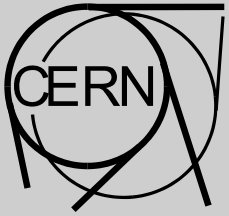


Higgs Physics at ATLAS

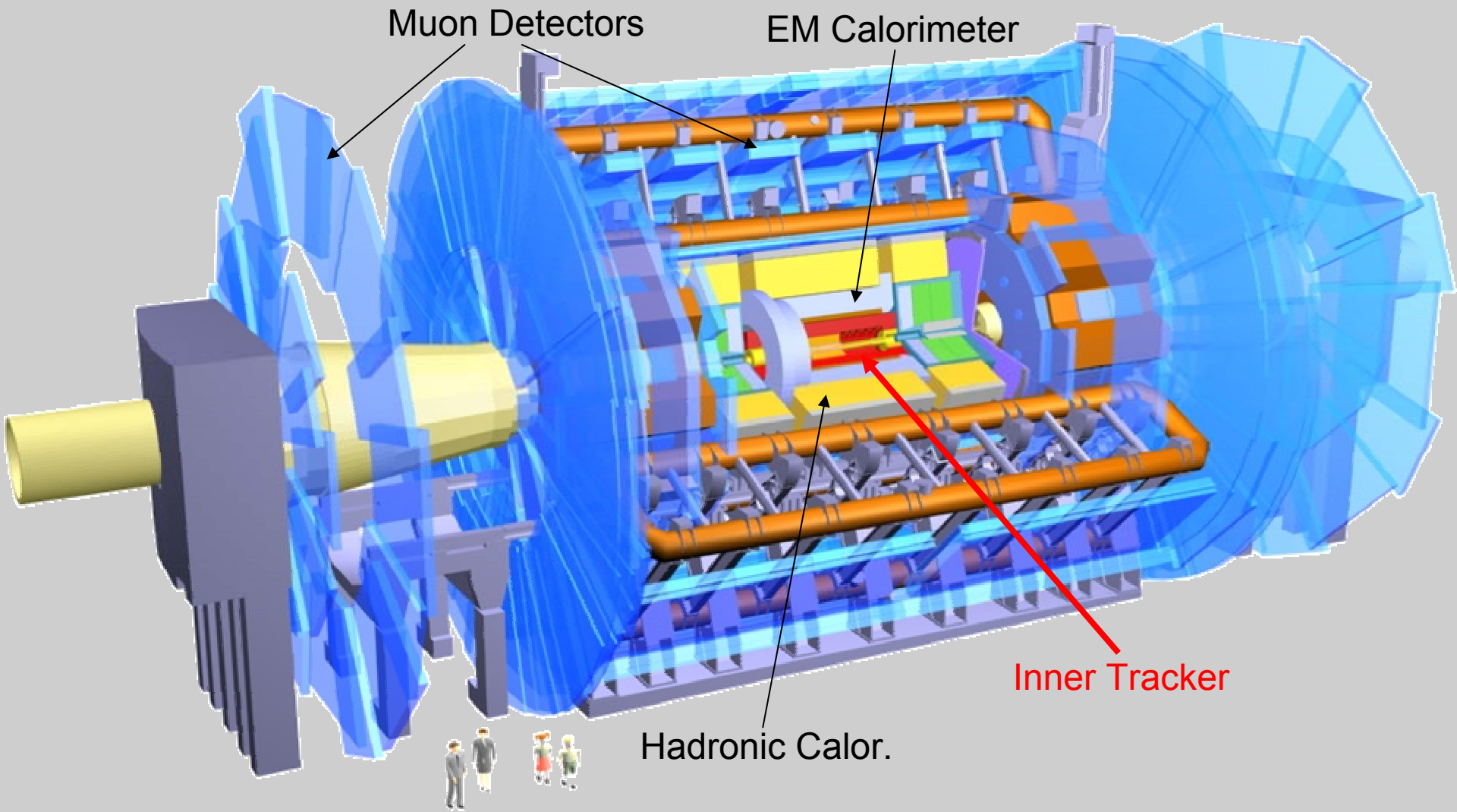
Stathes Paganis
University of Sheffield
On Behalf of the ATLAS Collaboration

SUSY05, 19-July-2005, Durham UK

Outline

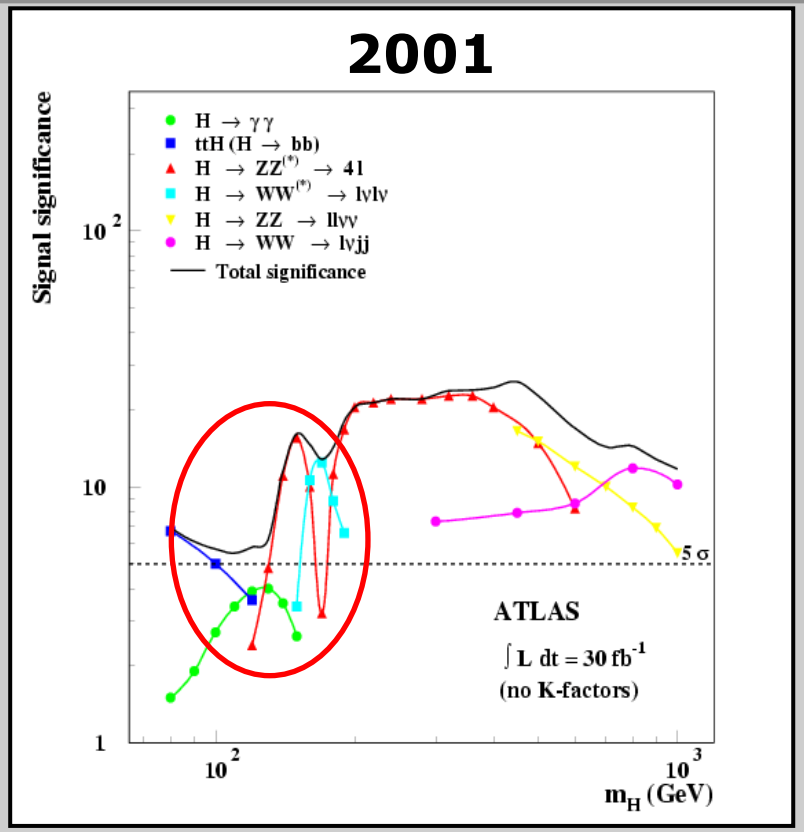
- Standard Model Higgs
- Higgs Properties
- MSSM Higgs

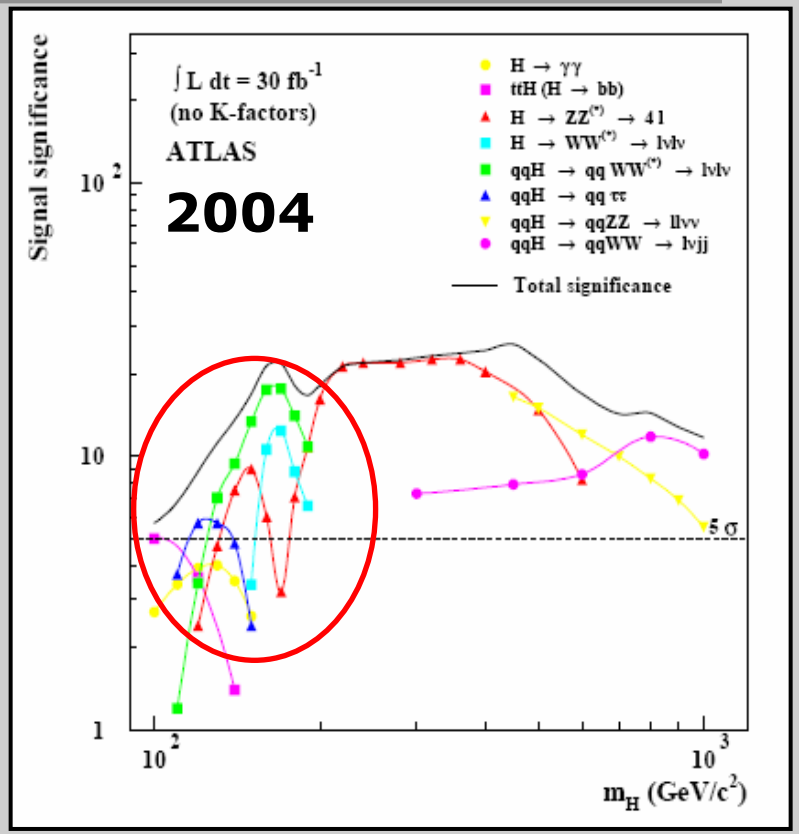
ATLAS @ LHC


Muon Detectors
EM Calorimeter
Inner Tracker
Hadronic Calor.

SM Higgs: ATLAS Discovery Potential

SM Higgs Discovery Potential





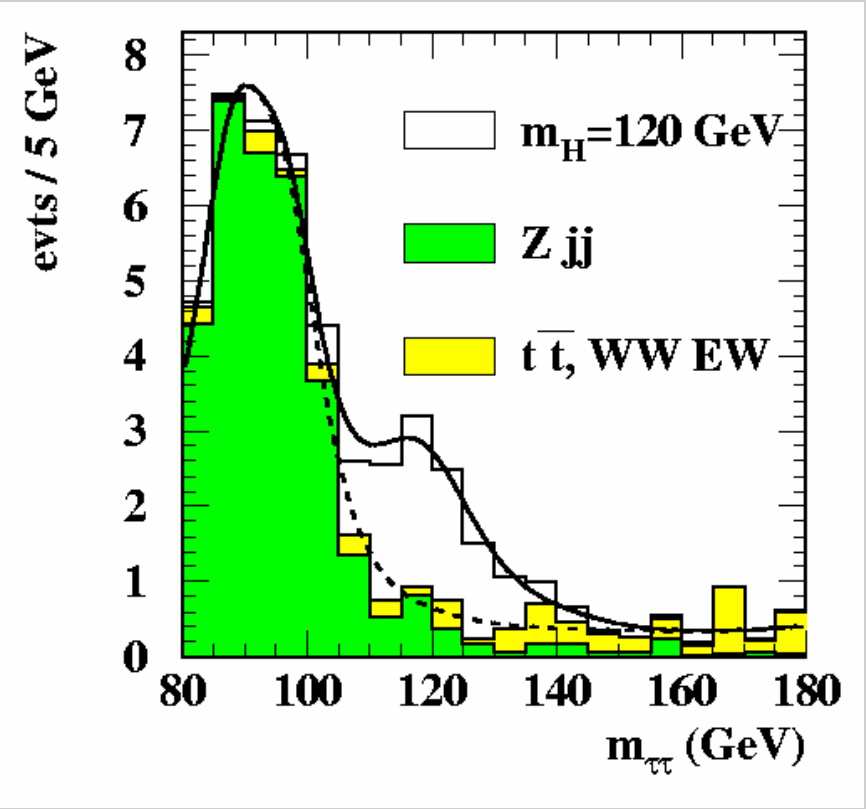
new : Vector Boson Fusion (VBF), H→ ττ and H →WW

updated: ttH, H→bb: significance TDR 5.0 (3.6) → now 4.6 (2.7)

@ 100 (120) GeV, L = 30 fb^{-1}

(influence of changes on discovery potential in the MSSM?)

115GeV Higgs: first year (10fb^{-1})



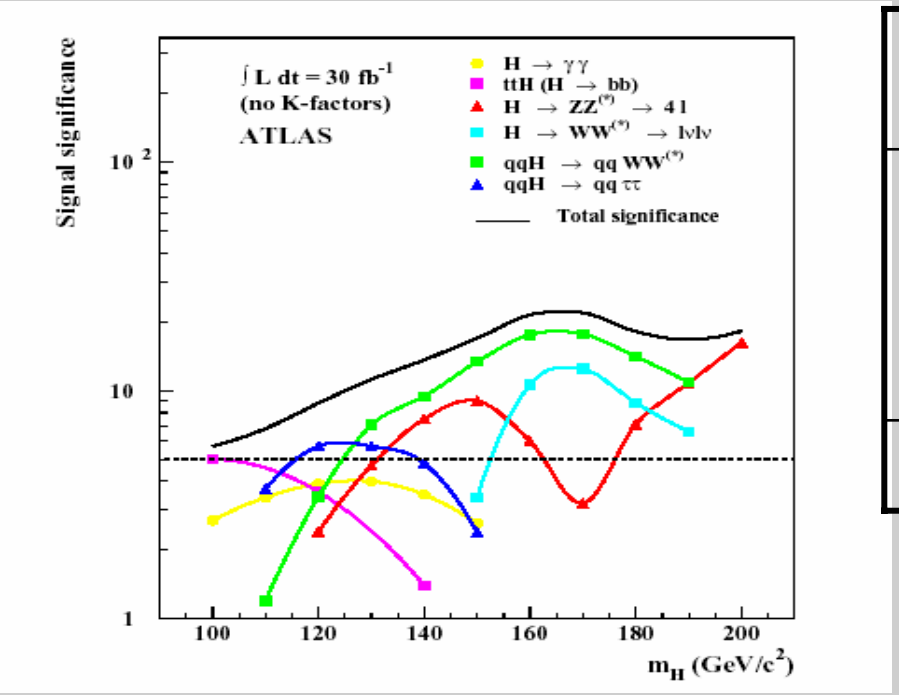
complete detector

	H->γγ	ttH->ttbb	qqH->qqττ
S	150	15	~10
B	3900	45	~10
S/B	0.04	0.33	
S/√B	2.4	2.2	~2.7

Total S/ √B for complete detector: ~ 4.2 σ

- 3 Channels all around 2σ, large backgrounds.
- Quite challenging.

130GeV Higgs: first year (10fb^{-1})



complete detector

	H->γγ	H->4l	qqH-> qqWW	qqH-> qqττ
S	120	5	18	~8
B	2500	<1	15	~6
S/B	0.05		~1	
S/√B	2.4	2.8	3.9	2.6

Total S/ √B for complete detector: ~ 6 σ

- H->4l small signal but small background
- 3/4 channels with less than 3σ
- qqH->qqWW counting channel (no clear peak); relies on knowledge of background

Higgs Properties

Higgs Properties

- **Higgs Mass**
  - Expect ~0.1% accuracy using H->ZZ->4leptons 300fb^{-1} and for M_H<400GeV.
- **Higgs J^{CP}**
  - Spin from H->ZZ and H->WW.
  - Parity sensitive to angular correlations in H->ZZ->4lepton.
  - Needs full luminosity.
- **Higgs Couplings**
  - Only ratios of couplings (or partial widths) are measured in a fairly model independent way.
  - Absolute coupling determination requires further theoretical assumptions.
  - Needs full luminosity.

Coupling Ratio determination

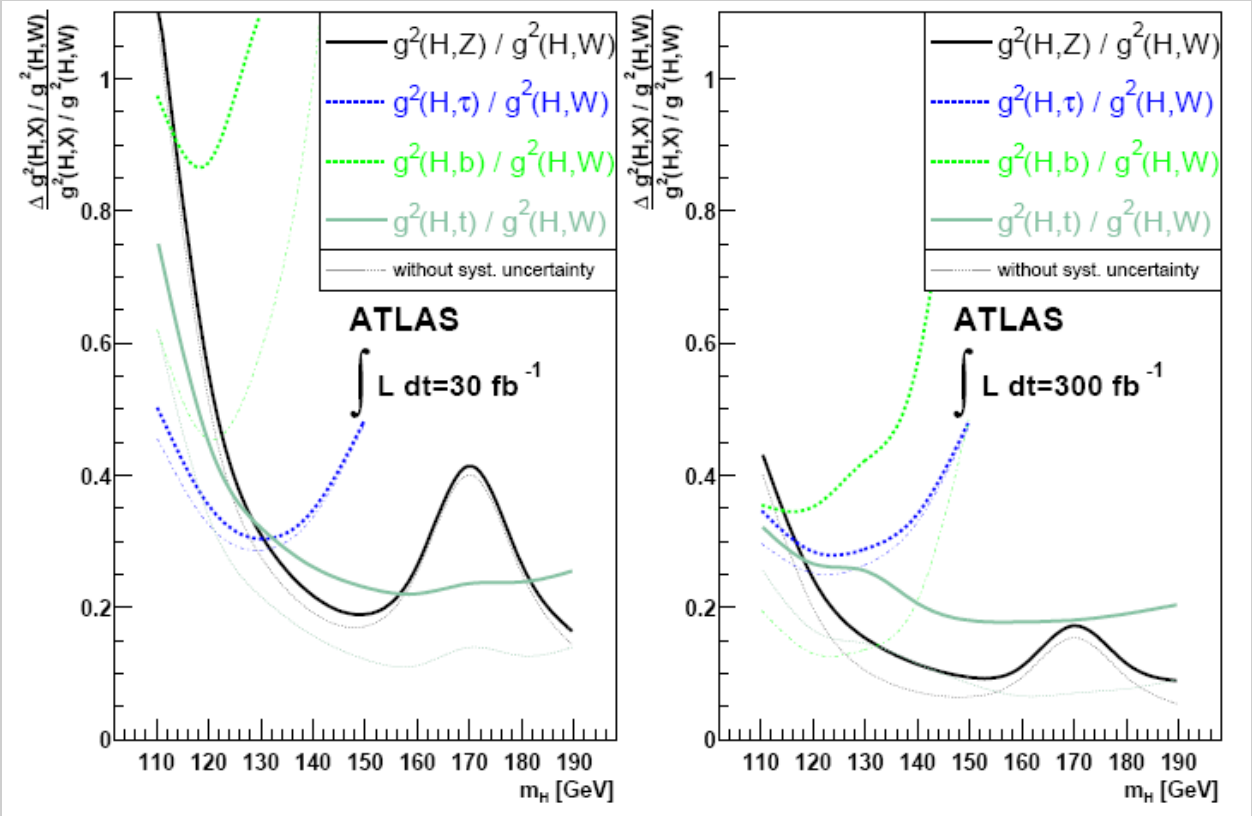
Assumptions

A single $J^{CP}=0^{++}$ Higgs

No extra particles in loops, Only SM particles couple to Higgs boson

Taken into account

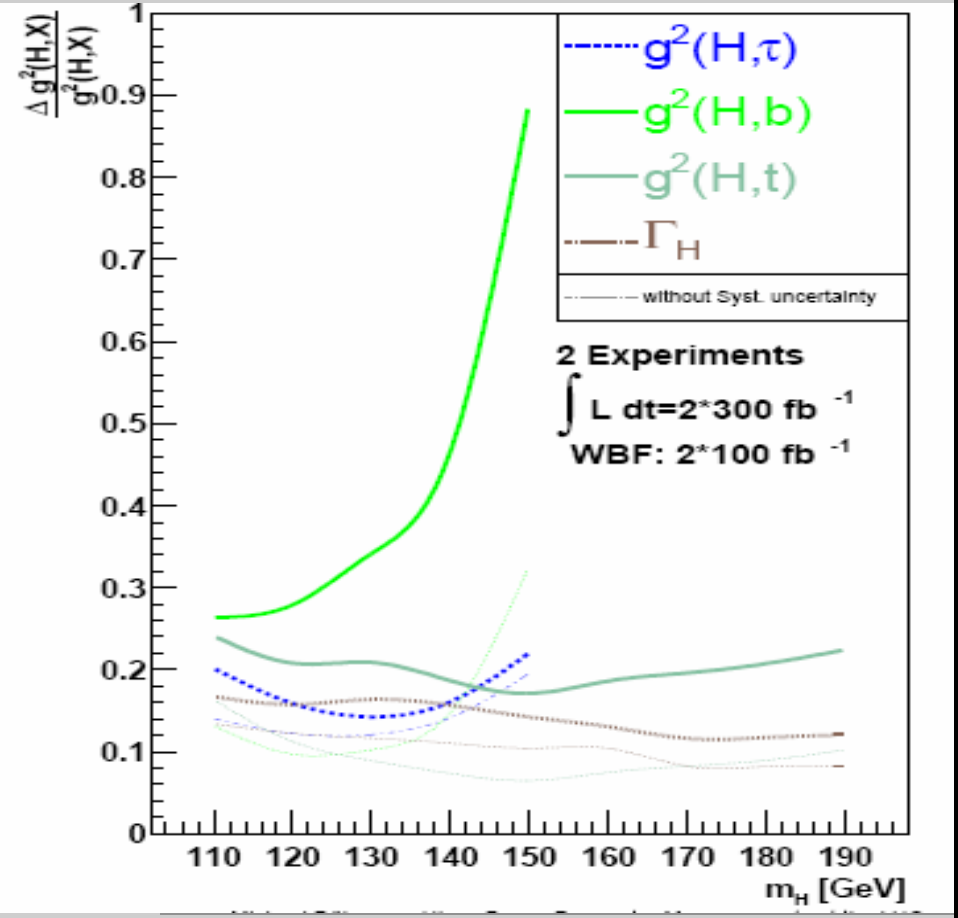
Experimental and theoretical uncertainties for signal and background



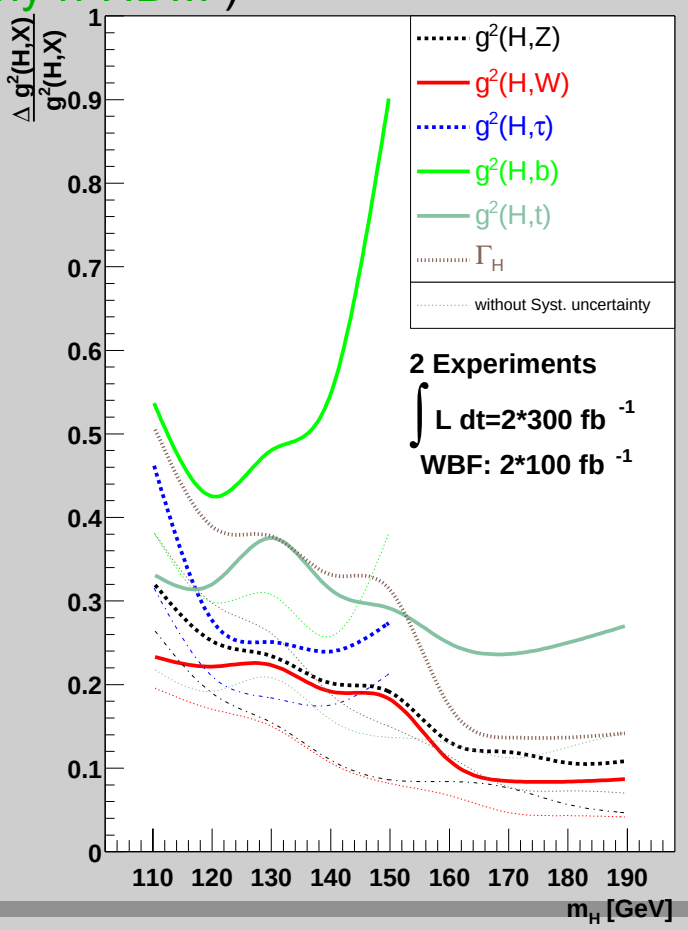
Absolute couplings after assumptions

Duehrssen et al hep-ph/0407190

Couplings to W and Z as in the SM.
No new particles enter the loop for $\gamma\gamma$ decay.



Upper limit for either a coupling or a total width is required. The couplings to W,Z are not stronger than in the SM (true for any n-HDM)



MSSM Higgs: ATLAS Discovery Potential

MSSM

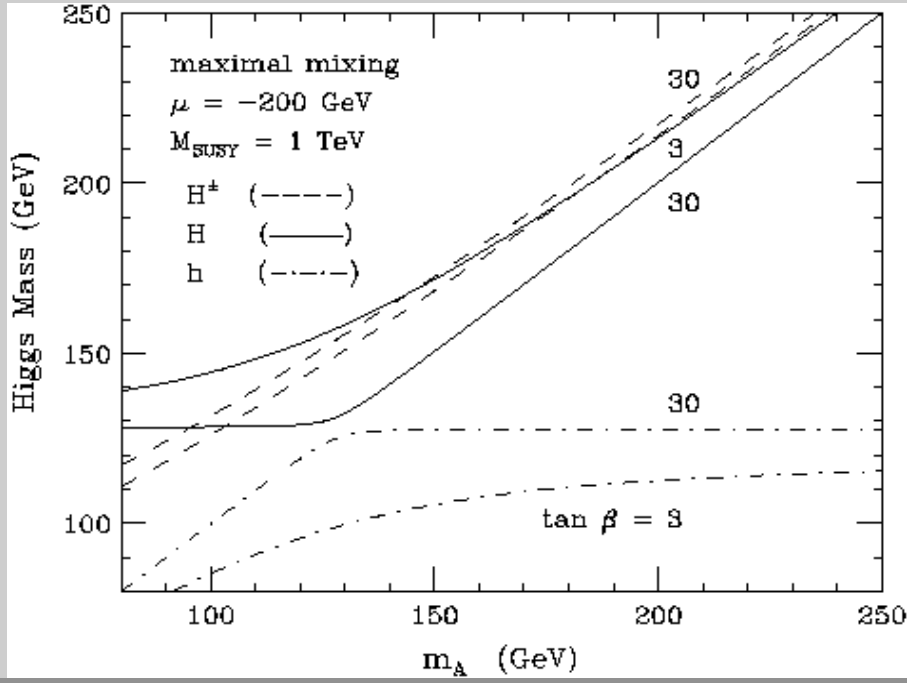
Minimal Supersymmetric extension: two Higgs doublets $\Rightarrow$ 8 degrees of freedom (5 particles):

CP-even : h,H CP-odd: A Charged: H^+,H^-

Couplings to SM particles modified w.r.t. SM. Decay into third generation fermions enhanced at high tanβ

	g_u	g_d	g_V
h	cosα/sinβ	-sinα/cosβ	sin(β-α)
H	sinα/sinβ	cosα/cosβ	cos(β-α)
A	1/tanβ	tanβ	0

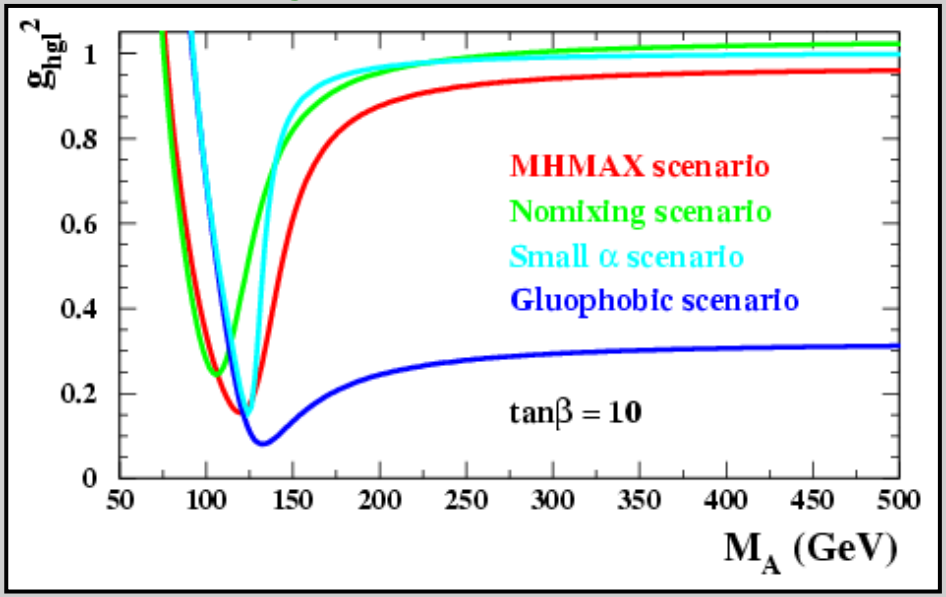
At high M_A the heavy bosons degenerate in mass while the h saturate at a limit value (around 130 GeV)

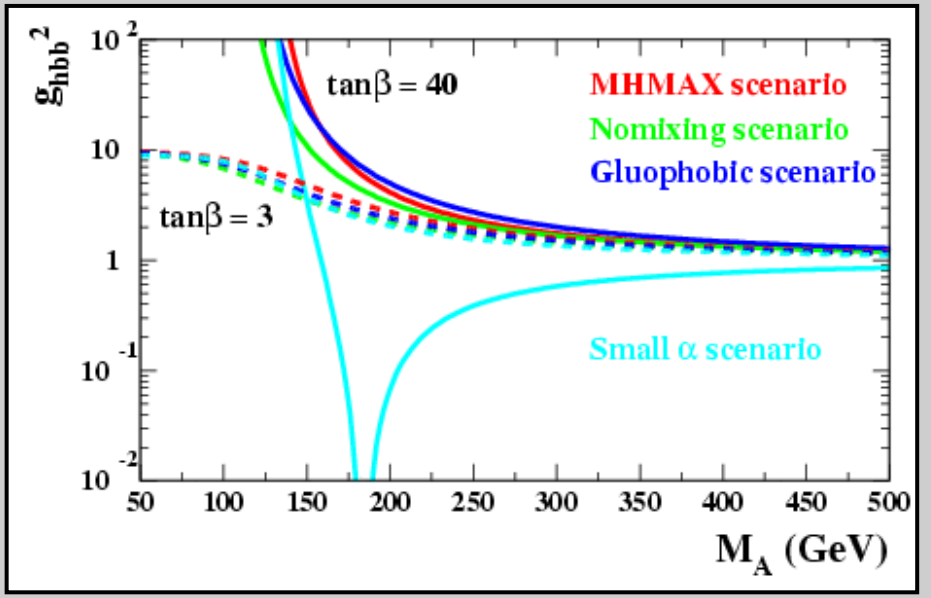


4 CPConserving Benchmark Scenarios

Carena et al. , Eur.Phys.J.C26,601(2003)

- MHMAX scenario maximal m_h < 133 GeV → conservative LEP exclusion
- Nomixing scenario small m_h < 116 GeV → difficult for LHC
- Gluophobic scenario
  small $g_{h,gluon}$ m_h < 119 GeV
- Small α scenario
  → small g_{hbb} and $g_{h\tau\tau}$ m_h <123 GeV

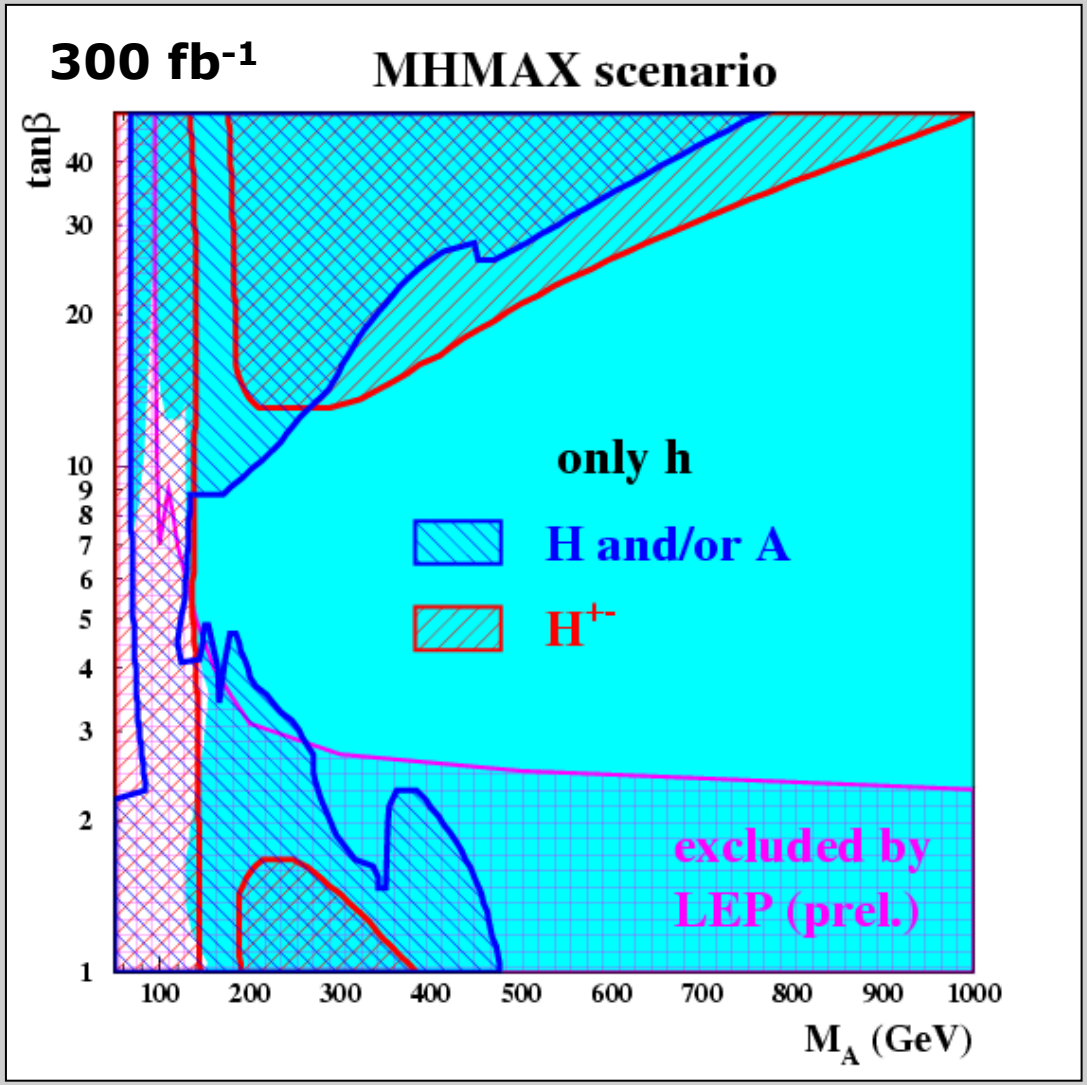




Affects gluon fusion channels:
gg→ h, h→γγ and h→ZZ→4 l

Affects:
VBF, h→ττ tth, h→bb

Overall Discovery Potential: 300 fb^{-1}



- at least one Higgs boson observable for all parameters in all four CPC scenarios
- significant area where only lightest Higgs boson h is observable
- can SM be discriminated from extended Higgs sector by parameter determination?

similar results in other benchmark scenarios

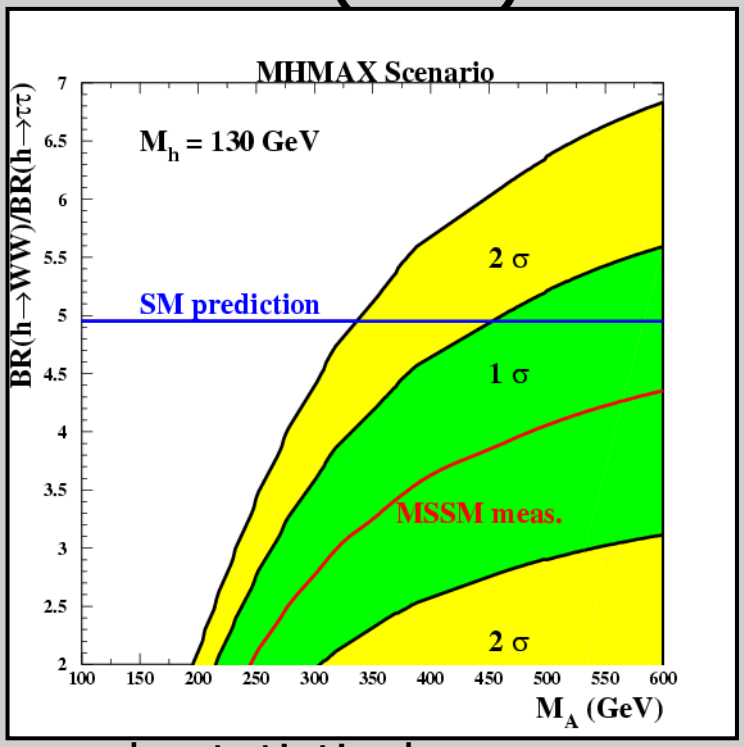
VBF channels , H/A→ττ only used with 30fb^{-1}

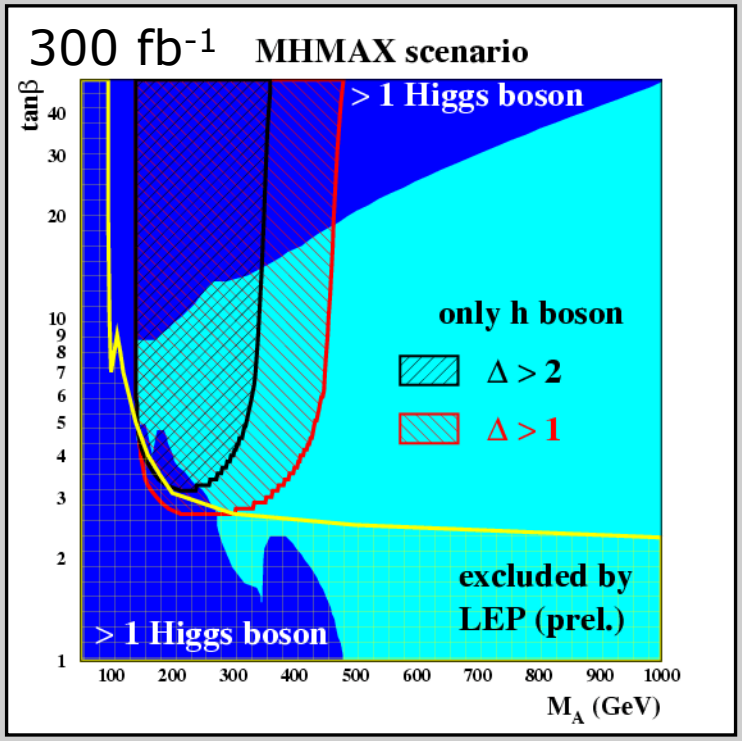
SM vs MSSM Higgs discrimination

- estimate of sensitivity from rate measurements in VBF channels ($30fb^{-1}$)
- compare expected measurement of R in MSSM with prediction from SM

$$R = \frac{BR(h \to WW)}{BR(h \to \tau\tau)}$$

$$\Delta = |R_{MSSM} - R_{SM}| / \sigma_{exp}$$



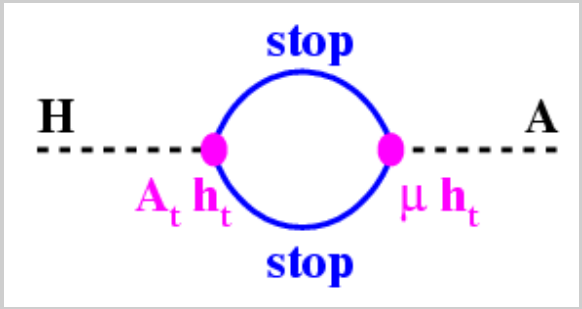


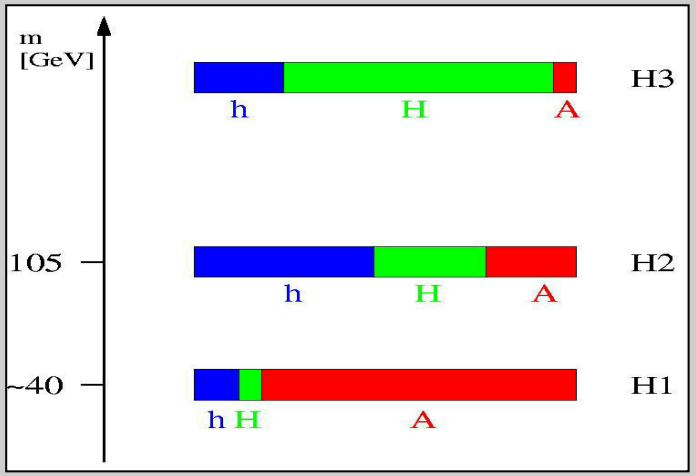
- only statistical errors
- assume M_h exactly known

needs further study incl. sys. errors

The CP violating CPX scenario

- CP conserving at Born level, but CP violation via complex $\mathbf{A_t}$, $\mathbf{A_b}$ $\mathbf{M_{gl}}$

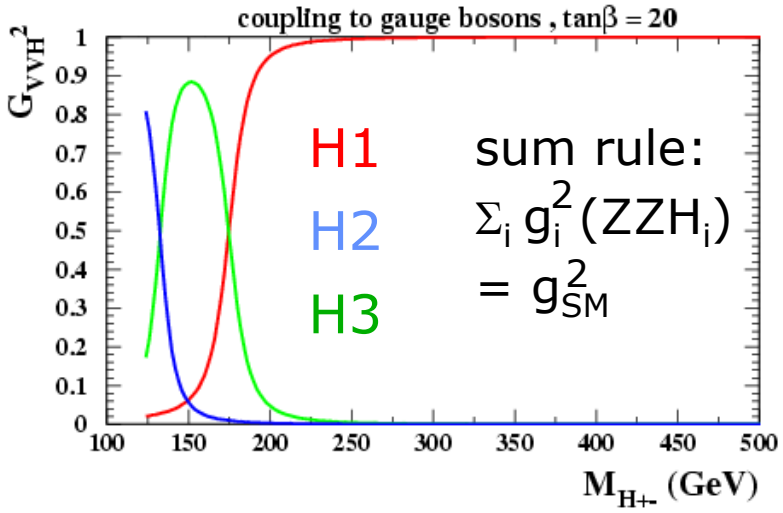




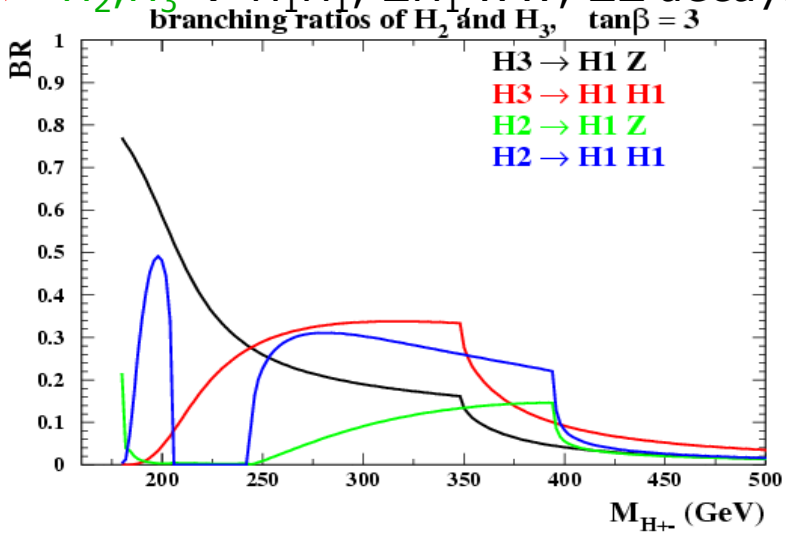
- CP eigenstates h, A, H mix to mass eigenstates H_1, H_2, H_3
- maximise effect → CPX scenario (Carena et al., Phys.Lett B495 155(2000))
  $\arg(A_t)=\arg(A_b)=\arg(M_{gluino})=90$ degree
- scan of Born level parameters: tanβ and M_{H+-}

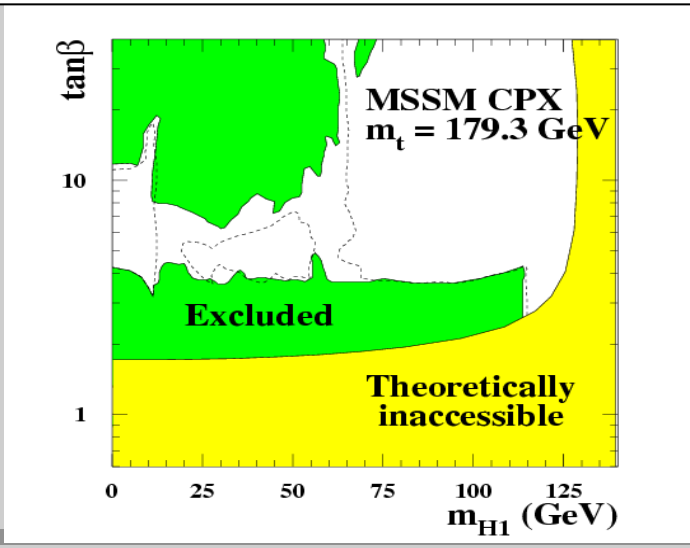
CPX Phenomenology

➢ H_1, H_2, H_3 coupling to W,Z



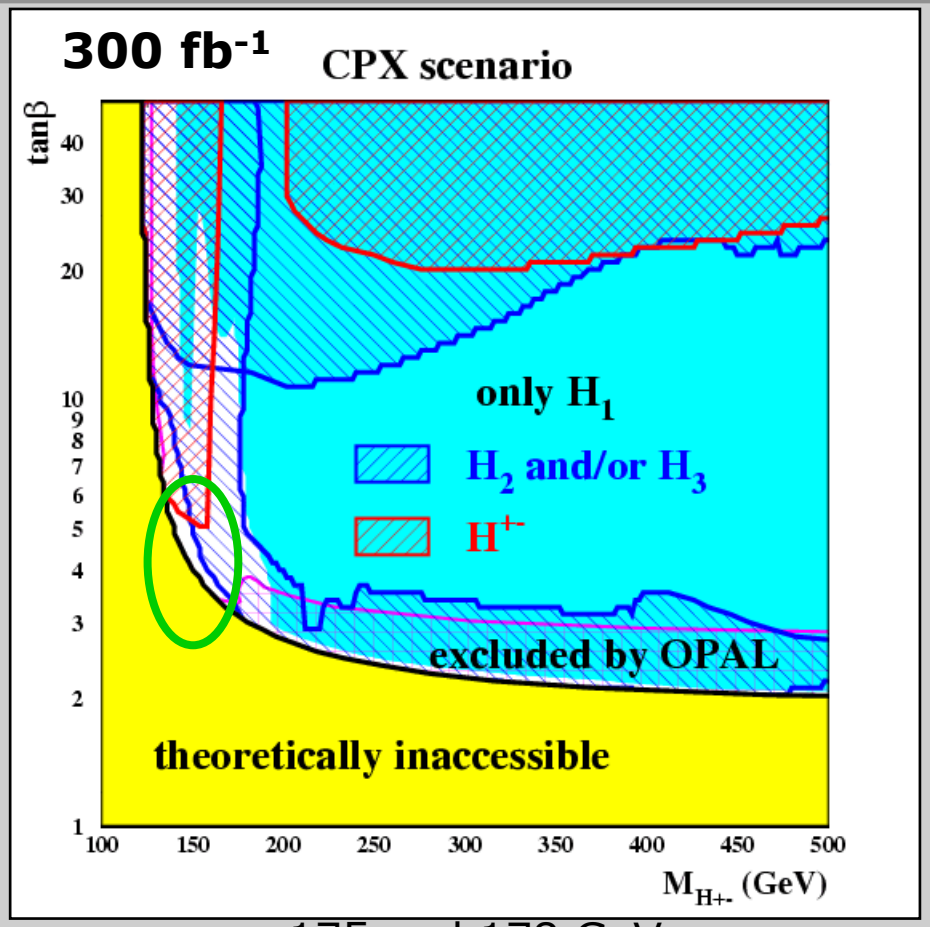
➢ $H_2, H_3 \rightarrow H_1H_1$, ZH_1 WW, ZZ decays





- no absolute limit on mass of H_1 from LEP
- strong dependence of excluded region
  - on value for m_{top}
  - on calculation used FeynHiggs vs CPH

CPX scenario: overall discovery potential



- FeynHiggs with M_t=175 GeV
- OPAL exclusion for M_t=174.3GeV
- small uncovered area at low M_{H+-}

M_{H1}: < 70 GeV
M_{H2}: 105 to 120 GeV
M_{H3}: 140 to 180 GeV

small masses below 70 GeV
not yet studied in ATLAS

now: m_{top} = 175 and 178 GeV

FeynHiggs and CPSUPERH calculations (LEP uses conservative excl.)

preliminary LEP combined results for m_{top} = 174.3 and 179.3 GeV

Summary

- SM Higgs should be discovered with a few tens of fb^{-1} over the full mass range.
- Higgs coupling measurement will require full luminosity. Accuracies of 15-50% are expected depending on the channel.
- MSSM Higgs discovery potential in 4 CP-Conserving scenarios and in the CPX scenario have been studied.