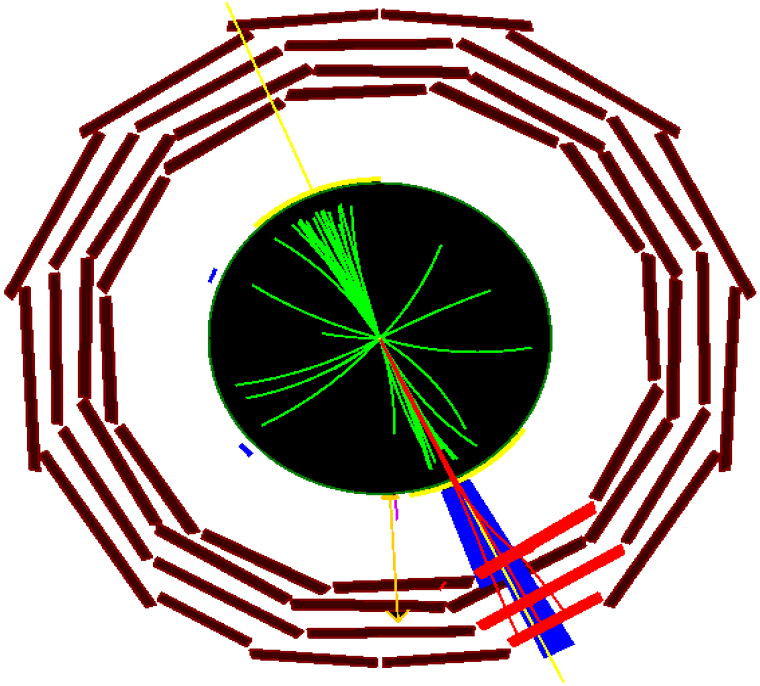
Detection of Punchthrough of High Energetic Jets



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DESY-CMS HCAL Upgrade Meeting
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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

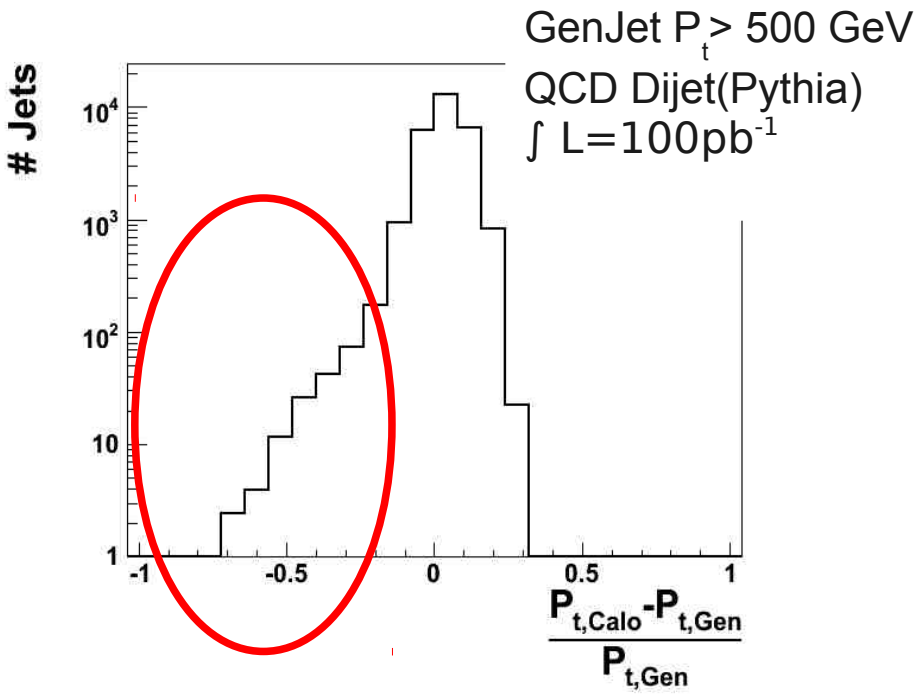
Overview

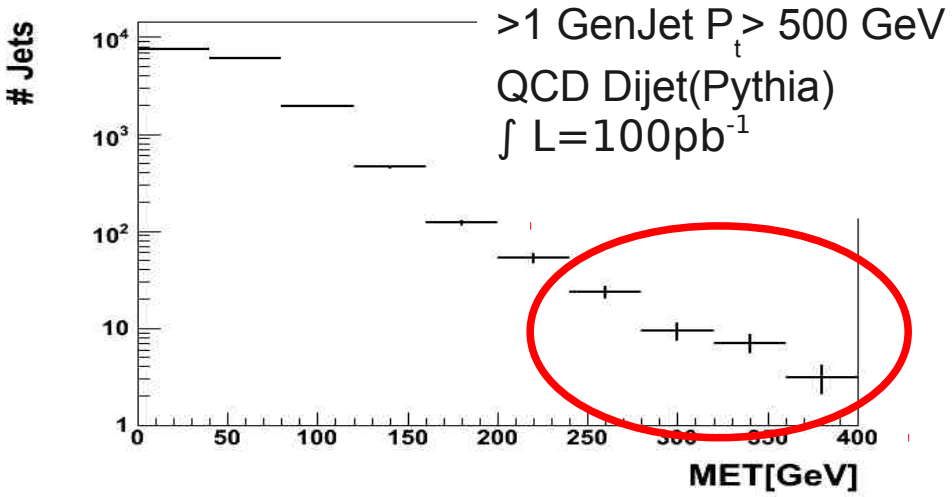
- Mismeasured high energetic jets

Understanding of tails fundamental for SUSY/Exotica searches

➡ Try to identify jets in tail according to effects (punchthrough,heavy flavor jets) using HO & hits in muon chambers

- Today:
  - results from an old study (2009)
  - only MC simulation





Mismeasured High Energetic Jets

1. B/C jets: heavy flavor jets with large fraction of energy in b-/c-quarks

→ Muons from b/c decays in jets should be measured in muon system

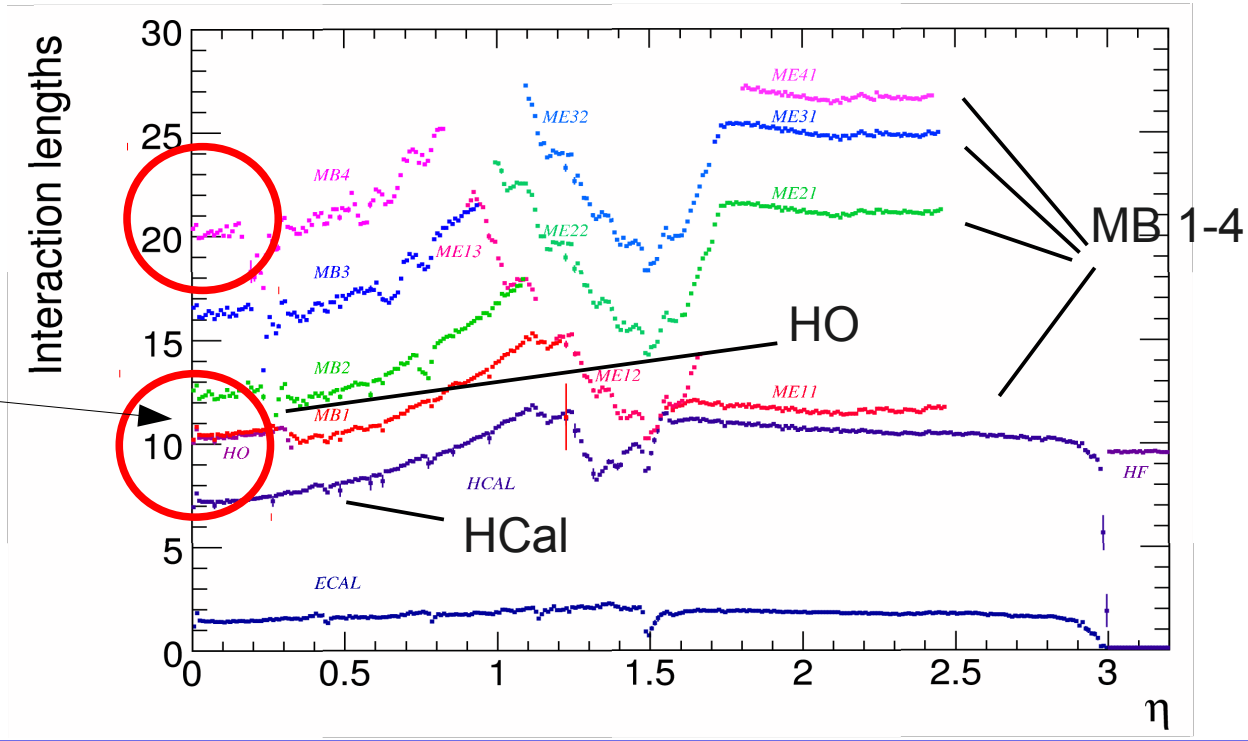
2. Punchthrough: only part of jet energy deposited inside calorimeters

Hadron calorimeter in barrel region ~7 interaction lengths (~10 with HO)

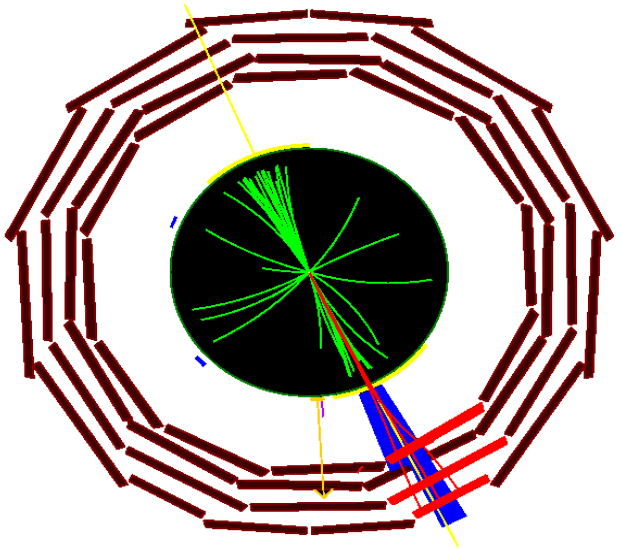
Including the 4 muon chambers ~20 interaction lengths

→ Punchthrough jets should cause hits in muon system

Thickness
HO only ~1.2 λ



Used Variables



Event display punchthrough:

QCD dijet event (MC)

Jets with 421 and 343 GeV

$\not{E}_t$ 72 GeV

Idea: Use muon hits in jet cone and HO to measure energy not deposited in calorimeters (barrel) → Use muon system as calorimeter!

Variables:

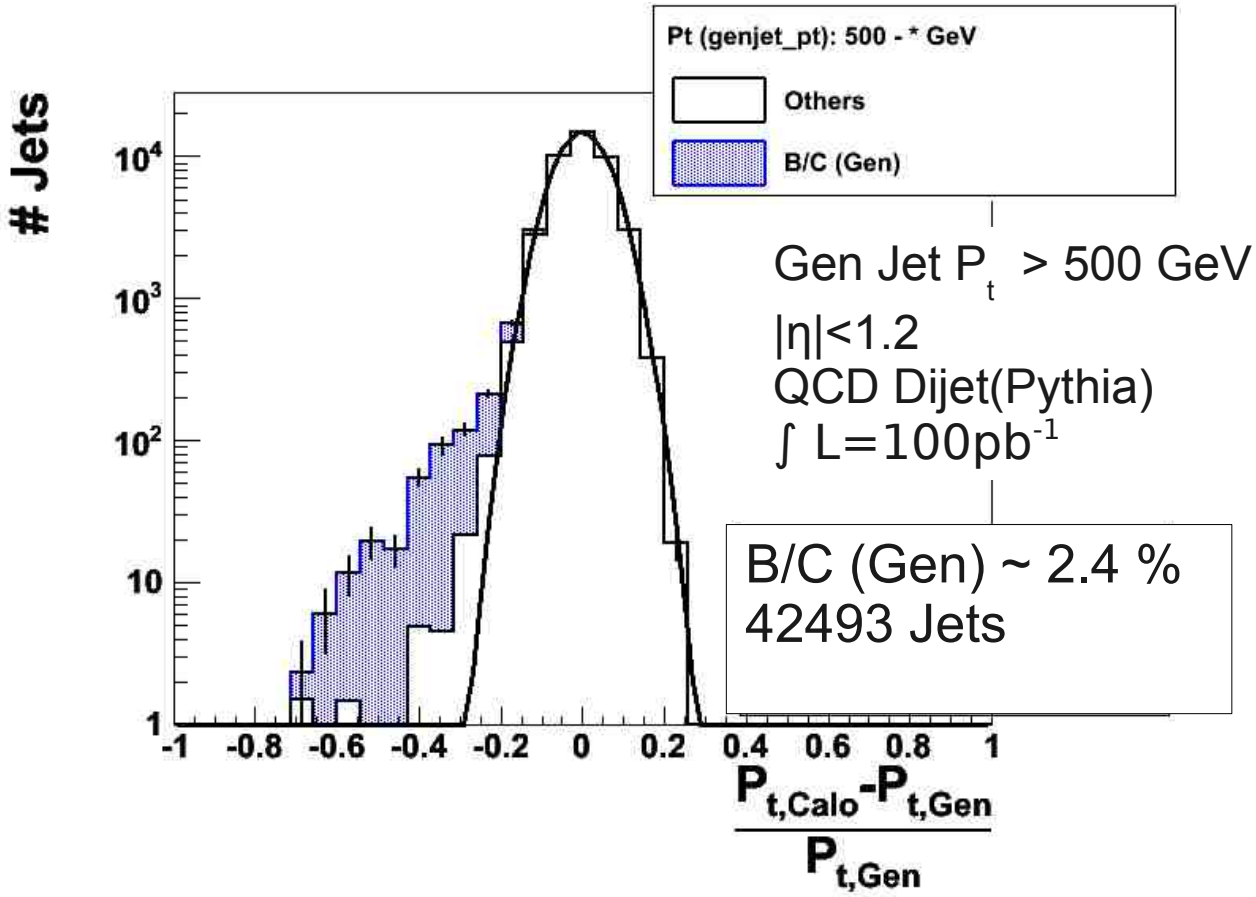
- #Hits in DT/RPC in muon station 1, 2, 3, 4, 3+4, 1+2, 1+2/3+4
- HO-fraction of jet
- P_t of reconstructed muons behind jet

Event selection: Summer09 10TeV MC; QCD dijet samples $\hat{P}_t$ >120 GeV; L2L3 corrected jets; MET corrected for JES and Muons

B/C Jets

Mismeasured B/C s on gen level:

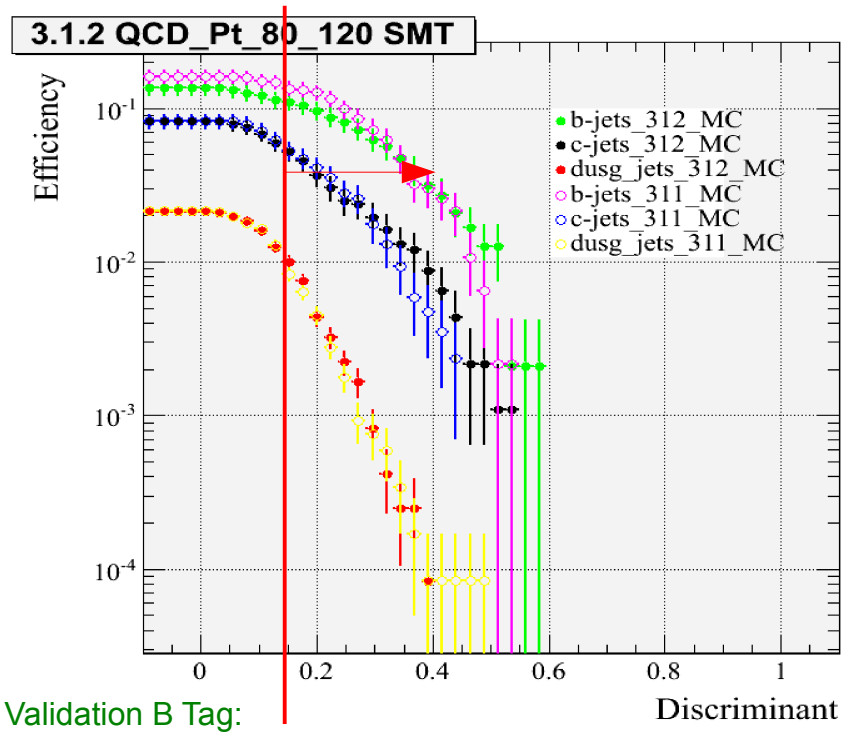
Invisible fraction of jet > 5% and B/C-fraction >20%

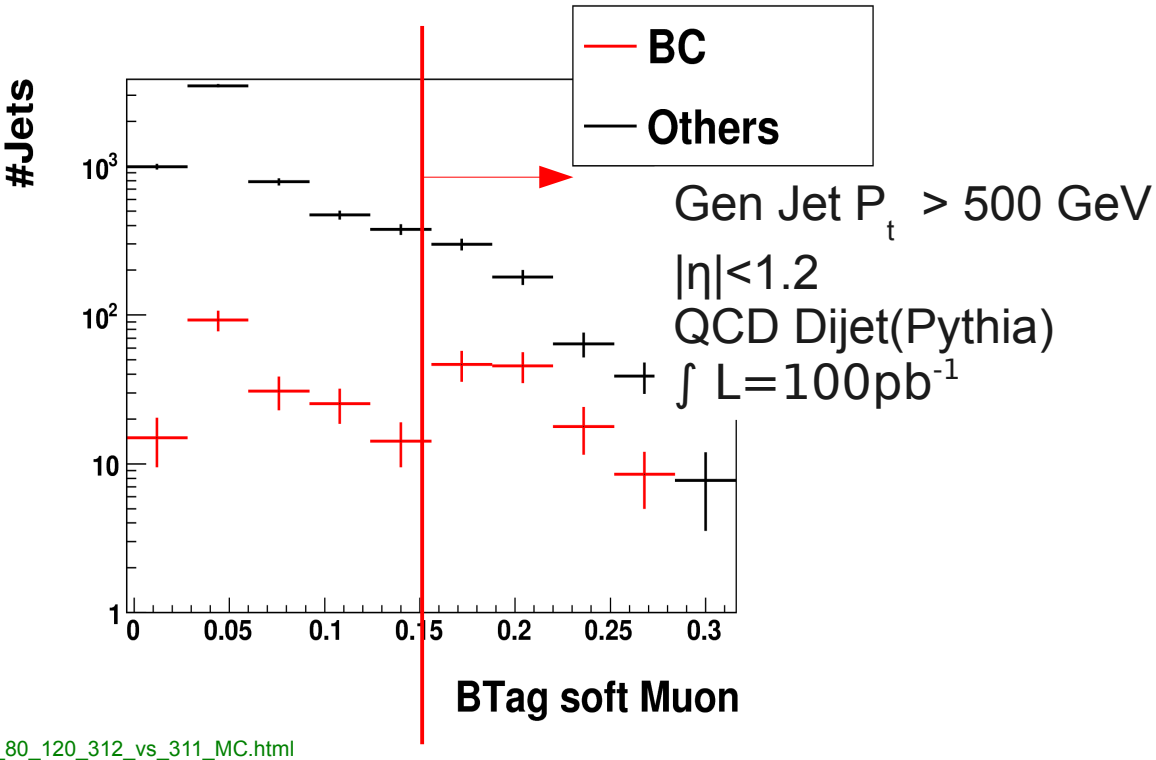


Selection of B/C Jets on Data Level

- Select b/c jets in tail on data level using soft muon b tag (> 0.15)
- b/c jets in tail can be selected with higher purity and efficiency using other muon system variables & other b tags
- Here: cut only used to reject b/c jets for punchthrough study

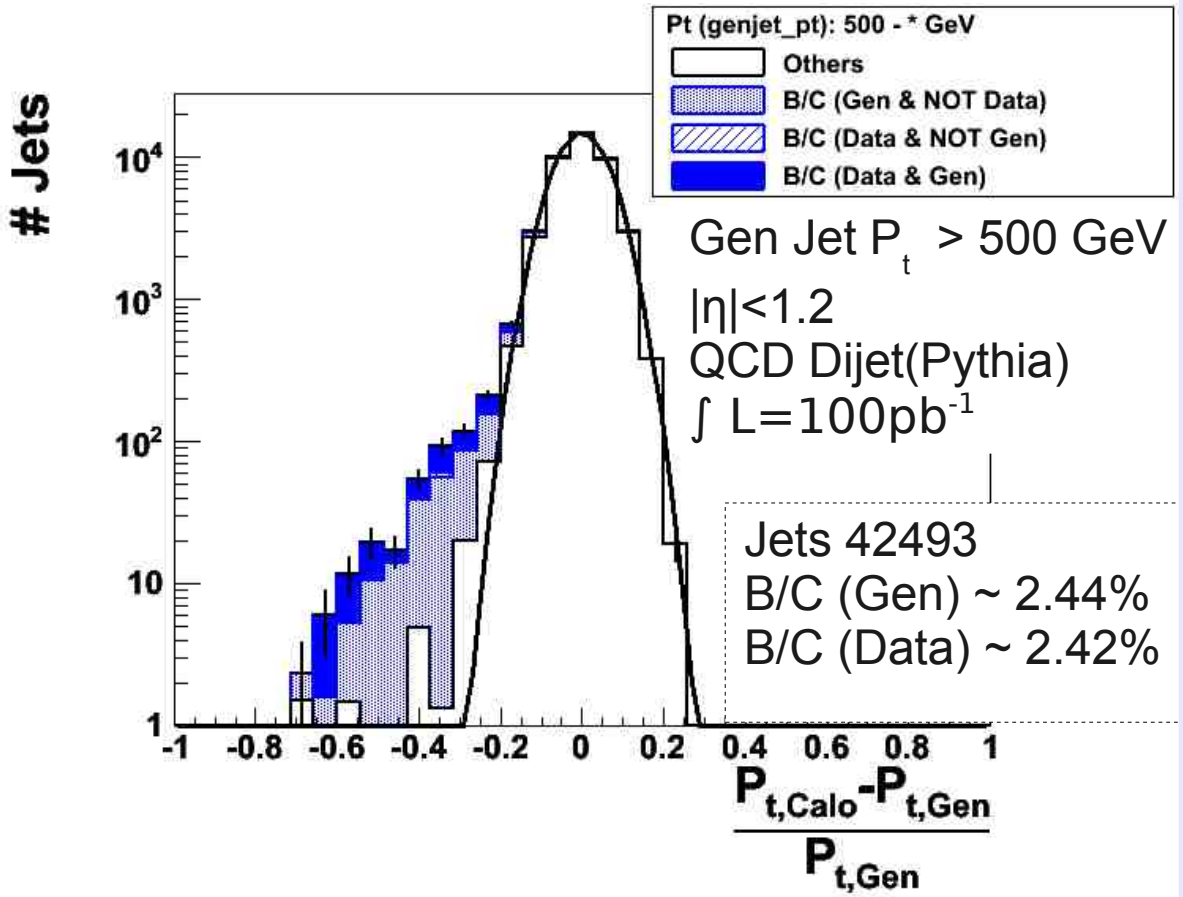
➡ use simple data level selection





s. Validation B Tag:
http://cmsrocstor.fnal.gov/lpc1/cmsroc/yumiceva/validation/index_RecoB_CMSSW_3_1_2_QCD_Pt_80_120_312_vs_311_MC.html

Selection of B/C Jets on Data Level



- Efficiency ~24%

$$\frac{N_{B/C}\ jets\ gen + data\ level}{N_{B/C}\ jets\ gen\ level}$$

~2/3 of B/C jets in tail are not sensitive to muon variables (as expected due to B/C decays in eν/τν)

- Purity ~27%, but 84% in the tail 3б below mean

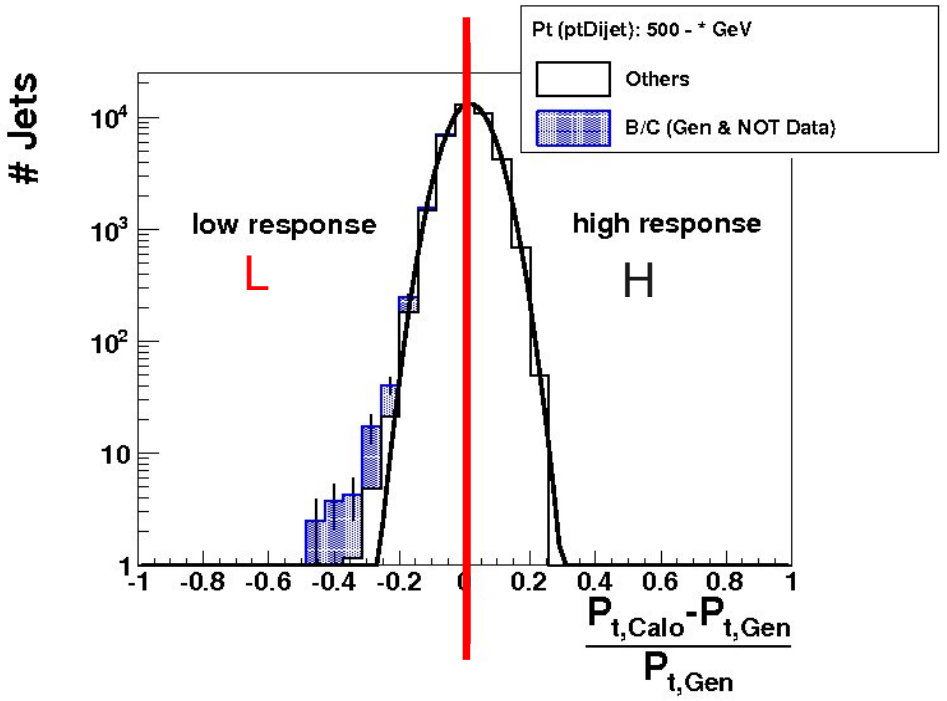
$$\frac{N_{B/C}\ jets\ gen + data\ level}{N_{B/C}\ jets\ data\ level}$$

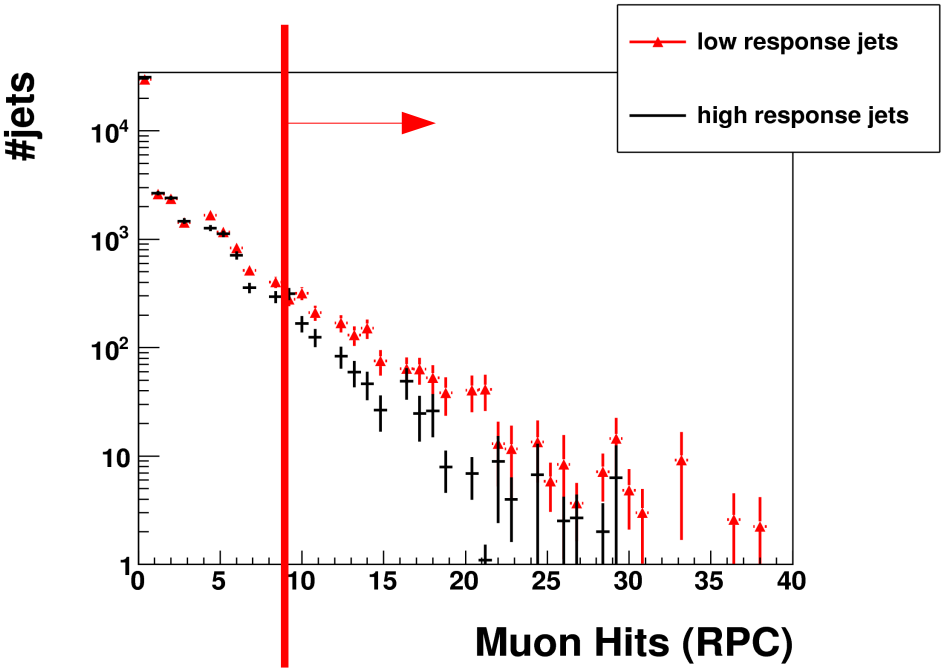
Mismeasurement of jets tagged wrong as B/C jets is very small → no importance for MET tails

Selection of Punchthrough Jets

- Reject B/C jets selected on data level!
- Divide jets left/right from mean in $\frac{CaloJet\ Pt - GenJet\ Pt}{GenJet\ Pt}$ -distribution
- Assumption: Difference between low/high response jets (sensitive to muon var.) is punchthrough
- Select most separating variables:

  Optimize $\frac{L-H}{\sqrt{L+H}}$ for each variable/ variable combination



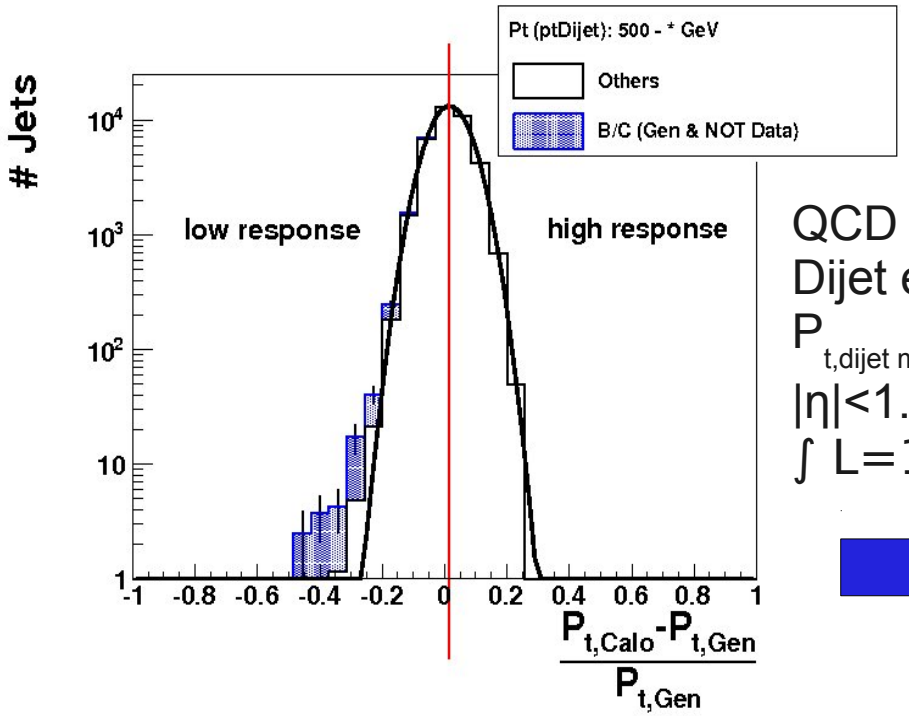


Data Driven Determination of Mismeasurement

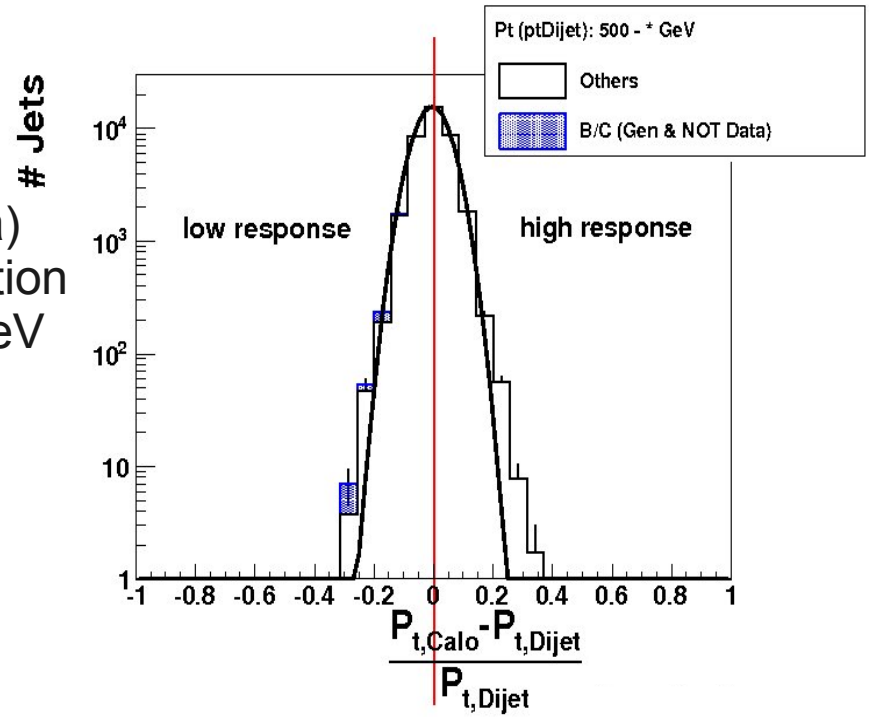
Identify jets in jet resolution tail in data using dijet balance

Event selection:

- at least 2 jets in barrel region ($|\eta|<1.2$)
- $\Delta\phi_{12}>2.7$ ($0>\Delta\phi<\pi$)
- $P_{t,jet3}/P_{t,dijet\ mean}<0.1$ $P_{t,jet3}<2$ GeV, where $P_{t,dijet\ mean}=\frac{P_{t,jet1}+P_{t,jet2}}{2}$

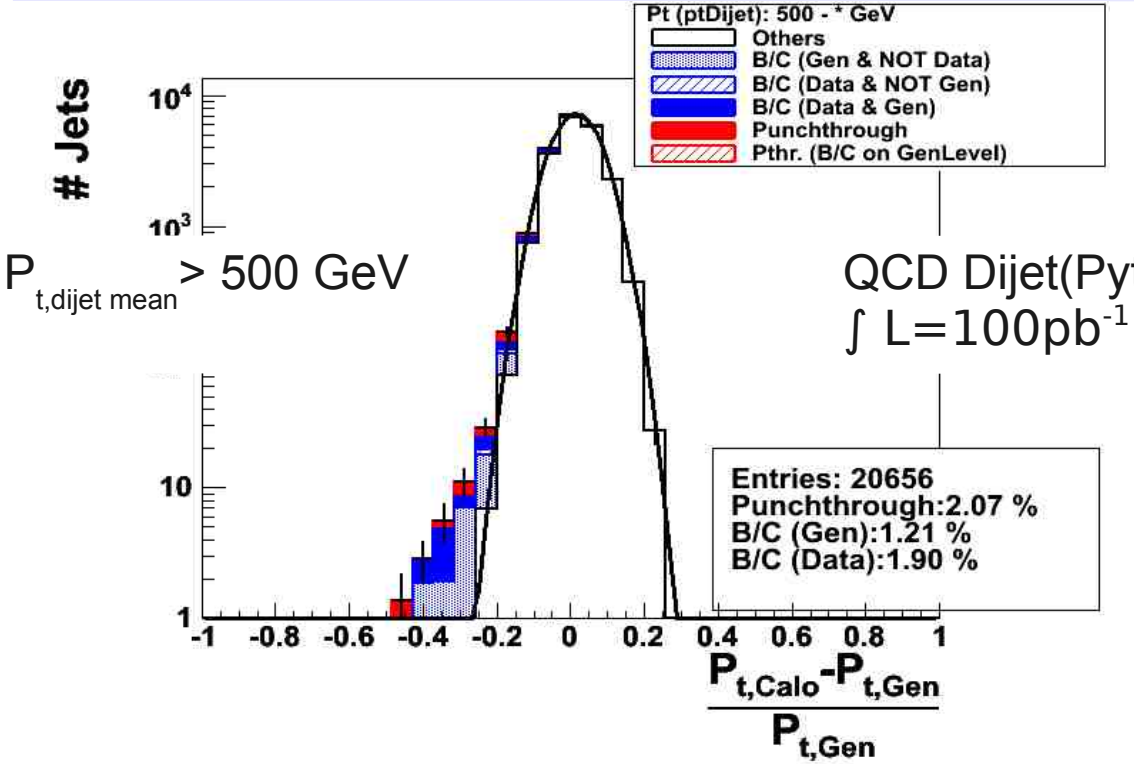


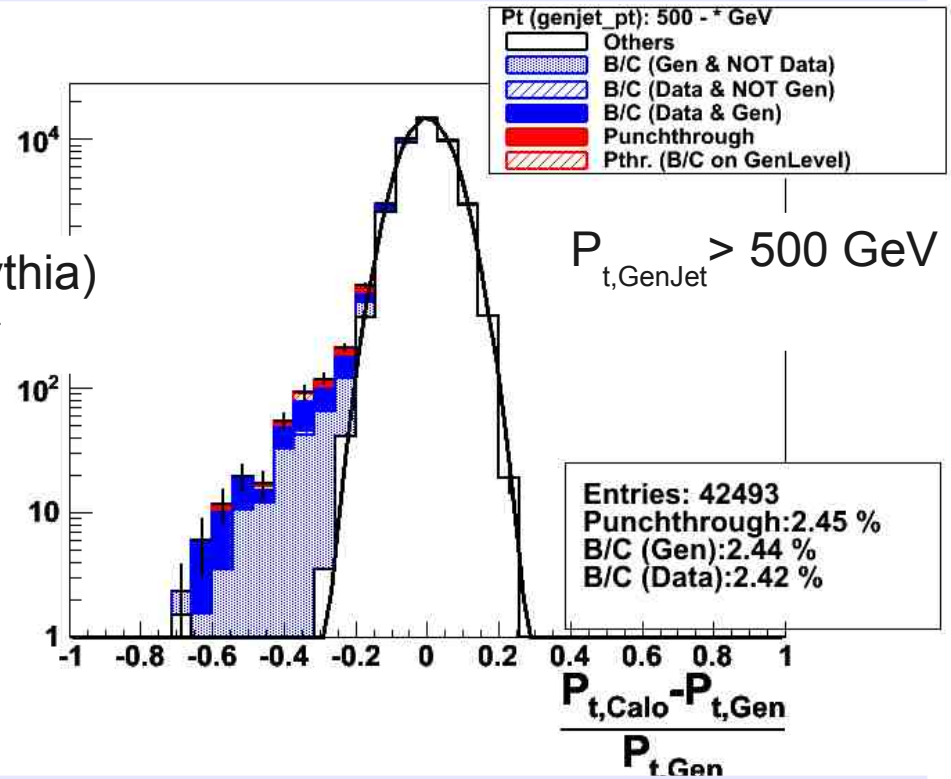
QCD Dijet(Pythia)
Dijet event selection
$P_{t,dijet\ mean}$ > 500 GeV
$|\eta|<1.2$
$\int L=100pb^{-1}$



Selection of Punchthrough

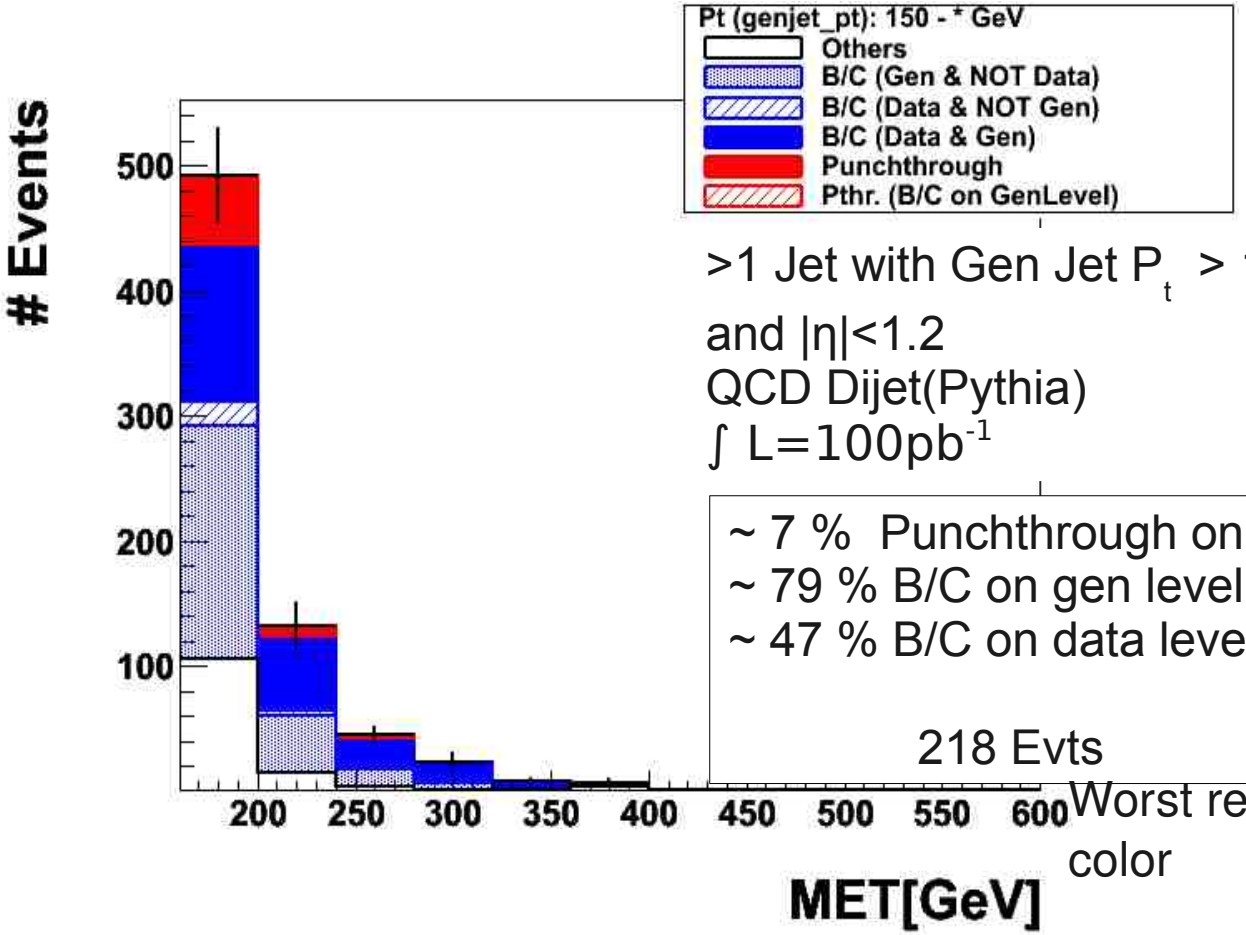
Selected variable: #Hits in Muon RPC>9 and other less separating variables





- Rather complete description of events in tail
- Data driven selection of variables and cuts – $P_{t,GenJet}$ used only for validation
- Only small percentage of high energetic jets is mismeasured
- But jets in tail cause fake MET → implications for SUSY/Exotica searches

MET



>1 Jet with Gen Jet P_t > 150 GeV

and $|\eta|<1.2$

QCD Dijet(Pythia)

$\int L=100pb^{-1}$

~ 7 % Punchthrough on data level
~ 79 % B/C on gen level
~ 47 % B/C on data level

218 Evts

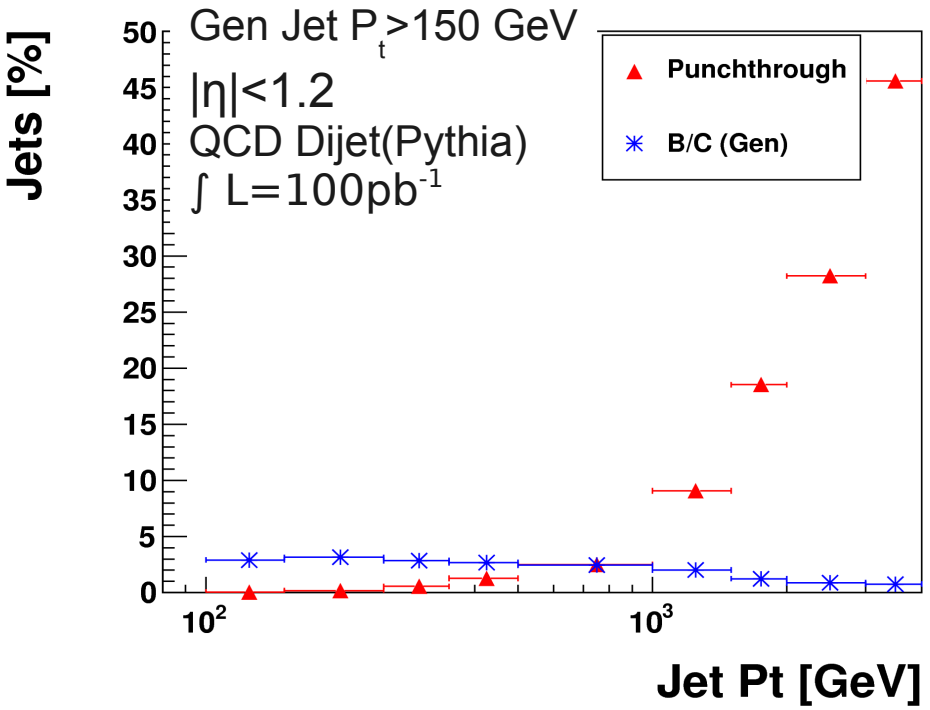
Worst reconstructed jet appoints color

QCD dijet events → only fake MET

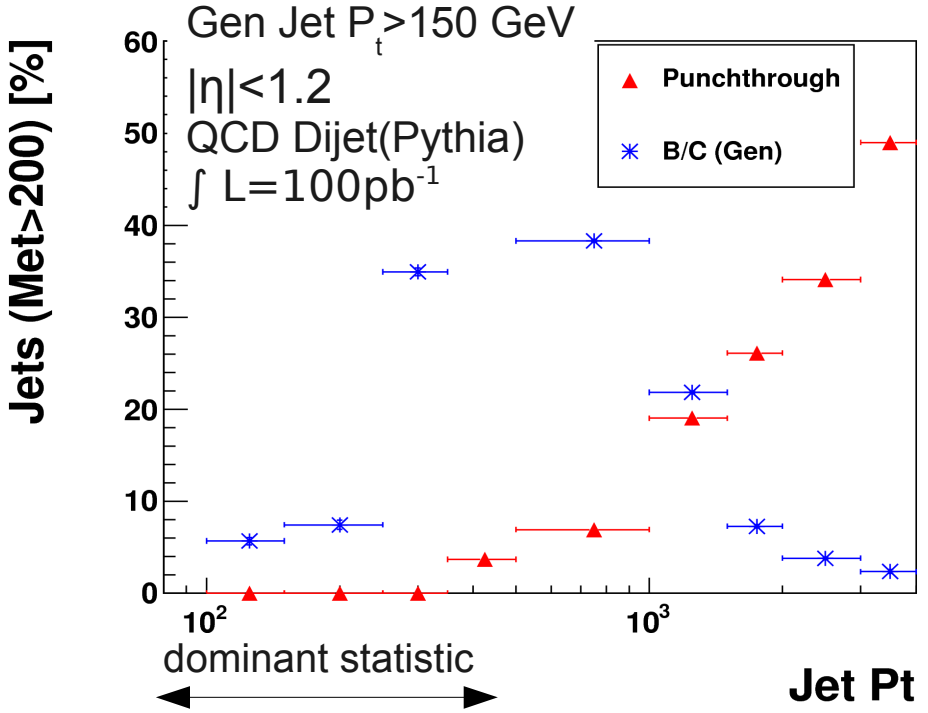
On gen level ~86% of MET tail are tagged as punchthrough or B/C

On data level ~ 54% (due to B/C jets not sensitive to muon variables)

MET



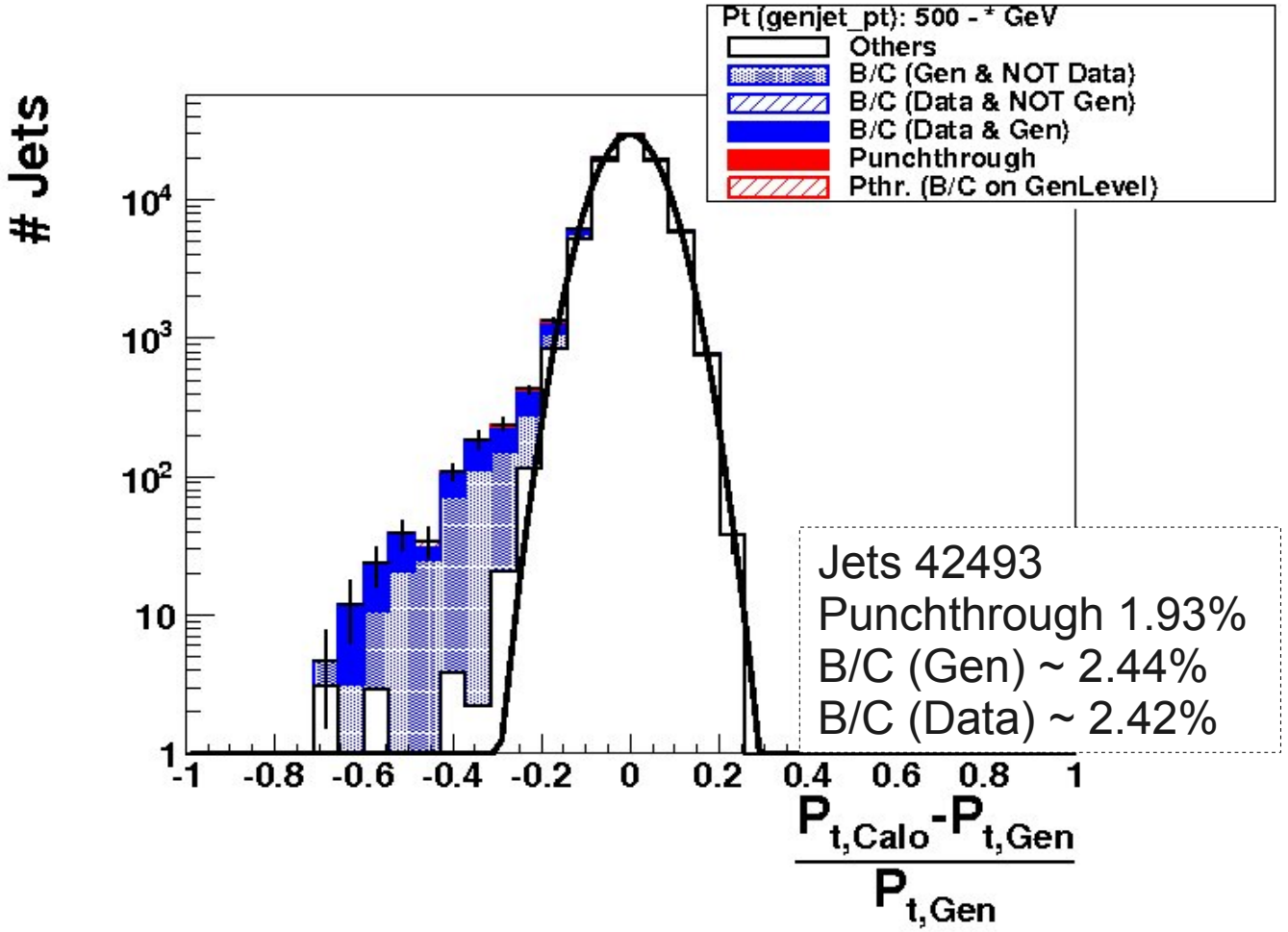
B/C on Gen Level



Punchthrough on Data Level

- Percentage of punchthrough increases with jet energy
- Percentage of B/C jets not strongly dependent on jet energy
- Both effects play an important role for studies with high energetic jets and high cuts on MET ➡ will become more important in 2012 & beyond!

Punchthrough tags using only HO



- Less complete description of events in tail (compared to usage of muon hits)
- Percentage of punchthrough decreases from 2.4% to 1.9% and considering only the outermost tail (3б below mean) from 15% to 7%

Summary & Outlook

- B/C jets and punchthrough: complete description of tail in resolution for high p_t jets
  - e.g masked ECAL cells not considered in simulation

- Data driven tagging of punchthrough
  - Muon system: use hits behind jet ➡ variables in JetID
  - HO only: lower efficiency
  - Generator level information of energy deposited outside HCAL would be very useful for further studies

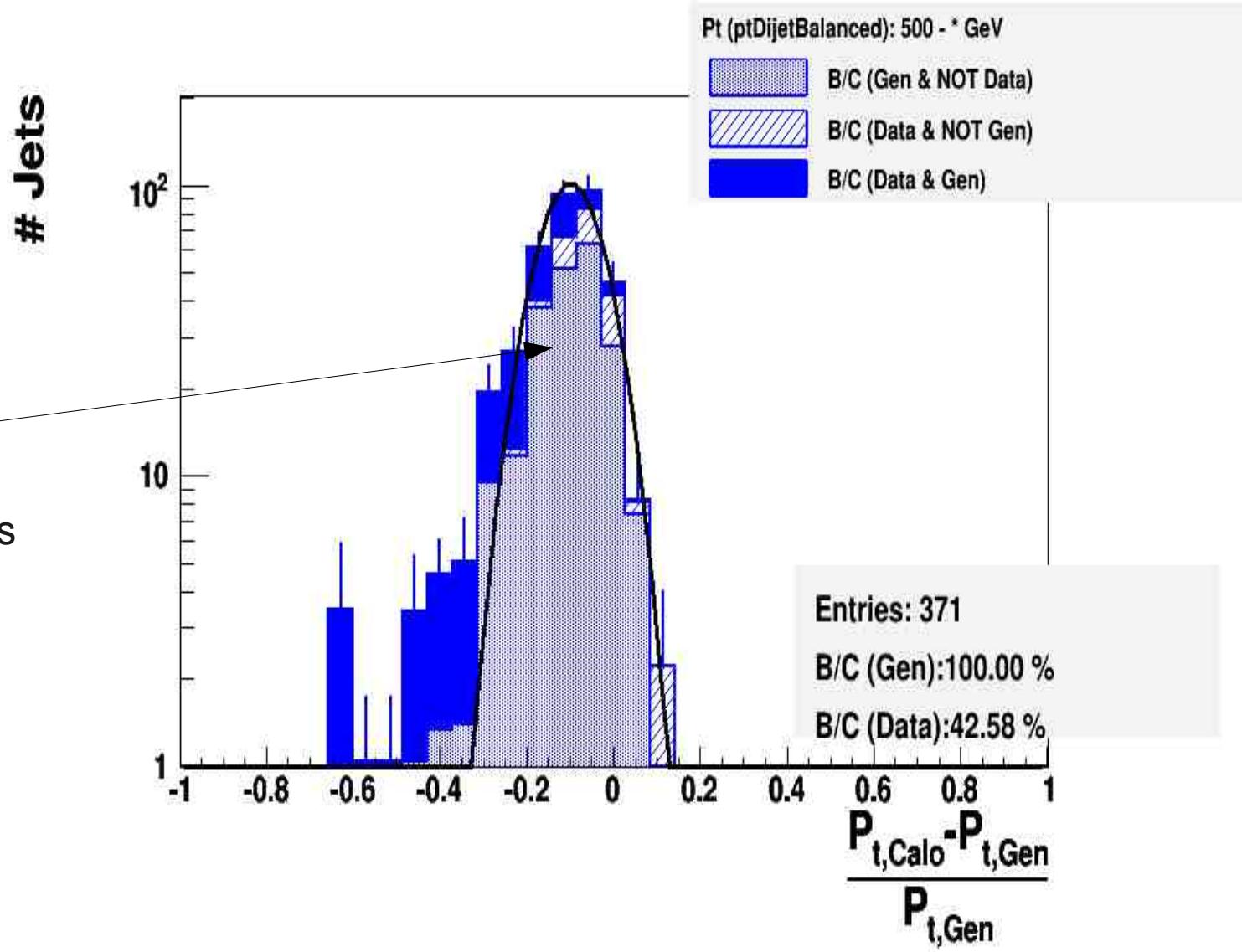
- First look on data: similar results (slightly more muon hits)
  - Tail analysis of high MET events shows contributions from punch through ➡ more importance in 2012 & beyond!
  - MET group interested in more detailed studies (lack of manpower)

Backup

Impurity of B/C Jet Veto

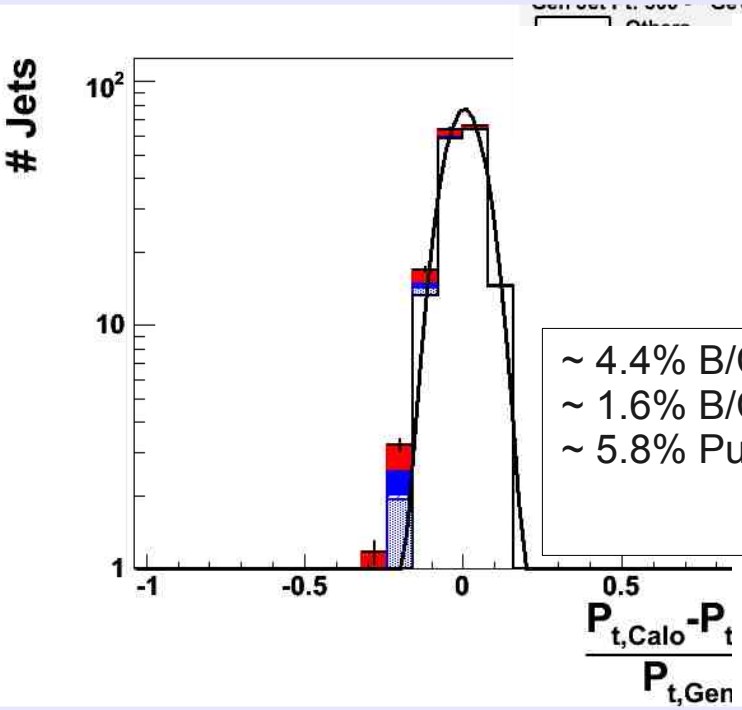
Only B/C jets on data or gen level are shown

High impurity
of B/C selection probably
due to definition of B/C jets
(invisible fraction > 5%)

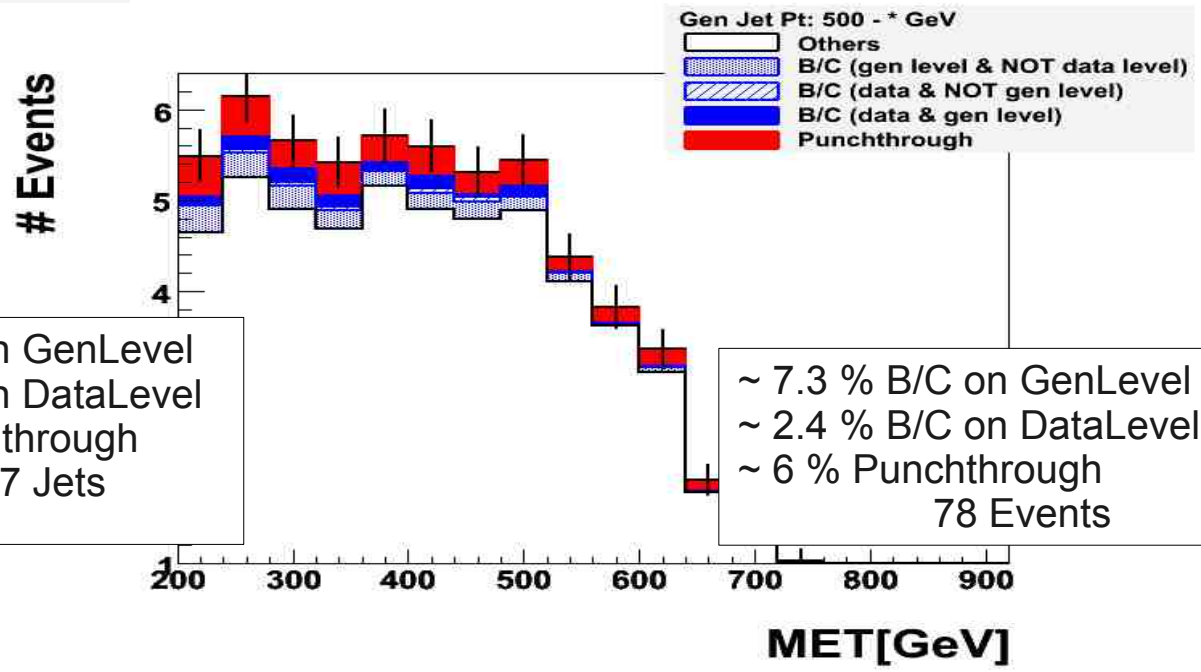


Implications on SUSY

- SUSY sample (CMS Benchmarkpoint LM1)
- Same event selection as for dijet samples (jet P_t >500 GeV, etc.)



~ 4.4% B/C on GenLevel
~ 1.6% B/C on DataLevel
~ 5.8% Punchthrough
167 Jets



~ 7.3 % B/C on GenLevel
~ 2.4 % B/C on DataLevel
~ 6 % Punchthrough
78 Events

- Rather complete description of mismeasured tail
- Selection efficiency of B/C jets comparable to dijet samples
- Percentage of tagged (fake) MET much smaller than in dijet samples (as expected due to high intrinsic MET in SUSY events)