OBJECTIVE ANALYSIS OF EXTANT FORM FACTORS DATA



ECT*
EUROPEAN CENTRE
FOR THEORETICAL STUDIES
IN NUCLEAR PHYSICS AND RELATED AREAS
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Theoretical Motivations and Empirical Evidence for Diquark Correlations in Hadrons

OCTOBER 19 - 23 2026, TRNTO, ITALY



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(classical)
LAGRANGIAN

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pure-glue QCD displays a **mass gap**

$$m_g \sim 0.5 \text{ GeV}$$

Cornwall, PRD 26 (1982)

GAUGE SYMMETRY IS FINE

2-point STI can be still satisfied with

$$\Delta_{\mu\nu}(q) = \frac{P_{\mu\nu}(q)}{q^2[1+\Pi(q^2)]}, \quad q^\mu P_{\mu\nu}(q) = 0$$

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("only" requires the presence of longitudinally coupled massless poles)

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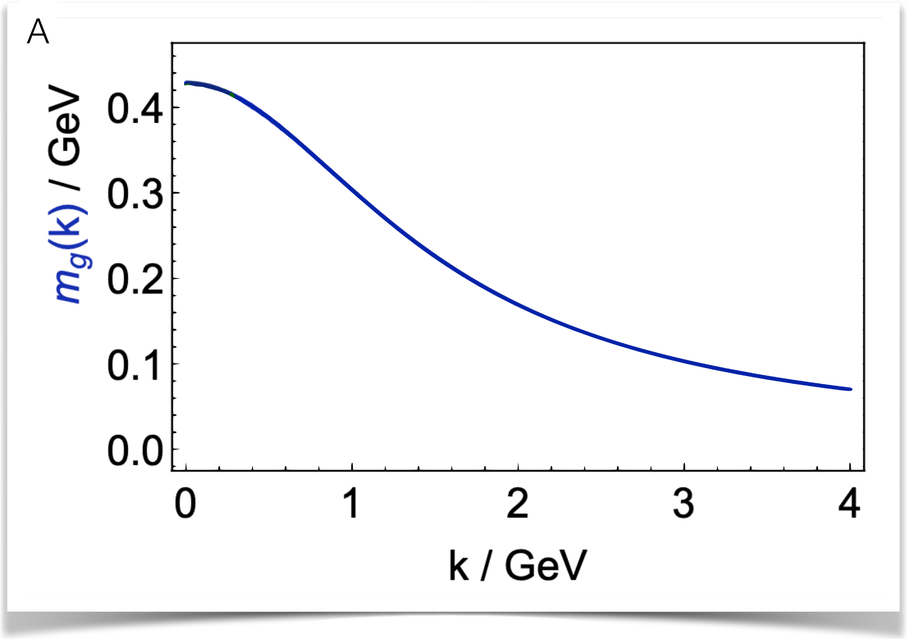

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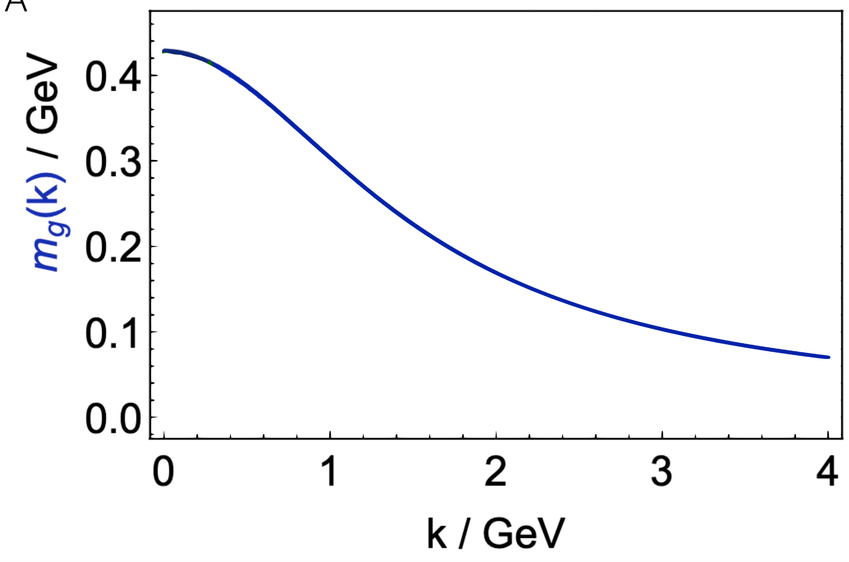

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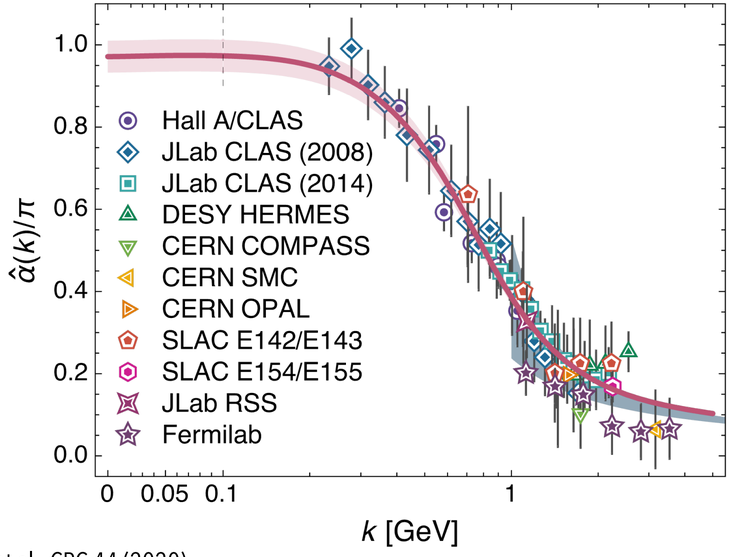

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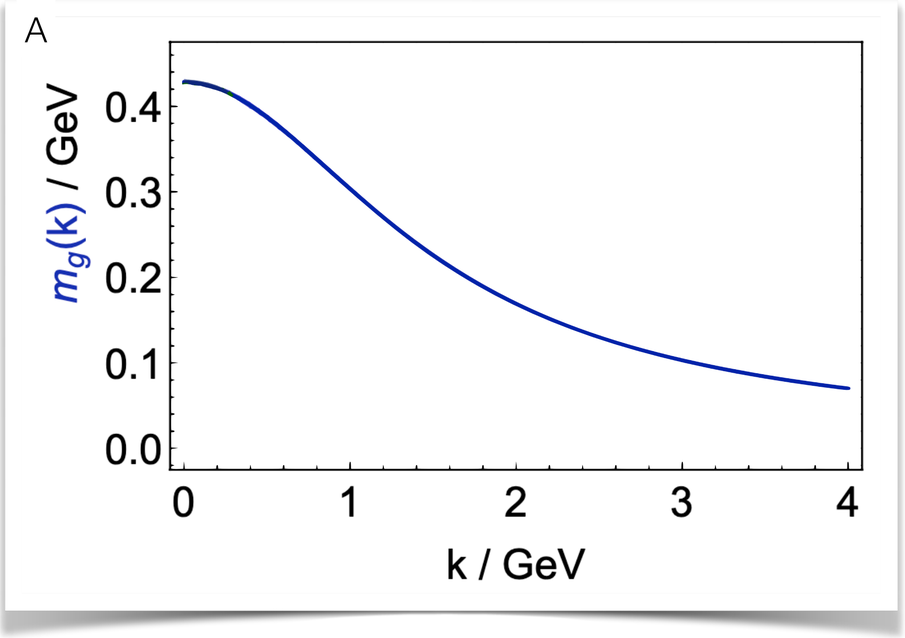

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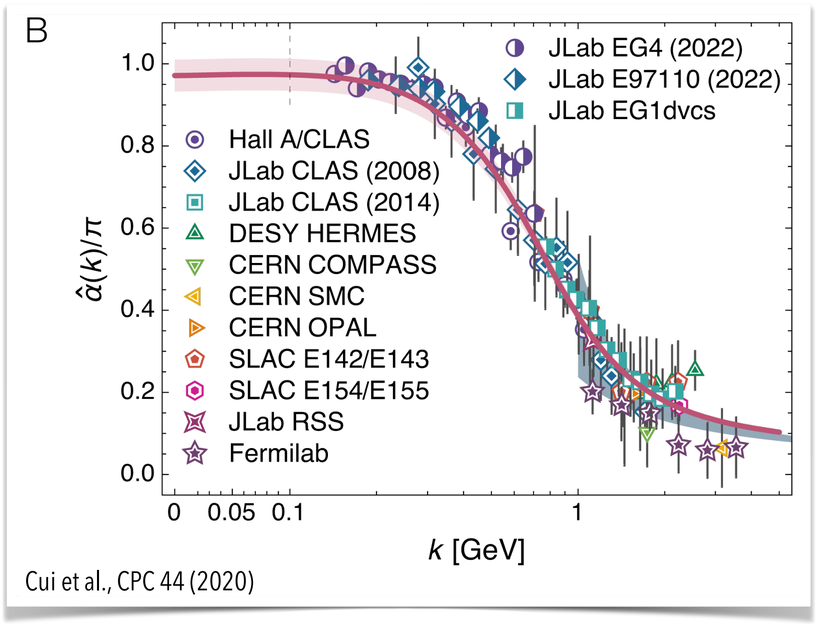

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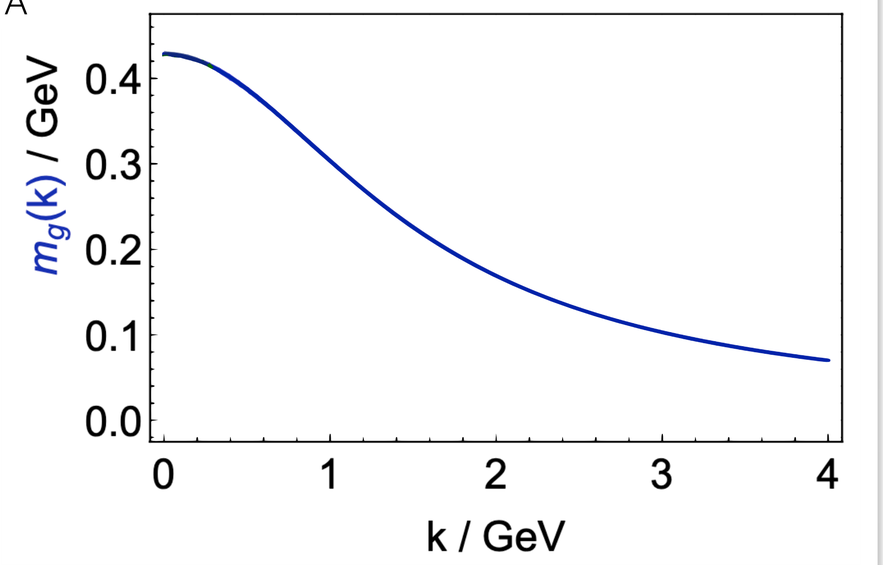

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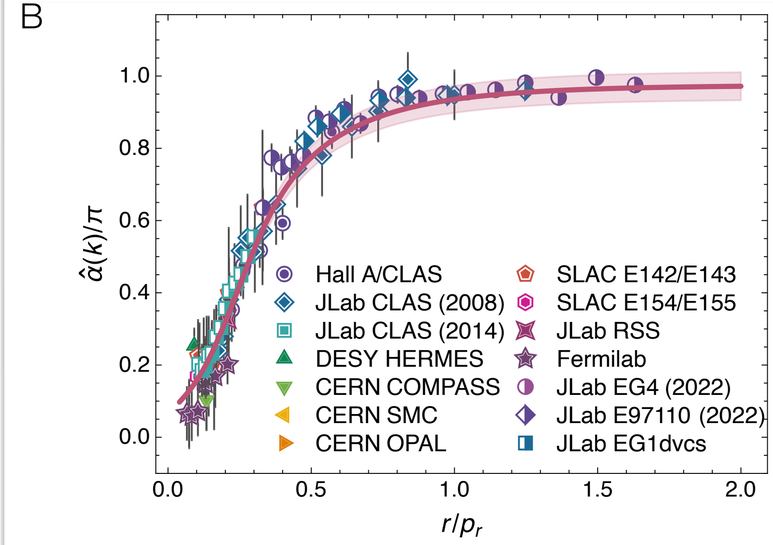

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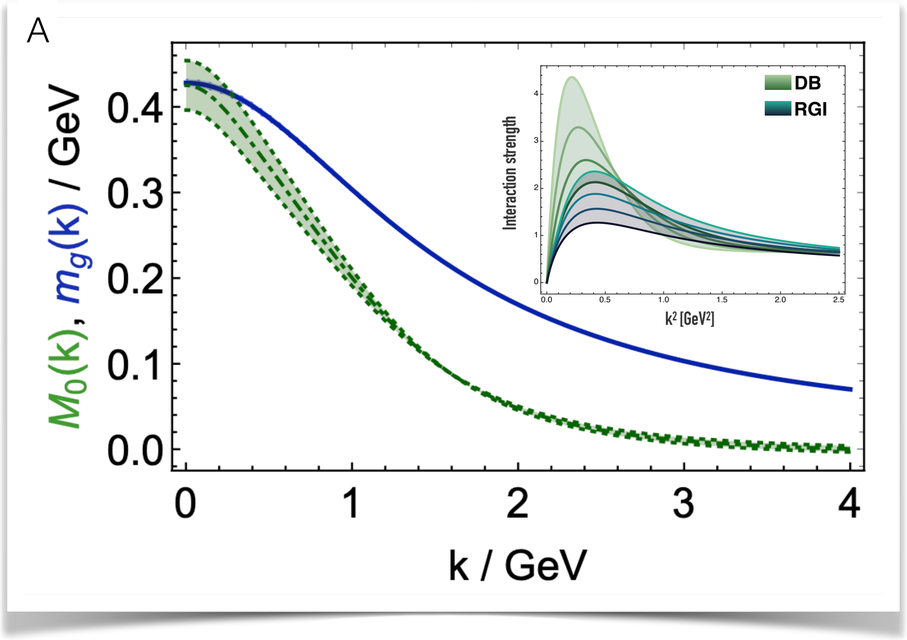

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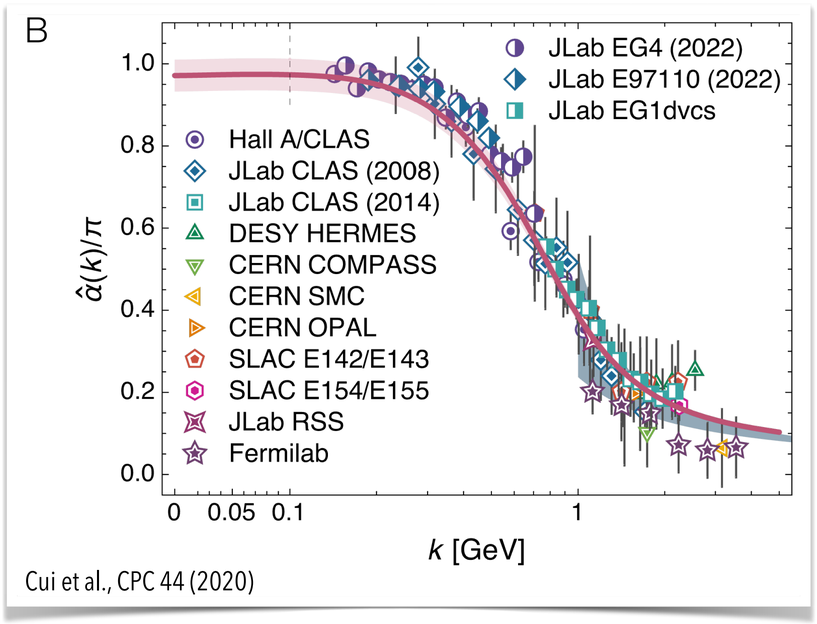

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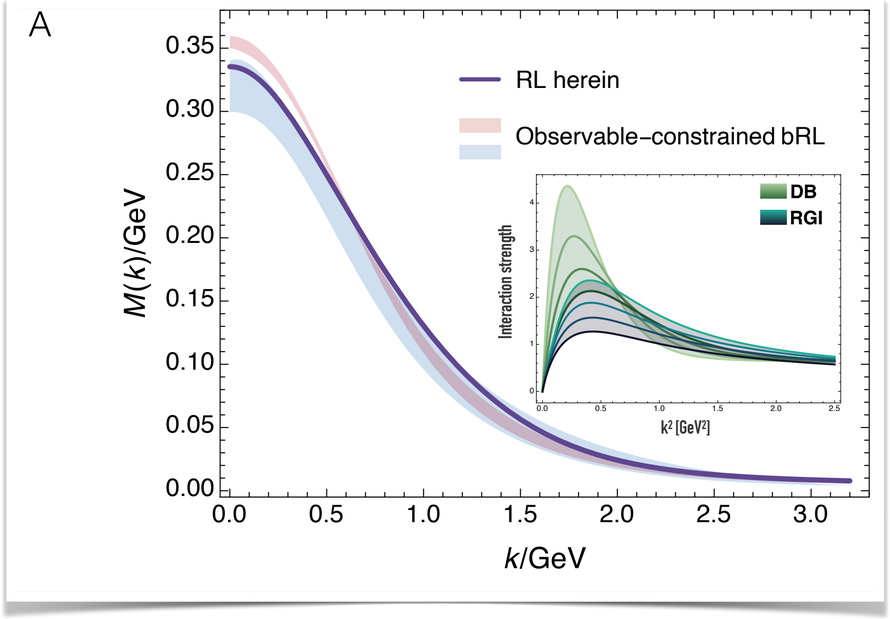

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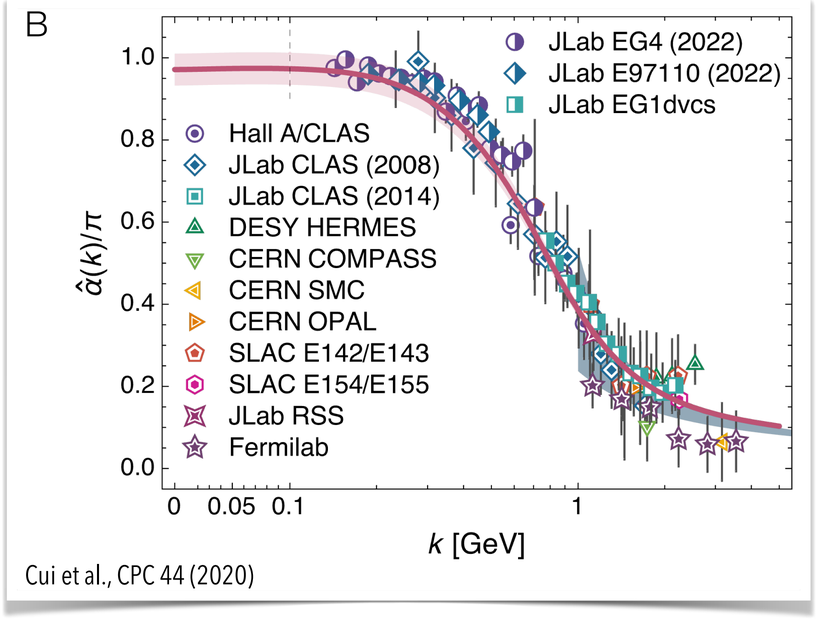

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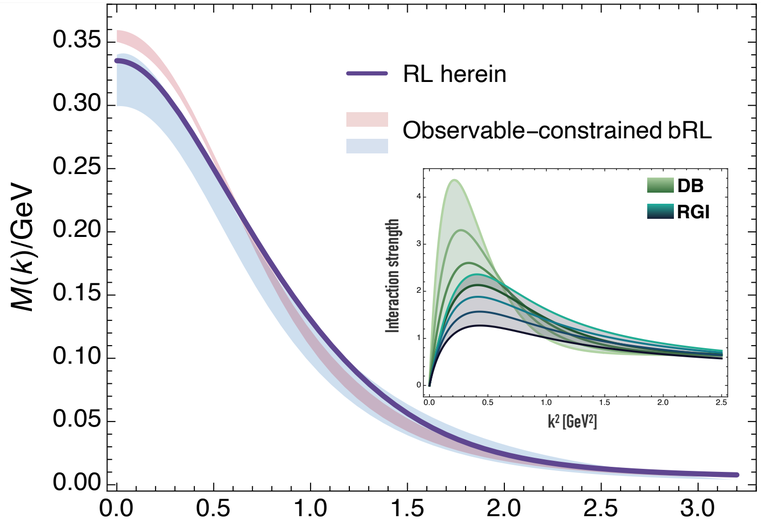

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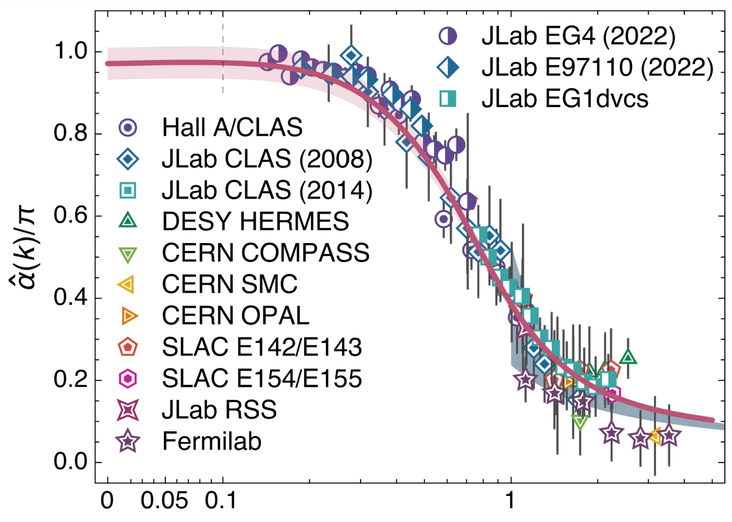

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$$m_g \sim 0.5 \text{ GeV}$$

Cornwall, PRD 26 (1982)

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2-point STI can be still satisfied with

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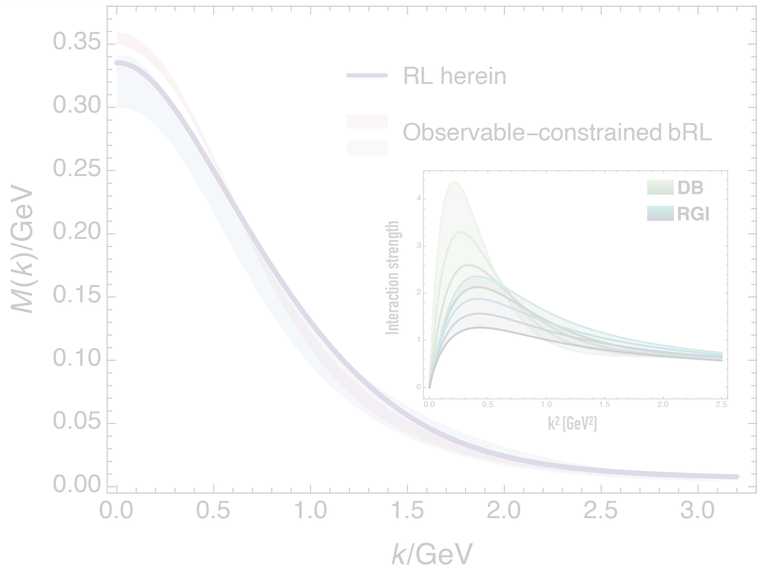

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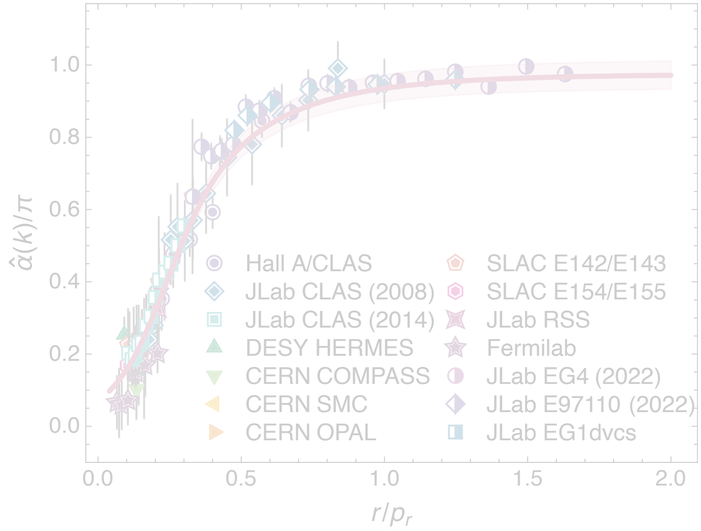

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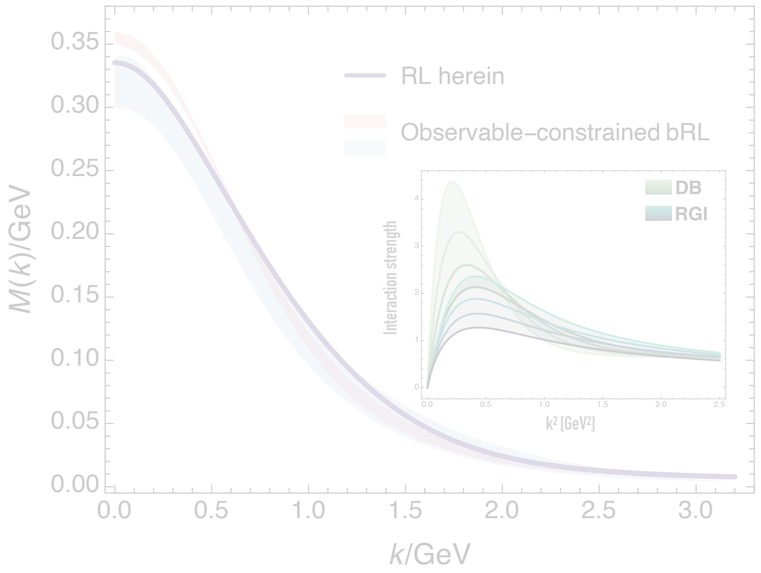

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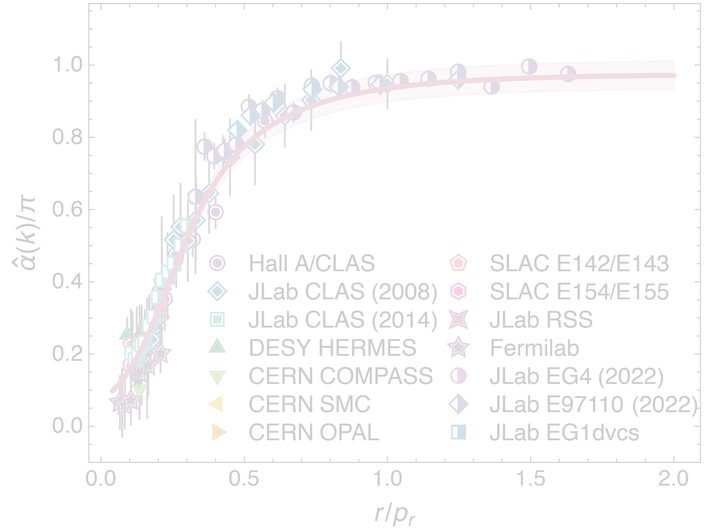

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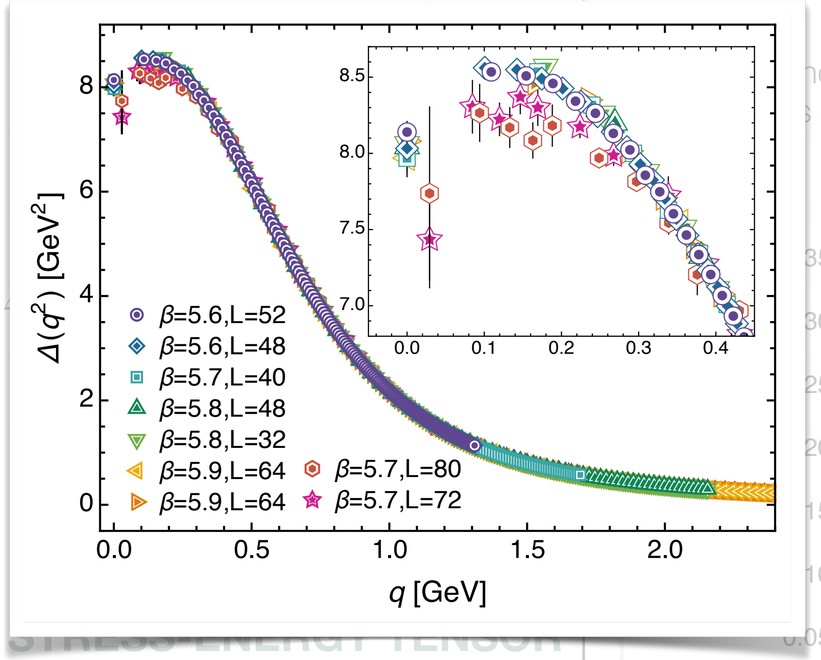

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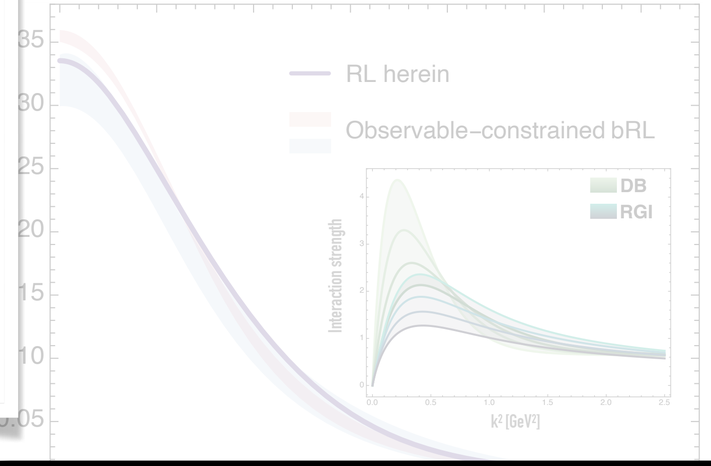

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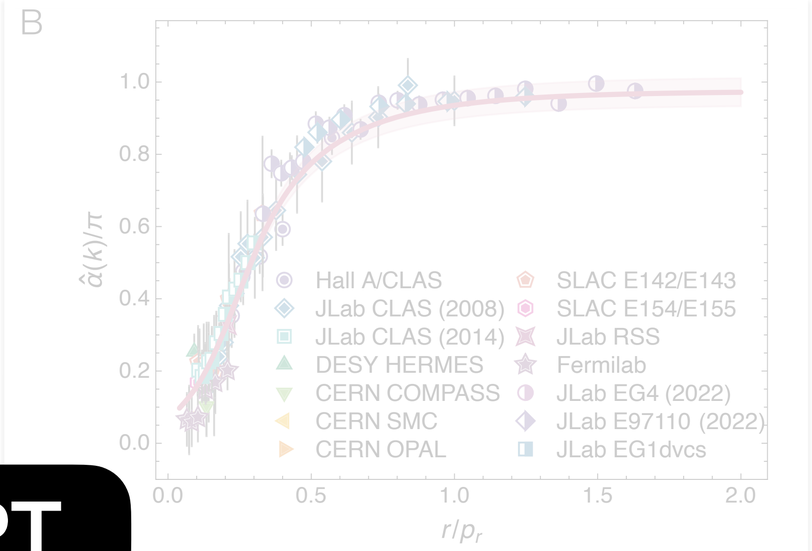

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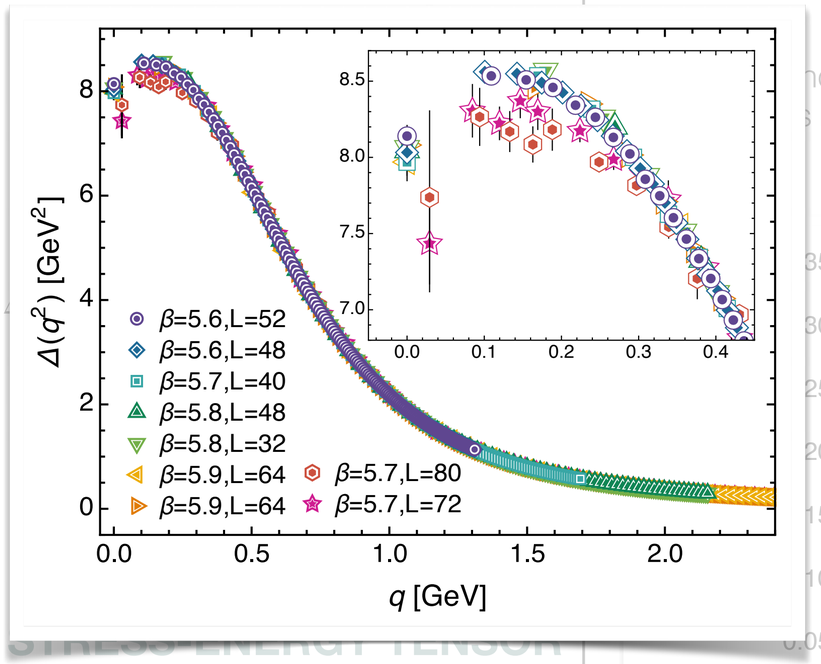

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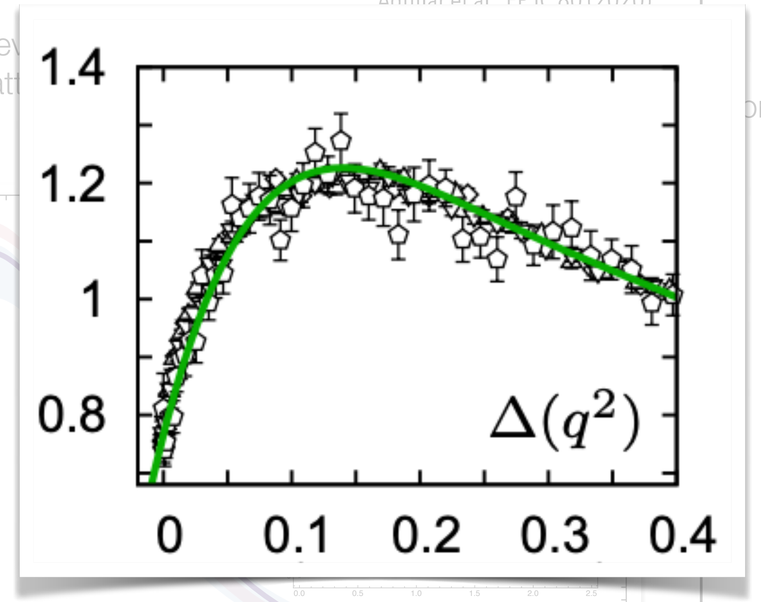

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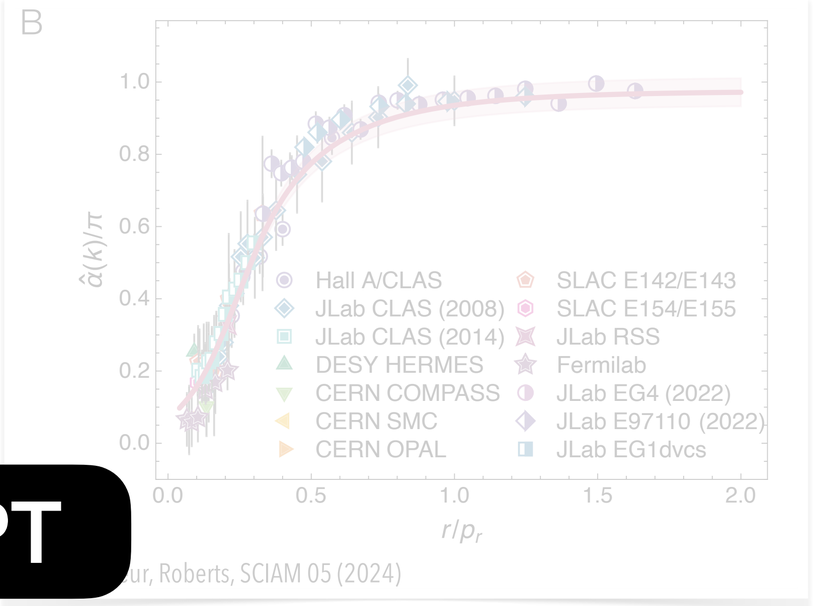

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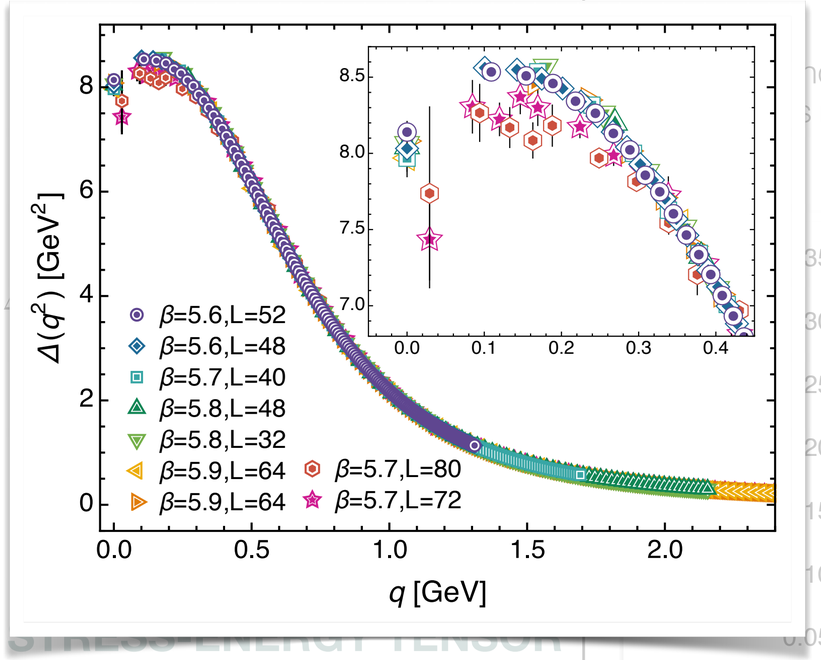

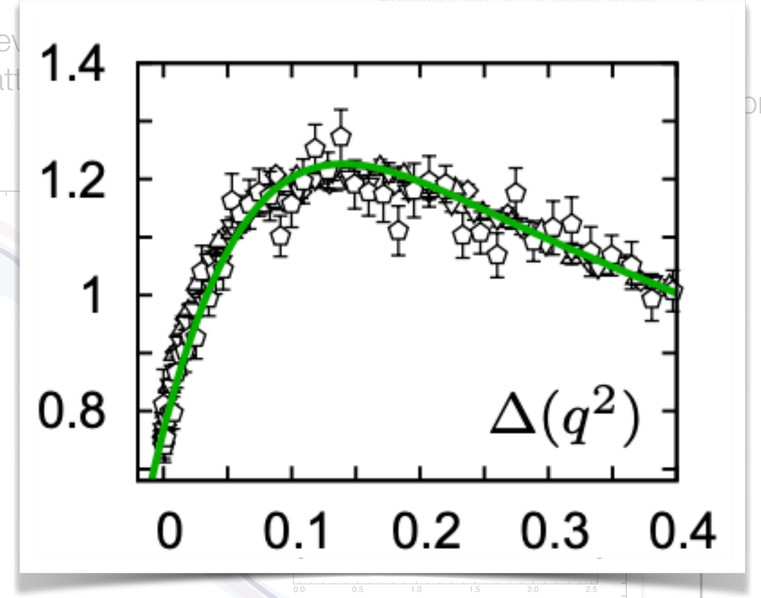

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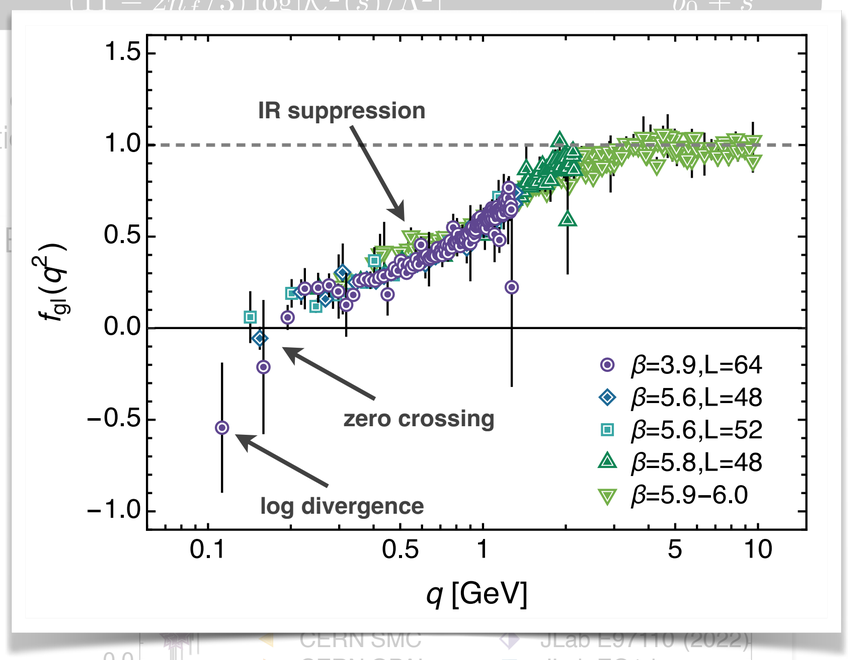

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Yao, DB, Roberts, PLB 855 (2024)

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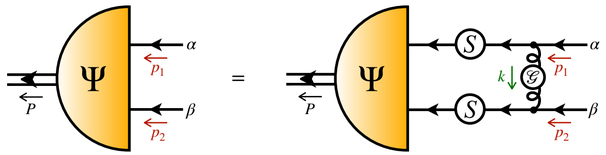

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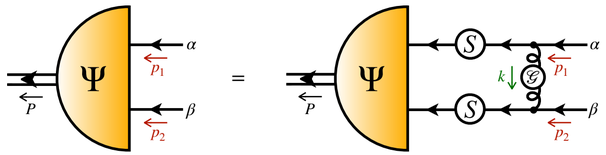

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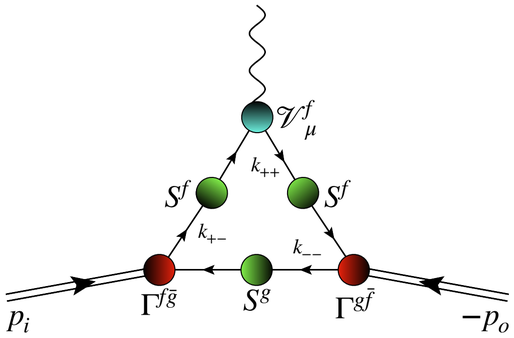

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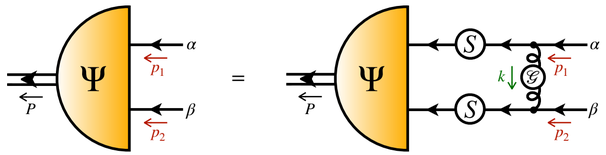

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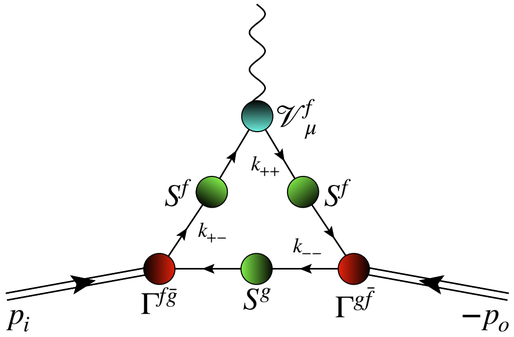



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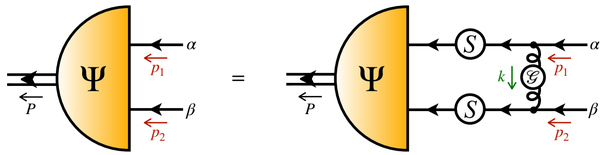

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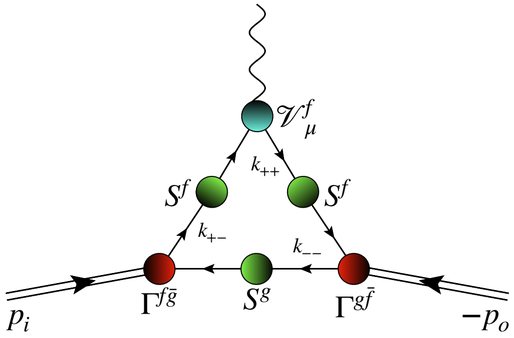



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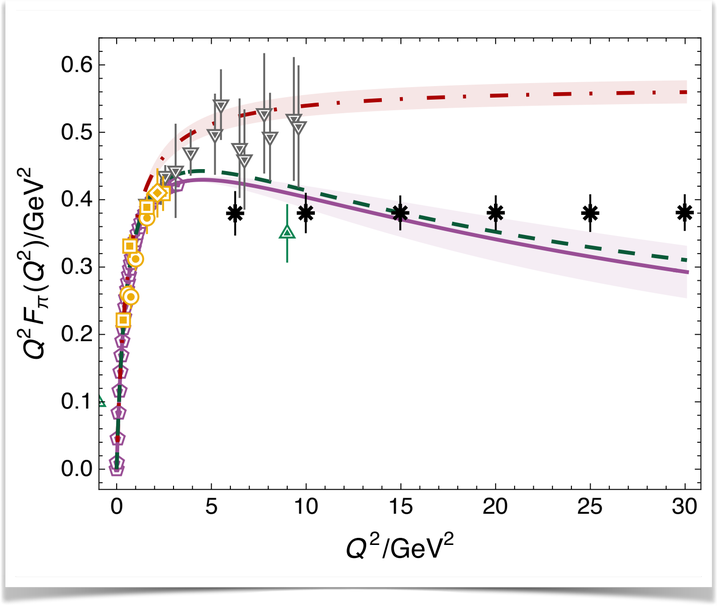

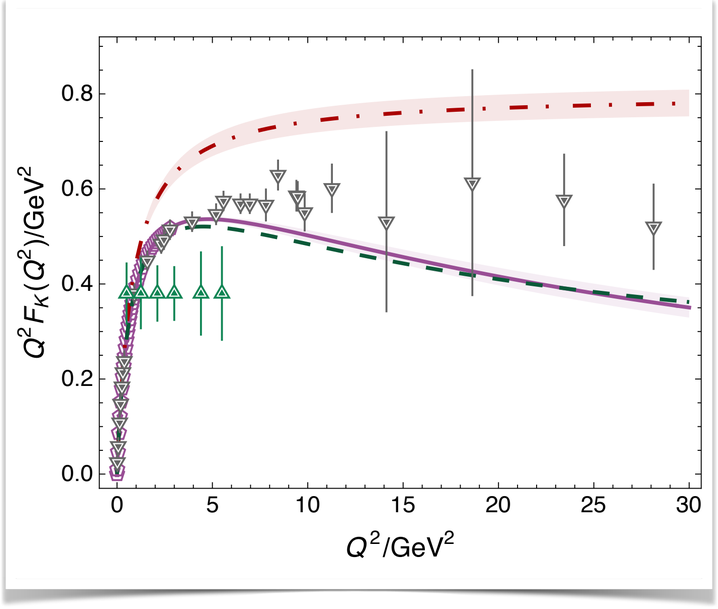

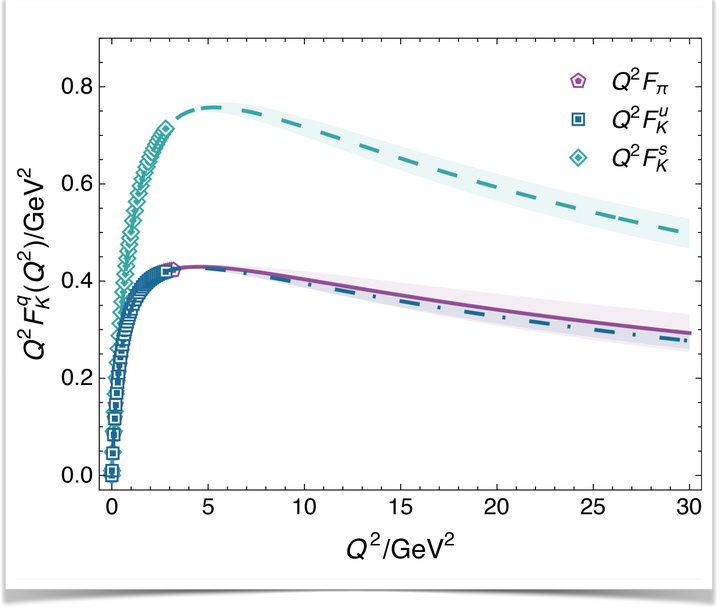

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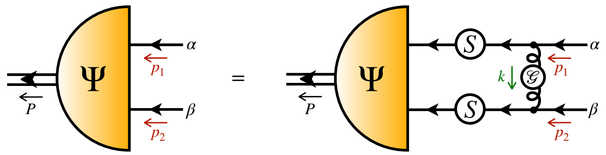

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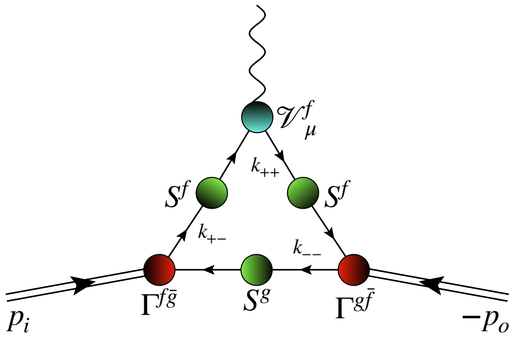



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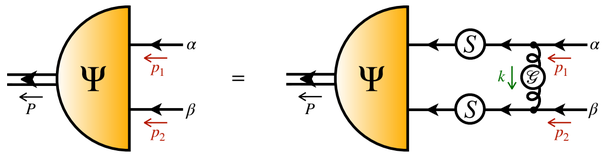

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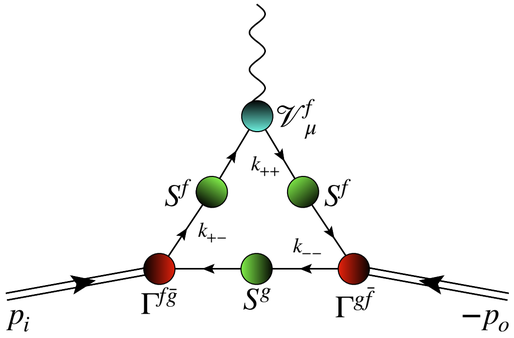



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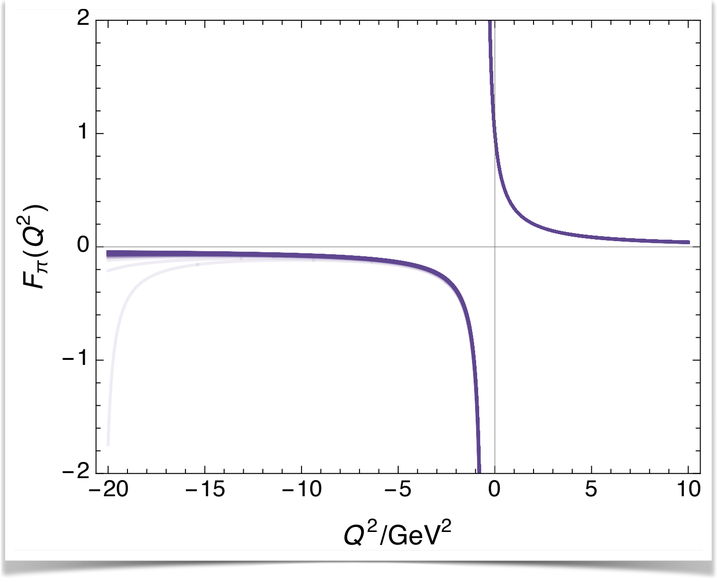
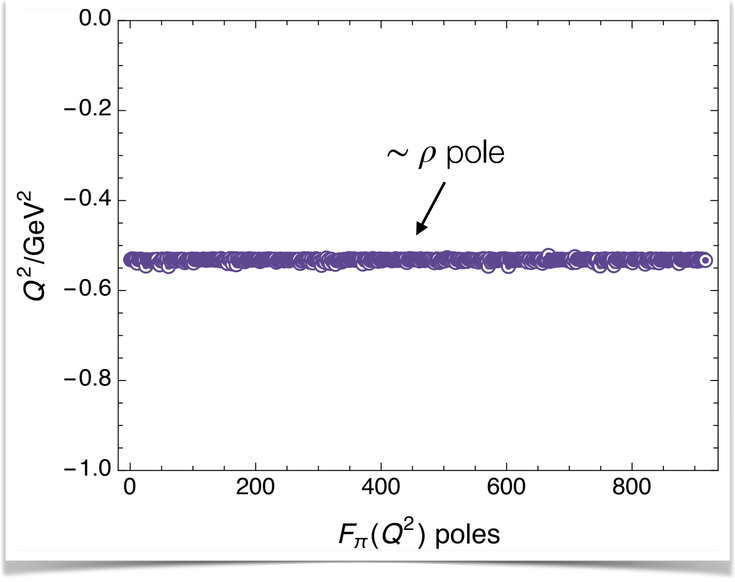
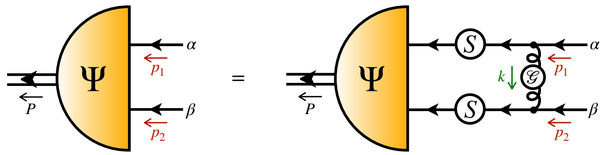




ELECTROMAGNETIC π/K FORM FACTORS

Yao, DB, Roberts, PLB 855 (2024)

BETHE-SALPETER EQUATION



dressed-quark propagators singularities limit mass of bound-state

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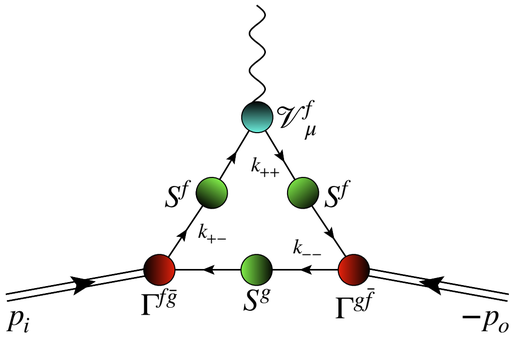
Q^2_{max}

TRIANGULAR DIAGRAM





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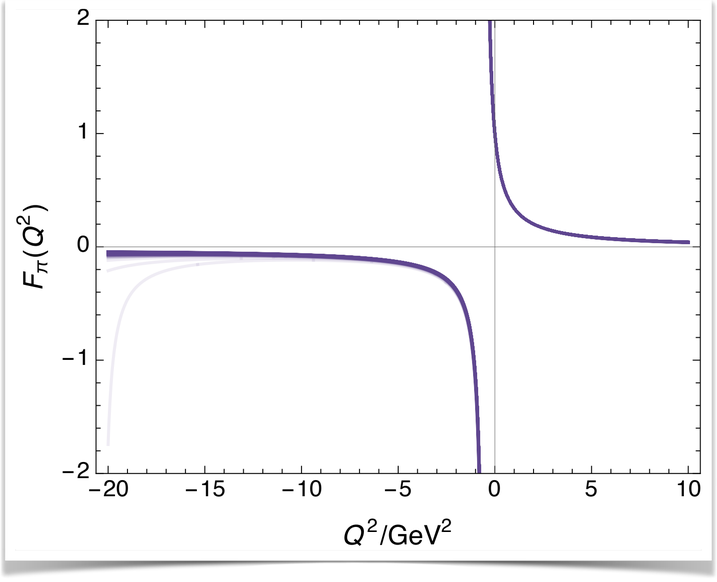

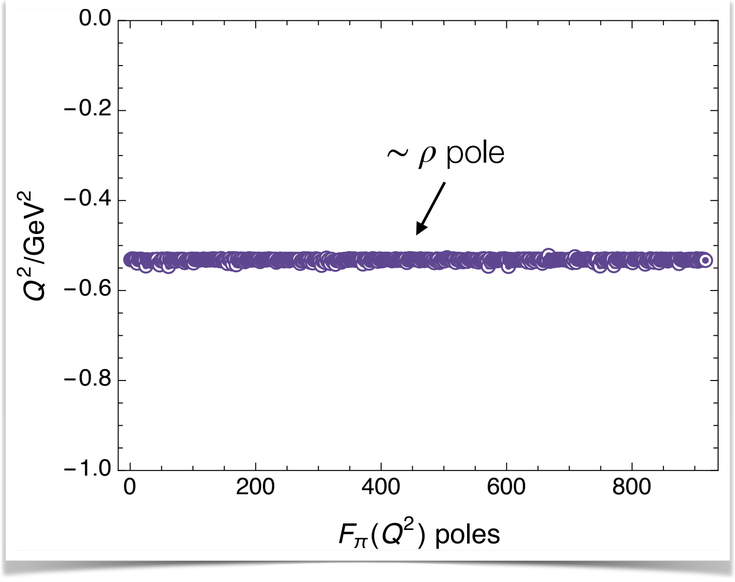

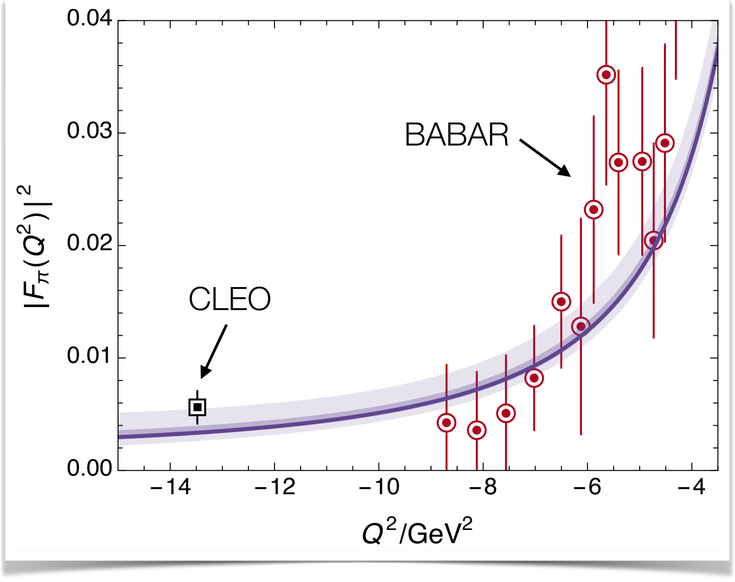

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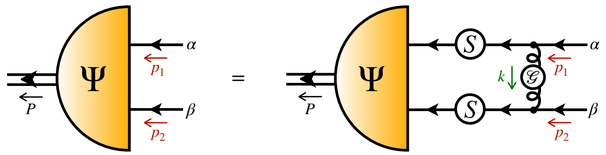

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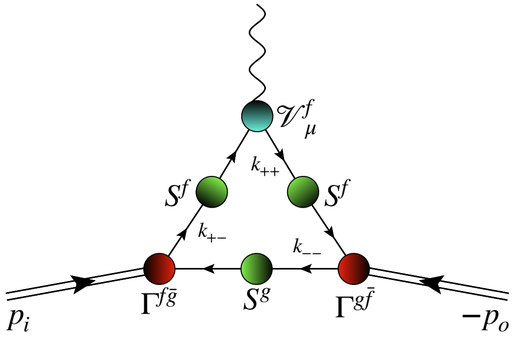



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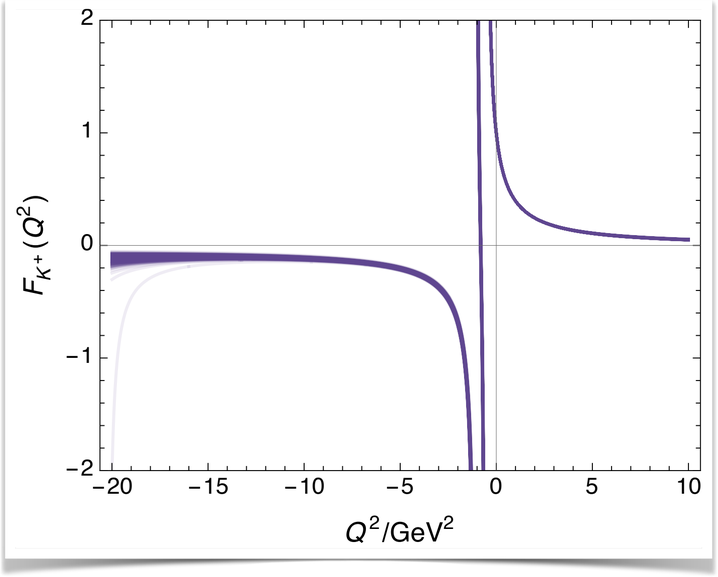

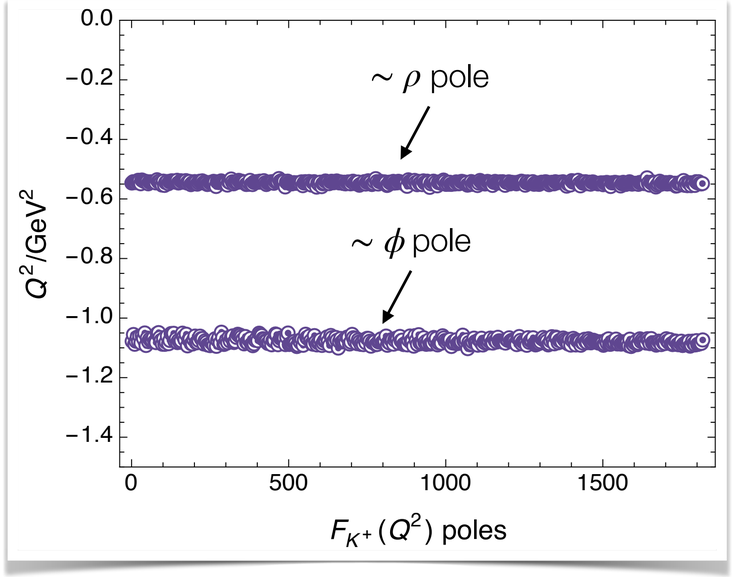

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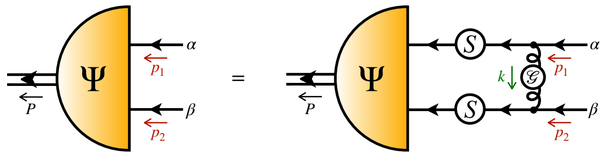

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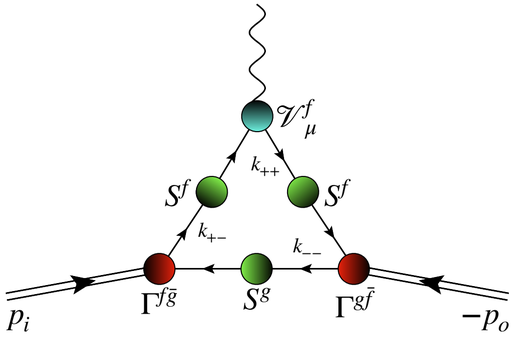



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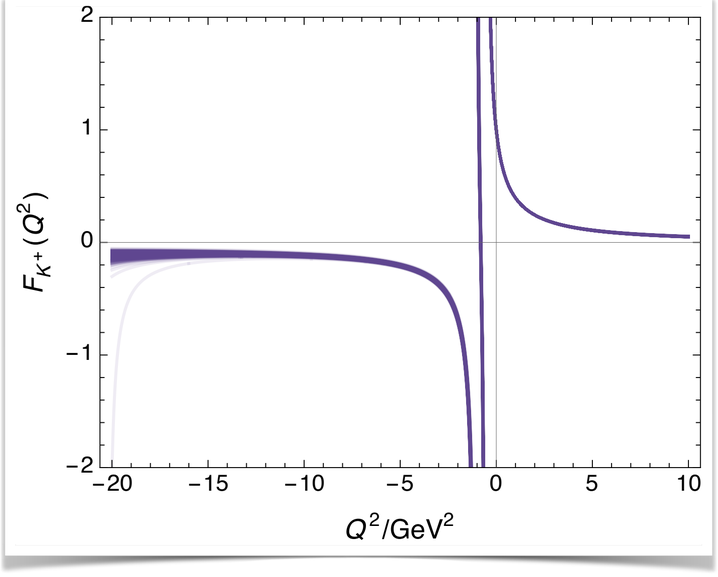
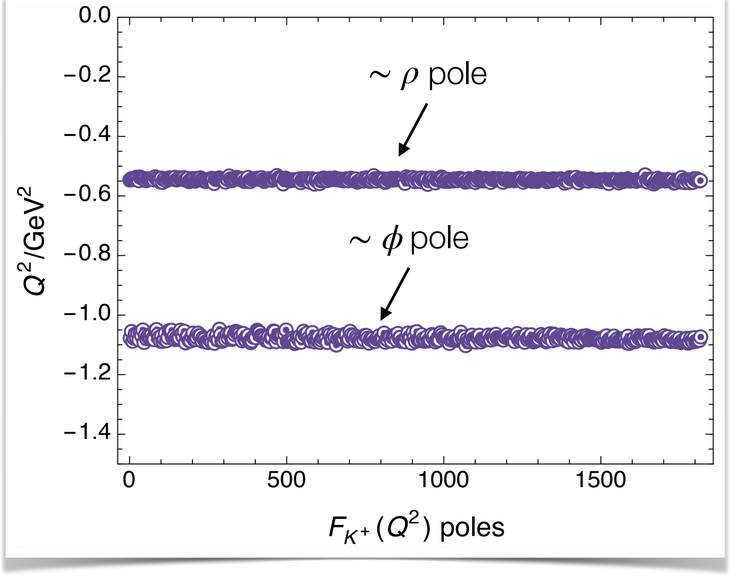
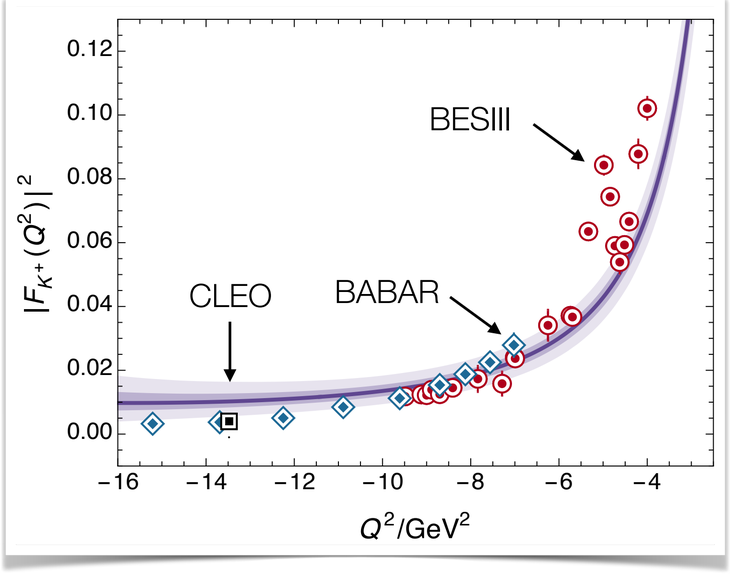
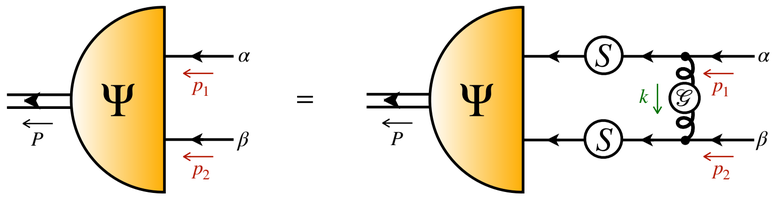






π/K PDFs

BETHE-SALPETER EQUATION



dressed-quark propagators singularities
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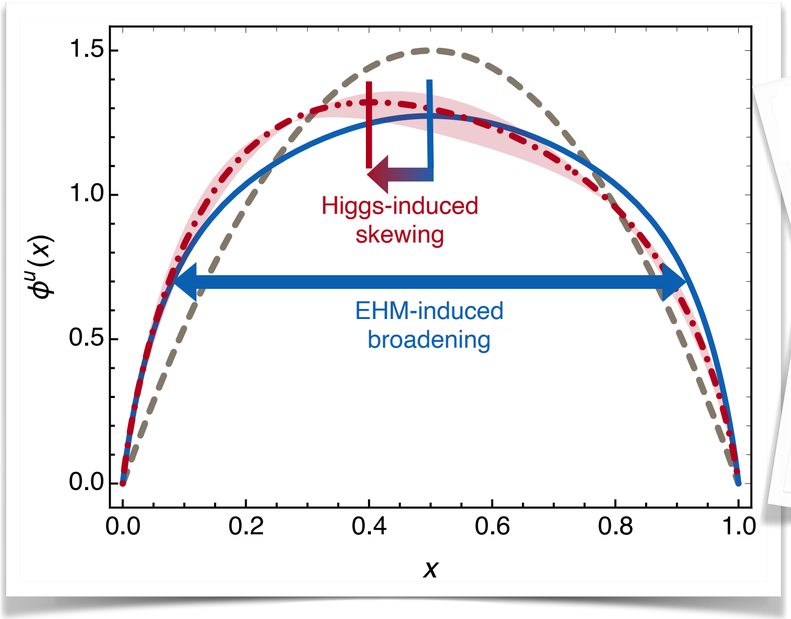
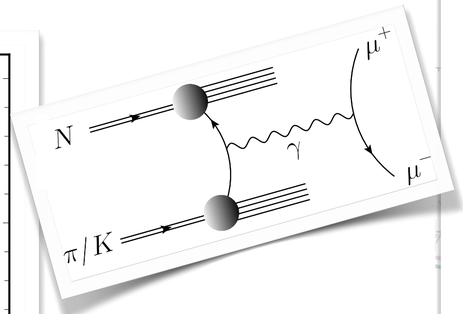
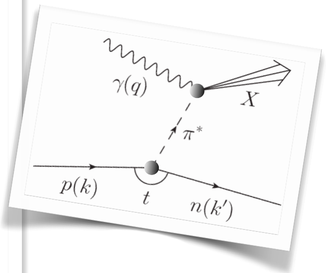
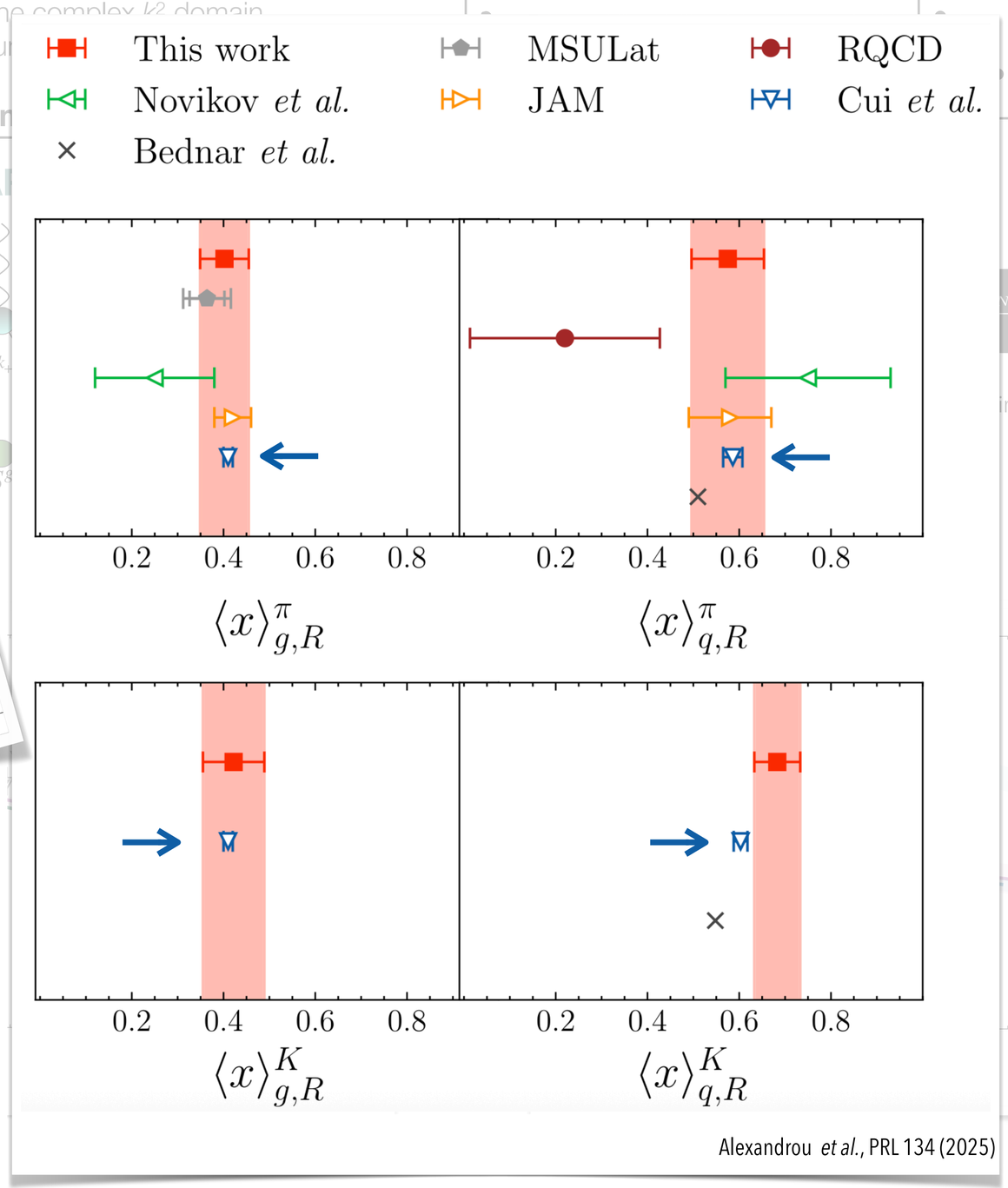






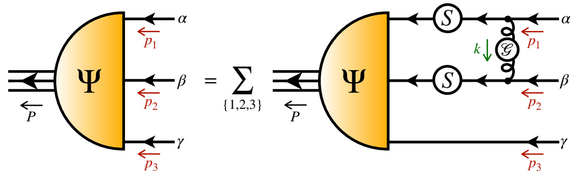


Alexandrou *et al.*, PRL 134 (2025)

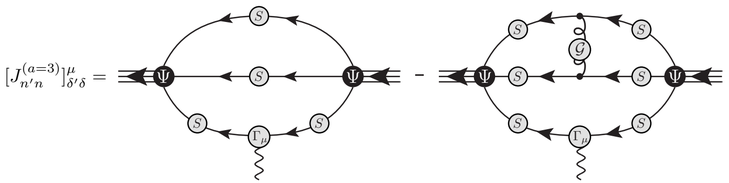
ELECTROMAGNETIC p/n FORM FACTORS

Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

FADDEEV EQUATION



TRIANGULAR DIAGRAM



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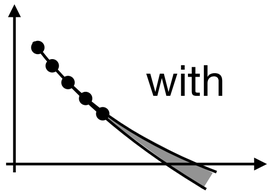

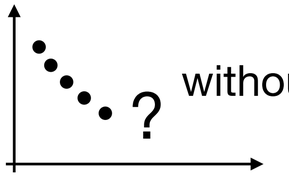

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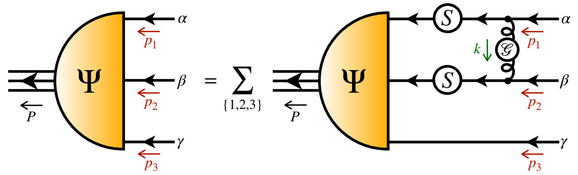
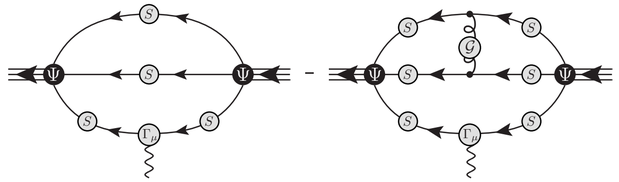


TRIANGULAR DIAGRAM

$[J^{(a=3)}_{n'n}]^{\mu}_{\delta'\delta} =$



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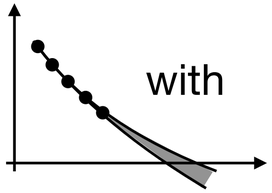

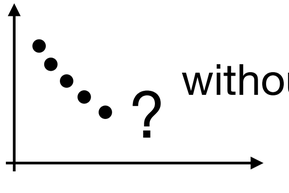

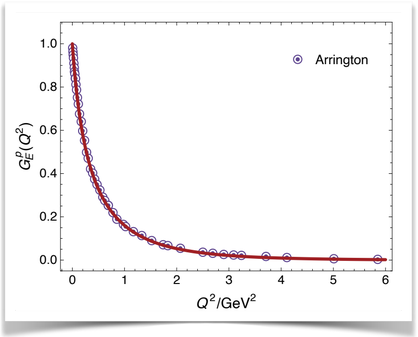

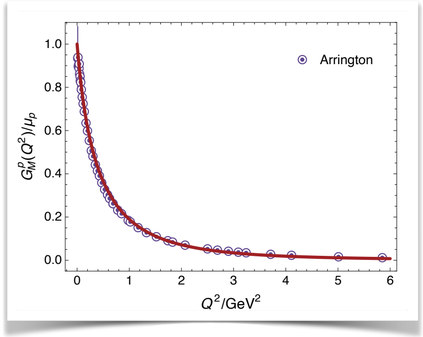

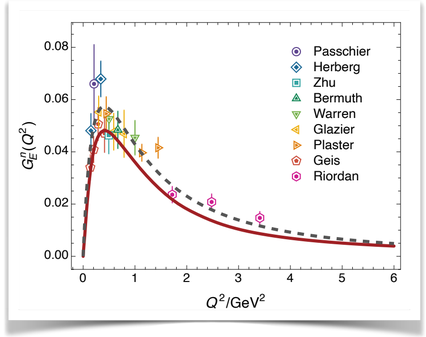

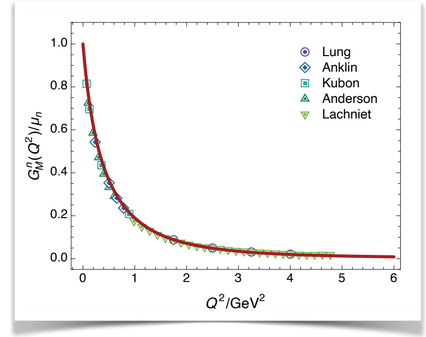

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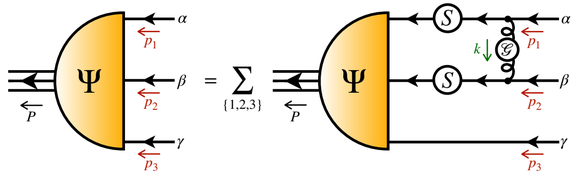

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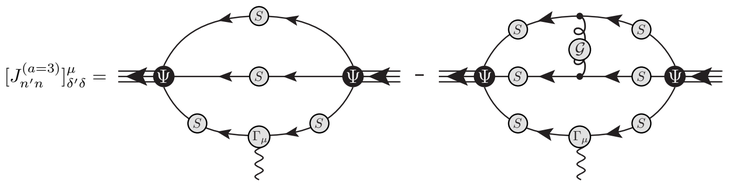

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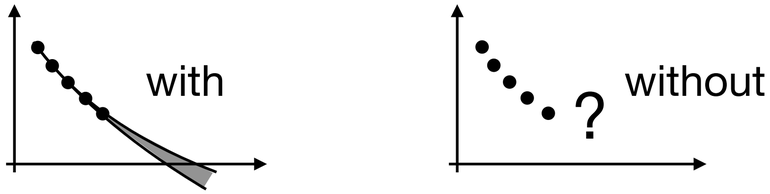

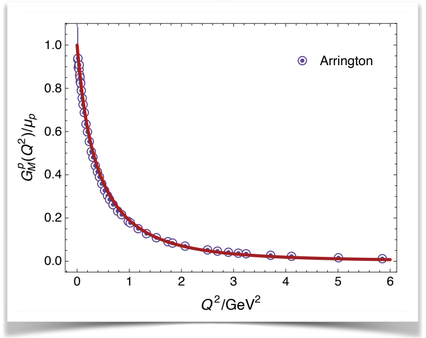

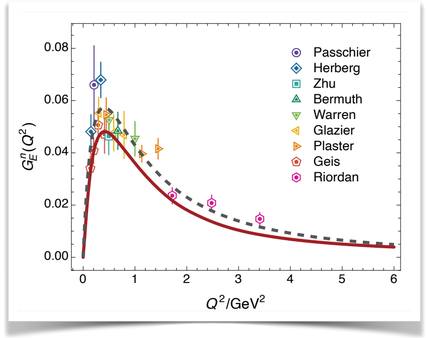

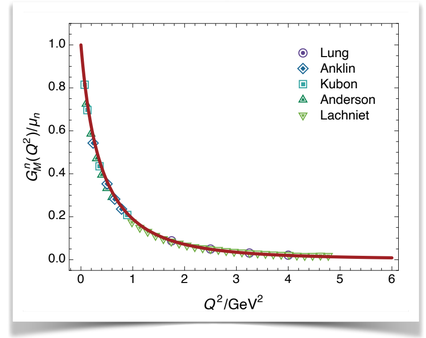

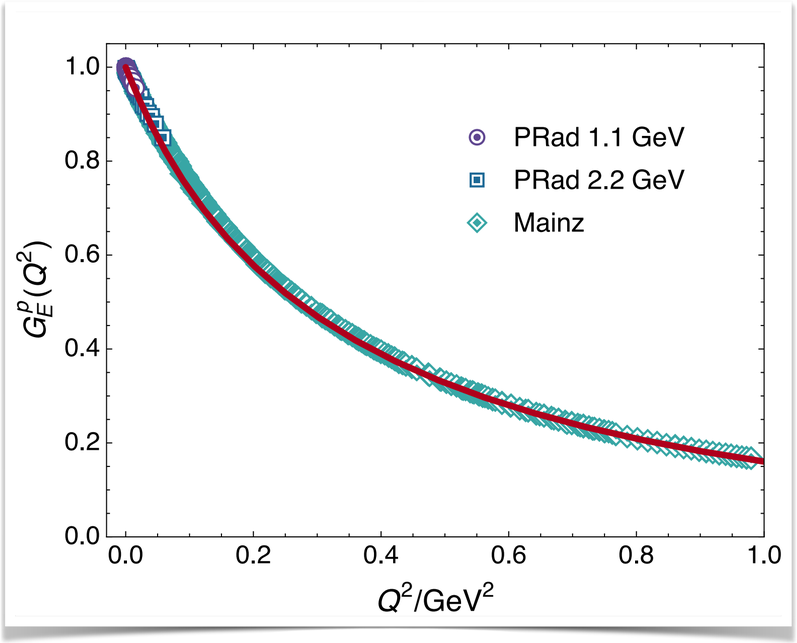

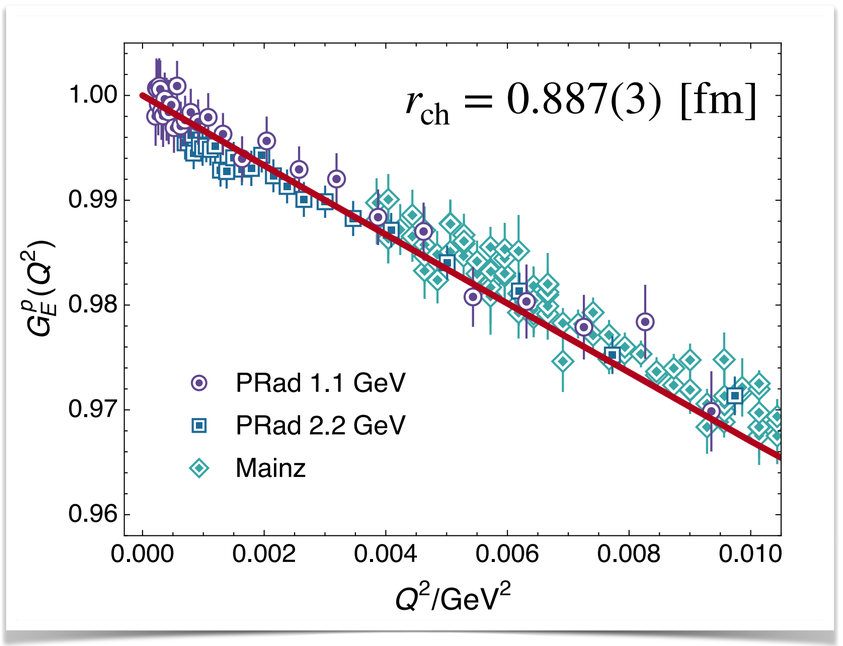

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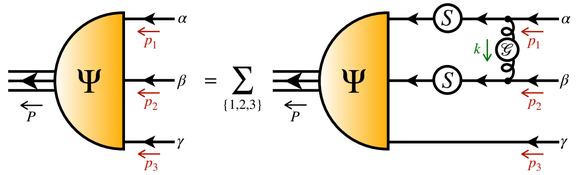

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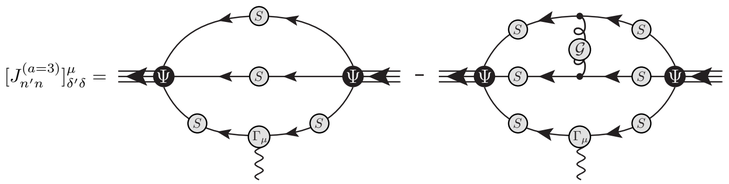

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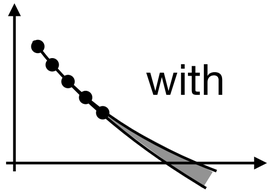
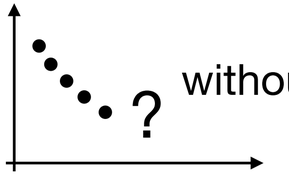
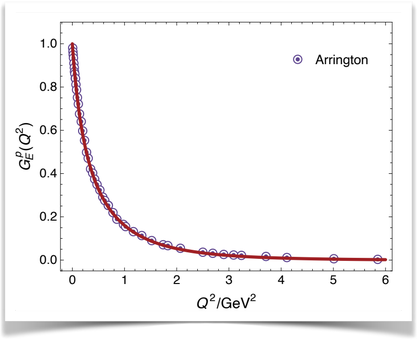
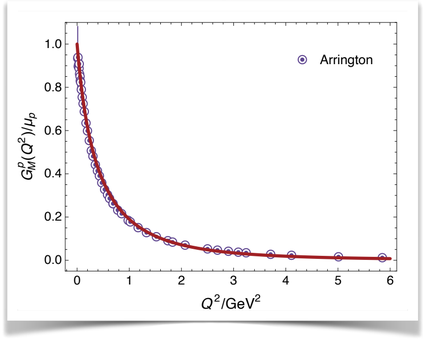
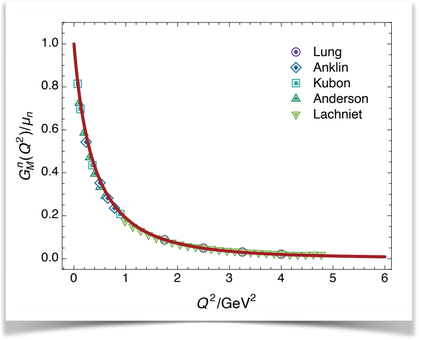
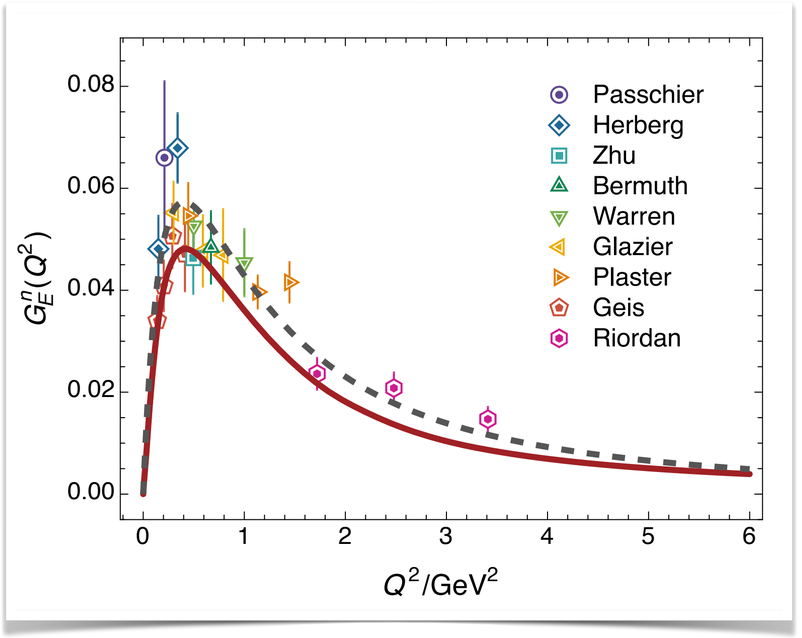


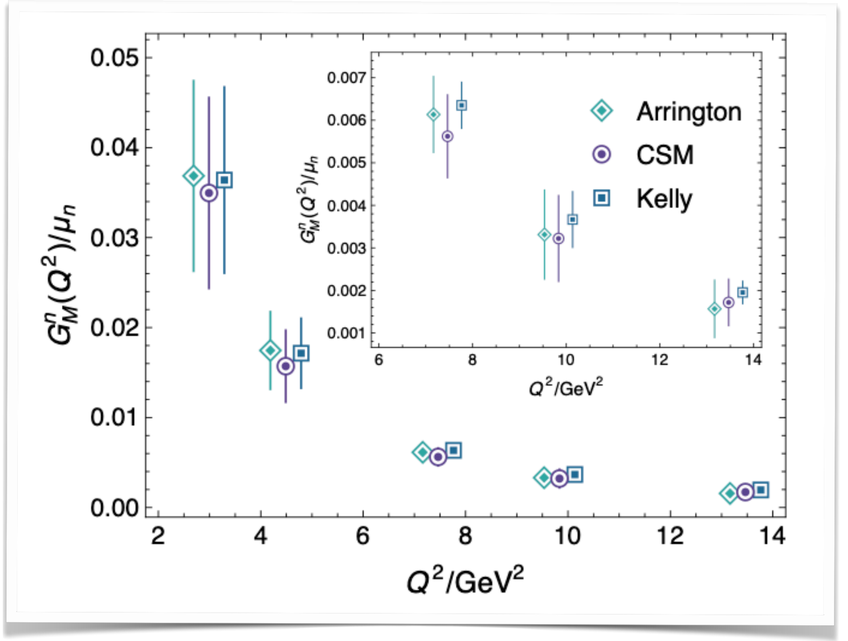








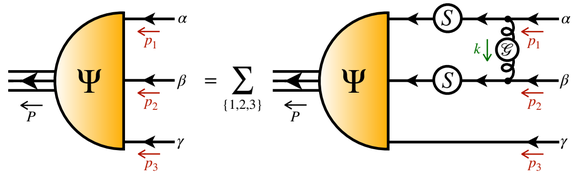




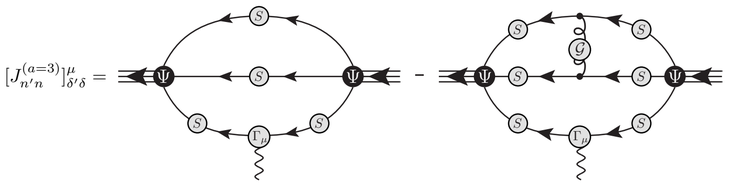
ELECTROMAGNETIC p/n FORM FACTORS

Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

FADDEEV EQUATION



TRIANGULAR DIAGRAM



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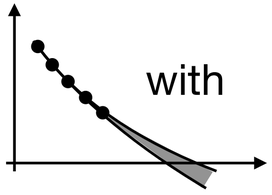

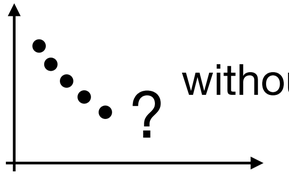

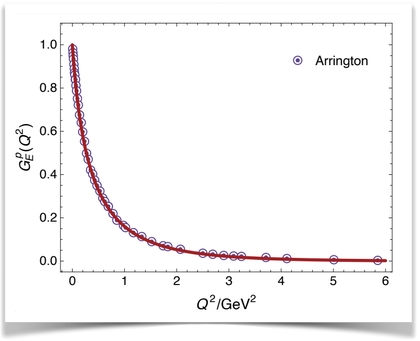

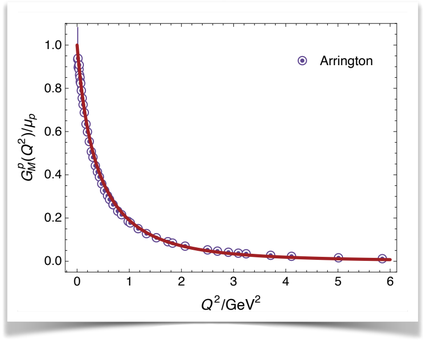

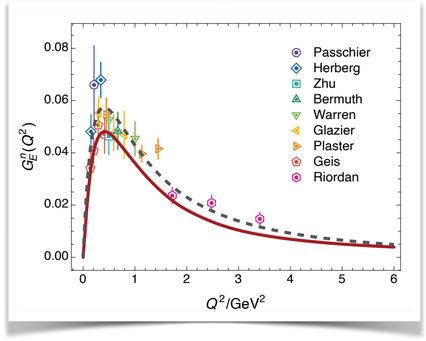

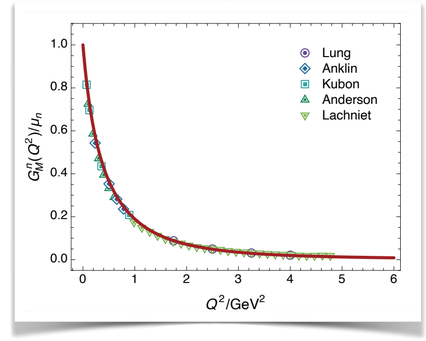

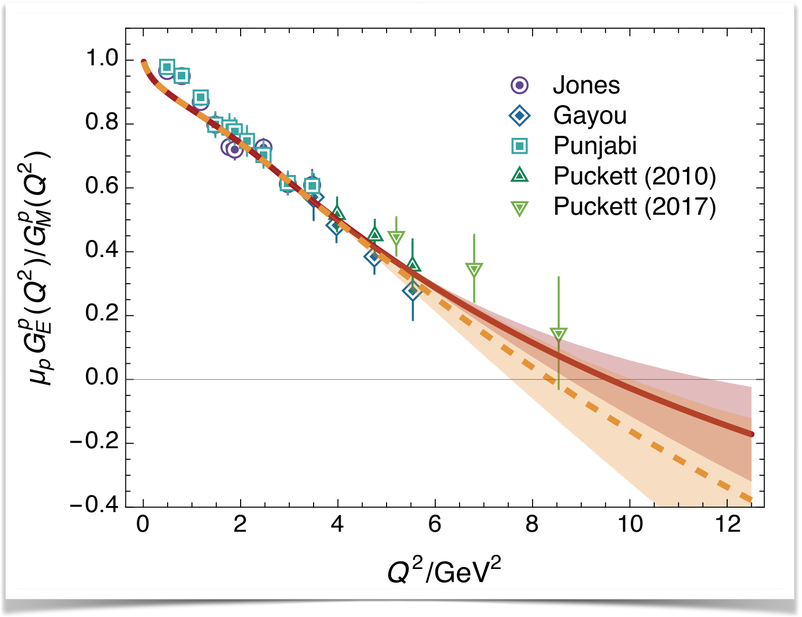

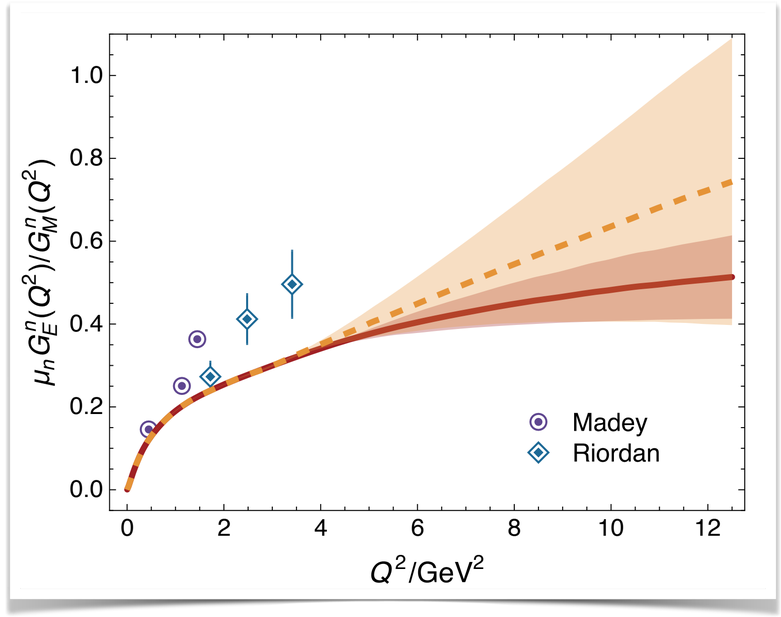

ELECTROMAGNETIC p/n FORM FACTORS

Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

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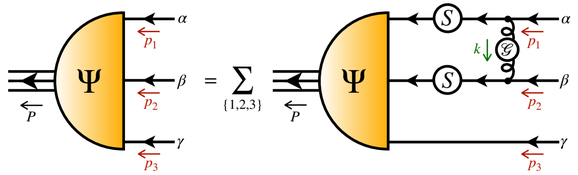
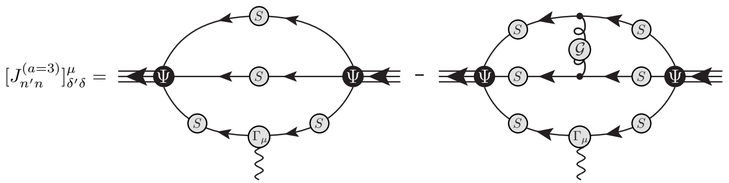


TRIANGULAR DIAGRAM



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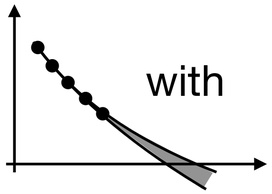

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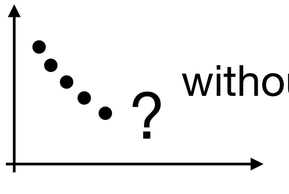

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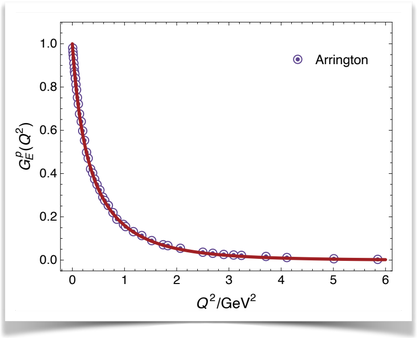
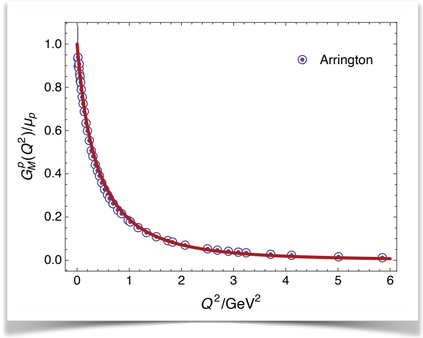
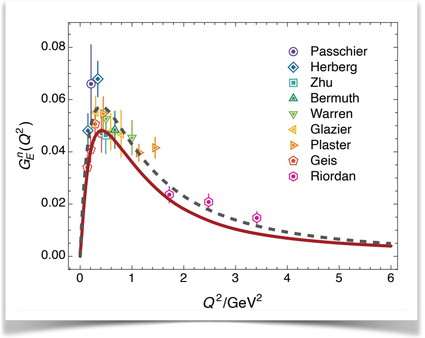
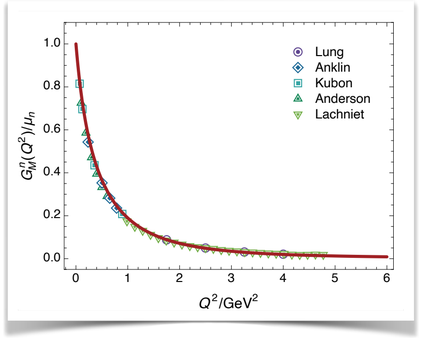
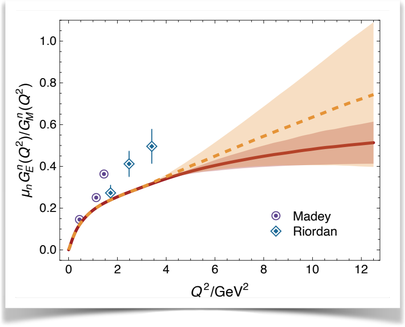
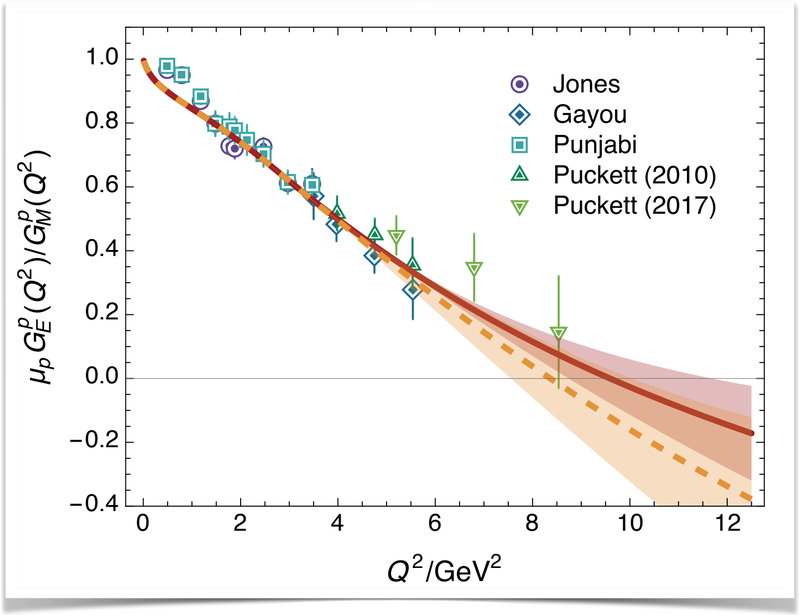


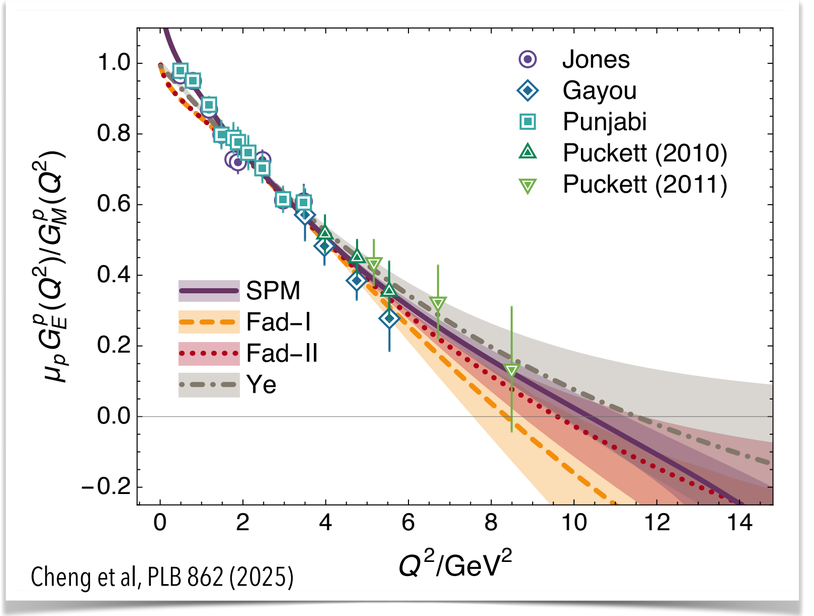








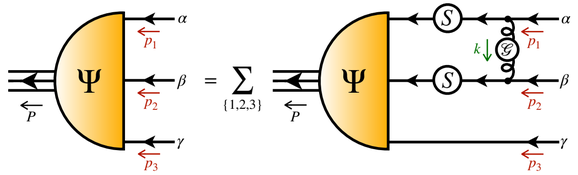




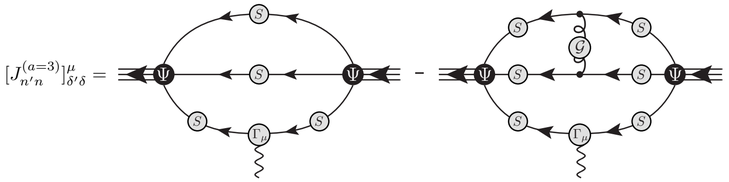
ELECTROMAGNETIC p/n FORM FACTORS

Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

FADDEEV EQUATION



TRIANGULAR DIAGRAM



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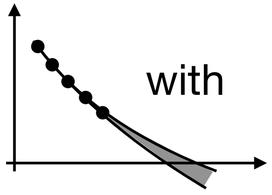
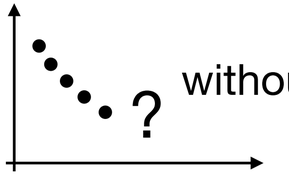
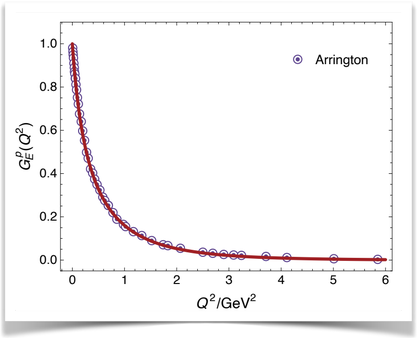
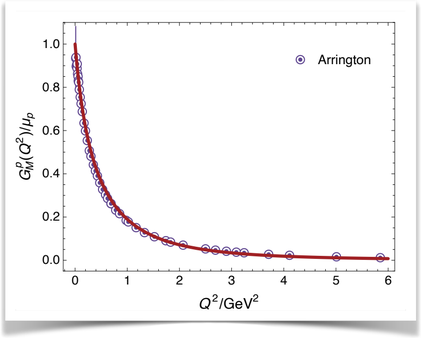
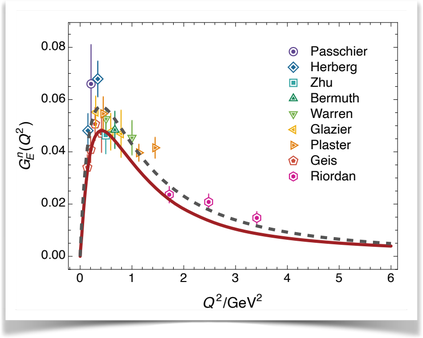
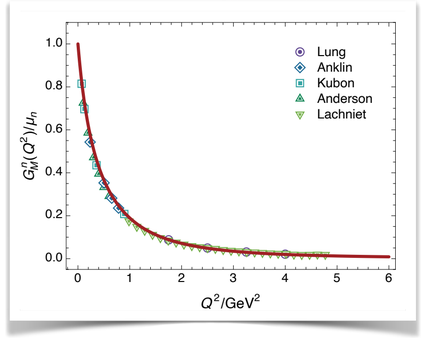


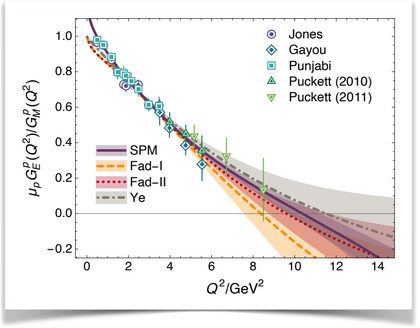


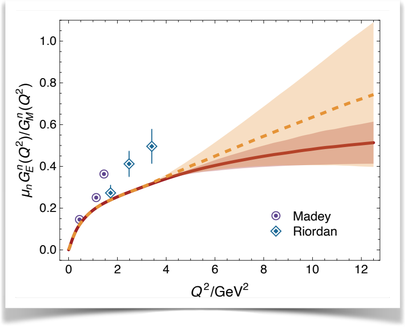


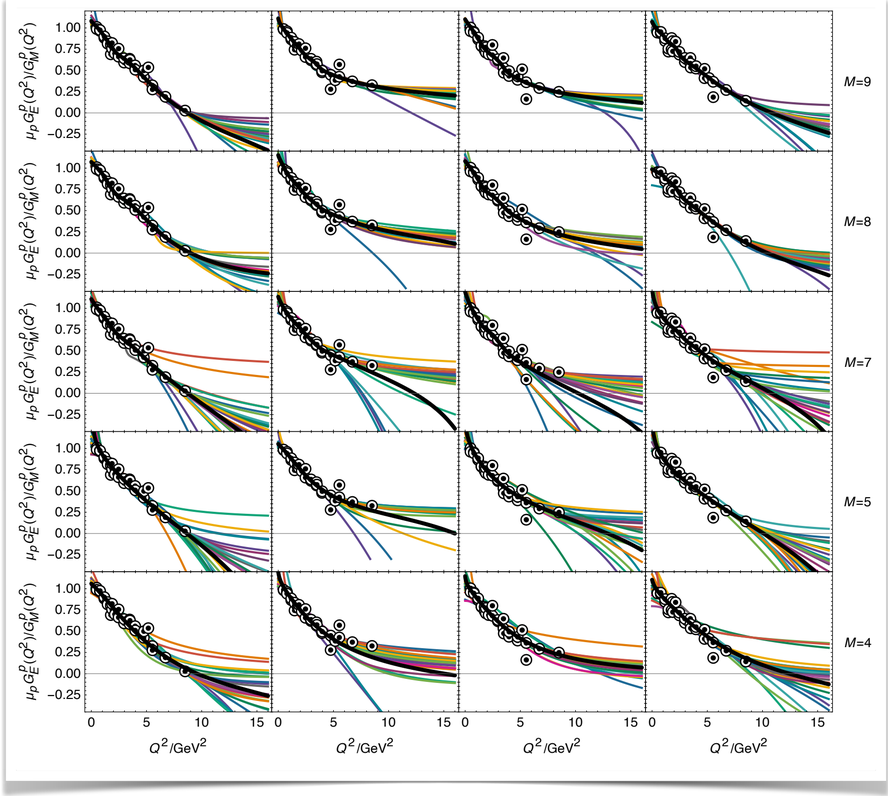








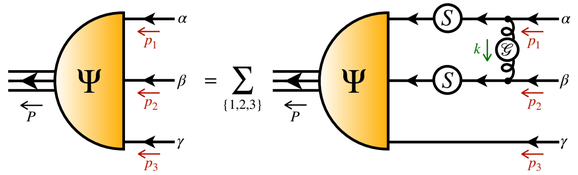




ELECTROMAGNETIC p/n FORM FACTORS

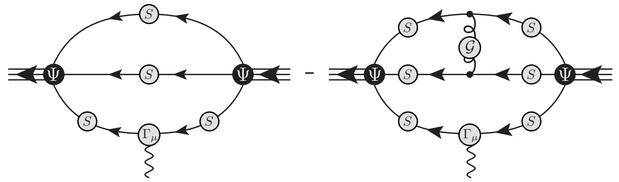
Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

FADDEEV EQUATION



TRIANGULAR DIAGRAM

$$[J^{(a=3)}_{n'n}]^{\mu}_{\delta'\delta} =$$



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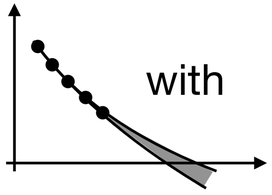
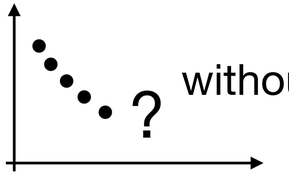


with



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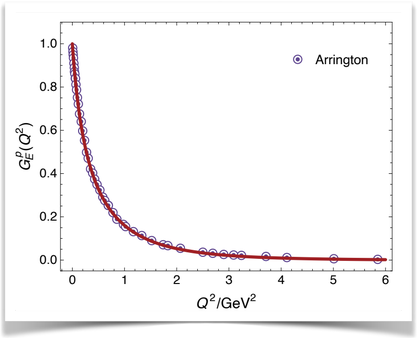

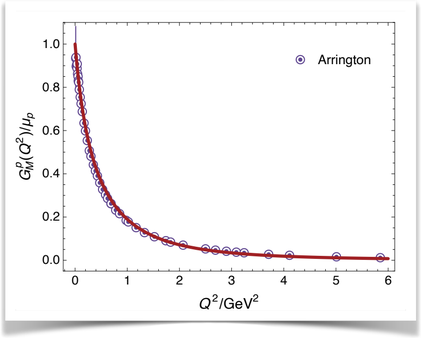

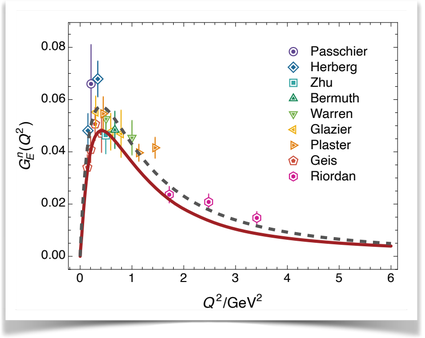

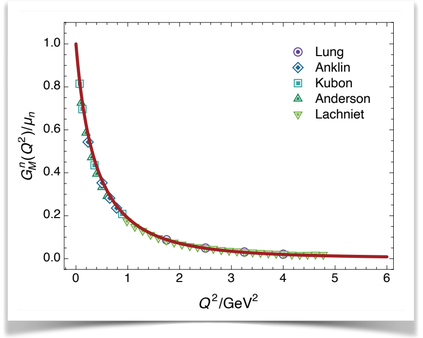

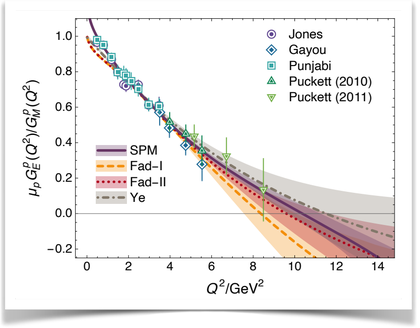

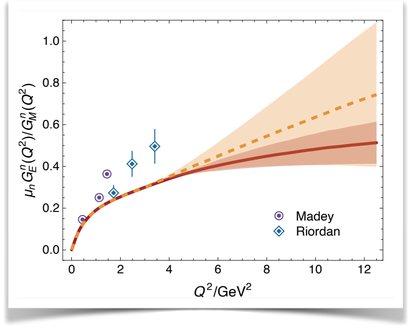

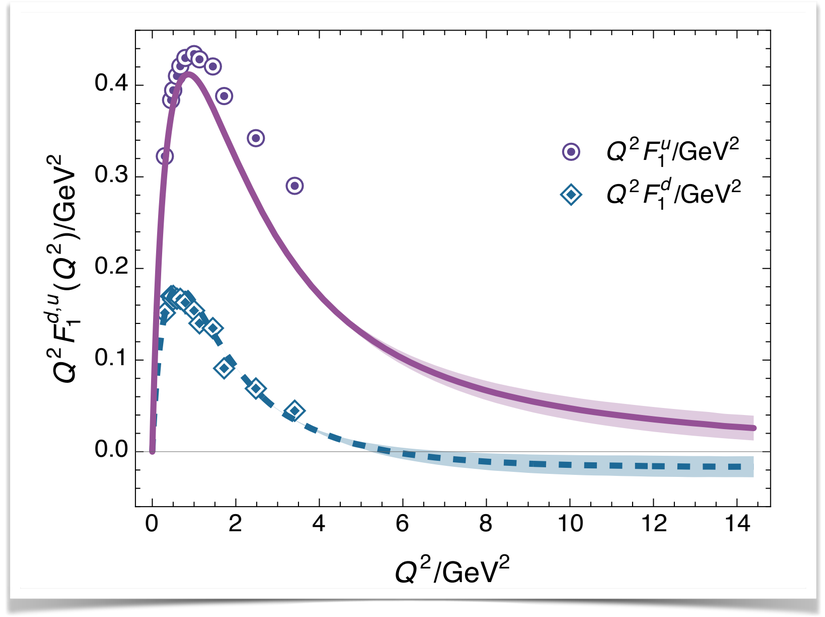

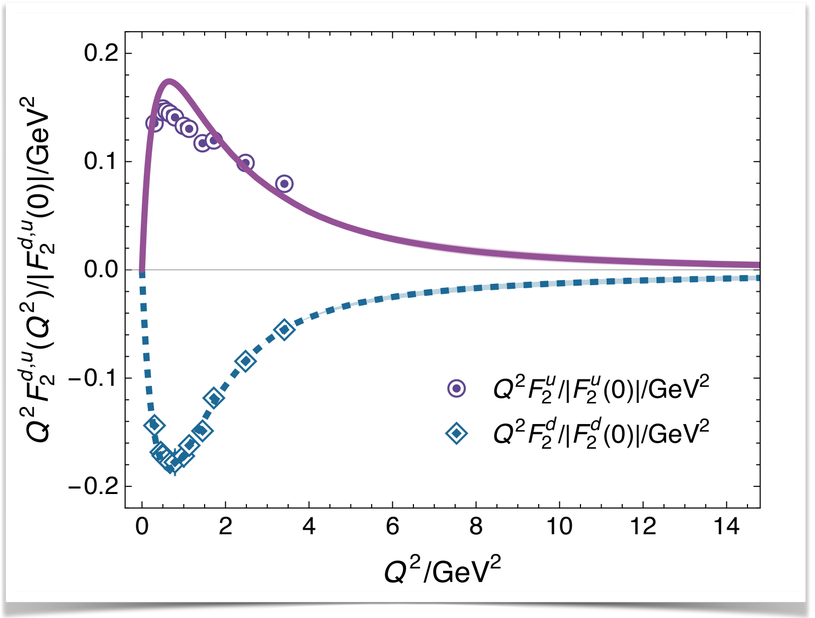

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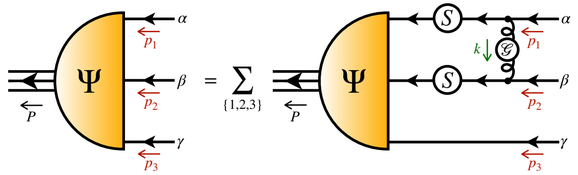
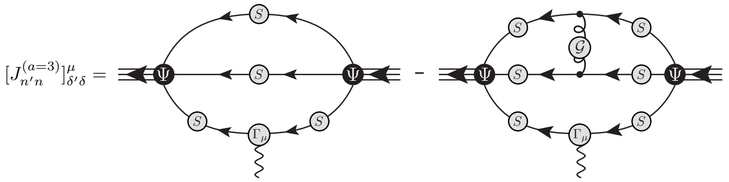
FADDEEV EQUATION



TRIANGULAR DIAGRAM



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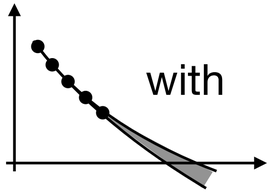
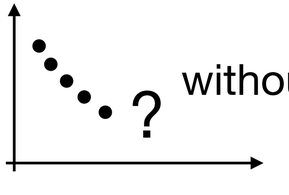
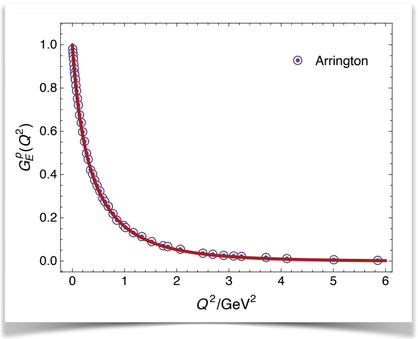
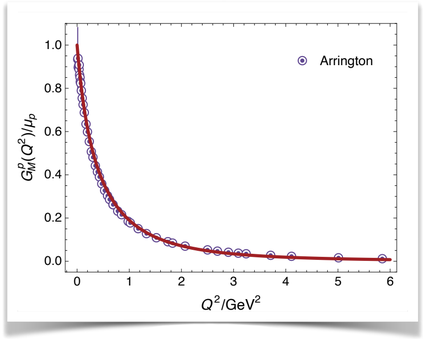
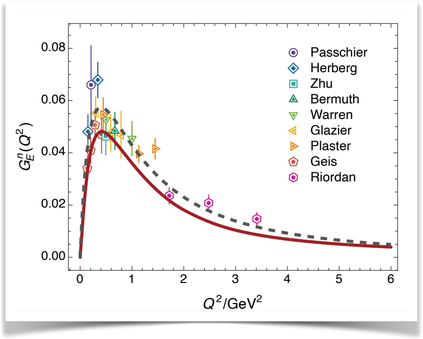
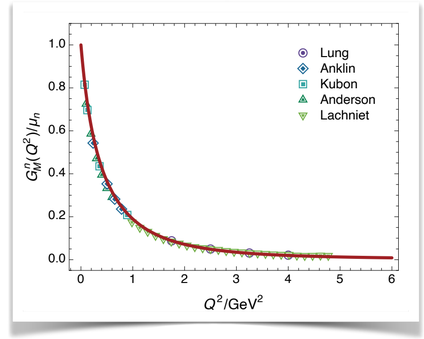


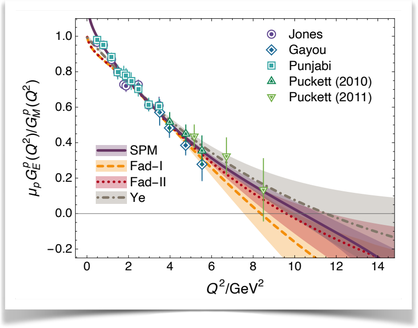


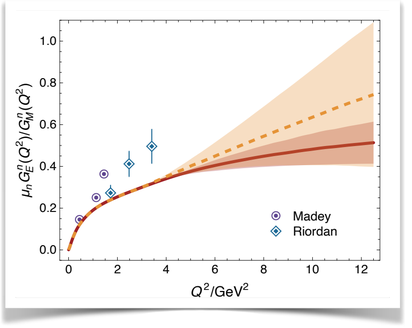


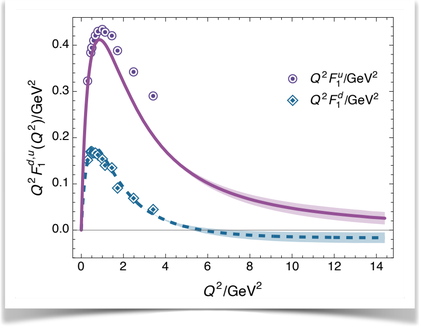


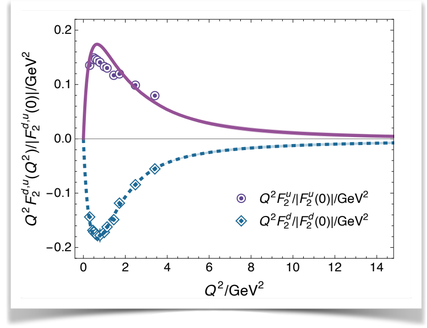


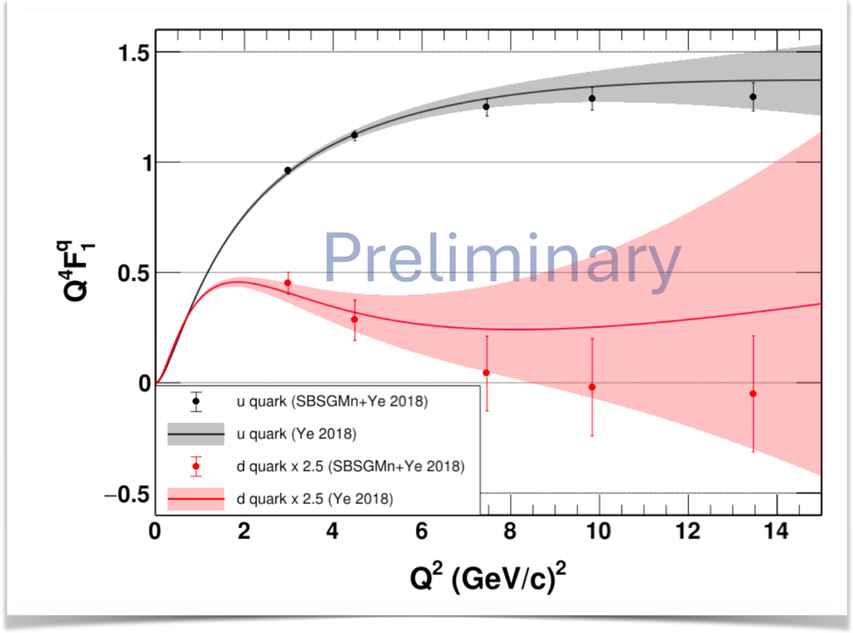












Jefferson Lab
Exploring the Nature of Matter

SUPER BIGBITE SPECTROMETER

Zero-crossing of F_1^d (linear fit to data)

$$Q^2 = 9.8 \pm 1.8\ \mathrm{GeV}^2$$

EHM prediction

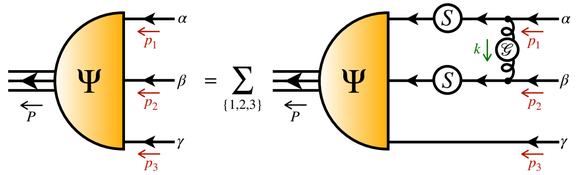
$$Q^2 = 5.7^{+1.5}_{-0.5}\ \mathrm{GeV}^2$$

experiment is only 1.4σ away from our prediction!

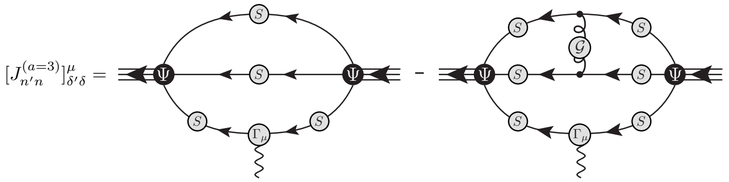
ELECTROMAGNETIC p/n FORM FACTORS

Yao, DB, Cui, Roberts, 2403.08088 (FR in press)

FADDEEV EQUATION



TRIANGULAR DIAGRAM



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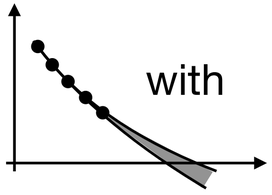
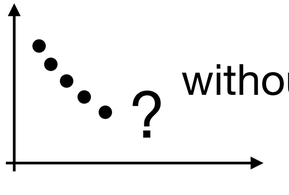
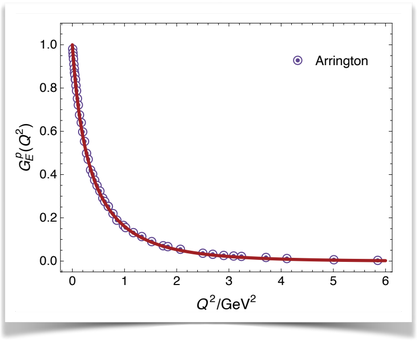
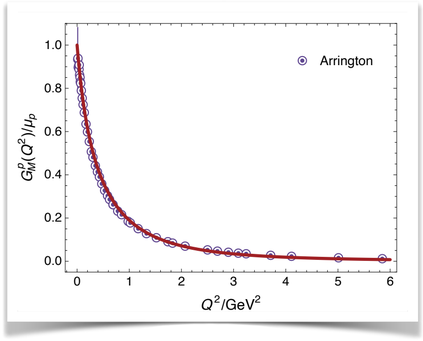
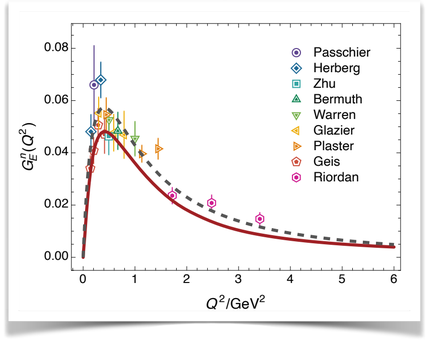
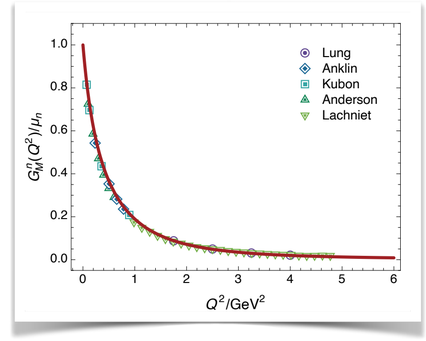


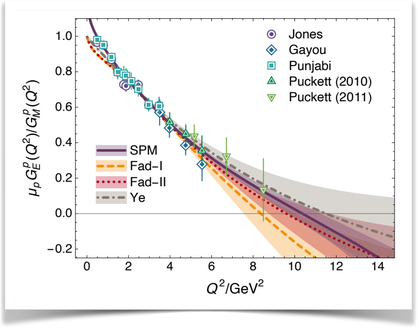


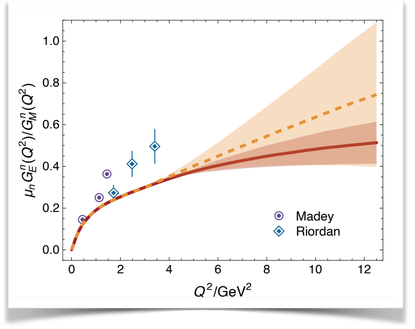


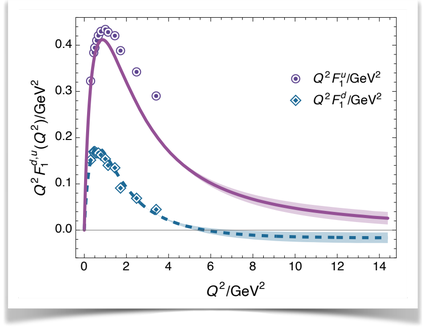


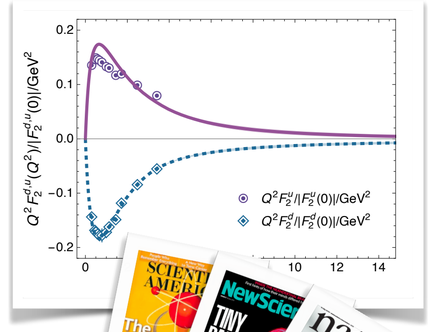




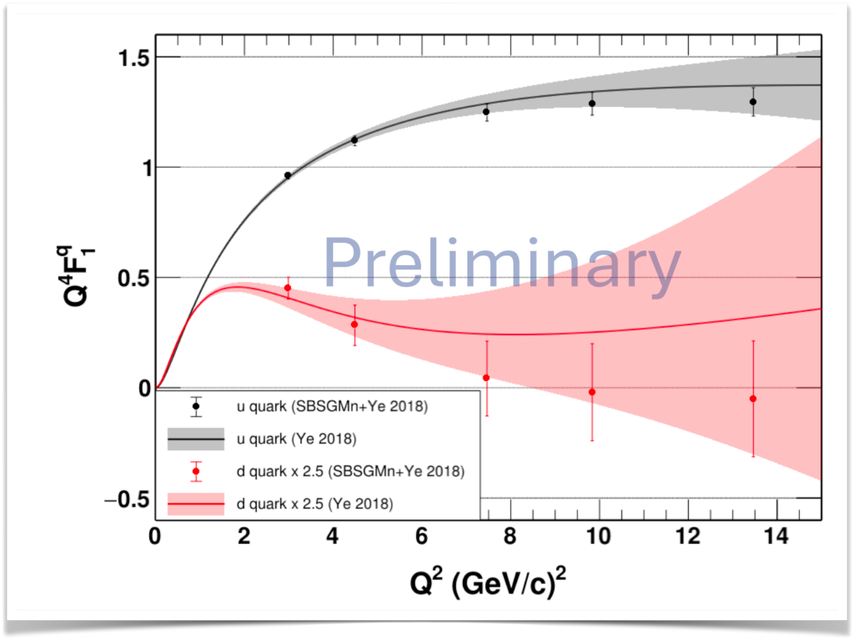


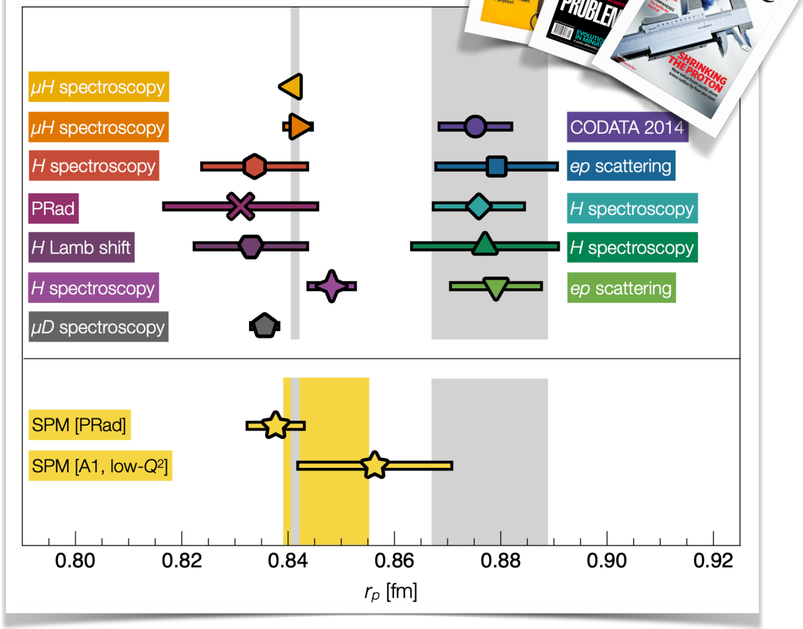










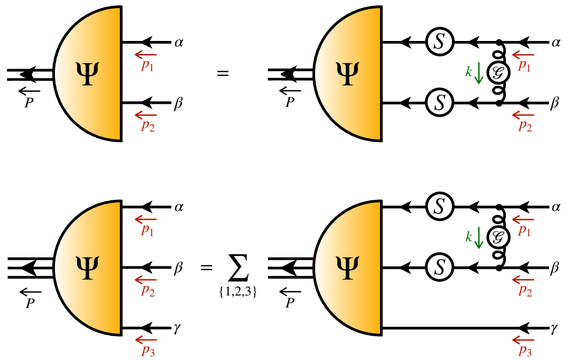


GRAVITATIONAL p/n FORM FACTORS

Yao et al, EPJA 61 (2025)



BETHE-SALPETER + FADDEEV EQUATIONS



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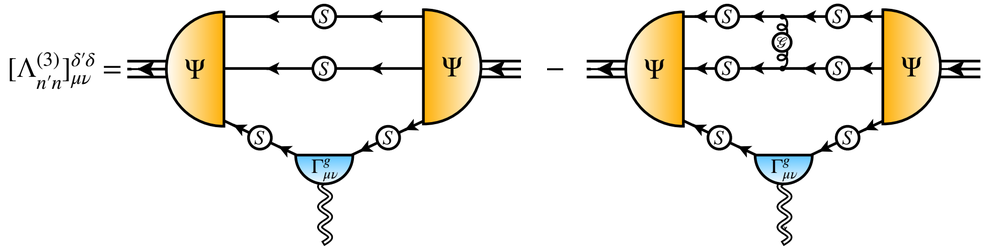

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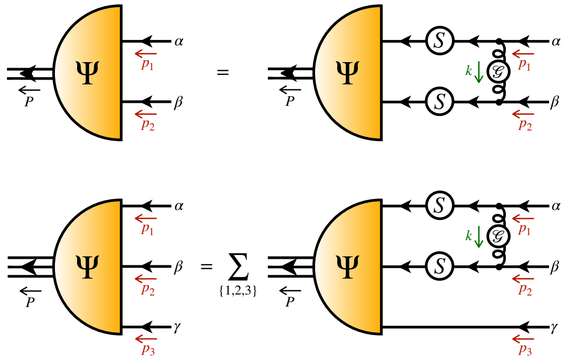

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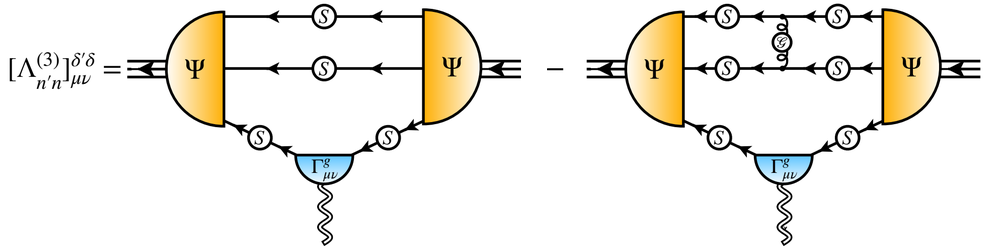

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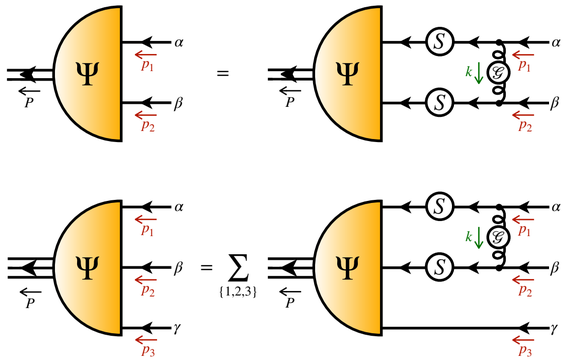

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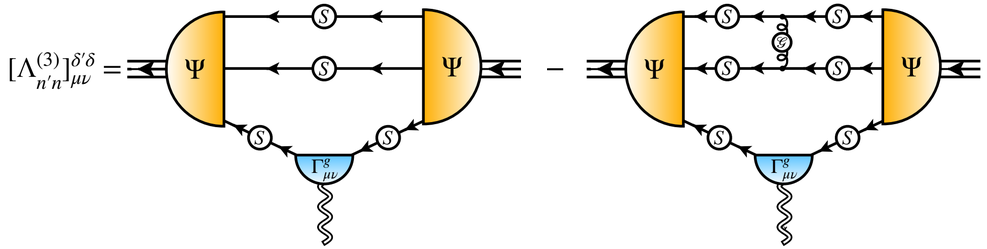

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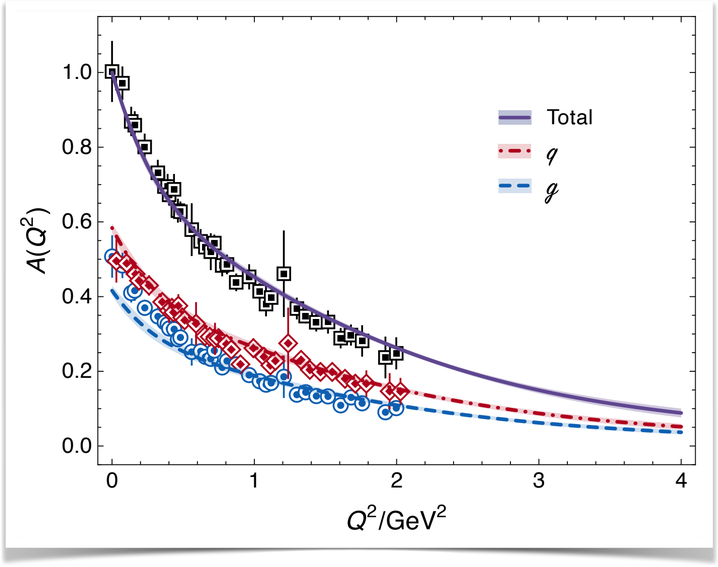

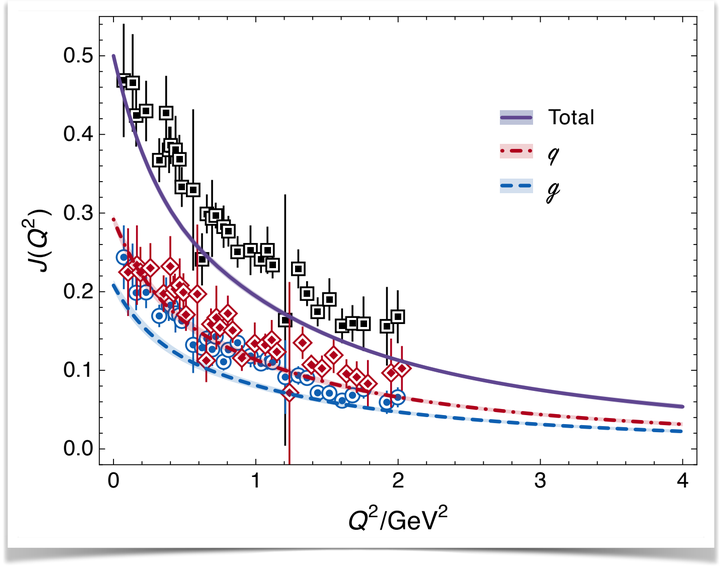

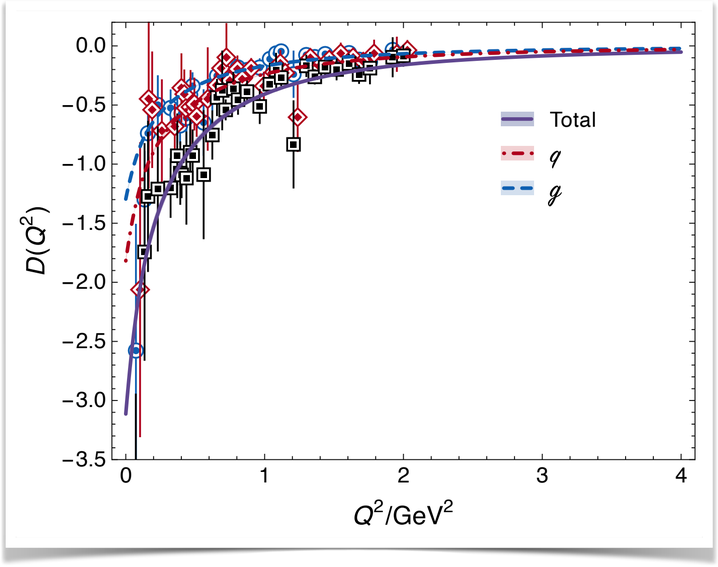

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Yao et al, EPJA 61 (2025)

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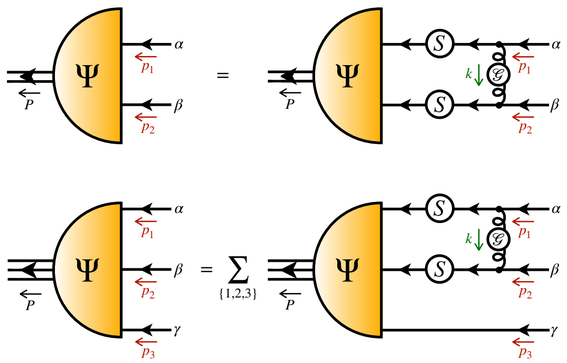
BETHE-SALPETER + FADDEEV EQUATIONS



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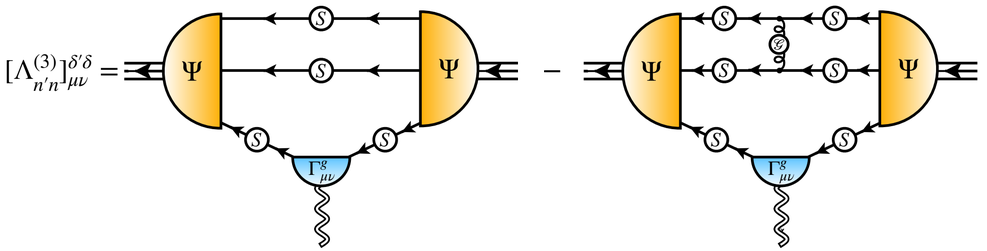

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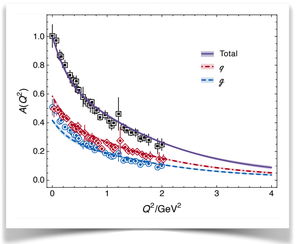

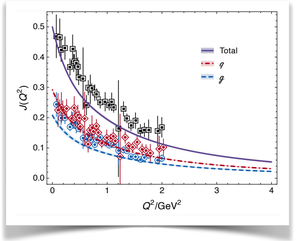

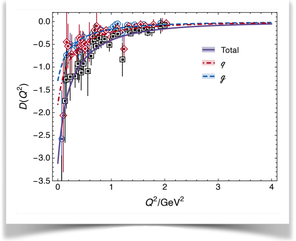

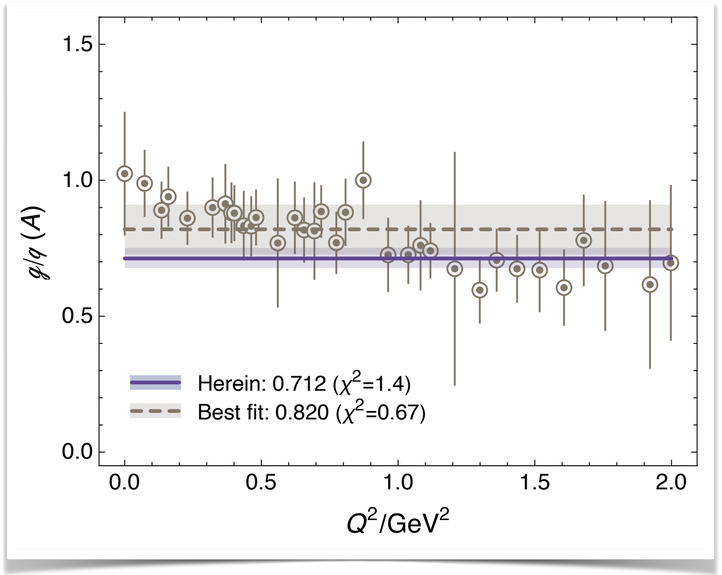

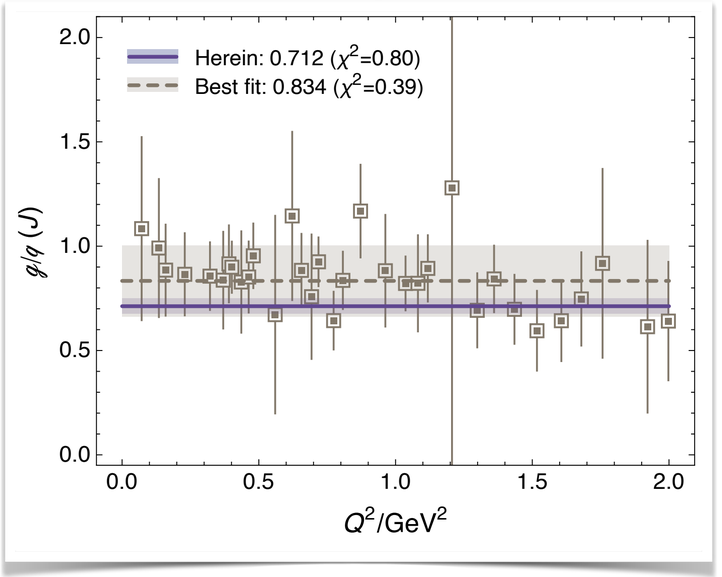

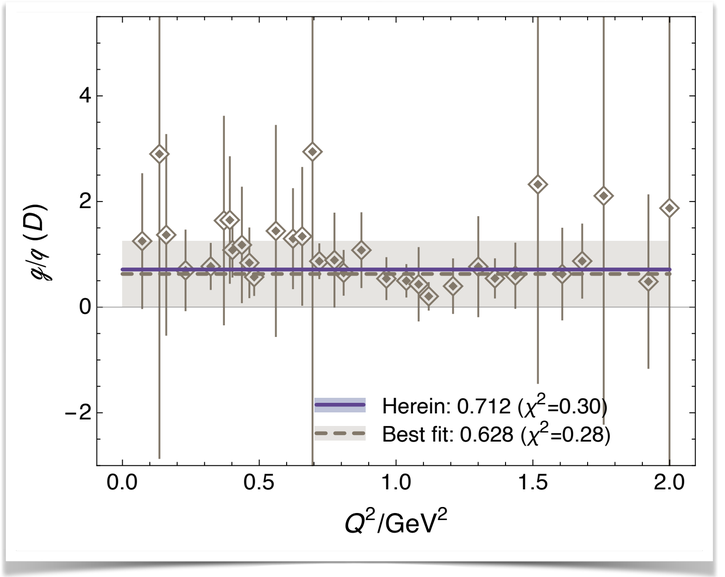

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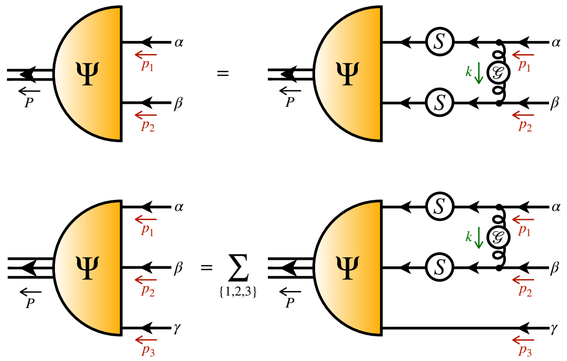

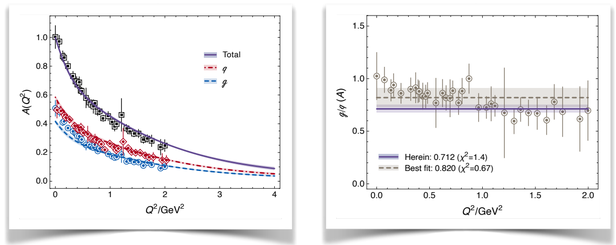

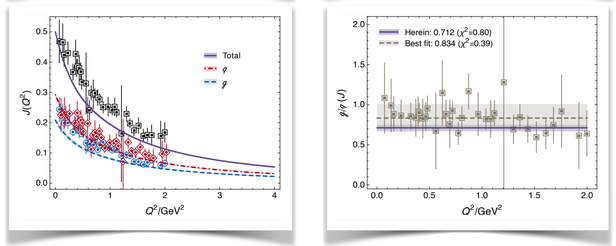

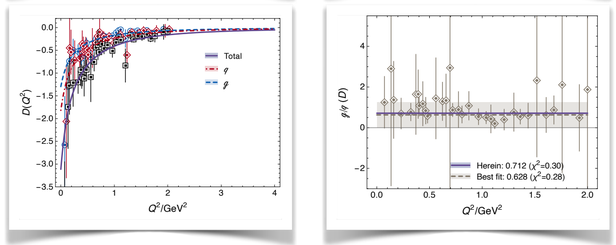

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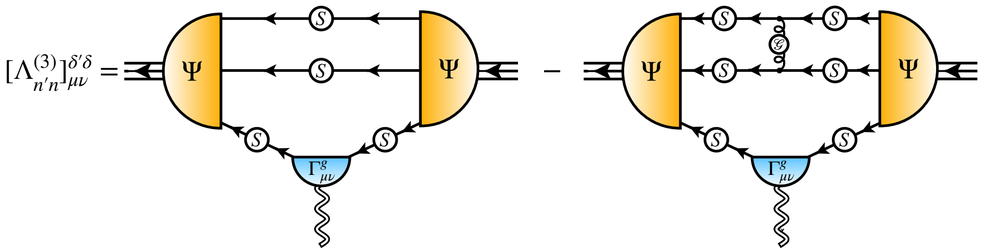

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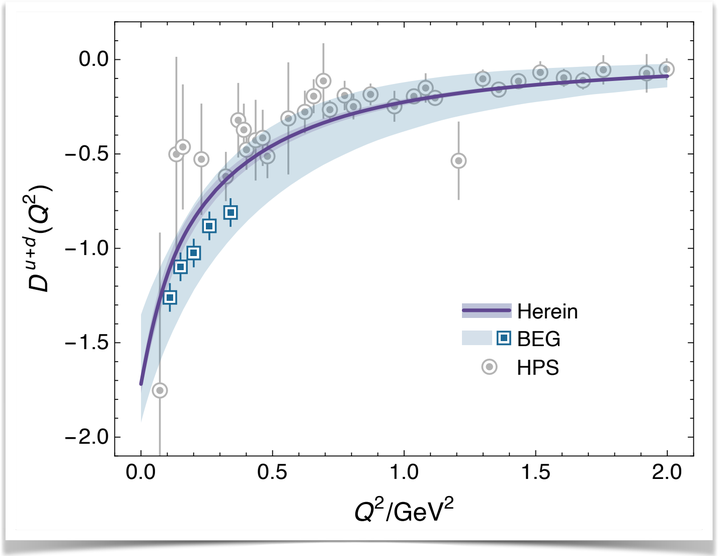

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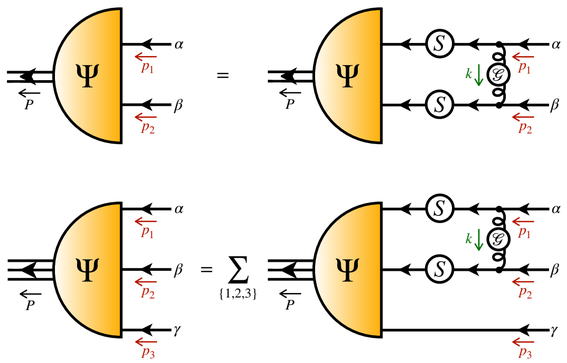
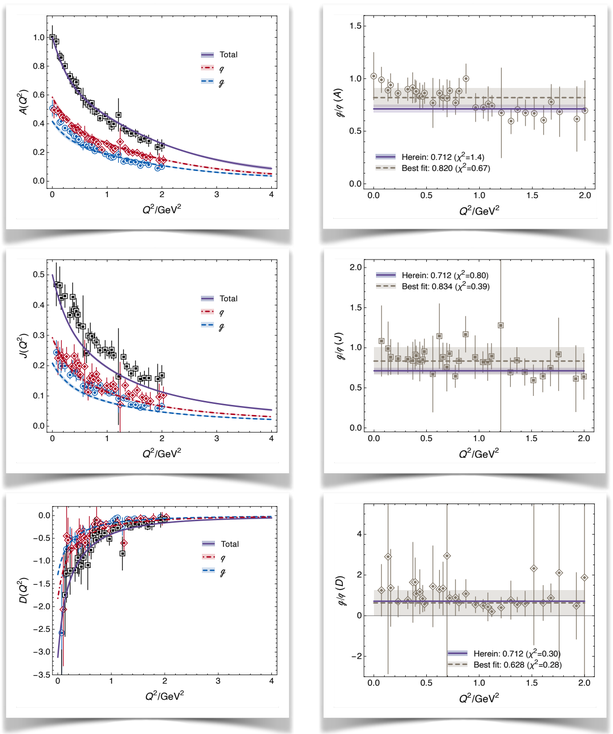
…the last unknown property of the nucleon…

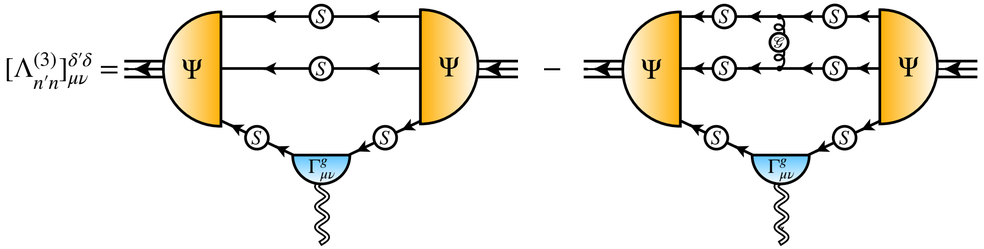


BETHE-SALPETER + FADDEEV EQUATIONS





TRIANGULAR DIAGRAM



$$m_N \Lambda^{Ng}_{\mu\nu}(Q) = -\Lambda_+(p_f)[K_\mu K_\nu A(Q^2) + iK_{\{\mu}\sigma_{\nu\}\rho}Q_\rho J(Q^2) + \tfrac{1}{4}(Q_\mu Q_\nu - \delta_{\mu\nu}Q^2)D(Q^2)]\Lambda_+(p_i)$$

SPM INTERPOLATION

$$\mathsf{D} = \{(x_i, y_i = f(x_i)),\ i = 1, \ldots, N\}$$

$$C_N(x) = \frac{y_1}{1+}\frac{a_1(x-x_1)}{1+}\frac{a_2(x-x_2)}{1+}\cdots\frac{a_{N-1}(x-x_{N-1})}{1}$$

$$C_N(x_i) = y_i \qquad \forall x_i \in \mathsf{D}$$

Schlessinger, PR 167 (1968)

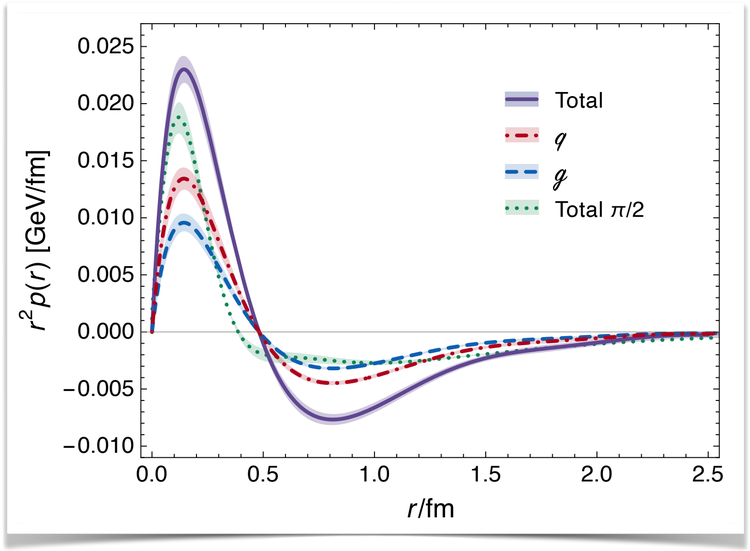
EHM predictions

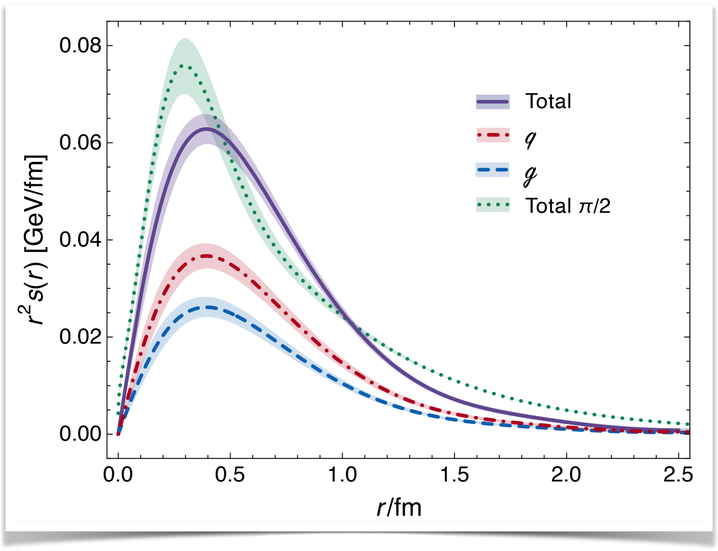
D(0)=-3.11(1)

$r_{\rm ch} > r_{\rm mass} > r_{\rm mech}$

$r_{\rm mass} = 0.81(5) r_{\rm ch}$ $\quad r^{q,\zeta_2}_{\rm mass} = 0.62(4) r_{\rm ch}$ $\quad r^{g,\zeta_2}_{\rm mass} = 0.52(3) r_{\rm ch}$

$r_{\rm mech} = 0.72(2) r_{\rm ch}$ $\quad r^{q,\zeta_2}_{\rm mech} = 0.55(2) r_{\rm ch}$ $\quad r^{g,\zeta_2}_{\rm mech} = 0.47(2) r_{\rm ch}$





THANK YOU

