Nuclear modification of charged hadrons in isobar collisions at $\sqrt{s_{NN}} = 200$ GeV at STAR

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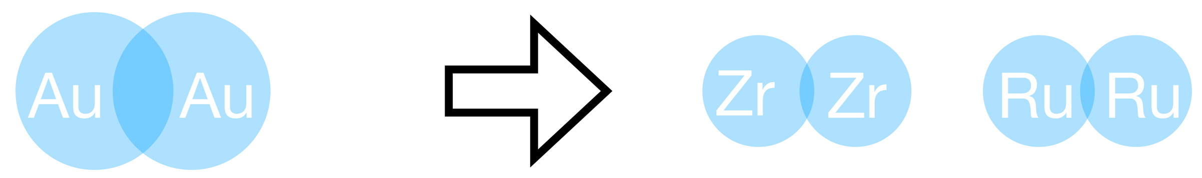
Abstract

Partonic scatterings with high momentum transfers occur before the formation of the quark-gluon plasma (QGP) in heavy-ion (A+A) collisions and result in collimated collections of hadrons called jets. The modification of the parton shower in the QGP compared to that in proton-proton (p+p) collisions offers insight into the nature of the medium's interaction with colored probes. Typically, this is measured as a ratio of hadron or jet spectra in A+A and p+p collisions, scaled by the number of binary nucleon-nucleon collisions, called the R_{AA}. The nominal RHIC A+A collision species is gold (Au) with 197 nucleons, but the high-statistics 2018 STAR isobar data from Zr+Zr and Ru+Ru collisions, each with 96 nucleons, offer the opportunity to study the system size dependence of nuclear modification of hard probes. We present a measurement of the inclusive charged hadron R_{AA} differentially with average number of participants ($\langle N_{part}\rangle$) in isobar collisions at STAR. The large available range of $\langle N_{part}\rangle$ in these data allows for comparisons to both small and large collision systems. Finally, we discuss ongoing work to control the path length of the partons through the medium via event shape engineering.

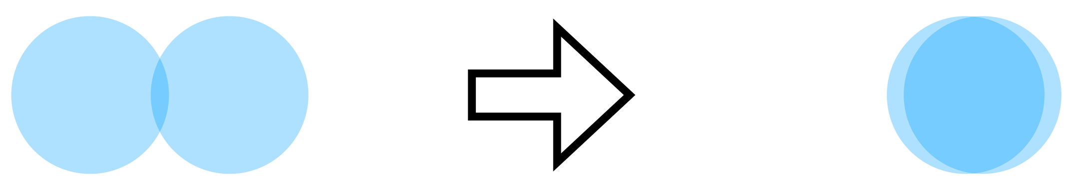
Motivation

Jet-medium interaction can be influenced by:

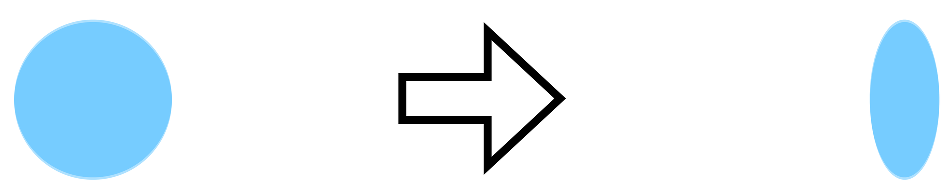
System *size* — vary by changing colliding species



Energy Density of overlapping region — vary by selecting on average number of participants, $\langle N_{part}\rangle$

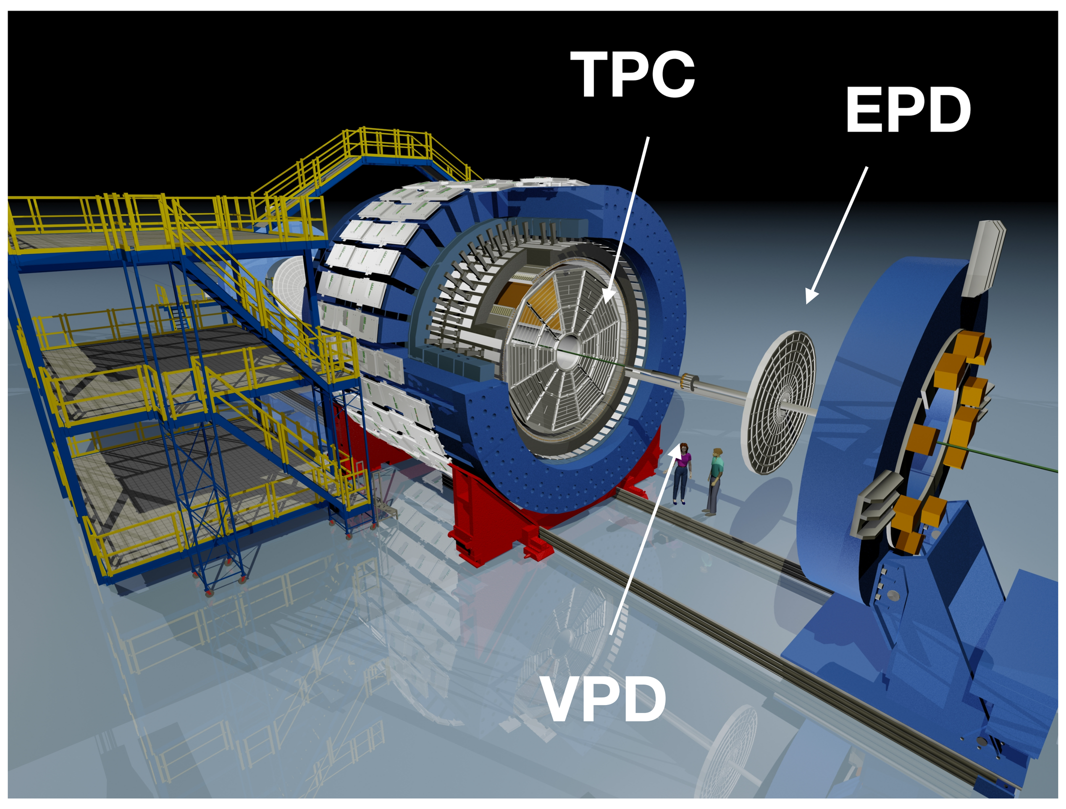


System *geometry* → path length dependence — vary with "event shape engineering"



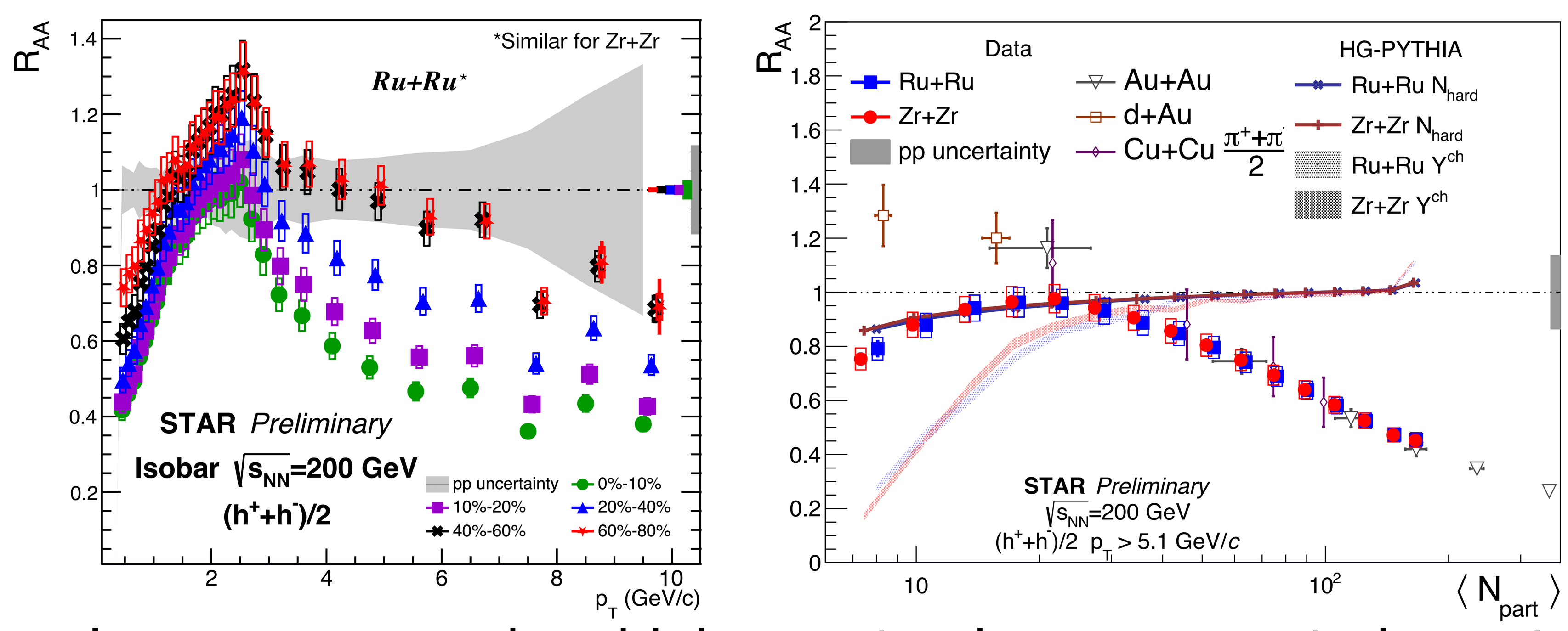
The STAR Experiment

Time Projection Chamber (**TPC**):
Charged track reconstruction + momentum
Vertex Position Detector (**VPD**): Trigger + vertexing
Event Plane Detector (**EPD**):
West: Event plane angle + East: eccentricity determination



Charged hadron suppression in isobar collisions

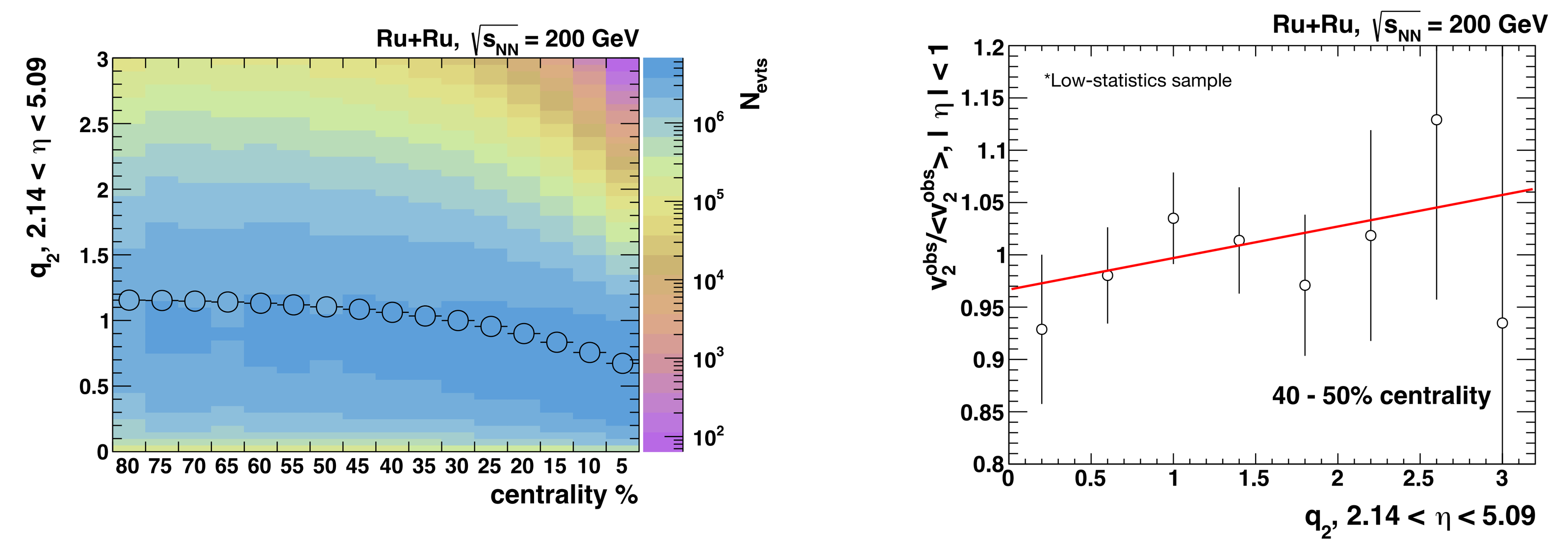
$$R_{AA} = \frac{1}{N_{ev}^{AA}} \frac{d^2N^{AA}/d\eta dp_T}{T_{AA} d^2\sigma^{NN}/d\eta dp_T}$$



- Larger suppression: higher p_T tracks, more central events
- Breakdown of scaling of N_{hard} with N_{coll} apparent in peripheral isobar data
- Across collision systems, $\langle N_{part}\rangle \gtrsim 20$ → common trend & magnitude of suppression, increasing with centrality
- For given $\langle N_{part}\rangle$, how does geometry influence E-loss?

Event shape engineering

$$Q_2 = \left(\sum_{i=1}^{M} w_i \cos(2\phi_i), \sum_{i=1}^{M} w_i \sin(2\phi_i)\right), \; q_2 = |Q_2|/\sqrt{M}$$



- For a given centrality, large variation in event shapes
- Selecting on higher/lower eccentricity (q_2) events, comparing spectra of particles/jets traversing major/minor axis controls path length through medium
- q_2 sensitive to azimuthal anisotropy $v_2 = \langle \cos(2(\phi - \Psi_2))\rangle$
- Avoid autocorrelation: EPD-W (q_2), EPD-E (Ψ_2), TPC (v_2)
- [Done by ALICE; see talk 73 by C. Beattie, 10:20 on 30th]

→ *path length dependence of jet energy loss!*

- Hadron suppression shows universality across collision systems, with only dependence on $\langle N_{part}\rangle$
- Work ongoing to select on the collision geometry to allow for comparison between jets with longer or shorter path length

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The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations