What about HHZ when m(H) = 170 GeV ?

Pierre Lutz
IRFU (Saclay)

Introduction

- Since long, we have been asked to look for triple Higgs coupling in the case of a heavy Higgs (H -> WW)
- It means that a HHZ event is a 5 boson event, or a 10 fermion event !
- Many challenges :

1. Cross-section very small
2. Many possible final states
3. Combinatorics !

Why 170 GeV ?

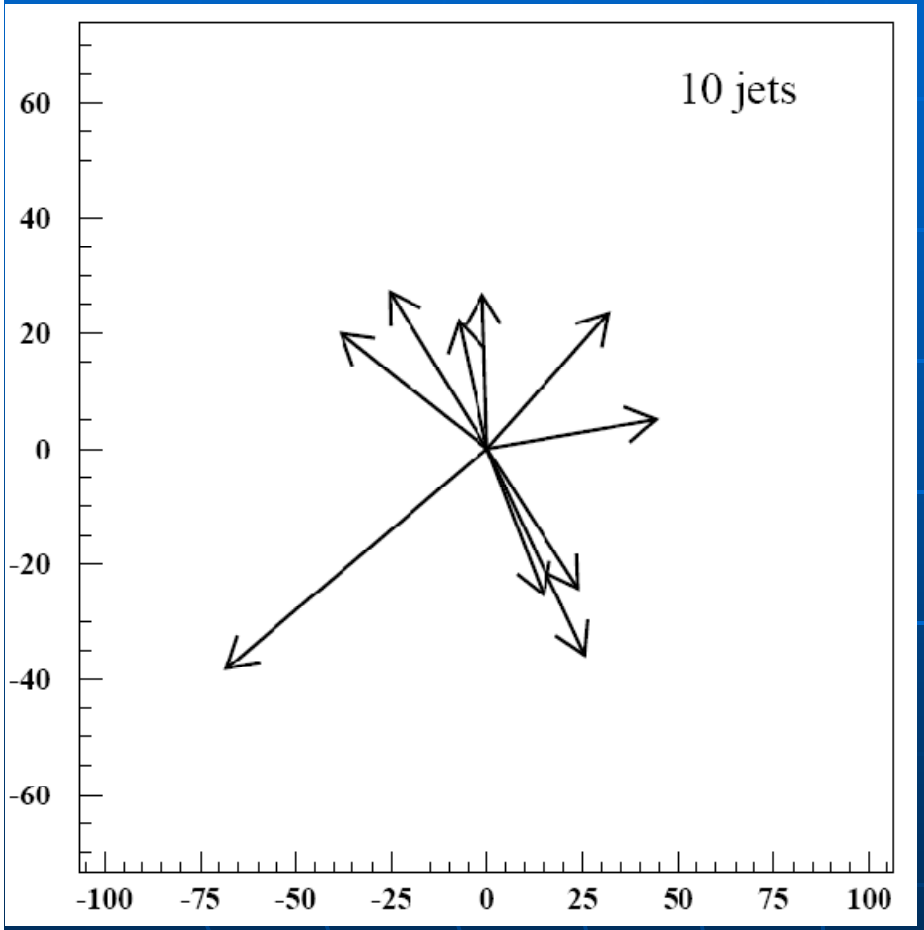
- Because the BR into WW is maximal: we observed ~2.5% of events with one H decaying into bb or gg.
- Because we can study it at 500 GeV since 90 + 2x170 = 430, despite a tiny cross-section (~40 ab).

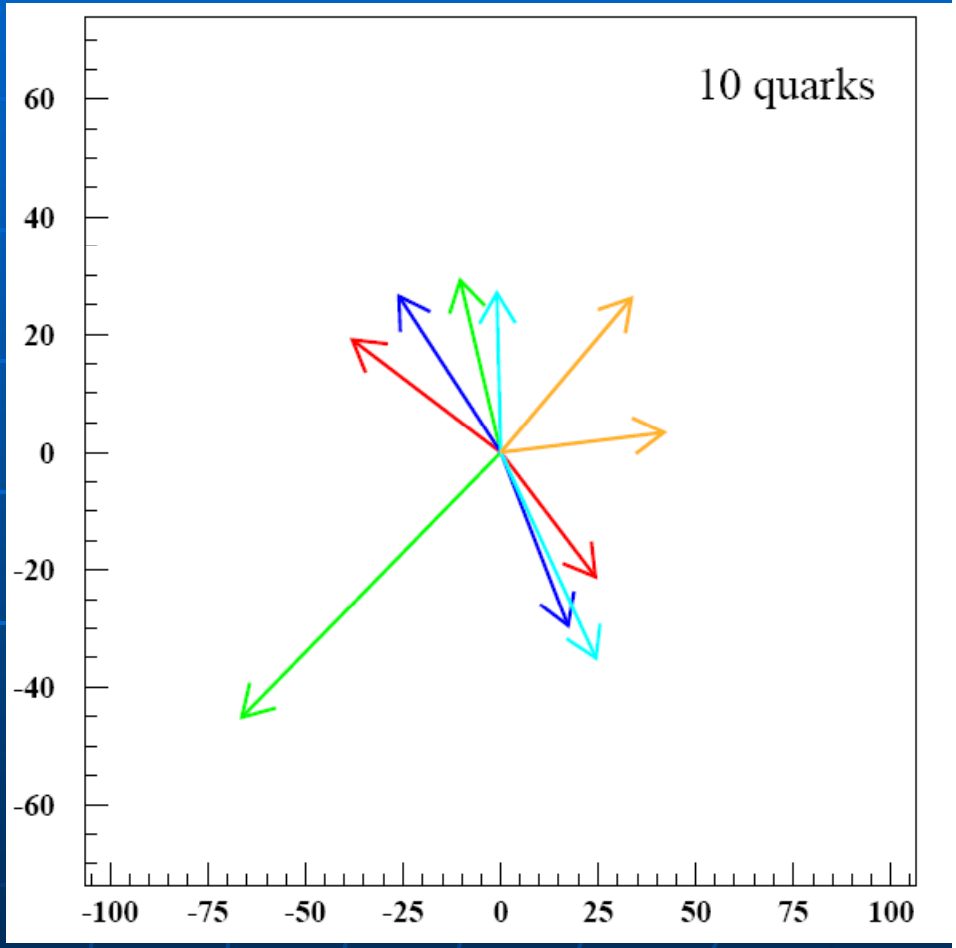
First step : going from 10 jets to Z4W

- In Valencia, I showed it is possible, at generation level, to find a comb. of 5 di-jets compatible with a Z4W event within the 4725 ways to form 5 di-jets out of 10 jets.

- The efficiency was not so bad, around 47% for pure hadronic decays of the 5 bosons.

Differences, but not so big !





2nd step : a bit more ambitious

- Still at generation level !
- I used the SLAC files prepared by Tim in order to perform a preliminary feasibility analysis (removing events with a Higgs boson)
- Strategy :

  1/ Determine the number of prompt leptons.

  2/ Preselection based on multiplicities and shape variables

  3/ Clusterization and combinatorics (already demonstrated)

  4/ Study of remaining background

The various channels (1)

Z	4W	Br(%)	Nlept.	Yes/no	Njets
Hadr.	All h.	14.6	0	yes	10
Hadr.	1W e/μ	18.7	1	yes	8
Hadr.	1W tau l.	3.4	1	yes	8
Hadr.	1W tau h.	5.9	0	yes	9
Hadr.	2W e/μ	8.9	2	yes	6
Hadr.	others	18.4	var.	NO	
Invisible	All h.	4.2	0	yes	8
Invisible	1W e/μ	5.3	1	yes	6
Invisible	1W tau	2.7	0 or 1	?	7 or 6
Invisible	others	7.8	var.	NO	

The various channels (2)

Z	4W	Br(%)	Nlept.	Yes/no	Njets
e+e-/μμ	All had.	1.4	2	yes	8
e+e-/μμ	1W e/μ	1.8	3	yes	6
e+e-/μμ	1W tau	0.9	2 or 3	?	7 or 6
e+e-/μμ	2W e/μ	0.9	4	yes ?	4
e+e-/μμ	others	1.8	var.	NO	
tautau	All had.	0.7	var.	?	10,9 or 8
tautau	1W e/μ	0.9	var.	?	8,7 or 6
tautau	others	1.8	var.	NO	

Only 65% can be used (too many missing neutrinos otherwise)

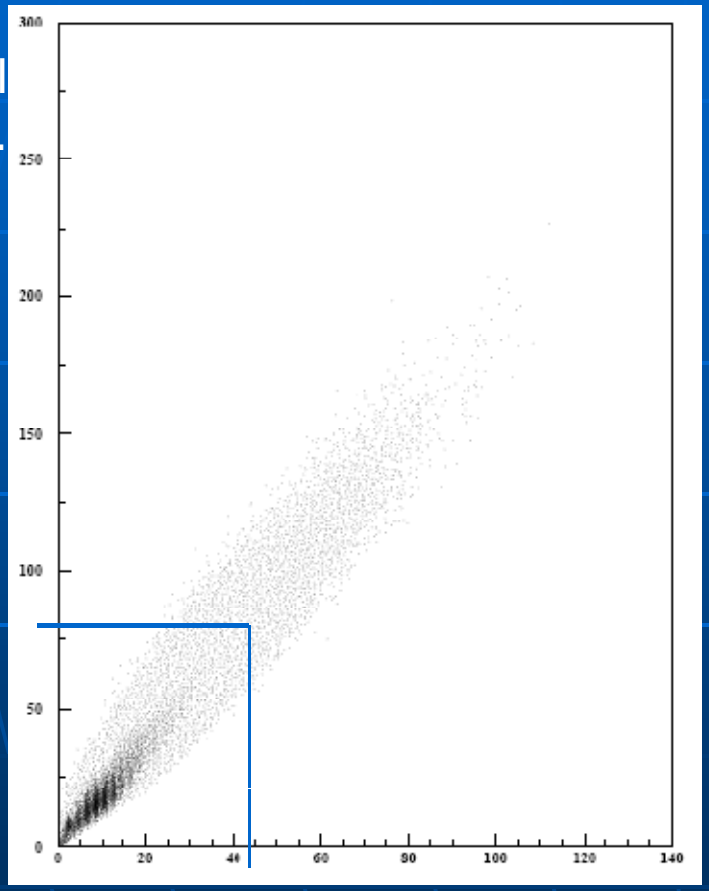
Many different analyses necessary, based on Nlept

Exemple of strategy (Nlep = 1)

- First hypo. : 3 W had. + 1 W lep.
  Thus try 8 jets + (W = lep. + mis4m)
- If OK, go on !
- If not (means lepton + mis4mom does not match a W), look for mult. min among the jets. If « small », can be a hadronic t !
- Second hypo : 2Whad, 1W lep., 1Wtau, means 7 jets for the hadronic system.

Preselection (multiplicities)

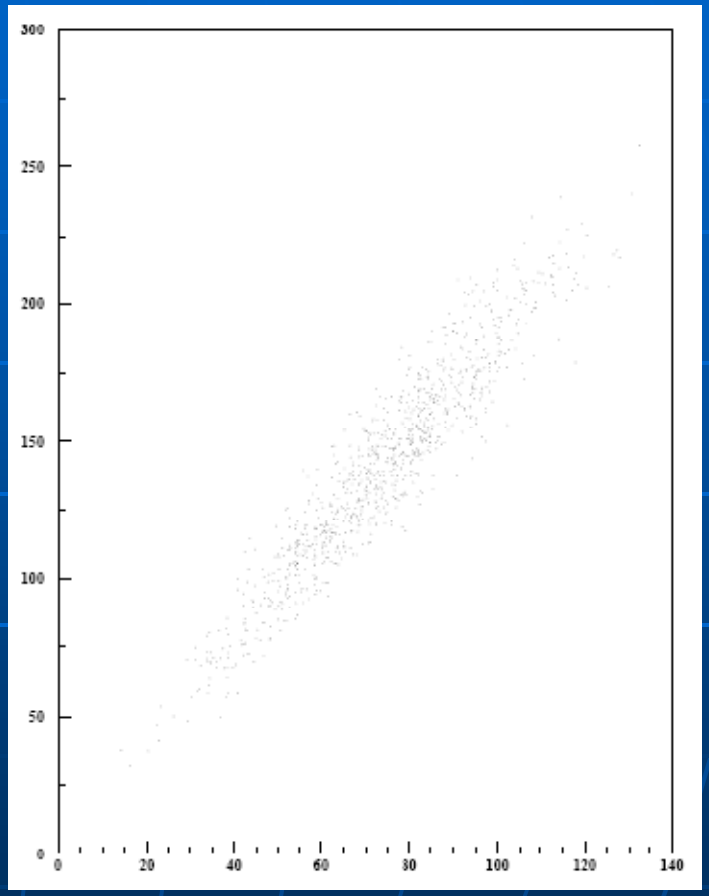
total mult.



charged mult.

Background

total mult.

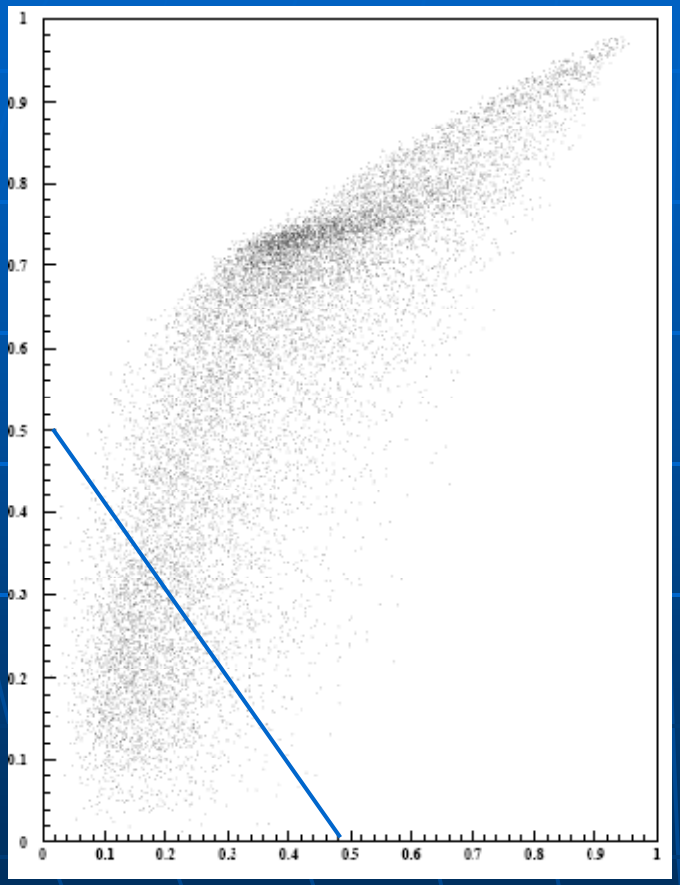


charged mult.

Signal (qqbar4W)

Preselection (shape variables)

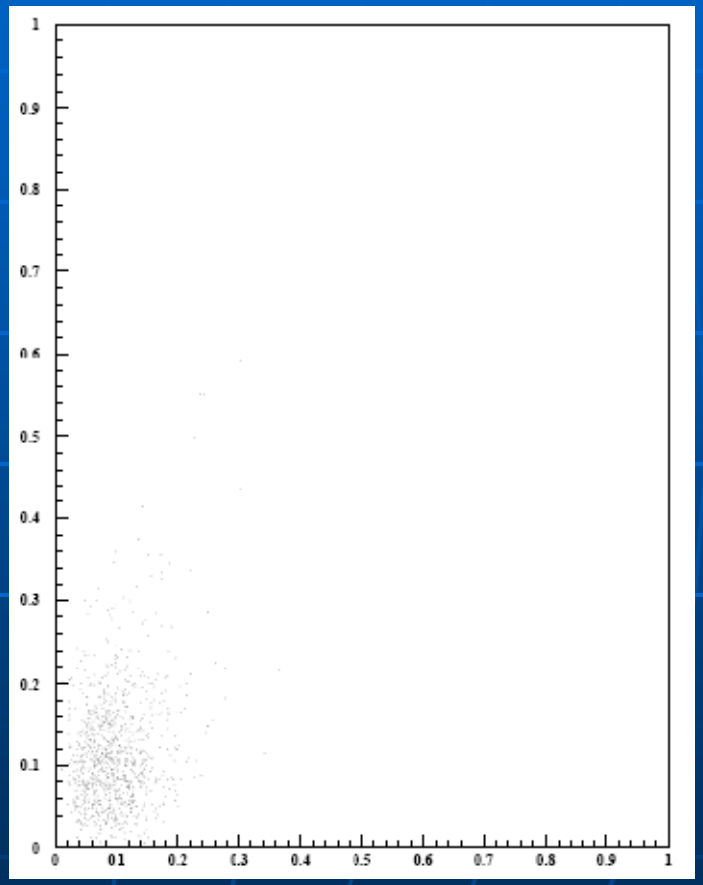
H2



H4

Background

H2



H4

Signal (qq4W)

Background content at Z4W level

- The remaining background is dominated by ttbar events.
- Depending on the beam polarisations ttbar events make 84 to 89%,

  other events with bb : 4%,

  events without b : 12 to 7%.

  (most of them are « 2fermion » like ugggssbargubar !!)
- Thus, a b-tagging can help !!

Results (efficiencies)

Polarisation	e^- : -80% e^+ : 30%		e^- : 80% e^+ : -30%	
	Background (rej. factor)	Signal (eff.)	Background	Signal
Preselection	2155	94.2%	5128	95.3%
Z4W comp.	31250	46.3%	58820	44.2%
ZHH comp.	42200	36.4%	80000	31.7%
Ymin >5	75750	36.3%	158000	31.7%
$M_{bb} = M_Z$	500000	36.0%	833333	31.3%
for 500 fb^{-1}				

Background : without H + X (yet)

Signal : qqHH only

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for 500 fb^{-1}	1920	4.2	1120	2.5

NOT DESPERATE, but far from the end of the story !!!

Conclusion (to do list)

- Add background with H, and study also signals $\nu\nu HH$ and l^+l^-HH
- Optimize all steps of all analyses
- Suppress cheated steps (btag as ex.)

- We have to gain a rej. factor of 1000
- Help welcome !