A. Nikitenko, Imperial College

What TeV can do for Higgs at LHC ?

TeV4LHC Workshop, FNAL, 16 Sept. 2004

Apologize that I will emphasis on CMS Higgs studies.
Capabilities of Higgs searches in ATLAS and CMS are very similar

The best would be :

discover Higgs before LHC !

but . . .

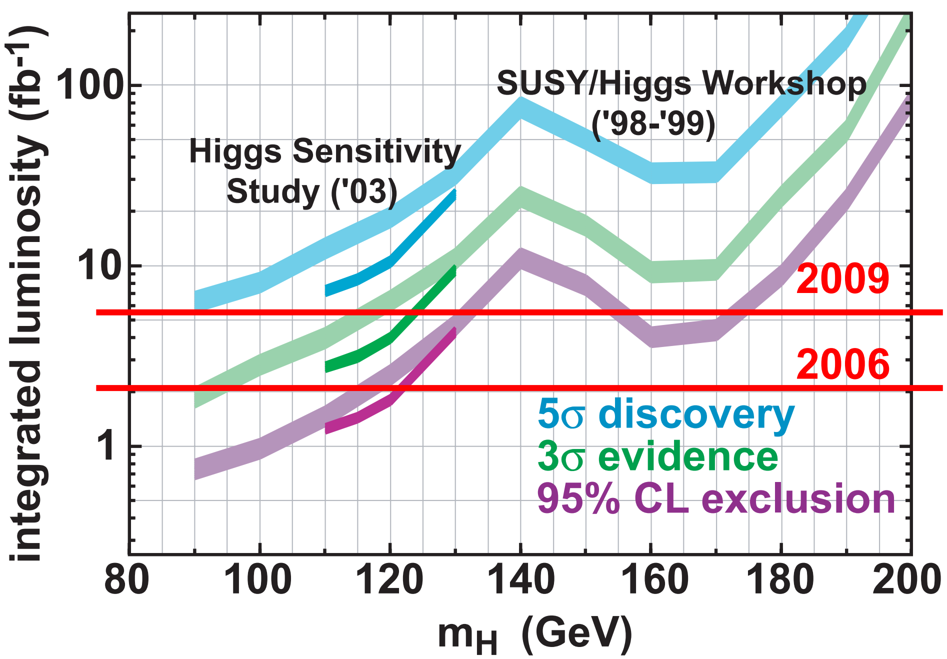
Prospects for SM Higgs

Tevatron

SM Higgs at 120 GeV/c^2

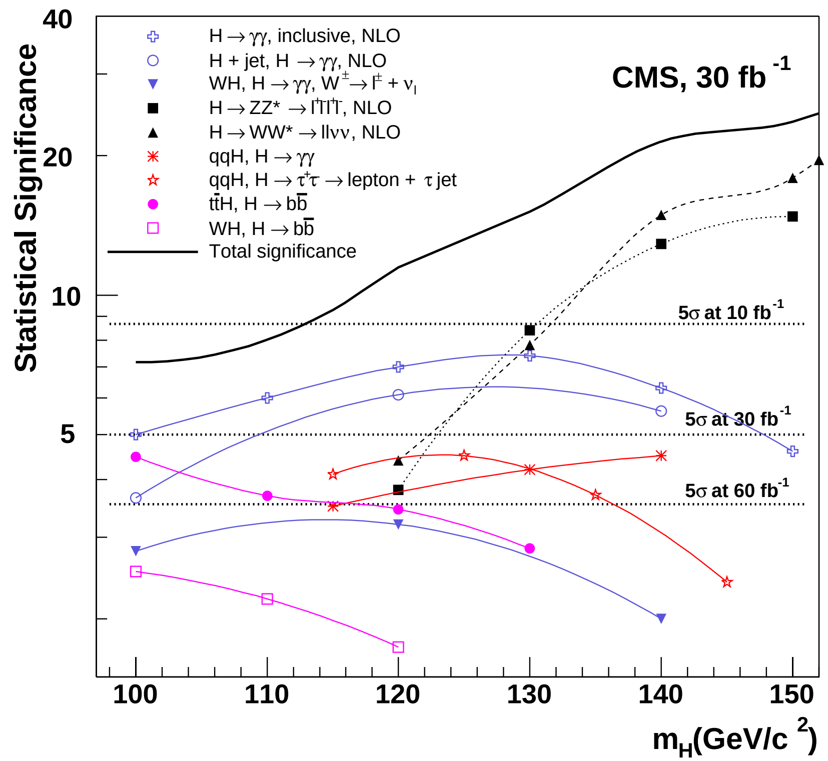
- exclude at 95 % C.L. in 2006
- 3 σ evidence in 2009

B. Heinemann talk on UK Forum, April 2004

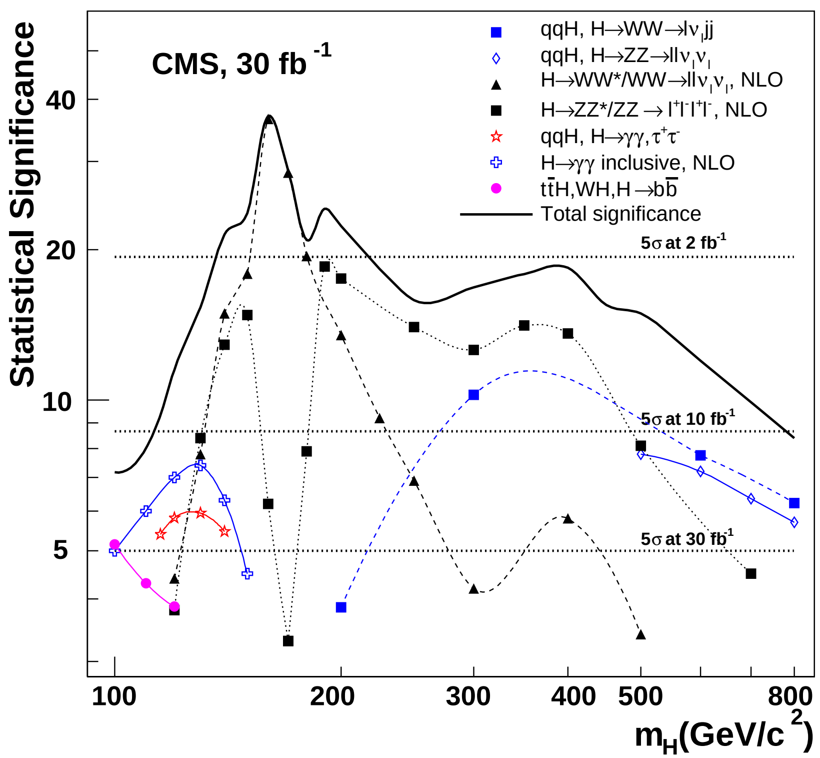


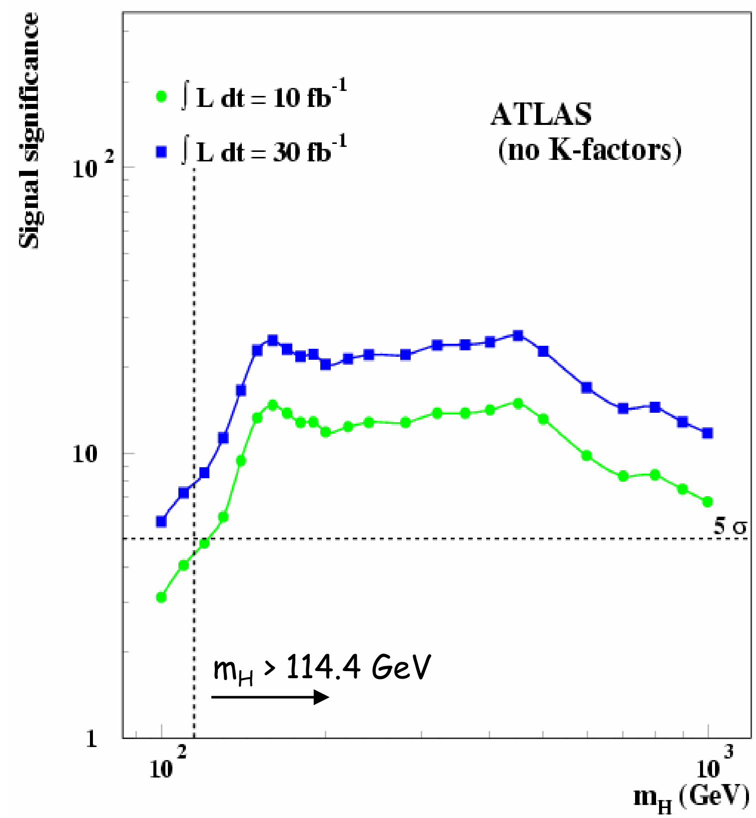
LHC; one experiment (CMS example)

10 fb^{-1} : 5 σ discovery combining all channels for M_H > 114 GeV;



The whole mass range for SM Higgs discovery at LHC





Tevatron data and experience are invaluable for success of Higgs searches at LHC !

Physics environment at the LHC is very similar to that at the Tevatron.
For LHC Higgs physics it is very important what Tevatron is doing with:

Tuning of min-bias and multiple interaction models with TeV data; uncertainties

Understanding of reliability and limitations of MC generators; uncertainties

Test of theoretical N…LO calculations; uncertainties.

Experimental methods and techniques for

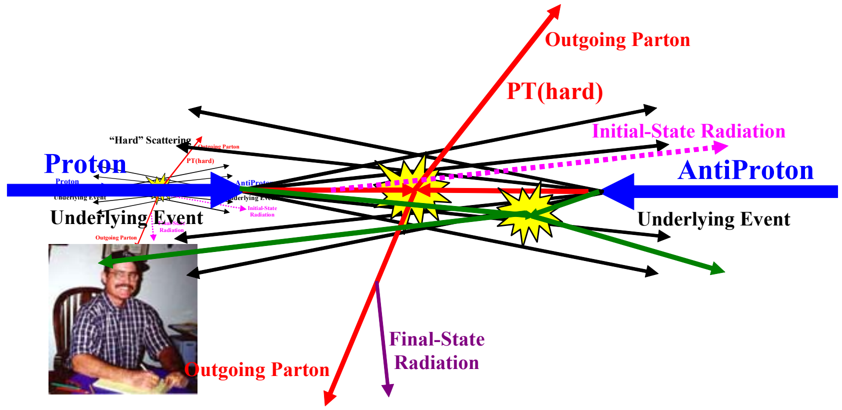
- measurement of background from the data
- measurement of b, τ tagging efficiency from the data
- measurement of jet -> e, γ, τ, b, c miss id efficiency from the data
- jets and missing E_T measurement; reconstruction, calibration

Understanding of the signal and background systematic; theory + experiment

I will go through these points giving some examples . . .

MC tuning on min-bias and UE data; propogate to LHC

R. Field



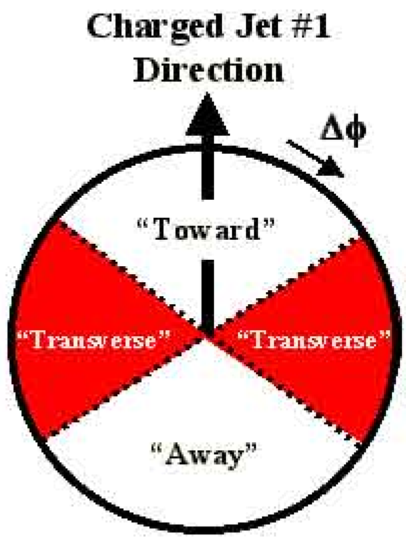
Pile up and underlying events affect :

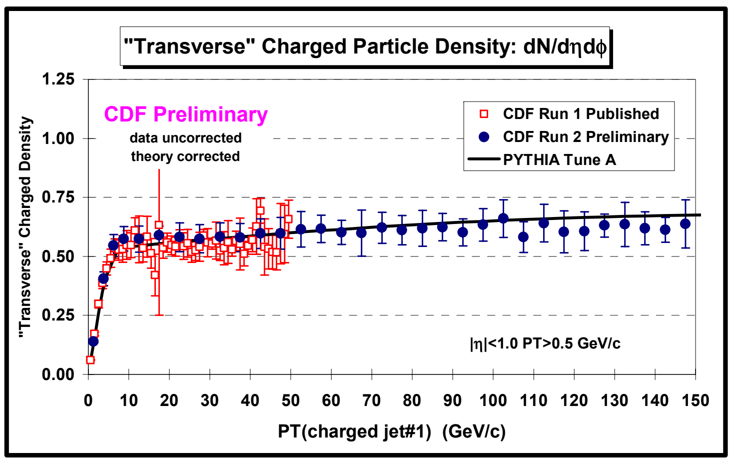
- isolation of γ, τ, e, μ
- jet energy reconstruction ("pedestal")
- jet veto
- forward jet tagging in VBF Higgs

Very important to understand uncertainties if efficiency can not be evaluated directly from the data

Current PYTHIA tunings (used in CMS production)

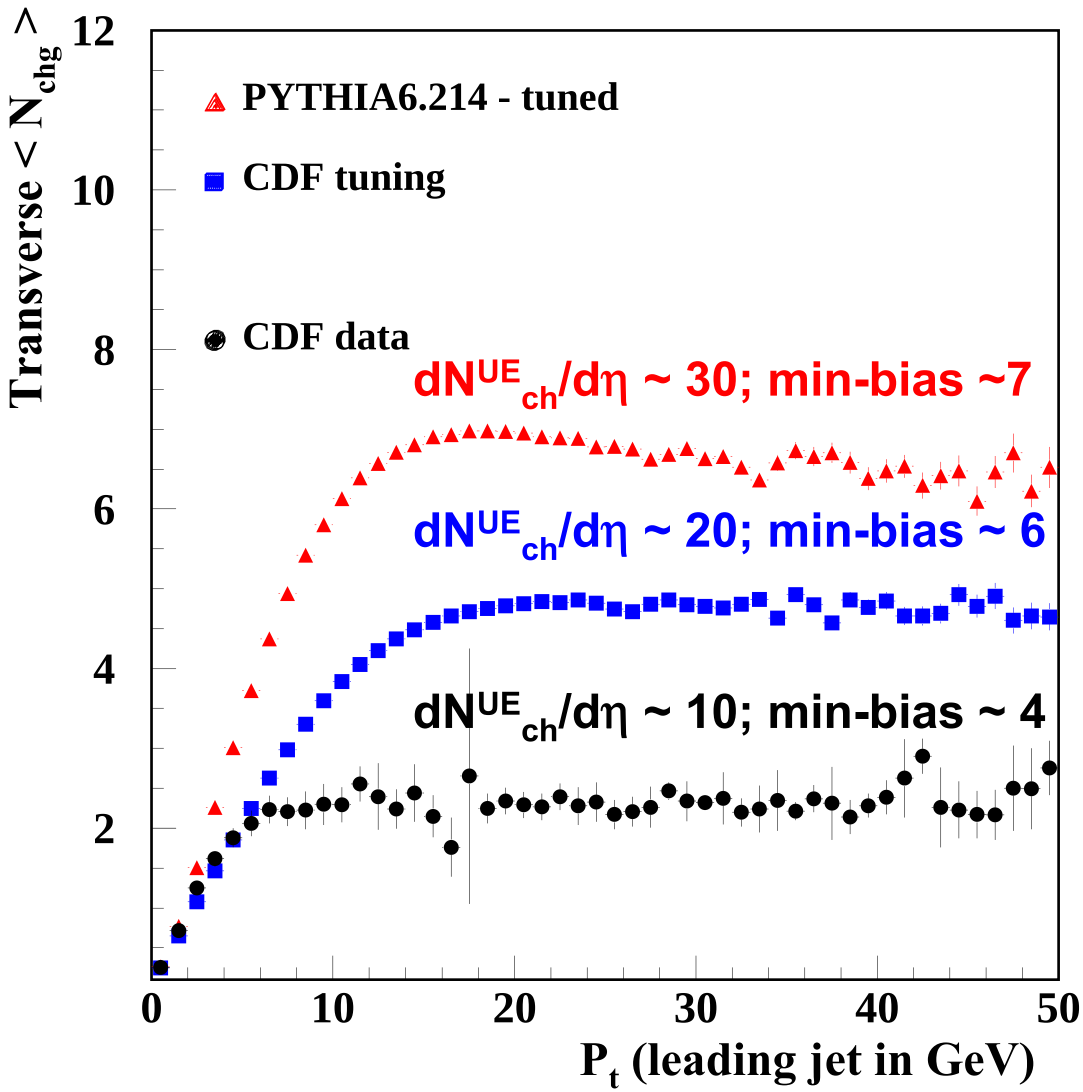
R. Field; CDF UE tuning method





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**

LHC predictions: PYTHIA6.214 (ATLAS tuning) vs. CDF tuning; different predictions !



NEW Multiple Interaction Model In PYTHIA 6.3 !

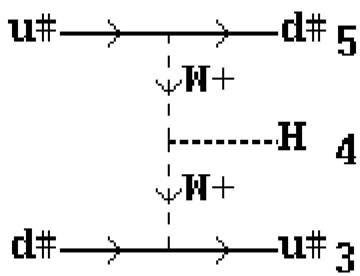
T. Sjostrand and P.Z. Skands
hep-ph/0408302

NEW JIMMY
JIMMY4.01 & HERWIG6.505

Talk of J. Butterworth & M. Seymor
HERA-LHC Workshop 01.06.04

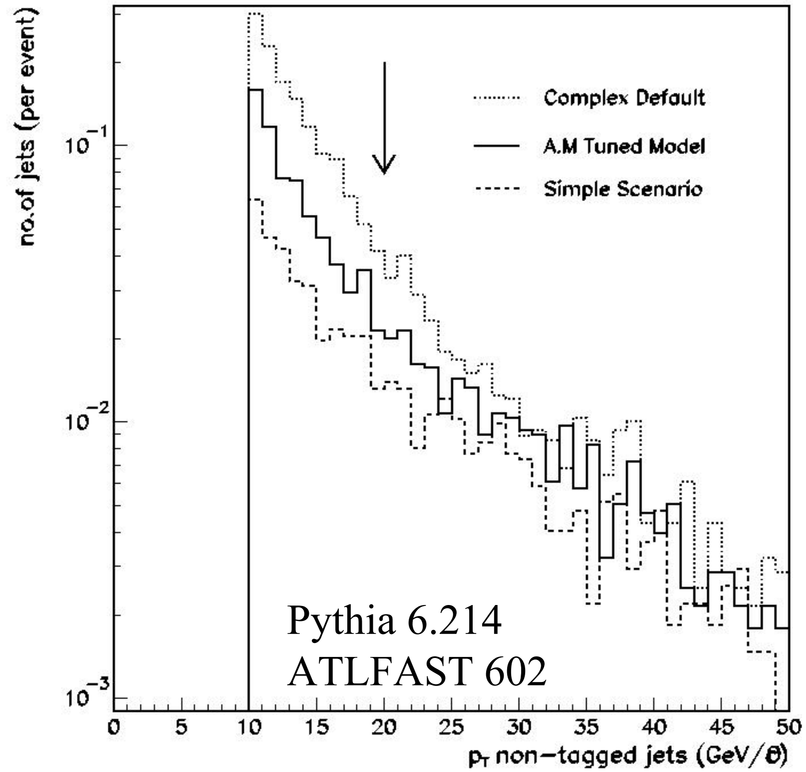
TUNNING . . . .

Effect of underlying event on central jet veto in VBF Higgs



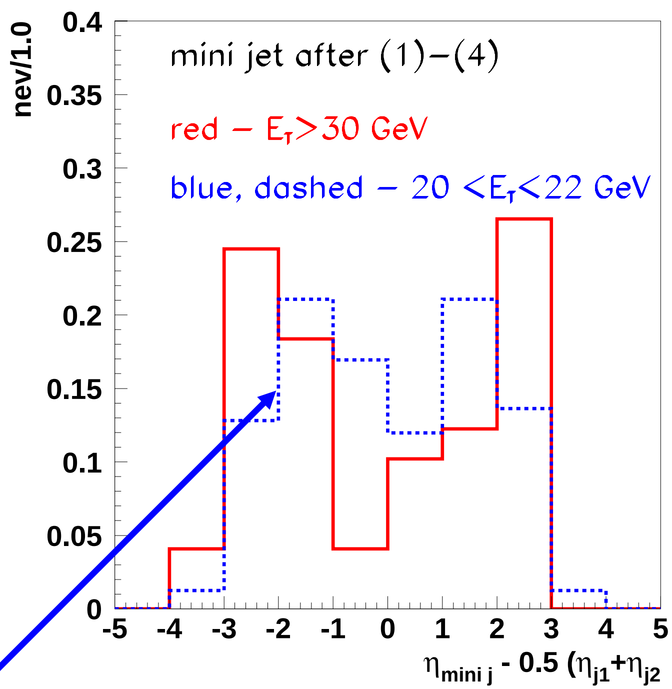
H->WW*->2l in qqH prod.

Uncertainty of the central jet veto efficiency due to UE model; ATLAS.



Model	CJV efficiency	Significance
Default pythia	85%	8.2
Default DG	75%	7.7
AM tuning	79%	7.9

Rapidity of the central jet in Higgs events; CMS; full simulation, L=2x10^{33}cm^{-2}s^{-1}

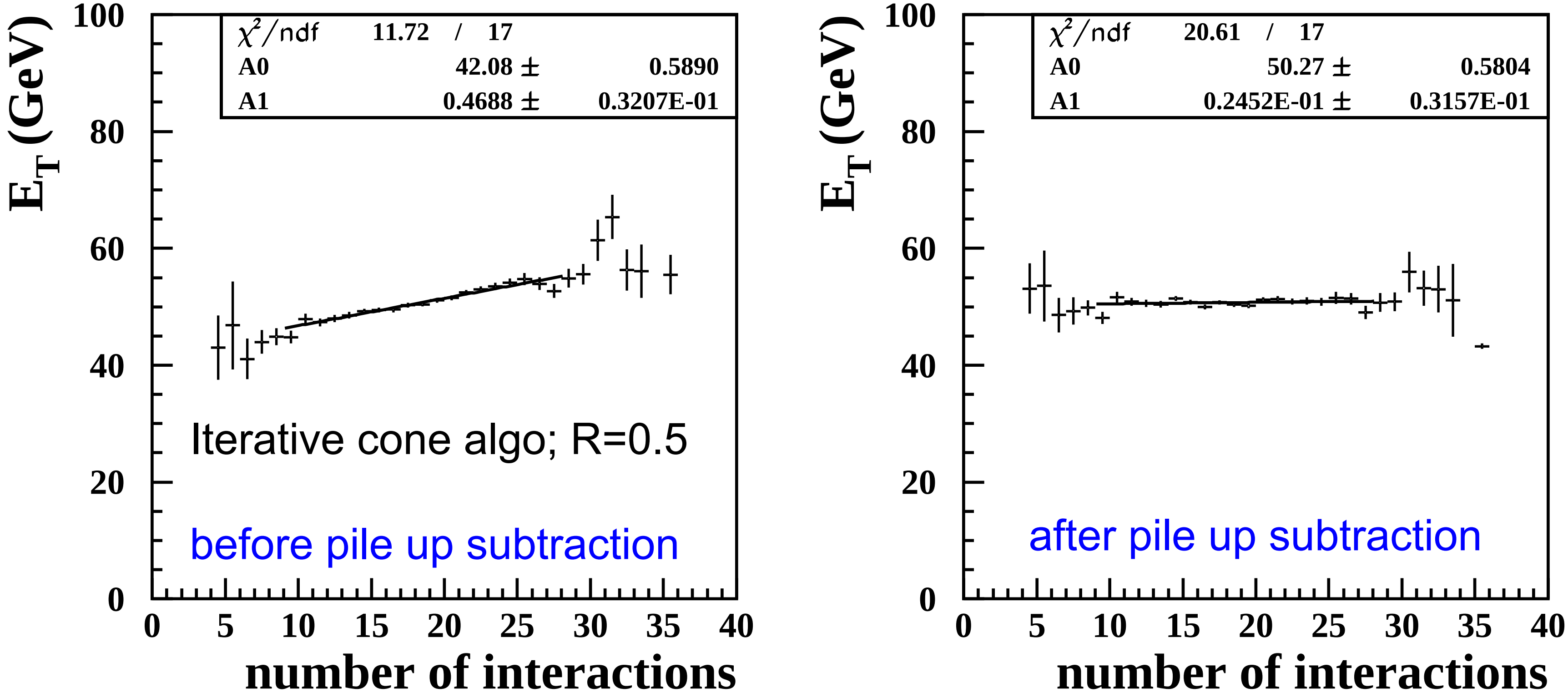


"bkg. like" behaviour for soft jets; fake jets: pile up+UE+detector

Can we avoid pile up effect on the jet energy reconstruction ?

Performance of CMS pile up subtraction algorithm (on event by event basis) for jet energy reconstruction at high ($L=10^{34} cm^{-2}s^{-2}$) luminosity.

Reconstructed energy of 50 GeV jets as a function of number of min-bias interactions



W/Z+nJets is very important background for Higgs at LHC

topology	Background for Higgs channel (one example)
W+1j+X	gg->WW*->2l (?)
W+2j+X	MSSM gg->bbH, H->ττ->*l*+jet (one b-tag)
W+3j+X	VBF qq->qqh, h->ττ->*l*+jet + 2 tag. jets
W+4j+X	VBF qq->qqh, h->WW->*l*νjj + 2 tag jets
Z+1j+X	MSSM gg->bbH, H->ττ->l+jet (one b-tag)
Z+2j+X	VBF qq->qqh, h->ττ->*l*+jet + 2 tag jets
Z+4j+X	VBF qq->qqh, h->ZZ->*ll*jj + 2 tag jets

Zbb,Zcc, Wbb, Wcc (W/Z+QQ+nj) are as important as W/Z+nj

W/Z rates at LHC

Z, W, tt cross sections and expected number of events after trigger in CMS with 10 fb^{-1}

channel, NLO σ x Br	Level-1 + HLT efficiency	events for10 fb^{-1}
W->e ν, 20.3 nb	0.25	5.1×10^7
W->μν, 20.3 nb	0.35	7.1×10^7
Z->ee, 1.87 nb	0.53	1.0×10^7
Z->μμ, 1.87 nb	0.65	1.2×10^7
tt~->μ+X, 187 pb	0.62	1.2×10^6

Very important to understand Z+nj, W+nj, tt~ as background for Higgs (and SUSY) searches

J. Campbell, R.K. Ellis, D. Rainwater hep-ph/0308195

W/Z+nJ+X NLO predictions at LHC with cuts :

$p_T^l > 15$ GeV
$|\eta l| < 2.4$
$p_T^j > 20$ GeV
$|\eta^j| < 4.5$
$\Delta R lj > 0.4$
$\Delta R ll > 0.2$

process	σ_{LO}	σ_{NLO}
$e^+\nu_e + X$	5670	6780^{+290}_{-130}
$e^-\bar{\nu}_e + X$	3970	4830^{+210}_{-90}
$e^+e^- + X$	803	915 ± 31
$e^+\nu_e\, j + X$	1660	1880^{+60}_{-50}
$e^-\bar{\nu}_e\, j + X$	1220	1420 ± 40
$e^+e^-\, j + X$	248	288^{+8}_{-7}
$e^+\nu_e\, jj + X$	773	669^{+0}_{-18}
$e^-\bar{\nu}_e\, jj + X$	558	491^{+0}_{-7}
$e^+e^-\, jj + X$	116	105^{+1}_{-5}

W/Z bb + X

$|\eta^b| < 2.5$

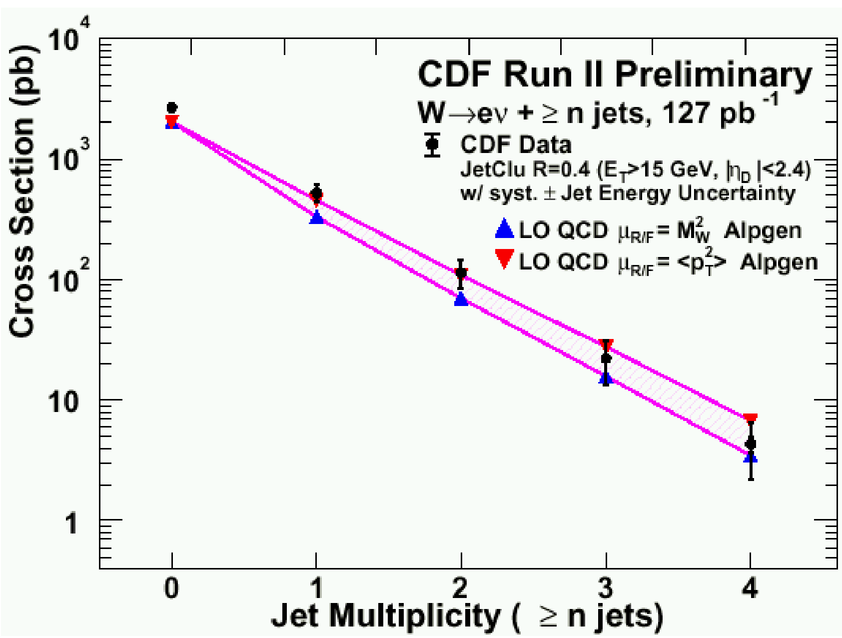
process	σ_{LO}	σ_{NLO}
$e^+\nu_e\, b\bar{b} + X$	$1.30^{+0.21}_{-0.18}$	$3.06^{+0.62}_{-0.54}$
$e^-\nu_e\, b\bar{b} + X$	$0.90^{+0.14}_{-0.12}$	$2.11^{+0.46}_{-0.37}$
$e^+e^-\, b\bar{b} + X$	$1.80^{+0.60}_{-0.40}$	$2.28^{+0.32}_{-0.29}$

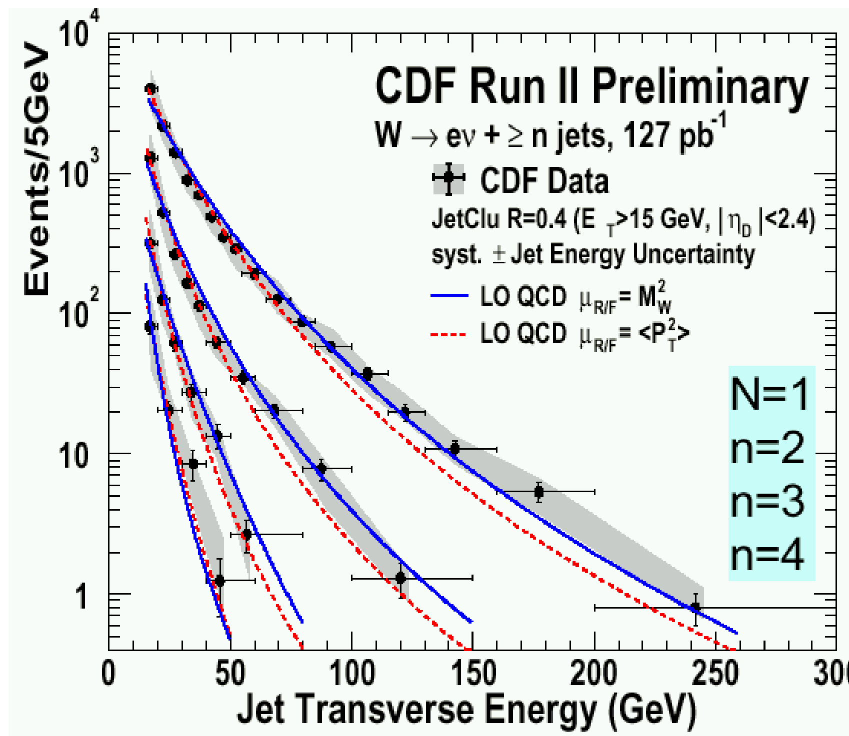
ME+PS Monte-Carlo verification with Tevatron date is crucial

- improve estimates of the background for Higgs studies
- test of theoretical calculations and MC generators :

ME + PS with HERWIG and PYTHIA (CKKW & MLM approaches)
S. Mrenna and P. Richardson hep-ph/0312274; LesHouches QCD group report, hep-ph/0403100.

ALPGEN + HERWIG works well . . .

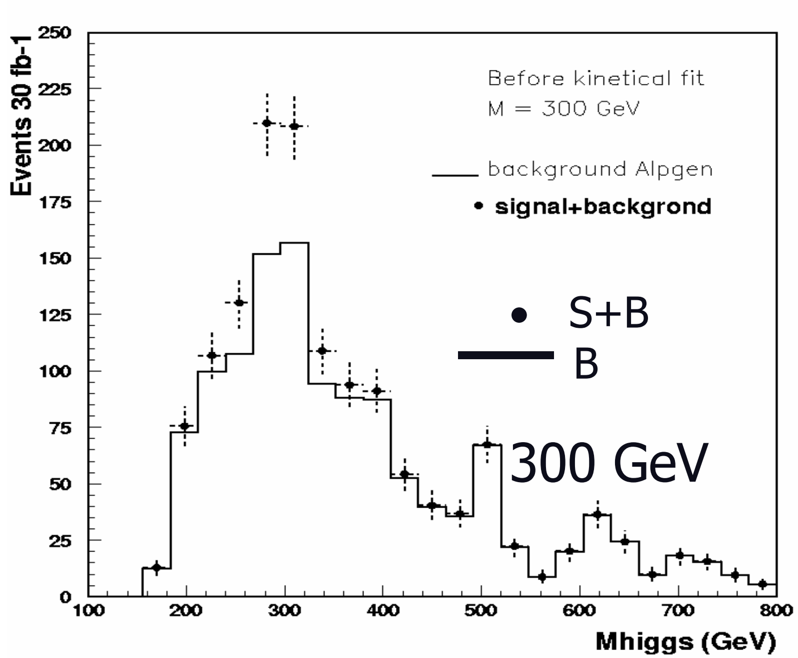




Example:

qq->qqh, h->WW->l jj+2tag jets

CMS; very preliminary, Jacopo Bernardini



M_{higgs} = 300 GeV

Number of events (30 fb^{-1})

Signal = 144

tt = 66

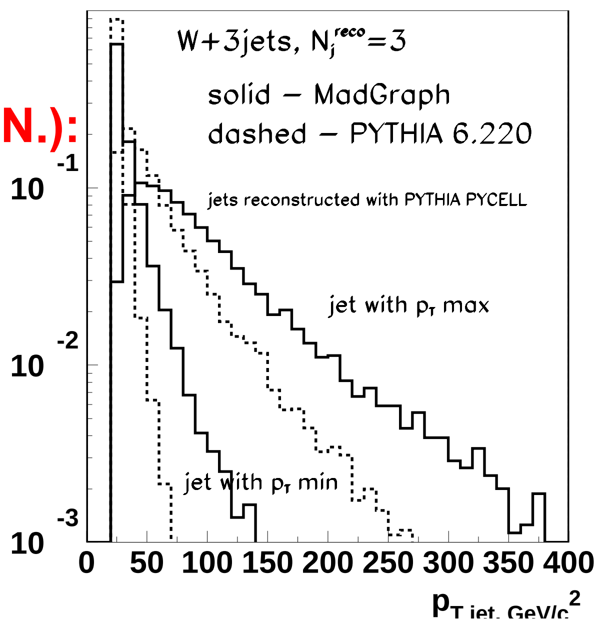
W+4jets^{ALPGEN} = 442; σ=6.4 (stat)

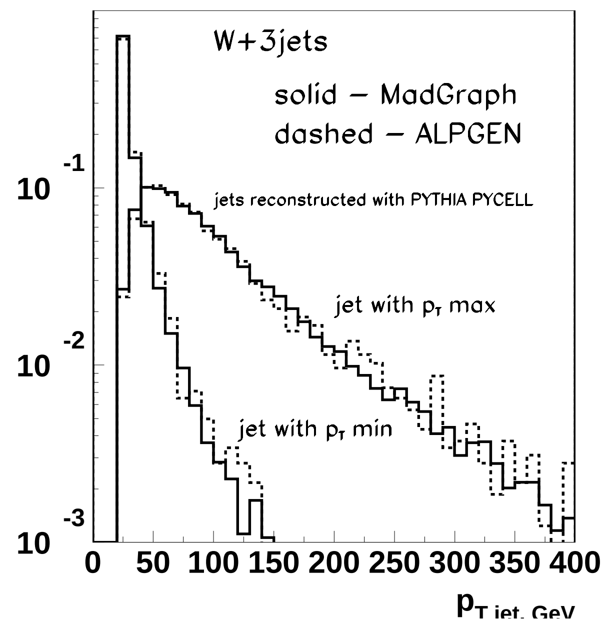
W+4jets^{PYTHIA} = 79; σ=12 (stat);

with 5% bkg. unc. σ=4.3; $\sigma = n_S/\mathrm{sqrt}(n_B)$

CMS home work (A.N.):

W+3jets with
- PYTHIA
- MadGrapg
- ALPGEN



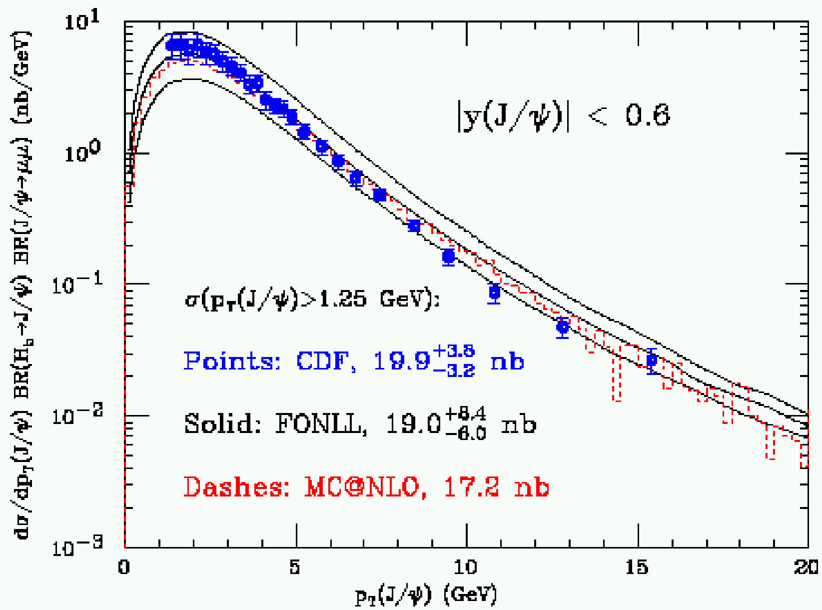


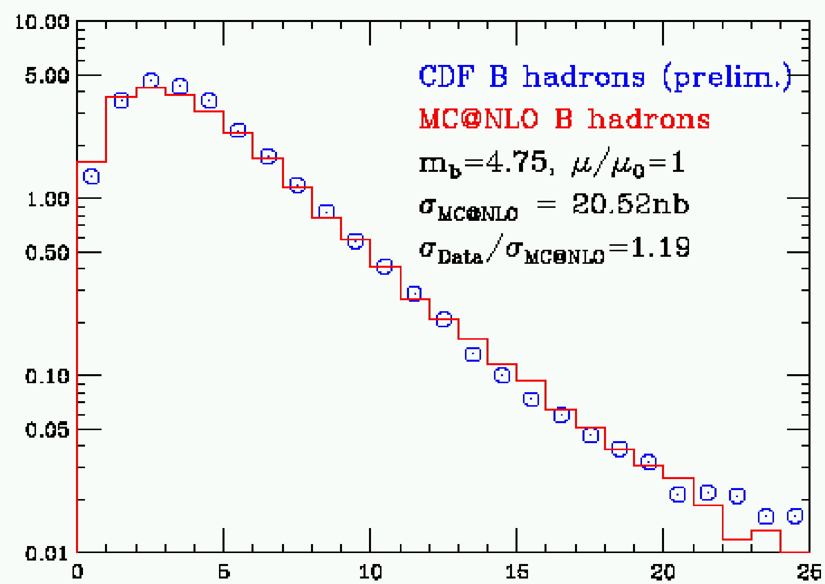
MCatNLO

S. Frixione and B. Webber JHEP 0206 (2002) 029, hep-ph/0309186
S. Frixione, P. Nason and B. Webber JHEP 0308 (2003) 07 [hep-ph/0305252]

Hadron-level Results on B production

$B \to J/\psi$ results from Tevatron Run II $\Rightarrow$ B hadrons (includes BR's)





No significant discrepancy!

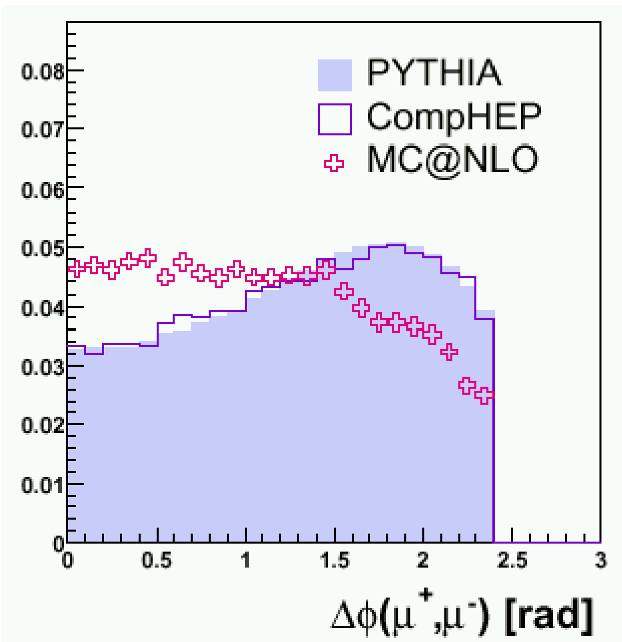
B. Webber talk on UK HEP Forum. April 2004

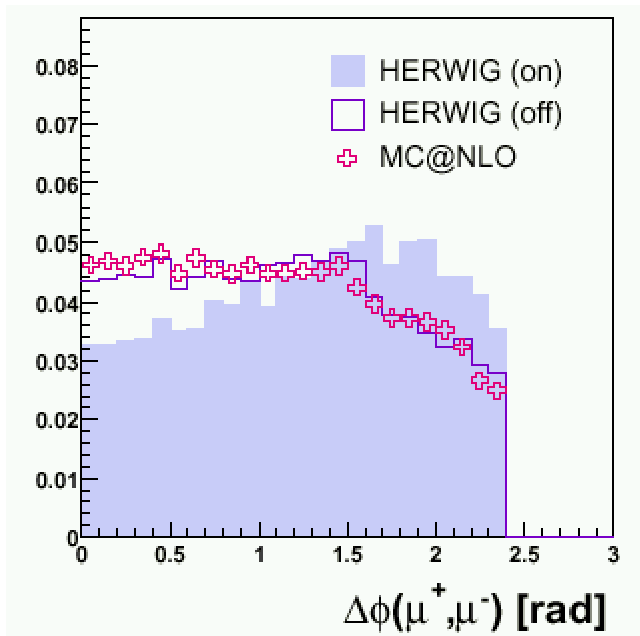
MCatNLO: is it ready for H->WW->2l analysis ?

pp->WW->$\mu^+\mu^-$ at LHC; $\Delta\phi_{ll}$

Important to include VV spin correlations in MCatNLO

V. Drollinger comparison (CMS)

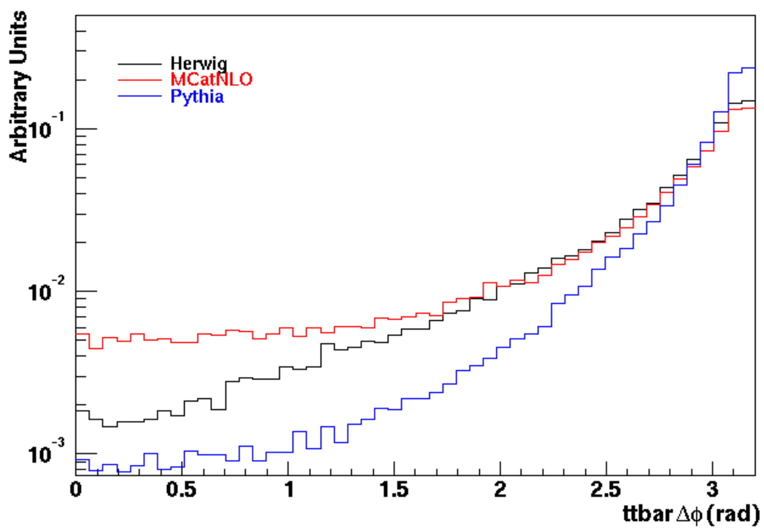


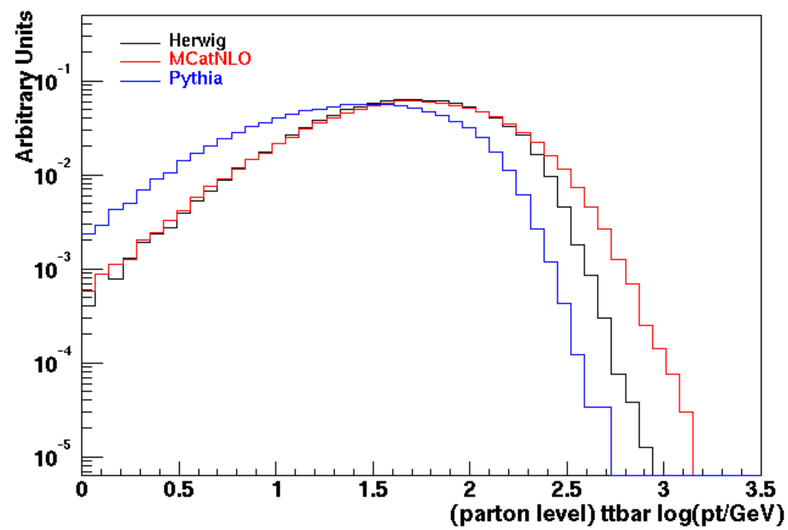


MCatNLO: pp->tt~ at LHC

Plots from S. Paganis talk on MC at LHC Workshop, CERN 2003

PYTHIA vs HERWIG vs MCatNLO comparison for LHC





Some points on top background for h->WW->analysis at LHC :

- tt~ spin correlations are not yet in MC@NLO; ~ 7% effect in h->WW->2l analysis
- both on-shell and off-shell contributions to top production are important after jet veto
- **σ_{NWA}(tt~) + σ_{NWA}(Wtb)** after cuts leads to large double counting

N.Kauer and D. Zeppenfeld arXiv:hep-ph/0107181

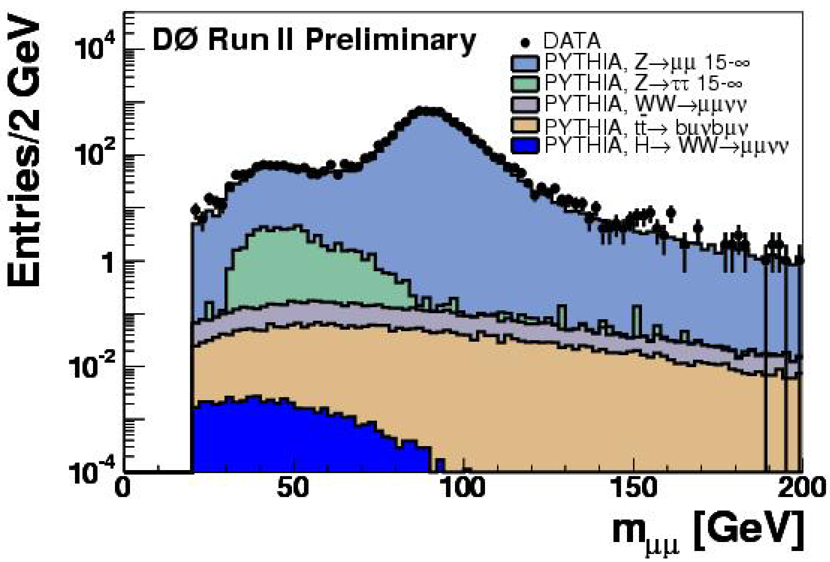
In the next slides I will go through a few selected analyses and a few selected points (biased view) where TeV can help (or already helped !)

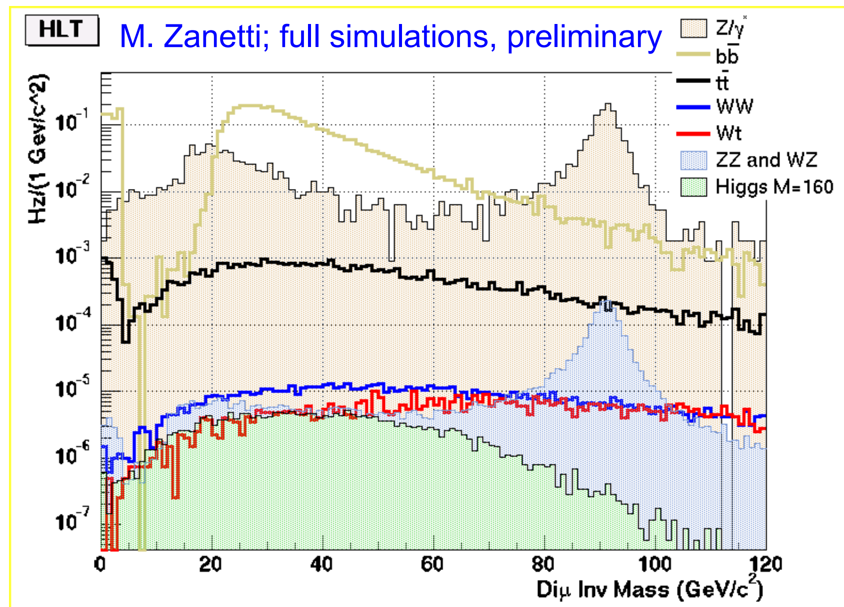
- **inclusive h->WW->2l**
- **inclusive h->$\gamma\gamma$**
- **tth, h->bb**
- **MSSM ggH, H->bb**
- **MSSM ggH, H->$\tau\tau$**

H->WW->2l analysis at TeV and LHC (I)

Tevatron data and MC (PYTHIA) **LHC (CMS) Monte Carlo (PYTHIA)**

M_H=160 GeV





<u>**Very similar event selections:**</u>

- cuts on lepton p_T
- cut on miss E_T, Z resonance veto
- jet veto against tt~
- $\Delta\phi$(ll) cut is particularly important; exploit spin correlations

Tevatron results

Number of events after selections

	ee	eμ	μμ
Observed	2	2	5
Expected	2.7±0.4	3.1±0.3	5.3±0.6

0.11 ev Higgs
Expected in SM

Dominant bkg. in eμ sample

WW	W+jets	WZ	tt
2.51±0.05	0.34±0.02	0.11±0.01	0.13±0.01

LHC "results" (tab. from old M. Dittmar, H. Dreiner analysis; 30 fb^{-1})

Higgs	WW	tt~	Wtb
879	376	64	146

From ATLAS analysis of K. Jakobs and T. Trefzger

W+jets / WW < 2 % !

WZ+ZZ / WW = 2 %

W+Jet background in H->WW->2l

Ratio of W+jets and WW backgrounds in Tevatron analysis is much bigger than in LHC analysis (CMS did not take into account W+jet)

It can not be explained by difference in cross sections at TeV and LHC :

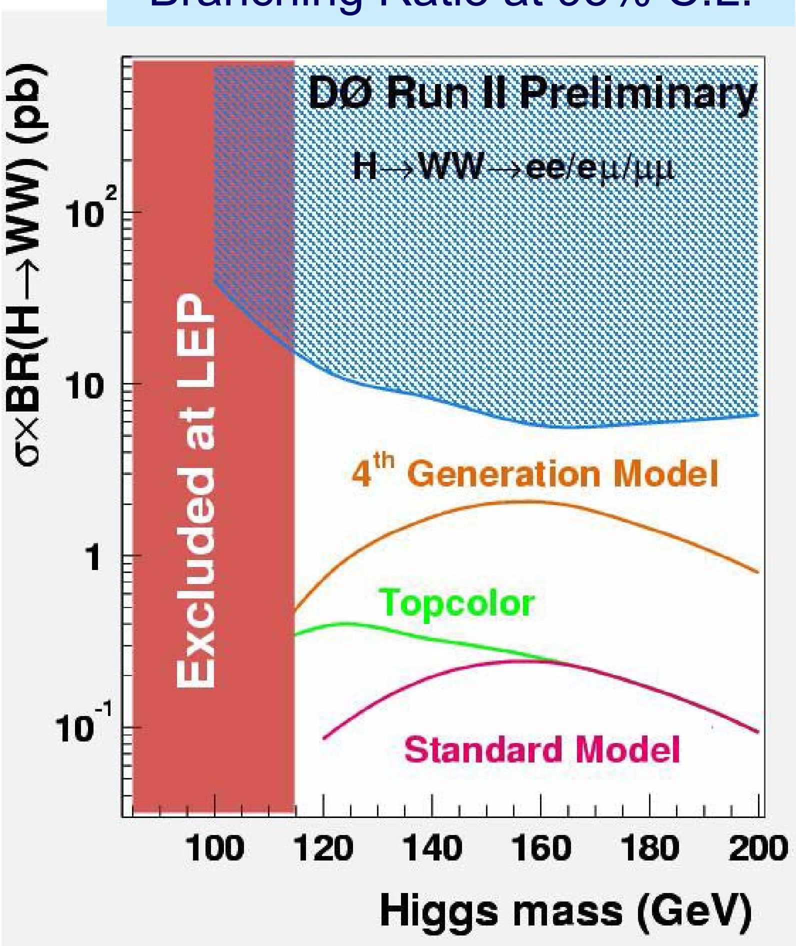
σ, pb	W	WW	WW / W
LHC	1.65×10^5	74	4.5×10^{-4}
TeV	1.80×10^4	8.4	4.7×10^{-4}

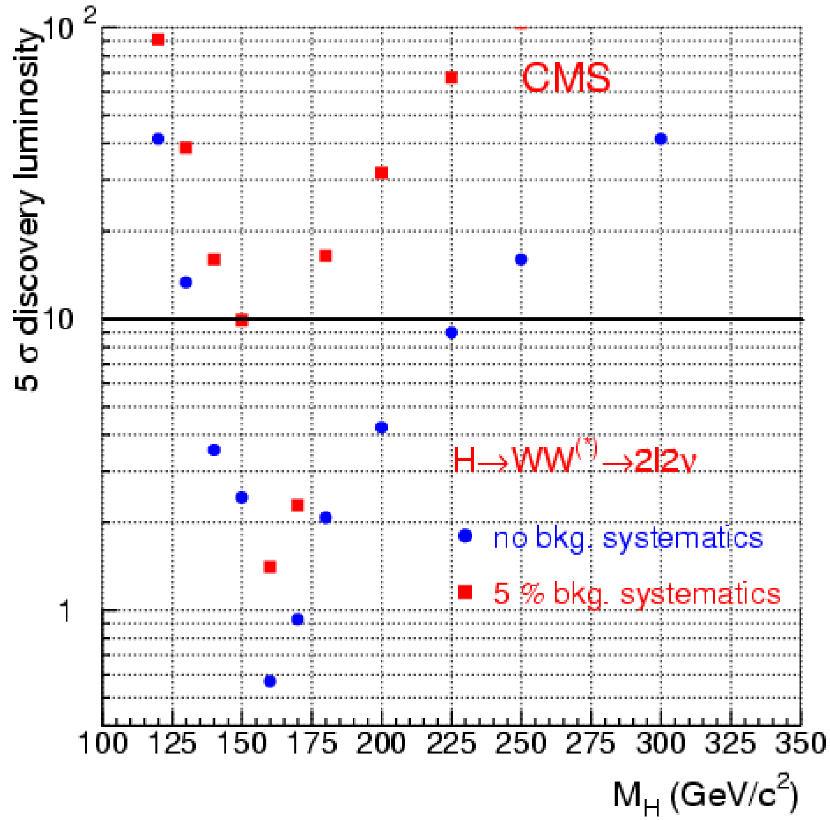
Calculated by E. Boos, CompHEP (LO); $Q^2 = M_W^2$, CTEQ6l1

LHC should check W+jets bkg. with realistic simulation of jet->e miss id.

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; learn systematic from Tevatron analysis

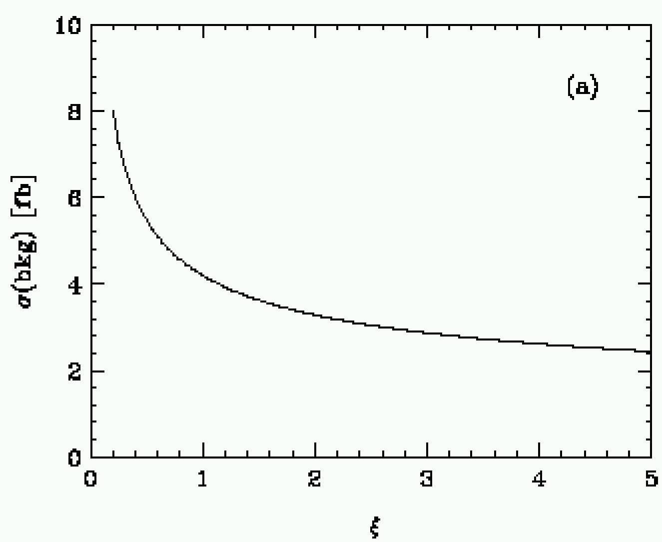
Possible way to estimate WbWb background for h->WW->2l at LHC:

prospects for **tt~** bkg. uncertainty in h->ww->2l; extrapolation method

N. Kauer. hep-ph/0404045: ATLAS/CMS cuts (parton level) + $\varepsilon_{b\text{-tag}}$

method (D. Zeppenfeld, N. Kauer) : $N_{bkg} = (\sigma_{bkg}\, \varepsilon_{bkg} / \sigma_{ref}\, \varepsilon_{ref})\ N_{ref}$

WbWb scale uncertainties (LO):
$\mu_F = \mu_R = \xi\, m_t$

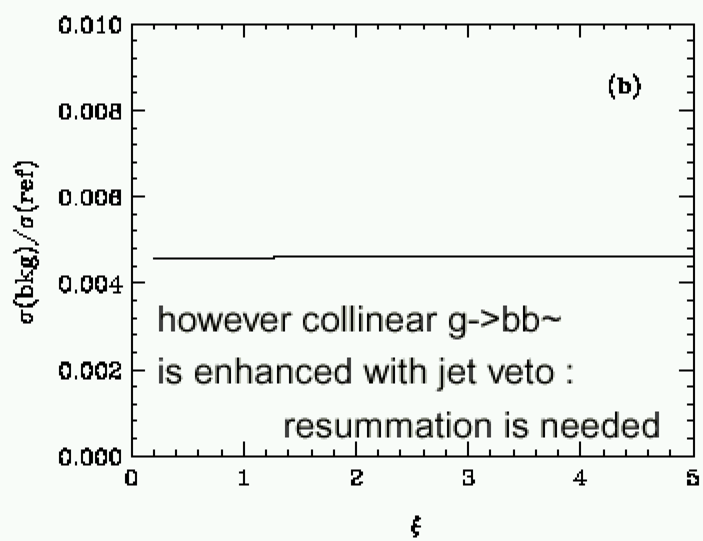


- stat error (N_{ref}) ~ < 1 % (> 10 fb^{-1})
- σ_{bkg} / σ_{ref} (scale) < 1 %
- σ_{bkg} / σ_{ref} (pdf) ~ 3 %

σ_{bkg} / σ_{ref} scale uncertainties (LO):

reference selections :

- no jet veto E_T > 20 GeV, η < 3
- at least one b jet
- the rest select. are the same



H->WW->2l: from discovery to cross section measurement at LHC

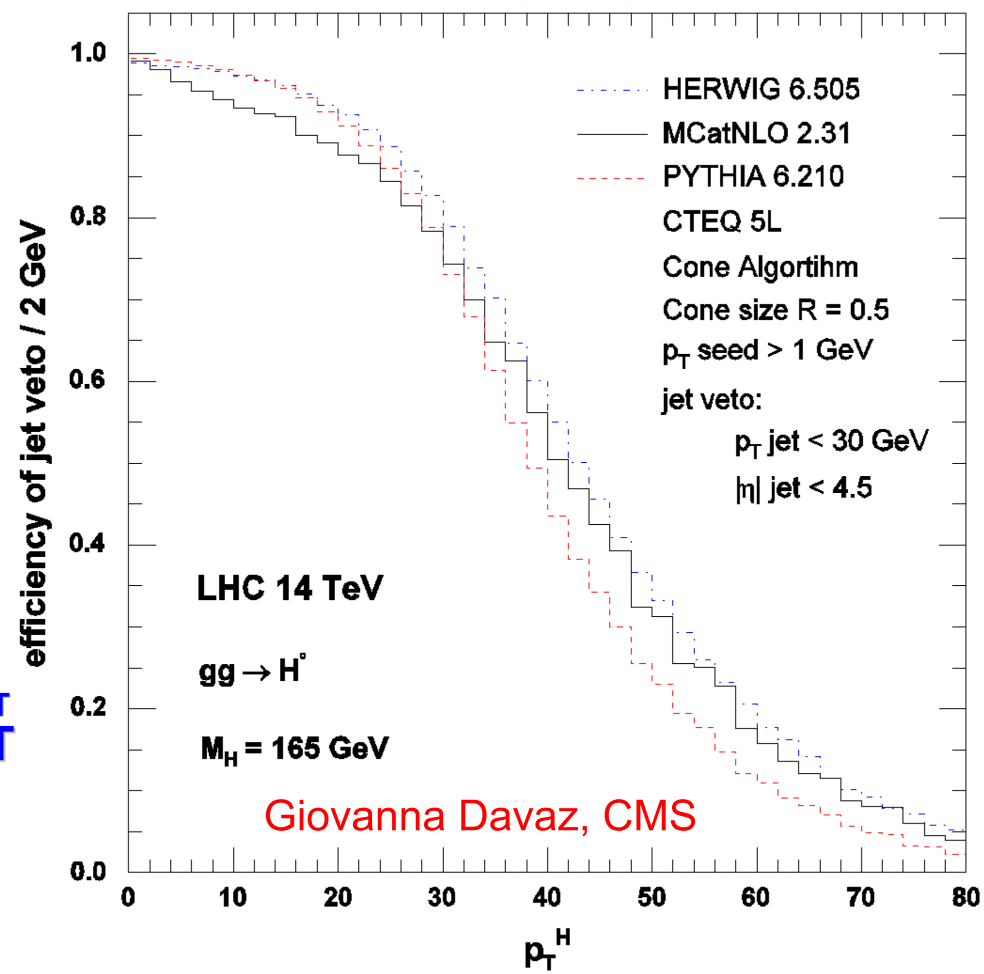
For cross section measurement signal systematic becomes as important as background one.

Monte Carlo systematic may be significant due to Jet Veto

Effect of UE model was shown already.

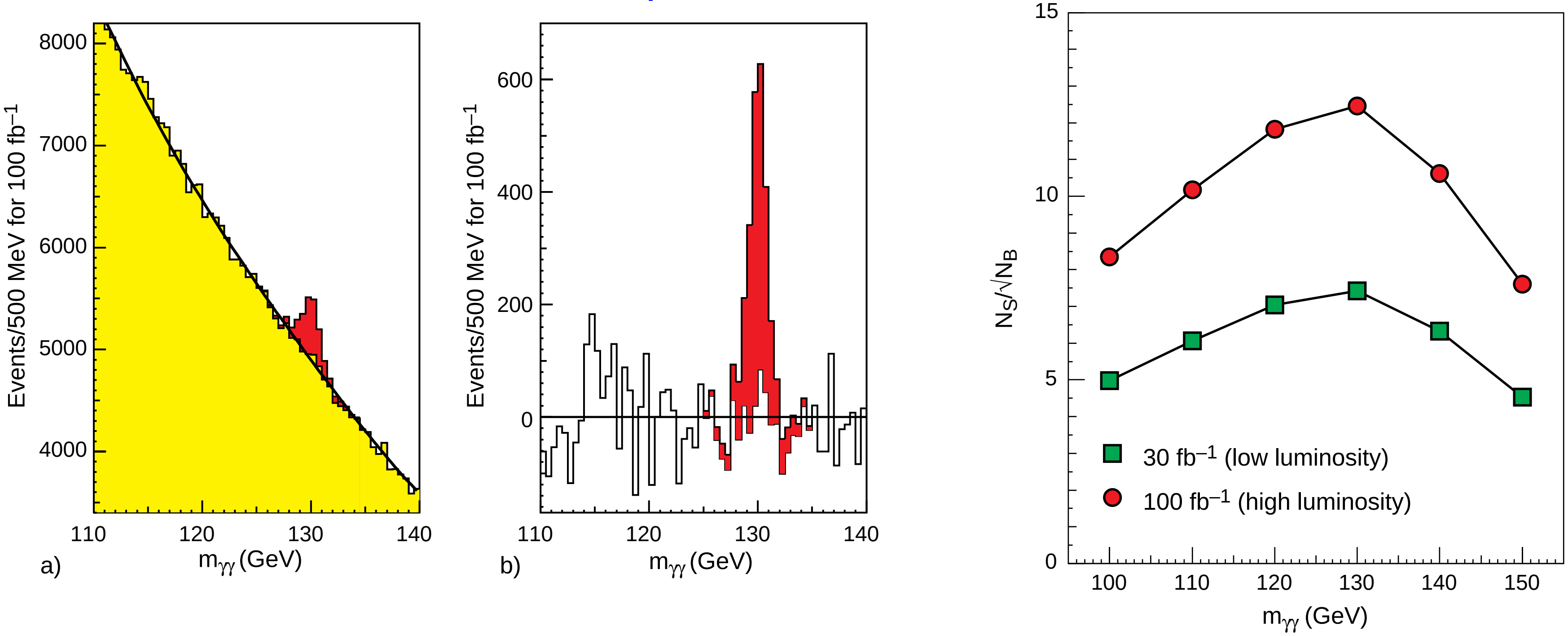
This plot shows efficiency of Jet Veto as a function of Higgs p_T for different generators WITHOUT multiple interactions.
Uncertainty is ~ 10 %

Jet veto efficiency at generator level



H->2γ: how TeV can help ?

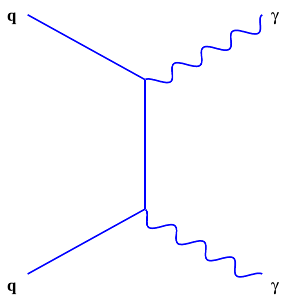
CMS plots. K factors included

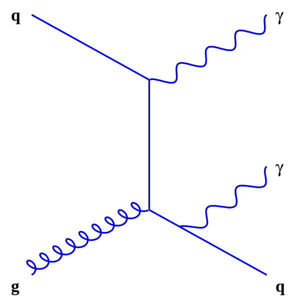


Background under mass peak will be obtained from the data, but background predictions at LHC can be evaluated today from comparison and tuning of NLO Monte Carlo with TeV data

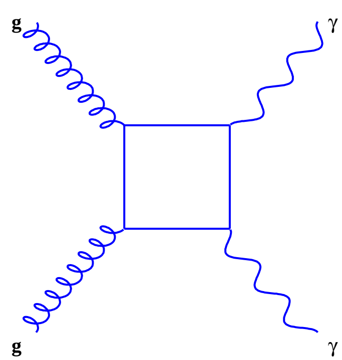
$M_{\gamma\gamma}$ at Tevatron: data comparison with PYTHIA and DIPHOX

In CMS we use K factors
obtained from comparison
of PYTHIA with DIPHOX
after “experimental” selections
for different backgrounds:

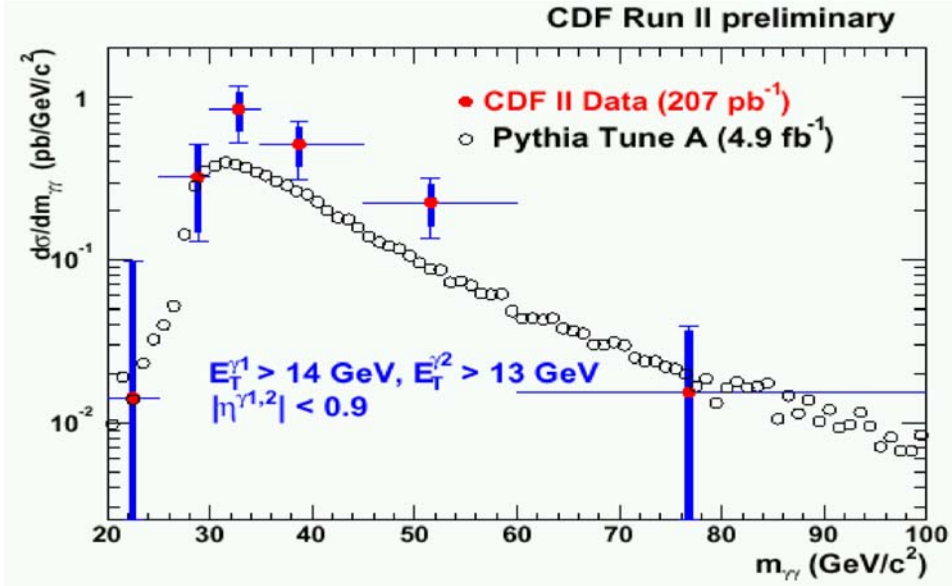


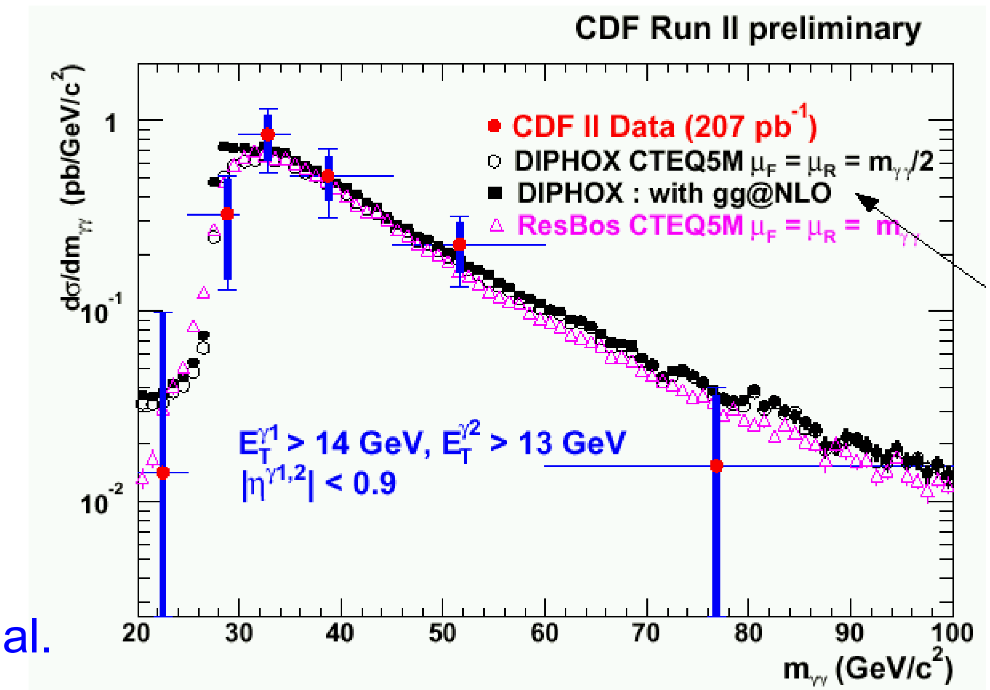


pp->γ”π⁰”
pp->”π⁰π⁰”



Box: K from Dixon et al.





Composition of the background for LHC. CMS case: full simulation study by S. Shevchenko, T. Lee, V. Litvin, H. Newman (preliminary). PYTHIA K factors from:

T. Binoth et al., Les Houches 2001; hep/ph-0203316

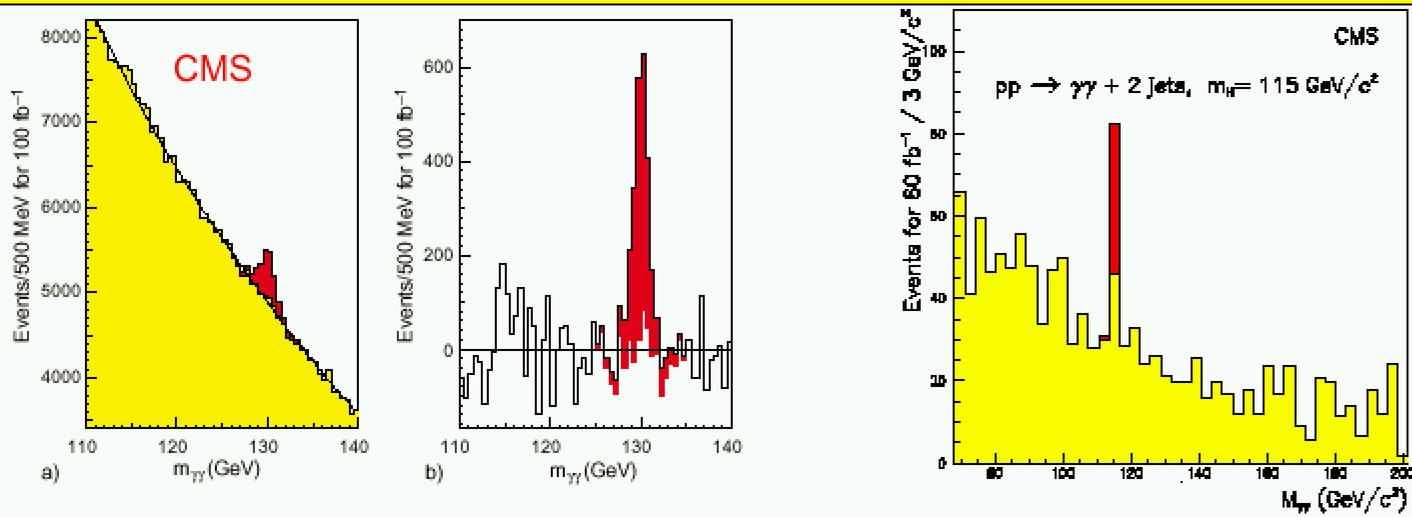
T. Binoth, K. Lassila-Perini (CMS), Les Houches 2003; hep-ph/0403100

Z. Bern, L. Dixon, C. Schmidt, Phys. Rev. **D 66** (2002) 074018

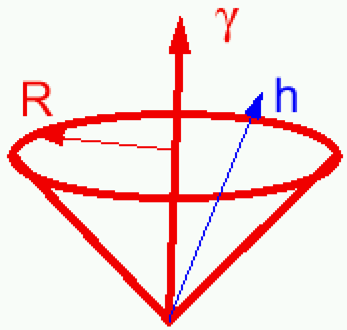
Table 6: Remaining background in fb/(GeV/c^2) at different mases. The recently calculated next-to-leading order corrections to background cross sections are included. The numbers, shown in brackets, do not include the next-to leading order corrections. The γ + jets background is splitted into two parts: i) the part of the background, which contains two real photon in the final state and ii) the part of the background, which contains one real photon and one fake photon in the final state.

Background	110 GeV/c^2	120 GeV/c^2	130 GeV/c^2	140 GeV/c^2	150 GeV/c^2
QCD pp->jj	35.6 (35.6)	40.9 (40.9)	32.0 (32.0)	21.4 (21.4)	14.2 (14.2)
γ + jets two real photons	67.1 (40.4)	51.6 (31.1)	36.3 (21.8)	27.9 (16.8)	13.9 (8.4)
γ + jets one real + one fake photons	60.6 (60.6)	46.6 (46.6)	32.8 (32.8)	25.2 (25.2)	12.6 (12.6)
Gluon fusion	43.4 (36.2)	32.5 (27.1)	24.0 (20.0)	17.3 (14.4)	11.3 (9.4)
Quark annihilation	55.1 (36.7)	45.6 (30.4)	37.1 (24.7)	30.0 (20.0)	21.0 (14.0)
Total	262	217	162	122	73

Background from “side bands”. But how to compare with analytical NLO ?



need to match theoretical and experimental definitions for isolation ?



1. smooth cone isolation (S. Frixione, hep-ph/9801422)

$E_T < p_T(\gamma)\, \varepsilon\, [(1\text{-}\cos r\,)/(1\text{-}\cos R)]^n$, $r < R$

2. “standard” theor. cone isolation

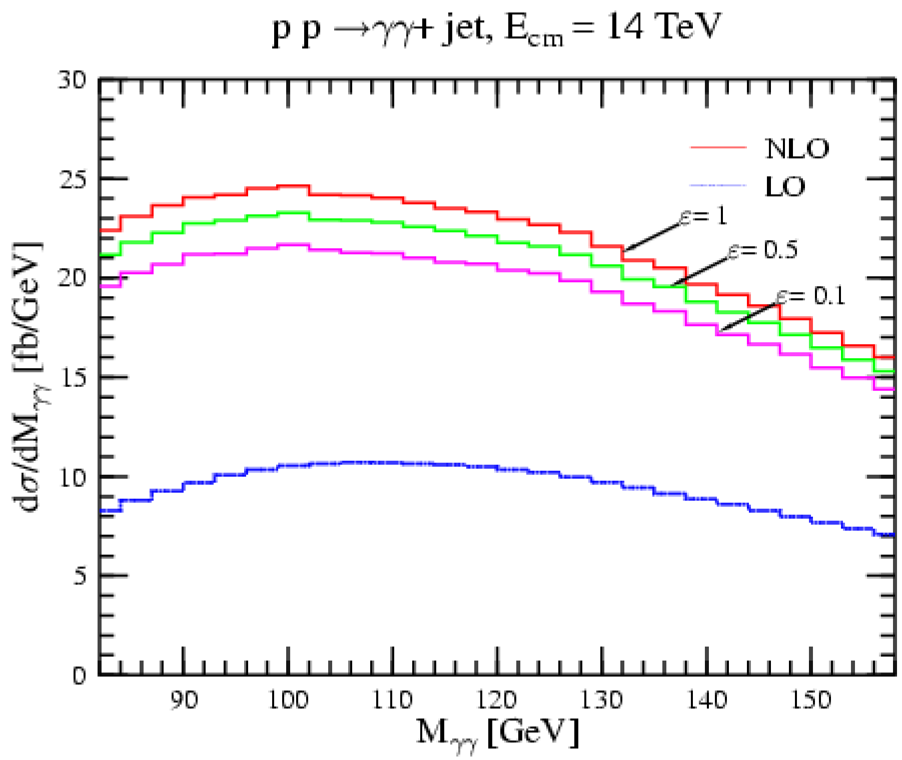
$E_T < E_T^{cut}$ inside cone R

3. “standard” exp. cone isolation (CMS / ATLAS)

no tracks p_T > 1-2 GeV/c inside cone R

E_T in calorimeter inside cone R < E_T^{cut}

NLO γγ+jet background for h->γγ + jet topology using smooth isolation



V.Del Duca et al, hep-ph/0303012

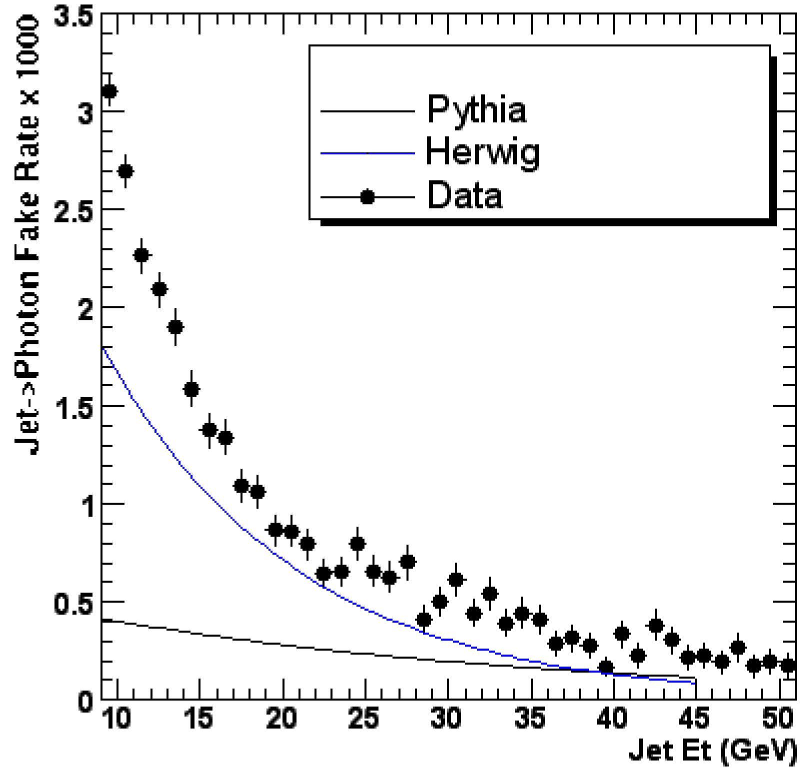
Would be problematic to compare directly with the background data, since at Level 1 and High Level trigger for 2γ stream the different isolation criteria has been already optimized in CMS using PYTHIA as bkg. (and signal) generator

Photon Fake Rate from data

- Rate of jets with leading meson (pi0, eta) which cannot be distinguished from prompt photons: Depends on
  - detector capabilities, e.g. granularity of calorimeter
  - Cuts!
- Systematic error about 30-80% depending on Et
- Data higher than Pythia and Herwig
- Pythia describes data better than Herwig

B. Heinemann. UK Forume, April 2004

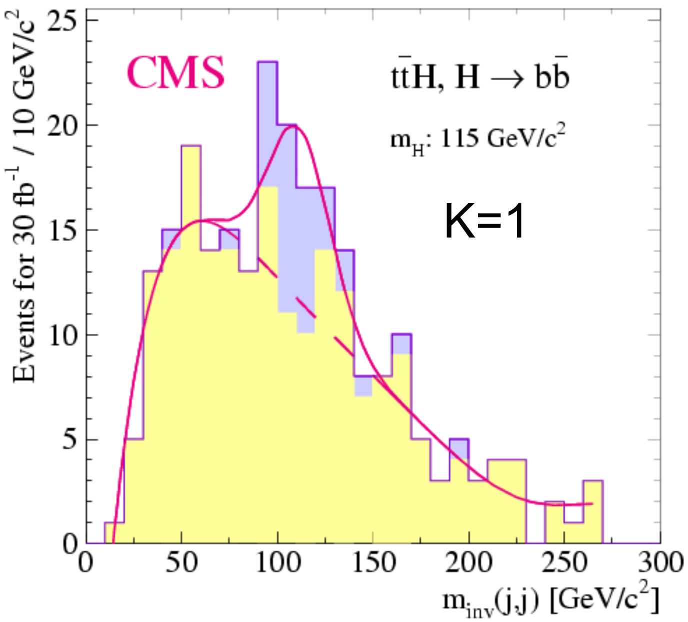
CDF (preliminary result)



At TeV Jet->γ miss ID is obtained from γ+jet data.
We should evaluate how does it work with LHC detectors

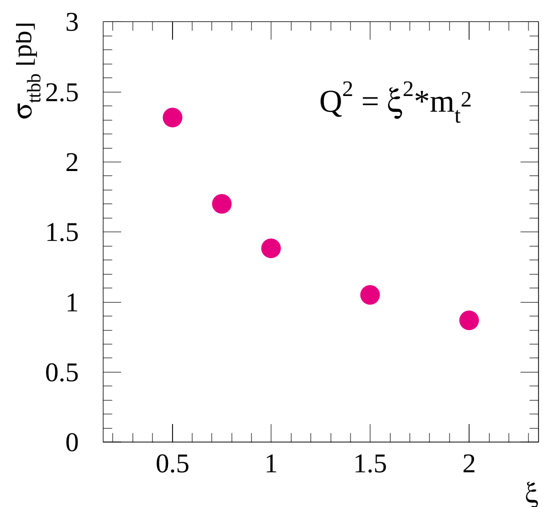
“Difficult channel”: tth, h->bb

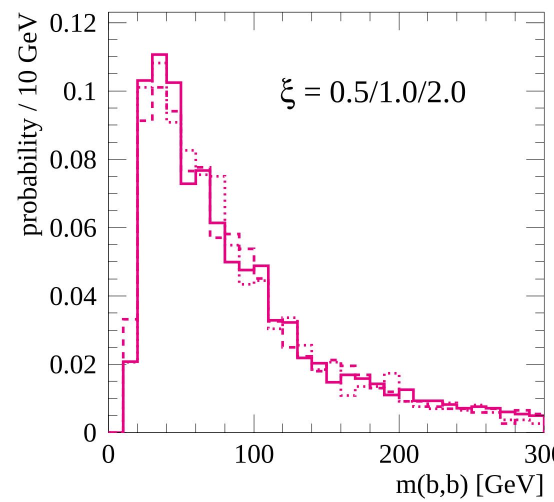
NLO tth from M. Spira et al., hep-ph/0107081



Backgrounds:
ttb, ttjj, Ztt from LO CompHEP
ttbb is dominant after selections

ttbb (and ttjj) predictions at LO has very big scale uncertainties ~ factor 2.
V. Drollinger , Les Houches 2003; ALPGEN
$Q^2=m_t^2$, CTQ5L, $p_T(b)>25$ GeV, $|\eta|< 2.4$, $\Delta R(bb) > 0.4$





ttbb shape is not affected by scale change, BUT additional jets (at NLO) can give different combinatorics which could change the shape

NLO predictions for ttbb and ttj(j) is very desirable;
NLO ttj(j) can be verified by Tevatron data

tt~ + nJet Production Rates at Tevatron

(Elizabeth Graves , DO; talk on CMS Higgs meeting)

- Alpgen production results

Cross-section (pb)			
	t tbar +		
	0 jets	1 jet	2 jets
TeV	**6.08**	**3.08**	**1.44**

- Expected number of events in W→ lν channel

Tevatron: L=5fb^{-1}

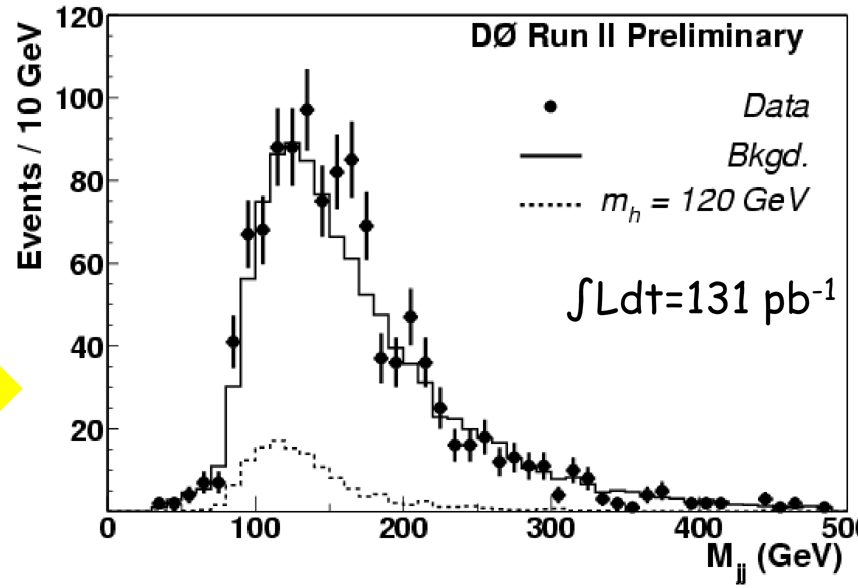
Number of produced events			
	t tbar +		
	0 jets	1 jet	2 jets
TeV	**4408**	**2236**	**1041**

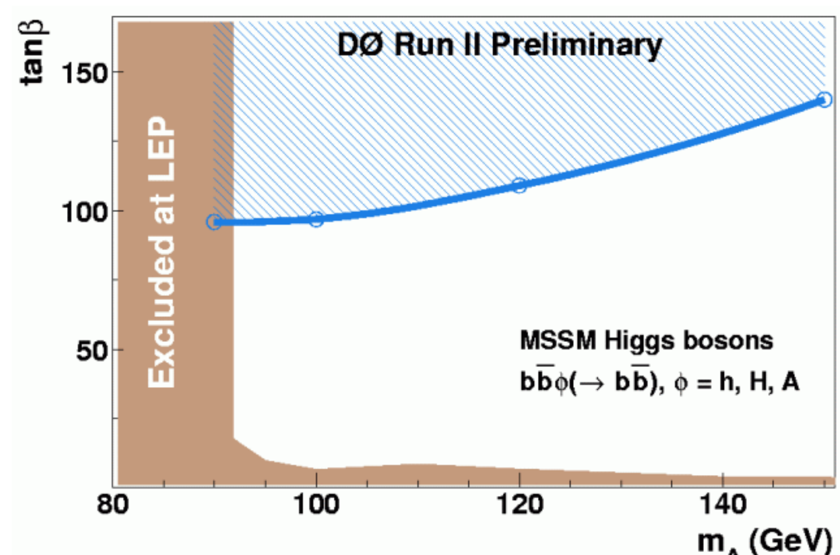
Take care :

qq->tt dominates at Tevatron, gg->tt dominates at LHC
same FSR, but different ISR

D0: MSSM bbH, H->bb at high tanβ

- Event Selection:
  - At least 3 jets:
    E_T cuts on jets optimized for different Higgs mass values
  - ≥ 3 b-tagged jets
- Look for signal in the invariant mass spectrum from the two leading b-jets
- Main Background:
  - QCD multi b-production
  - Difficult for LO MC: determined from data and/or ALPGEN 1.2
- Signal acceptance about 0.2-1.5% depending on Mass





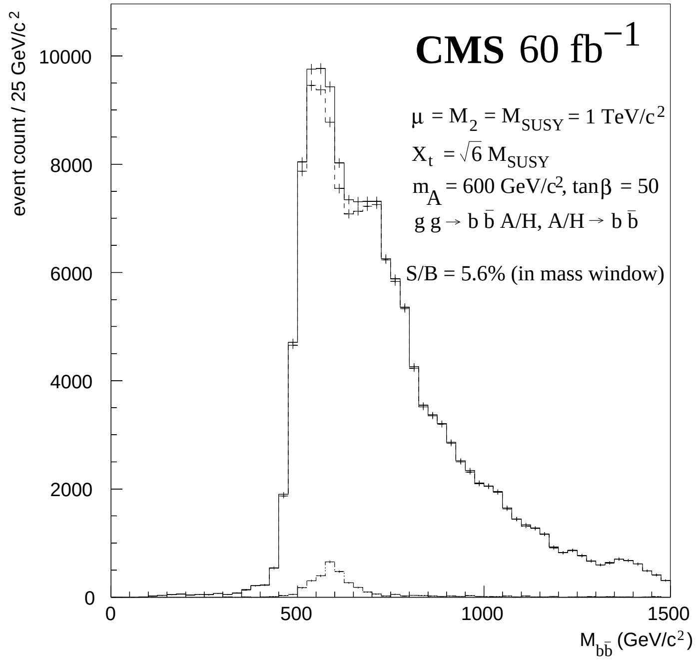
From Beate Heinemann talk at UK Forum, April 2004

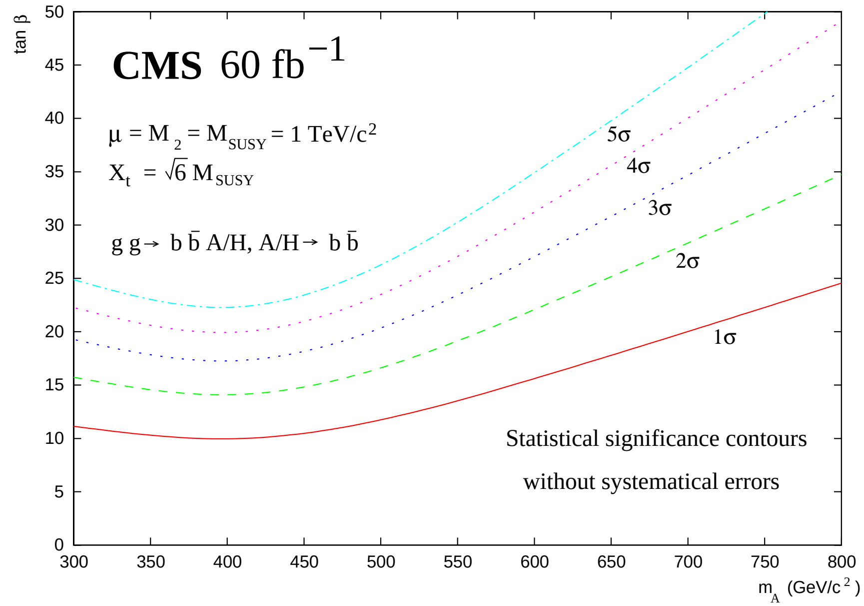
CMS: MSSM bbH, H->bb at high tanβ

Level 1 multi-jet trigger : 1J or 3J or 4J ; thresholds 177, 86, 70 (95% eff) => 3 kHz
HLT – single b tagging for next-to-leading jet E_T > 160 GeV => 5 Hz

Off-line selections are similar to D0 : two hard jets (E_T > 220 GeV for M_H=600 GeV)
two soft jets E_T > 20 GeV
>= 3 b tagged jets

PYTHIA simulations

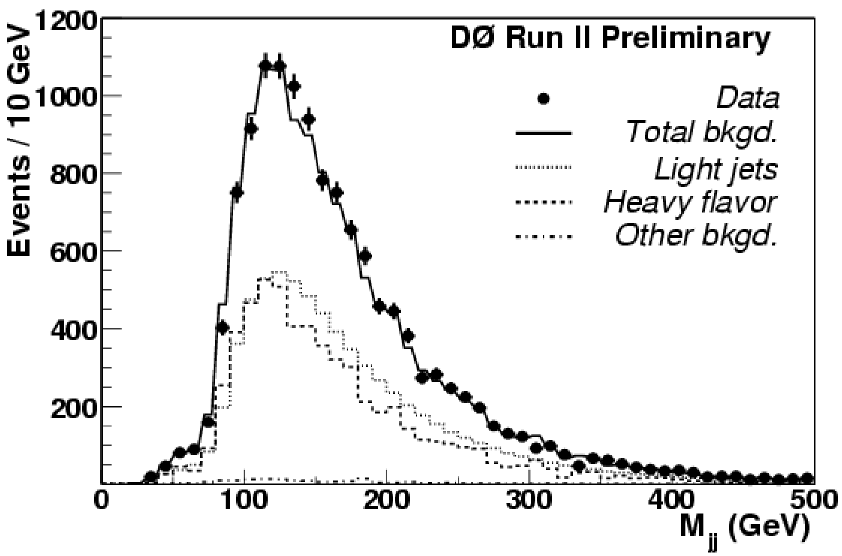


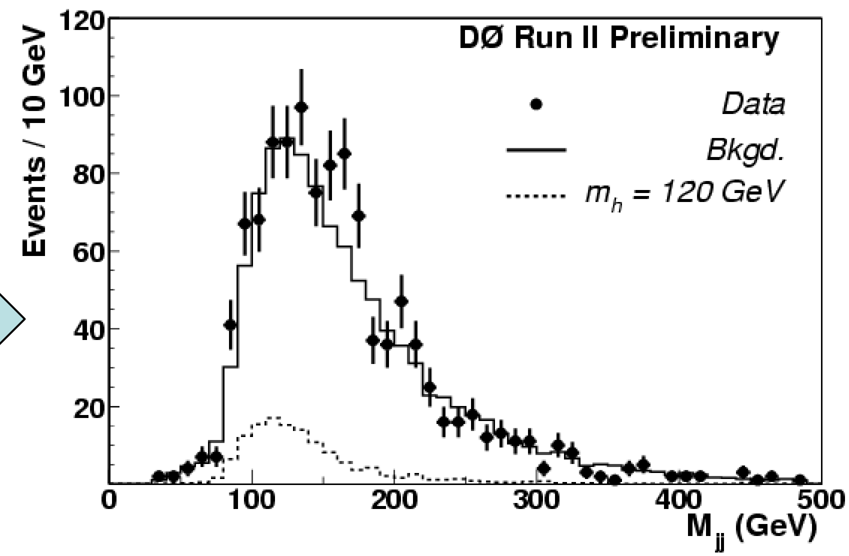


Common question : how to evaluate background shape ?

… learning D0 way …

From the double b-tagged data to triple b-tagged data background





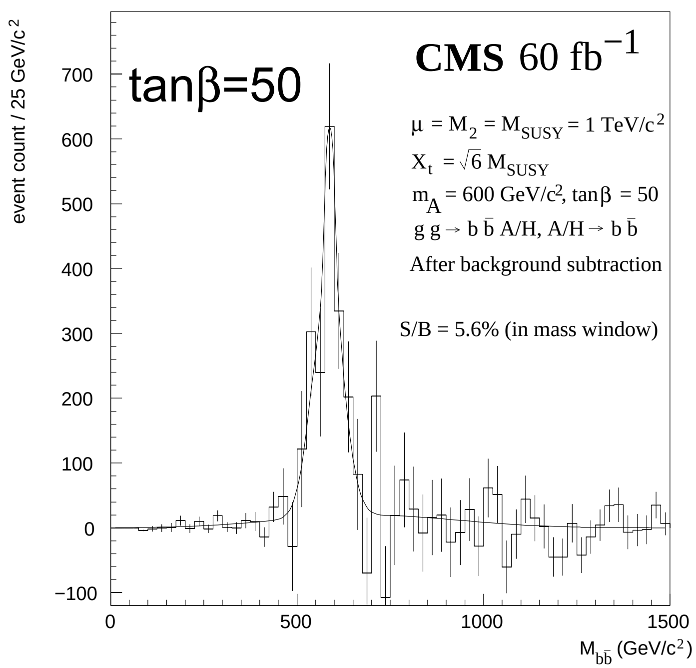
"The shape of the triple b-tagged data was estimated from double b-tagged data and extrapolated using a **tag-rate-function** derived on the multi-jet data sample. This background was then normalized to the triple b-tagged data outside 1 σ signal mass window" from the D0 Higgs results page

Can it be applied at LHC ? Background composition should be different at LHC

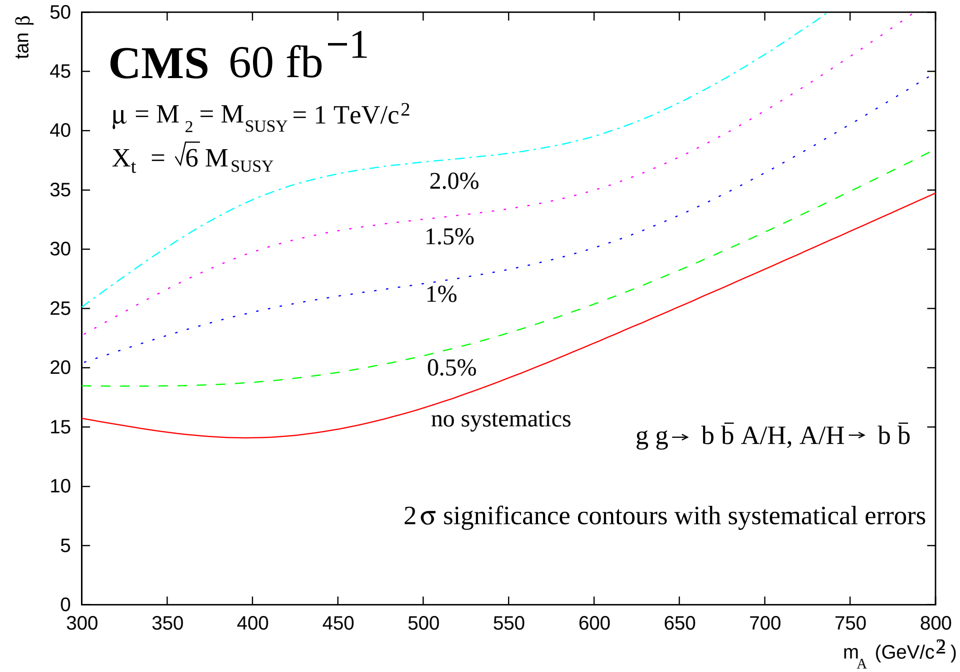
- triple b-tagged background with two of three real b jets is dominant (~ 72%)
- the main contribution come from gg->gg, gb->gb with g->bb~

CMS “results” on bbH, H->bb

Higgs mass after bkg. subtraction with known bkg. shape



The 2 σ discovery reach with different assumptions on the level of systematic



MSSM bbH, H->2τ. What we should learn from TeV

Cross section exhibits a large sensitivity to tan(β) and thus can add a significant observable to a global fit of the SUSY parameters

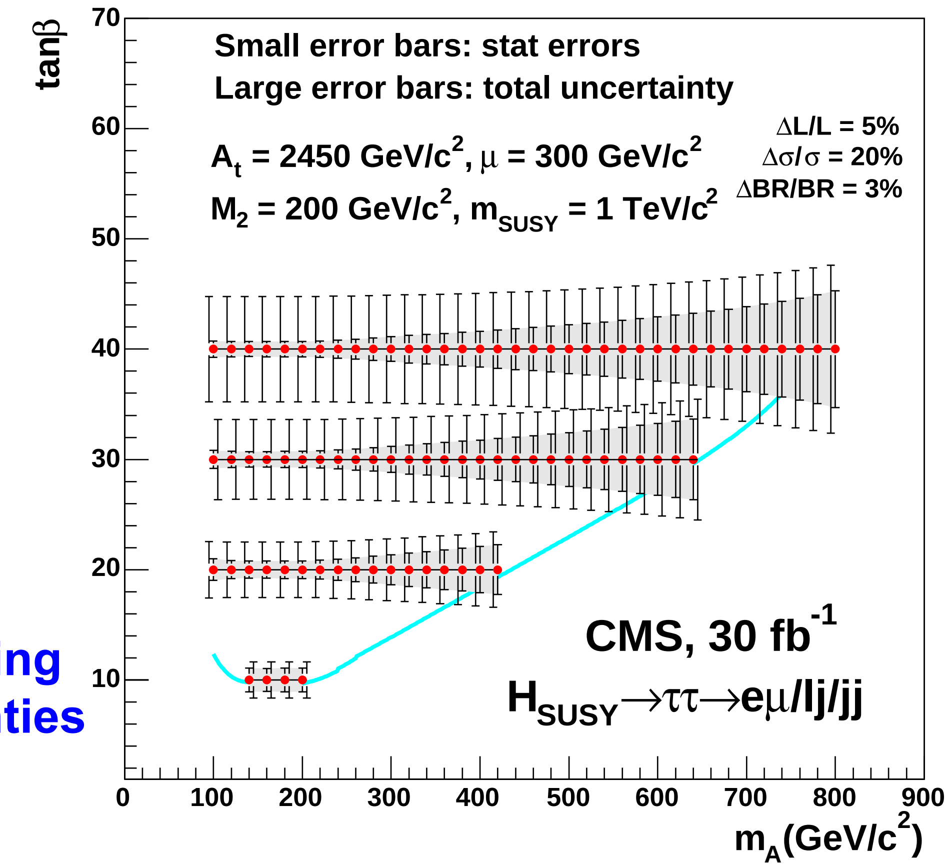
R. Kinnunen, S. Lehti, F. Moortgat, A. Nikitenko, M. Spira. hep-ph/0406152

Uncertainty is NLO calculations
~ 20 % for 1b tag
[S. Willenbrock, M. Spira et al.]
is bigger than stat. uncertainty.

However systematic due to event selections in this analysis:

- **τ tagging**
- **b tagging (1 b tag)**
- **jet veto (2nd b veto)**
- **calo scale**

should be more understood learning how Tevatron estimates uncertainties from the data



Uncertainties involved in the $\tan(\beta)$ measurement

At large $\tan(\beta)$, σ x Br ~ $\tan^2(\beta)_{eff}\ f(M_A)$ at fixed μ, M_2, A_t, M_{SUSY}
$N_S = \tan^2(\beta)_{eff}\ f(M_A)\ L\ \varepsilon_{sel}$

$$\mathbf{\tan(\beta) = \tan(\beta)_{mes} +/- \Delta_{stat} +/- \Delta_{syst} +/- \Delta_{MCgen}}$$

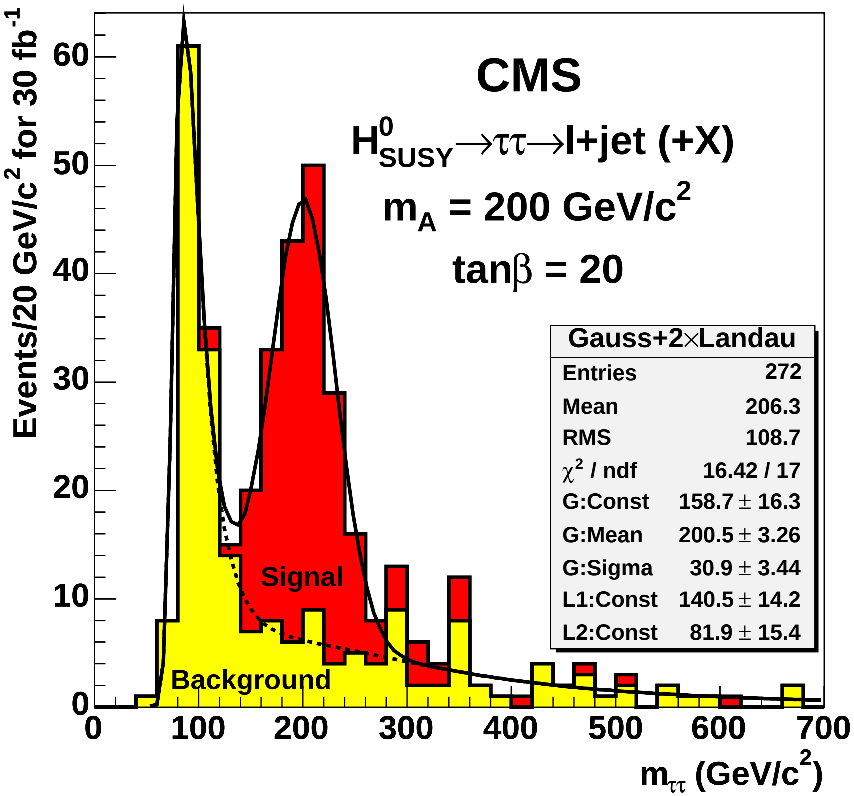
$$\mathbf{\Delta_{syst} = 0.5\ (\Delta L + \Delta\sigma_{th} + \Delta Br_{th} + \Delta\sigma(\Delta M_H) + \Delta\varepsilon_{sel} + \Delta B)}$$

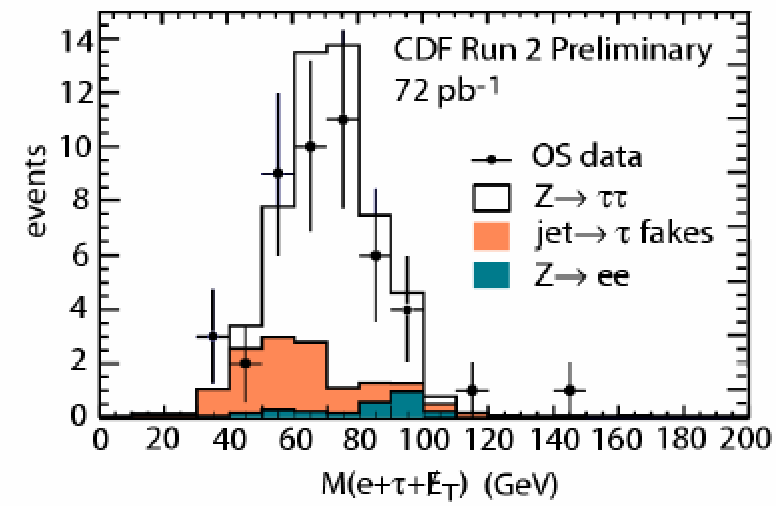
$\Delta\sigma_{th}$ = 20 % due to NLO scale dependence
ΔBr_{th} = 3 % uncertainties of SM input parameters
ΔL = 5 % luminosity uncertainty
$\Delta\sigma(\Delta M_H)$ = 10-12 % due to mass measurement at 5σ discovery limit
$\Delta B = \Delta N_B / N_S$ = 10 % at 5σ discovery limit (preliminary)

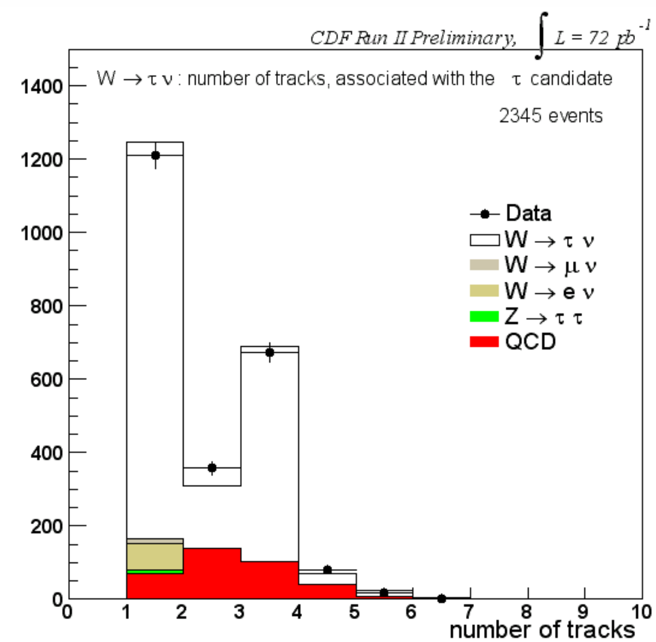
$\Delta\varepsilon_{sel} = \Delta\varepsilon_{calo} + \Delta\varepsilon_{b\ tag} + \Delta\varepsilon_{\tau\ tag}$
$\Delta\varepsilon_{b\ tag}$ = 2.0 % (prelim.)
$\Delta\varepsilon_{\tau\ tag}$ = 2.5 % (prelim.)
$\Delta\varepsilon_{calo}$ = 2.9 % (prelim.)

THIS HAS TO BE MORE JUSTIFIED EXPLOITING TEVATRON EXPERIENCE

Exploiting TeV $Z\rightarrow\tau+\tau-$ and W->$\tau\nu$







- **How TeV evaluates τ id efficiency from the data ?**
- **We even did not think about Z->ee background. Need to check !**

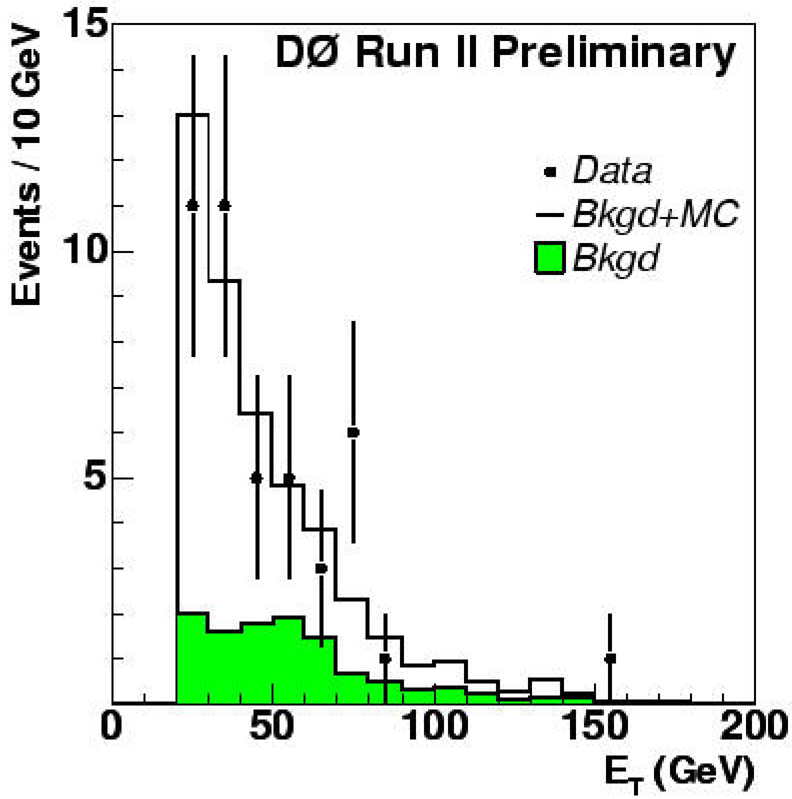
Z+b at TeV as benchmark for gb->bh (gg->bbh)

Z+b can be used as a benchmark for gb->hb at LHC: test N(N)LO predictions and Monte Carlo.

However, be careful:
at Teatron both contributions gb->Zb and qq~->Zbb are important while only gb->Zb is dominant at LHC and thus relevant to gb->hb
[J. Campbell et all hep-ph/0312024]

N(N)LO calculations are available for bb->h, gb->hb and gg->bbh and compared in J. Campbell et al, arXiv:hep-ph/0405302

184 pb^{-1} for e^+e^-
152 pb^{-1} for $\mu^+\mu^-$

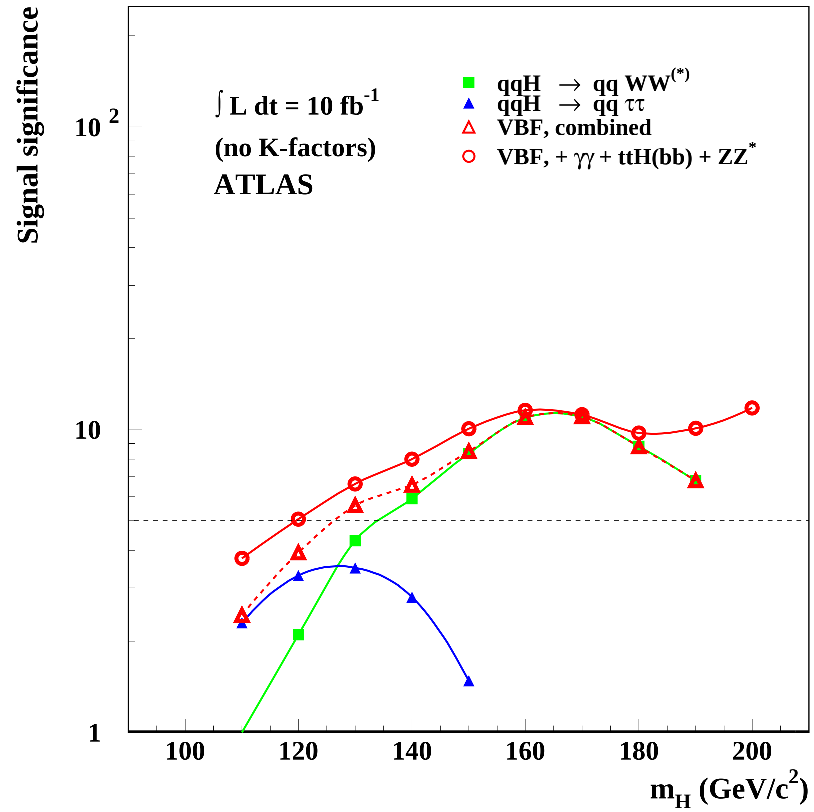


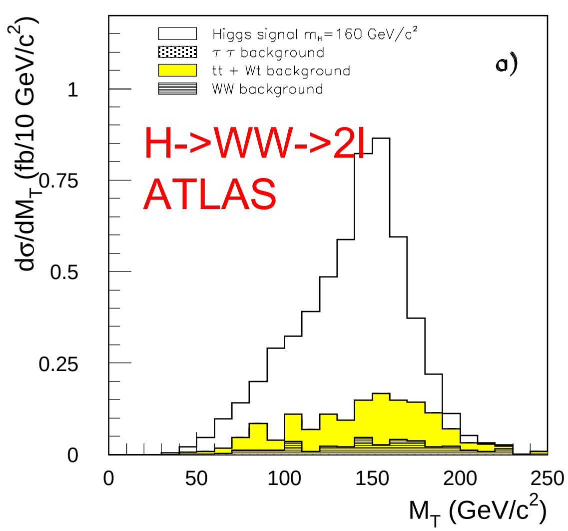
Comparison of p_T^b between PYTHIA and NLO gb->hb, gg->bbh was presented in A.N. talk on HERA-LHC Workshop meeting 27 March, 2004

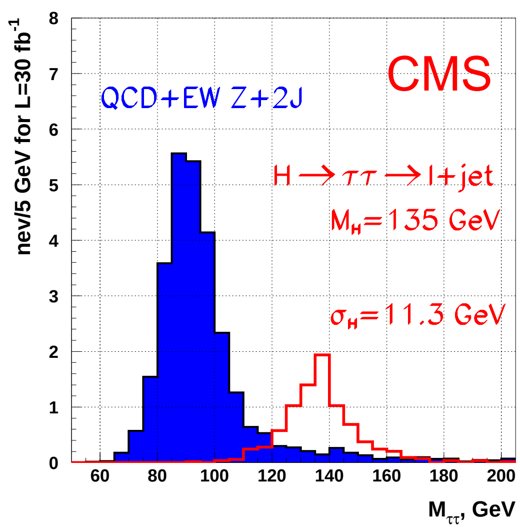
VBF Higgs channels (qq->qqh)

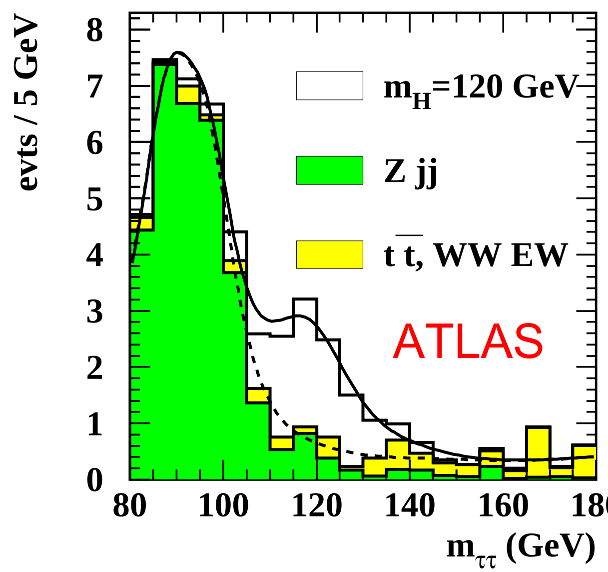
Very important for Higgs early discovery at LHC and coupling measurement

How TeV can help HLC VBF program, see talk of Dieter Zeppenfeld



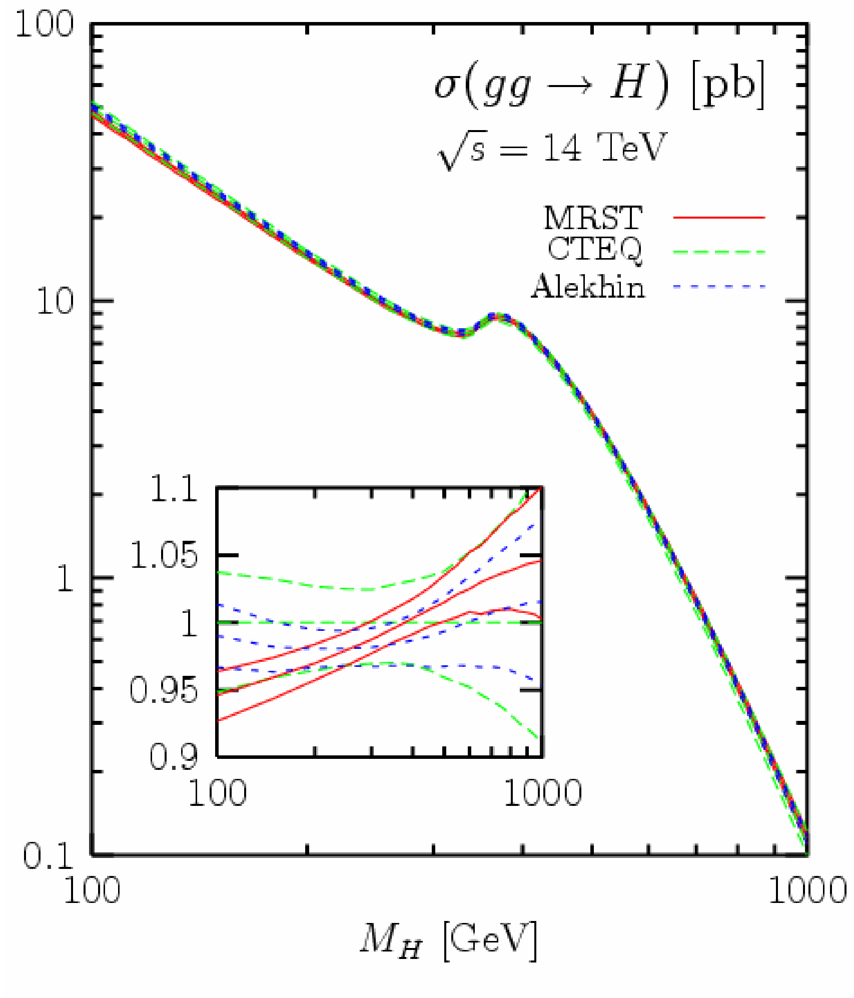


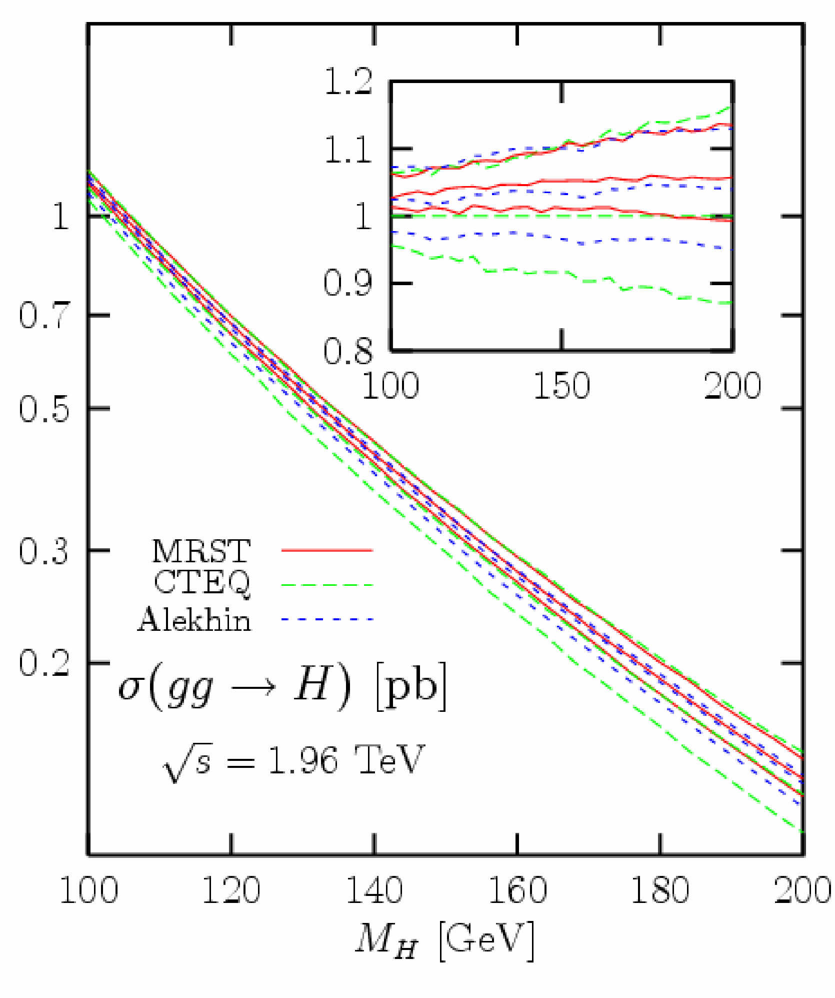




Higgs cross section: pdf uncertainties

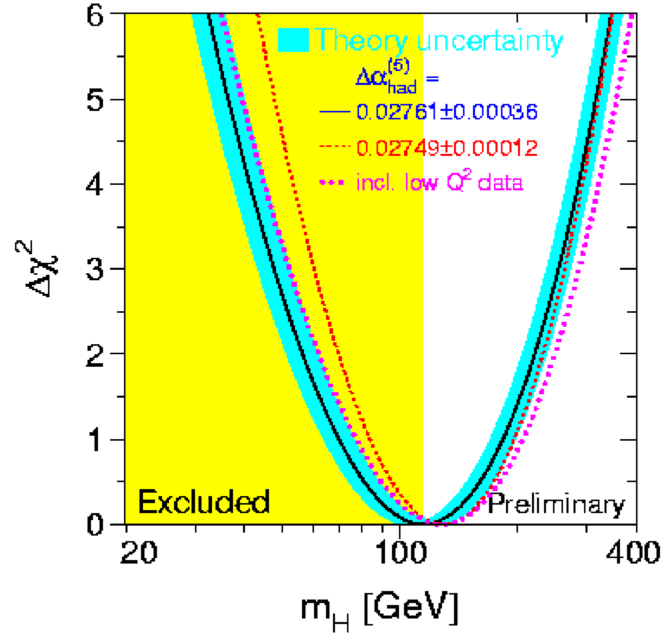
see talk of Albert de Roeck





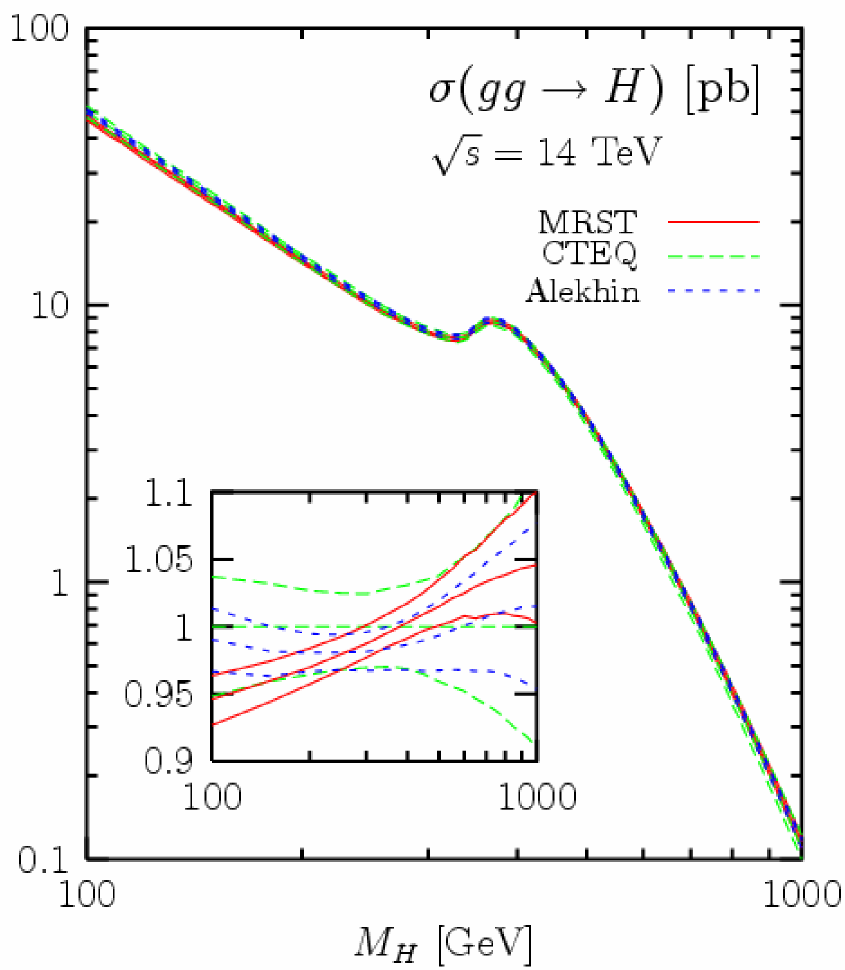
Djouadi and Ferrag, hep-ph/0310209

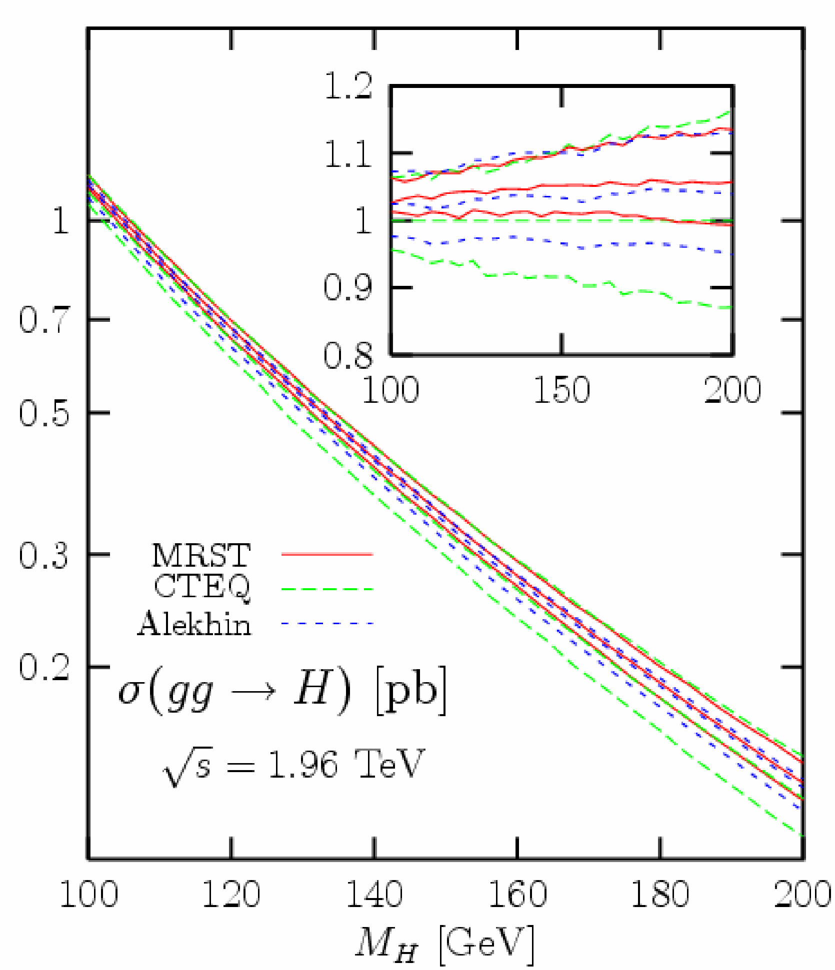
THE END



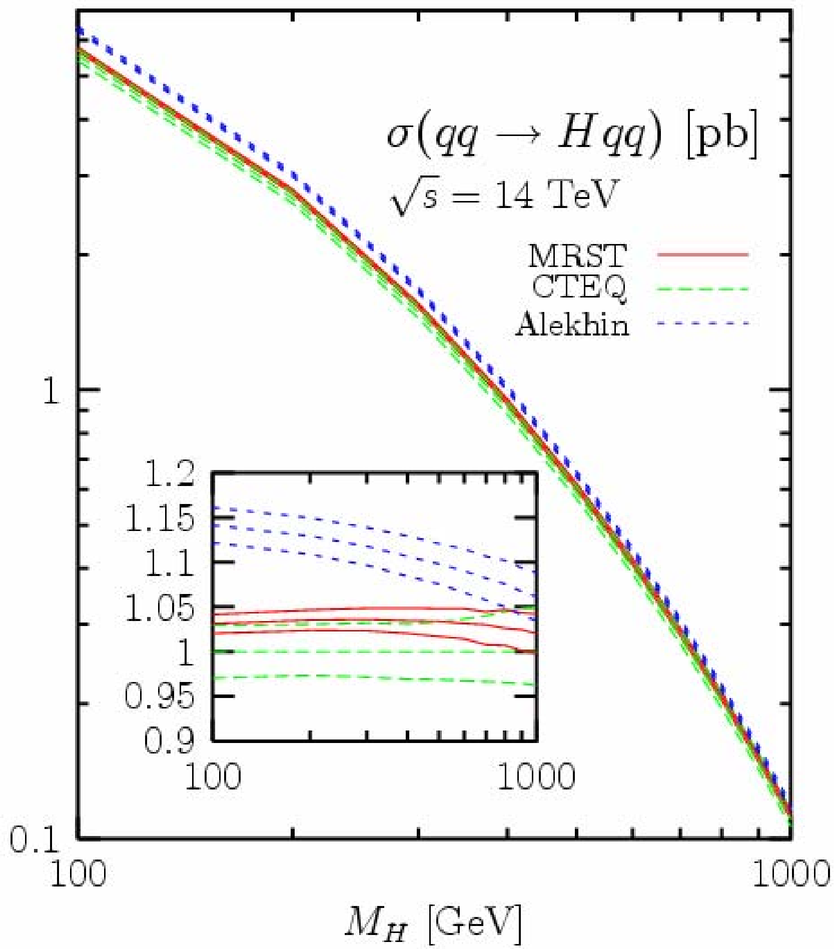
6
5
4
3
2
1
0
$\Delta\chi^2$
20
100
400
m_H [GeV]
Theory uncertainty
$\Delta\alpha^{(5)}_{had}$ =
0.02761±0.00036
0.02749±0.00012
incl. low Q^2 data
Excluded
Preliminary

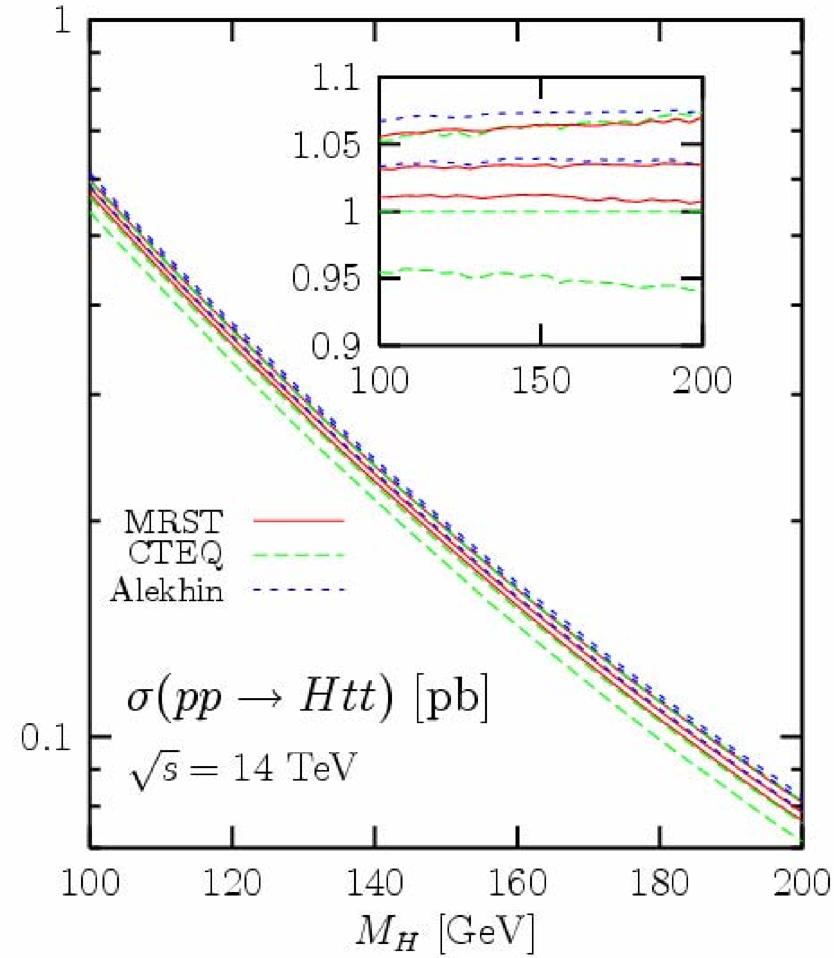
Higgs cross section: dependence on pdfs



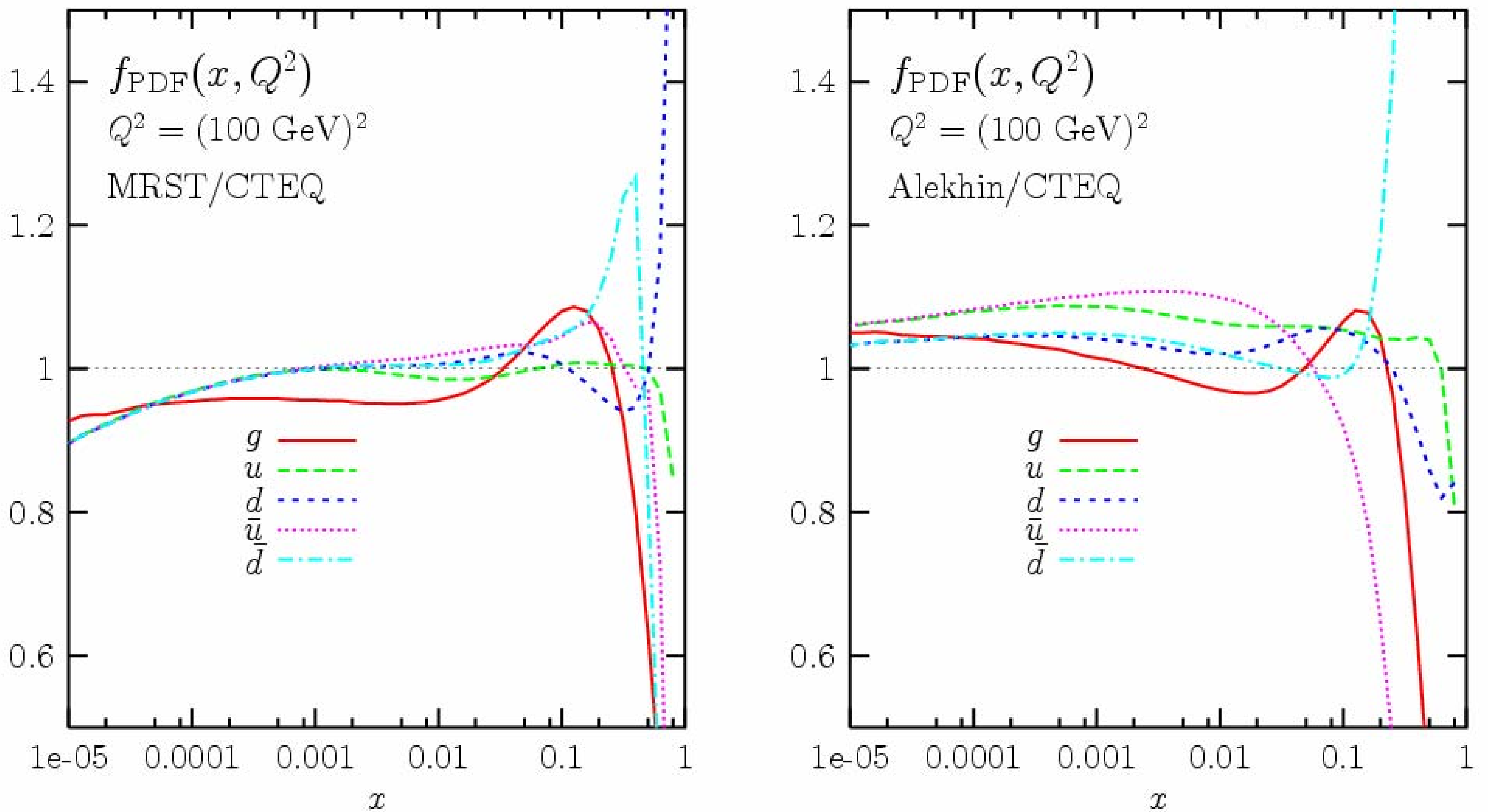


Djouadi & Ferrag, hep-ph/0310209



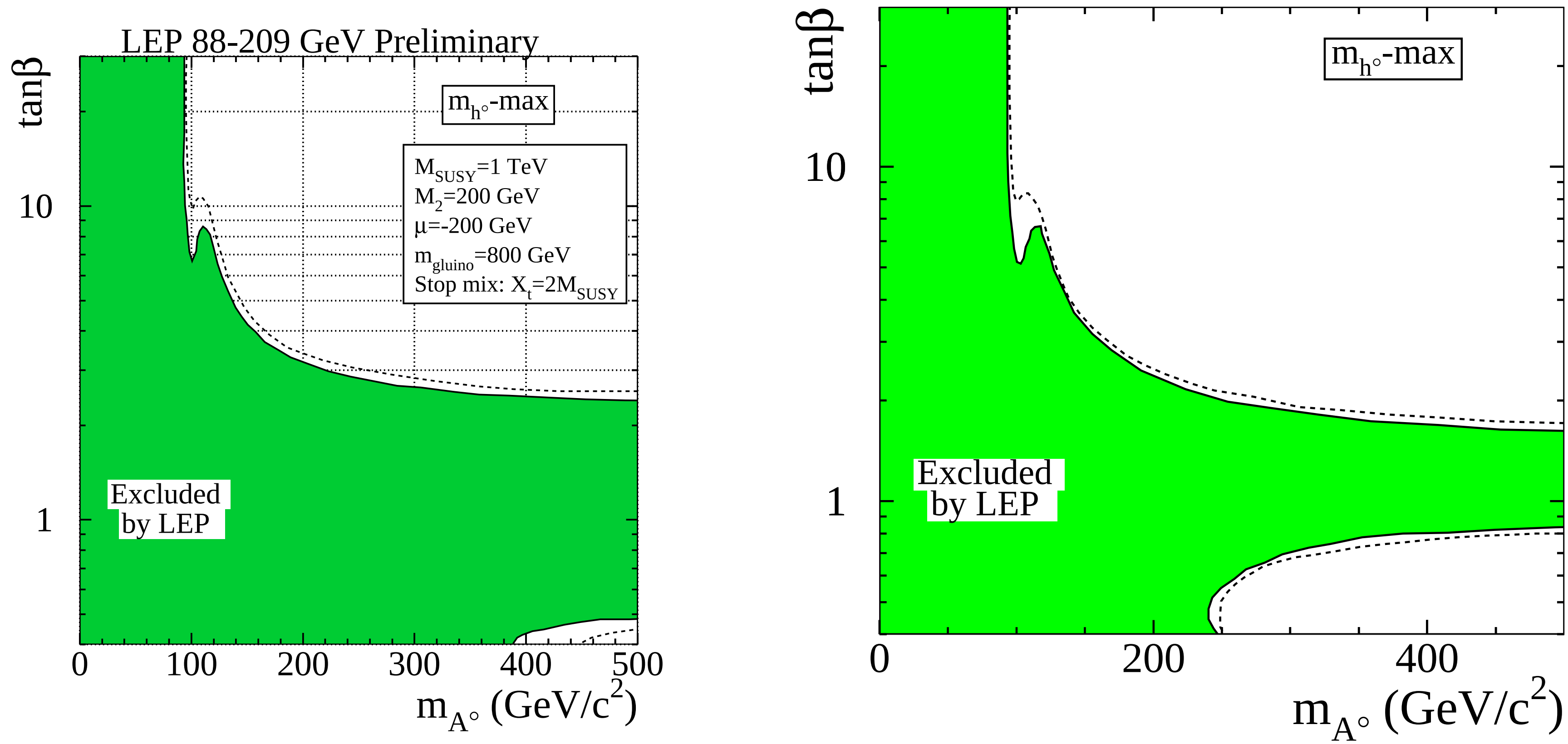


Djouadi & Ferrag, hep-ph/0310209



the differences between pdf sets needs to be better understood!

Djouadi & Ferrag, hep-ph/0310209



LEP 88-209 GeV Preliminary
tanβ
m_{h°-max
M_{SUSY}=1 TeV
M_2=200 GeV
μ=-200 GeV
m_{gluino}=800 GeV
Stop mix: X_t=2M_{SUSY}
Excluded
by LEP
10
1
0
100
200
300
400
500
m_{A° (GeV/c^2)
tanβ
m_{h°-max
10
1
Excluded
by LEP
0
200
400
m_{A° (GeV/c^2)

MSSM Higgs boson channels important at low tan(β) could be also included :

S. Heinemeyer, G. Weiglein, 04

No tan(β) exclusion for

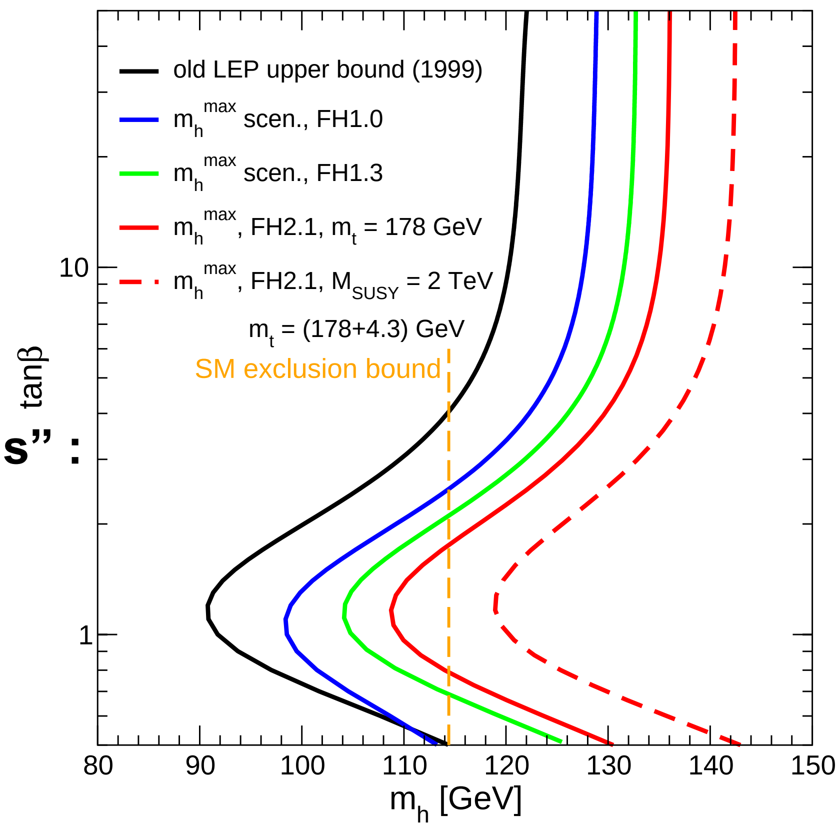
$m_t \to m_t + \sigma_{mt}$

M_{SUSY}=1 TeV->2 TeV

=> Low tan(β) not fully excluded by LEP !

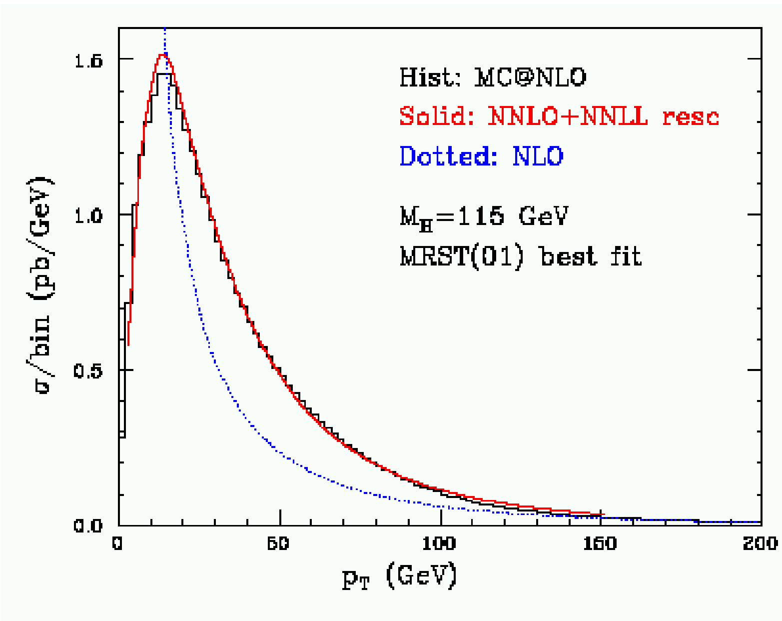
We should not forget "low tan(β) channels" :

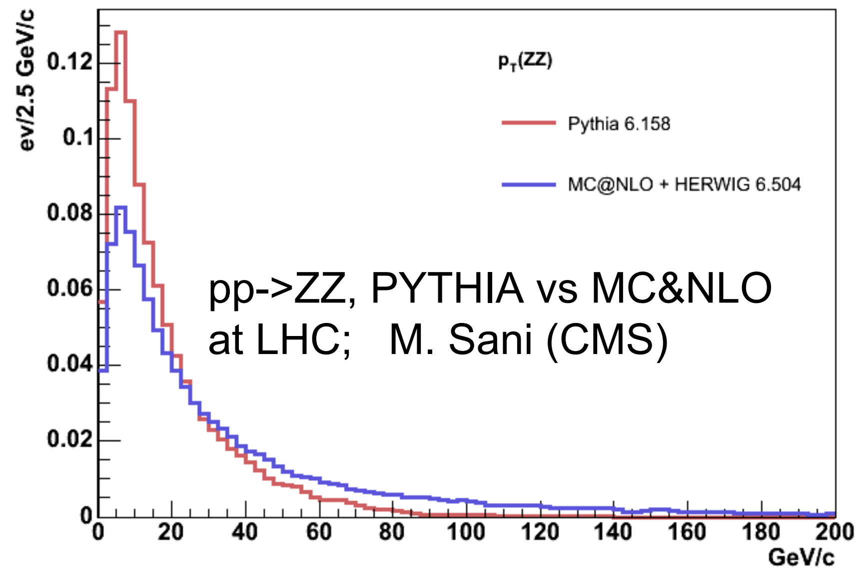
A->Zh (Z->ll, h->bb)
A->tt
A->2γ
H->hh->2γ 2b



MCatNLO

B. Webber talk on UK HEP Forum. April 2004





p_T(ZZ)

Current tt~ generation project for H->WW->2l in CMS Higgs group (I)

tt->2*l* simulation project : generators

Number of events : 2.0-2.4 M tt->2*l* events (~30 fb^{-1}), bkg. for $H \to WW^{(*)} \to 2l$ and $A \to 2\tau \to 2l$

Generators : CompHEP, MadGraph, ALPGEN, TopRex, PYTHIA, HERWIG

400K ALPGEN file done by Fulvio Piccinini & Michelangelo Mangano
400K MadGraph file done by Fabio Maltoni
400K CompHEP file done by Eduard Boos

400+400K TopRex (S. Slabospitsky) + PYTHIA generation request by A.N.

400K with HERWIG still has to be requested

Input parameters for generator and cross-sections. PDF - CTEQ5L for all generators

Generator	Process	M_t, Γ_t GeV/c^2	M_W, Γ_W GeV/c^2	M_b GeV/c^2	Q^2 GeV^2	σ, pb without Br(W->lν)
CompHEP	WbWb(->2l in pyth)	175, 1.51	80.42, 2.05	4.70	m_t^2	599.6 *
MadGraph	WbWb->2l	175, 1.51	80.42, 2.05	4.70	m_t^2	590.5
ALPGEN	tt->WbWb->2l	175, 0.00	80.42, 0.00	4.75	m_t^2	573.8
TopRex	tt->WbWb->2l	175, 1.55	80.45, 2.07	4.80	$m_t^2+p_t^2$	495.0
PYTHIA6.22	tt->WbWb->2l	175, 1.40	80.45, 2.07	4.80	$m_t^2+p_t^2$	491.6
HERWIG		… is coming …				

*651.8 / 1.087 = 599.6. difference due to gw = e/sin(thetaW). gw_eduard=0.667 gw_fabio=0.653

Current tt~ generation project for H->WW->2l in CMS Higgs group (II)

tt->2*l* simulation project : first comparizon at kinematics level

100 000 ev. from every generator passed through H->WW(*)->2l selection criteria at parton level :

A.N.

selection 1: $p_T^{\,l} > 25,\ 10\ GeV/c^2$, $|\eta^{\,l}| < 2.5$

selection 2: $\Delta\phi_{\,ll} < 40^o$

selection 3: Jet veto : no b's $E_T > 20$ GeV, $|\eta^{\,b}| < 3.0$

Generator	number of events left after selection. $N_{init} = 100000$		
	selection 1	selection 2	selection 3
CompHEP W->ln in pythia	75450	14598	920
MadGraph W->ln in pythia	75703	14554	880
MadGraph,	74748	15457	880
ALPGEN	74413	16807	660
TopRex	74214	17410	673
PYTHIA6.22	72775	21158	855
HERWIG			

- Big difference for jet veto between WbWb and tt~ production (expected).

- Efficiencies of $\Delta\phi$(ll) cut for MadGraph llννbb and MadGraph WbWb (W->lν in PYTHIA) are different by ~ 7 %. => effect of the spin correlations