Near-Threshold J/psi Production and Gravitational Form Factors

Yuxun Guo

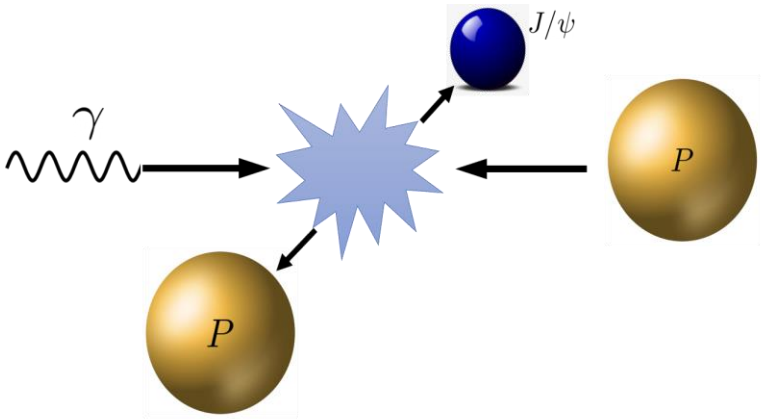
University of Maryland, College Park

J/psi and Beyond

Aug. 16 - 17th

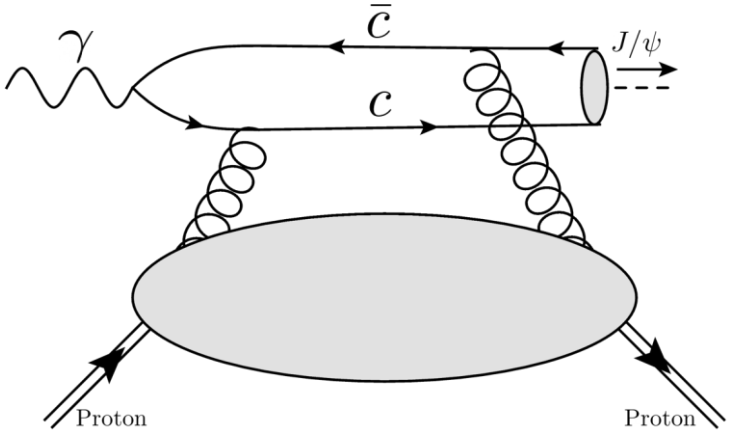
Based on 2103.11506 with
Xiangdong Ji and Yizhuang Liu.

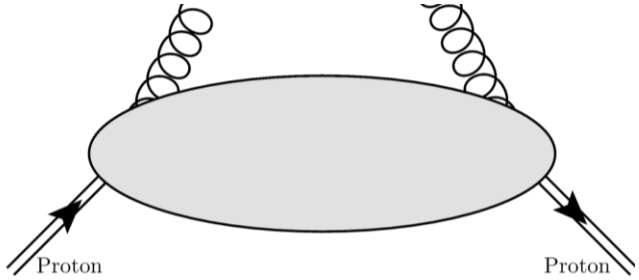
A quick overview



Collinear

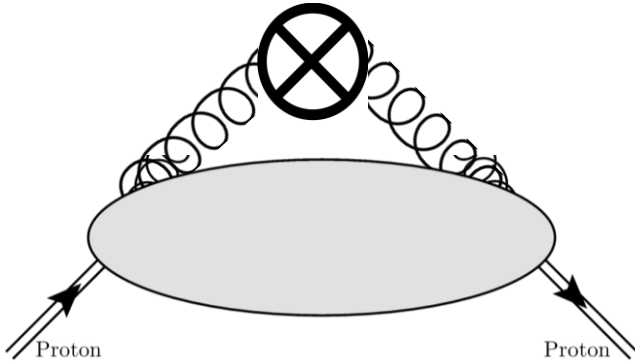
Factorization





Large xi

Expansion

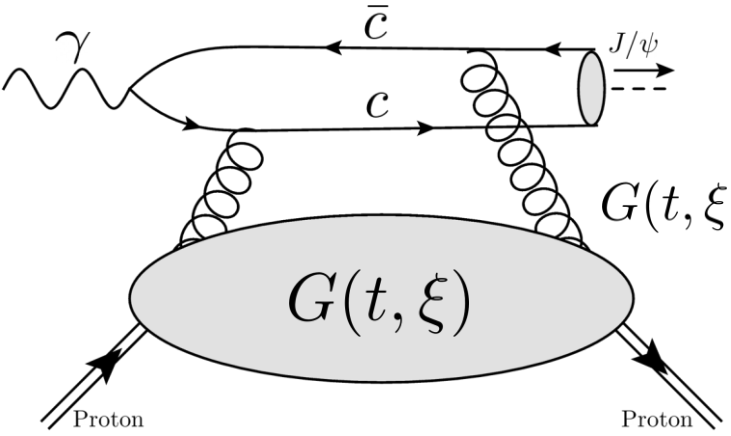


Outline

- When/how would large xi expansion work?
- The relevance of JLab 20+ GeV

Compton form factor (CFF)

Before large xi expansion, the nucleon matrix element is just CFF



$$G(t,\xi) = \frac{1}{2\xi}\int_{-1}^{1} \mathrm{d}x \left(\frac{1}{x+\xi-i0} - \frac{1}{x-\xi+i0}\right) F_g(x,\xi,t)$$

The inverse problem - reconstruct GPDs from CFFs

Alternatively, can we get just the gravitational form factors (GFFs)?

$$F_g^{\mathrm{asym}}(x,\xi,t) \propto \left(1-\frac{x^2}{\xi^2}\right)^2 \theta\left(1-\frac{x}{\xi}\right)$$

Hatta's talk

When do GFFs (Leading FFs) dominate?

Equivalently, when are the higher order form factors suppressed?

One obvious example: $\mu_f \to \infty$

$$\mathcal{F}_j(\mu_f) \sim \left(\frac{\alpha_S(\mu_f)}{\alpha_S(\mu_0)}\right)^{-\gamma_j/\beta_0} \mathcal{F}_j(\mu_0)$$

A less obvious example: the end-point constraint at x=1

The higher order FFs must vanish fast
to satisfy the end-point constraints!

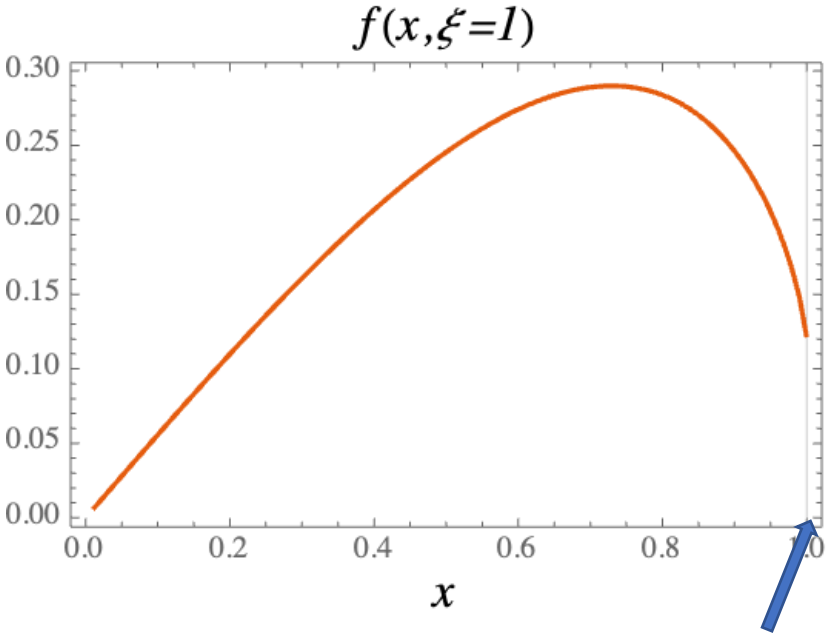
PDF-like and DA-like GPDs

PDF-like

- Higher order FFs power suppressed

$$\mathcal{F}_j \sim j^{-\beta-1}$$

- Long tail in DGLAP region

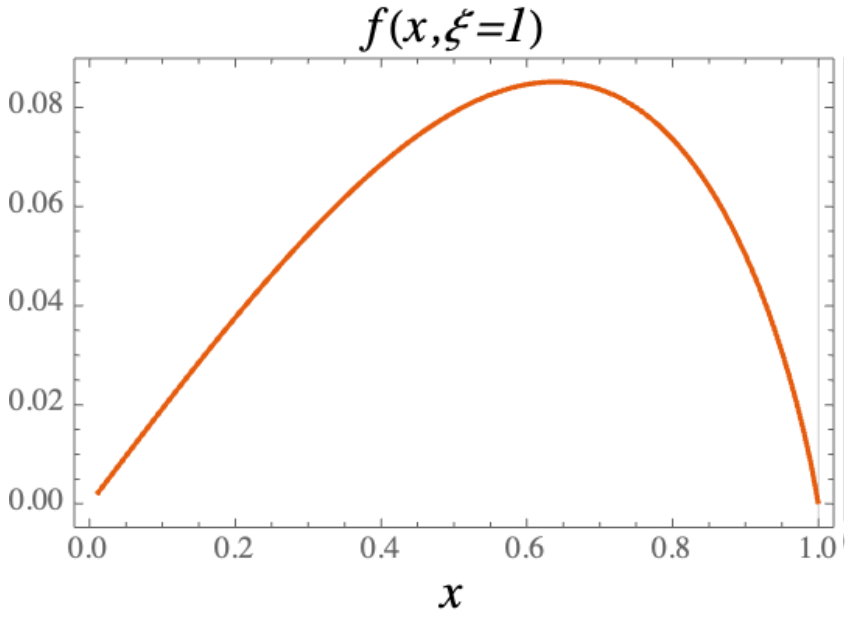


DA-like

- Higher order FFs exp. suppressed

$$\mathcal{F}_j \sim j^{-\beta-1}\exp(-\alpha j)$$

- Vanish fast in DGLAP region

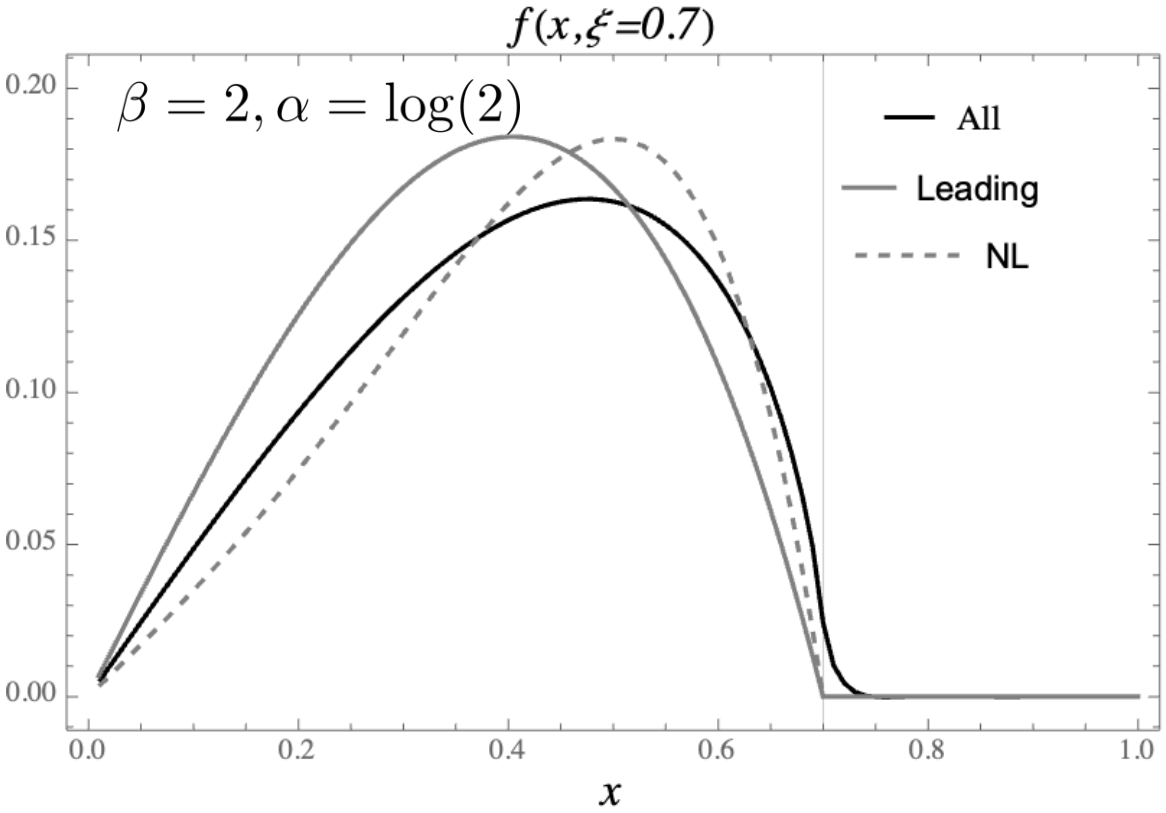


$f(x=1,\xi=0.7)=0.01$

Higher moments must be exponentially suppressed as xi increases!

Leading moment dominance

In order to satisfy the end-point constraint at x=1, the higher moments must be exponentially suppressed at large xi

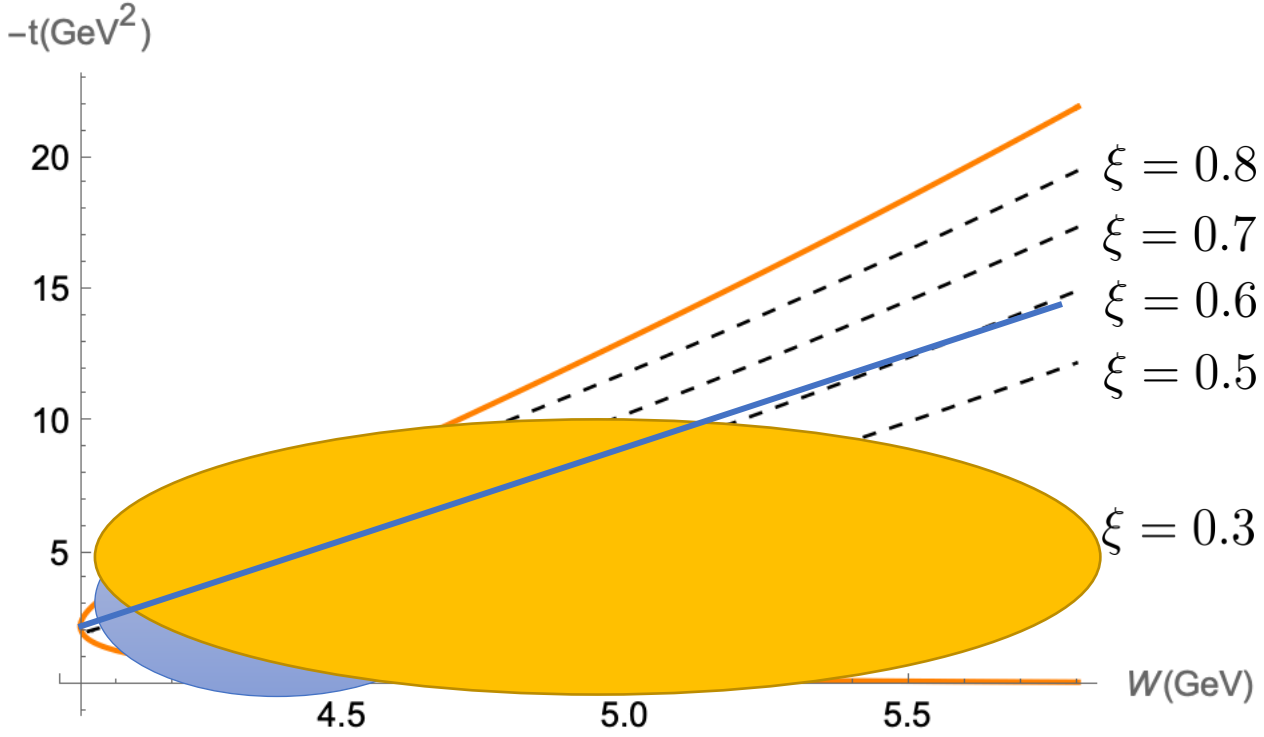


Order	CFFs
LO	-0.378
NL	-0.418
NNL	-0.445
All	-0.497-0.07i

Caveat - what's the alpha when xi is less than 1?

What does JLab 20+ GeV do?

For photo-production of J/psi, large xi region needs higher photon beam energy

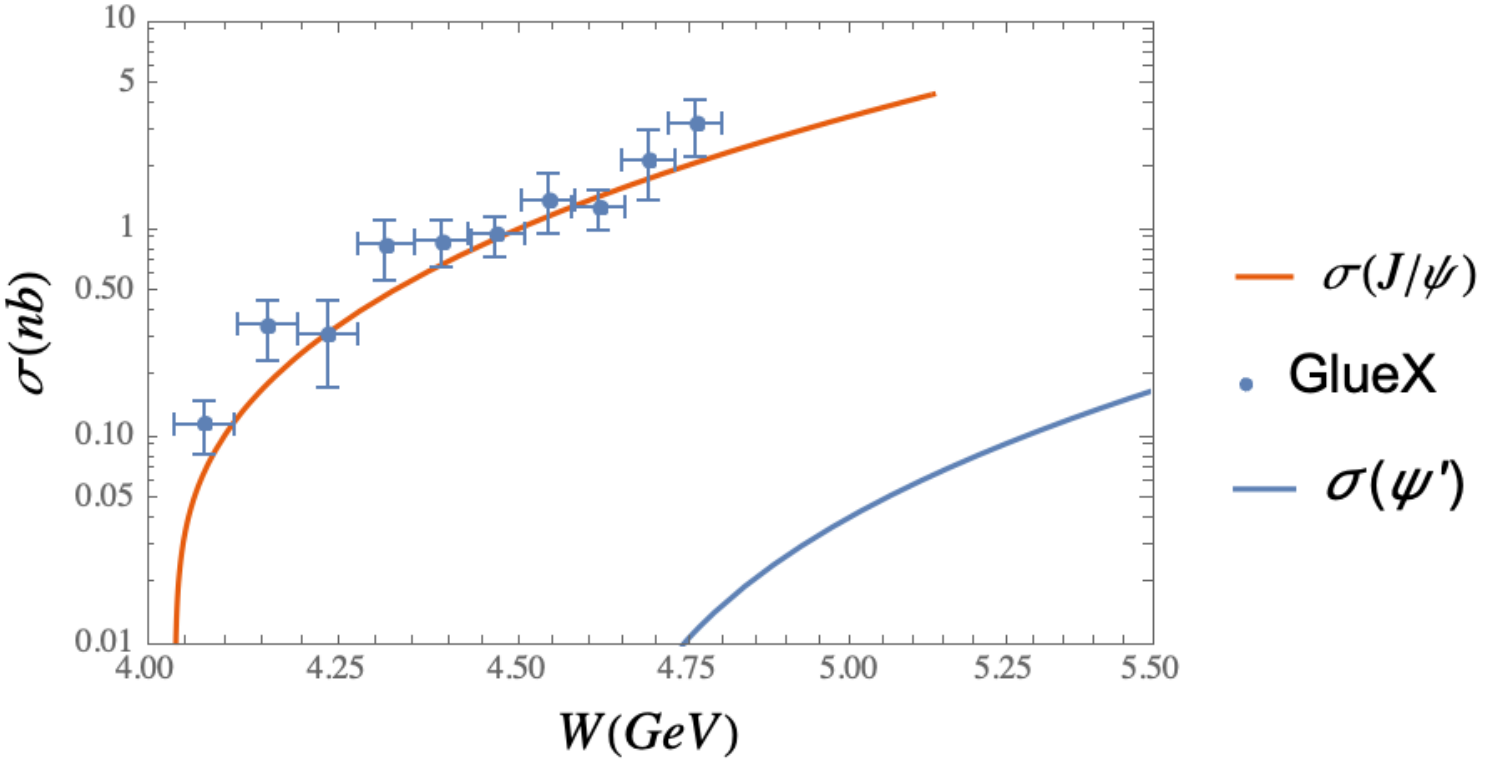


Joosten's talk

Psi(2s) production at JLab 20+

Psi(2s) with larger mass is more ideal for heavy meson limit

The larger meson mass help push the xi higher



The factorization and universality can be tested

J/psi production with polarized target

Separation of different GFF (A and C) is not easy.

More information can be extracted with polarized measurements.

To the leading twist we have trans. photon and Jpsi

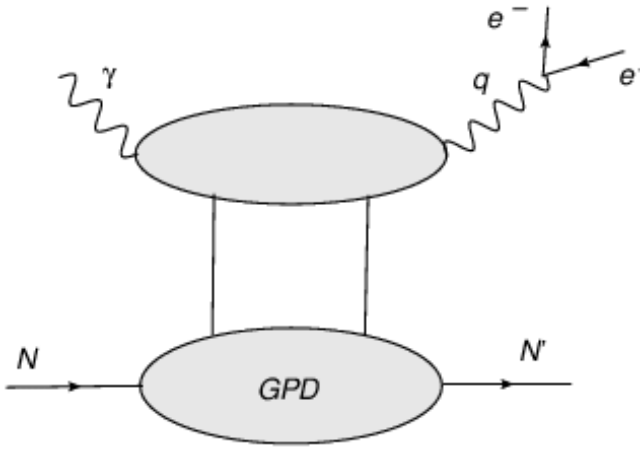
For instance, for trans. polarized target, we have

$$|G(t,\xi,S',S)|^2 = \frac{1-S\cdot S'}{4}\sum_{S,S'}|G(t,\xi,S,S')|^2 + \frac{S'^{+}(P'\cdot S)}{2\xi^4\bar{P}^{+}}\left[H_2+E_2\right]\left[(1+\xi)H_2+\xi E_2\right] + \frac{(P\cdot S')(P'\cdot S)}{4\xi^4 M_N^2}E_2^2 \ .$$

Different combination of GFFs will be measured.

One step back – exploring GPD at large xi

Quark sector



Time-like Compton scattering

Gluon sector

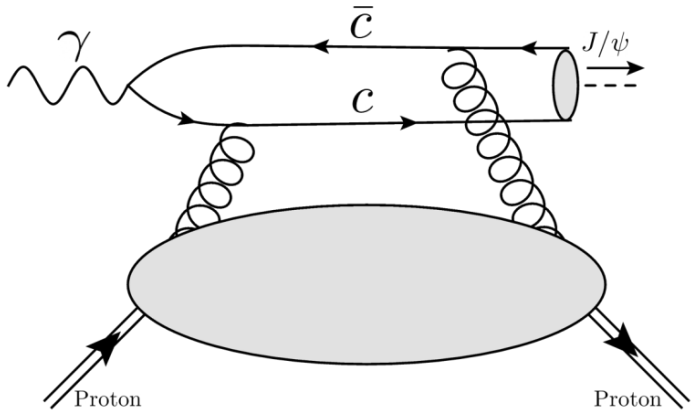
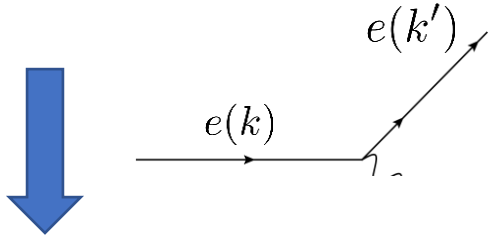


Photo-production of J/psi



Doubly DVCS

Lepto-production of J/psi

GPDs at large xi reveal more information about GFFs

Summary

- At large xi, GPDs are more sensitive to the GFFs
- High energy photon is important to reach high xi region
- Psi(2s) production provides unique opportunities
- Polarized measurements are also helpful in separating GFFs

Thank you!