Trigger efficiency for supersymmetric events in ATLAS

ROMA TRE UNIVERSITÀ DEGLI STUDI
DESY
DIPARTIMENTO EDOARDO AMALDI DI FISICA

Motivation

SM extremely successful at low energies but:

✗ no explanation for the gauge hierarchy stability

✗ no unification of the gauge symmetries couplings at high energy (Planck scale)

✗ no explanation for the existence of the dark matter

Need of a new physics at TeV scale!

TeV-Scale SUSY is an attractive extension of the SM and this has motivated many searches for supersymmetric particles

More about SUSY

SUSY is a symmetry between bosons and fermions, but it is :

- Not exact: particles and their superpartners not degenerate in mass
- Broken: superpartners not been observed...yet!

SUSY Models

MSSM : SUSY does not break spontaneously , 105 parameters!!

(m)SUGRA : SUSY broken in a hidden sector, breaking communicated via gravity, 5 parameters:

m0	m1/2	A0	tanβ	sgnμ = ±1

GMSB : SUSY broken in a hidden sector but at much lower scale, breaking communicated via gauge interaction

R-Parity

- B and L violation possible in SUSY theories : weak-scale proton decay allowed!

$$R = (-1)^{3(B-L)+2S}$$

Starting from an initial state involving ordinary particles, SUSY particles are produced in pairs

↓

unstable SUSY particles decay into lighter states to the stable LSP

↓

Cosmological constraints: LSP must be weakly interacting and escapes detection

↓

Thus, canonical signature for R-Parity conserving interactions is Missing Et

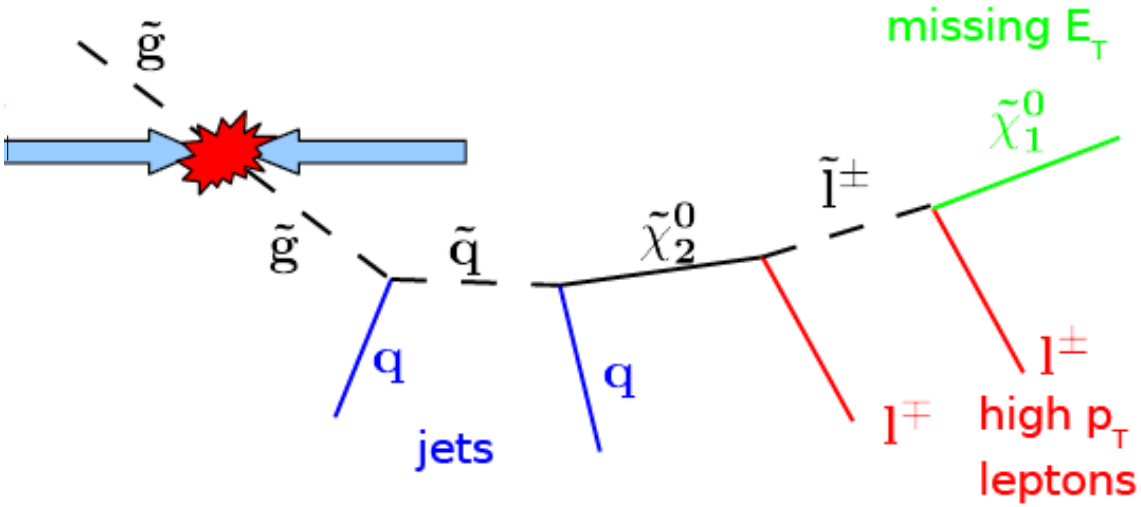
SUSY searches at hadron machines

First step in searching SUSY is to look for deviations from the SM

SUSY cross section at LHC energies dominated by pairs of gluinos and squarks.

They decay directly or via cascades to at least two LSP.

Squarks, sleptons, neutralinos produced down the cascade



In most models:

$\tilde{\chi}_1^0$ = LSP = stable

Typical SUSY signatures

multi leptons

Missing Et + High Pt Jets + b-jets

τ-jets

→ Missing Et and High Pt jets are key for discovery of SUSY

The contribution of the SM is considered to be relatively small : main background for SUSY is typically SUSY itself

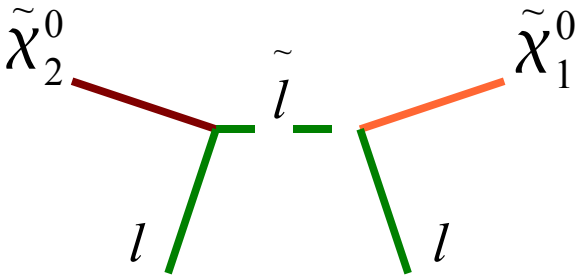
Once SUSY is discovered, one might want to reconstruct sparticles masses... but no mass peak can be recostructed directly!

Strategy : pick out particular multi-body decay modes and detemine combinations of masses by measuring the endpoints of the visible mass distribution

Exclusive measurements

The starting point of exclusive analyses is generally to reconstruct a specific mode at the bottom of a decay chain

Many analyses involve decays of the second neutralino:



In the decays:

$$\tilde{\chi}_2^0 \rightarrow \tilde{\chi}_1^0 l^+ l^-$$

$$\tilde{\chi}_2^0 \rightarrow \tilde{l}^{\pm} l^{\mp} \rightarrow \tilde{\chi}_1^0 l^+ l^-$$

the endpoint of the dilepton mass distribution measures :

$$M(\tilde{\chi}_2^0) - M(\tilde{\chi}_1^0)$$

SU3 : Di-lepton Invariant Mass

- Signal Sample ntuples made from fullsim AOD's used :

user.JelenaKrstic.SU3_jimmy_susy.merge.v12000605.SV_HPTV_12071

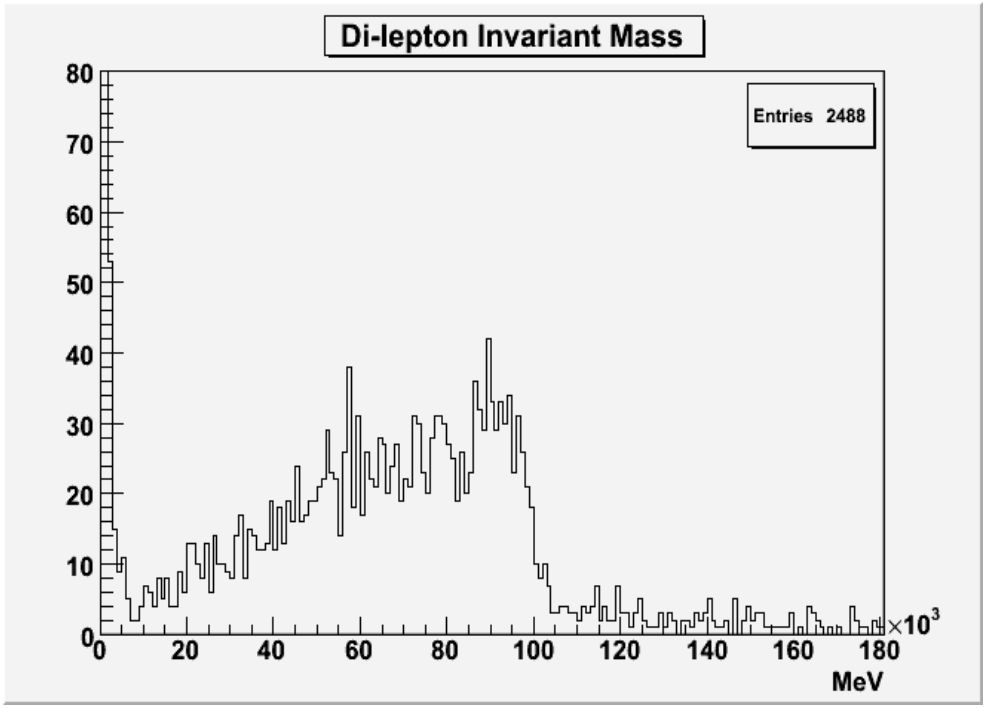
- SU3 point is a benchmark scenario for SUSY for full simulation studies :

m0 = 100 GeV m1/2 = 300 GeV A0 = -300 GeV tan(β) = 6 sgn(μ) = + x-sec = 18.59 pb

Events were selected to have :

- Missing Et > 100 GeV
- 2 opposite-sign leptons with Pt > 20 GeV
- |η| < 2.5

$$M_{ll}^{max} = M(\tilde{\chi}_2^0)\sqrt{1-\frac{M^2(\tilde{l}_R)}{M^2(\tilde{\chi}_2^0)}}\sqrt{1-\frac{M^2(\tilde{\chi}_1^0)}{M^2(\tilde{l}_R)}} = 101.31\,GeV$$



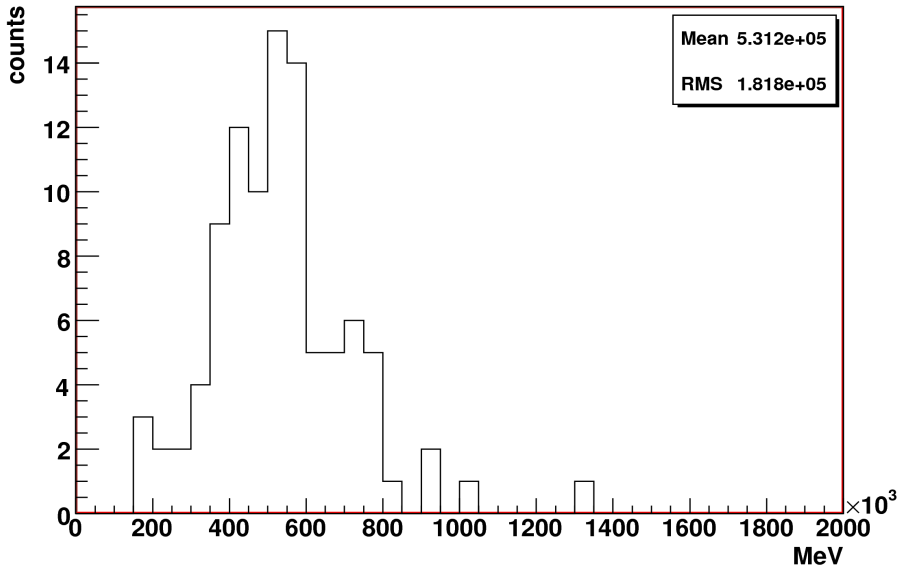
SU3 : Jets + leptons

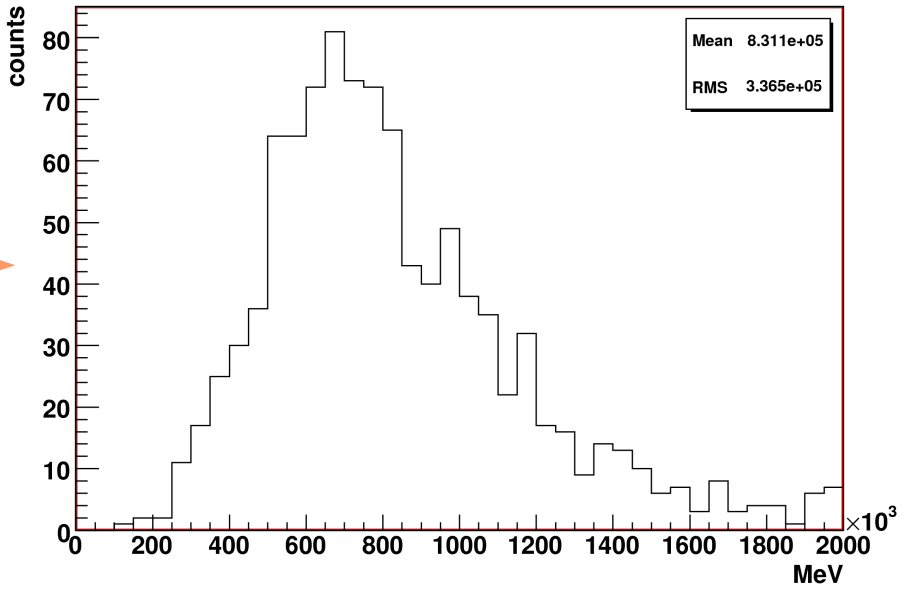
The $\tilde{\chi}_2^0 \to \tilde{l}^{\pm} l^{\mp} \to \tilde{\chi}_1^0 l^+ l^-$ decays come primarily from : $\tilde{g} \to \tilde{\chi}_2^0 q \bar{q}$

Additional requirement :

- 2 hard jets with Pt > 125 GeV

qqll invariant mass distribution sensitive to the gluino mass



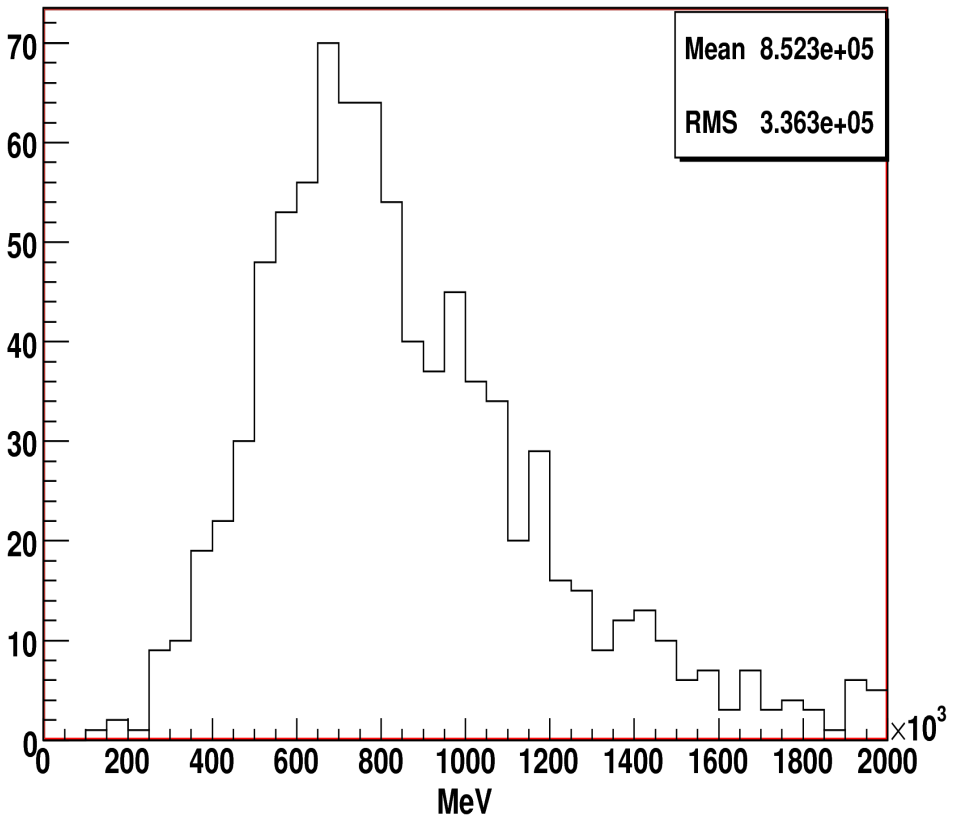


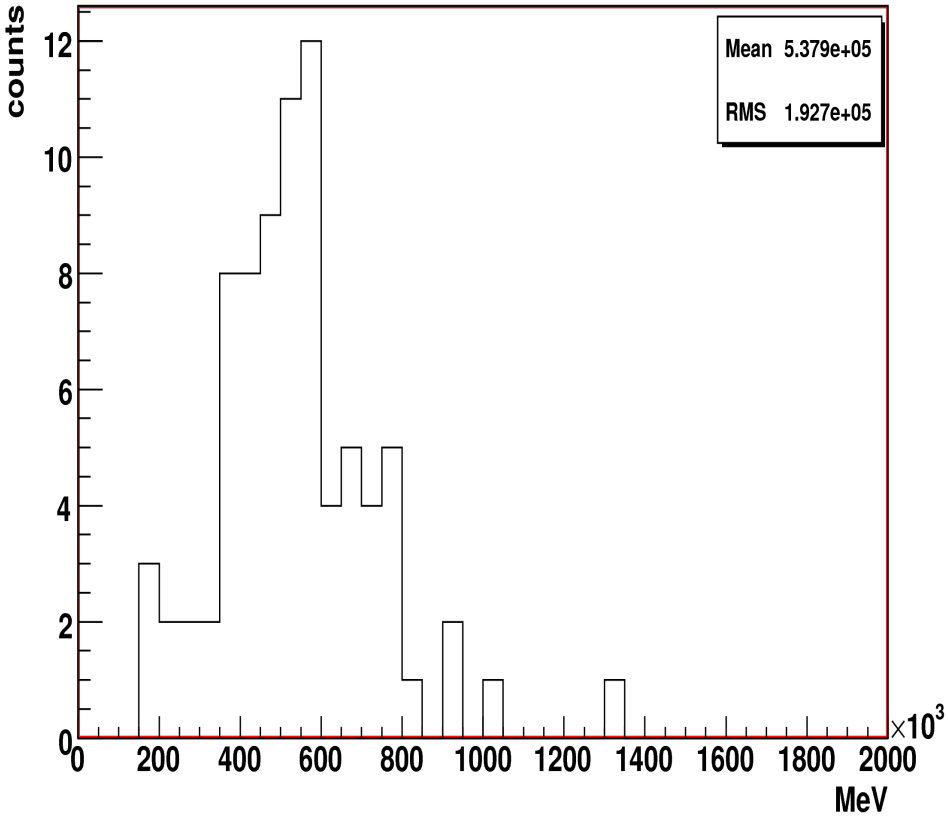
BR for $\tilde{g} \to \tilde{\chi}_2^0 b \bar{b}$ = 6.5%

djet distributions with selected events

- Trigger decision is based on different algorithms (uses only fragments of the detector information

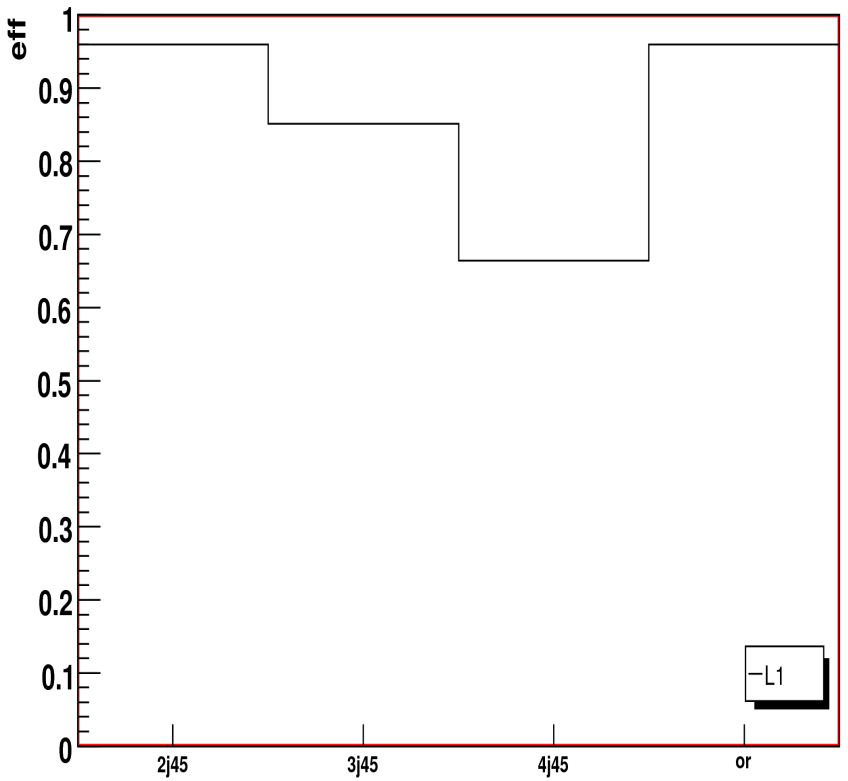
If (PassedL2_2j120 != 0 && PassedEF_2j120 != 0) {

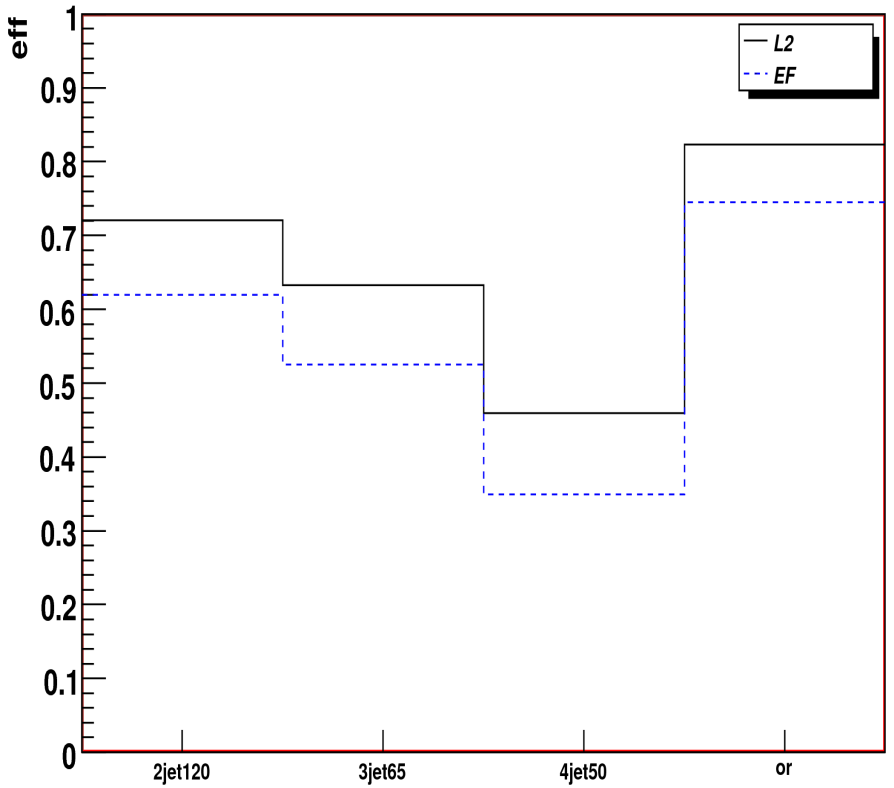




} = Good agreement with previous ones

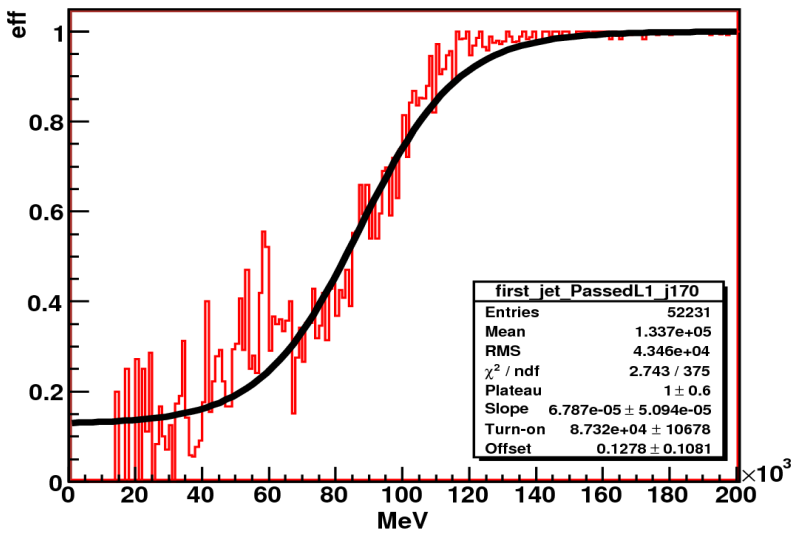
Trigger efficiency vs jet multiplicity

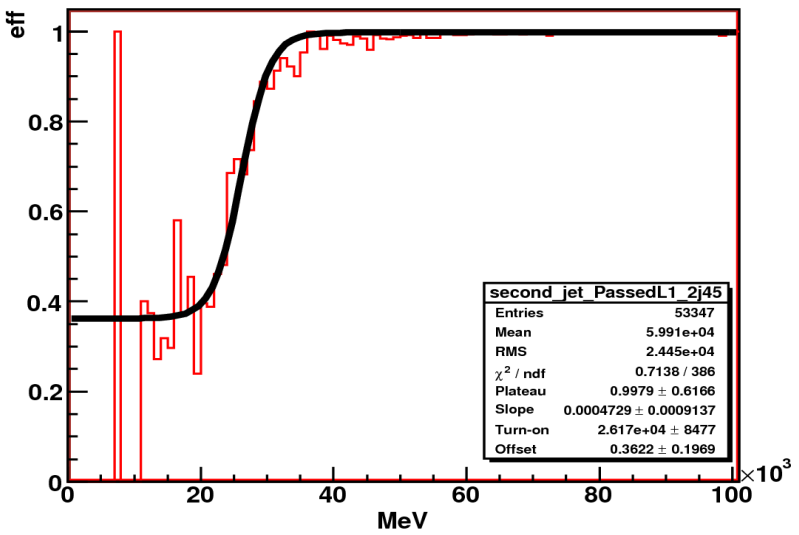


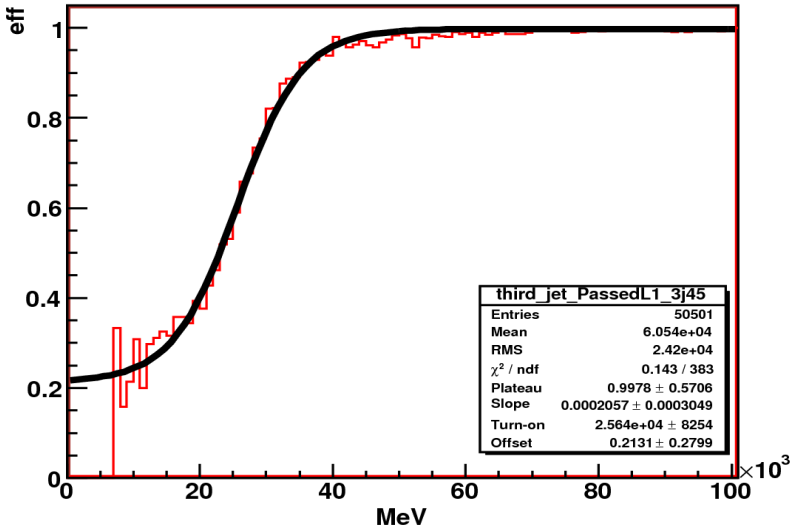


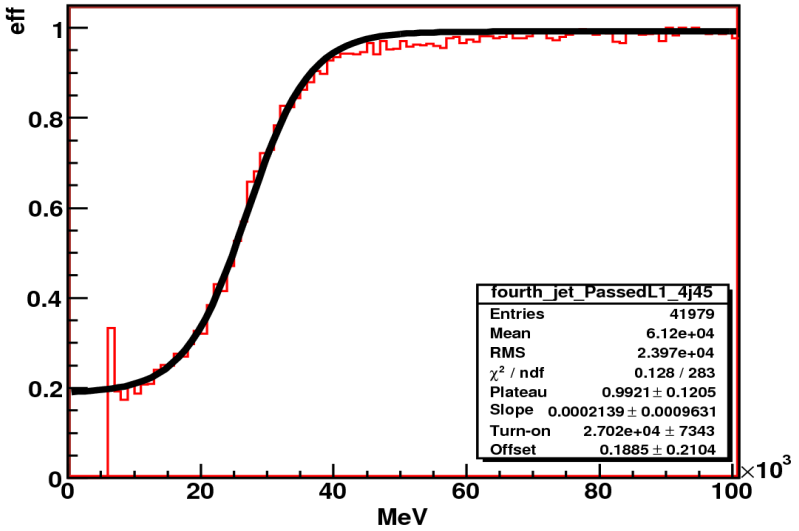
Efficiency decreases with increasing multiplicity and trigger level

L1 Trigger

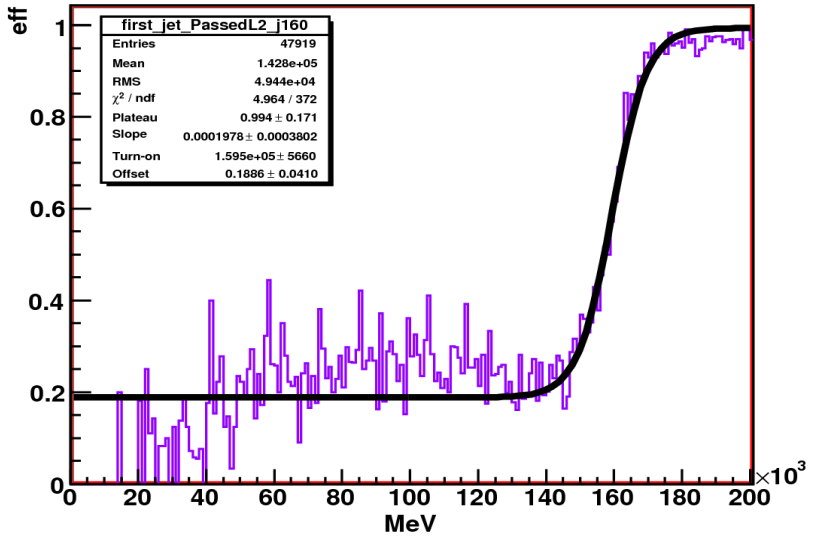

eff
MeV
×10³
first_jet_PassedL1_j170
Entries 52231
Mean 1.337e+05
RMS 4.346e+04
χ² / ndf 2.743 / 375
Plateau 1 ± 0.6
Slope 6.787e-05 ± 5.094e-05
Turn-on 8.732e+04 ± 10678
Offset 0.1278 ± 0.1081

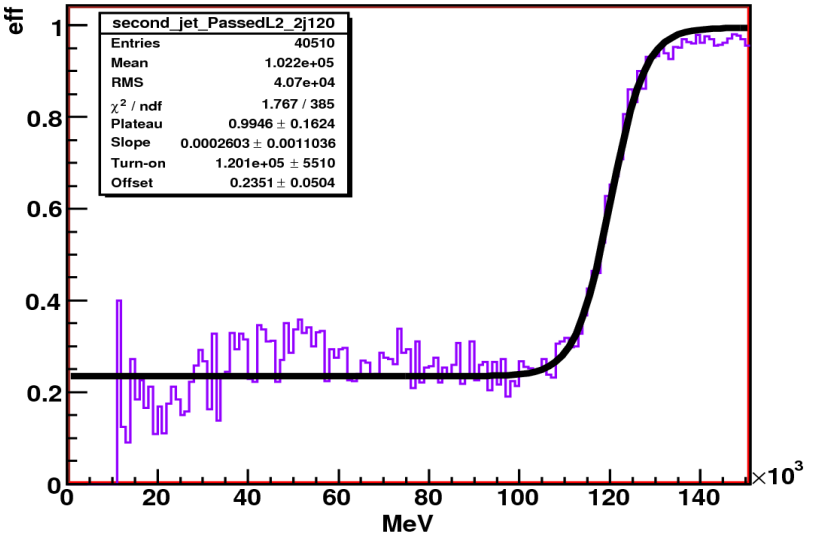

eff
MeV
×10³
second_jet_PassedL1_2j45
Entries 53347
Mean 5.991e+04
RMS 2.445e+04
χ² / ndf 0.7138 / 386
Plateau 0.9979 ± 0.6166
Slope 0.0004729 ± 0.0009137
Turn-on 2.617e+04 ± 8477
Offset 0.3622 ± 0.1969

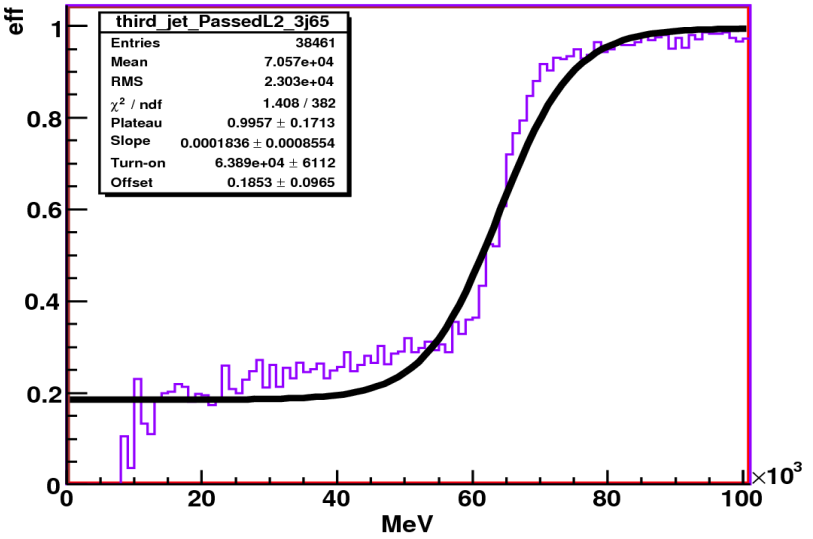

eff
MeV
×10³
third_jet_PassedL1_3j45
Entries 50501
Mean 6.054e+04
RMS 2.42e+04
χ² / ndf 0.143 / 383
Plateau 0.9978 ± 0.5706
Slope 0.0002057 ± 0.0003049
Turn-on 2.564e+04 ± 8254
Offset 0.2131 ± 0.2799

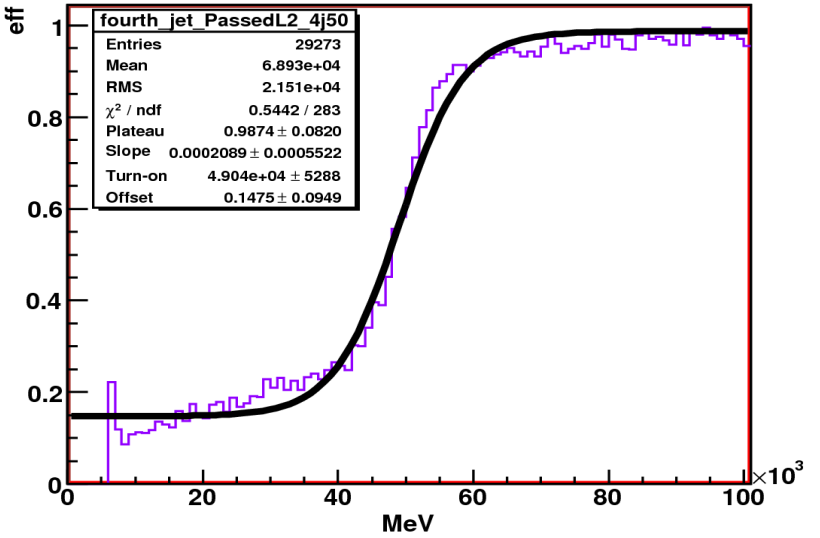

eff
MeV
×10³
fourth_jet_PassedL1_4j45
Entries 41979
Mean 6.12e+04
RMS 2.397e+04
χ² / ndf 0.128 / 283
Plateau 0.9921 ± 0.1205
Slope 0.0002139 ± 0.0009631
Turn-on 2.702e+04 ± 7343
Offset 0.1885 ± 0.2104

L2 Trigger

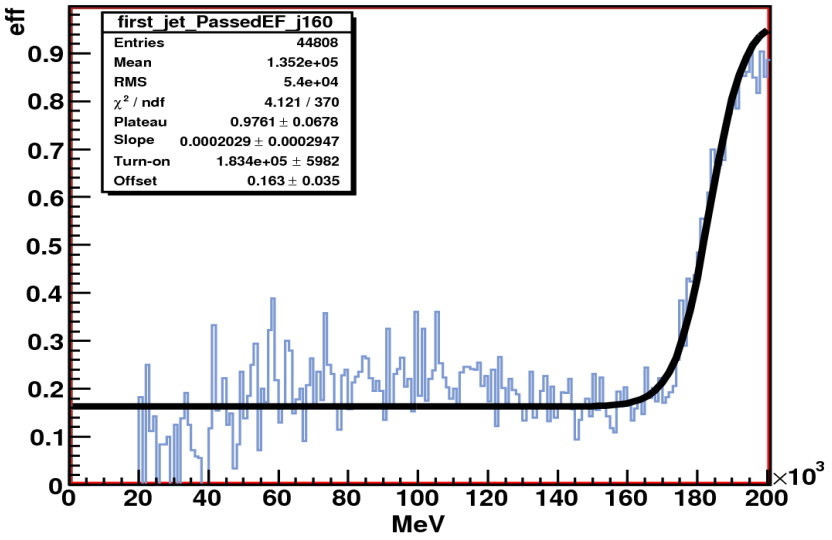

first_jet_PassedL2_j160
Entries 47919
Mean 1.428e+05
RMS 4.944e+04
χ² / ndf 4.964 / 372
Plateau 0.994 ± 0.171
Slope 0.0001978 ± 0.0003802
Turn-on 1.595e+05 ± 5660
Offset 0.1886 ± 0.0410
eff
MeV
×10³

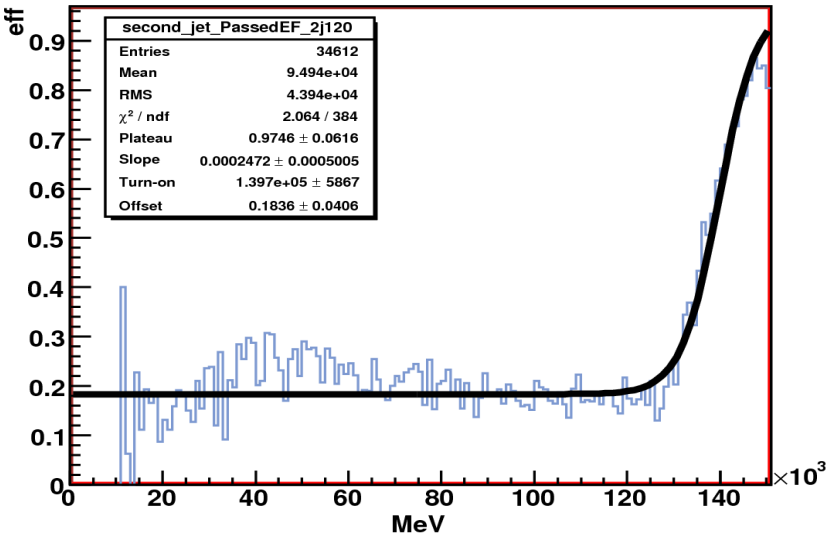

second_jet_PassedL2_2j120
Entries 40510
Mean 1.022e+05
RMS 4.07e+04
χ² / ndf 1.767 / 385
Plateau 0.9946 ± 0.1624
Slope 0.0002603 ± 0.0011036
Turn-on 1.201e+05 ± 5510
Offset 0.2351 ± 0.0504
eff
MeV
×10³

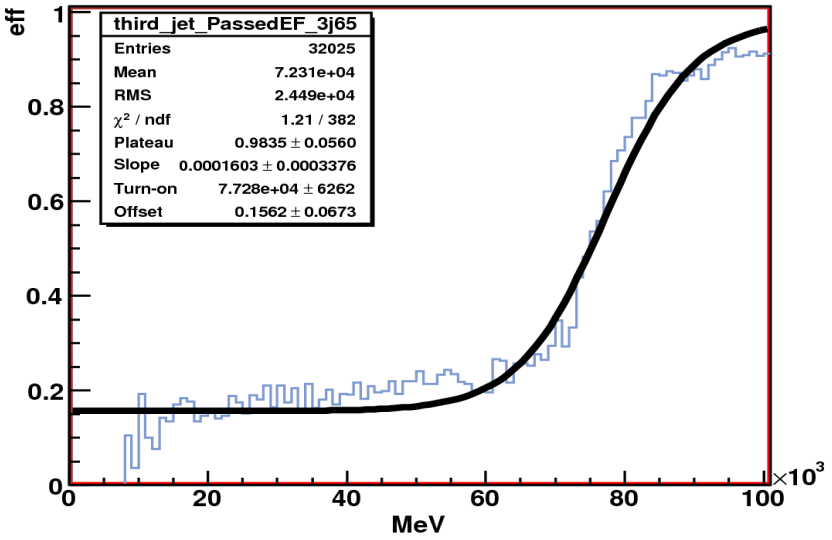

third_jet_PassedL2_3j65
Entries 38461
Mean 7.057e+04
RMS 2.303e+04
χ² / ndf 1.408 / 382
Plateau 0.9957 ± 0.1713
Slope 0.0001836 ± 0.0008554
Turn-on 6.389e+04 ± 6112
Offset 0.1853 ± 0.0965
eff
MeV
×10³

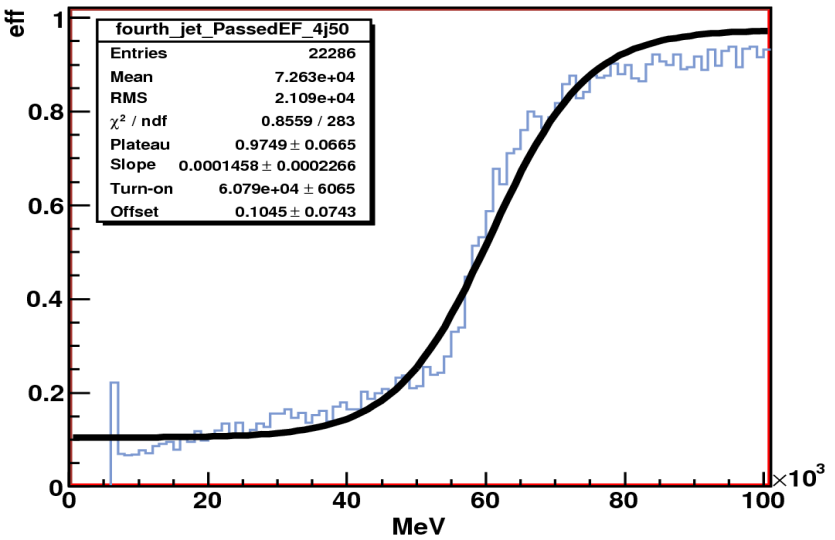

fourth_jet_PassedL2_4j50
Entries 29273
Mean 6.893e+04
RMS 2.151e+04
χ² / ndf 0.5442 / 283
Plateau 0.9874 ± 0.0820
Slope 0.0002089 ± 0.0005522
Turn-on 4.904e+04 ± 5288
Offset 0.1475 ± 0.0949
eff
MeV
×10³

EF


first_jet_PassedEF_j160
Entries 44808
Mean 1.352e+05
RMS 5.4e+04
χ² / ndf 4.121 / 370
Plateau 0.9761 ± 0.0678
Slope 0.0002029 ± 0.0002947
Turn-on 1.834e+05 ± 5982
Offset 0.163 ± 0.035
eff
MeV
×10³

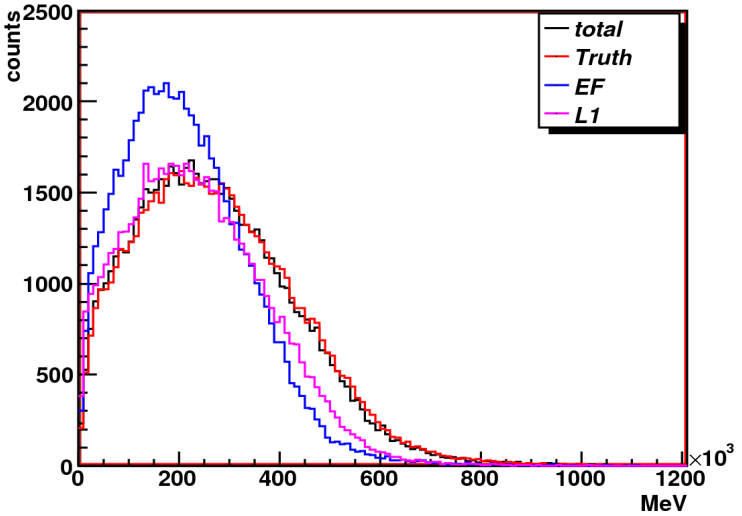

second_jet_PassedEF_2j120
Entries 34612
Mean 9.494e+04
RMS 4.394e+04
χ² / ndf 2.064 / 384
Plateau 0.9746 ± 0.0616
Slope 0.0002472 ± 0.0005005
Turn-on 1.397e+05 ± 5867
Offset 0.1836 ± 0.0406
eff
MeV
×10³

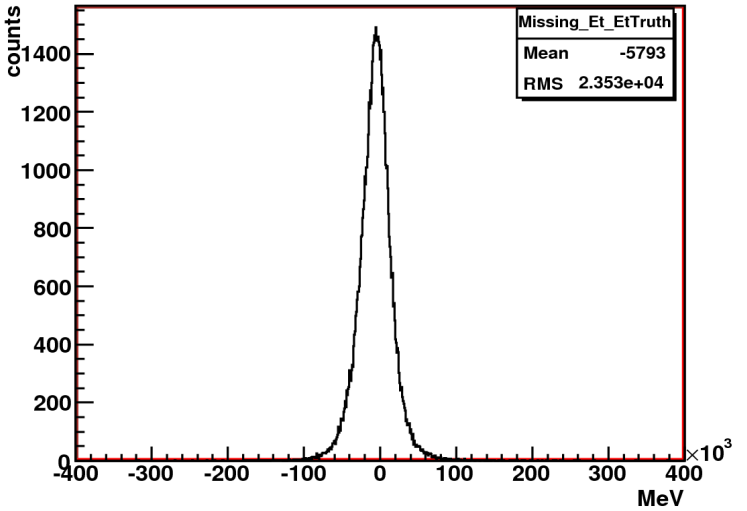

third_jet_PassedEF_3j65
Entries 32025
Mean 7.231e+04
RMS 2.449e+04
χ² / ndf 1.21 / 382
Plateau 0.9835 ± 0.0560
Slope 0.0001603 ± 0.0003376
Turn-on 7.728e+04 ± 6262
Offset 0.1562 ± 0.0673
eff
MeV
×10³

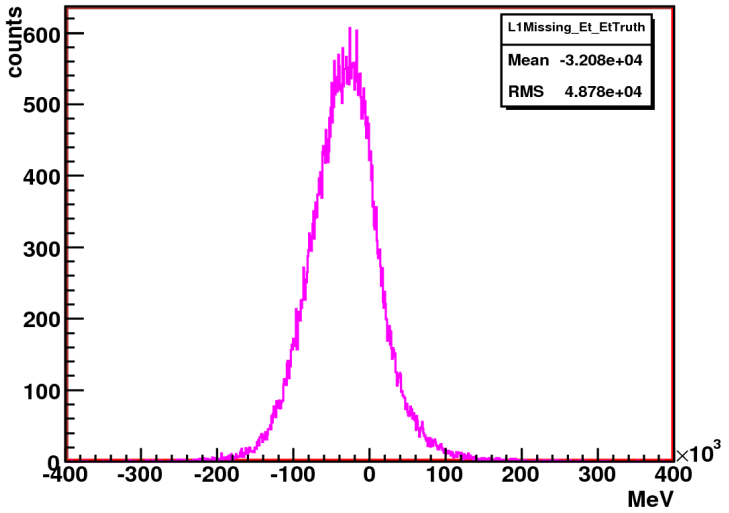

fourth_jet_PassedEF_4j50
Entries 22286
Mean 7.263e+04
RMS 2.109e+04
χ² / ndf 0.8559 / 283
Plateau 0.9749 ± 0.0665
Slope 0.0001458 ± 0.0002266
Turn-on 6.079e+04 ± 6065
Offset 0.1045 ± 0.0743
eff
MeV
×10³

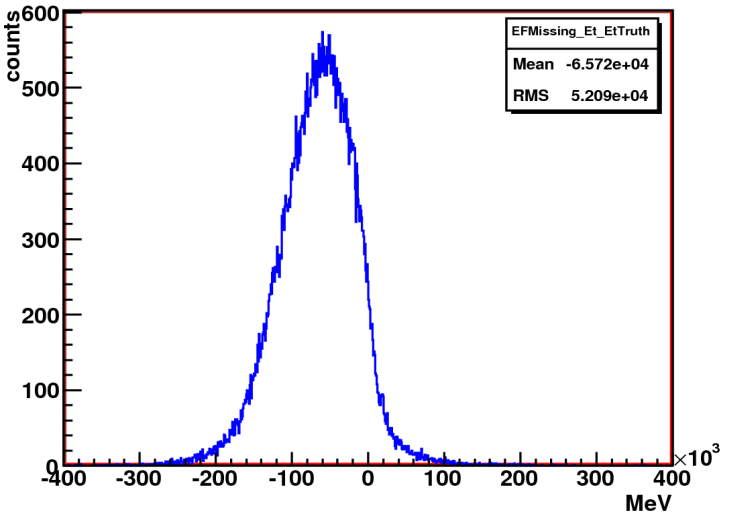
SU3 : Missing Et Recostruction

- Comparing Missing Et from reconstruction and MC Truth : shift observed









Summary

- From Di-Lepton mass distribution : Tools used (data Ntuples + Sframe) are consistent and can be used for further studies toward SUSY understanding

- From Di-Jet-Lepton mass distribution : jet algorithms and trigger recostruction OK!

- From 4-jets channels : need of a narrower study to find more precise cuts to be implemented as a trigger for selection of SUSY events in future

- From Reconstructed Missing Et : need of further investigation and correction!

Thanks !!!