DVCS From 12 to 24 GeV

A look at current and future data

Kyle Shiells, May 3 2022

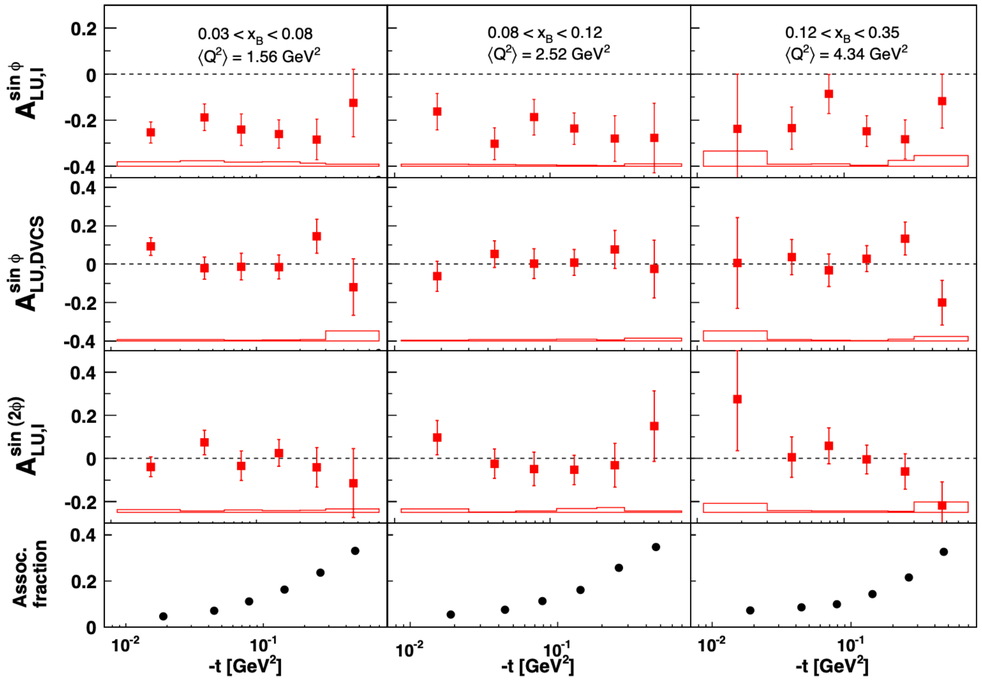
Outline

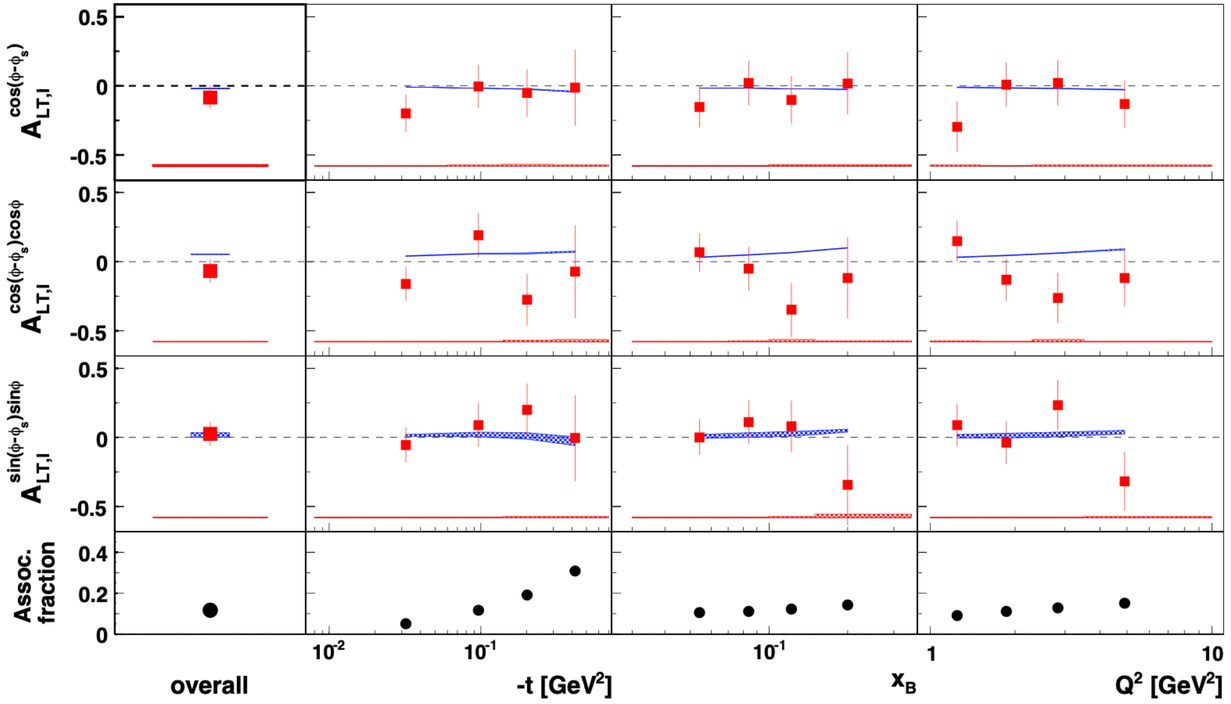
- A brief review of HERMES data
- Compare that to JLAB data
- Future wishlist, some general remarks
- Effects of doubling beam energy

First let's look at the HERMES data..

- HERMES raw data runs from 2001-2007, publications from ~2006-2012
- Exclusive study of ASYMMETRIES
- Electron and positron beams used
- Many observables measured: $A_C, A_{LU}, A_{UL}, A_{LL}, A_{UT}, A_{LT}$ totals over 14 harmonic coeff's
- Beam energy of 27.6 GeV
- Lower luminosity $\leq 10^{31} cm^{-2} s^{-1}$
- Most data within $0.05 \leq x_B \leq 0.2$ $2\ \text{GeV}^2 \leq Q^2 \leq 6\ \text{GeV}^2$

Examples of HERMES data



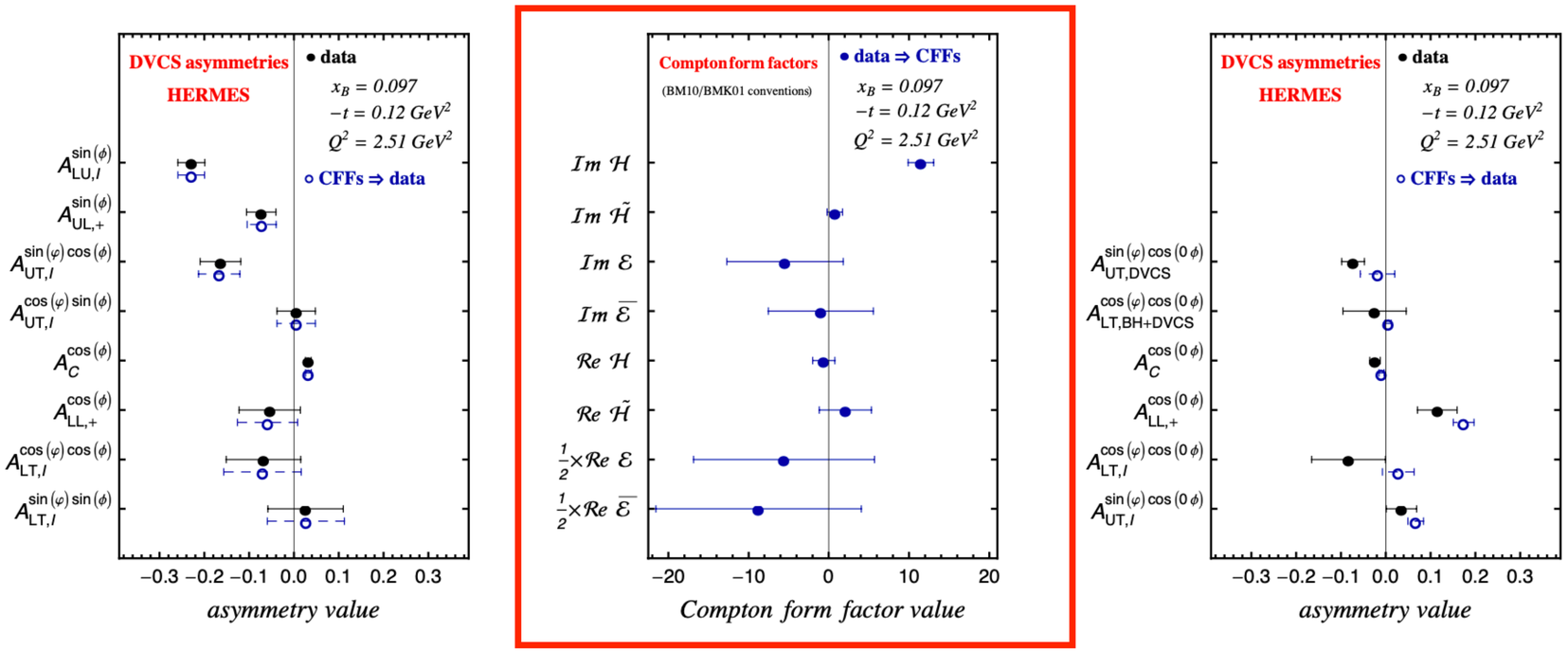


- Okay, so what does this data give us ??...

An analysis of HERMES data

e.g. Kumericki, Muller & Murray 2014:

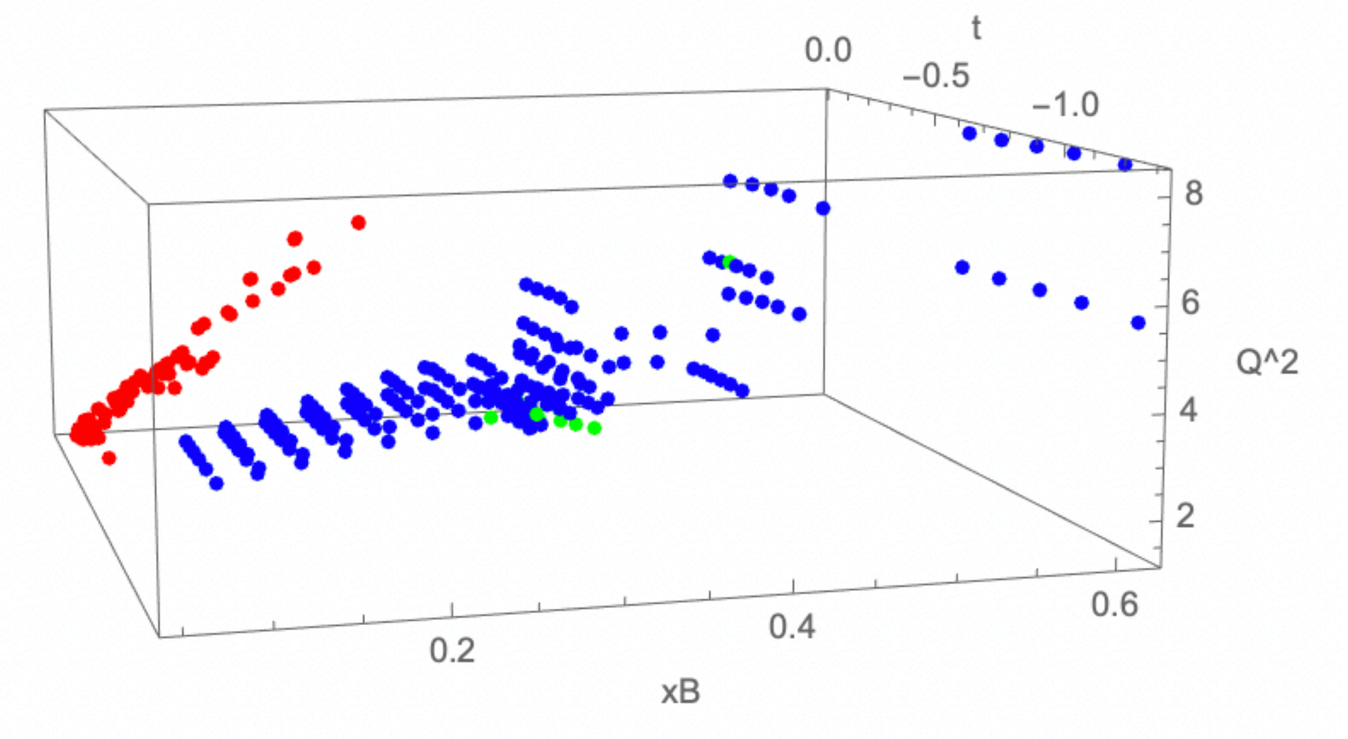
- Extracted all 8 twist-2 CFFs using linear approximations



- Other, more rigorous analyses have been done, which also includes JLab data, but for this case here is a “best-case scenario” given only HERMES data

HERMES vs JLAB data

- Each data set covers different kinematical regions
- This means for traditional local extraction of CFFs they're "incompatible"
- However for global fits with models or NNs, they can be used together

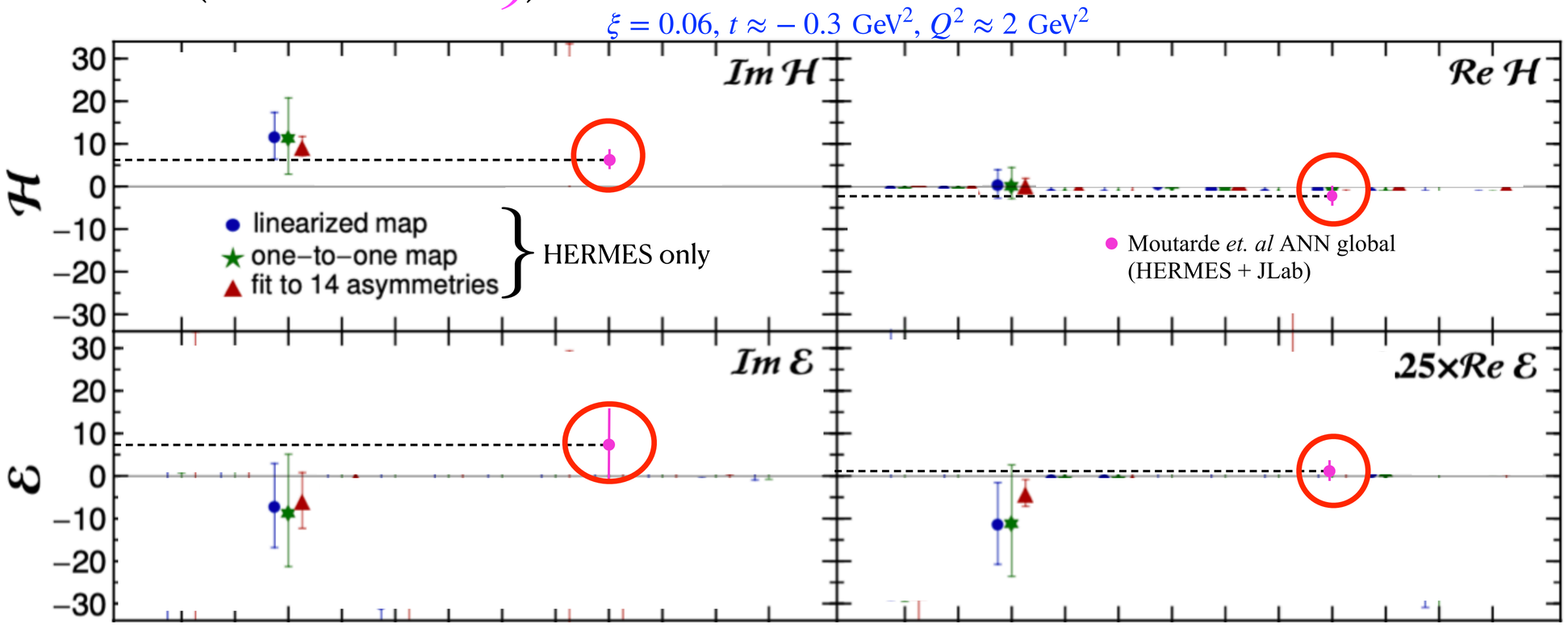


HERMES

JLAB Hall A

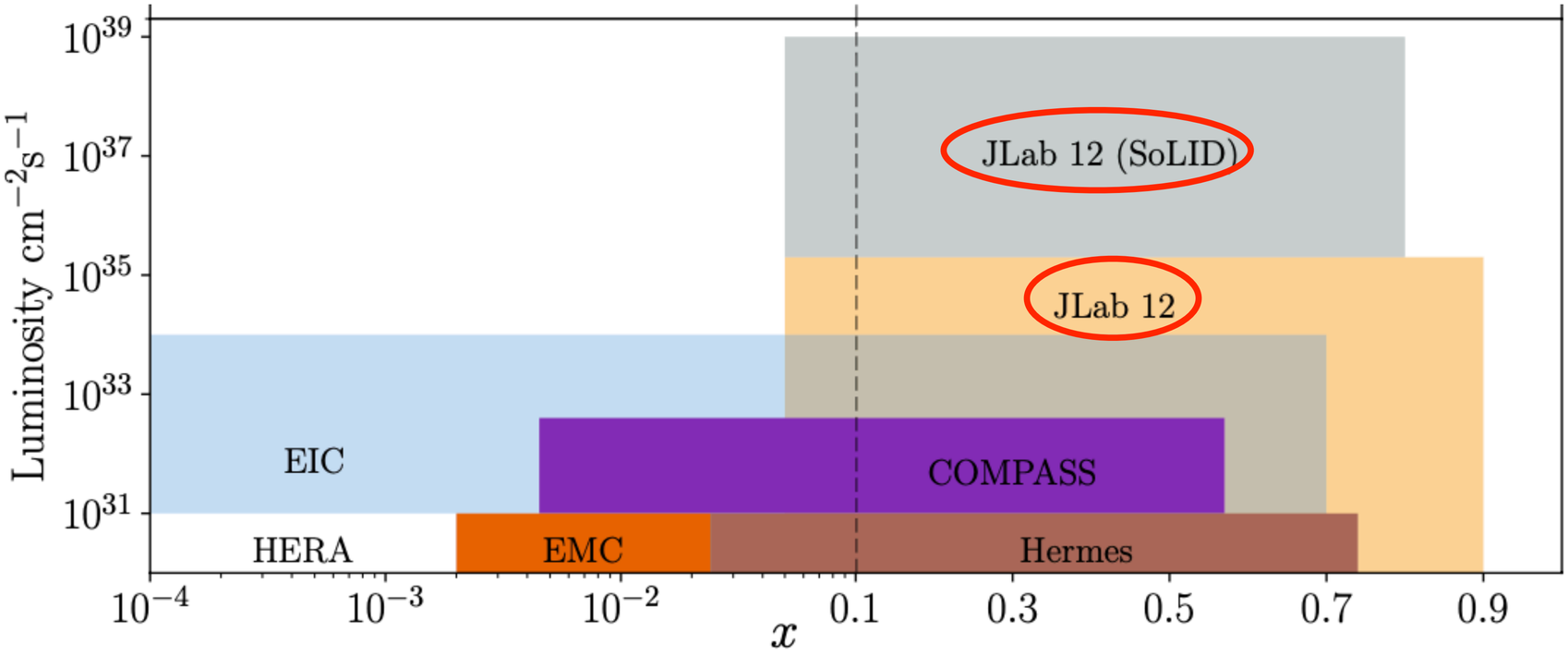
Global Analyses of DVCS data

- A general global analysis should not use linear approximations
- They should either use numerical χ^2 fitting method (Guidal & Boer 2015) or NNs (Moutarde 2019)



- The inclusion of higher luminosity, higher precision data results in determining CFFs (and thus GPDs) with smaller uncertainties

JLab CBAF: Luminosity frontier



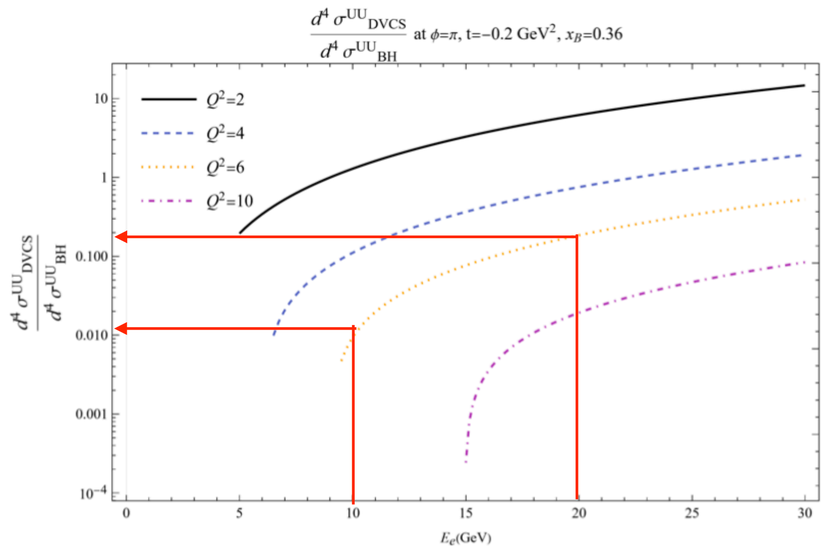
What we need next:

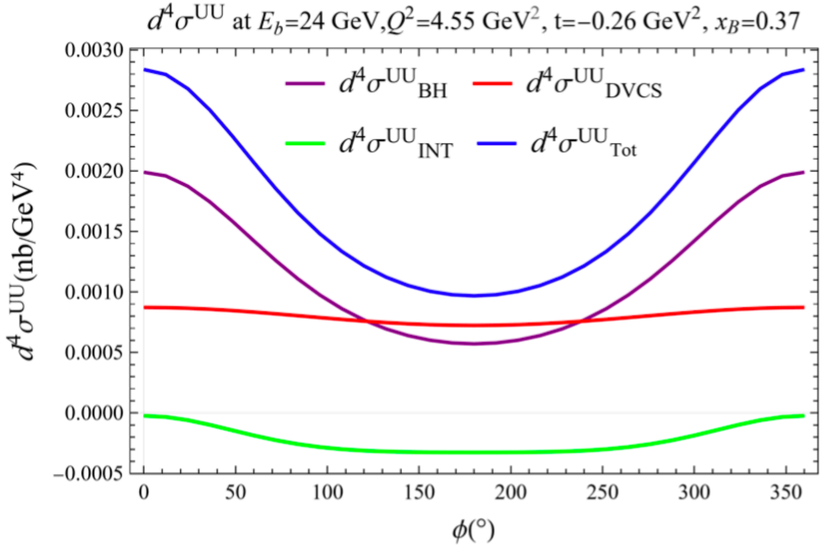
- We need MORE data:
  - A. More data points in general but also…
  - B. More kinematical coverage in: (Q^2, x_B, t)
  - C. More observable variety: UU, LU, UL, LL, UT, LT
  - D. Even extend that to charge asymmetries (positrons) and even other processes like DDVCS and TCS
  - E. Spread over full range of ϕ (and ϕ_S for Transverse targets)

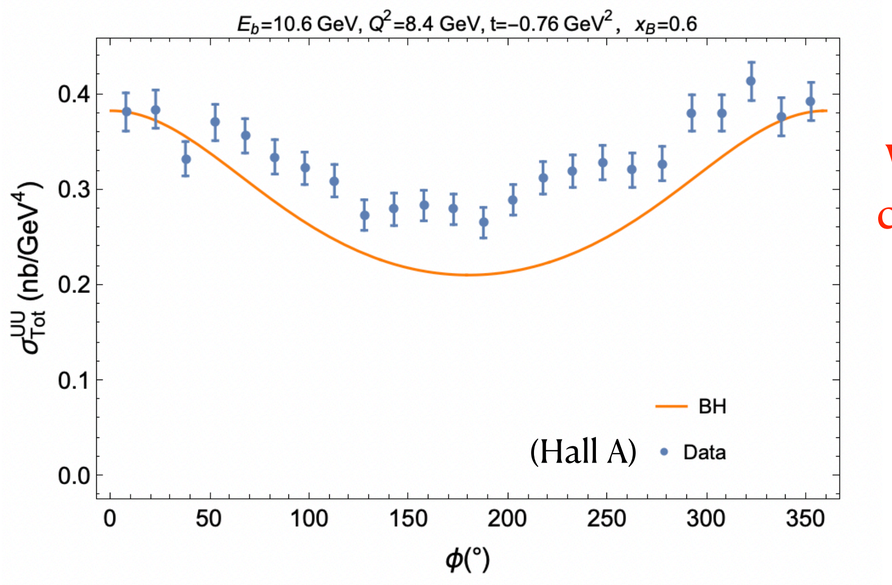
Hall B asymmetries

- With that understood, going to 24 GeV gives additional advantages:
  1. It allows higher Q^2 data where twist-3 effects minimized
  2. It gives a better DVCS signal to BH background
  3. Could allow more options for DVMP production

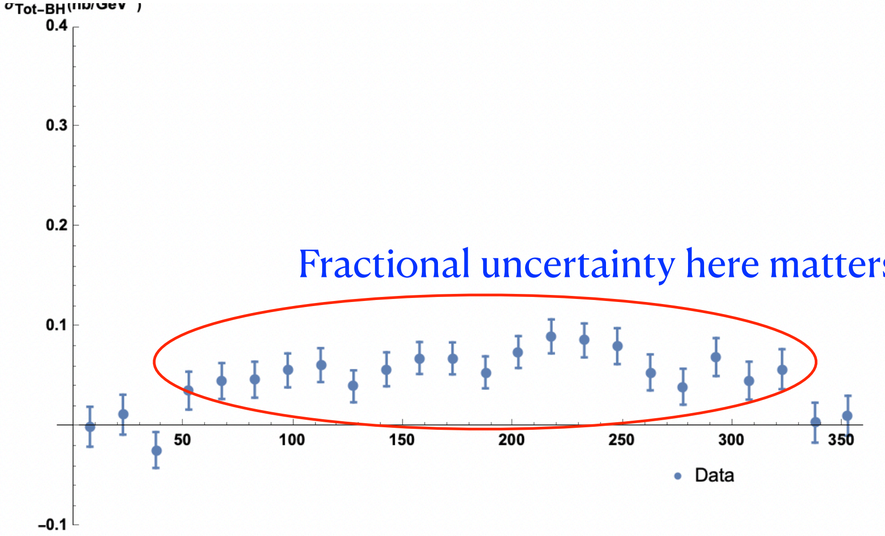
The Effect of Doubling Beam Energy



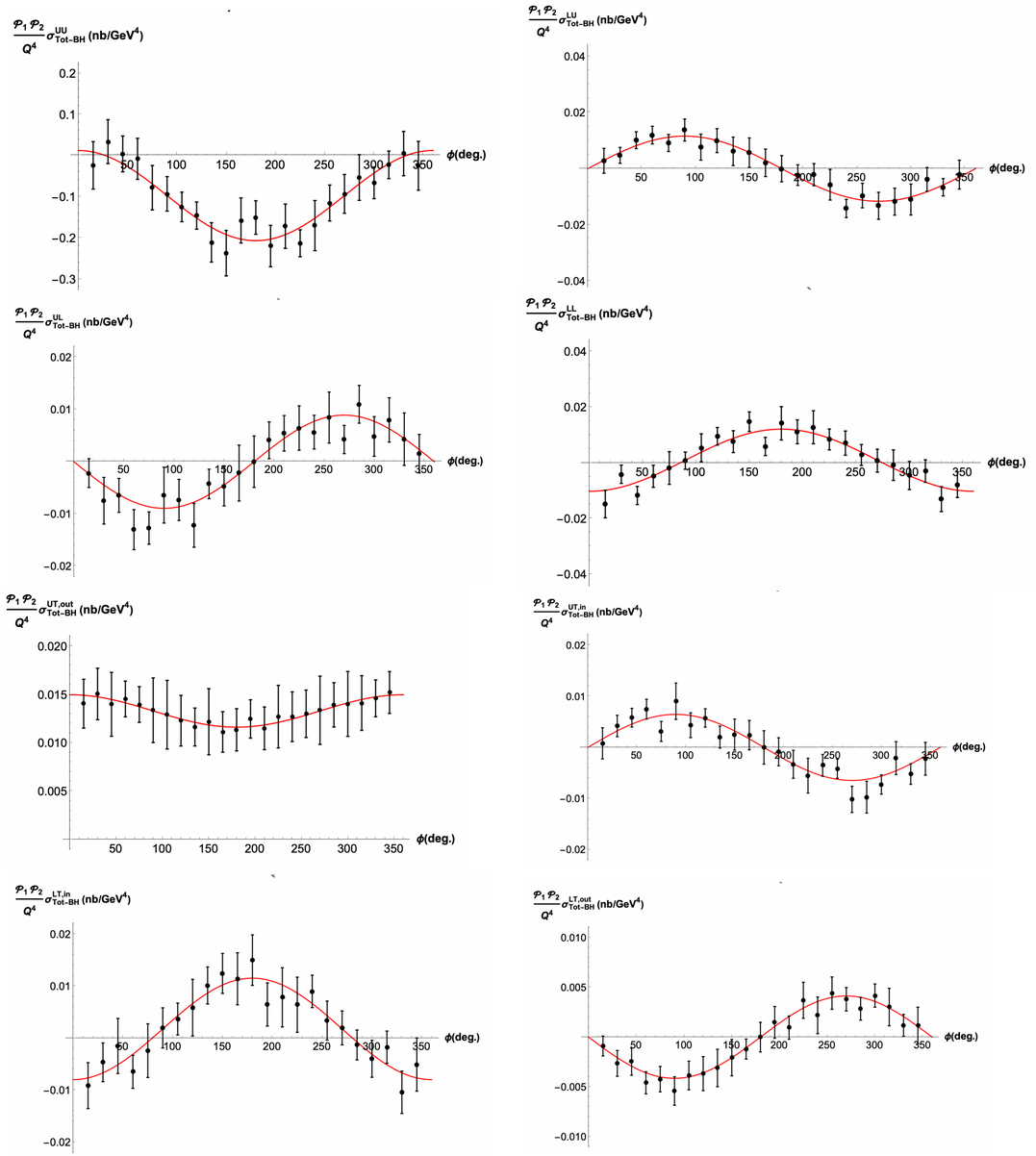


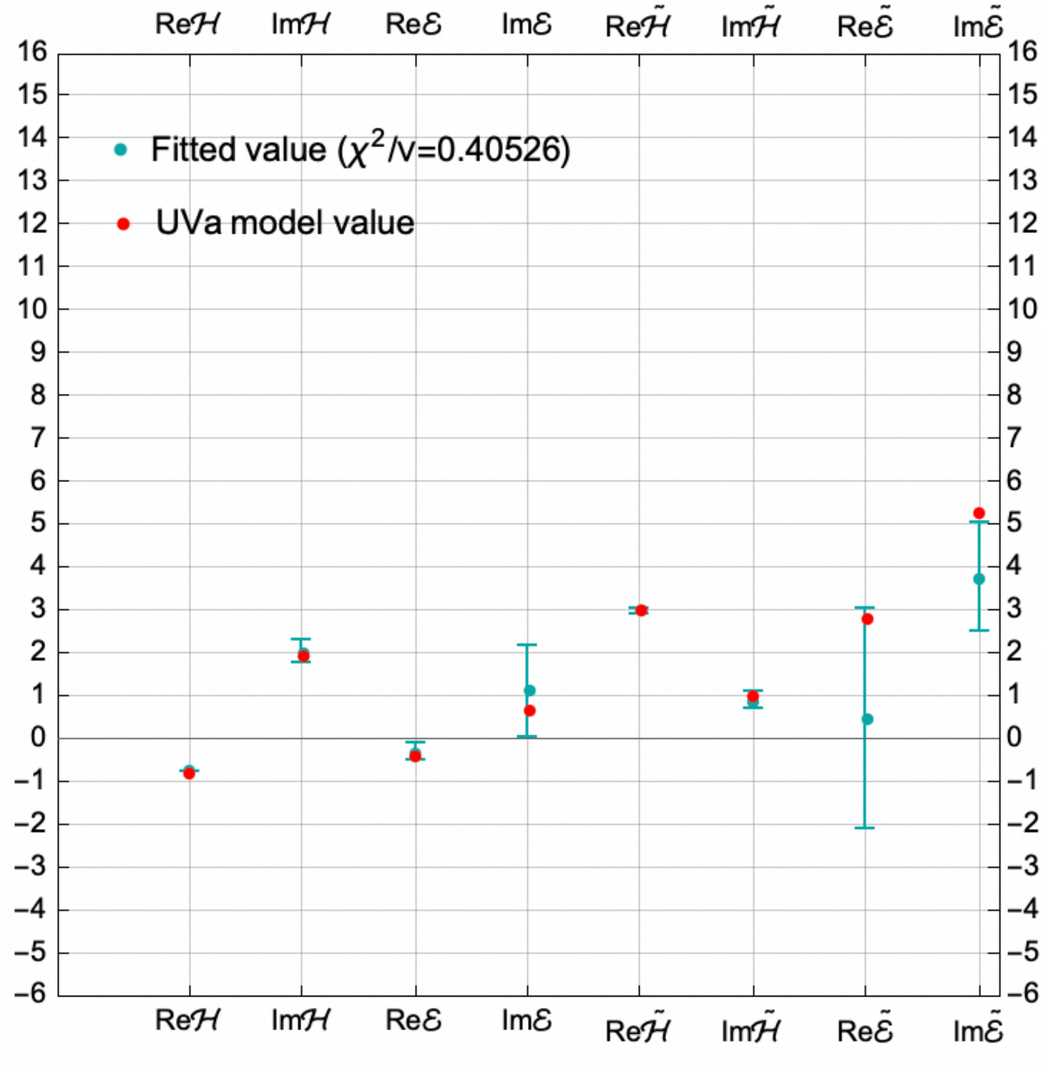


When you subtract the BH cross section, you decrease your SNR



12 GeV Pseudodata Study





- Now what happens to the CFFs when we DOUBLE the beam energy?
  - The BH cross section decreases w.r.t. the DVCS and INT
    - This means the fractional uncertainty of $\sigma_{\text{Tot}-\text{BH}}$ decreases
      - This will decrease the uncertainty of the extracted CFFs!
      - However, not all measurements are affected
      - σ_{BH} only applies to UU, LL, LT polarization channels

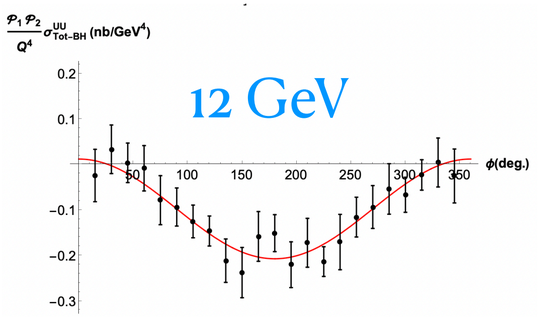
$$\delta = \frac{\Delta\sigma_{\text{Tot}}}{\sigma_{\text{tot}} - \sigma_{\text{BH}}}$$

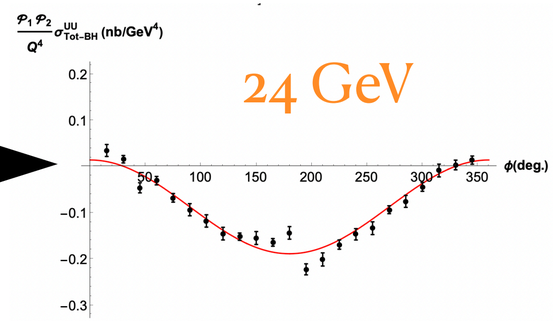
$$\begin{cases} E_b = 10.6 \text{ GeV} \rightarrow \dfrac{\sigma_{\text{BH}}}{\sigma_{\text{Tot}}} \approx .83 \rightarrow \delta \approx 0.4 \\ E_b = 21.2 \text{ GeV} \rightarrow \dfrac{\sigma_{\text{BH}}}{\sigma_{\text{Tot}}} \approx .40 \rightarrow \delta \approx 0.11 \end{cases}$$

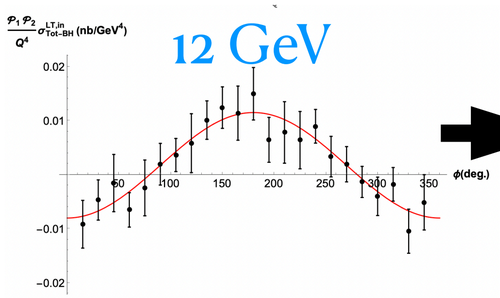
In the extreme case, a factor of 4 improvement!!

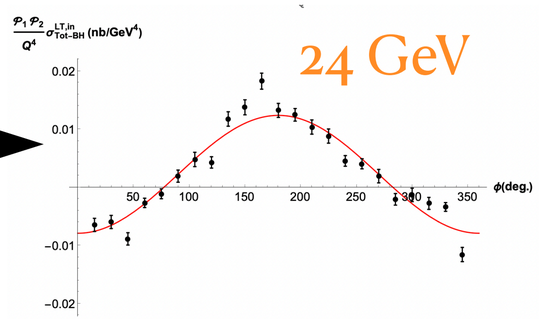
Note: A more careful treatment needs to include the BH uncertainty, which is more relevant now that the BH signal is smaller. There is also an expected difference in # of expected events at this kinematic vs the 12 GeV case, which will also affect this factor.

24 GeV Pseudodata Study

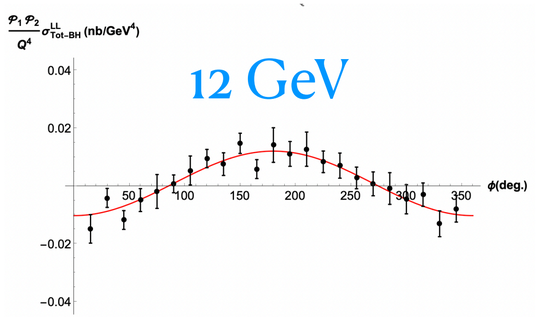


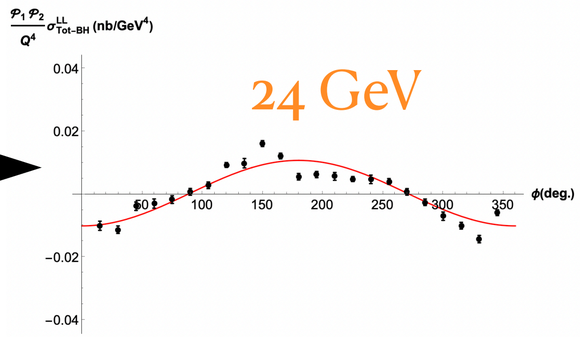


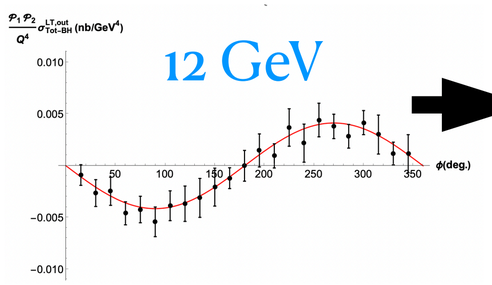


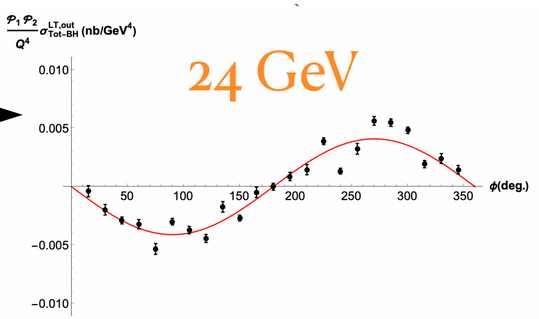


Actually, the error bars do not shrink, but the signal grows, these are just depicting the SNR effect



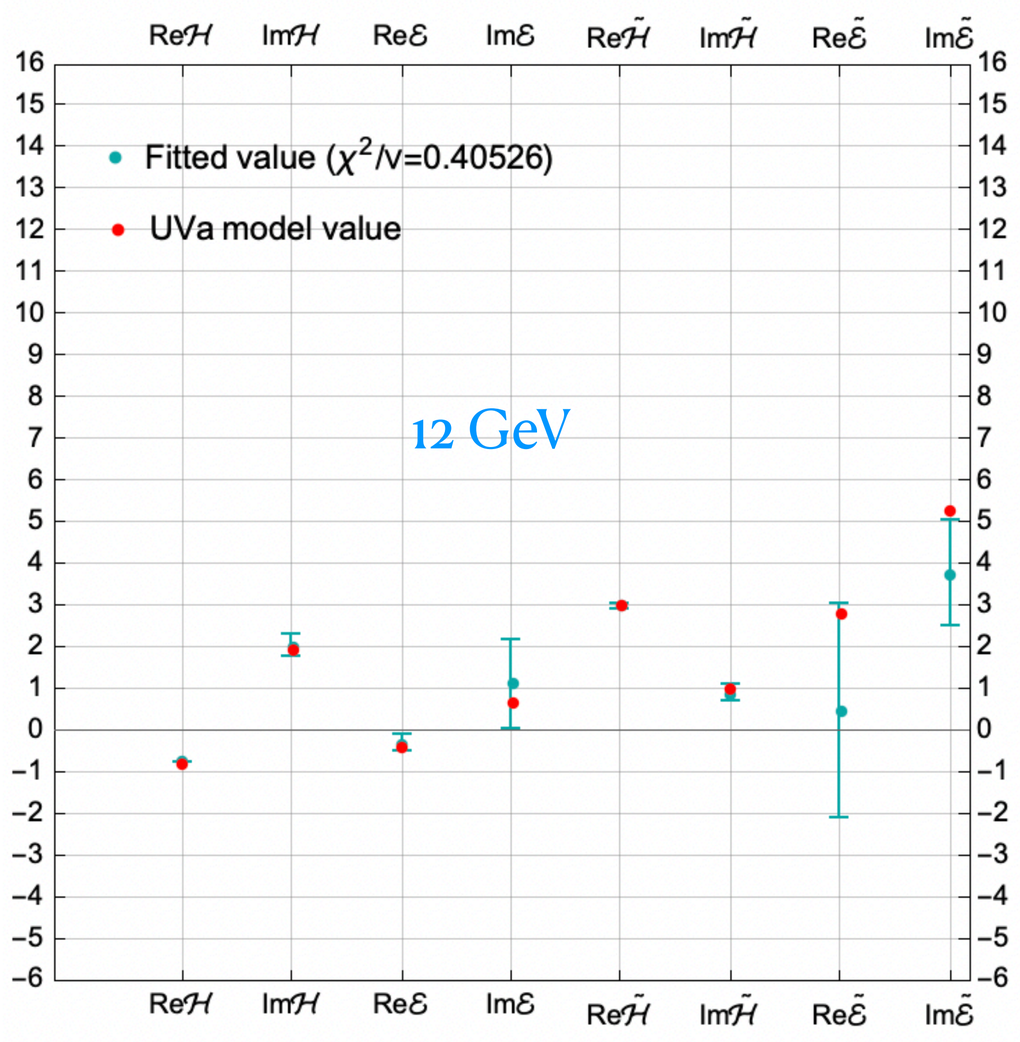




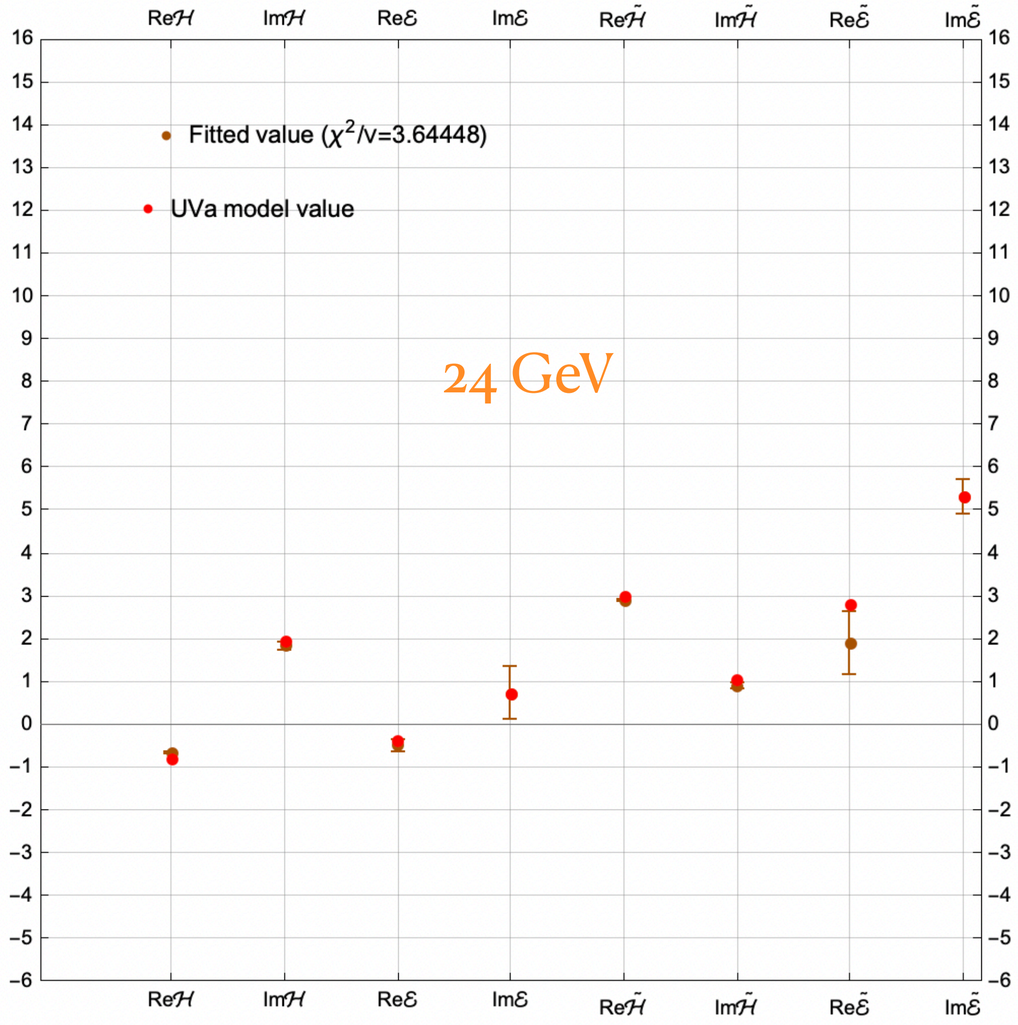


- All other polarization measurements unchanged

Comparison of Extracted CFFs



Extreme (best) case



BOTTOM LINE: Doubling beam energy can give more precise CFFs and thus GPDs

Further general considerations

- It would be useful to coordinate with experimentalists on seeing what more realistic pseudo data should look like at Jlab for our studies
- Could make new predictions of extracted CFFs from including Hall B target spin asymmetries (instead of total cross sections) at higher beam energies
- We plan to make a preliminary GPD fit to current Jlab data using **GPDs from Universal Moment Parameterization (GUMP),** and could compare this to the inclusion of new hypothetical Jlab data at higher beam energy