

The physics programme of Run II

Delia Hasch
on behalf of the HERMES collaboration



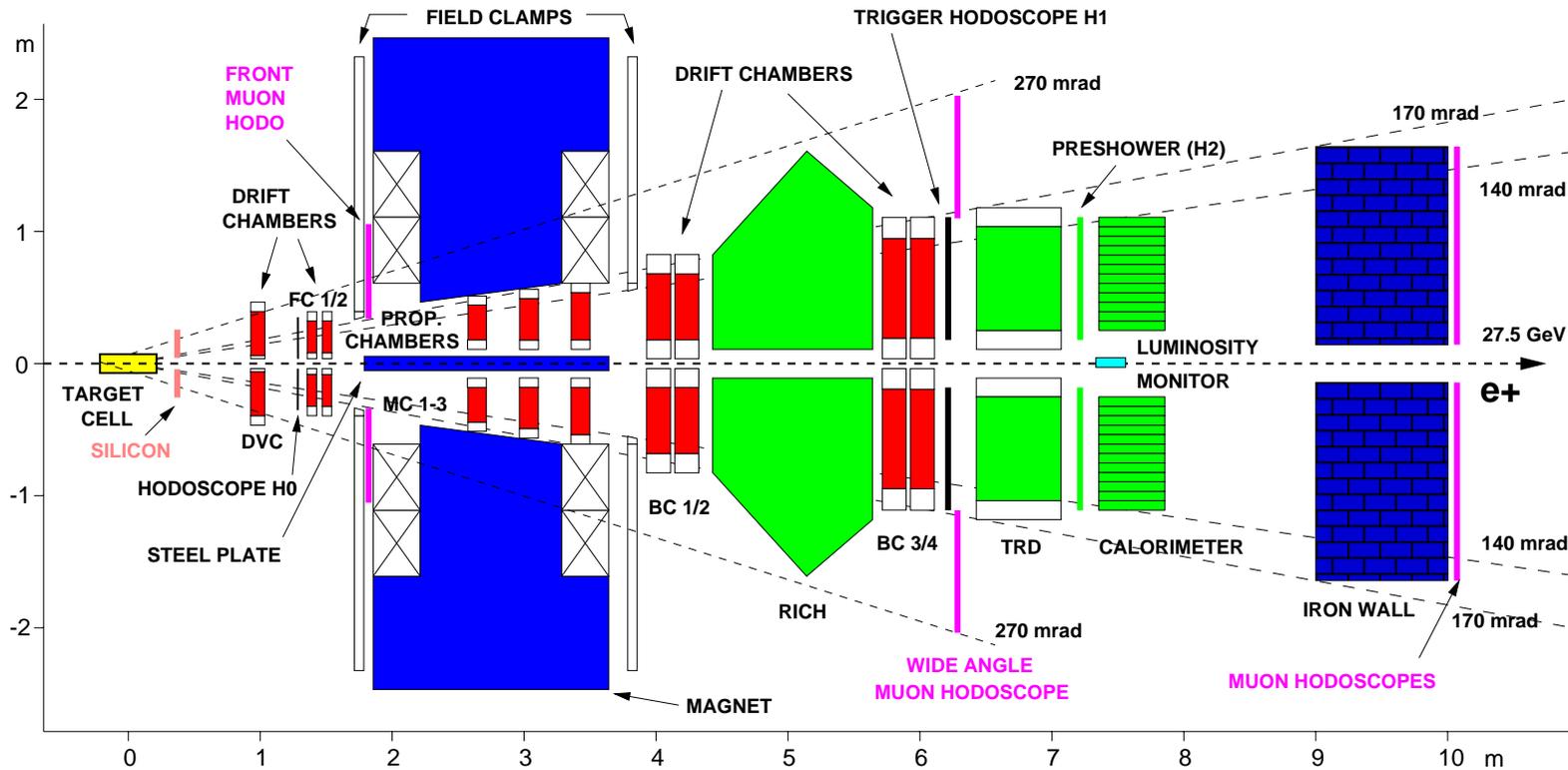
15th International Spin Physics Symposium
September 9-14, 2002; BNL, New York, US

- HERMES overview
- transversity distribution functions: SSA, (interference, Λ)
- exclusive processes: dvcs, vector + pseudoscalar meson production



overview

HERMES experiment



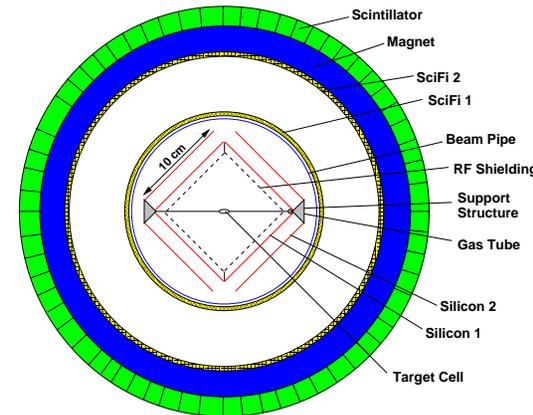
- momentum + angular resolution: $\delta p/p = 0.7 \dots 1.3\%$, $\delta\theta < 0.6$ mrad
- particle ID: calorimeter, TRD, RICH → RICH: $\pi/K/p$ separation @ all momenta



overview

plans for HERMES run-II

year	target	P_t	beam	physics	
↓	↓	↓	↓	↓	
2002	H	transverse	$e^+, (e^-)$	δu	⇒
2003	H	transverse	e^-	δu	
2004	H	transverse	e	δu	
2004	H	longitudinal	e	Δu	
2005	H	unpol	e^-	exclusive	⇒
2006	H	unpol	e^+	exclusive reactions	

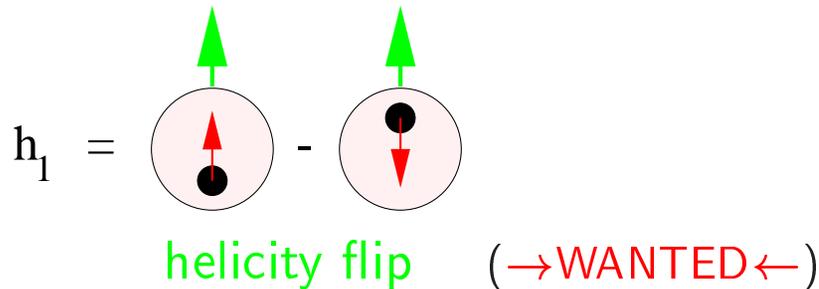
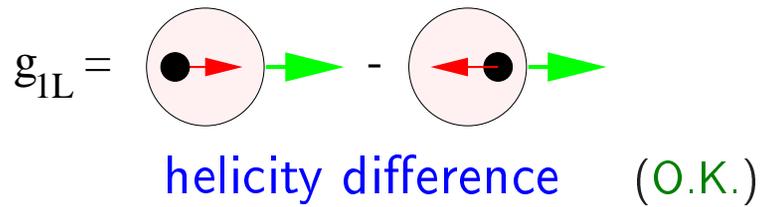


↓

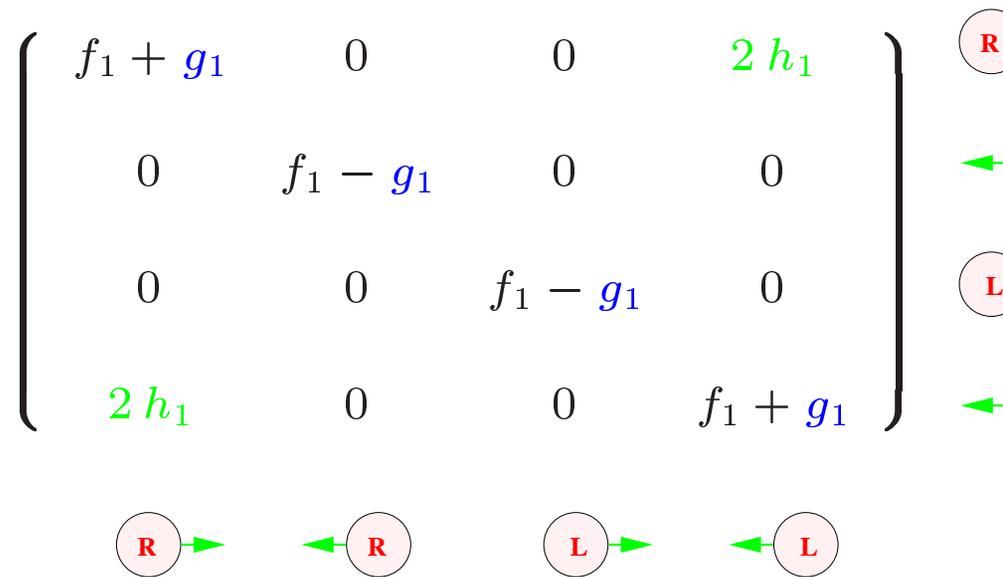
needs 3-4 month shutdown to install recoil detector



$$\Phi_{\text{corr}}^{\text{LO}}(x) = \frac{1}{2} [f_1(x) + S_L g_1(x) \gamma_5 + h_1(x) \gamma_5 \not{S}_T] \not{n}_+$$

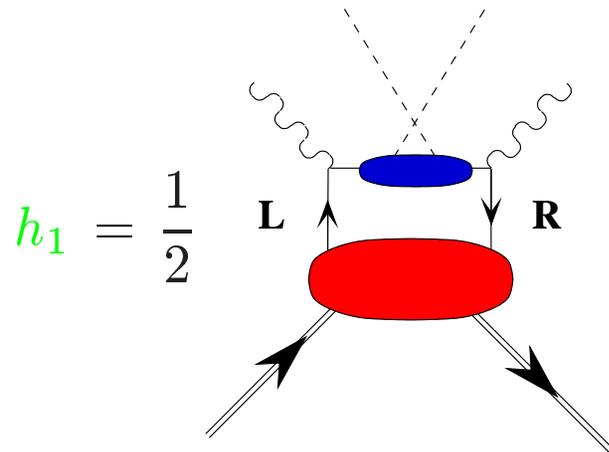


transverse spin state =
off-diagonal state in the helicity basis:



transversity

how to measure in SIDIS



→ **chiral odd**

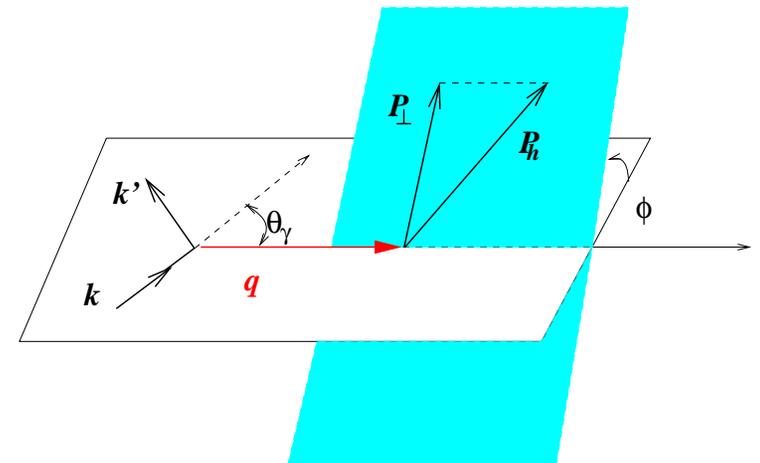
→ observed only in combination with another chiral odd structure

→ interference fragmentation: $A_T (|p_{\perp} \rightarrow l + (\pi^+, \pi^-) + X)$

→ final state polarisation:
spin-1/2 (Λ) and spin-1 (ρ) fragmentation

→ Collins effect: $A_T (|p_{\perp} \rightarrow l + \pi + X)$

$$A_T = \langle \sin \phi \rangle_{UT} \propto h_1(x) \otimes H_1^{\perp}(z, k_T)$$



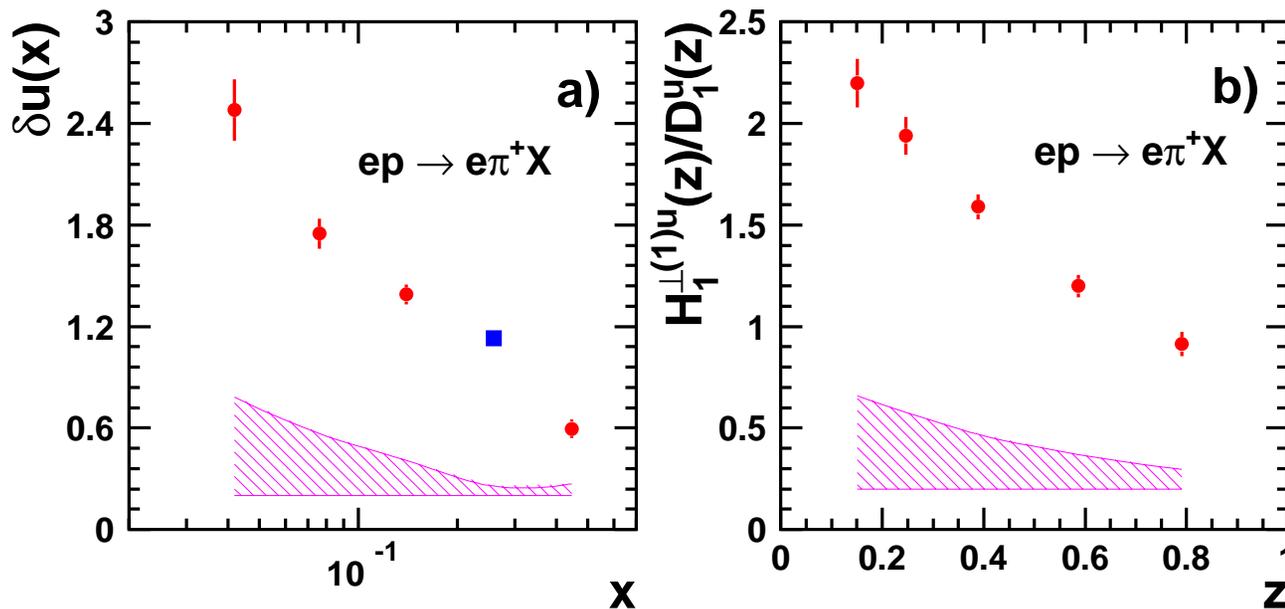
transversity

projection

$$h_1^u = \delta u$$

$$A_{\text{UT}}(x, y, z) \equiv \frac{\int d\phi^\ell \int d^2 P_{h\perp} \frac{|P_{h\perp}|}{zM_h} \sin(\phi_s^\ell + \phi_h^\ell) (d\sigma^\uparrow - d\sigma^\downarrow)}{\int d\phi^\ell \int d^2 P_{h\perp} (d\sigma^\uparrow + d\sigma^\downarrow)}$$

$$\propto \frac{\sum_q e_q^2 \delta q(x) H_1^{\perp(1)q}(z)}{\sum_q e_q^2 q(x) D_1^q(z)} \approx \frac{\delta u(x)}{u(x)} \cdot \frac{H_1^{\perp(1)u}(z)}{D_1^u(z)}$$



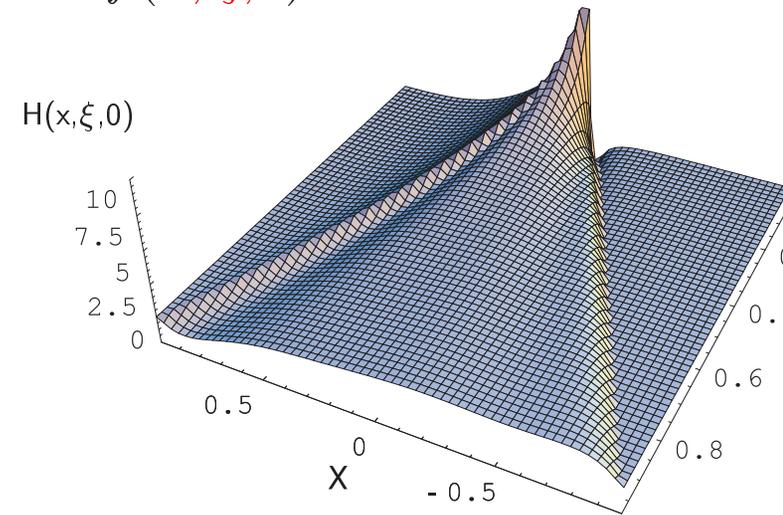
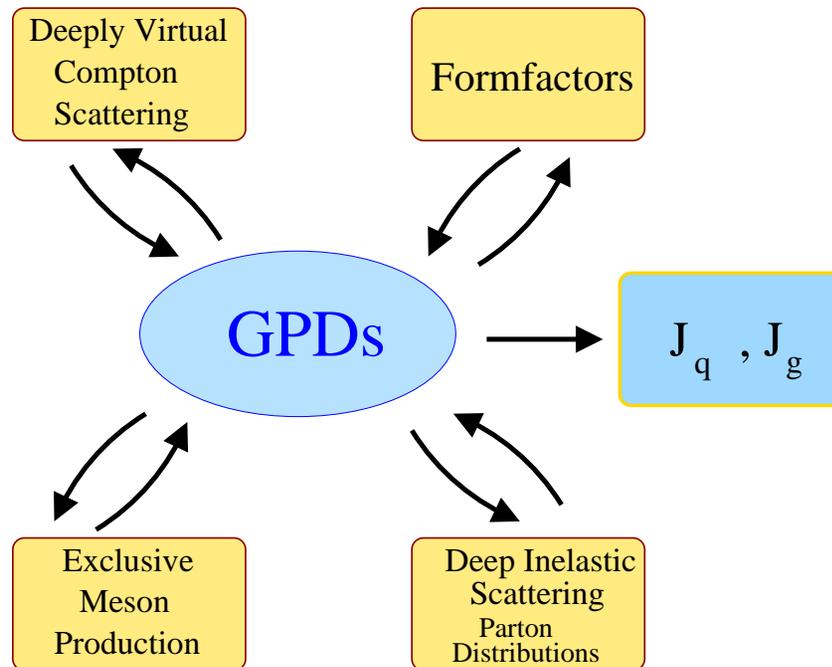
$Q^2 > 1 \text{ GeV}^2$
 $W > 2 \text{ GeV}$
 $0.02 < x < 0.7$

based on $7.0 \cdot 10^6$ DIS events
 (@ year 2000 running conditions $\propto 4.0 \cdot 10^6$ DIS)



new observables in hard exclusive processes:

Generalised Parton Distributions ($H, E, \tilde{H}, \tilde{E}$) $\implies f(x, \xi, t)$

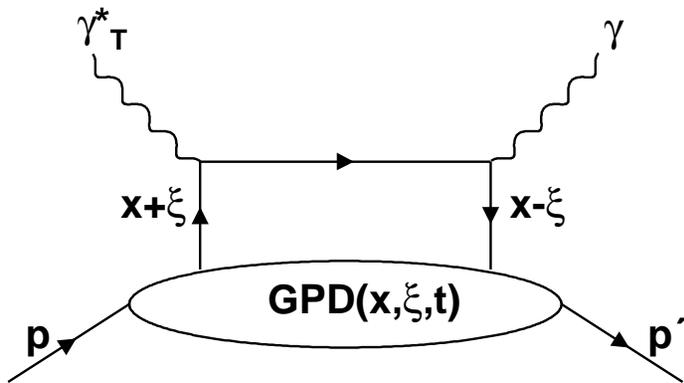


\implies access to orbital angular momentum:

$$\frac{1}{2} \int_{-1}^1 x dx (H_q(x, \xi, 0) + E_q(x, \xi, 0)) = J_q$$

exclusive reactions

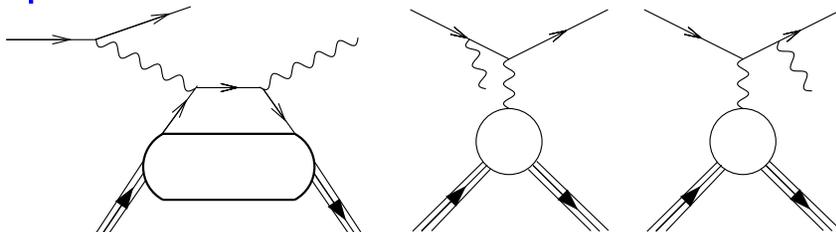
access to GPDs



DVCS: $H, E, \tilde{H}, \tilde{E}$

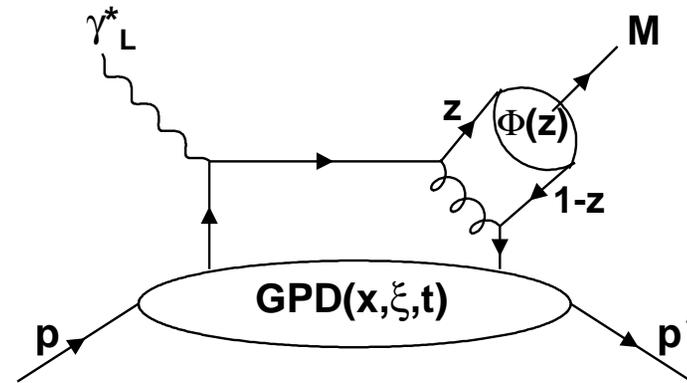
→ cleanest way to access GPDs

→ interference with Bethe-Heitler process



(a)

(b)



vector mesons: H, E

$e p \rightarrow e' \rho^0(\phi, \omega) p$

pseudoscalar mesons: \tilde{H}, \tilde{E}

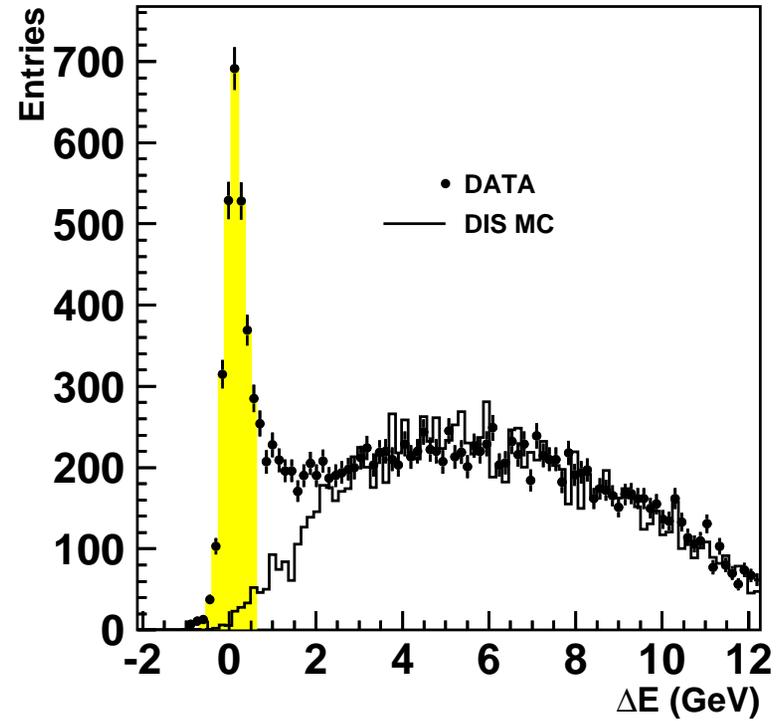
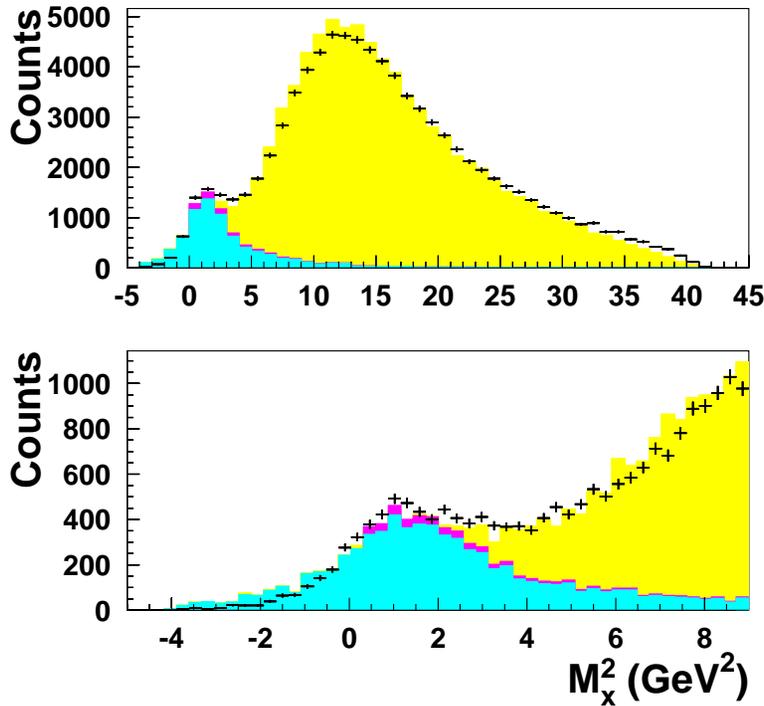
$e p \rightarrow e' \pi^+ n$ / $e p \rightarrow e' \pi^0 p$

$e p \rightarrow e' \eta p$ / $e p \rightarrow e' \pi^0 p$

$e p \rightarrow e' \pi^0 p$ / $e n \rightarrow e' \pi^0 n$

$$ep \rightarrow ep \gamma$$

$$ep \rightarrow ep \rho^0$$



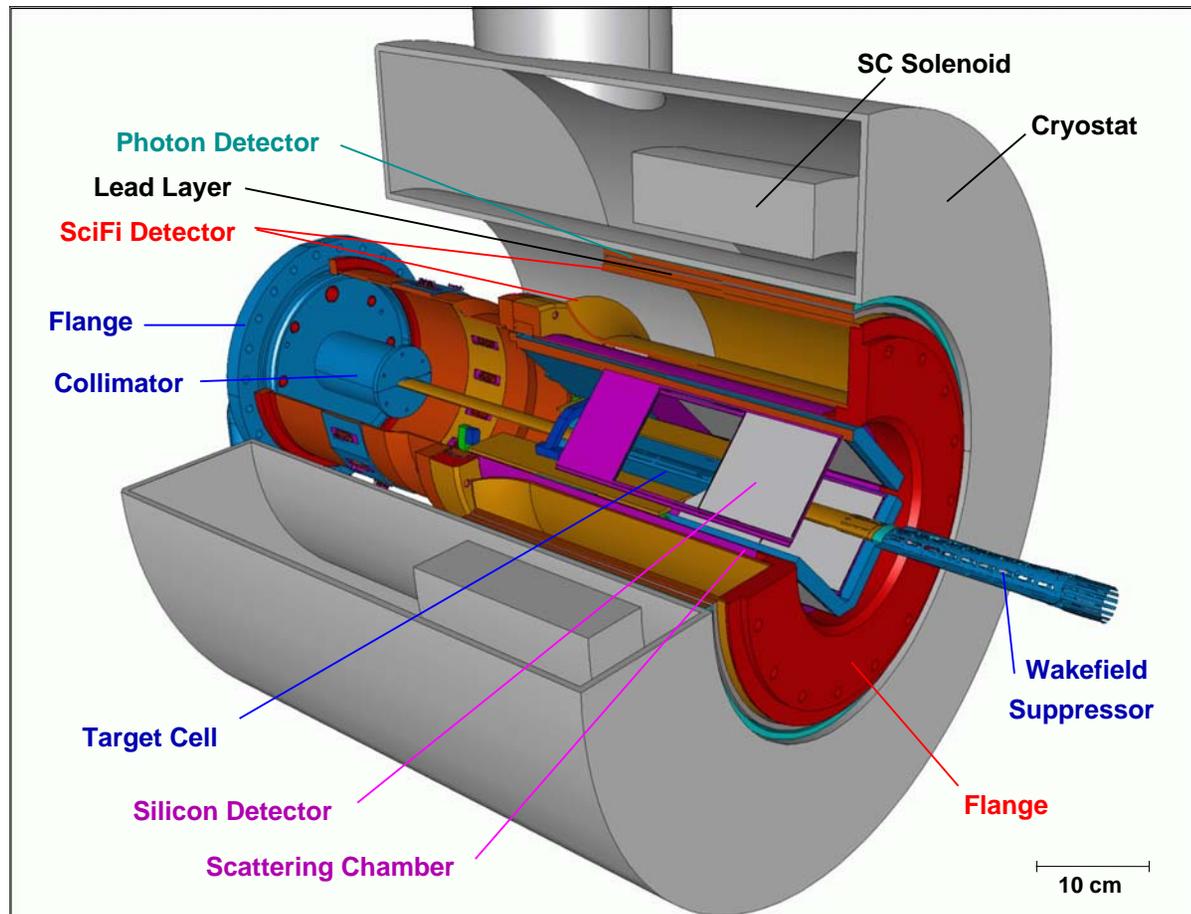
exclusivity established for event sample but not event-by-event

→ detect recoiling proton



exclusive reactions

recoil detector



particles in the recoil:

p, n (not detected)

$\pi^+, \pi^-, \pi^0 (\rightarrow 2\gamma)$

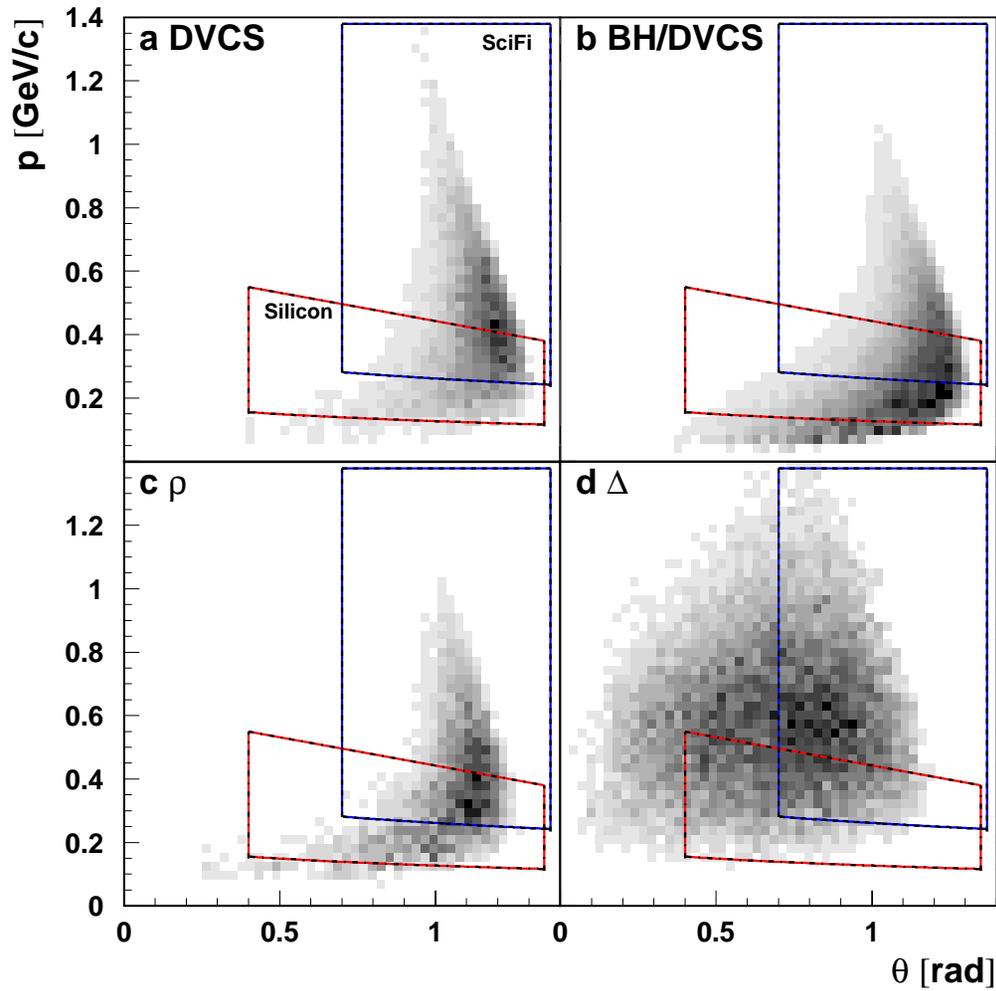
$\Delta \rightarrow \pi + \text{nucleon}$

Si / SciFi detector:

- recoil proton tracking
 $0.1 < P < 1.2 \text{ GeV}$
- π/p pid from dE/dx
- secondary vertex determination

recoil detector

kinematic coverage



process	detection + exclusivity cuts
BH/DVCS	52 %
BH, Δ	08 %
ρ^0	70 %
π^0	59 %



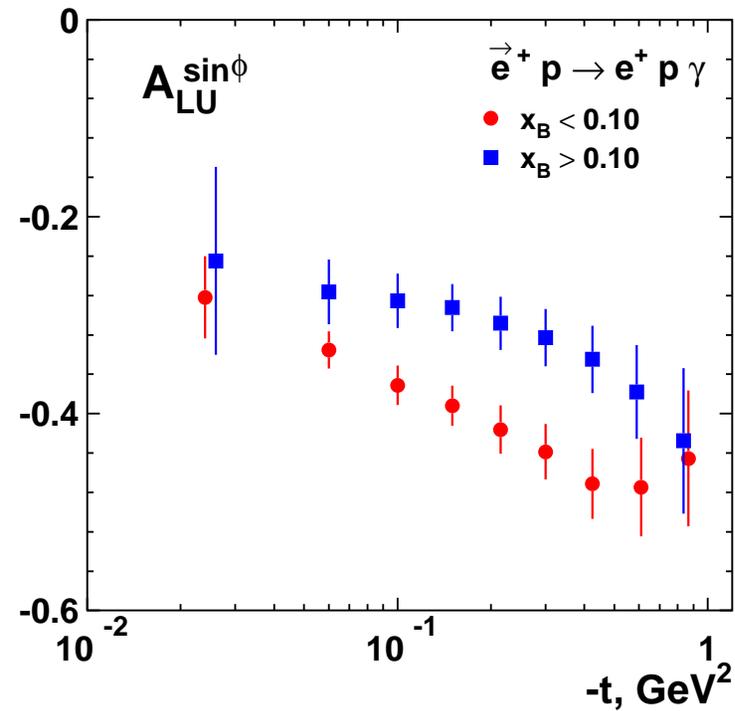
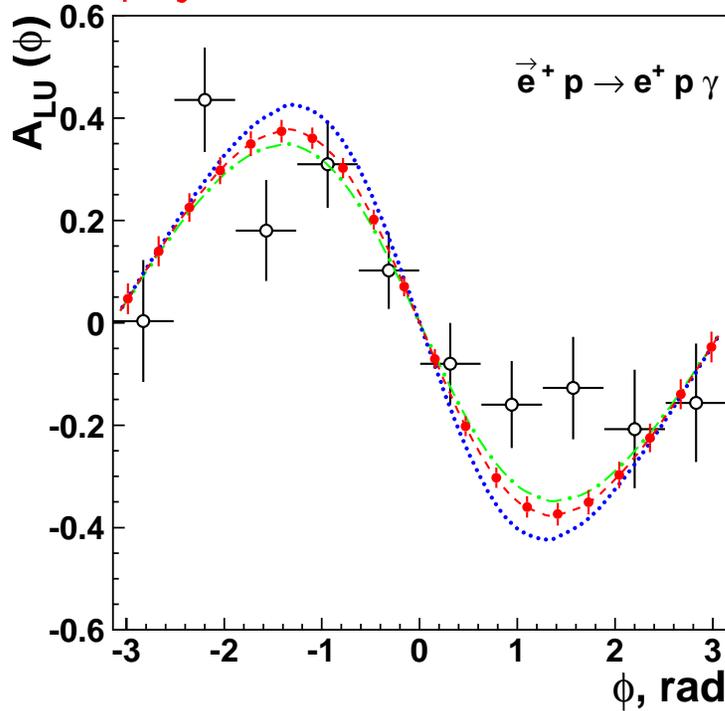
recoil

projection for dvcs

A_{LU}

$$A_{LU} : d\sigma_{e^+}^{\leftarrow} - d\sigma_{e^+}^{\rightarrow} \propto \text{Im}(\mathcal{T}_{BH}\mathcal{T}_{DVCS}) \propto \sin\phi$$

projections for $2 \text{ fb}^{-1} \approx 90 \cdot 10^6 \text{ DIS}$

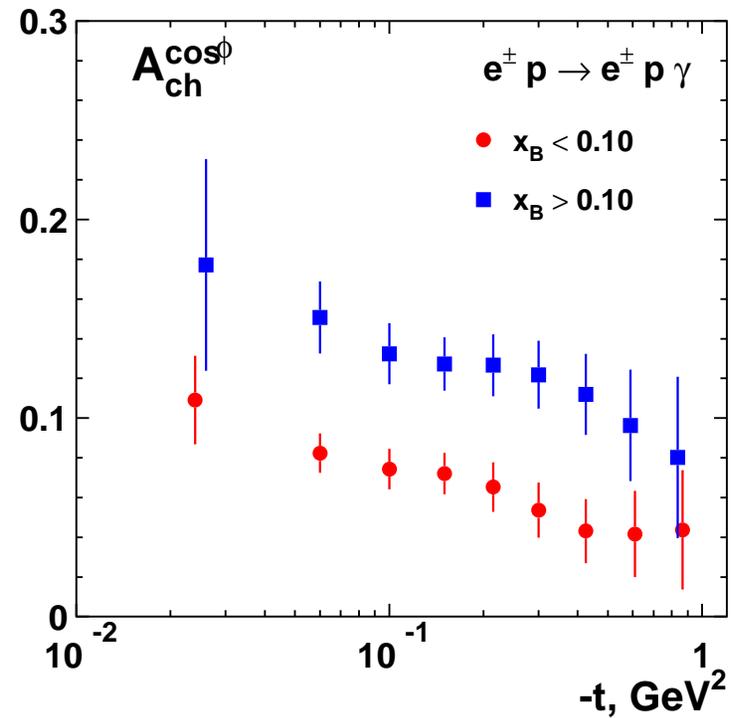
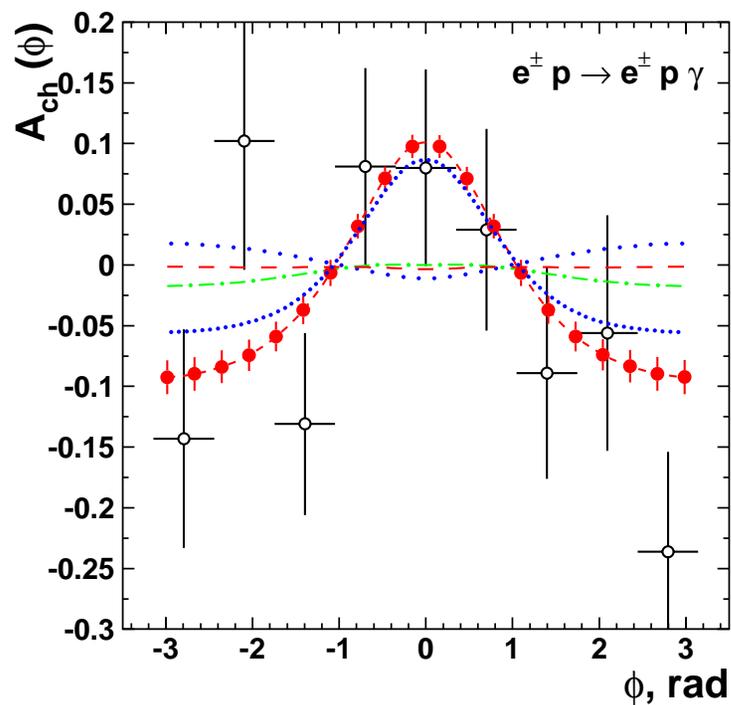


recoil projection for dvcs

$$A_C$$

$$A_C : d\sigma_{e^+} - d\sigma_{e^-} \propto \text{Re}(\mathcal{T}_{BH}\mathcal{T}_{DVCS}) \propto \cos\phi$$

projections for $2 \text{ fb}^{-1} \approx 90 \cdot 10^6 \text{ DIS}$



recoil detector improved exclusivity

- @ **dvcs** → detect recoil proton → open cut on M_x
→ main background from intermediate Δ -excitation:

$$\gamma^* p \rightarrow \gamma p$$

$$\gamma^* p \rightarrow \gamma \Delta^+, \quad \Delta^+ \rightarrow \pi^0 p (\pi^+ n) \quad 2/3 (1/3)$$

Δ -yield ≈ 10 % of groundstate dvcs/BH;

unknown asymmetrie (could be large)

$\Rightarrow \Delta$ -contribution reduced to ≈ 1 %

systematic uncertainty in asymmetry ≈ 0.5 % \approx statistical accuracy

→ improved resolution in t : current: $\Delta t \approx 0.17 \text{ GeV}^2$

$$\Rightarrow \Delta t/t \approx 0.2$$



HERMES run-II summary

HERMES run-II: exciting physics programme 2002-2004

milestones:

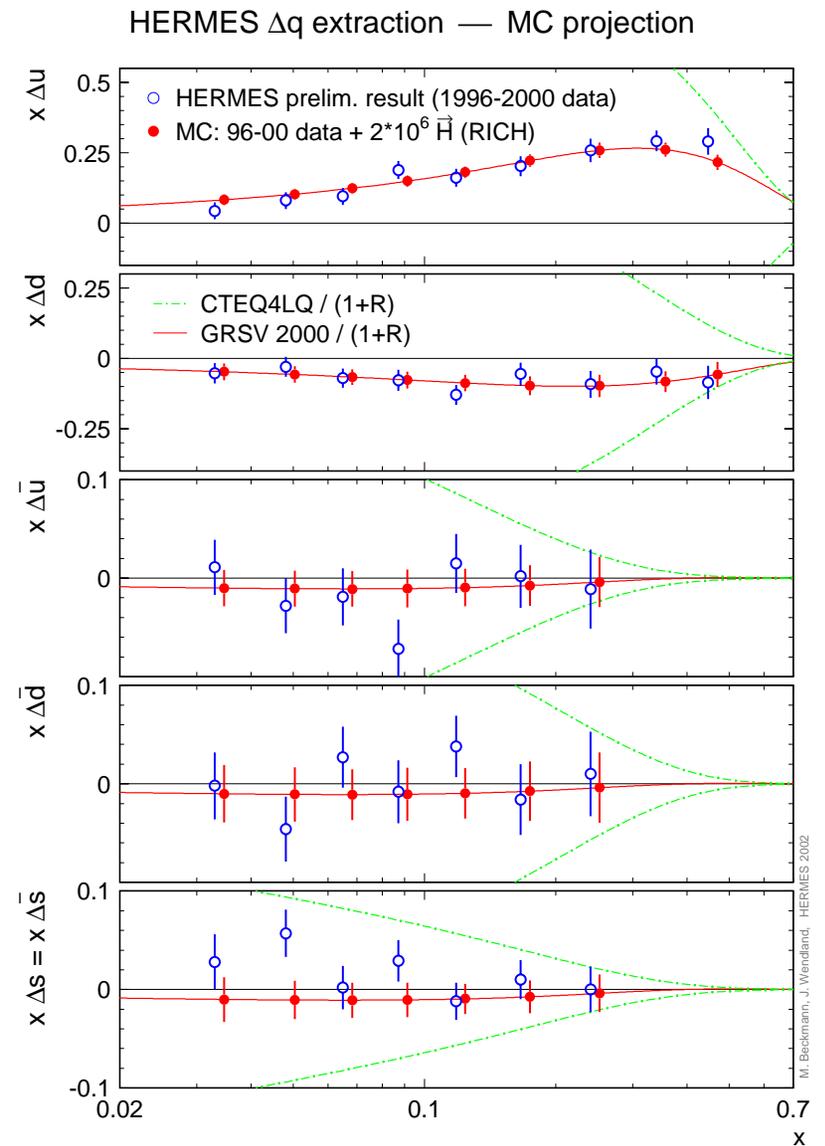
- ⇒ **transversity** Collins effect in semi-inclusive π (K) electroproduction:
⇒ single-spin azimuthal asymmetry from transversely polarised protons
- ⇒ **GPDs** exclusive production of pseudoscalar mesons (xsection ratios)
exclusive production of vector mesons (absolut xsections)

beam helicity and beam charge asymmetries in dvcs/BH

... variety of further projects going on ...



- RICH installed in 1998
- since 1998: longitudinally polarised D
- ⇒ extra $2 \cdot 10^6$ DIS on longitudinally polarised H
- ⇒ increase accuracy of Δq measurement transverse → longitudinal ≈ 2 weeks



Si-detector close to target region: significantly increases acceptance for Λ s

- detector in HERA-vacuum
- double sided Si
pitch=150 μm , thickness=300 μm
- installed in March 2002
- all 24 modules operational
- commissioning under way

