UGBOD Meeting Winter 2017

CC F326/327, Jefferson Lab, January 10, 2017

Theory Program at Jefferson Lab update

Members and the organization

Report on the DOE's recent Comparative Review

Strength of the JLab Theory Program

Summary and outlook

Jianwei Qiu

Associate Director for Theoretical and Computational Physics

Members and the Organization

❑ 5 JLab Staff:

R. Edwards, W. Melnitchouk, J. Qiu, D. Richards, C. Weiss

Theory Center Director:	Jianwei Qiu (Joined on October 3, 2016)
Former Director:	Michael Pennington (left in June, 2016)
Interim Director:	Robert Edwards

❑ 10 [+1] Staff with joint ½-time faculty appointments:

Hampton U:	A. Accardi, J. Goity
Indiana U:	A. Szczepaniak
ODU:	I. Balitsky, A. Radyushkin, T. Rogers, R.Schiavilla, W. Van Orden, [Search]
W&M:	J. Dudek, K. Orginos

❑ 3 [+1] bridged faculty positions – fixed term:

GWU:	M. Doring (5-year: 2012 – 2017)
Indiana U:	E. Passemar (5-year: 2015 – 2020)
PSU-Berks:	A. Prokudin (5-year: 2015 – 2020)
W&M:	P. Shanahan (to join in August, 2017, 5-year: 2017 - 2022)

Members and the Organization

- **8 JLab postdoctoral fellows in FY2017:**

Fall14:	**N. Sato (move to UConn in Feb, 2017)** **B. Wang (ODU/Jlab, finish the max 3-year term)**
Fall15:	**V. Pauk (finish the 2-year term, leaving)** **A. Pilloni (finish the 2-year term, extended to a 3rd-year)**
Fall16:	**J.M. Alarcon, B. Chakraborty, A. Signori,** **R. Briceno (Isgur Distinguished Postdoctoral Fellow)**
Fall17:	**3 Replacement Hires (2-year term)** **1 Start-up support for new Theory Director (2-year term)** **1 New position from the new Exascale Award (2-year term)**

- **8 supported graduate students (3-year term):**

Hampton:	**J. Guerro (Accardi)**
ODU:	**A. Baroni (Schiavilla), E. Moffat (Rogers)**
W&M:	**A. Kusno (Orginos), S. Jia (Pennington)** **J. Either (Melnitchouk/Orginos), M. Fried (Walker-Loud)**

Report on the DOE's recent Comparative Review

Department of Energy
Washington, DC 20585

DEC 19 2016

Dr. Hugh Montgomery
Director
Thomas Jefferson National Accelerator Facility
12000 Jefferson Avenue
Newport News, Virginia 23606

Dear Dr. Montgomery:

Enclosed is the Department of Energy (DOE) Office of Nuclear Physics (NP) report on the review of the Thomas Jefferson National Accelerator Facility (TJNAF) Nuclear Theory Group held on September 7-9, 2016. This report contains remarks on the TJNAF nuclear theory program and its assessment based on the charge elements for the review. The composition of the panel and copies of the charge letter, the review agenda, and excerpts of the reviewers' comments are included as appendices. Overall, this review finds that the TJNAF Nuclear Theory Group is performing at an excellent level.

Please feel free to contact George Fai or myself if you wish to arrange a phone conference with us to discuss the report. We thank the members of the TJNAF Nuclear Theory Group for their effort in preparing for and participating in this review. We trust the enclosed material will be helpful for guiding and strengthening the future nuclear theory program at TJNAF and look forward to progress in response to the review toward making an excellent program even stronger.

Sincerely,

Timothy J. Hallman
Associate Director of the Office of Science
for Nuclear Physics

Enclosure

cc: Robert Edwards, TJNAF
Jianwei Qiu, TJNAF

U.S. DEPARTMENT OF ENERGY
Office of Science

Office of Nuclear Physics Report

Review of the

Thomas Jefferson National Accelerator Facility
Nuclear Theory Research Group

September 7-9, 2016

Report on the DOE's Recent Comparative Review

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Office of Nuclear Physics Report

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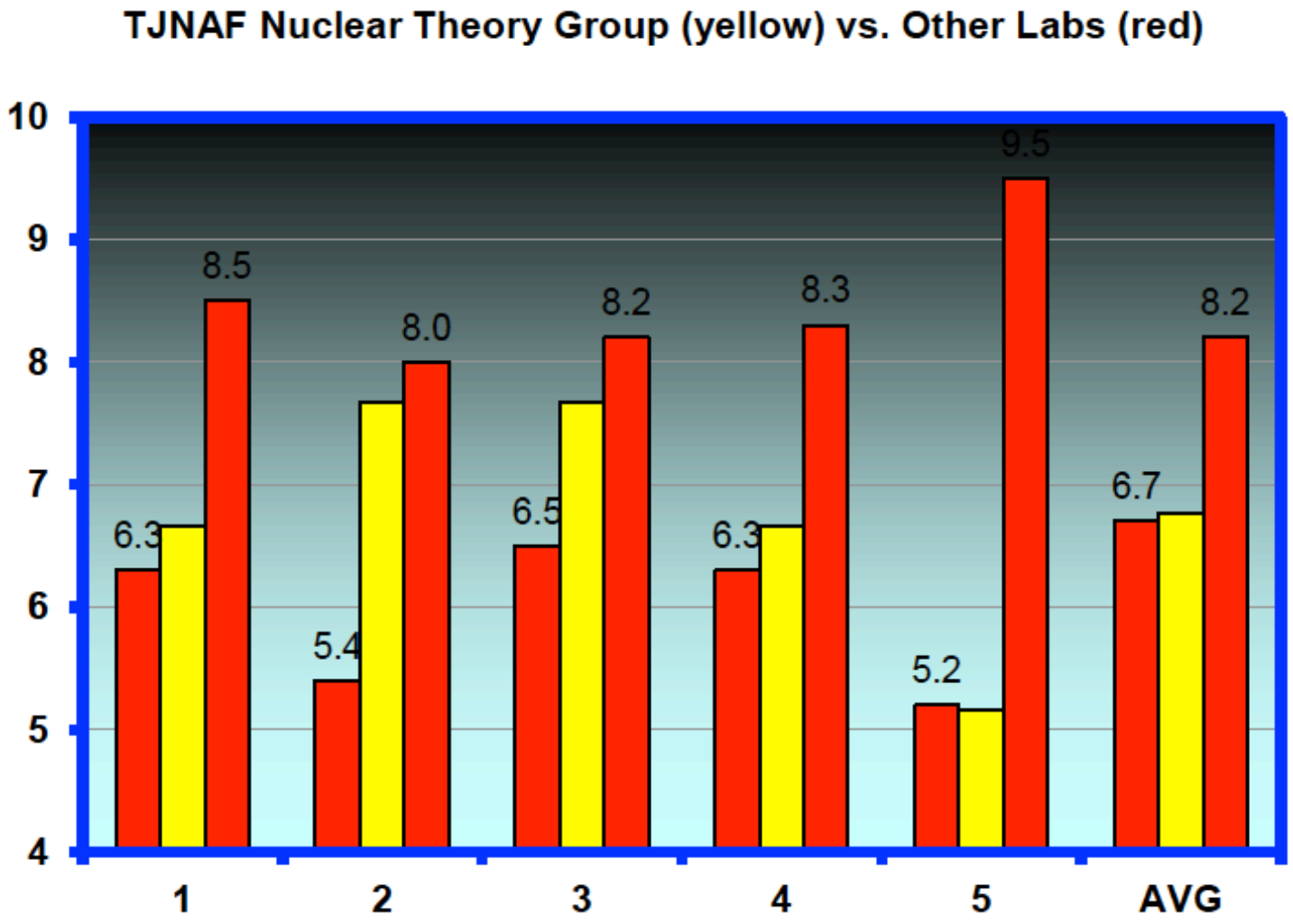
cc: Robert Edwards, TJNAF
Jianwei Qiu, TJNAF

Thomas Jefferson National Accelerator Facility
Nuclear Theory Research Group

September 7-9, 2016

Report on the DOE's Recent Comparative Review

- **But, the challenges are ahead!**



Outstanding (9-10), Excellent (6-8), Good (3-5), and Poor (1-2)

Report on the DOE's Recent Comparative Review

- **But, the challenges are ahead!**

1. The quality and significance of each group's scientific and technical accomplishments

The research accomplishments of the TJNAF Nuclear Theory Group were rated by the review panel to be excellent (6.7[6.3,8.5]).

2. The merit, feasibility, and potential impact of the proposed future research

The review panel evaluated the merit, feasibility, and potential impact of the research proposed by the TJNAF Group very positively as indicated by the average rating of excellent (7.7 [5.4,8.0]) given for this charge element. There was only one laboratory group that scored higher for this criterion among the groups reviewed.

3. Contribution of the past and proposed research to the national nuclear theory research effort

The proposed research is "precisely" aligned with the 2015 Long Range Plan for Nuclear Science, "Reaching for The Horizon." The scientific contributions of the Group to the national nuclear theory research effort are very strong, and the research of the Group is well integrated into the national effort. The rating given by the panel on this charge element was excellent (7.7 [6.5,8.2]).

Report on the DOE's Recent Comparative Review

❑ But, the challenges are ahead!

4. The leadership, creativity, and productivity of group personnel

The overall rating of this charge element by the panel is in the excellent range (6.7 [6.3,8.3]), but this score is closer to the lower range of the scores provided by the panel. This outcome might be attributable to the fact that "[t]he publication record is not evenly distributed over the group, which negatively affects the overall publication rate of the group."

5. Cost-effectiveness of the requested funding including any support from the laboratory

The panel was strongly dissatisfied with the cost-effectiveness of the Group, and rated this charge element only as good (5.2 [5.2, 9.5]). This score is the lowest among all average criteria scores provided by the panel and it pulls down the aggregate score for the TJNAF Theory Group.

Comments

- ✧ the potential for future accomplishments and contributions to the national nuclear theory research effort were rated highly,
- ✧ The numerical scores given by the panel for past accomplishments and leadership are relatively low compared to other groups,
- ✧ seriously consider the panel's strong concerns regarding the cost-effectiveness …

Plan to Address the Findings in the Report

- Staff meetings starting next week (after postdoc hiring)
- Low past accomplishments and leadership, …
  - In view of the report, try to understand the weakness in the 5-year proposal that the group submitted for the Review
  - Identify the lessons to be learned
- High potential for future accomplishments and contributions, …
  - Organize the group's effort to fulfill the expectations, …
  - Increases the productivity and visibility, …
  - More coordinated working groups, focused short workshops, …
- Cost effectiveness, …
  - Unevenness in the group's overall productivity, …
  - Evaluating the overall direction and productivity of current activities, …
  - Best way forward with an integrated EIC theory effort, …

Strength of the JLab Theory Program

- ***Focus on 3 of the 5 Research Areas identified in 2015 NSAC LRP Document***

  Area 1 – QCD and the structure of hadrons and nuclei
  Area 3 – Nuclear structure and reactions
  Area 5 – Fundamental symmetries and neutrinos

- ***QCD and the structure of hadrons and nuclei***
  - **Quark structure of Hadrons**

    Accardi, Balitsky, Melnitchouk, Orginos, Prokudin, Radyushkin, Qiu, Richards, Rogers, Shanahan, Weiss
  - **Hadron spectroscopy**

    Doring, Dudek, Edwards, Goity, Passemar, Szczepaniak
  - **QCD & Nuclei**

    Accardi, Melnitchouk, Orginos, Qiu
- ***Nuclear structure and reactions***

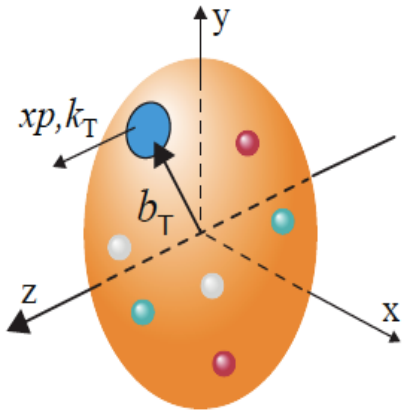
  Goity, Schiavilla, Van Orden
- ***Fundamental symmetries and neutrinos***

  Melnitchouk, Schiavilla, Van Orden

Need more coordinated involvement in the EIC effort!

QCD and the structure of hadrons and nuclei

❑ The structure of a colliding hadron:



✧ *Parton Distribution Functions (PDFs)*

Probability density to find a parton carrying the 1-D momentum fraction, x, of the hadron

✧ *Generalized Parton Distribution Functions (GPDs)*

Probability density to find a parton carrying the 1-D momentum fraction, x, at the impact parameter, b_T, of the colliding hadron – Spatial Imaging

✧ *Transverse Momentum Dependent Parton Distribution Functions (TMDs)*

Probability density to find a parton carrying the 3-D momentum, 1-D longitudinal momentum fraction, x, plus 2-D transverse motion, k_T, of the colliding hadron – Confined Motion

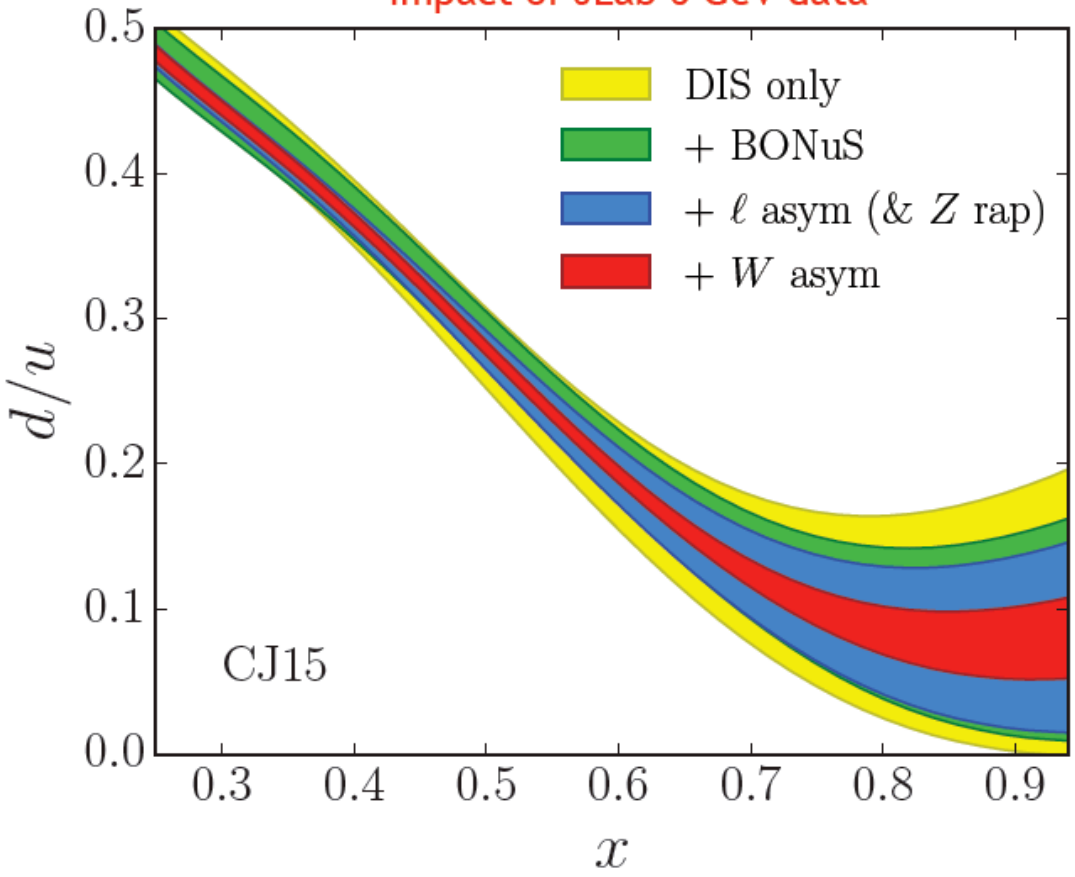
Strength of the JLab Theory Program

❑ PDFs – Unpolarized:



Accardi Melnitchouk

Impact of JLab 6 GeV data



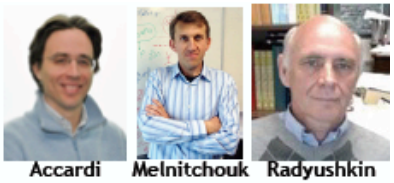
Significant reduction in uncertainty with additional BONUS, W-asymmetry and Z-rapidity

PRD 93 (2016) 074005 & 114017

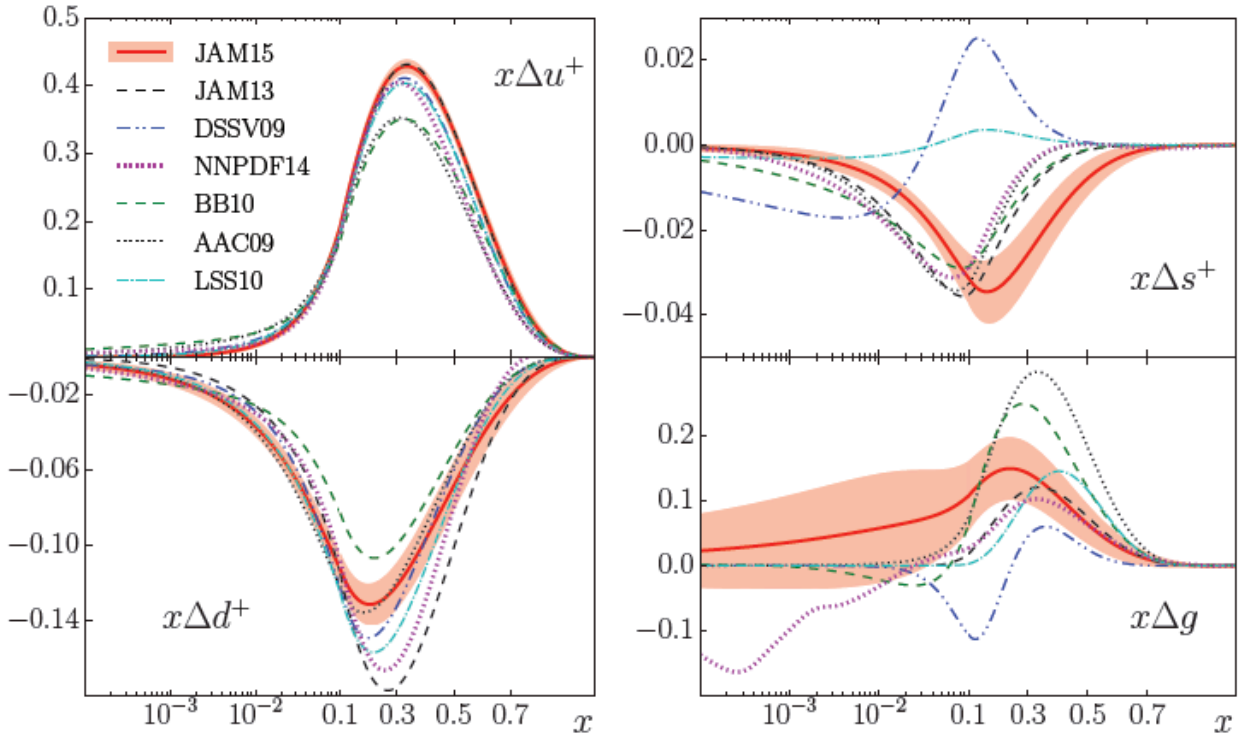
Strength of the JLab Theory Program

❑ PDFs – Polarized:

Jefferson Lab Angular Momentum Collaboration



Impact of JLab 6 GeV data

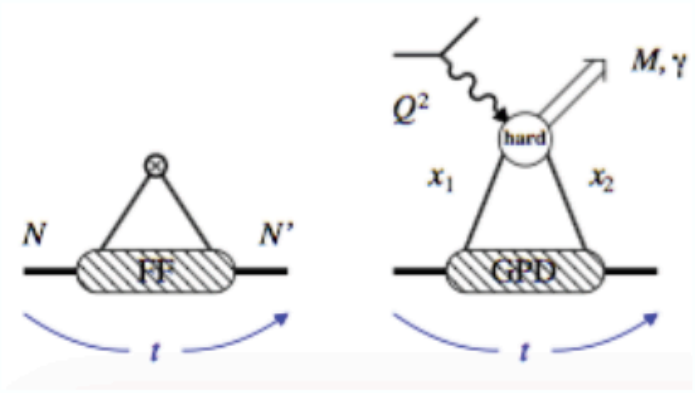


- Future:
  - Unpolarized + polarized PDFs + frag. funcs
  - Essential infrastructure for JLab 12 GeV & EIC

PRD 93 (2016) 074005 & 114017

Strength of the JLab Theory Program

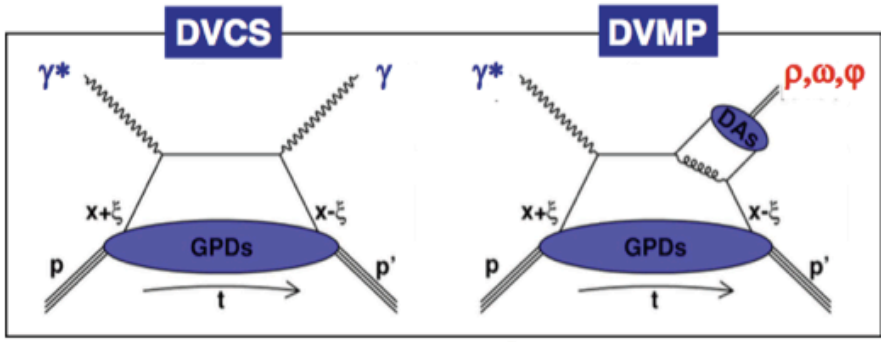
❑ GPDs – Spatial imaging:




Radyushkin


Weiss

Hard exclusive processes at JLab 6/12GeV & EIC



- Theory:
  - Unify form-factors & parton densities
  - Scale evolution of GPDs
  - Parameterization via "Border Functions"
  - Power corrections: "Virtuality Distributions"
- Future directions:
  - Collaborations with JLab expts. and *PARTONS* initiative

Radyushkin, Tandogan PRD 89 (2014)
Radyushkin PRD 87 (2013)
Radyushkin PRD 88 (2013); PLB735 (2014); PRD93 (2016)

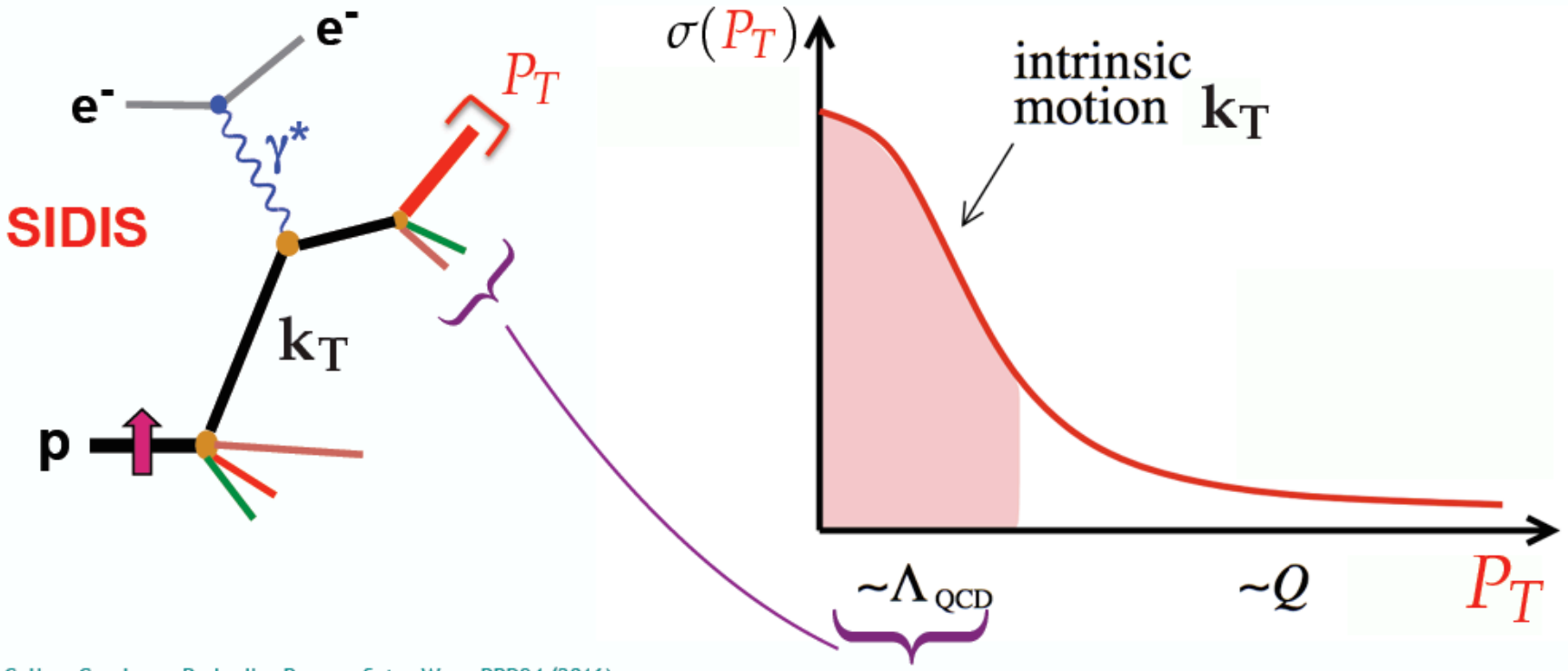
Strength of the JLab Theory Program

❑ TMDs – Confined Motion:

Major programs for JLab12 & EIC

- Non-perturbative, but universal evolution
- Relate SIDIS, Drell-Yan, e+e-

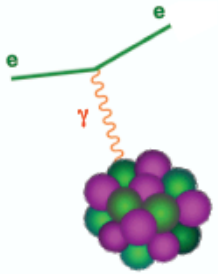
- JLab members of DOE TMD Topical Collab



Colins, Gamberg, Prokudin, Rogers, Sato, Wang PRD94 (2016)

Strength of the JLab Theory Program

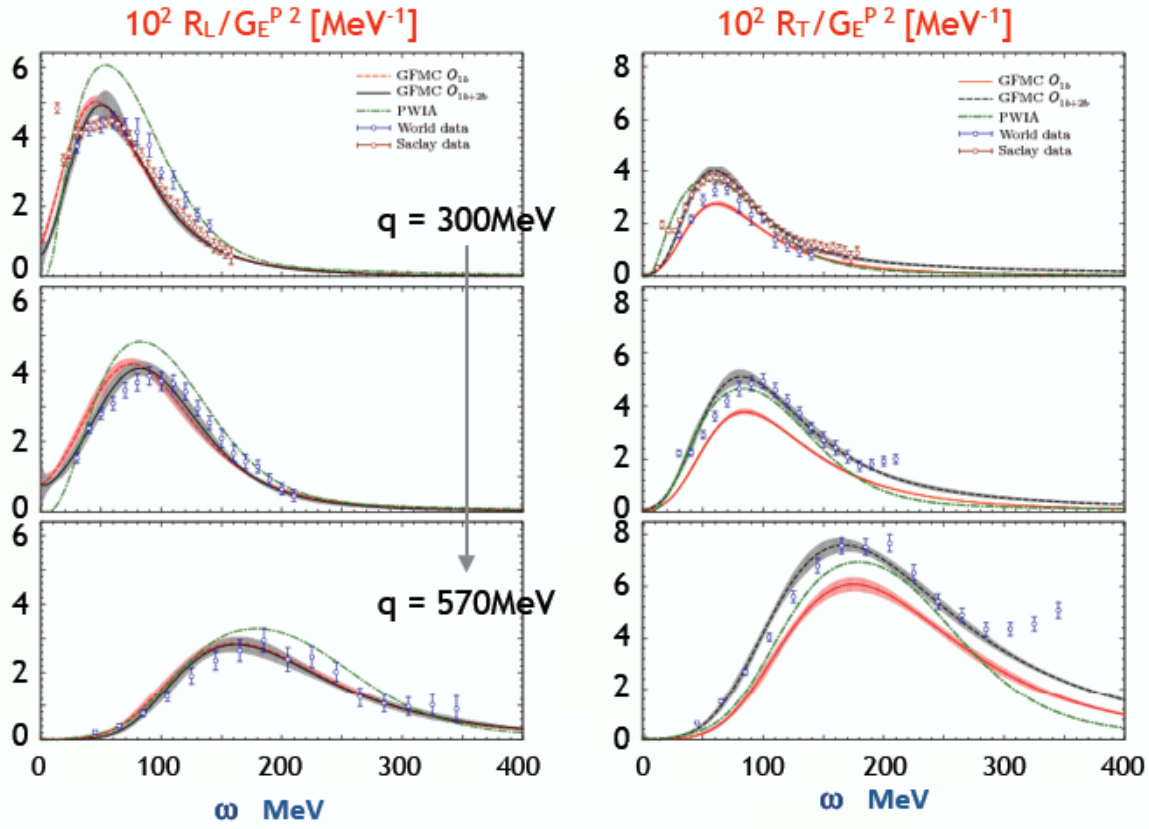
❑ Nuclear Structure – Quantum Monte Carlo:



Argonne NATIONAL LABORATORY

Jefferson Lab
Thomas Jefferson National Accelerator Facility
Exploring the Nature of Matter

Los Alamos NATIONAL LABORATORY



- E&M response in A=12
  - Dynamical approach agrees with expt.
  - Suggests no in-medium mods !

PRL 112 (2014); PRL 117 (2016)

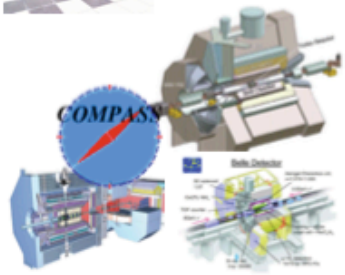
Strength of the JLab Theory Program

❑ JPAC – Joint Physics Analysis Center:


Szczepaniak

- Started Fall 2013 - support analyses of expt. data from JLab12 & other accel. labs
- Theoretical/phenomenological/data-analysis tools
- Successful 3-year by external membership panel (May 2016)
- Avg. 1 paper/month, 100 invited talks, ~10 ongoing expt. analyses
- Supports data curation, workshops, summer schools

- Applications:
  - Light meson spectroscopy & structure (η,ω,φ)
  - Heavy meson spectroscopy, XYZ's, & implications for JLab
  - Light meson exotics
  - Baryon spectroscopy (global analyes, hyperons, novel states)

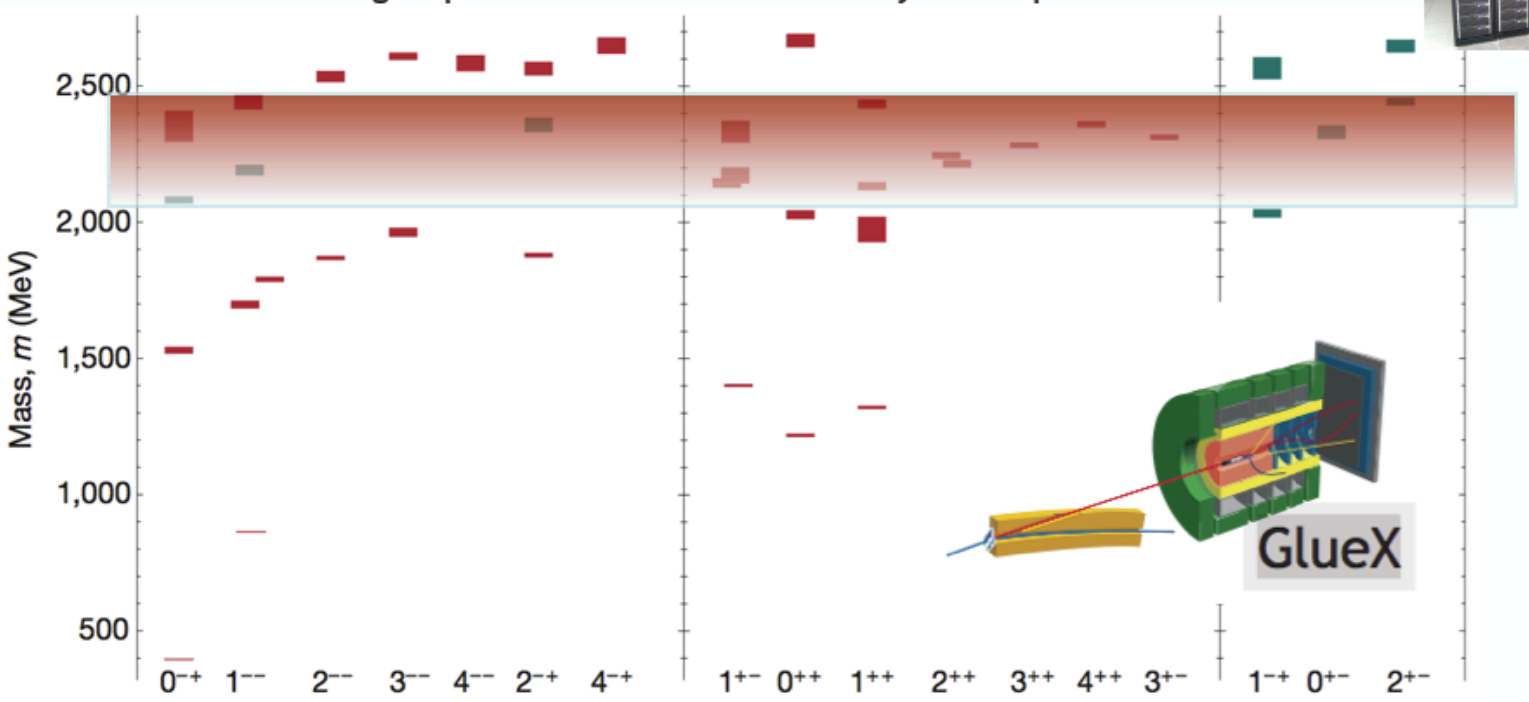


- Future:
  - Structure studies (form factors, transverse densities)
  - BSM searches (precision amplitude analysis of hadron final states in EW processes)
  - International collaborations with China (BESIII) and Germary

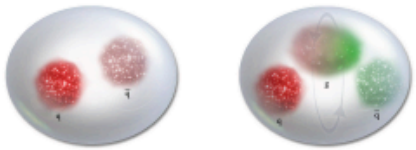
Strength of the JLab Theory Program

❑ Hadron Spectroscopy – role of the glue:

Focus of GlueX & CLAS12 @ JLab & COMPASS, BES, & LHCb



Pattern of states suggest gluonic excitations



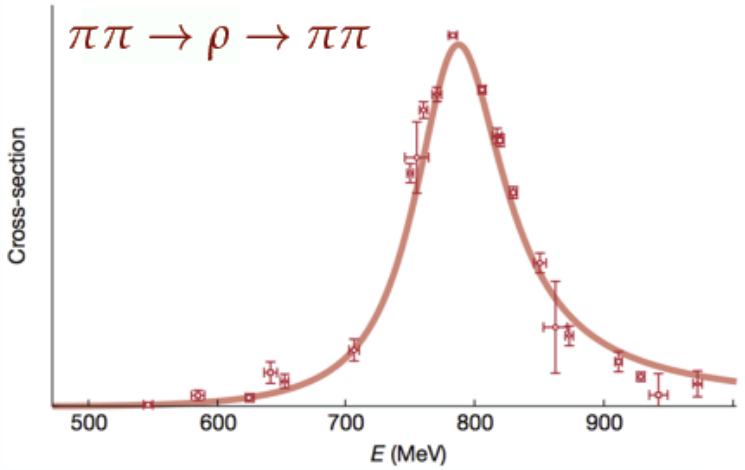
➡ Need to know decay modes and rates to compare to expt.

Hadron Spectrum: PRD83 (2011); PRD88 (2013)

Strength of the JLab Theory Program

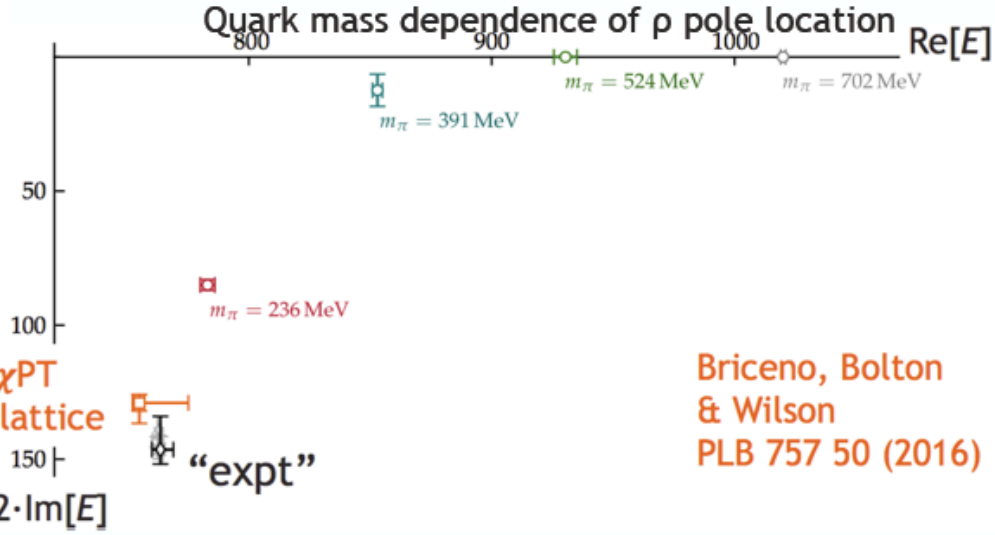
❑ Scattering from the Lattice:

- Goal: understand dynamical mechanisms that form hadrons from quarks & gluons
- LQCD ➜ scattering amplitudes and also decay rates



Resonance parameters

Hadron Spectrum: PRL 115 (2015); PRD92 (2015); PRD93 (2016)

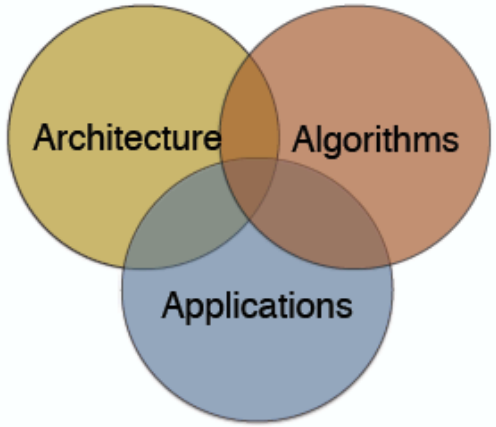


Briceno, Bolton
& Wilson
PLB 757 50 (2016)

Strength of the JLab Theory Program

❑ LQCD – Software Development:

SciDAC I, II, III (2001 - 2017) - $2.4M for JLab (2013-2017)



And just recently:

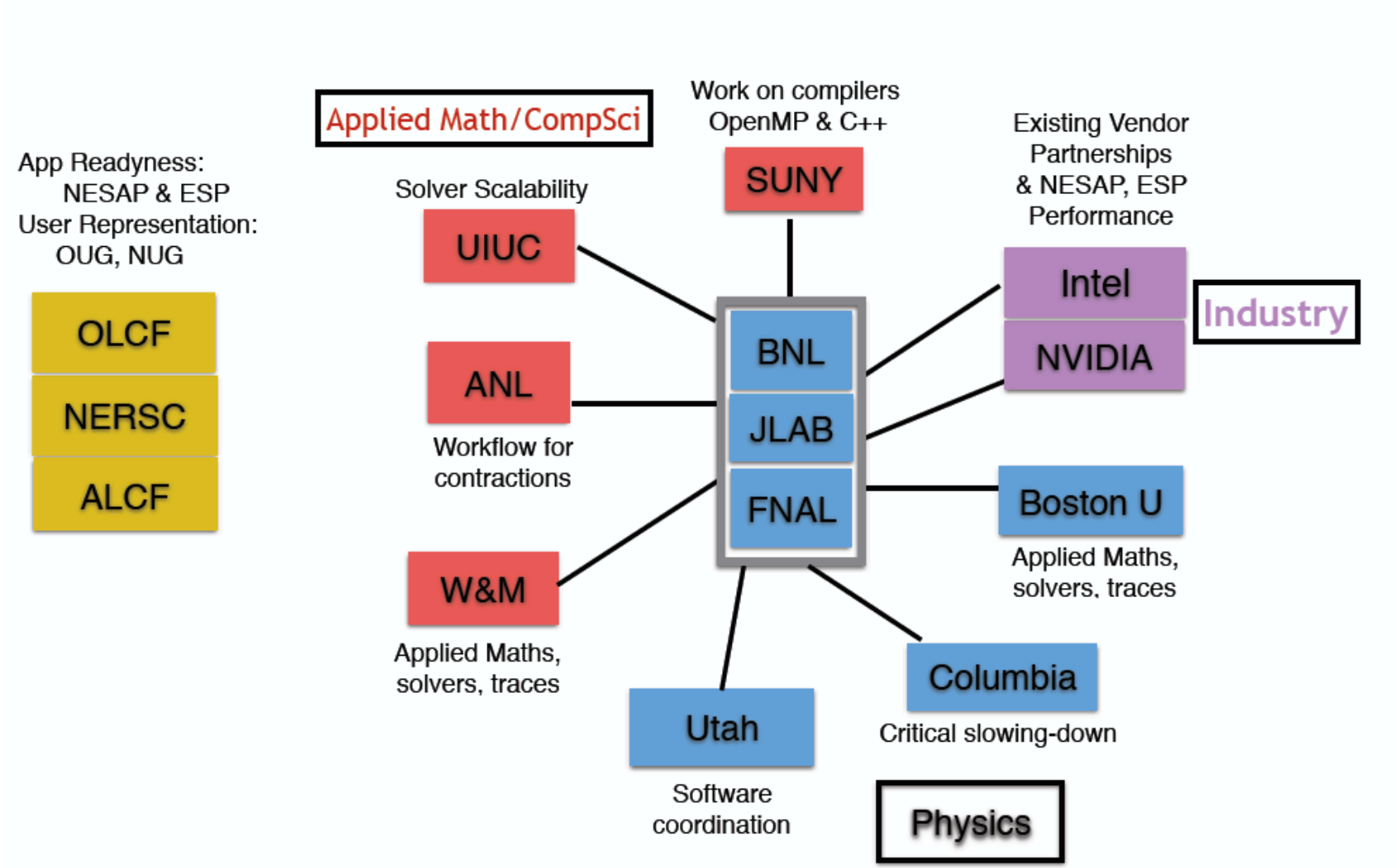
Exascale Computing Project (ECP): $2.1M for JLab (2016-2020)

Exascale Lattice Gauge Theory Opportunities and Requirements for Nuclear and High Energy Physics

Co-PI: Robert Edwards (JLab), Paul Mackenzie (FNAL), Chulwoo Jung (BNL)
& Boston U, Columbia, Utah, Stony Brook, UIUC, W&M

Strength of the JLab Theory Program

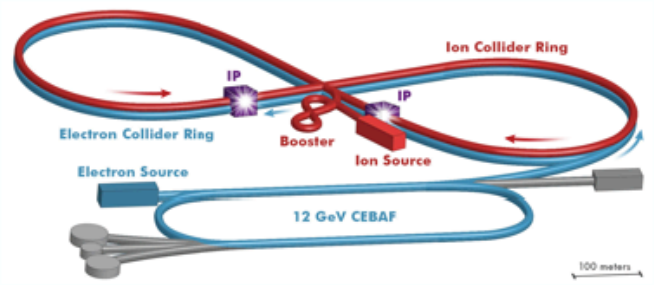
❑ Exascale – Links with ASCR, Facilities & Vendors:



Hiring a postdoc from the initial award

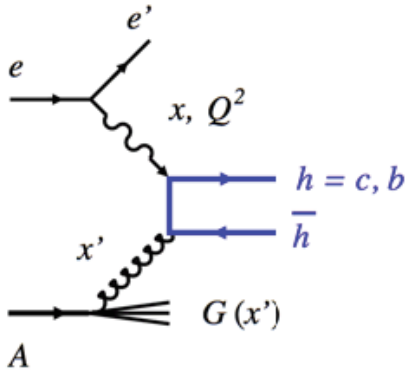
Strength of the JLab Theory Program

❑ Physics of EIC:

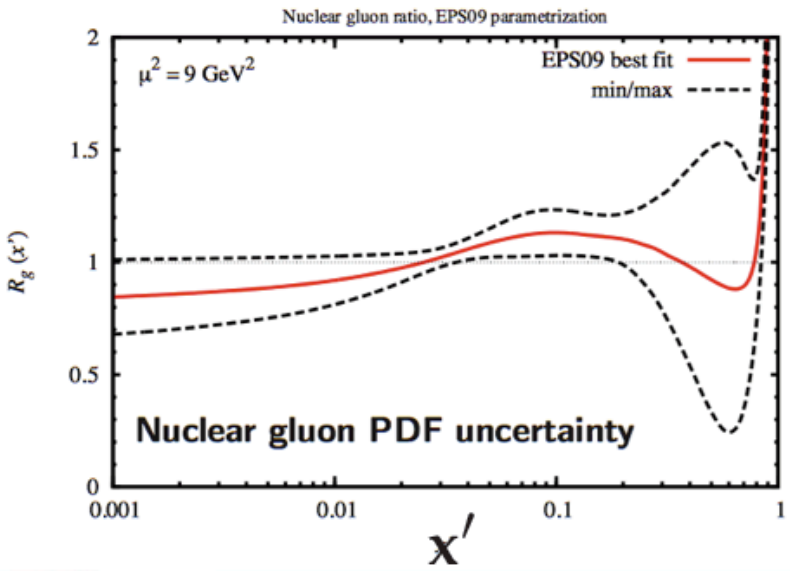


JLab theory lead on interdisciplinary LDRD projects

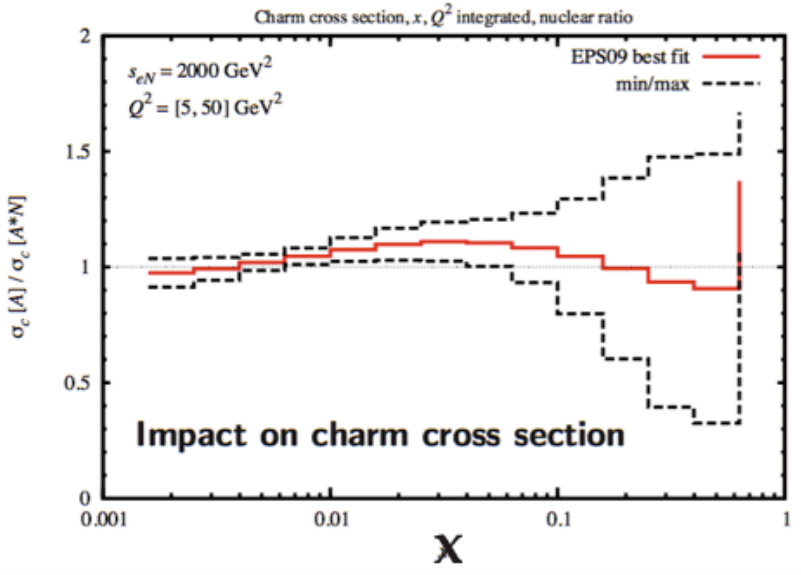
Weiss



Probing nuclear gluons with heavy quarks



Glue PDF sensitive to charm cross section



Summary and outlook

- **The Theory Program at Jlab is a strong and diversified group:**

  As stated in the DOE's Review Report:

  - **The scientific contributions of the Group to the national nuclear theory research effort are very strong, and**
  - **the research of the Group is well integrated into the national effort**

- **Improvements and changes are critically needed in some areas:**

  - **The leadership, creativity, and productivy of group personnel**
  - **Cost-effectiveness of the requested DOE and Lab's funding**

Action is on the way!