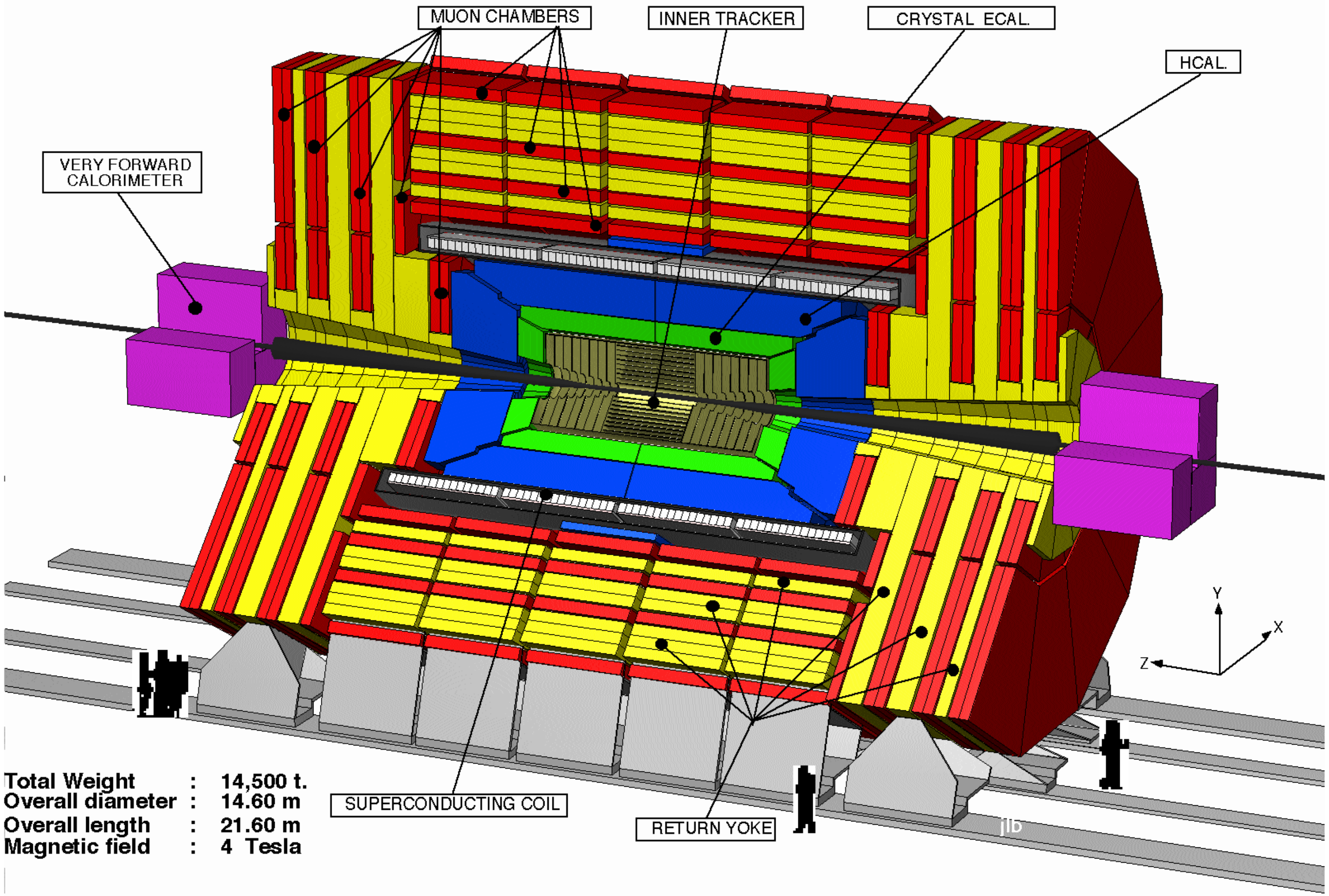
PROSPECTS FOR THE DETECTION OF NEUTRAL MSSM HIGGS BOSONS DECAYING INTO TAU LEPTONS IN THE CMS DETECTOR

S. Lehti
Helsinki Institute of Physics

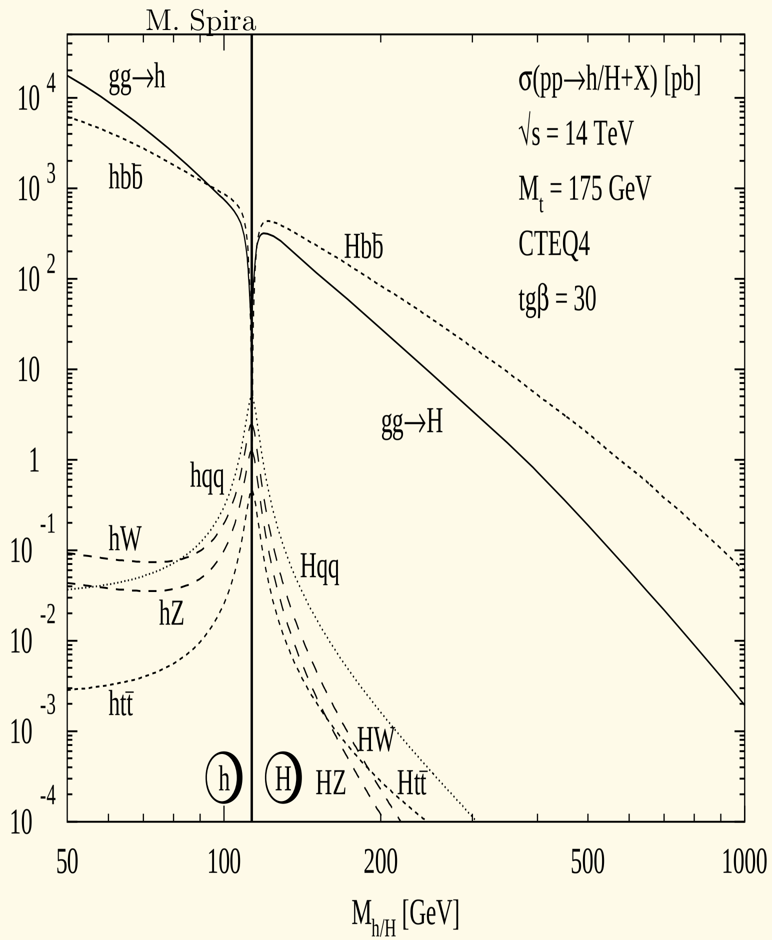
5.1.2002

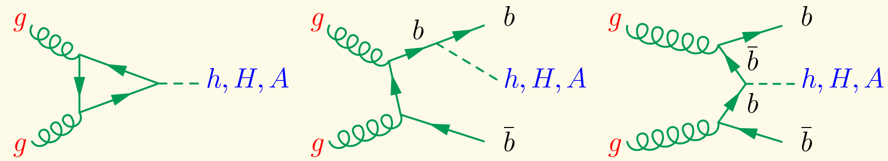
A Compact Solenoidal Detector for LHC



Total Weight	:	**14,500 t.**
Overall diameter	:	**14.60 m**
Overall length	:	**21.60 m**
Magnetic field	:	**4 Tesla**

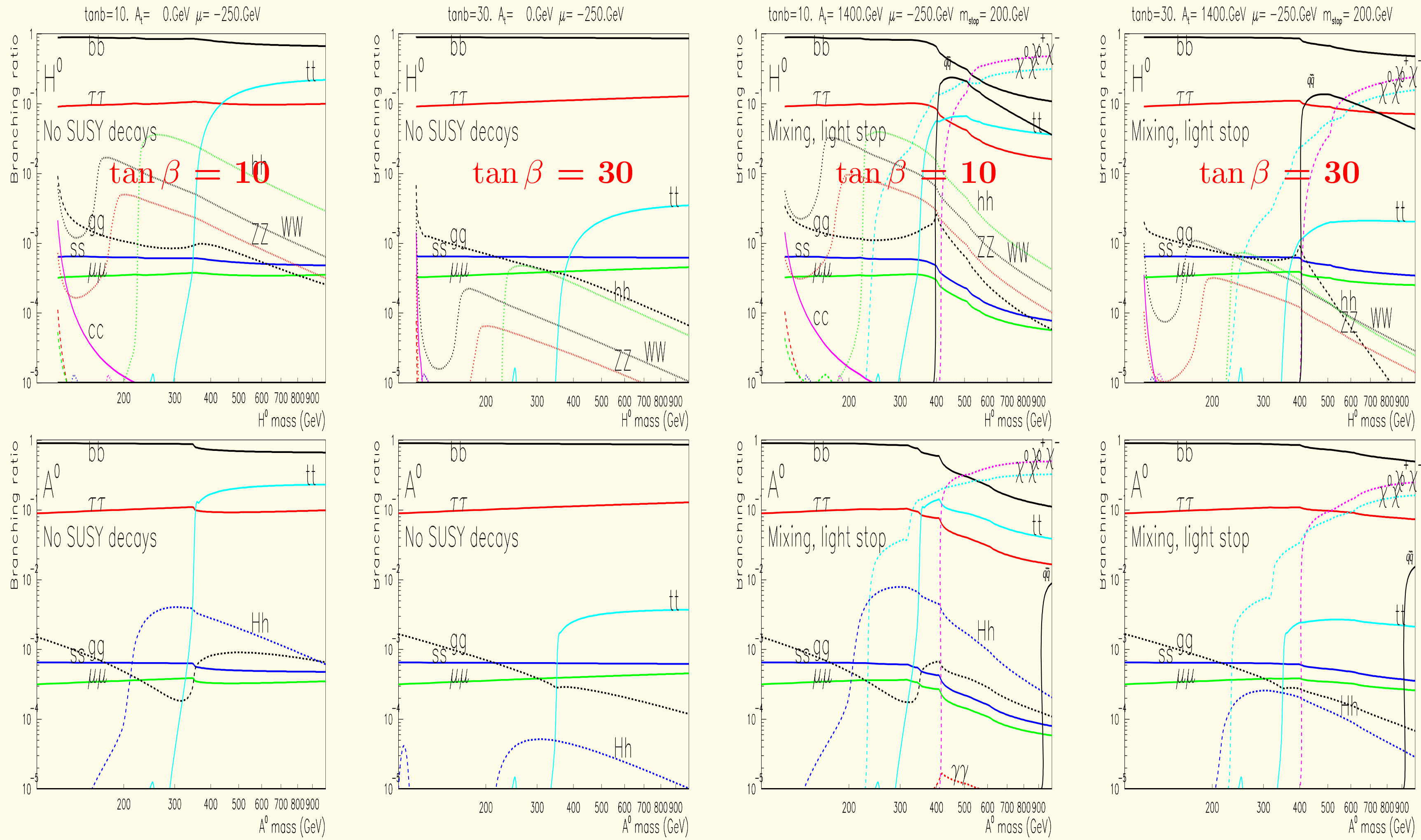
Higgs production



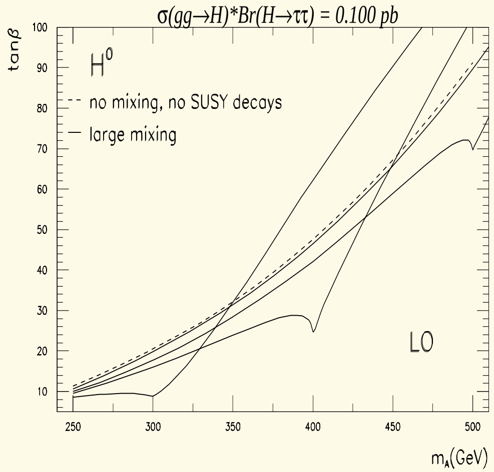


- Most important mechanisms are gluon fusion and Higgs strahlung off b-quarks (associated production)
- Couplings to b-quarks $\tan\beta$ enhanced
- Vector boson fusion could cover the whole (m$_A$,$\tan\beta$) space, but the rate is small. Can be used to study the CP-even Higgs bosons separately from A^0
- For m$_A$ = 140 GeV, $\tan\beta$ = 14 the cross section into $\tau\tau$ channel is $\sigma(gg \to b\bar{b}H/b\bar{b}A) \times BR(H/A \to \tau\tau) \sim$ 10 pb

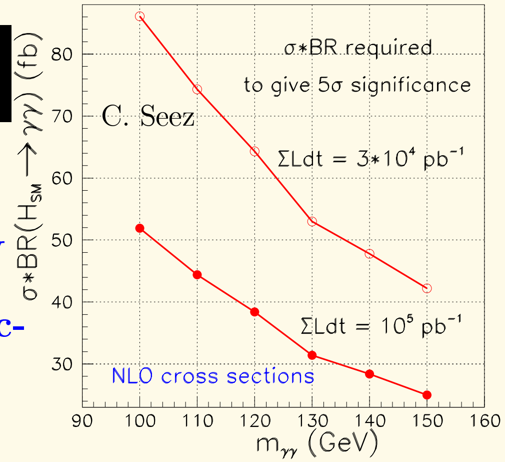
Branching ratios



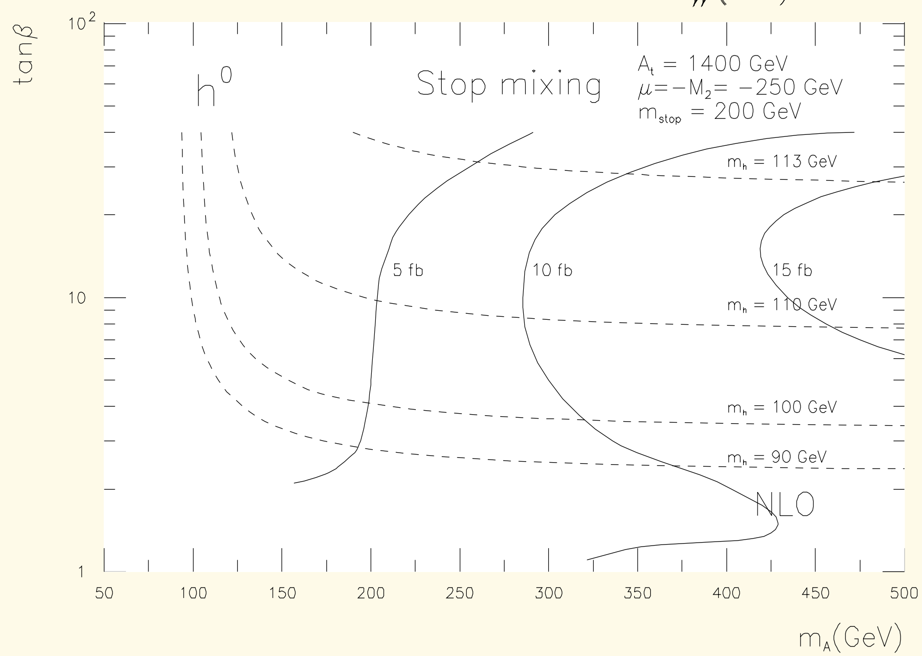
Stop mixing effects



- **Large mixing, light stop ($m_{\tilde{t}_1} \sim m_t$)**
- **A_t = 1400 GeV, $M_2 = -\mu$ = 250 GeV**
- **A^0 and the associated Higgs production not affected**

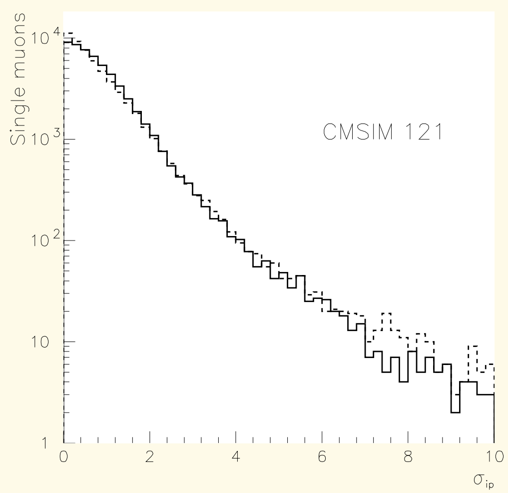


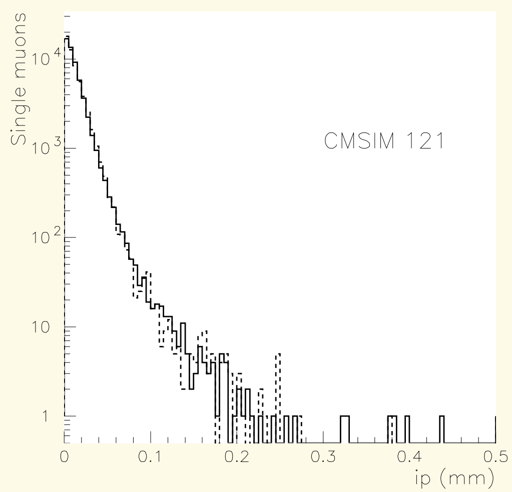
$gg \to H_{SUSY}$, $gg \to b\bar{b}H_{SUSY}$, $H_{SUSY} \to \tau\tau$	$\sigma \cdot$Br[fb]
large mixing, $m_{\tilde{t}_1}$ = 200 GeV	
m_A=400 GeV, tanβ = 25	910.3
m_A=500 GeV, tanβ = 25	253.4
m_A=800 GeV, tanβ = 50	113.0
no mixing, $m_{\tilde{t}_1}$ = 1000 GeV	
m_A=400 GeV, tanβ = 25	887.8
m_A=500 GeV, tanβ = 25	334.5
m_A=800 GeV, tanβ = 50	140.3

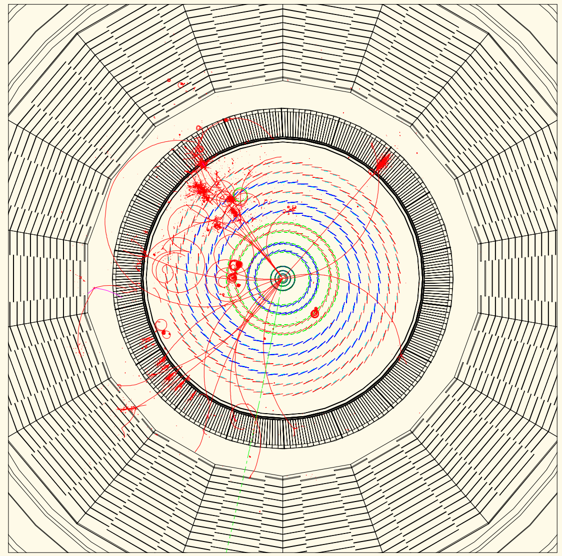


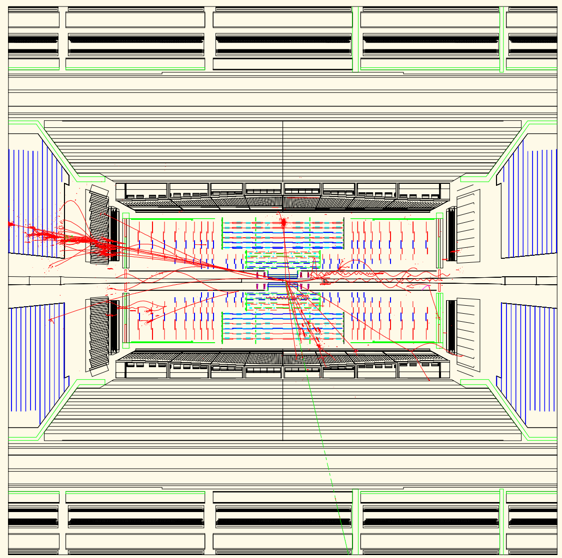
Detailed detector simulations

- GEANT based CMSIM and ORCA simulations
- Time consuming
- Used to confirm the results from fast simulations or to parametrize the detector response for fast simulations studies
- Single particle performance of the tracker, jet reconstruction, b-tagging, mass reconstruction



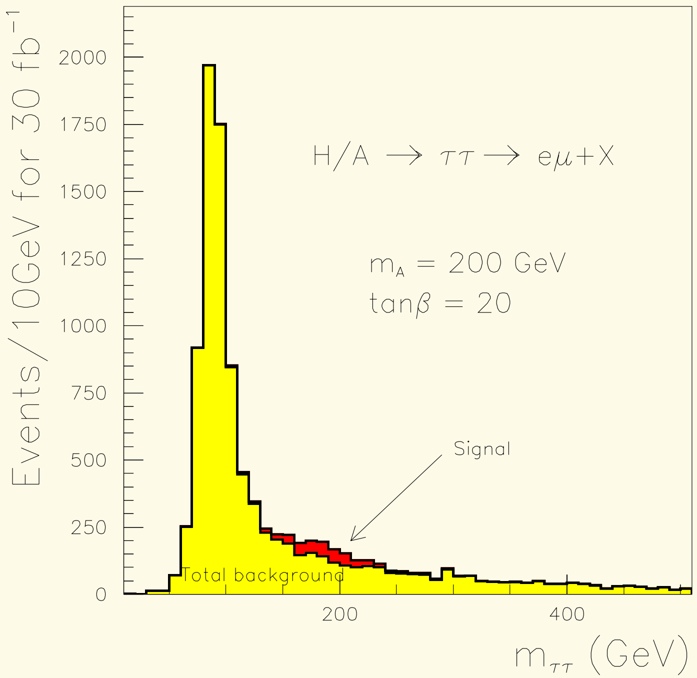


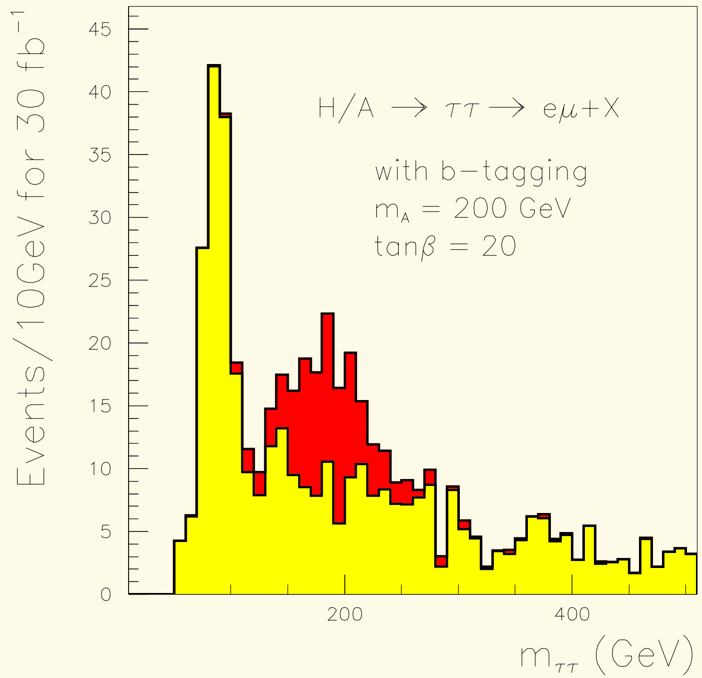




b-tagging

- Higgs produced mostly in association with b-quarks
- DY irreducible if no b-tagging is used
- With simple algorithm a tagging efficiency of 35% achieved for b-jets in signal while keeping the mistagging rate at $\sim 1\%$
- b-jets in $t\bar{t}$ background more central and more energetic





Fast simulations

- **Three years at low luminosity, $3 \cdot 10^4$ pb^{-1}, no pile-up**
- **PYTHIA Monte Carlo with CTEQ4L structure functions**
- **m_t = 175 GeV (CDF and D0)**
- **No stop mixing, heavy SUSY particles**
- **Detector response with CMSJET**
- **Reconstruction efficiency 95% for both e and μ**
- **A 5σ signal required, possible around $m_A \sim$ 100 - 300 GeV at large tanβ**

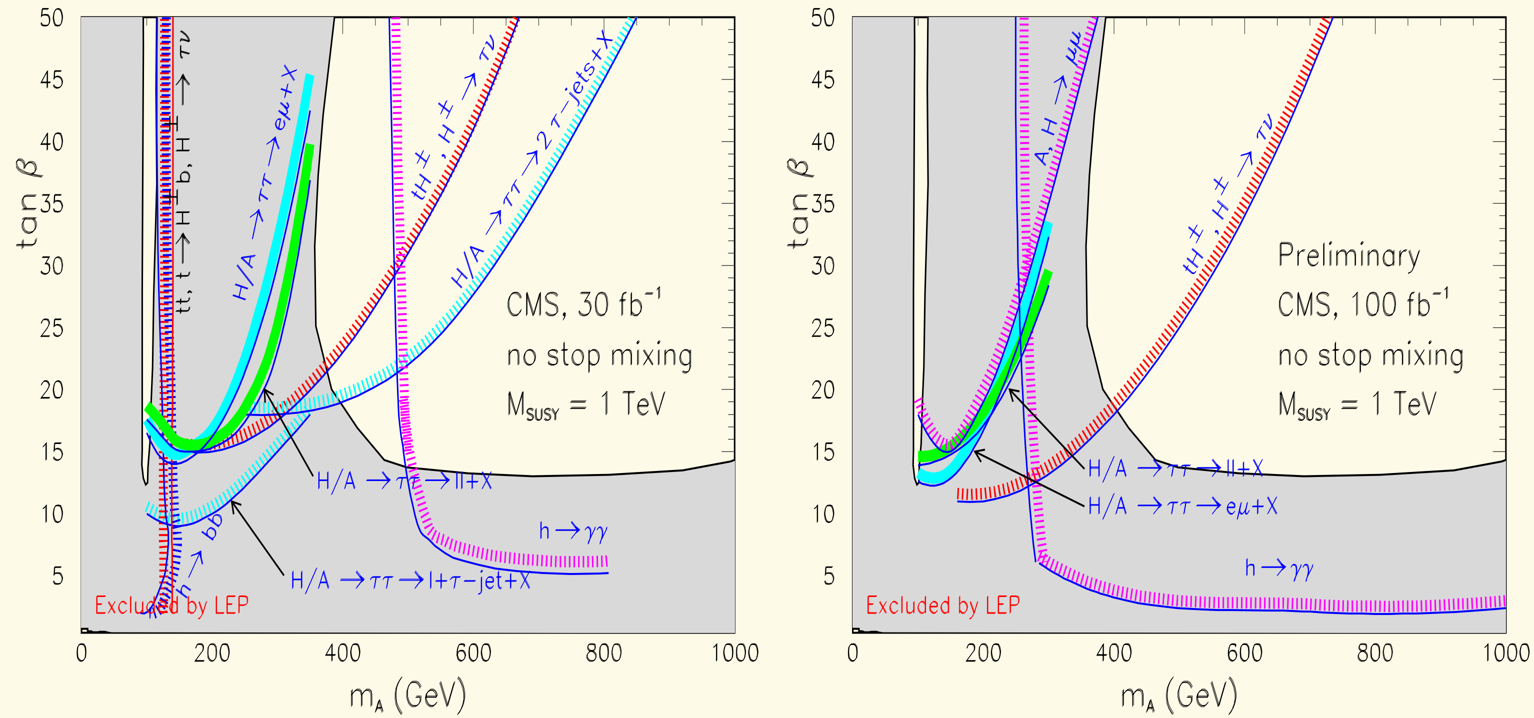
Cut	Signal	Z,γ^*	$t\bar{t}$	$b\bar{b}$	WW,WZ	signif.
All events	26260	2706900	604270	$8.69{\cdot}10^{10}$	33406	
$\lvert\eta\rvert < 2.5, p_T^l > 20$ GeV, isol.	3830	77066	204103	2416	18682	
$\Delta\phi(e,\mu) < 175^\circ$	2844	54702	193111	1818	17359	
$\sigma_{ip}^e \oplus \sigma_{ip}^\mu > 2.3$	1344	22353	13000	1648	638.4	
one jet, $E_T > 20$ GeV	360	6068	3237	107.8	70.6	
b-tagging	107	244	1855	36.7	1.49	
110 GeV $< m_{\tau\tau} <$ 160 GeV	66.5	17.9	65.4	0.856	0.0147	5.4

High luminosity

- At $L > 10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$ several separate events at the same bunch crossing
- Add a non-negligible level of background
- Track and jet reconstruction affected
- Soft particles, no significant effect on isolation
- b-tagging less efficient
- The background can be suppressed by smaller jet cone and larger p_T threshold, and by using the primary vertex
- The 5σ reach for $H_{SUSY} \rightarrow \tau\tau \rightarrow e\mu$ with 10^5 pb^{-1} is slightly different as a function of m_A than the reach at low luminosity
- New Higgs channels possible, better coverage

Significance contours for SUSY Higgses

- **Regions explorable through various SUSY Higgs channels**
- **No stop mixing, $M_{SUSY} = 1$ TeV**



Significance contours for SUSY Higgses

- Regions explorable through various SUSY Higgs channels
- Stop mixing, maximal m_{h^0}