

# EF03 highlights and activities

## Heavy flavor and top quark physics

### Introduction

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# EF03 highlights so far

- Productive topical group meetings every other week
  - Overview talks with discussion plus 5-minute presentations
- HL/HE-LHC top studies (<https://indico.fnal.gov/event/44043/>)
  - Studies done within ATLAS/CMS
  - Differential cross sections and PDFs
  - top-pair + X and EFT and FCNC
  - Lots more interesting studies could be done for Snowmass
- Top and heavy flavor physics at ILC (<https://indico.fnal.gov/event/43738/>)
  - Top mass to 50 MeV
  - top EFT - in particular running up to 500 GeV
  - b-pair production  $\rightarrow$  3<sup>rd</sup> generation EFT
- Top quark mass measurement ideas (<https://indico.fnal.gov/event/43738/>)
  - At hadron colliders
- Projected uncertainties limited by theoretical modeling
  - Generators, parton shower models
  - Theory predictions

# HL-LHC EFT studies

Steve Wimpenny

- Rare production modes

- 4-top
- tWZ, etc
- top+DM

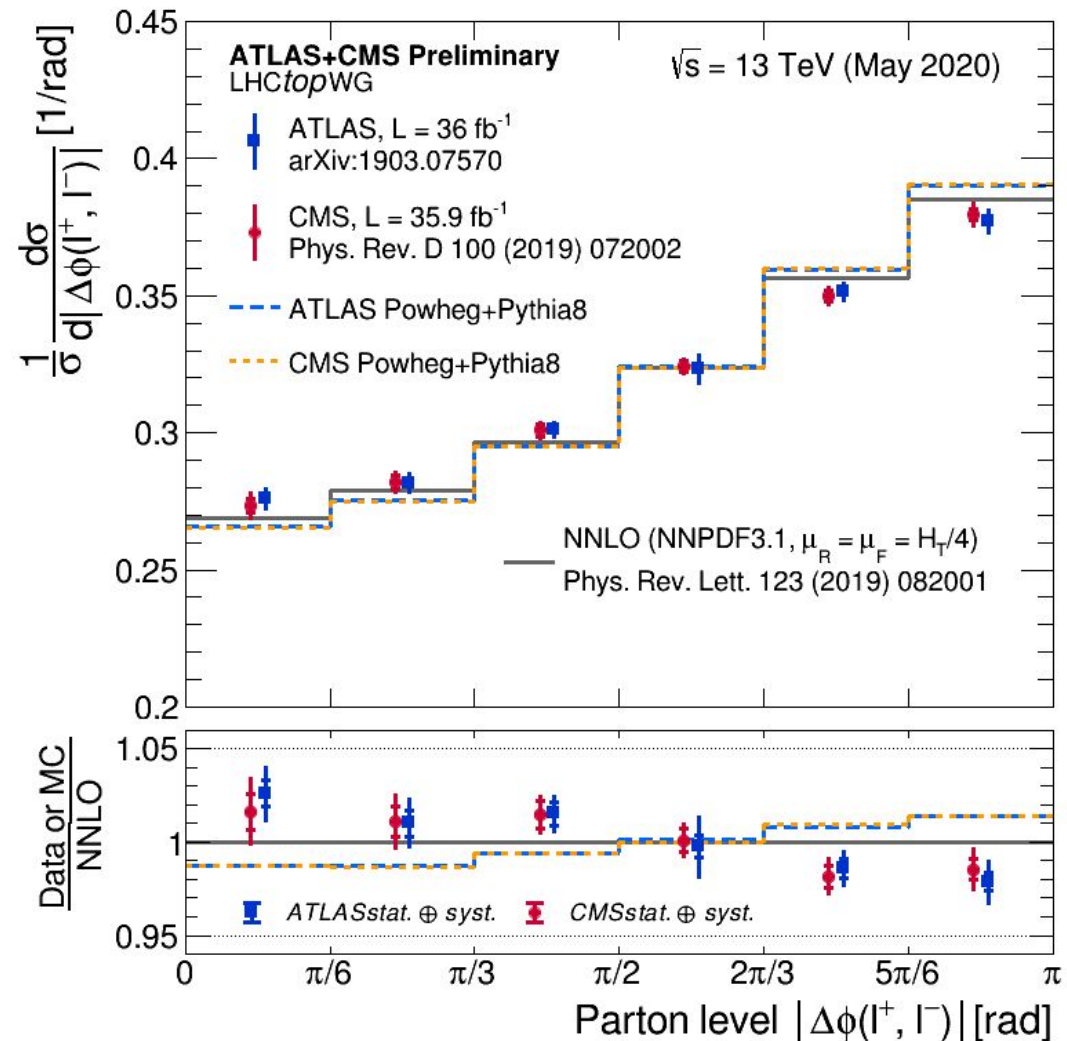
Alexander Moreno Briceño

- Inputs for Effective Field Theory fits

- Spin correlation variables
- Systematic uncertainties dominate: Modeling of ttbar and showering

James Keaveney, Alexander Grohsjean

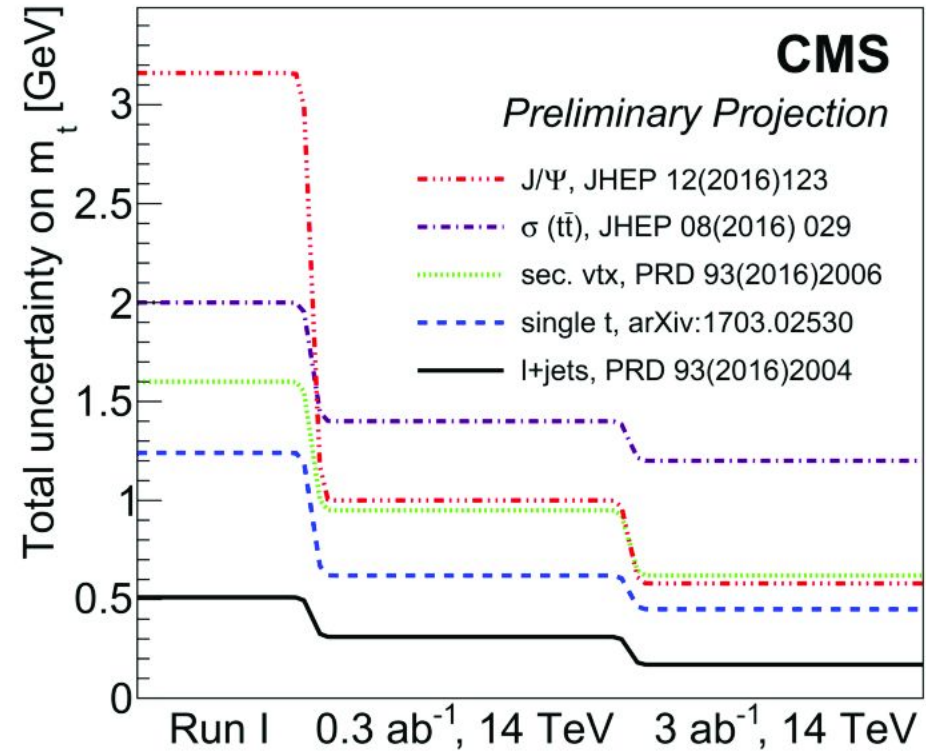
Andreas Jung, Giulia Negro, Amandeep Bakshi



# HL-LHC top mass

- Standard top mass measurements
  - Where to put effort to reduce uncertainties?
  - Modeling vs detector vs theory prediction
  - e+e- threshold scan is far in the future

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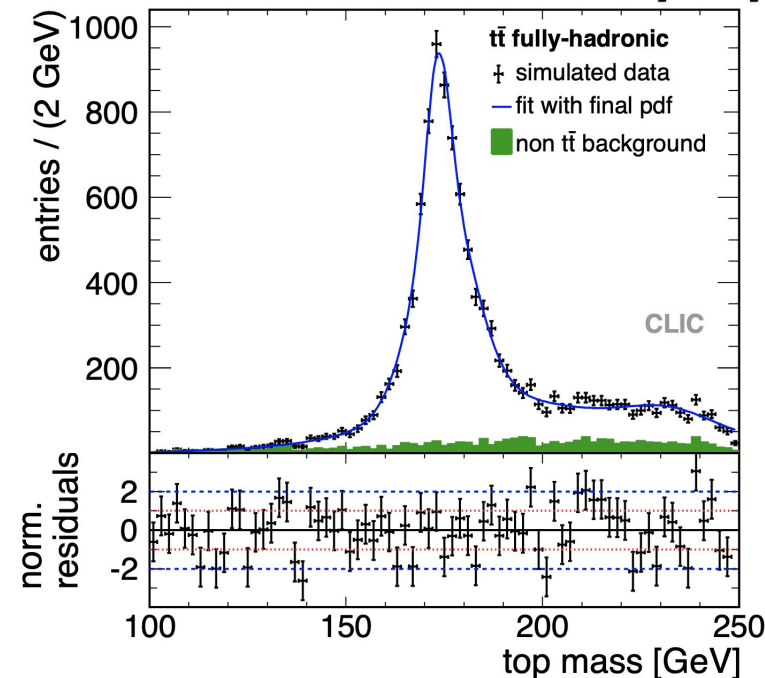
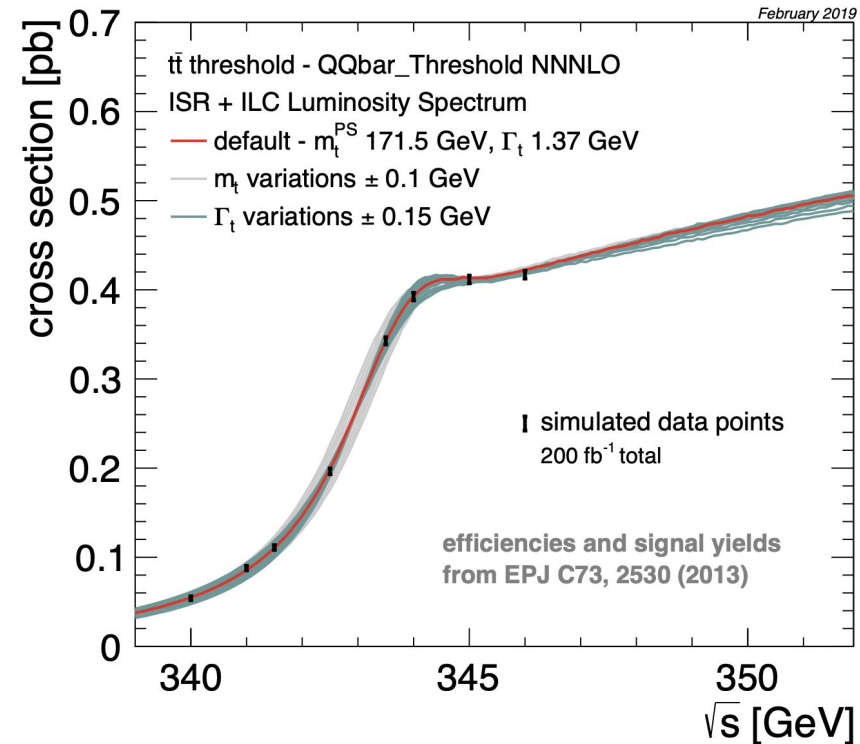
- Alternative ideas
  - Reduce sensitivity to certain set of uncertainties
  - Example: b-hadron decay length distribution
    - ▶ Independent of top production model
    - ▶ Still sensitive to fragmentation/hadronization

Kaustubh Agashe et al

# ILC studies

- Top mass
  - Mass scan optimization
  - Mass from decay products
  - Mass from radiative events ( $t\bar{t}\gamma$ )
- Top (and bottom) EFT fits
  - Many interesting measurements at  $t\bar{t}$  threshold
  - Bottom pair production measurements as input for EFT fits
- Heavy (and light) quark production and EFT fits

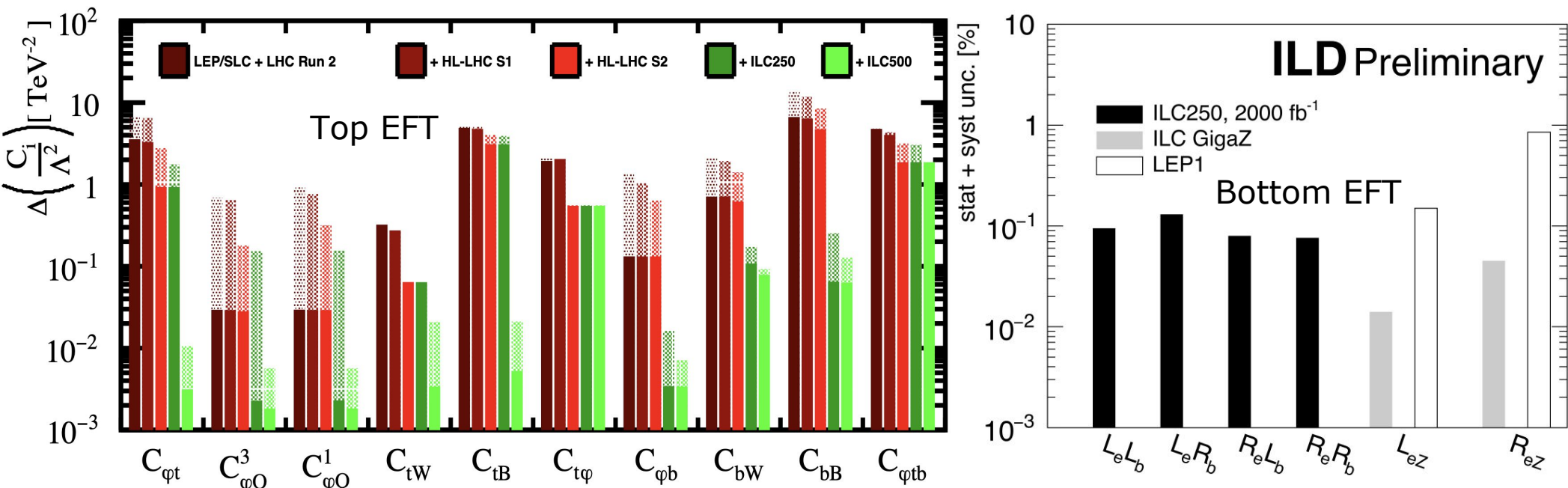
Esteban Fullana, Frank Simon  
Aleksander Filip Zarnacki, Kacper Nowak  
Roman Pöschl



# Top EFT

- HL-LHC: Add final states and variables for more comprehensive inputs
- Lepton Colliders: Long list of possible measurements

Martin Perello, Gauthier Durieux, Roman Pöschl et al



# Problems to address: systematic uncertainties

- Most of top physics and HF production studies are dominated by systematic uncertainties
  - Detector-related: object reconstruction, b-tagging, luminosity
  - Simulation-related: parton shower, scale, PDF, underlying event
  - Theory-prediction-related: scale, PDF,  $\alpha_s$ , higher-order corrections: QCD, EW, mixed EW-QCD
  - Discussion of EW corrections to  $ee \rightarrow tt$ ,  $bb$  at next EF03 meeting <https://indico.fnal.gov/event/44297>
- Consistent treatment in projections for different collider options?
- Theory predictions require close cooperation with all EF groups, in particular EF05, 06, as well as theory frontier

# Problems to address: Top and HF input to fits

- EFT fits
  - Active area at LHC today
  - Fits of top data, working towards global fits
    - ▶ Across multiple top-quark measurements
    - ▶ Across top, Higgs, EW, QCD, across multiple colliders
  - See presentation and discussion yesterday  
<https://indico.fnal.gov/event/43963/contributions/191331>
- PDF fits
  - Active area at LHC today
  - Fits include top and HF production data
- Precision electroweak fits
  - Active area today
  - top mass is key, but other top measurements can enter as well
- Space for new ideas, variables, measurements
- Close cooperation with EF04, EF05, EF06



# Looking for new ideas

- Top quark physics at FCC-hh
  - Rare processes at LHC become copious production modes
- Top physics at a muon collider
- Need simulation samples
  - top-pair production and other top-quark production modes
  - SM samples (backgrounds for searches)
  - Opportunities for precision top measurements
- HL-LHC studies
  - Limited number of HL-LHC studies for ESG
  - Also consider measurements limited by theoretical uncertainties
    - ▶ Theory will progress after LHC stops running
    - ▶ Opportunities to re-visit theory-limited LHC analyses

# Summary/Outlook

- Many opportunities to contribute to Top/HF production physics
  - So far input from ILC and HL-LHC
  - Study top at other colliders
  - Need many more HL-LHC studies to explore full program
  - Across topical group boundaries
- We invite you to contribute to top/HF production studies
  - EF03 wiki page at [https://snowmass21.org/energy/heavy\\_flavour](https://snowmass21.org/energy/heavy_flavour)
  - Email the conveners: [schwier@msu.edu](mailto:schwier@msu.edu), [dw24@buffalo.edu](mailto:dw24@buffalo.edu)
  - Mailing list [SNOWMASS-EF-03-TOP HEAVY-FLAVOR@FNAL.GOV](mailto:SNOWMASS-EF-03-TOP_HEAVY-FLAVOR@FNAL.GOV)
  - Looking for presentations at our biweekly meetings
- Informal list of projects, possible collaborations, open questions, etc.:  
<https://docs.google.com/document/d/17aPp9XpJAImmPInPNtgV21rG2zEiFS2IHkO-ooC4rcQ>