Status and discovery prospects for light pseudoscalars in the NMSSM

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Outline

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Why Supersymmetry?

- We have discovered the Higgs, is there any reason to expect more from the LHC?
- If we are worried about fine tuning; Yes, the Higgs mass term needs to be stabilized.
- Naively, any such stabilisation mechanism should show up at the LHC.
- Supersymmetry is the most straight forward solution.
- The absence of experimental evidence is getting troublesome, but we do not have any better idea.

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NMSSM

- In the MSSM superpotential we have $\mu \widehat{H}_u \widehat{H}_d$.
- μ has dimension mass, so what value should it have?
- Naively: M_{GUT} or so; phenomenologically: M_Z.
- The NMSSM instead has $\lambda \widehat{S} \widehat{H}_u \widehat{H}_d$ and S gets a VEV so we get the μ term $\lambda \langle S \rangle \widehat{H}_u \widehat{H}_d$.

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Light pseudoscalar

The scalar sector

NMSSM has 3 neutral scalars and 2 neutral pseudoscalars.
The $H_{\rm SM}$ is the non-singlet-like of H_1 and H_2.
m_{A_2}, m_{H_3} and $m_{H^\pm}$ are all similar and typically $\gtrsim$ 400 GeV.

Light particles

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- As m_{A_1} can take any value, it can be very small.
- Hard to produce directly: no VBF nor Higgstrahlung; gluon fusion small.
- Maybe associated $b\bar{b}A_1$ production.
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Parameters of interest

Scan methods

We use scans with fixed sfermion masses, as well as GUT boundary conditions, both random scans and nested sampling;
results are mostly the same.

Scan parameters

$\lambda, \kappa, \mu_{\rm eff}, A_\lambda$ and A_κ or M_p.

Constraints

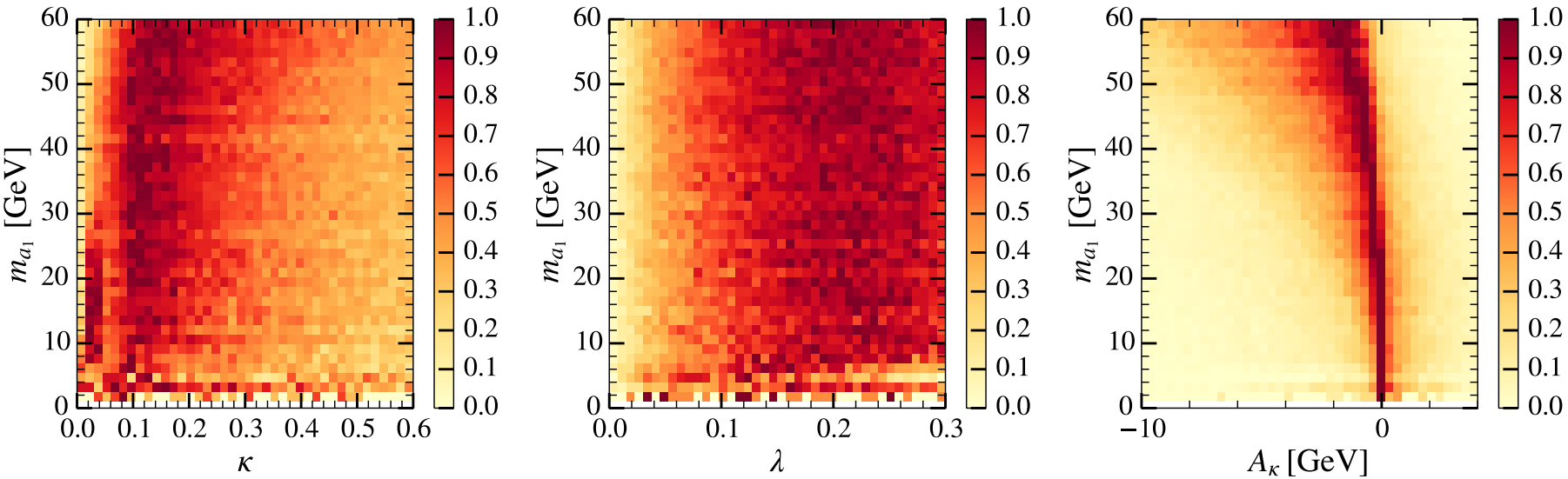
Use loose constraints

$122 < m_{H_{\rm SM}} < 128$ GeV, wide range due to theoretical uncertainties.
$\Omega_\chi h^2 < 0.131$; no $(g-2)_\mu$ constraint.
In addition constraints from LEP searches, B-physics, perturbativity etc. from NMSSMTools.

The most important constraint

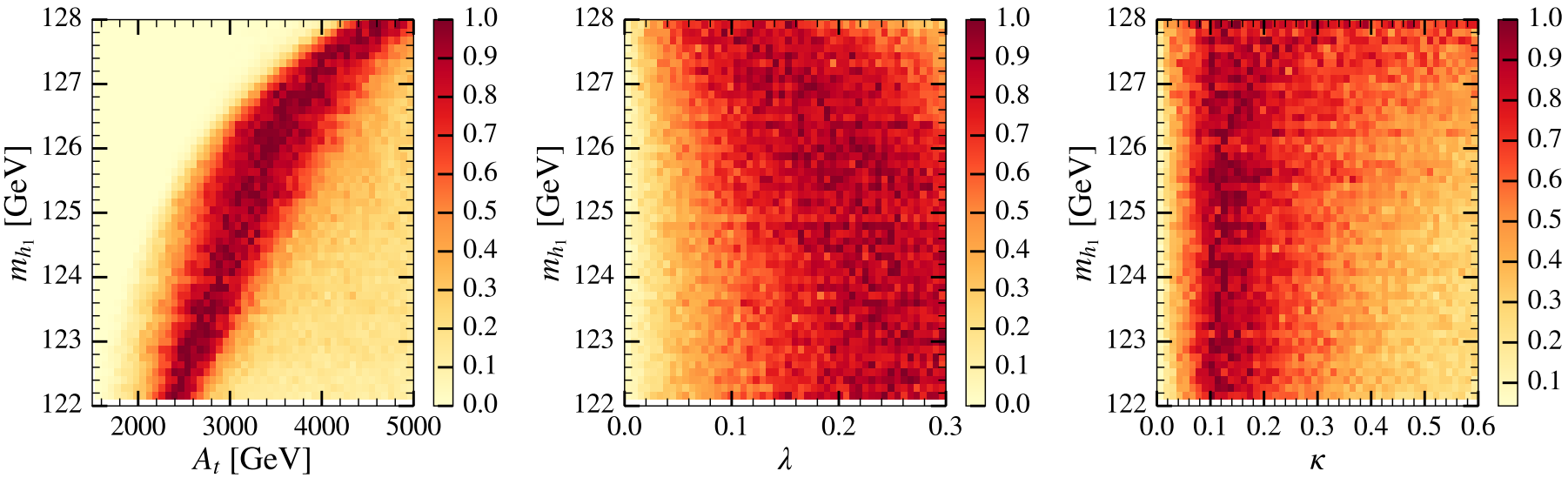
Also constraints on $H_{\rm SM}$ signal rates from lilith as included in NMSSMTools, cross-checked with HiggsSignals.

Light pseudoscalars



small $A_\kappa \Rightarrow$ light A_1

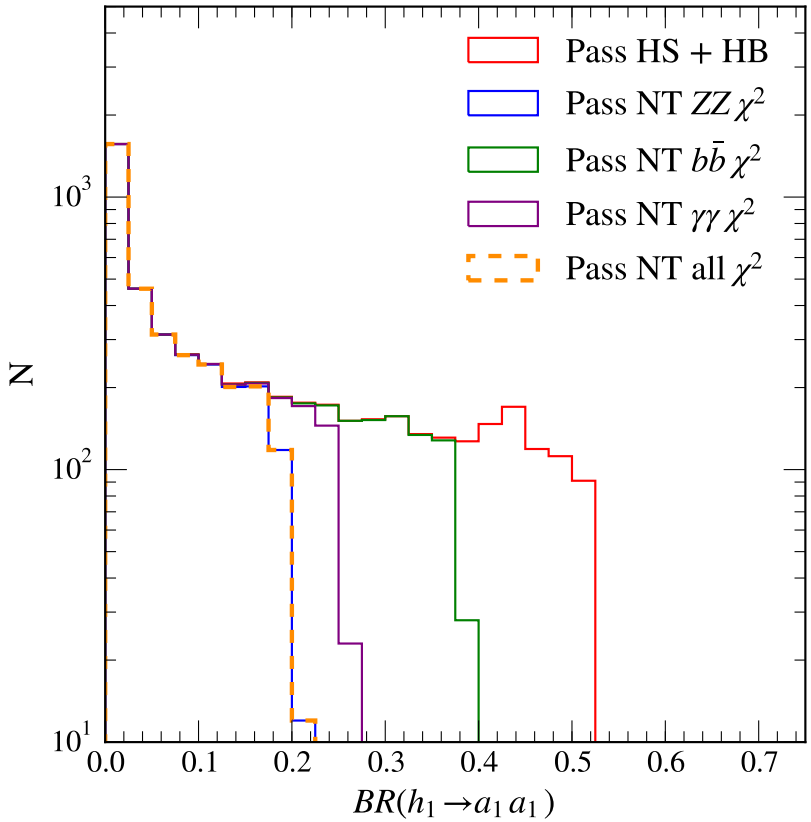
The mass of $H_{\rm SM}$



The Higgs mass is most often achieved through large A_t

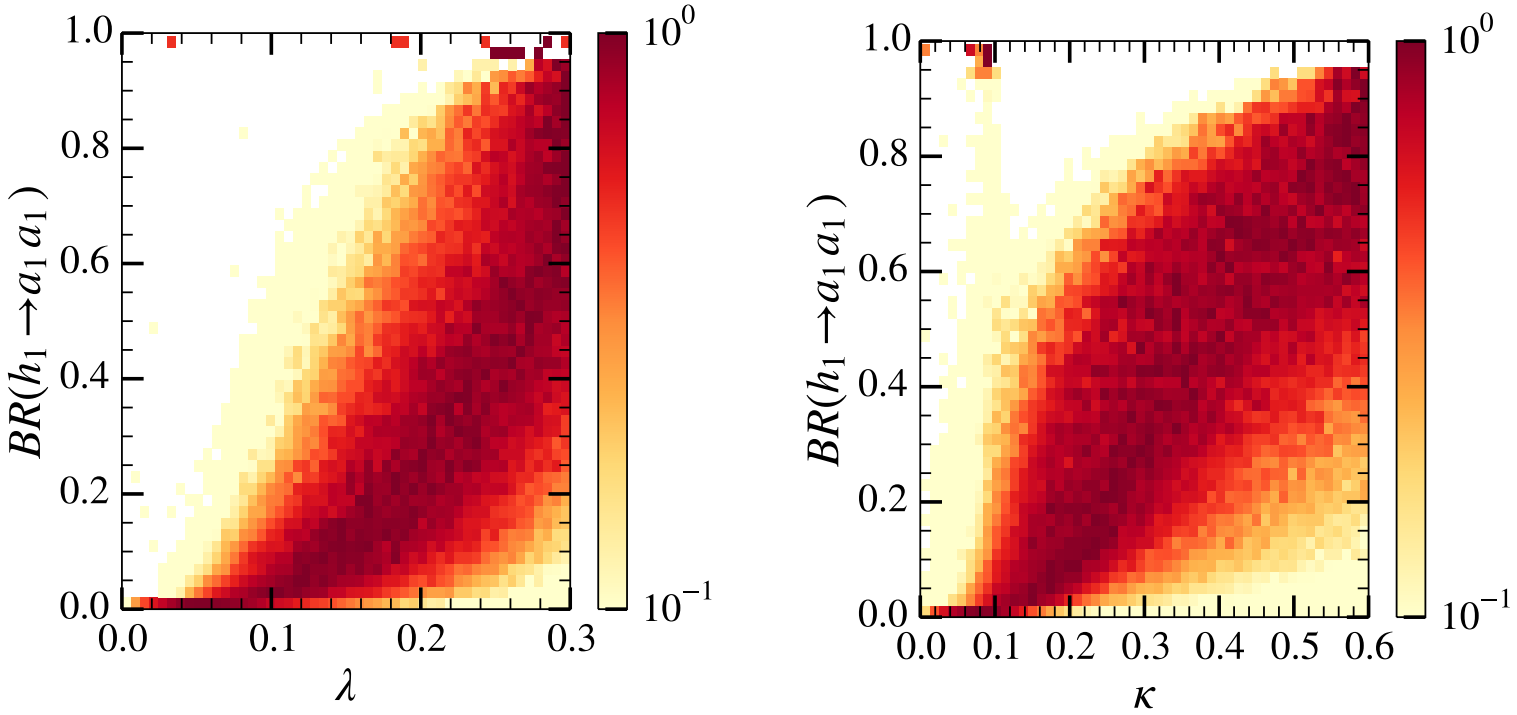
Outline

Comparing constraint on Br($H_{SM} \to A_1 A_1$)



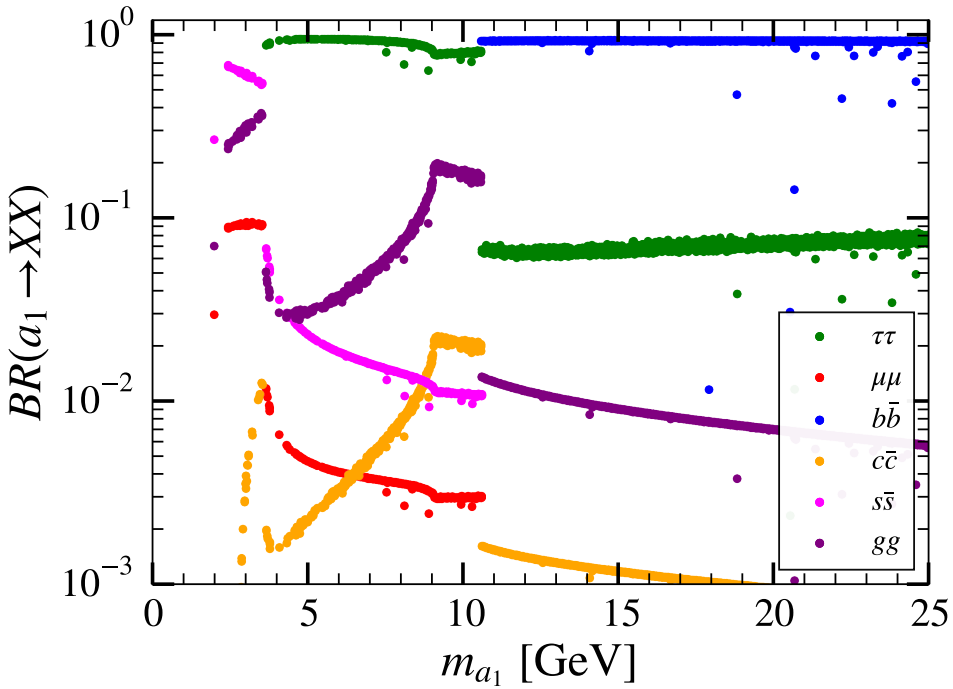
Allowed Br depends strongly on treatment of limits!

Parameter dependence of Br($H_{SM} \to A_1 A_1$)



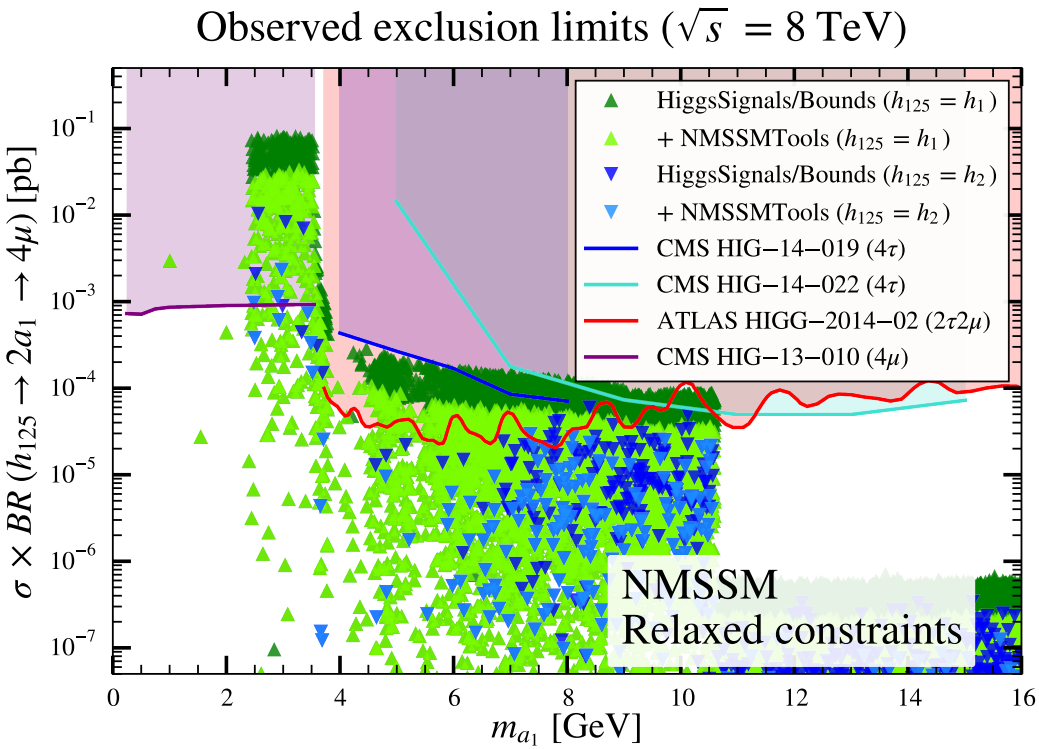
Sets limit $\lambda < 0.4$ and constrains $\lambda\kappa$

Possible decays of light pseudoscalars



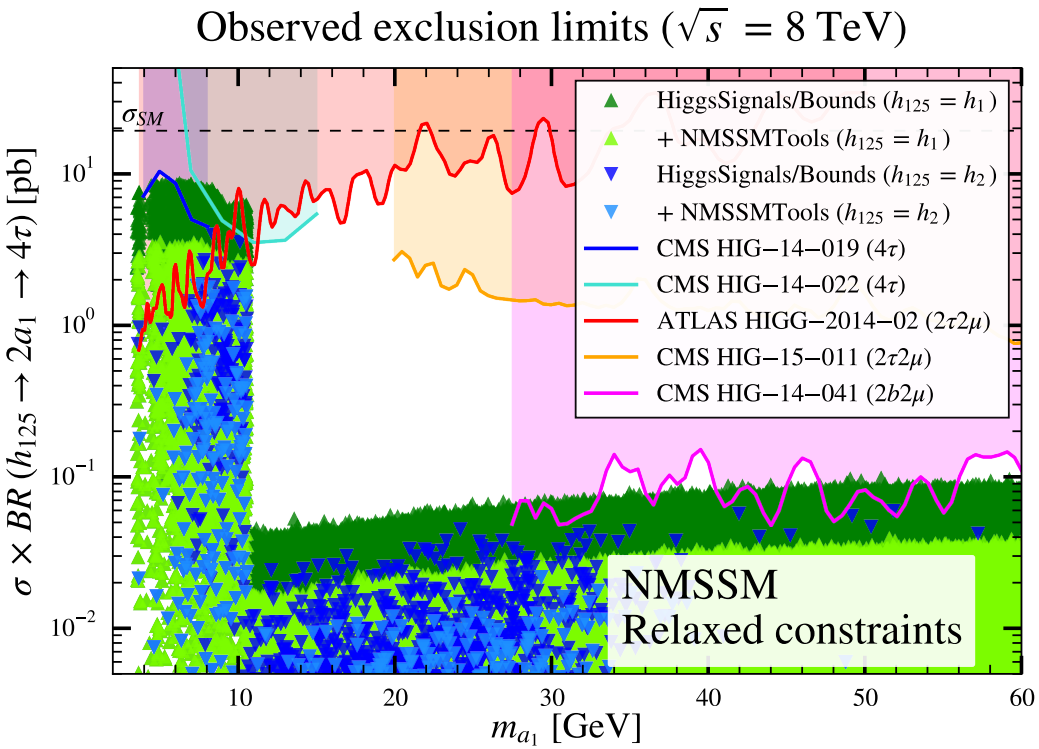
Much more promising for $m_{A_1} < 10$ GeV

Low mass searches



Significant constraints for $m_{A_1} < 4$ GeV.

Higher mass searches



$m_{A_1} > 10$ GeV more difficult but $2b2\mu$ promising.

Summary

- Light scalars and pseudoscalars are possible in well motivated theories for new physics.
- Such light particles might be hard to detect due to very weak interactions.
- LHC searches are starting to nag the relevant parameter space.