Higgs trilinear self coupling Revisited

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ECFA Valencia 11-2006

Higgs trilinear self coupling Revisited

- Introduction
- Reminder
- hhZ event selection
- Results and interpretation
- The next step

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Reminder : higgs self coupling @ 500 GeV

C. Castanier, P. Gay, P. Lutz, J. Orloff

Hep-ex/0101028 LC-PHSM-2000-061

- Study of the experimental feasibility of the measurement
- $\Delta\lambda/\lambda$ measured with 3 hhZ selections
- Relative precision on $\Delta\lambda/\lambda$ = 18% (for a Luminosity of 2 ab^{-1}, m_h = 120 GeV/c²)

- **Analysis :**
  - Use of the reconstructed masses
  - Use of the 4-b signature of hhZ events
  - Use of both Neural Network and Cut analyses
  - σ extracted by a likelihood method
  - selection performance : $s/\sqrt{s+b} = 5.7$

hhZ @ 500 GeV

- **The aim**
  - Perform an independant analysis
  - Optimize the analysis
  - Include the missing backgrounds
  - remove part of background double countings

- **Context**
  - $\sqrt{s}$ = 500 GeV
  - Energy flow resolution $\Delta E/\sqrt{E}$ = 30%
  - typical b-tag efficiency = 90%

- **Monte Carlo production**
  - Events generated with Whizard
  - Fast detector simulation

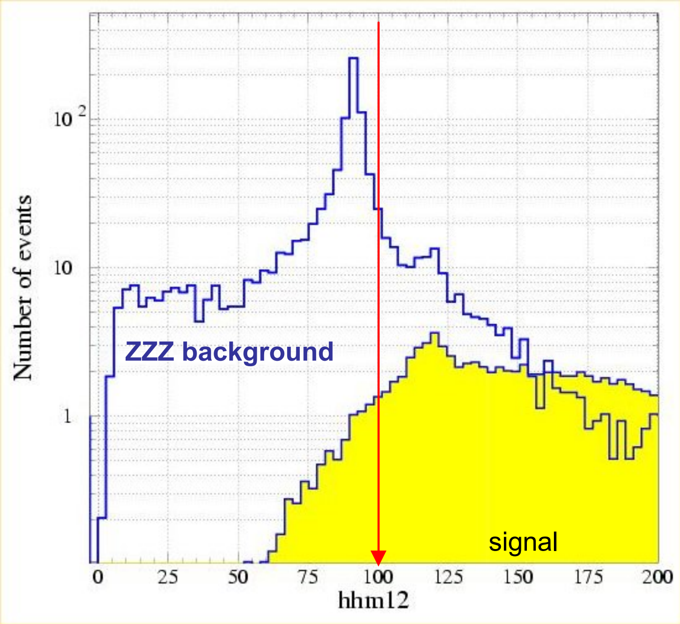
MC production @ 500 GeV

Processes	σ(pb)	N Generated	Generated luminosity (pb^{-1})	N expected ($L = 500\ pb^{-1}$)
hhZ	0,18441	15k	81340,49	**92,2**
Backgrounds	699	1820k		**332167**
tt	526,4	740k	1880,7	263200
ZZZ	1,051	40k	38059,0	525
tbtb	0,7	20k	28571,4	350
ZZ	45,12	50k	1108,2	22560
nntt	0,141327	20k	141515,8	70
wwz	35,3	130k	3682,7	17650
wtb	16,8	200k	2976,2	8400
eezz	0,287	10k	34843,2	143
nnww	3,627	30k	8271,3	1813
evzw	10,094	60k	5944,1	5047
nnzz	1,08257	20k	18474,6	541
ttZ	0,6975	20k	28673,8	541

Main backgrounds (tt, ZZ, wwz)

hhZ selection @ 500 GeV

- **Global variables**
  - visible energy
  - sphericity
  - $m_{hemispheres}$



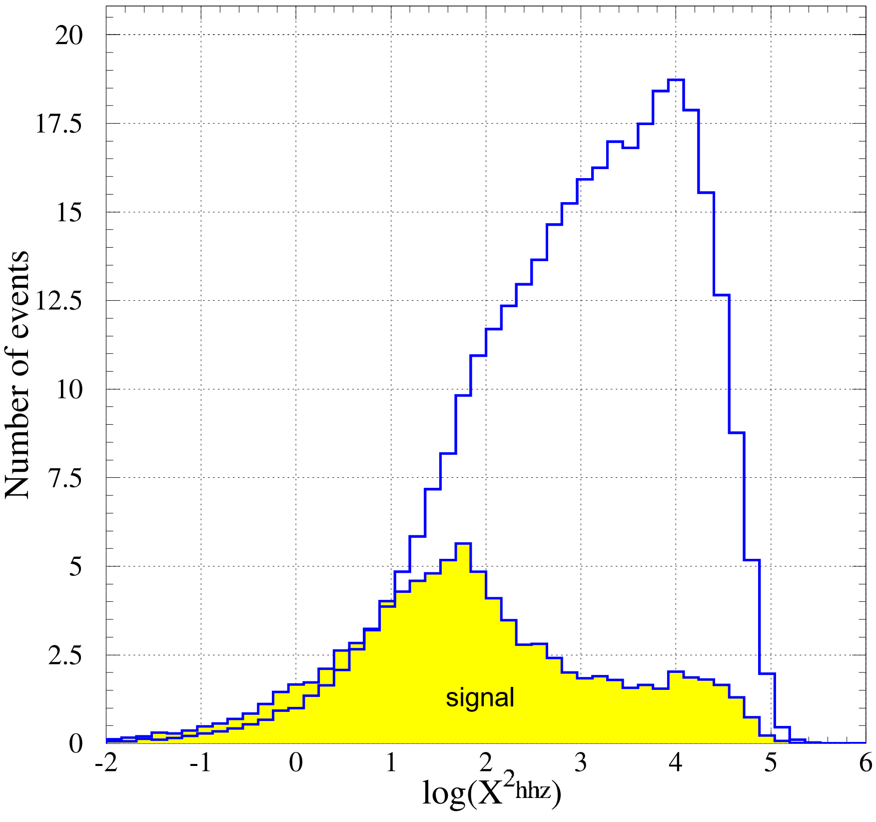
- Event reconstruction
  - clusturisation (in 4 and 6 jets)
  - jet pairing based on di-jet masses associated to bosons

- **Topological variables**
  - boson masses
  - χ^2 (hhZ, hZ, ZZZ,WW,ZZ)

$\Rightarrow$ Test process hypothesis based on the expected masses of h,Z,W.

hhZ selection @ 500 GeV

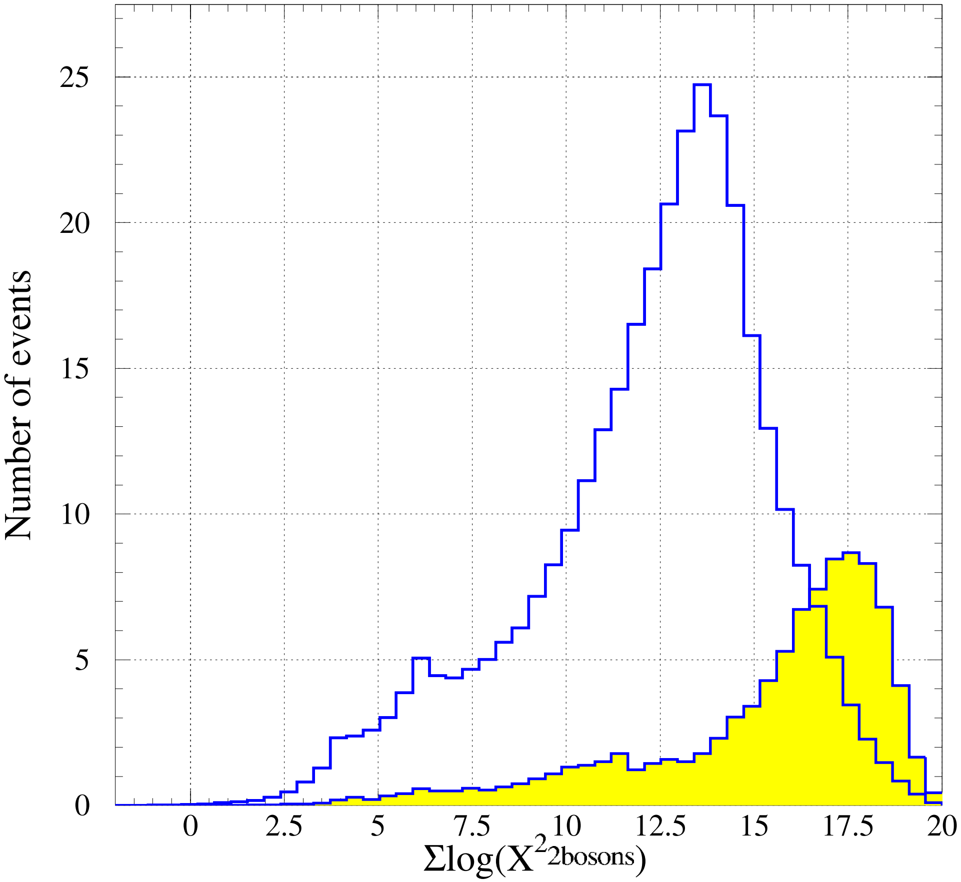
$$\chi^2_{hhZ} = (m_{h1}^{Reco} - m_h^{exp.})^2/\sigma_{mh}^2$$
$$+ (m_{h2}^{Reco} - m_h^{exp.})^2/\sigma_{mh}^2$$
$$+ (m_Z^{Reco} - m_Z^{exp.})^2/\sigma_{mZ}^2$$



hhZ selection @ 500 GeV

$\Sigma\log(\chi^2_{2bosons})$ =

$\log(\chi^2_{zz}) + \log(\chi^2_{hZ}) + \log(\chi^2_{WW})$



Use of the b-tag

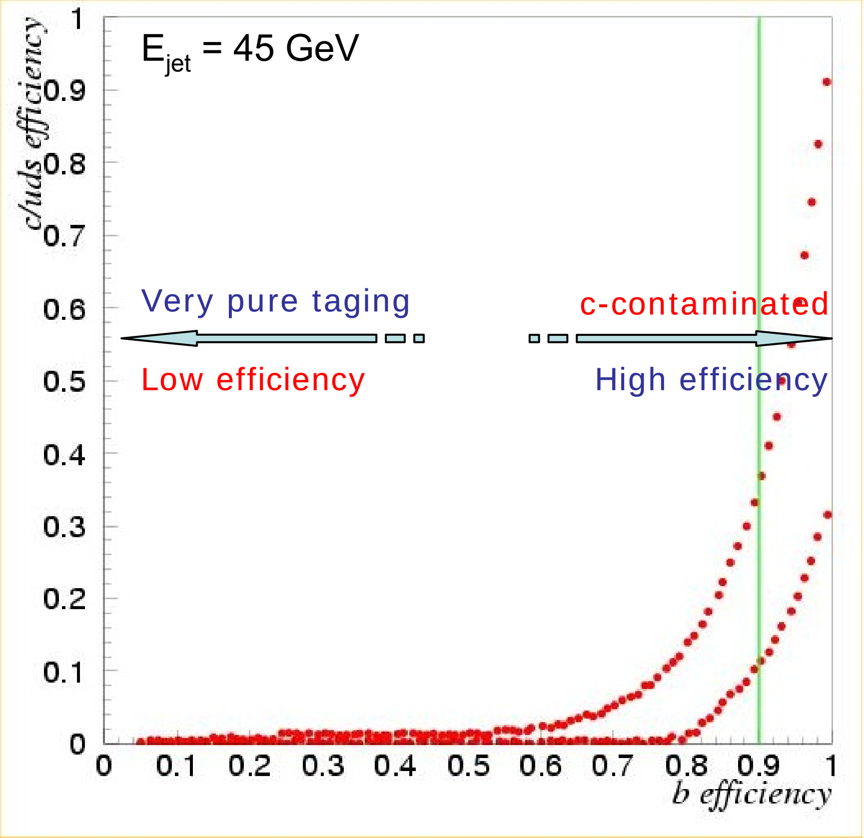
A jet b-tagging performed jet per jet

- b-tagging efficiency fixed to 90%
- $\Rightarrow$ c efficiency = 40%

- Definition of an estimator by event based on the jet b-tag

$\rightarrow$ independent from EFlow

$\rightarrow$ Unused in jet combinatory



(Richard Hawkings parametrisation)

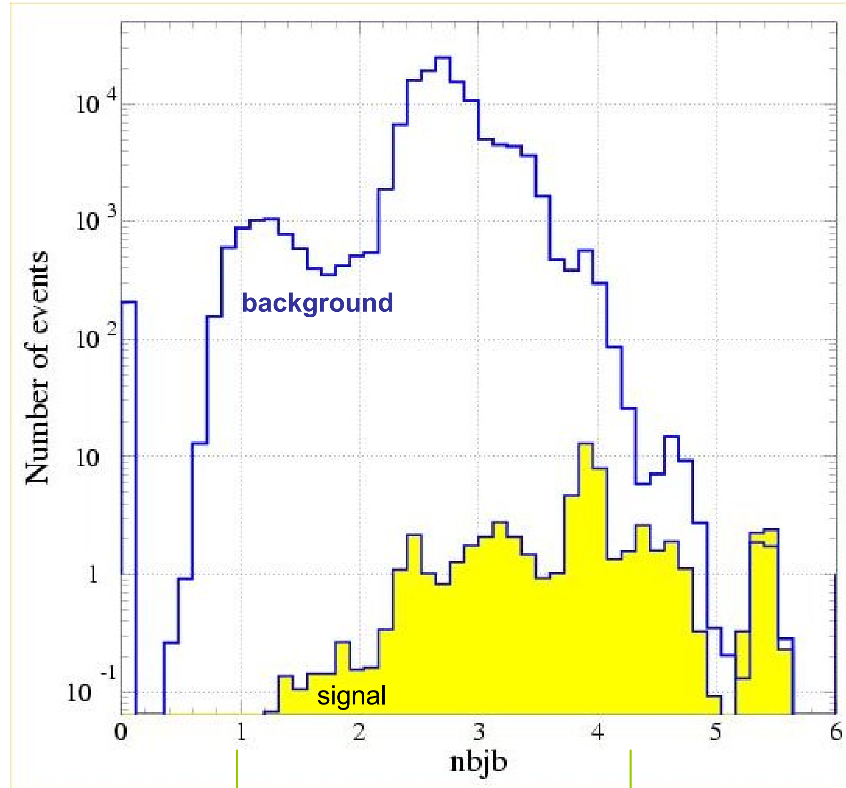
hhZ selection @ 500 GeV

→ Use of the hhZ b signature to reduce the background

Most reduced backgrounds :

- tt
- ννtt
- llZZ
- WWZ

Global variable (crude approach)



No b-like jet / event

4 b-like jets / event

Neural network

→ Multivariable method is adopted to take into account the correlation between selection variables

→ Two Neural Network packages are tested

- → MLP Fit (implemented in PAW and ROOT)
- → CFMipANN package

Neural network

MLP Fit

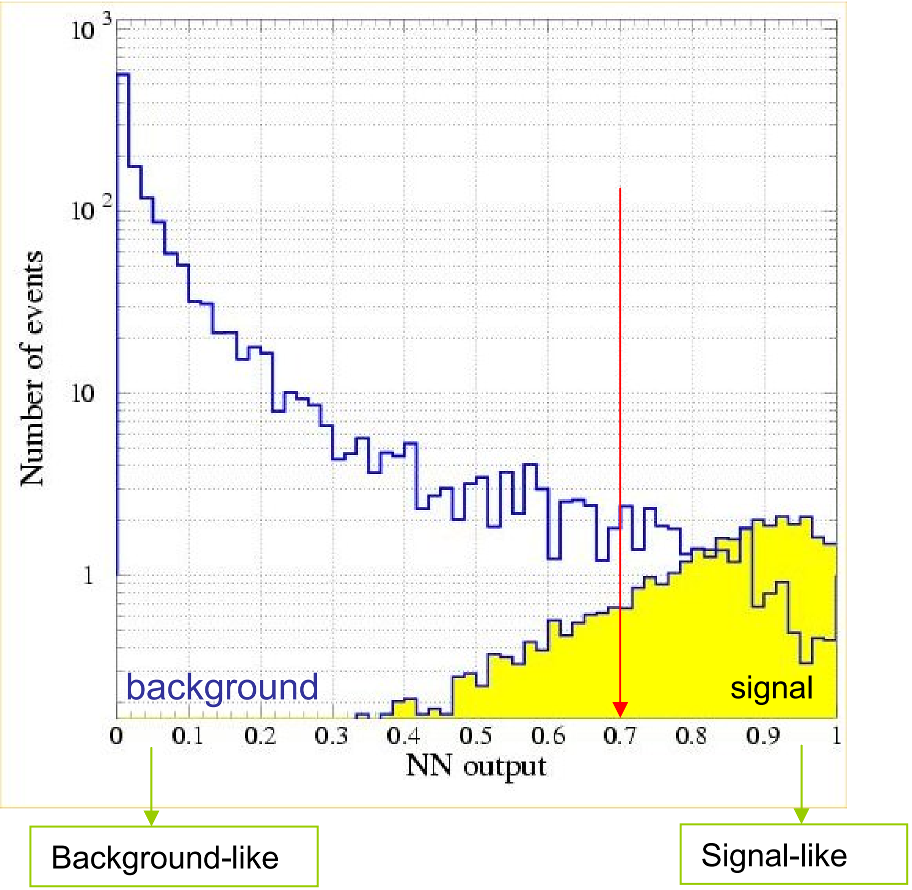
Input variables : $\chi^2_{2bosons}$, $\chi^2_{3bosons}$, Event-b-tag, Global variables (evis, sphericity)

→ cut on NN output at 0.7 leads to

$s/\sqrt{s+b}$ = 5.6 (for 2 ab^{-1})

→NN instabilities (NN output can be greater then 1, convergence problem)

→Careful use needed



CFMipANN

→ cut on NN output at 0 leads to

$s/\sqrt{s+b}$ = 5.9 (for 2 ab^{-1})

→ no instabilities : no nn output values greater then 1

nn selection of hhZ @ 500 GeV : Results

Processes	σ(pb)	N Generated	generated lumi. (pb-1)	N selected	Eff	N attendu (L = 500 pb-1)
hhZ	0,18441	15K	81340,5	4435	29,56%	**27,3**
Background						**16,8**
tt	526,4	740K	1880,7	15	0,001%	5,3
ZZZ	1,051	40K	38059,0	115	0,733%	1,5
tbtb	0,7	20K	28571,4	339	**4,995%**	5,9 ←
ZZ	45,12	50K	1108,2	0	0,010%	0
nntt	0,141327	20K	141515,8	0	0,000%	0,0
wwz	35,3	130K	3682,7	0	0,002%	0,0
wtb	16,8	200K	2976,2	10	0,008%	0,4
eezz	0,287	10K	34843,2	11	0,070%	0,2
nnww	3,627	30K	8271,3	0	0,000%	0,00
evzw	10,094	60K	5944,1	0	0,000%	0,00
nnzz	1,08257	20K	18474,6	1	0,015%	0,03
ttZ	0,6975	20K	28673,8	112	2,590%	1,9

hhZ $N_{expected}$ (for Br ($h \to bb$) = 85.3%) = 27.3 $\Rightarrow$ to be corrected by a factor 1/1.582

hhZ $N_{expected}$ (for Br ($h \to bb$) = 67.8%) = **17.2** (Following results include the correction)

Results

- **Selection caracteristics**
  - $\sqrt{s}$ = 500 GeV
  - Br(h→bb) = 62%
  - Lumi. = 2 ab^{-1}

Selection	**Present analysis**	**Paper**
Signal **Br(h→bb) = 62%**	hhqq 69	hhqq 110 hhll 25
Signal eff.	29%	46%
Background	67	257
$s/\sqrt{(s+b)}$	hhqq 5.9	hhqq 5.7

- $\Delta\lambda/\lambda \sim 1.75\, d\sigma/\sigma$
- since a similar significance is obtain includind this time missing background and removing part of the doubling counting a relative precision of 18% is reachable

- better results may be expected
  - when hhZ → hhll are included
  - Vertex charge put in the game

SUMMARY

- λ measurement (@ 500GeV, $2ab^{-1}$)

    - Previous published results are confirmed
        - including the missing background
        - it corresponds to a relative precision
          $\Delta\lambda/\lambda = 18\%$

    - Analysis based on
        - Reconstructed masses
        - jet b-taging
        - Neural Network

- Next step …

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EFlow and b-tag impact

→ EFlow, b-tag, vertex charge impact on $\Delta\lambda/\lambda$ will be studied independently

→ Which improvement on $\Delta\lambda/\lambda$ for a better $\Delta E/\sqrt{E}$?

→ What is the optimal btag ?

- **higher ε_b ?**

high b-tag efficiency (ε_b > 90%)

⇒ high c contamination

⇒ more background events are signal-like

⇒ significance loss

→ What do we gain if we include the vertex charge ?

→ Investigation running, results expected soon