SIDIS experiments on nuclear targets with upgraded JLab/ CLAS12

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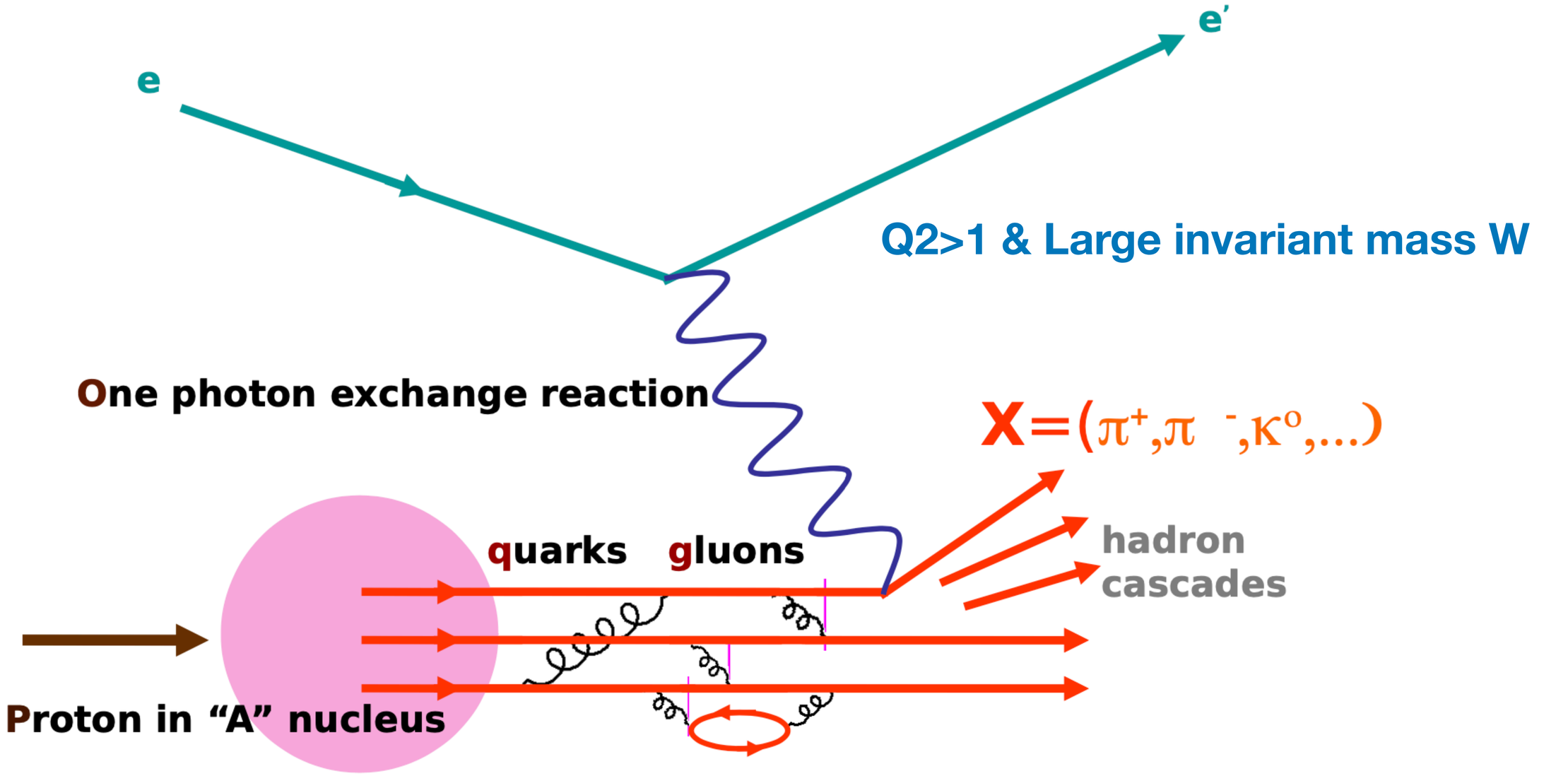
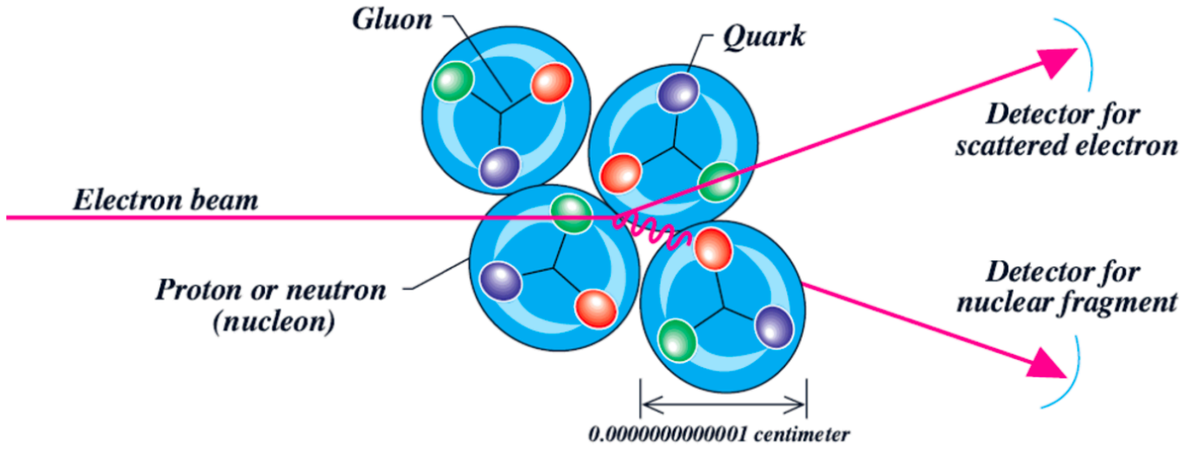
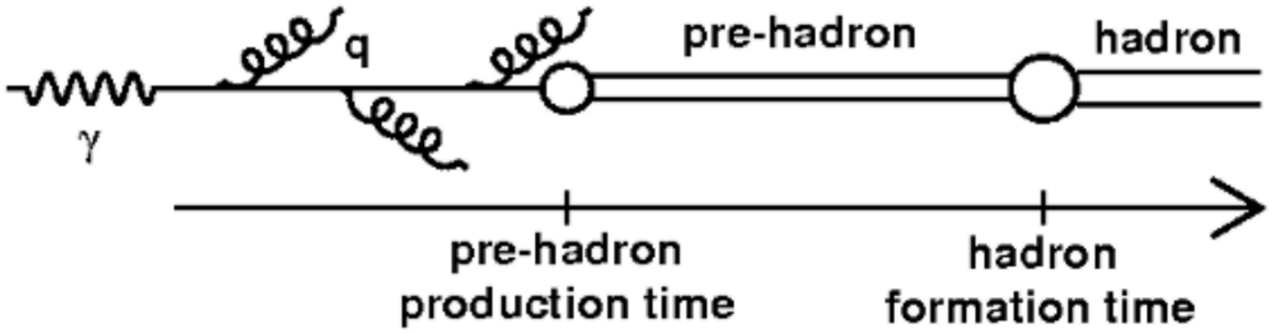
APCTP Focus Program in Nuclear Physics 2022:
Hadron Physics Opportunities with JLab Energy and Luminosity Upgrade,
Pohang, Republic of Korea, July 2022

Schematic diagram describing semi-inclusive Deep Inelastic Scattering of a lepton off a nucleon



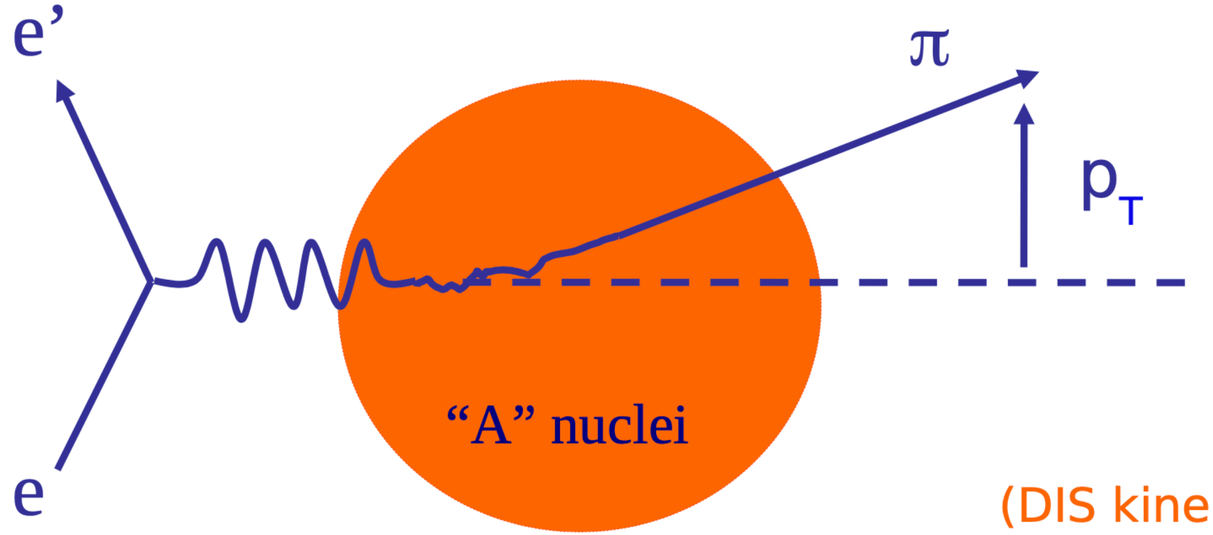


For a comprehensive study of the impact of the nuclear medium on quark hadronization, a multidimensional cinematical analysis of a variety of hadrons is required. Thus the color properties of the nuclear medium itself are revealed as well.



Experimental observables

Transverse momentum broadening: $\Delta p_T^2 = p_T^2(A) - p_T^2(^2H)$

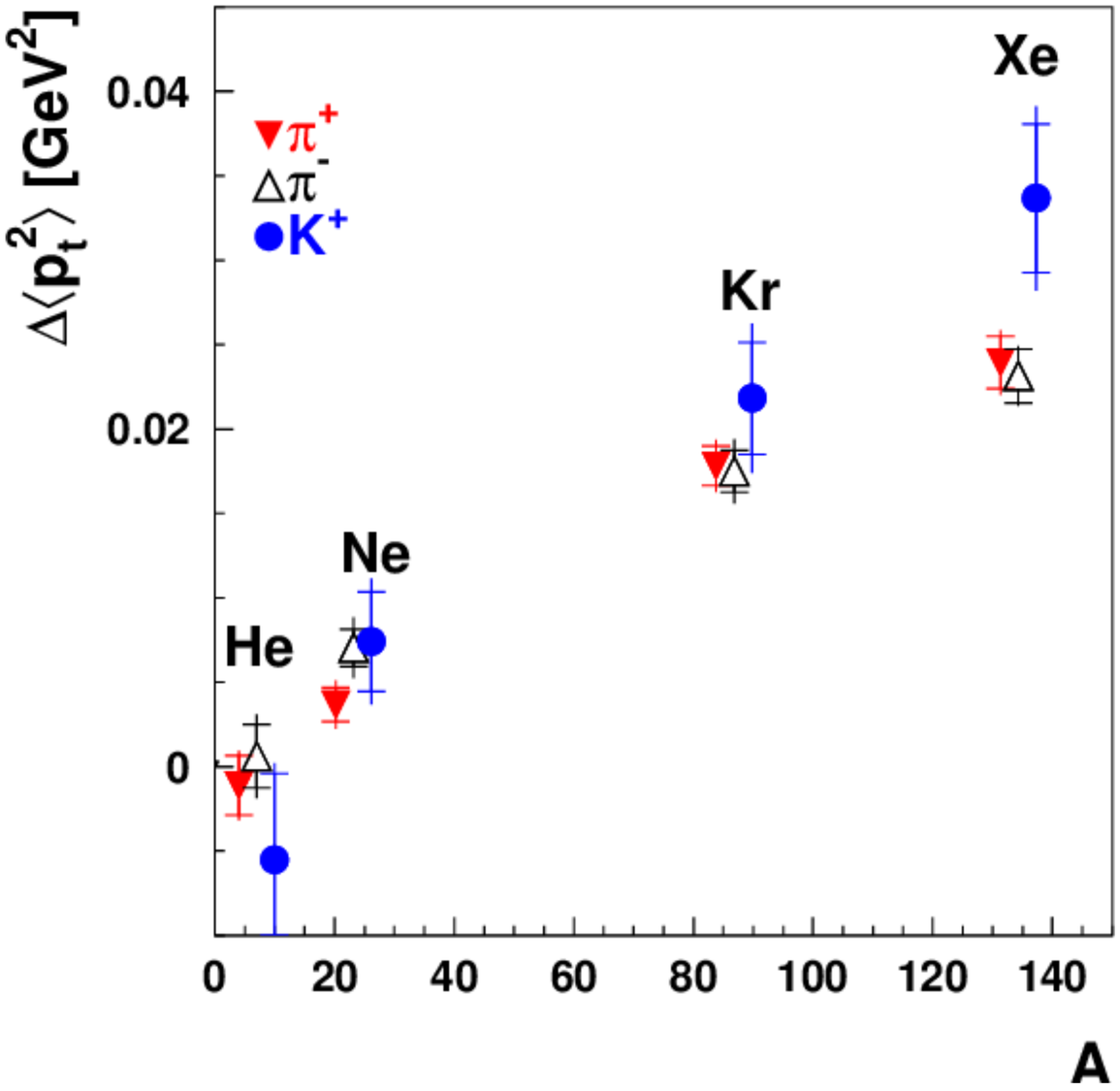


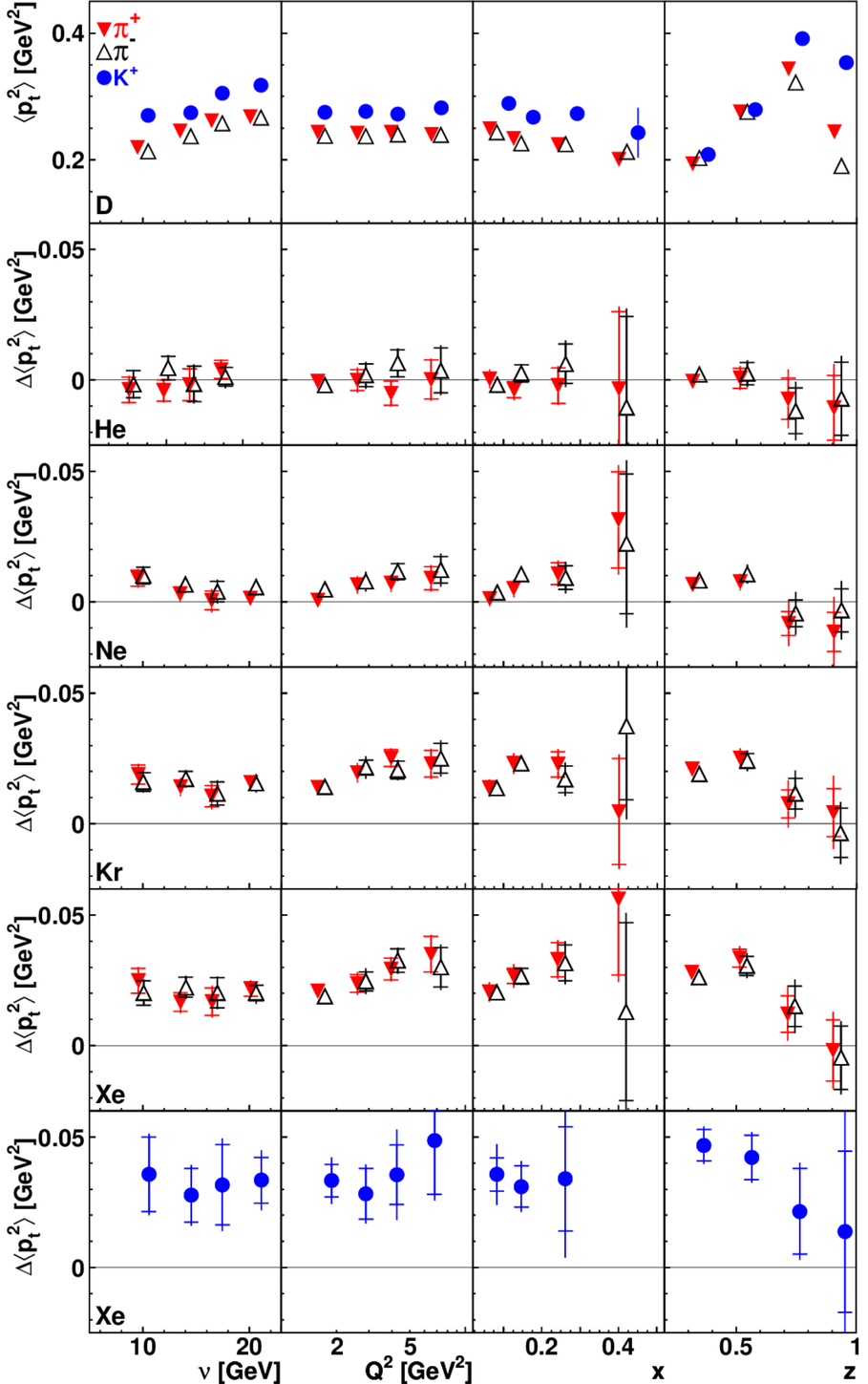
(DIS kinematics)

Hadronic multiplicity ratio:

$$R_M^h(z,\nu,p_T^2,Q^2,\phi) = \frac{\left\{ \frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_A}{\left\{ \frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_D}$$

Studies with HERMES on He, Ne, Kr, Xe





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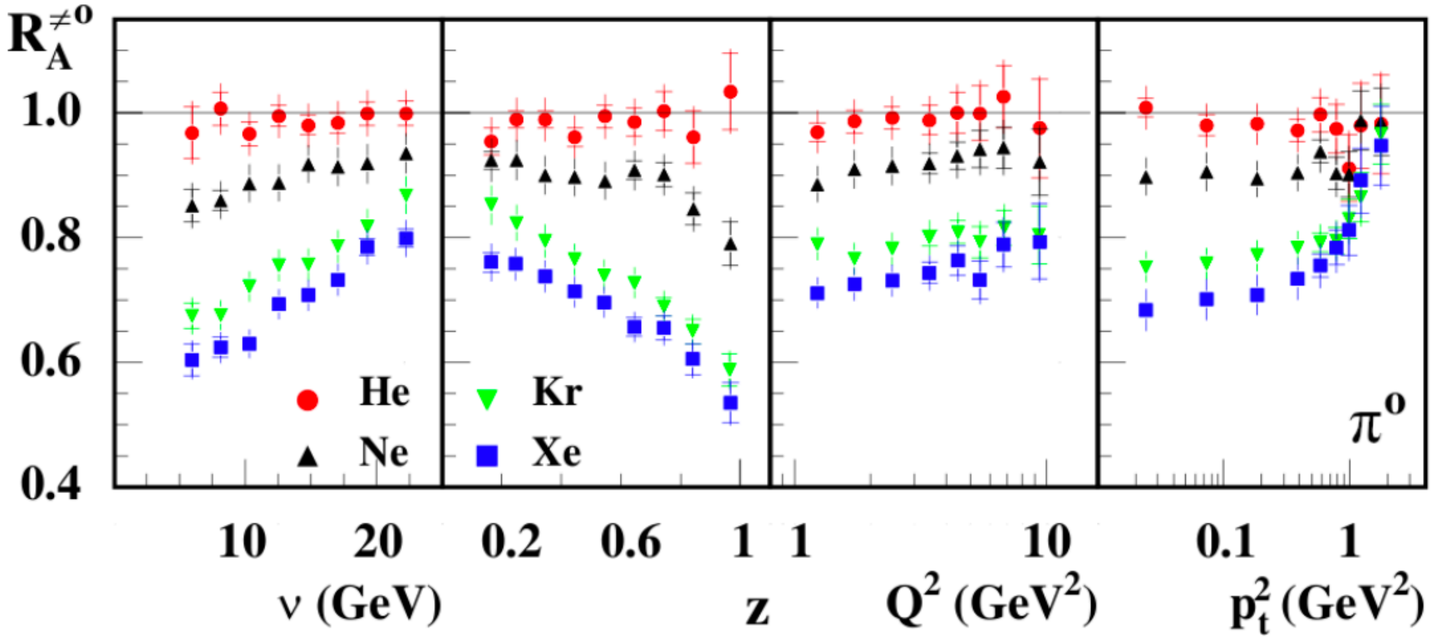
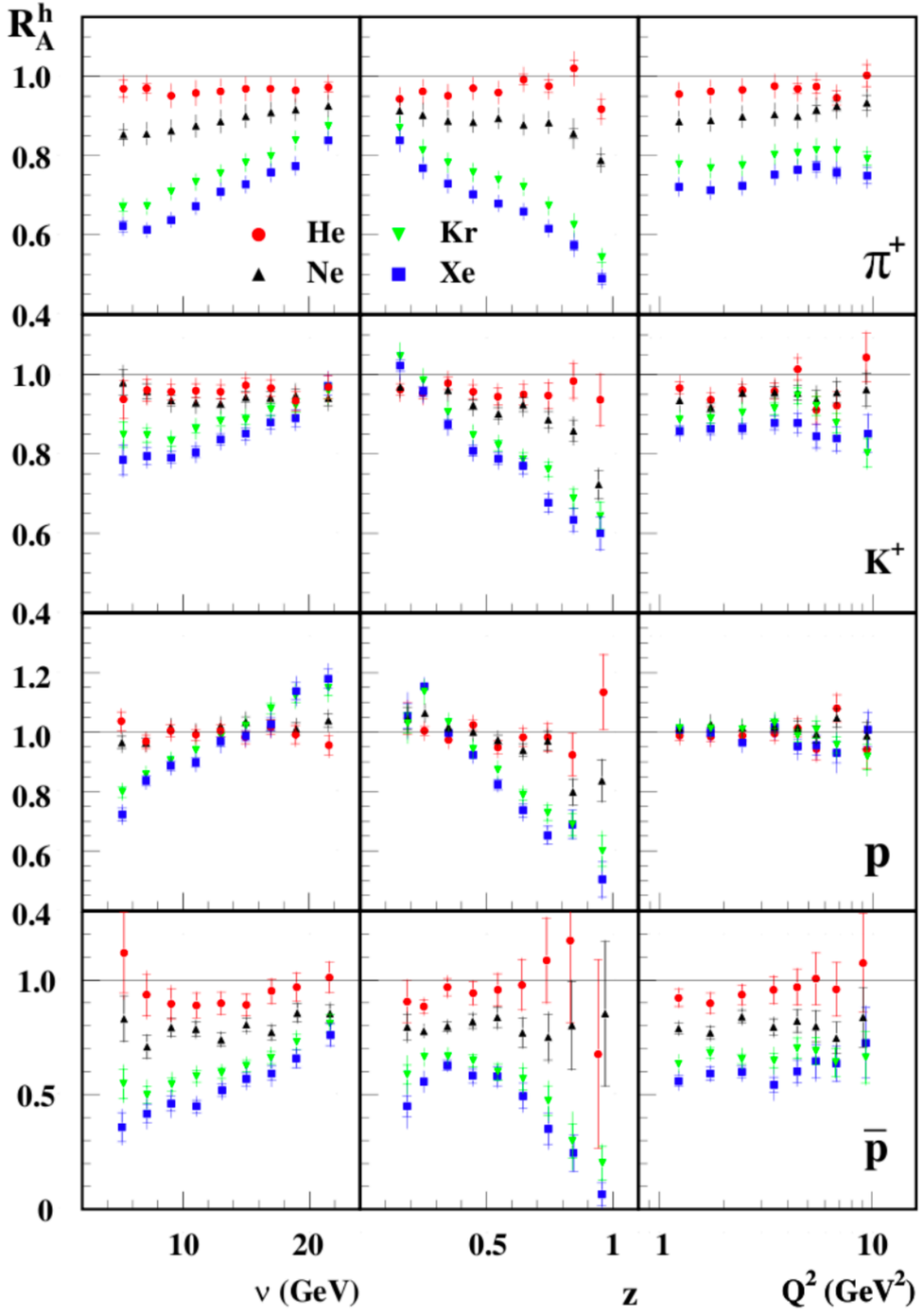
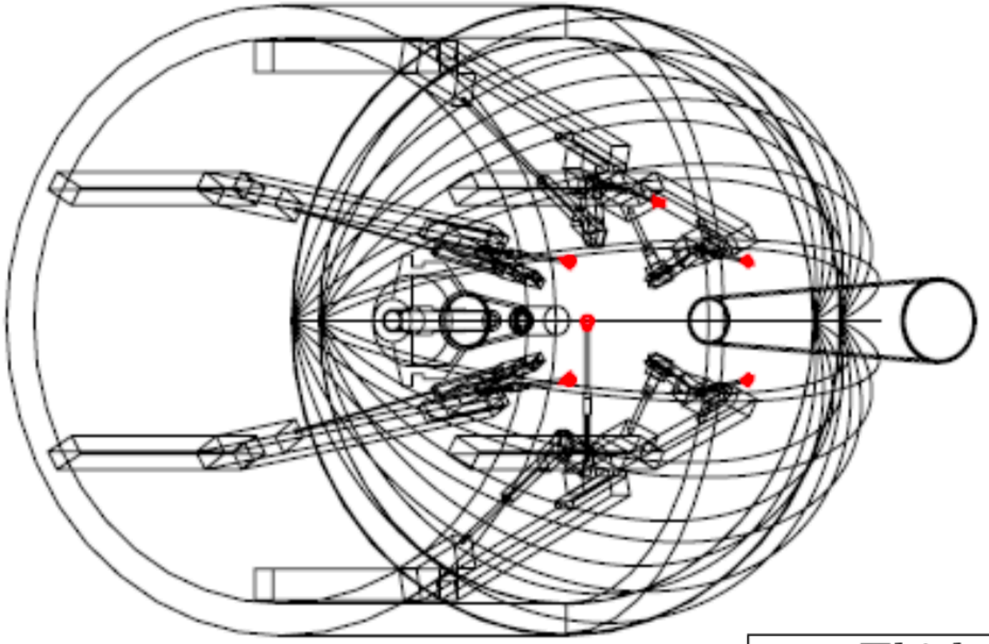
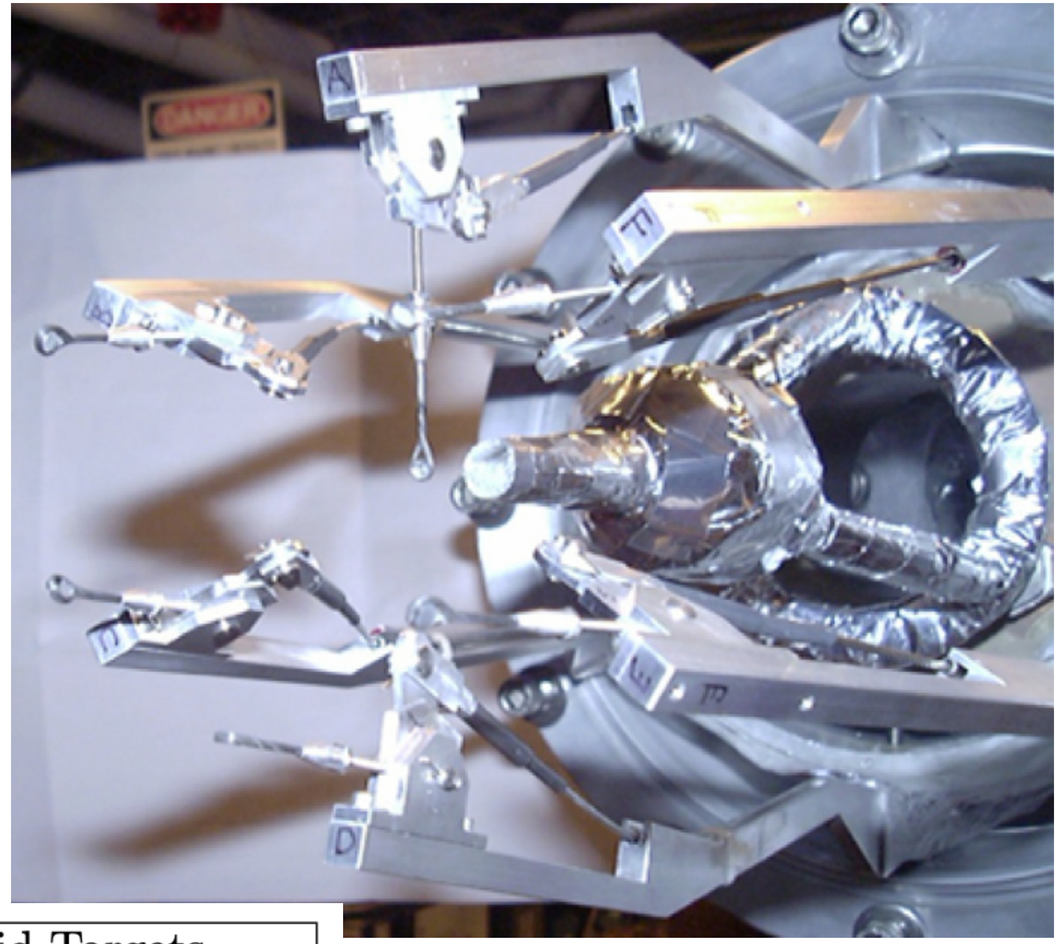




Eg2 Double-Target





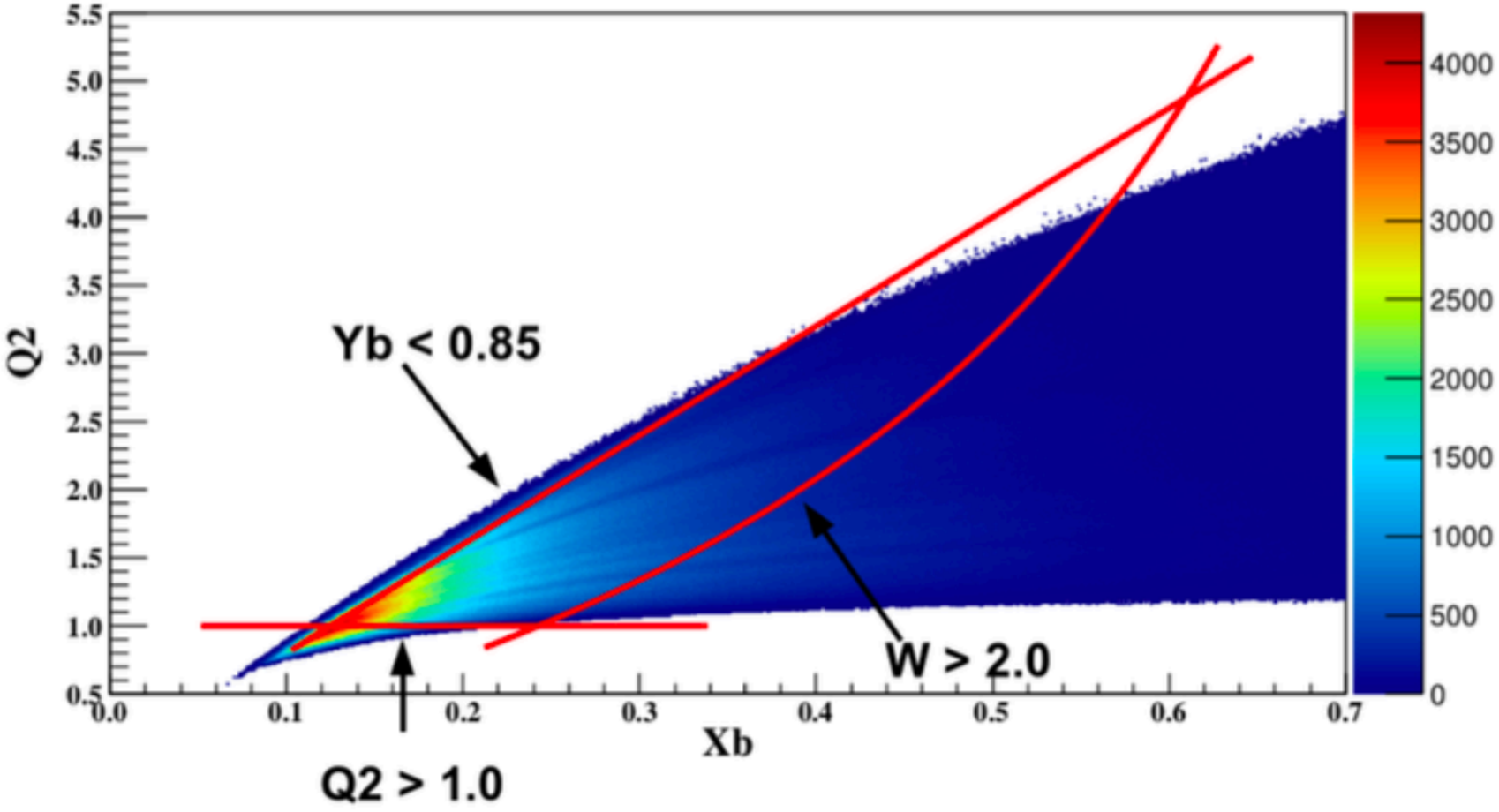
Thickness of Solid Targets		
Target	Thickness (cm)	ρ_A/ρ_D
C	0.17	0.894
Fe	0.04	0.949
Pb	0.014	0.478

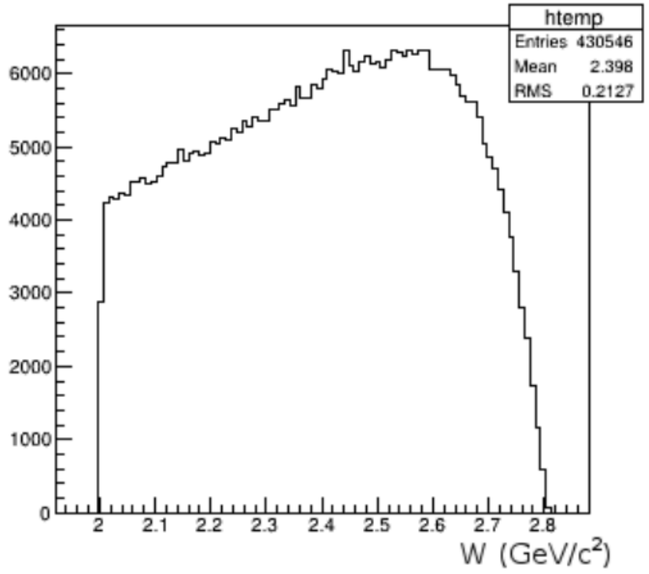
H. Hakobyan, W. Brooks et al, Nucl. Instrum. and Meth. A592:218-223, 2008.

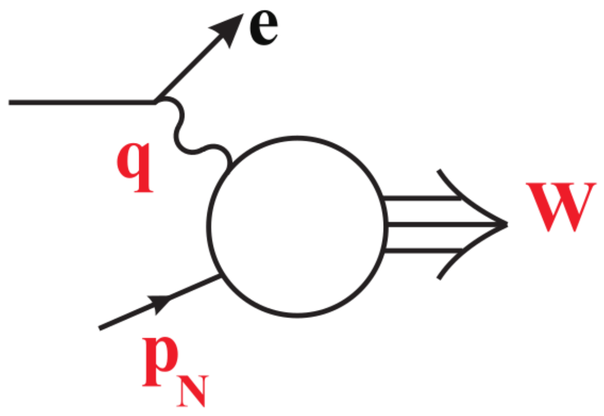
Studies performed with EG2 data

- Hadronization studies in nuclear medium
- Color transparency
- Short-Range Nuclear correlations
- Two-pion BEC correlations
- Dihadron supresión
- Etc.

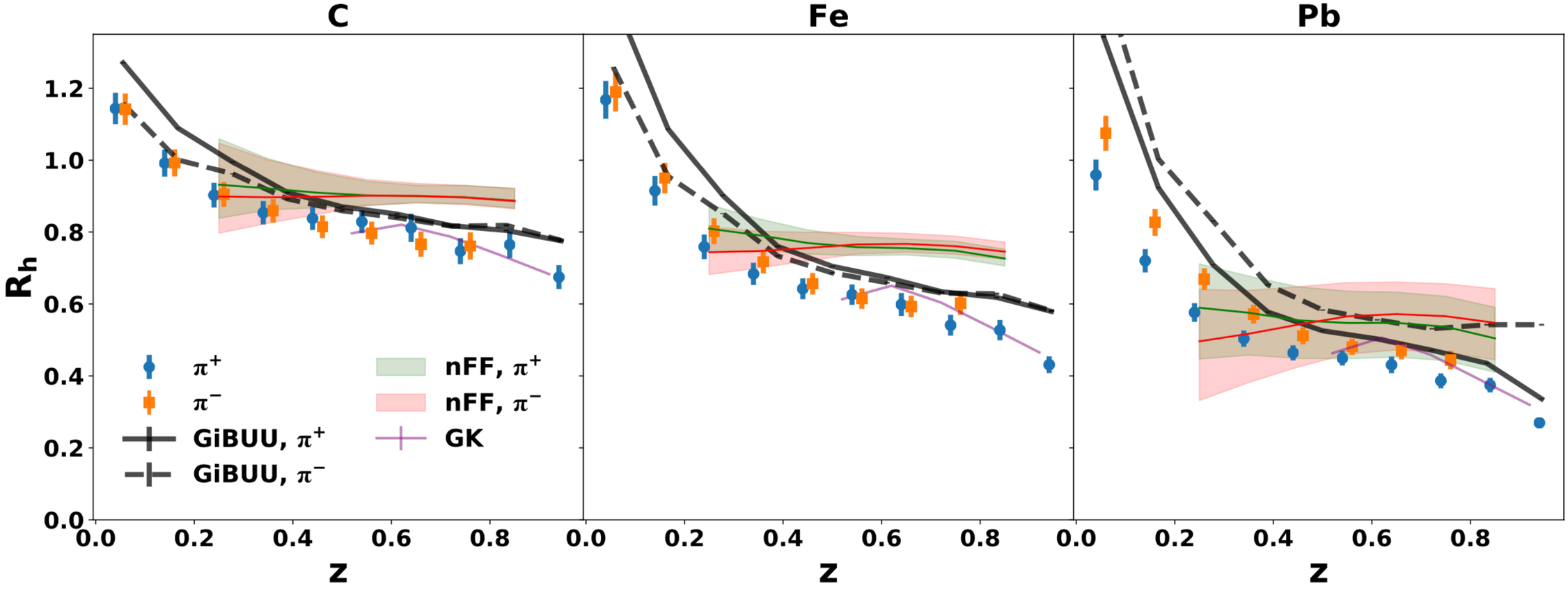
DIS cinematics on CLAS6





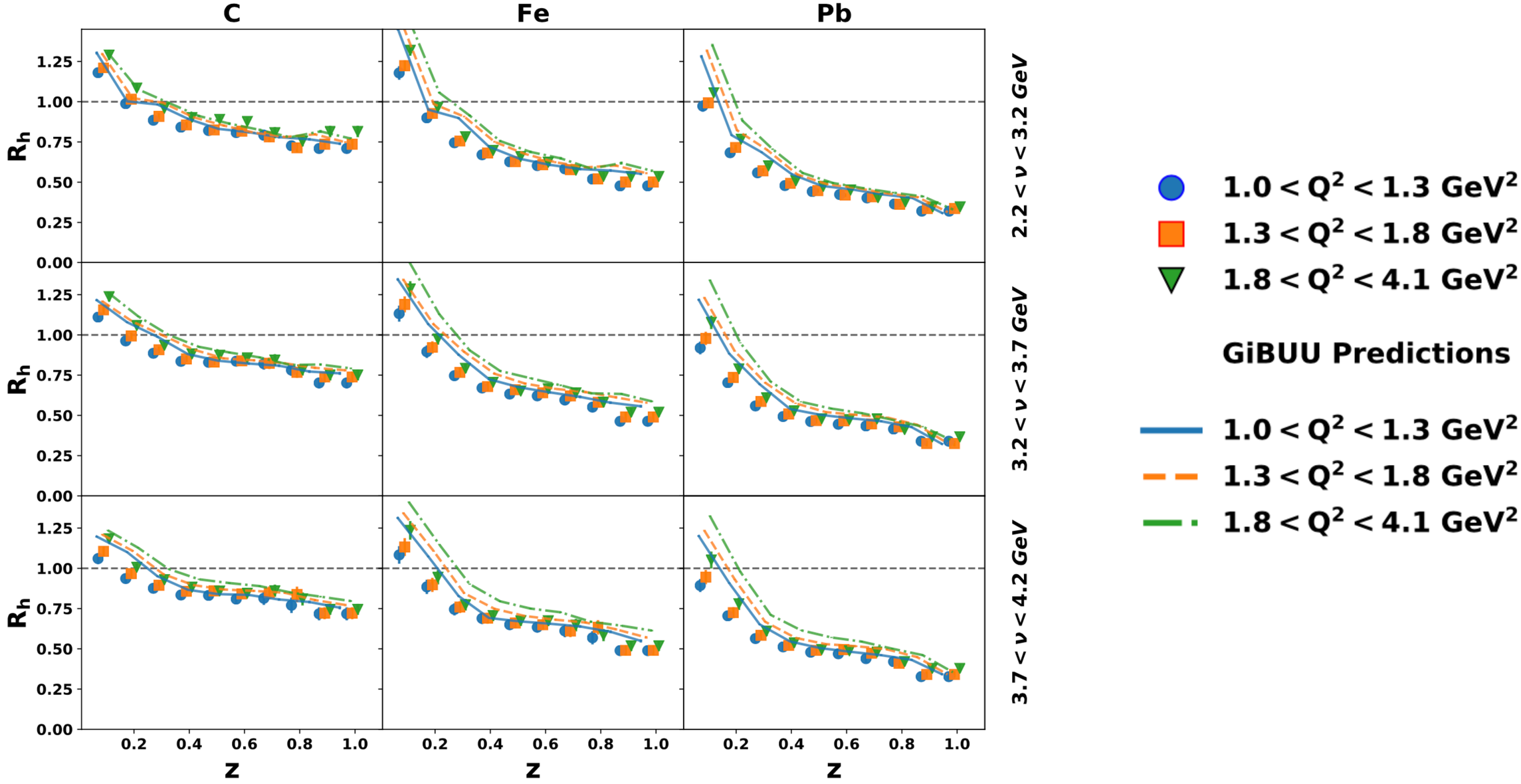


Charged pions - multiplicity ratio



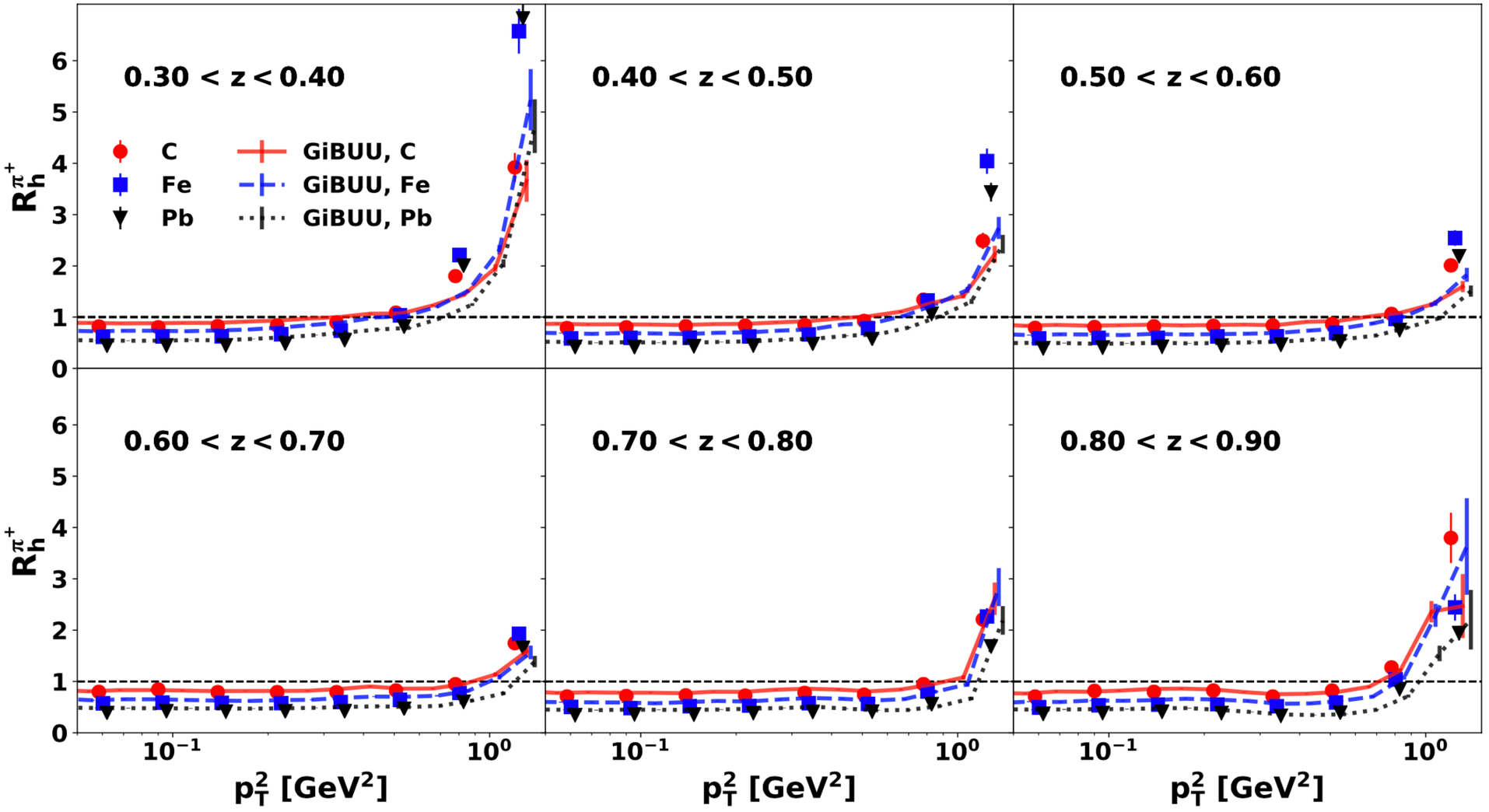
S. Moran, et al. (CLAS collaboration). Phys. Rev. C **105**, 015201 – January, 2022

Charged pions - multiplicity ratio - multidimensional



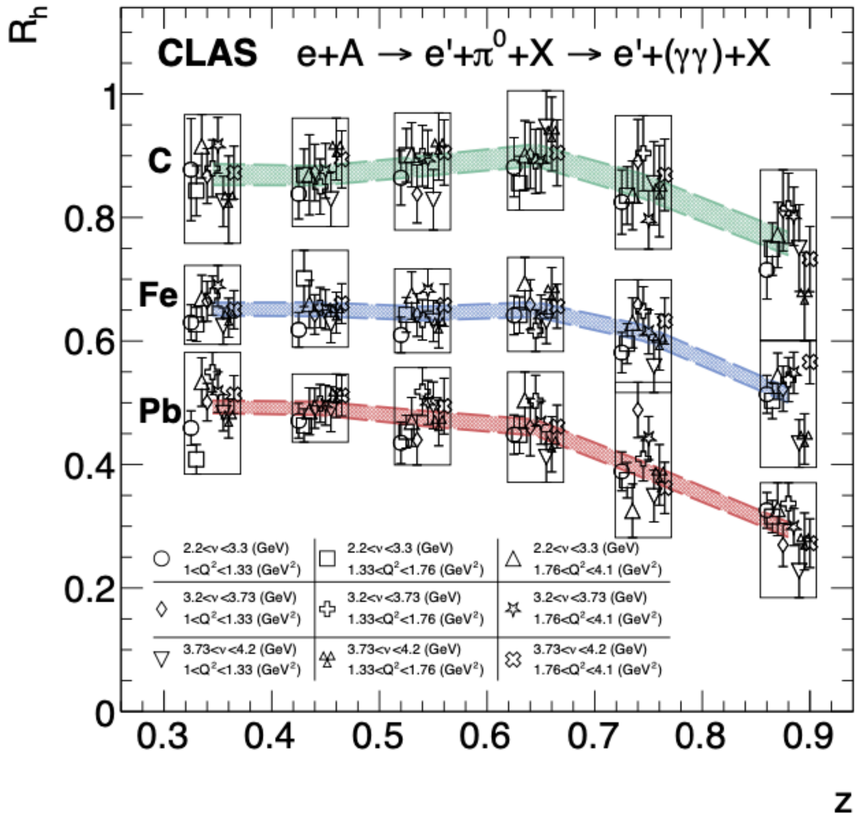
S. Moran, et al. (CLAS collaboration). Phys. Rev. C **105**, 015201 – January, 2022

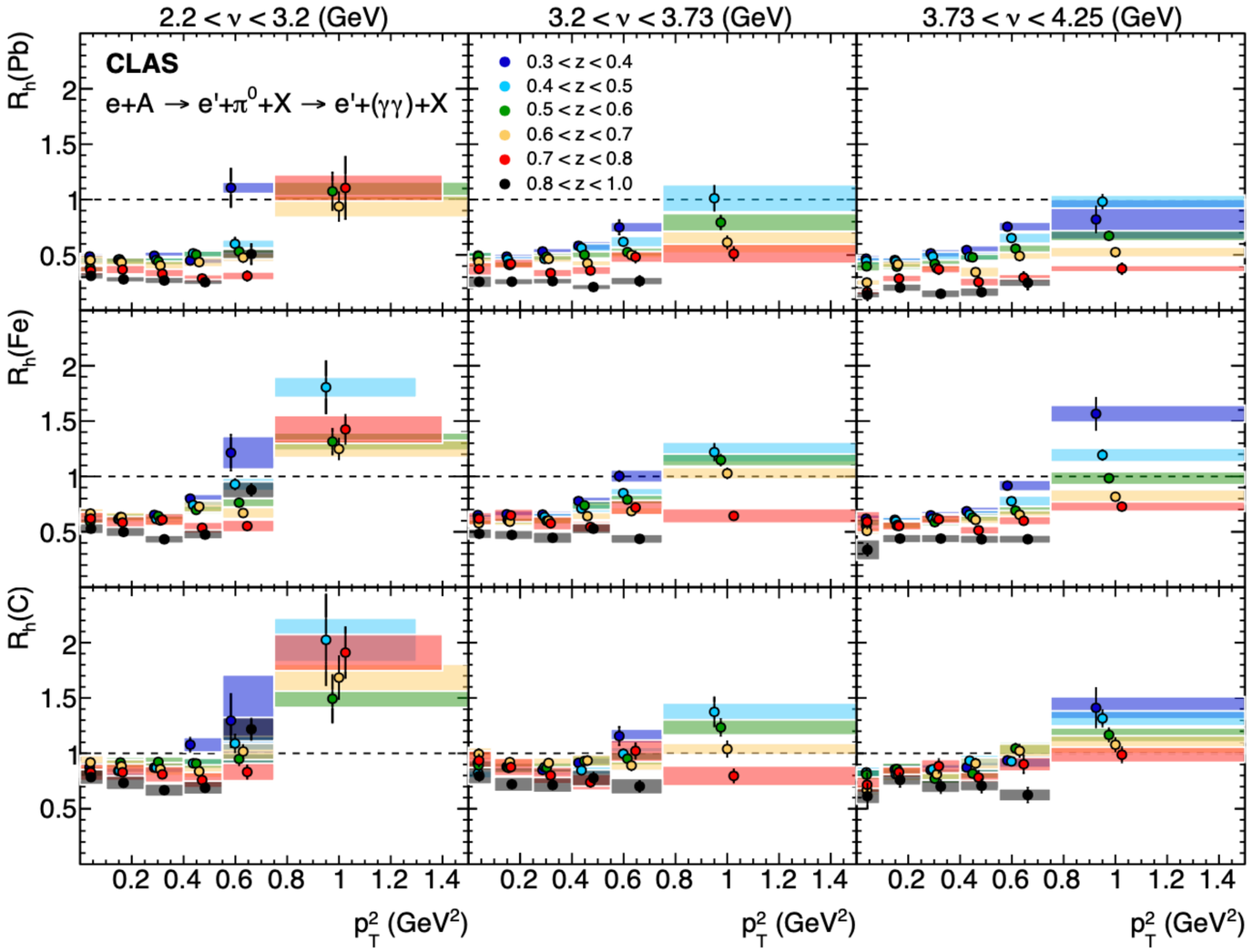
Charged pions - ‘Cronin Effect’ - positive pions



S. Moran, et al. (CLAS collaboration). Phys. Rev. C **105**, 015201 – January, 2022

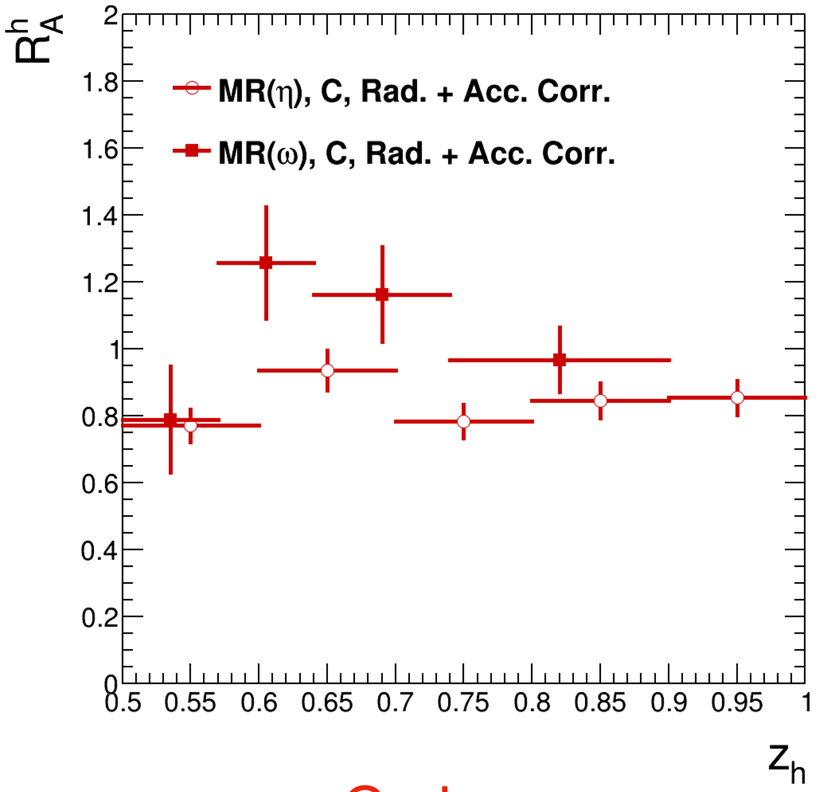
Neutral Pions



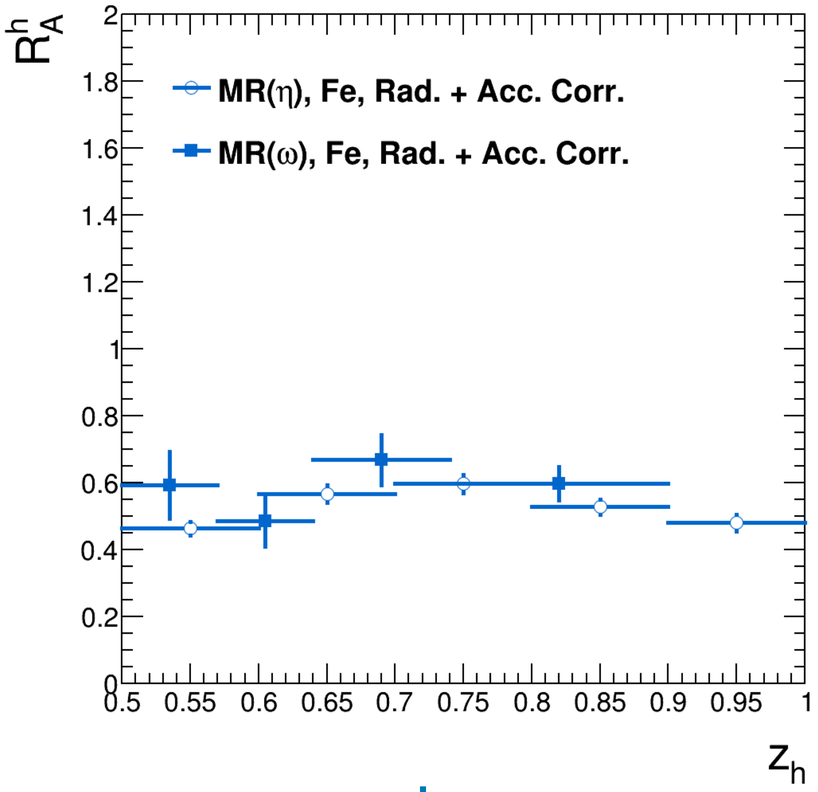


Tayisia Mineeva et al. approved analysis note.

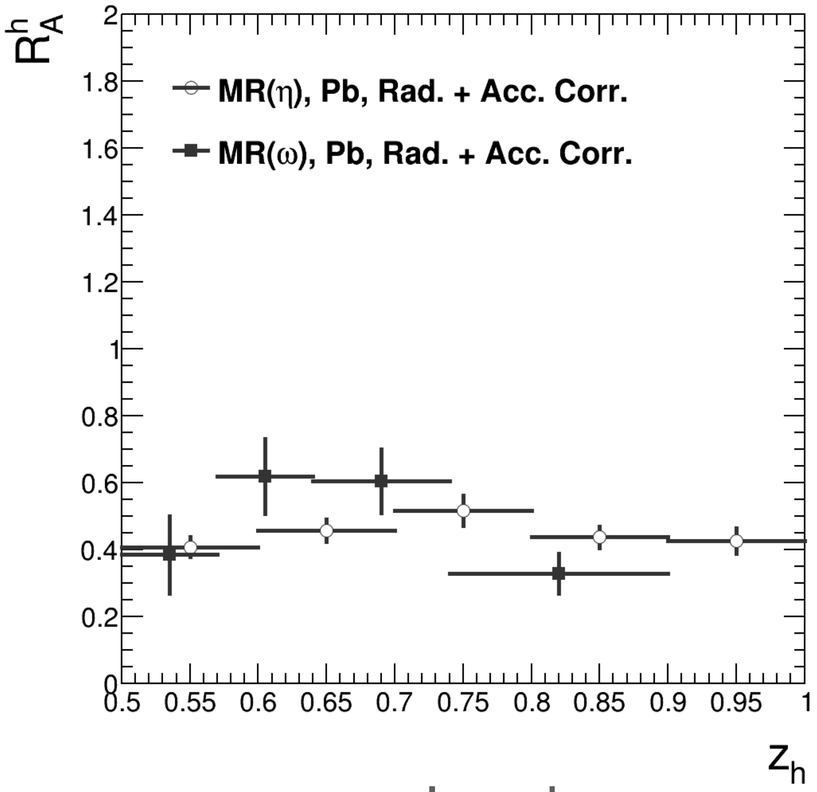
Etas and Omegas



Carbon



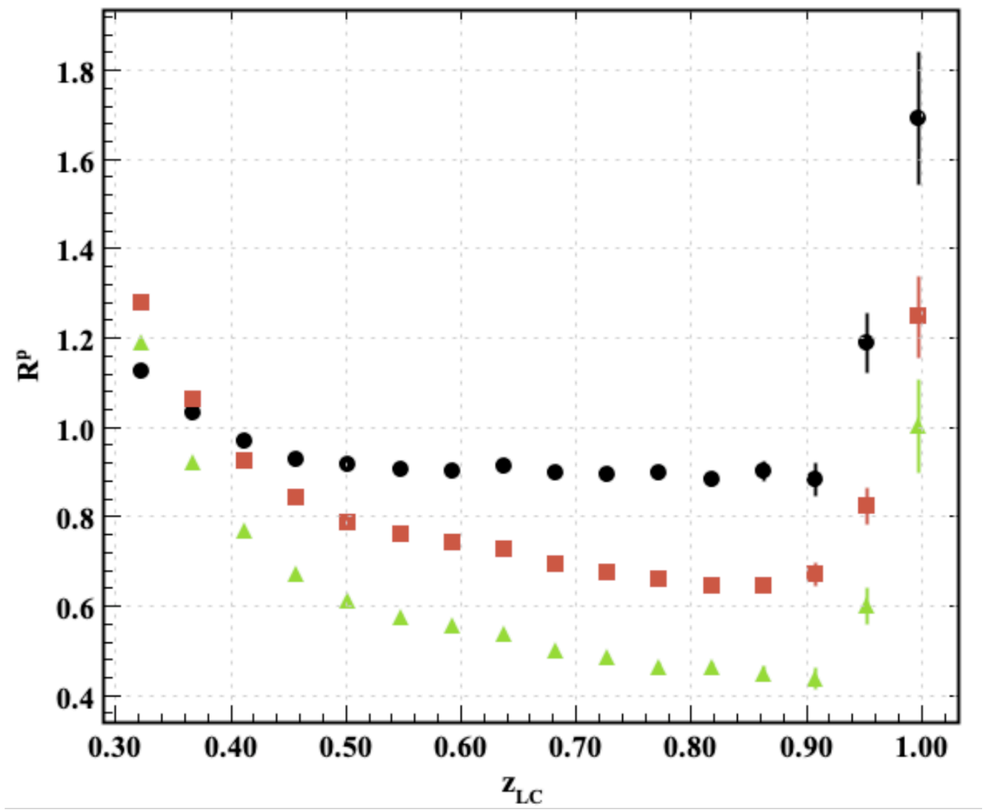
Iron



Lead

Andres Borquez, Orlando Soto et al. analysis note.

Multiplicity Ration on protons as a function of Z_{LC}



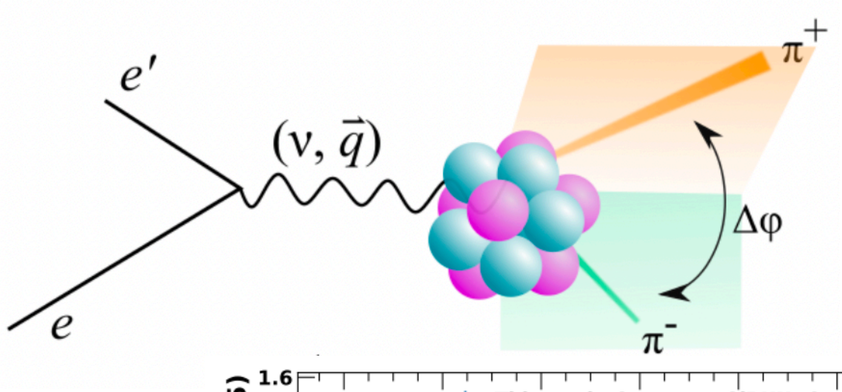
CLAS Preliminary Plot from Michael Wood

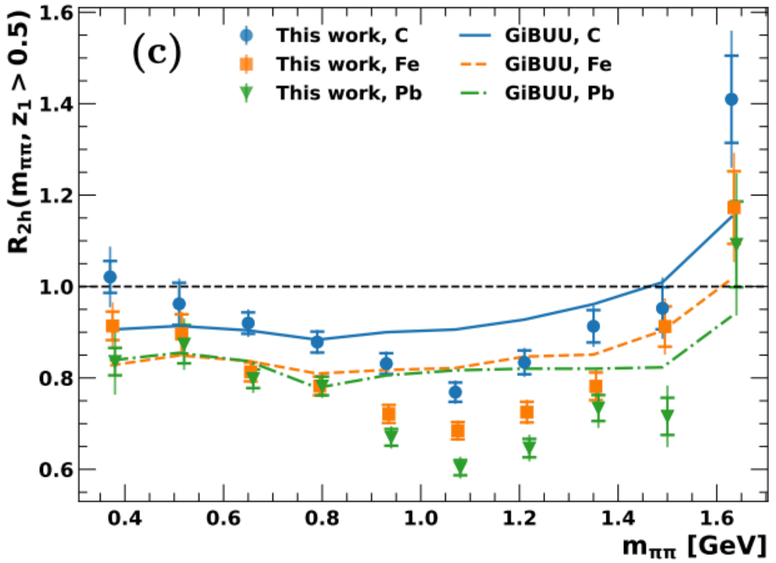
● C

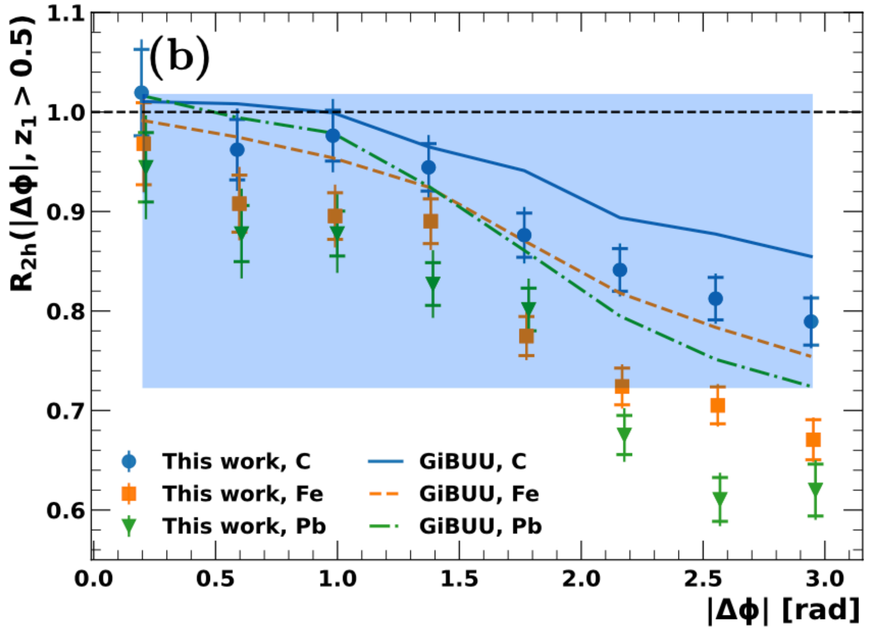
■ Fe

▲ Pb

Multihadron events studies: Two-hadron azimuthal correlations



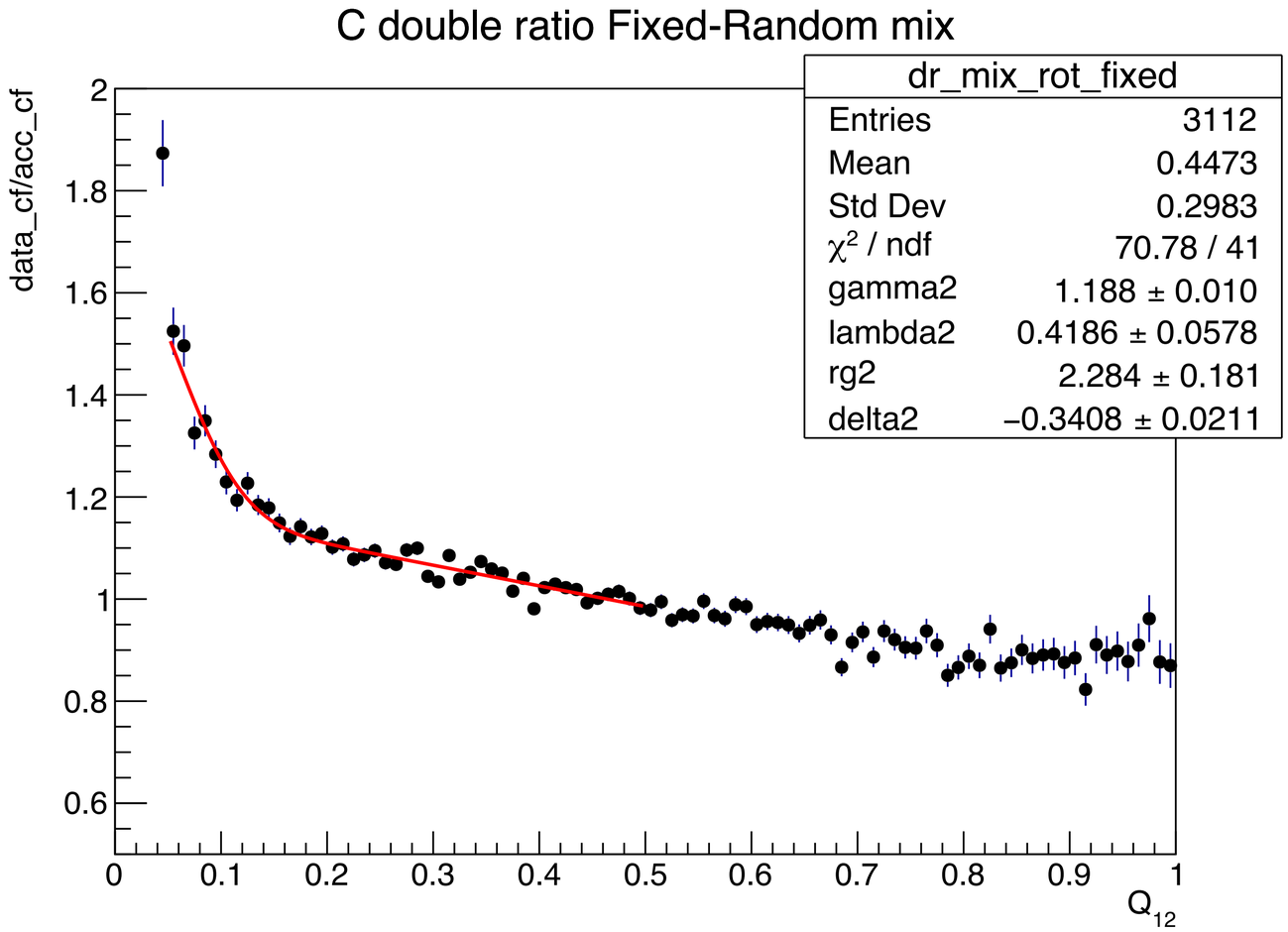




S.J. Paul , etc. https://arxiv.org/abs/2207.06682

"Observation of azimuth-dependent suppression of hadron pairs in electron scattering off nuclei."

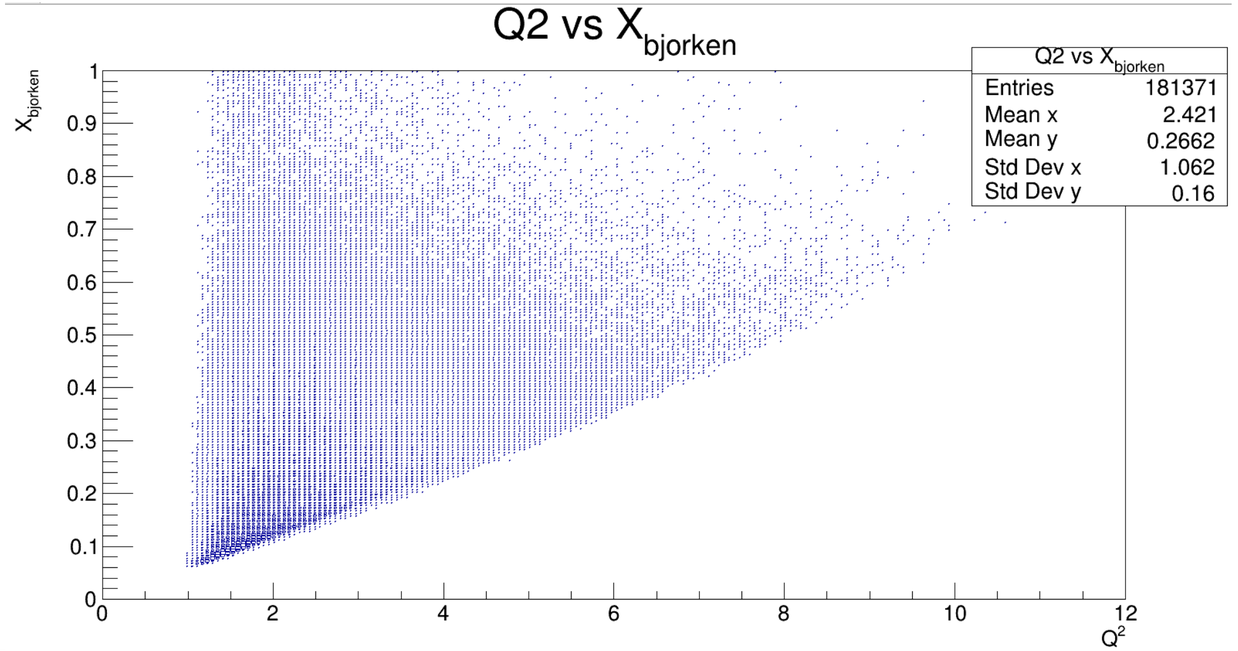
Multihadron events studies: Two-pion BEC correlations

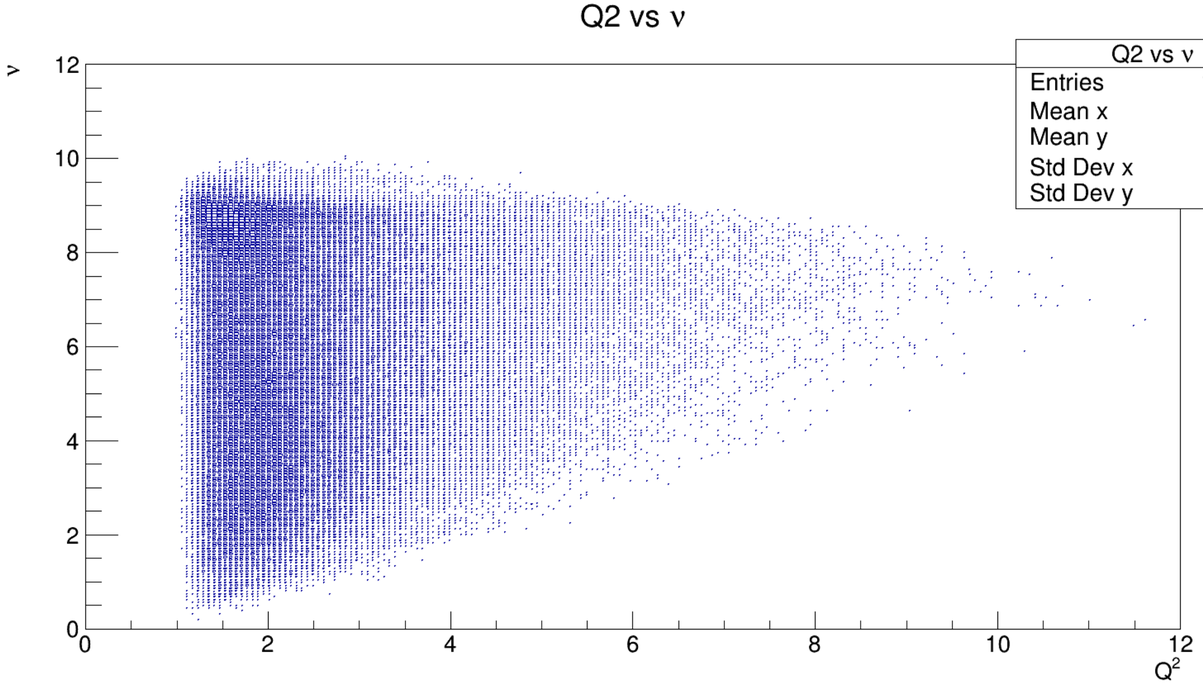


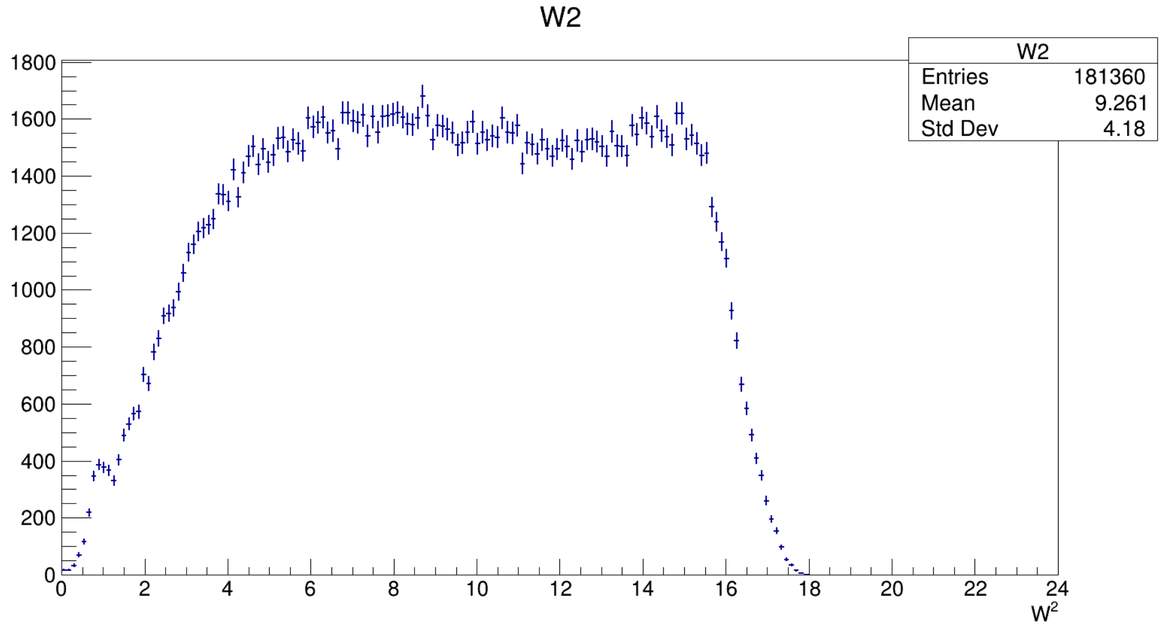
Antonio Radic et al. analysis note.

12 GeV cinematics

Data from RGF experiment





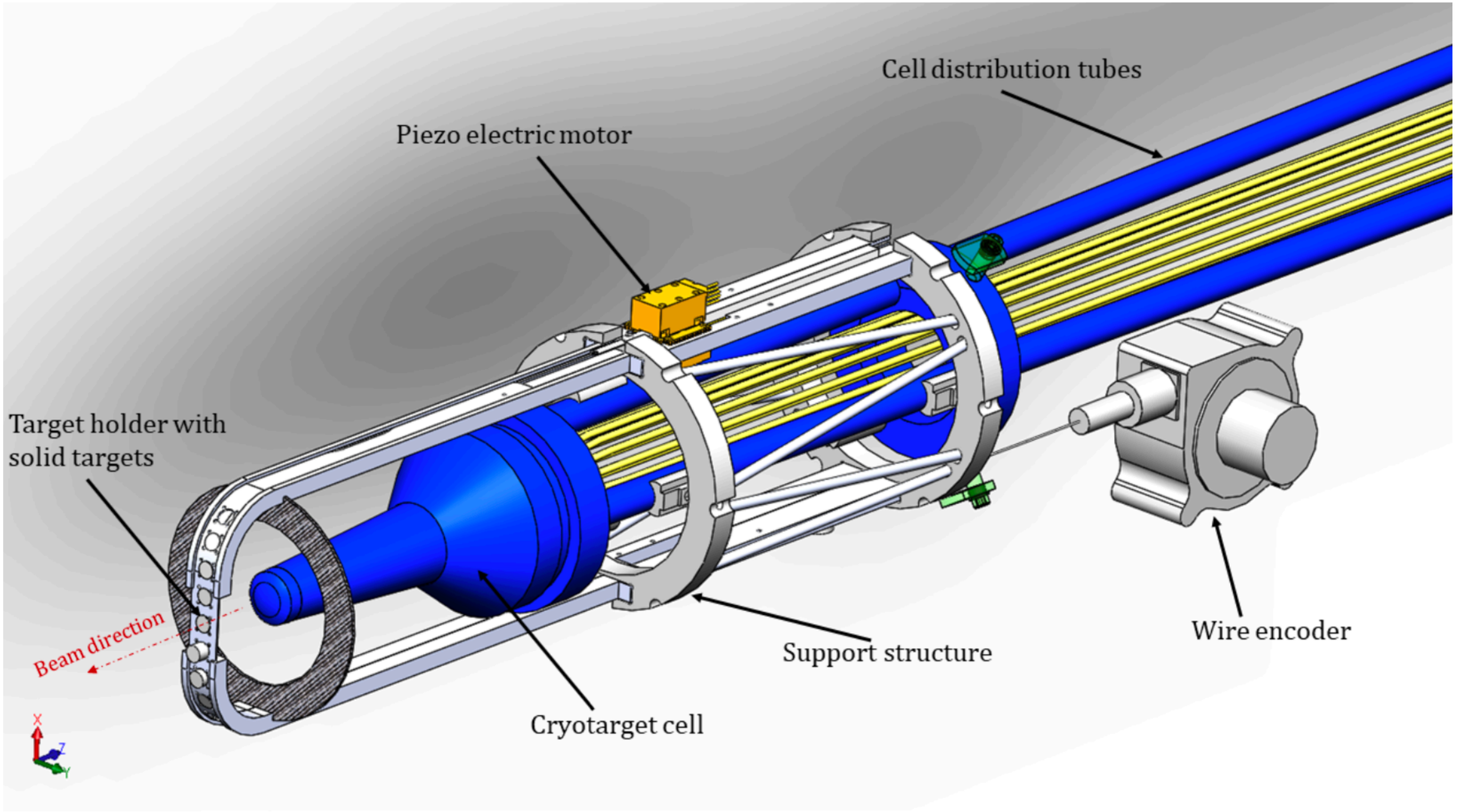


hadron	$c\tau$	mass (GeV)	flavor content	detection channel	Production rate per 1k DIS events
π^0	25 nm	0.13	$u\bar{u}d\bar{d}$	$\gamma\gamma$	1100
π^+	7.8 m	0.14	$u\bar{d}$	direct	1000
π^-	7.8 m	0.14	$d\bar{u}$	direct	1000
η	0.17 nm	0.55	$u\bar{u}d\bar{d}s\bar{s}$	$\gamma\gamma$	120
ω	23 fm	0.78	$u\bar{u}d\bar{d}s\bar{s}$	$\pi^+\pi^-\pi^0$	170
η'	0.98 pm	0.96	$u\bar{u}d\bar{d}s\bar{s}$	$\pi^+\pi^-\eta$	27
ϕ	44 fm	1.0	$u\bar{u}d\bar{d}s\bar{s}$	K^+K^-	0.8
$f1$	8 fm	1.3	$u\bar{u}d\bar{d}s\bar{s}$	$\pi\pi\pi\pi$	-
K^+	3.7 m	0.49	$u\bar{s}$	direct	75
K^-	3.7 m	0.49	$\bar{u}s$	direct	25
K^0	27 mm	0.50	$d\bar{s}$	$\pi^+\pi^-$	42
p	stable	0.94	ud	direct	530
$\bar{p}$	stable	0.94	$\bar{u}\bar{d}$	direct	3
Λ	79 mm	1.1	uds	$p\pi^-$	72
$\Lambda(1520)$	13 fm	1.5	uds	$p\pi^-$	-
Σ^+	24 mm	1.2	us	$p\pi^0$	6
Σ^0	22 pm	1.2	uds	$\Lambda\gamma$	11
Ξ^0					
Ξ^-	49 mm	1.3	ds	$\Lambda\pi$	0.9

With new Eg2 target, designed and built in UTFSM

Hadrons in CLAS12

RGE Experiment (12 GeV)

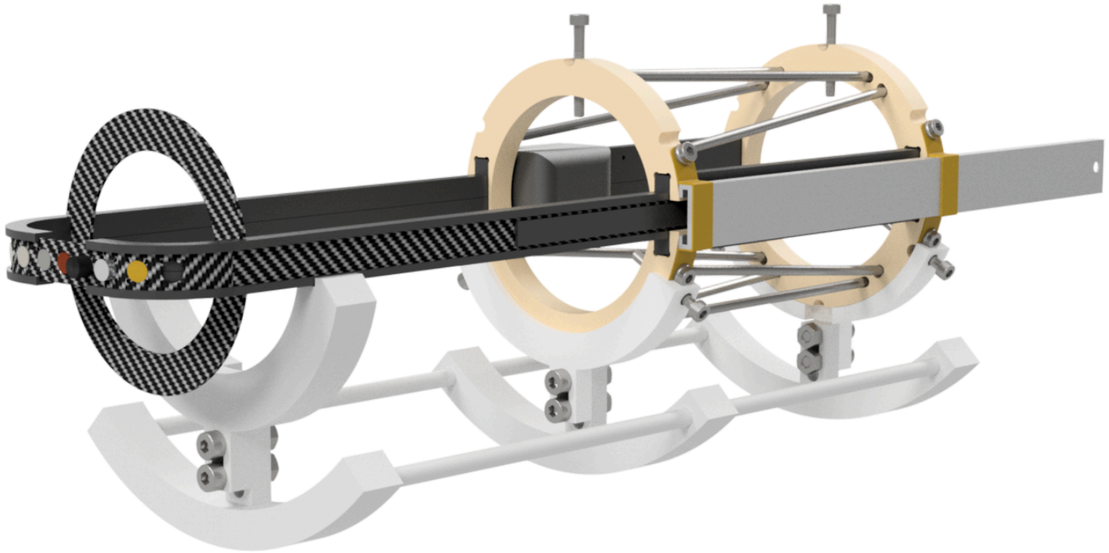


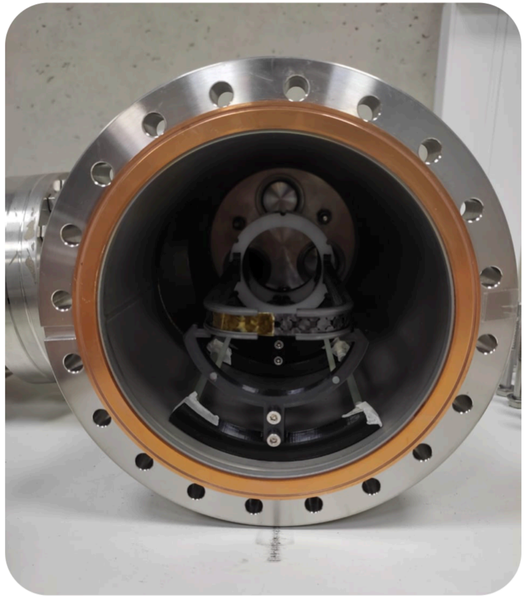
Requiremnts for it (targets + luminosity)

Target	PAC days	Beam current (nA) calculated by Milan U.	Luminosity (/cm²s)	Backup target in case of melting
Deuterium	4	32	1.00E+35	
Carbon	6	31	1.00E+35	
Aluminum	7	45	1.00E+35	
Copper	8	83	1.00E+35	
Tin	15	72	6.00E+34	Ag; 83*0.60 = 50 nA
Lead	18	108	6.50E+34	Au; 99*0.65 = 64 nA

JLab Target group will start working on the new cryotarget since July,
our engineers are on touch with them to adapt to new geometry requirements if necessary

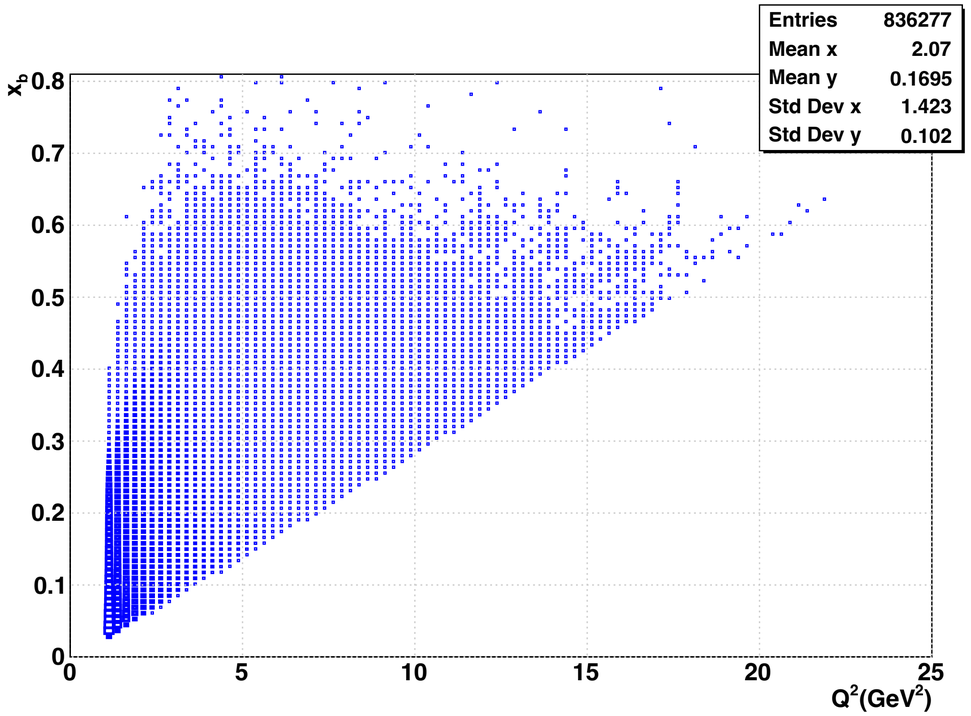
CLAS12 RGE experiment

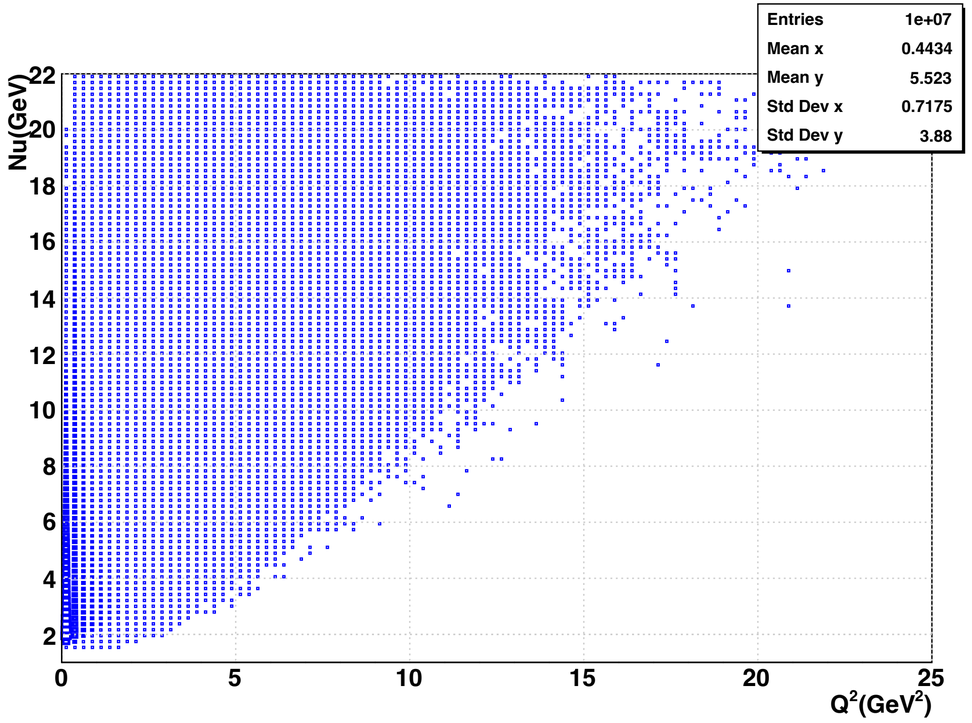


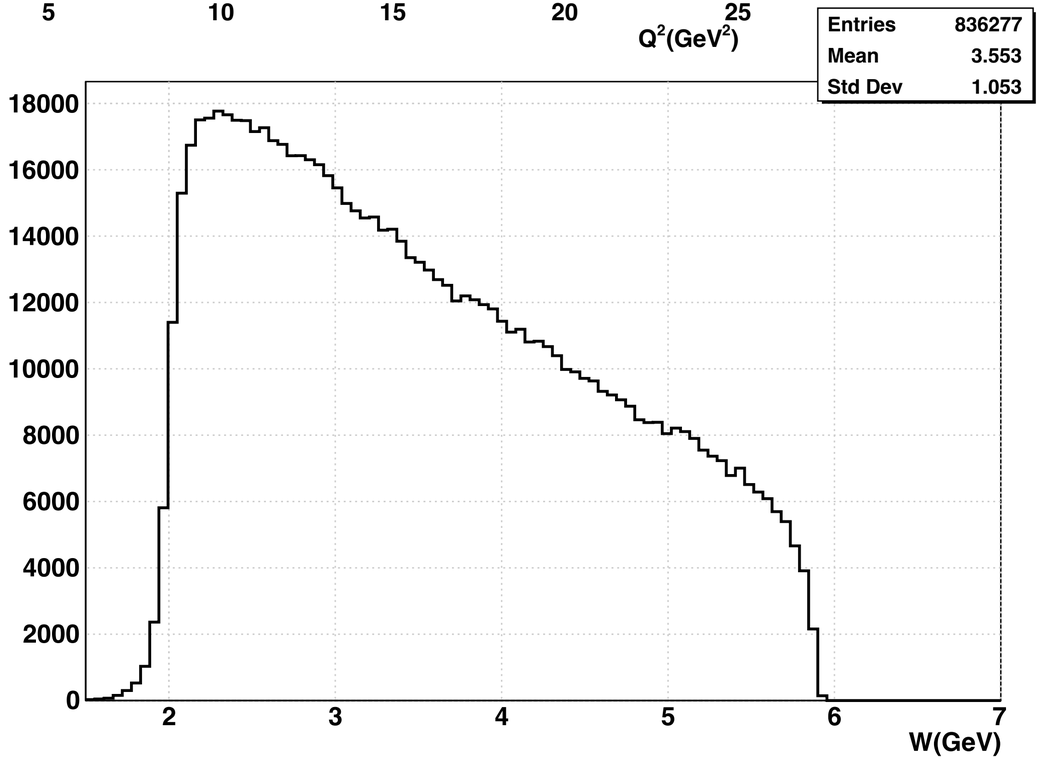


CLAS with 22 GeV

- Wider kinematical spectrum
- Larger variety of hadrons and with better statistics
- Cleaner signal to background ratio







Conclusions - higher beam energy and higher luminosity will allow:

- Multifold, model independent corrections on acceptance, radioactivity, etc.
- Analysis of broad spectrum of hadron types
- Multidimensional cinematical analysis of different types of hadrons
- Transverse Momentum Studies for different types of hadrons
- Multihadron events studies - correlations

매우 감사합니다! - Thank You

8th International Conference on High Energy Physics in the LHC Era

Jan 9 – 13, 2023
Universidad Técnica Federico Santa María
Chile/Continental timezone

Contact

hep-chile@usm.cl

HEP2023 is the VIII international conference on High Energy Physics in the LHC Era. It will be held from the 9th to the 13th of January 2023 in the Universidad Técnica Federico Santa María (UTFSM), Valparaíso, Chile.

The scientific program of the Conference will address a broad range of topics covering the main areas of high-energy particle and nuclear physics such as: Higgs and EW Physics, Neutrino Physics, QCD, Beyond the SM Physics, Dark Matter particle searches, Astroparticles, Nuclear Physics, Heavy Ion collisions, Gravitational Waves measurements, Particle Detectors and Instrumentation, Future experimental facilities, and other topics.

We strongly encourage experimentalists and theoreticians from all around the world to participate to the conference to discuss the recent progress and latest development in high energy particle and nuclear physics.