

ECFA

European Committee for Future Accelerators

ECFA workshops on
 e^+e^- Higgs/EW/Top
factory

WWdiff focus topic

Focus topic team:

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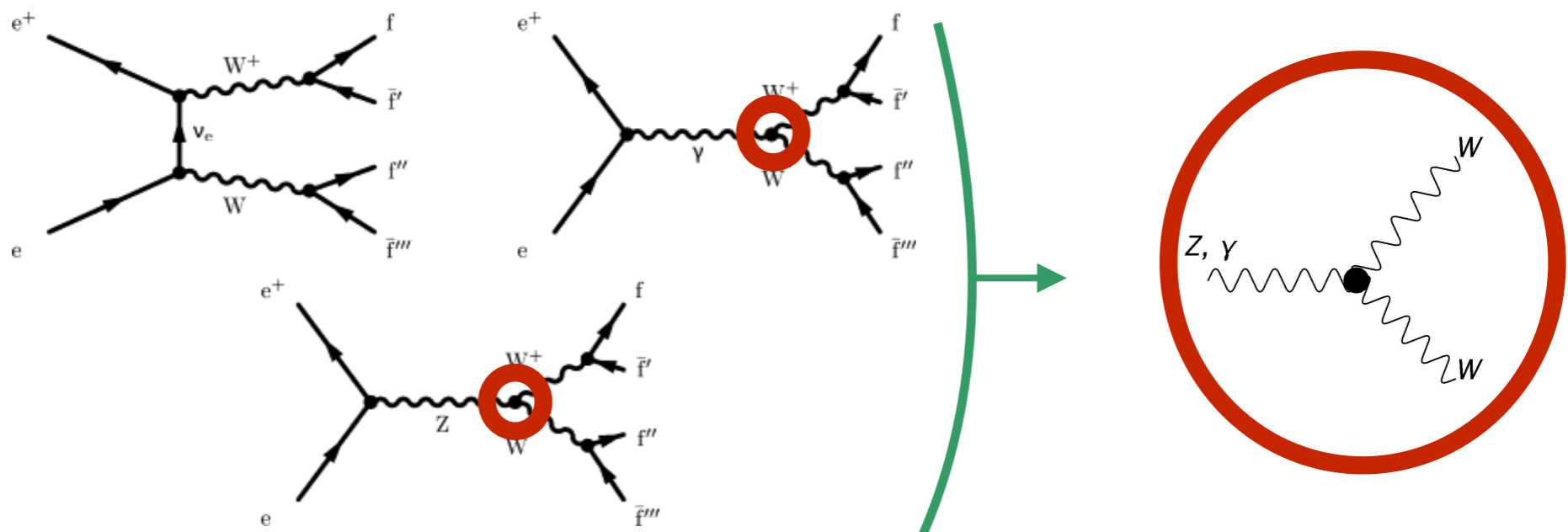
WWdiff Focus Topic

- Full studies of WW (and evW) at \sqrt{s} between 161 GeV up to ~ 365 GeV
- Typically covered in projections for future e^+e^- colliders within the so-called aTGC-dominance assumption (justified at LEP2, not so clear at future e^+e^-):

All possible new physics effects correcting the process other than aTGC are constrained much better by other processes (typically EWPO) and can be neglected

→ Studies performed in the context of sensitivity to aTGC (only)

$$\Delta\mathcal{L}^{\text{aTGC}} = ie\delta\kappa_\gamma A^{\mu\nu}W_\mu^+W_\nu^- + ig\cos\theta_w \left[\delta g_{1Z} (W_{\mu\nu}^+W^{-\mu} - W_{\mu\nu}^-W^{+\mu})Z^\nu + (\delta g_{1Z} - \frac{g'^2}{g^2}\delta\kappa_\gamma)Z^{\mu\nu}W_\mu^+W_\nu^- \right] + \frac{ig\lambda_z}{m_W^2} \left(\sin\theta_w W_\mu^{+\nu}W_\nu^{-\rho}A_\rho^\mu + \cos\theta_w W_\mu^{+\nu}W_\nu^{-\rho}Z_\rho^\mu \right),$$



WWdiff Focus Topic

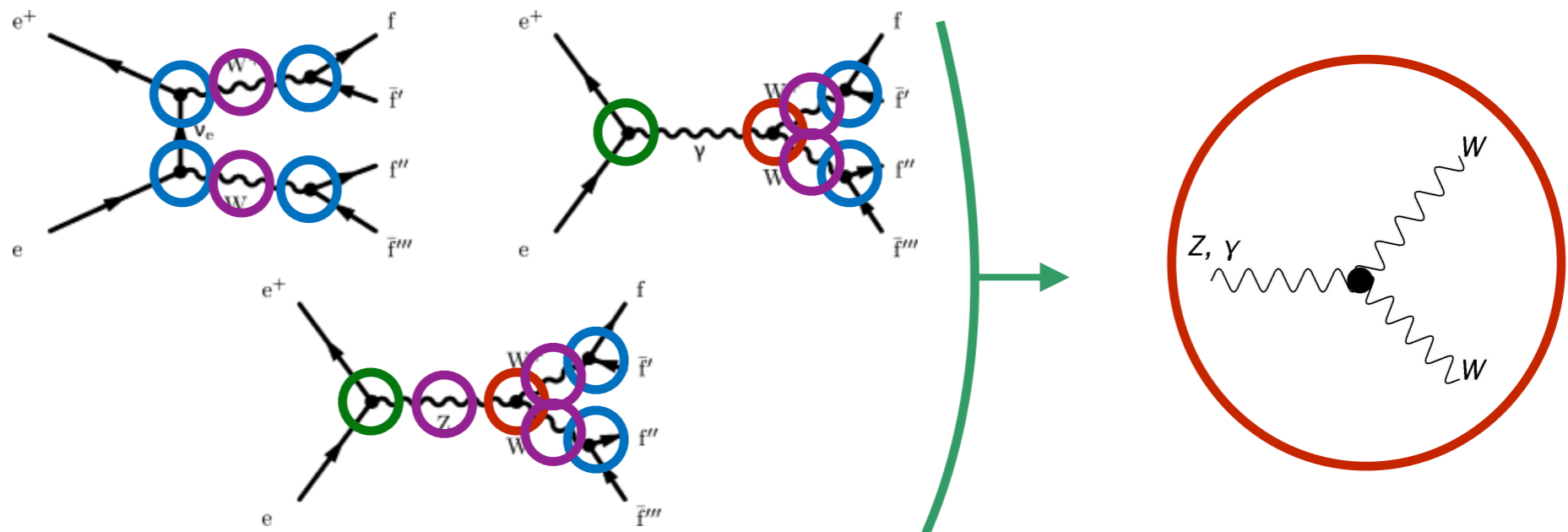
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Uncertainties in other interactions can hinder precision of aTGC



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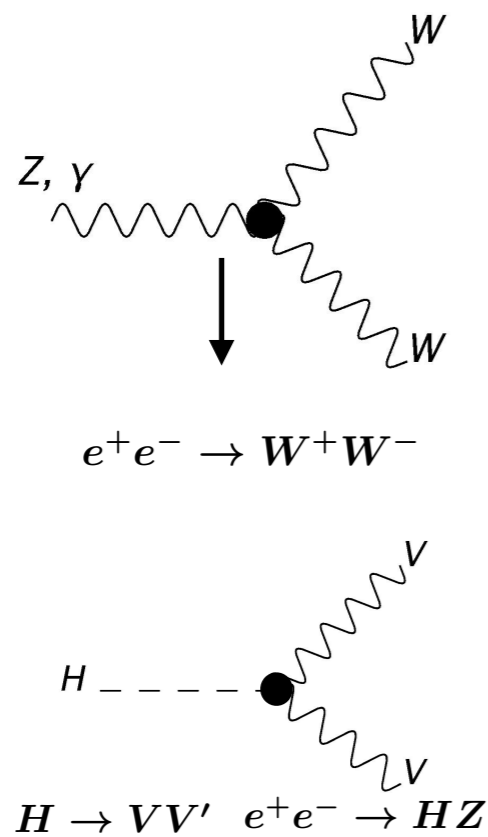
- Plus one can also study sensitivity to CP-violating couplings at future e^+e^-

$$(\mathcal{L}_{\text{CPV}}^{\text{bosonic}})_{\text{broken}}^{V_1V_2V_3} = ie \left(\tilde{\kappa}_\gamma \tilde{F}_{\mu\nu} W^{+\mu}W^{-\nu} + \frac{\tilde{\lambda}_\gamma}{M_W^2} \tilde{F}^{\nu\lambda} W_{\lambda\mu}^+ W^{-\mu}_\nu + \cot\theta_w \tilde{\kappa}_Z \tilde{Z}_{\mu\nu} W^{+\mu}W^{-\nu} + \cot\theta_w \frac{\tilde{\lambda}_Z}{M_W^2} \tilde{Z}^{\nu\lambda} W_{\lambda\mu}^+ W^{-\mu}_\nu \right)$$

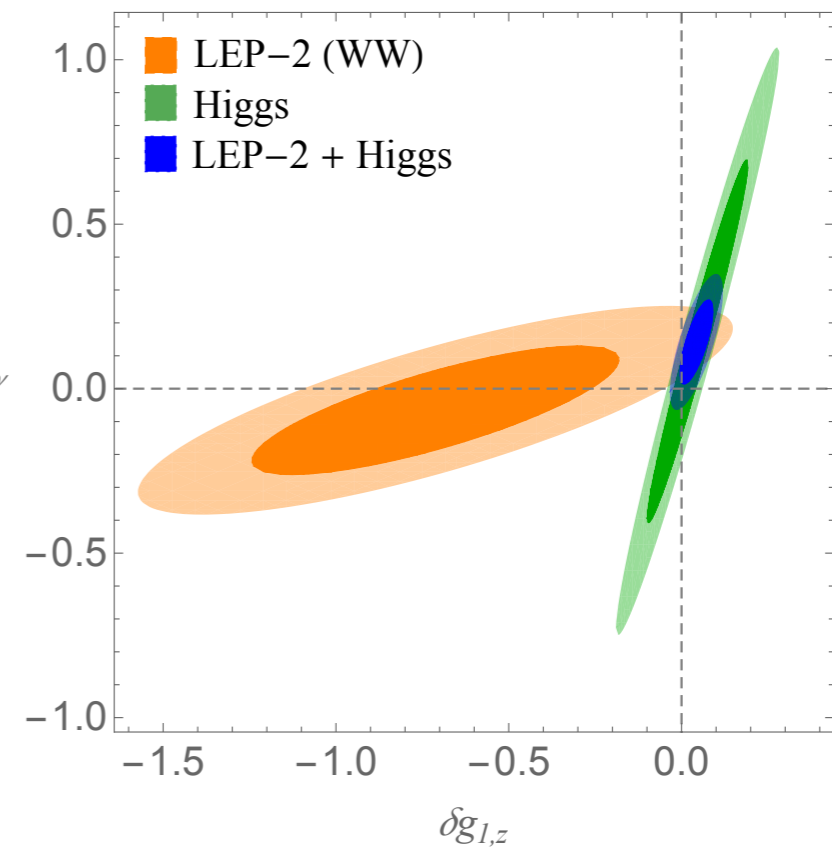
WWdiff Focus Topic

- Full studies of WW (and evW) at \sqrt{s} between 161 GeV up to ~ 365 GeV
- Understanding aTGC precision is also important for Higgs

aTGC and Higgs to vector couplings generated by same new physics (SMEFT correlations)



Complementarity H/aTGC $\delta\kappa_\gamma$

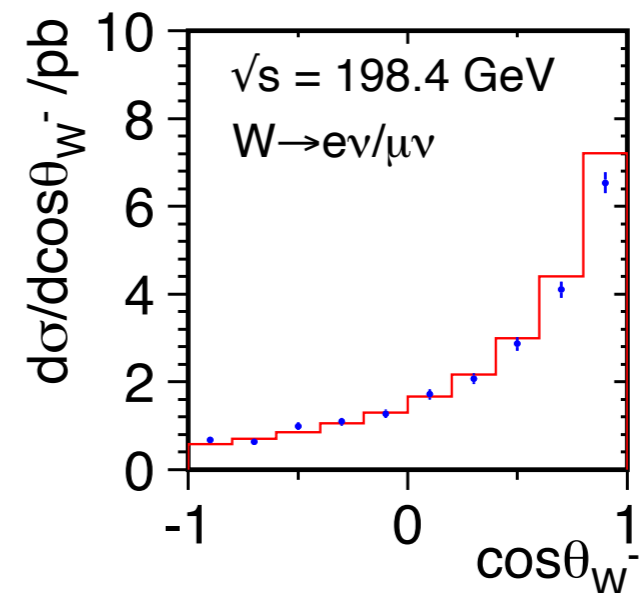
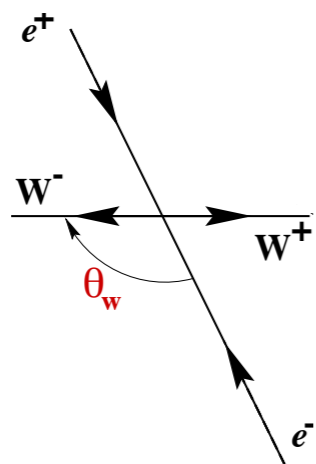


A. Falkowski et al., PRL 116 (2016) 011801

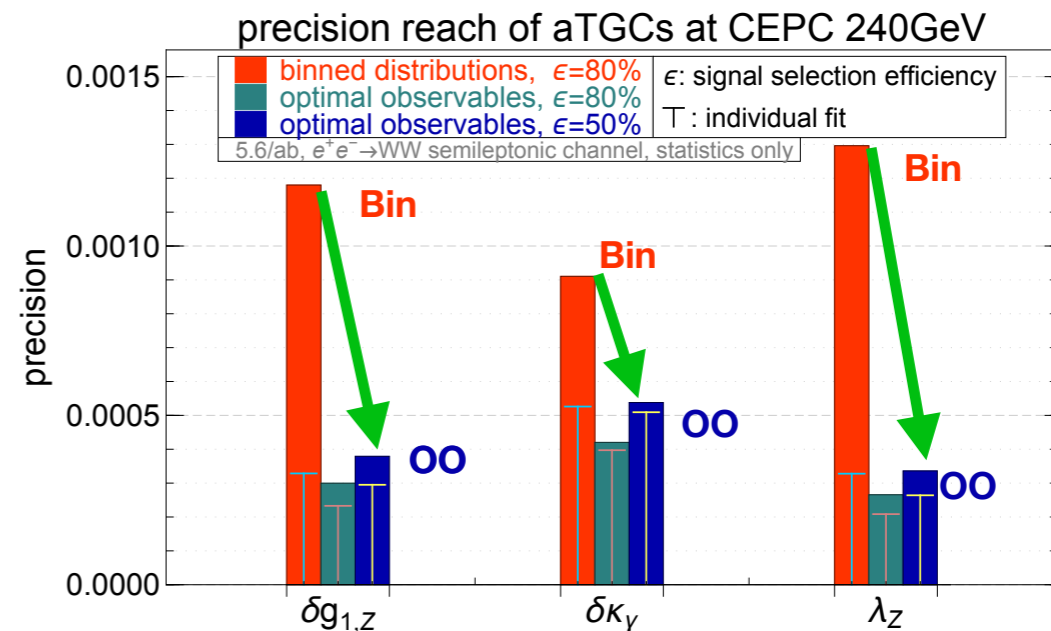
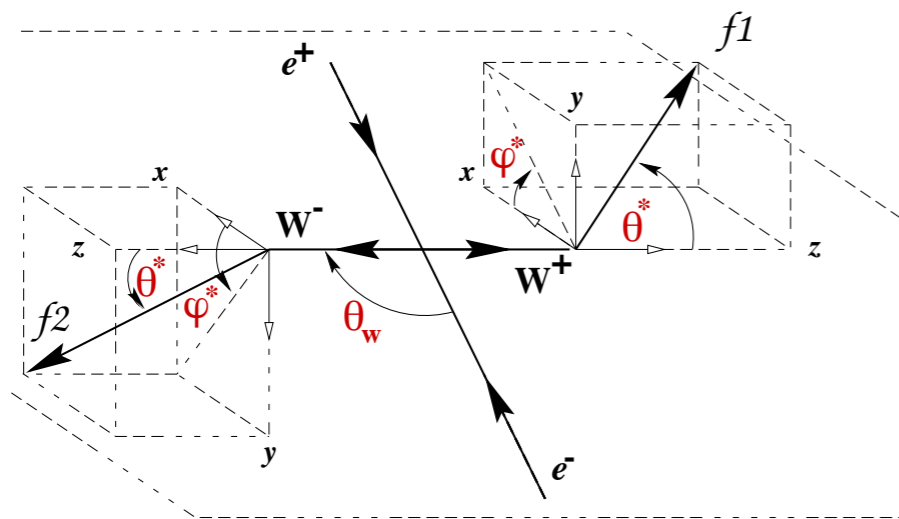
- and in general for global interpretations, be in the SMEFT or in UV complete models

WWdiff Focus Topic

- Also in most cases restricted to use partial information, e.g. differential in polar angle as in LEP2 final results:



- Use all differential information, e.g. Statistical Optimal Observables



OO vs. $\cos \theta_W$ distr: Improvement in aTGC $\sim 2-4x$

Idealized: Full simulation studies needed

WWdiff Focus Topic

- Basic questions on $e^+e^- \rightarrow W^+W^-$ at future Higgs factories:
 - Sensitivity to aTGC (CP-preserving & CP-odd) from full simulation studies
 - ✓ Impact of polarization/energy?
 - ✓ Gain from combining with evW ?
 - ✓ Can we neglect other contributions at future e^+e^- ?
 - Answer may depend on other EW measurements → Global study
 - ✓ What are the needs in terms of precision of SM calculations to match the experimental precision? Doable?
 - ✓ Interplay WW-Higgs for aTGC/HVV?
 - Sensitivity gain wrt HLLHC? ← HLLHC projections?
 - Monte Carlo samples needed?
 - ✓ Start from semi-leptonic, then consider fully leptonic and hadronic
- **Practical question:** Output of studies so they can be included in Global interpretations?

WWdiff Focus Topic

- More details:

<https://arxiv.org/pdf/2401.07564>

Focus topics for the ECFA study on Higgs / Top / EW factories

Juan Alcaraz Maestre¹, Juliette Alimena², John Alison³, Patrizia Azzi⁴, Paolo Azzurri⁵, Emanuele Bagnaschi^{6,7}, Timothy Barklow⁸, Matthew J. Basso⁹, Josh Bendavid¹⁰, Martin Beneke¹¹, Eli Ben-Haim¹², Mikael Berggren², Jorge de Blas¹³, Marzia Bordone⁶, Ivanka Bozovic¹⁴, Valentina Cairo⁶, Nuno Filipe Castro¹⁵, Marina Cobal¹⁶, Paula Collins⁶, Mogens Dam¹⁷, Valerio Dao⁶, Matteo Defranchis⁶, Ansgar Denner¹⁸, Stefan Dittmaier¹⁹, Gauthier Durieux²⁰, Ulrich Einhaus², Mary-Cruz Fouz¹, Roberto Franceschini²¹, Ayres Freitas²², Frank Gaede², Gerardo Ganis⁶, Pablo Goldenzweig²³, Ricardo Gonçalo^{24,25}, Rebeca Gonzalez Suarez²⁶, Loukas Gouskos²⁷, Alexander Grohsjean²⁸, Jan Hajer²⁹, Chris Hays³⁰, Sven Heinemeyer³¹, André Hoang³², Adrián Irlles³³, Abideh Jafari², Karl Jakobs¹⁹, Daniel Jeans³⁴, Jernej F. Kamenik³⁵, Matthew Kenzie³⁶,

...

WWdiff → Pages 23-24

5 WWdiff — Full studies of WW and $e\nu W$

Expert Team: Patrizia Azzi, Timothy Barklow, Jorge de Blas, Ansgar Denner, Alexander Grohsjean, Wolfgang Kilian, Jenny List, Frank Siegert

Motivation

Constraints on gauge boson interactions are crucial ingredients to global interpretations, be it in SMEFT or in UV complete models. In particular, in models where the electroweak symmetry is linearly realised in the light fields, new physics contributions to anomalous triple gauge couplings are directly connected to corrections on Higgs couplings, establishing a complementarity between the two sectors of measurements.

- GitLab page:

<https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/-/wikis/FocusTopics/WWdiff>

arXiv:2401.07564v3 [hep-ph] 18 Jan 2024

Timeline of ECFA e^+e^- Higgs/EW/Top factory study

- Any results related to this focus topic to be included in *ECFA e^+e^- Higgs/EW/Top factory report* ← *Input to the next European Strategy Update*
- Timeline dictated by next update of the European Strategy for Particle Physics
 - ▶ Accelerated wrt original estimates
 - ▶ Community input to be submitted by March 31, 2025 (ESPPU process to be concluded in June 2026)
- First version of ECFA study report should be completed by (mid) December
 - ▶ Comments could be included later, but updates of results will be difficult
- Effective deadline: *3rd ECFA workshop on e^+e^- Higgs, Top & Electroweak Factories*
<https://indico.in2p3.fr/event/32629/>
 - ▶ October 9-11, 2024
 - ▶ Results should be presented there
 - ▶ 1 page draft summery of results should be available
- Studies can continue afterwards and can be published independently

Agenda of this meeting

Mini-workshop on WWdiff focus topic



📅 martes 25 jun 2024, 17:00 → 19:00 Europe/Zurich

👤 Alexander Grohsjean (Hamburg University (DE)), Jorge de Blas (Universidad de Granada (ES)), Junping Tian (The University of Tokyo),
Marcel Vos (IFIC Valencia (ES)), Sven Heinemeyer (CSIC (Madrid, ES))

Descripción Zoom link:
<https://cern.zoom.us/j/62514084522?pwd=bLni4ghU1czUuC3B4oz8azvQoGNOel.1>
Meeting ID:
625 1408 4522
546249

17:00 → 17:10 Introduction to WWdiff focus topic and ECFA timeline

🕒 10m

17:10 → 17:40 From Optimal Observables to Machine learning in EFT analyses of $e^+ e^- \rightarrow W+W^-$

🕒 30m

Ponente: Jiayin Gu (Fudan University)

17:40 → 18:10 WW and multiboson projections and EFT interpretation at the HL-LHC

🕒 30m

Ponente: Alexander Savin (University of Wisconsin Madison (US))

18:10 → 18:40 WW studies at future e^+e^- colliders

🕒 30m

Ponente: Jenny List (Deutsches Elektronen-Synchrotron (DE))

18:40 → 19:00 Discussion

🕒 20m