Some thoughts on possible benchmark scenarios for the NMSSM

* Define typical or challenging scenarios for Higgs boson discovery at the LHC
* Six Higgs bosons: H1, H2, H3, A1, A2, H+
* 6 parameters in Higgs-Sector at tree-level: λ, kappa, tanβ, μeff, Aλ Ak
  => scan parameter space over these parameters, but in which combination?

Nothing final yet, help & suggestions highly welcome !

Plots done using NMHDECAY, mtop=172GeV, RenScale=1000 GeV, ...

IDEA NR. 1: a very simple scenario

μeff=250 GeV (EW-scale)
Aλ=Aκ=0
tanβ=3 & 30
scan λ, κ

→ Do not find unexcluded region!

Vary parameters a bit:
e.g. μeff=-250 GeV,
e.g. Aλ=Ak= -100
e.g. Aλ=Ak= 1000

→ Either excluded or with a light H1 ~ 120 GeV with SM-like couplings and no decays into A1.
=> rather boring

Is a SM-like Higgs “frequent” in the NMSSM?
(also see this in other scenarios)

IDEA NR. 2: Maximal H1 mass

Paper from U. Ellwanger, C. Hugonie (hep-ph/0612133)
M1 = 150 GeV, M2 = 300 GeV, M3 = 1 TeV
MSusy = 1 TeV
At=Ab=Atau=2.5 TeV

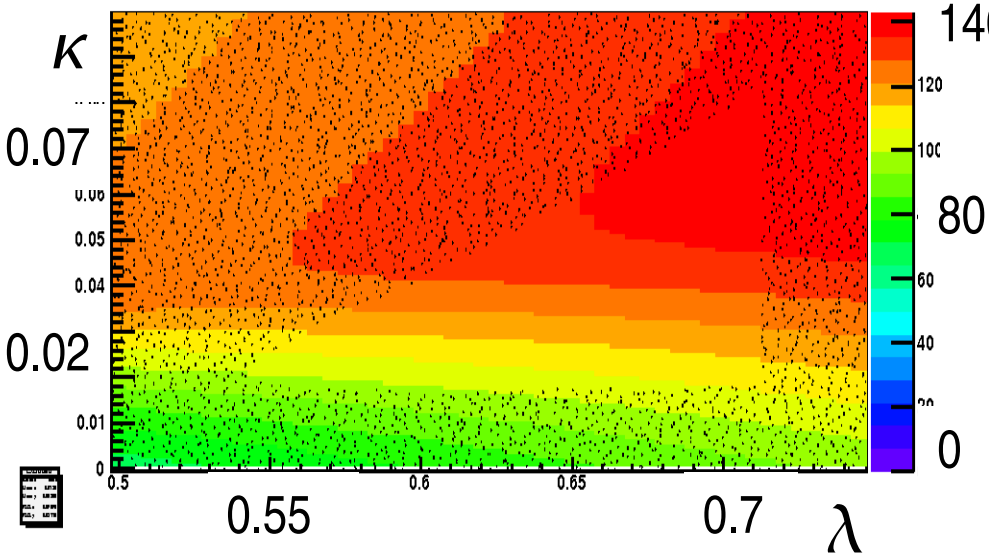
μeff= 620 GeV
Aλ= 1530 GeV
Aκ=10 GeV
tanβ = 2.14
λ = 0.678
κ = 0.067

Scan in parameter-pairs around this point:
λ, κ
Aλ, Aκ
μeff, tanβ

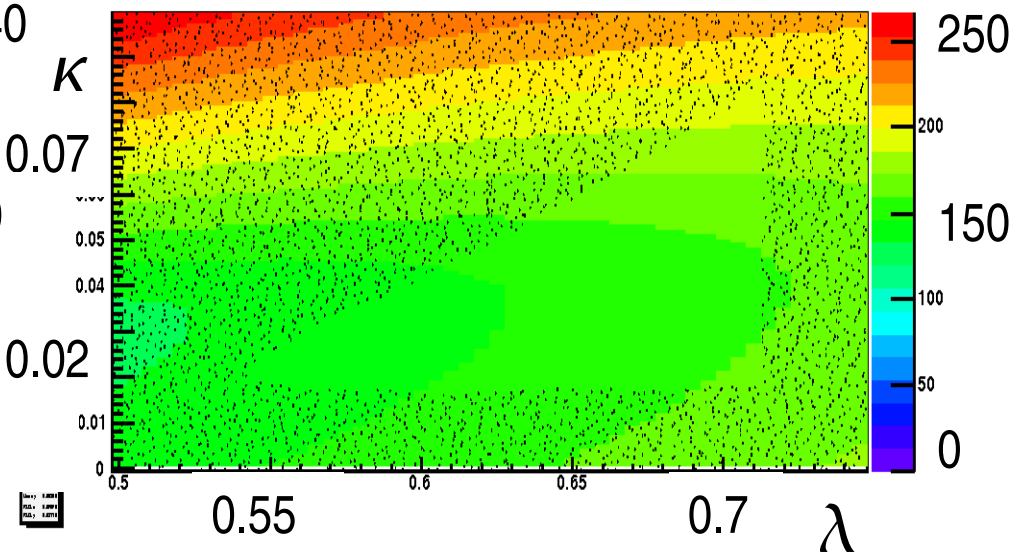
Are there better combinations for scanning?

Maximal H1 mass - λ - κ Scan

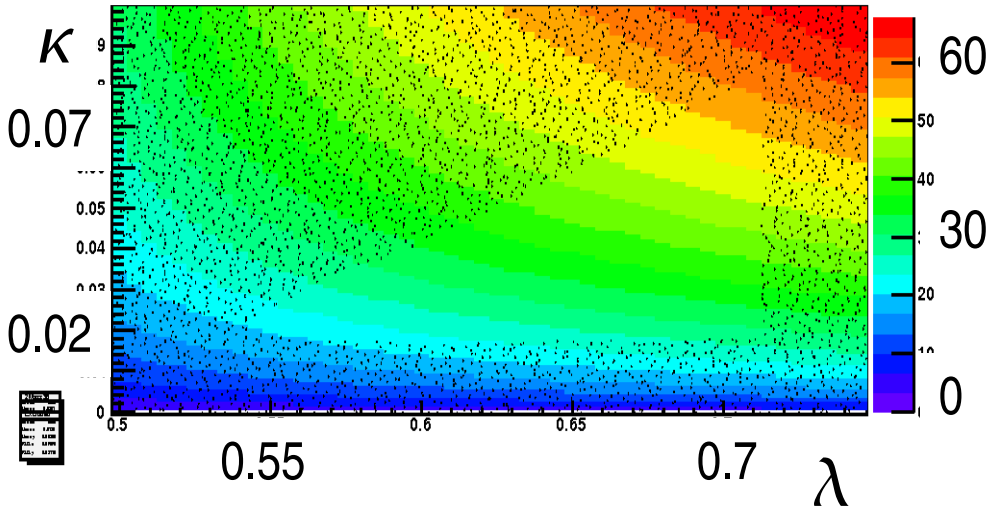
Mass of H1



Mass of H2



Mass of A1

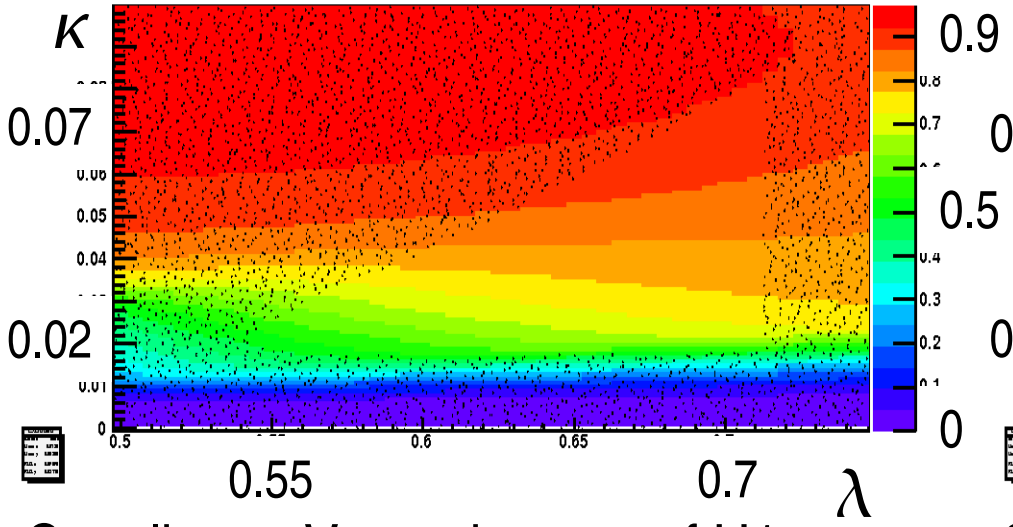


MH3~MA2~MH+~1800 GeV

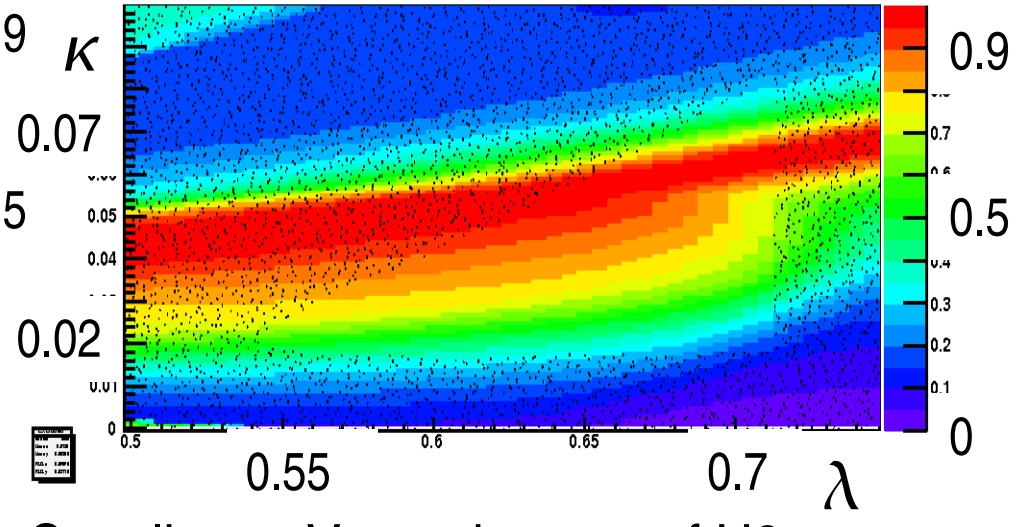
Black dots: Excluded region!

Maximal H1 mass - λ - κ Scan

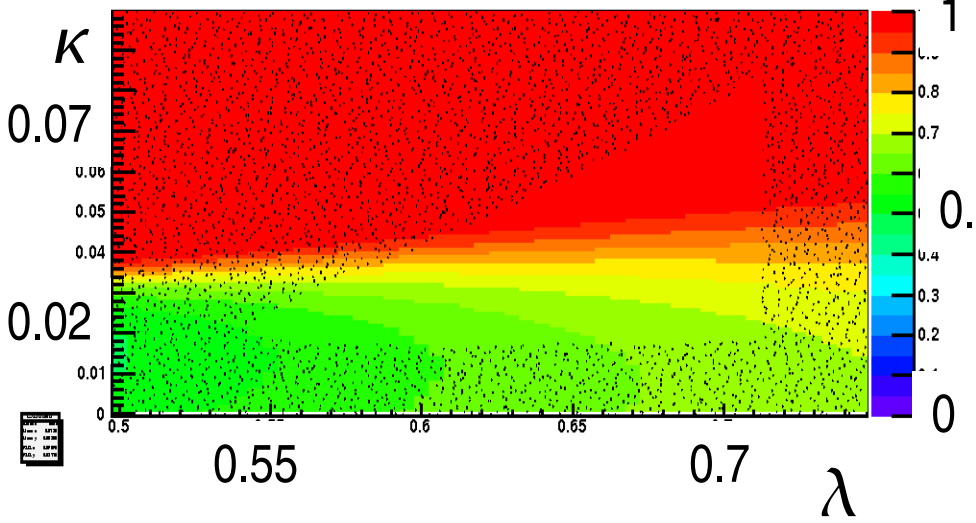
BR H1->other Higgses



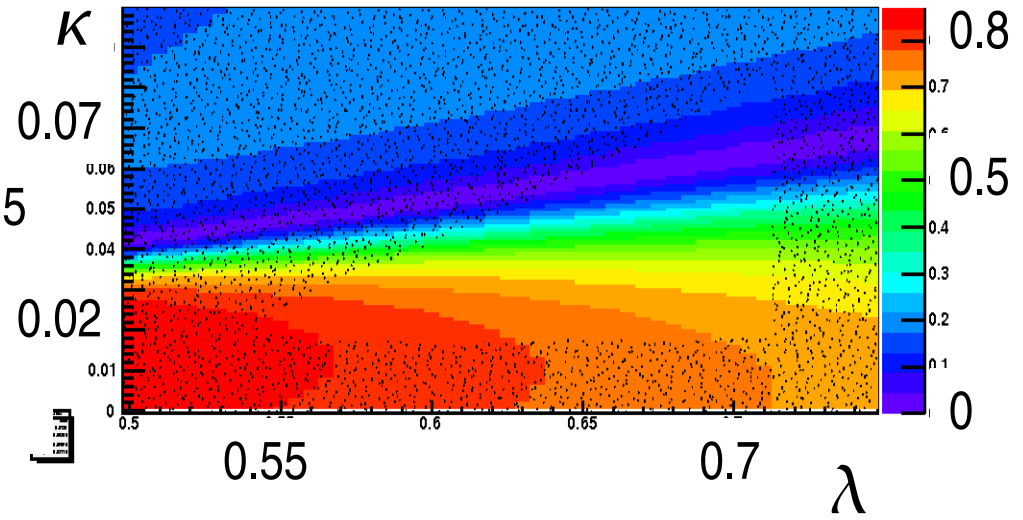
BR H2->other Higgses



Coupling to Vector bosons of H1



Coupling to Vector bosons of H2



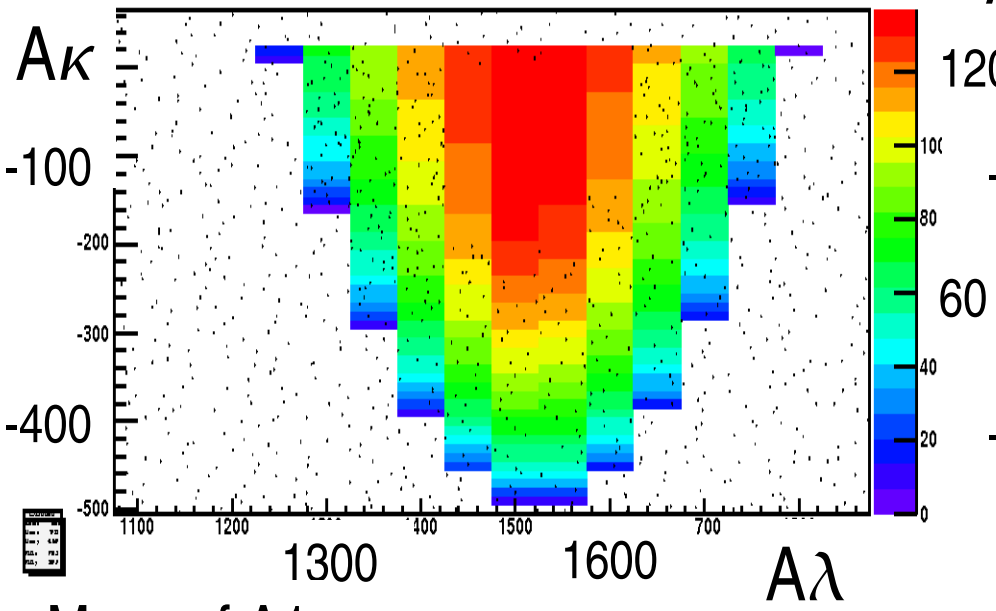
BR (A1->bb) ~ 0.9

BR (A1->tautau) ~ 0.06-0.08

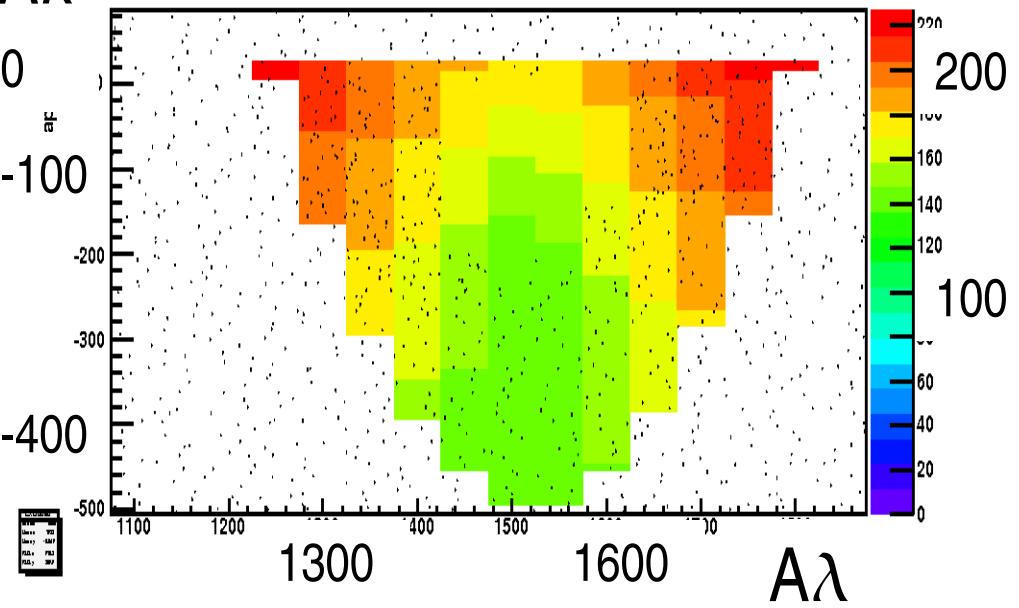
Black dots: Excluded region!

Maximal H1 mass - Aλ - Aκ Scan

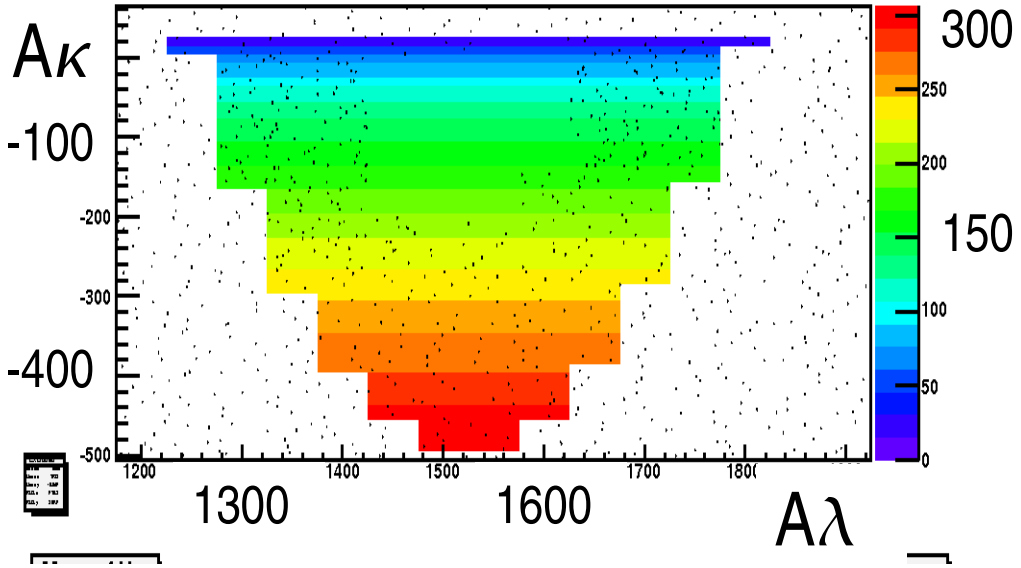
Mass of H1



Mass of H2



Mass of A1

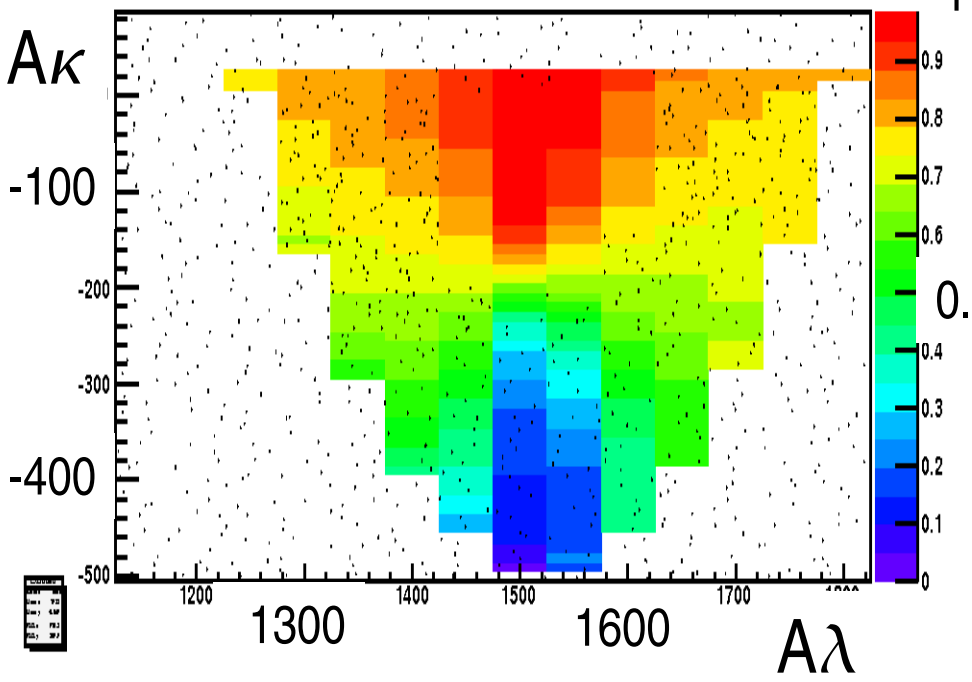


A1 gets heavy quickly =>
H1->A1A1 possible only in marginal region

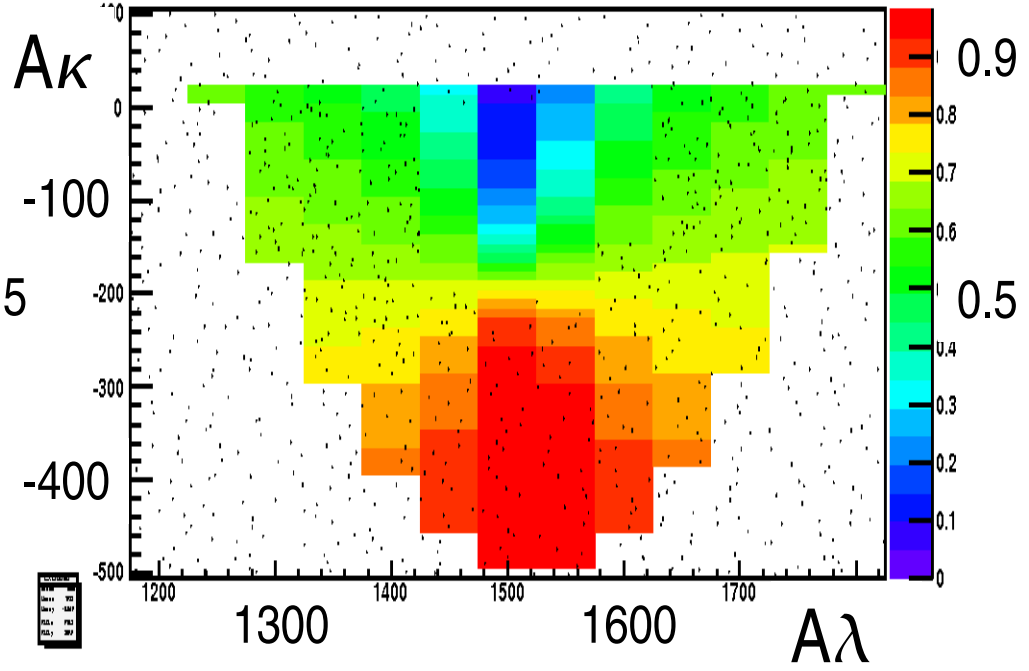
Black dots: Excluded region!

Maximal H1 mass - Aλ - Aκ Scan

Coupling to Gluons of H1



Coupling to Gluons of H2



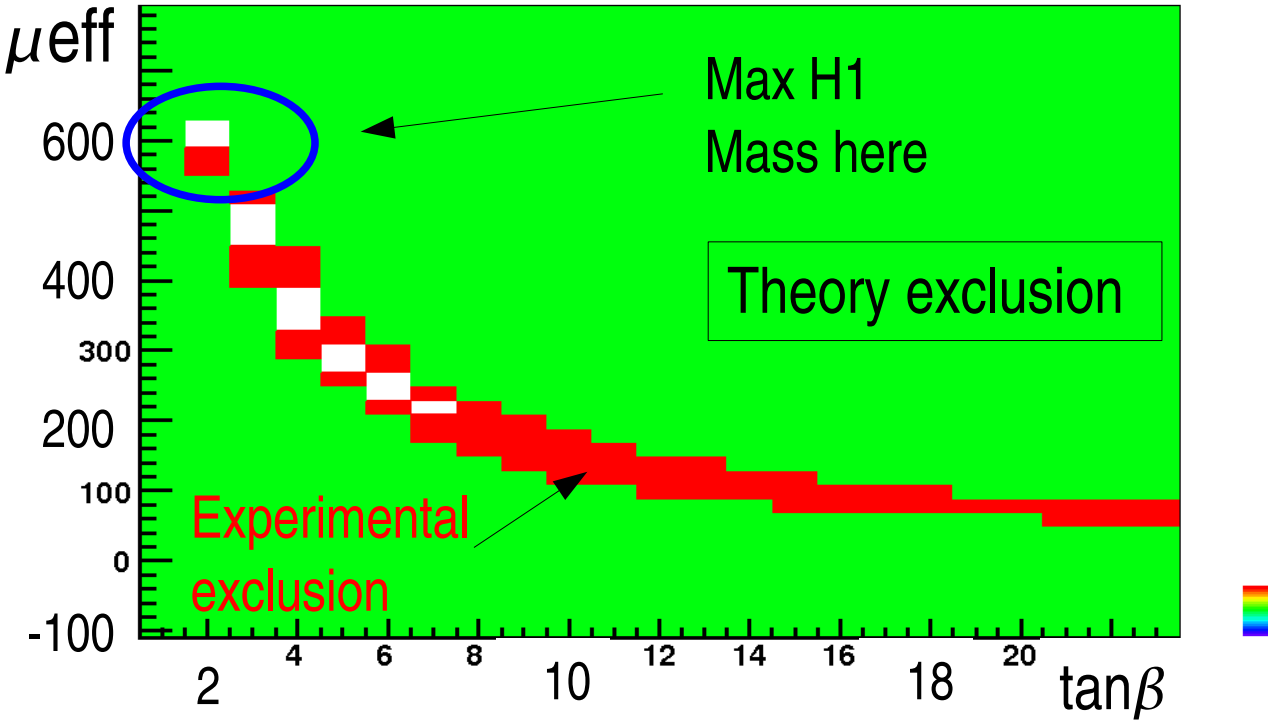
Black dots: Excluded region!

Couplings from H1 & H2 vary inversely

Maybe this scan is also interesting to see the effect of suppressed couplings?

Maximal H1 mass - μeff - tanβ Scan

Excluded Region



allowed region
rather small,
no big variation
seen inside

Proposal for Benchmark scan:
Keep tanbeta, mueff fixed,
scan lambda, kappa & Alamda, Akappa

?

IDEA NR. 3: Points from Paper: Difficult Scenarios for NMSSM Higgs Discovery at the LHC by Ellwanger, Gunion, Hugonie

(hep-ph/0503203)
M1 = 500 GeV, M2 = 1 TeV, M3 = 3 TeV
MSusy = 1 TeV
At=Ab=Atau=1.5 TeV

First Point:
No H1->A1A1 decays allowed, but the lowest expected significance at LHC

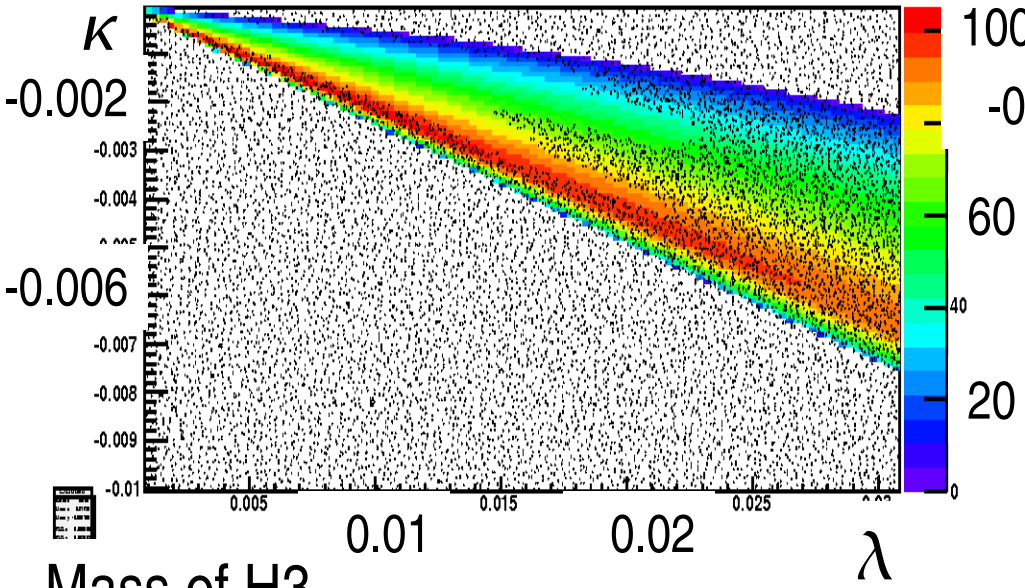
μeff= -284 GeV
Aλ= -70 GeV
Aκ= -54 GeV
tanβ = 5.7
λ = 0.0163
κ = -0.0034

Scan in parameter-pairs around this point:
λ, κ
Aλ, Aκ
μeff, tanβ

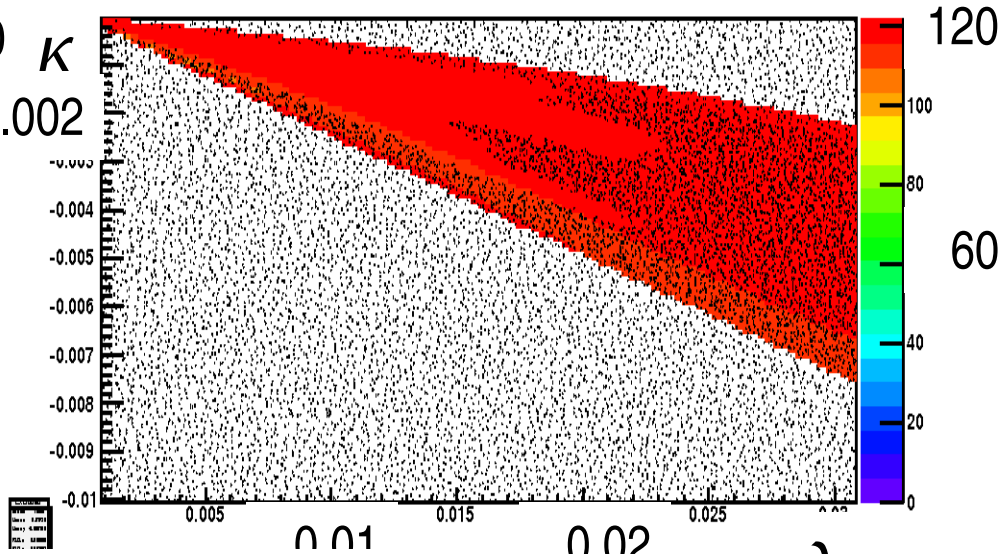
"Point 1" - λ - κ Scan

Black dots: Excluded region!
Only small region unexcluded!

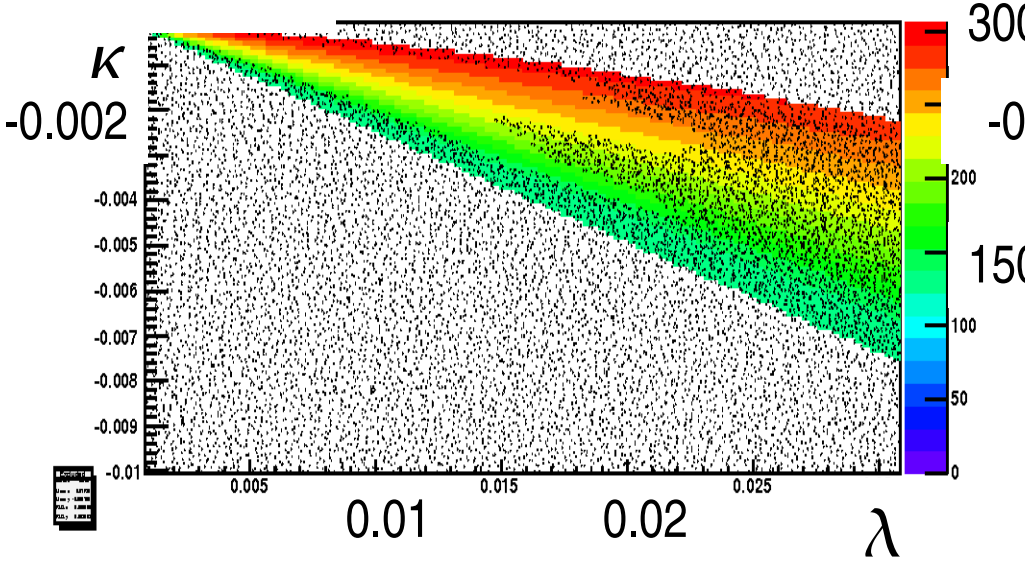
Mass of H1



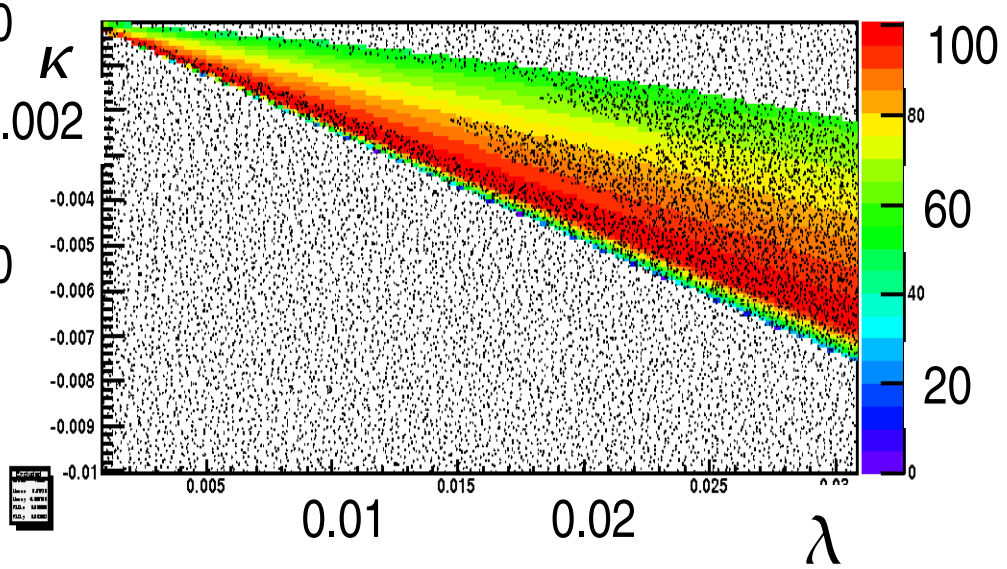
Mass of H2



Mass of H3



Mass of A1

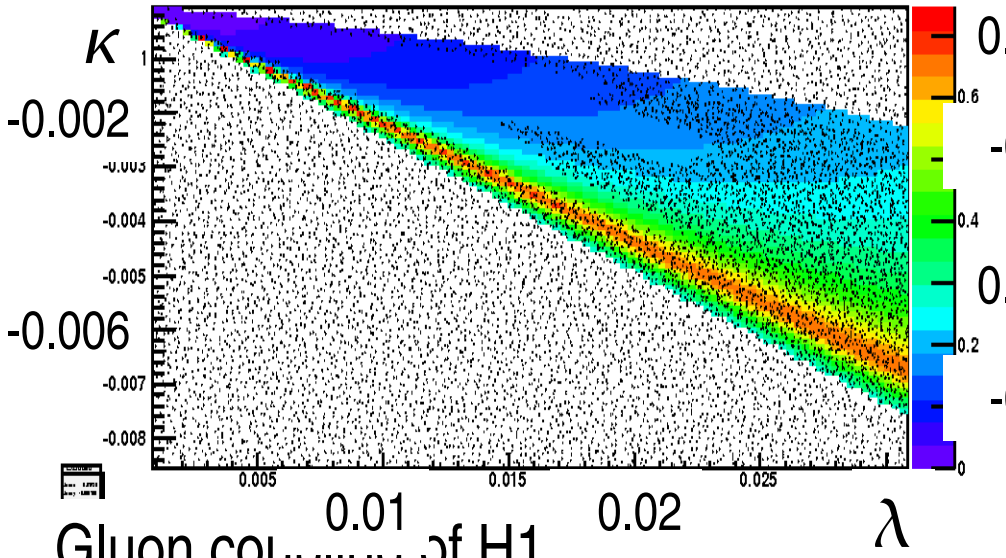


All masses relatively light!

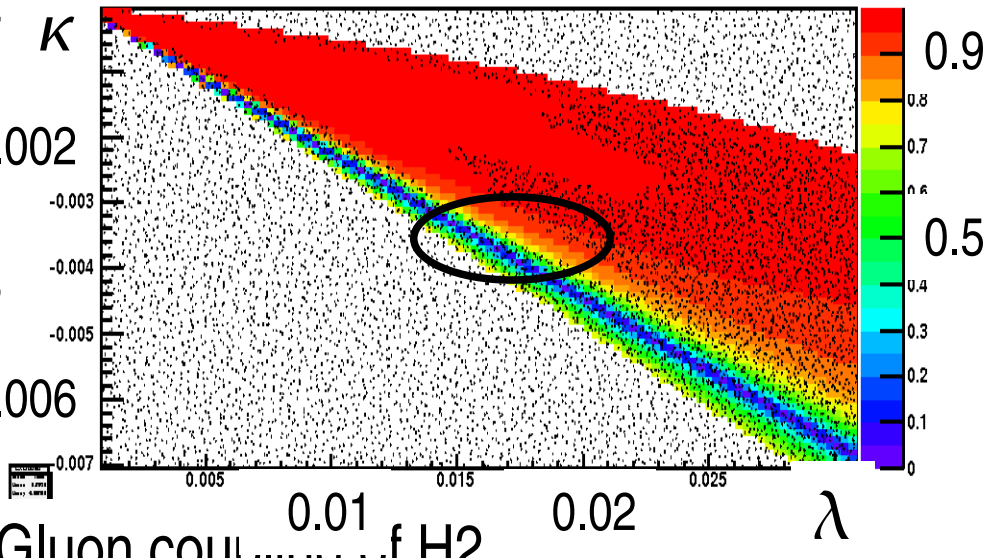
“Point 1” - λ - κ Scan

Black dots: Excluded region!

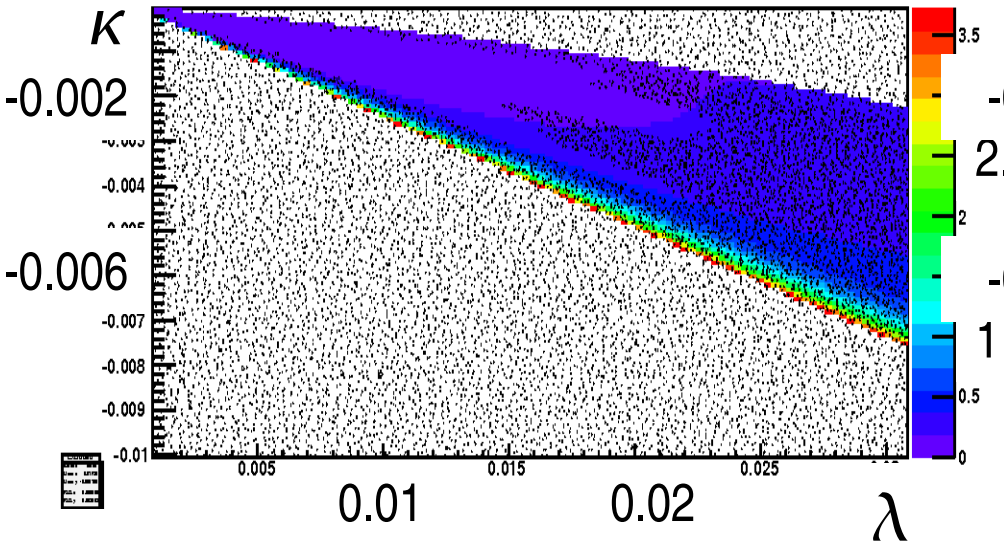
Vector boson coupling of H1



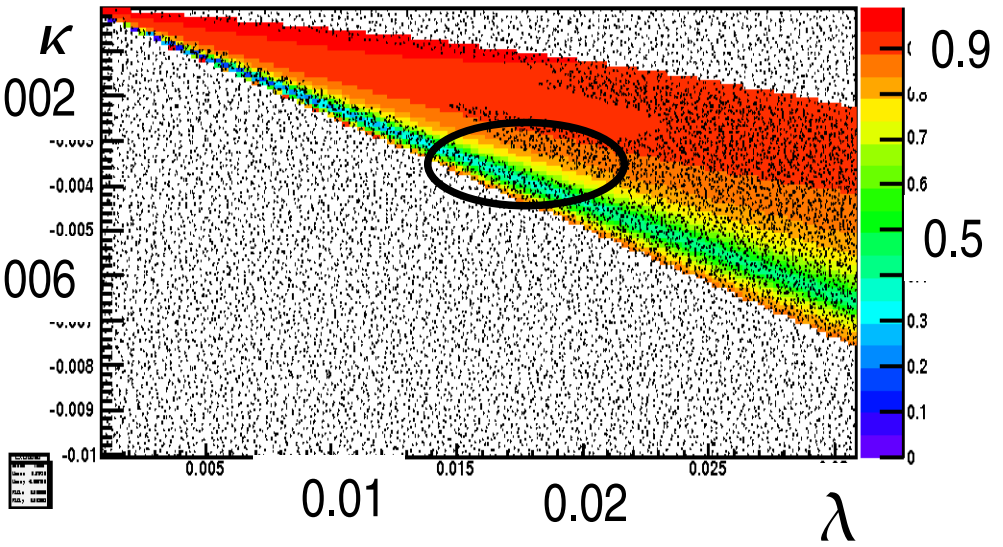
Vector boson coupling of H2



Gluon coupling of H1



Gluon coupling of H2

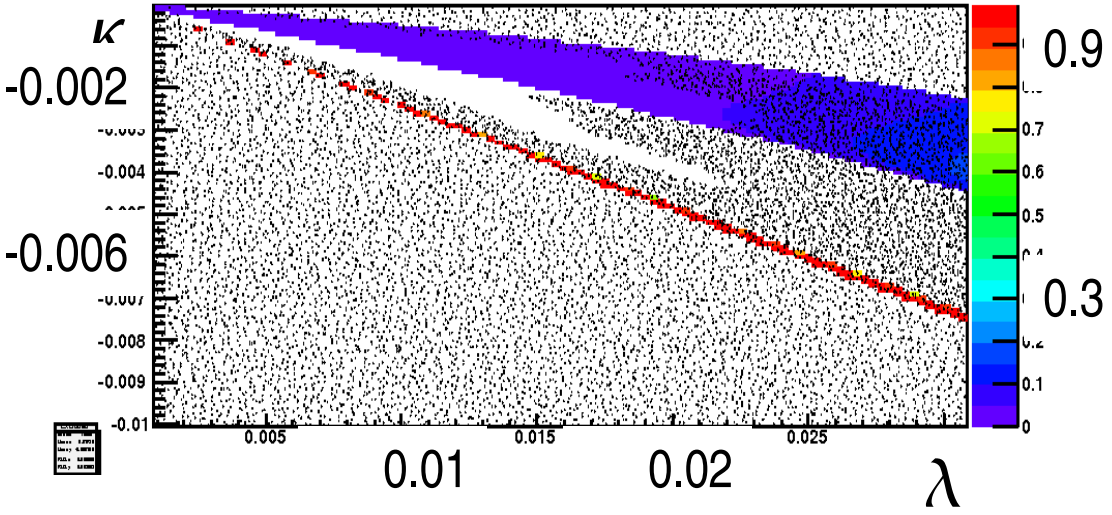


Reduced couplings of H1, reduced couplings of H2 in some region around original point (black circle)

"Point 1" - λ - κ Scan

Black dots: Excluded region!

BR H2->other Higgses



"Point 1" - Aλ - Aκ Scan

Masses of H1, A1 vary with Akappa (in different direction)
Masses of H3, A2 and H+ vary with Alamdba (in same direction)
Mass of H2 relatively stable
Also some variation of couplings & BRs

"Point 1" - mu-tanβ Scan

Masses of H1, A1 vary with mueff
Masses of H3, A2 and H+ vary with tanbeta
Mass of H2 relatively stable
Only small variation of couplings & BRs

→ Use these three scans as a benchmark ??? Interesting region is quite small ?

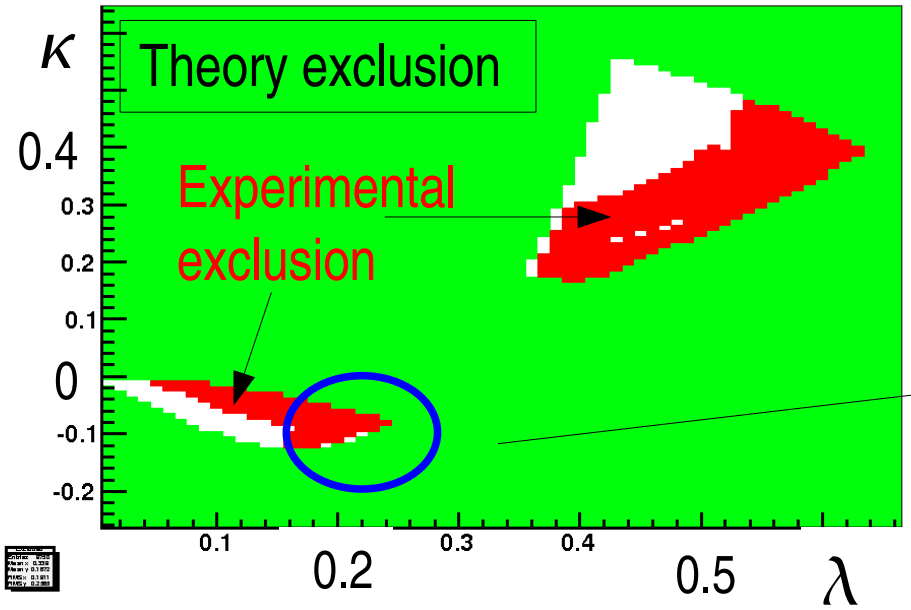
Second Point:

M(H1) ~ 90 GeV, M(H2) ~ 480 GeV, M(A1) ~10 GeV

μeff= -520 GeV
Aλ= -580 GeV
Aκ= -2.8 GeV
tanβ = 5.0
λ = 0.22
κ = -0.1

→ Scan in parameter-pairs around this point:
λ, κ
Aλ, Aκ
μeff, tanβ

Excluded Regions

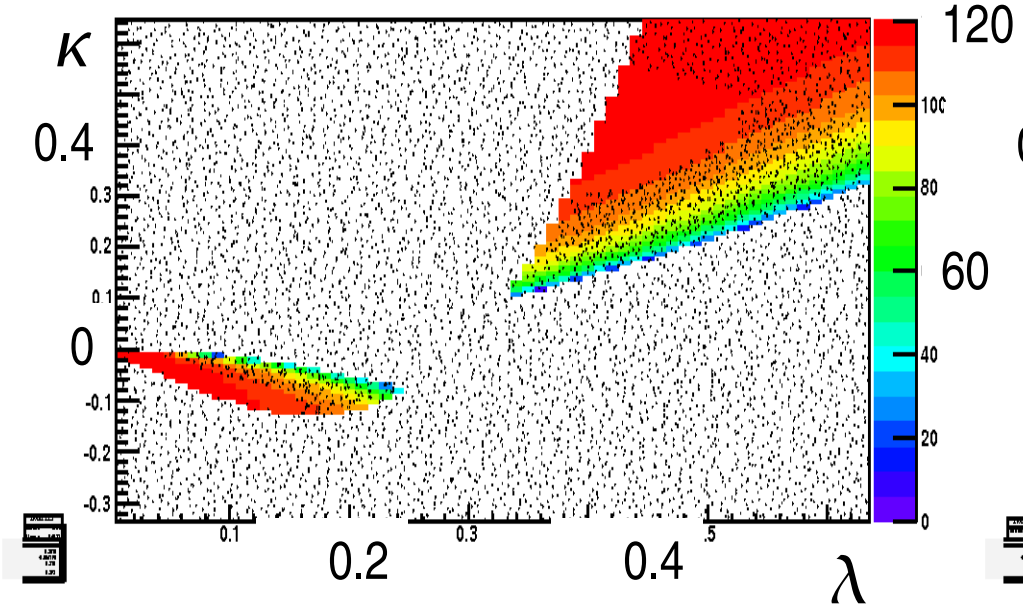


Point lies in rather small unexcluded region => look at other regions also!

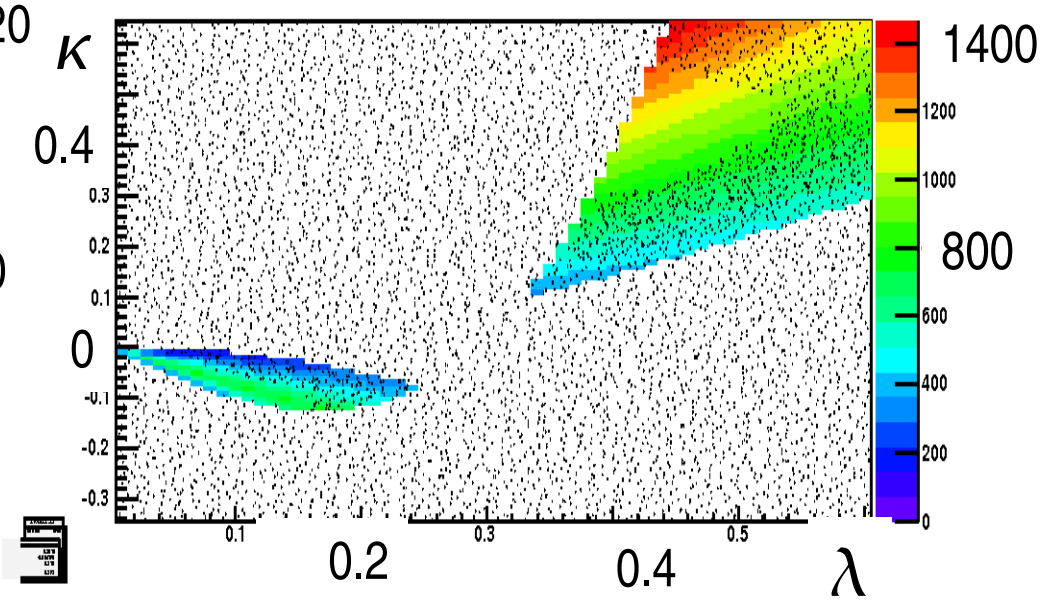
“Point 2” - λ - κ Scan

Black dots: Excluded region!

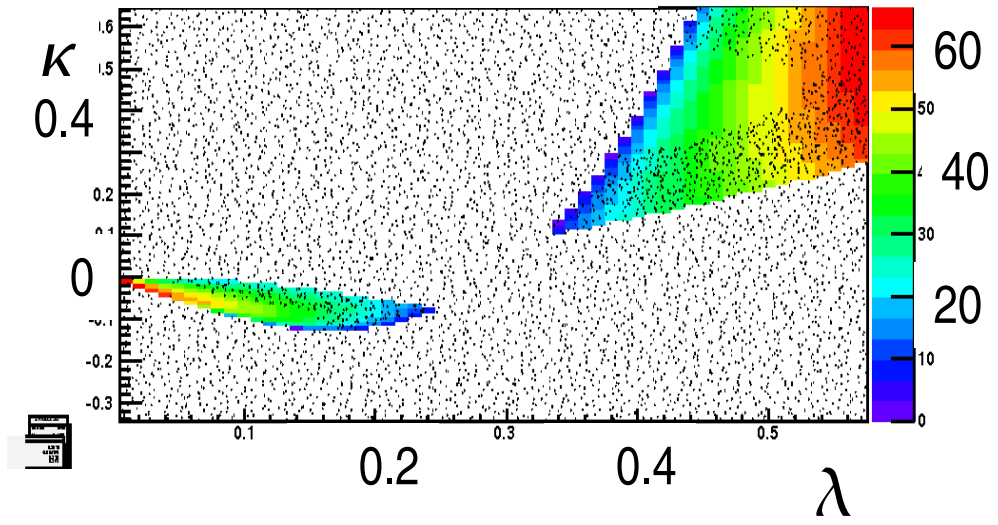
Mass of H1



Mass of H2



Mass of A1



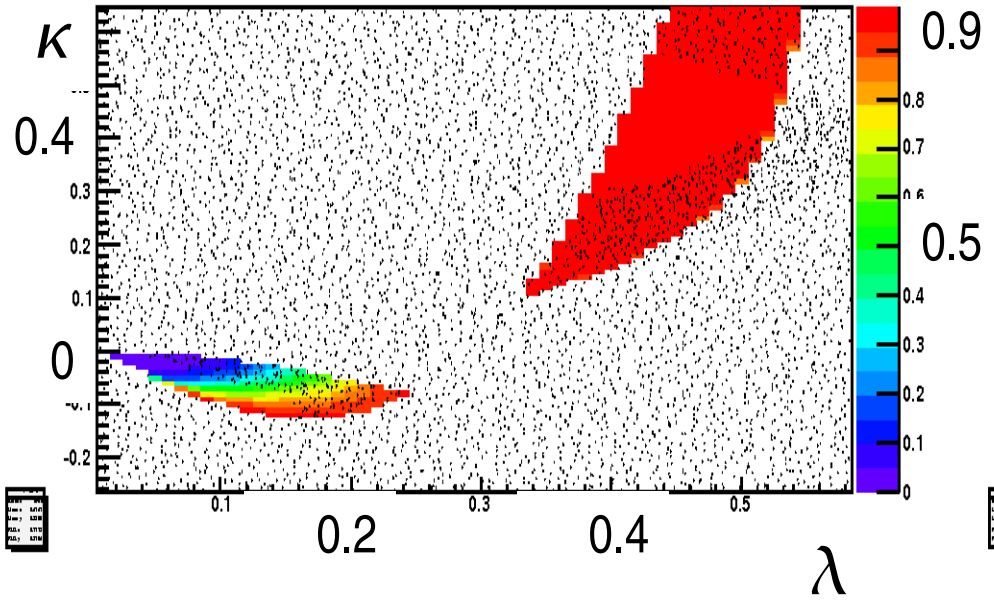
H2-mass heavier than in H1-max-Scenario!

H1 has SM-like couplings

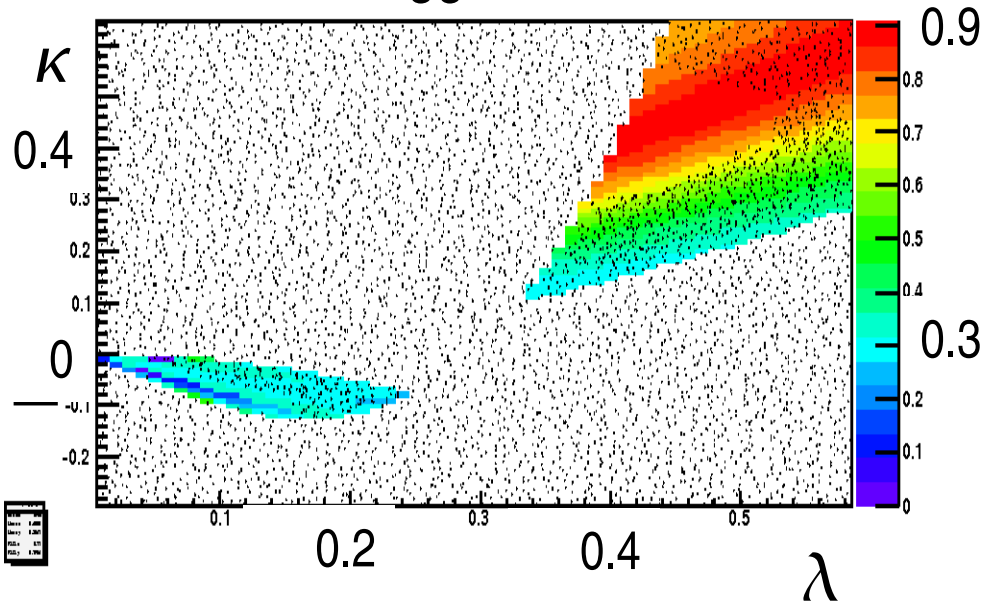
“Point 2” - λ - κ Scan

Black dots: Excluded region!

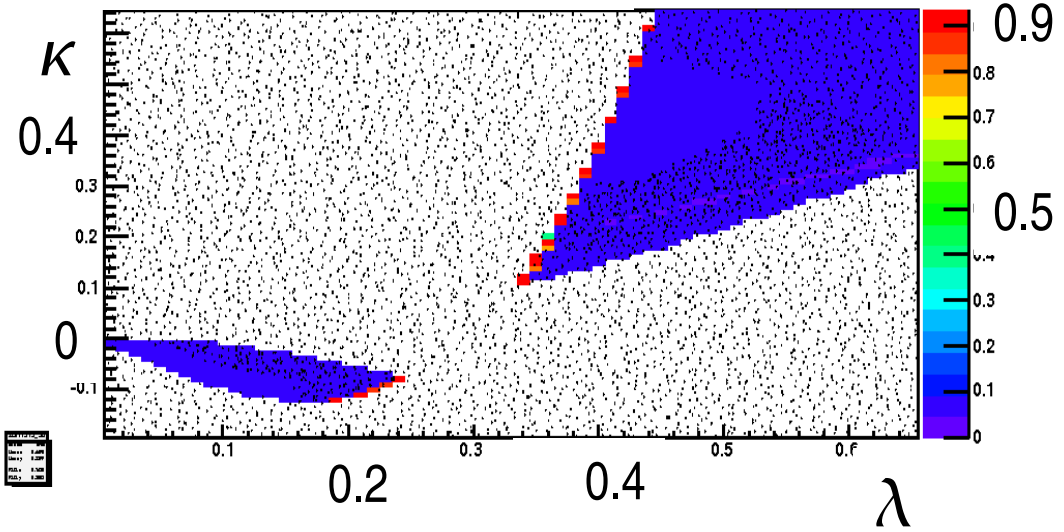
BR H1->other Higgses



BR H2->other Higgses



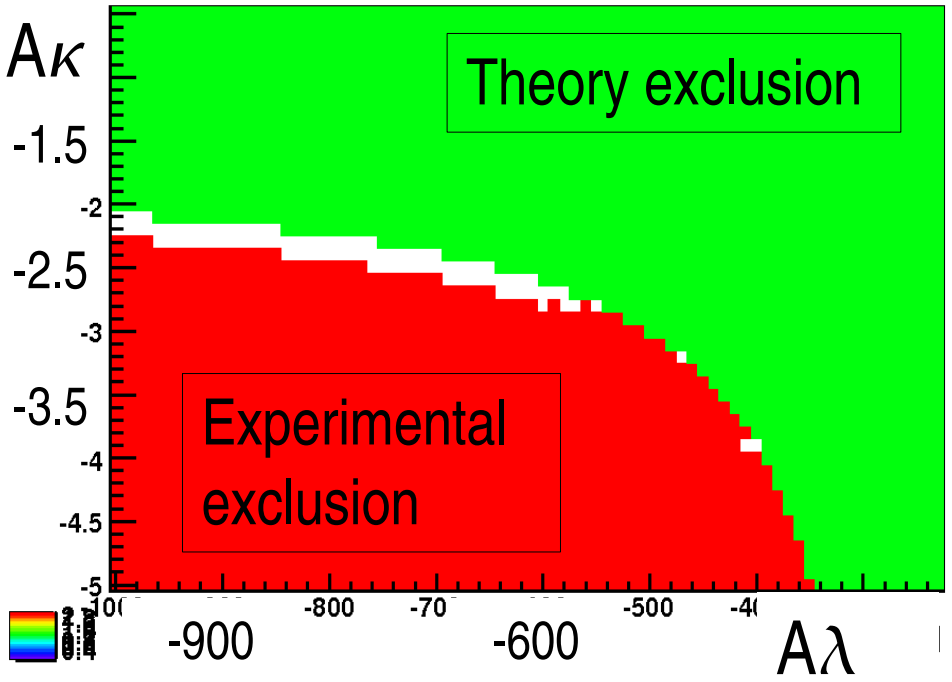
BR A1->taus



2 regions (red) with predominant A1->tautau covered by scan!

“Point 2”- Aλ - Aκ Scan

Excluded Region



allowed region rather small,
no big variation seen inside

maybe instead take point from
“bigger” regions as starting point?

Proposal for Benchmark scan:

scan lambda, kappa around this point

for tanbeta/mueff & Alambda/Akappa scans: use less marginal values of lambda and kappa when scanning

=> need to check whether this give something interesting!

?

Third Point:

M(H1) ~ 119 GeV, M(H2) ~ 1431 GeV, M(A1) ~31 GeV

μeff= 530 GeV
Aλ= -920 GeV
Aκ= -2.1 GeV
tanβ = 7.8
λ = 0.22
κ = 0.59

Scanning lambda, kappa gives only small region where H1->A1A1 is allowed, other regions “SM-like”
Phenomenologie of this point (H->A1A1->bb) already covered by previous scans ??

Forth Point:

M(H1) ~ 40 GeV, M(H2) ~ 125 GeV, M(A1) ~144 GeV => H2->H1H1

Did not look into that yet
Is phenomenologie different from H1->A1A1 case ?

IDEA NR. 4: Point from Paper: An Interesting NMSSM Scenario at the LHC and LC by Miller & Moretti

Has region where H1->cc is dominant!
Seems to be very challenging experimentally
Did look into that yet.

Other Ideas/Suggestions?

Thank you for your attention!