Argonne NATIONAL LABORATORY

# Preliminary studies from top/detector group report: "unboosted" top reconstruction

(from ~45 page Snowmass report of the top/detector group)

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# Conclusions from the previous presentations
**(EF meeting, April 3-6, BNL)**

- Understanding of jets (jet resolution, jet energy-scale uncertainty), b-tagging and missing ET are the most crucial for top reconstruction
- ~70% of uncertainties are due to jet uncertainties (jet energy scale, resolution)
- CMS & ATLAS have very similar systematics due to this common factor
- What can we say about future LHC runs using the Snowmass detector?

Delphes 3 for the Snowmass detector geometry uses:

- PFlow jets
- Jet-area correction for neutral particles to deal with pile up.

https://atlaswww.hep.anl.gov/snowmass13

## Fast Monte Carlo simulation for Snowmass2013

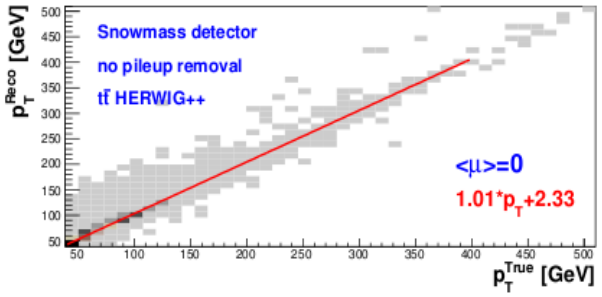
Here are top-quark "signal" samples generated by requests for Snowmass 2012-2013. Samples are generated using ANL ATLAS Tier3 computer farm based on Arcond/Condor. Details about the Delphes samples for Snowmass are given in this wiki.

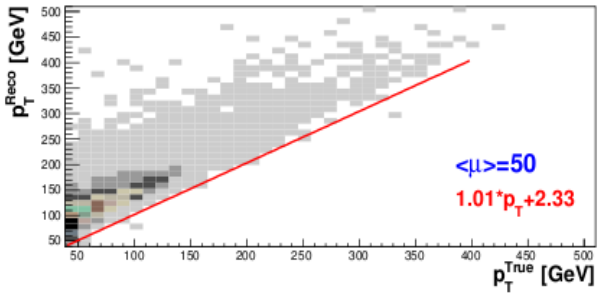
- Delphes 3.09.
- 14 TeV pp collision energy.
- The Snowmass detector geometry See "updateMay8" input cards
- PFlow jets with jet area correction.
- Each sample is generated for **<mu>=0,50,140 pileup** pileup scenarios (soft events are generated with HERWIG++)

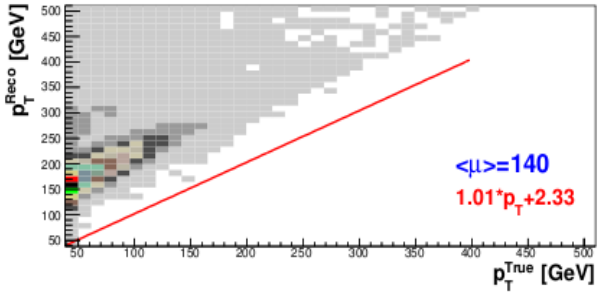
One can view and browser directories with all simulated samples using the ANL Monte Carlo repository. Here is a detailed description:

1. **HERWIG++ for low pT ttbar**
2. **HERWIG++ for ttbar with pT>650 GeV**
3. **HERWIG++ for QCD dijets with pT>650 GeV** New
4. **HERWIG++ for ttbar with pT>650 GeV** (finer CAL segmentation in Phi only)
5. **HERWIG++ for ttbar with pT>1500 GeV** (finer CAL segmentation)
6. **HERWIG++ for dijets with pT>1500 GeV** (finer CAL segmentation)
7. **HERWIG++ for ttbar with pT>1.5 TeV**
8. **PYTHIA8 for Zprime(3000) to ttbar**
9. **PYTHIA8 for H0+ttbar**
10. **MG5+PYTHIA for single-top (t-channel)**
11. **MG5+PYTHIA for single-top (tW-channel)**
12. **Madgraph+Pythia samples** New
    I. ttbar+1 gamma
    II. ttbar+2 gamma
    III. W+2 gamma
    IV. Z+2 gamma
    V. ttbar+H→ 2 gamma
13. **Madgraph+Pythia samples for Higgs+ttbar** New
    I. ttbar→dileptons
    II. ttbar→lepton+jet
    III. W+2 gamma
    IV. Z+2 gamma
14. **Madgraph+Pythia samples for Higgs+ttbar (different channels)** New
    I. ttWW + up to 1 parton
    II. ttH, H → tau tau
    III. tt + ll + up to 2 partons, dilepton invariant mass >= 10 GeV
    IV. ttH, H → ZZ, generic Z decay + up to 1 parton
    V. ttW + up to 3 partons, generic W decay
    VI. ttH, H→WW + up to 1 parton, generic W decay

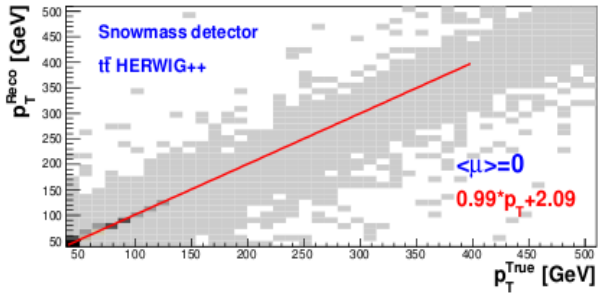
# Jets: before and after pile-up corrections

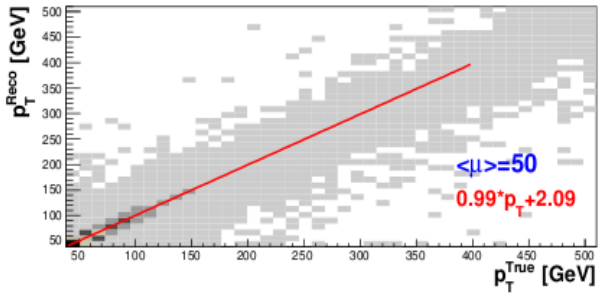


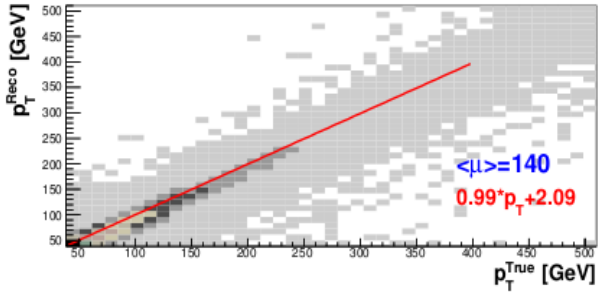




(a) Jets in $t\bar{t}$ events without pileup removal



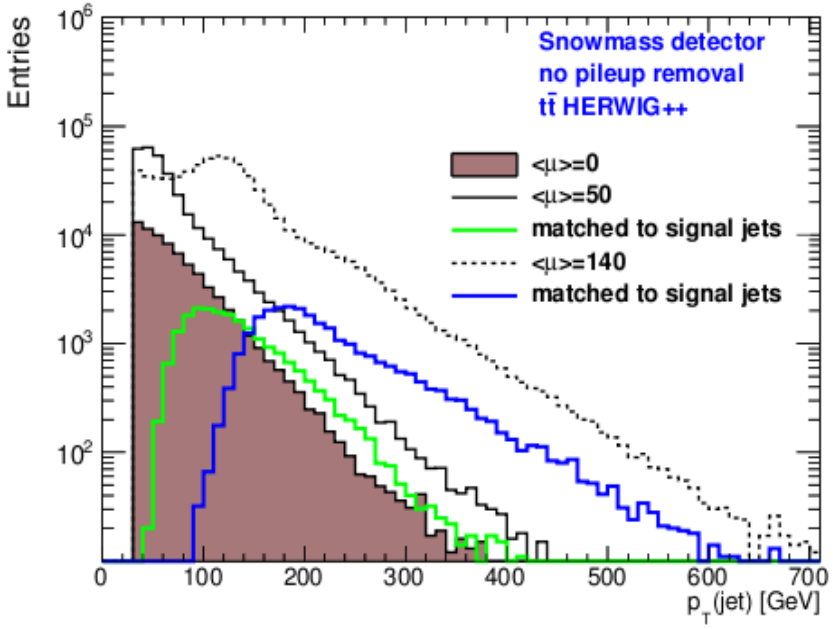



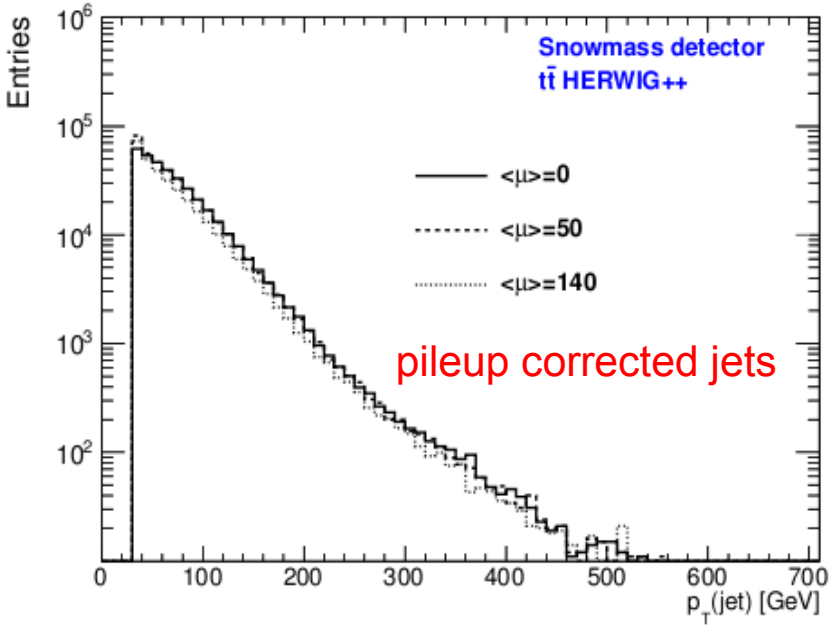

(b) Jets in $t\bar{t}$ events after pileup removal

# Jets. Snowmass detector

(no out-of-time pileup!)




(a) Jets in $t\bar{t}$ events without pileup removal




(b) Jets in $t\bar{t}$ events after pileup removal

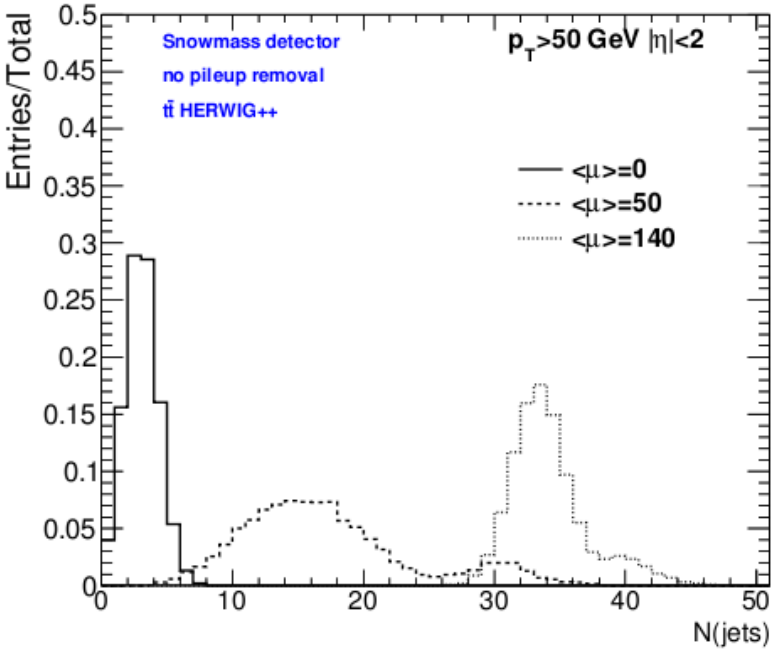
25 GeV jet → ~50 GeV (μ=50) or ~150 GeV jets (μ=140)

~ 1 additional GeV from each pileup event

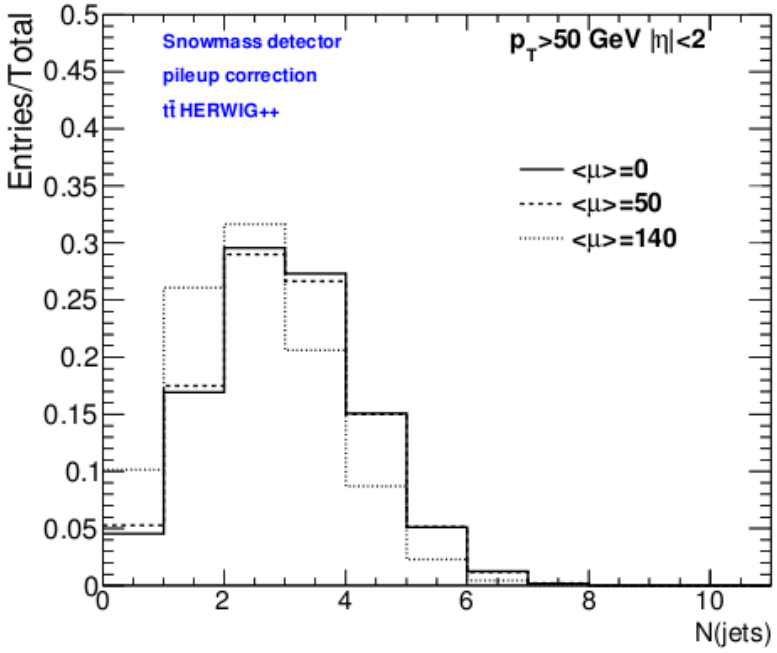
After the correction, agreement between jets with different pileup scenario look good

# Jets for $t\bar{t}$. Distributions for Nr of jets

pileup corrected jets




(c) Nr of jets in $t\bar{t}$ events without pileup removal

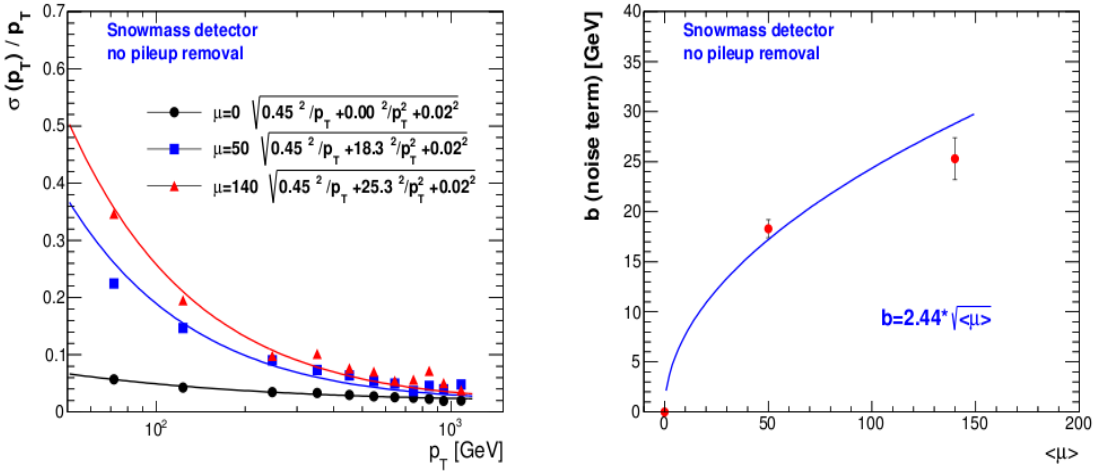



(d) Nr of jets in $t\bar{t}$ events after pileup removal

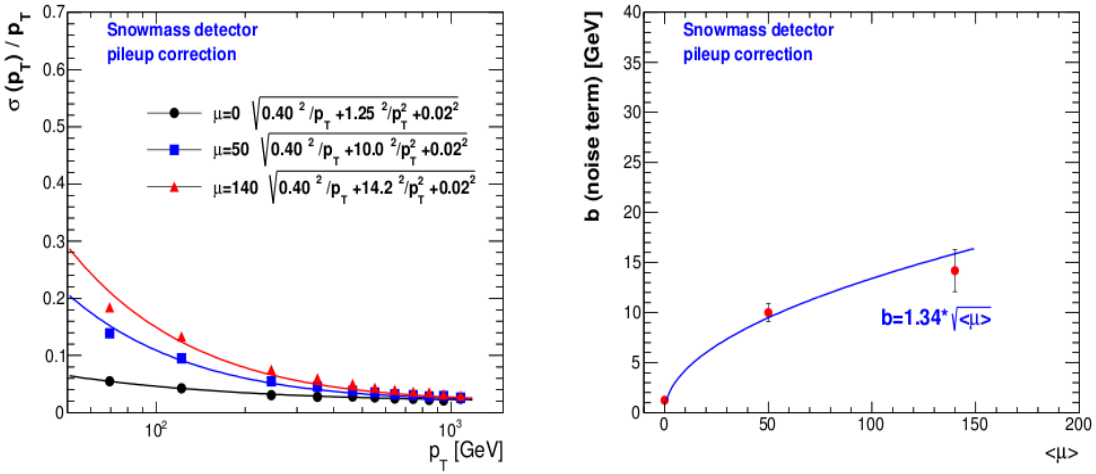
Seems pile-up correction is too large for <μ>=140 case

# Jet resolution studies

Noise term in the jet resolution




(a) PFlow-jets without pileup removal




(b) PFlow jets with pileup removal

No pileup corrections

+Pileup corrections

Smaller sampling term

Smaller dependence of the noise term on <μ>

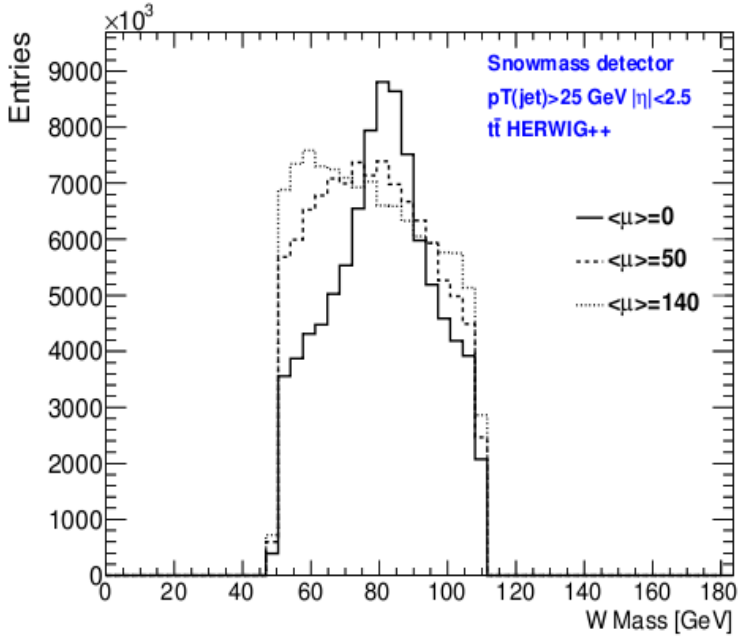
# Top reconstruction for high-luminosity LHC

- In the past, jet uncertainties where dominated by intrinsic “measurement” uncertainty
- For high-luminosity LHC, the dominant uncertainty for low-pT jets will be from our understanding of pileup corrections
- Example:
  - 30 GeV “signal” jets becomes ~160 GeV after 140-pileup events
  - Assume 2% JES uncertainty on the signal jet (typical for 2011 data)
  - Assume same 2% uncertainty on pileup energy (very optimistic!)
  - Consider only uncertainties on neutral pileup component (~50%):
  - 80 GeV contribution with 2% uncertainty has ±1.6 GeV uncertainty
  - ±1.6 GeV on 30-GeV corrected jet is 5% uncertainty
- So we expect ~ x2 or more larger uncertainty on PFlow low-pT jets after pileup subtraction
- **This should increase jet-related uncertainty for top reconstruction based on jets by a factor ~ x2 assuming 140-pileup scenario**

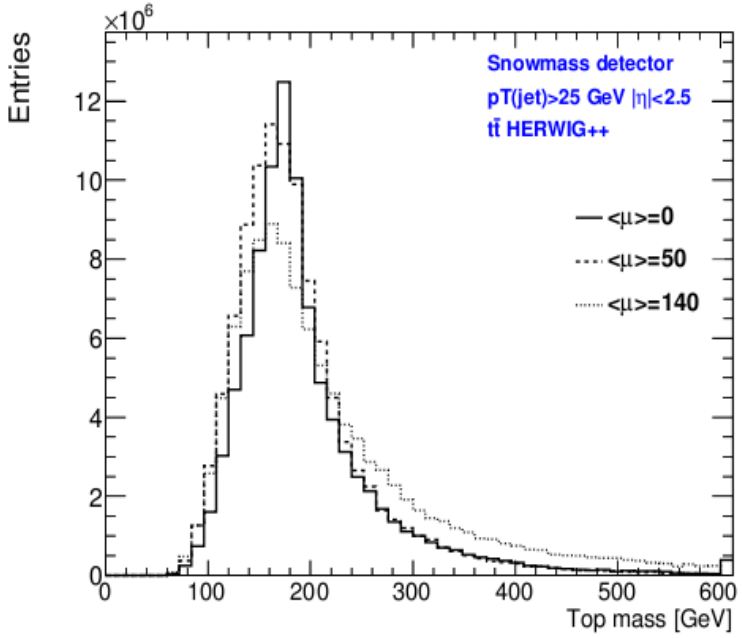
# “Standard” top mass reconstruction

Robert Calkins

1 b-tagget  jet, 2 untagget jets
Assumes one hadronically decaying top




(a)

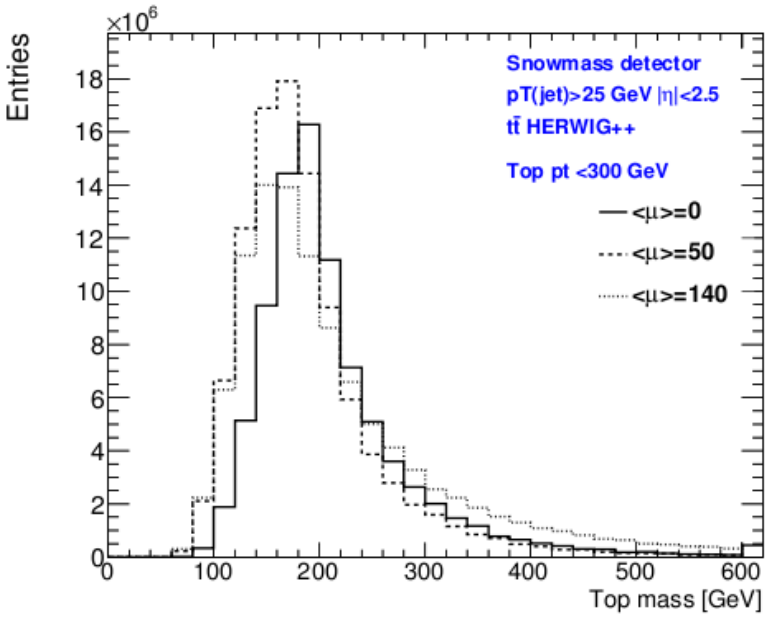



(b)

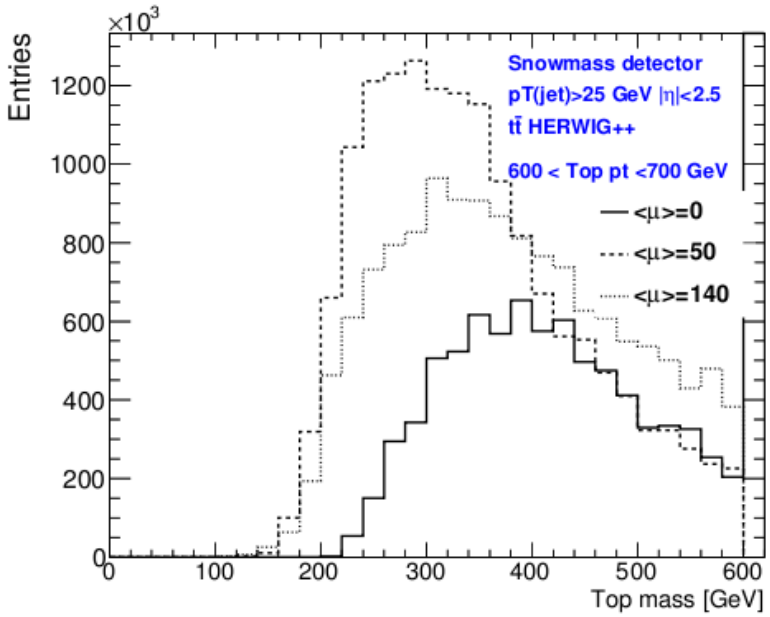
Top mass measurements is not very attractive for such pileup conditions
Pileup jet  corrections should be well tunned for each pileup scenario

# Standard top mass reconstruction

Robert Calkins




(a)




(b)

- Top masses from 3-jet invariant mass for low pT  vs high-pT
- Top mass shifts (likely due to FS jets) at large pT
- Effect of pileup is clearly seen (“overcorrection”?)
- Show challenges we are facing for high-pT reconstruction

# Conclusions. Unboosted regime

- High-luminosity runs will bring us to the regime in which uncertainties on our understanding of pileup correction for low and medium -pT jets will be the dominant factor (rather than instrumental uncertainties for signal jets as this was in the past). We expect that all jet-related uncertainties will increase by a factor two or more.
- High-luminosity runs will be unfavorable for inclusive SM studies based on reconstruction of low-pT jets (such as tt and single top studies). It is likely that the uncertainty on top cross sections will be a factor two or more larger for the pileup scenario with $\mu > 100$ compared to 2011/2012 studies
- Searches for new physics at the LHC that require a good understanding of low pT (<100 GeV) will also be affected by the new pileup environment.
  - Impacts on extracted limits are still need to be determined (input for other groups)
  - observations should still be possible but jets will have larger uncertainties
- For high-precision SM top measurements based on jets, we need low-pileup runs or a different experiment (LC?)

Next: Boosted regime & LC detector studies