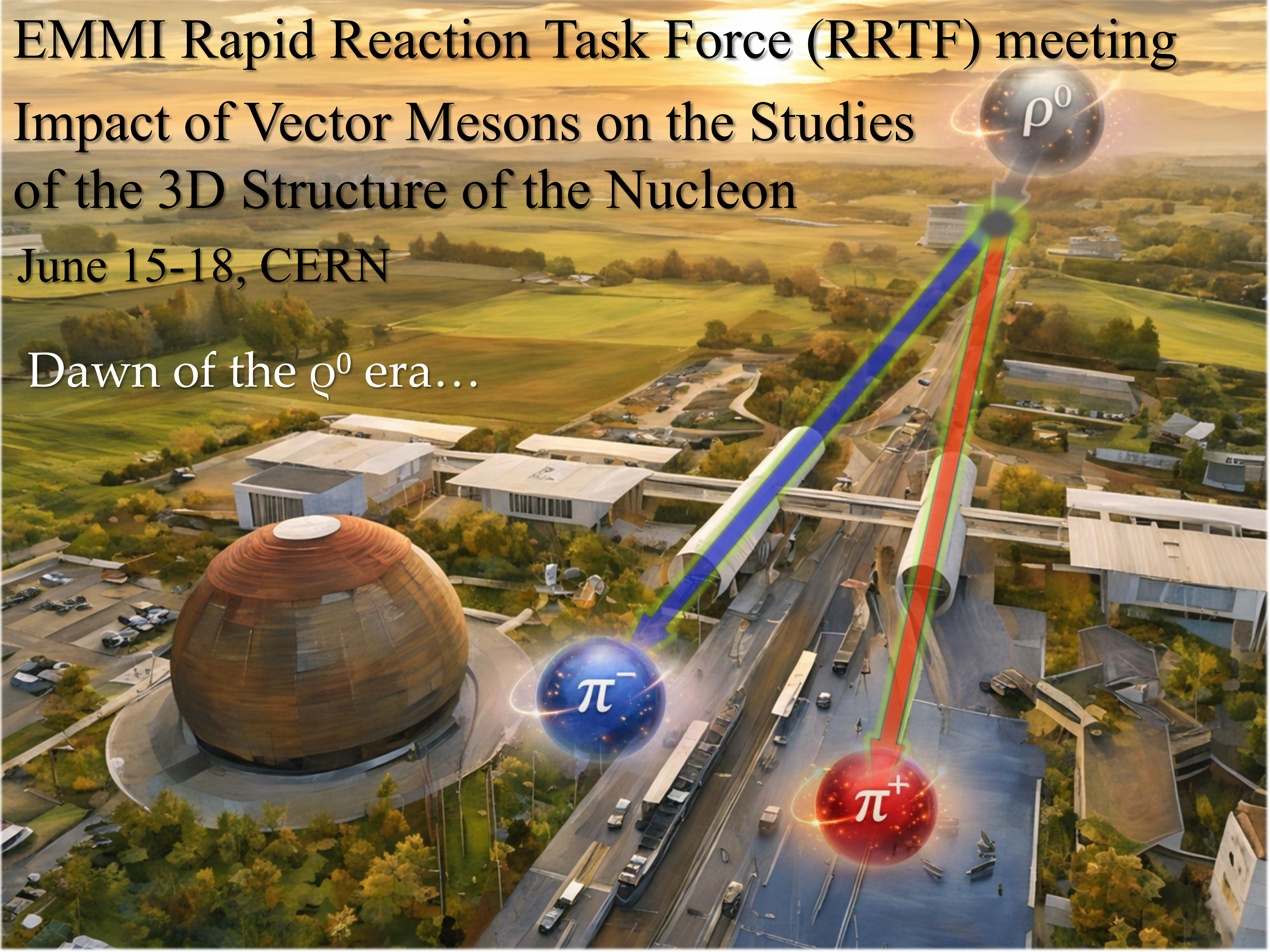
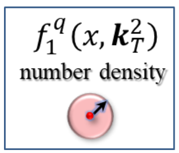

EMMI Rapid Reaction Task Force (RRTF) meeting
Impact of Vector Mesons on the Studies of the 3D Structure of the Nucleon
June 15-18, CERN
Dawn of the ϱ⁰ era…
ρ^0
π^-
π^+

- The role of vector mesons

Cahn effect in SIDIS

$$\frac{d\sigma}{dx\,dy\,dz\,dp_T^2\,d\phi_h\,d\phi_S} = \left[\frac{\alpha}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\right]\left(F_{UU,T}+\varepsilon F_{UU,L}\right)$$

$$\times\left(1+\underbrace{\sqrt{2\varepsilon(1+\varepsilon)}\,A_{UU}^{\cos\phi_h}\cos\phi_h}_{\text{Cahn effect}}+\ldots\right)$$



As of 1978 – simplistic kinematic effect:

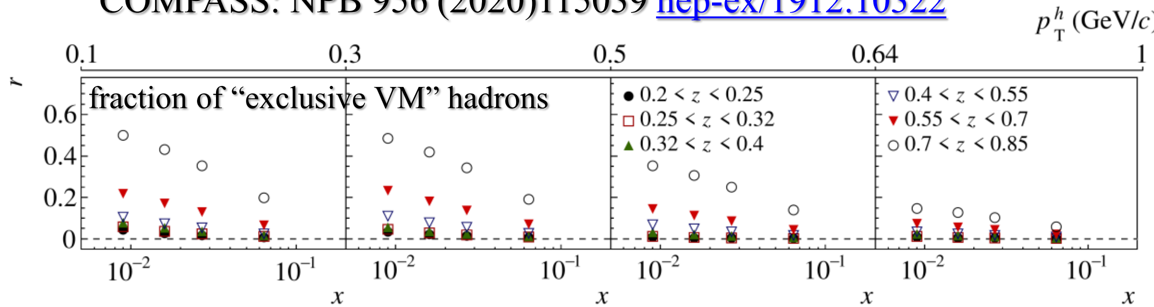
- non-zero k_T induces an azimuthal modulation

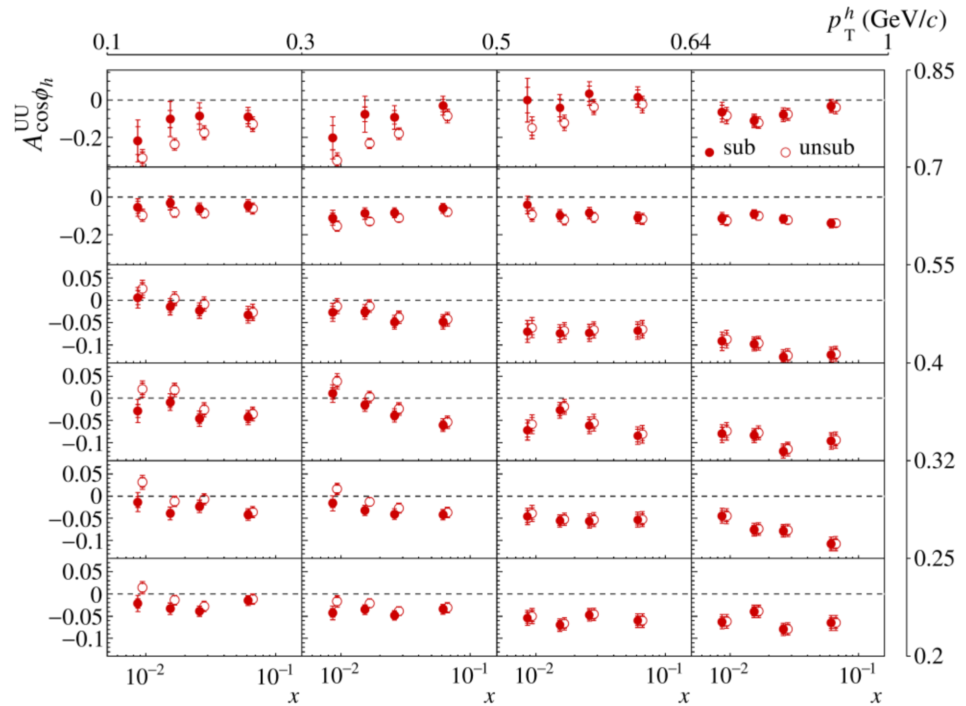
As of 2023 – complex SF (twist-2/3 functions)

- Measurements by different experiments
- Complex multi-D kinematic dependences
  - So far, no comprehensive interpretation
- A set of complex corrections:
  - Acceptance, diffractively produced VMs, radiative corrections (RC), etc.

Contribution of exclusive diffractive processes to the measured azimuthal asymmetries in SIDIS

COMPASS: NPB 956 (2020)115039 hep-ex/1912.10322





See Jan Matousek's talk

Cahn effect in SIDIS

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

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$f_1^q(x, \boldsymbol{k}_T^2)$
number density

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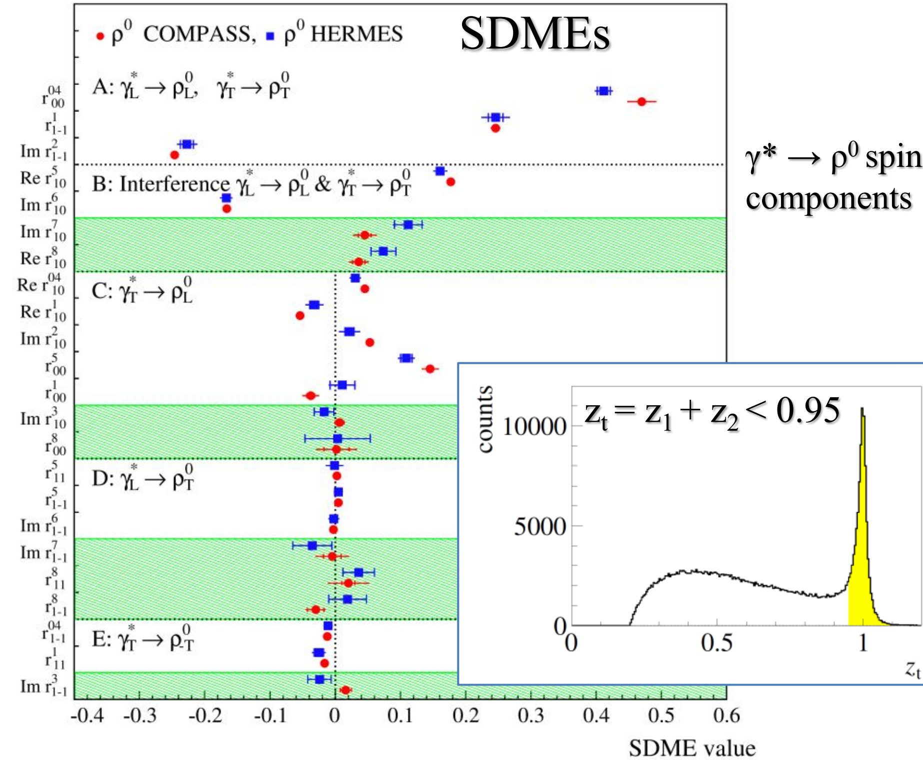
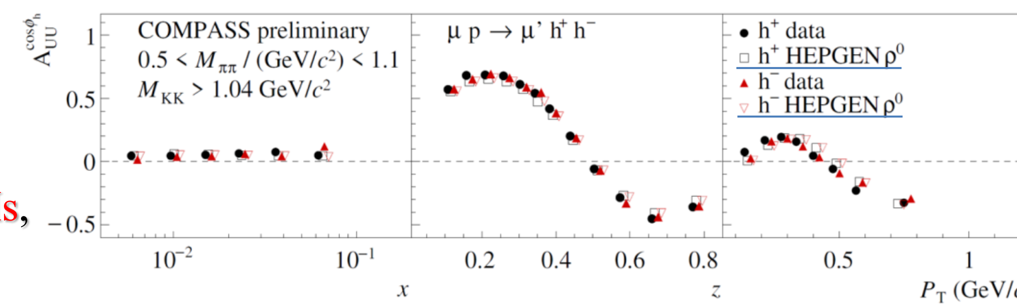
COMPASS, EPJC (2023) 83 924



$\gamma^* \to \rho^0$ spin components

VM contribution



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Cahn effect in SIDIS

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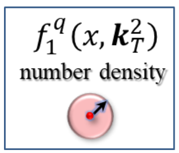

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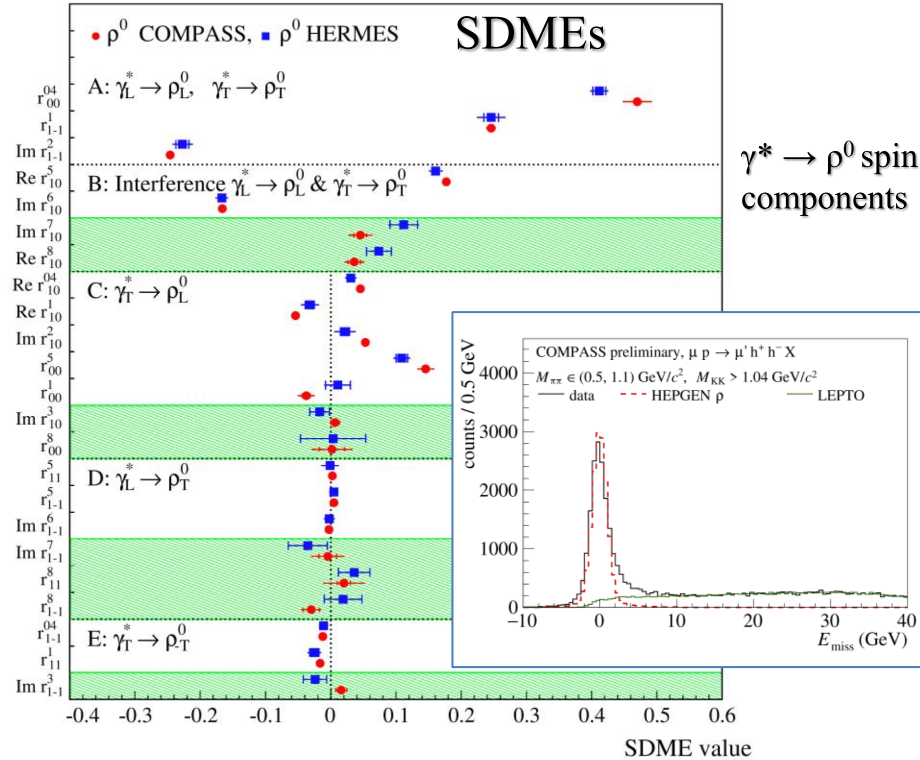
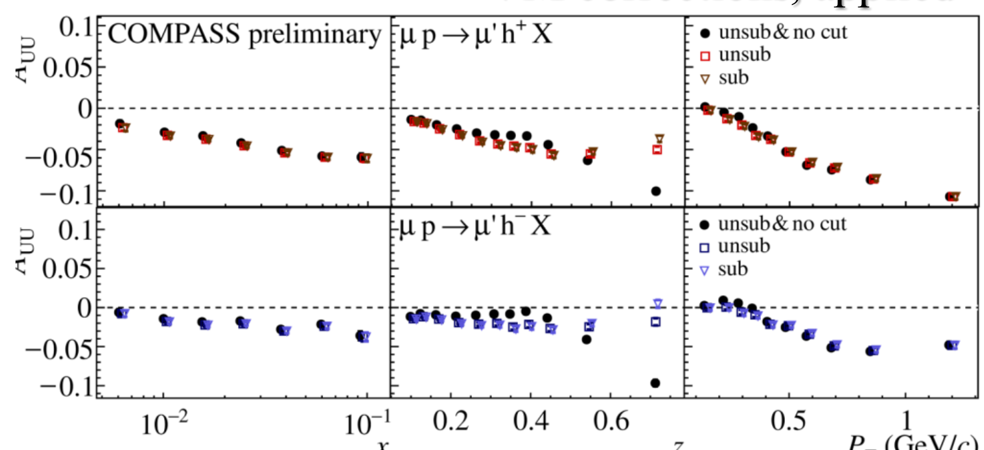
COMPASS, EPJC (2023) 83 924



$\gamma^* \to \rho^0$ spin components

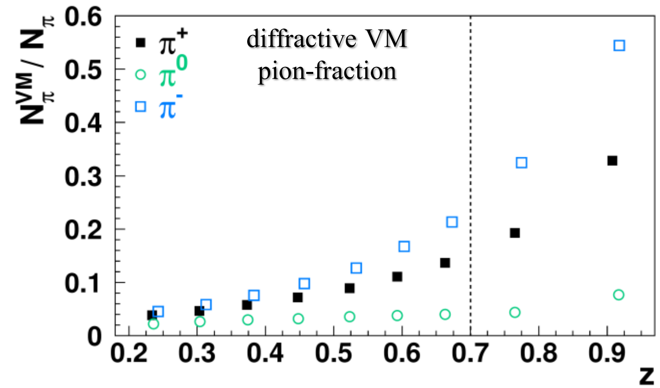
VM corrections, applied



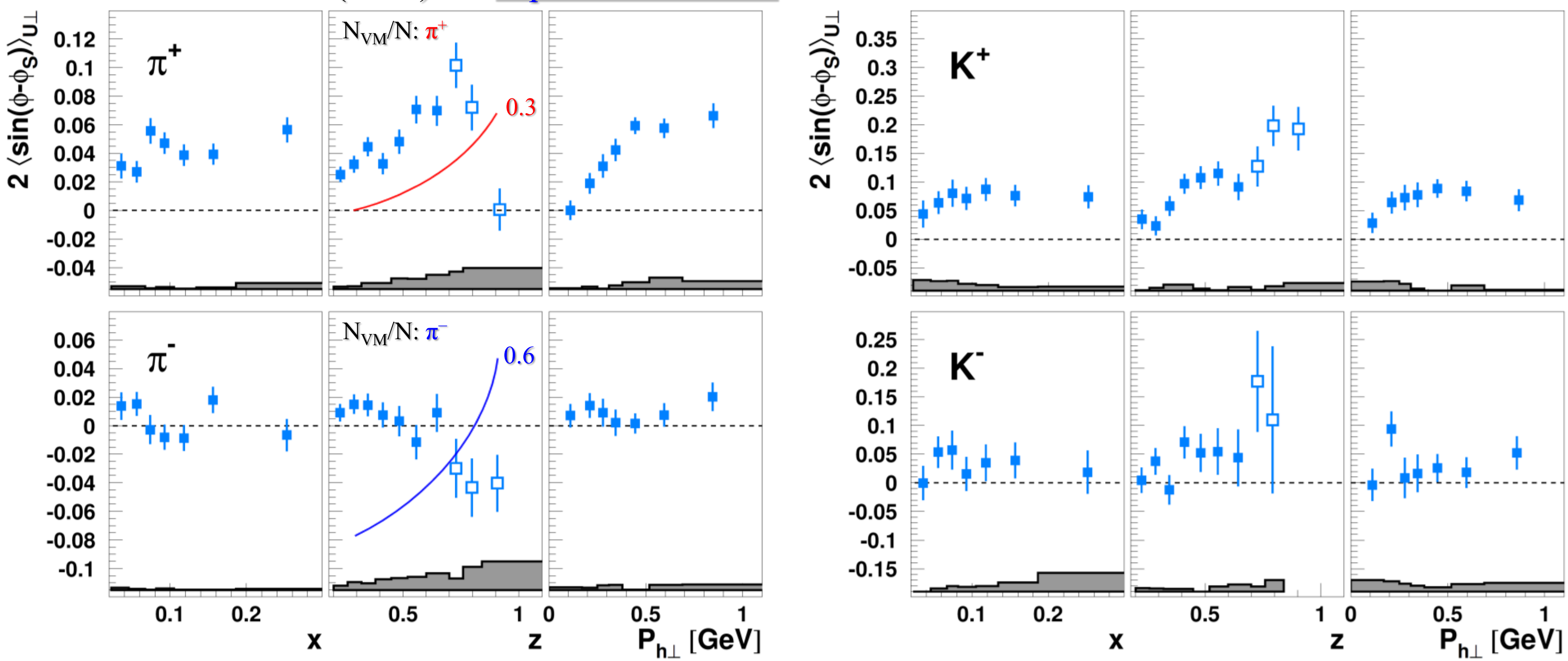
See Jan Matousek's talk

HERMES: Sivers effect and diffractive VMs

- The asymmetry drops at large z for pion
  - Not the case for kaons
- Can it be caused by exclusive diffractive VMs?
- The contamination indeed grows with *z* for pions
  - At the level of 10% for kaons



HERMES: JHEP 12(2020)010 [hep-ex/2007.07755](hep-ex/2007.07755)



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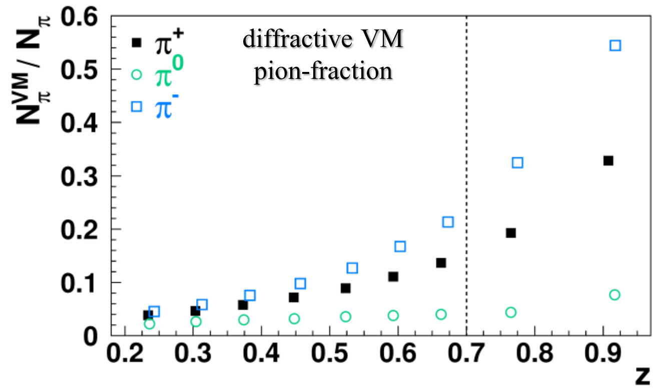
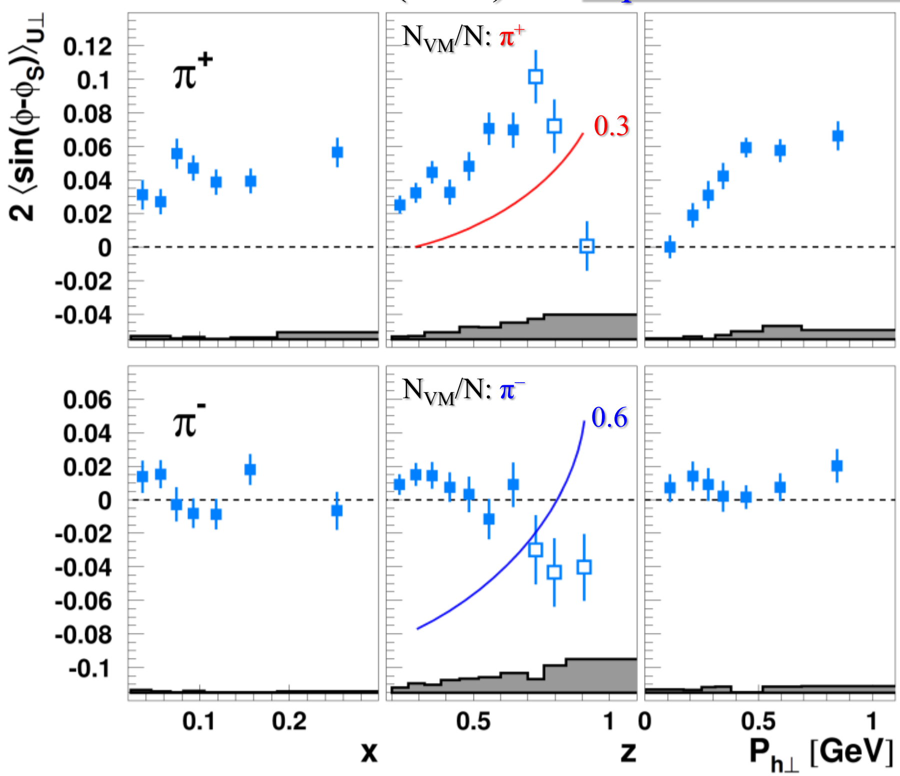
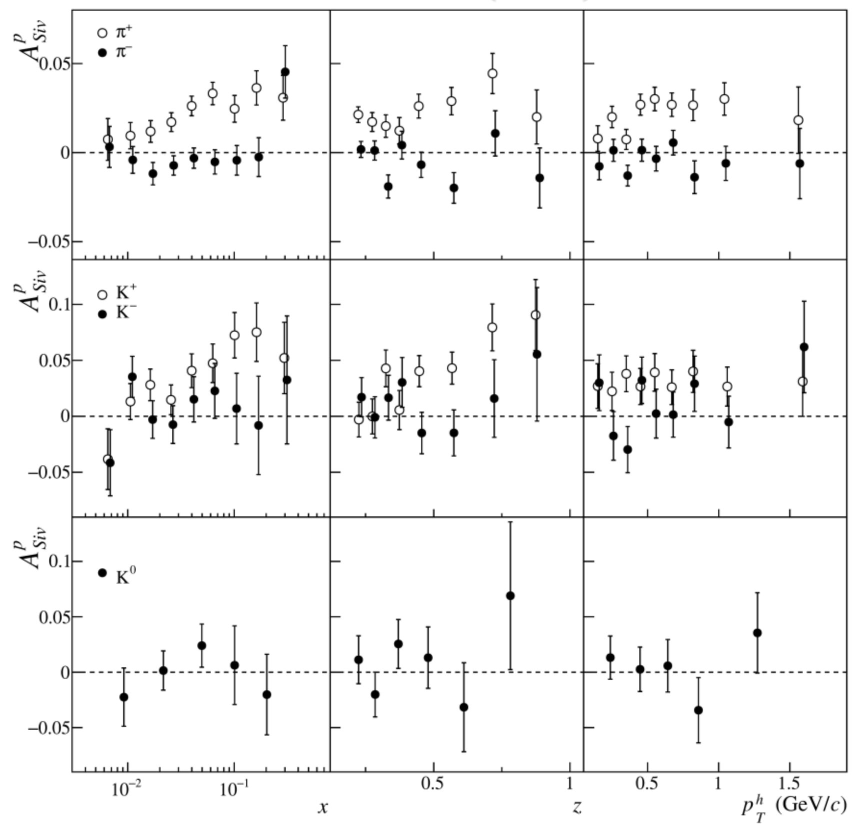


COMPASS: PLB 744 (2015) 250

HERMES: JHEP 12(2020)010 hep-ex/2007.07755





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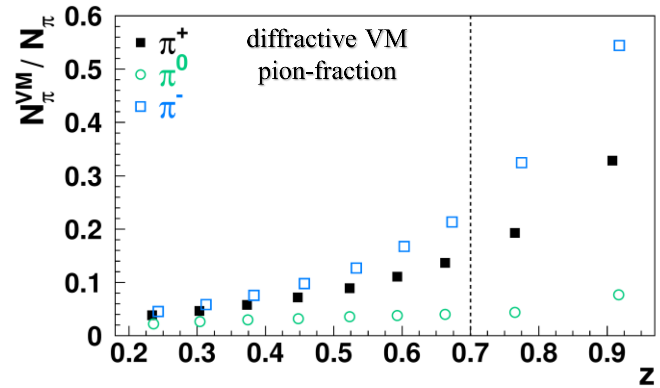

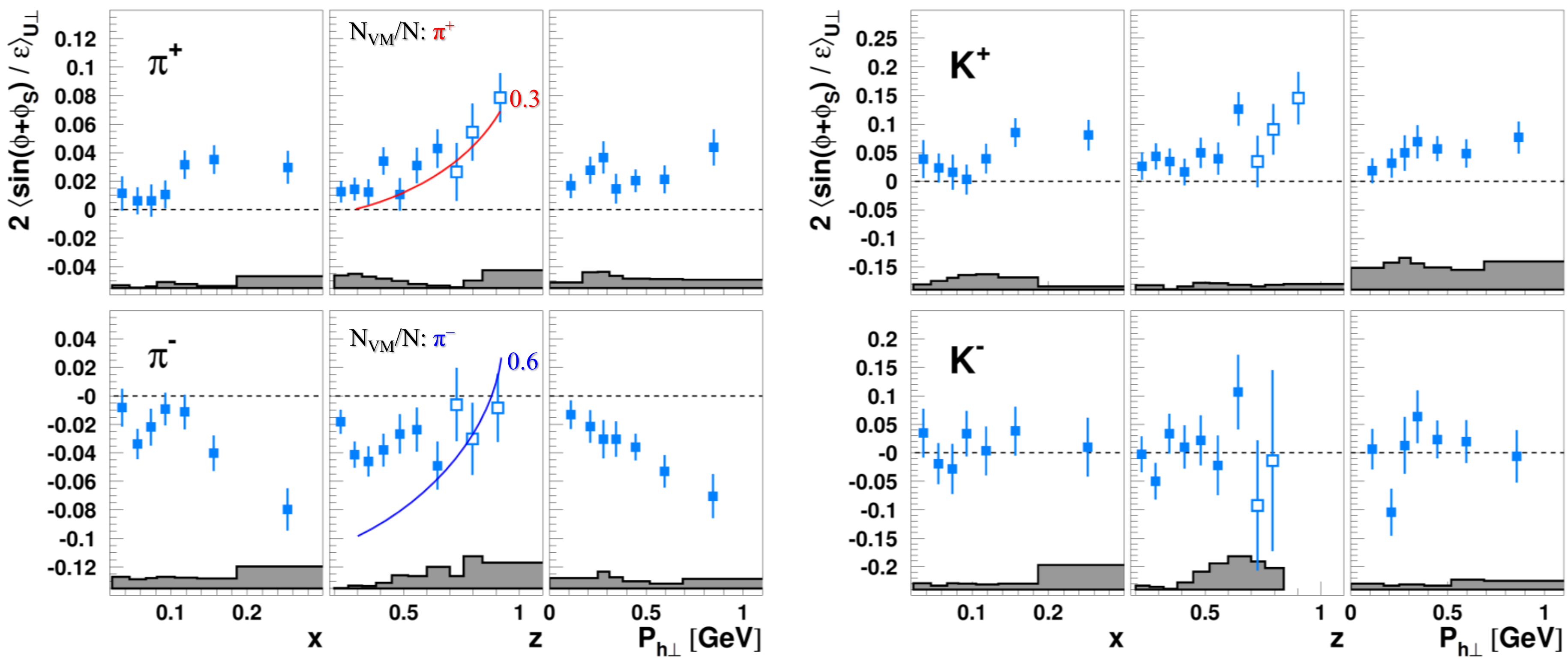

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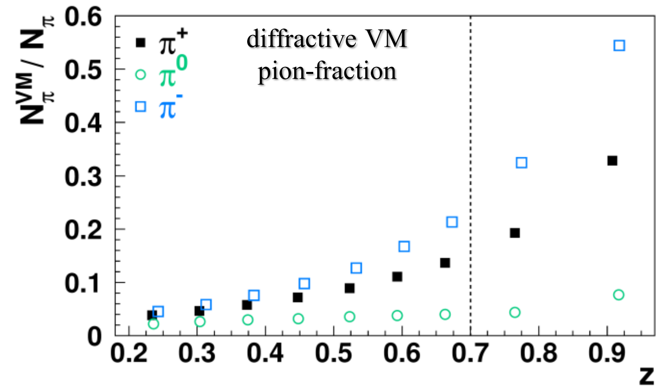
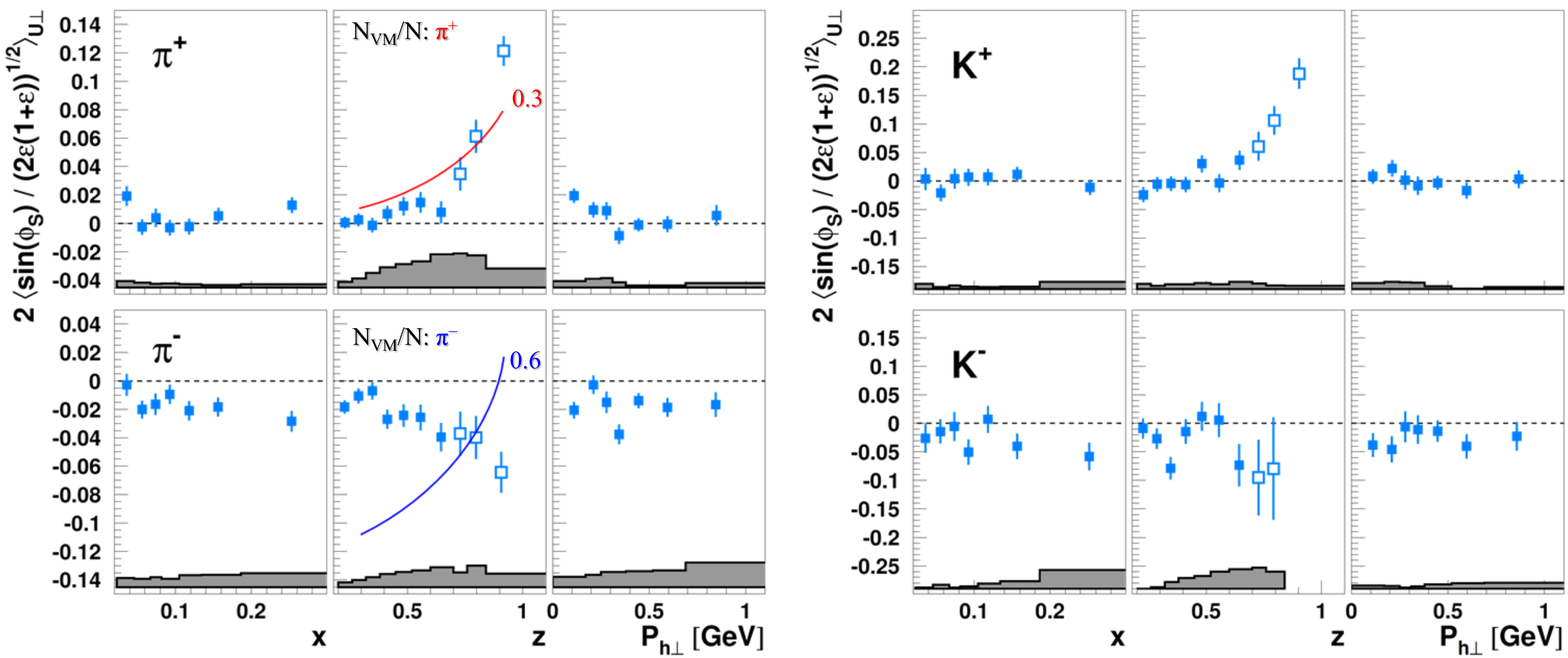
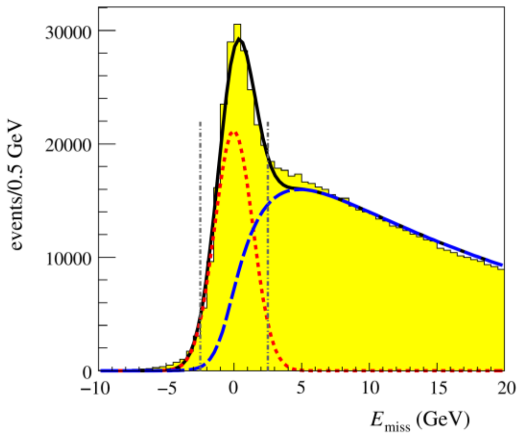
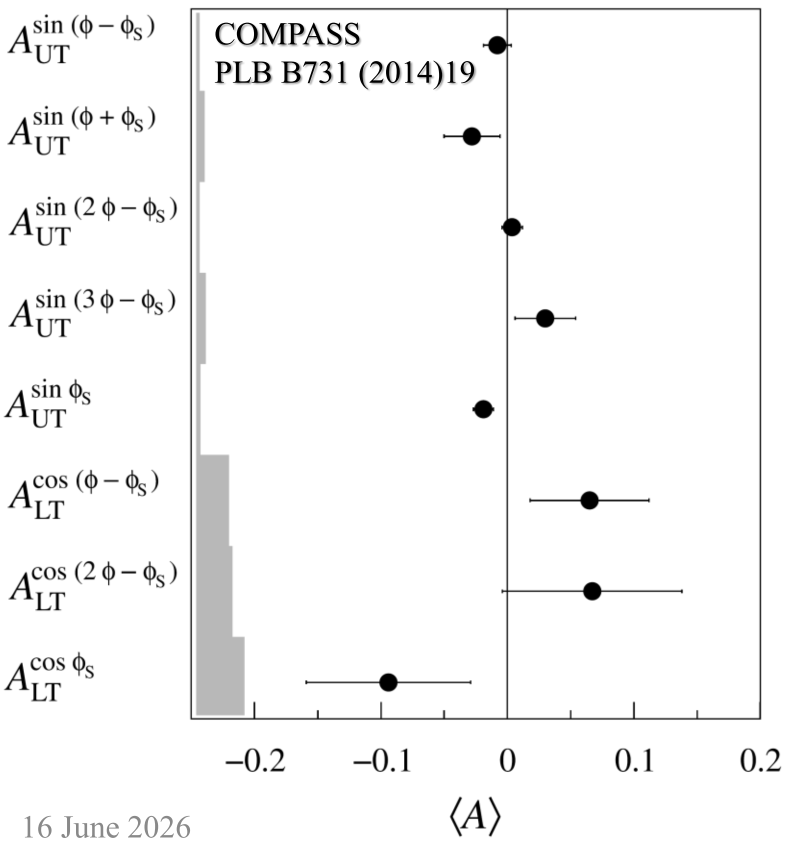




COMPASS: Exclusive ρ^0 TSAs



exclusive



- Both Collins and Sivers TSAs are small an compatible with zero
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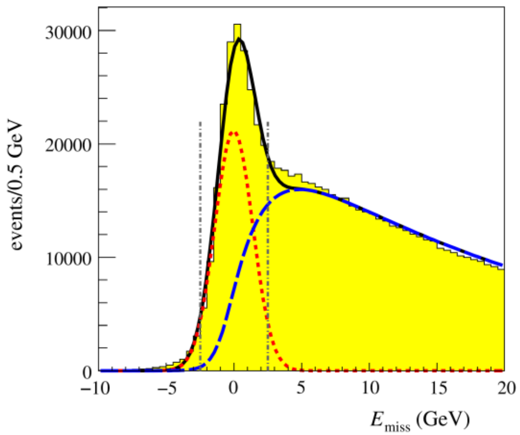

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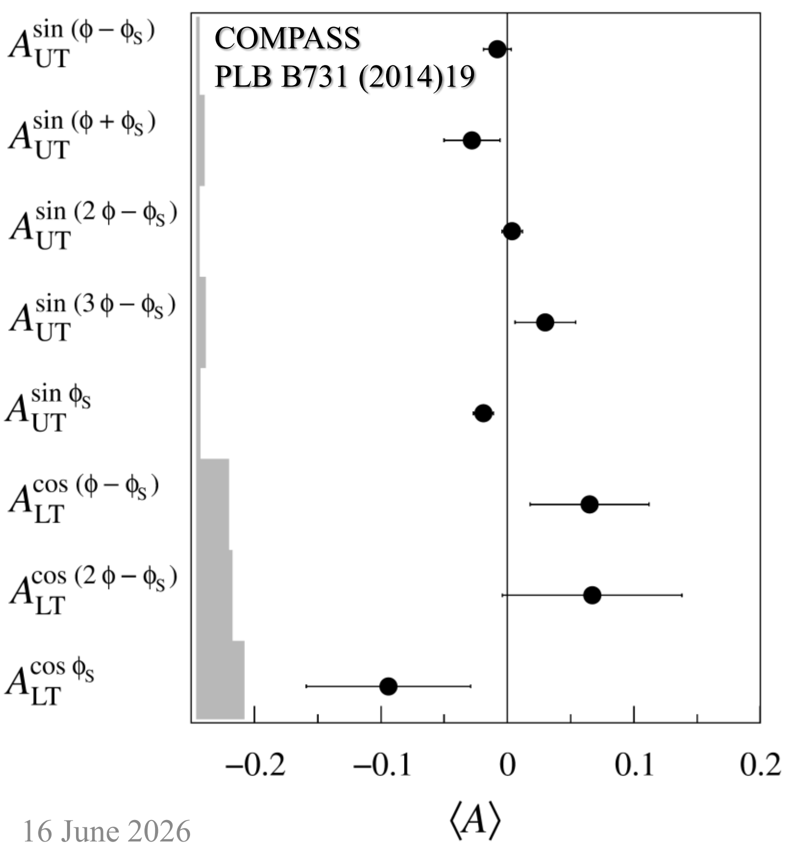
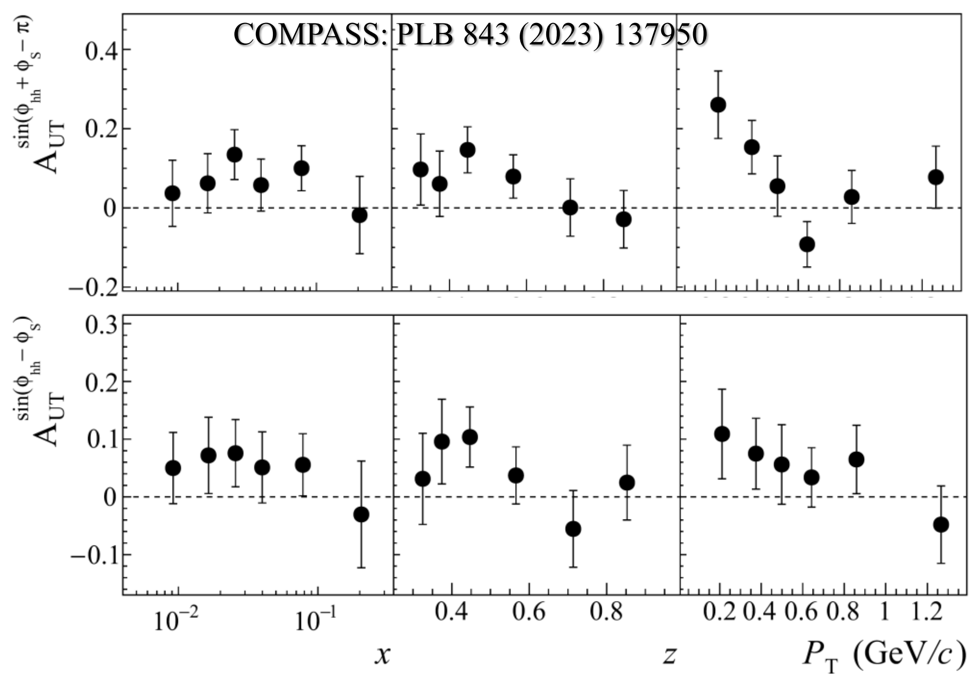
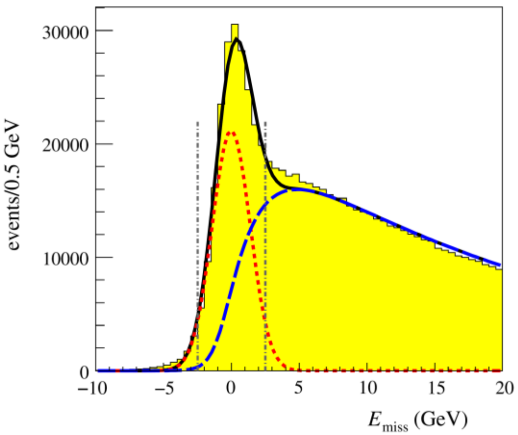


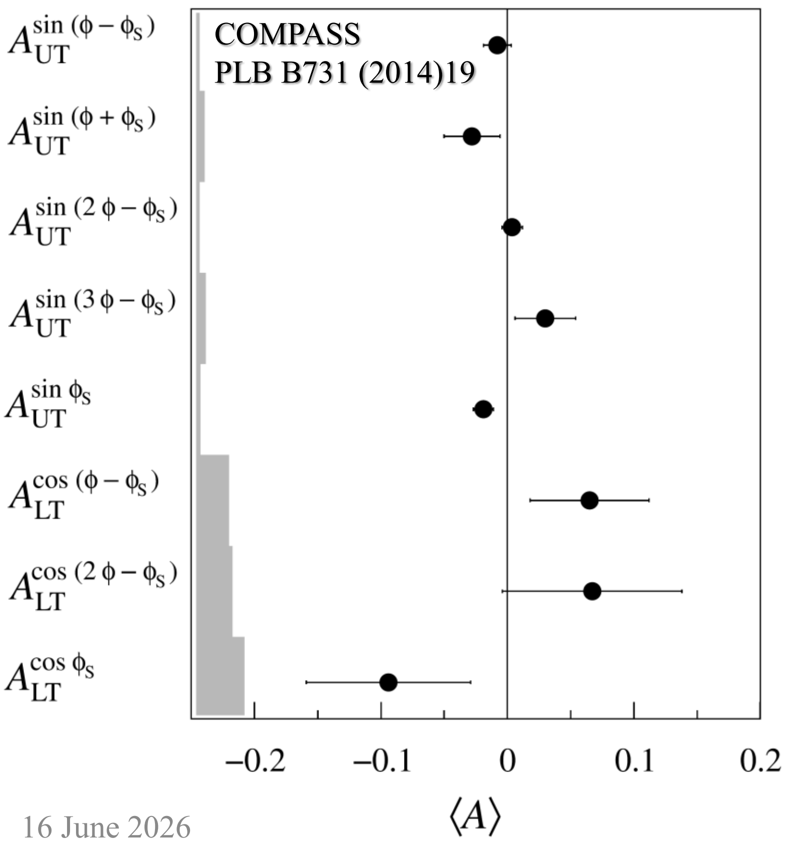
- Both Collins and Sivers TSAs are small an compatible with zero
  - $\sin(\varphi_S)$ is small, but possibly non zero
  - Can VM pion asymmetries still be large?
- COMPASS has checked also the inclusive ρ^0 Collins and Sivers asymmetries
  - Both tend to be positive
  - The fraction of inclusive ρ^0 in the selected dihedron sample is below 20%
  - Further checks needed, StringSpinner?



COMPASS: Exclusive and Inclusive ρ^0 TSAs



exclusive



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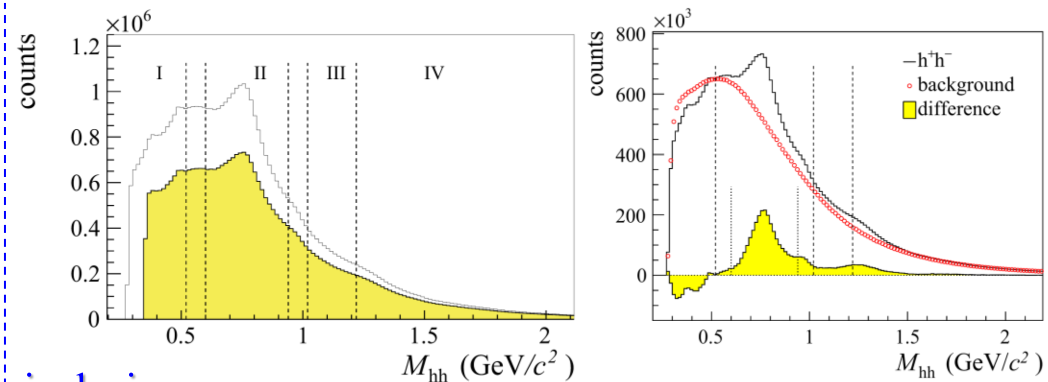
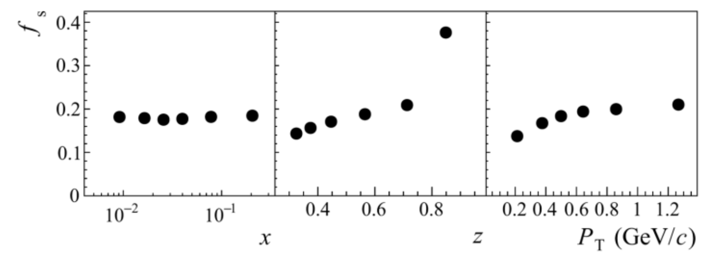
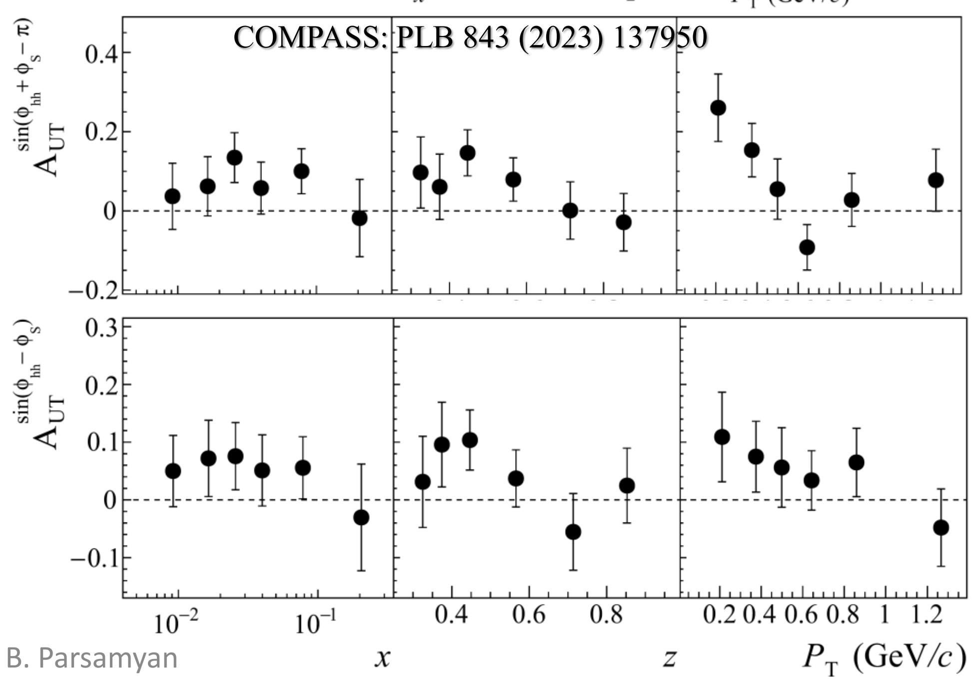




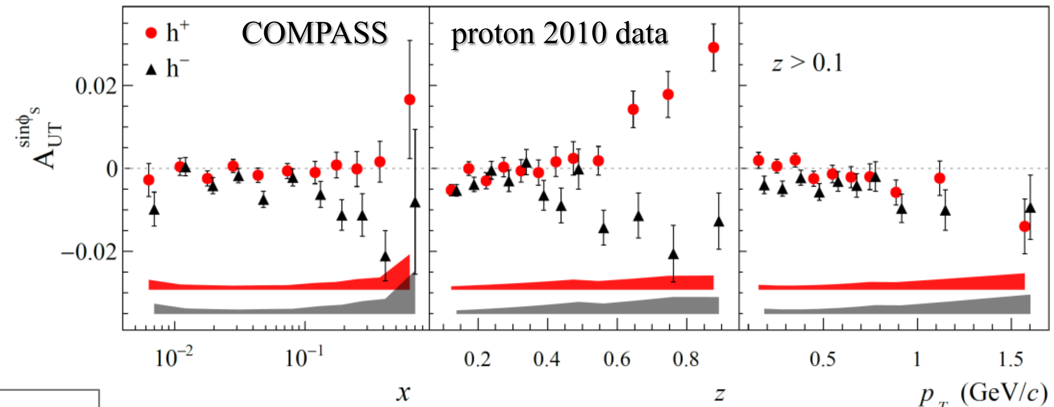


SIDIS TSAs: subleading twist effects

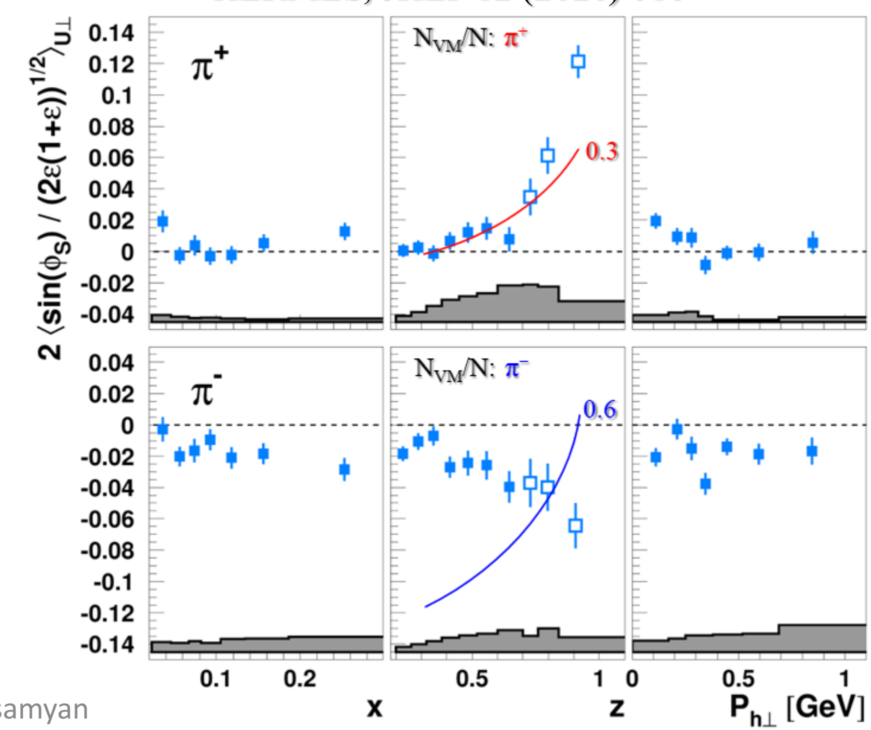
$$\frac{d\sigma}{dxdydzdp_T^2 d\phi_h d\phi_S} \propto \left(F_{UU,T} + \varepsilon F_{UU,L}\right)\left\{1 + \ldots + S_T \sqrt{2\varepsilon(1+\varepsilon)} A_{UT}^{\sin\phi_S} \sin\phi_S + \ldots\right\}$$

$$F_{UT}^{\sin\phi_S} = \frac{2M}{Q} C\left\{\left(x f_T^q D_{1q}^h - \frac{M_h}{M} h_1^q \frac{\tilde{H}_q^h}{z}\right) - \frac{\boldsymbol{p_T}\cdot\boldsymbol{k_T}}{2MM_h}\left[\left(x h_T^q H_{1q}^{\perp h} + \frac{M_h}{M} g_{1T}^q \frac{\tilde{G}_q^{\perp h}}{z}\right) - \left(x h_T^{\perp q} H_{1q}^{\perp h} - \frac{M_h}{M} f_{1T}^{\perp q} \frac{\tilde{D}_q^{\perp h}}{z}\right)\right]\right\}$$

COMPASS, PBL 770 (2017) 138; PoS QCDEV2017 (2018) 042



HERMES, JHEP 12 (2020) 010



COMPASS/HERMES results

$A_{UT}^{\sin\phi_S}$

- Q-suppression
- various "twist-2/3" ingredients
- non-zero signal for $h^{\pm}$ at large z?
- Survives integration of hadron p_T
  - gives access to transversity PDF (without involving convolution over k_T)

See Daniel Pitonyak's talk

Conclusions

- Importance of careful understanding and confrontation of experimental data from different experiments
  - Different kinematic domains and phase-space limitations
  - Experiments employ complex analysis techniques, Monte-Carlo simulations, and sophisticated corrections (acceptance, VMs, radiative corrections)
- Close collaboration between different experiments → general benefit for the field
  - Knowledge transfer, comparison of the analysis techniques, tools, and methodology, cross-analyses between different experiments
- Close collaboration between experiment and phenomenology/theory
  - Flexibility in adapting on the analysis side to the choice of the observables, phase-space selections, etc. (before publishing the data)
  - Different possibilities for common paper projects, external membership
- Possibility to organize effective and fruitful collaborative work