Overview of recent HERMES results

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- Inclusive measurements
- Semi-inclusive measurements
- Exclusive measurements
- Summary





HERMES at DESY



Polarized hydrogen (Long., Trans.), deuterium (Long.) Polarization flipped at 60-180 s time intervals

HERMES experiment: main research topics

- Origin of nucleon spin
- Details of nucleon structure





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$$g_{1}(x) = \frac{1}{2} \sum_{q} e_{q}^{2} \Delta q(x)$$
$$\Delta q = \int_{0}^{1} \Delta q(x) dx$$
$$\Delta \Sigma = \sum_{q} \Delta q$$
$$\Delta \Sigma = 0.330 \pm 0.025 \pm 0.0111 \pm 0.02$$
(from Γ_{1}

 $\Delta g / g = 0.049 \pm 0.034 \pm 0.126$ (high-p_T hadrons)

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 \overline{MS}

Inclusive measurements: DIS cross section @ F₂



Semi-inclusive @ exclusive measurements

 $W_{p}^{q}(x,k_{T},r)$ Wigner distributions



Semi-inclusive DIS: Charged-hadron multiplicities I



Semi-inclusive DIS: Charged-hadron multiplicities II

 $\sigma_{UU} \propto f_1^{\ q} \otimes D_1^{q \to h}$

• Disentanglement of z and $P_{h\perp}$ dependences

- Access to the quark intrinsic transverse \boldsymbol{p}_{T} and fragmentation \boldsymbol{k}_{T}



Semi-inclusive DIS: Double-spin asymmety A₁^h

Refined studies \Rightarrow extend the results published in PRD 71 (2005) 012003

$$\sigma_{LL} \propto g_1^{q} \otimes D_1^{q \to h}$$



Sensitive to differences in transverse momentum Dependence of g_1 and f_1

No significant P_{h⊥} Dependence observed

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Semi-inclusive DIS: Double-spin asymmety A₁^{h⁺ - h⁻}

 $\sigma_{LL} \propto g_1{}^q \bigotimes D_1{}^{q \to h}$

Refined studies \Rightarrow extend the results published in PRD 71 (2005) 012003



Semi-inclusive measurements: Leading-twist TMDs

- In Nucleon structure described by 8 leading-twist transverse-momentum dependent quark distributions (TMDs).
- HERMES has access to all of them through specific azimuthal modulations (φ,φ_s) of the cross section.



Semi-inclusive measurements: Leading-twist TMDs



Semi-inclusive measurements: Worm-gear DF $g_{1T}^{\perp,q}$



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Exclusive measurements: GPDs



Ji sum rule \implies access OAM $\int_{q} = \frac{1}{2} \lim_{t \to 0} \int dxx [H^{q}(x,\xi,t) + E^{q}(x,\xi,t)]$



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Correlated information about longitudinal momentum xp and transverse spatial position r₁

H^q and E^q : quark Generalized Parton Distributions (GPDs)



Spin-½ target: 4 chiral-even leading-twist quark GPDs $H, E, \widetilde{H}, \widetilde{E}$

Final state sensitive to different GPDs DVCS (γ) $H, E, \widetilde{H}, \widetilde{E}$ Vector mesons (ρ, ω, ϕ) H, E, Pseudoscalar mesons (π, η) $\widetilde{H}, \widetilde{E}$

Exclusive measurements: ρ^0 -meson production I



Exclusive measurements: ρ^0 -meson production II



Exclusive measurements: DVCS & GPDs



- Theoretically cleanest way to access GPDs
- Interference between DVCS and Bethe-Heitler amplitude

 $\geq |\tau_{\text{DVCS}}| \ll |\tau_{\text{BH}}|$ at HERMES

Access to GPD combinations through azimuthal asymmetries

- HERMES: Complete set of asymmetries
 - Both beam charges
 - Both beam helicities
 - Unpolarized H, D and nuclear targets
 - Longitudinally polarized H and D targets
 - Transversely polarized H target





Exclusive measurements: DVCS asymmetries at HERMES



Exclusive measurements: Double-spin asymmetry A_{LT}



Exclusive measurements: DVCS with Recoil Detector





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Exclusive measurements: DVCS with Recoil Detector



Exclusive measurements: Pure elastic DVCS



Indication that leading amplitude for pure elastic process is slightly larger than for unresolved signal (elastic+associated)

Summary



Backup slides

Backup Slides

Semi-inclusive DIS: Double-spin asymmety A₁^h

 $\sigma_{LL} \propto g_1{}^q \bigotimes D_1{}^{q \to h}$

Refined studies \Rightarrow extend the results published in PRD 71 (2005) 012003



Semi-inclusive measurements: Boer-Mulders DF h₁^{⊥,q}



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Semi-inclusive measurements: Collins amplitudes





- Both Collins fragmentation function and transversity distribution function are sizeable
 - Surprisingly large π^- asymmetry
- Possible source: large contribution (with opposite sign) from unfavored fragmentation;

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 $\mathsf{H}_{1}{}^{\perp}{}_{,disf} {=} {\text{-}} \mathsf{H}_{1}{}^{\perp}{}_{,fev}$

Semi-inclusive: Sivers amplitudes for pions



Exclusive measurements: Target-spin asymmetry A_{UT}



Exclusive measurements: Pure elastic DVCS



Indication that leading amplitude for pure elastic process is slightly larger than for unresolved signal (elastic+associated)

Semi-inclusive: Anti-Lambda longitudinal spin transfer

