

Focus topic meeting “ttbar threshold”

Marcel Vos, IFIC, CSIC/UV, Valencia, Spain

17 April '24

Expert team: Z. Bahariyoon, M. Beneke (TUM, theory), F. Cornet (Case Western, theory), M. Defranchis (CERN), G. Durieux (Louvain, theory), A. Hoang (U. Vienna, theory), A. Jafari (DESY), J. Kieseler (KIT), V. Miralles (Manchester, theory), M. Moreno (IFIC), L. Pintucci (Trieste), Jürgen Reuter (DESY, theory), R. Schwienhorst (Michigan State), F. Simon (KIT), F. Zarnecki (Warsaw)

R. Franceschini, A. Irlles J. de Blas (related focus topics), P. Azzi (liaison FCCee)



CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS



VNIVERSITAT
ID VALÈNCIA



GENERALITAT
VALENCIANA

AITANA

Practical

The ECFA focus topics document:

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

Note the mailing list for this group:

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

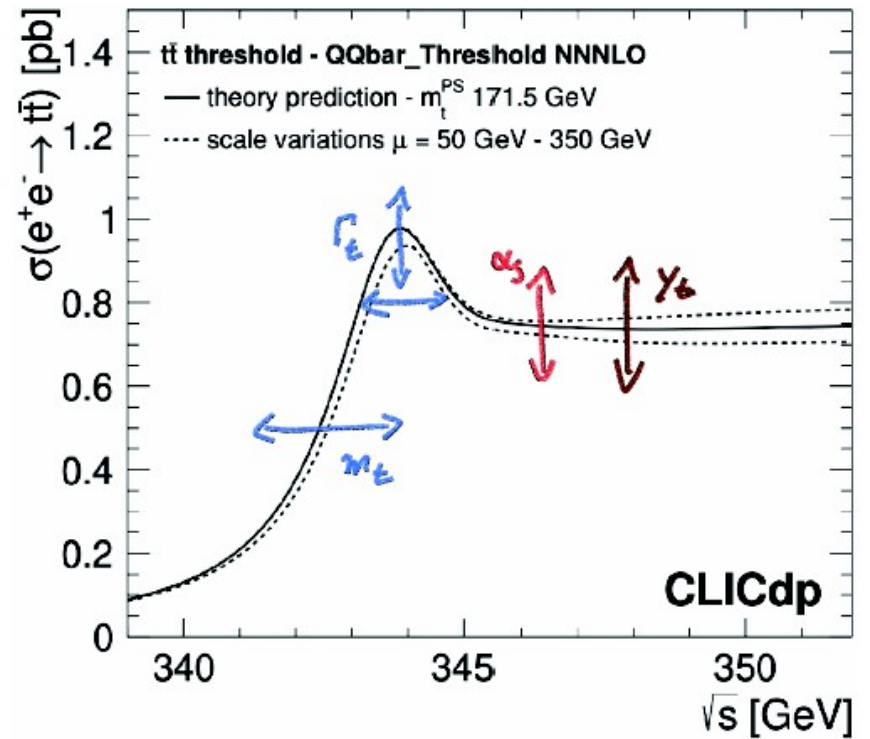
Date for European strategy update: ~1 year earlier than you might have expected.

The bottom line: results for the focus topic report are due by the ECFA Higgs/EW/top factory meeting Paris, 9-11 October 2024, <https://indico.cern.ch/event/1399276/>.

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 Gonalo^{24,25}, Rebeca Gonzalez Suarez²⁶, Loukas Gouskos²⁷, Alexander Grohsjean²⁸, Jan Hajer²⁹, Chris Hays³⁰, Sven Heinemeyer³¹, Andr  Hoang³², Adri n Irls³³, Abideh Jafari², Karl Jakobs¹⁹, Daniel Jeans³⁴, Jernej F. Kamenik³⁵, Matthew Kenzie³⁶, Wolfgang Kilian³⁷, Markus Klute²³, Patrick Koppenburg³⁸, Sandra Kortner³⁹, Karsten K neke¹⁹, Marcin Kucharczyk⁴⁰, Christos Leonidopoulos⁴¹, Cheng Li⁴², Zoltan Ligeti⁴³, Jenny List², Fabio Maltoni²⁰, Elisa Manoni⁴⁴, Giovanni Marchiori⁴⁵, David Marzocca⁴⁶, Andreas B. Meyer², Ken Mimasu⁴⁸, Tristan Miralles⁴⁷, Victor Miralles⁴⁹, Abdollah Mohammadi⁵⁰, St phane Monteil⁵¹, Gudrid Moortgat-Pick²⁸, Zohreh Najafabadi⁵², Mar a Teresa N n ez Pardo de Vera², Fabrizio Palla⁵, Michael E. Peskin⁸, Fulvio Piccinini⁵³, Laura Pintucci⁵⁴, Wieslaw Placzek⁵⁵, Simon Pl tzer^{56,32}, Roman P schl⁵⁷, Tania Robens⁵⁸, Aidan Robson⁵⁹, Philipp Roloff⁶, Nikolaos Rompotis⁶⁰, Andrej Saibel³³, Andr  Sailer⁶, Roberto Salerno⁶¹, Matthias Schott⁶², Reinhard Schwienhorst⁶³, Felix Sefkow², Michele Selvaggi⁶, Frank Sieger⁶⁴, Frank Simon²³, Andrzej Siodmok⁵⁵, Torbj rn Sj strand⁶⁵, Kirill Skovpen⁶⁶, Maciej Skrzypek⁴⁰, Yotam Soreq⁶⁷, Raimund Str hmer¹⁸, Taikan Suehara⁶⁸, Junping Tian⁶⁸, Emma Torro Pastor³³, Maria Ubiali³⁶, Luiz Vale Silva³³, Caterina Vernieri⁸, Alessandro Vicini⁶⁹, Marcel Vos³³, Aidan R. Wiederhold⁷⁰, Sarah Louise Williams³⁶, Graham Wilson⁷¹, Aleksander Filip Zarnecki⁷², Dirk Zerwas^{73,57}

The $t\bar{t}$ threshold scan



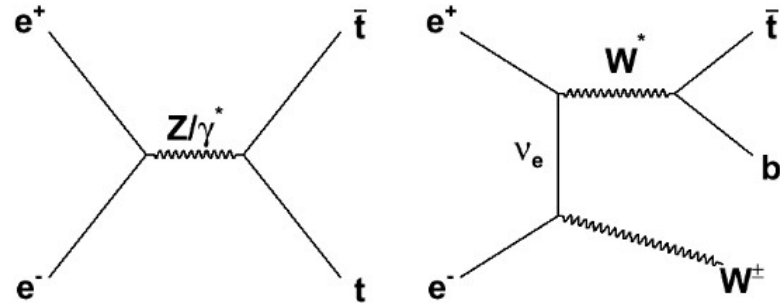
Signal samples

WHIZARD $e^+e^- \rightarrow WbWb$ **signal** samples

Top quark pairs + single top + ...

Backgrounds:

- **6f without b-jets** (small if b-tagging is good)
- **2f & 4f backgrounds** (use WW as a proxy)
- **Higgs production is** part of $e^+e^- \rightarrow WbWb$ sample, but is not accounted for in calculations



Test samples produced by Louis Portales in FCCee, with DELPHES description of IDEA detector response:

https://fcc-physics-events.web.cern.ch/fcc-physics-events/FCCee/winter2023/Delphesevents_IDEA.php

use the search bar with input “Wb”, to find a set of samples with names like:

`/eos/experiment/fcc/ee/generation/DelphesEvents/winter2023/IDEA/wzp6_ee_WbWb_lep_ecm350/`

Experimental systematic uncertainties

Is the acceptance constant vs. \sqrt{s} over the range of the threshold scan?

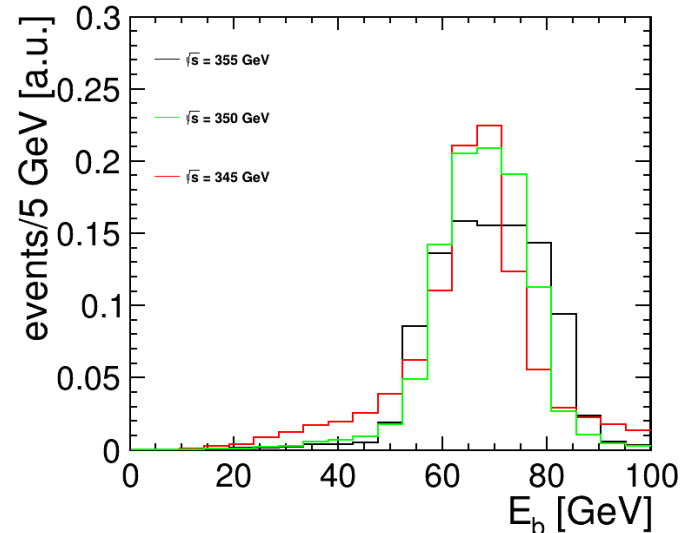
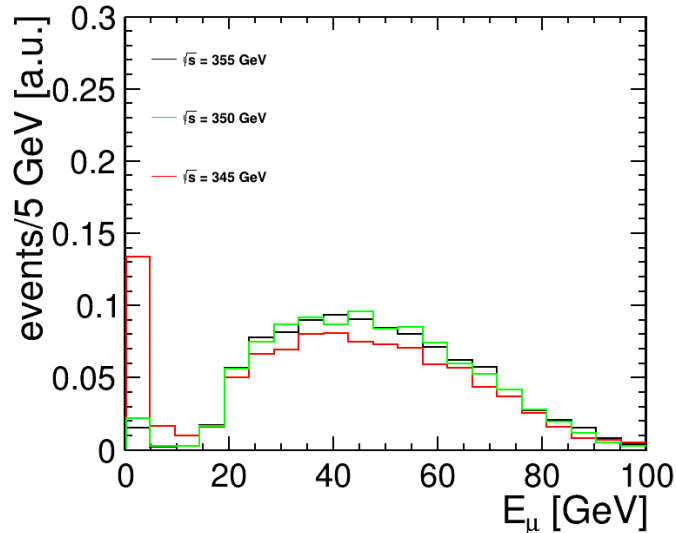
- Realistic selection requires one/two b-tags and isolated leptons, with “near-complete polar angle coverage” (<https://arxiv.org/pdf/1307.8102.pdf> + CLIC 380 <https://arxiv.org/pdf/1807.02441.pdf>)

Is the b-tagging efficiency constant? Or can we calibrate it in-situ?

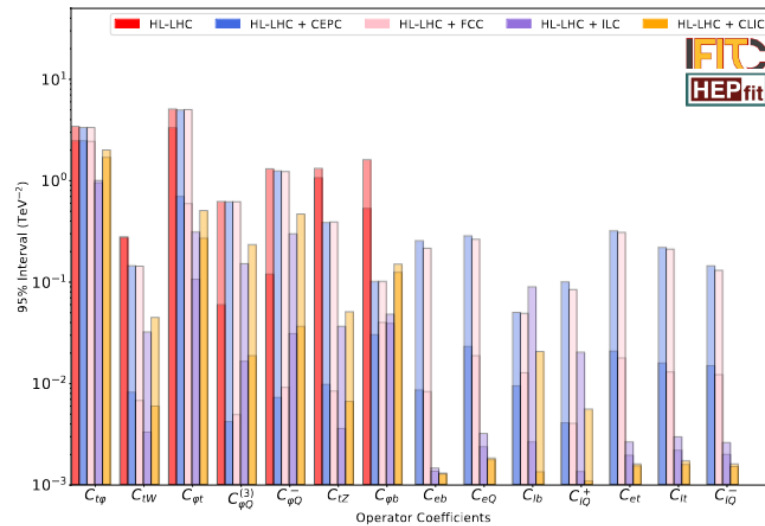
- Double-tag method, ATLAS (<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/TOPQ-2023-21/>), LEP (<https://arxiv.org/abs/hep-ex/0509008>), or ILD (<https://arxiv.org/pdf/2306.11413.pdf>)

No reconstruction?

- Required by measurement of A_{FB} , but not needed (or desirable) for cross section



Top quark (EW) couplings



From Snowmass report:

<https://arxiv.org/pdf/2209.11267.pdf>

And global SMEFT fits at future colliders

<https://arxiv.org/pdf/2206.08326.pdf>

Top couplings - efforts

Snowmass report based on optimal analysis of $e^+e^- \rightarrow WbWb$ from Durieux et al.

Efforts going beyond the Snowmass report:

Update collider operation scenarios, add muon collider ... Victor Miralles/Fernando Cornet + iFIT/C

Study interplay with the Higgs/EW sector ... Juan Rojo/Eleni Vryonidou + SMEFiT

Revisit circular colliders and study CKM sensitivity ... Jan Kieseler

Note also interesting new work on entangled top quark pairs and their role in the SMEFT:

<https://arxiv.org/pdf/2404.08049.pdf>

Summary

Threshold scan for top mass etc.

WHIZARD signal MC samples are available (WbWb, fast simulation)
Several people have expressed an interest. Please, provide feedback.

Top couplings studies:

Several groups are developing studies: we'll hear their plans today
Coordinate so we have a coherent set of results for ECFA report