Searches for a light Higgs boson in association with a photon and two forward jets

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work made in coll. with

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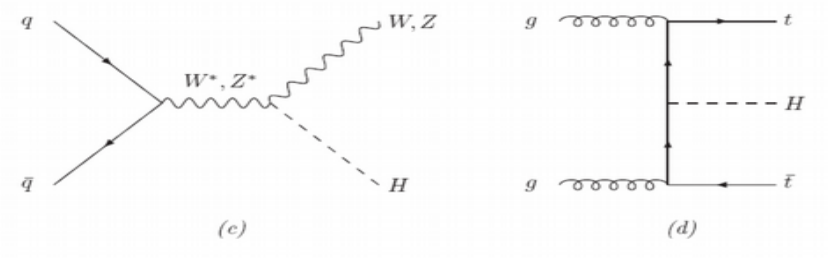
(preliminary)

Higgs decay in bb(bar)

- not a discovery channel, but…relevant for measuring the Hbb coupling
- up to now the processes Htt(bar) and HW + 2 forward JETS have been considered
- bckg can be reduced approximatively at the level of the signal
- resulting x-sections after optimized cuts are of the order of few fb.



inclusive cross sections of HW in fb

M_H	110	120	130	140	150
inclusive	84	80	76	72	70
$B_H(b\bar{b})$	0.77	0.67	0.52	0.33	0.17
$B_W \cdot B_H \cdot \sigma$	**13.9**	**11.2**	**8.6**	**5.1**	**2.5**

Rainwater (2001)

HW allows to measure Hbb coupling for mH=120 GeV with an uncertainty of 50%

mH = 120 GeV

	a	b	c
$WHjj$ signal	1.4	1.4	1.1
$Wb\bar{b}jj$ bkg	8.8	5.7	4.3
$t\bar{t}jj$ bkg	4.9	3.7	1.2
S/B	**1/10**	**1/7**	**1/5**

Rainwater (2001)

a

$$p_{T_j} \geq 30\ \text{GeV}\,, \quad |\eta_j| \leq 5.0\,, \quad \triangle R_{jj} \geq 0.6\,,$$
$$p_{T_b} \geq 15\ \text{GeV}\,, \quad |\eta_b| \leq 2.5\,, \quad \triangle R_{jb} \geq 0.6\,,$$
$$p_{T_\ell} \geq 20\ \text{GeV}\,, \quad |\eta_\ell| \leq 2.5\,, \quad \triangle R_{j\ell,b\ell} \geq 0.6\,,$$
$$\eta_{j,min} + 0.7 < \eta_{b,\ell} < \eta_{j,max} - 0.7\,,$$
$$\eta_{j_1} \cdot \eta_{j_2} < 0, \quad \triangle\eta_{tags} = |\eta_{j_1} - \eta_{j_2}| \geq 4.4\,.$$

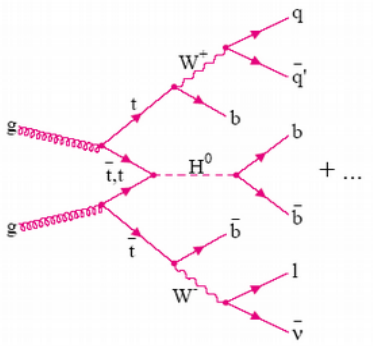
b

$$m_{jj} > 600\,\text{GeV}\,, \quad p_T(b_1, b_2) > 50, 20\,\text{GeV}$$

c

$$\not{p}_T < 100\,\text{GeV}\,, \quad m_T(\ell, \not{p}_T) < 100\,\text{GeV}$$

Htt(bar) and H → bb(bar)



- extremely exclusive signature suitable for low Higgs mass, disfavored by low x-section
- 3 final states considered: fully leptonic, semileptonic, fully hadronic

LO cross sections			masses		
$\sigma_{t\bar{t}H^0} \times BR_{H^0 \to b\bar{b}}$	=	1.09 - 0.32 pb	m_{H^0}	=	100 - 130 GeV/c^2
$\sigma_{t\bar{t}Z^0}$	=	0.65 pb	m_{Z^0}	=	91.187 GeV/c^2
$\sigma_{t\bar{t}b\bar{b}}$	=	3.28 pb	m_b	=	4.62 GeV/c^2
$\sigma_{t\bar{t}jj}$	=	507 pb	m_t	=	175 GeV/c^2

Htt(bar) L=30/fb mH=115 GeV

Drollinger, Muller, Denegri (2001)

b-tagging scenario	jet acceptance	S	B	S/B	$S/\sqrt{B}$
without lepton information	$\|\eta\| < 2.5$	26	31	84%	4.7
with lepton information	$\|\eta\| < 2.5$	38	52	73%	5.3
with lepton information	$\|\eta\| < 2.0$	30	41	75%	4.8
with lepton information	$\|\eta\| < 1.5$	20	27	73%	3.8

main problems

- many jets in the event
- major bckg from ttbb , Ztt, tt+Njets and QCD multijets
- major problem, normalization of the bckg from data
- many sources of uncertainties: MC predictions, Jet energy scale
- all these systematics might Kill the signal !

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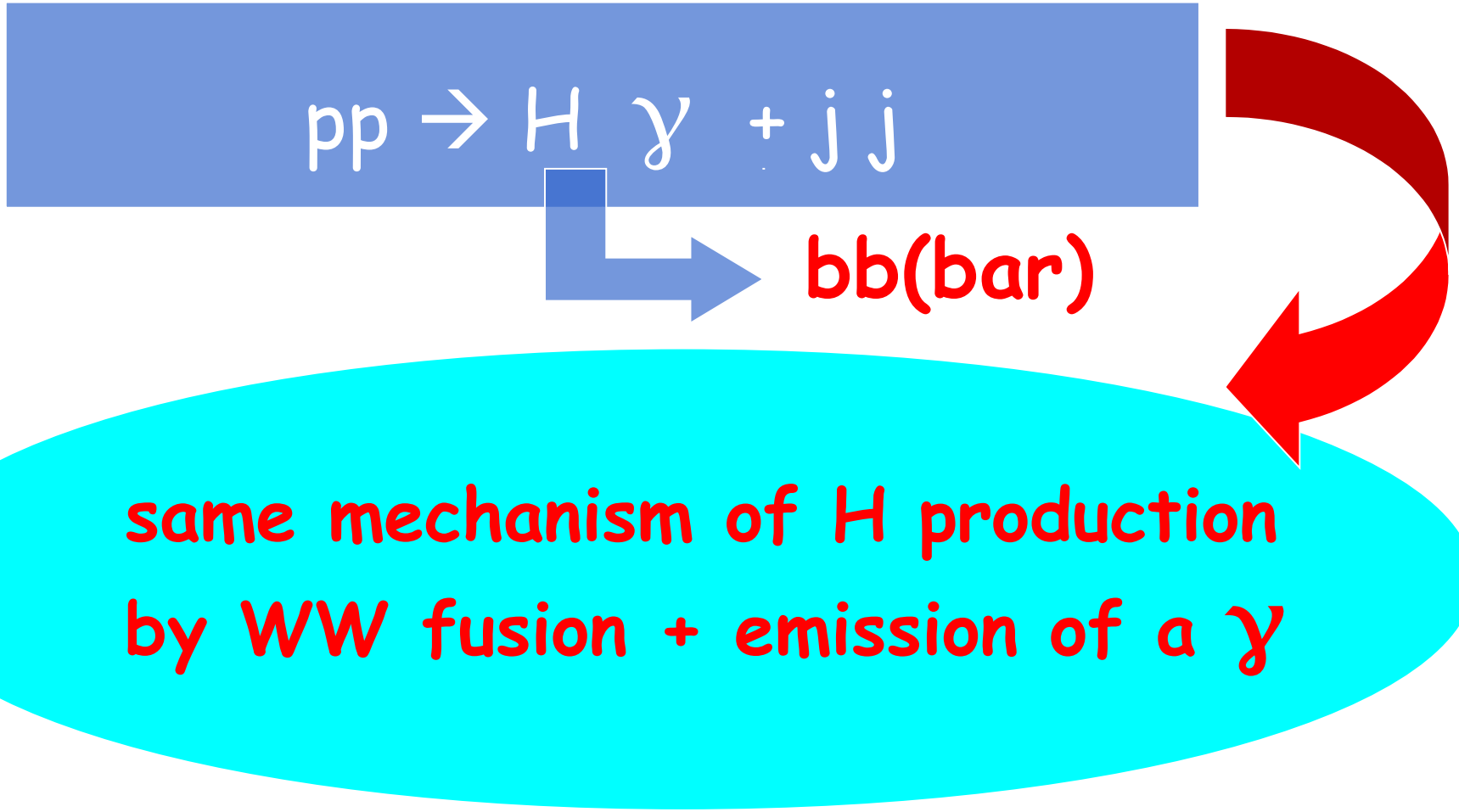
(preliminary)

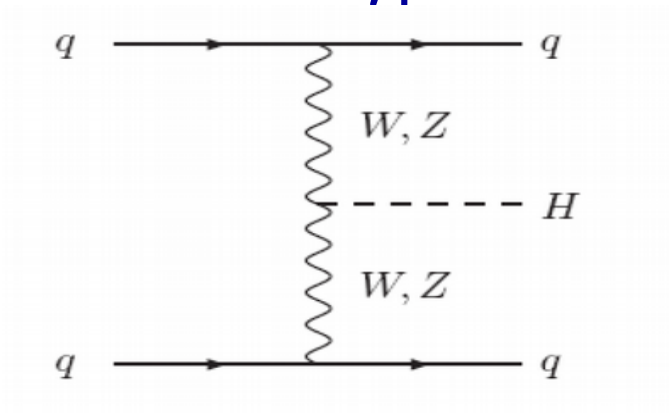


main advantages

- trigger on gamma
- the bckg is less active than Hjj when a central photon is required
- large x-section
- provide a new independent test of Hbb(bar) and HWW couplings

Higgs production in WW fusion

characteristic signal is the presence of two forward Jets with a typical transverse momentum



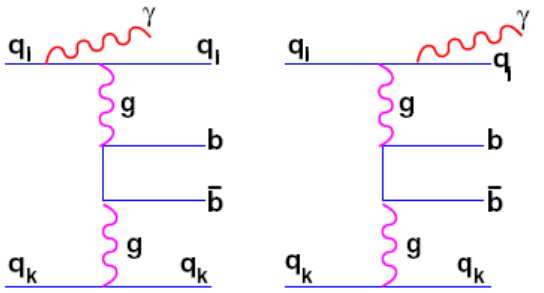
$p_T \approx 30 - 40\ \mathrm{GeV}$

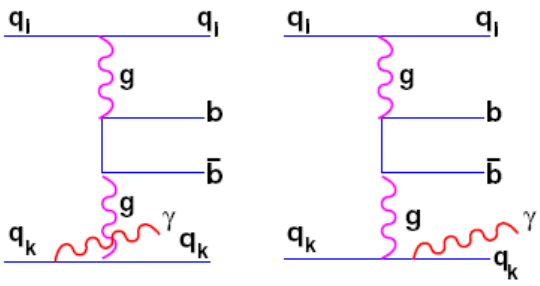
Mangano, Moretti, Piccinini, Pittau, Polosa (2003)

- large x-section, BUT it is difficult to measure due to the huge bckg with respect to signal
- emission of a photon provide a trigger and also allows to reduce the bckg with respect to the signal
- the mechanism: the angular cuts on gamma play a crucial role

main bckg to pp → H γ + j j

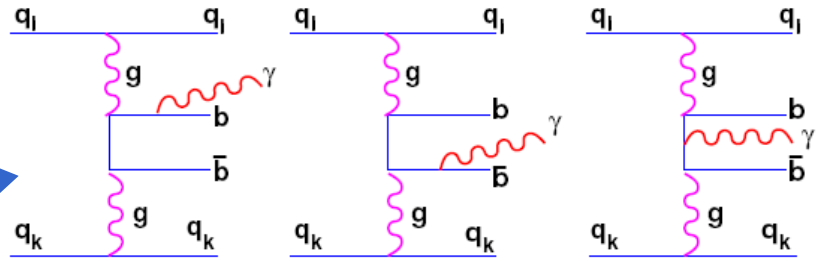
gauge invar. contribs. destr. interference for gamma at large angles



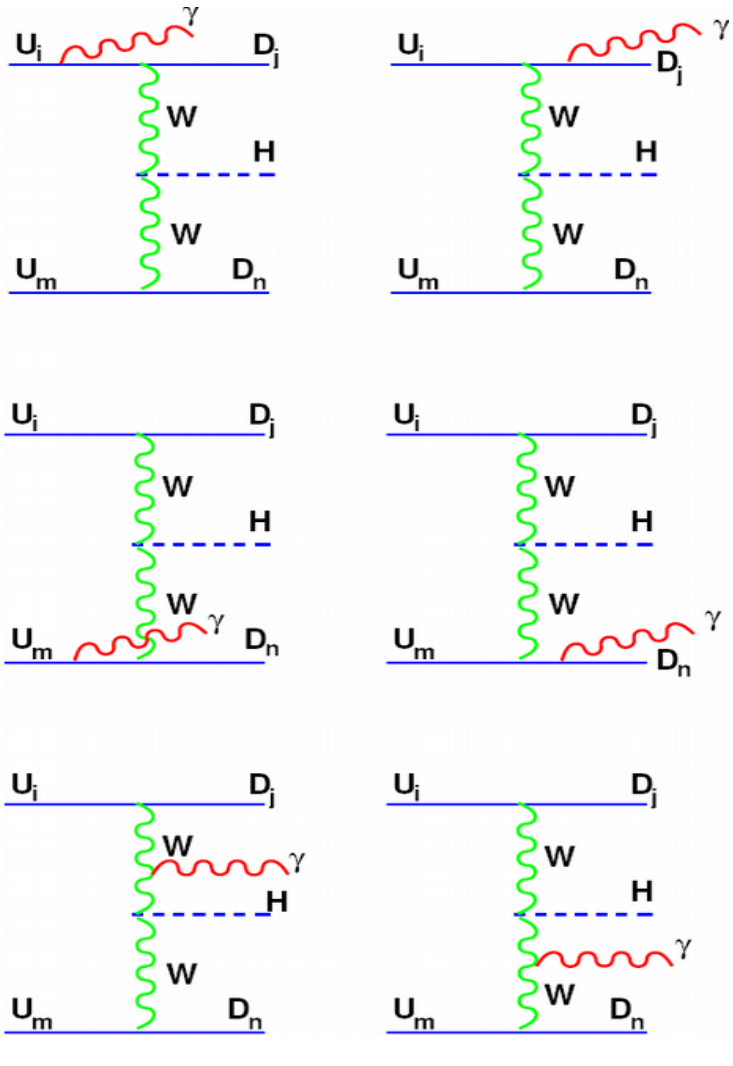


bckg is less active by requiring a central photon

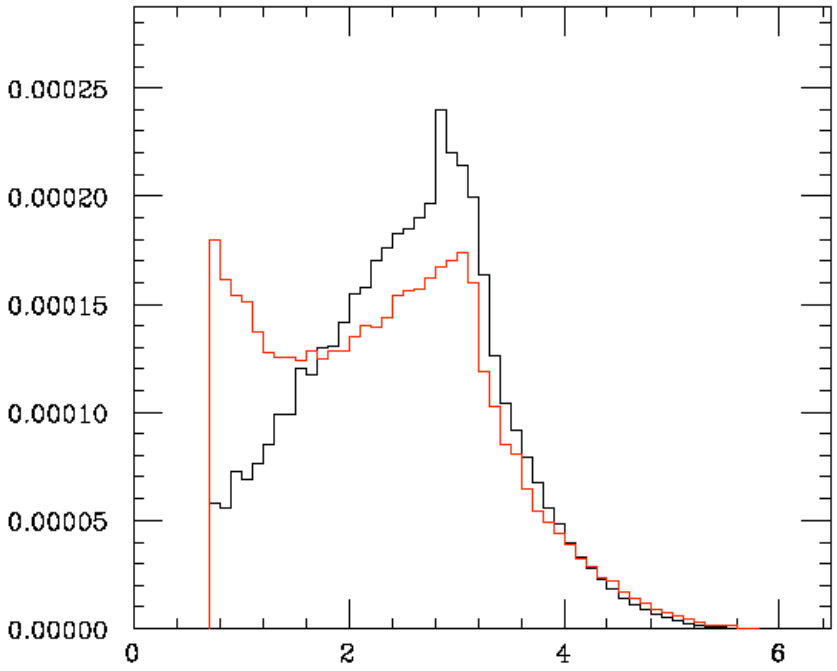
gauge invariant contr. comparable with others



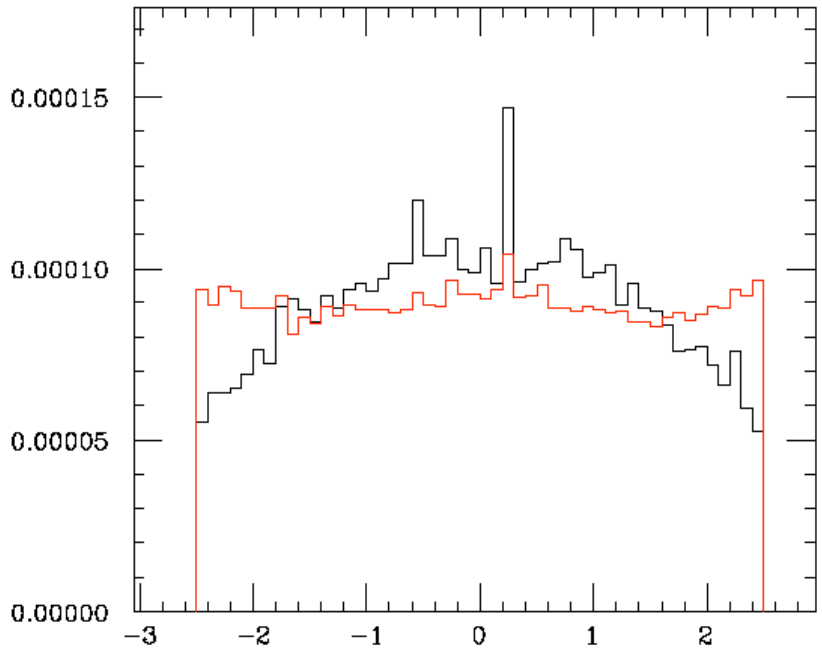
no destructive interference at large angle, due to the charged gauge boson



- different angular photon distribution with respect to bckg
- sensitive to HWW and WWg couplings



$\Delta R(\gamma, b)$



$\eta(\gamma)$

signal

bckg

same normalization

optimized cuts to enhance S/B

$p_T(j) > 30\,\mathrm{GeV}$

All $\Delta R > 0.7$

$|\eta(b)| < 2.5$

$p_T(j_1), p_T(b_1) > 60\,\mathrm{GeV}$

$m(j_1, j_2) > 800\,\mathrm{GeV}$

$|\eta(b_1) - \eta(b_2)| > 4$

$(120-12)\,\mathrm{GeV} < m(b_1, b_2) < (120+12)\,\mathrm{GeV}$

$m(H, \gamma) > 160\,\mathrm{GeV}$

$N(S) = L\sigma(S)BR \times \varepsilon(b)\varepsilon(b)\varepsilon(bb)$

$N(B) = L\sigma(B) \times \varepsilon(b)\varepsilon(bb)$

$$\mathrm{signf} = \frac{N(S)}{\sqrt{N(B)}}$$

mH = 120 GeV

BR = 69%

L=100/fb

ε(b) = 50% → eff. b-tag

ε(bb) = 80% → eff. bb reconstr.

$pp \rightarrow H\ \gamma + j\ j$

signal (fb)	bckg (fb)
6.6 x BR pT(g) > 20 GeV	54.1 pT(g) > 20 GeV
4.9 x BR pT(g) > 30 GeV	41.6 pT(g) > 30 GeV

S/B	signf
1/8	2.7
1/9	2.3

signal no rad (pb)	bckg no rad (pb)
0.472	103.8
S/B=1/220	

Conclusions

- The measure of Hbb coupling is challenging at the LHC
- known promising channels are HW and Htt
- we propose an alternative channel

  $pp \rightarrow H\,jj + \gamma$ (WW fusion)
- main advantages with respect to Hjj
  - less active bckg after requiring a central photon
  - trigger on photon
- after suitable cuts → signf = 2.7
- viable channel to measure Hbb, HWW couplings