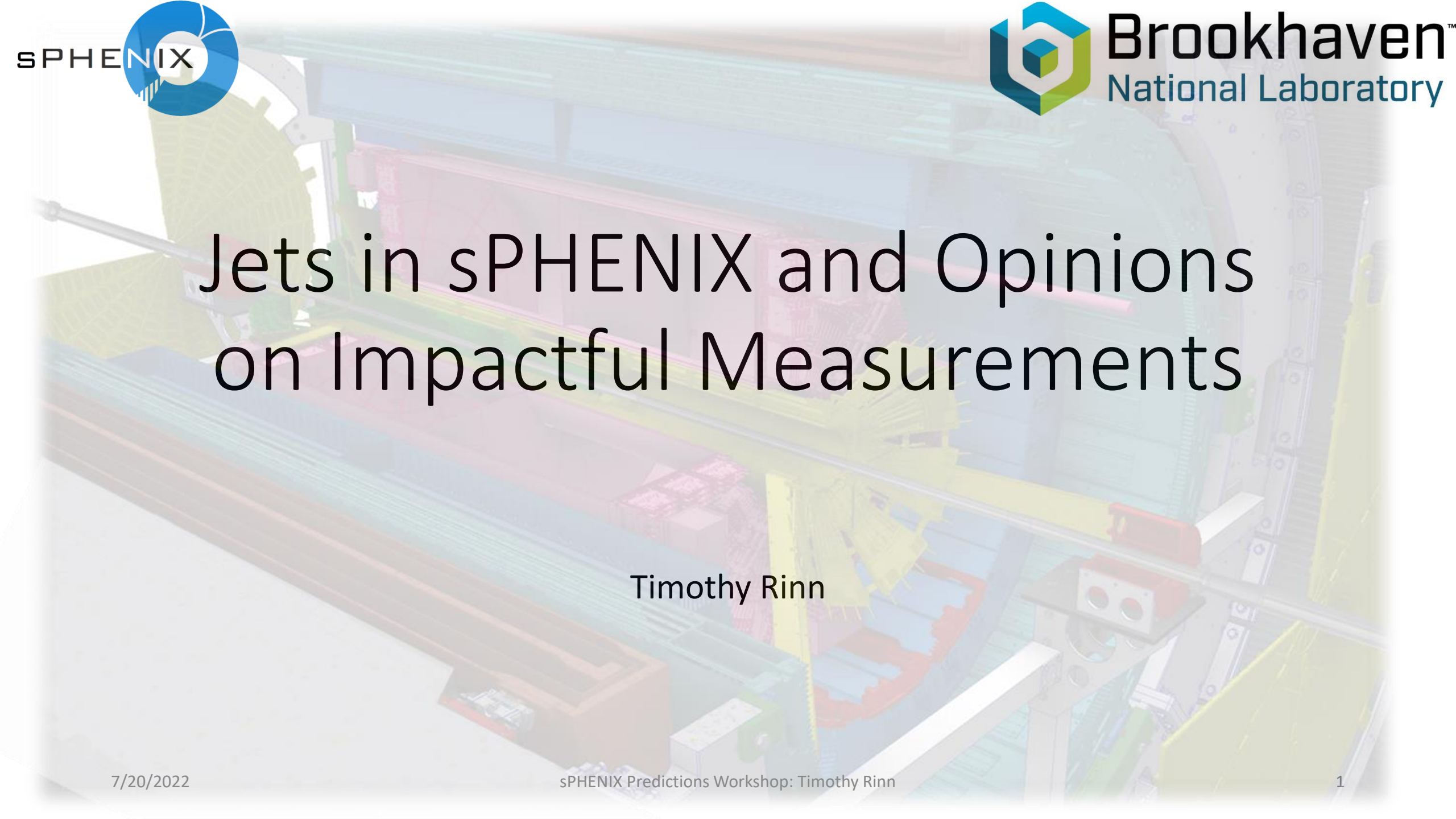


Jets in sPHENIX and Opinions on Impactful Measurements

Timothy Rinn

sPHENIX a Jet Detector:

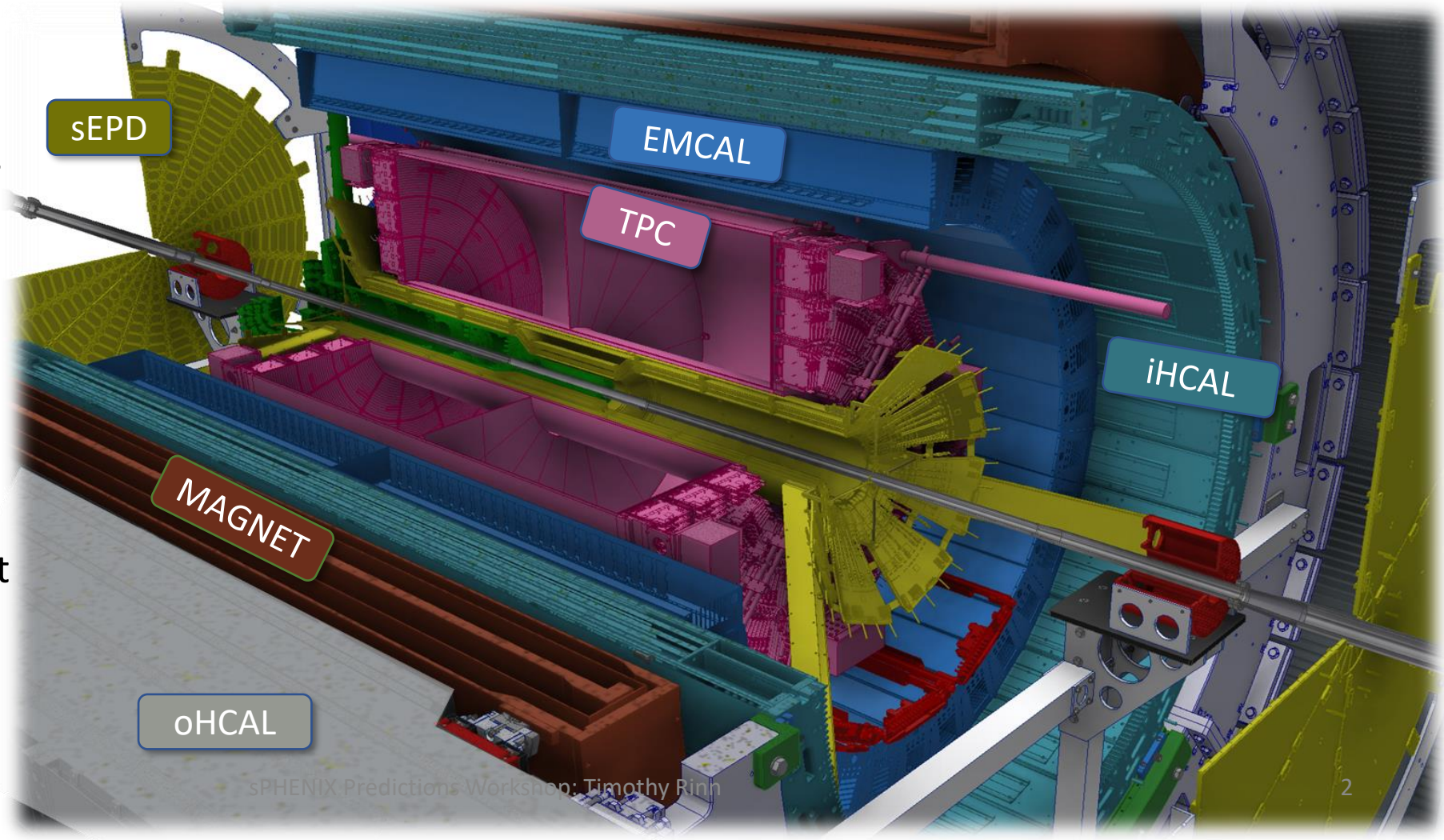
Complete **Electromagnetic** and **Hadronic** Calorimeter system:

- Differential measurements of complete jets

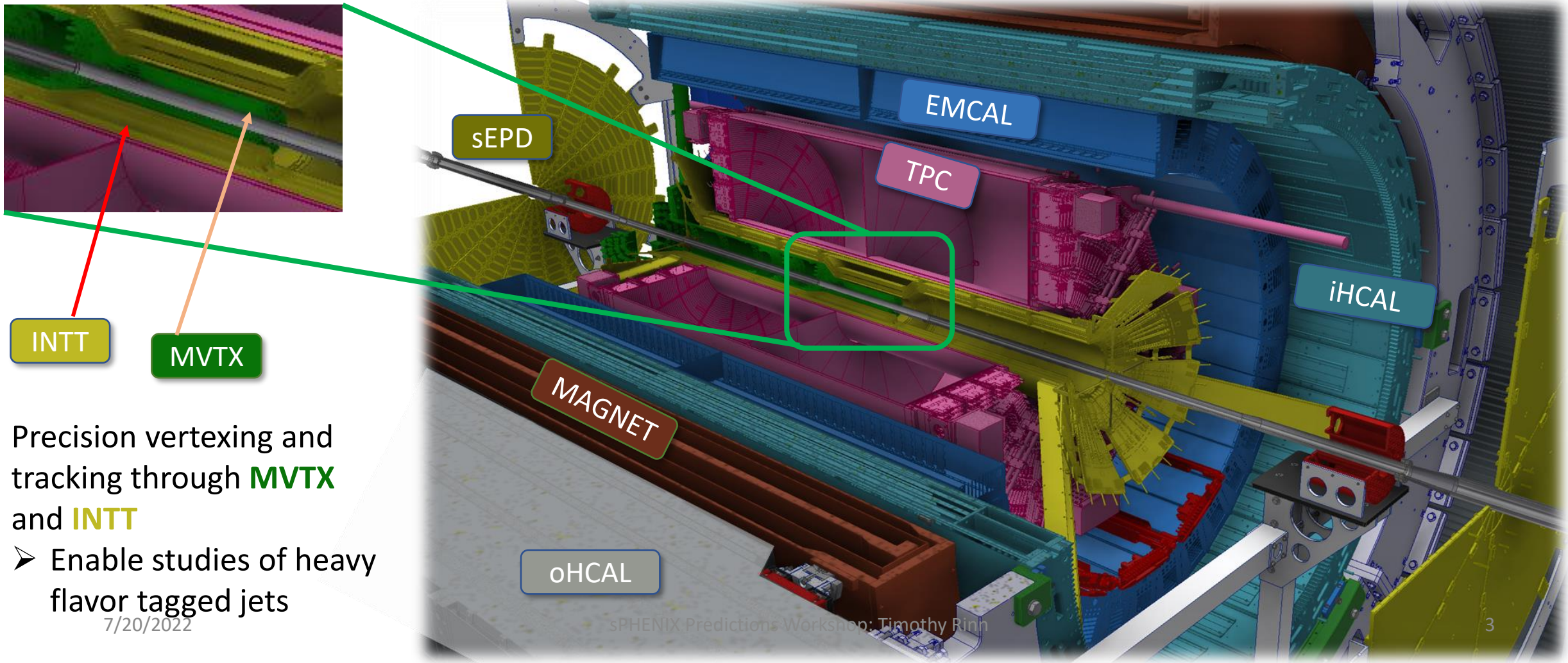
Precision tracking with the **Time Projection Chamber**

- Detailed studies of jet structure

Event plane correlations of jet observables with the **Event Plane Detectors**



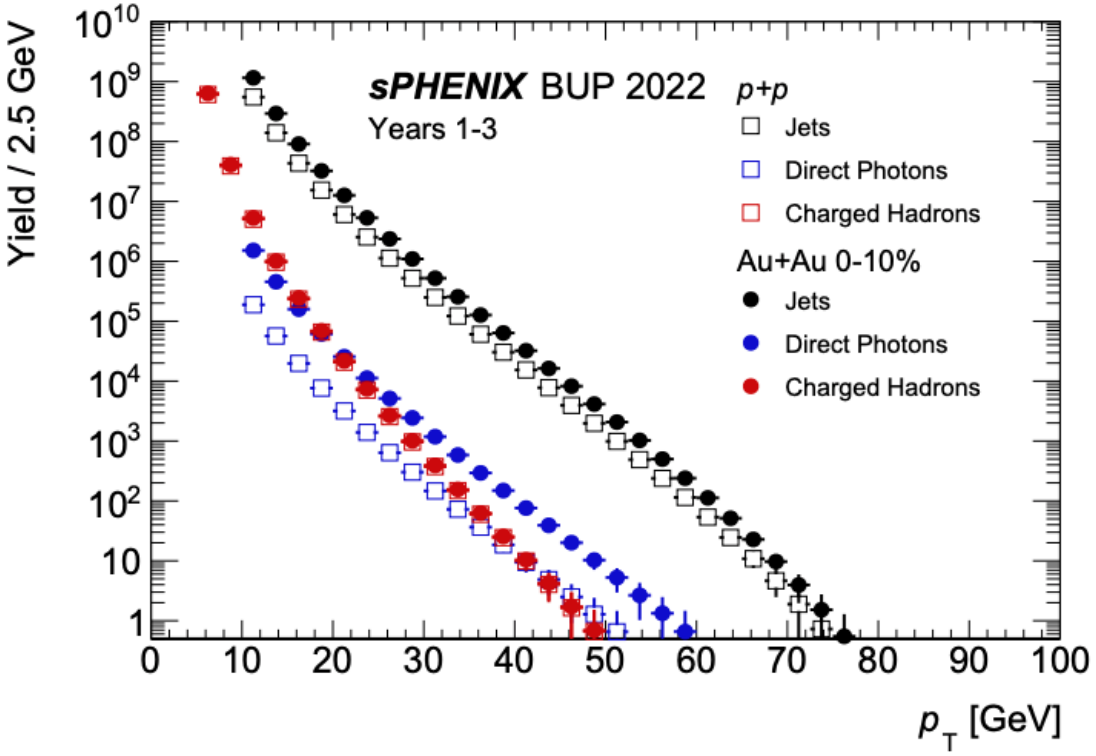
sPHENIX a Jet Detector:



Precision vertexing and tracking through **MVTX** and **INTT**

- Enable studies of heavy flavor tagged jets

sPHENIX Run Plan:

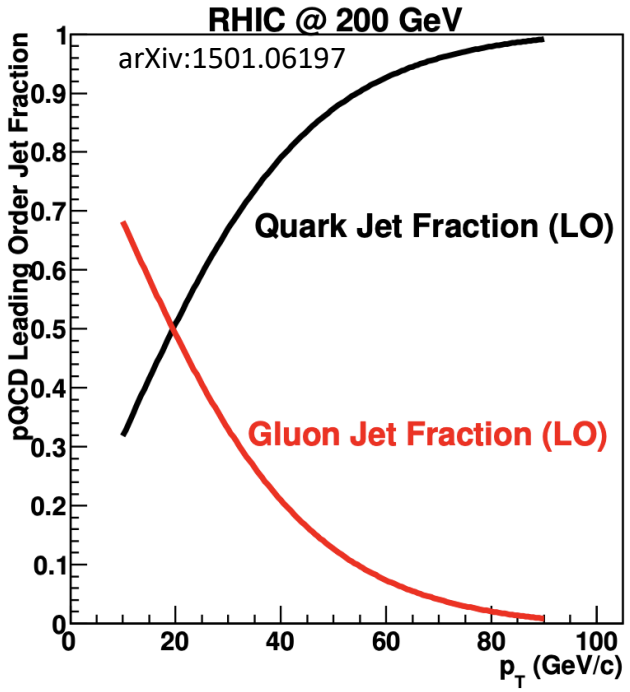


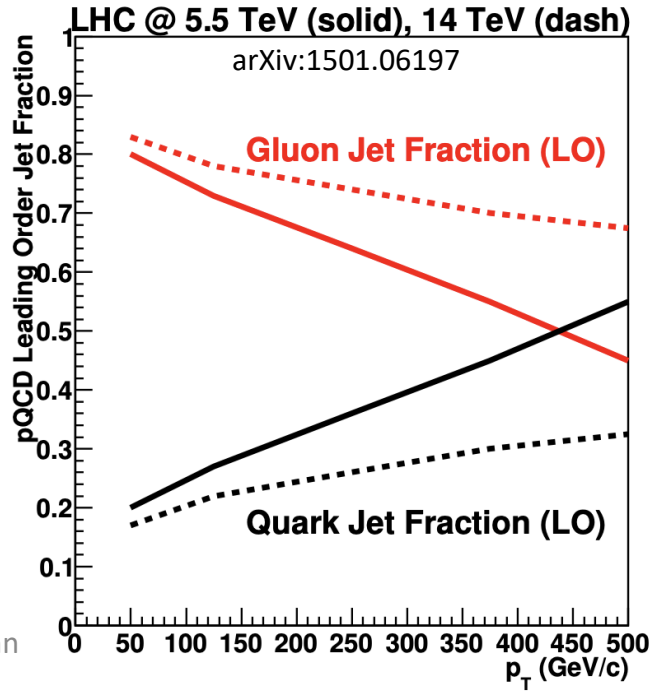
Year	Species	$\sqrt{s_{NN}}$ [GeV]	Cryo Weeks	Physics Weeks	Rec. Lum. $\lvert z\rvert$ <10 cm	Samp. Lum. $\lvert z\rvert$ <10 cm
2023	Au+Au	200	24 (28)	9 (13)	3.7 (5.7) nb^{-1}	4.5 (6.9) nb^{-1}
2024	$p^{\uparrow}p^{\uparrow}$	200	24 (28)	12 (16)	0.3 (0.4) pb^{-1} [5 kHz] 4.5 (6.2) pb^{-1} [10%-*str*]	45 (62) pb^{-1}
2024	$p^{\uparrow}$+Au	200	–	5	0.003 pb^{-1} [5 kHz] 0.01 pb^{-1} [10%-*str*]	0.11 pb^{-1}
2025	Au+Au	200	24 (28)	20.5 (24.5)	13 (15) nb^{-1}	21 (25) nb^{-1}

- Large data sets will enable a multitude of differential jet measurements
- Precision measurements of low p_T jets
- Jets out to 70 GeV
  - Enable comparisons to LHC results

Jets at RHIC versus the LHC

- RHIC produces a lower QGP temperature
  - Jets travers a different QGP than at LHC
- Different Quark/Gluon fractions at RHIC
  - Significant relative enhancement of quark jets
- Reduced underlying event at RHIC energies
  - Enables precise measurements of low p_T Jets

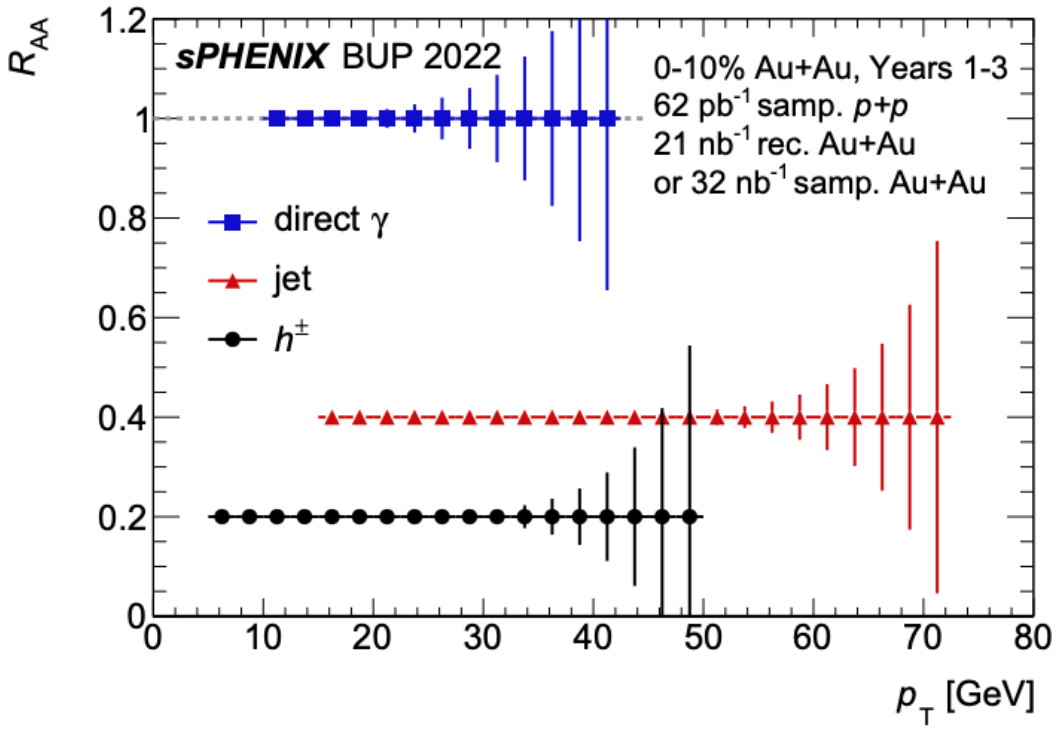


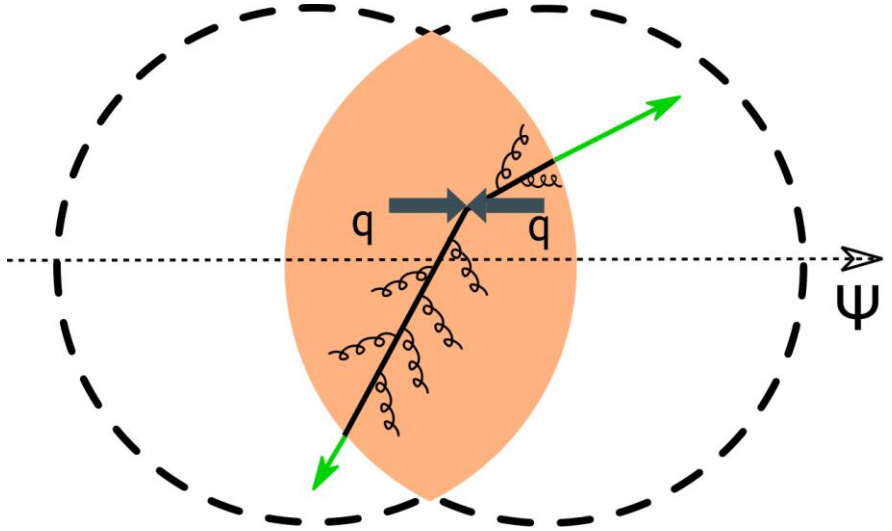


Some Key Jet Observables:

- Nuclear Modification Factors
  - Measurements of low p_T jet quenching
- Jet Correlations:
  - Event plane correlations (v_2)
  - Dijet momentum balance (x_J)
  - $\gamma + Jet$ balance $(x_{J\gamma})$
- Jet Structure/Substructure:
  - Momentum fraction and opening angle
  - Jet splitting angle dependence to quenching
  - Jet quenching as a function of jet size
- Jet Flavor Dependencies:
  - Heavy flavor tagged jets

Far From an Inclusive List





Cartoon from Martin Rybar

What are my expectations for first sPHENIX jet measurements?

- Year one of sPHENIX consists of a significant Au+Au sample
  - No *pp* reference until year two
- First measurements to focus on observables which do not require a p+p baseline using calorimetric jets
  - Jet-correlations will provide key insights

- Nuclear Modification Factors
  - Measurements of low p_T jet quenching
- Jet Correlations:
  - Event plane correlations (v_2)
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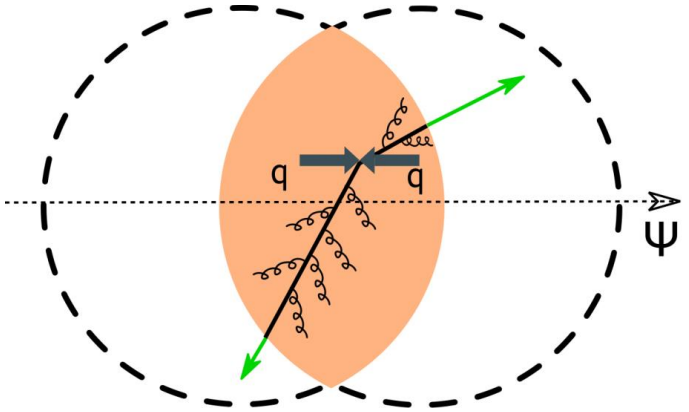
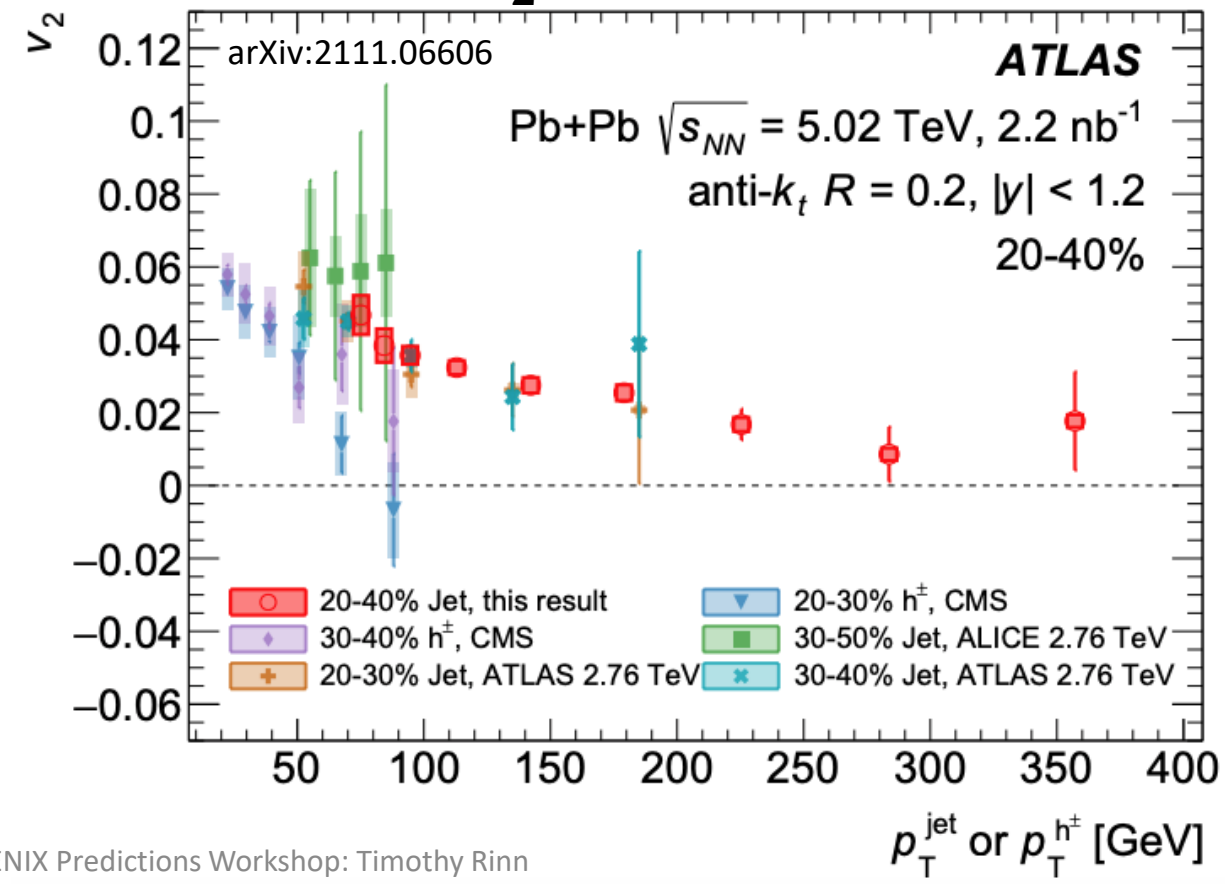
Jet Event-Plane Correlations: v_2



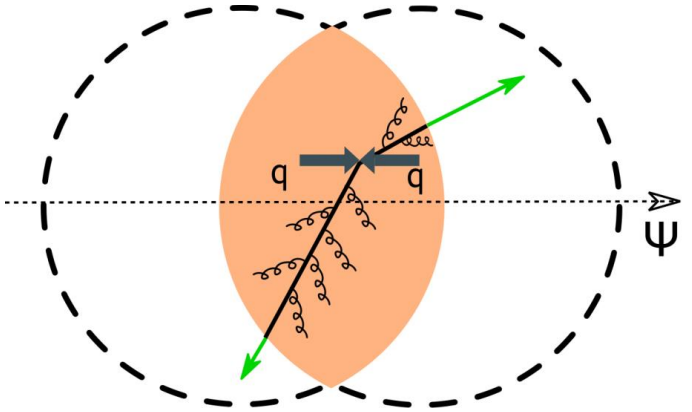
Cartoon from Martin Rybar

- Correlations of jet yields with Ψ_2 gives insight on nature of interactions with the QGP
  - v_2 at high p_T driven by initial geometry effects
    - Path-length dependent energy loss
  - v_2 at low p_T driven by flow
- LHC has performed precise measurements of Jet v_2 at high p_T

v_2 at the LHC



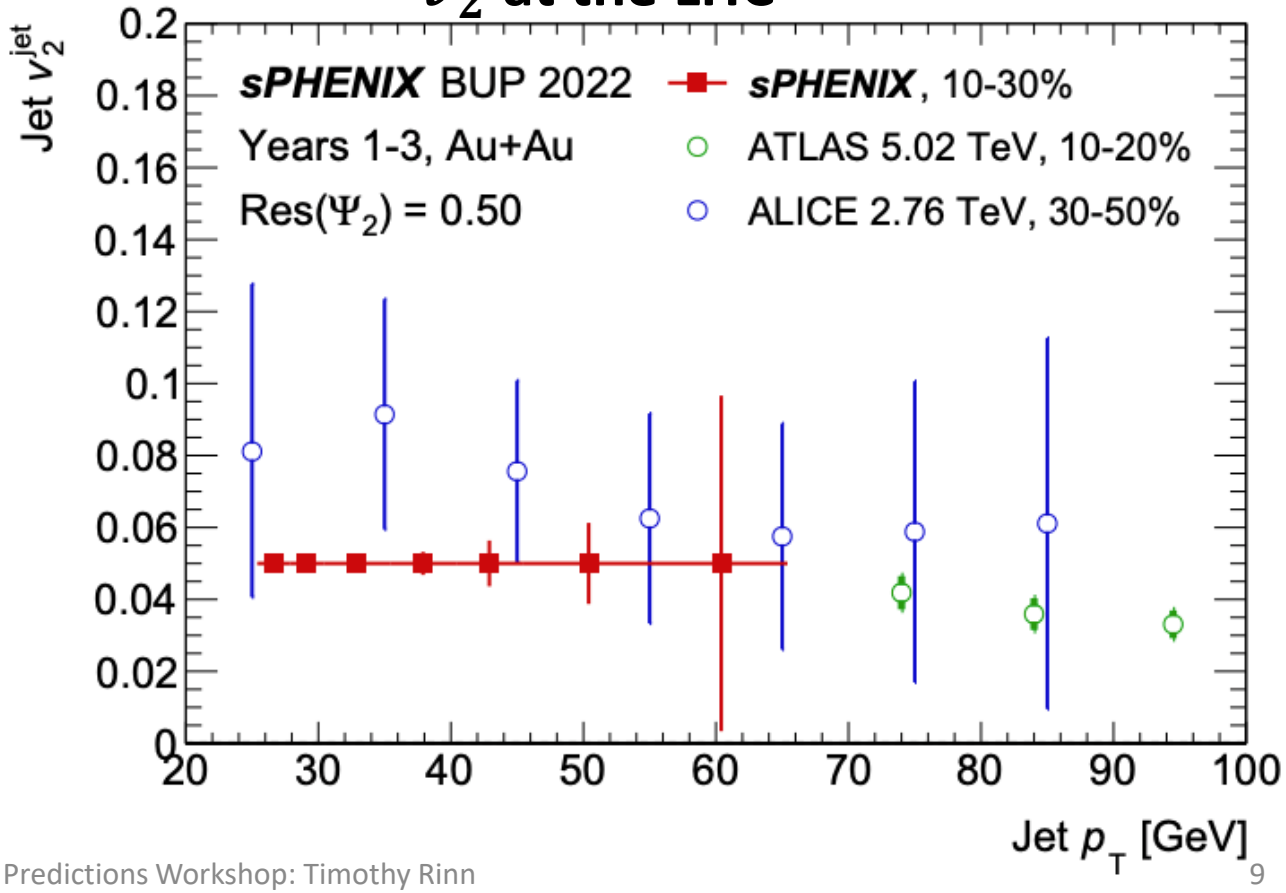
Jet Event-Plane Correlations: v_2



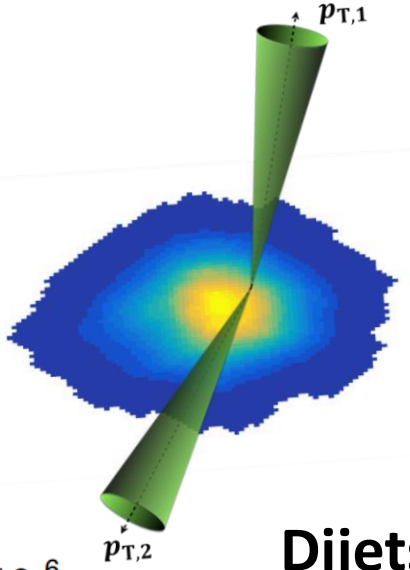
Cartoon from Martin Rybar

- Correlations of jet yields with Ψ_2 gives insight on nature of interactions with the QGP
  - v_2 at high p_T driven by initial geometry effects
    - Path-length dependent energy loss
  - v_2 at low p_T driven by flow
- sPHENIX will provide precision measurements of **unfolded** jet v_2
  - Significantly improve model constraint for lower p_T^{Jet}

v_2 at the LHC



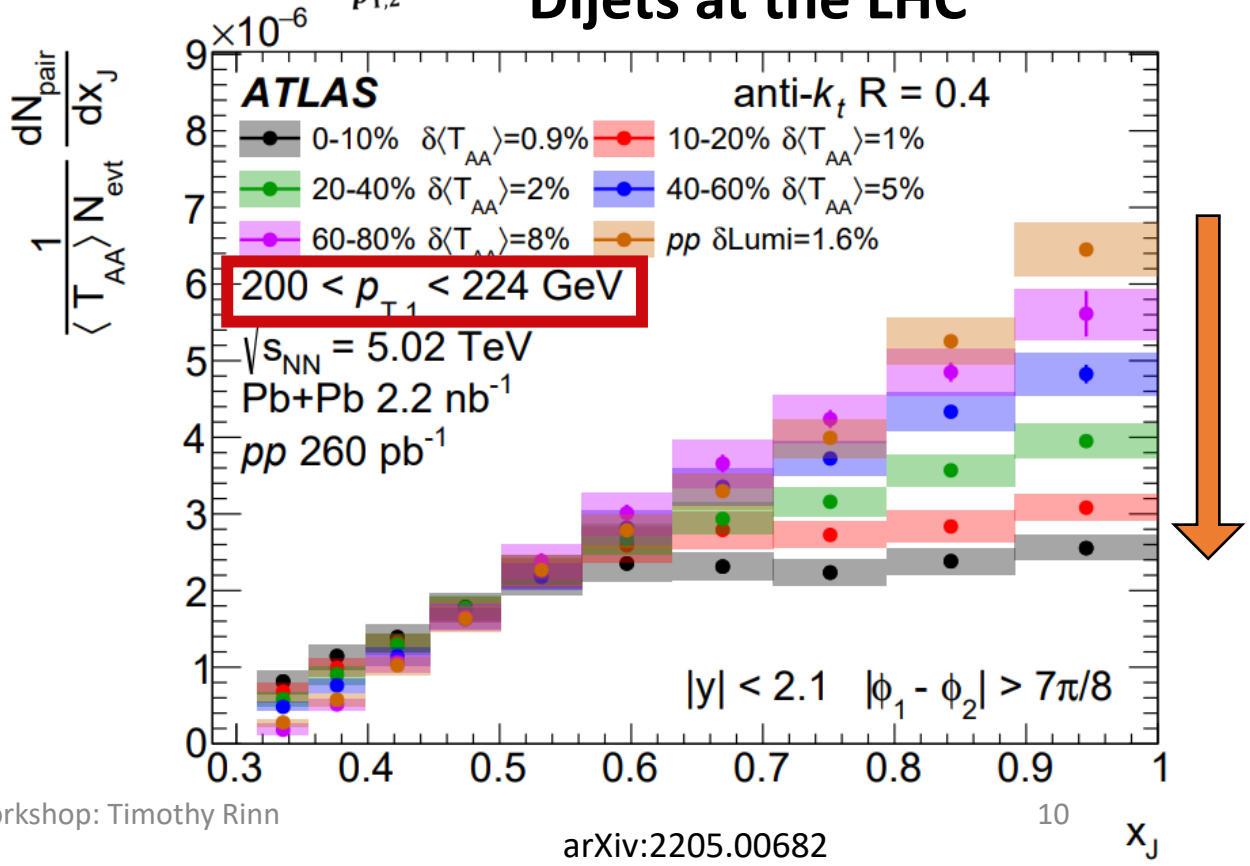
Back-to-back jets: x_J



$$x_J \equiv p_{T,2}/p_{T,1}$$

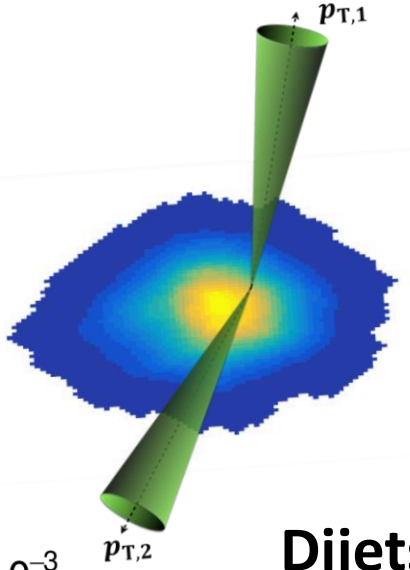
- Momentum balance of back-to-back jets provide insight to path length dependent energy loss and energy loss fluctuations
- Measurements from ATLAS indicate favorable suppression of symmetric dijets

Dijets at the LHC



arXiv:2205.00682

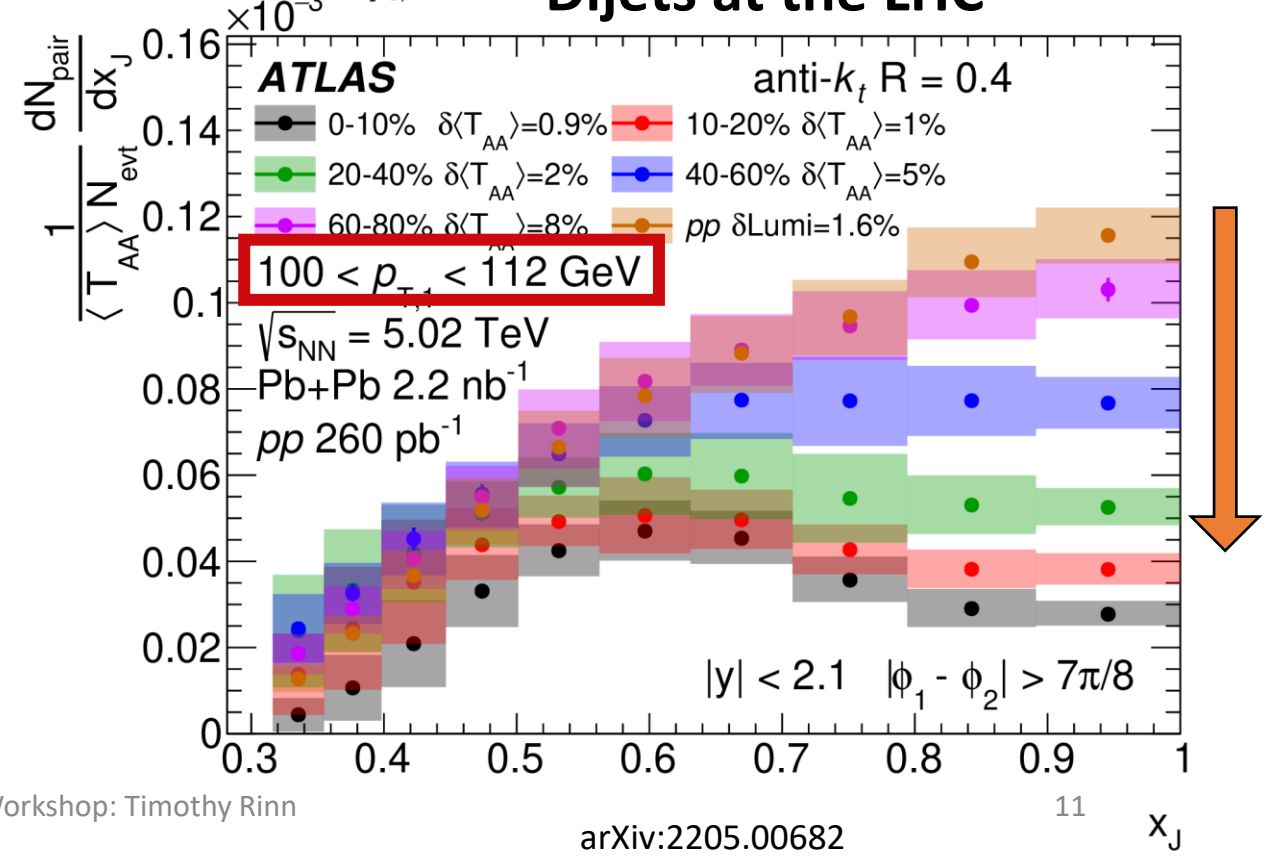
Back-to-back jets: x_J



$$x_J \equiv p_{T,2}/p_{T,1}$$

- Momentum balance of back-to-back jets provide insight to path length dependent energy loss and energy loss fluctuations
- Measurements from ATLAS indicate favorable suppression of symmetric dijets
- sPHENIX will provide key constraint on the quenching of low p_T dijet pairs
  - Correlation with event plane angle will directly probe the role of P.L. energy loss

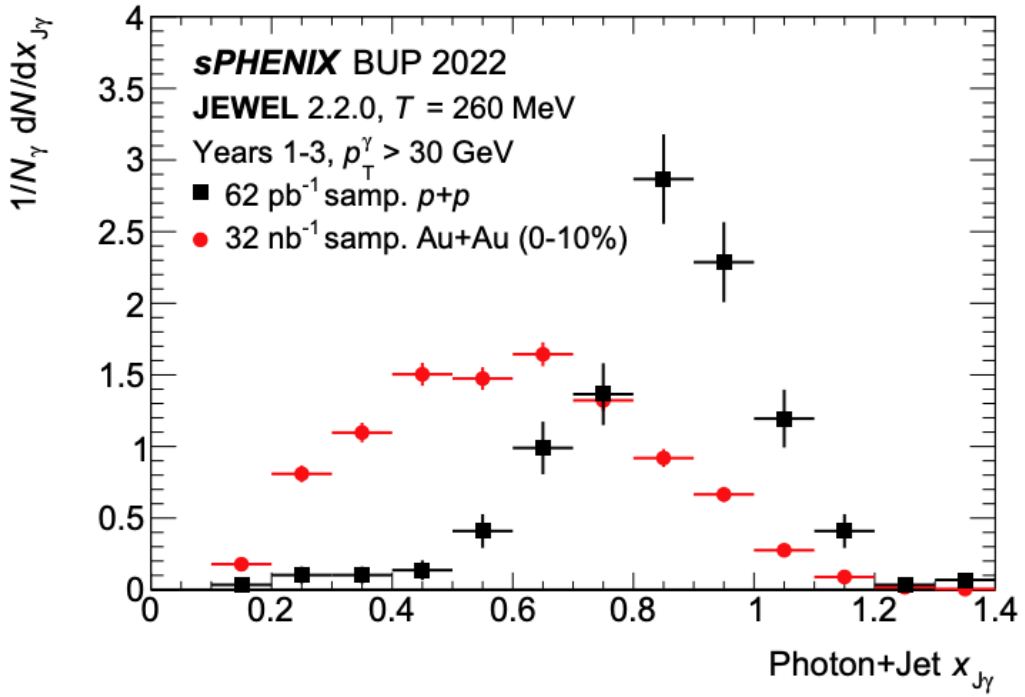
Dijets at the LHC

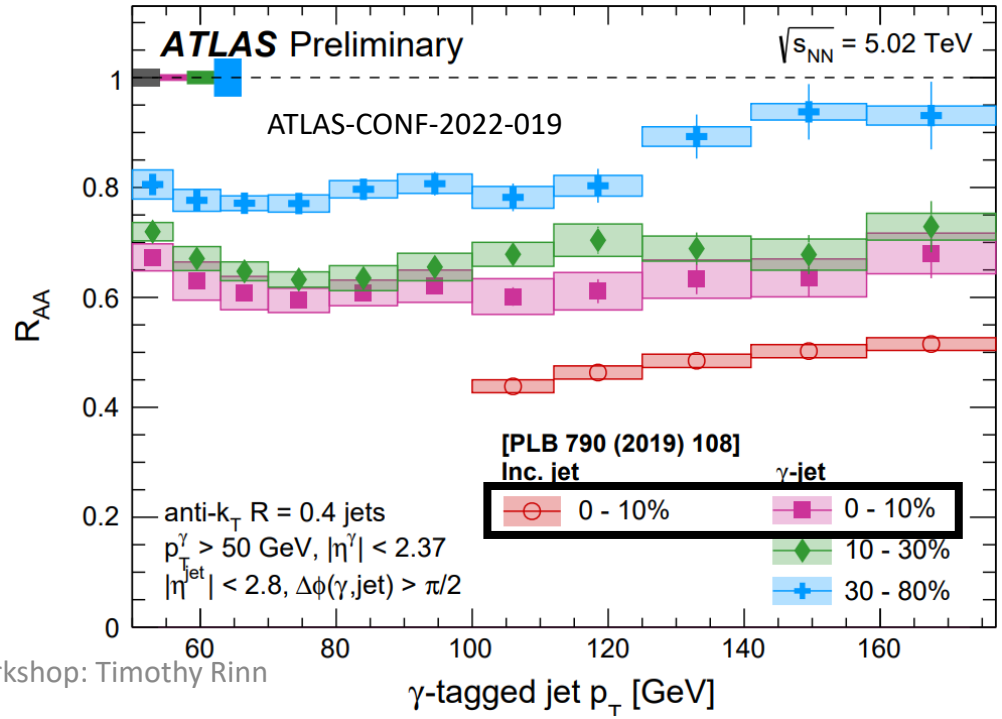


arXiv:2205.00682

$\gamma + Jets$

- Transverse momentum balance of photon+jets enables direct study of jet quenching in Au+Au collisions
  - Photon-jets provide golden-channel to study jet quenching
- γ tagged jets enable quark vrs gluon energy loss
  - Produce enhanced quark jet sample
- sPHENIX can precisely quantify tagged jet energy loss at low p_T^{Jet}





Heavy Ion Measurements using years 1-3

- Extensive two year Au+Au data sample
  - Enable differential jet measurements
- High statistics *p+p* will provide a critical reference for jet production
  - Enable measurements of jet modification in HI collisions

- Nuclear Modification Factors
  - Measurements of low p_T jet quenching
- Jet Correlations:
  - Event plane correlations (v_2)
  - Dijet momentum balance (x_J)
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- Jet Structure/Substructure:
  - Momentum fraction and opening angle
  - Jet splitting angle dependence to quenching
  - Jet quenching as a function of jet size
- Jet Flavor Dependencies:
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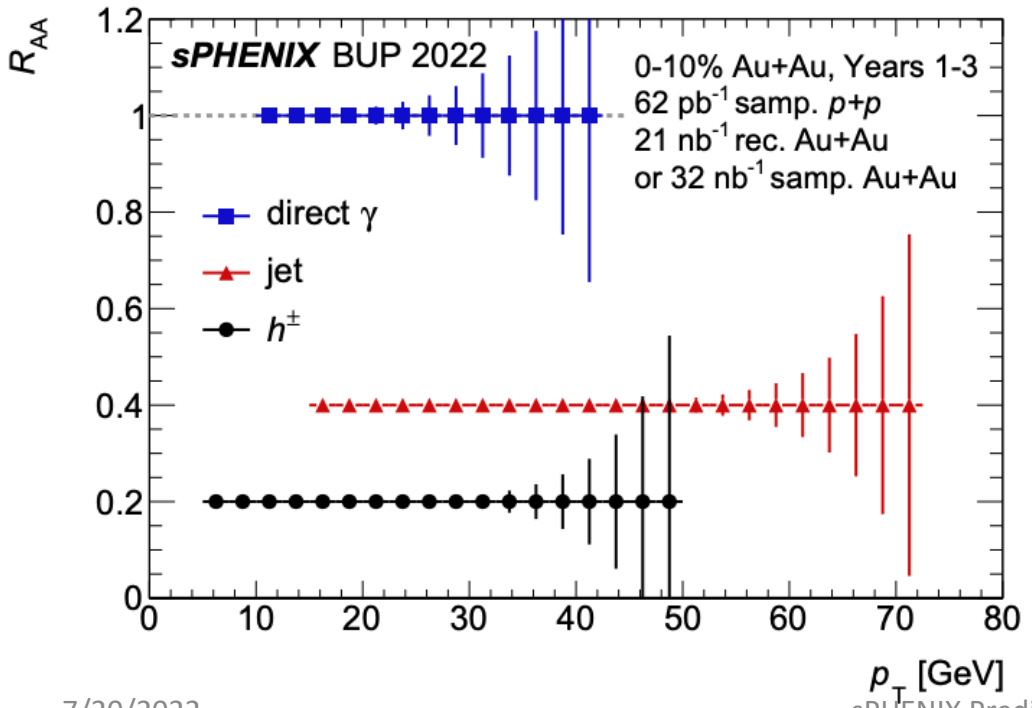
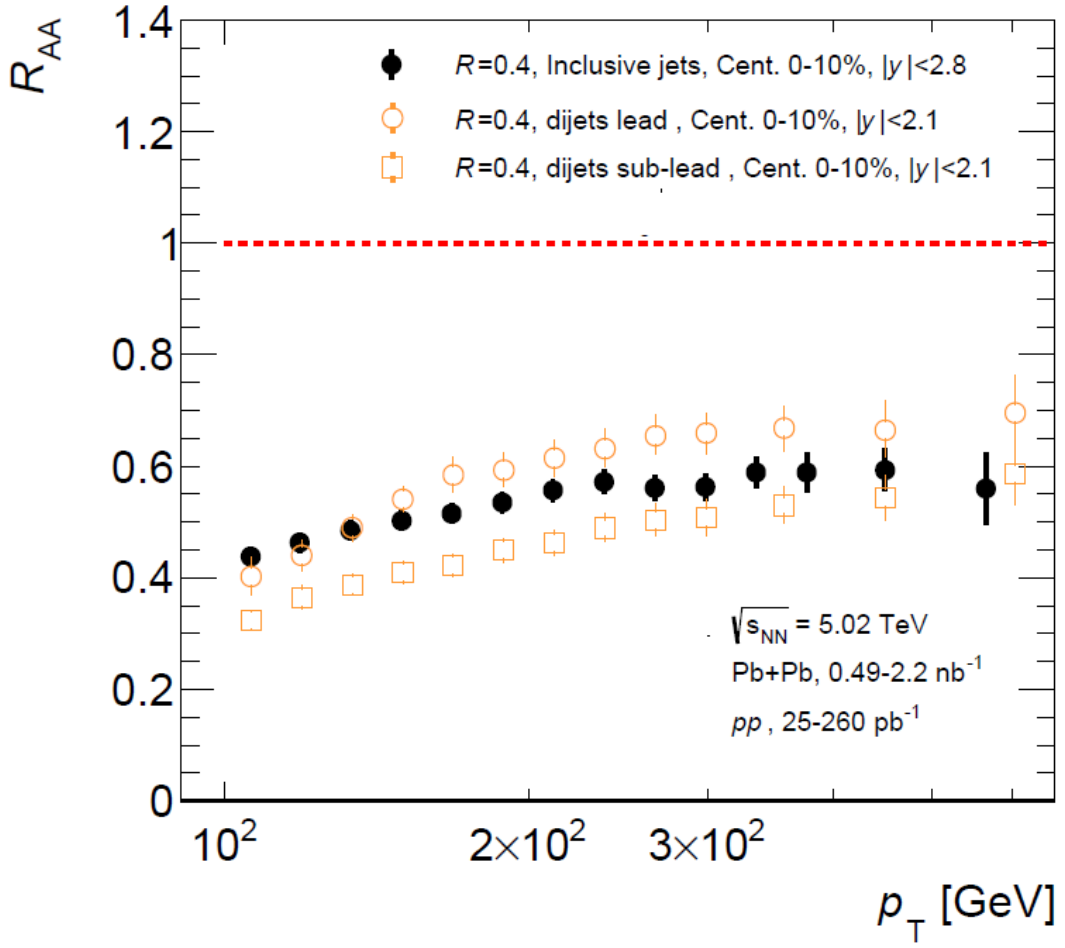
Far From an Inclusive List

Jet Quenching:

- sPHENIX will perform precise measurements of the R_{AA} of jets
- sPHENIX will provide key insight to jet quenching at low p_T^{Jet}



At the LHC

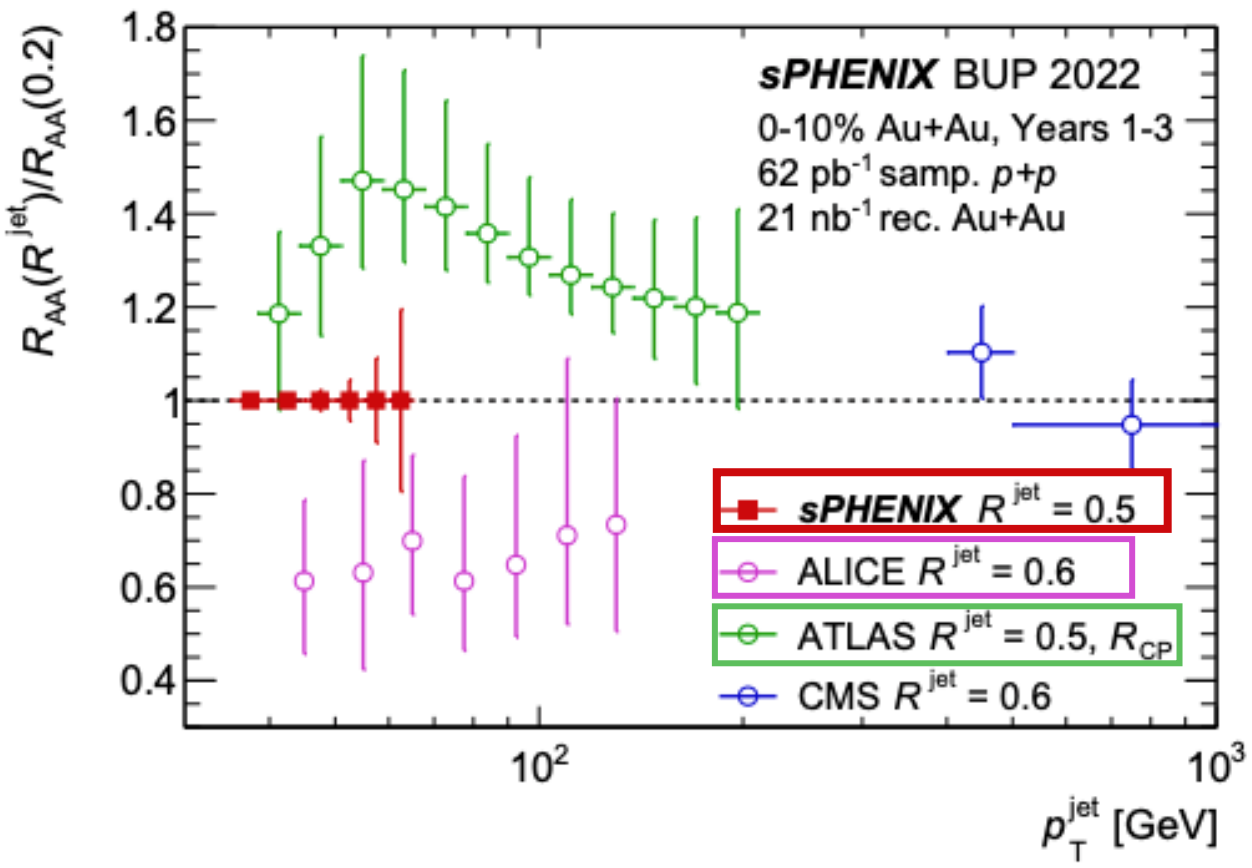


ATLAS: https://arxiv.org/pdf/1805.05635.pdf

ATLAS: arXiv:2205.00682

Jet Quenching: Radius dependence

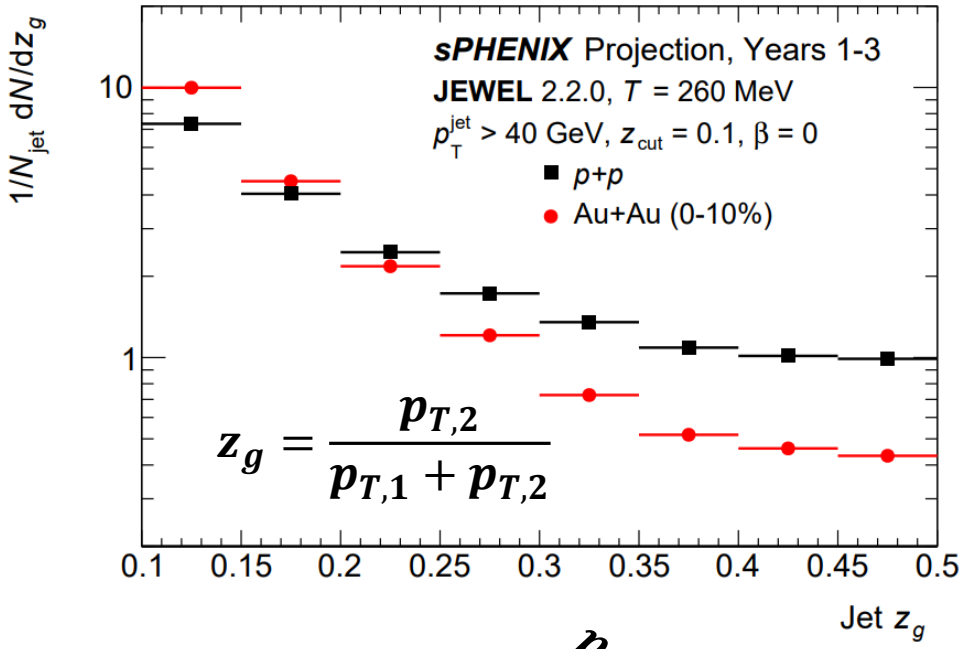
- Jet quenching vrs R probes balance of recovery of out of cone E-Loss and medium response, versus jet structure dependence
  - Larger R ⇒ recovery of E-Loss
  - Larger R ⇒ more medium response
  - Wider jet splitting angle ⇒ more suppressed
- Tension at the LHC for low p_T^{Jet}
- sPHENIX will be able to perform precise measurement in region of tension

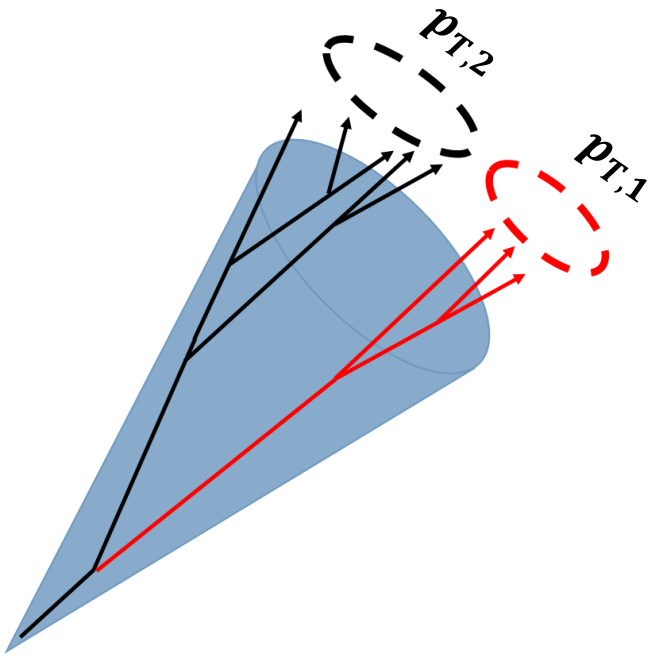


Jet Substructure

- Measurements of jet substructure provide access to the nature of interactions with the QGP
  - Does the medium resolve early parton shower?
  - How does jet quenching depend on the width of the jet?

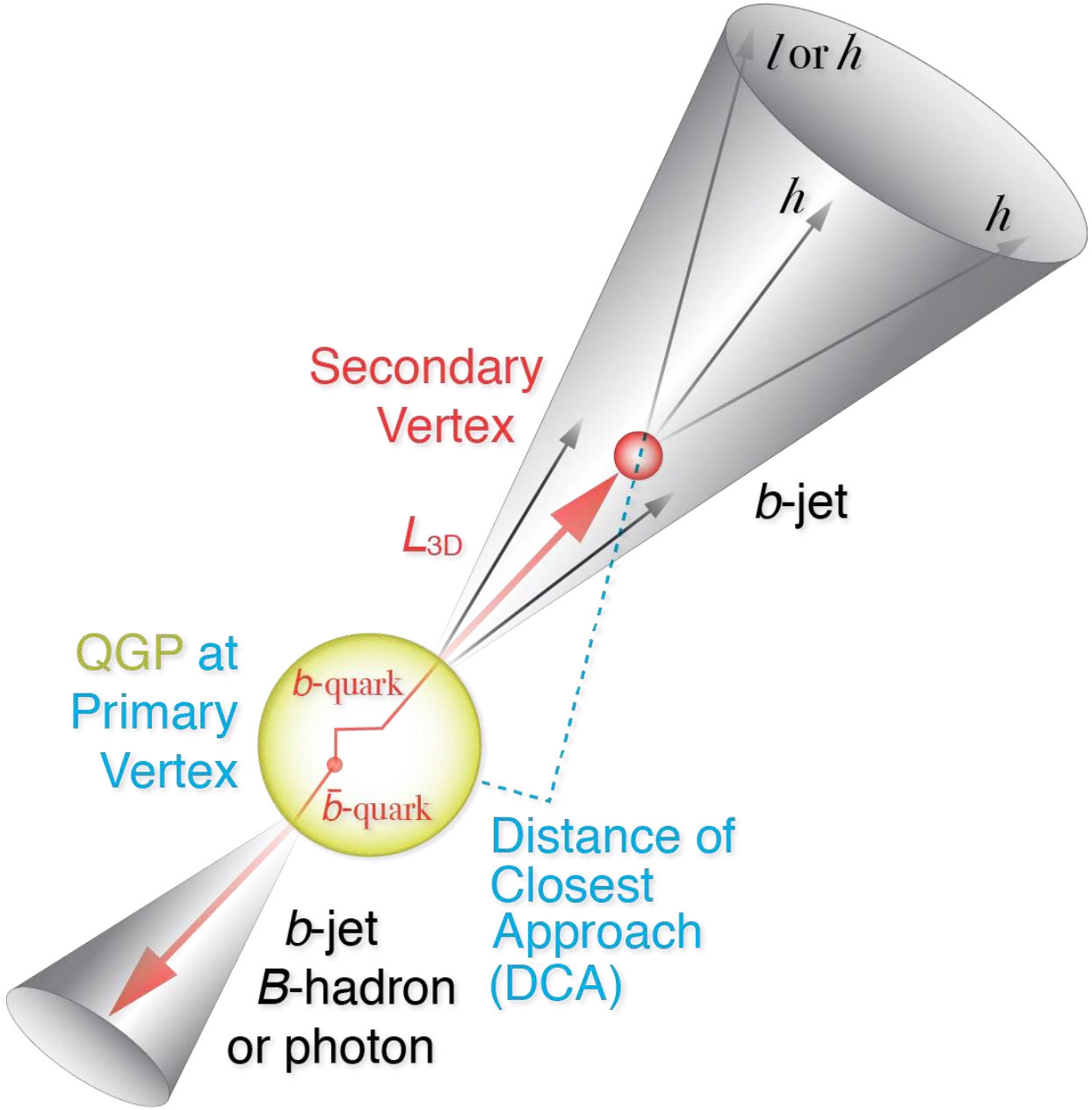
- sPHENIX will probe jet sub-structure
  - Groomed jet substructure with soft drop
  - Large R jet substructure with re-clustered small R jets
  - Studies of the energy deposition and correlations within and around jets using calorimeter clusters, TCCs, and particle flow objects



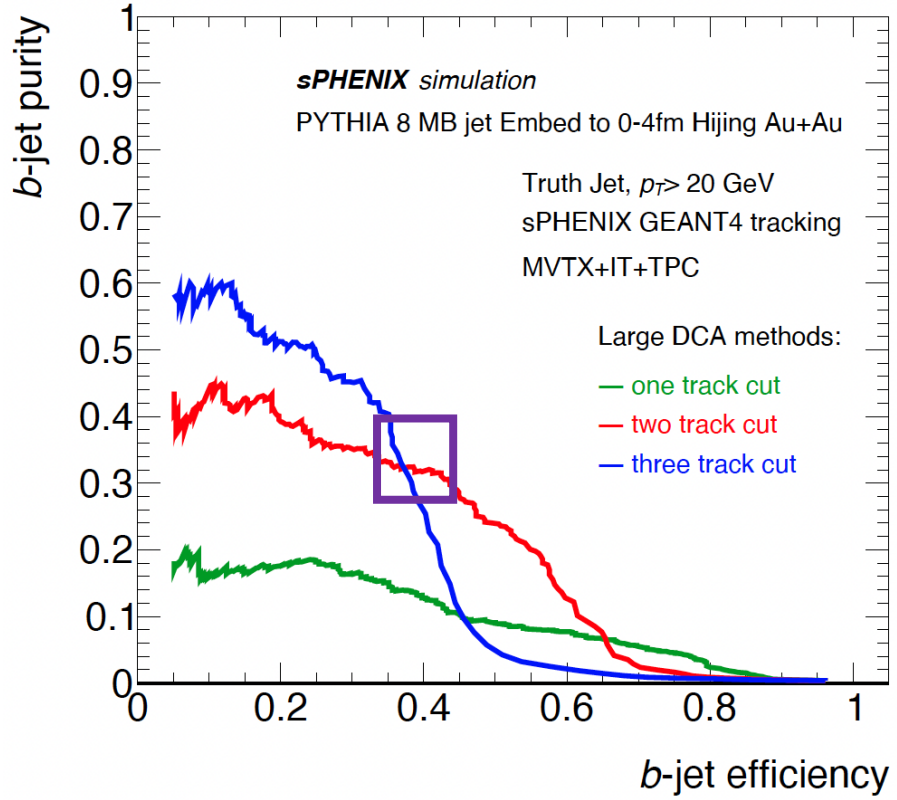


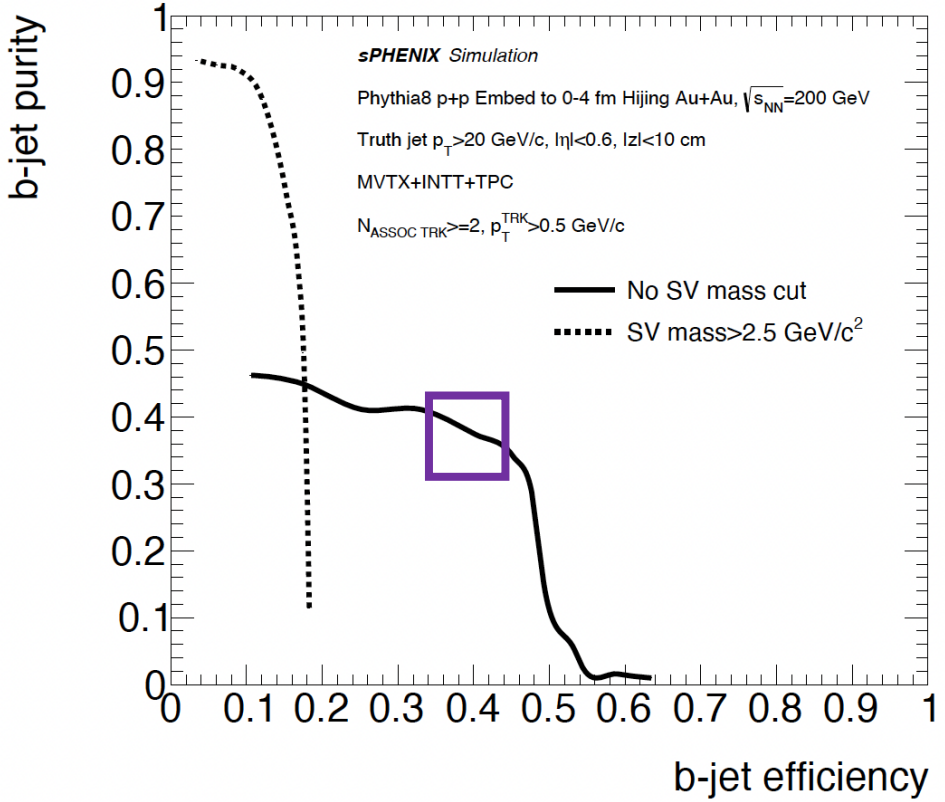
B-jet Tagging

- Heavy Flavor Tagged jets:
  - **Secondary Vertex Tagging**
    - Identify b-jets based on 3D flight distance of secondary vertex reconstructed within jet cone
  - **Large DCA Track Counting**
    - Tag b-jets through the number of tracks with large DCA



B-jet tagging in Au+Au

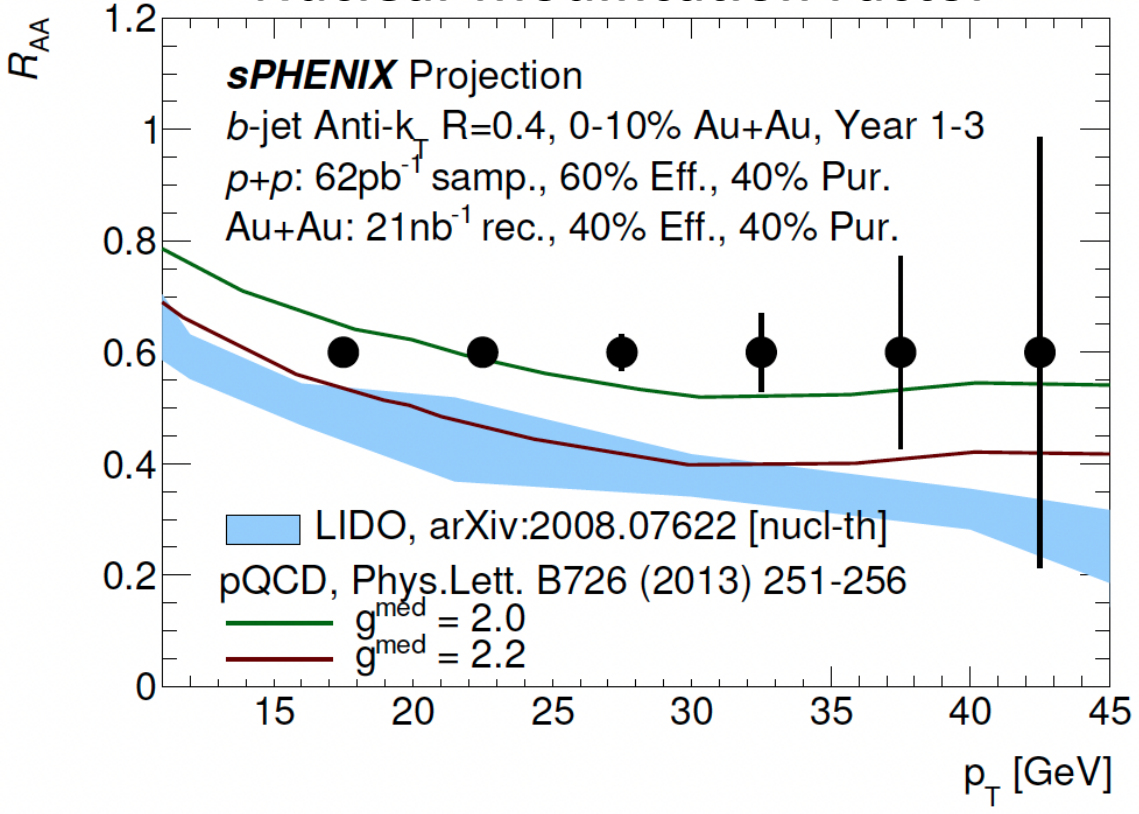




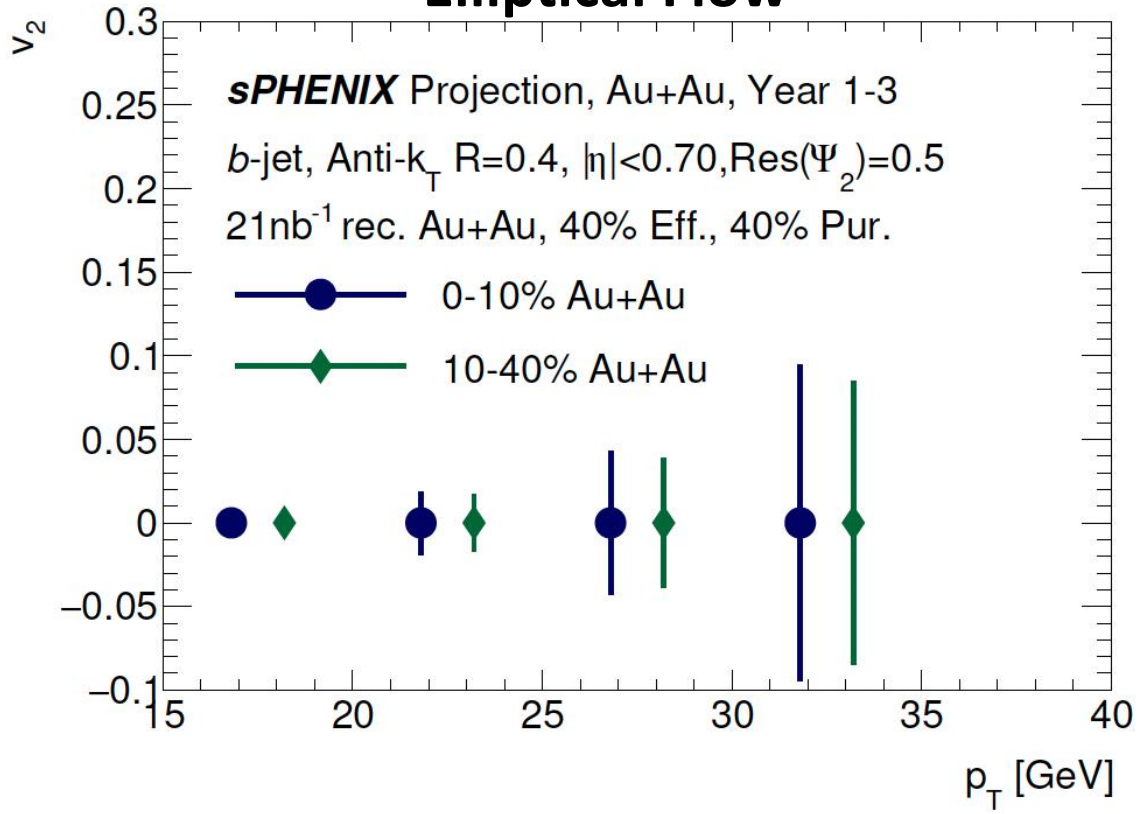
- Simulation study performed on inclusive jets in PYTHIA8 embedded into central HIJING events
- Both methods perform ~40% efficiency at ~40% purity
- Application of a SV mass cut can create a very high purity b-jet sample

Anticipated first b-jet measurements

Nuclear Modification Factor



Elliptical Flow



First measurements will provide important insight to the mass dependence of jet medium interactions at RHIC

Summary:

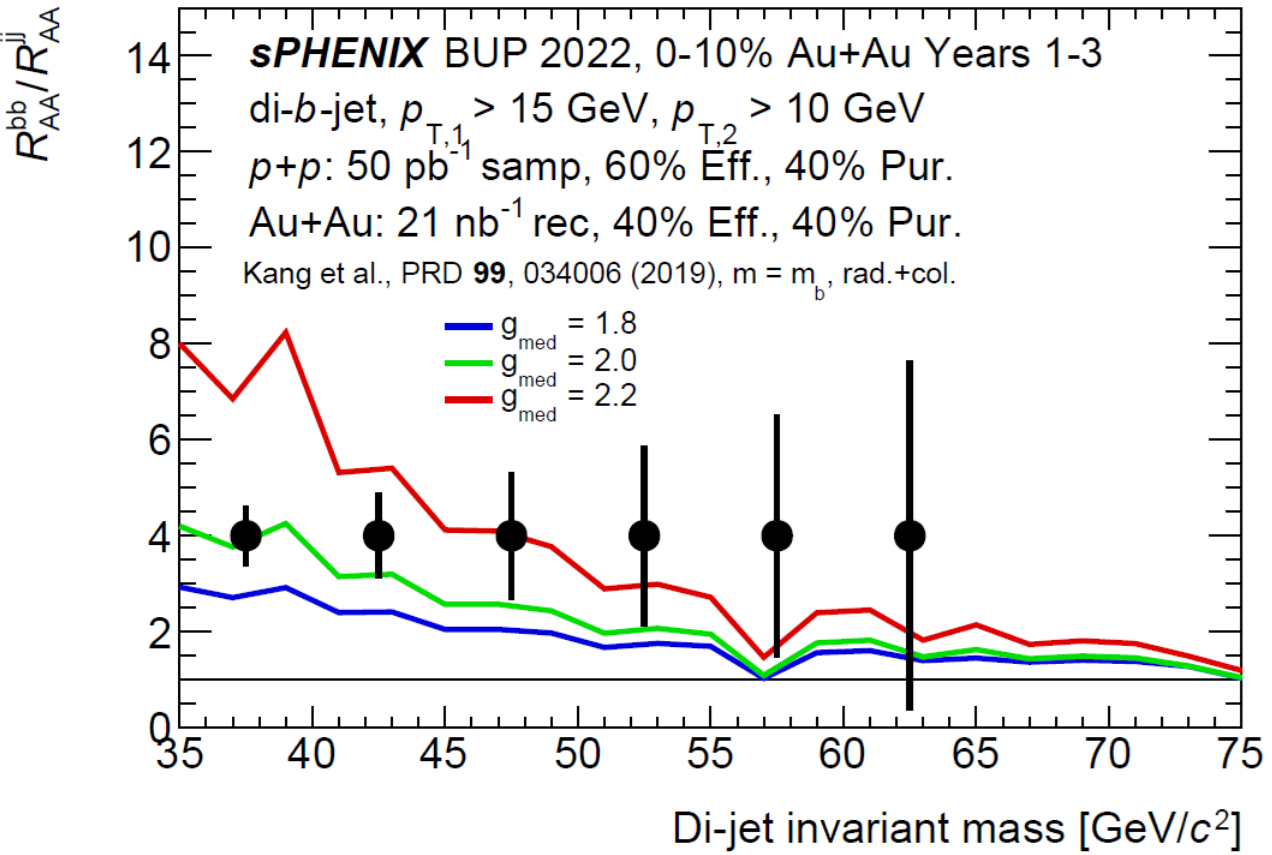
- sPHENIX is designed as a state of the art jet detector and will enable precise characterization of a magnitude of jet observables
  - Precise measurements of jets, jet correlations, and jet structure

- Will provide key insights into jet quenching effects at the *lower* QGP temperatures produced at RHIC
  - Complimentary to measurements at the LHC
  - Provide constraint to the temperature dependence to jet-medium coupling

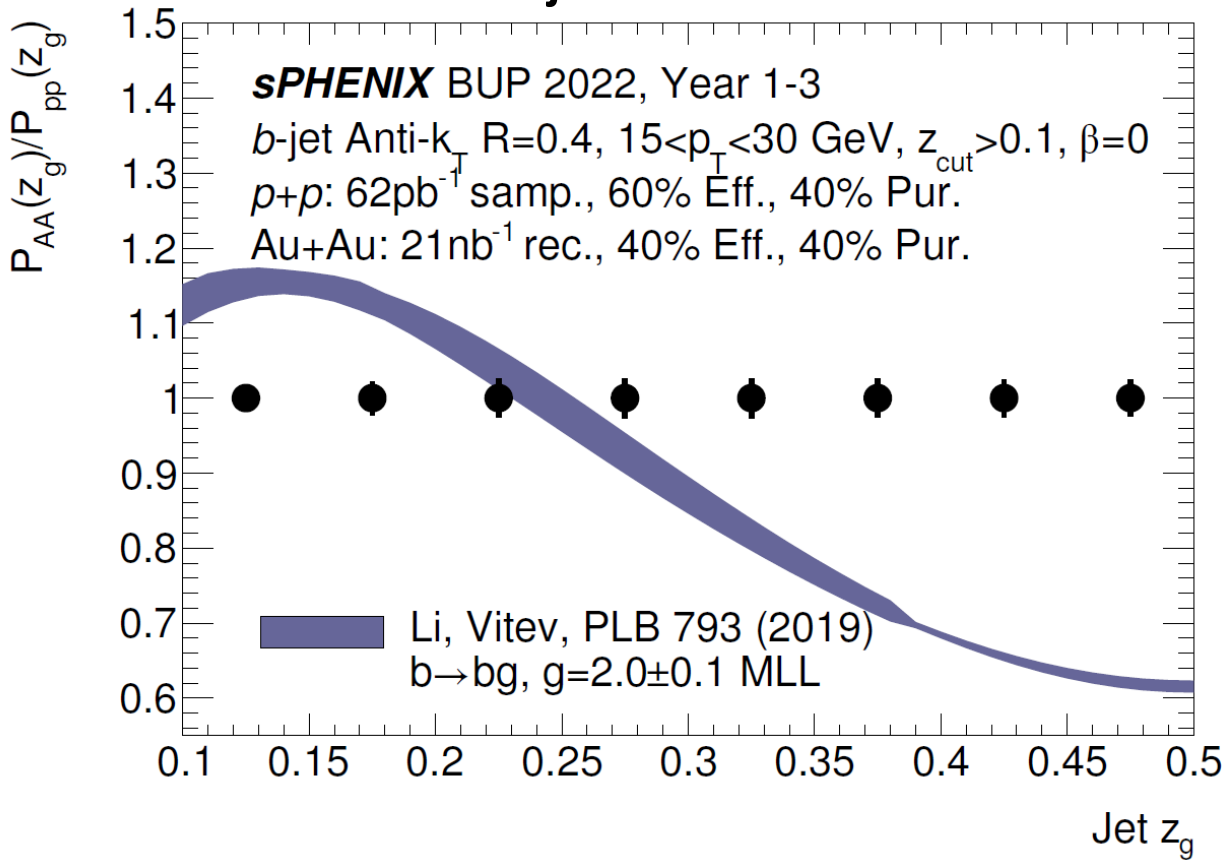
Backups

Differential studies of b-jets

Di-b-jet invariant mass



b-jet substructure



Large statistic samples will enable differential studies of b-jets

- Significant mass dependence in the sPHENIX kinematic region