SEARCH FOR AN INVISIBLY DECAYING HIGGS BOSON IN DILEPTON EVENTS AT CDF

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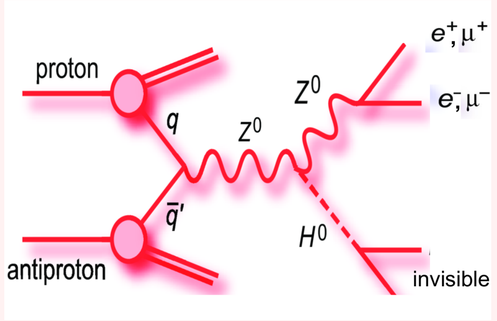
Introduction: What are we searching for?

▶ **Aim: Search for a Higgs boson that decays to invisible particles.**
Observing a larger than expected invisible Higgs decay branching ratio would be an indication of physics BSM.

▶ Higgs boson decays to weakly interacting and neutral particles
⇒ Only missing transverse energy in the final state



▶ Higgs-strahlung process
- H produced with $Z \to \ell^+\ell^-$
- Clean signatures
- Dominant Higgs production mechanisms at Tevatron

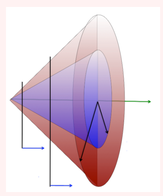
Final Discriminant

Highest discriminating power between signal and background

$$\Delta R \equiv \sqrt{\Delta\phi^2 + \Delta\eta^2}$$

Takes in account the recoil of a $Z \to \ell\ell$ with respect to the particle decaying invisibly.

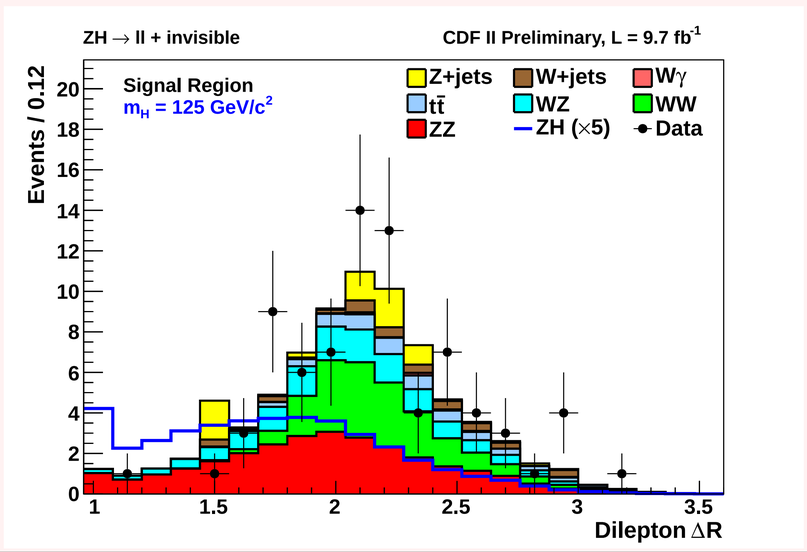
▶ Leptons recoiling against H
▶ Leptons recoiling against Z



Signal modeling

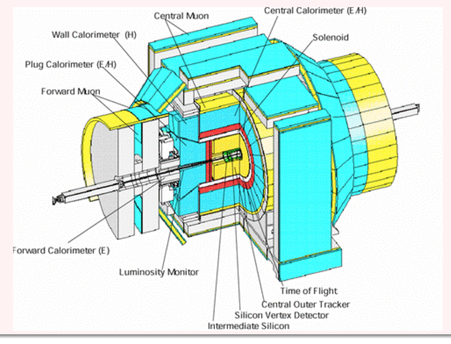
- $115 \leq m_H \leq 150\ \ \mathrm{GeV}/c^2$
- $\sigma_{ZH,\mathrm{SM}} \times [\mathcal{B}\,(H \to \text{ invisible}) = 100\%]$
- NNLO production cross section for ZH
- For $m_H = 125\,\mathrm{GeV}/c^2$

σ_{ZH} (fb)	scale (%)	PDF+$\alpha_s{}^{exp}$ (%)	$\alpha_s{}^{th}$
78.5	$^{+0.7}_{-1.0}$	$^{+6.6}_{-6.7}$	$^{+0.8}_{-0.6}$



CDF Run II

Tevatron Run II (2005–2011): $\sim 12\mathrm{fb}^{-1}$ **of** $p - \bar{p}$ **collisions @** $\sqrt{s} = 1.96$ **TeV**



CDF II: multipurpose detector, $\sim 4\pi$ coverage, $12 \times 12 \times 12$ m, 5000 t

- Tracking: inner tracking system (Si) + outer tracker (gas drift chamber) in solenoidal 1.4 T magnetic field
- Calorimeter: central + endplugs, e.m. (Pb/scintillator) + hadronic (steel/scintillator)
- Muon detectors: planar drift chambers + scintillators

Event selection

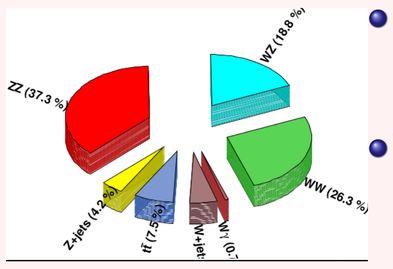
▶ High-p_T muon and high-E_T electron as triggers
▶ **Z** $\to \ell^+\ell^-$
- Exactly two opposite charge and same flavor leptons
- Reconstructed invariant mass: $82 \leq m_{\ell\ell} \leq 100\ \mathrm{GeV}/c^2$

▶ **Z** $\to \ell^+\ell^-$ **candidates**
- $p_T(\ell\ell) \geq 45\ \mathrm{GeV}/c$ Signal sample
- $30 \leq p_T(\ell\ell) \leq 45\ \mathrm{GeV}/c$ Control sample

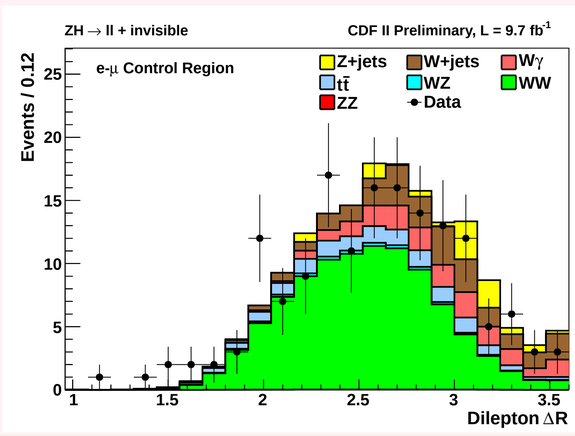
▶ **Reduce background events**
- No reconstructed jets with $\Delta\phi \geq 2.0$ rad from the Z
- $\not\!\!E_T \geq 60\ \mathrm{GeV}$
- $\Delta\phi(\not\!\!E_T, \ell) \geq 0.5$ rad

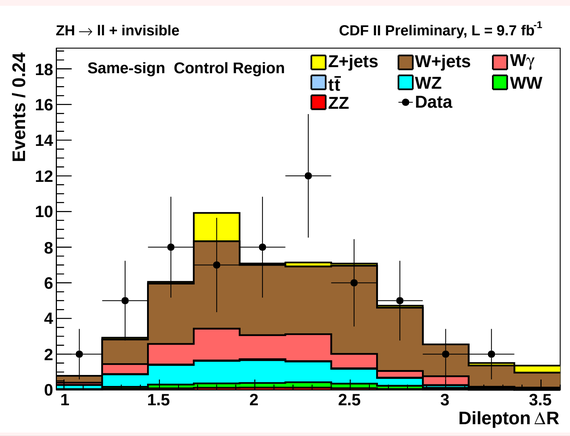
$ZH \to \ell^+\ell^-$ + **invisible** (signal region) CDF Run II Preliminary, $\mathcal{L} = 9.7\ \mathrm{fb}^{-1}$	
Z +jets	7.1 ± 3.1
W+jets	3.8 ± 0.6
$W\gamma$	0.5 ± 0.1
$t\bar{t}$	5.5 ± 0.9
WZ	13.7 ± 1.5
WW	19.2 ± 1.8
ZZ	27.2 ± 2.9
Total prediction	$\mathbf{76.9 \pm 7.2}$
ZH ($m_H = 125\ \mathrm{GeV}/c^2$)	8.2 ± 1.3
Data	**78**

Background modeling



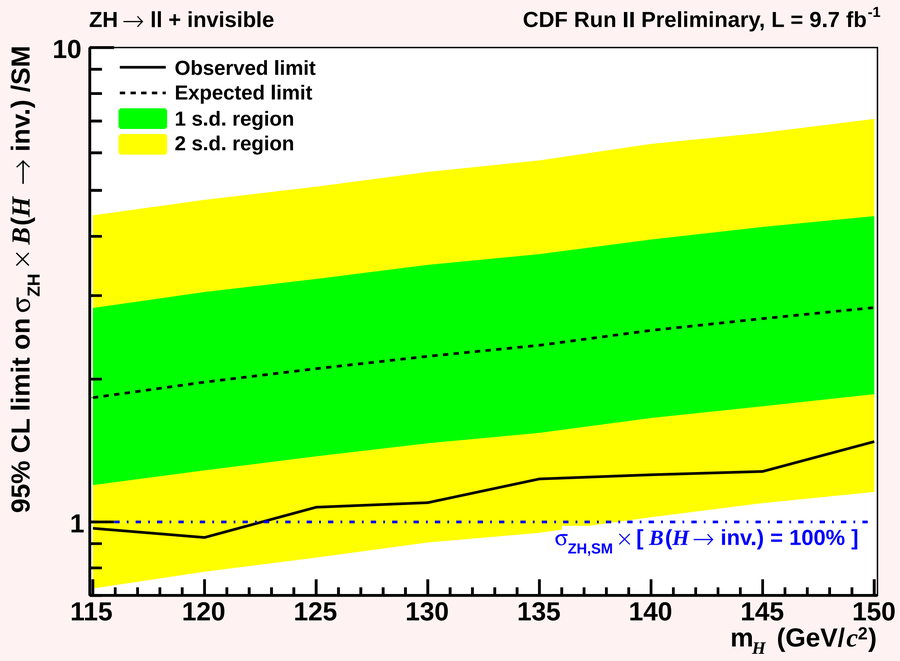
- Diboson (ZZ, WW, WZ), top quark production ($t\bar{t}$): modeled from Monte Carlo simulations, normalized to theoretical cross section
- WW/W+jets: modeled from Monte Carlo simulations, normalized with data-driven method

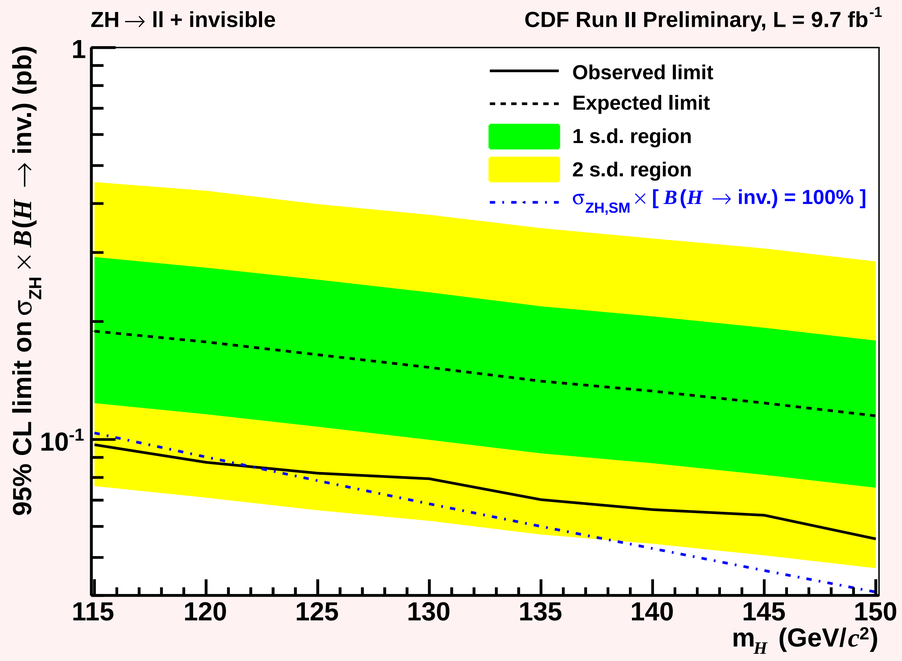




$(Z \to ll)(H \to \nu\nu)$ production Limit Calculation

No significant departure from SM is shown: perform a binned maximum likelihood fit on distribution, taking into account all uncertainties and their correlations, to obtain observed (from data) and expected (from simulated experiments) 95% C.L. upper limits on the ΔR distribution of the two leptons





Results

We exclude at 95% Credibility Level

- $\mathcal{B}$ (**H** $\to$ *invisible*) $=$ **100% assumption at Higgs boson masses lower than 120** $\mathrm{GeV}/\mathbf{c^2}$
- $\sigma_{\mathbf{ZH}} \times \mathcal{B}(\mathbf{H} \to \text{ inv}) \geq$ **90 fb at a Higgs boson mass of 125** $\mathrm{GeV}/\mathbf{c^2}$

Acknowledgments

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