Future Exclusive Measurements at HERMES

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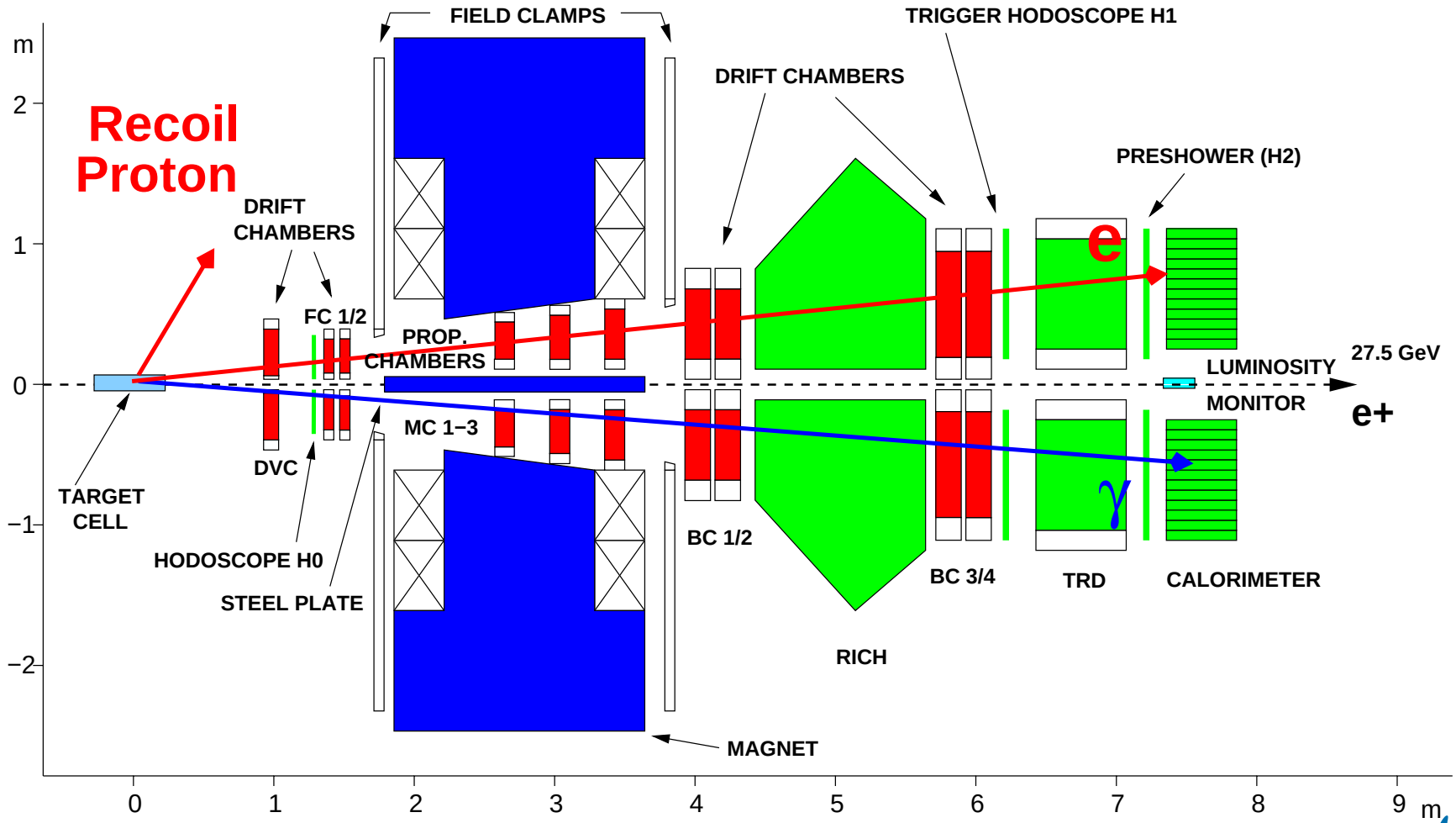
on behalf of the HERMES Collaboration

- The Recoil Detector Upgrade
- Data Taking in 2006/7
- Projections for Exclusive Measurements

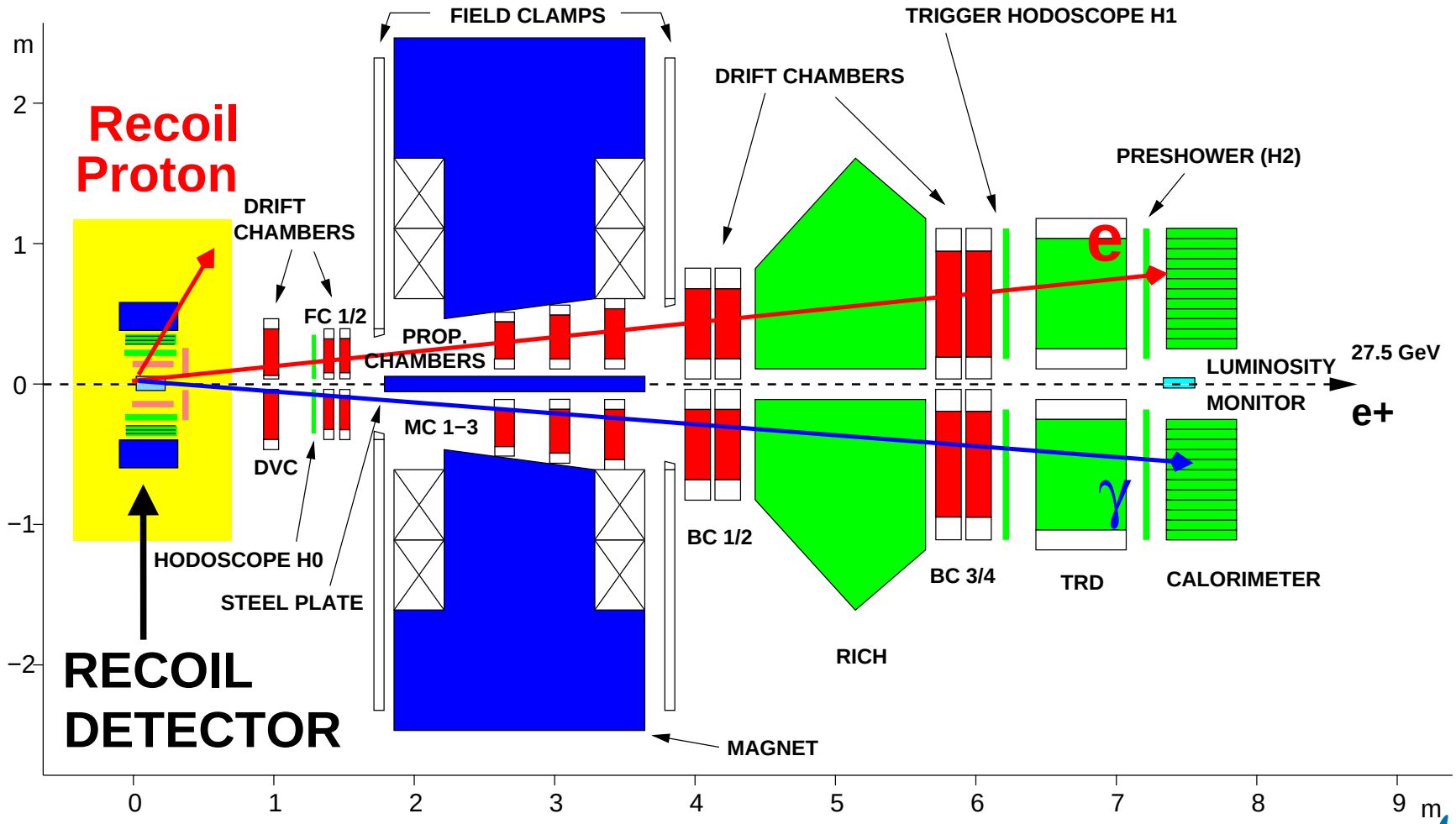
HERMES Physics

- Development from inclusive over semi-inclusive to exclusive measurements over decade 1995 - 2005.
- Physics emphasis moved from polarised structure functions to quark helicities and transversity to GPDs.
- Upgrades/changes to the experimental apparatus: RICH detector for semi-inclusive measurements, transverse target for transversity
- The final step is the recoil detector upgrade for exclusive measurements, the focus of the final year of HERMES data taking.
- Recent exclusive HERMES results: C.Hadjidakis (overview), A.Rostomyan, Z.Ye.

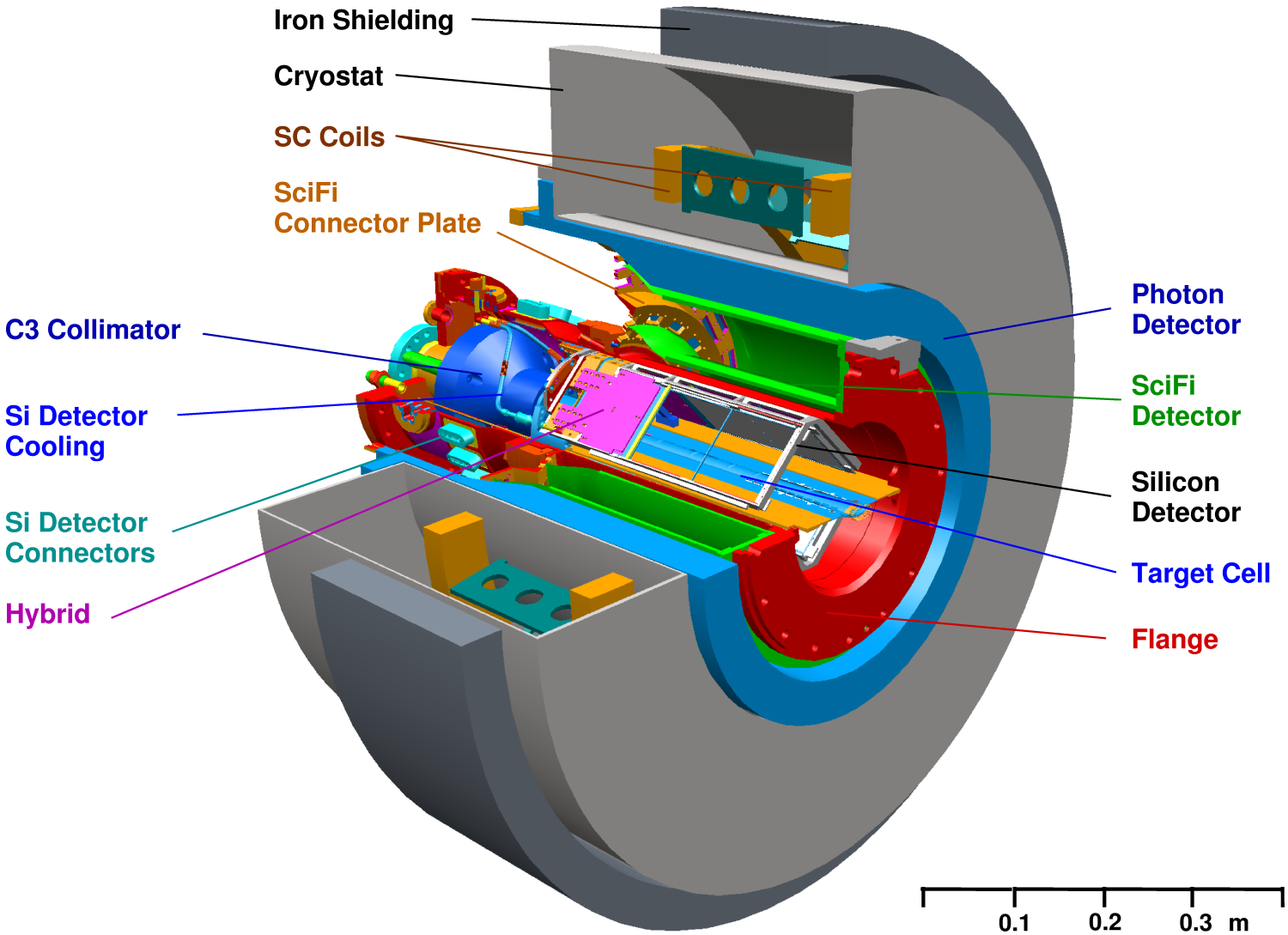
HERMES with Recoil Detector



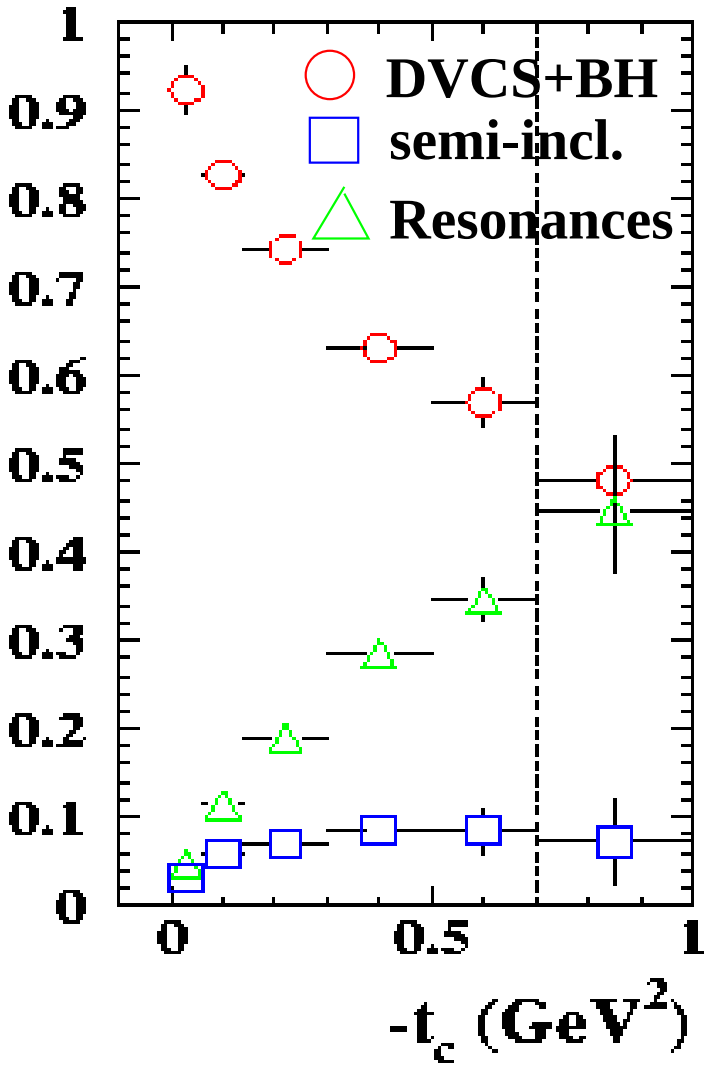
HERMES with Recoil Detector



HERMES Recoil Detector - 3D CAD

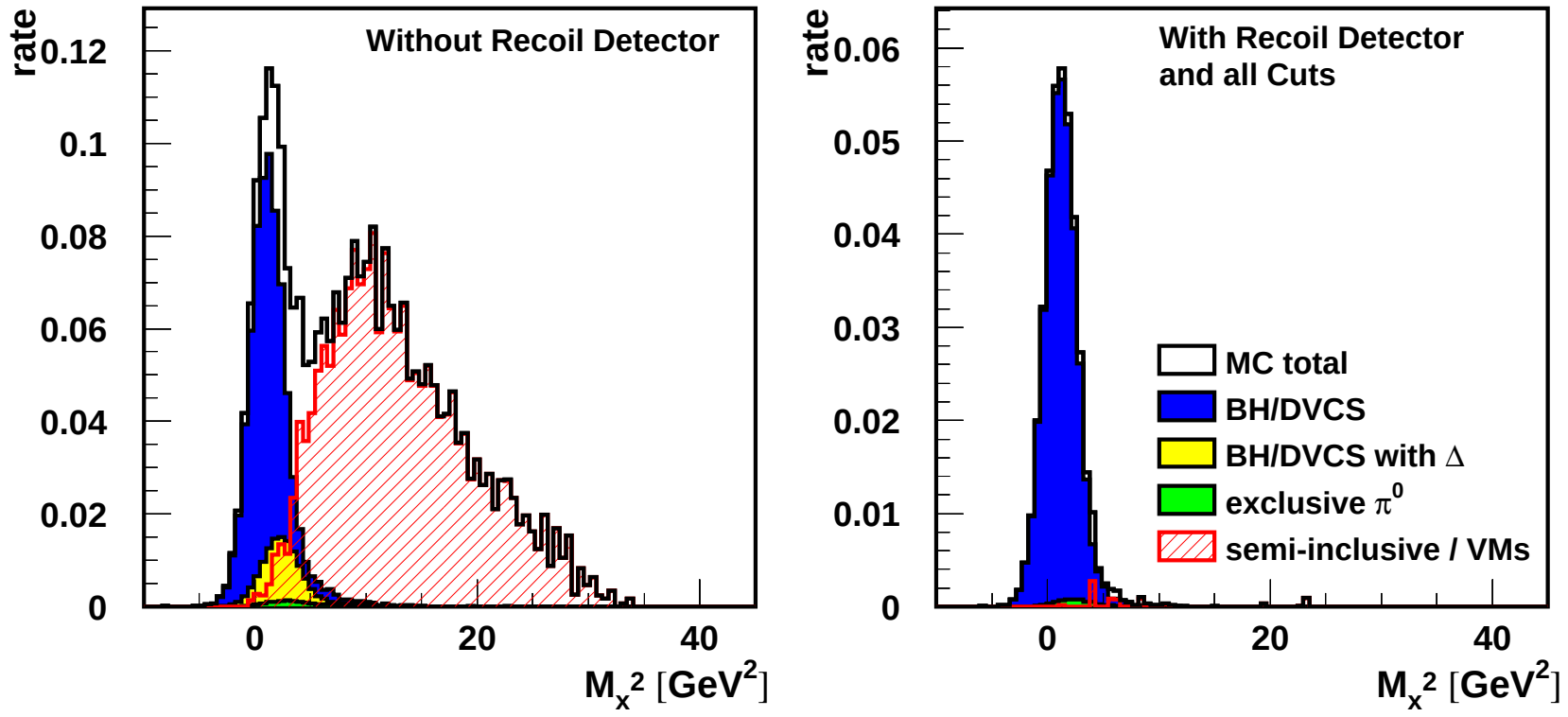


Goals of the Recoil Detector



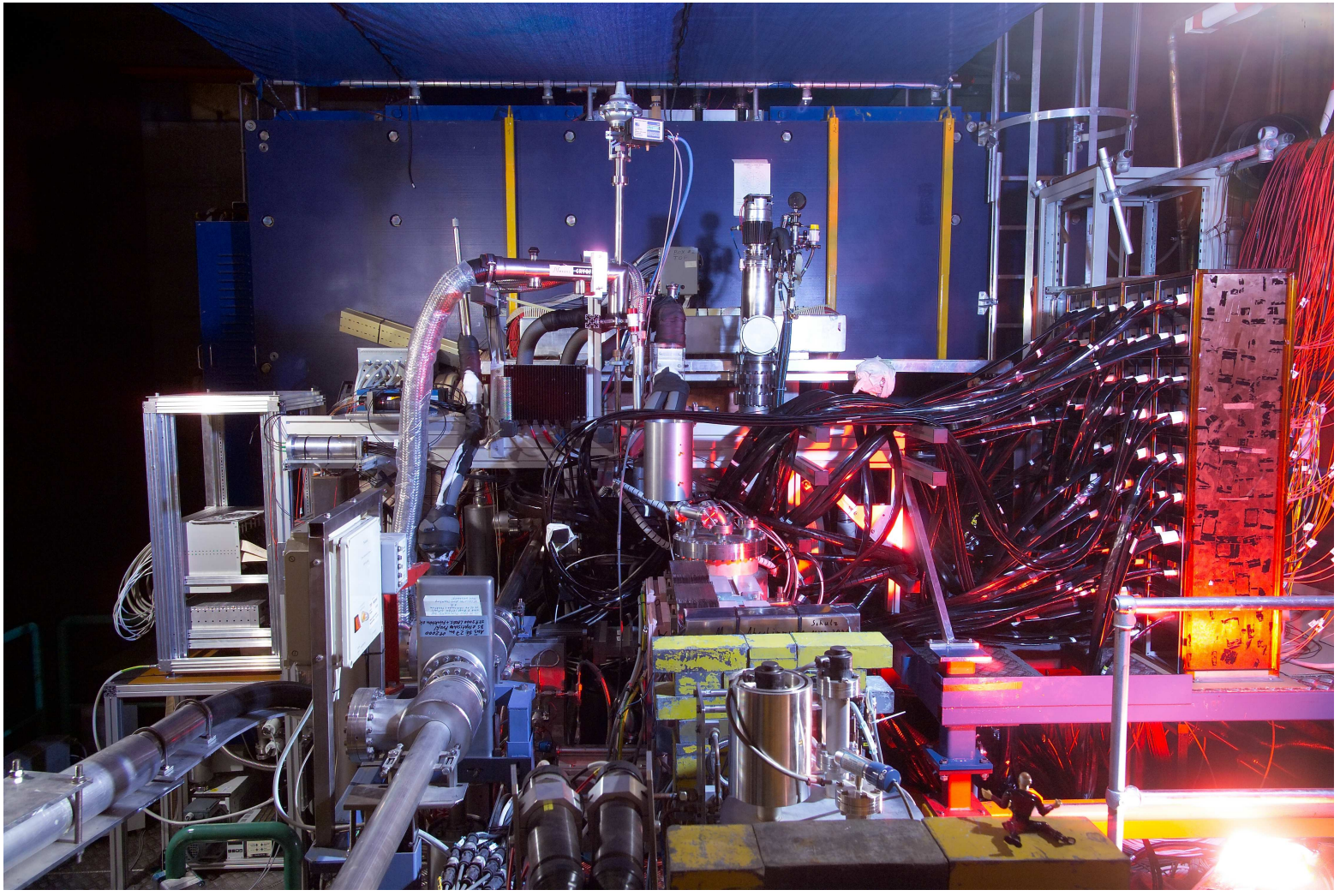
- Detection of all reaction products over the entire momentum range to guarantee the exclusivity of the reaction:
  - Recoil protons
  - Pions and protons from background processes e.g. Δ^+-production with bremsstrahlung
  - Photons from $\pi^0 \rightarrow \gamma\gamma$
- Sufficient t-resolution to allow binning in t.
- Si-detector: low t, SciFi detector: higher t
- Improved systematics due to removal of background (see left).
- Improved statistics due to high density unpolarised target.

Exclusivity

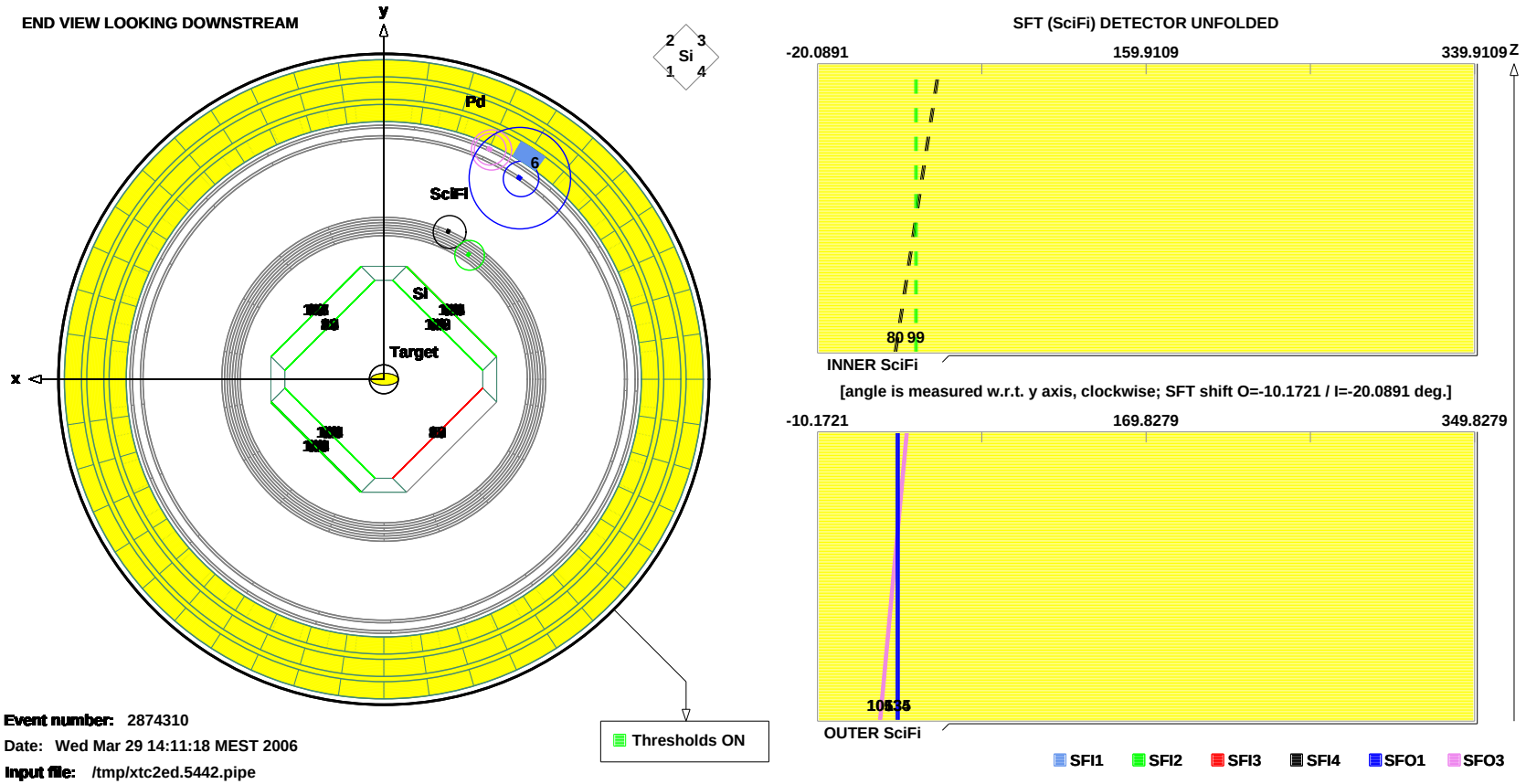


- Coplanarity cut, pion suppression, photon detection; efficiency ∼50% (MC simulation)
- Reduction of the non-exclusive background:
  - semi-incl.: 5%→≪1%
  - associated prod.: 11%→∼1%

Recoil Detector - Complete Setup



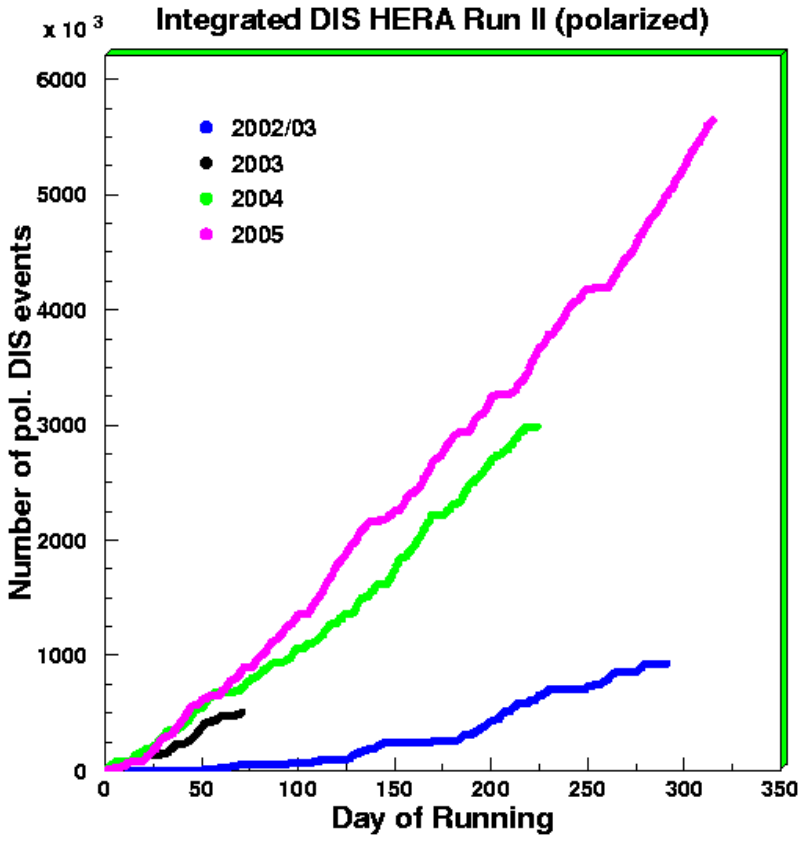
Recoil Detector Event



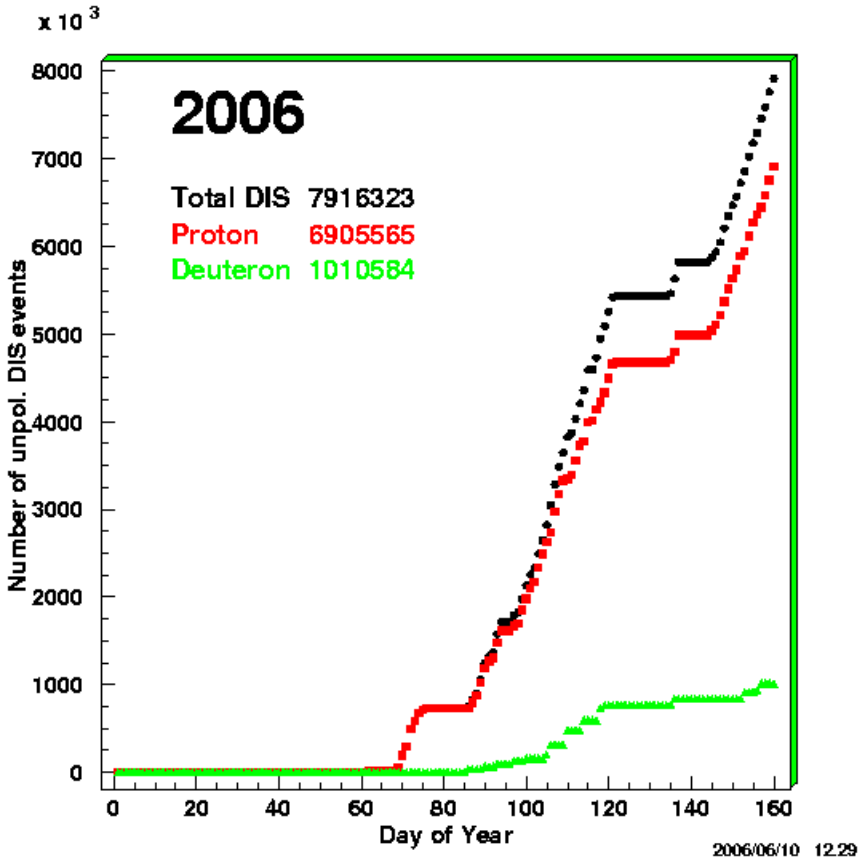
Event with single track in SFT and photon detector.

Average hit multiplicity per SFT layer ~ 3.

HERMES Data Taking HERA Run II



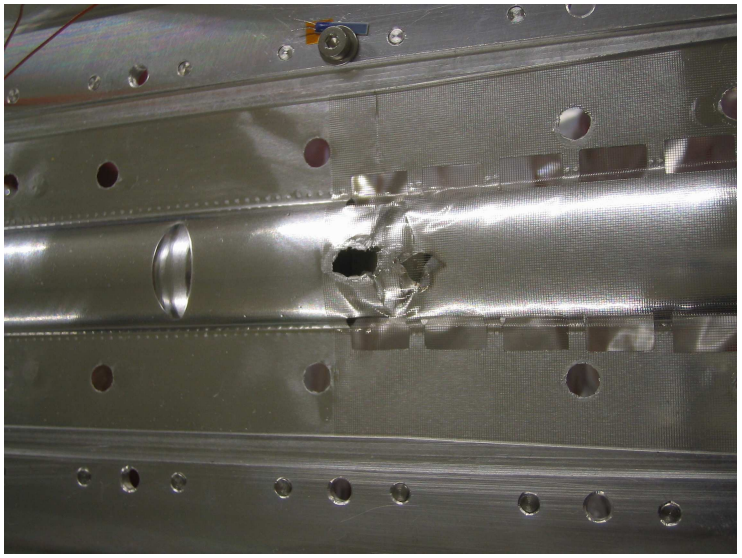
2002-5 transverse target

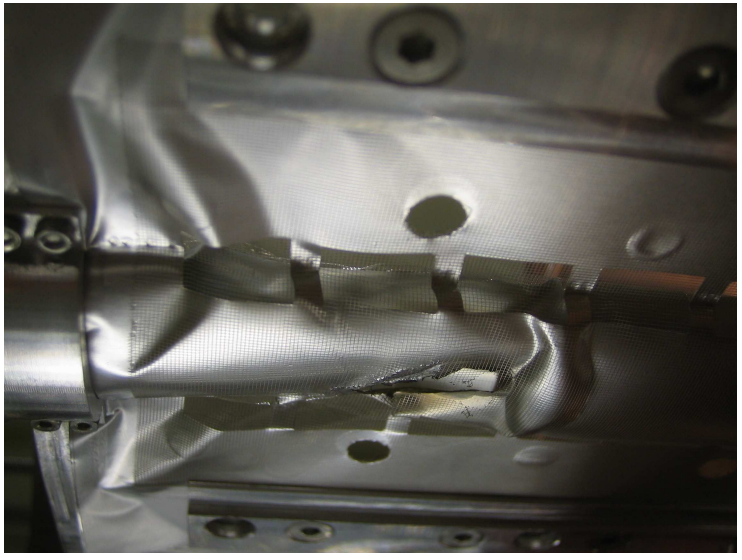


2006-7 unpol. target

e^- March-June 06

Target Cell Accident





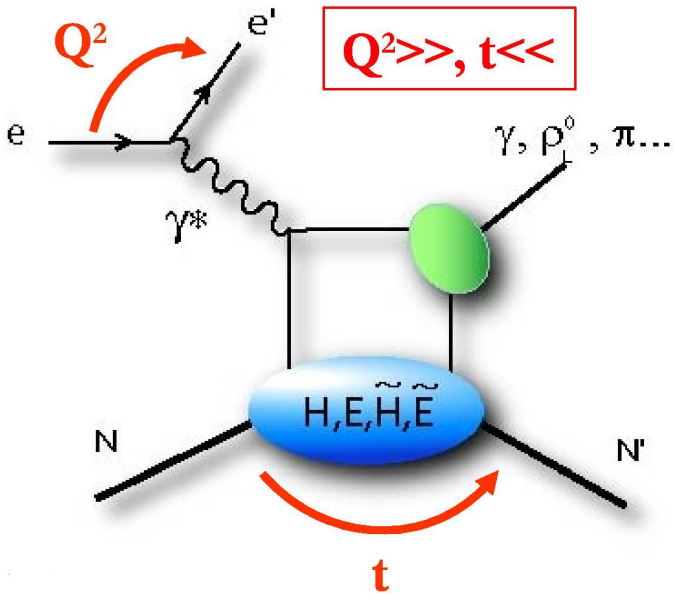
- March: damage probably due to accidental beam loss
- May: radiation damage to silicon detector due to second incident
- Si detector removed for repair, re-installation end of June
- DVCS BCA affected most, lose recoil protons at small t
- SciFi detector available for part of the e^- data, MC studies under way.

HERMES Statistics Overview (pb^{-1})

HERA-I (1996-2000)	H	D	^{4}He	N_2	Ne	Kr	Xe
e^-	11	50	-	-	-	-	-
e^+	240	320	30	50	86	30	-
HERA-II (2002-2007)							
e^-	250	150	-	-	-	50	50
e^+	820	200	-	-	-	55	30
of which e^+ with RD	750	200	-	-	-	-	-

- DVCS BCA: Published 10 pb^{-1} e^-. Expect to have 250 pb^{-1} e^-.
- Total cross section for VM and PSM production on hydrogen: 1.3 fb^{-1}.
- 2006/7 running: 23M $\rightarrow$ 56M DIS events on (unpolarised) hydrogen
- Average beam polarisation only $\sim$35% for HERA-II, while $\geq$50% for HERA-I.

Exclusive Processes to Constrain GPDs



Quantum number of final state selects GPD.

DVCS	$e \overset{\leftrightarrows}{p} \rightarrow ep\gamma$	H
(BSA/BCA)	$e^{\pm} \rightarrow ep\gamma$	
Vector	$ep \rightarrow ep\rho^0$	H, E
Mesons	$ep \rightarrow ep\phi^0$	
Pseudoscalar	$ep \rightarrow en\pi^+$	$\tilde{H}, \tilde{E}$
Mesons		

HERMES measures many different final states simultaneously with the same spectrometer !

Exclusive Measurements at HERMES

Process	Comments	Learn about GPDs	Recoil Detector	Can Do
DVCS BCA	unique !	D-term	desirable (but n/a)	++
DVCS BSA	vs x_B, t	constrain H^u	desirable	++
ΔDVCS	first measurement	$N \to \Delta$ GPDs	required	?
$\sigma_L(\rho^0, \phi^0)$	vs Q^2	quarks/gluons	not necessary	++
$\sigma_L(\omega^0, \rho^+)$	vs Q^2	quarks/gluons	not necessary	+
$\rho : \omega : \phi$	cross.sec. ratio	H, E flavours	not necessary	+
ρ^0, ϕ^0 SDME	vs t	comp. GPD model	not necessary	++
$\sigma_L(\pi^+)$	vs x_B	$\widetilde{H}^u - \widetilde{H}^d$	not necessary	++
$\pi^+ : \pi^0 : \eta$	cross.sec. ratio	$\widetilde{H}, \widetilde{E}$ flavours	not necessary	+
$K^+\Lambda^0$	transv. asym. $A_{K^+\Lambda}$	$\widetilde{H}^{p\to\Lambda}, \widetilde{E}^{p\to\Lambda}$	required	?
$\pi\Delta$	vs x_B	$N \to \Delta$ GPDs	required	?

Exclusive Measurements at HERMES

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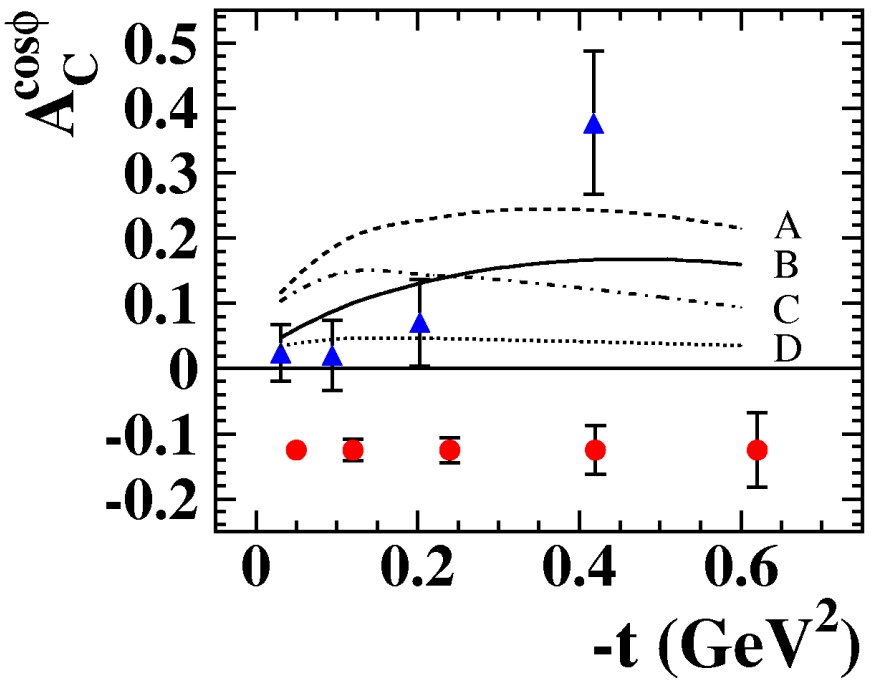
$\sigma_L(\rho^0, \phi^0)$	vs Q^2	quarks/gluons	not necessary	++
$\sigma_L(\omega^0, \rho^+)$	vs Q^2	quarks/gluons	not necessary	+
$\rho : \omega : \phi$	cross.sec. ratio	H, E flavours	not necessary	+
ρ^0, ϕ^0 SDME	vs t	comp. GPD model	not necessary	++
$\sigma_L(\pi^+)$	vs x_B	$\widetilde{H}^u - \widetilde{H}^d$	not necessary	++
$\pi^+ : \pi^0 : \eta$	cross.sec. ratio	$\widetilde{H}, \widetilde{E}$ flavours	not necessary	+
$K^+\Lambda^0$	transv. asym. $A_{K^+\Lambda}$	$\widetilde{H}^{p\to\Lambda}, \widetilde{E}^{p\to\Lambda}$	required	?
$\pi\Delta$	vs x_B	$N \to \Delta$ GPDs	required	?

DVCS Beam Charge Asymmetry

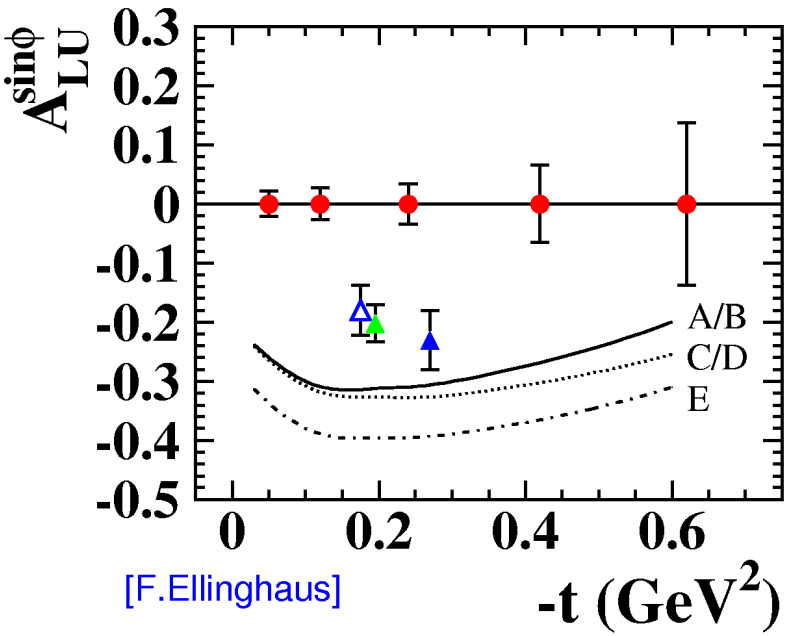


[F.Ellinghaus]

- GPD H dominates, $\tilde{H}$ and E suppressed

  [Goeke et al. PPNP 47(2001)401]
- t-dependence can distinguish different GPD model versions.
- More background in higher t-bins.
- 25x e^-1 statistics !
- A-D Curves from code by VGG for HERMES kinematics.

DVCS Beam Spin Asymmetry



[F.Ellinghaus]

HERMES PRL 2001

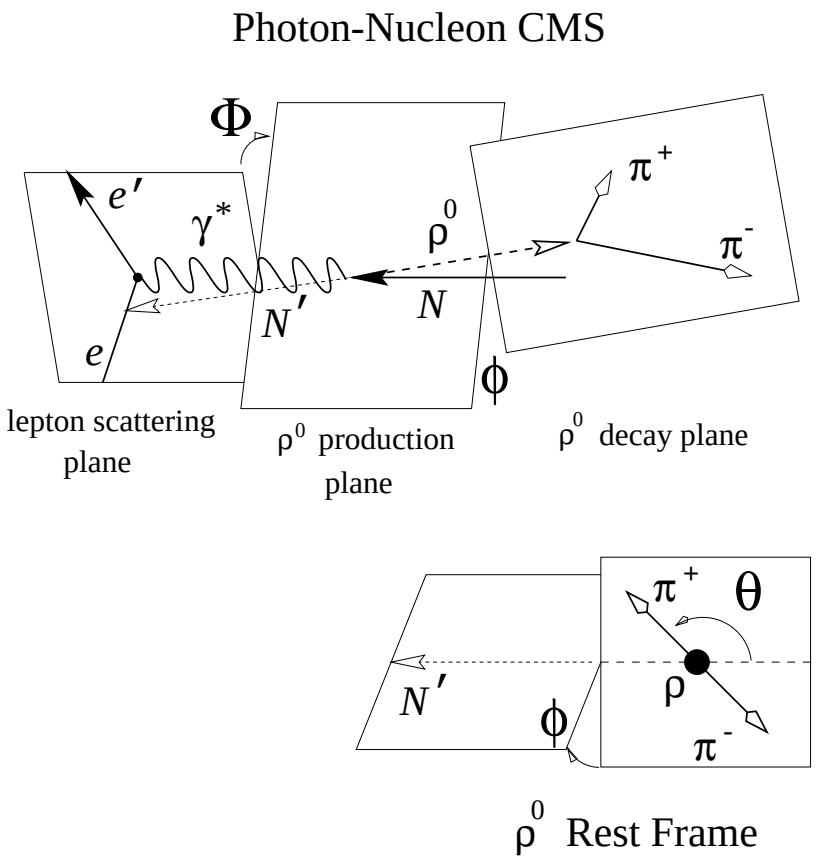
CLAS PRL 2001

HERMES hep–ex/0212019

HERMES 2002–2007

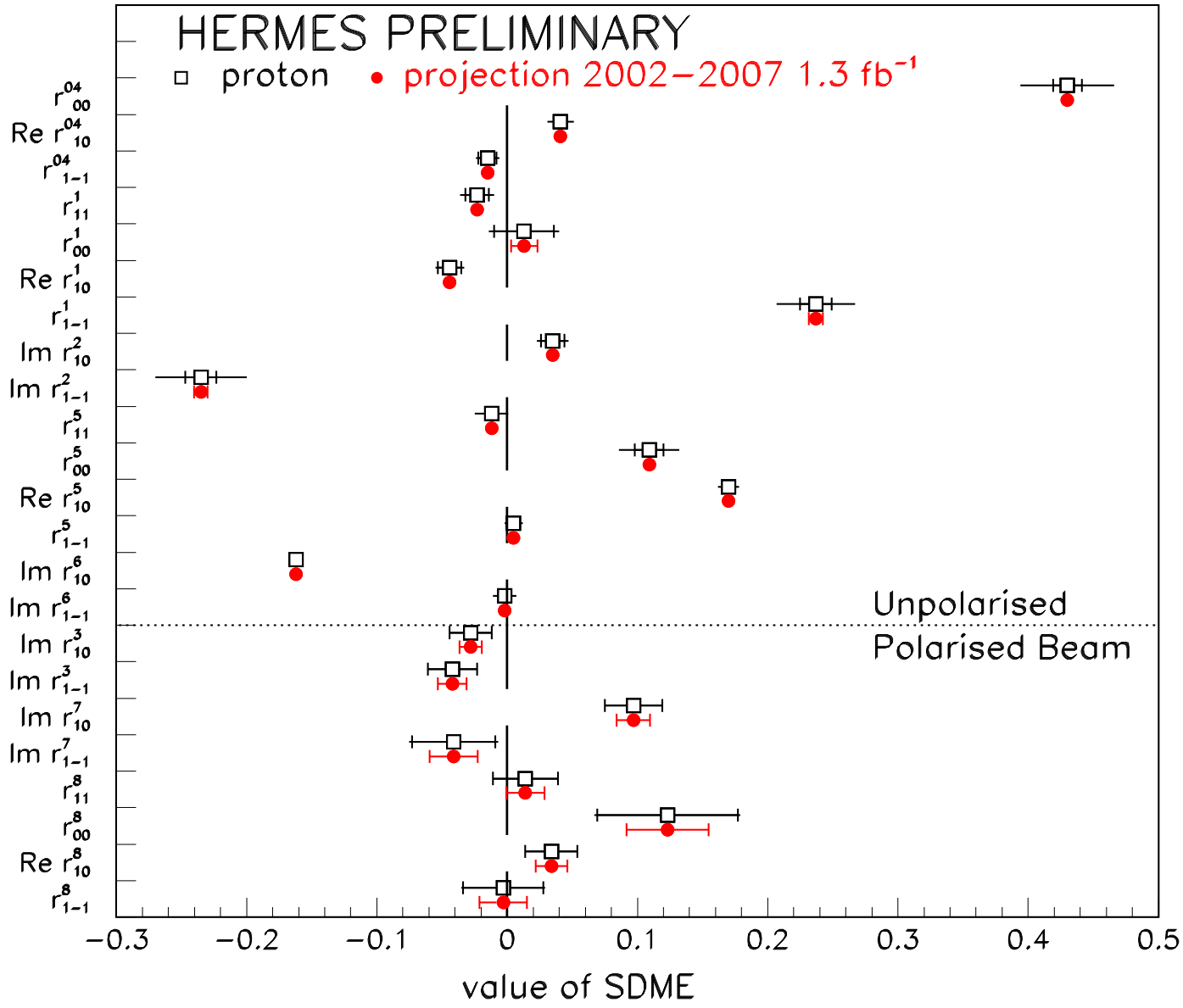
- $H_u(x = \xi, \xi, t)$ (model depedent)
- GPD models distinguishable via t-dependence
- 1996-2000: $P_B \approx 55\%$
  2002-2007: $P_B \approx 35\%$
- Statistics marginal for 2-dim dependences.
- A-E Curves from code by VGG for HERMES kinematics.

ρ^0 Spin Density Matrix Elements

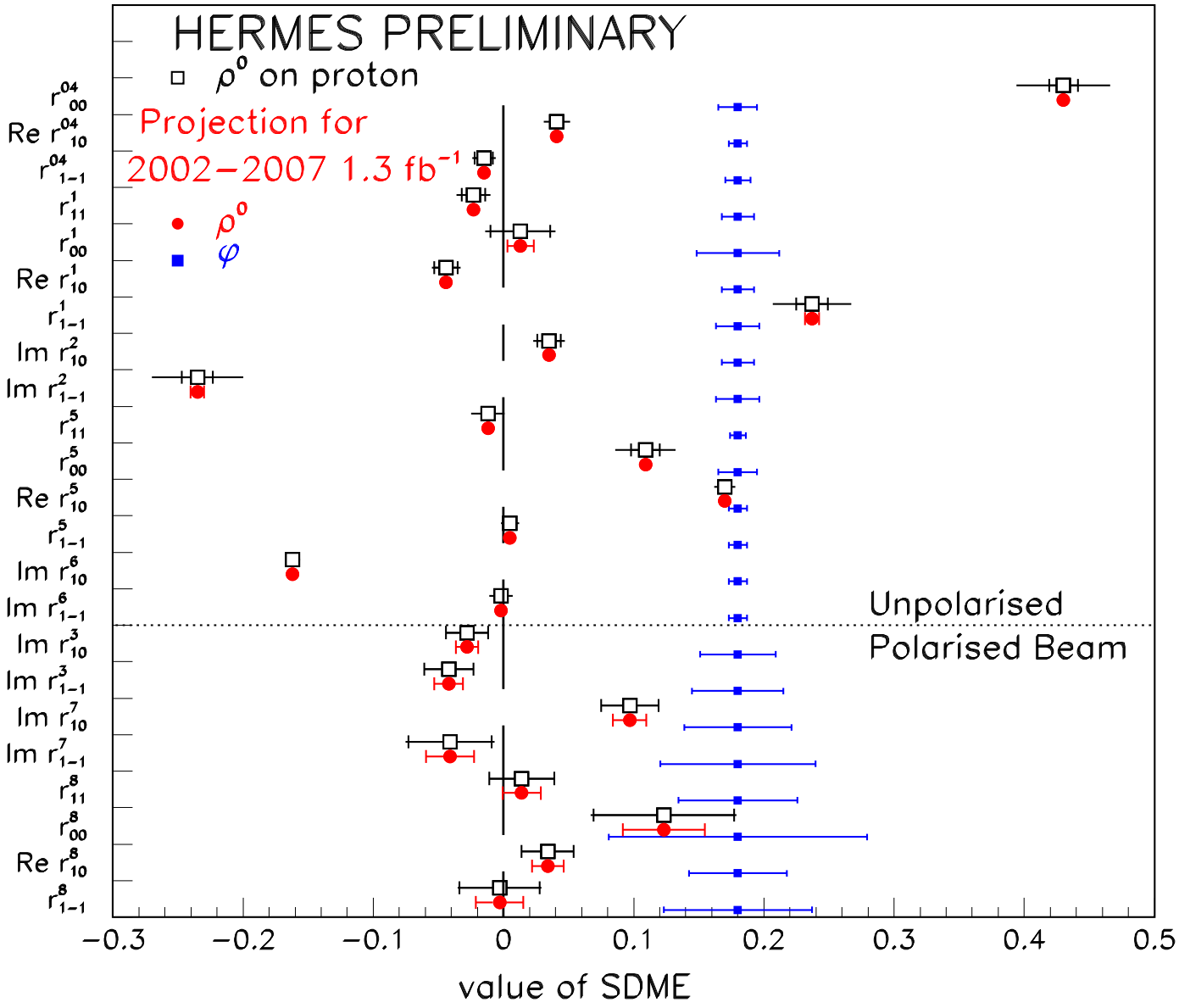


- SDMEs from maximum likelihood fit minimising difference between 3-dim. $(\cos\Theta, \phi, \Phi)$ decay angle matrix and fully reconstructed high statistics Monte Carlo data set.
- 15 'unpolarised' SDMEs, 8 'polarised' SDMEs (require beam polarisation)
- For SDME definitions see [Schilling,Wolf Nucl.Phys.B61(1973)381].

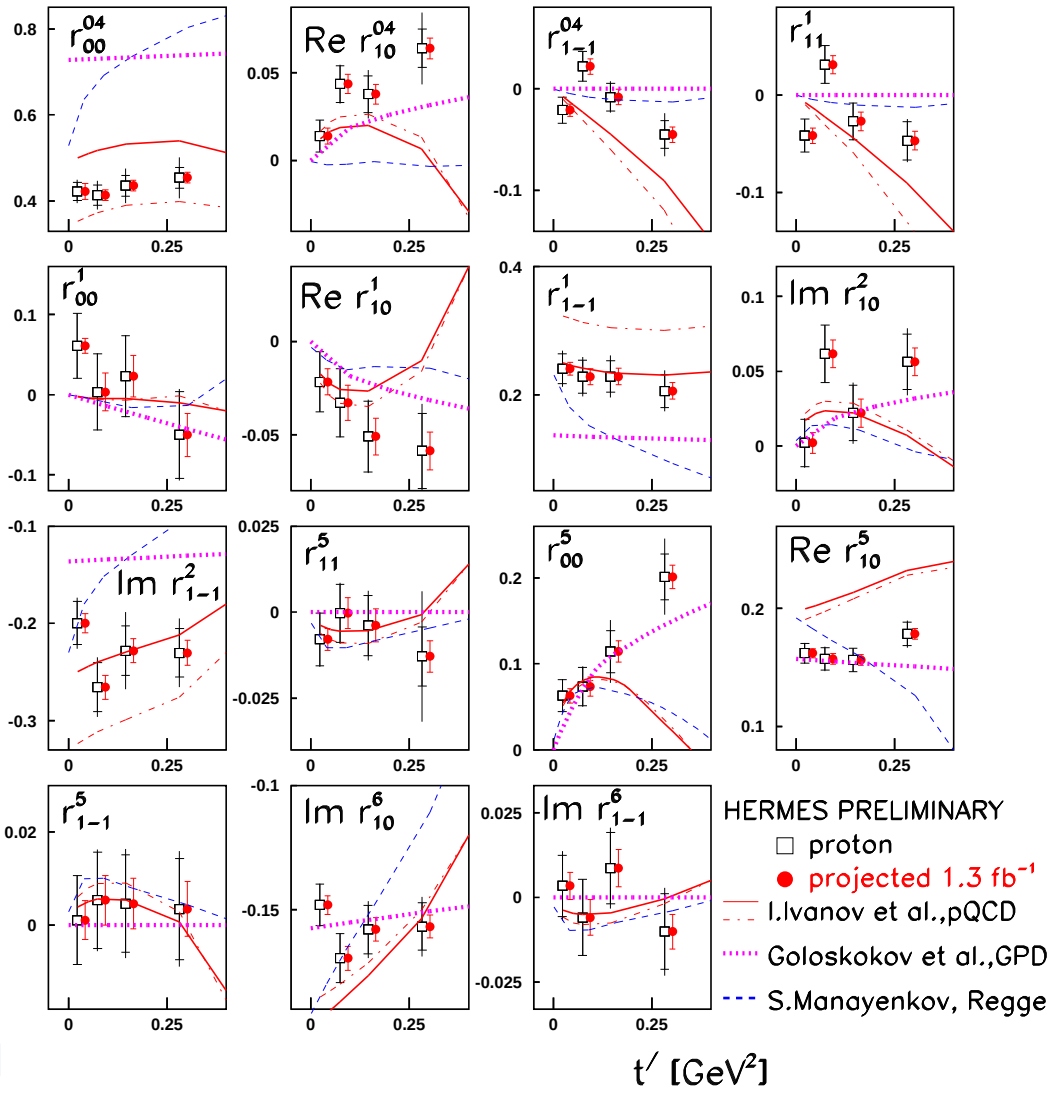
Spin Density Matrix Elements for ρ^0/ϕ^0



Spin Density Matrix Elements for ρ^0/ϕ^0

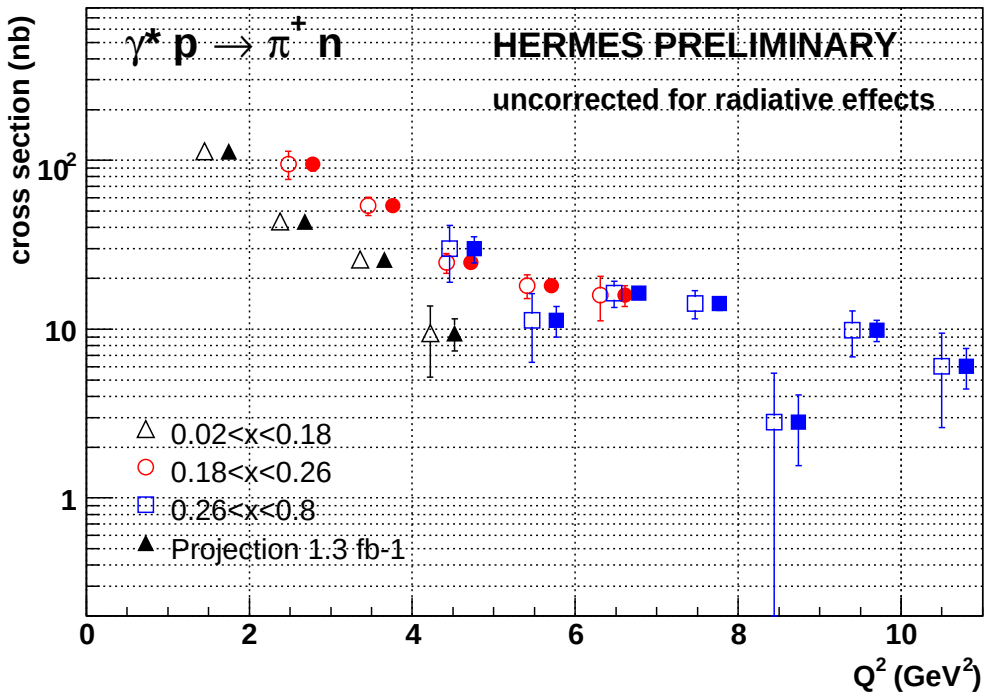


SDMEs t-Dependence



- GPD-based model for t-dependence [Goloskokov,Kroll, EPJ C 42 (2005) 02298]
- Model for $Q^2 > 3$ GeV^2, 2-gluon exchange only.
- 2-quark exchange being incorporated.
- Projections A.Borissov.

Exclusive π^+-Cross-Section



- Access to polarised GPDs $\widetilde{H}$, $\widetilde{E}$
- Improve errors at higher Q^2
- Projection C.Hadjidakis

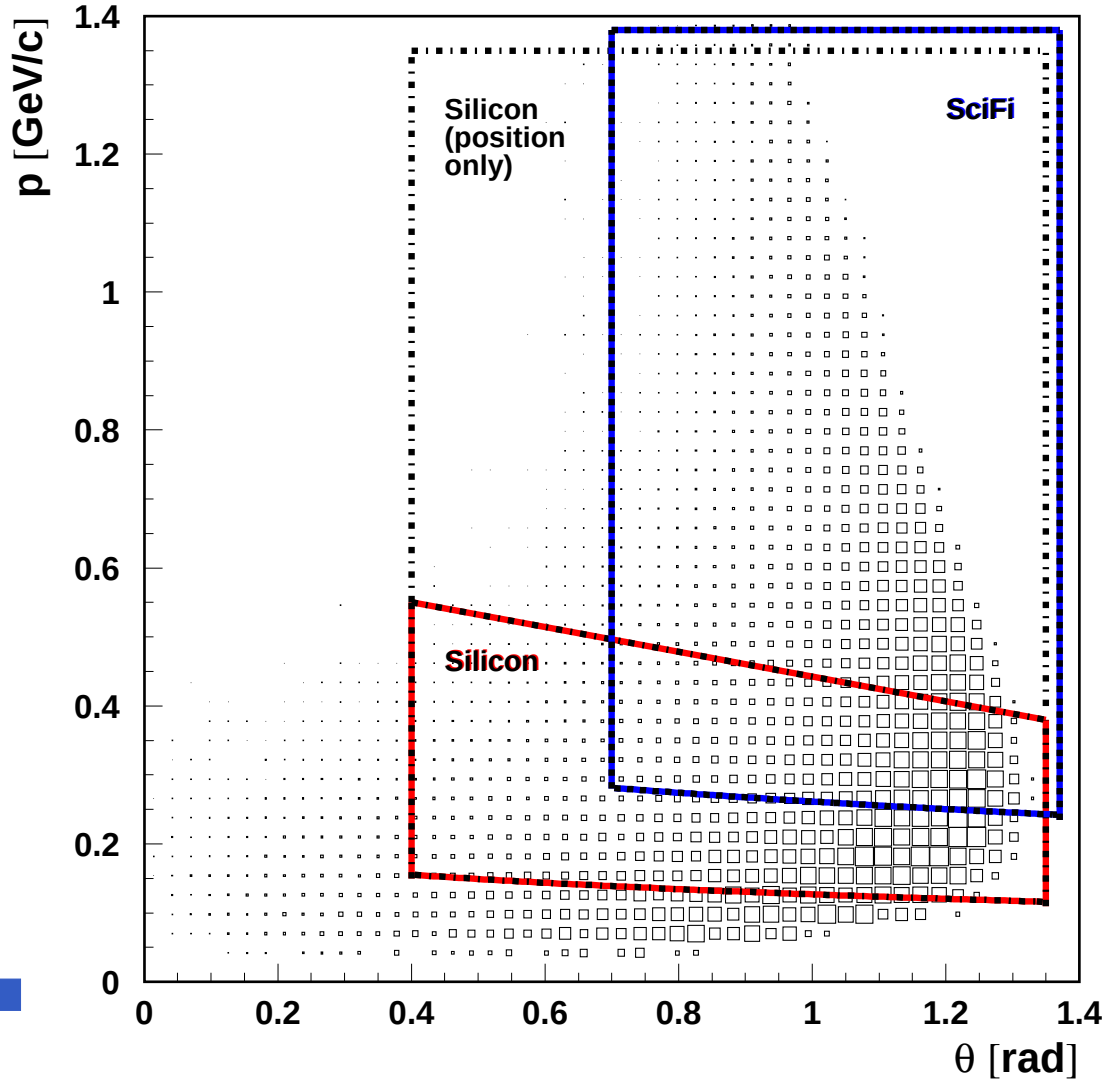
- L/T separation at HERMES not possible
  $\sigma_{tot} = \sigma_T + \epsilon\sigma_L$ (0.8< ϵ <0.96)
- σ_T suppressed by $1/Q^2$
  $\Rightarrow \sigma_L$ dominates at higher Q^2

Summary

- HERMES is playing a pioneering role exploring the potential of exclusive photon/meson production in the context of Generalised Parton Distributions.
- The new Recoil Detector, combined with an unpolarised target, is expected to lead to significant improvements of both statistics and systematics in exclusive measurements at HERMES.
- In the last year of data taking 2006/7 HERMES is expecting to take about as much data as in the 10 years before.

Additional Slides

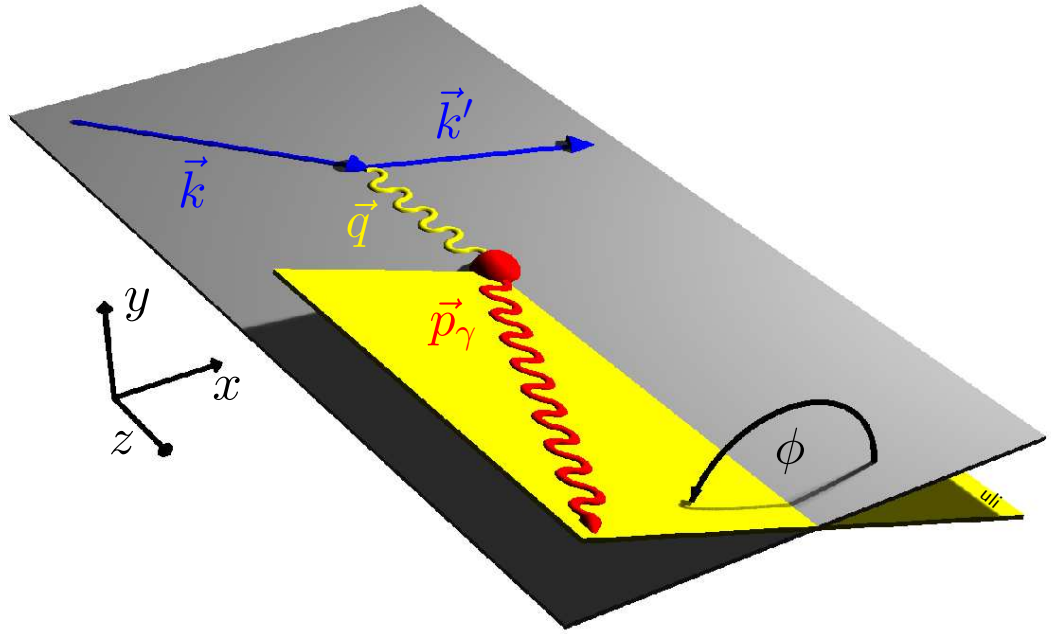
Recoil Detector - Kinematics



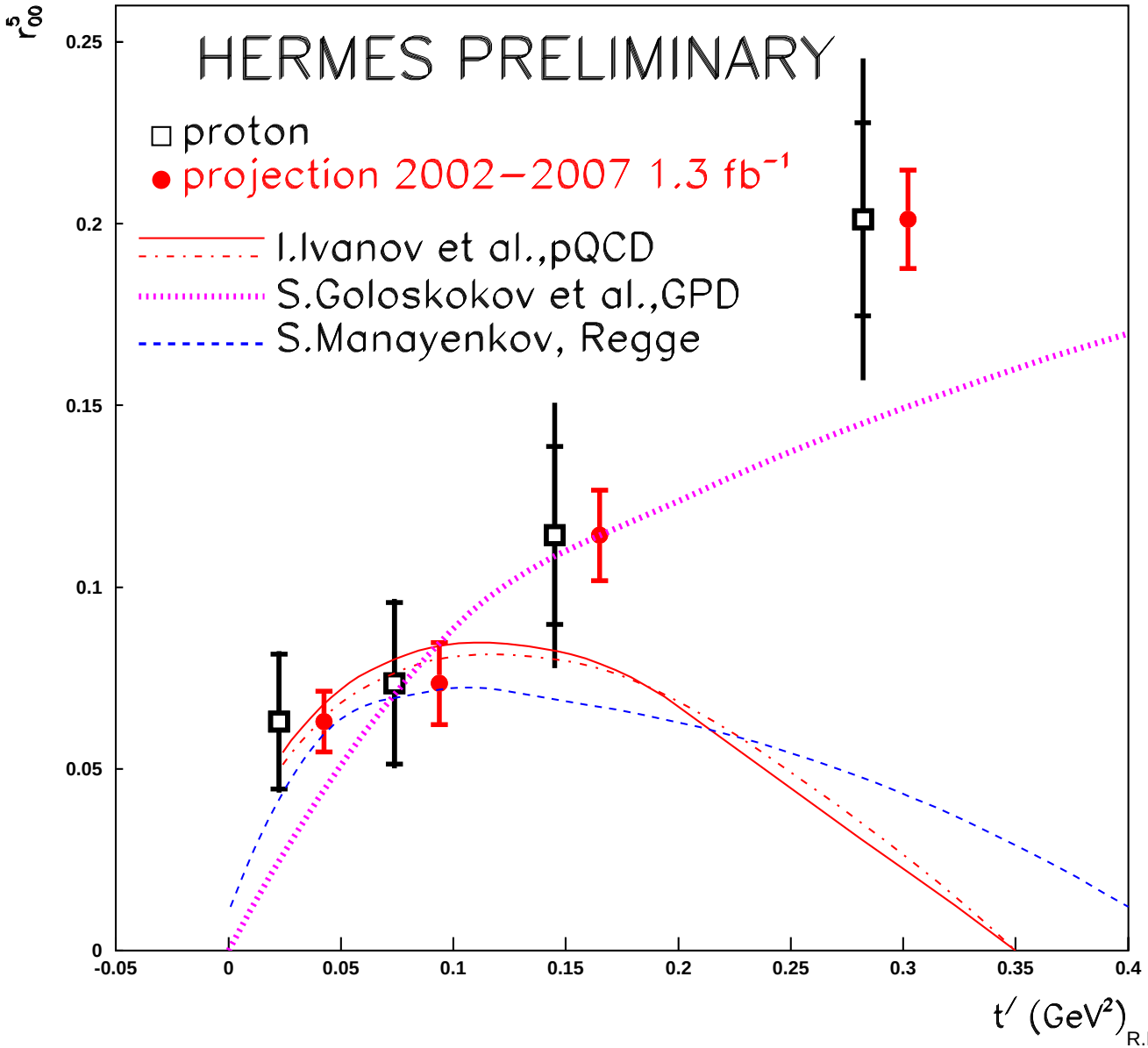
DVCS Asymmetries

Beam Spin $A_{LU}(\phi) = \frac{d\sigma^{\uparrow}(\phi) - d\sigma^{\downarrow}(\phi)}{d\sigma^{\uparrow}(\phi) + d\sigma^{\downarrow}(\phi)} \propto \sin\phi \Rightarrow \mathfrak{Im}(H)$

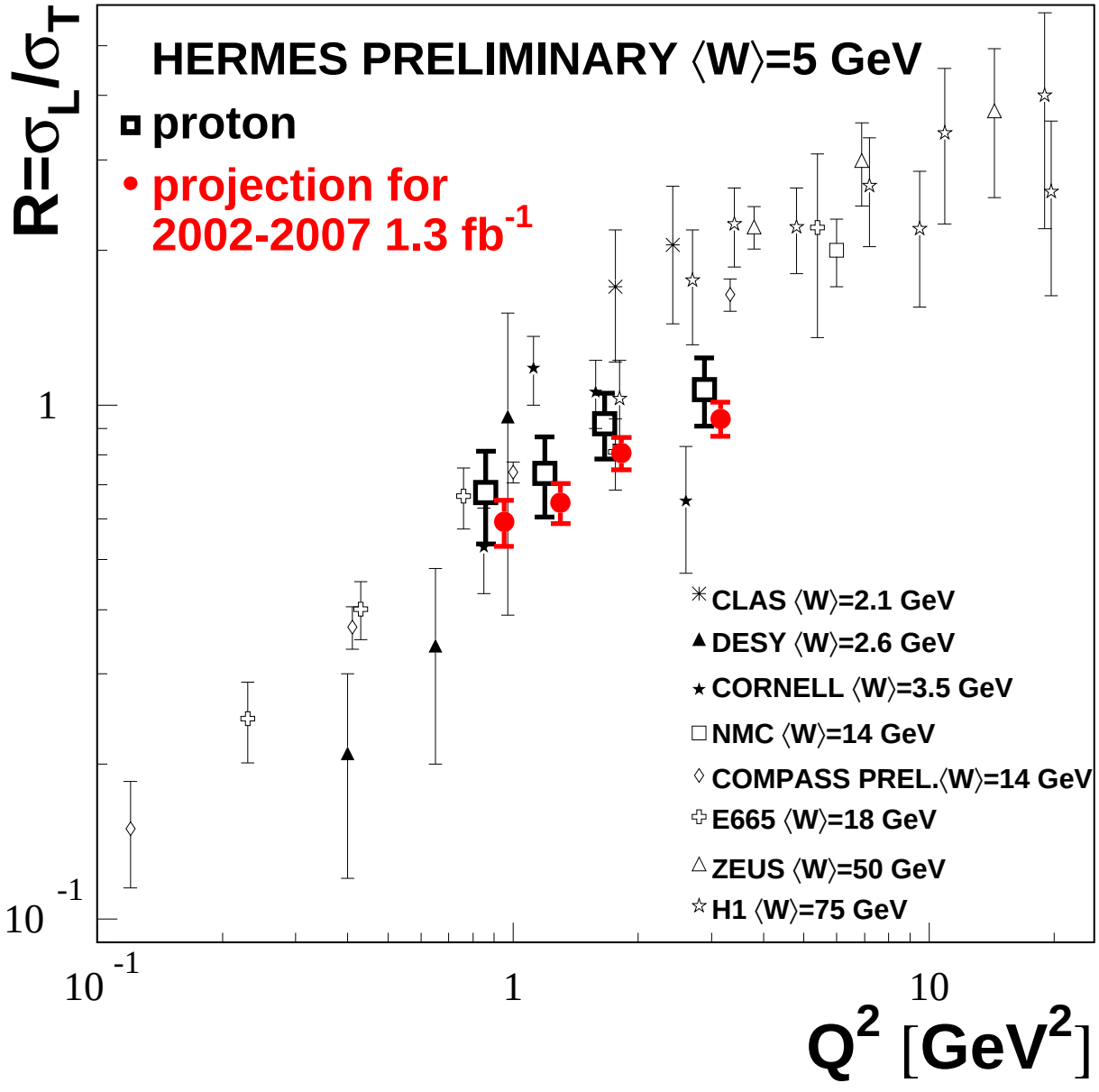
Beam Charge $A_{ch}(\phi) = \frac{d\sigma^{+}(\phi) - d\sigma^{-}(\phi)}{d\sigma^{+}(\phi) + d\sigma^{-}(\phi)} \propto \cos\phi \Rightarrow \mathfrak{Re}(H)$



SDMEs t-Dependence: r^5_{00}



Q^2-Dependence of R = σ_L/σ_T



Exclusive Pion-Pair Production