Photon Isolation

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Isolation:

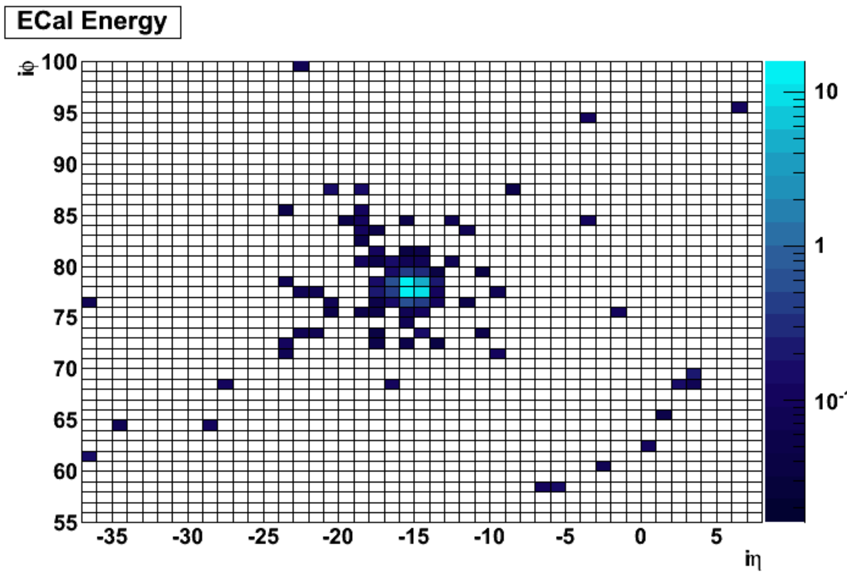
- Isolation is really key to discriminating against jets. This is effectively requiring a small amount of additional activity surrounding your nicely contained small electromagnetic shower (see both clustering and shower shape exercises).
- You do face however two very real issues:
  - Isolation as we use it presently uses particle flow particles, which is good, but recognize that they're the product of a completely different event reconstruction.
  - The amount of pileup we face severely complicates our ability to determine whether or not the energy surrounding our shower comes from the rest of the products of a jet, or whether this is energy from an uncorrelated collision.

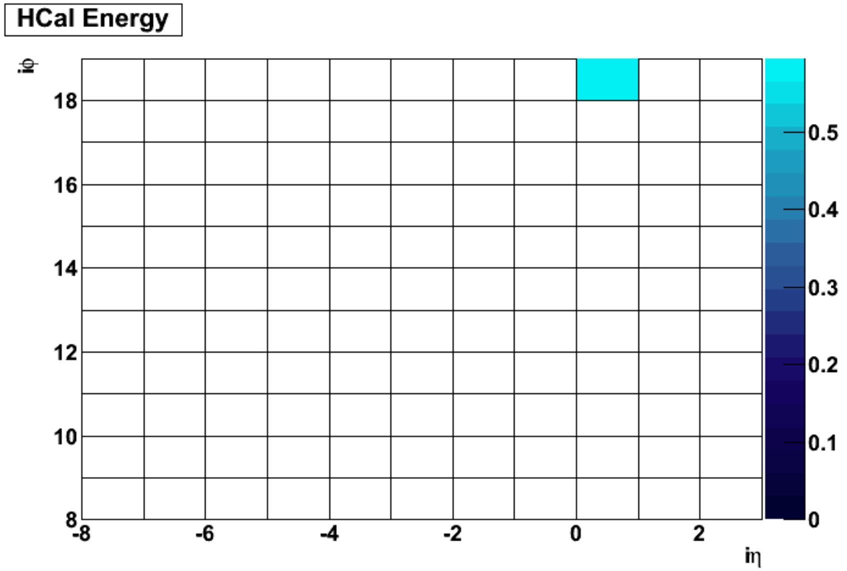
Previous version of isolation:

- Previously, what we did for isolation is to take three pieces of information separately, the energy within the ECAL, HCAL and the tracker.
  - Look at the total sum of transverse momentum within a cone of a radius (0.4, 0.3).
  - Exclude certain regions (hollow cone tracker isolation, "Jurassic" ECAL isolation), since there can be contamination from real photon showers within those regions. You'd then have a slight p_T dependence due to leakage of the photon energy, and the final cuts would have sliding values.
  - This is STILL how the isolation was calculated at the trigger level.
- This is not what we do anymore offline.

Real Estate:

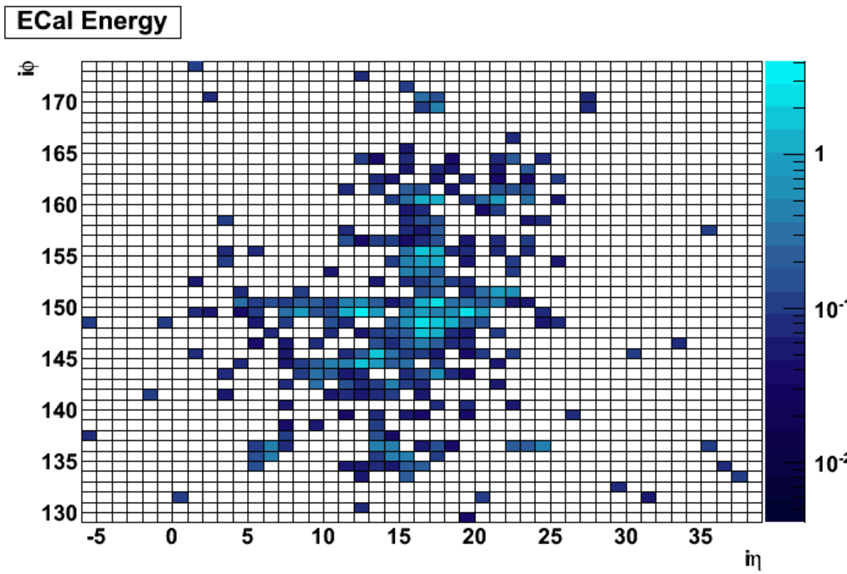
- One of the things I would like you to take from this description is how large these isolation cones actually ARE.
- On the right is a data example of the ECAL and HCAL from an isolated event, where the squares are the actual granularity, and this is a 0.4 square in $\Delta\eta/\Delta\phi$.

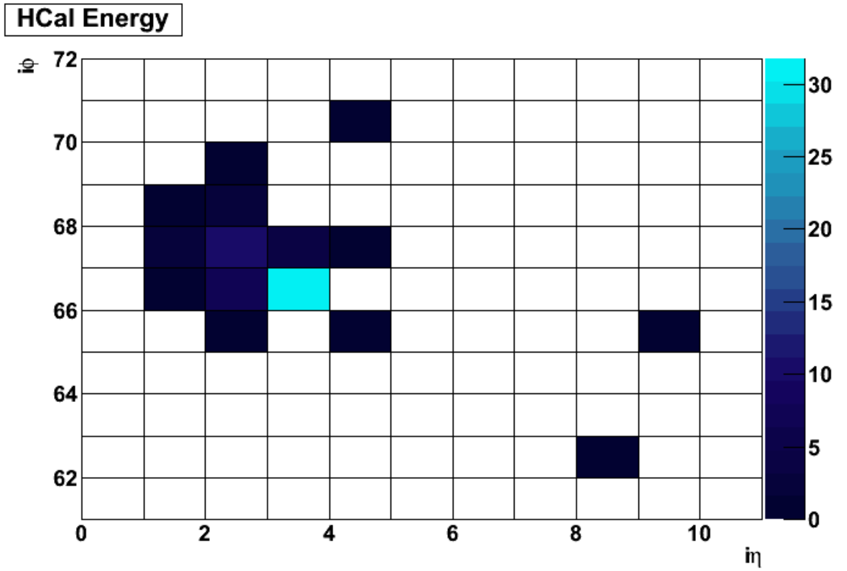




Real Estate:

- One of the things I would like you to take from this description is how large these isolation cones actually ARE.
- On the right is a data example of the ECAL and HCAL from an non-isolated event, where the squares are the actual granularity, and this is a 0.4 square in $\Delta\eta/\Delta\phi$.





Particle Flow:

- The full description of particle flow is beyond the scope of this particular talk.
- Basically, instead of the various different detector level information that you have in the previous version, instead you start out combining HCAL, ECAL and tracker information across detectors to create particles.
  - A Charged Hadron at least has some information from the tracker, and possibly both ECAL and HCAL.
  - A Neutral Hadron has no tracker information, but does have information from HCAL and possibly ECAL.
  - A Photon "particle" (as I call it to distinguish it from your analysis photon candidate) is a cluster of energy only in the ECAL.
- Please try to keep in mind that these don't exactly map to the previous isolations! We often think of Charged Hadron Isolation as track isolation, but it isn't exactly the same thing.

ρ

- All of the cool kids are doing pileup subtraction these days. And since we're cool kids…
- We calculate a quantity called ρ, which is defined more or less as the median of the distribution of (jet p_T/jet area) for an event.
  - A full discussion of how we define this is WAY outside the scope of this talk. Though it is super interesting, and you should read about it. Here's a reference: arXiv:1111.6097, specifically chapter 8.
  - The takeaway should be that this number characterizes the amount of "stuff" everywhere, event by event. And thus how much "stuff" on average would be spread over your isolation region.

Into the weeds:

- We define an "effective area" for our different isolations:
  - Different for charged, neutral and photon isolations
  - Characterizes the extent to which each different particle type is susceptible to pileup related energy.
- What you're doing is characterizing a linear dependence of your isolation on this ρ number, and then subtracting it off. Corrects on average for the pileup dependence.

Into the weeds:

- We define an "effective area" for our different isolations:
  - Different for charged, neutral and photon isolations
  - Characterizes the extent to which each different particle type is susceptible to pileup related energy.

bin	EA charged hadrons	EA neutral hadrons	EA photons
abs(η)<1.0	0.012	0.030	0.148
1.0<abs(η)<1.479	0.010	0.057	0.130
1.479<abs(η)<2.0	0.014	0.039	0.112
2.0<abs(η)<2.2	0.012	0.015	0.216
2.2<abs(η)<2.3	0.016	0.024	0.262
2.3<abs(η)<2.4	0.020	0.039	0.260
abs(η)>2.4	0.012	0.072	0.266

Charged Hadron Isolation Region:

- Must be separated by at least $\Delta R > 0.02$ from the photon candidate, and be within the cone of $\Delta R<0.3$.
  - Minor thing: in calculating $\Delta\eta$ and $\Delta\phi$, the photon direction is calculated using the vertex of the PF candidate and the supercluster position. This is usually not that different than the original photon direction.
- Charged hadrons are required to originate from the primary vertex associated with the photon by:
  - $|dz|<0.2$cm, $|dxy| < 0.1$cm
- It's worth noting that there is a version of this quantity that is calculated using all the different vertices. It isn't standard though.

Neutral Hadron and Photon Isolation Regions:

- Neutrals are the easy ones: any neutral hadron within the isolation cone counts.
- Photons isolation is slightly complicated. You count IF:
  - You are in the cone of $\Delta R < 0.3$ and
  - You are outside of $\Delta R = 0.02$
  - You have a $\Delta\eta > 0.015$ in the barrel, and $\Delta R > 0.00864$*fabs(sinh(phoSCEta))*4 in the endcap.
    - I swear I didn't make that up. This is meant to keep the excluded region in terms of number of crystals in the EE fixed. This in turn enlarges the excluded region in the η coordinate.

What's with the exclusions?

- Right now we're sitting in a weird situation. We use RECO photons, but almost everything else Particle Flow. In order to keep from double counting (e.g. counting the photon energy against itself), we make these exclusions.
- We then have some small amount of "leakage" energy, which we work around by having a sliding cut on neutral hadron and photon isolation values.

To Pass Isolation:

- Isolation is no longer as simple a beast as it once was:
  - First you sum up all of the “particles” in the cone area, which are not in the excluded regions.
  - Next you check your ρ for the event, and look up the effective area of your cone. You then subtract this product from your previous sum.
  - Then you calculate your actual cut value, as two out of three of the cuts slide with p_T
    - BTW – Why would this be?

Selection Summary:

Cuts optimized for non-triggering photons

The cone size for all isolation sums is 0.3

BARREL	Loose (90%)	Medium (80%)	Tight (70%)
Conversion safe electron veto	Yes	Yes	Yes
Single tower H/E	0.05	0.05	0.05
$\sigma_{i\eta i\eta}$	0.012	0.011	0.011
Rho corrected PF charged hadron isolation	2.6	1.5	0.7
Rho corrected PF neutral hadron isolation	3.5 + 0.04*pho_Pt	1.0 + 0.04*pho_Pt	0.4 + 0.04*pho_Pt
Rho corrected PF photon isolation	1.3 + 0.005*pho_Pt	0.7 + 0.005*pho_Pt	0.5 + 0.005*pho_Pt

ENDCAPS	Loose (85%)	Medium (75%)	Tight (65%)
Conversion safe electron veto	Yes	Yes	Yes
Single tower H/E	0.05	0.05	0.05
$\sigma_{i\eta i\eta}$	0.034	0.033	0.031
Rho corrected PF charged hadron isolation	2.3	1.2	0.5
Rho corrected PF neutral hadron isolation	2.9 + 0.04*pho_Pt	1.5 + 0.04*pho_Pt	1.5 + 0.04*pho_Pt
Rho corrected PF photon isolation	-	1.0 + 0.005*pho_Pt	1.0 + 0.005*pho_Pt

- This comes directly from the e/γ twiki.

That is all prologue:

- The best way to get a feel for how these choices we've made will actually work is to take these descriptions and try them out for yourself on the data.
- I've assembled three examples each for the barrel and the endcap. Based on the descriptions that I've given here, calculate the isolation, and check your result against that of the reconstruction.
  - More to the point, see if you AGREE with this choice.
- Work your way through them!