SUSY02

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# Higgs Physics at LHC

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## LHC schedule:

April 2007:

First collisions, $L = 5 \times 10^{32}$ - $2 \times 10^{33}$

August 2007 - February 2008:

Physics run, $L = 5 \times 10^{32}$ - $2 \times 10^{33}$, $Lt = 10\ fb^{-1}$

2008 ->

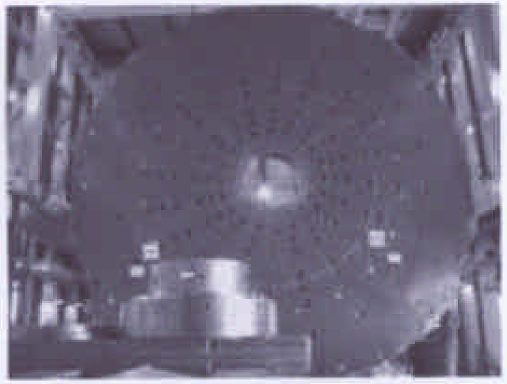
$L = 2 \times 10^{34}$, $Lt = 100\ fb^{-1}$ per year

## Civil engineering

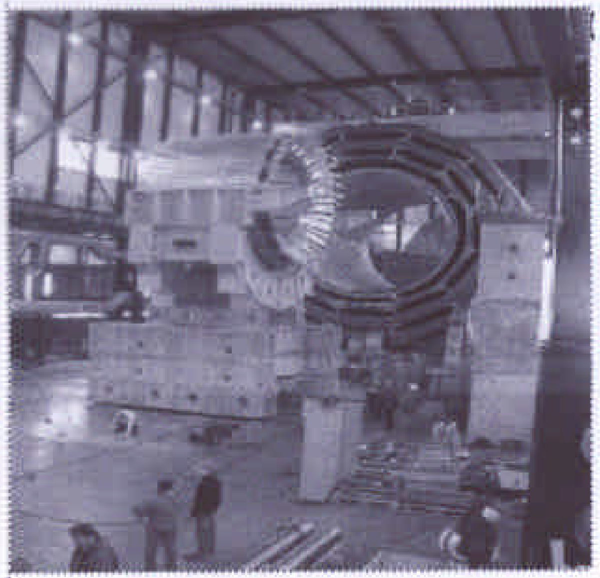
ATLAS cavern

## Construction of detectors

CMS magnet system - endcap yoke



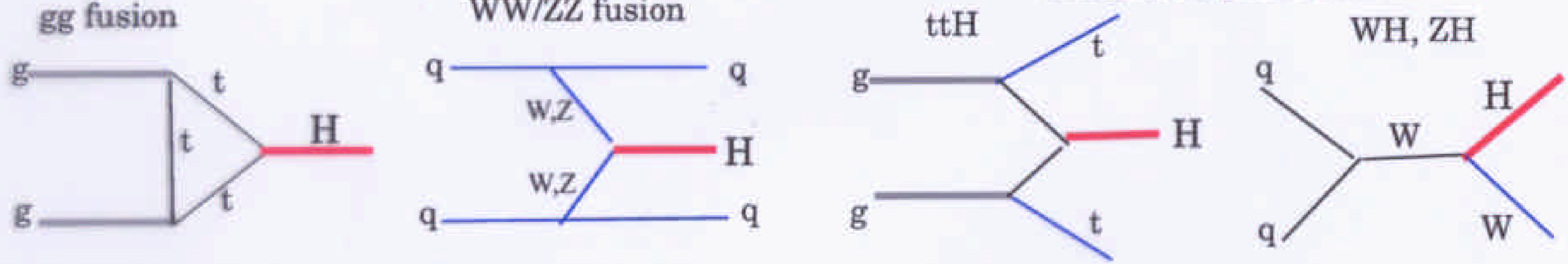
CMS HCAL and barrel yoke

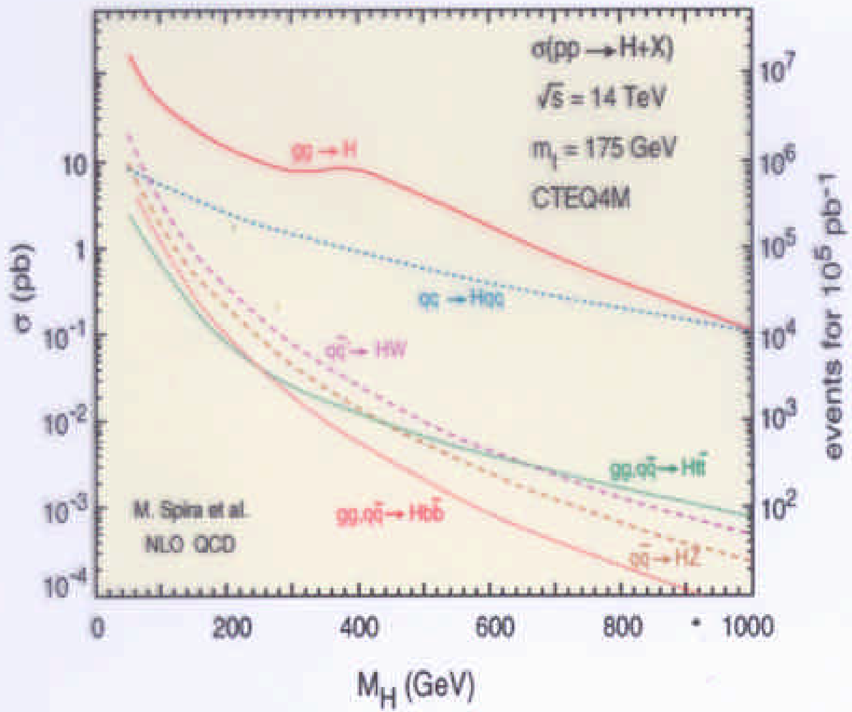


# Simulation of Higgs in ATLAS and CMS

- In most cases full (GEANT) for the benchmark channels, including trigger simulations for signal and background
- Systematic errors estimated in some cases
- Simple cuts (No Neural Nets) used

# SM Higgs production at LHC




Production dominated by gg -> H

qq -> qqH comparable at large $m_H$

~ 10 - 20% at low $m_H$

QCD corrections:

large for gg -> H, k-factor ~ 1.5 - 1.9

small for ttH, WW/ZZ fusion,

k-factor ~ 1.1 - 1.2

Following results are shown

for LO cross sections

# Channels studied for SM Higgs

$m_H < 2\, m_Z$:

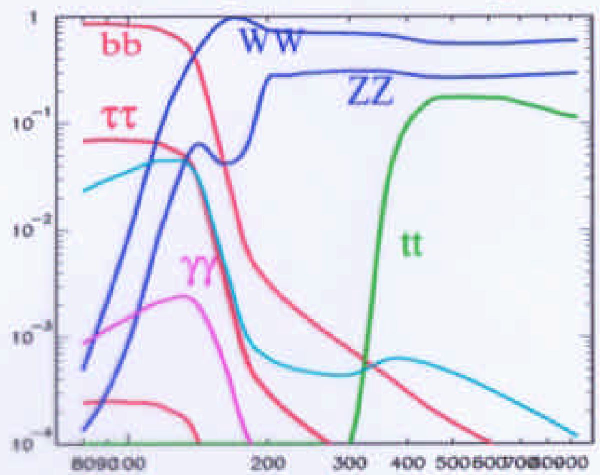
H -> $\gamma\gamma$, inclusive, in ttH and WH

H -> ZZ* -> 4 leptons

H -> WW* -> $l\nu l\nu$

H -> $b\bar{b}$ in $t\bar{t}$H and WH

Branching ratios for SM Higgs




qqH, H -> WW* -> $l\nu l\nu$
qqH, H -> $\tau\tau$ -> $l$+$\tau$ jet, $ll$
qqH, H -> $\gamma\gamma$

} New studies! Simulations in progress

$m_H > 2\, m_Z$:

H -> ZZ -> 4 leptons

qqH, H -> WW -> $l\nu jj$, qqH, H -> ZZ -> $ll\nu\nu$, qqH, H -> ZZ -> $ll$jj

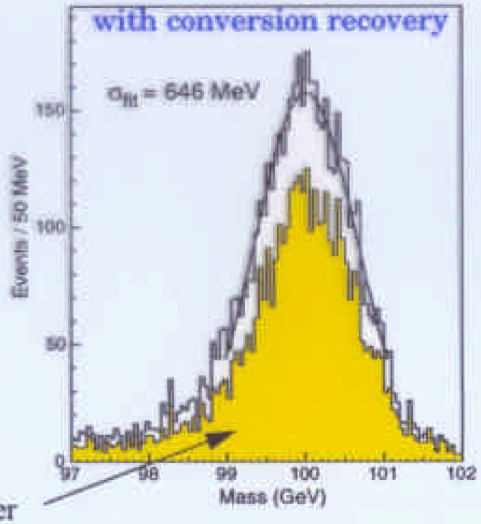
# H -> $\gamma\gamma$

A high precision EM calorimeter is needed to observe the H -> $\gamma\gamma$ signal over the large and dominant prompt $\gamma$ background

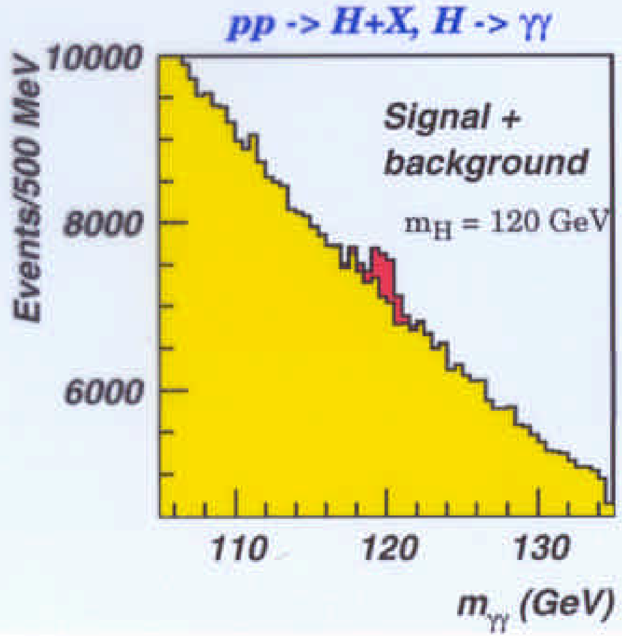
Higgs mass resolution: better than 1% is expected with the CMS PbWO4 crystal calorimeter for 100 GeV < $m_H$ < 150 GeV

Lead -Tungstate Crystal

CMS full simulation



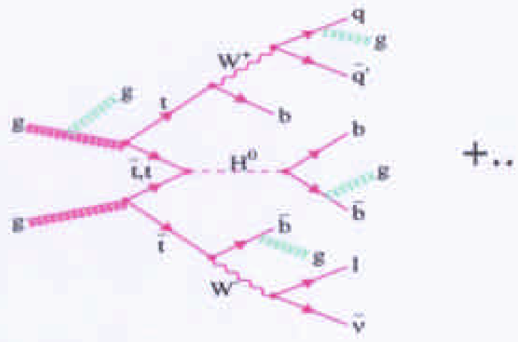

no conversions in tracker




Reconstruction efficiency for single photons 74.5%

# $pp \to t\bar{t}H+X,\ H \to b\bar{b}$

with $t_1 \to jjb$, $t_2 \to l\nu b$

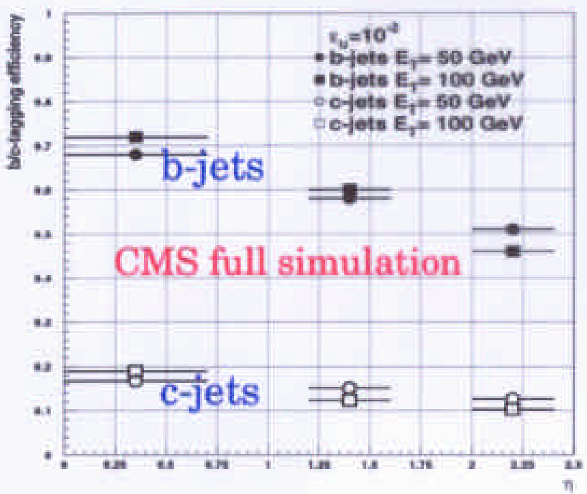



Main background from $t\bar{t}jj$ (including $t\bar{t}b\bar{b}$)

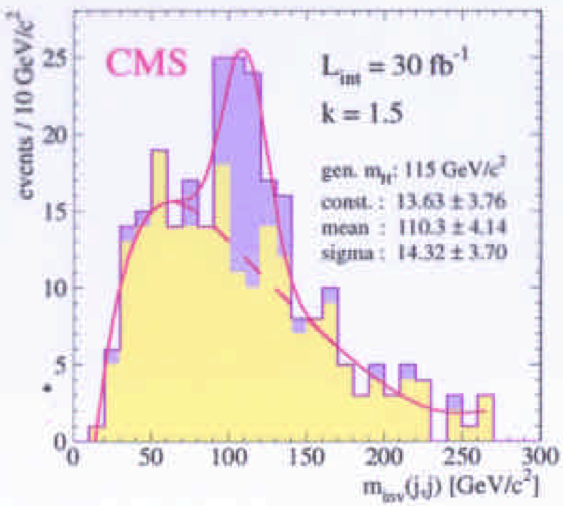
Event generation with CompHEP + PYTHIA

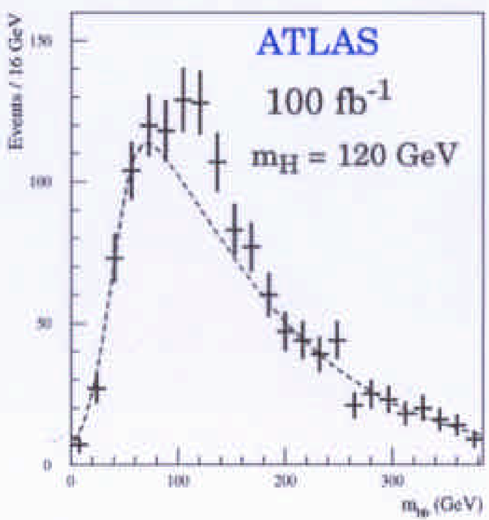
Signal can be extracted with full event reconstruction (leptonic and hadronic top) with 4 tagged b-jets

Tagging efficiency for b - and c - jets with 1% mistagging rate from q, g jets




Log-likelihood method in CMS

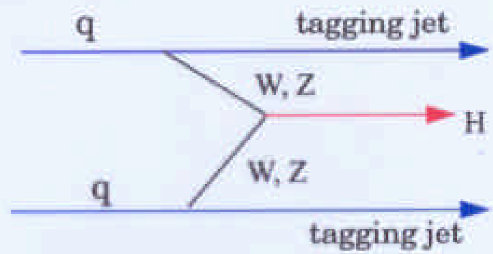


# Higgs searches in qq -> qqH

Main discovery channels for heavy SM Higgs

Interest for light Higgs triggered by recent phenomenological papers (D. Zeppenfeld et al....)



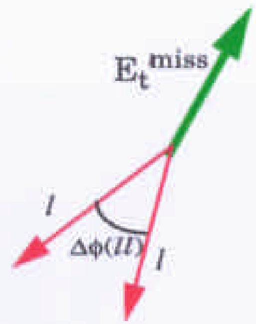

- Important for measurements of Higgs couplings and $\Gamma_H$ measurement

Two hard forward jets: use double forward jet tagging to identify the process

No colour exchange in the signal process between $q_1$ and $q_2$ thus central jet veto between tagging jets leads to large background reduction

Challenging experimentally, detailed simulations are going on

# qq -> qqH, H -> WW* -> $l\nu l\nu$




Backgrounds: $t\bar{t}jj$ (main background)

WWjj, W -> $l\nu$ and Zjj, Z* -> $ll$ in electro-weak (EW) and QCD production

(event generations with matrix element calculations interfaced to PYTHIA)

Background reduction with:

double forward jet tagging
central jet veto between tagging jets

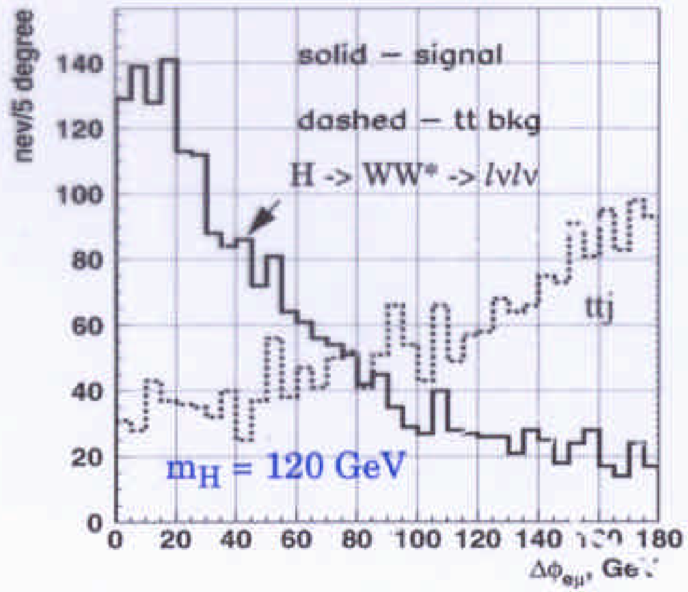
Further reduction from spin correlations in H -> $W^+W^-$ -> $l^+\bar{\nu}l^-\nu$:

emission of leptons in the same direction in WW rest frame

-> small $l$-$l$ opening angle, small $m_{ll}$

Clear signal in relative $ll$ azimuthal angle near the WW threshold

CMS full simulation



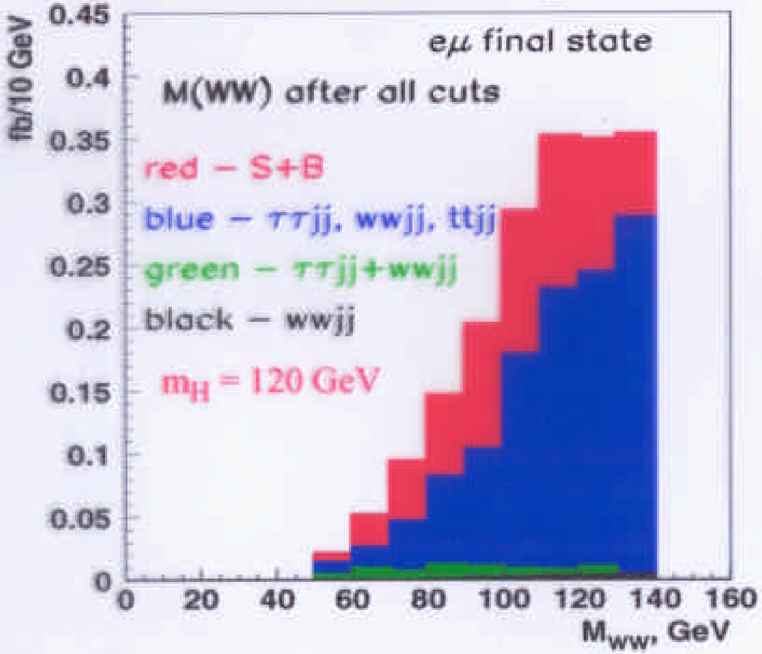
# Transverse Higgs mass can be reconstructed

$$m_T^2(WW^*) = (E_T^{ll} + E_T^{miss})^2 - (p^{ll} + p^{miss})^2$$

where $E_T^{ll} = ((p_T^{ll})^2 + (m^{ll})^2)^{1/2}$, $E_T^{miss} = ((p_T^{miss})^2 + (m^{ll})^2)^{1/2}$

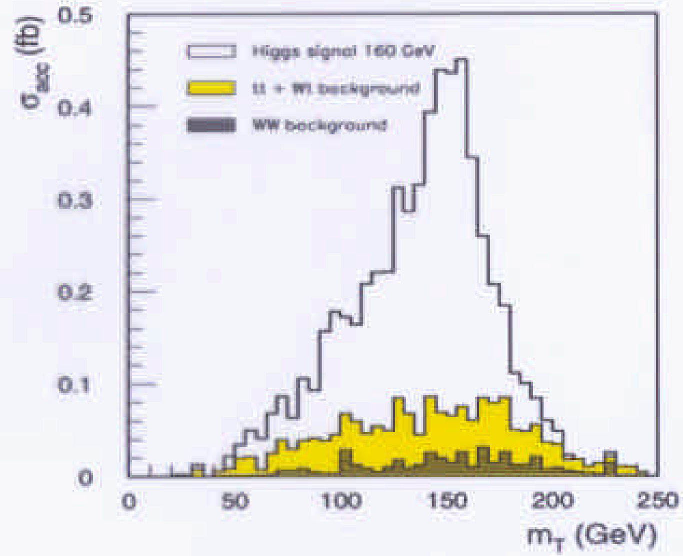
thanks to spin correlations -> ~ two body decay with $\bar{p}_{ll}$ and $\bar{p}_{\nu\nu}$

CMS full simulation , $m_H$= 120 GeV




5σ significance for 68$fb^{-1}$
including all backgrounds

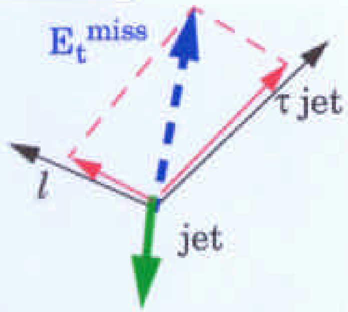
ATLAS simulation, $m_H$= 160 GeV




Significance > 5σ
for 140 < $m_H$ < 200 GeV
already with 10 $fb^{-1}$

## qq -> qqH, H -> ττ -> $l$+τ jet + $E_t^{miss}$ , $ll$ + $E_t^{miss}$

Small event rate, BR(H -> ττ) ~ 3 - 7%, efficiencies critical

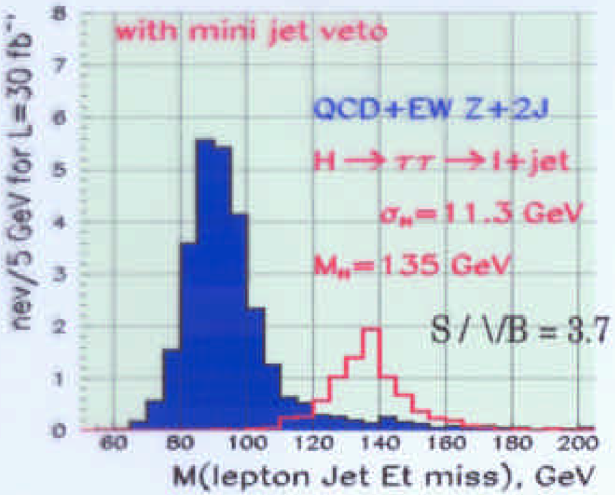



Main background from EW and QCD Zjj, Z -> ττ

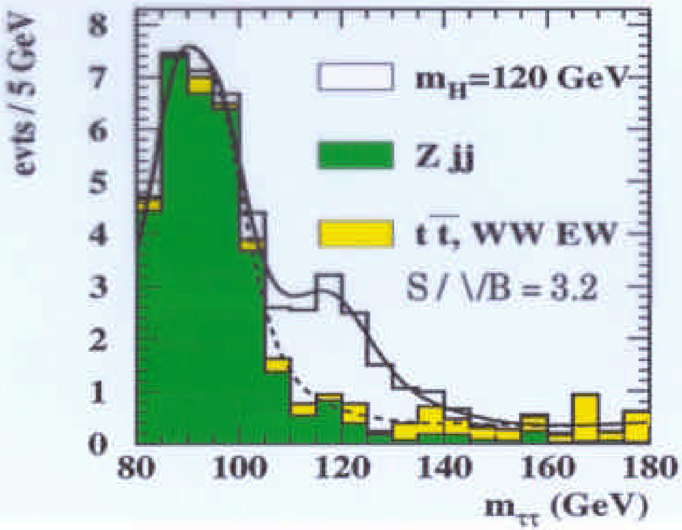
(event generations with matrix element calculations interfaced to PYTHIA)

Higgs mass can be reconstructed using collinearity approximation for the neutrinos from τ decays

CMS fast simulation for
H -> ττ -> $l$ + τ-jet + $E_t^{miss}$
Mass resolution 8 %



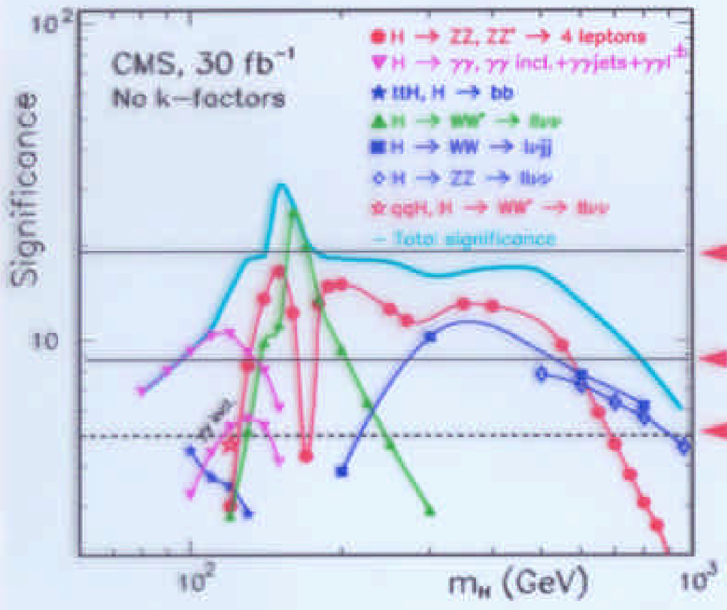

ATLAS fast simulation for
H -> ττ -> $ll$ + $E_t^{miss}$
Mass resolution 10%



# SM Higgs discovery potential

No k-factors included

Sensitivity over full expected mass range with at least two channels

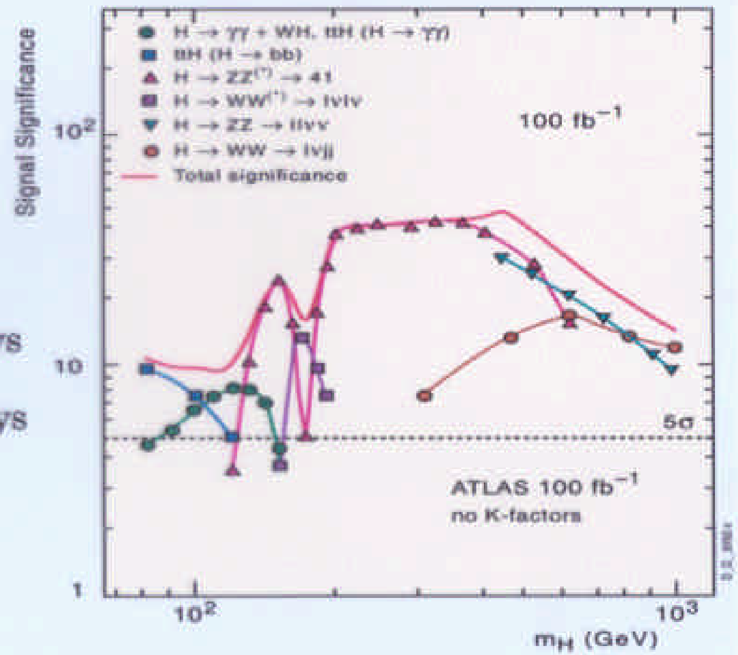



5σ at

- 2 fb$^{-1}$, ~ 36 days
- 10 fb$^{-1}$, ~ 180 days
- 30 fb$^{-1}$, ~ 546 days

for L= 2x10$^{33}$ cm$^{-2}$s$^{-1}$

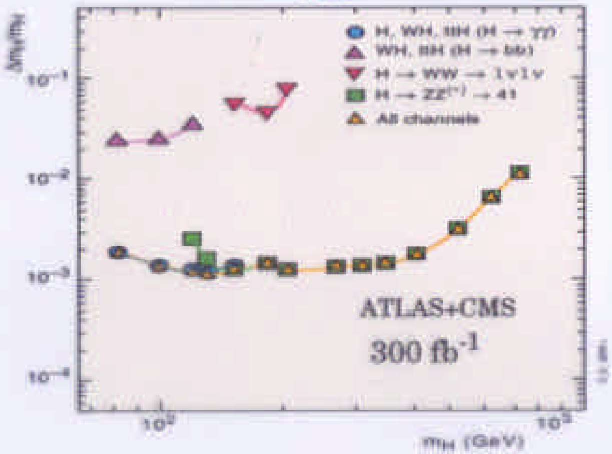
Discovery reach for SM Higgs in ATLAS



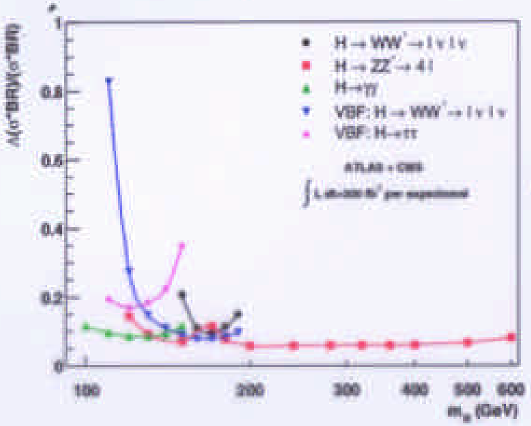

Discovery possible for 120 GeV < $m_H$ < 800 GeV already with 10 fb$^{-1}$ combining all channels; $m_H$ < 125 GeV region hardest requiring $\gtrsim$ 10 fb$^{-1}$

# Precision on SM Higgs parameters

## SM Higgs mass




## SM Higgs production rates



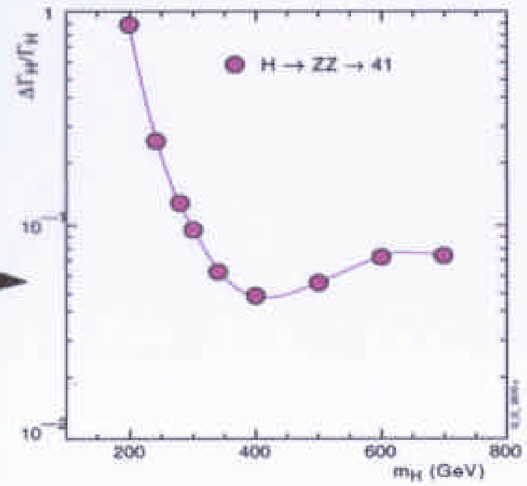

5 -10% systematic uncertainty from lumionosity measurement

10% uncertainty from background substraction

Absolute energy scale limiting factor for mass measurement:

leptons and photons 0.1%, jets 1%

## SM Higgs width




Direct measurement $m_H > 200$ GeV in H -> ZZ -> 4 leptons

Precision < 10% for $m_H > 250$ GeV

Limiting factor radiative decays, systematic uncertainty 1.5%

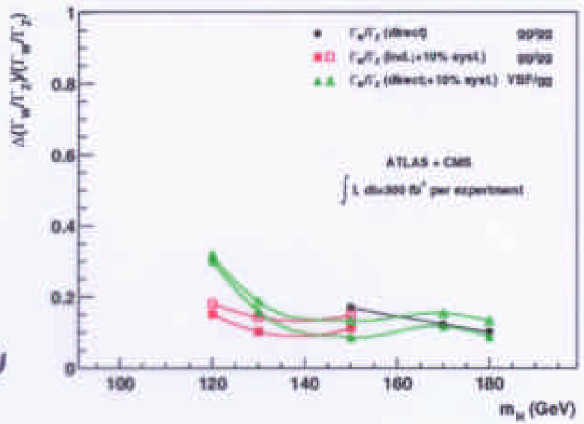
10-20% precision expected from indirect measurement using qq -> qqH channels for $m_H < 200$ GeV (D. Zeppenfeld et al.)

# Measurement of Higgs couplings

Only coupling ratios can be measured, rate uncertainties largerly cancel

## Couplings to weak bosons

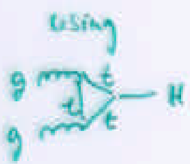
- Direct measurement – $\frac{\sigma\times BR(H\to WW^*)}{\sigma\times BR(H\to ZZ^*)} = \frac{\Gamma_g\Gamma_W}{\Gamma_g\Gamma_Z} = \frac{\Gamma_W}{\Gamma_Z}$
  $\lesssim 15\%$ for 150 – 180 GeV
- Indirect measurement – $\frac{\sigma\times BR(H\to\gamma\gamma)}{\sigma\times BR(H\to ZZ^*)} = \frac{\Gamma_g\Gamma_\gamma}{\Gamma_g\Gamma_Z} \sim \frac{\Gamma_W}{\Gamma_Z}$
  using H–W loop–γγ $\lesssim 20\%$ for 120 – 150 GeV

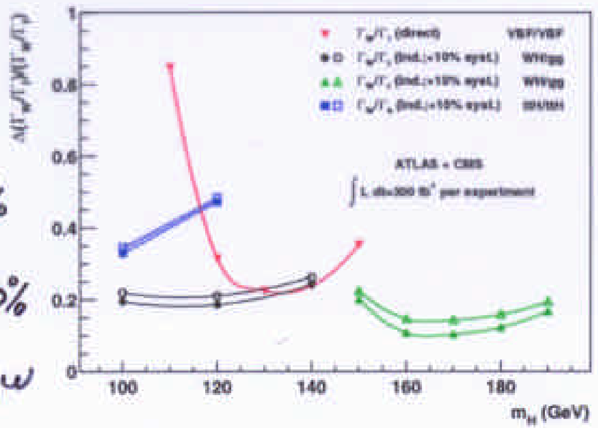



## Ratios of boson/fermion couplings

- Direct measurement
  – $\frac{\sigma\times BR(qq\to qqH(H\to WW))}{\sigma\times BR(qq\to qqH(H\to\tau\tau))} = \frac{\Gamma_W\Gamma_W}{\Gamma_W\Gamma_\tau} = \frac{\Gamma_W}{\Gamma_\tau}$
  $\lesssim 30\%$ for 120 - 150 GeV
- Indirect measurement
  – $\frac{\sigma\times BR(WH(H\to\gamma\gamma))}{\sigma\times BR(H\to\gamma\gamma)} = \frac{\Gamma_W\Gamma_\gamma}{\Gamma_g\Gamma_\gamma} \sim \frac{\Gamma_W}{\Gamma_t} * C_{QCD}$ $\sim 20\%$
  – $\frac{\sigma\times BR(WH(H\to WW))}{\sigma\times BR(H\to WW^*)} = \frac{\Gamma_W\Gamma_W}{\Gamma_g\Gamma_W} \sim \frac{\Gamma_W}{\Gamma_t} * C_{QCD}$ $\gtrsim 20\%$
  – $\frac{\sigma\times BR(ttH(H\to bb))}{\sigma\times BR(ttH(H\to\gamma\gamma))} = \frac{\Gamma_t\Gamma_b}{\Gamma_t\Gamma_\gamma} \sim \frac{\Gamma_b}{\Gamma_W}$ $\sim 40\%$, 100-120 GeV

using

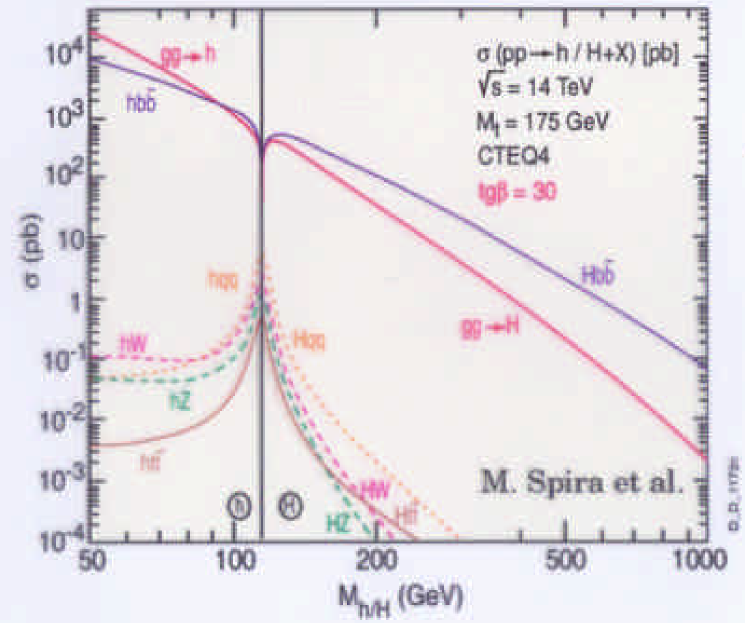


# Neutral MSSM Higgs sector (h, H, A)

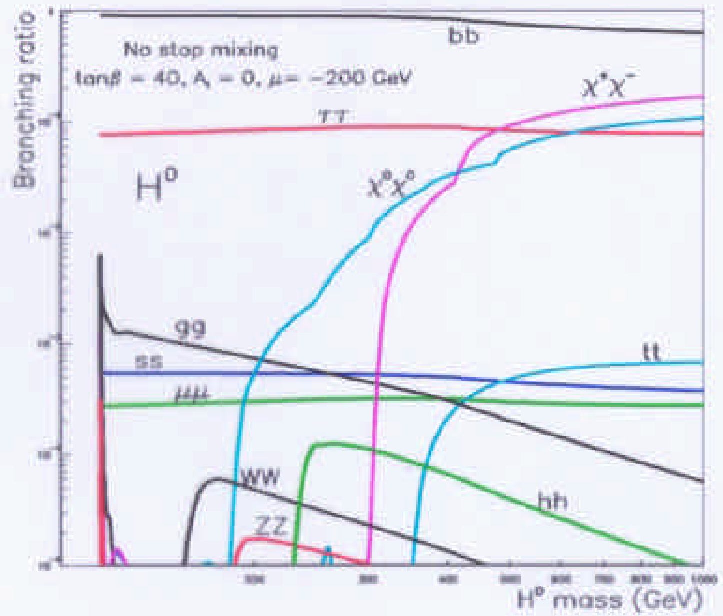
$Hb\bar{b}$, $H\tau\tau$, $H\mu\mu$ enhanced at high $\tan\beta$:

Production dominated by gg -> $b\bar{b}H$




Important decay channels

A/H -> $\tau\tau$, $\mu\mu$, $b\bar{b}$, $\chi\chi$




**b and τ tagging aspects (high precision tracking) enhanced**

gg, qq -> bbH theoretically well-known for large enough $p_t^b$

→ selecting $b\bar{b}H$ with double b-tagging would allow a precise $\tan\beta$ measurement

# Discovery channels investigated for neutral MSSM Higgs

h -> $\gamma\gamma$, incl., in tth, Wh and qqh  
h -> $b\bar{b}$ in tth and Wh  
h -> $\tau\tau$ in qqh  
h -> $b\bar{b}$ in SUSY cascades

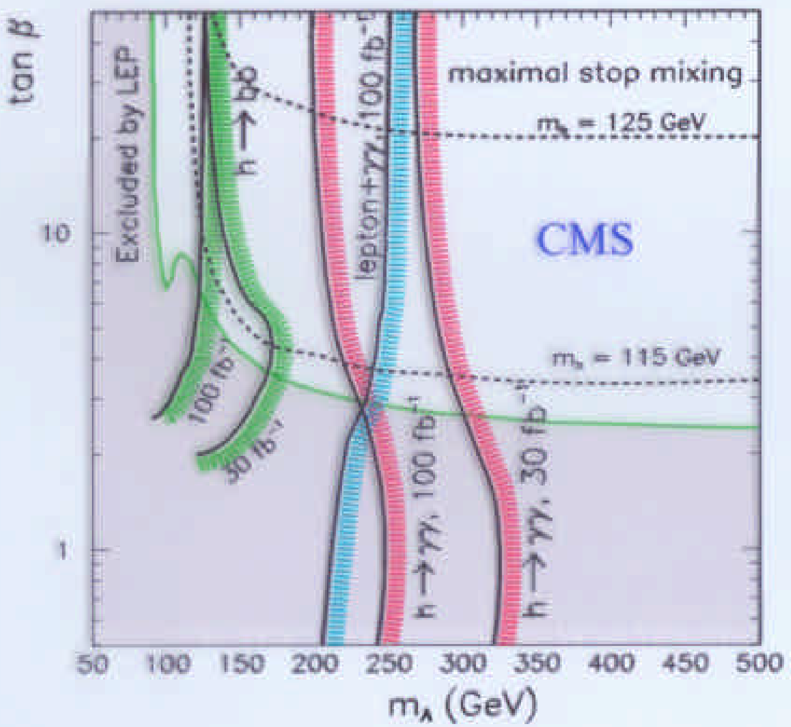
} SM Higgs like  
h -> $\tau\tau$ reach not yet established

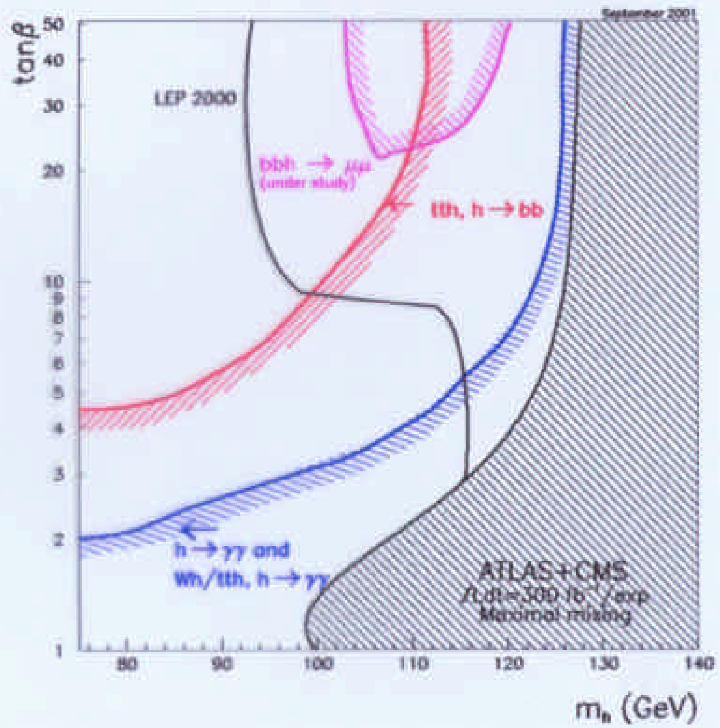
A, H -> $\tau\tau$ -> $ll$, $l$+$\tau$-jet, 2 $\tau$-jets  
A, H -> $\mu\mu$  
A, H -> $\chi^0\chi^0$ -> 4 leptons+X

} Detailed simulations,  
trigger optimizations

A, H -> $b\bar{b}$, in $b\bar{b}$A/H } investigations with detailed simulations started, difficult but not hopeless

# MSSM parameter space coverage for light Higgs




Almost full parameter space covered alredy with 30 $fb^{-1}$

SUSY loops at production ($gg \to h$) can reduce the discovery range for $m_{\tilde{t}_1} \lesssim 300$ GeV

# pp -> $b\bar{b}$H/A -> $\mu^+\mu^- b\bar{b}$ (new study with full simulation)

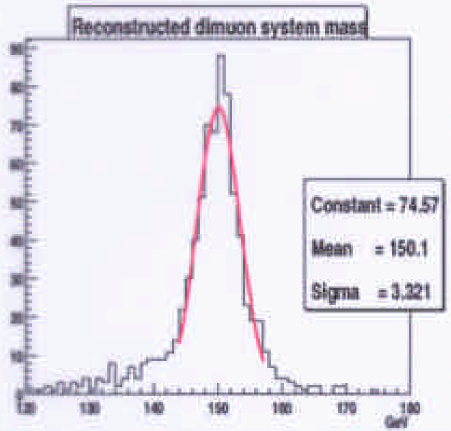
BR(A/H -> $\mu^+\mu^-$) ~ $(m_\mu / m_\tau)^2$ ~ 4 x $10^{-3}$ small but

clean signature and good Higgs mass resolution ($\lesssim$ 2 %)

-> expect precise $m_H$, tanβ measurement

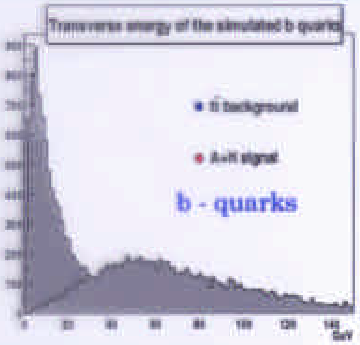
possibly $\Gamma_H$ measurement

CMS full simulation




Main backgrounds from Z,γ*-> μμ, $t\bar{t}$

Suppression of Z,γ*-> μμ exploiting bbH production with secondary B-vertex tagging (eff. 40%)



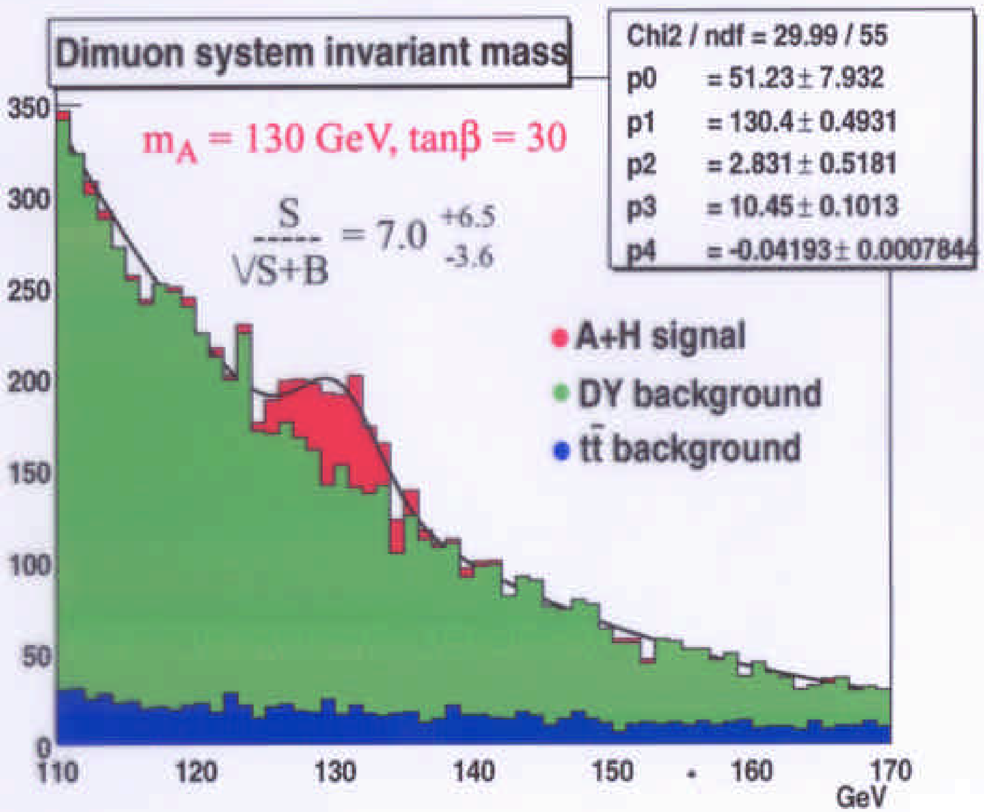

b-jet tagging can be also used but b-jets are soft

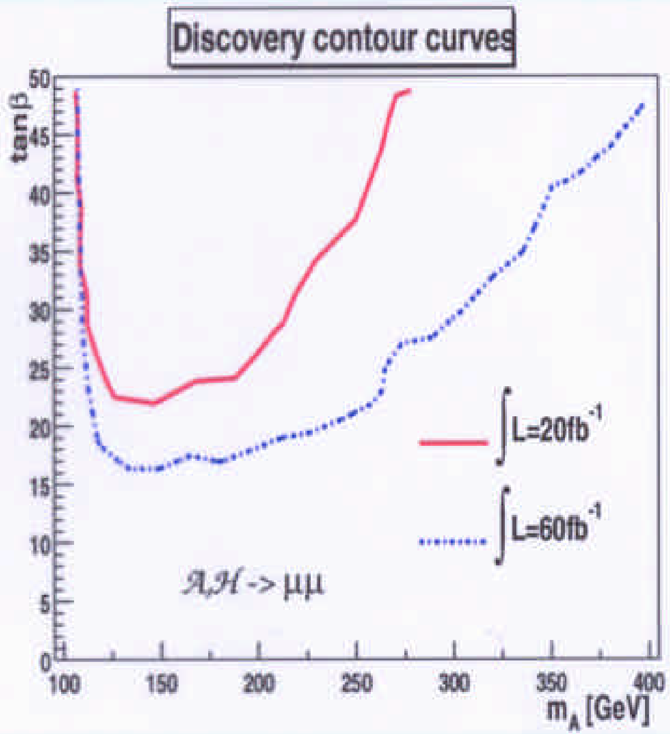
(b-jet tagging eff. including jet $E_t$ threshold $<$ 20% for ~1% Z->μμ rejection)

$t\bar{t}$ -> $\mu^+\mu^-$+X reduction with central jet veto

# Good discovery potential (also) near the Z mass peak thanks to efficient b-tagging

Signal superimposed on the total background for 20 $fb^{-1}$



# H/A -> $\tau\tau$ - main search channel at large A/H masses

3 final states: 2 leptons +$\nu$'s: BR ~ 12 %, lepton + $\tau$-jet + $\nu$'s: BR ~ 35 %
2 $\tau$-jets + $\nu\nu$: BR ~ 25 % 1 prong, ~ 44 % 1 + 3 prongs

Special hadronic $\tau$ trigger needed for 2 $\tau$-jet final states (see talk of P. Vanlaer)

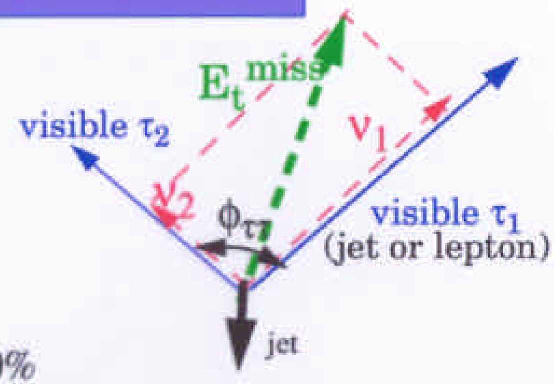
Main backgrounds from Z,$\gamma^*$ -> $\tau\tau$, $t\bar{t}$, W+jets, QCD jets (for 2 $\tau$-jets)

Background reduction:

| | |
|---|---|
| $\tau$-jet identification (isol., hard tracks) | - fake $\tau$–jets from QCD, W+jets.. |
| B-tagging | - Z,$\gamma^*$ -> $\tau\tau$, QCD |
| $\tau$-tagging | - QCD, Z-> $ll$, $t\bar{t}$ .. |
| central jet veto | - $t\bar{t}$ |
| $E_t^{miss}$ cut | - QCD .. |

# Higgs mass reconstruction in H -> $\tau\tau$

Mass reconstruction possible using calorimeter jets and and $E_t^{miss}$ measurement, assuming collinear neutrinos

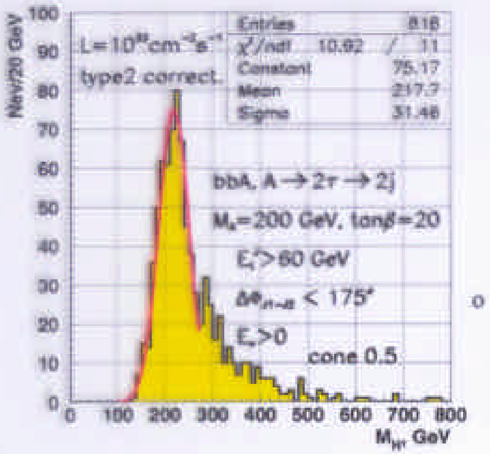



Higgs mass resolution dominated by

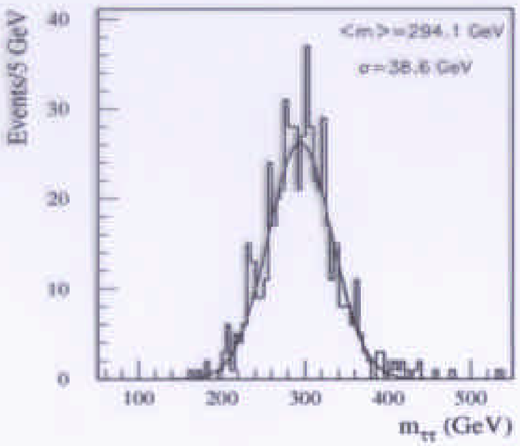
$E_t^{miss}$ measurement, depends on $\phi_{\tau\tau}$ as $1/\sin\phi_{\tau\tau}$

Efficiency for "good" mass reconstruction ($E_\nu>0$) typically ~50%

CMS full simulation

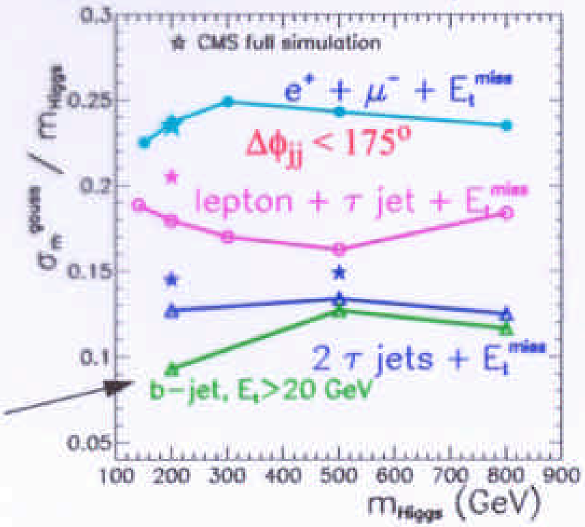



ATLAS full simulation




More favorable mass reconst. with b-tagging: improvement of eff. by ~2

A/H mass resolution, CMS



# b - and $\tau$ - tagging in $b\bar{b}A/H$, A/H -> $\tau\tau$

Soft b-jets with a wide $\eta$-range:

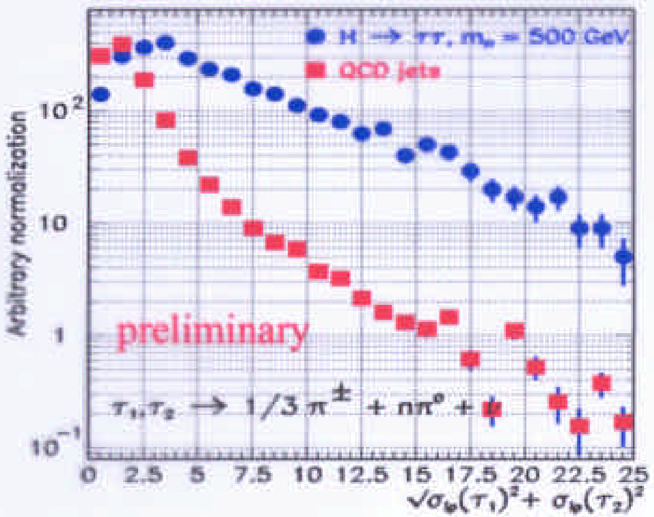
Efficiency to tag one b-jet ~ 35% for ~1% mistagging rate (CMS)

$\tau$ - tagging with impact parameter measurement

combining the ip measurements of the hard tracks in the two $\tau$'s ($\tau$ -> hadron, $\tau$ -> lepton) into one variable: $\sqrt{\sigma_{ip}(\tau_1)^2 + \sigma_{ip}(\tau_2)^2}$

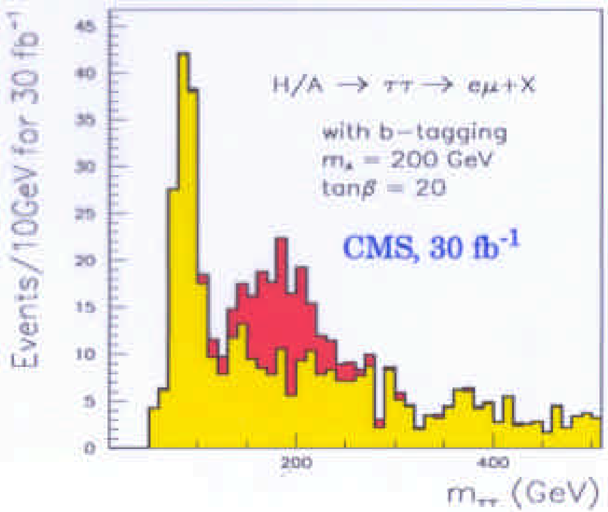
CMS full simulation for

H -> $\tau\tau$ -> 2 $\tau$-jets and QCD events




Expect rejection of 5 - 10 against QCD background and backgrounds with W -> $l\nu$, Z -> $ll$

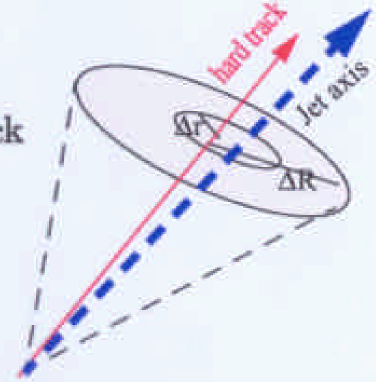
Signal superimposed on the total background for $m_A$ = 200 GeV, $\tan\beta$ =20



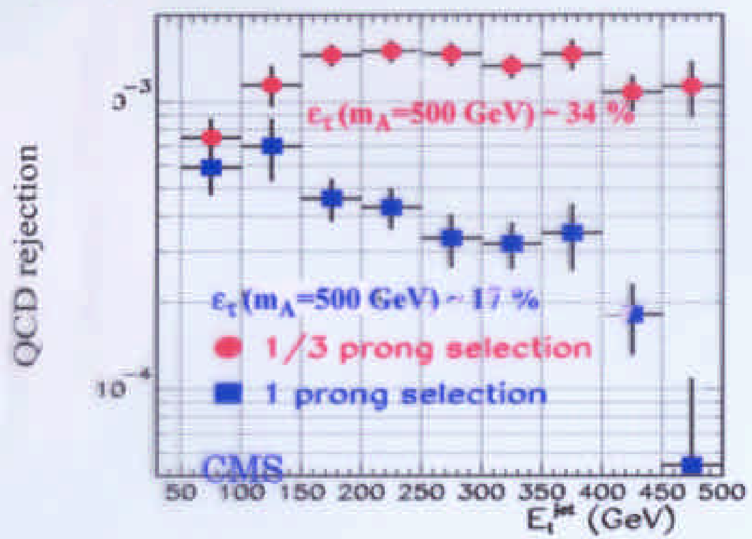
# QCD jet rejection in A/H -> $\tau\tau$ -> 2 $\tau$ jets + X

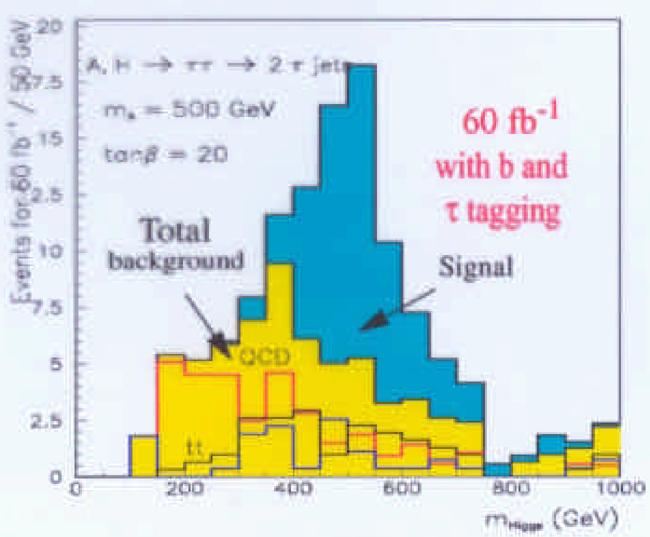
$\tau$-jet ($E_t^{\tau\text{-jet}} > 60$ GeV) identification (mainly) in the tracker:

- **Hard track**, $p_t^{max} > 40$ GeV, within $\Delta R < 0.1$ around calorimeter jet axis
- **Isolation**: no tracks, $p_t > 1$GeV, within $0.03 < \Delta R < 0.4$ around the hard track
- For 3-prong selection 2 more tracks in the signal cone $\Delta r < 0.03$




QCD jet rejection from isolation and hard track cuts



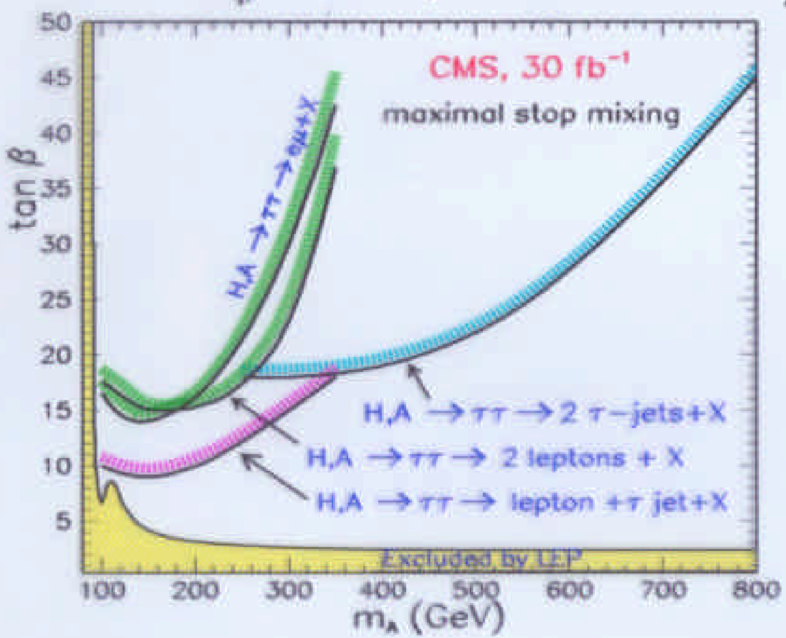



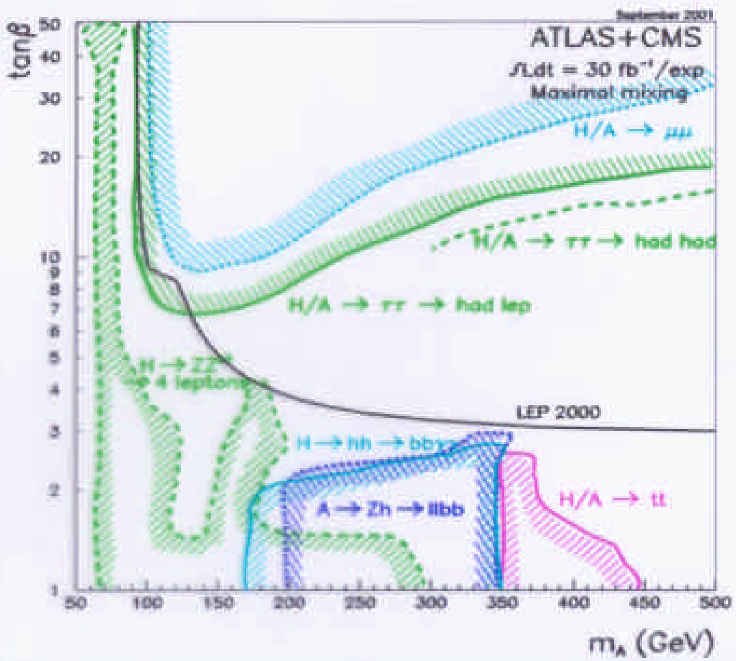

$m_{H/A}$(GeV)

Further reduction by ~ 5 expected for 3-prong QCD jets from $\tau$ vertex reconstruction (CMS full simulation)

# $5\sigma$ discovery contours for A/H -> $\tau\tau$

$M_2 = 200$ GeV, $\mu = -200$ GeV, $M_{\tilde{g}} = 800$ GeV,
$M_{\tilde{q},\tilde{l}} = 1$ TeV, $A_t = 2.4$ TeV




Discovery reach not sensitive to stop mixing

Light SUSY spectrum -> BR(H/A -> $\tau\tau$) can be reduced at high masses

Large $\mu$ -> BR(H/A -> $\tau\tau$) can be enhanced at high masses

SUSY loops in production (light stop and large mixing) -> only gg -> H affected

# Search for A,H in SUSY particle decay modes, A,H -> $\tilde{\chi}\tilde{\chi}$

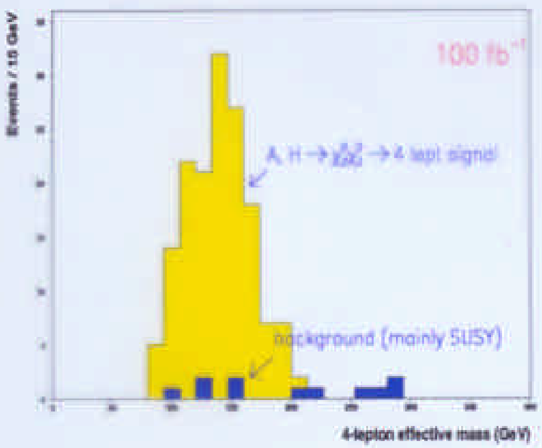
Assume MSSM, $M_2 \sim 2M_1$, light slepton, $m_{\tilde{g},\tilde{q}} \sim 1$TeV

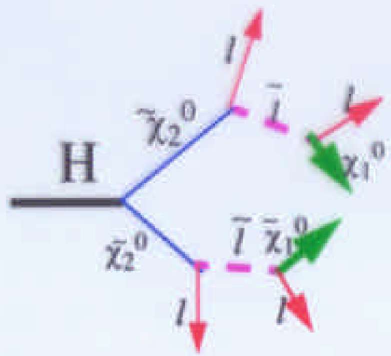
Clean signature expected from $\tilde{\chi}_2^0\tilde{\chi}_2^0$, $\tilde{\chi}_2^0 \to ll\tilde{\chi}_1^0$ with $4l$ final state

Backgrounds from SM ($t\bar{t}$, ZZ, $Zb\bar{b}$, $Zc\bar{c}$, Wtb), SUSY ($\tilde{q}/\tilde{g}$, $\tilde{l}\tilde{l}$, $\tilde{\nu}\tilde{\nu}$, $\tilde{q}\tilde{\chi}$, $\tilde{\chi}\tilde{\chi}$)

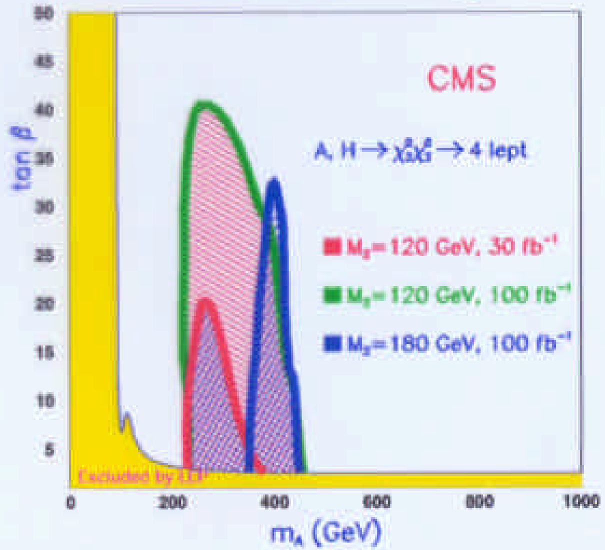
Suppression of $t\bar{t}$ and SUSY backgrounds with jet veto, ZZ, $Zb\bar{b}$, $Zc\bar{c}$ with Z veto

$m_A$ = 350 GeV, $\tan\beta$ = 5, $M_1$=60 GeV, $M_2$=120 GeV,
$\mu$ = -500 GeV, $M_{\tilde{l}}$ = 250 GeV, $m_{\tilde{g},\tilde{q}}$ = 1 TeV




5σ discovery reach in $m_A$, $\tan\beta$




Discovery range sensitive to $M_1$, $M_2$, $\mu$, $m_{\tilde{l}}$, small $M_1$, $M_2$, $m_{\tilde{l}}$, large $\mu$ more favourable

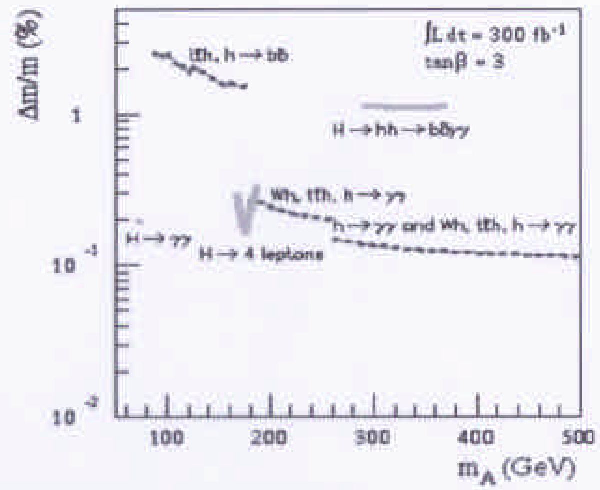
# Precision measurements for MSSM Higgs

## Precision on Higgs mass recoctruction

Uncertainty of the absolute energy:

leptons and photons ~ 0.1%, jets ~ 1%

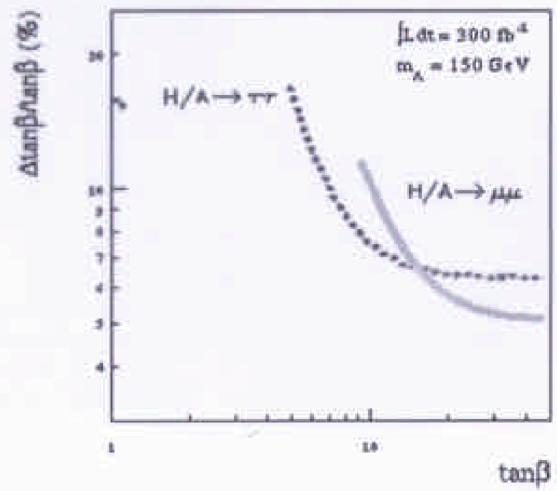
| | | |
|---|---|---|
| high tanβ | A/H -> μμ | 0.1 - 1.5 % |
| | A/H -> ττ | 1 - 10 % |




## Precision on tanβ measurement from event rates

Expected accuracy for 300 $fb^{-1}$:

| | |
|---|---|
| A/H -> μμ | 5 - 15 % |
| A/H -> ττ | 5 - 12 % |
| A/H -> ZZ*-> 4$l$ | 10 - 25 % |



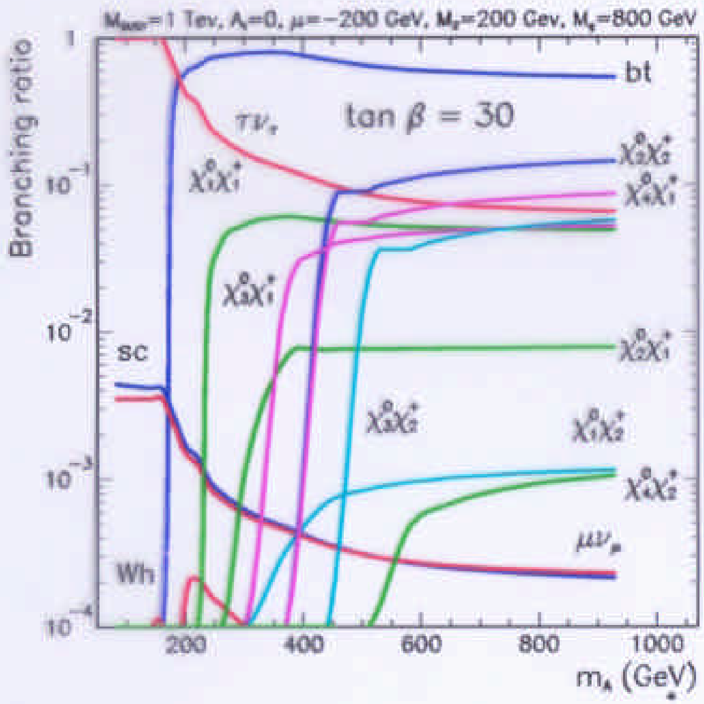

including systematic error of 10%

dominated by luminosity measurement

# Charged Higgs at LHC

## Discovery clearly signals physics beyond SM

$H^+$ branching ratios at high $\tan\beta$




Decay channels studied:

$H^+ \to tb$, dominant for $m_{H+} \gtrsim 200$ GeV

$H^+ \to \tau\nu$, BR ~ 10% for $m_{H+}$ ~ 400 GeV

$H^+ \to Wh^0$, for low $\tan\beta$

$H^+ \to \chi^0_i \chi^+_j$, under study

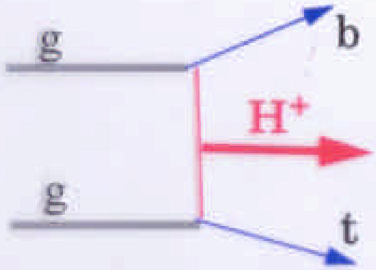
Largest reach expected with $H^+ \to \tau\nu$

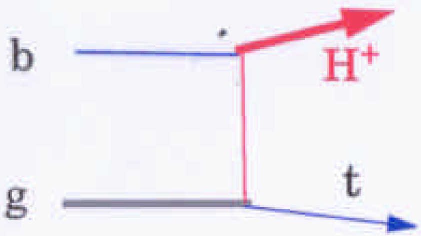
in the associted production $gg \to tbH^+$

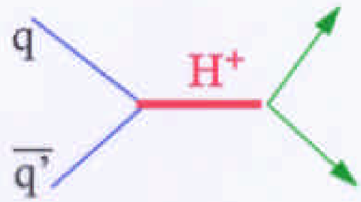
in fully hadronic events ($t \to bqq$)

## Production mainly through $gg \to \bar{t}bH^+$, $g\bar{b} \to \bar{t}H^+$ and $qq' \to H^+$

smaller rate from $pp \to H^+H^- + X$, $pp \to H^+W$



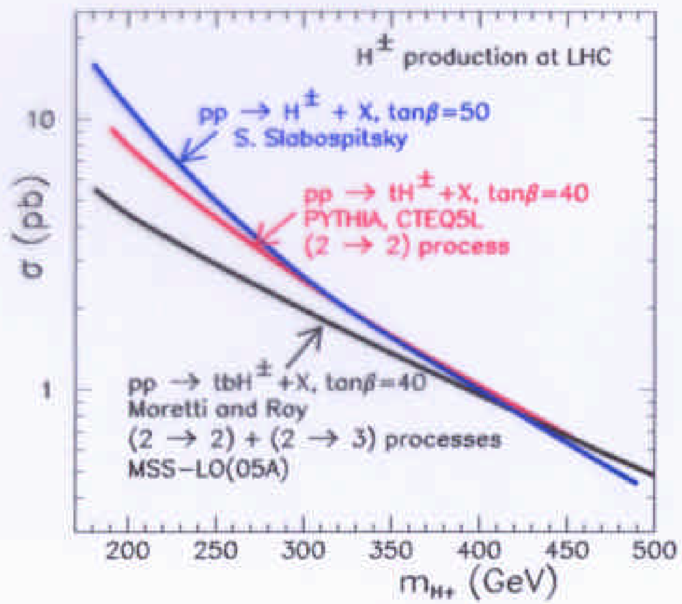




Associated production sum of
$gg \to tbH^+$ and $gb \to tH^+$
with substraction of common terms

$gb \to tH^+$ used in PYTHIA simulations

For $qq' \to H^+$ strong dependence on
the light quark masses through
$m_u^2 \cot^2\beta + m_d^2 \tan^2\beta$

Production of $H^+$ in $\tilde{g}$, $\tilde{q}$ cascades can be large



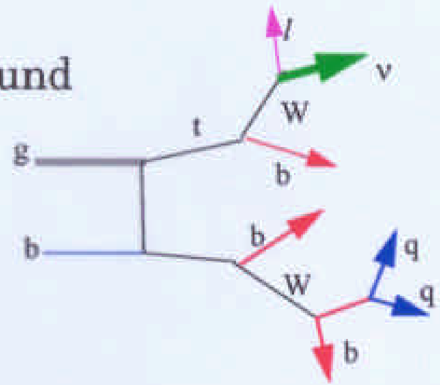
# Search for $H^+$ in gb -> $tH^+$, $H^+$ -> tb

with one lepton + 5 jet (3 b-jet) final state

Background from $t\bar{t}bb$, $t\bar{t}jj$, $t\bar{t}j$ .. + combinatorial background

$t\bar{t}j$ with one mistagged jet (q,g) dominates

Present studies with PYTHIA event generation




Signal can be extracted with full event reconstruction:

reconstruction of leptonic and hadronic top with

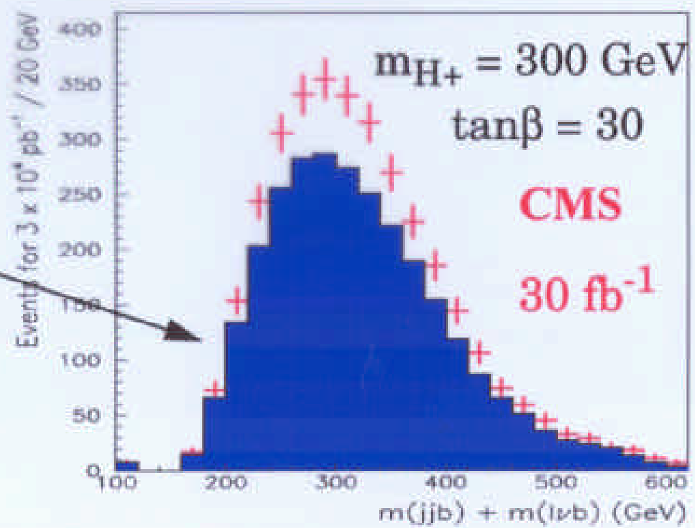
3 tagged b-jets

challenge for b-tagging

unfavourable background shape,

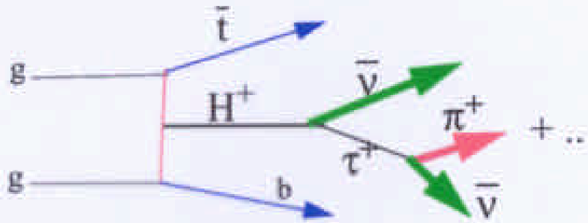
good backgroud calculation needed

Signal superimposed on the background



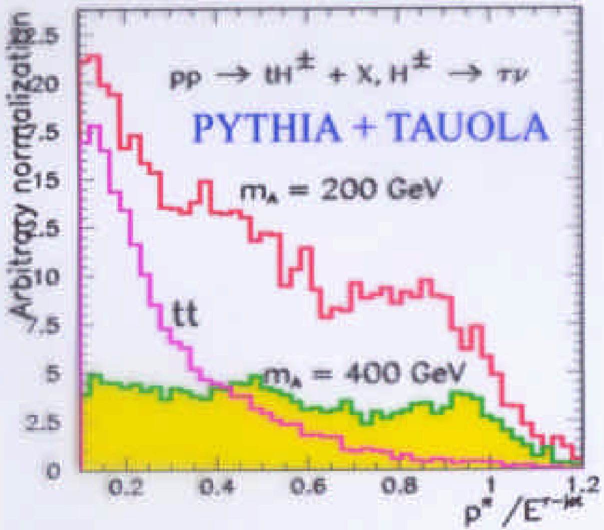
# Search for $H^+$ in $tbH^+$, $H^+ \to \tau\nu$, $\tau \to$ hadron+X, top -> jjb

Background from $t\bar{t}$, Wtb and W+jets




Spin correlations can be exploited to enhance signal/background using

$p^{\pi} / E^{\tau\text{-jet}} > 0.8$, $E_t^{\tau\text{-jet}} > 100$ GeV



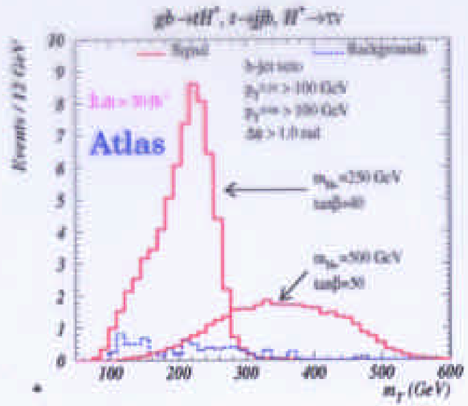

$\tau$ spin opposite in $H^+ \to \tau^+\nu$ and $W^+ \to \tau^+\nu$

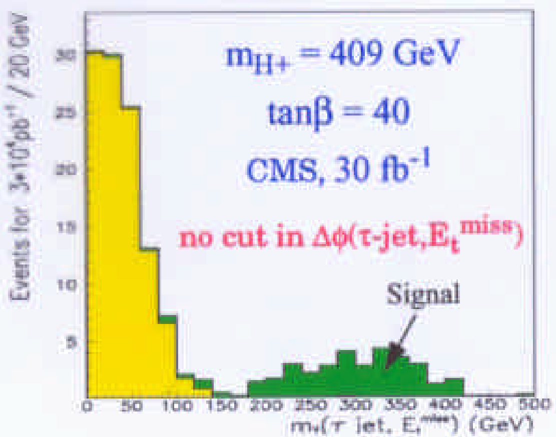
**-> harder pions from H -> $\tau\nu$ than from W -> $\tau\nu$**

Almost background-free signal expected in

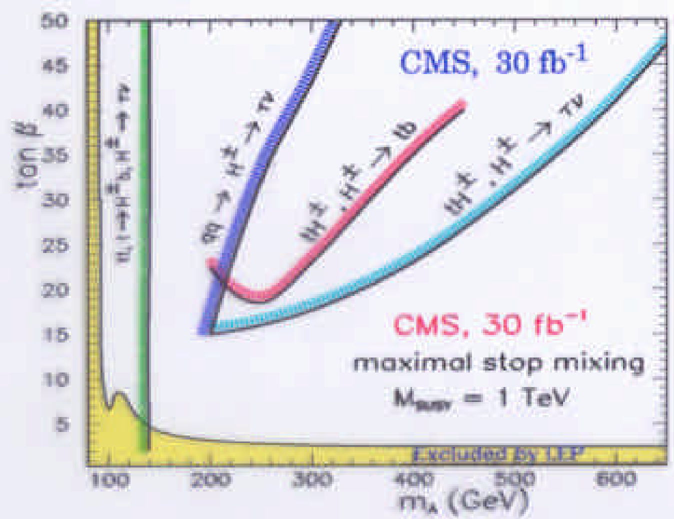
$m_T(\tau\text{-jet}, E_t^{miss})$ in fully hadronic events

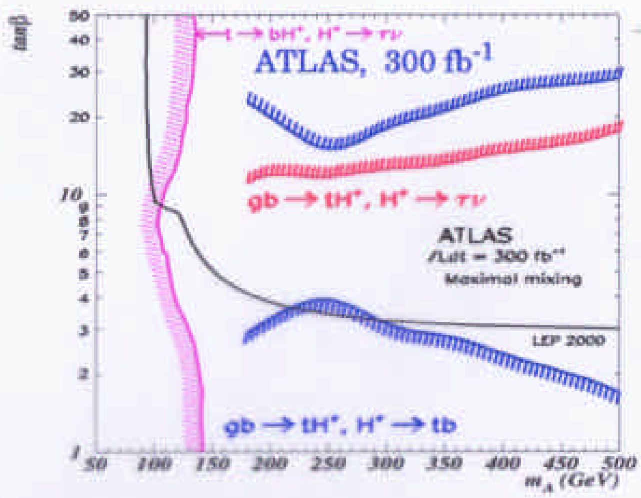
Discovery reach limited by signal statistics



# Expected 5σ discovery reach for charged Higgs at LHC




$\sigma \sim m^2_t \cot^2\beta + m^2_b \tan^2\beta$ -> no sensitivity in intermediate tanβ for heavy Higgs in gb -> $tH^+$ with SM decays

Other possibilites under study:

- Decays to SUSY particles: $H^+ \to \chi_1^+\chi_2^0 \to$ 3 leptons + $E_t^{miss}$ may cover only small area
- $H^+ \to Wh$, $h \to b\bar{b}$ viable signal only at tanβ~2-3, $m_{H+}$= 200 GeV, ATLAS study

  in NMSSM may be dominant at low tanβ (no more excluded by LEP)

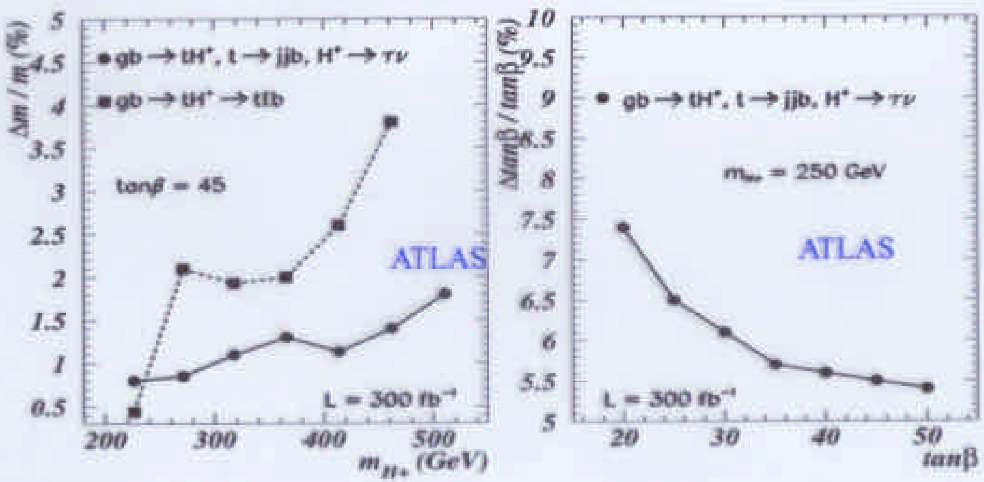
- $H^+ \to \tau\nu$ produced in SUSY cascades looks promising
- $H^+ \to \tau\nu$ in large extra dimensions (ATLAS): promising channel, τ polarization may help to disentangle the model

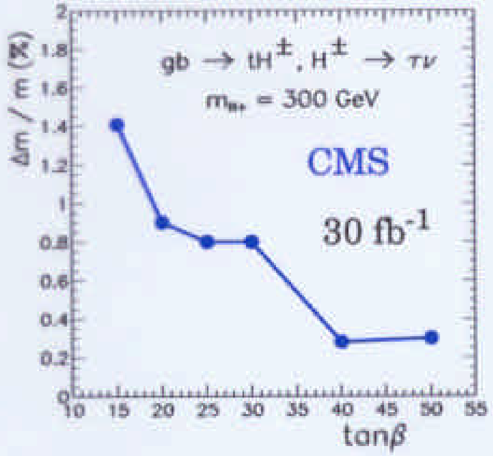
# Determination of $m_{H^+}$ and $\tan\beta$

Mass determination from $m_T(\tau\text{-jet}, E_t^{miss})$ for $H^+ \to \tau\nu$ using log-likelihood method (Atlas), fits to $m_T$ (CMS)

Precision dominated by statistics .

Systematics: background shape (10%), background rate (5%), energy scale (1% jets, 0.1% $\gamma$,e,$\mu$)



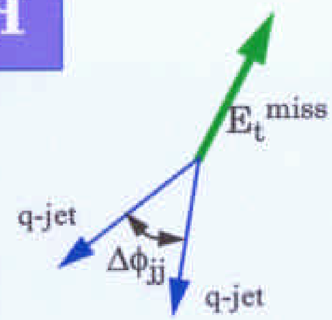




$\sigma \times BR \sim \tan^2\beta$ at high $\tan\beta$ -> $\tan\beta$ can be measured from event rates

Precision $\frac{\Delta\tan\beta}{\tan\beta} = \frac{1}{2}\frac{\Delta(\sigma \times BR)}{\sigma \times BR}$

limited by uncertainties in luminosity (10% assumed)

## Search for invisible Higgs in qq -> qqH




Higgs can decay to stable neutral weakly interacting particles:

lightest neutralinos, gravitinos..

Challenge for trigger and calorimeter as a trigger on pure jets and $E_t^{miss}$ is needed

CMS: trigger uses jets up to $|\eta| < 5$ and $E_t^{miss}$ , topological cuts ($\Delta\eta_{jj} > 4$..) on Level2

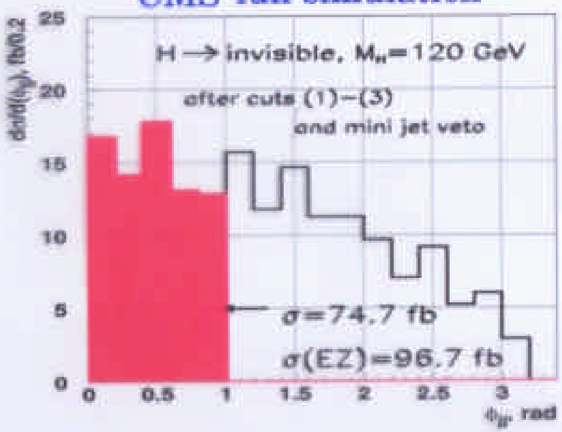
ATLAS: trigger for this channel still under study

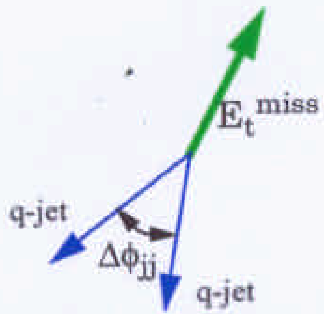
Backgrounds: EW Zjj, Z->νν, EW Wjj, W->lν (CompHEP + PYTHIA)
QCD Wjj and Zjj (matrix elem. calc. + PYTHIA)
QCD, instrumental $E_t^{miss}$ or heavy flavours (PYTHIA)

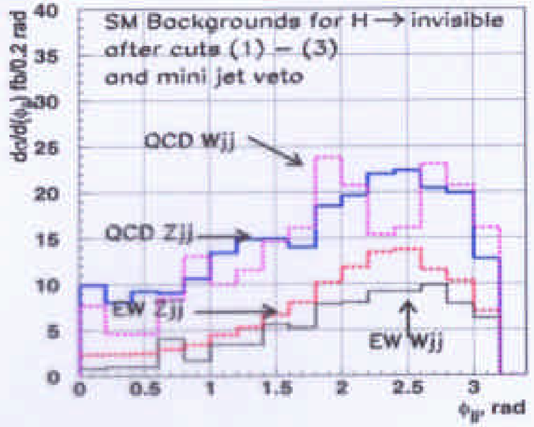
Background reduction: double forward jet tagging, central jet and lepton veto,
large $E_t^{miss}$ (>100 GeV), $E_t^{miss}$ isolation (ATLAS)

qq -> qqH dynamics, favours small $\Delta\phi_{jj}$ angles -> look for excess of events in $\Delta\phi_{jj} < 1$

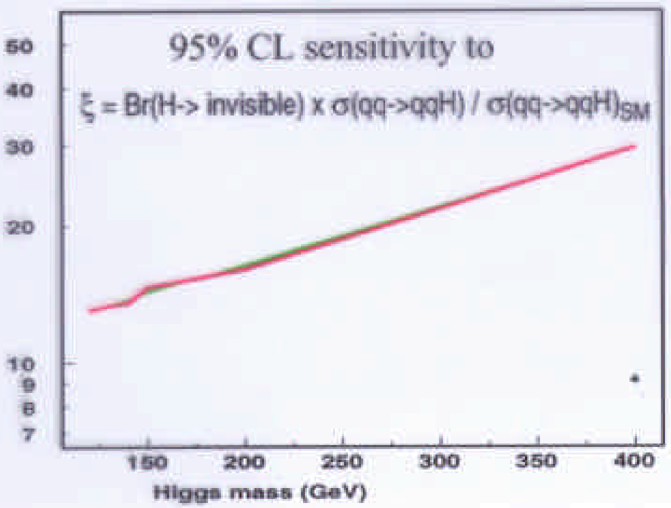
CMS full simulation




## Sensitivity to invisible Higgs




assuming that the background can be determined with an accuracy of 3%

Good knowledge of background level essential

-> will be known from data

using Wjj, W-> $l\nu$ and Zjj, Z-> $ll$ events

systematic error still under study

# MSSM Higgs:

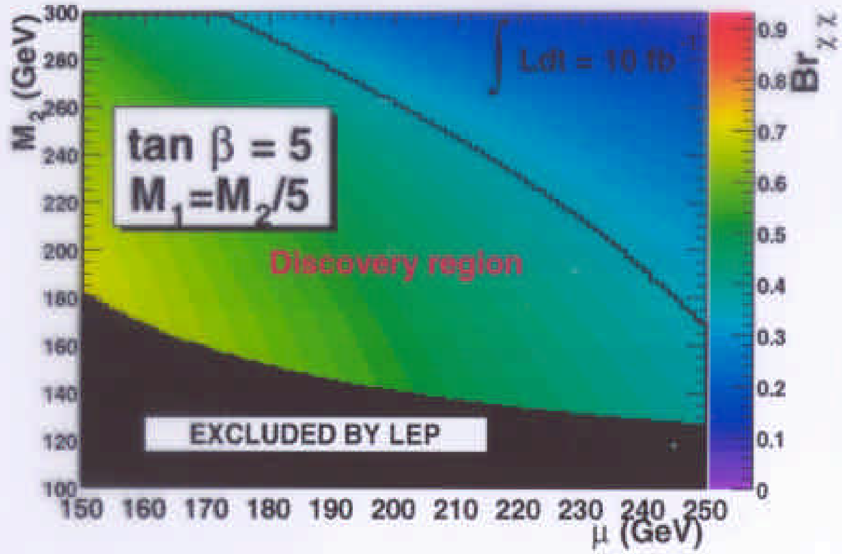
$$\frac{\sigma(qq\text{->}qqH)_{MSSM}}{\sigma(qq\text{->}qqH)_{SM}} = (g_V^{h/H})^2$$

$(g_V^{h})^2 = \sin^2(\alpha-\beta)$

$(g_V^{H})^2 = \cos^2(\alpha-\beta)$

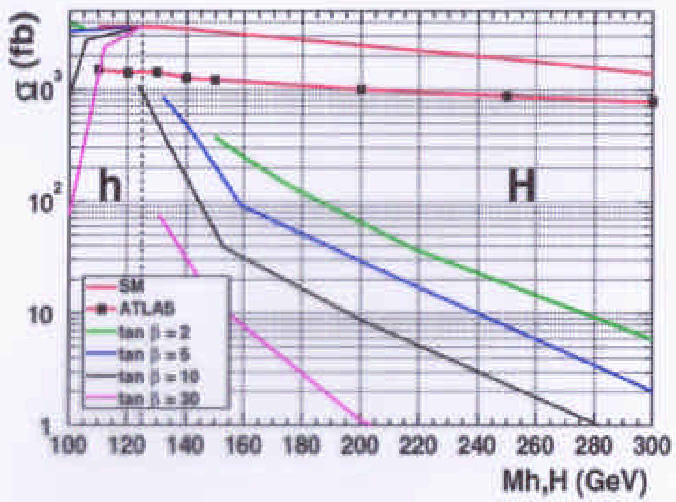
Strong suppression of qq-> qqH

Limit for BR(H->$\chi\chi$)




95% LC limit for σ(qq->qqh)

assuming BR(h->invisible)=1




## Large H -> $\chi\chi$ scenario:

relaxing gaugino mass unification

For $M_1/M_2 = 1/5$

BR(H->$\chi\chi$) $\lesssim$ 60%

at medium tanβ values

# Conclusions

## Discovery for SM Higgs already for 10 $fb^{-1}$ over full mass range

$m_H < 125$ GeV is the more difficult part but searches with qq -> qqH add promising possibilities to already well known channels $H \to \gamma\gamma$, $b\bar{b}$

More full simulation studies needed to understand the efficiencies - especially for central jet veto in qqH final states

## For MSSM Higgs full parameter space covered already with 30 $fb^{-1}$

For heavy MSSM Higgs intermediate $\tan\beta$ values difficult - difficult to distinguish between SM and MSSM

Decays to SUSY particles and production in SUSY cascades can cover partly this range and are being actively investigated

## Studies going on for Higgs parameter measurements:

$m_H$, $\Gamma_H$, $\tan\beta$, spin, CP measurement...