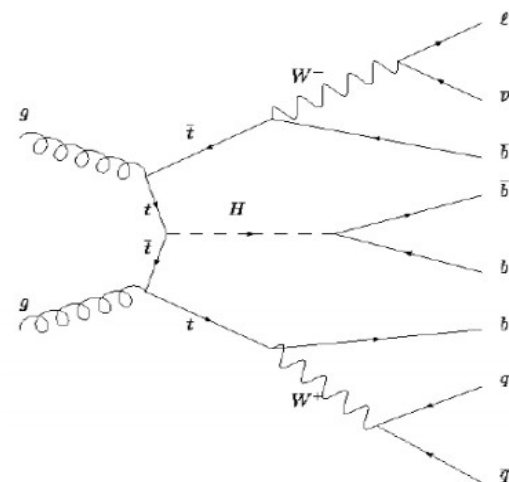


Report from ttH group

7th LHC Higgs Cross Section WG

CERN, Dec 5-6 2012



Th Conveners: L.Reina, M.Spira
Exp Conveners: C.Neu, C.Potter, A.Rizzi

Joined the group so far: P. Artoisenet, S. Bevilacqua, S. Dittmaier,
R. Fredrix, M. V. Garzelli, A. Juste, A. Kardos, S. Pozzorini, E. Shabalina,
Z. Trócsányi, D. Wackerroth, M. Worek, . . .

Outline

- Introduction
- Progress on experimental side
- Theory update
- YR3

Working group recent activities

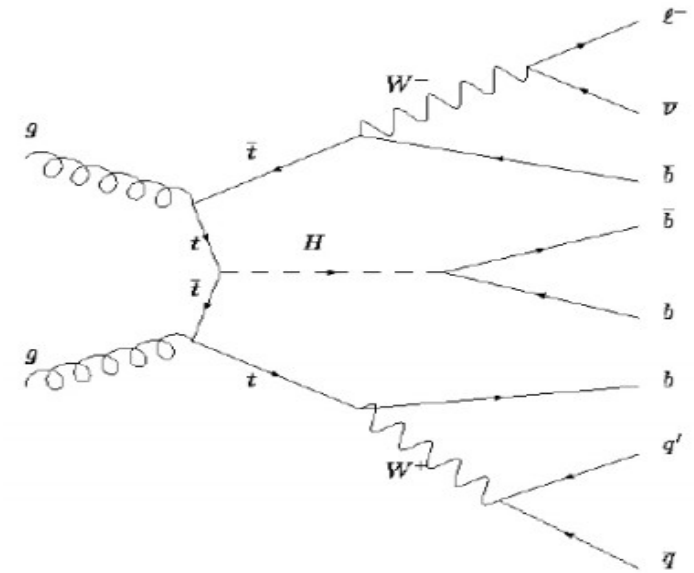
- Meeting on Sept. 28th
 - Main focus discussion on ttbb/ttjj
 - Experimentalist wishlist
- Meeting on Nov. 29th
 - Preparation for Dec WS
 - Update on ongoing activities

Experimental side

- Some relevant preliminary results since last workshop:
 - *CMS Higgs $t\bar{t}H$ search, CMS-PAS-HIG-12-025*
 - *CMS $t\bar{t}b\bar{b}/t\bar{t}j\bar{j}$ measurement, CMS-PAS-TOP-12-024*
 - *CMS $t\bar{t}$ jet multiplicity, CMS-PAS-TOP-12-18,23*
 - *Atlas Higgs $t\bar{t}H$ search, ATLAS-CONF-2012-135*
 - *Atlas $t\bar{t}$ jet multiplicity, ATLAS-CONF-2012-155*
- Searches are not yet reaching SM Higgs sensitivity
- Still useful to see how the analyses are designed and what can be measured already

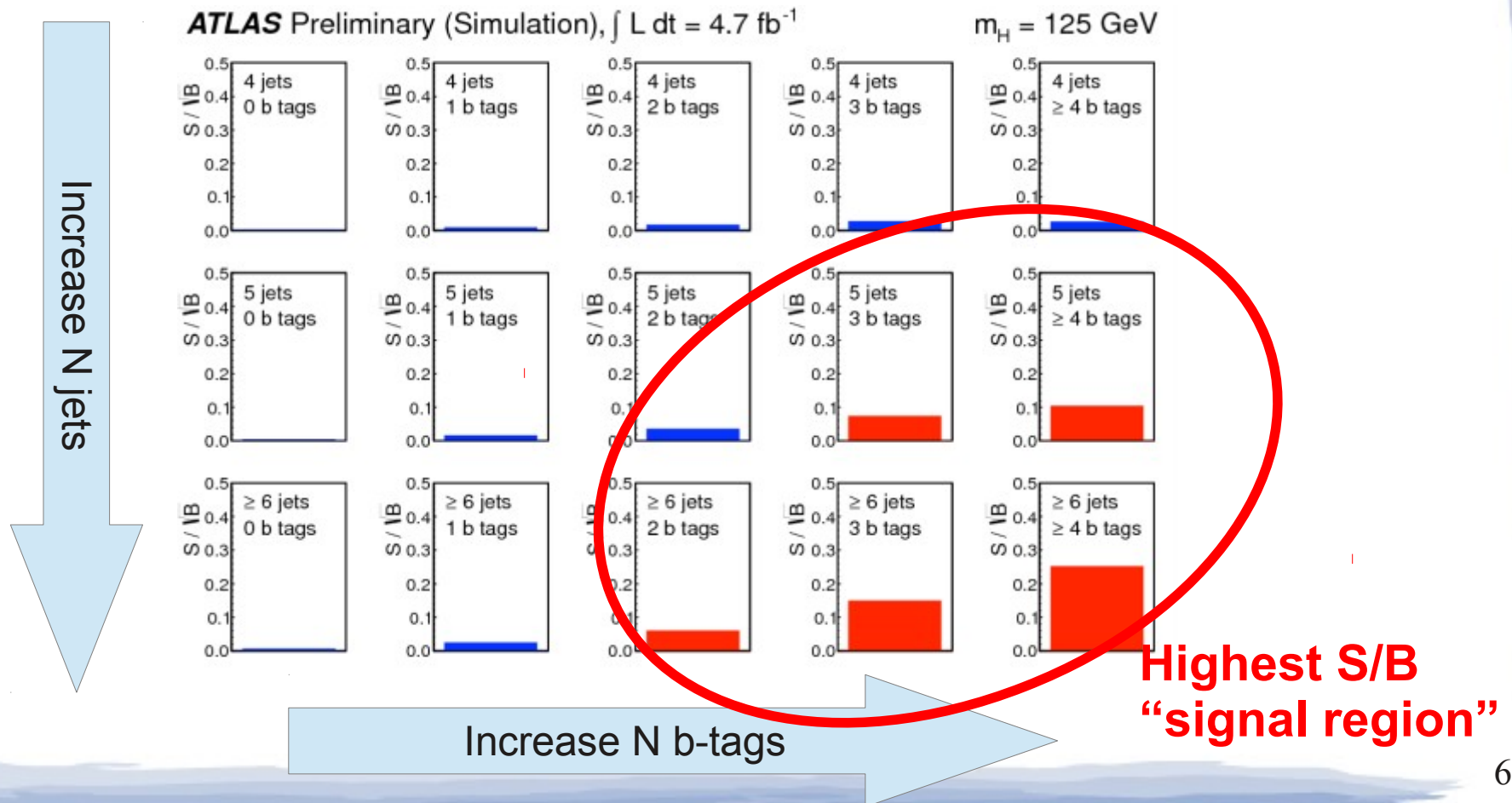
Event selection

- Basic selection (both for Atlas and CMS) requires:
 - 1 Mu or Ele (in CMS also di-lepton), $p_t > 20\text{-}25$ GeV
 - Missing $E_t > 20\text{-}30$ GeV
 - N-jets $> 4\text{-}6$
 - B-tagging applied to the jets
- Main backgrounds:
 - tt+jets
 - In particular: tt+bb, tt+cc
 - EWK background (W+jets, DY+jets, di-boson)



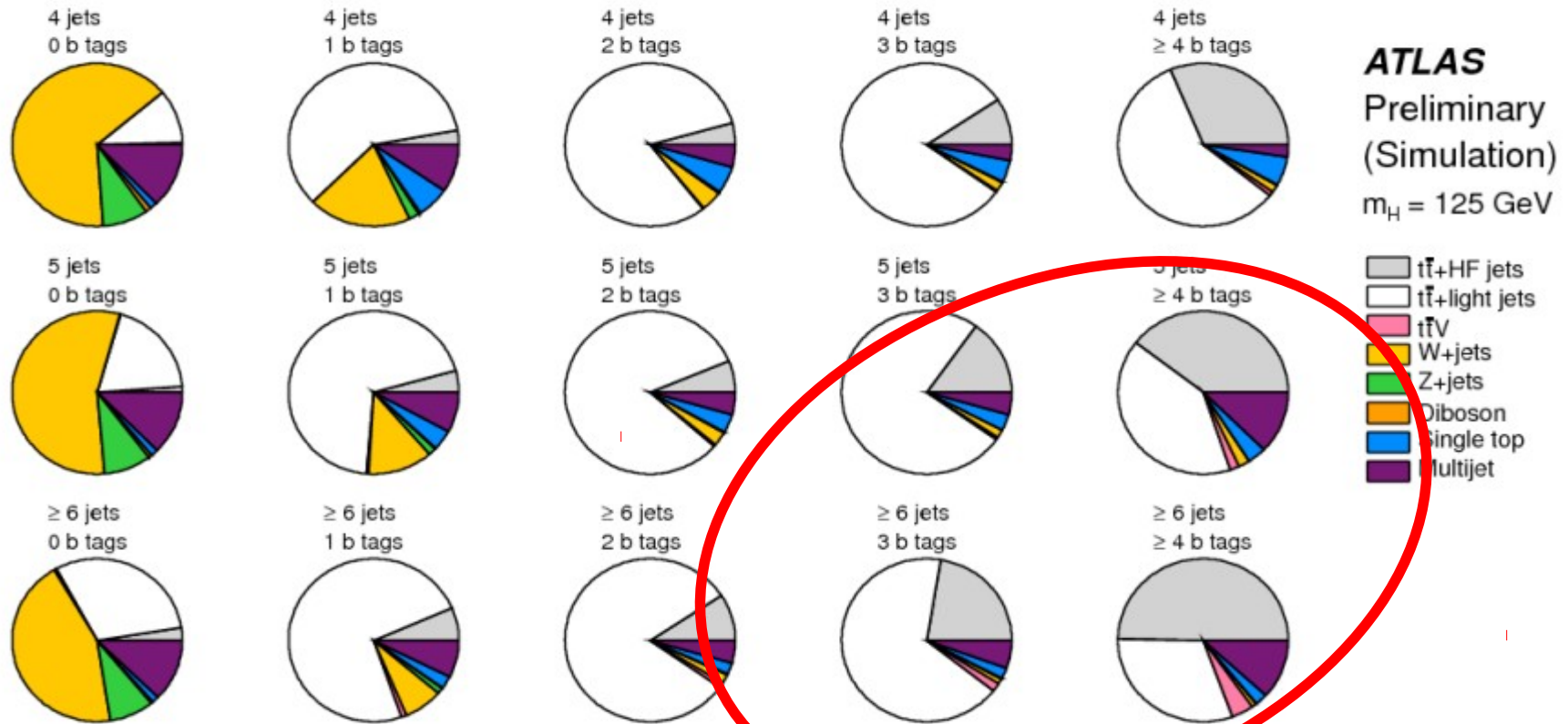
Analyses overview

- Both Atlas and CMS ttH analyses rely on categorization of the events in N-jets, N-btag-jets



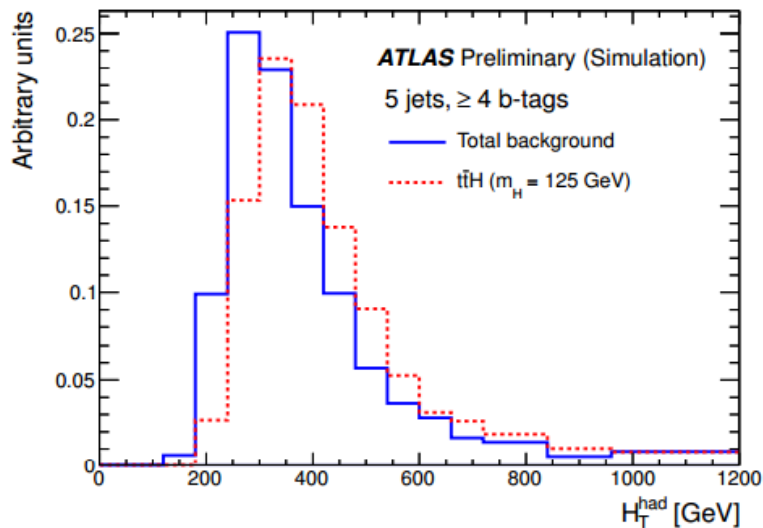
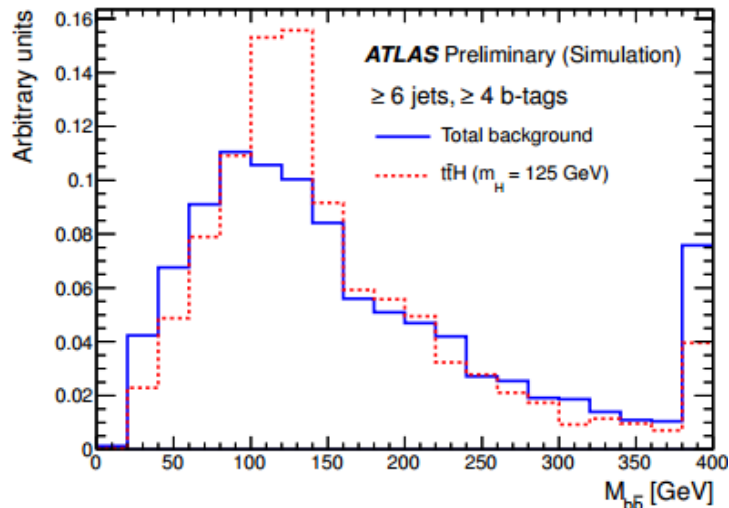
Backgrounds per category

- $t\bar{t}+b\bar{b}$ become the dominant background in highest S/B region

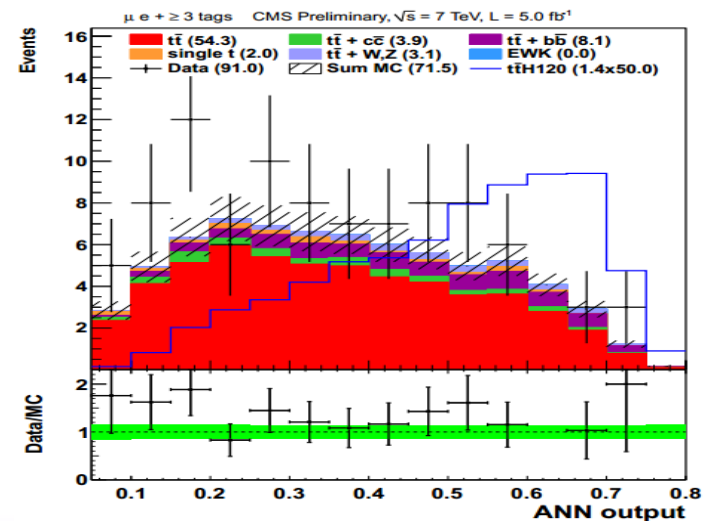
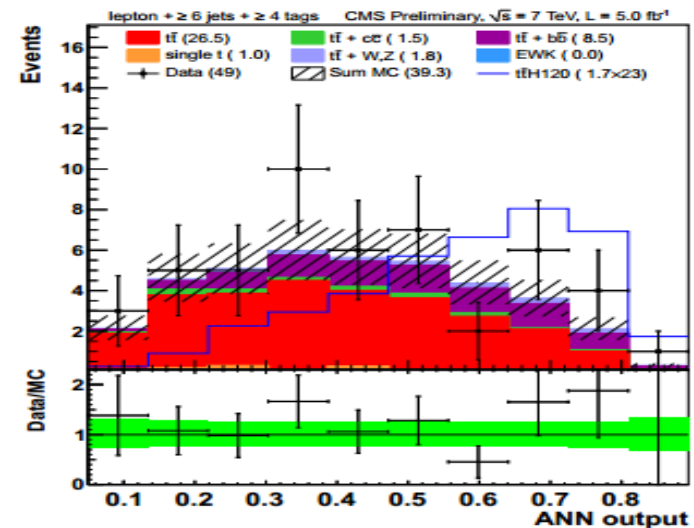


Final discriminating variables

- Atlas Mbb and HT

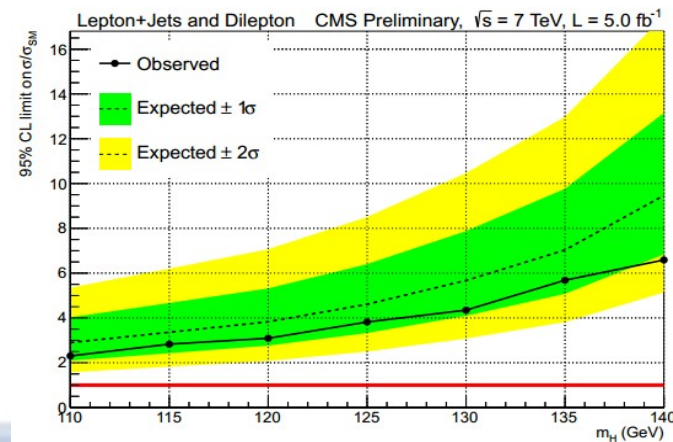
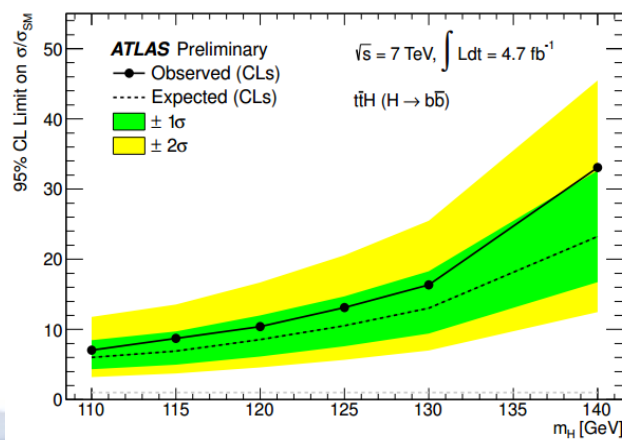


- CMS: Neural Net



Results

- Limits are extracted with a global fit where all uncertainties are treated as nuisance parameters
- Uncertainties (th. or exp.) can affect:
 - The relative yields of the various categories
 - The shapes of the final discriminating variables
- Atlas and CMS took quite different systematic uncertainties on $ttbb$ vs $ttjj$ (50% vs 20%)
- Other differences in fitted final variable, event selection, usage of dilepton channel



ttH NLO signal predictions

- Existing NLO prediction compared with MC (Pythia 6/8)
- Differences visible in some variables
- Gen-level reweighting on ttH and top pT successfully tested in Atlas

Theory:

Phys. Rev. Lett. 87 (2001) 201805

Nucl. Phys. B 653 (2003) 151203

Phys. Rev. D 67 (2003) 071503

Phys.Rev. D 68 (2003) 034022

Eur.Phys.Lett. 96:11001,2011

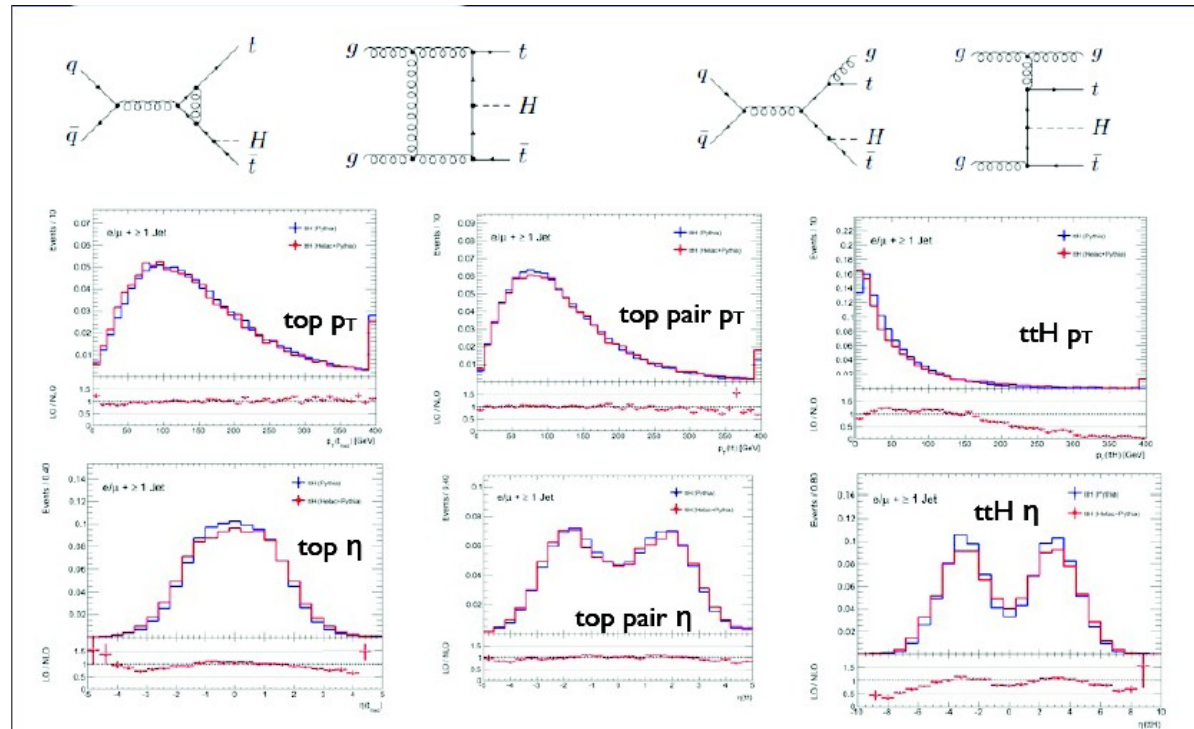
arXiv:1110.1499

Experiment:

E.Shabalina et al. (Atlas)

Exp. study made possible thanks to samples from

<http://grid.kfki.hu/twiki/bin/view/DbTheory/TthProd>



The big issue

- Current results on 5/fb (we have $> 25/\text{fb}$ by now) \Rightarrow stat uncertainty is decreasing
- The splitting in categories and the “shape analysis” can effectively constrain the background yields in the signal region

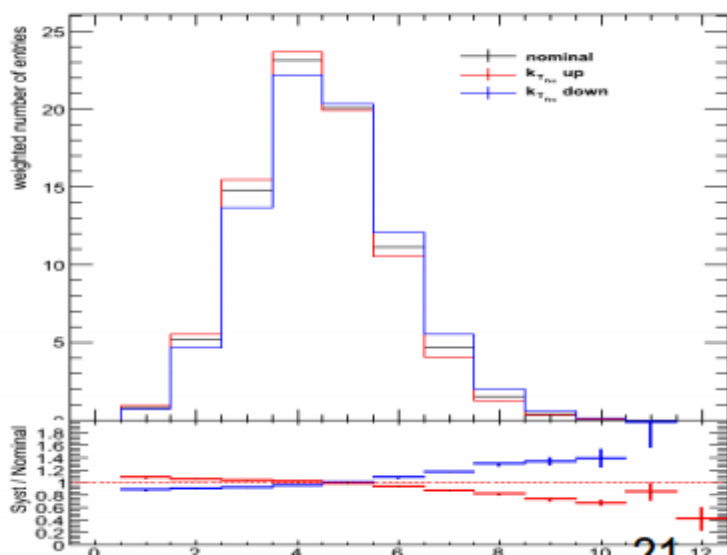
...but...

- We need reliable background shape (e.g. jet multiplicity) predictions (especially for $t\bar{t}+j\bar{j}$ and $t\bar{t}+b\bar{b}$)
- We need uncertainties on those predictions

The two main topics

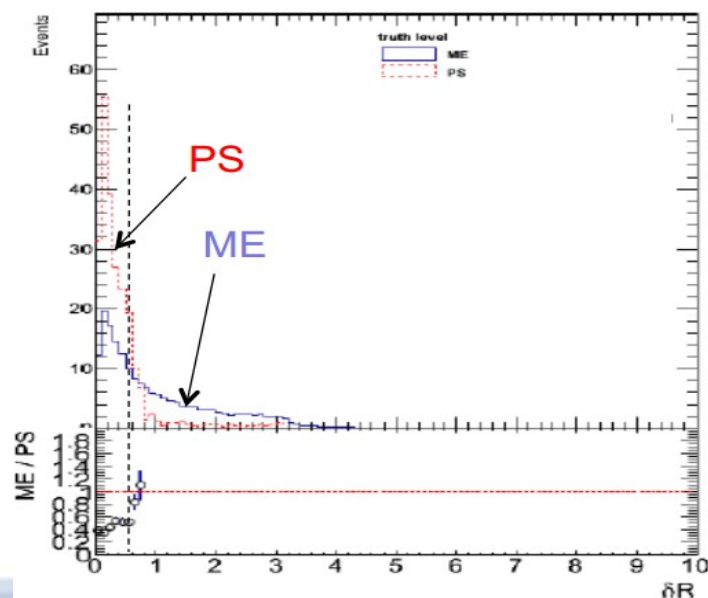
Jet multiplicity

- NLO ttj & ttbb predictions?
- Tuning of ME+PS ?
- NLO MC ?
- How to set an uncertainty?



B-jets

- Gluon splitting
- Arbitrary choice in PS vs ME regime separation (e.g. deltaR cut ~ 0.4)
- How to set an uncertainty?



Available tools for bkgnd prediction

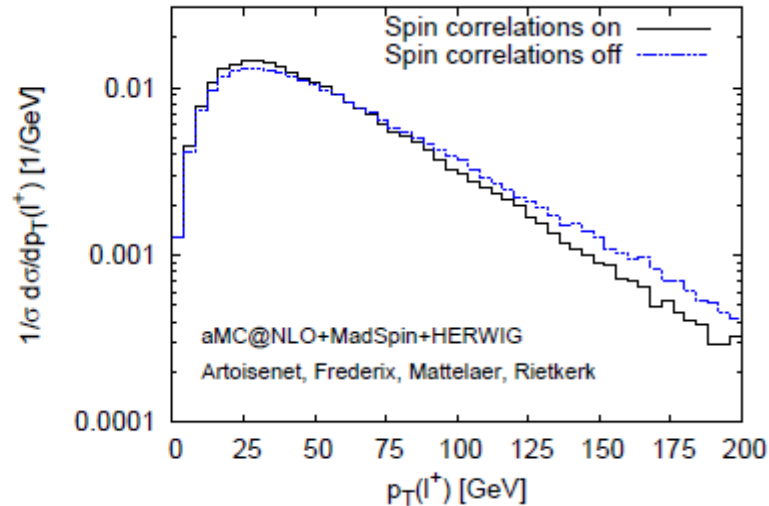
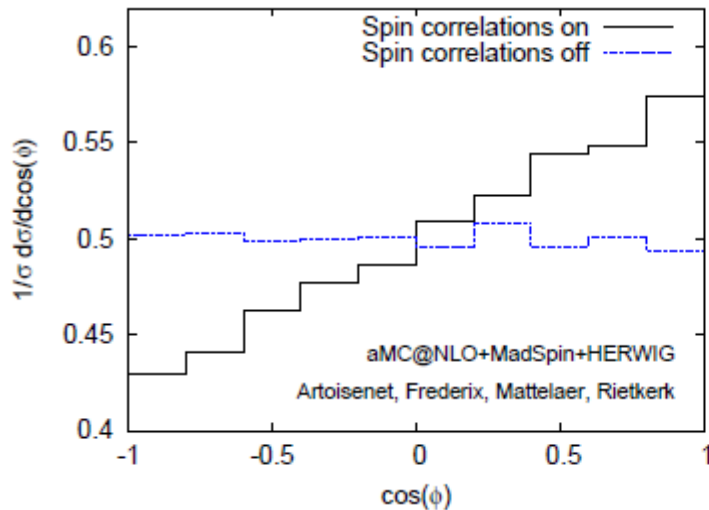
- $tt + bb$
 - fixed order NLO calculation (Bredenstein, Denner, Dittmaier, Pozzorini, Bevilacqua, Czakon, Papadopoulos, Pittau, Worek)
 - AcerMC: LO, QCD+EW contributions
 - ALPGEN/Madgraph: LO, QCD ME+PS (PYTHIA or HERWIG)
 - SHERPA: LO, QCD ME+PS
- $tt + jj$
 - fixed order NLO calculation (Bevilacqua, Czakon, Papadopoulos, Worek)
 - ALPGEN/Magraph: LO, QCD ME+PS
 - SHERPA: LO, QCD ME+PS
 - MC@NLO: tt , more jets by PS (HERWIG)
 - POWHEG: $tt + j$, more jets by PS (PYTHIA or HERWIG)

Rephrasing the questions..

- Questions on $tt + bb$ and $tt + 2j$ modeling
- Q1: How to assess the systematic error when using tools such as ALPGEN to model the background?
- Q2: How do we assess systematic uncertainties on the relative fraction of $tt(QQ)$ and $ttQQ$ events?
- Q3: How can we use existing NLO calculations to normalize ALPGEN at particular jet multiplicity bins? What are the related uncertainties?
- We need:
 - consistent NLO results for 7 and 8 TeV;
 - NLO predictions consistent with experimental choices;
 - NLO fixed order results interfaced with PS Monte Carlo.
- Progress is being made (M. Worek et al.) → Results expected for YR3.

Other progress (signal production): top decay

From aMC@NLO+MADSPIN:



(Artoisenet, Frederix, Mattelaer, Rietkerk, preliminary)

- spin correlations and off-shell effects retained to very good accuracy
- (following method proposed by Frixione, Laenen, Motylinski, Webber);
 - use only tree level matrix elements: efficient generation of events;
 - validated using NLO $pp \rightarrow tt$ and single top (MCFM);
 - implemented into Madgraph 5 (module MADSPIN).

Summary and plans for YR3

- Updated experimental studies integrating new calculations in the analysis
- Comparison between tree level Monte Carlos and NLO calculation for signal events.
- From ttbb and tt + 2j NLO calculations:
 - parton level results at @7 and @8 TeV, for normalization purposes;
 - assessment of systematic uncertainty on ttbb/ttjj ratio;
 - NLO background events to compare with tree level Monte Carlos.
- Developments in MC generators that can affect tth studies (e.g.: better modelling of top-decays at NLO).