Search for the Supersymmetric Stop:
Top Reconstruction Techniques in 0-Lepton Direct Stop Searches

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University of Michigan REU at CERN: Initial Presentations
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Overview

- ❑ Refresher
- ❑ Previous Results
- ❑ Current Work
- ❑ Next Steps
- ❑ The Big Picture
- ❑ Travels

REFRESHER

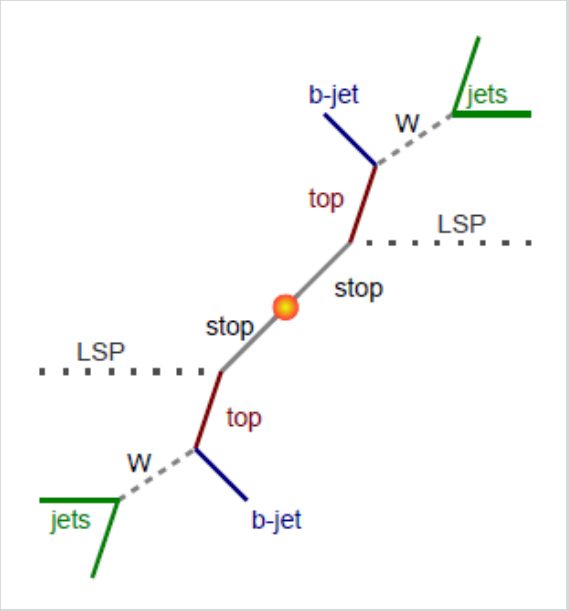
0-Lepton Direct top Squark Searches

- Proton collisions produce a stop anti-stop pair:

$$pp \rightarrow \tilde{t}\bar{\tilde{t}} + X$$

- Stop decays within the detector to a top quark and an undetected particle (model dependent e.g. neutralino):

$$\tilde{t} \rightarrow t + \tilde{\chi}^0_1$$



- Each top quark decays hadronically to 3 jets (6 total):

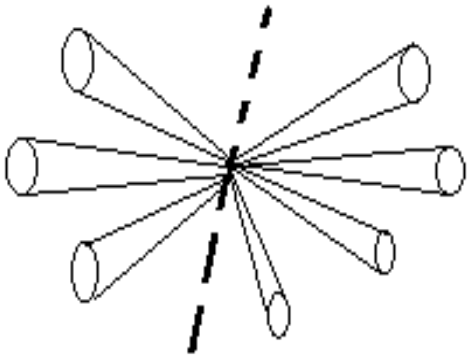
$$t \rightarrow b + W, W \rightarrow \text{jets}$$

- Largest Background: $t\bar{t} \rightarrow bjj + b\tau\nu$

Top Reconstruction

Goal:

Determine a more efficient way to reconstruct two top quarks, given an event with 6+ jets. Where "efficient" refers to recovering top quarks that decay from top squarks more often than those from non-stop processes (for example ttbar).



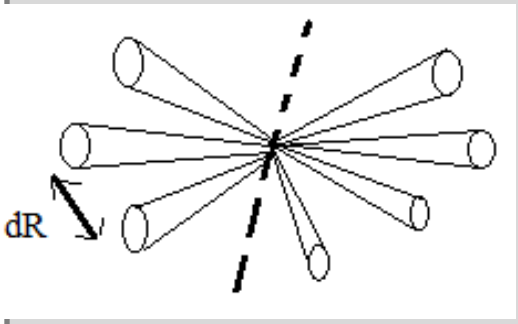
How Will It Be Used?:

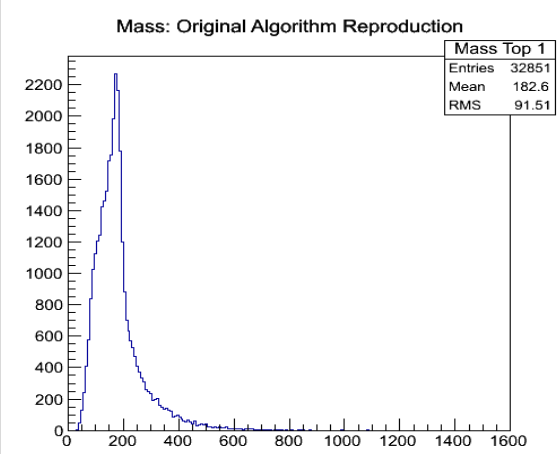
- The most efficient algorithm will be implemented into the 0-lepton direct stop search. Events with large amounts of missing E_T will be reconstructed into two top quarks. If found, it may be an indication that a top squark pair decayed in the event.

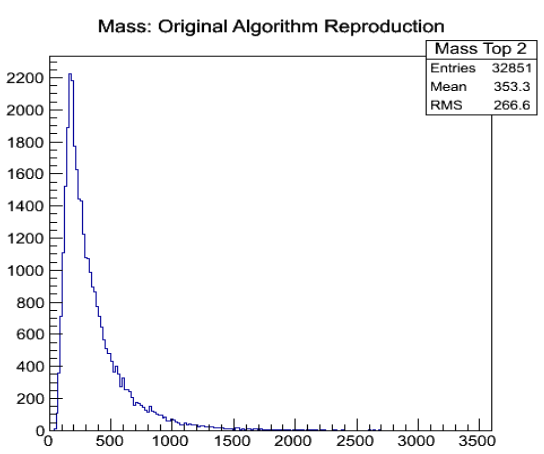
RESULTS AND CURRENT RESEARCH

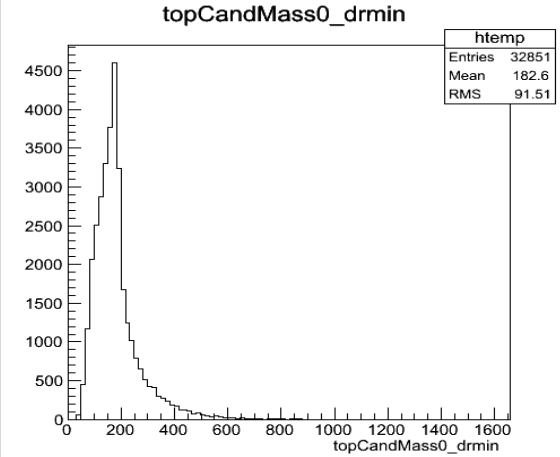
Recreating “dR Method”

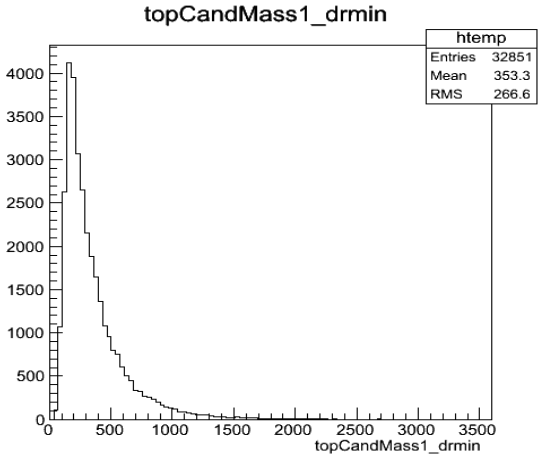
Background:





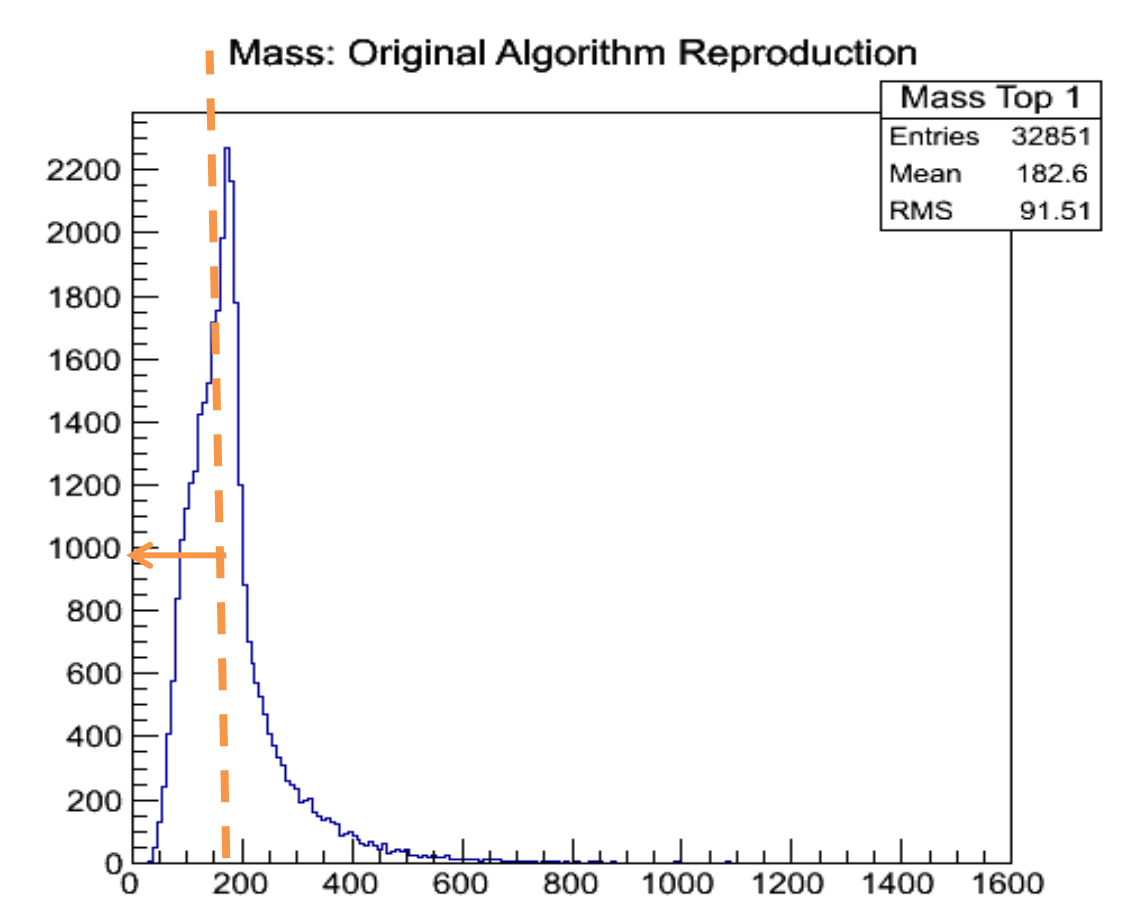






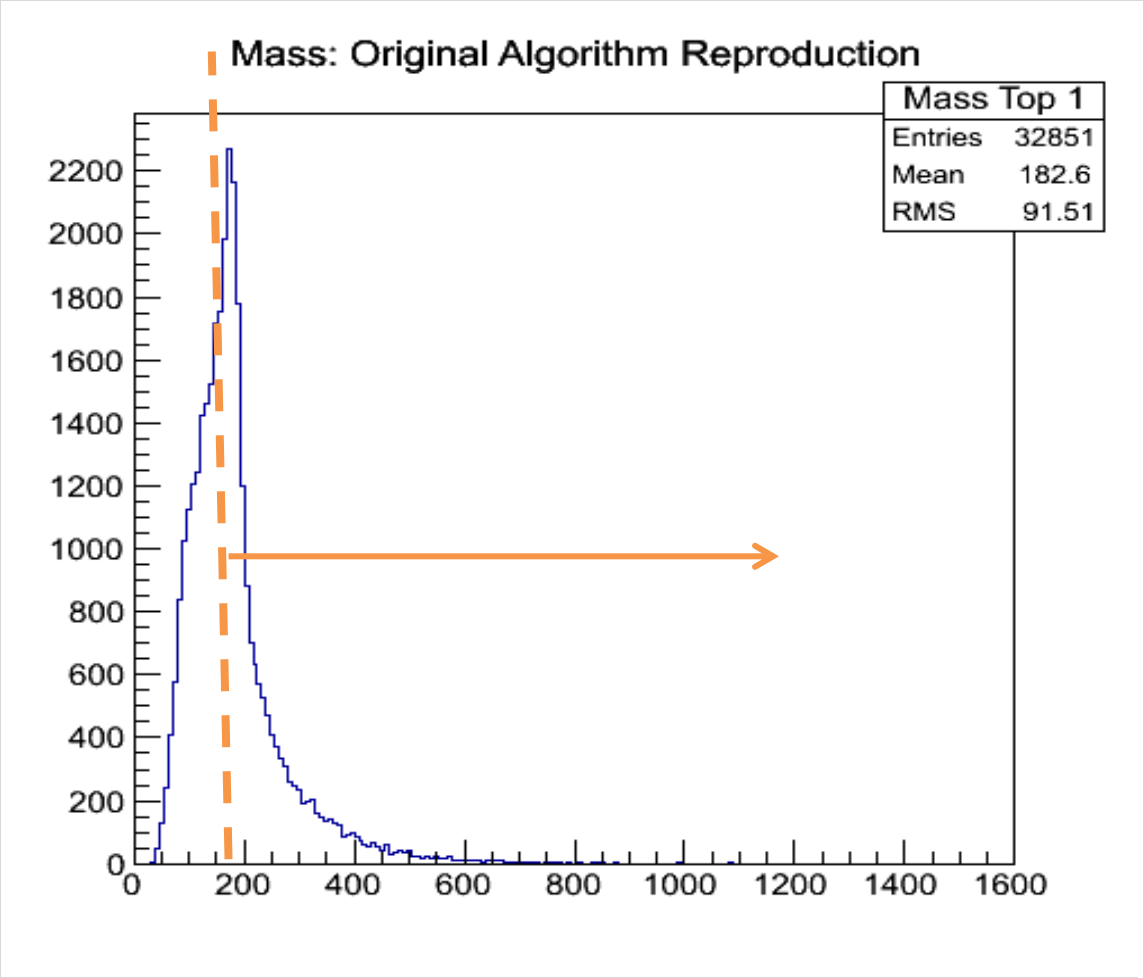
Response Curve: Explanation

- Integrate from top Mass to points less than the top mass.
- Normalize to the total integral from zero to the top mass.

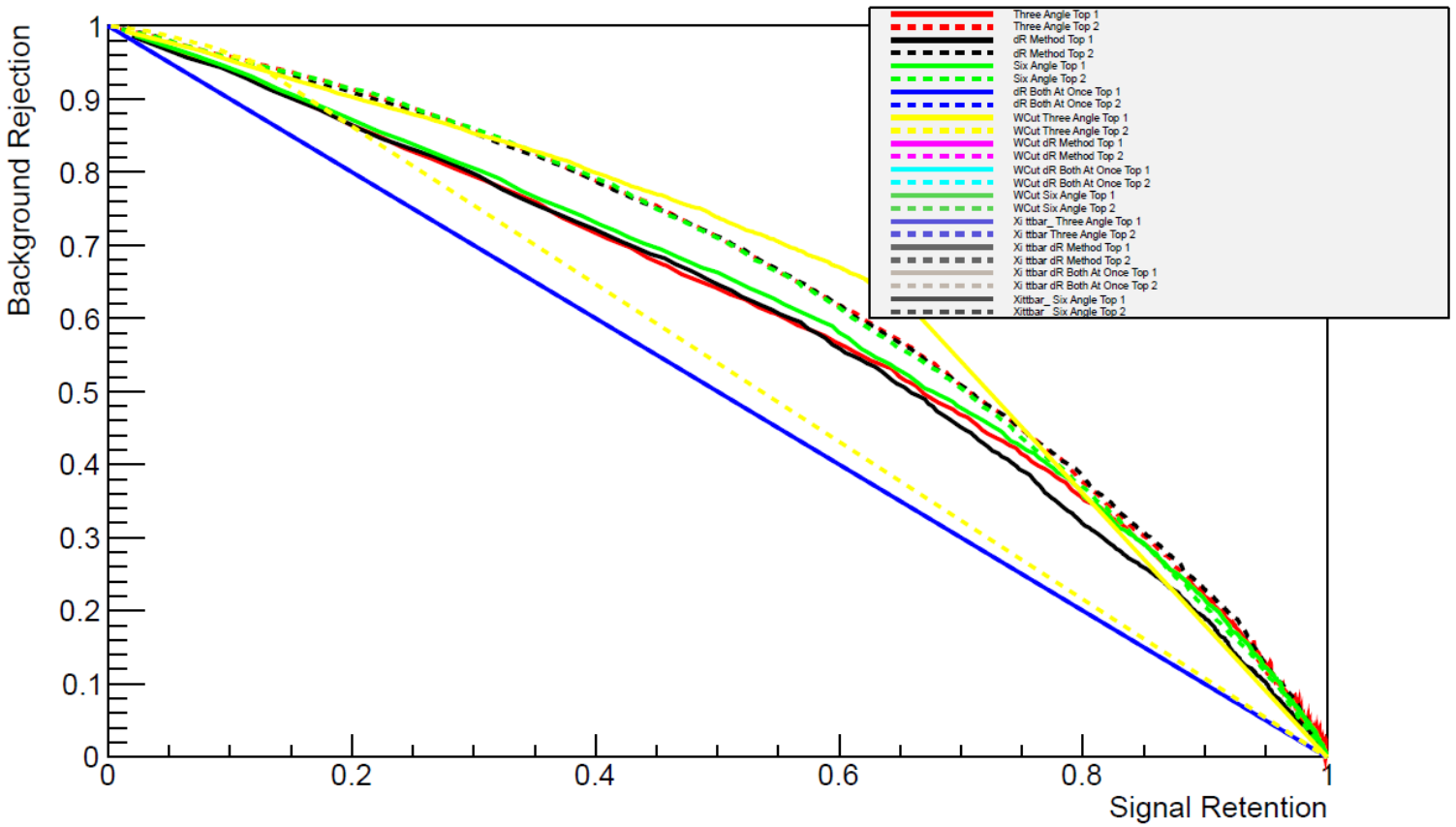


Response Curve Explanation (cont.)

- Integrate from top Mass to points more than the top mass.
- Normalize to the total integral from top mass to end of Histogram.

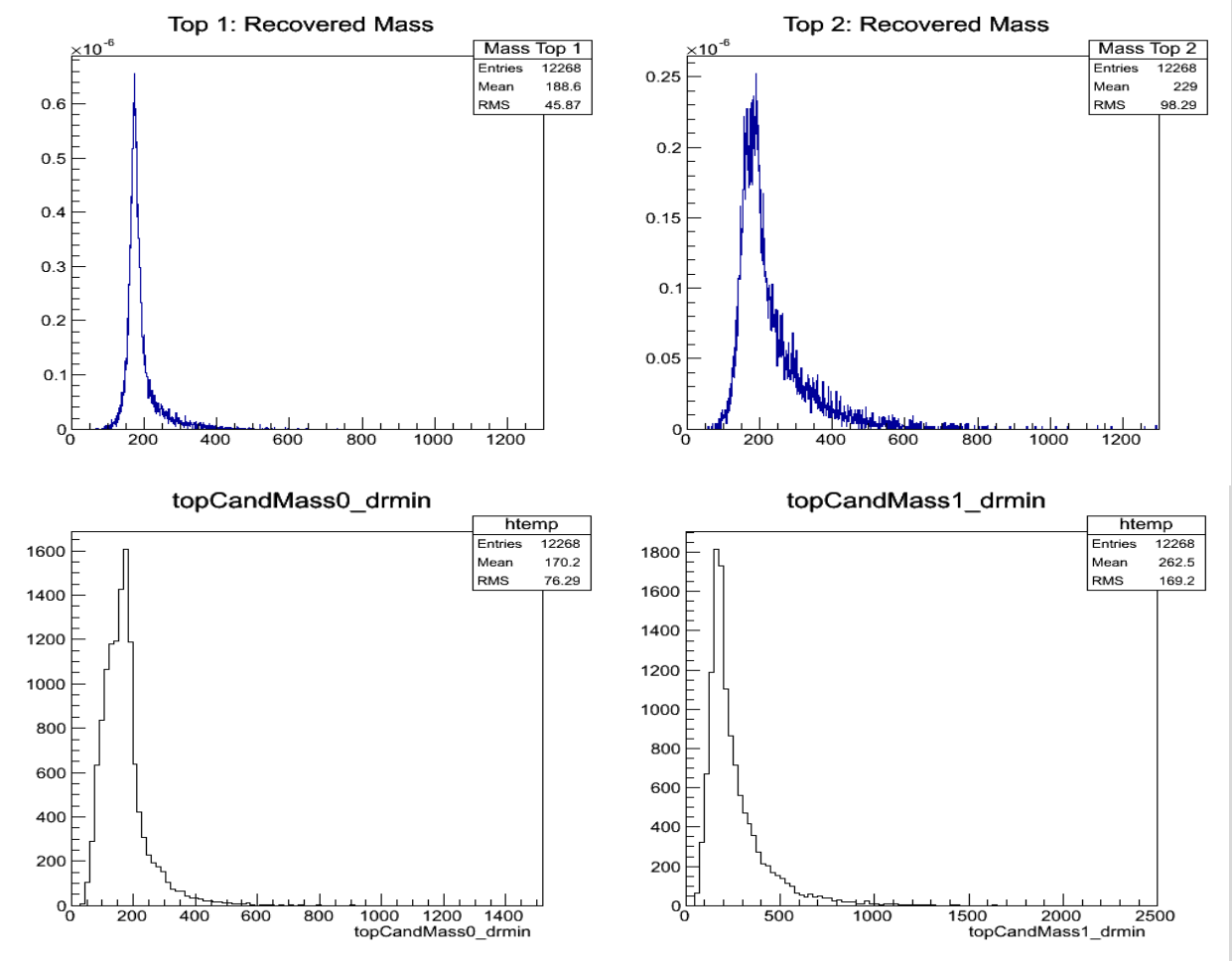


Work to Date: Response Curve (one-sided)



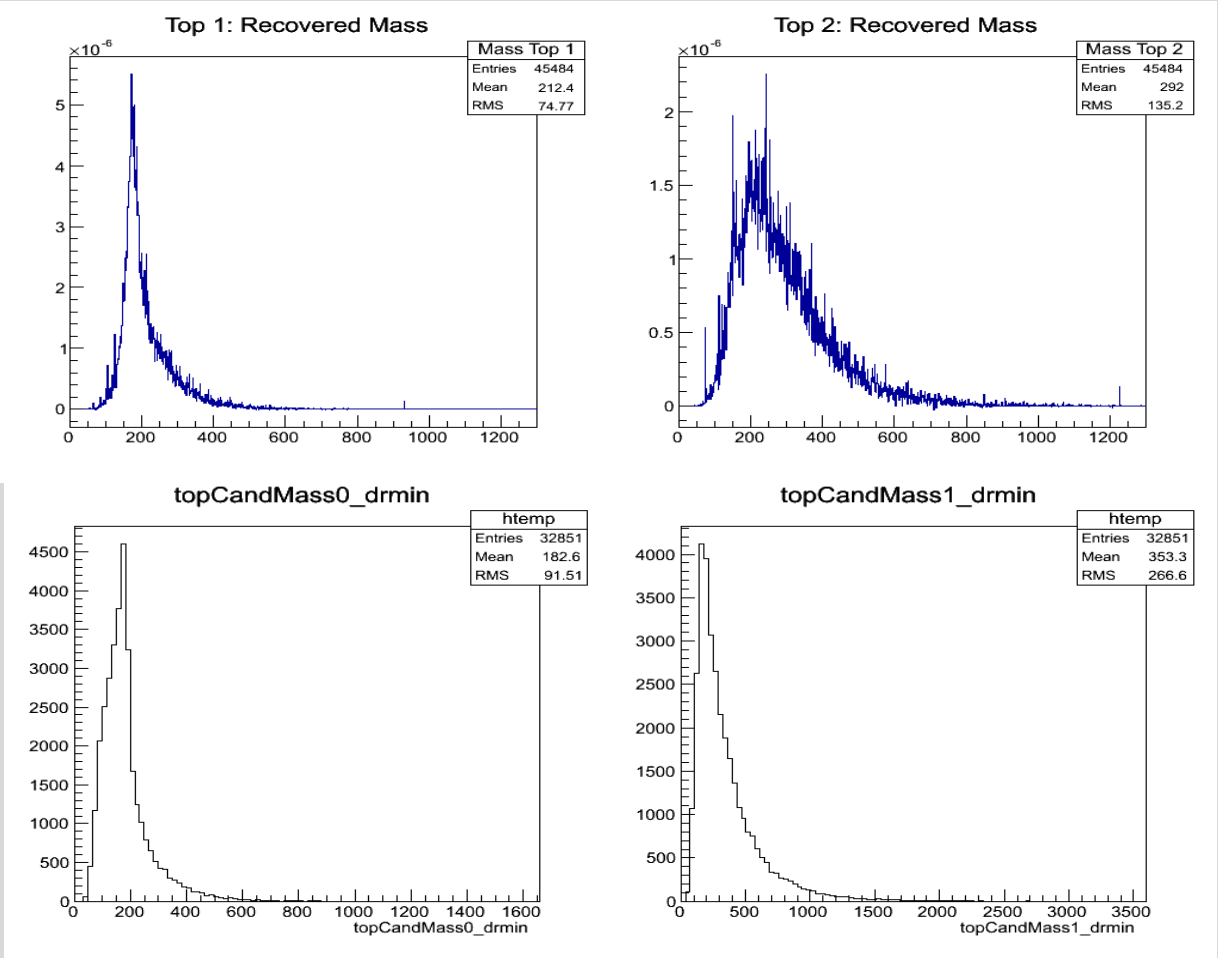
Most Promising Result: "Six Angle" χ^2 Method

Signal:

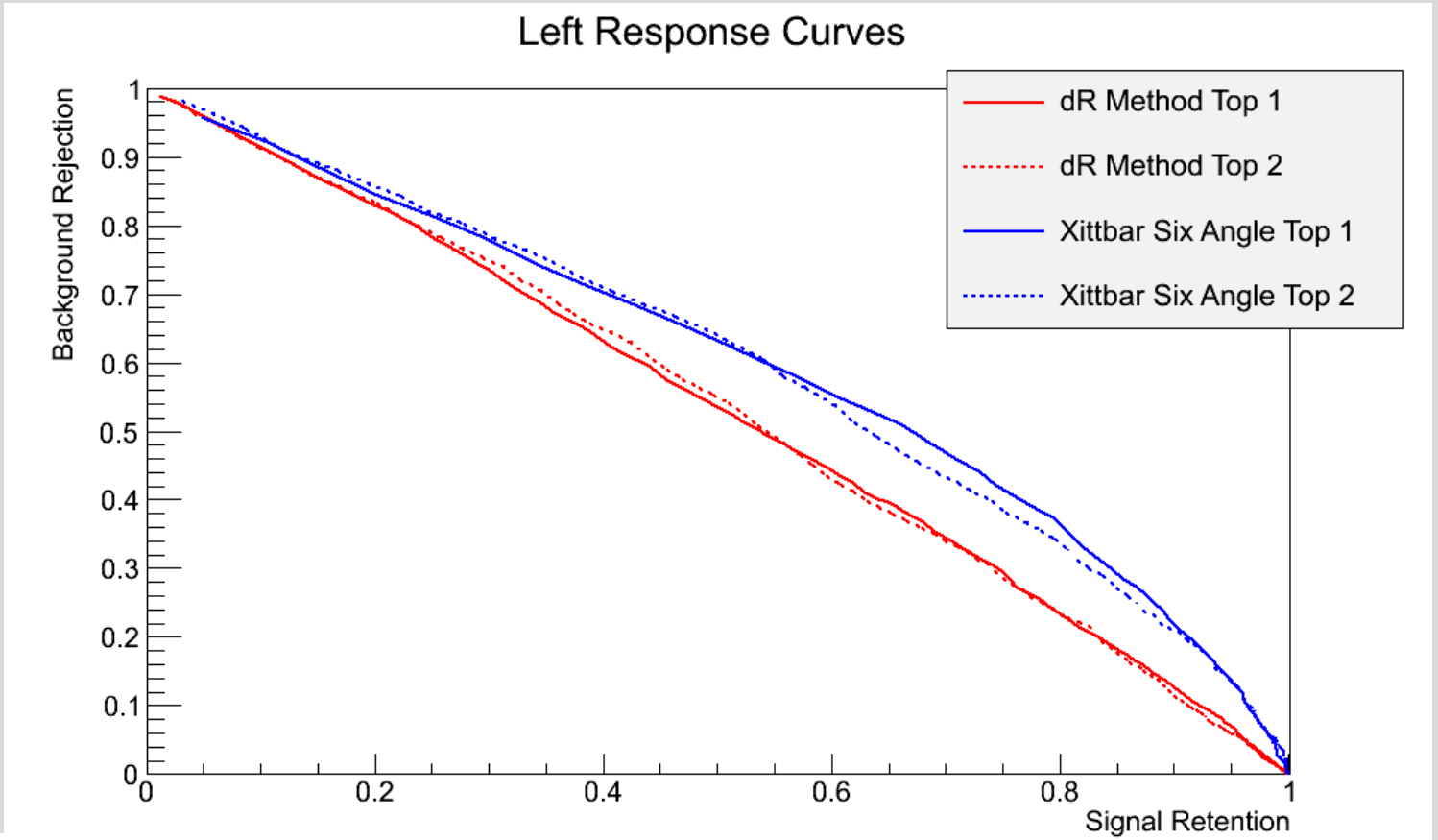


Most Promising Result: "Six Angle" χ^2 Method

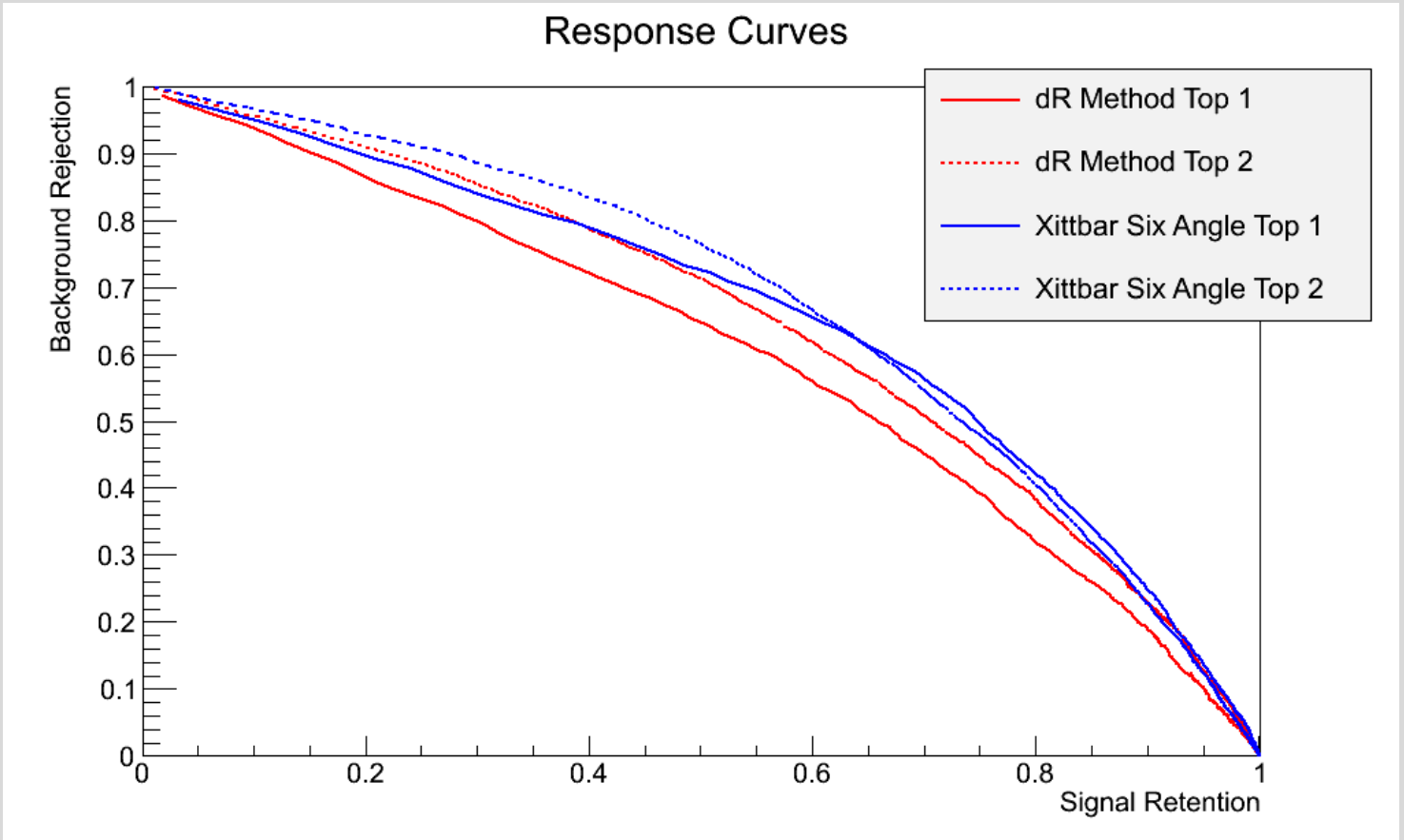
Background:



Best Response (left)



Best Response (right)



χ^2 Method

- Define a χ^2 variable*:

$$\chi^2 = \frac{(m_{j_1,j_2} - m_W)^2}{\sigma_W^2} + \frac{(m_{j_1,j_2,b_1} - m_t)^2}{\sigma_t^2} + \frac{(m_{j_3,j_4} - m_W)^2}{\sigma_W^2} + \frac{(m_{j_3,j_4,b_2} - m_t)^2}{\sigma_t^2}$$

- σ_W = 10.2GeV and σ_t = 17.4 GeV are the respective mass resolutions given by Monte Carlo*.
- Loop over all combinations to minimize the global value of χ^2 for the two recovered tops.

*See: ATLAS Collaboration, *Determination of the Top Quark Mass with a Template Method in the All-Hadronic Decay Channel*. ATLAS-CONF-2011-030.

Next Steps

- New, modified χ^2 variables?
- Finalize b-tagging code
- Cuts on the W mass?
- Go after the background directly by reconstructing and removing lepton events.
- New, untested search methods?

BIG PICTURE AND A LITTLE FUN

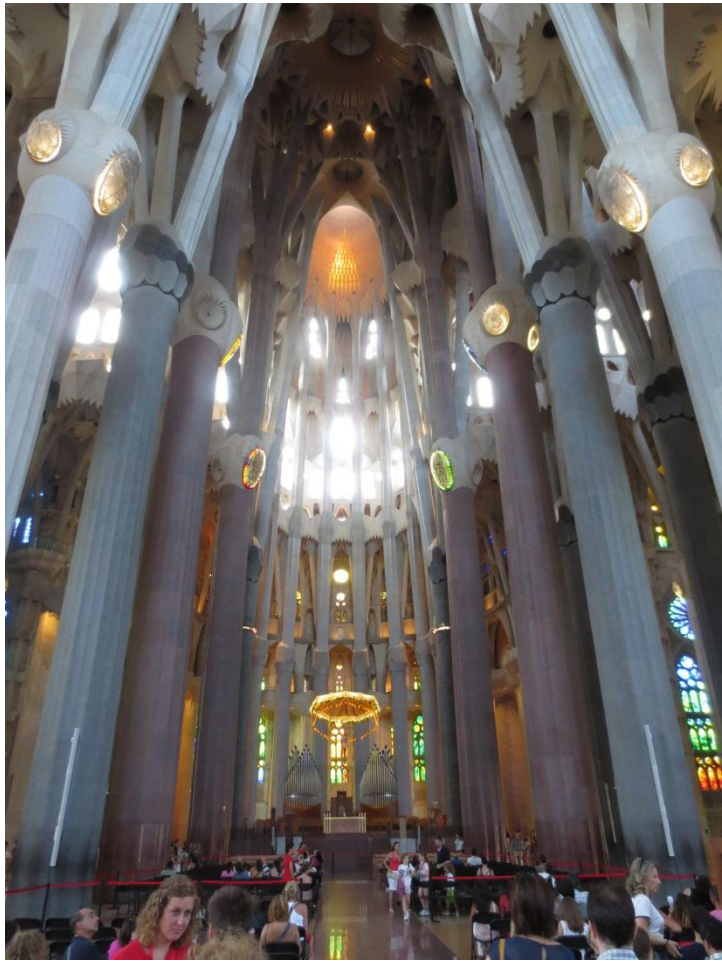
The Big Picture

- **Why stop?**
  1. Generally one of the lightest SUSY particles, meaning it is one of the most likely to be found at the LHC.
  2. Key to the stability of the Higgs.

- **Why SUSY?**
  1. Provides answers to the “fine-tuning” problem of the SM.
  2. Neutralinos could help us understand Dark Matter.
  3. Is a component in nearly all String Theory Models. No SUSY, no String Theory.

Outside the Office

Bern, Switzerland



La Sagrada Familia,
Barcelona, Spain

Zurich,
Switzerland

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Questions?

Monte Carlo

- Signal Events -HERWIG++ with MRST2007LO* parton-distribution functions
- Ttbar -ALPGEN using CTEQ6L1 PDF interfaced with HERWIG for particle production.
  -JIMMY used for underlying event model.
- Ttbar+V -MadGraph interfaced with PYTHIA.
- Single top events -MC@NLO and ACERMC
  -associated W and Z productions made using ALPGEN.