Nucleon-spin-dependent azimuthal asymmetries and beyond: AKM 55-70

Բակուր Պարսամյան

CERN, JINR,
University of Turin and INFN

on behalf of the COMPASS Collaboration

International workshop on
"Correlations in Partonic
and
Hadronic Interactions - 2020"
(CPHI-2020)

CERN, 3-7 February, 2020

August 2003: First time I met Aram

The 2003 European School of High-Energy Physics

Tsakhkadzor, Armenia
24 August - 6 September 2003

The 2003 European School of High-Energy Physics (formerly the CERN-JINR School of Physics) will be organized jointly by the Joint Institute for Nuclear Research (JINR), Dubna, Russia, and the European Organization for Nuclear Research (CERN), Geneva, Switzerland together with the International Center for Advanced Studies at Yerevan State University, Armenia. The basic aim of the School is to teach various aspects of high-energy physics, but especially theoretical physics, to young experimental physicists, mainly from the Member States of CERN and of JINR.

The Sevan Lake

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T.S. Donskova (JINR) Organizing secretary
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D. Metral (CERN) Organizing secretary
A. Olchevski (JINR and CERN)
A.N. Sissakian (JINR)

2004 – becoming a PhD student in Turin under Aram's supervision!

Subject **Shnorhavor!** 20-Oct-04, 15:50

To Bakur

Bakur barev,
Ashchatavartz gtnvets!!!
Es aysor zangetsi Triest Prof. Bradamantein. Na naxkin COMPASSi spoksmanner ev menq irar het shat enq ashchatel. Ka mi Evropakan tzragir Trieste -- Turin "transversity study". Du karogh e arden tesel es ays gaghapar@ ete nael es COMPASSi physics program@. Bradamantei xumb@ hents transversity-i patasxanatun e isk es unem tesakan gortzer ayd temaov. Na hamadzaynvets vor du gas Turin ayn paymanov vor zbaghves COMPASSi tvialneri transversity analizov.
Technikakan manramasnutyunneri masin (erb ev inchpes dram@ kpoxantsvi Turin) Bradamanten kgri motaka orers ev es qez khaynem norutyunner@.
Lav lines, sksi COMPASSi web page@ qchporel, vor qich te shat imanas inchi masin enq chosum.
Best regards -- Aram

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Best regards -- Aram

ELSEVIER

Nuclear Physics B 441 (1995) 234–256

NUCLEAR PHYSICS B

25 years!

New quark distributions and semi-inclusive electroproduction on polarized nucleons

Aram Kotzinian [1]

Yerevan Physics Institute, Alikhanian Brothers St. 2, AM-375036 Yerevan, Armenia

Received 23 December 1994; revised 9 February 1995; accepted 23 February 1995

Abstract

The quark-parton model calculation including the effects of intrinsic transverse momentum and of all six twist-two distribution functions of quarks in polarized nucleons is performed. It is demonstrated that new twist-two quark distribution functions and polarized quark fragmentation functions can be investigated in semi-inclusive DIS at leading order in Q^2. The general expression for the cross-section of semi-inclusive DIS of polarized leptons on polarized nucleons in terms of structure functions is also discussed.

SIDIS x-section

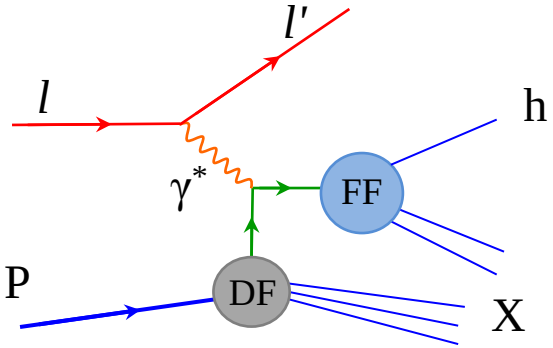
A.Kotzinian, Nucl. Phys. B441, 234 (1995) – 25 years!!!

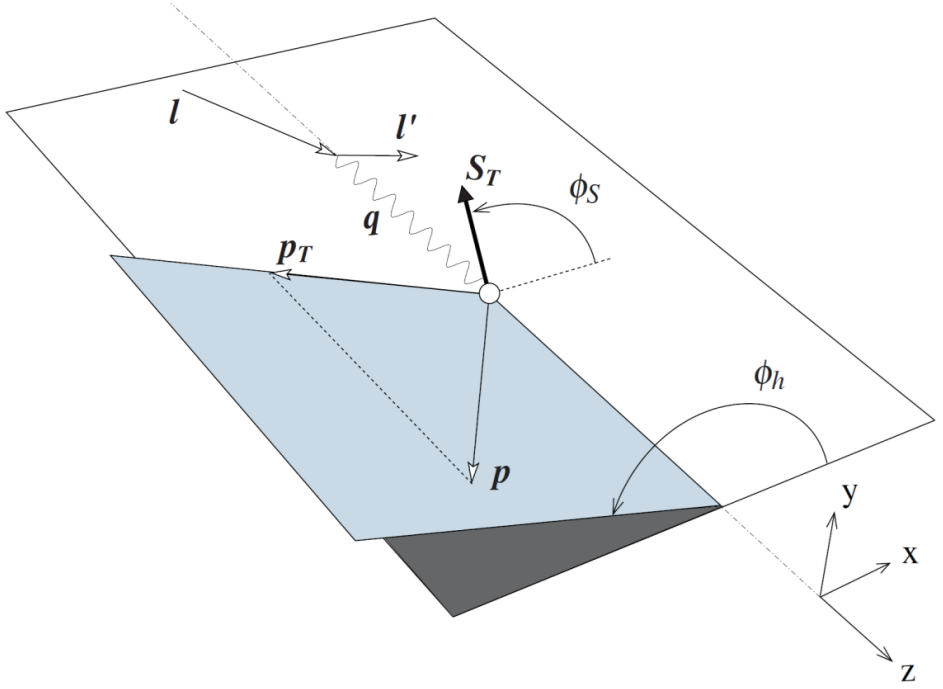
Bacchetta, et al. JHEP 0702:093 (2007) – 13 years!

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} =$$

$$\left[\frac{\alpha}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\right]\left(F_{UU,T}+\varepsilon F_{UU,L}\right)$$

$$\times\left\{\begin{array}{l}
1+\sqrt{2\varepsilon(1+\varepsilon)}A_{UU}^{\cos\phi_h}\cos\phi_h+\varepsilon A_{UU}^{\cos 2\phi_h}\cos 2\phi_h \\
+\ \lambda\sqrt{2\varepsilon(1-\varepsilon)}A_{LU}^{\sin\phi_h}\sin\phi_h \\
+\ S_L\left[\sqrt{2\varepsilon(1+\varepsilon)}A_{UL}^{\sin\phi_h}\sin\phi_h+\varepsilon A_{UL}^{\sin 2\phi_h}\sin 2\phi_h\right] \\
+\ S_L\lambda\left[\sqrt{1-\varepsilon^2}A_{LL}+\sqrt{2\varepsilon(1-\varepsilon)}A_{LL}^{\cos\phi_h}\cos\phi_h\right] \\
+\ S_T\left[\begin{array}{l}
A_{UT}^{\sin(\phi_h-\phi_S)}\sin(\phi_h-\phi_S) \\
+\ \varepsilon A_{UT}^{\sin(\phi_h+\phi_S)}\sin(\phi_h+\phi_S) \\
+\ \varepsilon A_{UT}^{\sin(3\phi_h-\phi_S)}\sin(3\phi_h-\phi_S) \\
+\ \sqrt{2\varepsilon(1+\varepsilon)}A_{UT}^{\sin\phi_S}\sin\phi_S \\
+\ \sqrt{2\varepsilon(1+\varepsilon)}A_{UT}^{\sin(2\phi_h-\phi_S)}\sin(2\phi_h-\phi_S)
\end{array}\right] \\
+\ S_T\lambda\left[\begin{array}{l}
\sqrt{(1-\varepsilon^2)}A_{LT}^{\cos(\phi_h-\phi_S)}\cos(\phi_h-\phi_S) \\
+\ \sqrt{2\varepsilon(1-\varepsilon)}A_{LT}^{\cos\phi_S}\cos\phi_S \\
+\ \sqrt{2\varepsilon(1-\varepsilon)}A_{LT}^{\cos(2\phi_h-\phi_S)}\cos(2\phi_h-\phi_S)
\end{array}\right]
\end{array}\right\}$$





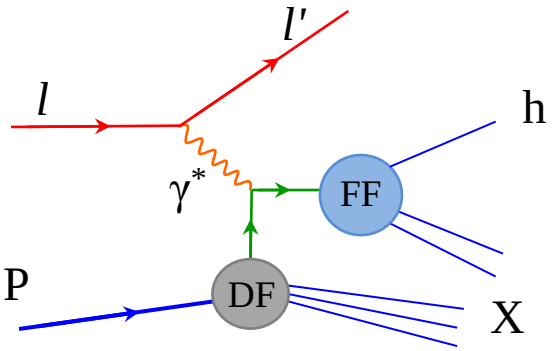
$$A_{U(L),T}^{w(\varphi_h,\varphi_S)} = \frac{F_{U(L),T}^{w(\varphi_h,\varphi_S)}}{F_{UU,T}+\varepsilon F_{UU,L}};\ \varepsilon = \frac{1-y-\frac{1}{4}\gamma^2y^2}{1-y+\frac{1}{2}y^2+\frac{1}{4}\gamma^2y^2},\ \gamma=\frac{2Mx}{Q}$$

SIDIS x-section and TMDs at twist-2

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} =$$

$$\left[\frac{\alpha}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\right]\left(F_{UU,T}+\varepsilon F_{UU,L}\right)$$

$$\times\Big\{1+\sqrt{2\varepsilon(1+\varepsilon)}A_{UU}^{\cos\phi_h}\cos\phi_h+\varepsilon A_{UU}^{\cos 2\phi_h}\cos 2\phi_h$$
$$+\lambda\sqrt{2\varepsilon(1-\varepsilon)}A_{LU}^{\sin\phi_h}\sin\phi_h$$
$$+S_L\left[\sqrt{2\varepsilon(1+\varepsilon)}A_{UL}^{\sin\phi_h}\sin\phi_h+\varepsilon A_{UL}^{\sin 2\phi_h}\sin 2\phi_h\right]$$
$$+S_L\lambda\left[\sqrt{1-\varepsilon^2}A_{LL}+\sqrt{2\varepsilon(1-\varepsilon)}A_{LL}^{\cos\phi_h}\cos\phi_h\right]$$
$$+S_T\Big[A_{UT}^{\sin(\phi_h-\phi_S)}\sin(\phi_h-\phi_S)+\varepsilon A_{UT}^{\sin(\phi_h+\phi_S)}\sin(\phi_h+\phi_S)+\varepsilon A_{UT}^{\sin(3\phi_h-\phi_S)}\sin(3\phi_h-\phi_S)+\sqrt{2\varepsilon(1+\varepsilon)}A_{UT}^{\sin\phi_S}\sin\phi_S+\sqrt{2\varepsilon(1+\varepsilon)}A_{UT}^{\sin(2\phi_h-\phi_S)}\sin(2\phi_h-\phi_S)\Big]$$
$$+S_T\lambda\Big[\sqrt{(1-\varepsilon^2)}A_{LT}^{\cos(\phi_h-\phi_S)}\cos(\phi_h-\phi_S)+\sqrt{2\varepsilon(1-\varepsilon)}A_{LT}^{\cos\phi_S}\cos\phi_S+\sqrt{2\varepsilon(1-\varepsilon)}A_{LT}^{\cos(2\phi_h-\phi_S)}\cos(2\phi_h-\phi_S)\Big]\Big\}$$



Quark / Nucleon	U	L	T
U	$f_1^q(x,\boldsymbol{k}_T^2)$ **number density**		$h_1^{\perp q}(x,\boldsymbol{k}_T^2)$ **Boer-Mulders**
L		$g_1^q(x,\boldsymbol{k}_T^2)$ **helicity**	$h_{1L}^{\perp q}(x,\boldsymbol{k}_T^2)$ **Kotzinian-Mulders** worm-gear L
T	$f_{1T}^{\perp q}(x,\boldsymbol{k}_T^2)$ **Sivers**	$g_{1T}^q(x,\boldsymbol{k}_T^2)$ **Kotzinian-Mulders** worm-gear T	$h_1^q(x,\boldsymbol{k}_T^2)$ **transversity** $h_{1T}^{\perp q}(x,\boldsymbol{k}_T^2)$ **pretzelosity**

+ two FFs: $D_{1q}^h(z,P_\perp^2)$ and $H_{1q}^{\perp h}(z,P_\perp^2)$

Cahn effect: the first thing I learned to derive

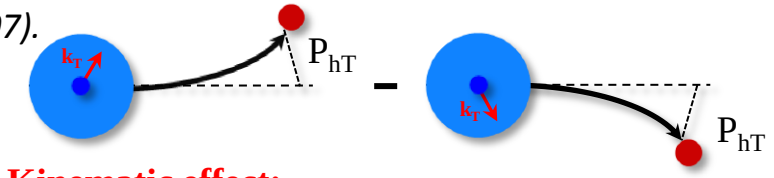
Bacchetta, Diehl, Goeke, Metz, Mulders and Schlegel JHEP 0702:093 (2007).

$$\frac{d\sigma}{dxdydzdP_{hT}^2 d\varphi_h d\psi} = \left[\frac{\alpha}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\right]\times\left(F_{UU,T}+\varepsilon F_{UU,L}\right)\times$$

$$1+\underbrace{\cos\varphi_h \times\sqrt{2\varepsilon(1+\varepsilon)}A_{UU}^{\cos\varphi_h}}+\cos(2\varphi_h)\times\varepsilon A_{UU}^{\cos(2\varphi_h)}+\ldots$$

Cahn effect

***R. N. Cahn*, PLB 78 (1978)**



Kinematic effect:
non-zero k_T induces an azimuthal modulation

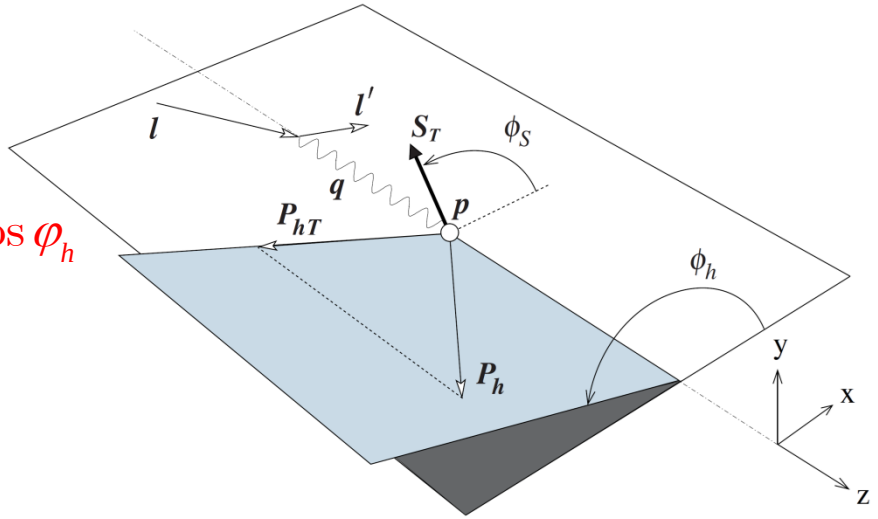
$$\hat{s} \simeq xs\left[1-2\sqrt{1-y}\,\frac{k_T}{Q}\cdot\cos\varphi_q\right]$$

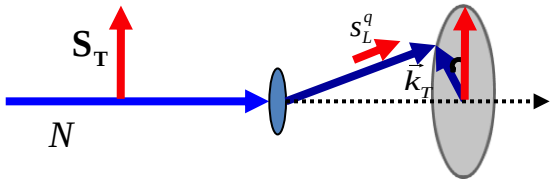
$$\hat{u} \simeq -xs(1-y)\left[1-\frac{2k_T}{Q\sqrt{1-y}}\cdot\cos\varphi_q\right]$$

$$\hat{t} = -Q^2 = -xys, \quad where \quad s=(l+P)^2$$

$$d\sigma^{lp\to l'hX} \propto d\sigma^{lq\to lq} \propto \frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}$$

$k_T \to \cos\varphi_q \to \cos\varphi_h$





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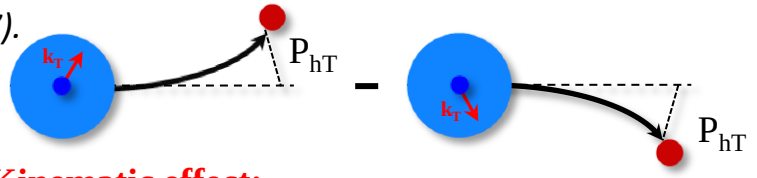

Kinematic effect:
non-zero k_T induces an azimuthal modulation

Cahn effect

***R. N. Cahn*, PLB 78 (1978)**

The point that there are azimuthal dependences which arise from the transverse momenta of the partons was clearly stated in this papers:
T.P. Cheng and A. Zee, Phys. Rev. D6 (1972) 885;
F. Ravndal, Phys. Lett. 43B (1973) 301.
R.L. Kingsley, Phys. Rev. D10 (1974) 1580;
A.M. Kotsinyan, Teor. Mat. Fiz. 24 (1975) 206;
(Engl. transl. Theor. Math. Phys. 24 (1976) 776).

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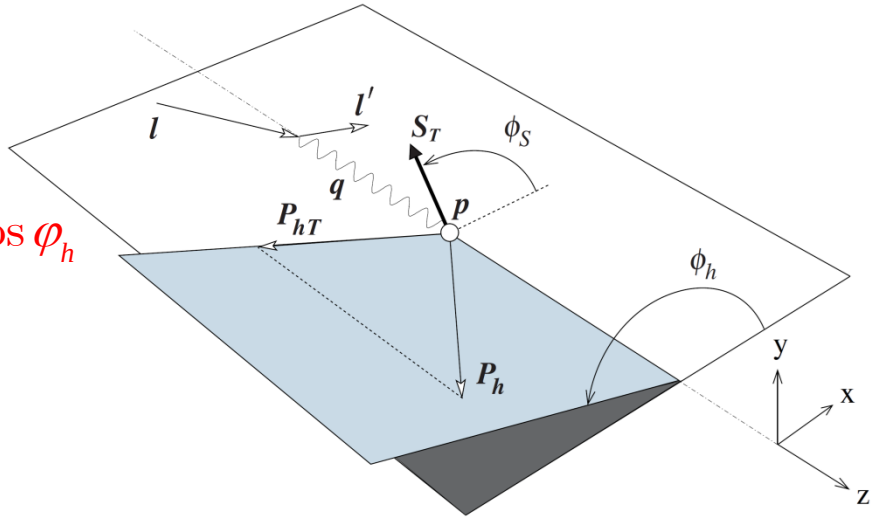
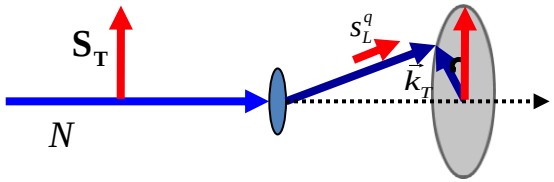
$$k_T \to \cos\varphi_q \to \cos\varphi_h$$





"Longitudinal" Cahn effect

Bacchetta, Diehl, Goeke, Metz, Mulders and Schlegel JHEP 0702:093 (2007).

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Longitudinal Cahn effect

***Kotzinian et al.* Phys. Rev. D 74,** 074015 (2006)

$$1+\underbrace{\cos\varphi_h\times\sqrt{2\varepsilon(1+\varepsilon)}A_{UU}^{\cos\varphi_h}}+\cos(2\varphi_h)\times\varepsilon A_{UU}^{\cos(2\varphi_h)}+\ldots+\underline{S_L\lambda\sqrt{2\varepsilon(1-\varepsilon)}\cos\varphi_h\times A_{LL}^{\cos\phi_h}}+\ldots$$

Cahn effect

***R. N. Cahn*, PLB 78 (1978)**

$$F_{LL}^{\cos\phi_h}=\frac{2M}{Q}C\left\{\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p_T}}{M_h}\left(xe_L H_{1q}^{\perp h}-\frac{M_h}{M}g_{1L}^q\frac{\tilde{D}_q^{\perp h}}{z}\right)-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k_T}}{M}\left(xg_L^{\perp q}D_{1q}^h+\frac{M_h}{M}h_{1L}^{\perp q}\frac{\tilde{E}_q^h}{z}\right)\right\}$$

xe_L ↓ $\quad$ $xg_L^{\perp q}+\frac{m}{M}h_{1L}^{\perp q}+g_{1L}^q$ ↓

$$F_{LL}^{\cos\phi_h}=\frac{2M}{Q}C\left\{\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p_T}}{M_h}\left(\cancel{xe_L H_{1q}^{\perp h}}+\frac{M_h}{M}g_{1L}^q\cancel{\frac{\tilde{D}_q^{\perp h}}{z}}\right)-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k_T}}{M}\left(\left(\cancel{xg_L^{\perp q}}+\cancel{\frac{m}{M}h_{1L}^{\perp q}}+g_{1L}^q\right)D_{1q}^h+\frac{M_h}{M}\cancel{h_{1L}^{\perp q}}\cancel{\frac{\tilde{E}_q^h}{z}}\right)\right\}$$

↓

$$F_{LL}^{\cos\phi_h}=\frac{2M}{Q}C\left\{-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k_T}}{M}g_{1L}^q D_{1q}^h+\ldots\right\}$$

$$\hat{s}\simeq xs\left[1-2\sqrt{1-y}\frac{k_T}{Q}\cdot\cos\varphi_q\right]+O\left(\frac{k_T^2}{Q^2}\right)$$

$$\hat{u}\simeq -xs(1-y)\left[1-\frac{2k_T}{Q\sqrt{1-y}}\cdot\cos\varphi_q\right]+O\left(\frac{k_T^2}{Q^2}\right)$$

$$\hat{t}=-Q^2=-xys,\quad where\quad s=(l+P)^2$$

$$d\sigma^{lp\to l'hX}\propto d\sigma^{lq\to lq}\propto\frac{\hat{s}^2+\hat{u}^2+\lambda\lambda_q(\hat{s}^2-\hat{u}^2)}{\hat{t}^2}$$

Wandzura-Wilczek approximation

+ neglecting m_q scaled terms

sub-leading effect

$$C[wfD]=x\sum_q e_q^2\int d^2\boldsymbol{k}_T d^2\boldsymbol{p}_T\delta^{(2)}(\boldsymbol{k}_T-\boldsymbol{p}_T-\boldsymbol{P}_{hT}/z)w(\boldsymbol{k}_T,\boldsymbol{p}_T)f^q(x,\boldsymbol{k}_T^2)D_q^h(z,\boldsymbol{k}_T^2)$$

$\hat{\boldsymbol{h}}=\vec{P}_{hT}/|\vec{P}_{hT}|$, $\boldsymbol{p}_T$ – TM of the quark w.r.t. the direction of the produced hadron

"Longitudinal" Cahn effect and A_{LL}

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{1 + \ldots + S_L \lambda \sqrt{1-\varepsilon^2}\, A_{LL} + S_L \lambda \sqrt{2\varepsilon(1-\varepsilon)}\, A_{LL}^{\cos\phi_h} \cos\phi_h + \ldots\right\}$$

PHYSICAL REVIEW D **74,** 074015 (2006)

Transverse momentum dependence of the quark helicity distributions and the Cahn effect in double-spin asymmetry A_{LL} in semiinclusive DIS

M. Anselmino,[1] A. Efremov,[2] A. Kotzinian,[2,3,4] and B. Parsamyan[3]

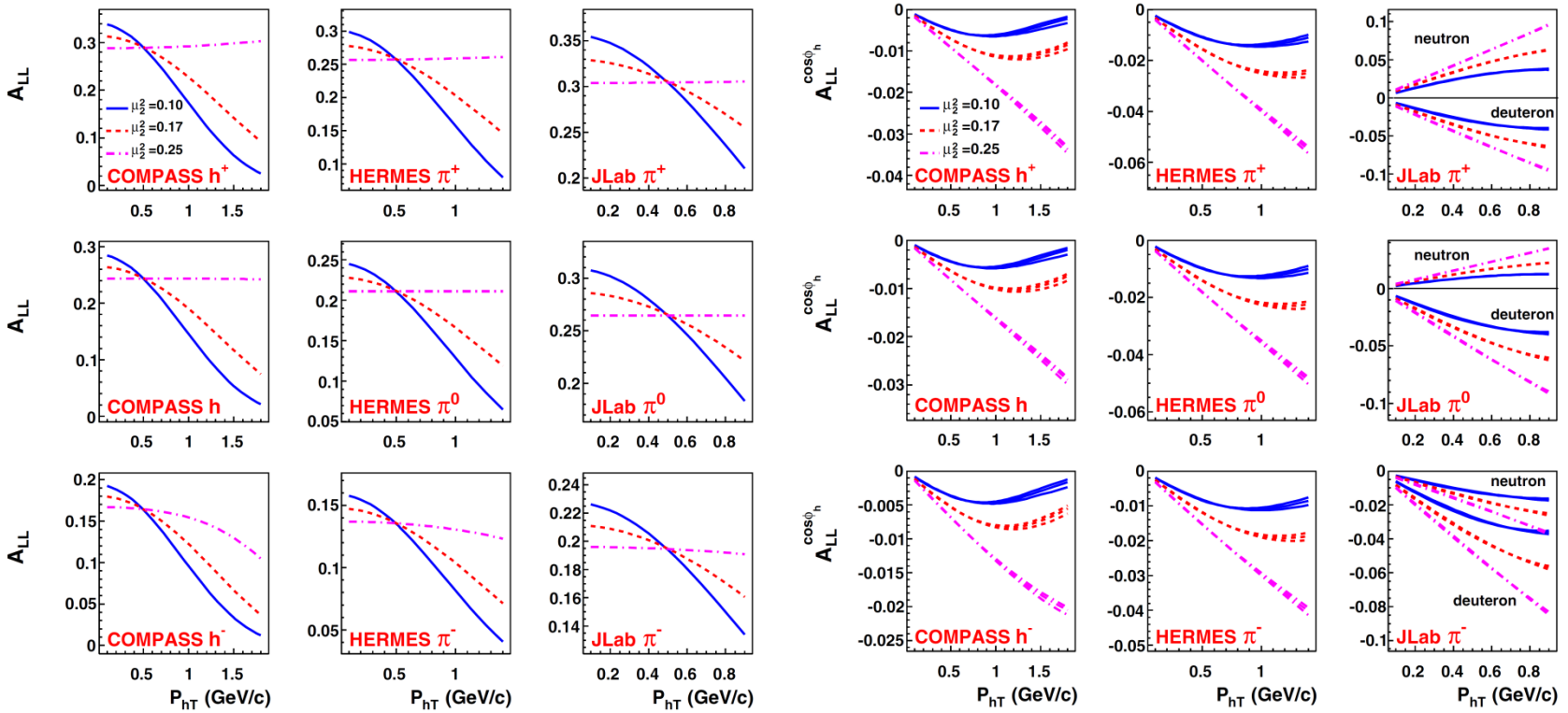
[1]*Dipartimento di Fisica Teorica, Università di Torino, and INFN, Sezione di Torino, Via P. Giuria 1, I-10125 Torino, Italy*

[2]*JINR, 141980 Dubna, Russia*

[3]*Dipartimento di Fisica Generale, Università di Torino, and INFN, Sezione di Torino, Via P. Giuria 1, I-10125 Torino, Italy*

[4]*Yerevan Physics Institute, 375036 Yerevan, Armenia*

(Received 4 August 2006; published 23 October 2006)

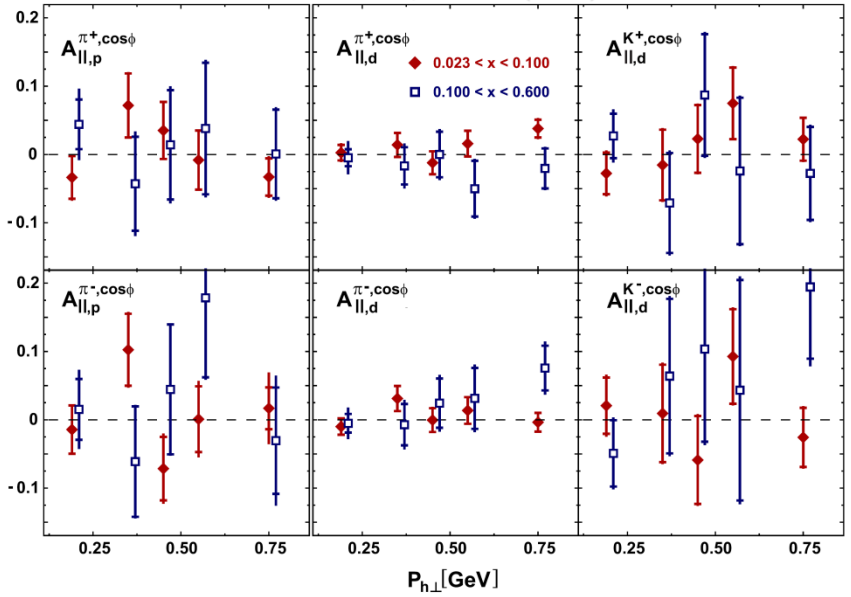


“Longitudinal” Cahn effect

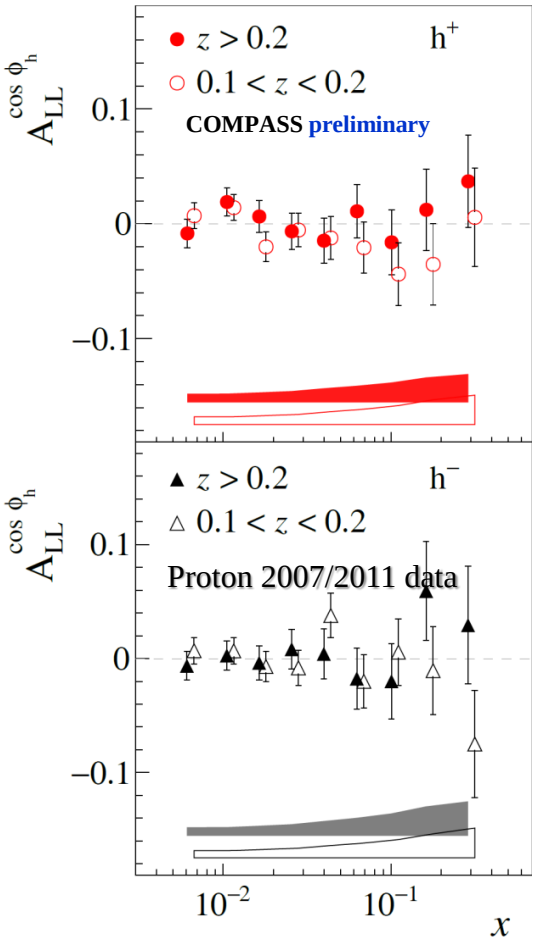
$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{1 + \ldots + S_L \lambda \sqrt{2\varepsilon(1-\varepsilon)}\, A_{LL}^{\cos\phi_h} \cos\phi_h + \ldots\right\}$$

$$F_{LL}^{\cos\phi_h} = \frac{2M}{Q}\mathcal{C}\left\{-\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{p}_T}{M_h}\left(x e_L^q H_{1q}^{\perp h} + \frac{M_h}{M} g_{1L}^q \frac{\tilde{D}_q^{\perp h}}{z}\right) + \frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M}\left(x g_L^{\perp q} D_{1q}^h - \frac{M_h}{M} h_{1L}^{\perp q} \frac{\tilde{E}_q^h}{z}\right)\right\}$$

HERMES: PRD 99, 112001 (2019) **NEW**



B. Parsamyan (for COMPASS)
arXiv:1801.01488 [hep-ex]



- Various different “twist” ingredients, factor Q^{-1}
- Non zero at JLab
- HERMES/COMPASS - small and compatible with zero, in agreement with model predictions

“Longitudinal” Cahn effect

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{1 + \ldots + S_L \lambda \sqrt{2\varepsilon(1-\varepsilon)}\, A_{LL}^{\cos\phi_h} \cos\phi_h + \ldots\right\}$$

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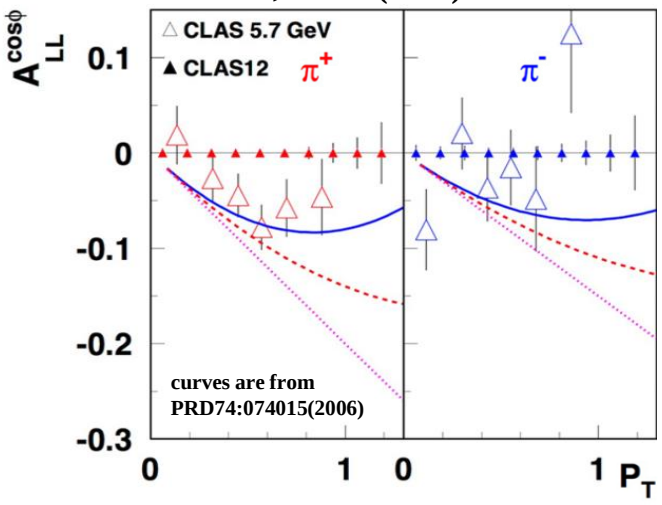
PRL 105,262002(2010)



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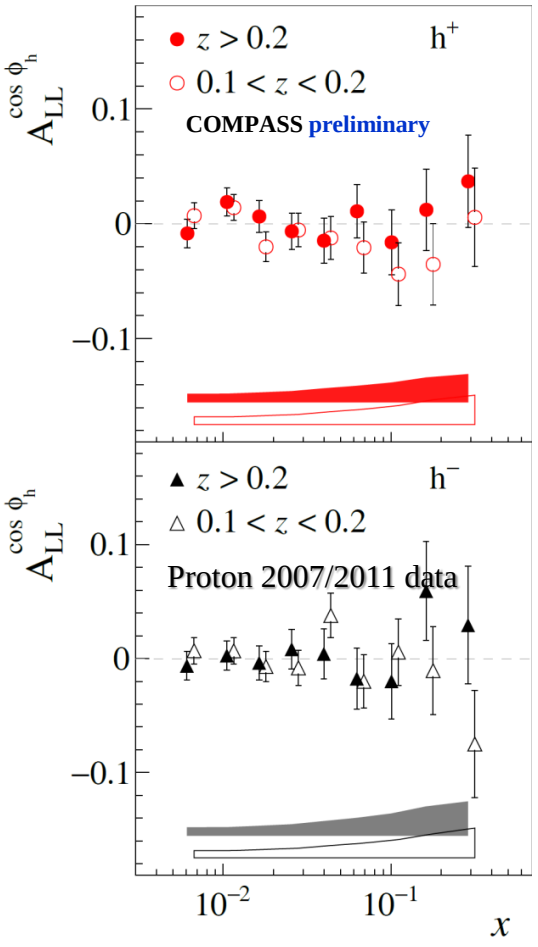
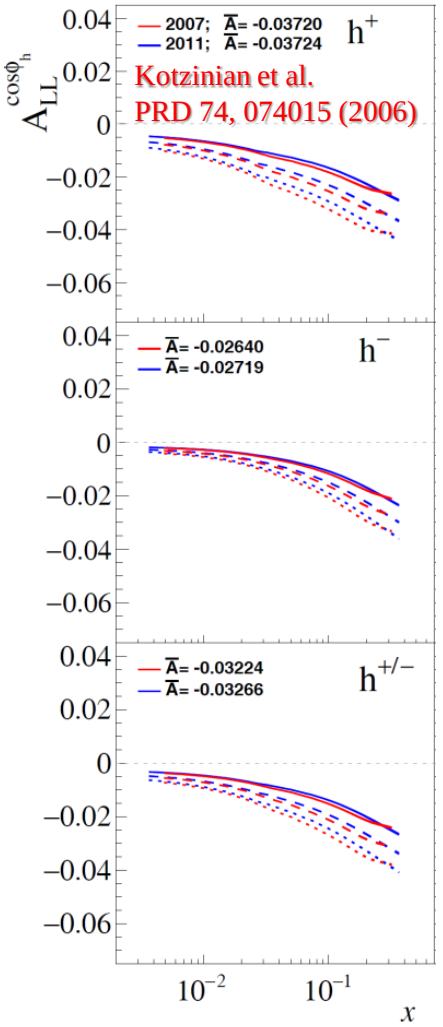




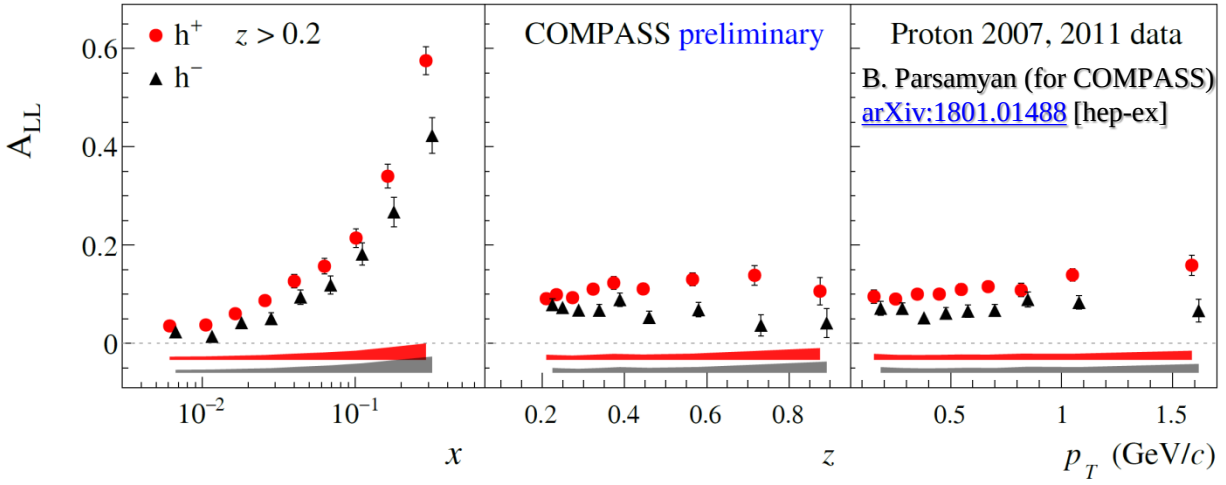
- Various different “twist” ingredients, factor Q^{-1}
- Non zero at JLab
- HERMES/COMPASS - small and compatible with zero, in agreement with model predictions

SIDIS: double LL-spin constant term asymmetry

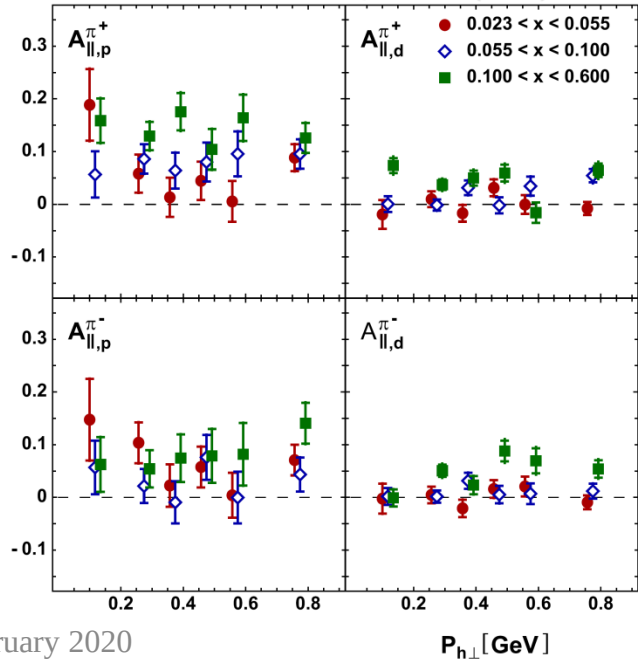
$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{1 + \ldots + S_L \lambda \sqrt{1-\varepsilon^2}\, A_{LL} + \ldots\right\}$$

$$F_{LL}^1 = \mathcal{C}\left\{g_{1L}^q D_{1q}^h\right\}$$

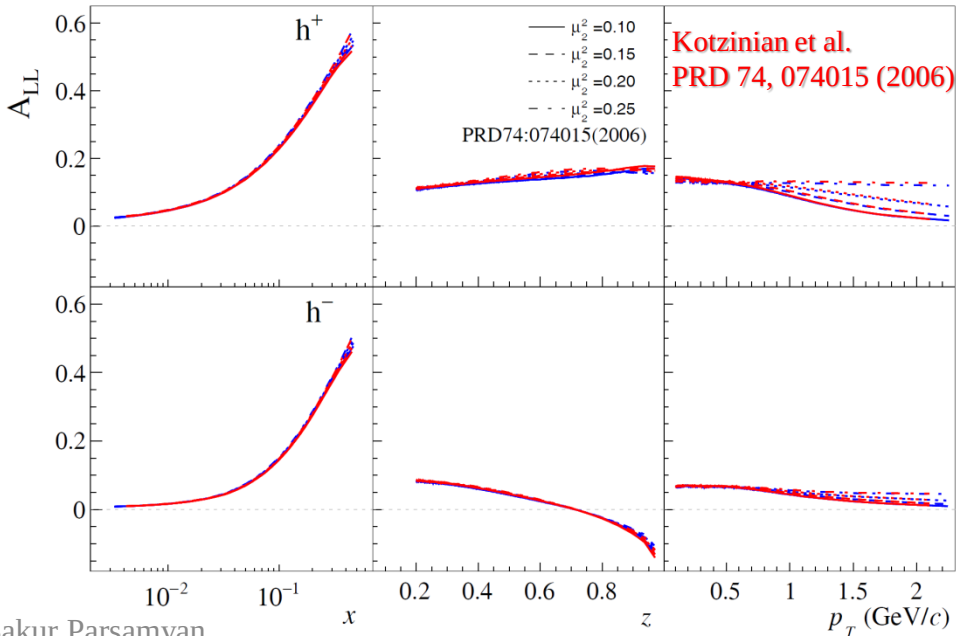
- Measurement of (semi-)inclusive $A_1(A_{LL})$ is one of the key physics topics of HERMES/COMPASS
- Large amount of P/D data
- No P_T-dependence observed



HERMES: PRD 99, 112001 (2019) **NEW**



COMPASS Proton-2007, -2011 kinematics



SIDIS: target transverse spin dependent asymmetries

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{ 1 + \ldots \right.$$

$$+ S_T \left[\begin{array}{l} + \varepsilon A_{UT}^{\sin(3\phi_h - \phi_S)} \sin(3\phi_h - \phi_S) \\ + \sqrt{2\varepsilon(1+\varepsilon)} A_{UT}^{\sin\phi_S} \sin\phi_S \\ + \ldots \end{array} \right]$$

$$\left. + S_T \lambda \left[\begin{array}{l} \sqrt{(1-\varepsilon^2)} A_{LT}^{\cos(\phi_h - \phi_S)} \cos(\phi_h - \phi_S) \\ + \ldots \end{array} \right] \right\}$$

$A_{LT}^{\cos(\phi_h - \phi_S)}$ *Kotzinian-Mulders asymmetry*

- Only "twist-2" ingredients
- **Sizable non-zero effect for h⁺ !**
- **Similar effect at HERMES**

$$F_{LT}^{\cos(\phi_h - \phi_S)} = C\left[\frac{\hat{\boldsymbol{h}} \cdot \boldsymbol{k}_T}{M} g_{1T}^q D_{1q}^h\right]$$

PHYSICAL REVIEW D **73,** 114017 (2006)

Predictions for double spin asymmetry A_{LT} in semiinclusive DIS

A. Kotzinian,[1,2,4] B. Parsamyan,[1,4] and A. Prokudin[3,4]
[1]*Dipartimento di Fisica Generale, Università di Torino, Italy*
[2]*Yerevan Physics Institute, 375036 Yerevan, Armenia and JINR, 141980 Dubna, Russia*
[3]*Dipartimento di Fisica Teorica, Università di Torino, Italy*
[4]*INFN, Sezione di Torino, Via P. Giuria 1 I-10125 Torino, Italy*
(Received 29 March 2006; published 16 June 2006)

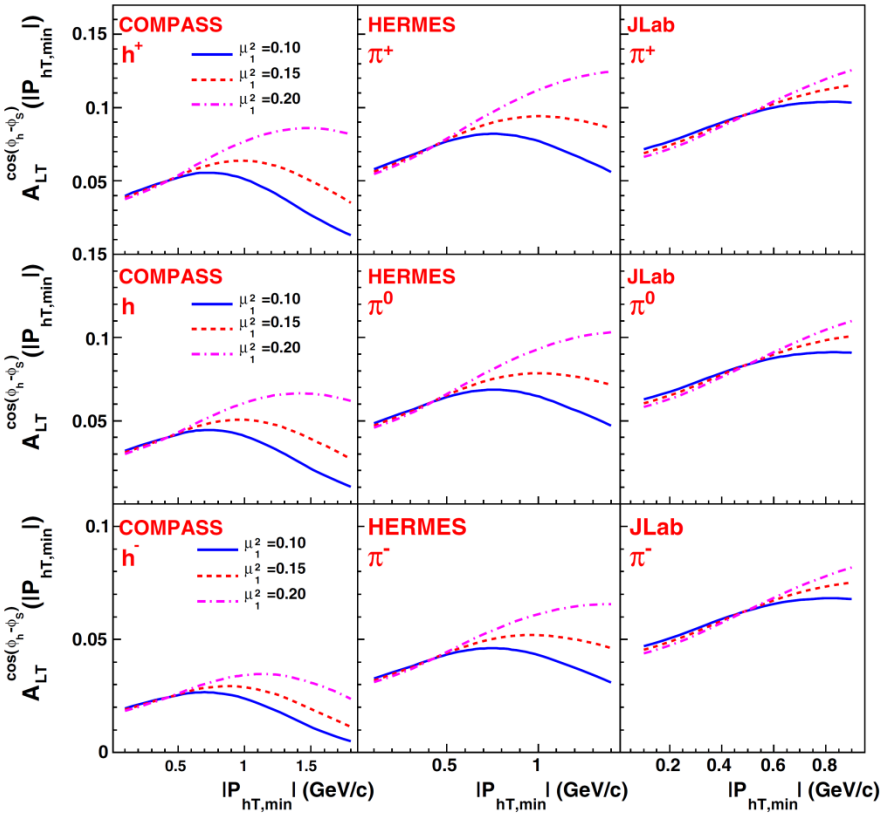


FIG. 5 (color online). Predicted dependence of $A_{LT}^{\cos(\phi_h - \phi_S)}(|\mathbf{P}_{hT,\min}|)$ on $|\mathbf{P}_{hT,\min}|$ for proton target.

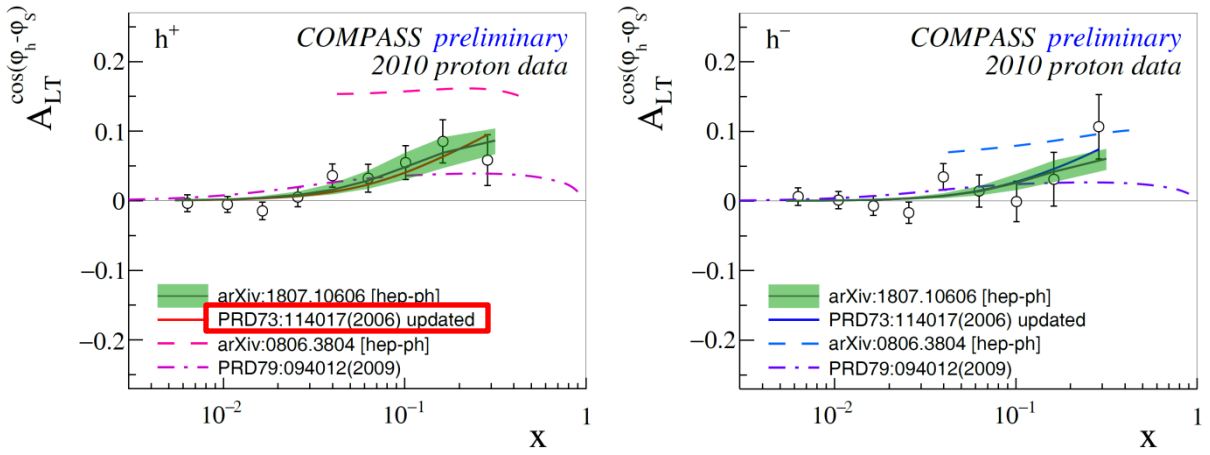
SIDIS: target transverse spin dependent asymmetries

$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\Big\{ \quad 1 + \ldots$$

$$+ S_T \left[\begin{array}{l} + \varepsilon A_{UT}^{\sin(3\phi_h - \phi_S)} \sin\left(3\phi_h - \phi_S\right) \\ + \sqrt{2\varepsilon(1+\varepsilon)} A_{UT}^{\sin\phi_S} \sin\phi_S \\ + \ldots \end{array} \right]$$

$$+ S_T \lambda \left[\begin{array}{l} \sqrt{\left(1-\varepsilon^2\right)} A_{LT}^{\cos(\phi_h - \phi_S)} \cos\left(\phi_h - \phi_S\right) \\ + \ldots \end{array} \right] \Big\}$$

B.Parsamyan (for COMPASS) PoS QCDEV2017 (2018) 042

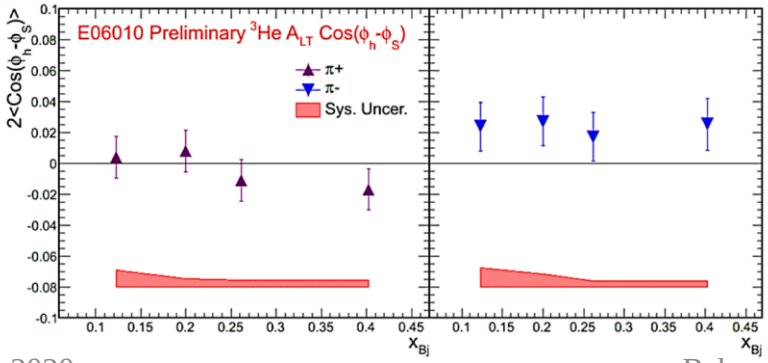


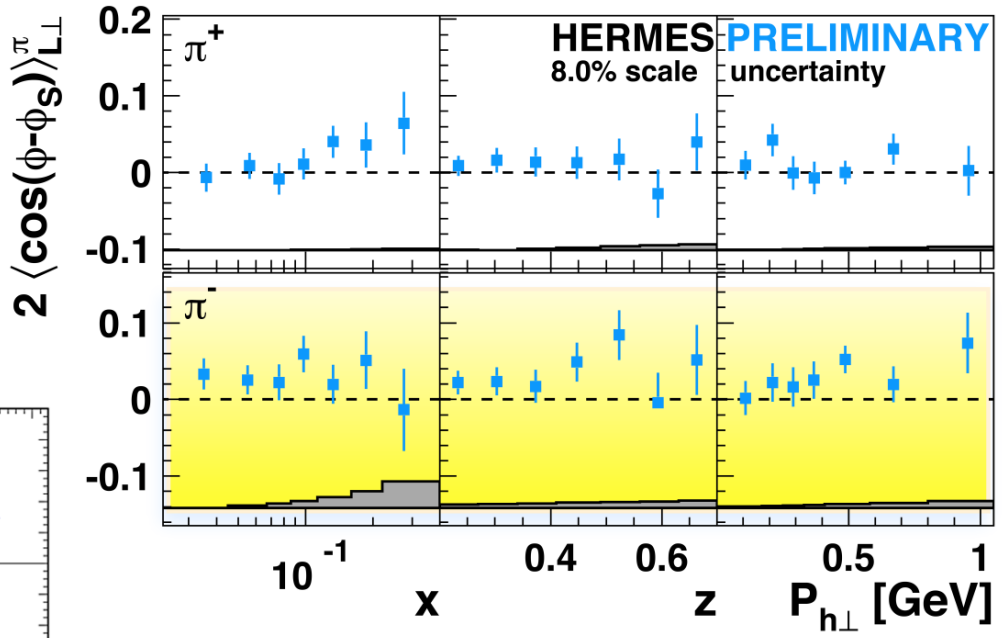
COMPASS/HERMES/JLab results

$A_{LT}^{\cos(\phi_h-\phi_S)}$ *Kotzinian-Mulders asymmetry*

- Only "twist-2" ingredients
- **Sizable non-zero effect for h^+ !**
- **Similar effect at HERMES**

$$F_{LT}^{\cos(\phi_h-\phi_S)} = C\left[\frac{\hat{\boldsymbol{h}}\cdot\boldsymbol{k}_T}{M} g_{1T}^q D_{1q}^h\right]$$





Defense day…

28 November 2007

Defense day… but that was far not the end!

28 November 2007

10 April 2019 - the day CPHI-2020 was born!

Selected Aram's topics discussed at COMPASS in past ~15 years

2019	Comparison of LEPTO and PYTHIA simulations for vector mesons production in DIS
2019	Cahn effect implementation in LEPTO
2018	Accessing polarized quark TMD DiFFs
2018	Lambda polarization in polarized SIDIS at twist-2
2017	QCD effects in 'unpolarized' cos φ and cos2 φ SIDIS asymmetries
2016	Theory of weighted Sivers
2015	CAMERA and SIDIS in the target fragmentation
2014	About Sivers and transversity effects in h+ h- production
2014	ΔΦ-dependence of the Structure Functions of h+h-production in SIDIS. Model independent analysis
2014	Azimuthal Correlations in 2h SIDIS
2013	Phenomenology of Transverse 1h and 2h asymmetries
2012	Finite Q^2 effects on asymmetry extractions in SIDIS
2012	Hadron pT in SIDIS
2010	Preasymptotic effects in polarized SIDIS: azimuthal asymmetries
2009	How well we know R(PGF) for Delta-G extraction from high-pt hadrons asymmetries
2008	Comments on Cahn effect and on extraction of SIDIS distributions
2008	Δs from SIDIS
2008	Lambda - analysis of systematics
2008	Target polarization dependence of (anti) Lambda polarization
2008	Longitudinal target polarization dependence of Lambda-bar polarization. MC free methods of Lambda polarization extraction
2007	Acceptance effects in asymmetries extraction
2007	Some studies on azimuthal asymmetry extraction
2007	SIDIS asymmetries in Quark-Diquark model
2007	Extraction of target transverse spin dependent asymmetries on identified pions and kaons from 2003-4 runs
2007	Comments on a "bias-free transverse asymmetry fit"
2006	Azimuthal dependance of SIDIS
2006	p_T-dependence of A_{LL} in semi-inclusive DIS
2006	Transverse spin azimuthal asymmetries in SIDIS
2005	Cahn and Sivers effects in the target fragmentation region of SIDIS
2005	Remarks on high-pt analysis
2005	g_2 and g_{1T}
2004	LEPTO & Fragmentation Functions
2004	Sivers effect at HERMES and COMPASS

No sign of efficiency decay!

Շնորհավոր՝ Արամ Միխայլովիչ
С Днём Рождения, Арам Михайлович!
Happy Birthday, Aram!

The show must go on!