12 GeV Upgrade
Future Science at Jefferson Lab

J/ψ Near Threshold Production with SoLID

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SoLID Collaboration

Jefferson Lab
EXPLORING THE NATURE OF MATTER

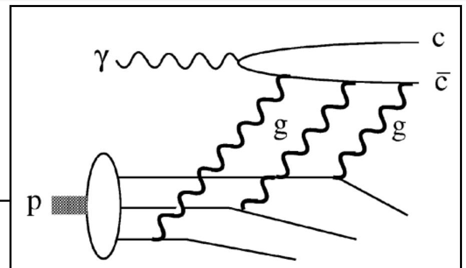
OLD DOMINION UNIVERSITY
IDEA FUSION

J/ψ as a Unique Probe of Strong Color Field in Nucleon

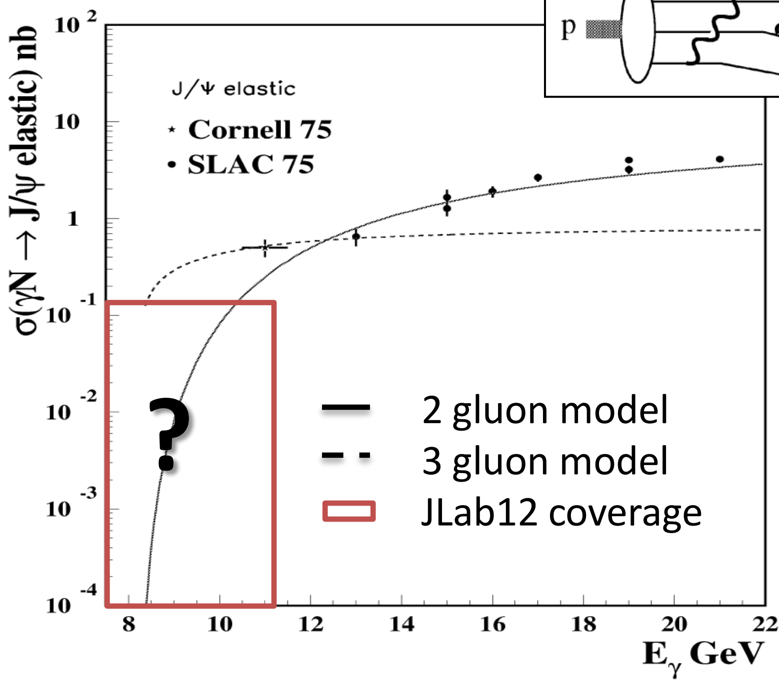
- **Probes strong gluonic interaction between two color neutral objects J/ψ and nucleon near threshold**
- **Models relate J/ψ production near threshold to trace anomaly and proton mass budget**

(D. Kharzeev et al Eur.Phys.J. C9 459 (1999), A. Sibirtsev et al. Phys. Rev., D71:076005 (2005))

Multiple gluon exchange may cause enhancement near threshold

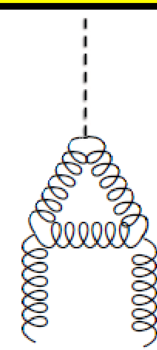


Trace anomaly of QCD energy momentum tensor plays an essential part in proton mass budget

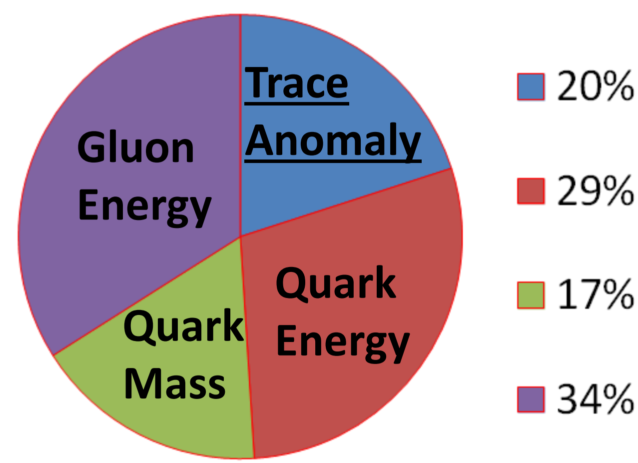


S.J. Brodsky et al. Phys.Lett.B 498 23 (2001)

$$G^{\alpha\beta\gamma}G^{\gamma}_{\alpha\beta}$$

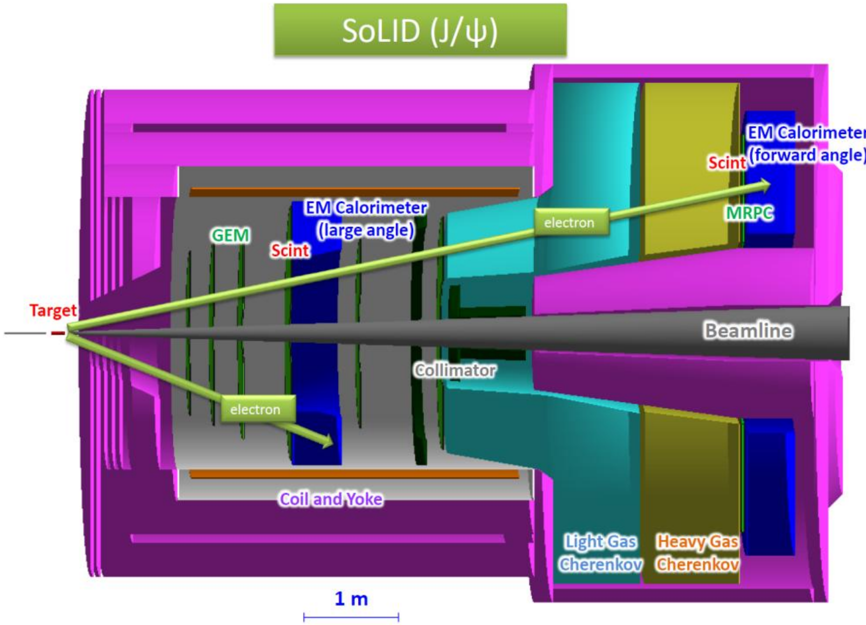


Proton Mass Budget

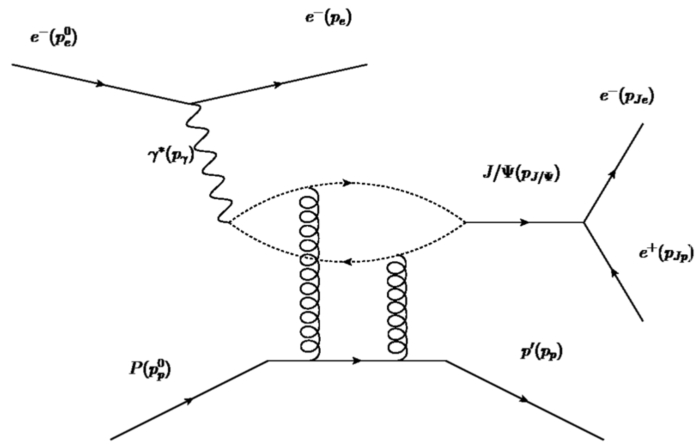


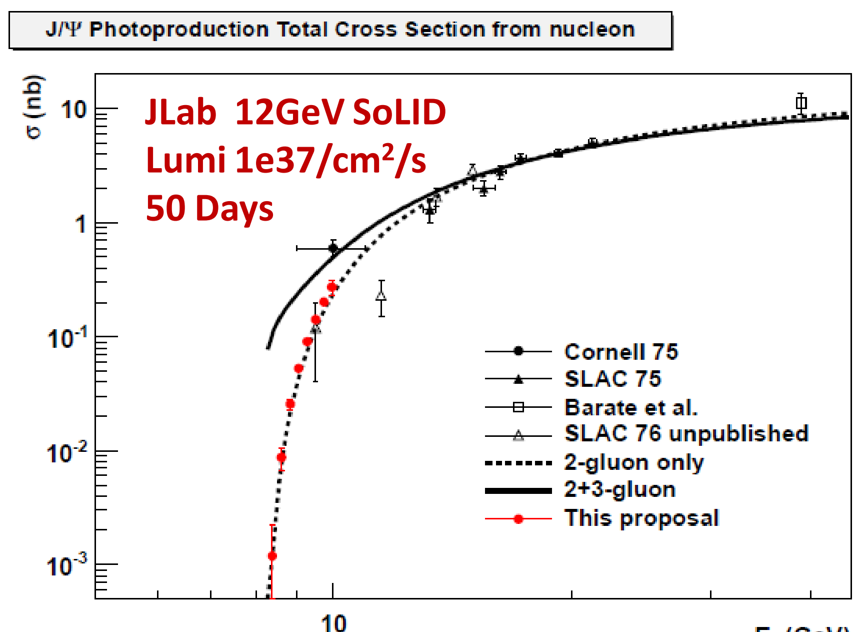
X. Ji PRL 74 1071 (1995)

J/ψ Near Threshold Production with SoLID



$$\gamma^* + N \rightarrow N + J/\psi$$





- **high luminosity & large acceptance** capability of SoLID enables a unique "**precision**" measurement near threshold
- Search for possible enhancement
- Study multiple gluons exchange
- Shed light on the low energy J/ψ-nucleon interaction (**color Van der Waals force**)
- Shed light on the **trace anomaly**, an important piece in the proton mass budget

Zhiwen Zhao, SoLID Collaboration, JLab

Trace Anomaly and Proton Mass Budget

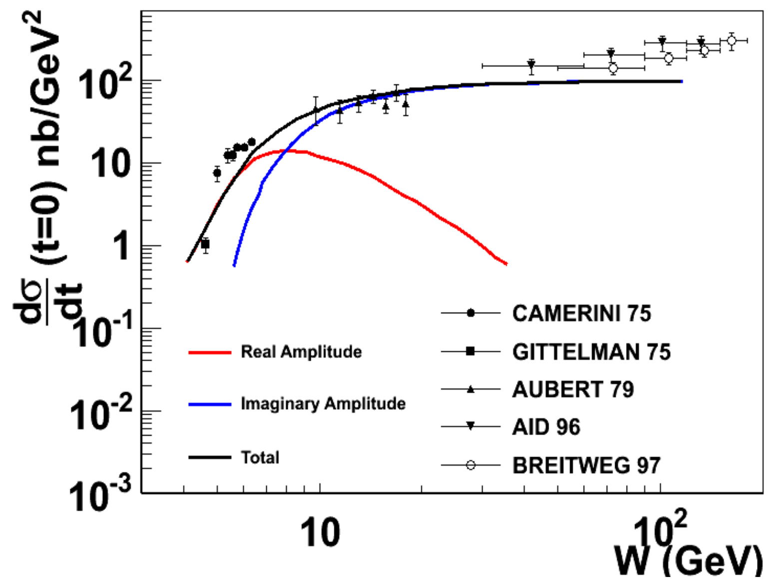
Backup

D. Kharzeev. Quarkonium interactions in QCD, 1995

D. Kharzeev, H. Satz, A. Syamtomov, and G. Zinovjev, Eur.Phys.J., C9:459–462, 1999

$$\frac{d\sigma_{\gamma N\to\psi N}}{dt}(s,t=0) = \frac{3\Gamma(\psi\to e^+e^-)}{\alpha m_\psi}\left(\frac{k_{\psi N}}{k_{\gamma N}}\right)^2 \frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0)$$

$$\frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0) = \frac{1}{64\pi}\frac{1}{m_\psi^2(\lambda^2 - m_N^2)}|\mathcal{M}_{\psi N}(s,t=0)|^2$$



$$H_{QCD} = H_q + H_m + Hg + H_a$$

$$H_a = \int d^3x \, \frac{9\alpha_s}{16\pi}\left(\mathbf{E}^2 + \mathbf{B}^2\right)$$

$$H_q = \int d^3x \, \psi^\dagger \left(-i\mathbf{D}\cdot\alpha\right)\psi$$

$$H_m = \int d^3x \, \bar{\psi} m \psi$$

$$H_g = \int d^3x \, \frac{1}{2}\left(\mathbf{E^2} + \mathbf{B^2}\right)$$

$$H_a = \int d^3x \, \frac{9\alpha_s}{16\pi}\left(\mathbf{E^2} - \mathbf{B^2}\right)$$

$$\mathcal{T}_{AB} = 2\sqrt{M_A M_B}\,\alpha_{AB}\langle N|\frac{1}{2}\vec{E}^a\cdot\vec{E}^a|N\rangle,$$

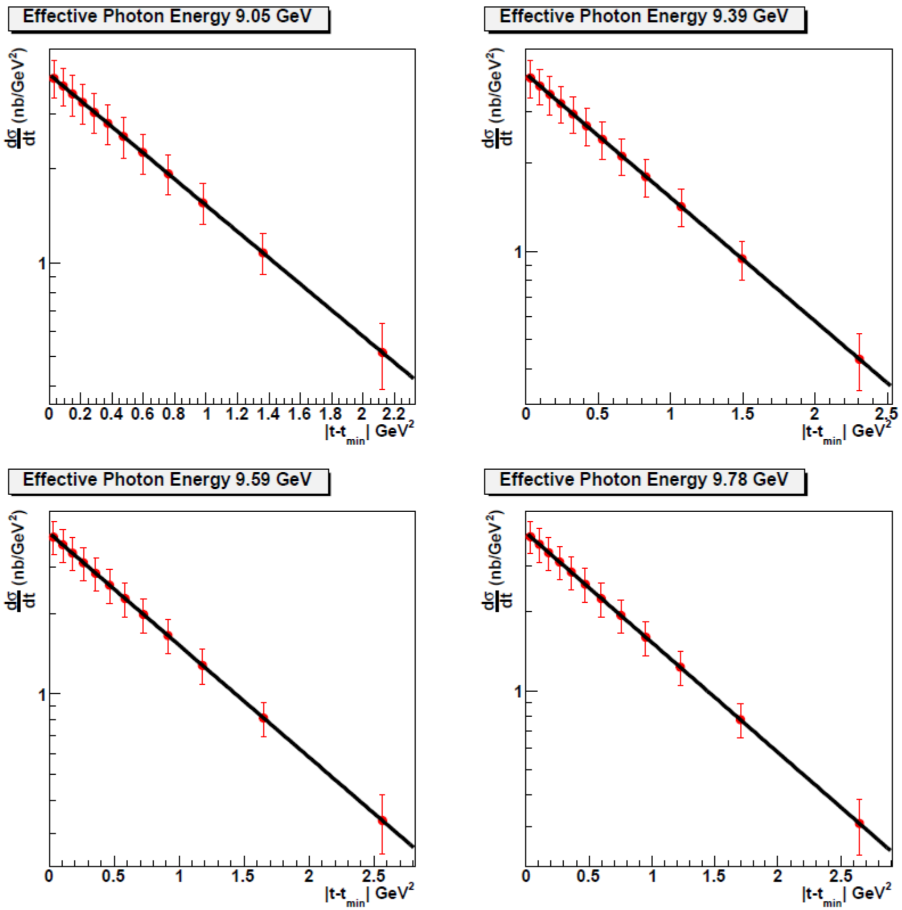
$$\langle N|\frac{1}{2}\vec{E}^a\cdot\vec{E}^a|N\rangle \geq \frac{8\pi^2}{b}2m_N^2,$$

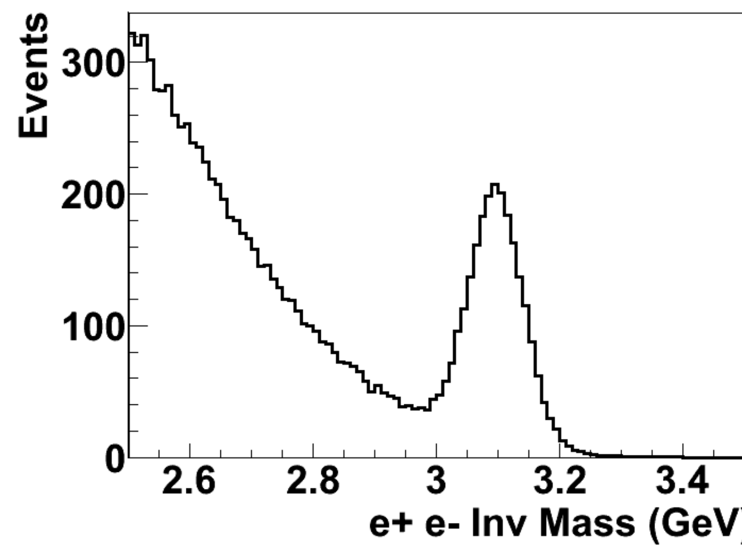
X. Ji PRL 74 1071 (1995)

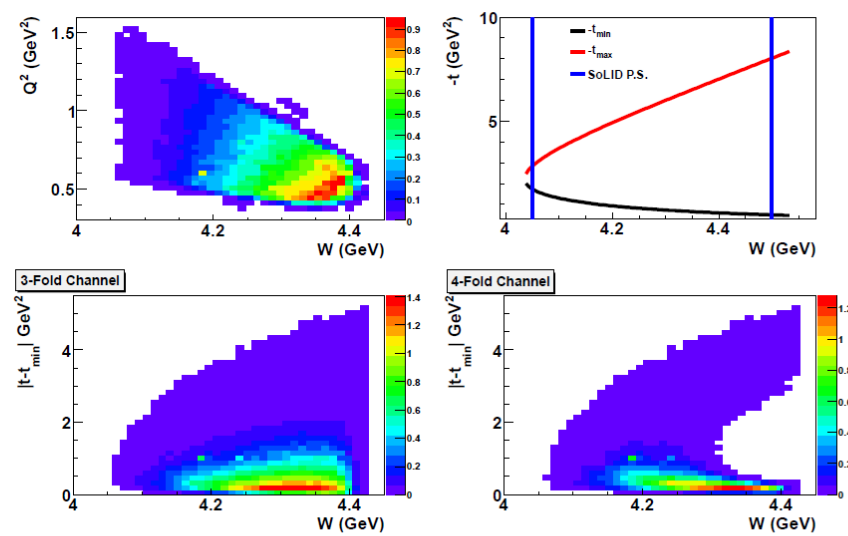
A. Sibirtsev et al. Phys. Rev., D71:076005 (2005)

SoLID J/ψ Exp Details

Backup







$$E_{\gamma}^{eff} = \frac{W^2 - M_p^2}{2M_p}$$

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