

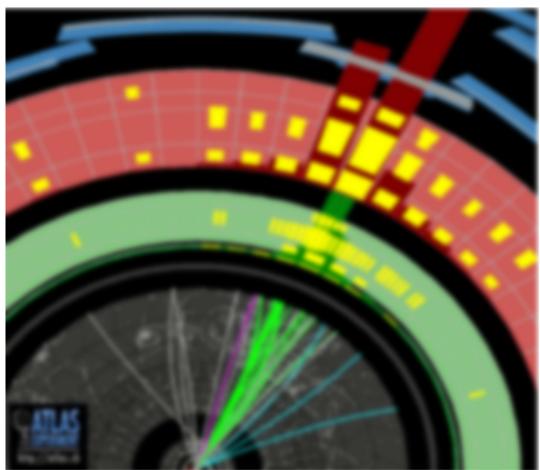
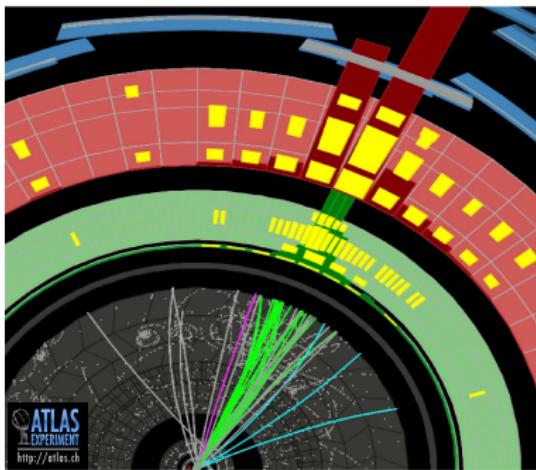


Overlay Use in ATLAS

Chris Young



“Monte-Carlo in ATLAS” Tutorial, 28th September 2015





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Outline

- ▶ Introduction
- ▶ Why people don't use overlay in ATLAS
- ▶ Who uses overlay in ATLAS
- ▶ Conclusions



Introduction

- ▶ Andy has just explained what Monte-Carlo Overlay is.
- ▶ Using samples with Monte-Carlo overlay is very simple - they are used in the same way as normal Monte-Carlo samples.
- ▶ Even the pile-up distribution is already correct without the need for pile-up re-weighting due to the way the events are sampled.
- ▶ If you are using pre-scaled triggers then you can use the pile-up re-weighting tool to correct for the μ distribution of your data.
- ▶ The samples are available in the same way as usual Monte-Carlo samples depending on what the different physics and performance groups have requested.
- ▶ They are distinguished from other Monte-Carlo datasets by their different digi+reco tags. For example in 2012 d840 was one of the most used tags.



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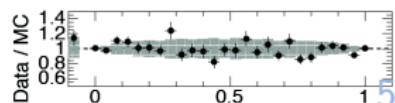
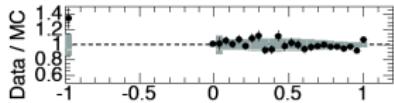
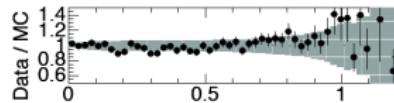
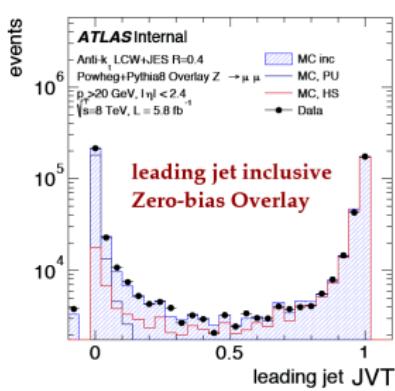
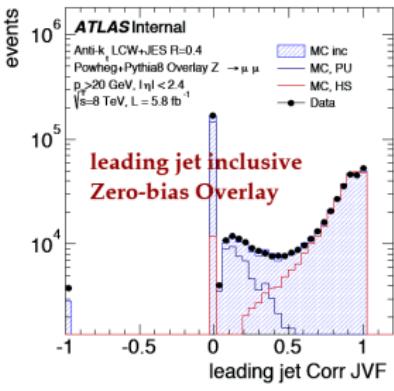
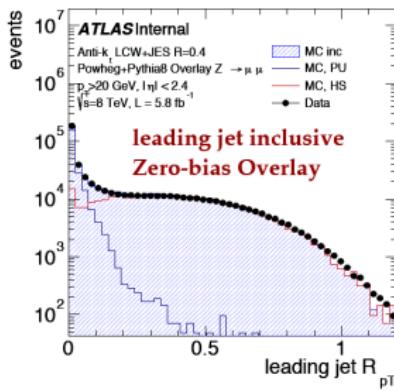
Why people don't use overlay in ATLAS

- ▶ Andy explained the advantages of overlay; it gets the **electronic noise**, **pile-up simulation** and **cavern background** all correct!
- ▶ However, most analyses don't use overlay samples.
- ▶ This is primarily due to two reasons;
 1. The samples need to be made after the data is taken (and has been distributed) such that overlay samples are later than a lot of analyses want to start looking at the data.
 2. Analyses are usually designed to be as insensitive to the modeling of these effects that overlay gets correct such that they don't (yet) see large advantages.
- ▶ In the future we hope for more wide-spread use of these samples.

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Who uses overlay? - CP groups

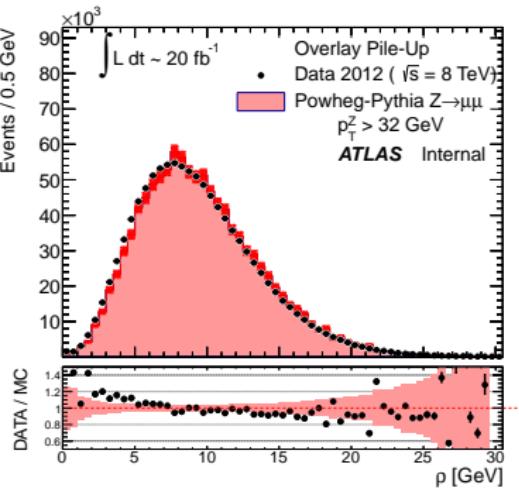
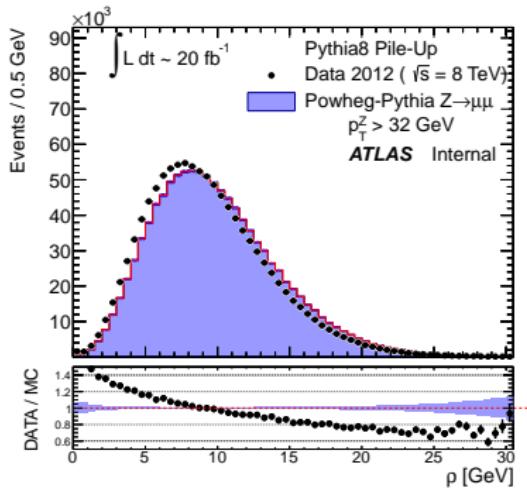
- The JetEtmiss group have used overlay to investigate several issues related to the modeling of pile-up.
- For example the JVF and JVT distributions appeared poorly modeled in 2012 - by using overlay we can show that this is due to the pile-up jet rate rather than the modeling of the signal jets.



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Who uses overlay? - CP groups

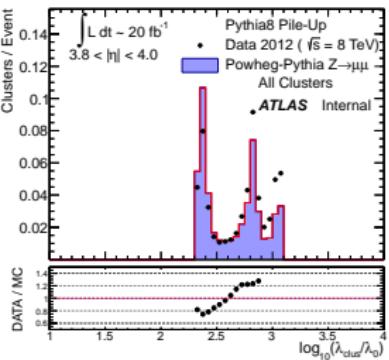
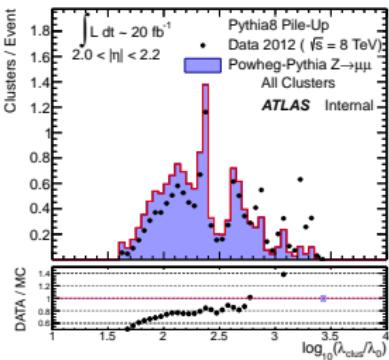
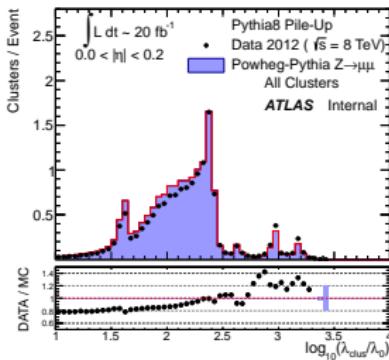
- ▶ Similarly the ρ distribution which is used to correct for the average energy falling inside a jet from pile-up is poorly modeled in the pure simulation samples (even after pile-up re-weighting).
- ▶ Overlay shows that again this is the modeling of the pile-up simulation as using overlay improves things considerably (some small remaining discrepancies are probably from UE).



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Who uses overlay? - CP groups

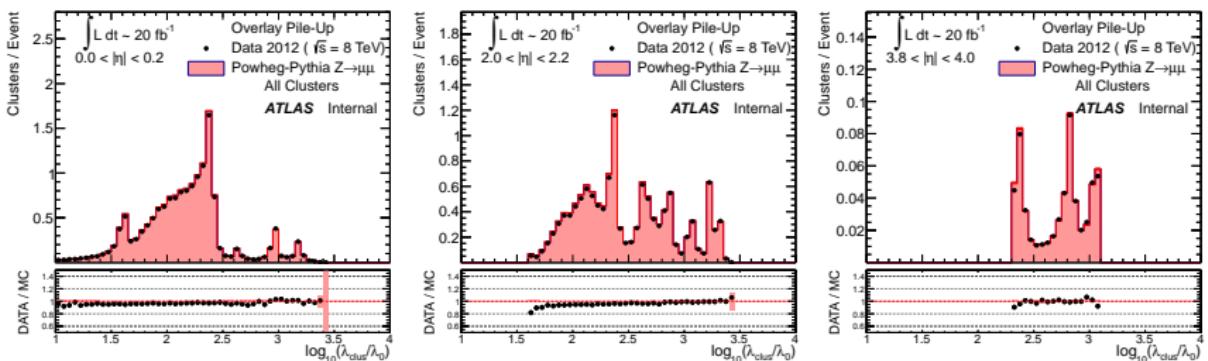
- We can also look at the number of topoclusters in the detector to see if there are any problematic regions (this is dominated by pile-up so is effectively closure of the overlay simulation).



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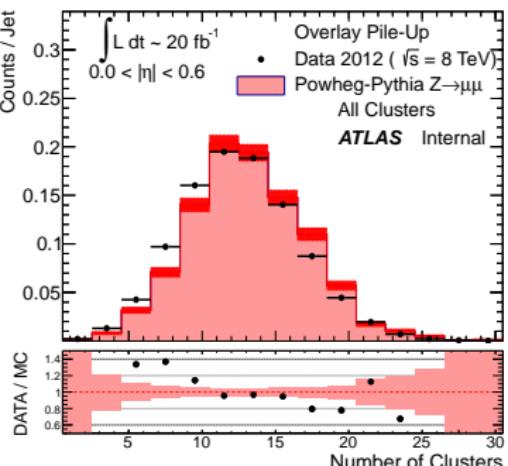
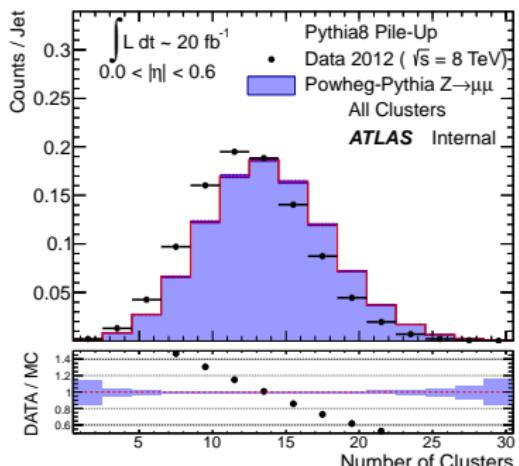
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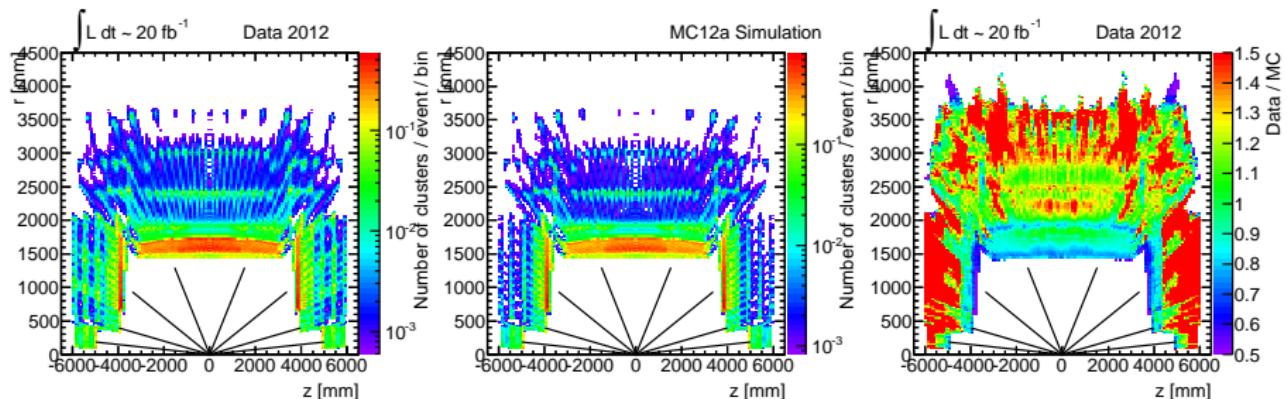
- We can then look in jets to see if the observed mis-modeling of the number of clusters is due to the pile-up simulation and we find that this is only part of the problem (as expected from 2010 studies too).



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Who uses overlay? - CP groups

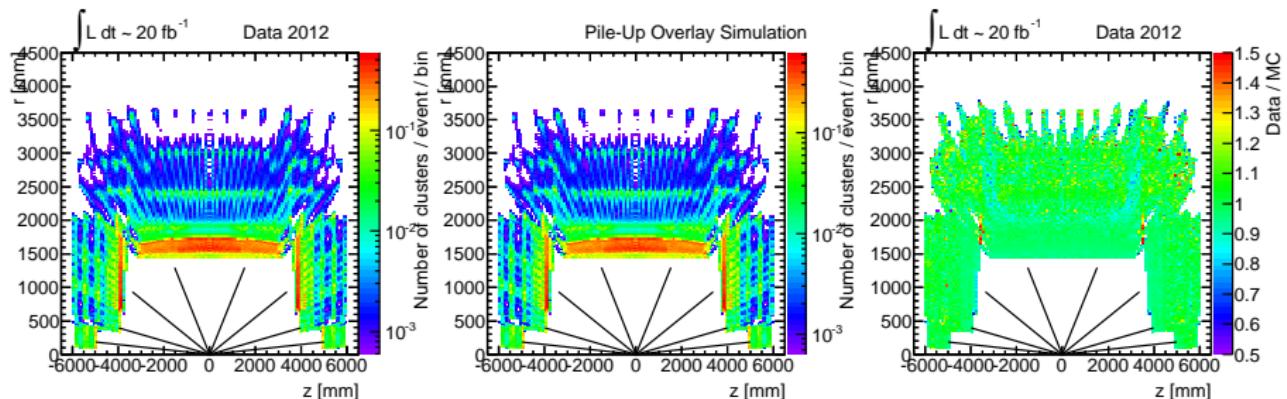
- ▶ Staying with topoclusters we can look at 2D distributions of the number of clusters to see where things agree well and where they differ.
- ▶ Looking at a map of r, z of the cluster density we can see which regions of the detector have modeling issues which are solved by the use of overlay.



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Who uses overlay? - CP groups

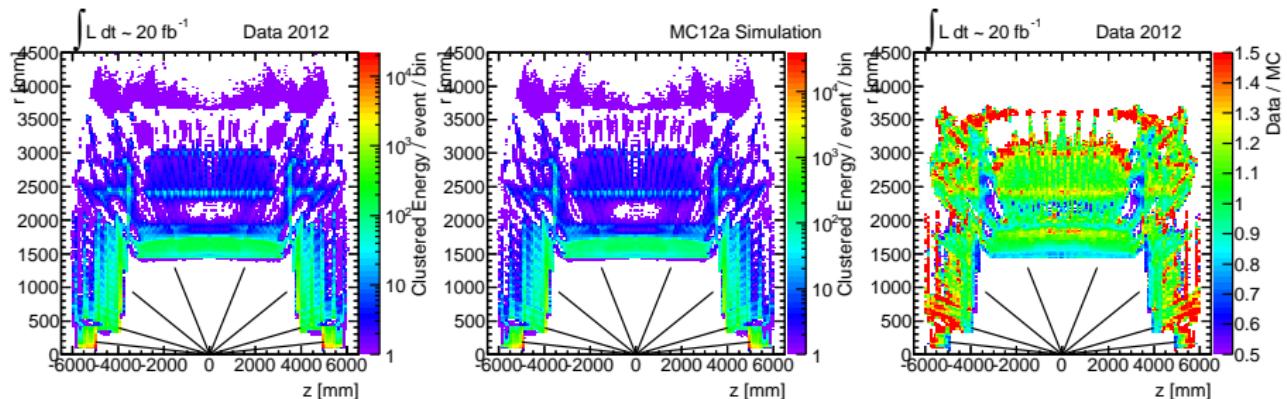
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Who uses overlay? - CP groups

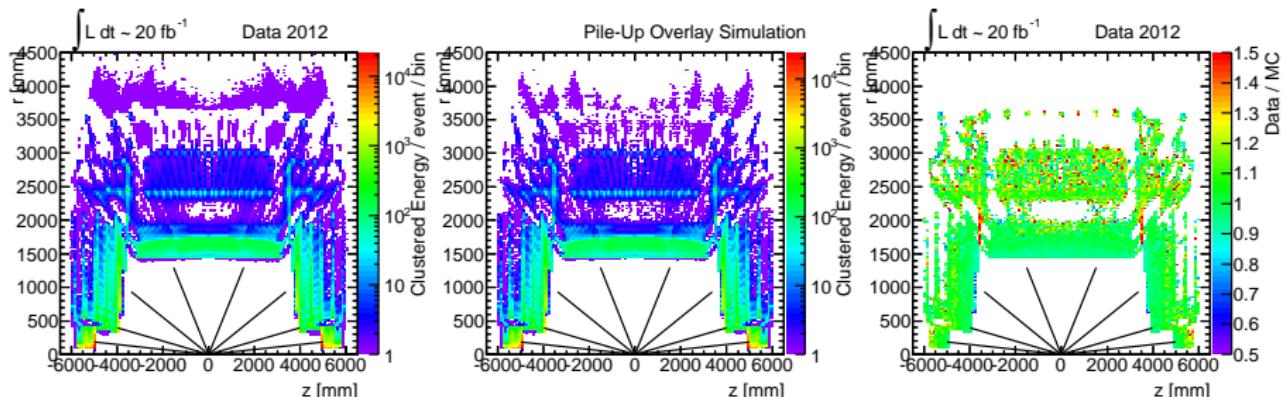
- ▶ Weighting these by the transvers energy of the topocluster gives another handle on the source of the disagreement in the different regions.



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Who uses overlay? - CP groups

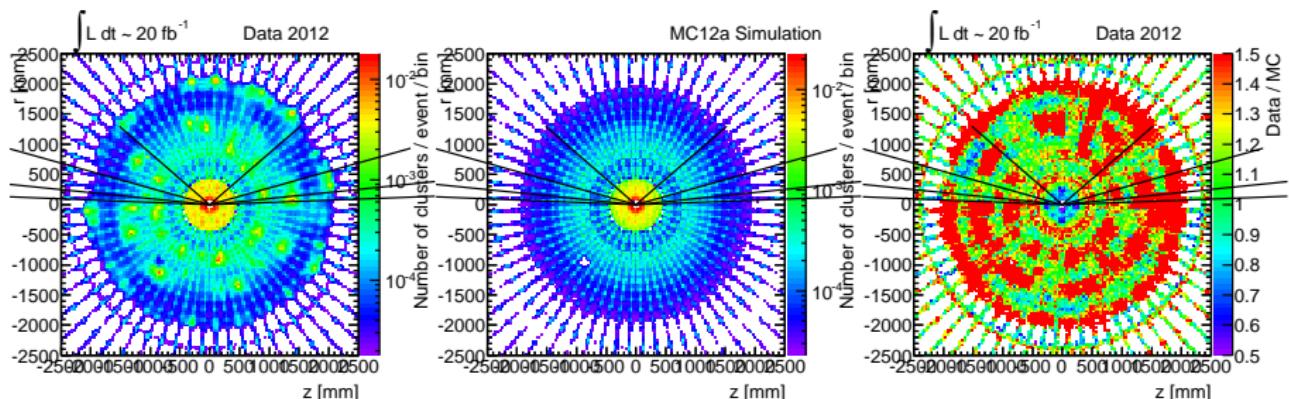
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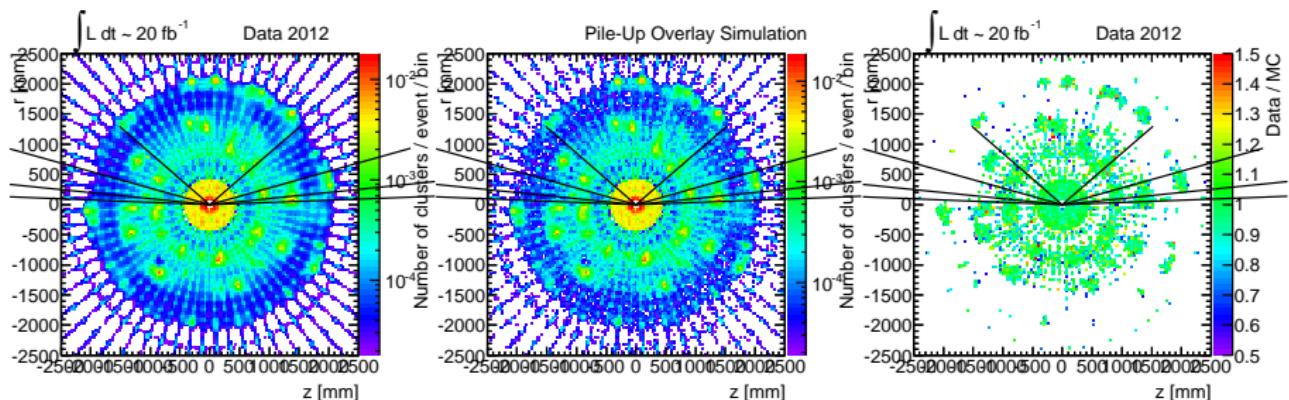
- ▶ Staying with topoclusters we can look at 2D distributions of the number of clusters to see where things agree well and where they differ.
- ▶ Here we look at a slice of the end-cap ($4750 < z < 5250\text{mm}$) to see the number of clusters which shows the noisy and dead regions.



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Who uses overlay? - CP groups

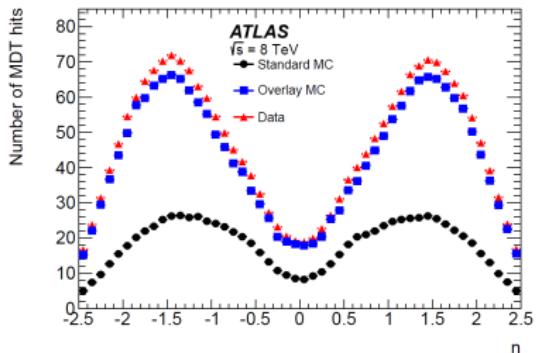
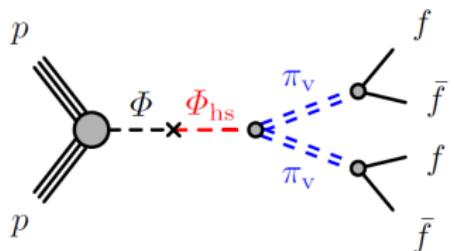
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Who uses overlay? - Exotics Analyses

- ▶ A search for neutral, long-lived, weakly interacting particles has a significant background from the **cavern background**.
- ▶ They reconstruct tracks in the muon spectrometer to find the decay vertex from the displaced exotic particle.
- ▶ As the standard simulation doesn't model the cavern background there is significant differences in the number of MDT hits between MC and data.
- ▶ Using overlay to simulate the cavern background leads to better data/MC agreement.





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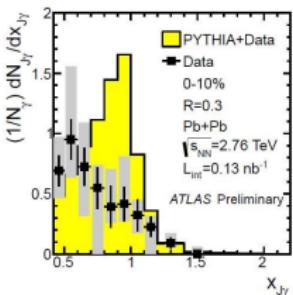
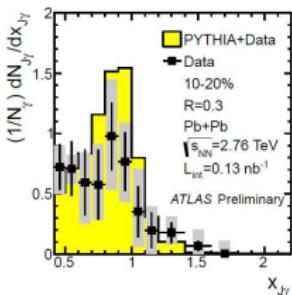
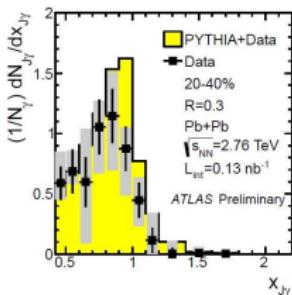
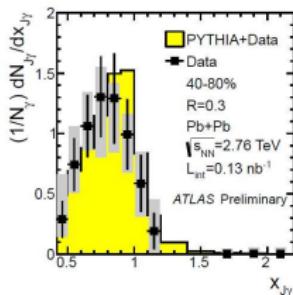
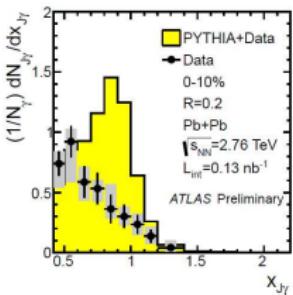
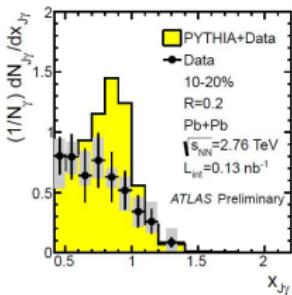
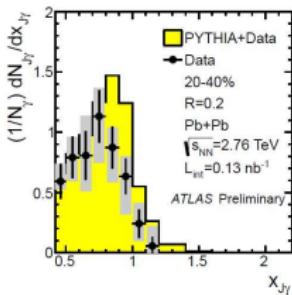
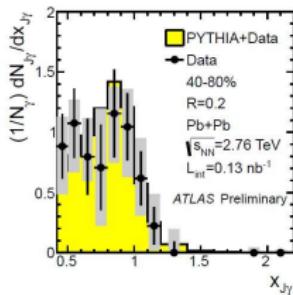
Who uses overlay? - Heavy Ions

- ▶ In Pb-Pb collisions the simulation of pile-up isn't a problem.
- ▶ Instead overlay is used to get the **underlying event** correct.
- ▶ Heavy Ion collisions are taken and then a single additional monte-carlo event is added which is the interaction of interest.
- ▶ For example, the plots on the next slide show photon-jet events where the photon-jet interaction is from Pythia generating a single nucleon-nucleon interaction and the rest of the event comes from another data event without any selection.

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Who uses overlay? - Heavy Ions

- ▶ Example plots from <https://cds.cern.ch/record/1473135> showing the “Pythia+Data” overlay samples compared to data.





Conclusions

- ▶ Overlay has been shown in 2012 data to accurately model some of the subtleties that the Monte-Carlo simulation struggles to re-produce.
- ▶ Analyses have in general stayed clear of selections which are highly dependent on the modeling of the pile-up such that in general wide-spread use of these samples was limited.
- ▶ In the future we hope that these will be more widely used as pile-up becomes more and more important.
- ▶ Any questions?