

How do we define jets?

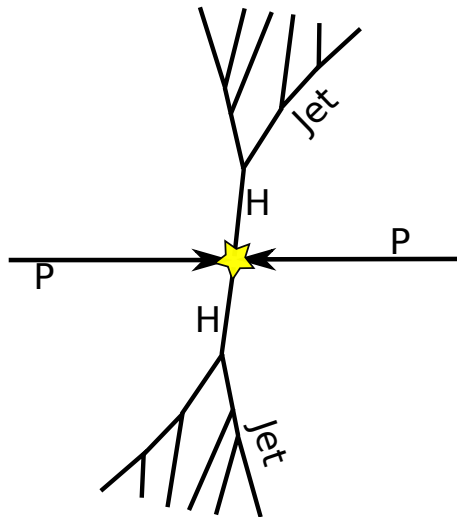
Dan Guest

UC Irvine

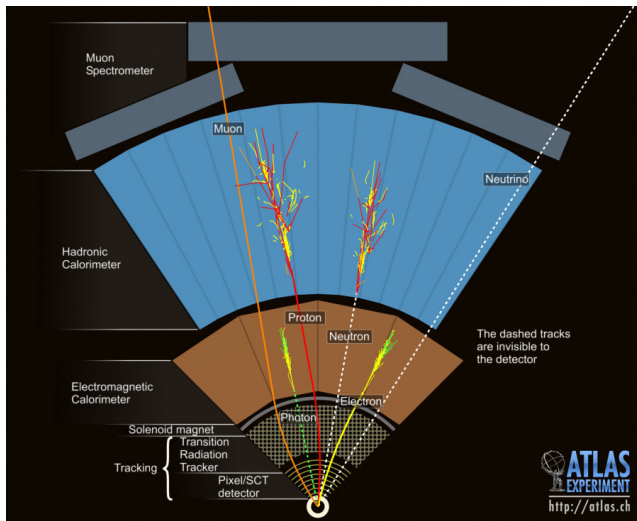
July 20, 2017

What is a jet?

- ▶ Protons go in
- ▶ Some *interesting* particle produced
- ▶ Decays to *intermediate*
 - ▶ 2 H in this example
- ▶ Decay to more *boring* particles
- ▶ **We want to reconstruct the *intermediate* particle**
 - ▶ Particle type
 - ▶ Momentum

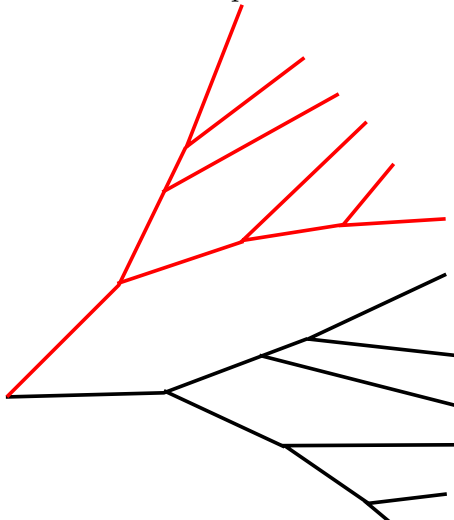


Where do the boring particles go?

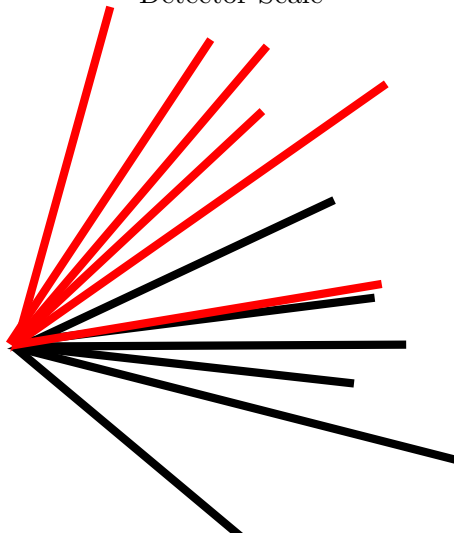


The challenge: multiple jets

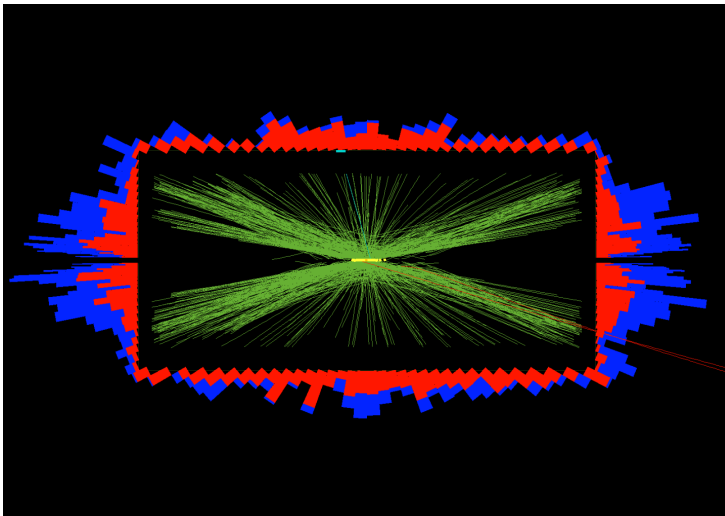
Microscopic Scale



Detector Scale



But wait, it gets worse

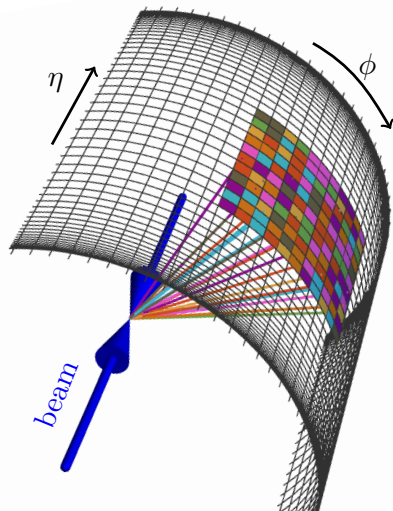


This is 79 collisions! Remove tracks and calo energy 78 of them.

Pretend it's a 2d problem

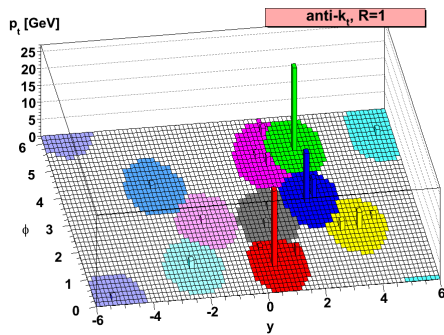
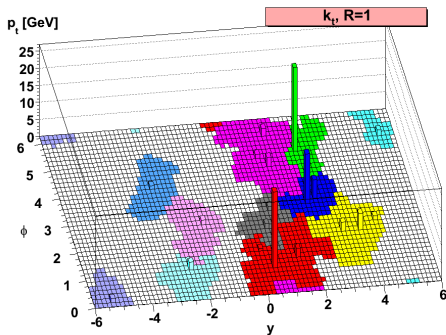
Figure from [arXiv:1612.01551](https://arxiv.org/abs/1612.01551)

- ▶ Of course it's not
- ▶ Multiple types of particles
 - ▶ Tracks have 5 parameters
 - ▶ Calo energy has depth, shape
- ▶ But thinking in 5d is hard
 - ▶ Also experiment-specific



Then cluster in 2d

1. Make every particle into a vector
2. Cluster in ϕ - y space ($y \approx \eta$)



Clustering algorithm

1. Calculate d_{iB} for each particle,
 d_{ij} for each pair
2. If $d_{ij} > d_{iB}$ for all j call it a
“jet”
3. Find smallest d_{ij} , combine i
and j
4. to back to step 1

Stop when everything is a jet

$$d_{ij} = \min(p_{Ti}^{2n}, p_{Tj}^{2n}) R_{ij}^2$$

$$R_{ij}^2 \equiv (\phi_i - \phi_j)^2 + (y_i - y_j)^2$$

$$d_{iB} = p_{Ti}^{2n} R_0^2$$

Algorithm	n
k_T	1
Cambridge-Aachen	0
Anti- k_T	-1

Theorists love this

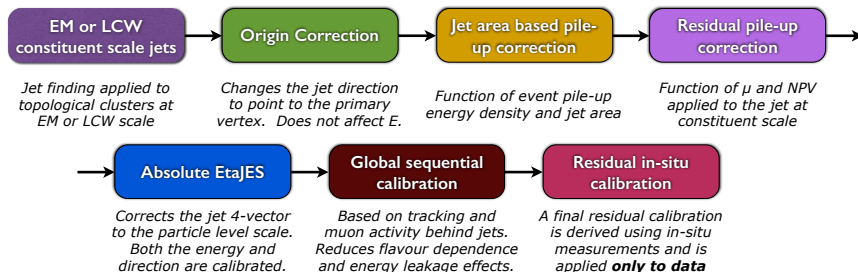
- ▶ Completely standardized via FASTJET
- ▶ They even built a workshop around it



This is the 9th year!

Correcting the Particle Momentum (Calibration)

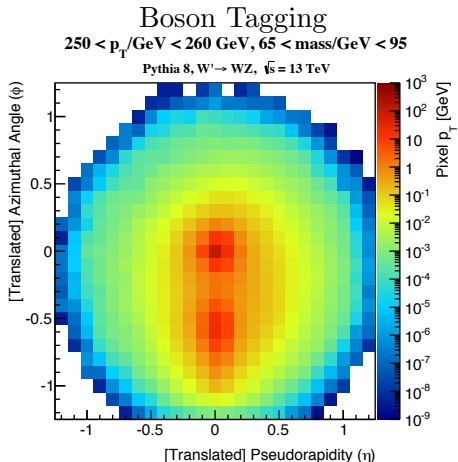
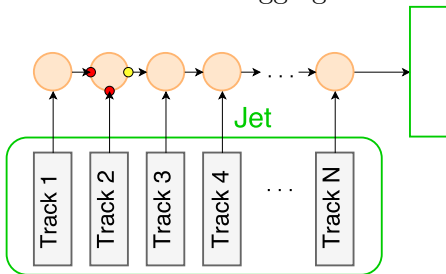
- ▶ Problem: the (clustered) jet momentum is wrong
 - ▶ Neutrinos, incorrect clustering, detector response
- ▶ Solution: several grad-student years of work (per experiment)



Classification

- So far this is all the machine learning

Flavor Tagging



In Summary

- ▶ All the ML happens *after* we define jets
- ▶ But there are lots of places we could use it
 - ▶ Definition of jet inputs
 - ▶ Sequential clustering
 - ▶ Lots of input from theory here
 - ▶ **But still ignores everything but momentum**
 - ▶ Calibration

You can still make it

