gg->H->WW$^{(*)}$->2l group

Les Houches 2005: preparation for Higgs discovery

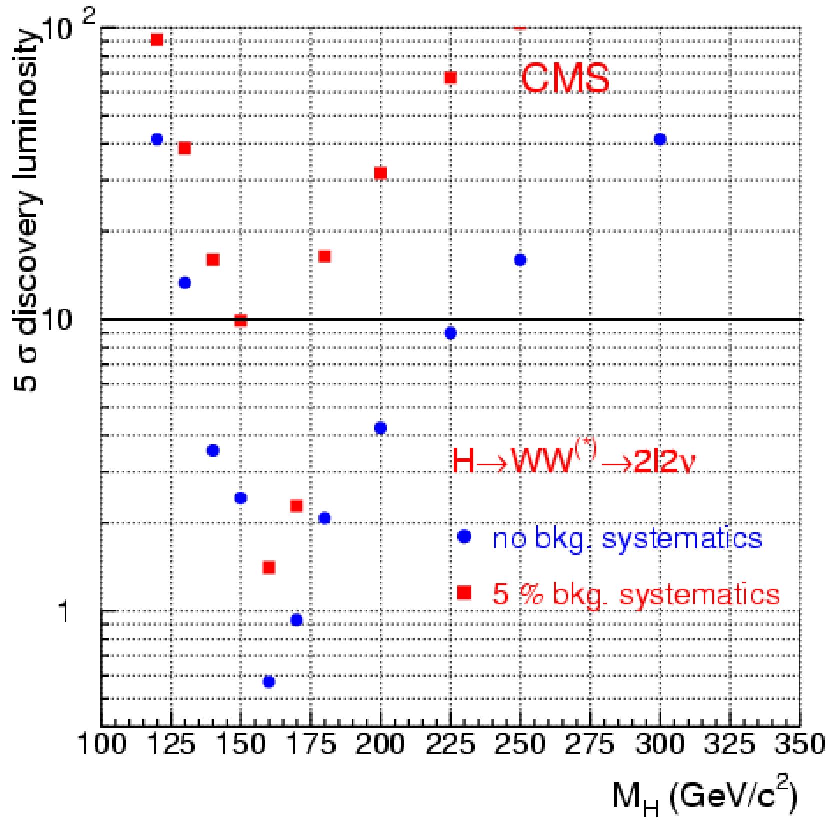
E.W.N. Glover, J. Ohnemus and S. Willenbrock
Phys. Rev., D 37 (**1988**) 3193

V. Barger, G. Bhattachatya, T, Han, B.A. Kniehl
Phys. Rev., D43 (1991) 779

D. Dittmar and H. Dreiner hep-ph/9703401

M. Dittmar, H. Dreiner, G. Davatz, G. Dissertori,
M. Grazzini, F. Pauss 2004

LHC 2008 discovery ?



"Counting" discovery : background knowledge and systematic is a key issue

gg->H->WW$^{(*)}$->ll

list of topics for Workshop

- gg->WW background.
  - Fetch gg->WW MC into CMS software; effect of showering in PYTHIA (isolation, jet veto).
  - Can it be separated in data from qq->WW ? Extrapolation uncertainties.
- WbWb background with jet veto
  - tt + Wt with jet veto. NLO
  - Effect of spin correlations in WbWb
  - Evaluation from data : theory + exp. systematic
- Uncertainty of jet veto in gg->H with different MC's and UE "benchmarks"

Gluon-induced WW background to Higgs boson searches at the LHC

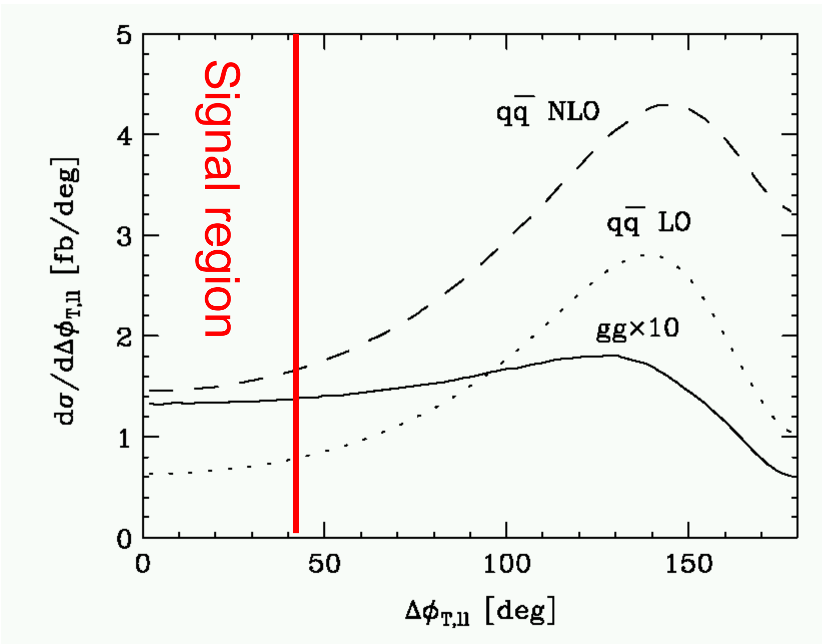
Nikolas Kauer

RWTH Aachen

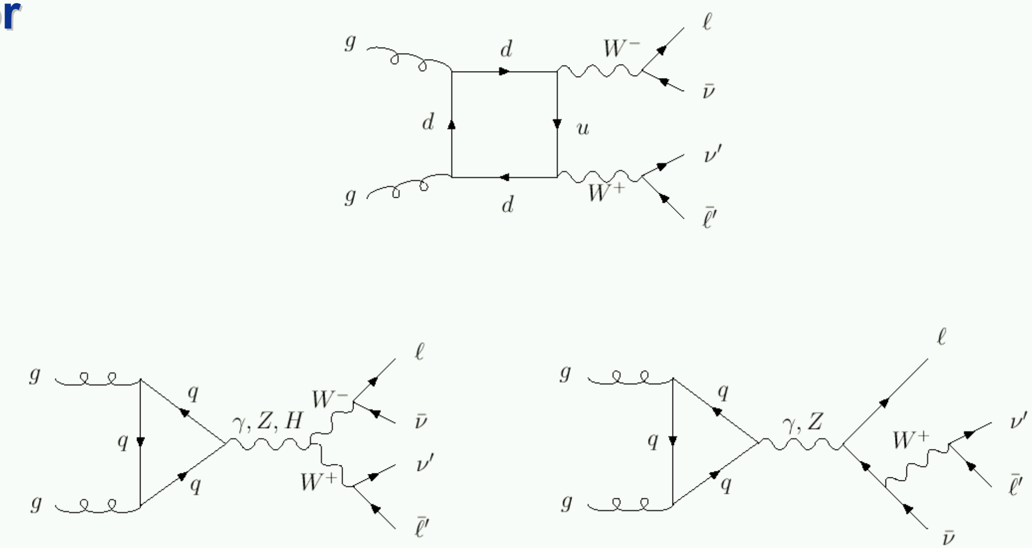
in collaboration with

T. Binoth, M. Ciccolini and M. Krämer

30 % of total WW background after all cuts ! “signal like behavior



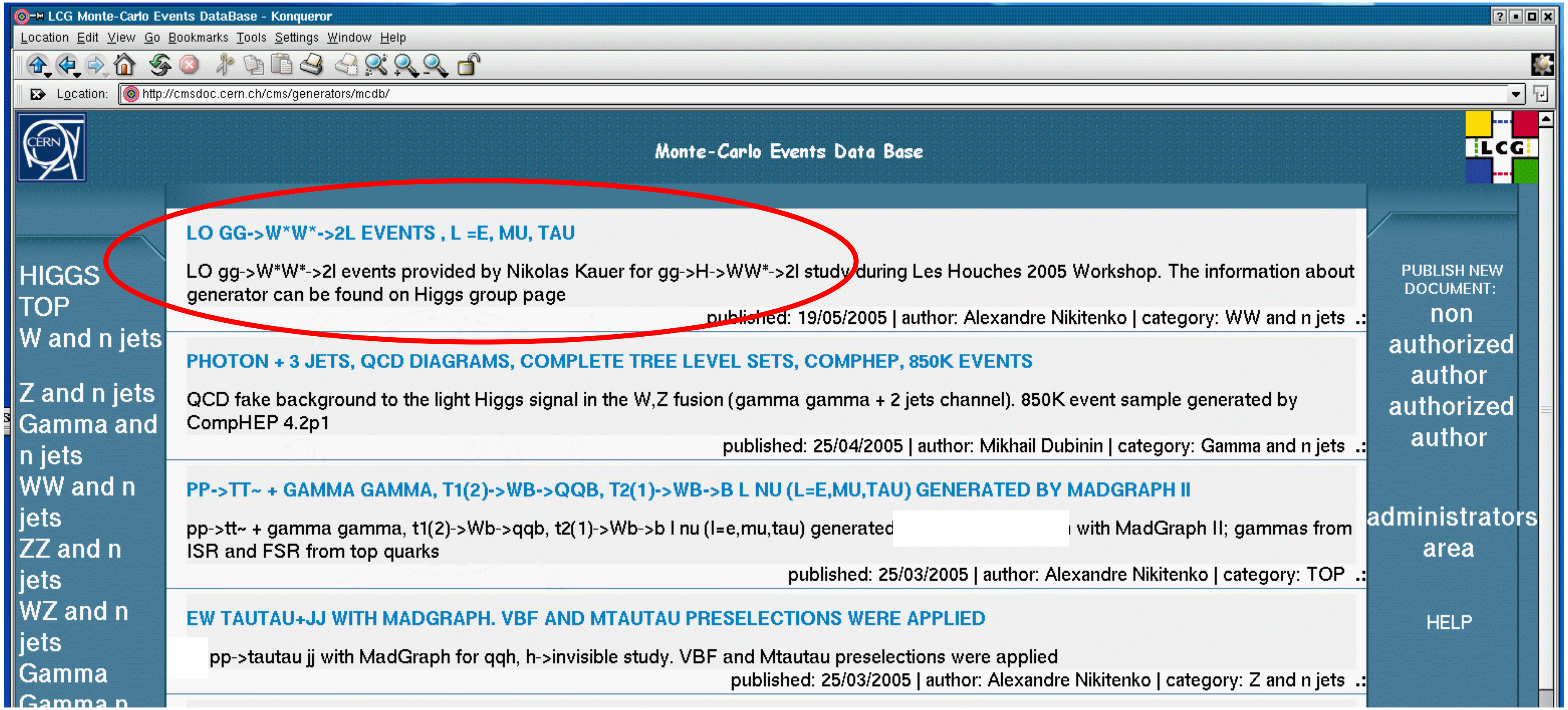
$gg \to W^{-*}W^{+*} \to \ell\bar{\nu}\bar{\ell}'\nu'$ (LO)



without W decays: J.J. van der Bij, E.W.N. Glover; C. Kao, D.A. Dicus

200K parton level gg->W*W*->4l events were simulated during Workshop by Nikolas Kauer and propogated for PYTHIA showering and hadronization using MadGraph format and Les Houches interface

CMS MCDB page



Questions :

how much is the influence of jet veto, isolation due to ISR ?
should we take it into account ?

gg->W*W*->2l efficiency

Giovanna Davatz and Anne-Sylvie Giolo

Isolation + jet veto with ISR bring ~ 20 + 10 % of reduction in σ_{LO}

	Pythia without ISR	Pythia with ISR
Basic cuts	0.47 isolation	0.34
+ jet veto 20 GeV		0.28
+ jet veto 30 GeV		0.31
Full selection cuts	0.025 isolation	0.017
+ jet veto 20 GeV		0.014
+ jet veto 30 GeV		0.015

tt + Wt after jet veto are comparable
Normalization at NLO

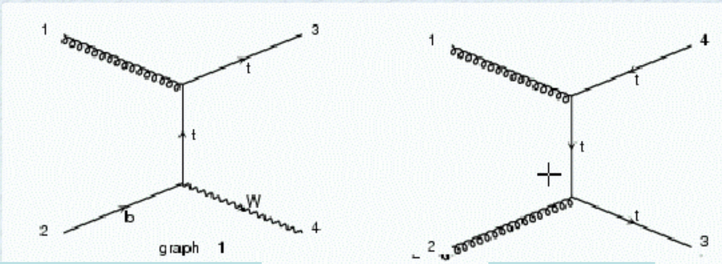
- in a gauge invariant way
- in a generator friendly way

SIMPLER SOLUTION

Scott's proposal:

- Use tt at NLO and gb>tW at NLO, but consistently leave out $\alpha_s^2\alpha_W$ terms

IN

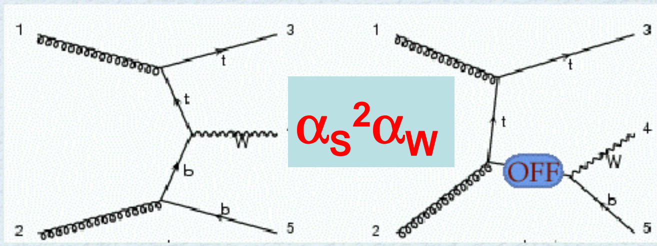


+ α_s **corrections**

$\alpha_s^2\alpha_W$ **log**

α_s^2

OUT



$\alpha_s^2\alpha_W$

Action plan by Fabio Maltoni, John Campbell and Scott Willenbrock:

- Check that the neglected contributions are small in various areas of phase space
- Provide reference numbers for normalization of background

Effect of spin correlations in WbWb background

Anne-Sylvie Giolo

Selection efficiency: Cross section after cuts

(σ_{tot}(pp→wbwb) X BR(e,μ,τ) = 60.6pb)

	W decayed in MadGraph	W decayed in Pythia
2 isolated leptons (p_t>10GeV, |η|<2)	11pb	12pb
Jet veto (pt>30GeV,|η |<2.5) Et^{miss}>40GeV	400fb	410fb
ϕ_{ll}<45° 5GeV<m_{ll}<40GeV	34fb	30fb
30GeV<p_t^{max}(lep)<55GeV p_t^{min}(lep)>25GeV	4.7fb ⟷ 10 %	5.3fb

tt bkg. evaluation from data and th. : 1st proposal

Exploit background extrapolation method proposed by N. Kauer and D.Zeppenfeld in Les Houches 2003

tt reference region:

- same selections on leptons and MEt
- no jet-veto
- jet Pt > 50 GeV
- **one b-tagged jet (no veto on extra jets)**

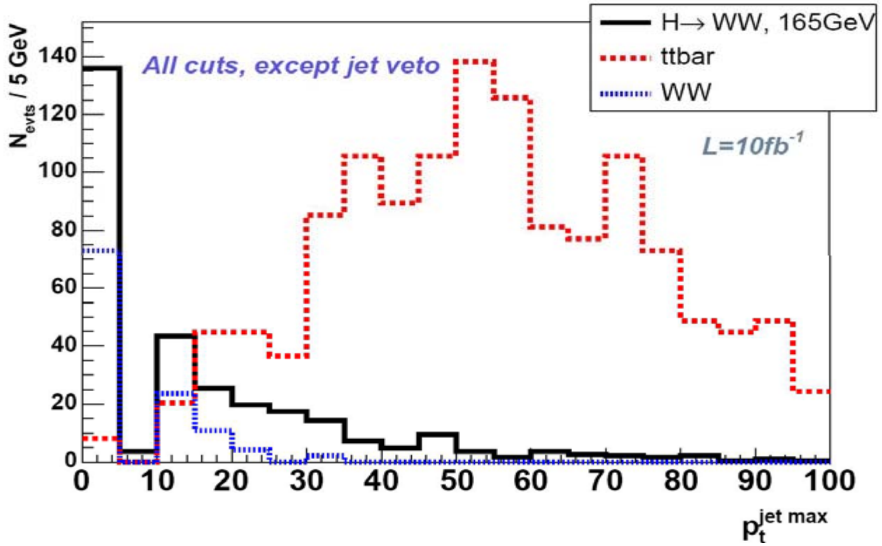
Results for LO *signal, DY* and *tt*. *Wt* not included

	Events* for 10 fb^{-1}
Higgs	0
DY	15
tt	280

* 2 μ final state

tt bkg. evaluation from data and th. : 2nd proposal

***tt* Reference Region: same selections as before but NO request for a b-tagged jet**



- To be applied only for different flavor leptons final state (avoid DY)

- Topology: $\mu^{\pm} + e^{-/+}$ +MEt+1j. Contamination from WW+j(s) (negligeble?)

- Systematics coming from uncertainty on jets energy scale (~10%) and from jets misidentification. (10^{-4} for *e*'s and 10^{-5} for μ's). Possible contamination by W+2j

	Events* for 10 fb^{-1}
Higgs	70
tt	1050

ETH Institute for Particle Physics

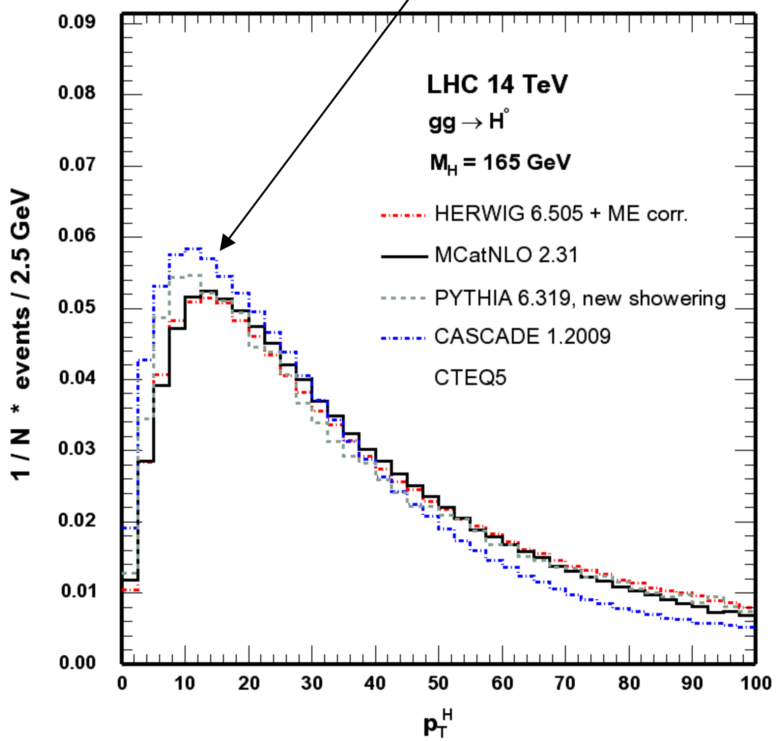
gg→H for different MCs:

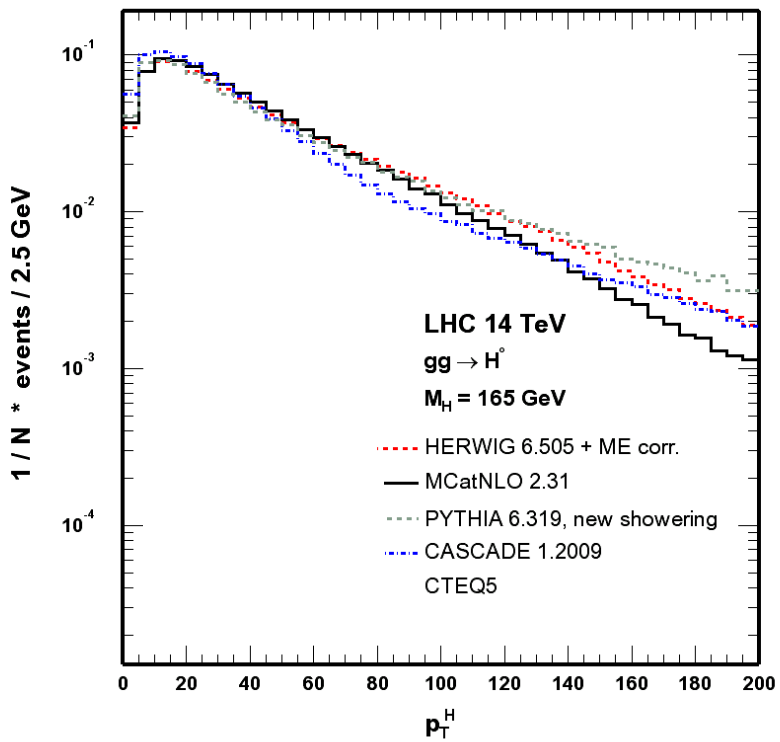
uncertainties due to jet veto

Giovanna Davatz, ETH Zurich

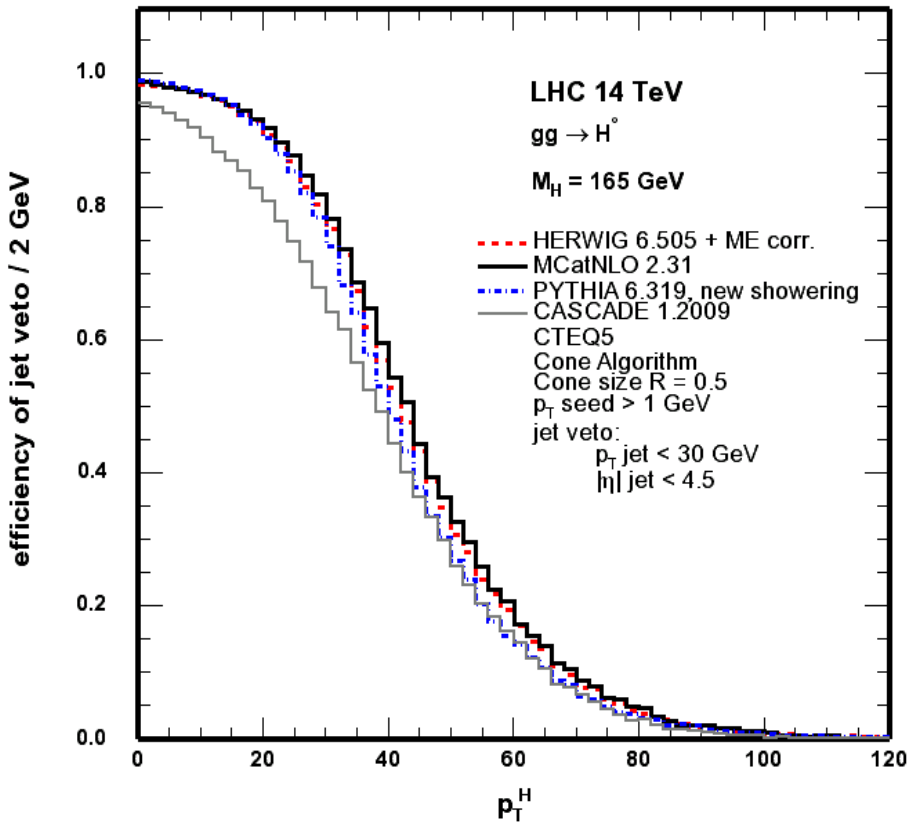
p_T Higgs varies for different MCs (new showering for Pythia used)

Pythia now much more like Herwig and MCatNLO in low pt





Efficiency numbers of the jet veto



Differences vary over the p_T spectrum:

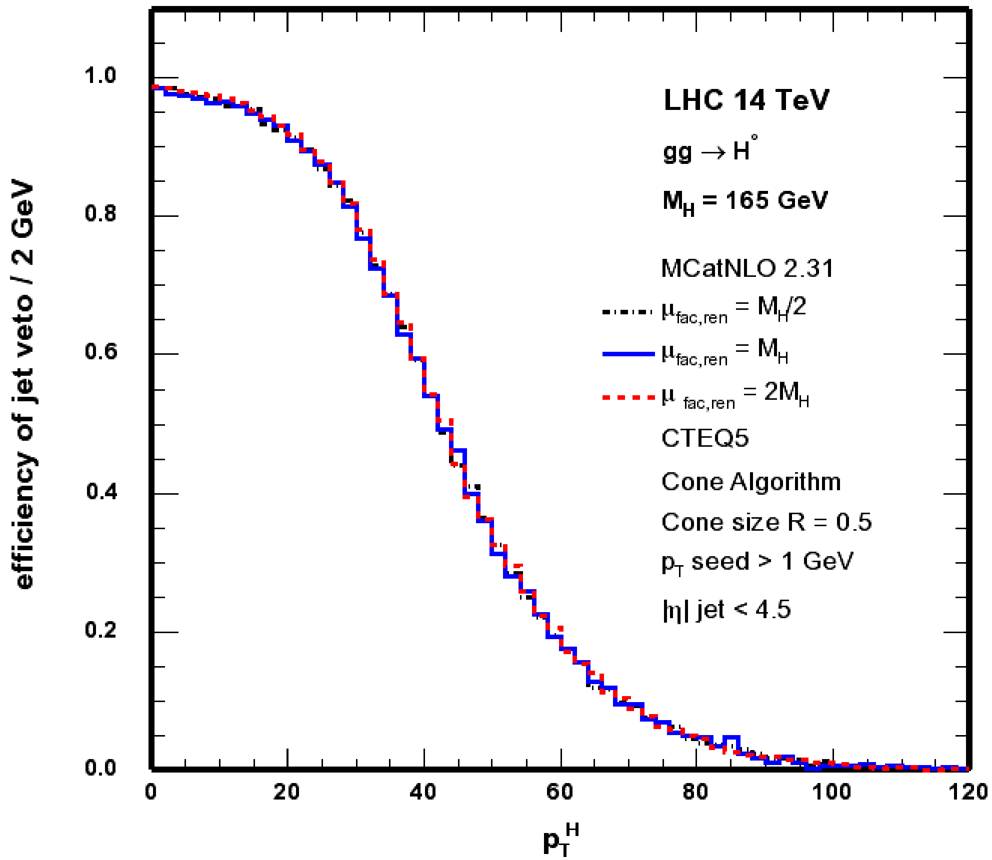
Integrated efficiency over whole p_T spectrum and up to a p_T Higgs of 80 GeV:

	ε total	ε up to 80 GeV
PYTHIA	**0.53**	**0.68**
HERWIG	**0.54**	**0.68**
MCatNLO	**0.58**	**0.69**
CASCADE	**0.55**	**0.65**

→ efficiency spread ≈ 10%

(without CASCADE up to 80 GeV 1%)

Efficiency numbers of the jet veto for MCatNLO, different scales



Integrated efficiency over whole p_T spectrum and up to a p_T Higgs of 80 GeV:

	ε total	ε up to 80 GeV
$\mu_{fac,ren}$ = M_H /2	0.585	0.685
$\mu_{fac,ren}$ = M_H	0.583	0.692
$\mu_{fac,ren}$ = 2 M_H	0.582	0.687

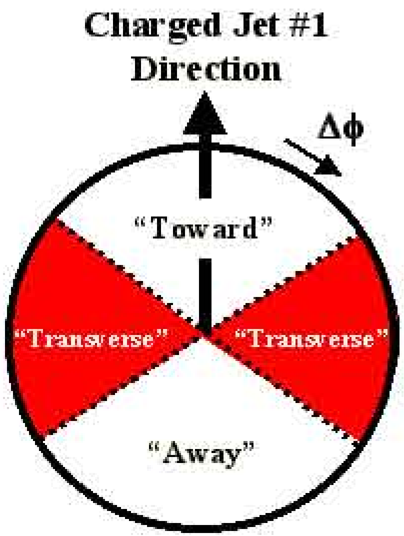
→ efficiency spread < 1%

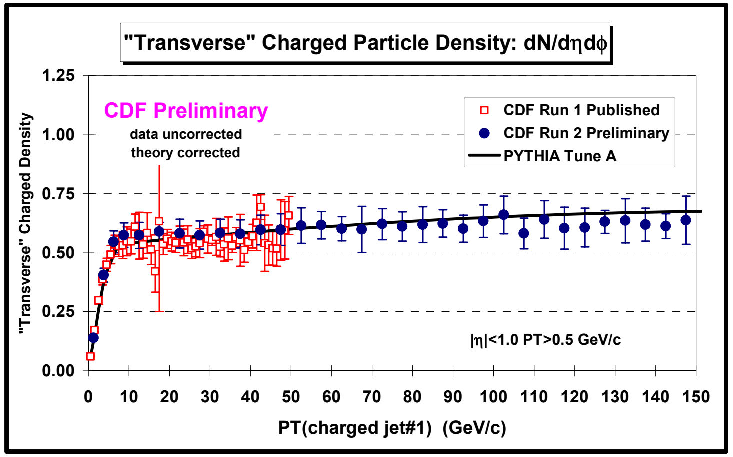
Excellent collaboration between experimentalists and theorists in the group

THE END

PYTHIA6.2 tunnings (on the way for 6.3…)

R. Field; CDF UE tuning method

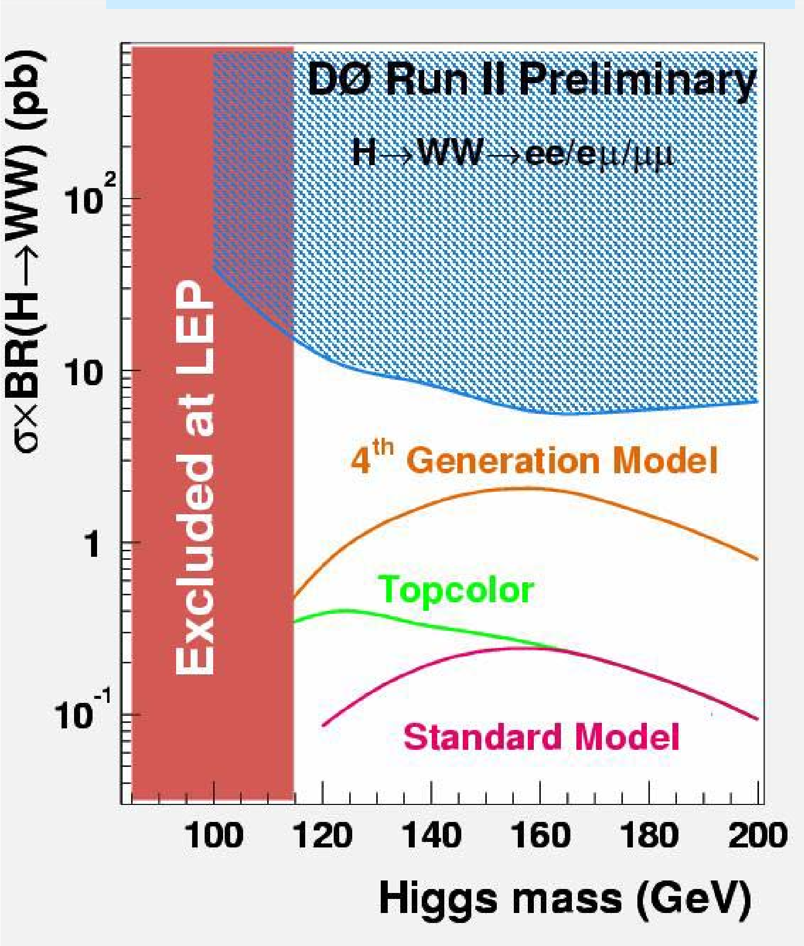


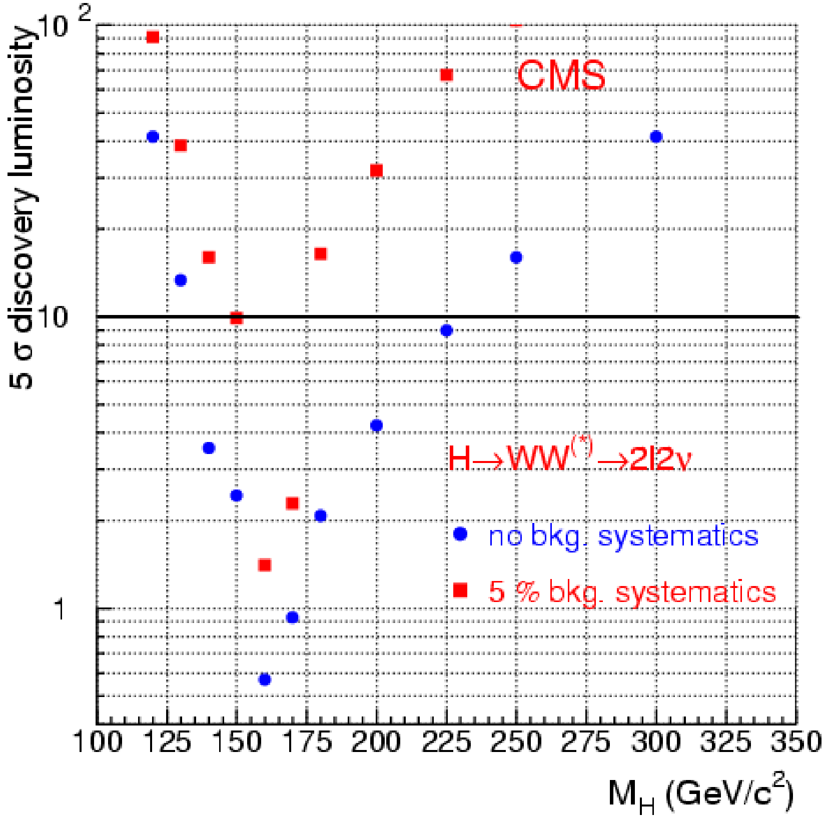


Comments	CDF – Tune A (PYTHIA6.206)	PYTHIA6.214 – Tuned (ATLAS)
Generated processes (QCD + low-pT)	Non-diffractive inelastic + double diffraction (MSEL=0, ISUB 94 and 95)	**Non-diffractive + double diffraction (MSEL=0, ISUB 94 and 95)**
p.d.f.	CTEQ 5L (MSTP(51)=7)	**CTEQ 5L (MSTP(51)=7)**
Multiple interactions 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**

Discovery reaches with H->WW->2l

Excluded cross section times Branching Ratio at 95% C.L.





+/- 5 % bkg. systematic were taken both in ATLAS and CMS; need more justification;

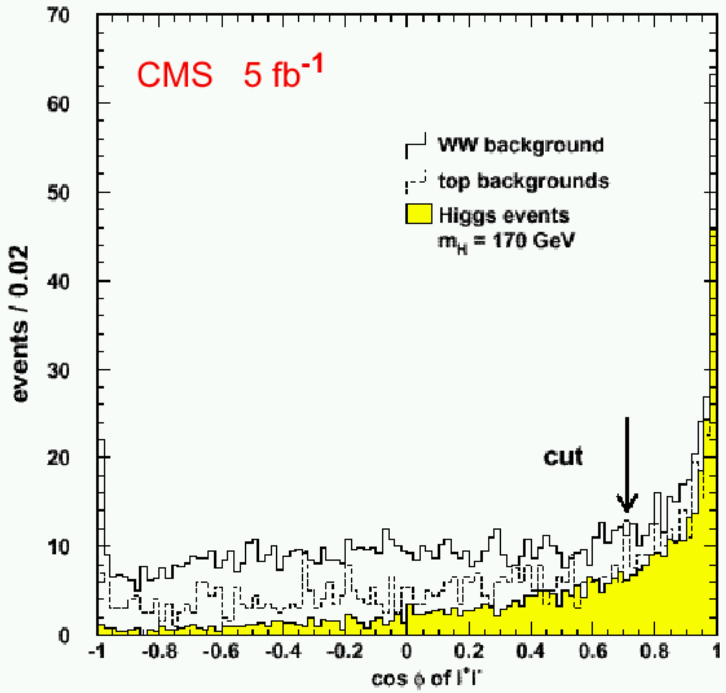
"Counting experiment" – no sidebands

H->WW$^{(*)}$-> 2 l 2 ν

Backgrounds : tt, WW$^{(*)}$, Wt

Selections :

- lepton tracker + calo isolation
- jet veto. No jets E_T>20 GeV, $|\eta|$ < 3
- W^+W^- spin correlation: cut on ϕ_{ll}



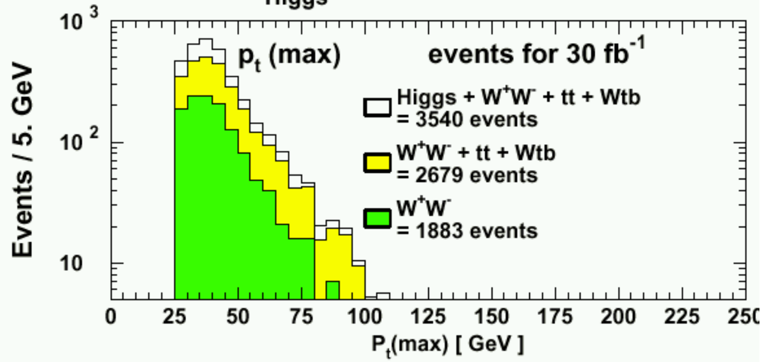
Backgrounds has to be estimated from data

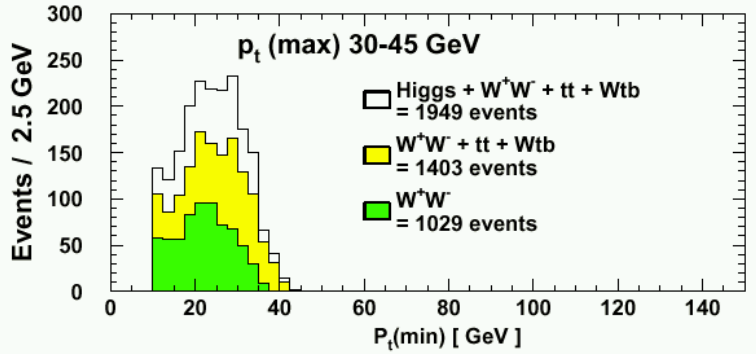
$\sigma_{bkg} = \sigma_{ref} \times (\sigma_{bkg}/\sigma_{ref})$

σ_{ref} - low experim. uncertainty

$\sigma_{bkg}/\sigma_{ref}$ - low theoret. uncertainly

M_{Higgs} = 140 GeV





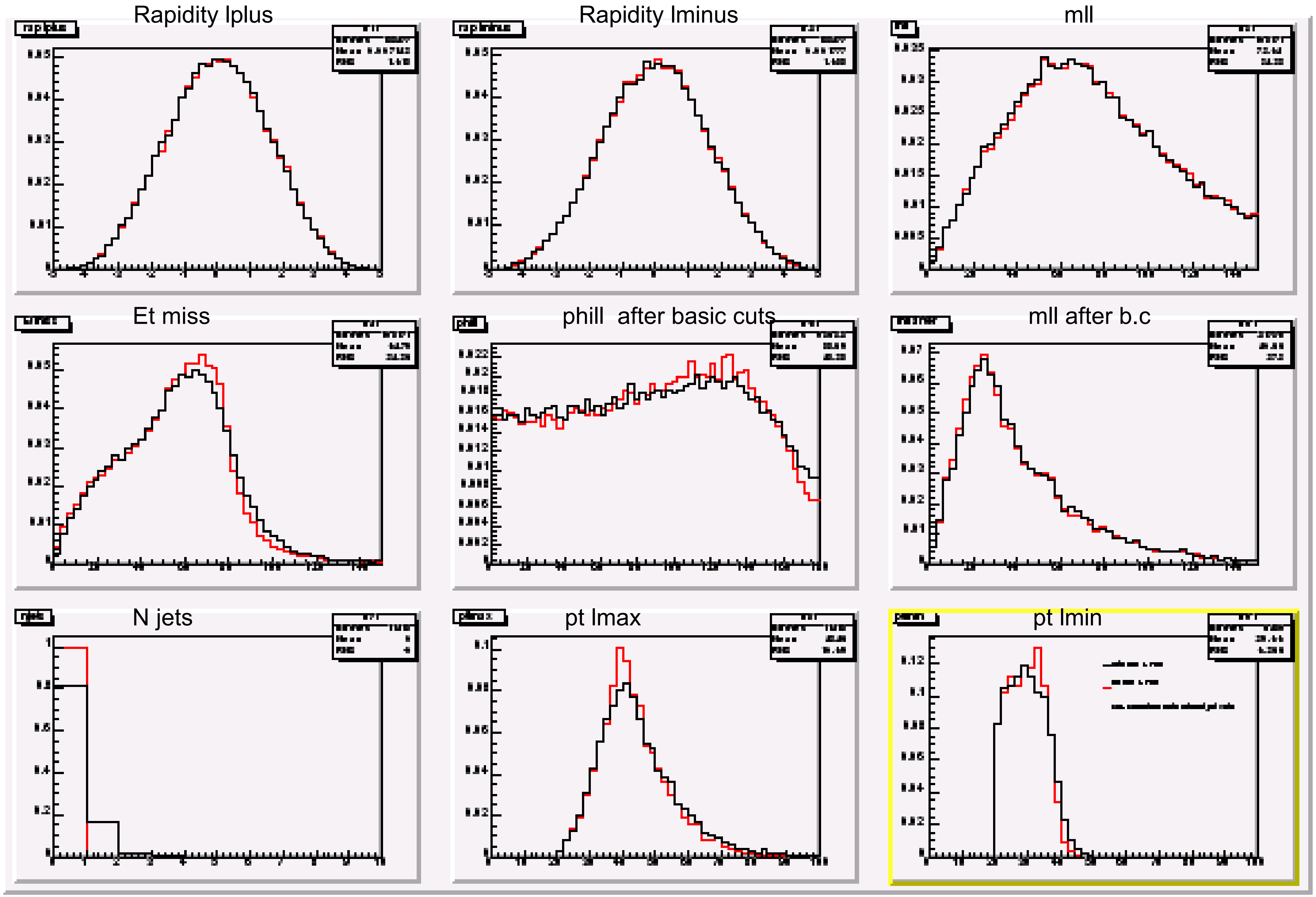
Selection cuts (comparable to hep-ph/0503094)

- basic cuts:
  - p^T lepton >20 GeV
  - $|\eta$ lepton$|$ <2.5
  - E^T miss > 25 GeV
  - 2 isolated leptons

- Full selection cuts: basic cuts +
  - phi(ll) < 45
  - mass(ll) < 35 GeV
  - p^T lmin >25 GeV
  - 35 GeV < p^T lmax <50 GeV

Selection cuts without jet veto, scaled

- NO ISR
- With ISR



Results

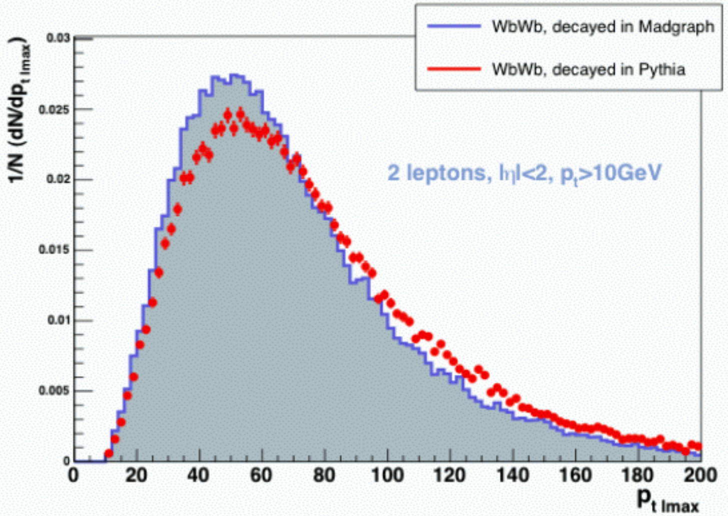
$pp \to W^*W^* \to \ell\bar{\nu}\bar{\ell}'\nu'$ ($\sqrt{s} = 14$ TeV)

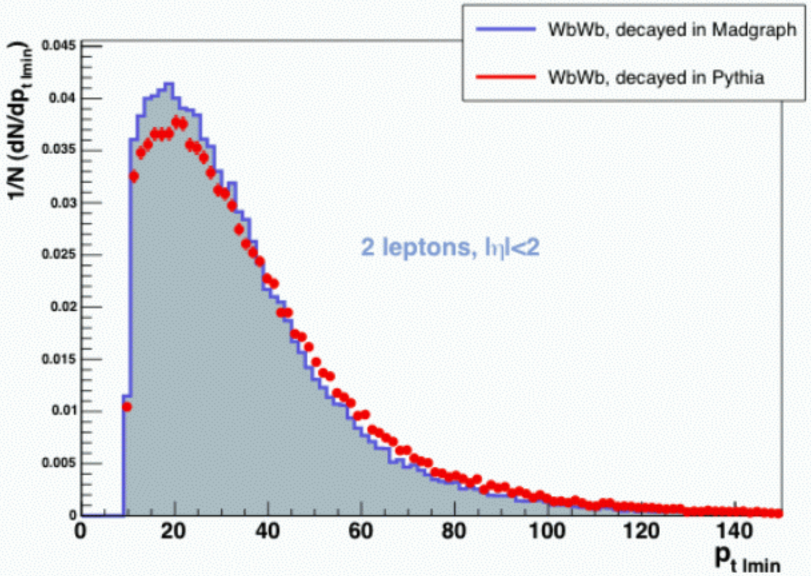
	$\sigma(pp \to W^*W^* \to \ell\bar{\nu}\bar{\ell}'\nu')$ [fb]				
	gg	$q\bar{q}$ LO	$q\bar{q}$ NLO	$\frac{\sigma_{\rm NLO}}{\sigma_{\rm LO}}$	$\frac{\sigma_{{\rm NLO}+gg}}{\sigma_{\rm NLO}}$
σ_{tot}	$53.61(2)^{+14.0}_{-10.8}$	$875.8(1)^{+54.9}_{-67.5}$	$1373(1)^{+71}_{-79}$	1.57	1.04
σ_{std}	$25.89(1)^{+6.85}_{-5.29}$	$270.5(1)^{+20.0}_{-23.8}$	$491.8(1)^{+27.5}_{-32.7}$	1.82	1.05
σ_{bkg}	$1.385(1)^{+0.40}_{-0.31}$	$4.583(2)^{+0.42}_{-0.48}$	$4.79(3)^{+0.01}_{-0.13}$	1.05	1.29

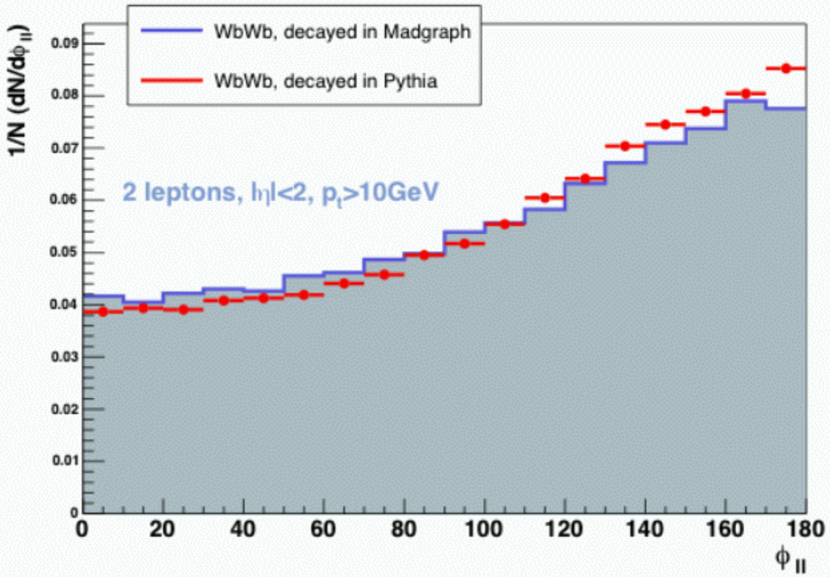
std: $p_{T,\ell} > 20$ GeV, $|\eta_\ell| < 2.5$, $\not{p}_T > 25$ GeV

$M_W/2 \leq \mu_{\rm ren,fac} \leq 2M_W$

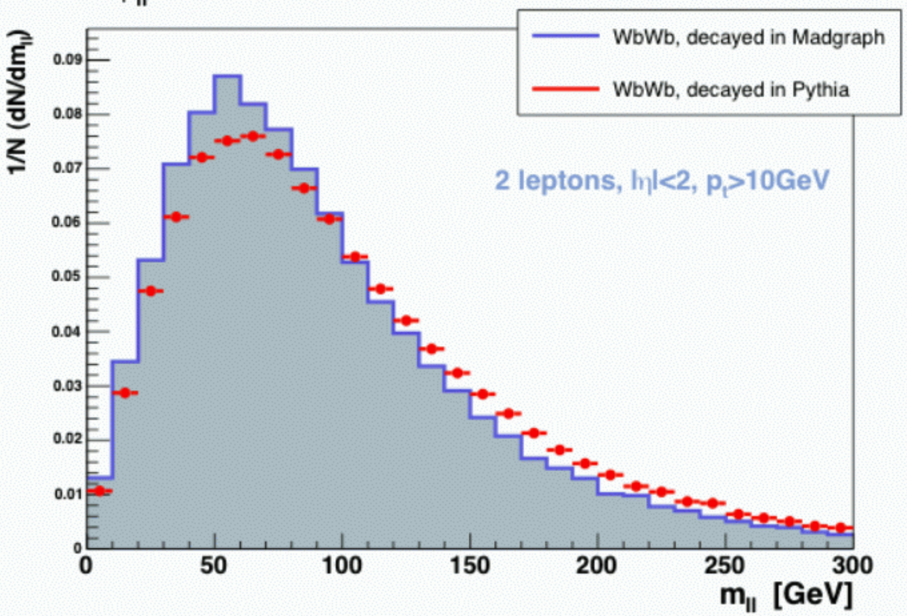
The pt spectrum of the leptons is harder when the W's are decayed in PYTHIA







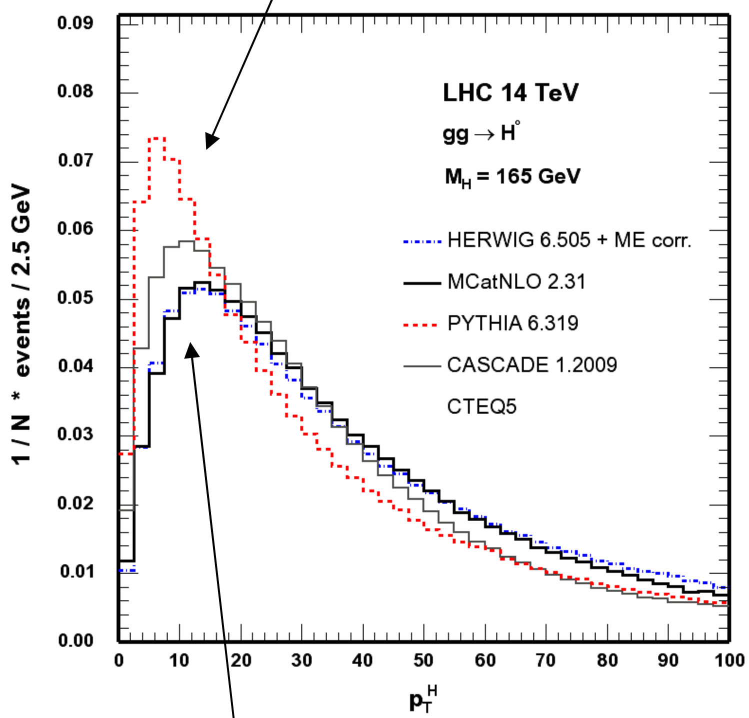
Leptons tend to be more back-to-back when W are decayed by pythia (leading to a high m_{ll})

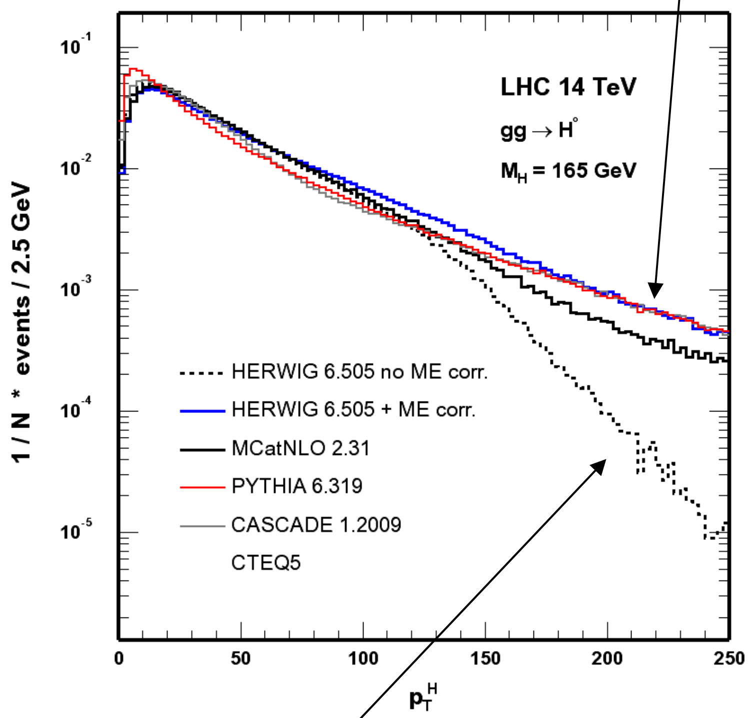


p_T Higgs varies for different MCs old Pythia showering

Low pt: different shape for Pythia

High pt: Pythia + Herwig+ME ≈ same





Low pt: Herwig+ME and MCatNLO ≈ same

Herwig without ME correction