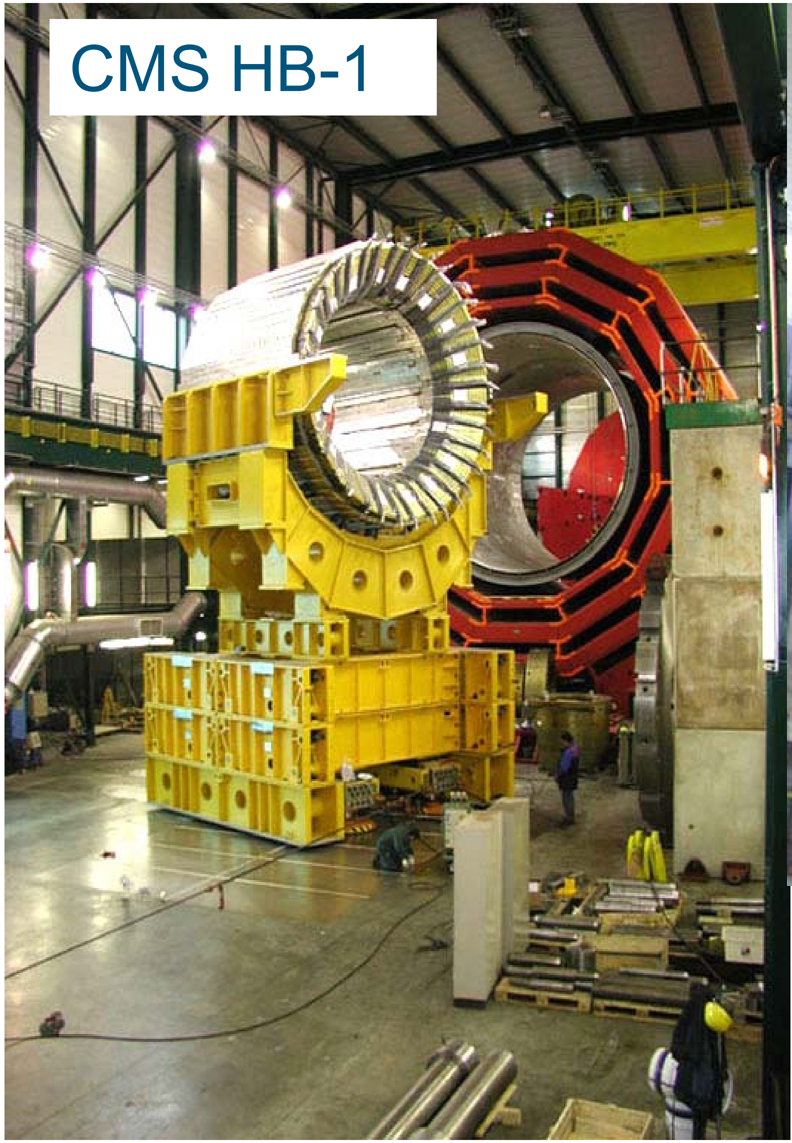
SM and Higgs WG (II)

"Experimental view" on subjects of sub-groups

A. Nikitenko IC, London

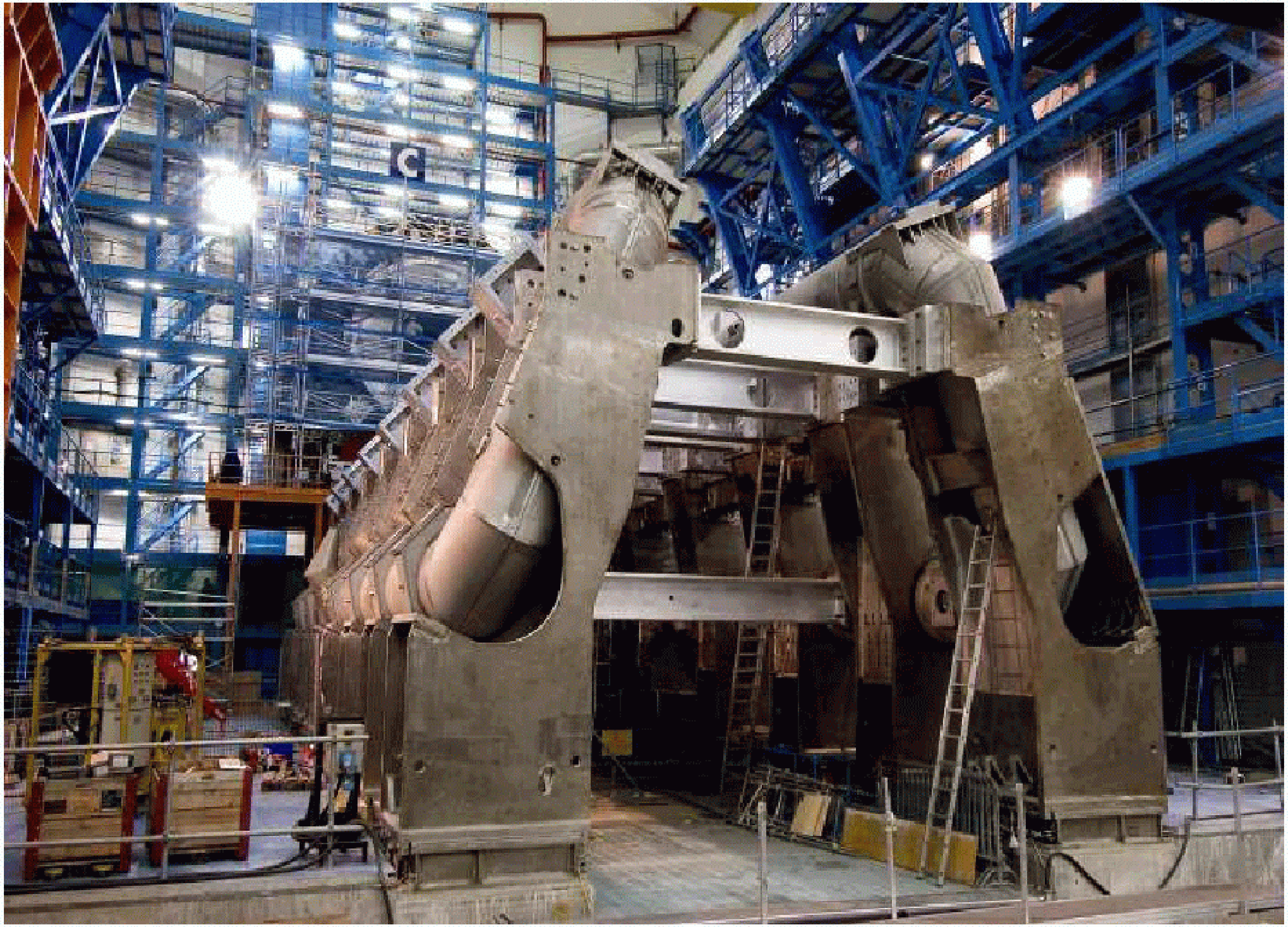
Les Houches 12th May 2005

We will start in 2007



Installation of readout boxes started
source calibration in 2005.
Insertion in vacuum tank: Summer 2005.

CMS. 11 MB stations installed in YB+2



- construction of the ATLAS detector underground
  - two (out of eight parts of the barrel toroid)

SM benchmarks and PDF's

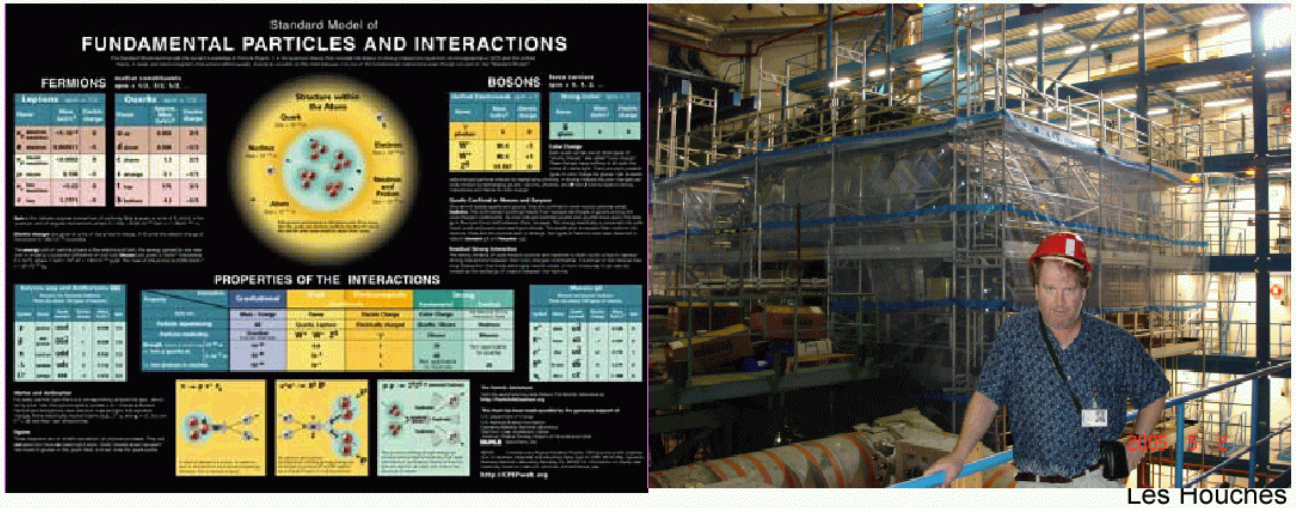
Message from 1st session :

first, we should discover Standard Model

Discovering the Standard Model during the first year(s) of the LHC (and reliability of SM predictions)

J. Huston

Michigan State University



Les Houches 2005

http://www.pa.msu.edu/~huston/Les_Houches_2005/Les_Houches_SM.html

~ 10^{7-8} Z->ll, W->lν on tape during physics run in 2008 (~ $10 fb^{-1}$)

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

~ 10^6 tt->μ+X with 10 fb^{-1}

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

Project running over two sessions

Analyses by final state signatures: ll, $\gamma\gamma$, jj, ...

Proposal for (B)SM working group

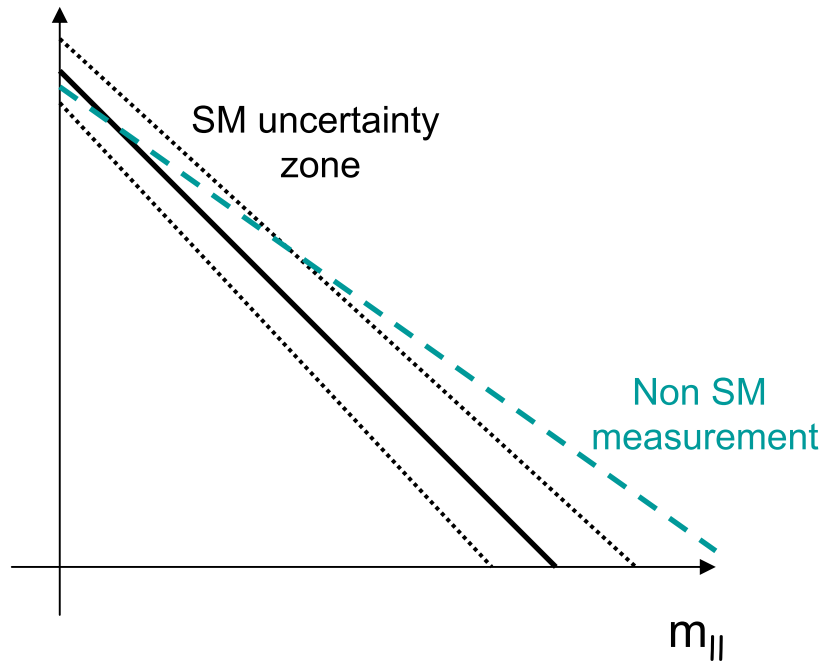
Samir FERRAG

University of Oslo

- Motivation:
  - Understand the SM predictions and establish their uncertainty band
  - Every prediction outside this band is a signature of new physics
- 1st year of LHC:
  - Simple topologies and robust analyses:
    - Di-leptons, di-photons, dijets…

2 sides: Limits of the SM and possible BSM signature

SM

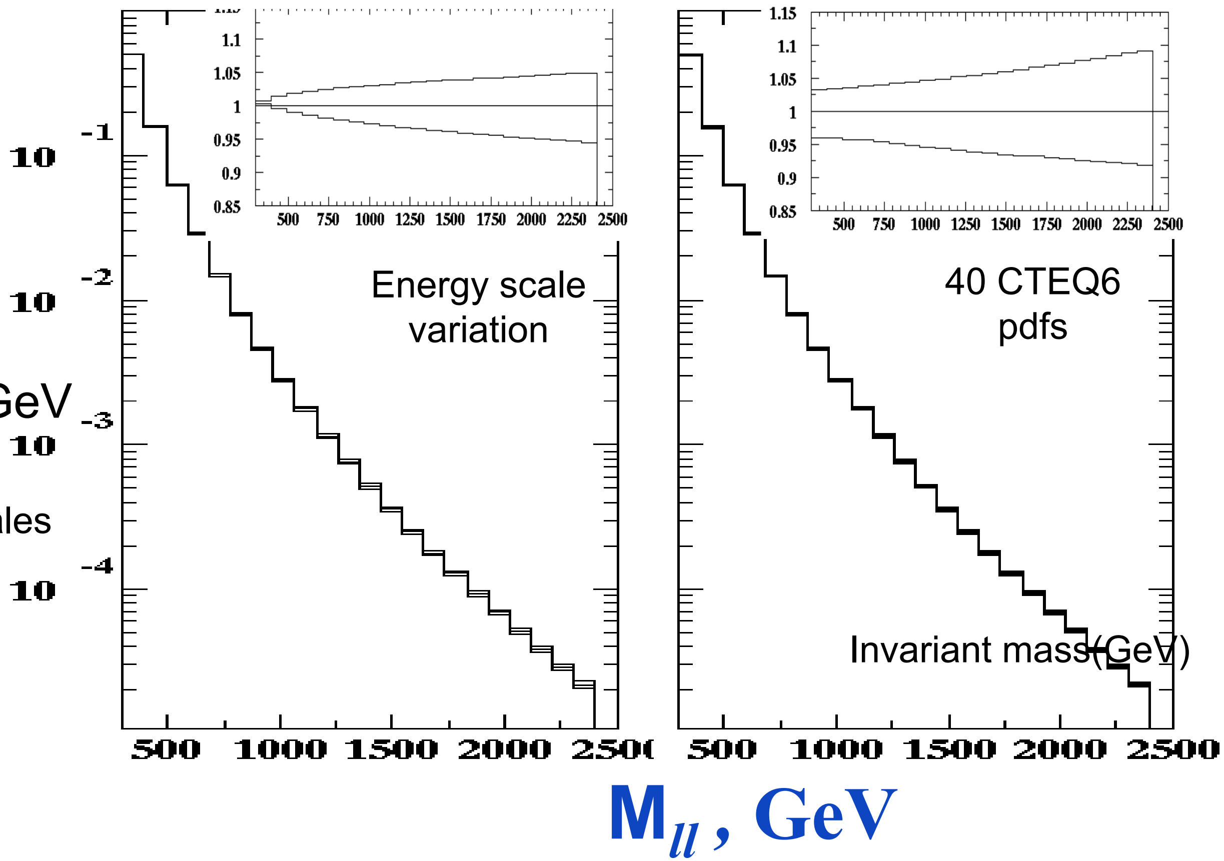


BSM →

	Observable 1	Observable 2	
Class1: Z' models	Spin study	A_{fb}	
Class2: model X: G → ll	Spin study		…
Class3: SUSY: model Y			
…			

Output of 1st session- Benchmark: Drell-Yan (Ferrag)

- Goal:
  - Limits on the SM predictions
- Observables:
  - M_{ll}, P_t, boost, $\Delta\eta$
- MC@NLO:
  - σ computed by 100 GeV bin
  - 200 GeV < invMass< 2500 GeV
- Sources of uncertainties:
  - -Factorisation and Renormalisation scales
    - $1/\pi * m_t < \mu < \pi * m_t$
  - -PDFs
    - CTEQ6 40+1 pdf1



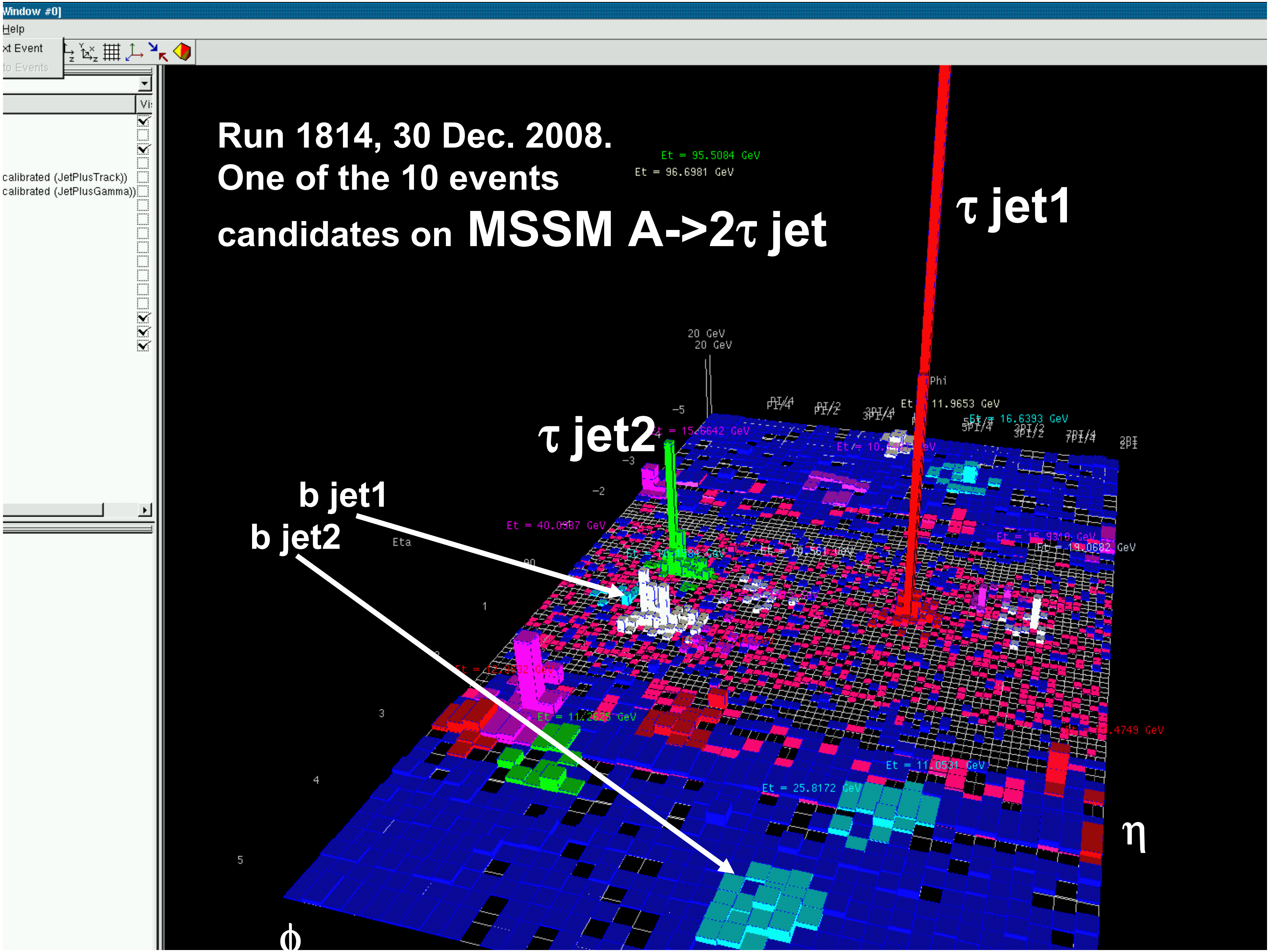
$\gamma\gamma$, jj to be continued during 2nd session.

Join this project

Higgs production in association with heavy quarks

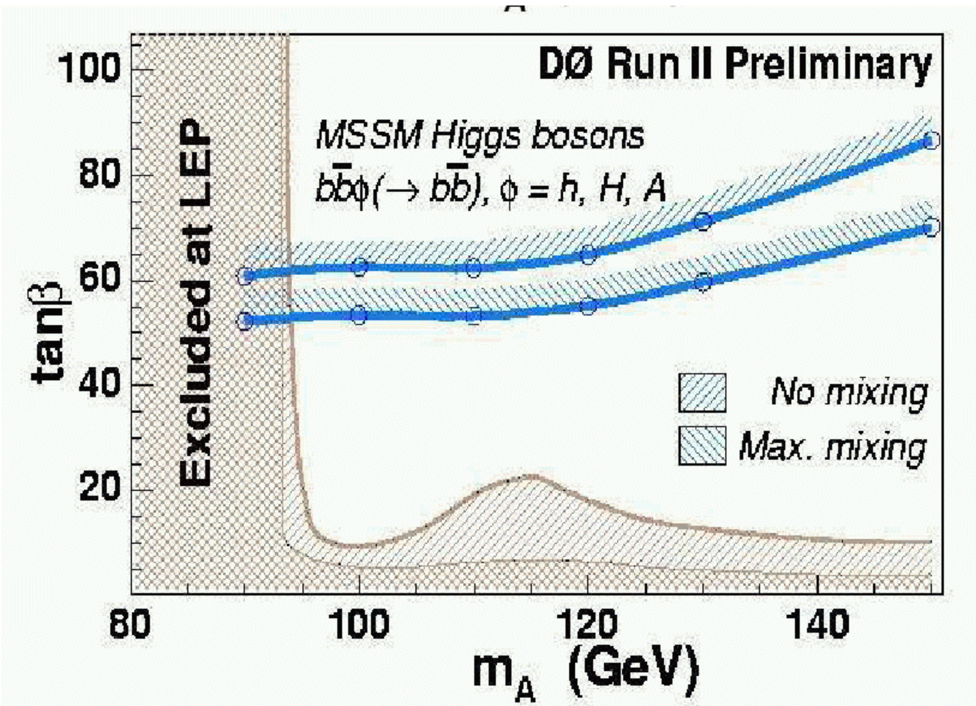
b(b)h, b(b)Z**,**

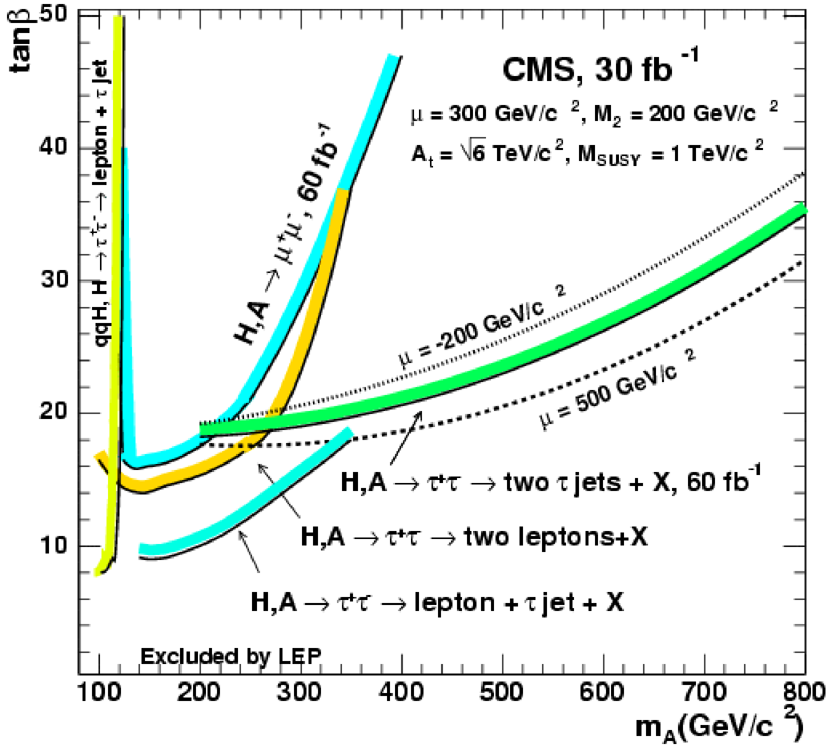
gg(b)->t(b)H$^+$



Run 1814, 30 Dec. 2008.
One of the 10 events
candidates on MSSM A->2τ jet
τ jet1
τ jet2
b jet1
b jet2
η
ϕ
Et = 95.5084 GeV
Et = 96.6981 GeV
20 GeV
20 GeV
Et = 40.0387 GeV
Et = 11.9653 GeV
Et = 16.6393 GeV
Et = 15.6642 GeV
Et = 19.0682 GeV
Et = 11.2625 GeV
Et = 11.0531 GeV
Et = 25.8172 GeV
Eta
Phi
Help
calibrated (JetPlusTrack))
calibrated (JetPlusGamma))

Tevatron bbϕ (->bb) ϕ=h, A, H   LHC bbϕ (->ττ, μμ) ϕ=h, A, H





Exclusion

Discovery/measurement

Both heavily relay on Monte Carlo of ϕ production

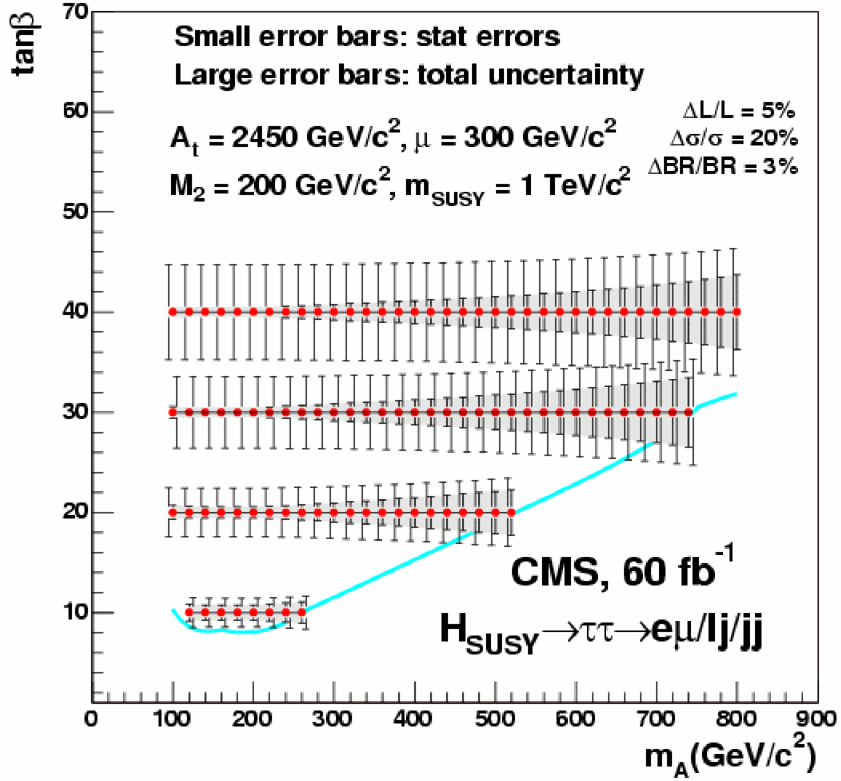
tan(β) measurement with MSSM bbA, A->2τ

Syst. uncertaities

$\Delta\varepsilon_{b\text{-}tag}$	2.0%
$\Delta\varepsilon_{\tau\text{-}tag}$	2.5%
$\Delta\varepsilon_{calo}$	3.0%
$\Delta\sigma_{th}$ nlo	20%
ΔBr_{SMinp}	3%
$\Delta\sigma(\Delta M\tau\tau)$	10%
Δbkg	10%
ΔMC	?????

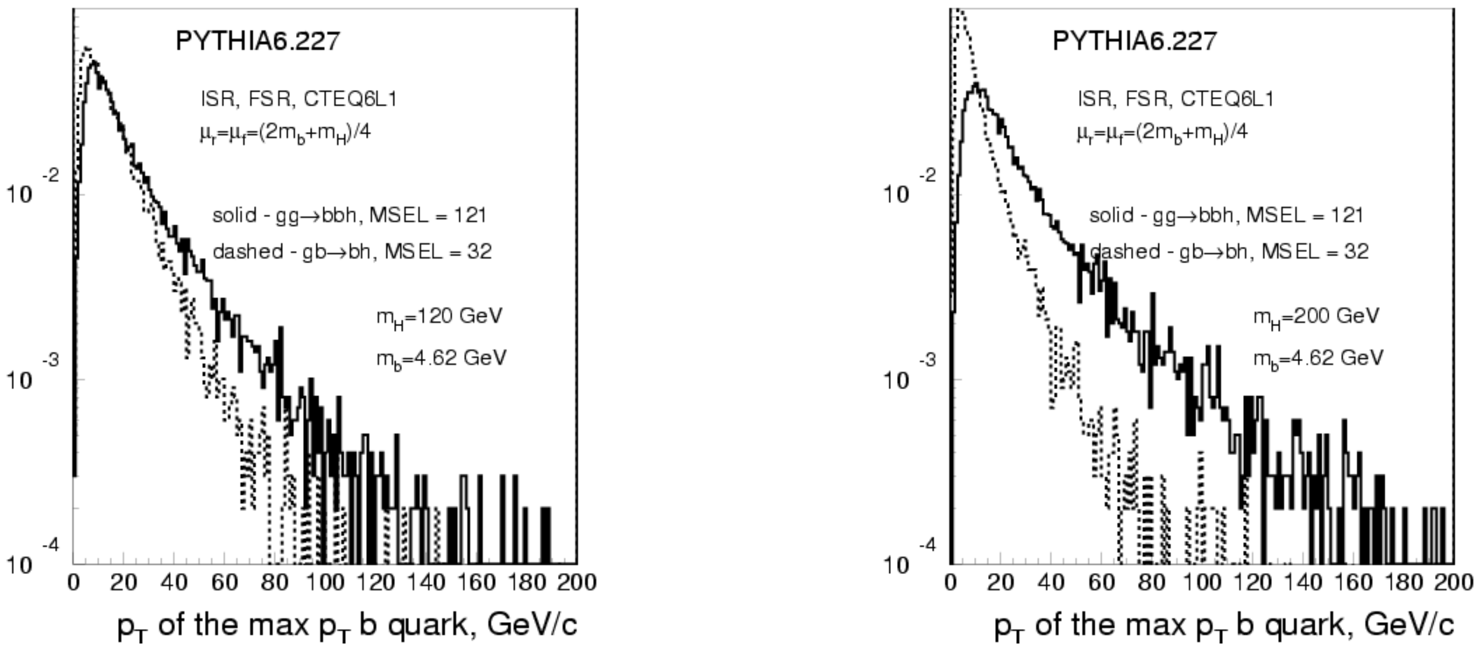
Cross section exhibits a large sensitivity to tan(β) and thus can add a significant observable to a global fit of the SUSY parameters

R. Kinnunen, S. Lehti, F. Moortgat, A. Nikitenko, M. Spira. CMS Note 2004/007



Single “b – tagging” with PYTHIA6.227: gb->bH vs gg->bbH

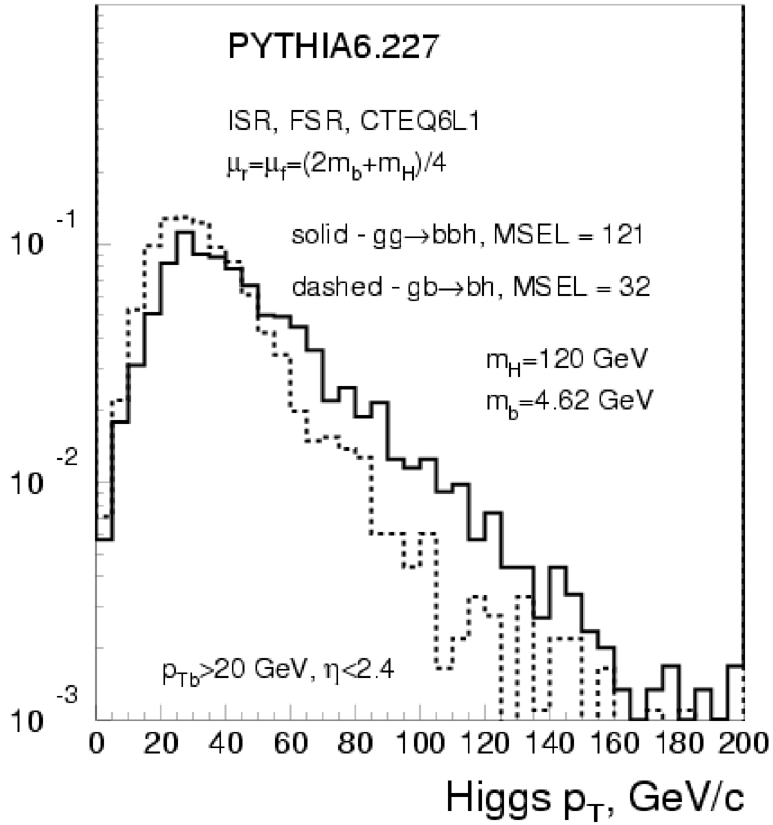
$p_T^b > 20$ GeV, $|\eta^b| < 2.4$

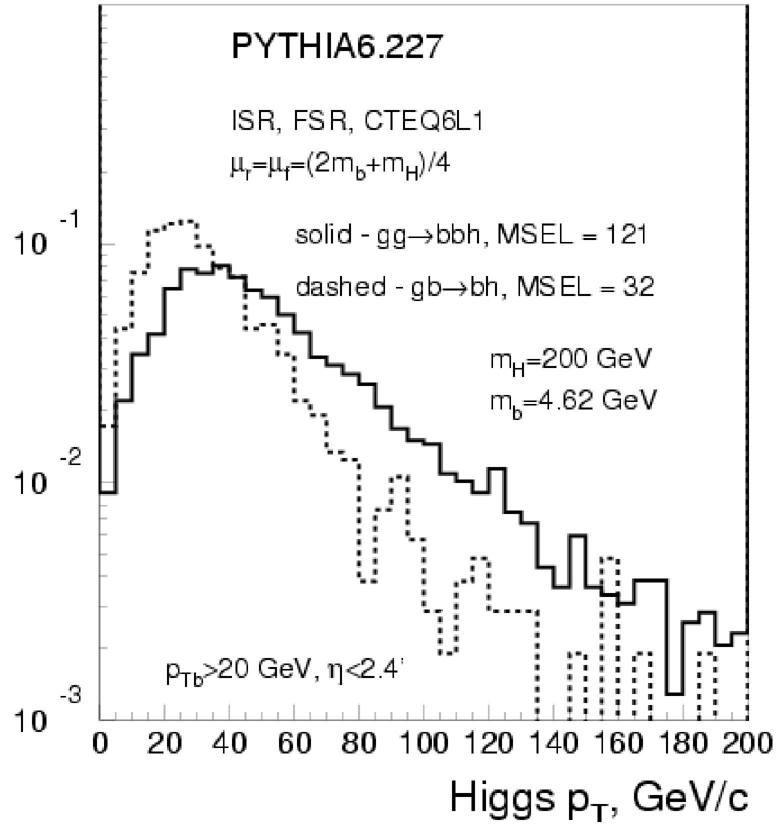


Single “b –tagging” efficiency (no jet veto yet, used in CMS)

m_H, GeV	gg->bbH	bg->bH
120	31 %	19%
200	40 %	11%

p_T Higgs with PYTHIA6.227: gb->bH vs gg->bbH affects missing E_T and Higgs mass reconstruction





Comparison with NLO is on the way …

b(b)H within MC@NLO is VERY desirable

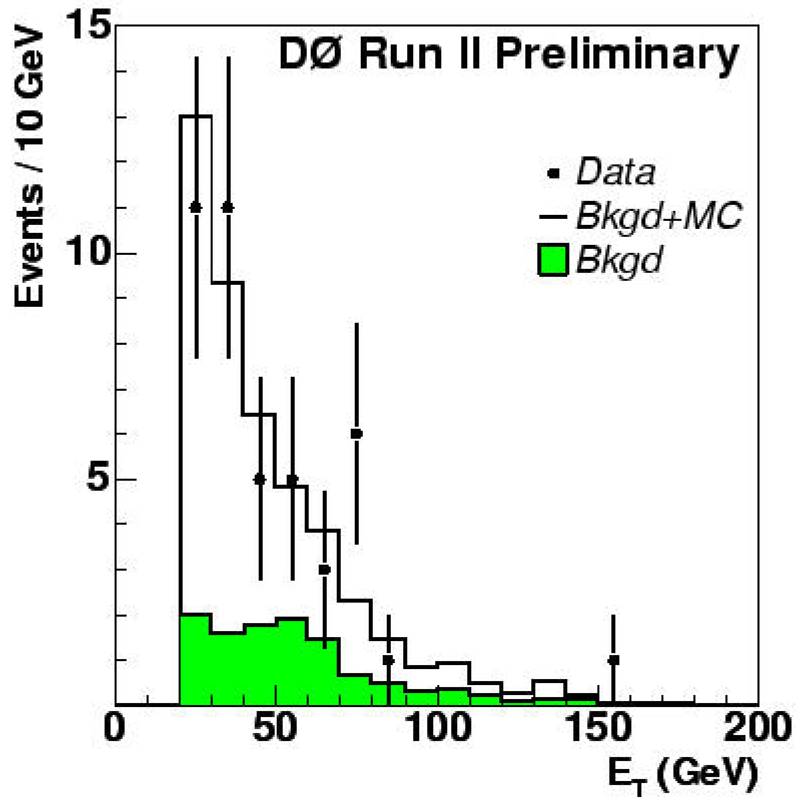
Z+b(b) as benchmark for gb->bh (gg->bbh)

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 $\mu^+\mu^-$



How well we can select it at LHC ?

gg->H->WW(*)->ll

- gg->WW background. Monte-Carlo
- WbWb = tt+Wt with jet veto ? NLO
- “tt” bkg. extrapolation errors: th. + exp.
- Uncertainty of jet veto for gg->H

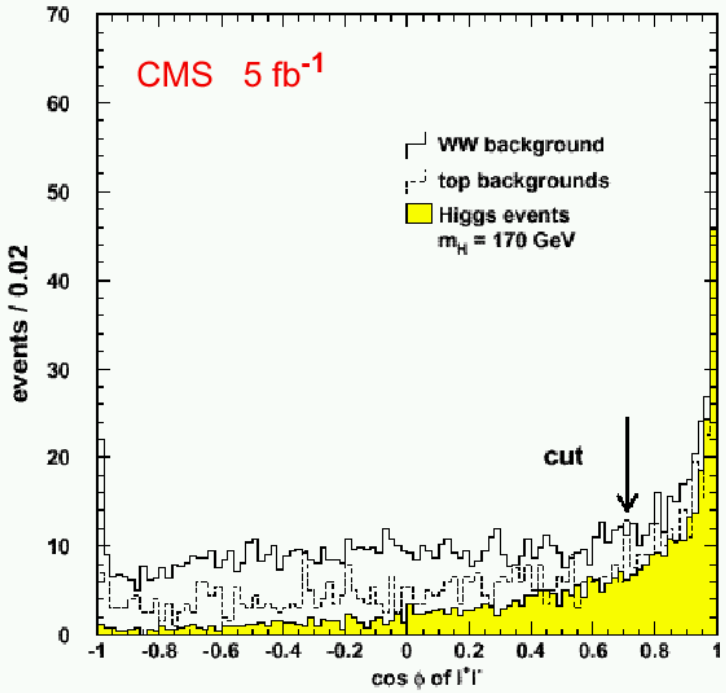
"Counting experiment" – no sidebands

H->WW$^{(*)}$-> 2 l 2 ν

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

Selections :

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



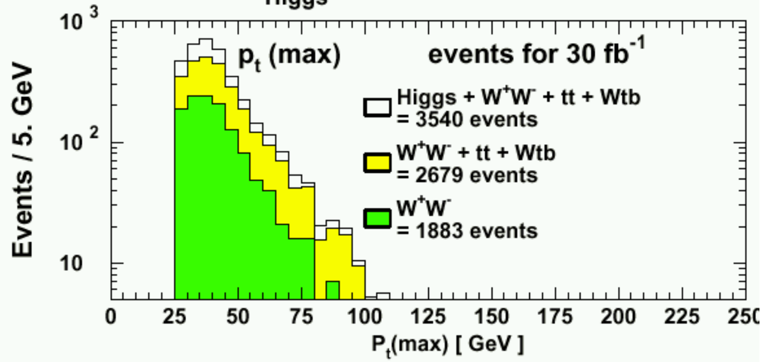
Backgrounds has to be estimated from data

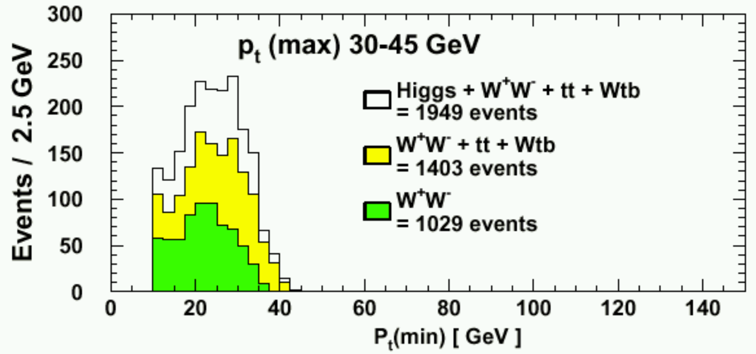
$\sigma_{bkg} = \sigma_{ref} \times (\sigma_{bkg}/\sigma_{ref})$

σ_{ref} - low experim. uncertainty

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

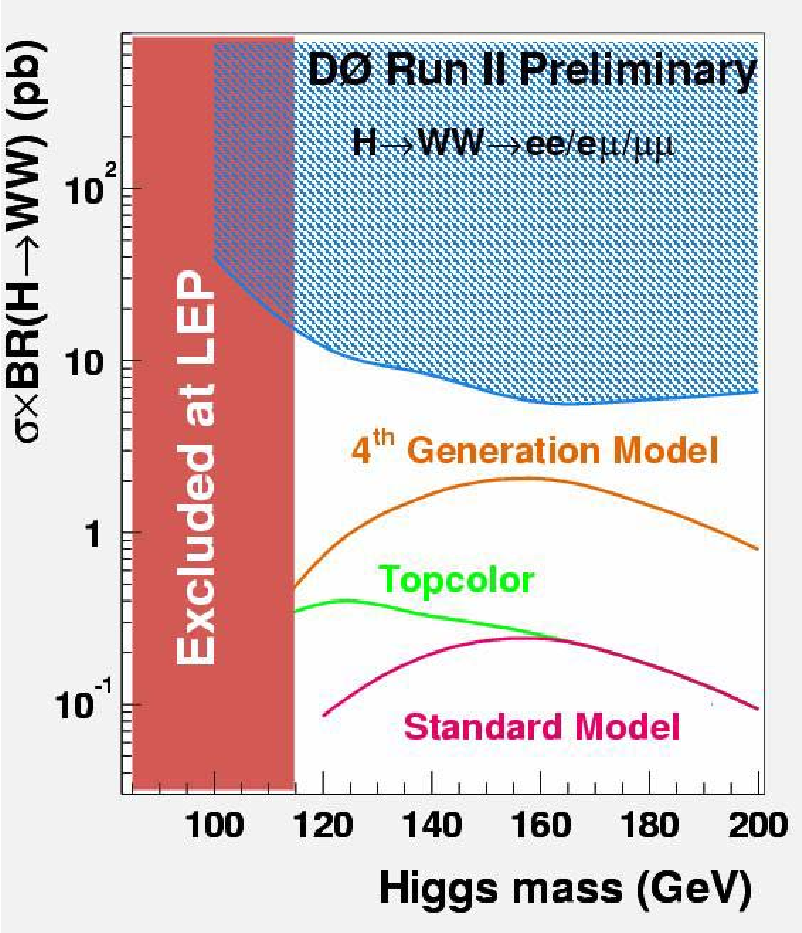
M_{Higgs}= 140 GeV

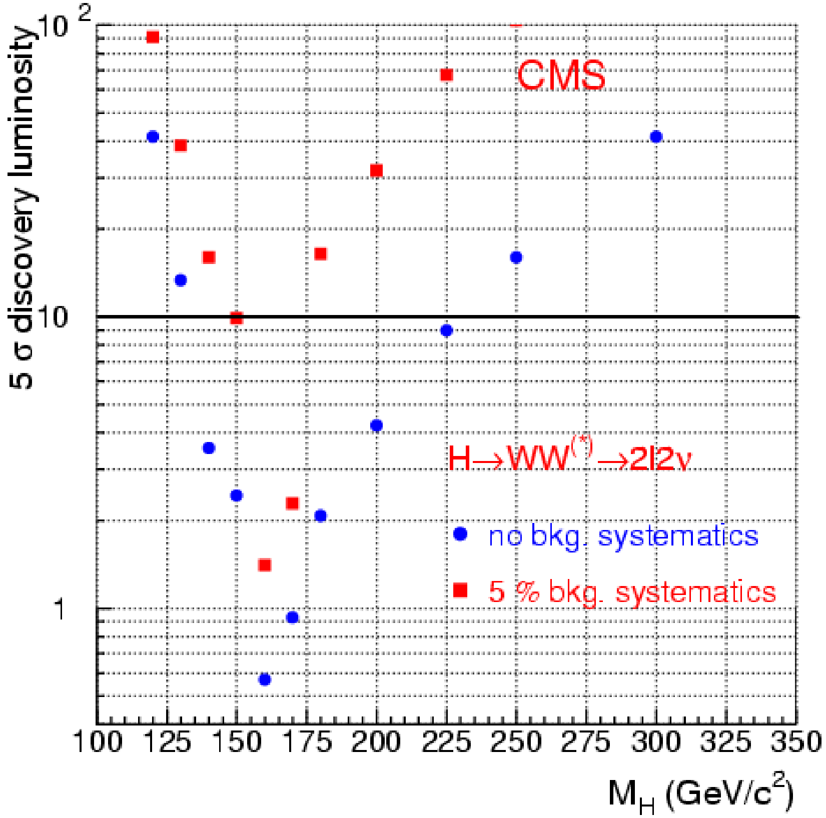




Discovery reaches with H->WW->2l

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





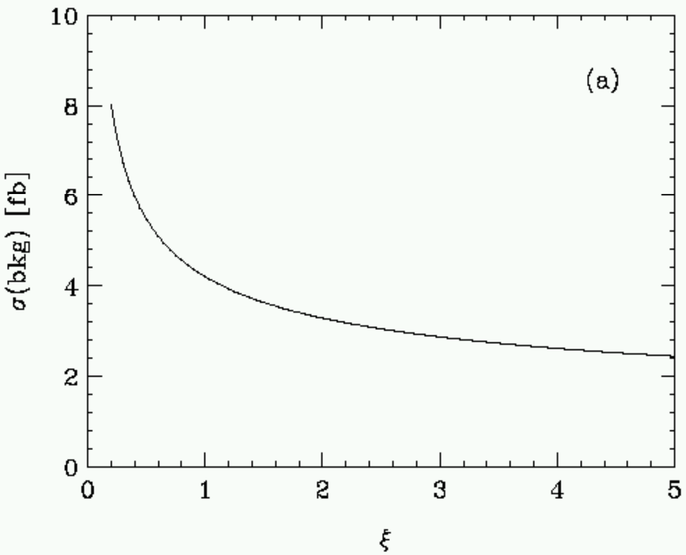
+/- 5 % bkg. systematic were taken both in ATLAS and CMS; need more justification;

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):
$\mu_F = \mu_R = \xi\, m_t$

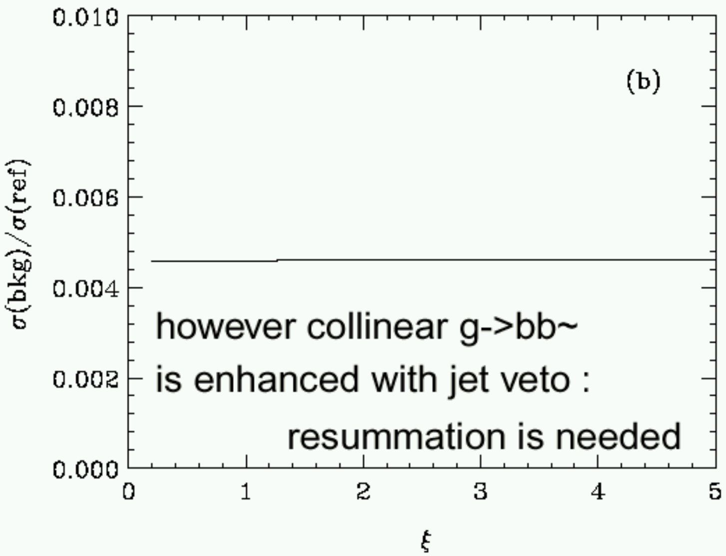


- stat error (N_{ref}) ~ < 1 % (> 10 fb^{-1})
- $\sigma_{bkg} / \sigma_{ref}$ (scale) < 1 %
- $\sigma_{bkg} / \sigma_{ref}$ (pdf) ~ 3 %

$\sigma_{bkg} / \sigma_{ref}$ 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

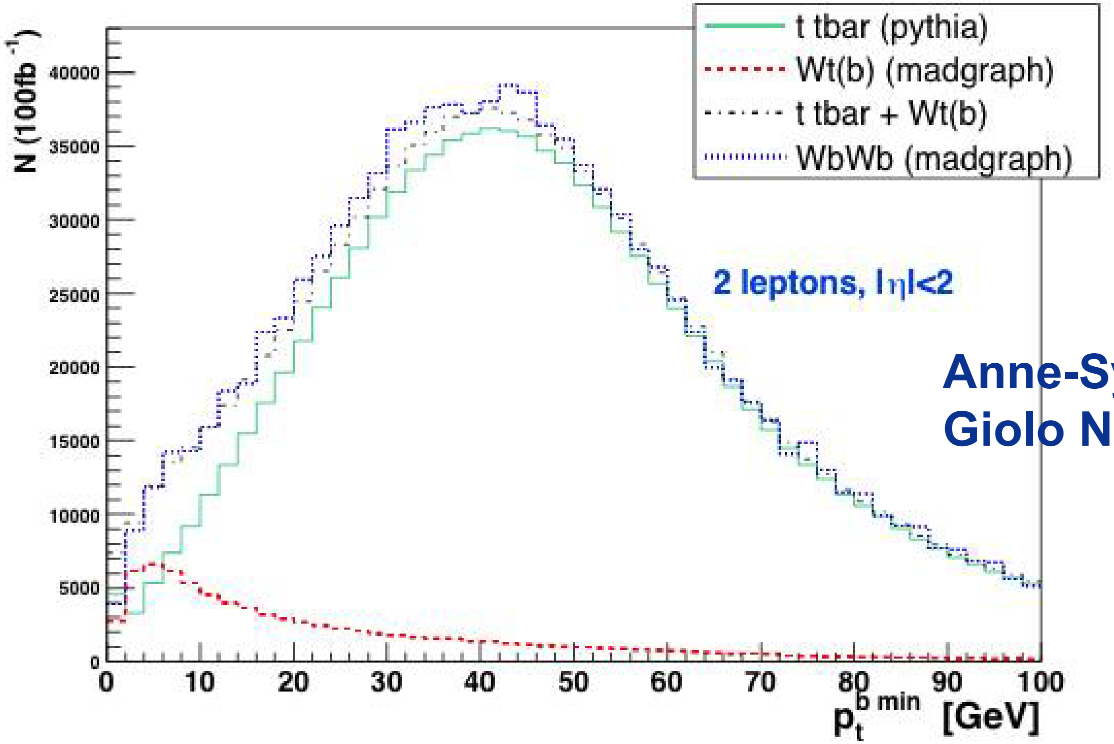


extrapolation involves also experimental uncertainties; how are they big ?

- WbWb = tt + Wt with jet veto ?

Solution 1. Wt with Toprex where one b coming from from ISR. BUT too soft p_T of b.

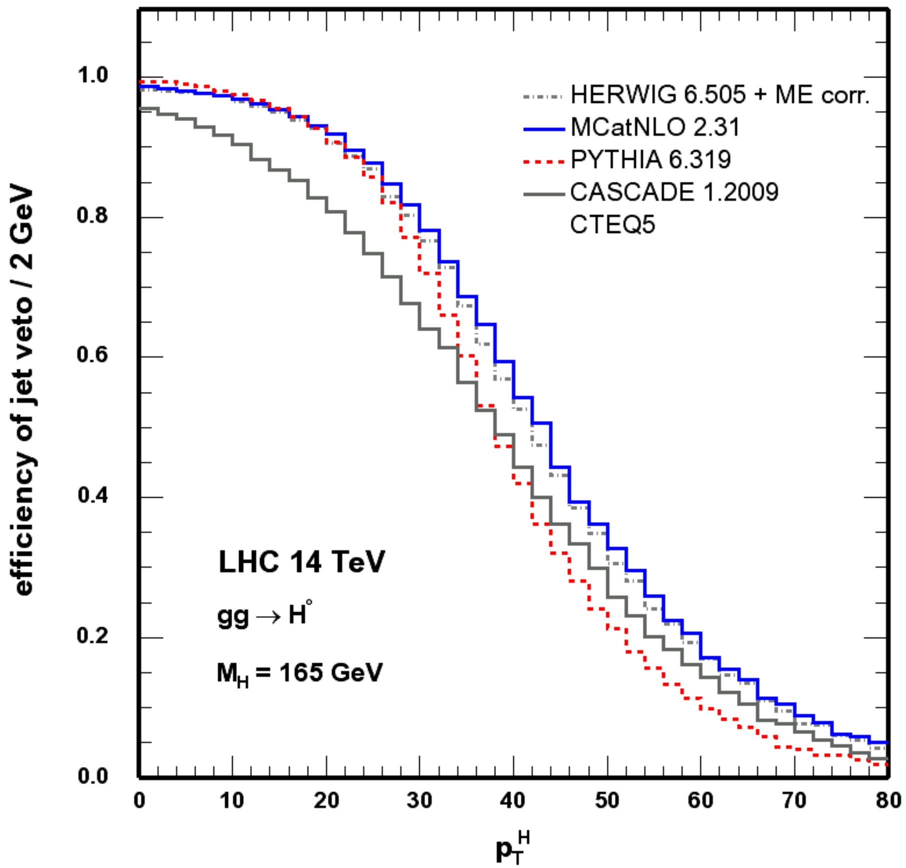
Solution 2. by Fabio Maltony: Madgraph with full WbWb matrix elements, taking out ttbar-onshell contributions (not gauge invariant !)



Anne-Sylvia Giolo Nicollerat

- How about NLO; is NLO tt~ + NLO Wt correct way ?
- ϕ_{ll} : WbWb with PYTHIA W decays =
  WbWb with MadGraph decays = full lνlνbb ?

Jet veto in gg-h with MC@NLO, PYTHIA6.3, HERWIG and CASCADE. Giovanna Davatz



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	0.61	0.72
HERWIG	0.54	0.68
MCatNLO	0.59	0.69
CASCADE	0.56	0.65

Within MC@NLO jet veto uncertainty should be estimated changing the scale (S. Frixione); uncertainty due to UE.

gg->WW background to gg->WW->2l

Calculations from two groups:

- T. Binoth, M. Ciccolini, N. Kauer, M. Krämer

  (hep-ph/0503094) :

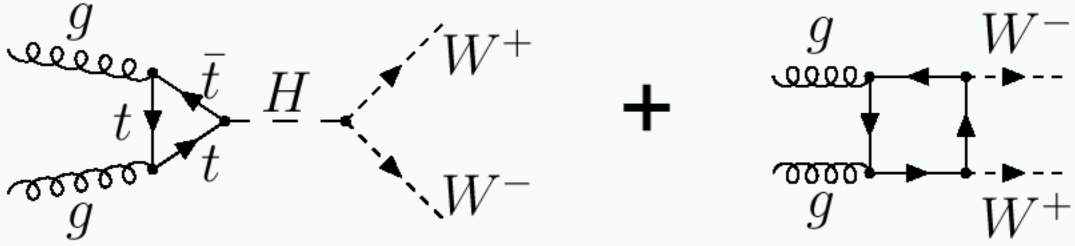
  Off-shell Ws, only light quarks in the loop

- P. Marquard, J. J. van der Bij (M. Dührssen, K. Jakobs)

  (hep-ph/0504006) :

  On-shell Ws, heavy quark loop

Context: Background process to gg $\longrightarrow$ H $\longrightarrow$ WW



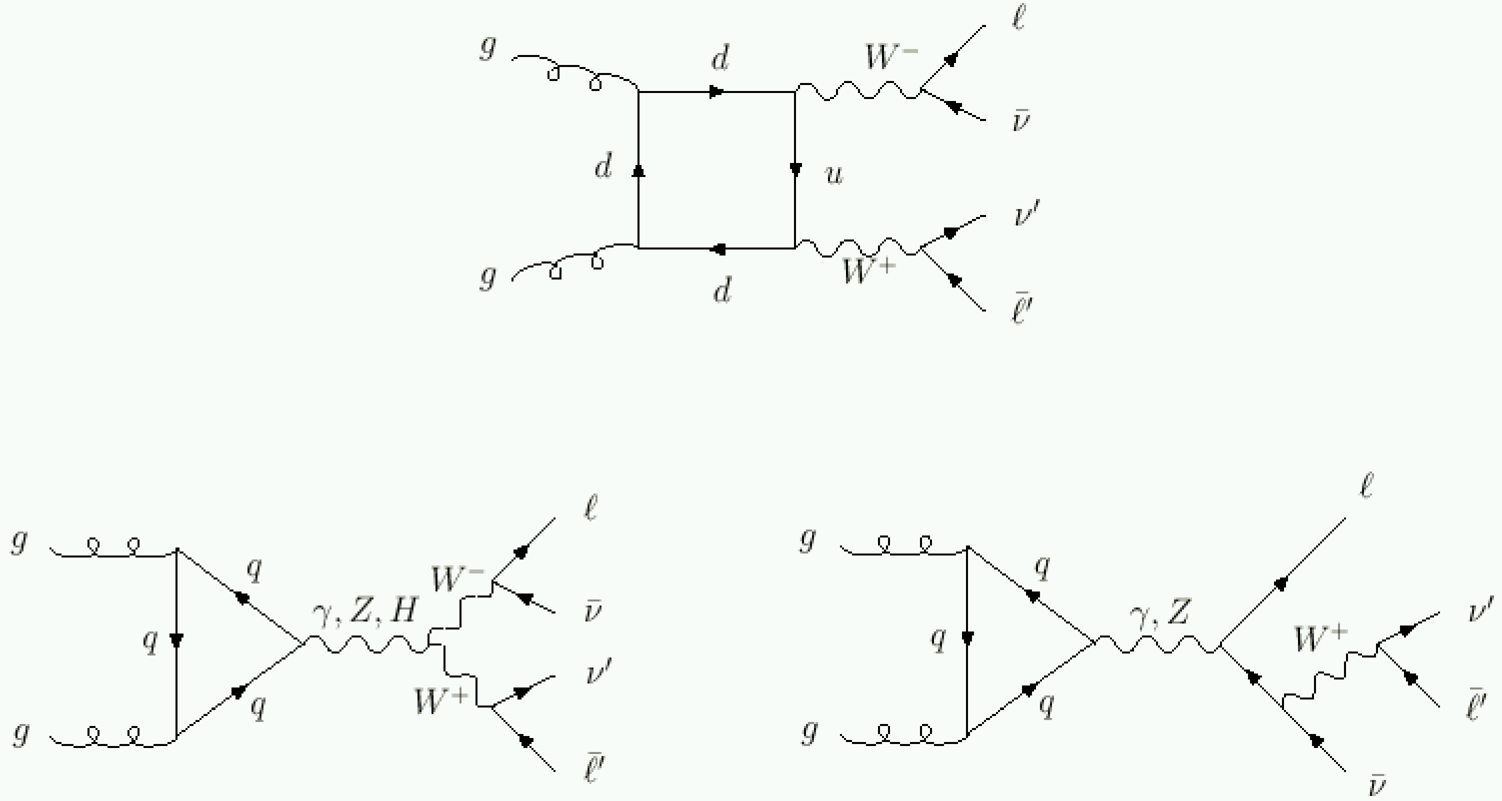


Figure 1: Generic Feynman diagrams for the process $gg \to W^*W^* \to \ell\bar{\nu}\bar{\ell}'\nu'$.

Contribution of gg->W*W* background to the total W*W*

hep-ph/0503094

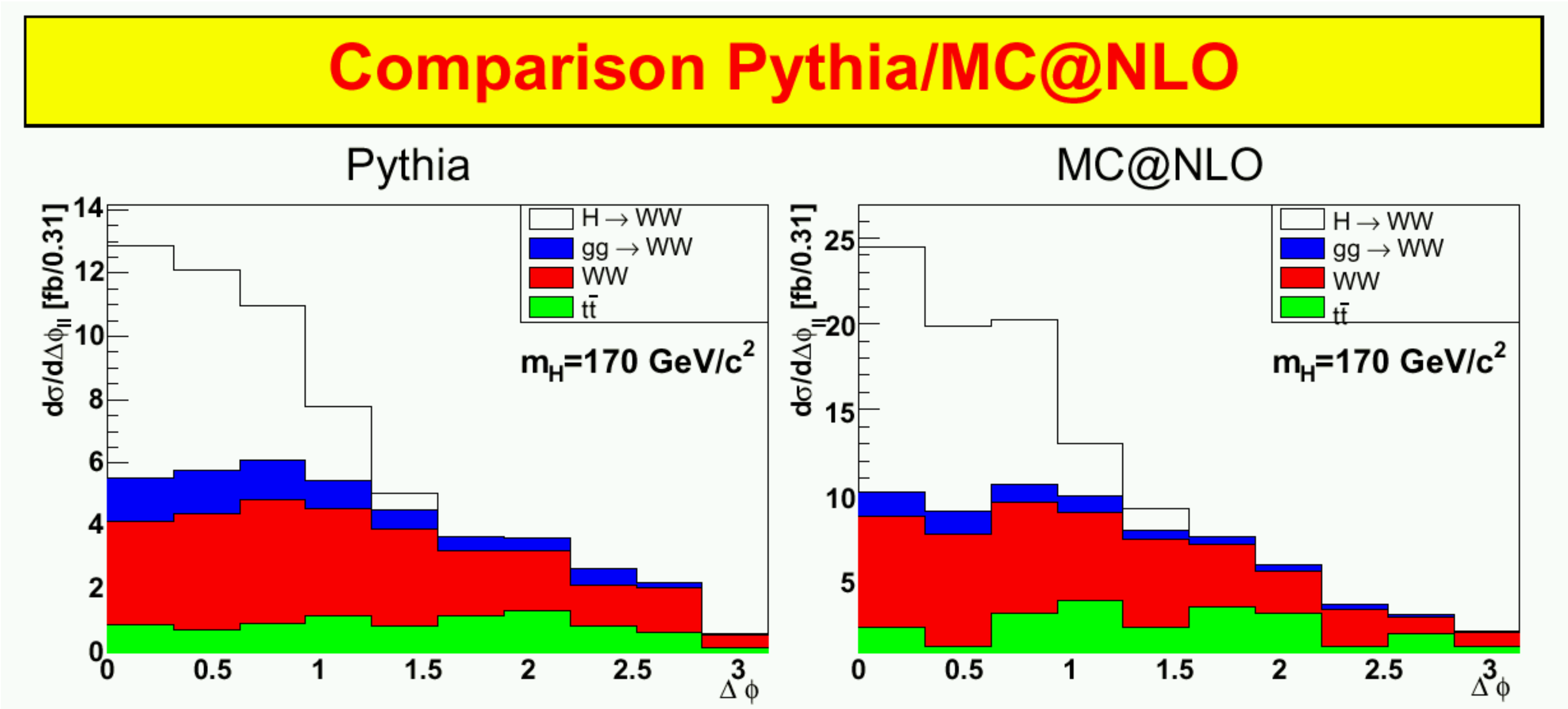
	$\sigma(pp \to W^*W^* \to \ell\bar{\nu}\bar{\ell}'\nu')$ [fb]				
	gg	$q\bar{q}$ LO	$q\bar{q}$ NLO	$\frac{\sigma_{\rm NLO}}{\sigma_{\rm LO}}$	$\frac{\sigma_{\rm NLO+gg}}{\sigma_{\rm NLO}}$
σ_{tot}	$53.61(2)^{+14.0}_{-10.8}$	$875.8(1)^{+54.9}_{-67.5}$	$1373(1)^{+71}_{-79}$	1.57	1.04
σ_{std}	$25.89(1)^{+6.85}_{-5.29}$	$270.5(1)^{+20.0}_{-23.8}$	$491.8(1)^{+27.5}_{-32.7}$	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

Table 1: Cross sections for the gluon and quark scattering contributions to $pp \to W^*W^* \to \ell\bar{\nu}\bar{\ell}'\nu'$ at the LHC ($\sqrt{s}$ = 14 TeV) without selection cuts (*tot*), with standard LHC cuts (*std*: $p_{T,\ell} > 20$ GeV, $|\eta_\ell| < 2.5$, $\not{p}_T > 25$ GeV) and Higgs search selection cuts (*bkg*, see main text) applied. The

After all cuts including jet veto. But LO gg->WW does not include jet veto, thus gg->WW contribution could be smaller, but NLO gg->WW ?

Estimates of WW background to gg->H->WW->2l from the data

Michael Duhrssen (first session)

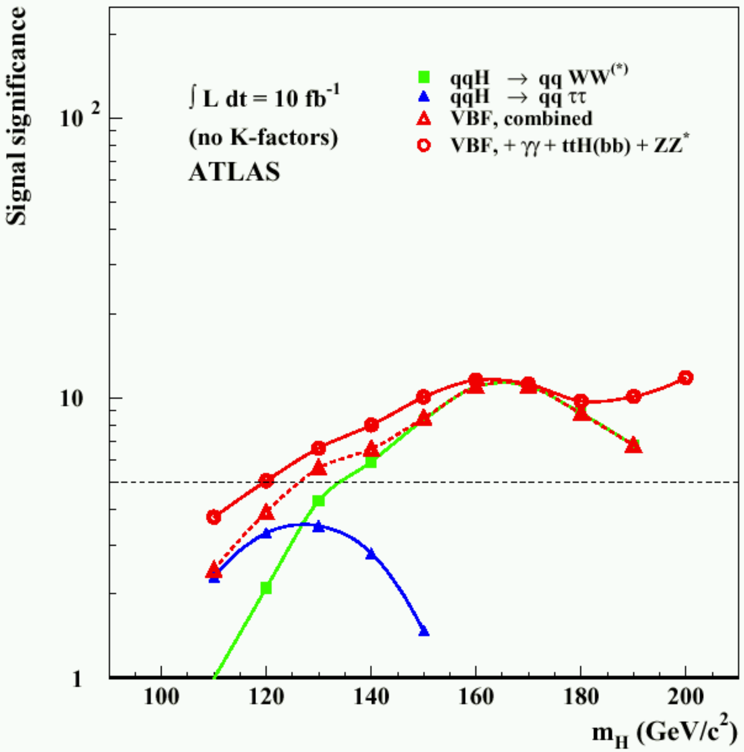


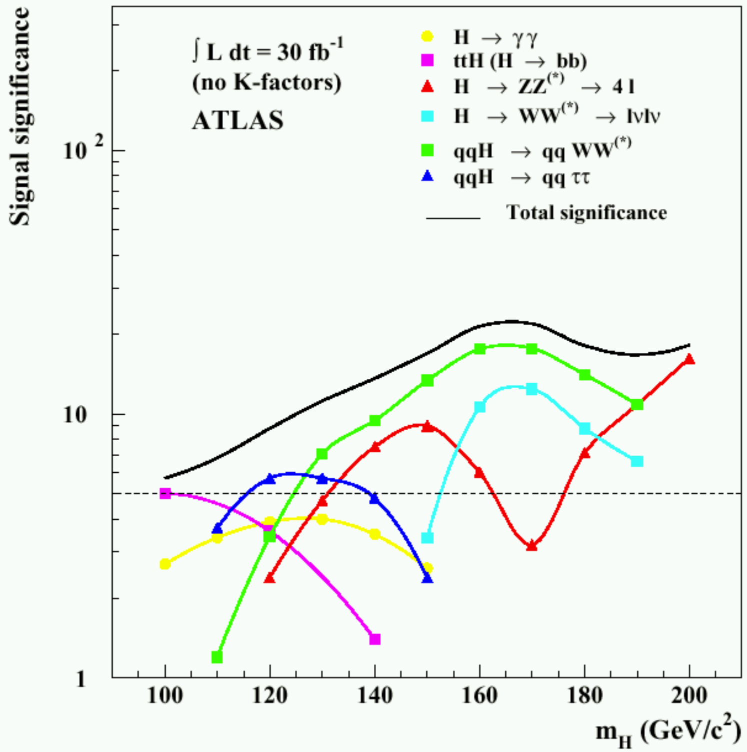
WW background propagation in ϕ_{ll} using data will be problematic, since gg->WW part behaves similar to signal and does not show up in a signal free region of high ϕ_{ll}.

VBF Higgs

- Z+2(3)J background; “Zeppenfeld plot” (TeV4LHC)
- Jet veto uncertainties (UE, …)
- Fake jets suppression
- VBF Higgs in MC@NLO (project started in Les Houches: C. Oleari, V. del Duca)

ATLAS: contribution of VBF channels to SM Higgs discovery



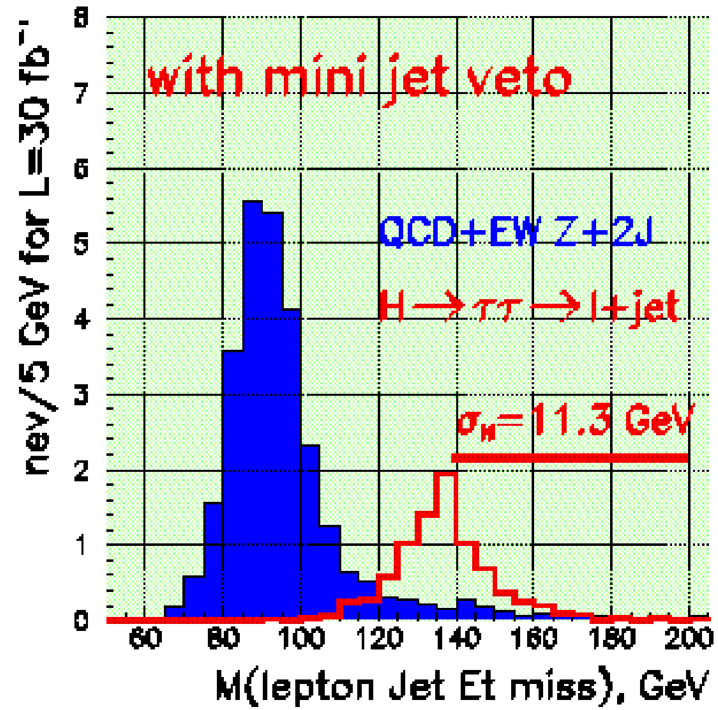


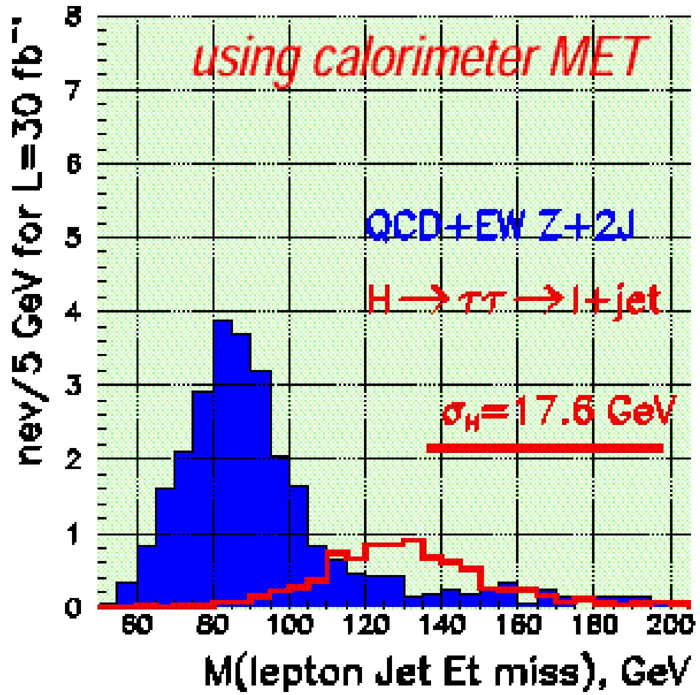
Going to full VBF simulation: challenge I

improve calo missing E_T: *one of the most suffering Higgs channels is light Higgs in qq->qqH, H->2τ->lepton + jet*

CMSJET fast simulation | **full simulation and OO/c++ reco**

qq->qqH, M_H = 135 GeV **H->ττ->l+jet**





First try in 2002. CMS, ORCA4

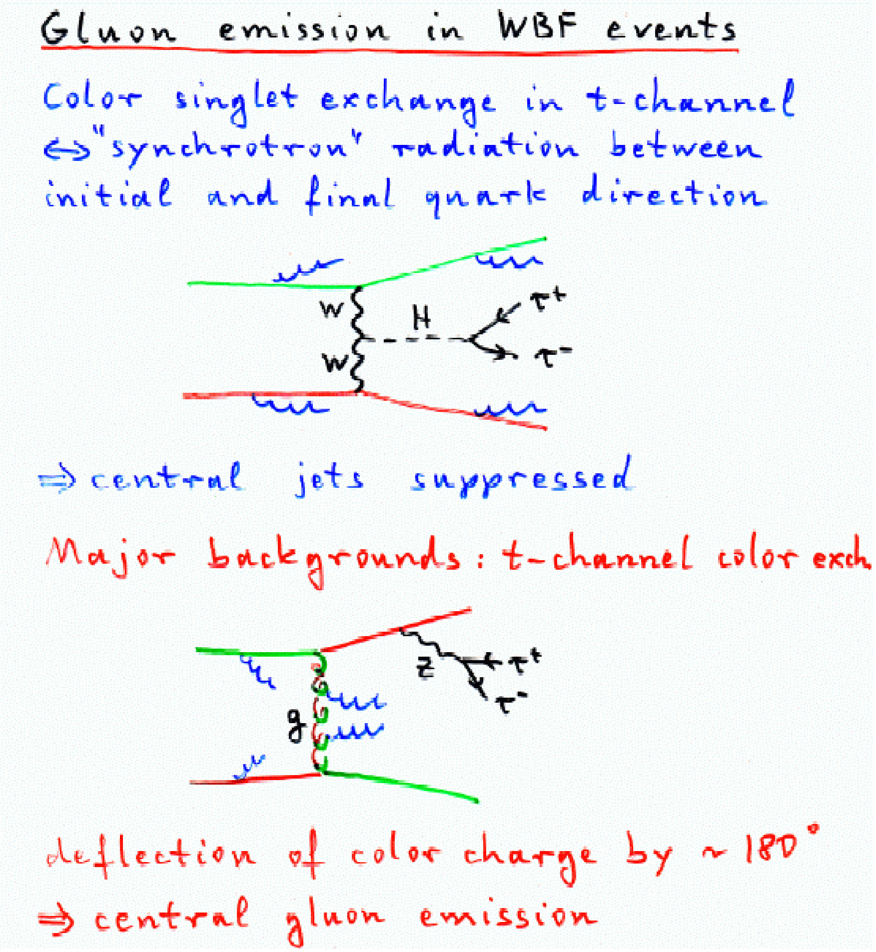
Jet veto in VBF (WW->H) production

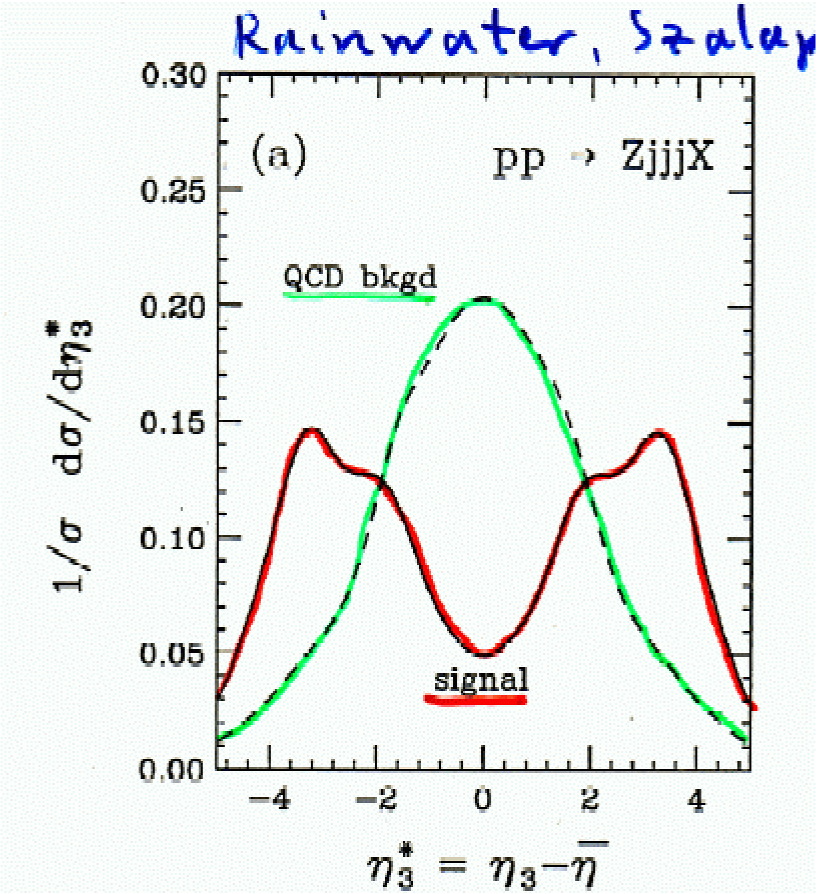
first discussed in :

Yu. Dokshitzer, V. Khoze and S. Troyan, Sov.J.Nucl. Phys. 46 (1987) 712

Yu. Dokshitzer, V. Khoze and T. Sjostrand, Phys.Lett., B274 (1992) 116

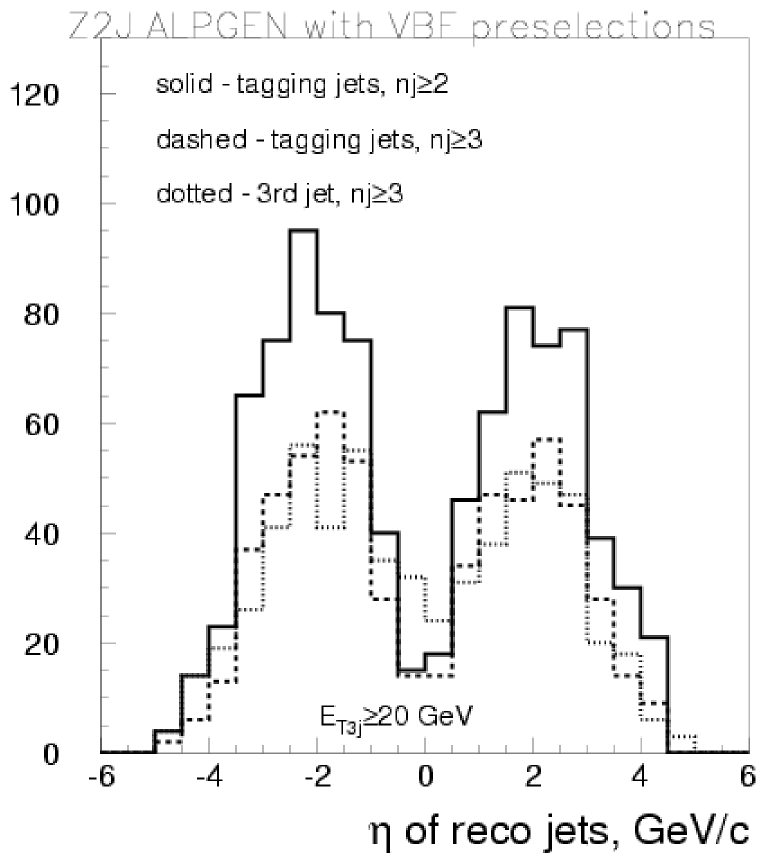
From D. Zeppenfeld talk on TeV4LHC, 2004



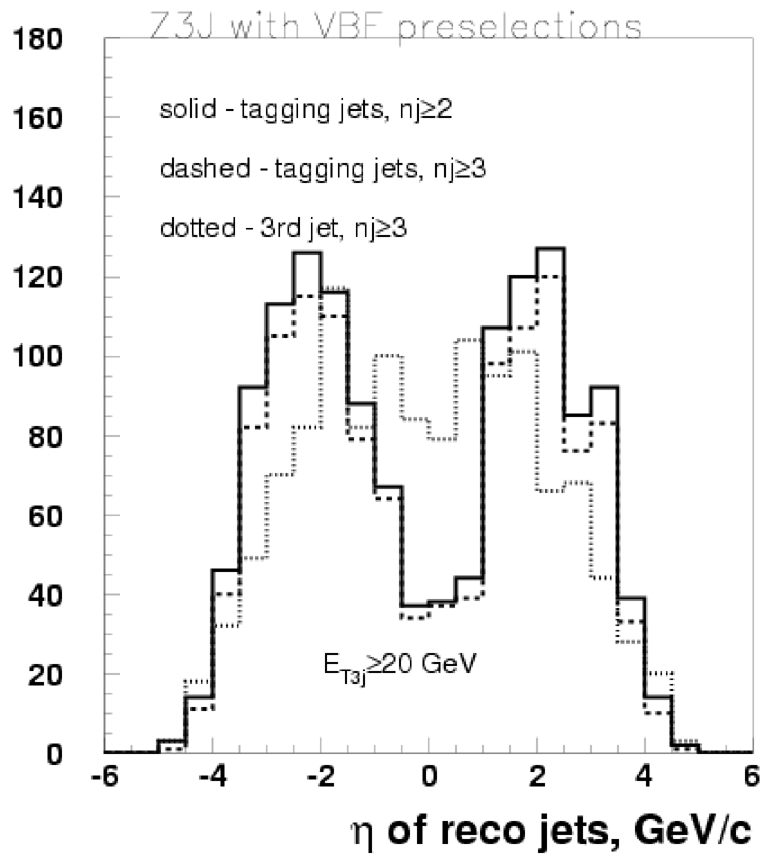


Challenge 2: “correct” generation of 3rd jet for jet veto

ALPGEN Z+2J with VBF+ PYTHIA6.227



ALPGEN Z+3J with VBF + PYTHIA6.227

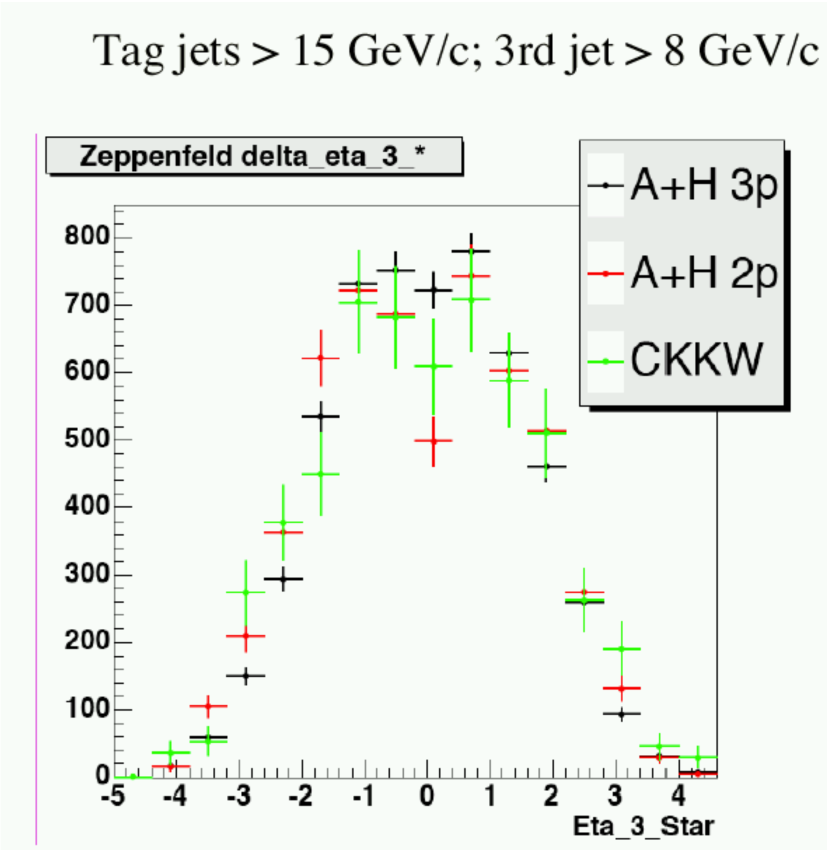


A. Nikitenko in collaboration with Fulvio Piccinini and M. Mangano

“Zeppenfeld plot”

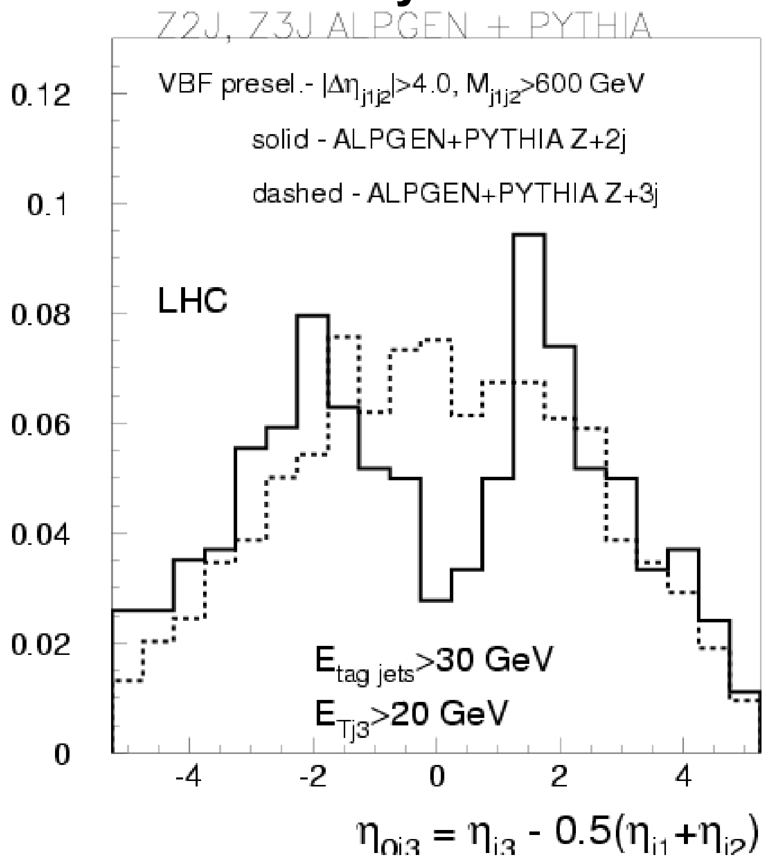
$$\eta_o=\eta_{j3}-0.5(\eta_{j1}+\eta_{j2})$$

Tevatron W+2(3)J MC , $\Delta\eta_{j1j2} > 2.0$
shown by J. Huston in 1st session



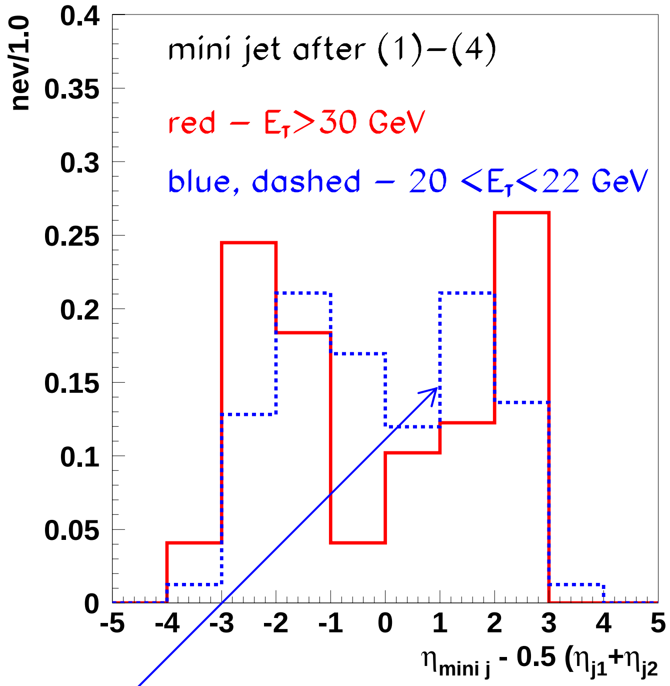
LHC Z+2(3)j MC , $\Delta\eta_{j1j2} > 4.0$

No ME+PS yet

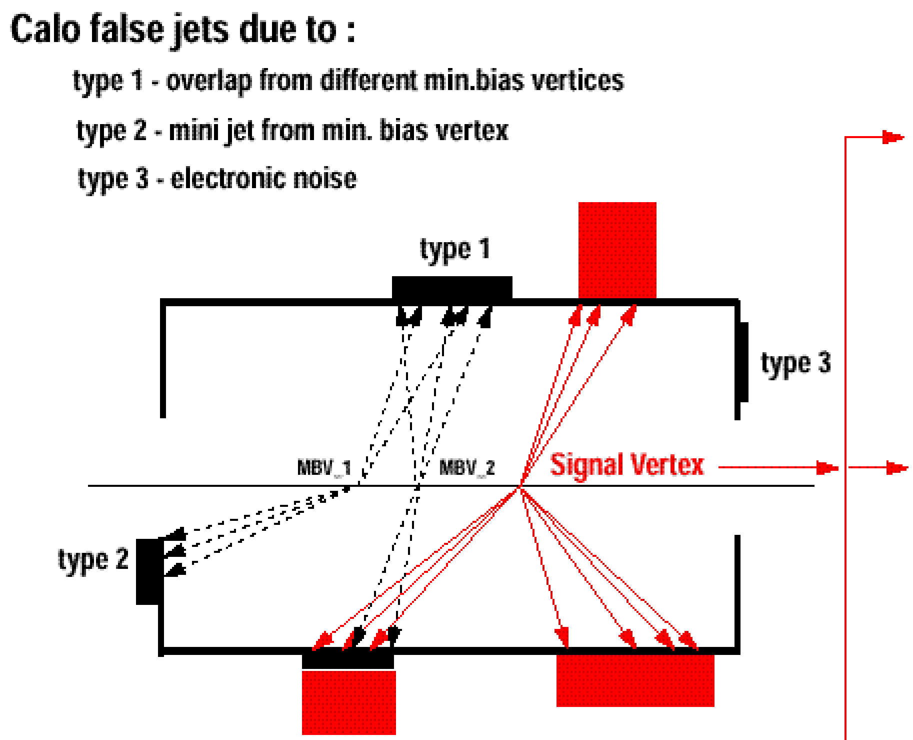


Going to full VBF simulation: challenge III : fake jets degrade jet veto performance

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

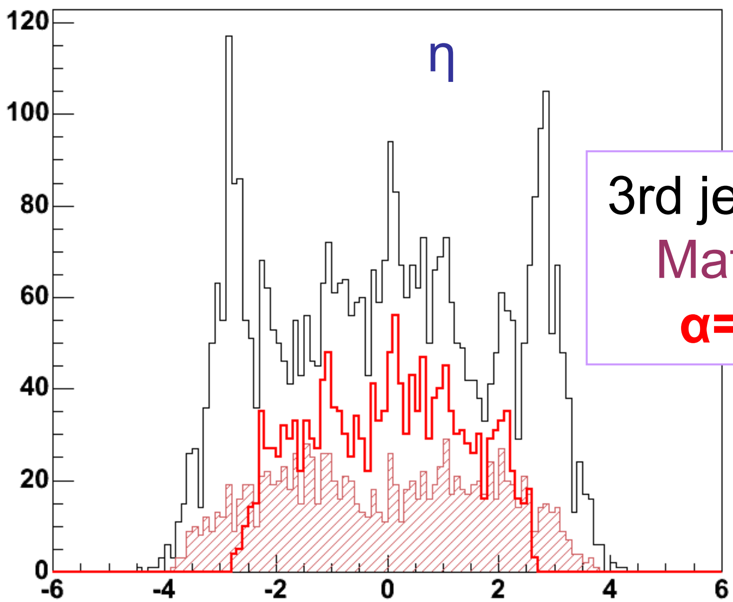


"bkg. like" behaviour for soft jets; fake jets: pile up+UE+detector

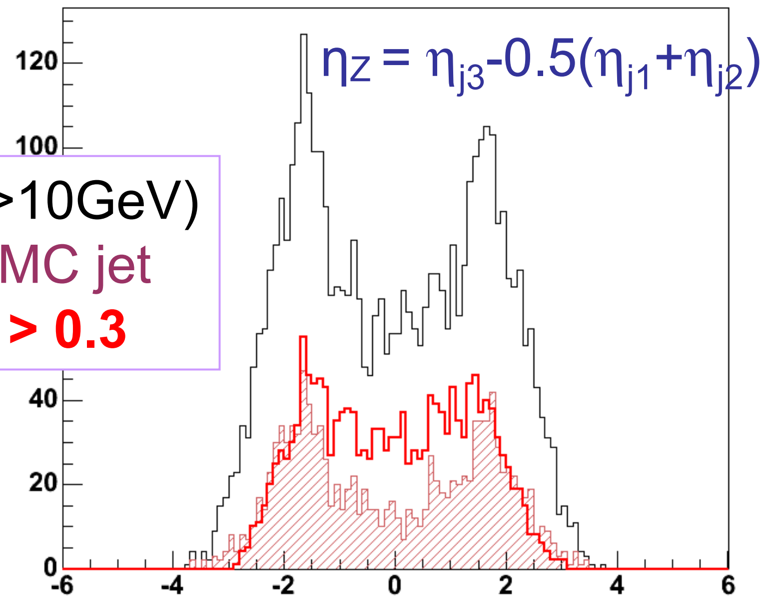


False jets

problem is solved using calo –tracker jet matching



3rd jets (raw E_T>10GeV)
Matched with MC jet
$\alpha=\Sigma p_T^{trk}/E_T^{jet} > 0.3$



- Improvement in the η distribution but still some excess jets in the central region
- Zeppenfeld behaviour is reproduced with much less fake jets

M. Takahashi + A. Nikitenko

Events Passing the Jet Veto

		Number of events	Fraction over VBF events (%)	Fraction passing the veto(%)
VBF selected		12112	-	-
No additional jet with raw E_T>10		3950	-	32.6
3rd MC jet (p_T>20)		1657	13.7	86.3
3rd jet (raw E_T>10)		**4820**	**40.0**	**60.0**
3rd jet matched with MC*		**1216**	**10.0**	**90.0**
3rd jet (raw E_T>10)	**α > 0.**	**2142**	**17.7**	**82.3**
	α > 0.2	**1844**	**15.2**	**84.8**
	α > 0.4	1418	11.7	88.3

* Additional jet with raw E_T>10 that has a matching MC jet with p_T>20

M. Takahashi + A. Nikitenko

Monte Carlos huge world !

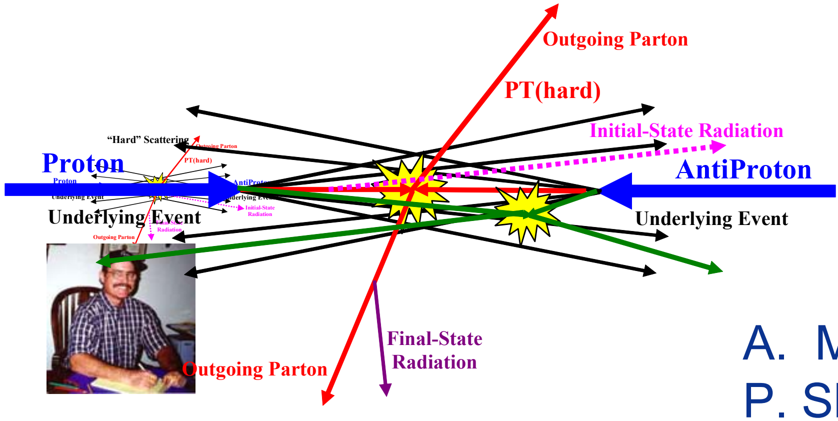
I will mention only one particular issue discussed in 1st session :

UE “benchmarks” to be considered in ATLAS and CMS analyses within pythia6.2 :

1. Compare CDF Tune A and ATLAS Tune;
2. Consider variation of the most important parameters within the fit errors

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

R. Field



A. Moraes, C. Buttar,
P. Skands, T. Sjostrand,
P. Bartalini

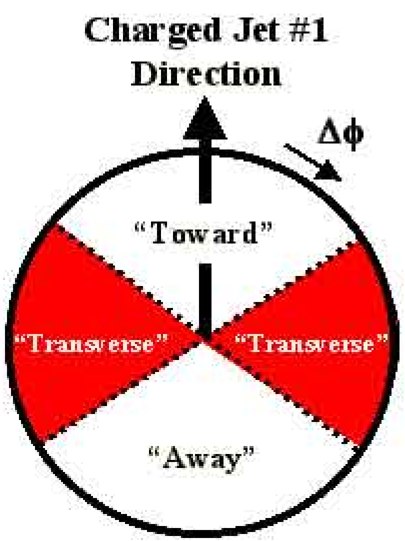
Pile up and underlying events affect :

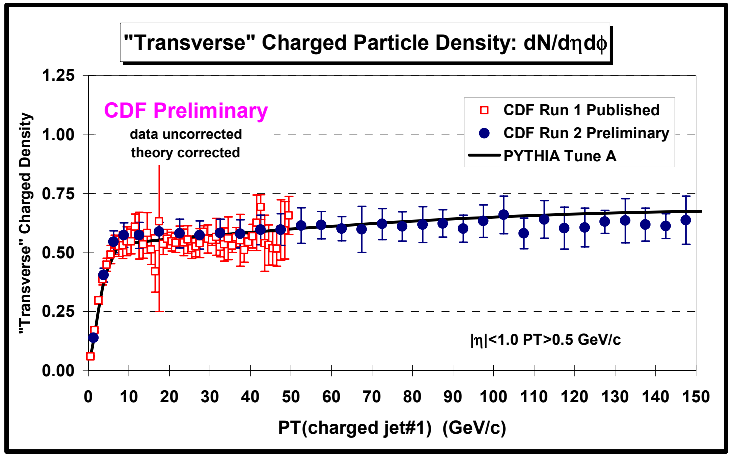
- isolation of γ, τ, e, μ
- jet energy reconstruction ("pedestal")
- jet veto
- forward jet tagging in VBF Higgs

Very important to understand uncertainties

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

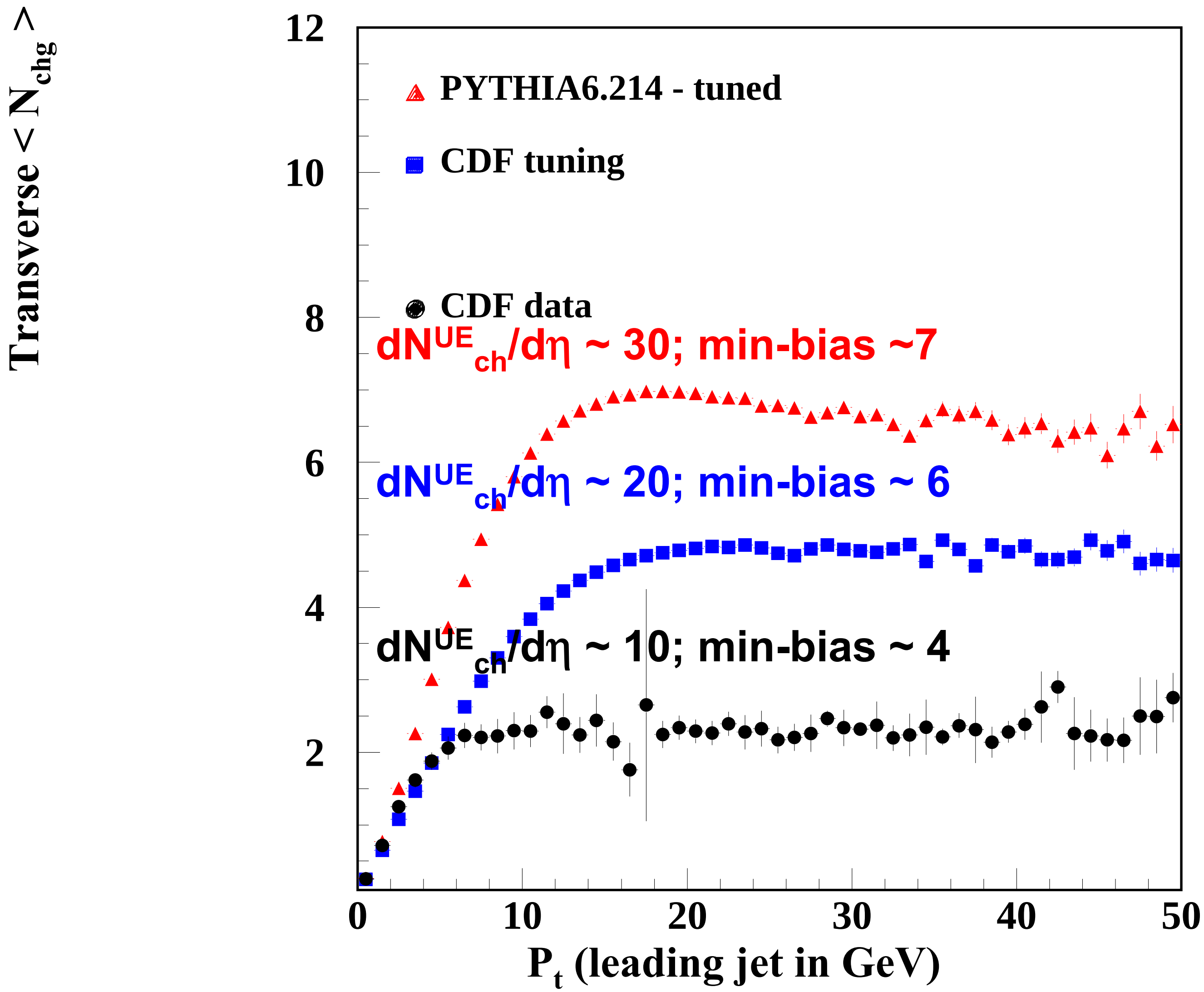
R. Field; CDF UE tuning method





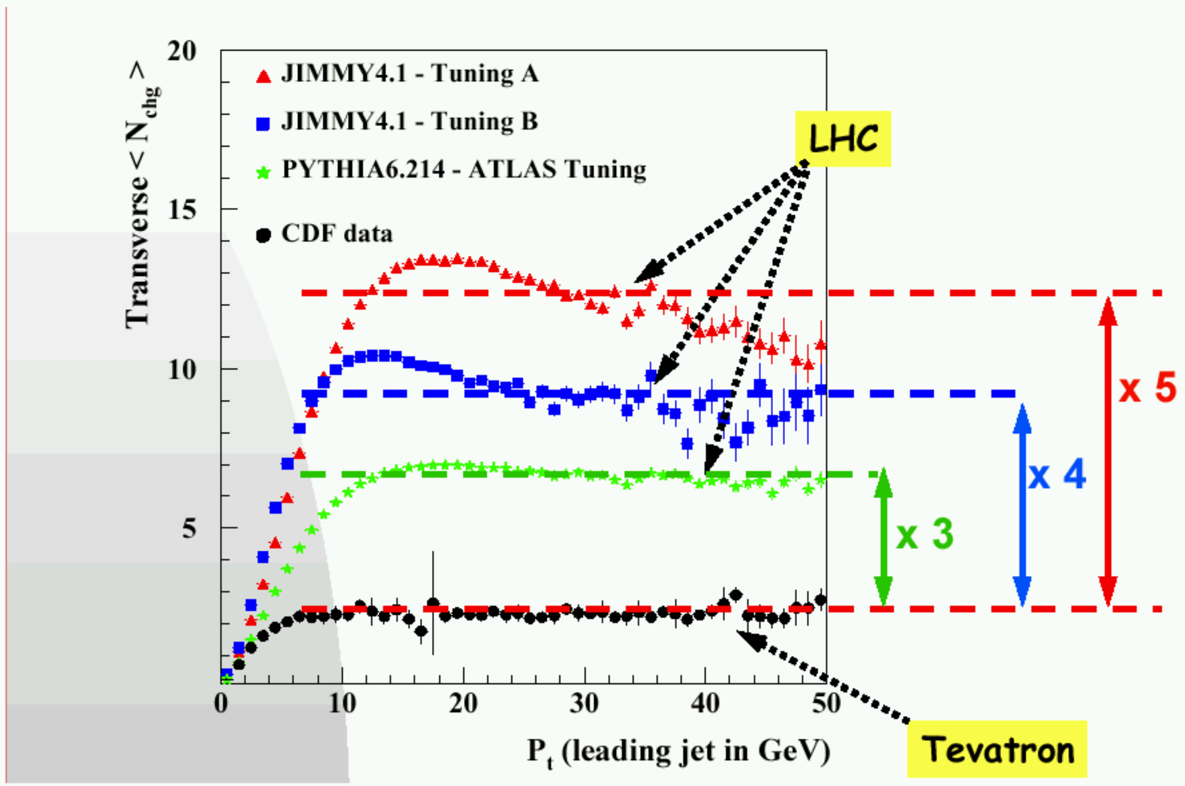
Comments	CDF – Tune A (PYTHIA6.206)	PYTHIA6.214 – Tuned (ATLAS)
Generated processes (QCD + low-pT)	Non-diffractive inelastic + double diffraction (MSEL=0, ISUB 94 and 95)	**Non-diffractive + double diffraction (MSEL=0, ISUB 94 and 95)**
p.d.f.	CTEQ 5L (MSTP(51)=7)	**CTEQ 5L (MSTP(51)=7)**
Multiple interactions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

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



LHC predictions for different generators

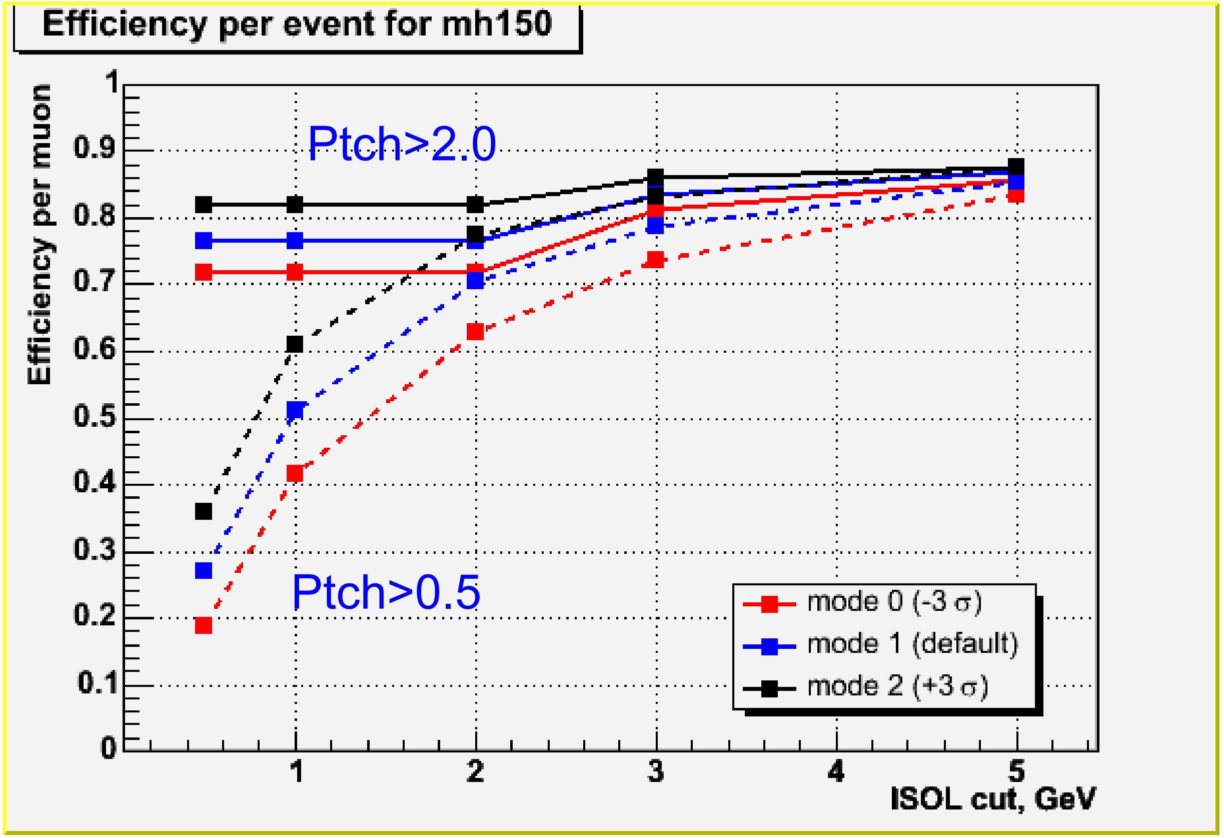
Consider PYTHIA and JIMMY underlying events tuned to the Tevatron data



effect of UE on isolation in H->ZZ->4μ

A. Drozdetski 1st session. ATLAS tune + change PARP(82) within 3σ

$P_T$cut_off = 2.9 GeV – default scenario
$P_T$cut_off = 2.4 GeV – pessimistic scenario
$P_T$cut_off = 3.4 GeV – optimistic scenario



PYTHIA6.2

ATLAS Tune +
change of
p_T cut off for UE
within 3σ .
Proposed by Paolo Bartalini, CMS contact for UE tunning

NLO for important processes.

S. Dittmaier : Theorists need a clear list of important processes including arguments for "why calculation and what ?!"

List given by J. Huston on 1st session matches well the ability of theoretical calculations and LHC experimental analysis needs

From talk of G. Heinrich "One-loop corrections to many-particle production"

See also talks of Z. Kunszt and Y. Kurihara on 1st session

feasible (?) until LHC starts (SM):

list to be discussed/modified/completed !

- $2 \to 3$
  - $pp \to V\,V\,jet$
  - $pp \to V\,V\,V$
- $2 \to 4$
  - $pp \to 4\,jets$
  - $pp \to t\bar{t}\,b\bar{b},\ pp \to t\bar{t} + 2\,jets,$
  - $pp \to t\bar{t}\,H + jet$
  - $pp \to V + 3\,jets$
  - $pp \to V\,V + 2\,jets$
  - $pp \to V\,V\,V + jet$

calculations/collaborations to be started at Les Houches

Some already expected “events” during 2nd session

- MC generators session on standartization of MC’s in c++ (org. by S. Frixione)
- Discussion on interplay between SUSY and Higgs searches: SUSY-> Higgs->SUSY (org. by S. Moretti)
- In tth group : report on NLO for ttA at LHC
- In EW : presentation on EW corrections for high E_T jet production by S. Moretti
- Hard work in groups – enjoy it ☺