The Importance of Transition Form Factors for a Complete QCD Theory

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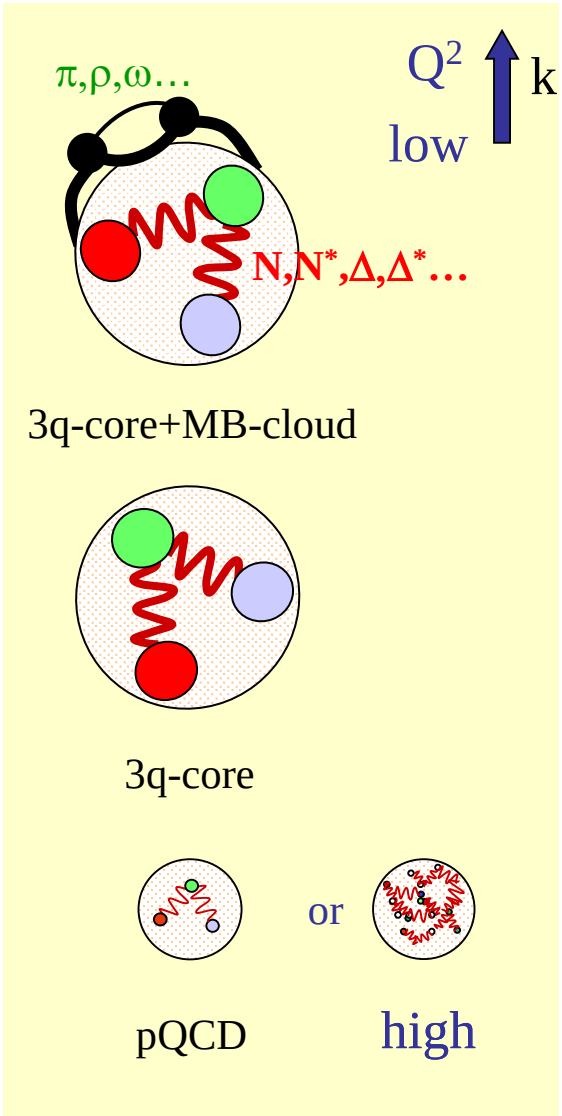
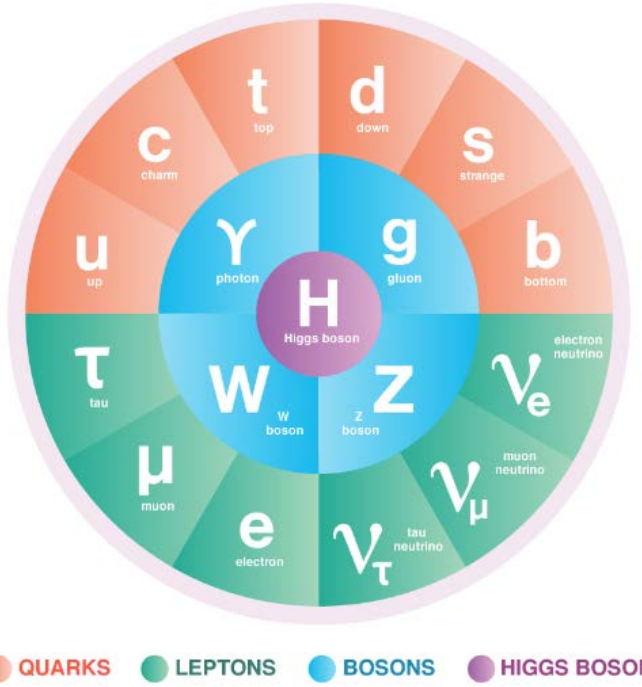
- Why are $\gamma_v NN^*$ electrocouplings interesting? Probing bound valence quarks, baryon wave functions, the emergence of mass, and finally strong QCD.
- How do N*s emerge from QCD? Mapping the J^π- and distance-dependent bound dressed quarks structure, dressing, and interaction by continuously transitioning from sQCD to pQCD.
- Why do we need CLAS22? Bridging safely the gap to small enough α_s to calculate the $\gamma_v NN^*$ electrocouplings perturbatively.

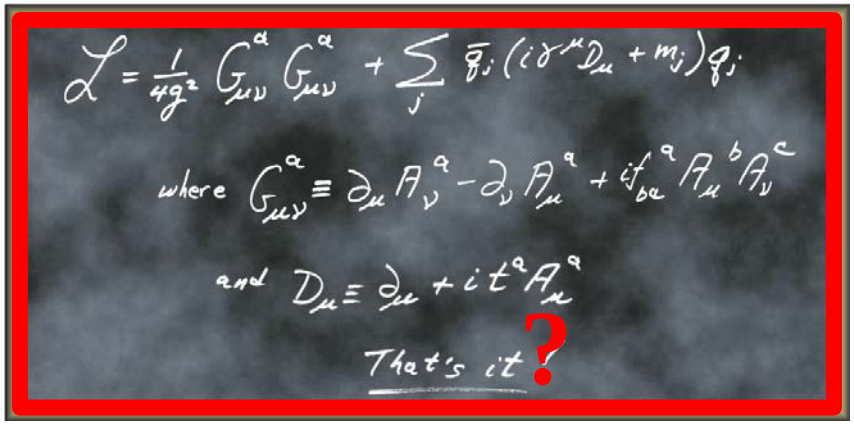
This work is supported in parts by the National Science Foundation under Grant PHY 10011349.

Emergence of Hadron Mass Traced by Electromagnetic Probes



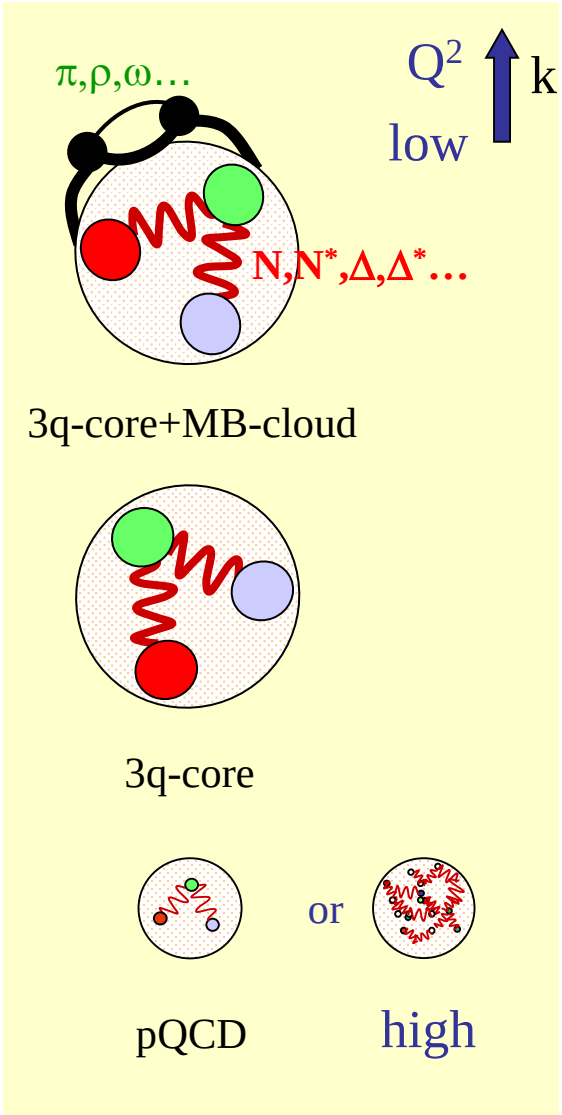
SM



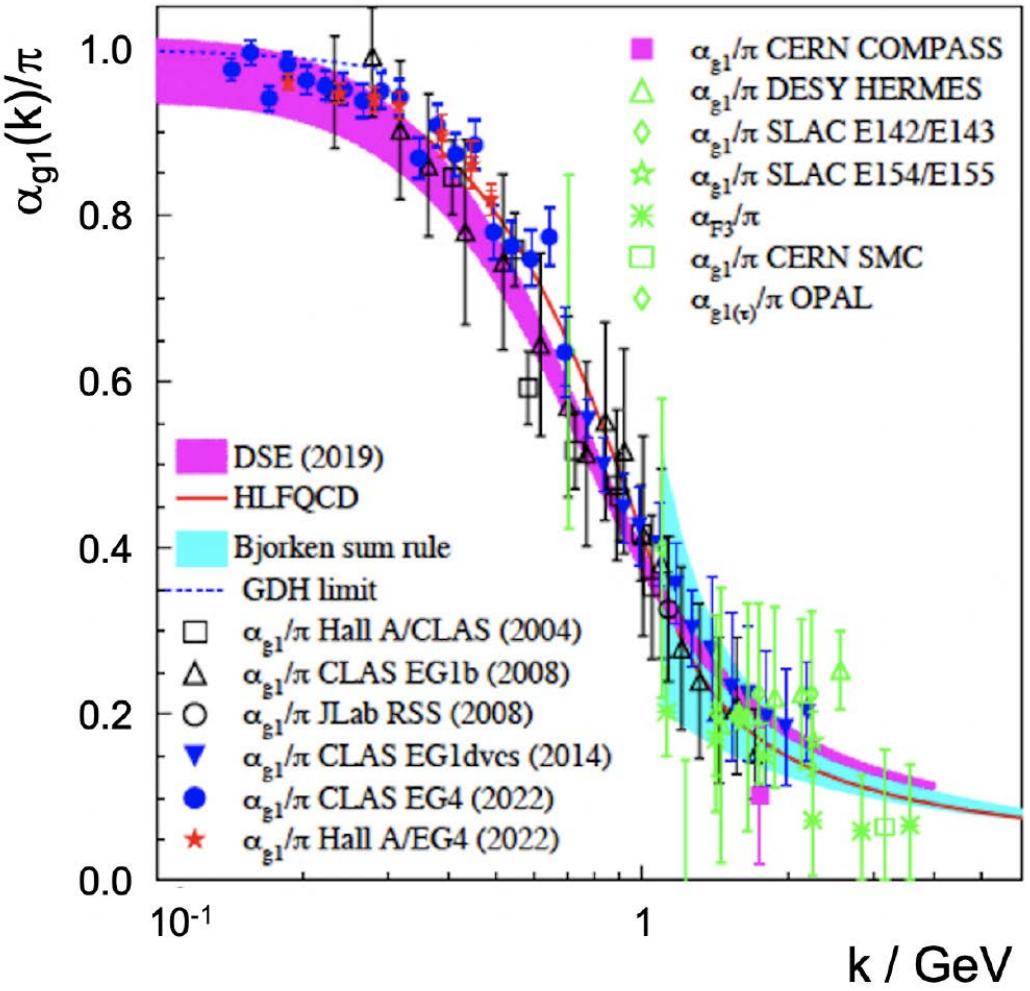


Frank Wilczek, Physics Today, August 2000

Hadron Structure with Electromagnetic Probes



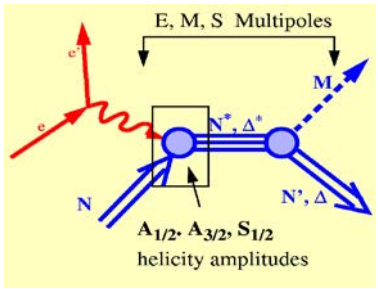
- The SM α_s diverges as Λ_{QCD}^2 approaches zero, but confinement and the meson cloud heal this artificial divergence as QCD becomes non-perturbative.

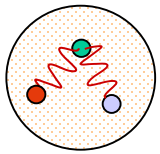


Structure Analysis of the Baryon

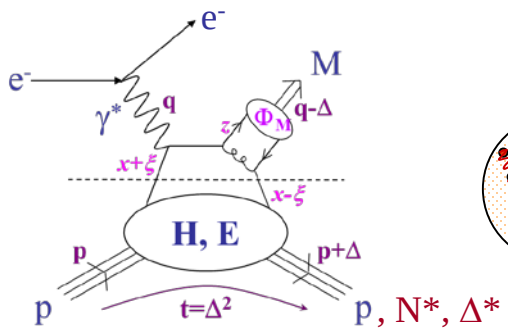
Demolition of a chimney at the "Henninger Brewery" in Frankfurt am Main, Germany, on 2 December 2006

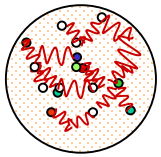
hard and bound



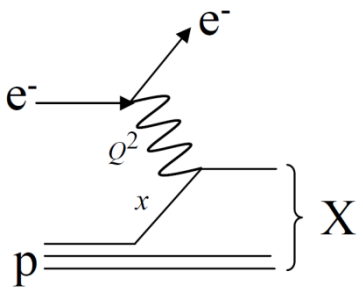


hard and soft

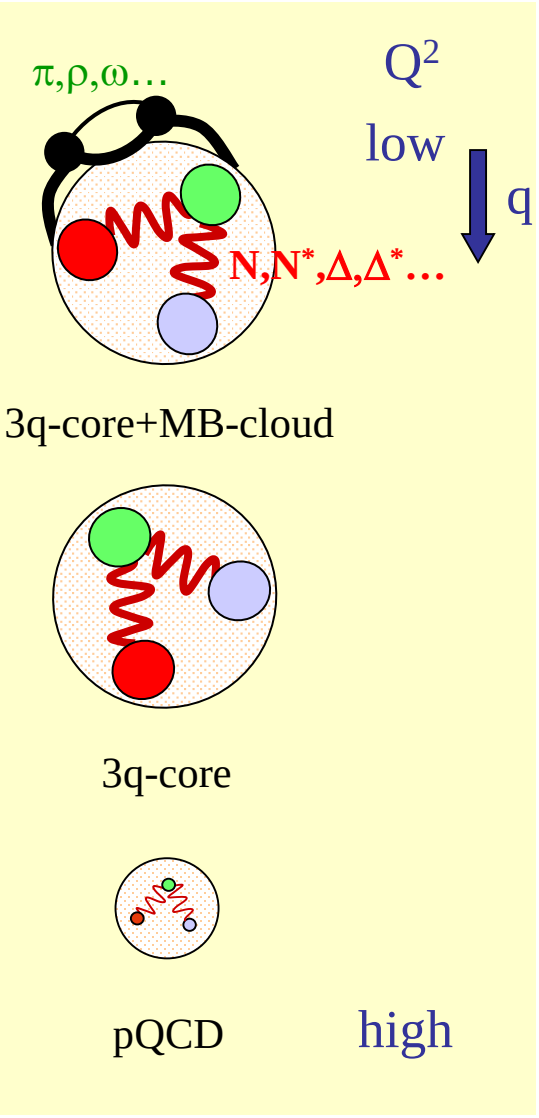




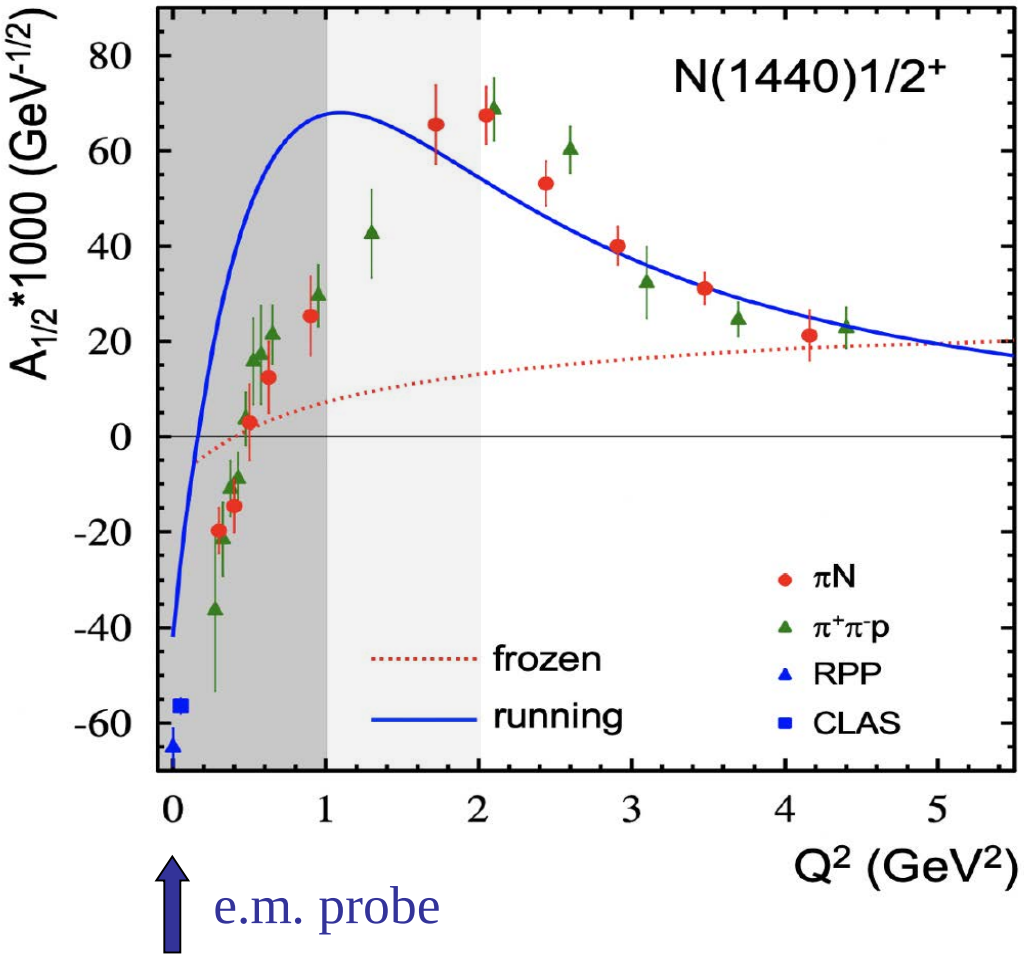
quasi-elastic



Emergence of Hadron Mass Traced by Electromagnetic Probes



- Study the structure of the nucleon spectrum in the domain where dressed quarks are the major active degree of freedom.



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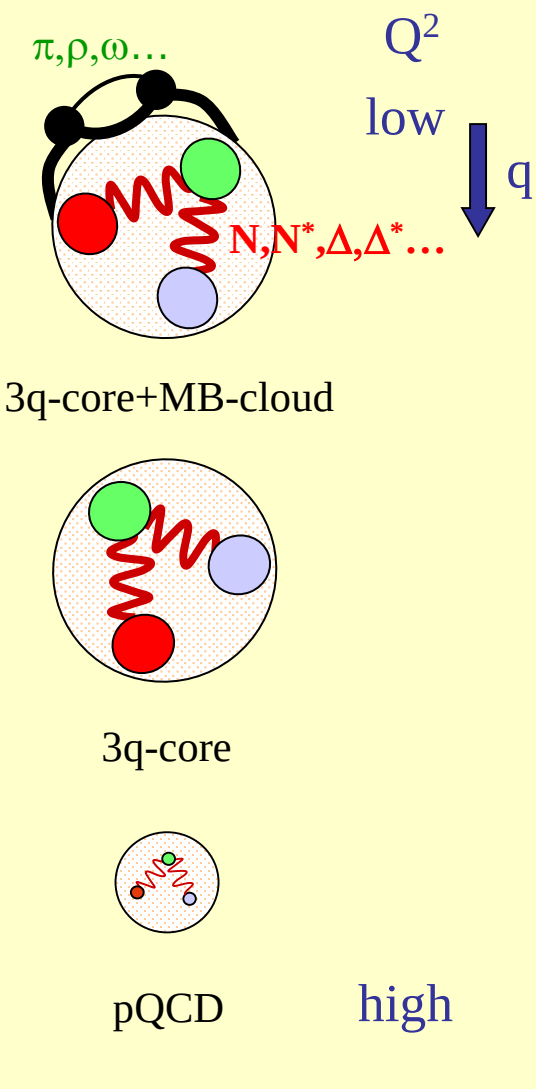
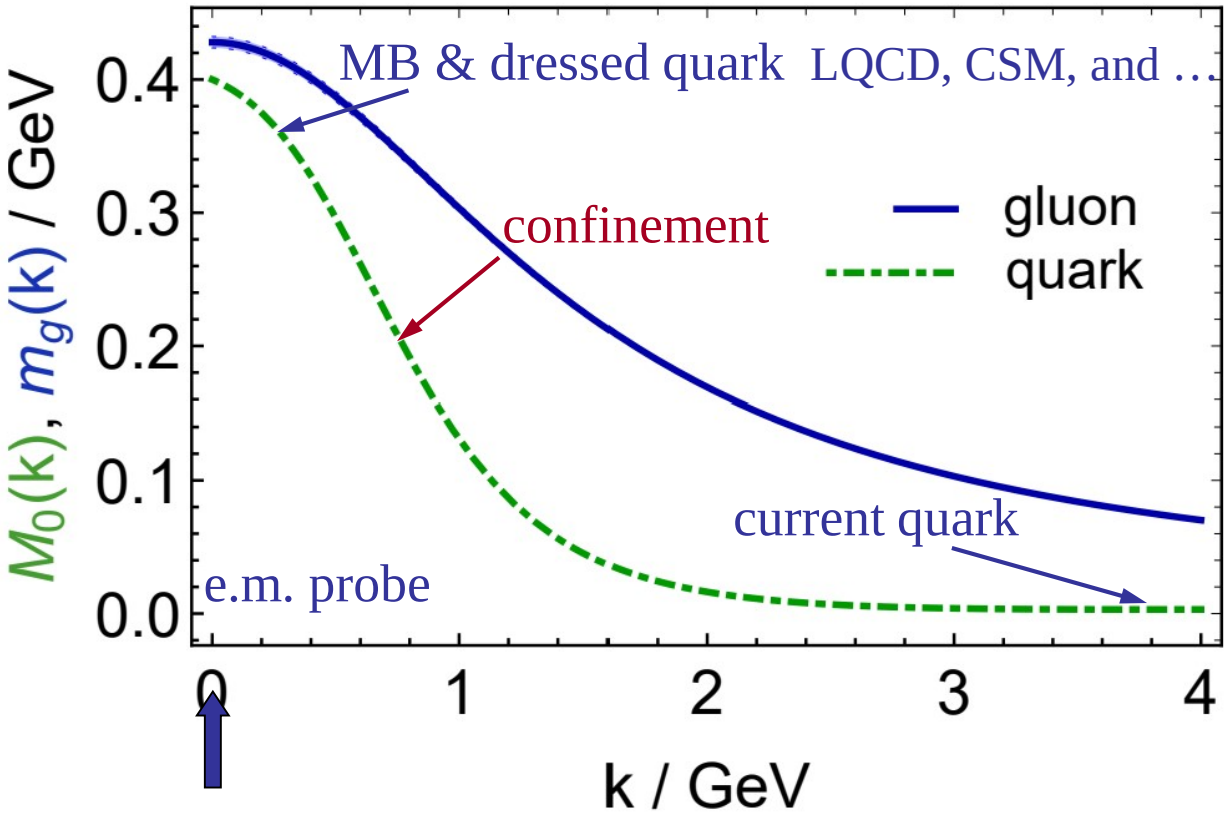


- Study the structure of the nucleon spectrum in the domain where most of the mass is generated by the strong field and dressed quarks are the major active degree of freedom.

Zhu-Fang Cui et al., Chin. Phys. C **44** (2020) 083102/1-10



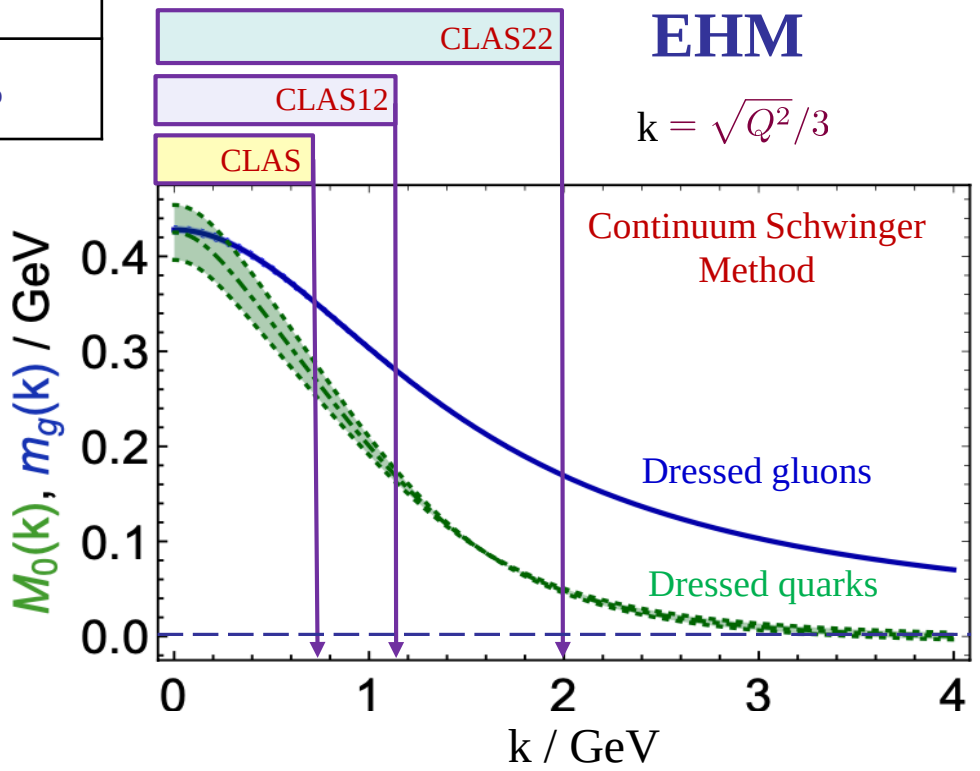
Hadron Structure Needs for CLAS22

	Q^2-coverage of electrocouplings	Range of quark momenta k	Fraction of dressed quark mass at $k<k_{max}$
CLAS	< 5 GeV^2	< 0.8 GeV	30%
CLAS12	< 12 GeV^2	< 1.2 GeV	50%
CLAS22	< 35 GeV^2	< 2.0 GeV	90%

- Beam energy 22 GeV
- Nearly 4π acceptance

Increasing knowledge on running dressed quark mass from the results on γ_vpN* electrocouplings.

Measured γ_vpN* electrocouplings of most prominent N* states of different structure will provide sound evidence for understanding how the dominant part of the hadron mass and the N* structure itself emerge from QCD and will make CEBAF@22 GeV the ultimate QCD-facility at the luminosity frontier.



Luminosity "frontier" is the *unique* advantage of JLab.

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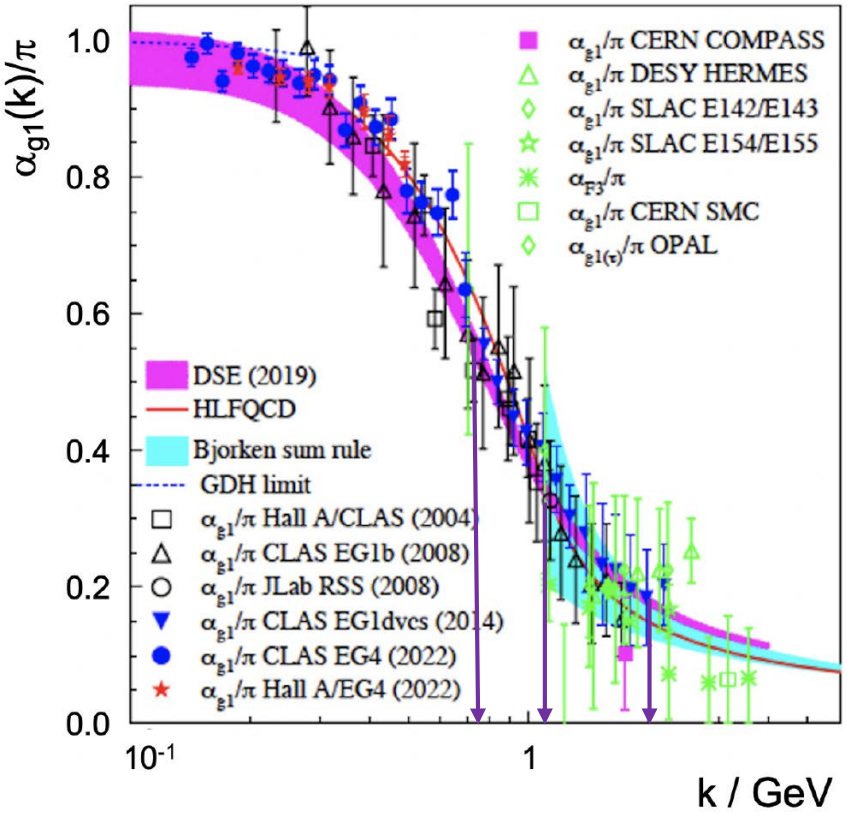

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