

# *Focus topic meeting “ $t\bar{t}$ bar threshold”*

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# Practical

The ECFA focus topics document is out:

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

There is a mailing list for this group:

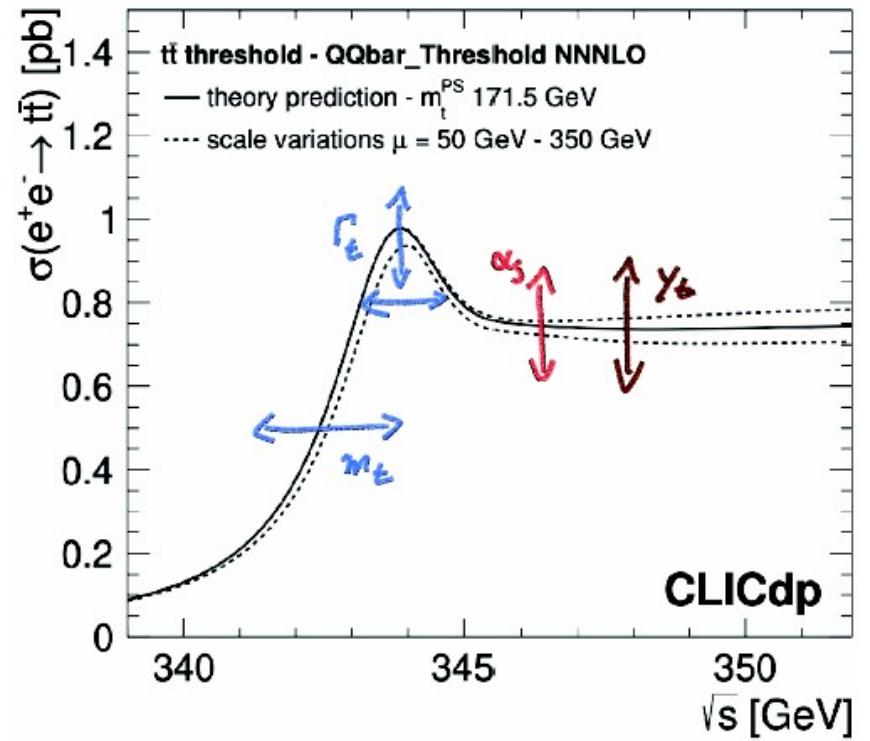
<https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/-/wikis/FocusTopics/TTthresh>

Please, tell people to sign up if they want to join or follow this group

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

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# The $t\bar{t}$ threshold scan



# Scope of the study

Exp:

- Full-simulation study to revisit and harmonize experimental systematic uncertainties

Theo:

- Fully differential predictions at adequate precision (QQthreshold, F. Simon to perform fits)
- Specify procedure for comparison of data and theory (clarified last week)

Study width prospects in more detail (i.e. comparison LHC, interpretation in NP scenarios)

Embed top mass prospect in global EW fit environment (J. De Blas)

Find a way to make top Yukawa and strong coupling results more competitive

## Theoretical and phenomenological targets

- Complete and harmonised assessment of systematic uncertainties on SM parameters extracted from the threshold scan.
- Degeneracies in a EFT analysis including only “one” energy point. How to disentangle effects combining with other (non-top-quark) measurements. Indirect constraints on top Yukawa.

## MC samples needed

Basic samples available as listed in the Motivation Section, dedicated samples for threshold scan are needed.

## Existing tools / examples

- ILD  $t\bar{t}$  analysis [https://github.com/ILDAnaSoft/ILDbench\\_QQbar](https://github.com/ILDAnaSoft/ILDbench_QQbar)

## Contact & Further Information

- Gitlab wiki: <https://gitlab.in2p3.fr/ecfa-study/ECFA-HiggsTopEW-Factories/-/wikis/FocusTopics/TTthresh>
- Sign up for egroup: ECFA-WHF-FT-TTthres@cern.ch via <http://simba3.web.cern.ch/simba3/SelfSubscription.aspx?groupName=ecfa-whf-ft-ttthres>
- and/or email the conveners of ECFA WG1 GLOBAL group: <mailto:ecfa-whf-wg1-glob-conveners@cern.ch>

# Towards a standard sample

WHIZARD sample in preparation by M.V. (with help from J. Reuter, J. Tian)

$e^+e^- \rightarrow 6$  fermions ( $b\bar{b}$ , 2 charged leptons, 2 neutrinos)

- Mostly  $e^+e^- \rightarrow t\bar{t} \rightarrow WbWb$ , with all W decays
- Using SM\_CKM (LO, no threshold enhancement, pole mass scheme)

With luminosity spectrum and ISR

- ILC 350, also FCCee is possible
- Generate (L,R),(R,L) + some (0,0)

```
#!/init>
11 -11 1.7250000000E+02 1.7250000000E+02 -1 -1 -1 -1 3 1
7.444539235E-04 1.3433748188E-05 1.0000000000E+00 1
generator version="3.1.4" WHIZARD/generator>
xsxinfo neve="10000" totxsec="7.444539235E-04" />
#!/init>
event>
147 1 1.0000000000E+00 3.4499999996E+02 -1.0000000000E+00 1.1780000000E-01
11 -9 0 0 0 0.0000000000E+00 0.0000000000E+00 1.7250000000E+02 1.7250000000E+02 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
11 -9 0 0 0 0.0000000000E+00 0.0000000000E+00 -1.7250000000E+02 -1.7250000000E+02 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
11 2 1 2 0 0 0.0000000000E+00 0.0000000000E+00 1.7249999996E+02 1.7249999996E+02 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
11 2 1 2 0 0 0.0000000000E+00 0.0000000000E+00 -1.7249999996E+02 -1.7249999996E+02 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
11 -1 3 0 0 0 2.0845224664E-18 -3.5864876827E-18 1.7249999996E+02 1.7249999996E+02 5.1108927662E-04 0.0000000000E+00 9.0000000000E+00
11 -1 4 0 0 0 4.4784651592E-11 -9.2536895478E-11 -1.7249999996E+02 1.7250000000E+02 5.1098791857E-04 0.0000000000E+00 9.0000000000E+00
22 1 3 0 0 0 -2.0844242199E-18 3.5862840720E-18 5.0849668854E-19 4.1796939994E-18 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
22 1 4 0 0 0 -4.4784651592E-11 9.2536895478E-11 1.4514972623E-10 1.7786844877E-10 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
13 2 5 0 0 0 1.1235558051E+01 -1.3523220158E+01 1.4833737471E+01 2.3083309931E+01 3.3717478892E-07 0.0000000000E+00 9.0000000000E+00
-13 2 5 0 0 0 -1.7754951862E+01 3.3867081191E+01 1.6676514299E+01 4.1717186304E+01 1.2615925365E-06 0.0000000000E+00 9.0000000000E+00
14 2 5 0 0 0 3.3779281573E+01 -2.8776514815E+01 1.0964769923E+01 4.5709450313E+01 6.7434957617E-07 0.0000000000E+00 9.0000000000E+00
-14 2 5 0 0 0 3.6755202780E+01 9.9755192092E+01 -1.9502094063E+01 1.0808503575E+02 -1.3486991523E-06 0.0000000000E+00 9.0000000000E+00
5 2 5 6 501 0 -4.8694112043E+01 -9.4108577314E+01 -2.7841908146E+01 1.8963736715E+02 4.2800000000E+00 0.0000000000E+00 9.0000000000E+00
-5 2 5 6 501 0 -1.5320979063E+01 2.7868398045E+00 4.8689724837E+00 1.6847590505E+01 4.2000000000E+00 0.0000000000E+00 9.0000000000E+00
14 1 11 0 0 0 3.3177407184E+01 -2.8263779006E+01 1.0769401227E+01 4.4895005891E+01 6.7434957617E-07 0.0000000000E+00 9.0000000000E+00
-14 1 12 0 0 0 3.6168383854E+01 9.7977768403E+01 -1.9154608551E+01 -1.0615919210E+02 0.0000000000E+00 0.0000000000E+00 9.0000000000E+00
```

Hadronization handled by Pythia (volunteers for Pythia variations?)

Example sample to get going shared in CERNBOX with Nadjieh/Zohreh and Matteo/Laura

Simulation requested in:

- ILD (full simulation, MC meeting 28/02),
- FCC (DELPHES?, meeting with Higgs/top conveners on Friday, March 1st), etc.

# Threshold scan MC samples

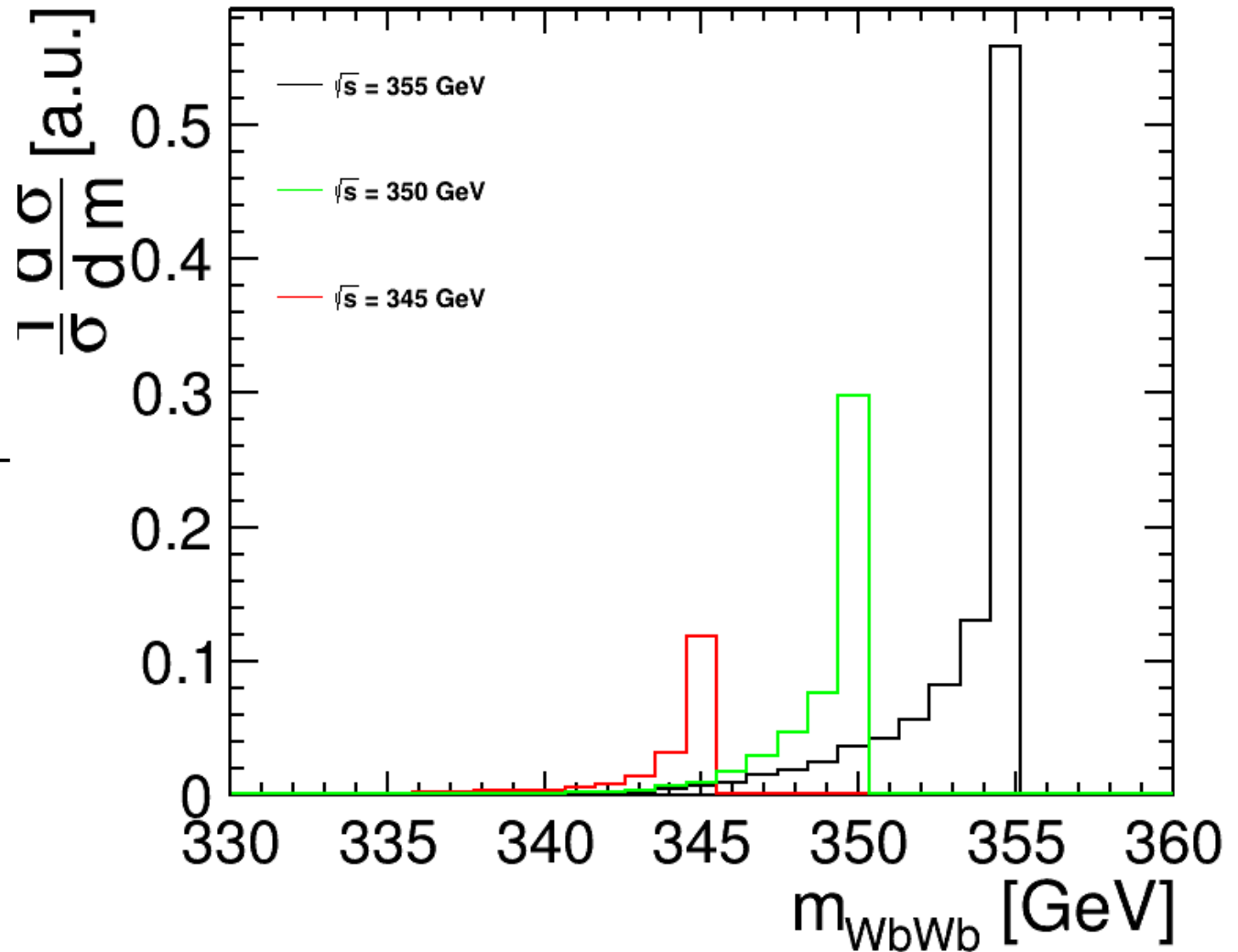
ISR and luminosity spectrum lead to low- $\sqrt{s}$  tails

$$m_t^{\text{pole}} = 172.5 \text{ GeV}$$

<https://arxiv.org/abs/2402.08713>

$$m_t^{\text{PS}} \rightarrow \sim 170.5 \text{ GeV}$$

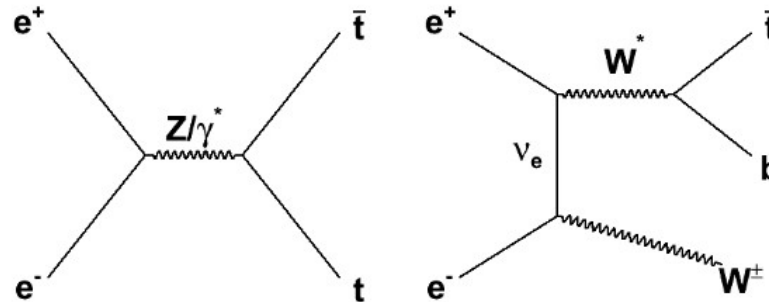
$$m_t^{1S} \sim 170.9 \text{ GeV}$$



# Signal vs. background

We need a working definition of **signal** and **background** between experiment and theory

## Single top signal

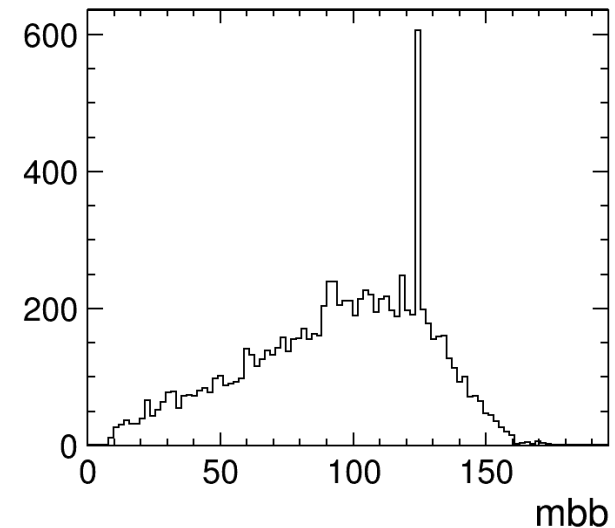


## Backgrounds:

- 6f without b-jets (small if b-tagging is good)
- 2f & 4f backgrounds (rejected by requiring  $2 \times \text{\#leptons} + \text{\#jets} = 6$ )
- **Higgs contamination,  $e^+e^- \rightarrow ZH, Z \rightarrow W^+W^-, H \rightarrow bb$** 
  - is part of  $e^+e^- \rightarrow WbWb$ , but not accounted for in calculations

Martin Beneke (last meeting):

- single top is included in the calculation and should be considered signal
- Higgs diagrams are not included and are a (small) reducible contamination that must be dealt with by experimentalists



# Experimental systematic uncertainties

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

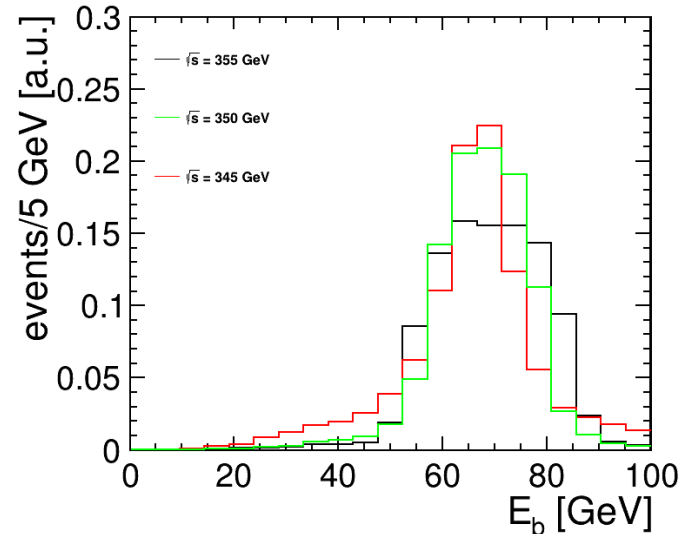
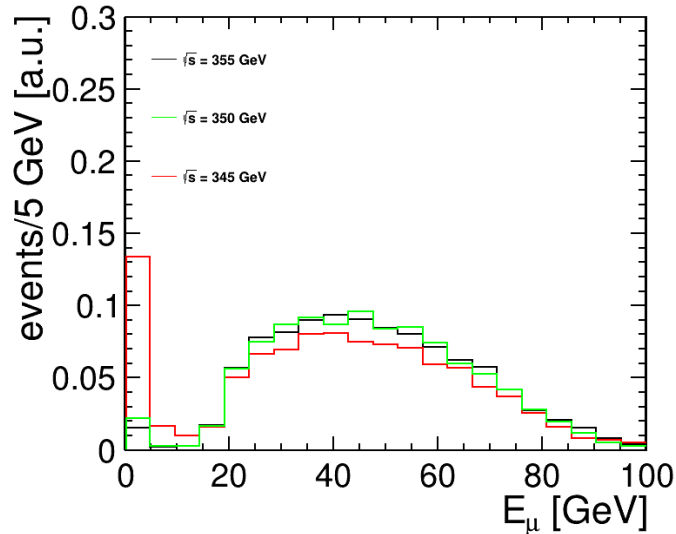
- Realistic selection requires one/two b-tags and isolated leptons, with “near-complete polar angle coverage” (<https://arxiv.org/pdf/1307.8102.pdf> + CLIC 380 <https://arxiv.org/pdf/1807.02441.pdf>)

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





# Summary

## **Threshold scan signal MC samples are in development:**

- WHIZARD six-fermion (with single top, Higgs, etc.) pure leading order in pole mass scheme → example samples available
- Samples with more advanced model, including threshold enhancement, could be produced in the future

Volunteers to analyze these will present their plans today

Plenty of related activities are still looking for personpower

## **Practical:**

Will use official mailing list from now on

Regular meetings on Wednesday afternoon (17:00 CERN time)