

# Working Group 4

## TopPhysics@FCC-ee

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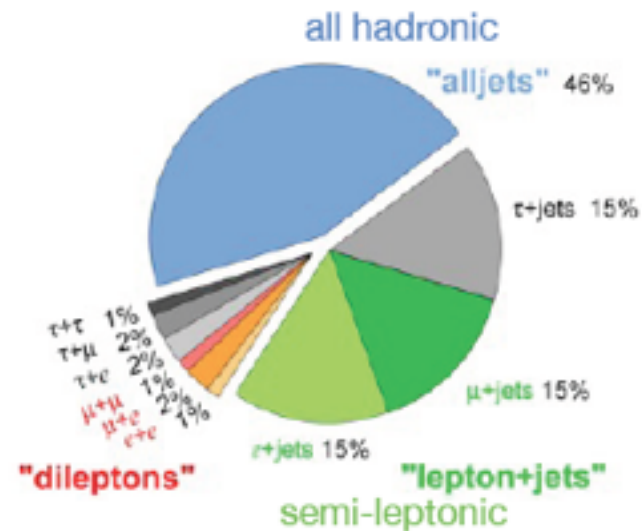
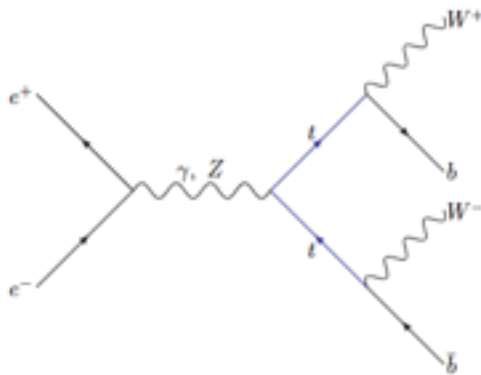
# Top Physics at FCC-ee

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- The strength of the FCC-ee program is to be able to span several centre of mass energies: from Tera-Z to 350GeV and maybe up to a 500GeV option.
- Where/when does top physics come in the program?
  - **dedicated run at threshold @350GeV « Mega-Top »** because of the 1M top pair produced
  - **studies with production of single top quarks profiting of the run at 240GeV** dedicated to Higgs precision measurement
  - **higher energy run @500GeV for ttH**
- The organization of the work to be done now is based on the deliverables needed from this physics program for the 2015 Spring deadline (which is very tight!):
  - planning physics presentations for FCC-ee 9th workshop in Pisa Feb 2015

# Production and decay

- analysis driven by production and decays modes
  - at threshold pair production dominates
  - at lower energies can enhance also the single production wrt to background



- $\sim 100\%$  BR in  $Wb$
- final states classified on the basis of the W decay

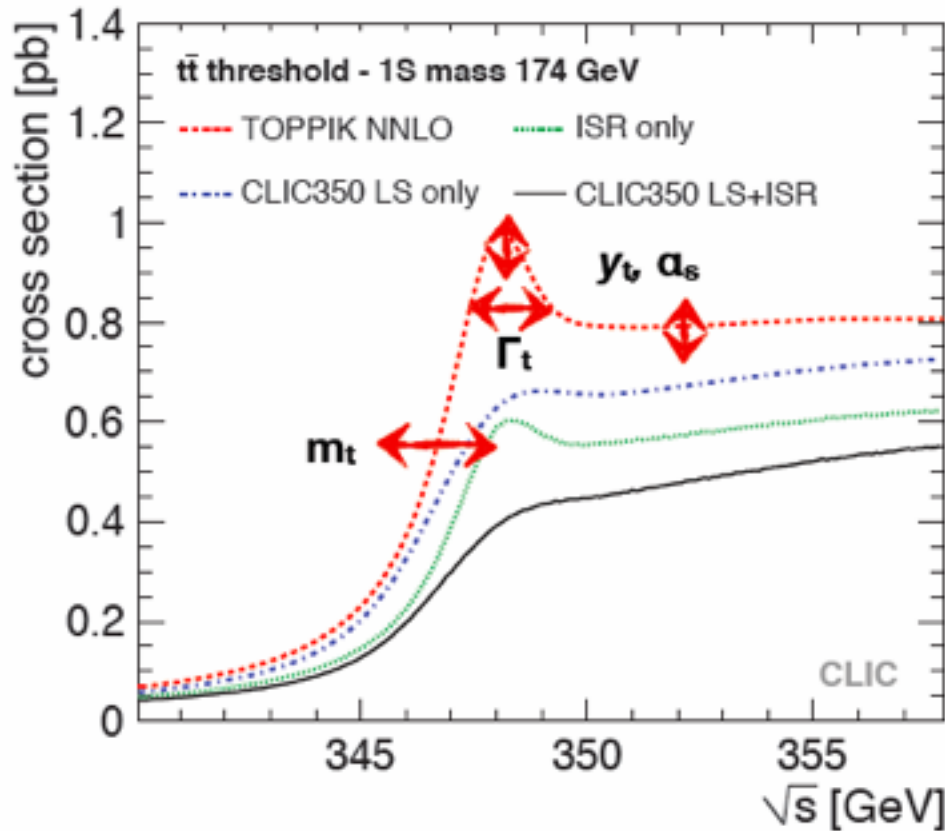
# Deliverables

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- There are few clear high priority topics: either because we know they are important, either to assess their real potential with appropriate studies.
  - (scarce) Available literature comes from ILC and (old) Tesla studies.
- Shopping list (see also <https://tlep.web.cern.ch/content/wg4-exp>) :
  - **top mass measurement at threshold @350GeV: « the measurement »**
    - need to compare with current ILC expectation. *some work being done (see later)*
    - need to have specific FCC-ee complete analysis (i.e. with detector simulation)
    - as a byproduct of these analyses would come the precise determination of other precision variables: width,  $Y_t$ , etc
  - **top rare decays and anomalous couplings (240 or 350): the real fast way to find BSM physics.**
    - need to explicitly evaluate the potential. *some work being done here (see later)*
    - in particular use of single top final states profiting of higher luminosity run at 240 GeV
  - **the case for 500 GeV run:**
    - direct extraction of  $Y_{tt}$  from  $ttH$  signal
    - any other BSM signal to look for?

# Threshold scan - Ultimate sensitivity

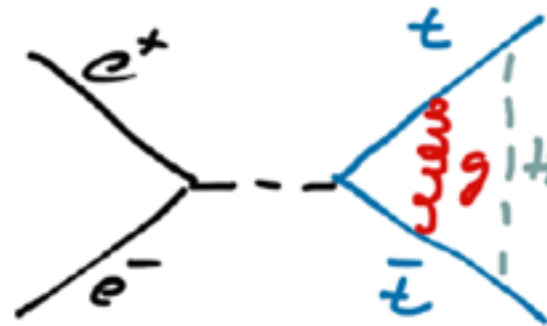
F. Simon @Top2014



- Effects of some parameters are correlated; dependence on Yukawa coupling rather weak - precise external  $\alpha_s$  helps

The cross-section around the threshold is affected by several properties of the top quark and by QCD

- Top mass, width, Yukawa coupling
- Strong coupling constant

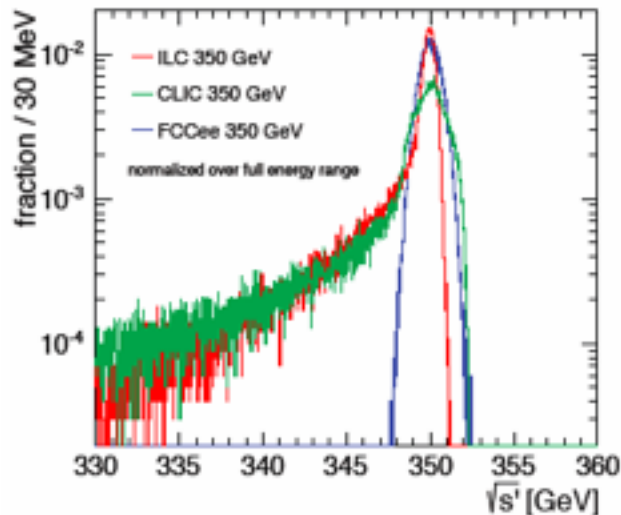


Here: Extract mass and  $\alpha_s$

# Perspectives on precision mass measurement

F. Simon  
@Top2014

## Side Remark - Threshold Scan at LCs and FCCee

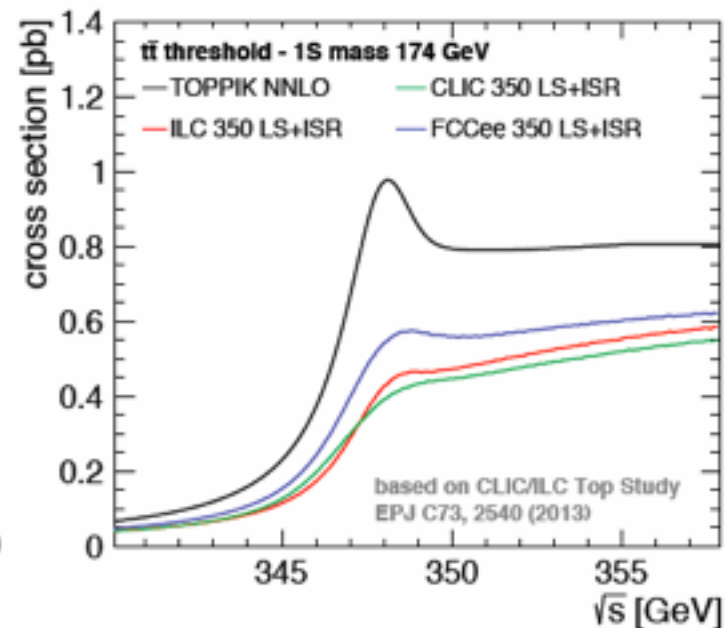


- Somewhat different luminosity spectra for different machines:
- no beamstrahlung tail in storage ring
- sharper main peak at ILC, broader at CLIC

► Slight differences in statistics due to cross section, changes in sensitivity due to steepness of threshold turn-on

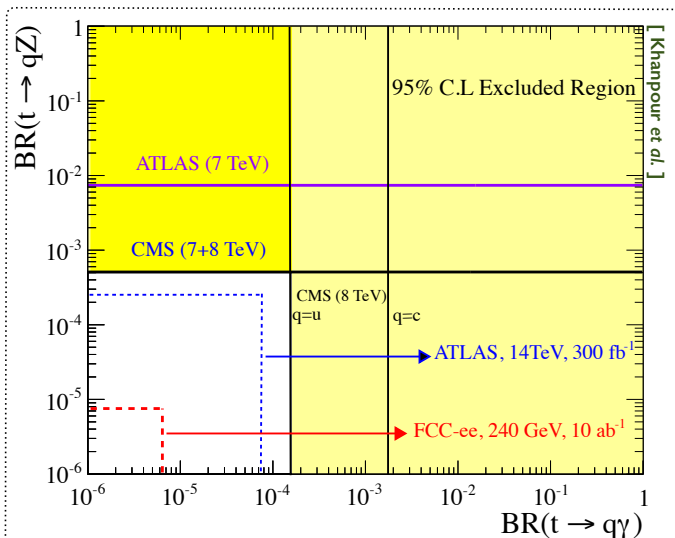
► For  $100 \text{ fb}^{-1}$ , no polarization, 1D mass fit:

16 MeV  $\rightarrow$  18 MeV  $\rightarrow$  21 MeV (stat)  
FCCee ILC CLIC



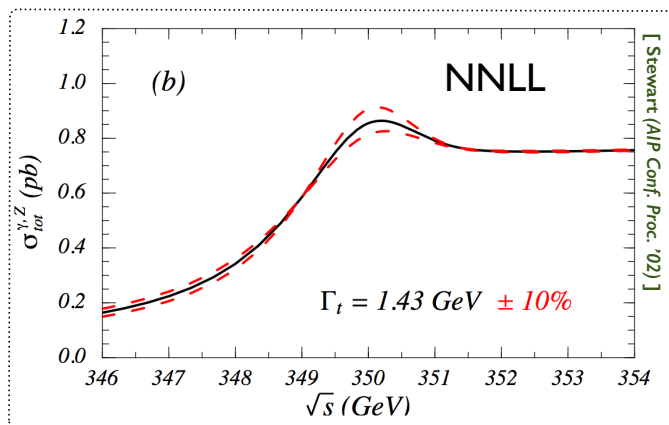
## ◆ FCNC production of a top and a light quark

❖ At a center-of-mass energy of 240 GeV



## ◆ Inclusive approach via $t\bar{t}$ production cross section

- ❖ At a center-of-mass energy of 350 GeV
- ❖ Five-year scan of the top-antitop threshold



[ TLEP Design Working Group (JHEP'14) ]

	$m_{top}$	$\Gamma_{top}$	$\lambda_{top}$
TLEP	10 MeV	11 MeV	13%
ILC	31 MeV	34 MeV	40%

- ❖ Indirect constraints from the top width
  - ★ Constraining the magnitude of the rare decay modes

very preliminary results (IPM group) cross checks in progress: also hadronic channel being studied (Rome)

- Plan from the pheno-side to use a complete approach with dim-6 operators and 4 fermion interactions
- Plan from the exp-side: use a Delphes simulation to include the charm-tagging option to evaluate the potential for the  $Ztc$  case and to be used for the detector design

# Top Group planning - Phase 00

- Before dealing with the group structure I started from collecting the interest by few experts to set the basis of the planning.
  - *However after a very enthusiastic initial phase now the interference with other projects schedule is hindering a stronger participation from the same people.*
- Current expression of interest:
  - **Mass reconstruction:** Frank Simon (exp) excellent example of synergy with the ILC effort.
  - **Rare decays:**
    - Barbara Mele(th), with S. Biswas (th) and F. Margaroli(exp)
    - Benjamin Fuks(th), already participating to efforts in top physics at CMS and FCC-hh
    - IPM Teheran (exp) group already doing similar analyses in CMS
  - **Single Top:** some interest from previous LEP experts M.Antonelli (exp) retrieved for us some specific MC generator code



# Top Group planning - Phase I

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- As it is natural, in the course of this initial work lots of new details for the analysis and new topics have come up.
- Currently suggesting the following WG structure with openings to fill:
  - **2 WG conveners: looking for a co-convener.** would like someone with some expertise, enthusiast and energetic, either experimentalist or phenomenologist to join me in this adventure.
  - **3 subgroups** that will need one(or two) convener each:
    - **Cross Section & Mass:** precision measurements in single and pair production
    - **Properties & NP:** couplings, rare decays, FCNC, differential distributions
    - **High Energy:** the case for 500GeV
- Planning also to move from specific discussion with specific groups, to calling « Top Group meetings » on a need-to basis.

# Other areas of work/contacts

- Inside the bigger scheme of the FCC-ee physics community we should not forget that we need also people that can cover the following roles:
- **Theory and Generator responsible:** for signal generation and systematics:
  - fully exploit the synergy with the studies done for ILC/CLIC
  - **Contact toward the Theory section of FCCee organization**
- **Contact with SM and BSM Physics Group:** for backgrounds and models
- **Contact with Machine interface Group** for energy measurement for mass measurement
- **Contact with FCCee Offline Group:** for development of simulation and reconstruction tools:
  - profit from previous tools developed for Snowmass ( Delphes)
  - *Reconstruction issues (and detector requirements) for Top physics are not « extreme » and they overlap largely with the Higgs.* (similar backgrounds and energy scale)
    - One need in common that is fairly 'new' compared to previous studies would be the *development of a strong c-tagging (would make the difference for single-top as well)*
    - *currently preparing (IMP Teheran+Roma) a ILD-inspired Delphes card to be used for these studies. If anyone is interested in helping out or validating it please contact me.*



# What next

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- Some real work in progress but need to switch gears.
- Noticed way more interest for FCNC topics and very little for precision measurements. Interesting.
- The synergy with ILC is particular as the physics case is very similar. Can we strengthen and profit from this?
- Continuing scouting of interested people:
  - with personal contact with experimentalists
  - profiting of synergy with theorists/phenomenologists
  - profiting of synergy with activities with FCC-hh as top expert in general are involved in both
- please nominate yourself or colleagues for the positions in the Top Working Group!