



Center for Frontiers
in Nuclear Science



Stony Brook
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Transverse Momentum Structure from QCD Vacuum

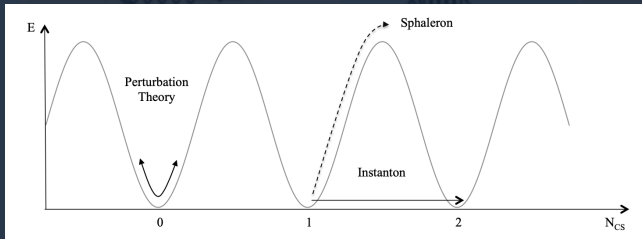
vacuum-based nonperturbative approach

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Stony Brook University
September 9, 2025

QCD vacuum: Field Theory



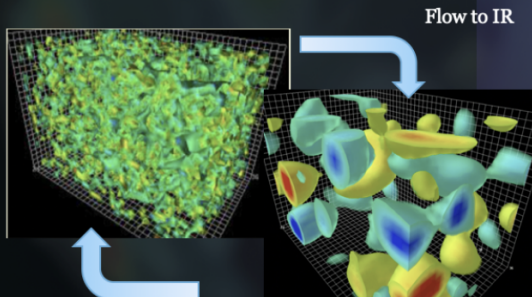
- c The basis of a quantum system ground state (vacuum)
- c QCD vacuum landscape:



- c Degenerate vacuum

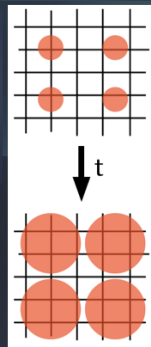


QCD VACUUM



Flow to UV

carrying topological charges
CP conjugated



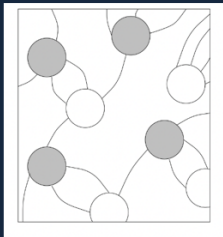
$$\partial_t B_\mu = D_\nu G_{\nu\mu}[B], \quad B_\mu|_{t=0} = A_\mu$$

Gradient Flow

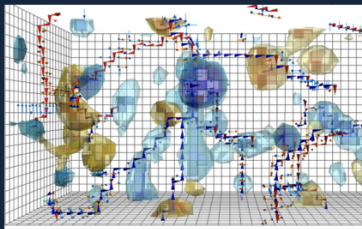
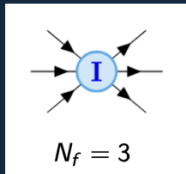


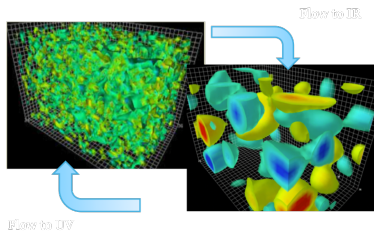
QCD Vacuum Phenomenology

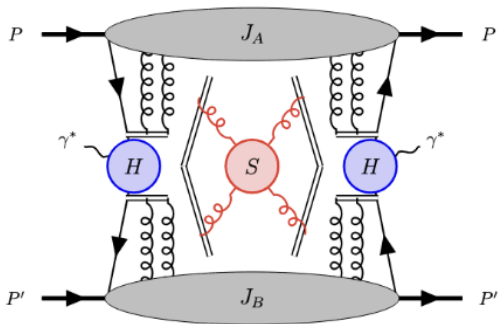
- Topologically active below 1 GeV
- Pseudoparticles carrying topological charges and CP conjugated
- Stabilized at $\rho = \frac{1}{3}$ fm with density $n_{I+A} = 1 \text{ fm}^{-4}$
- Perturbative gluons depleted, regenerated by RG evolution



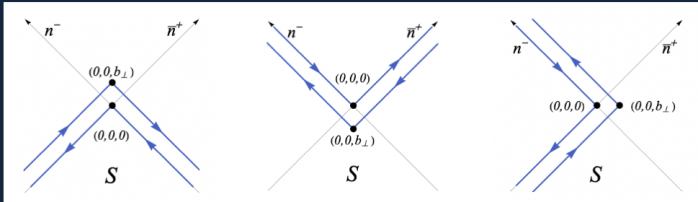
L to R handed quark







Final state $+\infty$

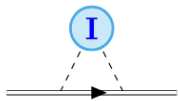
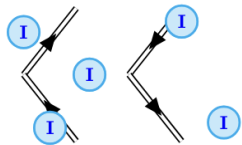


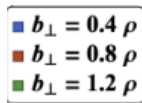
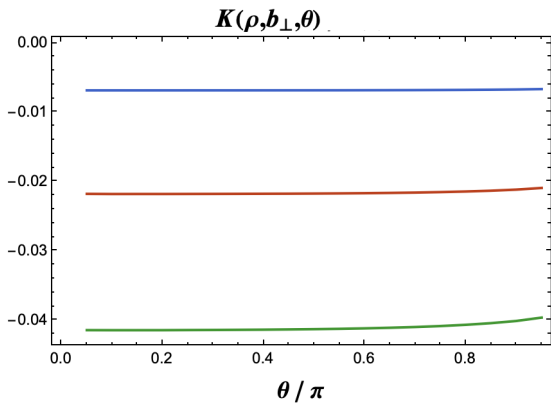
Initial state $-\infty$

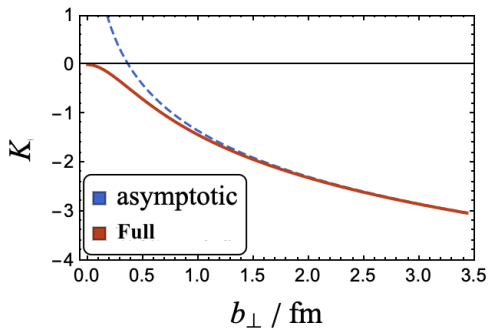
DY

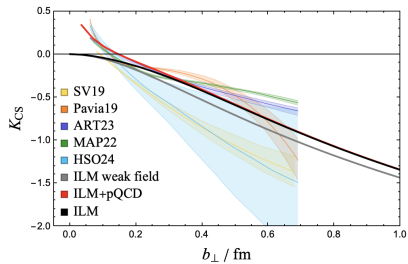
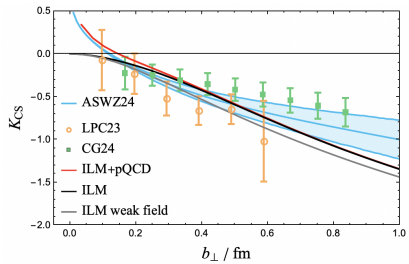
e^+e^-

SIDIS

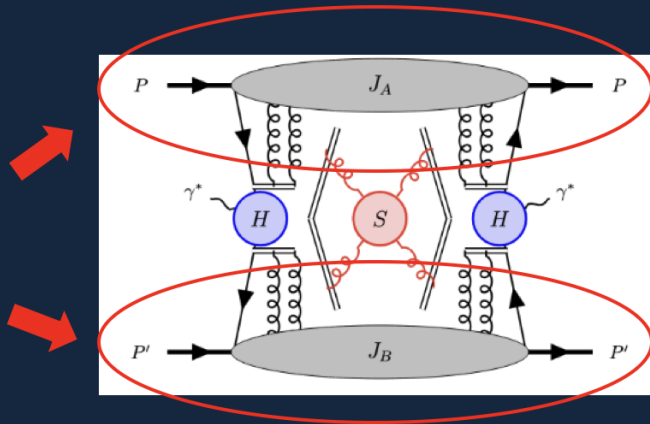


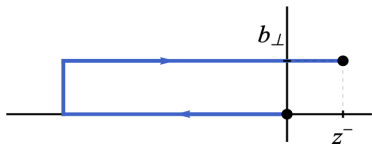
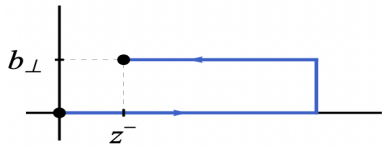


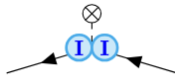
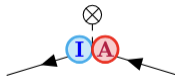
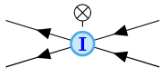
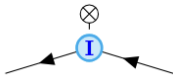
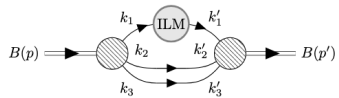
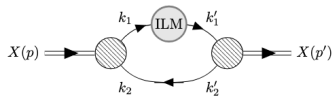


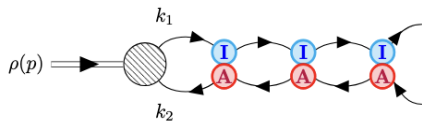
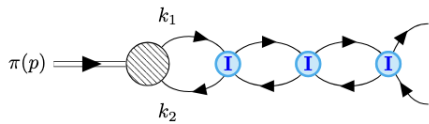


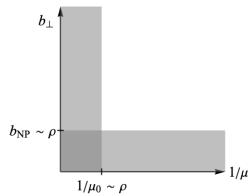
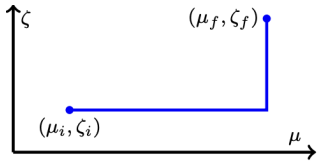
TMD functions

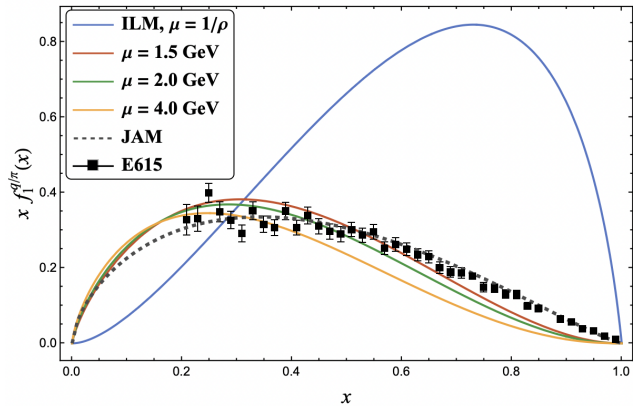


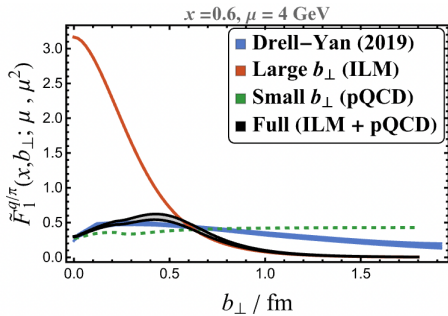
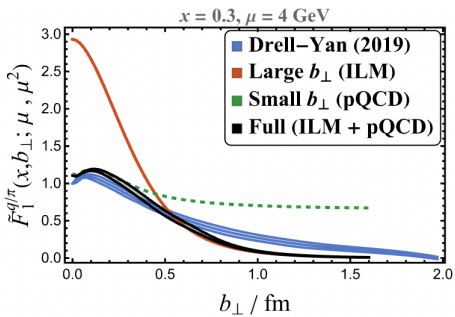


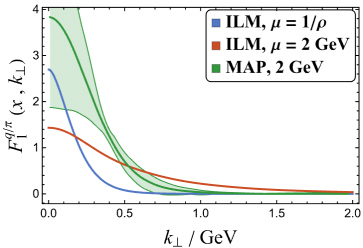
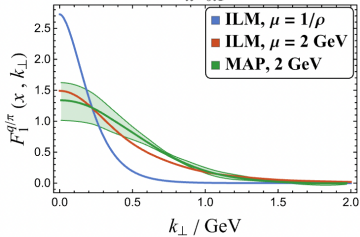
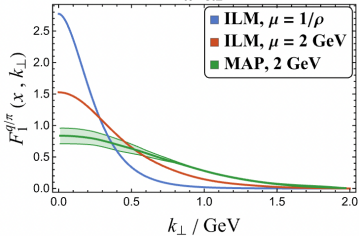










$x=0.05$  $x=0.1$  $x=0.2$  $x=0.3$ 