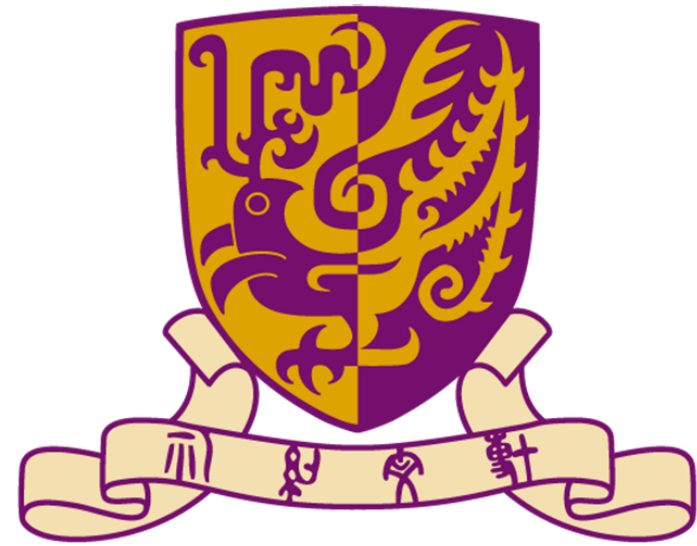




Quark-Gluon Vertex under Complete Tensor Basis

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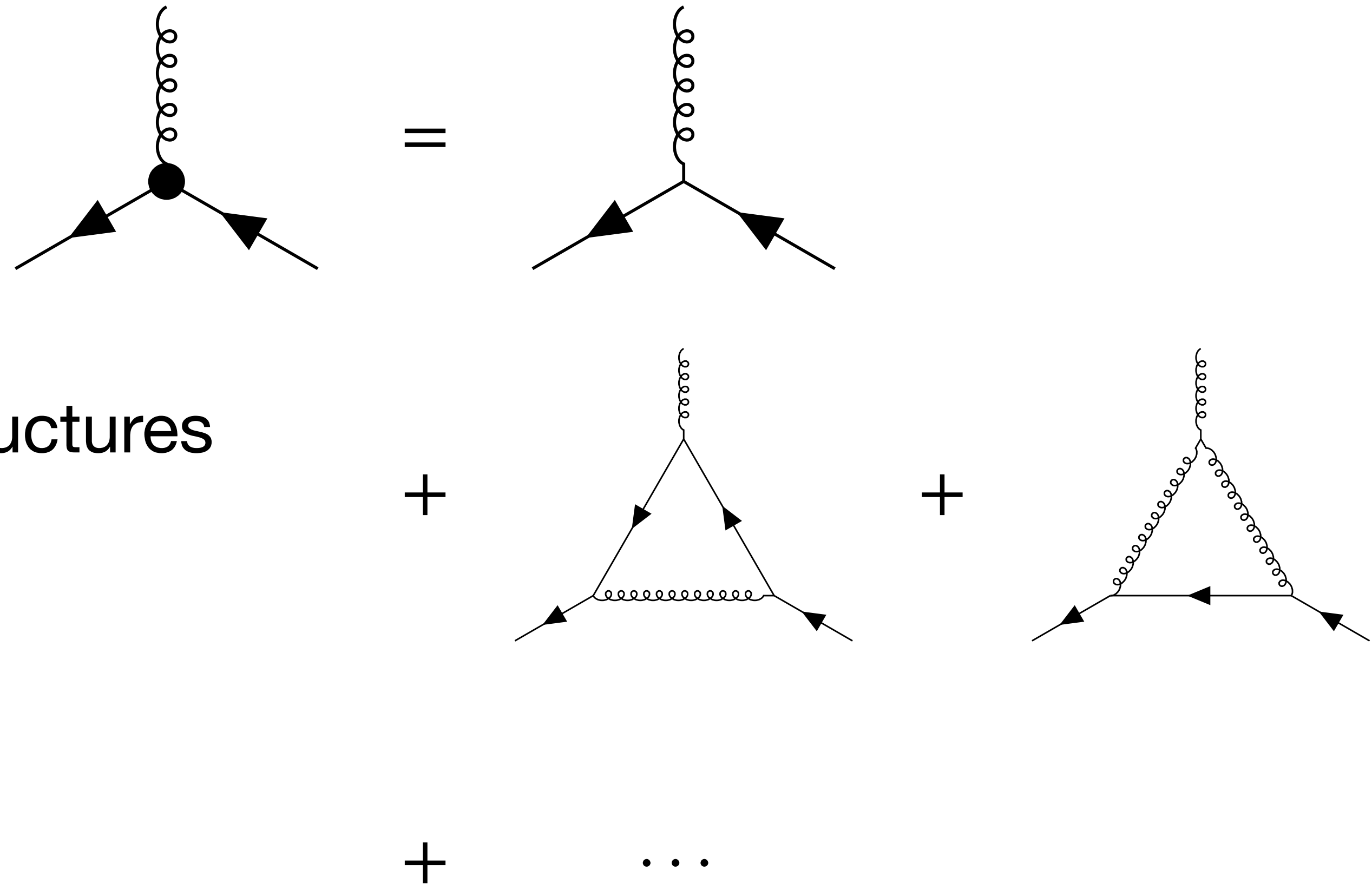
in collaboration with Wei-Jie Fu and Yi-Bo Yang

2026-10-11 in CUHK

Quark Gluon Vertex: More than Classical

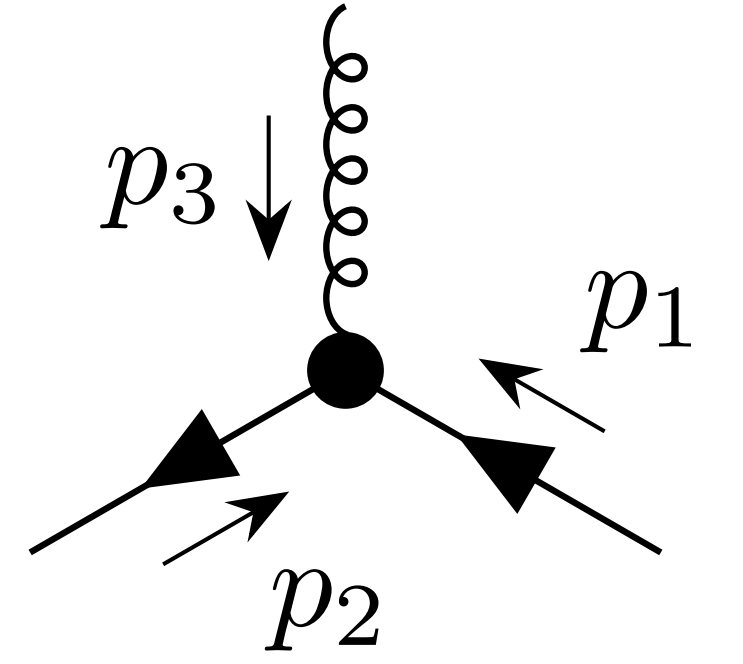
- * Tree-level structure:

$$\Gamma_{\mu}^{(0)} = g\gamma_{\mu}t^a$$



- * Loop correction gives more non-classical Dirac tensor structures which form a tensor space

Complete Transverse Tensor Basis



- * Ball-Chiu basis:
8 transverse + 4 longitudinal

$$\left[\Gamma_{\psi\bar{\psi}A}^{(3)} \right]_{\mu}^a(p_2, p_1) = t^a \times$$

$$\left(\Pi_{\mu\nu}^{\perp}(p_1 + p_2) \sum_{i=1}^8 \lambda_{\psi\bar{\psi}A}^{(i)}(p_2, p_1) \left[\mathcal{T}_{\psi\bar{\psi}A}^{(i)} \right]_{\nu}(p_2, p_1) \right.$$

$$\left. + \Pi_{\mu\nu}^{\parallel}(p_1 + p_2) \sum_{i=9}^{12} \lambda_{\psi\bar{\psi}A}^{(i)}(p_2, p_1) \left[\mathcal{T}_{\psi\bar{\psi}A}^{(i)} \right]_{\nu}(p_2, p_1) \right)$$

$$\begin{aligned} \bar{\psi} \not{D} \psi : & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(1)} \right]_{\mu}(p_2, p_1) = -i\gamma_{\mu}, \\ \bar{\psi} \not{D}^2 \psi : & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(2)} \right]_{\mu}(p_2, p_1) = (p_1 - p_2)_{\mu} 1_s, \\ & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(3)} \right]_{\mu}(p_2, p_1) = (\not{p}_1 - \not{p}_2) \gamma_{\mu}, \\ & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(4)} \right]_{\mu}(p_2, p_1) = (\not{p}_1 + \not{p}_2) \gamma_{\mu}, \\ \bar{\psi} \not{D}^3 \psi : & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(5)} \right]_{\mu}(p_2, p_1) = i(\not{p}_1 + \not{p}_2)(p_1 - p_2)_{\mu}, \\ & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(6)} \right]_{\mu}(p_2, p_1) = i(\not{p}_1 - \not{p}_2)(p_1 - p_2)_{\mu}, \\ & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(7)} \right]_{\mu}(p_2, p_1) = \frac{i}{2} [\not{p}_1, \not{p}_2] \gamma_{\mu}, \\ \bar{\psi} \not{D}^4 \psi : & \left[\mathcal{T}_{\psi\bar{\psi}A}^{(8)} \right]_{\mu}(p_2, p_1) = -\frac{1}{2} [\not{p}_1, \not{p}_2](p_1 - p_2)_{\mu}. \end{aligned}$$

Methodology

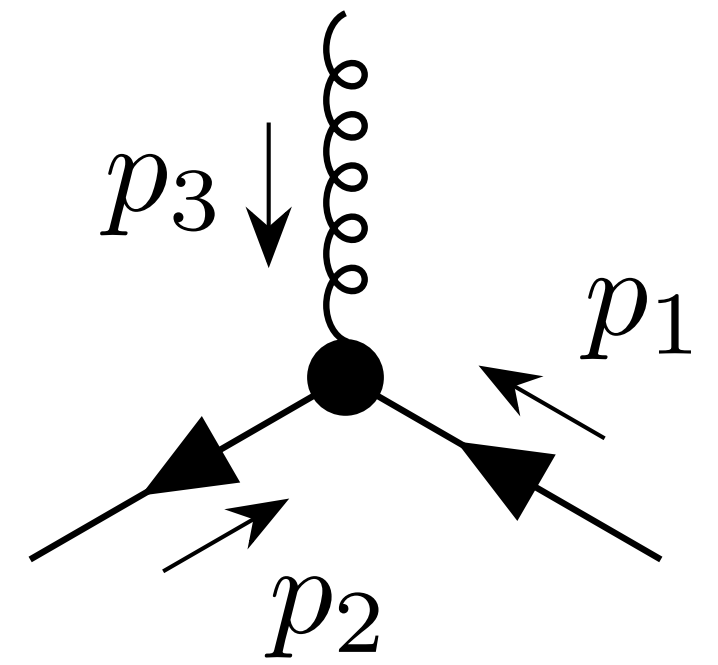
- * Landau gauge: transverse subspace

- * SMOM momentum condition $p_1^2 = p_2^2 = p_3^2$

- * Dual Projectors

$$\text{tr} \left(P_j \sum_{i=1}^8 \lambda_i \mathcal{T}^{(i)} \right) = \lambda_j, P_j = \sum_{i=1}^8 p_{j,i} \mathcal{T}^{(i)}$$

$p_{j,i}$ is a function of p_1, p_2, p_3 and can be determined by solving a set of linear equations



Lattice Simulation

✱ Valence overlap fermions on (2+1+1) flavor CLQCD HISQ ensembles.

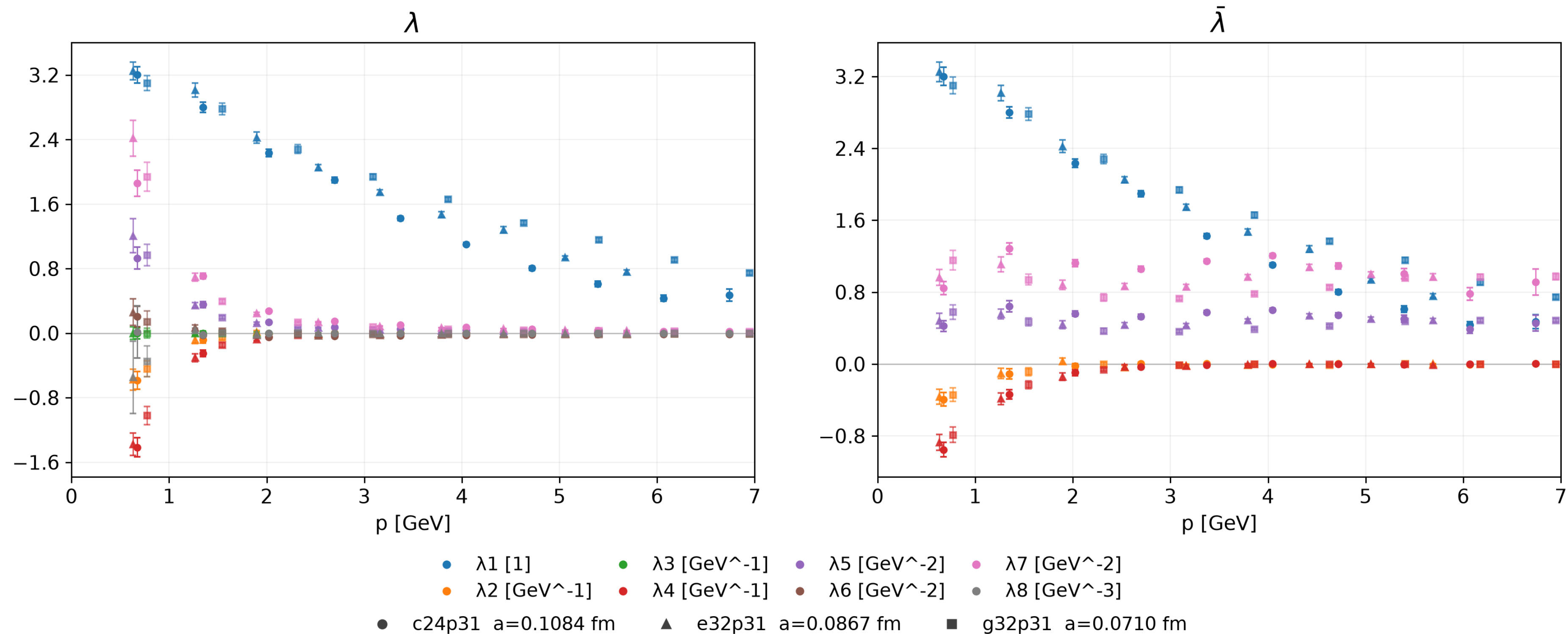
Action	Symbol	$\hat{\beta}$	$L^3 \times T$	$a(\text{fm})$
HISQ+S ^{tad}	c24p31	7.29	24 ³ ×48	0.1084(4)
	c24p22	7.29	24 ³ ×48	0.1084(4)
	e32p31	7.54	32 ² ×64	0.0867(4)
	g32p31	7.75	32 ² ×64	0.0710(3)
	h48p31	8.20	48 ³ ×96	0.0473(3)

✱ Dimensionless coupling

$$\bar{\lambda}_i = \frac{|p|^{n_i}}{Z_q^{ver} \sqrt{Z_3}} tr \left(S^{-1} \langle \psi \bar{\psi} A \rangle S^{-1} D^{-1} P_i \right)$$

Tensor structure of the quark-gluon vertex

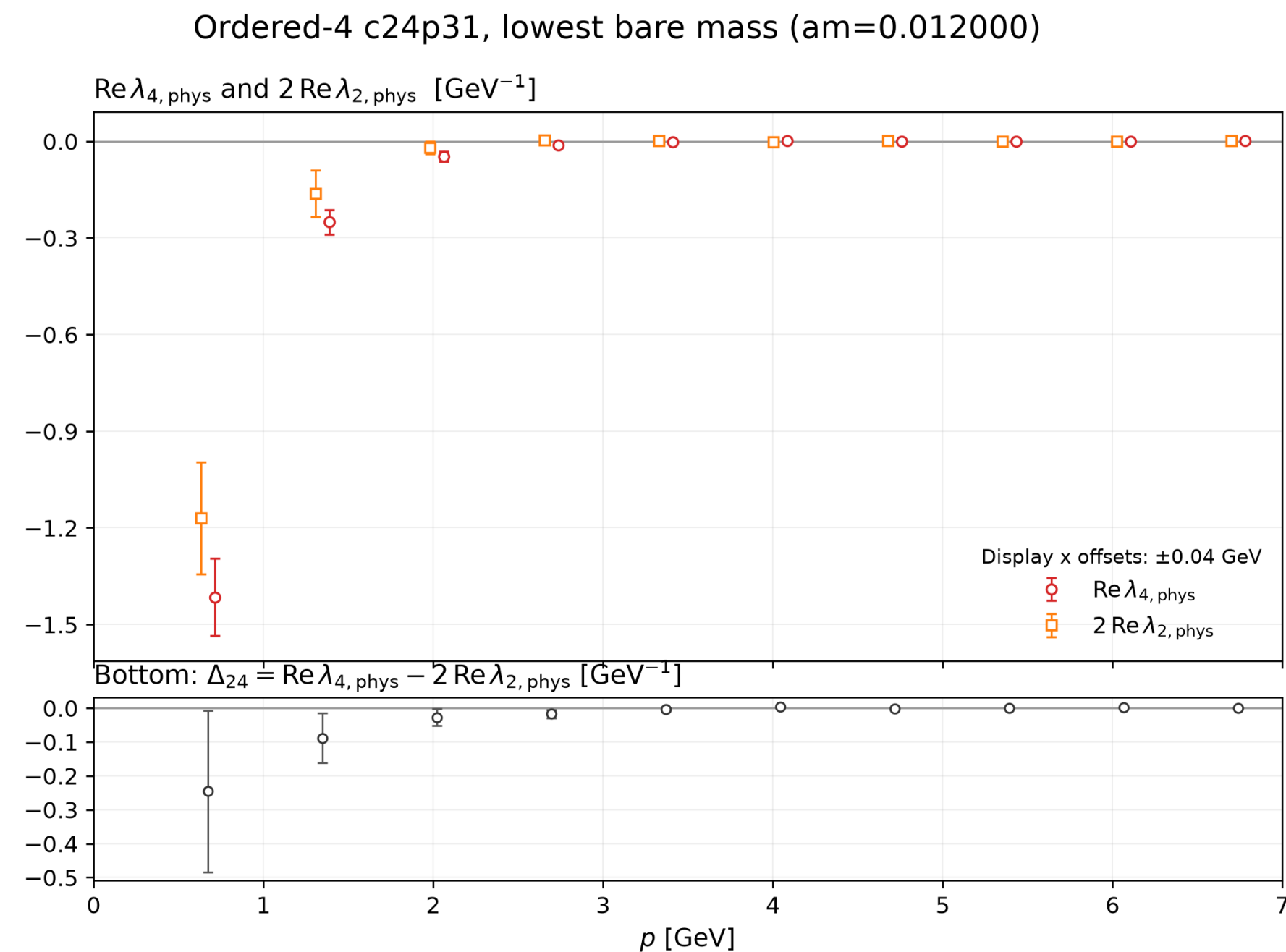
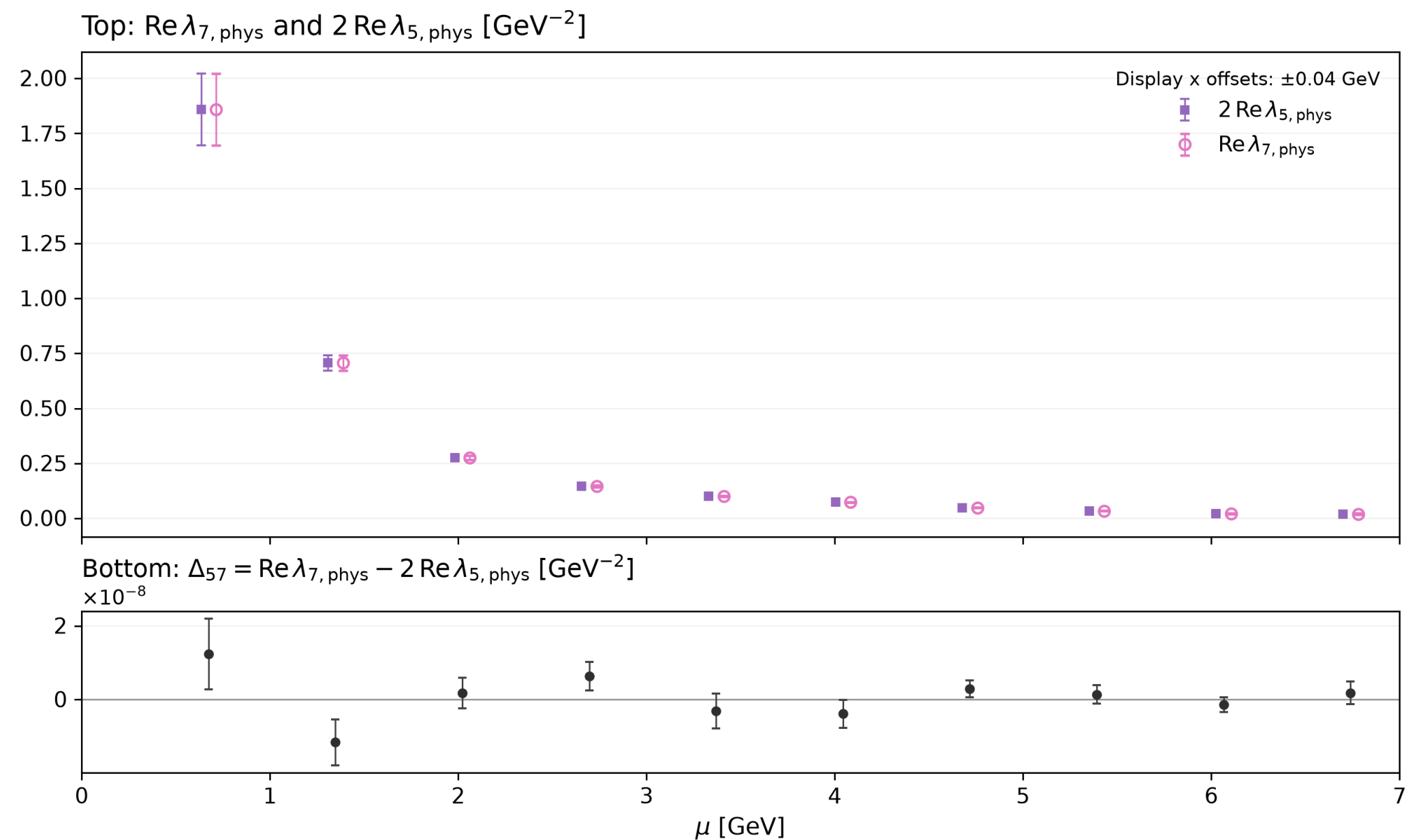
- * Symmetric kinematics on three ensembles
- * Clear signals in several non-tree-level channels



Relations between tensor dressings

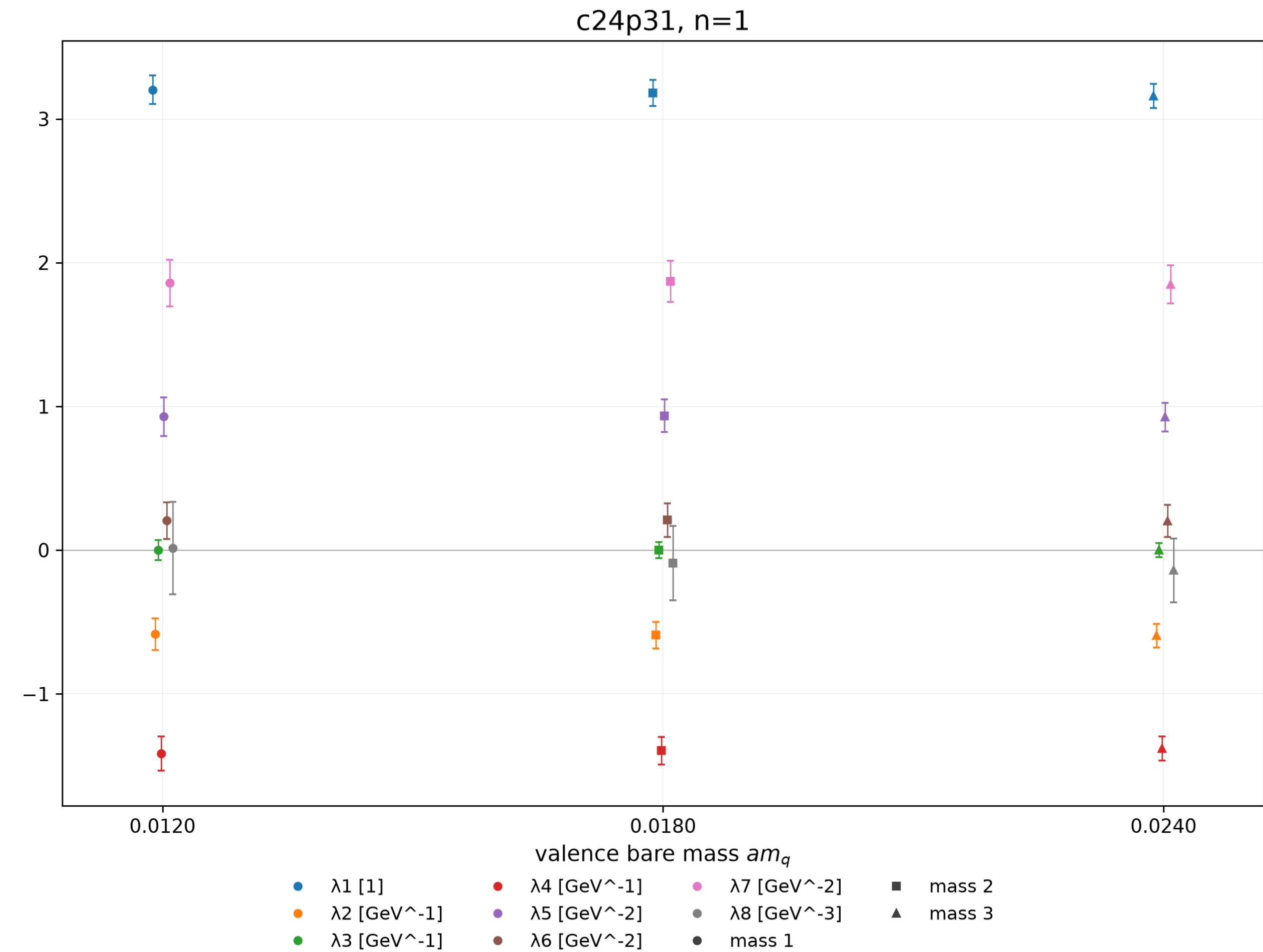
- * λ_5 & λ_7 : real-part consistency check
- * λ_2 & λ_4 : exploratory comparison of chiral-symmetry-breaking structures

C24P31 ordered-4 5/7 real-part consistency check



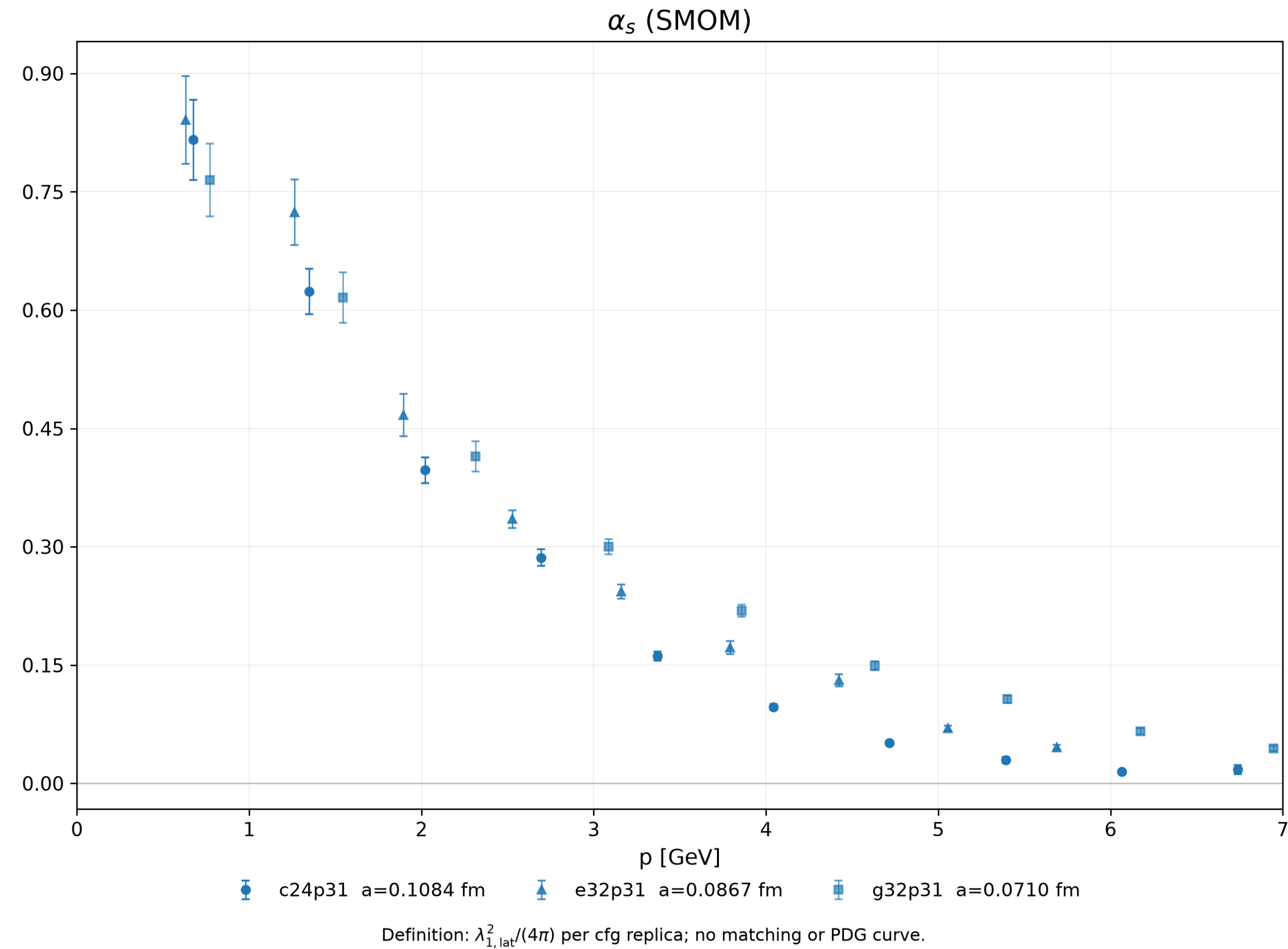
Valence-quark mass dependence

- * c24p31 at the lowest available momentum
- * Small changes in $\lambda_{1,5,7}$ over the tested mass range



α_s under SMOM

- * Results at three finite lattice spacings
- * Continuum extrapolation and matching to $\overline{\text{MS}}$ remain necessary



Summary and Outlook

- * Successfully calculated all the channels of quark-gluon vertex
- * The validity of the relation among channels
- * **TODO**: Matching for $\alpha_s^{\overline{\text{MS}}}$
- * **TODO**: Angular dependency of quark-gluon vertex

Thanks for your attention!