

Overview of the Higgs searches at LEP

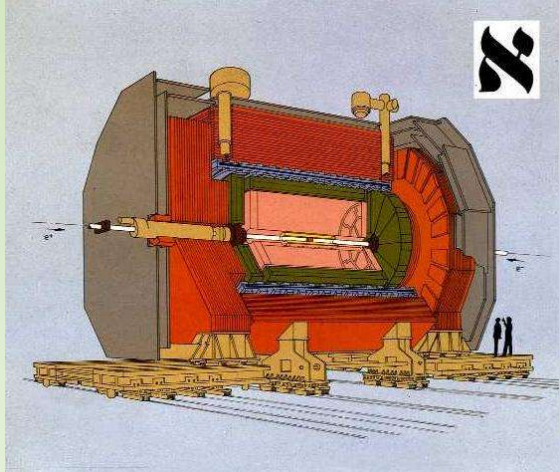
Thorsten Kuhl
DESY

Content:

- Introduction
- Neutral Higgs in SM, CP conserving/violating MSSM
- Charged Higgs bosons
- Summary

Introduction

ALEPH



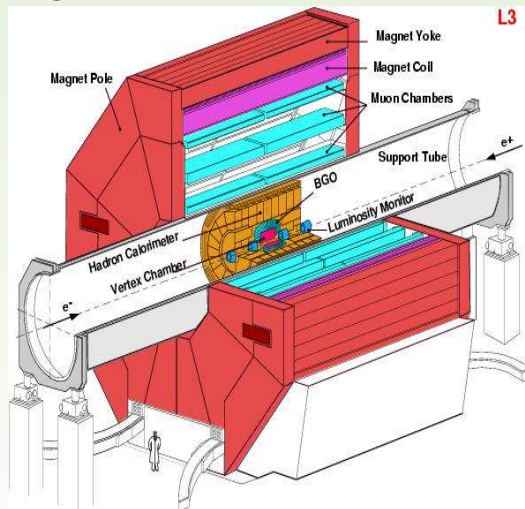
Standard Model (SM)

⇒ only missing ingredient
Minimal Supersymmetry SM
(MSSM)

⇒ at least one light Higgs

~450 pb⁻¹ of e⁺e⁻-data per
experiment at energies above
190 GeV available

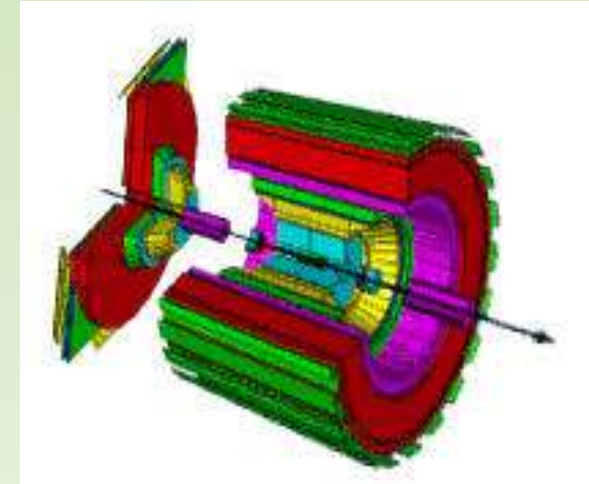
L3



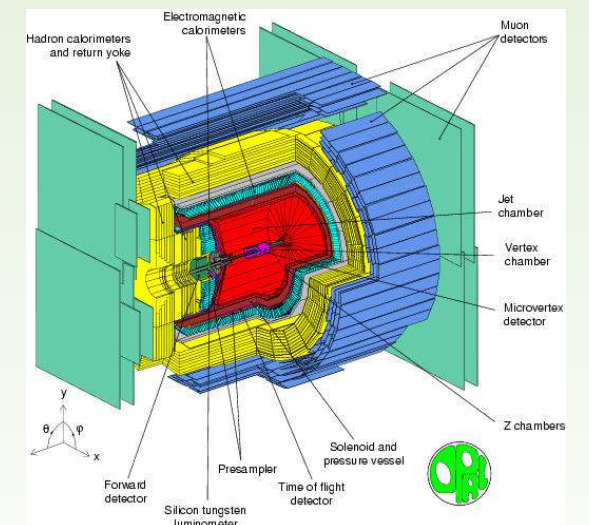
4 experiments still finalizing
some analyses: some
results still preliminary

LEP combination still ongoing
(SM published)

DELPHI



OPAL

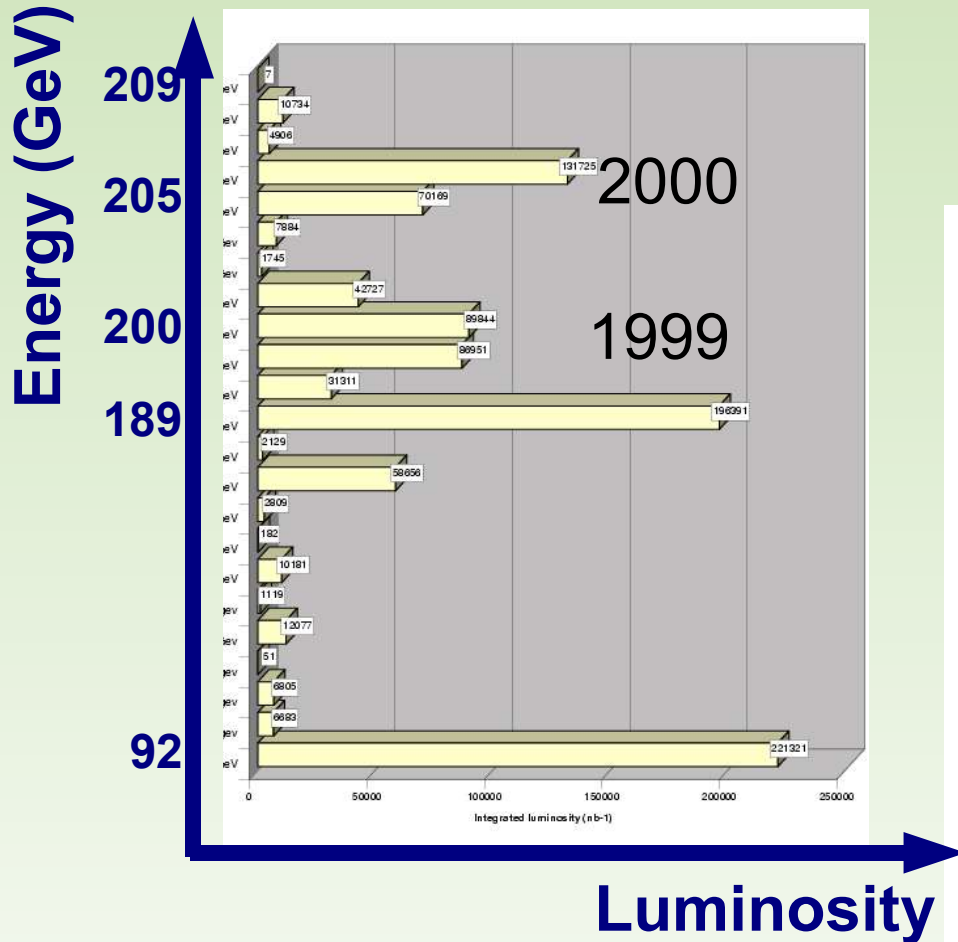


Other

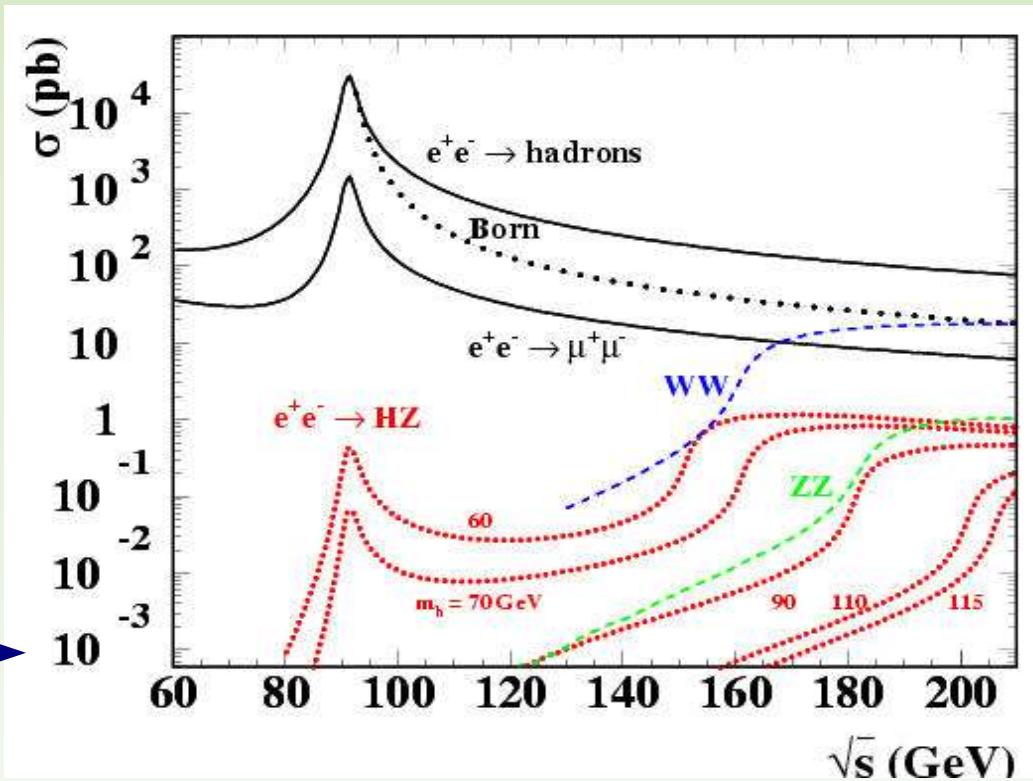
Do not talk about:

- Yukawa production
- Fermiophobic Higgs bosons
- Invisible Higgs bosons
- Higgs searches via anomalous couplings
- Decay mode independent searches
- 2 Higgs doublet interpretations
- ...

Data samples



Standard Model Cross sections:



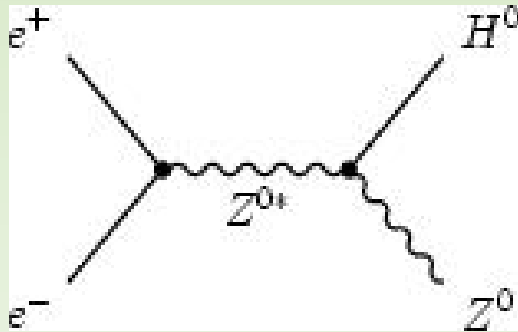
During the last 2 years per experiment:

- 240 pb⁻¹ in 1999 from 191 to 202 GeV
- 220 pb⁻¹ in 2000 from 202 to 209 GeV

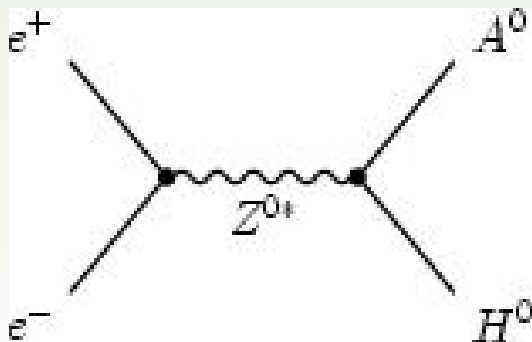
Higgs at LEP

Production:

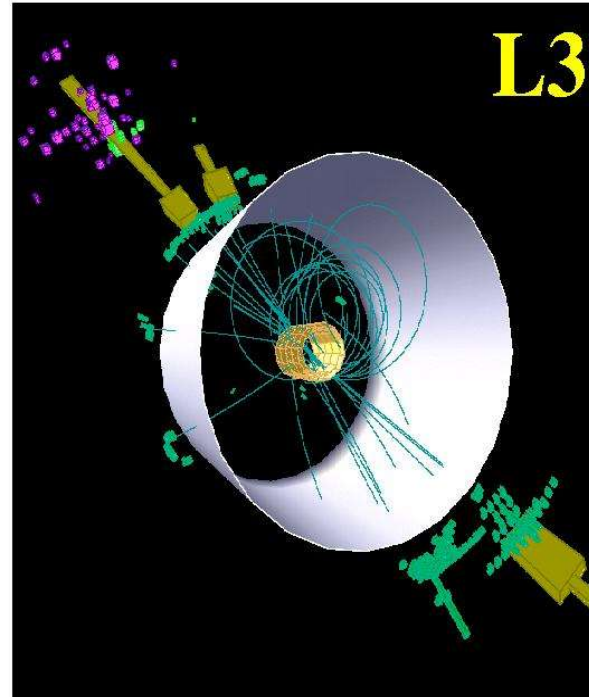
Higgsstrahlung



Pair production (MSSM only)

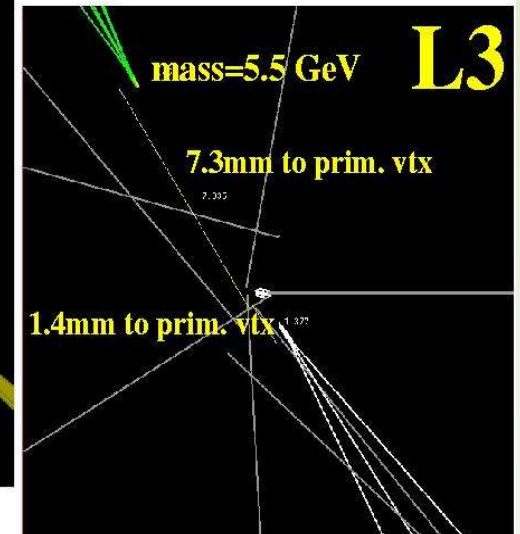


$ZH \rightarrow \nu\nu b\bar{b}$



$M_{rec} = 114 \text{ GeV}$

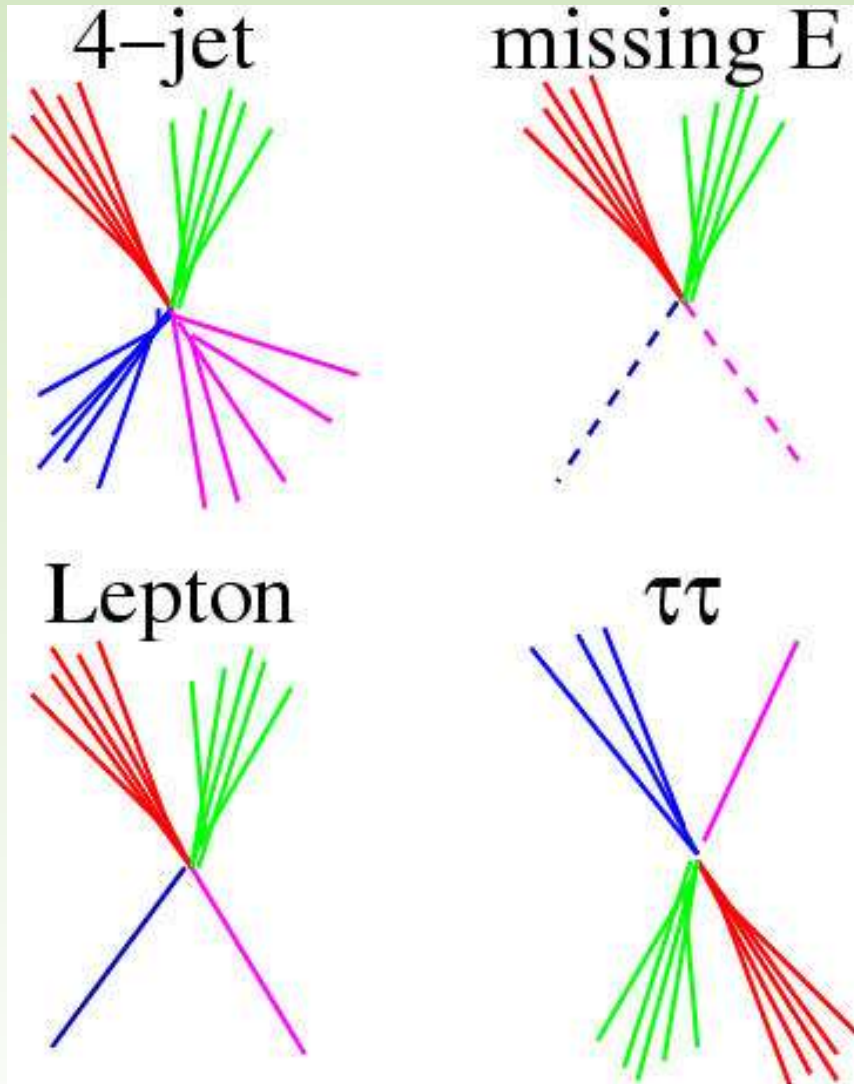
Vertex region



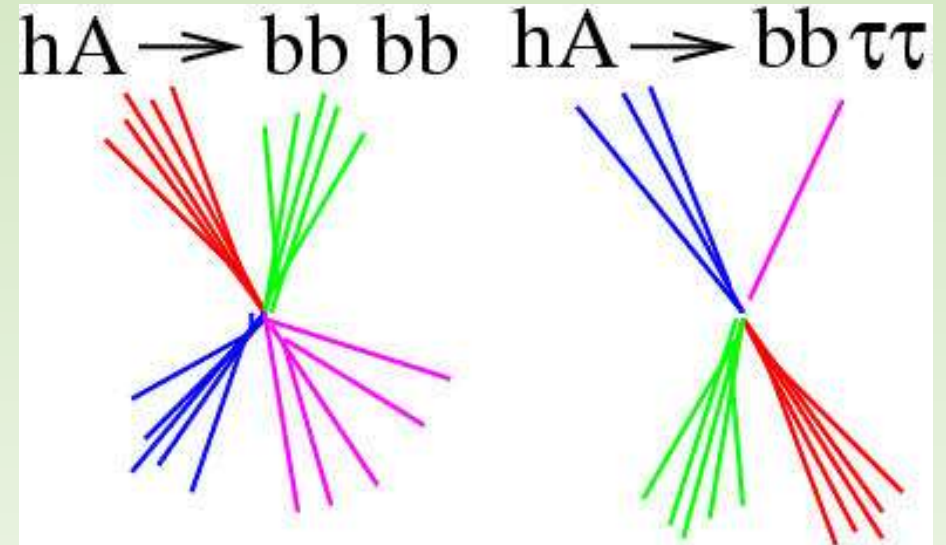
Decay: coupling to mass \Rightarrow
heaviest allowed particles

Search channel

SM search channels:



Pair production channels:

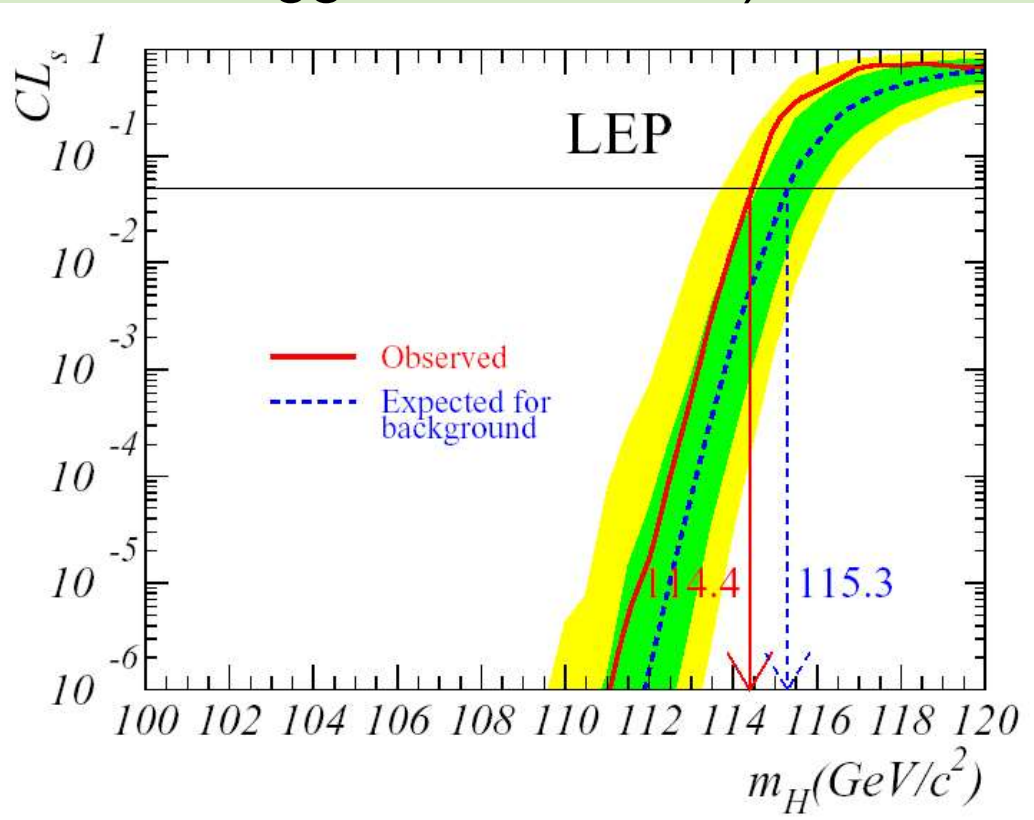


Special search channels:

- $h \rightarrow AA \rightarrow bbbb$
- flavour independent
- $h \rightarrow$ invisible
- H^+ and H^{++} searches

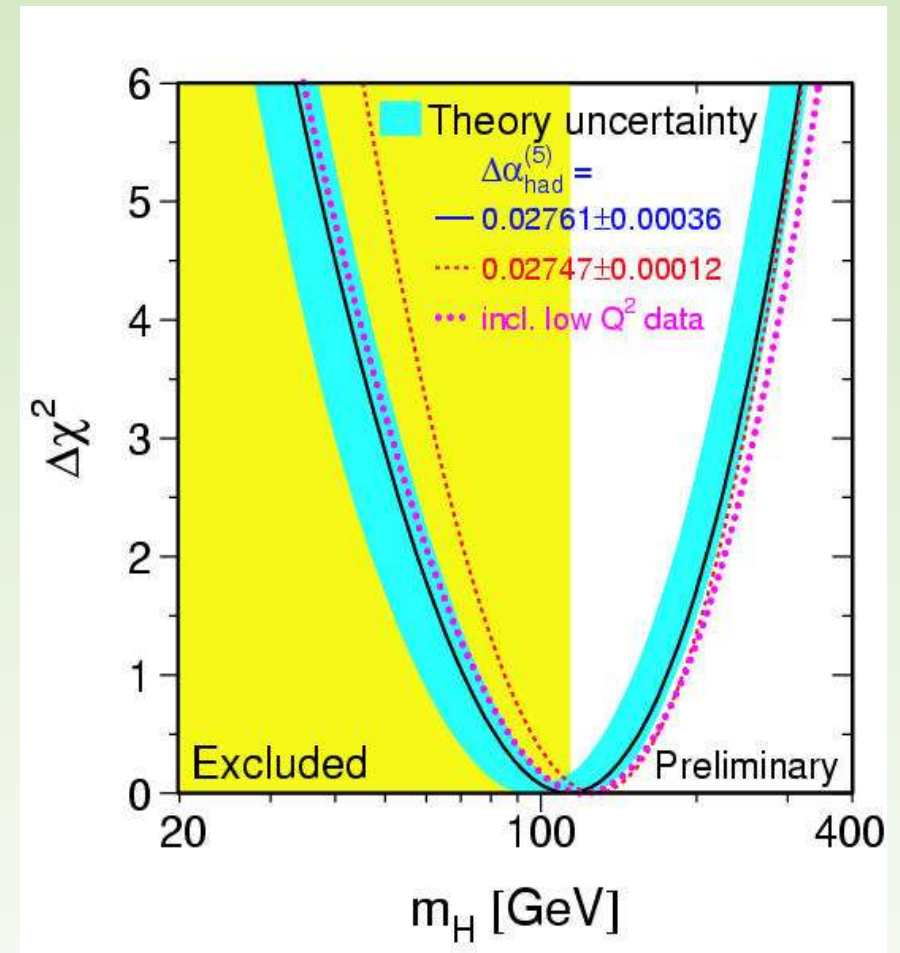
SM Higgs

Direct searches (only published LEP Higgs combination):



$$m_H > 114.4 \text{ GeV (CL=95\%)}$$

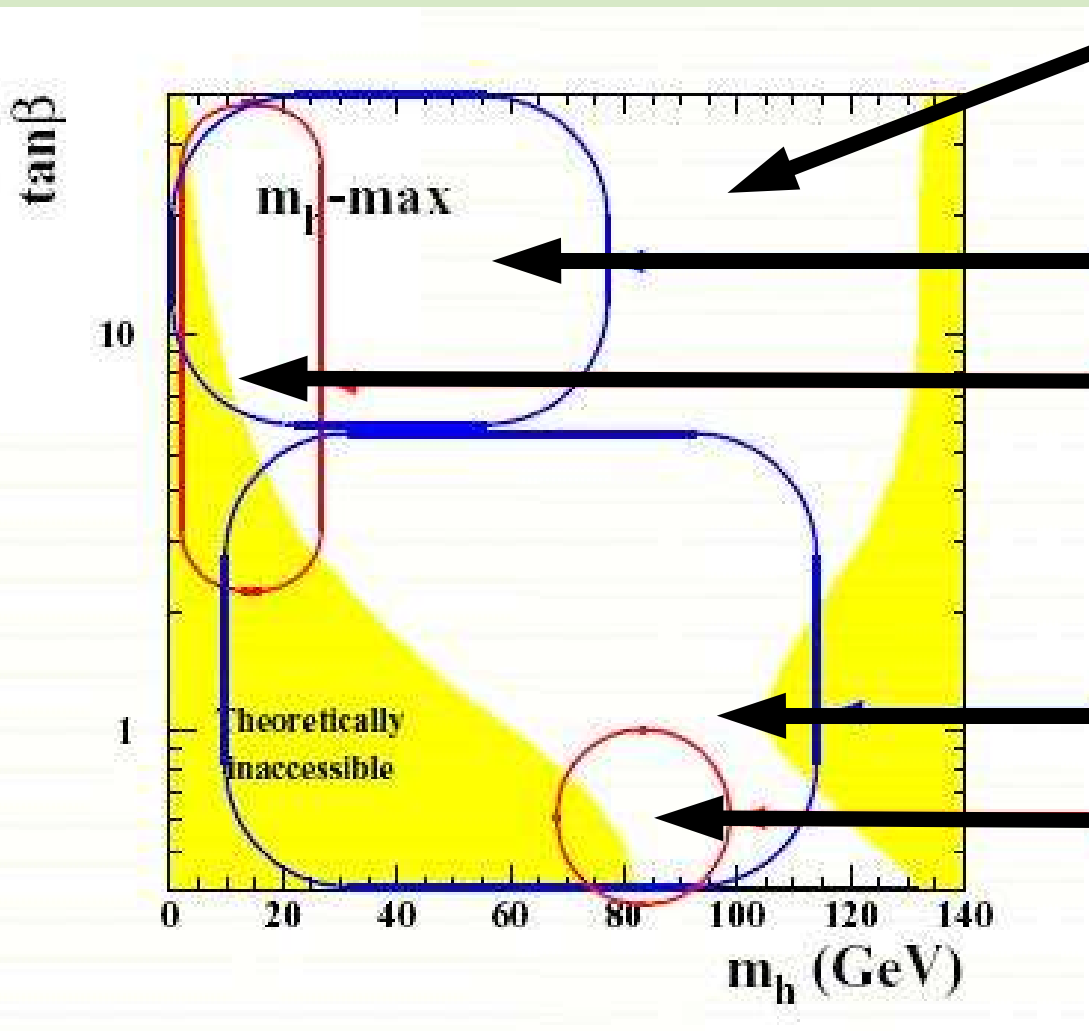
Indirect measurements:



$$m_H < 251 \text{ GeV (CL=95\%)}$$

MSSM search regions

$$\tan\beta = v_2/v_1$$



Zh suppressed
Ah kinematically forbidden

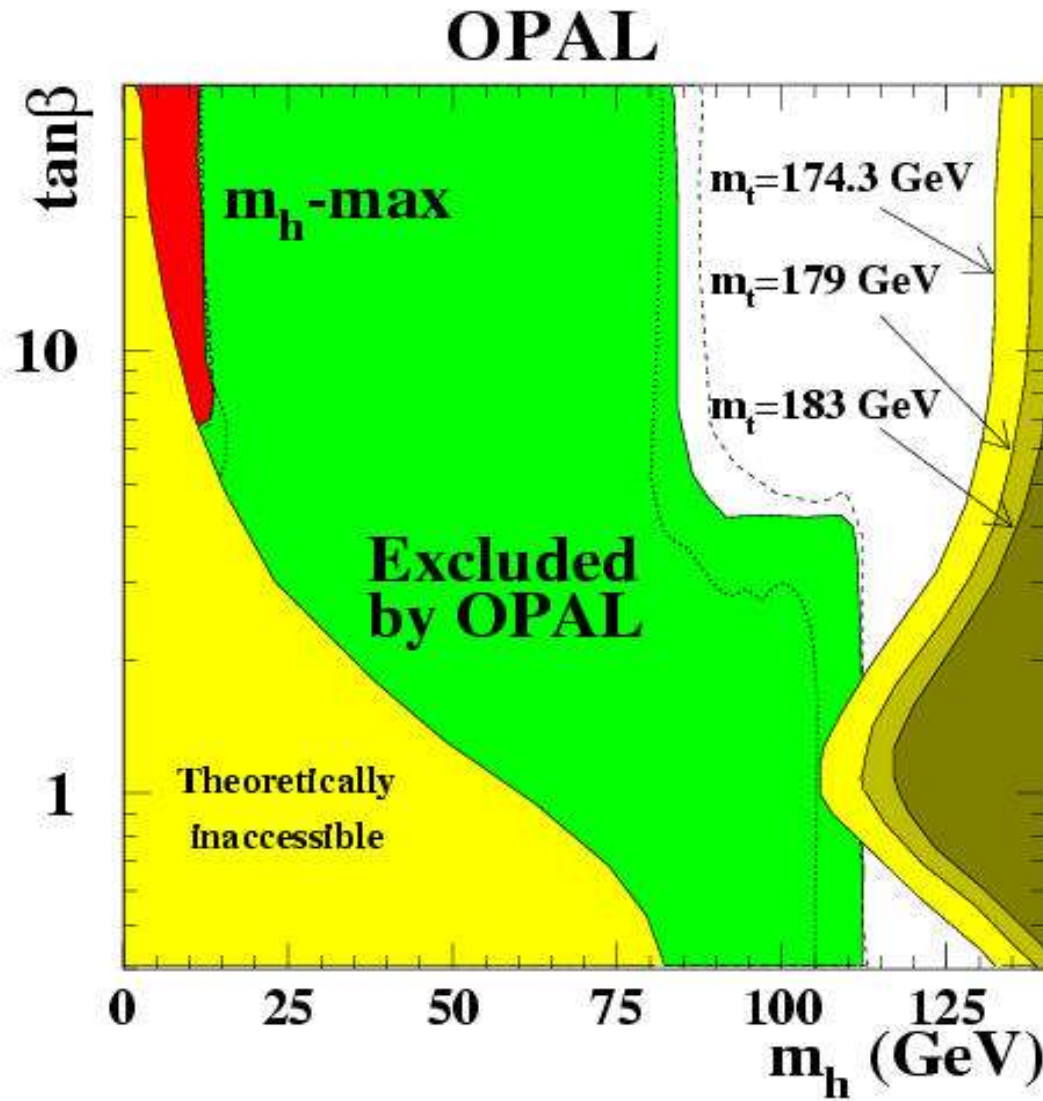
Ah \rightarrow bbbb($\tau\tau$)

Zh \rightarrow llX

Zh \rightarrow qq($\nu\nu, ll$)bb and qq $\tau\tau$

Zh \rightarrow ZAA \rightarrow qq($\nu\nu, ll$)bbbb

Exclusion areas for MSSM



M_h -max scenario:
maximize m_h for given
 $\tan\beta=v_2/v_1$ and m_A

$$m_h > 79.5 \text{ GeV}$$

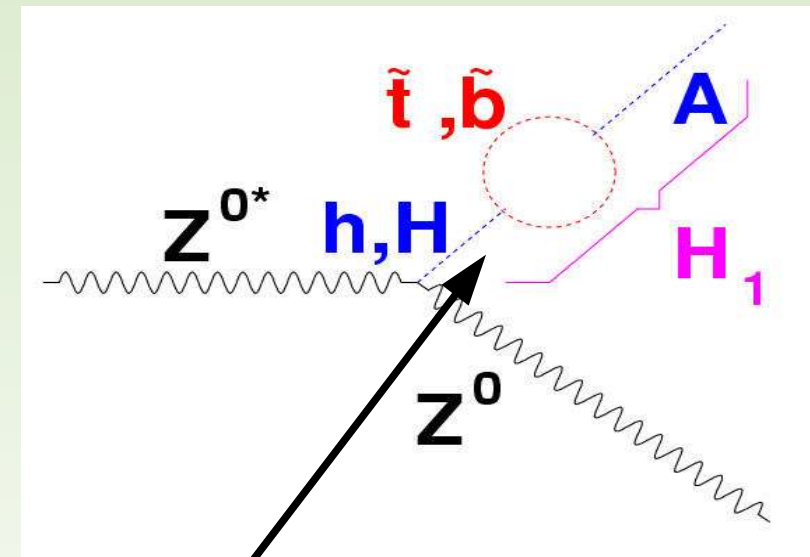
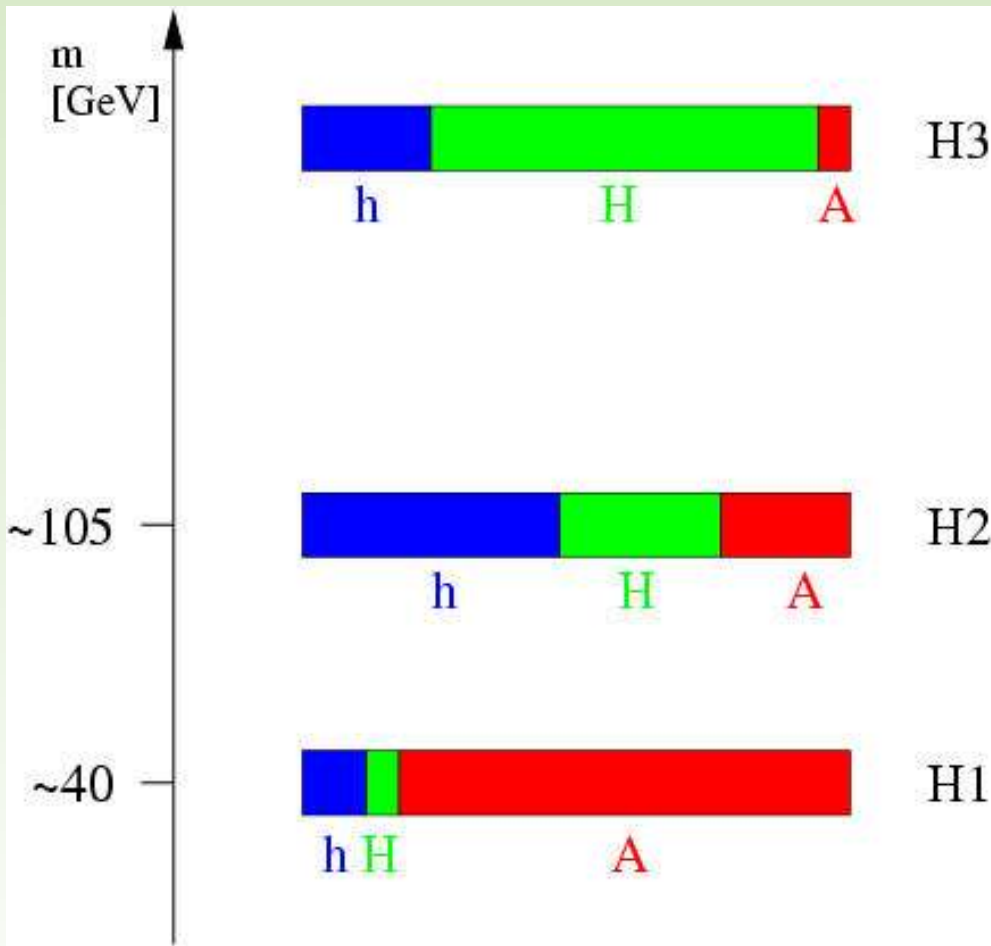
Excluded $\tan\beta$ region
largely dependence on
top mass \Rightarrow

No exclusion for
 $m_t \geq 179 \text{ GeV}$

CP violating MSSM

CP eigenstates \neq mass eigenstates

Mixing and coupling suppression:



- $\arg(A_{t,b})$
- Can search for H_1 and H_2 in Higgsstrahlung

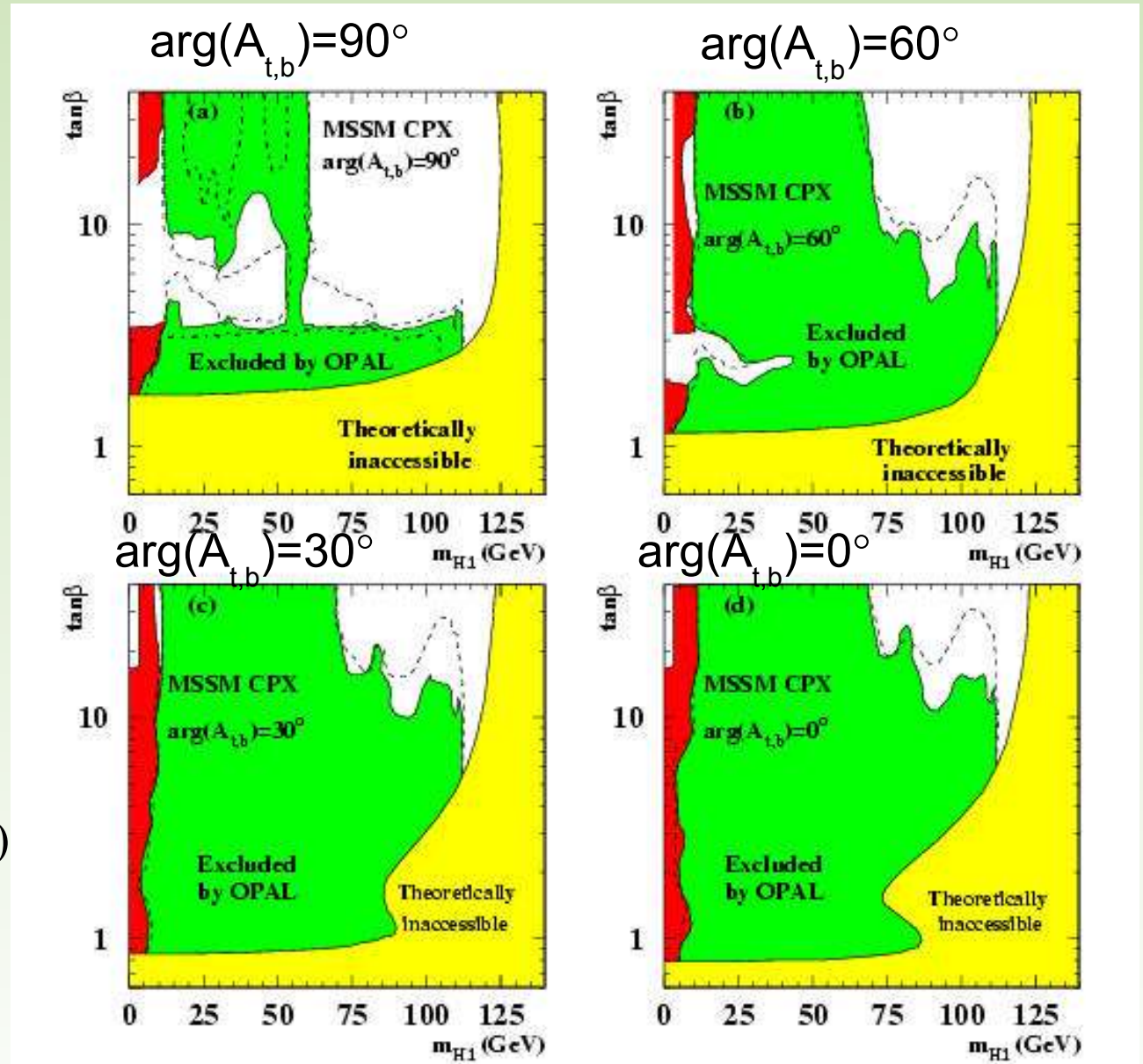
CP violation MSSM

CPX:
different $\arg(A_{t,b})$

Limit:
 $\tan\beta > 2.8$

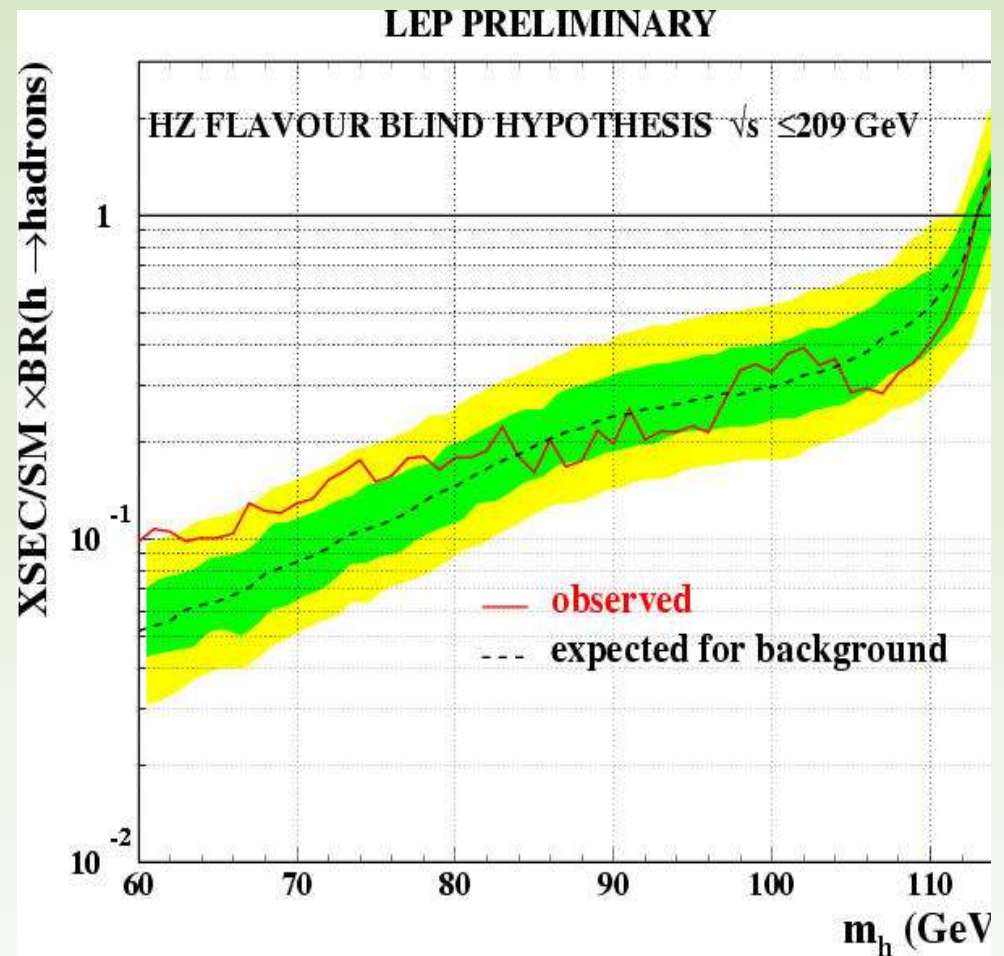
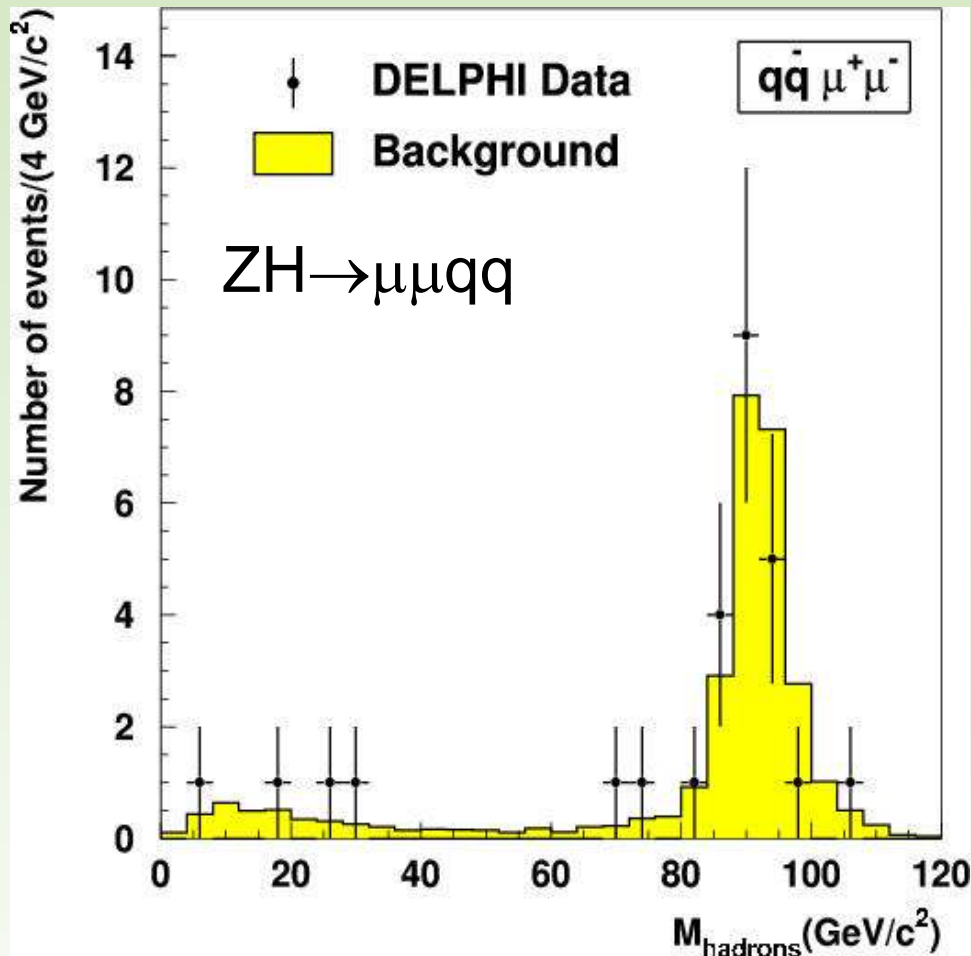
No exclusion of m_{H_1}

Larger m_t (here : 174 GeV)
larger CPX effects



Flavour independent

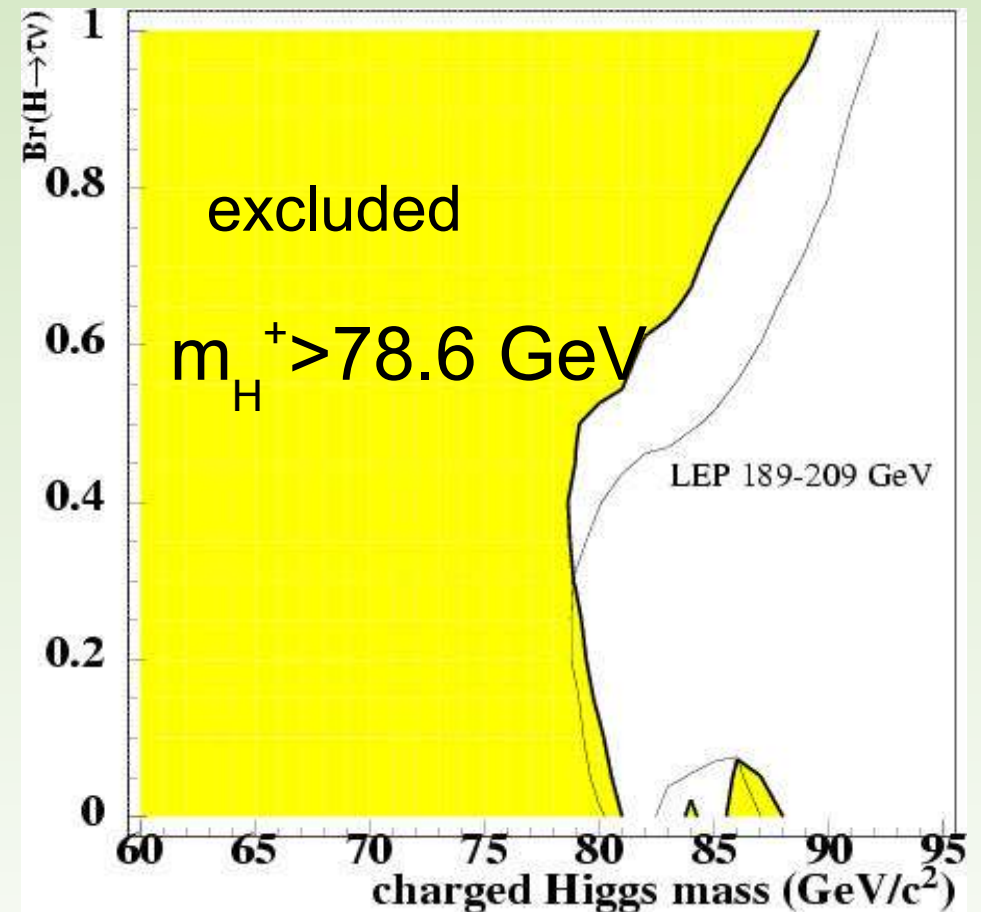
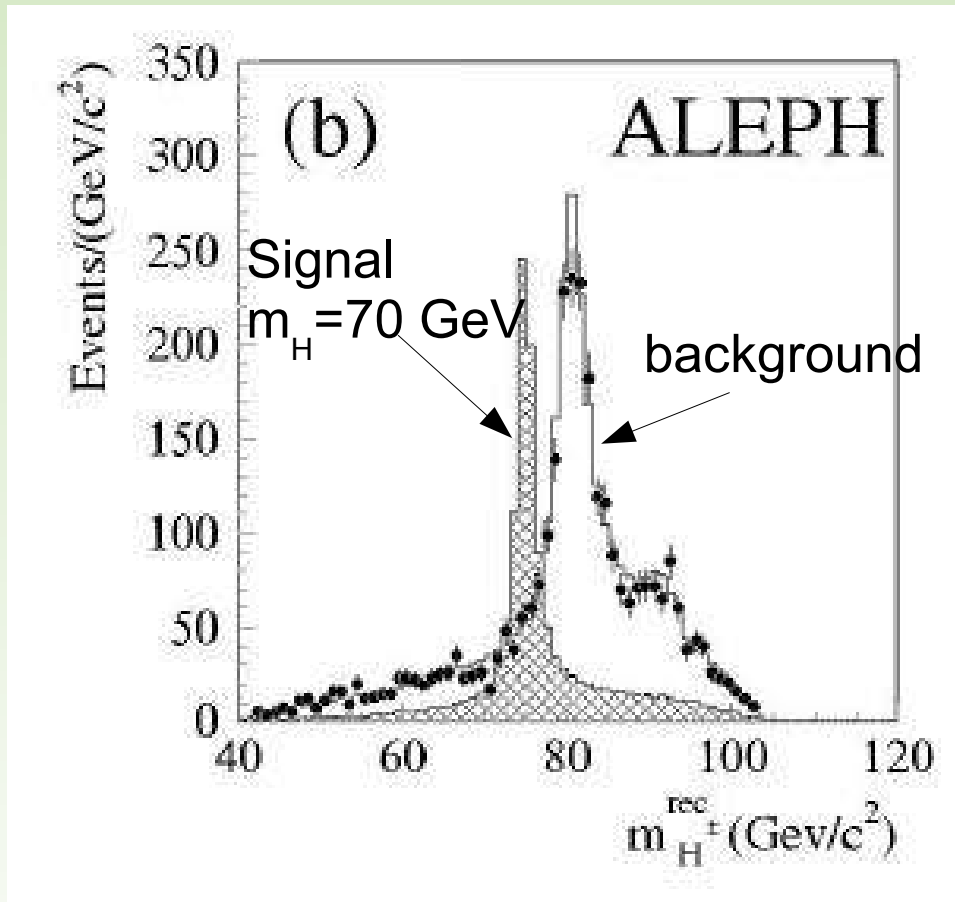
No flavour tag requirement



$m_h > 112 \text{ GeV}$

Charge Higgs Bosons

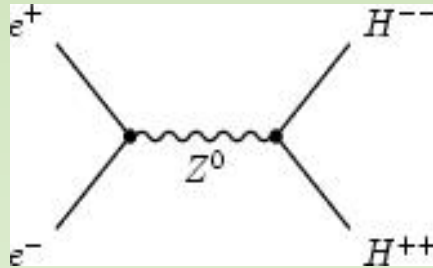
Search for $H^+H^- \rightarrow cscs$, $cst\tau^+\nu$ and $\tau^+\nu\tau^+\nu$



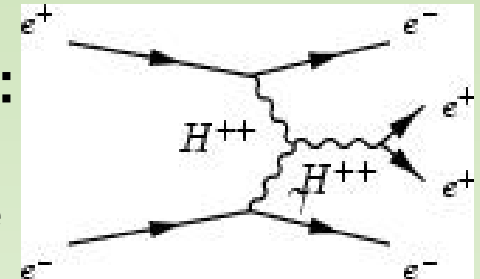
Also searched for $H^\pm \rightarrow W^\pm A^0$ (DELPHI/OPAL)

Doubly charged Higgs

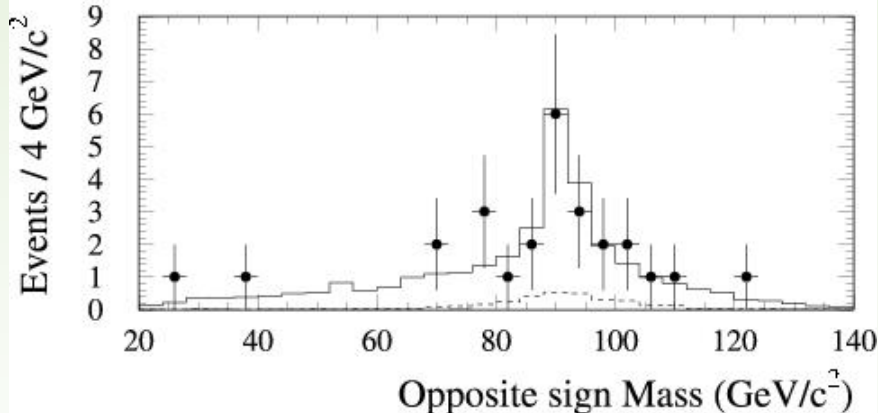
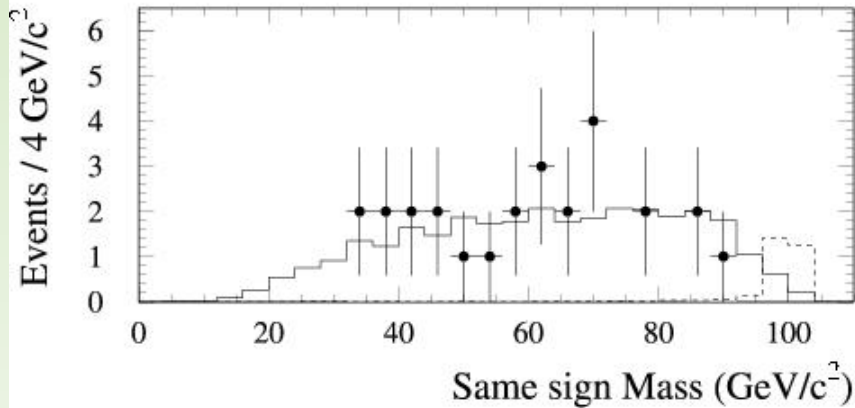
Pair production:
Range up to $\sqrt{s}/2$.



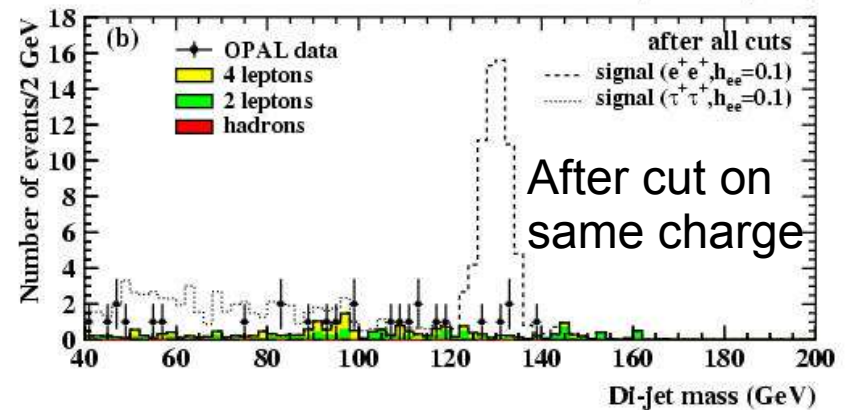
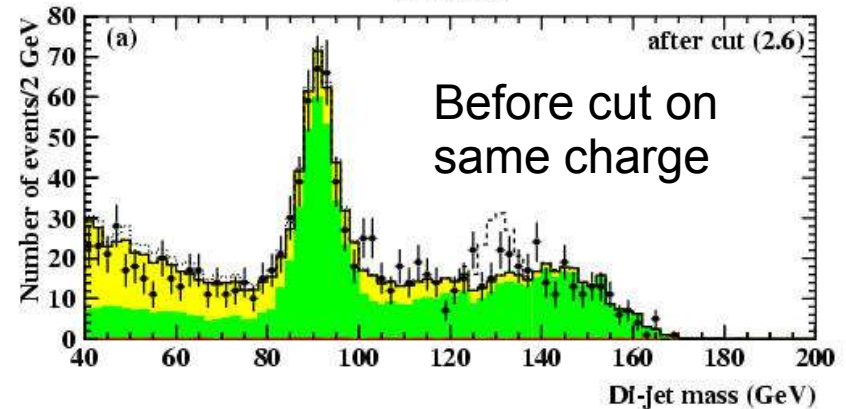
Single Production:
Larger mass range,
but h_{ee} dependence



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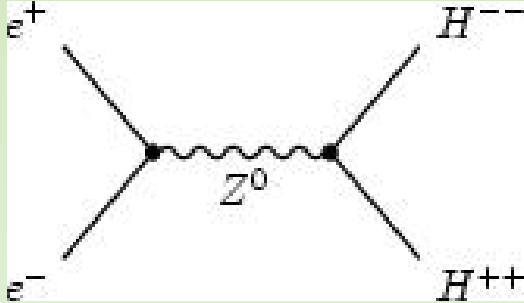


OPAL

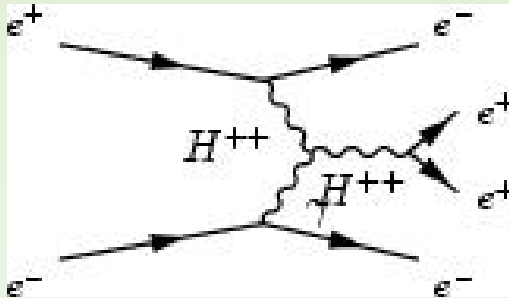


Doubly charge Higgs

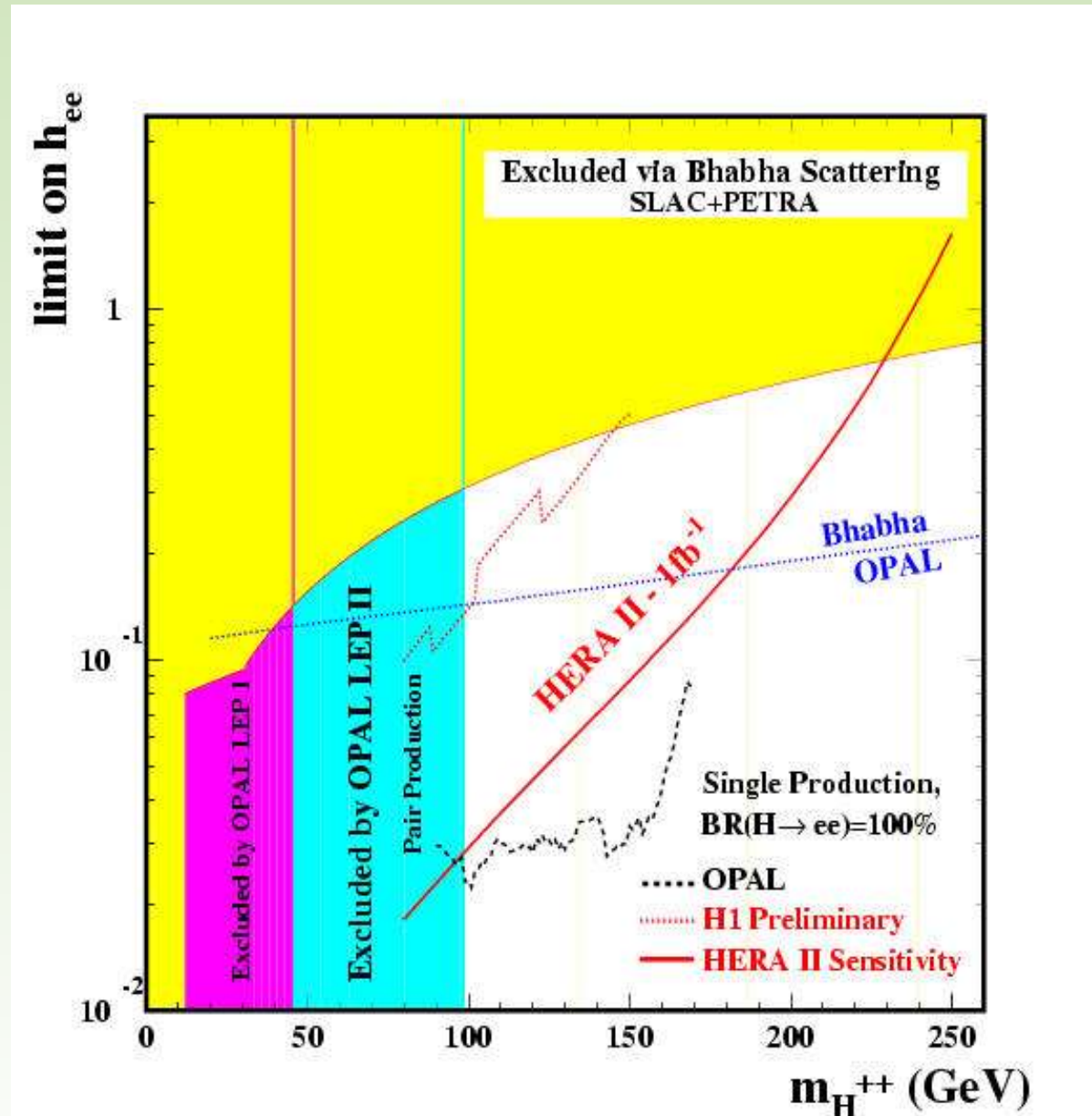
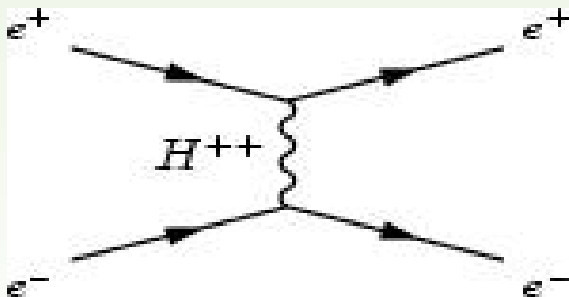
Pair Production:



Single Production:



Bhabha scattering (indirect):



Summary

LEP: 450 pb⁻¹ of e⁺e⁻ data above 190 GeV

Standard Model fit:

- Higgs mass increased because of larger m_t :
 $m_H < 251$ GeV (95% CL)

Neutral Higgs boson:

- MSSM: No $\tan\beta$ exclusion for $m_t > 180$ GeV
- CPX: Opal cannot exclude any Higgs mass with $m_t = 175$ GeV (larger m_t larger effects)
- CPX: preliminary LEP results for Beijing

LEP still analysing data for some more 'exotic' channels
LEP combinations still ongoing (except SM)