Searches for Neutral Higgs Bosons in MSSM-like Topologies with ATLAS and CMS

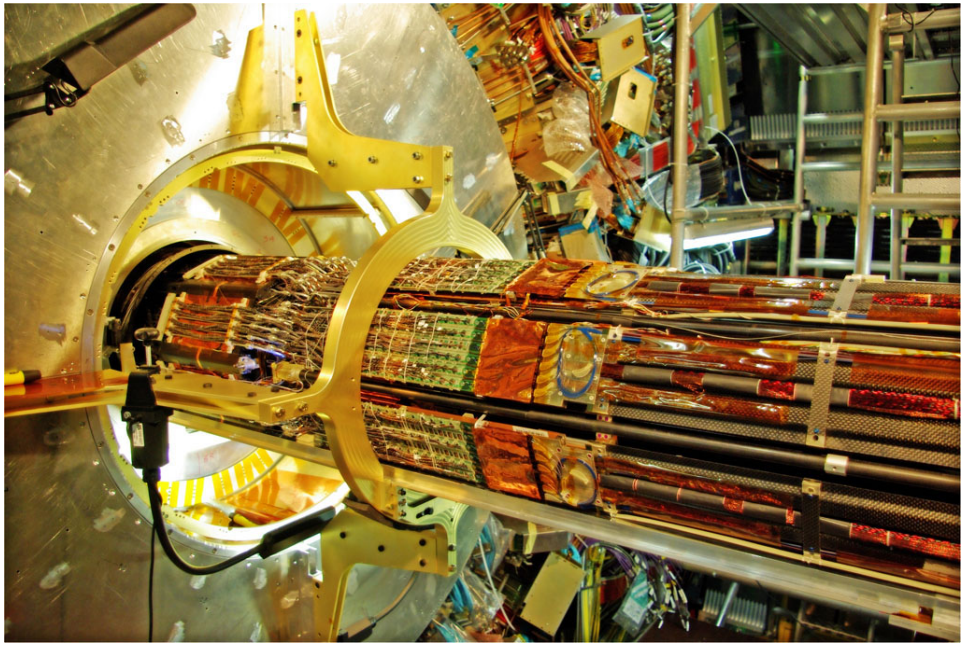
Markus Klute
Massachusetts Institute of Technology

On behalf of the ATLAS and CMS collaborations

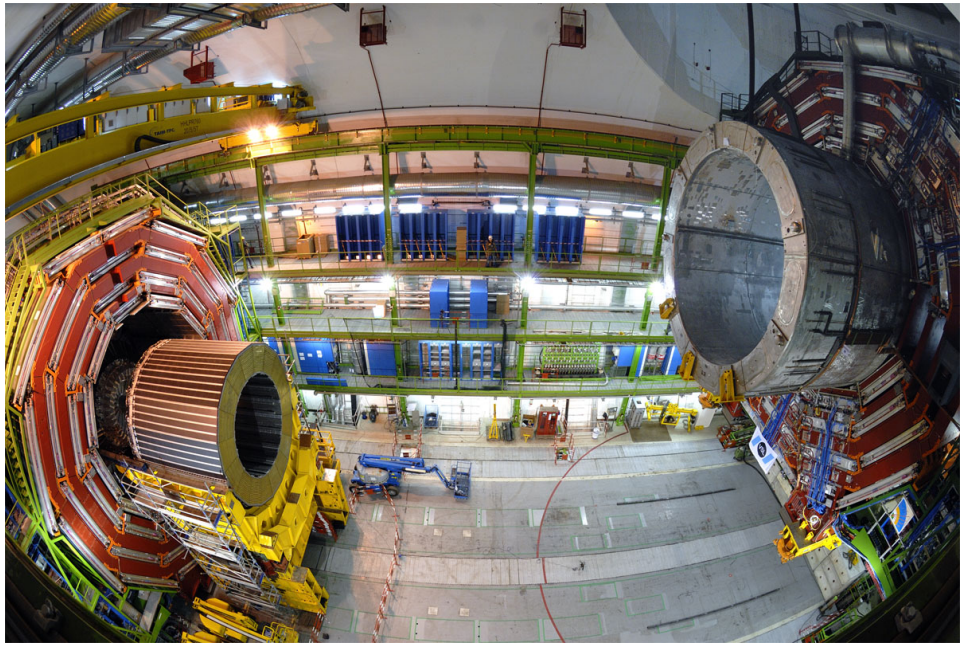
ATLAS & CMS

- experiments are preparing for first collision data in 2008.
- see previous talks or EPS 2007 talks on detector status.

Installation of the
ATLAS pixel detector
06/28/2007



Lowering of CMS
central barrel wheel
02/28/2007



Outline

- Higgs Sector in the MSSM
- Searches in:

$$\mathrm{bb}\Phi \rightarrow \mathrm{bb}\mu\mu$$
$$\mathrm{bb}\Phi \rightarrow \mathrm{bb}\tau\tau$$
$$\mathrm{A} \rightarrow \mathrm{Zh}$$

- Conclusion

Higgs Sector in the MSSM

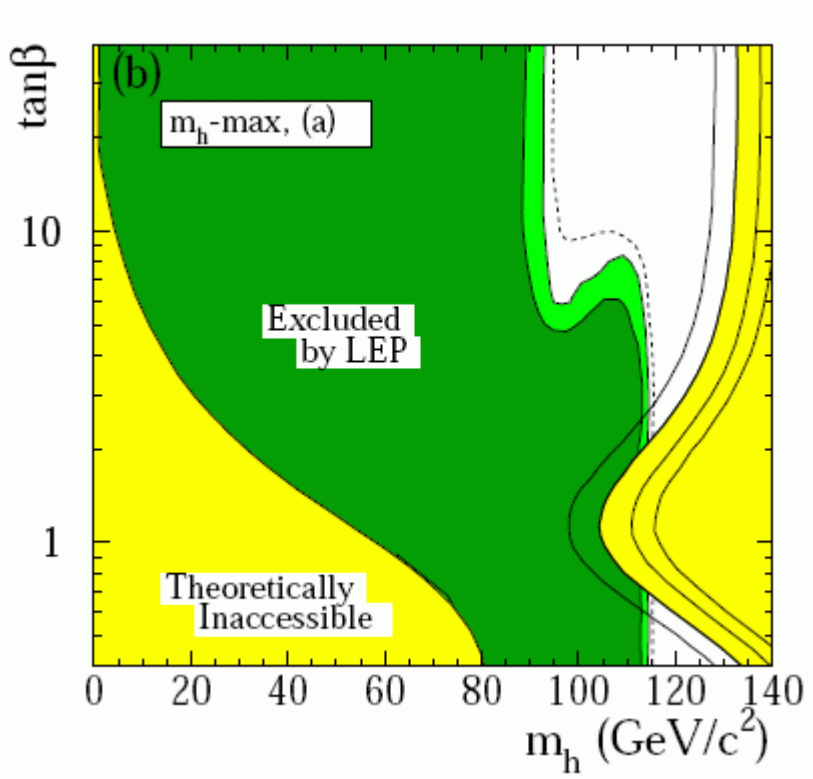
- 2 Higgs doublets, 5 physical bosons
  - 2 CP-even h, H, 1 CP-odd A and 2 charged H+, H-
- at Born level 2 parameter: tan β, m_A ($m_h < m_Z$)
- large loop corrections from SUSY parameters
  - $m_h < 133$ GeV (for $m_{top} = 175$ GeV, $M_{SUSY} = 1$ TeV)
- corrections depend on 5 SUSY parameter:
  - X_t, M_0, M_2, M_{gluino}, μ
  - fixed in benchmark scenarios

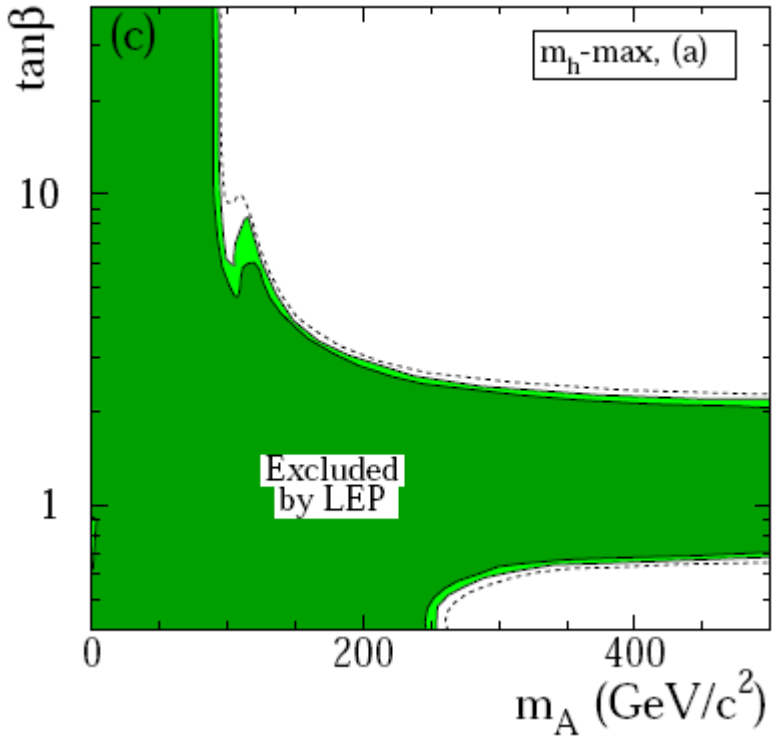
MSSM Benchmark Scenarios

for hadron collider already at LEP

- as suggested by M. Carena et al. (hep-ph/0202167)
- The m_h^{max} scenario
- The no-mixing scenario
- The large-μ scenario (completely ruled out by LEP)
- The gluophobic Higgs scenario
  - designed to affect discovery via gg → h, h → $\gamma\gamma$ and h → ZZ
- The small α^{eff} scenario
  - coupling of hbb (h$\tau\tau$) suppressed
  - designed to affect discovery via VBF, h→$\tau\tau$ and tth, h→bb

Higgs Sector in the MSSM





- high tan β main LHC search area:

$$\mathrm{pp} \to \mathrm{bb}\phi\,(\phi = \mathrm{h}, \mathrm{H}, \mathrm{A}) \text{ and } \phi \to \mu\mu, \tau\tau$$

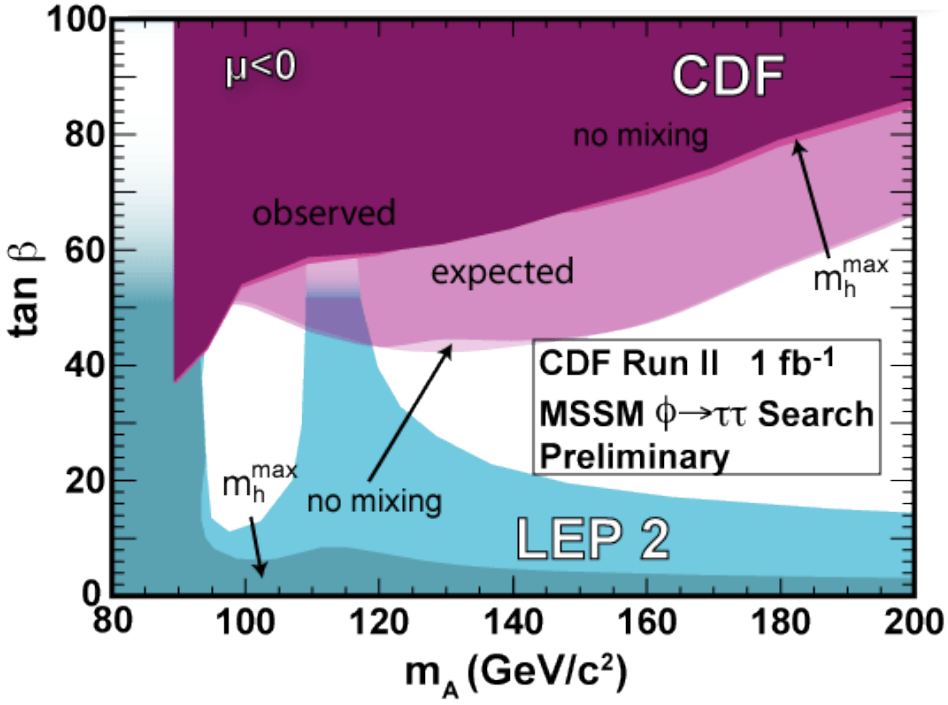
- low tan β is not completely excluded:

$$\mathrm{pp} \to \mathrm{A}; \mathrm{A} \to \mathrm{Zh}$$

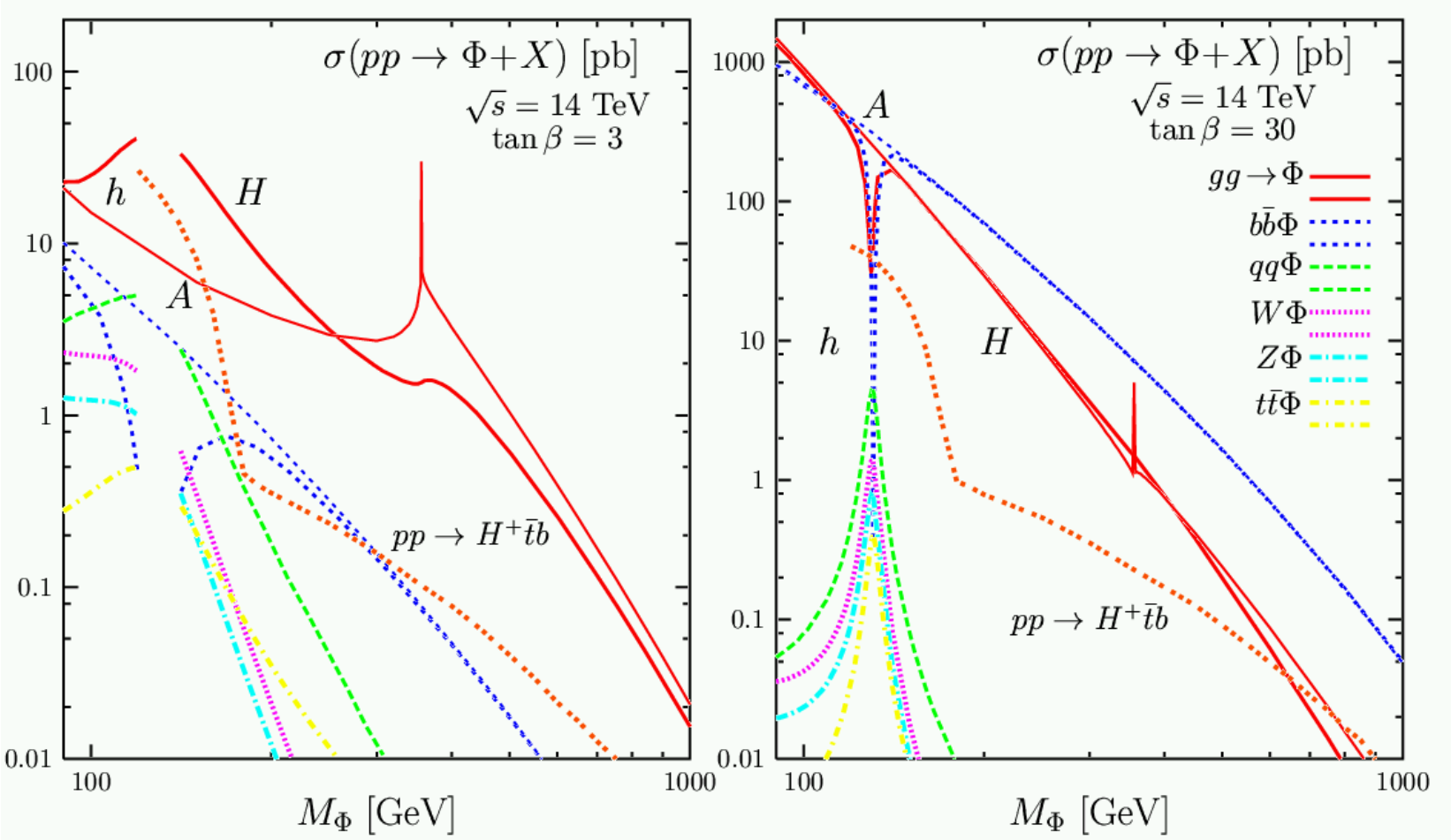
Higgs Sector in the MSSM

Tevatron exclusion region in MSSM in no mix. & m_h^{max} scenario.

(see I. Kravchenko's talk yesterday)

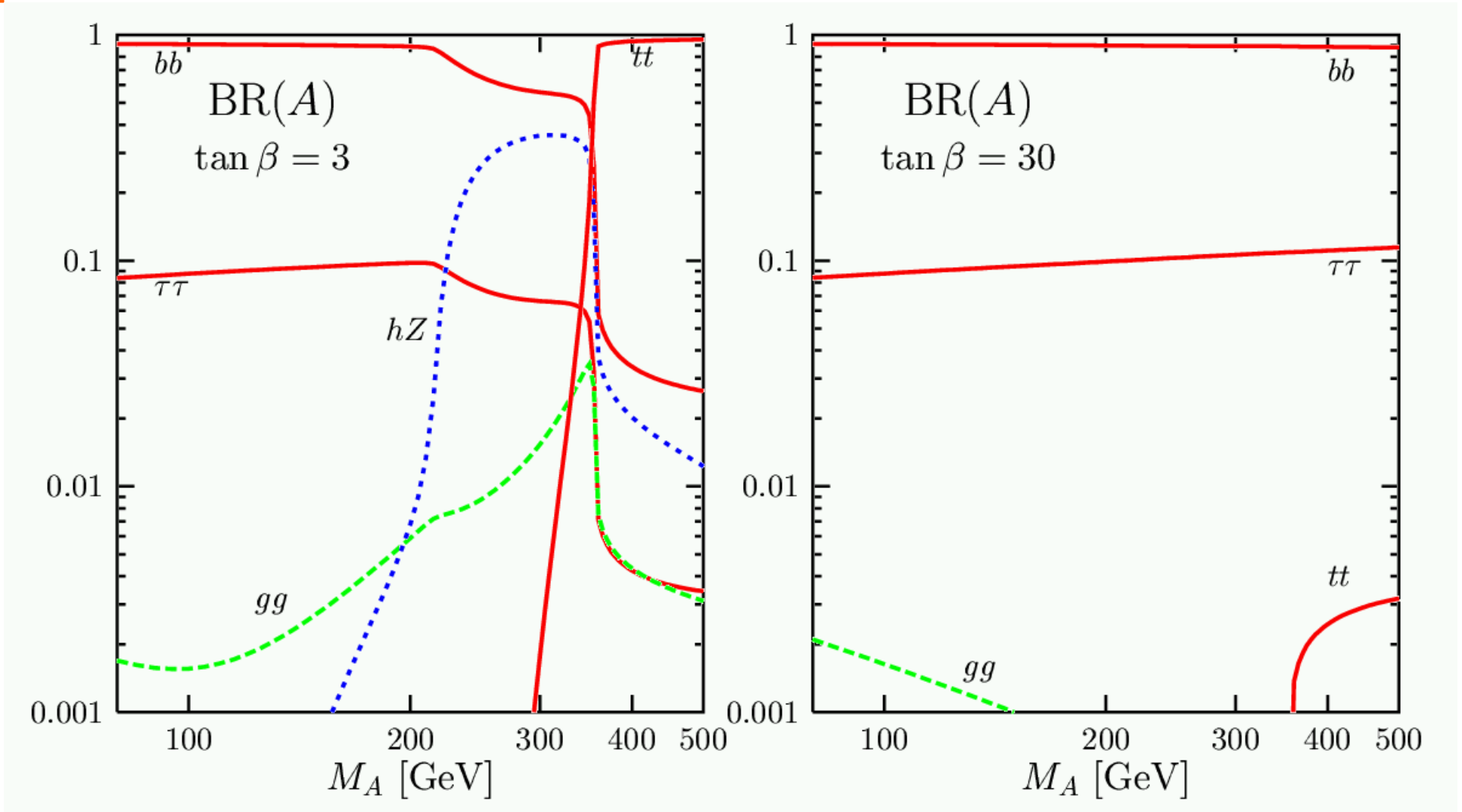


MSSM Higgs Boson Production



m_h^{max} scenario, m_{top}=178GeV

CP-odd Higgs Boson Decay



Search for neutral Higgs Bosons

high tan β:

$$pp \to bb\phi \; (\phi = h, H, A)$$
$$\phi \to \mu\mu$$
$$\phi \to \tau\tau$$

low tan β:

$$pp \to A$$
$$A \to Zh$$
$$Z \to ll \; (l = e, \mu)$$
$$h \to bb$$

++ SM-like topologies

b-tagging

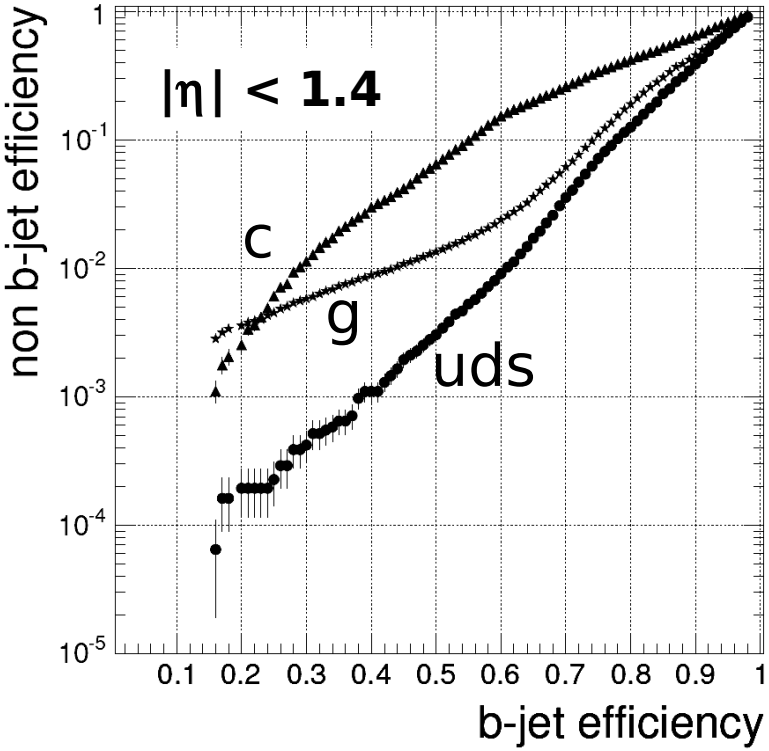
- b-tagging essential for:
  bb ϕ, ϕ → bb, ttH, top final states

- algorithm ranging from track counting, 2d impact parameter to secondary vertex reconstruction

- key performance issues:
  charge hadron reconstruction
  high efficiency and impact parameter resolution
  control fake track reconstruction

- ongoing studies: performance measurements with data

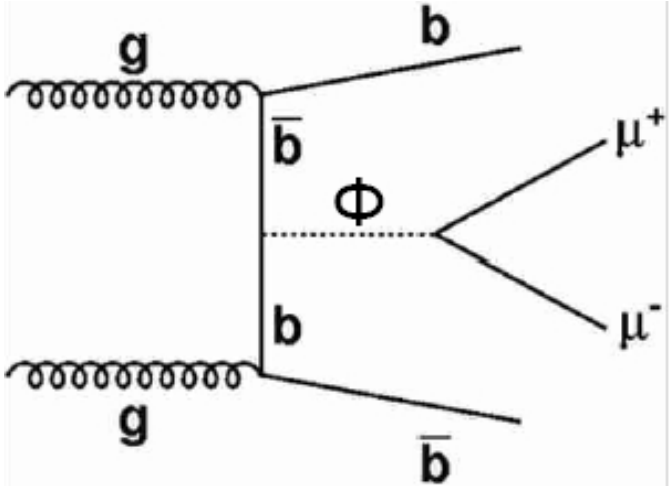
CMS secondary vertex tagger

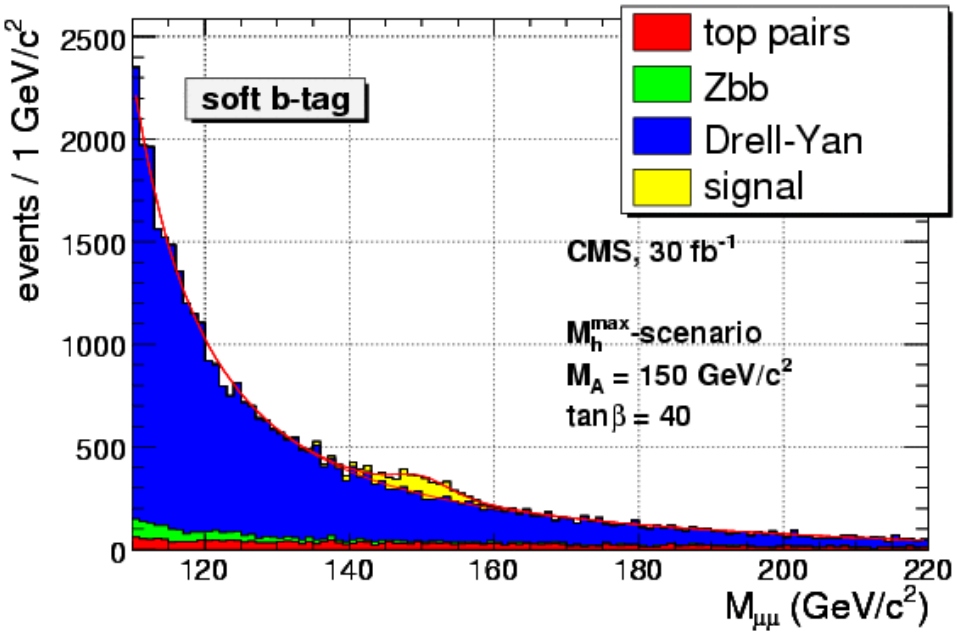


EPS '07 talk by I. Tomalin

Higgs Search: $\mathrm{bb}\Phi \rightarrow \mathrm{bb}\mu\mu$

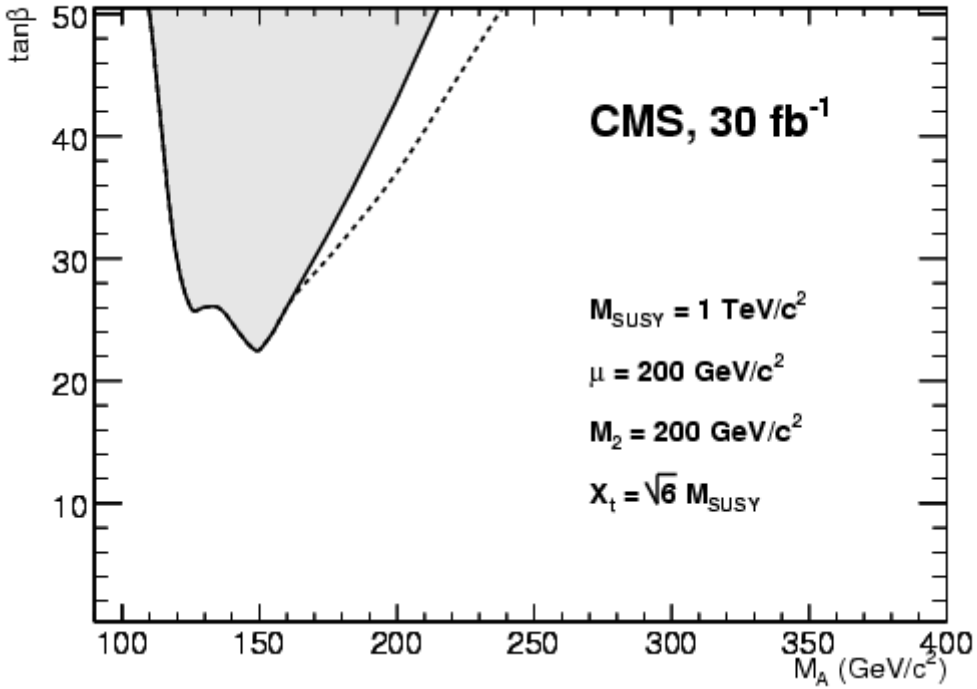
- small branching ratio ($3 \cdot 10^{-4}$)
- precise Higgs mass reconstruction
- measurement of the Higgs width
- main backgrounds: Z+jets, ttbar, Zbb
- signal and background rates can be determined from data.

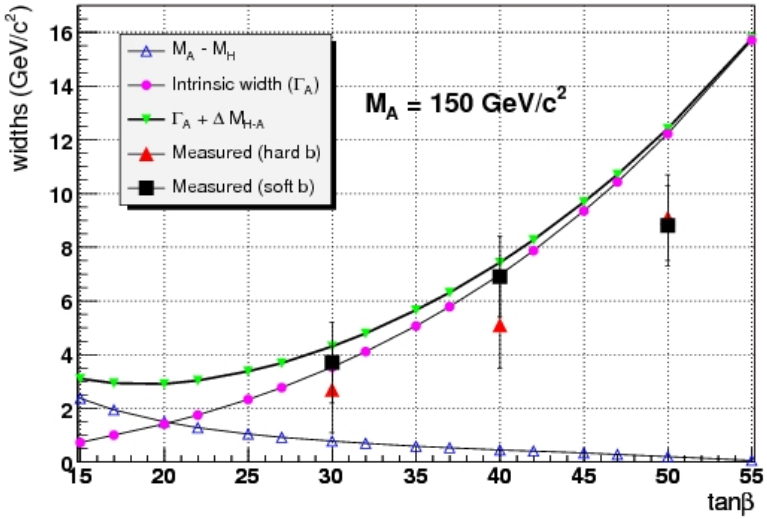


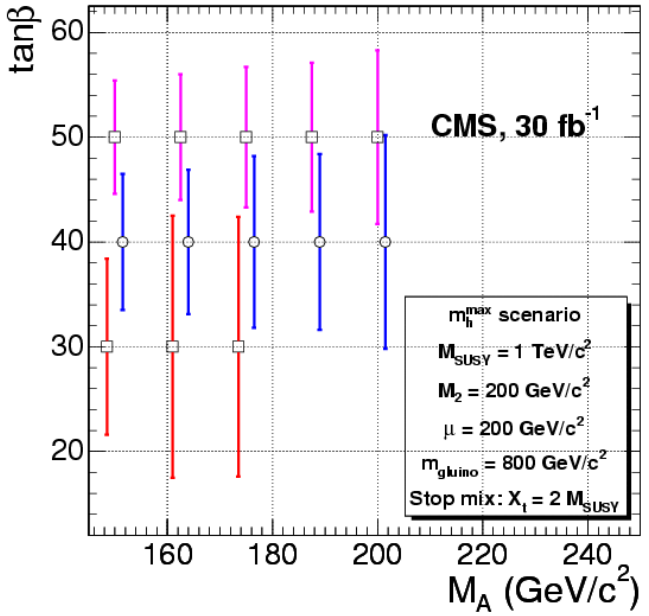


Higgs Search: $bb\Phi \rightarrow bb\mu\mu$

- cross section and width exhibits large sensitivity to tan β



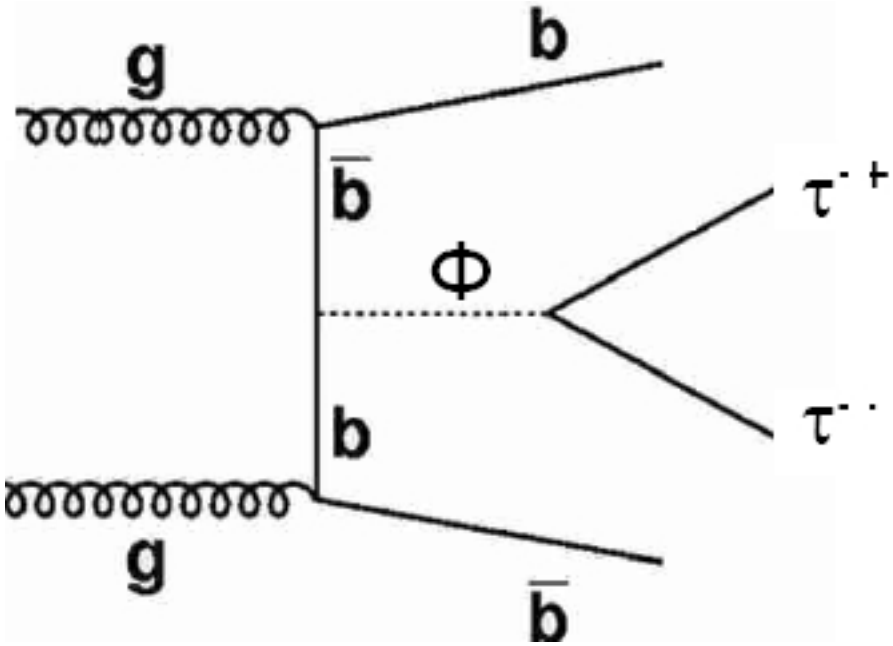




- similar results from ATLAS

Higgs Search: $\mathrm{bb}\Phi \rightarrow \mathrm{bb}\tau\tau$

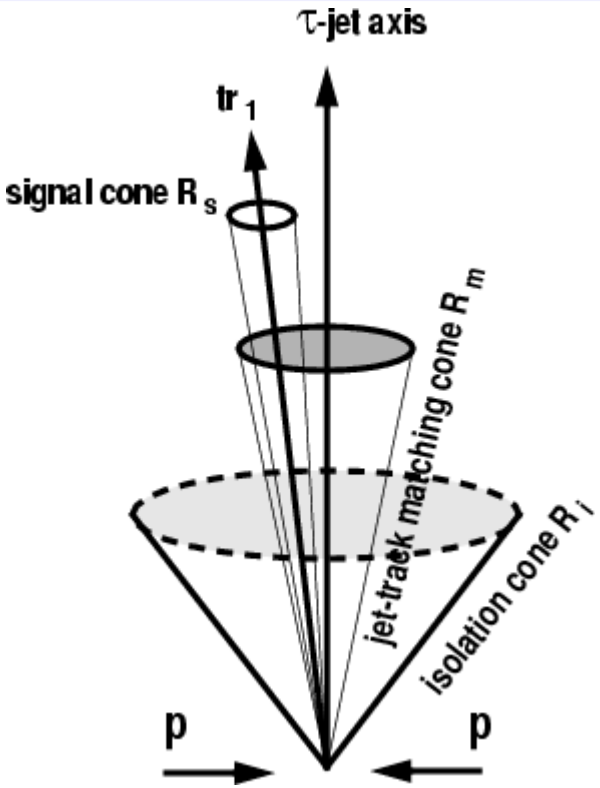
- branching ratio ~10%
- Higgs mass reconstruction using collinear approximation method. Requires excellent missing E_T resolution.
- main backgrounds: Z+jets, ttbar, Zbb



τ-tagging

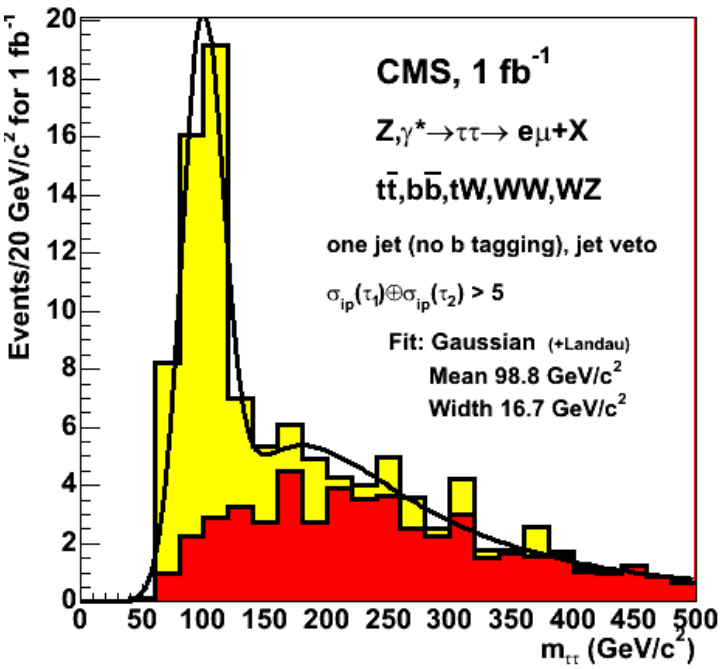
- $c\tau \sim = 87 \mu m$, $m_\tau = 1.78$ GeV/c^2
- leptonical decays
  - $\tau \rightarrow e(\mu)\, \nu\, \nu$: ~ 35.2 %
    - Identification done through the final lepton
- hadronical decays
  - 1 prong
    - $\tau \rightarrow \nu_\tau + \pi^{+/-} + n(\pi^0)$: 49.5 %
  - 3 prongs
    - $\tau \rightarrow \nu_\tau + 3\,\pi^{+/-} + n(\pi^0)$: 15.2 %
  - **"τ jet"**

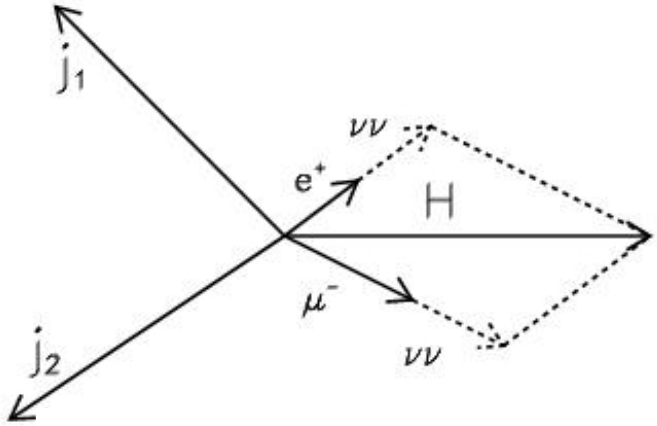
- very active area:
  - track based
  - impact parameter
  - mass tag
  - calorimeter based
  - particle flow
  - performance with data

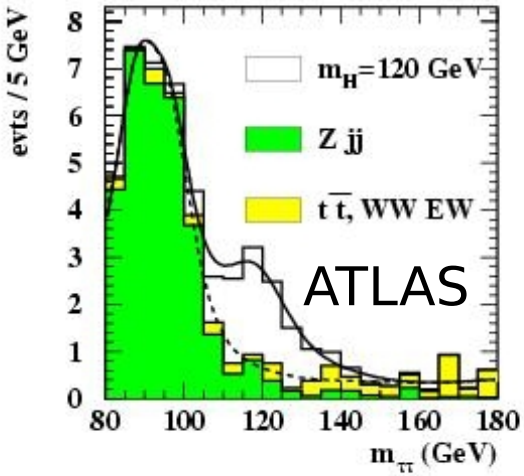


Z and Higgs Mass Reconstruction with τ Decays

- ττ decay modes
  - 12 % ll ν
  - 46% l jet ν
  - 42% jet jet ν







p(l) = x * p(τ) , collinear approximation

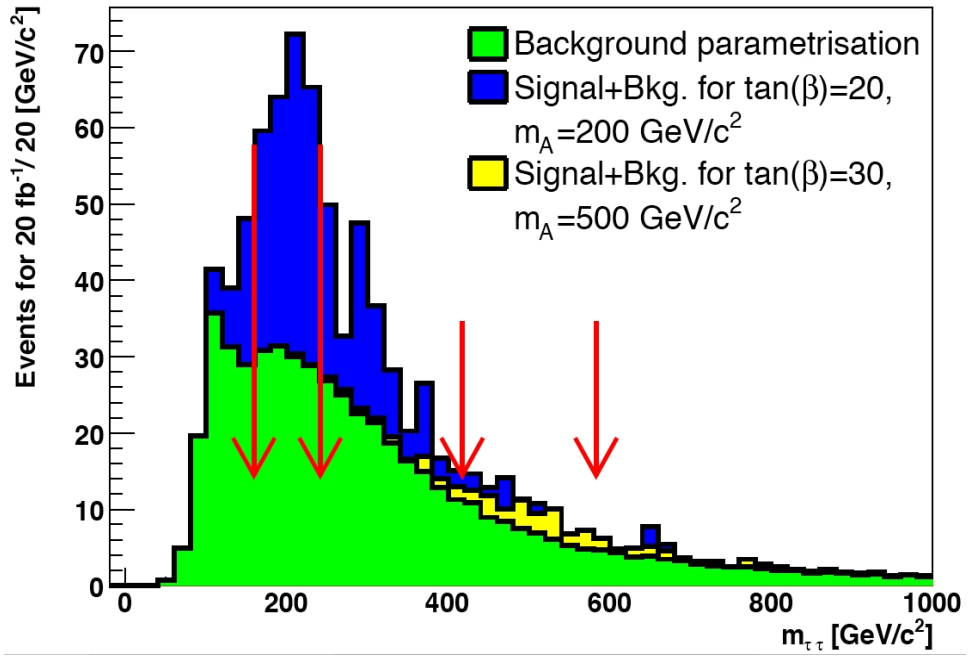
$p_T(H) = p_T(\tau 1) + p_T(\tau 2) = p_T(e) + p_T(\mu) + \not{p}_T$

$m^2_{\tau\tau} = m^2_{e\mu} / (x_{\tau e} * x_{\tau\mu})$

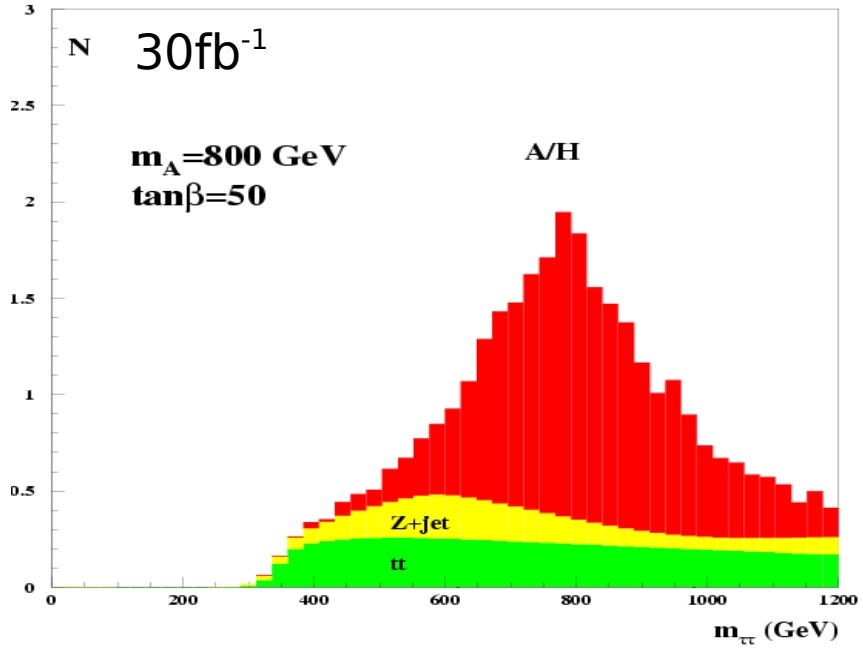
Higgs Search: $bb\Phi \rightarrow bb\tau\tau$

- ATLAS and CMS developed analyses in various channels
  - e+jets, μ+jets, two jets, e+μ

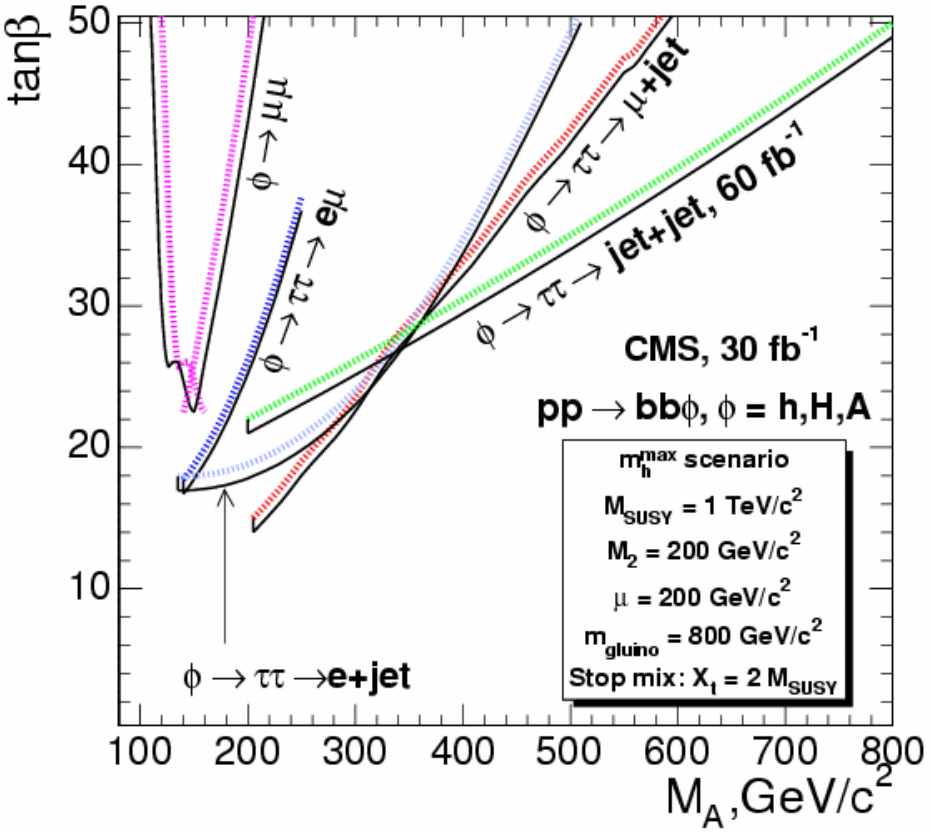
μ+jets (CMS)

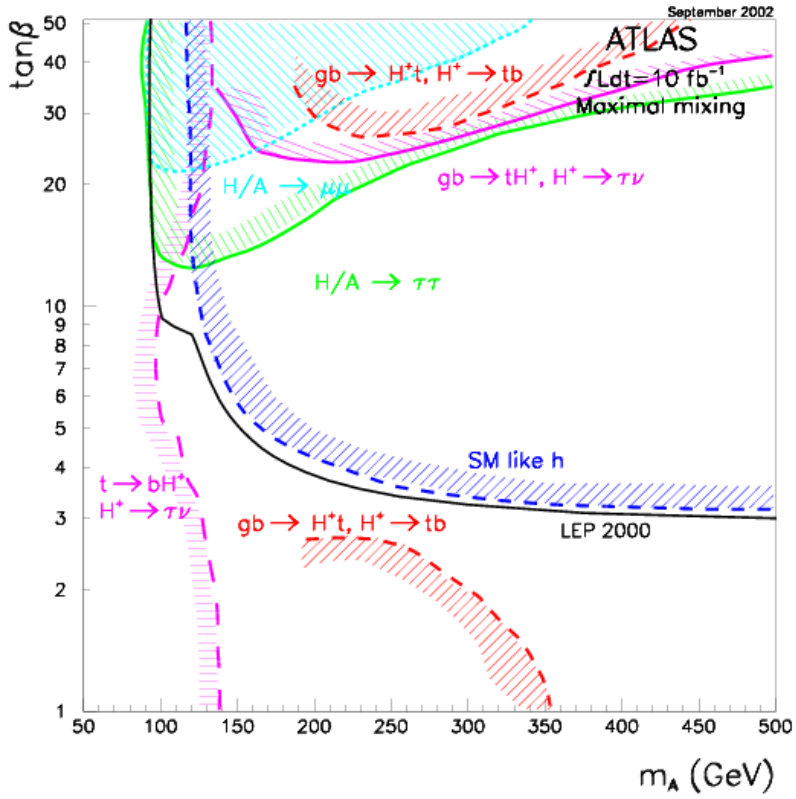


two jets (ATLAS)

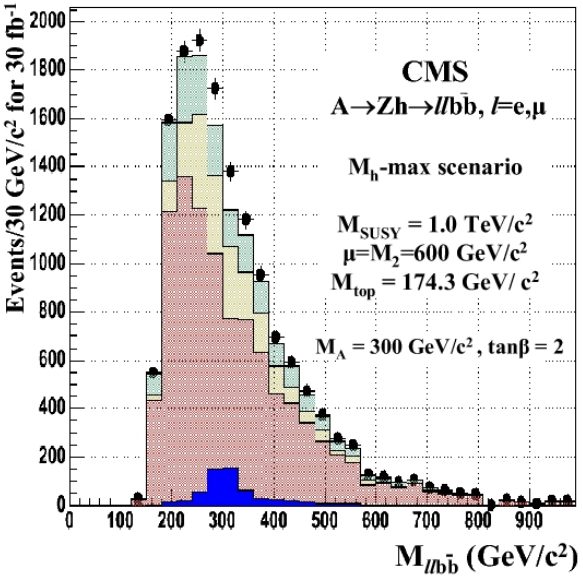


Discovery Potential

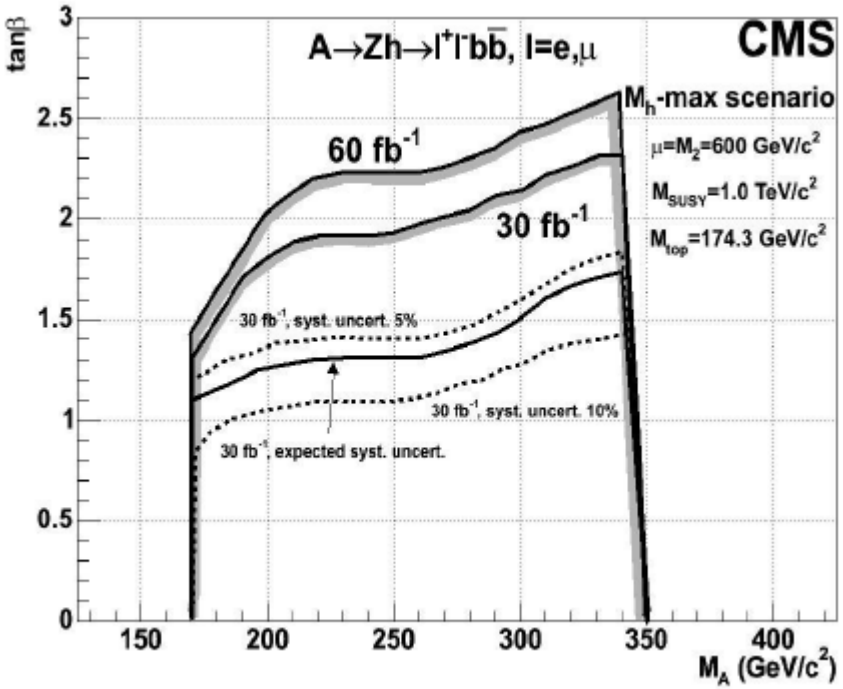




Higgs Search: $A \to Zh$



- low tan β region
- final state: $Z \to ll\,(l = e, \mu)\;\; h \to bb$
- low tan β and $m_Z + m_h \leq m_A \leq 2m_{top}$
- depends strongly on MSSM parameter
- exclusion from b → sγ
- main backgrounds: Zbb, ttbar and Z+jets
- systematic uncertainty important



Conclusion

- ATLAS & CMS are preparing for first collision data.
- Discussed MSSM-like neutral Higgs topologies.
- SM-like topologies and charged Higgs very powerful.
- Discovery potential of MSSM Higgs bosons has been estimated by ATLAS & CMS.
- First data has potential to exclude entire MSSM parameter space.
- Exiting times ahead!