Theoretical setup

$$F^{\mu}_{\lambda,\lambda'} = \bar{u}(p',\lambda')\left[\frac{P^\mu}{M}A_1 + z^\mu MA_2 + \frac{\Delta^\mu}{M}A_3 + i\sigma^{\mu z} MA_4 + \frac{i\sigma^{\mu\Delta}}{M}A_5 + \frac{P^\mu i\sigma^{z\Delta}}{M}A_6 + \frac{z^\mu i\sigma^{z\Delta}}{M}A_7 + \frac{\Delta^\mu i\sigma^{z\Delta}}{M}A_8\right]u(p,\lambda)$$

Goals

(A) A_i **are to the standard** H, E **GPDs** $\mathcal{H}^s_0(A^s_i; z) = A_1 + \frac{z(\Delta_1^2+\Delta_2^2)}{2P_3}A_6$

(B) Extraction of standard GPDs using A_i **obtained from any frame**

(C) quasi-GPDs may be redefined (Lorentz covariant) inspired by light-cone:

$$H(z\cdot P, z\cdot\Delta, t=\Delta^2, z^2) = A_1 + \frac{\Delta_{s/a}\cdot z}{P_{avg,s/a}\cdot z}A_3$$

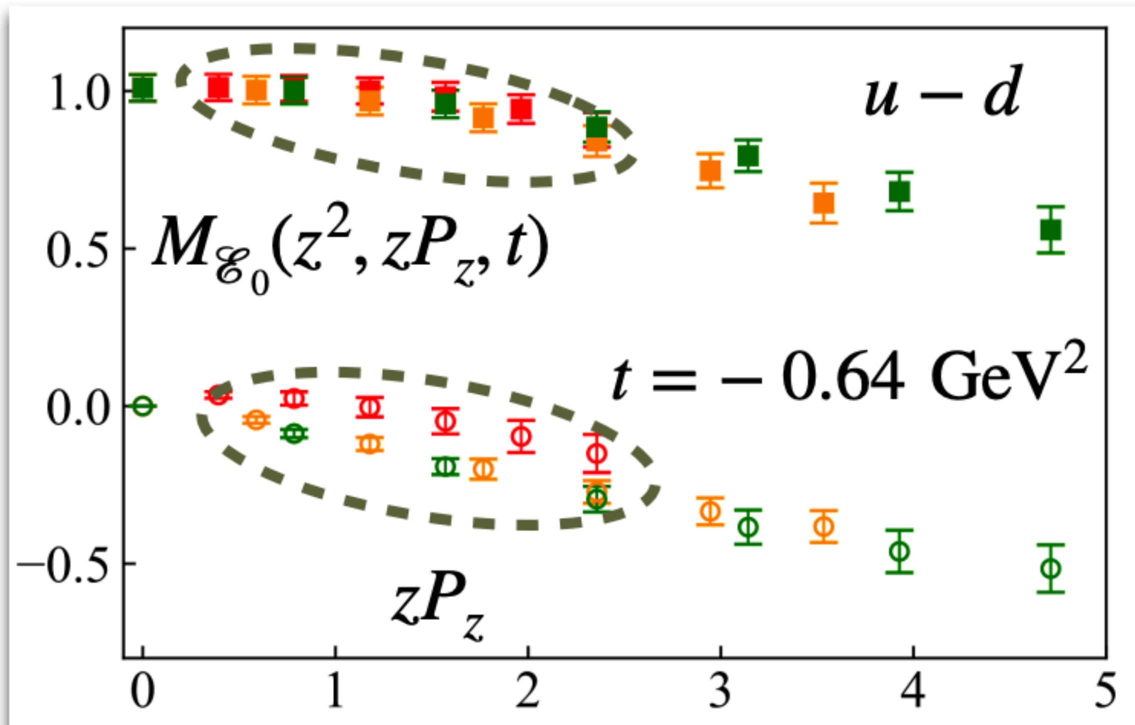
$$E(z\cdot P, z\cdot\Delta, t=\Delta^2, z^2) = -A_1 - \frac{\Delta_{s/a}\cdot z}{P_{avg,s/a}\cdot z}A_3 + 2A_5 + 2P_{avg,s/a}\cdot zA_6 + 2\Delta_{s/a}\cdot zA_8$$

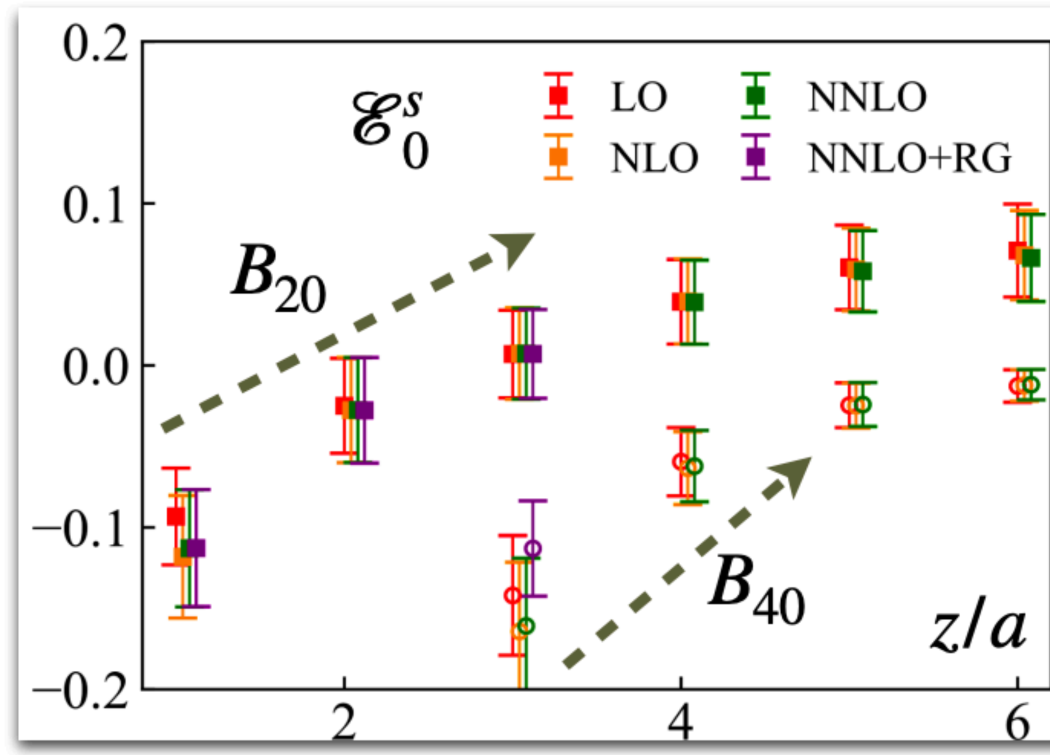
(A) Proof-of-concept calculation ($\xi = 0$**):**

- symmetric frame: $\vec{p}^{\,s}_f = \vec{P} + \frac{\vec{Q}}{2}, \quad \vec{p}^{\,s}_i = \vec{P} - \frac{\vec{Q}}{2} \qquad -t^s = \vec{Q}^2 = 0.69\, GeV^2$

- asymmetric frame: $\vec{p}^{\,a}_f = \vec{P}, \qquad \vec{p}^{\,a}_i = \vec{P} - \vec{Q} \qquad t^a = -\vec{Q}^2 + (E_f - E_i)^2 = 0.65\, GeV^2$

13 Mellin moments of GPDs: γ_0 definition





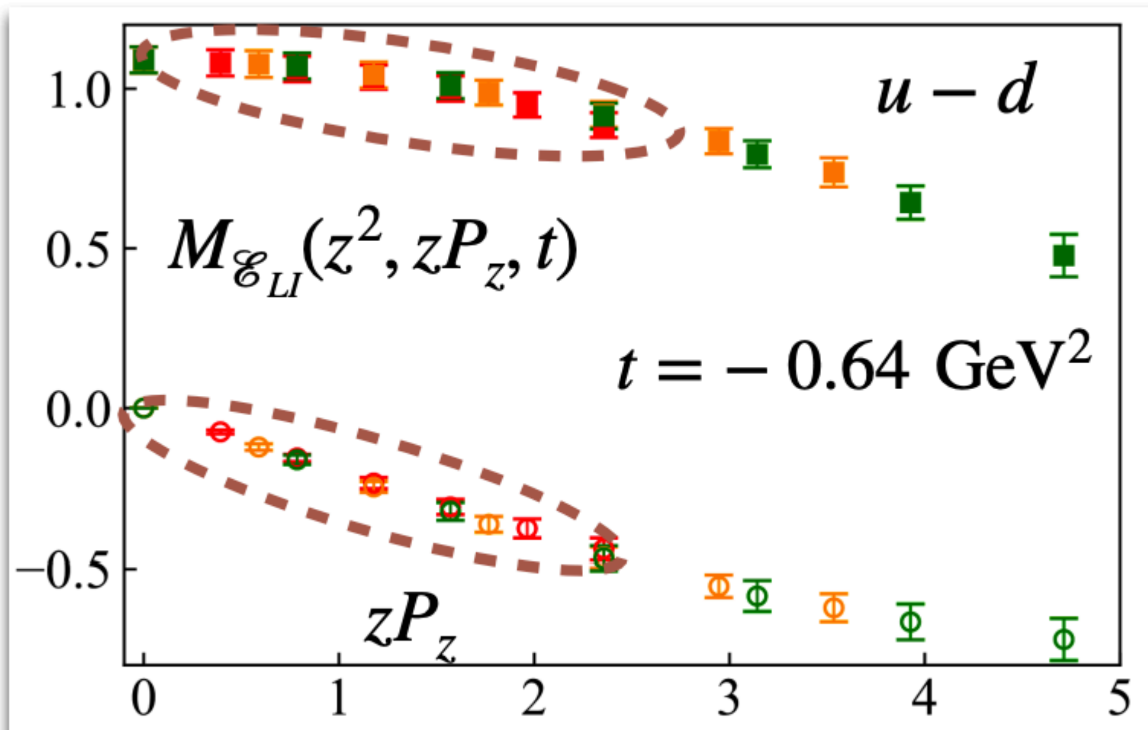
- no scaling with zP_z
- not constant in z

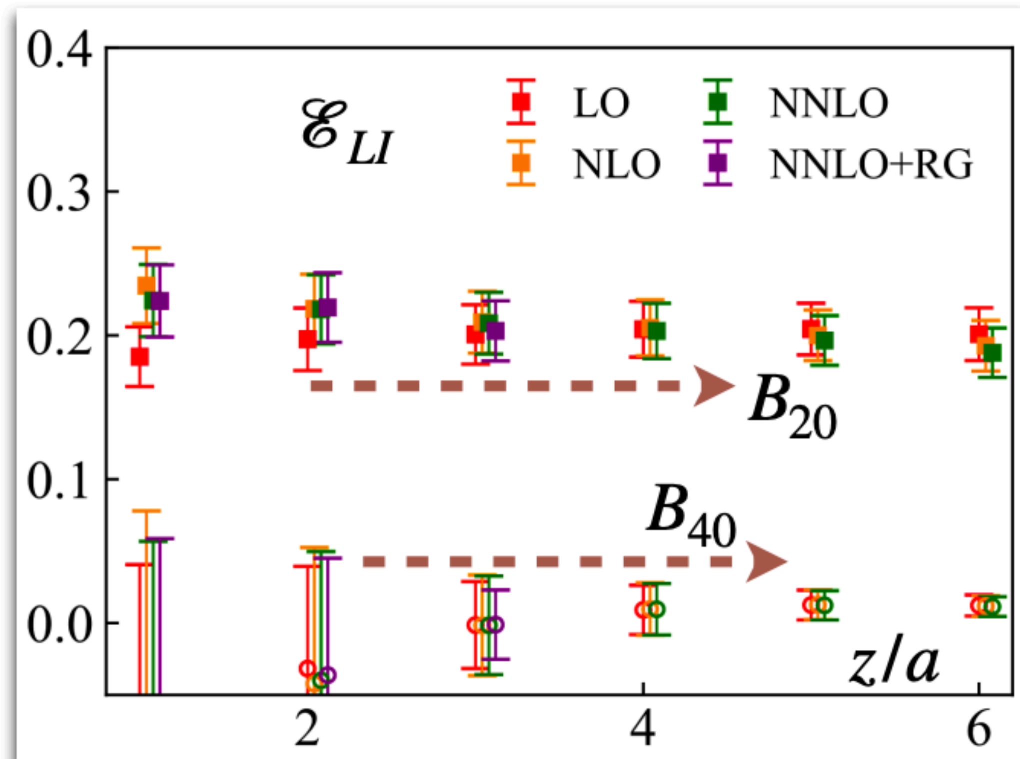
$$\mathscr{M}(z^2, zP, \Delta^2) = \sum_{n=0}^{\infty} \frac{(-izP)^n}{n!} \frac{C_n(z^2\mu^2)}{C_n(z^2\mu^2)} \langle x^n \rangle(\mu) + \mathscr{O}(z^2\Lambda^2_{\mathrm{QCD}})$$

$$F^0(z, P, \Delta) = \bar{u}(p_f, \lambda')\left[\gamma^0 \mathscr{H}_0(z, P, \Delta) + \frac{i\sigma^{0\mu}\Delta_\mu}{2m}\mathscr{E}_0(z, P, \Delta)\right]u(p_i, \lambda)$$

$\mu = 2$ GeV $\quad P_z = 0.83,\ 1.25,\ 1.67$ GeV

14 Mellin moments of GPDs: LI definition





- Perturbative corrections $C_n(z^2\mu^2) = 1 + \mathcal{O}(\alpha_s)$
- Stable moments $\langle x^n \rangle(\mu)$

$$\mathcal{M}(z^2, zP, \Delta^2) = \sum_{n=0}^{\infty} \frac{(-izP)^n}{n!} \frac{C_n(z^2\mu^2)}{C_n(z^2\mu^2)} \langle x^n \rangle(\mu) + \mathcal{O}(z^2\Lambda^2_{\mathrm{QCD}})$$

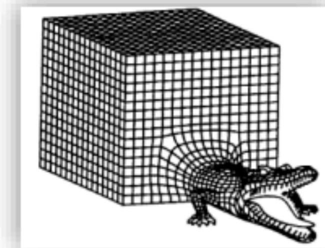
$$\mathcal{E}(z, P, \Delta) = -A_1 - \frac{\Delta \cdot z}{P \cdot z} A_3 + 2A_5 + 2P \cdot z A_6 + 2\Delta \cdot z A_8$$

$\mu = 2$ GeV $\quad P_z = 0.83,\ 1.25,\ 1.67$ GeV

Isovector Nucleon GPDs

§ Nucleon GPD using quasi-PDFs at physical pion mass

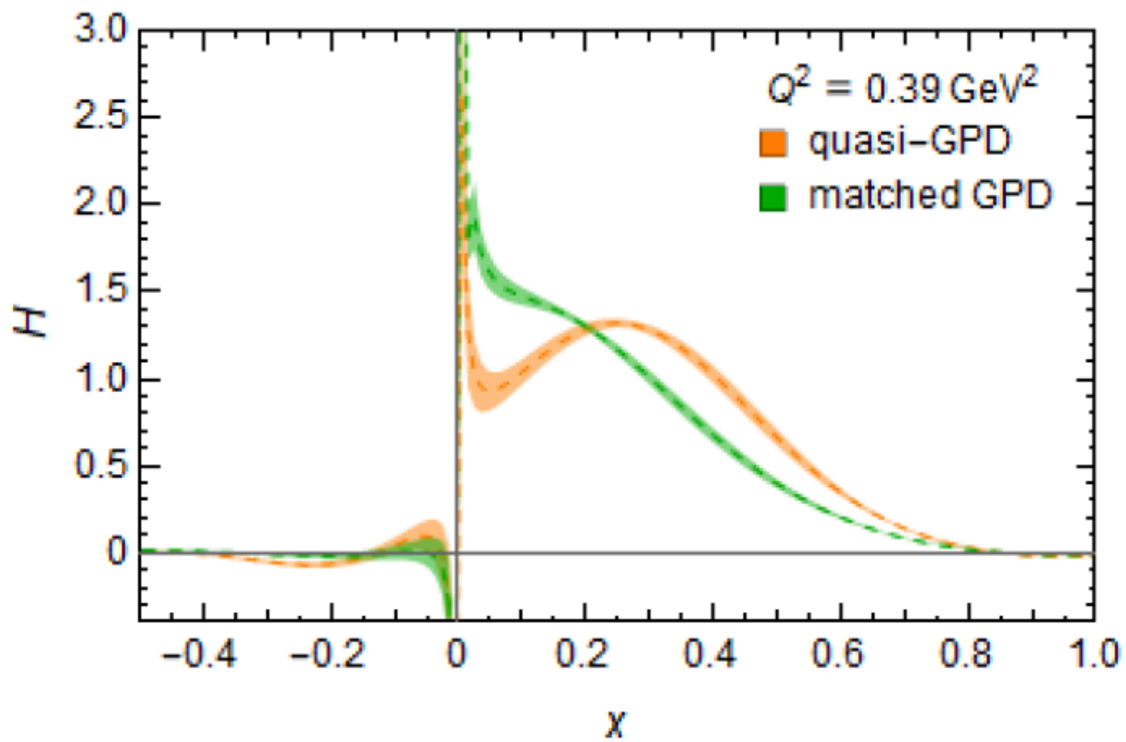
- Lattice details: clover/2+1+1 HISQ
  0.09fm, **135-MeV** pion mass, $P_z \approx 2$ GeV
- $\xi = 0$ *isovector* nucleon quasi-GPD results

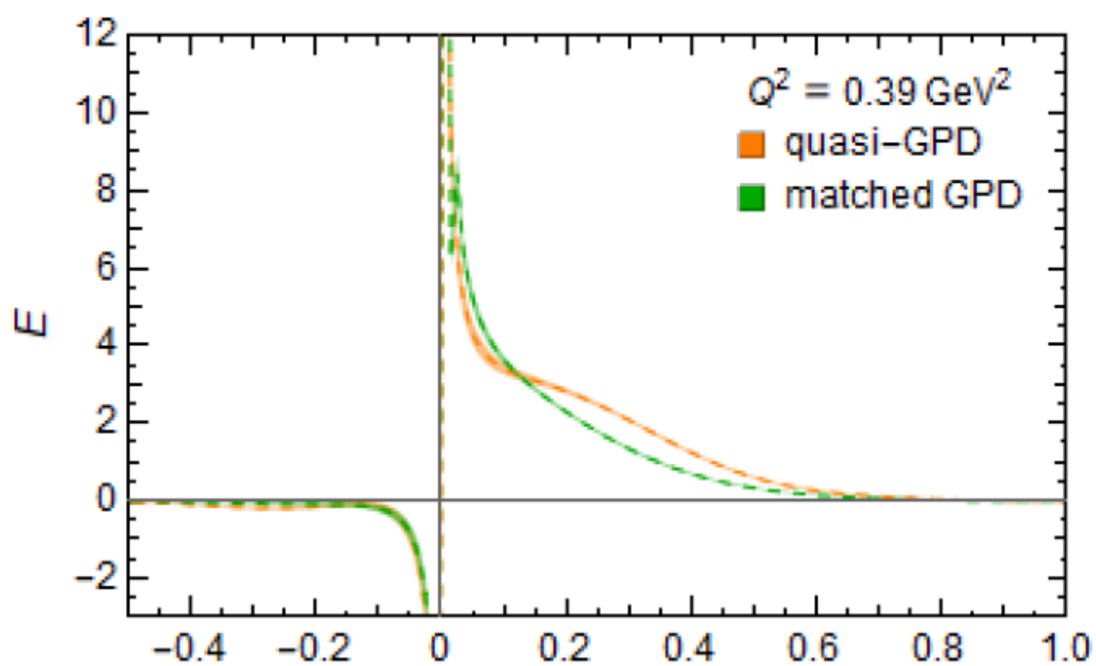


finite-volume,
discretization,
...

$$\tilde{F}(x,\xi,t,\bar{P}_Z) = \frac{\bar{P}_z}{\bar{P}_0}\int \frac{dz}{4\pi} e^{ixz\bar{P}_z}\langle P'|O_{\gamma_0}(z)|P\rangle = \frac{\bar{u}(P')}{2\bar{P}^0}\left(H(x,\xi,t,\bar{P}_Z)\gamma^0 + E(x,\xi,t,\bar{P}_Z)\frac{i\sigma^{0\mu}\Delta_\mu}{2M}\right)u(P'')$$

$$p^\mu = \frac{p''^\mu + p'^\mu}{2}, \qquad \Delta^\mu = p''^\mu - p'^\mu, \qquad t = \Delta^2 = Q^2, \qquad \xi = \frac{p''^+ - p'^+}{p''^+ + p'^+}$$





HL, Phys.Rev.Lett. 127 (2021) 18, 182001