Focus topic meeting "ttbar threshold"

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

FCCee physics meeting, 22nd 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. Irles J. de Blas (related focus topics), P. Azzi (liaison FCCee)

marcel.vos@ific.uv.es

Practical

The ECFA focus topics document:

https://arxiv.org/abs/2401.07564

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

Juan Alcaraz Maestre[1], Juliette Alimena[2], John Alison[3], Patrizia Azzi[4], Paolo Azzurri[5], Emanuele Bagnaschi[6,7], Timothy Barklow[8], Matthew J. Basso[9], Josh Bendavid[10], Martin Beneke[11], Eli Ben-Haim[12], Mikael Berggren[2], Jorge de Blas[13], Marzia Bordone[6], Ivanka Bozovic[14], Valentina Cairo[6], Nuno Filipe Castro[15], Marina Cobal[16], Paula Collins[6], Mogens Dam[17], Valerio Dao[6], Matteo Defranchis[6], Ansgar Denner[18], Stefan Dittmaier[19], Gauthier Durieux[20], Ulrich Einhaus[2], Mary-Cruz Fouz[1], Roberto Franceschini[21], Ayres Freitas[22], Frank Gaede[2], Gerardo Ganis[6], Pablo Goldenzweig[23], Ricardo Gonçalo[24,25], Rebeca Gonzalez Suarez[26], Loukas Gouskos[27], Alexander Grohsjean[28], Jan Hajer[29], Chris Hays[30], Sven Heinemeyer[31], André Hoang[32], Adrián Irles[33], Abideh Jafari[2], Karl Jakobs[19], Daniel Jeans[34], Jernej F. Kamenik[35], Matthew Kenzie[36], Wolfgang Kilian[37], Markus Klute[23], Patrick Koppenburg[38], Sandra Kortner[39], Karsten Köneke[19], Marcin Kucharczyk[40], Christos Leonidopoulos[41], Cheng Li[42], Zoltan Ligeti[43], Jenny List[2], Fabio Maltoni[20], Elisa Manoni[44], Giovanni Marchiori[45], David Marzocca[46], Andreas B. Meyer[2], Ken Mimasu[48], Tristan Miralles[47], Victor Miralles[49], Abdollah Mohammadi[50], Stéphane Monteil[51], Gudrid Moortgat-Pick[28], Zohreh Najafabadi[52], María Teresa Núñez Pardo de Vera[2], Fabrizio Palla[5], Michael E. Peskin[8], Fulvio Piccinini[53], Laura Pintucci[54], Wiesław Płaczek[55], Simon Plätzer[56,32], Roman Pöschl[57], Tania Robens[58], Aidan Robson[59], Philipp Roloff[6], Nikolaos Rompotis[60], Andrej Saibel[33], André Sailer[6], Roberto Salerno[61], Matthias Schott[62], Reinhard Schwienhorst[63], Felix Sefkow[2], Michele Selvaggi[6], Frank Siegert[64], Frank Simon[23], Andrzej Siodmok[55], Torbjörn Sjöstrand[65], Kirill Skovpen[66], Maciej Skrzypek[40], Yotam Soreq[67], Raimund Ströhmer[18], Taikan Suehara[68], Junping Tian[68], Emma Torro Pastor[33], Maria Ubiali[36], Luiz Vale Silva[33], Caterina Vernieri[8], Alessandro Vicini[69] Marcel Vos[33], Aidan R. Wiederhold[70], Sarah Louise Williams[36], Graham Wilson[71], Aleksander Filip Zarnecki[72], Dirk Zerwas[73,57]

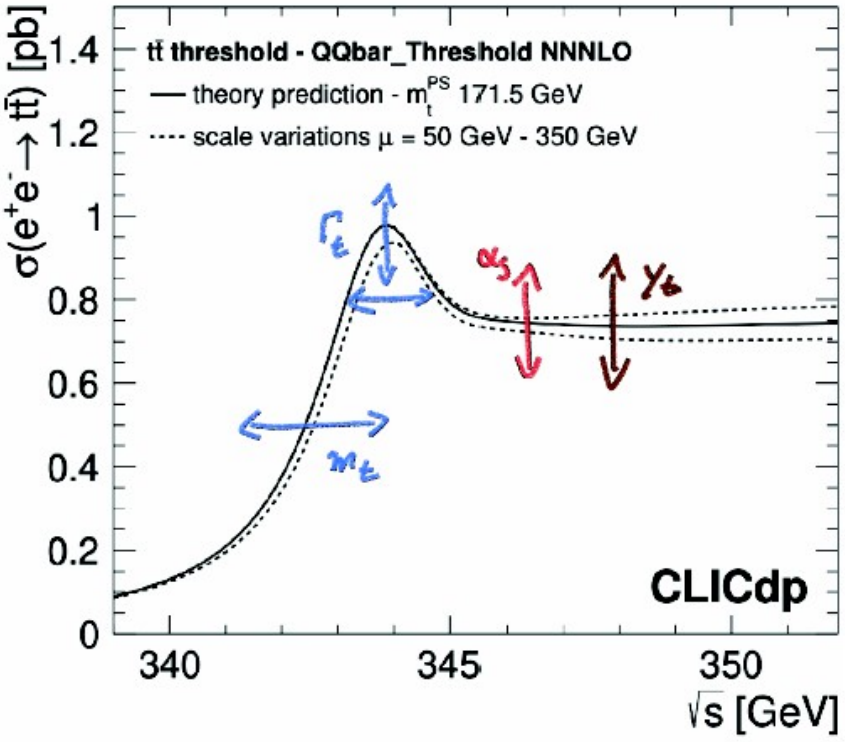
Note the mailing list for this group:

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/.

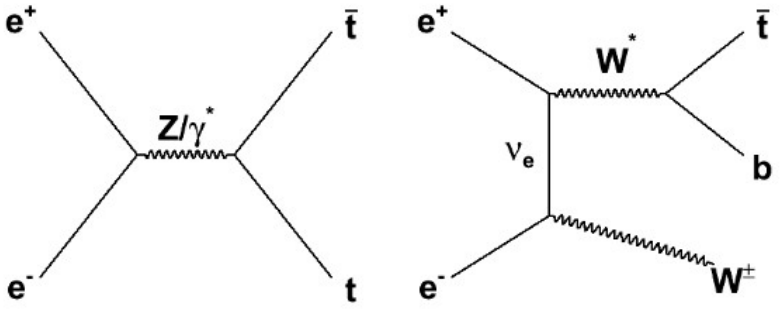
The $t\bar{t}$ threshold scan



Signal samples

WHIZARD e+e- → 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- → 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?

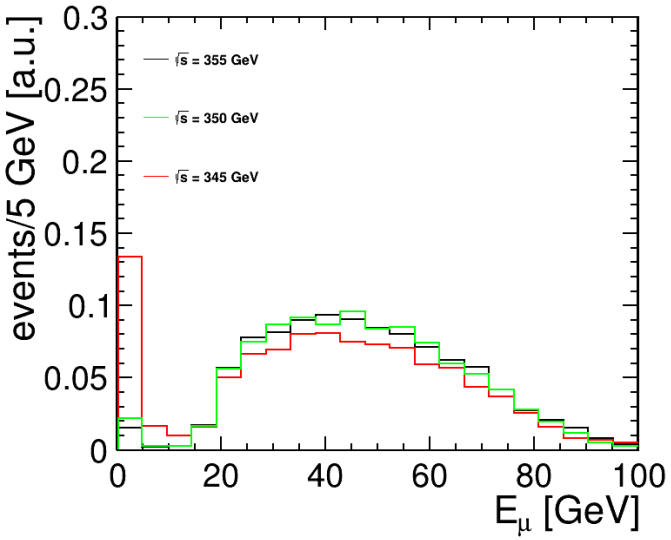
- Realistic selection requires one/two b-tags and isolated leptons, with “near-complete polar angle coverage” (https://arxiv.org/pdf/1307.8102.pdf + CLIC 380 https://arxiv.org/pdf/1807.02441.pdf)

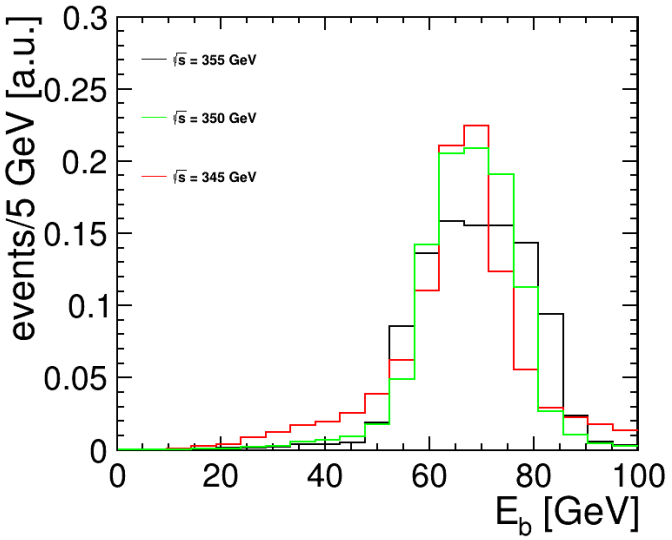
Is the b-tagging efficiency constant? Or can we calibrate it in-situ?

- 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)

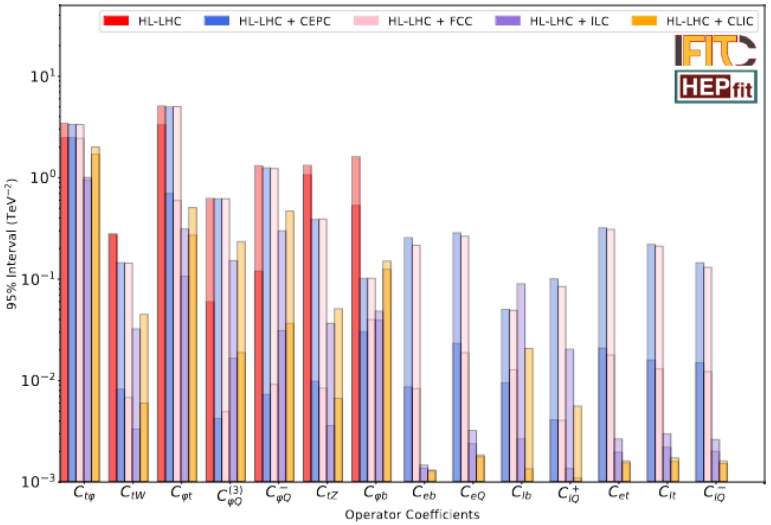
No reconstruction?

- 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- → 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

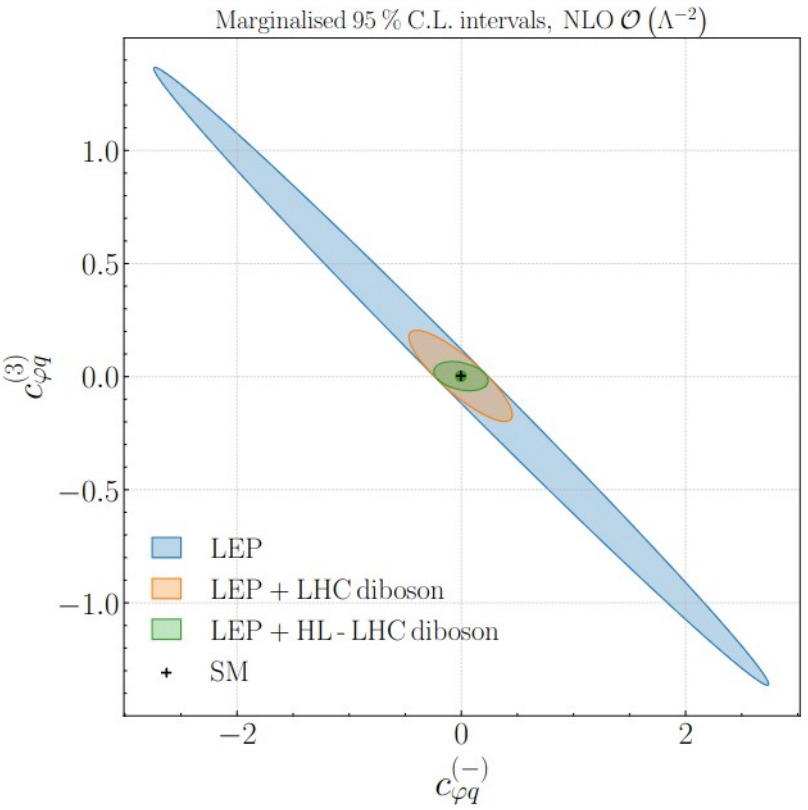
SMEFiT prospect studies

Quite complete fit of Higgs, EW and top sectors with FCCee prospects

Allows to study interplay between the sectors

Paper online: https://arxiv.org/pdf/2404.12809.pdf

Degeneracy (blind direction) left by e+e- → bb measurements at LEP is resolved by adding LHC di-boson data

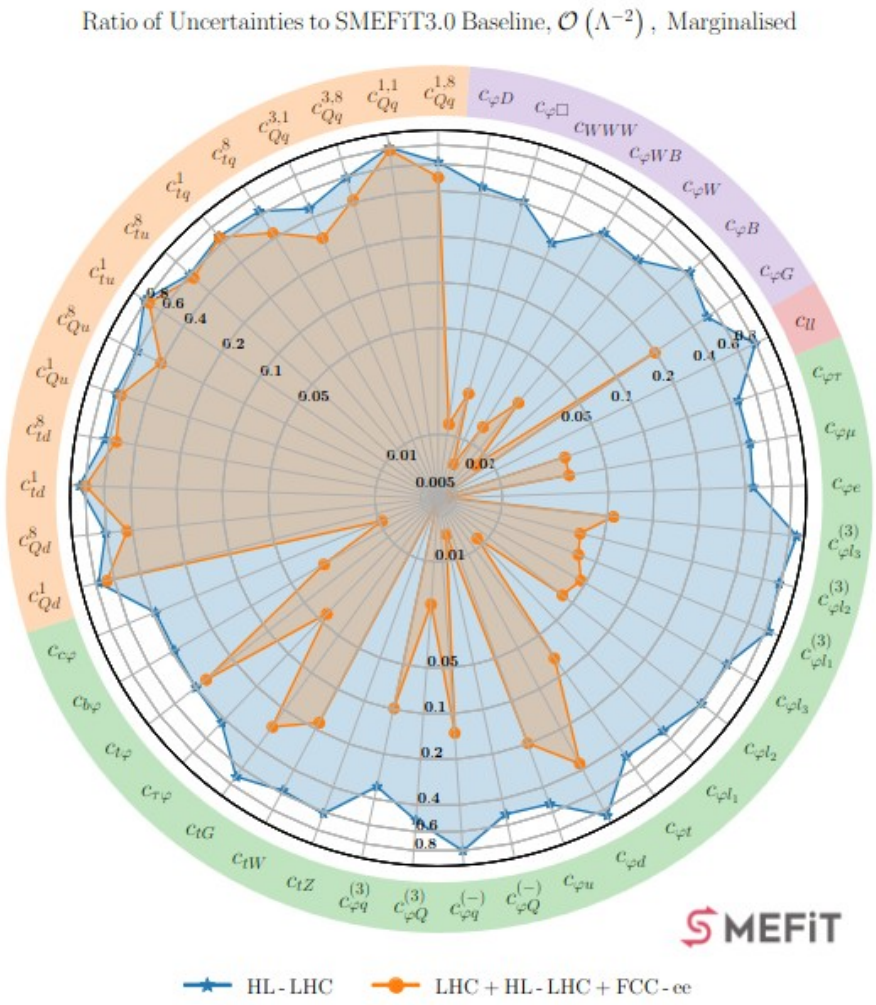


SMEFiT global fit results

https://arxiv.org/pdf/2404.12809.pdf

Top di-fermion operators improv
strongly with FCCee top data
Top qqtt operators improve very
Top lltt operators not included
(require top data at two energies

Key study of Higgs self-coupling
from ZH cross section in “global”
environment requires more work



Summary

Threshold scan for top mass etc.
WHIZARD signal MC samples are available (WbWb, fast simulation)
Several people have expressed an interest; produce results over summer.

Top couplings studies:
Several groups are developing studies: plans are explained on the agenda:
https://indico.cern.ch/event/1404821/
Coordinate so we have a coherent set of results for ECFA report

(KIT + iFIT/C team – compare circular collider projections)
(KIT – bring Vts to maturity)
(SMEFiT team – extend to other collider projects, add self-coupling)