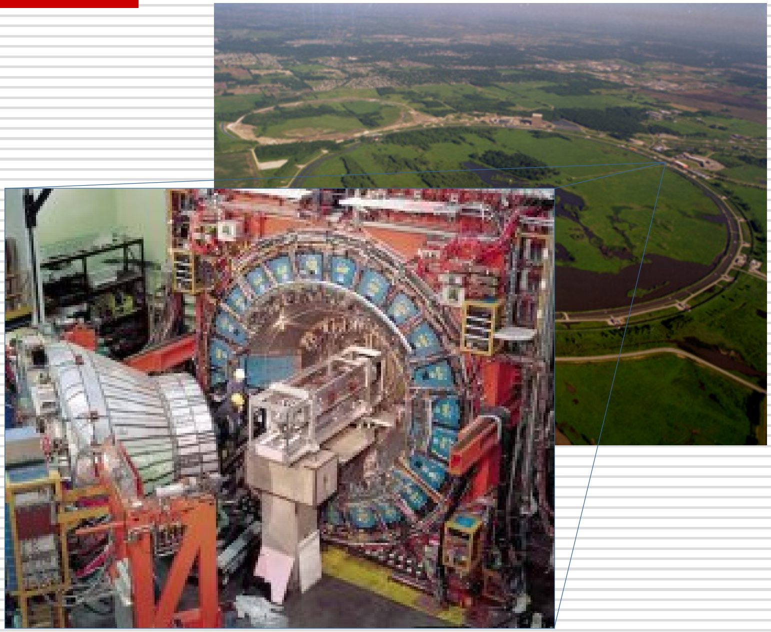
Search for a SM Higgs Boson in the WW Dilepton Decay Channel with 200/pb CDF II Data

Shan-Huei Chuang
UW−Madison
for the CDF Collaboration

2004 PHENOMENOLOGY SYMPOSIUM

Madison WI

April 27 2004

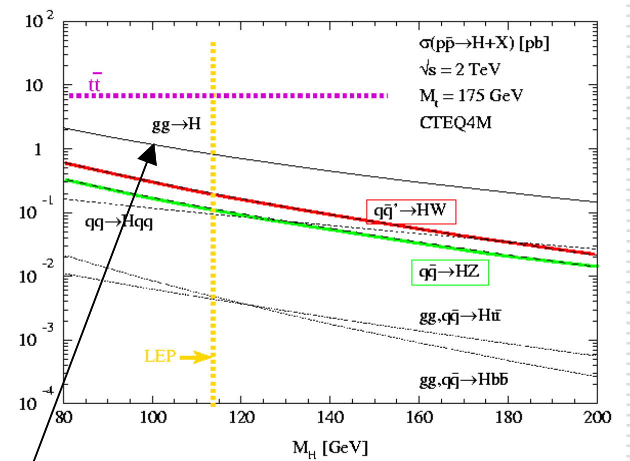


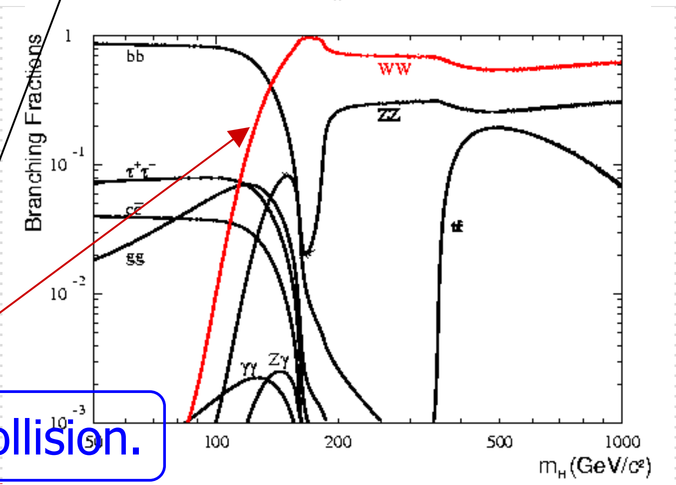
Fermi National Accelerator Laboratory

Why Do Higgs? And $gg \rightarrow h^0 \rightarrow WW^*$?

HIGGS

- Electroweak symmetry breaking dynamics?
- Mass generation of electroweak gauge bosons and fermions?
- Indication of the scale of new physics where the Standard Model will fail?



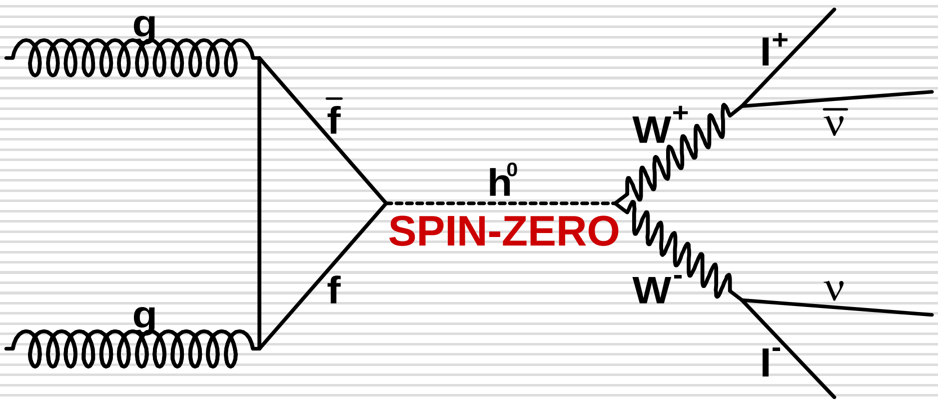


major leading-order production mechanism

dominant decay mode in high mass region

- TeVatron provides an opportunity with $p\bar{p}$ collision.

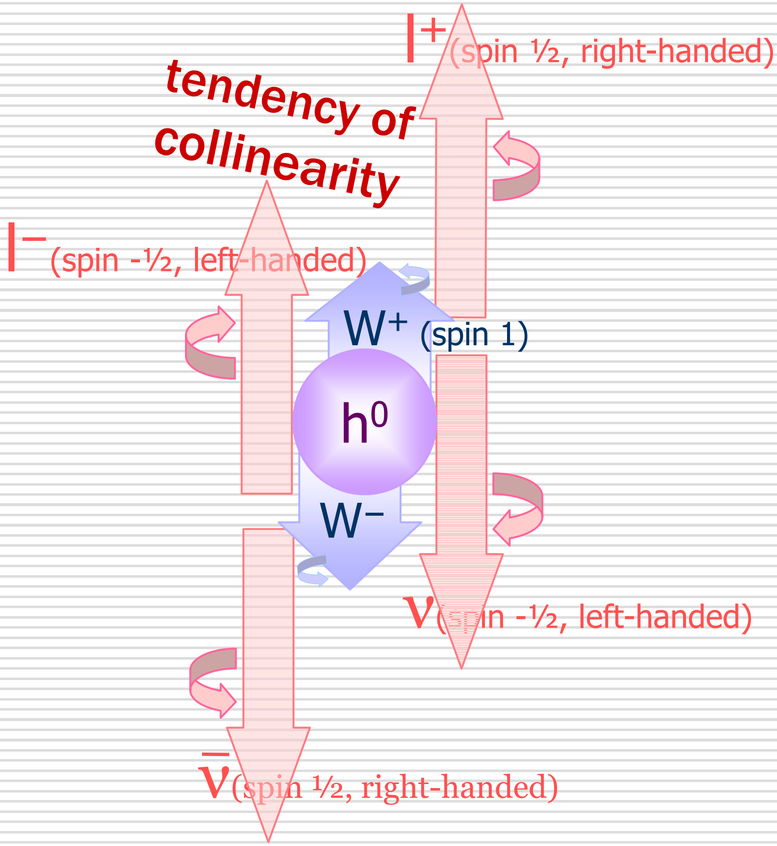
How to Approach Higgs?



- parity conservation
- spin conservation

MAKES TWO DISTINCTIVE HIGGS FEATURES:

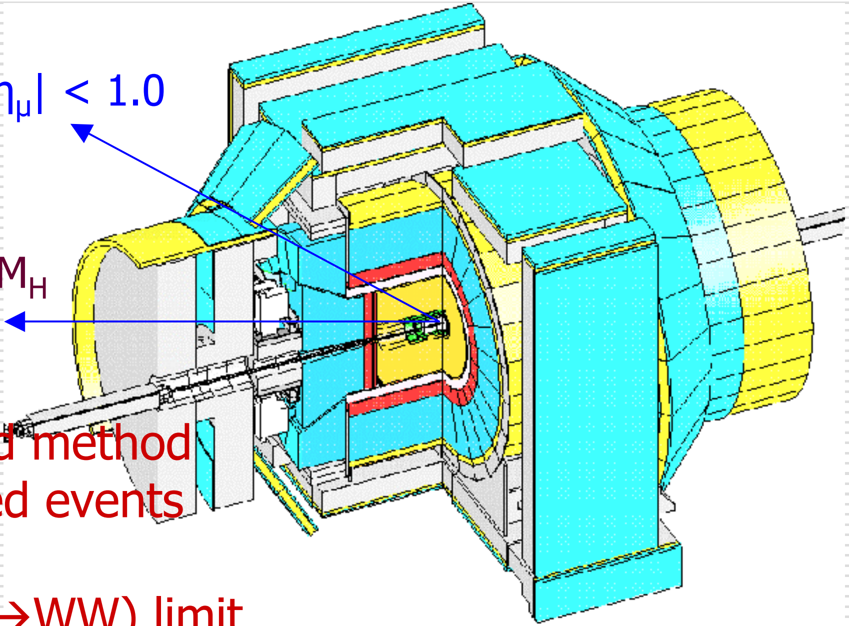
- small dilepton angular separation
- small dilepton invariant mass



in the rest frame of the higgs boson

Event Selection

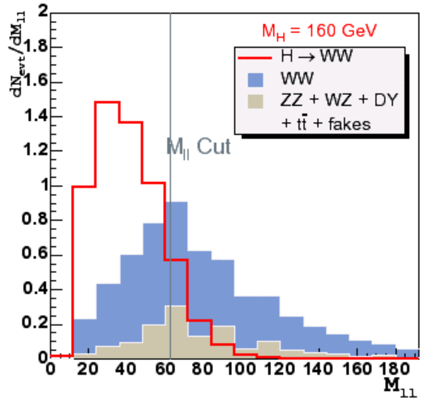
1. Select events that have
   - "well-detected" two electron/mμons, each with $E_t > 20$ GeV
   - missing $E_t > 25$ GeV
   - no jets with $E_t > 15$ GeV and $|\eta| < 2.5$
   - $\Delta\Phi$(missing E_t, closest lepton or jet) > 20° for missing $E_t < 50$ GeV
   - not $76 < M_{Z\rightarrow ee/\mu\mu} < 106$ GeV
   - opposite lepton charge signs
   - dilepton invariant mass $M_{ll} \lesssim \frac{1}{2}M_H$



2. Use a binned maximum likelihood method on the $\Delta\Phi_{ll}$ distribution of selected events

3. Extract the 95% CL $\sigma\cdot BR(gg\rightarrow h^0\rightarrow WW)$ limit

Signal Acceptance



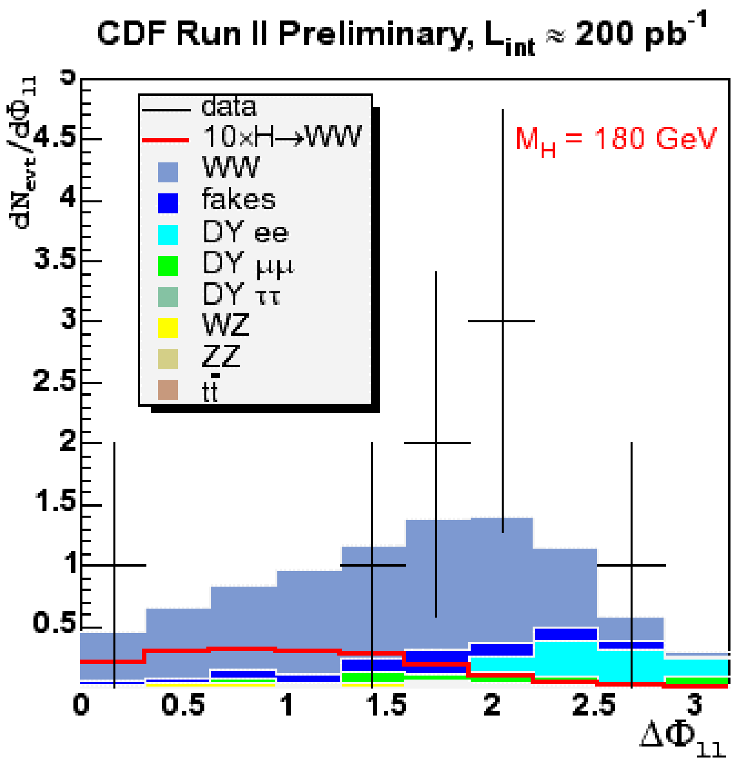
MC study shows the tendency of small H→WW* dilepton invariant mass, which is not a property of other SM background processes.

SM gg→H→WW* signal acceptance
in each dilepton channel for each higgs mass

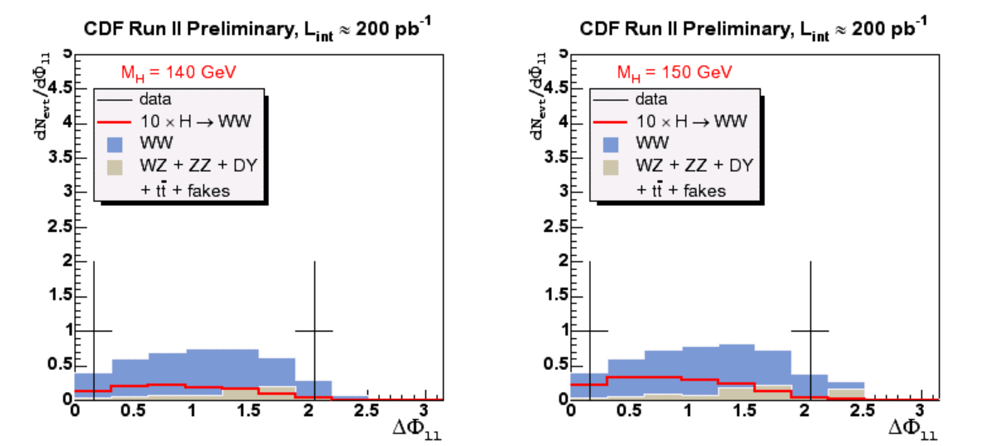
M_H	M_{ll} Cut (GeV)	ee (%)	eμ (%)	μμ (%)	ee+eμ+μμ (%)
140	55.0	0.030±0.001	0.060±0.001	0.034±0.001	0.124±0.002
150	57.5	0.055±0.002	0.110±0.002	0.063±0.002	0.228±0.003
160	62.5	0.093±0.002	0.196±0.003	0.113±0.002	0.402±0.004
170	70.0	0.115±0.003	0.230±0.004	0.131±0.003	0.476±0.005
180	80.0	0.110±0.003	0.219±0.003	0.119±0.002	0.449±0.005

Signal and Background Expectations

SM M_H (GeV)	180
M_{ll} cut (GeV)	80.0
ttbar	0.02 ± 0.01
ZZ	0.06 ± 0.01
WZ	0.18 ± 0.02
DY ττ	0.03 ± 0.01
DY μμ	0.43 ± 0.19
DY ee	0.87 ± 0.44
fakes	0.81 ± 0.25
WW	6.49 ± 0.76
total bg	8.90 ± 0.98
HWW	0.17 ± 0.02
data	8



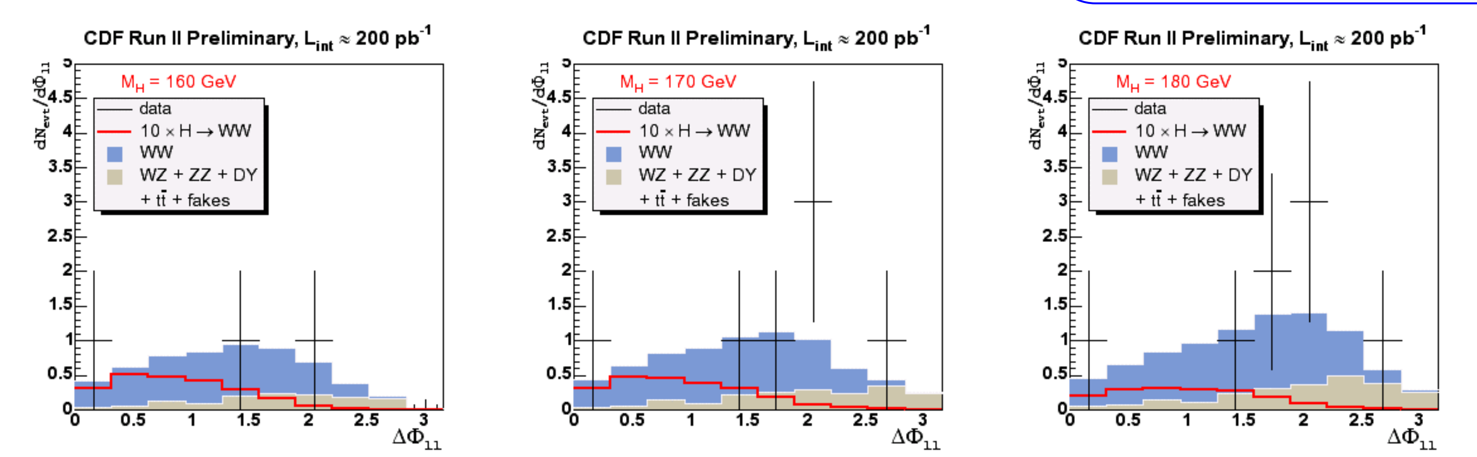
Dilepton ΔΦ Distribution



Q: Why do we separate the **to-be-fitted** into data, $h^0 \rightarrow WW^*$, WW and all other SM backgrounds?

A: Because of the different distribution shape expectations

- $h^0 \rightarrow WW^*$ – small ΔΦ
- WW – large ΔΦ
- all other SM – any



Limit on σ·BR(gg→H→WW*) as a function of Higgs Mass at $\sqrt{\hat{s}}$ = 1.96 TeV

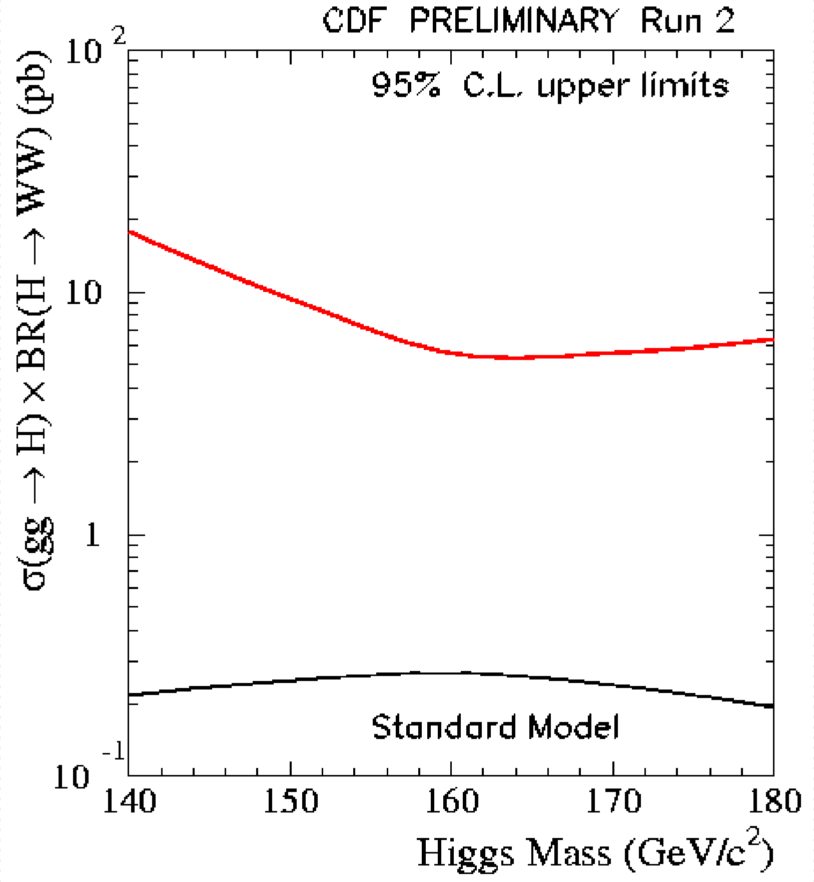
CDF Run II Preliminary, $L_{int} \approx 200\ pb^{-1}$

SM Higgs Mass (GeV)	140	150	160	170	180
$\sigma(gg \to h^0)$ (pb)	0.45	0.36	0.30	0.25	0.21
BR (H → WW*)	0.48	0.68	0.90	0.97	0.94
Integrated Luminosity (pb^{-1})	184 ± 11				
Total Acceptance (%)	0.124±0.012	0.228±0.023	0.402±0.040	0.476±0.048	0.449±0.045
Expected Signal (event)	0.10 ± 0.01	0.15 ± 0.02	0.22 ± 0.03	0.22 ± 0.03	0.17 ± 0.02
WW Background (event)	3.51 ± 0.41	3.82 ± 0.45	4.45 ± 0.52	5.38 ± 0.63	6.49 ± 0.76
Other Background (event)	0.68 ± 0.16	0.90 ± 0.24	1.34 ± 0.35	1.91 ± 0.47	2.40 ± 0.55
95% CL Limit – Counting (pb)	18.4	9.8	6.2	8.2	8.8
Expected Limit – ΔΦ-fitting	18.1	9.8	6.0	7.4	8.0
95% CL Limit – ΔΦ-fitting (pb)	17.8	9.4	5.6	5.6	6.4

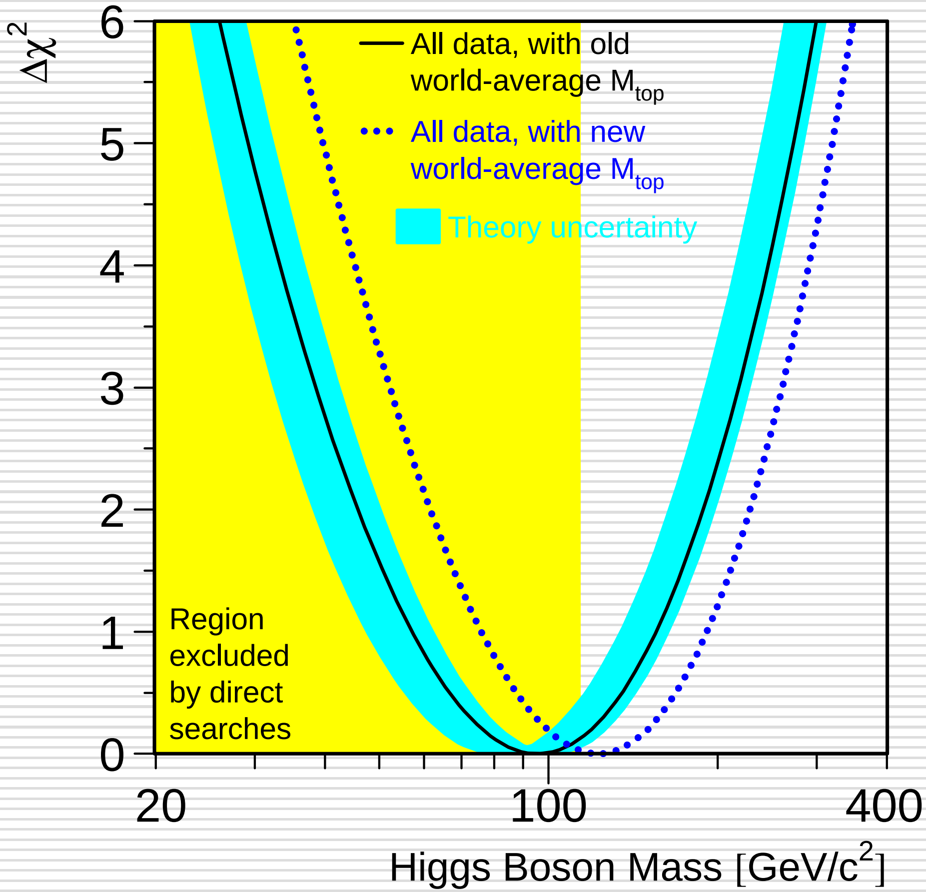
→ $BR(W \to l\nu)^2$ included (applies to Total Acceptance)

Conclusion

- We studied the production of $gg \rightarrow h^0 \rightarrow WW^* \rightarrow l\nu l\nu$ ($l = \{e,\mu\}$) at TeVatron.
- We extracted 95% C.L. limits on higgs production at $\sqrt{\hat{s}}$ = 1.96 TeV as a function of the higgs mass.
- Our results are good yet preliminary. We are making progress on the optimization of our approach while waiting for data increase to advance the results.



Backup



Indirect searches:

- For M_{top} = 174.3 ± 5.1 GeV,
  $\log M_H = 1.98^{+0.21}_{-0.22}$
  $M_H = 96^{+60}_{-38}$ GeV
  M_H < 219 GeV @ 95% CL
- For M_{top} = 178 ± 4.3 GeV,
  $\log M_H = 2.07^{+0.20}_{-0.21}$
  $M_H = 117^{+67}_{-45}$ GeV
  M_H < 251 GeV @ 95% CL

➡ LARGE uncertainties!

LEP2 direct searches:

➤ M_H > 114.4 GeV @ 95% CL