A first look at the channel

$$H \rightarrow W^+W^- \rightarrow l^+\nu_l l^-\overline{\nu}_l$$

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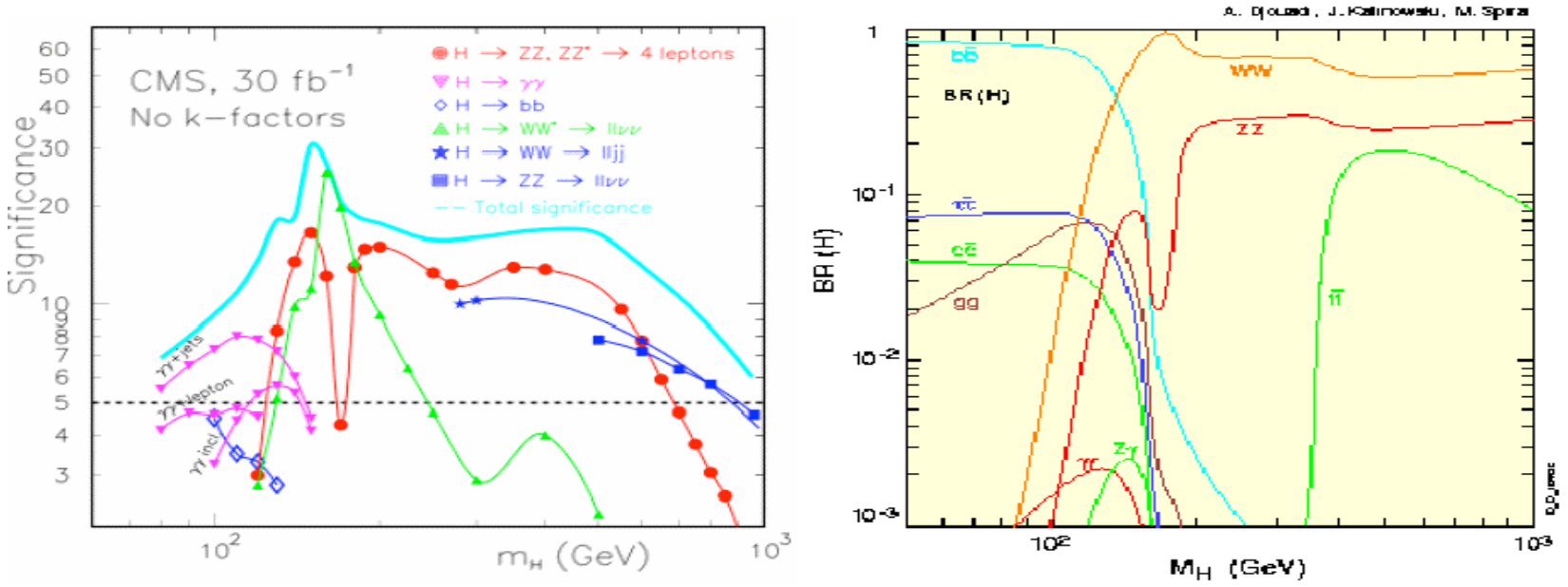
Outline

- Introduction of the channel
- different approaches
- event topologies and selections
- background studies
- very preliminary results at the fast simulation level

$$H \rightarrow W^+W^- \rightarrow l^+\nu_l l^-\bar{\nu}_l$$



Past analyses demonstrated that this could be a very fast channel for the discovery of the SM Higgs in the intermediate mass region 130 GeV< M_H < $2M_Z$ filling the gap of σ * BR (H→ ZZ → 4l).
It can be very useful also for lower mass (~ 120 GeV)

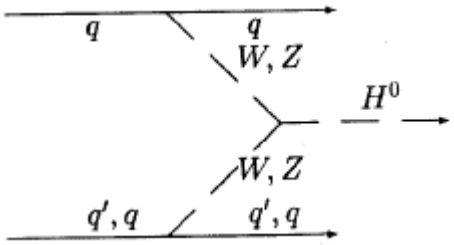
Possible approaches

In the past two different kinds of analysis have been performed:

- study of the general kinematics of the channel without any specific requirements on the Higgs production mechanism
- study of the vector boson fusion channel for the Higgs production to exploit its characteristic 2 jet signature

In both cases, because of the 2 ν, it is impossible to distinguish a peak in the invariant mass distribution $\Longrightarrow$ not easy counting channel $\Longrightarrow$ the precise knowledge of all possible backgrounds processes is fundamental

Vector Boson Fusion

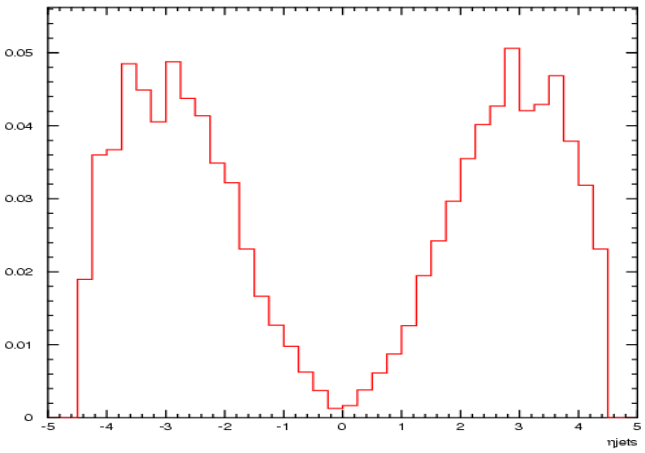


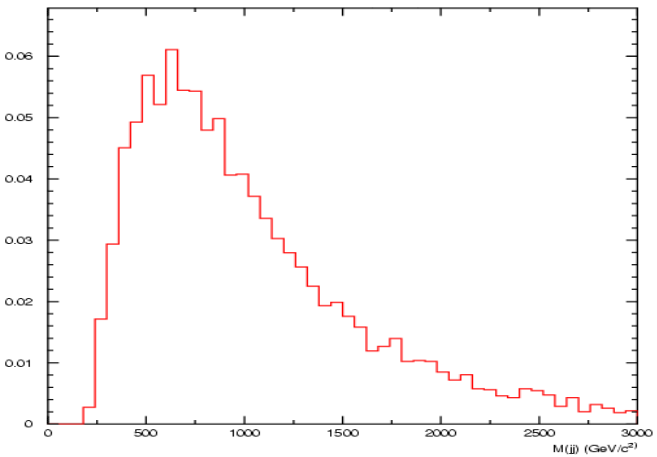
Production cross section is 20% (~ 4pb)
of the total σ for m_H=120GeV

The signal can be described as the scattering of q via t-channel W and Z exchange with the Higgs radiated off this weak bosons
$\Longrightarrow$ the signal contains two forward quark jets in addition to $H \rightarrow WW \rightarrow 2l2\nu$ decay products.

Backgrounds: any process resulting in 2 jets, 2 charged leptons and missing energy (ttjj, WWjj, ….)

Vector Boson Fusion





Extra event tags :

* Two high P_T forward jets in opposite hemisphere with large dijet invariant mass

* Charged leptons between the tagging jets

* Little jet activity in the central region (no color flow; $\longrightarrow$ suppression of QCD background)

Inclusive analysis

Signature: 2 leptons and missing momentum

Possible backgrounds: WW non resonant,
tt pair production
single t production (pp → Wtb)
ZZ, Z/γ^*
bb pair production

Up to now (very beginning) :
preliminary analysis including the qq → WW background
(tt & t back. at a qualitative level) and considering l = e, μ

The WW nr background, I

Signal : Higgs scalar, W vectors => to have J_{Tot}= 0 spin wave function must be:

$$WW(0,0_z) = \frac{1}{\sqrt{3}}\left(\underset{TT}{W^+(+_z)W^-(-_z)} + \underset{TT}{W^+(-_z)W^-(+_z)} - \underset{LL}{W^+(0_z)W^-(0_z)} \right)$$

TL coupling not allowed

✓ Case TT: each lepton has the same S_Z of the mother and must be produced with definite elicity => max prob to have the leptons emitted in the same direction

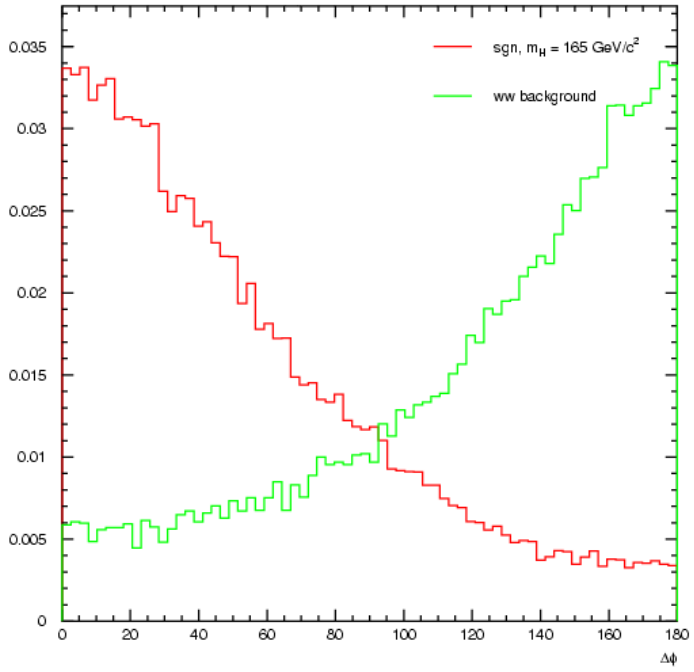
✓ Case LL: again max prob to have leptons emitted in the same direction

WWnr:

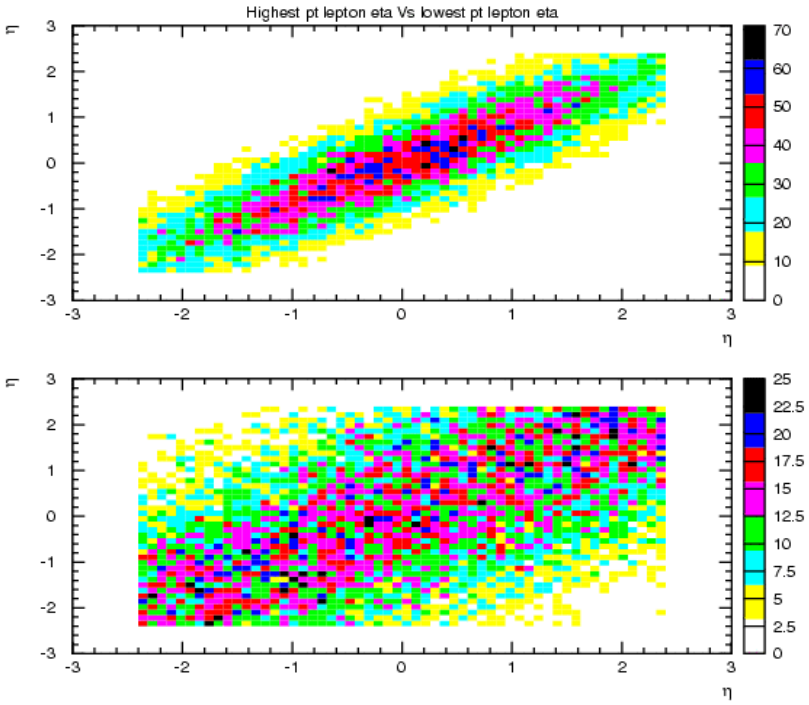
✓ Unpolarized initial state => TL coupling is allowed and @ M_{WW}~160 half of the production rate

✓ Case TL: no correlation in leptons emission

Spin correlation



$\Delta\varphi$ between the two leptons
in the transverse plane



η of the first leptons
Vs η of the second one

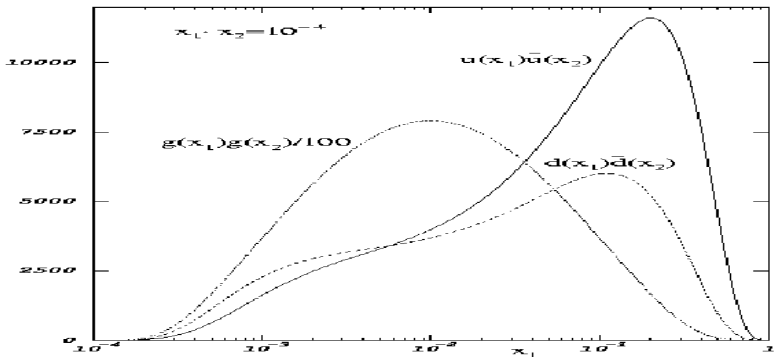
The WW nr background, II

γ_z~10

Higgs produced mainly via g-g fusion

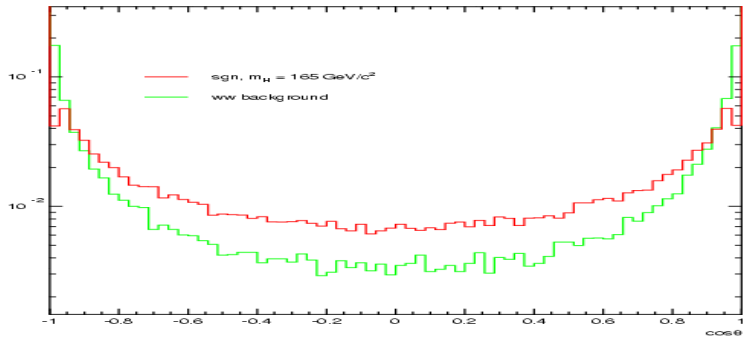
WWnr mainly produced by qq

Z boost $\gamma_z = \frac{x_1 + x_2}{\sqrt{4 x_1 x_2}}$



WWnr events more boosted

along the beam



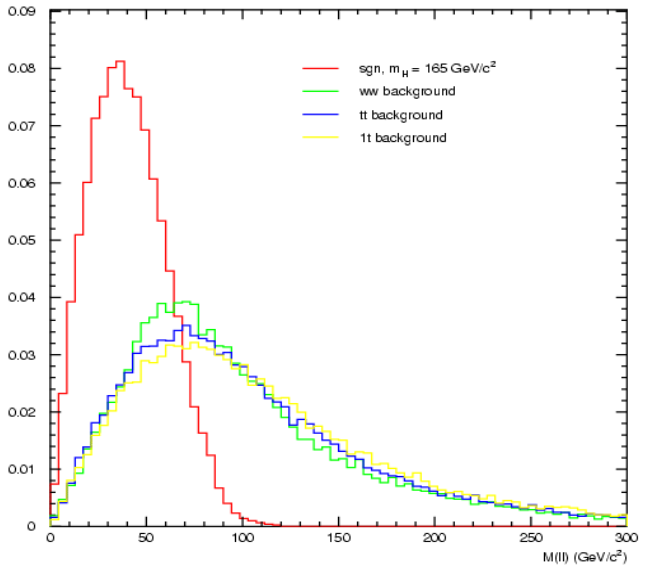
More isotropic signal leptons spatial distribution

Analysis

Signal and backgrounds generated using PYTHIA and TOPREX (for t/tt back) and the fast simulation for CMS (CMSJET)

Selections:

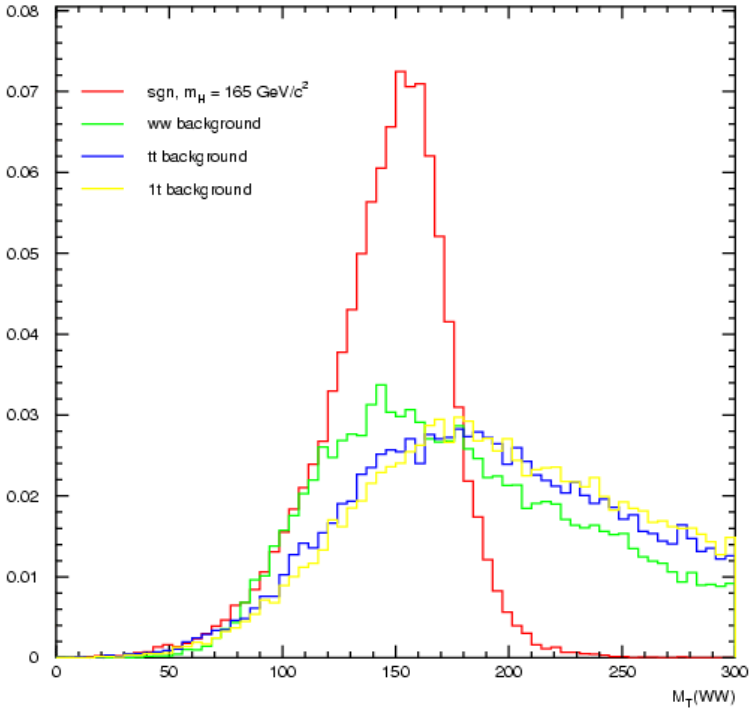
- Search for relatively central events with isolated charged leptons (e: PT > 20 GeV; μ: PT > 10 GeV; $|\eta| < 2$; leptons separated in space by more than 10 ° and isolated in the calorimeter)
- Missing PT cut: MPT > 20 GeV/c
- Invariant mass cut: M(ll) < 80 GeV (to reject leptons from Z peak)



Analysis

Selections:

- Jet veto: rejected events with one jet with PT > 20 GeV and $|\eta| < 2.4$
- $10° < \Delta\varphi < 45°$ (spin correlation)
- $|\cos\theta\,(ll)| < 0.8$ (boost of WW background)
- $M_T(WW) > 140$



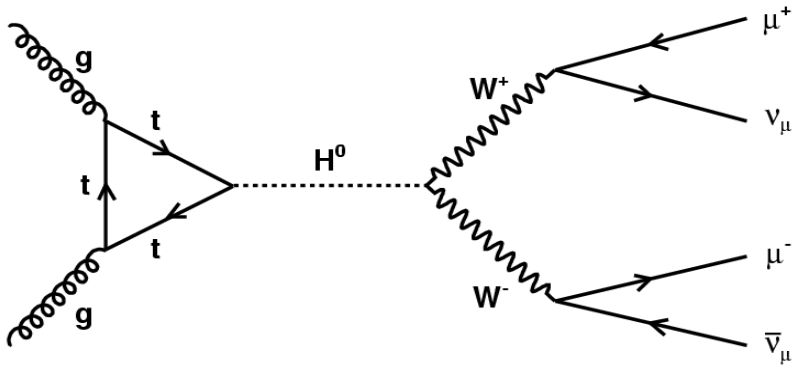
Summary & next steps

- This analysis showed that channel H $\rightarrow$WW$\rightarrow$ ll$\nu\nu$ can be a potential and quite fast channel for the Higgs discovery at the LHC

Our goals:

- quantitative study of all the backgrounds source to find the significance signal/noise
- inclusion of the l = τ channel, considering both leptonics and hadronic τ decays
- study of this channel with the full simulation chain

Signal



Reference sample

$H^0 \to W^+W^- \to \mu^+\nu_\mu\mu^-\bar{\nu}_\mu$	x-sec (pb)	events in the sample
M_H=120	0.036	9999
M_H=140	0.114	9997
M_H=160	**0.182**	**9998**
M_H=200	0.104	9999

Backgrounds

WWnr is the main bkgr, with the *same final states* but *reducible* (next slides)

Process	Pt_{min}	x-sec (*pb*)	N events	L
$q\bar{q} \to W^+W^- \to \mu^+\nu_\mu\mu^-\bar{\nu}_\mu$	5,5	77	17599	0.2 fb^{-1}
$b\bar{b} \to \mu^+\mu^- + X$ (Pt_{hard}>20)	7,7	$(1.4)\cdot 10^7$	48471	3.5 nb^{-1}
$Z/\gamma^* \to \mu^+\mu^- + X$	3,3	10^6	49489	49 nb^{-1}
$t\bar{t} \to \mu^+\mu^- + X$	5,5	621	17991	29 pb^{-1}
$ZW, ZZ \to \mu\mu + X$	5,5	29, 12	36990	$O(fb^{-1})$

Not yet considered:

- Single top ($pp \to Wtb \to \mu^+\mu^- + X$)
- $gg \to W^+W^- \to \mu^+\nu_\mu\mu^-\bar{\nu}_\mu$

Statistical Results

M_H=160	N_{ev} @ $5fb^{-1}$	N_{ev} @ $20fb^{-1}$
Signal	35	138
Background	22	88
σ	7.4	14.7

Results for other masses:

	Eff (%)	σ @ $5fb^{-1}$	σ @ $20fb^{-1}$	$L_{5\sigma}(fb^{-1})$
M_H=120	1.9	0.5	1.1	390
M_H=140	3.2	3.0	6.0	14
M_H=200	2.7	2.5	4.9	21

✓ ***M_H=120:*** not viable; other H production processes like Vector Bosons Fusion can be used (CMS Note 2002/26: pp->jjH, H->WW->llνν)

✓ ***M_H=200:*** different kinematic (e.g. no so effective spin correlation) different selections should be used