Looking for the Higgs the hard way

- **Not the most likely channel**
- **High backgrounds**
- **Low cross-section**

… but nevertheless worth looking for

Pauline Gagnon – Indiana University

Motivation

- Extensions of the SM such as Majoron models predict different signatures for Higgs decays
- In such models, the Higgs could decay invisibly into a pair of Majorons: $H \longrightarrow \chi^0 \chi^0$
- ZH and WH from Bjorken processes:

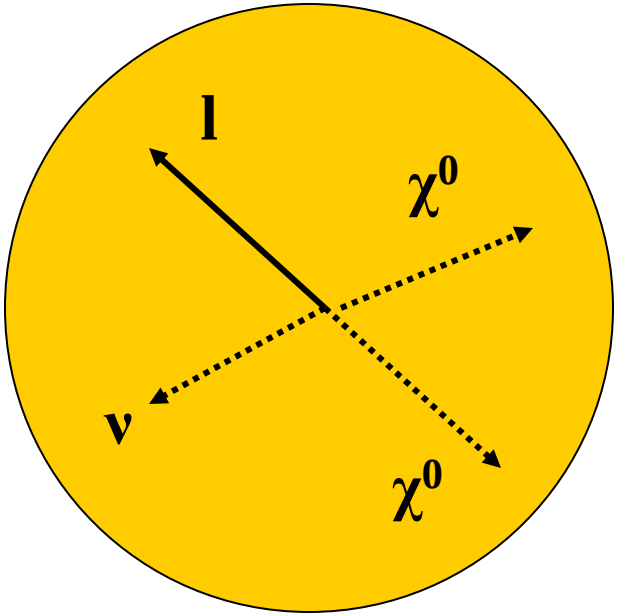
$$q\bar{q} \xrightarrow{Z^*} ZH \qquad q\bar{q} \xrightarrow{W^*} WH$$

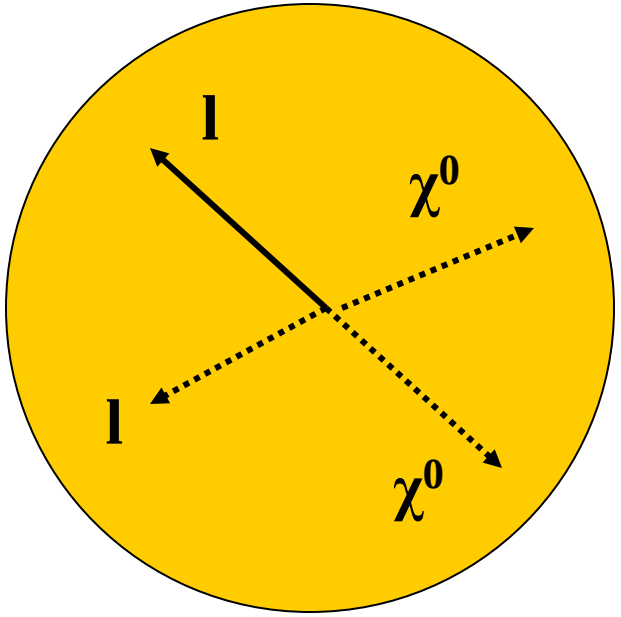
(see Choudhury and Roy, hep-ph 9312347)

Higgs to SUSY: Two possible channels:

WH: $H \longrightarrow \chi^0 \chi^0$, $W \longrightarrow l\,\nu$

ZH: $H \longrightarrow \chi^0 \chi^0$, $Z \longrightarrow l^+l^-$





Event selection

Work all done with fortran based ATLFAST

WH channel

- large missing p_T
- one prompt lepton
- no jets

Background:

- $WZ \rightarrow l\nu\ \nu\nu$
- W incl., $W \rightarrow l\nu$
- $t\bar{t} \rightarrow b\bar{b}$, $b \rightarrow cl\nu$

ZH channel:

- large missing p_T
- 2 prompt leptons
- no jets

Background:

- $ZZ \rightarrow ll\ \nu\nu$
- Z incl., $Z \rightarrow \nu\nu$
- $t\bar{t} \rightarrow b\bar{b}$, $b \rightarrow cl\nu$

Production cross-sections

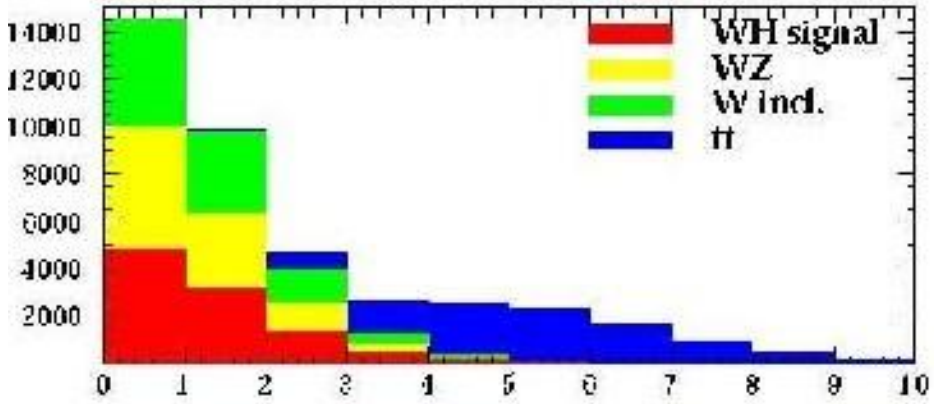
For mH = 120 GeV

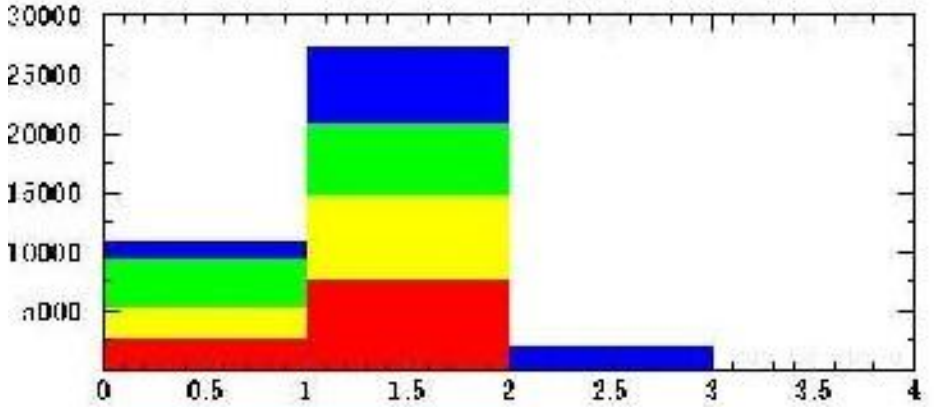
	WH	WZ	W incl	tt
σ (pb)	0.2244	1.055	28540	126.1
#evts @ 10 fb^{-1}	2244	10050	285.4 M	1.261 M
# generated	1.5 M	1.51 M	158.4 M	59.16 M

	ZH	ZZ	Z incl	tt
σ (pb)	0.0424	0.3004	2819	126.1
#evts @ 10 fb^{-1}	424	3004	28.2 M	1.261 M
# generated	0.2 M	0.41 M	68.11 M	56.11 M

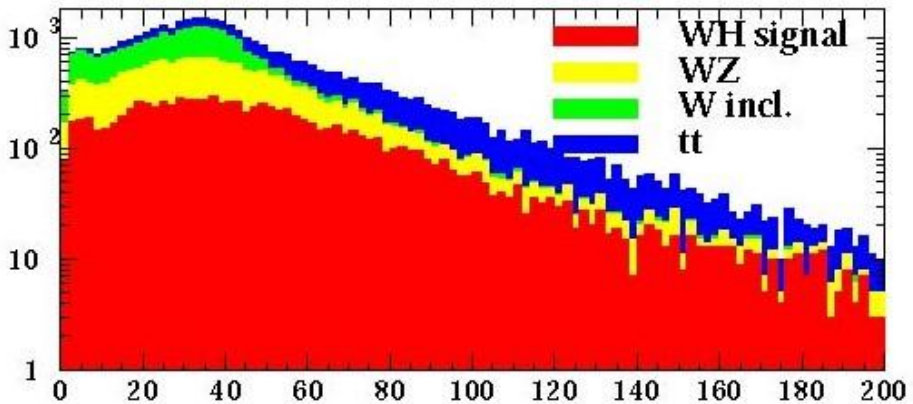
WH channel – 10 K evts each not scaled to σ*BR

of jets and # leptons

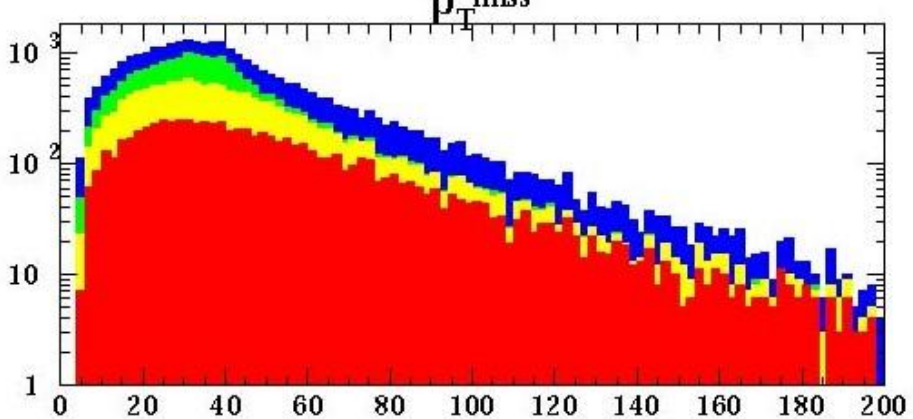




missing p_T and lepton p_T



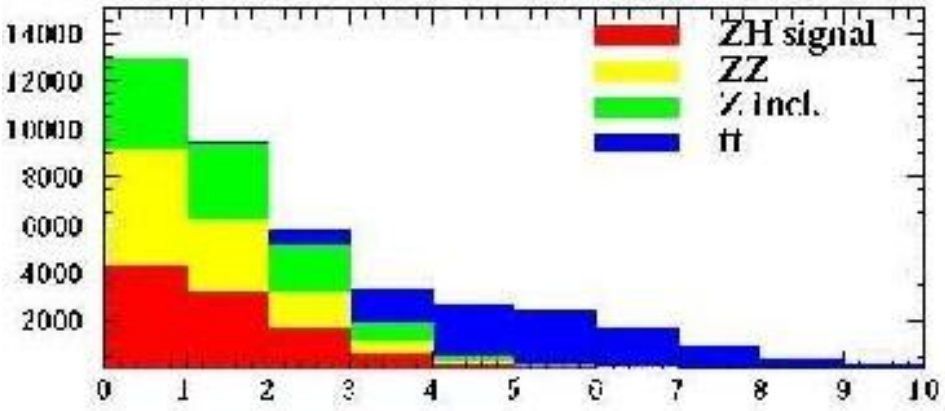
p_T^{miss}

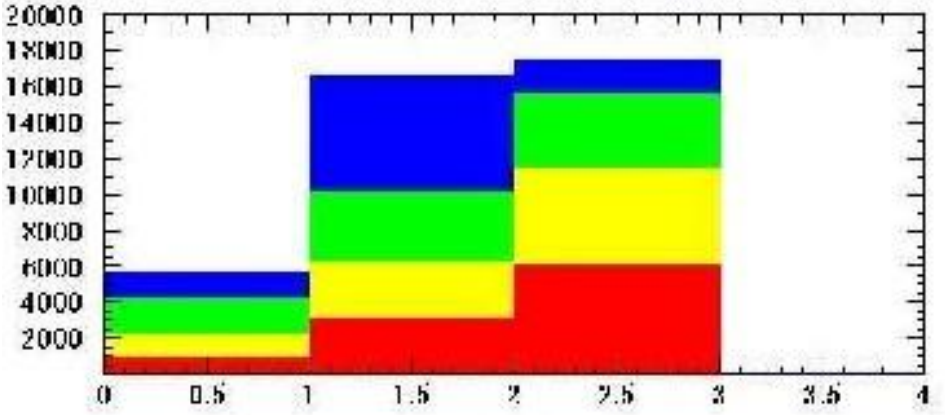


p_T^{lepton}

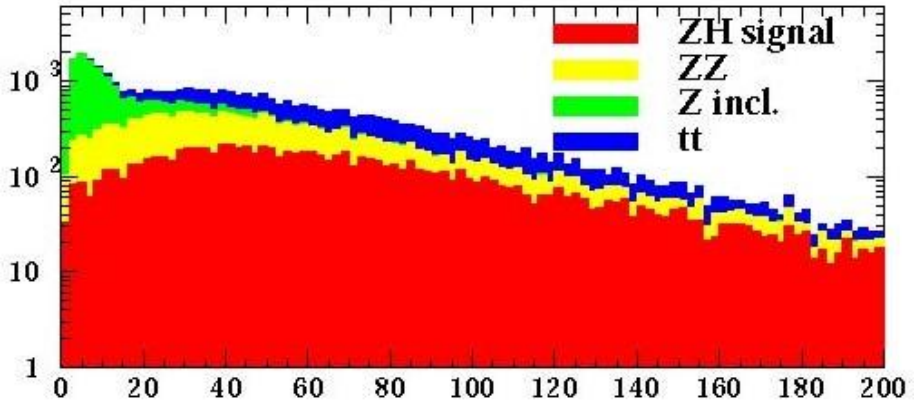
ZH channel - 10 K evts each not scaled to σ*BR

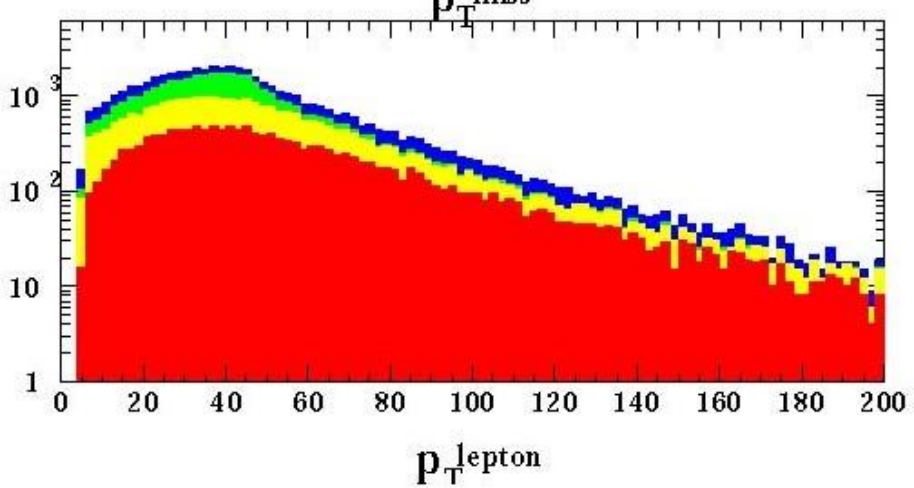
of jets and # leptons





missing p_T and lepton p_T





Preliminary selection

- Anti b-tag (reject tt)
- pt miss >100 GeV
- njets: 0 or 1
- lepton trigger

- WH: single lepton
- ZH: two leptons

Refine the selection for each channel using the PC method

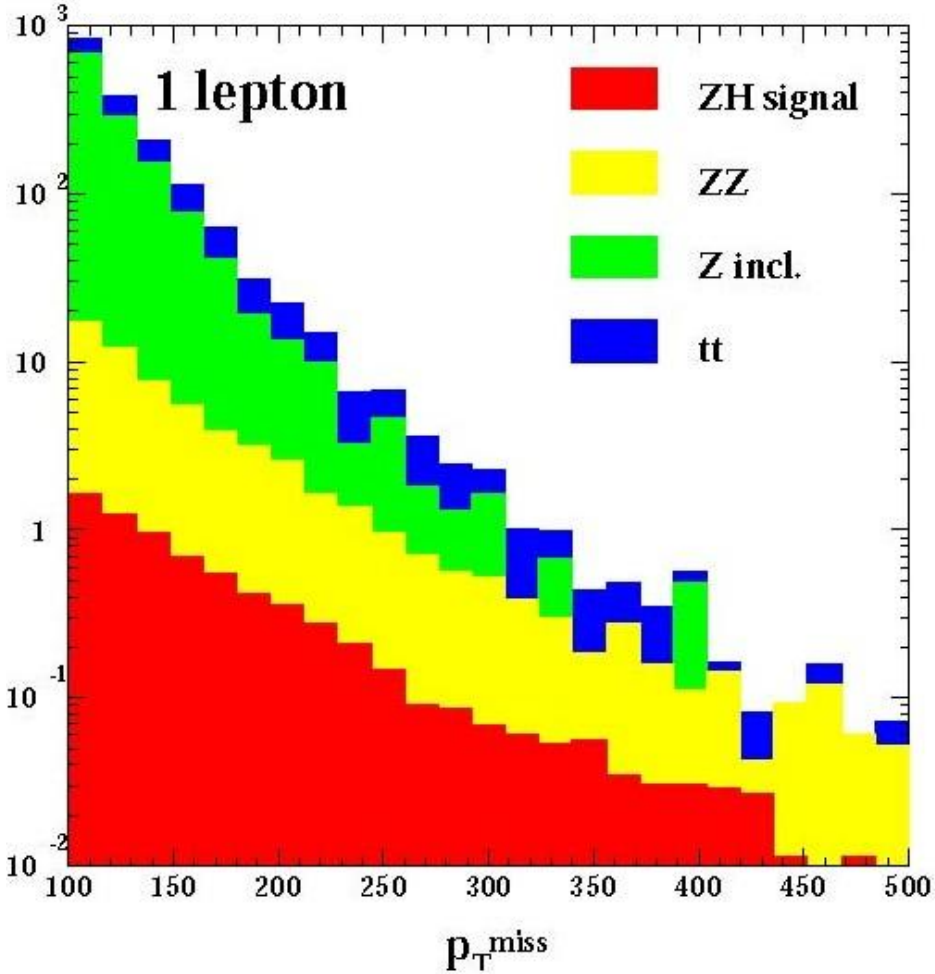
Projection and Correlation method

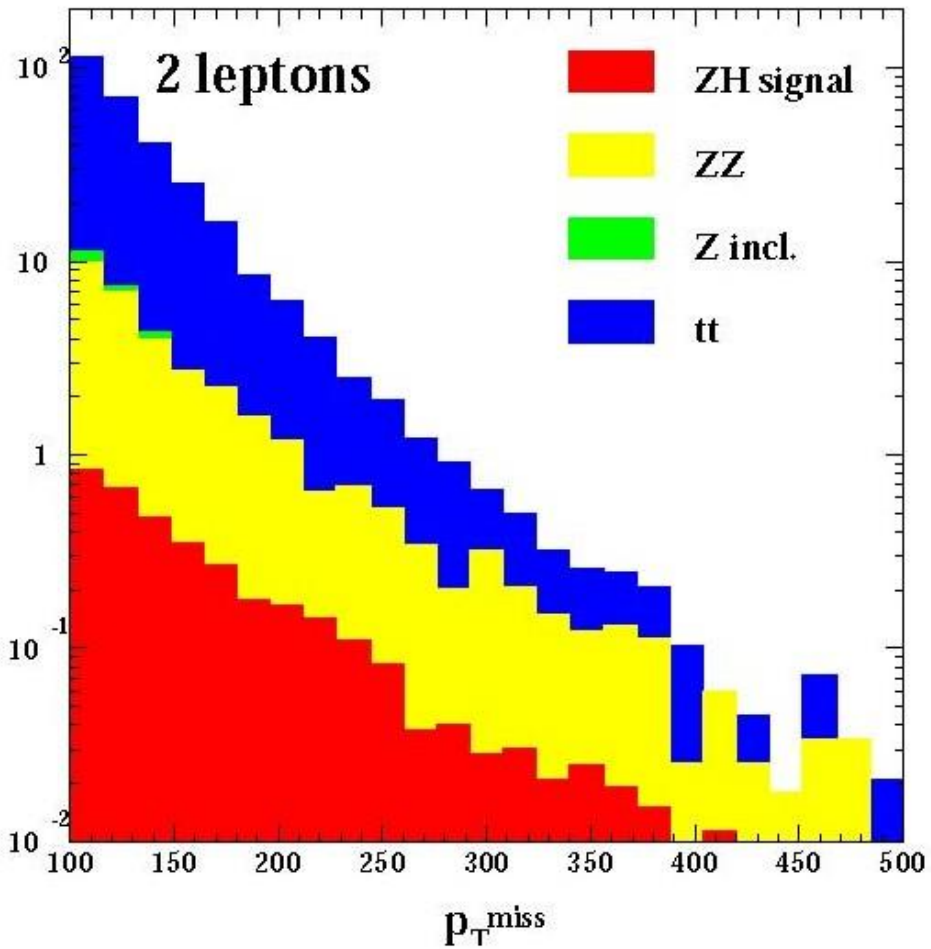
- Simple method to build a likelihood function
- Developed by Dean Karlen:
- (see Computers in Physics, 12:4 (1998) 380).
- Uses correlations between variables
- Uses mapping to project onto Gaussians
- Code is publicly available
- More info on my web page: http://cern.ch/pauline

PC method: general features

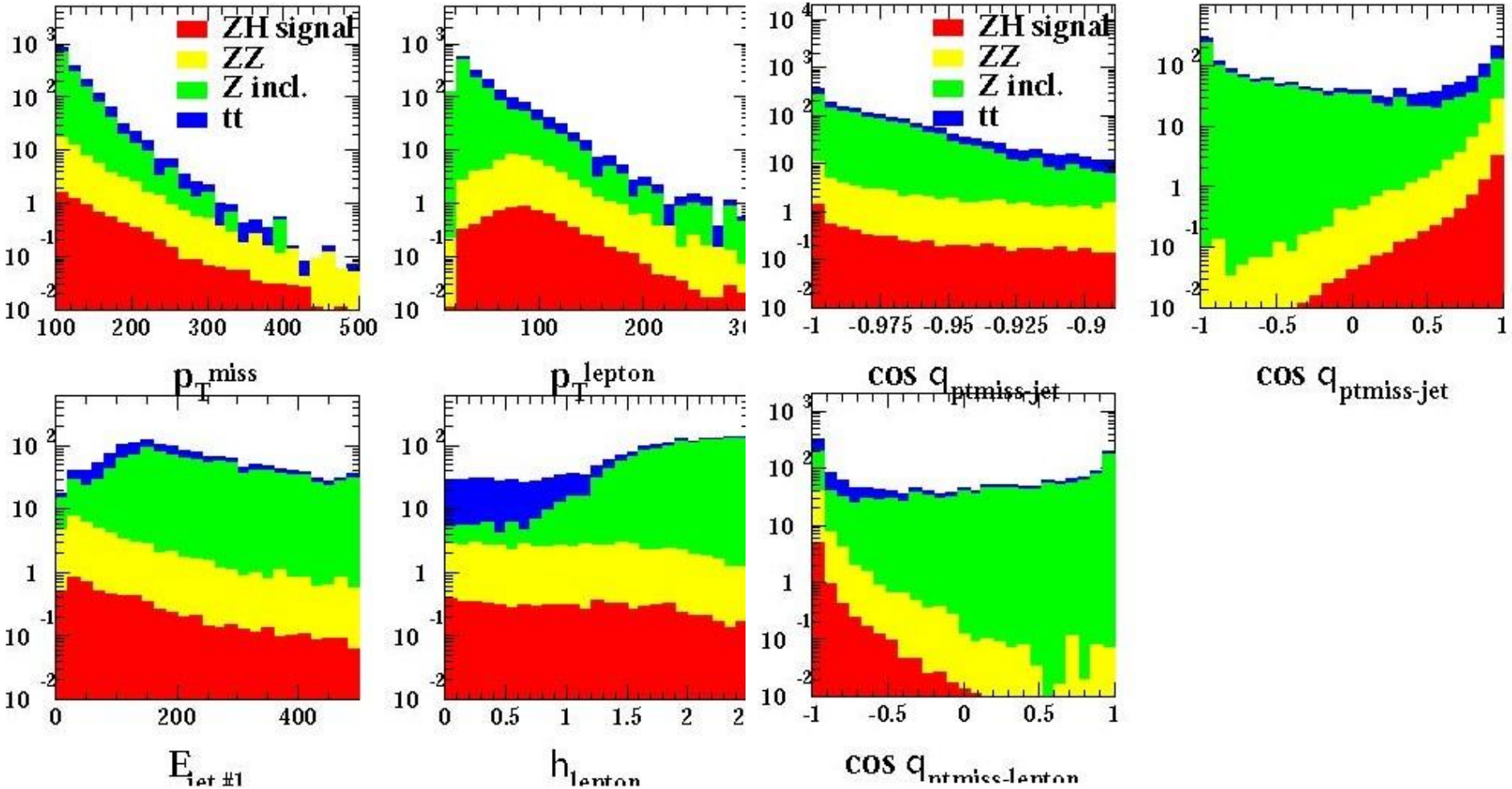
- Uses Row Wise Ntuples as inputs
- Helps user to optimize preselection cuts
- Selects optimal set of input variables for the likelihood
- Uses correlations between variables:
  - more powerful than a simple likelihood
  - simpler and more versatile than a NN

ZH channel: Ptmiss distribution vs #lepton

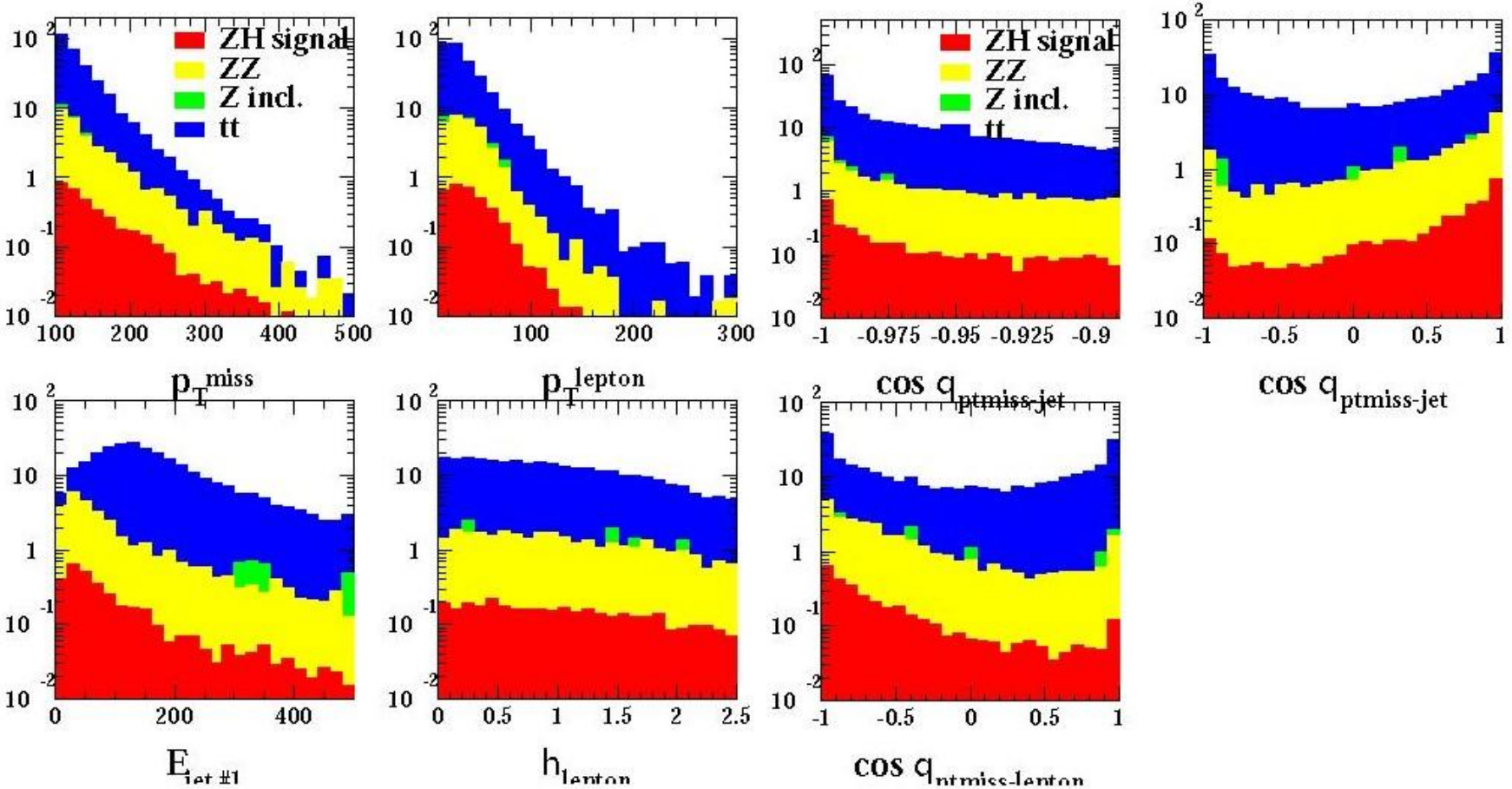




ZH channel inputs to the likelihood with 1 lepton

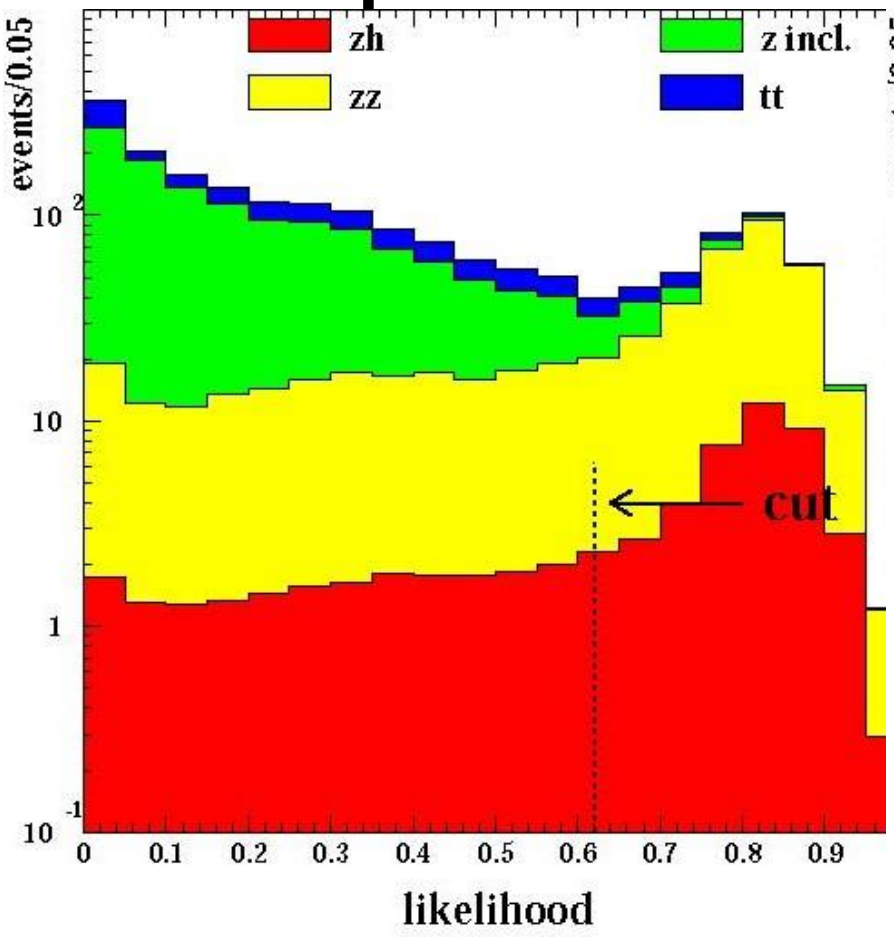


ZH channel inputs to the likelihood with 2 leptons

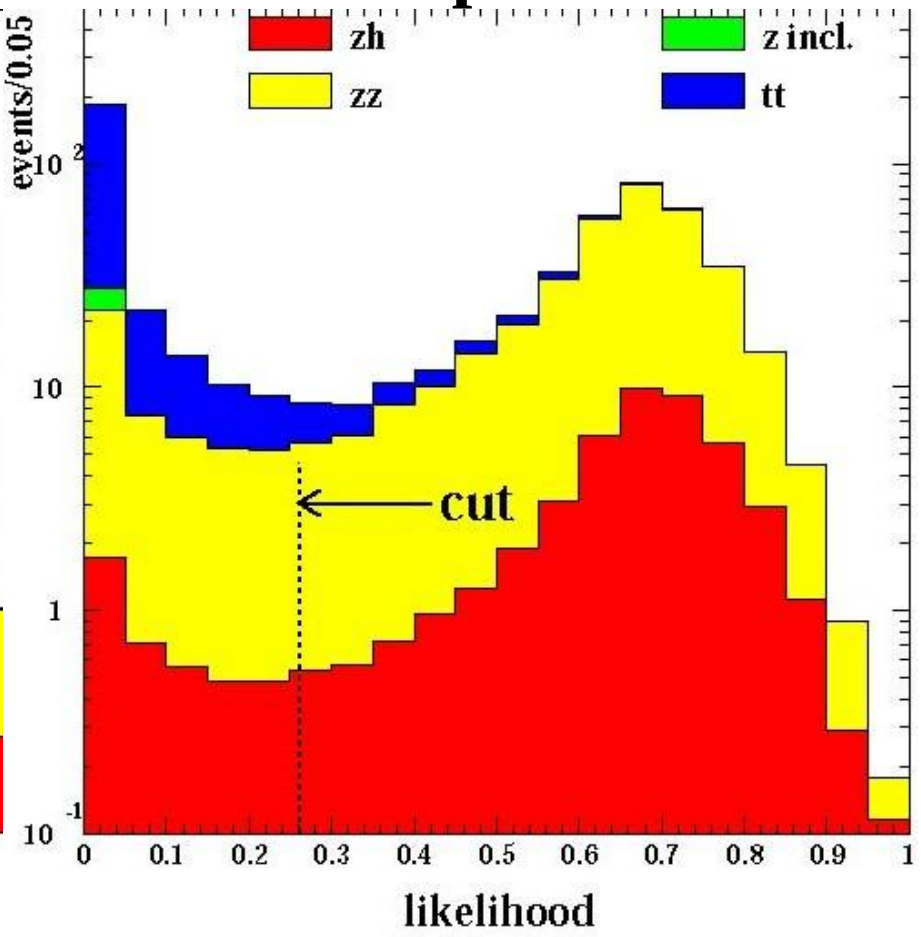


ZH: likelihood distributions

1 lepton



2 leptons



Number of selected events

After PC optimization and likelihood cut

# generated	ZH 0.2 M	ZZ 0.41 M	Z incl 68.11 M	tt 59.16 M
1 lepton	40.4	271.1	36.9	31.3
2 leptons	44.5	305.7	3.7	20.7
total	84.9	576.8	40.6	52.0

S/B = 3.3

Summary

- Invisible SUSY decays of the Higgs are worth further investigation
- ZH channel has a low cross-section but a 3.3 σ discovery potential for 10 fb^{-1} (1 yr).
- Very close to Chadhoury and Roy prediction but they neglect contributions from Z incl. and tt.
- WH channel should be even more powerful – but needs more work