Jet reconstruction in heavy ion collisions at the ATLAS detector

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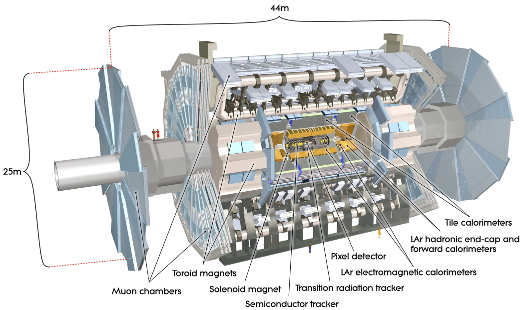
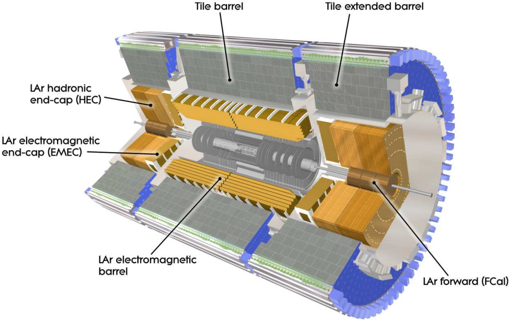
The ATLAS detector

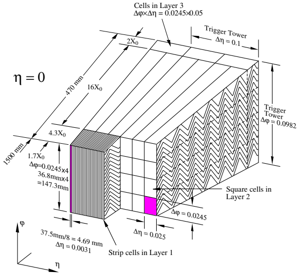
- ATLAS is one of two general purpose detectors at the LHC
- Precise tracking, excellent calorimetry, good muon identification
- Large acceptance in pseudorapidity, full coverage in azimuth
- Overall dimensions are $\approx 45 \times 25$ m, 7000 tones
- Can be very well used for the study of the HI collisions



Calorimetry

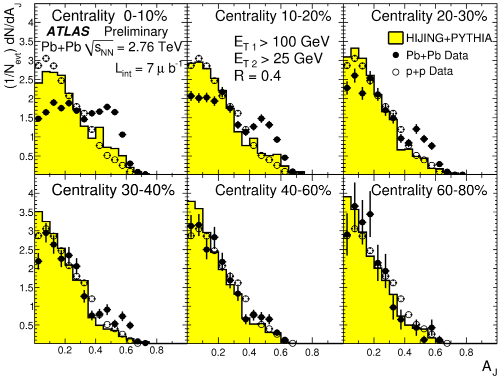
- Sampling electromagnetic and hadronic calorimeters
- Fine granularity of calorimeters enables precise measurements of high p_{T} electrons, photons and jets
- Calorimeters cover range $|\eta| < 4.9$





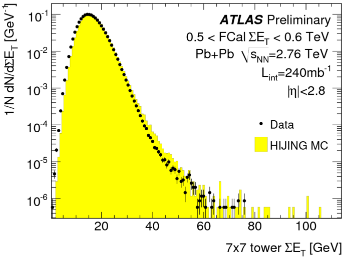
Jets in HI collisions

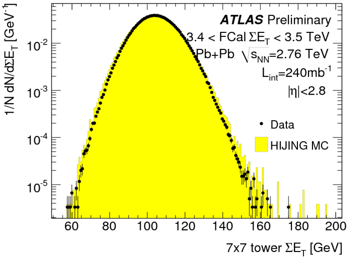
- Jet measurement in HI collisions provides important insight on the properties of the medium created in the collisions (jet quenching)
- Example: centrality dependent dijet asymmetry



Jet reconstruction

- Reconstruction of jets in HI collisions is challenging by itself
- Presence of large underlying event background (UE) requires subtraction procedure
- Large variations of UE energy density due to geometry of the collisions and physics effects such as elliptic flow implies that UE subtraction procedure must be on the event-by-event basis





Jet reconstruction in ATLAS

- Input into the reconstruction procedure is the measured E_{T}^{tower} distribution

$$\frac{\mathrm{d}E_{\mathrm{T}}^{total}}{\mathrm{d}\eta\mathrm{d}\phi} = \frac{\mathrm{d}E_{\mathrm{T}}^{UE}}{\mathrm{d}\eta\mathrm{d}\phi} + \frac{\mathrm{d}E_{\mathrm{T}}^{jet}}{\mathrm{d}\eta\mathrm{d}\phi} \tag{1}$$

- UE background is estimated and subtracted from the jet energy in the subtraction procedure at the cell level (separately for each calorimeter layer)
- Fake jets are rejected by matching to the track jets or calorimeter clusters
- Self energy bias correction is applied
- Numerical Inversion calibration is used to get the final jet energy

UE subtraction

- The UE background density is estimated at the cell level (separately for each calorimeter layer)
- Elliptic flow modulation of the background is taken into account
- Jets have to be excluded from the background density calculation, this is done iteratively in two steps
  1. clustering algorithm gives set of jets, real jet candidates identified by a discrimination factor based on the measure of the collimation of the jet (seeds)
  2. background density $\rho_i(\eta)$ is calculated from cells excluding cells from seeds
  3. background is subtracted at the cell level and as a function of the calorimeter sampling
  4. the whole procedure is repeated but with UE subtracted and thus more precise seeds

Numerical Inversion I

- Energy deposits in the calorimeter are reconstructed at the electromagnetic (EM) scale
- The response of the calorimeter to jets (hadronic processes) is lower and has to be corrected
- The NI is the procedure that determines the calibration factor for jet with given η and $E_{\mathrm{T,calo}}^{\mathrm{EM}}$, is based on the MC simulation
- The goal of NI is to derive Response $R = E_{\mathrm{T,calo}}^{\mathrm{EM}} / E_{\mathrm{T,truth}}$ as a function of $E_{\mathrm{T,calo}}^{\mathrm{EM}}$ in η bins

Numerical Inversion II

- For each bin in η_{det} and $E_{\mathrm{T,truth}}$ response distribution is fitted by the gaussian function
- Mean Response $\langle R \rangle$ is then defined as the mean of the gaussian fit
- Mean reconstructed energy is then $\langle E_{\mathrm{T,calo}}^{\mathrm{EM}} \rangle = \langle R \rangle E_{\mathrm{T,truth}}$
- $(\langle E_{\mathrm{T,calo}}^{\mathrm{EM}} \rangle, \langle R \rangle)$ points are fitted for each η bin with function parametrised as:

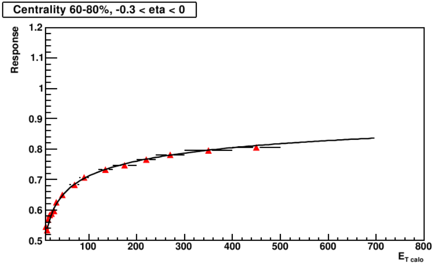
$$F_{\mathrm{calib}}(E_{\mathrm{T,calo}}^{\mathrm{EM}}) = \sum_{i=0}^{N_{\mathrm{max}}} a_i \left(\ln(E_{\mathrm{T,calo}}^{\mathrm{EM}})\right)^i \qquad (2)$$

Numerical Inversion III

- Having the Response the jets are calibrated via relation

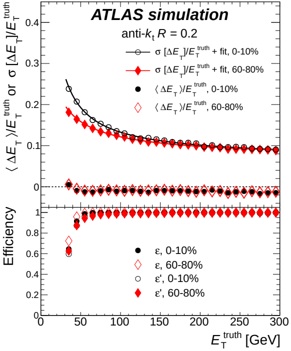
$$E_{\mathrm{T,calo}}^{\mathrm{EM+JES}} = \frac{E_{\mathrm{T}}^{\mathrm{EM}}}{F_{\mathrm{calib}}(E_{\mathrm{T,calo}}^{\mathrm{EM}})} \tag{3}$$

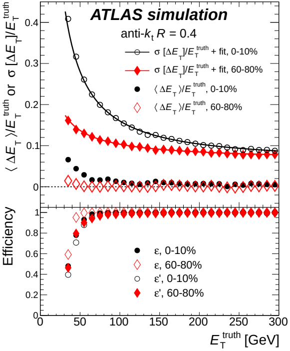
- In order to improve the $\mathrm{JES}(\eta)$ we developed iterative method that improves our closure significantly and enables us use finer η binning



Performance

- Performance of $R = 0.2$ (left) and $R = 0.4$ (right) anti-k_{T} jets
- Very small difference of $\Delta E_{\mathrm{T}}/E_{\mathrm{T}}^{\mathrm{truth}}$ between central and peripheral events
- Significantly higher JER in central events for $R = 0.4$ jets





Conclusions

- Sophisticated and carefull UE background subtraction together with SEB correction and NI performs very well
- It allows us to do nice and precise measurements like dijet asymmetry, jet R_{CP}, fragmentation functions...