Status of the $b\bar{b}$4l sample in CMS

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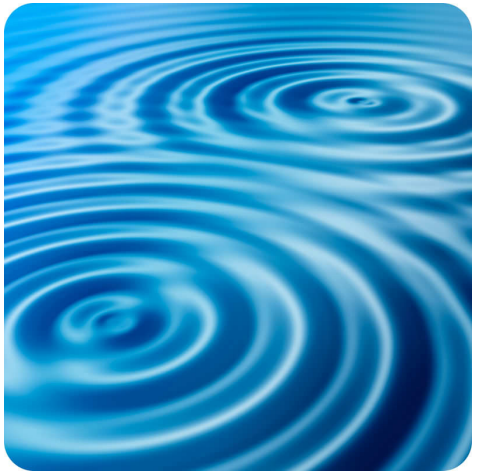
TOP Workshop

6/11/2018

The motivation

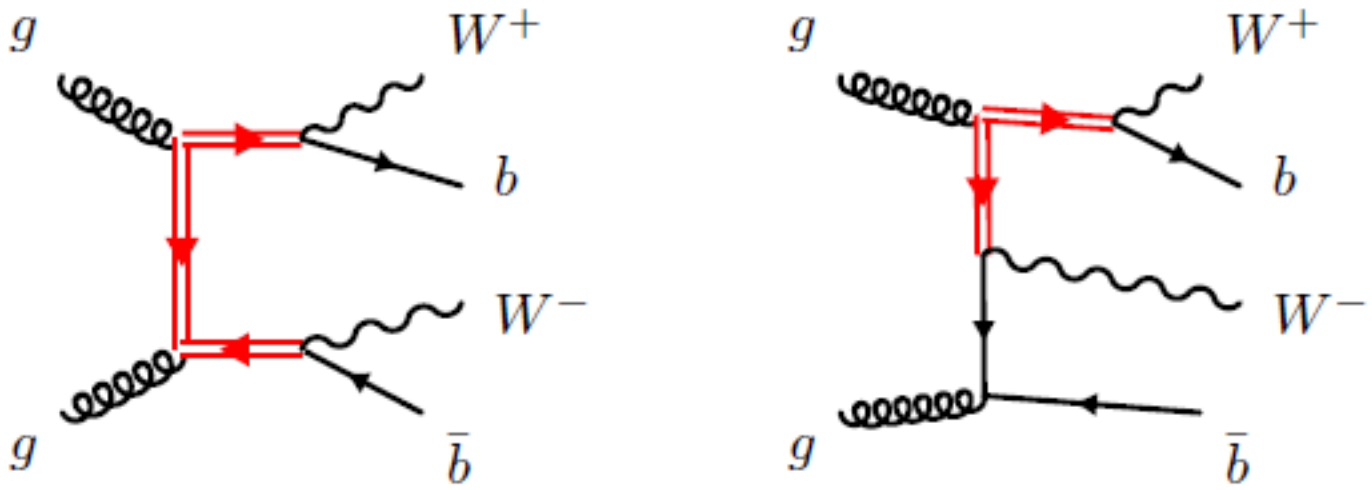
Interference between ttbar and single top + wb:
Very useful data to challenge new models in development



NLO corrections to the LO *tW* amplitude:

$$|A_{tW}|^2 = |A_{t\bar{t}}|^2 + |A_{tWb}|^2 + 2Re\{A^*_{t\bar{t}} \cdot A_{tWb}\}$$

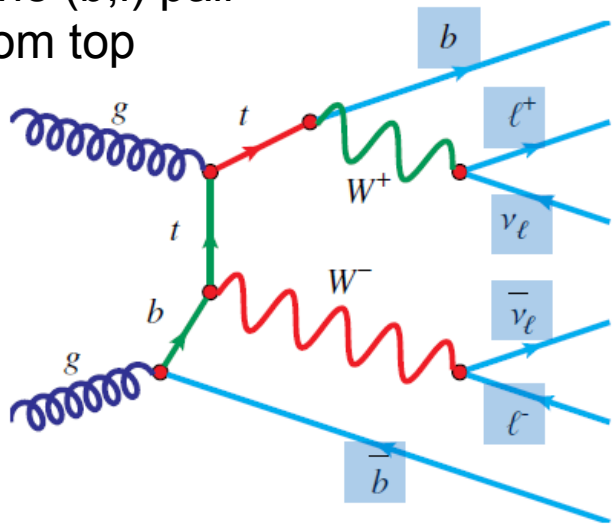
$t\bar{t}$ @LO | tW@NLO | interference



The diagrams for single top are the same as very off-shell ttbar

tW interfere with $t\bar{t}$ beyond LO

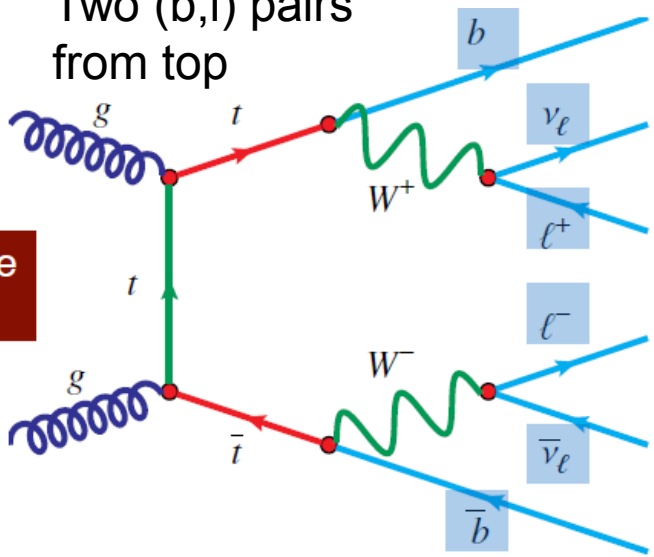
One (b,l) pair from top



single resonant

same final state WW*bb*

Two (b,l) pairs from top



double resonant

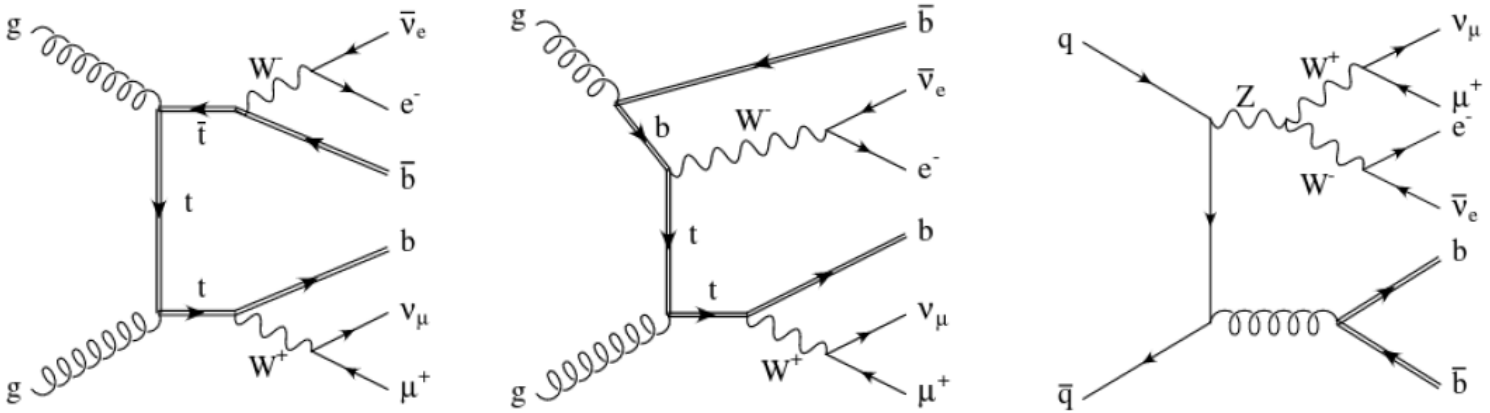
- Standard calculations factorise both processes (narrow-width approx.)
- Different interference schemes used to estimate the impact of this effect
- Size of the interference depends on the phase space → large impact on searches

POWHEG bb4l (lvlvbb): *EPJC76(2016)691*

• no narrow-width approx., interference is automatically handled

The process: $b\bar{b}4l$

- implemented in POWHEG-BOX-RES
- **NLO matrix elements** for $\ell^- \bar{\nu}\ \bar{b}\ \ \ell^+ \nu\ b$
- full NLO accuracy in $t\bar{t}$ production and decay, including interference between NLO radiation,
- exact treatment of off-shell effects associated with the top-quark and W boson resonance
- unified treatment of $t\bar{t}$ and Wt production with interference at NLO
- exact spin correlations at NLO
- Born level example diagrams for $O(\alpha_S^2, \alpha_{EM}^4)$:

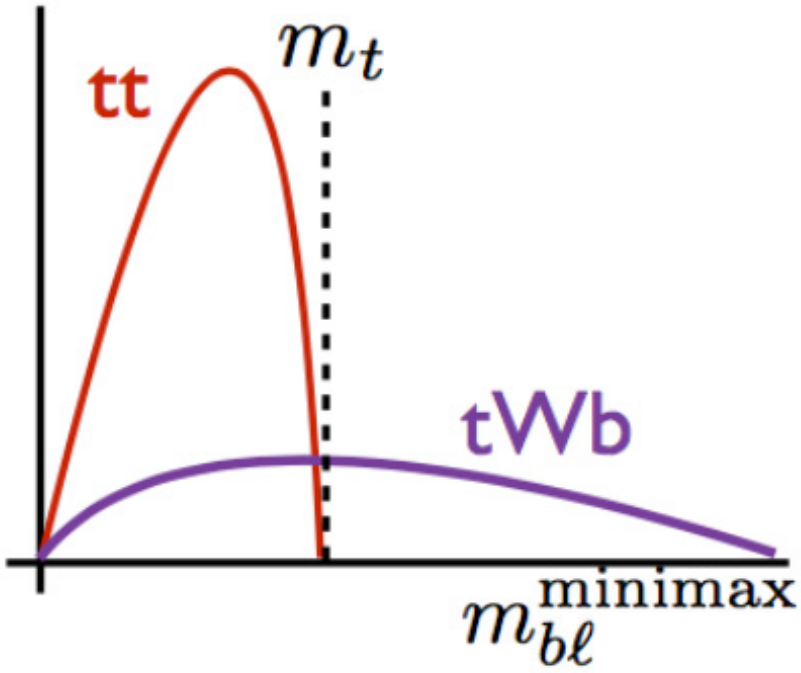


The discriminant

Idea from ATLAS paper:

- Take both possible combinations of b-l mass.
- For each combination take the **max** b-l pair, then take the minimum from the two combinations:

$$\min\{\max\{m(b_1l_1),m(b_2l_2)\},\max\{m(b_1l_2),m(b_2l_1)\}$$



For $t\bar{t}$:
- When *b*-jet/lepton correctly assigned: m(*bl*) ≤ mt
- Correct assignment not known a priory:
- min{max{m(*b1l1*),m(*b2l2*)},max{m(*b1l2*),m(*b2l1*)} ≤ mt

For tWb:
- One m(*bl*) smaller than mt, the other could be larger
- min{max{m(*b1l1*),m(*b2l2*)},max{m(*b1l2*),m(*b2l1*)} ≥ mt

The discriminant

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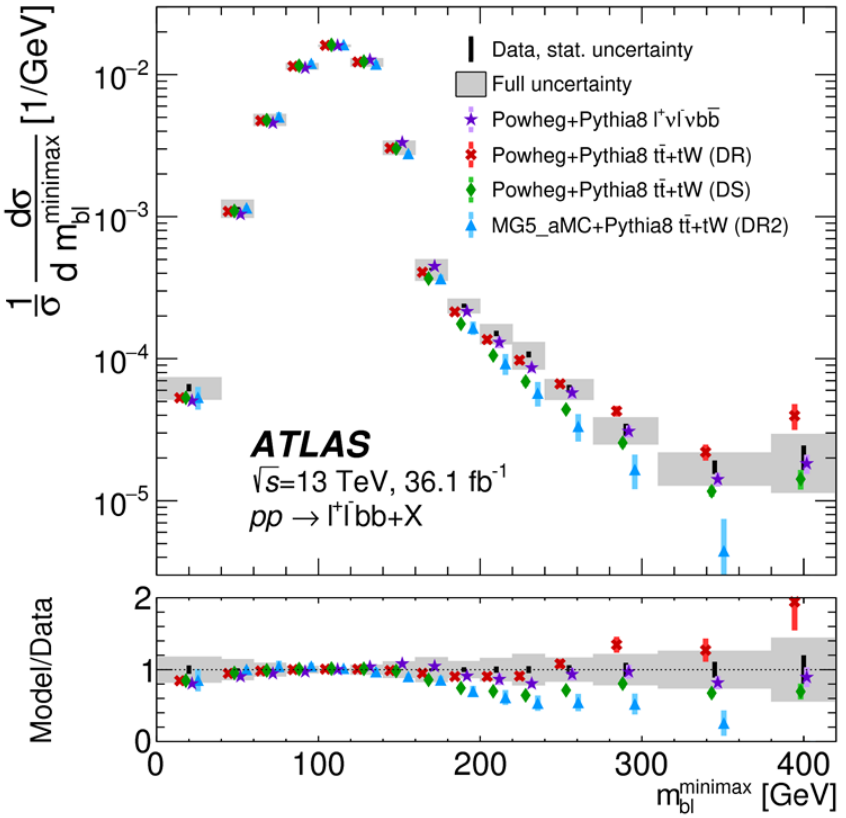

For tt̄:
- When *b*-jet/lepton correctly assigned: m(*bl*) ≤ mt
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arXiv:1806.04667

The status in CMS

- Gridpack exists: file location, POWHEG datacards in git
  - powhegboxRES_rev3468_date20171122, taus included
- Pythia8 configuration and UserHook updated for an improved FSR veto, thanks to Alexander Grohsjean, based on previous work/code by Markus and Tomas, thanks!
- Validated against arXiv:1607.04538 by A.G. and Gerrit van Onsem: thanks!!
- Integrated in CMSSW 10_2_X PR#23469, backported to 71X
- PrepID for Fall18 campaign, 50M events requested: TOP-RunIIFall18wmLHEGS-00094

Details of PrepIDs

- **~350s / event** with o(1k) ME+PDFs weights: on **hold**, PrepID TOP-RunIIFall18wmLHEGS-00026

- **~30s / event** with **reduced** set of ME+PDF weights (α_S variations of NNPDF3.1 NNLO): requested PrepID TOP-RunIIFall18wmLHEGS-00094

- Dataset name: **b_bbar_4l_TuneCP5_13TeV-powheg-pythia8**

The acid test…

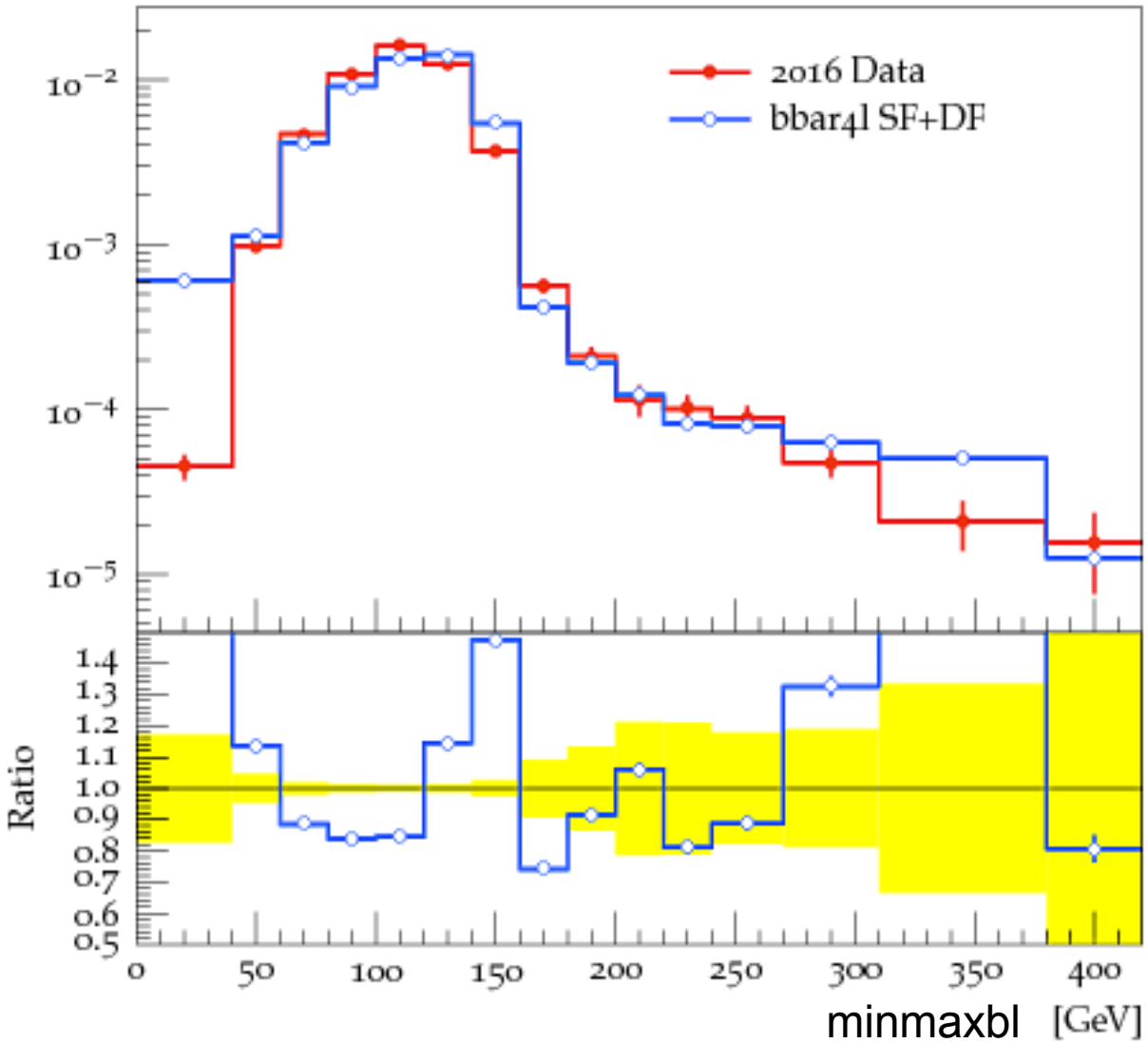
- First look at Simulation vs Data
- **Preliminary plots**, just taken from the
- Please take with a grain of salt

The selection

Particle level at **RECO** (data) and **GEN** (RIVET) level :

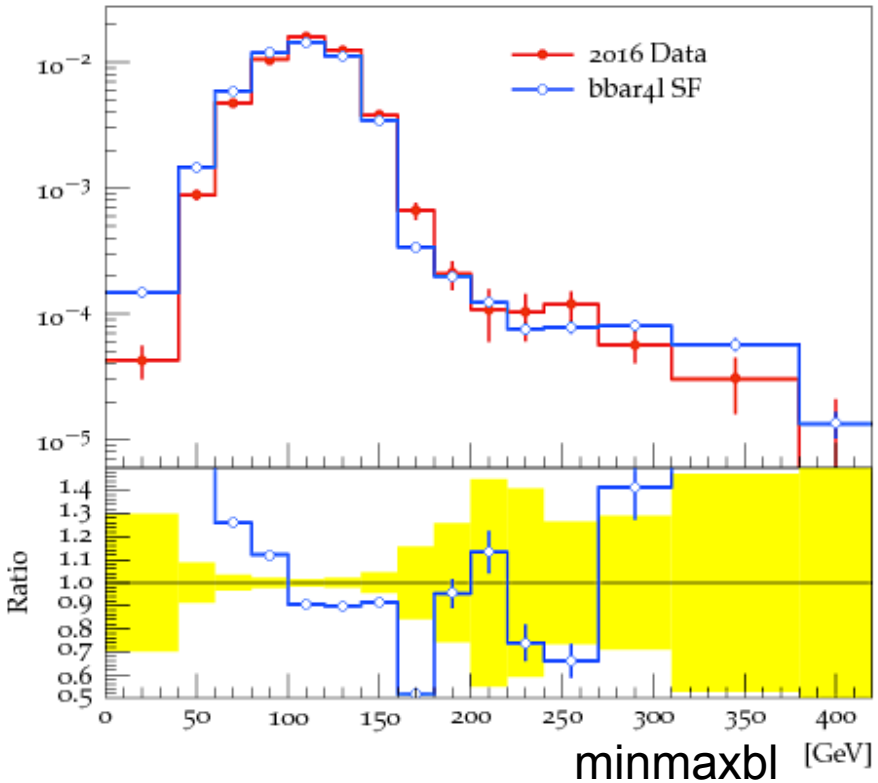
- m_{leplep} > 20 GeV and veto to Z peak (only SF) | m_Z - m_{leplep} |<15GeV
- **2 leptons (ee/μμ/eμ)**: p_T (any leptón/dressed lepton) > 20 GeV
  - p_T (leading lepton) > 25 GeV, |η|<2.4
  - Opposite charge
- **2 jets** p_T > 30 |η|<2.4
  - Tagged as b-jets (ghost tagging at GEN, Medium b-tag WP in data)
- Any jet is cleaned from leptons satisfying cuts above in ΔR<0.4 cone
- Veto event with any additional jet p_T > 20 GeV
- Signal **is extracted from Data (2016)** after substracting backgrounds: DY, $t\bar{t}$ Semilep, $t\bar{t}$+X, Dibosons, Fakes(W+jets)

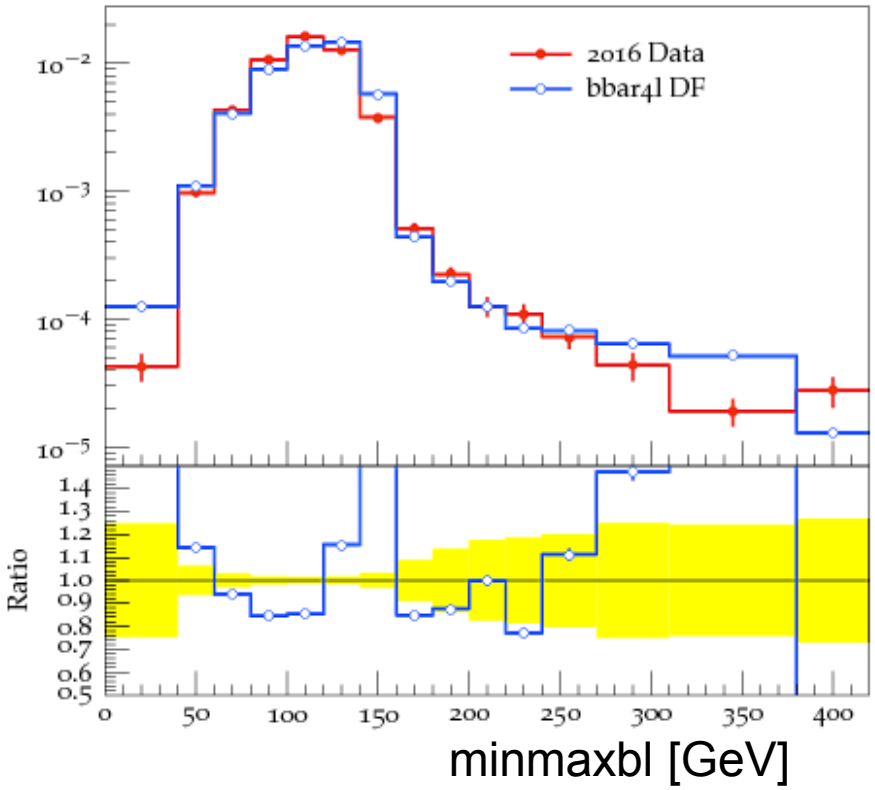
The plot



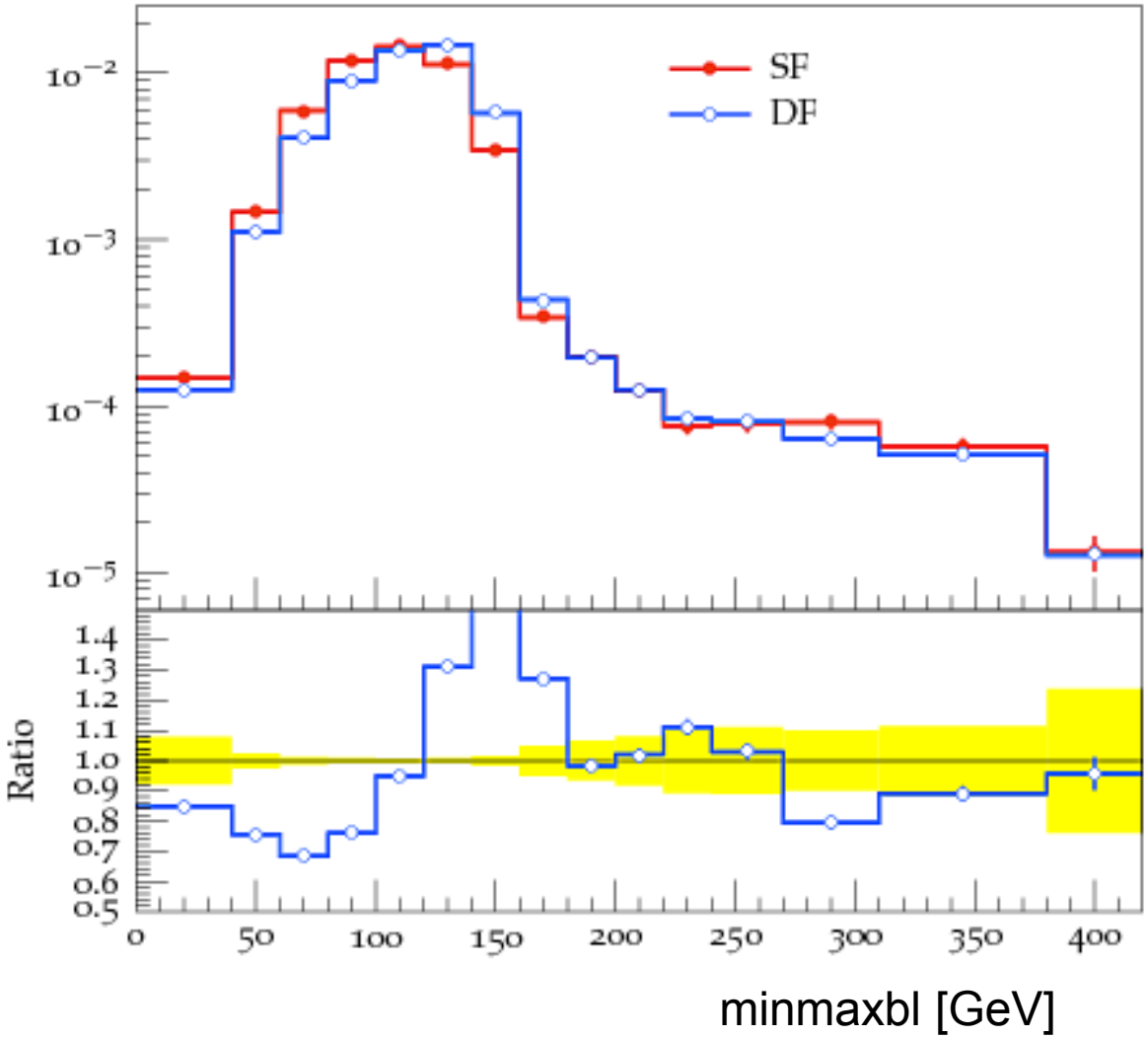
- Very preliminary plot
- Just plain Data and Simulation distributions normalized
- No unfolding yet, no scale factors, no anything

SF vs DF


2016 Data
bbar4l SF
Ratio
minmaxbl [GeV]


2016 Data
bbar4l DF
Ratio
minmaxbl [GeV]

The difference



DF distribution shifted 1 bin in MC:

- Possible bug in RIVET plugin

Conclusions(?)

- First full implementation of POWHEG **$b\bar{b}4l$** process in CMSSW including Pythia8 improved FSR Veto

- Preliminary sample to be submitted in Fall18 campaign 50M

- Next steps: carefully and improved tests, unfolding, full analysis…