

# R-Parity Violating SUSY

Vasia, Emma

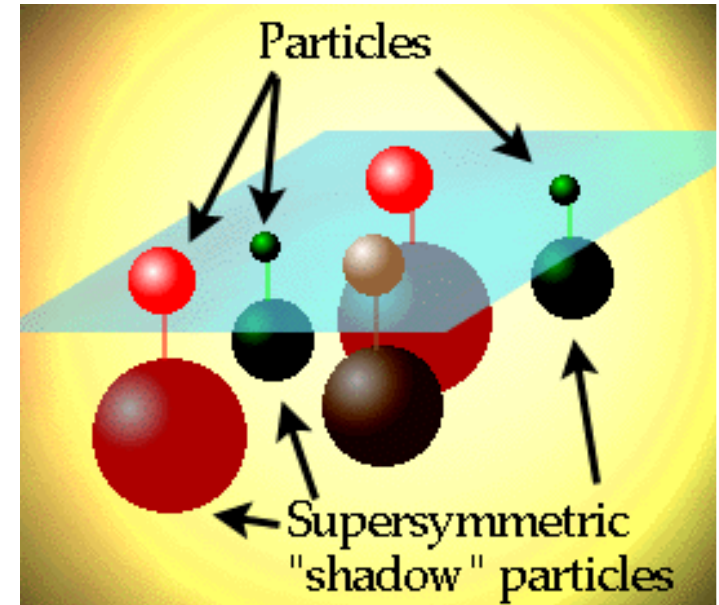
30-11-07

# Motivation for SUSY

- Avoids Fine-tuning
- Grand Unification ew+strong interactions
- Provides a candidate to DM (if RPC)
- Explains neutrino mixing
  - RPV

# Supersymmetry...

- Supersymmetry = fermion-boson symmetry:  
all SM particles have SUSY-partners
- SUSY-partners of quarks and leptons are squarks and sleptons, with spin=0
- SUSY-partners of gauge particles ( $\gamma$ , W, Z, gluon, graviton) are "photinos, winos, zinos, gluinos, gravitinos" with spin=1/2 (3/2)
- LHC: very good chances to observe squarks, gluinos, supersymmetric Higgs, ...



**SUSY breaking!!**

# R-parity

- **Constructing a theory....**

- Renormalizable
- Conserving Symmetries of the system

Lorentz Invariant  
Gauge invariant  
⋮

- $L_{MSSM}$ : no ~~L~~, no ~~B~~  $\rightarrow$  RPC  $\rightarrow$  implies LSP stable

no em charge  
no strong int  
undetactable;  $2 E_{miss}$

- Defined as:

$$R = (-1)^{3B + L + 2S}$$

$$R = \begin{cases} +1 & \text{for SM particles} \\ -1 & \text{for superpartners} \end{cases}$$

- B, L violating terms

L-number violating terms

$$W_{RP} = \underbrace{\sum_{ijk} \hat{L}_i \hat{L}_j \hat{E}_k^C + \sum_{ijk}^0 \hat{L}_i \hat{Q}_j \hat{D}_k^C + \sum_i^2 \hat{L}_i \hat{H}_u}_{\text{L-number violating terms}} + \underbrace{\sum_{ijk}^{\infty} \hat{U}_i^C \hat{D}_j^C \hat{D}_k^C}_{\text{B-number violating term}}$$

bilinear terms

# $R$ -parity violation

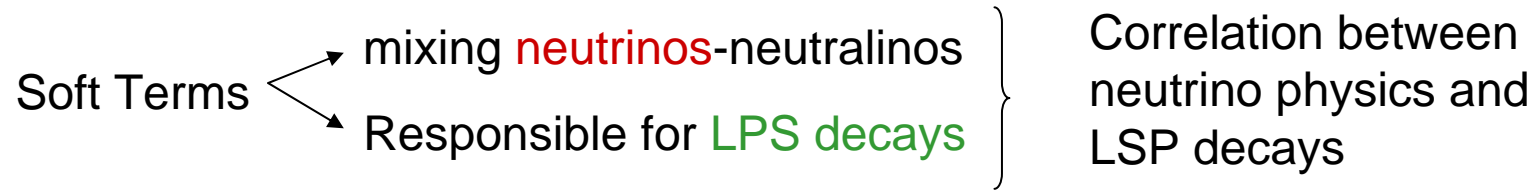
- RPV through bilinear terms ( $\epsilon_i \neq 0$ ) in the super-potential and the SUSY-breaking potential: [c.f. M. Hirsch et al., JHEP 0503 (2005) 062 and references therein]

$$W = W_{\text{MSSM}} + \sum_i \epsilon_i \hat{L}_i \hat{H}_u$$

$$V_{\text{soft}} = V_{\text{soft}}^{\text{MSSM}} + \sum_i B_i \epsilon_i \hat{L}_i \hat{H}_u$$

- $R$ -parity violation  $\rightarrow$ 
  - Single sparticle production *is* allowed
  - LSP is not stable!
  - No missing energy (if LSP decays in the detector)!
  - LSP may be charged (e.g. stau, sleptons)

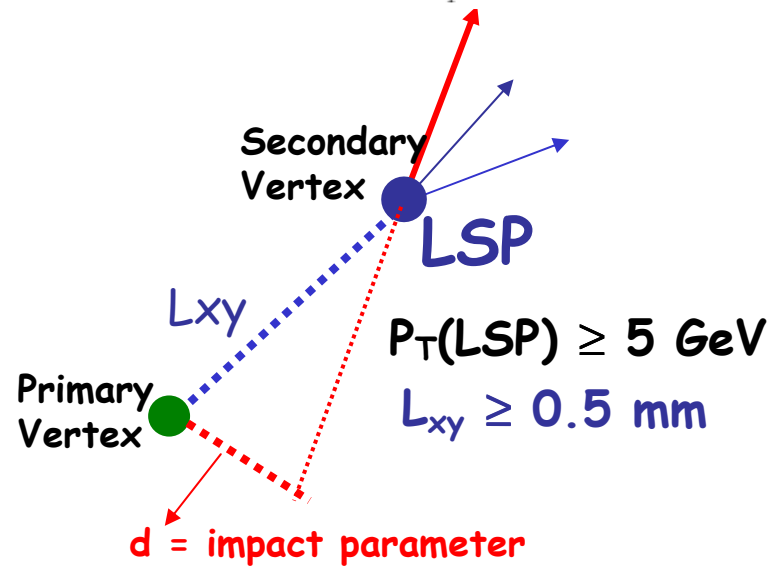
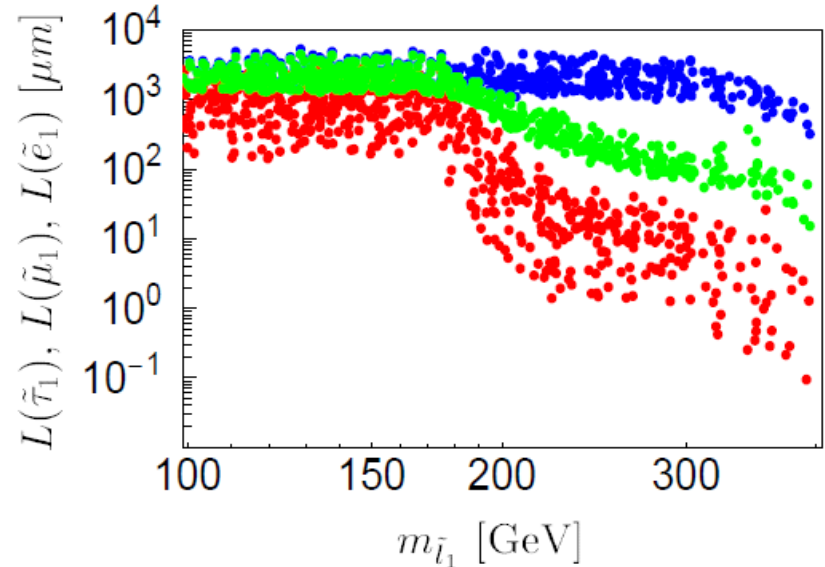
# R-parity violation



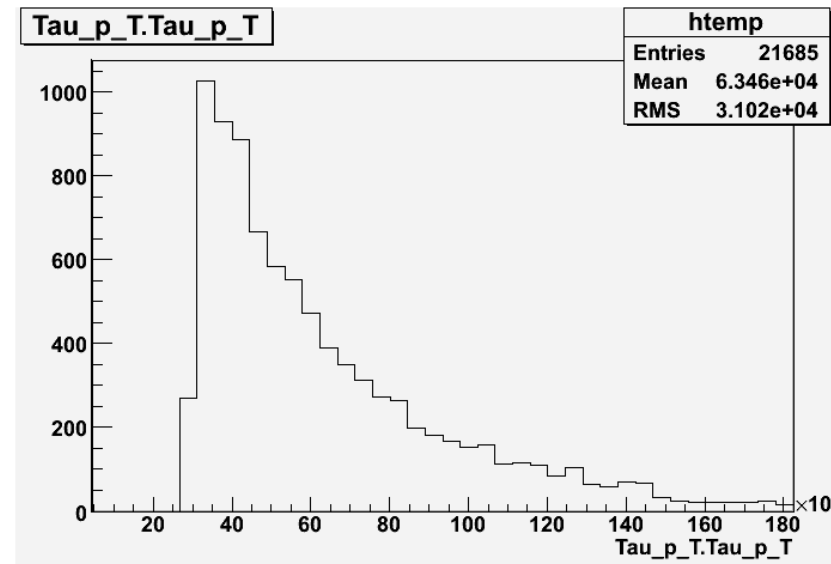
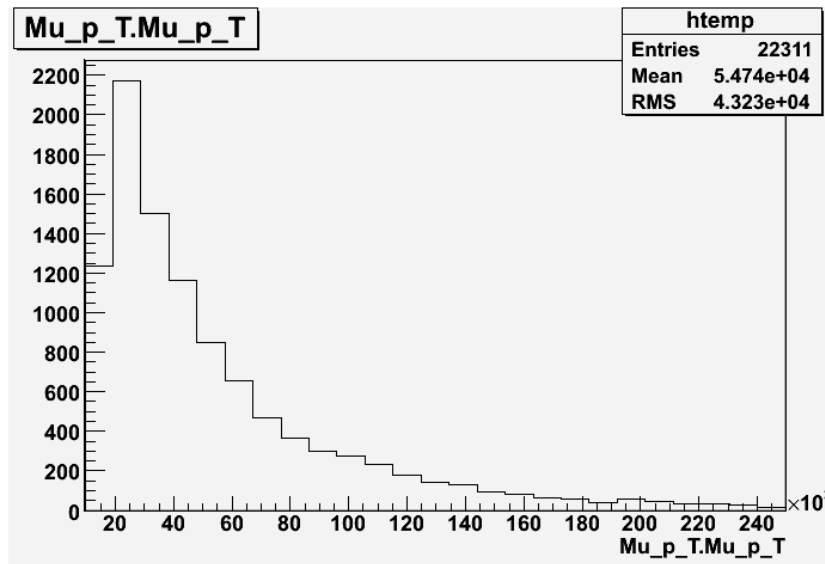
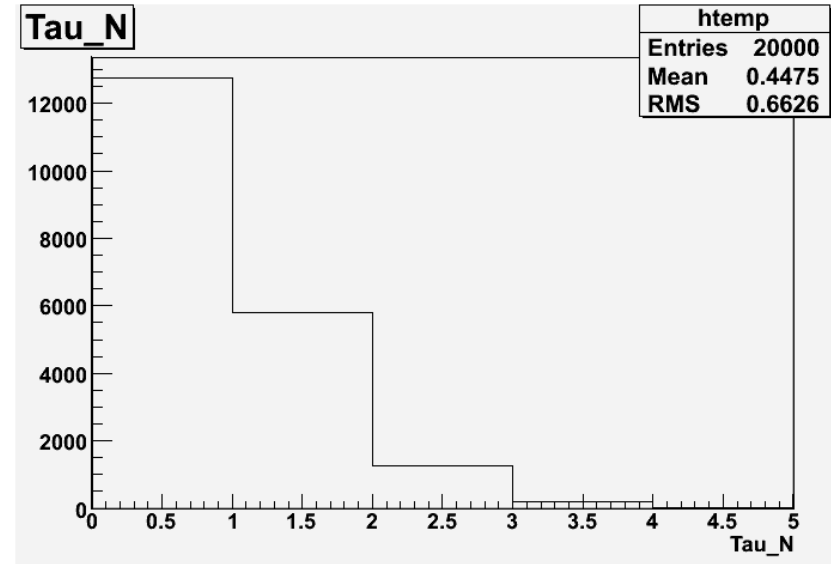
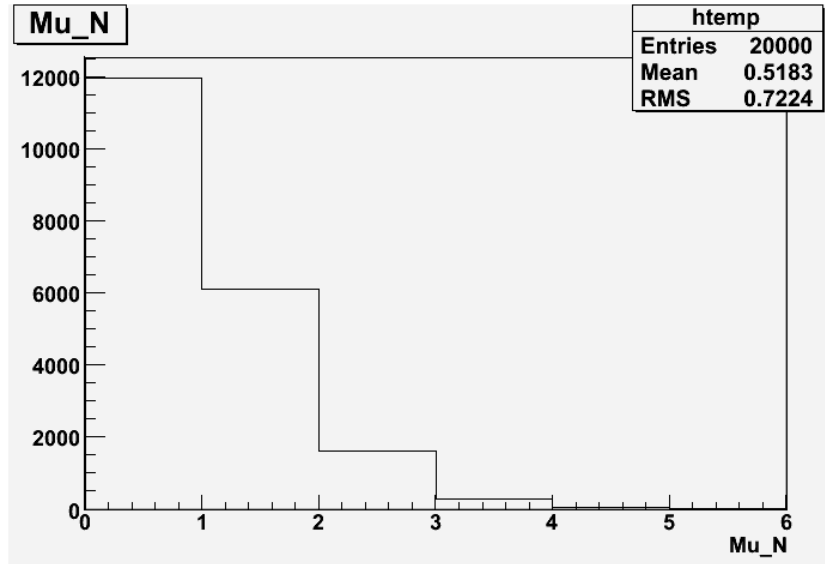
$$\tan^2 \mu_{\text{atm}} \sim \frac{\text{BR}(\hat{A}_1^0 \rightarrow \nu \chi \chi^0)}{\text{BR}(\hat{A}_1^0 \rightarrow \bar{\nu} \chi \chi^0)}$$

# Analysis strategy

- Choose RPV parameters fulfilling the requirements from neutrino physics:  $\Delta m_{\text{atm}}^2$ ,  $\Delta m_{\text{sol}}^2$ ,  $\tan 2\theta_{\text{atm}}$ ,  $\tan 2\theta_{\text{sol}}$
- In a wide range of parameters the LSP decay is visible ( $c\tau \sim \text{mm}$ )
- Fast simulation (signal production; ATLFAST bgd samples exist)
  - AOD to DPD (SUSYView)
  - Inclusive analysis at selected RPV point
  - RPV parameters scan  $\boxtimes$
  - Isolate LSP decays
- Full simulation
  - Use vertex reconstruction to identify LSP decays  $\boxtimes$
  - Estimate sensitivity on neutrino mixing parameters

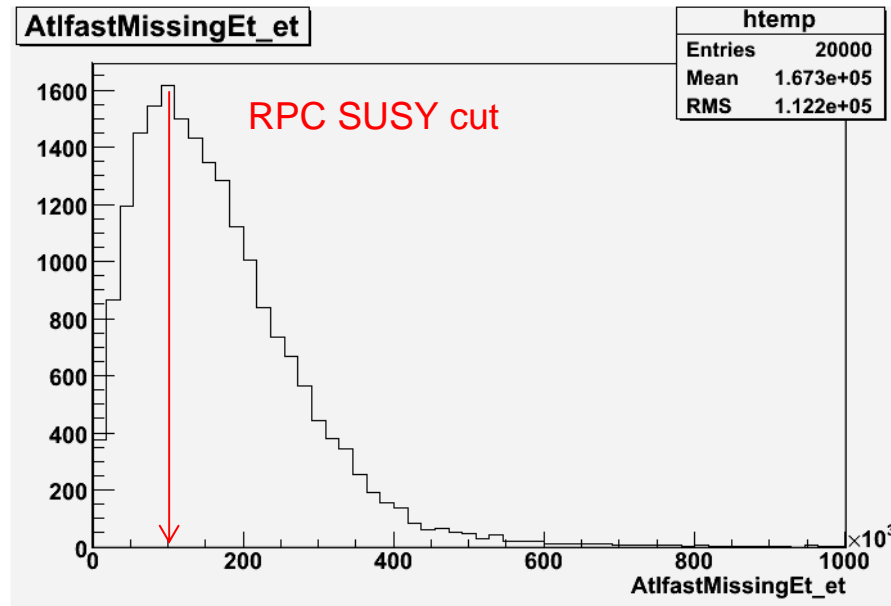


# Signal: muons and taus

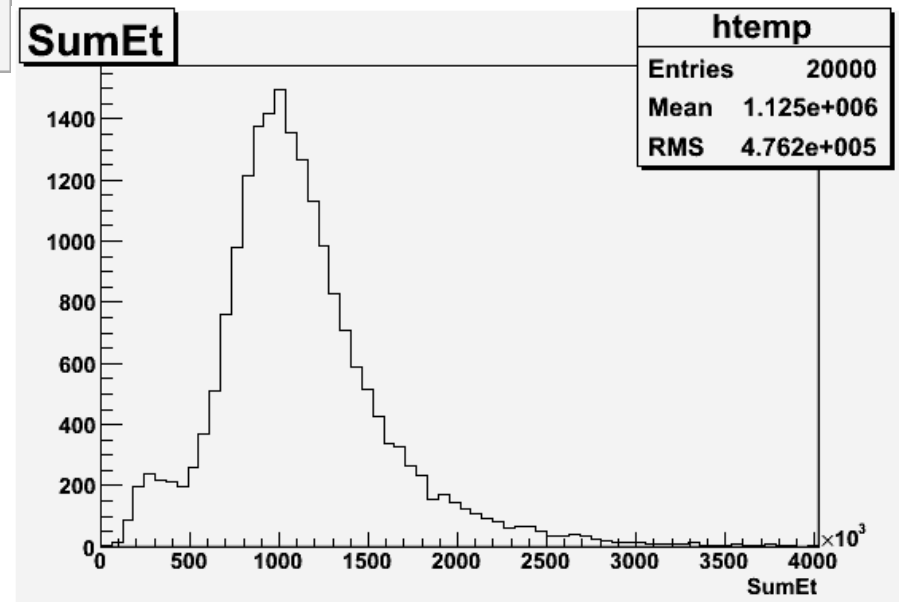




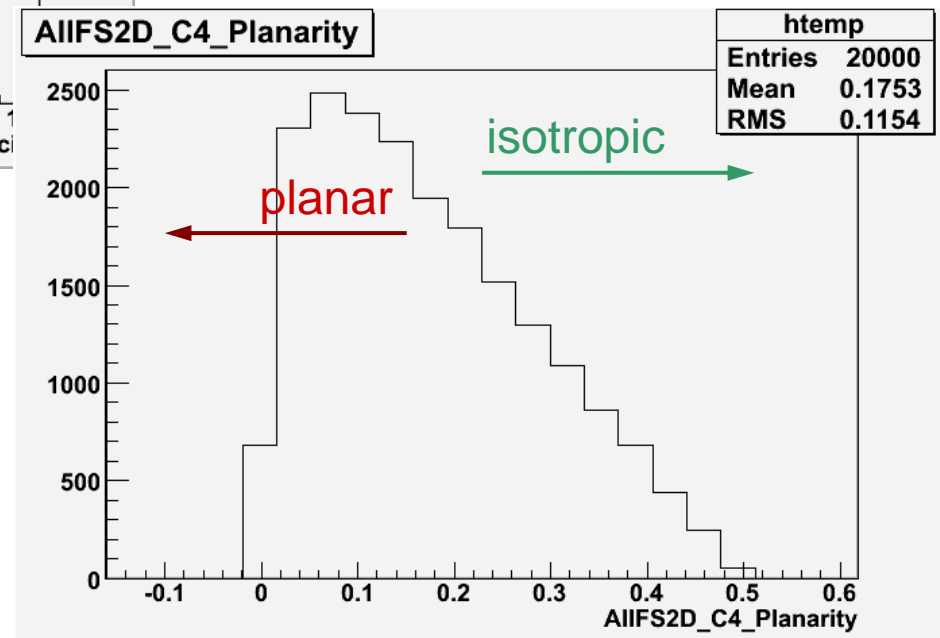
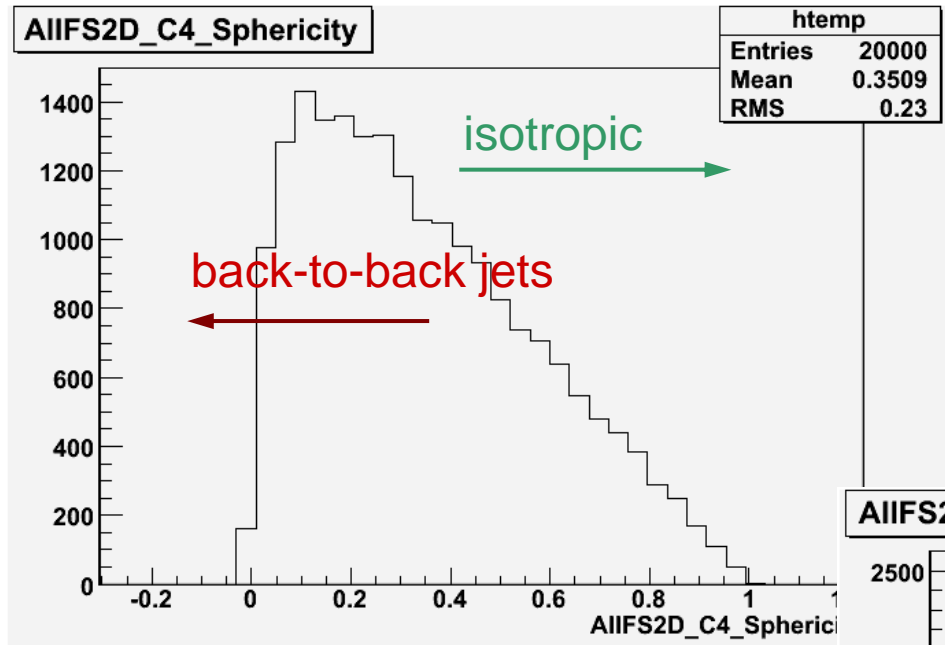
# Signal: missing $E_T$ and SumEt



- $E_{T}^{\text{miss}}$  considerably lower than  $R_p$  conserving SUSY
- SumEt comparable to RPC SUSY




# Event shape



Event shape distributions similar to those for  $R_p$  conserving SUSY

# Analysis

- Background:
  - QCD jets
  - W+jets
  - Z+jets
  - tt(bar)
  - ZZ / WZ / WW



Samples available by SUSY WG  
ATLFAST production task force

# Next steps

- Produce AAN for bgd (QCD,  $t\bar{t}$ , W+jets, Z+jets)
  - Define analysis cuts for these parameters
  - Other RPV/SUGRA points?
  - Triggering?
- 
- Full simulation study
  - Use secondary vertex reconstruction
  - What about other RPV models
    - E.g. trilinear RPV
    - Is the analysis relevant for them?
    - How do we discriminate them?
    - Especially those providing dark matter candidate (e.g. long-lived gravitino as LSP)

# Full Simulation Study

- Generation of 10000 RPV MSSM events ✓
- Simulation + Digitization: ~ 20 min/event  
10000 events ~ 4 months!!  
necessary to use the grid  
split the input file in 200 jobs of  
50 events each and run in parallel
- Reconstruction
- Analysis