BACKGROUNDS OF HIGGS IN ASSOCIATION WITH TOP-PAIRS

Tim Wolf - Nikhef

OUTLINE

- Introduction to ttH - or: Why should we care about the top Yukawa coupling?
- Uncertainties in association with ttbb - importance as a background to ttH
- Monte-Carlo simulation of ttbb
- Outlook/Plans

WHY SHOULD WE CARE ABOUT THE TOP YUKAWA COUPLING?

F. Bezrukov, M. Shaposhnikov
[arxiv: 1411.1923]

STANDARD MODEL

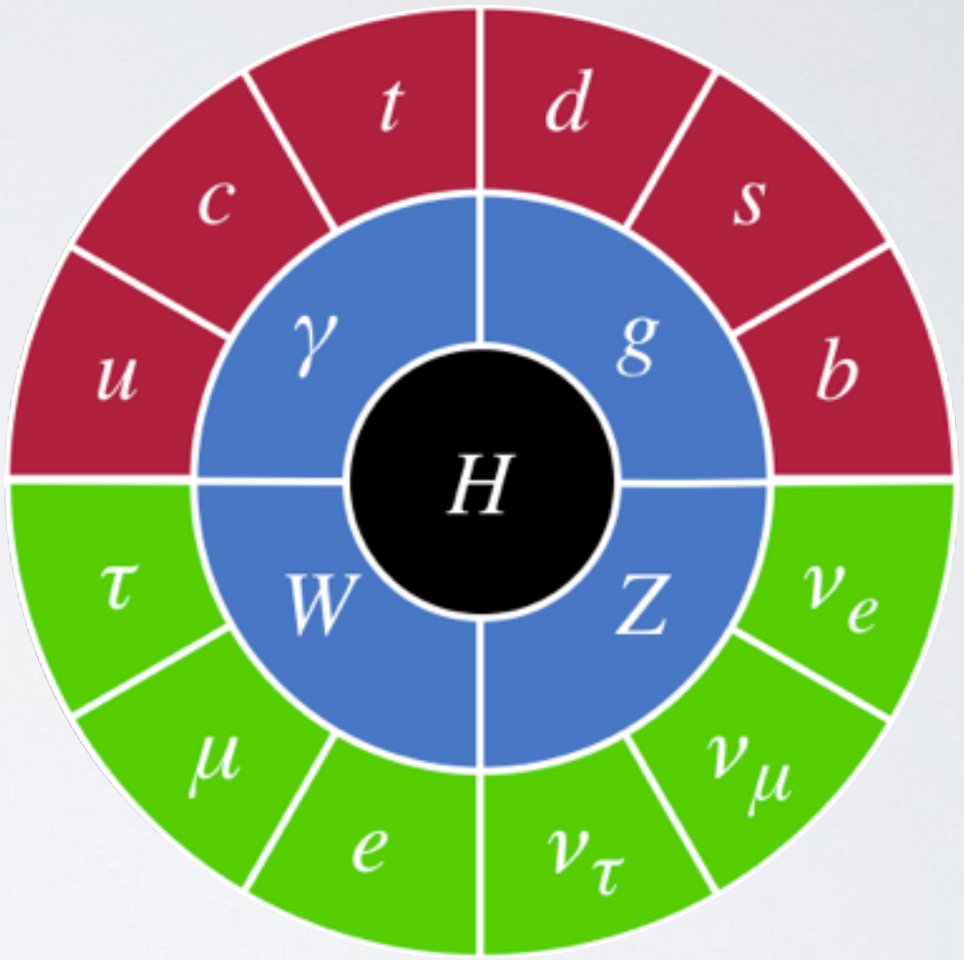
- SM explains all observed phenomena in particle physics to a very high precision (at least almost)
- SM consistent QFT up to high energies
- SM is by no means complete

WHY DO WE NEED MORE?

- SM does not account for neutrino masses
- SM does not explain the baryon asymmetry in the universe
- Dark matter not incorporated in SM
- Problems arising from theory arguments:
  - Hierarchy problem
  - Strong CP-problem

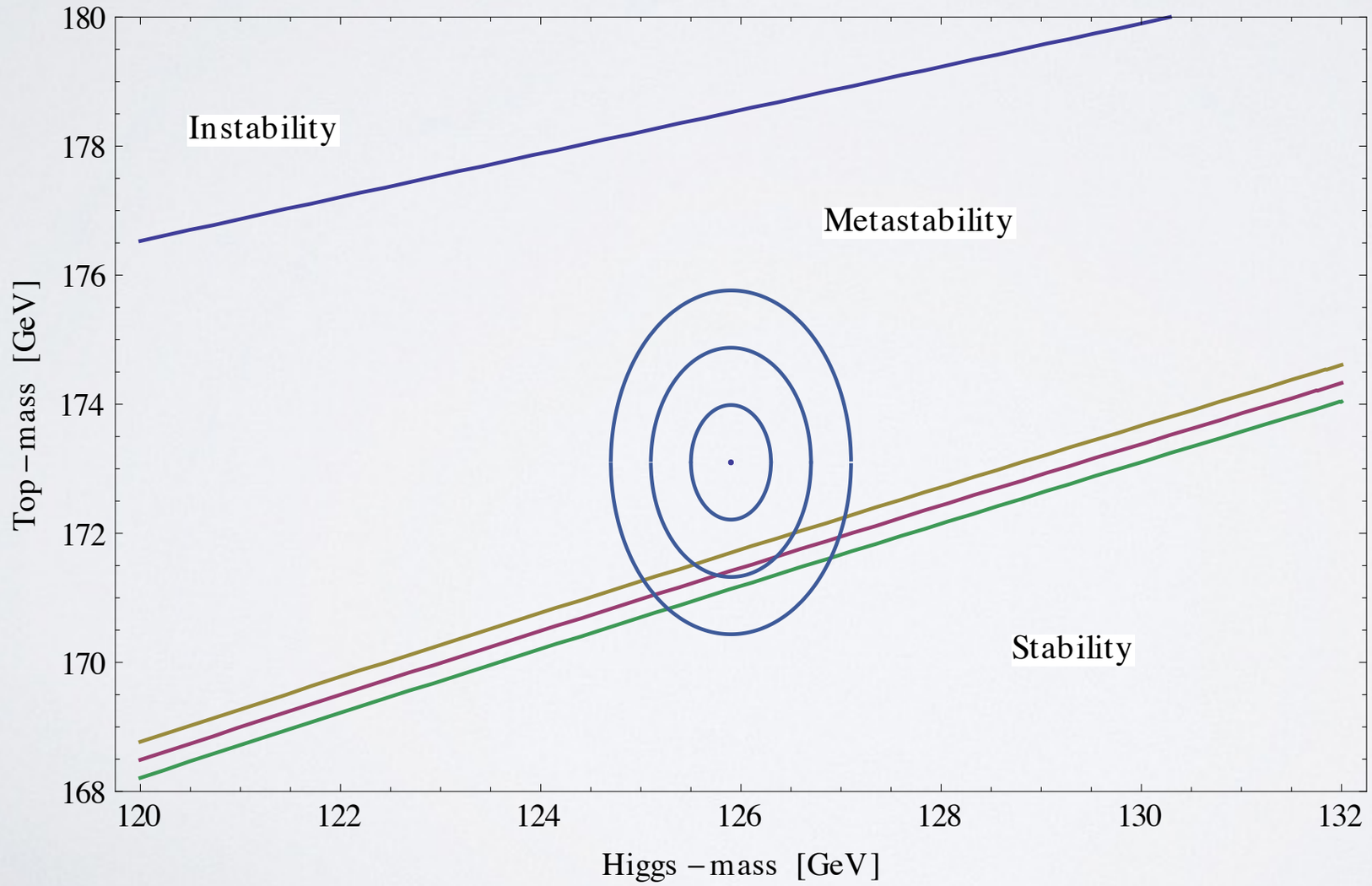
WE NEED BSM PHYSICS!

But where should we search for new physics?



TOP YUKAWA COUPLING

- Interplay between Higgs mass and top Yukawa coupling determines stability of the SM potential



Original work:
Degrassi et al.
arXiv:1205.6497

MEASUREMENT OF TOP YUKAWA COUPLING

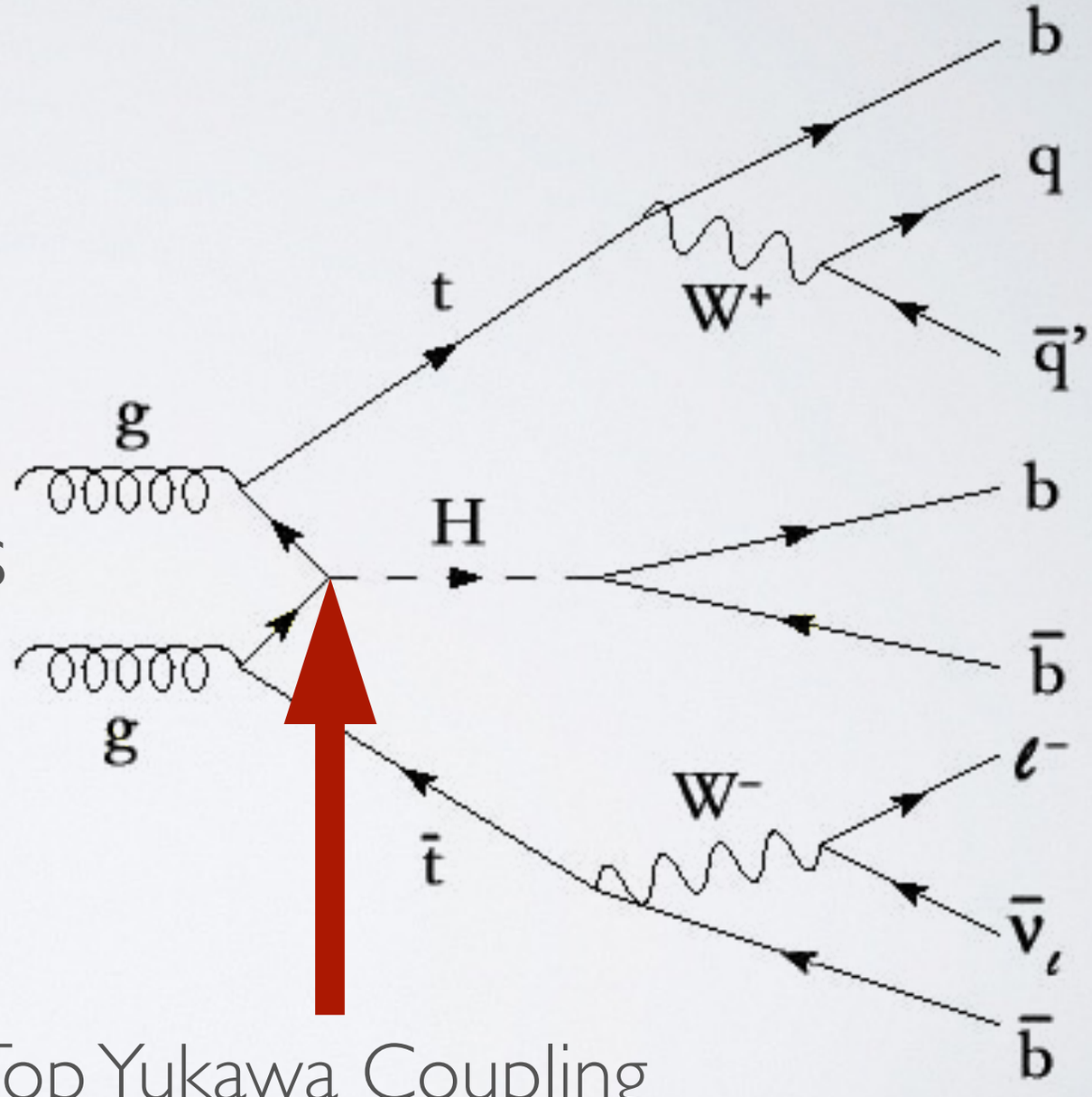
- measurement through top-mass (caveat: What are we measuring?/What is a top pole-mass?)

- measurement through tt cross-section

- ttH provides a direct measurement of the top Yukawa coupling

TTH MEASUREMENT

- Challenging final state with up to 8 quarks
- B-tagging performance is crucial to be able to observe ttH



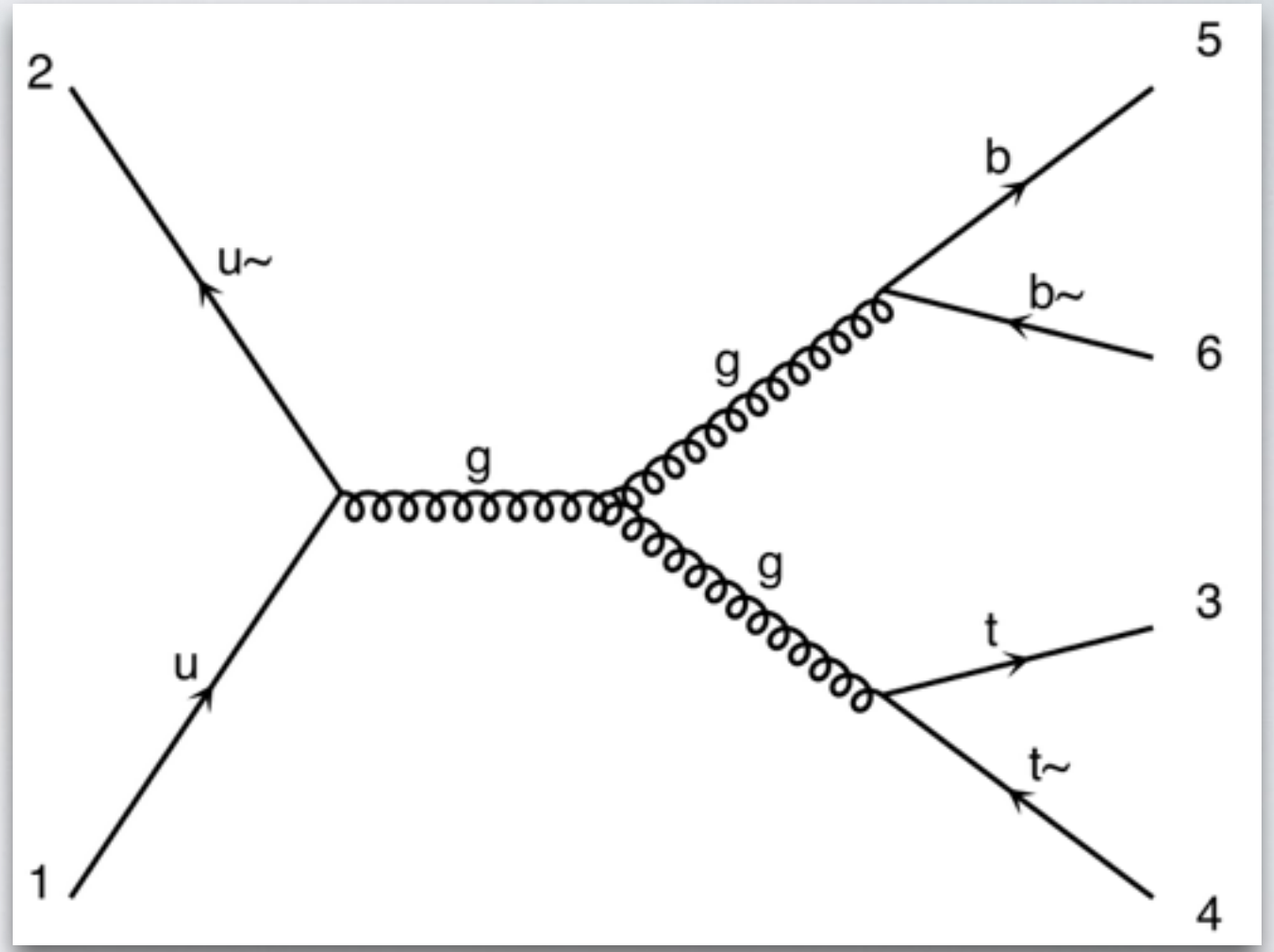
Top Yukawa Coupling

TTH BACKGROUND

- ttbb is the main-background for ttH(bb)
- irreducible background
- no dedicated measurement possible
- no signal-free control region available
- modelling of the background relies heavily on Monte-Carlo generation

MC SIMULATION OF TTBB

Background(s) of ttH(bb)



MC SIMULATION

- What is MC@NLO?
- (too) short: combine NLO with parton showers without double counting, different programs on the market (e.g aMC@NLO+PS, Sherpa +OpenLoops)
- long: S.Frixione, B. Webber - hep-ph/0204244
- Relevance to ttbb:
  - ttbb has been calculated before
  - brief review of what has been done

TTBB SIMULATION

- S. Frixione, V. Hirschi, D. Pagani, H.-S. Shao, M. Zaro [arXiv: 1407.0823]
- G. Bevilacqua, M. Czakon, C. Papadopoulos, R. Pittau, and M. Worek, [arXiv: 0907.4723]
- A. Bredenstein, A. Denner, S. Dittmaier, and S. Pozzorini [arXiv:0905.0110]
- A. Bredenstein, A. Denner, S. Dittmaier, and S. Pozzorini [arXiv:1001.4006]
- A. Kardos and Z. Trcsnyi [arXiv:1303.62911]
- Fabio Cascioli, Philipp Maierhoefer, Niccolo Moretti, Stefano Pozzorini, Frank Siegert [arXiv:1309.5912]

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TTBB REVIEW

(CASCIOLI ET AL. [ARXIV:1309.5912])

- Simulation of ttbb with Sherpa+OpenLoops (also MC@NLO based) [arXiv: 0811.4622, 1111.5206, 1309.0500] <- original papers

- top quarks are stable

- 4 flavor scheme, e.g massive b-quarks, no singularity if b-quarks are close by

- choice of renormalization and factorization scale:

$$\mu_R^4 = \xi_R^4 \prod_{i=\mathrm{t},\bar{\mathrm{t}},\mathrm{b},\bar{\mathrm{b}}} E_{\mathrm{T},i} = \xi_R^4 \prod_{i=\mathrm{t},\bar{\mathrm{t}},\mathrm{b},\bar{\mathrm{b}}} \sqrt{m_i^2 + p_{\mathrm{T},i}^2}$$

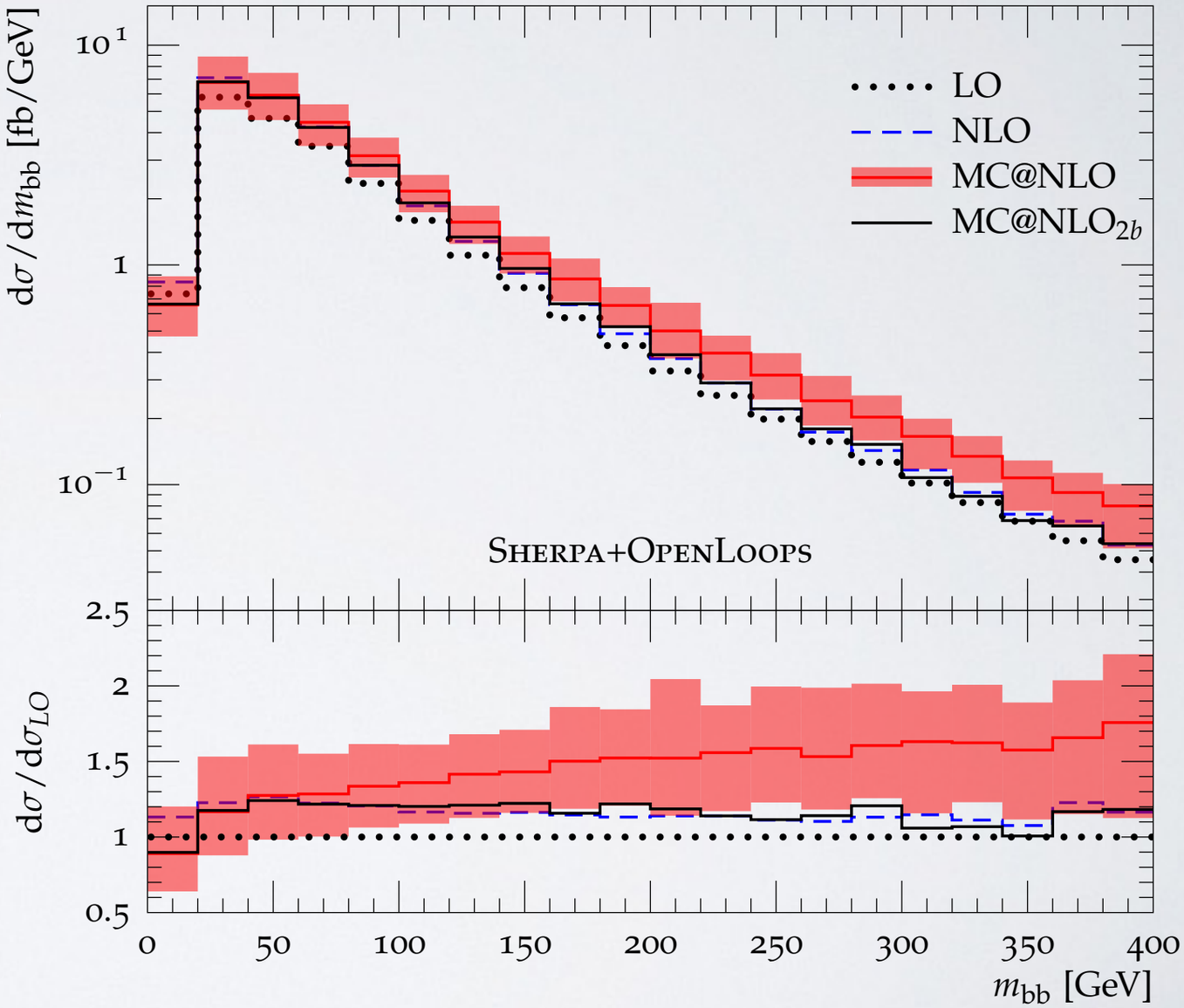
$$\mu_{\mathrm{F}} = \frac{\xi_{\mathrm{F}}}{2}(E_{\mathrm{T,t}} + E_{\mathrm{T},\bar{\mathrm{t}}}), \qquad \mu_Q = \xi_Q \mu_{\mathrm{F}}.$$

- generalisation of: $\mu^2 = m_{\mathrm{t}}\sqrt{p_{\mathrm{T,b}} p_{\mathrm{T},\bar{\mathrm{b}}}}$ from Bredenstein et al. [arXiv:1001.4006]

TTBB REVIEW

(CASCIOLI ET AL. [ARXIV:1309.5912])

- jet reconstruction: anti-kt with R=0.4
- "b-tagging": if at least 1 b-quark is constituent of a jet => b-jet
- asking for: 2 b-jets with
  - $p_T > 25\ \mathrm{GeV}$
  - $|\eta| < 2.5$



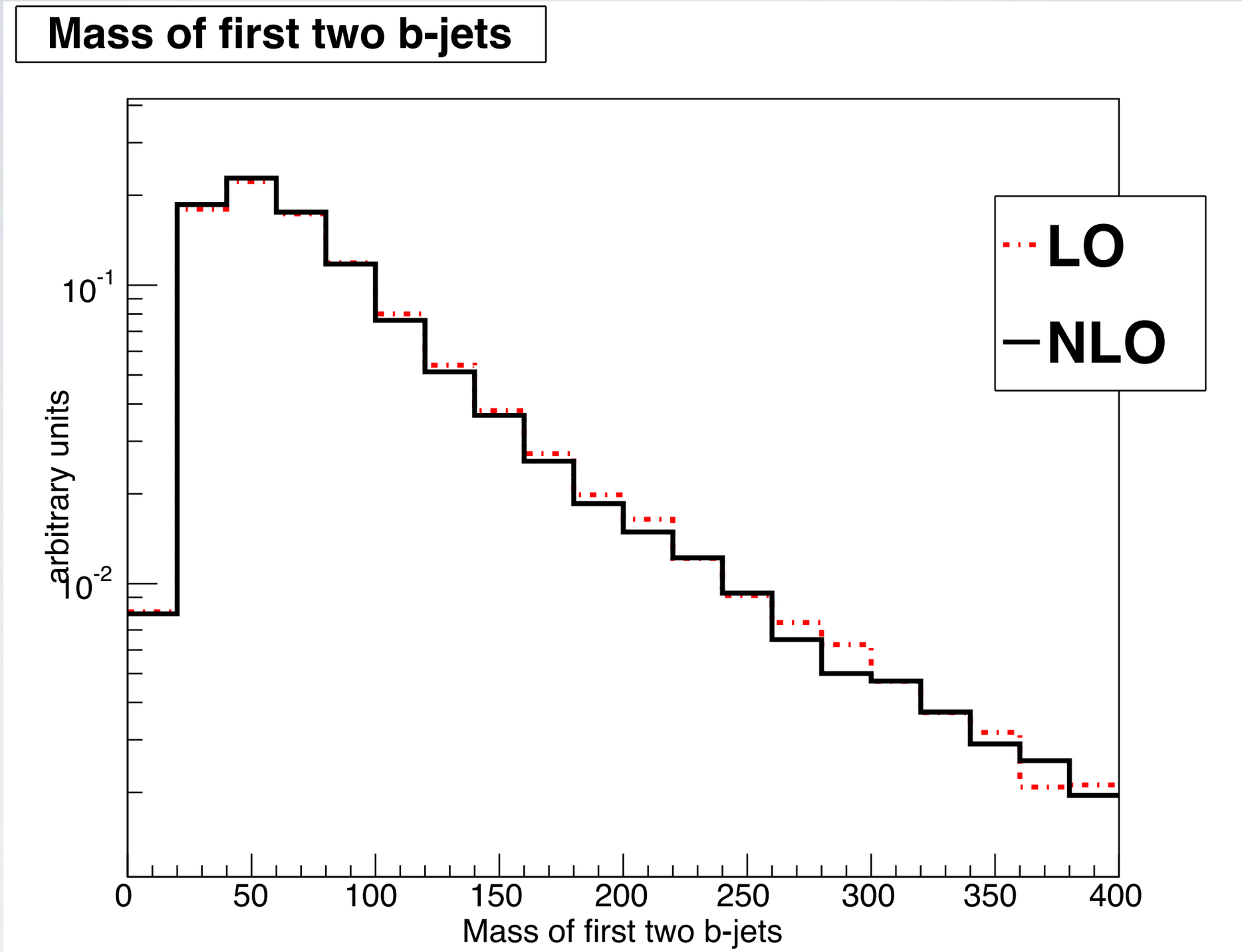
TTBB REVIEW

(CASCIOLI ET AL. [ARXIV:1309.5912])

- Conclusions:
  - significant impact of renormalization/factorization scale on the ttbb cross-section
  - importance of g -> bb splitting in parton shower in 4 flavor scheme
  - enhancement of m_bb if g->bb splitting is turned on
  - relevant for ttH-measurement at the LHC

TTBB-PROJECT

- perform calculation of ttbb within aMC@NLO + Pythia8
- 4-flavor scheme/massive b-quarks
- study g->bb splitting
- study dependence on parton shower (Pythia8, Herwig++?)
- study relevance for ttH, deriving more involved variables for suppression of background



preliminary plots - NOT scaled to cross-sections

OUTLOOK/PLANS

- Study of the impact of g->bb splitting in the parton shower of ttbb with massive b-quarks
- Similar study to 1309.5912v2 based on aMC@NLO + Pythia8: p p —> ttbb NLO+PS in 4 flavor-scheme
- Crucial is the choice of renormalisation and factorisation scale for this study
- different studies carried out with fixed ren./fac. scale and dynamical ren./fac. scale, also non-standard choices have been made in the past
- insights to the main background of the study of ttH which might be important for run II analysis
- contribution to ATLAS analysis of ttH

BACKUP

TTBB REVIEW

(CASCIOLI ET AL. [ARXIV:1309.5912])