Inclusive jet and charged particle $R_{AA}$ in PbPb collisions at 2.76 TeV with CMS

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Compact Muon Solenoid (CMS)

- EM and HAD calorimeters: $|\eta| < 5$
- Beam Scintillator Counters (BSC): $3.2 < |\eta| < 4.7$
- HF$^\pm$: $2.9 < |\eta| < 5.2$
- CASTOR
- ZDC: $\pm 140m$
- Magnet yoke: 3.8 T
- Silicon tracker: $|\eta| < 2.4$
- Muon chambers: $|\eta| < 2.5$
Charged particle analysis

- **Triggering:**
  - Min. bias: coincidence triggers
  - BSC (3.2<|η|<4.7) or HF (2.9<|η|<5.2)
  - 2011 jet triggers extend statistical reach of track $p_T$
  - Jets: Iterative cone + background subtraction
  - Thresholds: 65 and 80 GeV

- **Event Selection:**
  - Beam Halo veto
  - Beam-scraping cleaning
  - ECAL, HCAL noise cleaning
  - Vertex with at least 2 tracks
  - 3 towers ($E>3$ GeV) in HF±
Track reconstruction

- **Track reconstruction:** iterative algorithm
  - Find tracks in consecutive steps
  - Remove hits belonging to tracks in each step
  - Merge tracks based on the fraction of shared hits
  - “Calorimeter compatibility”: tracks are matched to closest calorimeter cells (for track $p_T \gtrsim 30$ GeV/c)

→ High efficiency, low fake track rate at high-\(p_T\)
PbPb charged particle spectra

- Measured up to 100 GeV/c in six centrality bins
- Uses full 2011 run statistics at high \( p_T \) – 150 \( \mu b^{-1} \)
- Use to make \( R_{AA} \)

\[
R_{AA} = \frac{dN^{AA}/dp_T}{\langle T_{AA} \rangle \sigma^{pp}/dp_T} \]

\[
\langle T_{AA} \rangle = \frac{\langle N_{coll} \rangle}{\sigma^{NN}_{inel}}
\]
Charged particle $R_{AA}$

- Dip structure develops as a function of centrality
- $R_{AA}$ increases at high $p_T$

Charged particle $R_{AA}$ evolution

- Below 10 GeV/c, LHC is 50% more suppressed than RHIC
- Most models predict the rise at LHC, but the slope varies
Central charged particle $R_{AA}$ shows suppression up to high $p_T$
Jet $R_{AA}$ analysis

- Make measured jet spectra
  - Jet triggered events $E>80$ GeV
  - Inclusive jets $p_T>100$ GeV/c, $|\eta|<2$
  - Anti-kT particle flow jets, iterative background subtraction (PbPb)
- Remove detector effects in both PbPb and pp ($p_T$ resolution and jet $p_T$ scale):
  - Main technique: unfold jet spectrum based on performance of PbPb MC (Bayesian unfolding)
    - Cross-checks:
      - Generalized Singular Value Decomposition (GSVD) unfolding
      - Bin-by-bin unfolding
      - Smear pp data based on jet resolution & scale from PbPb MC (different $p_T$, centrality bins)
- Construct ratio of jet spectra: unfolded PbPb to unfolded pp
- Also analyzed with calorimeter jets instead of particle flow
Jet background from PbPb

- Average background $p_T$ subtracted from each jet
  - Example: $100 < \text{jet } p_T < 110 \text{ GeV/c}$
- Remaining jet bins have similar agreement for data & MC
Jet background in PbPb

- Mean and width for background $p_T$ subtracted from jets
- Not detector $\eta$ & $p_T$ energy corrected (factor $\sim$10-25%)

⇒ Be careful when comparing directly to jet $p_T$
Jet $R_{AA}$ methods comparison

- Good agreement between 4 different methods
- Unfolding only makes a small difference in the jet $R_{AA}$
Different jet cone size

- No strong dependence on jet radius
Jet $R_{AA}$ decreases with increasing number of participants.
Central $R_{AA}$

CMS (∗ preliminary) PbPb $\sqrt{s_{NN}} = 2.76$ TeV

$$\int L \, dt = 7-150 \, \mu b^{-1}$$

- $Z$ (0-100%) $p_T > 20$ GeV/c
- $W$ (0-100%) $p_T > 25$ GeV/c
- Isolated photon (0-10%)

Charged particles (0-5%)

Looking at the same parton $p_T$ range

Charged particles from $p_T=20-100$ GeV/c: $z = p_T(\text{track})/p_T(\text{jet}) = 0.5$
In central PbPb collisions:

- Charged particle $R_{AA}$: minimum of 0.13 at low $p_T$
  - Dip structure increases from peripheral to central
- Charged particle $R_{AA} \approx 0.5$ at high $p_T$
- Jet $R_{AA} \approx 0.5$ for jets from $p_T$ of 100 to 300 GeV/c
- Jet $R_{AA}$ is independent of cone size for jets from $p_T$ of 100 to 300 GeV/c

Charged particle and jet $R_{AA}$ decrease from peripheral to central PbPb collisions at 2.76 TeV