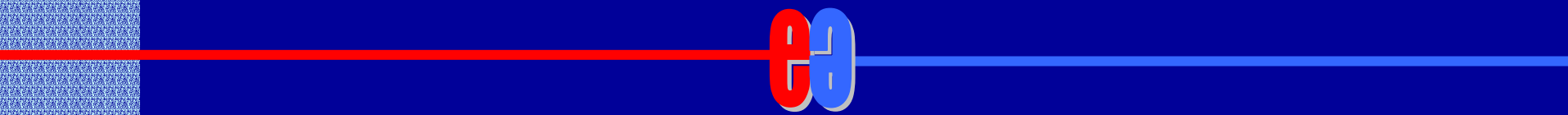
Energy-Flow



Norman Graf

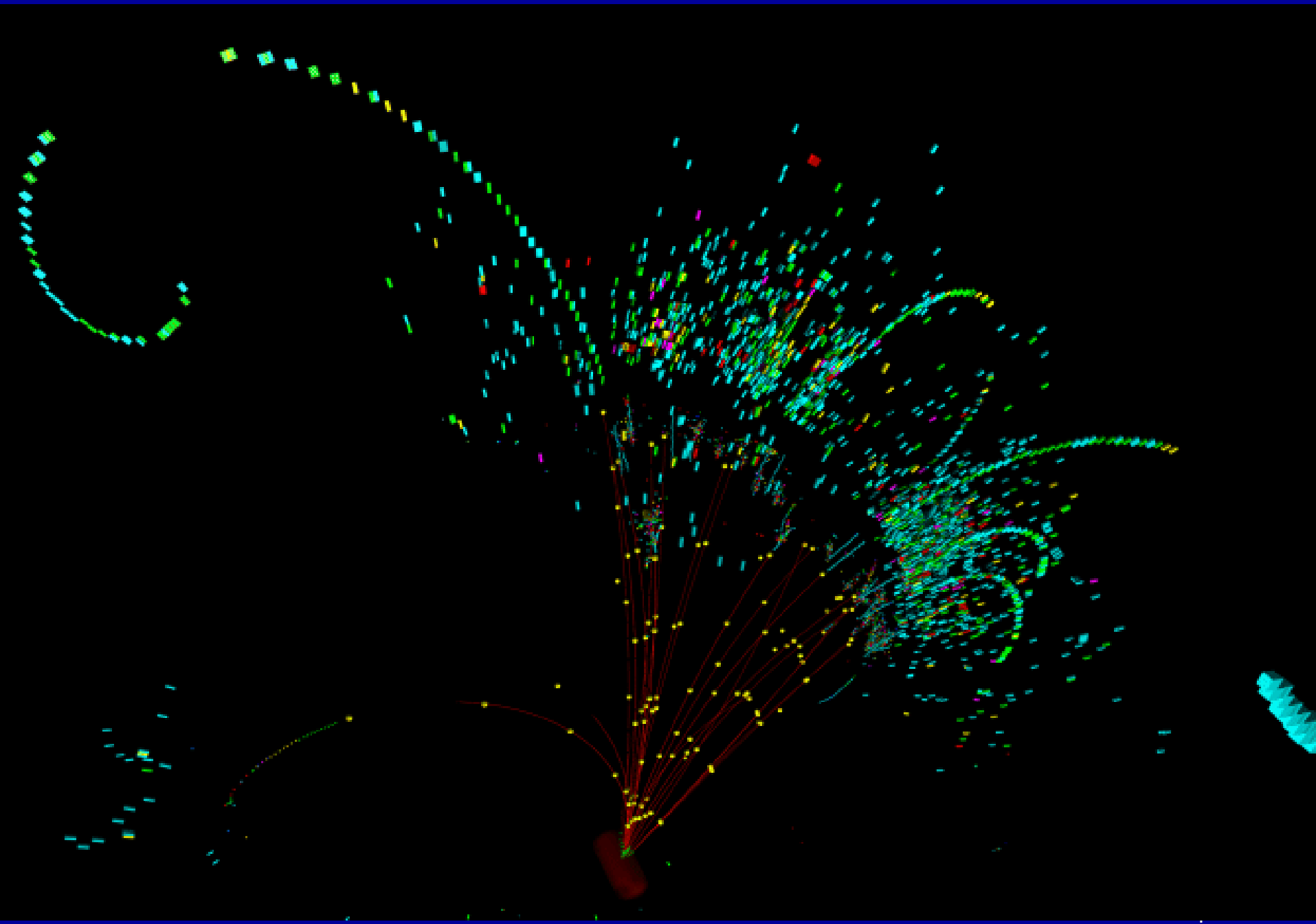
Santa Cruz '02

Introduction

- Requirements from future linear collider
  →very good jet energy resolution
  typical multi-jet event
  chrg. part. carry 64% E→ tracker
  photons carry 25% E→ EM cal.
  neut. had. carry 11% E→ HAD cal.
- →"Energy Flow" method
- Detector must be optimized:
  - Concentrate on calorimeter.
  - Don't forget tracker!

Energy Flow Overview

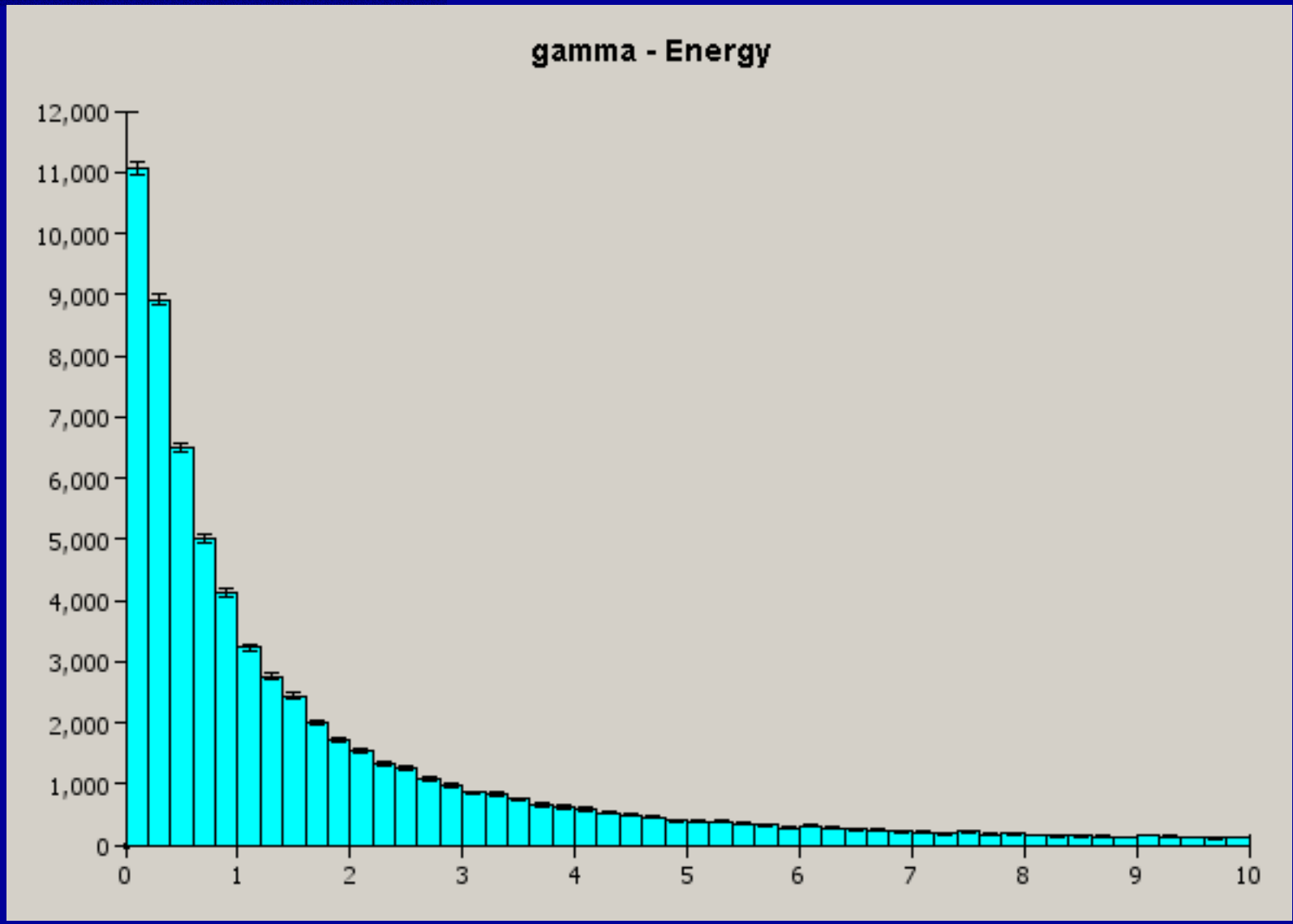
- The basic idea is to use the tracking detector for the measurement of charged particle momenta and the calorimeter for neutrals.
- Requires robust and efficient trackers!
  - Can't lose tracks in dense core of jet.
- Identify and remove calorimeter contributions arising from the individual charged particles.
  - Highly segmented, "imaging" calorimeter.



Calorimeter Analysis (γ)

- EM showers are energetic, very localized and highly correlated.
  - Clustering works well.
  - Can achieve high efficiency and purity.
    - Shower shape analysis χ^2
    - Distance to nearest found track
    - E/p matching to matched track
- Challenge is high efficiency at low energy.
- See talks by Abe and Bower in afternoon session.

γ Energy Spectrum in Z H Events

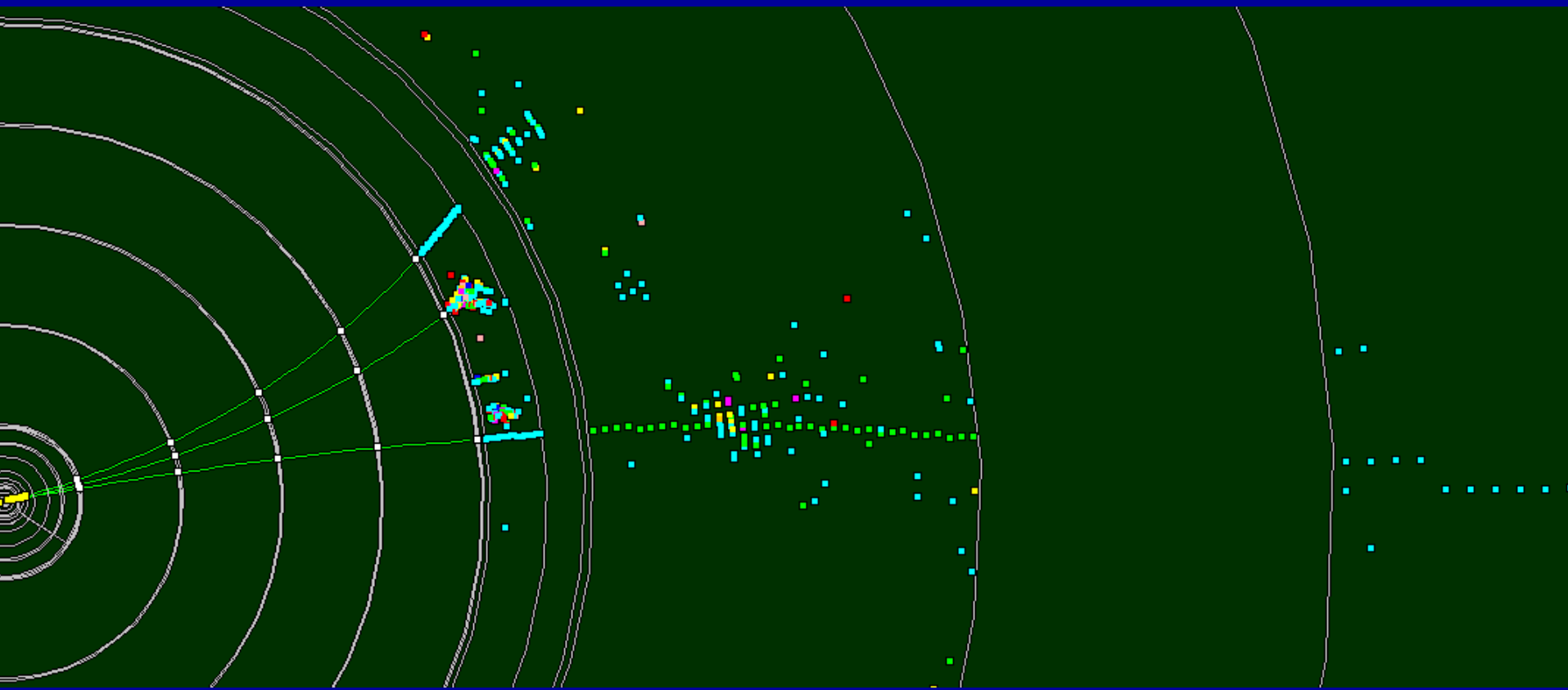


Calorimeter Analysis (μ)

- Muons deposit only minimum ionization, but do so along their trajectory
  - Tracking in calorimeter.
  - Important to identify as muons so we remove only MIP deposition, not full energy of track from the calorimeter.
  - Requires efficient μ ID, down to low energies and within jets.
  - Need good suppression of π punchthrough.

Calorimeter Analysis ($\pi^{+/-}$)

- Hadron showers much more complex!

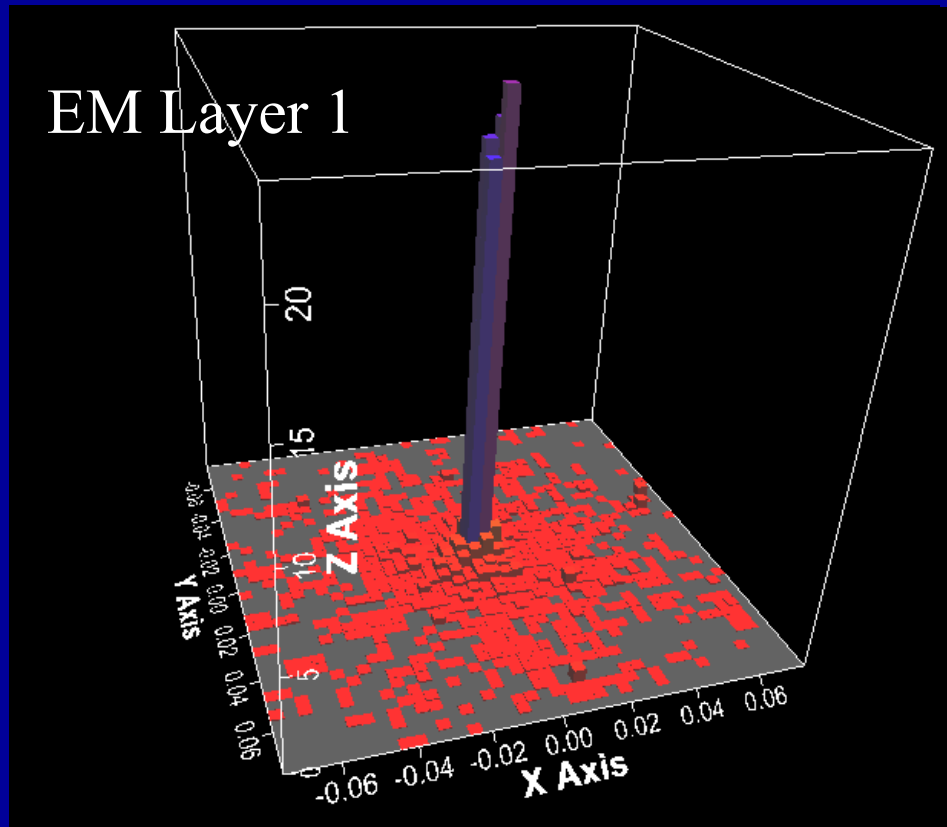


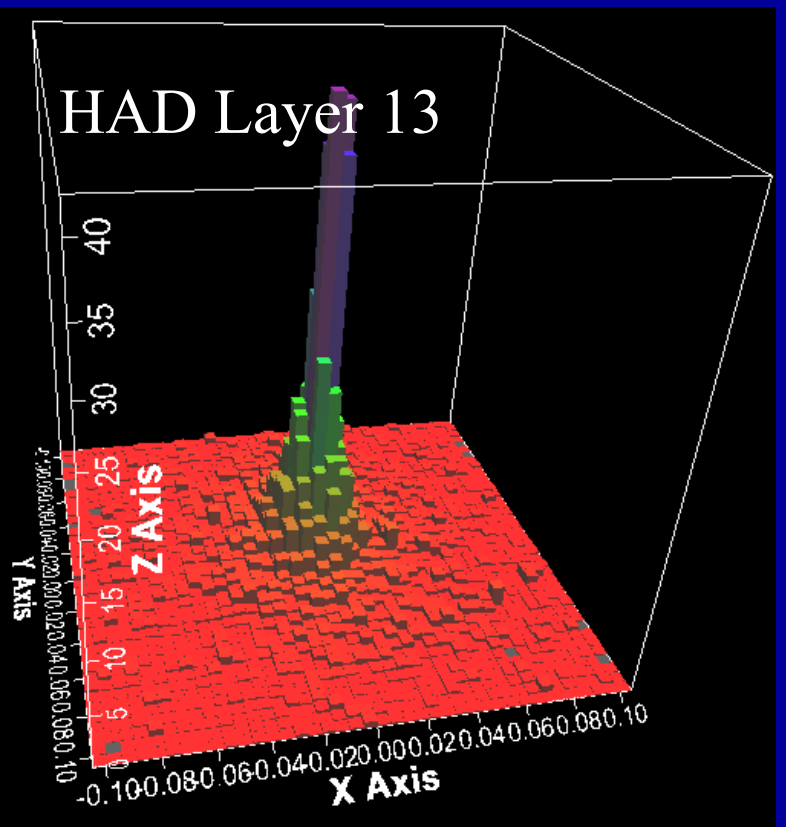
Calorimeter Analysis ($\pi^{+/-}$)

- Don't try to identify the hadron showers in the calorimeter ab initio!
- Already have excellent measure of particle's 4-momentum.
  - Easier to answer "Is this cell/cluster commensurate with a found track?"
- Propagate tracks through calorimeter and associate cells/clusters along the way.

Calorimeter Analysis ($\pi^{+/-}$)

- Each shower is stochastic, but on average shower shape is characterized by energy and #interaction lengths since shower start.



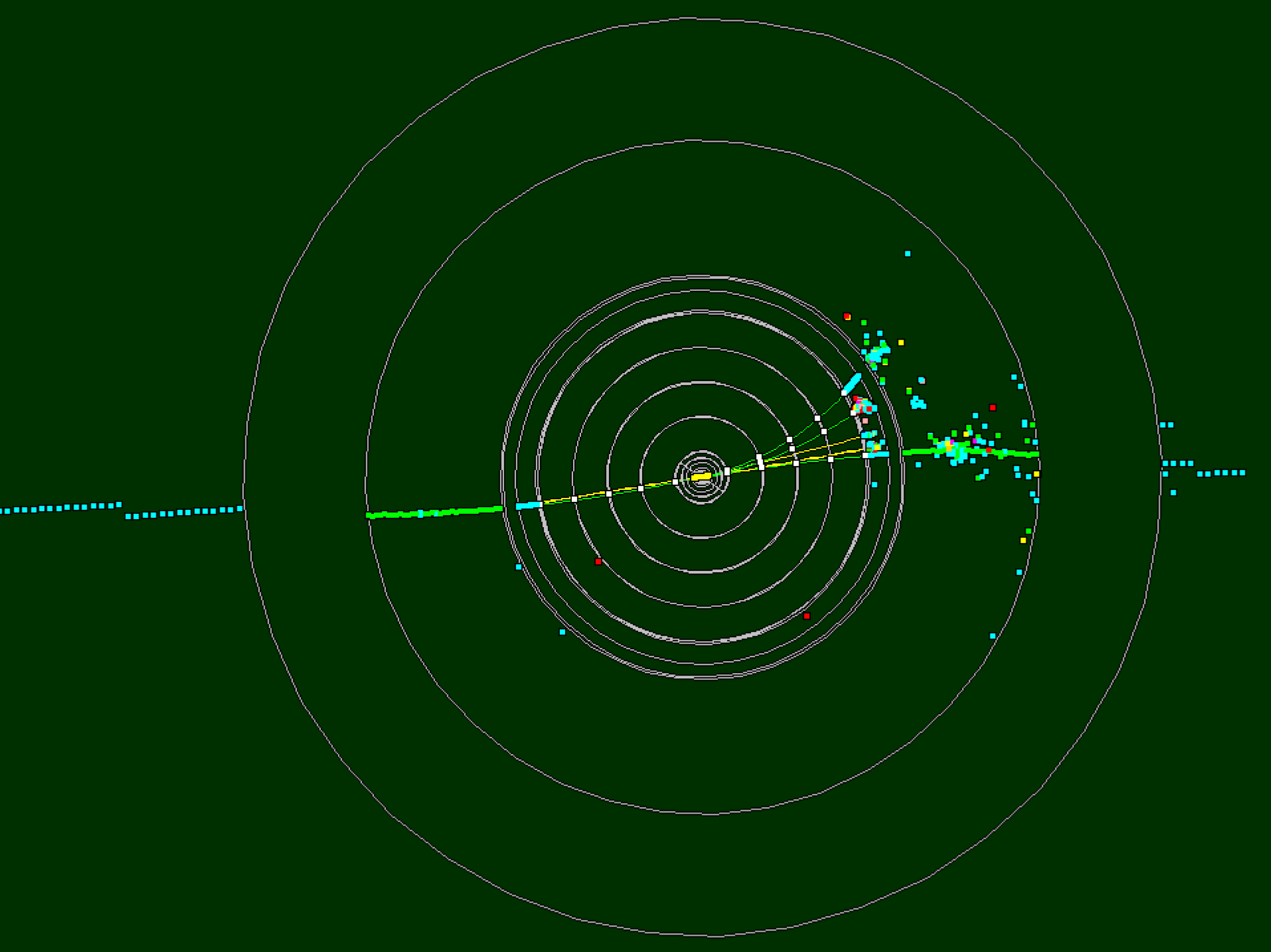


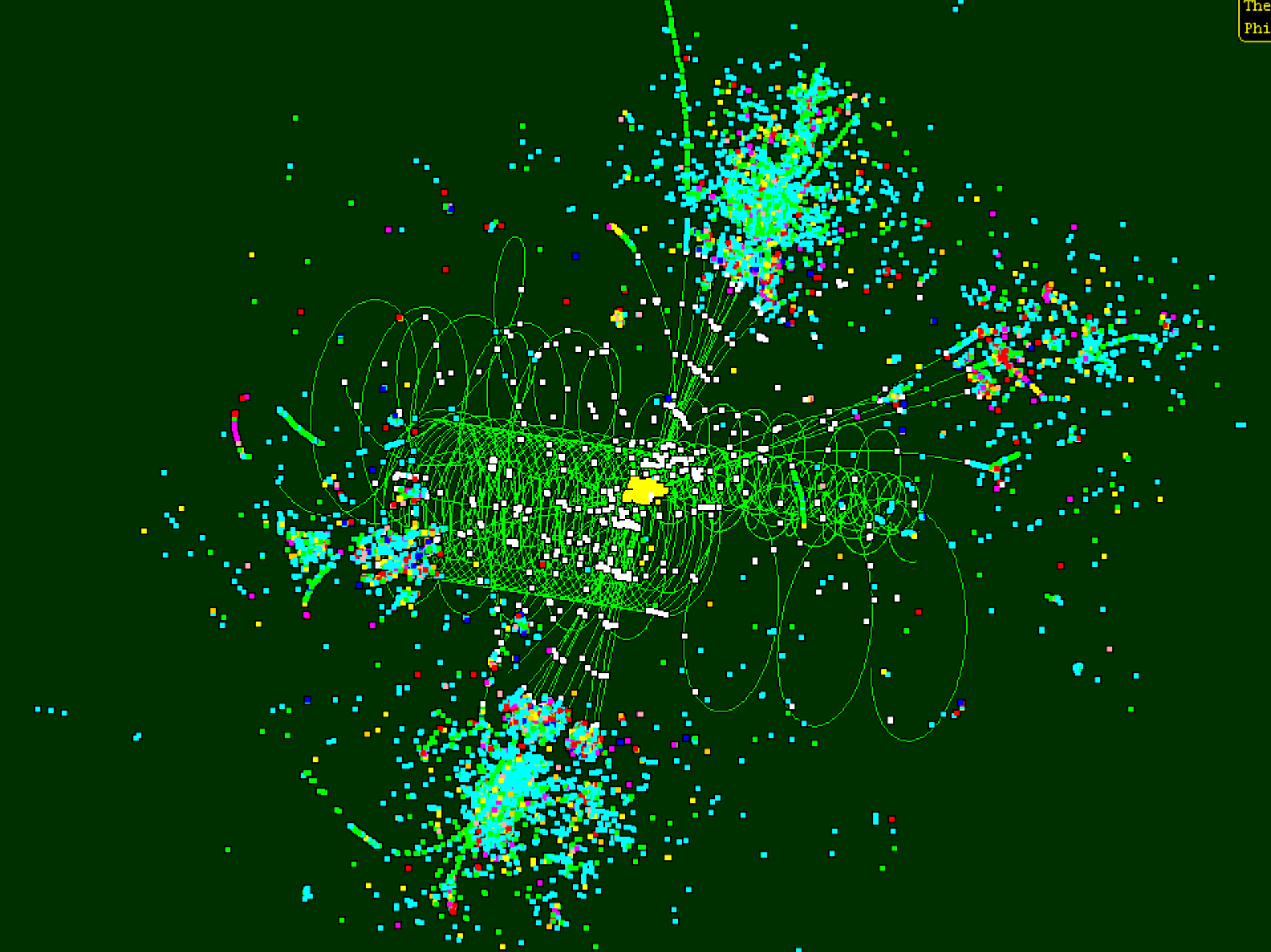
Calorimeter Analysis ($\pi^{+/-}$)

- After propagation, have a list of cells/clusters along with χ^2 for matching to reconstructed track.
- Remove cells until χ^2_{max} is reached, or appropriate E/p is met/exceeded.
  - Know calorimeter energy resolution.
- Repeat for all the tracks.

Calorimeter Analysis (h^0)

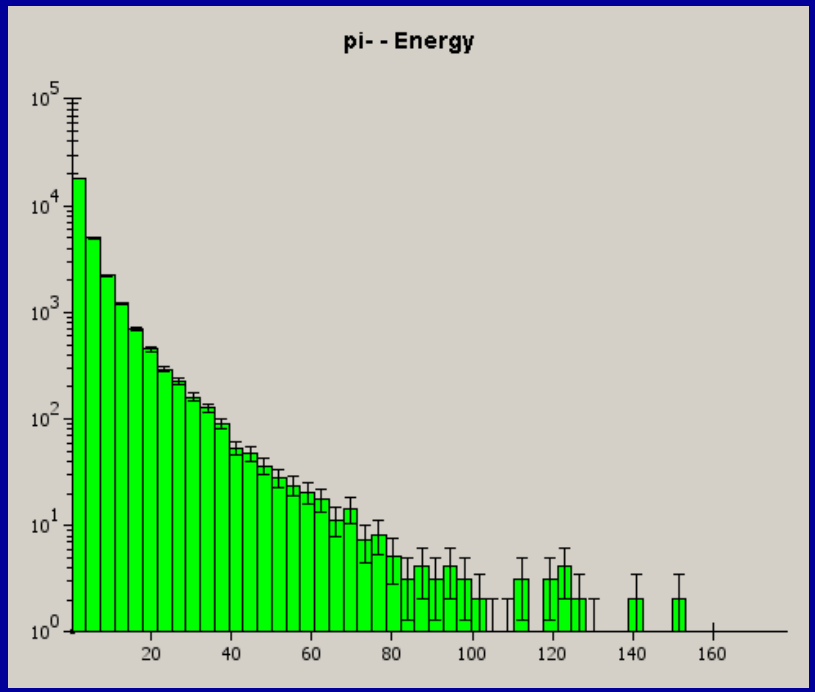
- Whatever is left in calorimeter is from neutral hadrons!
- Can cluster and try to identify as arising from individual neutral hadrons.
- Can also simply find jets using charged and EM particles, then adjust jet energy by the amount of neutral hadron energy in jet "cone".
  - EFlow without clustering!



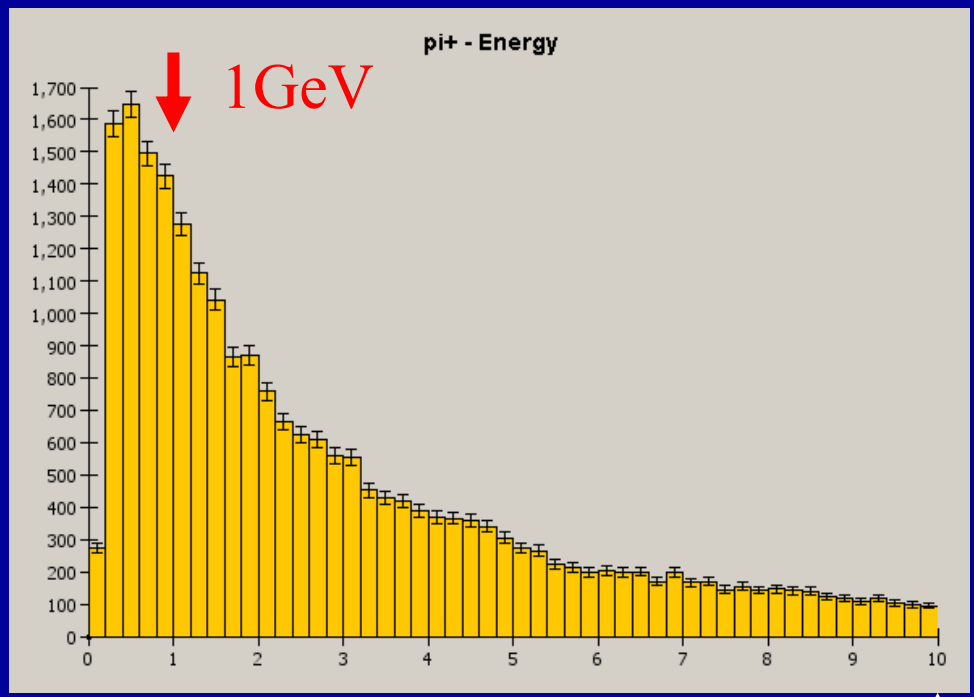

The
Phi

Importance of Tracking

- Even at high cms energies, particles produced at low energies



100GeV



10GeV

Low Energy Tracks

- In SD, 1GeV tracks "loop".
- Need to be able to reconstruct loopers
  - To be able to include the track in the correct central jet.
  - To be able to remove the track's energy deposition from the forward calorimeter and not count it as a neutral contribution to a forward jet.

Benchmark processes

- $WW\nu\bar{\nu}$ and $ZZ\nu\bar{\nu}$
  - Stresses jet-jet mass resolution
  - Removes beam-energy constraint
- $t\bar{t}$
  - Stresses jet pattern recognition in dense environments
  - Allows flavor-tag studies
- 800GeV cms
  - Studies higher-energy dependence.