TCS with transversally polarized target at NPS

- Observables
- Fits of Compton Form Factors
- Simulations
- PAC theoretical review in 2015 for LOI

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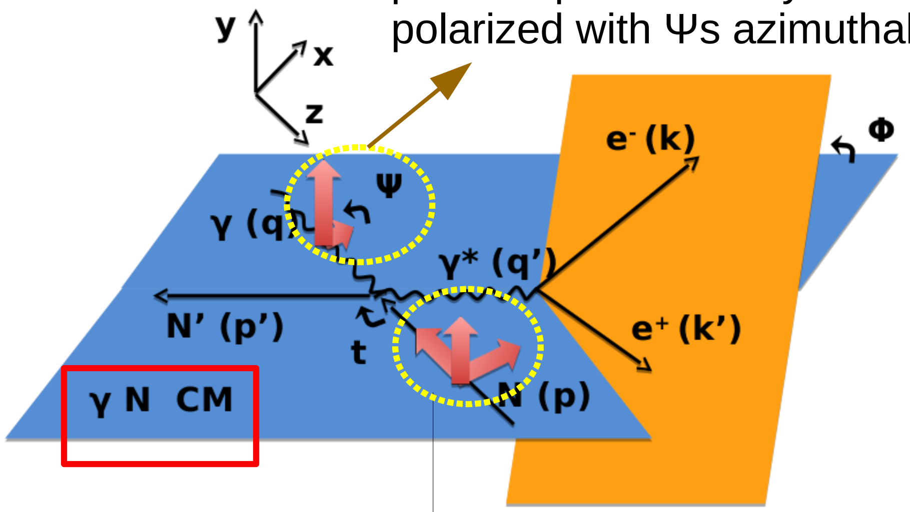
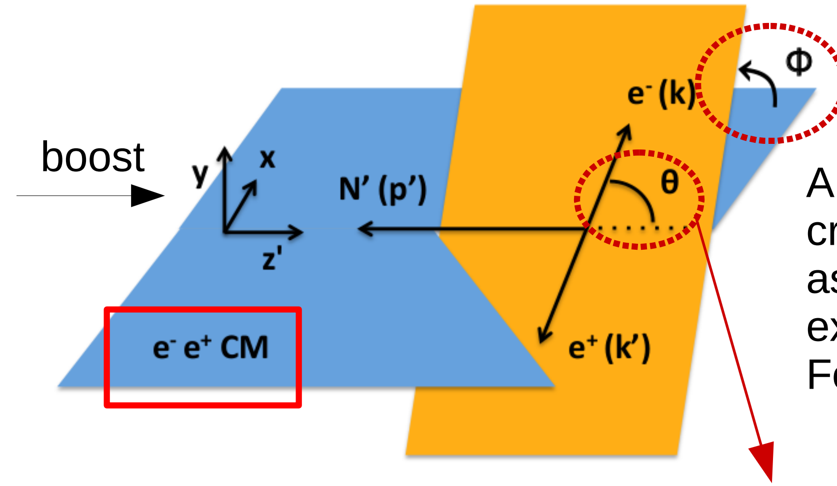
NPS collaboration meeting, JLab, Jan 21, 2016.

TCS reaction and polarization angles

photon spin: circularly or linearly polarized with Ψs azimuthal angle



boost

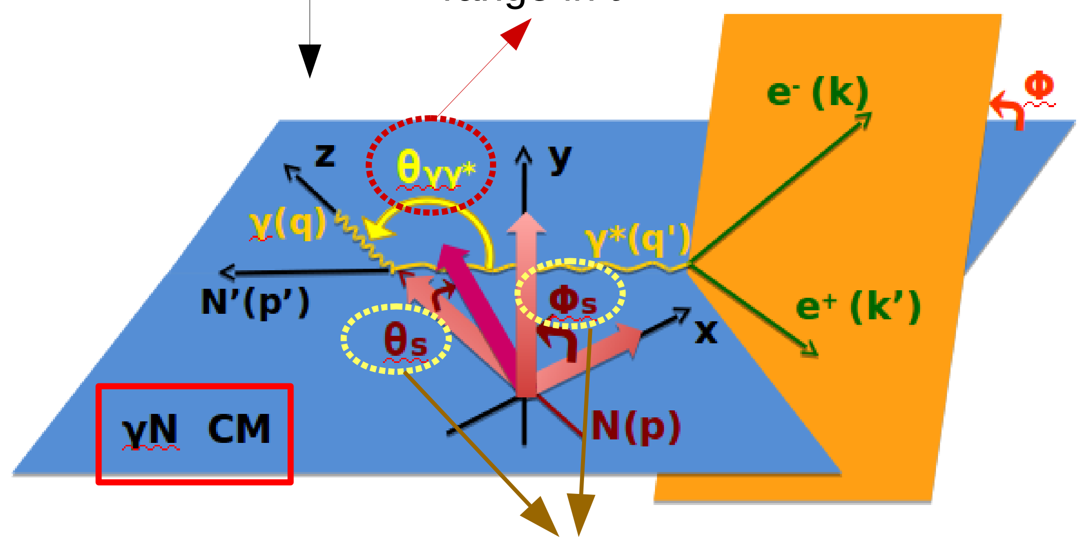


Angular analysis of cross section and asymmetries to extract Compton Form Factors

zoom

define range in t

rate of TCS/BH maximal at θ=90°, BH→∞ at θ→0° or θ→180°



Independent observables to express the cross sections:

Unpolarized cross section:
5 independent variables
→ E, t, Q'², θ, Φ

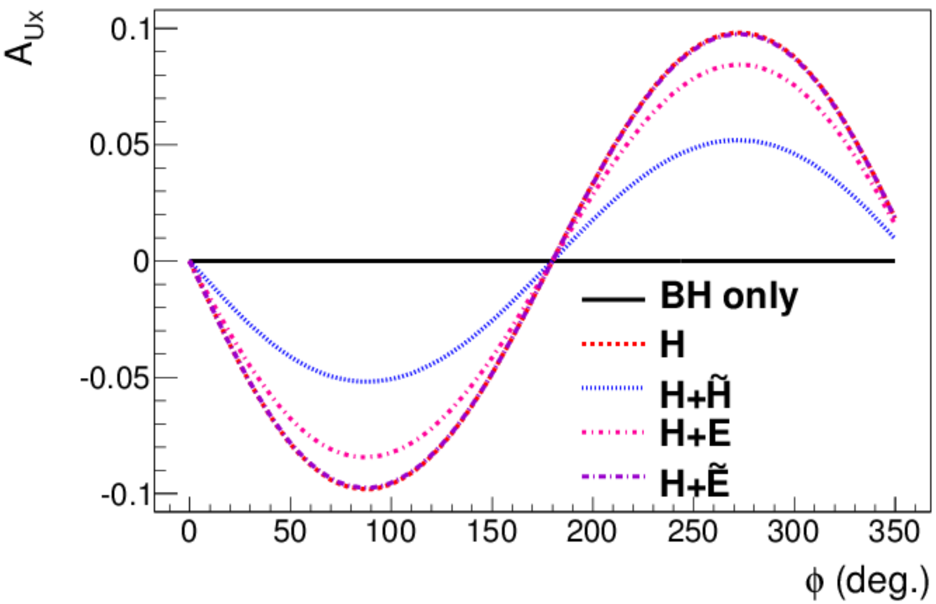
Linearly polarized beam: + Ψ

Polarized target: + θs, Φs

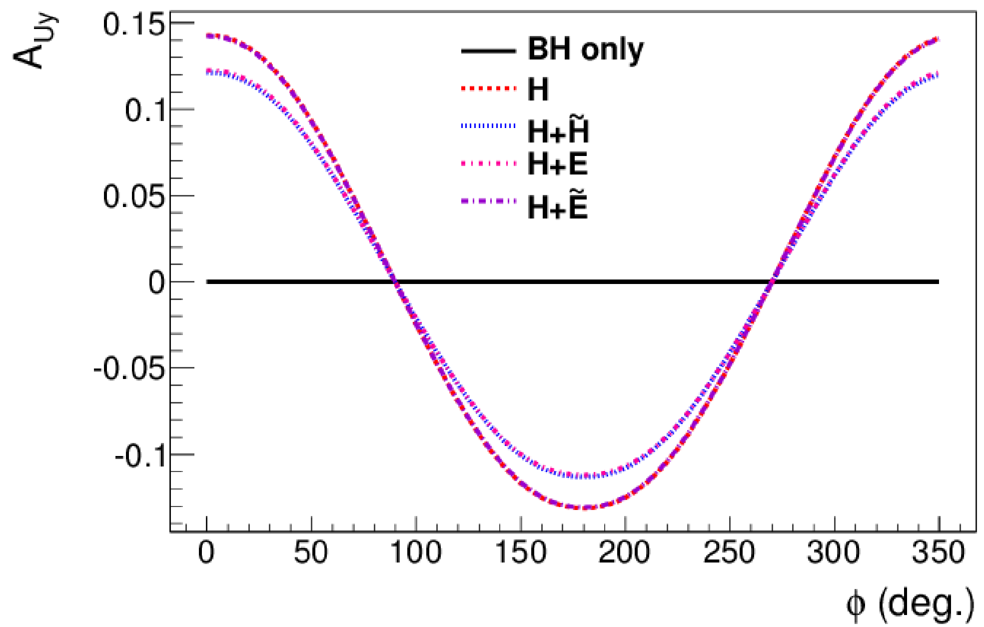
proton spin angles / target spin orientation => target spin asymmetries...
transversally polarized target: θs=90° , Φs=0° (x) or Φs=90° (y)

Transversally polarized target spin asymmetries (I)

Asym vs Φ with different GPD parametrization
θs=90°, Φs=0°, integrated over θ [45°, 135°].



Asym vs Φ with different GPD parametrization
θs=90°, Φs=90°, integrated over θ [45°, 135°].



Two independent (orthogonal) transverse target spin asymmetries
(above: x-axis: Φs=0° and y-axis: Φs=90°)

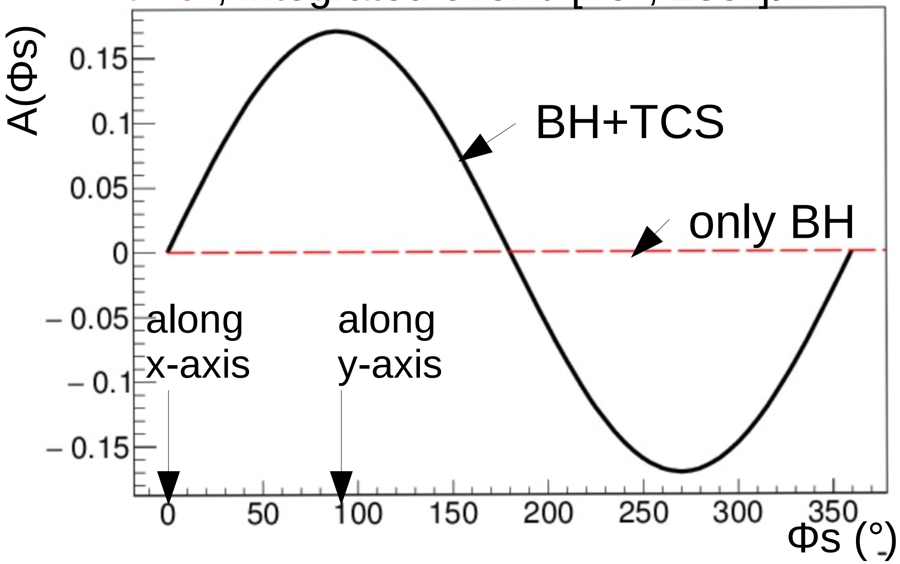
- sensitive to imaginary part of the amplitude → bh only cancels, it makes interpretation easier
- allow for GPD separation, in particular H, $\tilde{H}$, E.
- for this kinematic: asymmetries are measurable

=> fits of these distributions allow for GPD extraction

Experimental data: bins in Φ and Φs, studies of these distributions

Transversally polarized target spin asymmetries (II)

Asym vs Φs, θs=90°,
Φ=0°, integrated over θ [45°, 135°].



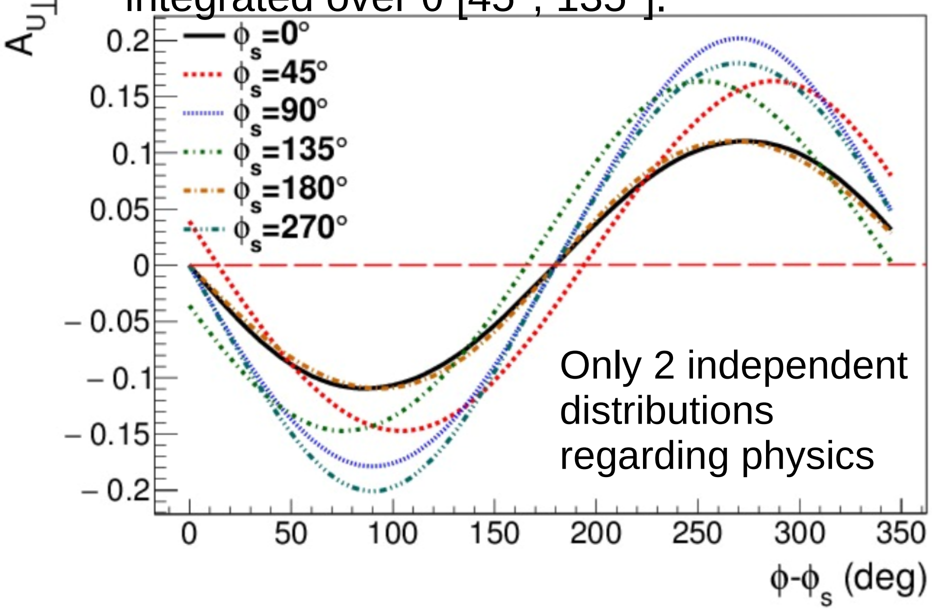
Observable

Transverse target spin asymmetry behaviour:
$A_{U\perp}$ = ∑ s_i [Φs, kinematic, CFF] sin^i (Φ – Φs)

With non zero θs (small angle correction)
$A_{U\perp}$ = ∑ s_i [θs, Φs, kinematic, CFF] sin^i (Φ – Φs)

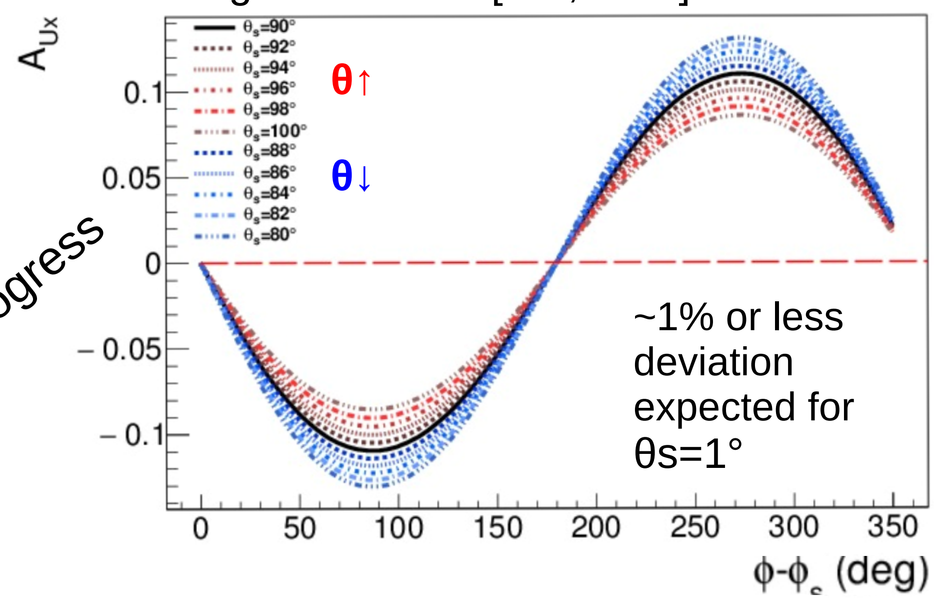
Proposed observable for experiment:
measure and fit single target spin asymmetry as a function (Φ – Φs) for different bins in Φs

Asym vs Φ - Φs, θs=90°, different Φs
integrated over θ [45°, 135°].



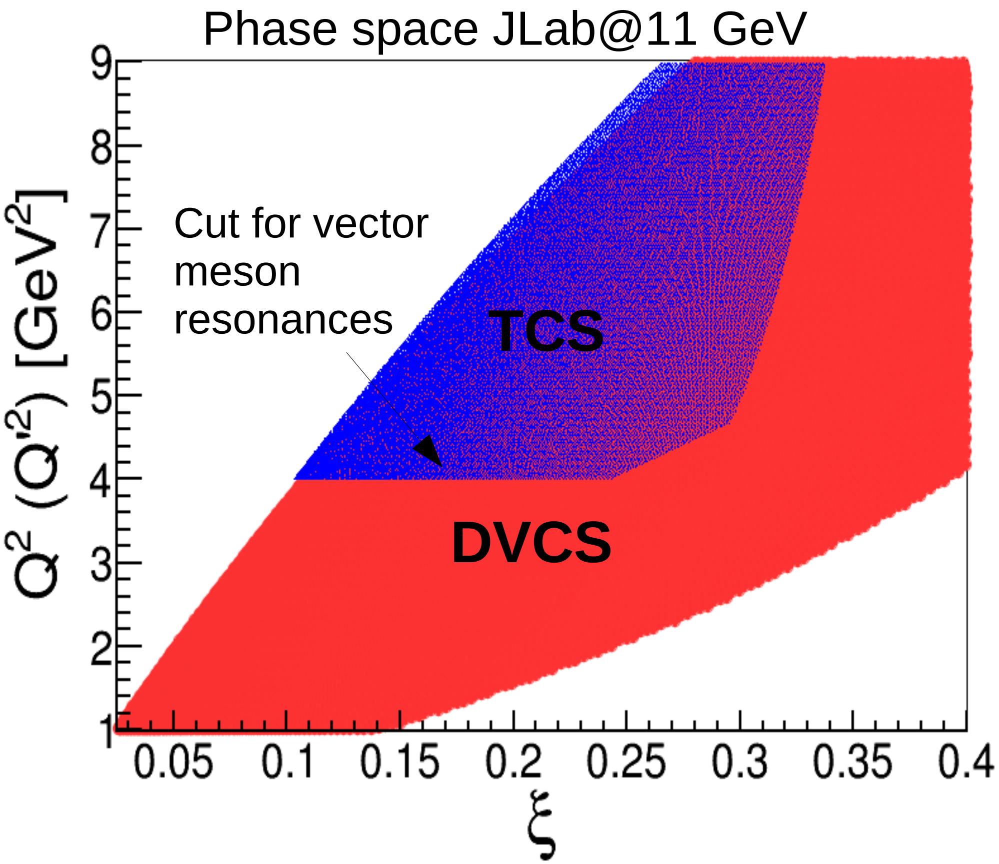
In progress

Asym vs Φ - Φs, here: Φs=0°, different θs
integrated over θ [45°, 135°].



=> binning in Φ and Φs to be defined according to statistics and to the Φs dependence of s_i
=> θs to be considered as small corrections for quasi-real photon beam (in progress)

Fits of Compton Form Factors



Fit CFF not directly GPD:

$$T^{DVCS} \sim \int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi + i\varepsilon} dx + \ldots$$

$$\sim P\int_{-1}^{+1} \frac{H(x,\xi,t)}{x \pm \xi} dx - i\pi H(\pm\xi,\xi,t) + \ldots$$

DVCS and TCS: leading twist amplitudes are complex conjugate, same CFF

→ check of GPD universality by comparison (requires high precision)

→ combination of DVCS and TCS observables (assuming same CFF) to better constrain the fits and/or get more independent observables

<u>Approach for NPS with 2 new independent observables</u>

Hall A adress these 2 points but no independent observ.

<u>Method</u>:

- 7 independent observables: Im and Re of CFF
- set of data are cross sections, asymmetries… with >2 independent observables
- here: simulations, we know what CFF are generated. Assume 5% uncertainties.

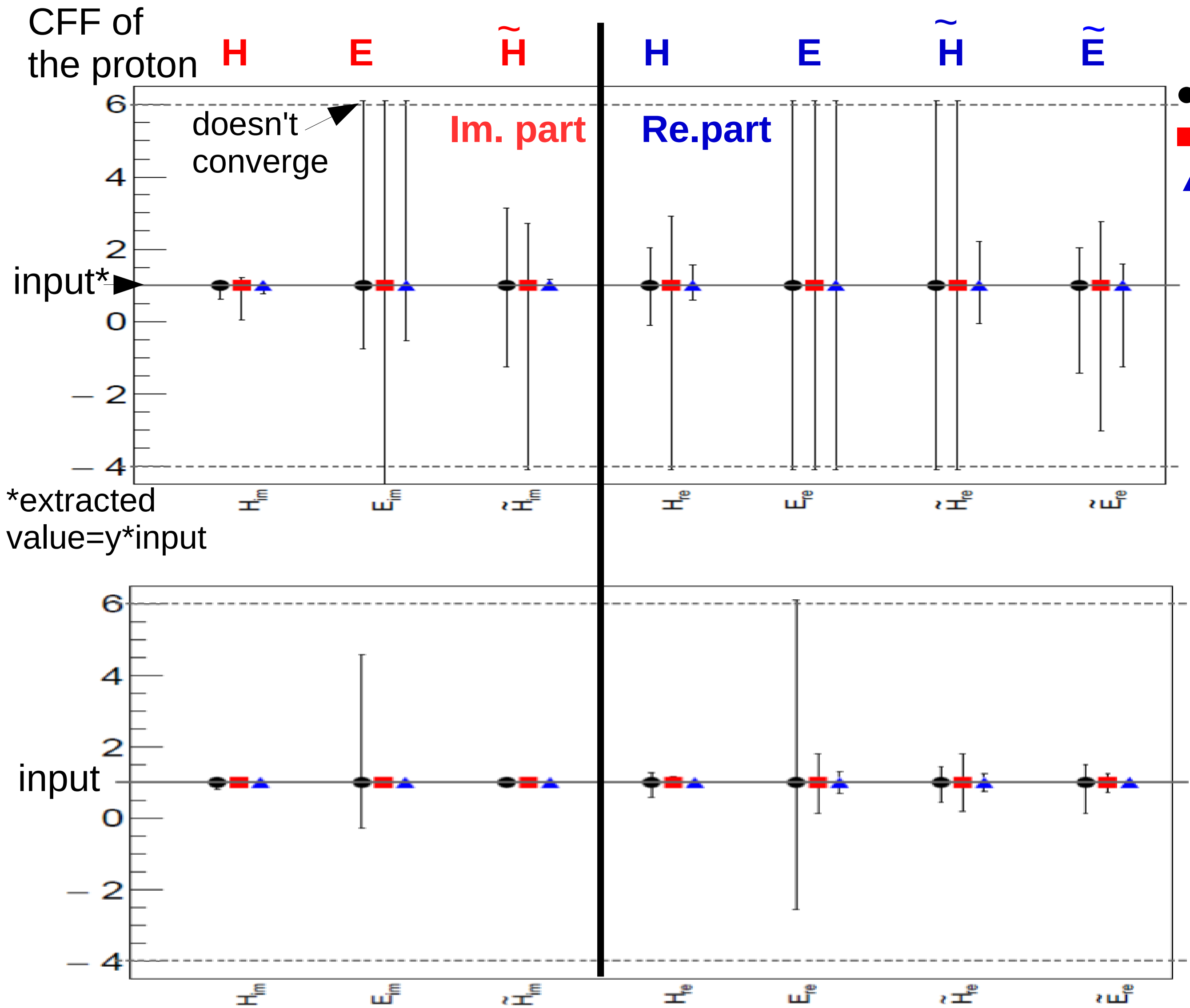
<u>Particularity of this approach:</u>

- fit CFF in a limited range (max. x5 of expected value)
- dependence to GPD H >> other GPD, suppressed by kinematic factors => fits converge even if underconstrained, in that case not all CFF maybe extracted at the same time

Complementarity on fits: what could we achieve with DVCS + TCS?

exercise with simulation: doesn't represent any realistic case / <u>just comparative</u> (relative statistics...) [in progress]

DVCS: observables already measured at JLab@6 GeV, TCS: proposed measurements



- ● DVCS $\sigma, \Delta\sigma_{LU}$
- ■ TCS $\sigma, \Delta\sigma_{\odot U}$
- ▲ **DVCS+TCS**

poorly constrained: 2 indep. observables for 7 free parameters

→ **Im. part better constrained**
→ **DVCS more sensitive to GPD than TCS**
→ **improvement with both reactions**
→ **Re(H), Im(H), Im(H̃)**

- ● DVCS $\sigma, \Delta\sigma_{LU}, \Delta\sigma_{Uz}, \Delta\sigma_{Lz}$
- ■ TCS $\sigma, \Delta\sigma_{\odot U}, \Delta\sigma_{LU}, \Delta\sigma_{Ux}, \Delta\sigma_{Uy}$
- ▲ **DVCS+TCS**

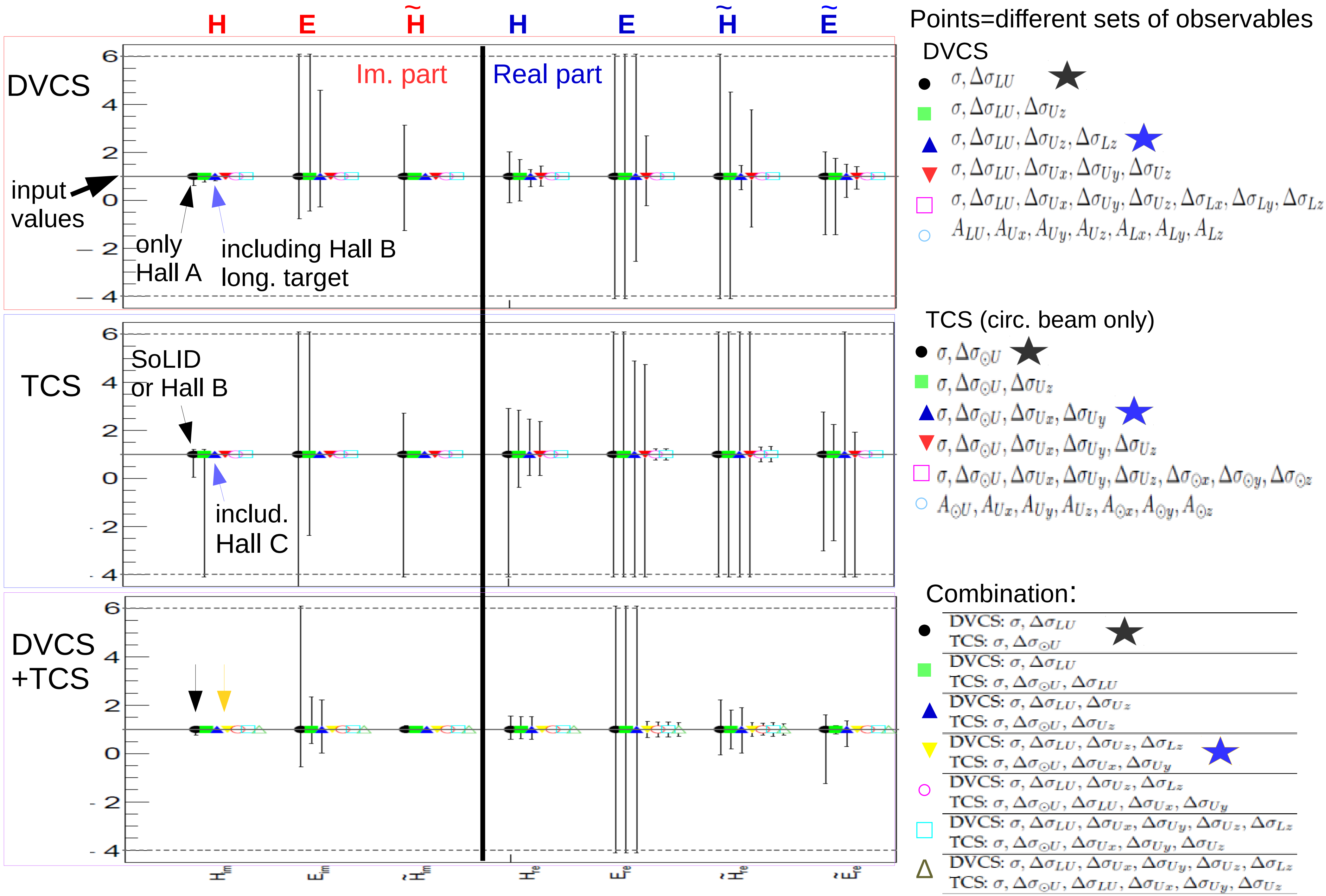
5 independent obs. for TCS, 4 for DVCS
7 independent obs. for DVCS+TCS

→ **extraction of E with DVCS+TCS**
→ **constraint Re. Part of CFF**
→ **7 independent obs. for 7 CFF with combined fits: extraction of all of them**

- fits with TCS only are more difficult: smaller TCS/BH ratio than DVCS/BH ratio
- DVCS+TCS: provide a set of 7 independent observables, all CFF extracted at the same time
- this example <u>is not</u> exclusive, other sets of observables can lead to same results

Complementarity: what could we achieve with DVCS and TCS?

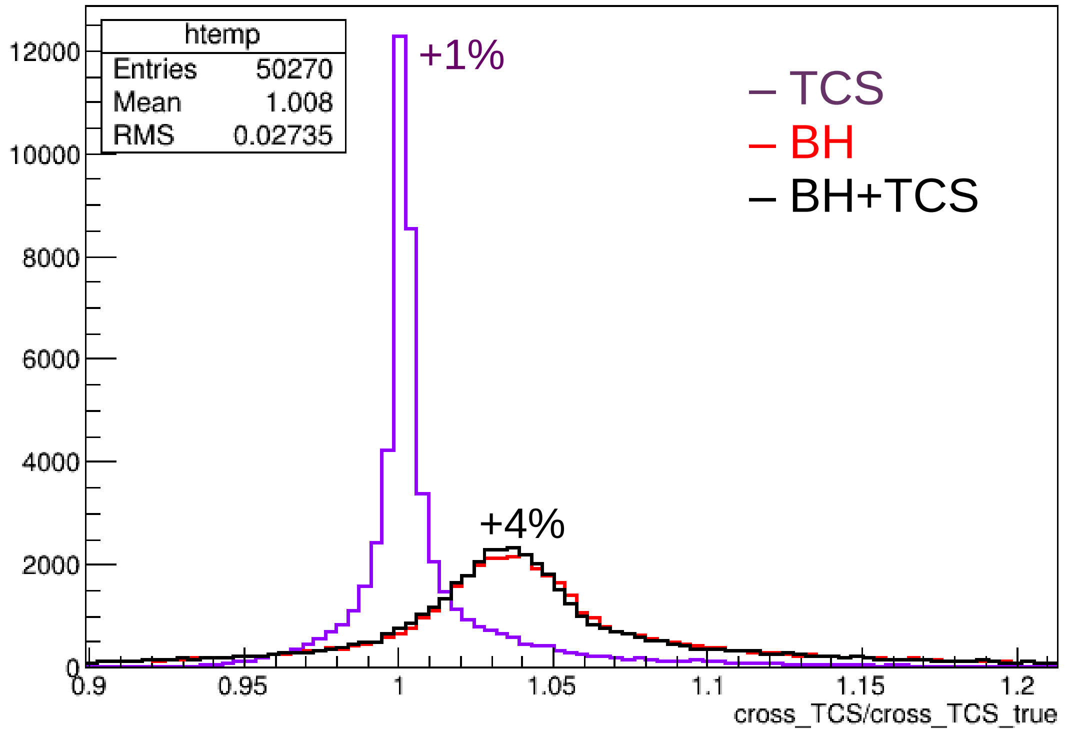
exercise with simulation: doesn't represent any realistic case (relative statistics, systematic errors...) [in progress]



TCS event generator

- Real or quasi-real photon beam + bremsstrahlung in 15 cm NH3 target, 4 < Eg < 12 GeV max.
- User defined kinematic limits (maximal kinematic limitations are close to JLab limits)
- Output = root file with 4-vectors, can be processed through acceptance program
- Weighting with cross sections tables: weights for only BH or TCS, BH+TCS, and “weights” corresponding to all different single or double target and/or beam spin asymmetries for the generated kinematic

Accuracy of the generator: Weight generated (from table) / Weight calculated directly (same model)



Remarks:

1) % order overestimation, to be accounted in systematics, due to the use of a discrete cross section table and interpolation method

2) larger deviation for BH than TCS as BH cross section vary strongly (depend bins)

3) overestimation maybe reduced by reducing the steps in table (in progress)

4) other consideration to be “numerically safe”: BH calculation induces numerical divergences… (in progress)

5) safer and more realistic use of generator with table than direct calculations (too long + uncontrolled numerical divergencies)

Status: public version coming soon. Some specific options still to include, new inputs are running.

PAC theoretical review (S. Szczepaniak)

1) Remark on the needs to turn the LOI into a proposal

The cross-section signal is expected through interference with the BH production (at the level of 30%) and in spin symmetries. Preliminary simulations of the count rate were preformed as a function of the azimuthal angle in a total 8 bins in the (Q'^2; ξ). Simulation of target spin asymmetries was not provided.

2) Conclusion of the report

The experiment complements the approved CLAS12 TCS cross-section and beam asymmetry experiment, E12-12-001 and virtual Compton measurements. This would be the second TCS related measurement, after (an unpublished) g12 analysis of a single moment of the angular distribution. Together with DVCS measurements the proposed TCS aims at probing nucleon GPD's and the data provided in this experiment will be an useful input for extraction of nucleon GPD's. This is a solid experimental idea well allied with the JLAB nucleon structure studies program. The proposed experiment has the potential to explore nucleon GPD's in a novel kinematical region where parton knockout is followed by qq formation. Given the diffractive nature of photon nucleon scattering and a broad range of photon masses accessible the experiment could also explore interference between quark exchange (GPD's) and diffraction. The authors should explore the effect of the latter on cross section and asymmetries.

Yellow (work to do or in progress):
→ we are working on the improvement of the simulations (generator+setup).
→ choice of binning and observables will be done according to these new results
→ would be useful to have another theoretical input

Blue (interest of the experiment):
→ we are trying to emphasize these points with fits… new ideas are welcome

Pink (new ideas):
→ need another theoretical input

Summary

- Transverse target measurement at NPS could provide unique informations in particular for GPD E, but TCS signal is more difficult to extract than DVCS signal
- Combination of DVCS and TCS results may allow for extraction of all GPD at the same time
- Real or quasi-real photon beam could be used, interpretation of results will lead this choice. Both option are studied
- Work in progress for a proposal this year:

  - experimental: cf Arthur's talk

  - analysis: binning, counting rates and uncertainties…

  - interpretation: maximal allowed error bar for fits, angular deviations…

  - simulations: in progress

=> join our workshop "ECT dileptons" at Trento, Oct. 24-28, 2016
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