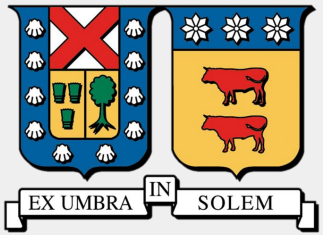
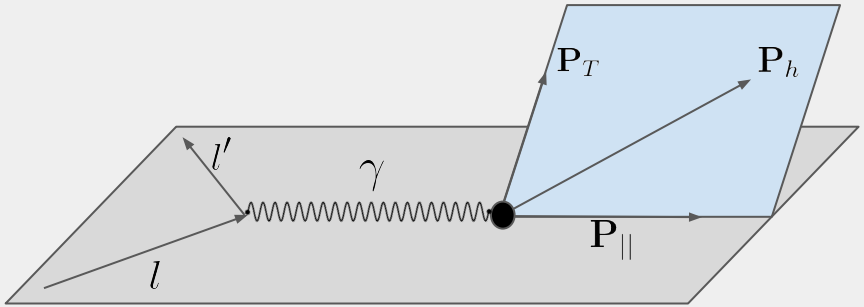
Transverse Momentum Broadening in Nuclear Media at Jefferson Lab's CLAS

Esteban Molina C.



Semi-Inclusive Deep Inelastic Scattering (SIDIS)



$$e(l)+N(p_N) \rightarrow e'(l')+h(p_h)+X(p_X)$$

Kinematical variables:

$$Q^2 = (l - l')^2$$
$$\nu = (E - E')$$
$$z_h = \frac{p_N \cdot p_h}{p_N \cdot q} = \frac{E_h}{\nu}$$
$$P_T^2 = P_h^2 - P_{||}^2$$
$$\phi_h = \text{angle(leptonic plane, hadronic plane)}$$

Additionally, we used:

$$x_f = \left(\frac{\mathbf{P}_{||}}{\mathbf{P}_{||_{max}}}\right)_{CM}$$

$$A^{1/3} = (\text{Mass Number})^{1/3}$$

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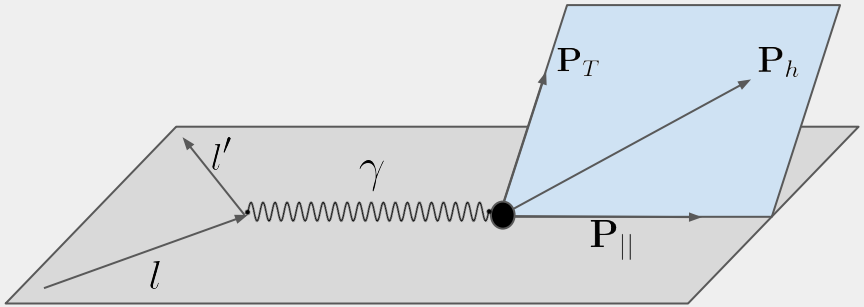

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Additionally, we used:

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⟹ Positive values to select current fragmentation region events.

$$A^{1/3} = (\text{Mass Number})^{1/3}$$

Transverse Momentum Broadening

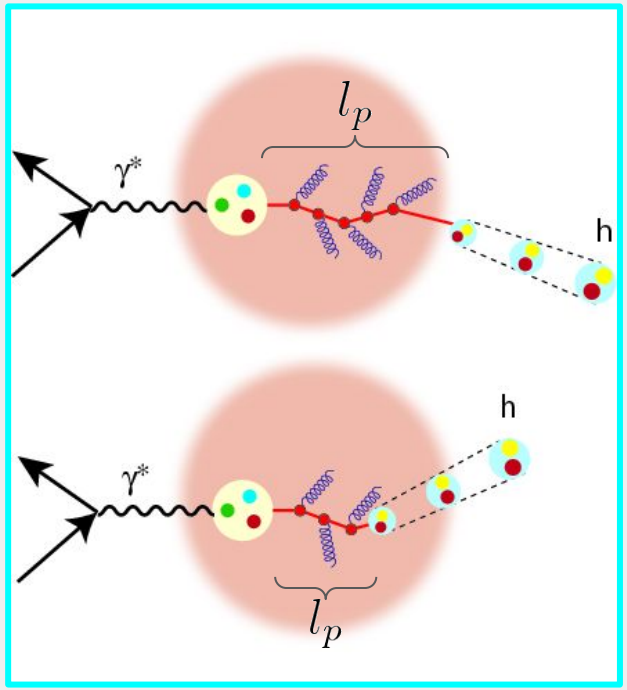


Diagram of hadronization in nuclear medium **[1]**.

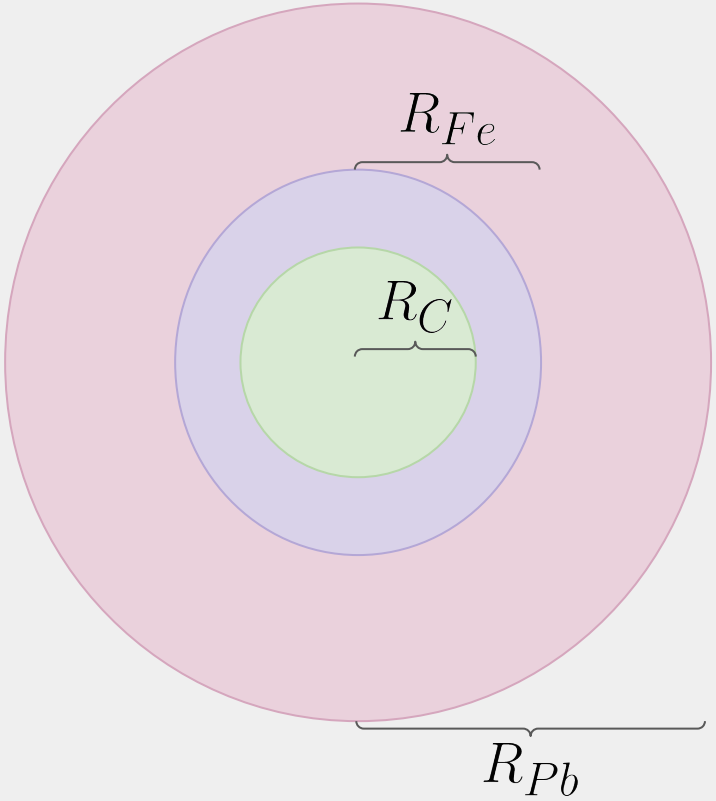
$$\Delta P_T^2 = \langle P_T^2 \rangle_A - \langle P_T^2 \rangle_D$$

$$\Delta P_T^2 \propto l_p \quad [2]$$

Broadening shows how **much/long** the deconfined quark traveled!

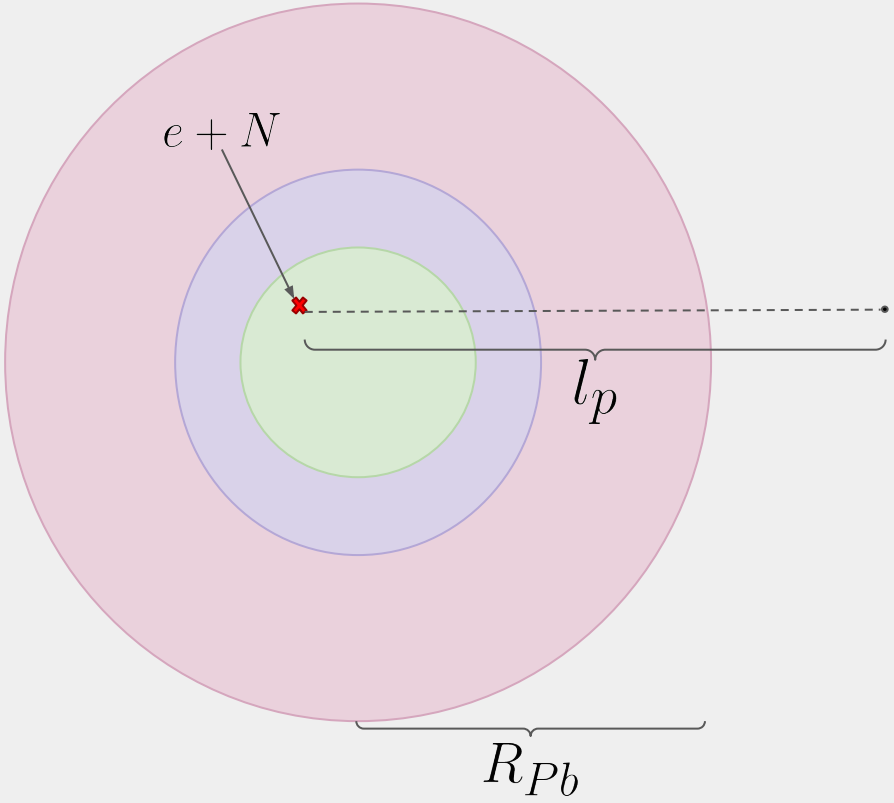
[1] **Guiot, B.; Kopeliovich, B.** (2020). *Spacetime Development of in-medium hadronization : Scenario for Leading Hadrons.*
[2] **Baier, B.; Dokshitzer, Y.; Mueller, A.; Peigné, S.; Schiff, D.** (1997). *Radiative energy loss and pt-broadening of high energy partons in nuclei.*

Transverse Momentum Broadening



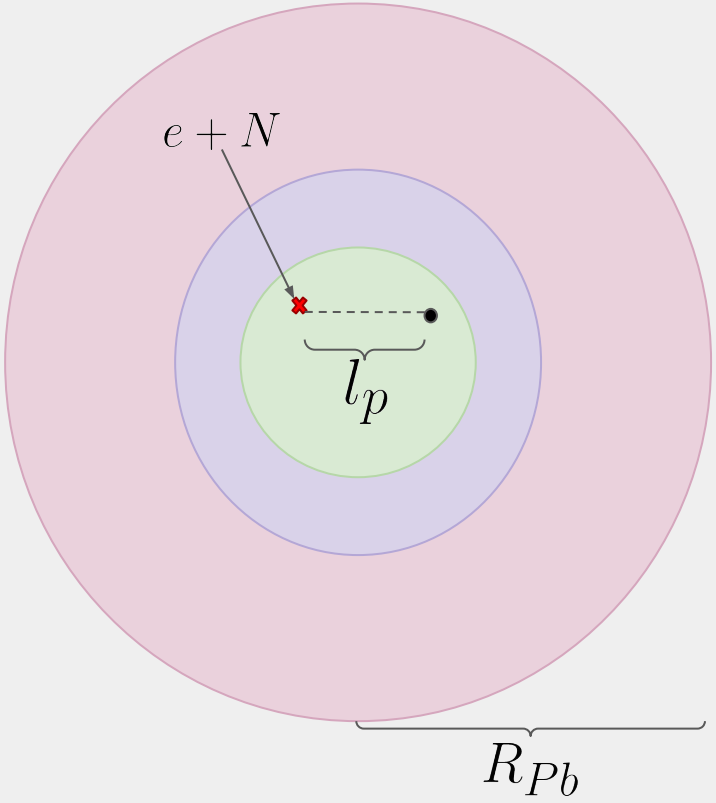
Broadening shows **where** the deconfined quark transitioned into a forming hadron!

Transverse Momentum Broadening



$$\Delta P_T^2 \propto R_A \propto A^{1/3}$$

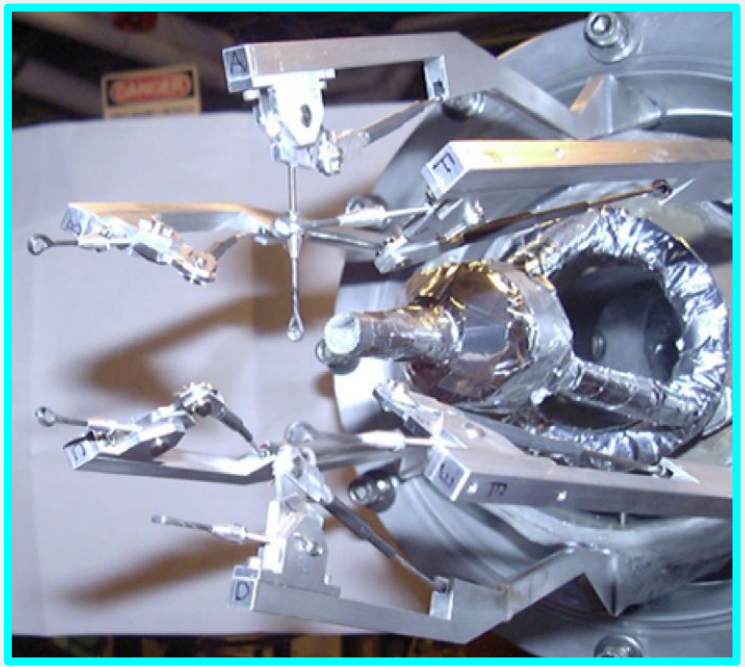
Transverse Momentum Broadening



$$\Delta P_T^2(A) = \text{Constant}$$

CLAS and The Eg2 Run Period

CLAS detector.



Double-target system **[3]**.

[3] **Hakobyan, H.; Brooks, W.; *et al.*** (2008). *A double-target system for precision measurements of nuclear medium effects.*

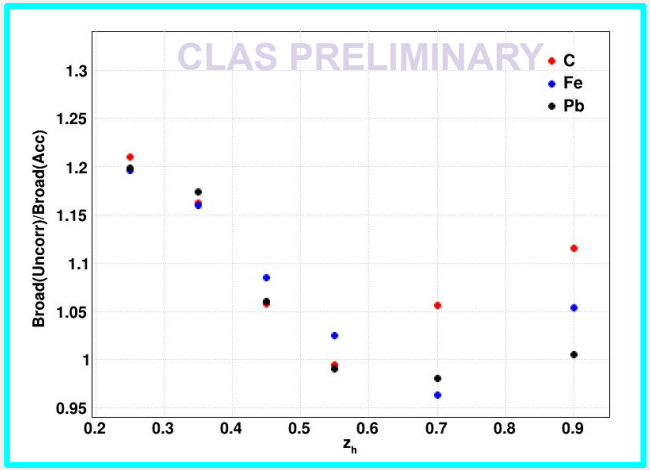
Corrections Applied to Data : Acceptance Correction

Acceptance correction is used to account for detector inefficiencies. Is defined as:

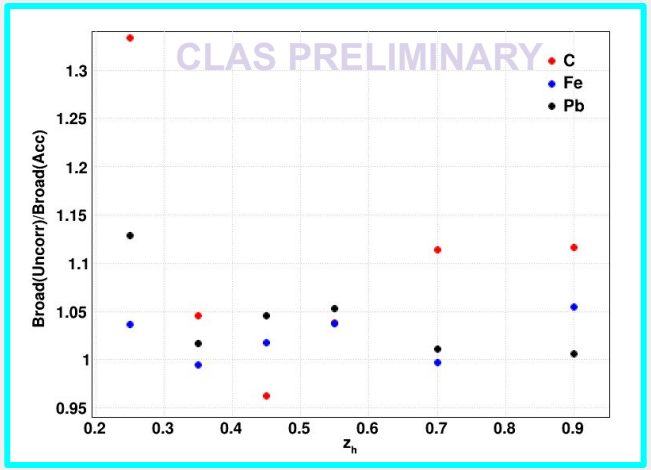
$$\mathrm{Acc}(Q^2,\nu,z_h,P_T^2,\phi_h) = \frac{N_{\mathrm{rec}}(Q^2,\nu,z_h,P_T^2,\phi_h)}{N_{\mathrm{thr}}(Q^2,\nu,z_h,P_T^2,\phi_h)}$$

N_{rec} ⟹ Geant3

N_{thr} ⟹ Pythia6



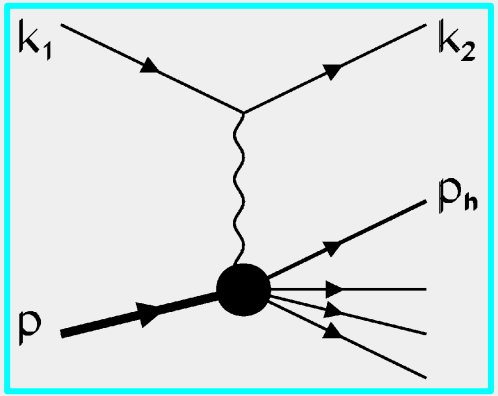
No xf cut applied.



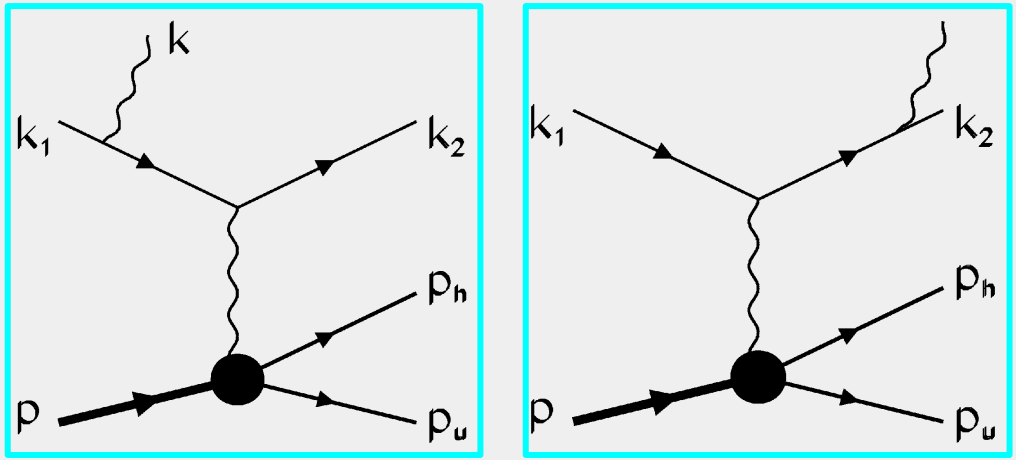
xf>0 cut applied.

Corrections Applied to Data : Radiative Correction

Radiative correction accounts for events with real photon emission, among others:



Non-radiative SIDIS event



Radiative SIDIS events

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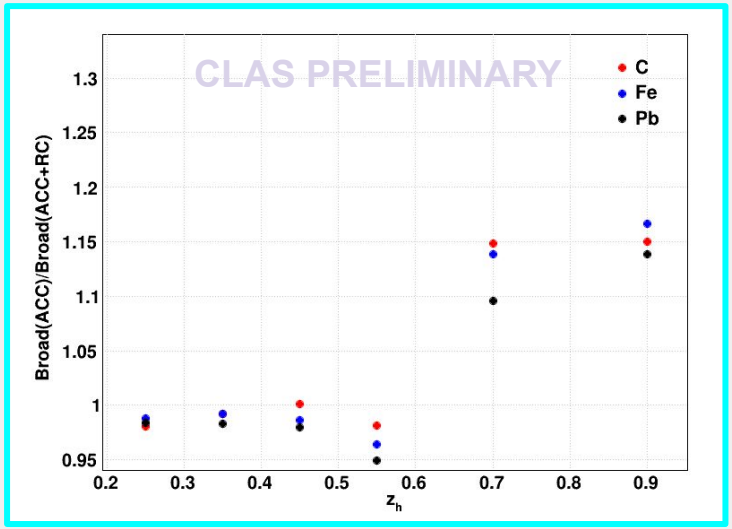

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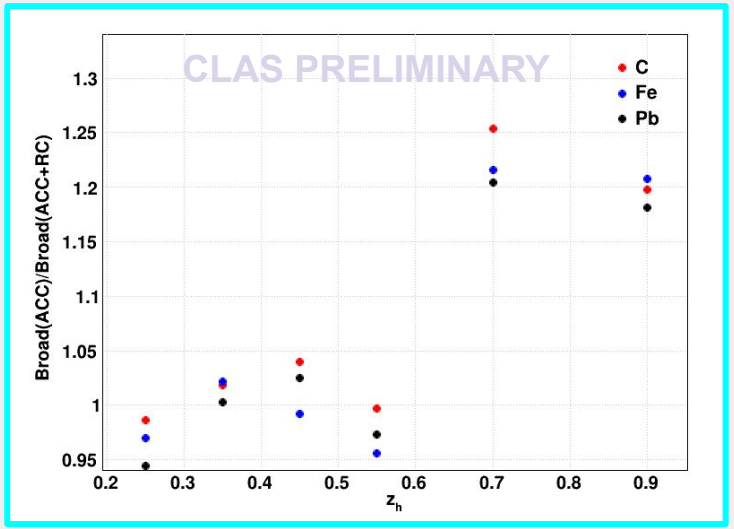
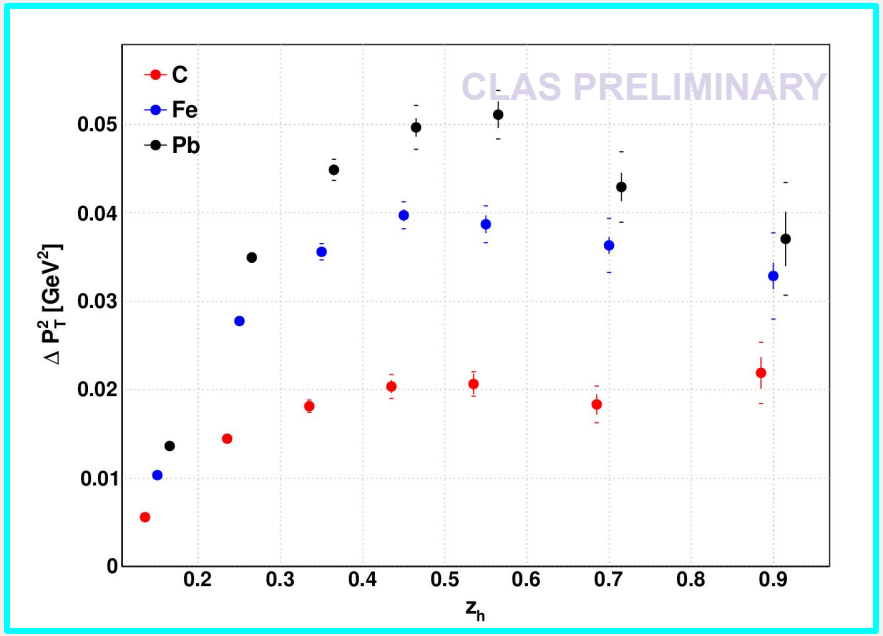
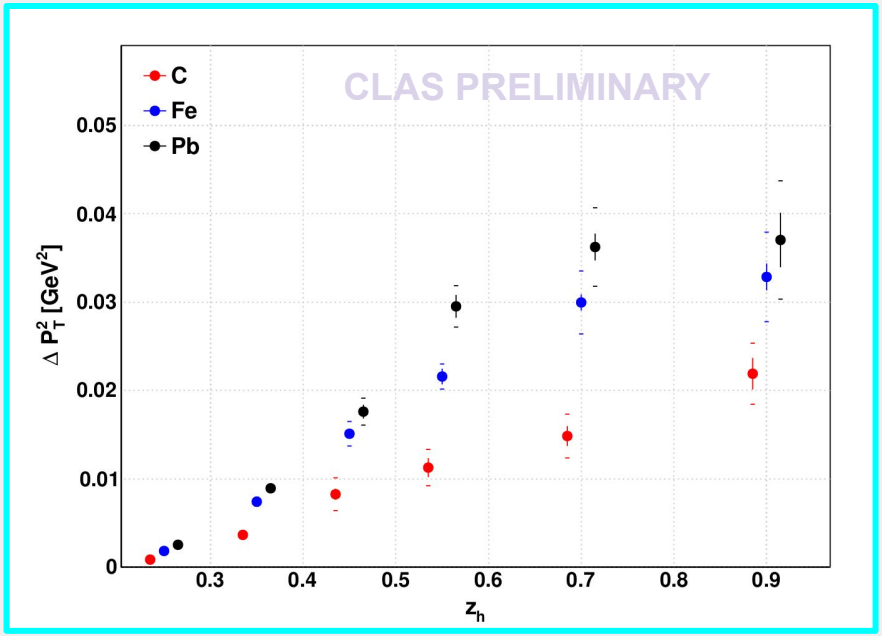


xf>0 cut applied.

Broadening Results





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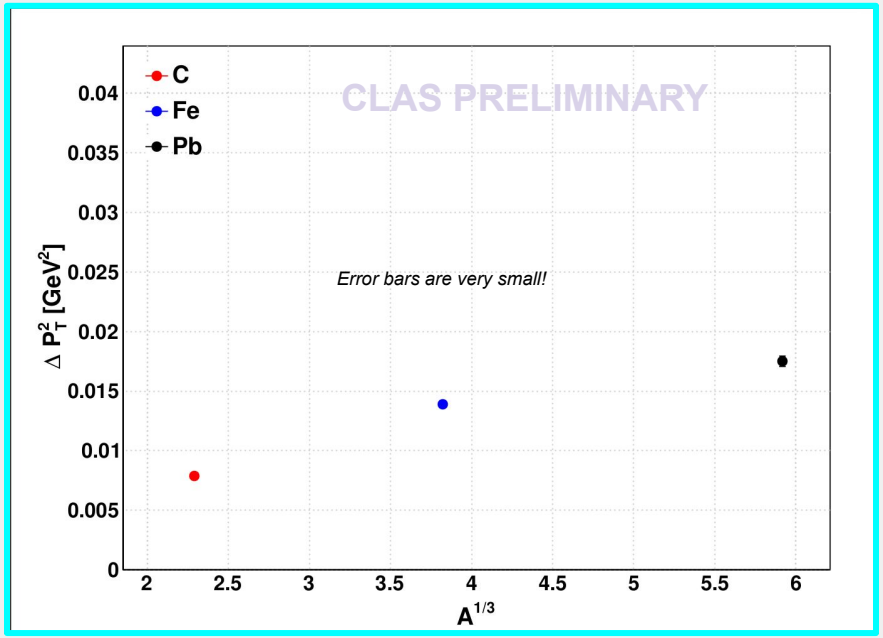

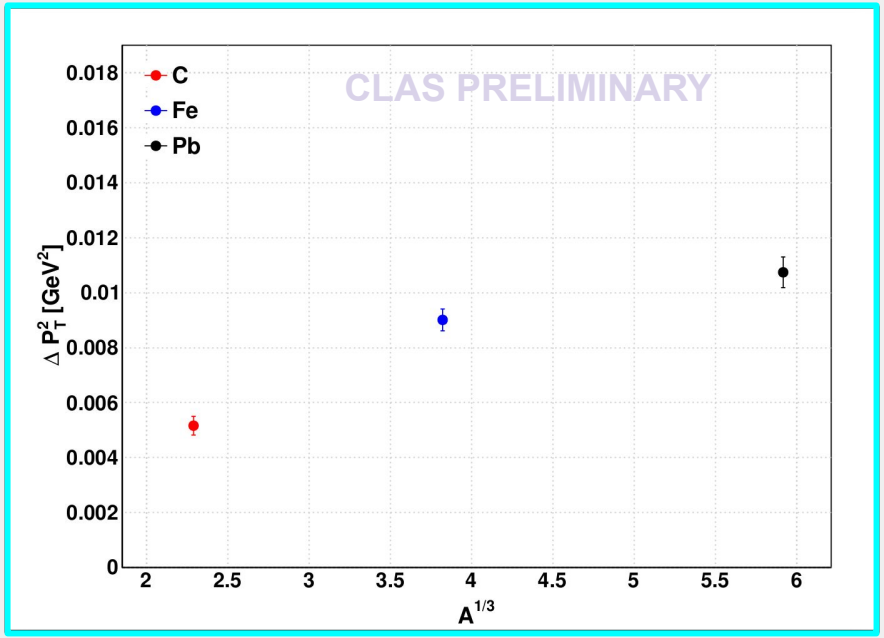

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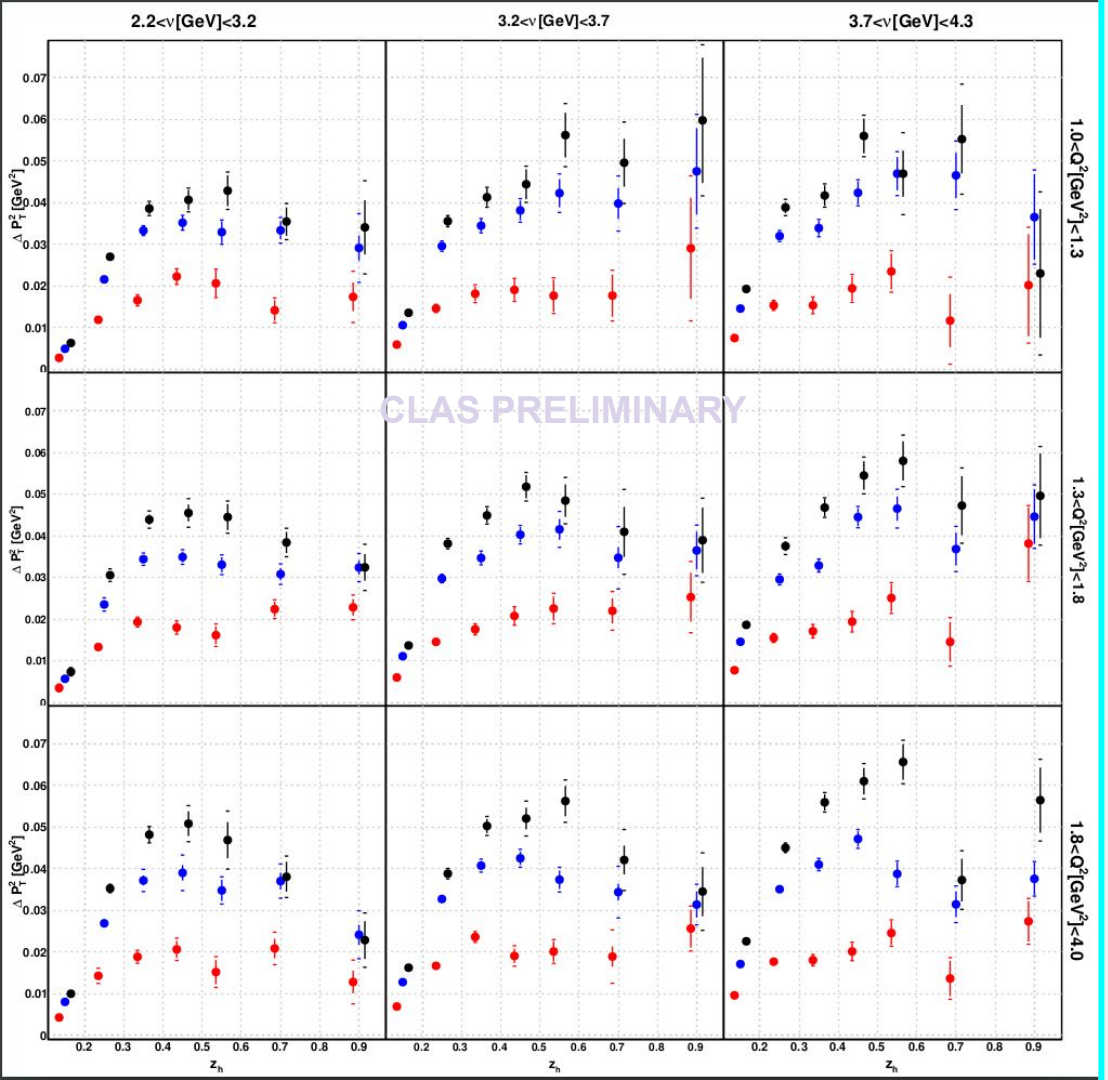


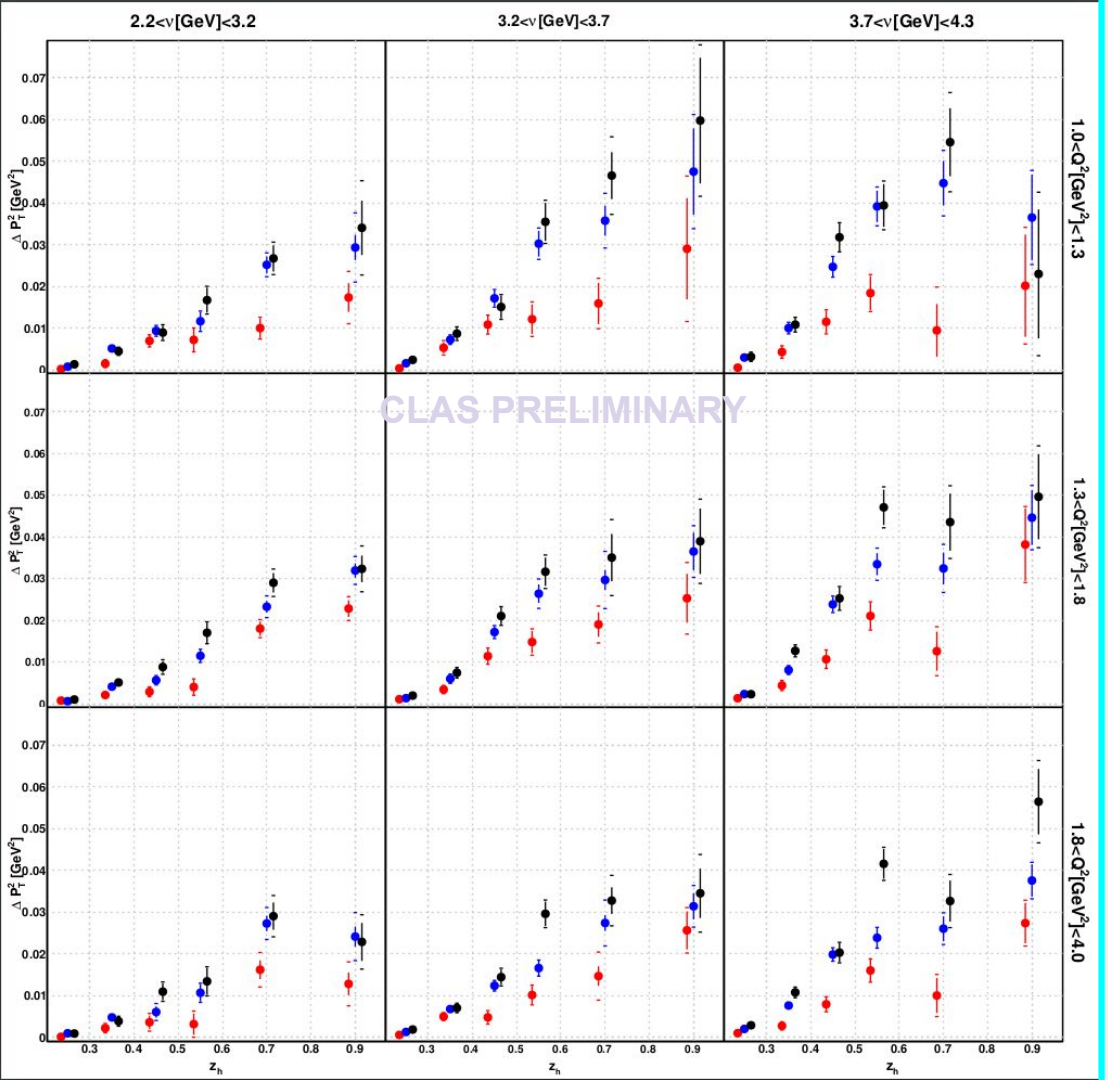
Broadening Results

Legend:

- Carbon
- Iron
- Lead

Observations:

- Strong correlation with zh.
- Weak correlation with nu and Q^2.



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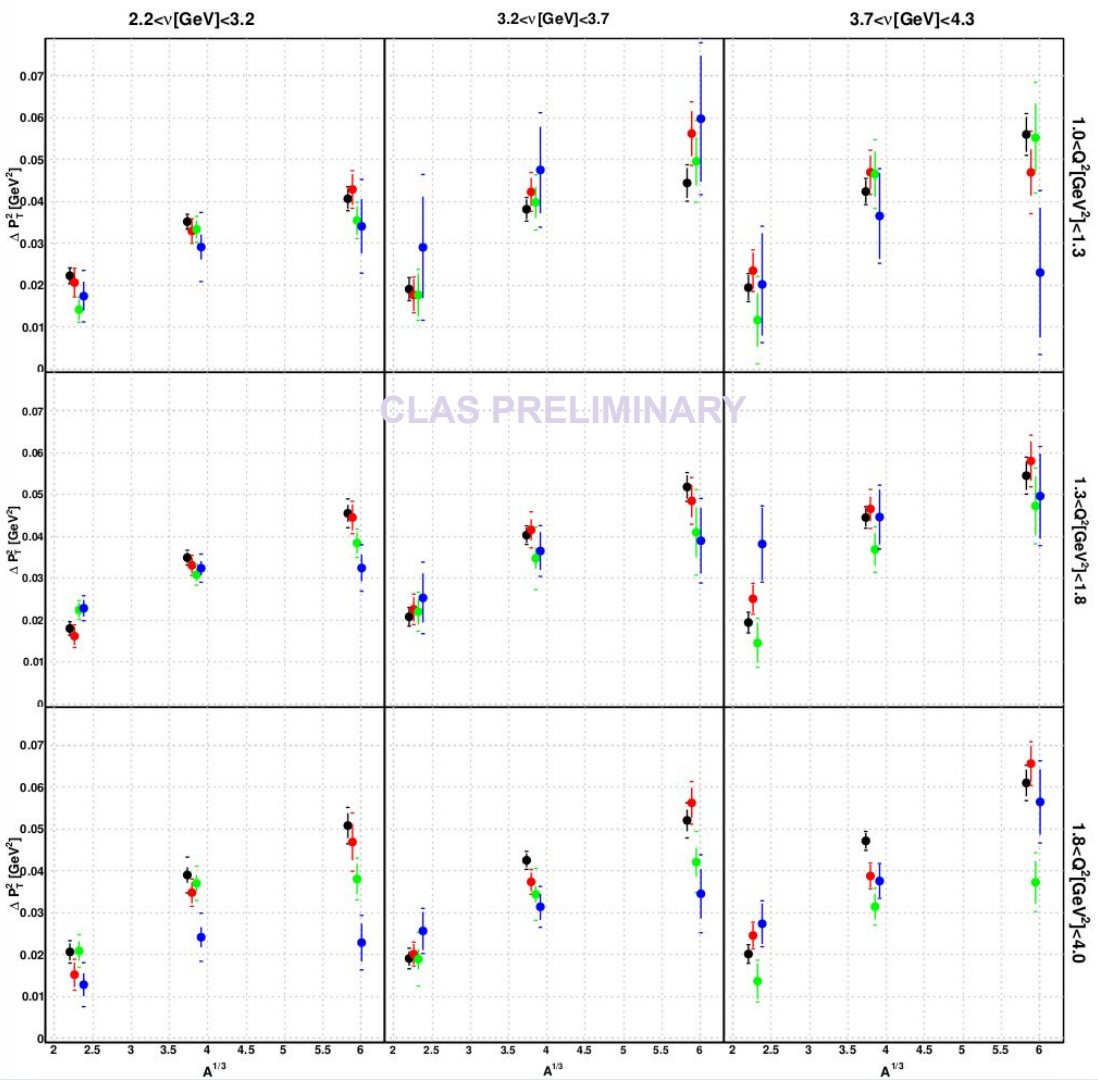


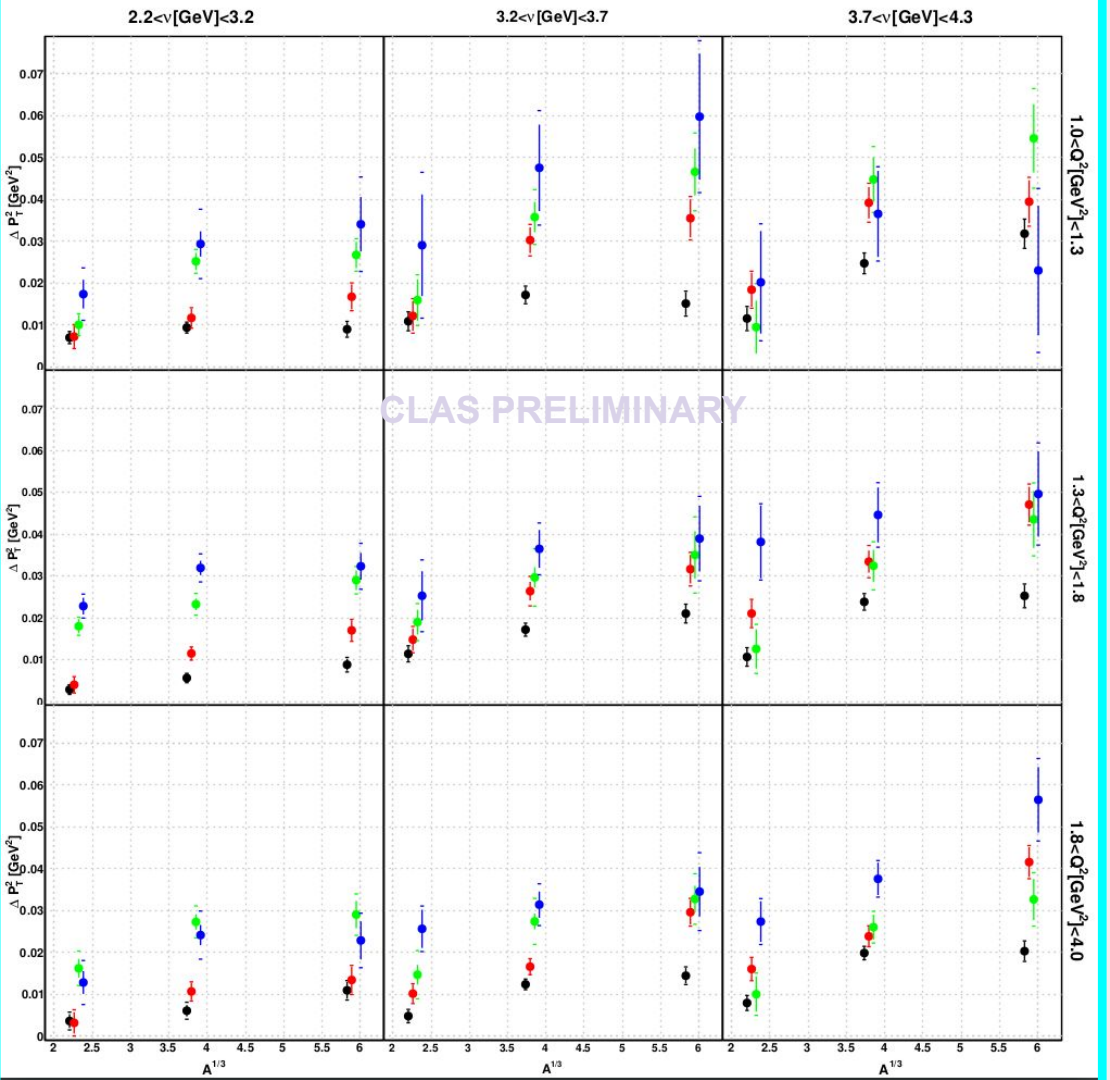
Broadening Results

Legend:

- $0.4 < z_h < 0.5$
- $0.5 < z_h < 0.6$
- $0.6 < z_h < 0.8$
- $0.8 < z_h < 1$

Observations:

- Strong correlation with zh.
- Weak correlation with nu and Q^2.
- Linear or curve behavior w.r.t. $A^{1/3}$.



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Observations:

- Strong correlation with zh.
- Weak correlation with nu and Q^2.
- Mostly linear behavior w.r.t. $A^{1/3}$.

Summary

- The preliminary positive pions broadening results for CLAS detector were presented in this talk.
- Acceptance correction had the biggest impact on the data.
- There is a noticeable correlation of the broadening with respect to zh and $A^{1/3}$.
- The broadening presents a behavior not observed in previous experimental results.

Last but not least…

Acknowledgements!

Dr. Hayk Hakobyan

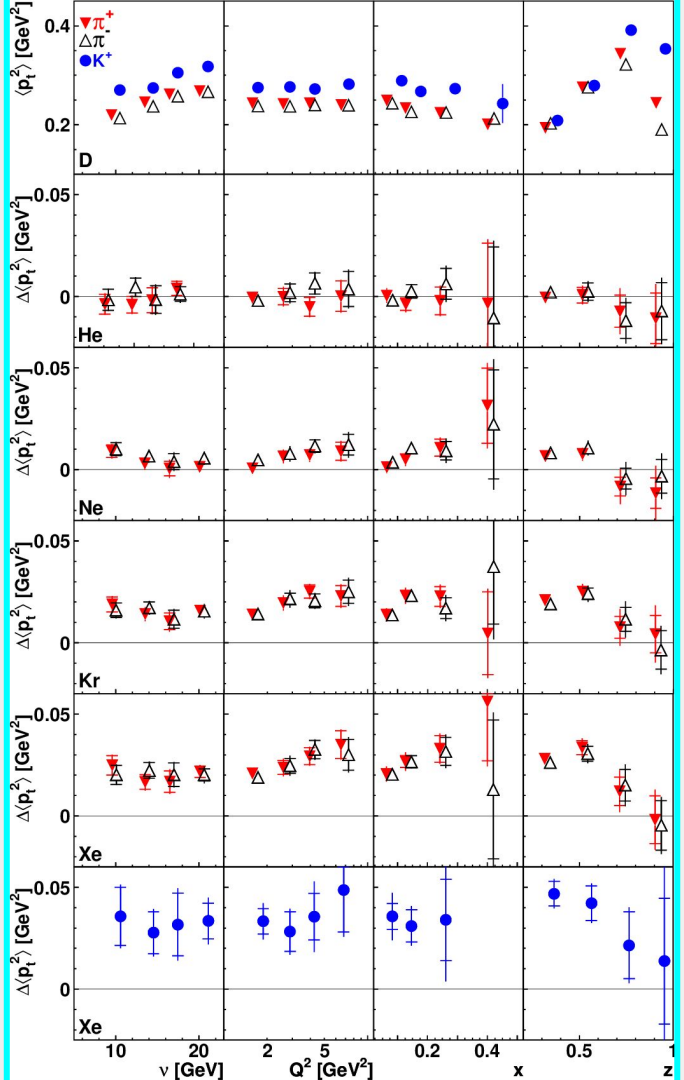
Dr. William Brooks

Dr. Benjamin Guiot

Dr. Taisiya Mineeva

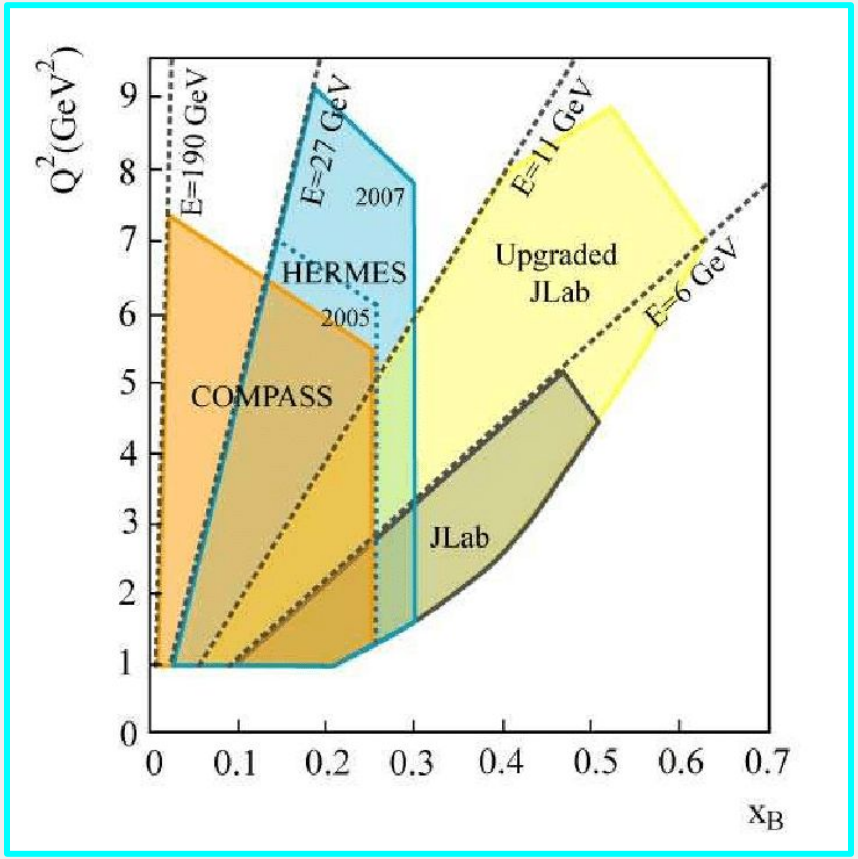
Thank you!

Backup Slides



HERMES Broadening

Kinematic Coverage



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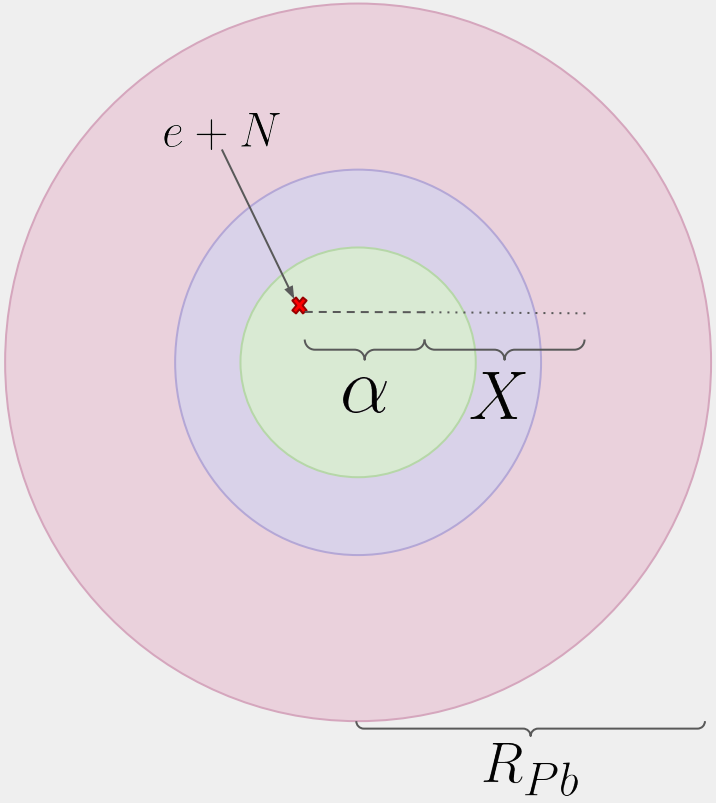
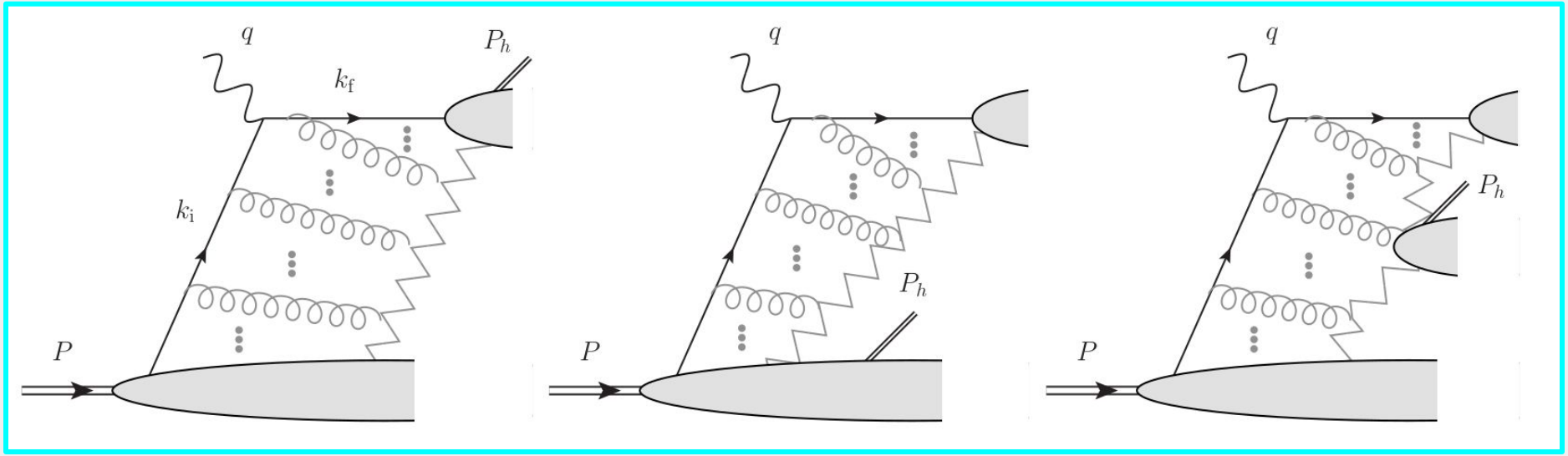


$$l_p = \alpha + X$$

Fragmentation Regions



Current

Target

Mixed

[-] **Boglione, M.; *et al.*** (2017). *Kinematics of current region fragmentation in semi-inclusive deep inelastic scattering.*