Discussion on Benchmarks

M Battaglia
E Eichten

Muon Collider Workshop 2011, Telluride, CO
July 29 2011

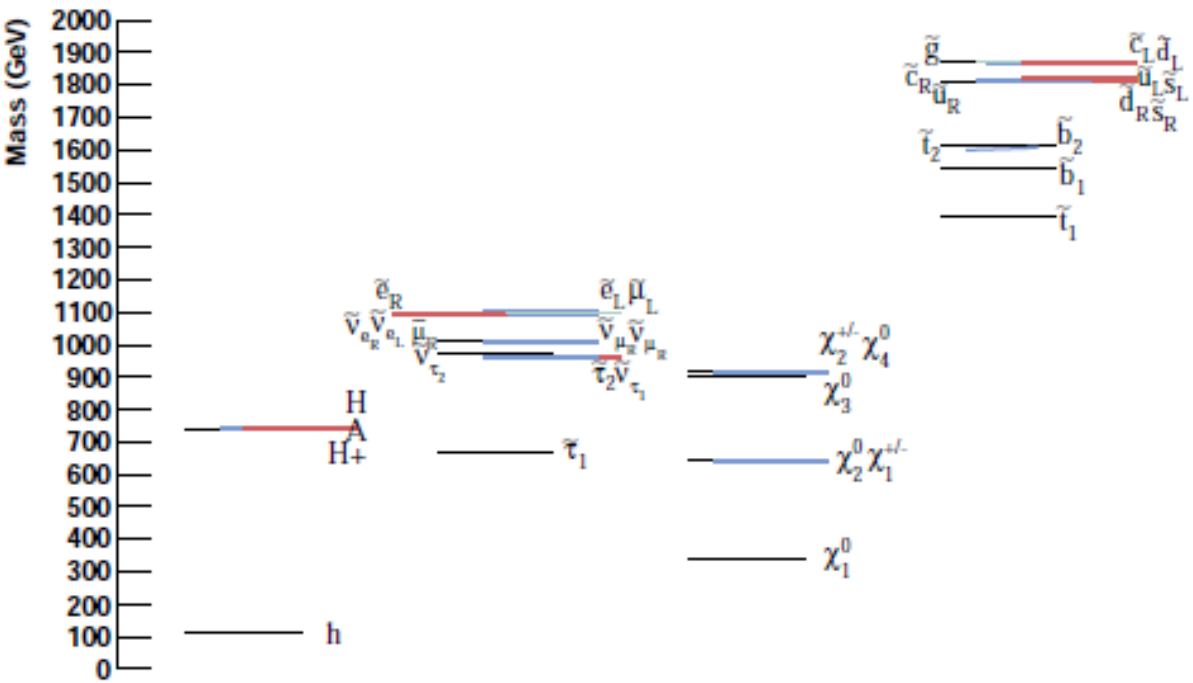
Process	Signature	Detector Challenges	Machine Challenges
$H^0, A^0 \to bb$ $H^+H^- \to tb$	Multi-jets	b tagging δE_{jet} w/ kin fitting	δE_{beam}
Gaugino pairs, $\chi \to W/Z/h$	Multi-jets+ $E_{missing}$	dEjets w/o kin fitting Jet clustering	δE_{beam}, bkg L vs E_{beam} Threshold scan
Slepton pairs	Leptons+ $E_{missing}$	Lepton id δE at high E	L vs E_{beam} Threshold scan Polarisation
Squark pairs	Multi-jets+ $E_{missing}$	δE_{jet} at highest E	
EW observables in $\mu\mu$, bb, tt	Multi-jets, Fwd	b tagging at highest E Quark charge, Fwd	Polarisation, bkg
$\nu\nu H \to \mu\mu$ $\nu\nu H \to bb$	Fwd Fwd b jets	Fwd E reco Fwd b tagging	bkg
$\nu\nu HH \to bbbb$	Fwd b jets	Fwd b tagging, Jet clustering	L, bkg, Polarisation
$\nu\nu WW$ / $\nu\nu ZZ$	Multi-jets Fwd	W/Z separation, Fwd	bkg

SUSY Gaugino Pair Production

cMSSM Point adopted
for the CLIC CDR

Ωh^2 compatible with WMAP 7 year data

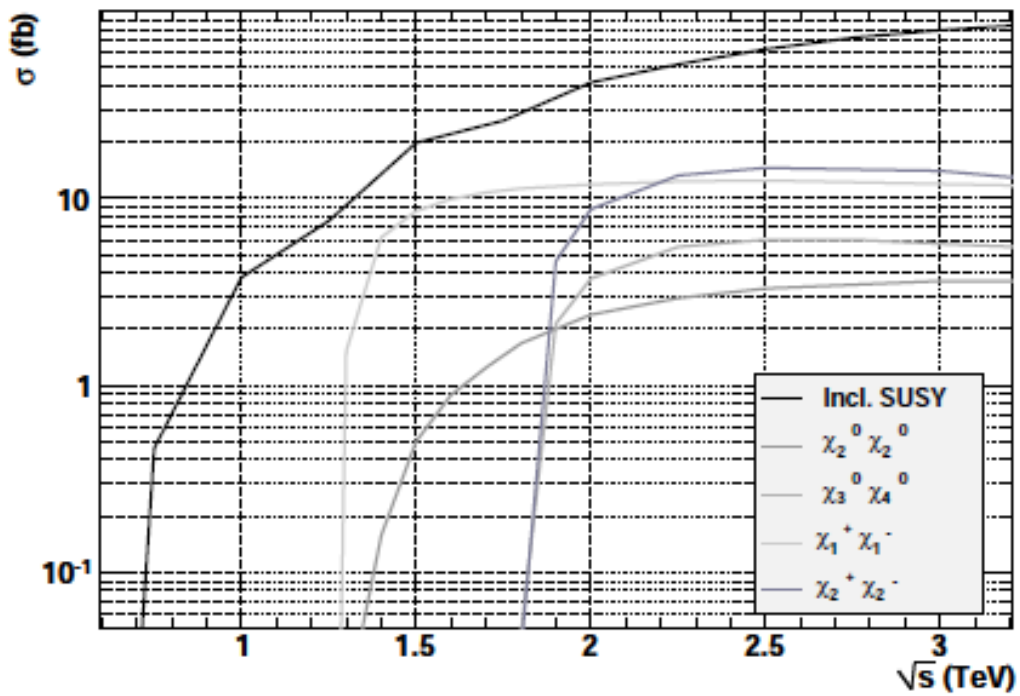
Parameter	Model I
m_0 (GeV)	966
$m_{1/2}$ (GeV)	800
$\tan\beta$	51
A_0	0.
sgn(μ)	+
m_{top} (GeV)	173.3



Particle	Mass (GeV)	Width (GeV)
χ_1^0	340.3	-
χ_2^0	643.2	0.02
χ_3^0	905.5	4.55
χ_4^0	916.7	4.64
$\chi_1^\pm$	643.2	0.02
$\chi_2^\pm$	916.7	4.63

SUSY Gaugino Pair Production

Process	no Rad (fb)	ISR (fb)	ISR+BS (fb)	Pol +0.8/0.0 (fb)	Pol +0.8/-0.6 (fb)
Model I					
Inclusive SUSY	103.3	97.4	79.3		
$e^+e^- \to \chi_1^+\chi_1^-$	11.5	11.6	11.9	21.4	34.0
$e^+e^- \to \chi_2^0\chi_2^0$	4.2	4.1	3.6	6.5	10.4
$e^+e^- \to \chi_2^+\chi_2^-$	14.5	14.4	13.8	21.1	33.3
$e^+e^- \to \chi_3^0\chi_4^0$	6.1	6.1	6.0	6.8	10.3

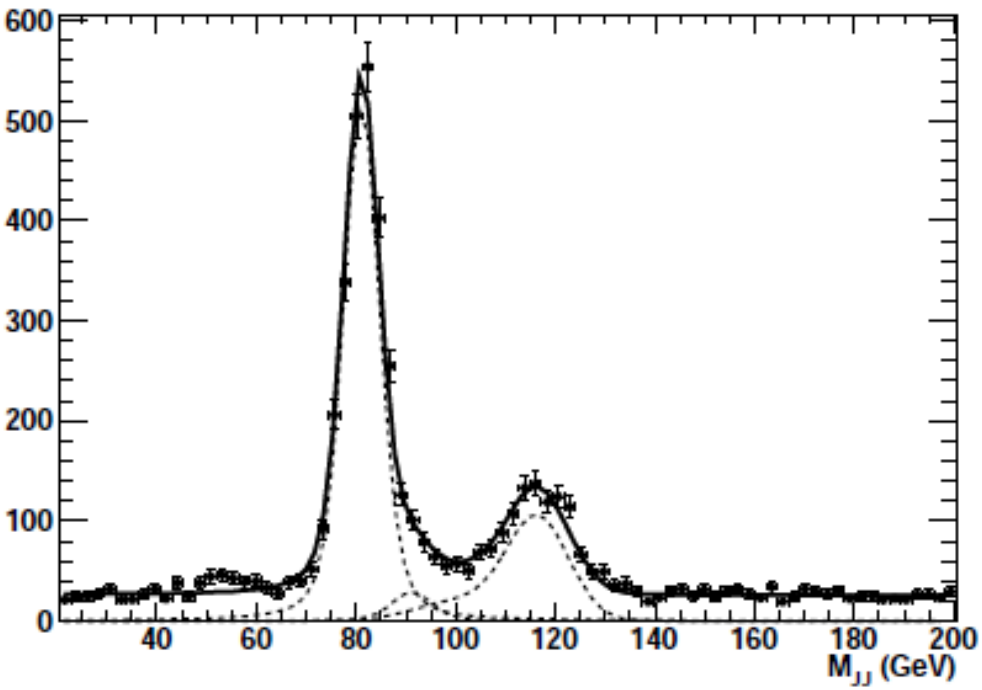


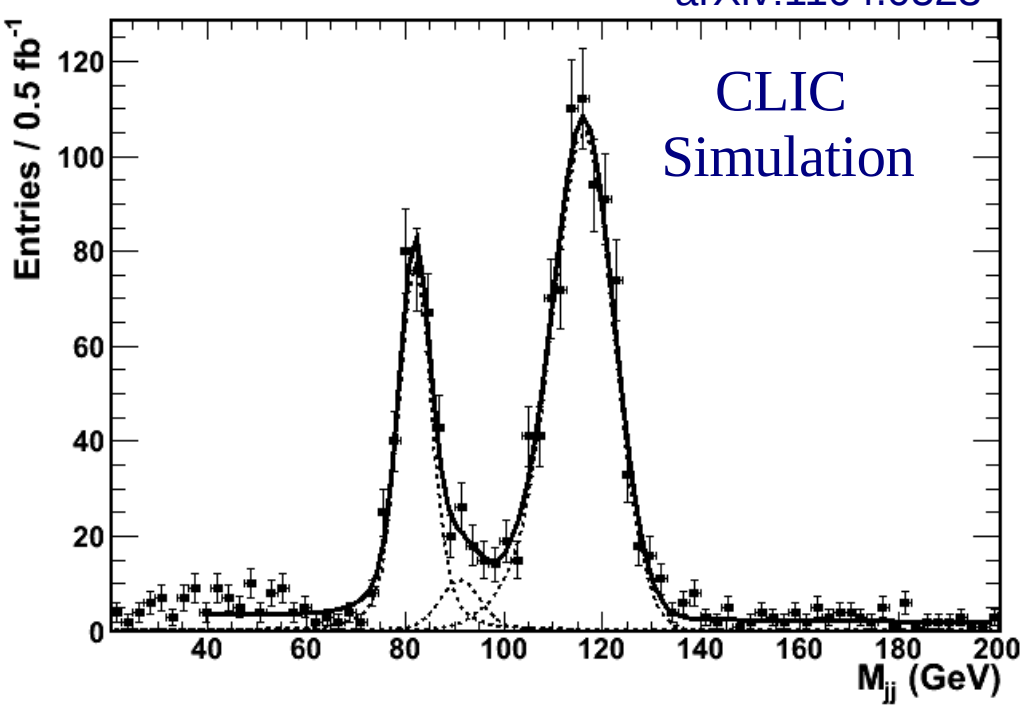
arXiv:1104.0523

SUSY Gaugino Pair Production

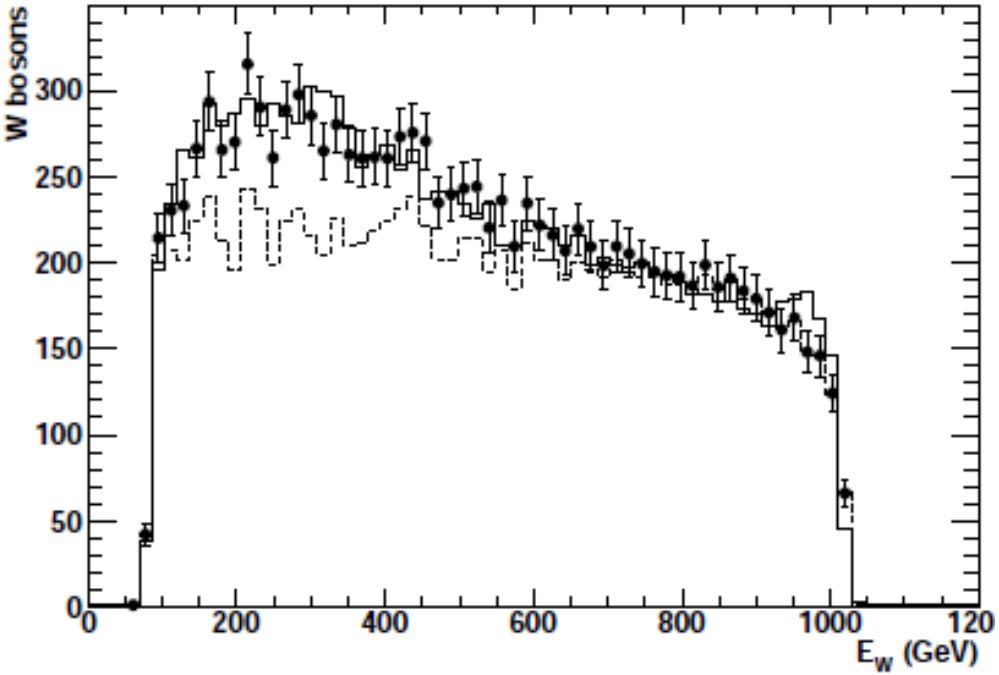
- $e^+e^- \to \chi_1^+\chi_1^- \to W^+\chi_1^0 W^-\chi_1^0;\ W \to q\bar{q}',$
- $e^+e^- \to \chi_2^0\chi_2^0 \to h^0\chi_1^0 h^0\chi_1^0;\ h \to b\bar{b},$
- $e^+e^- \to \chi_2^+\chi_2^+ \to W^+\chi_2^0 W^-\chi_1^0 \to W^+h^0\chi_1^0 W^-\chi_1^0;\ h \to b\bar{b},\ W \to q\bar{q}',$
- $e^+e^- \to \chi_2^+\chi_2^+ \to h^0\chi_1^+ W^-\chi_1^0 \to h^0 W^+\chi_1^0 W^-\chi_1^0;\ h \to b\bar{b},\ W \to q\bar{q}',$
- $e^+e^- \to \chi_2^+\chi_2^+ \to Z^0\chi_1^+ W^-\chi_1^0 \to Z^0 W^+\chi_1^0 W^-\chi_1^0;\ Z \to q\bar{q},\ W \to q\bar{q}',$
- $e^+e^- \to \chi_4^0\chi_3^0 \to W^+\chi_1^- W^-\chi_1^+ \to W^+W^-\chi_1^0 W^-W^+\chi_1^0;\ W \to q\bar{q}'.$

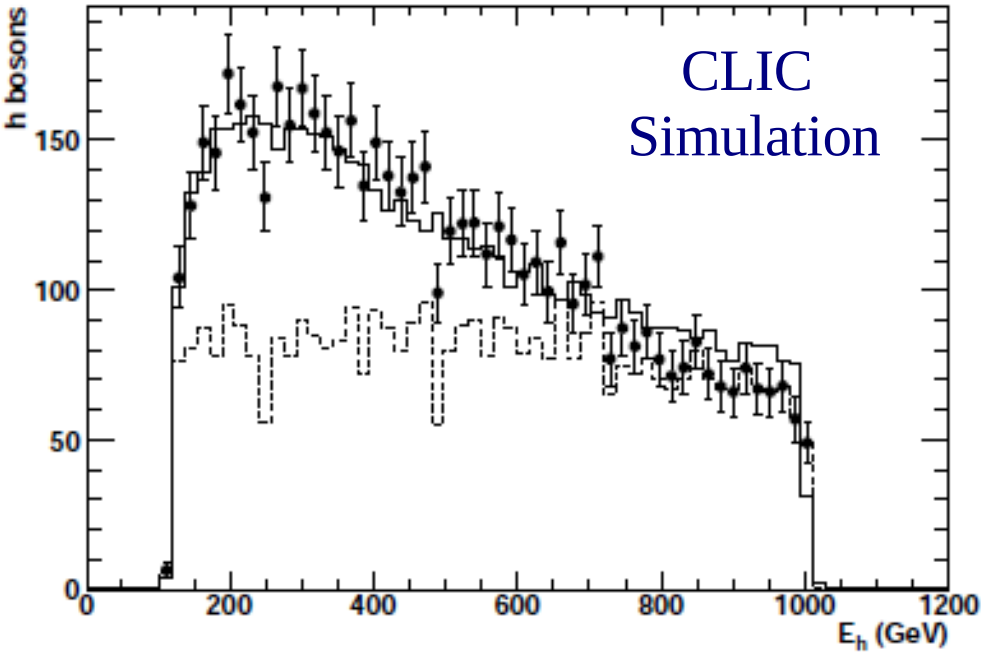
arXiv:1104.0523





SUSY Gaugino Pair Production





arXiv:1104.0523

Determine $M(\chi)$-$M(\chi^0_1)$ from fit to boson energy, $M(\chi)$ from threshold scan

SUSY Heavy Higgs Production

CLIC CDR H Benchmark

MSSM model
with non-unified gaugino masses

M_1=780 GeV, M_2=940 GeV, M_3=540 GeV
m_0 = 303 GeV, A_0 = -750 GeV,
tan β = 24, μ>0

M_A = 902.6 GeV
M_H = 902.4 GeV
M_{H+} = 906.3 GeV

CLIC CDR χ Benchmark

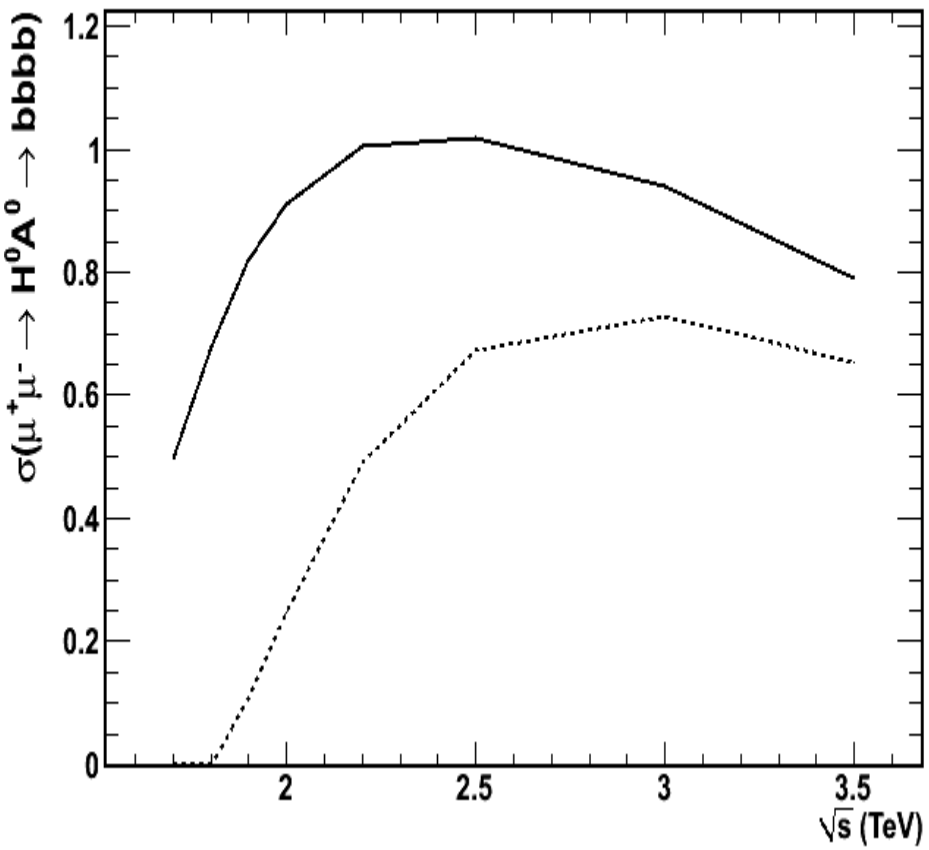
cMSSM model

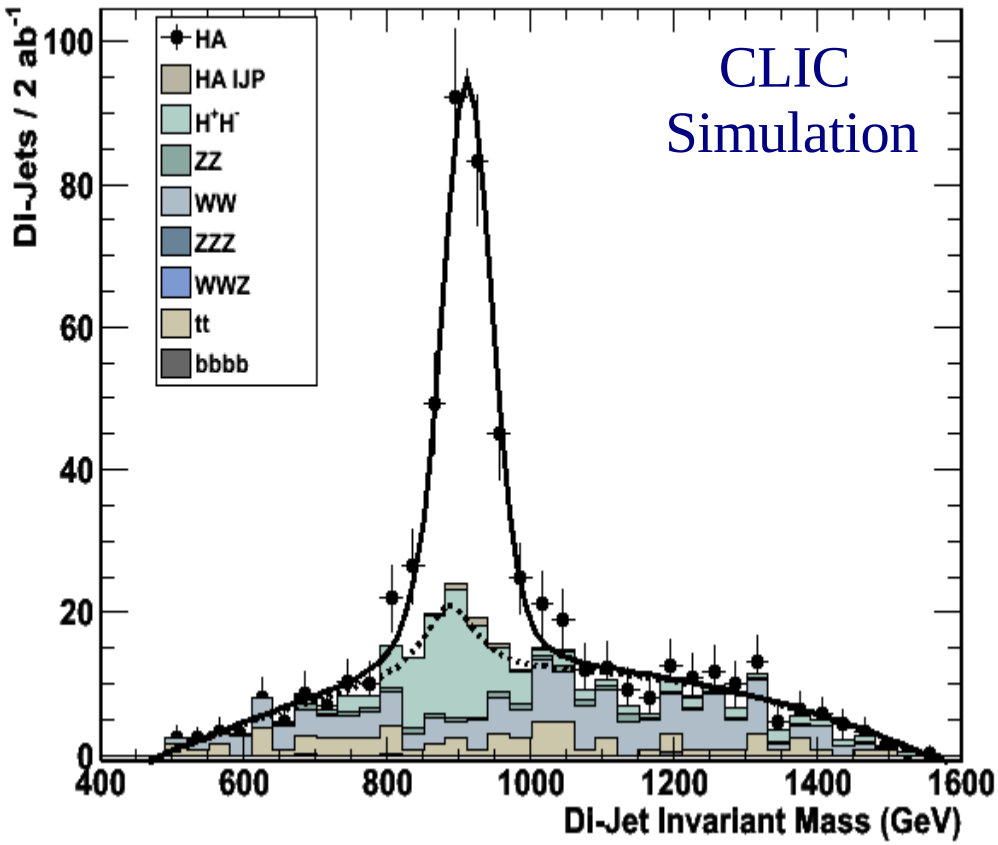
$m_{1/2}$=966 GeV, m_0 = 800 GeV,
A_0 = 0, tan β = 51, μ<0

M_A = 742.8 GeV
M_H = 742.0 GeV
M_{H+} = 747.6 GeV

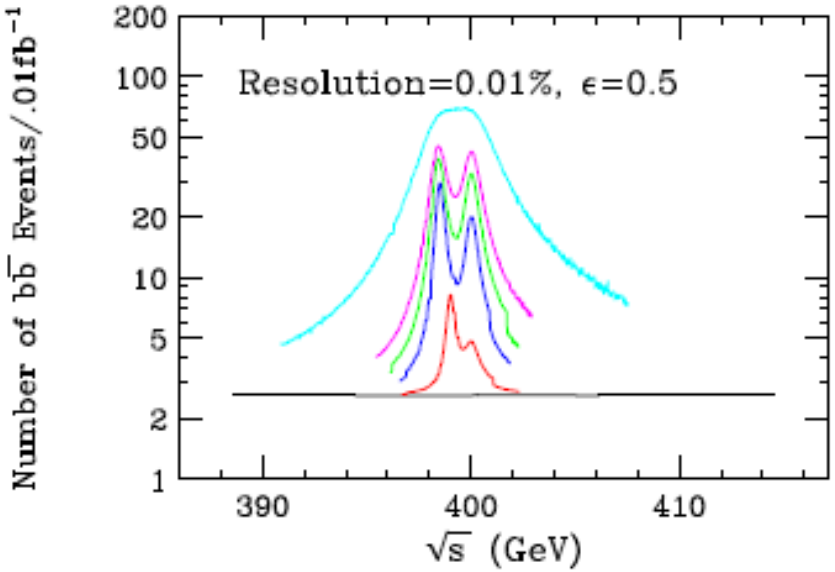
Determine M(A), Γ(A) from fit to bb invariant mass distribution

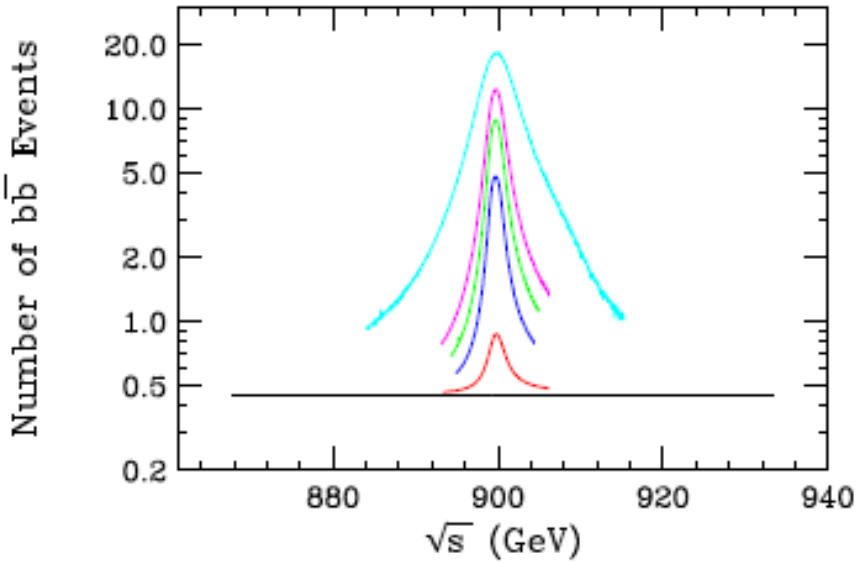
SUSY Heavy Higgs Production





SUSY Heavy Higgs Production



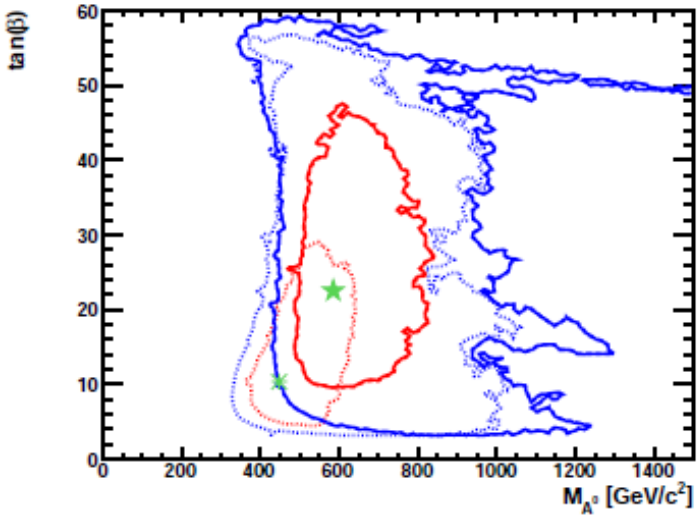


Separating A from H. Beamstrahlung=0.01%, bremsstrahlung included. $L = .01$ fb^{-1} at any given $\sqrt{s}$. Ok for $m_A = 400$ GeV; Impossible for $m_A = 900$ GeV.

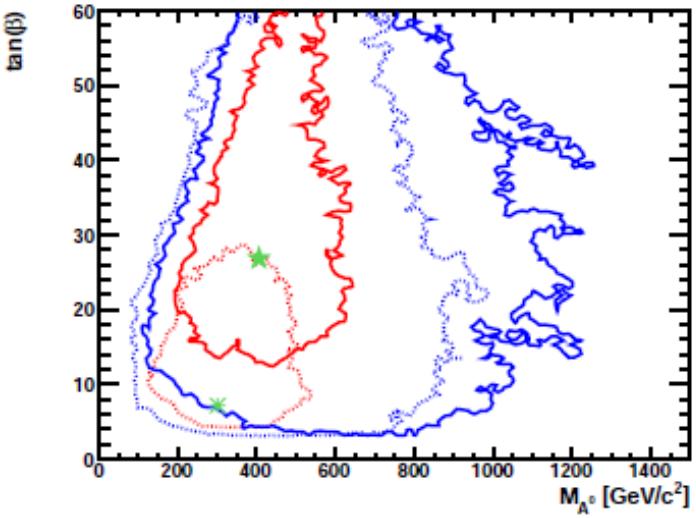
J Gunion

SUSY Heavy Higgs Production

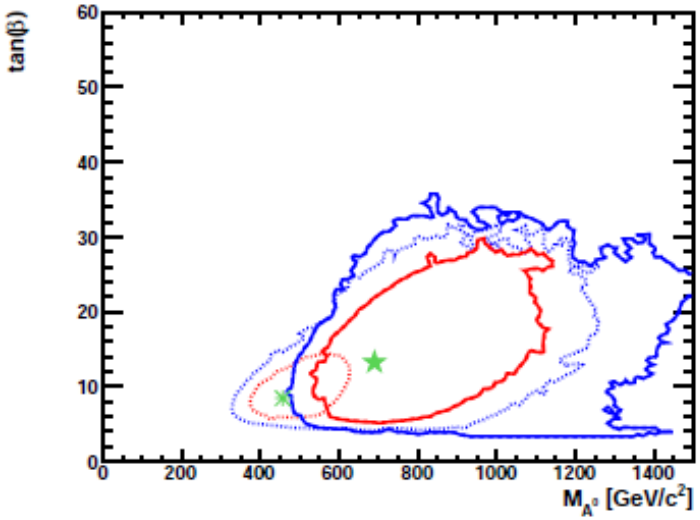
CMSSM



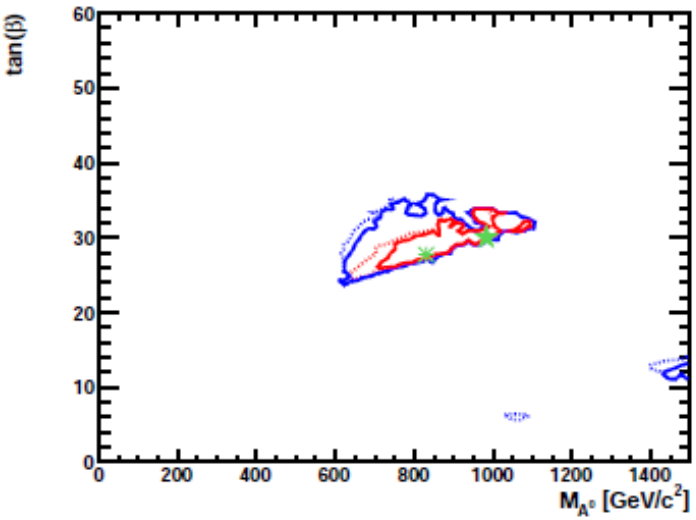
NUHM



VCMSSM

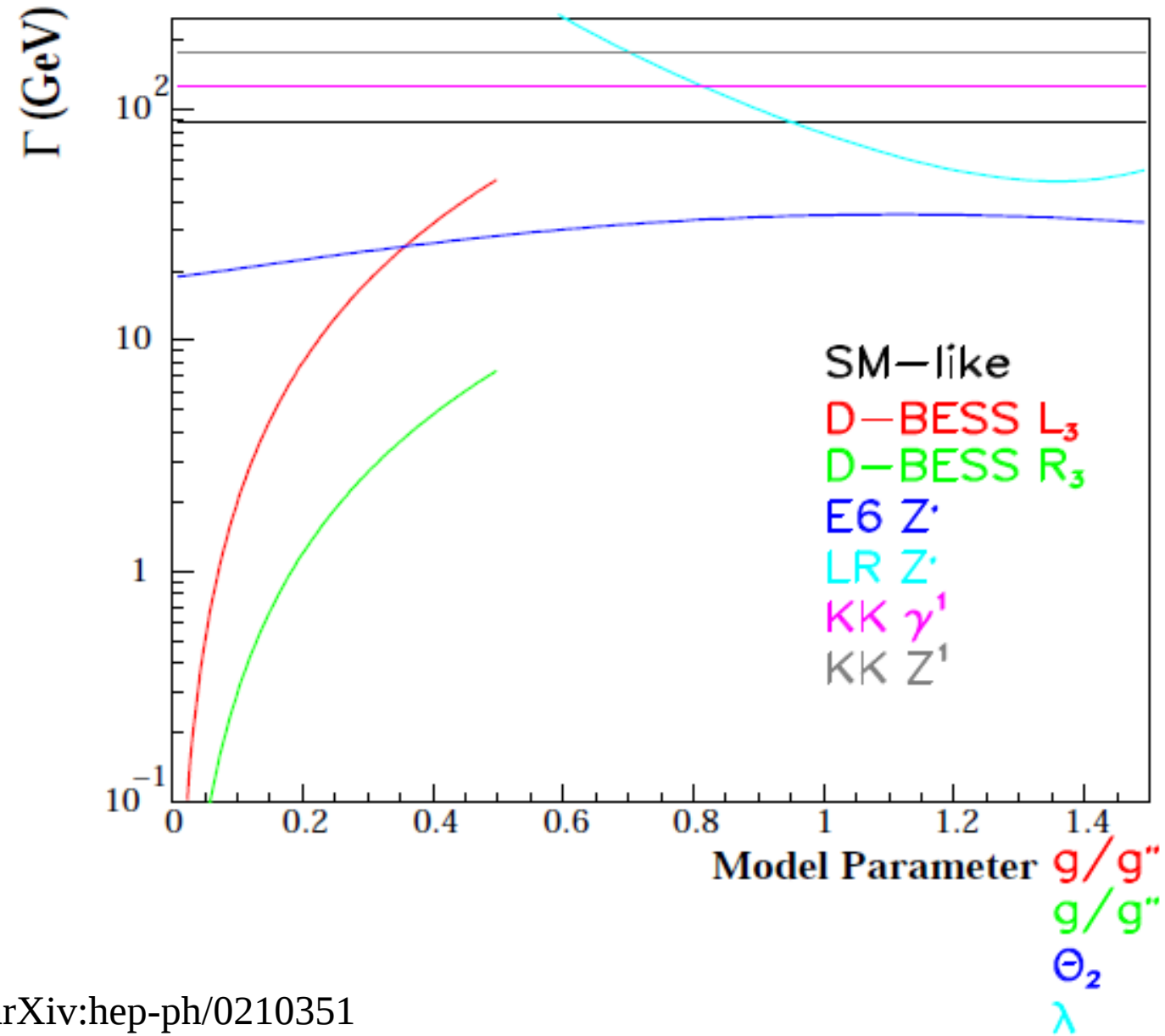


mSUGRA



arXiv:1106.2529

S-channel New Boson Production



arXiv:hep-ph/0210351

WW scattering

No Higgs or Higgs-like states: the Strongly-Interacting Electroweak Scenario

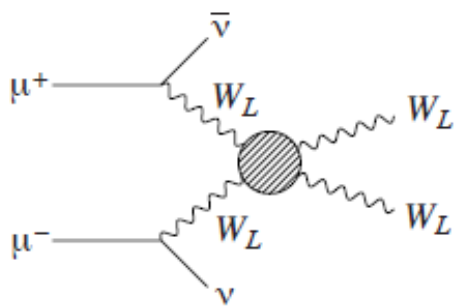
Much of the following material is based on papers by the Muon-Quartet (Barger, Berger, Gunion, Han).

- If no Higgs boson exists with $m_H < 600$ GeV, then, naively, partial wave unitarity of $W_L W_L \to W_L W_L$ will be violated at large s_{WW}.
  The $W_L W_L \to W_L W_L$ scattering amplitude behaves as

$$A \sim \begin{cases} m_H^2/v^2 & \text{if light Higgs}, \\ s_{WW}/v^2 & \text{if no light Higgs}. \end{cases} \tag{1}$$

  Understanding the manner in which unitarity violation is avoided at high energies will be crucial.

- $W_L W_L \to W_L W_L$ scattering will be probed via



Other Processes