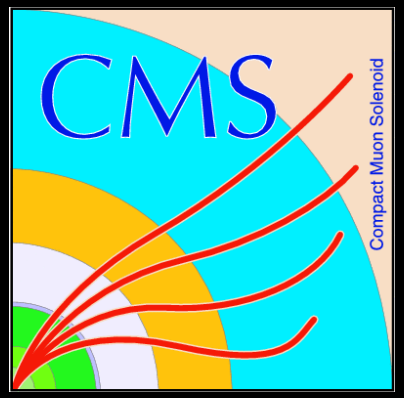

Photon Identification in the Future

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WHAT IS IN STORE?

- "Predictions are difficult to make, especially about the future." –Yogi Berra
- Everything I've showed you here has really been about the present state of CMS Photon Reconstruction. But we KNOW beyond a shadow of a doubt that things are going to change.
  - Besides the speed of light, it's one of the few universal constants.
  - You should really read this as viewed through the lens of my opinions, which after sticking with me this long, you probably already knew.

GED INTEGRATION

- First let me say: I'm really looking forward to this.
- We already use PFlow/GED for our missing E_T, electrons were integrated a while back, photons were one object that were missing in a glaring way, and the fingerprints are definitely all over the isolation.
- Once you have a single description of everything, then you no longer need to worry about excluding regions within your cone, you KNOW that you aren't going to double count things.
- And I personally prefer the choices that are made in the clustering over the present default.

GED INTEGRATION

- There's at least two, if not more catches here though.
  - One is that you HAVE to move in a less inclusive direction. One of the nicest things about our current algorithm is that it starts from everything, and you whittle stuff down at the object level. You can't be doing that with GED, you need a hypothesis for the particle so that you know how to treat the visible energy.
  - Every choice made has an efficiency associated with it: if you select too tightly, then you have a reconstruction inefficiency. If you select too loosely, you're going to screw up your missing E_T.

GED INTEGRATION

- There's at least two, if not more catches here though.
  - Electrons and photons will be distinguished at the reconstruction level, unlike right now where we identify all electrons as photons. It remains to be seen how this will affect the process by which we do electron/photon discrimination, and also the validation of how the reconstruction is performing. In these days of Zγ photon efficiency measurements, maybe this is okay.
  - An upshot is that we can, in princple, with a given chosen particle hypothesis do something adaptive the way that ATLAS does.

NEW SUPERCLUSTERING

- I alluded to this earlier, in the transition to GED, I think it's pretty natural to re-evaluate how we're choosing to associate clusters of energy within the Ecal into superclusters.
  - So first, we'll be using particle flow clusters, which as you have seen are distinctly different from the other two methods.
  - Two, we're still learning about the patterns (by which I mean geometrical patterns, but one could consider energy and time as well) by which we should logically associate these clusters.
  - We started with a "box" much like the hybrid, but with softer edges (because of how the algorithm clusters), and have progressed to the mustache region, and who knows what next will perform best?
  - I still happen to believe there is some unused information here, concerning the individual shower widths of the clusters in question.

REFINING SUPERCLUSTERS

- So the term "refined supercluster" hasn't been around very long. Lindsey Gray was the first person I recall using it.
  - Effectively, at the reconstruction level, you use tracking information and conversion information to assess how consistent a particular cluster may be with a group of clusters. In principle, you could add or subtract clusters from a supercluster based on what the tracking and conversion finding say about who this cluster should belong to.
  - A long awaited injection of some sophistication, but will need a bunch of low level studies to check on the failure modes. It COULD simply work as advertised, but in my experience, most things don't.

ENERGY

- So whenever we look at jet backgrounds to photons, we are looking at a tiny fraction of the total number of jets that fluctuate just enough to appear nearly identical to real photons. It's worth considering that the cross section for everything goes up as the energy goes up. Thus for a fixed ET cut, it's reasonable to expect that the jet→γ background will probably increase.
  - The same is probably not true of e→γ backgrounds, since those are highly instrumental and electroweak cross section based.

ISOLATION

- We just did a whole exercise about isolation and pileup subtraction this morning. Nothing we've seen thus far is indicative of the kind of pileup that we're expecting coming out of the shutdown.
  - 100 or more interactions per crossing is a lot.
  - Is this average subtraction we're doing going to be sufficient? Is it reasonable to think that we might make a more local characterization of the energy deposition in the vicinity, and would that be more efficient?

ISOLATION:

- You've seen firsthand that the clustering will very efficiently account for all energy depositions which are deemed as being above the noise level.
  - PFlow clustering will split out local maxima with the resultant clusters sharing the energy as a function of proximity. Is there going to be a failure mode with too much overlay?
  - Do we need to retune the thresholds for noise? Or add in a more sophisticated termination given how much energy will be strewn about?

SHOWER SHAPE

- Does it make sense to cling to a fixed array of crystals when our clusters can actually have natural soft edges?
  - Should we make it smaller or larger?
  - Should we have an overall supercluster based shape? If so, clearly it shouldn't be log weighted.
  - Can we actually correct the damn calculation so that it ACTUALLY calculates the dispersion, as opposed to this… whatever it is?

THIS CLASS

- Early on, I called this a "Photon Masterclass", because just like musicians take master classes, the implication is never that your techniques are fixed and don't evolve. Rather, the emphasis must be on the manner in which you can improve your technique according to what both you've learned and the experience of others.
- That's why I'm ending with all these questions. We need people to think critically about all of the aspects of the choices we make so that we can make better informed choices.
- I hope that you're going away from this with a new understanding of what we do now, and some new ideas as to what we can do in the future, whether you work with photons, electrons or something else.

THANK YOU

ACKNOWLEDGEMENTS

- The LPC of course, for not only having me as a fellow but for providing the impetus for me to have thought up this class. Special thanks to R. Cavanaugh, he probably doesn't remember, but the exercises here first got conceived in a conversation we had in 2009.
- The FSU HEP graduate and undergraduates for going through the exercises and finding many bugs. Special thanks to Prof. T. Adams who had to listen to me swear on end about Excel for multiple months.
- AND of course, thanks to all of you who have participated!