

Scientific Discoveries from RHIC to EIC through Advance Computing in Lattice QCD

August 2026, Washington DC

Swagato Mukherjee





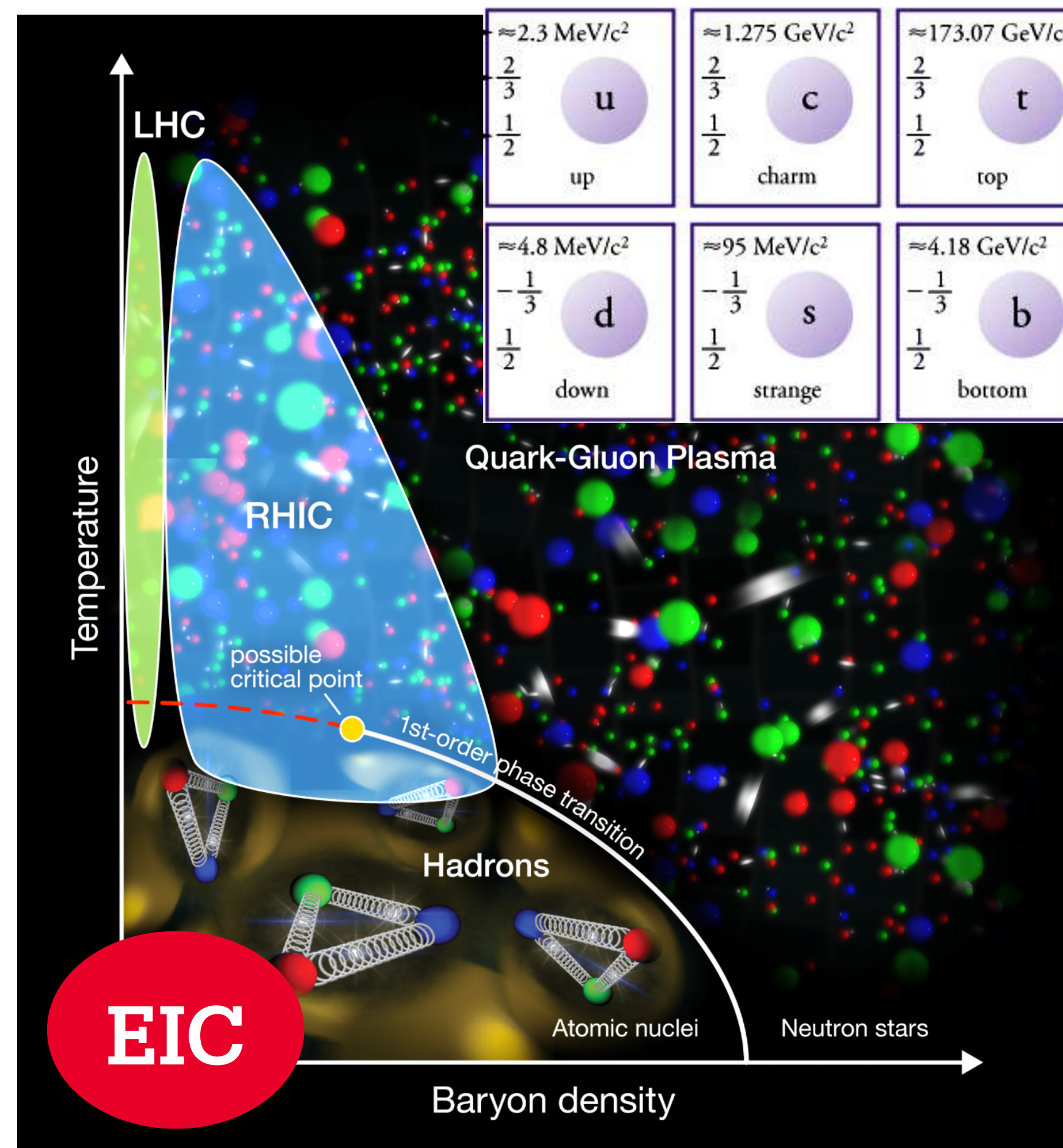
SciDAC-4
(2022-2027)



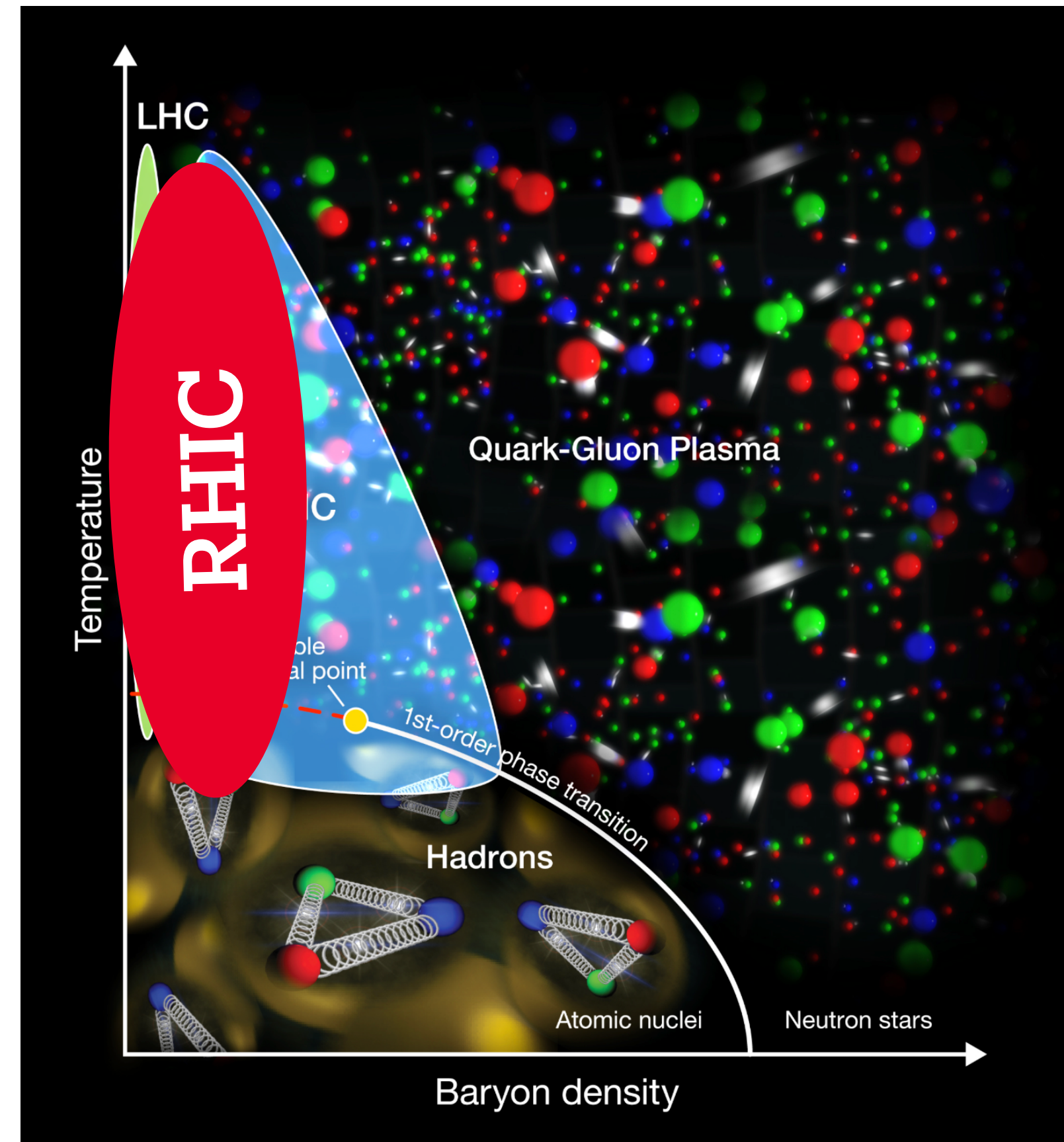
SciDAC-4
(2017-2022)



SciDAC-3
(2012-2017)



SciDAC-3

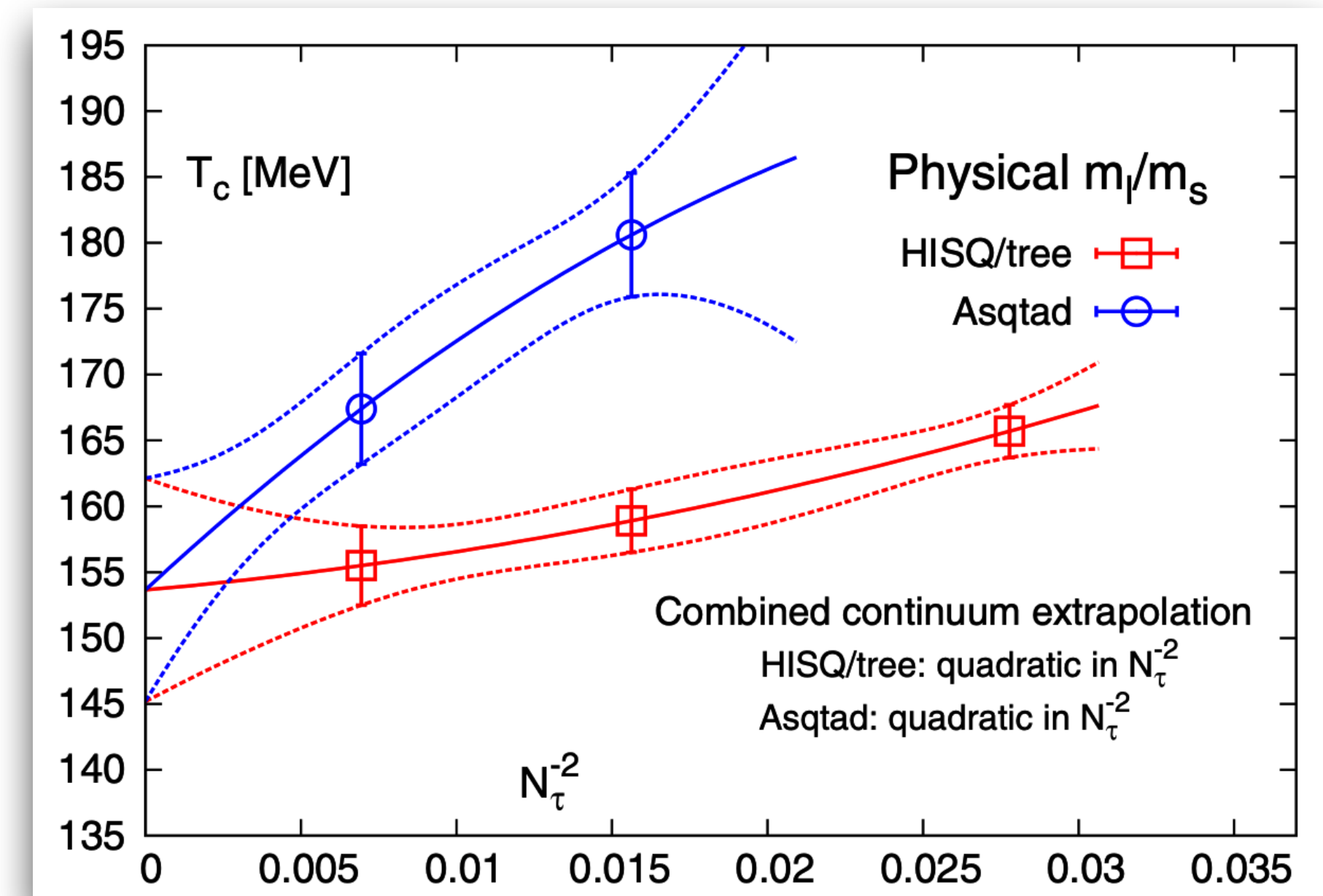


PHYSICAL REVIEW D **85**, 054503 (2012)**Chiral and deconfinement aspects of the QCD transition**

Google Scholar citations: 1881



a landmark paper in QCD

PRL **113**, 082001 (2014)

Selected for a **Viewpoint in Physics**
PHYSICAL REVIEW LETTERS

week ending
22 AUGUST 2014

**QCD Phase Transition with Chiral Quarks and Physical Quark Masses**

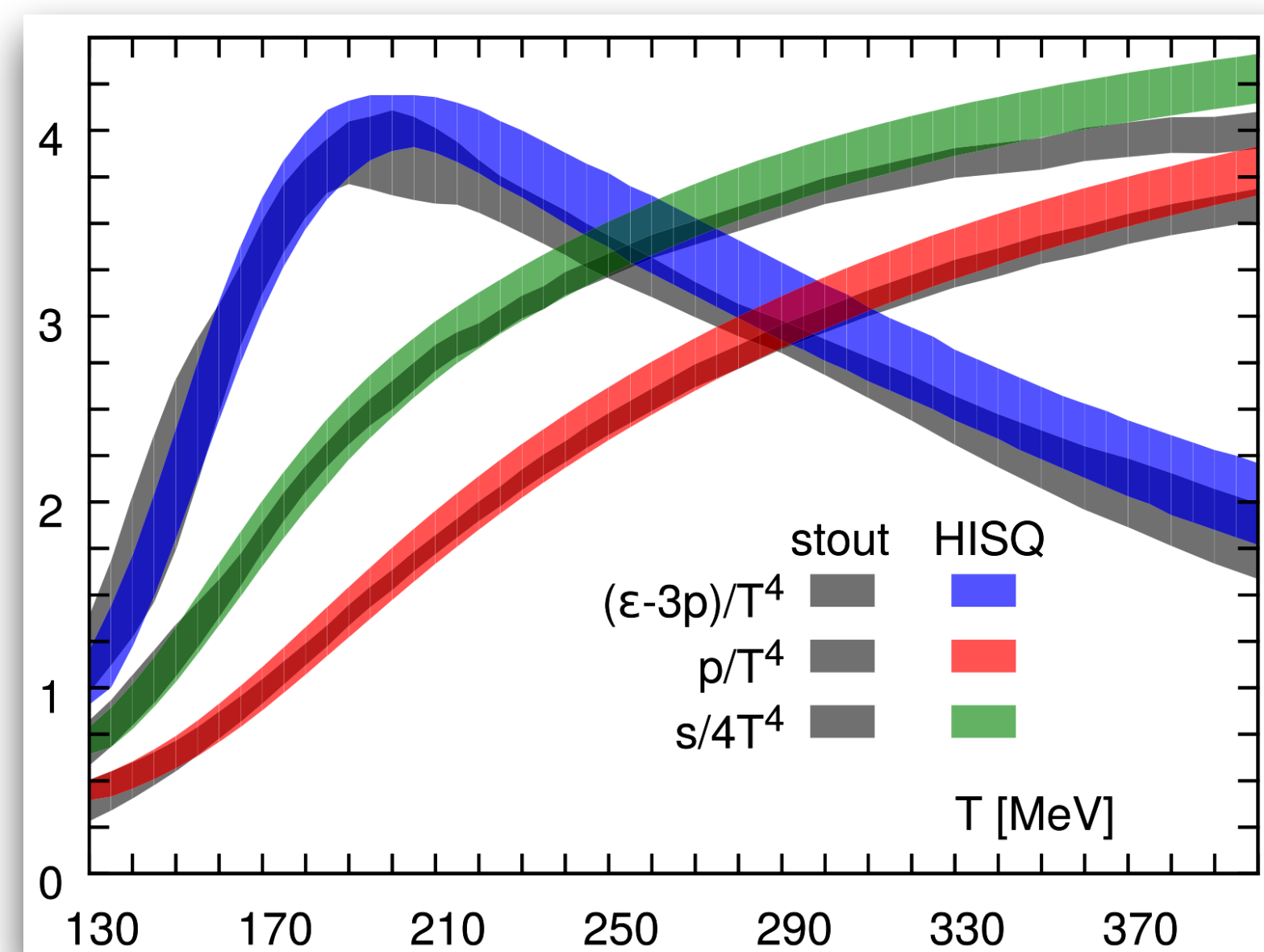
Google Scholar citations: 606

how do energy & pressure of QGP change with temperature ?

PHYSICAL REVIEW D **90**, 094503 (2014)

Equation of state in $(2 + 1)$ -flavor QCD

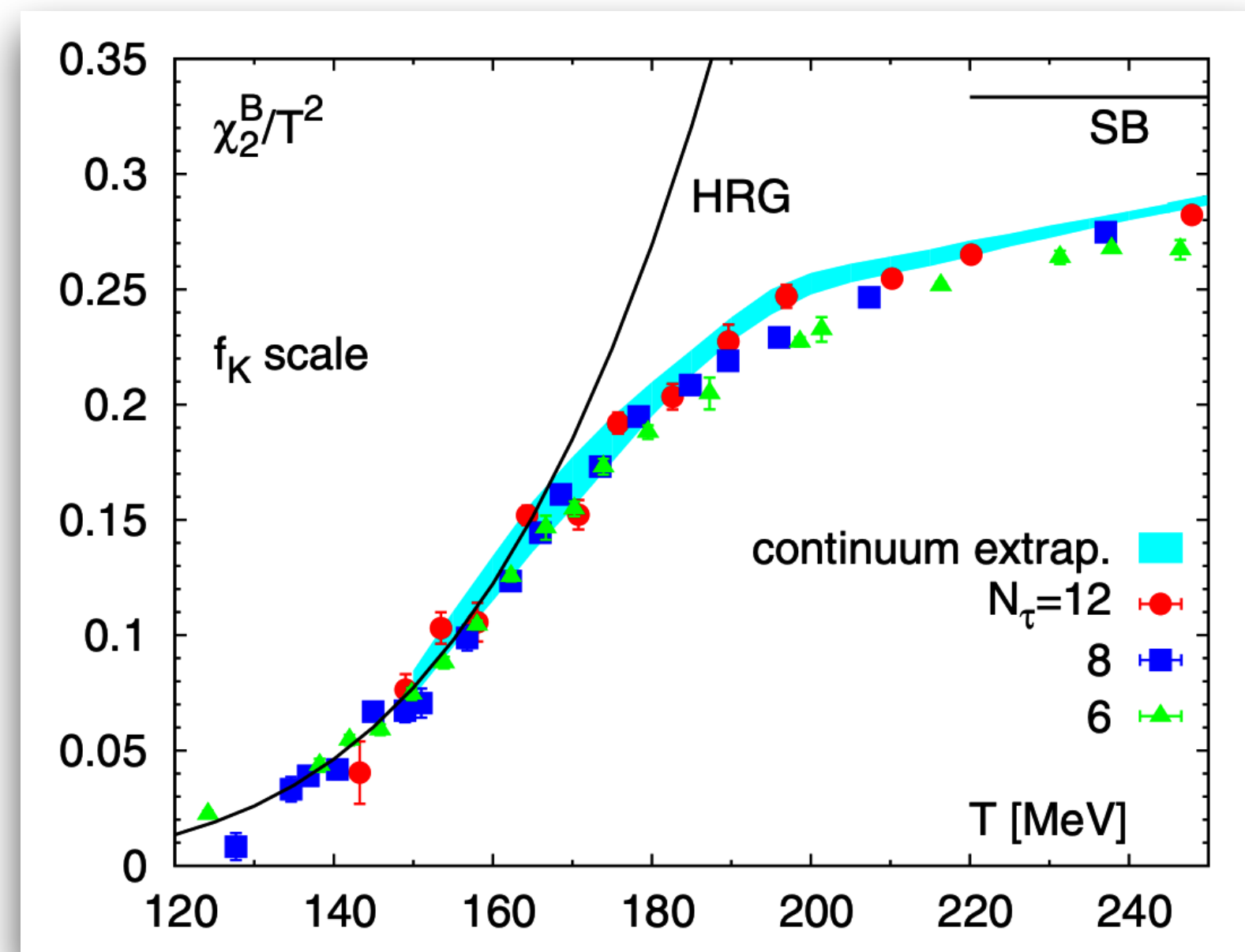
Google Scholar citations: 2050



PHYSICAL REVIEW D **86**, 034509 (2012)

**Fluctuations and correlations of net baryon number, electric charge, and strangeness:
A comparison of lattice QCD results with the hadron resonance gas model**

Google Scholar citations: 475



SciDAC-3 how to determine the thermal conditions of QGP using conserved-charge fluctuations ?

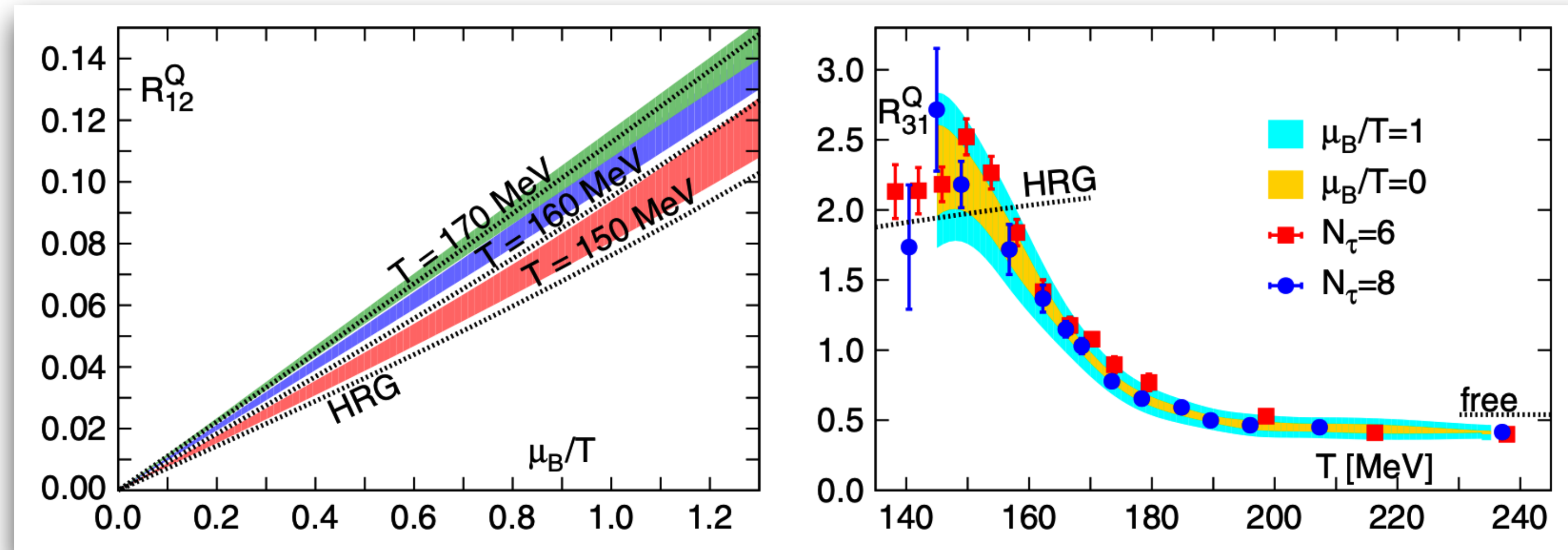
PRL **109**, 192302 (2012)

PHYSICAL REVIEW LETTERS

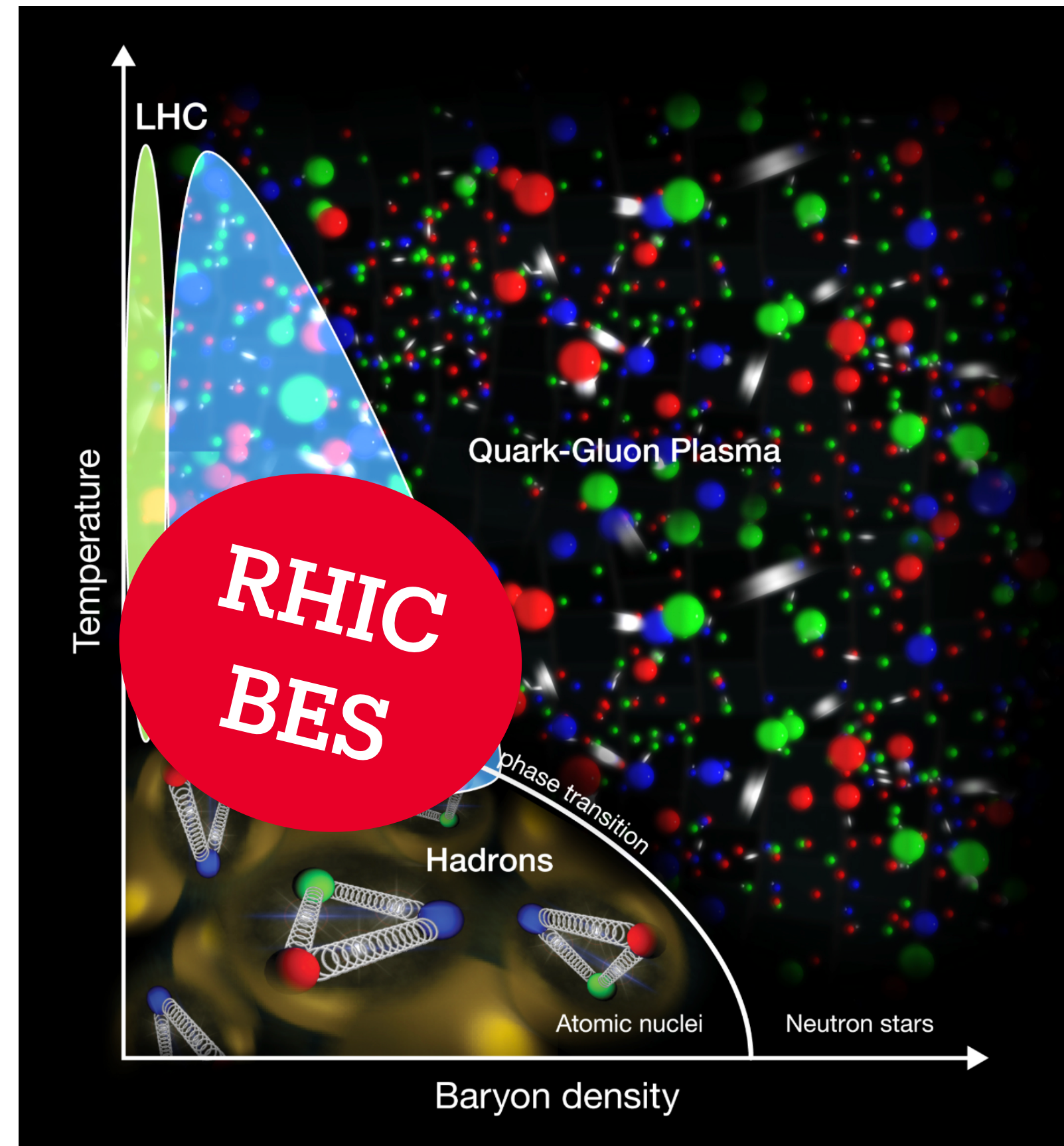
week ending
9 NOVEMBER 2012

Freeze-Out Conditions in Heavy Ion Collisions from QCD Thermodynamics

Google Scholar citations: 358



SciDAC-4

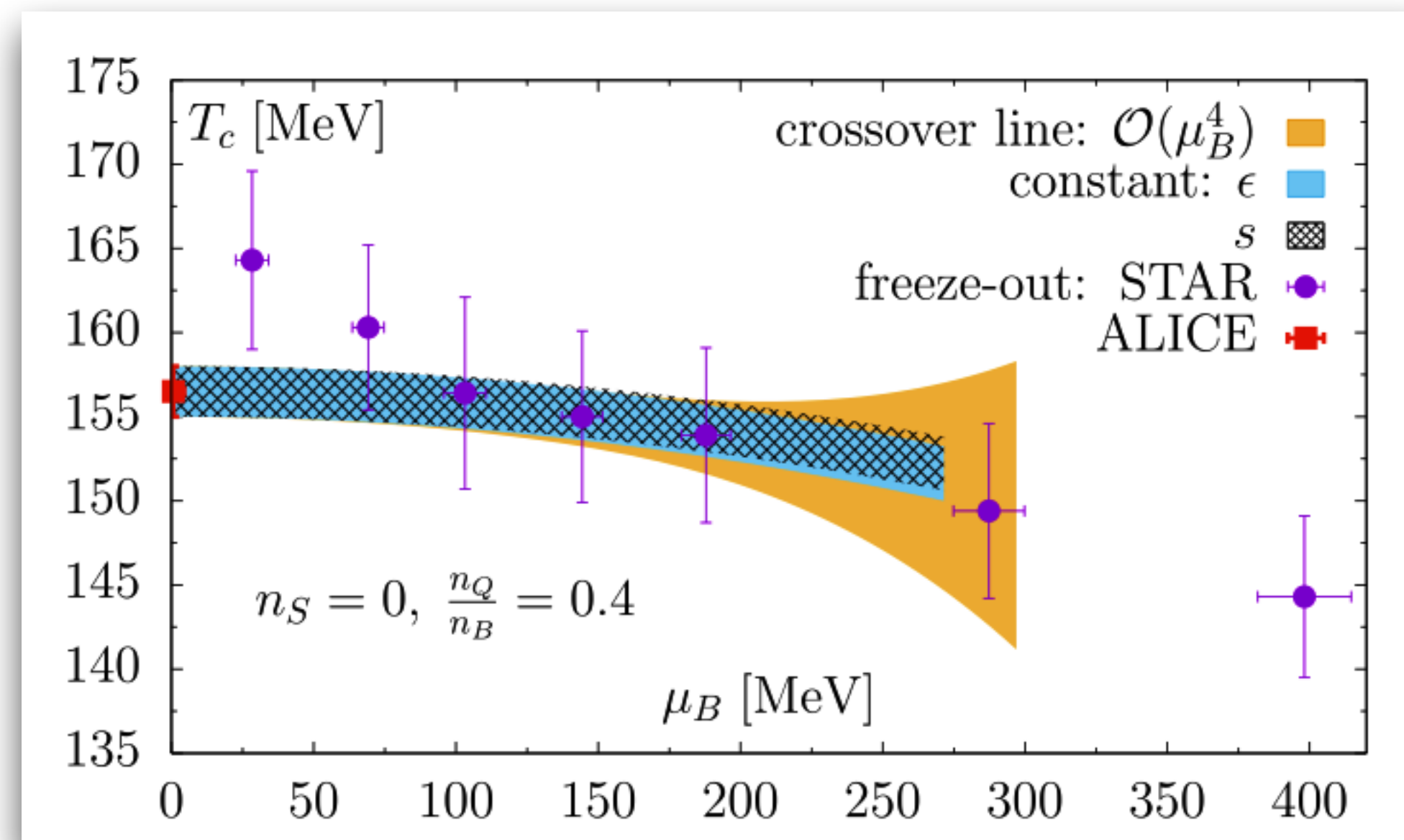


where is the phase boundary in QCD
phase diagram ?

Physics Letters B 795 (2019) 15–21

Chiral crossover in QCD at zero and non-zero chemical potentials

Google Scholar citations: 953

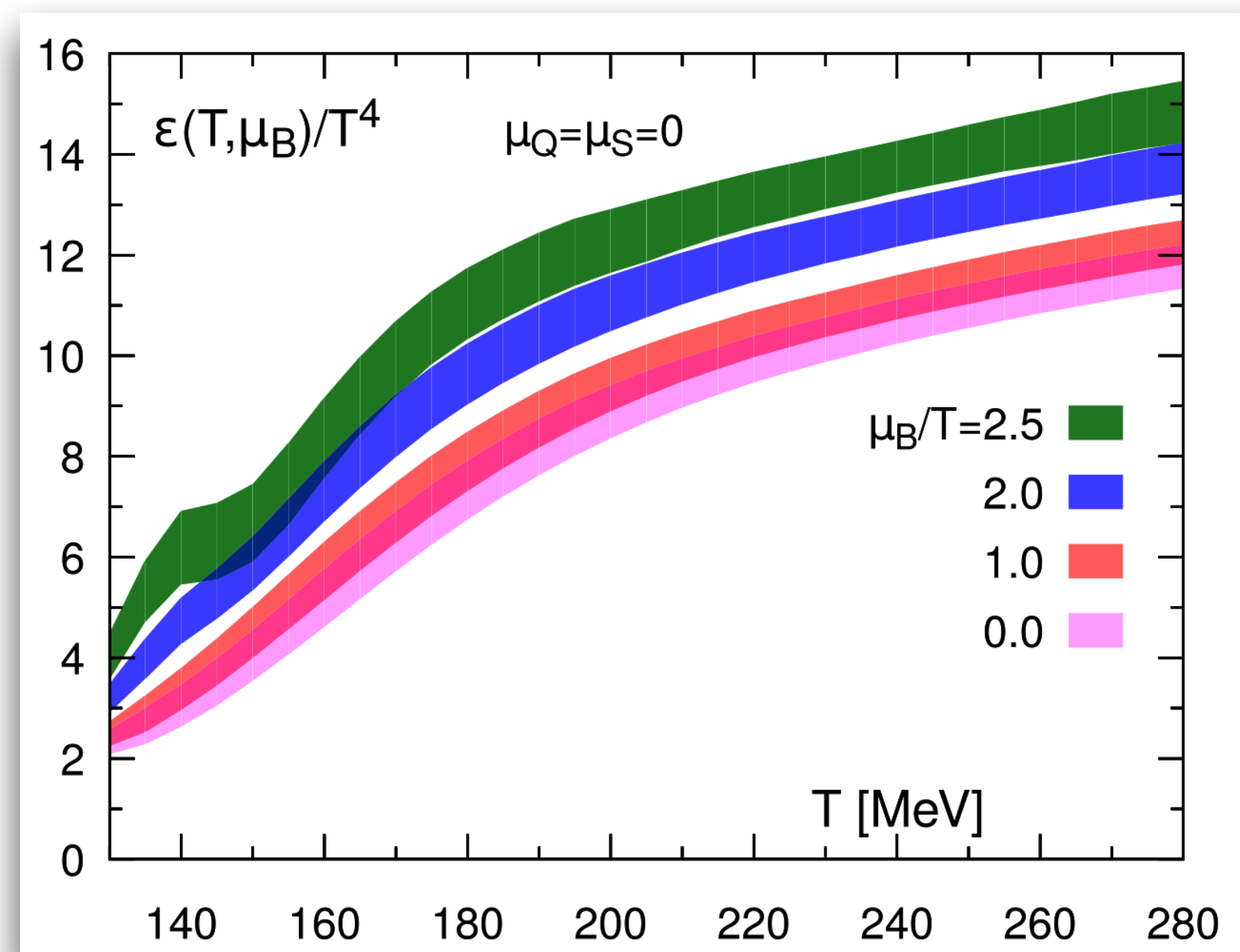


how do energy & pressure of QGP change with baryon density ?

PHYSICAL REVIEW D **95**, 054504 (2017)

QCD equation of state to $\mathcal{O}(\mu_B^6)$ from lattice QCD

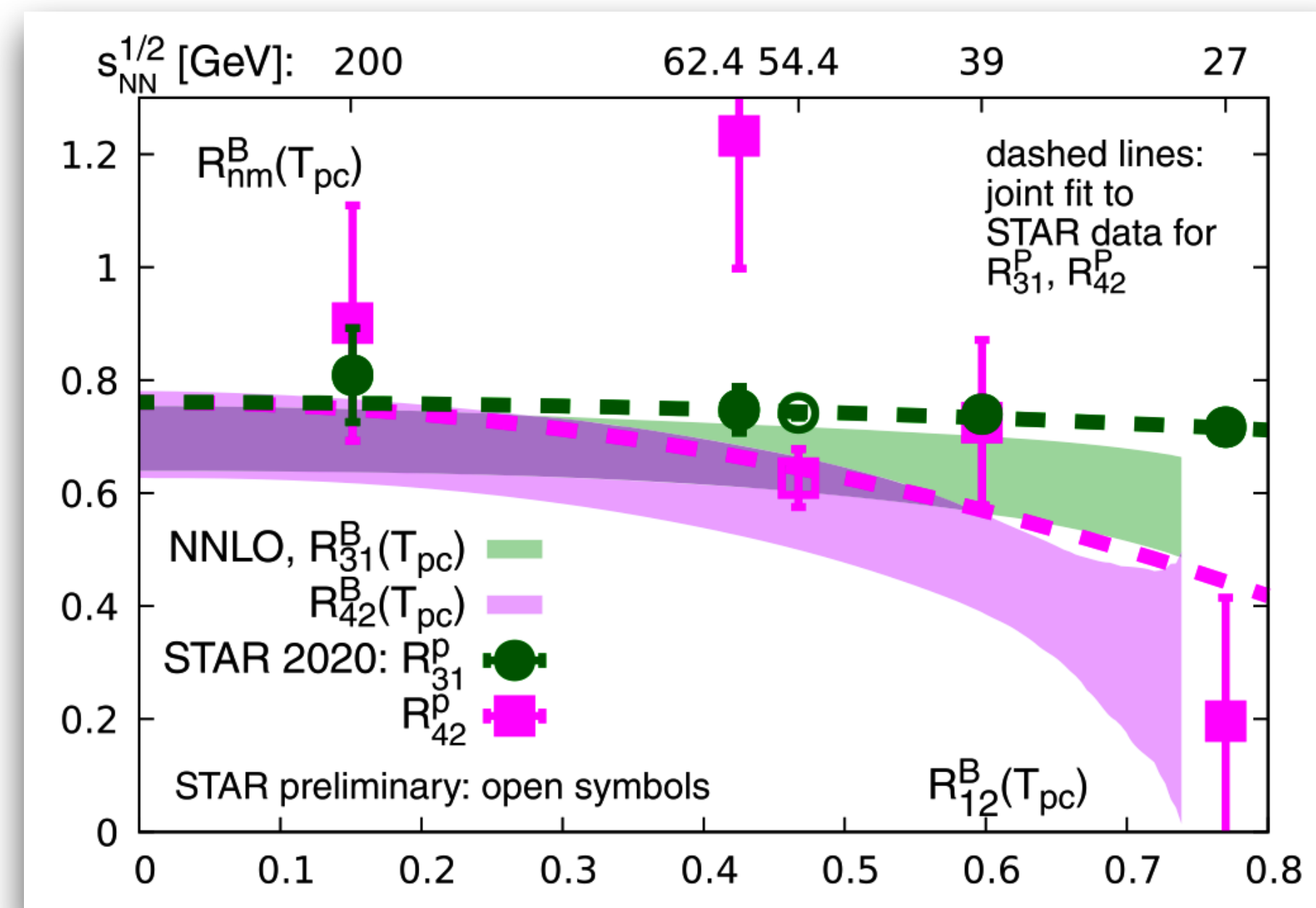
Google Scholar citations: 662



PHYSICAL REVIEW D **101**, 074502 (2020)

**Skewness, kurtosis, and the fifth and sixth order cumulants
of net baryon-number distributions from lattice
QCD confront high-statistics STAR data**

Google Scholar citations: 254

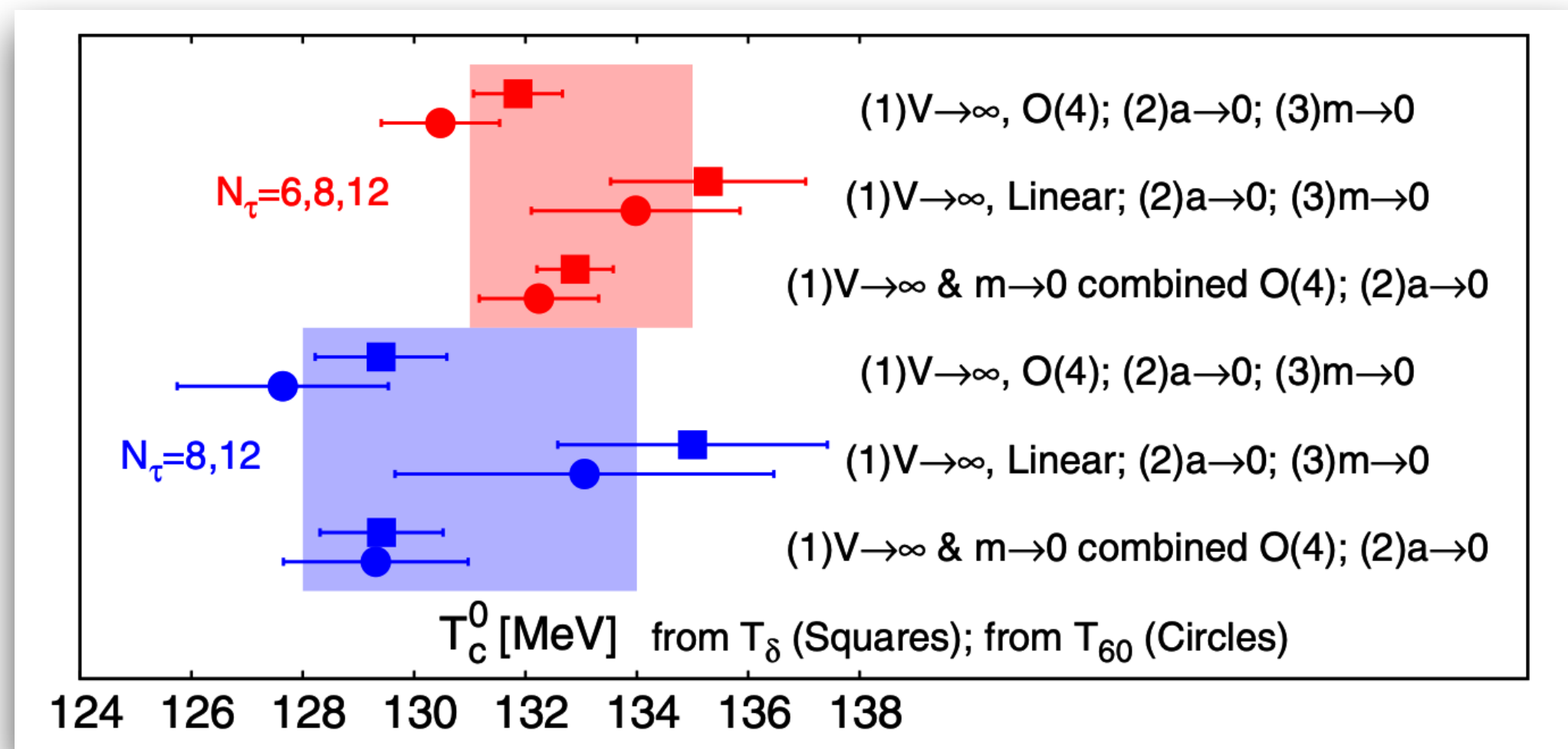


SciDAC-4 QCD chiral transition temperature — fundamental scale of chiral symmetry breaking

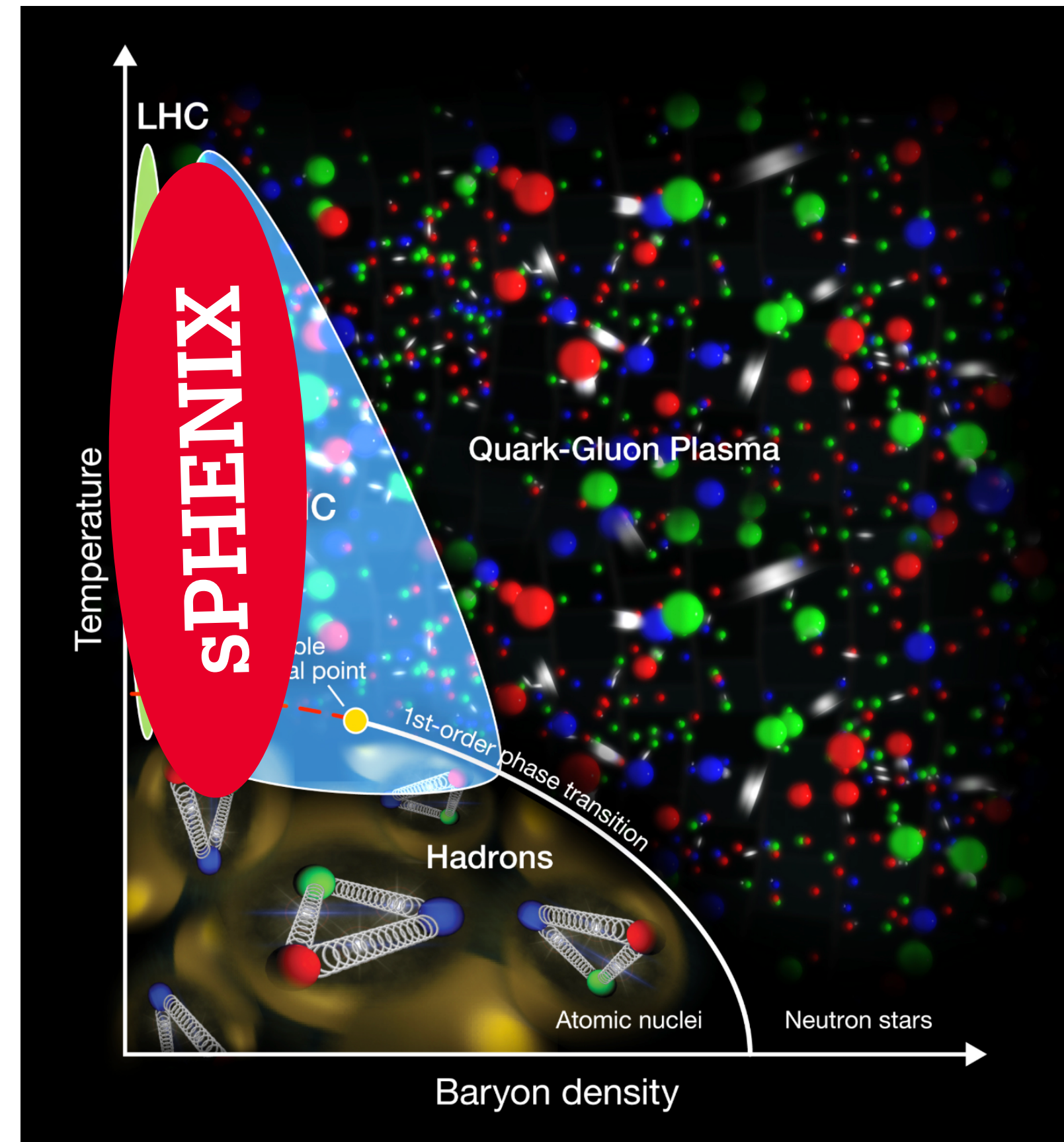
PHYSICAL REVIEW LETTERS **123**, 062002 (2019)

Chiral Phase Transition Temperature in (2 + 1)-Flavor QCD

Google Scholar citations: 315



SciDAC-5



SciDAC-5 how do heavy-quark probes travel within QGP ?

PHYSICAL REVIEW LETTERS **130**, 231902 (2023)

Heavy Quark Diffusion from 2+1 Flavor Lattice QCD with 320 MeV Pion Mass

Google Scholar citations: [111](#)

PHYSICAL REVIEW LETTERS **132**, 051902 (2024)

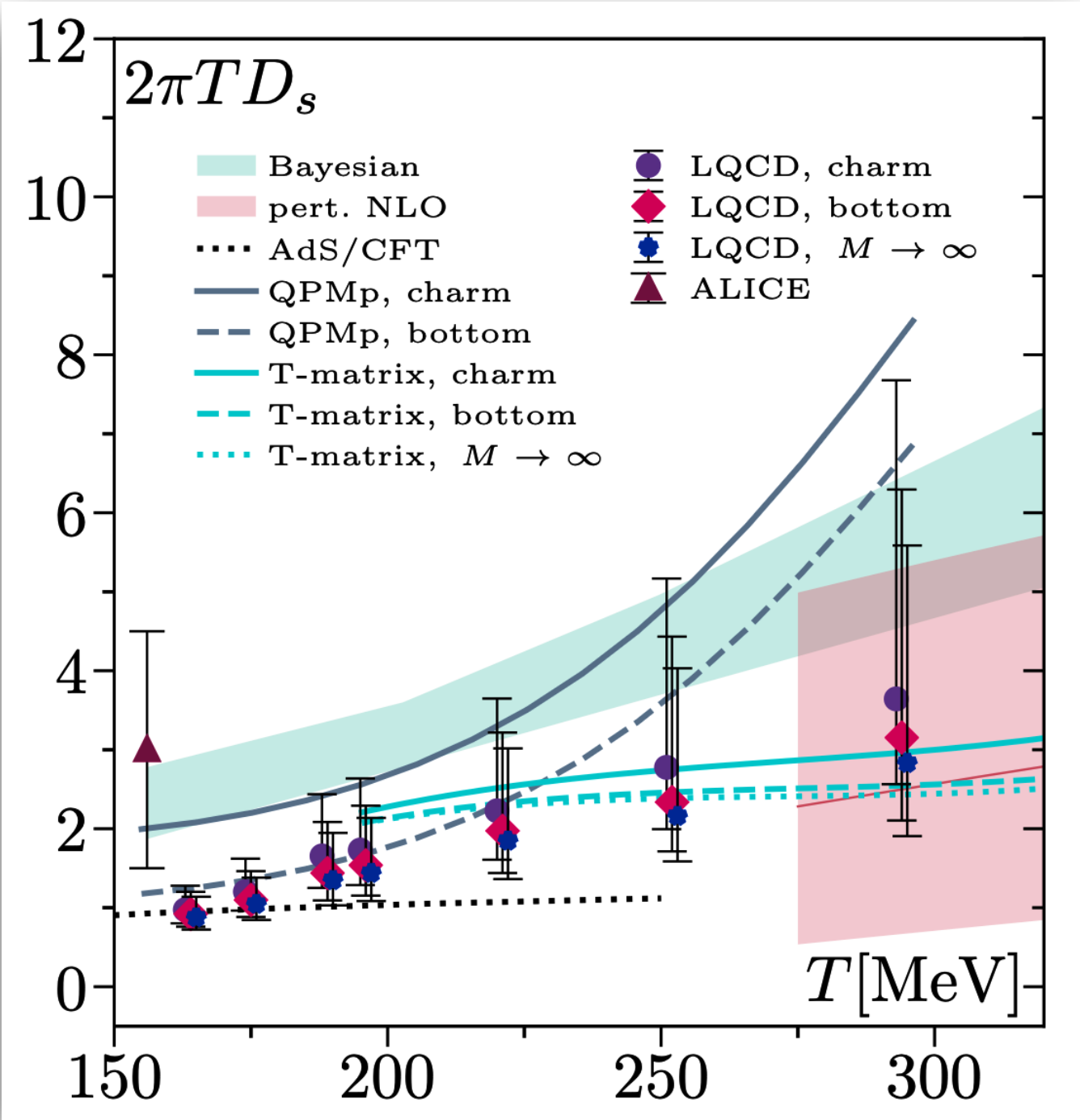
Quark Mass Dependence of Heavy Quark Diffusion Coefficient from Lattice QCD

Google Scholar citations: [68](#)



JHEP09 (2025) 180

Temperature dependence of heavy quark diffusion from (2+1)-flavor lattice QCD



[DOE NP Highlight](#)

[PHYS.org](#)

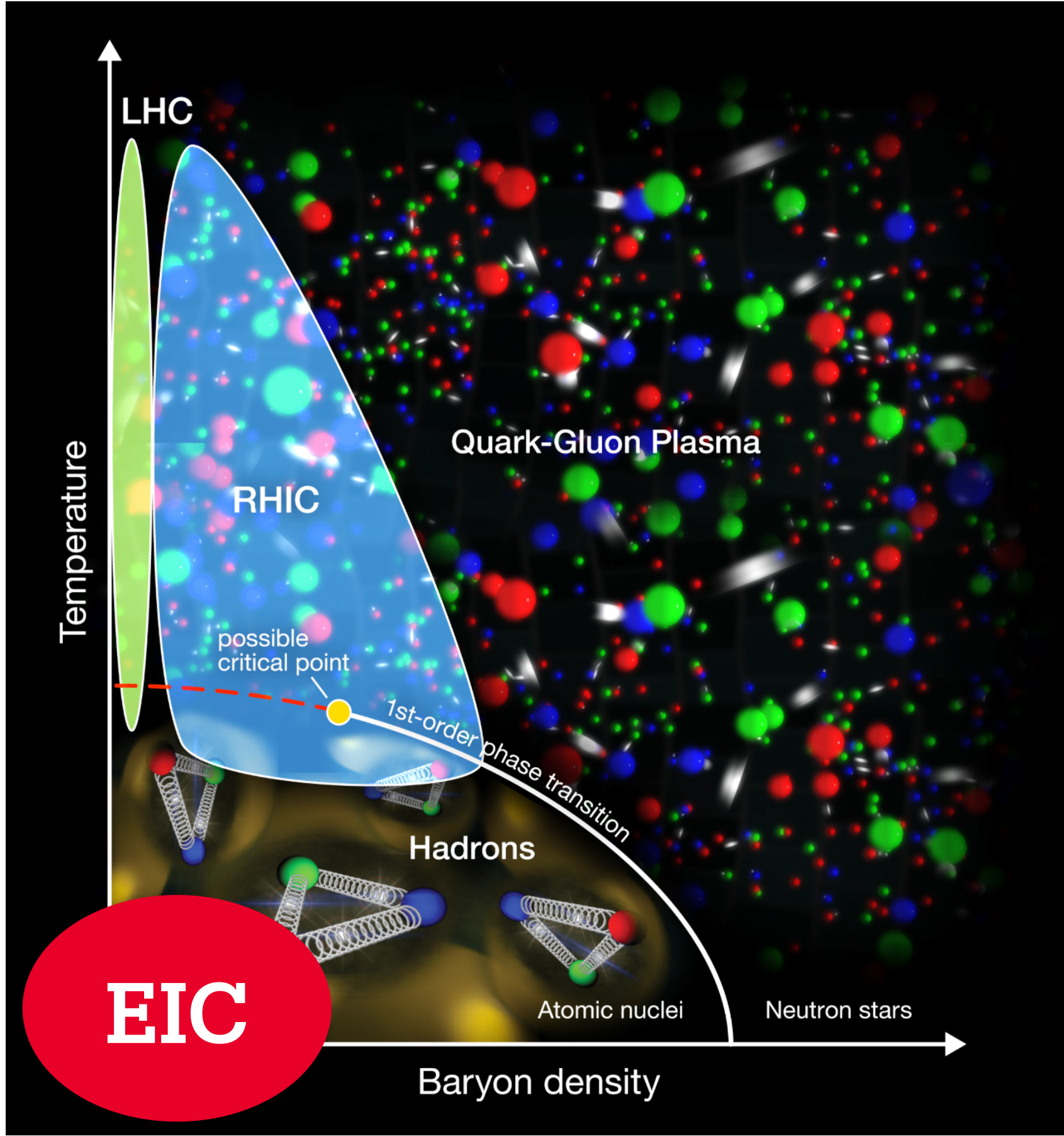
SciDAC-4: back to the future



January 9, 2020

U.S. Department of Energy Selects Brookhaven National Laboratory to Host Major New Nuclear Physics Facility

Planned Atom Smasher to Unlock the Secrets of the 'Strong Force.'



PHYSICAL REVIEW LETTERS **128**, 142003 (2022)

Lattice QCD Determination of the Bjorken- x Dependence of Parton Distribution Functions at Next-to-Next-to-Leading Order

Google Scholar citations: 96

PHYSICAL REVIEW D **106**, 114510 (2022)

Continuum-extrapolated NNLO valence PDF of the pion at the physical point

Google Scholar citations: 85

PHYSICAL REVIEW D **102**, 094513 (2020)

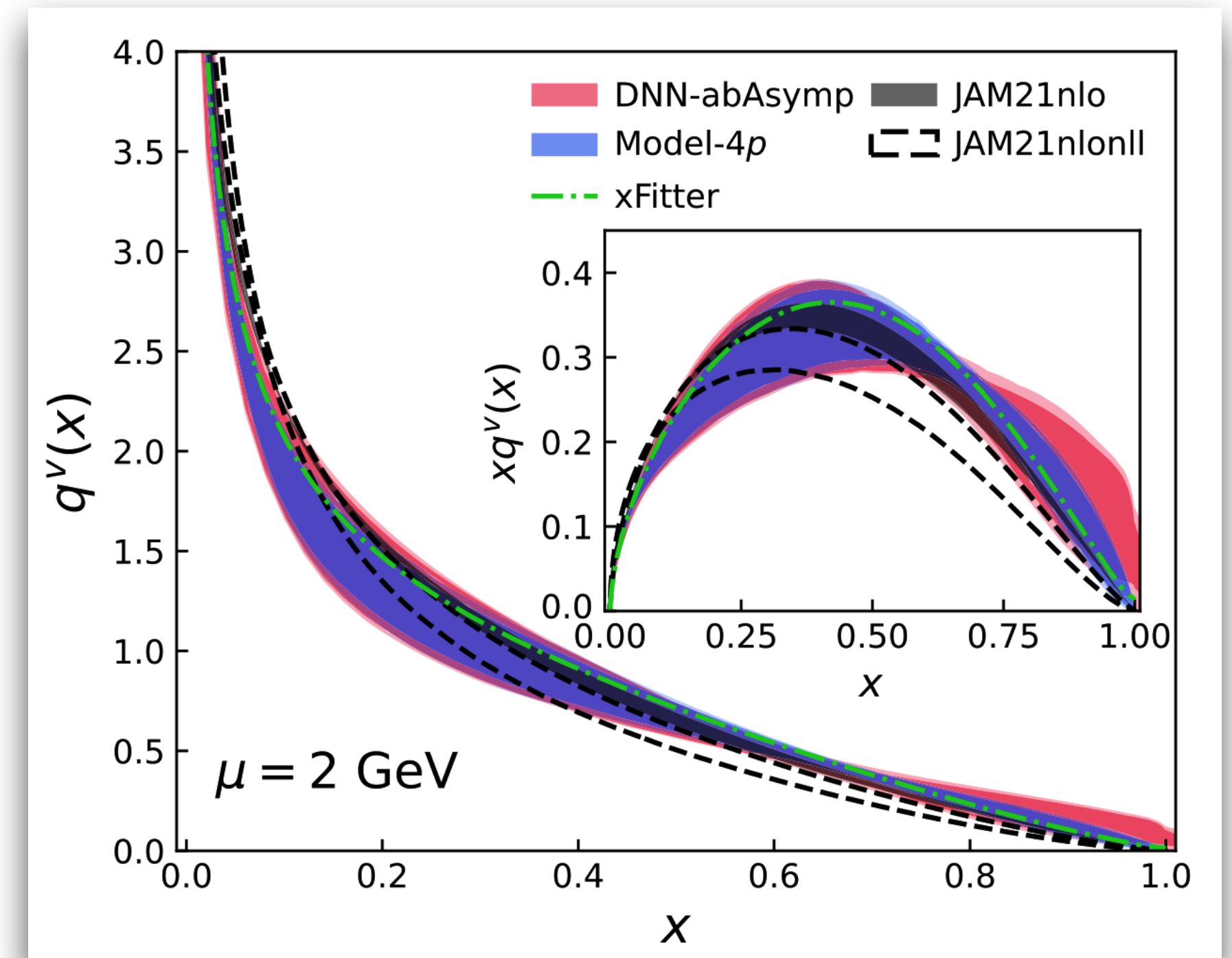
Valence parton distribution of the pion from lattice QCD: Approaching the continuum limit

Google Scholar citations: 133

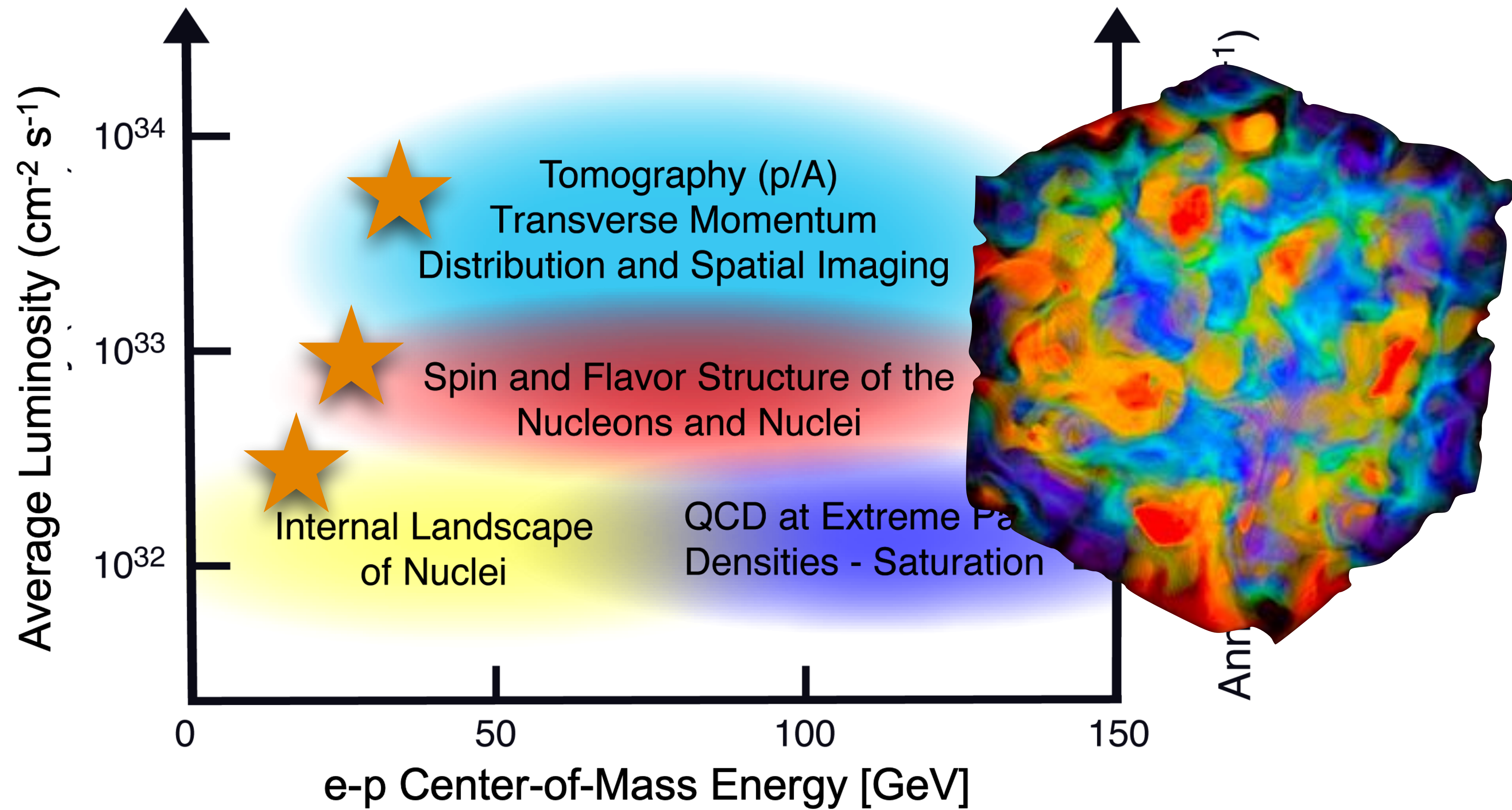
PHYSICAL REVIEW D **100**, 034516 (2019)

Valence parton distribution function of pion from fine lattice

Google Scholar citations: 150



SciDAC-5: climbing the science pillars of EIC



PHYSICAL REVIEW LETTERS 133, 181902 (2024)

QCD Predictions for Meson Electromagnetic Form Factors at High Momenta:
Testing Factorization in Exclusive Processes



U.S. DEPARTMENT
of ENERGY

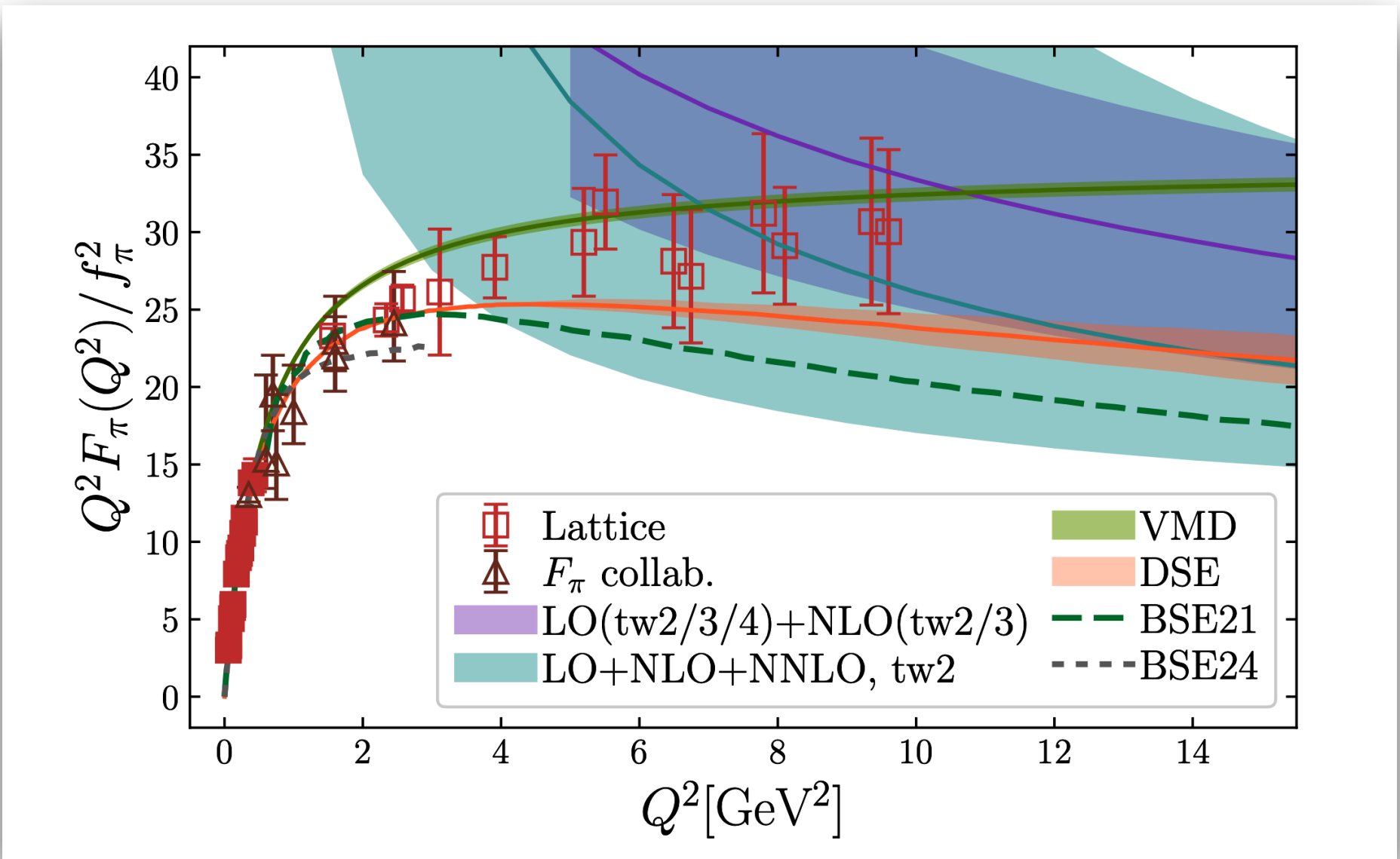
DOE NP Highlight

Scientists Calculate Predictions for
Electron-Ion Collider Measurements

Top 10 Discoveries of 2024



Brookhaven
National Laboratory

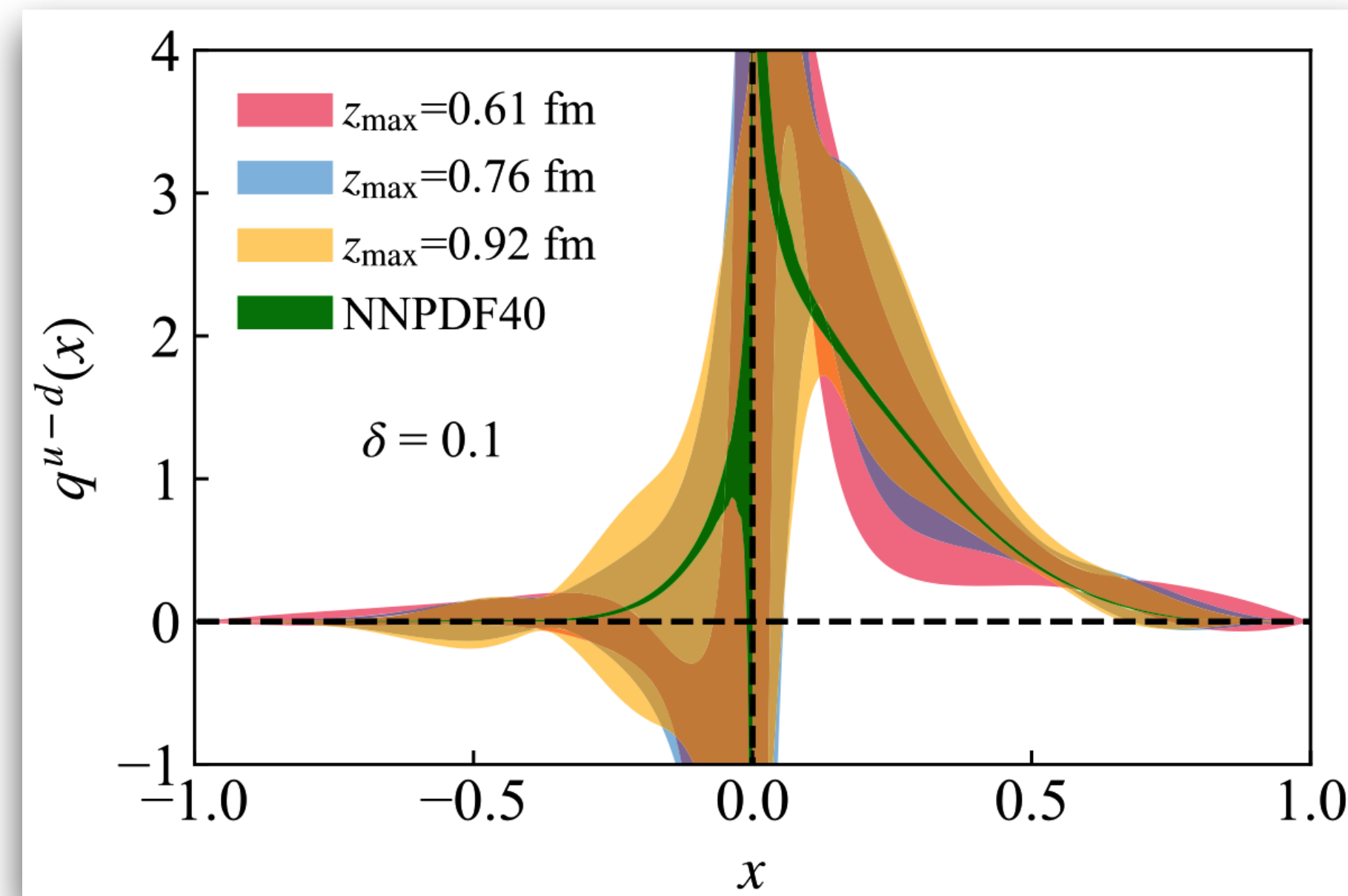


← JLab → EIC →

PHYSICAL REVIEW D **107**, 074509 (2023)

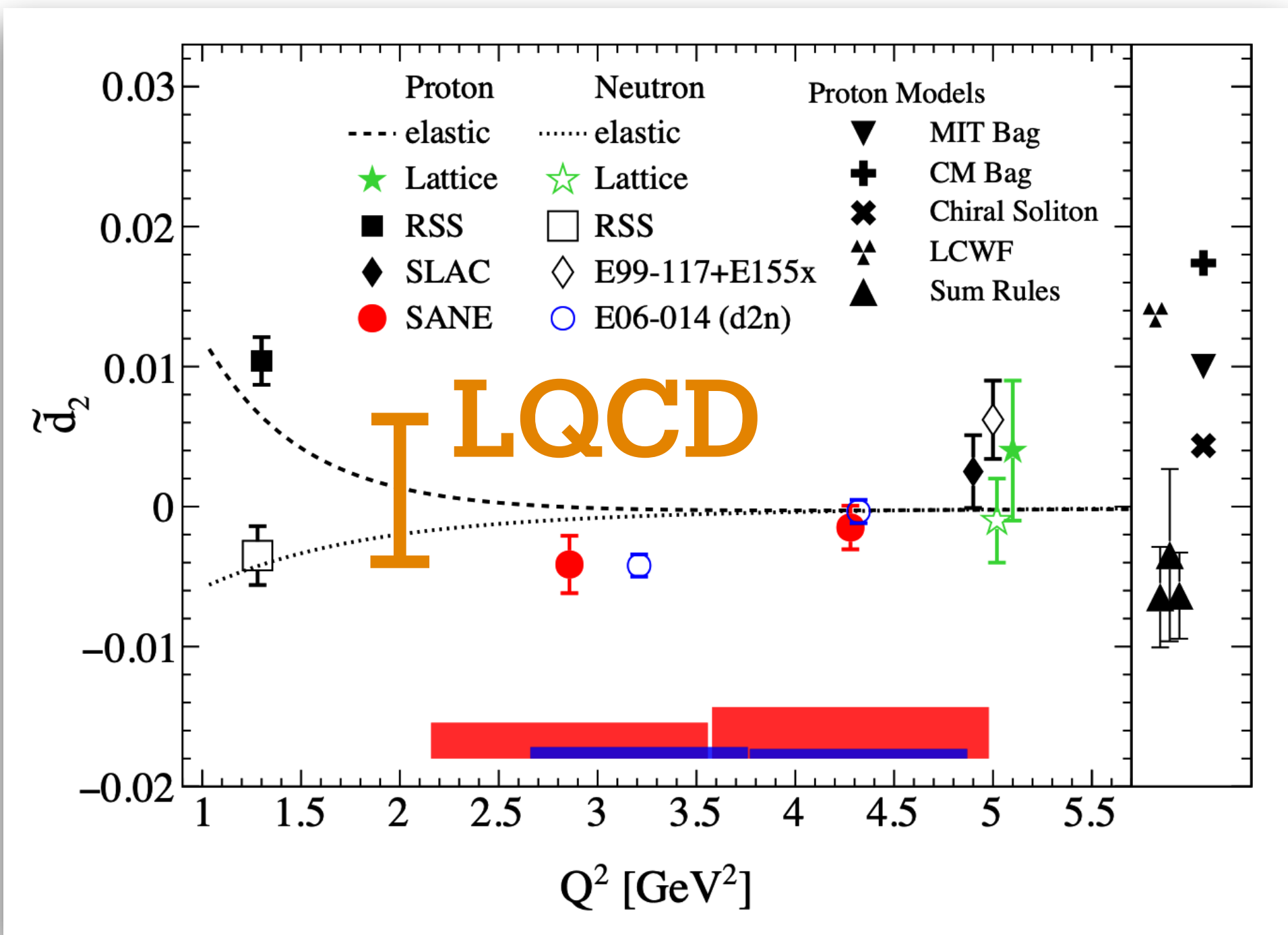
**Unpolarized proton PDF at NNLO from lattice QCD
with physical quark masses**

Google Scholar citations: 60



PHYSICAL REVIEW D **114**, 014505 (2026)

Proton isovector helicity PDF at NNLO and the twist-3 moment $\tilde{d}_2$ from lattice QCD at physical quark masses



PHYSICAL REVIEW D **106**, 114512 (2022)

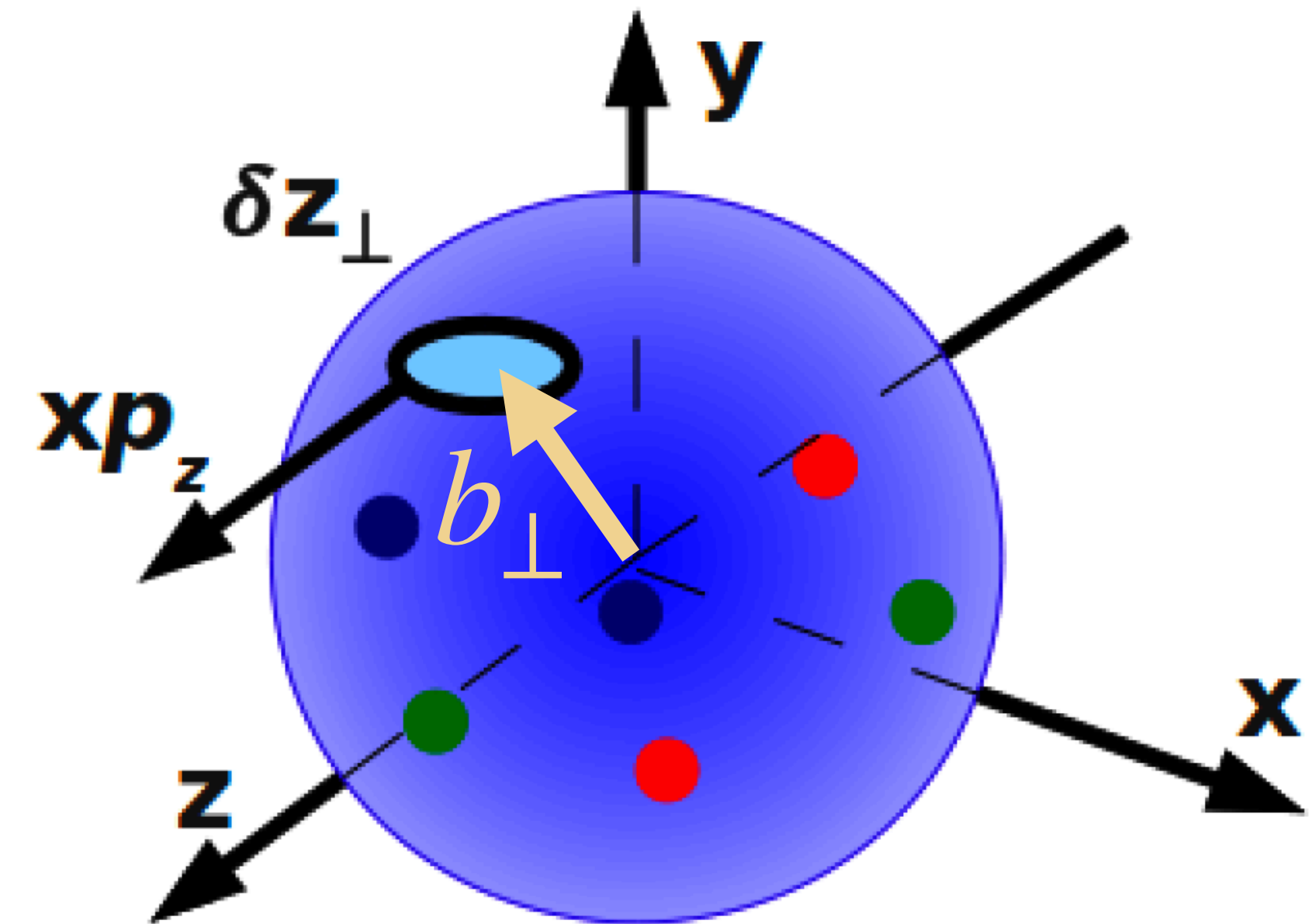
Generalized parton distributions from lattice QCD with asymmetric momentum transfer: Unpolarized quarks

Google Scholar citations: 100

PHYSICAL REVIEW D **108**, 014507 (2023)

Moments of proton GPDs from the OPE of nonlocal quark bilinears up to NNLO

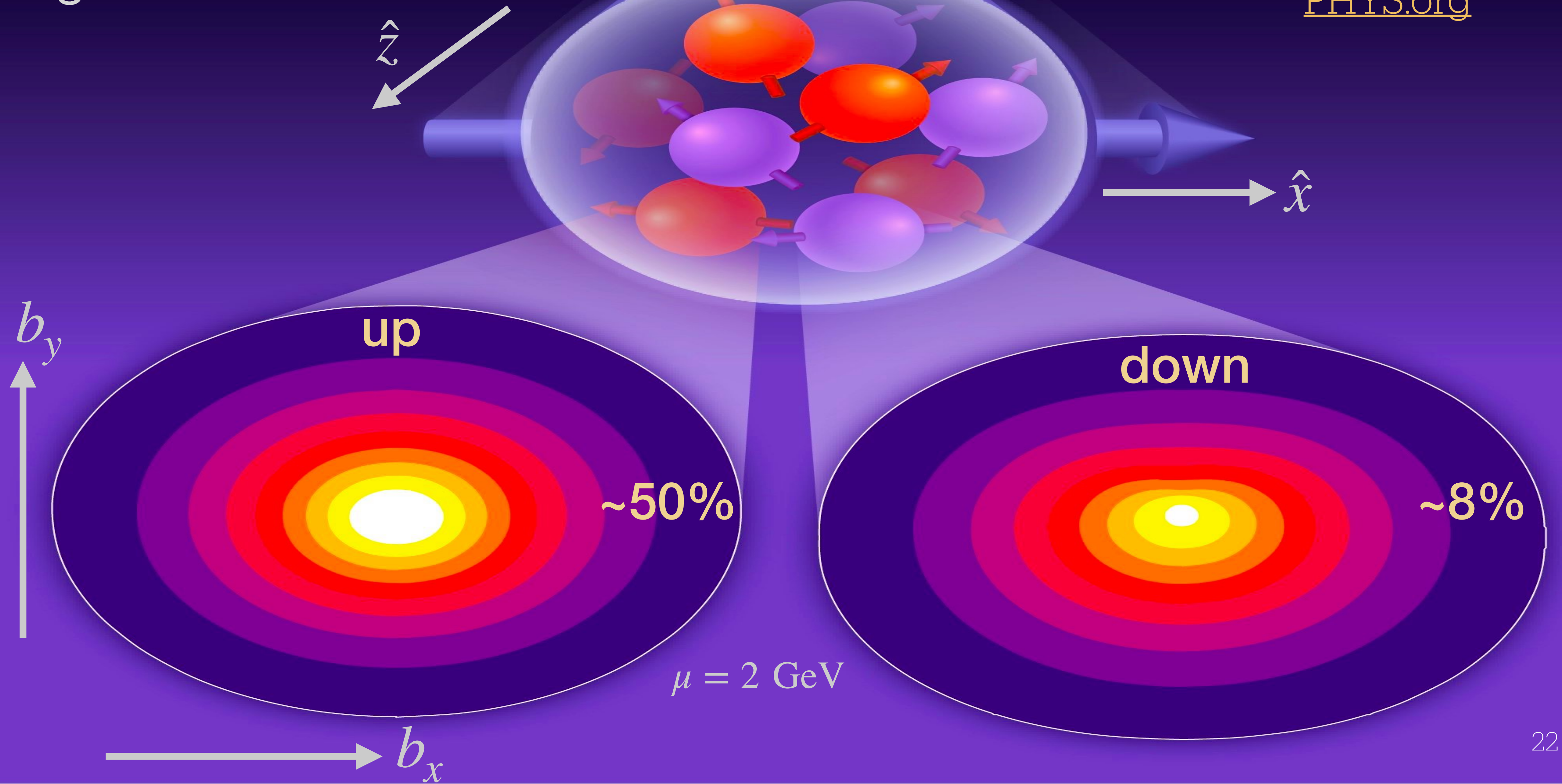
Google Scholar citations: 77



spatial distribution of quark's angular momentum

[DOE NP Highlight](#)

[PHYS.org](#)



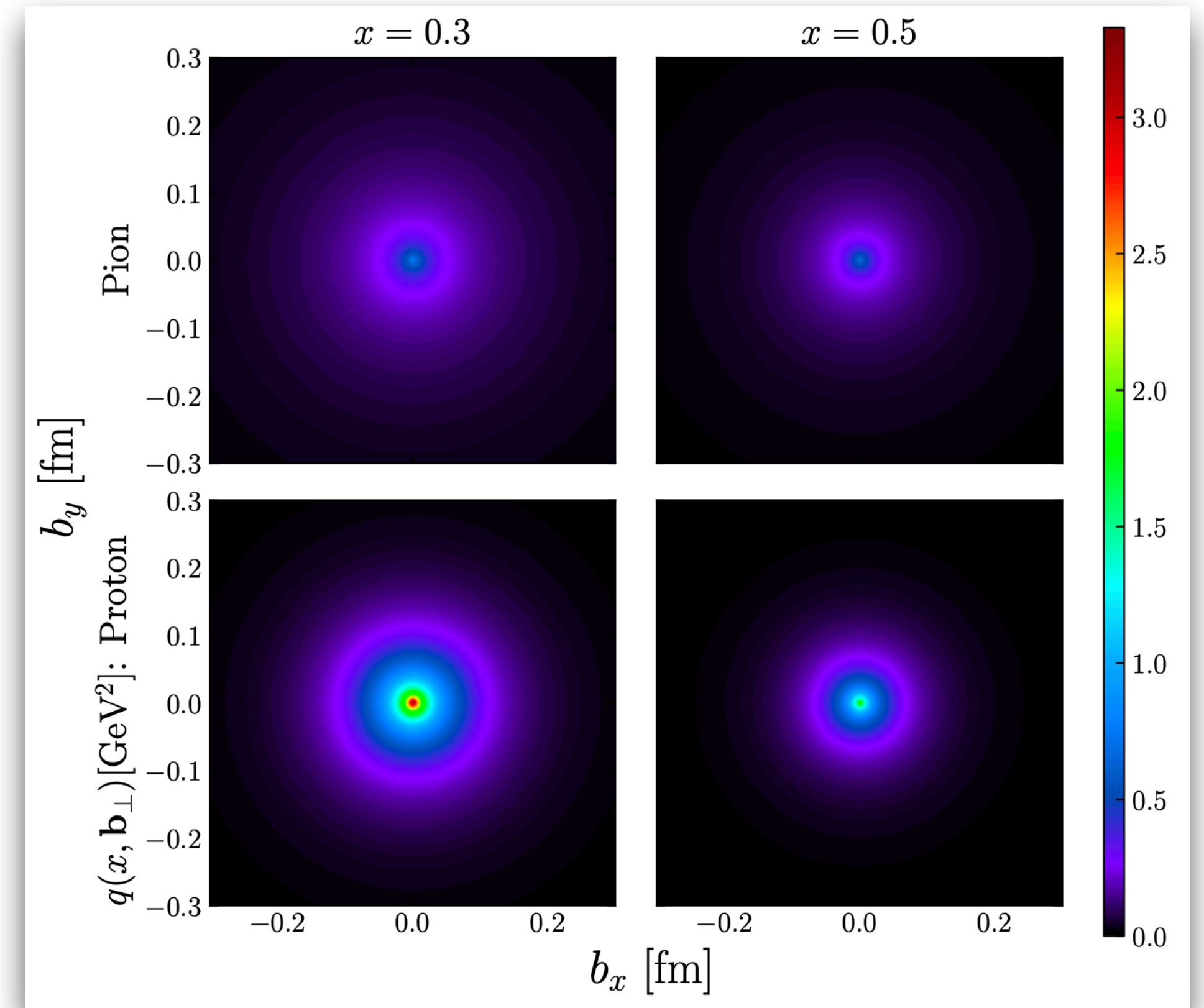


JHEP02(2025)056

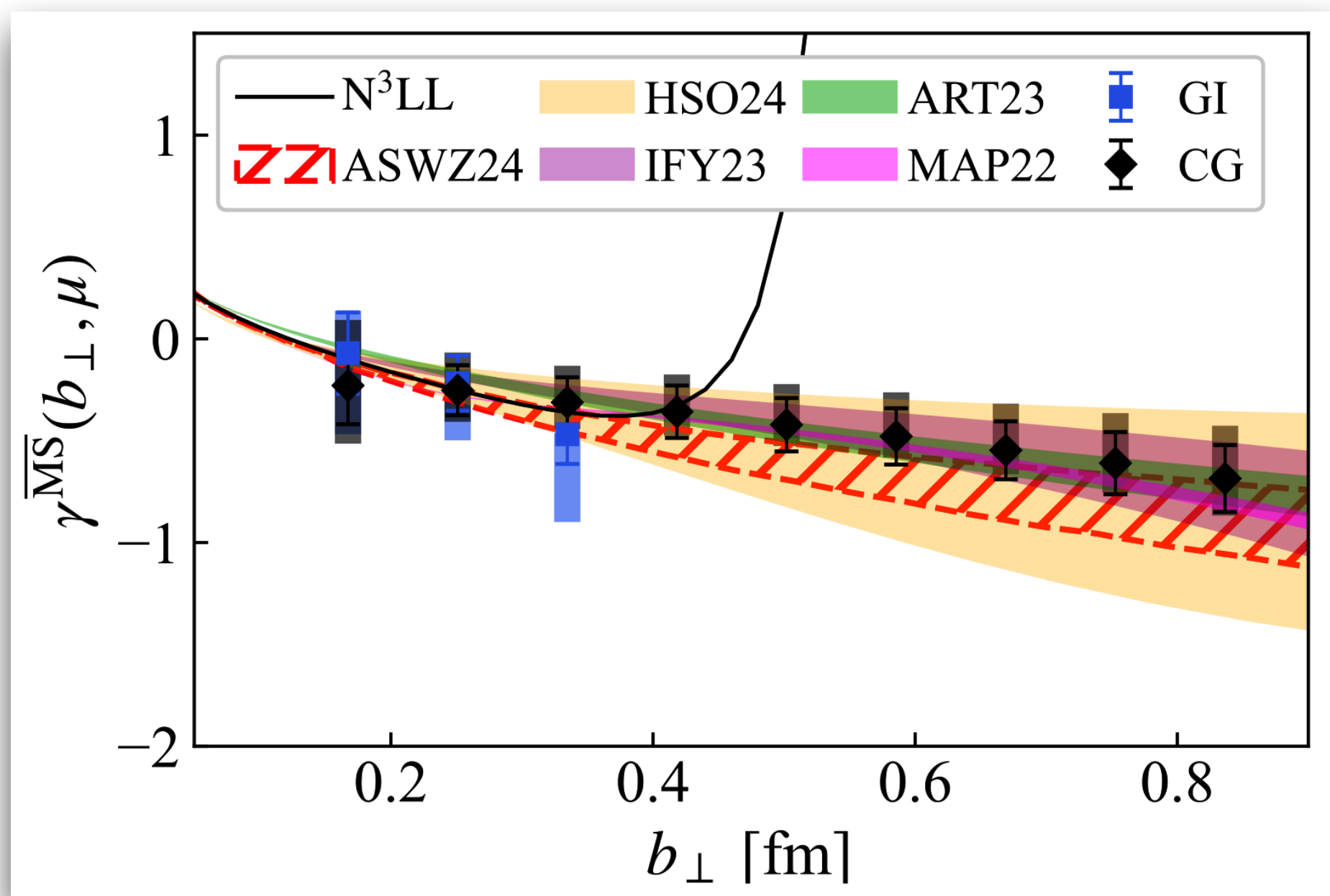
Three-dimensional imaging of pion using lattice QCD: generalized parton distributions

Highlight

Researchers use Argonne
supercomputer to illuminate the
subatomic particle that helps hold
matter together

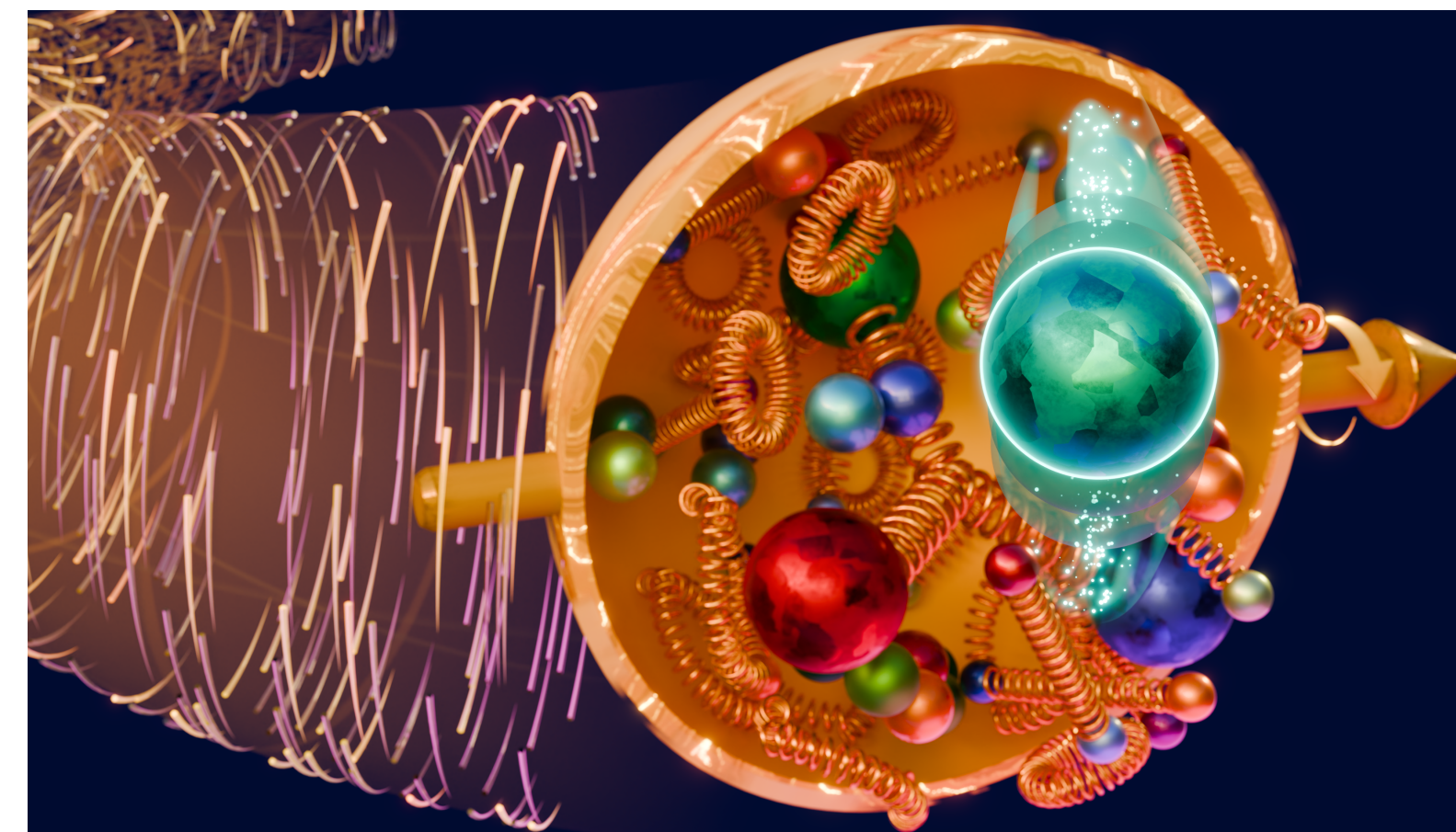


Nonperturbative Collins-Soper kernel from chiral quarks with physical masses



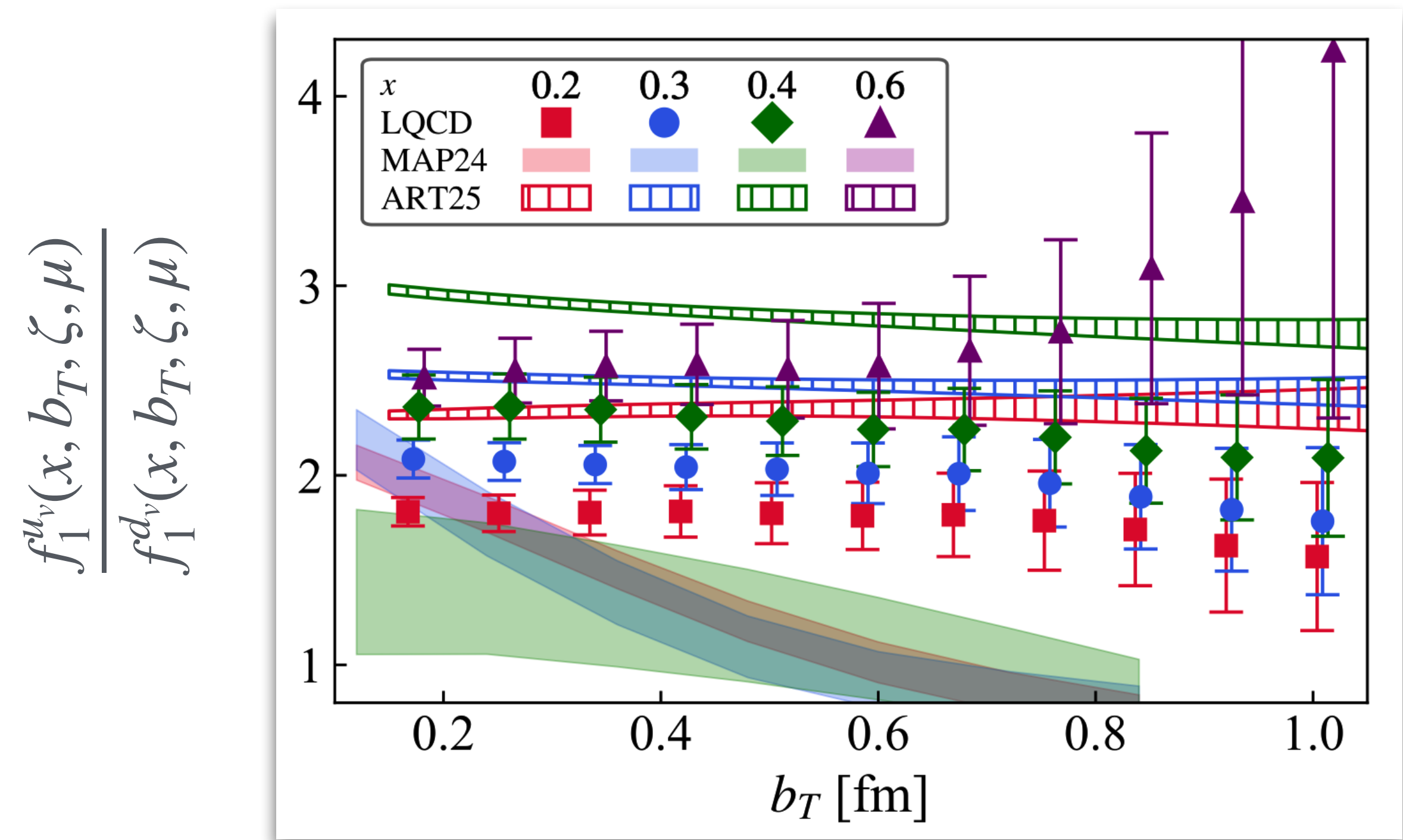
[DOE NP Highlight](#)

[SciTechDaily](#)



PHYSICAL REVIEW LETTERS **135**, 201901 (2025)

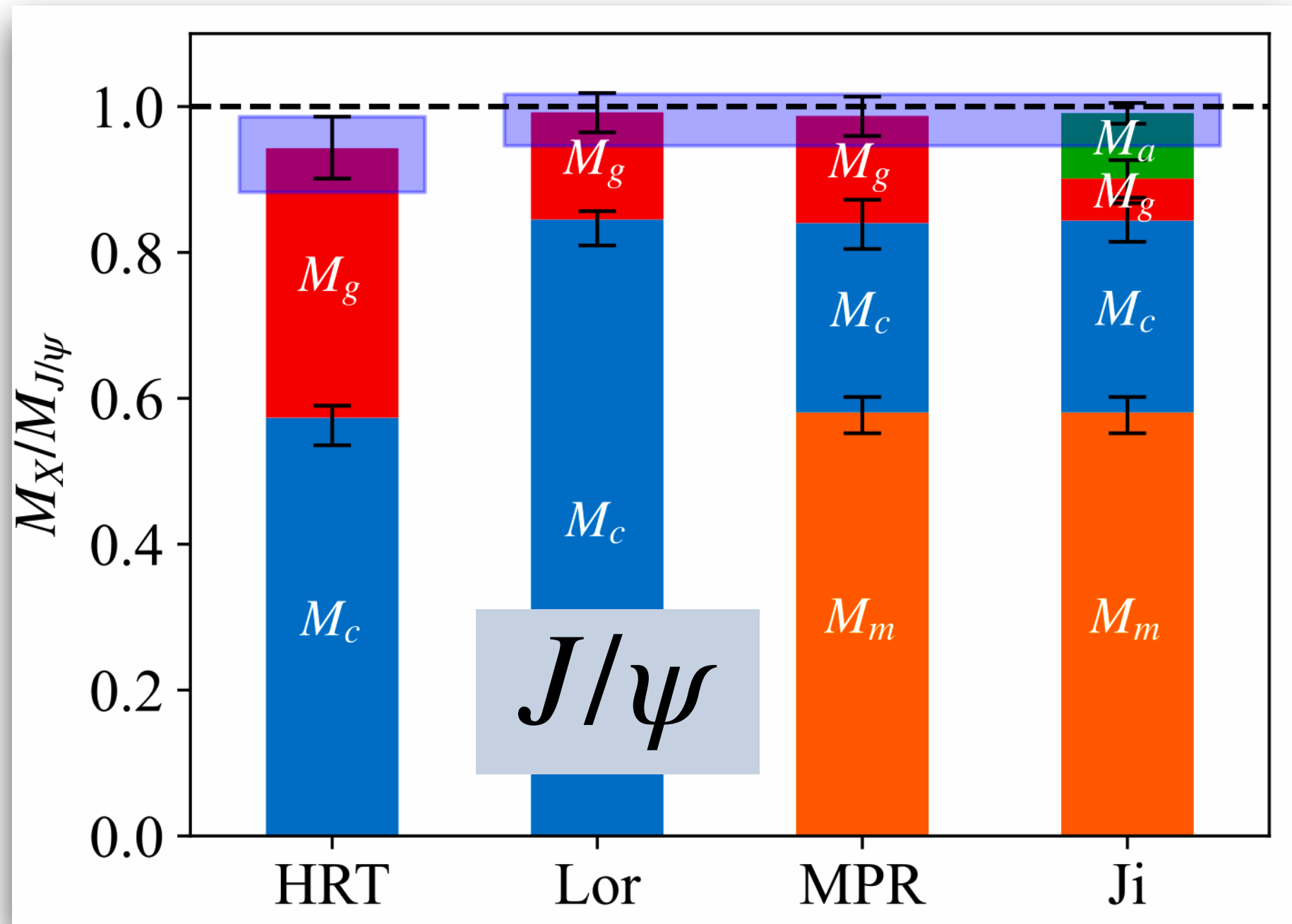
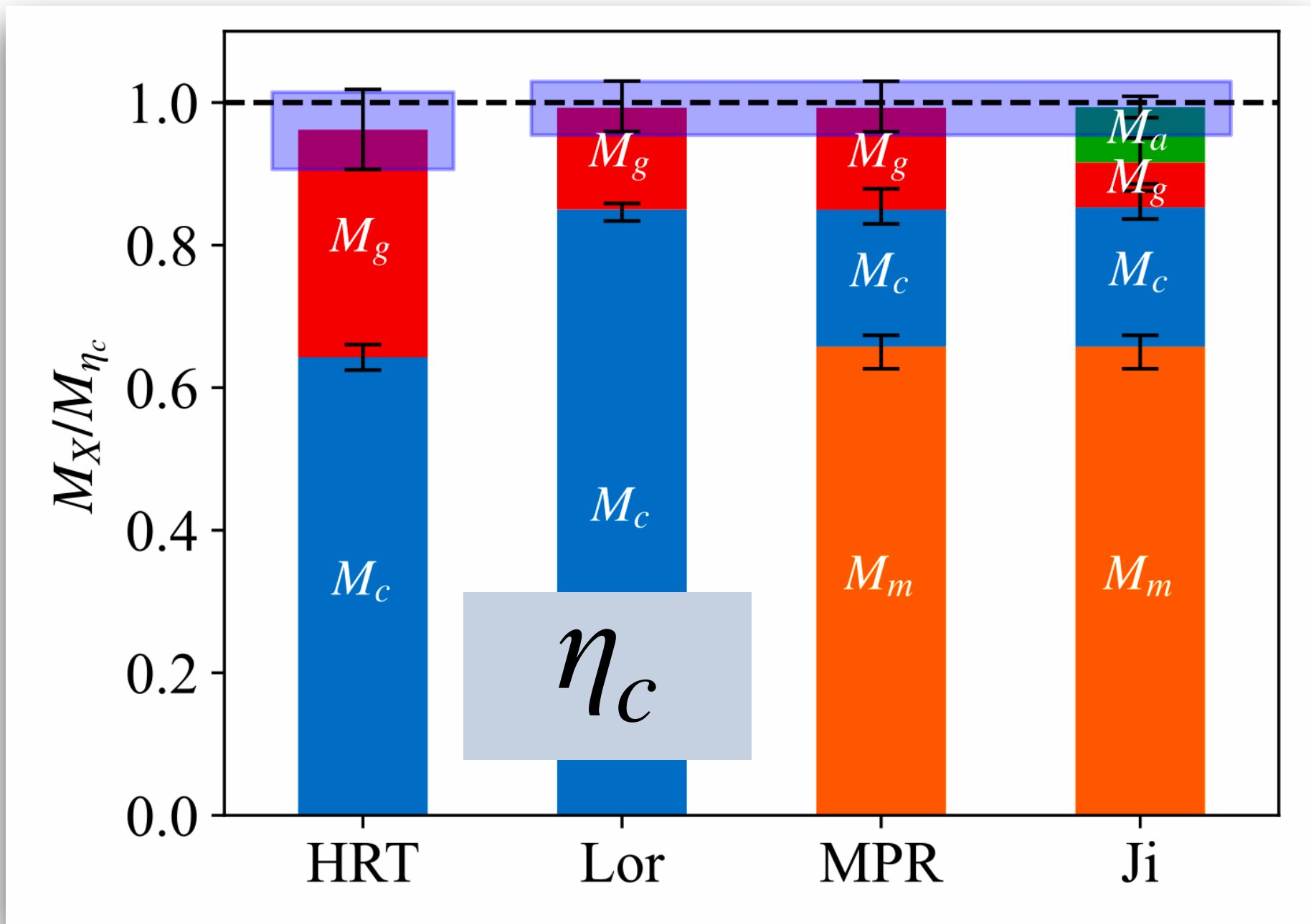
**Lattice QCD Benchmark of Proton Helicity and Flavor-Dependent
Unpolarized Transverse Momentum-Dependent Parton Distribution Functions
at Physical Quark Masses**



arXiv:2601.13070

Lattice-QCD validation of hadron mass and trace-anomaly decomposition sum rules

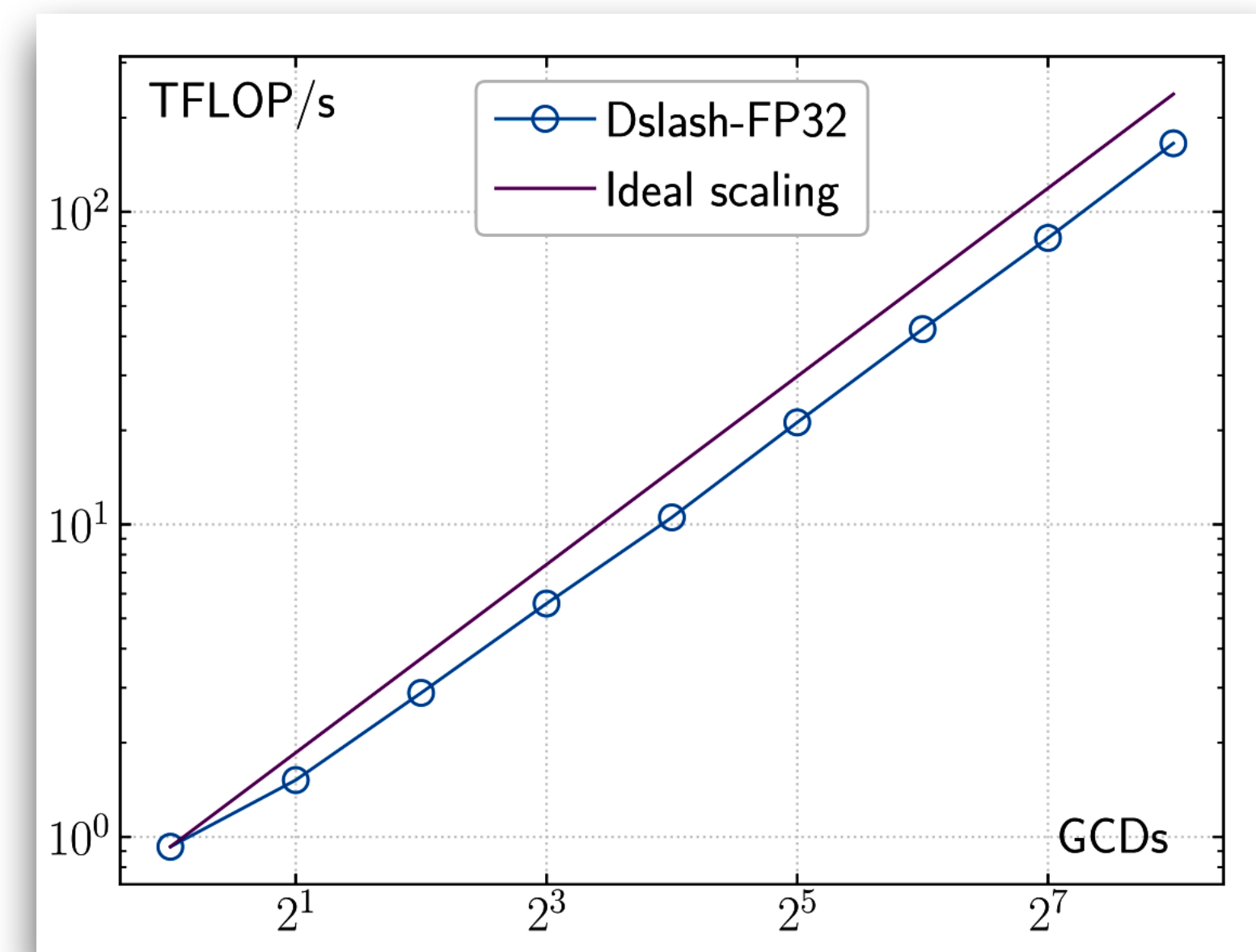
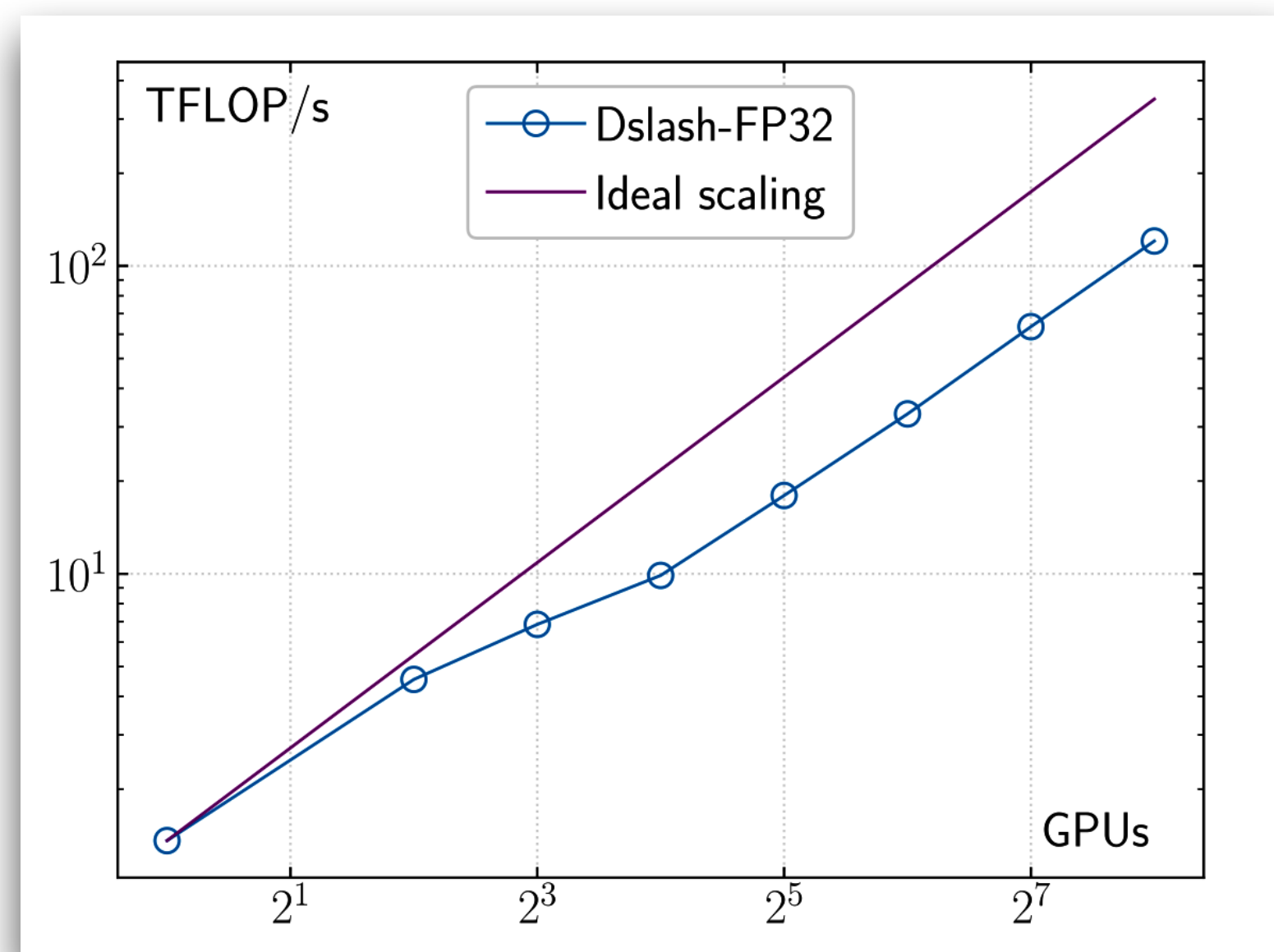
Phys. Rev. Lett., to appear



Computer Physics Communications 300 (2024) 109164

SIMULATeQCD: A simple multi-GPU lattice code for QCD calculations

iNSPIRE citations: 54



SciDAC-5: summary

Refereed journal publications: 32

Letters: 9

Total citations [iNSPIERE]: 1105

100+ citations: 2

50+ citations: 6

INCITE awards: 5

ALCC awards: 3