

Search for Neutral MSSM Higgs Bosons with ATLAS: Theoretical Uncertainties

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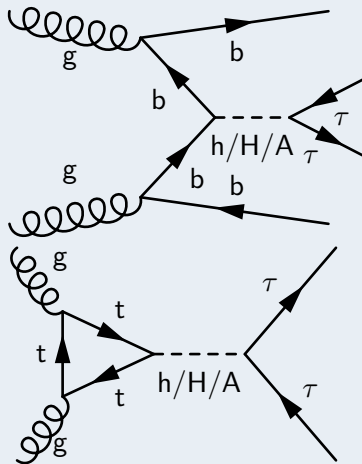
IKTP, TU Dresden

March 4, 2013



Introduction

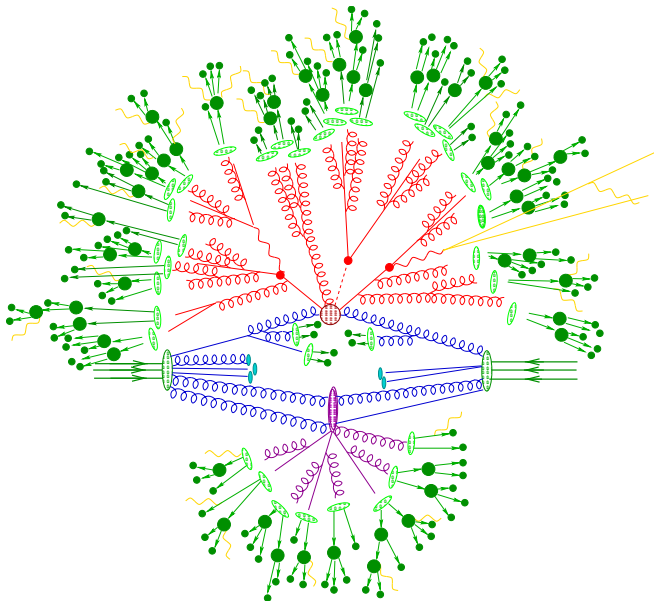
- search for MSSM Higgs bosons in $\tau\tau$ final state
- one source of systematic uncertainty:
dependence of simulated events on generator parameters, mainly on the modeling of the QCD part



Method

- generate MC samples with different variations of generator parameters
- implementation of selection in truth-level study using Rivet^[1]
- acceptance A
uncertainty $a_i = \frac{A(\text{parameter variation } i)}{A(\text{default})}$

[1] A. Buckley et al., Rivet user manual, arXiv:1003.0694 [hep-ph]



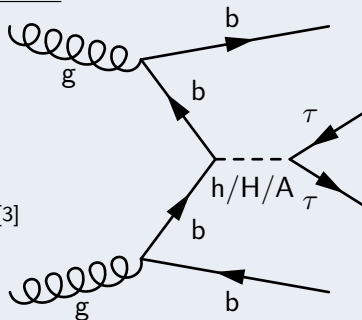
T. Gleisberg et al., Event generation with SHERPA 1.1, arXiv:0811.4622 [hep-ph]

Process: b associated production

Sherpa 1.4.1 - (N)LO MC generator ^[1]

Variation of:

- CKKW matching scale ^[2]
 - factorization scale
 - renormalization scale
 - parton density function: CT10 ^[3]
- usage of 52 error sets
RMS of acceptances used as uncertainty



[1] T. Gleisberg et al., Event generation with SHERPA 1.1, JHEP 02 (2009) 007.

[2] S. Catani, F. Krauss, R. Kuhn and B. R. Webber, QCD matrix elements + parton showers, JHEP 111 (2001), 063, [hep-ph/0109231].

[3] H. -L. Lai et. al., New parton distributions for collider physics, Phys. Rev. D82, 074024 (2010), [arXiv:1007.2241 [hep-ph]]

Process: gluon fusion production

POWHEG BOX 1.0^[1]

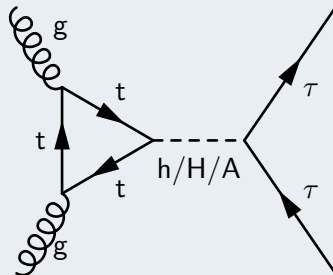
Variation of:

- factorization and renormalization scale: varied simultaneously
- parton density function: 52 error sets of CT10

Pythia 8^[2]

Variation of:

- final state radiation (FSR)
- initial state radiation (ISR)



[1] A. S. et al., Higgs boson production in gluon fusion, JHEP 02 (2009) 029.

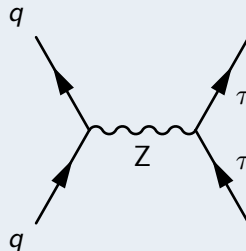
[2] T. Sjostrand, S. Mrenna and P. Skands, PYTHIA 6.4 physics and manual, JHEP 05 (2006) 026.

Process: Z background

ALPGEN 2.14^[1]

Variation of:

- functional form of scale definition
- Q^2 scale factor
- kt factor
- MLM matching^[2] conditions
- matrix element partons $\Delta R, p_{T\min}$
- parton density function



Herwig 6.520^[3]

- parton showering, hadronization, decay

[1] M. L. Mangano et al., ALPGEN, a generator for hard multiparton processes in hadronic collisions, JHEP 07 (2003) 001.

[2] M. L. Mangano et al., Matching matrix elements and shower evolution for top-quark production in hadronic collisions, JHEP 01 (2007) 013.

[3] G. Corcella et al., HERWIG 6: an event generator for hadron emission reactions with interfering gluons (including supersymmetric processes), JHEP 01 (2001) 010.

Rivet Event Selection for $h/H/A \rightarrow \tau_{\text{lep}}\tau_{\text{had}}$

Cuts

- require one had. tau and one lep. tau from the hard process
- Muon: $p_T > 17 \text{ GeV}, |\eta| < 2.5$
- Electron: $p_T > 20 \text{ GeV}, |\eta| < 1.37$ or $1.52 < |\eta| < 2.47$
- Tau: $p_T > 20 \text{ GeV}, |\eta| < 2.5$
- angular separation $\Delta R(\tau, \text{lepton}) > 0.2$
- $E_T^{\text{miss}} > 20 \text{ GeV}$ (optional)

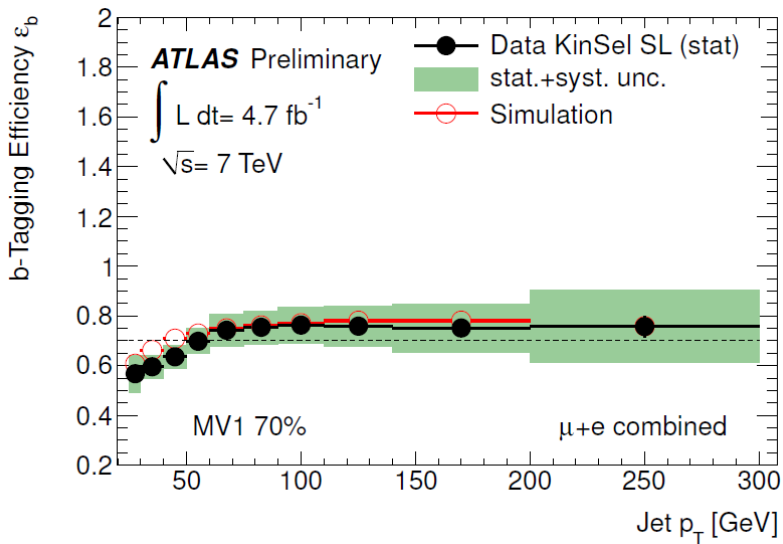
Rivet Event Selection for $h/H/A \rightarrow \tau_{\text{lep}}\tau_{\text{had}}$

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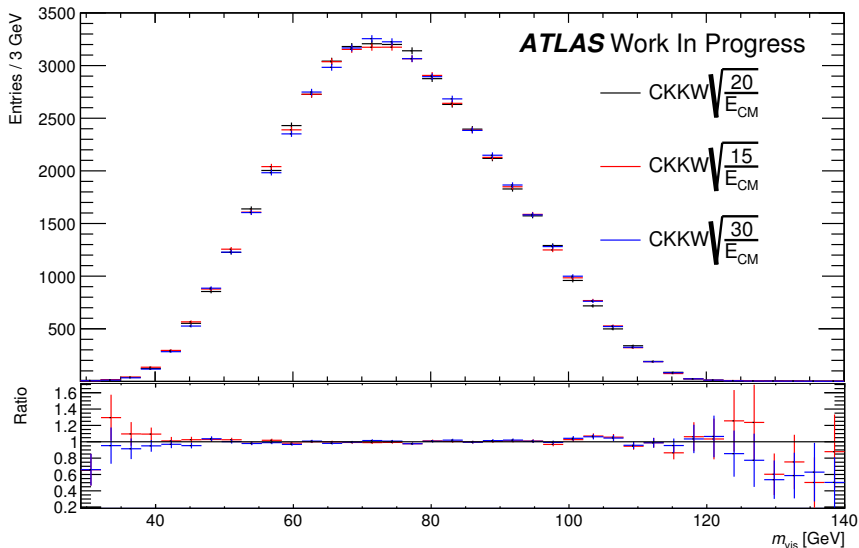
b-tagging

- Jets (Anti-kt 0.4): $p_T > 20 \text{ GeV}, p_T < 60 \text{ GeV}, |\eta| < 2.4$
- overlap removal
- b-tag / b-veto or leading b-tag/b-veto

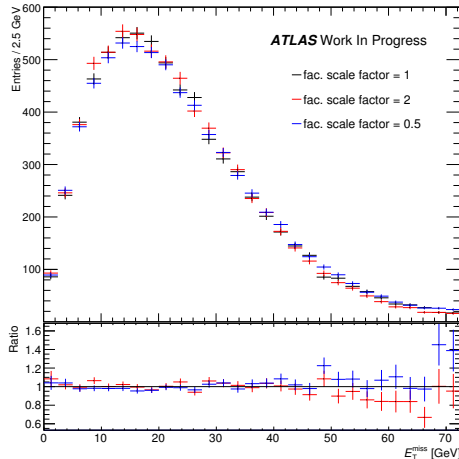
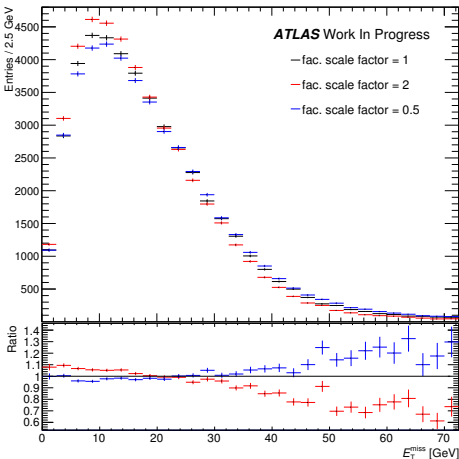


([ATLAS-CONF-2012-097](#), July 9 2012, page 26)

Shape Systematics: Visible Mass (inclusive)

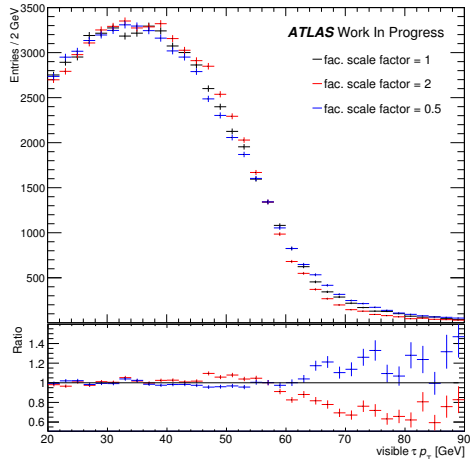
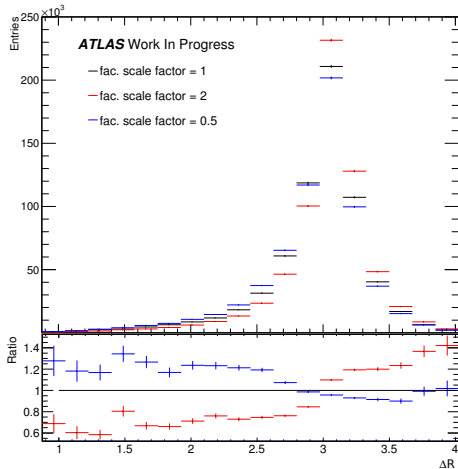


Shape Systematics: E_T^{miss} (bveto / btag)



A+bb production ($m_A = 120\text{GeV}$)

Shape Systematics: ΔR , $p_{T,\text{vis}}(\tau_{\text{had}})$ (bveto)



A+bb production ($m_A = 120\text{GeV}$)

Results

Relative systematic uncertainty on signal acceptance:

$m_{A,H} =$ 120 GeV	b-tag		b-veto		biggest effect
	up	down	up	down	
bb+A	14.0 %	-24.8 %	4.0 %	-3.7 %	fac. scale
gg→H	42.2 %	-17.8 %	0.4 %	-1.0 %	FSR / ISR

$Z \rightarrow \tau\tau$ acceptance variation: + 3.0 % and - 9.6 %

relative statistical uncertainty $\sim 10\%$

Computational Aspects

- large computational effort (some 50 CPU years, 5 TB)
- plans for future generator versions: systematic variation differences will be stored in weights vectors

Thank you for your attention.

BACKUP

Parameters - ALPGEN

- scale definition $Q^2 = m_W^2$ instead of $Q^2 = m_W^2 + p_{T,W}^2$
- Q^2 scale: double, half
- kt factor: double, half
- MLM matching condition $p_T > 15\text{GeV}$ instead of 20 GeV
- MLM matching condition $\Delta R > 0.4$ instead of 0.7
- matrix element partons $\Delta R > 0.4$ instead of 0.7
- matrix element parton $p_T > 12\text{GeV}$ instead of 15 GeV
- parton density function: CTEQ6L1, MRST2001J