Charged-particle jet spectra in event-shape engineered Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE

Caitie Beattie

on behalf of the ALICE Collaboration

Hard Probes

30.3.2023

Funded in part by:

Yale

U.S. DEPARTMENT OF ENERGY | Office of Science

Wright Laboratory

Jet energy loss

*Making several simplifying assumptions…

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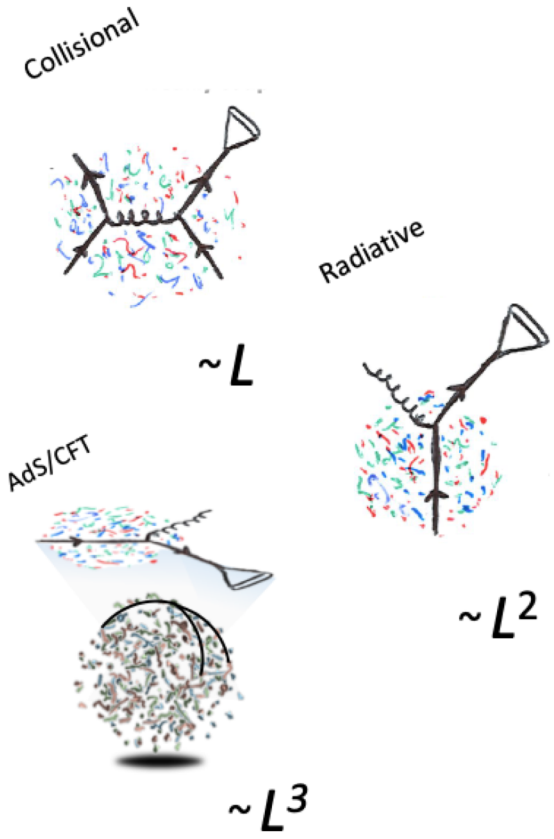
- Jets lose energy due to interactions with the QGP!
- Microscopic mechanism is well-studied theoretically.
- Theoretical relationship between mechanism and path-length dependence.

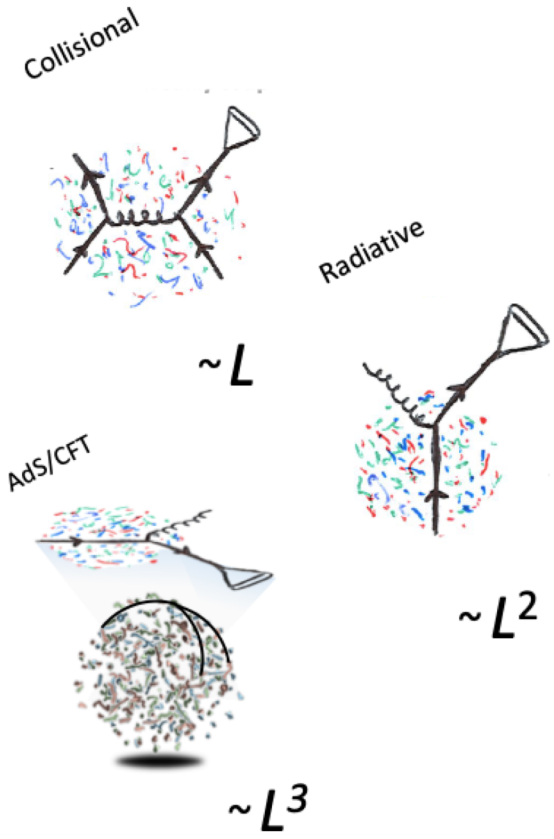


Jet energy loss

*Making several simplifying assumptions…

- Jets lose energy due to interactions with the QGP!
- Microscopic mechanism is well-studied theoretically.
- Theoretical relationship between mechanism and path-length dependence.

Strong motivation, but we need experimental constraints!



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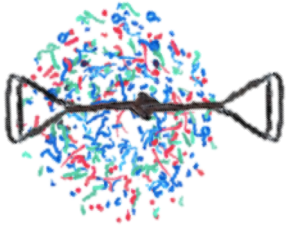
Traditional approaches

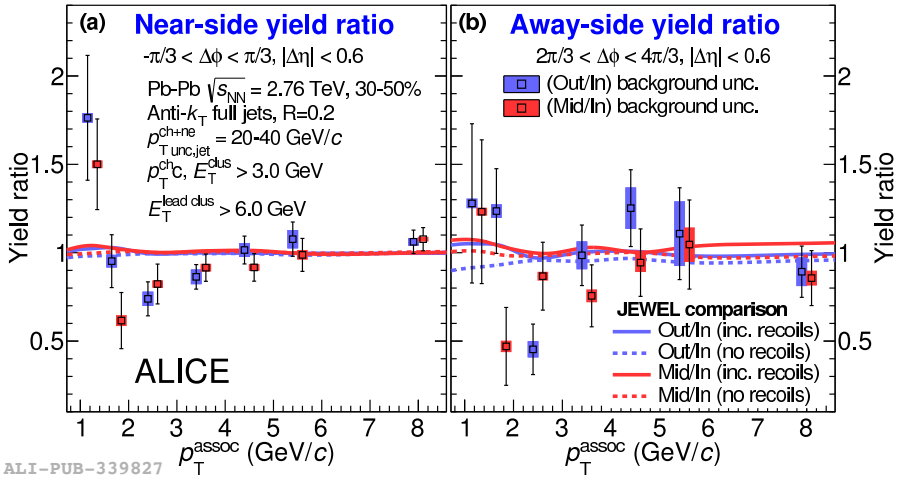
- Correlation studies



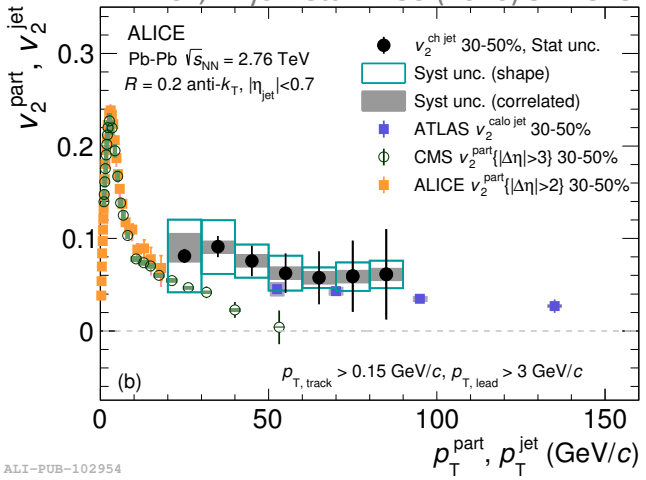
See talk by Yongzhen Hou
28.3.2023, 12:10

- Azimuthal studies

ALICE, Phys. Rev. C 101, 064901 (2020)



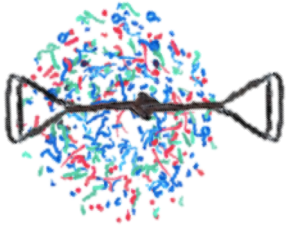
ALICE, Phys. Lett. B 753 (2016) 511-525



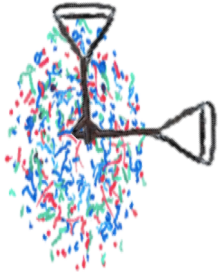
Traditional approaches

Interpretation of these observables is challenging.

- Correlation studies



- Azimuthal studies



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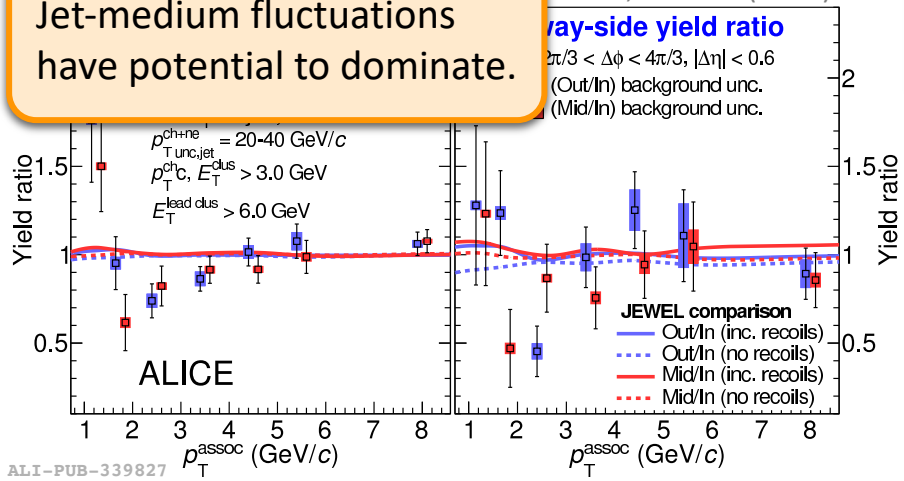
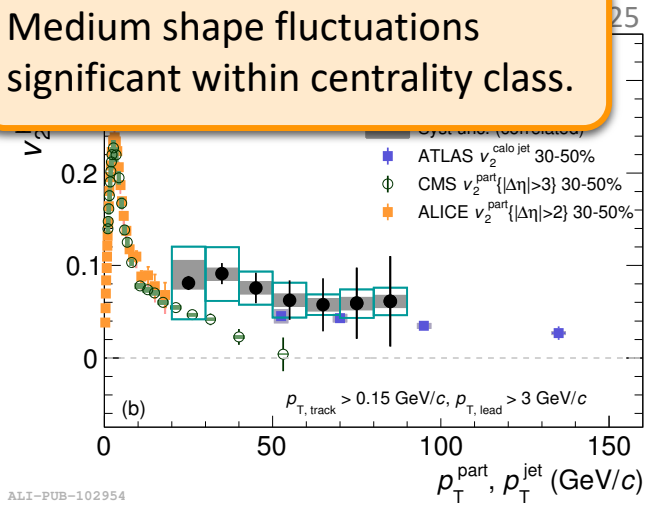
28.3.2023, 12:10

Jet-medium fluctuations have potential to dominate.

C 101, 064901 (2020)

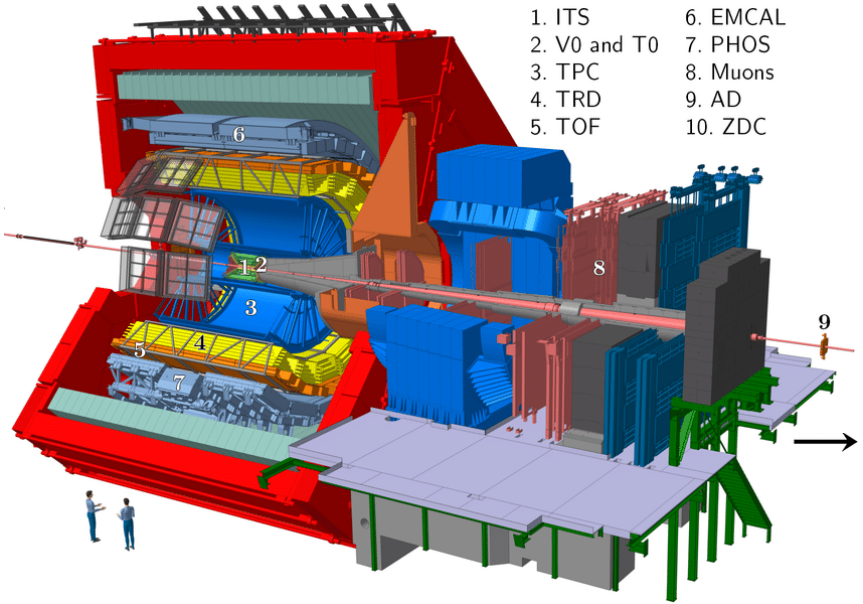


Medium shape fluctuations significant within centrality class.



ALICE

1. Time Projection Chamber
2. Inner Tracking System
   - Charged tracks
3. V0 Detectors
   - Centrality determination



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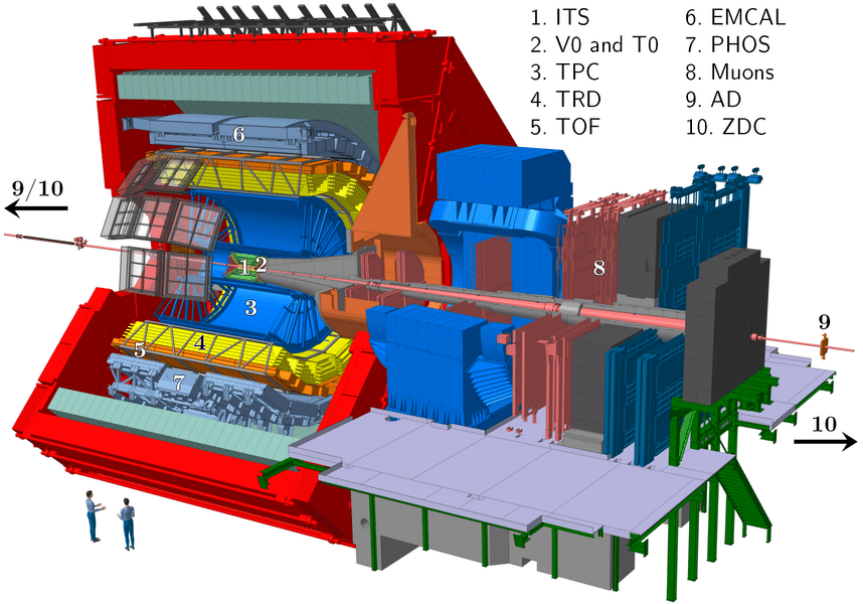
1. Time Projection Chamber
2. Inner Tracking System

   Charged tracks
3. V0 Detectors

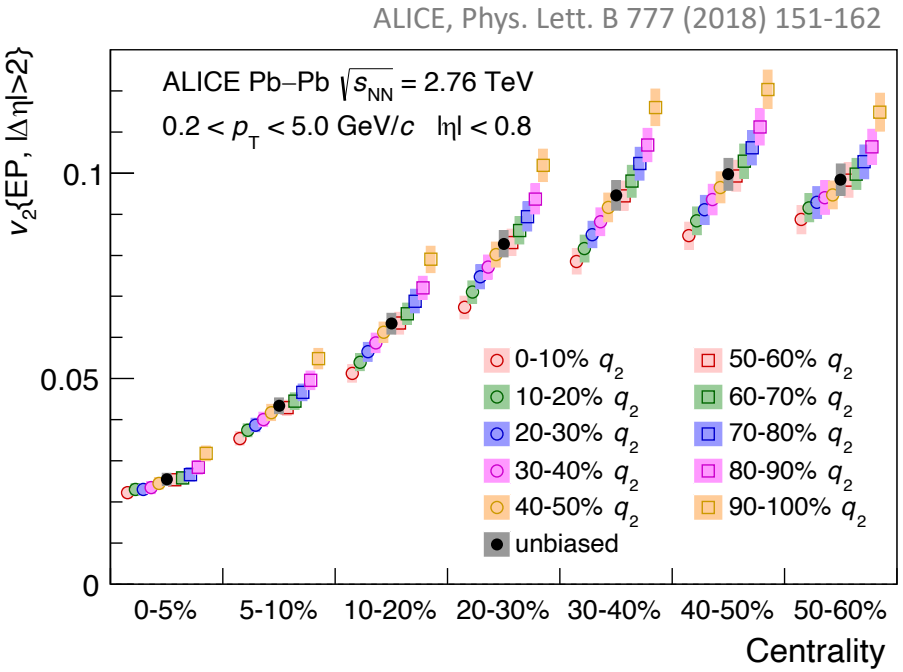
   Centrality determination



Event centrality is determined by **forward multiplicity**, not shape of overlap!

Event-shape engineering

There is a **wide distribution** of event shapes within a given **centrality class**.



$$\boldsymbol{Q}_2 = \left(\sum_{i=1}^{M} w_i \cos(2\varphi_i), \sum_{i=1}^{M} w_i \sin(2\varphi_i) \right)$$

φ_i = azimuthal angle

$$q_2 = \frac{|\boldsymbol{Q}_2|}{\sqrt{M}}$$

M = multiplicity

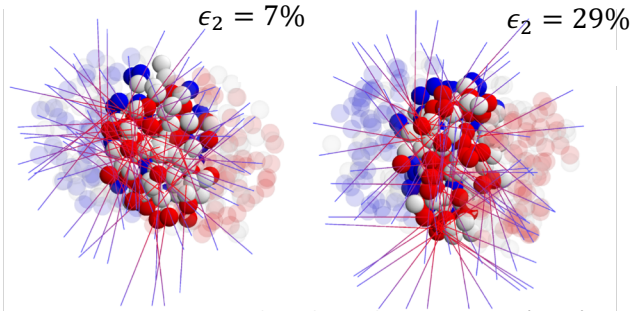


Figure: Beattie, Nijs, Sas, van der Schee, *Phys. Lett. B* 836 (2023) 137596

ESE and jets: the big picture

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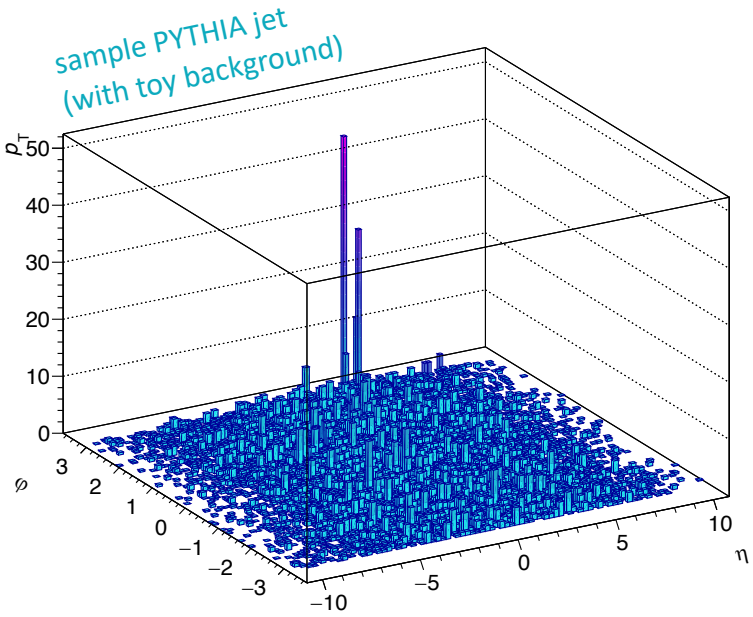
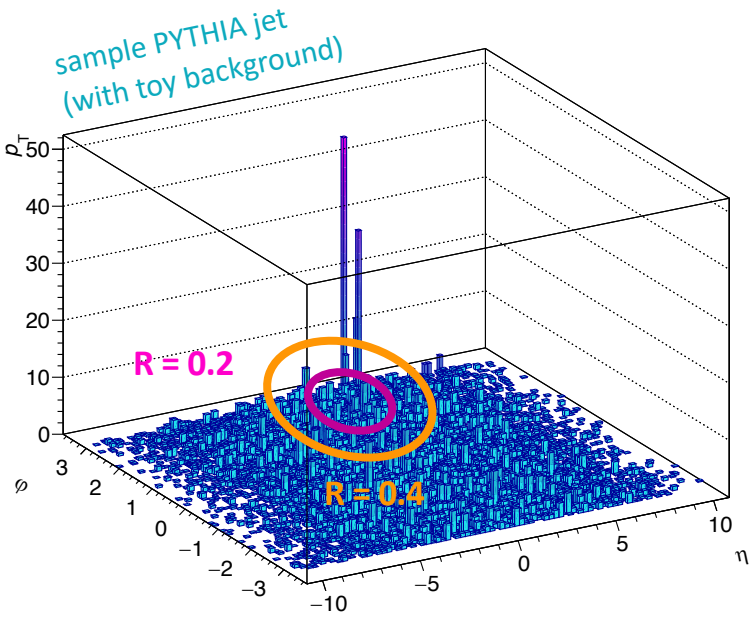
Can use **event-shape engineering (ESE)** as a dial with which to study **jet quenching** phenomena.



- Measure jets
- Combine with information from underlying event

Analysis technique

1. Jet finder
   - anti-k_T, R = 0.2, 0.4



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Analysis technique

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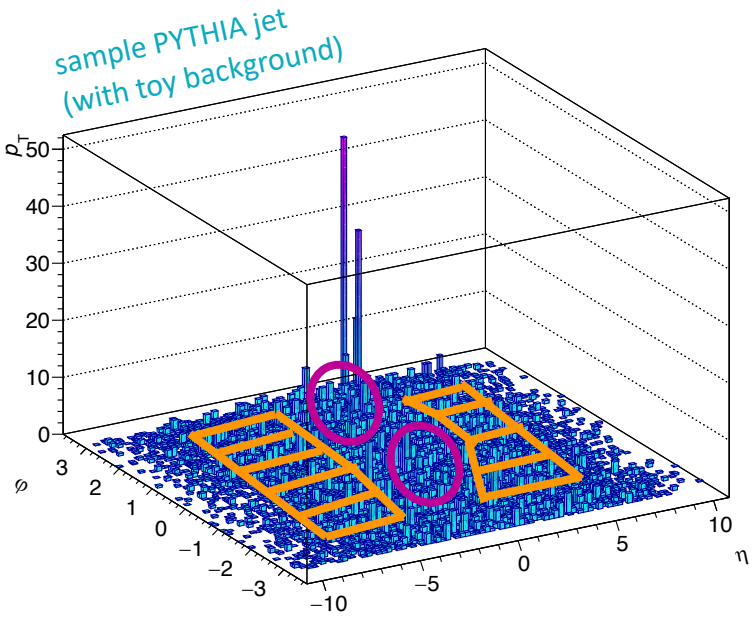
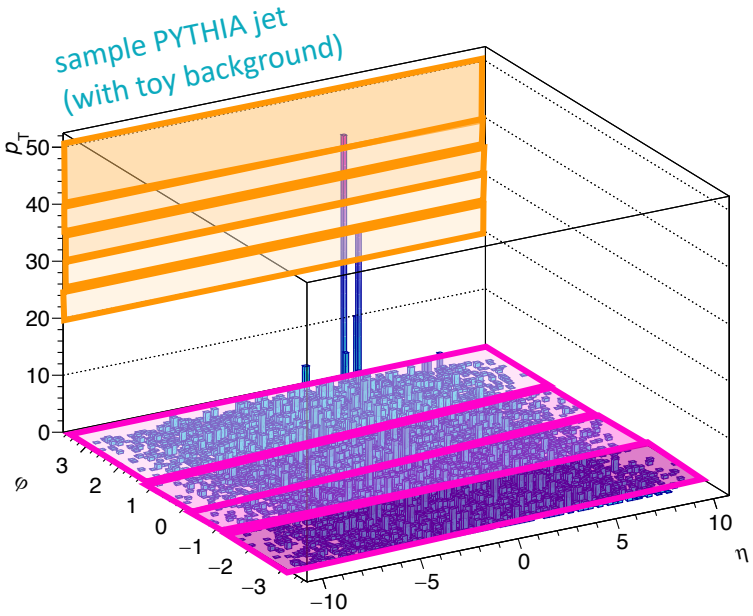
1. Jet finder
   - anti-k_T, R = 0.2, 0.4
2. Background subtraction
   - pedestal subtraction



$$p_{\mathrm{T}}^{\mathrm{jet}} = p_{\mathrm{T}}^{\mathrm{jet,\,rec}} - \rho A$$

Analysis technique

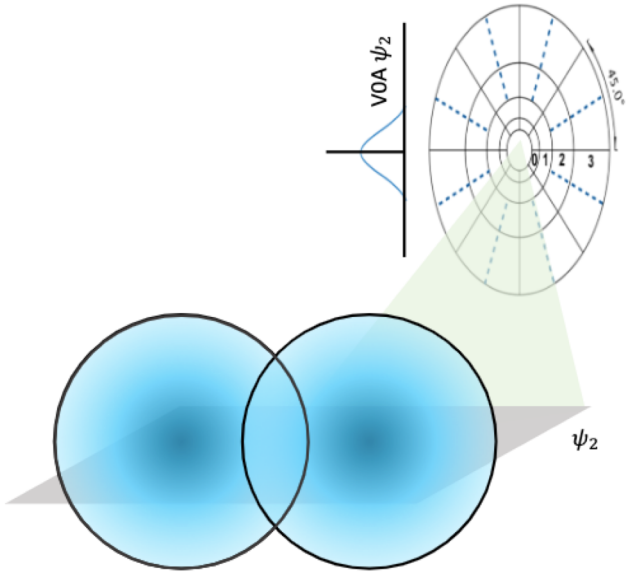
1. Jet finder
   - anti-k_T, R = 0.2, 0.4
2. Background subtraction
   - $p_{\mathrm{T}}^{\mathrm{jet}} = p_{\mathrm{T}}^{\mathrm{jet,\,rec}} - \rho A$
3. Unfolding + Efficiency Corrections
   - 2D Bayesian unfolding procedure
   - Reconstruction and kinematic efficiencies



Axes of unfolding:
- Jet p_T
- Event-plane angle, $\varphi - \psi_2$

Analysis technique

1. Jet finder
   - anti-k_T, R = 0.2, 0.4
2. Background subtraction
   - $p_T^{jet} = p_T^{jet,\,rec} - \rho A$
3. Unfolding + Efficiency Corrections
   - 2D Bayesian unfolding procedure
   - Reconstruction and kinematic efficiencies
4. Resolution Correction
   - Three−sub−event technique



Event-shape engineering in data

Event-Shape Engineering (ESE) classifies events according to their anisotropy **within a centrality class**.

$$\boldsymbol{Q}_2 = \left(\sum_{i=1}^{M} w_i \cos(2\varphi_i), \sum_{i=1}^{M} w_i \sin(2\varphi_i) \right)$$

φ_i = azimuthal angle

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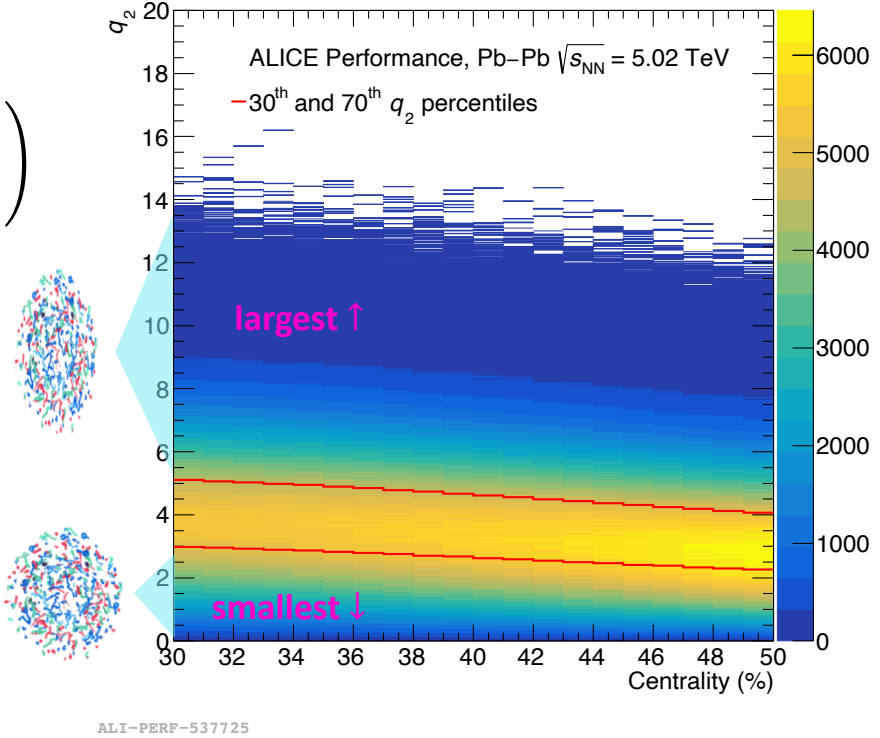
M = multiplicity



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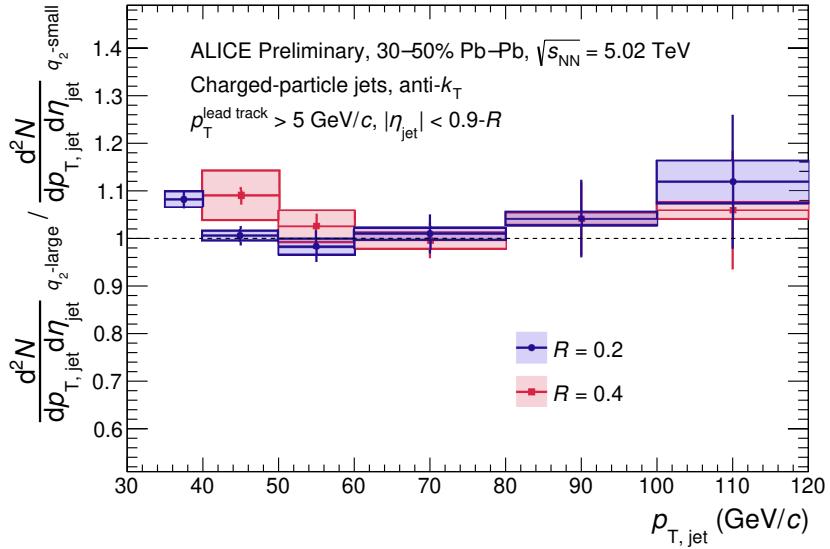
Event-shape engineering and jets in data

No sensitivity of jet spectra to shape of underlying event.



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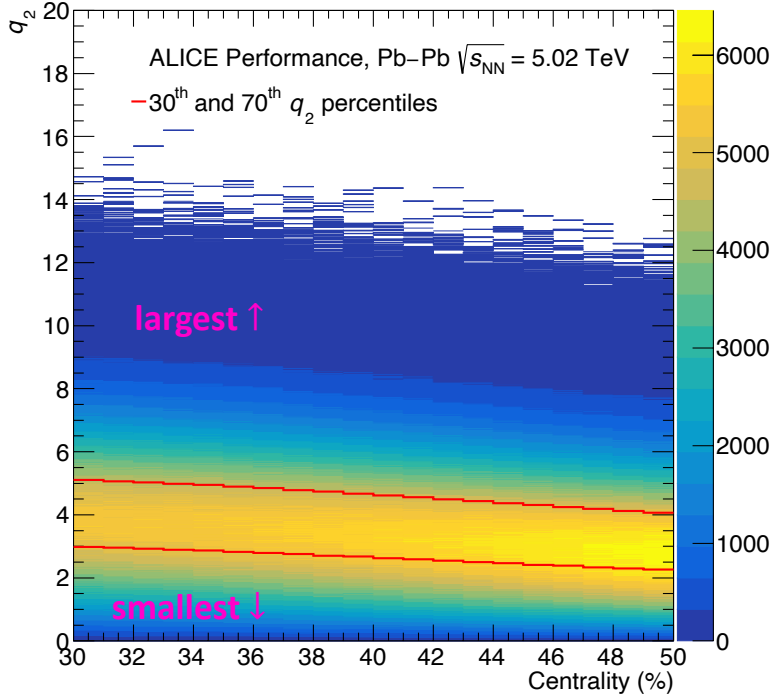

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Event shape and pathlengths

Pathlength differences not predicted in theory when considering event shapes alone.

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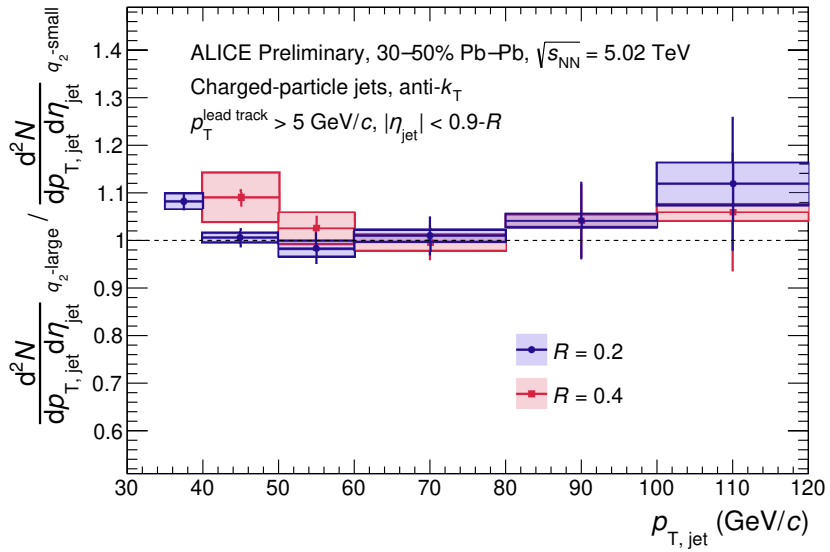

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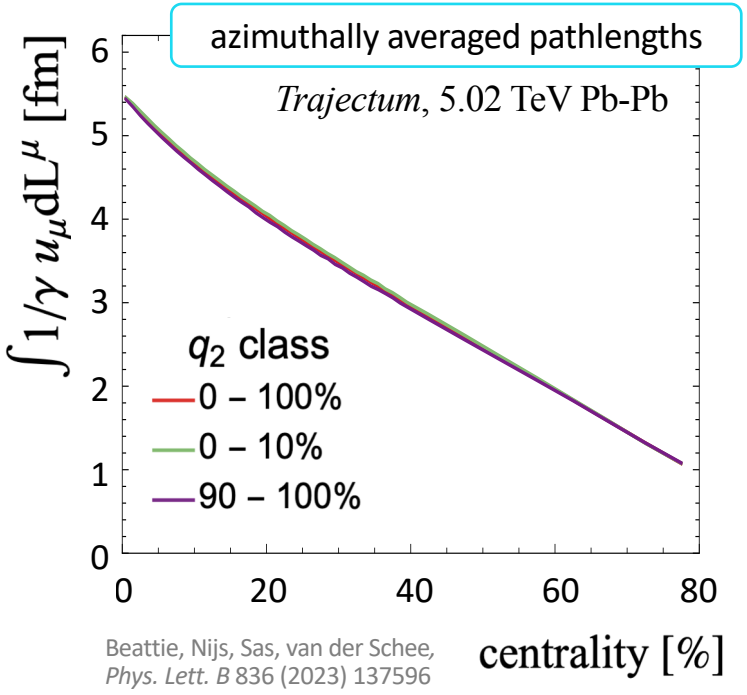
azimuthally averaged pathlengths



Beattie, Nijs, Sas, van der Schee, *Phys. Lett. B* 836 (2023) 137596

Event-plane angles and ESE

Need to reconsider event-plane angles, as in the v_2.

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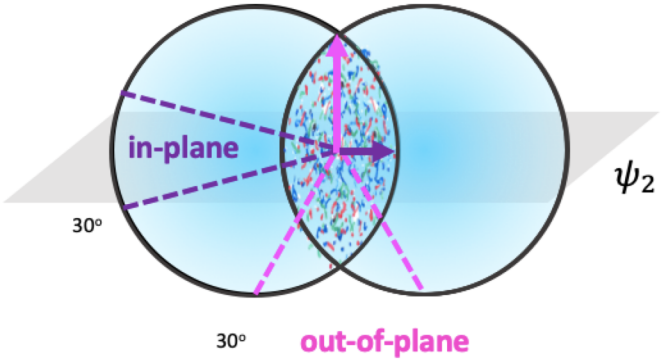
It is expected that the **in-plane** axis will be shorter than the **out-of-plane** axis.



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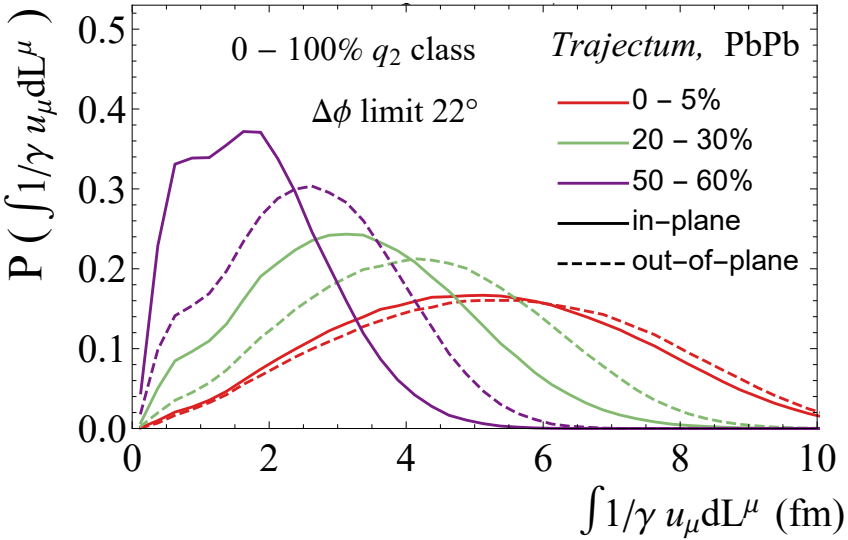

Event-plane angles and ESE

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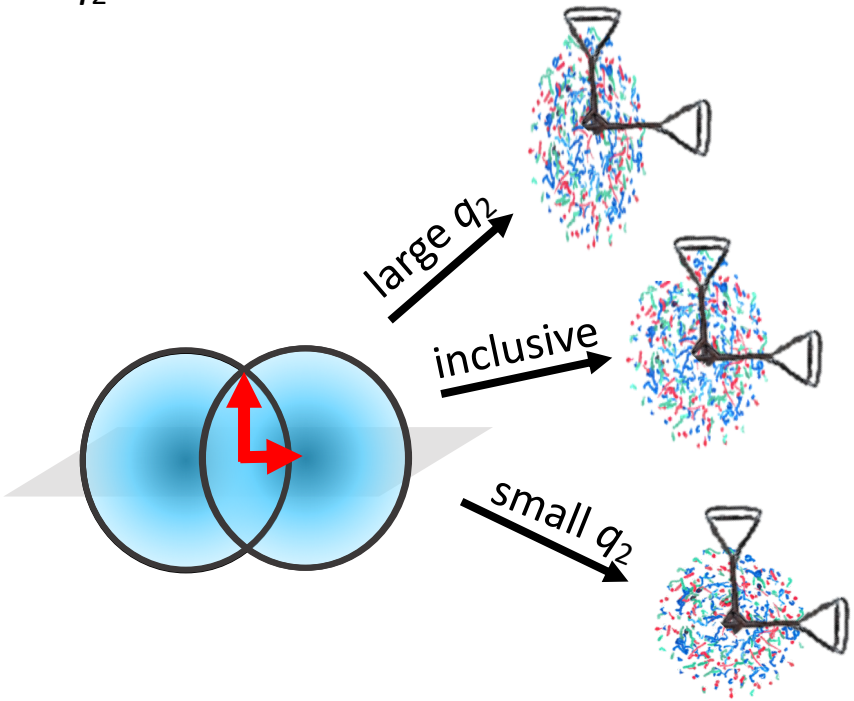
Greater in- vs. out-of-plane differences are predicted for q_2–large events than for q_2–small events.



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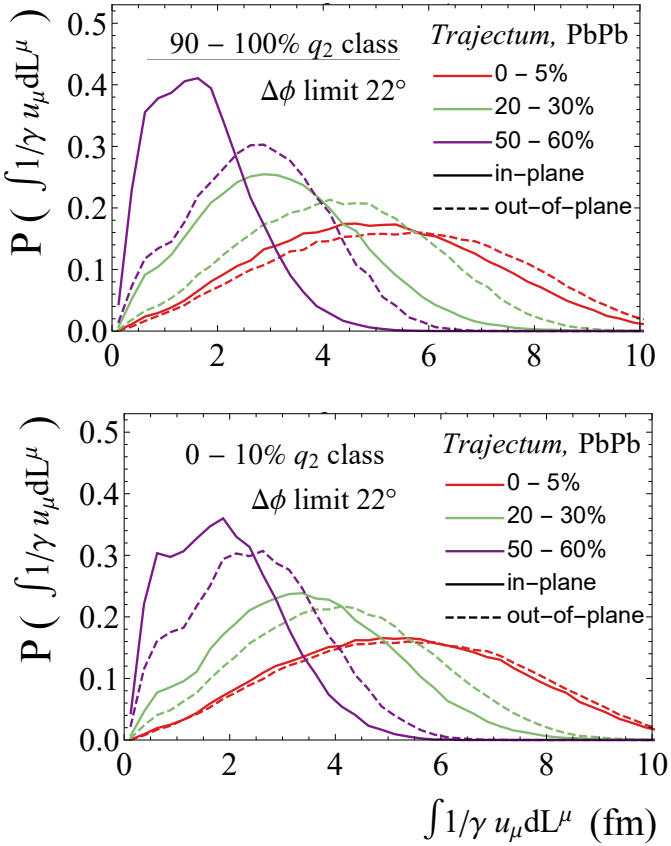

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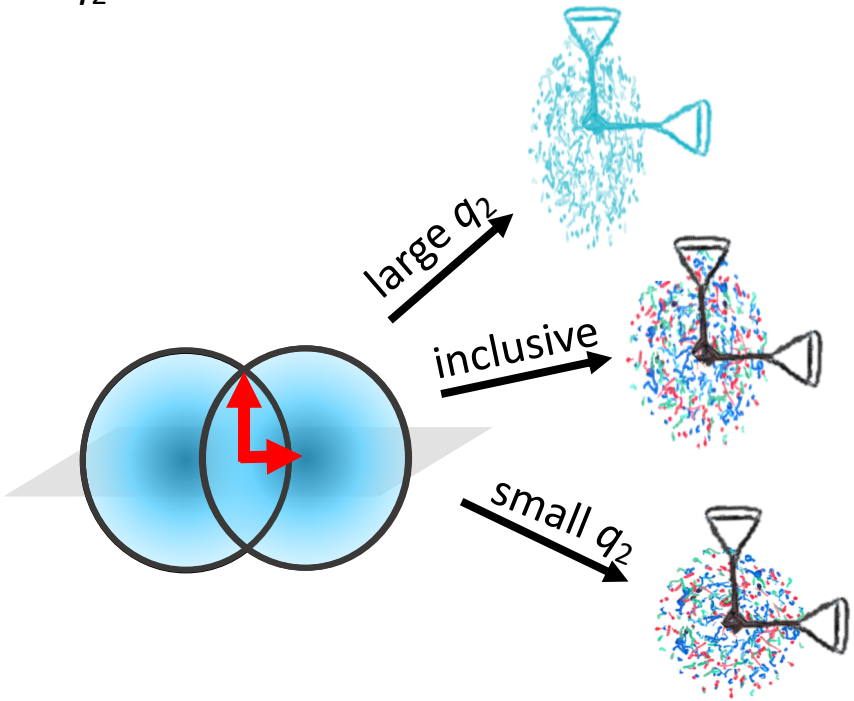

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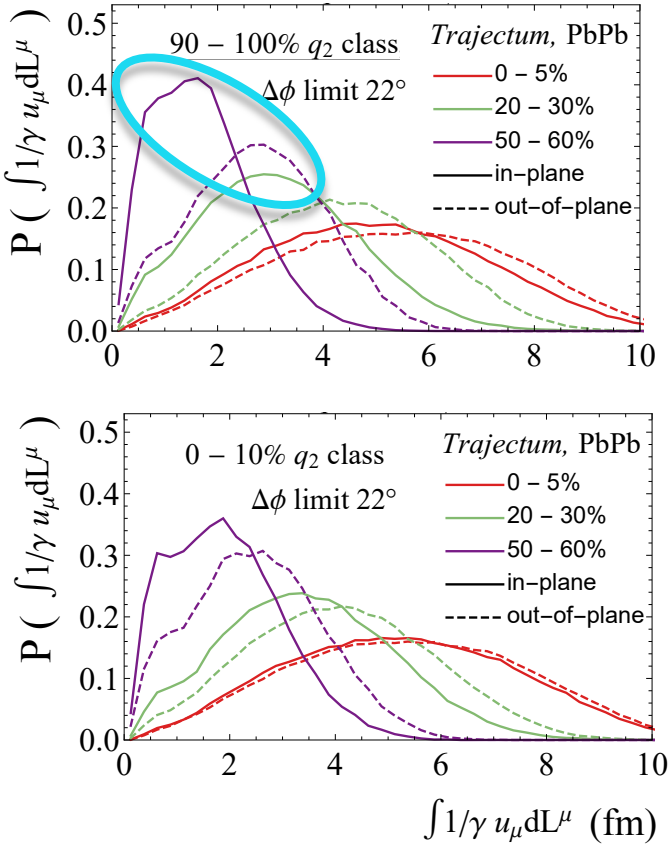

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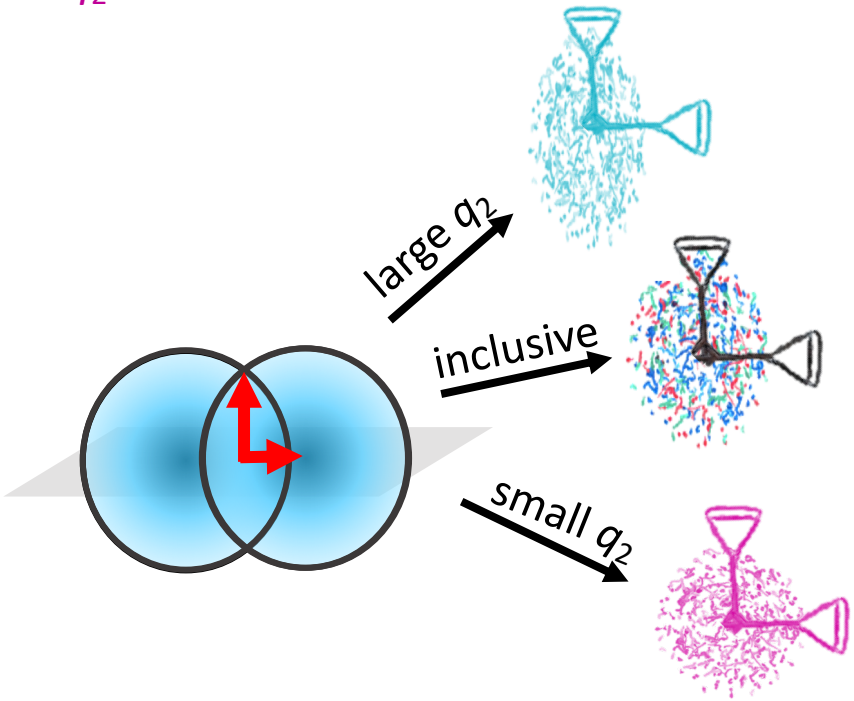
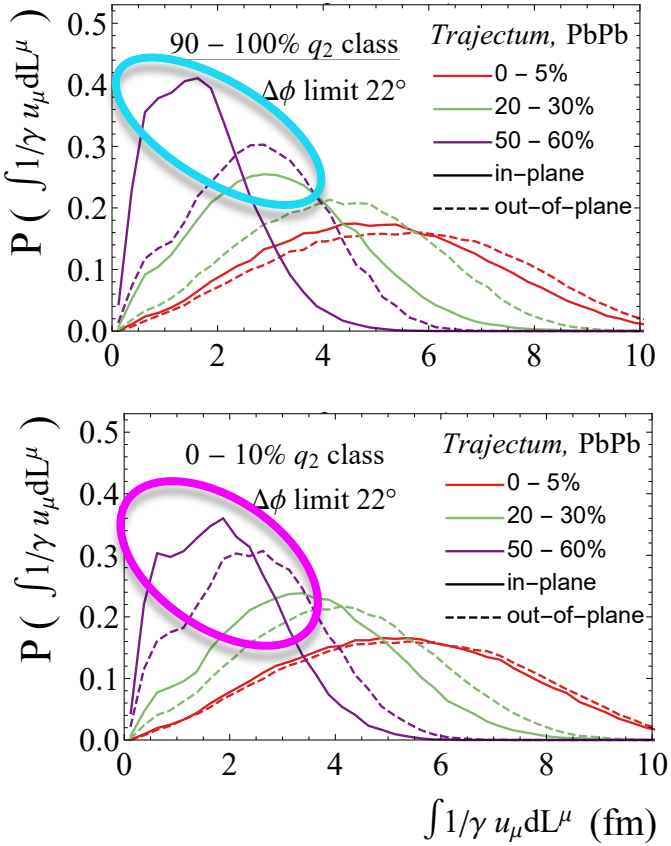


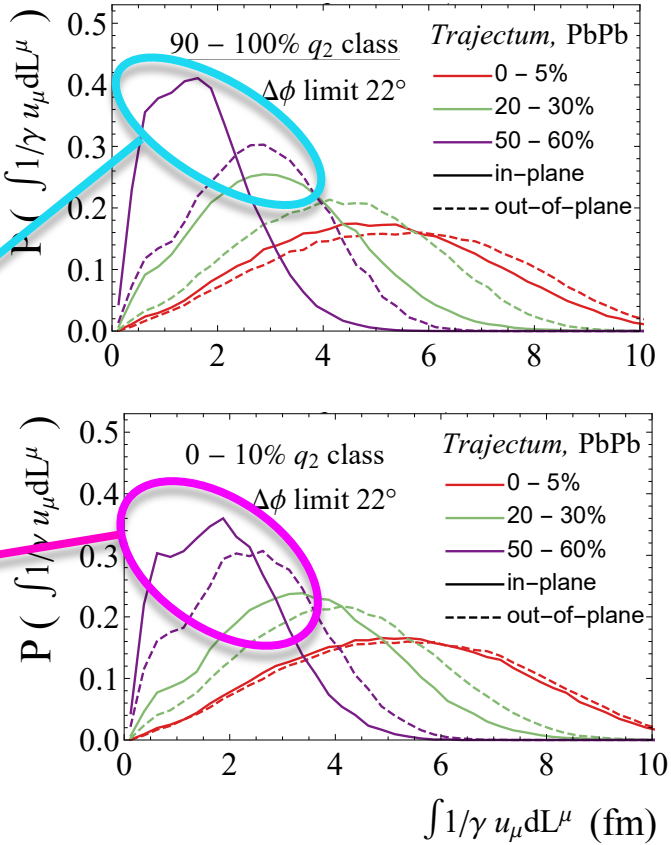
Beattie, Nijs, Sas, van der Schee, *Phys. Lett. B* 836 (2023) 137596



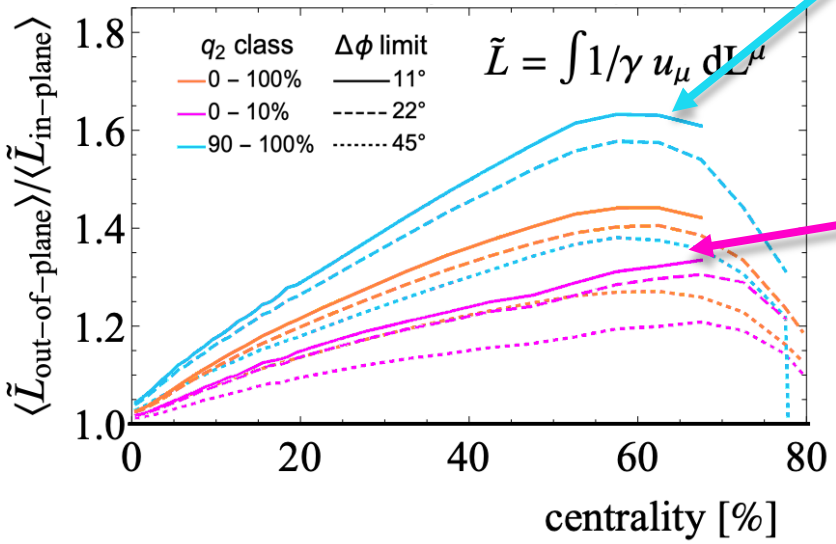
Event-plane angles and ESE

Greater **in- vs. out-of-plane differences** are predicted for large q_2 events than for small q_2 events.

Beattie, et. al., *Phys. Lett. B* 836 (2023) 137596



Beattie, Nijs, Sas, van der Schee, *Phys. Lett. B* 836 (2023) 137596



Event-plane angles and ESE

Greater **in- vs. out-of-plane differences** are predicted for large q_2 events than for small q_2 events.

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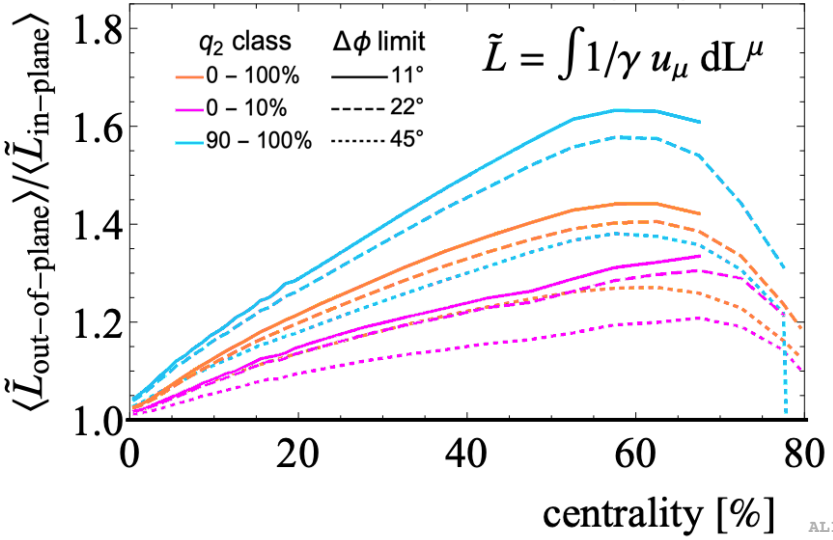

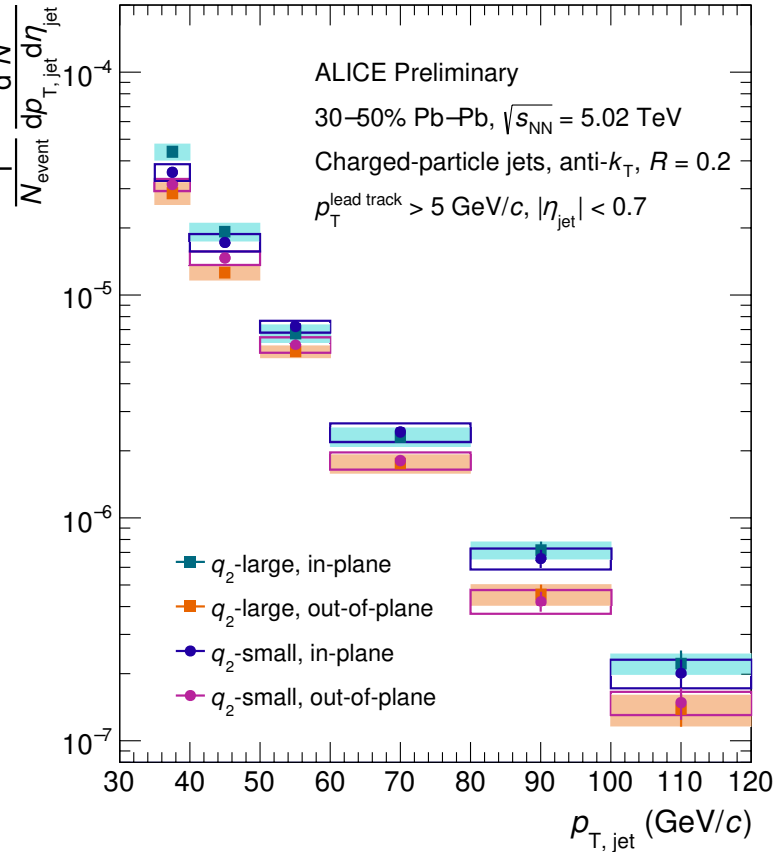

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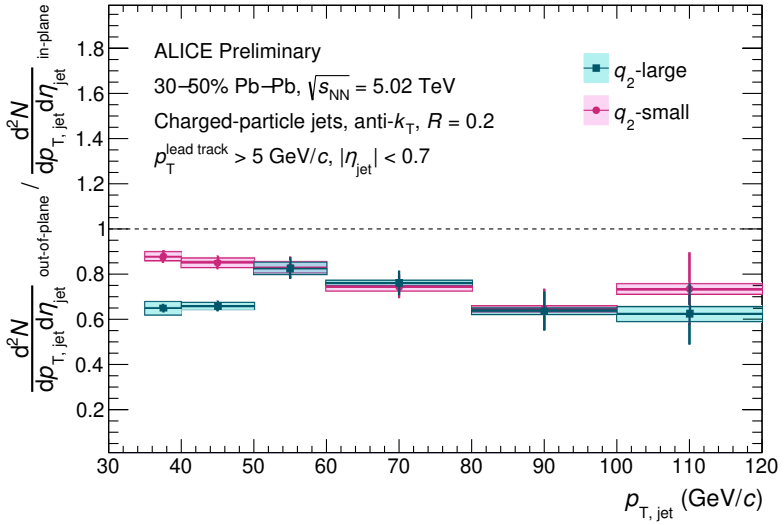
Event-plane angles and ESE

A **clear separation** is observed below $p_T < 50$ GeV/c.



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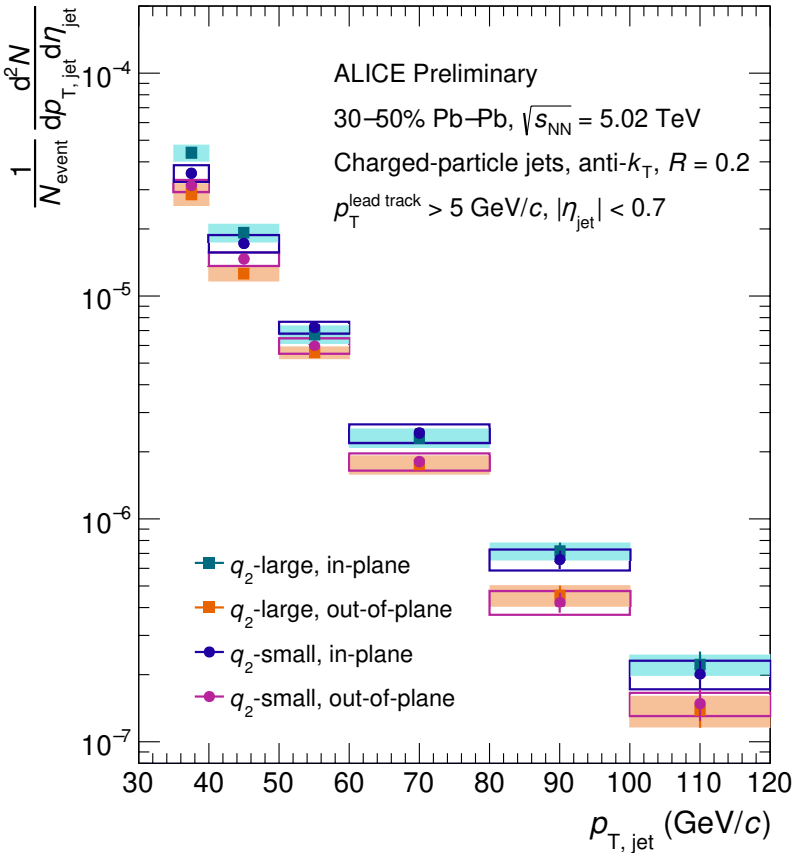

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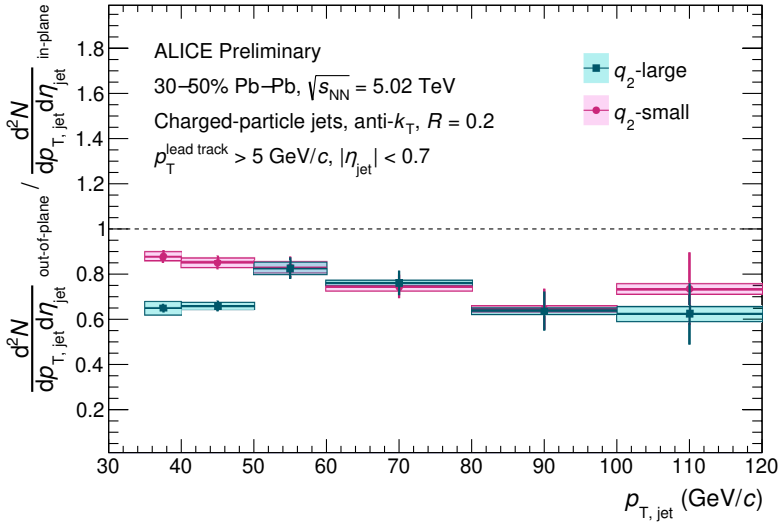
Event-plane angles and ESE

- Measurement was repeated with $R = 0.4$.
- Dominated by **systematics** in low p_T region.

See talk by Christos Pliatskas
28.3.2023, 9:00



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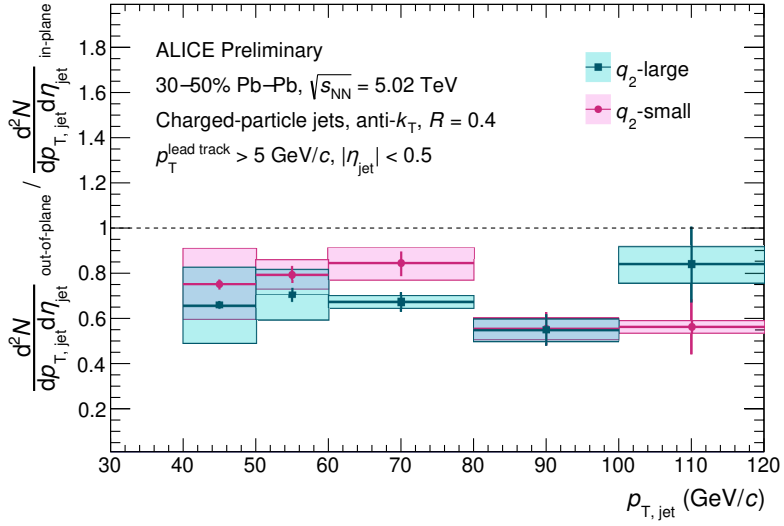

ALI-PREL-537722

Conclusions

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- **Experimental** measurements required to constrain pathlength dependence of jet quenching.
- **ESE**, in combination with **event-plane angle** information, offers a promising avenue.
- Preliminary results consistent with expected **path-length dependent suppression** in low to mid p_T.

Higher statistics in Run 3 will allow for **better precision** and a **more differential** measurement – stay tuned!