NMSSM STUDY

AT

LHC

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Outline

- Introduction
- Why SUSY ?
- MSSM
- NMSSM
- Work done
- Preliminary Results

Introduction

- V-A theory of weak interactions worked well, when used at the lowest order.
- The theory broke completely at the energy scale of 300 Gev due to **radiative corrections**
- Intermediate vector boson model alleviated this ailment but did n't cure it fully.
- Weinberg and Glashow employed the **spontaneous symmetry breaking** to generate the fermionic bosonic masses.

Contd.

- The standard model is the gauge theory based on total gauge symmetry of of particle interactions:
  $SU(3)_C \times SU(2)_L \times U(1)_Y$

- The higgs part of the Lagrangian is :

$$L_{SBS} = (D_\mu \phi)^\uparrow (D^\mu \phi) - V(\phi)$$

$$V(\phi) = -\mu^2 \phi \phi^\uparrow + \lambda (\phi^\uparrow \phi)^2 \;\; ; \lambda > 0$$

  Here ϕ is a fundamental complex doublet with hypercharge equal to 1 and $V(\phi)$ is the simplest renormalisable potential. D^μ is the covariant derivative.

- The scalar field ϕ serves to break the $SU(2)_L \times U(1)_Y \quad - - - > U(1)_e m$

- The minus sign in potential is essential for the SSB to operate.

- The vacuum expectation value of ϕ sets the scale for all the masses in the theory.

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- 't Hooft showed that such a theory does not spoil the renormalizability of massless theory.
- Electroweak experiments confirmed the calculated electroweak predictions and even the predicted mass of *top quark* .
- Noble prize

but the story does not end here! Some questions remain !!!

Why SUSY ??

- The four boson self interaction term generate at the one loop order , a contribution to scalar mass which is proportional to Λ^2. Here Λ represents the scale at which the new physics appears. Generally it is taken to be around Plank mass.
- This leads to corrections to Higgs mass, which are vastly greater than the electroweak scale. This problem can be tried with the fine tuning of the parameter but that will affect all the masses in the theory.
- Such a problem is not seen in the QED because the fermion(boson) masses are protected by the chiral (Gauge) symmetry.So it is an ailment unique to the theories having explicit presence of scalar fields.

contd.

- We now cook up a symmetry to contain the corrections (δm^2) for a scalar particle appearing in lagrangian.
- The large correction from the one loop self energy diagram is cancelled by contribution from the fermion loop correction. This becomes possible due to the equality of four bososn coupling constant and suqare of a boson fermion one. This is a characteristic of SUSY.
- Such A symmetry gives protection to scalar masses from quadratic divergences by virtue of being related by symmetry to the fermion masses which in turn are protected by the chiral symmetry.

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- SUSY stabilize the hirearchy ($M_{H,W} << \ M_P$) i.e the radiative corrections do not drag Higgs mass to Plank scale.
- The MSSM in stark contrast with SM ,has two Higgs doublets and it predicts that lightest Higgs should be no heavier than about 140 GeV.
- The convergence of Gauge couplings at high Q^2 occur more convincingly in MSSM, thus encouraging the ideas of unification.
- The mass parameters are mass dependent. In MSSM the evolution of Higgs mass parameter from a typical positve value (v^2) at Plank scale, takes it to a negative value of correct magnitude at the scales of order 100 GeV,thus providing a explanation for the origin of the EWSB.

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- SUSY transformations do not act on the SU(3), SU(2), U(1) degrees of freedom. So each if we have SU(2) doublet then we need to partner it with spin-0 boson doublet.
- The standard model higgs doublet or it's charge cojugate doublet can not be candidates for this partnership since do not carry lepton number
- So we need new particles to be partners: selectrons and sneutrino
- Similarly we have smuon,stau, and respectine sneutrinos. These all are SU(2) doublets and are in chiral multiplets.
- Similarly we have scalar color triplets to act as the partners for quarks. Call them squarks.

contd..

- Also we have a vector supermultiplet associating a massless $(fermion)_L$ generically called gaugino with massless vector fields.(color octet of gluinos, and after symmetry breaking - Winos and Zino and photino.)
- The supersymmetric SM need two Higgs doublets resulting in five physical states ususally referred to ad $H^+,\ H^-,\ h,\ H\ and\ A$ and we have coressponding Higgsinos.
  BUT IS THIS ENOUGH??
- The LEP limits on the Higgs Mass has pushed MSSM into a region of parameter space characterised by very high fine tuning, lack of electroweak baryogenisis without very high fine tuning ....
- At more fundamental level a satisfactory explanation of so calledμ term remain elusive in MSSM

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- We add just one extra singlet superfield, with the super potential $\lambda S H_u H_d$.
- The μ term is replaced by the trilinear terms

$$\lambda H_1 H_2 S \quad + \frac{\kappa}{3} S^3$$

- The only superpotential terms that are introduced have dimensionless couplings, the scale of VEVs is determined by the scale SUSY breaking.
- It can have minimum fine tuning.
- The extra singlet superfield of NMSSM contain 1)Extra neutral gaugino 2)An extra CP even Higgs boson and an extra CP -odd Higgs Boson.

contd..

- As compared to three independent parameters needed for MSSM (μ, $tan\beta$ and M_A),

the Higgs sector of NMSSM is described by six parameters

$$\mu_{eff},\ tan\beta, A_\lambda, A_\kappa, \lambda, \kappa$$

- In addition, the values for gaugino masses and some more parameters must be input. Due to a large parameter space NMSSM is much less constrained than MSSM, and is not neccessarily forced into the ackward fine tuning.

Work started

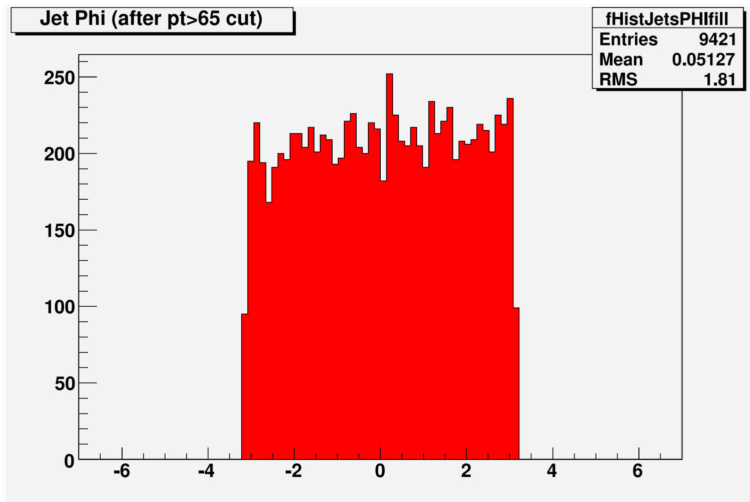
- The most favorite discovery mode is :

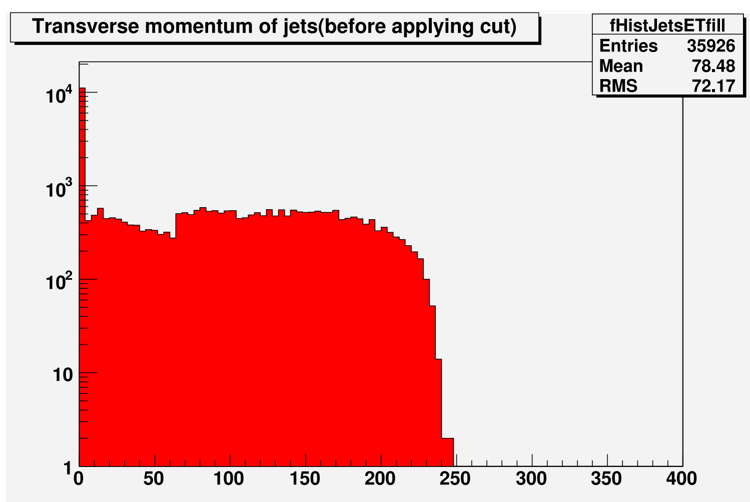
$$H_1 - - > A_1 A_2 - - > 4\tau(Why??)$$

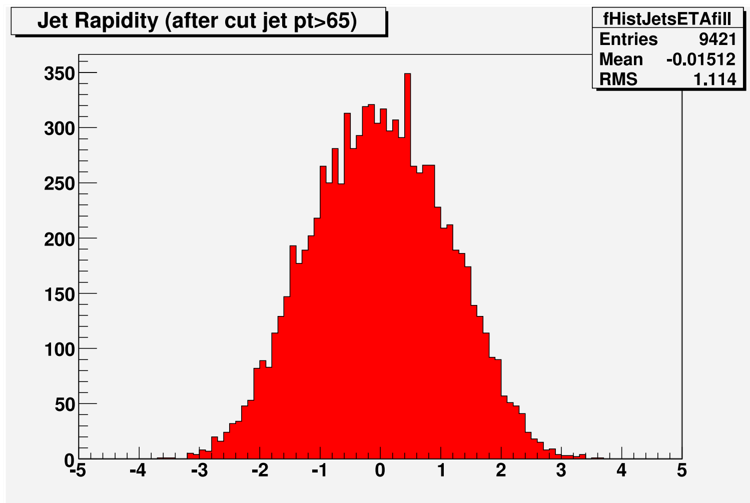
- $Zh_1 and Wh_1$ production seem to be most favorite modes (hep-ph/0401228, hep-ph/0603085 etc.)
- We started with hitherito unexplored mode $gg - - > H_1$
- Final state : μ^+, μ^-, 2jets,large MET
- Purpose was to see
  - if locally installed CMSSW framork worked well.
  - to get a feel of the event generation,detector simulation, and analysis chain using CMSSW framework.
- The parameters were taken : $tan\beta = 20$, $M_A = 500$
- So far, Event generation and detector

simulation has been completed and generator level analysis performed.

Preliminary plots



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RMS 1.114
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200
150
100
50
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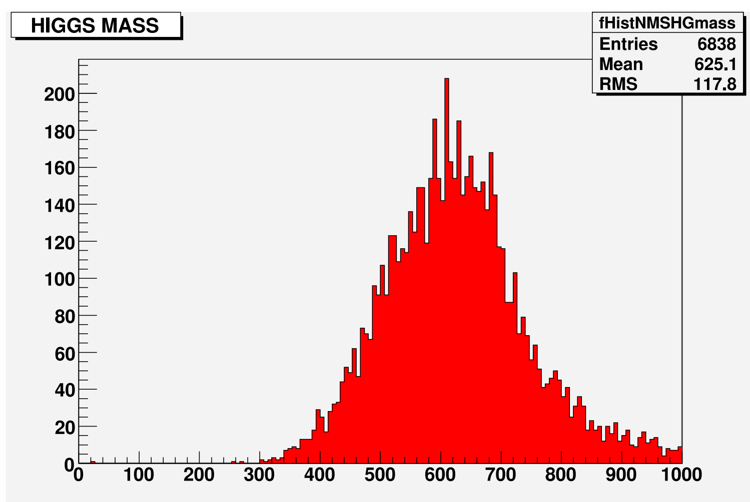
-3
-2
-1
0
1
2
3
4
5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RMS 117.8
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120
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0
100
200
300
400
500
600
700
800
900
1000