ETH Institute for Particle Physics

gg→H for different MC's:

uncertainties due to jet veto

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Outline

Uncertainty of jet veto efficiency: PYTHIA,HERWIG, MCatNLO

- **Without underlying events**
- **With underlying events (ATLAS, CDF tunings)**
- **Including HO QCD corrections with effective K-factors**
- **CASCADE**

Motivation

$gg \rightarrow H \rightarrow WW \rightarrow l\nu l\nu$:

- **Higgs discovery channel between $2M_W$ and $2M_Z$**
- **Dominant background: nonresonant WW, ttbar and Wtb**

jet veto crucial to reduce top-background

→ get uncertainty of jet veto for different Monte Carlos

Comparison between

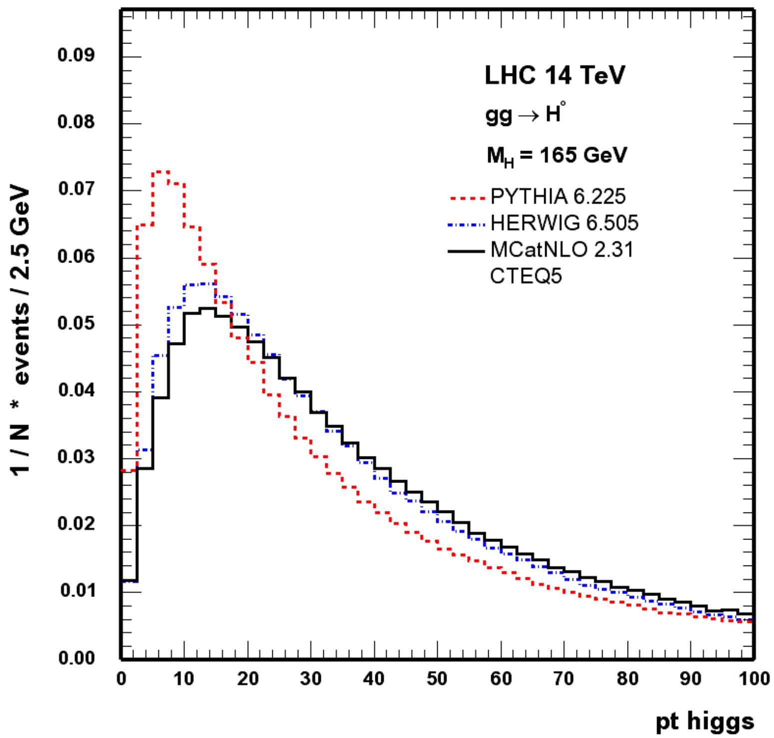
PYTHIA 6.225, HERWIG 6.505 and MCatNLO 2.31

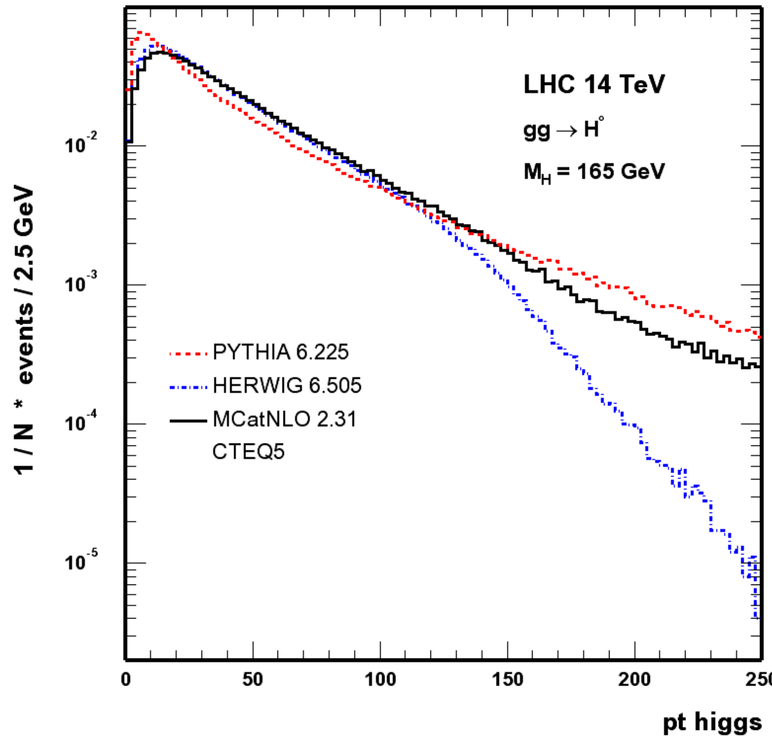
- **NO underlying events**
- **M(Higgs) = 165 GeV, M(top) =175 GeV**
- **HERWIG:** gg→ H : no hard ME Corrections

  PYTHIA, MCatNLO : with ME Corrections (PYTHIA: m(top)→∞, MCatNLO exact)

pdf	**MCatNLO:** **PYTHIA, HERWIG :**		**CTEQ 5M1** **CTEQ 5L**
CTEQ5M1 (NLO) **CTEQ5L (LO)**	α_s(Mz)=0.118 α_s(Mz)=0.127	Λ_{QCD}^4 = 0.326 Λ_{QCD}^4 = 0.192	Λ_{QCD}^5 = 0.226 Λ_{QCD}^5 = 0.146
Λ_{QCD}	**PYTHIA:** **HERWIG:** **MCatNLO:**		MRST(3)=**2** (Λ_{QCD} = Λ_{QCD} of pdf) QCDLAM=**0.18** LAMDAFIVE=**0.226**

pt Higgs varies for different MC's





pt Higgs versus jet pt

for this study:

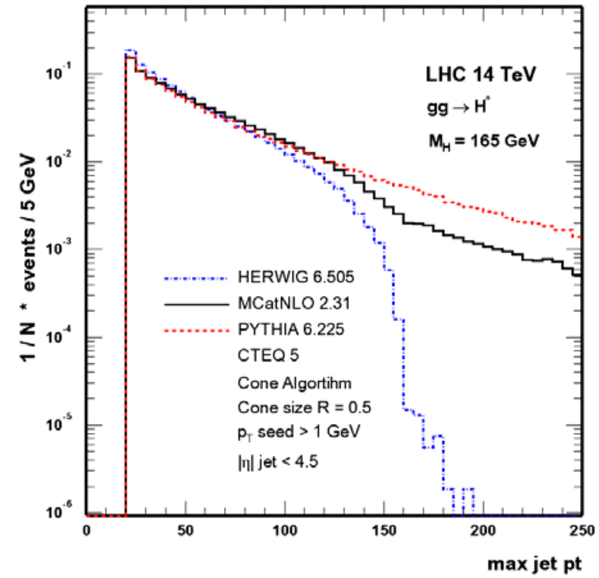
Cone algorithm

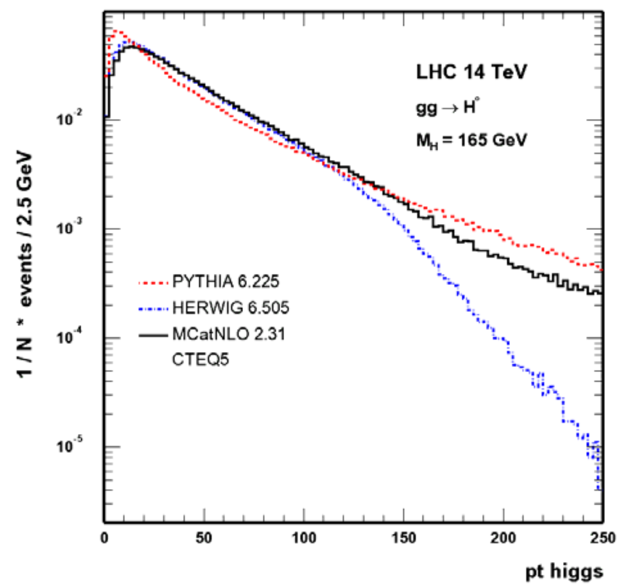
pt jet>20 GeV, |η| jet<4,5, R=0.5,

pt seed>1 GeV

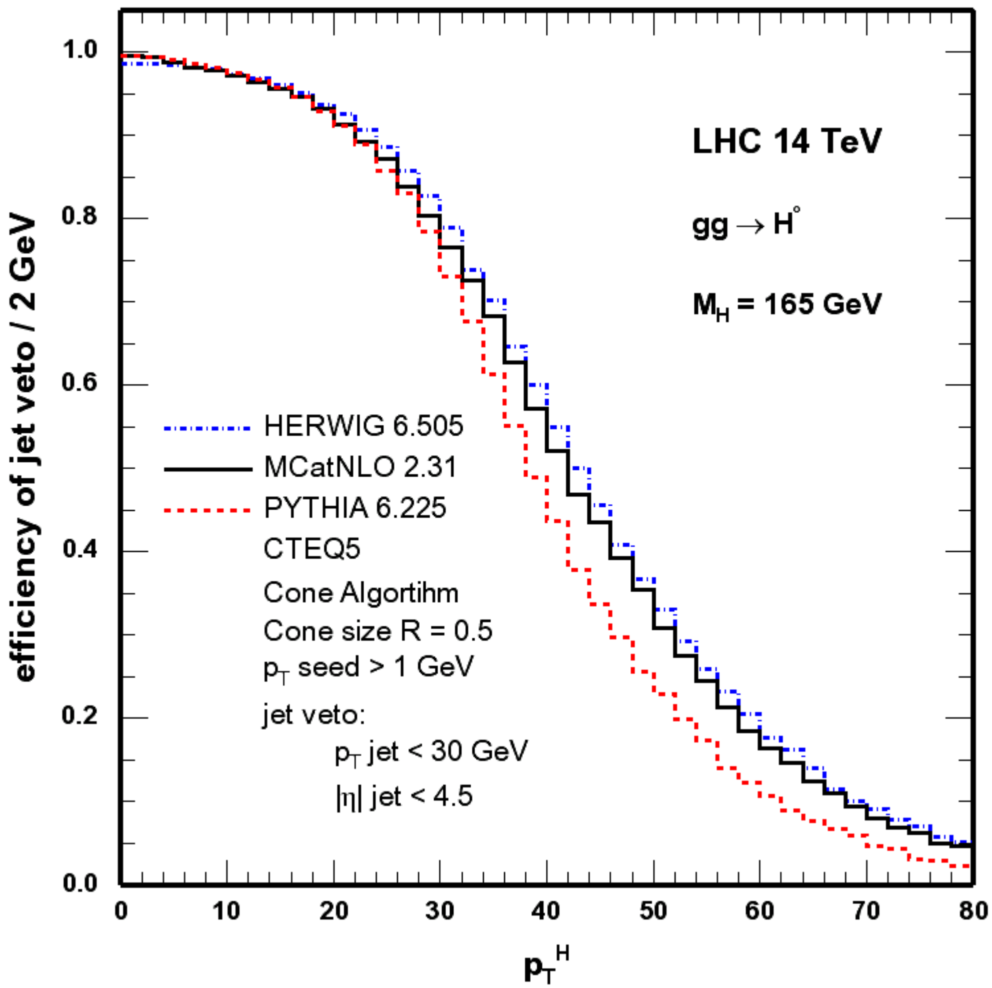
pt Higgs balanced by one or more jets
→ similar but not identical pt spectrum

Apply jet veto of 30 GeV
→ get the efficiency





Efficiency for the jet veto



Differences vary over the pt spectrum:

eg :

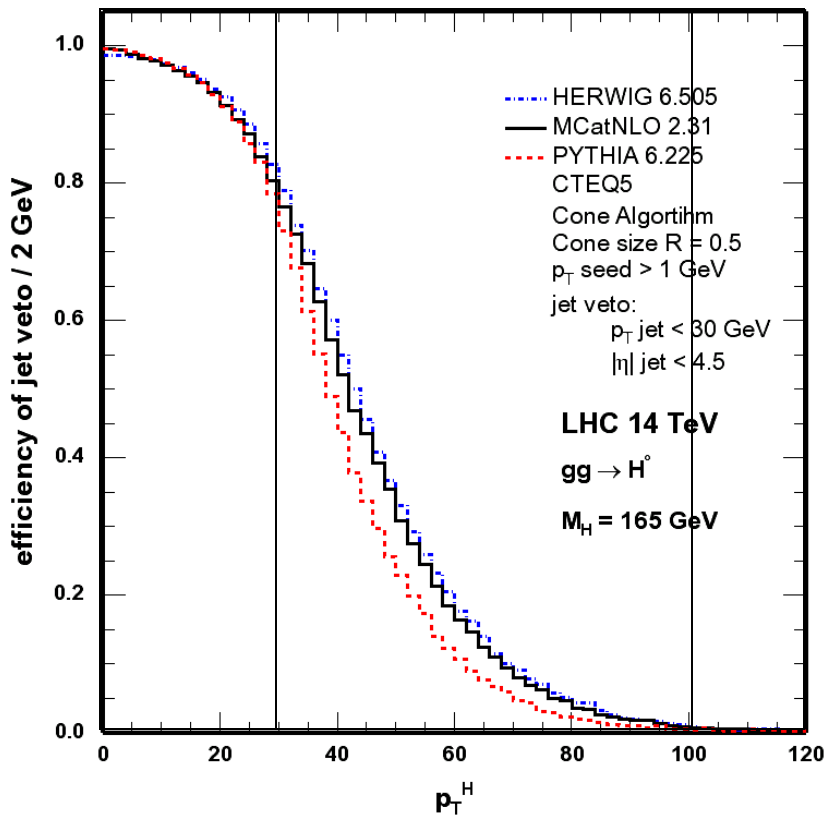
- **pt H < 20 GeV: differences very small**
- **pt H ≈ 50 GeV : difference around 30%**

Integrated efficiency over whole pt spectrum:

	ε
PYTHIA	0.62
HERWIG	0.63
MCatNLO	0.59

→ efficiency spread < 5%

To understand differences between the MC's: look at particular pt Higgs regions



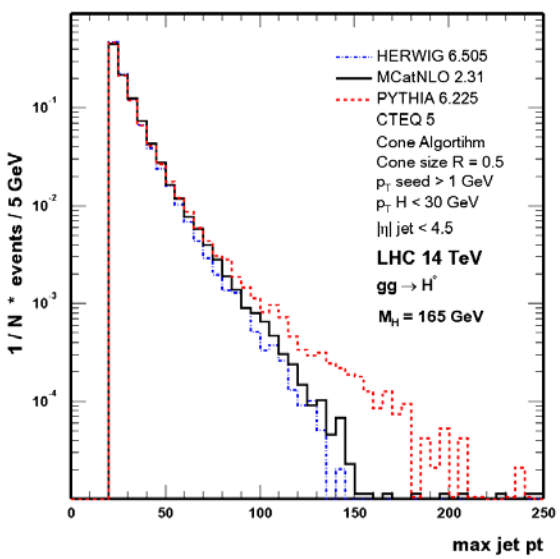
A) pt Higgs < 30 GeV

B) 30 GeV ≤ pt Higgs <100 GeV

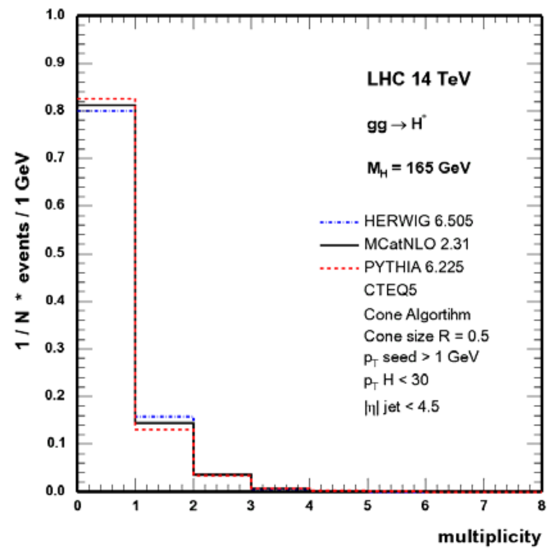
C) pt Higgs ≥100 GeV

A) pt Higgs < 30 GeV

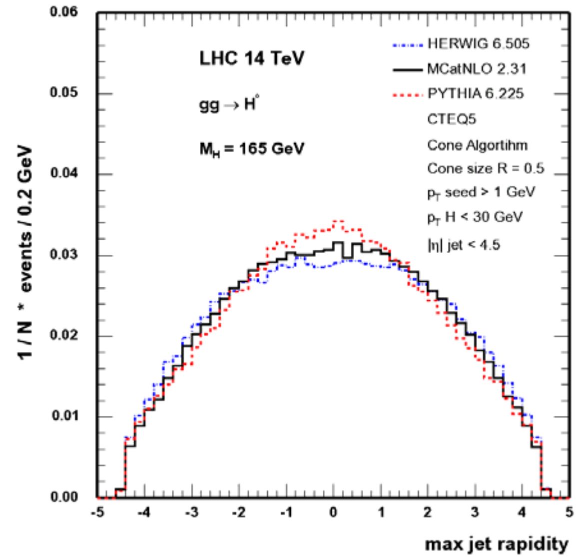
max jet pt



multiplicity



max jet rapidity

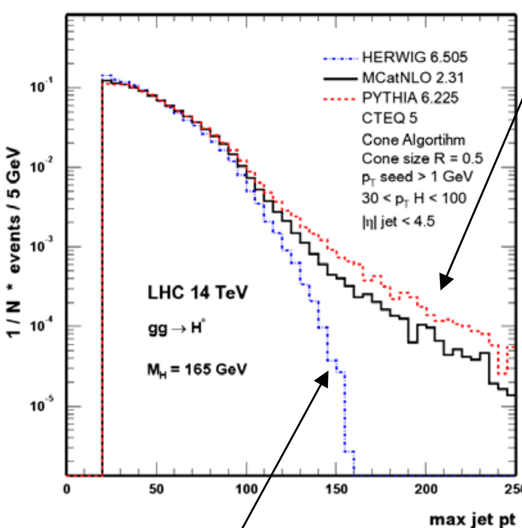


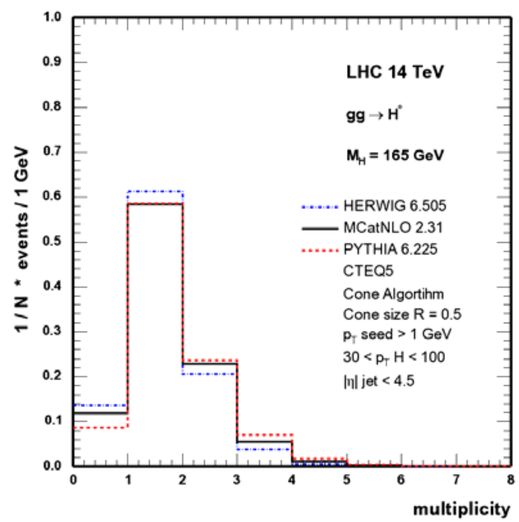
essentially identical distributions,
minor effects for very high pt

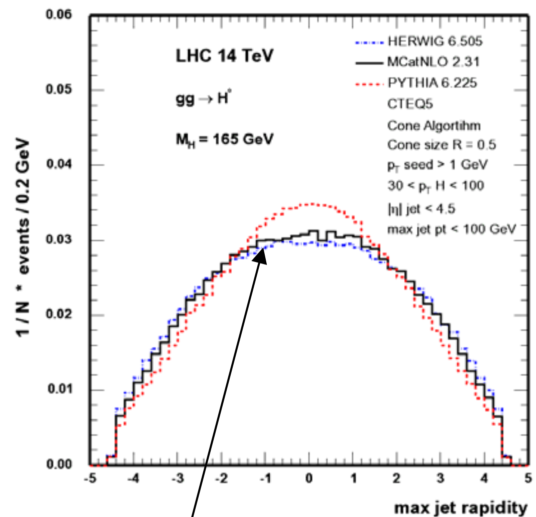
B) 30 GeV ≤ pt Higgs < 100 GeV

max jet pt **multiplicity** **max jet rapidity**

Pythia/MCatNLO: m(top)→ ∞ / m(top) exact , Λ_{QCD} , pdf





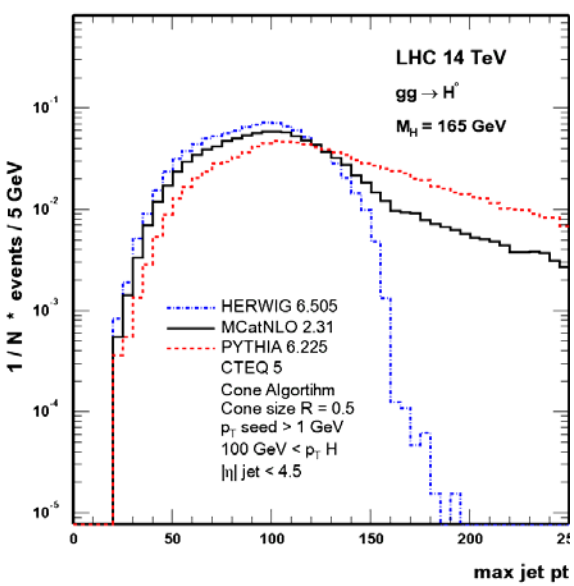


Herwig has no hard ME corrections

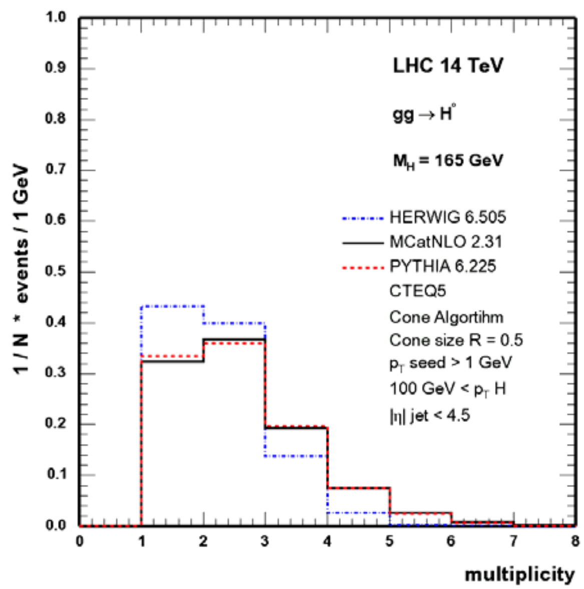
Pythia has more central jets

C) 100 GeV ≤ pt Higgs

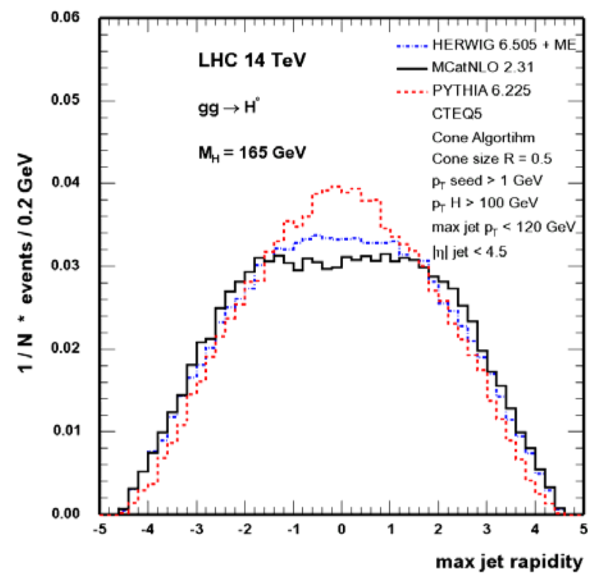
max jet pt



multiplicity



max jet rapidity

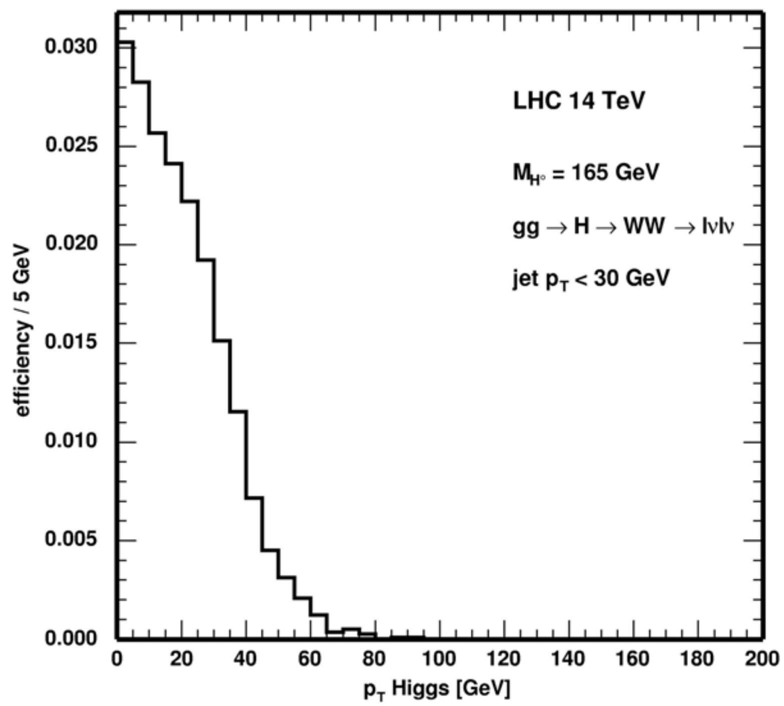


gg→H→WW→lνlν selection with all cuts

gg→H→WW→lνlν selection
(GD et al jhep05(2004)009)
shows:

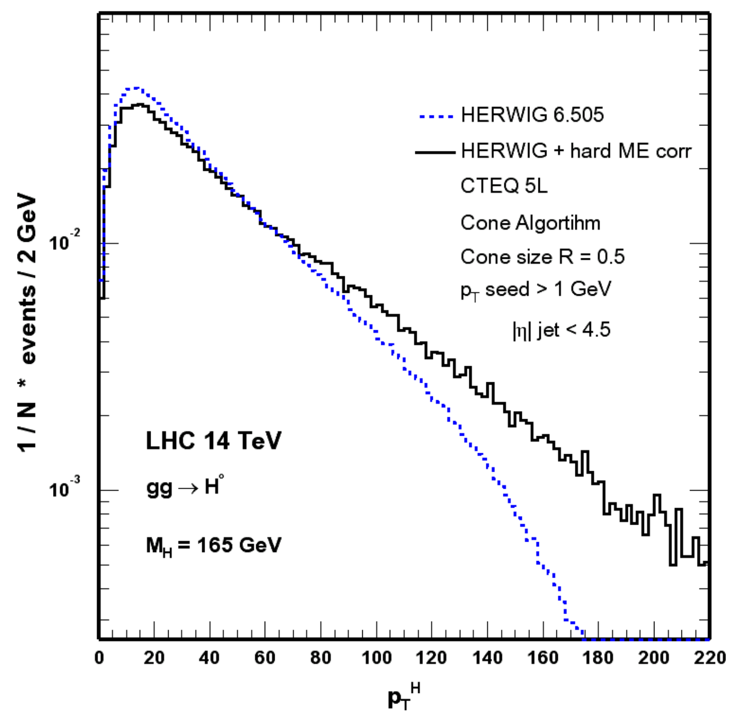
small pt Higgs region most important

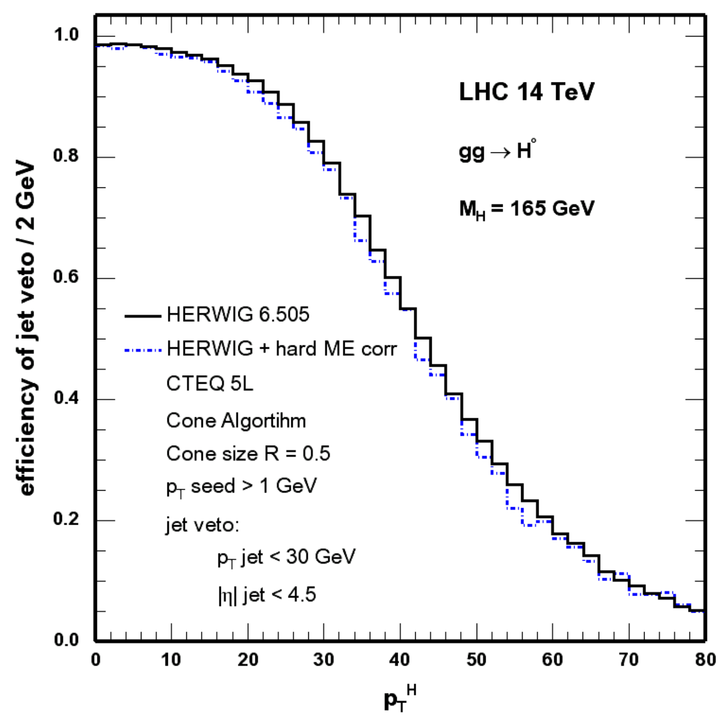
→ for our region of interest efficiency of jet veto does not vary much for different MC's !



HERWIG + ME Corrections

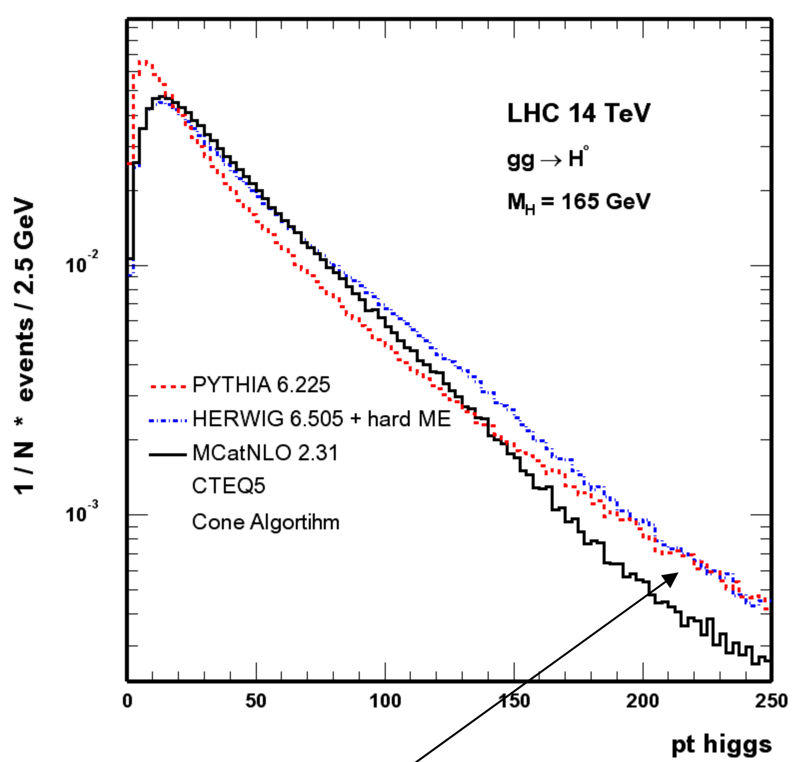
if hard ME corrections included *→ more jets with high pt
→total σ the same → less jets with low pt
→ overall efficiency ≈ 0.55 (10% smaller than for HERWIG 6.505)

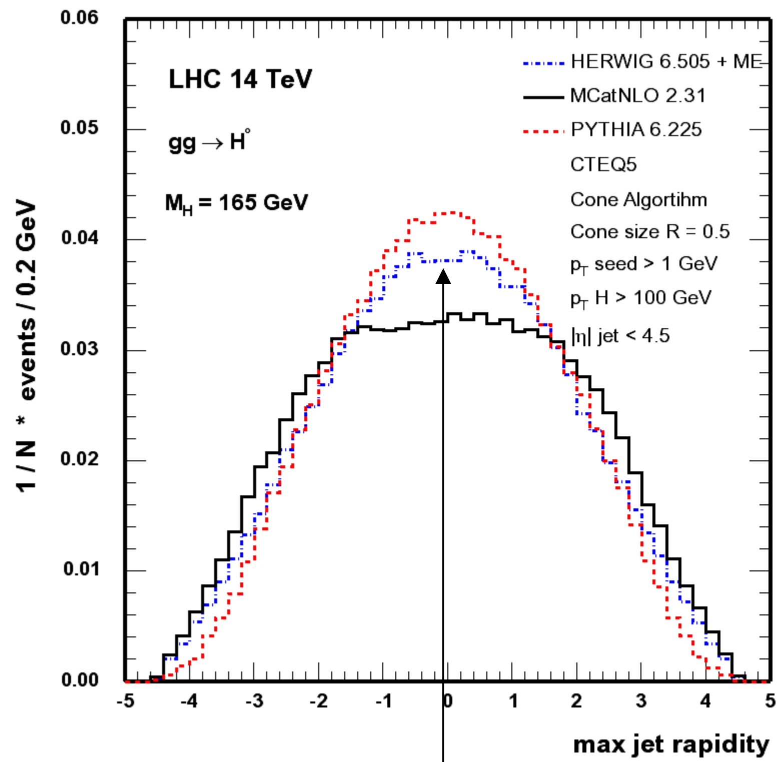




* This preliminary HERWIG + hard ME version was provided by G. Corcella (see Phys.Lett.B 590 (2004)249-257)

HERWIG + ME Corrections





High pt: Pythia + Herwig ≈ same

Pythia + Herwig: Similar rapidity shape also for pt Higgs>100 GeV

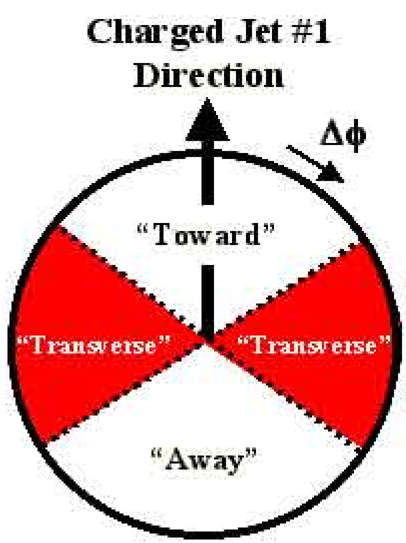
Underlying events (UE)

So far all events WITHOUT underlying events generated

→ Estimate uncertainty for UE according to the CDF and ATLAS tunings for PYTHIA

Current PYTHIA tunings (used in CMS production)

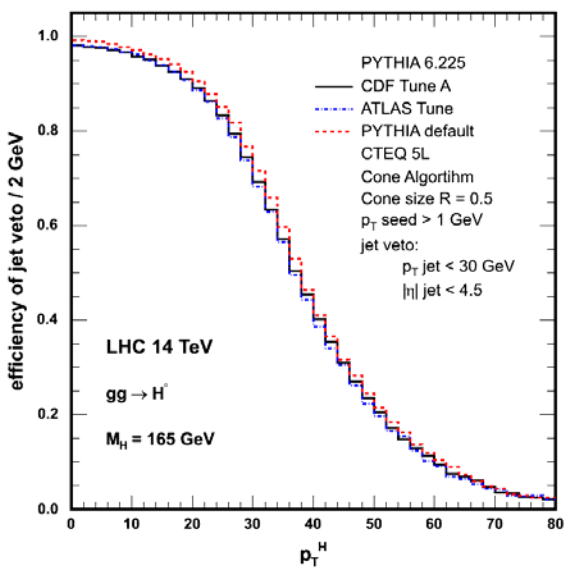
R. Field; CDF UE tuning method



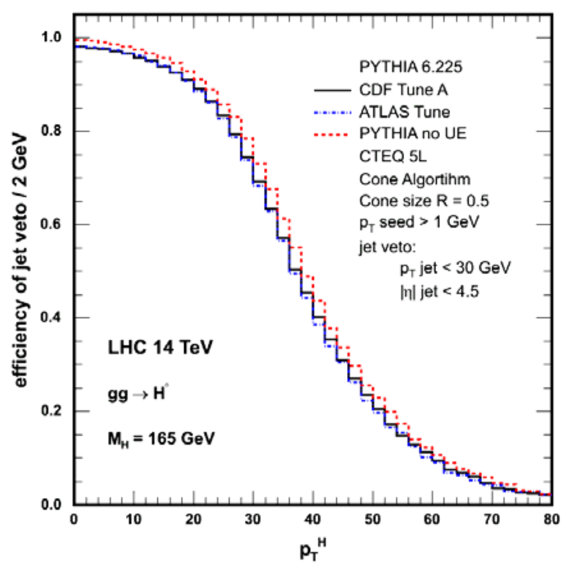
Comments	CDF – Tune A (PYTHIA6.206)	PYTHIA6.214 – Tuned (ATLAS)
Generated processes (QCD + low-pT)	Non-diffractive inelastic + double diffraction (MSEL=0, ISUB 94 and 95)	**Non-diffractive + double diffraction (MSEL=0, ISUB 94 and 95)**
p.d.f.	CTEQ 5L (MSTP(51)=7)	**CTEQ 5L (MSTP(51)=7)**
Multiple interactions models	MSTP(81) = 1 MSTP(82) = 4	**MSTP(81) = 1 MSTP(82) = 4**
pT min	PARP(82) = 2.0 PARP(89) = 1.8 TeV PARP(90) = 0.25	**PARP(82) = 1.8 PARP(89) = 1 TeV PARP(90) = 0.16**
Core radius	40% of the hadron radius (PARP(84) = 0.4)	**50% of the hadron radius (PARP(84) = 0.5)**
Gluon production mechanism	PARP(85) = 0.9 PARP(86) = 0.95	**PARP(85) = 0.33 PARP(86) = 0.66**
α_s and K-factors	MSTP(2) = 1 MSTP(33) = 0	**MSTP(2) = 1 MSTP(33) = 0**
Regulating initial state radiation	PARP(67) = 4	**PARP(67) = 1**

Jet veto efficiency with underlying events (PYTHIA)

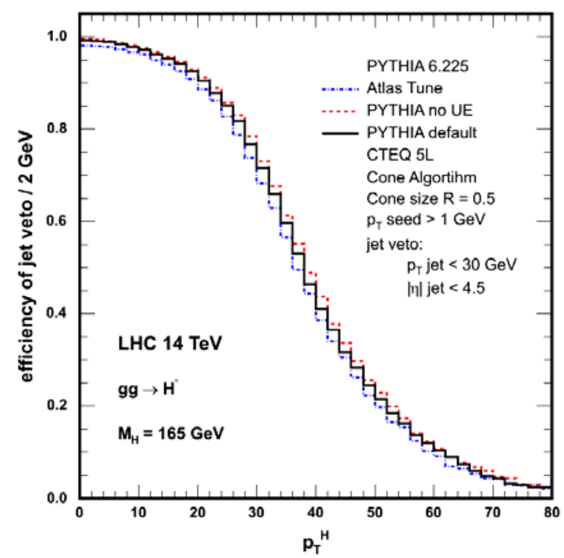
ATLAS Tune, CDF Tune A, PYTHIA default



ATLAS Tune, CDF Tune A, PYTHIA no UE



CDF Tune A, PYTHIA default, PYTHIA no UE

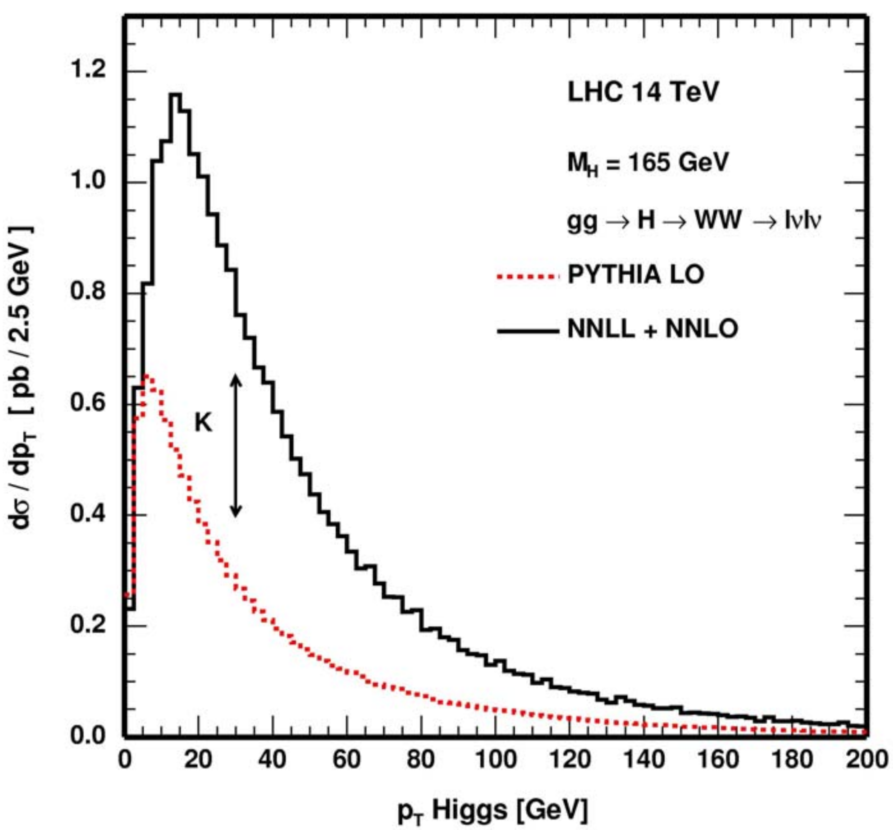


	Total ε	ε for pt ^{H} < 80 GeV
CDF tune A	0.596	0.709
ATLAS tune	0.600	0.706
PYTHIA default	0.613	0.723
PYTHIA no UE	0.620	0.730

- **CDF and ATLAS tuning ≈ same ε**
- **PYTHIA default and tuned PYTHIA: difference < 1 %**
- **PYTHIA with and without UE: difference < 1%**

Reweighting procedure *(GD et al. jhep05(2004)009)*

Simple method to include HO QCD corrections



gg→H→WW→lνlν :

pt Higgs balanced by pt jets

cannot use const. K-factor (because of jet veto)

Reweight Pythia with effective pt-dependent K-factors

Very promising results!

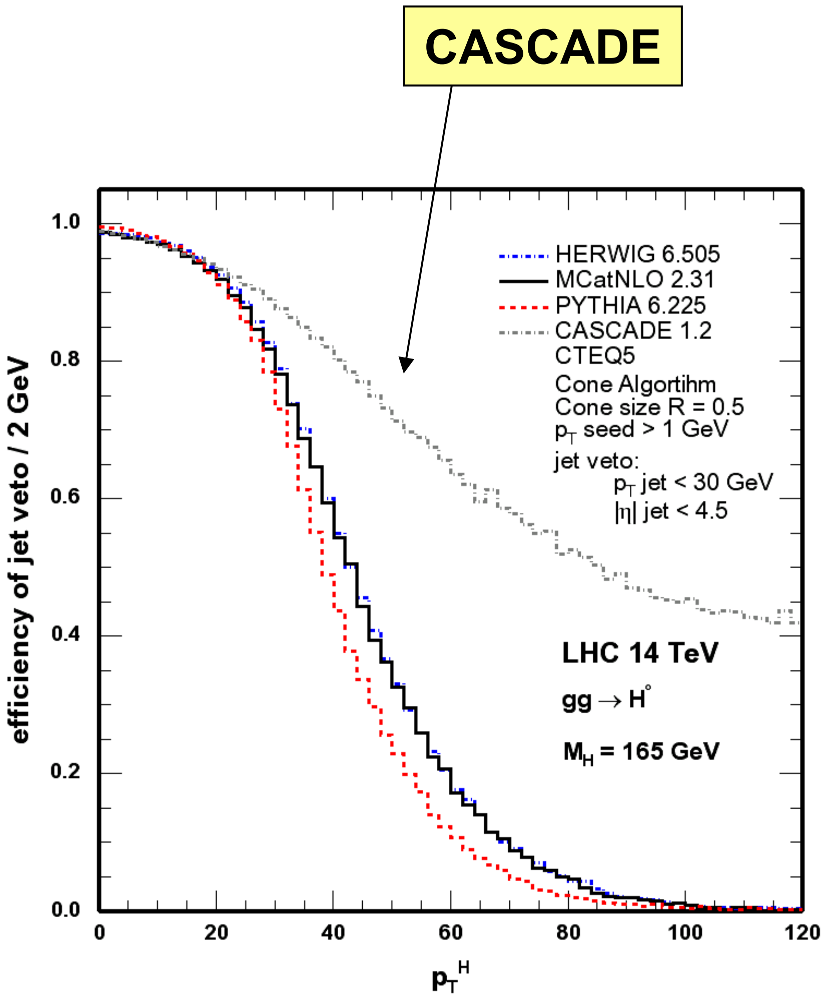
(for M_H=165 GeV, 5σ with already 0.4 fb^{-1})

Results:

Integrated efficiency for PYTHIA, HERWIG and MCatNLO and after reweighting

	ε	ε reweighted
Pythia 6.225	**0.62**	**0.56**
Herwig 6.505	**0.63**	**0.60**
MCatNLO 2.31	**0.59**	**0.57**

Efficiency for the jet veto including CASCADE



Difference due to missing quark induced processes in CASCADE ?

If so, way to distinguish quark and gluon induced processes!

Direct measurement at HERA for LHC..

under study

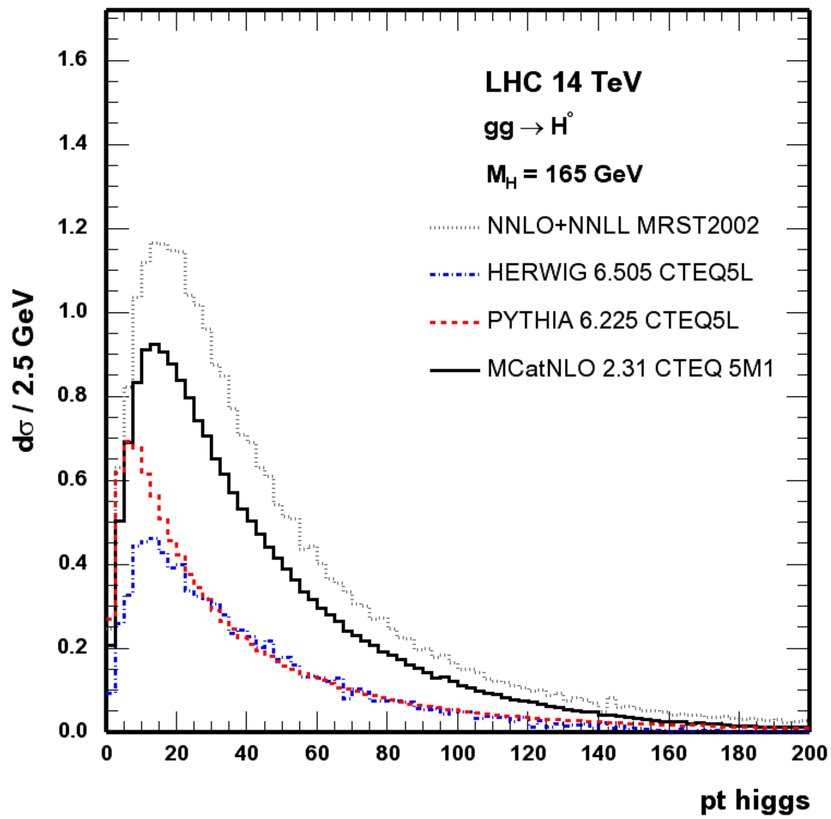
Conclusions

- **The total efficiencies for HERWIG, MCatNLO and PYTHIA vary around 5%**
- **In the region of interest for the $gg \rightarrow H \rightarrow WW \rightarrow l\nu l\nu$ signal selection, the difference is even smaller**
- **The different PYTHIA tunings for the underlying event lead to about the same efficiency**
- **The difference in the efficiency between PYTHIA with and without UE is smaller than 1%**

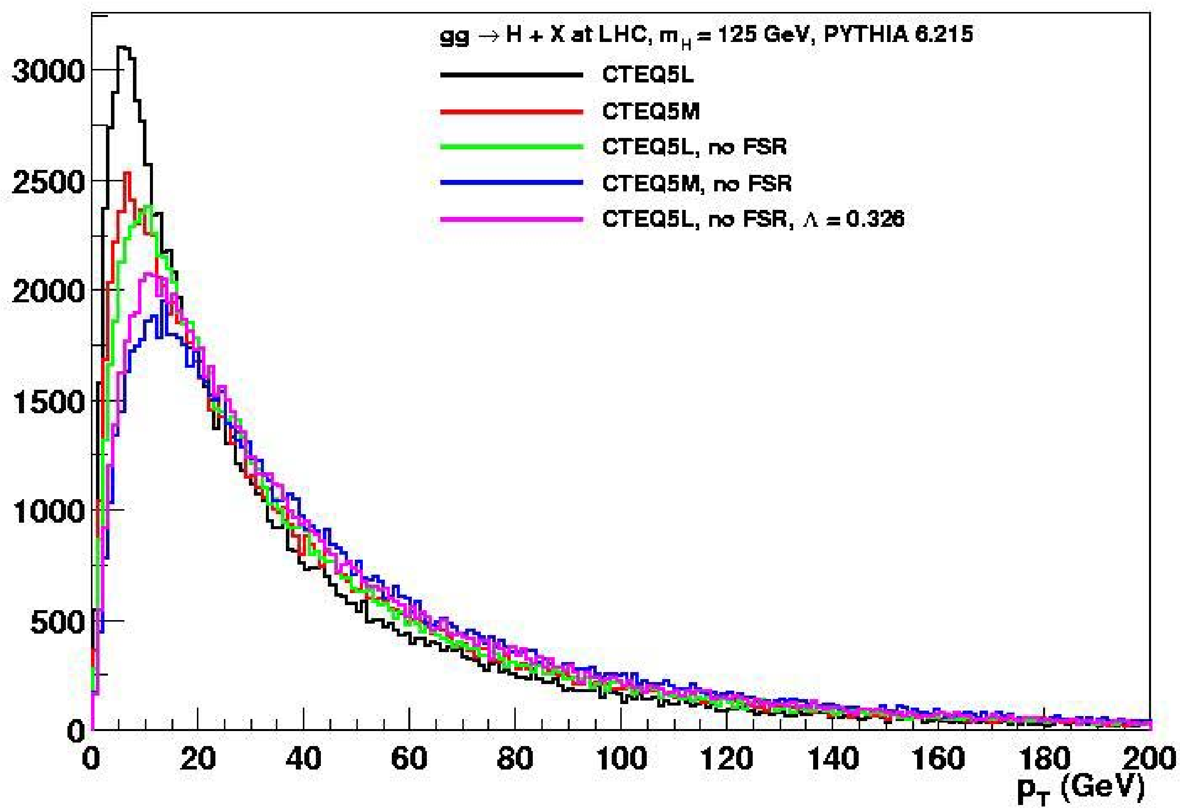
Special thanks to A.Nikitenko, A.Holzner, G.Corcella, T.Sjostrand, M.Dittmar, H.Jung

backup

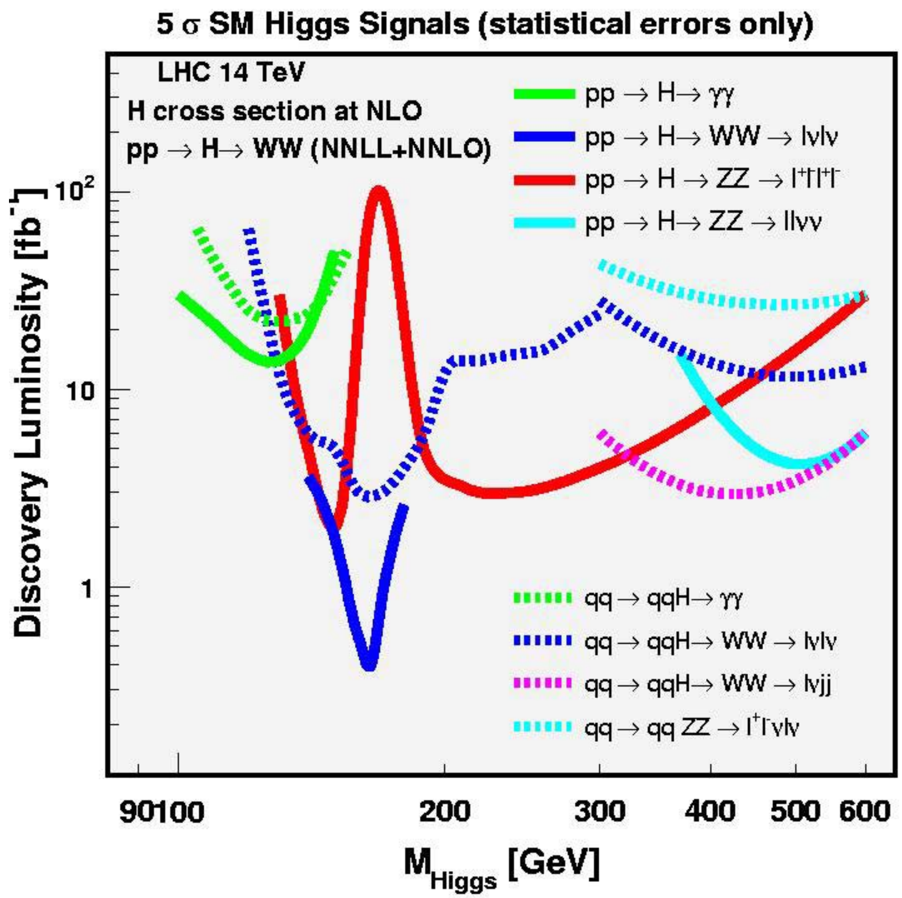
Cross sections

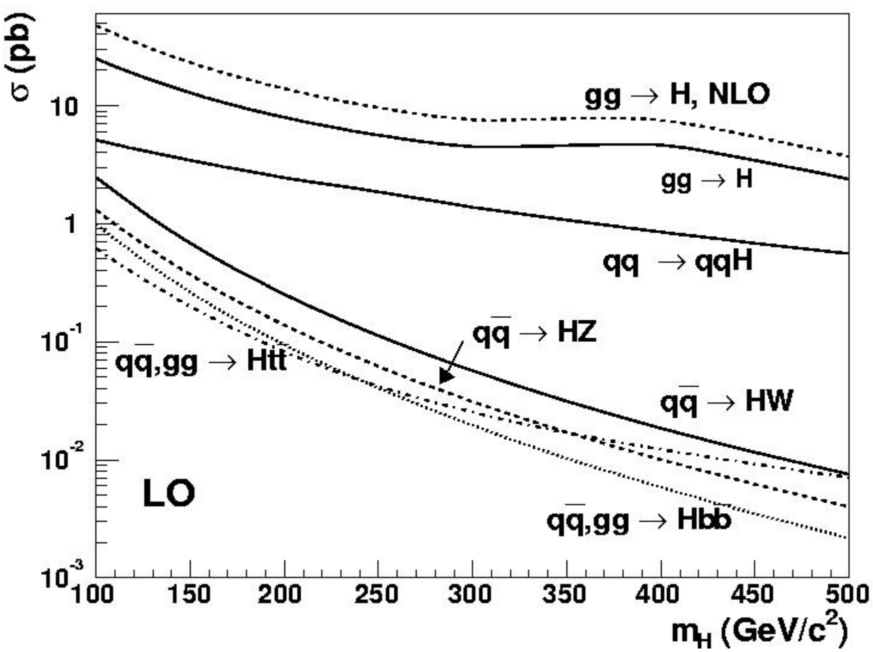


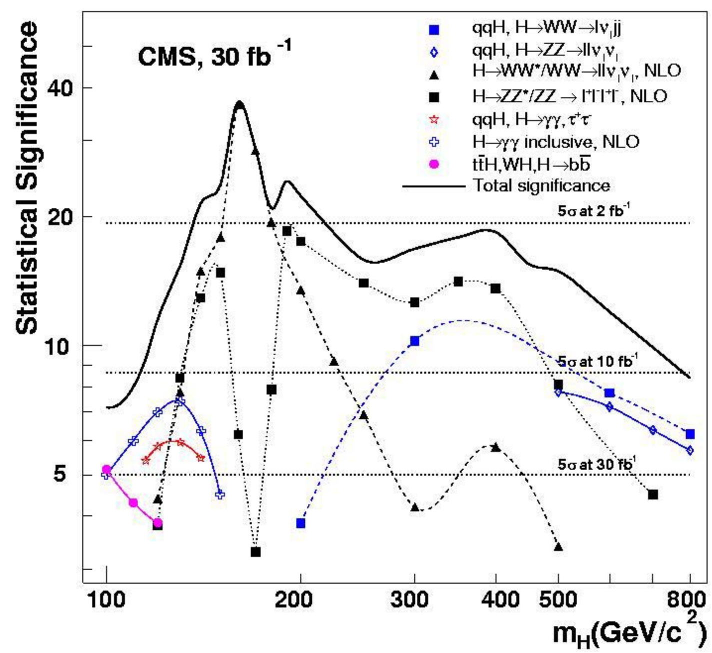
Les Houches 2003 proceedings



Discovery Luminosity as a function of Higgs Mass




σ (pb)
gg → H, NLO
gg → H
qq → qqH
q$\bar{q}$ → HZ
q$\bar{q}$,gg → Htt
q$\bar{q}$ → HW
LO
q$\bar{q}$,gg → Hbb
m_H (GeV/c^2)


Statistical Significance
CMS, 30 fb^{-1}
qqH, H→WW→lν$_l$jj
qqH, H→ZZ→llν$_l$ν$_l$
H→WW*/WW→llν$_l$ν$_l$, NLO
H→ZZ*/ZZ → l$^+$l$^-$l$^+$l$^-$, NLO
qqH, H→γγ, τ$^+$τ$^-$
H→γγ inclusive, NLO
t$\bar{t}$H,WH,H→b$\bar{b}$
Total significance
5σ at 2 fb^{-1}
5σ at 10 fb^{-1}
5σ at 30 fb^{-1}
m_H(GeV/c^2)

$gg \to H \to WW \to l\nu l\nu$ signal selection, M_H = 165 GeV

Cuts based on Phys. Rev. D 55 (1997) 167 and CMS Note 1997-083, M.Dittmar, H.Dreiner

Signal:

$gg \to H \to WW \to l\nu l\nu$

2 isolated leptons, small opening angle between leptons, missing p_T, no jets

'irreducible' background

Nonresonant **WW** production, **ttbar** and **Wtb** :

$pp \to WW \to l\nu l\nu$ [7.38 pb]
$pp \to ttbar \to bWbW \to bl\nu\ bl\nu$ [52 pb]
$pp \to Wtb \to WbWb \to l\nu bl\nu b$ [5.2 pb]

} cut on angle betw. l's, M_{ll}, p_T l's, jet veto (cut on p_T jet)

easily removable background:

$pp \to ZZ \to 4l, 2l2\nu, 4\nu$
$pp \to WZ \to l\nu l\bar{l}$
$pp \to Z^*/\gamma^* \to l\bar{l}$

} removed with $M_{ll} \neq M_Z$

Study with PYTHIA 6.210 and simple CMS geometrical acceptance