Differential Study of Nuclear Effects in Hadronization by DIS

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Overview:

Study hadronization in A$(e, e'[\pi, K])$X, on ^{2}H, ^{12}C, ^{64}Cu, and ^{184}W, by the attenuation of hadron yield

$$R(\nu, z, P_T, Q^2) = \frac{\frac{dN^h(A)}{N_e(A)dz}}{\frac{dN^h(D)}{N_e(D)dz}}.$$

* Main objective-

Provide precise data for understanding hadronization mechanism, study propagation of quarks and hadrons *under specific kinematic conditions.*

→ small acceptance detectors;

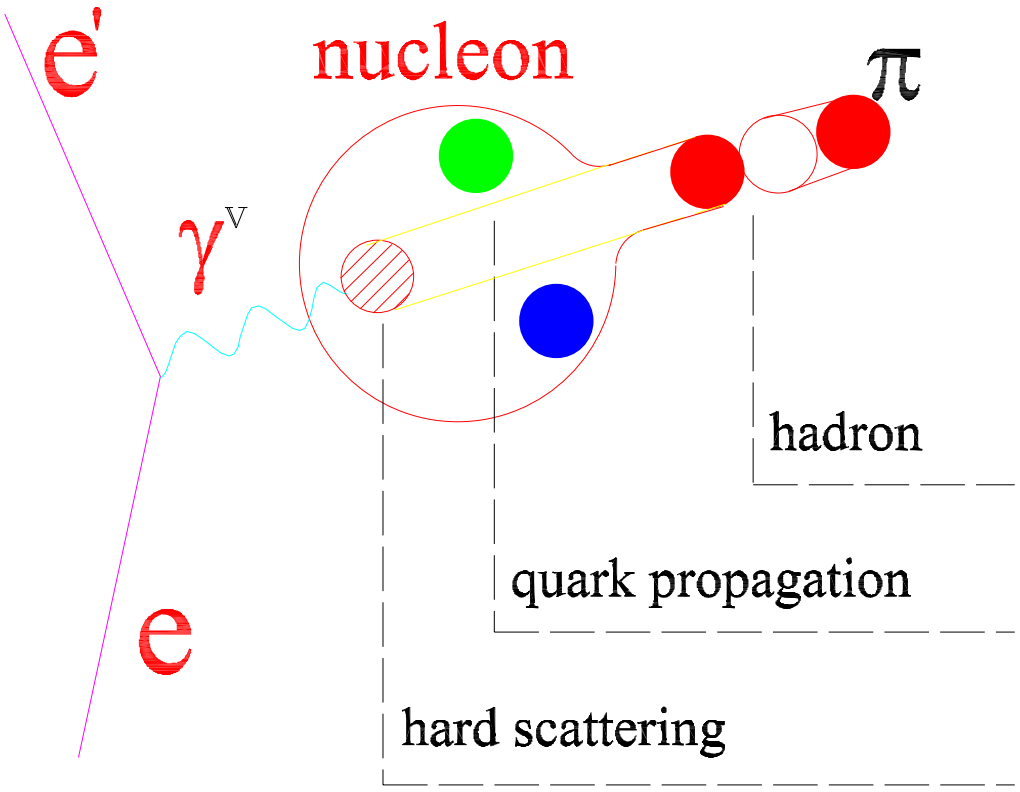
→ essential to QCD.

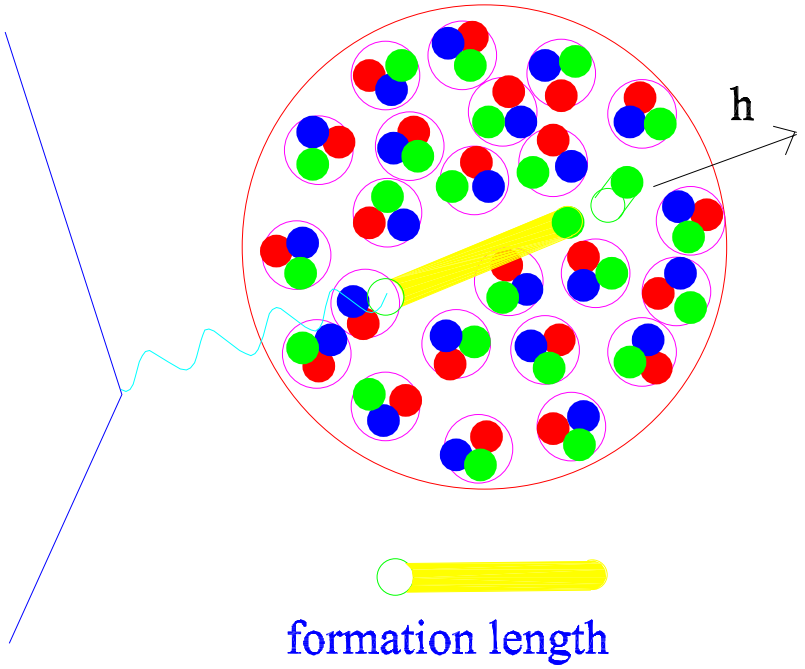
* Additional objective-

Input to RHIC data interpretation, jet quenching

→ Is QGP recreated at RHIC?

Hadronization by DIS





dependence on:

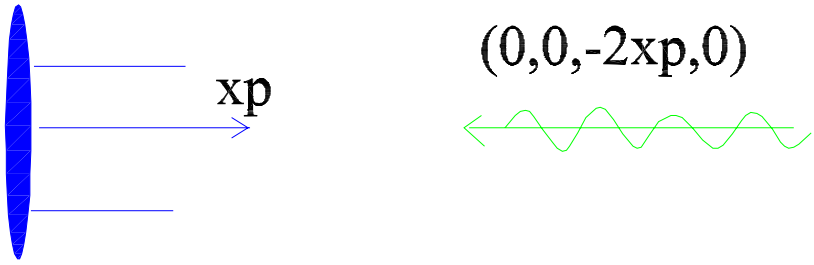
A

Q^2,ν, (x)

z, P_T

$z=E_h/\nu$

Fragmentation in Breit frame



before

after

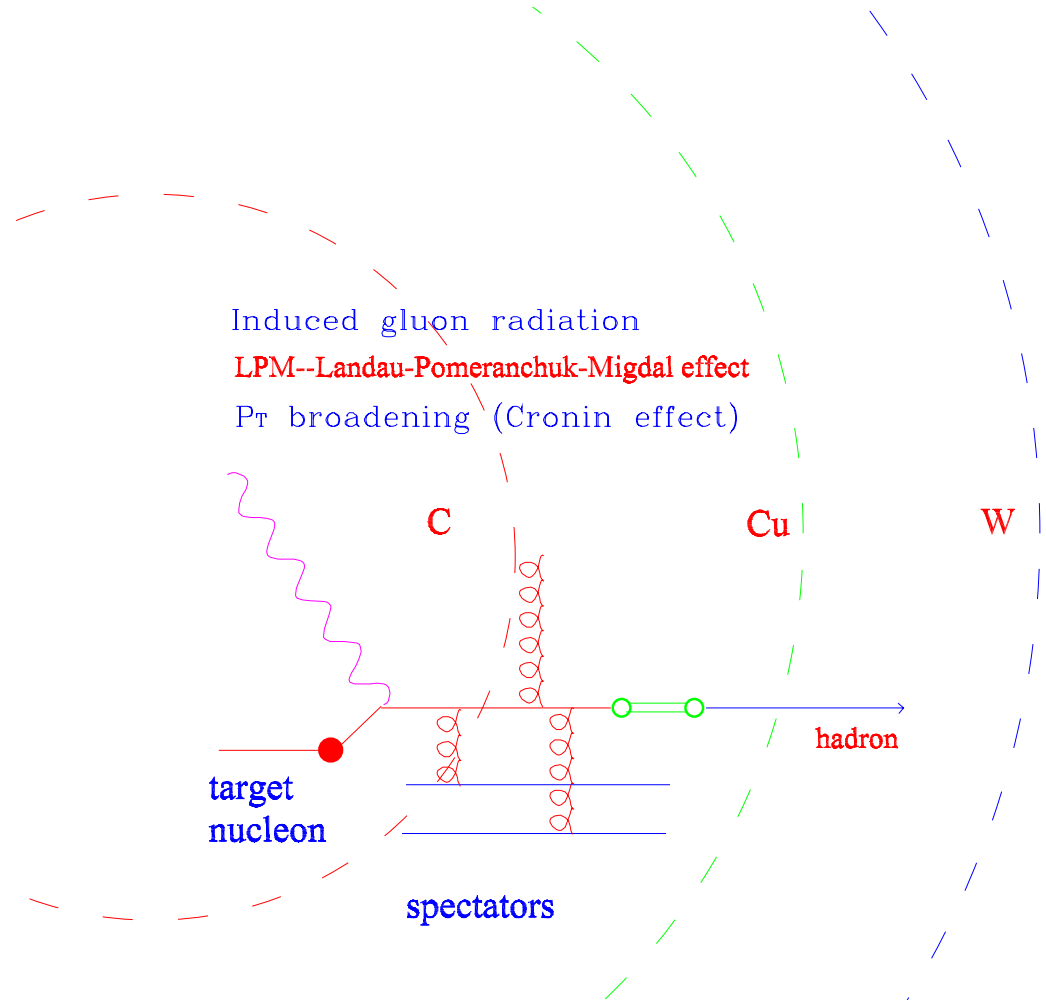
current fragmentation

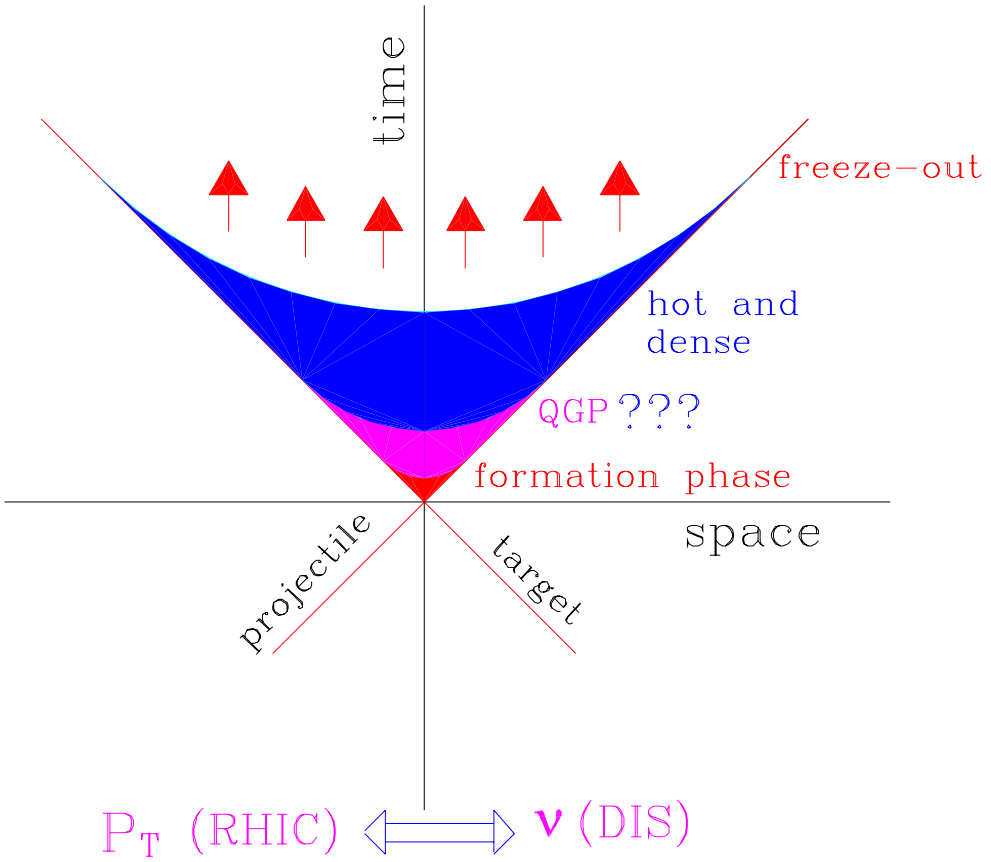
$P >> P_T$

$x_F > 0$

target fragmentation

$x_F = P_L / P_{Lmax}$ (c.m.)

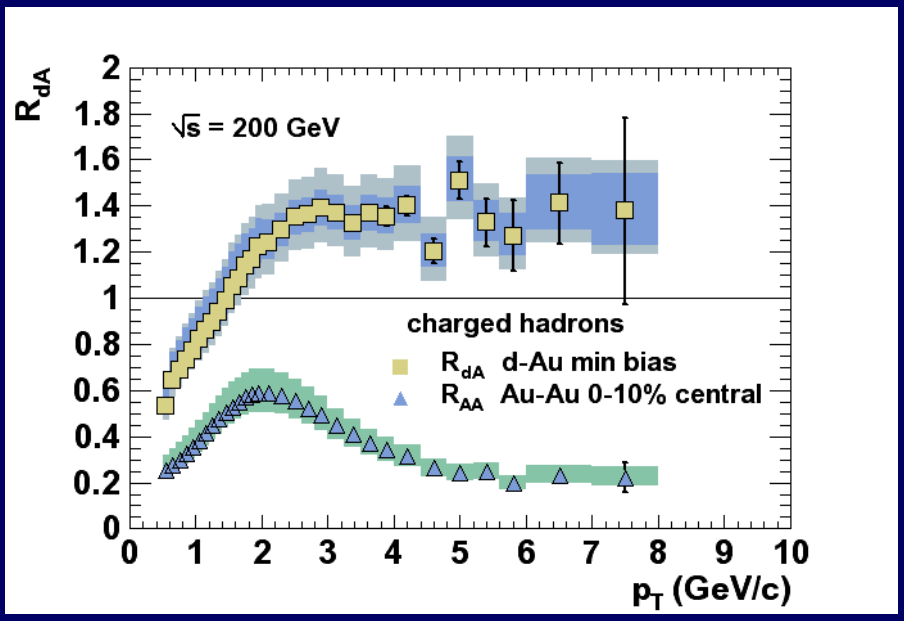

Induced gluon radiation
LPM--Landau-Pomeranchuk-Migdal effect
Pт broadening (Cronin effect)
C
Cu
W
hadron
target
nucleon
spectators


time
freeze−out
hot and
dense
QGP ???
formation phase
space
projectile
target
P_T (RHIC)
ν (DIS)

Charged Hadron Results

d+Au

Au+Au

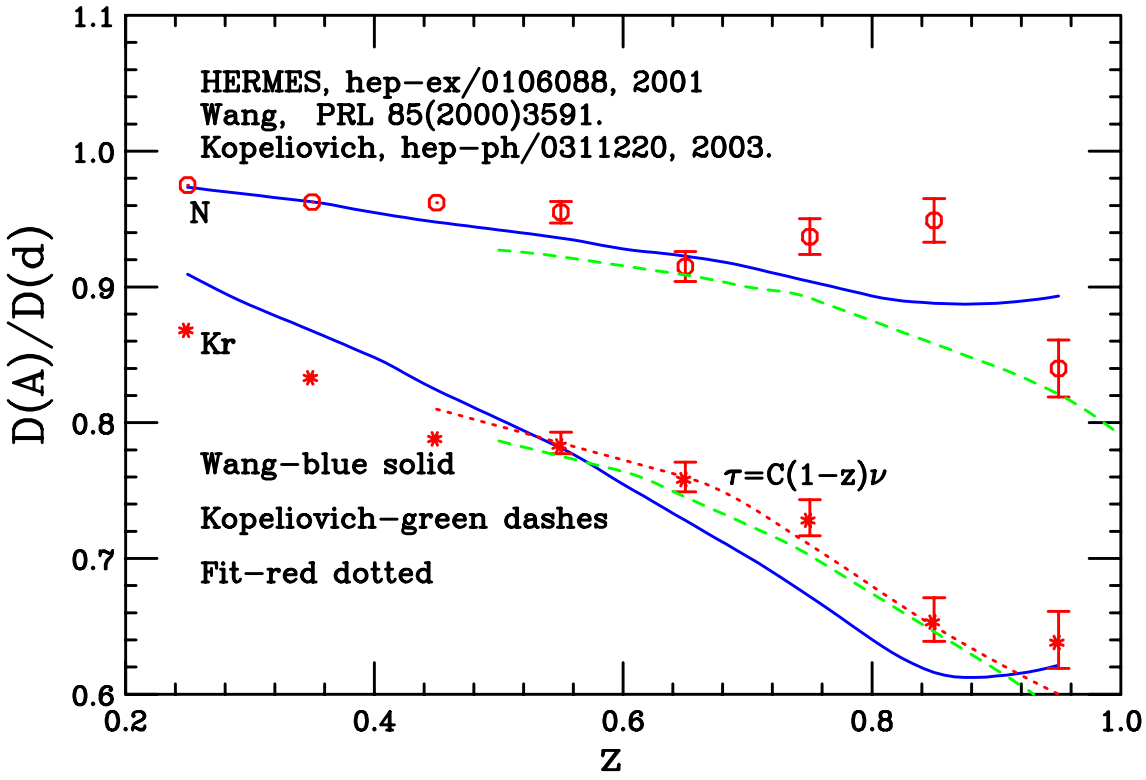


High P_T suppression in Au-Au collision, in comparison with dA data. Bathe (PHENIX). PRL 91(2003)072303.

Previous data:

data	beam	E_0 (GeV)	ν (GeV)	Q^2 (GeV/c)^2
FNL	μ	490	>100	0.1-150
EMC	μ	175	>10	> 2
SLAC	e^-	20.5	>4	0.35-5
HERMES	e^+	27	7-23	$< 2.5 >$
HERMES	e^+	12	2.5-9	$< 0.9 >$
CLAS	e^-	5.7	3-5	1.5-5
HRS*	e^-	6	4	2.8, 4.2

Data required at lower ν AND higher Q^2's:
DIS is dominating and factorization is valid.
Data required on larger A nuclei (^{184}W):
stronger attenuation and test of models.
Data required at various P_T's and high z:
sensitive to different dynamics.



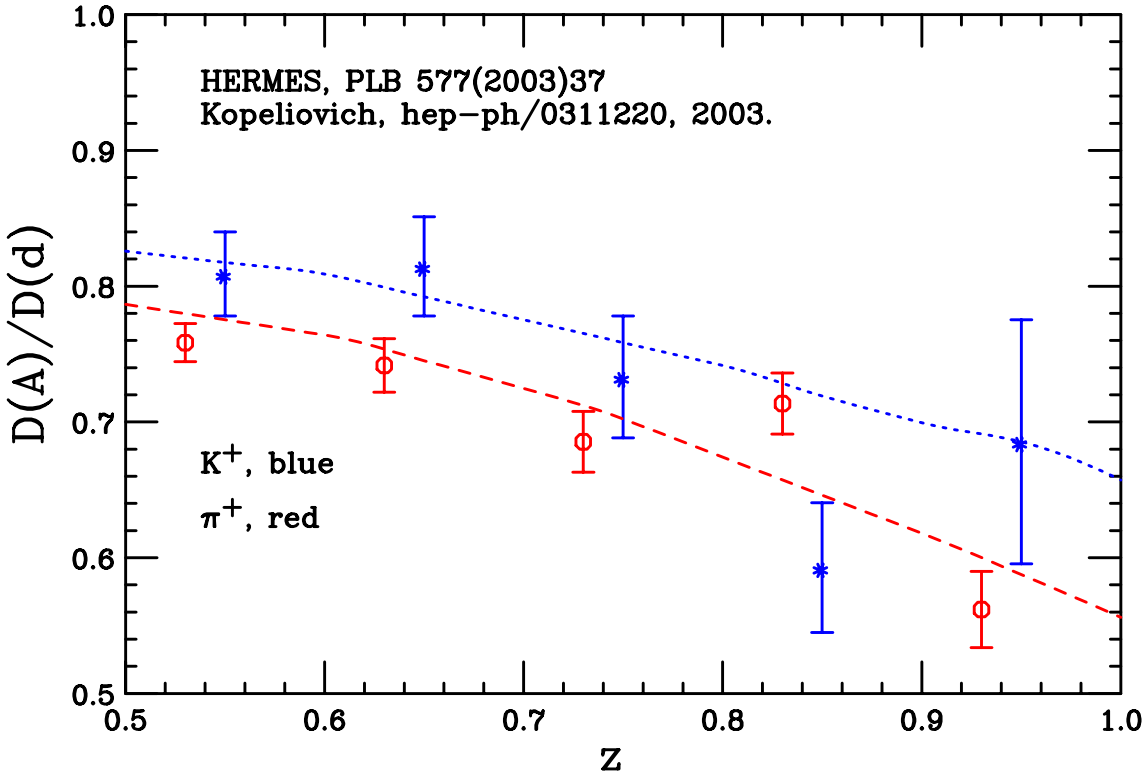
Sources of the attenuation?

HERMES hadronization inside nucleus;

Wang quark-medium interaction;

Kopeliovich colorless pre-hadronic state.

Flavor dependence is required.



Higher precision at large z is required.

The first major goal:

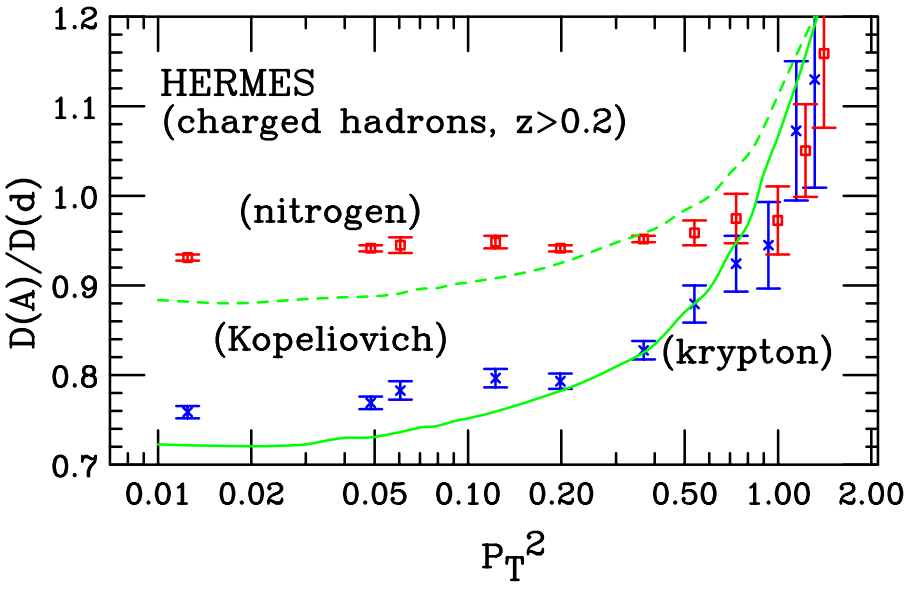
Determine

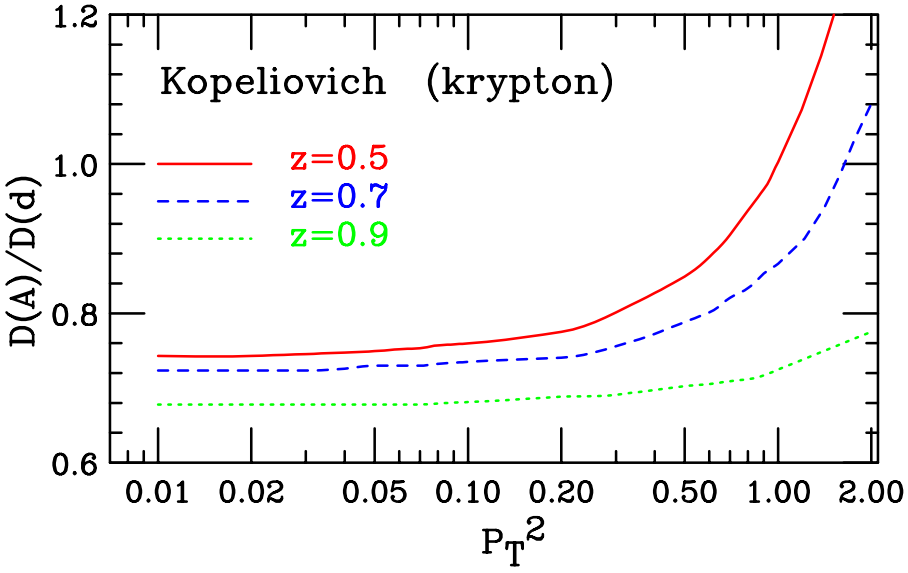
Whether the hadron is produced inside the nucleus.

Lower $\nu-$ shorter formation length; larger difference in σ_π and σ_K.

Larger A$-$ longer traversing path.

PID$-$ Different attenuation for π^+ and K^+ if they are formed inside the medium.





The second major goal:

Kopeliovich: Data required on variation with z, direct measure of formation length.

Large A - stronger effect.

Dynamic features

Multii-variable (Q^2, ν, z, P_T, A);

Multi-mechanism (quark, color-dipole, and hadron propagation);

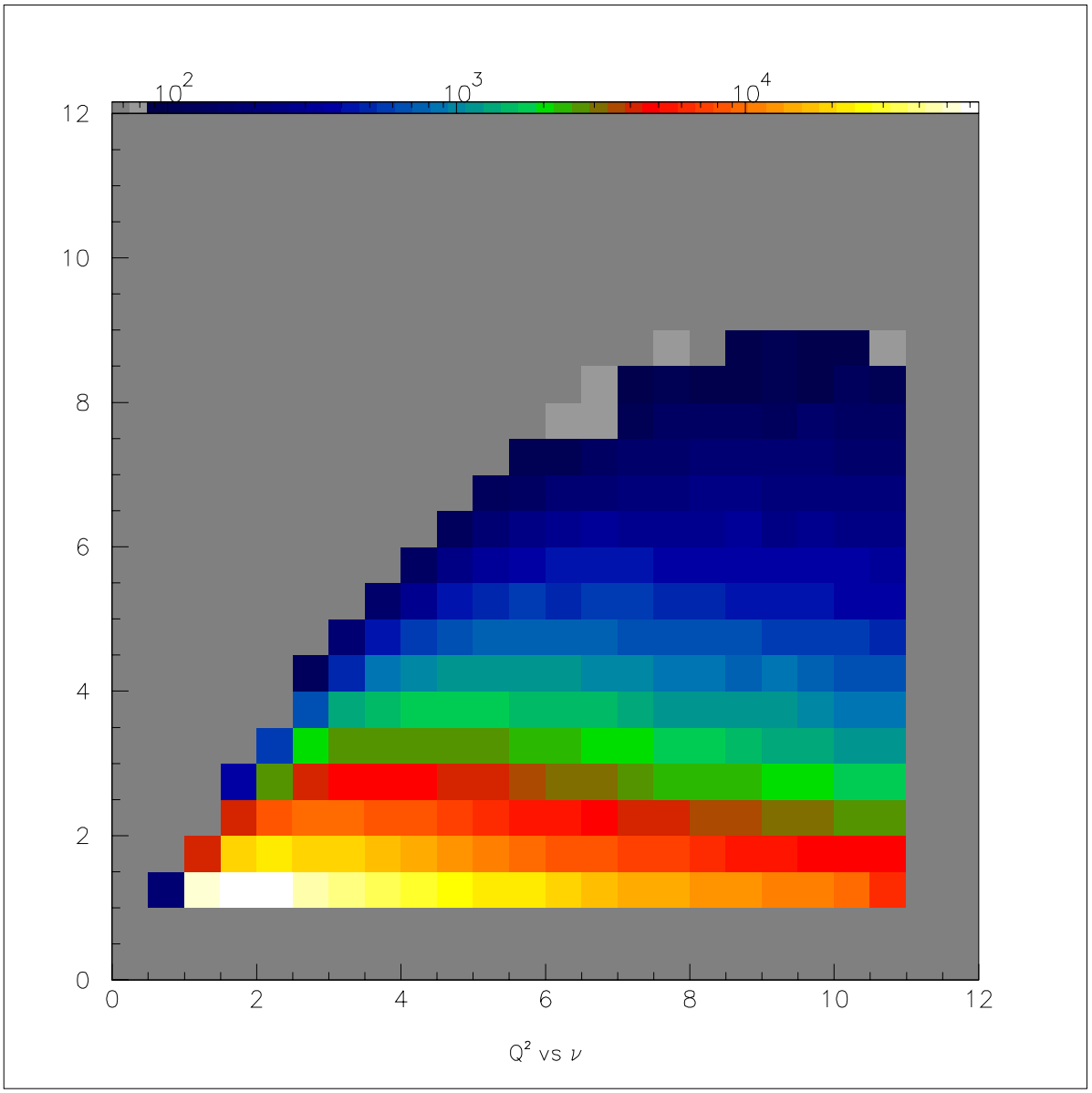
Multi-effects (gluon radiation, LPM, P_T broadening).

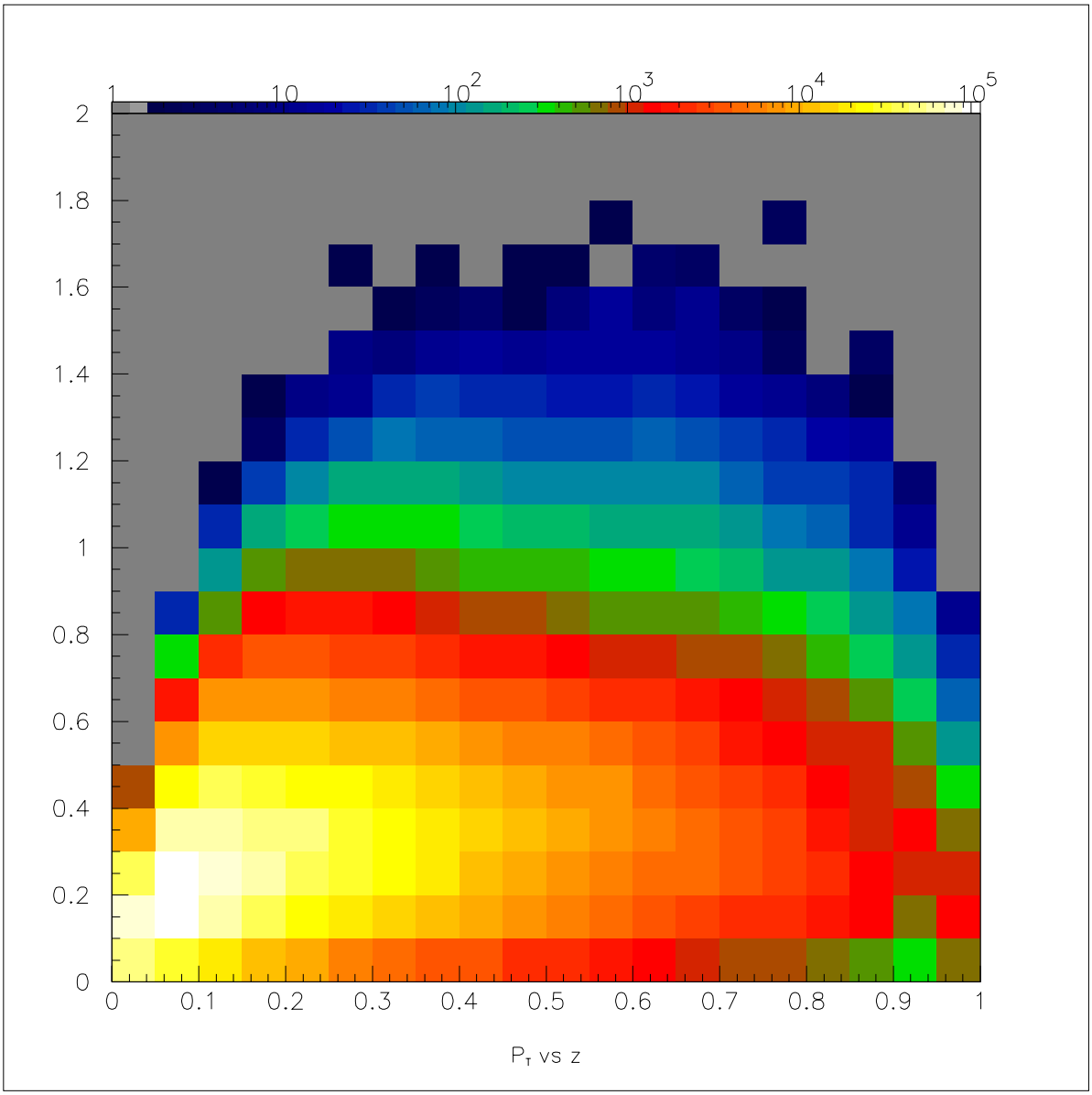
Requirements:

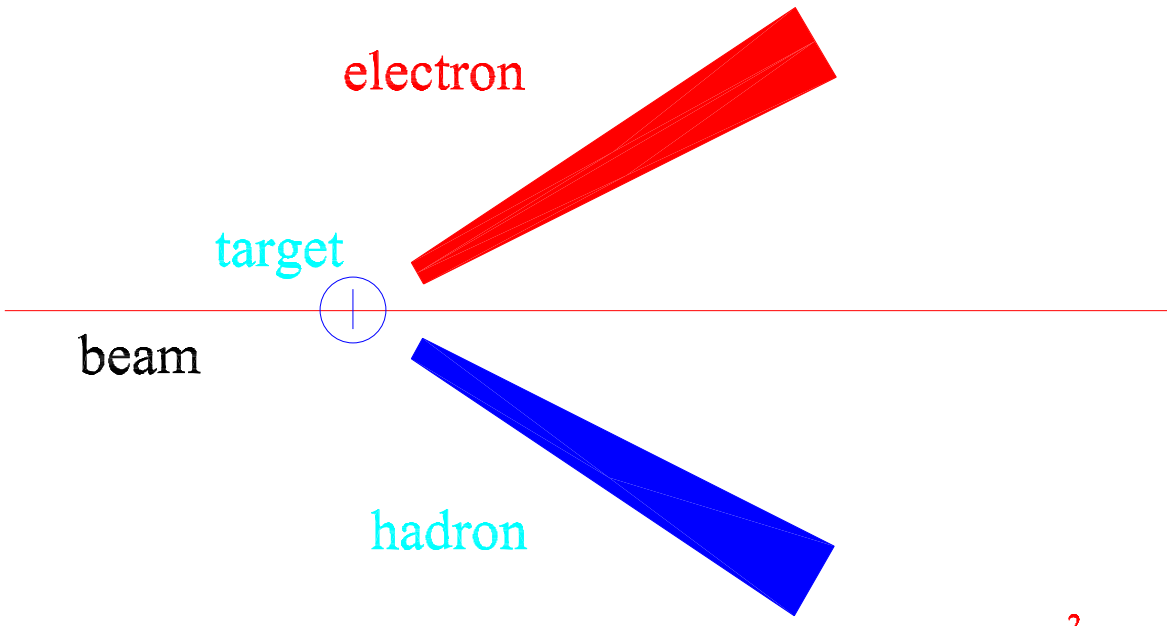
Higher Q^2 and larger Q^2 range;

Large $z = E_h/\nu$;

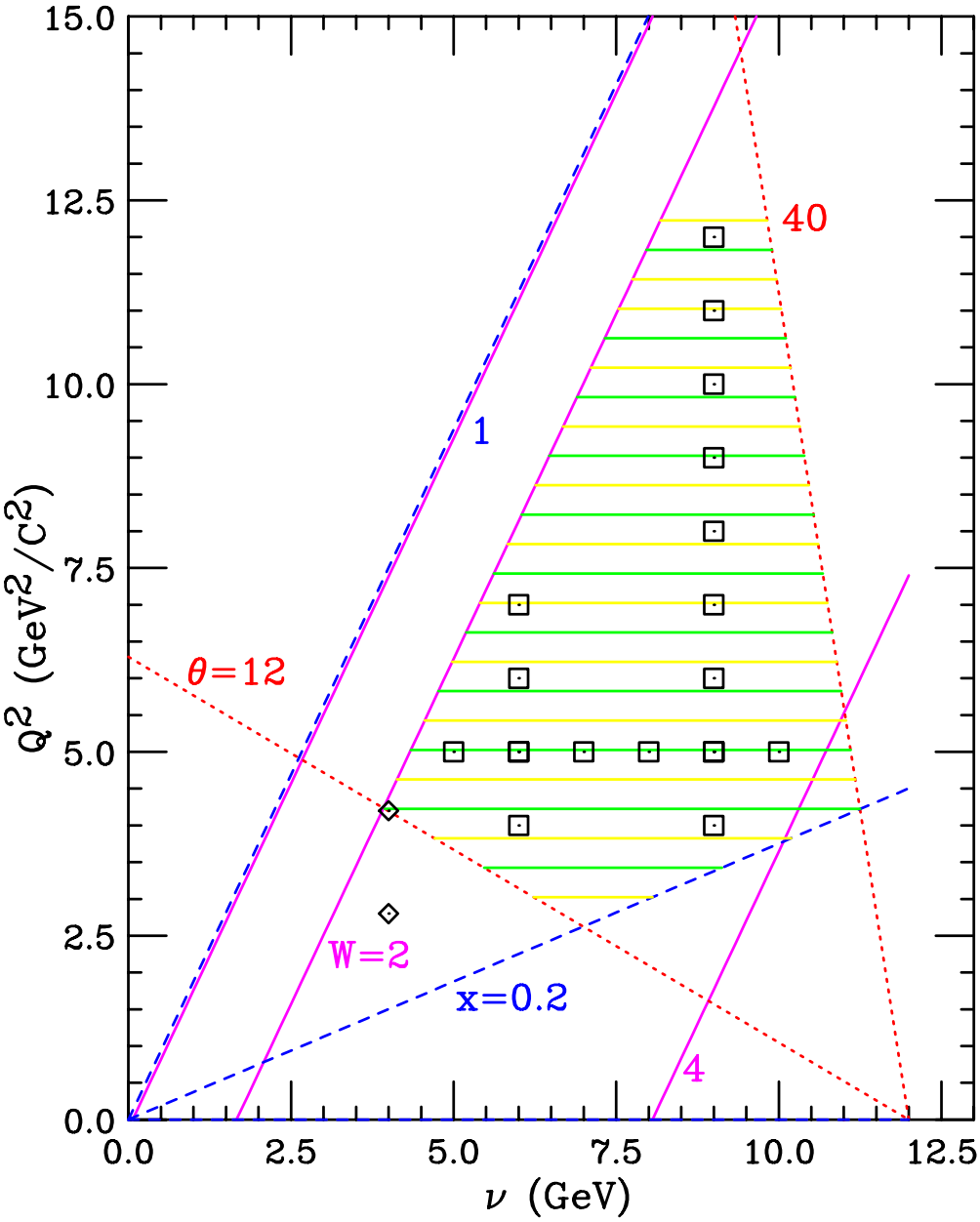
Particle ID.

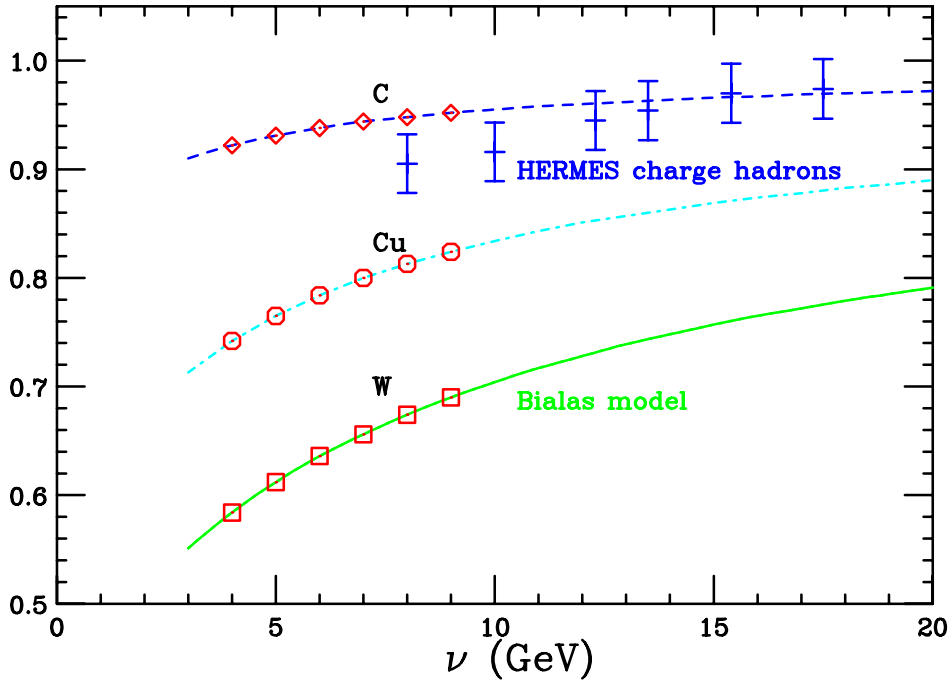

10^2
10^3
10^4
12
10
8
6
4
2
0
0
2
4
6
8
10
12
Q^2 vs ν


1
10
10^2
10^3
10^4
10^5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
P_T vs z



focus at high Q^2
focus at large z
P_T selection
π, K, p separation
high luminosity


15.0
12.5
10.0
7.5
5.0
2.5
0.0
0.0
2.5
5.0
7.5
10.0
12.5
Q^2 (GeV^2/c^2)
ν (GeV)
1
40
4
θ=12
W=2
x=0.2



Projected attenuation ratio $R(\nu)$ with 12 GeV beam, at different Q^2, z and PID;
HERMES data: z >0.5, all Q^2 and P_T (blue).

Summary:

Hadronization can be studied with small acceptance detectors by SIDIS from light to heavy nuclei at high Q^2, large z.

Select data at isolated high Q^2;
Select data at large z;
Select data at large P_T;

More sensitive to different effects;
More sensitive to the response of variable change.