Jet studies in 200 GeV d+Au collisions from the STAR experiment at RHIC

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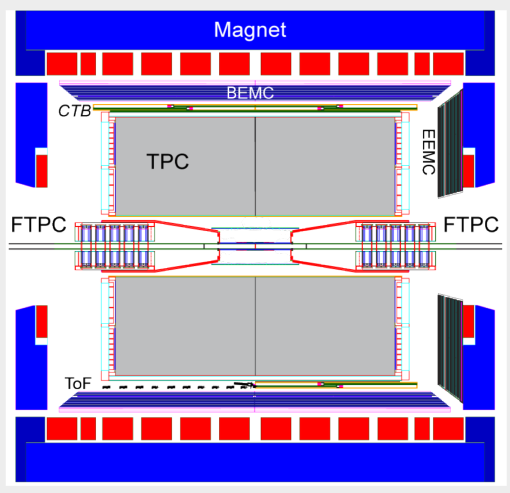
Abstract

Full jet reconstruction in heavy-ion collisions is a promising tool for the quantitative study of properties of the dense medium produced in heavy-ion collisions at RHIC.
Jet studies in d+Au collisions are important to disentangle initial state nuclear effects from medium-induced k_T broadening and jet quenching.
We present inclusive jet p_T spectra in d+Au collisions from the 2007-2008 RHIC run. We discuss correction for detector effects and underlying event background, including systematic uncertainties.

STAR experiment

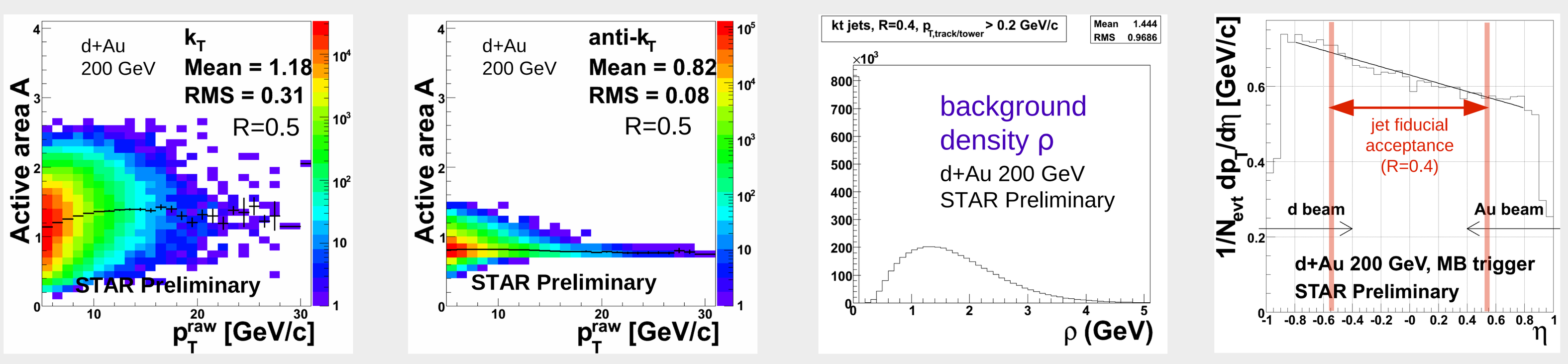


- acceptance: pseudo-rapidity $|\eta| < 1.0$, full azimuth
- detector subsystems used for jet reconstruciton:
  - charged energy: tracks from the Time Projection Chamber (TPC)
  - neutral energy: towers from the Barrel Electromagnetic Calorimeter (BEMC)
- 100% hadronic correction: associated charged track p_T subtracted off tower E_T: to avoid double-counting (MIP, electron&hadronic showers)

- 200 GeV d+Au data sample:
  - 20% highest multiplicity d+Au collisions: RHIC run 8 (2007-2008)
  - Minimum Bias (MB) trigger: ZDC East + VPD coincidence
  - High Tower (HT2) trigger: ZDC East + BEMC tower E_T>4.3 GeV
- 200 GeV p+p data sample:
  - High Tower (HT2, BEMC tower E_T>4.3 GeV +BBC coincidence) data: RHIC run 8 (2007-2008)
  - High Tower triggered data: RHIC runs 3,4 (2003,2004) – see [1] for details

Jet reconstruction

- **jet algorithms:**
  - Mid Point Cone (MPC) algorithm with cone radius R=0.4 and split/merge fraction 0.5: p+p runs 3,4
  - anti-k_T (from FastJet package [2,3]) with resolution parameter R=0.4 and 0.5: p+p and d+Au run 8
- **treatment of d+Au background:**
  - method [4] based on background density ρ and jet active area A (using ghosts with area 0.01)
  - k_T jet algorithm used to determine ρ on a per-event basis: ρ = median $\{r^i\}$, $r^i = p_T^i/A^i$
  - background density ρ modulated by pseudorapidity (inherent asymmetry of d+Au system)
  - background subtraction: $p_T = p_T^{raw} - A*\rho$
  - background further reduced for analysis of k_T effect by using a p_T cut for tracks and towers: p_T>0.5 GeV/c, otherwise track/tower p_T limited only by detector acceptance (p_T>0.2 GeV/c)



Jet corrections

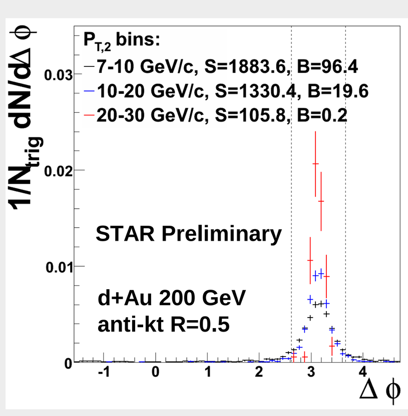
- detector effect corrections:
  - Pythia 6.410 ("PyMC") + STAR detector response simulation ("PyGe")
  - emulated trigger response
  - for jet spectra, tracking efficiencies from the simulation corrected for detector background effects (e.g. pile-up) using embedding of simulated tracks into real events at raw data level
- background fluctuations in d+Au quantified by embedding of Pythia jet events into real d+Au MB events at reconstructed track/tower level ("PyBg")
- Jet Energy Scale uncertainties – run 8 analysis:
  - TPC tracking efficiency: 10% (improvements under study)
  - BEMC calibration uncertainty: 5%

Di-jet analysis

- two highest energy jets in event: $p_{T,1} > p_{T,2}$
- three bins in $p_{T,2}$: 7-10, 10-20, 20-30 GeV/c
- anti-k_T algorithm
- p_T^{cut}=0.5 GeV/c

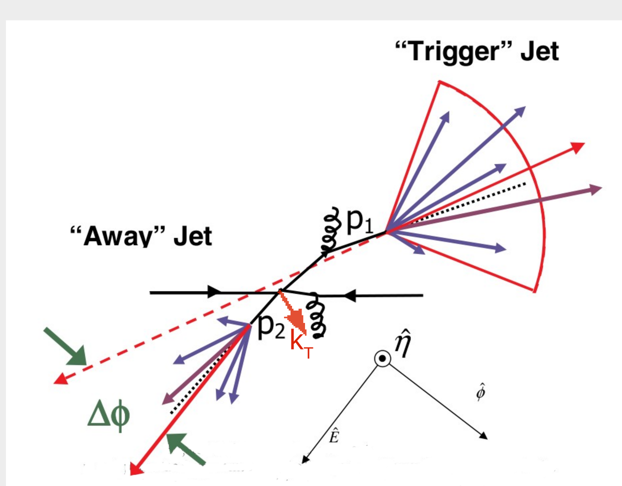
ΔΦ distributions for jet pairs:

- clear high-purity di-jet signal observed
- signal (S) and background (B) values correspond to the dashed-line region



k_T effect (di-jet ΔΦ broadening):

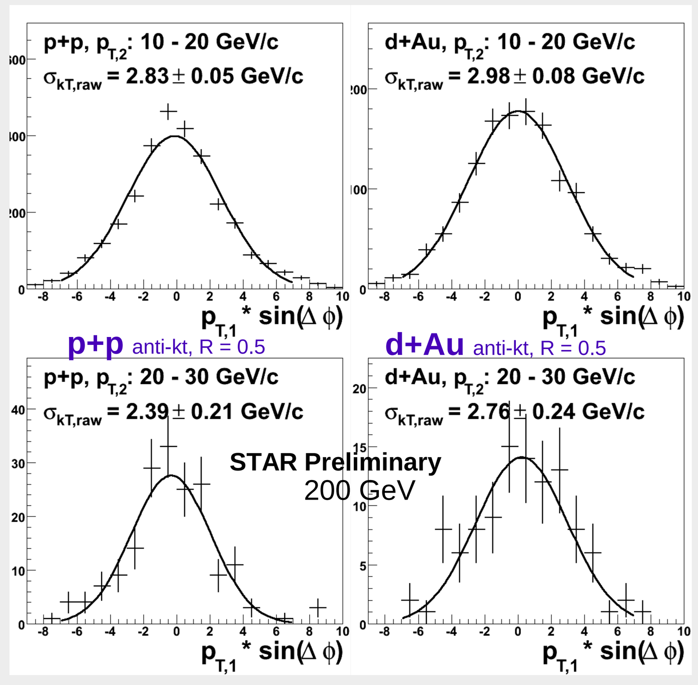
- intrinsic k_T (partons within hadrons)
- initial and final state radiation – including Cold Nuclear Matter (CNM) effects
- radiation: soft (Gaussian) and hard (NLO, power-law tails)
- quantified via Gaussian fit to $p_{T,1}$*sin(Δφ) – sensitivity to hard radiation is limited



partonic k_T projected to Φ direction

k_T measurement

Di-jet events from run 8 p+p and d+Au data (HT2 trigger)
Gaussian fit applied to $k_{T,raw} = p_{T,1}$*sin(ΔΦ)



Detector effects:

- same analysis run at Pythia simulated data
- detector effects on sigma widths of k_T found to be negligible [5] due to interplay of jet p_T and φ resolution

Results:

- values averaged over the two $p_{T,2}$ bins
- $\sigma_{kT,raw}$(p+p) = 2.8 ± 0.1 GeV/c
- $\sigma_{kT,raw}$(d+Au) = 3.0 ± 0.1 GeV/c

Under study:

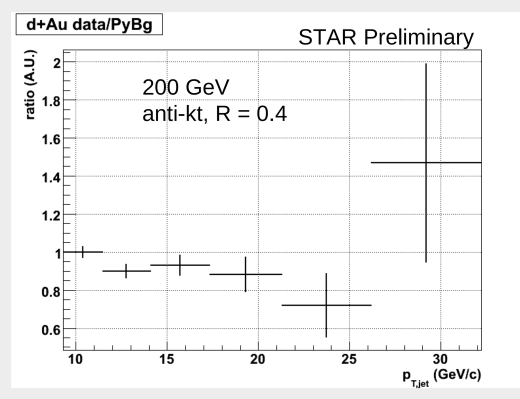
- evaluation of systematic uncertainties
- p_T dependence (quark/gluon jets)

Comparison to di-hadron correlation method:

- results from π^0-charged hadron correlations (see poster 231 [6])
- p+p collisions: $\sqrt{\langle k_T^2 \rangle}$ = 2.80 ± 0.04(stat.) ± 0.27(syst.) GeV/c
- d+Au collisions: $\sqrt{\langle k_T^2 \rangle}$ = 3.41 ± 0.03(stat.) ± 0.31(syst.) GeV/c

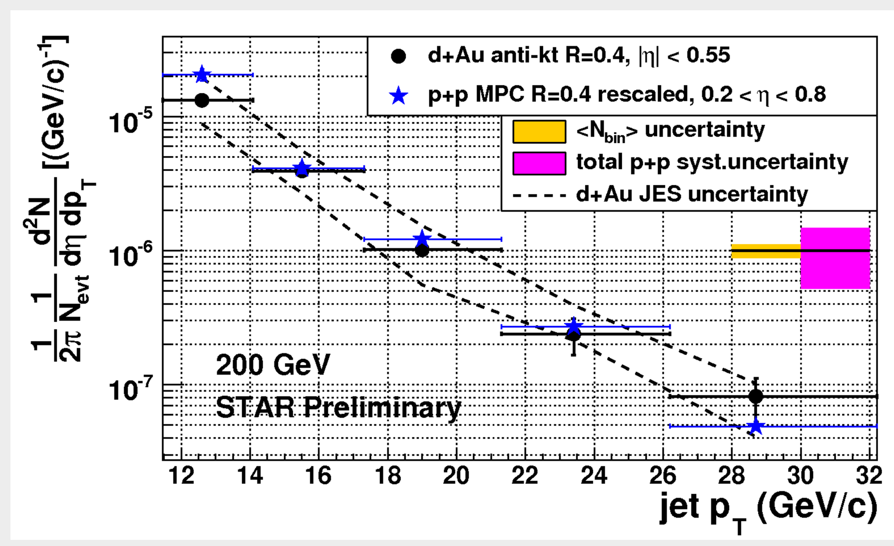
Jet p_T spectra:

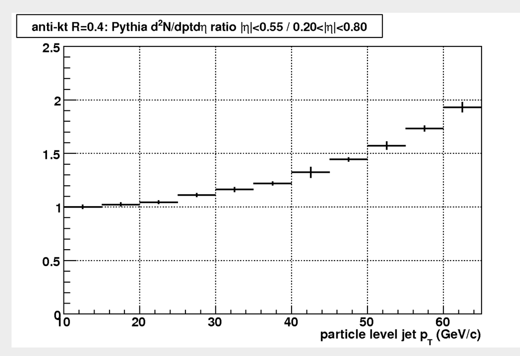
- MB d+Au data (run 8) and HT p+p data (run 3,4 [1])
- bin-by-bin correction based on Pythia used (same shape of p_T spectra required and verified)



comparison of p+p jet cross-section to d+Au per-event jet yield:

- N_{bin} scaling used with $\langle N_{bin} \rangle$ = 14.6 ± 1.7
- p+p inelastic cross-section 42 mb





Effect of different η acceptance small for p_T<30 GeV/c

- → No significant deviation from N_{bin} scaling observed
- → reduction of systematic uncertainties in progress:
  - → jet embedding at raw data level for d+Au
  - → jet analysis in run 8 p+p data

Towards jet R_{dAu}:

- decrease systematic uncertainties
- HT2 d+Au data to increase p_T reach
- p+p analysis with anti-k_T algorithm

Conclusions

Measurements of k_T effect

- → no strong CNM effects observed
- → consistent with di-hadron measurements

Jet spectrum in d+Au:

- → no significant deviation from N_{bin} scaled p+p
- → large systematic uncertainties, improvements under way
- → R_{dAu} for jets: work in progress

References

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