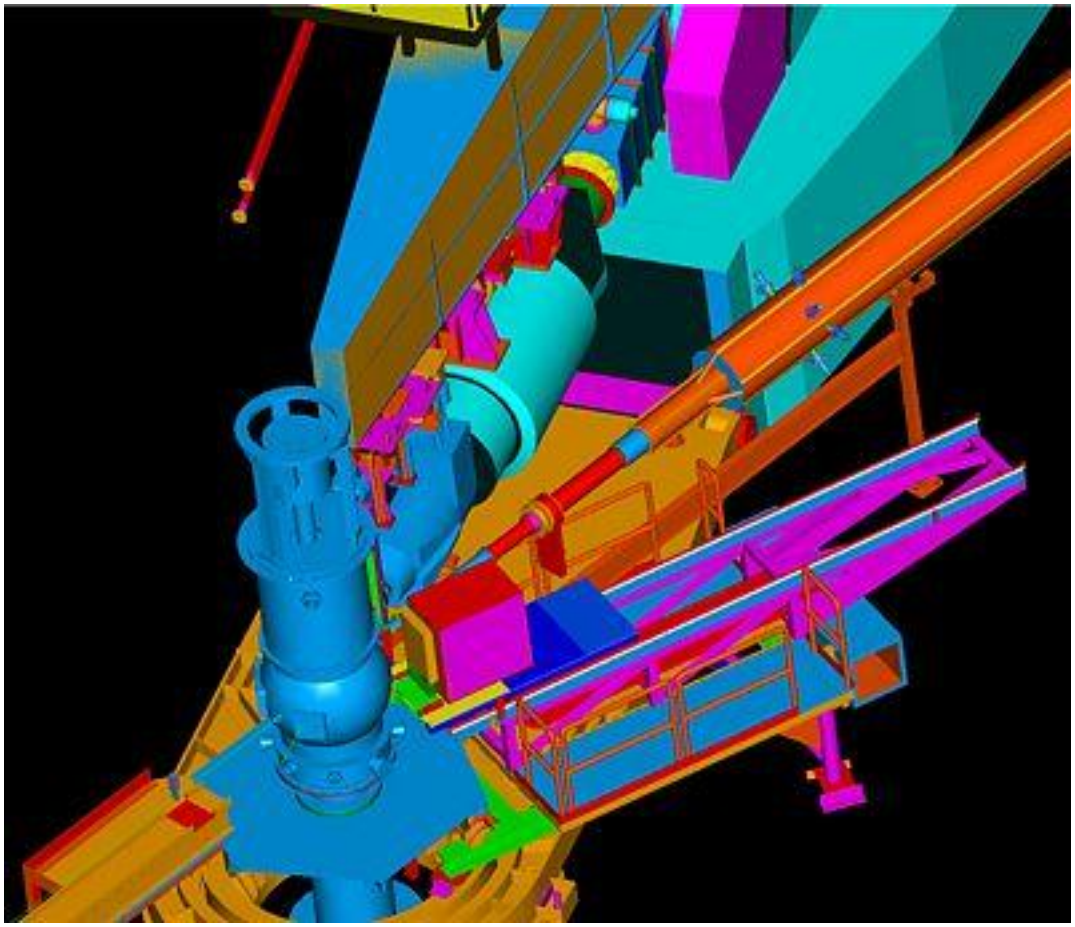
Deeply Virtual Compton Scattering in Hall C at 11 GeV



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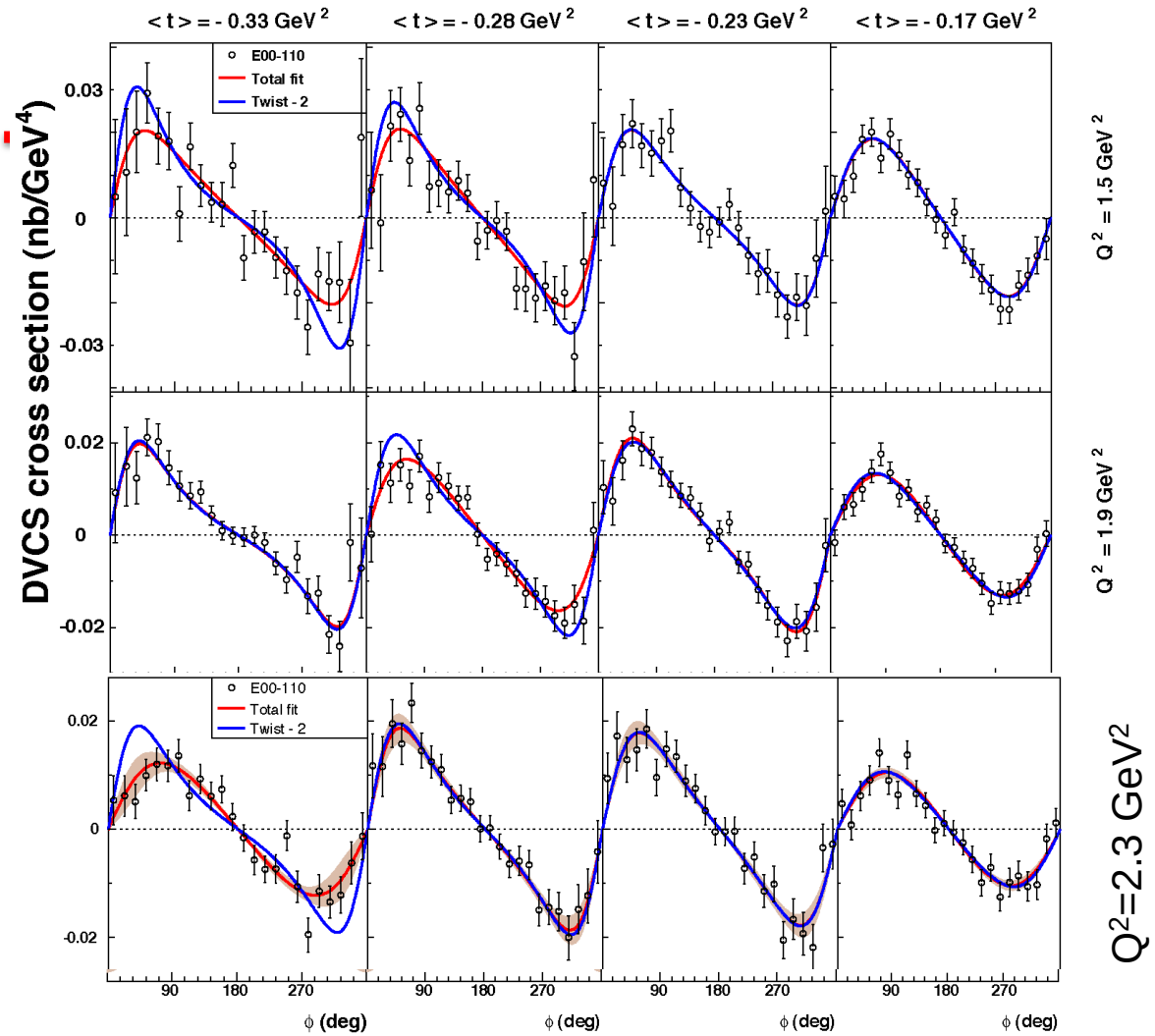
Why Use Spectrometers for DVCS?

- Precision cross sections are key to extracting physics
- $d\sigma(ep \rightarrow ep\gamma)$ = twist-2 (GPD) terms
  $+ \Sigma_n$ [twist-n]/Q^{n-2}
  - Isolate twist-2 terms → cross sections *vs* Q^2 at fixed (x_{Bj}, t); *or*
  - → Multiple beam energies at fixed (Q^2, x_{Bj}, t)
    - Two beam energies at fixed (Q^2, x_{Bj}, t) to isolate [$DVCS^{\dagger}BH$] from $|DVCS|^2$
    - **Three** beam energies at fixed (Q^2, x_{Bj}, t) to isolate all twist-2 and twist-3 terms in unpolarized cross section.
- $H(e,e'\gamma)p$ at low Δ^2, electron and photon are highly correlated
  - For a single kinematic setting, Luminosity·Acceptance ≥ with spectrometers than CLAS12



Hall A Helicity Dependent Cross Sections E00-110

PRL**97**:262002 (2006)
C. MUNOZ CAMACHO, et al.,

Twist-2(GPD)+…

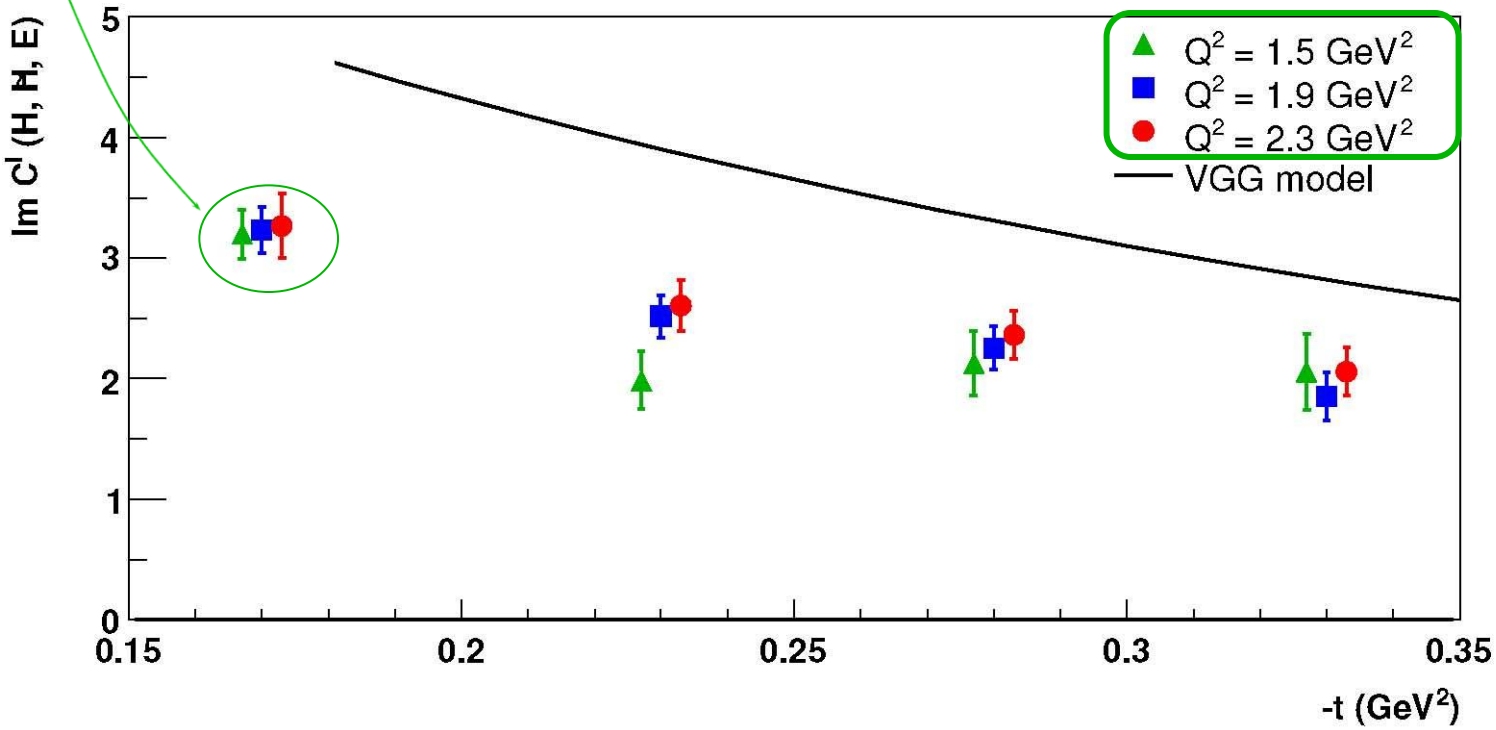
Twist-3(qGq)+…

$$\Gamma_{s1,2} = \text{kinematic factors}$$

$$\text{å}\, hds(h) = \frac{s_1 \sin(f_{gg}) G_{s1} + s_2 \sin(2f_{gg}) G_{s2}}{P_1(f_{gg}) P_1(f_{gg})}$$

GPD results from JLab Hall A (E00-110) (C.MUNOZ CAMACHO et al *PRL* **97**:262002)

- Q^2-independance of Im[DVCS*BH]
  - Twist-2 Dominance (GPD)
  - Model « Vanderhaeghen-Guichon-Guidal(VGG) » (based on Double Dist. of A.Radyushkin) accurate to ≈30%



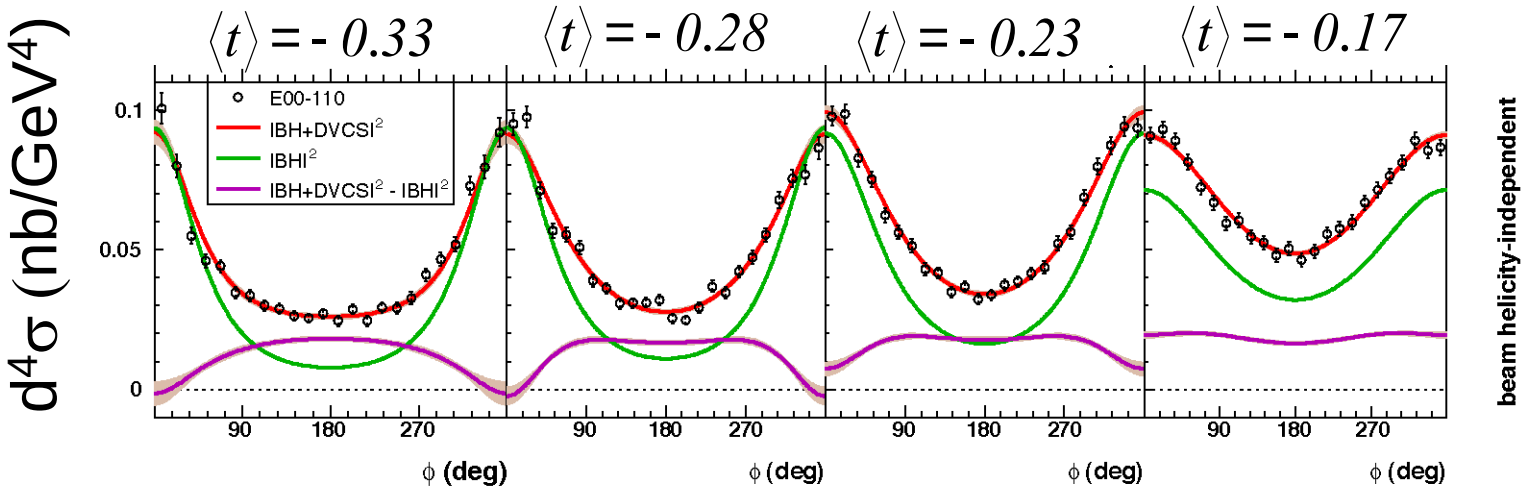
Extend to $Q^2 = 4.5$ GeV^2 @11GeV

Compensate the small lever-arm in Q^2 with precision in $d\sigma$.

Beam helicity-independent cross sections at Q^2=2.3 GeV^2, x_B=0.36

- Contribution of Re[DVCS*BH] + |DVCS|^2 large.
- Positron beam or measurements at multiple incident energies to separate these two terms and isolate Twist 2 from Twist-3 contributions

PRL**97**:262002 (2006) C. MUNOZ CAMACHO, *et al.*,



$$d\sigma = d\sigma(|BH|^2) + 2\,\mathrm{Re}[DVCS^* BH] + |DVCS|^2$$

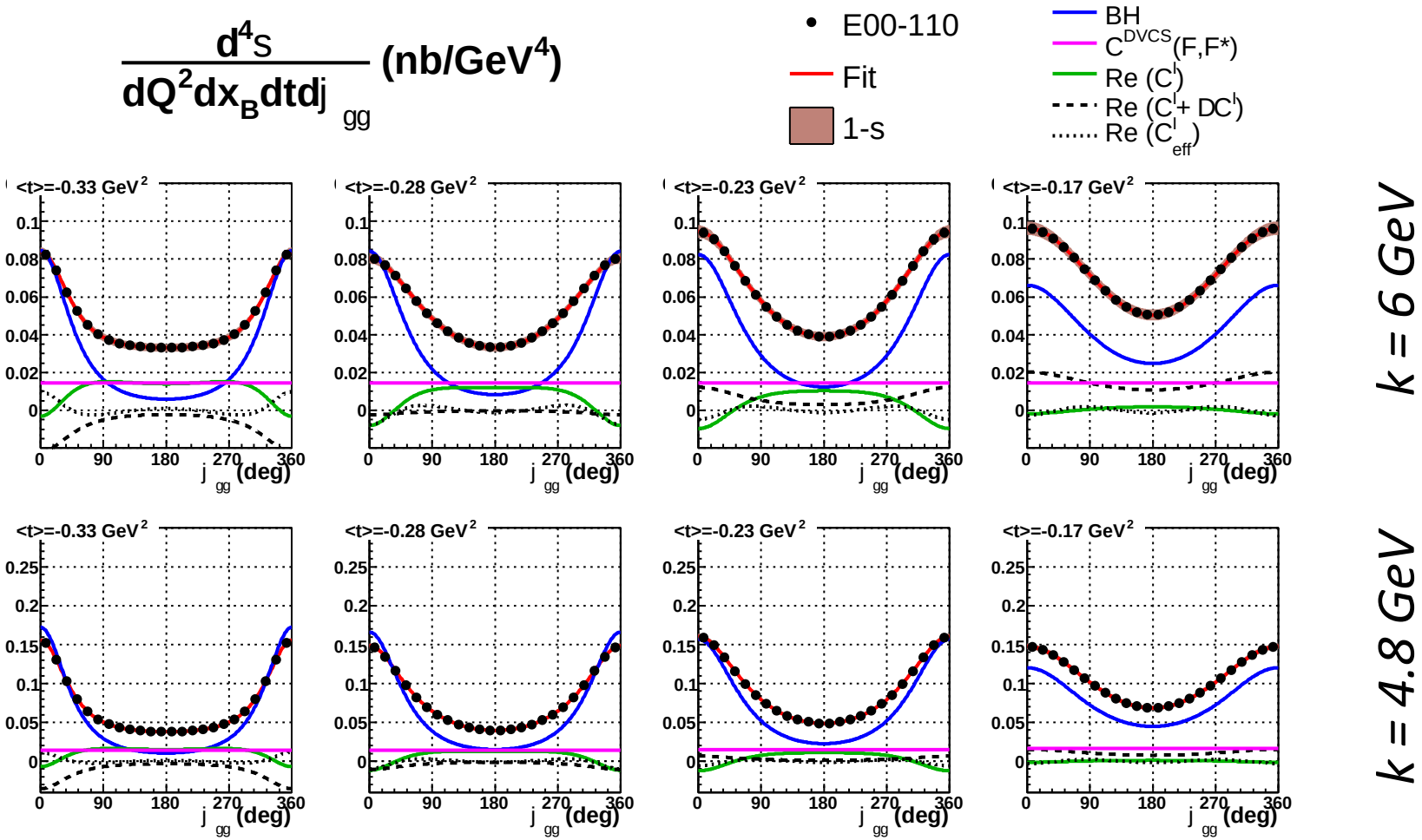
$$= d\sigma(|BH|^2) + \frac{c_0\Gamma_0 + c_1\cos(\phi_{\gamma\gamma})\Gamma_1 + c_2\cos(2\phi_{\gamma\gamma})\Gamma_2 + \ldots}{P_1(\phi_{\gamma\gamma})P_1(\phi_{\gamma\gamma})}$$

$$c_{0,1}(t) \approx \mathrm{Re}[C^I(GPD)] \pm C^{DVCS}\left(GPD^2\right) \ldots + \mathrm{Re}\left[\Delta C^I(GPD)\right]$$

$$c_2(t) = \mathrm{Twist-3} = (qGq)$$

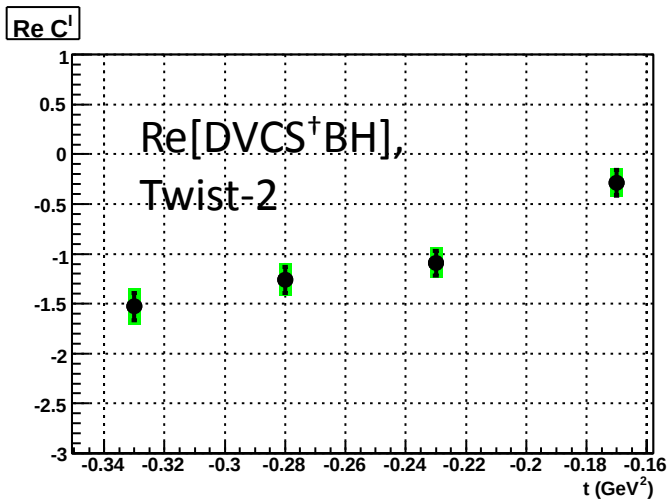
Projections for E07-007 (2010), $Q^2=1.9\ GeV^2$

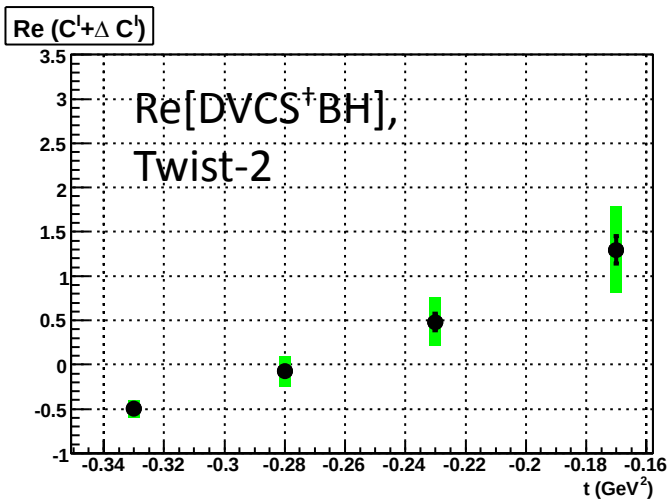
- Different dependence on incident energy for $|BH|^2$, $[DVCS^{\dagger}BH]$ (C^I twist-2), and $|DVCS|^2$(C^{DVCS} twist-3) terms

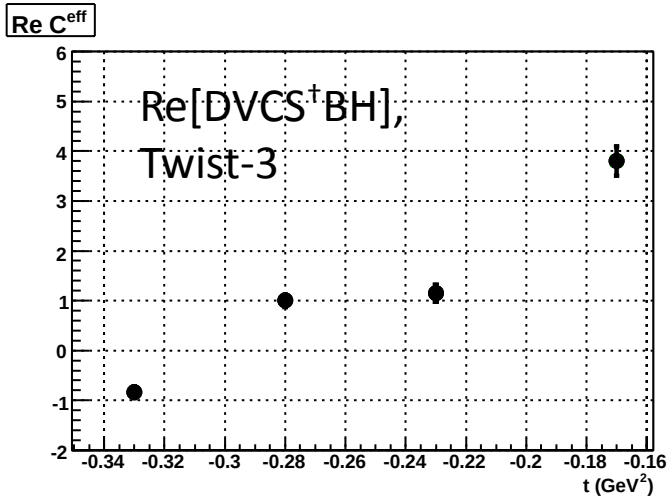


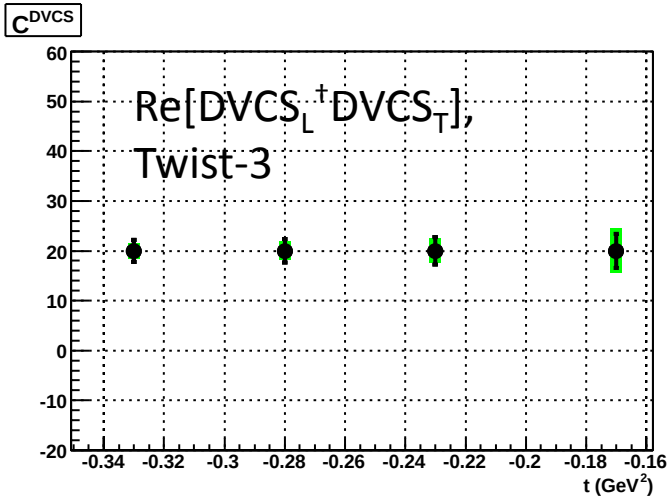
E07-007 Projected Extractions:

- green bands are systematic errors.
- Four different contributions to unpolarized cross sections
  - constant terms
  - $\cos\phi_{\gamma\gamma}$ terms
  - $\cos 2\phi_{\gamma\gamma}$ terms



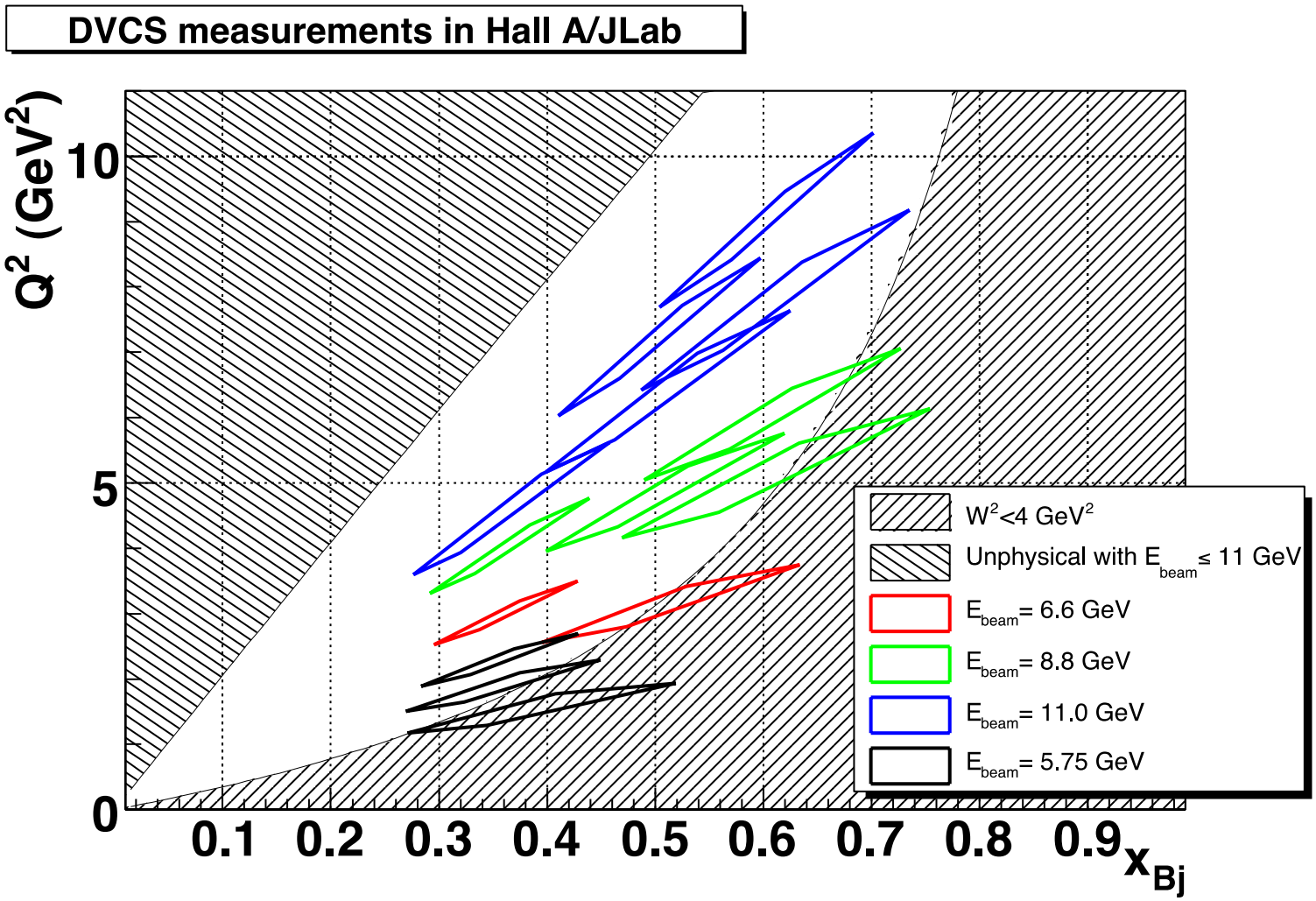






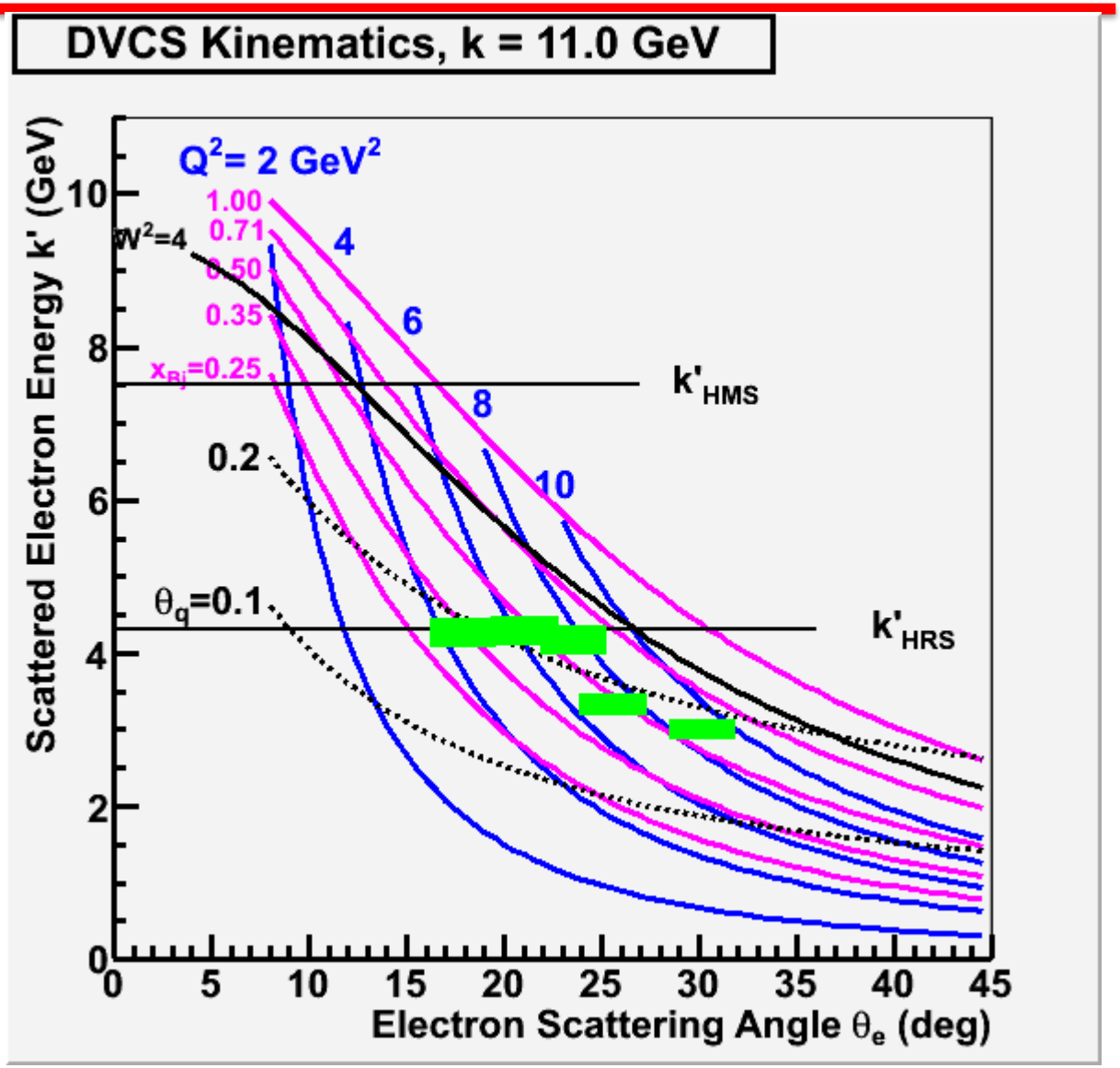
Hall A E12-06-116, approved for 100 days

- Multiple beam energies at fixed Q^2, x_{Bj} requires spectrometer momenta > k_{HRS}=*4.3 GeV/c*



DVCS Kinematics, Hall A & C

- Green rectangles are Hall A kinematics.
- Calorimeter centered at θ_q.
  - Require $\theta_q \geq 0.2$ rad to avoid small-angle background



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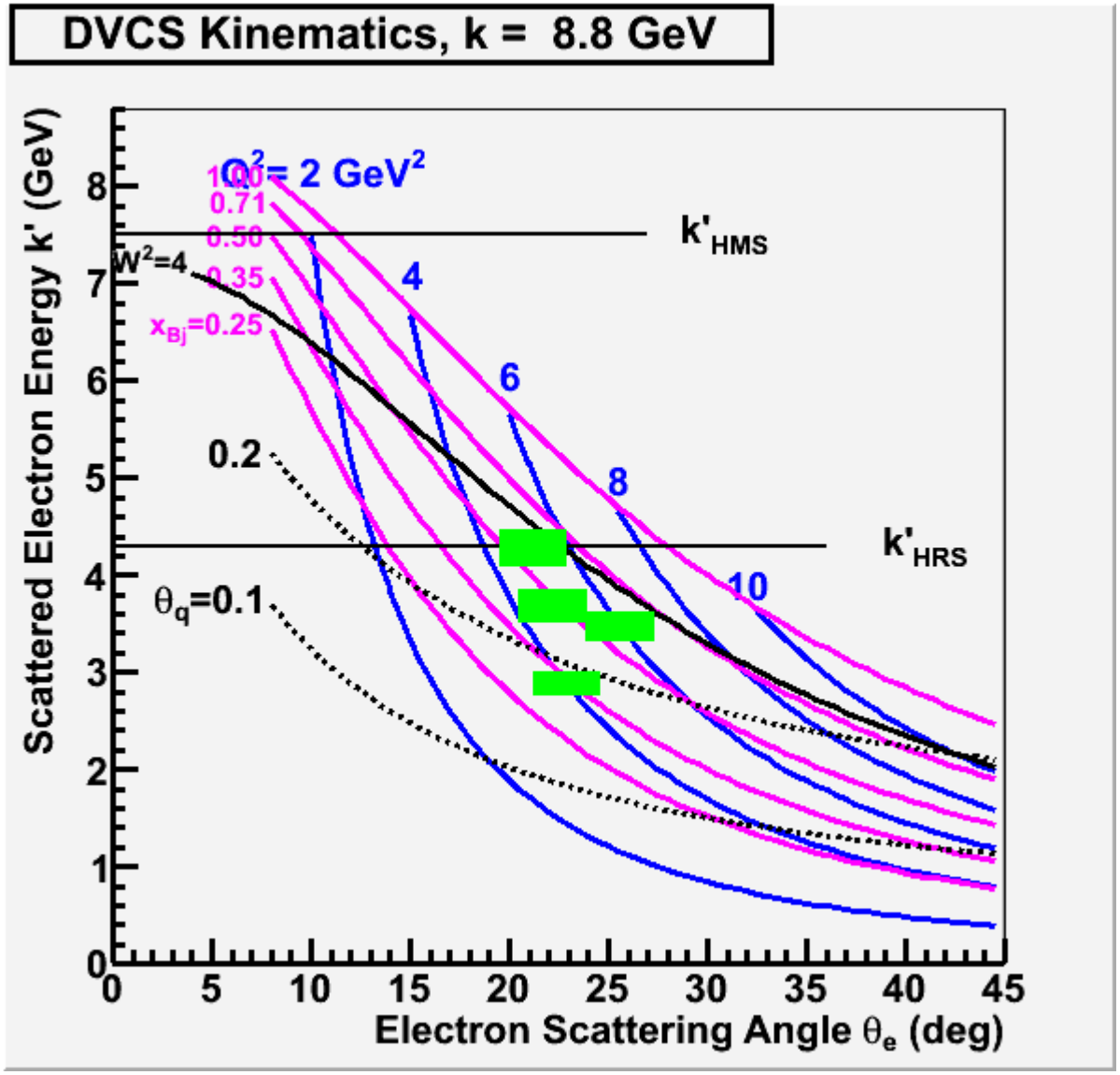

Kinematics Table Hall A E12-06-114

Hall A		E12-06-114		Hall C supplement at fixed (Q2, x_Bj)					
Q2	xBj	k	k'	k	k'	θe	k	k'	θe
3.00	0.36	6.60	2.16	8.80	4.36	16.08	11.00	6.56	11.70
4.00	0.36	8.80	2.88				11.00	5.08	15.38
4.55	0.36	11.00	4.26						
3.10	0.50	6.60	3.30	8.80	5.50	14.55	11.00	7.70	10.98
4.80	0.50	8.80	3.68				11.00	5.88	15.65
6.30	0.50	11.00	4.28						
7.20	0.50	11.00	3.32						
5.10	0.60	8.80	4.27				11.00	6.47	15.38
6.00	0.60	8.80	3.47				11.00	5.67	17.84
7.70	0.60	11.00	4.16						
9.00	0.60	11.00	3.00						

Conclusions

- Precision cross section measurements with spectrometers are essential to extracting the leading twist amplitudes from the ep→epγ cross section
- The Hall C HMS paired with the DVCS PbF_2 calorimeter (or alternate $PbWO_4$) will allow an extension to measure two or three energy points for each x_{Bj} value at one or two Q^2 values
  - Separation of all twist-2 and twist-3 contributions to cross sections, without positrons.