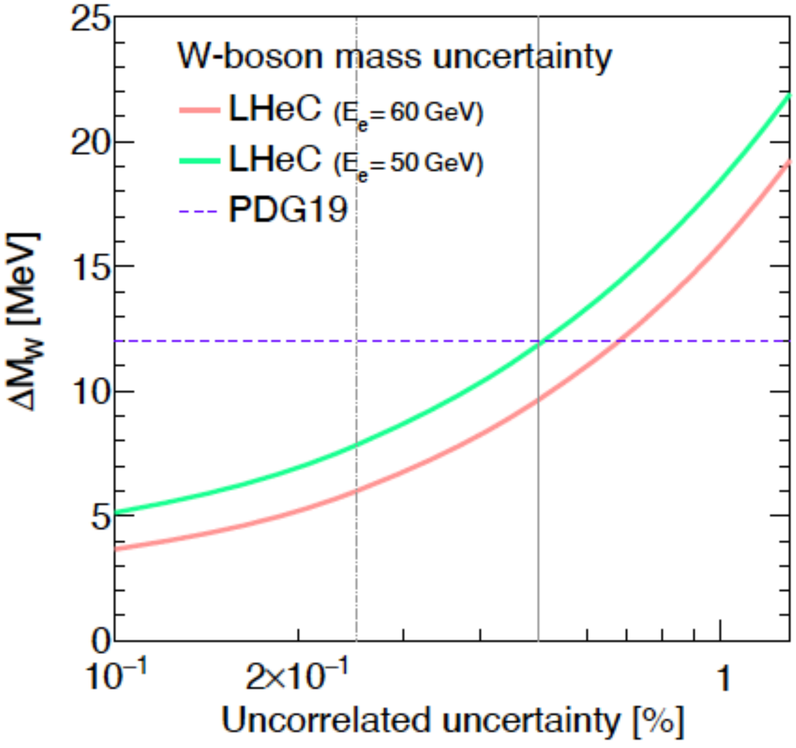
Charged Current (CC) and Neutral Current (NC)

Extract m_W from diff. CC cross-section as well as from direct production



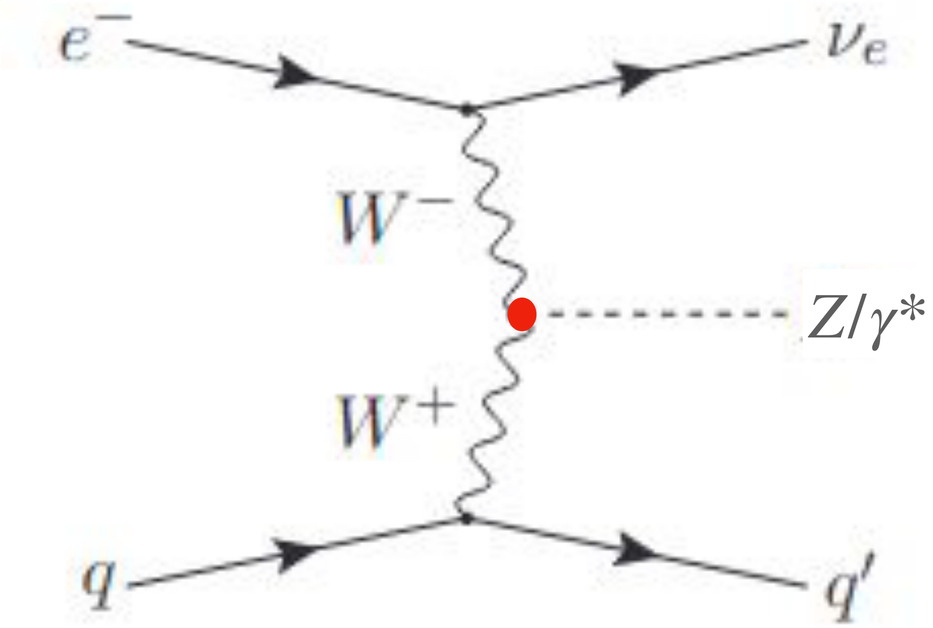




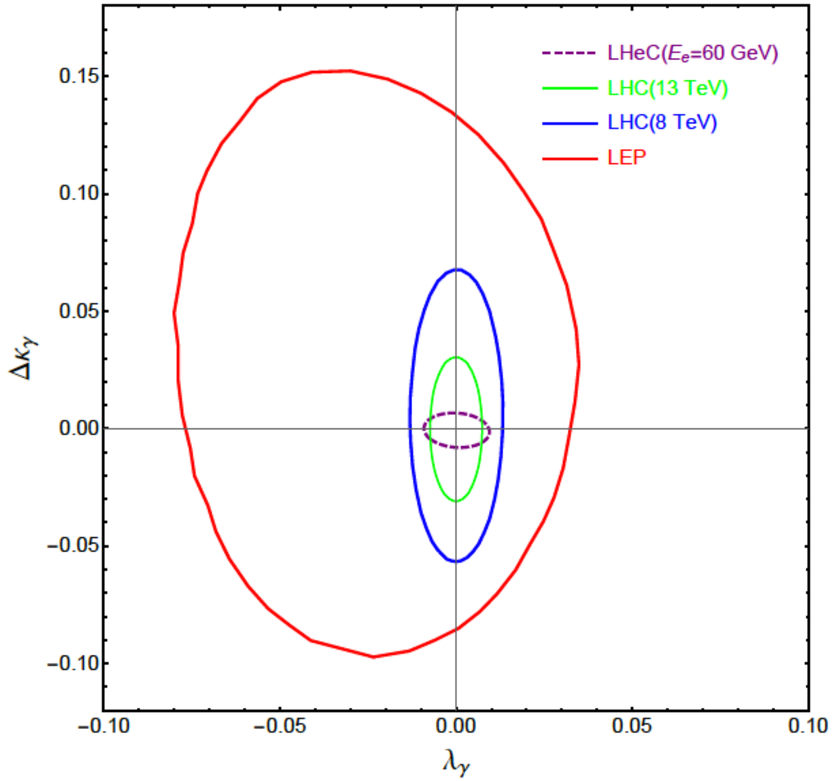


Triple gauge couplings

$$\begin{aligned}\mathcal{L}_{TGC}/g_{WWV} &= ig_{1,V}(W^+_{\mu\nu}W^-_\mu V_\nu - W^-_{\mu\nu}W^+_\mu V_\nu) + i\kappa_V W^+_\mu W^-_\nu V_{\mu\nu} + \frac{i\lambda_V}{M_W^2}W^+_{\mu\nu}W^-_{\nu\rho}V_{\rho\mu} \\ &+ g_5^V \epsilon_{\mu\nu\rho\sigma}(W^+_\mu \overleftrightarrow{\partial}_\rho W^-_\nu)V_\sigma - g_4^V W^+_\mu W^-_\nu(\partial_\mu V_\nu + \partial_\nu V_\mu) \\ &+ i\tilde{\kappa}_V W^+_\mu W^-_\nu \tilde{V}_{\mu\nu} + \frac{i\tilde{\lambda}_V}{M_W^2}W^+_{\lambda\mu}W^-_{\mu\nu}\tilde{V}_{\nu\lambda},\end{aligned}$$

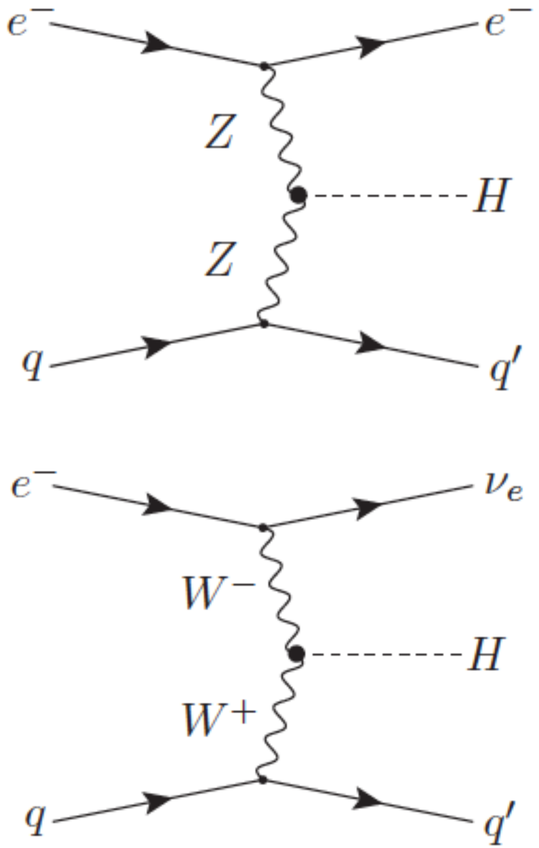


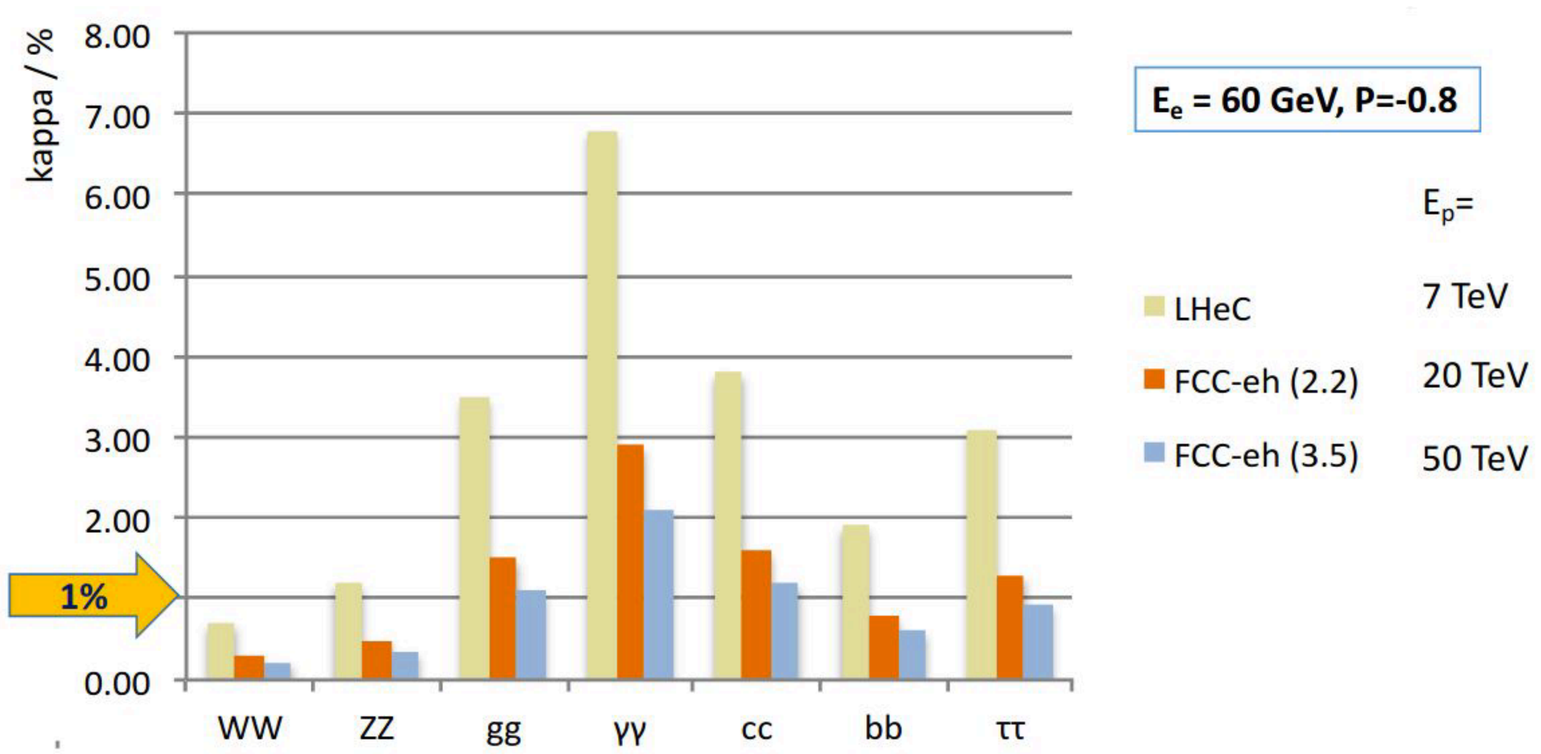
Projection for 1 ab^{-1}



Higgs production

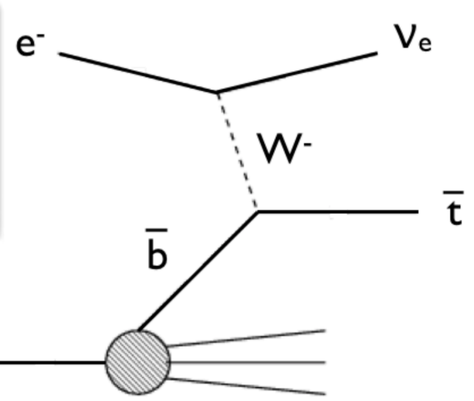
- Expect 200k Higgs events with 1 $ab^{-1}$of data
- High sensitivity in HVV coupling measurement ~ few %
- Contribute to the cross-experiment combination in all major decay channels





Anomalous *tWb* coupling

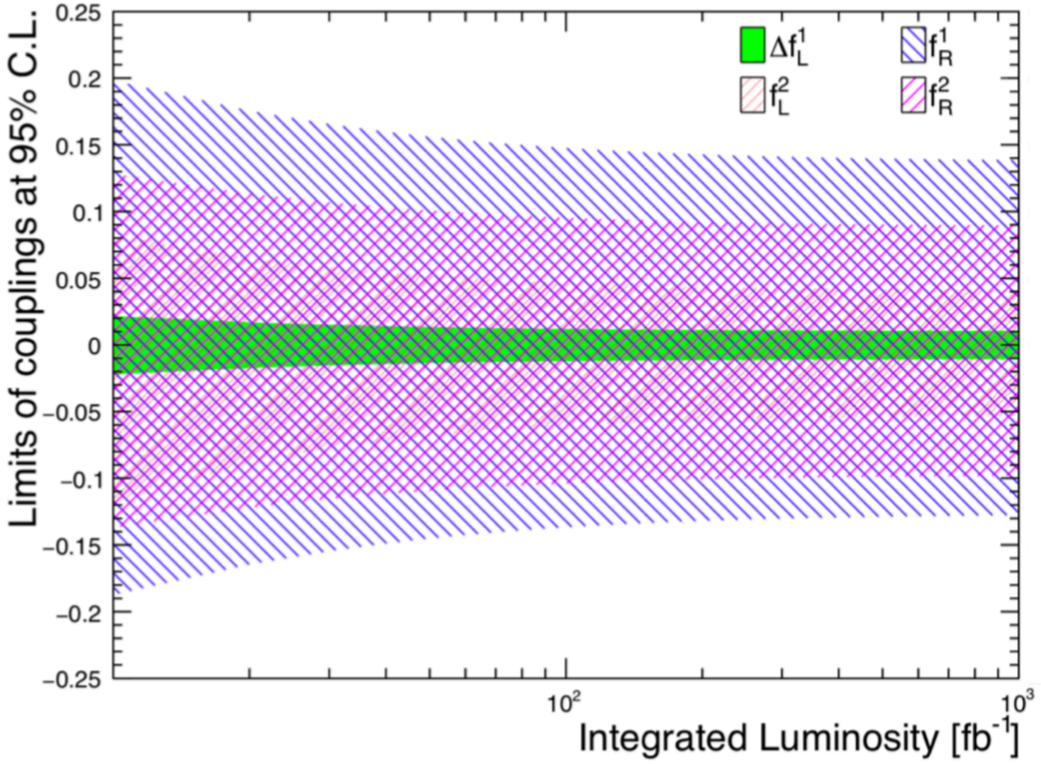
$$\mathcal{L}_{Wtb} = -\frac{g}{\sqrt{2}}\bar{b}\gamma^{\mu}V_{tb}(f_1^L P_L - f_1^R P_R)tW_{\mu}^{-} - \frac{g}{\sqrt{2}}\bar{b}\frac{i\sigma^{\mu\nu}q_{\nu}}{M_W}(f_2^L P_L - f_2^R P_R)tW_{\mu}^{-} + h.c.$$

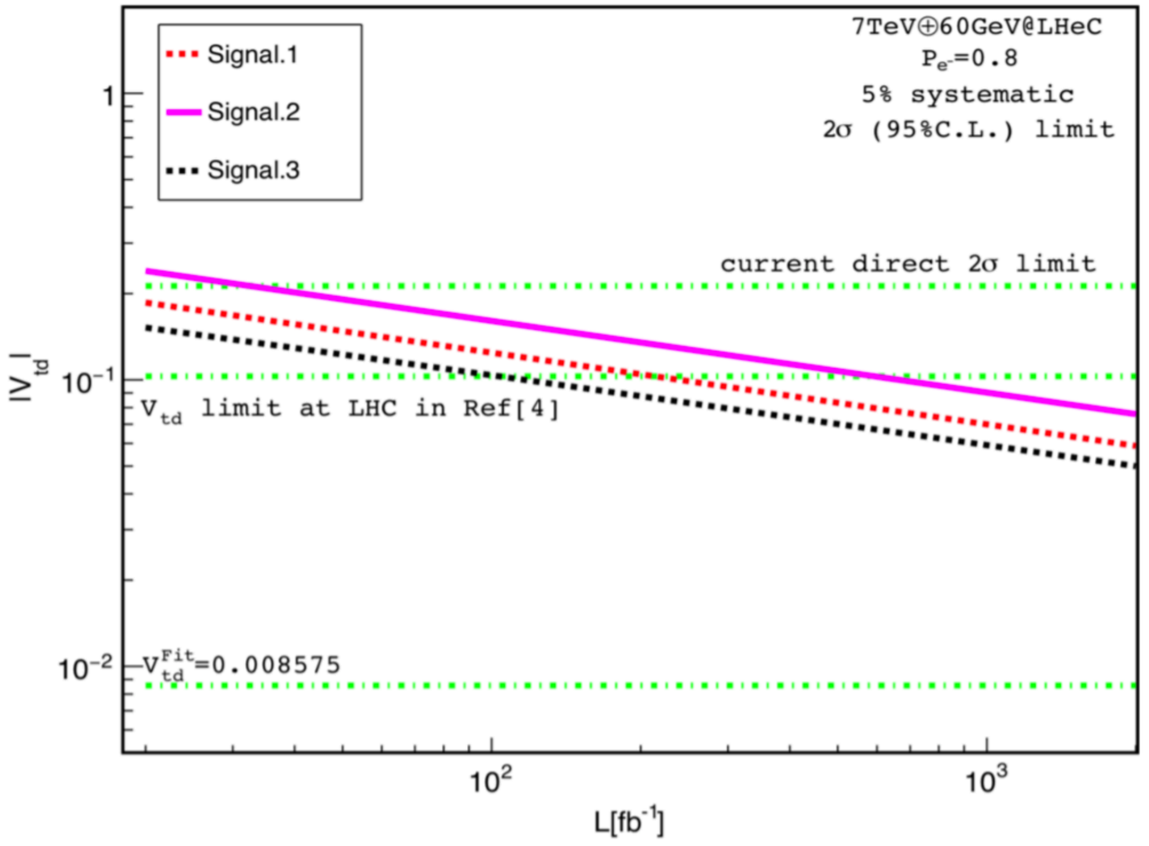


Signal 1: $pe^- \to \nu_e \bar{t} \to \nu_e W^- \bar{b} \to \nu_e \ell^- \nu_\ell \bar{b}$

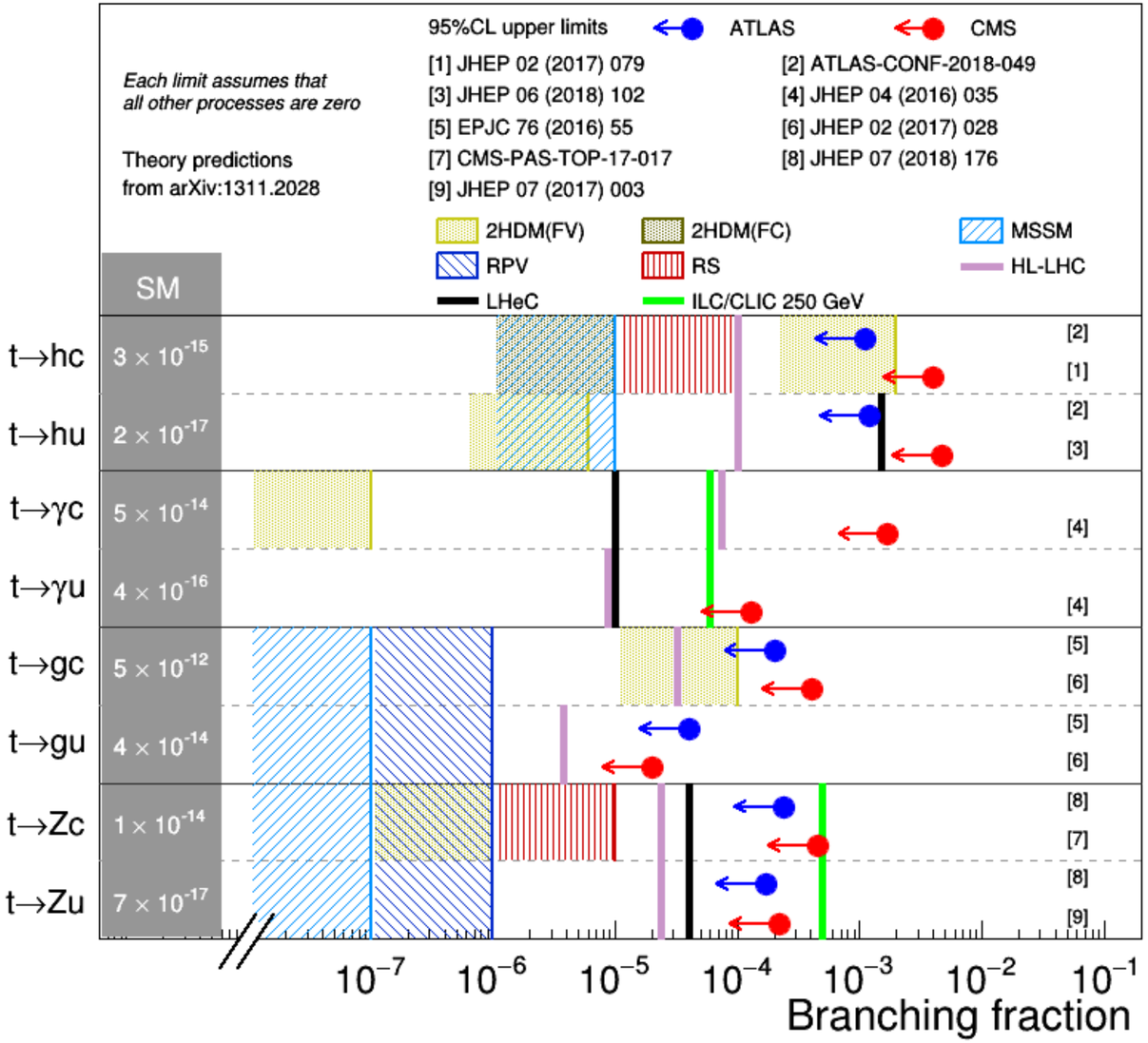
Signal 2: $pe^- \to \nu_e W^- b \to \nu_e \ell^- \nu_\ell b$

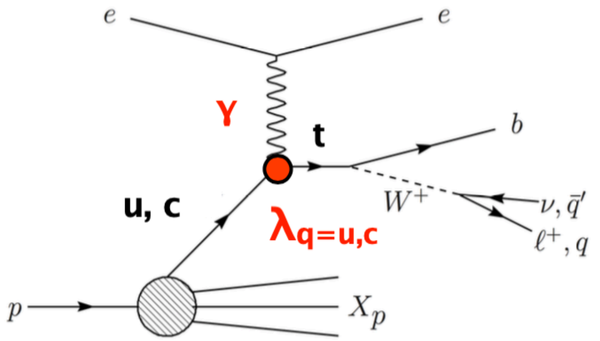
Signal 3: $pe^- \to \nu_e \bar{t} \to \nu_e W^- j \to \nu_e \ell^- \nu_\ell j$

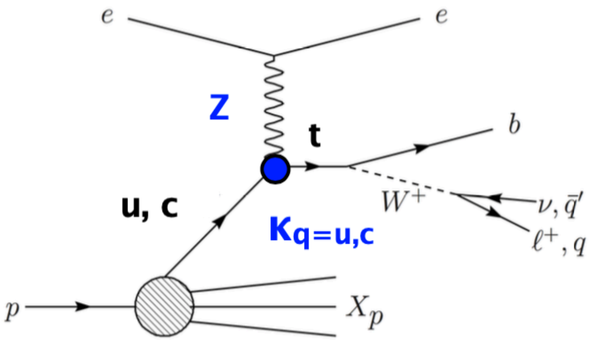


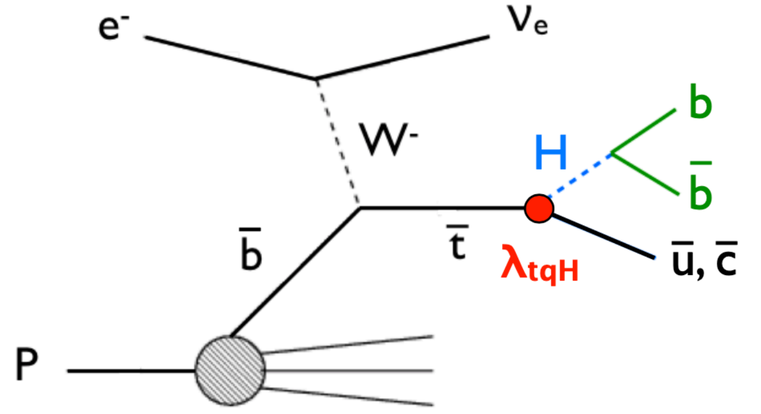


FCNC searches with top quarks





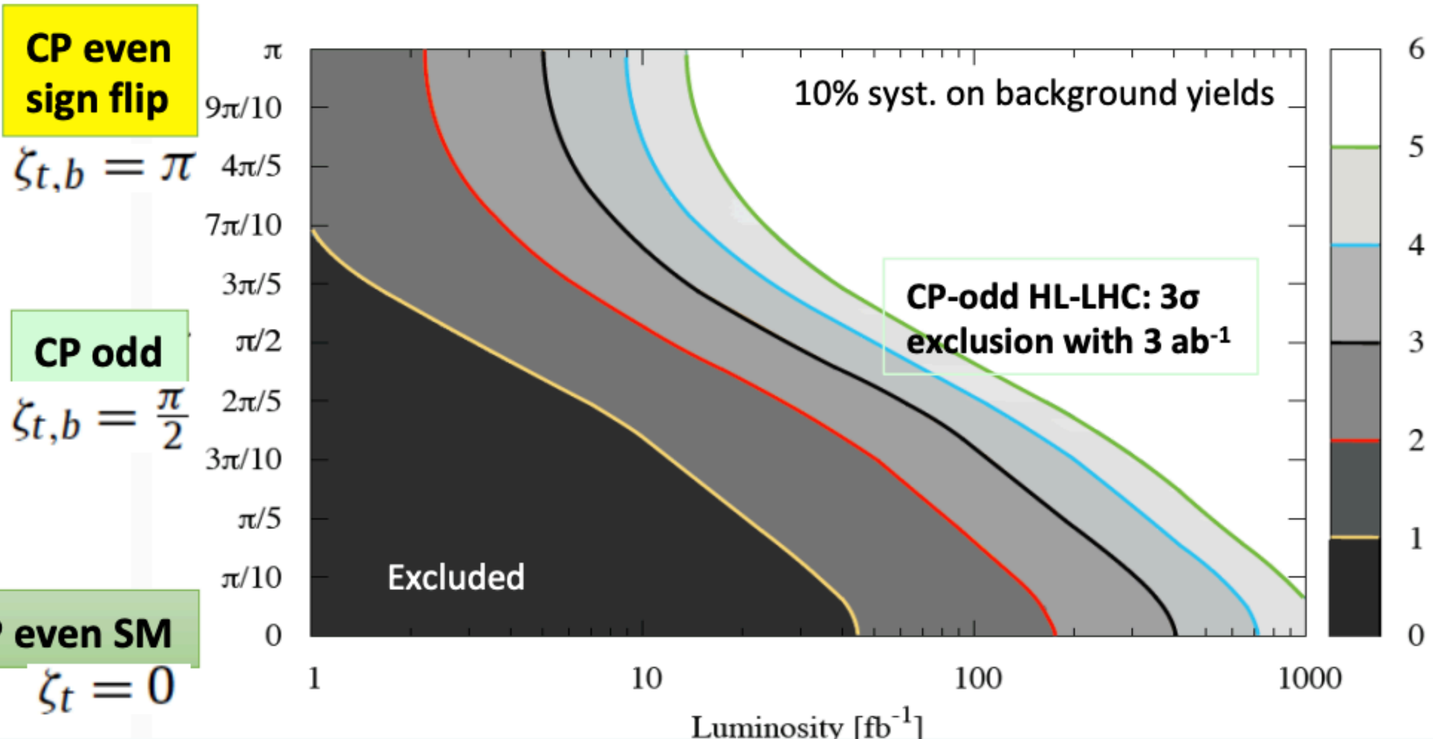


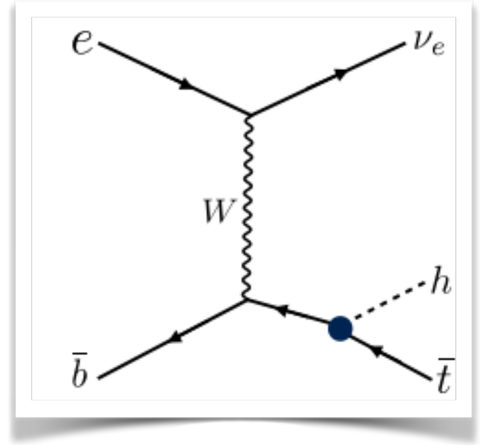


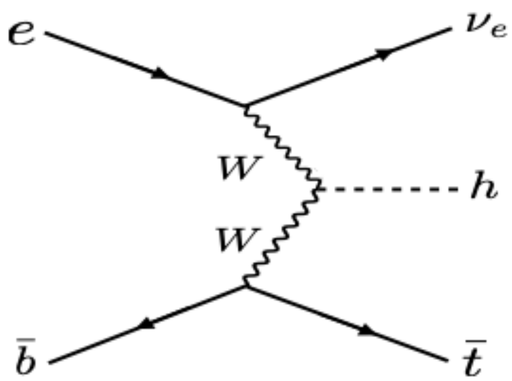
Top quark Yukawa coupling

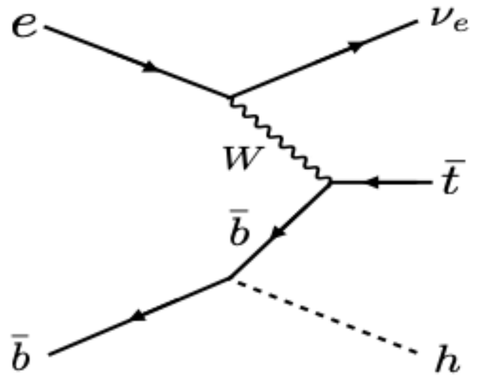
[Phys. Lett. B 770 (2017) 335]

$$\mathcal{L} = -i\frac{m_t}{v}\bar{t}\,[\cos\zeta_t + i\gamma_5 \sin\zeta_t]\; t\; h$$



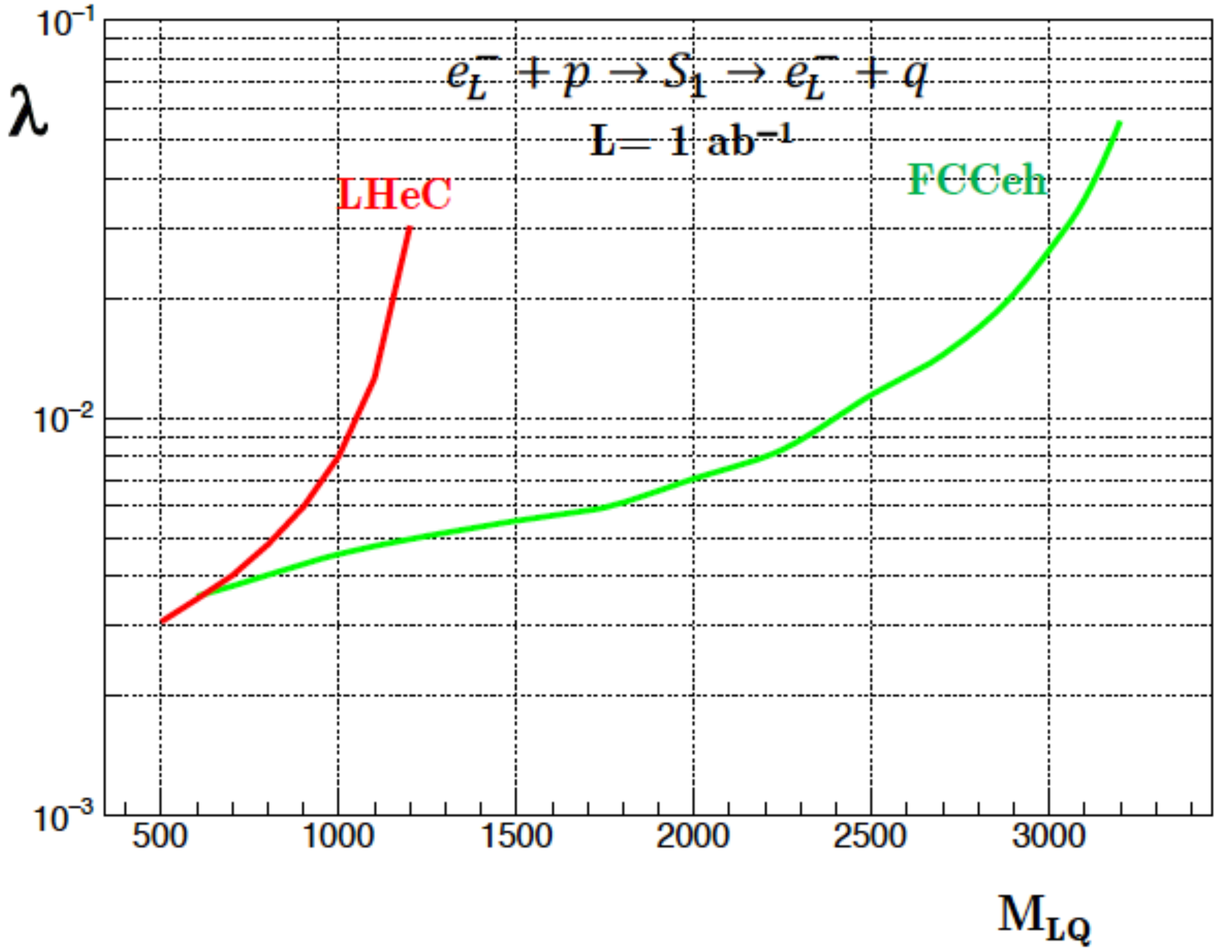




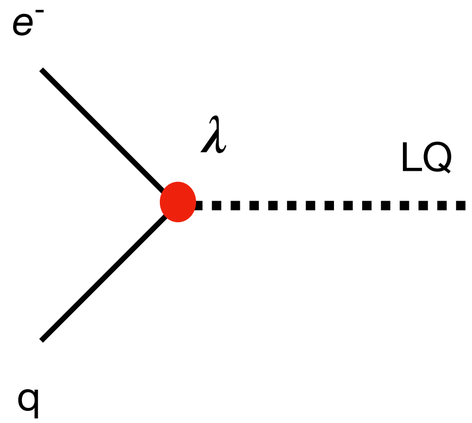


LQ production

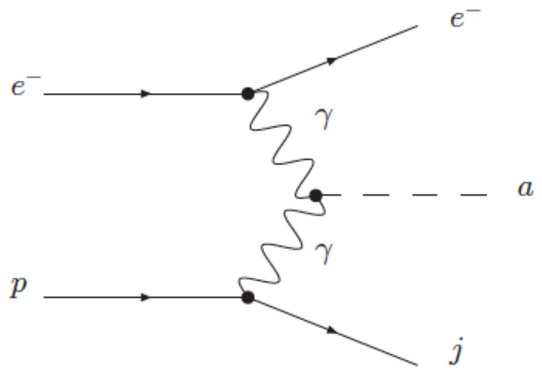
2σ significance for 1 ab^{-1}

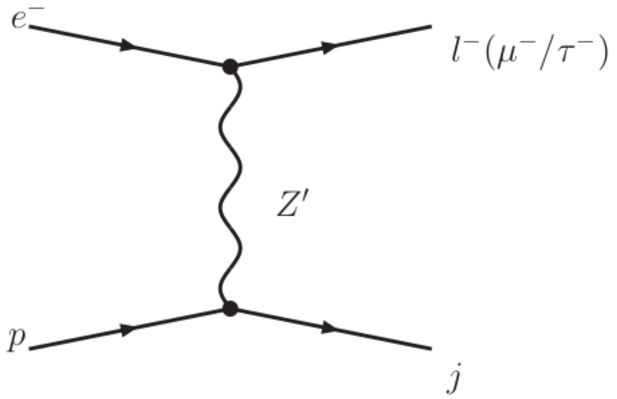


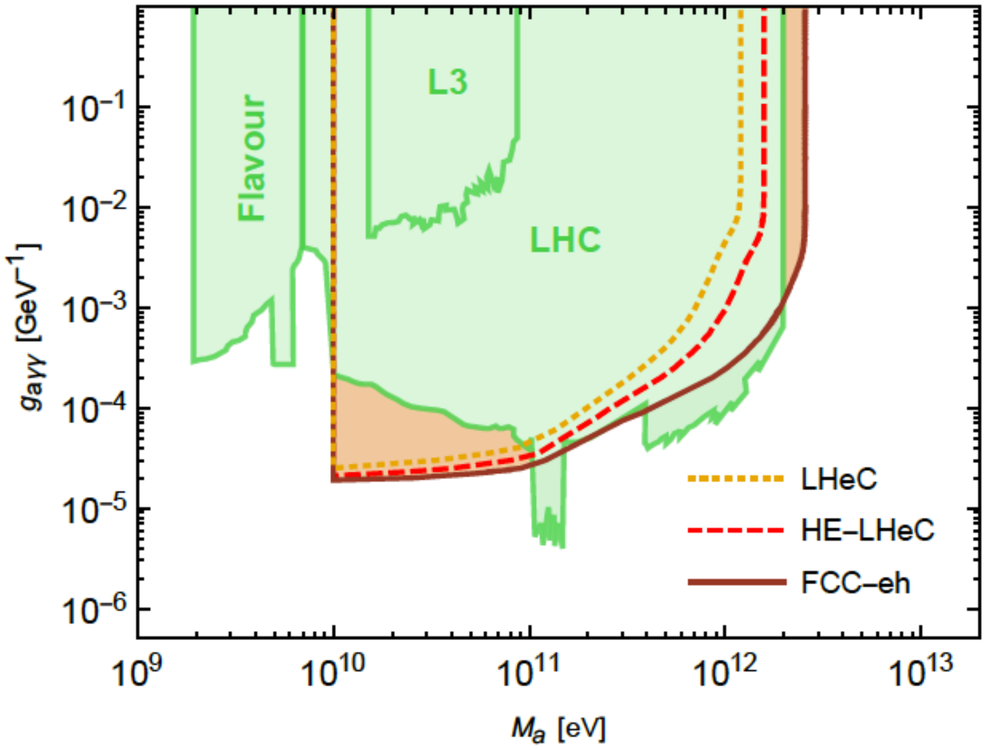
Scalar LQ production as *s*-channel resonance

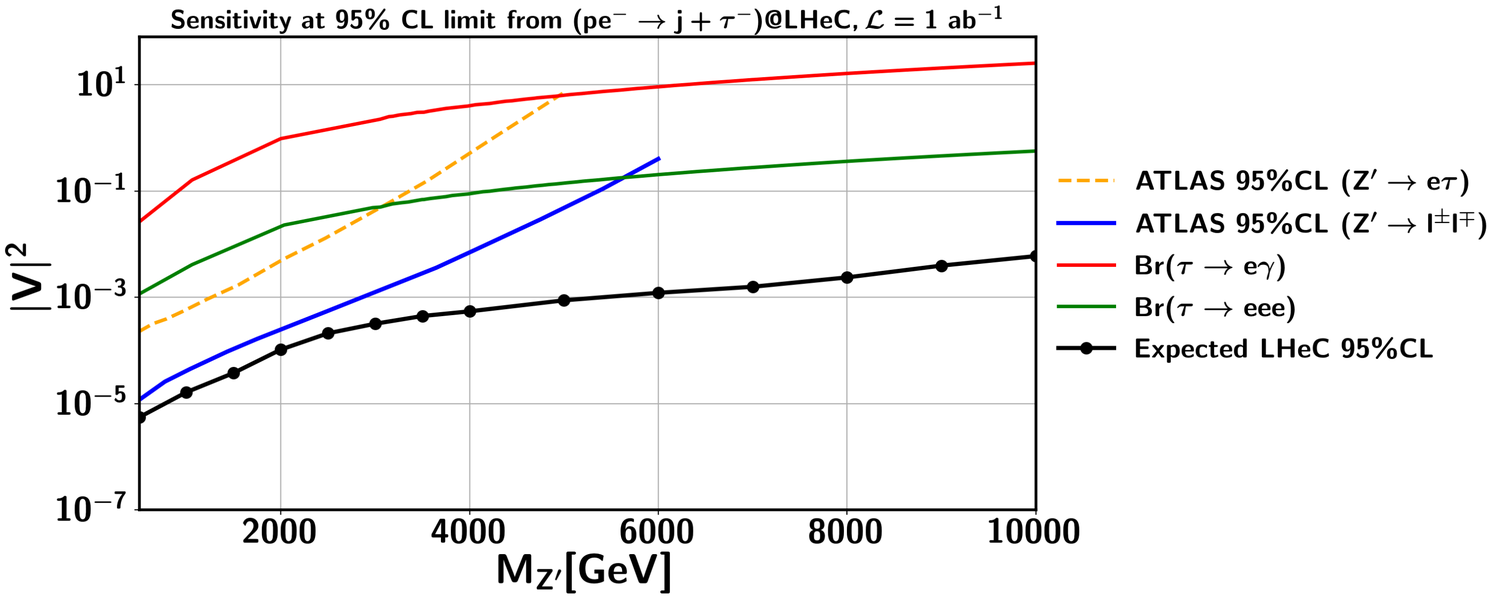


ALPs and Z′ production









Summary

- LHeC is slowly taking shape
- Excellent potential, extensive physics program
- PDFs, QCD with unprecedented precision
- Complementary coverage in EW, top, and Higgs sector can be covered
- Several BSM signals directly accessible
- Updated Conceptual Design Report available
- Stay tuned for more updates

Thank you for your attention