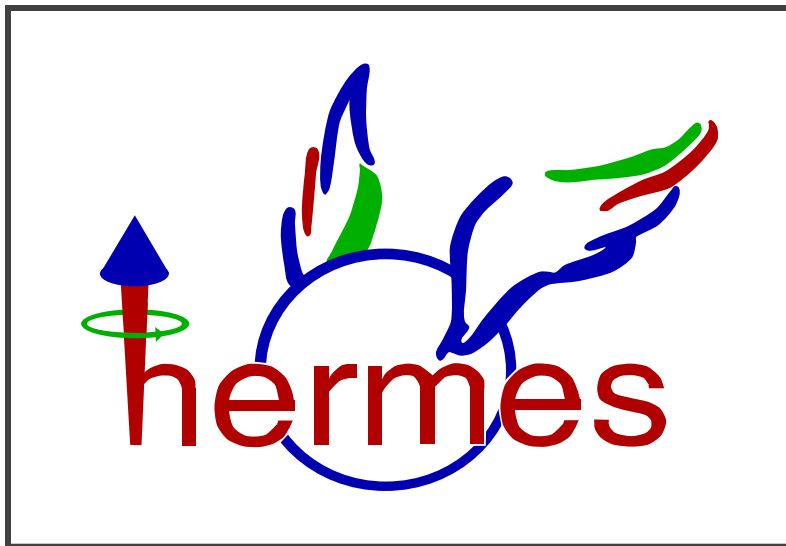


# Exploring New Kinematic Dependences of Semi-Inclusive Double-Spin Asymmetries at HERMES



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# Part 1: 3D-Binned Longitudinal Asymmetries

- A recent analysis goal at HERMES has been to explore more extensively additional kinematic dependences of observables. Let's look back at semi-inclusive longitudinal asymmetries: **Additional information about fragmentation process...**

$$A_1^h = \frac{\sigma_{1/2}^h - \sigma_{3/2}^h}{\sigma_{1/2}^h + \sigma_{3/2}^h}$$

$$\stackrel{LO}{=} \frac{\sum_q e_q D_q^h(z, p_{h\perp}) \Delta q(x)}{\sum_{q'} e_{q'} D_{q'}^h(z, p_{h\perp}) q'(x)}$$

Each x-bin	0.2 < z < 0.35	0.35 < z < 0.5	0.5 < z < 0.9
0 < p <sub>h⊥</sub> < 0.3			leading
0.3 < p <sub>h⊥</sub> < 0.5			
0.5 < p <sub>h⊥</sub> < 1.0	mid-rapidity		

Highest energy hadron & influenced by fewest q $\bar{q}$  pairs

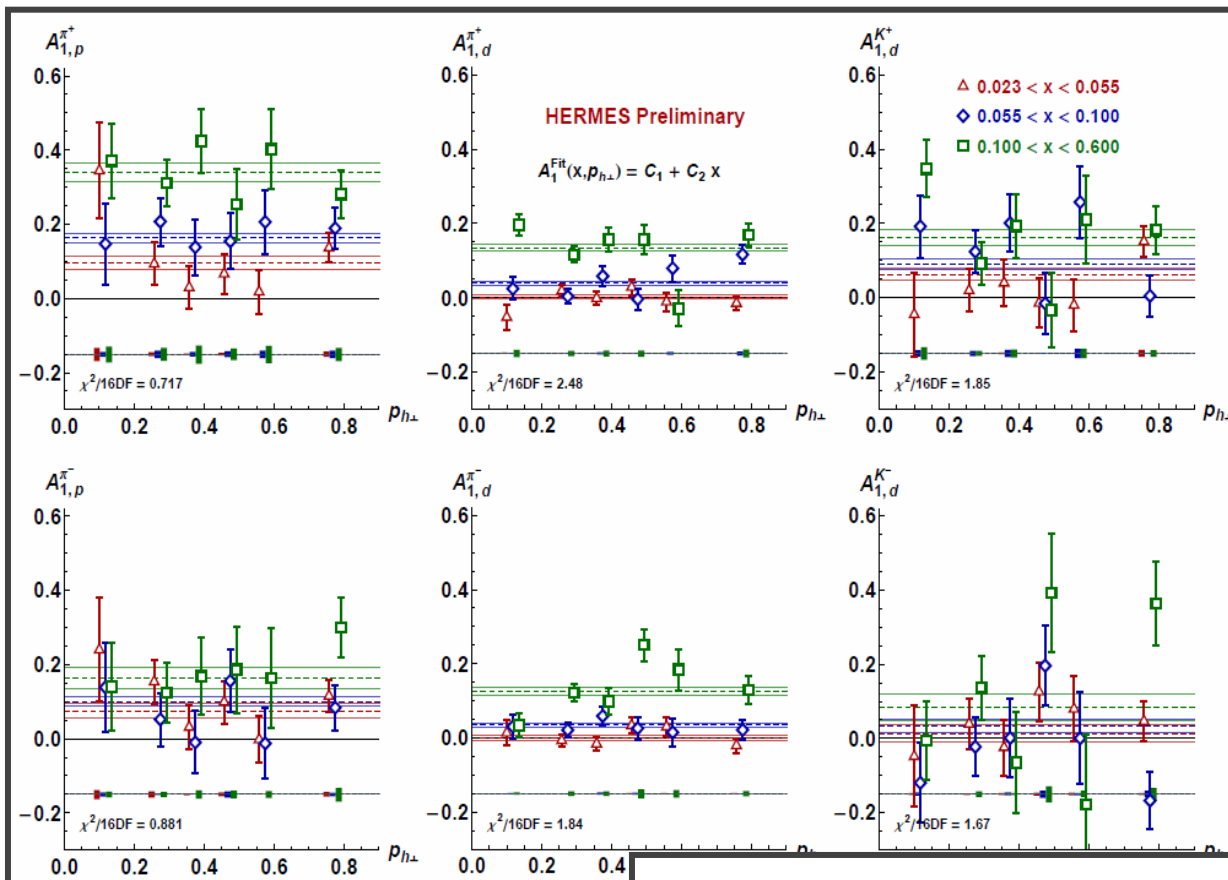
- Ultimately provide a dataset of semi-inclusive asymmetries binned simultaneously in x, z, and p<sub>h⊥</sub>
- 3D good for fitting, lets look at some 2D projections...

# You may have seen this: $A_1^h(x, p_{h\perp})$

A topic of recent interest: CLAS, Torino, TMDs!

Fits done in 2D:

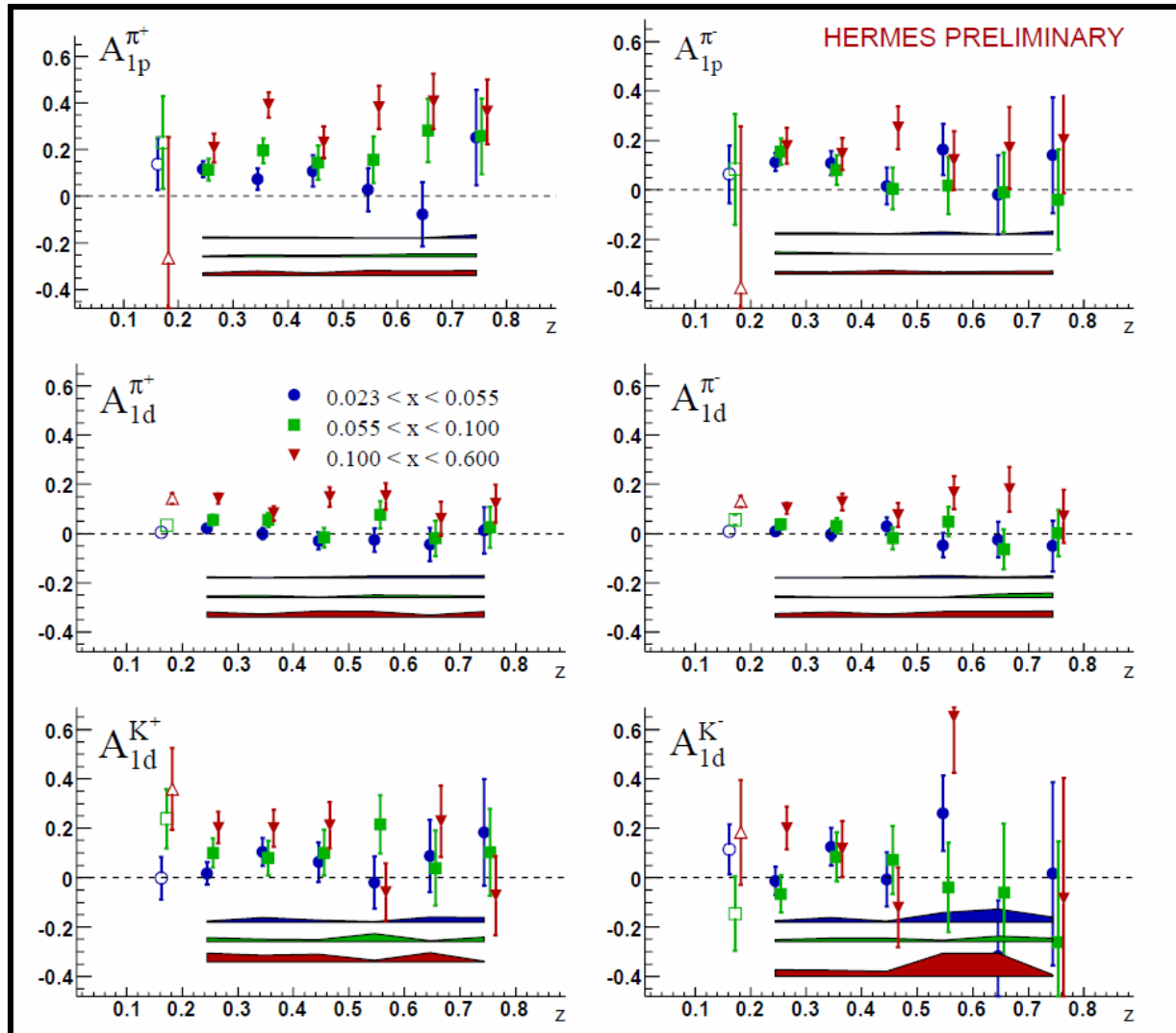
- Kinematics correlated! Determine real dependence of asyms.
- Conducted at *true* kinematics
- Covariance included providing fair representation of uncertainties
- Points fit with and without  $p_{h\perp}$  dependant term:



No significant  $p_{h\perp}$  dependence observed

	$p \rightarrow \pi^+$	$p \rightarrow \pi^-$	$d \rightarrow \pi^+$	$d \rightarrow \pi^-$	$d \rightarrow K^+$	$d \rightarrow K^-$
$\chi^2$ (NDF=16) $C_1^h + C_2^h x$	11.5	14.1	39.7	29.5	29.5	26.7
$\chi^2$ (NDF=15) $C_1^h + C_2^h x + C_3^h p_{h\perp}$	11.5	13.8	38.2	27.9	29.1	24.4
$\chi^2$ (NDF=12) $C_1^h + C_2^h x + C_3^h p_{h\perp} + C_4^h x^2 + C_5^h p_{h\perp} + C_6^h x p_{h\perp}$	7.78	5.31	36.4	14.9	20.1	16.9

# New Result: $A_1^h(x, z)$



- $z$  bin (0.1-0.2) – Excluded from main 3D result, but shows similar behavior
- Analysis in early stages, but preliminary fits suggest  $z$ -dependence seems statistically insignificant.

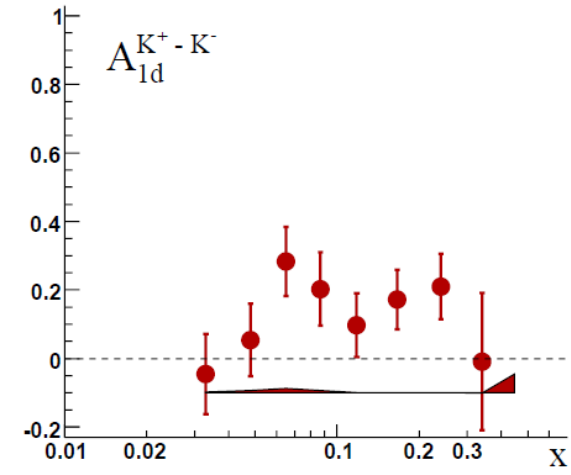
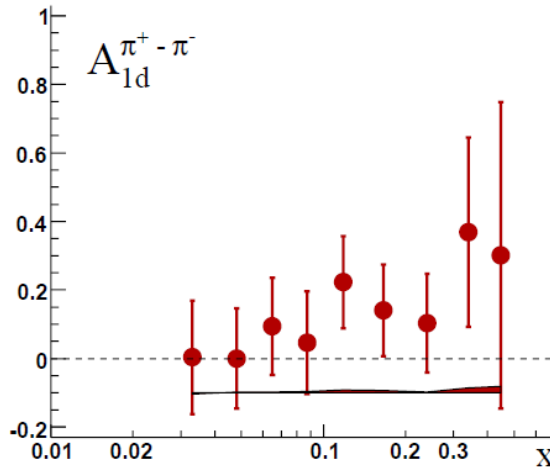
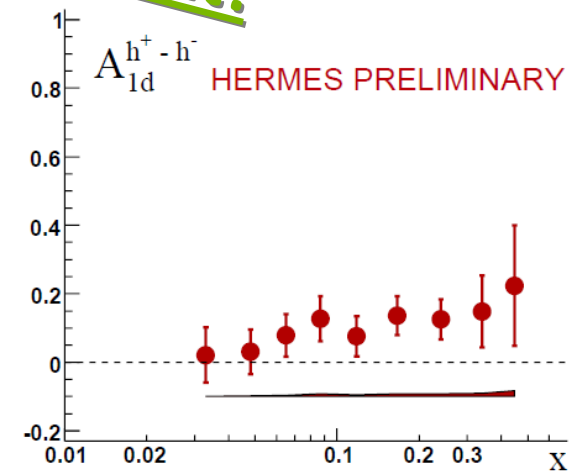
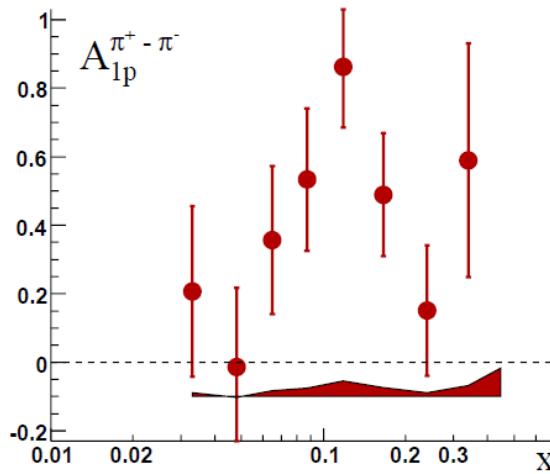


# Part 2: The Hadron Charge Difference Asymmetry

$$A_1^{h^+ - h^-} = \frac{(\sigma_{1/2}^{h^+} - \sigma_{1/2}^{h^-}) - (\sigma_{3/2}^{h^+} - \sigma_{3/2}^{h^-})}{(\sigma_{1/2}^{h^+} - \sigma_{1/2}^{h^-}) + (\sigma_{3/2}^{h^+} - \sigma_{3/2}^{h^-})}$$

**New result!**

- Longitudinal DSA of the difference of charged hadron cross sections
- Smaller error bars on the kaon sample due to larger difference in kaon yields



# Why is the charge difference asymmetry interesting?

Assuming:

Charge conjugation  
symmetry of fragmentation  
functions:

$$D_q^{h^+} = D_{\bar{q}}^{h^-}$$

On the Deuteron:

$$A_{1d}^{h^+ - h^-}(x) = \frac{\Delta u_v + \Delta d_v}{u_v + d_v}(x)$$

(Under leading order, leading twist, current fragmentation assumptions)

Interestingly, it makes no difference what species the hadron is... This relation comes from the cancellation of fragmentation functions in the asymmetry.

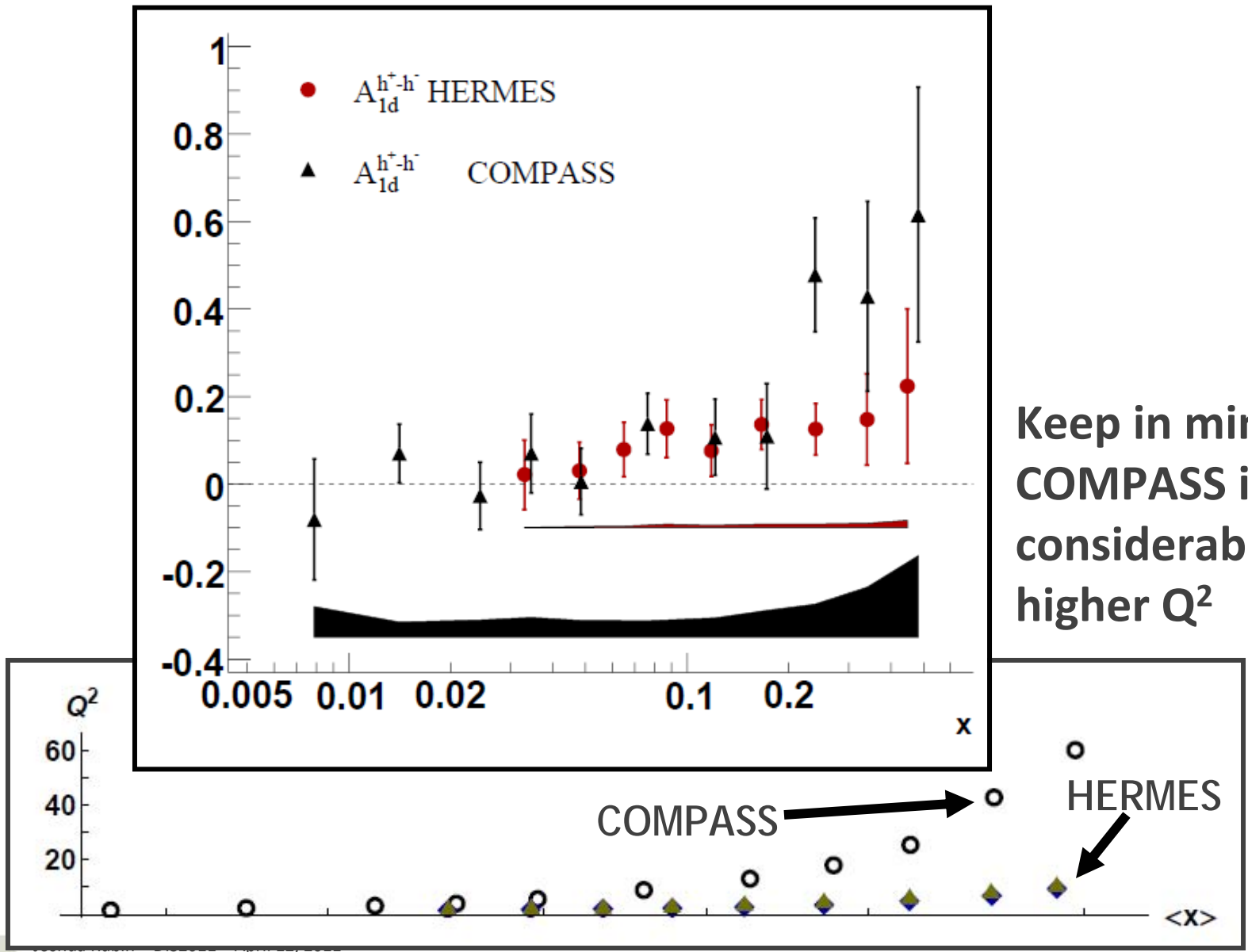
On the Proton:

$$A_{1p}^{h^+ - h^-}(x) = \frac{4\Delta u_v - \Delta d_v}{4u_v - d_v}(x)$$

(With which you can get at  $\Delta u_v$  and  $\Delta d_v$ ) and their interesting moments!

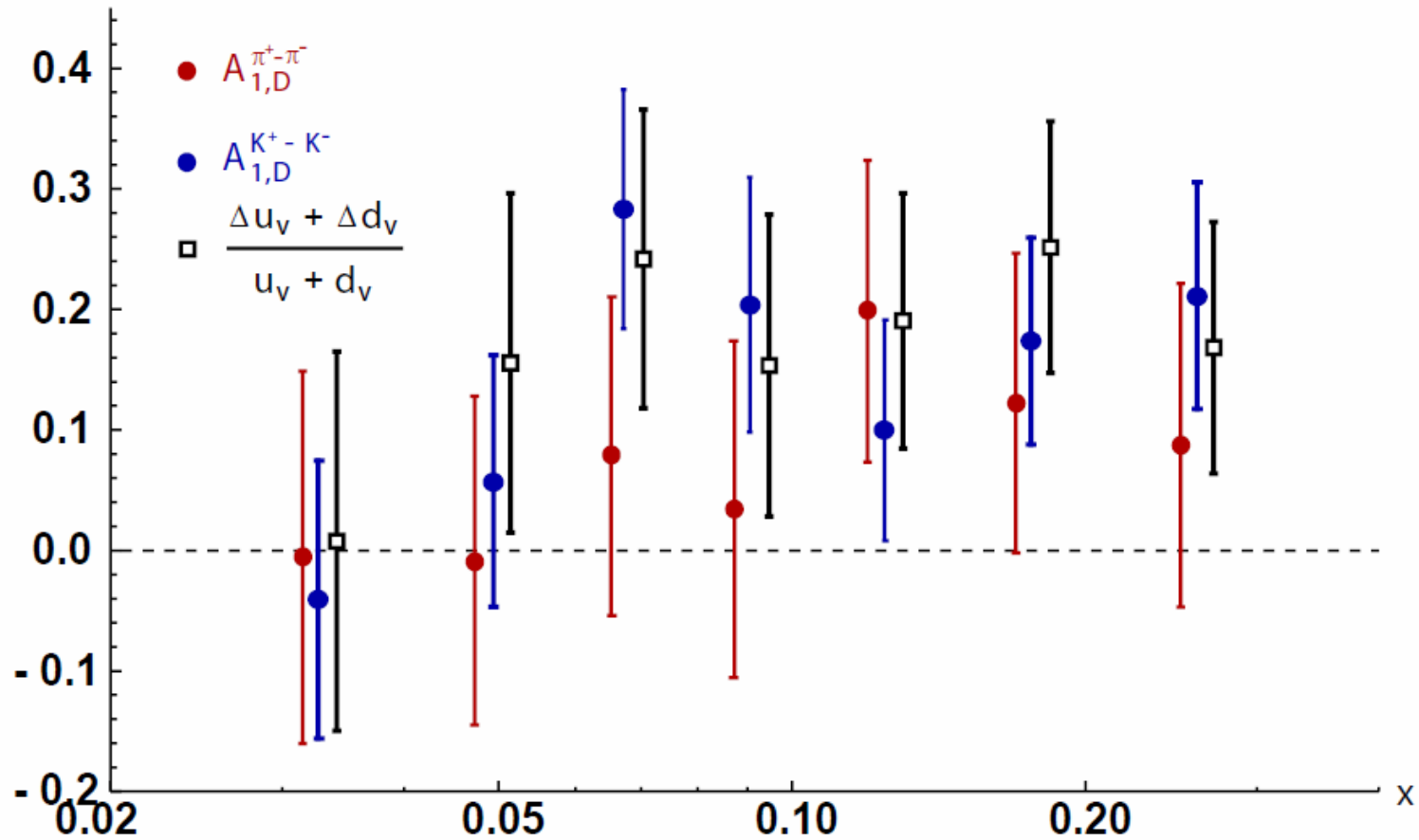


# Comparison with Measurement from COMPASS\*



\*M. Alekseev *et al.* *Phys. Lett. B*, 660, 458 2008

# Comparison with valence density ratio from purity method\*



Different models with different assumptions. Good agreement.

\*A. Airapetian *et al.* *Phys. Rev.*, D71:012003, 2005





## Conclusions

- $x$ - $p_{h\perp}$  and **(new!)**  $x$ - $z$  projections of  $A_1^h$  show no unusual semi-inclusive dependence. Fits crucial for understanding 1) kinematic dependence and 2) seeing through kinematic correlations 3) presenting statistical significance of a result with correlated errors.
- **(new!)**  $A_1^{h^+-h^-}$  provide access to leading order PDFs under different assumptions about fragmentation than the prior (complimentary) purity analysis.
- $A_1^h$  in  $x$ ,  $z$ , and  $p_{h\perp}$  and full statistical covariance will be available shortly.

