# Search for heavy isosinglet neutrino in CMS.

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There are only 3 types of conventional neutrino, but there could be neutrinos that are isosinglet under the standard $SU(2)_L$ gauge group.

Such neutrinos can be produced though the mixing with the ordinary neutrinos, in the case studied here $\nu_e$ or $\nu_\mu$. (diagram).

Was searched for in L3 at LEP in the mass range from 80 GeV to 180 GeV (Fig. 1). No signal, limits from $0.4 \cdot 10^{-2}$ (at 80 GeV).

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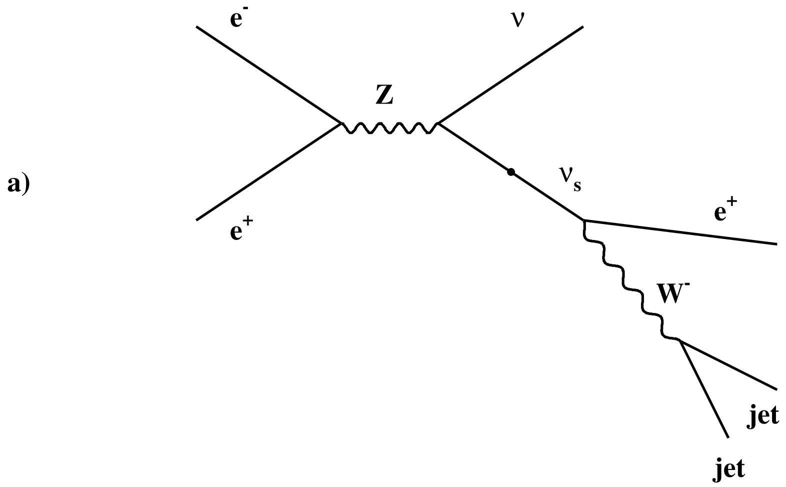


Figure 1: Process searched for in L3.

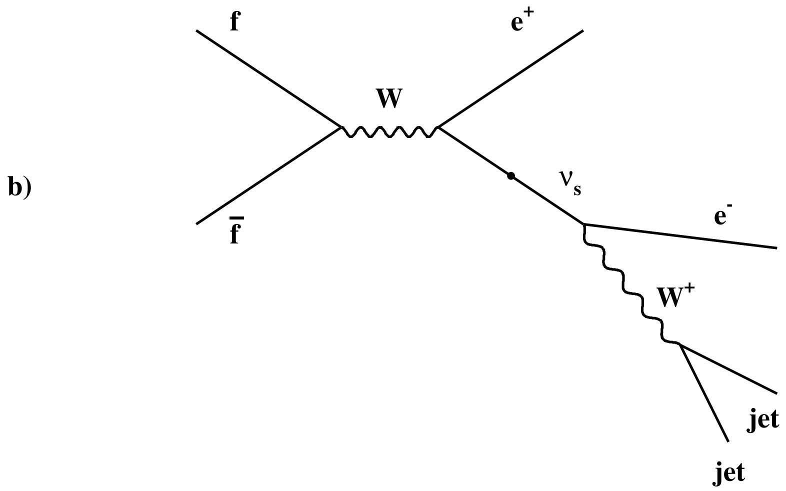


Figure 2: Process to be searched for in CMS.

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## Simulation of the signal in CMS (Fig. 2).

- **Event generator:** Pythia, process with 4-th generation production (called anomalous coupling in Pythia). One 4-th lepton is massive, another massless.
- The massive lepton is forced to decay into $eW$ or $\mu W$, the massless one is renamed as a muon or electron. The corresponding branching ratio is 0.67. W is forced to decay into jets.
- Pythia code modified in order to calculate correctly the effect of decay channels turned off without full turn-on of the fourth generation.
- The cross section (Pythia estimation) for the neutrino mass 300 GeV is $6.2 \times 10^{-11} mb$
- The particles are traced in CMS by **CMSJET**. Default cuts on the lepton PT (20 GeV for electrons, 10 GeV for muons, 40 GeV for jets) and on the isolation of leptons.

## Analysis and cuts.

- Should be at least 2 isolated leptons. Any pair of **all** leptons should not have invariant mass smaller than 200 GeV. Here and below cuts optimized for 300 GeV are shown.
- Should be at least 2 jets. From these jets the pair is chosen with a mass closest to the invariant mass of W. Event is accepted if $abs(m_{inv} - m_W) < 11 GeV$
- From these two jets and a lepton the invariant mass is calculated. A peak in this mass is to be searched for (Fig. 3).
- Upper cut on the missing $P_t$ : 22 GeV.
- Signal efficiency for the neutrino mass 300 GeV is about $10\%$.

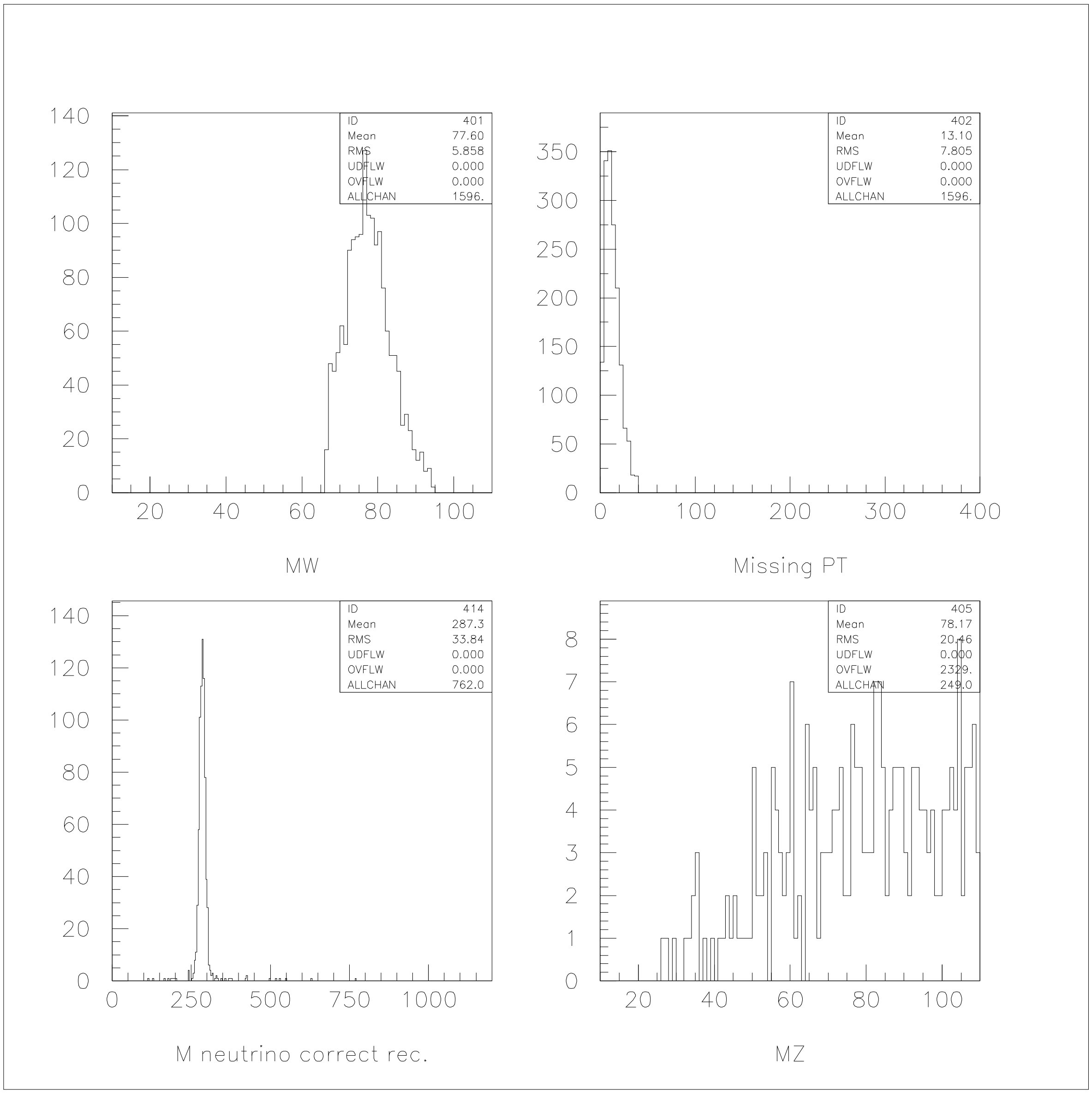


Figure 3: Signal 300 GeV distributions.

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## Background.

- Obvious background: $WZ$ production (Fig. 4). The cross section at least 10 times higher than for the signal at a mass of 300 GeV.
- Highest background: $t\bar{t}$ production (Fig. 5). The cross section at least 1000 times higher than for the signal at a mass of 300 GeV. Both $t$ and $\bar{t}$ decay to jet and W, both W to leptons.
- background: $Zg$ production (Fig. 6). The cross section at least 100000 times higher than for the signal at a mass of 300 GeV. Z gives a lepton, gluon gives a jet. To decrease the number of simulated events a $P_t$ lower cut 20 GeV is introduced; it is checked with loose selection cuts that it does not change the number of background events.
- $Z$ + Higgs (mass = 150 GeV). Some contribution, but small cross section.
- $WW$ and $ZZ$ production: no contribution found.

- $b\bar{b}$ production: suppressed by the requirement of isolation.

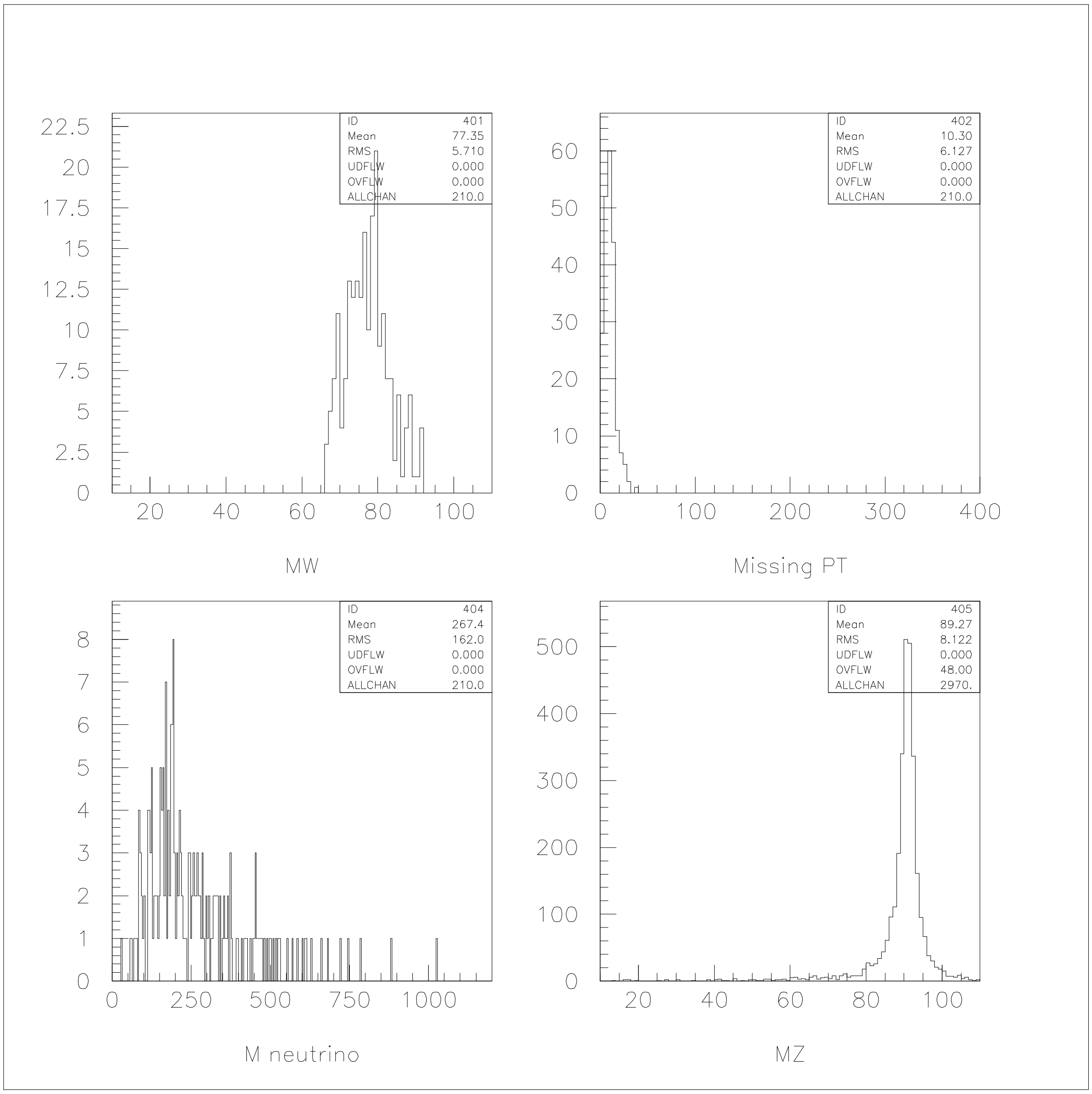


Figure 4: $ZW$ production distributions.

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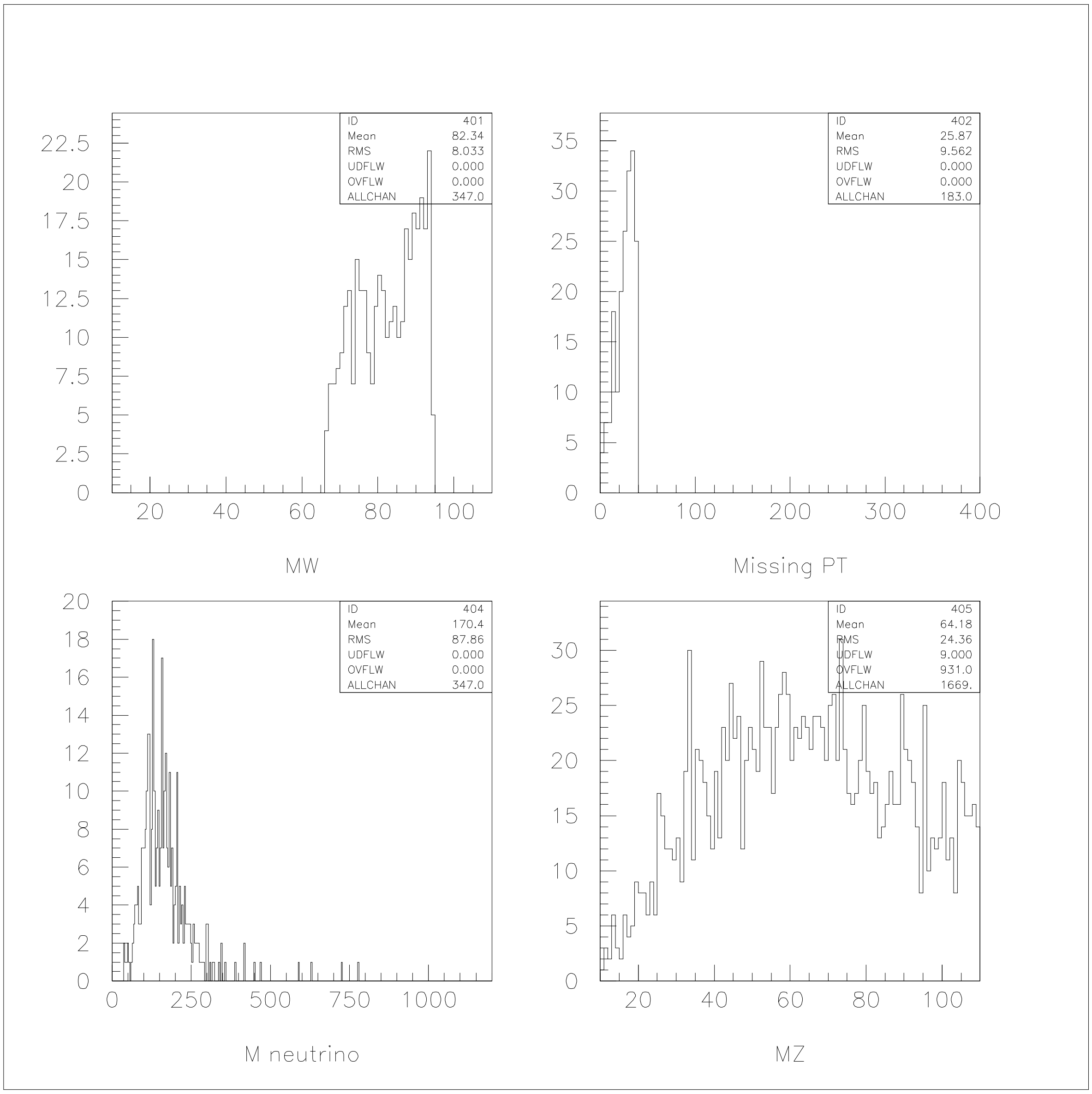


Figure 5: $t\bar{t}$ production distributions.

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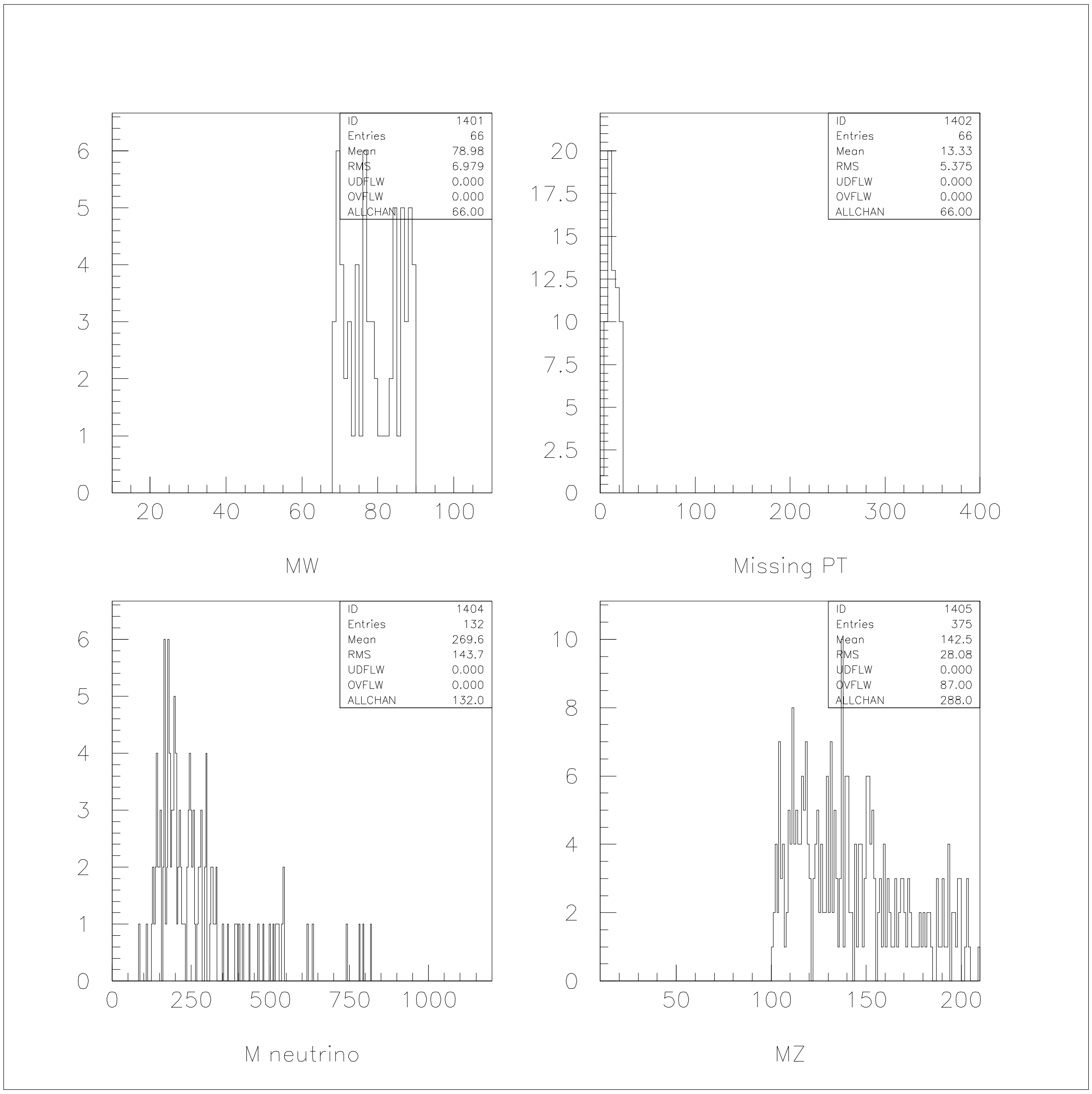


Figure 6: $Zg$ production distributions.

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**Sensitivity calculation.**

- Calculated for the integral luminocity of $3 \cdot 10^4 pb^{-1}$.
- It is assumed (where relevant) that the uncertainty of background is $10\%$.
- Feldman - Cousins table used for a background smaller than 15 events.

**Conclusion: In CMS it is possible to search for a heavy isosinglet neutrino with a mass up to 800 GeV.**

Look into the NC decay channel with $Z \to ll$. Reconstruction of transverse mass. Dominant background: $ZW$. Small cross section due to Z branching ratio. Sensitivity significantly smaller.

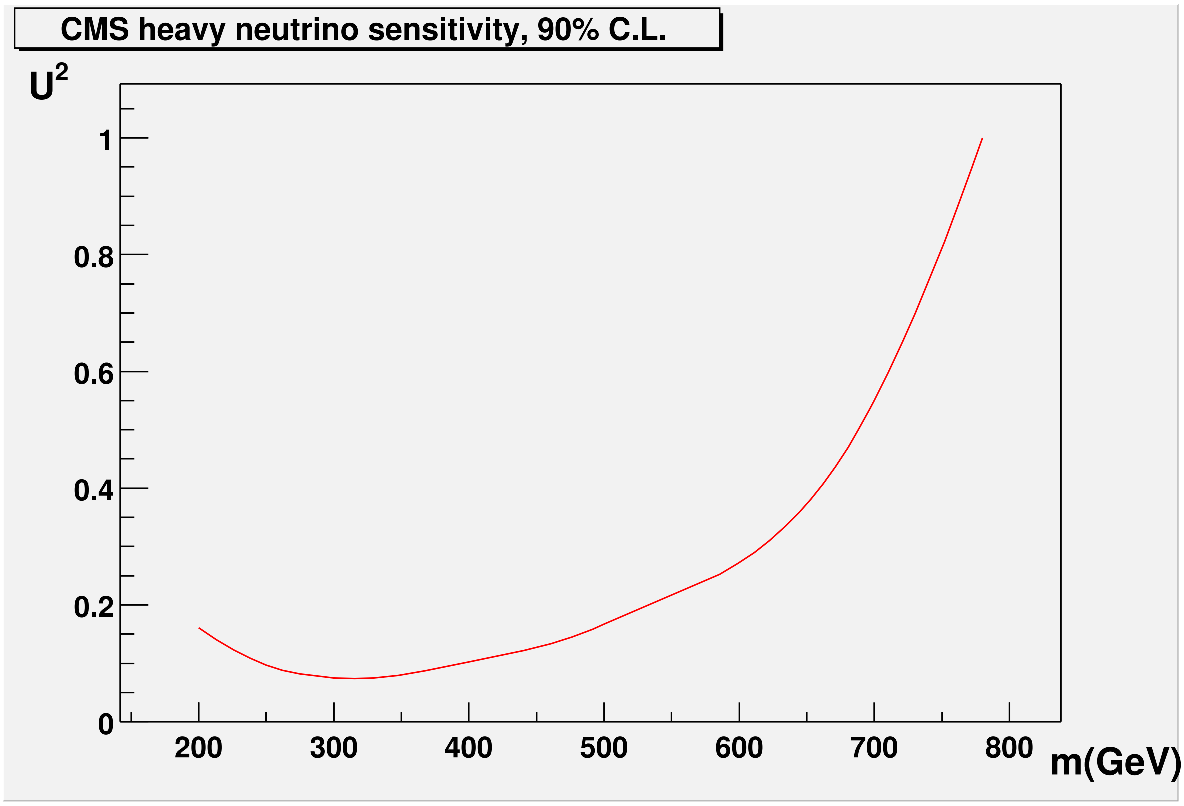


Figure 7: Expected CMS sensitivity for $3 \cdot 10^4 pb^{-1}$

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## ORCA studies.

- ORCA should be used for more realistic estimations of efficiencies and mass resolutions.
- The last studies made with ORCA 4.5.2 (june 2001)
- In most cases ORCA does not find jets since there is no jet splitting in that version (as in CMSJET).
- Temporary solution: dump towers from ORCA and make jetfinding by CMSJET. Preliminary result on small statistics: efficiency about 60% of the CMSJET value.
- We decided to make a separate study of this (separate presentation and probably Note)

**Plans.**

- ORCA studies.
- Tuning of cuts with ORCA.
- Look at the decay mode with $\tau$.

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