A Study of Chargino and Neutralino Masses using W and h Energy Spectra and Threshold Scans at CLIC.

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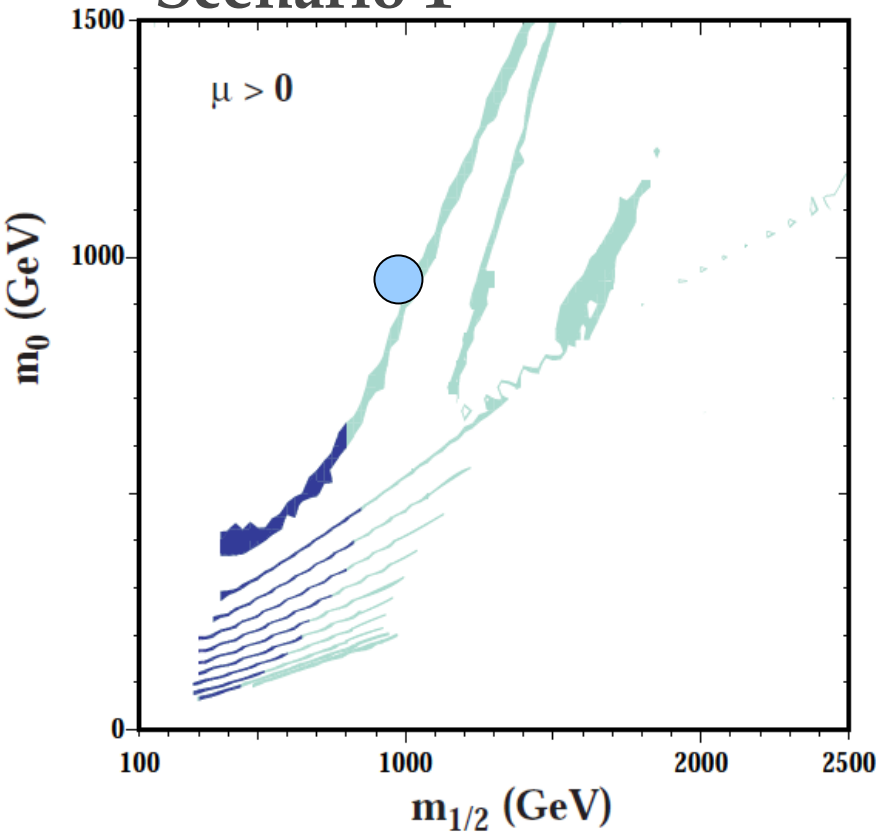
Introduction

-Dark Matter

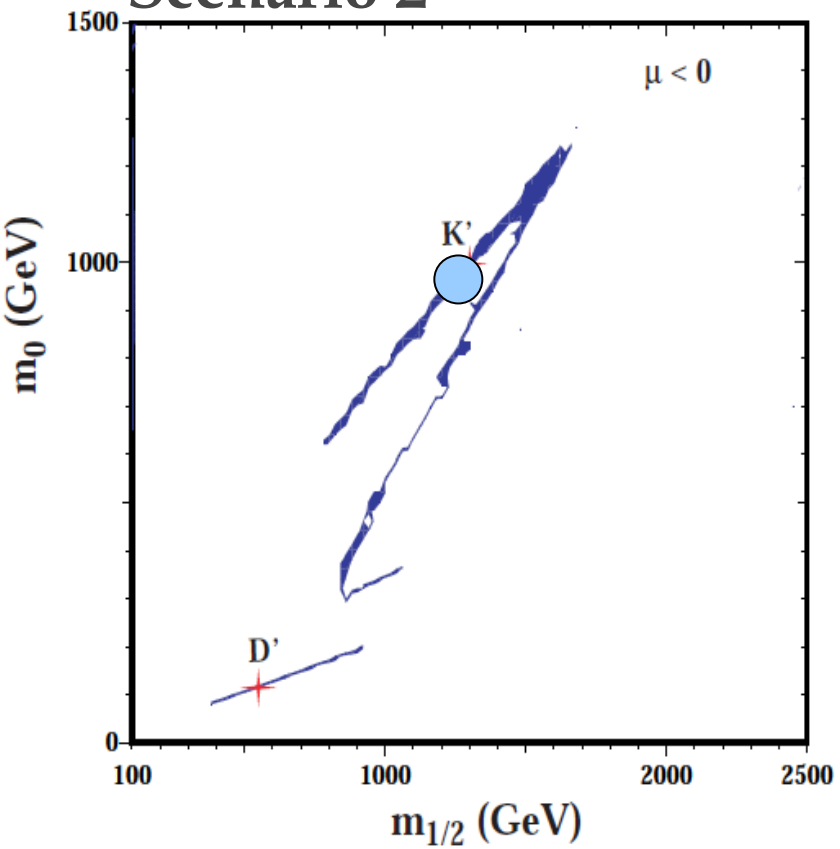
Study DM motivated MSSM scenarios @ 3TeV

Scenario 1



Ellis et al., PLB565 (2003)

Scenario 2

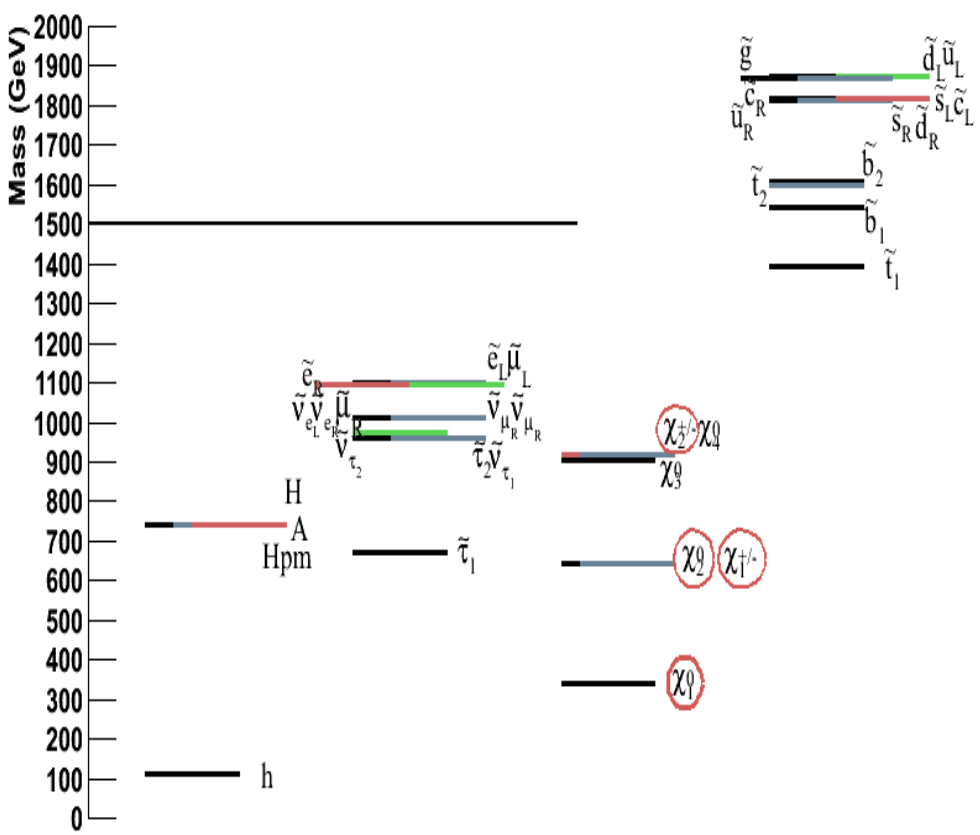


MB et al., EPJ C33 (2004)

Benchmark Scenarios

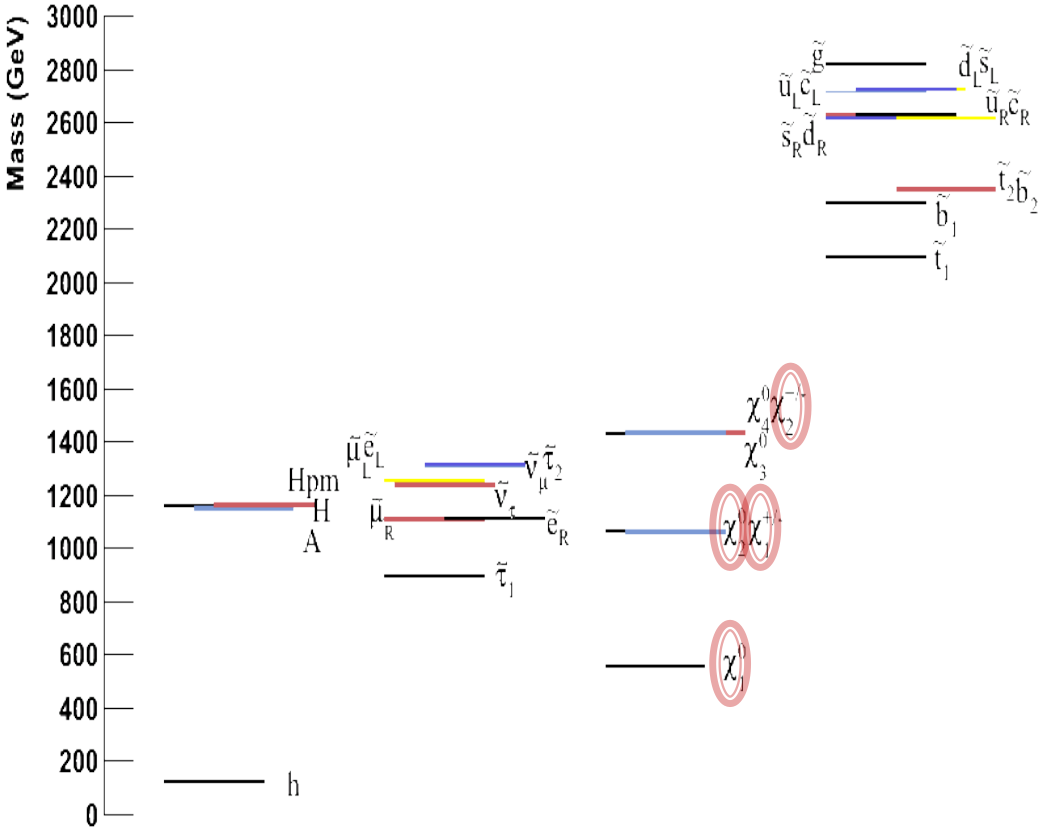
- **Scenario 1 :**

m_0 = 966 GeV $m_{1/2}$ =800 GeV
tanβ = 51 GeV A_0 = 0 GeV
sign(μ) +



- **Scenario 2:**

m_0 = 1001 GeV $m_{1/2}$ =1300 GeV
tanβ = 46 GeV A_0 = 0 GeV
sign(μ) -

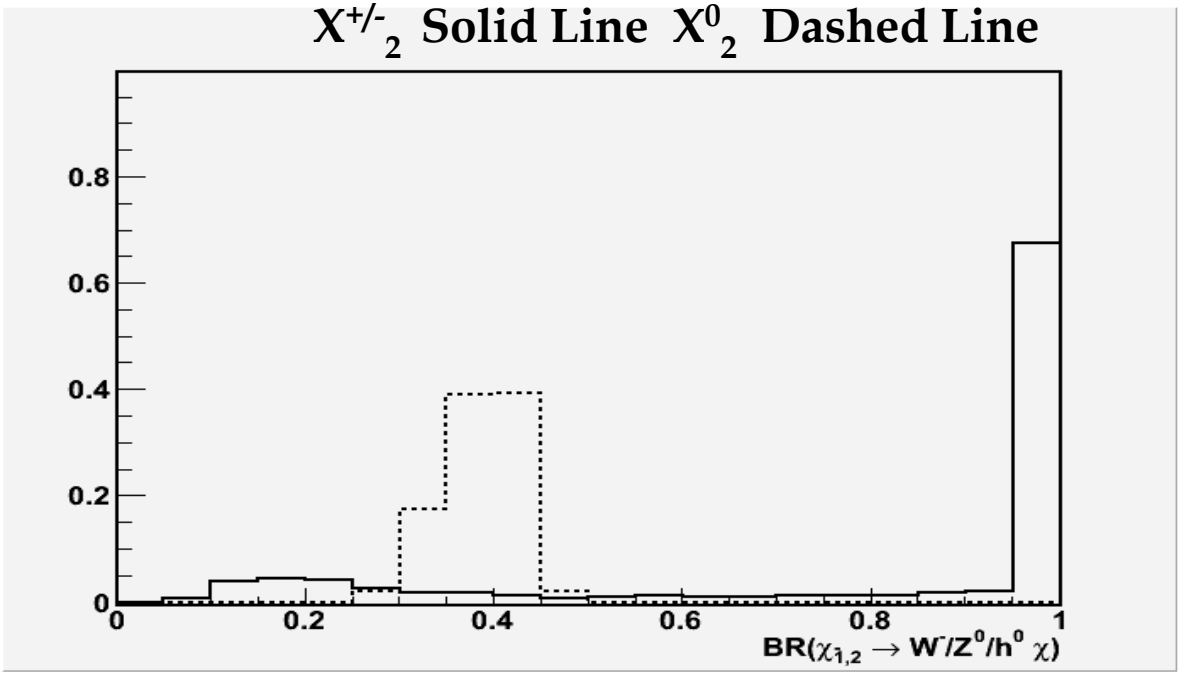


Gauginos are heavy

Dominant modes:
W/Z/h + lighter X

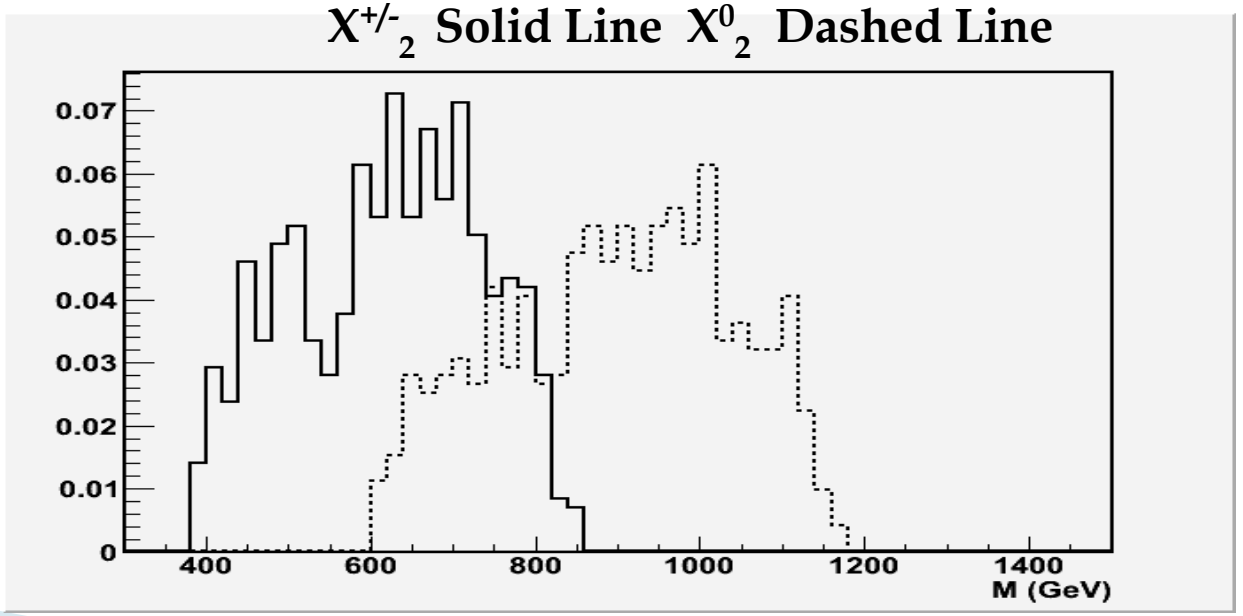
In Model: $m(X^0_2) = m(X^{+/-}_2)$

$BR(X^0_2) = BR(X^{+/-}_2)$



CMSSM DM compatible points obtained with MicroMEGAS 2.2

Spectrum with SuSPECT2
BR with SDECAY 1.3



Simulation and Assumptions

- Signal and backgrounds generated using:
  PYTHIA 6.215 (+ISASUGRA 7.67 or SuSPECT2.2)
  With ISR and including BeamStralung using:
  CLIC CALYPSO files
- Polarised cross sections computed with:
  SUSYGEN 3.0
- Full Simulation using:
  MOKKA + Marlin v01-09
- Assume: 0.5 ab^{-1} /year @ 3 TeV

Signal and background

- Main Signal Signature:

  pairs of boson + missing E

  Boson E Spectra can be used to determine mass.

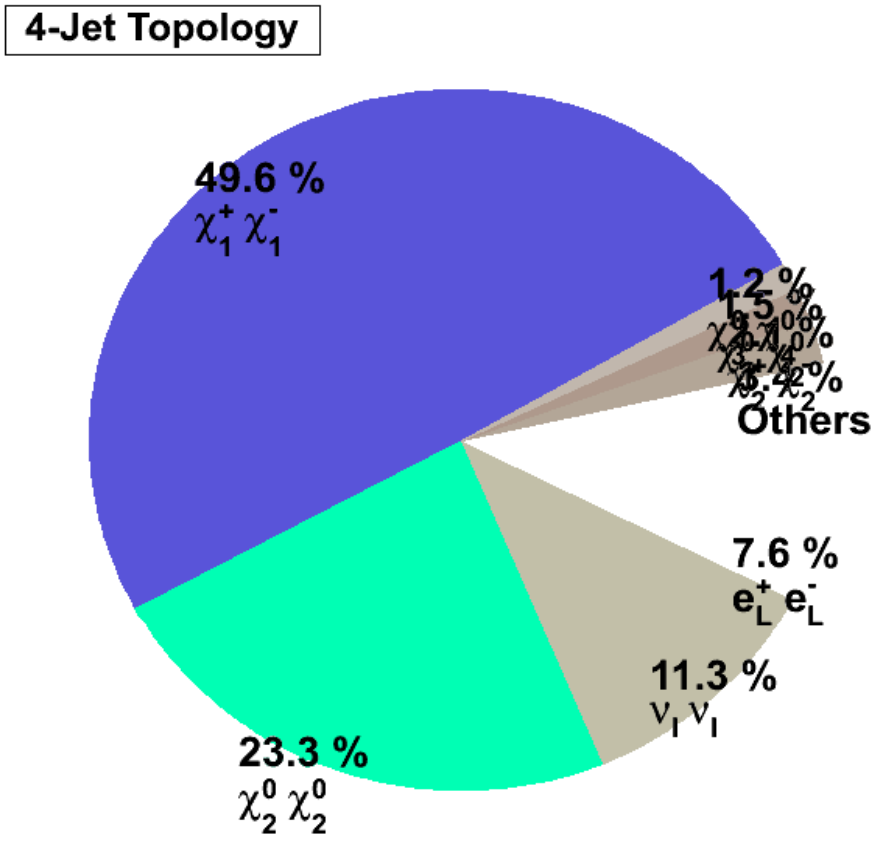
Considered in this Study:

Signal $X^0_2 \rightarrow X^0_1 h \rightarrow$ bbbar

Signal $X^{+/-}_1 \rightarrow X^0_1 W \rightarrow$ qqbar

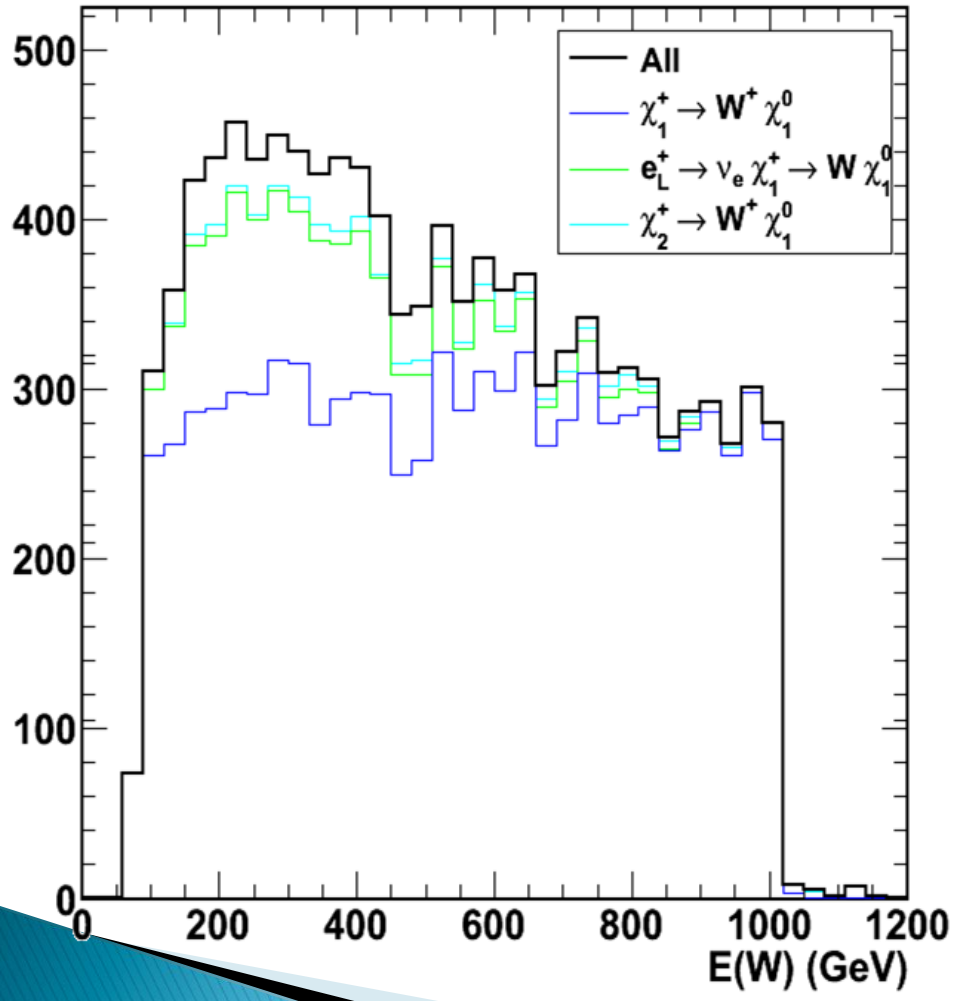
Final States:

4 Jets + Missing E

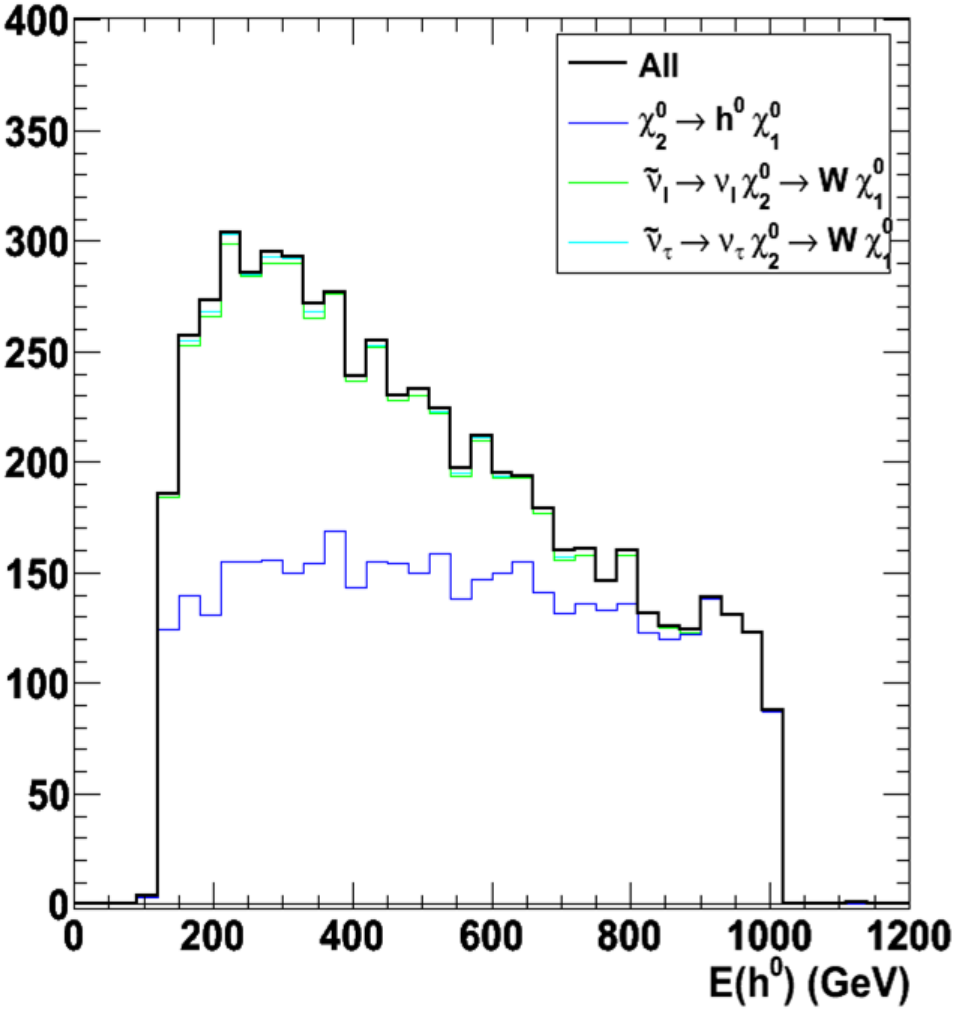


Signal and background

Generator Level



Generator Level

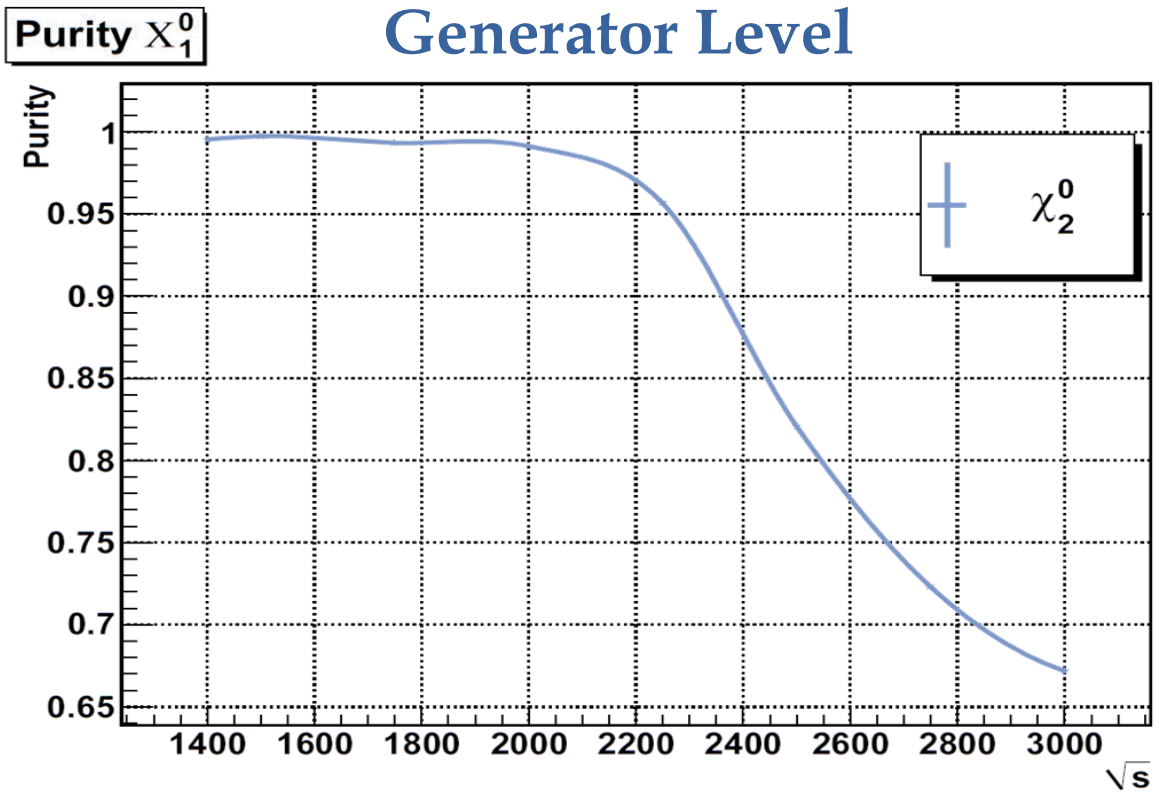


Scenario 1

Signal Selection at Generator level:
4 jets, 2 h + Missing E

Signal $X^0_2 \rightarrow h_0 X^0_1$
Bkg dominated by:
$s\nu \rightarrow X^0_2$

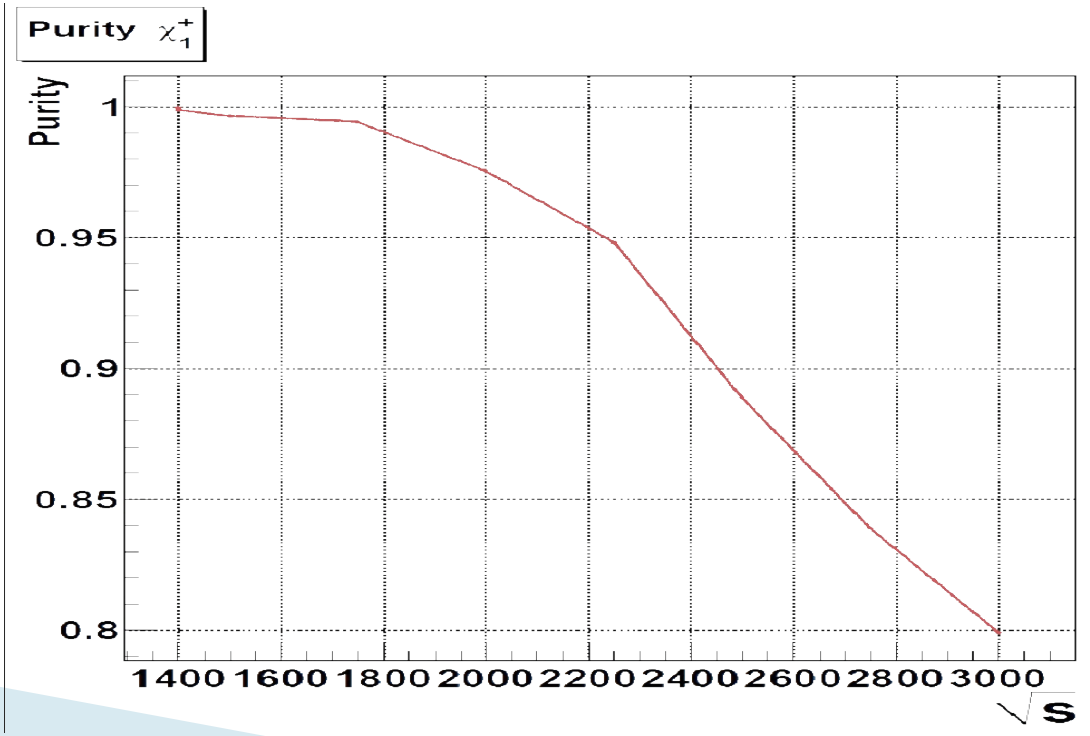
Generator Level



Only SUSY bkg considered

- 4 jets with 2 W

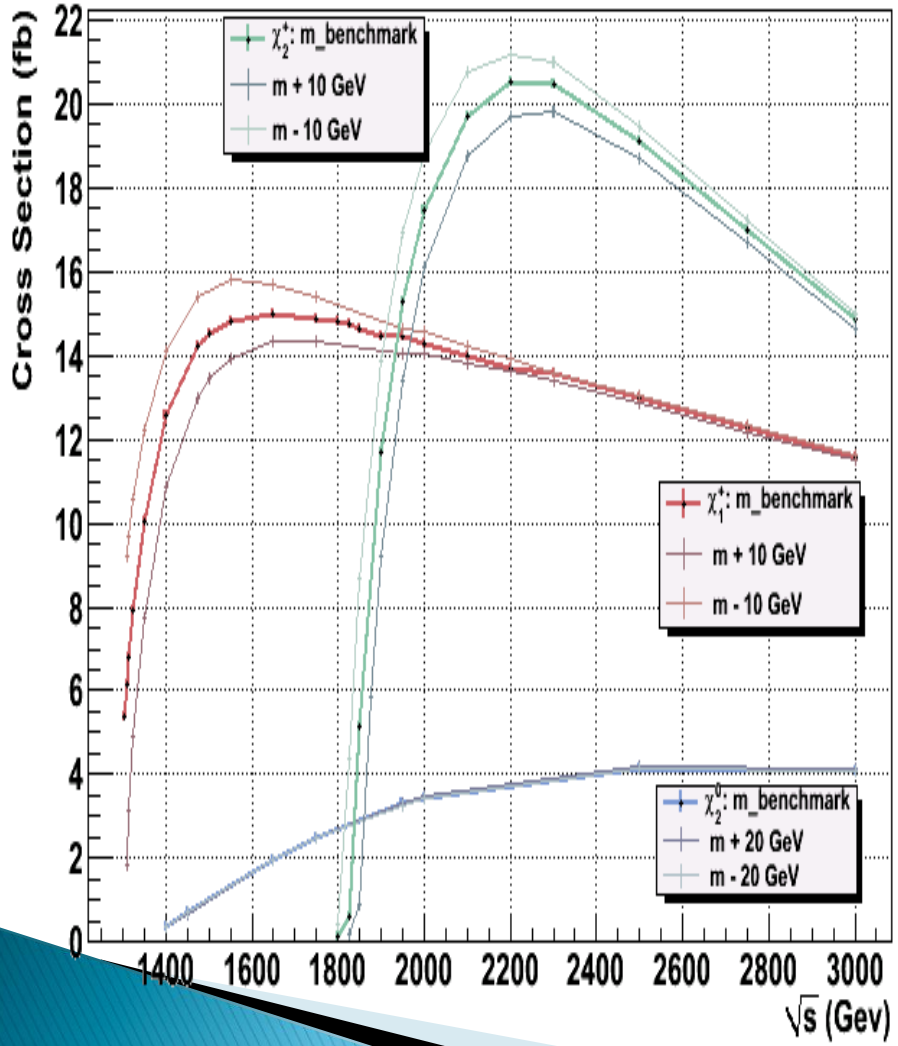
Signal $X^{+/-}_1 \rightarrow W^{+/-} X^0_1$



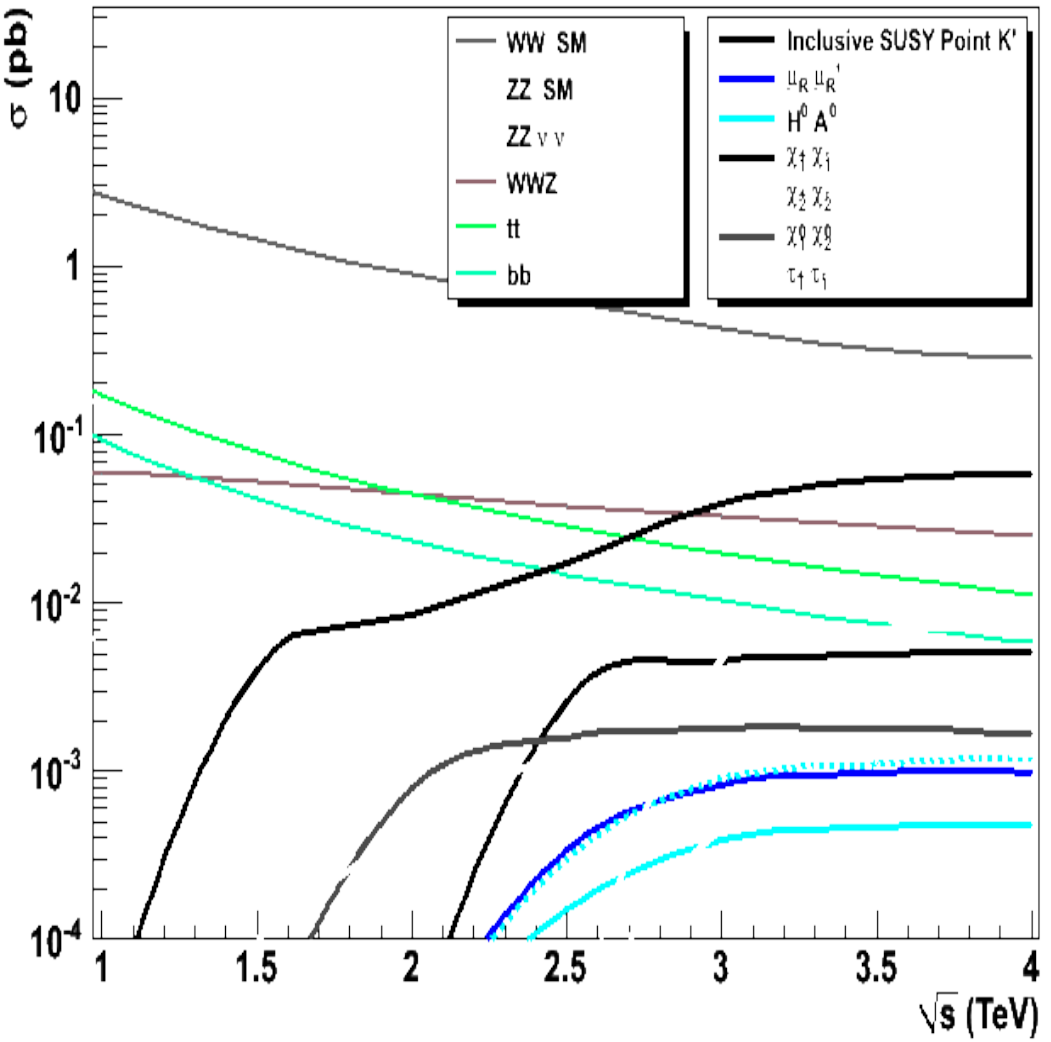
Threshold Scans Cross SectionVS. Center of Mass Energy

Generator level Plot w/ISR no BS

Scenario1



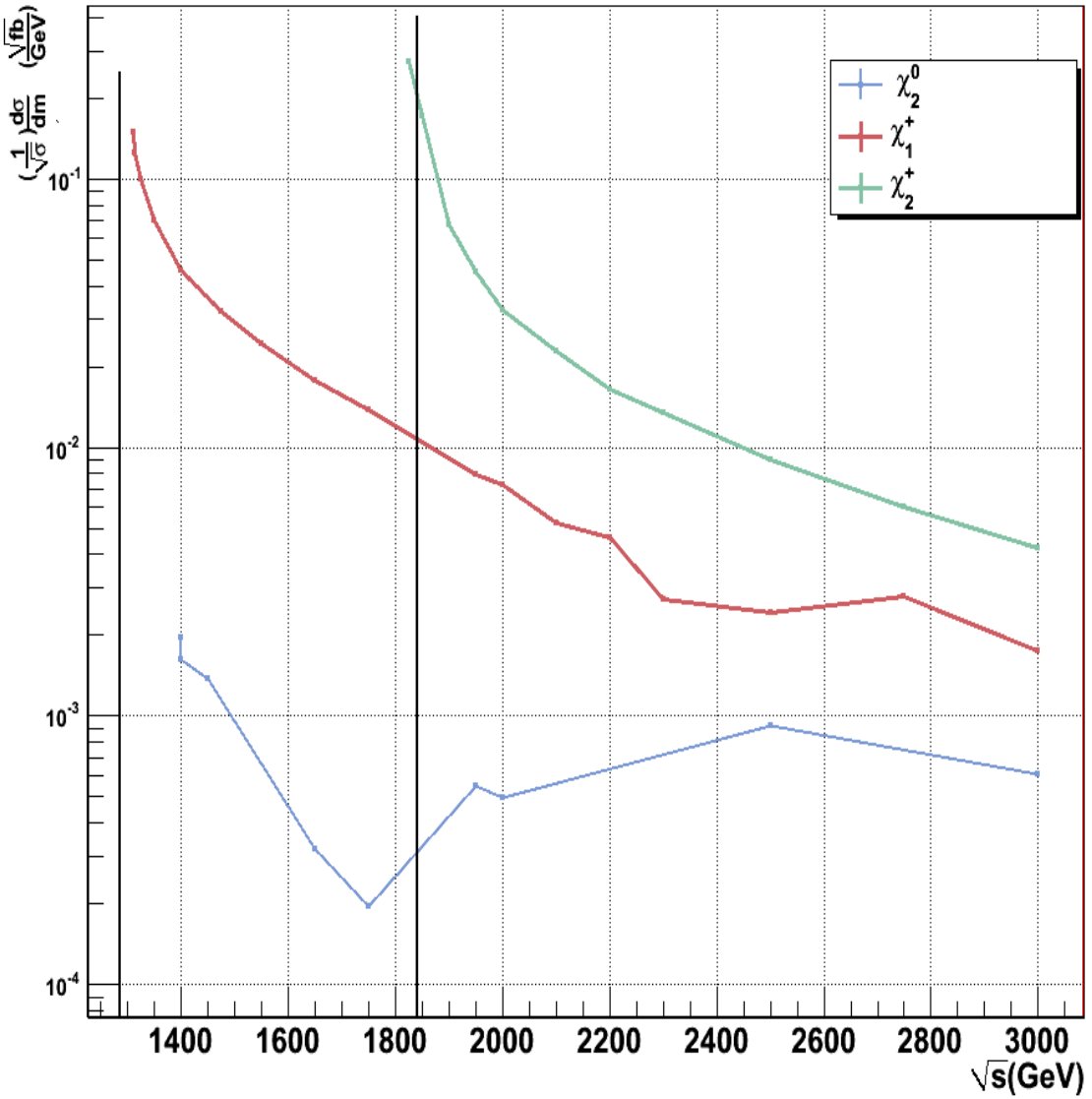
Scenario2



Threshold Scans Mass Sensitivity

- Find optimal energies and number of points within fixed luminosity budget

- Note: Width plays a role as well. Width $X^{+/-}_2$ ~ 4GeV



Threshold Scan

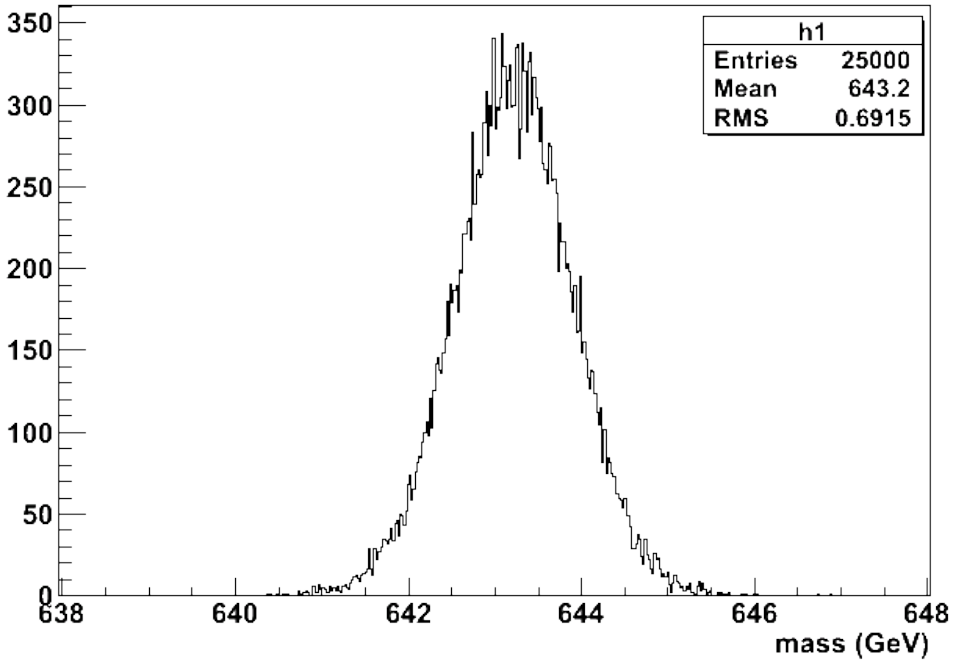
Mass Determination X^2

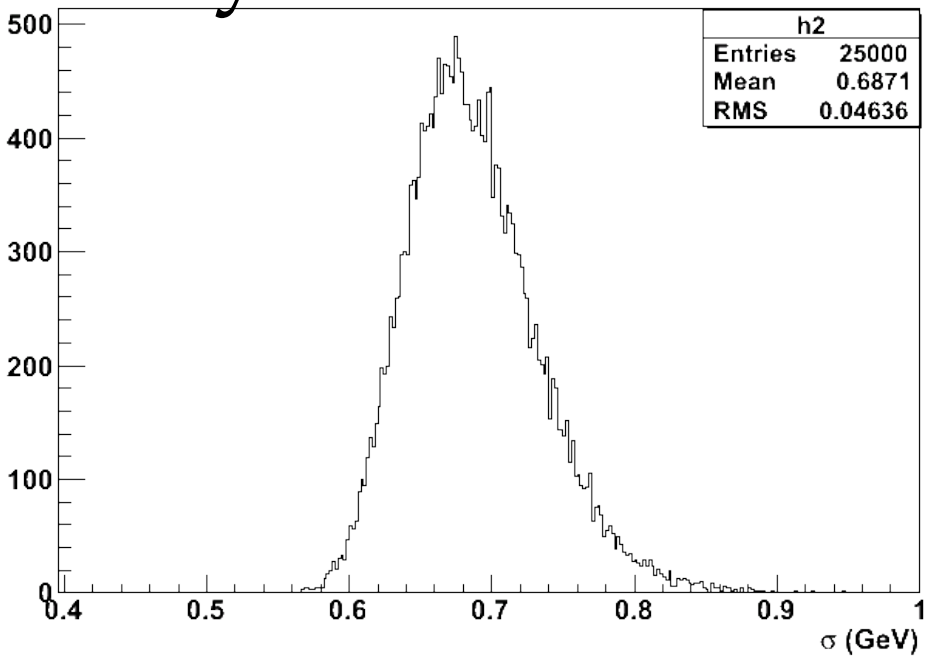
X^2 Fit

Masses extracted from X^2 fit to cross sections.

Validation of Central Value and Errors performed with toy test

Preliminary





From **X^2 fit:** 643.2+/- 0.68

Optimization

- Assuming: 2ab^-1 @ 3TeV

  1ab^-1 to share @ other Energies.

Scans performed at different distributions of luminosity @ several Energies:

Mass: 643.4 GeV +/- Error with: 1) Even distribution: +/-0.97
2) 4 point scan: +/-0.85 3) 3 point scan: +/-0.73 4) 2 point scan: +/-0.45

		No ISR NoBS No Bkg	ISR NoBS No Bkg	ISR BS No Bkg	ISR BS Bkg	With Pol: +80/0	With Pol +80/−60
	Mass	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)
X^0_2	643.1	+/− 3.02	+/− 13.79	+/− 24.11	+/− 25.62	+/− 18.43	+/− 18.87
$X^{+/-}_1$	643.2	+/− 0.43	+/− 0.45	+/− 0.56	+/− 0.57	+/− 0.42	+/− 0.33
$X^{+/-}_2$	916.7	+/− 0.46	+/− 0.51	+/− 0.83	+/− 0.86	+/− 0.70	+/− 0.54

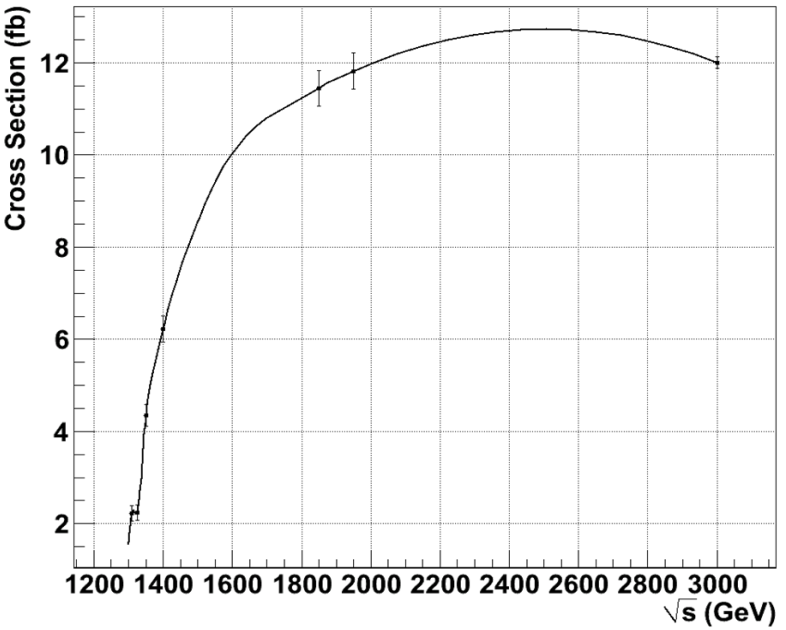
- Optimized Luminosity distribution for each particle:
  split the 1ab^-1 evenly 50% at sensitivity peak & 50% within 50 GeV of peak

Realistic Luminosity Distribution

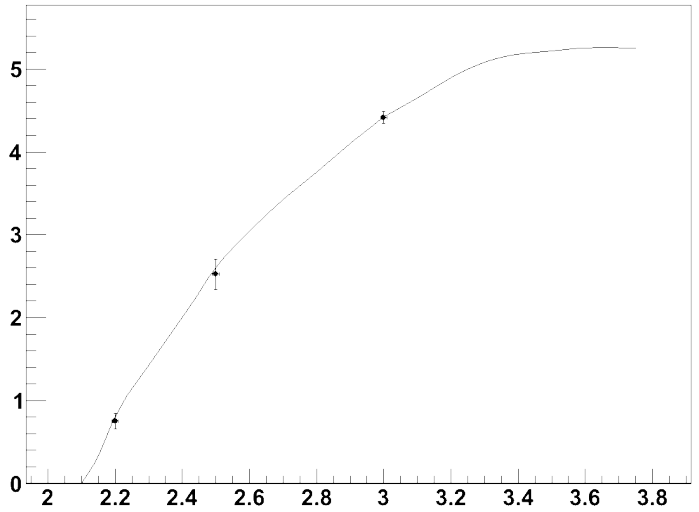
- in Scenario 1: Each State requires different optimization energies
- Results obtained from evenly sharing statistics below 3 TeV at all optimization points.

		ISR BS No Bkg	ISR BS Bkg	With Pol: +80/0	With Pol +80/−60
	Mass	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)
X^0_2	643.1	+/− 29.98	+/− 33.01	+/− 24.13	+/− 18.53
$X^{+/-}_1$	643.2	+/− 0.68	+/− 0.69	+/− 0.51	+/− 0.40
$X^{+/-}_2$	916.7	+/− 1.33	+/− 1.40	+/− 1.14	+/− 0.87
Scenario2 $X^{+/-}_1$	1062.2	+/− 6.42	+/− 6.86	+/− 5.11	+/− 2.81

Scenario1 generator level



Scenario2 generator level



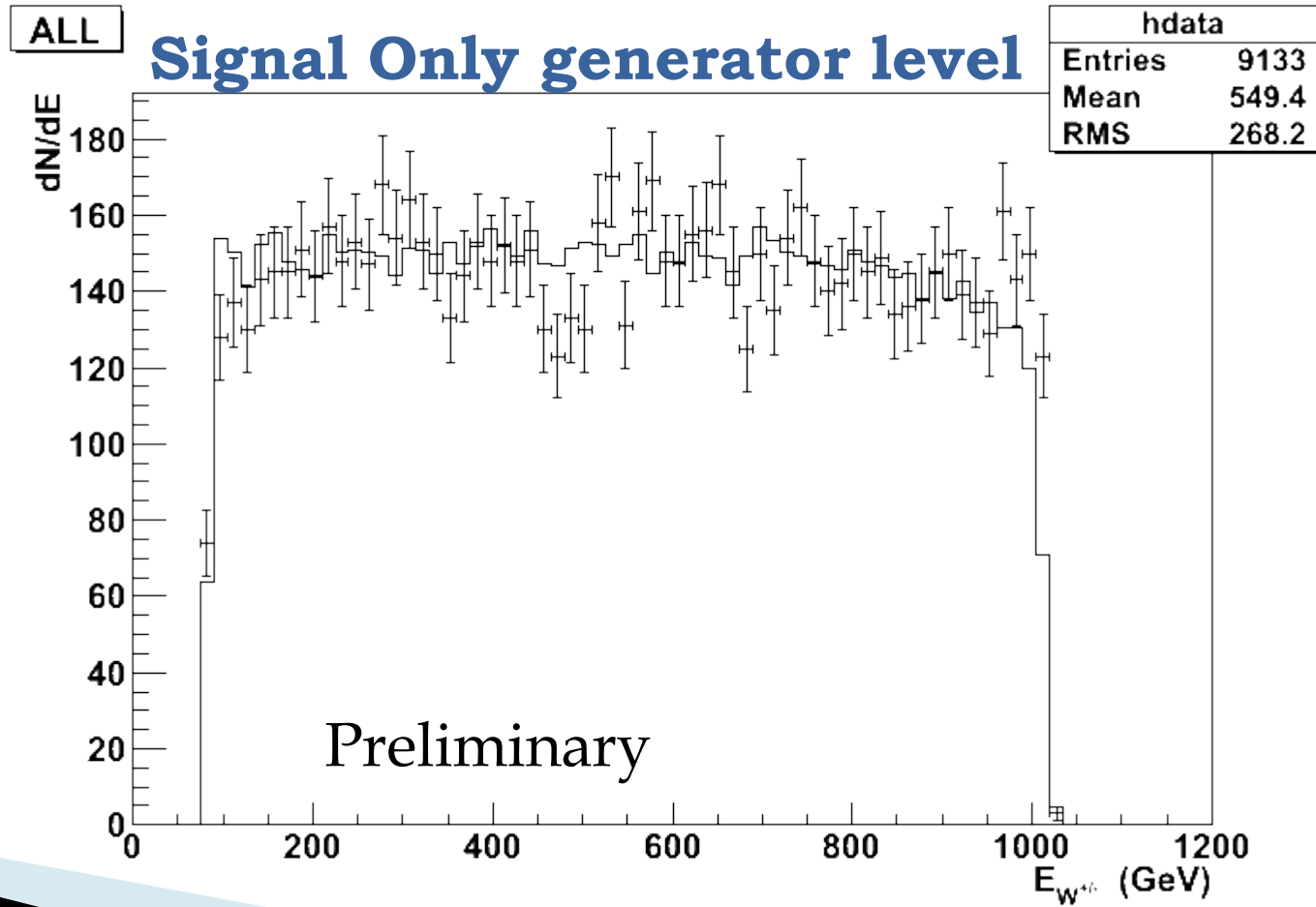
W Energy Fit at 3 TeV

		ISR NoBS	ISR BS	Reco Evt Selc. No E Res	Reco Evt Selc. w/E Res
	Mass (Gev)	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)
$X^{+/-}_1$	639.28	+/-1.21	+/-2.27	+/-4.93	+/-6.63

Using input from Threshold scan:

Input $X^{+/-}_1$ to hold as fixed variable & fit X^0_1

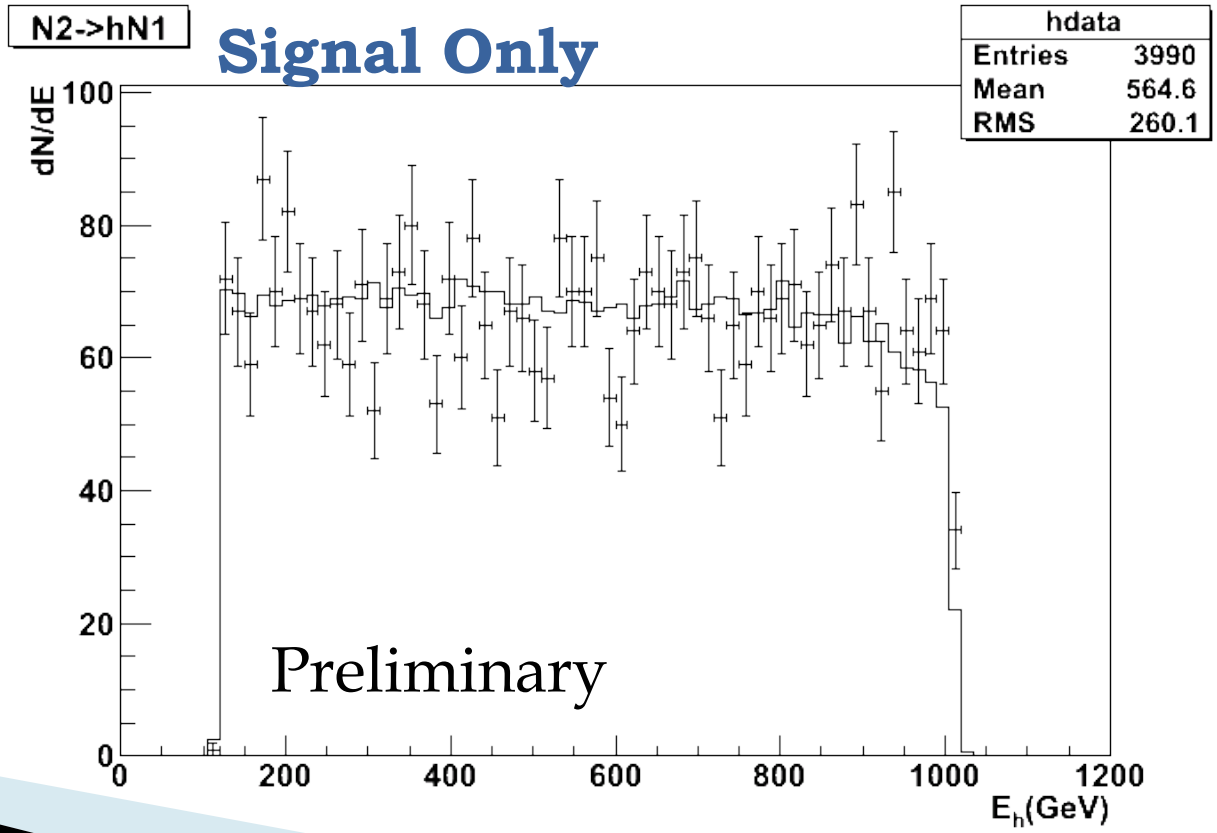
M X^0_1 = 341.797 GeV
+/-0.448976 (stat) +/- 0.50 (syst) GeV



h Energy Fit at 3 TeV

h_0 Energy fit (2 ab^{-1})

		ISR NoBS	ISR BS	Reco Evt Selc. No E Res	Reco Evt Selc. w/E Res
	Mass (Gev)	Error (GeV)	Error (GeV)	Error (GeV)	Error (GeV)
χ^0_2	643.1	+/-0.83	+/-4.17	+/-5.45	+/-8.64



Combined Energy Fit for mX^0_2 and m ν to h Energy Spectrum

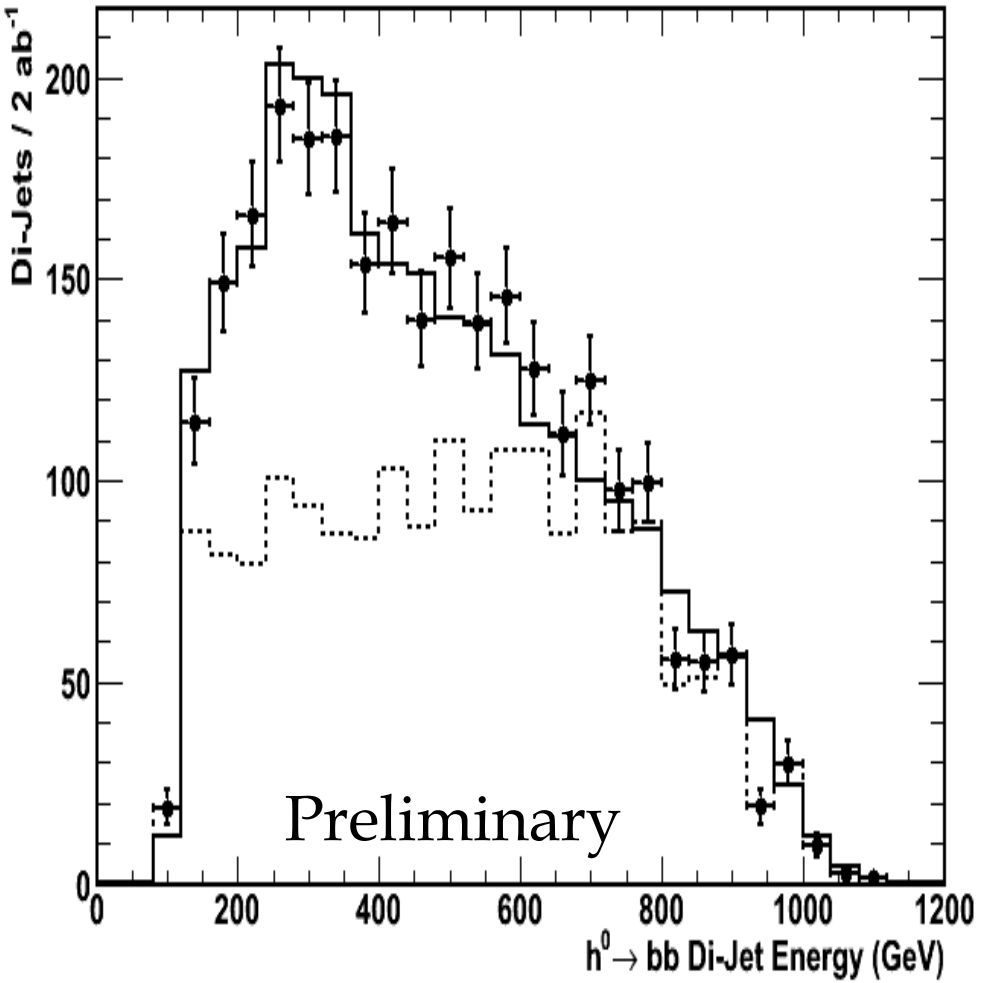
- In Scenario 1
- At Generator Level

  mX^0_2 = 639.91 +/-4.58 GeV

  m ν = 1097.35+/-55.88GeV
- With Full Simulation & Reconstruction

  mX^0_2 = 619.53 +/-12.85 GeV

  m ν = 1097.58+/-69.67GeV



Conclusions

Using Threshold Scan to determine masses

Can obtain accuracy on mass determination 0.5 per mil to 1 permil for good fits $X^{+/-}_1$ & $X^{+/-}_2$

To determine the N2 mass there seems to be no great benefit to using the threshold scan over the h energy fit.

Further Work needs to be done on full simulation and reconstruction including width sensitivity studies & SM bkg.

Thank You !