NPStrong


Teresa Peña


Alfred Stadler


Gernot Eichmann


Elmar Biernat


Ana Arriaga


André Torcato


Eduardo Ferreira


Raúl Torres

Physical background

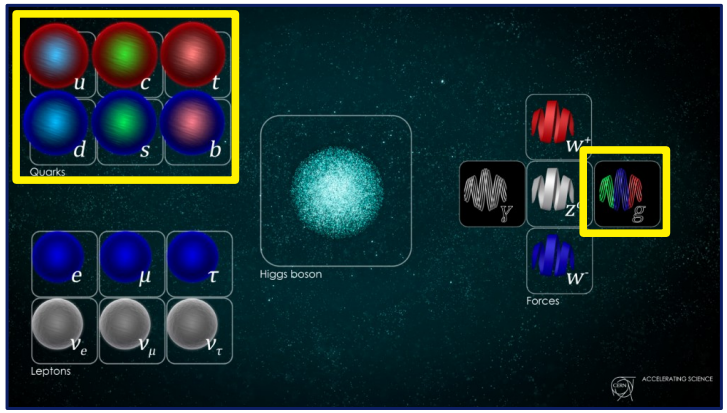
- Nuclear physics
- Quantum Chromodynamics (QCD)
- Low-energy regime of QCD ⇒ Non-perturbative analyses
- Functional methods: Dyson-Schwinger & Bethe-Salpeter eqs.

Research

- Mesons
- Baryons
- Multiquark systems
- Hadron structure
- Parton distributions
- Ab-initio calcs. In QCD
- Muon g-2
- Flavor matrix elements

Physical background

Quantum Chromodynamics (QCD)



https://home.cern/science/physics/standard-model

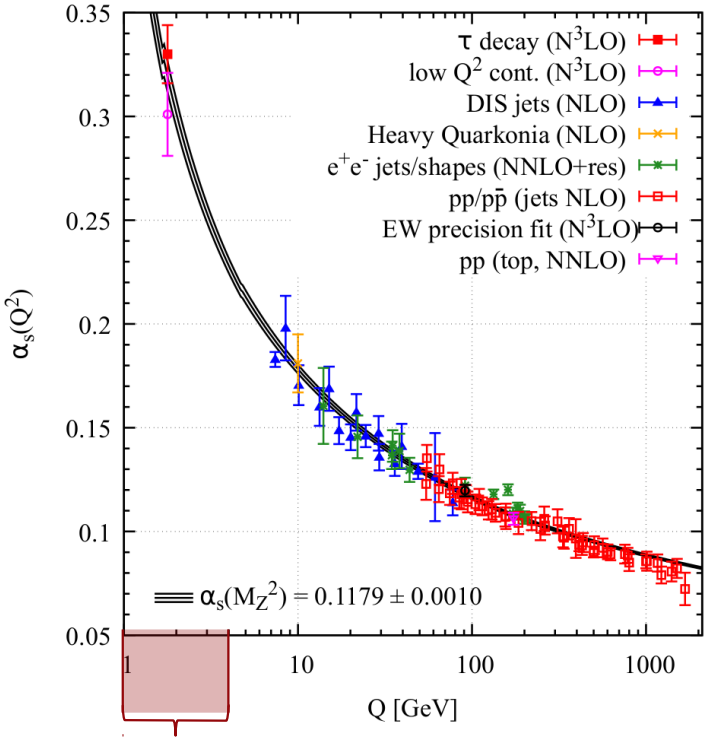
Fundamental degrees of freedom:

- Quarks (3 colors)
- Gluons (color-anticolor pair)

Quarks & gluons make up:

- Hadrons (colorless particles)
- E.g.: mesons ($q\bar{q}$) & baryons (qqq)

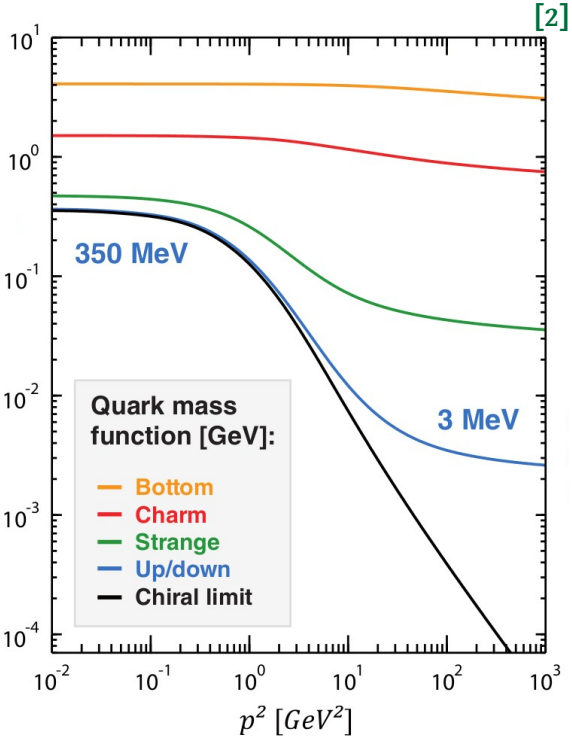
Strong coupling constant



Low-energy regime

Mass generation

[1]

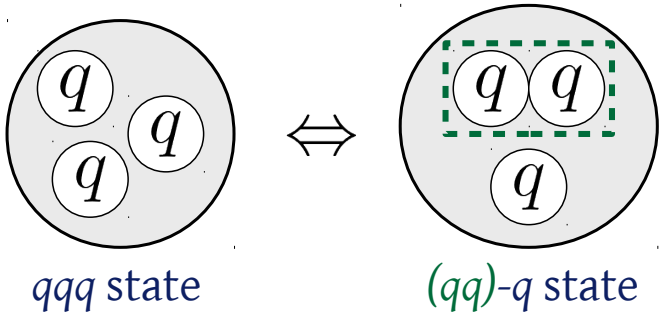


[1]: J. Huston, K. Rabbertz, G. Zanderighi, "9. Quantum Chromodynamics" (2019), pdg.lbl.gov/2019/reviews/rpp2019-rev-qcd.pdf

[2]: G. Eichmann, "Theory introduction to baryon spectroscopy" (2022), arXiv:2202.13378 [hep-ph]

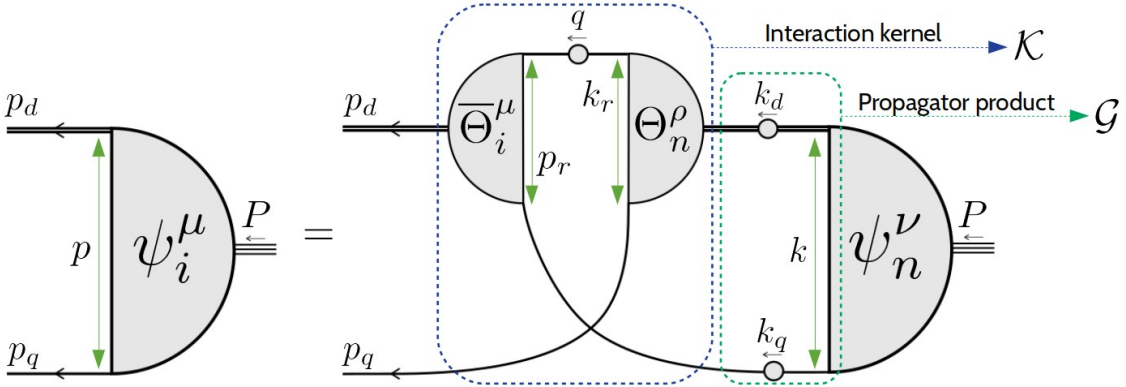
Quark-Diquark Model

Baryons as quark-diquark bound states

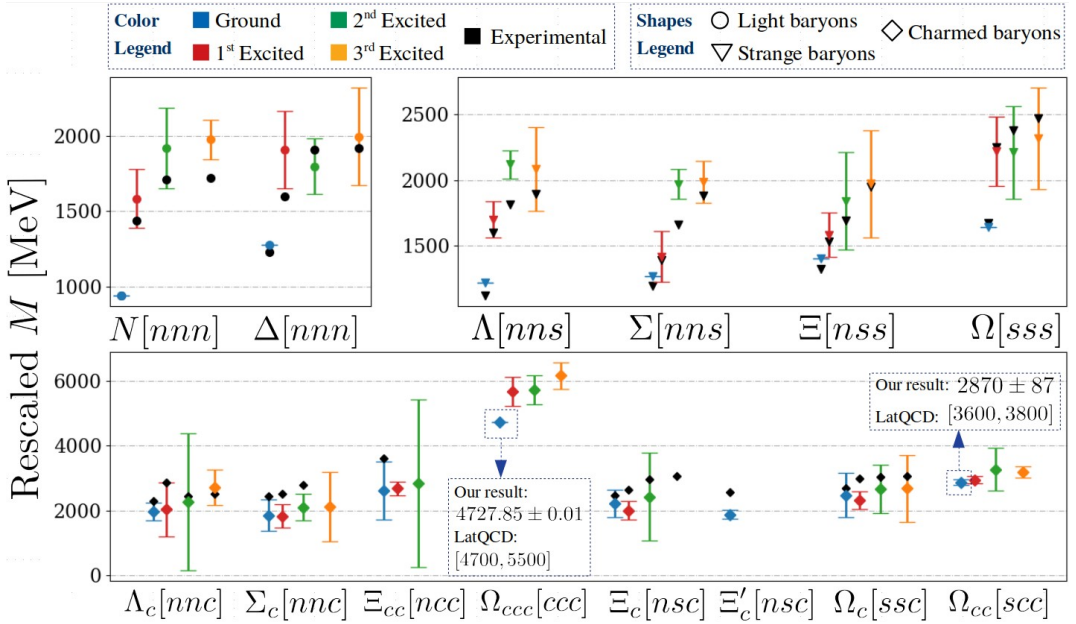


qqq state (*qq*)-*q* state

Bethe Salpeter equation of the quark-diquark



Results



Numerical implementation:

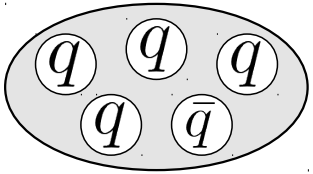
$$\lambda_i(P^2)\psi_i(P^2) = \mathcal{K}(P^2)\mathcal{G}(P^2)\psi_i(P^2)$$

$$\lambda_i(P^2) = 1 \text{ when } P^2 = -M_i^2$$

$$i = \text{ Ground state, 1st excited state,...}$$

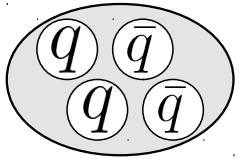
Pentaquarks

Exotic hadrons

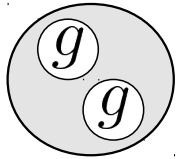


Pentaquark

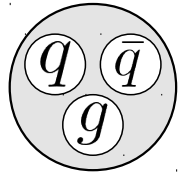
And also:



Tetraquarks,

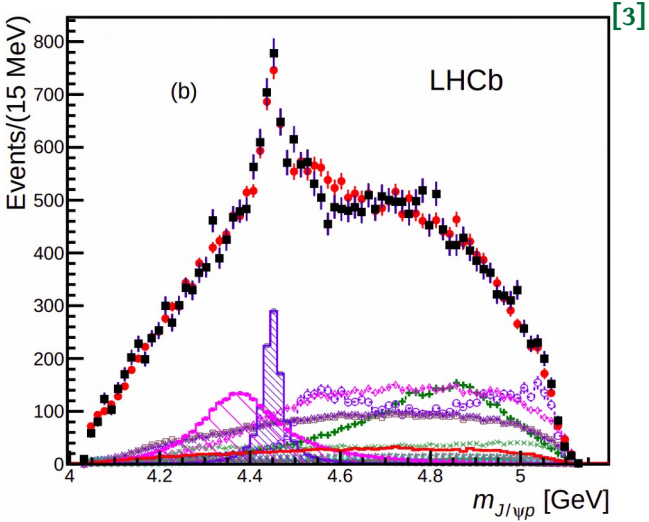


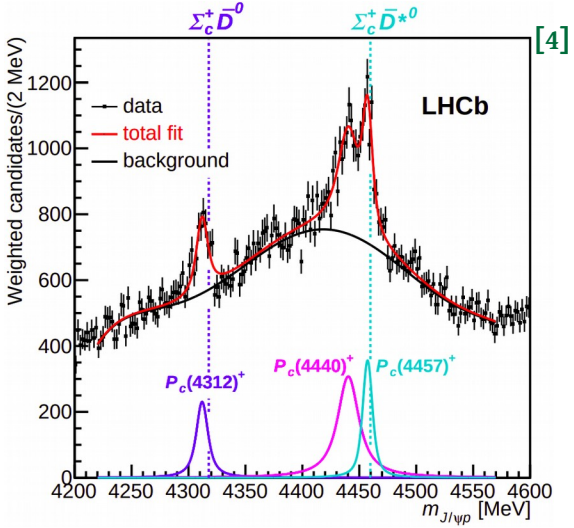
Glueballs,



Hybrids

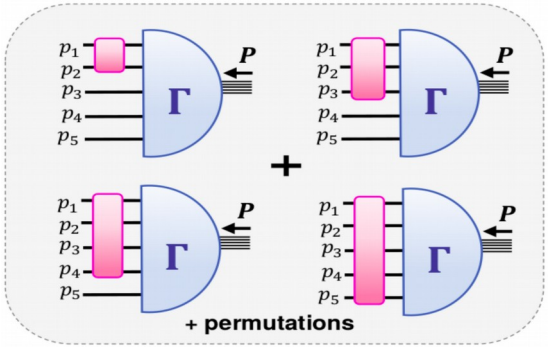
...





Objective

Calculate the properties of pentaquarks using functional methods



Properties: masses, eletromagnetic form factors, decay constants, charge radius,...

[3]: LHCb collaboration, "Observation of $J/\Psi p$ ressonances consistent with pentaquark states in $\Lambda_b^0 \to J/\Psi K^- p$ decays" (2015), arXiv:1507.03414 [hep-ex]

[4]: LHCb collaboration, "Observation of a narrow pentaquark state $P_c(4312)^+$, and of two-peak structure of the $P_c(4450)^+$" (2019), arXiv:1904.03947 [hep-ex]

Hadronic structure on the light-front

Objective

Understand hadronic composition and interactions

Main Idea

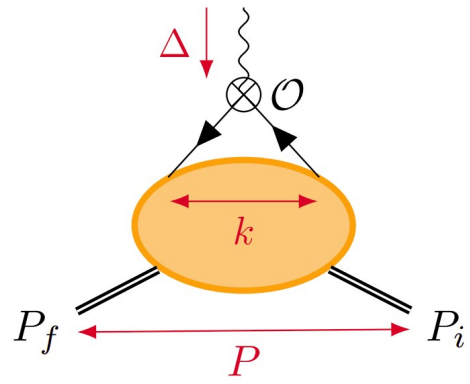
Processes = parton hard scattering **x** structure functions

Structure functions defined in the **light front** from the *qq* correlator, ***G***

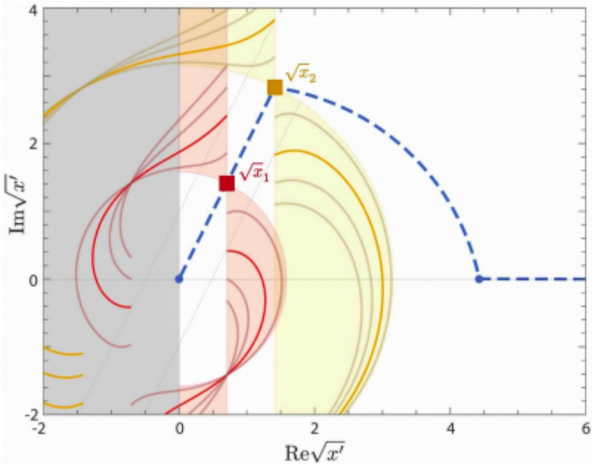
Recent

Novel method for the calculation of **light-front wave functions (LFWF),** using contour deformations and analytic continuation techniques

$\mathcal{G} =$



$$\mathcal{G} = \langle P_f | \, \mathrm{T}\overline{\psi}(x)\mathcal{O}\psi(0) \, | P_i \rangle$$



[5]

[5]: G. Eichmann, E. Ferreira, A. Stadler, "Going to the light front with contour deformations" (2022), **Phys. Rev. D 105,** arXiv:2112.04858 [hep-ph]

Editor's Suggestion

	$\mathcal{G}(q,P,\Delta=0)$	$\mathcal{G}(q,P,\Delta)$	$\Psi(q,P)$
$\int dq^-$	TMD	GTMD	LFWF
$\int d^2\boldsymbol{q}_\perp \int dq^-$	PDF	GPD	PDA