Tools For the LHC: Little Higgs with T-parity

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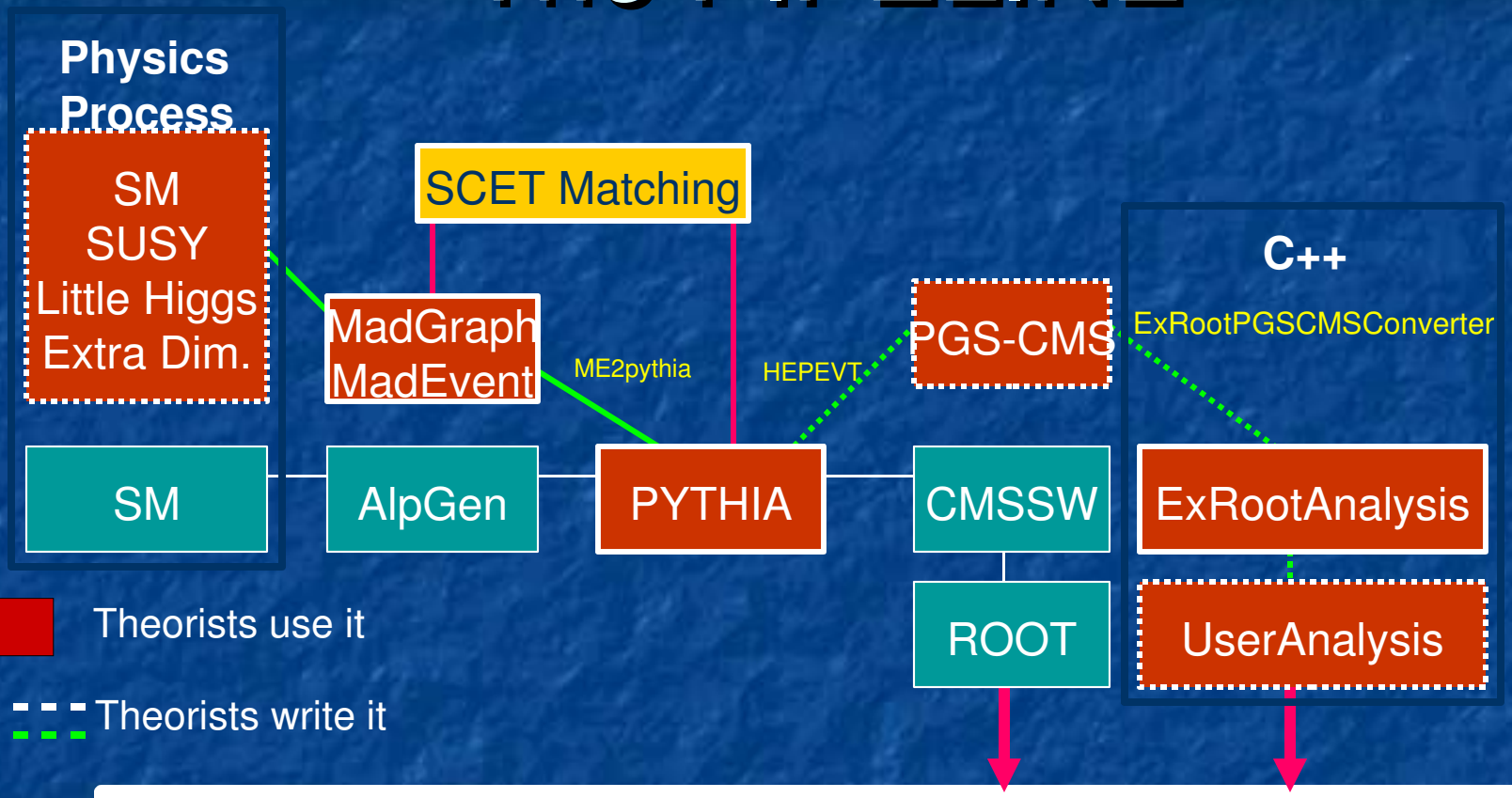
Outline

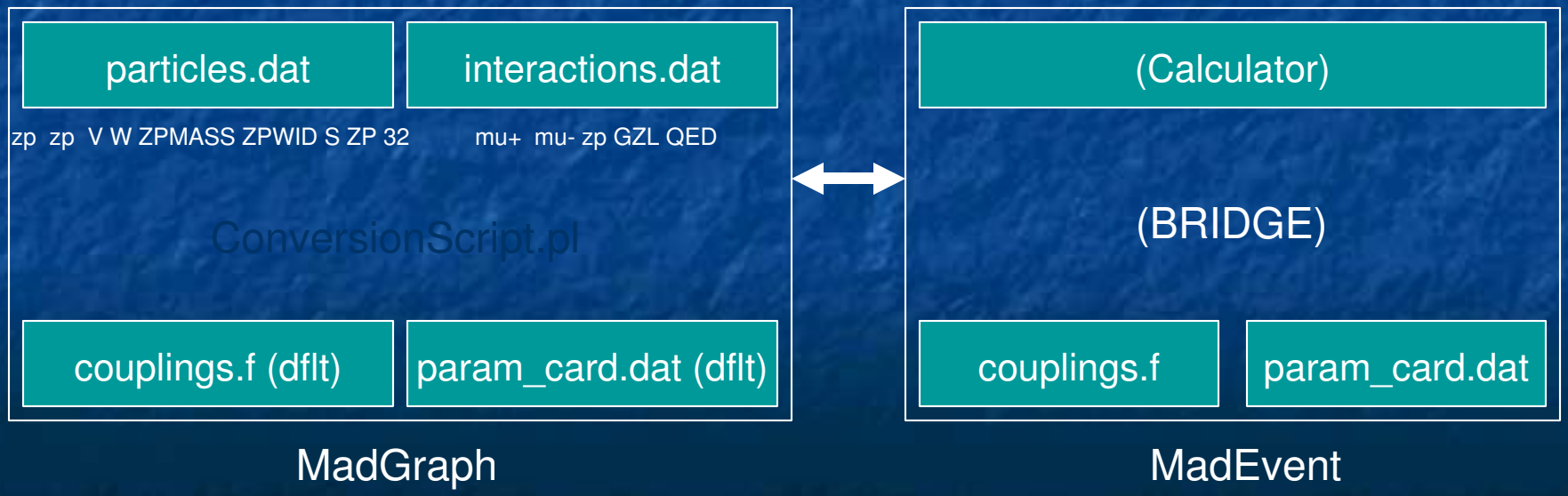
- Goals: Software pipeline from (SM or beyond) physics process to plots
  - Realistic
  - Fast
  - User friendly
- The Pipeline:
  - MadGraph/MadEvent
  - Pythia
  - NEW TOOL: Fast CMS detector simulation (PGS-CMS)
  - ROOT analysis routines (ExRootAnalysis) - plots
- An application:
  - compare first year running inclusive analyses (1 fb^{-1})

The PIPELINE



Beyond the Standard Model in Madgraph

- Simple format for entering in BSM Lagrangian
  - Similar to COMPHEP/CALCHEP
    - particles.dat, interactions.dat, couplings.f, param_card.dat
    - Aided by suite of scripts (usrmod) and BRIDGE
    - Zero to Z' in 5.7 minutes!



What is PGS?

- A Pretty Good Simulation
  - evolved out of ’98 SHW – Run 2 avg. of CDF and DØ
  - renamed PGS at Snowmass 2001
  - used for comparisons: VLHC, LHC, Tevatron
  - especially used by theorists
- How good (compared with full simulation)?
  - For most analyses, within factor of 2
  - Even as good as 20% agreement, for many cases

PGS is NGES

- Not good enough simulation!
  - ideally we have something that is closer to full simulation
    - at least for physics processes we are most interested in
- FAMOS not fast enough
- Tune PGS to work for CMS
  - analog of ATLFast
  - assumption: PGS is not hopeless for main features of central, high p_T signals (like SUSY)
  - **PGS-CMS -** Joe Lykken, Maria Spiropulu

PGS-CMS

- The physics of the CMS detector can be imitated in PGS
  - raw vs. corrected jets
  - add B-field
  - pileup and multiple interactions (via pythia interface)
  - z-vertex
  - …
- What is our reference point?
  - CMS Physics TDR
  - tweak physics parameters to match 3 benchmark SUSY scenarios cut-by-cut
    - helpful to have someone “in the know” to read between the lines in the TDR

PGS-CMS vs PGS

	PGS-CMS	PGS
Raw jets	Yes	No
Corrected jets	Yes	No
B field	Yes	Only track smearing
z-vertex	Yes	No
Realistic muon reconstruction	Yes	No
Realistic tau reconstruction	Yes	Yes
Charged hadron track reconstruction	Yes	No
Realistic cal and track isolation	Yes	No
Brem effects	Partially	No
Realistic triggering?	No	No
Pile-up and multiple interactions	Implement in Pythia	Implement in Pythia

How is it doing?

jetmet selection	PGS-CMS efficiency	diff wrt ORCA
trigger, $MET > 200$ GeV + central jet	54.2%	+0.3%
Njets ≥ 3	72.3%	+0.2%
$\lvert\eta_d\rvert < 1.7$ for leading jet	93.5%	+5.4%
Event Charged Fraction ≥ 0.175	98.6%	+0.7%
angular cuts: $\delta\phi_{\min}$, $\delta\phi_{MET-j2}$, $R1$, $R2$	78.8%	+1.5%
Indirect Lepton Veto	81.5%	-3.8%
$E_T(j1) > 180$ GeV, $E_T(j2) > 110$ GeV	62.8%	-0.2%
$H_T > 500$ GeV	91.9%	-0.9%
Final efficiency for LM1 signal	13.4%	+0.5%

trigger issue

need to model electrons faking raw jets

"Vanilla" PGS gives efficiency that is 30% too high

MadEvent to PYTHIA

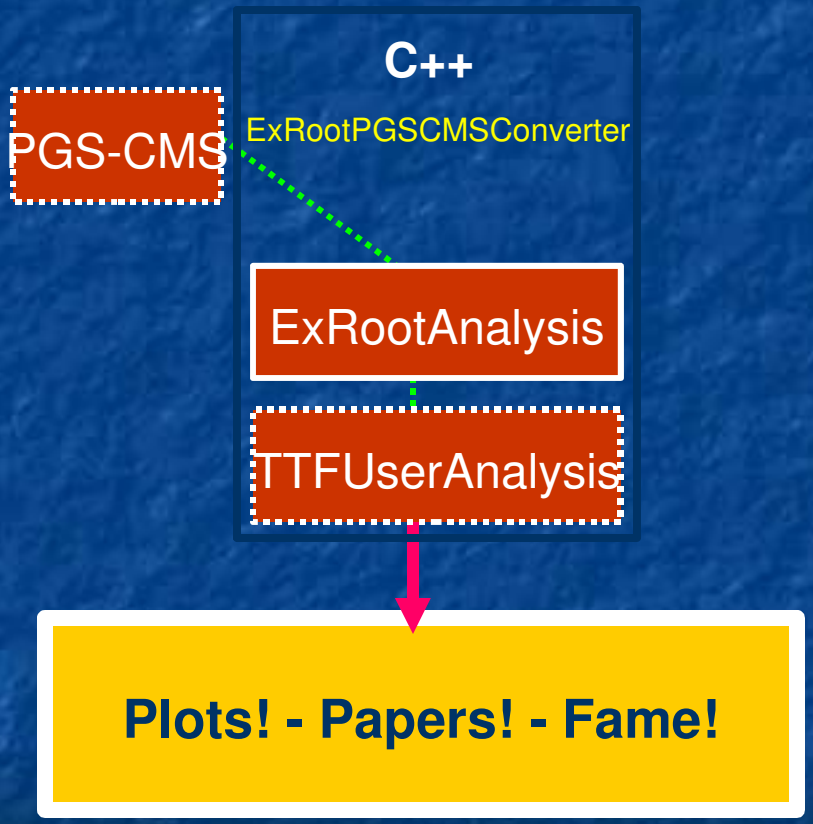
- ME2pythia reads ME output file
  - decays (SM) + parton shower + hadronization
    - could avoid BRIDGE and use PYTHIA QNUMBERS for exotic decays
    - flat phase space approximation - good enough for most purposes
  - output in STDHEP format (.hep file)
  - can add pileup, multiple interactions at this point

PYTHIA to PGS-CMS

- First version of PGS-CMS linked to SUSY generation via pythia
  - useful when tuning to SUSY benchmark studies
- Modified to read PYTHIA (.hep) output into PGSCMS format
  - keep track of number of pileup events

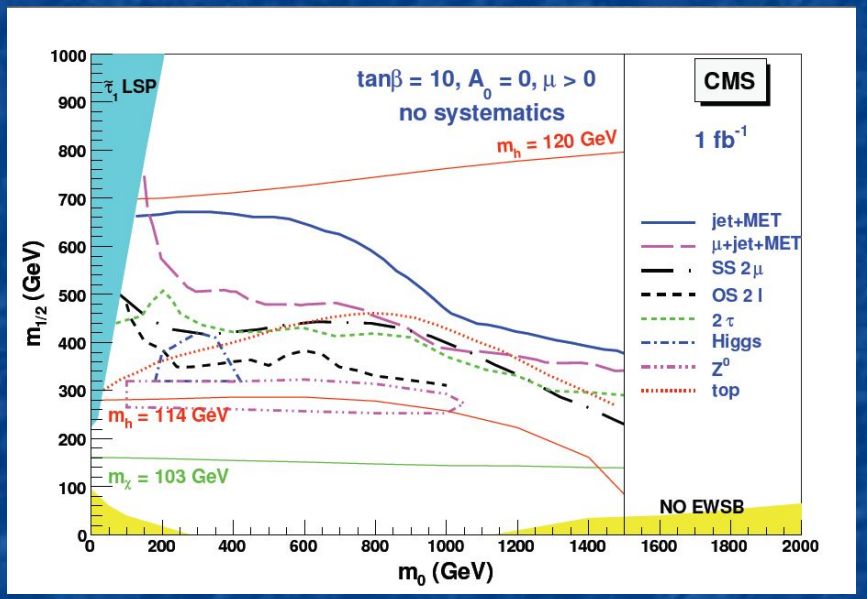
Analysis Tools

- Analysis level cuts
- define interesting functions of object variables
  - Njets, Meff, M_{ll}, M_{jj}
- booking histograms
- Once set up – immediately analyzes output of PGS-CMS and generates whatever plots you asked for



Inclusive Signatures

- Inclusive signatures
- 2008 analyses
- More inclusive → more reach
  - Not restricted to SUSY



First order of business

Joe Lykken, Maria Spiropulu

- What happens in 2008?
  - we go as inclusive as we can go
- SUSY
  - Jet + MET
  - Mu + Jet + MET
  - SS 2 Mu
  - OS 2 leptons
- Backgrounds done!

- Tale of Two Models
  - LM1
    - 600 GeV gluinos
    - 550 GeV squarks
  - NM1
    - 350 GeV gluinos
    - 1200 GeV squarks
- Picked to produce same signal in Jets+MET

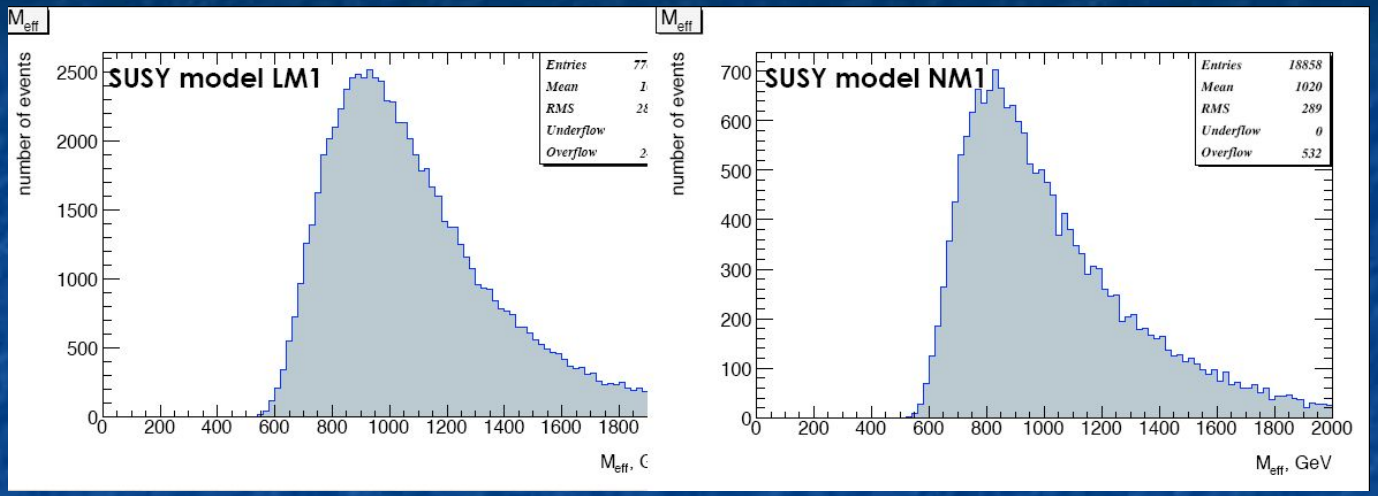
2^{nd}, 3^{rd}, etc orders of business

- NOT SUSY (Little Higgs – UED – more!)
  - Jet +MET
  - Mu+Jet+MET
  - SS 2Mu
  - OS 2 l
- Comparison with SUSY inclusive footprint
  - use same techniques to compare expected signatures with $1fb^{-1}$

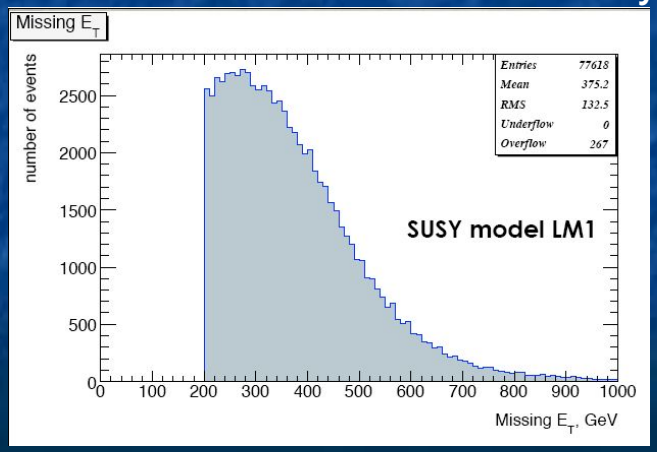
Comparison – Distinction

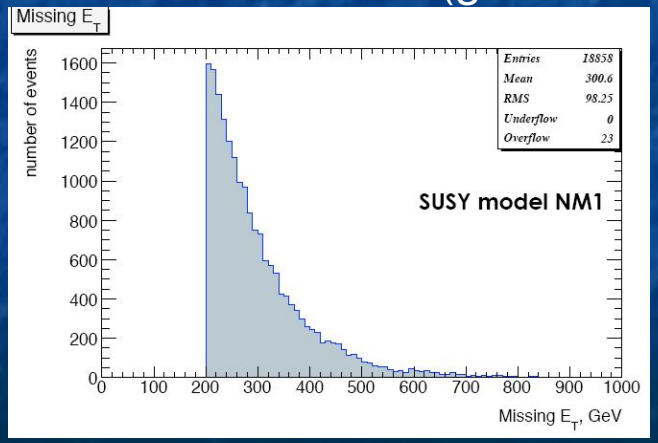
- What non-SUSY models are consistent with a given excess in one of these channels?
- Goal:
  - Match jets+MET for set of non-SUSY BSM theories to that of LM1, NM1, etc and compare various observables
  - Ideally: vary continuously over model parameters keeping jets+MET cross section fixed to scan the inclusive “<your model here> footprint”

Preliminary results



M_{eff} not a very useful observable –
doesn't actually measure SUSY scale (gluino mass)





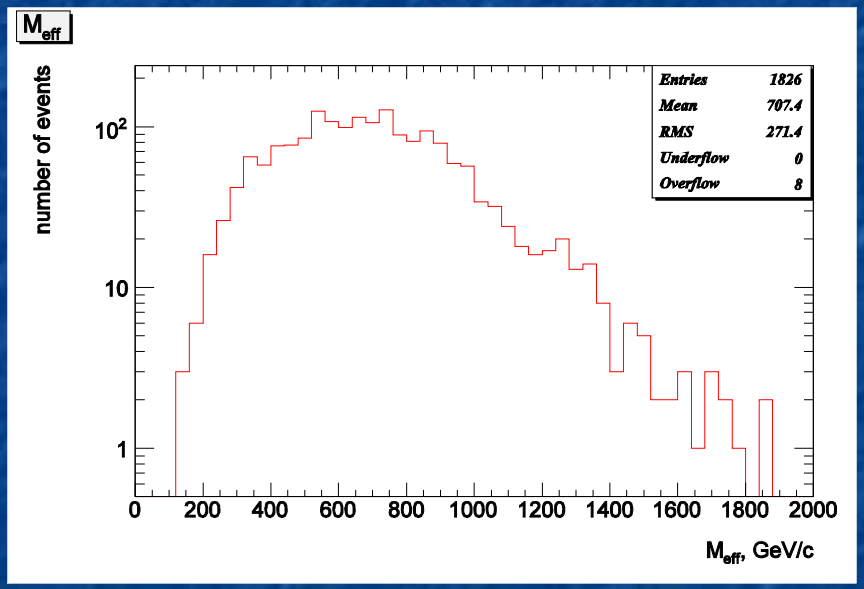
MET above the cut more distinctive

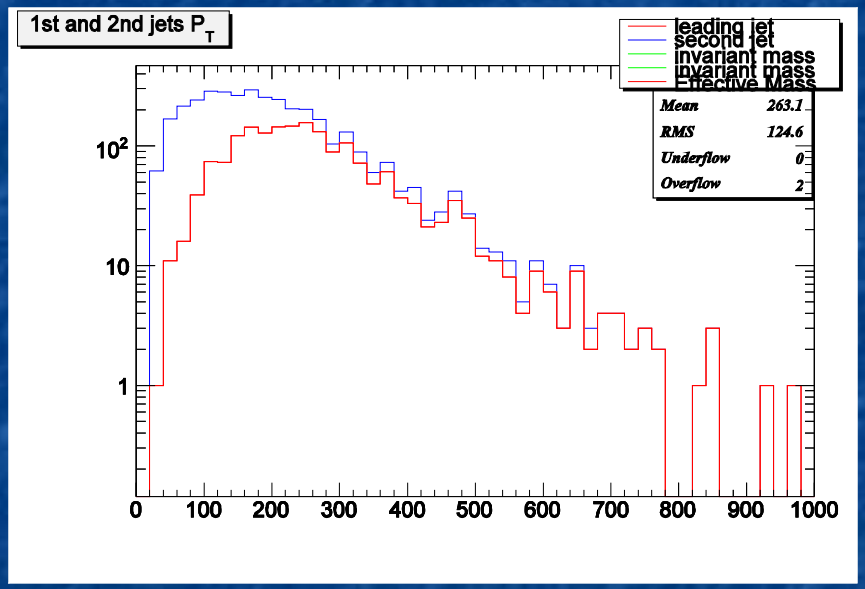
Littlest Higgs with T-parity

- Littlest Higgs with T-parity SU(5)/SO(5)
  - Higgs naturally light due to additional global symmetries (1-loop quadratic divergences in M_{Higgs} cancelled by new partners near 1 TeV)
  - T-parity is to LH as R-parity is to SUSY
    - T-parity alleviates electroweak precision constraints
  - lightest T-odd particle stable if symmetry exact ~ 100-300 GeV B'
    - MET in detector + dark matter

Littlest Higgs Plots

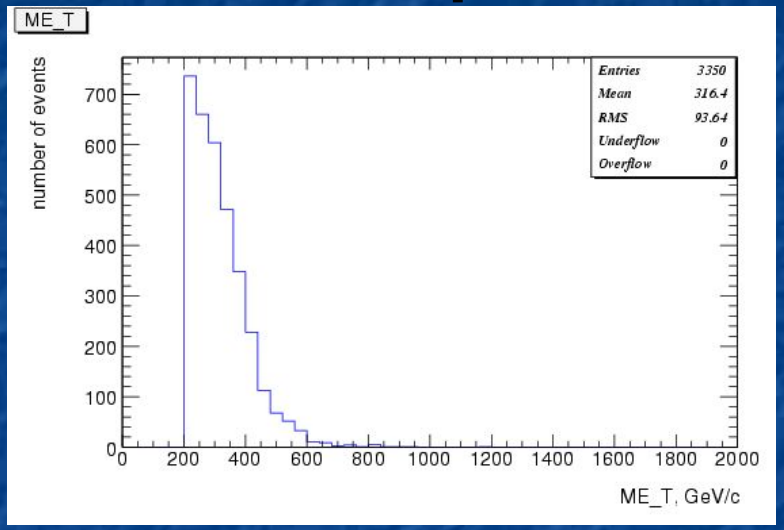
Process: $pp \to Q'\bar{Q}' \to jjB'B'$

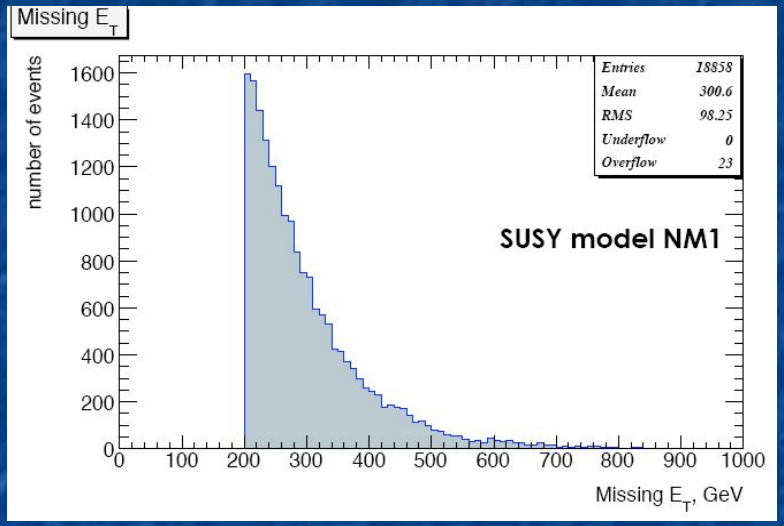




500 GeV T-parity odd Q'

Compare with SUSY NM1





LHT with 500 GeV W',Z'
450 GeV T-odd quarks
120 GeV B'

SUSY with 350 GeV gluinos
1200 GeV squarks
100 GeV neutralino

Future

- Automate scan of LHT footprint
  - calculate overlap (non-intersecting?) with SUSY
- Incorporate T-parity violating interactions
  - Compose new HELAS subroutines in MG
  - Topological effects can break T-parity
    - See Hill[2] paper (and talks) hep-ph/0701044

Conclusions

- We are creating an event generation software pipeline through a version of PGS tuned specifically for the CMS detector
  - Useful for theorists, and even (to some degree) for experimentalists
  - PGS-CMS - prelude to full detector simulation
- We need input and help from the experts!
  - Need to know how PTDR analyses were performed
  - Validation of PGS-CMS against full GEANT based simulation
- Status:
  - PGS-CMS up and running
  - Currently cleaning up MG/MEv4 interface
- Preliminary results in inclusive signature analysis
  - begin probe of SUSY/BSM inclusive signatures with software pipeline

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MG/MEv4

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