BSM Higgs at LHC prospects end 2011 and before

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On behalf of ATLAS and CMS Collaborations

Higgs Hunting Workshop
July 29-31, 2010 @ LAL-Orsay

1. Electroweak Symmetry Breaking Mechanism

- Higgs as the origin of Electroweak Symmetry Breaking
  - Weak gauge bosons and fermions are massive.
    - ⇨ Electroweak symmetry must be broken.
  - Higgs Mechanism

    Original idea on spontaneous symmetry breaking by Y. Nambu (1960).
    - ⇨ Application to relativistic gauge theory

      by P. W. Higgs, F. Englert and R. Brout (1964).

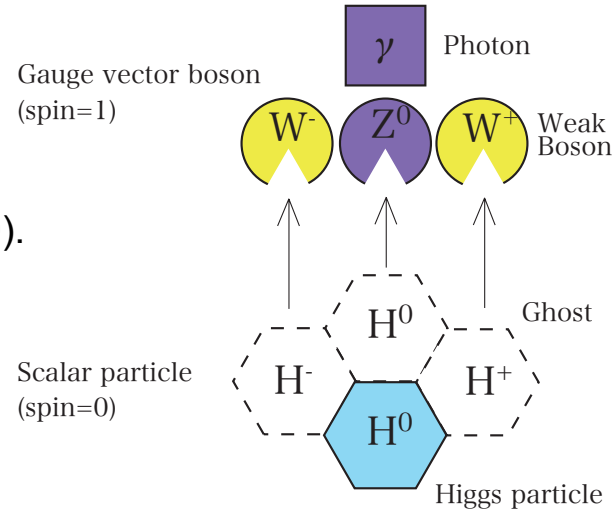
      … since then we are looking for Higgs particle …
- Only one Higgs doublet?
  - Fine tuning problem, naturalness …
  - ⇨ New physics may exist around electroweak energy scale (accessible by LHC) !
  - Most popular benchmark scenario
    - ⇨ SUSY-MSSM: Smoking-gun signature in 1991

      SUSY is still escaping from our detection.
  - But there are many other models:

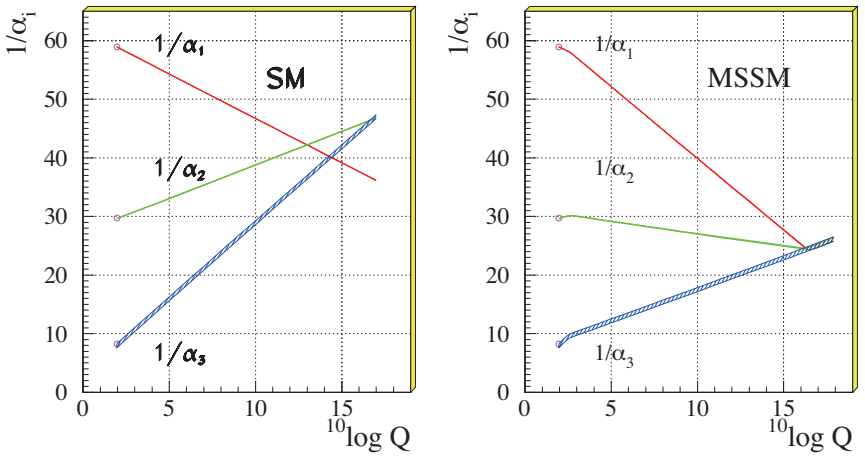
    like Extra-Dimension, Little Higgs,

    Composite Higgs or even Higgsless.
    - ⇨ Rich phenomenology.

G. 't Hooft, Scientific American **242** 6 (1980) 104-138.



W. de Boer



U. Amaldi, W. de Boer, H. Fürstenau, PL B260(1991)

$\alpha_1, \alpha_2, \alpha_3$ coupling constants of electromagnetic –, weak–, and strong interactions

$1/\alpha_i \propto \log Q^2$ due to radiative corrections (LO)

Electroweak Symmetry Breaking (EWSB)

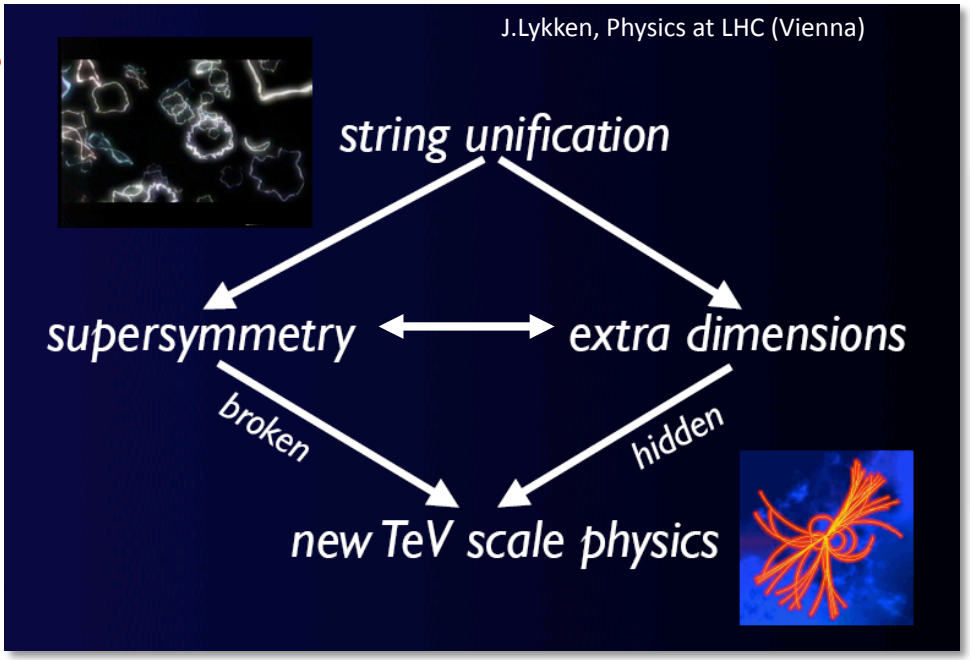
LHC early discovery?

Extended Gauge Symmetry
Higgsless
Left-Right Symmetric Model, Gauge-Higgs Unification

W', Z'

$\tilde{g}/\tilde{q}$, xMSSM Higgs

SUSY
(m)SUGRA
GMSB
AMSB
Mirage
Split SUSY
RPV, …



Graviton, BH

Extra-Dimension
LED(ADD)
Randall-Sundrum
Universal ED(KK)
…

Resonances

Dynamical Symmetry Breaking
Strong EWSB, Chiral Lagrangian, Technicolor
Top-quark Condensation
Composite Higgs, Little Higgs

Precision EW data

Poor experimentalist's compilation of models. Perhaps "Not even wrong"!

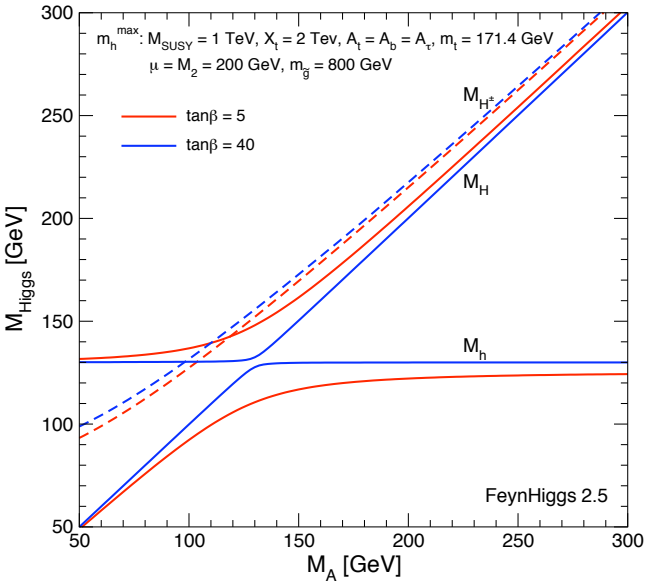
2. MSSM Higgs

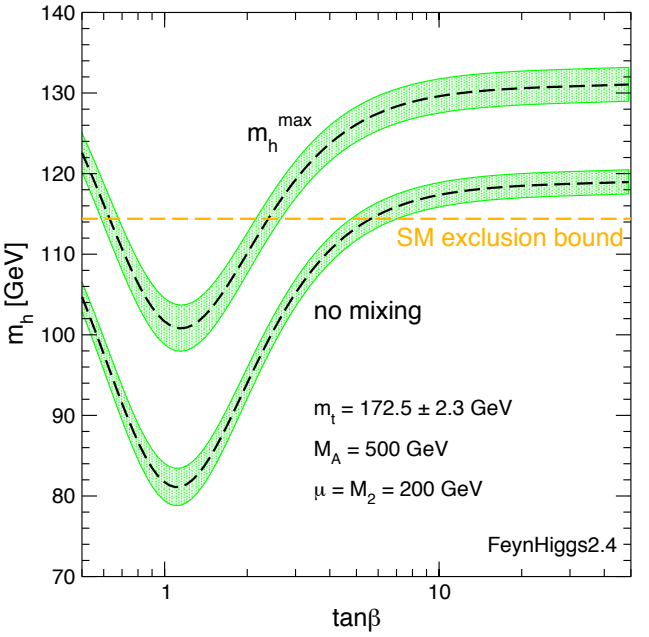
- MSSM Higgs (2HDM Type-II)
  - 2x4-3=5 physical scalar fields: h/H/A and $H^{\pm}$
  - Tree level: 2 free parameters: $m_A(m_{H^{\pm}}), \tan\beta = \frac{v_u}{v_d}$
  - CP-even h/H
    - LO mass $m_h < m_Z$ ($m_h > m_Z$ due to radiative corr.)
    - SM-like in large m_A
    - Enhanced coupling to down-type (b/τ) at large $\tan\beta$
  - CP-odd A
    - No coupling to W and Z.
    - Decay predominantly to bb, $\tau\,\tau$, tt.
  - Mass degeneration at large $\tan\beta$ (h/A, H/A)
  - Charged Higgs $H^{\pm}$
    - Decay predominantly to $\tau\,\nu$ and tb.
    - LO mass relation $m^2_{H^{\pm}} = m^2_A + m^2_W$ (+ loop correction)
- Benchmark scenario (m_h^{max} scenario most popular)

Scenario	$M_{\rm SUSY}$ (GeV)	$X_t^{\rm OS}$ (GeV)	μ (GeV)	M_2 (GeV)	$M_{\tilde{g}}$ (GeV)	Upper bound on m_h (GeV)
m_h^{max}	1000	2000	200	200	800	133
no mixing	2000	0	200	200	800	116
gluophobic	350	-750	300	300	500	119
small $\alpha_{\rm eff}$	800	-1100	2000	500	500	123

M. Carena et al., E.P.J. **C26** (2003) 601-607

S. Heinemeyer, http://www.ifca.es/users/heinemey/uni/plots/

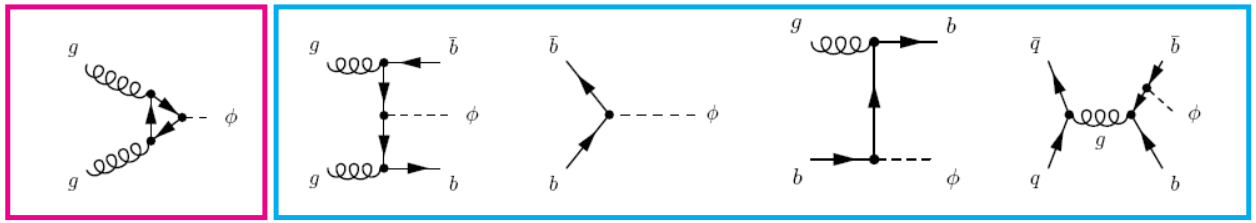




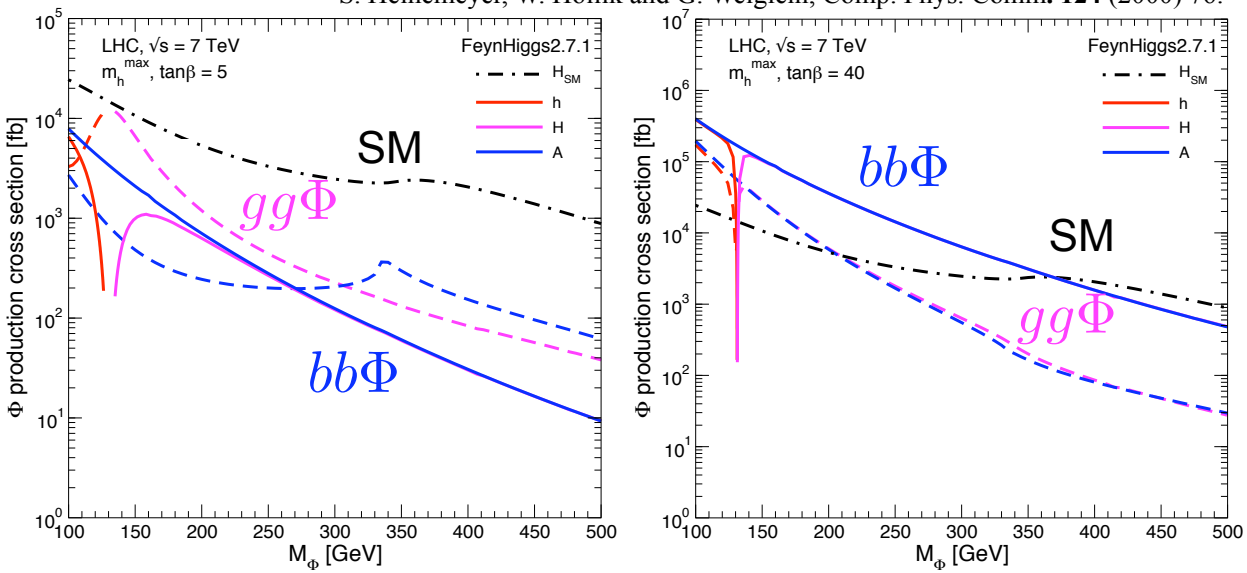
3. MSSM Neutral Higgs

- MSSM Neutral Higgs production

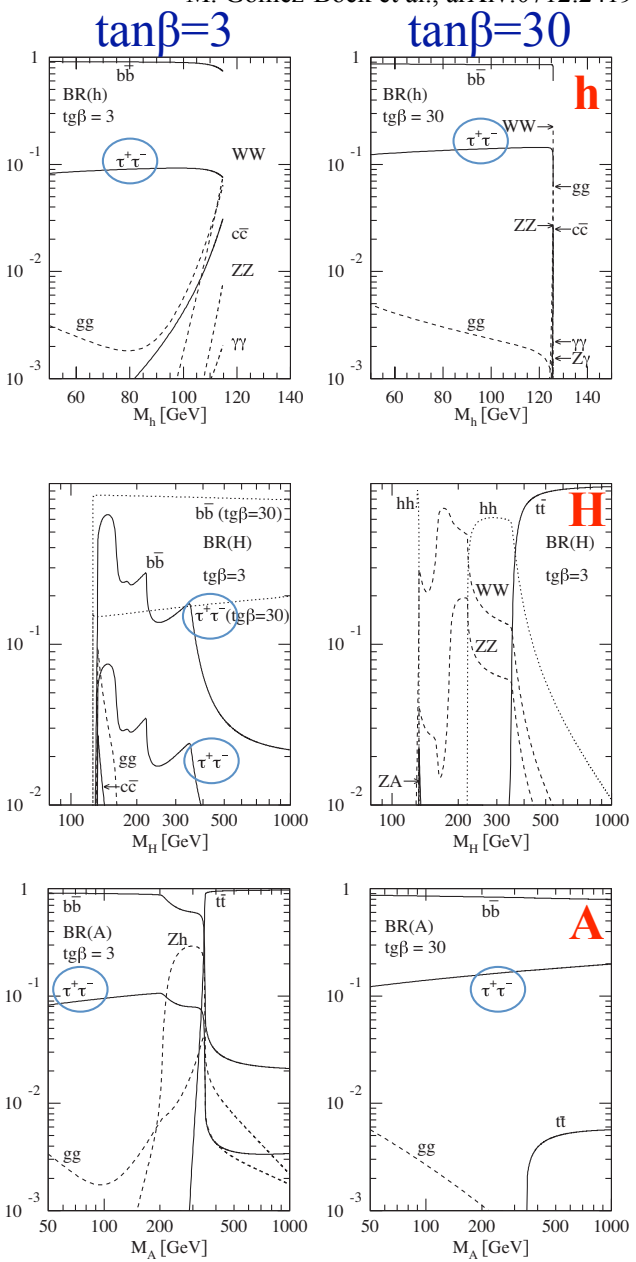
$$gg \to \Phi, bg \to b\Phi, gg \to bb\Phi(\Phi = h, H, A)$$



S. Heinemeyer, W. Hollik and G. Weiglein, Comp. Phys. Comm. **124** (2000) 76.



M. Gomez-Bock et al., arXiv:0712.2419



- MSSM Neutral Higgs decay
  - $\Phi \to \tau^+\tau^- \to \ell\ell, \ell h, hh + \nu's$
  - $\Phi \to b\bar{b}$ is difficult.

ATLAS Fast Tracker (FTK) LVL2 proposal for L=$10^{33\text{-}34}$ $cm^{-2}s^{-1}$ era (>2012).

- Event selection

difficult…

	$2\ell 4\nu$	$\ell\tau_{jet}3\nu$	$2\tau_{jet}2\nu$
Trigger	single- or di-lepton	single-lep. or lepton+τ_{jet}	single- or di-τ_{jet}
Higgs Decay	2 isolated leptons	1 isol. lepton + 1 τ_{jet}	2 τ_{jet}
b-tagging (against Z/γ^*)	ATLAS: ≥ 0 b-jet. CMS: $= 1$ b-jet. (Not exactly two b-jets, due to the soft p_T^b-spectrum from the signal.)		
Central jet-veto (against $t\bar{t}$)	ATLAS: Not more than two jets (including the b-tagging jets). CMS: No additional jets in the central region (except b- and τ-jets).		
Transverse mass (against W+jets)	$m_T = \sqrt{2p_T^\ell E_T^{miss}\left(\cos(\vec{p_T^\ell}, \vec{E_T^{miss}})\right)}$, key is $\vec{E_T^{miss}}$ measurement		
Higgs mass reconstruction	Collinear approximation: τ decay products emitted in τ-direction. No back-to-back decays, momentum fractions of ν's should be positive.		

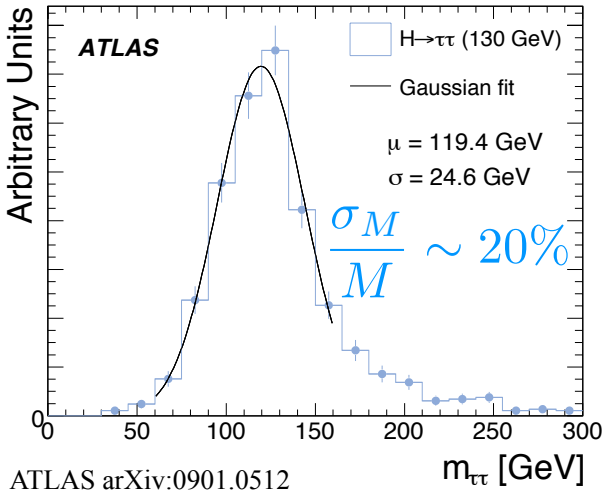
- Main backgrounds: $Z/\gamma^*(+\text{jets}), t\bar{t}, W+\text{jets}, \text{QCD multi}-\text{jets}$
- Higgs mass resolution

Collinear Approximation

$$m_{\tau^+\tau^-} = \frac{m_{\ell\ell,\ell h}}{\sqrt{x_1 x_2}}$$

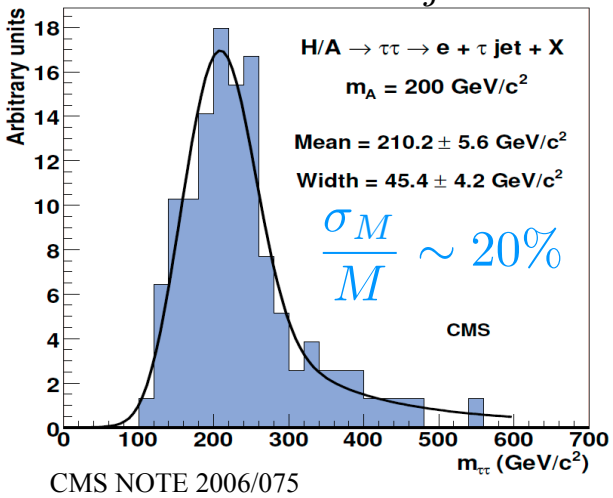
works except $\varphi \neq 0, \pi$

$H \rightarrow \tau\tau \rightarrow 2\ell 4\nu$



ATLAS arXiv:0901.0512

$H \rightarrow \tau\tau \rightarrow e\tau_{jet}3\nu$



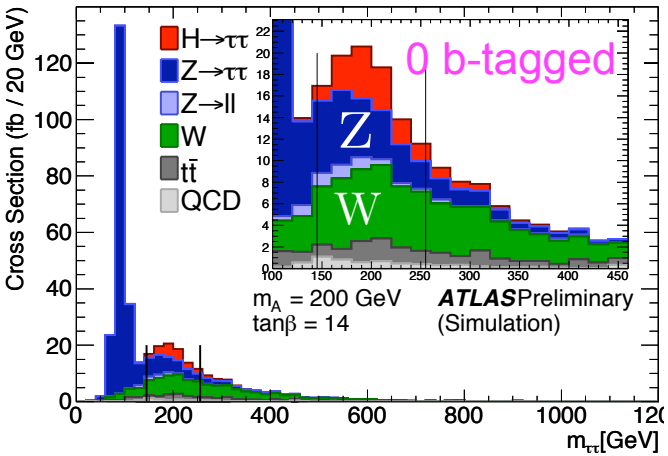
CMS NOTE 2006/075

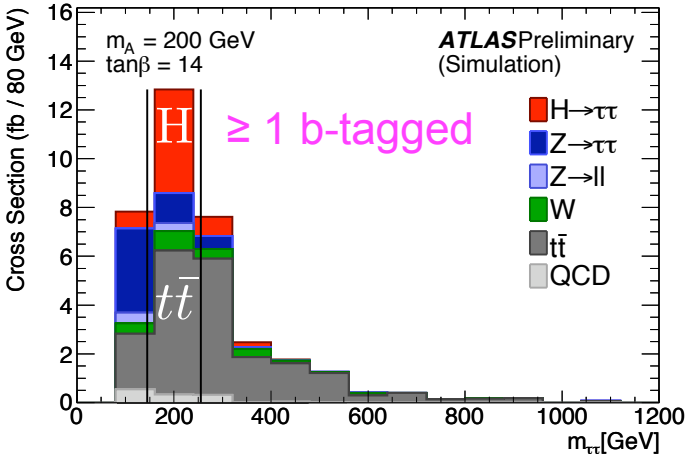
- $H/A \rightarrow \tau^+\tau^-$ invariant mass reconstruction

ATL-PHYS-PUB-2010-011

√s=14TeV, ∫Ldt=30fb^{-1}

$H/A \rightarrow \tau^+\tau^- \rightarrow \ell\tau_{\rm jet} + X \ (\ell = e, \mu)$

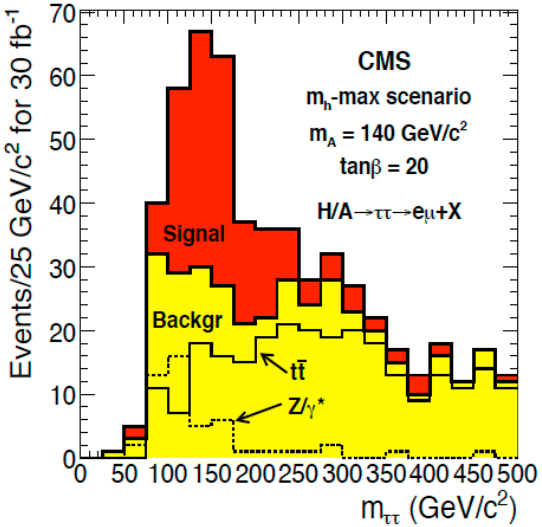




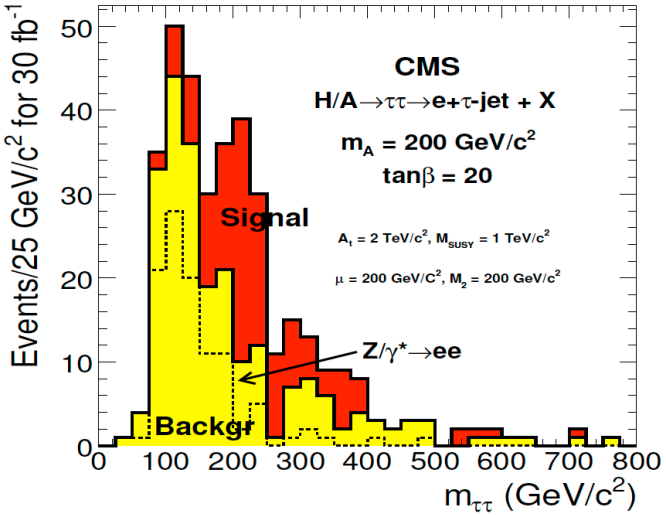
√s=14TeV, ∫Ldt=20-30fb^{-1}

CMS NOTE 2006/075,101,105

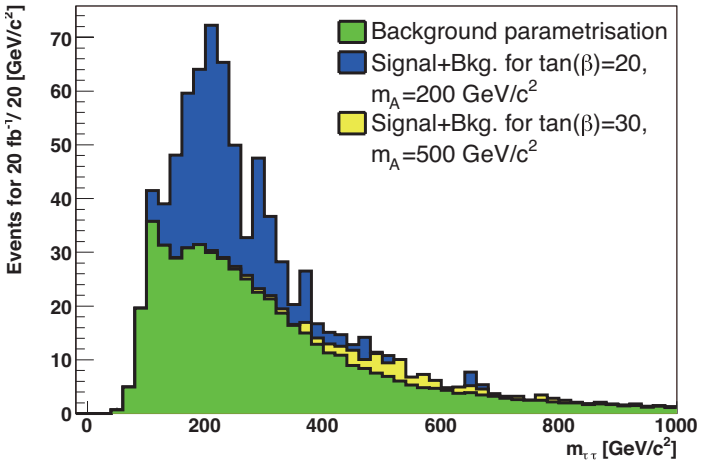
$H/A \rightarrow \tau^+\tau^- \rightarrow e\mu + X$



$H/A \rightarrow \tau^+\tau^- \rightarrow e\tau_{\rm jet} + X$



$H/A \rightarrow \tau^+\tau^- \rightarrow \mu\tau_{\rm jet} + X$



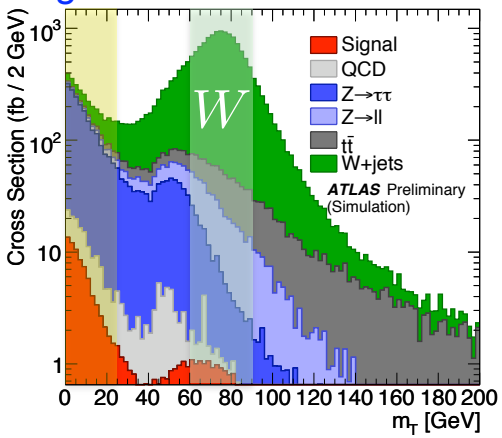
Data-driven background estim.

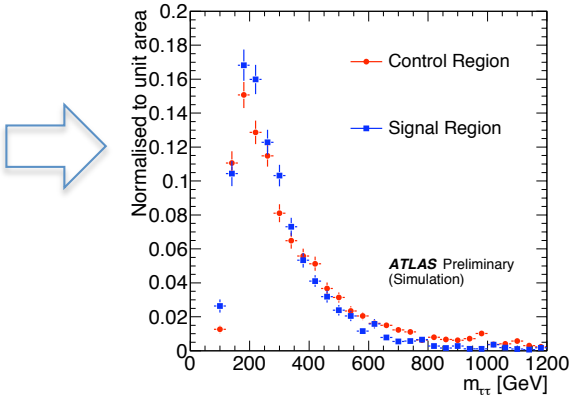
- W+jets transverse mass
  - Major bkg. in non b-tag ch.
  - Fake jet→tau.
  - Use control region at M_W.
- Z(→τ⁺τ⁻)+jets
  - Major bkg. for low $M_{H/A}$
  - Use high purity Z→e⁺e⁻ and μ⁺μ⁻ to emulate τ⁺τ⁻.
  - Match Z→ll to ττ kinematics.
- Jet multiplicity in $t\bar{t}$ events
  - Major bkg. for b-tag ch.
  - Use control region of $E_T^{\text{miss}} > 100\,\text{GeV}$ to get

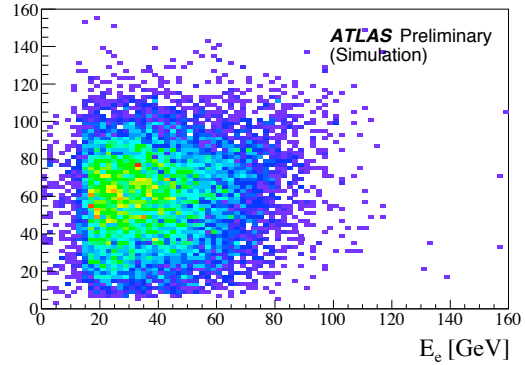
$$N^{\text{njets=1,2}}_{t\bar{t},\ \text{signal region}} = N^{\text{njets=1,2}}_{t\bar{t},\ \text{control region}} \cdot \frac{N^{\text{njets>3}}_{t\bar{t},\ \text{signal region}}}{N^{\text{njets>3}}_{t\bar{t},\ \text{control region}}}$$

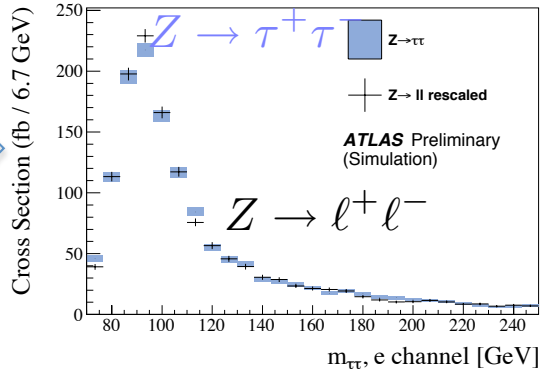
signal control

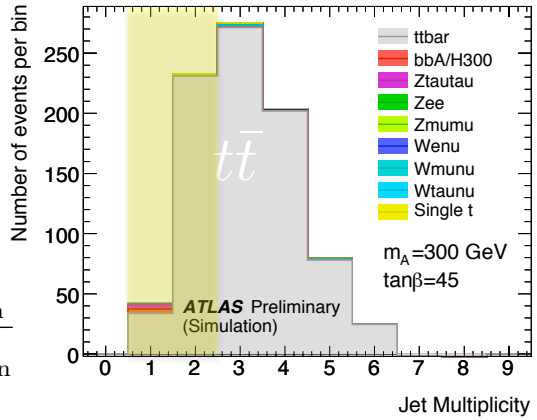
√s=14TeV, ∫Ldt=30fb^{-1} ATL-PHYS-PUB-2010-011

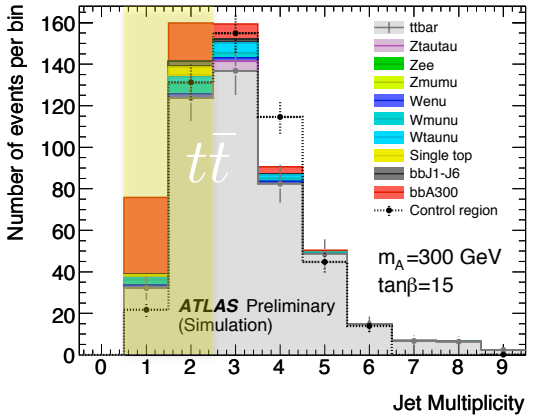








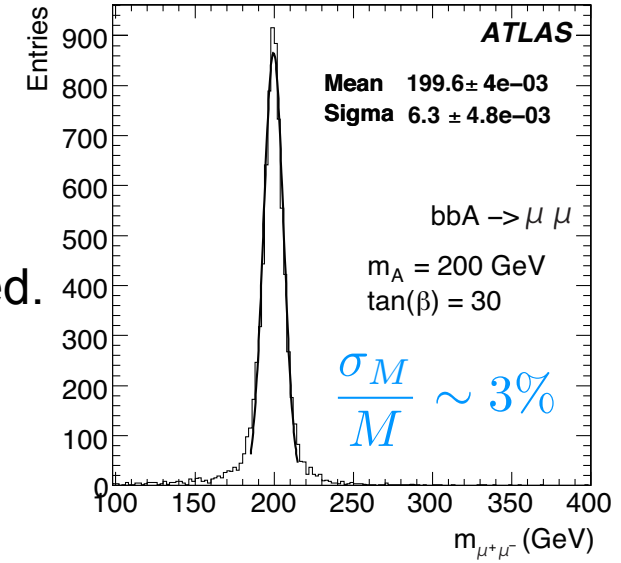


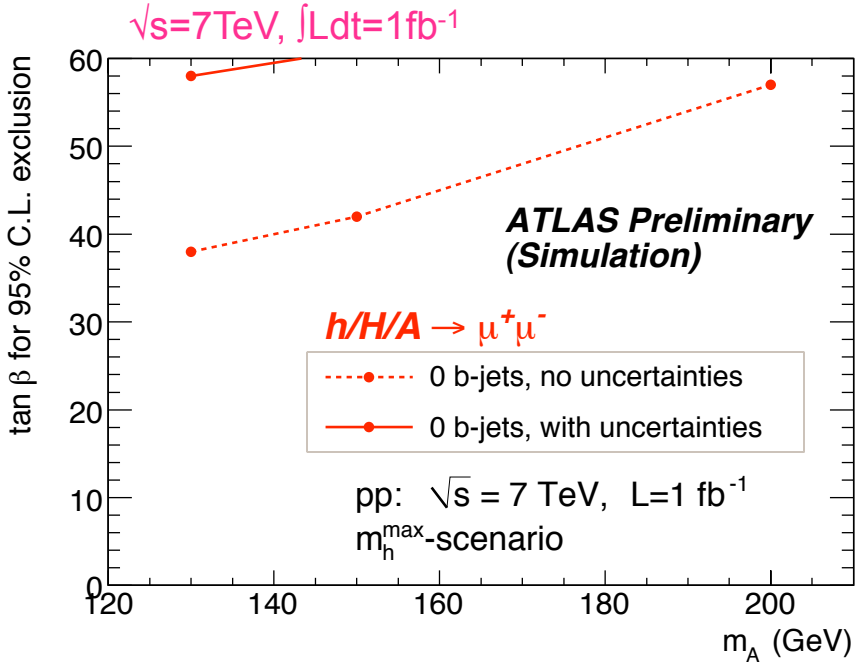


$b\bar{b}(h/H/A), \Phi \to \mu^+\mu^-$

- Branching ratio is small,
  $\mathrm{Br}(\Phi \to \mu^+\mu^-) \sim \mathrm{Br}(\Phi \to \tau^+\tau^-)/300$
- But very clean signature with muons,
  excellent mass resolution ~ 3% (20% for ττ),
  allows precise mass measurement once discovered.
- Analysis
  - 0 b-jets (ATLAS) or ≥ 1 b-jet (ATLAS and CMS) against Z,
  - 2 isolated muons of opposite charge,
  - Missing E_T and jet veto cuts against tt.

ATLAS arXiv:0901.0512





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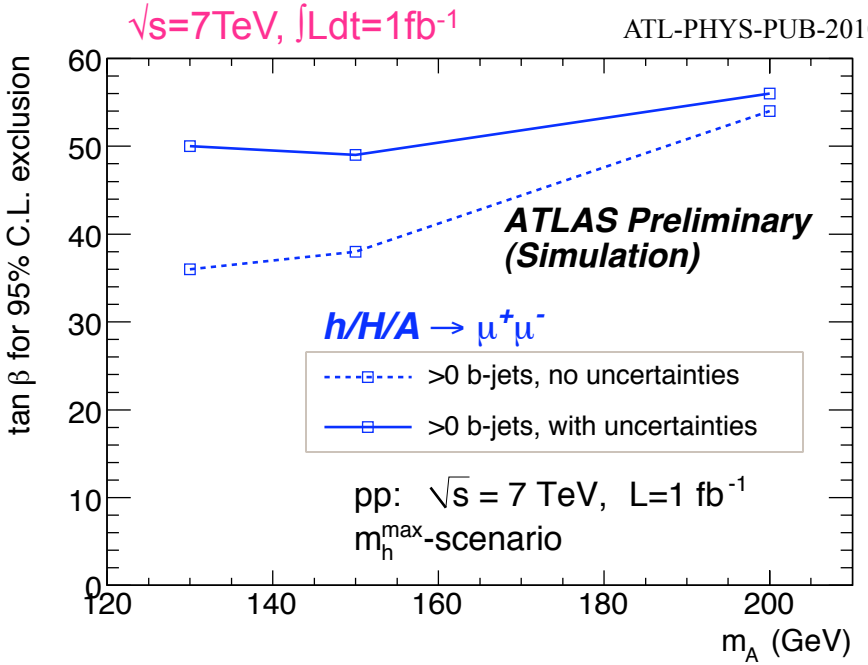
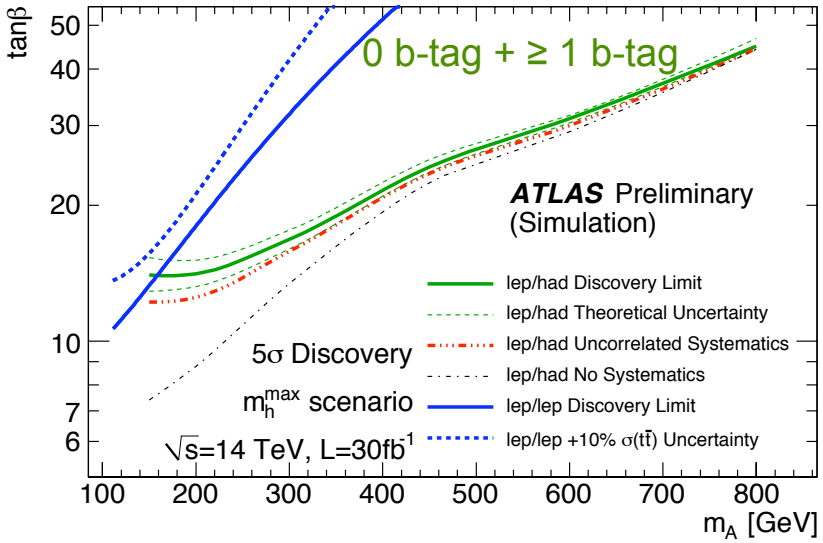
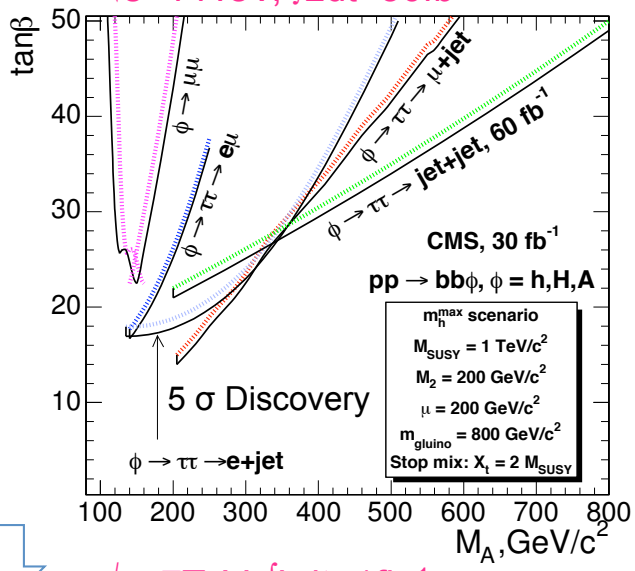


$gg\Phi/b\bar{b}\Phi, \Phi(h/H/A) \rightarrow \tau^+\tau^-$

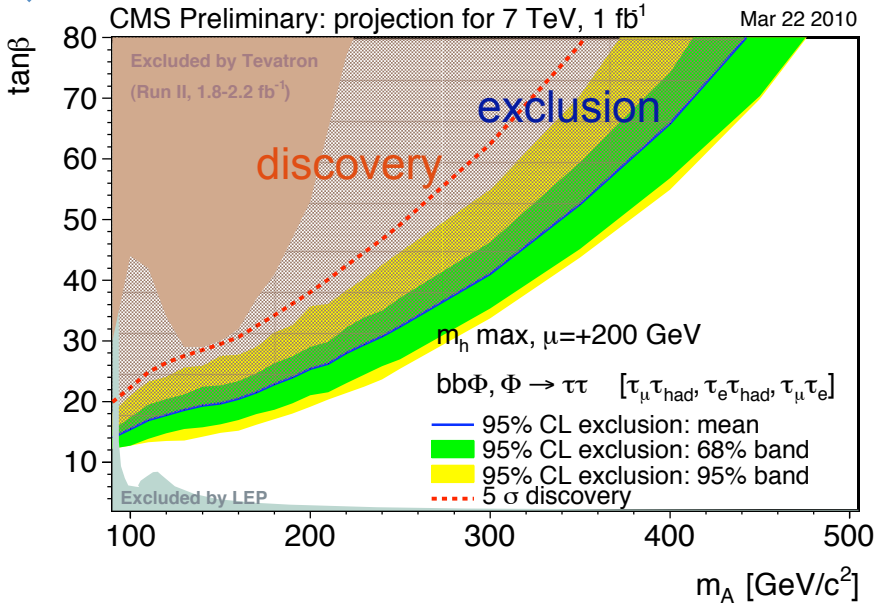
√s=14TeV, ∫Ldt=30fb^{-1} ATL-PHYS-PUB-2010-011



√s=14TeV, ∫Ldt=30fb^{-1} CMS CERN-LHCC-2006-021



√s=7TeV, ∫Ldt=1fb^{-1} CMS NOTE 2010/008 Mar 22 2010

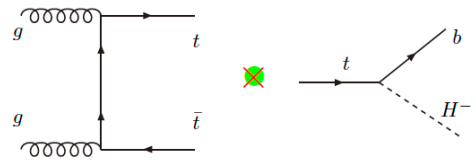


- Projection for discovery and exclusion potential at √s=7TeV, ∫Ldt=1fb^{-1}.

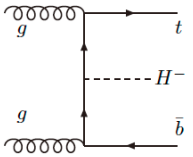
4. MSSM Charged Higgs

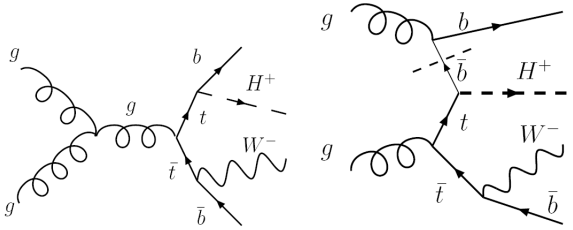
- Charged Higgs $H^{\pm}$
  - Observation is the direct sign of physics BSM
  - Light $H^{\pm}$: $t \to bH^{+}$ in tt ($H^{\pm} \to \tau\nu$, cs)
    - Early discovery possible.
  - Heavy $H^{\pm}$: $gg/gb \to t[b]H^{\pm}$ ($H^{\pm} \to tb, \tau\nu$)
    - Difficult at early LHC.

$pp \to t\bar{t}$ with $t \to bH^{\pm}$ for $M_{H^{\pm}} \lesssim m_{\mathrm{top}}$

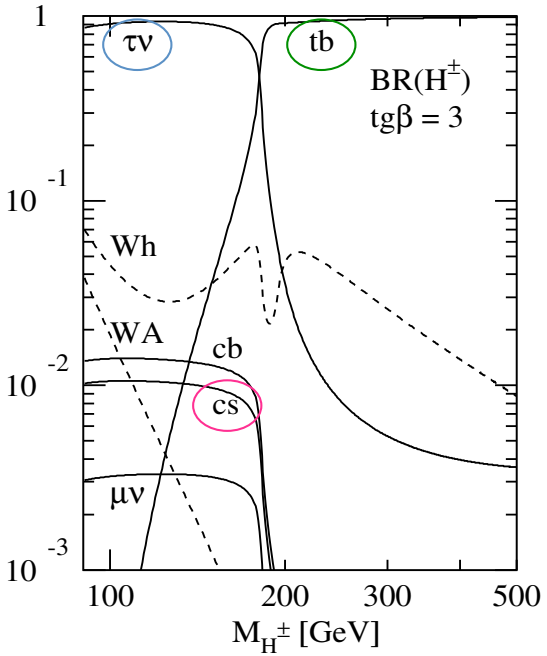


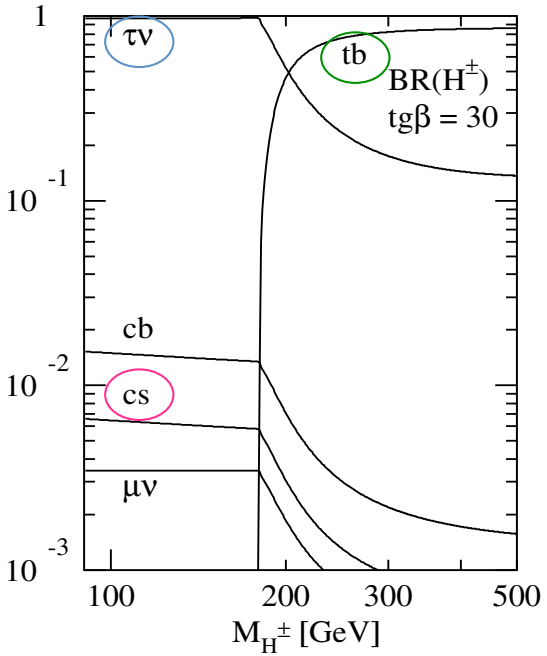
$pp \to tbH^{\pm}$ for $M_{H^{\pm}} \gtrsim m_{\mathrm{top}}$





M. Gomez-Bock et al., arXiv:0712.2419





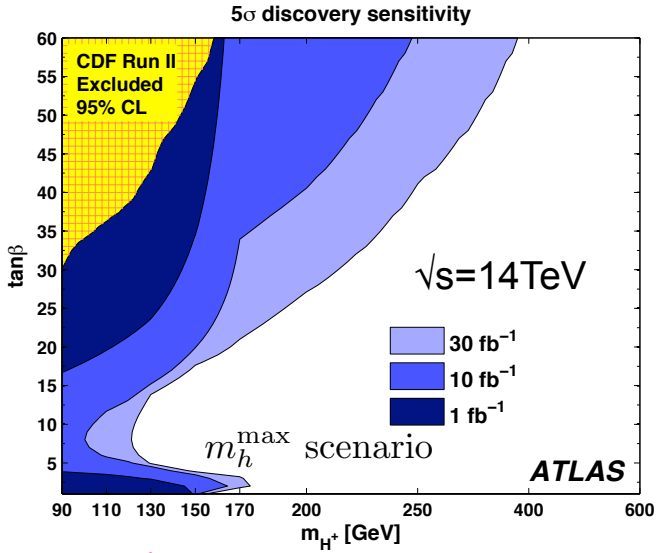
MSSM Charged Higgs search

- Light charged Higgs
  - $H^{\pm} \to \tau_{\rm had}\nu\nu$ mode highest discovery reach.
  - New ATLAS study in $H^{\pm} \to \ell\nu\nu\nu$ and $c\bar{s}$ at 7 TeV.
- Heavy charged Higgs
  - Limited sensitivity
    - Sensitive to the systematic uncertainties.

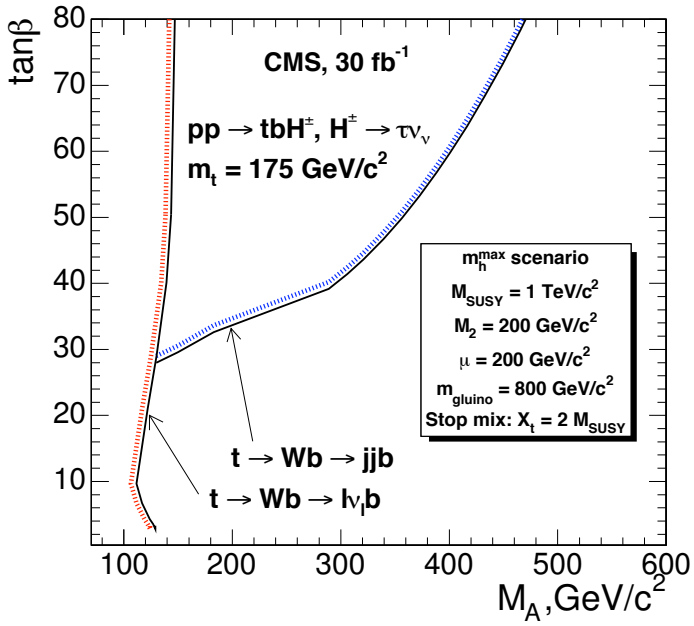
Charged Higgs Analysis Channels

Light Charged Higgs: $t\bar{t} \to (H^{\pm}b)(W^{\mp}b)$			
$H^{\pm}$		$W^{\mp}b$	
		$W^{\mp} \to \ell\nu$	$W^{\mp} \to q\bar{q}'$
$H^{\pm}b \to \tau^{\pm}\nu b$	$\tau_\nu \to \ell\nu\nu$	$(\ell\nu\nu\nu b)(\ell\nu b)$ ATLAS	$(\ell\nu\nu\nu b)(jjb)$ ATLAS
	$\tau_\nu \to \tau_{\rm had}\nu$	$(\tau_{\rm had}\nu\nu b)(\ell\nu b)$ ATLAS and CMS	$(\tau_{\rm had}\nu\nu b)(jjb)$ ATLAS
$H^{\pm}b \to c\bar{s}b$		$(jjb)(\ell\nu b)$ ATLAS	$(jjb)(jjb)$ -
Heavy Charged Higgs: $gg, gb \to H^{\pm}t[b]$			
		$t \to Wb$	
		$W \to \ell\nu$	$W \to q\bar{q}'$
$H^{\pm} \to \tau^{\pm}\nu$	$\tau_\nu \to \tau_{\rm had}\nu$	$(\tau_{\rm had}\nu\nu)(\ell\nu b)$ -	$(\tau_{\rm had}\nu\nu)(jjb)$ ATLAS and CMS
$H^{\pm} \to tb$	$t \to q\bar{q}'b$	$(jjbb)(\ell\nu b)$ ATLAS and CMS	$(jjbb)(jjb)$ -

$\sqrt{s}$=14TeV, $\int$Ldt=1-30fb^{-1} ATLAS arXiv:0901.0512



$\sqrt{s}$=14TeV, $\int$Ldt=30fb^{-1} CMS CERN-LHCC-2006-021



Light Charged Higgs $M_{H^\pm} < M_{top}$

ATL-PHYS-PUB-2010-006/009

- Event selection

$t\bar{t} \to (H^\pm b)(Wb)$		
Final state	Semi-leptonic $t\bar{t}, H^+ \to c\bar{s}$ $(c\bar{s}\,b)(\ell\nu\,b) \to (jj\,b)(\ell\nu\,b)$	Di-lepton $t\bar{t}, H^+ \to \tau^+\nu$ $(\tau\nu\,b)(\ell\nu\,b) \to (\ell\nu\nu\nu\,b)(\ell\nu\,b)$
Trigger	single-lepton	single-lepton
Offline	missing transverse energy ≥ 4 jets	2 oppositely charged leptons ≥ 2 jets
b-tagging	2 b-jets among leading 4 jets	2 b-jets
ν reconstruction	$\vec{p_T^{\nu}} = \vec{E_T^{miss}}$ M_W constraint via $p_L(\nu) = f\,(p_T(\nu), p_\ell)$	$\sum \vec{p_T^{\nu}} = \vec{E_T^{miss}}$
Kinematical ambiguity	4-fold ambiguity with 2 b-tagged jets (2 for ν, 2 for jj)	4-fold ambiguity (2ℓ, $2b$-jets assignment)
Kinematics W and top reconst.	**di-jet mass fitter**	**helicity angle** $\cos\theta^*_\ell$ **generalized transverse mass** $m_{T2}^{H^+}$
Systematic errors	jet energy resolution, b-jet energy scale, (pile-up events)	jet energy scale, b-tagging fake rate and efficiency

- Main backgrounds: $t\bar{t}$, single top, $Wb\bar{b}/Zb\bar{b}$+jets, W/Z+jets, QCD multi − jets

Di-jet Mass Fitter

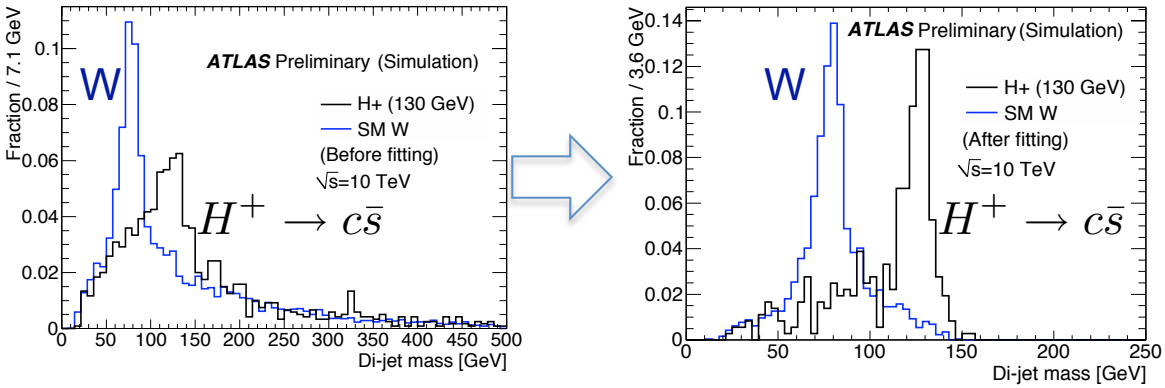
$$\chi^2 = \sum_{i=\ell,4\text{jets}} \frac{(p_T^{i,\text{fit}} - p_T^{i,\text{meas}})^2}{\sigma_i^2}$$ Jets

$$+ \sum_{j=x,y} \frac{(p_j^{\text{UE,fit}} - p_j^{\text{UE,meas}})^2}{\sigma_{\text{UE}}^2}$$ Unclustered Energy

$$+ \sum_{k=jjb,b\ell\nu} \frac{(M_k - M_{\text{top}})^2}{\sigma_{\text{top}}^2}$$ M_{top} constraint

$$+ \frac{(M_{\ell\nu} - M_W)^2}{\sigma_W^2}$$ M_W constraint

$t\bar{t} \to (H^+b)(Wb) \to (c\bar{s}b)(\ell\nu b)$ $\sqrt{s}$=10TeV, $\int$Ldt=200pb^{-1}

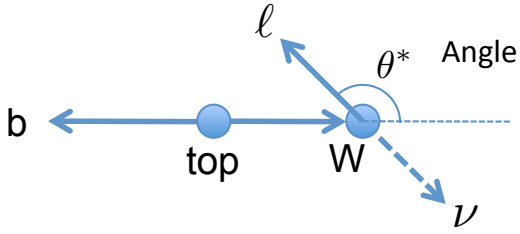


D. Eriksson et al.,JHEP **01** (2008) 024

E. Gross and O. Vitells, PRD **81** (2010) 055010

Helicity Angle $\cos\theta^*_\ell$

- SM top-quark decay: $t \to Wb \to \ell\nu$



$$\frac{1}{N}\frac{dN(W\to\ell\nu_\ell)}{d\cos\theta^*_\ell} = \frac{3}{4}\frac{m_t^2\left(1-\cos^2\theta^*_\ell\right)+m_W^2\left(1-\cos\theta^*_\ell\right)^2}{m_t^2+2M_W^2}$$

- Distortion in H⁺ distribution: $t \to H^+b$

  - H+ is scalar (isotropic decay)

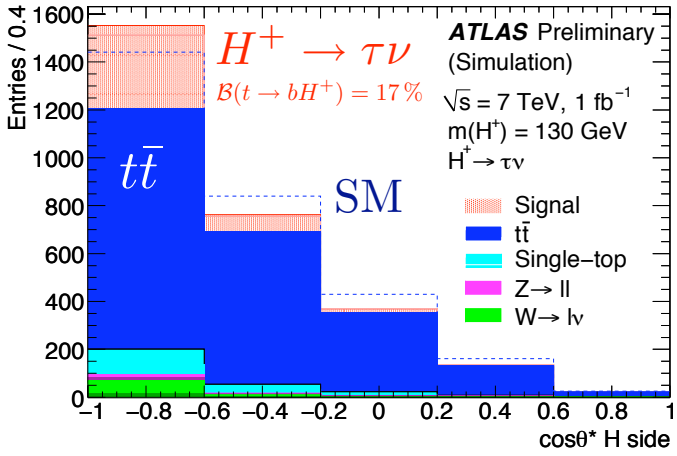
  - M_{H+} and M_W are different, τ leptonic decay (ν's)

  ⇨ H⁺ signal peaked at -1.

  Caveat: can measure in lab-frame:

$$\cos\theta^*_\ell \simeq \frac{4p_b\cdot p_\ell}{m_t^2-m_W^2} - 1$$

√s=7TeV
∫Ldt=1fb^{-1}



Generalized Transverse Mass $m_{T2}^{H^+}$

- Event-by-event determination of the lower limit for mass of the Higgs boson
  - 8 variables and 6 constraining equations.
  - p^{H^+} and $p^{\bar{\nu}_\ell}$ represents unknown quantities.
  - Assign $\vec{p}_z^{\,H}$ to be one of unconstrained d.o.f.

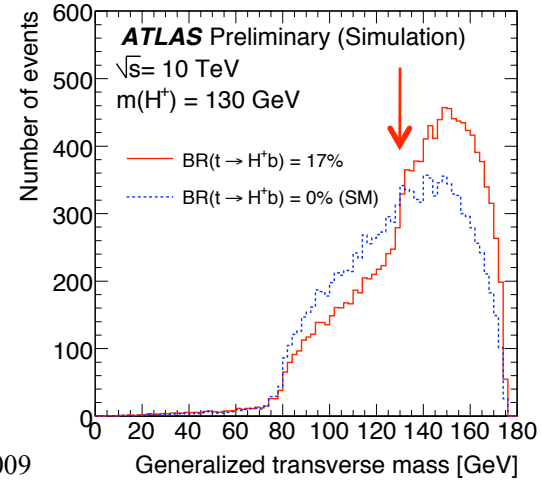
M_{top} constraint	$(p^{H^+}+p^b)^2 = m^2_{top}$
M_{top} constraint	$(p^{\ell^-}+p^{\bar{\nu}_\ell}+p^{\bar{b}})^2 = m^2_{top}$
M_W constraint	$(p^{\ell^-}+p^{\bar{\nu}_\ell})^2 = m^2_W$
ν mass	$(p^{\bar{\nu}_\ell})^2 = 0$
ν missing E_T	$(\vec{p}_T^{\,H^+}-\vec{p}_T^{\,\ell^+})+\vec{p}_T^{\,\bar{\nu}_\ell} = \vec{p}_T^{\,miss}$

  - Maximize H+ mass using Lagrange multipliers

$$m_{T2}^{H^+} = \max_{\vec{p}_T^{\,H^+}}\left[M_T^H(\vec{p}_T^{\,H^+})\right],$$

$$\text{with } (M_T^H)^2 = \left(\sqrt{m^2_{top}+(\vec{p}_T^{\,H^+}+\vec{p}_T^{\,b})^2}-p_T^b\right)^2-\left(p_T^{H^+}\right)^2.$$

√s=10TeV
∫Ldt=200pb^{-1}



ATL-PHYS-PUB-2010-006/009

Light Charged Higgs $M_{H^\pm} < M_{top}$

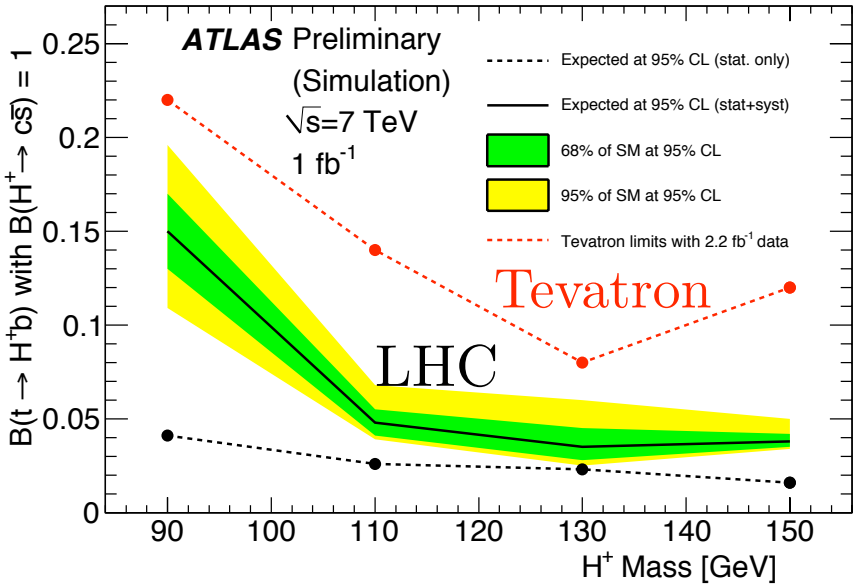
ATL-PHYS-PUB-2010-009

$t\bar{t} \to (H^+b)(W^-b)$

√s=7TeV, ∫Ldt=1fb^{-1}

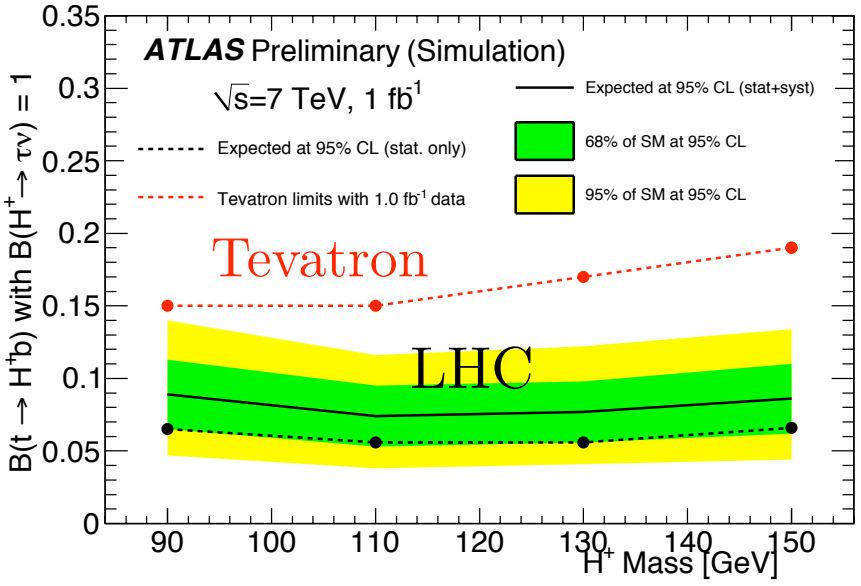
Semi – leptonic $t\bar{t}$, $H^+ \to c\bar{s}$

$t\bar{t} \to (H^+b)(W^-\bar{b}) \to (c\bar{s}b)(\ell^-\nu\bar{b})$



Di – lepton $t\bar{t}$, $H^+ \to \tau^+\nu$

$t\bar{t} \to (H^+b)(W^-\bar{b}) \to (\tau^+b)(\ell^-\nu\bar{b}) \to (\ell^+\nu\nu\nu b)(\ell^-\nu\bar{b})$



5. Beyond MSSM Higgs: 4th Generation

- Sequential 4th generation of fermions

  Main constraints:
  - ✓ Invisible Z width at LEP-I: $M_{\nu 4}$>50 GeV
  - ✓ Direct searches at Tevatron: M_{u4}>256 GeV
  - ✓ Generational mixing, EW oblique parameters
  - ✓ LEP2 bounds for unstable ν_4 : $M_{\nu 4}$>100 GeV

- 4th generation of quarks (extra doublet)
  - Higgs production cross sections:

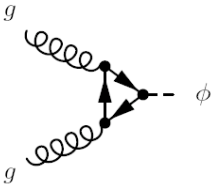
    Additional quarks enhance by x3 ggH coupling,

    gg→H enhanced by ~x9! (regardless of how massive the two extra quarks might be.)

    VH and VBF remain at SM rate.
  - Higgs decay BRs:

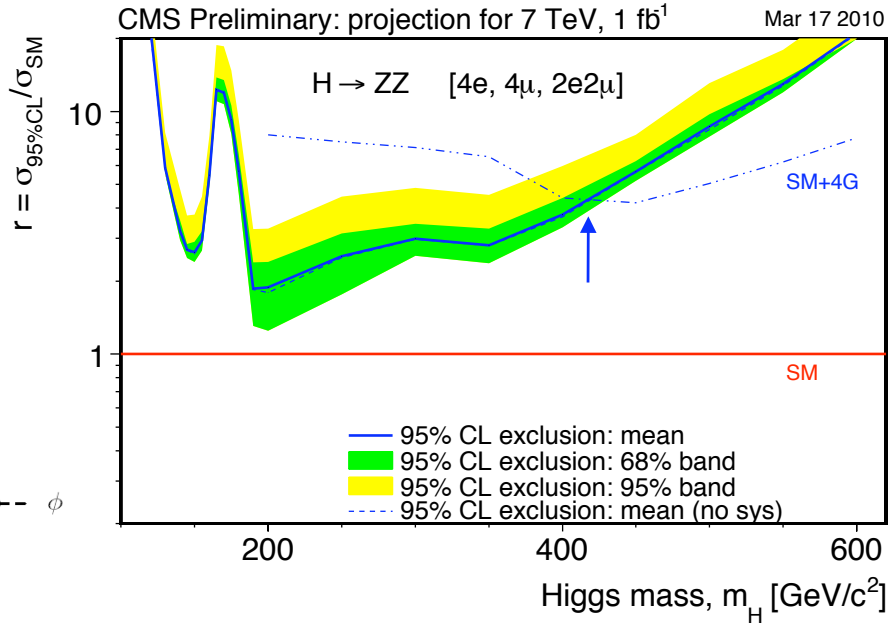
    H→gg significantly increased at low mass.

    H→WW/ZZ dominant mode for m_H>135 GeV.

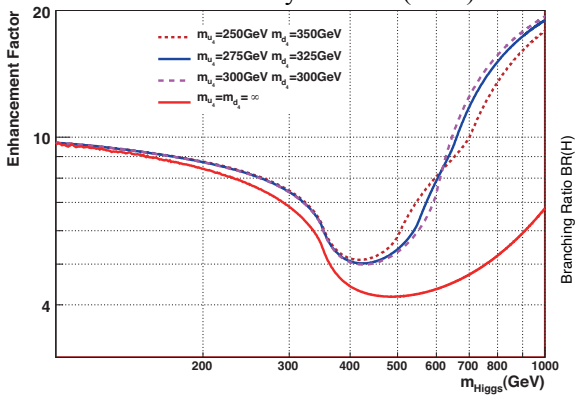


CMS NOTE 2010/008

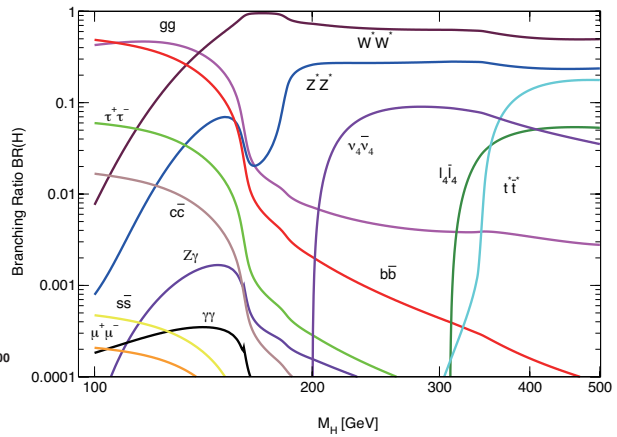
√s=7TeV, ∫Ldt=1fb^{-1}



N. Becerici Schmidt et al.,
Eur. Phys. J. **C66** (2010) 119



G.D. Kribs et al.,
PRD **76** (2007) 075016

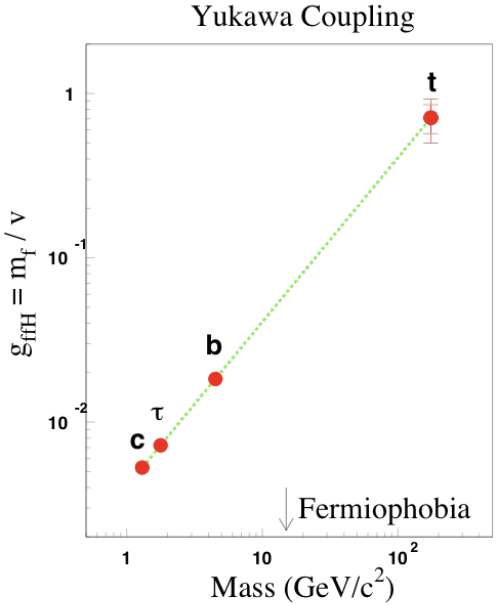


Current Tevatron limit (arXiv:1005.3216)
131<M_{higgs}<204 GeV/c^2 excluded at 95% C.L..

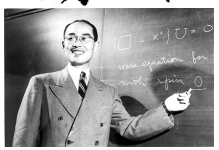
M_{Higgs} < 400 GeV/c^2 can be excluded at early LHC.

Fermiophobic Higgs

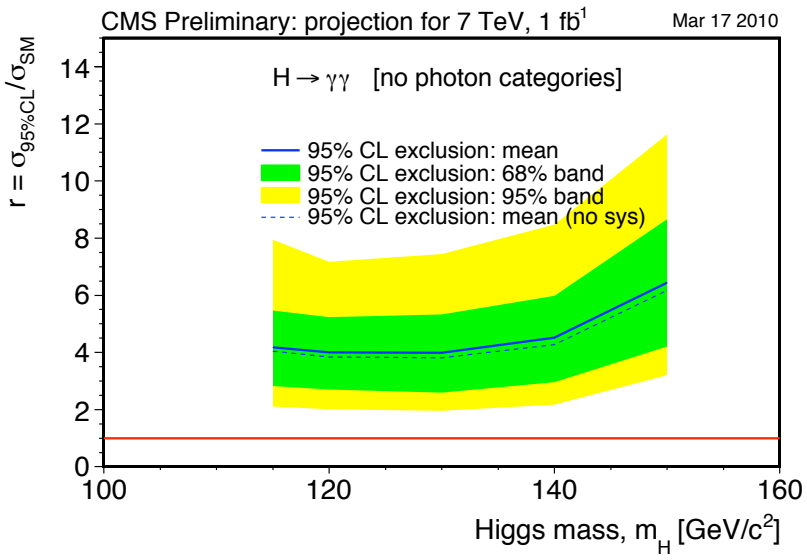
- Fermiophobic over SM Higgs
  - Higgs couples only to bosons
  - Lose a factor of 10 in cross section
  - Gain a large factor in Br(H→γγ)
  - σ x BR is larger than that of SM up to 130GeV
  - Current Tevatron exclusion $m_H < 106 GeV c^2$ (ICHEP2010)
- If we do nothing special for fermiophobic Higgs at LHC
  - r~4 for SM Higgs implies that we can exclude fermiophobic $M_{Higgs} < 110$ GeV/c^2 can be excluded at early LHC.

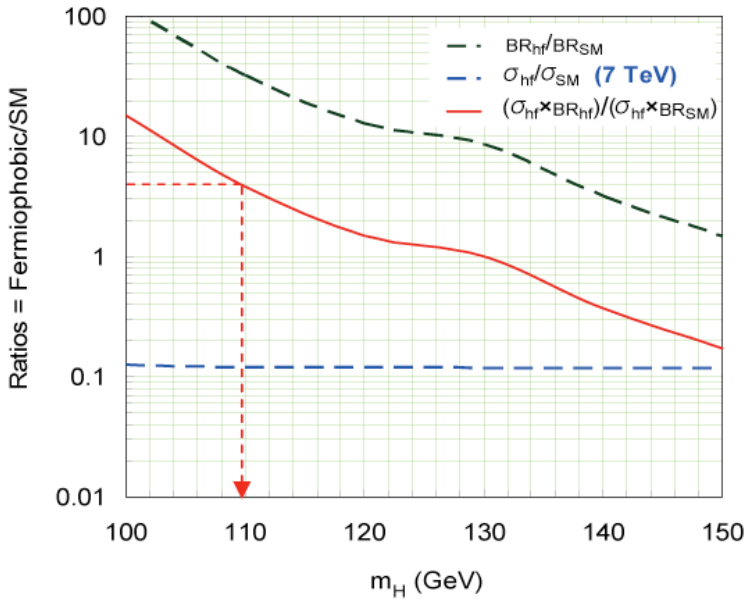


湯川



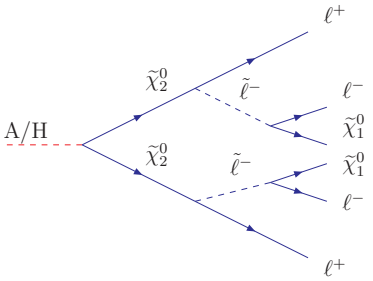
√s=7TeV, ∫Ldt=1fb^{-1}



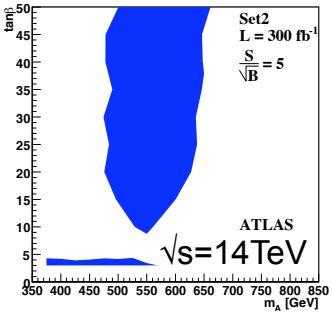


Other scenarios for BSM Higgs

- SUSY cascade decay



ATL-PHYS-PUB-2009-079



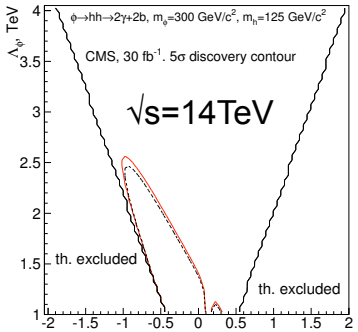
- Other SUSY scenarios, NMSSM etc.
- Invisible Higgs decay
- Radions in 5D Randall-Sundrum model

CMS CERN-LHCC-2006-021

$\phi \to hh \to \gamma\gamma b\bar{b}, \tau\tau b\bar{b}$

mixing parameter ξ

radion field vev Λ_ϕ

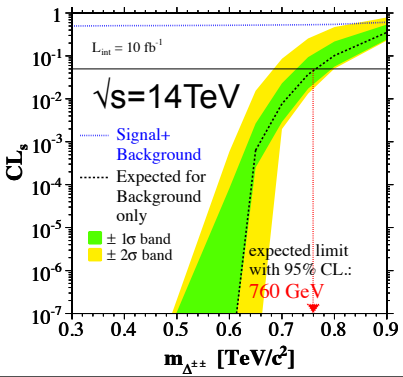


- Littlest Higgs model

CMS CERN-LHCC-2006-021

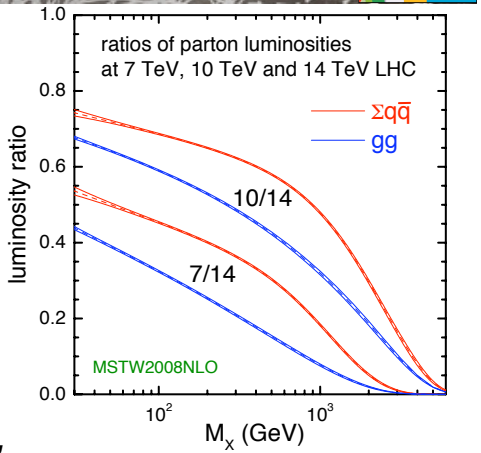
$\Delta^{\pm\pm}$

$H^{++}H^{--} \to 4\mu$



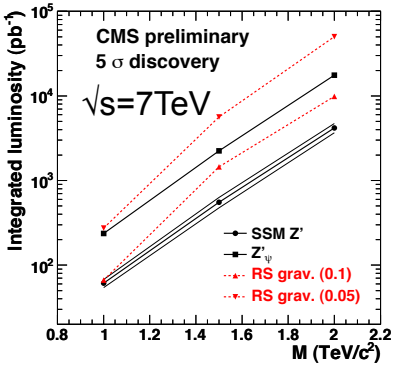
Parton luminosities

http://projects.hepforge.org/mstwpdf/

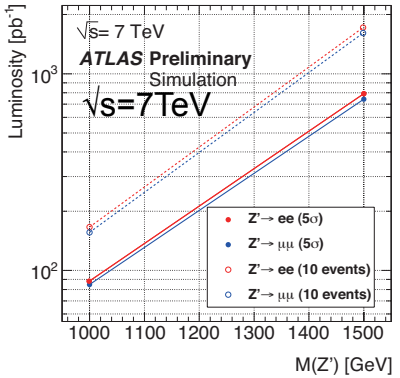


- RS gravitons and Z'

PAS EXO-09-006 scaled to 7 TeV

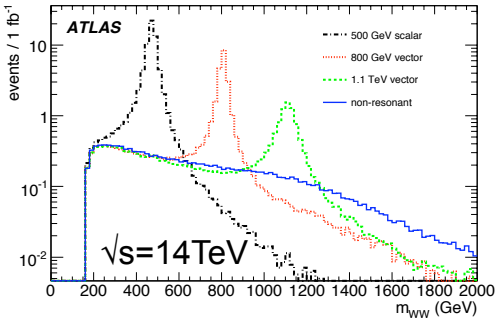


ATL-PHYS-PUB-2010-007



- Vector boson scattering at high mass

ATLAS arXiv:0901.0512



6. Summary and Outlook

- Rich BSM Higgs physics ahead of us at early LHC !
  - First search for light non-SM Higgs(es) at $\sqrt{s}$=7TeV and $\int Ldt$=1fb^{-1}.
    - MSSM Φ=h/H/A in ggΦ/bbΦ (Φ→ττ)
      - Discovery down to tanβ~20, exclusion down to tanβ~15 at low m_A.
    - MSSM Charged Higgs in $t \to H^+ b$ in $t\bar{t}$ $(H^\pm \to \tau\nu, cs)$
      - Limit on the branching ratio for Br(t→H$^+$b) < 5% for low m_{H^+}.
    - Number of opportunities beyond SM and MSSM scenarios.
  - But the analyses are complex. We have to understand W, Z, τ, b and top.
    - Need to find/understand particles from A, a to Z !
  - Experimental issue:data-driven method to estimate the backgrounds.
  - Theoretical issue: MSSM 4-FS&5-FS calc., bbΦ NLO MC, b-quark p_T etc.

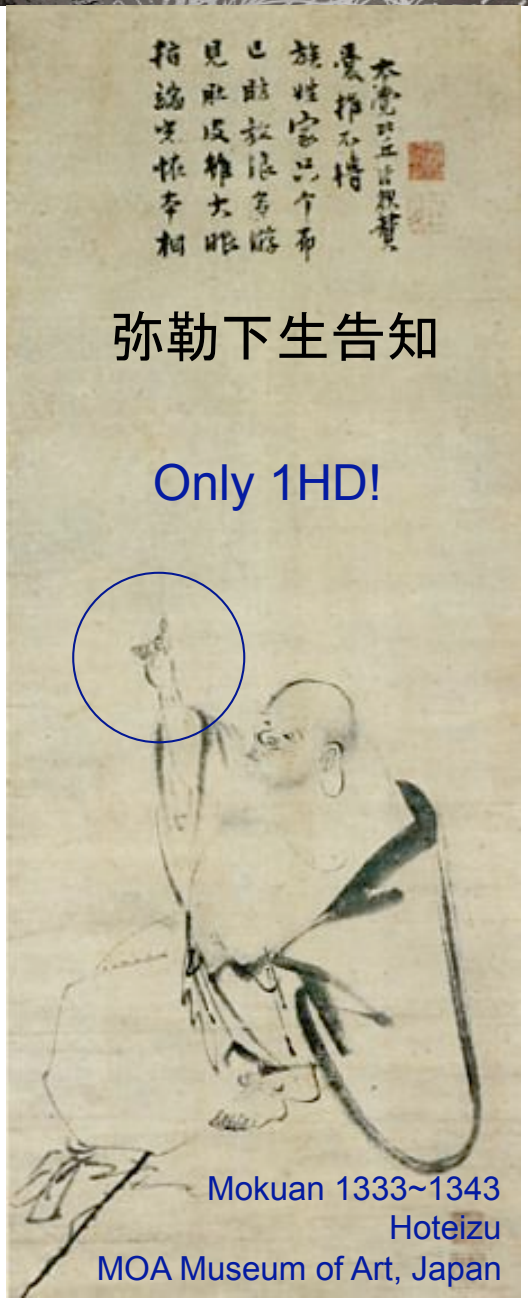
One day we may be able to use Higgs(es) to probe the EWSB mechanism !

Young Scientist Forum: SM/MSSM H→ττ by K. Leney (Liverpool) and L. Bianchini (LLR Palaiseau)

Many thanks to: S. Heinemeyer, M. Spira, K. Tobe, A. Korytov, V. Sharma, K. Assamagan, S. Horvat, B. Murray and M. Schumacher

Celui qui vient à la Lumière

Leonardo di ser Piero DA VINCI,
dit Léonard de Vinci - Vinci, 1452 - Amboise, 1519
Saint Jean-Baptiste © Musée du Louvre



Mokuan 1333~1343
Hoteizu
MOA Museum of Art, Japan

Theorists: “Zero Higgs is even better for my future papers…”

Experimentalists: “Let us concentrate on data analyses.”

Backups

References

- ATLAS https://twiki.cern.ch/twiki/bin/view/Atlas/HiggsPublicResults
  - ATLAS sensitivity prospects for Higgs boson production at the LHC running at 7TeV (ATL-PHYS-PUB-2010-009)
  - Discovery potential of $A/H \to \tau^+\tau^- \to lh$ in ATLAS (ATL-PHYS-PUB-2010-011)
  - Expected sensitivity in light charged Higgs boson searches for $H^+ \to \tau^+\nu$ and $H^+ \to cs$ with early LHC data at the ATLAS experiment (ATL-PHYS-PUB-2010-006)
  - Expected Performance of the ATLAS Experiment, Detector, Trigger and Physics ("CSC book") (CERN-OPEN-2008-020, arXiv:0901.0512)

- CMS https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResults
  - The CMS physics reach for searches at 7TeV (CMS NOTE 2010/008)
  - Search for MSSM heavy neutral Higgs boson in $\tau+\tau \to \mu+$jet decay mode (CMS NOTE 2006/105)
  - Search for the heavy neutral MSSM Higgs bosons with the $H/A \to \tau\tau \to$electron+jet decay mode (CMS NOTE 2006/075)
  - Study of MSSM $H/A \to \tau\tau \to e\mu+X$ in CMS (CMS NOTE 2006/101)
  - CMS Physics TDR, Volume II (CERN-LHCC-2006-021)

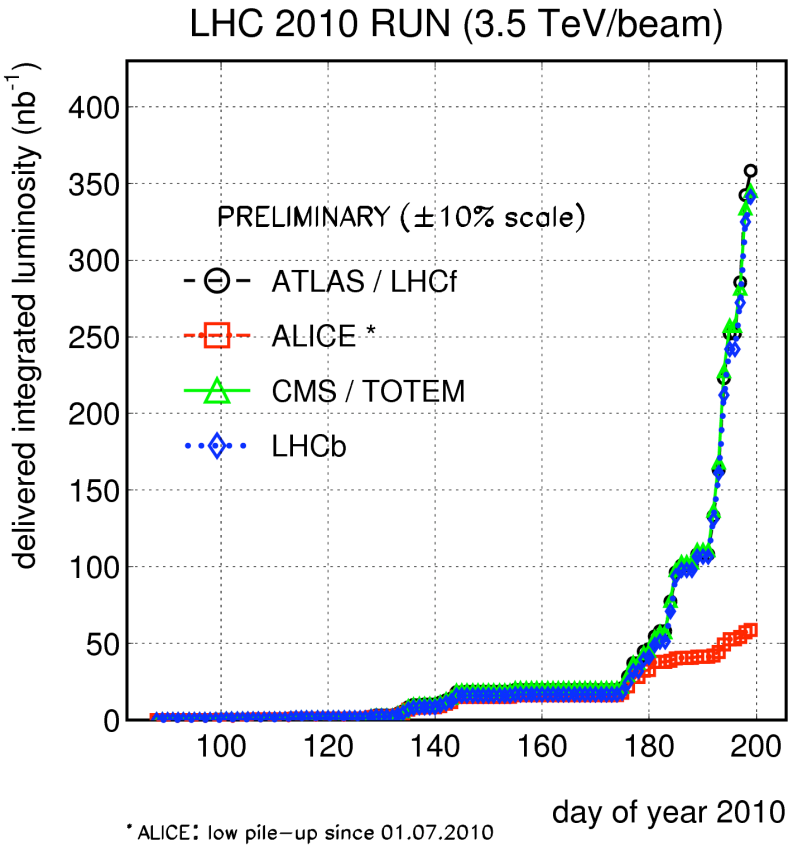
- LHC Higgs Cross Section Working Group

  https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections

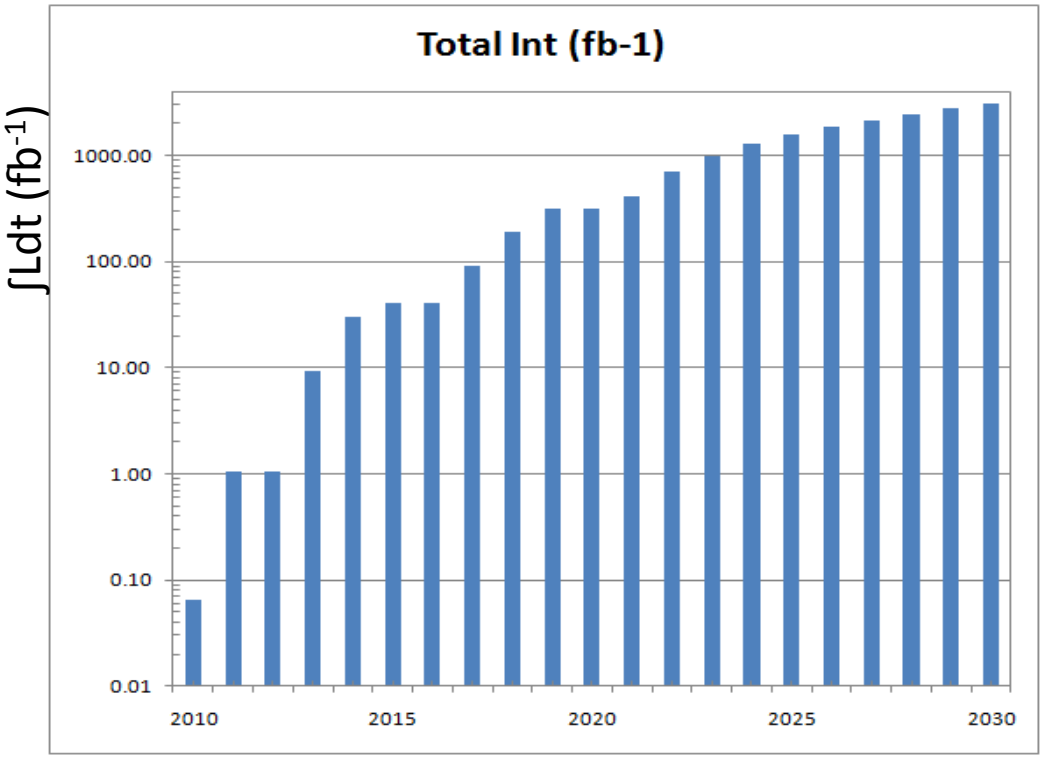
LHC Energy and Luminosity

- Integrated luminosity of ≥1fb^{-1} by the end of 2011
  - requires a peak luminosity of ≥ 1x10^{32} cm^{-2}s^{-1} during 2011
    → must reach ~1 x10^{32} cm^{-2}s^{-1} during 2010

2010/07/19 11.54



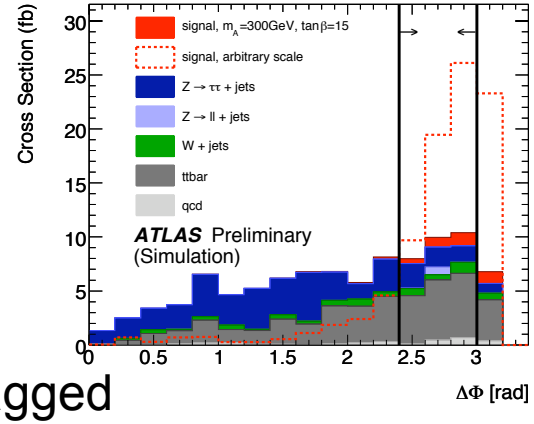
S. Meyers, ICHEP2010

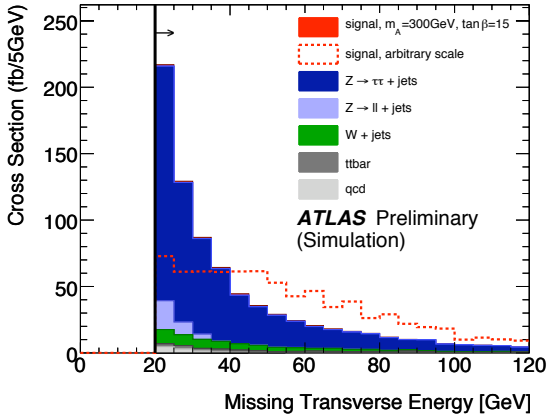


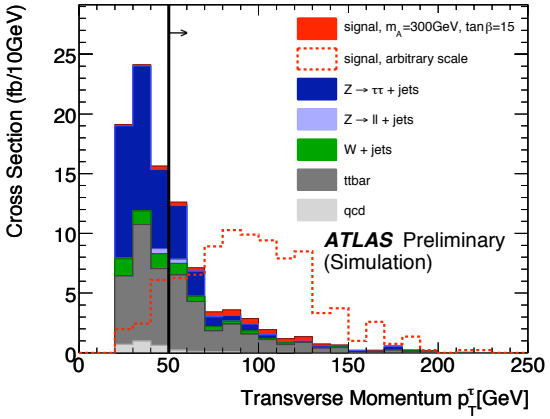
E_{cm}=7→13→14TeV

Non b-tagged

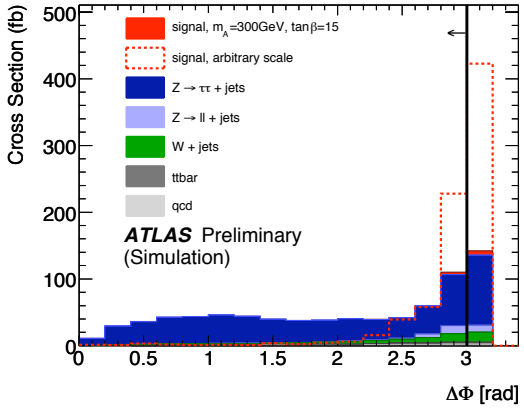
ATL-PHYS-PUB-2010-011

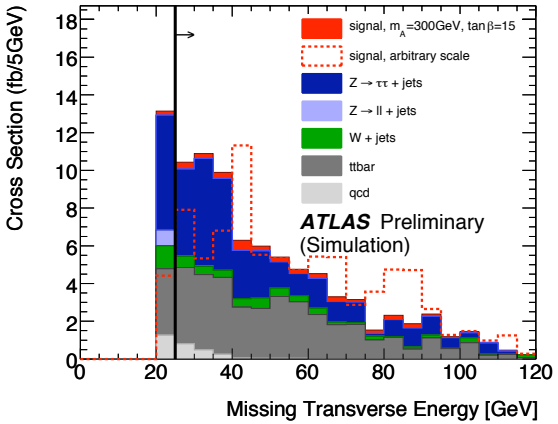


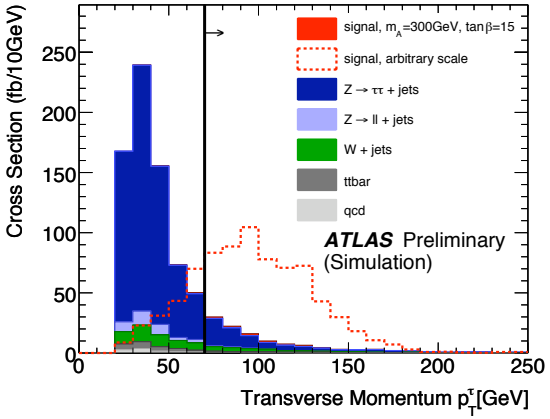




b-tagged







√s=14TeV, ∫Ldt=30fb^{-1}

b-tagged

m_A [GeV]	tanβ	$N_{b\bar{b}}$	N_{gg}	N_{bkg}	ΔN_B^{sys}	S (without ΔN_B^{sys})	S (with ΔN_B^{sys})
150	14	5.2	0.16	12	1.0	7.8	4.3
200	14	5.0	0.062	11	1.1	7.7	3.9
300	17	2.4	0.019	6.5	0.71	4.8	2.7
450	27	0.99	0.0043	0.53	0.17	5.9	3.7
600	31	0.59	0	0.25	0.035	5.0	4.5
800	45	0.35	0	0.093	0.011	4.4	4.3

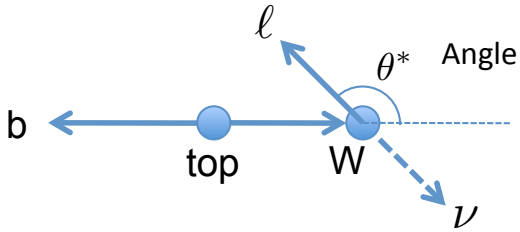
Non b-tagged

m_A [GeV]	tanβ	$N_{b\bar{b}}$	N_{gg}	N_{bkg}	ΔN_B^{sys}	S (without ΔN_B^{sys})	S (with ΔN_B^{sys})
150	14	14	13	99	5.1	14	4.9
200	14	12	5.4	79	2.9	10	5.0
300	17	3.8	0.82	13	0.56	6.5	5.0
450	27	1.8	0.36	4.8	0.23	5.1	4.4
600	31	1.0	0	2.5	0.14	3.3	3.0
800	45	0.7	0	1.3	0.067	3.1	2.9

Helicity angle in top decay

ATL-PHYS-PUB-2010-006

- SM top-quark decay: t→Wb

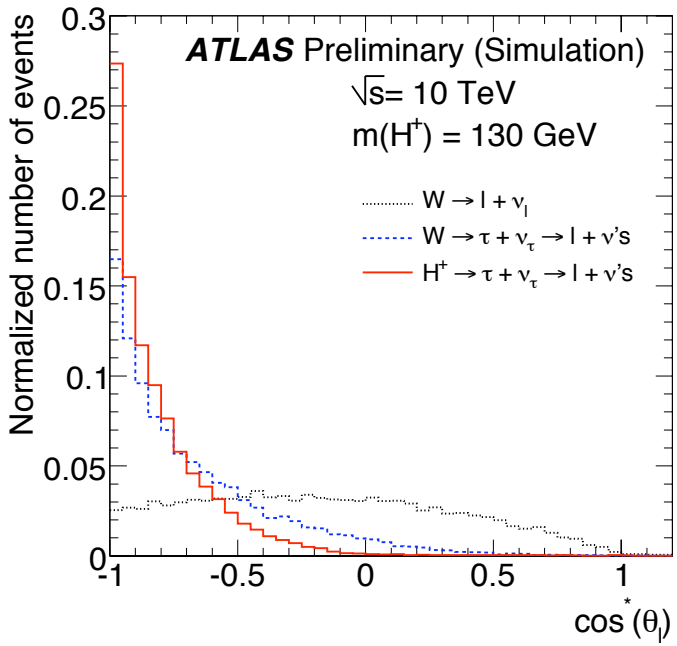


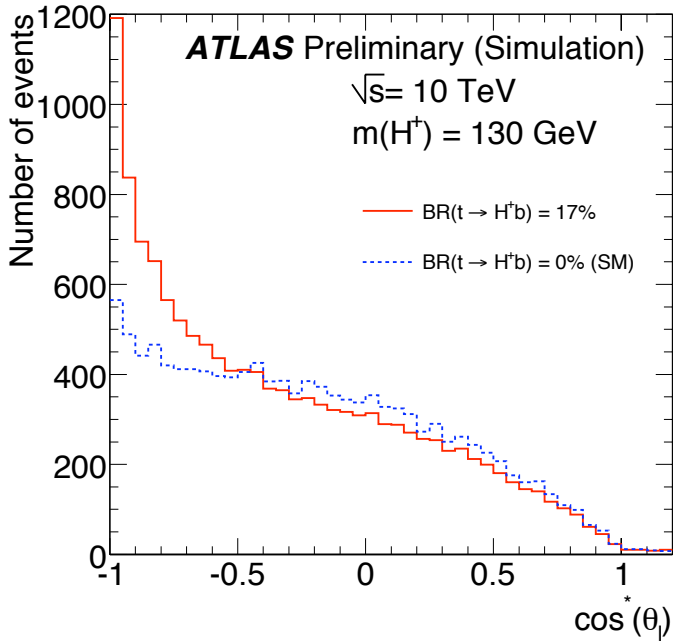
$$\frac{1}{N}\frac{dN(W\to\ell\nu_\ell)}{d\cos\theta^*_\ell}=\frac{3}{4}\frac{m_t^2\left(1-\cos^2\theta^*_\ell\right)+m_W^2\left(1-\cos\theta^*_\ell\right)^2}{m_t^2+2M_W^2}$$

- Distortion in H^+ distribution: t→H^+b
  - H+ is scalar (isotropic decay)
  - but M_{H+} and M_W are different, τ leptonic decay (ν's)
  - H^+ signal peaked at -1.
  - Caveat: can measure in lab. Frame

$$\cos\theta^*_\ell\simeq\frac{4p_b\cdot p_\ell}{m_t^2-m_W^2}-1$$

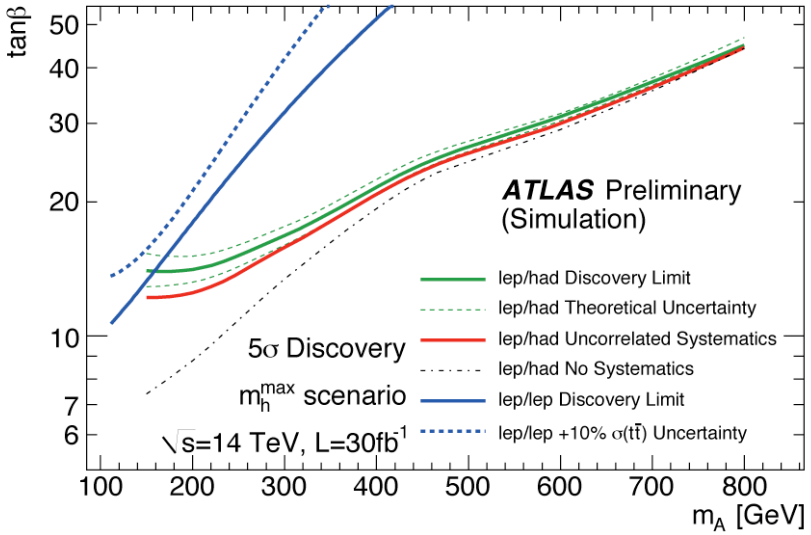
√s=10TeV, ∫Ldt=200pb^{-1}



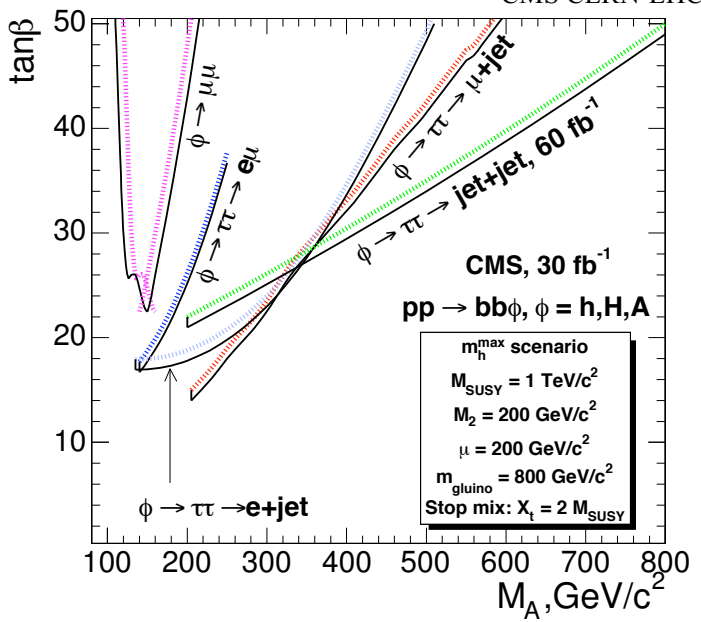


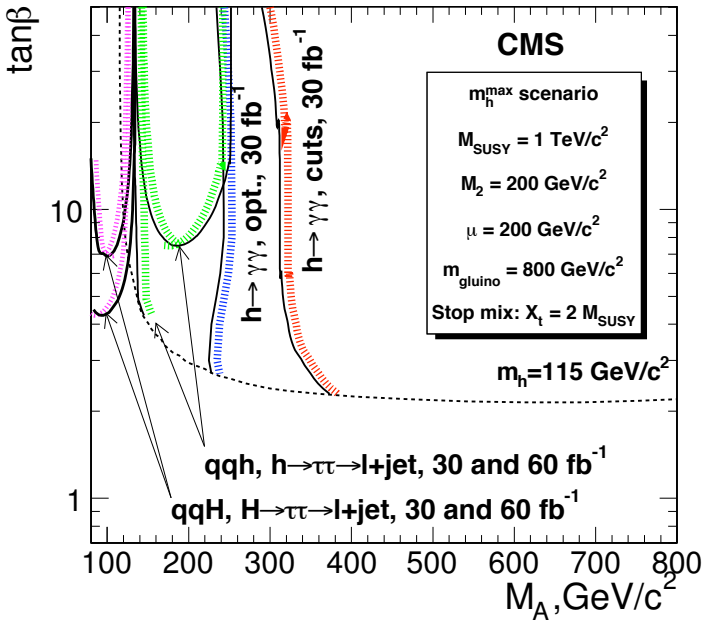
h/H/A Sensitivity at 14TeV

ATL-PHYS-PUB-2010-011



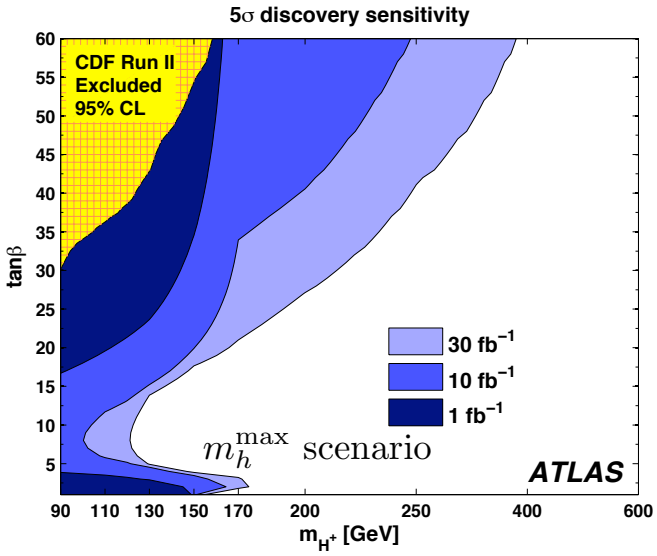
CMS CERN-LHCC-2006-021



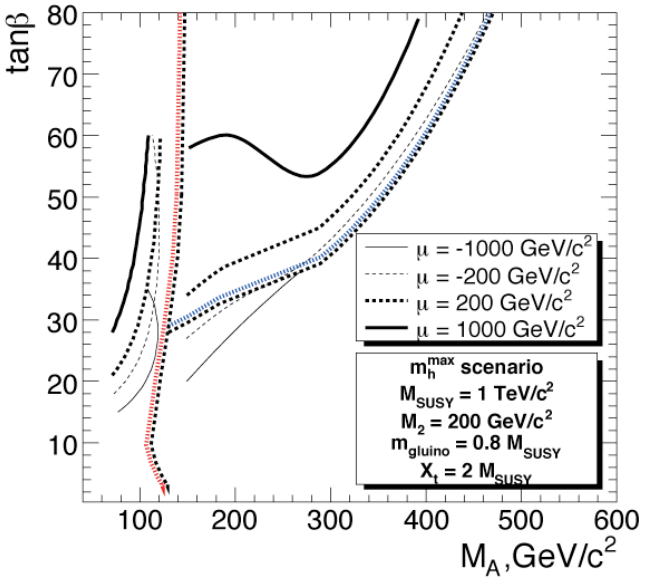


$H^{\pm}$ Sensitivity at 14TeV

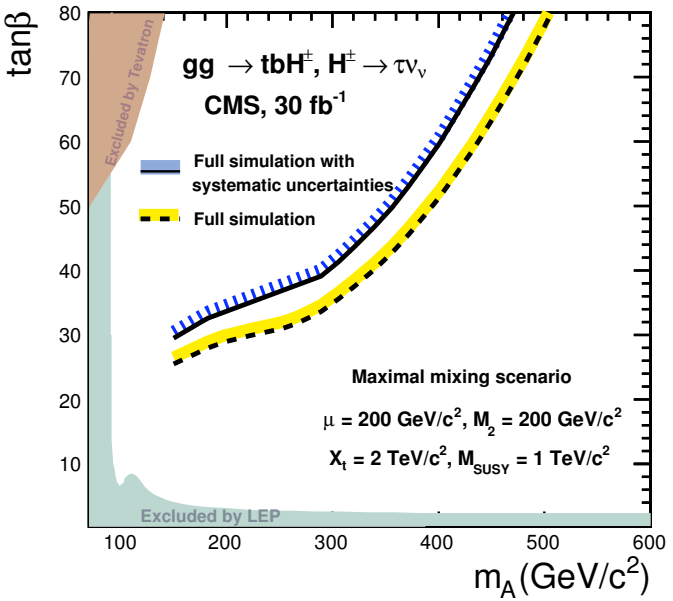
ATLAS arXiv:0901.0512



M. Hashemi et al., arXiv:0804.1228



CMS CERN-LHCC-2006-021



SUSY mSUGRA Sensitivity at 7TeV

ATL-PHYS-PUB-2010-010

CMS NOTE 2010/008

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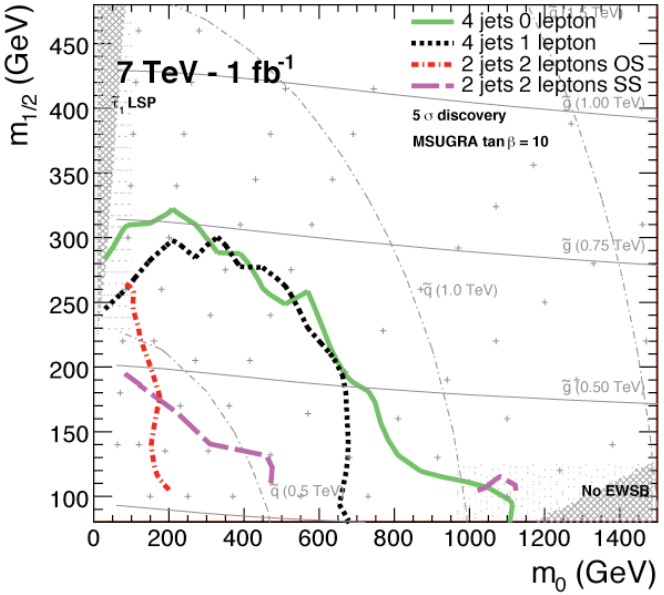

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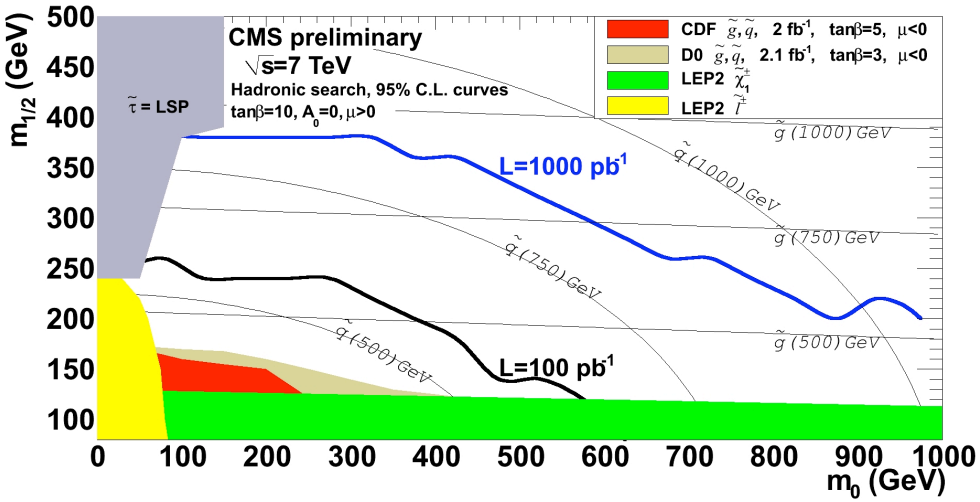

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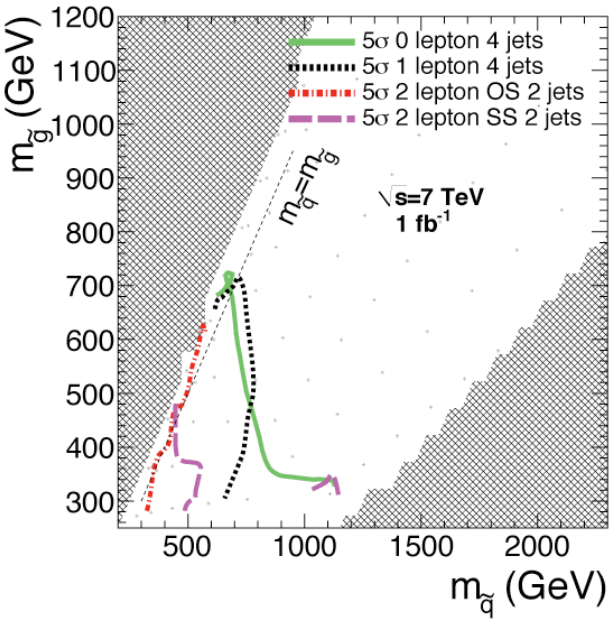

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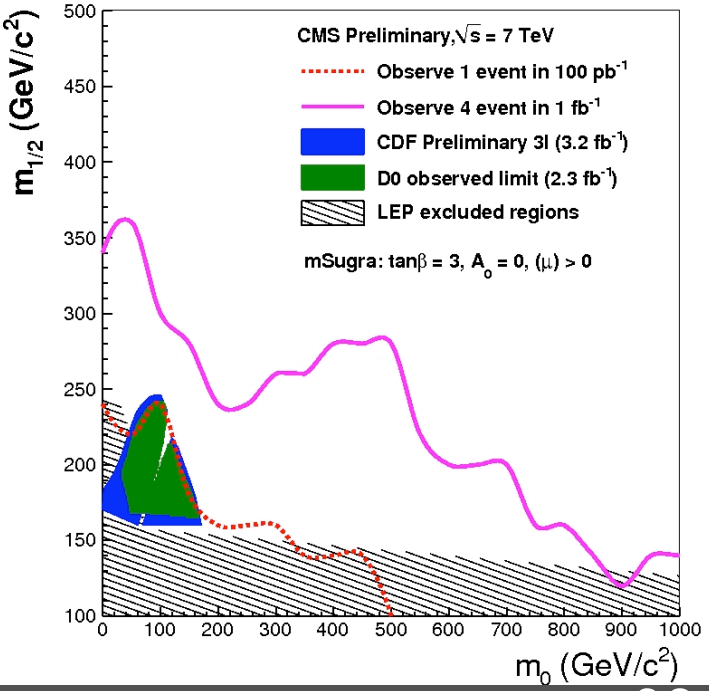
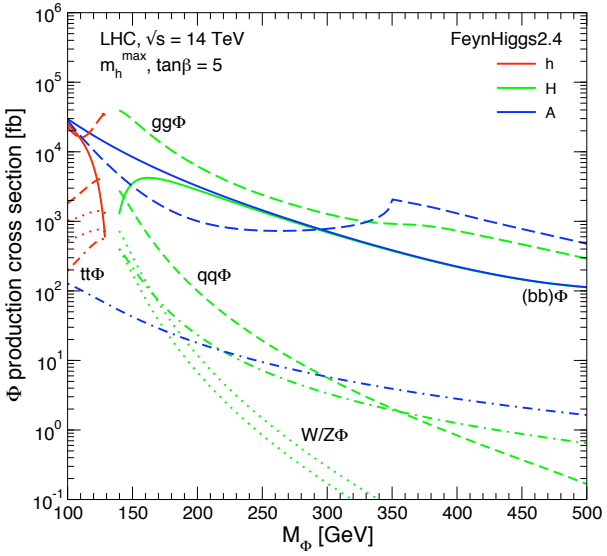
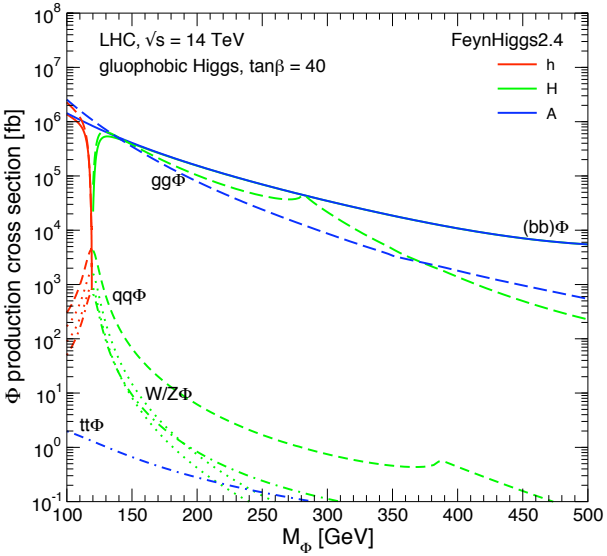


MSSM Neutral Higgs XS

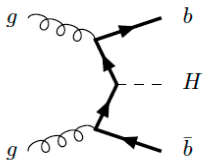
S. Heinemeyer

LHC Higgs XS working group





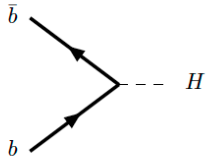
bbh associated prodcution



NLO

exact $g \to b\bar{b}$ splitting & mass/off-shell effects

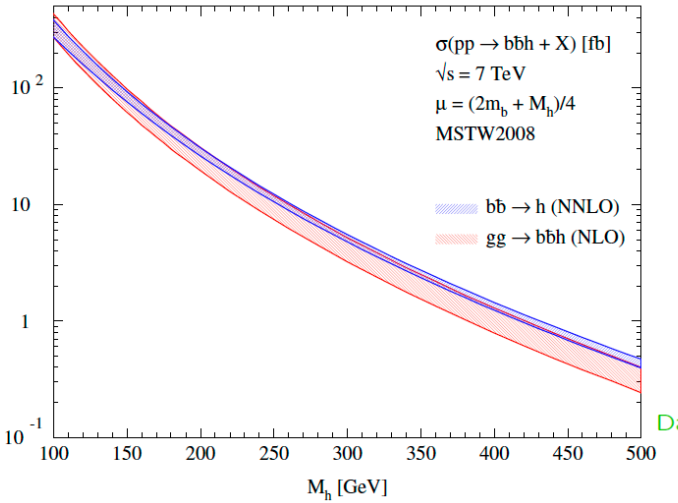
no resummation of $\log M_H^2/m_b^2$ terms



NNLO

massless/on-shell b's, no p_{Tb}

resummation of $\log M_H^2/m_b^2$ terms

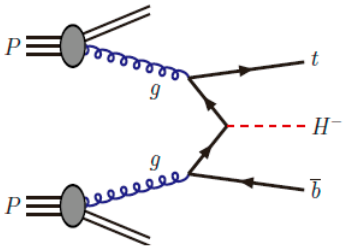


Dittmaier, Krämer, S.
Dawson, Jackson, Reina, Wackeroth
Harlander, Kilgore

MSSM Charged Higgs tbH± Cross Section

LHC Higgs XS working group

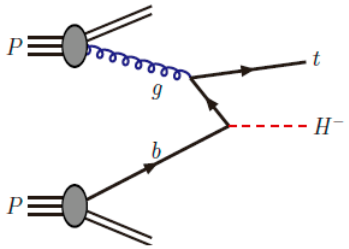
4-flavour scheme



+ exact $g \to b\bar{b}$ splitting & mass effects

− no summation of $\ln(M_H/M_b)$ terms

5-flavour scheme



+ summation of $\ln(M_H/M_b)$ terms

− LL approximation to $g \to b\bar{b}$ splitting

Plehn, Dittmaier, Krämer, Spira, Walser