Status update of analysis note on "Hadronization studies via pi0 electroproduction"

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FONDECYT
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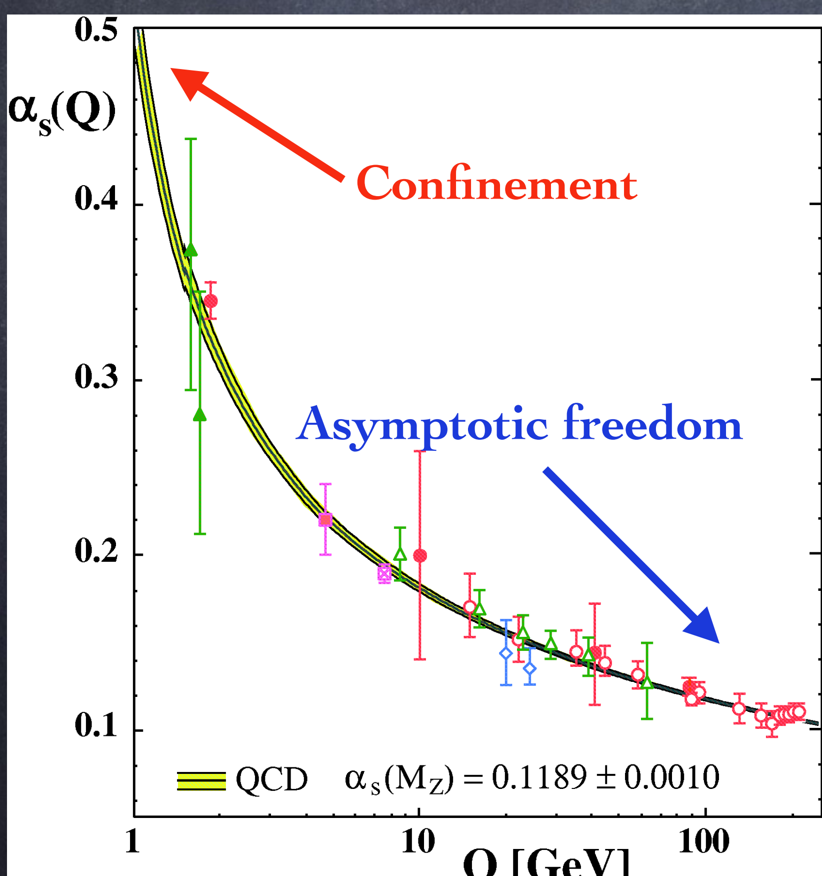
Hadronization - *why is it interesting?*

Color propagation is a fundamental QCD process

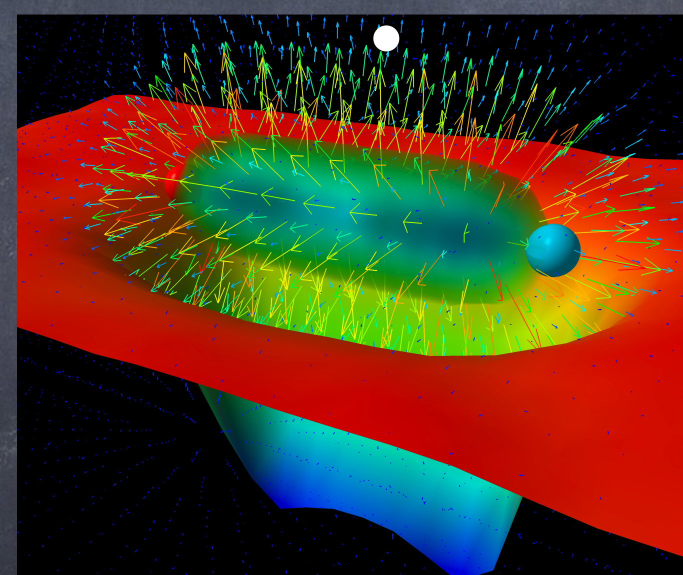
Hadronization describes the transition between colored d.o.f to composite colorless objects

*Propagation of color relies on key property of QCD as color gauge theory - **asymptotic freedom***

*Restoration of color neutrality from QCD vacuum is dynamical enforcement of **confinement***



from S.Bethke Prog.Part.Nucl.Phys.58 (2007)



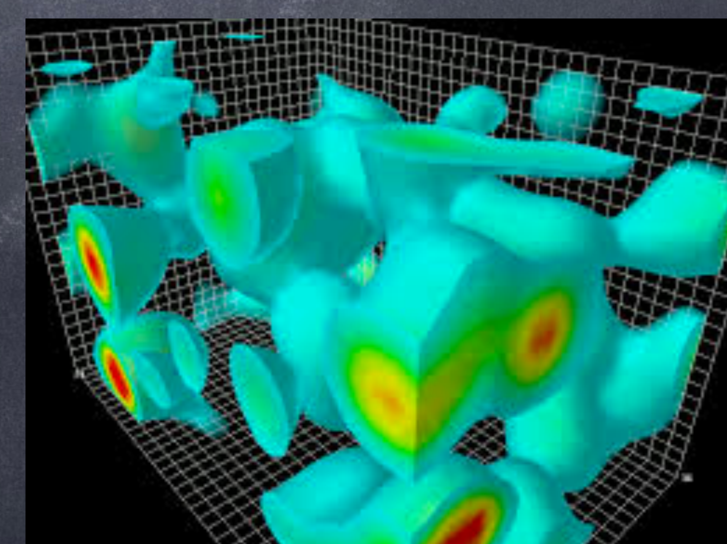
Long distances

color charge anti-screening

color flux tube between qq

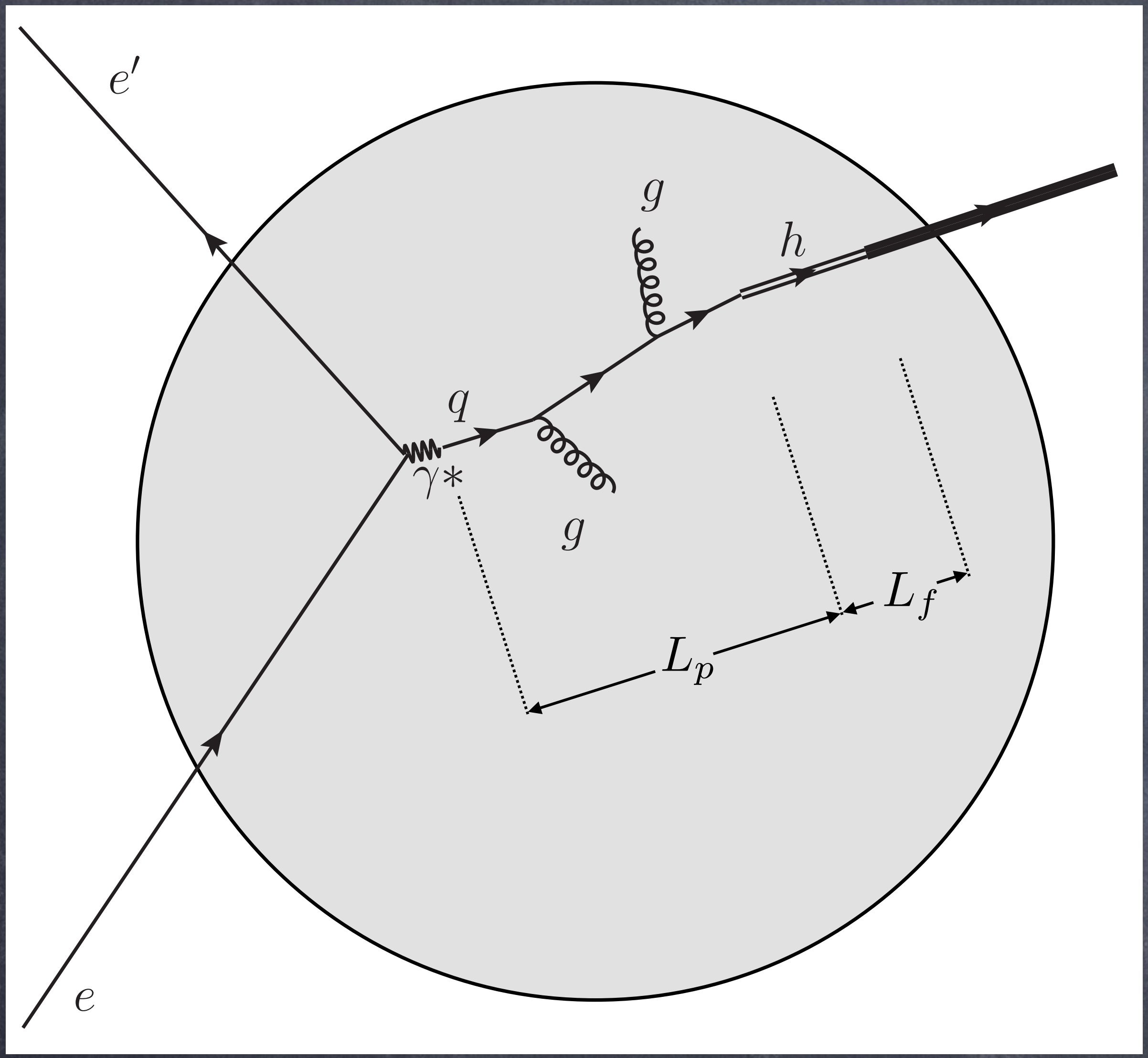
Short distances l<<1fm

q and g in QCD vacuum



Visualization of QCD from D.Leinweber

Color propagation in eA (x >0.1)

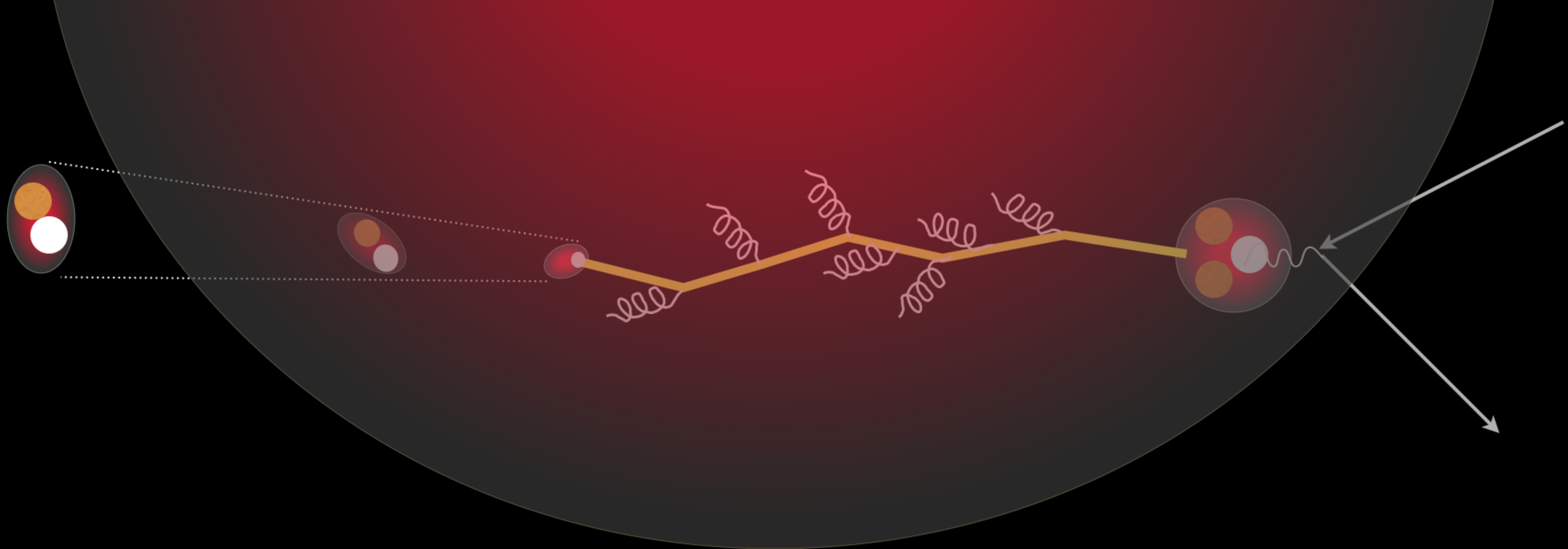


Fundamental QCD processes:

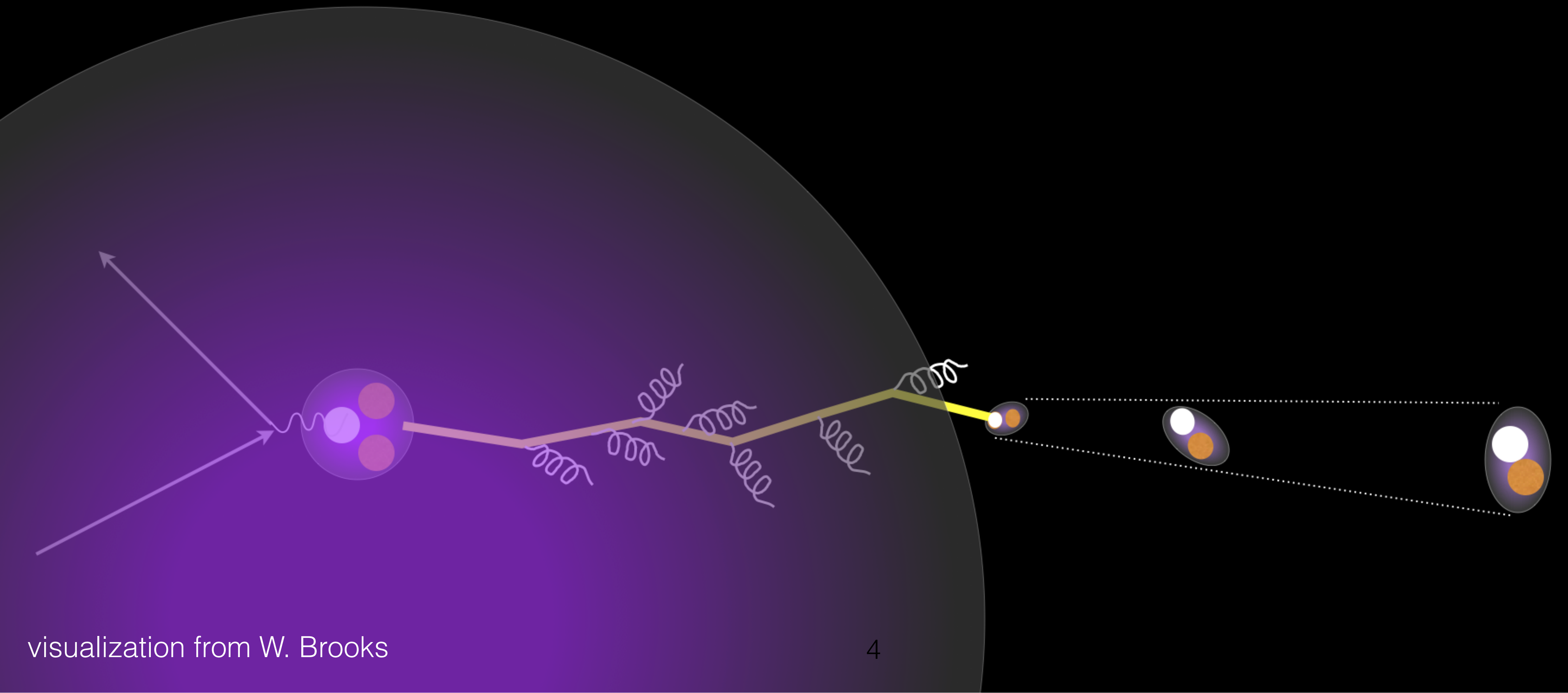
- Partonic elastic scattering
- Gluon bremsstrahlung, vacuum and medium
- Color neutralization
- Hadron formation
- Final State Interactions

Production length L_p relates to 'color lifetime' of quark following hard collision; it is the length required for colored system to neutralize its color

Formation length L_f is a distance over which a color neutral object *pre-hadron* evolves into observed hadron



e A : nuclei of increasing size act as space-time analyzer



visualization from W. Brooks

EG2 experiment @ 5 GEV

Jefferson Lab

clas

Two targets in the beam simultaneously!

CLAS **EG2** (E-02-104) conditions:

- Electron beam 5.014 GeV
- Targets ^{2}H, ^{12}C, ^{56}Fe, ^{207}Pb (Al, Sn)
- ^{2}H separated from solid targets by 4cm
- Instant luminosity $2 \cdot 10^{34}$ 1/(s $\cdot$ cm^{2})

Transverse Momentum Broadening

Connects to color lifetime L_p , quark k_T, transport coefficient **q**hat and quark energy losses

$$\Delta\langle p_{\mathrm{T}}^2\rangle = \langle p_{\mathrm{T}}^2\rangle_A - \langle p_{\mathrm{T}}^2\rangle_p$$

Hadronic Multiplicity Ratio

Connects to hadron formation phase L_f

Particle yield N = σ *L* , where *L* is luminosity
For a double target system with same *L*,
Multiplicity Ratio is the ratio of cross sections

$$R_{\mathrm{A}}^{h}\left(\nu, Q^2, z, p_T\right) = \frac{\left.\frac{N_h(\nu,Q^2,z,p_T)}{N_e(\nu,Q^2)|_{\mathrm{DIS}}}\right|_{\mathrm{A}}}{\left.\frac{N_h(\nu,Q^2,z,p_T)}{N_e(\nu,Q^2)|_{\mathrm{DIS}}}\right|_{\mathrm{D}}}$$

Analysis note web page:

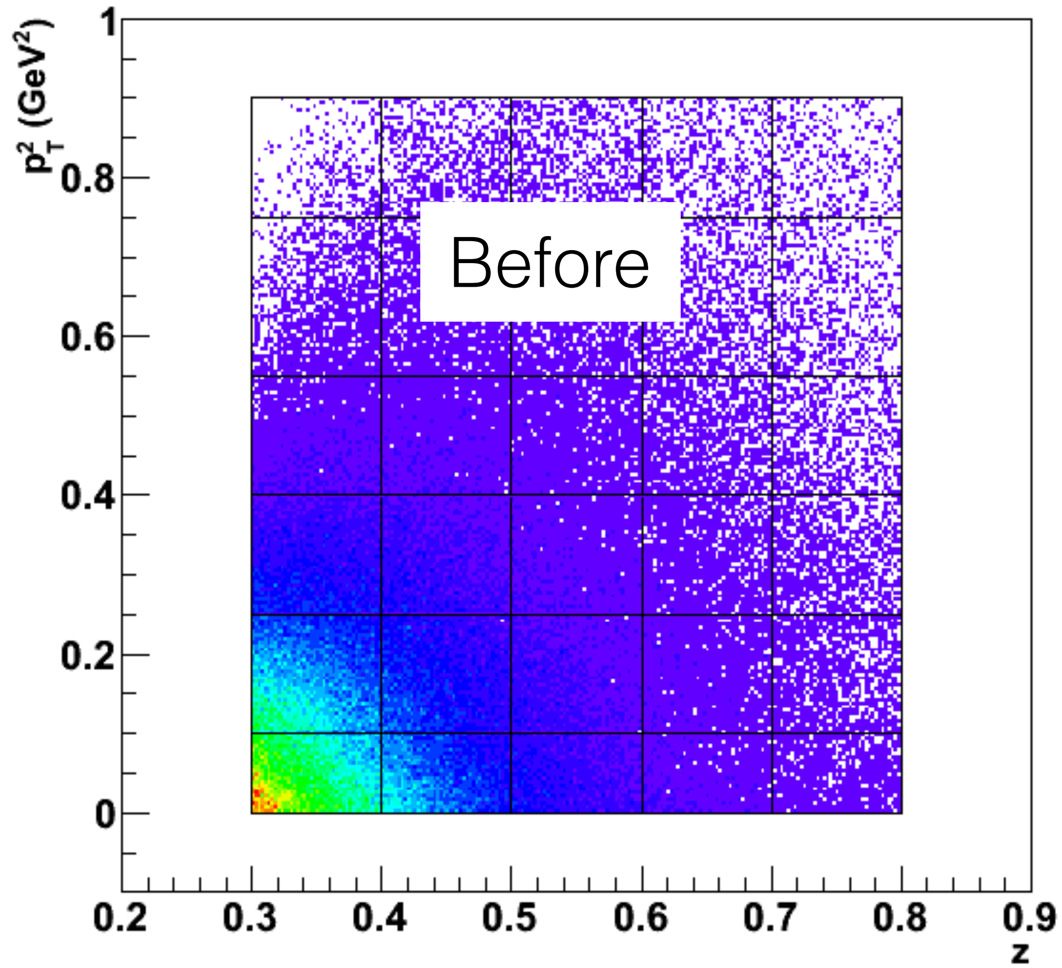
https://www.jlab.org/Hall-B/secure/eg2/taya/review.html

Analysis note: what changed

- Extended kinematical range

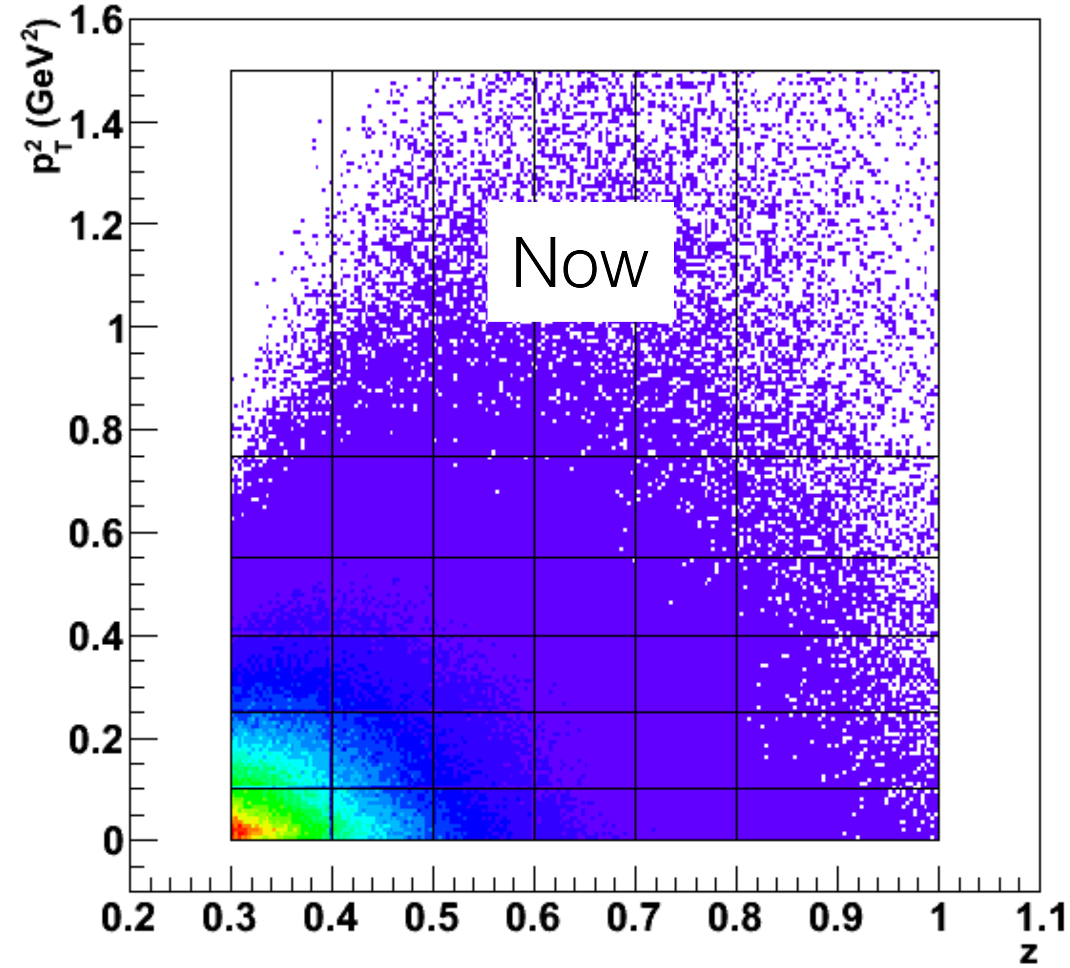
pT2 = 0., 0.1, 0.25, 0.4, 0.55, 0.75, **0.9**

z = 0.3 0.4 0.5 0.6 0.7 **0.8**



pT2 = 0., 0.1, 0.25, 0.4, 0.55, 0.75, **1.5**

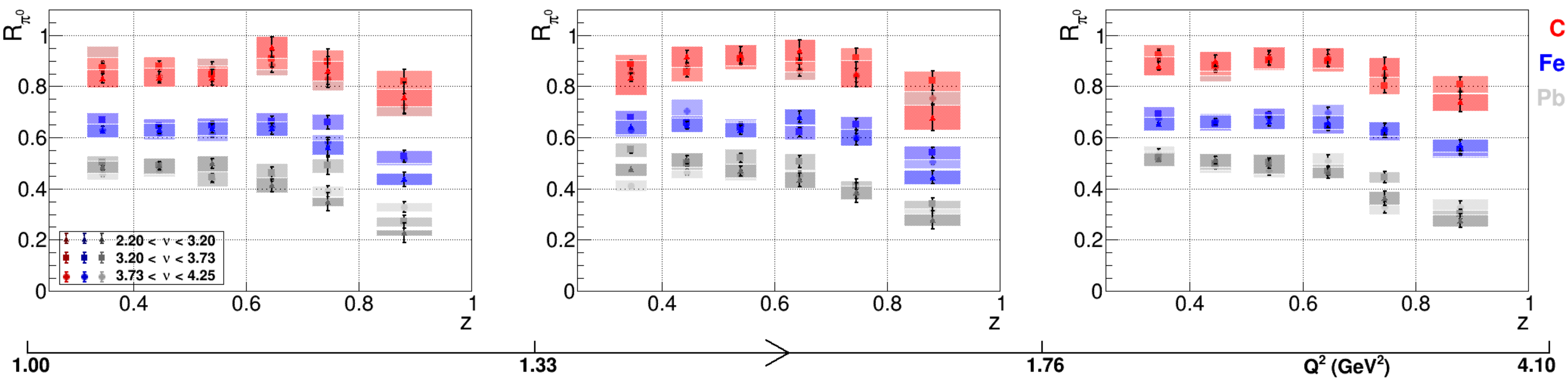
z = 0.3 0.4 0.5 0.6 0.7 0.8 **1.0**



Analysis note: what changed

- Extended kinematical range
- Improved two-photon invariant mass fitting procedure
- Electron radiative corrections were reevaluated and are now based on EXTERNALS code. Include inclusive and Coulomb correction on nuclei (Pb, Fe, C, D).
- SIDIS radiative corrections for π^0 are currently revisited: structure functions on nuclei are now parametrized only in terms of φ moments extracted from data
- Systematical uncertainties due to DC fiducial cuts, electron RC, π^0 SIDIS RC were calculated
- ….

Multiplicities in (Q^2,ν, z) bins



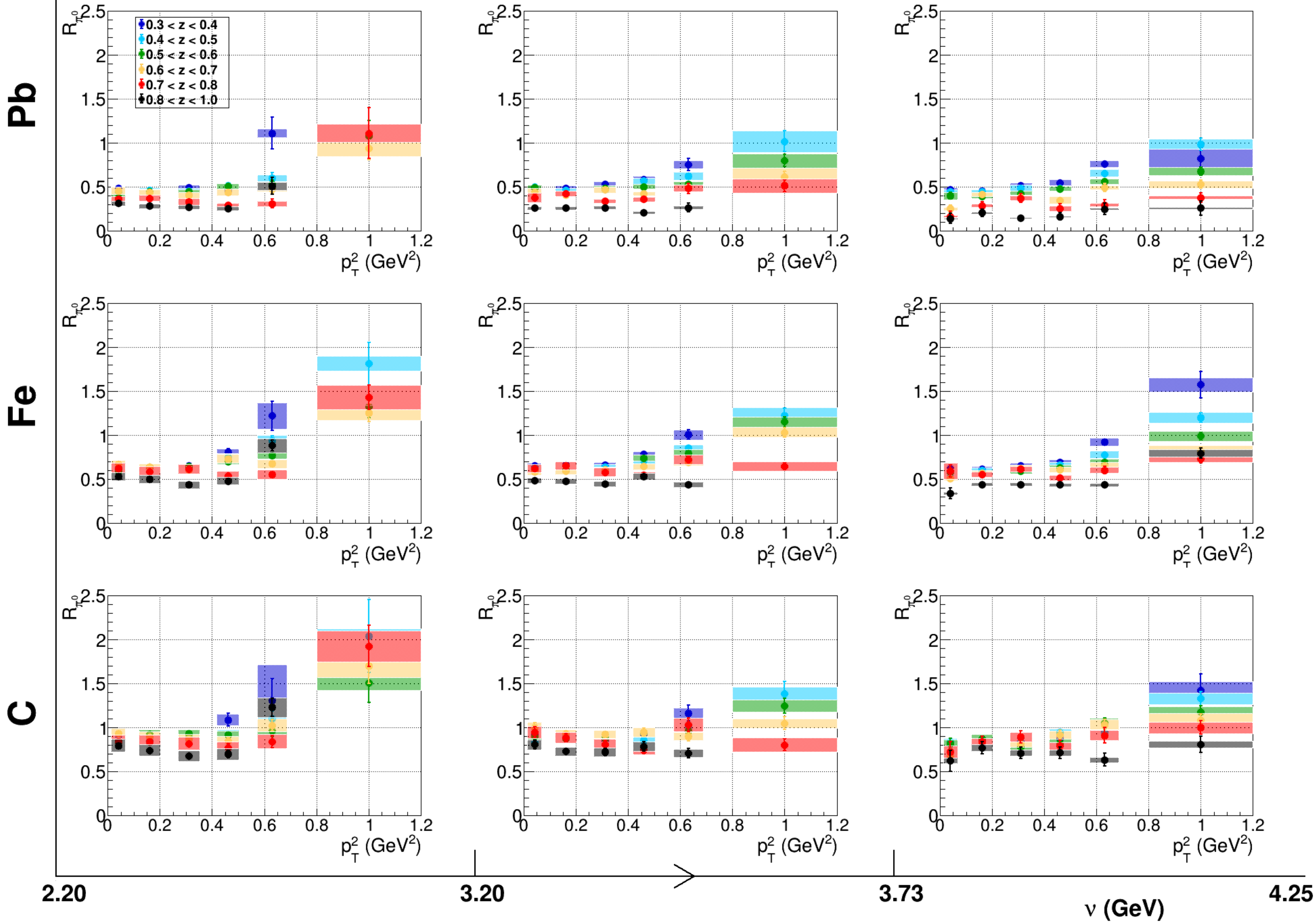
Color band - total systematical uncertainties
Error bars - statistical uncertainties

Data corrected for Acc, and RC effects on e. No SIDIS pi0 RC corrections here (few %)

Total errors in (Q^2,v, z) bins

Systematic uncertainty	Δ^{C}_{RMS}(%)	Δ^{Fe}_{RMS} (%)	Δ^{Pb}_{RMS} (%)
Normalization type			
Target vertex cut	0.3	0.3	0.3
Target leakage	0.9	0.9	0.9
Sampling fraction cut	0.5	0.5	0.5
Photon energy cutoff	1.2	1.2	2.7
EC time (beta) cut	0.8	0.8	0.8
DC fiducial cuts	0.9	0.9	0.9
Electron radiative corrections	3.3	3.3	3.3
SIDIS radiative corrections	1.5	1.5	1.5
Total normalization	4.1	4.1	4.8
Bin-by-bin basis			
Background shape	0.6	0.9	1.4
Signal shape	3.1	1.9	5.1
Acceptance in finite bin width	1.1	1.1	1.1
Average Systematics (Q^2, ν, z)	4.8	4.6	6.0
Average Statistics (Q^2, ν, z)	3.4	2.8	4.9
Total average Error (Q^2, ν, z)	5.9	5.4	7.8

Multiplicities in (ν, z, pT²) bins



Data corrected for Acc, and RC effects on e. No SIDIS pi0 RC corrections here (few %)

Total erros in (v, z, pT2) bins

Systematic uncertainty	$\Delta^{C}_{RMS}(\%)$	Δ^{Fe}_{RMS} (%)	Δ^{Pb}_{RMS} (%)
Normalization type			
Target vertex cut	0.5	0.5	0.5
Target leakage	0.9	0.9	0.9
Sampling fraction cut	0.4	0.4	0.4
Photon energy cutoff	2.1	2.1	2.2
EC time (beta) cut	0.6	0.6	0.6
DC fiducial cuts	1.3	1.3	1.3
Electron radiative corrections	3.3	3.3	3.3
SIDIS radiative corrections	1.5	1.5	1.5
Total normalization	4.6	4.6	4.6
Bin-by-bin basis			
Background shape	0.6	0.5	0.8
Signal shape	2.1	2.1	4.5
Acceptance in finite bin width	2.8	2.8	2.8
Average Systematics (ν, z, p_T^2)	6.4	6.6	7.2
Average Statistics (ν, z, p_T^2)	6.0	4.7	9.4
Total Error (ν, z, p_T^2)	8.7	8.1	11.8