Use of Tracks to Reconstruct Jets in Damaged Calorimeter Regions

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2009/02/18

Acknowledgments to
Jim Pilcher, Ariel Schwartzman, Tancredi Carli, Jimmy Proudfoot, David Miller, and others who reviewed this work and shared their ideas.

ATLAS week -- Jet/EtMiss

Motivation

- Calorimeter regions may fail.
  - Can we use tracks to identify jets there?
  - Can we then estimate their energy?

ATLAS NOTE

ATL-COM-PHYS-2009-020

Use of Tracks to Reconstruct Jets in Damaged Calorimeter Regions

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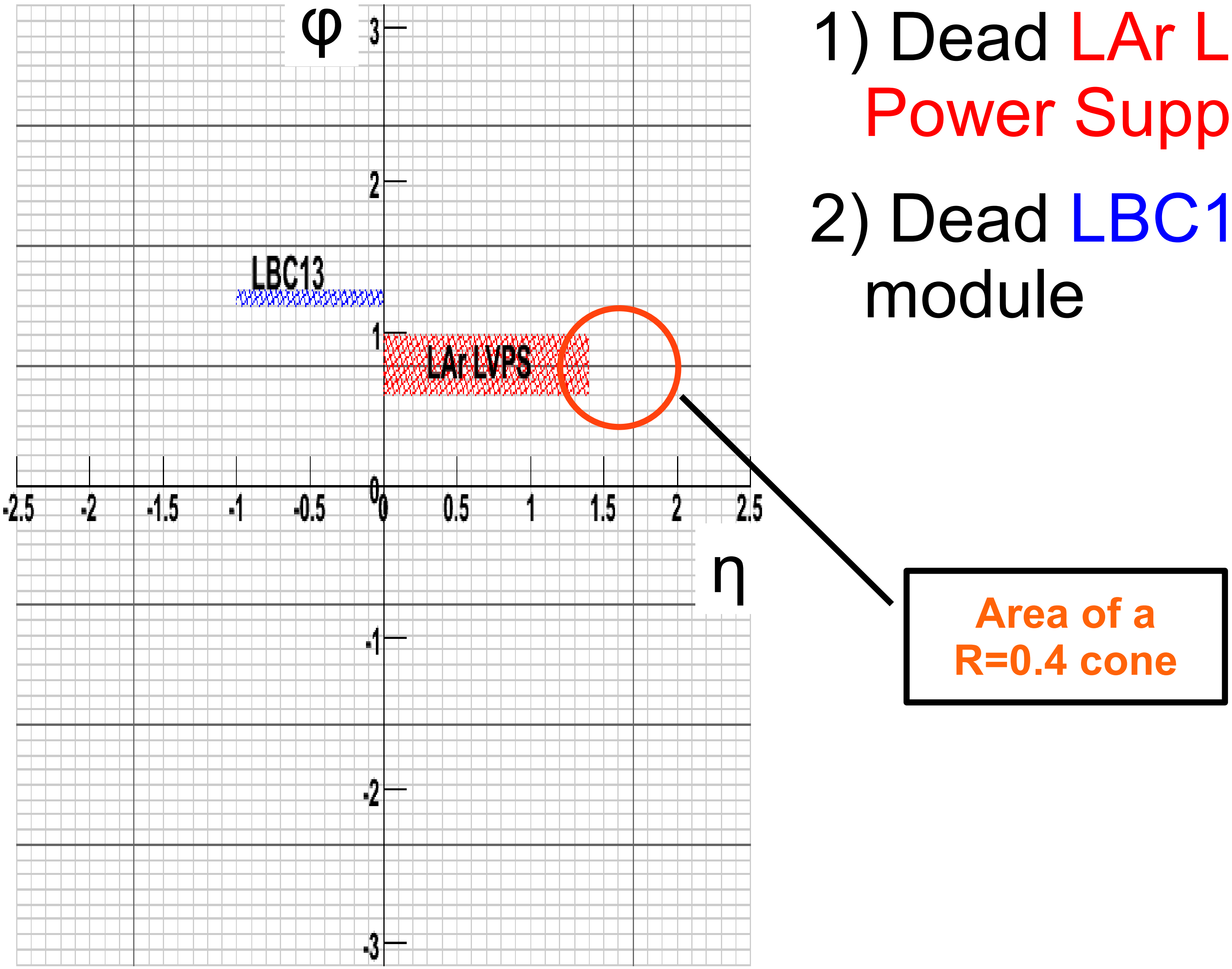
Outline

- The 2 damage scenarios studied
- Finding track jets
- Estimating true momentum
- Missing E_T
- Summary

The 2 damage scenarios studied



1) Dead LAr Low Voltage Power Supply

2) Dead LBC13 TileCal module

Part 1 / 3

Using tracks to find **where** jets are.

- Efficiency = $\text{matched}_{(\Delta R<0.2)}$ truth jets / truth jets
- Purity = $\text{matched}_{(\Delta R<0.2)}$ reco jets / reco jets
- Angular resolution : $\Delta R_{(\text{truth-reco})}$

The track clustering algorithm

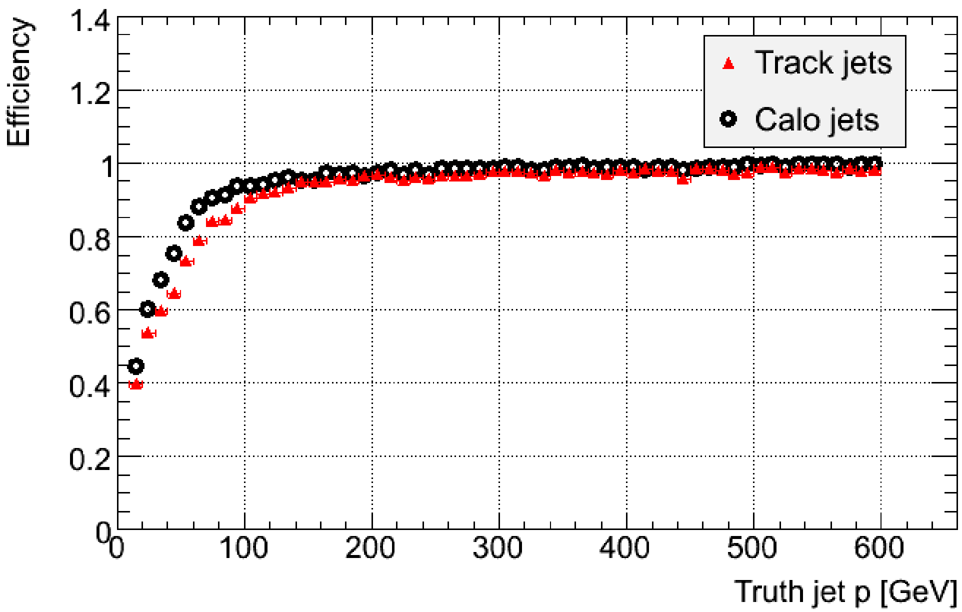
- **Method** : Seeded Cone algorithm (R=0.4). Tracks are used only once and then removed. (This is called "*Iterative Cone with Progressive Removal*")
- Use only tracks with ≥ 4 silicon hits.
- Seed tracks must have p_T > 1 GeV.
- Same vertex is required to cluster tracks together.
- Finally, a track jet is kept if tracks ≥ 3 and $\Sigma p_T \geq 5$ GeV.

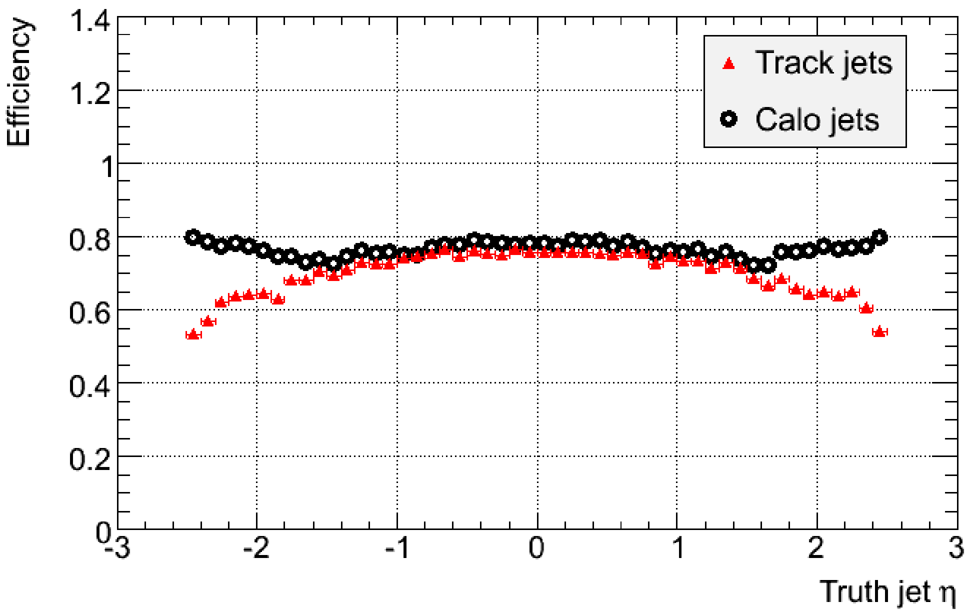
Case 1 / 3

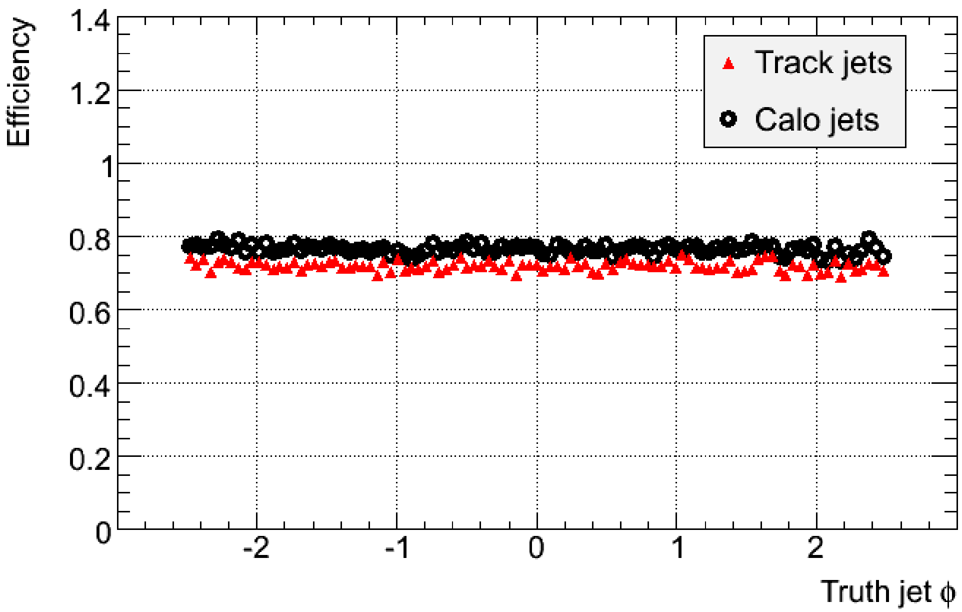
For a healthy detector,
using all jets in $|\eta|<2.5$.

(will show the effects of damage later)

Efficiency of Track jets vs Calo jets





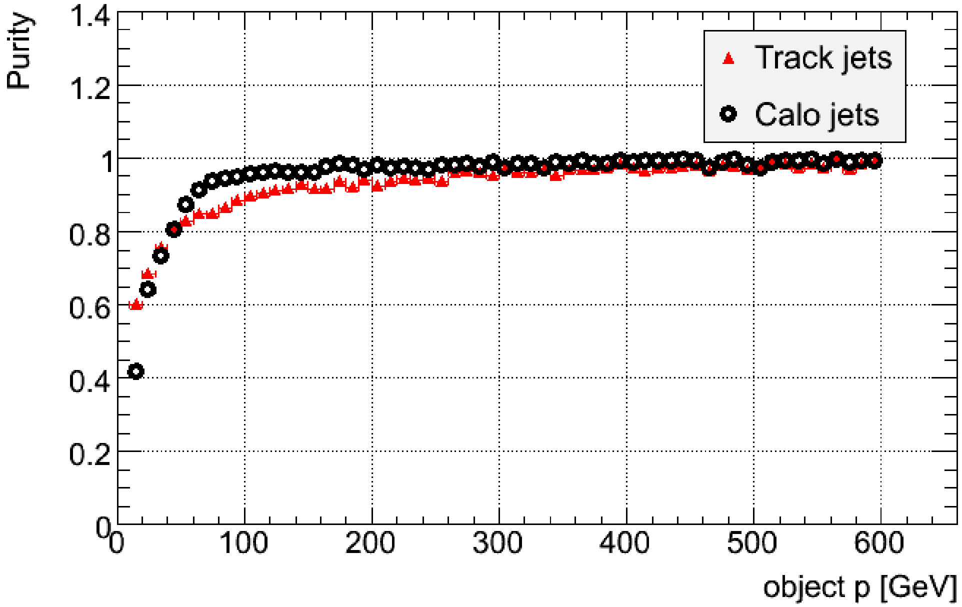


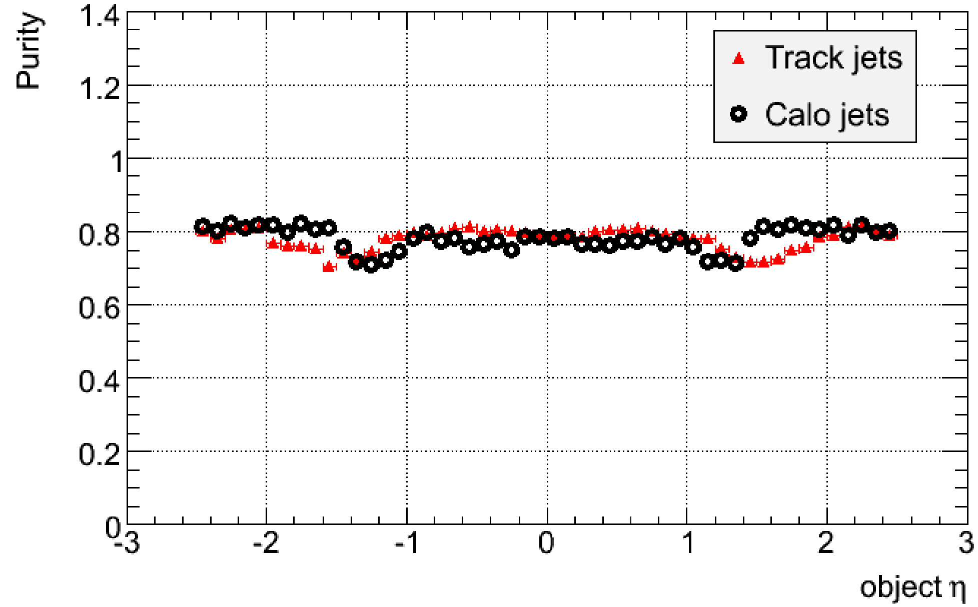
Track jets are about as efficient as Calo jets*.

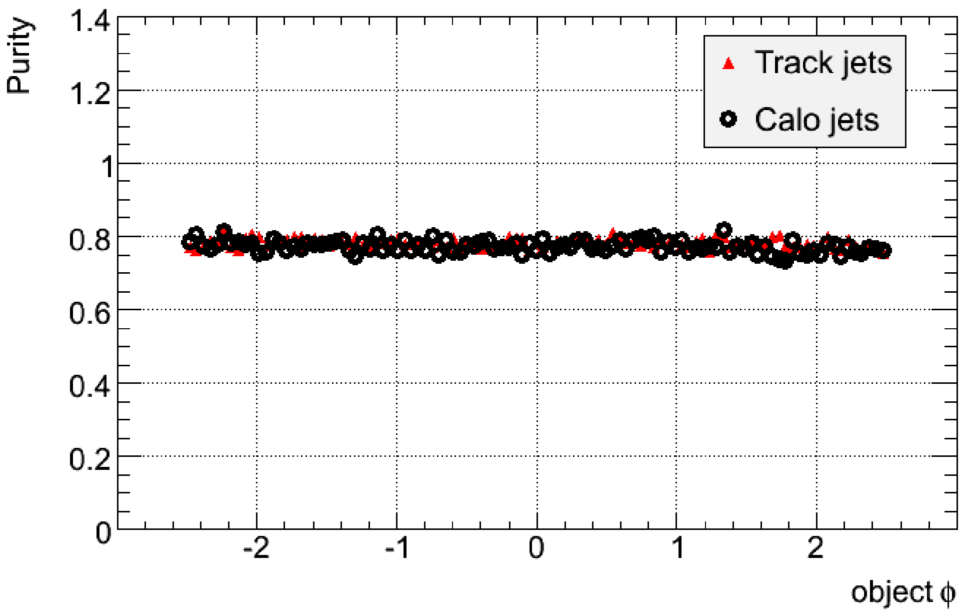
Efficiency drops at |η| near 2.5, where tracks start escaping out of Inner Detector coverage.

* Calo jets = H1 topocluster Cone R=0.4 jets

Purity of Track jets vs Calo jets



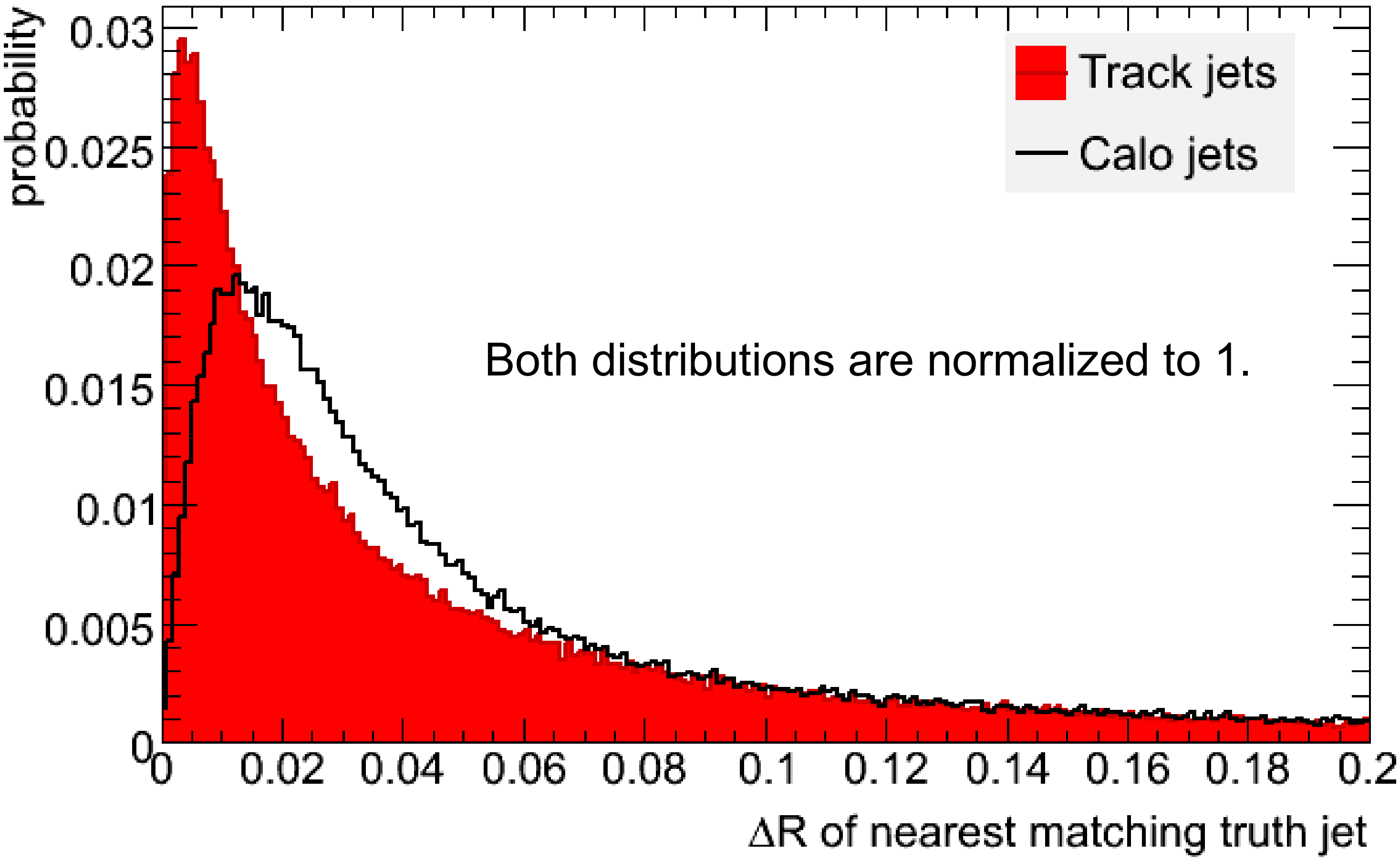




Purity equivalent to that of Calo jets.

(warning for those reading the slides: “object p” means H1 calibrated p for Calo jets, but for track jets it means simply the vector sum p of all tracks. So, the horizontal axis means different things for Calo and for Track jets in the upper left figure.)

Angular resolution

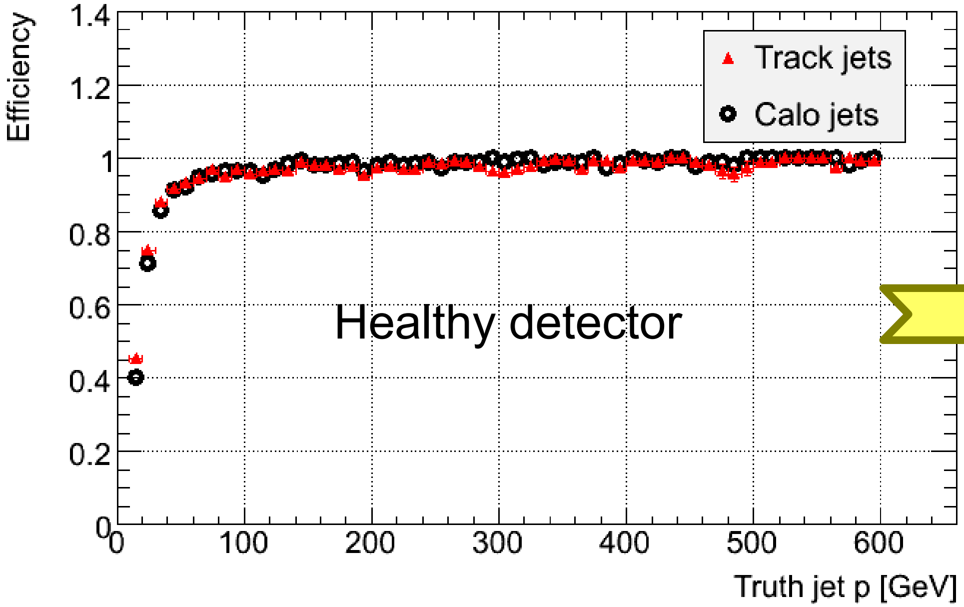


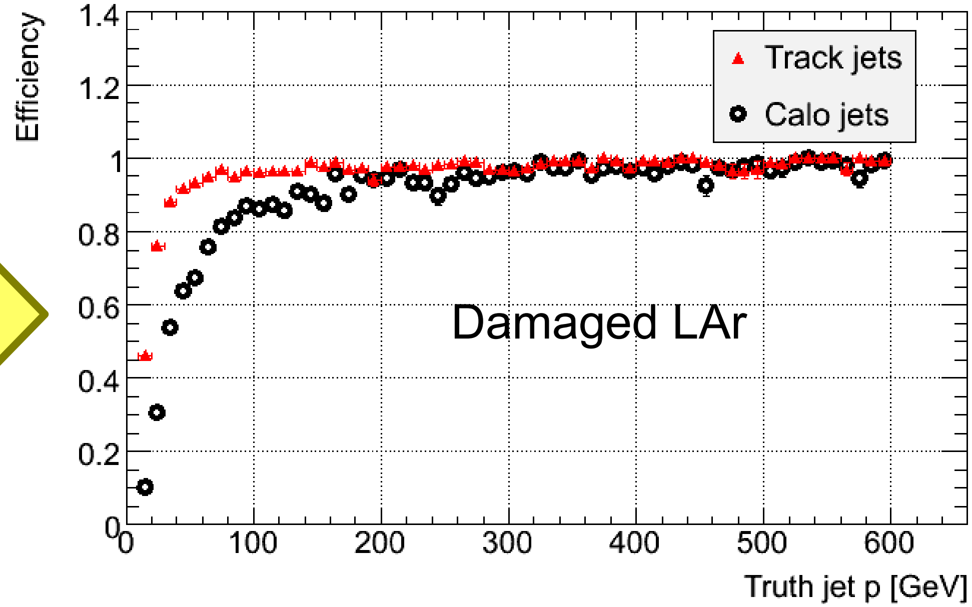
Track jets point closer to truth jets than calorimeter jets do. Better angular resolution.

Case 2 / 3

For a broken LAr LVPS,
using only jets whose axis lies in the
affected η-φ region :

Efficiency of Track jets vs Calo jets

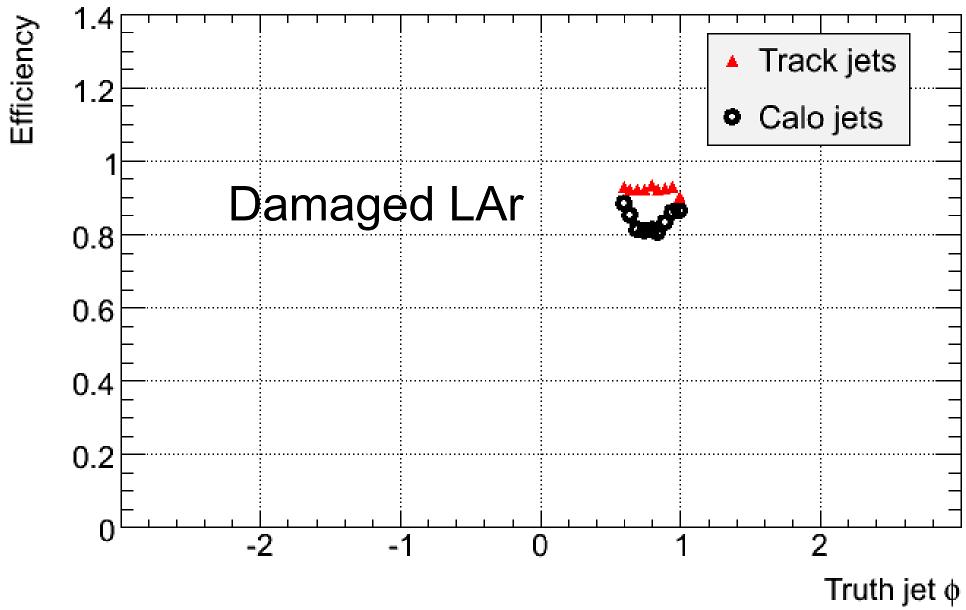




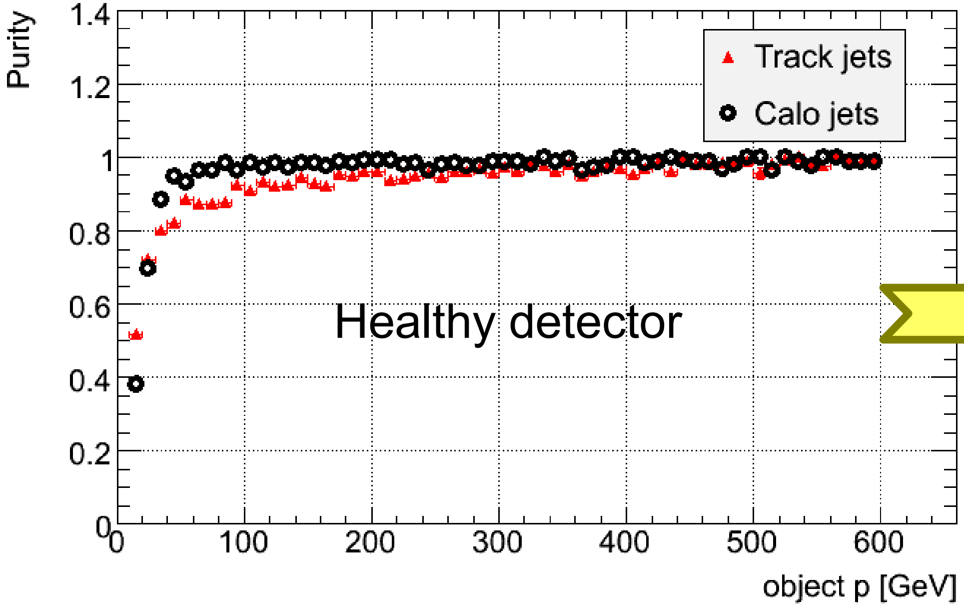
Calo jets become less efficient than Track jets.

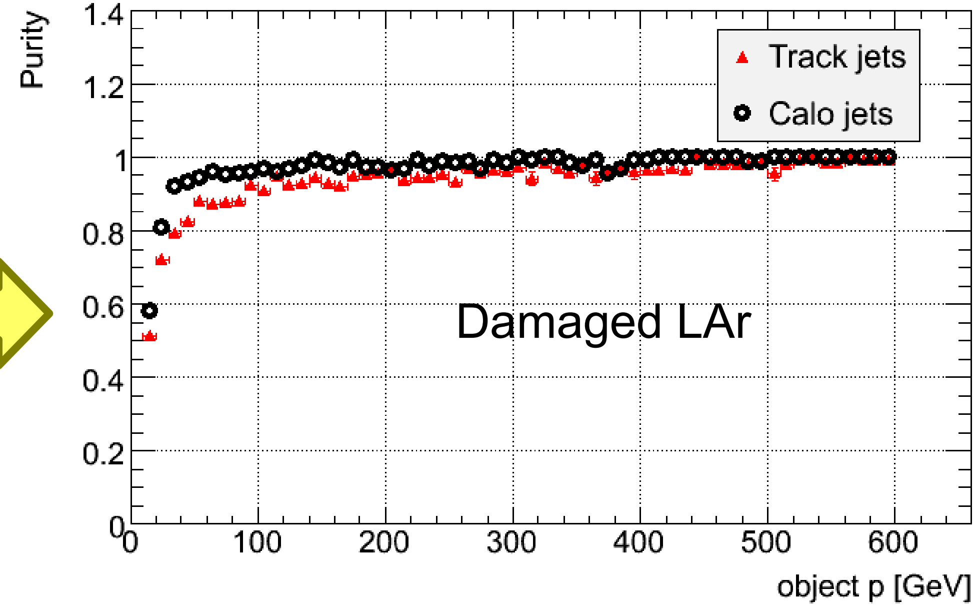
Especially if p_{truth} < 200 GeV.

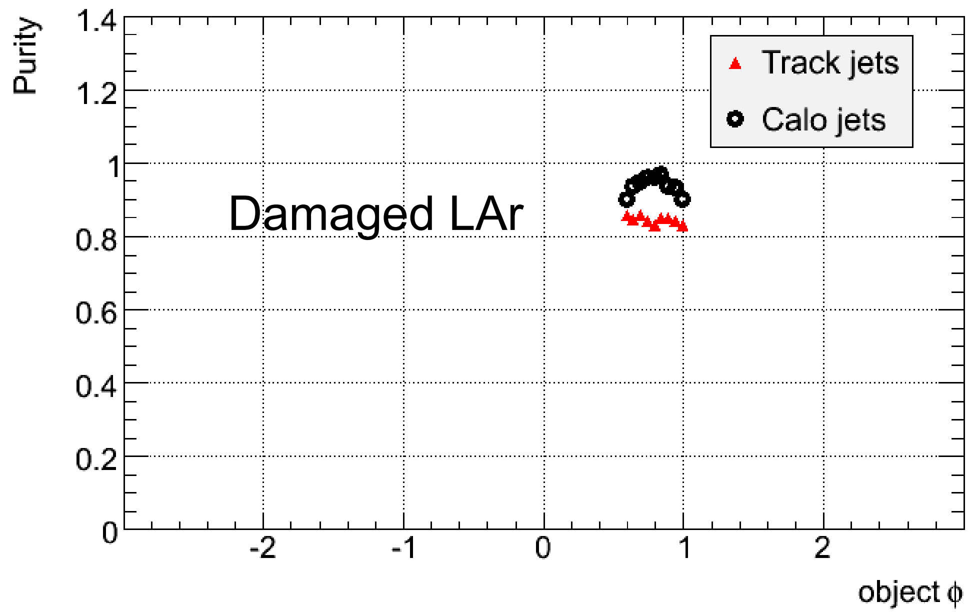
In φ one sees that Calo jets are more affected when their axis is in the middle of the dead region than near the edge.



Purity of Track jets vs Calo jets



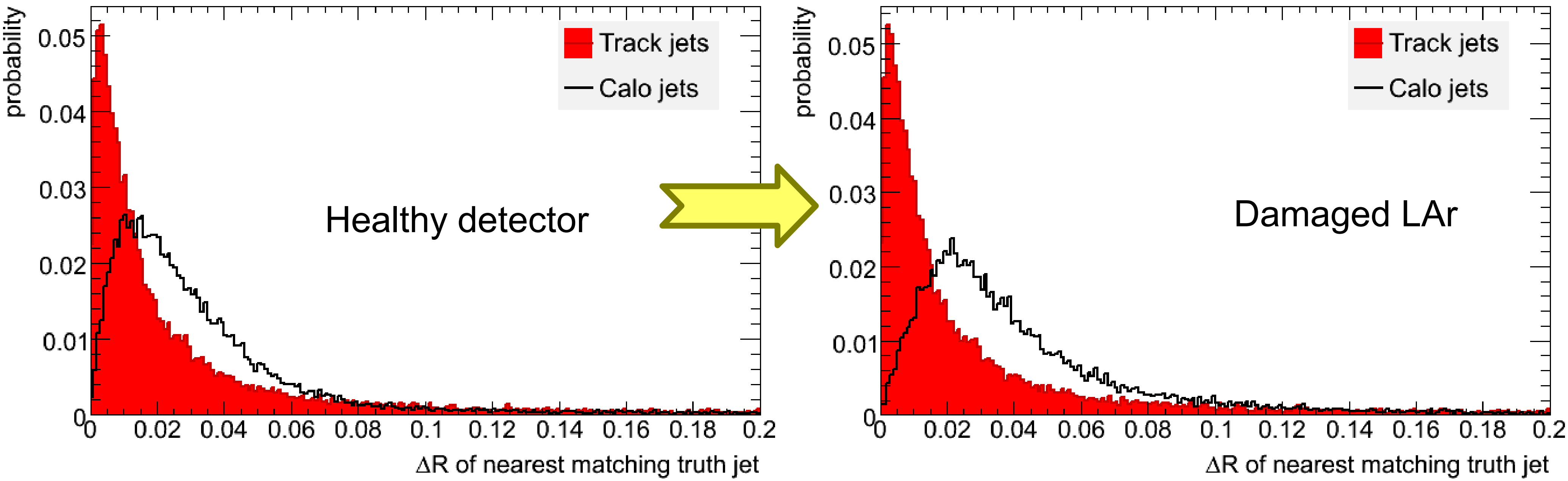




Purity of Calo jets improves for reconstructed p < 40 GeV.

The damage reduces spurious soft jets pointing there, since all cells in dead region have energy=0.

Angular resolution

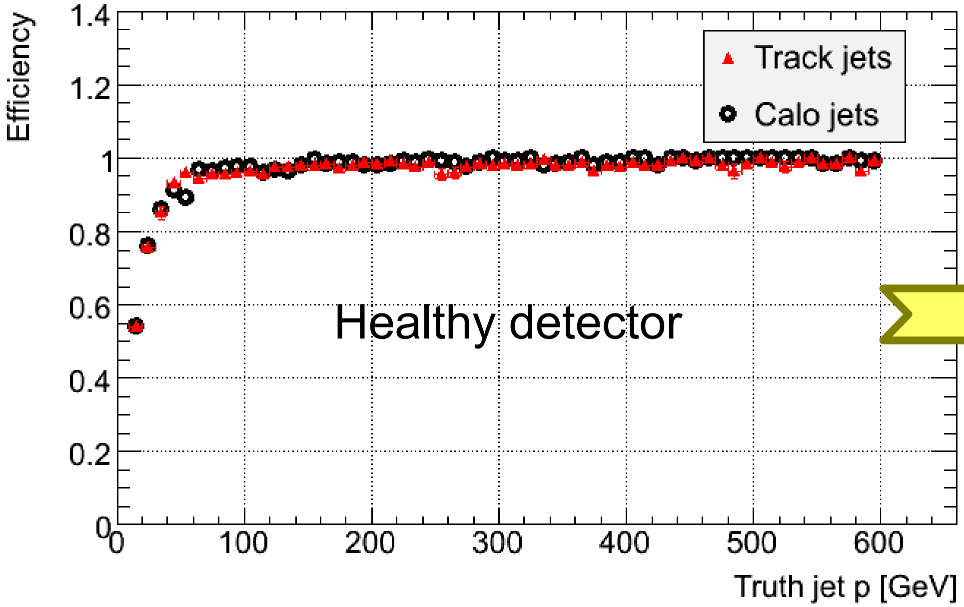


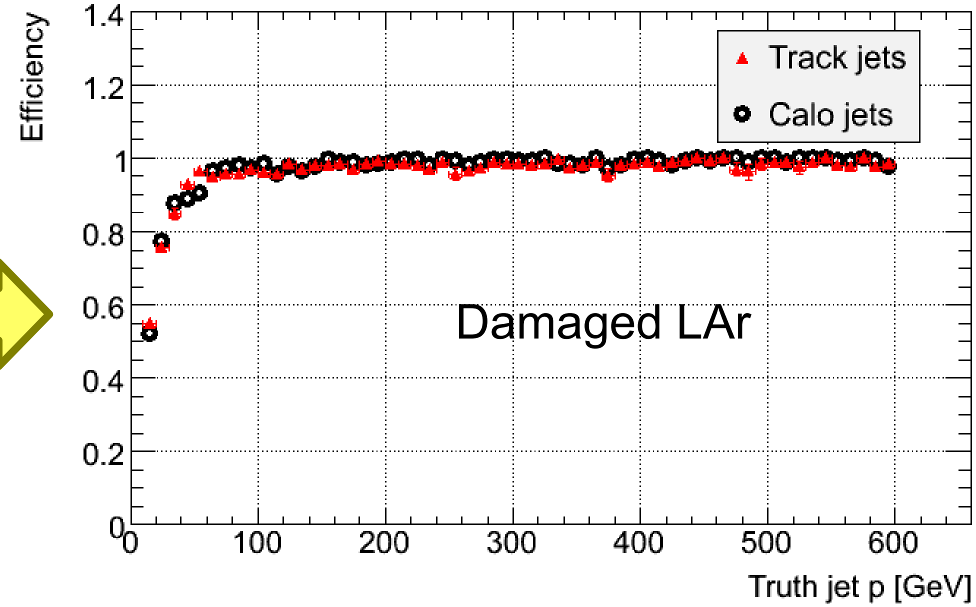
Track jets offer better angular resolution.
The damage makes angular resolution of Calo jets even worse.

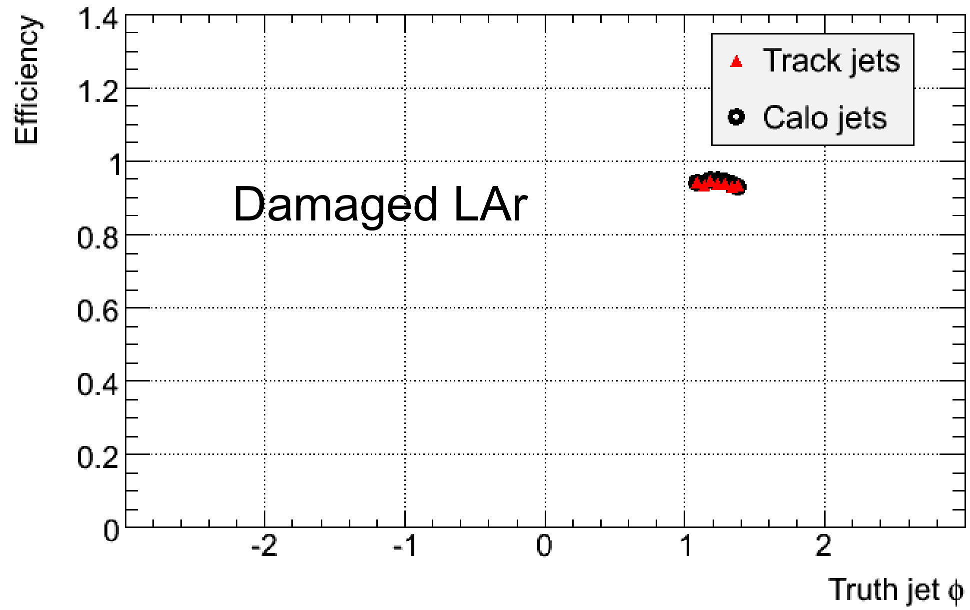
Case 3 / 3

For a broken TileCal LBC13, using only jets whose axis lies in the affected η-φ region :

Efficiency of Track jets vs Calo jets

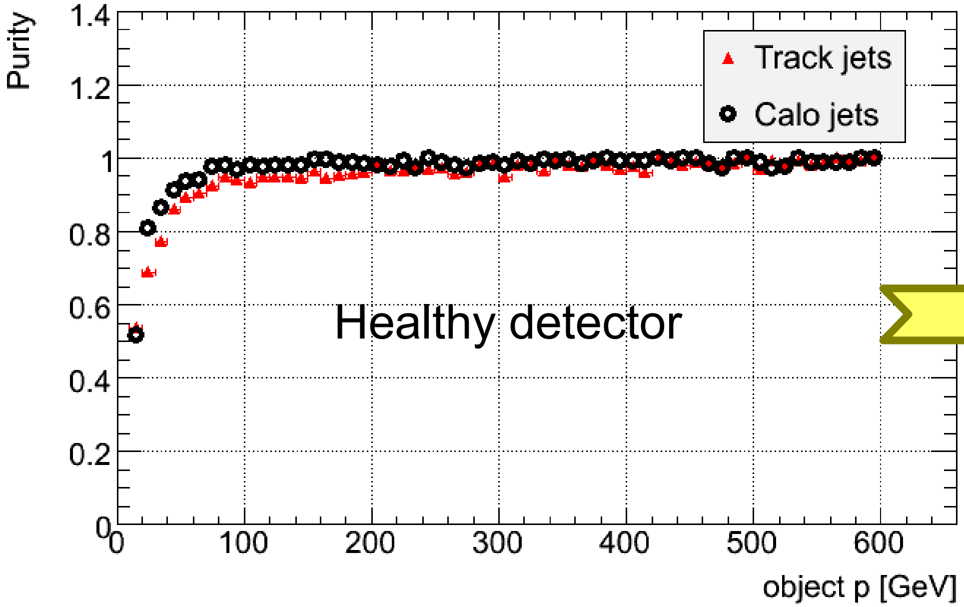


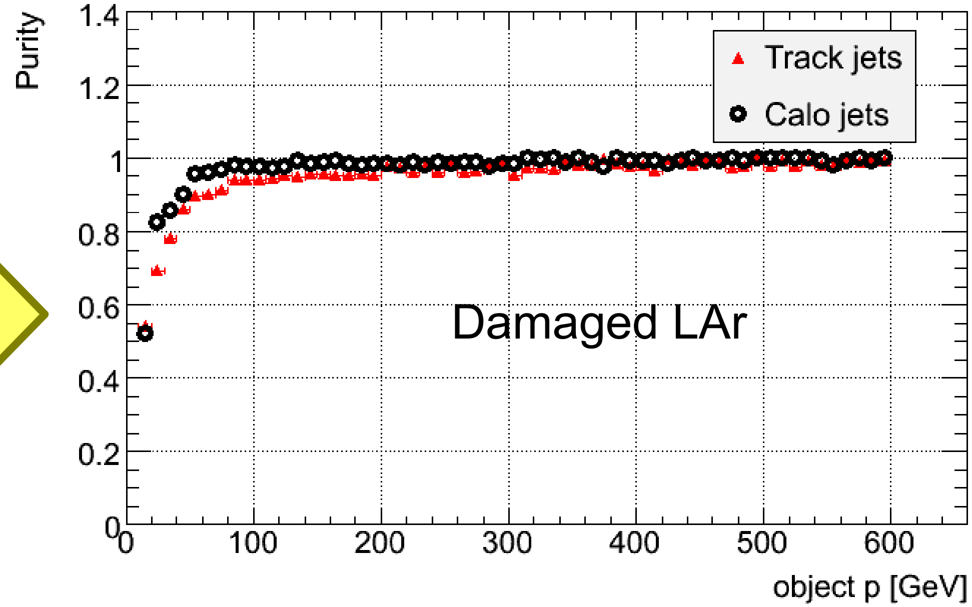




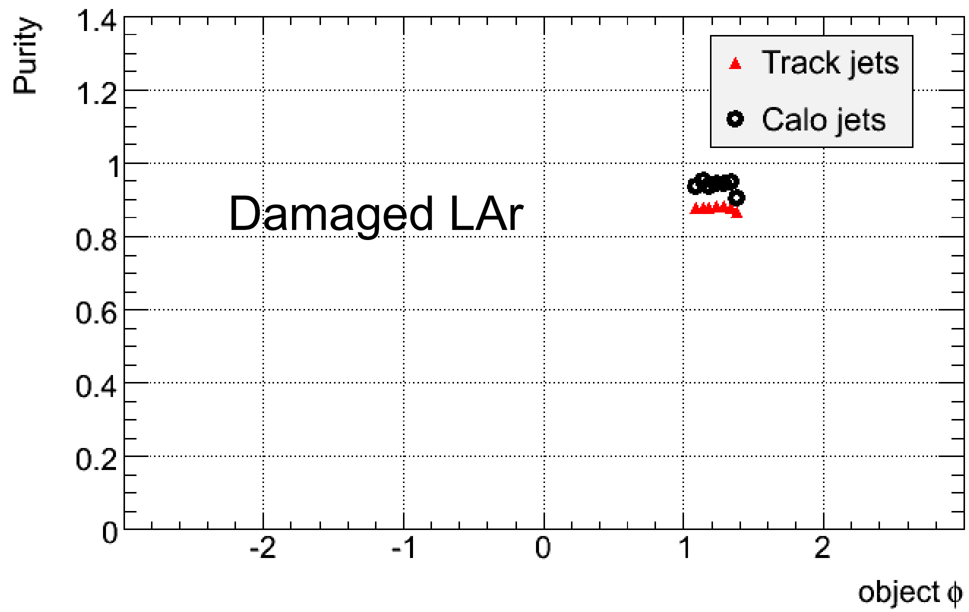
Small damage → Small effect.

Purity of Track jets vs Calo jets

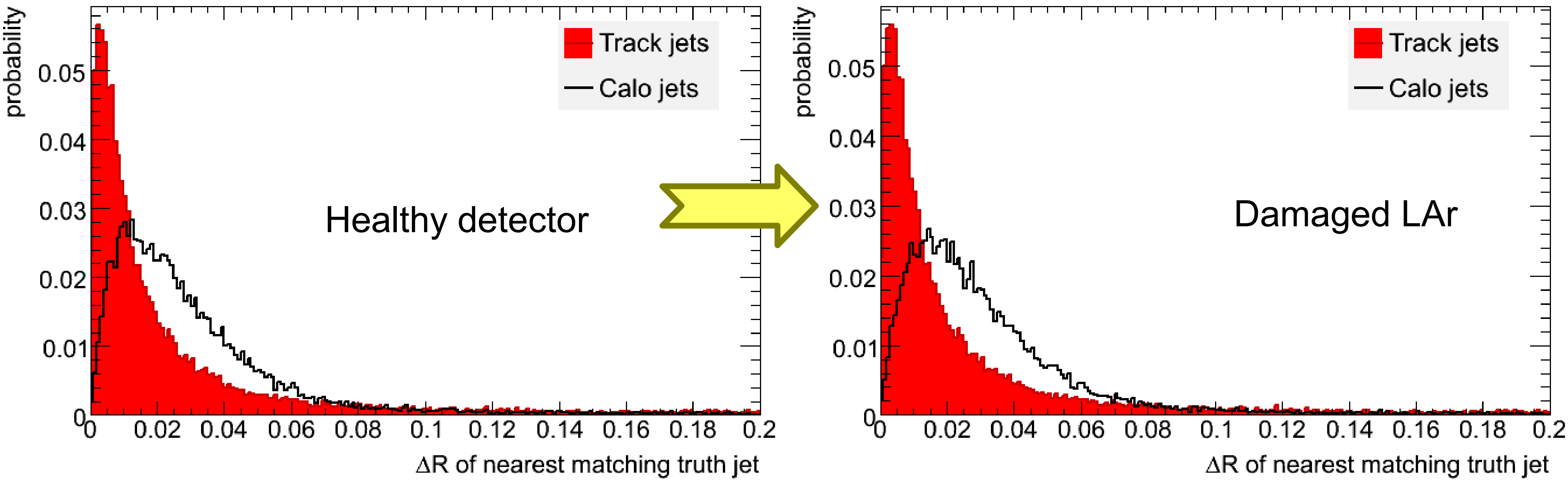




Small damage → Small effect.



Angular resolution



Track jets offer better angular resolution.
The damage is small, so it doesn't affect Calo jets much.

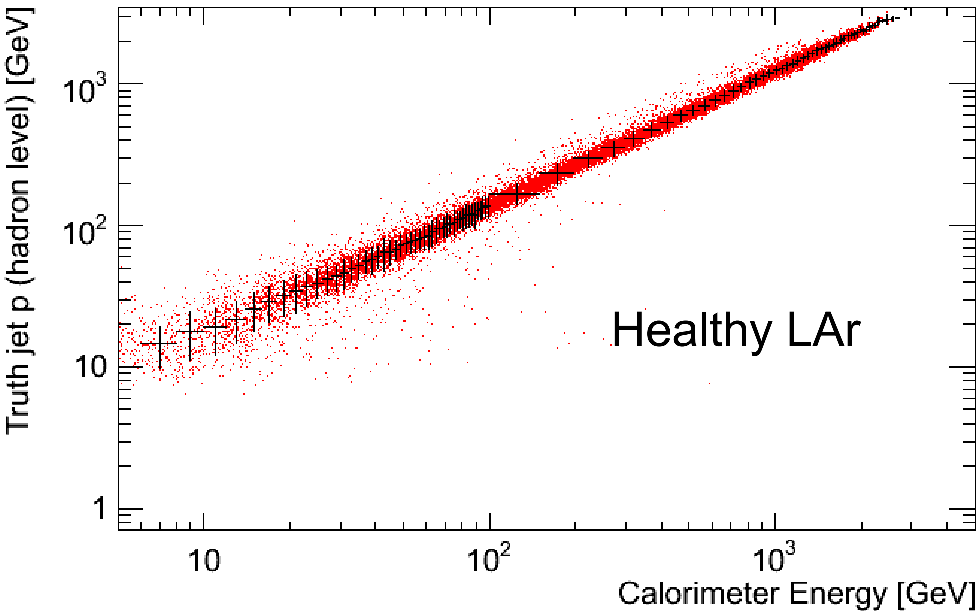
(Small damage → Small effect)

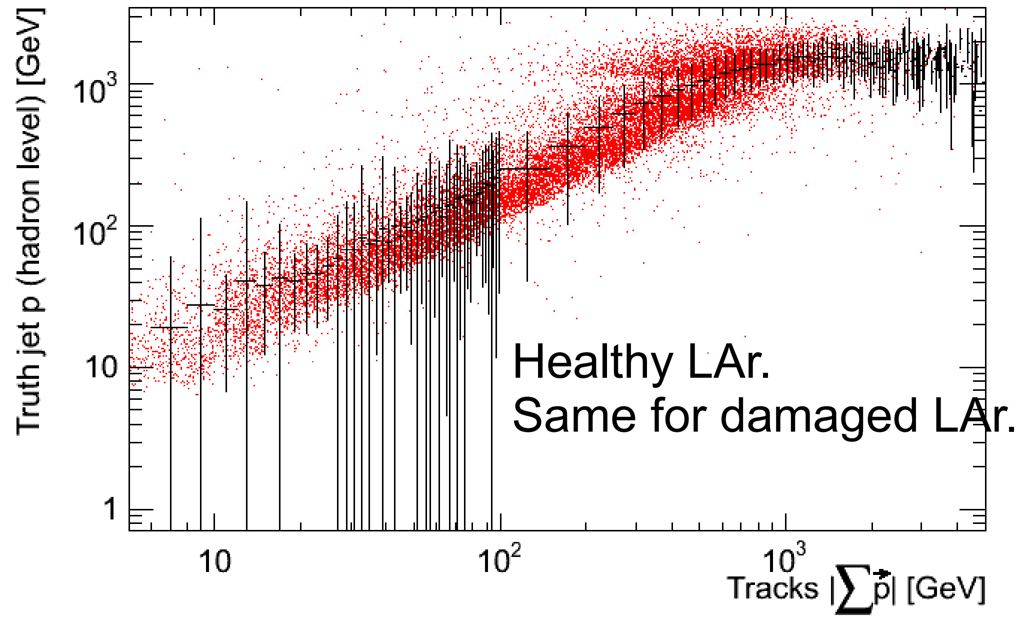
Part 2 / 3

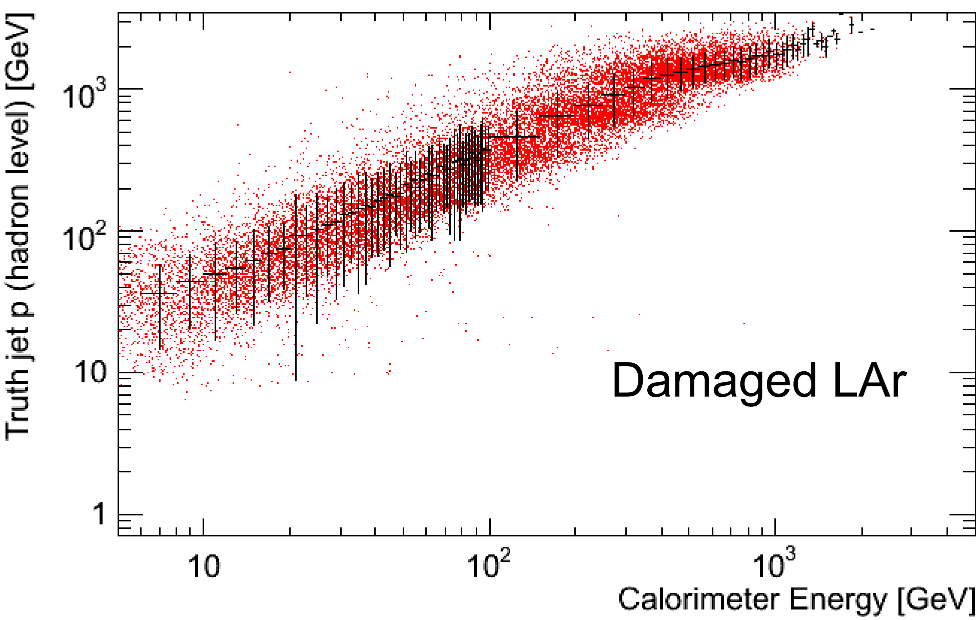
Estimation of true momentum of Track jets.

Attention: We use only tracks to identify Track jets, but to estimate their energy we exploit <u>also</u> any surviving <u>calorimeter</u> energy. So, we call our jets "Track jets", but their energy is not estimated only from tracks.

Calibration curves for the LAr LVPS





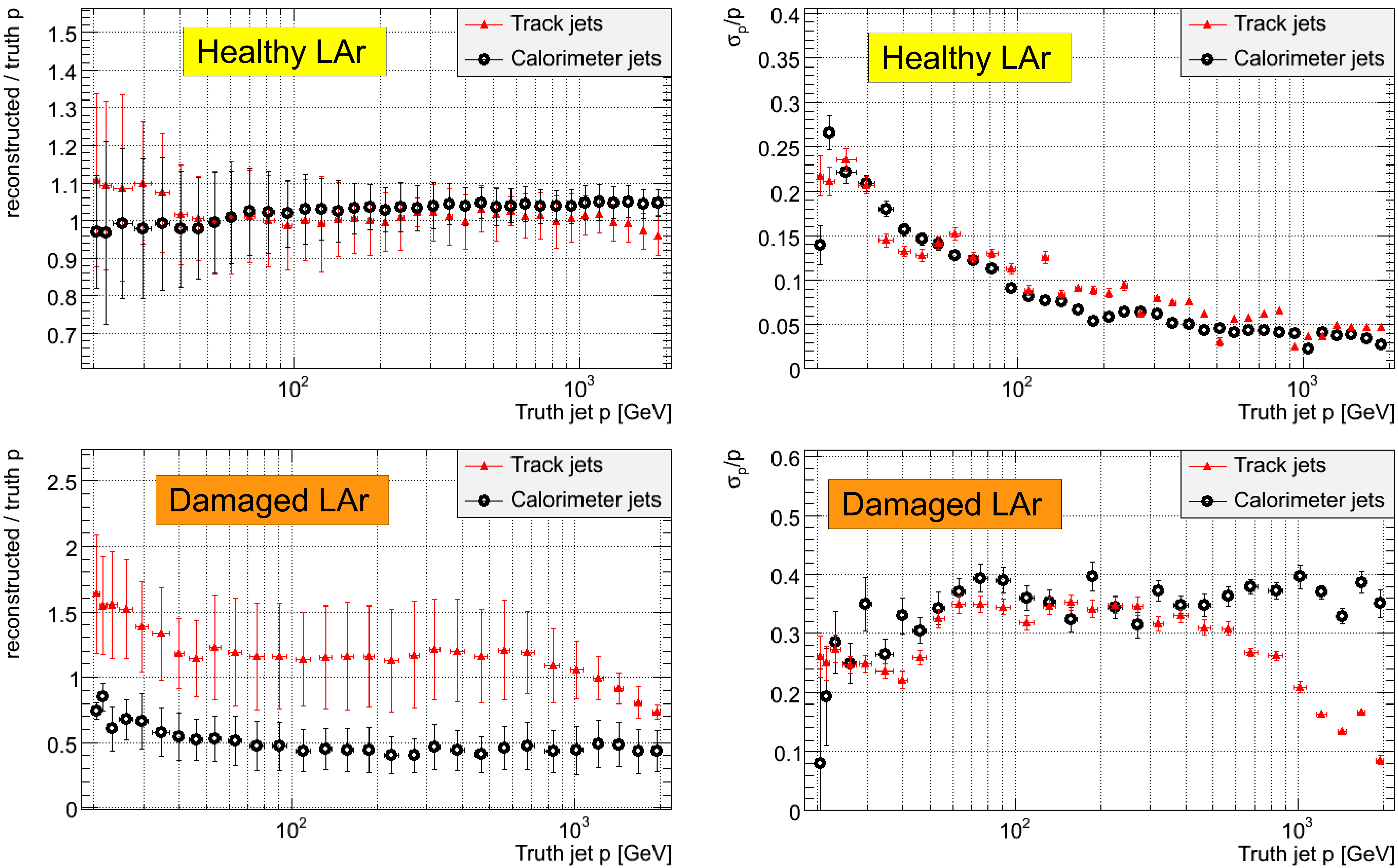


1) Calorimeter energy gives us a true p estimate.
2) Tracks' total p gives us another estimate.

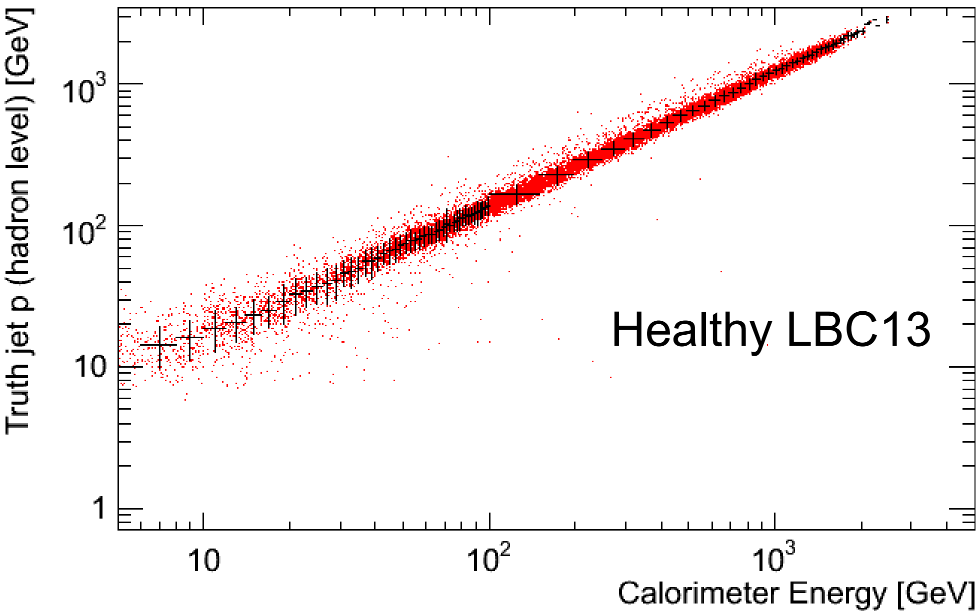
We average the two estimates (weighted). Unless calorimeter damage is very severe, calorimeter energy influences the average more than tracks' p.

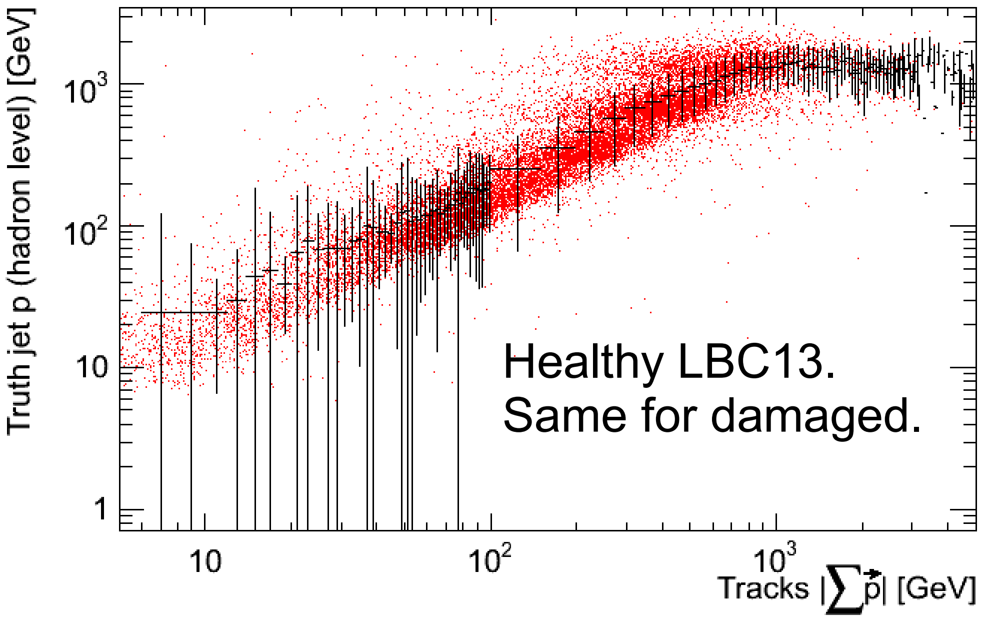
(No analytic function is fit. We use the TProfile as shown here, and connect the crosses with straight lines.)

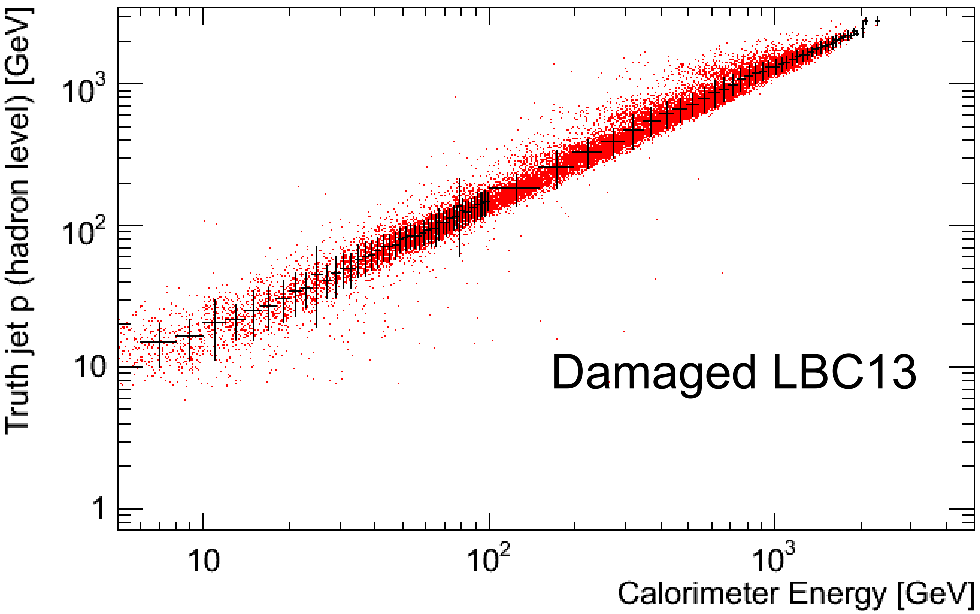
How accurate and precise is this?



Calibration curves for LBC13



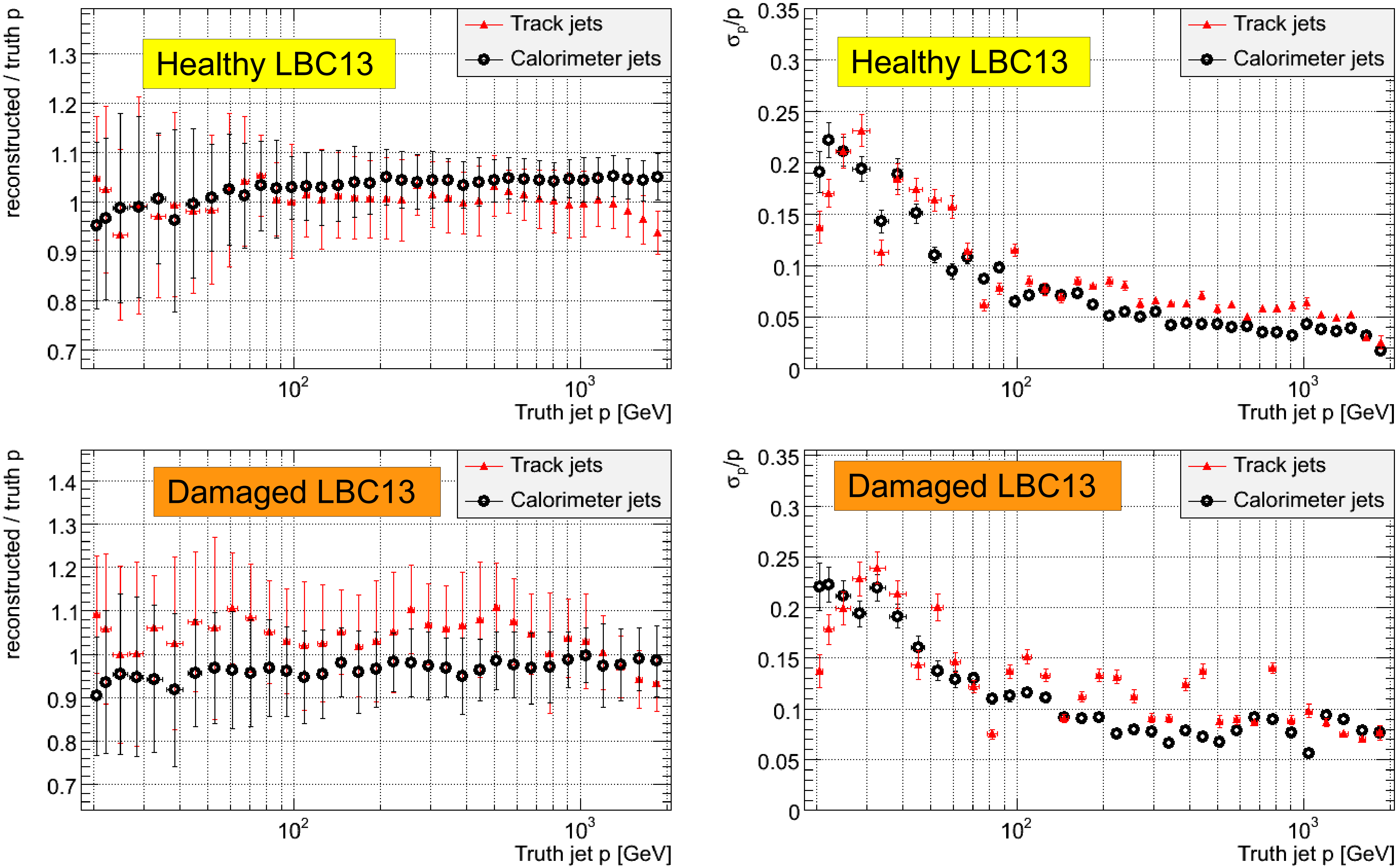




Compared to LAr damage, the LBC13 failure doesn't reduce much the predictive power of calorimeter energy.

Of course, the predictive power of tracks is not affected by the condition of the calorimeter.

How accurate is this?

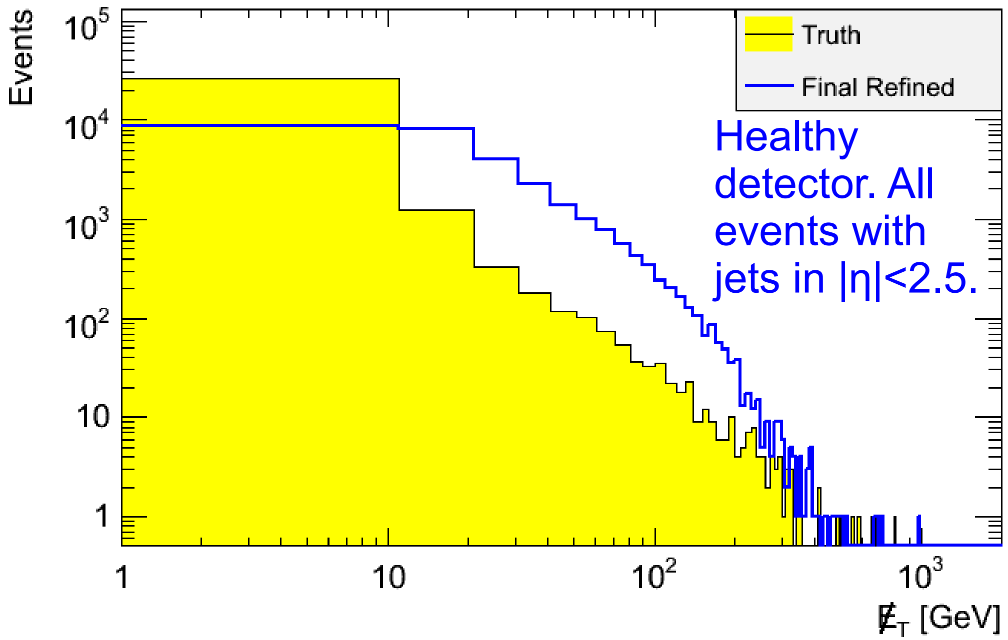


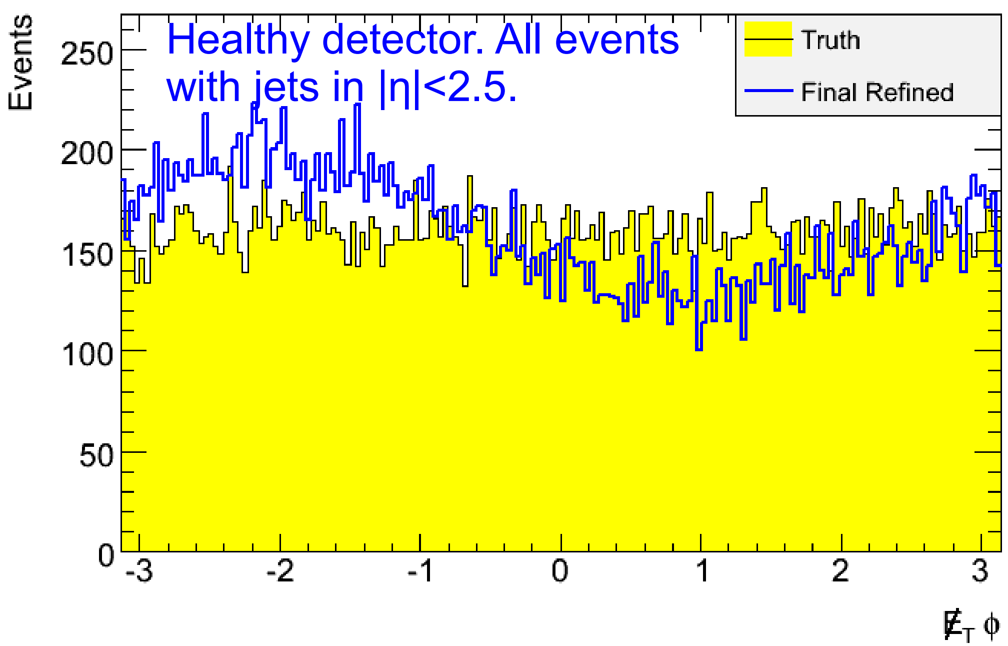
Part 3 / 3

Missing E_T

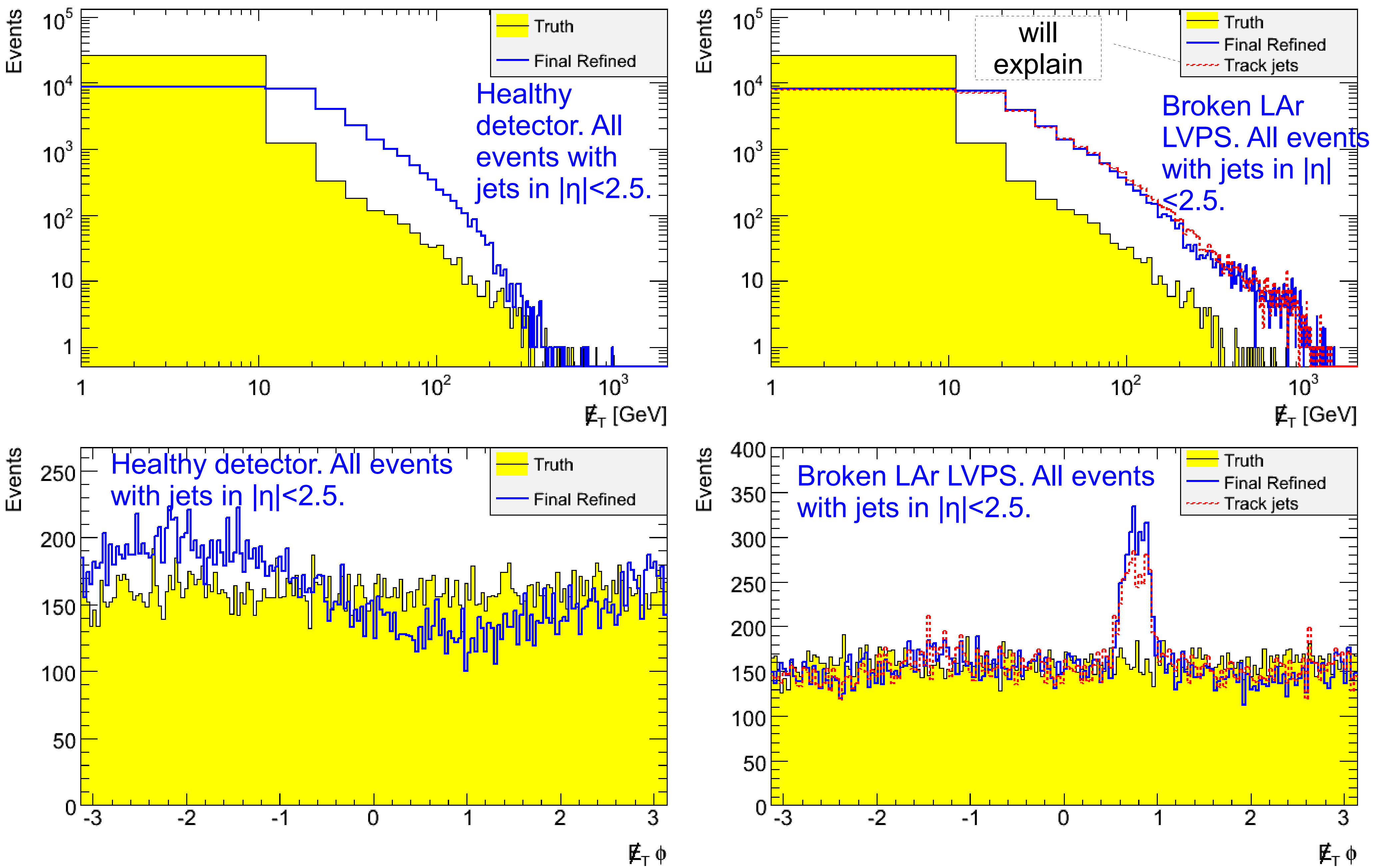
The effect of
- detector smearing
- detector damage
- correcting MET using Track jets

The effect of detector resolution





The effect of LAr LVPS damage



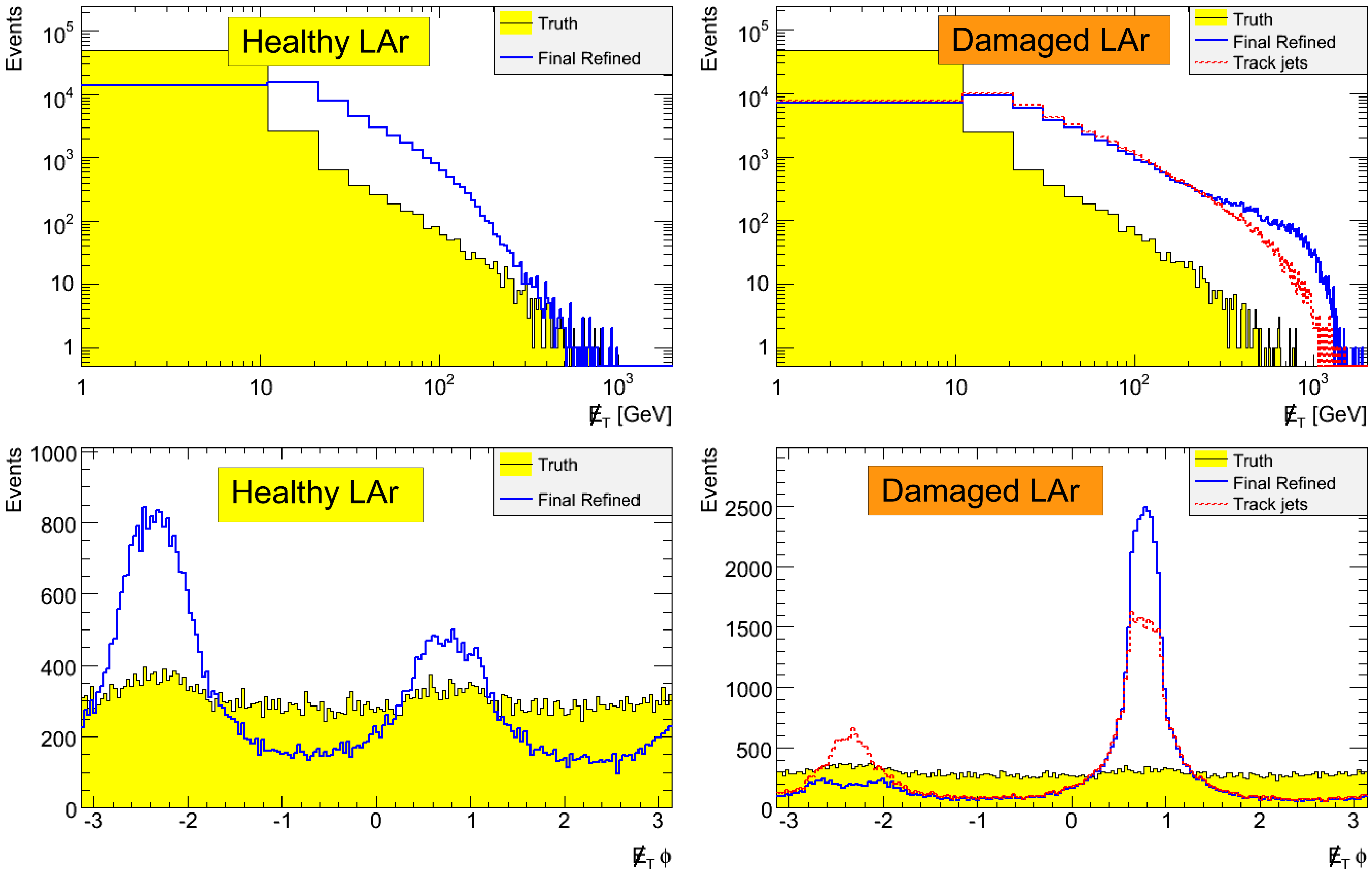
Missing E_T correction using Track jets

- Ideally, **MET** = - Σ$\mathbf{p}_T$ in the event.
- From Σ$\mathbf{p}_T$ we subtract the $\mathbf{p}_T$ of untrustworthy Calo jets from the damaged region, and then add in their place the $\mathbf{p}_T$ or the nearest Track jet.

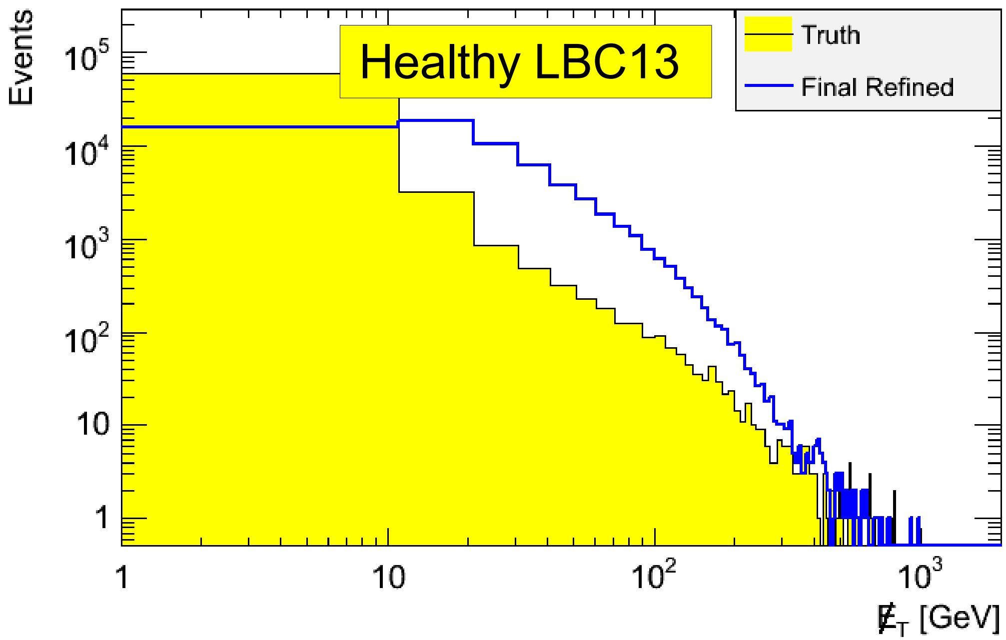
  (If there is no Track jet within $\Delta R<0.2$ from a Calo jet, then we don't subtract the Calo jet.)

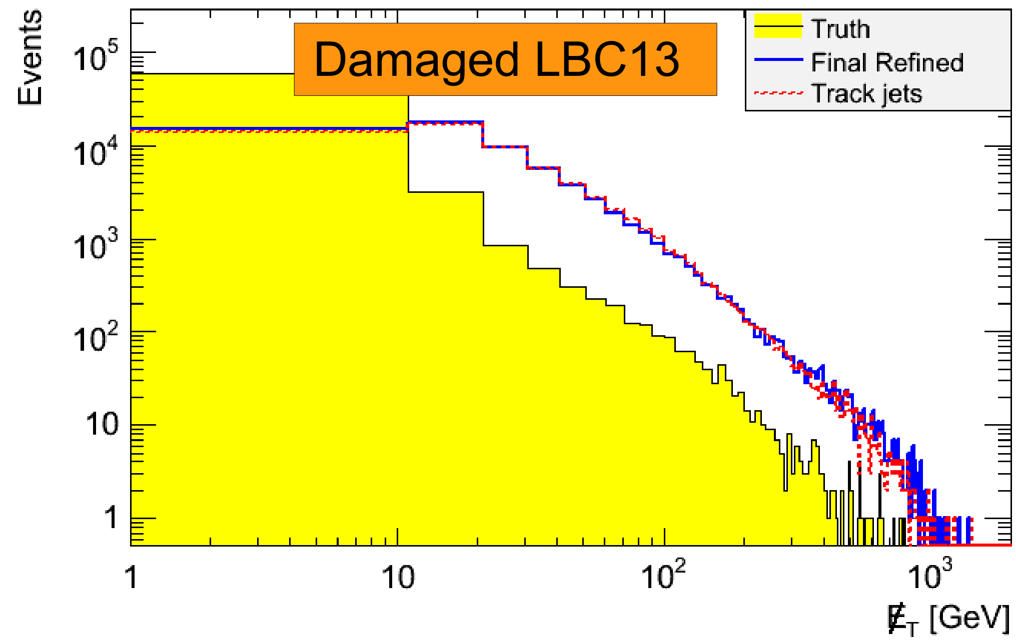
- Of course *this is a coarse correction*, unlike the cell-by-cell corrections found in `MET_RefFinal`. But
  - (1) it's easy to apply, and
  - (2) it actually doesn't make things worse!! 🙂

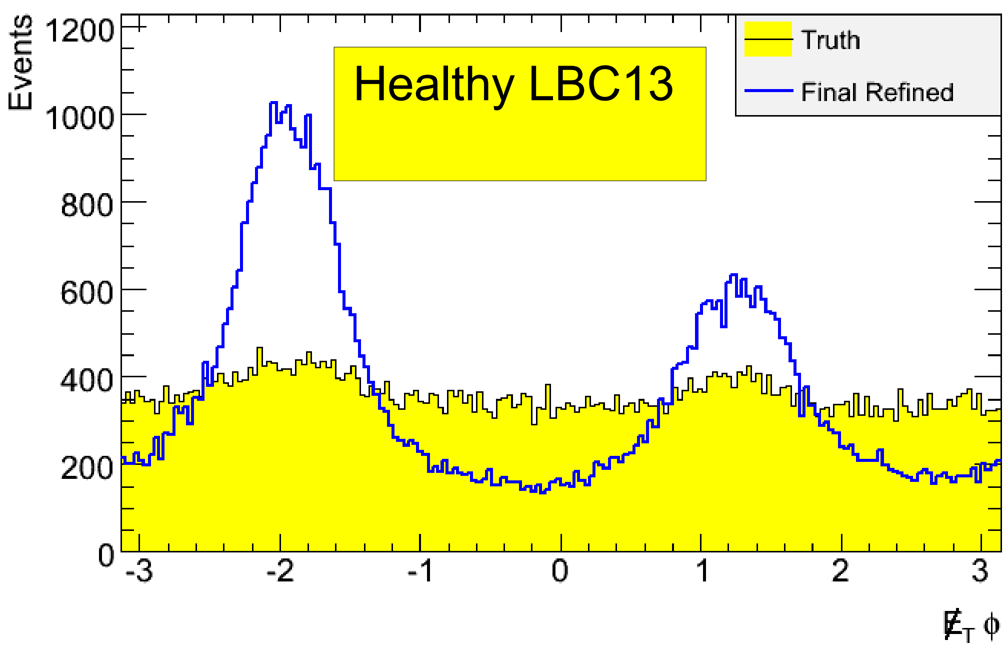
Just events with a jet in the LAr LVPS region

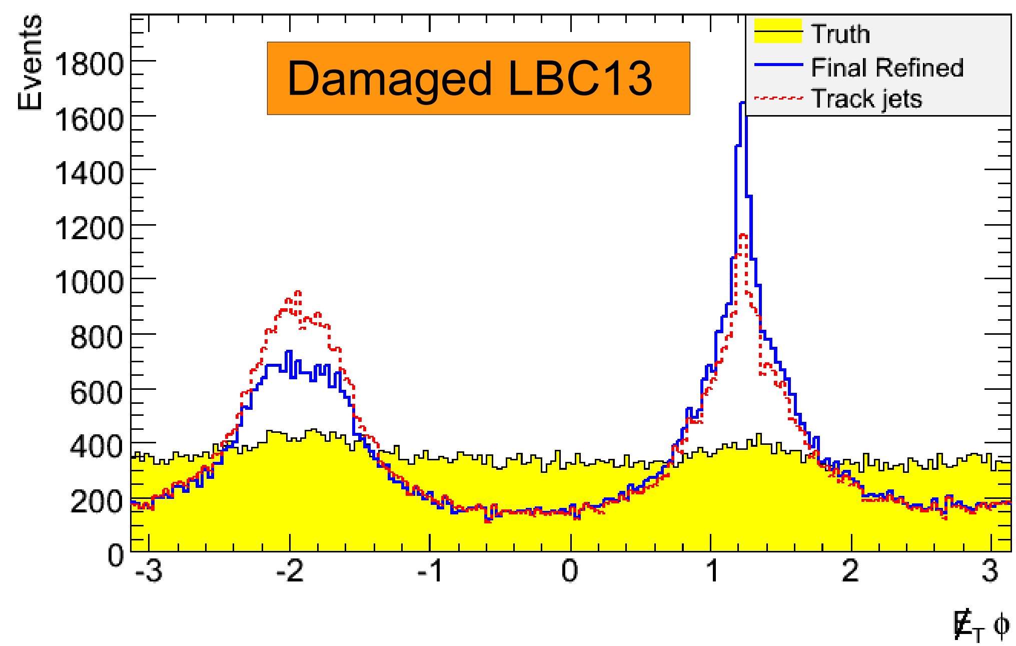


Just events with a jet in the LBC13 region









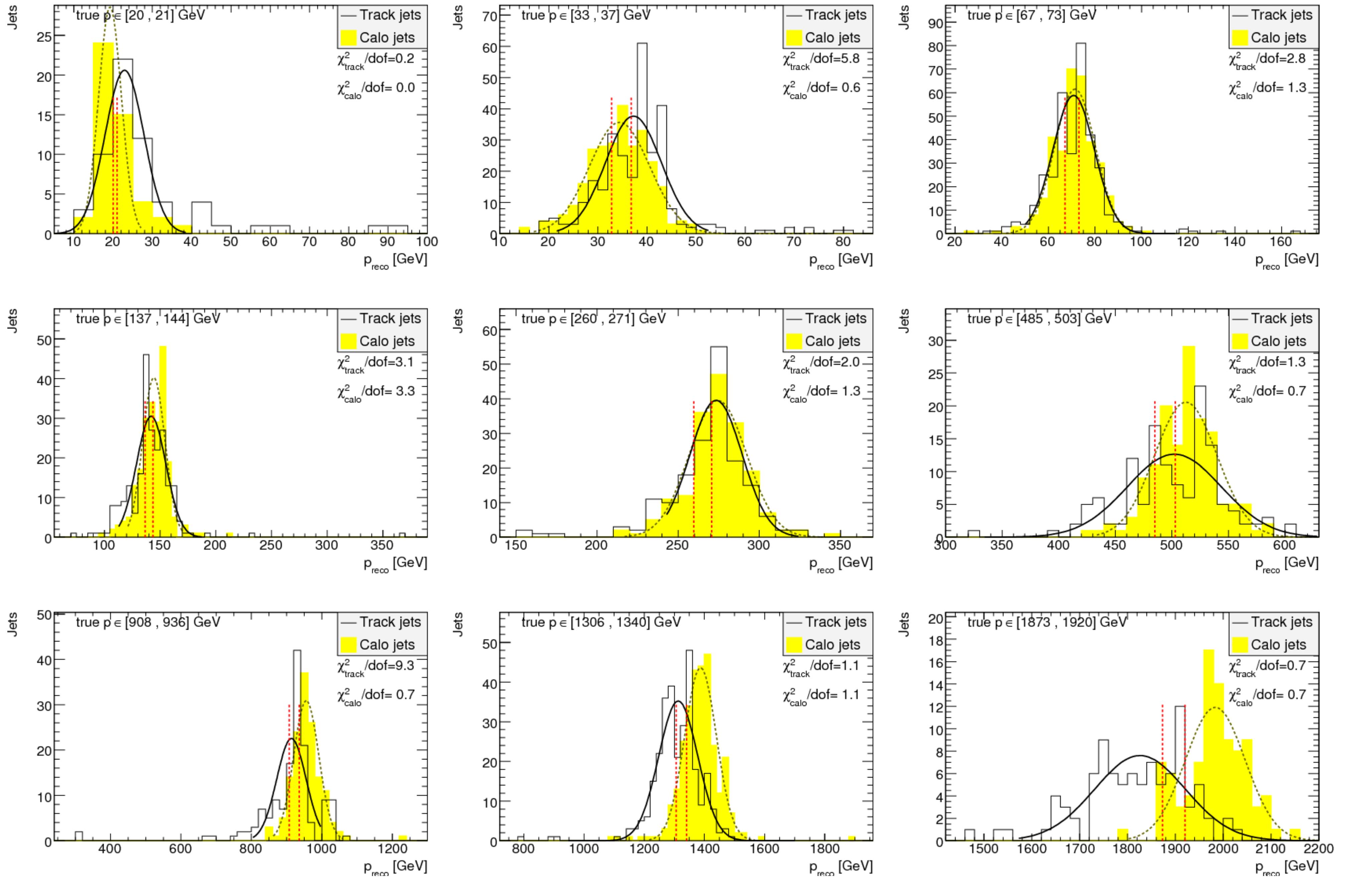
Summary/Conclusion

- We used tracks to find jets, and tracks+calorimeter to estimate their energy. The same can be repeated for any real damage, using Monte Carlo.
- Track jets are about as efficient and pure as Calorimeter jets, and offer superior angular resolution. In case of serious calorimeter damage, Calorimeter jets can deteriorate to be much less efficient than Track jets.
- Our simple calibration scheme removes the 50% bias introduced by a large LAr failure, and greatly improves energy resolution at high momentum.
- We demonstrated the effect of damage on MET, and made a correction using Track jets. A simple substitution of some Calorimeter jets with Track jets removes part of the fake MET.

backups

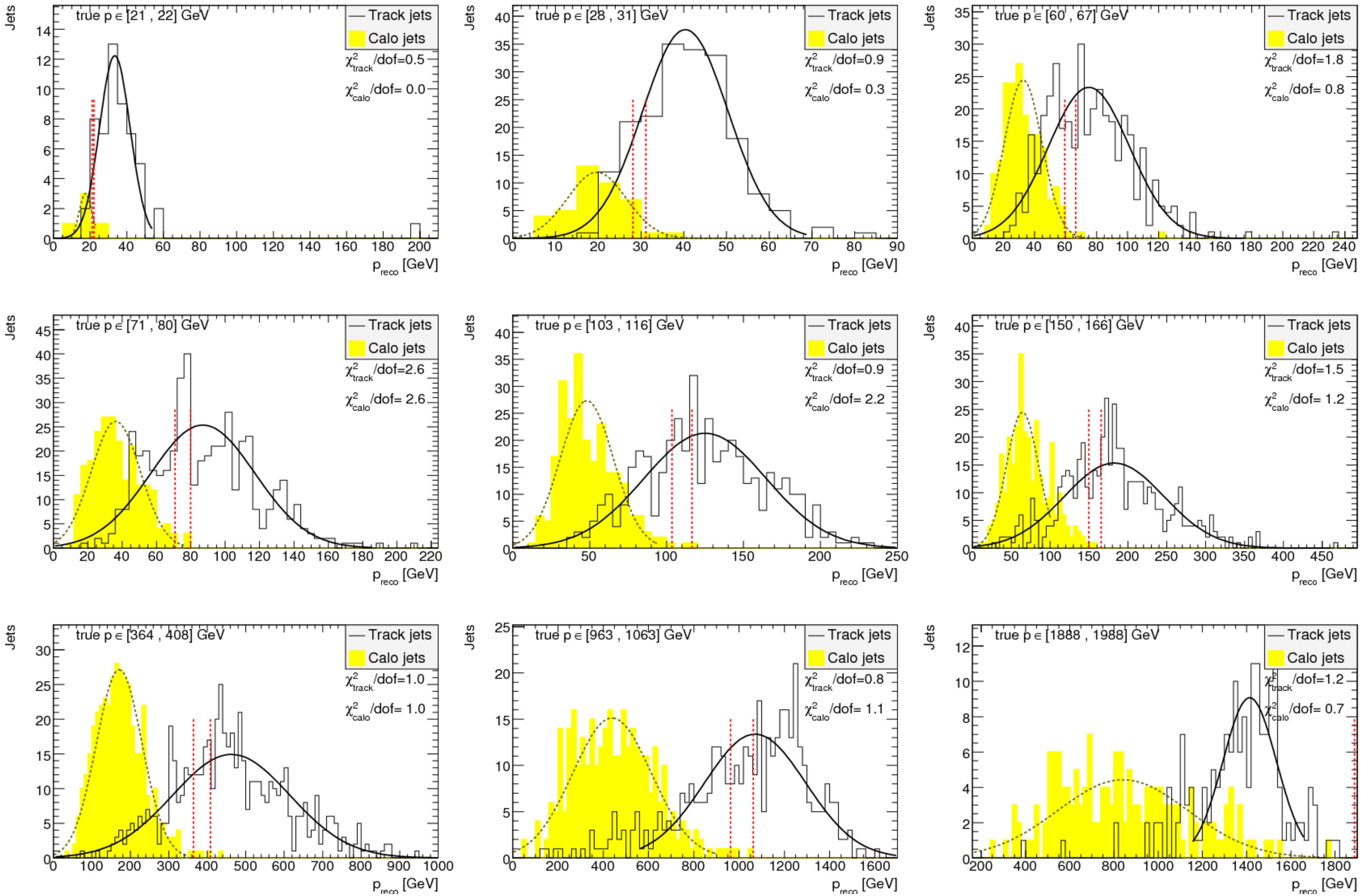
Distributions of p_{reco}

Healthy LAr



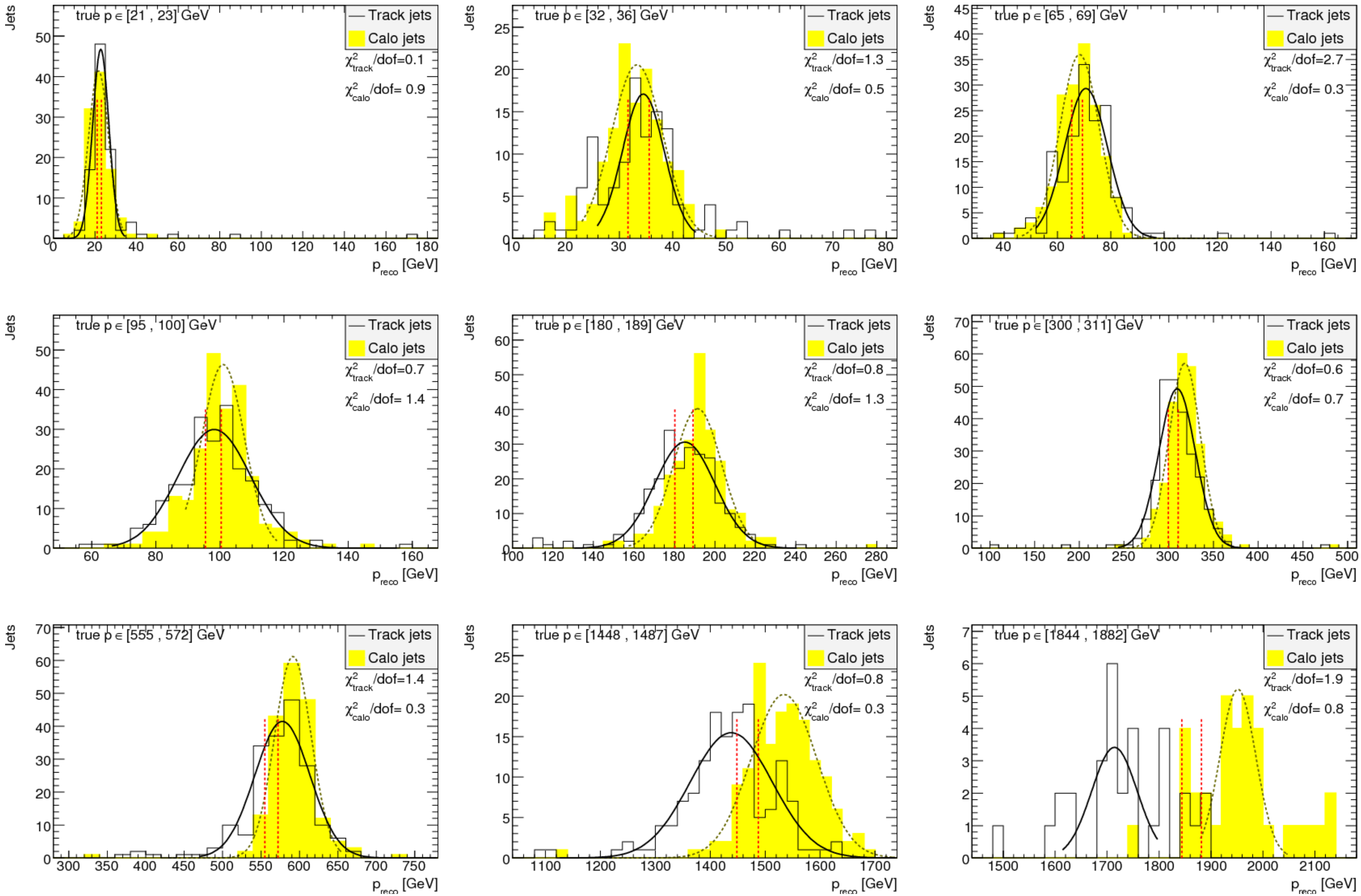
Distributions of p_{reco}

Damaged LAr



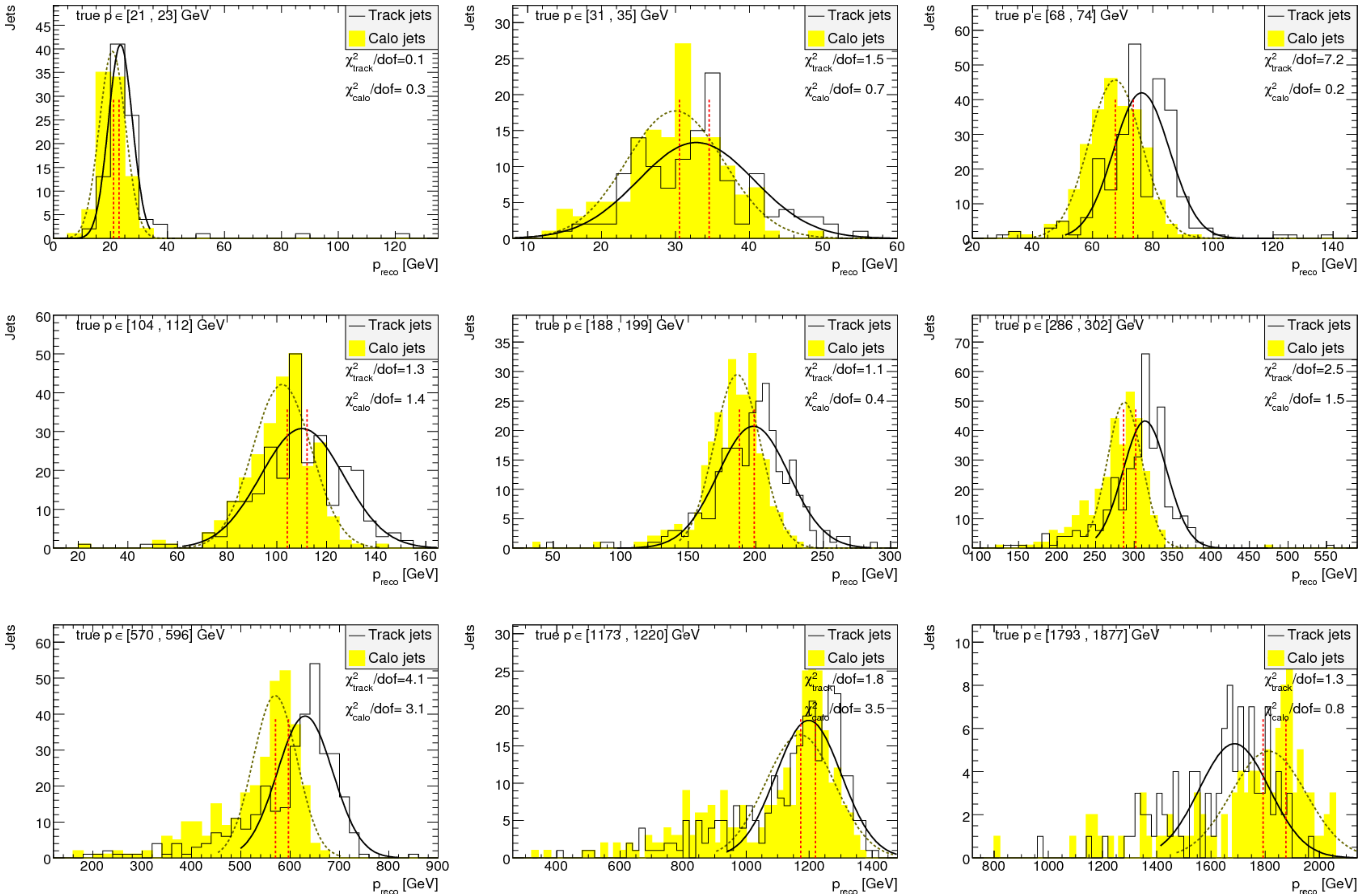
Distributions of p_{reco}

Healthy LBC13

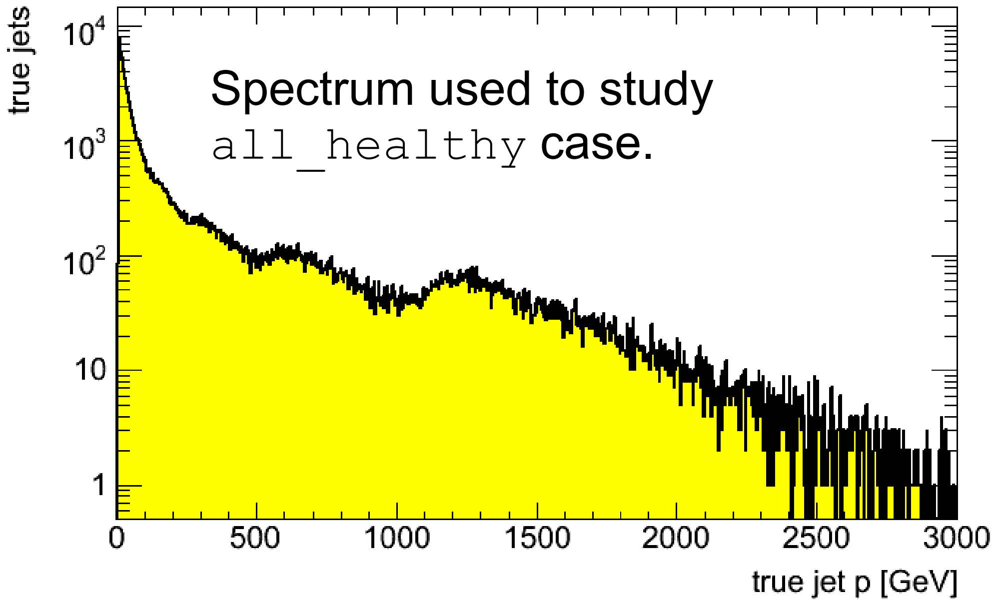


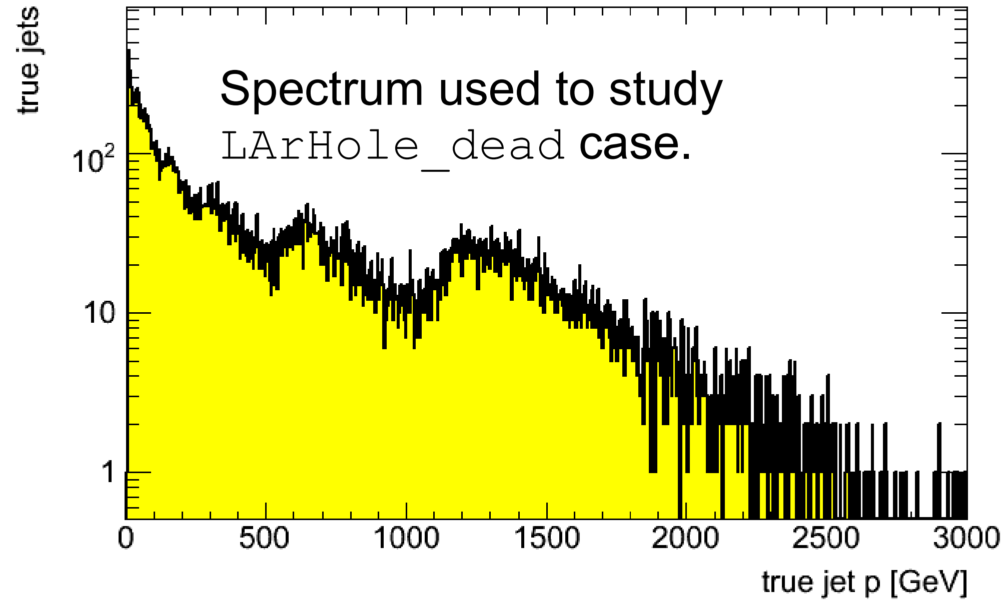
Distributions of p_{reco}

Damaged LBC13



True p spectra used





Dataset	p_T bin
mc08.105009.J0_pythia_jetjet.recon.ESD.e344_s456_r456	8-17 GeV
mc08.105010.J1_pythia_jetjet.recon.ESD.e344_s456_r456	17-35 GeV
mc08.105011.J2_pythia_jetjet.recon.ESD.e344_s456_r456	35-70 GeV
mc08.105012.J3_pythia_jetjet.recon.ESD.e344_s456_r456	70-140 GeV
mc08.105013.J4_pythia_jetjet.recon.ESD.e344_s456_r456	140-280 GeV
mc08.105014.J5_pythia_jetjet.recon.ESD.e344_s456_r456	280-560 GeV
mc08.105015.J6_pythia_jetjet.recon.ESD.e344_s456_r456	560-1120 GeV
mc08.105016.J7_pythia_jetjet.recon.ESD.e344_s456_r456	1120-2240 GeV