High Energy Theory at BNL

Frank E. Paige

BNL theory group is strong in phenomenology and especially collider physics. Well matched to LHC era.

This talk will give group overview and discuss a few physics topics.

Three additional, more detailed talks:

- Hooman Davoudiasl: Warped Extra Dimensions at LHC
- Chris Jackson: Higgsless models
- Amarjit Soni: Lattice physics and summary

Hence I will largely ignore work in these areas.

Group Overview

Group currently has 7 permanent staff, one term staff, and 3 postdocs:

Michael Creutz: lattice gauge theory

Sally Dawson: Higgs phenomenology, higher order QCD (Dept. Chair)

William Kilgore: N^kLO QCD

William Marciano: precision electroweak physics

Frank Paige: Event simulation, ATLAS

Amarjit Soni: lattice, *B* and EW phenomenology (Group Leader)

Larry Trueman: RHIC spin physics

Hooman Davoudiasl: collider phenomenology, model building

Shrihari (Shri) Gopalakrishna

Christopher Jackson

Tadas Krupovnickas

Larry is partially retired. Sally is chairman until the Fall, then will be on sabbatical at SLAC for a year.

Hooman joined group last year, initially replacing a postdoc. Extra money from DOE (thanks!!) allowed us to hire a third postdoc.

Have hired two new postdocs for next year, Christian Sturm (Torino) and Jennifer Kile (Cal Tech), replacing Tadas.

With addition of Hooman and having four postdocs our age distribution is much better than last year. Continued postdoc support is important to group.

Our theory group fits naturally with ATLAS physics. Have started program of occasional joint seminars with ATLAS.

Have also started joint seminar series with Stony Brook — thanks mainly to Hooman and Gilad Perez at Stony Brook (with management support from both sides).

Was tried three decades ago but failed. This time, just “special” seminars of common interest focused on LHC physics. Seems to work much better.

Precision Electroweak Physics (Marciano)

MuCap at PSI has measured singlet muon capture, $\mu^- p \to \nu_\mu n$. Standard Model calculation uses well-determined parameters from n decay plus G_P from chiral perturbation theory:

$$G_P = 8.23 \pm 0.25$$

Leading order result is

$$\begin{aligned} \Gamma_{\text{exp}} &= 725.1 \pm 13.8 \pm 10.8 \text{s}^{-1} \\ \Gamma_{\text{SM}} &= 693(1+R)\,[1 - 0.022(G_P - 8.23)]\,\text{s}^{-1} \end{aligned}$$

New calculation of EW radiative corrections [Czarnecki, Marciano, Sirlin] gives $R = 2.8\%$. Big impact on inferred G_P:

$$G_P = 6.1 \pm 1.1 \quad \Rightarrow \quad G_P = 7.4 \pm 1.1$$

Experiment will improve $\Rightarrow$ sensitive to new physics, e.g., charged Higgs.

Tale of Two Numbers: Combined data on $\sin^2\theta_W$, M_W, M_Z, and M_t consistent with Standard Model. Imply light Higgs, $M_H = 85\,^{+39}_{-28}$ GeV and $S = -0.13 \pm 0.10$, severely constraining new physics.

But two best measurements of $\sin^2\theta_w$, A_{LR} from SLC and A_{FB}^b from LEP, are inconsistent by $\sim 3\sigma$:

$$\begin{array}{lcll} \sin^2\theta_W & = & 0.2307(3) & A_{LR} \\ \sin^2\theta_W & = & 0.2320(3) & A_{FB}^b \end{array}$$

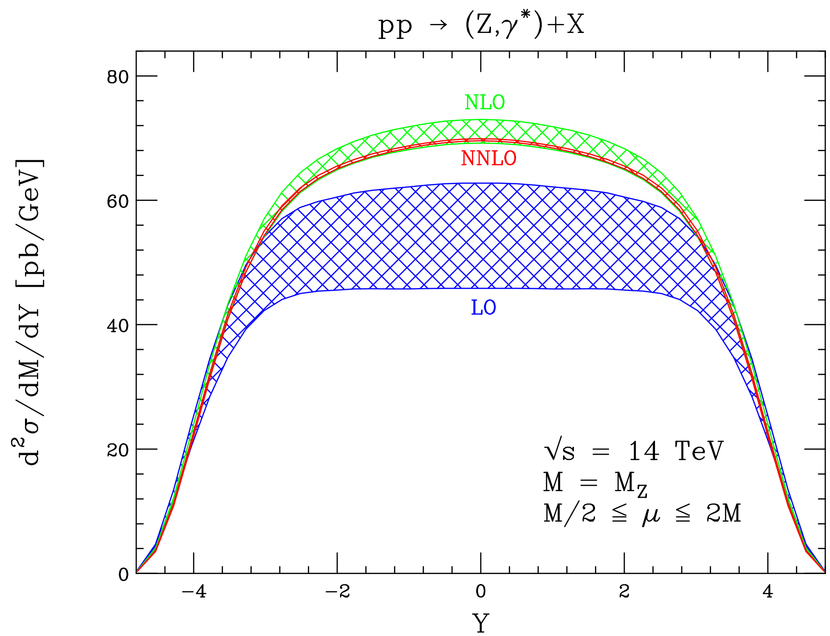
A_{LR} is quite consistent with supersymmetry.

A_{FB}^b value implies $M_H \sim 500\,\mathrm{GeV}$, $S \sim 0.45$, and $T \sim 0.65$. About what is expected in Technicolor models!

Existing data cannot resolve this. LHC?

Precision Calculation of W, Z Production (Kilgore)

Can calculate $d\sigma/dy$ for Z production to NNLO using a clever trick.
Extremely precise [Anastasiou, et al.]:



But acceptance cuts $\Rightarrow$ need full calculation including $Z \to \ell^+\ell^-$.

Very hard: Bill Kilgore has been working on it for more than a year. First results expected soon.

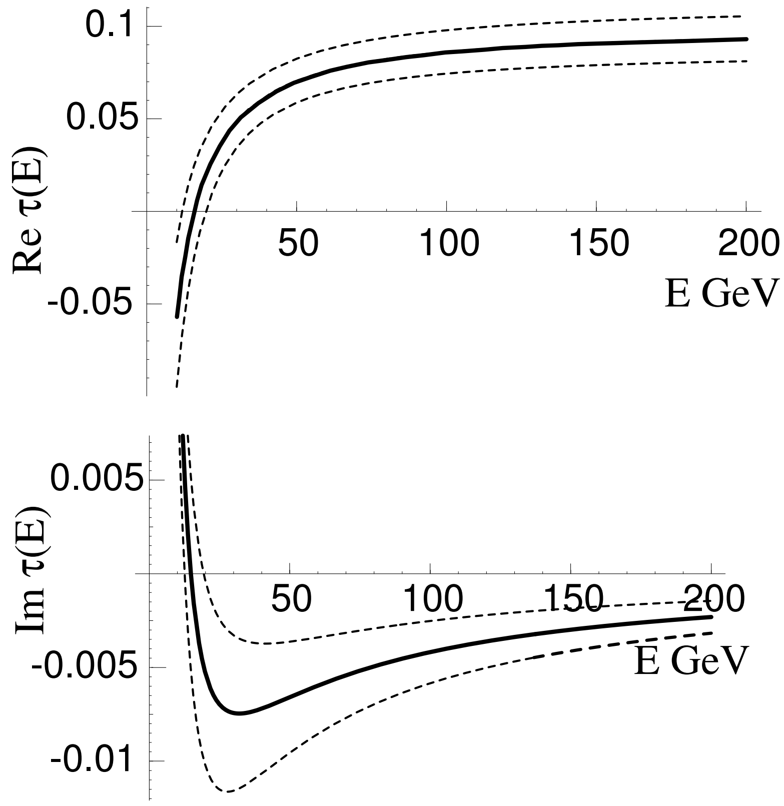
Polarized *pp* Scattering (Trueman)

Interesting both for understanding *pp* dynamics and for measuring polarization at RHIC. Need to understand energy dependence of analyzing power A_N.

Made P, ω, f, ρ, a_2 Regge fit to low-t pp and $\bar{p}p$ data including γ exchange and assuming

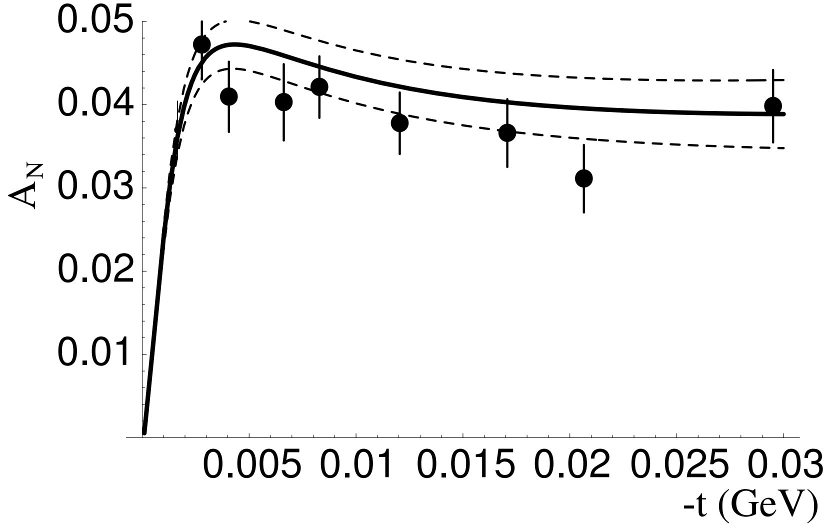
$$\frac{A_{\text{nonflip}}(s,t)}{A_{\text{flip}}(s,t)} = \frac{\sqrt{-t}}{m}\tau(s)$$

Fit uses high-energy A_N data from pC and polarized gas jet.



Compare with new *pp* polarization data at 24 GeV from RHIC.

Data and fit agree to $\sim 10\%$.



Agreement close to 5% goal for RHIC spin program: measure polarized parton distributions, study W and Z production, etc.

KK Gluons at LHC (Krupovnickas)

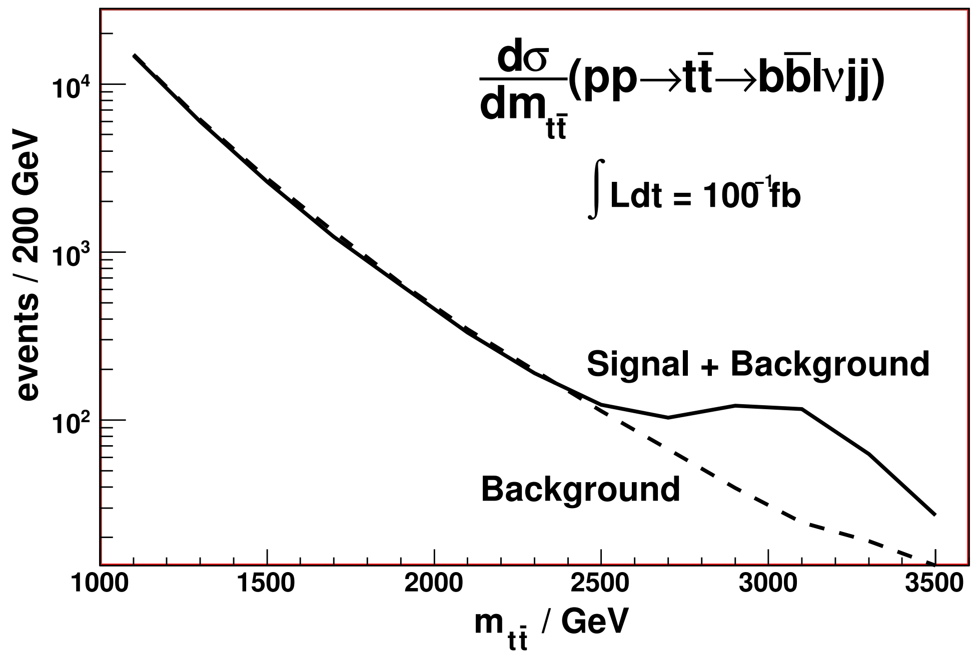
Particle-level (not just parton) study of KK gluon signatures in RS model with fermions and gauge bosons in bulk – c.f. talk by Davoudiasl.

KK gluon is probably best signature: produced by gg and $q\bar{q}$ and decays mainly to $t\bar{t}$. Require e or μ, $\not{E}_T$, and two b tags [hep-ph/0612015].

Reconstruct ν using W and t mass constraints.

Reconstruct hadronic t as "fat" jet. Require $p_{T,t} > 800\,\text{GeV}$.

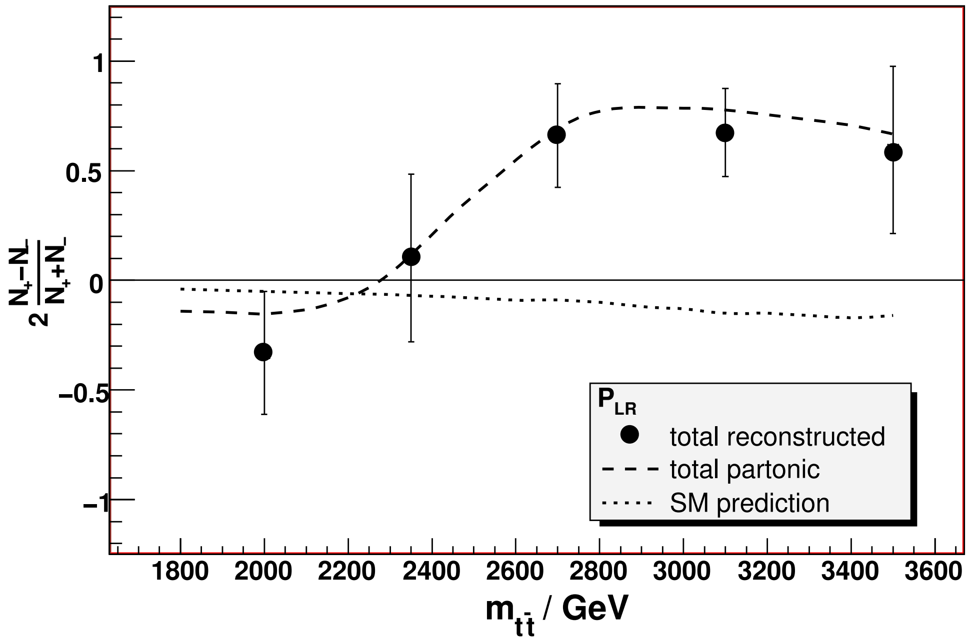
Find $S/\sqrt{B} \approx 11$ for $3\,\text{TeV}$, ≈ 4.2 for $4\,\text{TeV}$.



Coupling to t_R is enhanced in model $\Rightarrow$ polarization, with leptons emitted forward. Use Sherpa to include polarization for both signal and background.

Polarization after boost to top rest frame is observable for 3 TeV KK gluon.

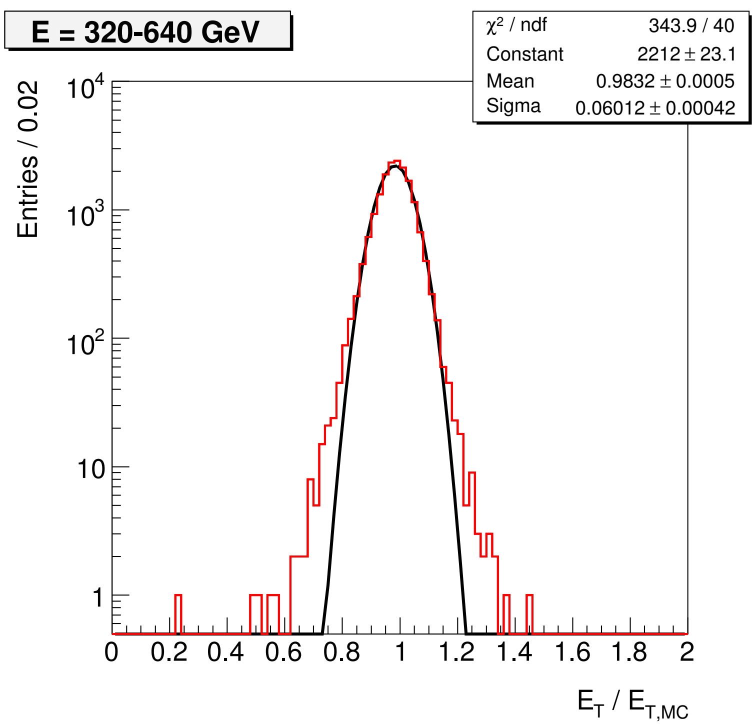
Would be good test of model.

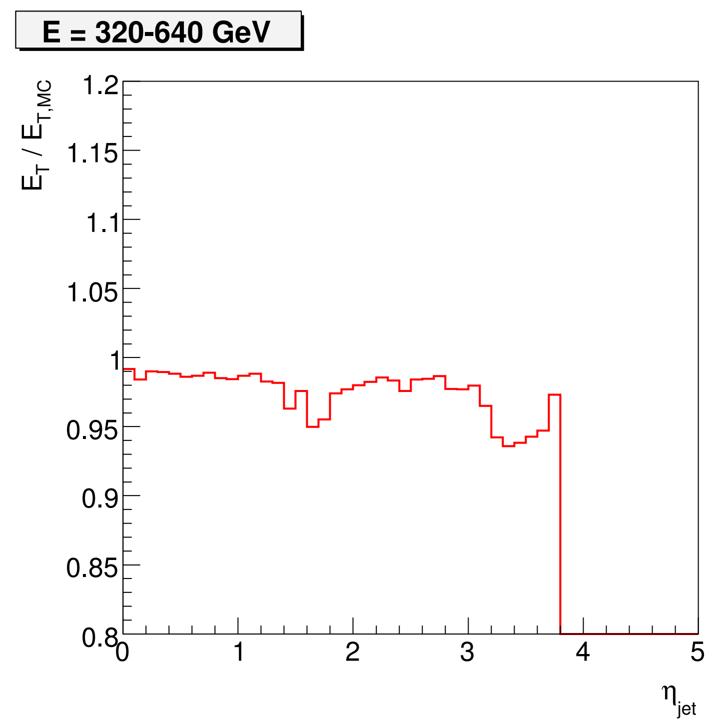


ATLAS (Paige)

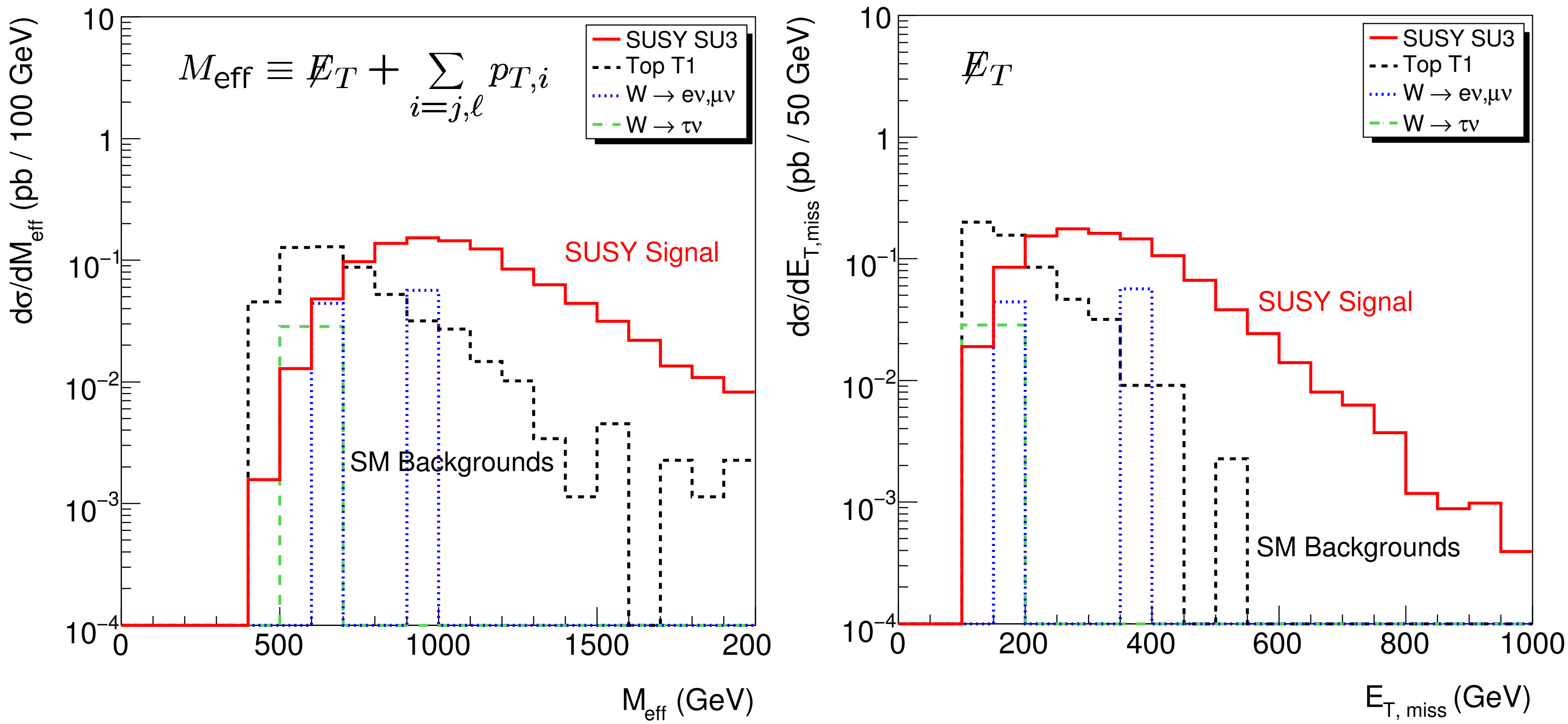
First got involved in ATLAS from event simulation and SUSY searches, but now working on reconstruction. . . .

ATLAS calorimeter optimized for EM response, so $e/h \sim 1.3$. Can correct using fact that EM showers are short and dense. Calibration not yet at 1% but probably adequate for initial physics:



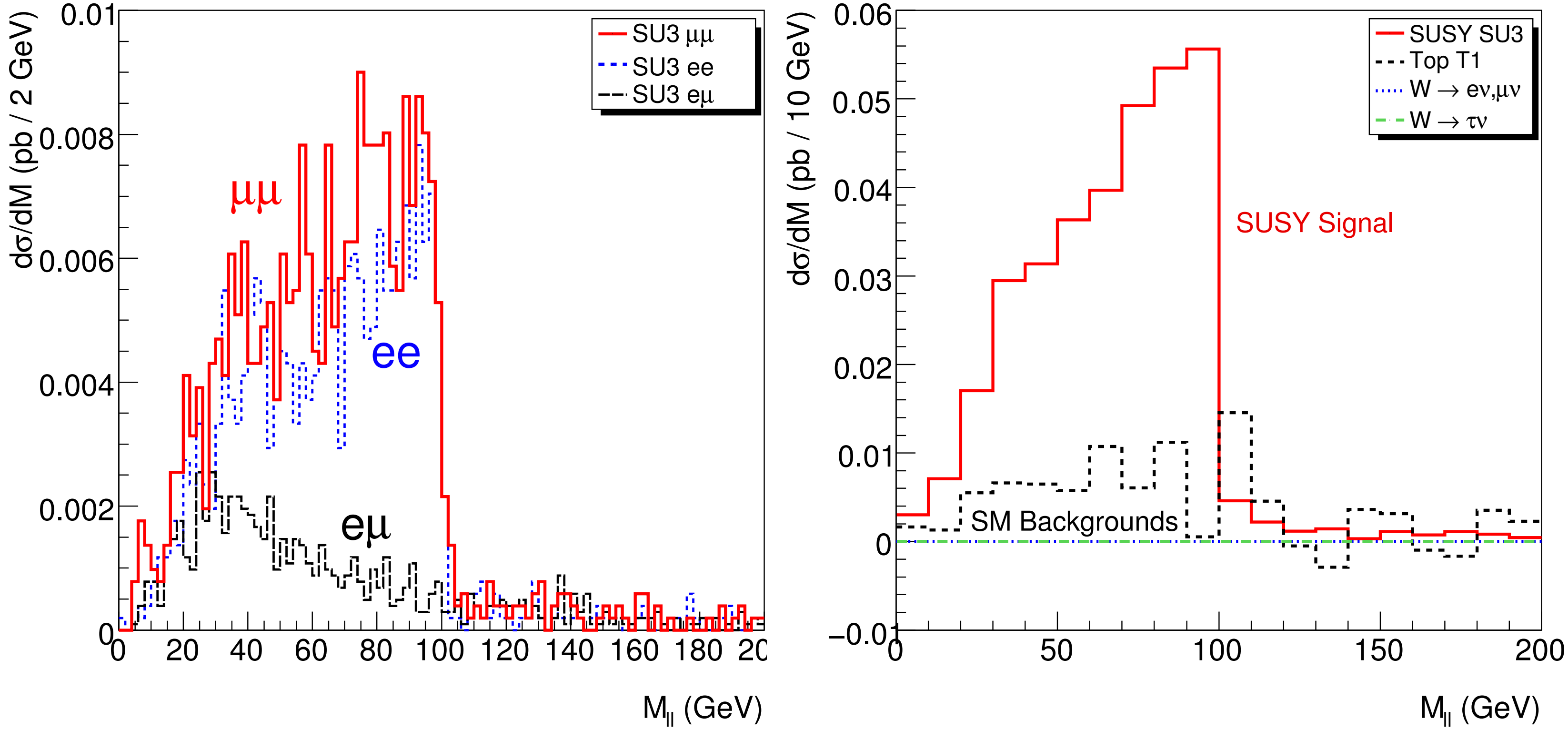


If R-parity conserved, most general signature for SUSY is multijets plus $\not\!\!E_T$. But background from mismeasured jets. Can require lepton, but τ's may dominate. Require at least one τ after cuts with full simulation:



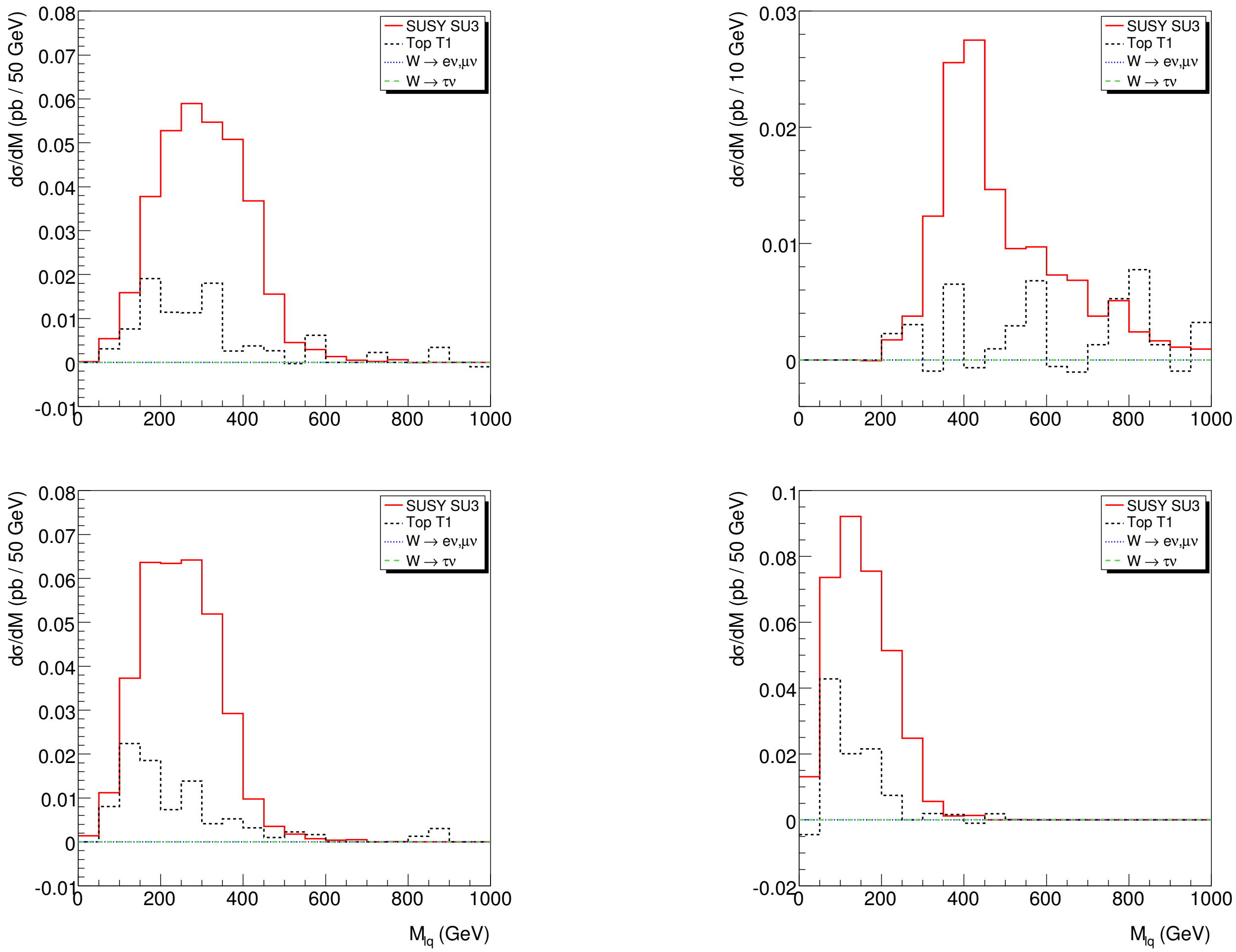
Looks promising; much more work needed.

Dilepton signatures from $\tilde{q}_L \to \tilde{\chi}_2^0 q \to \tilde{\ell}\ell q \to \tilde{\chi}_1^0 \ell\ell q$ is can be isolated



True endpoint is 107.0 GeV. Need work to understand lepton efficiency corrections, etc.

Can combine dileptons with leading jets. Expected endpoints are 521 GeV, 262 GeV, 434 GeV, and 340 GeV:



Full simulation studies essential to prepare for real data.