DDVCS

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Belitsky, Andrei V., and Dieter Mueller.
Phys. Rev. D 68.11 (2003): 116005.

of the first interference term. In case when only the lepton beam of a specified single charge is available, on can form asymmetries with an odd weight

$$w^{\mathrm{odd}}(\phi_\ell, \theta_\ell) \tag{167}$$
$$= \{\cos\theta_\ell,\ \cos\varphi_\ell,\ \cos(2\varphi_\ell)\cos\theta_\ell,\ \cos(3\varphi_\ell),\ \sin\varphi_\ell,\ \sin(2\varphi_\ell)\cos\theta_\ell,\ \sin(3\varphi_\ell),\ \dots\},$$

so that the squared amplitudes exactly drop out

$$\int d\Omega_\ell\, w^{\mathrm{odd}}(\phi_\ell, \theta_\ell)\frac{d\sigma}{d\Omega_\ell} \propto \int d\Omega_\ell\, w^{\mathrm{odd}}(\phi_\ell, \theta_\ell)\left\{\pm \mathcal{T}^*_{\mathrm{BH}_1}\mathcal{T}_{\mathrm{BH}_2} + \Re\mathrm{e}\left(\mathcal{T}^*_{\mathrm{BH}_2}\mathcal{T}_{\mathrm{VCS}}\right)\right\}. \tag{168}$$

After the subtraction of the remaining BH interference is done, one measures the leading twist-two Fourier coefficients. Still, this procedure may allow a handle on the real part of the Compton form factors. If both kinds of the lepton-beam charges are available, the BH contribution drops in the charge even combination

$$\int d\Omega_\ell\, w^{\mathrm{odd}}(\phi_\ell, \theta_\ell)\frac{d\sigma^+ + d\sigma^-}{d\Omega_\ell} \propto \int d\Omega_\ell\, w^{\mathrm{odd}}(\phi_\ell, \theta_\ell)\,\Re\mathrm{e}\left(\mathcal{T}^*_{\mathrm{BH}_2}\mathcal{T}_{\mathrm{VCS}}\right). \tag{169}$$

To illustrate the feasibility of the subtraction procedure, we consider the charge and the angular asymmetries

$$\left\{\begin{matrix} A^{\cos\varphi_\ell}_{\mathrm{CA}} \\ A^{\cos\varphi_\ell} \end{matrix}\right\} = \frac{1}{\mathcal{N}}\int_{\pi/4}^{3\pi/4} d\theta_\ell \int_0^{2\pi} d\phi \int_0^{2\pi} d\varphi_\ell\, 2\cos\varphi_\ell \left\{\begin{matrix} \left(d\sigma^+ + d\sigma^-\right)/2d\Omega_\ell d\phi \\ d\sigma^-/d\Omega_\ell d\phi \end{matrix}\right\}, \tag{170}$$

performed with respect to $2\cos\varphi_\ell$, where in both cases we choose the normalization to be

$$\mathcal{N} = \int_{\pi/4}^{3\pi/4} d\theta_\ell \int_0^{2\pi} d\phi \int_0^{2\pi} d\varphi_\ell \frac{d\sigma^-}{d\Omega_\ell d\phi}.$$

$$\mathrm{cc}^2_{10} \propto \Re\mathrm{e}\left\{\frac{\xi}{\eta}F_1\mathcal{H} - \frac{\xi}{\eta}\frac{\Delta^2}{4M_N^2}F_2\mathcal{E} + \eta\left(F_1 + F_2\right)\widetilde{\mathcal{H}}\right\},$$

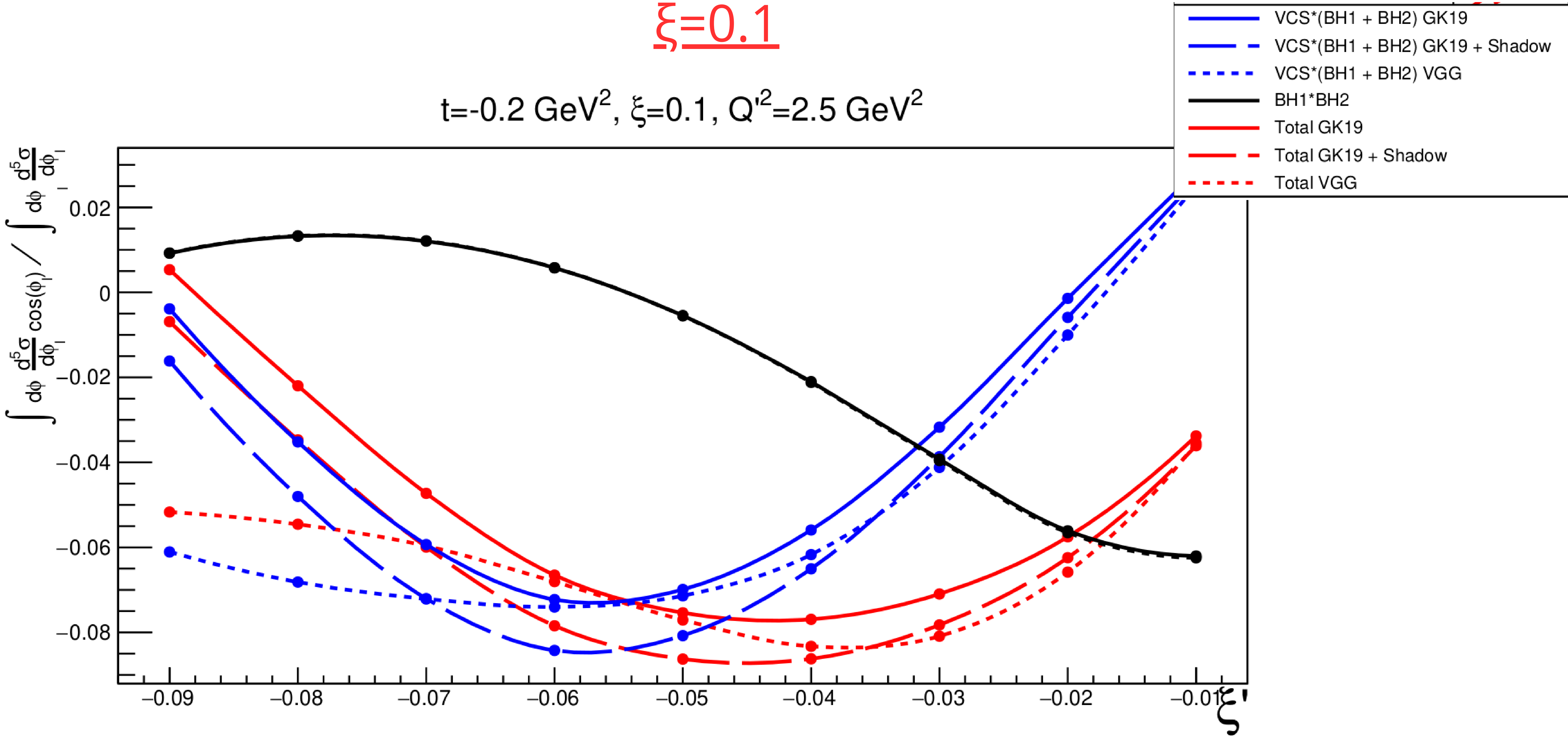
Following the results from Belitsky-Muller.
A cosine moment of the DDVCS cross-section access
the real part of CFF.

In particular:

- It access the same CFF combination of a Charge Asymmetry
- Depends only on the BH1*BH2 and VCS*BH2 terms
- As the BH can be computed, we might extract the VCS*BH2 term

<u>In the following, I will describe the workflow through cosine moment extraction</u>

ξ=0.1



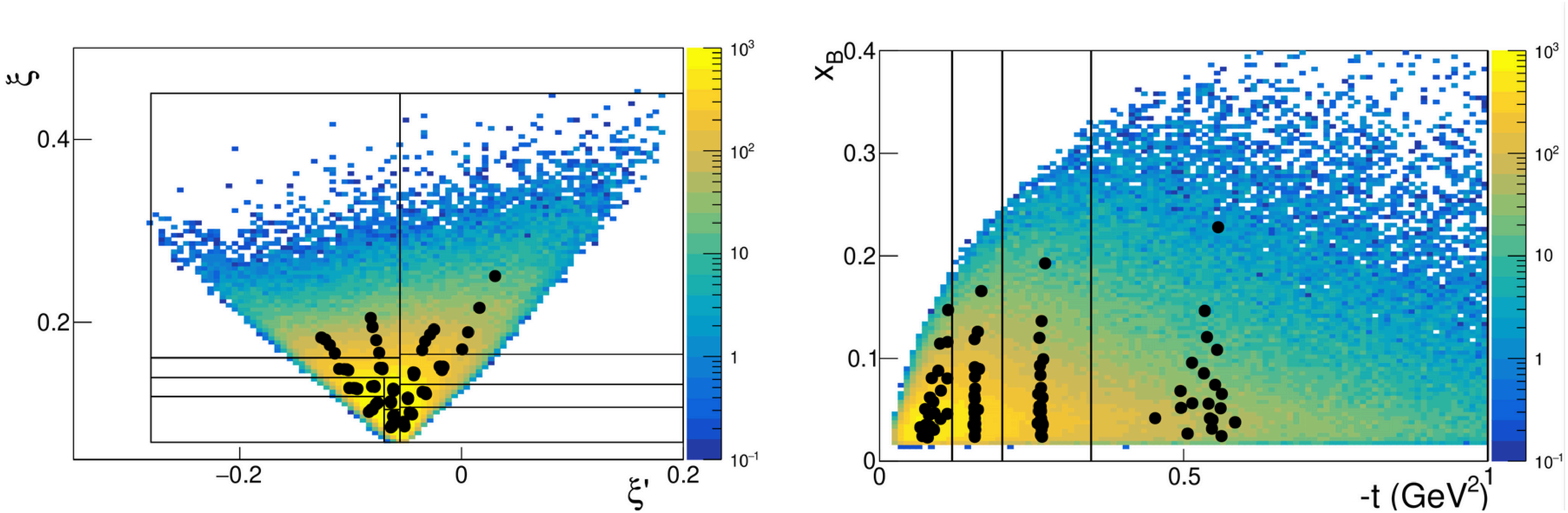
There are regions of BH << VCS

VGG and GK predictions are similar

Simulation workflow

For the statistical error:

1. I generated VCS + BH events I generated with EpIC
2. These events were passed to the uCLAS detector through OSG.
3. I re-scaled the events according to the cross-section and luminosity (1e37 * 200* 3600 * 24 * generator_xsec / N_events)



Using the expected number of events in the explored phase space I built

- 10 bins in (ξ',ξ)
- 4 bins in t
- 2 bins in Q^2

80 bins in total

Theory computation of the cos(φ) moment

1. I computed the cross-section in steps of 10° i.e. 5°, 15°, 25°,...,355°.
2. For the numerator:
   a. I multiplied the cross-section by cos(φ).
      i. φ is at the bin center i.e. 5°, 15°, 25°,...,355°.
   b. summed over all bins
3. For the denominator
   a. Sum of all cross-sections

$$\mathcal{O} = \frac{\sum_i \sigma(\phi_i) \cos \phi_i}{\sum_i \sigma(\phi_i)}$$

Generation of pseudo-data

1. Pseudo data is generated at the total DDVCS + BH cross-section value
    a. 36 evenly distributed points i.e. φ ranges of 10°
2. Data points are given a statistical error bar given the realistic simulation:
3. Pseudo-data is randomly distributed following Gaussian distribution $\sigma \to \mathcal{G}auss(\sigma, \Delta\sigma)$
    a. Mean at the nominal value
    b. Sigma equal to the statistical error bar
4. Pseudo-data is fitted to $\sigma = a + b\cos(\phi) + c\cos(2\phi) + d\cos(3\phi) + e\cos(4\phi)$
    a. cosφ moment is given by the 'b' parameter
5. Store 'b' parameter for posprocessing
6. The above steps are repeated 10K times

With this study we aim to determine if:

- There is a bias in the extracted VCS*BH2 cos moment
- The variance from the fit approach allows precise enough measurements

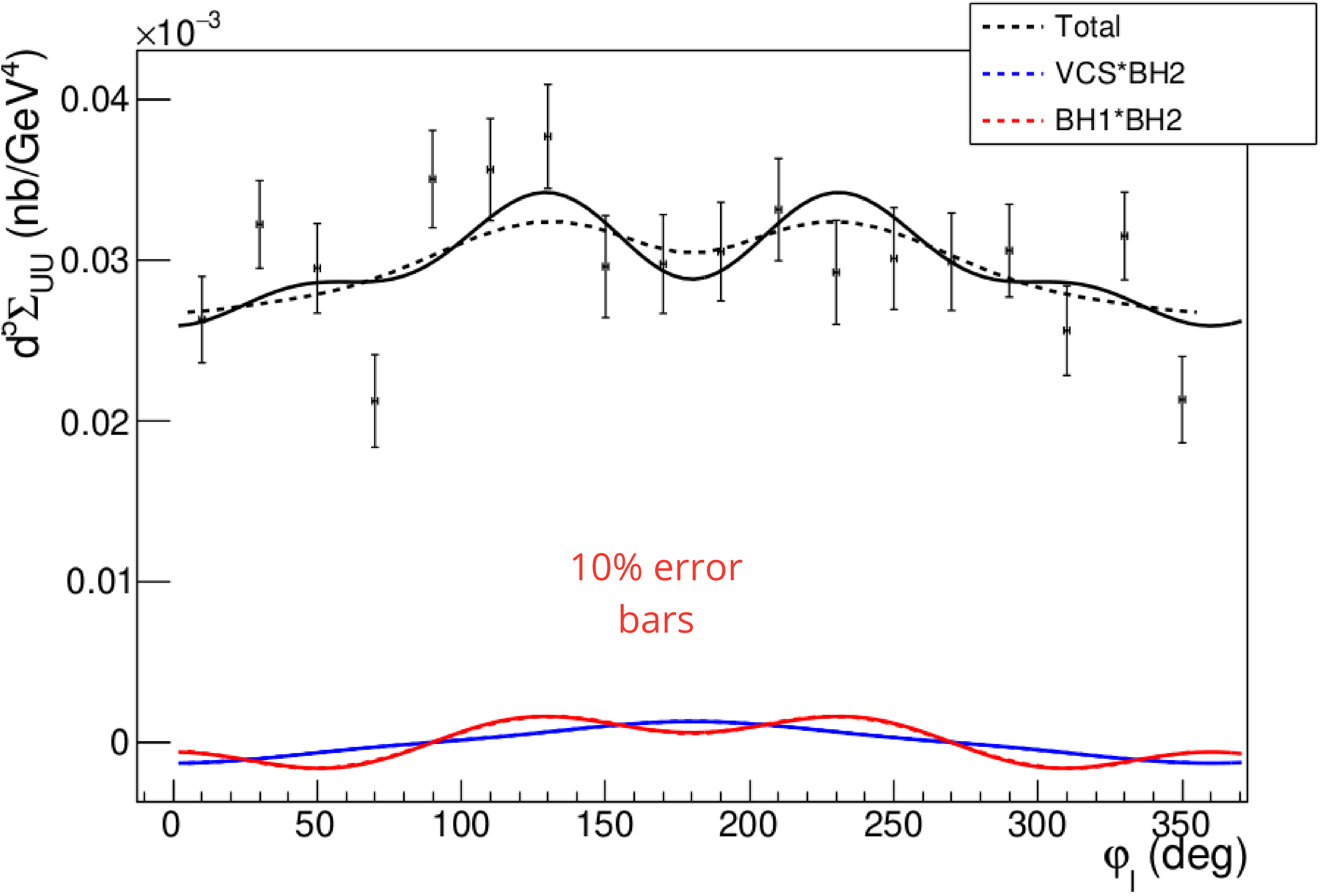
Experimental projection of the cross-section

I fit the theory curves and pseudo-data to the following function

$$\sigma_k = a_k + b_k \cos(\phi) + c_k \cos(2\phi) + d_k \cos(3\phi) + e_k \cos(4\phi)$$

where k=BH1*BH2, VCS*BH2

<u>We are interested in the ‘a’ and ‘b’ coefficients</u> as the BM observable is given by ‘b/2πa’

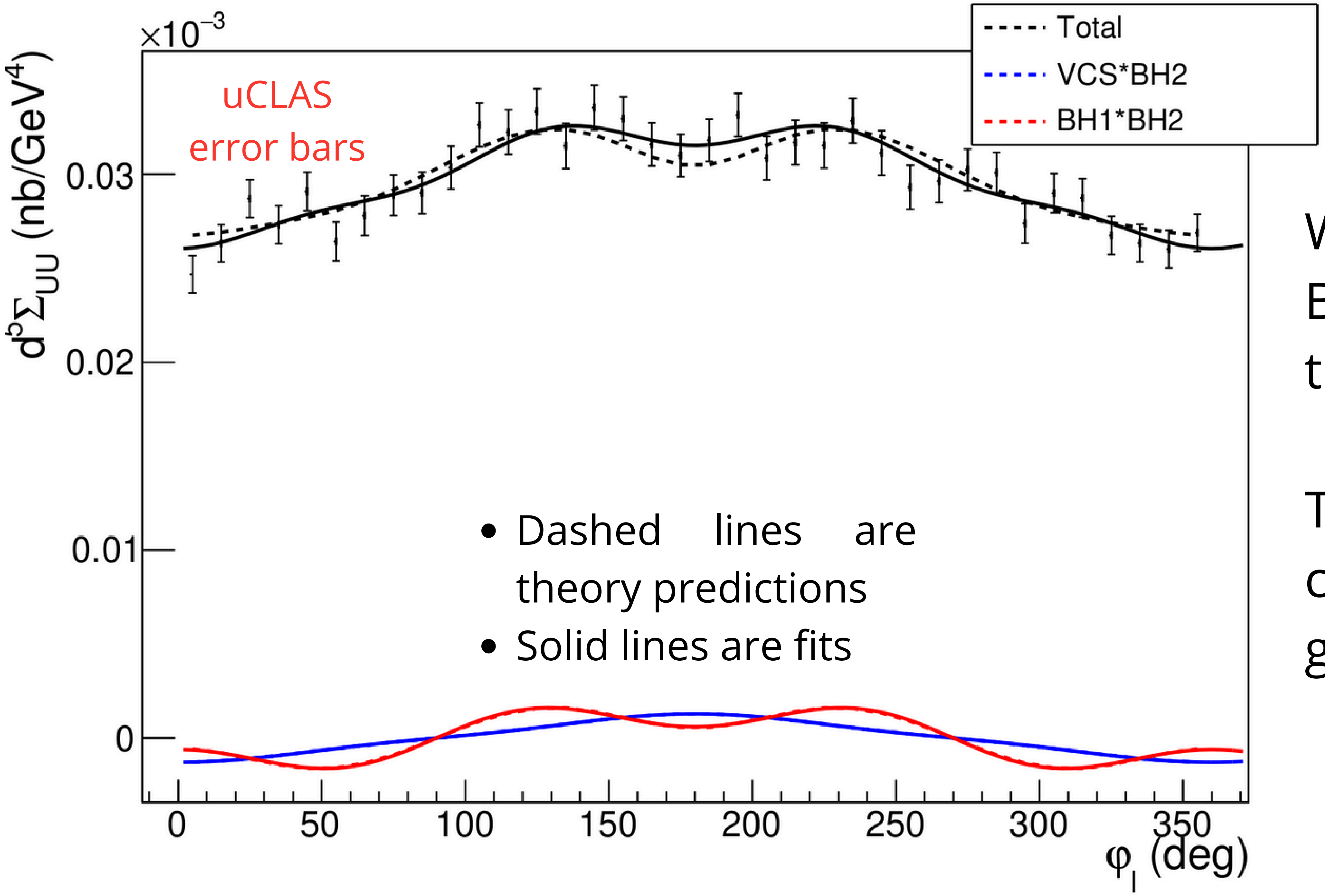


- Dashed lines are theory predictions
- Solid lines are fits

Experimental projection of the cross-section

The fit to the pseudo data (black fit) gives the coefficients

$$a_{Data} = \ldots$$
$$b_{Data} = b_{BH1*BH2} + b_{VCS*BH2}$$
$$c_{Data} = \ldots$$
$$d_{Data} = \ldots$$



We know the values of the BH2*BH1 coefficients from the theory fit (red fit)

Thus, the experimentally extracted cosφ moment (not normalized) is given by:

$$b_{VCS*BH2} = b_{Data} - b_{BH1*BH2}$$

Experimental projection of the cross-section

We can now compare the extracted value with the true value from the theory fit (blue fit)

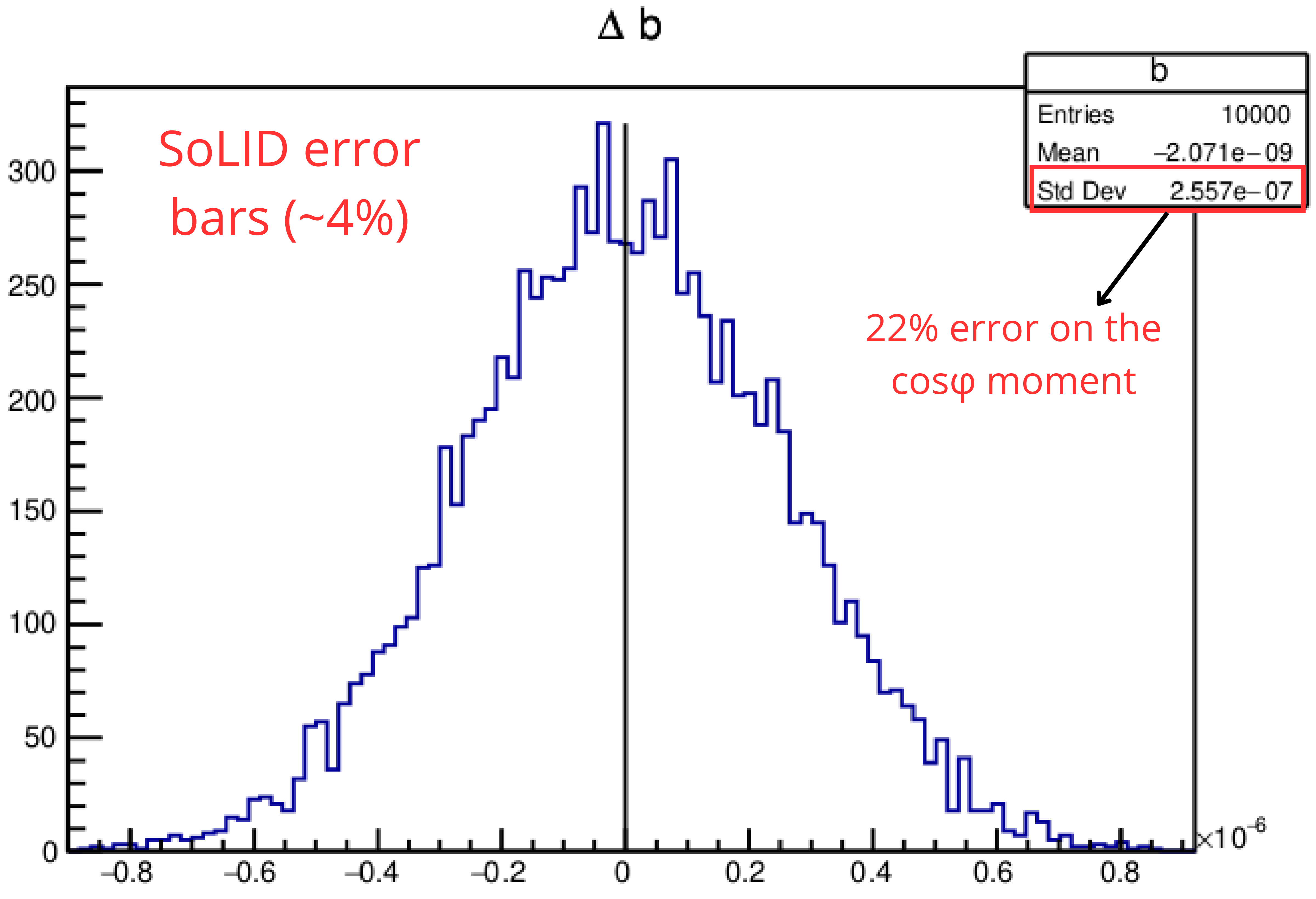
$$\Delta b = b_{VCS*BH2} - b_{True}$$

We repeat this process 10K times to see how Δb distributes

It looks like the cos(φ) moment can be extracted with good precision as:

- Mean of the distribution is at zero
- Standard deviation is small.

$$b_{true} = -1.17337 \times 10^{-6}$$



22% error on the cosφ moment

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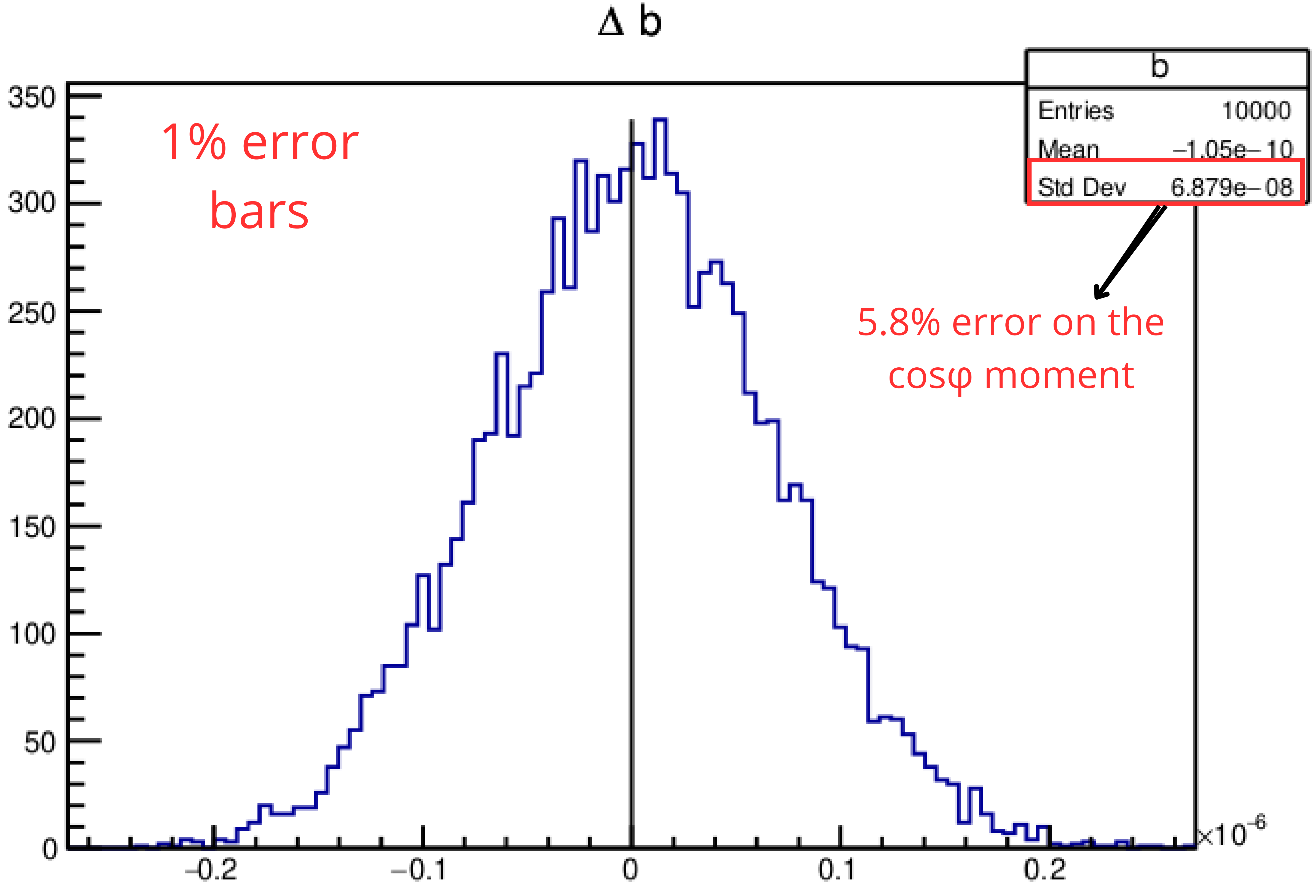


Experimental projection of the cross-section

- To achieve a 1% precision in the cross-section measurement we need 10k on each phi bin

$$\frac{\Delta\sigma}{\sigma} \sim \frac{1}{\sqrt{N}}$$

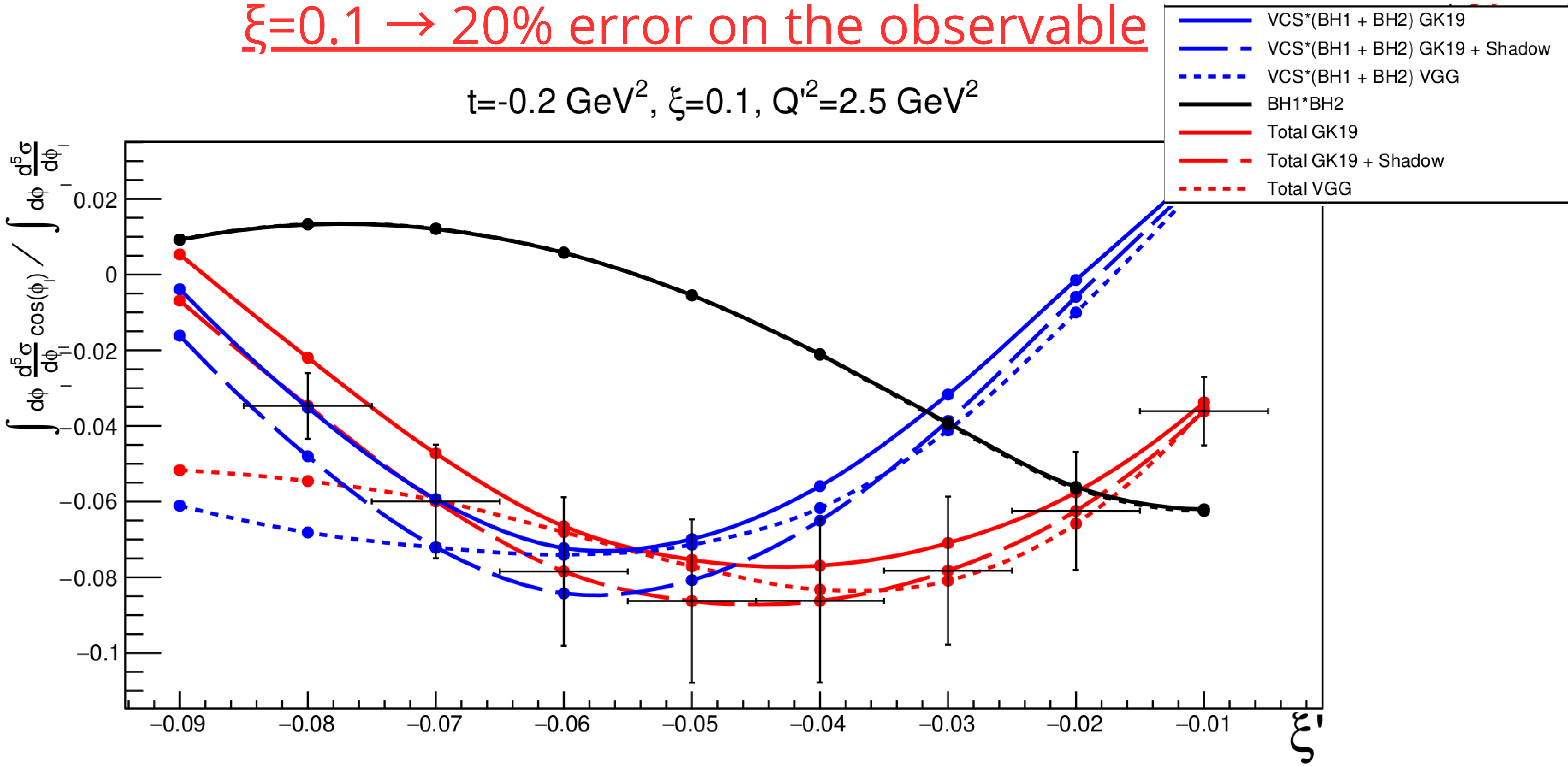
- Asumming 36 bins in φ → 360K events → Nearly half expected data for SoLID (~700K)

Therefore

- 4% precision → 22% error on the cosφ moment extraction for 80 (xi,xi',t,Q^2) bins
- 1% precision → 5.8% error on the cosφ moment extraction for 2 integrated bins.
- An equilibrium can be found to get at least 4 projections with cosφ error around 10%.

All in all, this might lead to an exploratory measurement

ξ=0.1 → 20% error on the observable



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