LPC JTerm IV- Jet+MET Topology
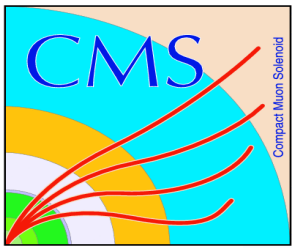
Search for Jets + MET + B-Jets in Final State

Harold Nguyen and Bill Gary

University of California, Riverside
5-August-2009
contact: harold.nguyen@cern.ch

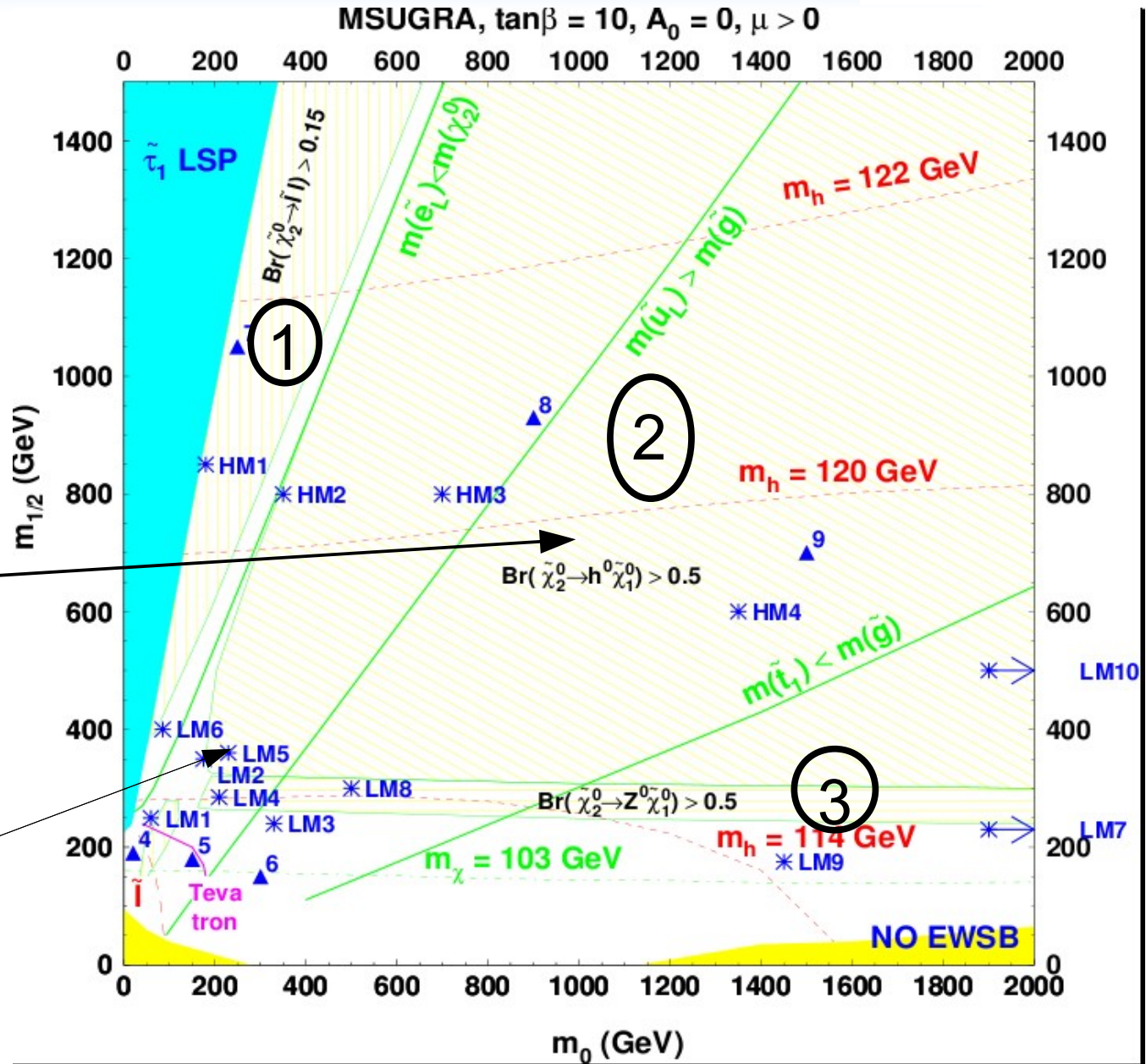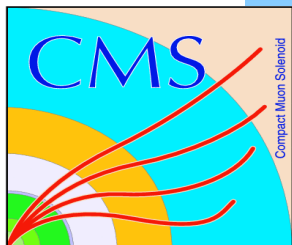# Introduction

•Search for Supersymmetry in the Minimal Supersymmetry Model (MSSM)

•Focus on version derived from Supergravity called mSUGRA

• Large parameter space of dominant decay of neutralino (χ_2)^0 to h0, which decays mainly to bb

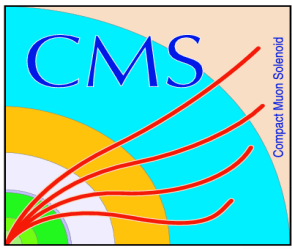• Work in LM5 for now (within this parameter space)

MSUGRA, $\tan\beta = 10$, $A_0 = 0$, $\mu > 0$

Why look at B-Jets in Final State

- Hadronic SUSY events are characterized by jets + MET

- The jets are typically rich in b-jets because the s-top and s-bottom quarks tend to be lighter than the other squarks in much of mSugra parameter space

- Thus the anomalous production of b-jets is a signature for SUSY

- In addition, SUSY might be observed through the h->bb-bar channel, where the Higgs h is produced in the SUSY decay chain.

- We mostly focus on a search for SUSY h->bbbar

- **Previous studies by**
  - **Wolfgang Adam June 08**
  - **Tanja Rommerskirchen Feb. 07**
  - **Filip Moortgat May 06**

Taken from CMS NOTE 2006/090, Filip et al

Table 1: Some sparticle masses at LM5.

Sparticle	Mass (GeV/c^2)
$\tilde{g}$	860
$\tilde{q}$	800
$\tilde{\chi}_2^0$	273
$\tilde{\chi}_1^0$	142
h^0	116

Table 2: Interesting branching ratios at LM5.

Decay	Branching ratio in %
$\tilde{g} \rightarrow \tilde{q} + q$	100
$\tilde{q} \rightarrow \tilde{\chi}_2^0 + q$	35
$\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 + h^0$	85
$h^0 \rightarrow b\bar{b}$	72
$\tilde{q} \rightarrow \tilde{\chi}_2^0 + q$ and $\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 + h^0 \rightarrow \tilde{\chi}_1^0 + b\bar{b}$	21

LM5
M_0 = 230 GeV
$M_{1/2}$ = 360 GeV
A = 0
Tan β = 10
Sign μ positive

Picture taken from Filip Moortgat's talk 2006
cms.umh.ac.be/site_web/protected/cms/an_approval2_26042006.pdf
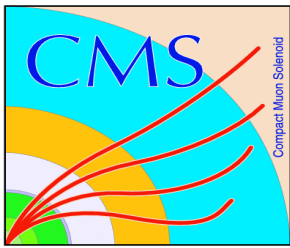
Goals

Inclusive Analysis:

- **Search for an anomalous rate of events with Jets + MET + b-jets**

Exclusive Analysis:

- **Reconstruct h0 ->bb invariant mass peak (this talk focuses on this)**

Outline of Talk:

- **Apply basic RA2 (Reference Analysis) selection cuts**

- **Apply B-Tagging Selection**

- **Develop strategy to identify h0->bbbar**

Samples Used

Using Software CMSSW_2_2_3 (CM energy = 10TeV)

Signal /SUSY_LM5-sftsht/Summer08_IDEAL_V9_v1/GEN-SIM-RECO (200k)

Electroweak Background
/TTJets-madgraph/Fall08_IDEAL_V9_v2/GEN-SIM-RECO (1 million)
/Wjets-madgraph/Fall08_IDEAL_V9_v1/GEN-SIM-RECO (10 million)
/Zjets-madgraph/Fall08_IDEAL_V9_reco-v2/GEN-SIM-RECO (1 million)
/ZinvisibleJets-madgraph/Fall08_IDEAL_V9_v2/GEN-SIM-RECO
(1 million)

Pythia QCD Background
/QCDpt80/Summer08_IDEAL_V9_v2/GEN-SIM-RECO
/QCDpt170/Summer08_IDEAL_V9_v3/GEN-SIM-RECO
/QCDpt300/Summer08_IDEAL_V9_v1/GEN-SIM-RECO (3 million)
/QCDpt470/Summer08_IDEAL_V9_v1/GEN-SIM-RECO
/QCDpt800/Summer08_IDEAL_V9_v5/GEN-SIM-RECO
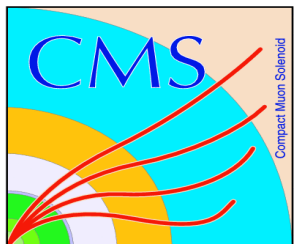/QCD1400/Summer08_IDEAL_V9_reco-v5/GEN-SIM-RECO
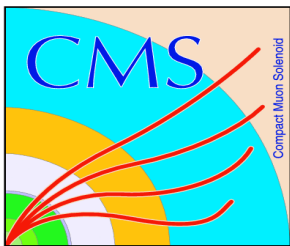
"Reference Analysis 2" Cuts

- Selection cuts according to:

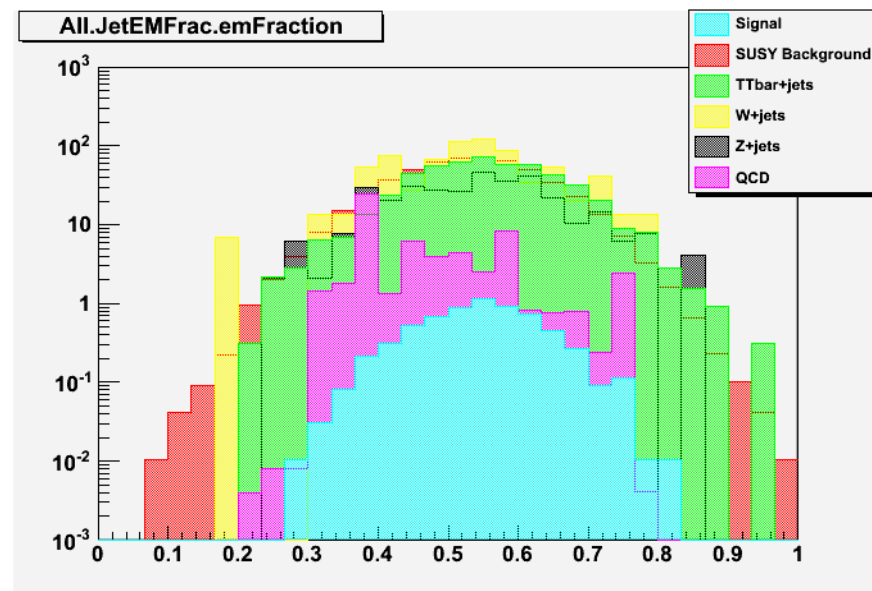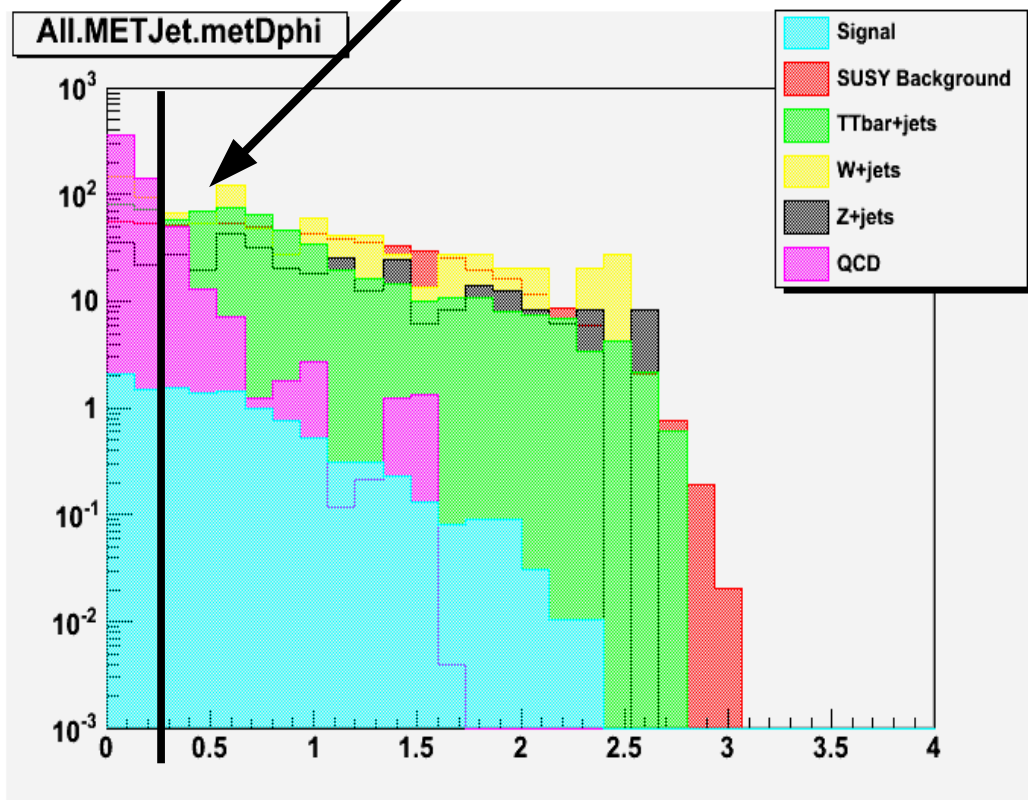https://twiki.cern.ch/twiki/bin/view/CMS/SusyRA2InclusiveNJetProjectTable

- SUSY Reference Analysis group with channel >= 3 jets and MET

- **Require at least 3 jets in each event**

- **Jet Pt cut at 180/110/30**

- **Jet |eta| < 2.5, 2.5, 2.5**

- **At least 1 Primary Vertex in each Event**

- **MET cut at 200 GeV**

- **Jet-MET correlation (dPhi>0.3, dPhi2>0.3)**

- **0.05<EmFraction<0.95 for each Jet**

-Using Iterative Cone 0.5 (SusyPAT v4 Tags)

UNIVERSITY of CALIFORNIA
Riverside

•Lower bound cut at 0.3
to remove QCD events
with mis-measured jets

All.METJet.metDphi

Legend:
- Signal
- SUSY Background
- TTbar+jets
- W+jets
- Z+jets
- QCD

All.JetEMFrac.emFraction

Legend:
- Signal
- SUSY Background
- TTbar+jets
- W+jets
- Z+jets
- QCD

•Cut at **low** EMfraction removes
potential muon beam halo
•Cut at **high** EMfraction
removes electrons and photons
that "fake" jets
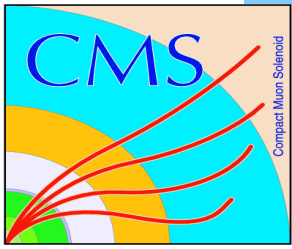
B-Tagging

Algorithm:

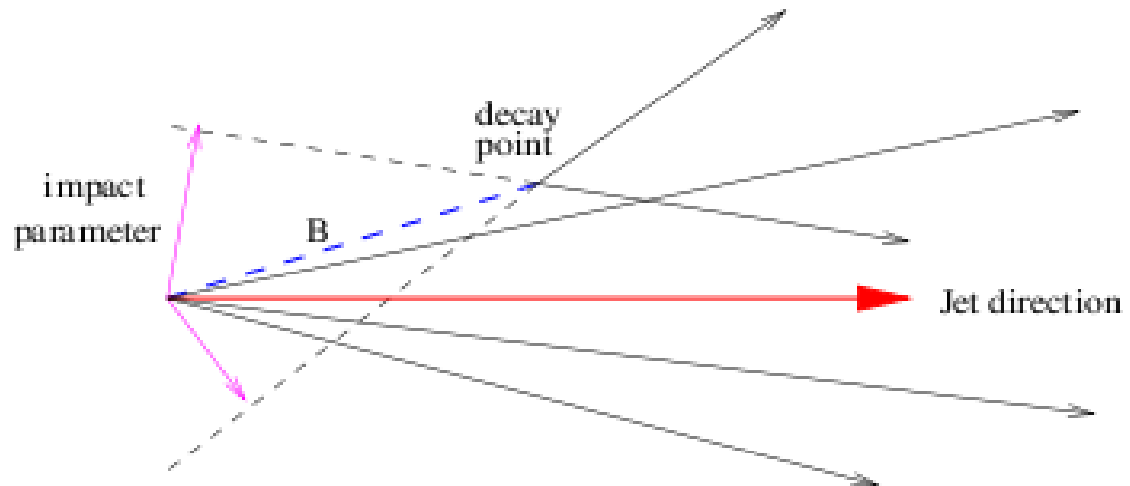• Used High Efficiency Track-Counting Algorithm
http://cms.cern.ch/iCMS/jsp/openfile.jsp?type=NOTE&year=2006&files=NOTE2006_019.pdf
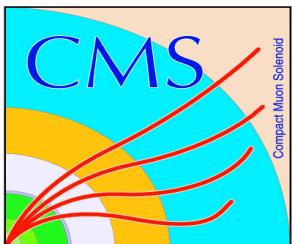
• Impact parameter significance is ratio between the track impact parameter and its uncertainty

Discriminator defined as the 2nd largest impact parameter significance

B-Jet Requirements:
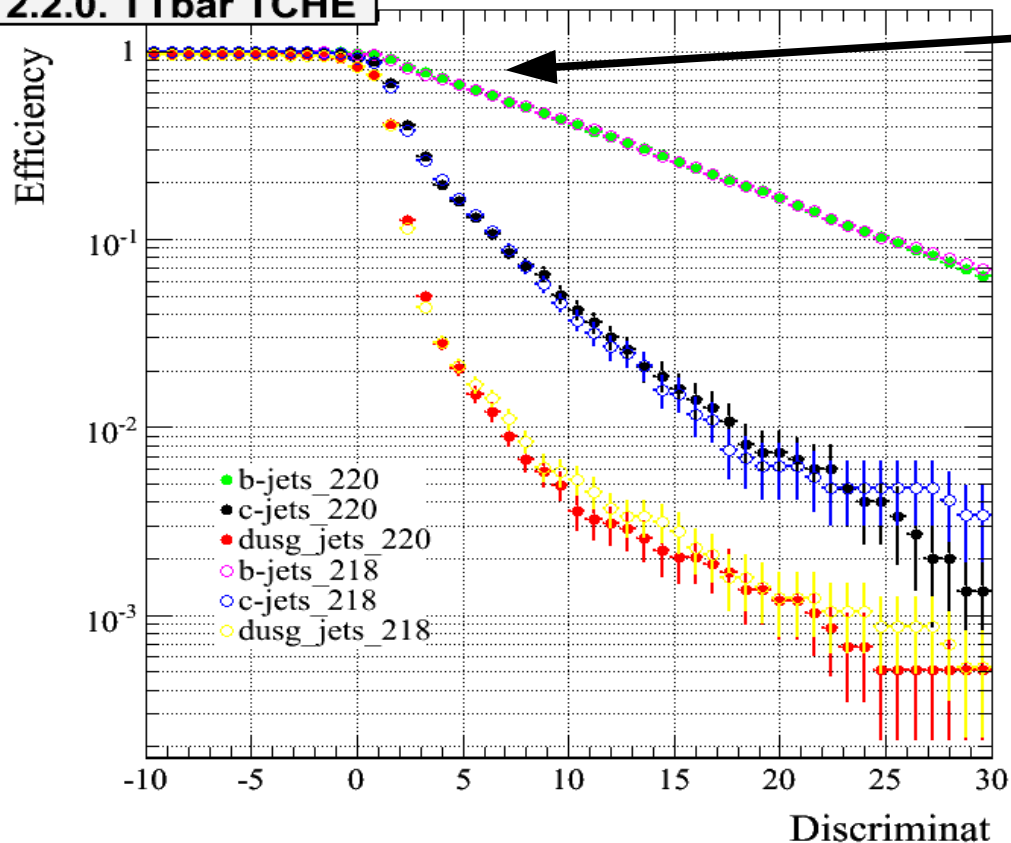
• pT > 30 GeV

• |eta| < 3

• Discriminator > 5

Efficiency and Purity Vs Discriminator

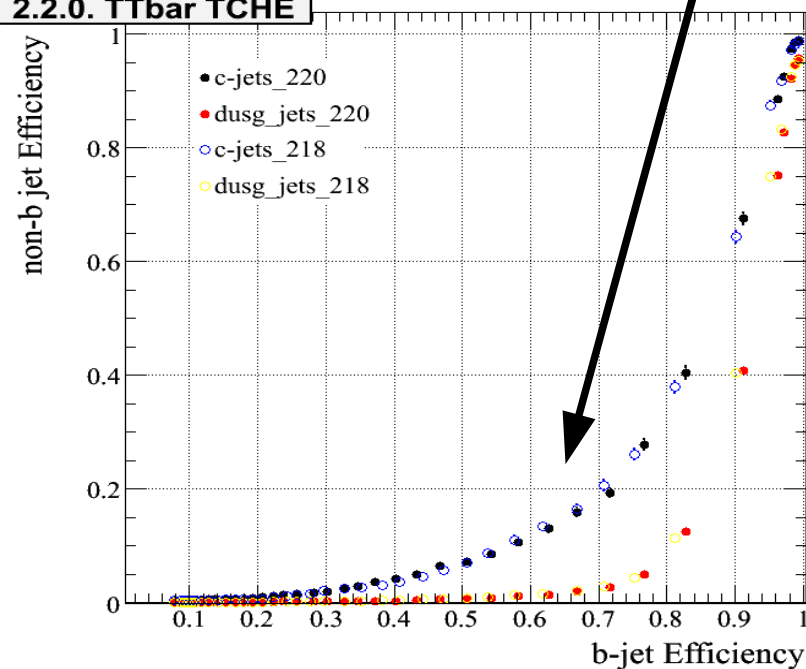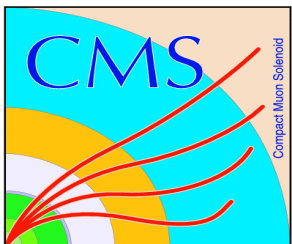Provided by B-Tagging group at:

http://cmsrocstor.fnal.gov/lpc1/cmsroc/yumiceva/validation/

Discriminator 5 gives 60-70% **efficiency**, and 70-80% **purity**

Cutflow for 100 pb^-1

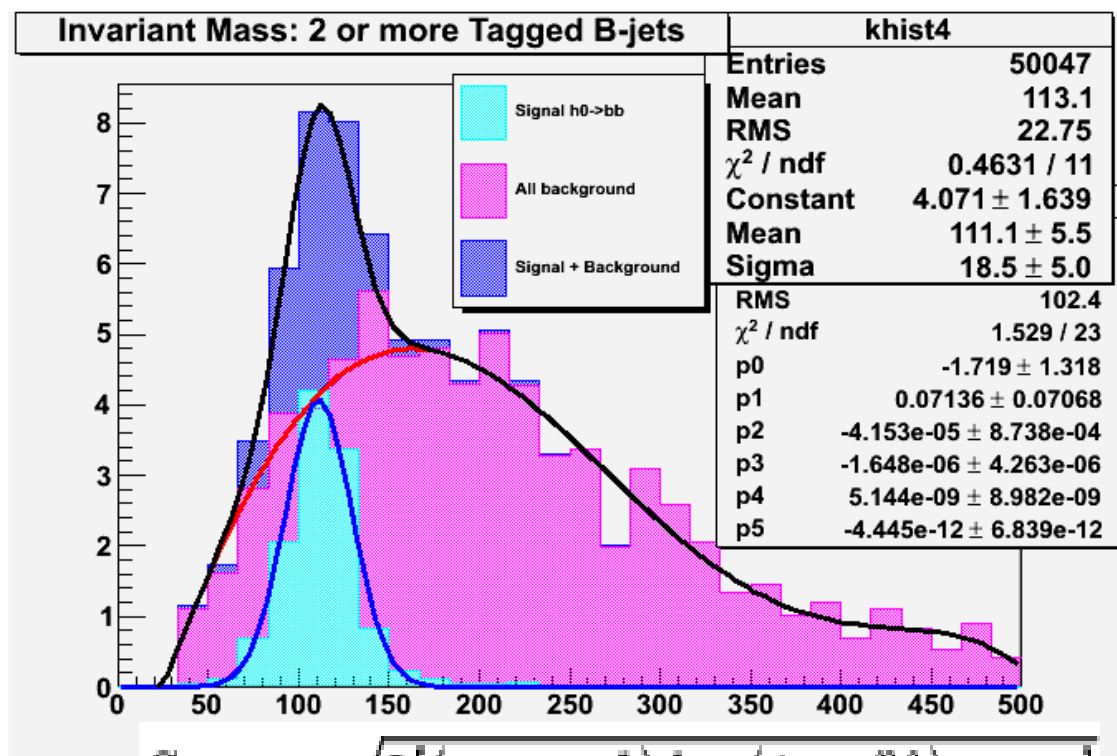| Quantity	LM5	TT-Jets	W-Jets	ZJets	Z-Invis	QCD 80 Pt	QCD 170 PT	QCD 300 PT	QCD 470 PT	QCD 800 PT	QCD 1400 PT
All Events	146	30466	1e06	1e05	5e04	2e08	6e06	3e05	3e04	1207	17
Jets-Preselect	98%	99%	23%	38%	28%	89%	96%	98%	98%	98%	98%
Direct LV	68%	62%	12%	13%	28%	87%	91%	90%	88%	85%	80%
Final Jet Select	52%	15%	0.05%	0.05%	0.31%	7%	58%	73%	76%	75%	71%
MET Cut	33%	0.07%	0	0	0.01%	0	0	0.04%	0.28%	1.2%	4.0%
Jet-MET	25%	0.04%	0	0	0.01%	0	0	0	0	0	0.35%
2 B-Jets (Events)	470	14	0	0	0	0	0	0	0	0	0
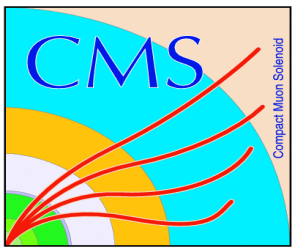
Invariant Mass Plot

- An important source of b-jets come from b-jet decays from a bottom squark to chi2 + b

- Therefore, sbottom daughters get more allowed phase space than Higgs daughters

- So choose 2nd and 3rd leading energetic b-jets as candidates for invariant mass plot

- TTJets dominates SM background
- No Z-Jets, W-Jets survive
- Main background contribution due to SUSY background

Invariant Mass: 2 or more Tagged B-jets

Legend:
- h0->bb
- SUSY Background
- TTbar+jets
- W+jets
- Z+jets
- QCD
- All Background
- Background + Signal

Fit Procedure
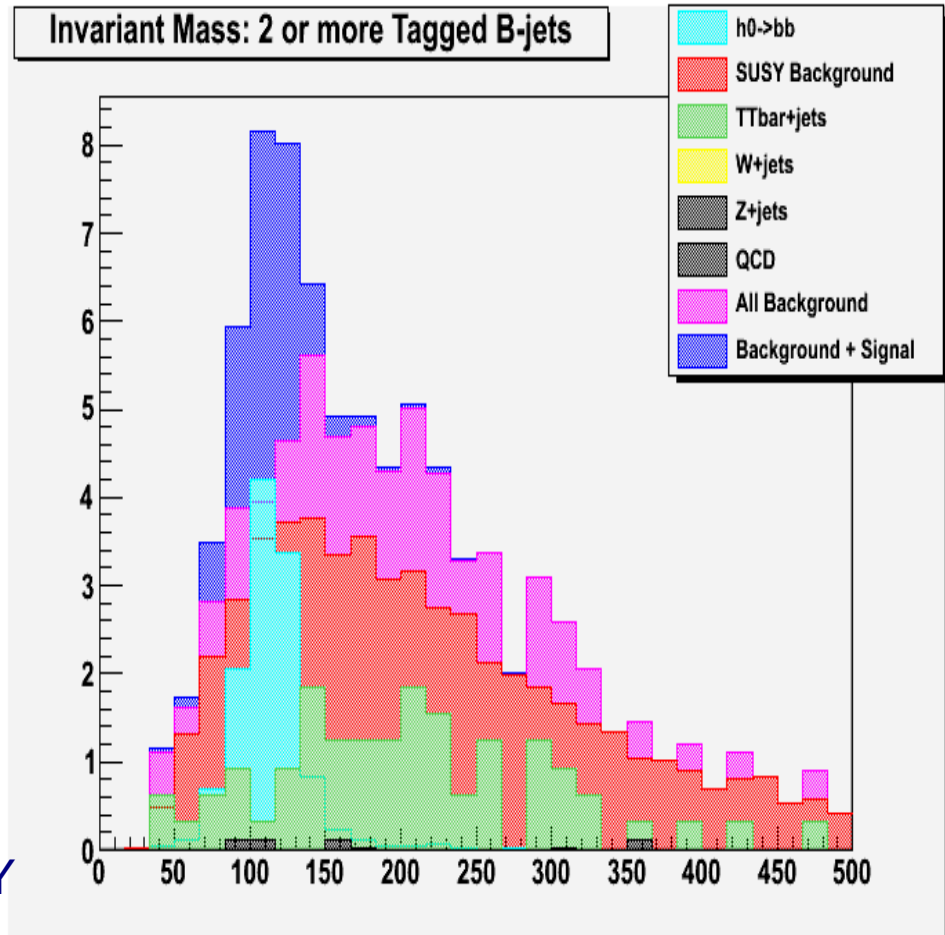
$$F(\alpha, m_h, \sigma) = N \left[(1. - \alpha) \, B + \alpha \, G(m_h, \sigma) \right]$$

- **F is global fit function**
- **B is background function (Poly5)**
- **G is Gaussian signal function**
- **N is normalization factor (fixed by no. of events in histogram)**
- **α is fraction of signal**

7 Free parameters:
- **mass of Higgs**
- **α**
- **5 Background shape coefficients**

Invariant Mass: 2 or more Tagged B-jets

Signal h0->bb
All background
Signal + Background

khist4	
Entries	50047
Mean	113.1
RMS	22.75
χ^2 / ndf	0.4631 / 11
Constant	4.071 ± 1.639
Mean	111.1 ± 5.5
Sigma	18.5 ± 5.0
RMS	102.4
χ^2 / ndf	1.529 / 23
p0	-1.719 ± 1.318
p1	0.07136 ± 0.07068
p2	$-4.153\text{e-}05 \pm 8.738\text{e-}04$
p3	$-1.648\text{e-}06 \pm 4.263\text{e-}06$
p4	$5.144\text{e-}09 \pm 8.982\text{e-}09$
p5	$-4.445\text{e-}12 \pm 6.839\text{e-}12$

Ns and nb calculated by counting number of b-jet pairs with invariant mass +/- 25 GeV around fitted center

$$S_{CL} = \sqrt{2\left[(ns + nb) \log\left(1 + \frac{ns}{nb}\right) - ns \right]}$$

SCL = 2.5

- **Actively looking at ways to improve signal and reduce background**
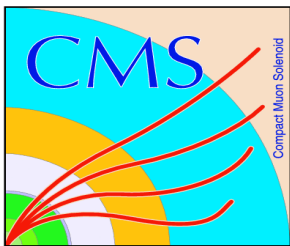
What We Can Expect at Start-Up

- Use RA2 selection, and data-driven techniques to evaluate SM background

- Top 3 b-tagging algorithms to tag b-jets at start-up:
    1) SoftMuonTagger – Needs further study to see if compatible with RA2 selection cuts
    2) TrackCounting – Algorithm used in study so far
    3) SimpleSecondaryVertexTagger – Looks to see if secondary vertex is constructed, is limited by 60% efficiency

- B-Tagging group will provide plots of mistag and efficiency as functions of et, eta, etc...

    B-Tagging performance will change based on topology – changes   from QCD to Ttbar, and will be expected to change for SUSY (if it exists)

**At start-up, resonance searches will probably be easier than looking at excess of b-jets.**

   Efficiency goes down when tagging more b-jets (60-70% efficiency for each b-jet, will be difficult for 3rd or 4th b-jet for low data)
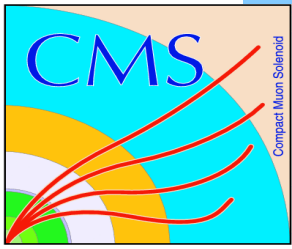
Summary

- Jet + MET + b's is an interesting channel and compliments RA2 SUSY search

  - Offers possibility to discover SUSY through h->bb channel

- We have been able to reconstruct the h->bb mass peak based on MC studies and at 100 pb^-1

- Finalize event selection and background estimation

- Summarize our study in a note
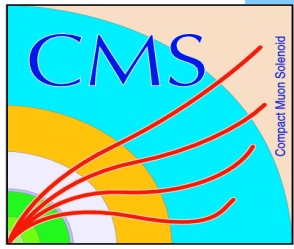
Thank You

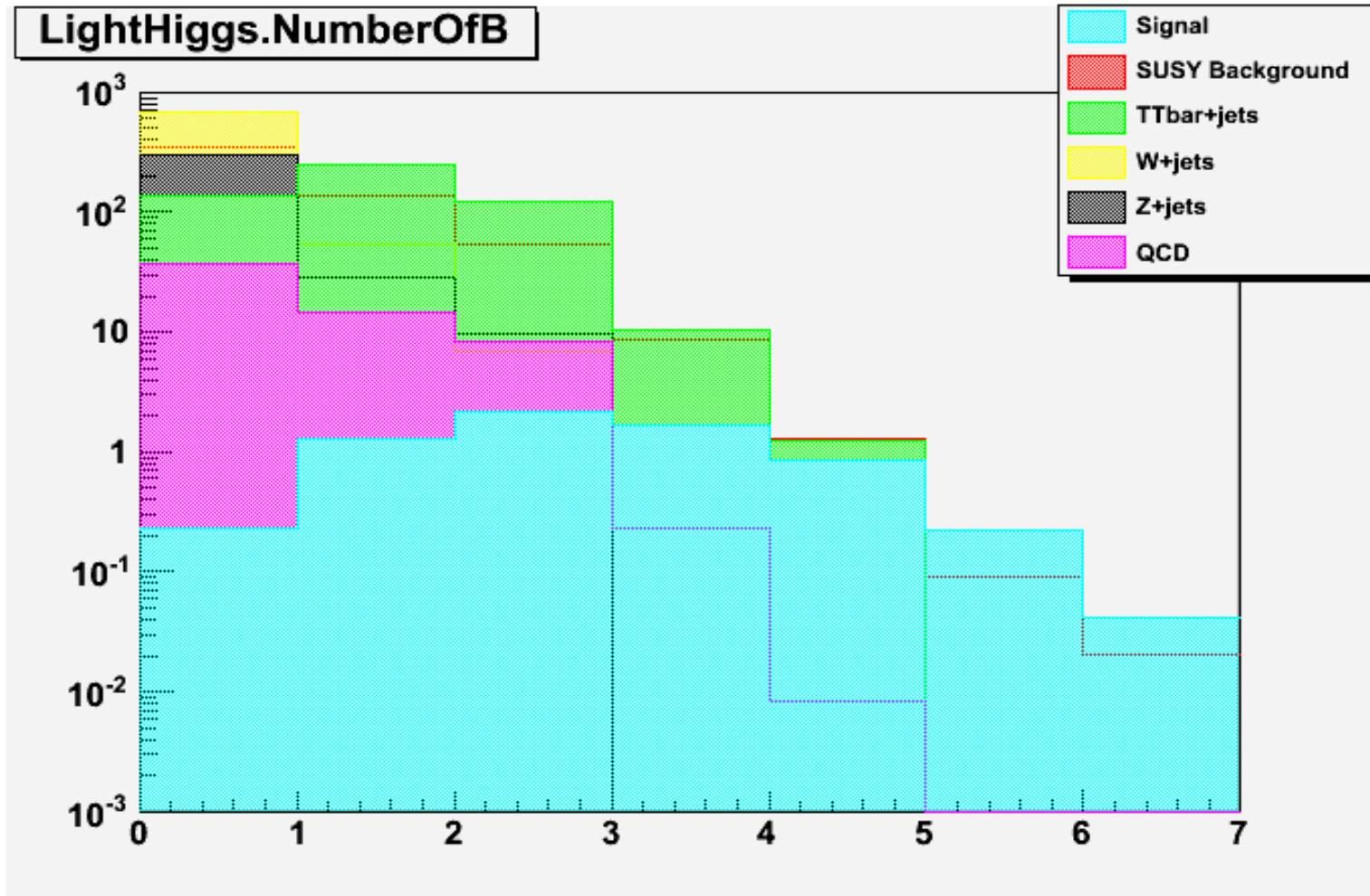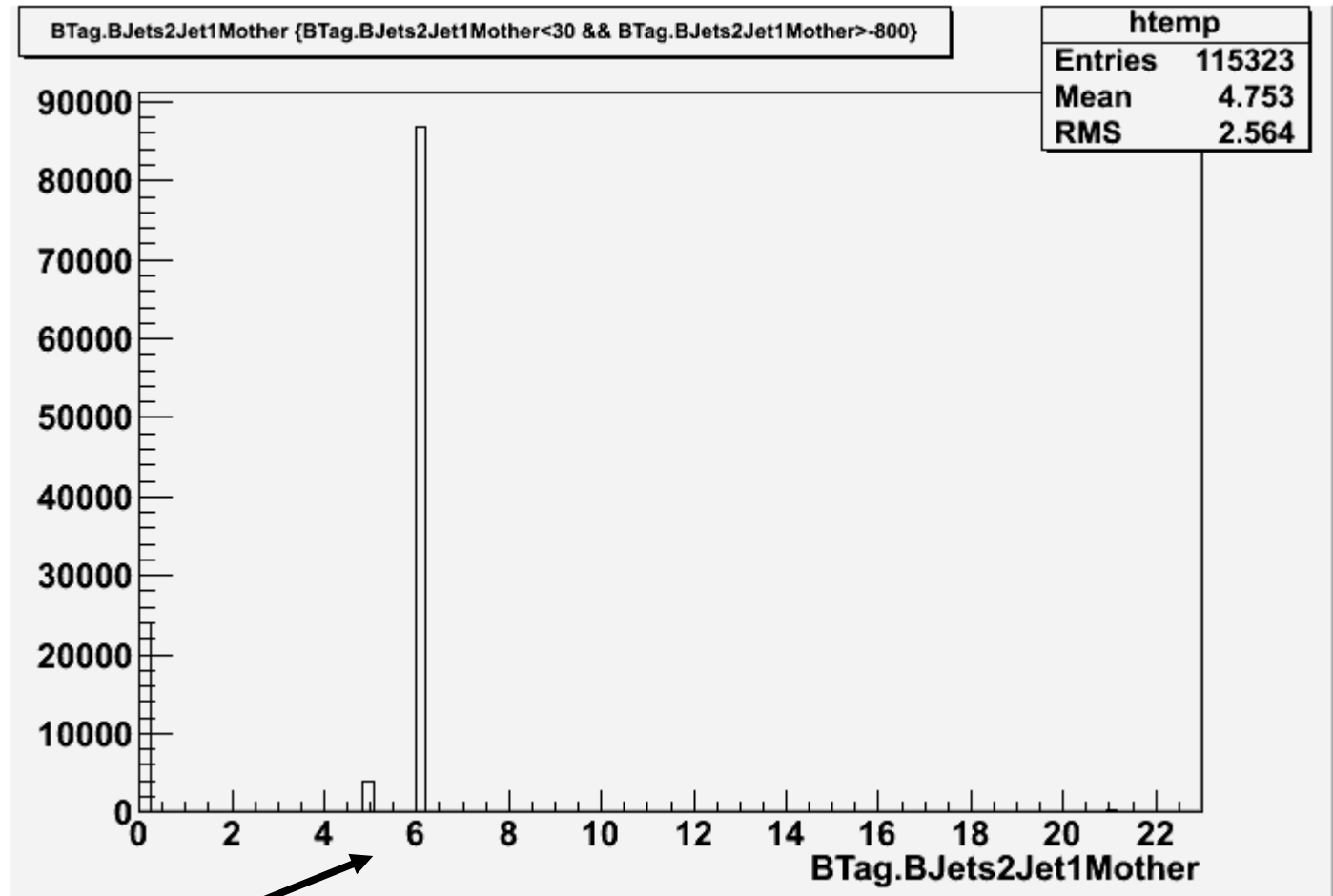# Backup Slides

Number of B-Jets

Distribution of mother pdg Id's of b-jets within TTJets

Events with exactly 2 tagged b-jets, we're looking at leading jet after passing through all cuts.
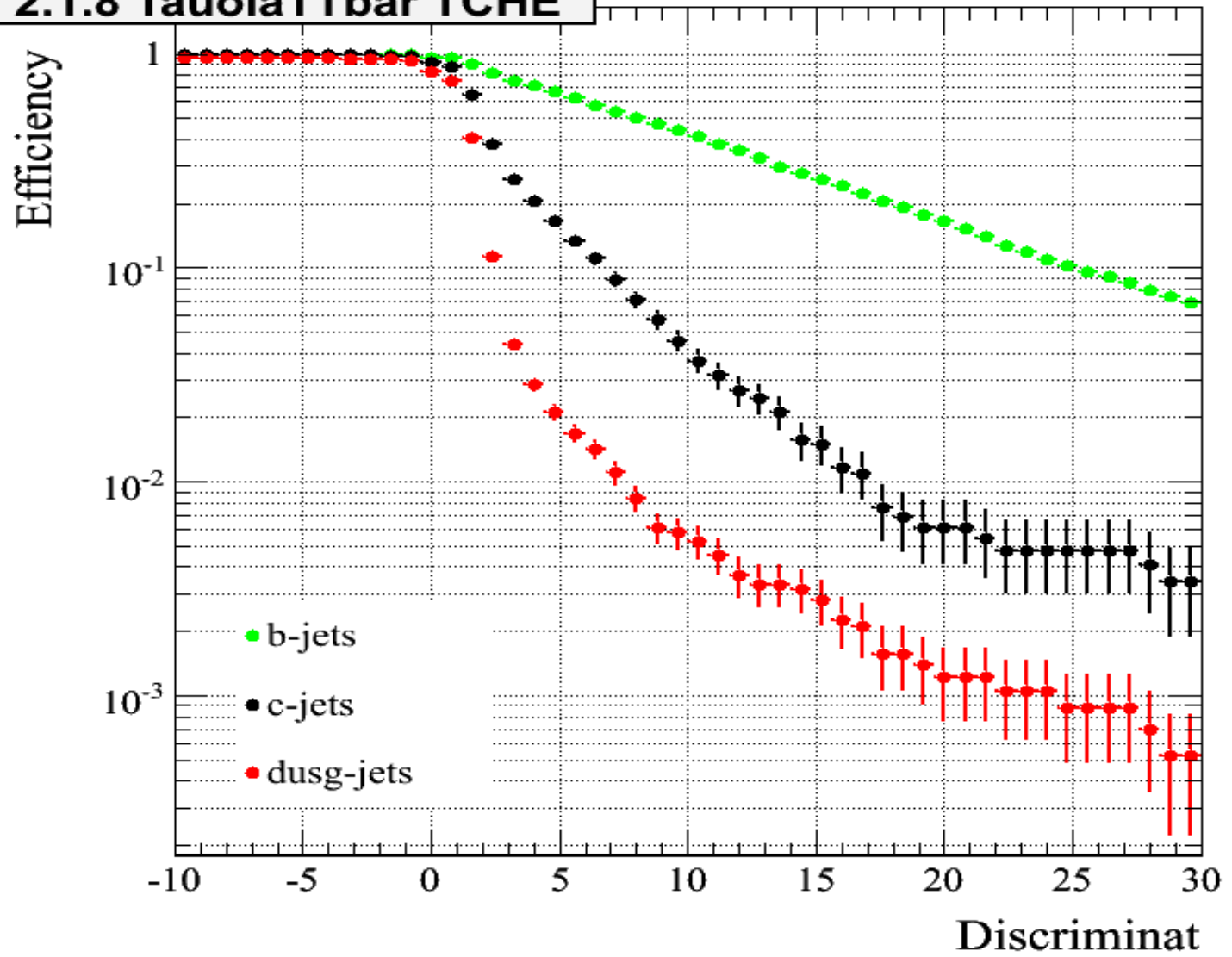

Top

As expected,

Mistag vs B-Tag Efficiency