Possibilities to Observe Heavy Higgs Signal in $H^0 \to Z^0Z^0 \to l^+l^-\nu\tilde{\nu}$ Decays at CMS

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- **Compared to $H^0 \to Z^0Z^0 \to 2l^+2l^-$**, channel $H^0 \to Z^0Z^0 \to l^+l^-\nu\tilde{\nu}$

  — has ∼6 times greater branching ratio;

  — possesses a clear signature – 2 high p_{T} leptons with inv. mass $\sim M_{\mathrm{Z}}$ and large $E_{\mathrm{T}}^{\mathrm{miss}}$;

  — knowledge of $E_{\mathrm{T}}^{\mathrm{miss}}$ is needed ⇒ good enough CMS hermeticity and HCAL resolution are required

- **Previous studies**

  N.Stepanov, CMS TN/93-87 (1993); *S.Abdullin and N.Stepanov*, CMS TN/94-38 (1994); *L.Levchuk*, CMS HCAL SW Meeting, MSU, Moscow, January 2000 ⇒ good $\mathrm{S}/\sqrt{\mathrm{B}}$, though "irreducible" background (IB) due to nonresonant ZZ/ZW production makes it difficult to observe a very heavy ($M_{\mathrm{H}} \geq 500$ GeV/c^2) Higgs signal

- **Purposes of this study**

  To extend analysis to lower H^0 masses with suppressing (if possible) IB

- **Computing tools**

  PYTHIA_6.152 & CMSJET_4.703

- **Kinematical cuts**

  i) $E_{\mathrm{T}}^{\mathrm{miss}} \geq 60$ GeV, $|\eta| \leq 2.4$, $p_{\mathrm{T}}^{\,l} \geq 20$ GeV/c, $P_{\mathrm{T}}^{\,ll} \geq 40$ GeV/c,

  $|M_{\mathrm{Z}} - M_{ll}| \leq$5 GeV, the number of high-p_{T} leptons $\equiv$2;

  ii) $\widehat{\vec{P}_{\mathrm{T}}^{ll}\vec{P}_{\mathrm{T}}^{\mathrm{miss}}} \leq 90°$, $\widehat{\vec{P}_{\mathrm{T}}^{ll}\vec{P}_{\mathrm{T}}^{\mathrm{jets}}} \geq 120°$, $\widehat{\vec{P}_{\mathrm{T}}^{\mathrm{miss}}\vec{P}_{\mathrm{T}}^{\mathrm{jets}}} \geq 120°$;

  iii) no "b-tagged" jets with $E_{\mathrm{T}} \geq 40$ GeV found

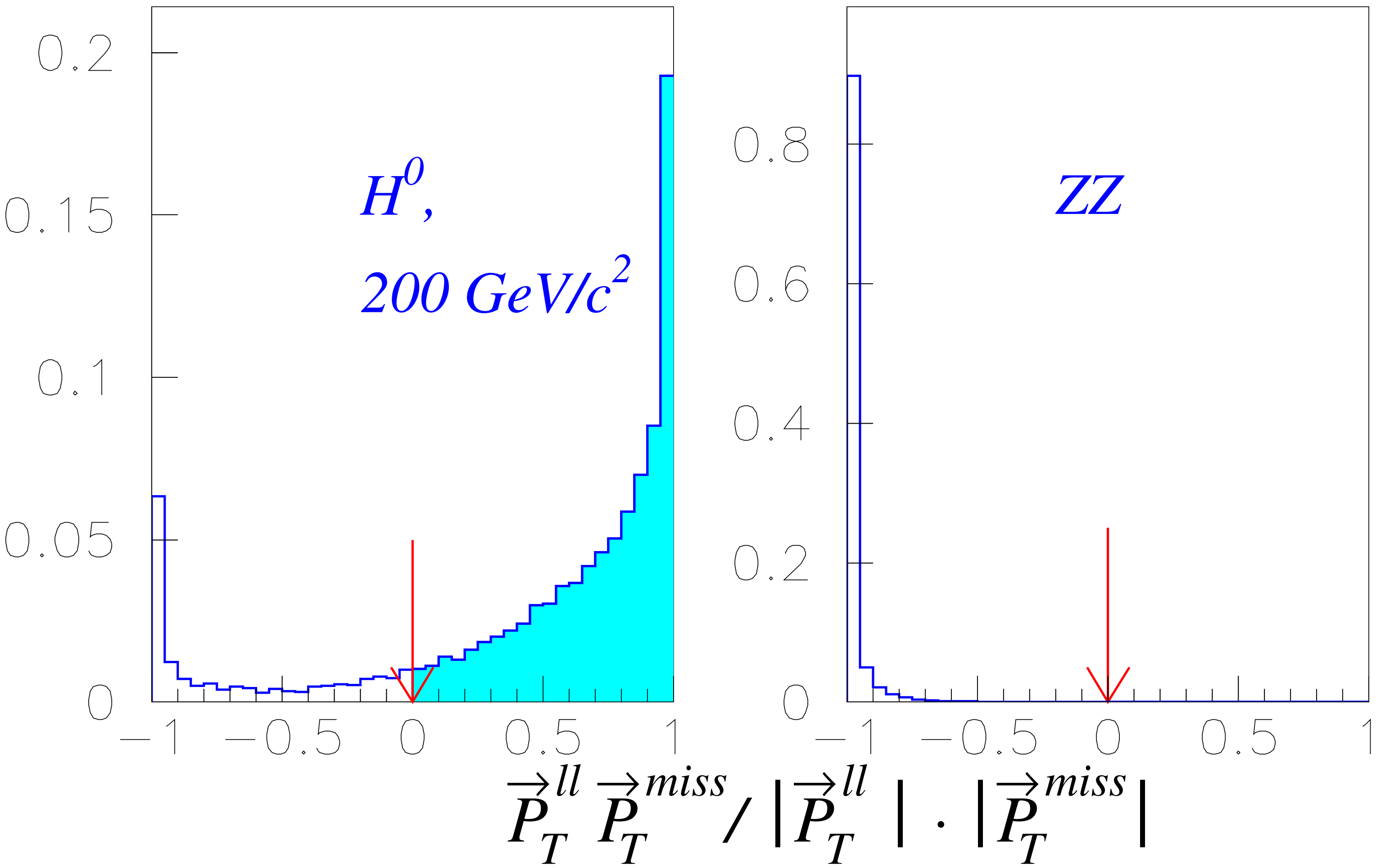
- **Results**

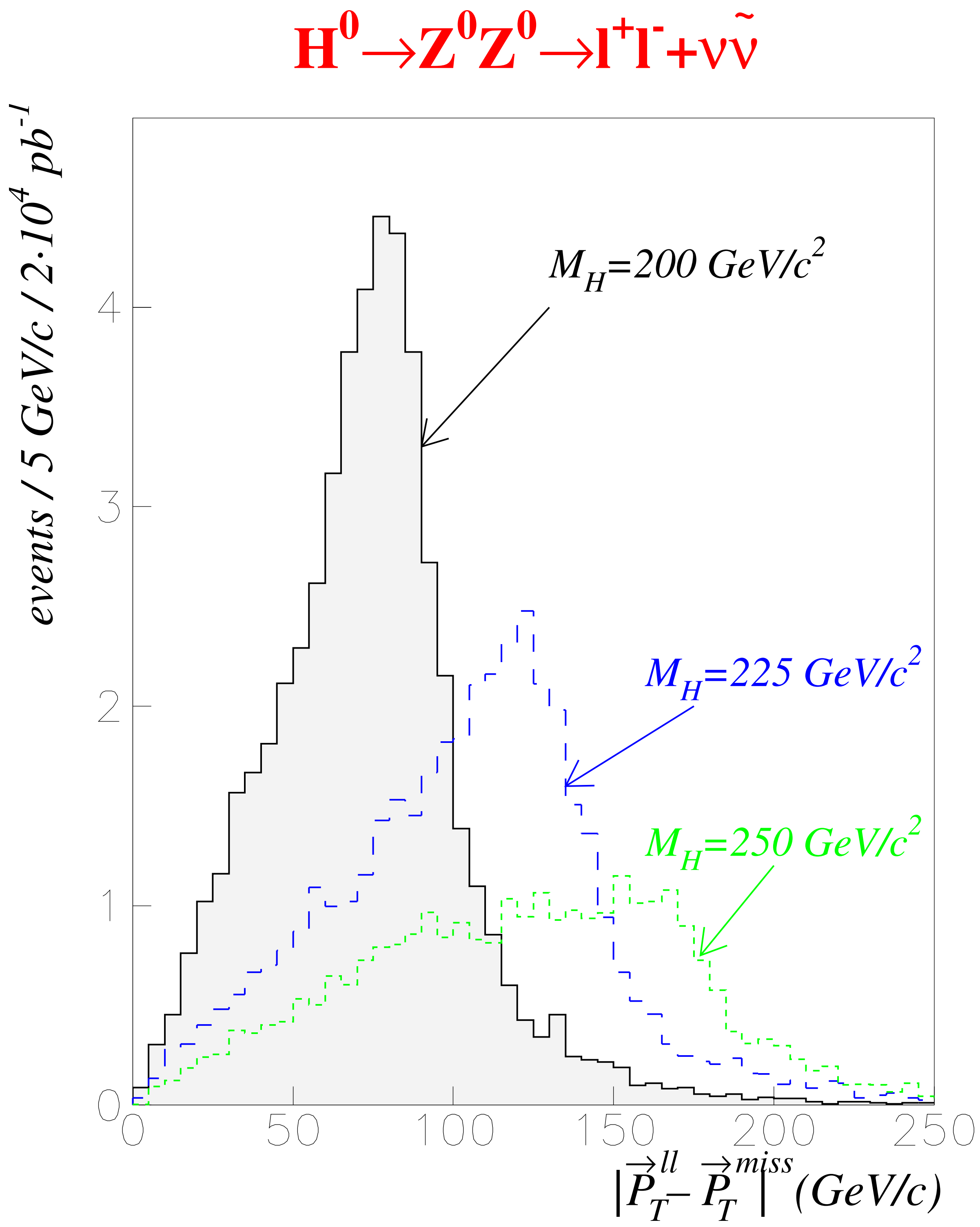
Channel (pp, $\sqrt{s}$ =**14 TeV**)	$\sigma\times$BR, pb	event rates / $2{\cdot}10^4$ pb^{-1}		
		i)	ii)	iii)
$H \to ZZ \to ll\nu\bar{\nu}$, $M_{\mathrm{H}} = 200$ GeV/c^2	.083	65	51	51
$H \to ZZ \to ll\nu\bar{\nu}$, $M_{\mathrm{H}} = 225$ GeV/c^2	.075	223	40	40
$H \to ZZ \to ll\nu\bar{\nu}$, $M_{\mathrm{H}} = 250$ GeV/c^2	.066	363	29	29
$Z + \mathrm{jets} \to ll + \mathrm{jets}$	1100*	1443	597	580
$t\bar{t} \to WW + \mathrm{jets} \to l\nu l\bar{\nu} + \mathrm{jets}$	28	2956	640	287
$ZZ \to ll\nu\bar{\nu}$	0.25	700	~0.1	~0.1
$ZW \to ll\, l\bar{\nu}$	0.36	311	~0.3	~0.3
Total background		5410	1237	867

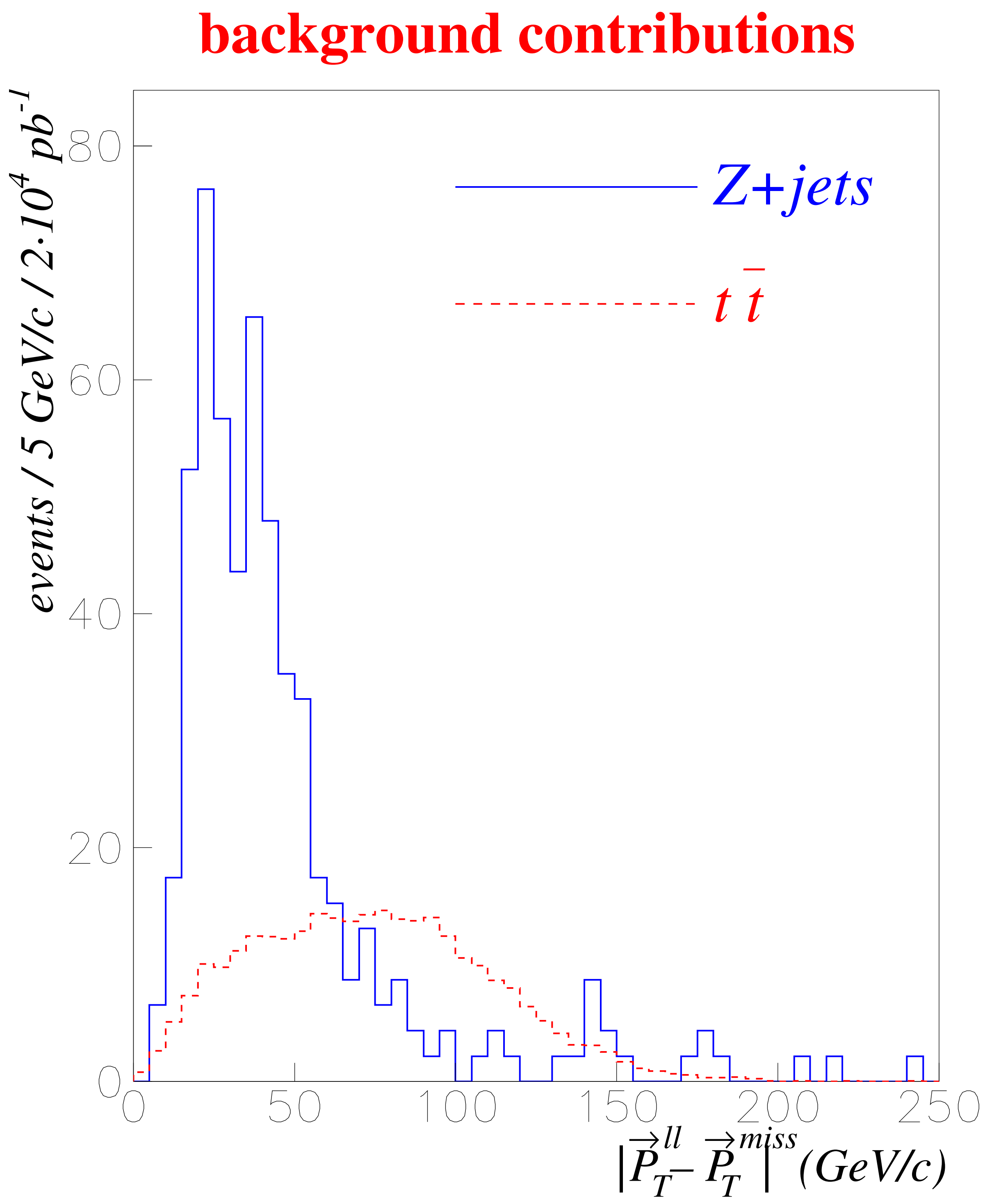
*) $p_{\mathrm{T}}^{\mathrm{Z}} \geq 20$ GeV/c

5 000 000 '$t\bar{t}$' and 10 000 000 'Z+jets' events have been generated $\Rightarrow$ it would be difficult to accomplish the "detailed" (CMSIM & ORCA based) simulation. Under above cuts, almost all "no jets with $E_{\mathrm{T}} \geq 40$ GeV in $|\eta| \leq 2.4$ range" events are rejected. Background due to nonresonant ZZ/ZW production is negligible, though S/$\sqrt{\mathrm{B}}$ appears to be not good enough.

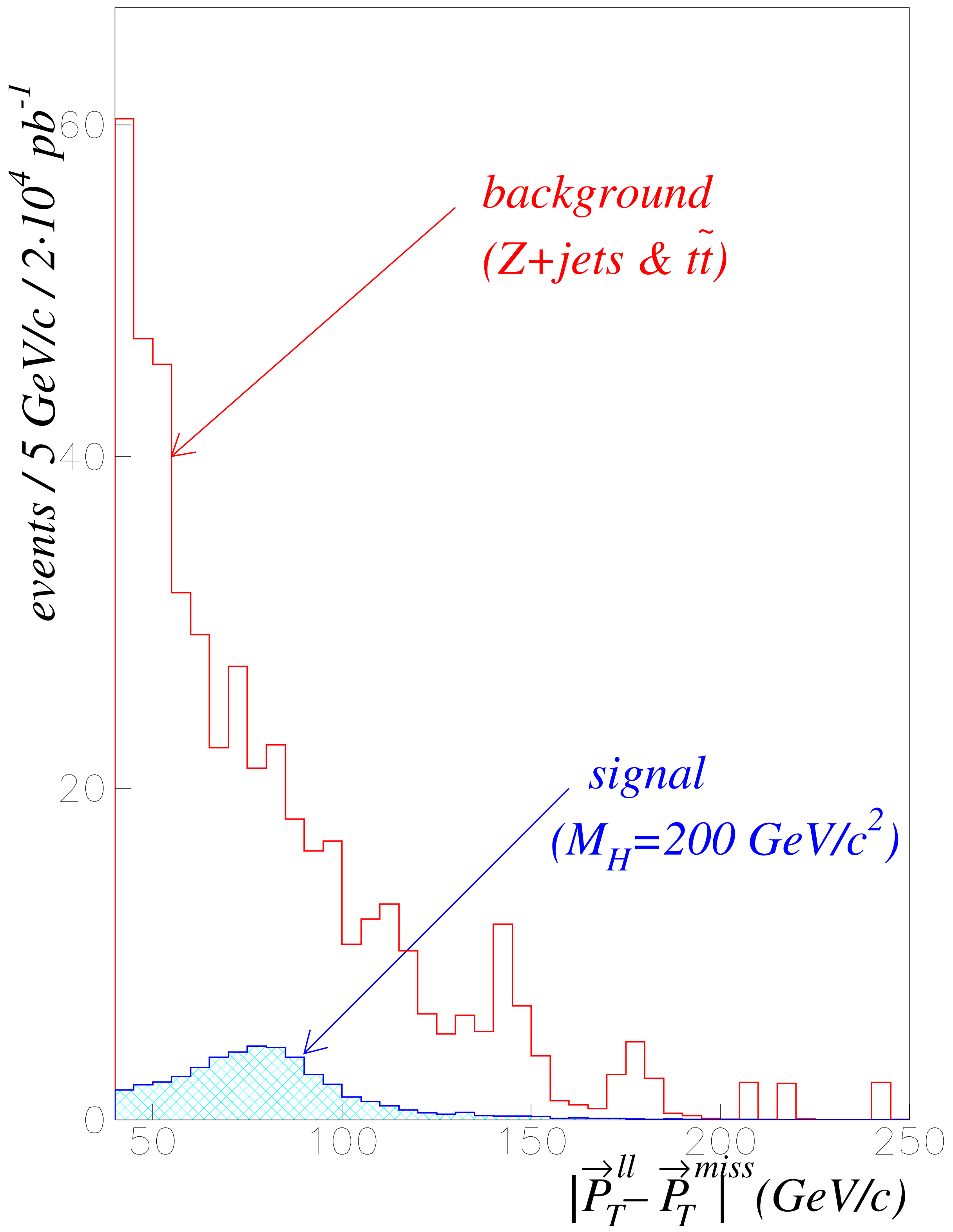
suppression of “irreducible” background




$H^0 \to Z^0 Z^0 \to l^+ l^- + \nu\tilde{\nu}$
events / 5 GeV/c / 2·10^4 pb^-1
M_H=200 GeV/c^2
M_H=225 GeV/c^2
M_H=250 GeV/c^2
0
1
2
3
4
0
50
100
150
200
250
$|\vec{P}_T^{ll} - \vec{P}_T^{miss}|$ (GeV/c)



background contributions
events / 5 GeV/c / 2·10^4 pb^-1
Z+jets
t t̄
0
20
40
60
80
0
50
100
150
200
250
|P_T^ll − P_T^miss| (GeV/c)



events / 5 GeV/c / 2·10^4 pb^-1
background
(Z+jets & t̃t)
signal
(M_H=200 GeV/c^2)
0
20
40
60
50
100
150
200
250
|P_T^ll − P_T^miss| (GeV/c)