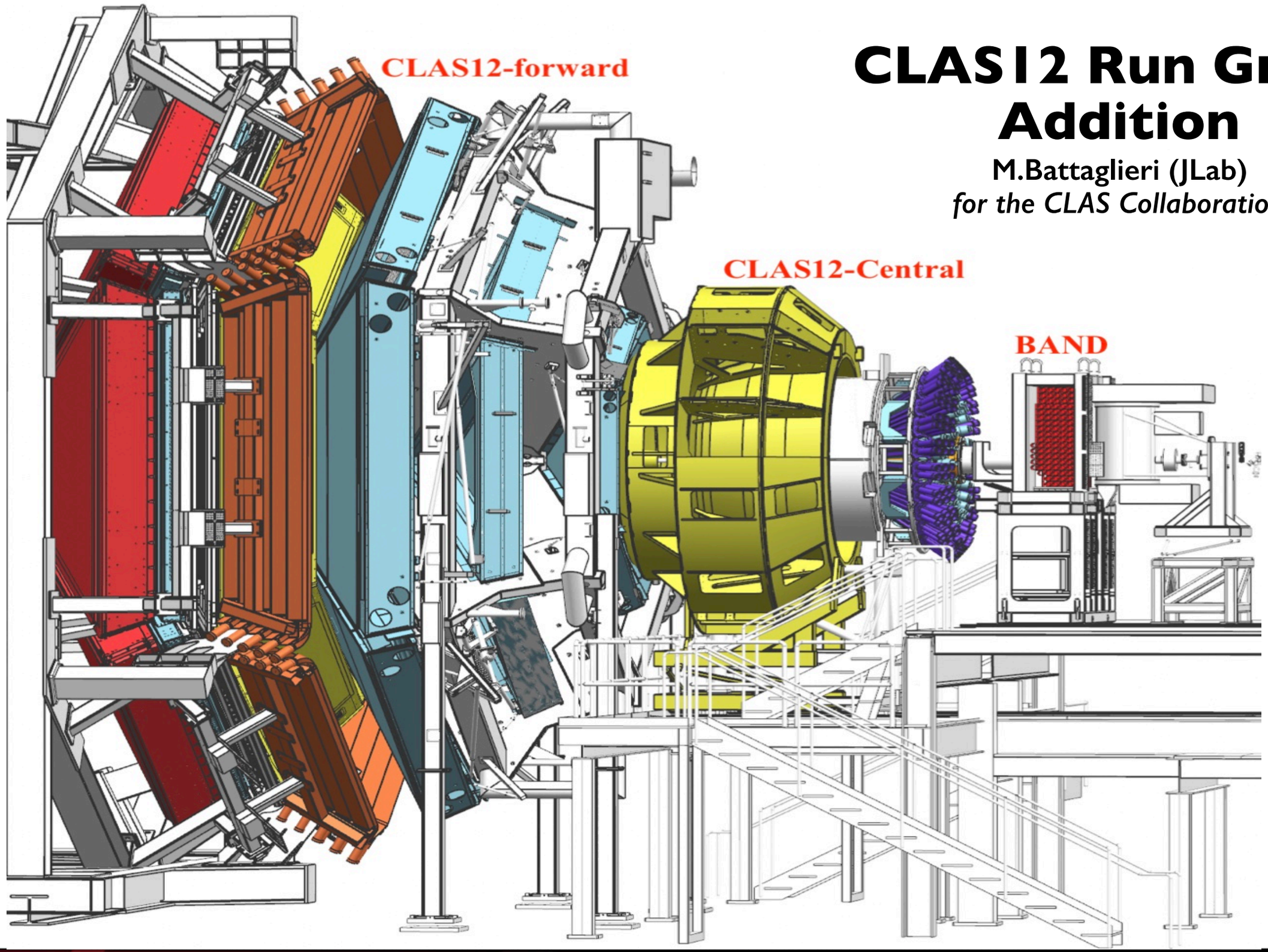
CLAS12 Run Group Addition

M.Battaglieri (JLab)
for the CLAS Collaboration



CLAS12 Run Group Additions

E12-06-106A

Nuclear TMDs in CLAS12

Contact: R.Dupre (Orsay)

RG-D addition

E12-09-007A

Di-hadron e-prod with Long Pol hydrogen and deuterium targets

Contact: C.Dilks (Duke)

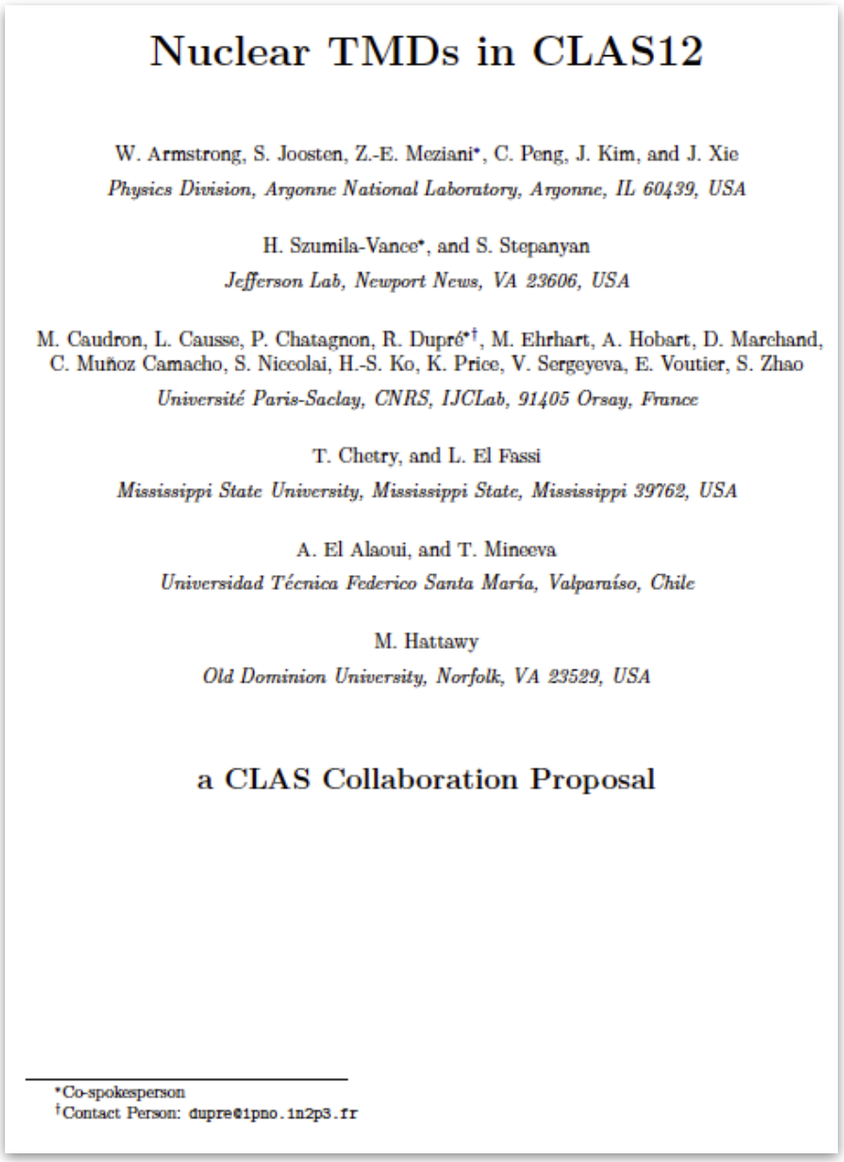
RG-C addition

E12-09-117A

Di-hadron e-nucleus with CLAS12

Contact: M.Arratia (SMTU)

RG-E addition



Nuclear TMDs in CLAS12

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a CLAS Collaboration Proposal

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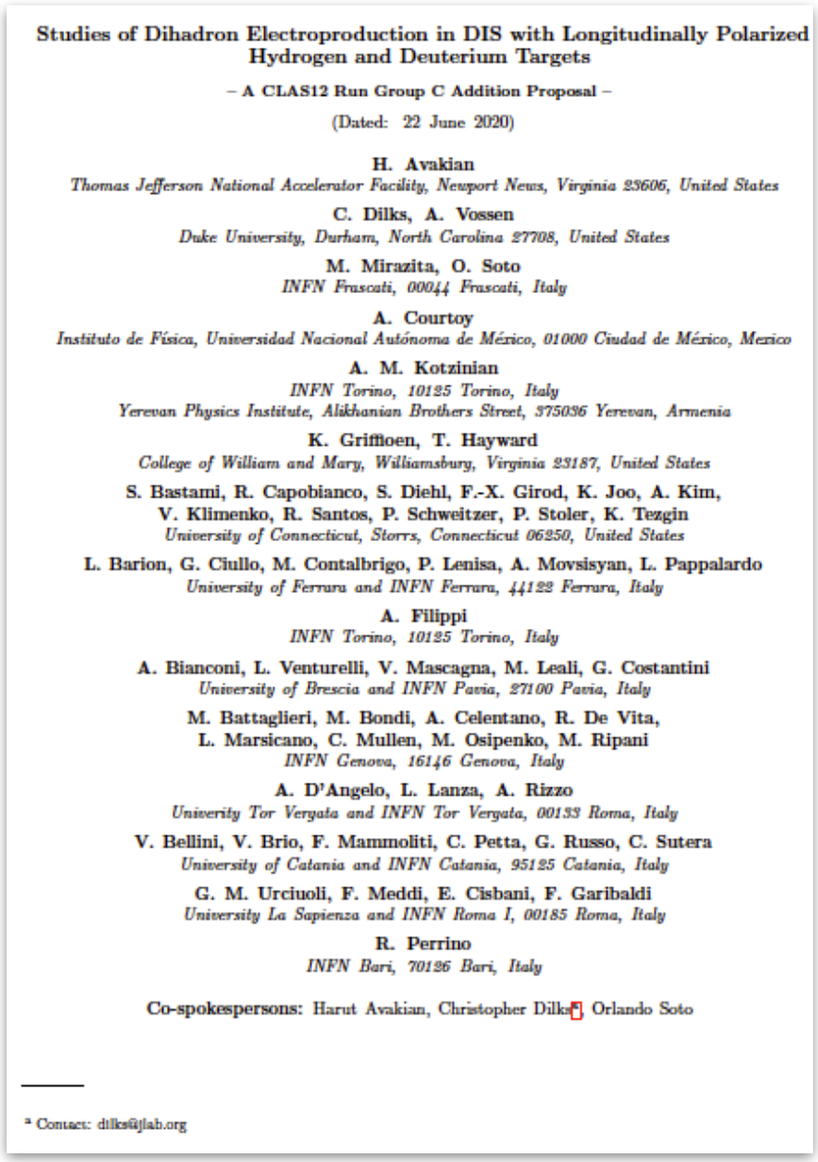

Studies of Dihadron Electroproduction in DIS with Longitudinally Polarized Hydrogen and Deuterium Targets

– A CLAS12 Run Group C Addition Proposal –

(Dated: 22 June 2020)

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Proposal for PAC48: "Dihadron measurements in electron-nucleus scattering with CLAS12"

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Abstract

We propose a new CLAS12 program based on studies of dihadron angular correlations in nuclear DIS, which have never been measured before. This proposal builds on the recently observed suppression of back-to-back pion pairs in CLAS6 data, which hints novel nuclear effects. The increase in beam energy and improved instrumentation will allow us to elucidate the nature of this effect. These measurements will also be complementary to the future EIC, as the high acceptance of CLAS12 makes it uniquely suited to cover a kinematic range that is difficult to access in collider mode but crucial for a full understanding of QCD in nuclei.

* Co-spokesperson
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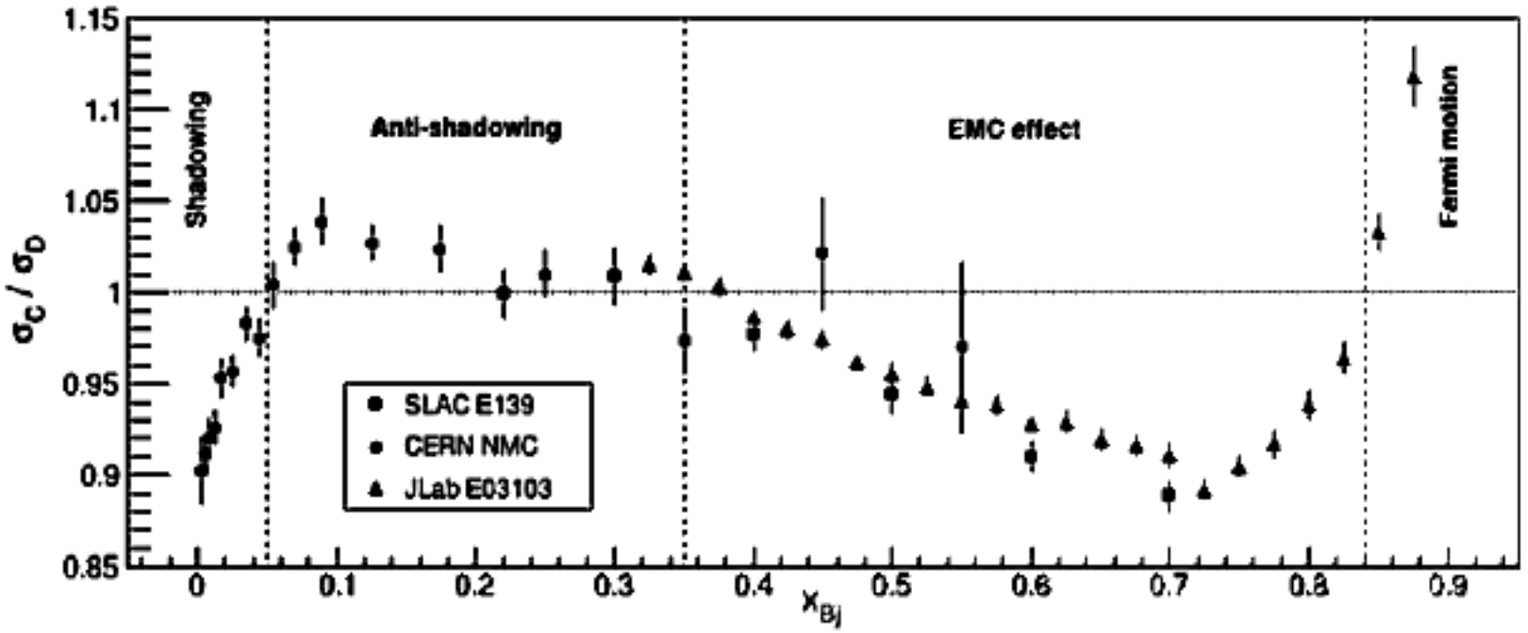
E12-06-106A - Nuclear TMDs in CLAS12 (RG-D)

The physics case



- Shadowing, anti-shadowing and EMC effects can be manifestation of quarks in nuclei
- The EMC remains unexplained (multiple q clusters, bound FF, meson content, …)

How to move forward?

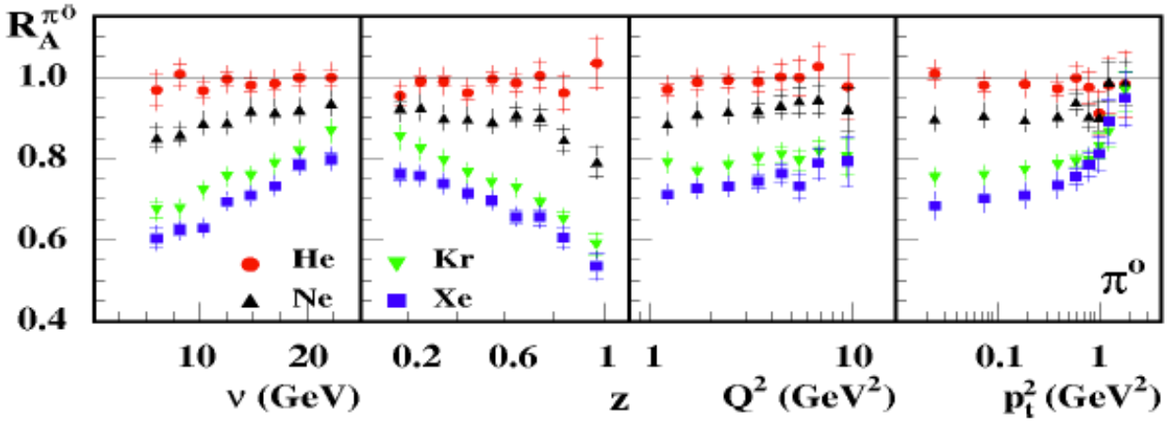
- High precision data: Hall-A/C
- New processes: tagging /SRC, nuclear DVCS, nuclear TMDs

Nuclear TMDs

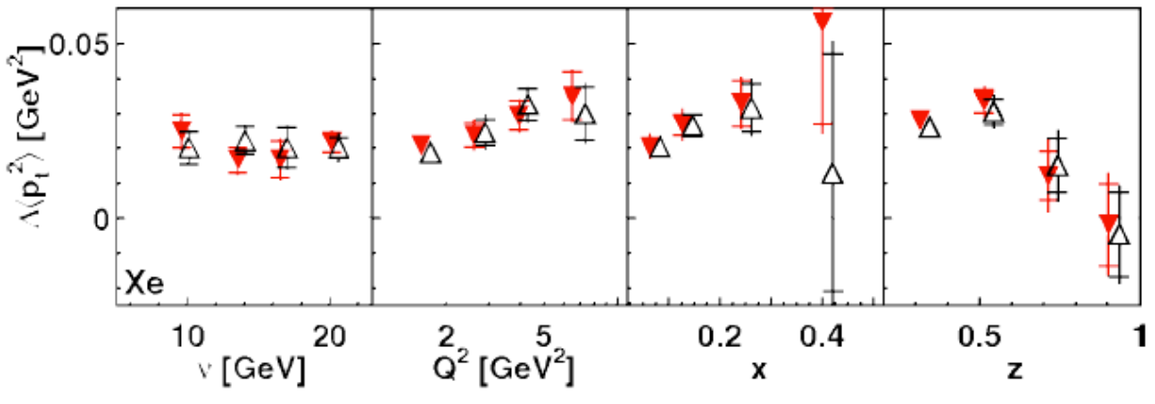
- modern approach to nuclear SIDIS
- microscopic description of nuclear effects
- fragmentation functions in medium

E12-06-106A - Nuclear TMDs in CLAS12 (RG-D)

What we know: Hermes data



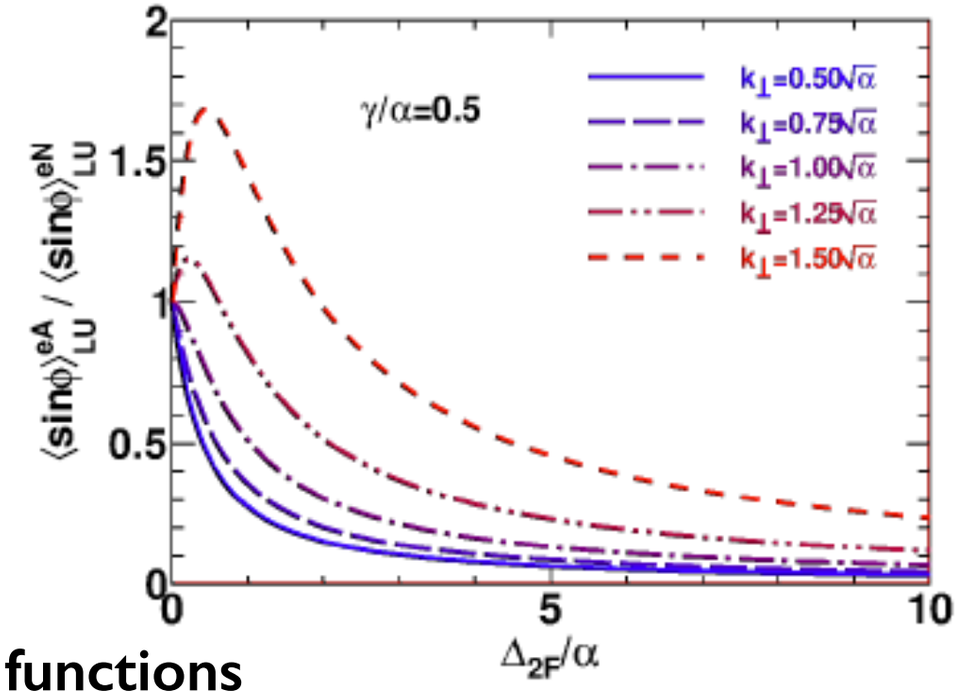
hadron absorption



transverse momentum broadening

Nuclear TMD: theory

- Not much developed
- Model-dependent
- Asymmetry are generated at parton level
- use TMD framework to study SIDIS



M.Battagl

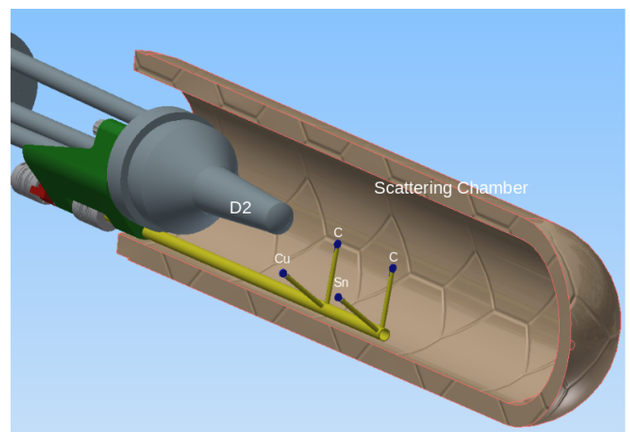
TMD extraction

- Similar to nucleon TMDs
- Different modulation of cross section terms
- complicated by the convolution with fragmentation functions
- Transport coefficient at parton level from first moments

E12-06-106A - Nuclear TMDs in CLAS12 (RG-D)

Experimental set up

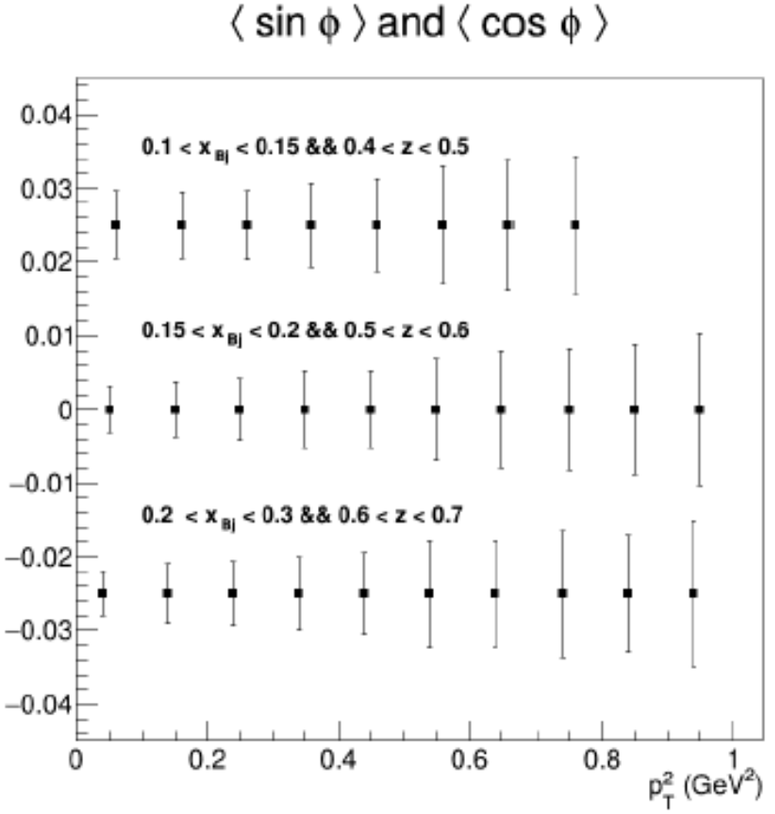
- Large acceptance: CLAS12!
- Polarized beam: routinely at JLab!
- Spin-0 targets (C and Sn)
- (Polarized target: for future)



- Addition to RG-D
- Single proposal: *Color transparency in exclusive vector meson production*
- 60 days, standard CLAS12 config., E_b=11 GeV, nuclear targets (H, C, Cu, Sn)
- Additional request: polarized electron and Pol measurement (Moeller)

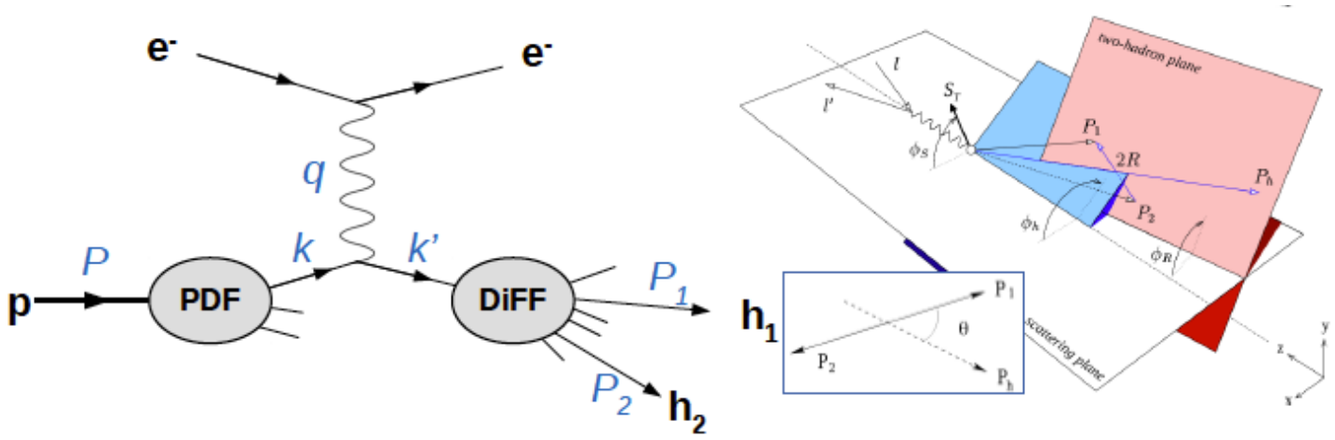
Expected results

- Based on realistic simulations (HERMES generator + full CLAS12 sim/analysis chain)
- Significant reach for the first measurement (even if smaller when compared to RGA expectations on proton)
- Control of systematics by measuring the ratio to proton
- Different targets to look for A-dependence



E12-09-007A - Di-hadrons from a longitudinally polarized target (RG-C)

The physics case



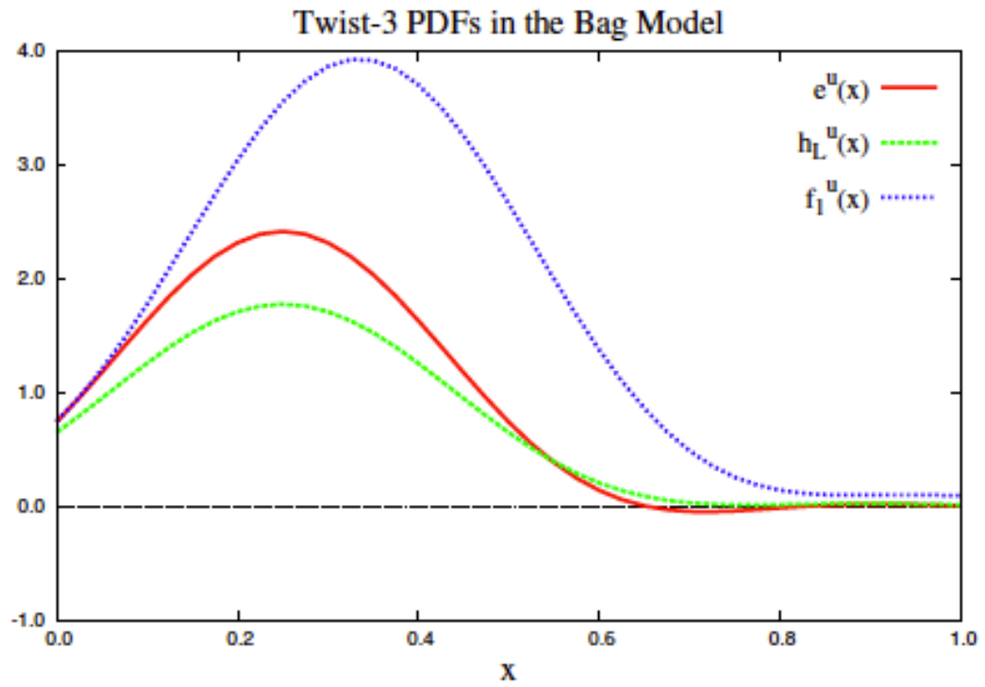
- Sensitive to *several* TMDs and Dihadron Fragmentation Functions (DiFFs)
- Spin-momentum correlations in hadronization
- Complement single-hadron SIDIS, with the advantage of another degree of freedom

Twist-3 collinear PDF

Collinear PDFs
– Twist-2
– Twist-3

Nucleon Polarization \ Quark Polarization	U	L	T
U	f_1		e
L		g_1	h_L
T		g_T	h_1

- Beam Spin Asymmetry A_{LU}
- Ongoing program: single/ di-hadron SIDIS measurements in RG-A



Target Spin Asymmetry A_{UL}

Components:

twist 2 PDFs — pure twist 3

$$h_L(x) \equiv \int d^2\boldsymbol{p}_T\, h_L(x, \boldsymbol{p}_T^2) = -2\frac{h_{1L}^{\perp(1)}(x)}{x} + \frac{m}{M}\frac{g_1(x)}{x} + \tilde{h}_L(x)$$

$$\int dx\, x^3$$

"Average longitudinal gradient of the transverse force that acts on transversely polarized [struck] quark"

– M. Abdallah and M. Burkardt

- Twist-3 TMDs are expressible in terms of multi-parton correlators
- Model predictions comparable to e(x)
- d-quark $h_L(x)$ much smaller, opposite in sign

E12-09-007A - Di-hadrons from a longitudinally polarized target (RG-C)

Double Spin Asymmetries

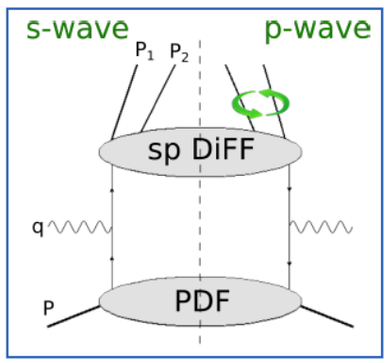
$$d^7\sigma_{LL} = \frac{\alpha^2}{2\pi Q^2 y}\,\lambda\, S_L \sum_a e_a^2 \left\{ C(y)\, g_1(x)\, D_1\left(z,\zeta,M_h^2\right) - W(y)\,\cos\phi_R\,\frac{|\vec{R}_T|}{Q}\left[\frac{1}{z}\, g_1(x)\,\widetilde{D}^{\sphericalangle}\left(z,\zeta,M_h^2\right) - \frac{M}{M_h}\, x\, e_L(x)\, H_1^{\sphericalangle}\left(z,\zeta,M_h^2\right)\right]\right.$$

Unpolarized DiFF D_1

– Constant modulation: $D_{1,ss+pp}$

– General modulation: $P_{\ell,m}(\cos\theta)\cos[m(\phi_h-\phi_R)] \rightarrow D_1^{|\ell,m\rangle}$

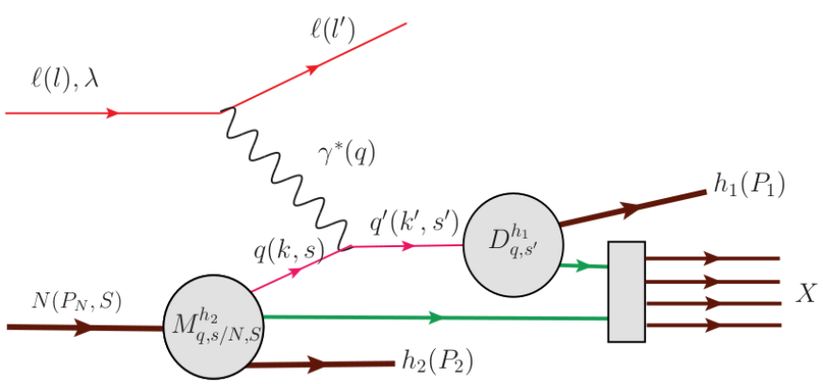
D_1 partial waves → σ_{UU}



Subleading Twist Contribution

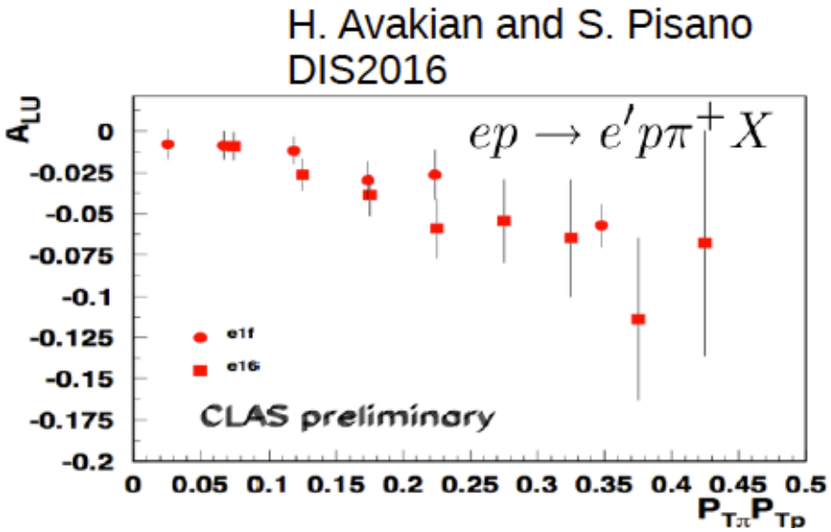
- **Twist-3 DiFF** $\widetilde{D}^{\sphericalangle}$
  helps with e(x) and h_L(x) extractions
- **Twist-3 PDF** $e_L(x)$

Target and current fragmentation



Fracture Functions: conditional probability to produce a TFR hadron

- **Fracture functions are accessible in "Double SIDIS" process:**
  One hadron in CFR
  Other hadron in TFR
- **A_{LU} only accesses one fracture function**
- **A_{UL} and A_{LL} access several more**



E12-09-007A - Di-hadrons from a longitudinally polarized target (RG-C)

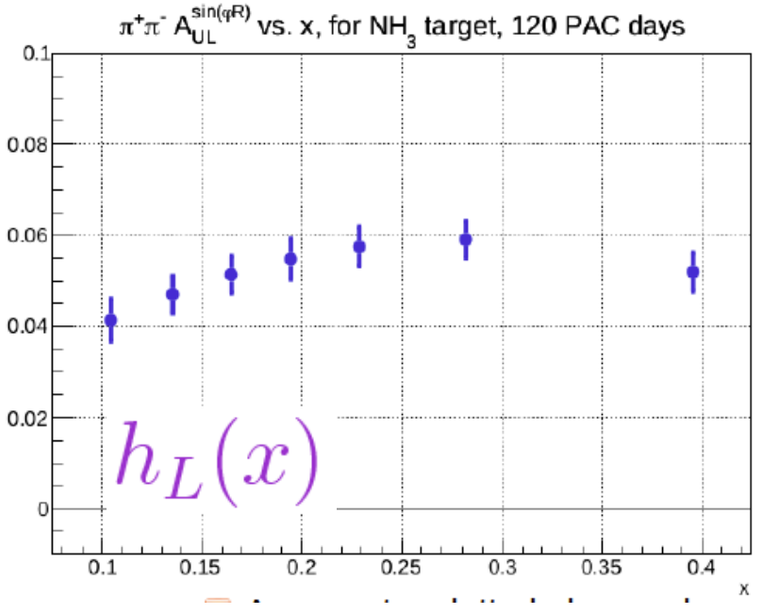
Experimental set up

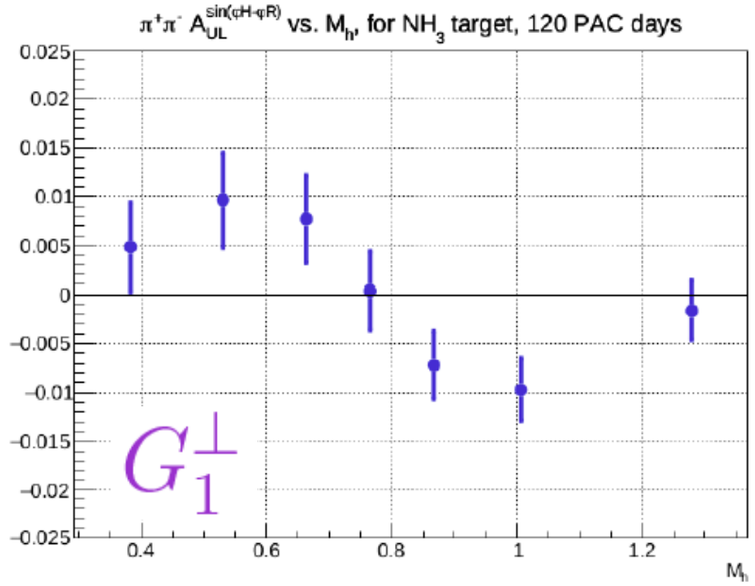
- Addition to RG-C
- RG-C (6 experiments so far): N spin structure, DVCS, single-h (π and K) SIDIS
- NH3 and ND3 longitudinally polarised target (P_p~85%, P_n~35%) + polarized electron beam, standard CLAS12 config., E_b=11 GeV

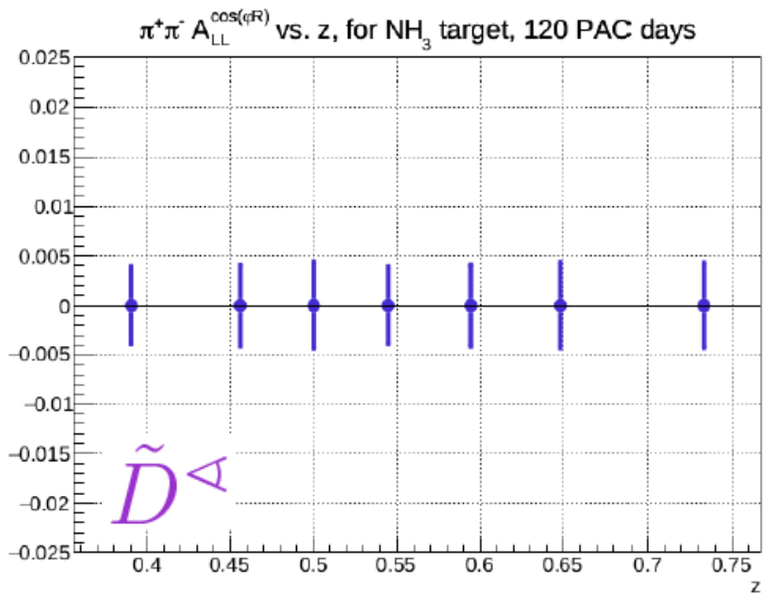
Expected results

- Dilution factor and kinematic depolarisation included
- Projection based on full RG-C PAC days (120+60)

Asymmetry	Physics Goal
$A_{UL}^{\sin\phi_R}$	$h_L(x)$
$A_{UL}^{\sin(\phi_h-\phi_R)}$	$G_1^\perp$
$A_{LL}^{\cos\phi_R}$	$\tilde{D}^\sphericalangle$

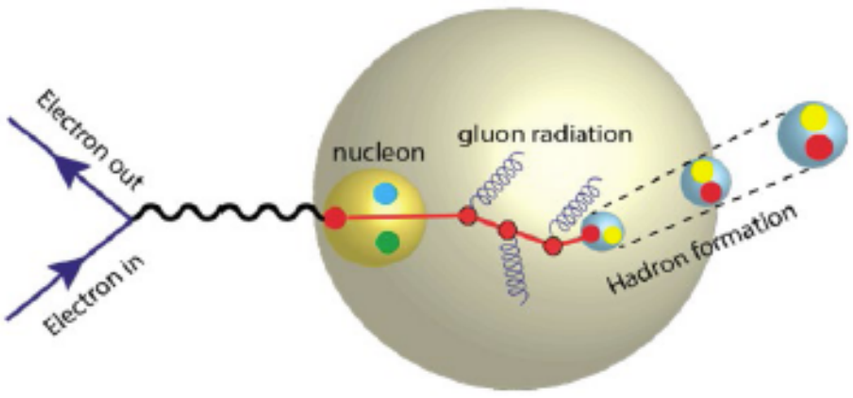


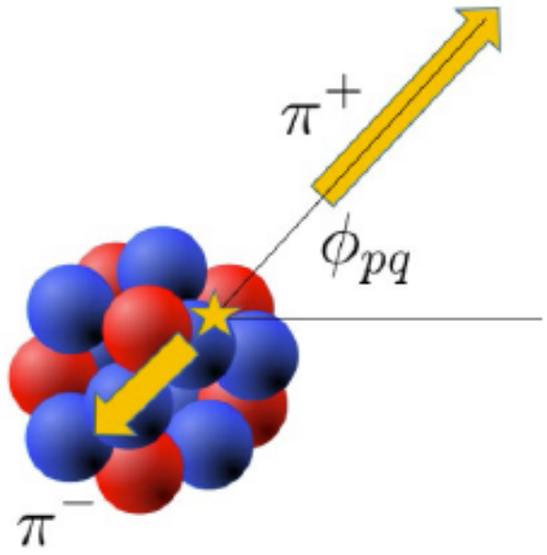




E12-09-117A - Di-hadrons measurements in e-Nucleus scattering (RG-E)

The physics case

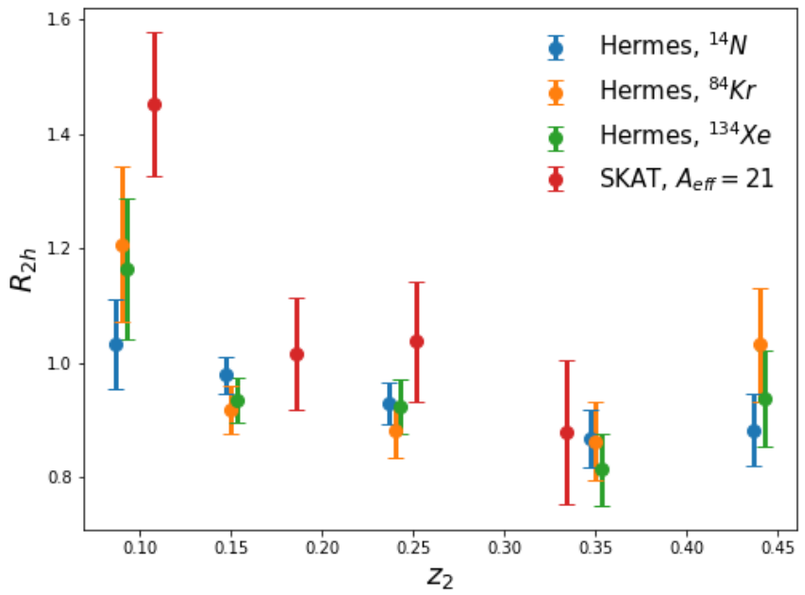




- First measurements of di-hadrons angular correlation in nuclear DIS (never done before)
- Complements and extends over single hadron-studies
- Correlations induced by nuclear effects

Double-hadron leproproduction

- Di-hadrons in nuclear media: exploratory measurements from HERMES
- Sensitivity to different models (parton energy loss, absorption, pre hadronic transport, …)
- Significant theoretical progress in the field since HERMES data appeared



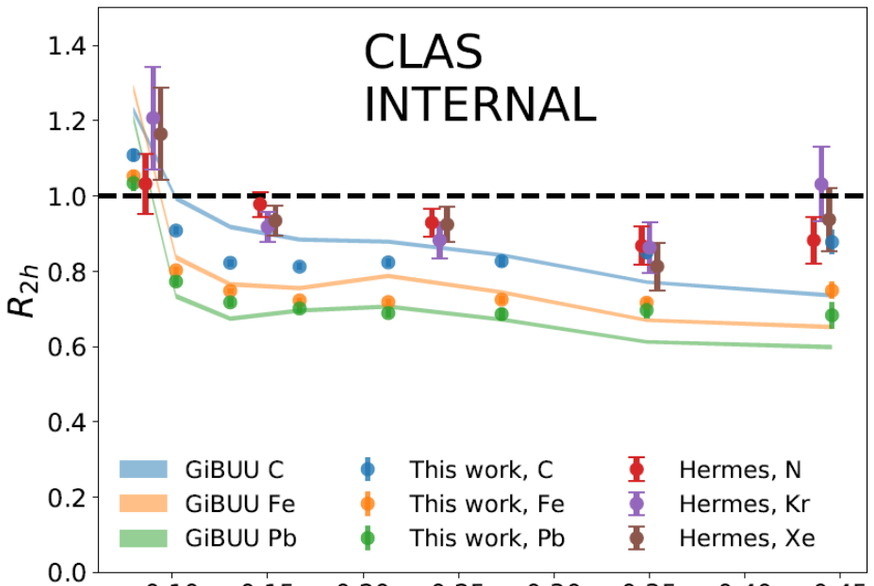
Conditional suppression factor

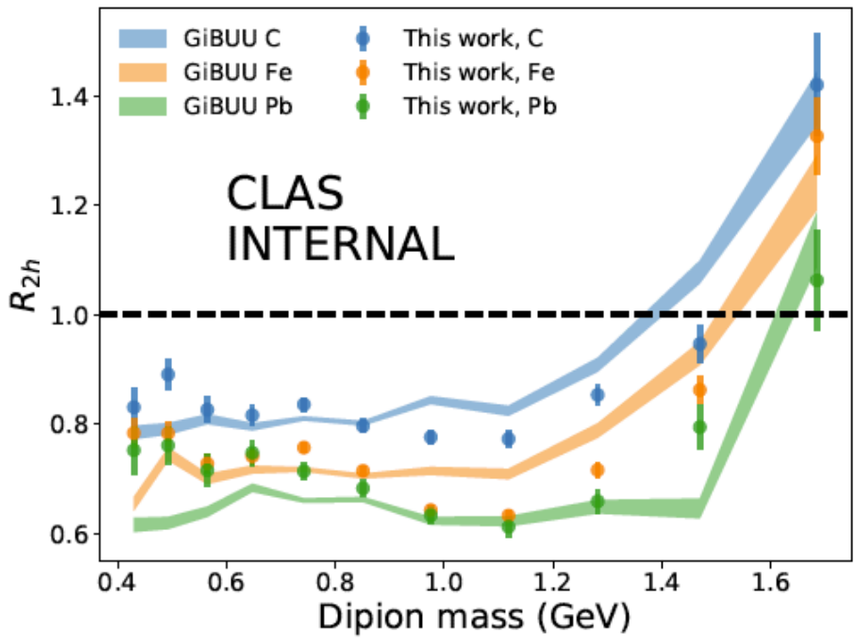
$$R_{2h}(z_2) = \frac{N_h^A(z_2|z_1 > 0.5)/N_h^A(z_1 > 0.5)}{N_h^D(z_2|z_1 > 0.5)/N_h^D(z_1 > 0.5)}$$

- No evidence of A dependence
- A-dependence reduced wrt single hadron
- agreement with nu-A data
- hint of enhancement at low z

E12-09-117A - Di-hadrons measurements in e-Nucleus scattering (RG-E)

CLAS6 (preliminary) data



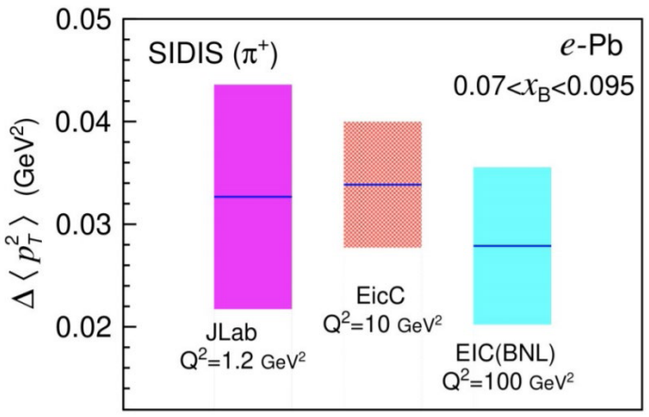


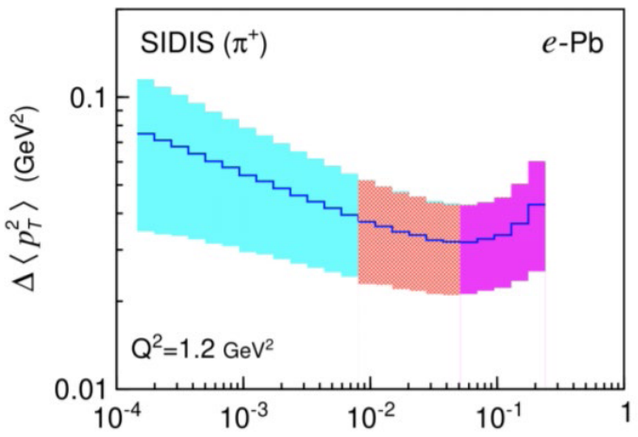
- Larger suppression
- A dependence hint
- No rho dominance
- strong kinematic dependence?
- well reproduced by GIBUU MC

CLAS12 will allow to explore the whole kinematic range!

- comparison to single-hadron modification shows less suppression for conditional events and reduced A-dependence
- larger kinematic and higher luminosity are required for multi-differential measurement

Complementarity with EIC



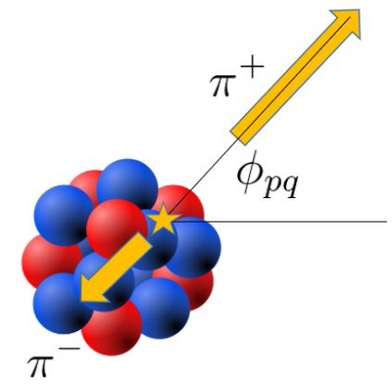


- Hadronization in nuclei: one of the four EIC science pillars
- The CLAS12 large acceptance provides a unique opportunity for an EIC pathfinder program
- Cold-nuclear matter effects need to be constrained over wide kinematic range, from JLab to EIC.
- Background for gluon saturation at EIC (note that the x dependence of transport parameter expected to be weak)

E12-09-117A - Di-hadrons measurements in e-Nucleus scattering (RG-E)

Experimental set up

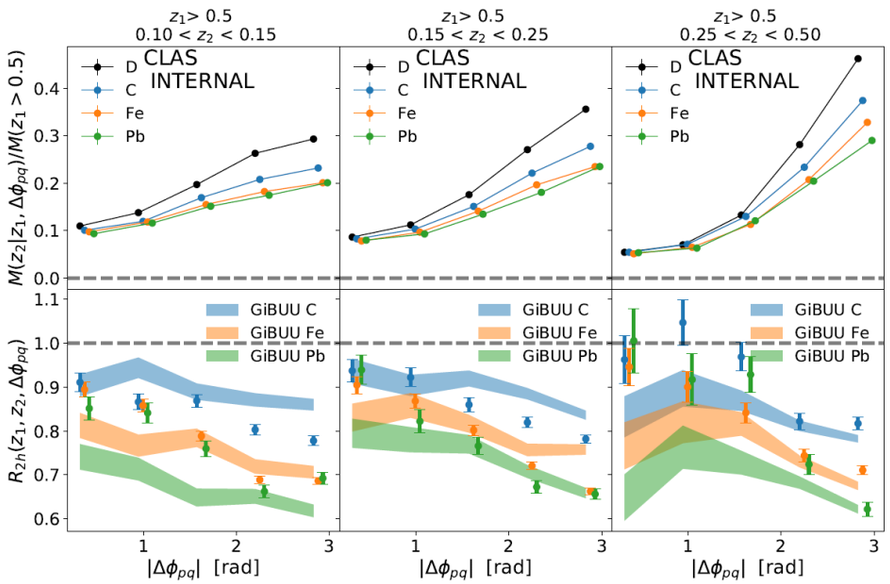
- Addition to RG-E (single Proposal): *Quark propagation and hadron formation*
- 60 days, polarized electron beam, standard CLAS12 config., E_b=11 GeV
- No special trigger requirements



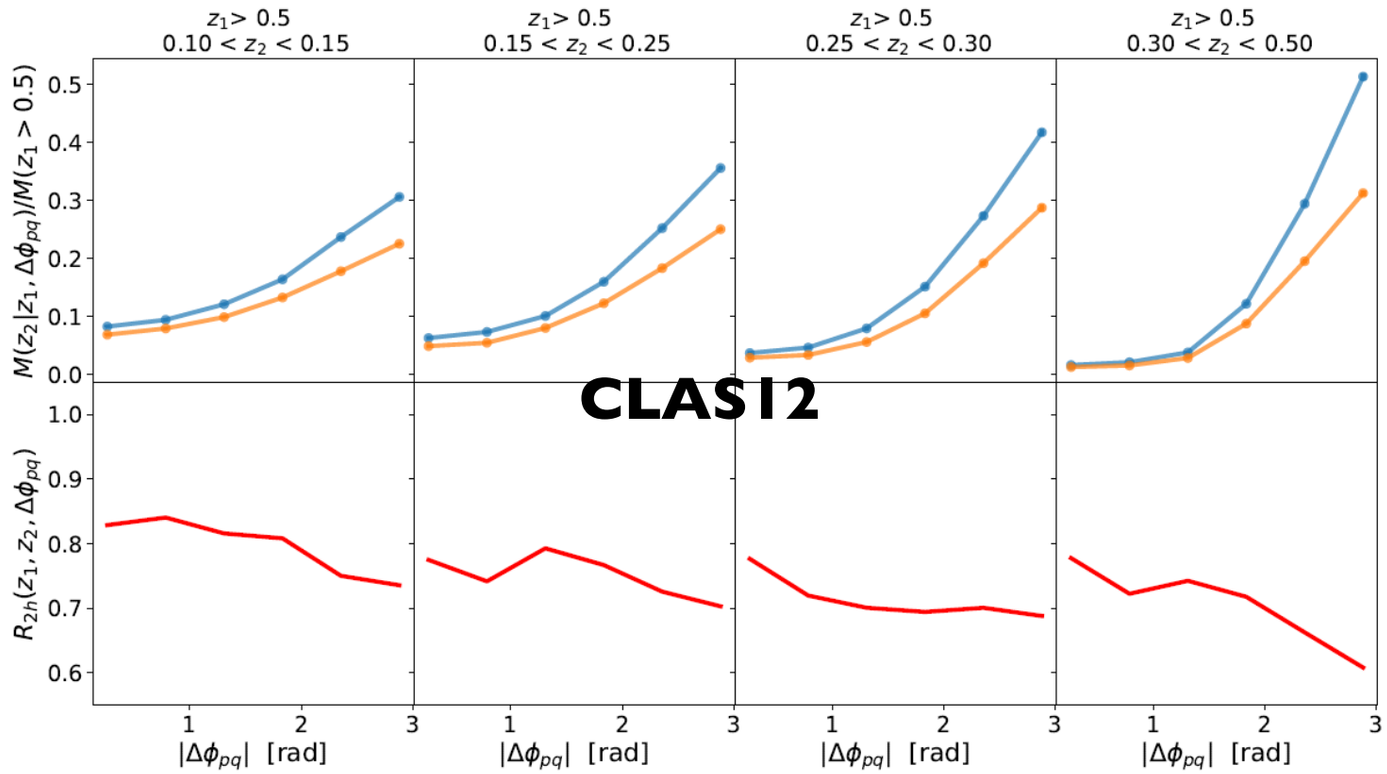
Expected results

- Projection based on full RG-E PAC days (60) and CLAS6 results
- Precise determination with the expected stat

CLAS6



CLAS12



CLAS12 Run Group Additions

Summary

- Three CLAS12 RG additions (RG-C, RG-D and RG-E)
- TMD in nuclei: exploratory measurement of never-measured asymmetries
- Di-hadron asymmetries with L polarized nucleons: T-3 collinear PDFs and FF
- Di-hadron in nuclei: multiplicity ratio in a wide kinematics
- Scrutinized and endorsed by the CLAS collaboration
- They all extend the approved current physics program (SIDIS, TMD on N, …)
- Best use of CLAS12 detector and already approved beam time
- No special requirements on running conditions (but polarized beam for RG-D)
- Experience with CLAS6 shows that open trigger data stimulated a significant interest in the community well beyond the original scope