EXPLORING THE ORIGIN OF THE PROTON'S MASS WITH NEAR-THRESHOLD PRODUCTION OF QUARKONIA

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HOW DOES THE PROTON'S MASS EMERGE FROM ITS CONSTITUENTS?



PROTON MASS DECOMPOSITION



X. Ji, PRL (1995)



MODELS RELATE TRACE ANOMALY TO $4 J/\Psi$ PRODUCTION NEAR THRESHOLD

e.g. D. Kharzeev, *EPJ* C9 459 (1999)



J/Ψ ELECTROPRODUCTION WITH CEBAF 12 GEV AND SOLID



J/Ψ production threshold W ~ 4.035 GeV SoLID: Expect 2k events within 50 days (within detector acceptance, recoil proton not detected)

PROJECTIONS FOR SOLID J/Ψ ELECTROPRODUCTION DATA



JLab PAC 39 Proposal: Near Threshold Electroproduction of J/Psi at 11 GeV (SoLID)

THE HEAVIER QUARKONIUM: NO DATA⁷ FOR THRESHOLD PRODUCTION OF Y



$$\frac{\sigma \left(\gamma \ p \to \Upsilon \ p\right)}{\sigma \left(\gamma \ p \to J/\psi \ p\right)} \sim 0.00$$

at W = 100 GeV

J/Ψ AND Y PRODUCTION NEAR THRESHOLD AT THE EIC?



$$\frac{d\sigma}{dt} = N_{2g} v \frac{(1-x)^2}{R^2 M^2} e^{1.13t}$$
$$x = \frac{(2m_p M + M^2)}{(W^2 - m_p^2)}$$

S. J. Brodsky et al, *Phys. Lett.*, B498:23, 2001

AN EIC EXPERIMENT BASED ON SPHENIX



Solenoid and flux return
Electromagnetic calorimeter
Hadron calorimeter

Central tracking GEM tracking RICH particle ID

RECONSTRUCTING ELECTRON DECAYS ¹⁰ OF Y STATES WITH BARREL SPHENIX



sPHENIX Proposal arXiv:1501.06197

Y ELECTROPRODUCTION AT EIC 5 GEV X 50 GEV



Y ELECTROPRODUCTION AT EIC 5 GEV X 50 GEV



Y ELECTROPRODUCTION AT EIC 5 GEV X 50 GEV



Y ELECTROPRODUCTION AT EIC 10 GEV X 250 GEV



EIC (5 GEV X 50 GEV) CAN ACCESSES ¹⁵ Y PRODUCTION NEAR THRESHOLD



EIC (10 GEV X 250 GEV) REACHES W OF EXISTING COLLIDER DATA



Measuring Y production near threshold at the EIC could access the trace anomaly contribution to the proton mass:

- Kinematics coverage including threshold region looks promising,
- But: Expected rates and backgrounds need careful study.





ADDITIONAL SLIDES

"The vast majority of the nucleon's mass is due to quantum fluctuations of quark-antiquark pairs, the gluons, and the energy associated with quarks moving around close to the speed of light."

Reaching for the Horizon

The 2015 Long Range Plan for Nuclear Science





Dedicated "Proton Mass" workshops in 2016 and 2017

EIC (5 GEV X 50 GEV) BARELY REACHES J/Ψ PRODUCTION THRESHOLD REGION

