

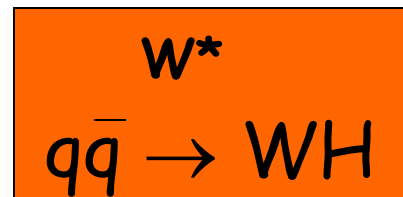
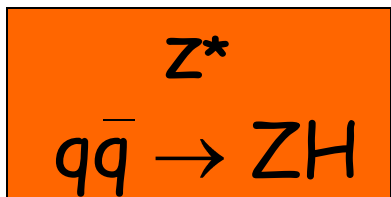
# Invisible Higgs decay in ZH and WH channels

- ⌘ Motivation and analysis description
- ⌘  $W$  inclusive background in WH channel
- ⌘ Discovery potential of ZH channel
- ⌘ Next steps

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# 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 neutralinos:  $H \rightarrow \chi^0 \chi^0$
- ⌘ ZH and WH produced from Bjorken (Higgstrahlung) processes:

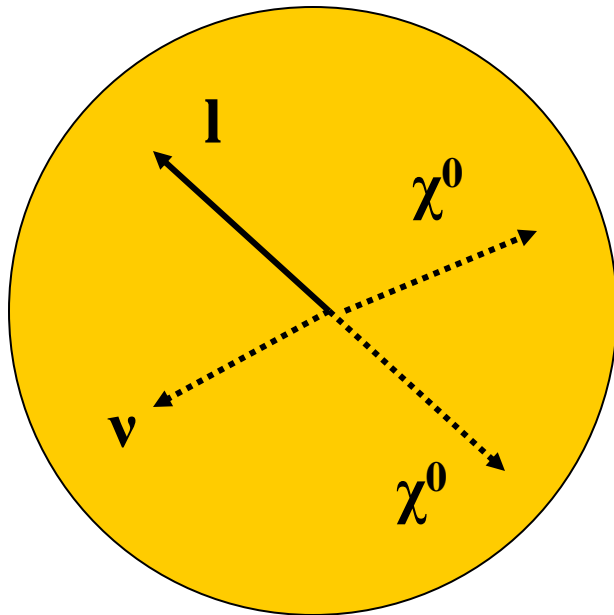


(see Choudhury and Roy, hep-ph 9312347)

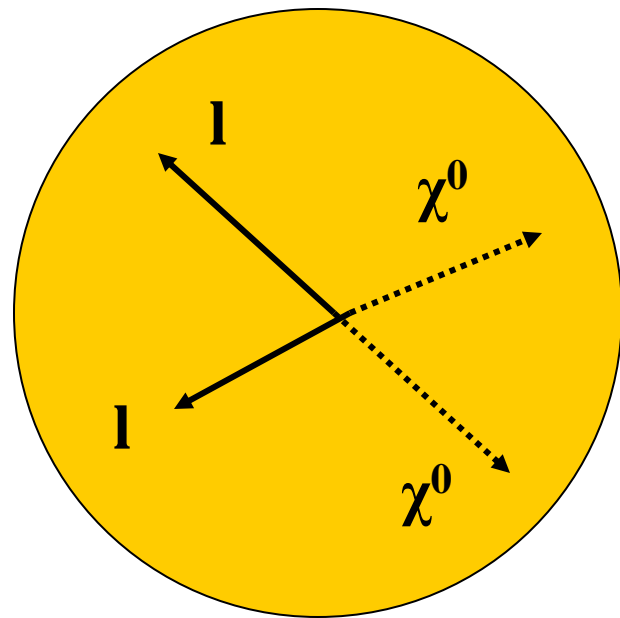
# Higgs to SUSY:

## Two possible channels:

$$\text{WH: } H \rightarrow \chi^0 \chi^0$$
$$W \rightarrow l \nu$$



$$\text{ZH: } H \rightarrow \chi^0 \chi^0$$
$$Z \rightarrow l^+ l^-$$



# Event selection

All work done with Fortran based ATLFAST

## WH channel

- ⌘ large missing  $p_T$
- ⌘ one prompt lepton
- ⌘ one or no jets

## Background:

- ⌘  $WZ \rightarrow l\nu \nu\nu, l=e,\mu,\tau$
- ⌘  $W$  incl.,  $W \rightarrow l\nu$
- ⌘  $\bar{t}t \rightarrow \bar{b}b, W \rightarrow l\nu$

## ZH channel:

- ⌘ large missing  $p_T$
- ⌘ 2 prompt leptons
- ⌘ one or no jets

## Background:

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

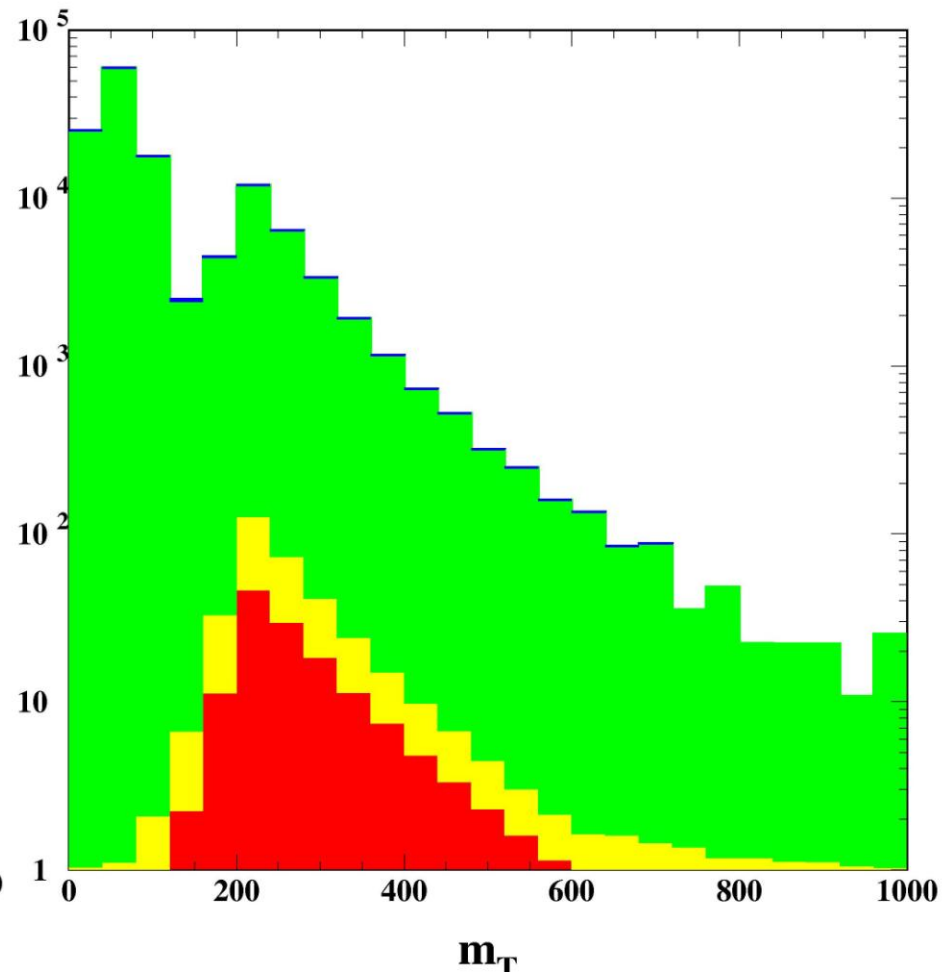
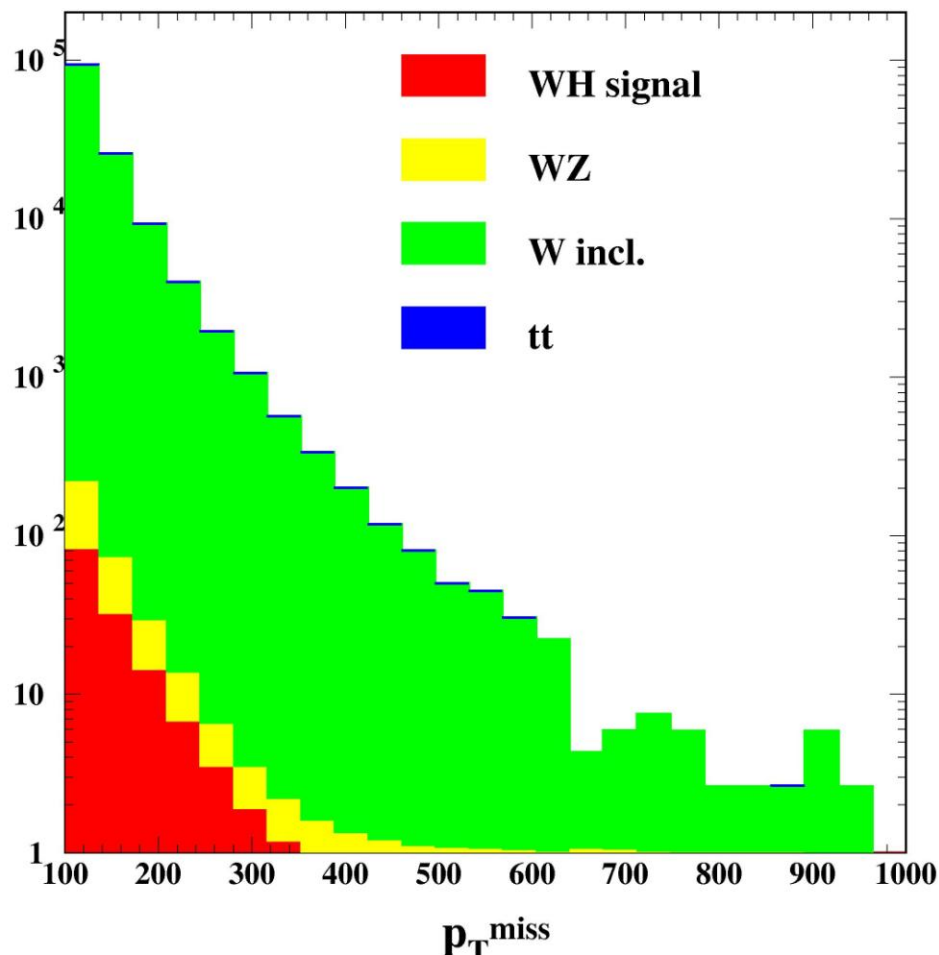
# Production cross-sections in WH channel

$m_H = 120 \text{ GeV}$	WH	WZ	W incl	tt
$\sigma$ (pb)	0.2244	1.055	28540	126.1
#evts $10 \text{ fb}^{-1}$	2244	10050	285.4 M	1.261M
# generated	1.5 M	1.51 M	158.4 M	59.16M

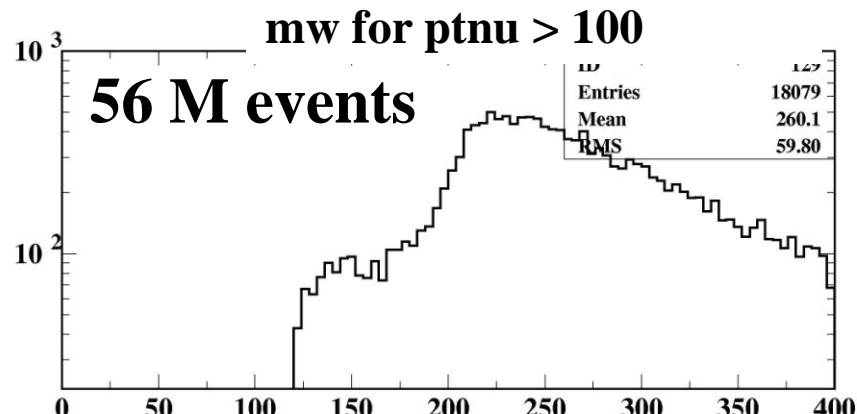
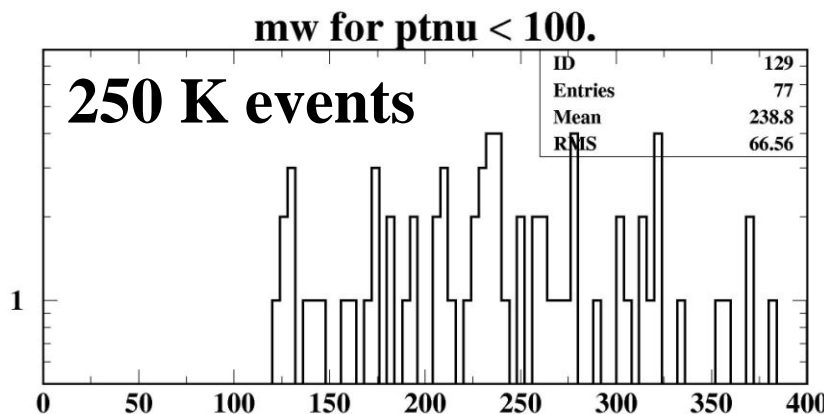
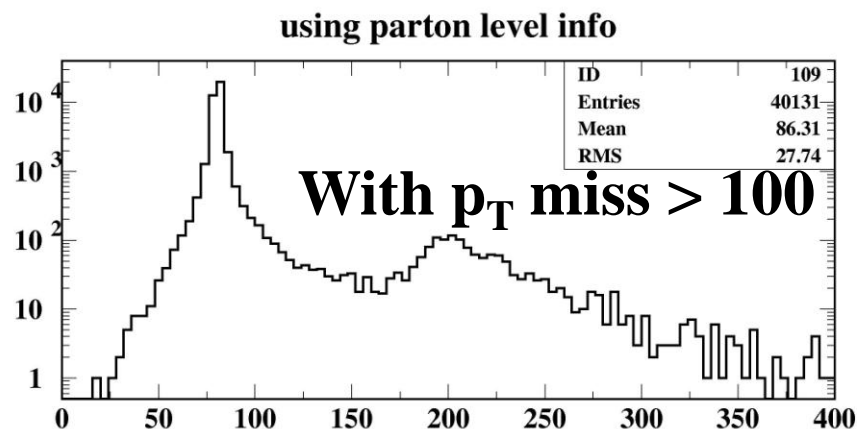
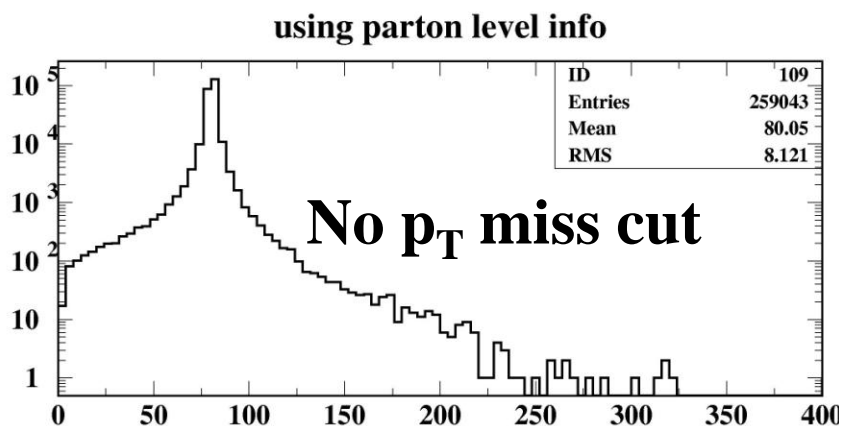
Overwhelming background from W inclusive:

Should disappear with high  $p_{T\text{miss}}$  cut  
combined with high transverse mass  $m_T$  cut.

# But the transverse mass cut is inefficient against W incl. bgnd



# W incl. events with high $p_T$ miss: from the tail of $m_W$ distribution



mw for  $p_{T\nu} > 100$ ,  $m_t > 120$

mw for  $p_{T\nu} > 100$ ,  $m_t > 120$

# Selected events in WH channel

source	WH	WZ	W incl.	tt
# events	82.1	525.1	15475	15.5

$$S/\sqrt{B} = 0.7$$

**This channel is excluded**



# ZH channel: signal and background production cross-sections

<b>mH (GeV)</b>	<b>110</b>	<b>120</b>	<b>130</b>
<b><math>\sigma</math> (pb)</b>	<b>0.0556</b>	<b>0.0426</b>	<b>0.0327</b>
<b>140</b>	<b>150</b>	<b>160</b>	<b>170</b>
<b>0.0253</b>	<b>0.0201</b>	<b>0.0172</b>	<b>0.0146</b>

<b>background</b>	<b>ZZ</b>	<b>Z incl.</b>	<b>tt</b>
<b><math>\sigma</math> (pb)</b>	<b>0.299</b>	<b>2804</b>	<b>125.1</b>

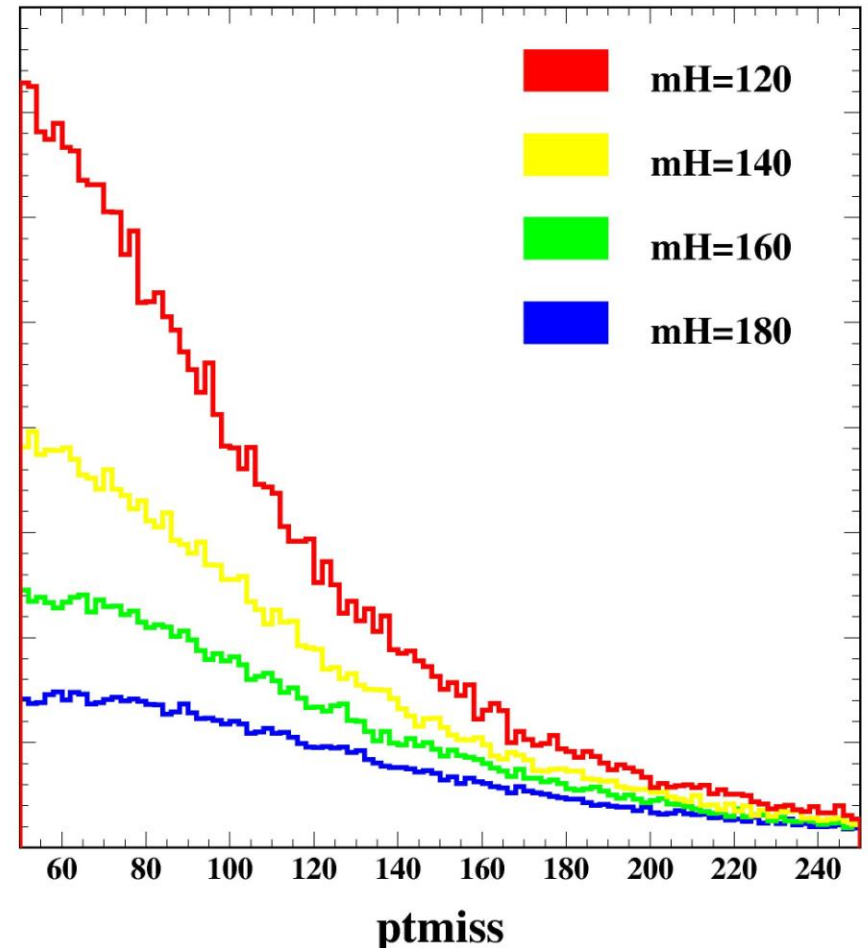
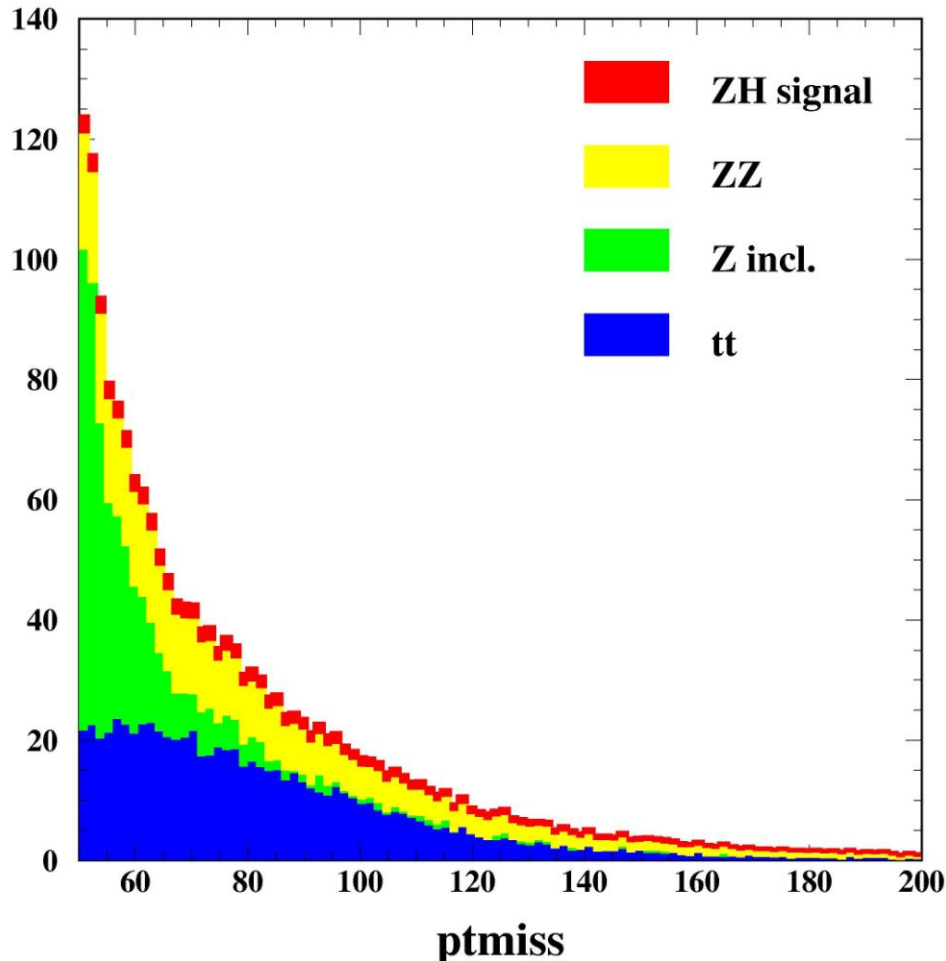
**LEP mass limit is 114.4 GeV**

# Preselection for ZH channel

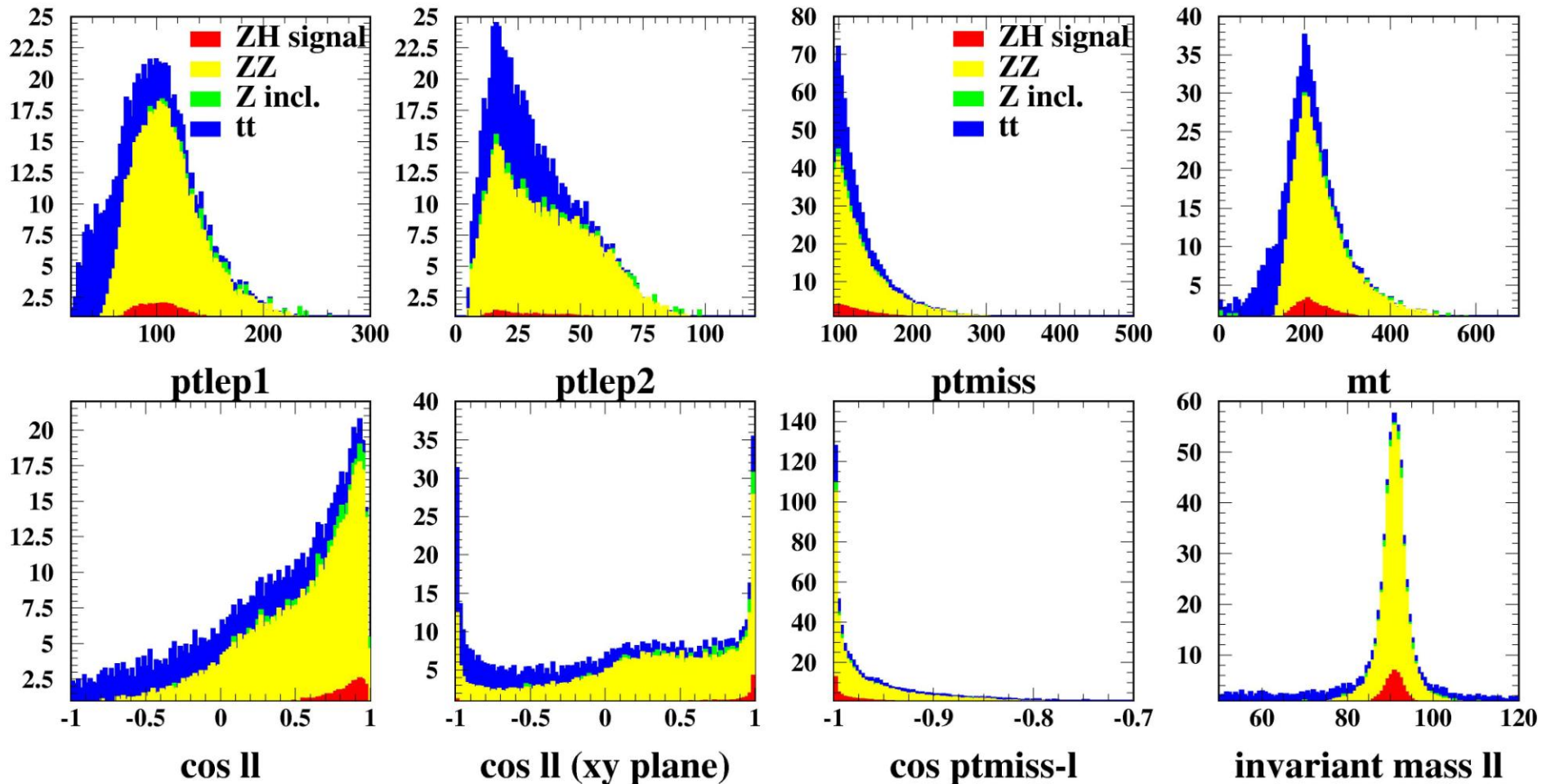
- ⌘ single or double lepton trigger
- ⌘ request two leptons:  $e^+e^-$  or  $\mu^+\mu^-$
- ⌘  $p_{T\text{-miss}} \geq 93.7 \text{ GeV}$  against Z incl. background
- ⌘ anti b-tag and 0 or 1 jet: to reject tt bgnd

**Use the Projection and Correlation package to form a likelihood which includes correlations**

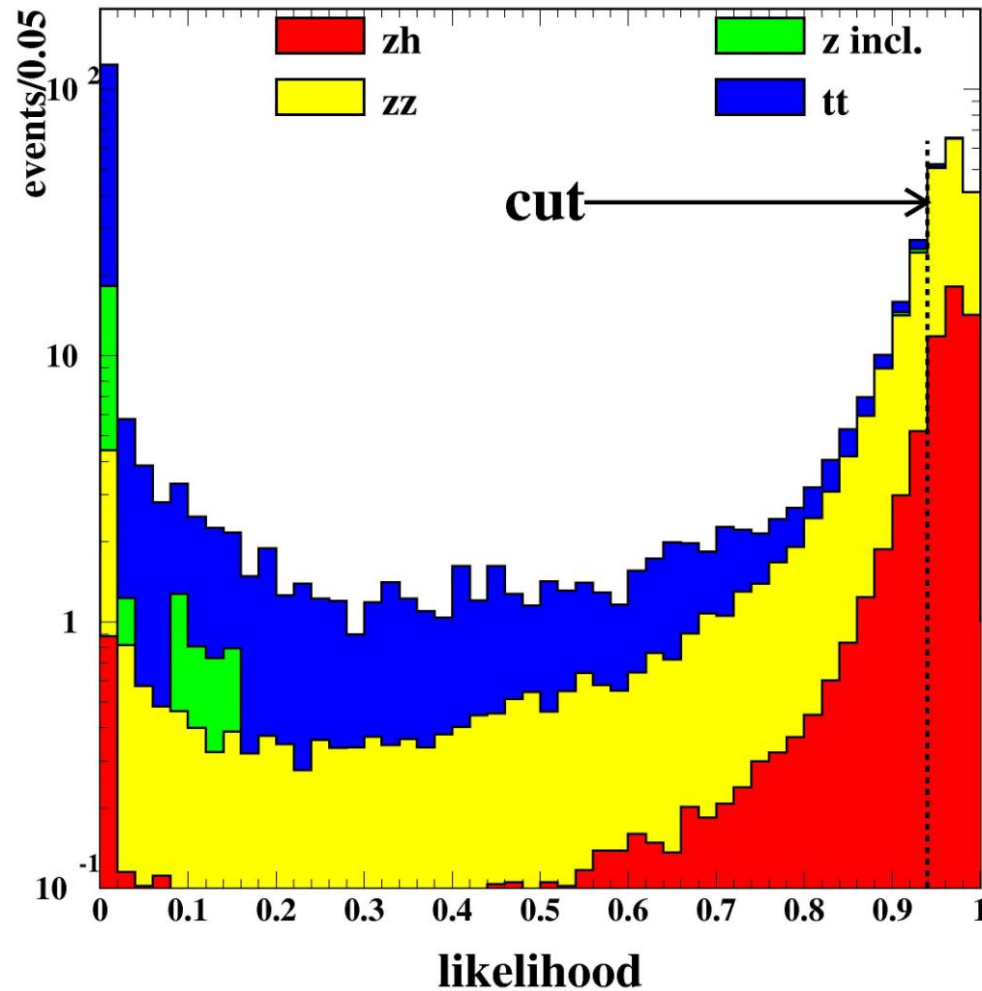
# Effect of $p_{T\text{miss}}$ cut on Z incl. bgnd



# Inputs to likelihood after cut on $p_{T\text{miss}} > 93.7 \text{ GeV}$ (for $10 \text{ fb}^{-1}$ )



# ZH: likelihood distributions, $m_h=120$ GeV



# Number of selected events

$m_H = 120 \text{ GeV}$	ZH	ZZ	Z incl	tt
# generated	0.2 M	0.41 M	62.11 M	22.26 M
exp. at $10 \text{ fb}^{-1}$	424	3004	28.2 M	1.261 M
preselected	<b>63.5</b>	<b>465</b>	<b>18</b>	<b>215</b>
selected $\perp$	<b>49.3</b>	<b>325</b>	<b>1.2</b>	<b>3.7</b>

$$S/\sqrt{B} = 2.7 \text{ for } 10 \text{ fb}^{-1}$$

# Discovery potential: $S/\sqrt{B}$ vs $m_H$

$m_H$ (GeV)	110	120	130	140	150	160	170
10 fb <sup>-1</sup>	3.0	2.7	2.3	2.0	1.7	1.5	1.4
30 fb <sup>-1</sup>	5.3	4.7	4.0	3.4	2.9	2.7	2.4
100 fb <sup>-1</sup>	9.6	8.6	7.4	6.2	5.2	4.9	4.4
$S/B = 5$	27 fb <sup>-1</sup>	34 fb <sup>-1</sup>	46 fb <sup>-1</sup>	64 fb <sup>-1</sup>	91 fb <sup>-1</sup>	106 fb <sup>-1</sup>	127 fb <sup>-1</sup>

**Feasible for the whole range  
of  $m_H = \{110 - 170\}$  GeV**

# Summary

- ⌘ Invisible SUSY decays of the Higgs are observable at  $5\sigma$  level with  $27-127 \text{ fb}^{-1}$  for  $m_H = \{110-170\} \text{ GeV}$
- ⌘ Chahoury and Roy predicted  $5\sigma$  with  $10 \text{ fb}^{-1}$  for  $m_H = 120 \text{ GeV}$ . I get  $2.7\sigma$ .
- ⌘ WH channel proved impossible due to overwhelming  $W$  incl. background coming from tail of  $W$  mass distribution - high  $p_{T\text{miss}}$  events



# Next steps

Compare the performance of ATLFAST  
with full reconstruction in Athena

- for fully simulated backgrounds (DC1)
- for generated signal events