

Theoretical uncertainty on Higgs production at ATLAS

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for the ATLAS collaboration

Introduction

Classify events in different categories:

- enhance sensitivity ($H \rightarrow \tau\tau$, $H \rightarrow bb$)
- separate different production mechanism ($H \rightarrow \gamma\gamma$, $H \rightarrow WW$, $H \rightarrow ZZ$)
- VBF selection and ggH contamination
- Boosted/VH Higgs selection

VBF Selection

VBF topology:

- High S/B ($\sim 1/10$)
- signal strength for VBF production

Tagging jets:

two leading anti-kt ($D=0.4$) jets

$Pt(\text{jet}) > 20/25$ $|\eta| < 4.5$

Further event selection driven by sensitivity optimization for individual channel.

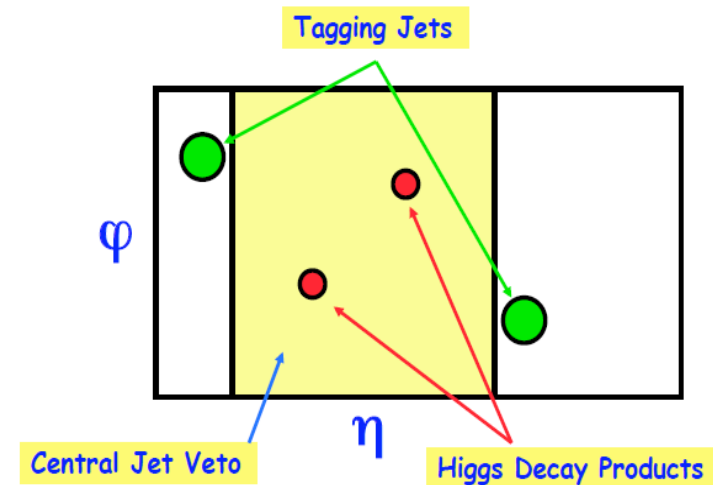
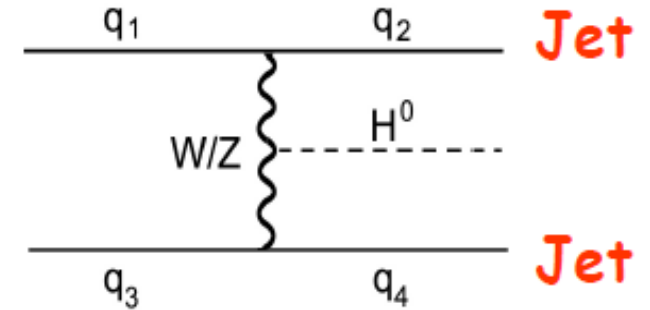
$$\min(|\eta_{j1}|, |\eta_{j2}|) < |\eta_{\gamma}|, |\eta_{\gamma}| < \max[|\eta_{j1}|, |\eta_{j2}|]$$

$$\eta_{j1} * \eta_{j2} < 0$$

$$\Delta\eta_{jj} > 3 - 4$$

$$M_{jj} > 300 - 500 \text{ GeV}$$

$$\text{CJV} / Pt(\text{TOT}) < 30$$



- $P_T(\text{TOT})$: more robust than CJV to Underlying events

$P_T(\text{TOT})$: transverse momentum of vector sum of tagging jets and Higgs decay products

ggH contamination in VBF sample

30% ggH contamination in VBF sample

Source	Error (%)
QCD scale uncertainty	25 (30 with c_{jv})
Underlying event	30
JES	19

Leading total systematic of ~45% on ggF+2j -> 13% on the extraction of VBF signal (leading systematic)

MVA analysis could reduce ggH contamination:

- make sure highest MVA score does not select region of phase-space where theory error difficult to assess

Scale Uncertainty

ggH:

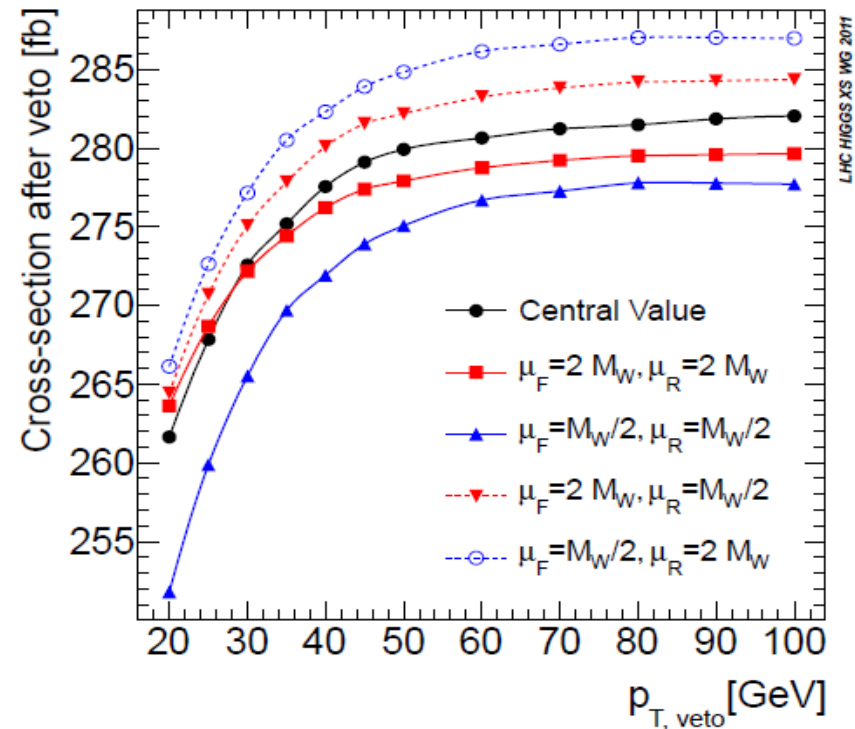
Use MCFM: 20%

Small fraction fails CJV/Pt(TOT) \rightarrow small effect on scale uncertainty

POWHEG+PYTHIA (+ HqT) - MCFM agree inside error band

VBF:

including CJV/pt(TOT) : $\sim 3-4\%$
(VBFNLO and YR11)



Underlying events

◆ Comparison of two pythia tunes: **AMBT2** and **Perugia2011**

◆ Number of expected events for 5 fb^{-1} :

E. Petit

	ggF			VBF		
	AMBT2	Perugia	rel. diff.	AMBT2	Perugia	rel. diff.
0-jet	63.34	64.42	2%	3.80	3.70	3%
2-jet	0.45	0.58	30%	1.53	1.63	6%

◆ Used for the moment:

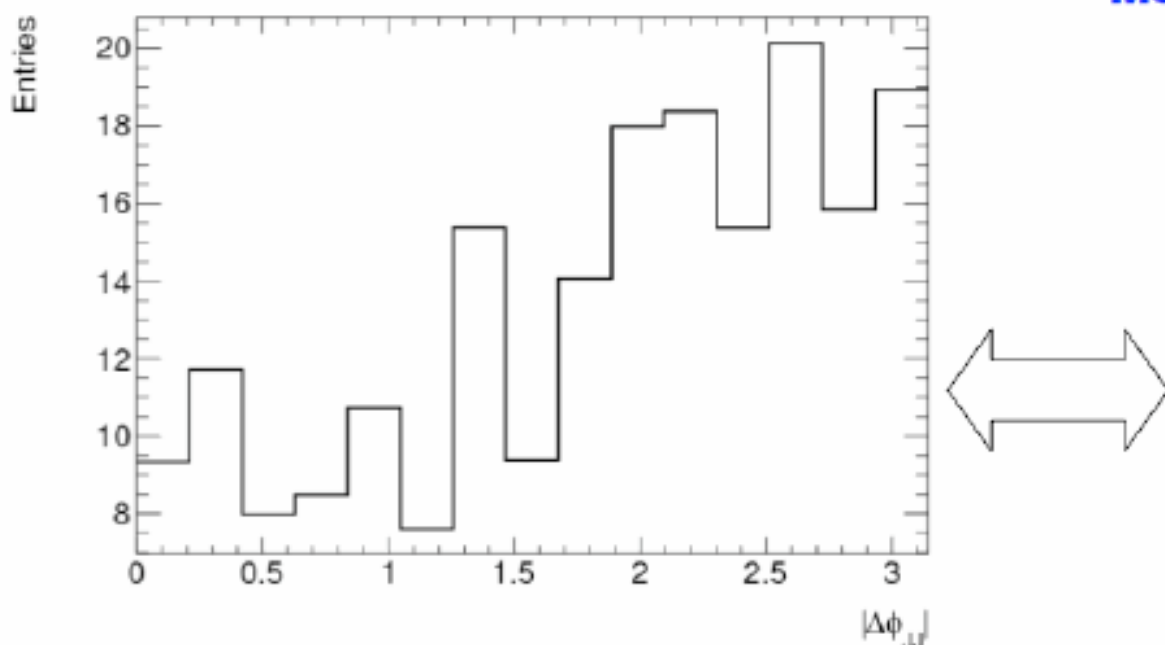
- 30% uncertainty for **ggF**
- 6% uncertainty for **VBF**

Need to be re-evaluated with next generation of MC: MINLO/aMC@NLO

Overall good agreement between MCFM and our baseline MC with regards to main topological variables. However, an important variable to disentangle ggF+2j and VBF

◆ $|\Delta\phi_{jj}|$ with Powheg+ pythia:

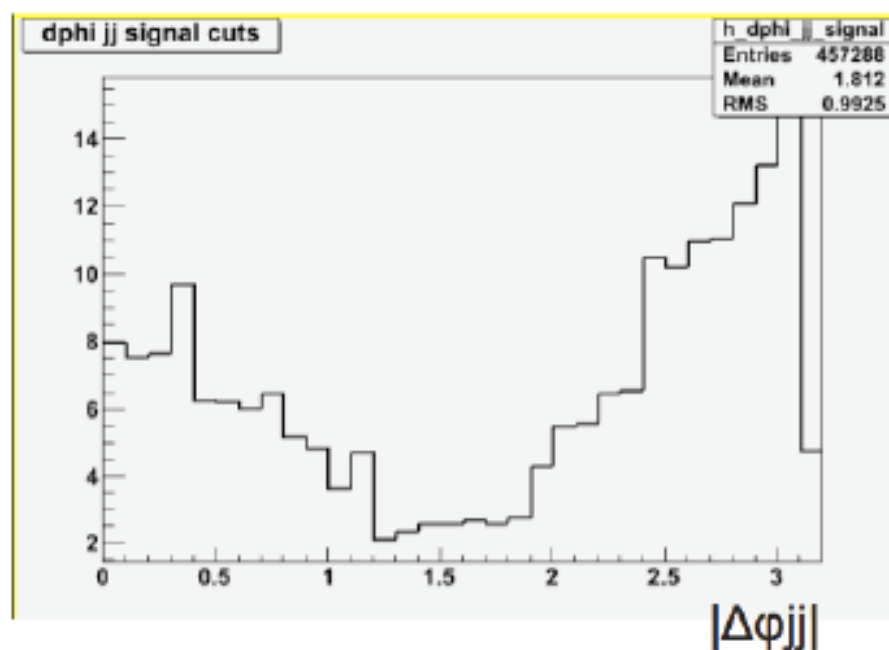
- 2 jets with $p_T^{\text{jet}} > 25$ GeV,
 $|\eta| < 4.5$, $|\Delta\eta_{jj}| > 2.8$,
 $m_{jj} > 400$ GeV, $|\Delta\phi(\gamma\gamma;jj)| > 2.6$



◆ $|\Delta\phi_{jj}|$ with MCFM:

- 2 jets with $p_T^{\text{jet}} > 25$ GeV, $|\eta| < 4.5$, $|\Delta\eta_{jj}| > 2.8$, $m_{jj} > 400$ GeV

Moving to MINLO directly



◆ Variable not described well by Powheg+pythia

- seems to be the same with Powheg+Herwig

A. Kruse, J.Huston et al.

$H \rightarrow \tau\tau$

- Re-design event categorization to enhance sensitivity

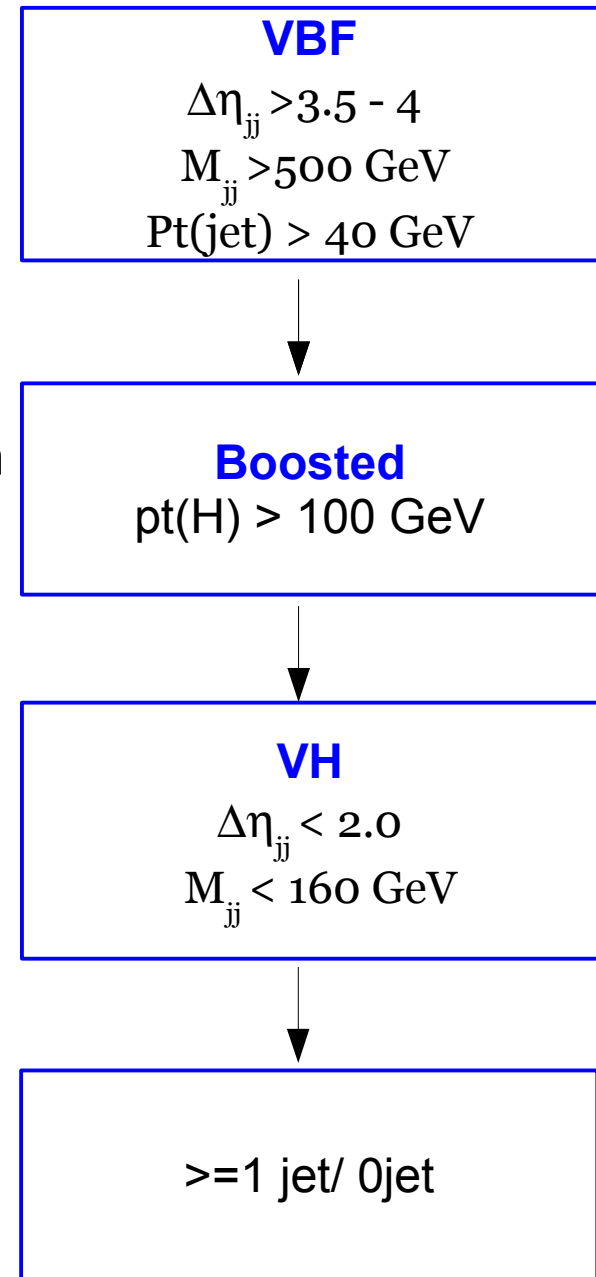
Boosted:

pt(Higgs) : Pt of the sum of Higgs decay products
Improved mass resolution \rightarrow better bkg to signal separation
No jet cut \rightarrow no JES systematic
 $\sim 70\%$ ggH / $\sim 20\%$ VBF / $\sim 10\%$ VH

VH:

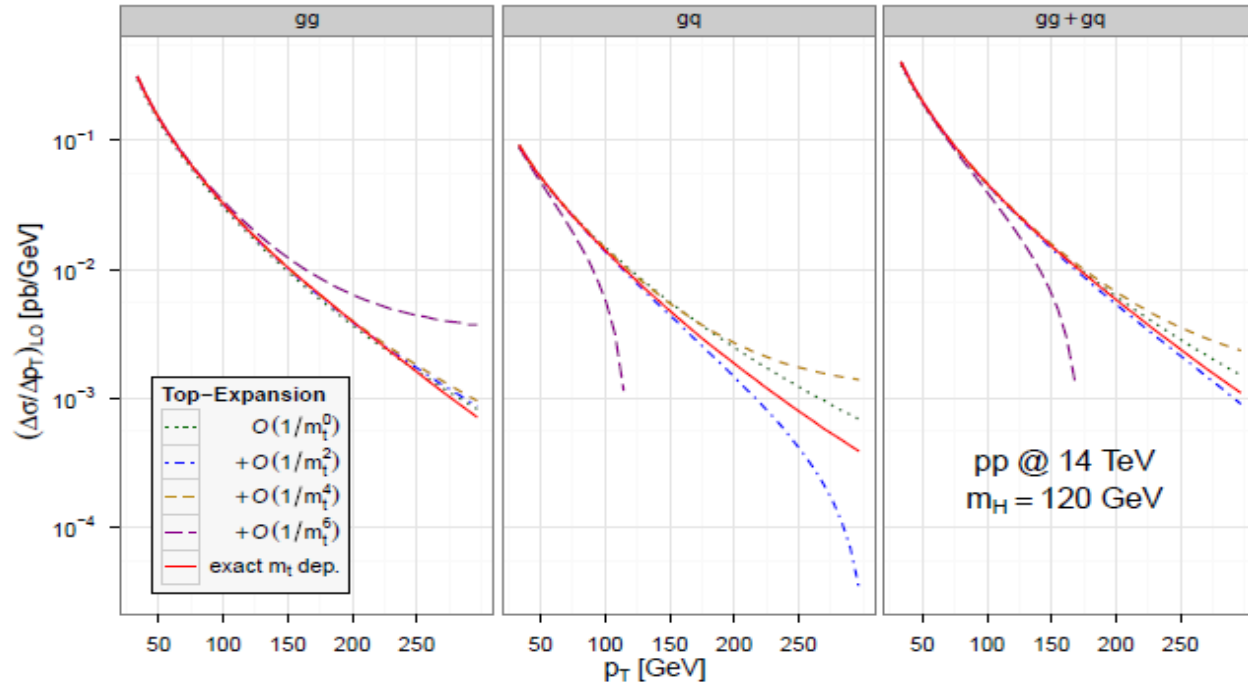
2 jets events
Revert $\Delta\eta_{jj}$ and M_{jj} used in VBF selection
 $\sim 60\%$ ggH / $\sim 10\%$ VBF / $\sim 30\%$ VH

VH also considered by other channels
 \rightarrow signal strength for VH



Approximate cuts

Finite Mass Effect in $d\sigma/dp_T$ (Higgs)



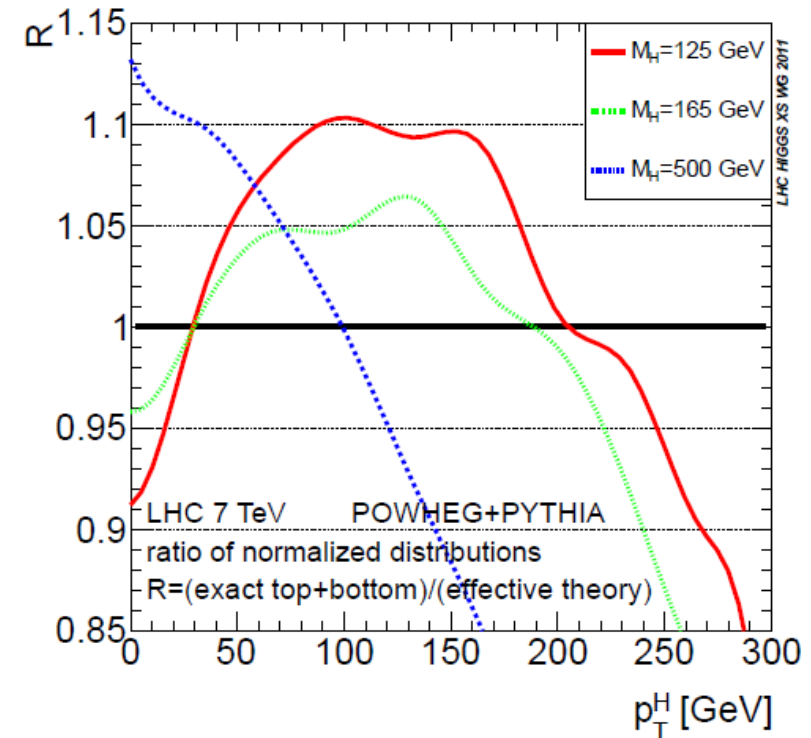
Harlander, Neumann et al.
<http://arxiv.org/pdf/1206.0157.pdf>

Yellow book report
<http://arxiv.org/abs/1201.3084>

At LO, $M_{TOP} \rightarrow \infty$ approximation seems to break down for $P_T(H) > 150$ GeV

Latest version of POWHEG includes finite quark mass effect for H+jets at LO

→ evaluate size of the effect for boosted selection
 IN PROGRESS



QCD scale and correlation among event category

Starting assumption of Tackman/Stewart:

$\sigma_{\geq N}$ and $\sigma_{\geq N+1}$ are independent, and $\Delta\sigma_{\geq N}$, $\Delta\sigma_{\geq N+1}$ are un-correlated

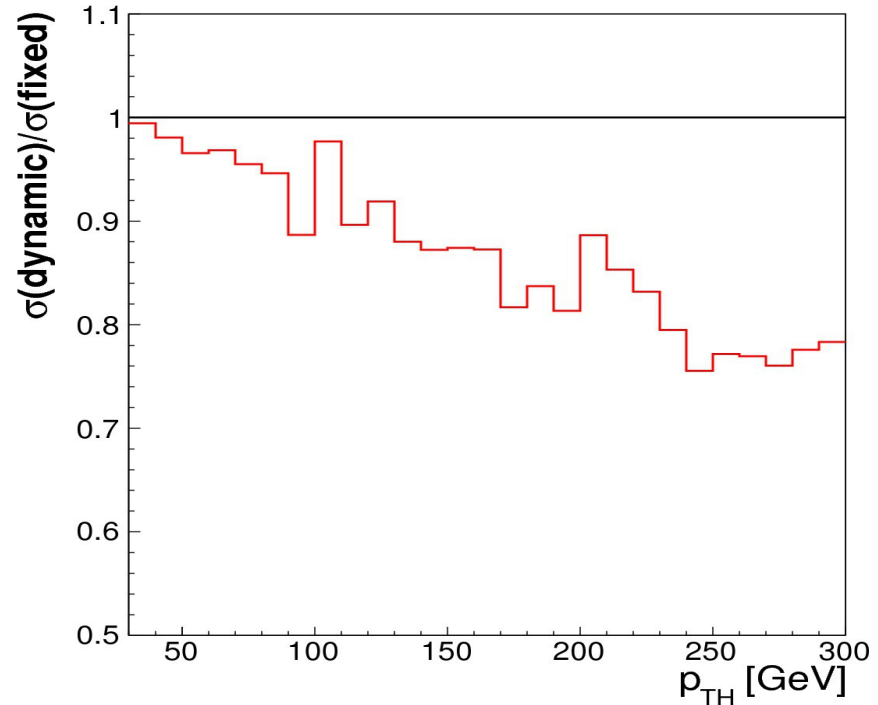
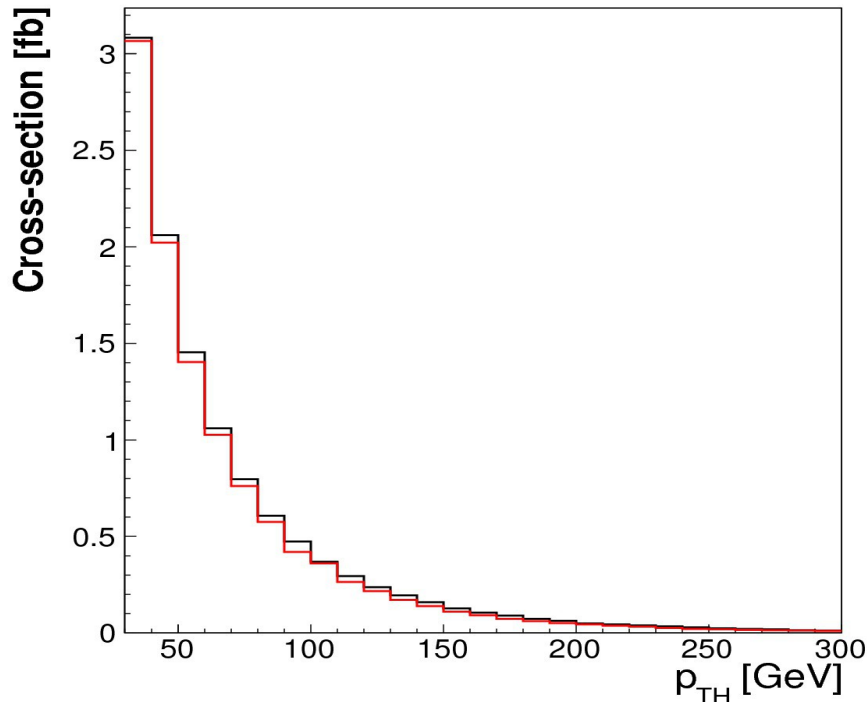
Is it true for $[\sigma_{\geq 1}, \sigma_{\text{BOOSTED}}]$ or $[\sigma_{\text{VH}}, \sigma_{\text{VBF}}]$?

$\Delta\sigma(\text{Boosted})$: 20% HNNLO / MCFM H+1jet NLO

$\Delta\sigma(\text{VH})$ = 23% MCFM H+2 jet NLO

Gavin suggestion: check what happens using fixed and dynamic scale ($\mu = \sqrt{m^2 + P_T^2}$)

- Fixed scale overestimate cross section. **What's used in HqT?**



Summary/Conclusion

- VBF channel crucial for:
 - VBF signal strength measurement
 - sensitivity to $H \rightarrow \tau\tau$
- ~30% ggH contamination is a major issue
 - large theoretical uncertainty
 - ggF + 2 jets needs to improve \rightarrow transition to use MINLO
- New Boosted/VH event categories
 - effect of finite quark mass
 - open question on correlation between inclusive cross sections
 - feedback from the community appreciated

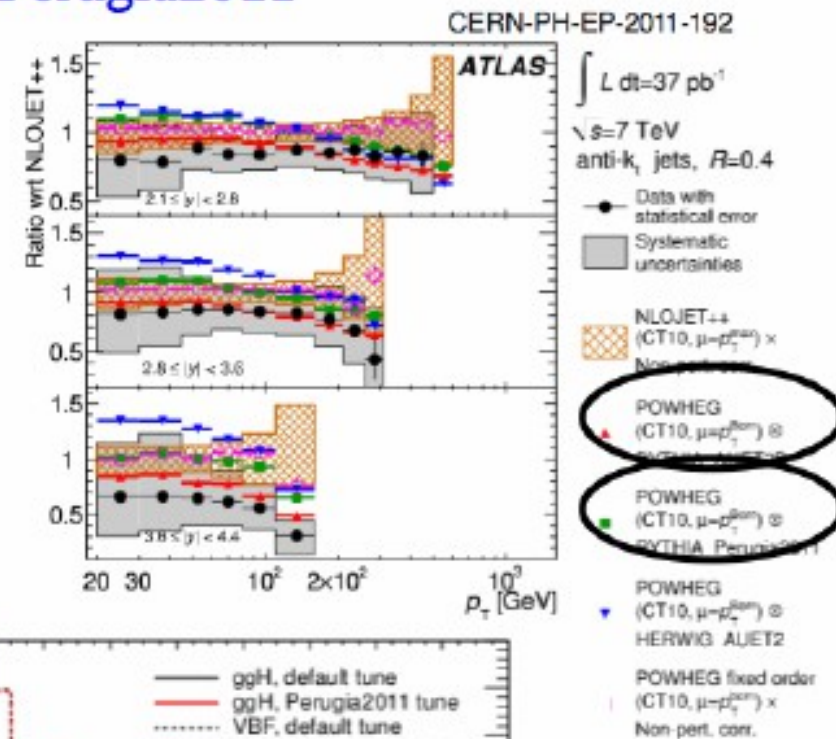
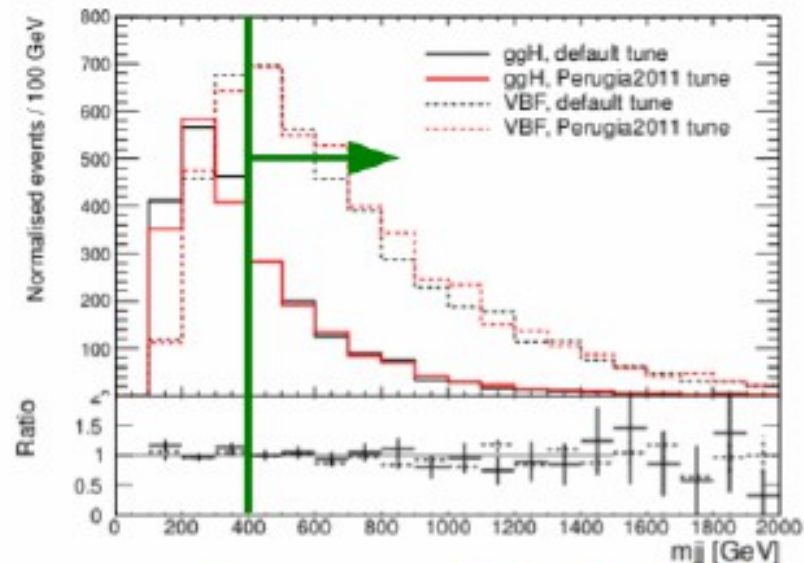
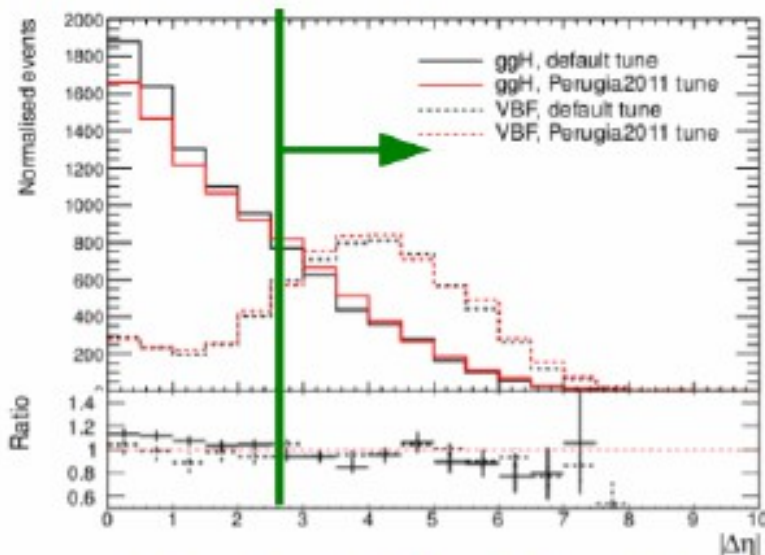
Back Up

◆ Comparison of two pythia tunes: **AMBT2** and **Perugia2011**

◆ Different description of forward jets

- example: Measurement of inclusive jet and dijet production in pp collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector

◆ $|\Delta\eta|$ and m_{jj} before cut:



Concerned raised that the tunings may tamper with the PS. This could lead to overestimate of systematics