LJMET: Results of Jterm III

Gennadiy Kukartsev on behalf of

Leptons + Jets + MET topological group (LJMET)

January 12-16, 2009

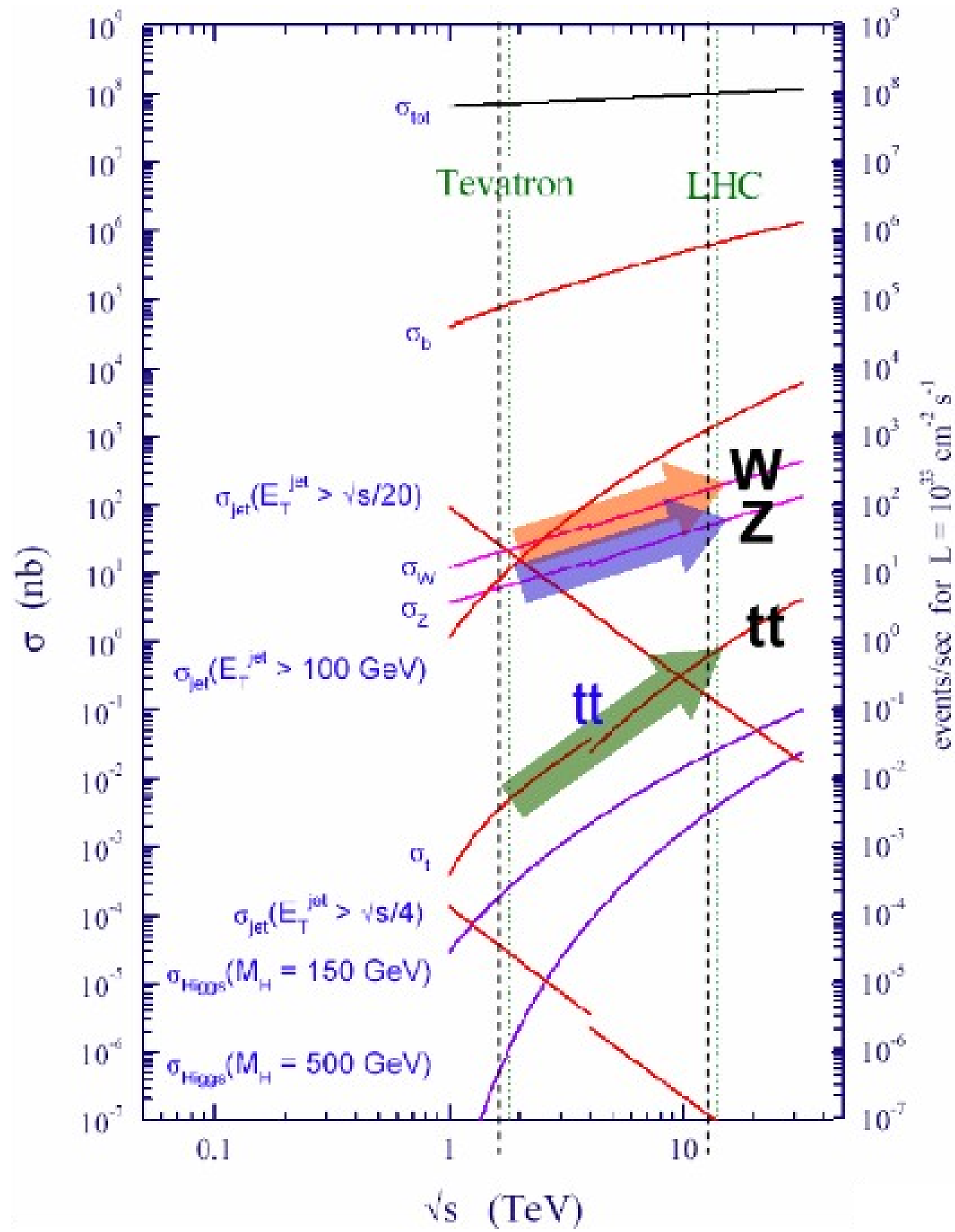
Fermilab

LJMET topological group

- Conveners:
  - Ken Bloom (kenbloom@unl.edu)
  - Meenakshi Narain (narain@hep.brown.edu)
- Meetings (FNAL and EVO):
  - Every other Wednesday, 12:30-14:00 Central time (FNAL)
  - At FNAL: the Round tableroom, Wilson Hall, 11th floor, Southeast
- Participants from
  - Fermilab, Brown, Purdue Calumet, Johns Hopkins, UCSB, UIC, UE,
  - Maryland, ... forgive if I forgot someone...

Physics

- W,Z and ttbar come in quickly after the turn on, and in great numbers
- We will have a chance to test Standard Model and understand control samples for Beyond SM searches quickly
- LJMET group:
  - Considers wide range of objects
  - Shared tools and expertise
  - Will help maintain focus without sacrificing breadth



Benefits of the LJMET group

- A variety of tools and expertise on how to use them
  - Simulation, production, CMSSW, btagging, trigger, standalone tools, multivariate analysis, fits of various flavors, you name it
  - Joint effort allows to get usable data very fast
- Experience from Tevatron, various level of discussion, informal

LJMET topological group

Wednesday 14 January 2009
from 10:30 to 15:30
US/Central
at FNAL and remote sites
chaired by: *Ken Bloom*

Description: Connect via EVO.
The modification password for this page is "ljmet".

Wednesday 14 January 2009 |

Wednesday 14 January 2009

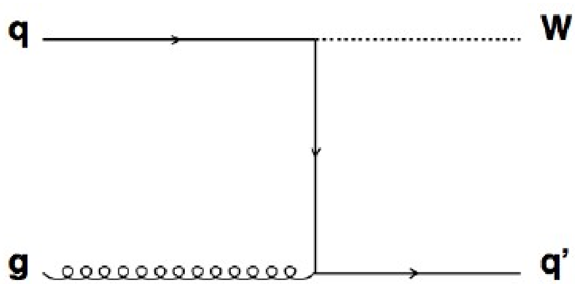
top

10:30	W plus heavy flavor modeling (20') (Slides)	Salvatore Rappoccio
10:50	Understanding QCD backgrounds to l+jets events (20') (Slides)	Jeffrey Temple (*University of Maryland/CMS*)
11:10	break/hidden valley meeting (2h20')	
13:30	ttbar cross section via templates of kinematic variables (20') (Slides)	Pratima Jindal (*Purdue University Calumet*) , Gennadiy Kukartsev
13:50	ttbar cross section via mass reconstruction (20') (Slides)	Dan Green (*Fermi National Accelerator Laboratory (FNAL)*) , Francisco X. Yumiceva (*FERMILAB*)
14:10	ttbar cross section via b-tagged jets (20') (Slides)	Helena Malbouisson (*Instituto de Fisica-Universidade do Estado do Rio De Janeiro (UE)*)
14:30	Top partners (20') (Slides)	Aram Avetisyan (*Department of Physics-Brown University*)
14:50	SUSY searches in LJMET (20') (Slides)	Finn O'Neill Rebassoo (*Physics Department-University of California*)

Modeling of W+heavy flavor

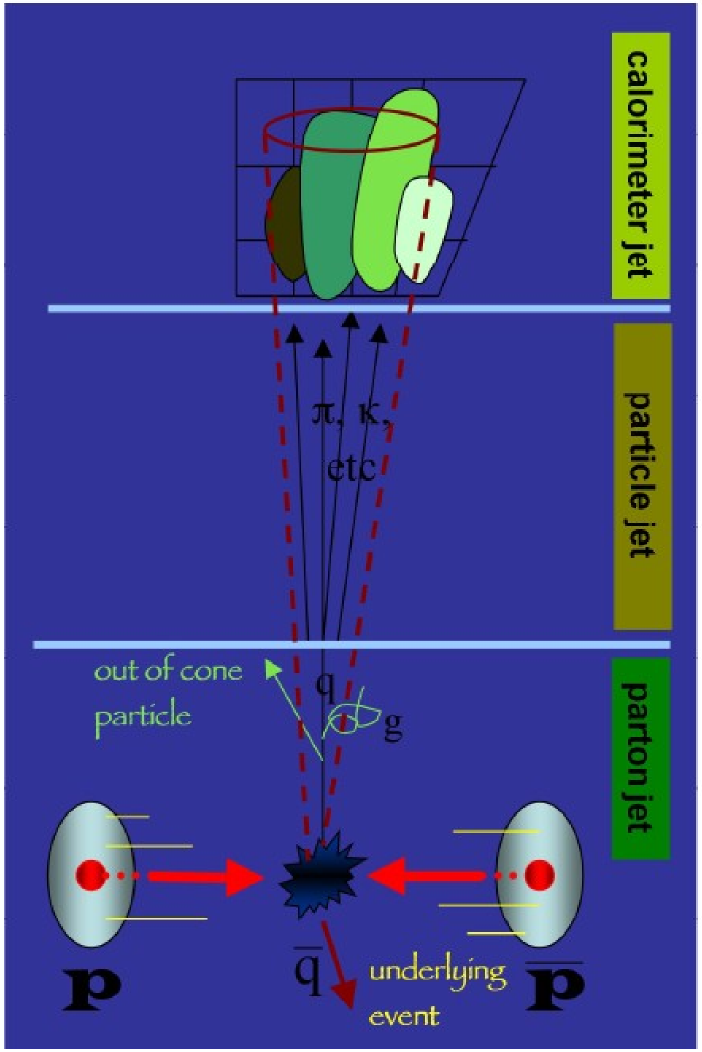
Salvatore Rappoccio (Johns Hopkins University)
Victor Bazterra (UIC)
Cecilia Gerber (UIC)
Gavril Giurgu (JHU)
Petar Maksimovic (JHU)
Stephen Mrenna (FNAL)
Sal Rappoccio (JHU)
Elizavetha Shabalina (UIC)

- At LHC, qg mechanism vastly dominates
- Outgoing q' depends on the probability of q in the PDF
- Rely on QCD calculations to predict rates



ME and parton showers

- Several exact matrix element calculations are available
  - MadGraph
  - Alpgen, etc...
- Parton showers are nonperturbative, must rely on the parametrizations
- Several parton shower calculations are available
  - PYTHIA
  - HERWIG
- Have to combine both approaches



Determining W+QQ Fractions

- •Performing two separate but similar analyses to estimate heavy flavor fractions from data:
  - Tag counting (UIC)
    - Look at overall number of tags
      - Input mistag rate, efficiency, use system of equations to solve for N_HF and N_LF
  - Two methods:
    - Estimates Frac(b+c) together
      - » Use tagged + anti-tagged samples
    - – 2: Estimates Frac(b) and Frac(c) separately
      - » Use 0, 1, 2 tag samples
      - » Only works in >= 2 jet bins

Determining W+QQ Fractions

- Discriminating variables (JHU)
  - Find discriminating variable per-jet
  - Use MC template fits for b, c, and light flavor separately
  - Estimates Frac(b) and Frac(c) separately
- Can use these as cross-checks of each other at the end

W+heavy flavor status

- W+ Heavy Flavor must be handled carefully.
- Lots of technical issues to sort out.
- Mostly developed by previous experiments.
- Need to handle this background when dealing with lepton plus jets channels
- Also, performing two separate but similar analyses to estimate heavy flavor fractions from data
  - Tag counting
  - Template analysis

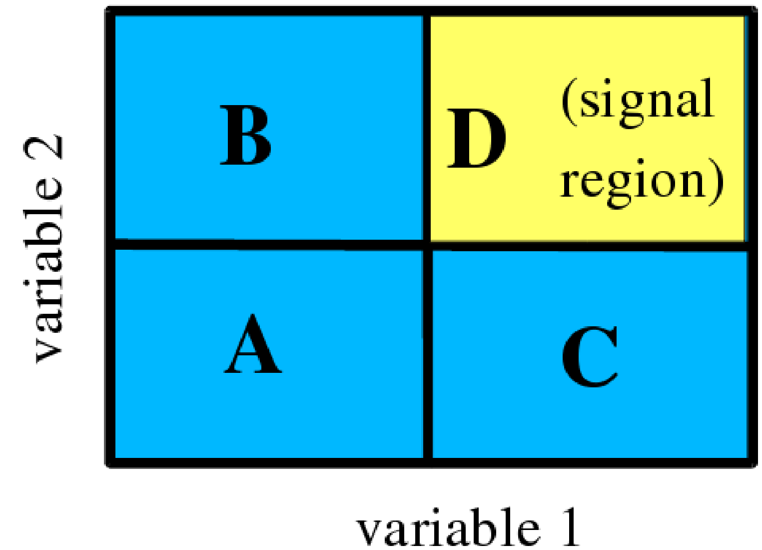
QCD backgrounds

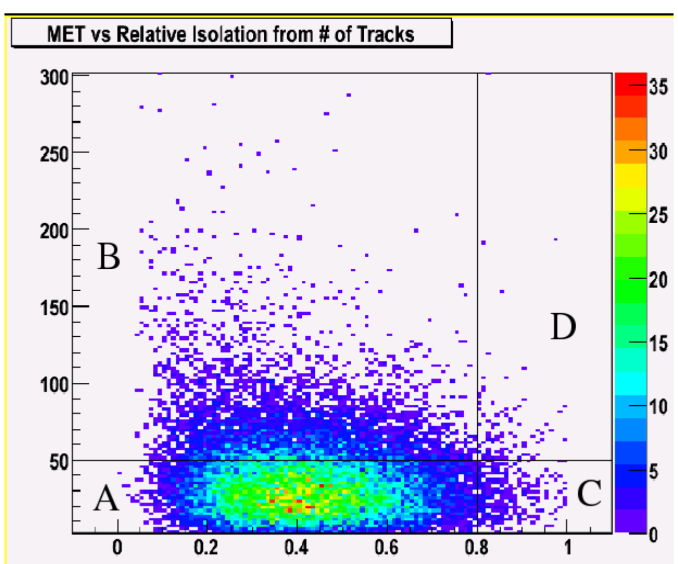
Jeffrey Temple, University of Maryland

- Estimate QCD background in signal region from data
- Minimize QCD background in that region
- Using default PAT Layer 1 objects (muons, jets, MET)
- QCD expected to be a small but non-negligible background to ttbar production
  - Muons can be produced in QCD events through b/c decays or othe r in-flight decays
  - We expect those muons to appear near jets in such events

"ABCD" method

- Find two independent variables
  - MET vs relative isolation work
  - Considering other variables
- Isolate signal in one quadrant
- Estimate background from data in non-signal regions





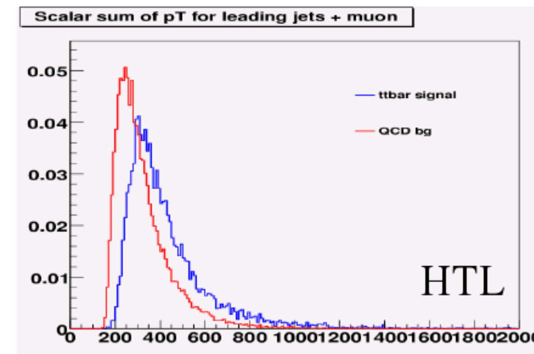
background in signal region =

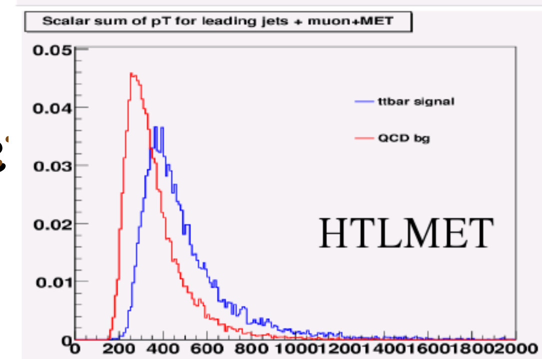
$$D = C(B/A)$$

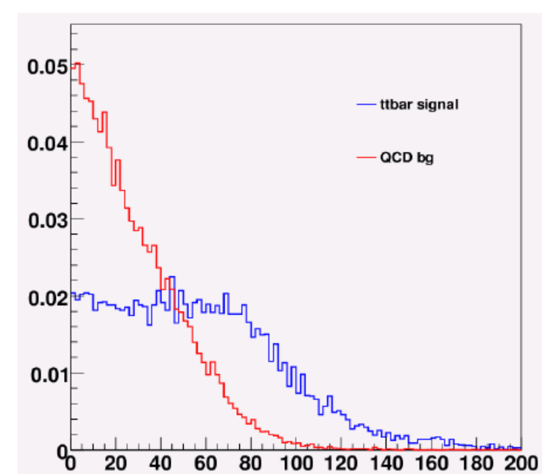
- **D (calculated) = 123.6**
- **D (observed) = 121**

Variables to Consider

- MET
- relIso
- deltaR = min deltaR (muon, any jet)
- deltaR_sel =min deltaR (muon, lead 4 selected je
- HTL = scalar sum of lead 4 jets + muon
- HTLMET = HLT + | MET |
- MWT = transverse W mass (from muon + MET)
- Not a complete list…







Status

- Relative isolation on muon provides a strong cut on
- QCD background
- MET/Relative Isolation cut provides good estimate of
- background in signal region (in Monte Carlo)
- However...
- ttbar muon event MET peaks near 50 GeV
- ttbar (MET + muon) transverse mass doesn't look great
- HTL may provide more stable estimator of QCD background in early running

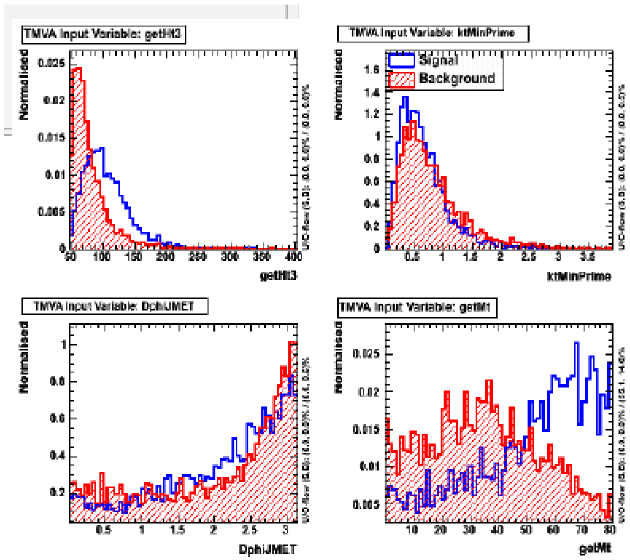
ttbar cross section using kinematics

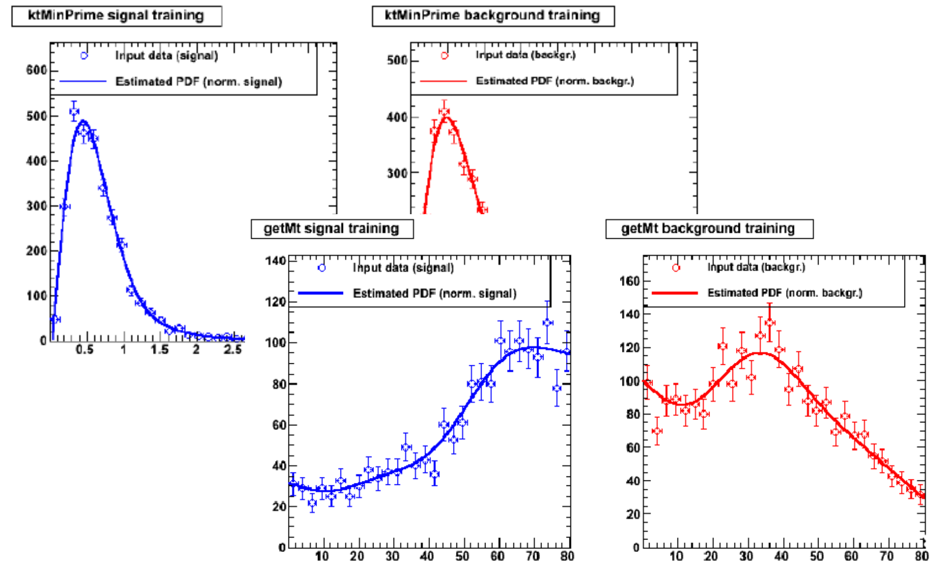
Pratima Jindal, Purdue University Calumet
Gena Kukartsev, Brown University
Meenakshi Narain, Brown University
Neeti Parashar, Purdue University Calumet

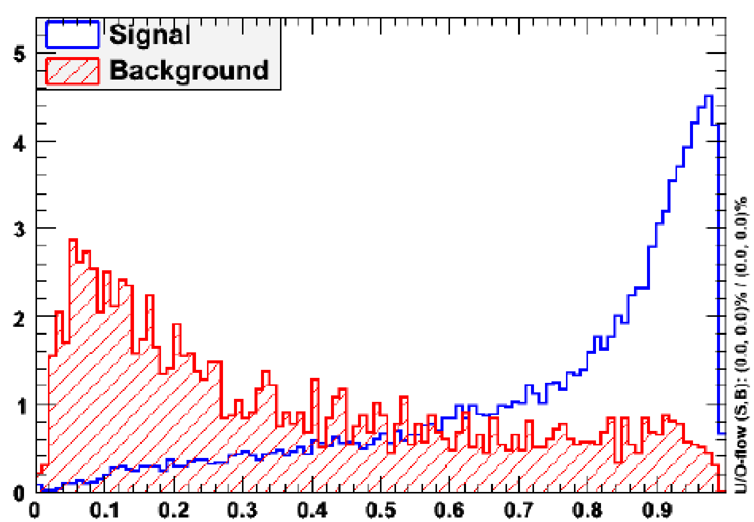
MultiVariate Analysis

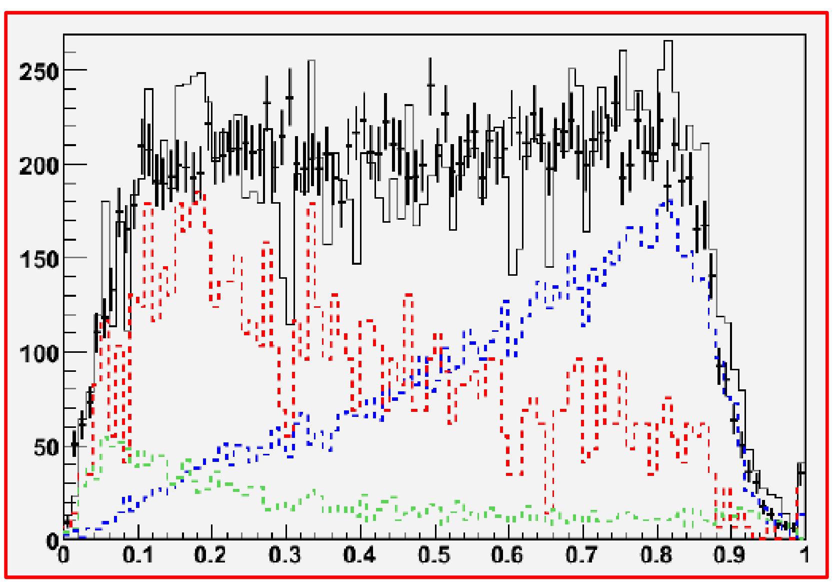
- Use kinematic/event topology observables (no b-tagging).
- Pick a set of variables that provide good signal/background separation.
- Combine observables into a single classifier quantity
- Obtain a classifier shape (template) for signal and background(s).
  - ttbar, W/Z+jets - MC with control samples and other cross checks.
  - QCD – Data (nominal selection with the reversed lepton quality).
- Fit the classifier distribution from data to a sum of signal and background templates and extract the signal yields.

Analysis flow



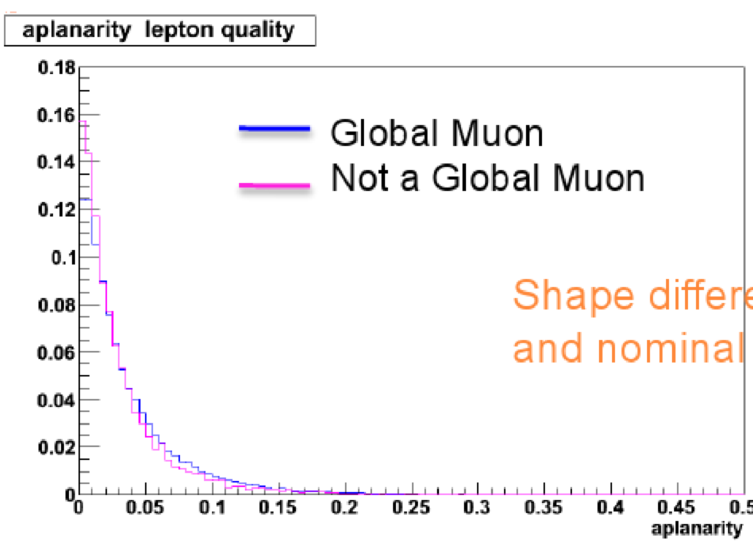


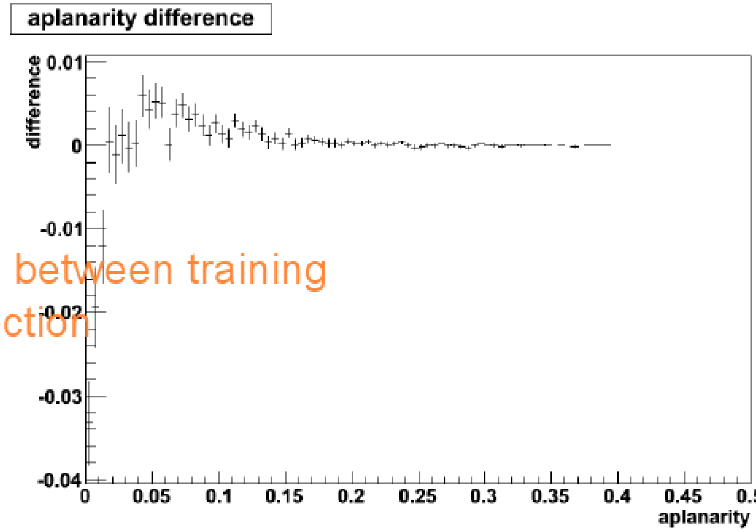




QCD estimate from data

- We need a QCD sample excluded by the nominal selection to train the QCD template.
- We require the observables to have same shape as with nominal selection.
- Our candidate for such a cut is lepton quality.





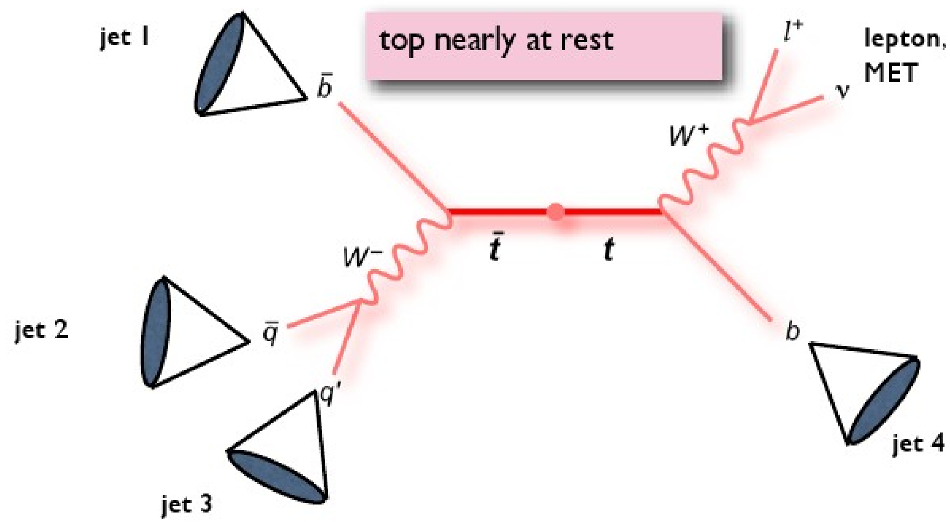
Shape difference between training and nominal selection

Ttbar cross section via mass reconstruction

Dan Green, FNAL
Francisco Yumiceva, FNAL

AN-2008-104

- Use the the best $\chi 2$ of the reconstructed masses to select a candidate (combinatorics)
- Apply for 4,5,6 jet samples
- Use "bad" $\chi 2$ to model background

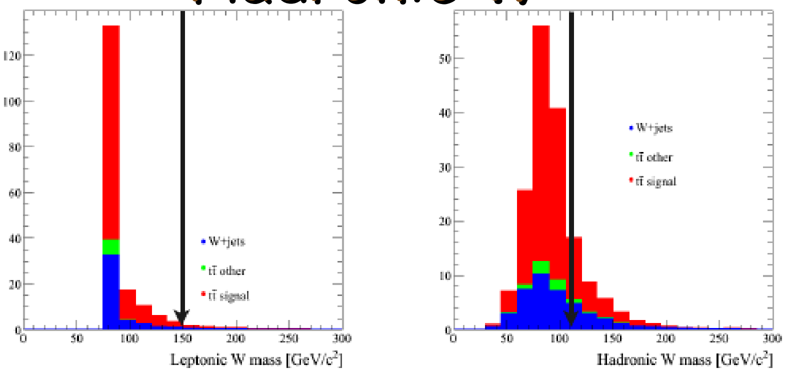


$$\chi^2 = \frac{(M_{j_1 j_2} - M_W)^2}{\sigma^2_{jj}} + \frac{(M_{j_1 j_2 j_3} - M_t)^2}{\sigma^2_{jjj}} + \frac{(M_{W_l j_4} - M_t)^2}{\sigma^2_{\mu\nu j}}$$

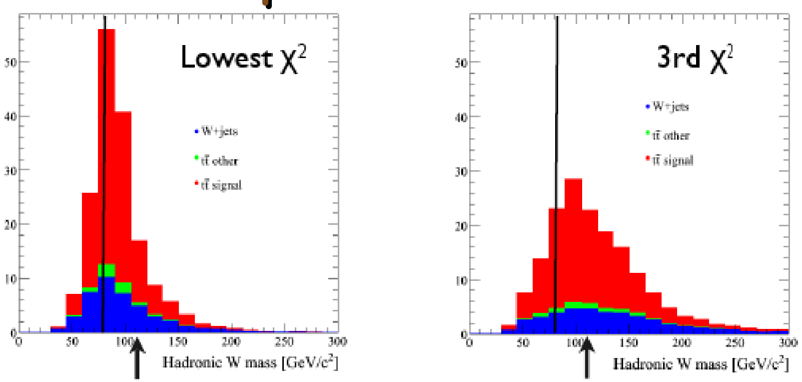
hadronic W — hadronic top — leptonic top

W and top masses

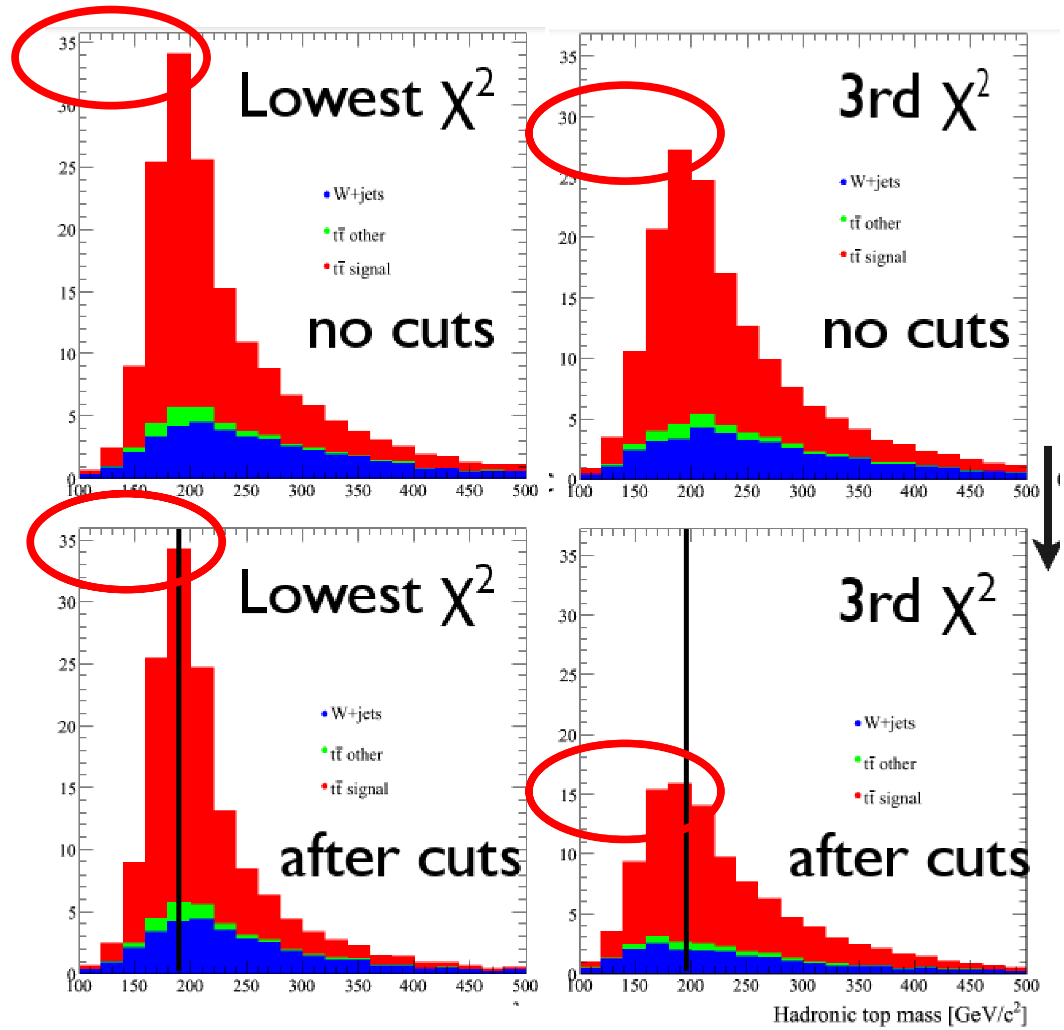
Hadronic W



Leptonic W

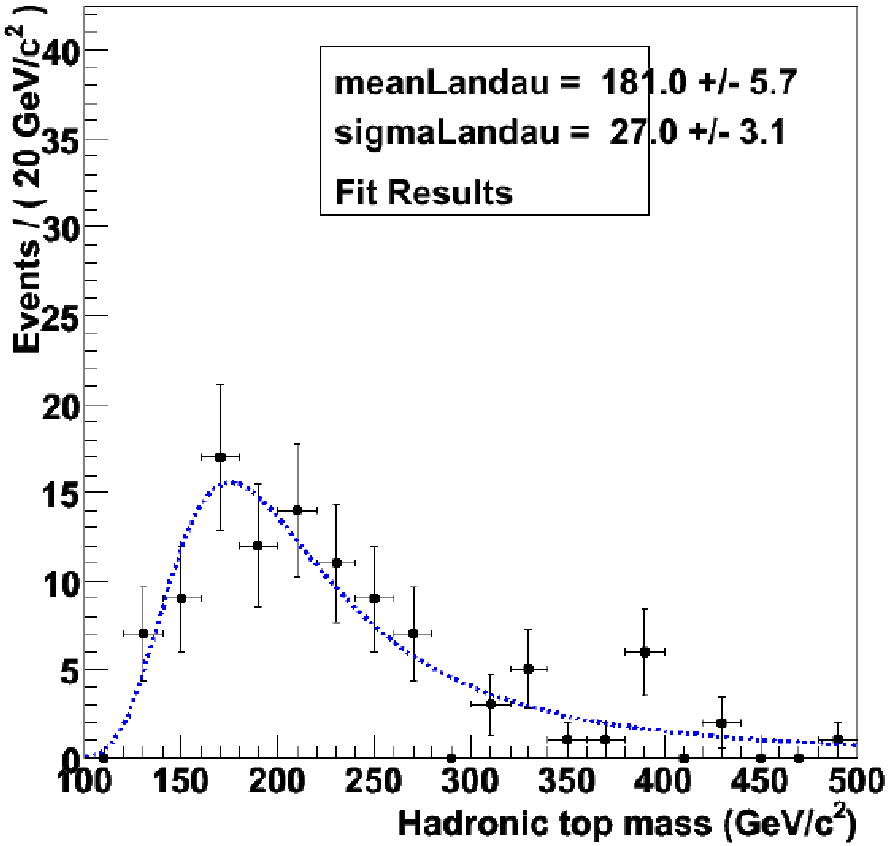


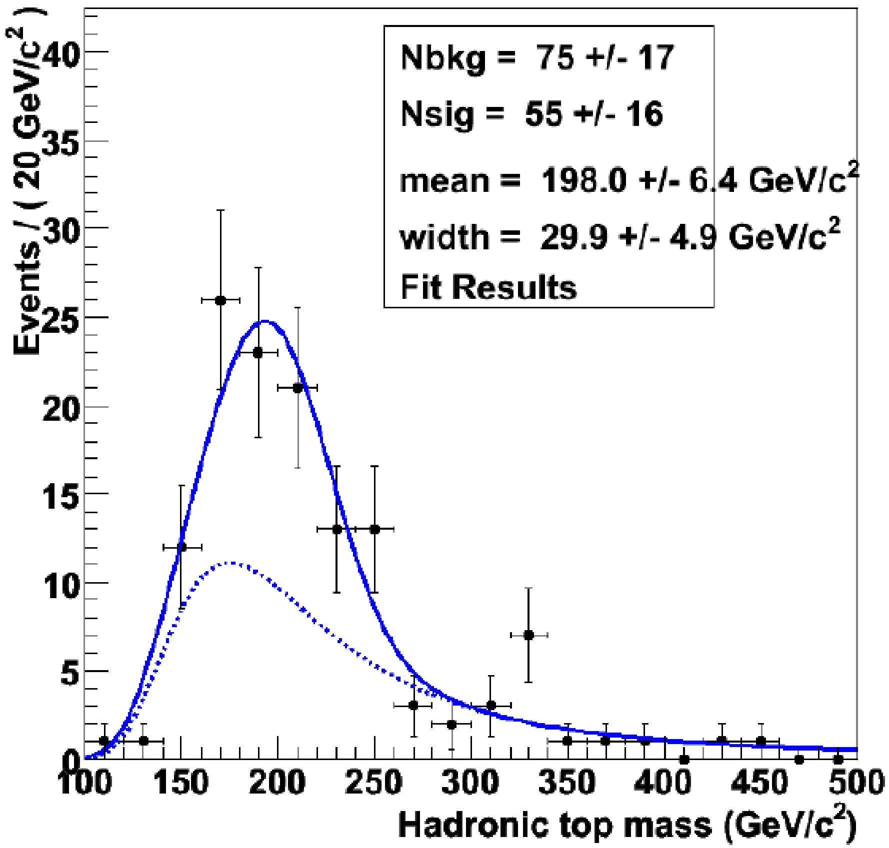
- Cutting tails of the reconstructed W masses reduces background



Reconstructed top mass

Fit and results





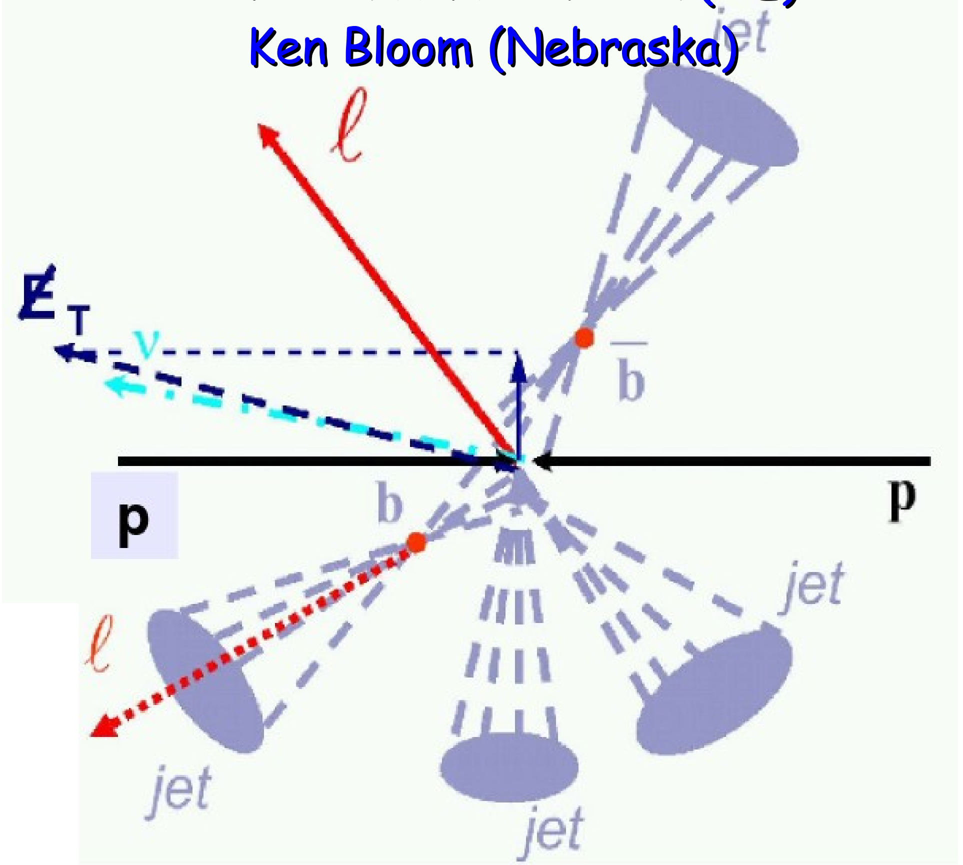
- Various crosscheck fits demonstrate the stability of the result: floating all shapes, different PDF parametrizations, different MC sets, background only (no artificial peak) etc...

AN-2008-104

ttbar cross section via b-tagged jets

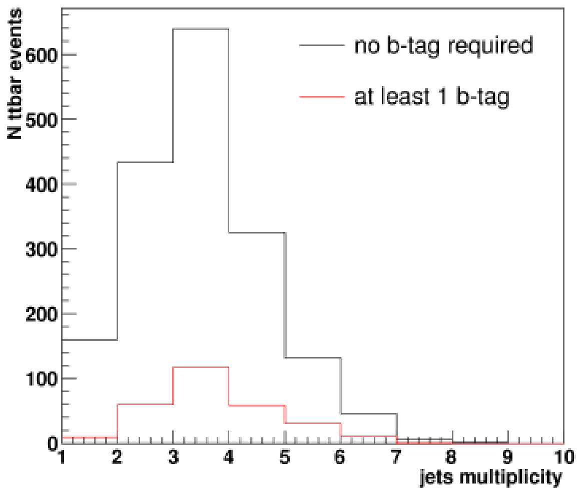
Helena Malbouisson (UE)
Ken Bloom (Nebraska)

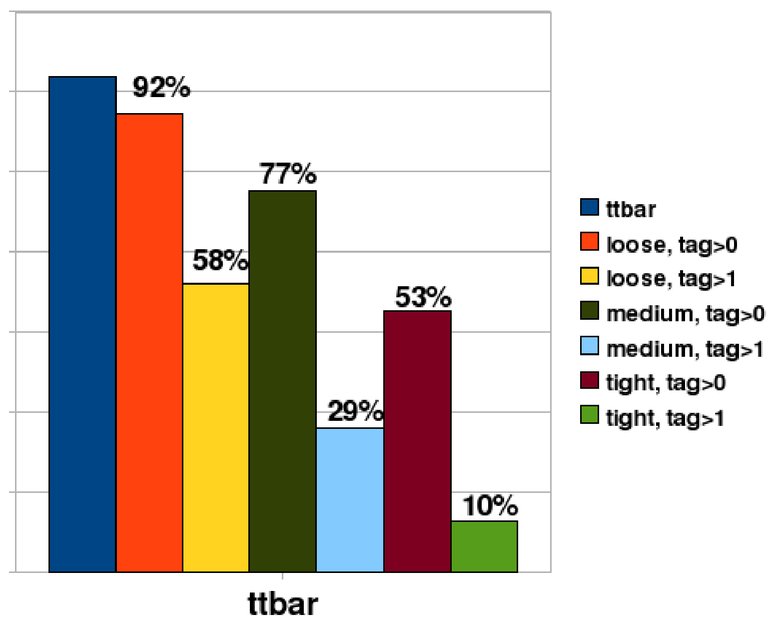
- Soft Lepton Tagger is likely to be available for early data
- Consider usual kinematical selection for jets and leptons: pT, h
- Special attention to the muon isolation and quality parameters, both for the muon from W (isolated) and the jet muon (tagger)



For details of this and other taggers see [the b-tagging presentation](#)

Multiplicity and efficiency



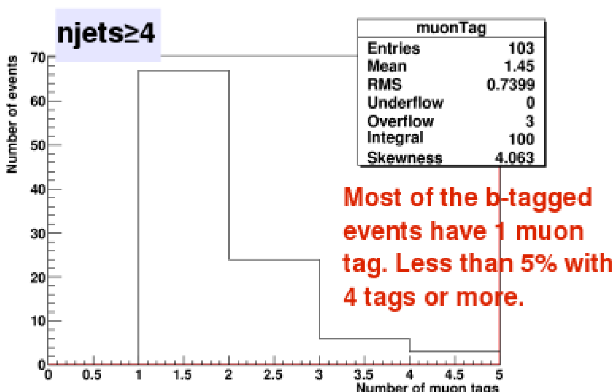


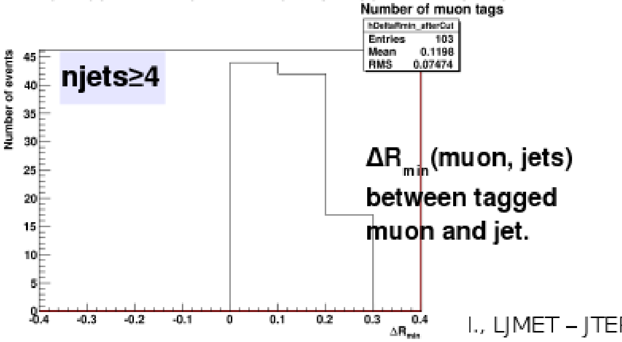
@100pb-1:

S/B (no b-tag): 0.0005

loose_1tag: S/B = 0.01590
loose_2tags: S/B = 0.0260
medium_1tag: S/B = 0.0214
medium_2tags: S/B = 0.0376
tight_1tag: S/B = 0.0267
tight_2tags: S/B = 0.0464

Number of tags per event:



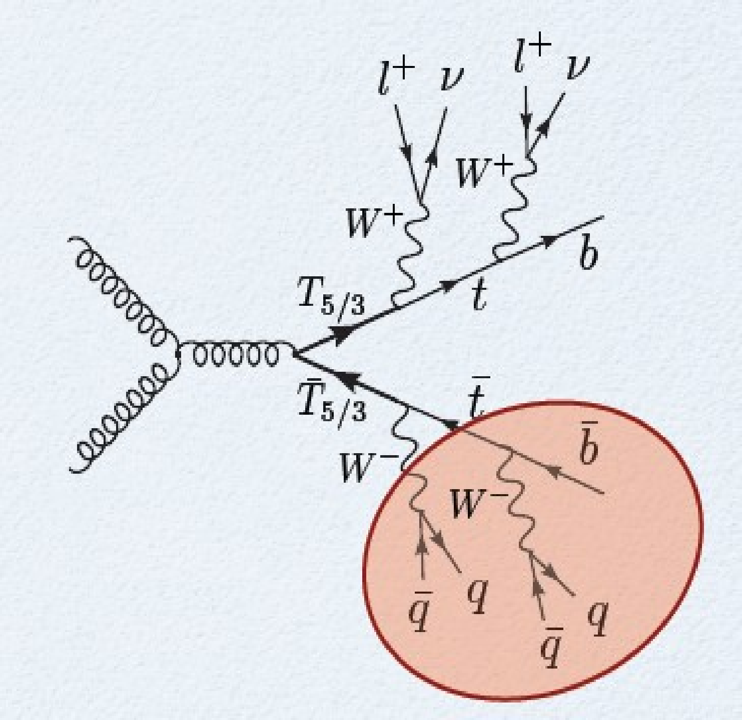


- Some of the plans
  - Improvements to be made to the muon selection
  - Optimize muon selection
  - Muon tagger efficiency
  - Estimating the muon tagger background

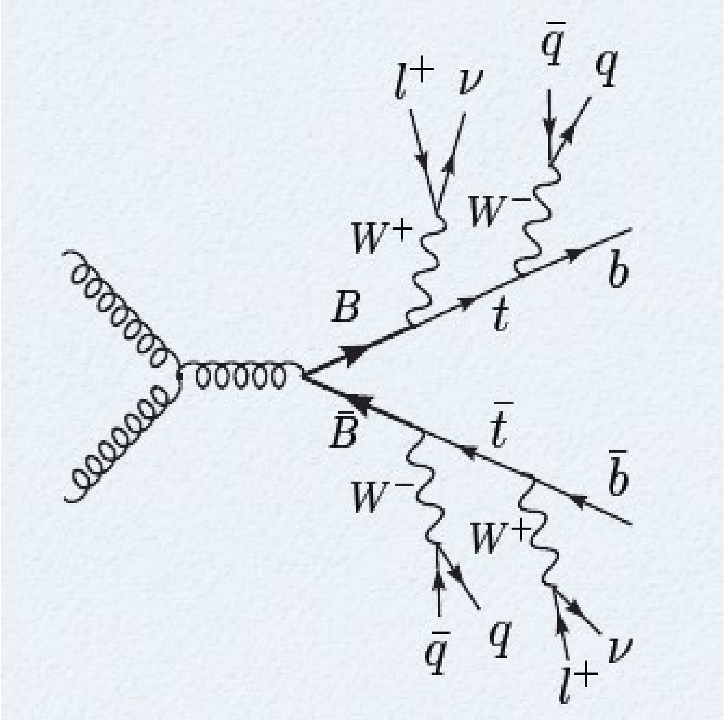
Top partners

Aram Avetisyan (Brown),
Meenakshi Narain (Brown)

Heavy Top Partner



Heavy Bottom Partner

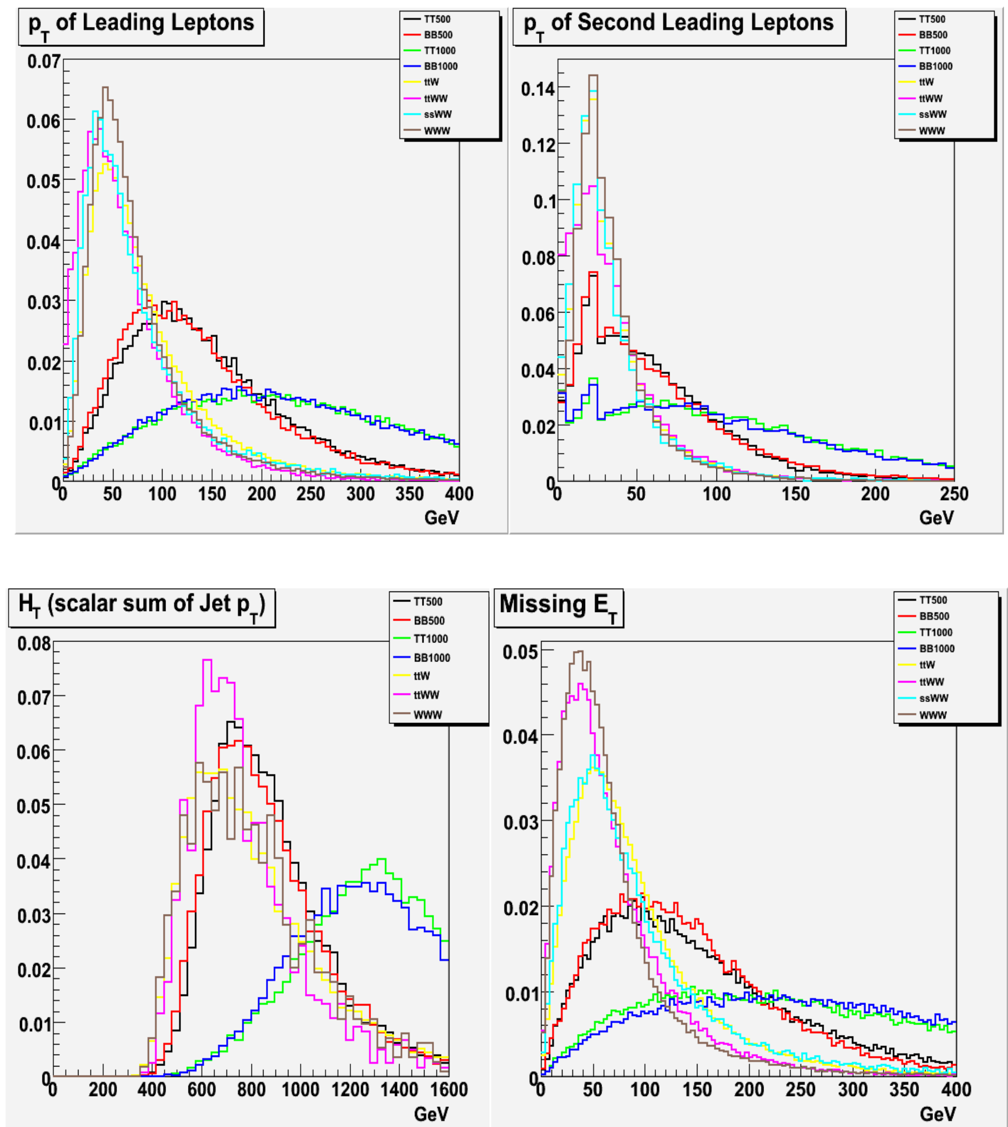


Signature: $l^{\pm}l^{\pm} + n\ jets + \not{E}_T\ (n \geq 5)$

Look for tW invariant mass peak ($T_{5/3}$)

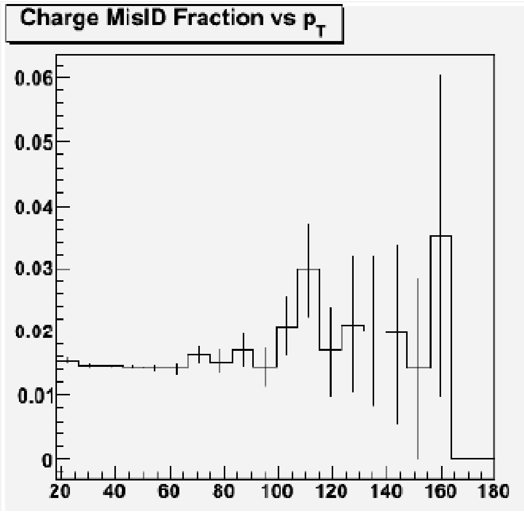
Top partners

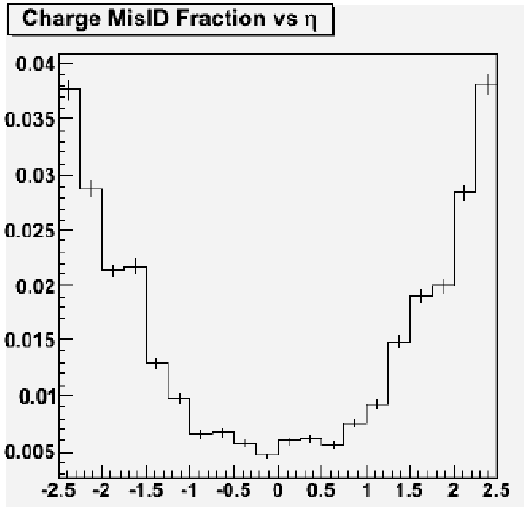
- Jets:
  - $|\eta| < 5$
  - Leading jet with $p_T > 100$ GeV
  - Second jet with $p_T > 80$ GeV
  - 5 jets with $p_T > 30$ GeV
- Leptons (electrons or muons):
  - $|\eta| < 2.4$
  - First lepton with $p_T > 50$ GeV
  - Second lepton with $p_T > 25$ GeV
  - Leptons must have same sign
- $E_T > 20$ GeV



Top partners: charge misID

- Most significant selection criterion: presence of same signed leptons
- Data-driven approach: Tag & Probe
  - Look at $Z \to l^+l^-$ events
  - Select pair of leptons with invariant mass near M_Z at least one of which is well-measured ("tag")
  - Look how often charge of the other lepton ("probe") is the same as that of the tag





SUSY searches

Finn Rebassoo (UCSB)

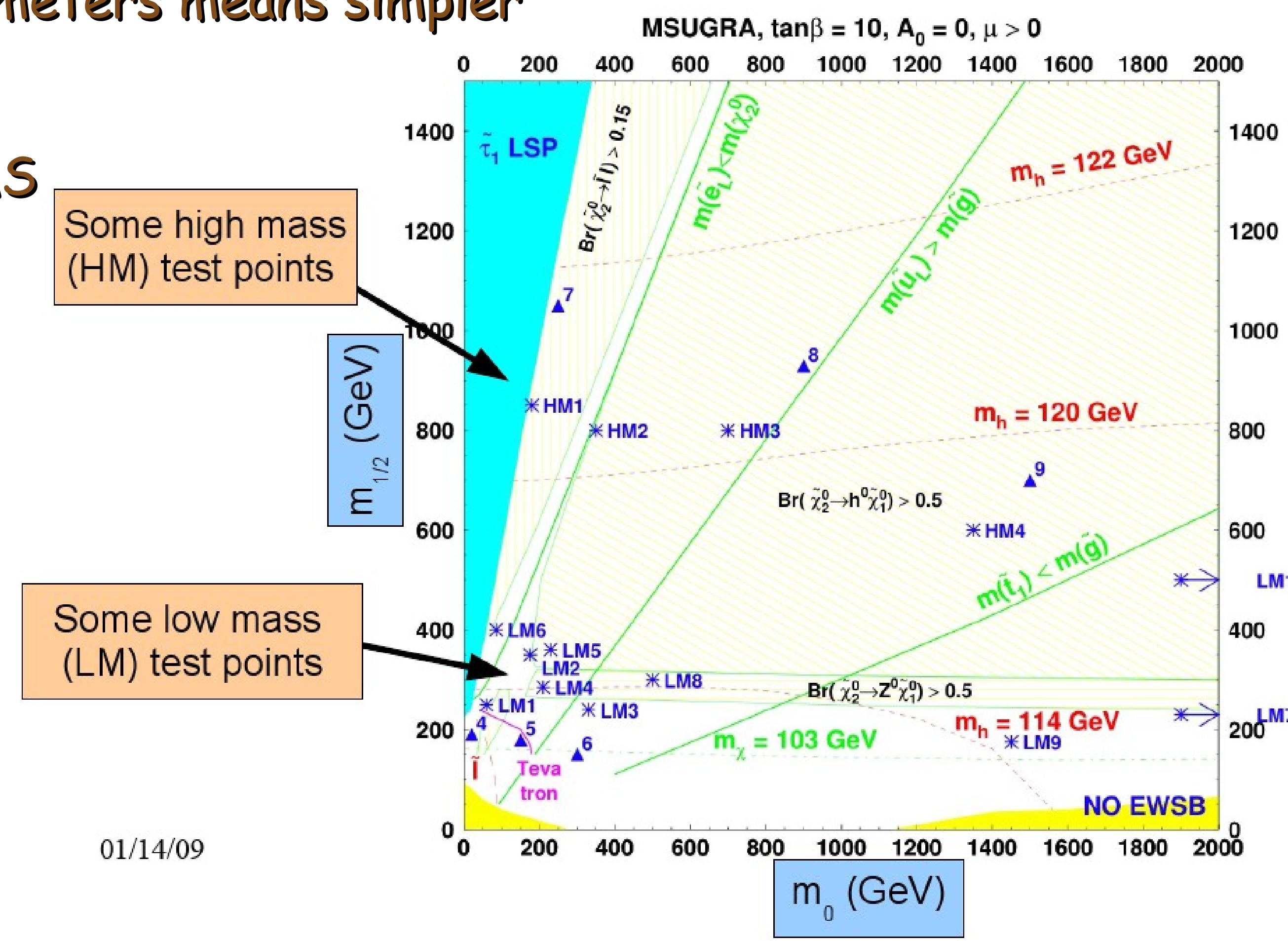
$$q \to \tilde{q} \qquad \gamma \to photino$$
$$l \to \tilde{l} \qquad g \to gluino$$
$$W^{\pm} \to winos \qquad H^{\pm} \to higgsino$$
$$Z \to zino$$

Charginos, $\tilde{\chi}^{\pm}_{1,2}$, neutralinos $\tilde{\chi}^{0}_{1,2,3,4}$ result from mixing of gauginos and higgsino

- SUSY: theory invariant w/ transformation fermion ↔ boson
- SUSY predicts spin ΔJ =±1/2 superpartner for each Standard Model particle
- If SUSY unbroken partner particles have same mass as SM particles, so SUSY must be broken!
- Minimal Supersymmetric Standard Model (MSSM) adds minimal possible number of particles to SM
- Unknown process of symmetery breaking leads to
  - ~100 parameters! Can't explore full parameter space

SUSY and mSUGRA

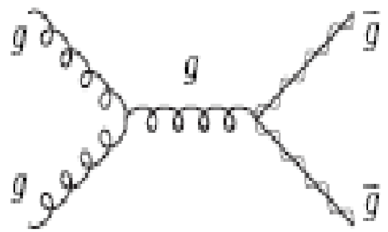
- Assumes symmetry breaking mediated by gravitational interaction
- Only 5 parameters: m_0, $m_{1/2}$, A_0, $\tan(\beta)$, $\mathrm{sign}(\mu)$
  - Small number of parameters means simpler to explore
- Main model studied in CMS
- Parameters determine:
- $m_{sparticles}$, $\sigma_{sparticles}$, Γ_i/Γ_{total}



01/14/09

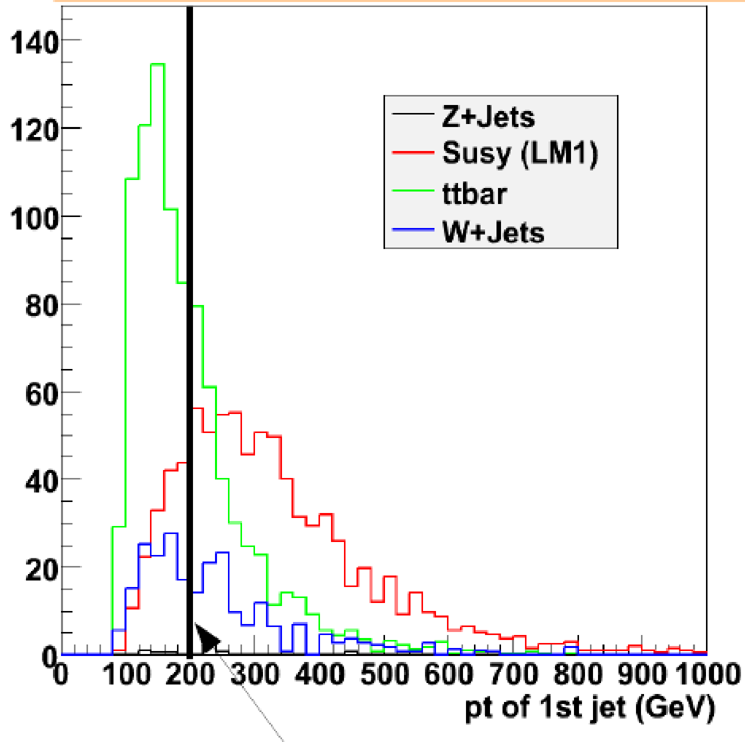
R-parity

- R-Parity, new quantum number in SUSY
  - Preserves baryonic and leptonic conservation
  - Sparticles produced in pairs
  - Lightest SUSY Particle (LSP) stable

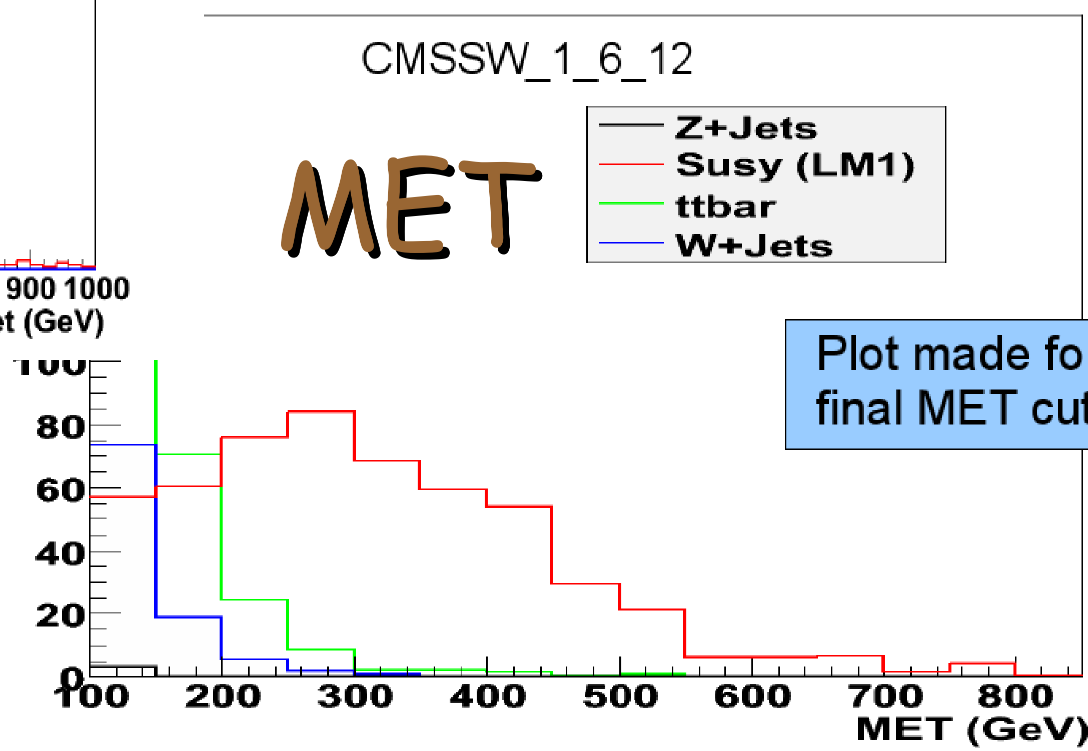


- LSP's interact weakly so can't detect directly
  - missing transverse energy (MET)
  - In general, MET SUSY > MET SM, b/c LSPs heavier than neutrinos
  - Common experimental signature when studying SUSY

p_T^{j1} after all cuts up to p_T^{j1} cut



MET

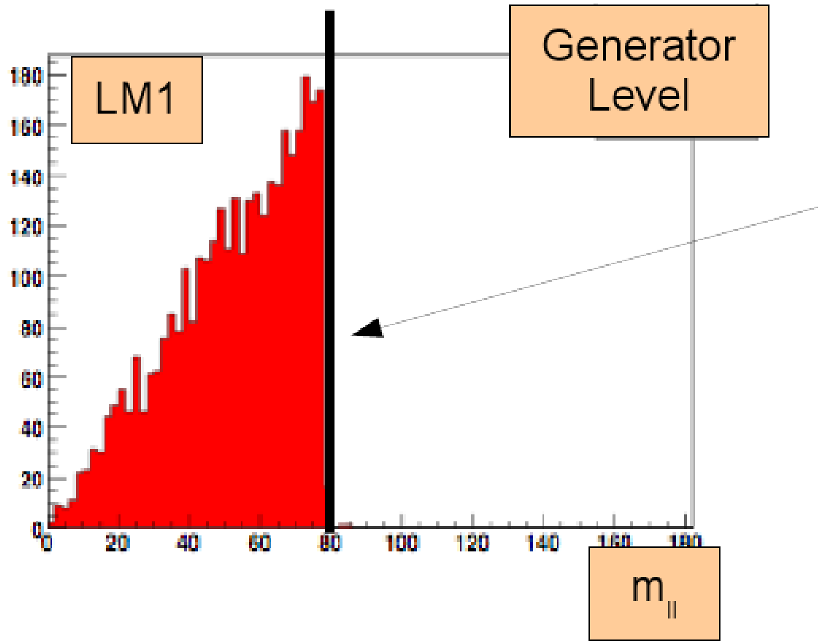


Plot made for all cuts except final MET cut at 250 GeV

Dilepton + jets + MET

Karapostoli, Sphicas, CMS Analysis note AN 2008/038

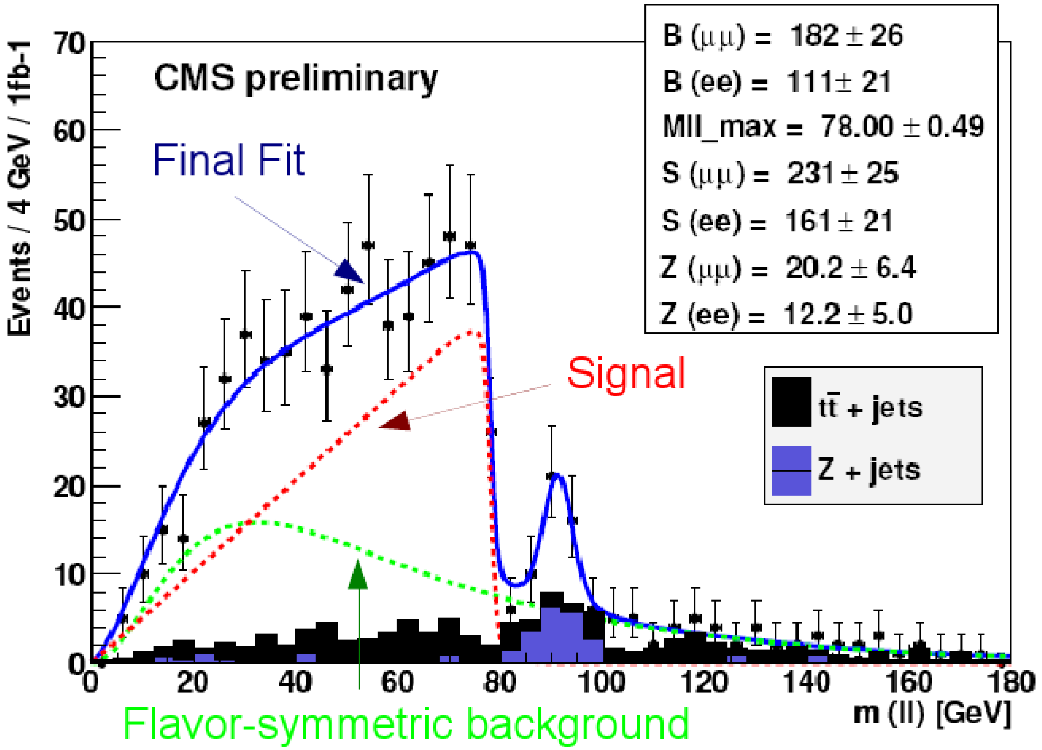
- Look at "mass peak" of leptons from $\tilde{\chi}_2^0 \rightarrow l^{\pm} l^{\mp} \tilde{\chi}_1^0$
- LSP missing, m_{ll}^{max} shape characterized by triangle function
- Predominantly flavor-symmetric background
  - Produces ee/μμ and eμ final states w/ equal probability
  - Comes from ttbar, WW, uncorrelated SUSY, etc.



Mass edge given by:

$$m_{ll}^{max} = m_{\tilde{\chi}_2^0} \sqrt{1 - \frac{m_{\tilde{l}_R}^2}{m_{\tilde{\chi}_2^0}^2}} \sqrt{1 - \frac{m_{\tilde{\chi}_1^0}^2}{m_{\tilde{l}_R}^2}}$$

Dilepton + jets + MET



Endpoint final fit values

$$m_{ee}^{max} = 77.90 \pm 1.07 \pm 0.36\, GeV/c^2$$

$$m_{\mu\mu}^{max} = 78.03 \pm 0.75 \pm 0.18\, GeV/c^2$$

$$m_{ll}^{max}(TH) = 78.15\, GeV/c^2$$

- Fit function: $F(m) = N_{sig} S(m) + N_{bkg} B(m) + N_Z Z(m)$

Signal Model, intended to fit for endpoint value

Describes flavor-symmetric background. Modeled from eμ shape in data

Describes Z-peak

Join!

- Many common issues, tools
  - Estimating multijet/fake lepton backgrounds from data
  - Understanding W+jets with data
  - Ttbar both as a source of physics and an important background
  - Generator tuning
  - Dealing with imperfect detector at low luminosity

These and other early topics to work on in a l+j group.

Of course, it's the CMS physics groups where things must go for approval. This group can serve as an incubator -- a place to have informal, free-wheeling discussions, polish up analyses, and provide much-needed mentorship.