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Comparison of Higgs Mass and Width Measurment

LHC vs LC

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- Higgs mass reconstruction at LHC
- Comparison with LC
- Higgs width determination at LHC
- Comparison with LC
- Conclusions

Status of the Comparison

Much progress on experimental studies after the 1999 Sitges workshop.

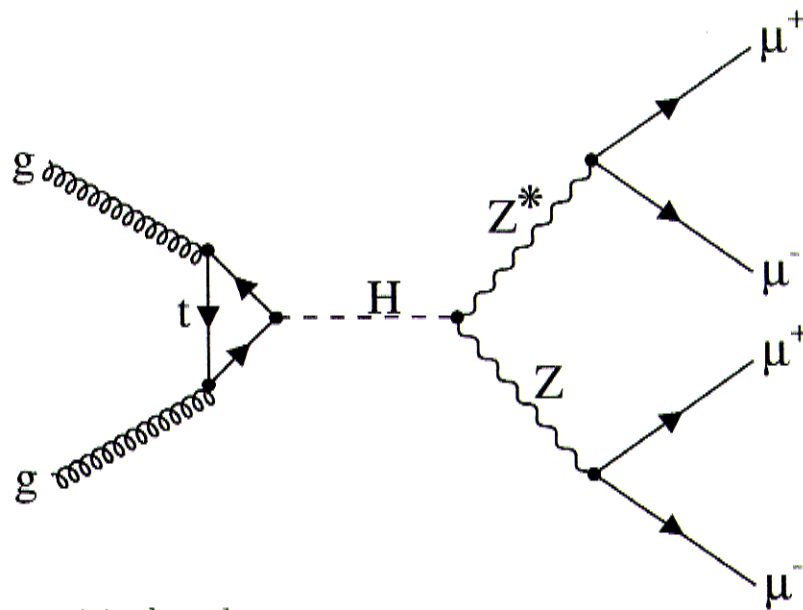
Here, summary of results presented at the ECFA workshops

- Obernai, Oct. 1999
- Padova, May 2000
- Hamburg, Sep. 2000
- LC-PHSM-2000-037

Including:

- New simulations for the LHC (CMS)
(cf. also ATLAS TDR LHCC99-15)
- Extrapolations of LC simulations.

LHC Higgs Mass Reconstruction



- 4 isolated μ :
 $|\eta| < 2.4$, $\epsilon = 90\%$
 $p_T > 20, 10, 7, 7$ GeV,
 small impact parameter
- Z reconstruction:
 onshell: $85 < m_{\text{rec}} < 97$ GeV
 offshell: $12 < m_{\text{rec}} < 76$ GeV ($m_H < 160$ GeV)
 $32 < m_{\text{rec}} < 96$ GeV ($160 < m_H < 200$ GeV)
 $85 < m_{\text{rec}} < 97$ GeV ($m_H > 200$ GeV)

Direct Reconstruction at CMS: $\mu\mu\mu\mu$ Channel

$m_H < 200$ GeV:
Gaussian distribution

$m_H \geq 200$ GeV:
Gaussian $\otimes$ Breit-Wigner distribution

Detector resolution:

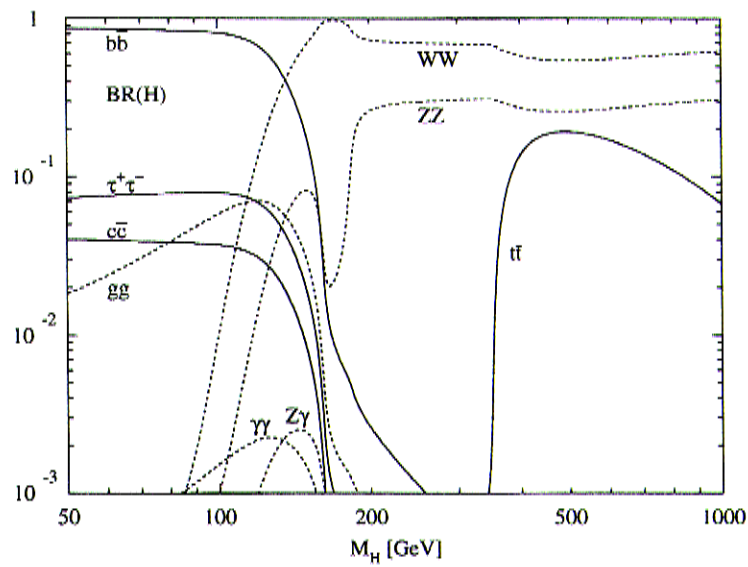
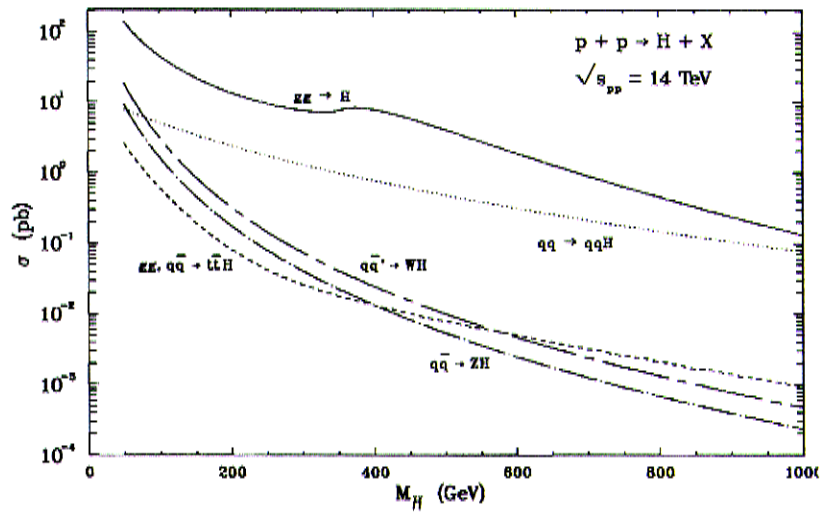
A) Gaussian fit with $\Gamma_H^{\text{th}} = 0$.

B) m_Z reconstructions.

Fit results from method A and B agree.

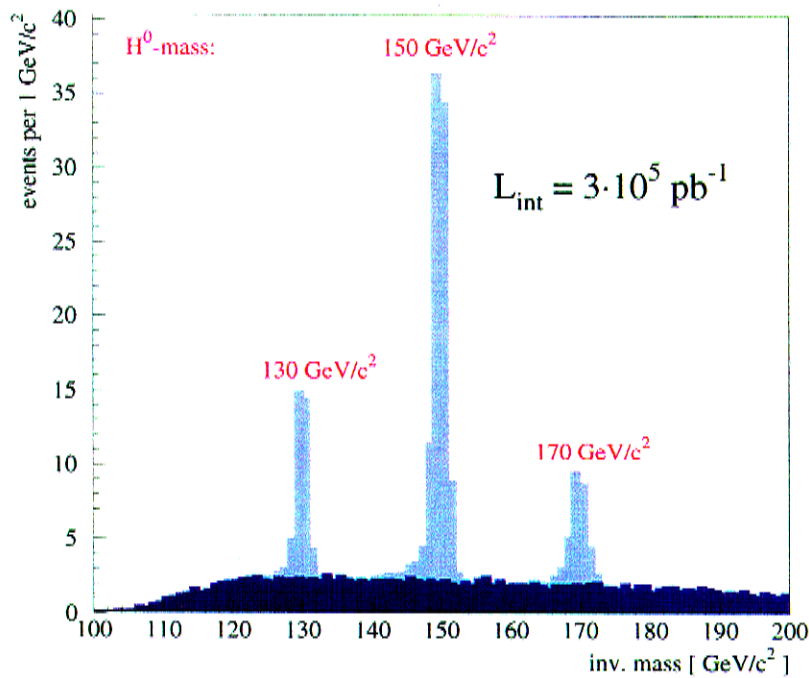
100 repetitions of LHC signal simulation
 $\Rightarrow$ statistical error reduction.

LHC Higgs Mass Reconstruction



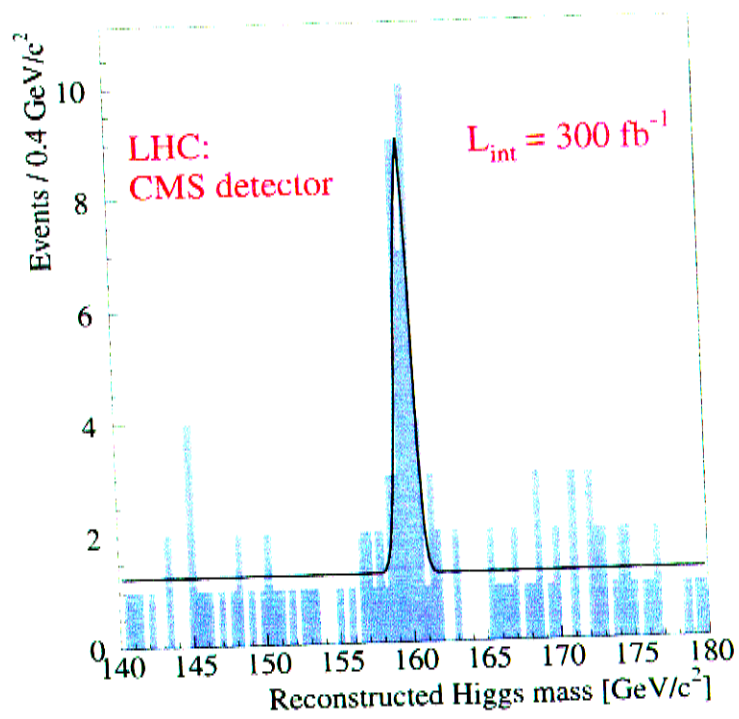
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LHC Higgs Mass Reconstruction



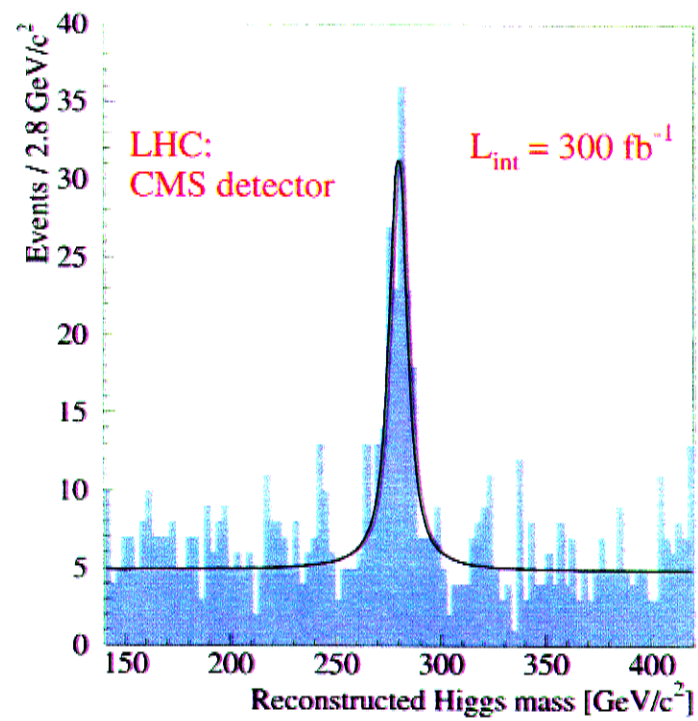
- clear signal above background
- expect ≈ 2 bg. events per 1 GeV
- background: ZZ , $Zb\bar{b}$, $t\bar{t}$

LHC Higgs Mass Reconstruction



$$m_H = 159.8 \pm 0.1 \text{ GeV}$$

LHC Higgs Mass Reconstruction

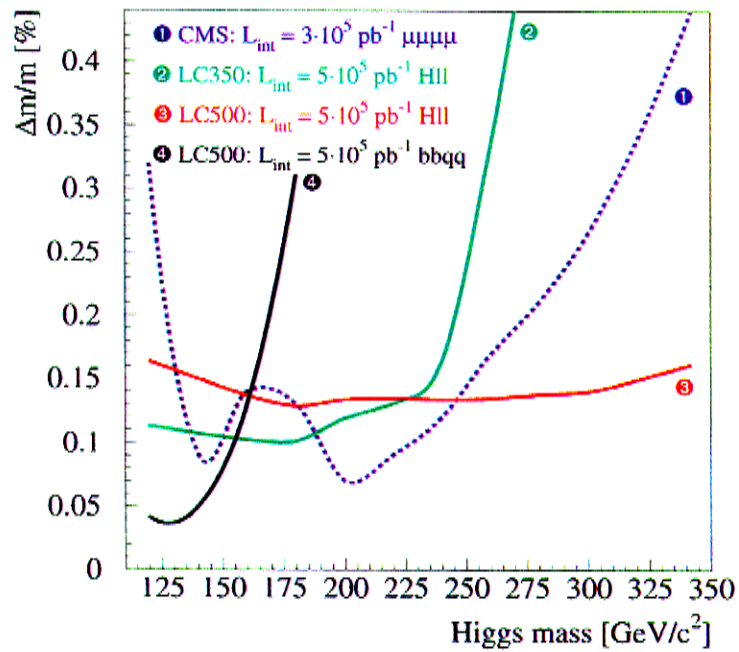


$$m_H = 280.2 \pm 0.6 \text{ GeV}$$

Investigated Channels at LHC and LC

- LHC: $\mu\mu\mu\mu$ simulated range 120 - 340 GeV
- LC Hll: simulated mass 120 - 160 GeV
at $\sqrt{s} = 350$ GeV (Garcia, Lohmann)
extrapolation:
$$\Delta m_H = \sqrt{\sigma_0/\sigma_H} \times \Delta m_0$$
for $\sqrt{s} = 350$ and 500 GeV
- LC bbqq: simulated mass 120 GeV
at $\sqrt{s} = 500$ GeV (Juste)
extrapolation:
$$\Delta m_H = \sqrt{BR_0(H \rightarrow b\bar{b})/BR_H(H \rightarrow b\bar{b})} \Delta m_0$$

Higgs Mass Determination: LHC vs LC



Summary of Direct Width LHC Reconstruction

Mass	Det. Res.	Rec. Width	Error	Th. Width
120	0.35	0.31	0.27	0.004
140	0.63	0.65	0.12	0.008
160	0.63	0.62	0.22	0.077
180	0.76	0.97	0.24	0.63
200	0.96	1.6	0.29	1.4
220	1.1	2.7	0.41	2.3
240	1.4	4.1	0.64	3.4
260	1.6	4.8	0.85	4.8
280	1.8	7.5	1.3	6.5
300	2.0	9.5	1.6	8.5
320	2.3	12.8	2.2	10.9
340	2.4	15.5	2.7	13.8

Lower Higgs Bosons Masses

Comparison with

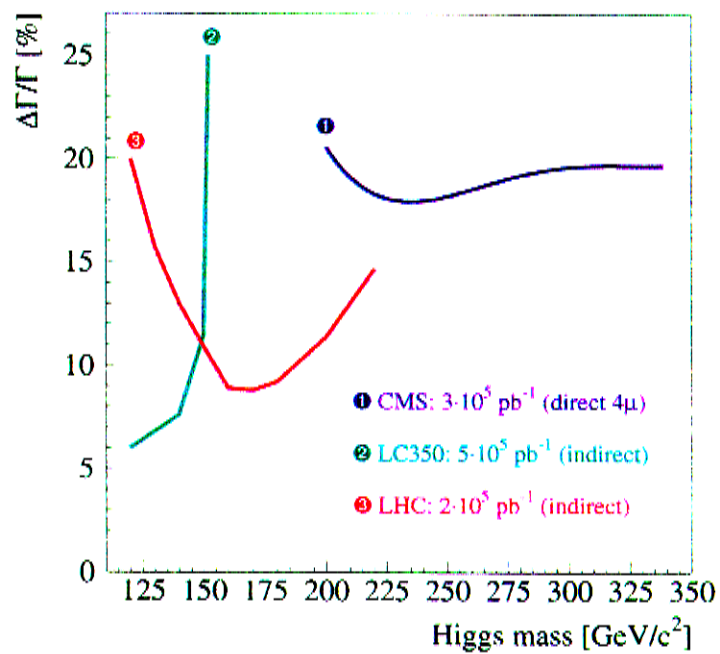
indirect methods via fusion production

$W^+W^- \rightarrow H$

Decay modes:

- LHC: $H \rightarrow W^+W^-$, D. Zeppenfeld et.al.
- LC: $H \rightarrow b\bar{b}$, K. Desch and N. Meyer.

Higgs Width Determination: LHC vs LC



Conclusions

- LHC (CMS) Higgs mass reconstruction in the range 120 to 340 GeV.
- Precise m_H prediction with 100 simulated test-experiments.
- LHC $\mu\mu\mu\mu$ results depend on $\mathcal{L}$, σ and BR.
- LC Hll channel largely independent of BR_H .
- LC bbqq channel, better resolution at 120 GeV, but $\text{BR}(H \rightarrow b\bar{b})$ too small for $m_H > 170$ GeV.
- Mass resolution around 0.1%!
- LHC width determination reaches theoretical width at $m_H \approx 190$ GeV.
- Unfolding of natural width and detector resolution in the 4μ LHC study.
- Complementarity between indirect methods (LHC and LC) and direct method (LHC).
- Coverage of the whole mass range about 5% to 20% relative error on Γ_H^{SM} .
- Future LC width determinations:
sensitivity increase for Higgs boson masses above 150 GeV ($H \rightarrow W^+W^-$, ZZ).