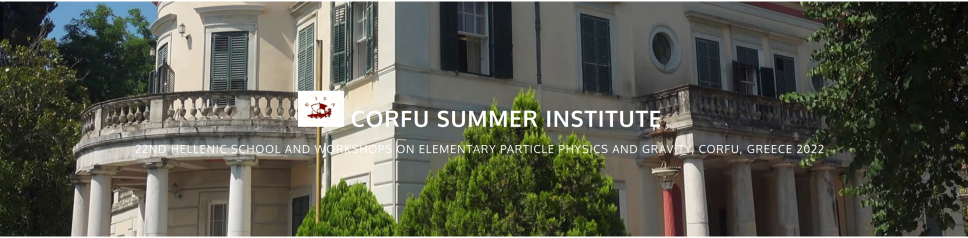
Higgs Properties and Supersymmetry

Nazila Mahmoudi

Lyon University and CERN

Based on arXiv:2201.00070 [PRD 106, 055002 (2022)]
with A. Arbey, M. Battaglia, A. Djouadi, M. Mühlleitner and M. Spira



10th anniversary of the Higgs boson

Discovery of a new scalar announced on July 4th, 2012!

Confirmation for a Higgs boson on March 14th, 2013:

"New results indicate that particle discovered at CERN is a Higgs boson"
– Rolf Heuer

The Higgs boson discovery $\rightarrow$ a vast program of studies of its properties as new tests of the SM and of models of NP!

In the **Standard Model**:
Higgs mass = free parameter related to the Higgs potential parameters:

$$M_H = \sqrt{-2\mu^2} = \sqrt{\frac{1}{2}\lambda v^2}$$

M_H measured $\Rightarrow$ all parameters of the Higgs theory fixed

Yukawa couplings determined by the measurement of all the fermion masses

In **extended Higgs scenarios**:
The Higgs couplings and its decay branching fractions can be shifted!

Precision study of the mass and the production and decay rates:

- essential for establishing the mechanism of ESB and mass generation
- exploring the contributions of new physics models to the Higgs sector
  $\rightarrow$ setting constraints on their parameter spaces

In this talk...

MSSM: excellent benchmark for an extended Higgs sector
$\rightarrow$ the MSSM effects on the light Higgs BRs and couplings

- Results for most of the Higgs decay and production channels of interest now in hand
- Mass bounds set by a broad variety of SUSY searches

$\Rightarrow$ Detailed assessment of the interplay between Higgs physics and SUSY at the LHC and beyond

In this talk:

- Brief introduction
- The dependence of the Higgs BRs on M_A and $\tan\beta$
- The effects of Δ_b corrections on the BRs
- Invisible decays into neutralino pairs and DM direct detection constraints
- The sensitivity of Higgs factories on the BRs to the MSSM

MSSM: excellent benchmark for an extended Higgs sector
$\rightarrow$ the MSSM effects on the light Higgs BRs and couplings

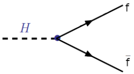
- Results for most of the Higgs decay and production channels of interest now in hand
- Mass bounds set by a broad variety of SUSY searches

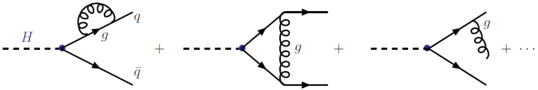
$\Rightarrow$ Detailed assessment of the interplay between Higgs physics and SUSY at the LHC and beyond

In this talk:

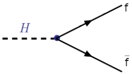
- Brief introduction
- The dependence of the Higgs BRs on M_A and $\tan\beta$
- The effects of Δ_b corrections on the BRs
- Invisible decays into neutralino pairs and DM direct detection constraints
- The sensitivity of Higgs factories on the BRs to the MSSM

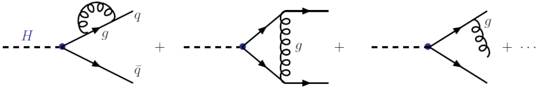
- Higgs to fermions



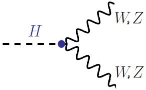


- Higgs to fermions



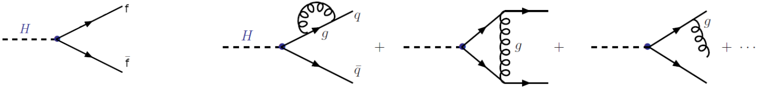


- Higgs to ZZ and WW

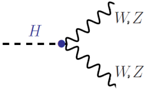


Higgs decay channels

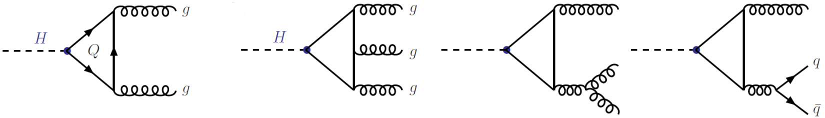
- Higgs to fermions



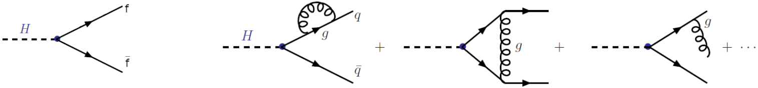
- Higgs to ZZ and WW



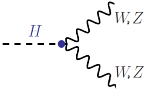
- Higgs to gluons



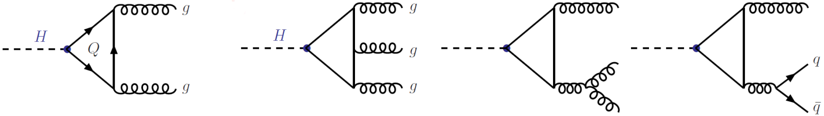
- Higgs to fermions



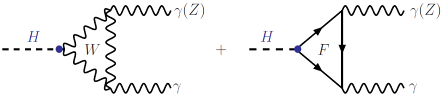
- Higgs to ZZ and WW



- Higgs to gluons

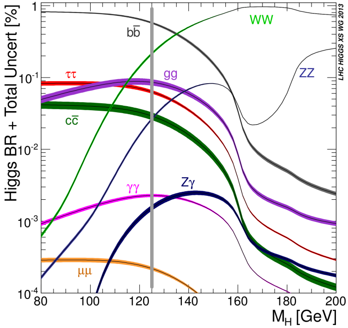


- Higgs to $\gamma\gamma$



- Higgs to $Z\gamma$

Higgs decay branching fractions:



LHC Higgs XS WG

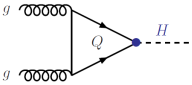
Mode	BR
$H \to b\bar{b}$	57.8%
$H \to WW^*$	21.6%
$H \to gg$	8.6%
$H \to \tau^+\tau^-$	6.4%
$H \to c\bar{c}$	2.9%
$H \to ZZ^*$	2.7%
$H \to \gamma\gamma$	0.2%

$H \to b\bar{b}$ main channel for $M_H \sim 125$ GeV

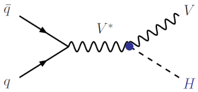
Higgs production channels

Main channels at the LHC

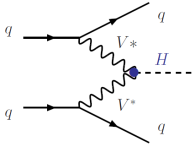
- gluon fusion:



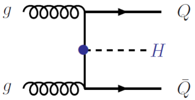
- associated production with Z or W:



- vector boson fusion:

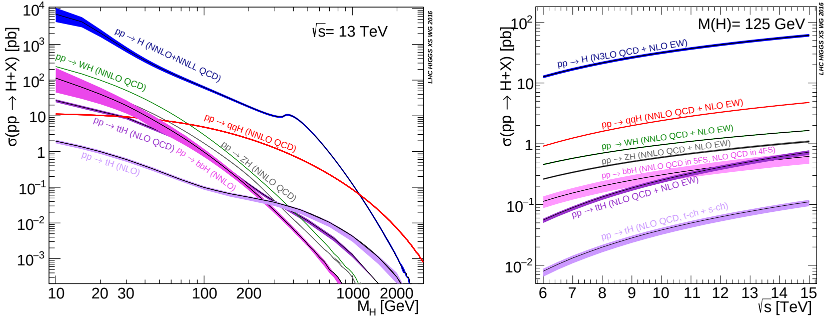


- associated production with heavy quarks:



- (double Higgs production)

Main channels at the LHC

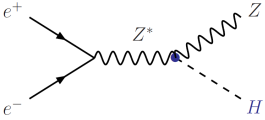


LHC Higgs XS WG

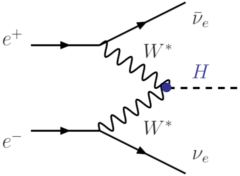
→ Uncertainties represented by the line widths

Main channels at e^+e^- colliders

- Higgs-strahlung:



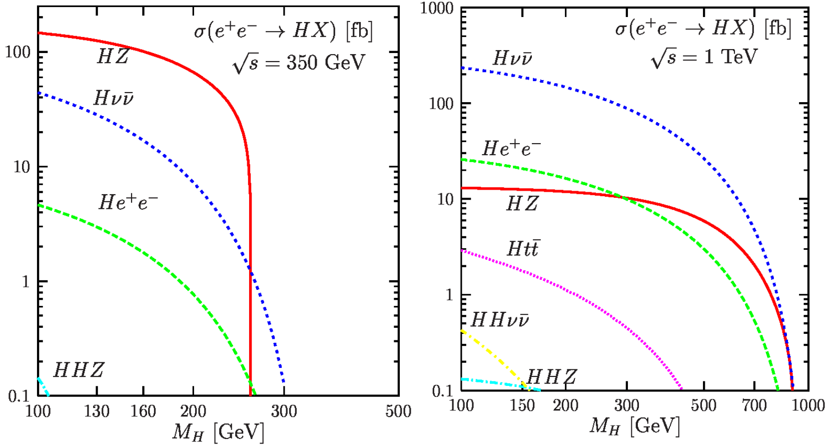
- *WW* fusion:



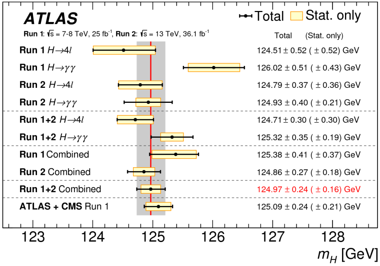
Other channels:

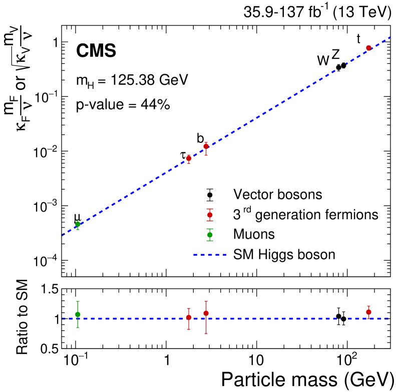
- *ZZ* fusion: $e^+e^- \to e^+e^-(Z^*Z^*) \to e^+e^-H$
- radiation of heavy fermions: $e^+e^- \to (\gamma^*, Z^*) \to f\bar{f}H$
- double Higgs production: $e^+e^- \to ZHH, \ell\ell HH$

Main channels at e^+e^- colliders

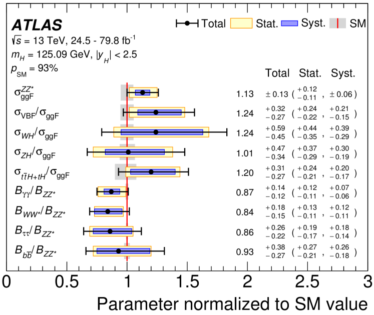


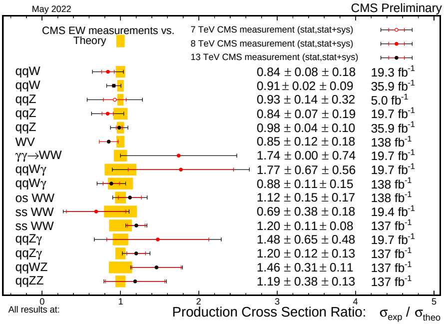
Higgs mass


ATLAS
Total
Stat. only
Run 1: √s = 7-8 TeV, 25 fb⁻¹, Run 2: √s = 13 TeV, 36.1 fb⁻¹
Total (Stat. only)
Run 1 H→4l 124.51 ± 0.52 (± 0.52) GeV
Run 1 H→γγ 126.02 ± 0.51 (± 0.43) GeV
Run 2 H→4l 124.79 ± 0.37 (± 0.36) GeV
Run 2 H→γγ 124.93 ± 0.40 (± 0.21) GeV
Run 1+2 H→4l 124.71 ± 0.30 (± 0.30) GeV
Run 1+2 H→γγ 125.32 ± 0.35 (± 0.19) GeV
Run 1 Combined 125.38 ± 0.41 (± 0.37) GeV
Run 2 Combined 124.86 ± 0.27 (± 0.18) GeV
Run 1+2 Combined 124.97 ± 0.24 (± 0.16) GeV
ATLAS + CMS Run 1 125.09 ± 0.24 (± 0.21) GeV
123
124
125
126
127
128
m_H [GeV]


35.9-137 fb⁻¹ (13 TeV)
CMS
m_H = 125.38 GeV
p-value = 44%
t
W Z
b
τ
μ
Vector bosons
3 rd generation fermions
Muons
SM Higgs boson
Ratio to SM
Particle mass (GeV)

Cross sections and partial decay widths





Minimal Supersymmetric extension of the Standard Model

The Higgs sector is extended (2HDM type II):

2 Higgs doublets $\rightarrow$ five Higgs states:

two CP–even h and H, one CP–odd A, and two charged Higgs bosons $H^{\pm}$

Phenomenological MSSM (pMSSM)

- The most general CP/R parity-conserving MSSM
- Minimal Flavour Violation at the TeV scale
- The first two sfermion generations are degenerate
- The three trilinear couplings are general for the 3 generations

$\rightarrow$ 19 free parameters

10 sfermion masses: $M_{\tilde{e}_L} = M_{\tilde{\mu}_L}$, $M_{\tilde{e}_R} = M_{\tilde{\mu}_R}$, $M_{\tilde{\tau}_L}$, $M_{\tilde{\tau}_R}$, $M_{\tilde{q}_{1L}} = M_{\tilde{q}_{2L}}$, $M_{\tilde{q}_{3L}}$, $M_{\tilde{u}_R} = M_{\tilde{c}_R}$, $M_{\tilde{t}_R}$, $M_{\tilde{d}_R} = M_{\tilde{s}_R}$, $M_{\tilde{b}_R}$

3 gaugino masses: M_1, M_2, M_3

3 trilinear couplings: $A_d = A_s = A_b$, $A_u = A_c = A_t$, $A_e = A_\mu = A_\tau$

3 Higgs/Higgsino parameters: M_A, $\tan\beta$, μ

Minimal Supersymmetric extension of the Standard Model

The Higgs sector is extended (2HDM type II):
2 Higgs doublets $\rightarrow$ five Higgs states:
two CP–even h and H, one CP–odd A, and two charged Higgs bosons $H^{\pm}$

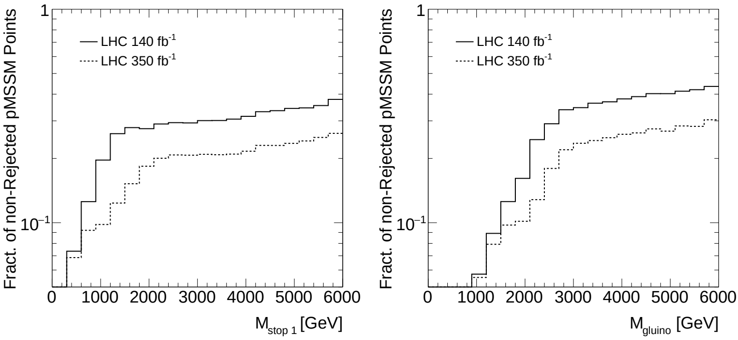
Phenomenological MSSM (pMSSM)

- The most general CP/R parity-conserving MSSM
- Minimal Flavour Violation at the TeV scale
- The first two sfermion generations are degenerate
- The three trilinear couplings are general for the 3 generations

$\rightarrow$ 19 free parameters

10 sfermion masses: $M_{\tilde{e}_L} = M_{\tilde{\mu}_L}$, $M_{\tilde{e}_R} = M_{\tilde{\mu}_R}$, $M_{\tilde{\tau}_L}$, $M_{\tilde{\tau}_R}$, $M_{\tilde{q}_{1L}} = M_{\tilde{q}_{2L}}$, $M_{\tilde{q}_{3L}}$, $M_{\tilde{u}_R} = M_{\tilde{c}_R}$, $M_{\tilde{t}_R}$, $M_{\tilde{d}_R} = M_{\tilde{s}_R}$, $M_{\tilde{b}_R}$
3 gaugino masses: M_1, M_2, M_3
3 trilinear couplings: $A_d = A_s = A_b$, $A_u = A_c = A_t$, $A_e = A_\mu = A_\tau$
3 Higgs/Higgsino parameters: M_A, $\tan\beta$, μ

Fraction of accepted pMSSM points not excluded at 95% C.L. by the present jet/ℓ+MET searches and the expected sensitivity of Run 3:



gluinos as light as 1 TeV or stops as light as 500 GeV can still escape the direct searches

- At leading order:

$$M_h^2 = M_Z^2 \cos^2 2\beta \left[1 - \frac{M_Z^2}{M_A^2} \sin^2 2\beta\right]$$

- Large one-loop correction from top/stop loops:

$$(\Delta M_h^2)_{\tilde{t}} \approx \frac{3\sqrt{2}G_F}{2\pi^2}\, m_t^4 \left[-\log\left(\frac{m_t^2}{M_S^2}\right) + \frac{X_t^2}{M_S^2}\left(1 - \frac{X_t^2}{12M_S^2}\right)\right]$$

with $X_t = A_t - \mu/\tan\beta$ and $M_S = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}}$

The maximal value can be reached for $X_t = \sqrt{6}M_S$ (maximal mixing)

- Contributions from sbottoms and staus in the large $\tan\beta$ limit

$$(\Delta M_h^2)_{\tilde{f}} \approx -\frac{N_c^{\tilde{f}}}{\sqrt{2}G_F}\,\frac{y_f^4}{96\pi^2}\,\frac{\mu^4}{m_{\tilde{f}}^4}$$

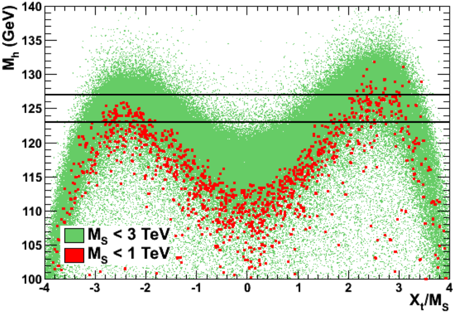
where $N_c^{\tilde{b}} = 3,\ N_c^{\tilde{\tau}} = 1,\ m_{\tilde{f}}^2 = m_{\tilde{f}_1} m_{\tilde{f}_2}$

$$M_h^2 \approx M_Z^2 \cos^2 2\beta \left[1 - \frac{M_Z^2}{M_A^2}\sin^2 2\beta\right] + \frac{3m_t^4}{2\pi^2 v^2}\left[\log\frac{M_S^2}{m_t^2} + \frac{X_t^2}{M_S^2}\left(1 - \frac{X_t^2}{12M_S^2}\right)\right]$$

- Important parameters for MSSM Higgs mass:
  - $\tan\beta$ and M_A
  - the SUSY breaking scale $M_S = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}}$
  - the mixing parameter in the stop sector $X_t = A_t - \mu\cot\beta$

- M_h^{max} is obtained for:
  - a decoupling regime with a heavy pseudoscalar Higgs boson, $M_A \sim \mathcal{O}(\text{TeV})$
  - large $\tan\beta$, *i.e.* $\tan\beta \gtrsim 10$
  - heavy stops, *i.e.* large M_S
  - maximal mixing scenario, *i.e.* $X_t = \sqrt{6}M_S$

- In contrast, much smaller M_h^{max} values for the no-mixing scenario, *i.e.* $X_t \approx 0$



A. Arbey, M. Battaglia, A. Djouadi, F.M., J. Quevillon, Phys.Lett. B708 (2012) 162

$M_h \sim 125$ GeV is easily satisfied in pMSSM

No mixing cases ($X_t \approx 0$) excluded for small M_S

Tree-level couplings, normalized to SM (in the decoupling limit when $M_A \gg M_Z$):

ϕ	$g_{\phi u\bar{u}}$	$g_{\phi d\bar{d}} = g_{\phi \ell\bar{\ell}}$	$g_{\Phi VV}$
h^0	$\cos\alpha/\sin\beta \to 1$	$-\sin\alpha/\cos\beta \to 1$	$\sin(\beta-\alpha) \to 1$
H^0	$\sin\alpha/\sin\beta \to -\cot\beta$	$\cos\alpha/\cos\beta \to \tan\beta$	$\cos(\beta-\alpha) \to 0$
A^0	$\cot\beta$	$\tan\beta$	0

$$\text{with } \alpha = -\arctan\left(\frac{(M_Z^2+M_A^2)\cos\beta\sin\beta}{M_Z^2\cos^2\beta + M_A^2\sin^2\beta - M_h^2}\right)$$

The couplings can be modified by QCD and EW corrections:

$$g^{\rm eff}_{hf\bar{f}} = \frac{g_{hf\bar{f}}}{1+\Delta_f}\left[1 - \frac{\Delta_f}{\tan\alpha\tan\beta}\right]$$

$$g^{\rm eff}_{Hf\bar{f}} = \frac{g_{Hf\bar{f}}}{1+\Delta_f}\left[1 + \Delta_f\frac{\tan\alpha}{\tan\beta}\right]$$

$$g^{\rm eff}_{Af\bar{f}} = \frac{g_{Af\bar{f}}}{1+\Delta_f}\left[1 - \frac{\Delta_f}{\tan^2\beta}\right]$$

where the Δ_f incorporates the QCD and EW corrections, and the SUSY-QCD corrections can make $|\Delta_f| \sim 1$.

Higgs couplings and SUSY corrections

Tree-level couplings, normalized to SM (in the decoupling limit when $M_A \gg M_Z$):

ϕ	$g_{\phi u\bar{u}}$	$g_{\phi d\bar{d}} = g_{\phi \ell\bar{\ell}}$	$g_{\Phi VV}$
h^0	$\cos\alpha / \sin\beta \to 1$	$-\sin\alpha / \cos\beta \to 1$	$\sin(\beta-\alpha) \to 1$
H^0	$\sin\alpha / \sin\beta \to -\cot\beta$	$\cos\alpha / \cos\beta \to \tan\beta$	$\cos(\beta-\alpha) \to 0$
A^0	$\cot\beta$	$\tan\beta$	0

$$\text{with } \alpha = -\arctan\left(\frac{(M_Z^2 + M_A^2)\cos\beta\sin\beta}{M_Z^2\cos^2\beta + M_A^2\sin^2\beta - M_h^2}\right)$$

The couplings can be modified by QCD and EW corrections:

$$g^{\text{eff}}_{hf\bar{f}} = \frac{g_{hf\bar{f}}}{1+\Delta_f}\left[1 - \frac{\Delta_f}{\tan\alpha\tan\beta}\right]$$

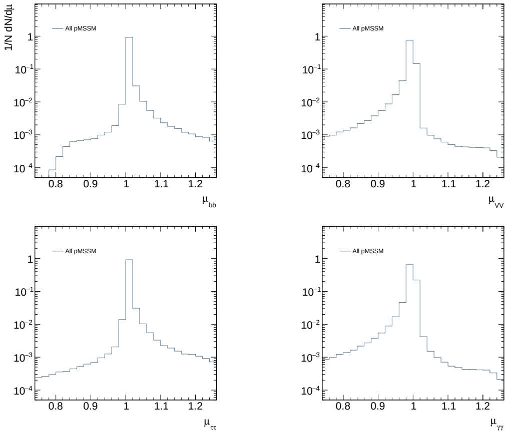
$$g^{\text{eff}}_{Hf\bar{f}} = \frac{g_{Hf\bar{f}}}{1+\Delta_f}\left[1 + \Delta_f\frac{\tan\alpha}{\tan\beta}\right]$$

$$g^{\text{eff}}_{Af\bar{f}} = \frac{g_{Af\bar{f}}}{1+\Delta_f}\left[1 - \frac{\Delta_f}{\tan^2\beta}\right]$$

where the Δ_f incorporates the QCD and EW corrections, and the SUSY-QCD corrections can make $|\Delta_f| \sim 1$.

Distributions of h decay branching fractions normalised to their SM prediction:

$$\mu_{XX} \equiv \frac{\sigma(pp \to h)\,\mathrm{BR}(h \to XX)}{\sigma(pp \to h)_{\mathrm{SM}}\,\mathrm{BR}(h \to XX)_{\mathrm{SM}}}$$

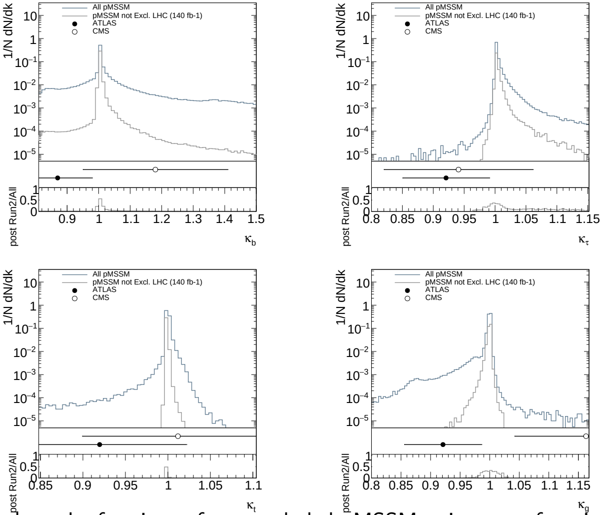


Best fit values for the Higgs coupling modifiers $\kappa_X = g_{hXX}^{\mathrm{MSSM}} / g_{hXX}^{\mathrm{SM}}$ from the combination of the **ATLAS** measurements, and projections for different stages of the LHC, and for the ILC and FCC-ee colliders:

Coupling modifier	ATLAS 13 TeV up to 140 fb^{-1}	ATLAS 14 TeV 3 ab^{-1} †	ILC 250 GeV 2 ab^{-1}	ILC 1 TeV 8 ab^{-1}	FCC-ee 365 GeV 1.5 ab^{-1}
κ_W	1.05 ± 0.09	± 0.022	± 0.0180	± 0.0024	± 0.0043
κ_Z	1.11 ± 0.08	± 0.018	± 0.0029	± 0.0022	± 0.0017
κ_t	$1.03^{+0.15}_{-0.14}$	$^{+0.043}_{-0.040}$	$-$	± 0.016	$-$
κ_b	$1.09^{+0.19}_{-0.17}$	$^{+0.044}_{-0.028}$	± 0.0180	± 0.0048	± 0.067
κ_τ	$1.05^{+0.16}_{-0.15}$	$^{+0.028}_{-0.027}$	± 0.0190	± 0.0057	± 0.0073
κ_g	1.05 ± 0.09	$^{+0.032}_{-0.030}$	± 0.0230	± 0.0066	± 0.0100
κ_γ	$0.99^{+0.11}_{-0.10}$	$^{+0.028}_{-0.023}$	± 0.0670	± 0.019	± 0.0390

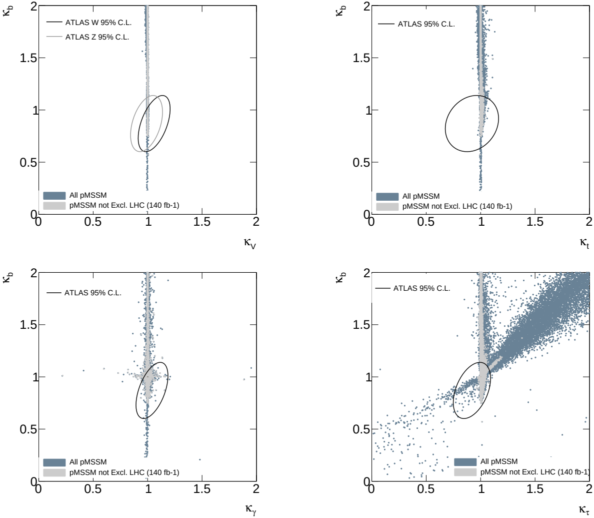
Current determination with precisions of the order of 10%, uncertainties will decrease by a factor 10 in the future.

h coupling modifiers, κ_X, for all valid pMSSM points and those not excluded by the LHC Run 2 searches compared to the present measurements by the ATLAS and CMS:

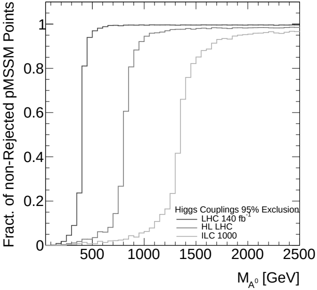


The lower panels show the fractions of non-excluded pMSSM points as a function κ_X

Correlations of *h* coupling modifiers comparing the valid pMSSM points, those not excluded by the LHC Run 2 searches and the 95% C.L. contours of the current measurements by the ATLAS experiment:



Fraction of accepted pMSSM points not excluded at the 95% of C.L. by the Higgs couplings as a function of the M_A mass:



dark grey: present Run 2 ATLAS results
medium grey: expected HL-LHC
light grey: ILC-1000 accuracies

Invisible Higgs decay is related to dark matter when neutralino 1 mass below $M_h/2$

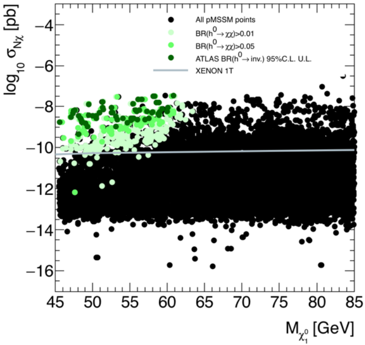
Decay width:

$$\Gamma(h \to \chi_1^0 \chi_1^0) = \frac{G_F M_W^2 M_h}{2\sqrt{2}\pi} g^2_{h\chi_1^0\chi_1^0} \beta_\chi^3 \quad \text{where} \quad \beta_\chi = (1 - 4m_\chi^2/M_h^2)^{1/2}$$

Light bino-like neutralinos can easily escape the LHC constraints

ATLAS limit on invisible decays: BR($h \to$ inv) < 0.11 **(ATLAS-CONF-2020-008)**

Spin-independent χ_1^0-nucleon scattering cross section driven by same coupling $g_{h\chi_1^0\chi_1^0}$



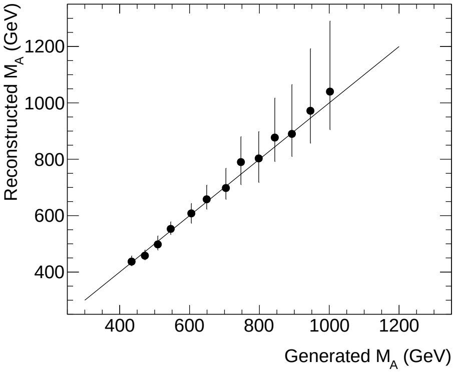
Black dots: all pMSSM points

Coloured dots: points with sizeable invisible BR

Dark green dots: points excluded by LHC Higgs invisible decay limit

Grey line: Xenon1T upper bound

Reconstruction of M_A at ILC 1 TeV from Higgs decay measurements



M_A (GeV)	$\tan\beta$	μ	$M_{\chi_1^0}$
434.4	5.58	-549.3	562.1
472.4	6.62	1993.7	314.8
509.8	5.48	-181.9	184.7
546.9	5.55	-50.5	49.9
605.7	6.31	369.1	380.1
649.5	3.15	1722.6	108.3
704.4	5.24	480.5	170.6
747.0	4.51	-3596.1	1072.0
798.4	5.75	-3301.7	1329.4
844.3	9.11	-1679.5	1695.1
893.2	7.14	-367.9	379.5
946.9	7.65	-4268.0	363.5
1001.9	5.39	715.9	732.0

ILC will be mainly sensitive to M_A and $\tan\beta$
because of the suppression of the Δ_b corrections

Conclusion

- Study of the Higgs boson properties
  $\rightarrow$ compelling perspectives for testing the effects of BSM physics at the LHC and at future colliders
- In the MSSM: The Higgs couplings to SM particles, both at tree level and through loops, are sensitive to new physics effects and can be used to discriminate the MSSM h from the SM H
- Higgs coupling measurements with the accuracies obtained on the LHC run 2 data and those expected for the HL-LHC and future e^+e^- colliders can exclude a significant fraction of the pMSSM points
- Future e^+e^- colliders of sufficient energy can indirectly determine M_A to a relative accuracy ranging from 8% to 40% for M_A values from 700 GeV to 1.1 TeV, from the deviations of the measured lightest h couplings with respect to their SM expectations

$\rightarrow$ Large parts of the MSSM parameters are still to be probed

$\rightarrow$ The properties of the observed Higgs boson are SM-like
they are also MSSM-like!

- Study of the Higgs boson properties
  $\rightarrow$ compelling perspectives for testing the effects of BSM physics at the LHC and at future colliders
- In the MSSM: The Higgs couplings to SM particles, both at tree level and through loops, are sensitive to new physics effects and can be used to discriminate the MSSM h from the SM H
- Higgs coupling measurements with the accuracies obtained on the LHC run 2 data and those expected for the HL-LHC and future e^+e^- colliders can exclude a significant fraction of the pMSSM points
- Future e^+e^- colliders of sufficient energy can indirectly determine M_A to a relative accuracy ranging from 8% to 40% for M_A values from 700 GeV to 1.1 TeV, from the deviations of the measured lightest h couplings with respect to their SM expectations

$\rightarrow$ Large parts of the MSSM parameters are still to be probed

$\rightarrow$ The properties of the observed Higgs boson are SM-like
they are also MSSM-like!

- Study of the Higgs boson properties
  $\rightarrow$ compelling perspectives for testing the effects of BSM physics at the LHC and at future colliders
- In the MSSM: The Higgs couplings to SM particles, both at tree level and through loops, are sensitive to new physics effects and can be used to discriminate the MSSM h from the SM H
- Higgs coupling measurements with the accuracies obtained on the LHC run 2 data and those expected for the HL-LHC and future e^+e^- colliders can exclude a significant fraction of the pMSSM points
- Future e^+e^- colliders of sufficient energy can indirectly determine M_A to a relative accuracy ranging from 8% to 40% for M_A values from 700 GeV to 1.1 TeV, from the deviations of the measured lightest h couplings with respect to their SM expectations

$\rightarrow$ Large parts of the MSSM parameters are still to be probed

$\rightarrow$ The properties of the observed Higgs boson are SM-like
they are also MSSM-like!

Conclusion

- Study of the Higgs boson properties
  $\rightarrow$ compelling perspectives for testing the effects of BSM physics at the LHC and at future colliders
- In the MSSM: The Higgs couplings to SM particles, both at tree level and through loops, are sensitive to new physics effects and can be used to discriminate the MSSM h from the SM H
- Higgs coupling measurements with the accuracies obtained on the LHC run 2 data and those expected for the HL-LHC and future e^+e^- colliders can exclude a significant fraction of the pMSSM points
- Future e^+e^- colliders of sufficient energy can indirectly determine M_A to a relative accuracy ranging from 8% to 40% for M_A values from 700 GeV to 1.1 TeV, from the deviations of the measured lightest h couplings with respect to their SM expectations

$\rightarrow$ Large parts of the MSSM parameters are still to be probed

$\rightarrow$ The properties of the observed Higgs boson are SM-like
they are also MSSM-like!

Extra slides

The most general CP/R parity-conserving MSSM, assuming Minimal Flavour Violation at the TeV scale and suppresed FCNC's at tree level, with 19 free parameters:

10 sfermion masses, 3 gaugino masses, 3 trilinear couplings, 3 Higgs/Higgsino parameters

A. Djouadi et al., hep-ph/9901246

Flat scans over the pMSSM 19 parameters

Parameter	Range (in GeV)
M_A	[50, 6000]
M_1	[-6000, 6000]
M_2	[-6000, 6000]
M_3	[50, 6000]
$A_d = A_s = A_b$	[-15000, 15000]
$A_u = A_c = A_t$	[-15000, 15000]
$A_e = A_\mu = A_\tau$	[-15000, 15000]
μ	[-6000, 6000]
$M_{\tilde{e}_L} = M_{\tilde{\mu}_L}$	[0, 6000]
$M_{\tilde{e}_R} = M_{\tilde{\mu}_R}$	[0, 6000]
$M_{\tilde{\tau}_L}$	[0, 6000]
$M_{\tilde{\tau}_R}$	[0, 6000]
$M_{\tilde{q}_{1L}} = M_{\tilde{q}_{2L}}$	[0, 6000]
$M_{\tilde{q}_{3L}}$	[0, 6000]
$M_{\tilde{u}_R} = M_{\tilde{c}_R}$	[0, 6000]
$M_{\tilde{t}_R}$	[0, 6000]
$M_{\tilde{d}_R} = M_{\tilde{s}_R}$	[0, 6000]
$M_{\tilde{b}_R}$	[0, 6000]
$\tan\beta$	[1, 60]

- Calculation of masses, mixings and couplings (SoftSusy)
- Computation of low energy observables and Z widths (SuperIso)
- Computation of dark matter observables (SuperIso Relic)
- Calculation of Higgs cross-sections and decay rates (HDECAY, Higlu, SusHi)
- Calculation of SUSY decay rates (SDECAY)
- Event generation and evaluation of cross-sections (PYTHIA, Prospino, MadGraph)
- Implementation of ATLAS and/or CMS SUSY and monoX search results
- Determination of detectability with fast detector simulation (Delphes)

We assume that the neutralino is the lightest SUSY particle and the light Higgs mass is between 123 and 127 GeV.