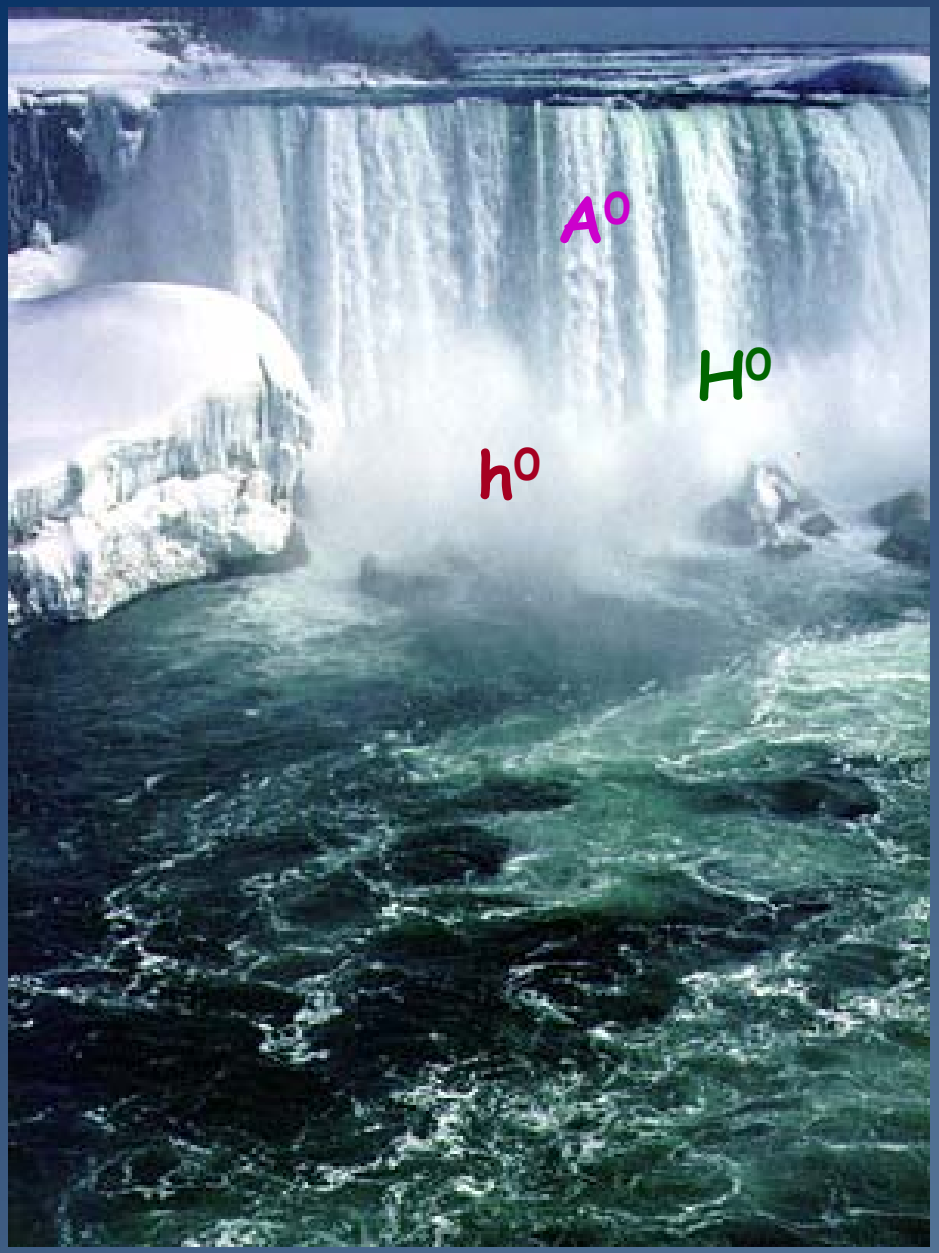

PHYSICS at LHC

13-17 July 2004

Academy of Sciences, Vienna, Austria

Neutral MSSM Higgs bosons from squark and gluino cascades with CMS

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I.A.S.A. - Athens

On behalf of the CMS Collaboration

Contents

- Recap about MSSM Higgs discovery potential with traditional techniques
- Exploring h,H,A production from strongly interacting sparticle cascades. Why ?
- Possible search scenarios
- Analysis strategies
- Expected outcomes
- Conclusions

MSSM Higgses

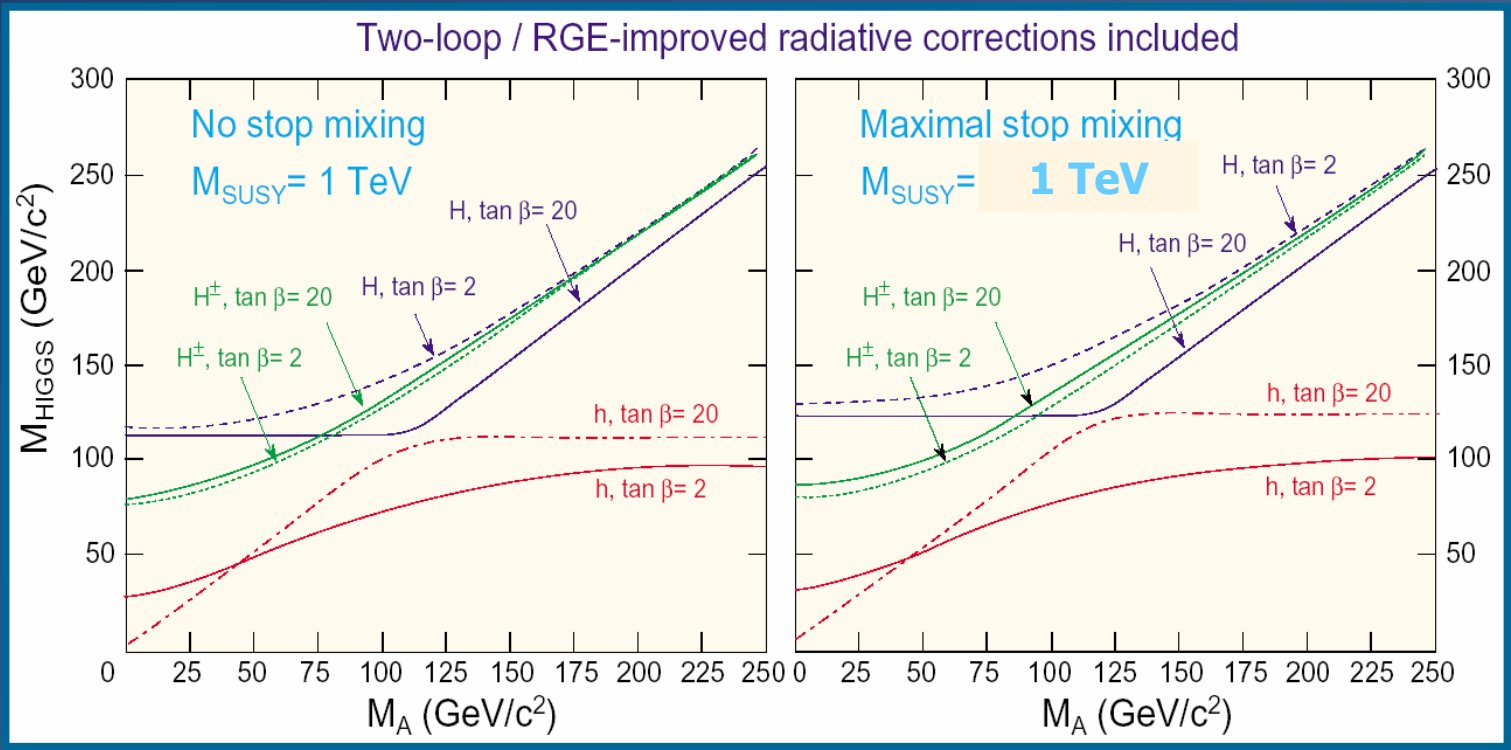
2 Higgs field doublets ➡ 5 physical states h, H, A, $H^{\pm}$

At tree level, masses and couplings depend only on

m_A, $tg\beta = v_1/v_2$

Stringent constraint: $m_h \sim |\cos 2\beta|\, m_Z \leq m_Z$

$m_A \sim m_H \sim m_{H^{\pm}}$ for $m_A \gg m_h^{max} \sim 130$ GeV with radiative corrections



Heavy neutral MSSM Higgs "classic" discovery channels……

Dominant production processes

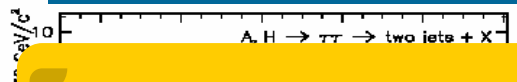
Couplings to fermions ∝ fermion mass
→ b,t quarks preferred
tgβ enhances the coupling to b quarks

Explored decay channels

$A^0, H^0 \to b\bar{b}$

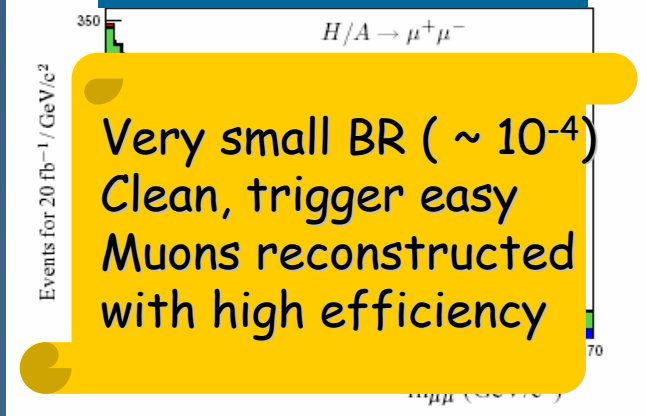
Difficult ……..
Large BR (~90%)
but
huge QCD
background

$A^0, H^0 \to \tau\tau$



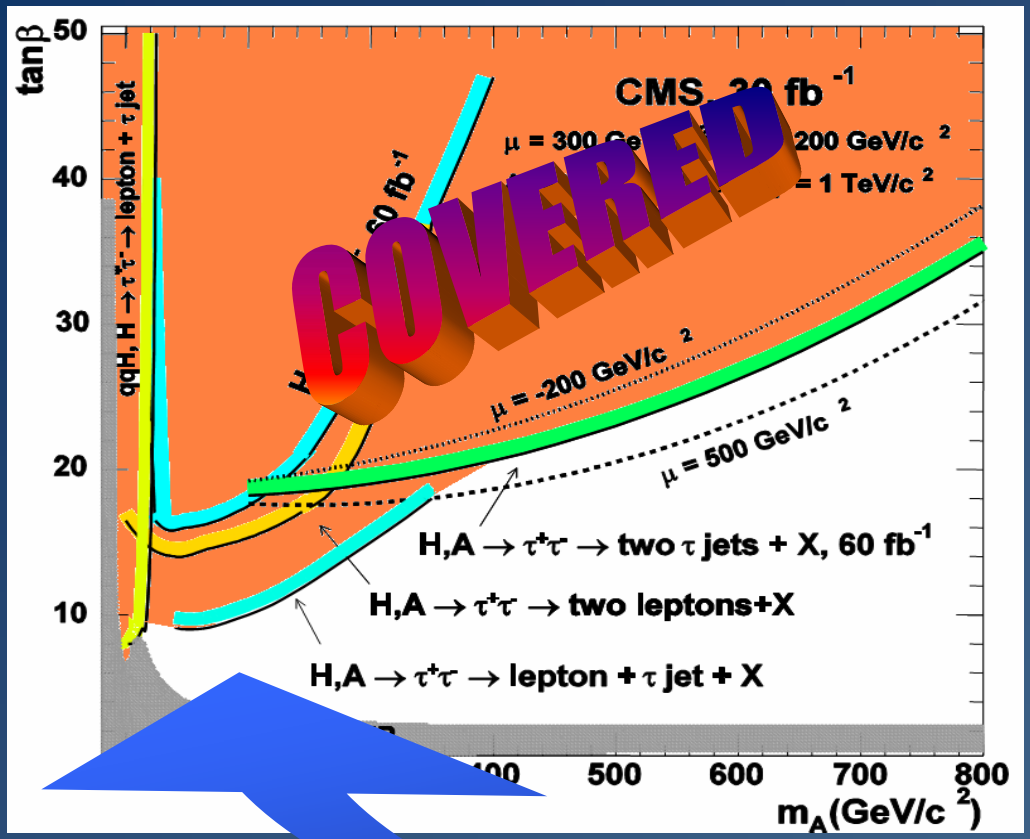
Sizeable BR (~10%)
All τ decay modes
can be exploited
Trigger with leptons
or jets. Most promising

$A^0, H^0 \to \mu\mu$



Very small BR (~ 10^{-4})
Clean, trigger easy
Muons reconstructed
with high efficiency

.....and their expected discovery reach



- While the h can always be found .....
- Heavy Neutral Higgs are limited to upper left triangle in (m_A,tgβ) plane
- bbA^0/H^0 production cross-section is small at low tg β

A,H production from gluino/squark cascades

Looking for new production processes ……

$\tilde{g}/\tilde{q}$ interact strongly → large production in pp interactions

They can decay into the heavier charg(neutral)-inos

$$\tilde{g} \rightarrow qq' \; \tilde{\chi}_3^0, \tilde{\chi}_4^0, \tilde{\chi}_3^{\pm} \rightarrow \tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_1^{\pm} \; h,H,A + X$$

Mild dependence on tg β +

Heavy Higgses would be accessible only up to $m_A \leq 250$ GeV −

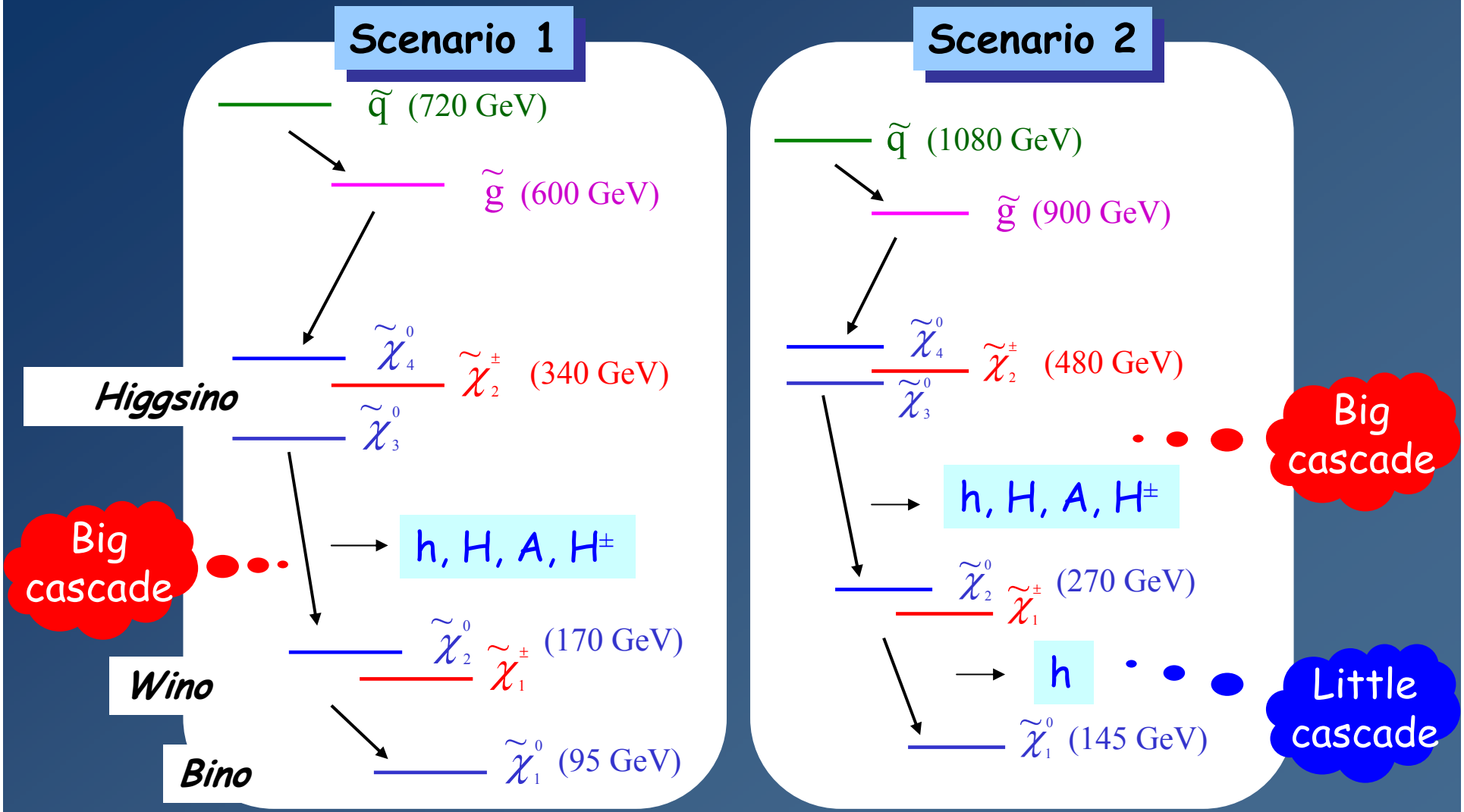
Higgs-sparticles couplings can be accessed/measured +

hep-ph/0303095

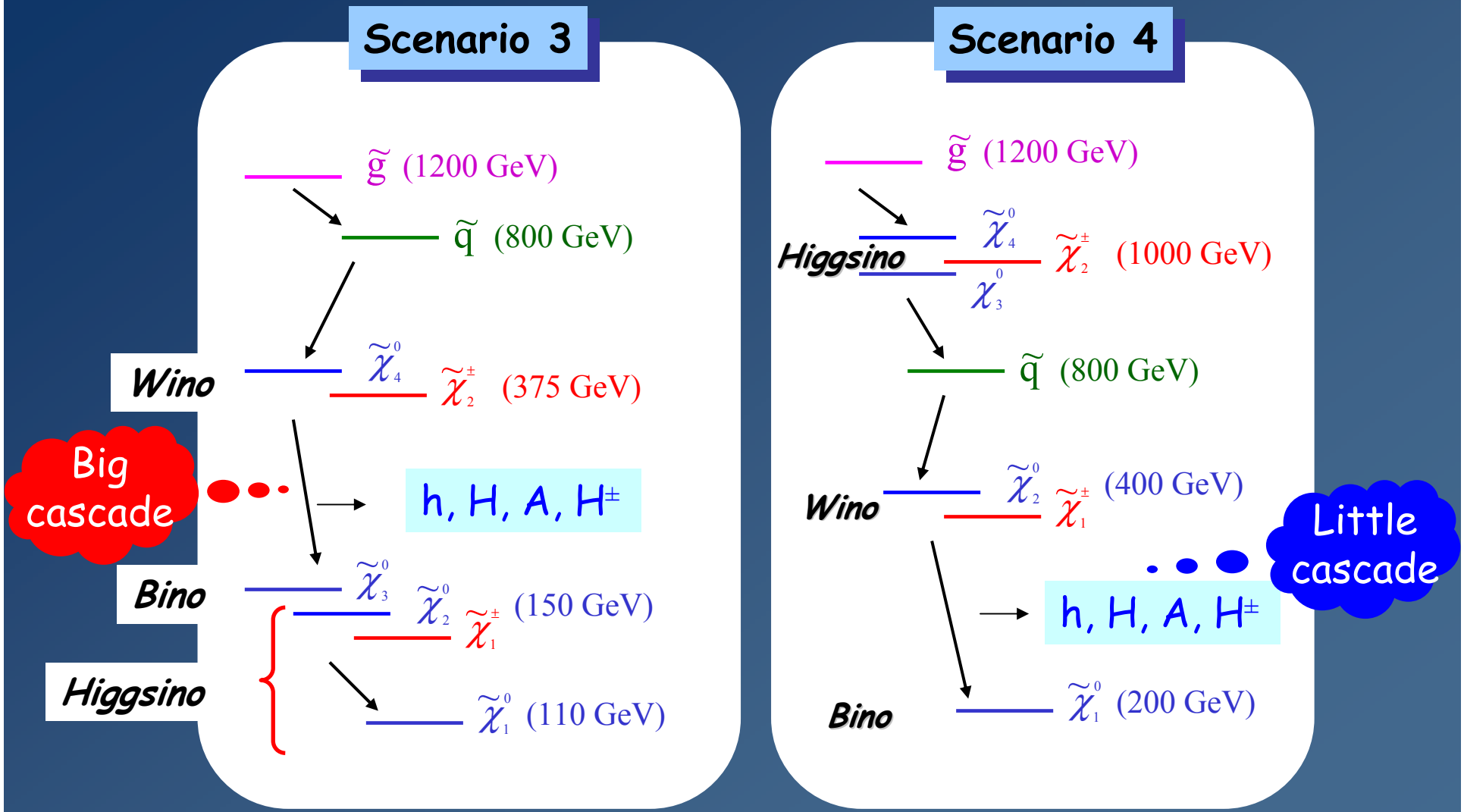
Assumptions on the theoretical framework

- Chargino and neutralino masses determined by μ and the soft SUSY-breaking masses, M_1, M_2 and M_3
- Gaugino masses unification $M_1 = M_2 = M_3$ at high-energy scale
- RGE $\rightarrow m_{\tilde{g}} \sim M_3 \sim 2\,M_2 \sim 3\,M_1$ at low-energy scale
- Sfermion mass unification at high-energy scale

Possible search scenarios (1)



Possible search scenarios (2)



Simulation tools

- SUSY mass spectrum: ISASUSY 7.58
  Interface to HERWIG with ISAWIG
- Signal and background events generator: HERWIG 6.4
- Fast detector simulation: CMSJET 4.8
  (parametrized description of the CMS response)

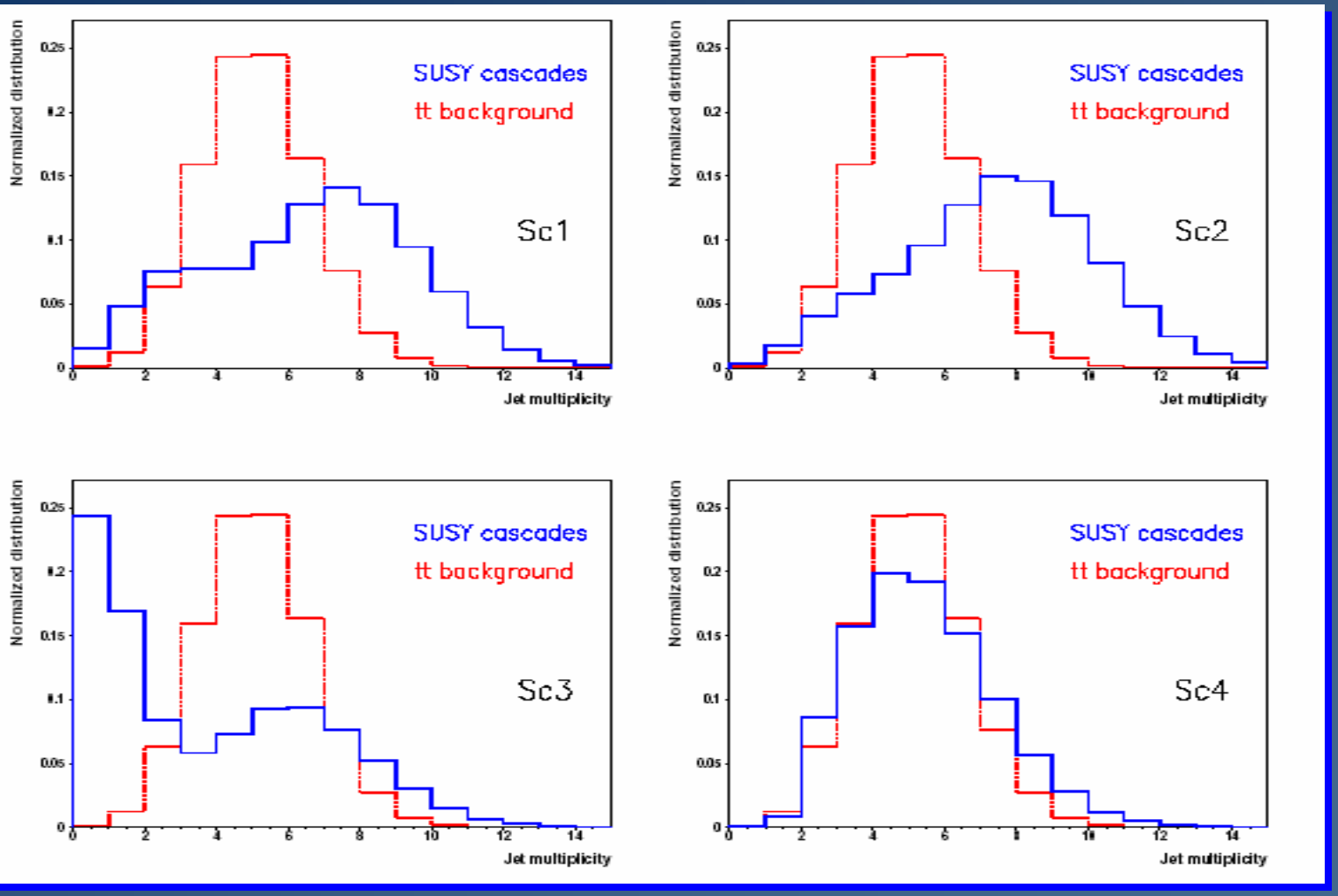
Analysis strategy

Possible decay channels
- h, A, H → bb Focus here
- A/H → ττ

Identify selection criteria such that:
- Standard Model background is negligible
- High selection efficiency at High Level Trigger

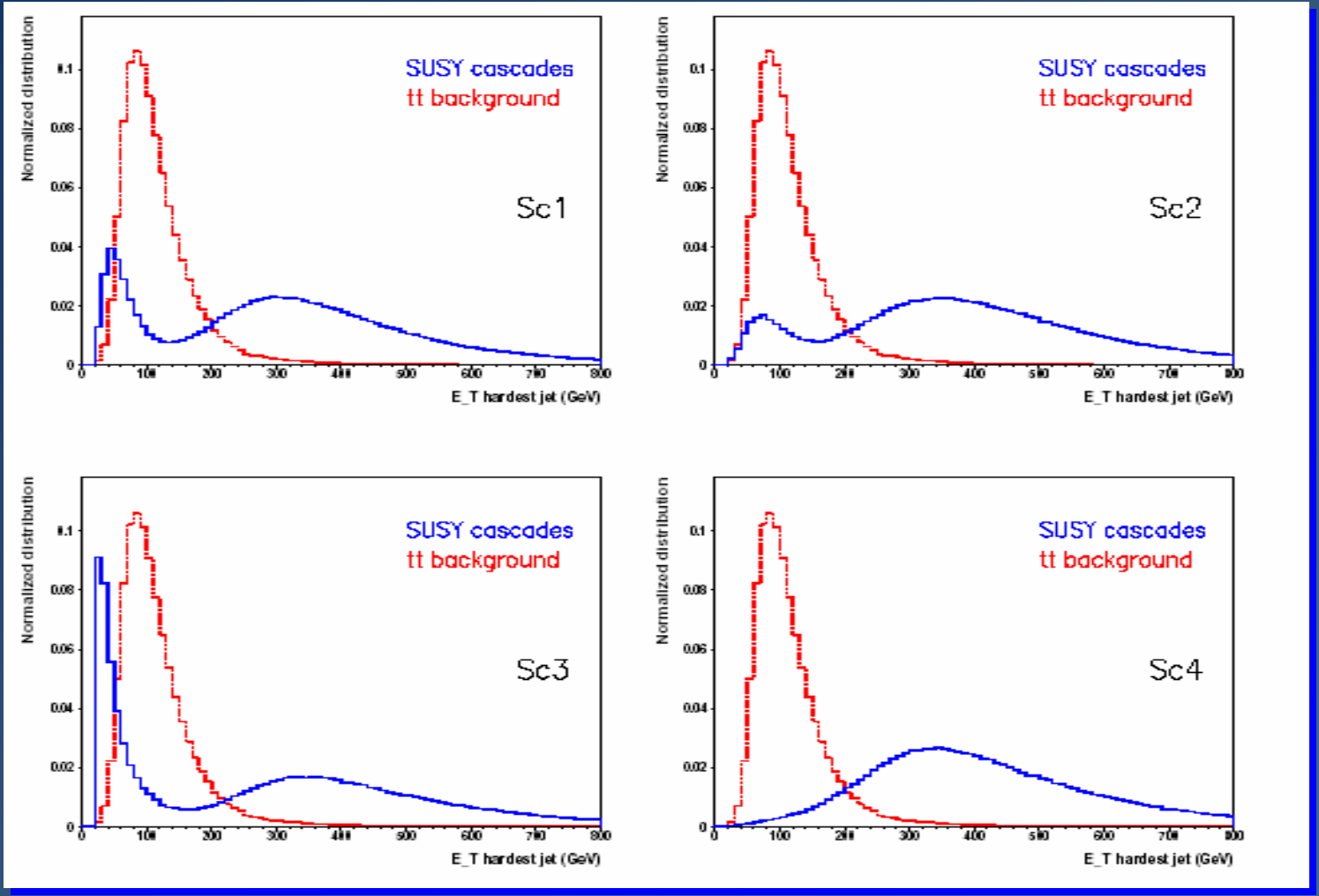
Try not to introduce bias → No attempts to reduce the SUSY background
- Just look for resonances in the $b\bar{b}$ invariant mass

Kinematics: jet multiplicity



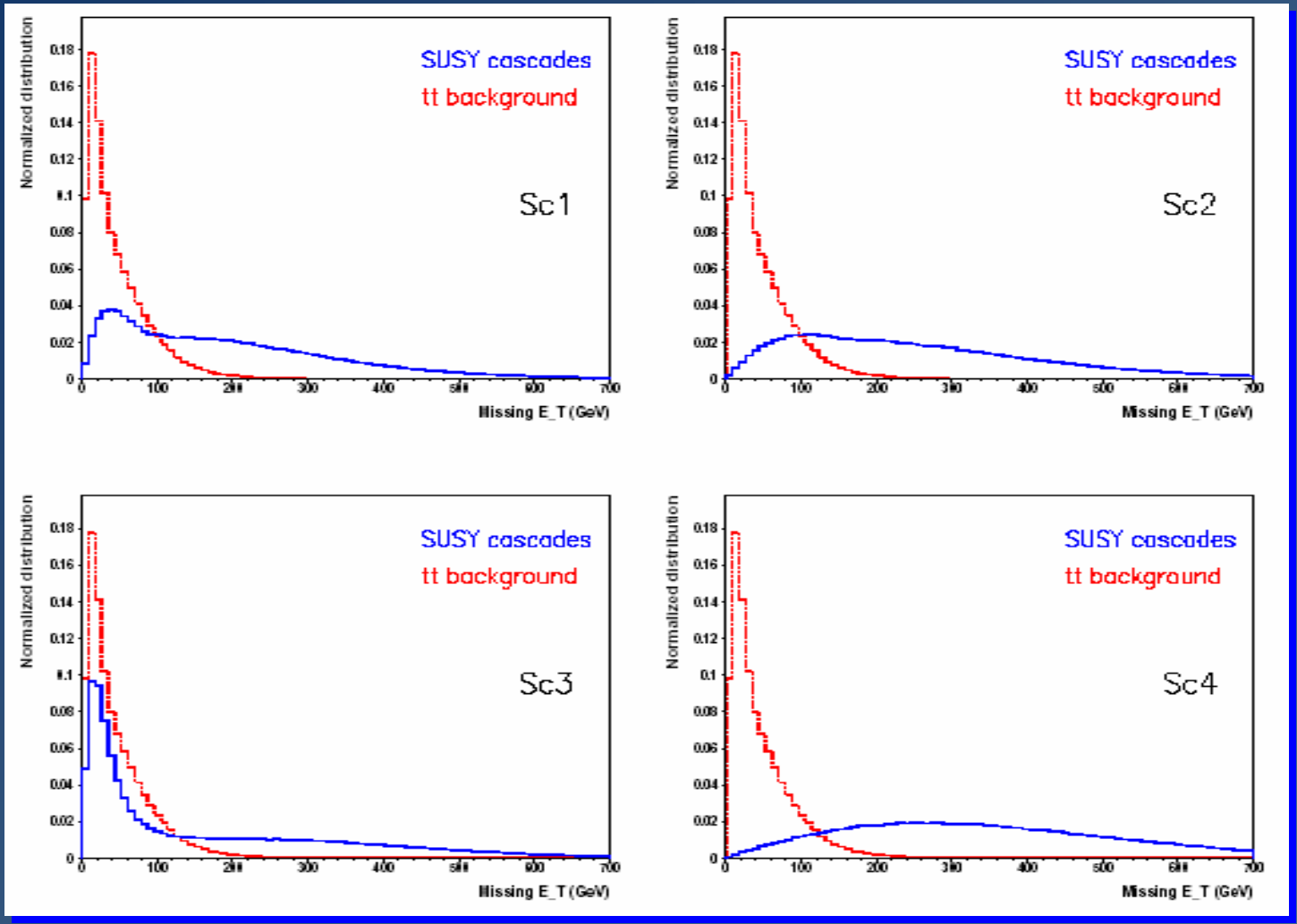
Only the main $t\bar{t}$ SM background is being considered

Kinematics: Jet E_T



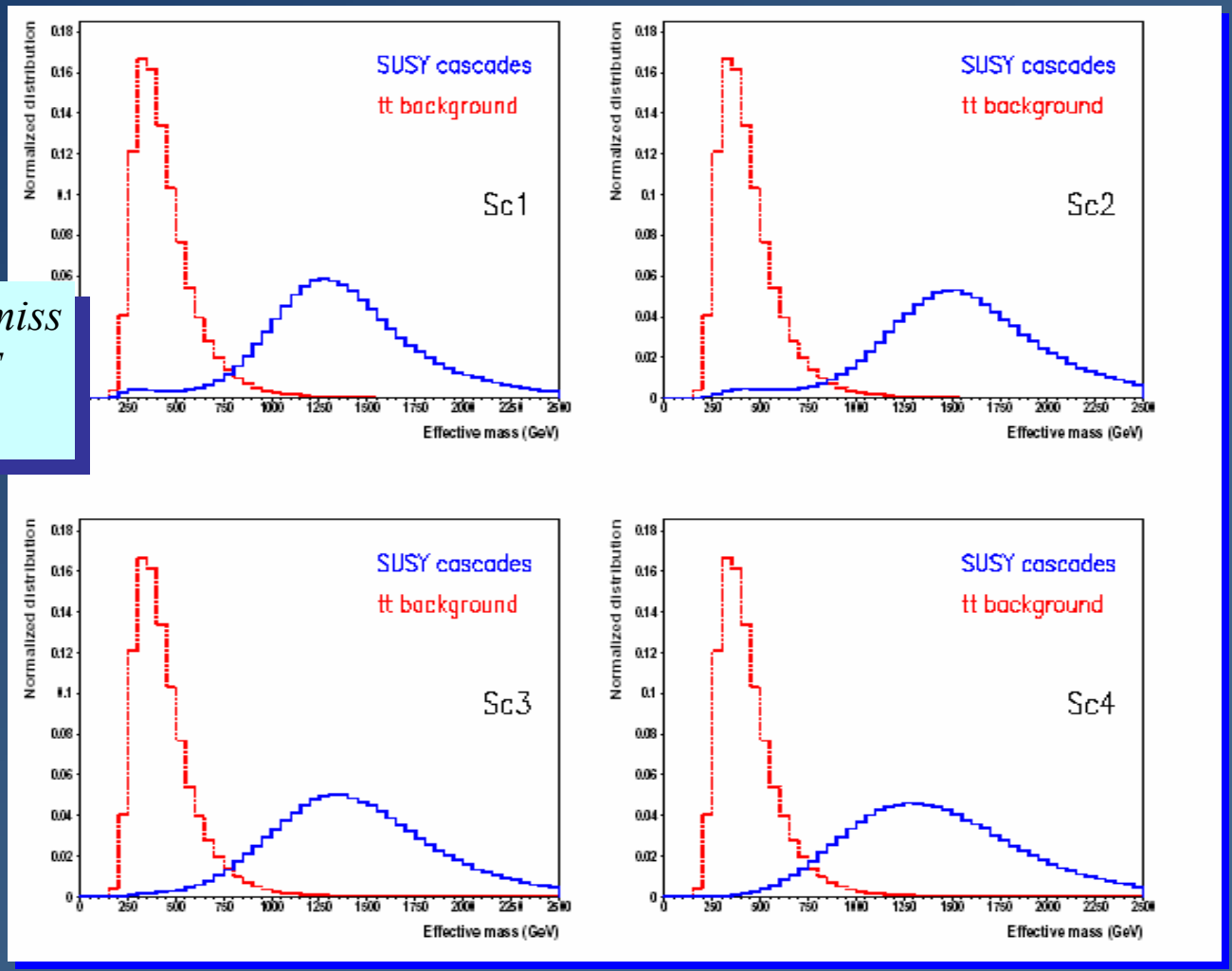
The most energetic jet is considered

Kinematics: Missing E_T



Kinematics: Total E_T

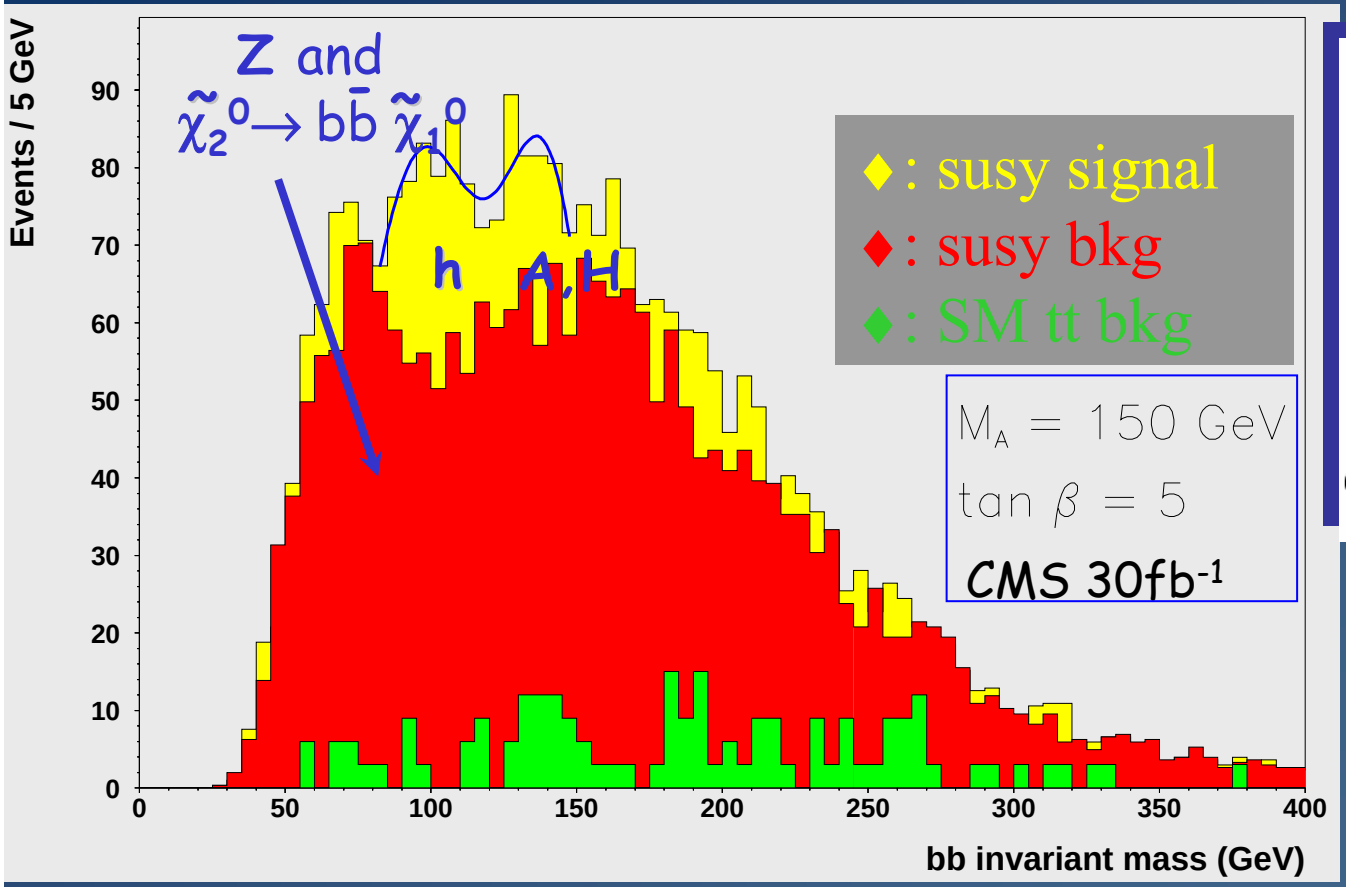
$$E_T^{total} = \sum_{jets} E_T + E_T^{miss}$$

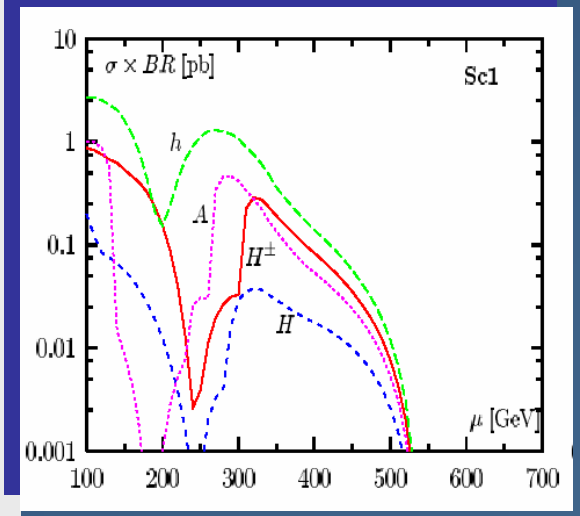


Selection criteria

- At least 5 jets in the event
- E_T (more energetic jet) > 300 GeV
- Transverse missing energy E_T^{miss} > 150 GeV
- Effective mass $E_T^{total} = \sum_{jets} E_T + E_T^{miss}$ > 1200 GeV
- At least 2 jets tagged as b with 45 GeV < E_T < 120 GeV
  - ↳ At least two tracks with $\sigma(ip) = ip_{xy}/\Delta ip_{xy} > 3$

Expectations from scenario 1



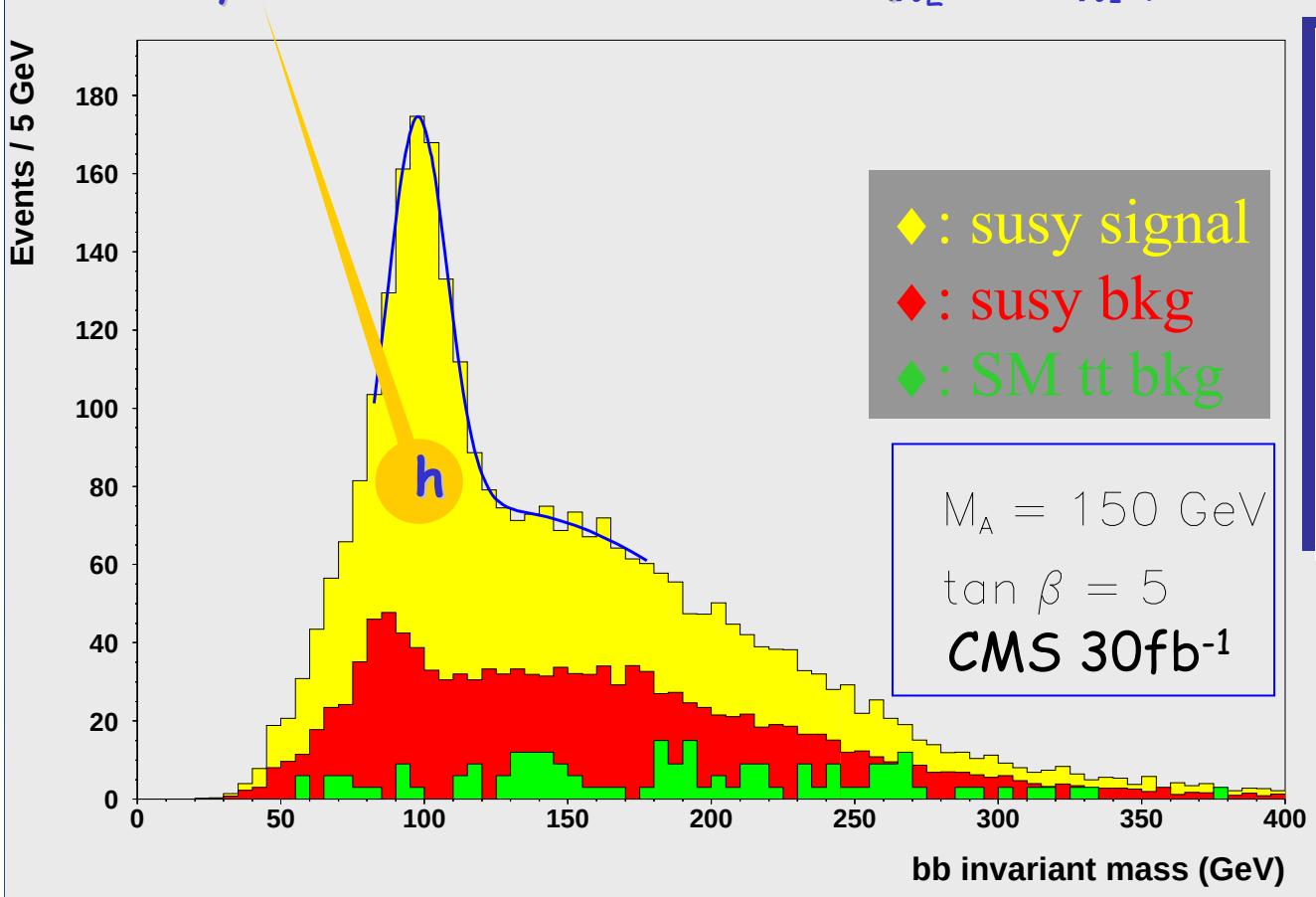


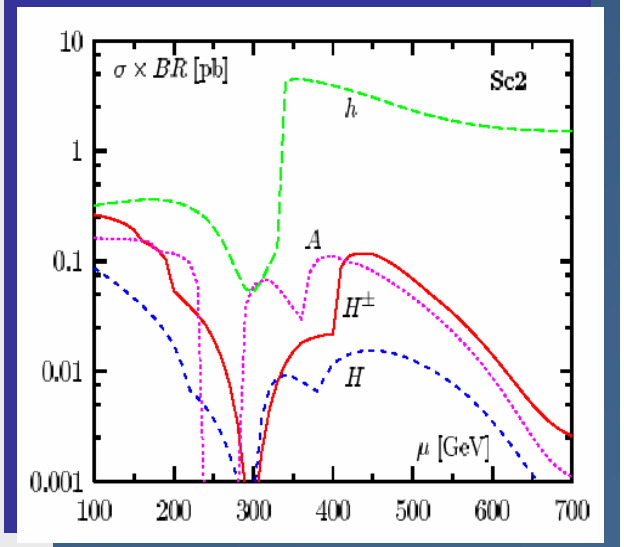
M_2 = 200 GeV
μ = 300 GeV
$m_{\tilde{g}}$ = 600 GeV
$m_{\tilde{q}}$ = 720 GeV

h,H,A all originate from the heavy chargino and neutralino decays

Expectations from scenario 2

Mostly due to little cascade $BR(\tilde{\chi}_2^0 \rightarrow h\, \tilde{\chi}_1^0) \sim 96\%$

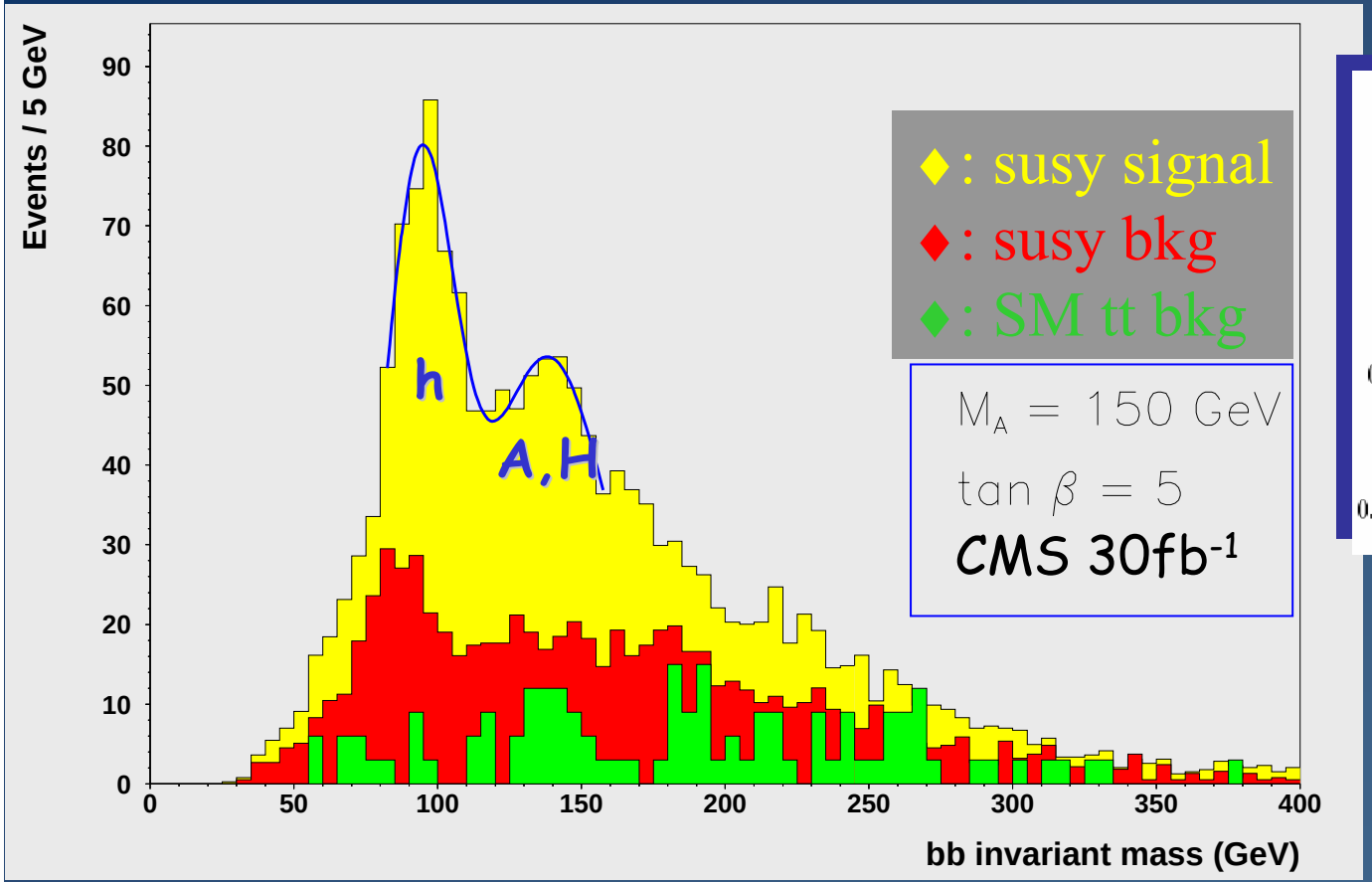


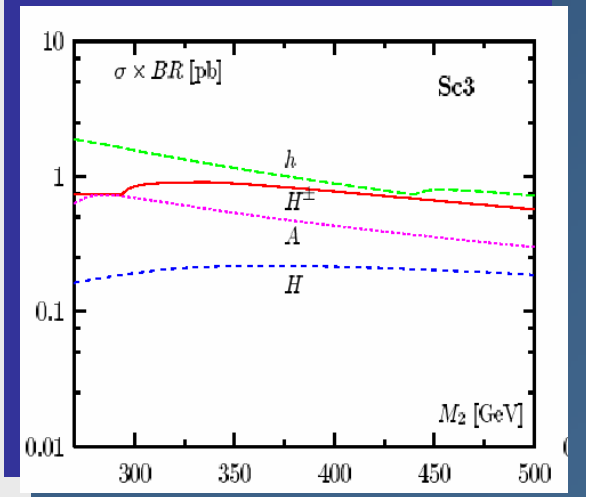


M_2 = 300 GeV
μ = 450 GeV
$m_{\tilde{g}}$ = 900 GeV
$m_{\tilde{q}}$ = 1080 GeV

A,H only produced in big cascades are not visible

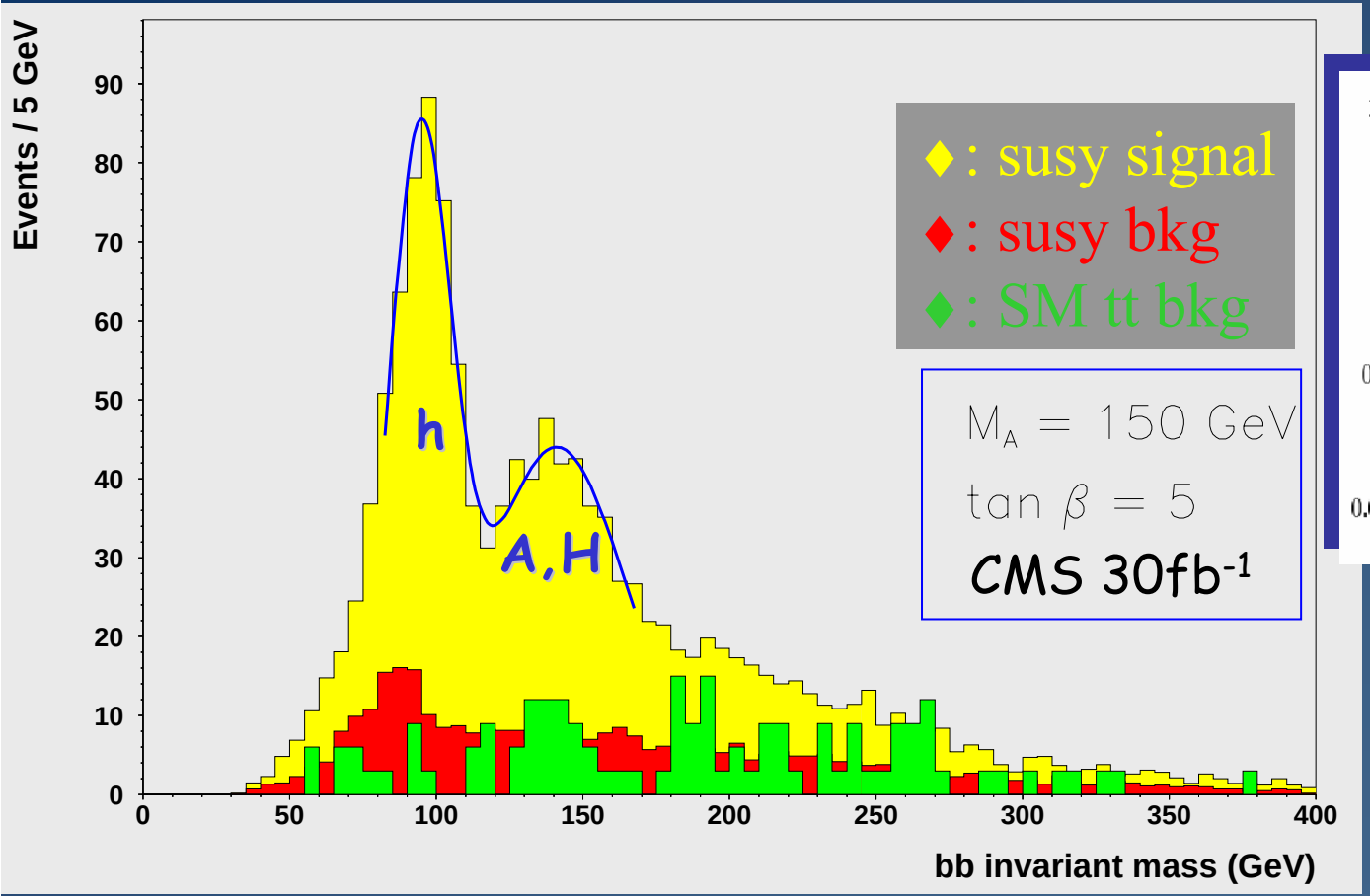
Expectations from scenario 3

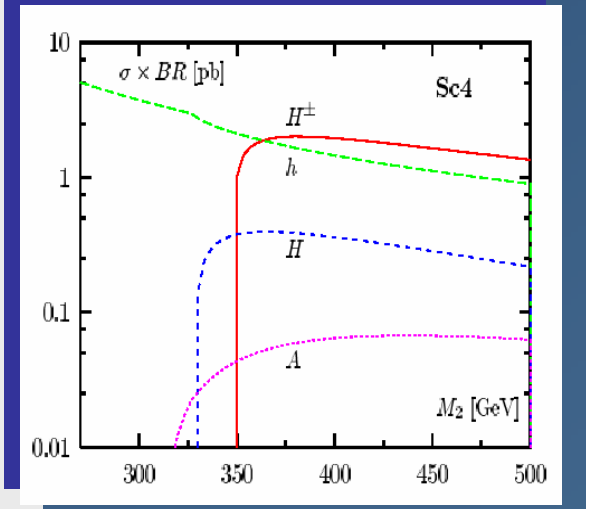




M_2 = 350 GeV
μ = 150 GeV
$m_{\tilde{g}}$ = 1200 GeV
$m_{\tilde{q}}$ = 800 GeV

Expectations from scenario 4

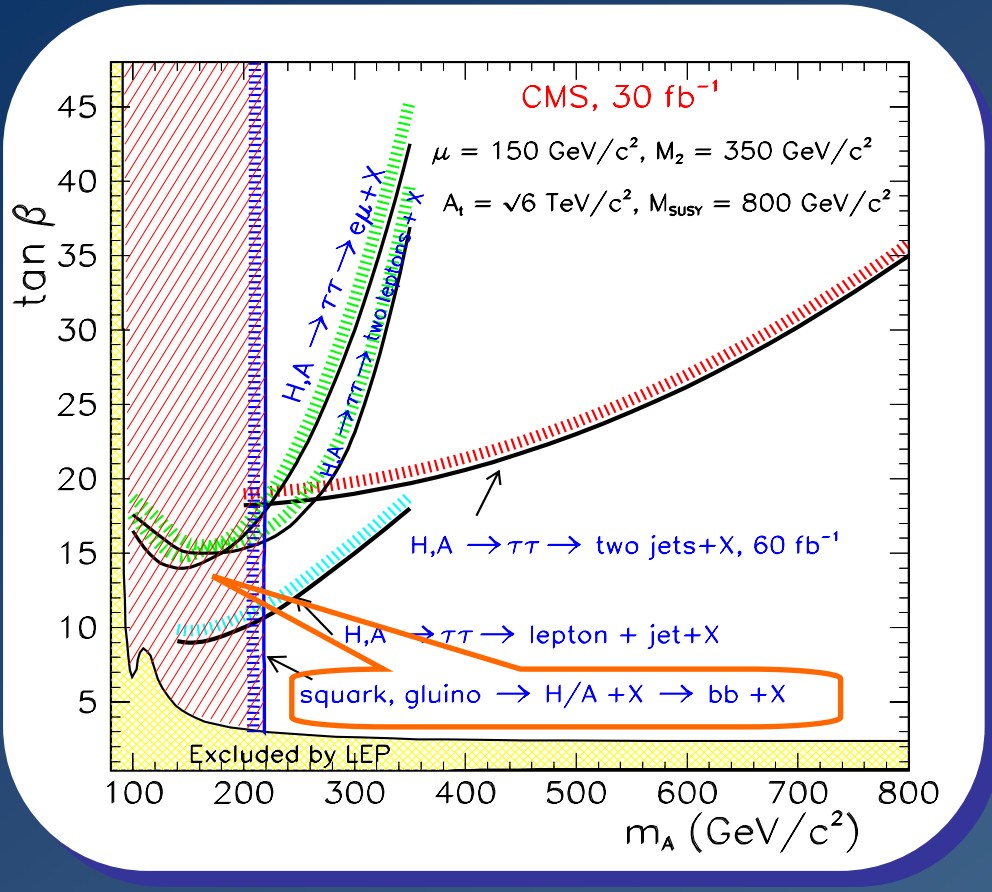




M_2 = 350 GeV
μ = 1000 GeV
$m_{\tilde{g}}$ = 1200 GeV
$m_{\tilde{q}}$ = 800 GeV

h,H,A are all produced in the little cascade
Squarks lighter than gluinos strongly enhance h,H,A visibility

Discovery reach with 30fb^{-1}
Scenario 3



The reach contour plot depends on the specific search Scenario

Search of A/H in $\tilde{g}/\tilde{q}$ cascades would complement the standard searches

h is always abundantly produced and can always be seen

Conclusions

The 'alternative' production of h,H,A via squark/gluino cascades is explored in 4 representative search scenarios

Good chance to detect H,A for low m_A and tgβ, where they are not accessible with the standard search channels

h can always be detected in cascades

Higgs production in SUSY cascade is very interesting since it would allow measuring the couplings between sparticles and Higgs bosons

Full detector simulation for this analysis is under way