



Theoretical Nuclear Physics Program

Robert Edwards
Deputy Director, JLab Theory Center

Jianwei Qiu
Associate Director, Theoretical & Computational Physics

Presented to:
JSA S&T Mission Committee

December 10, 2024

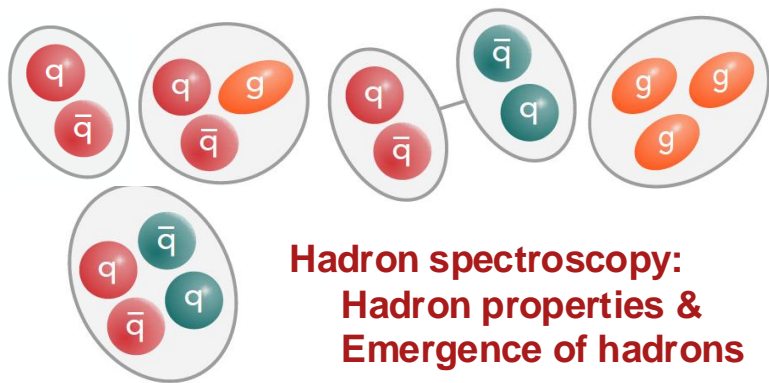
Division of Theoretical & Computational Physics @ JLab

Primary Objectives:

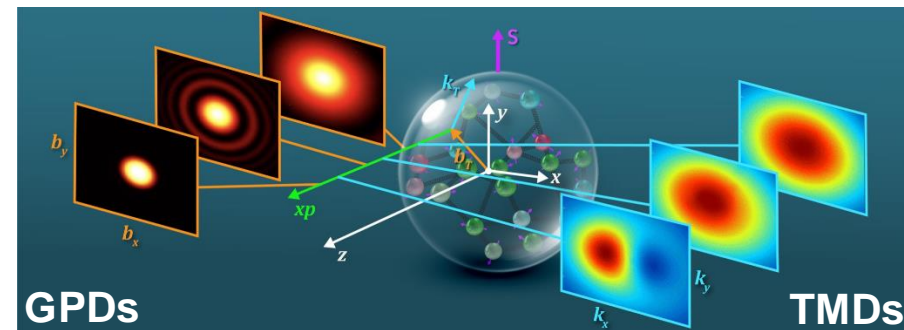
- Motivate, stimulate, justify, promote, and **support** CEBAF experimental program and the future EIC
- A comprehensive theoretical effort with **leadership** across nuclear physics community
- Recruit and nurture young researchers, **providing** the best workforce training

The Challenge:

- CEBAF has an extremely broad science program, largest users' group, covering **all aspects** of Nuclear Physics!



Nuclear structure & properties
dual description: hadron/parton

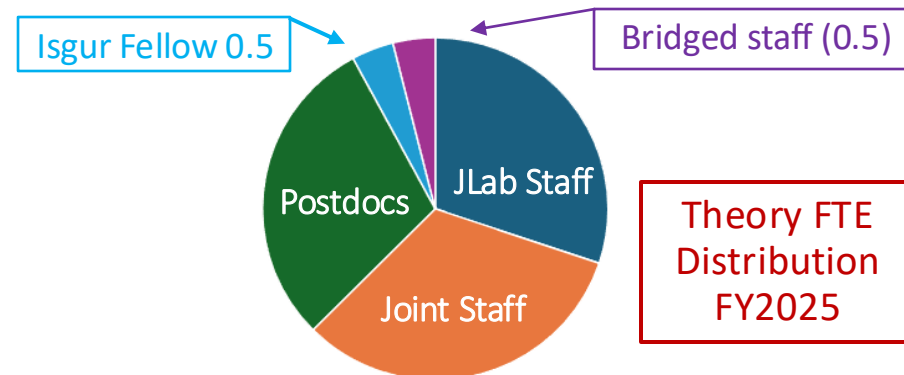


Hadron 3D structure at a femtoscale

JLab Theory Program:

- Small core of Lab staff + 1 Isgur Fellow
- Fully committed joint and bridged staff
- Young postdocs & Students

Highly cost effective,
great access to
students, and
commitment of
universities & local
communities



Research at Division of Theoretical & Computational Physics

Research focuses – organized in thrust areas:

Thrust area 1:
Hadron Spectroscopy - LQCD



Resonances &
Exotic/hybrid hadrons



Thrust area 2:
Hadron Spectroscopy - JPAC

Data



Thrust area 3:
Hadron Structure - LQCD



3D partonic structure
& QCD dynamics
PDFs, TMDs, GPDs, ...



Thrust area 4:
Hadron Structure - Partonic analysis

Thrust area 5:
Hadron & Nuclear Structure
Effective Field Theories (EFTs)



Low energy hadron
properties
Mass, spin, ...



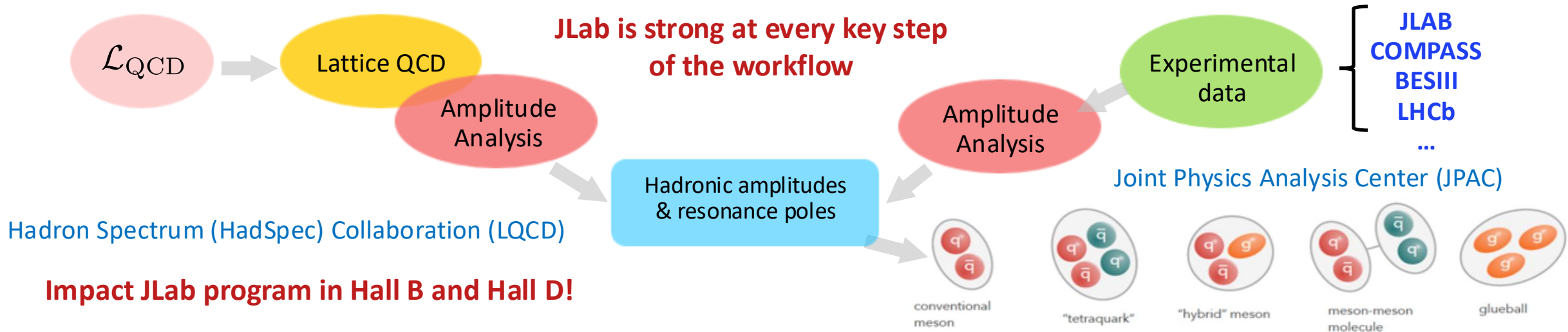
Low energy nuclear
properties &
Structure



Thrust area 6:
Nuclear Few Body Systems



Hadron Spectroscopy:



Impact JLab program in Hall B and Hall D!

Research at Division of Theoretical & Computational Physics

Research focuses – organized in thrust areas:

Thrust area 1:
Hadron Spectroscopy - LQCD



Resonances &
Exotic/hybrid hadrons



Thrust area 2:
Hadron Spectroscopy - JPAC



Data

Thrust area 3:
Hadron Structure - LQCD



3D partonic structure
& QCD dynamics
PDFs, TMDs, GPDs, ...



Thrust area 4:
Hadron Structure - Partonic analysis



Thrust area 5:
Hadron & nuclear Structure
Effective Field Theories (EFTs)



Low energy hadron
properties
Mass, spin, ...



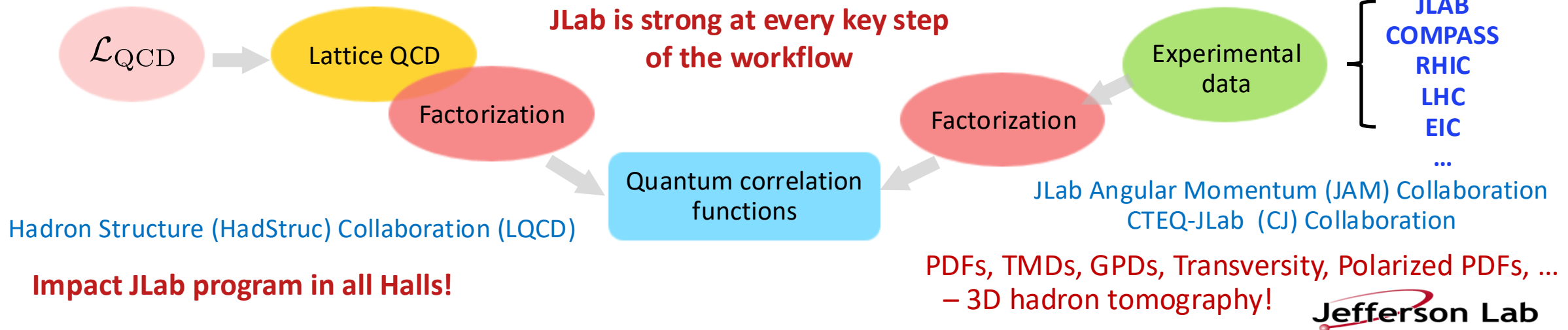
Low energy nuclear
properties &
Structure



Thrust area 6:
Nuclear Few Body Systems



Hadron/Nuclear Structure:

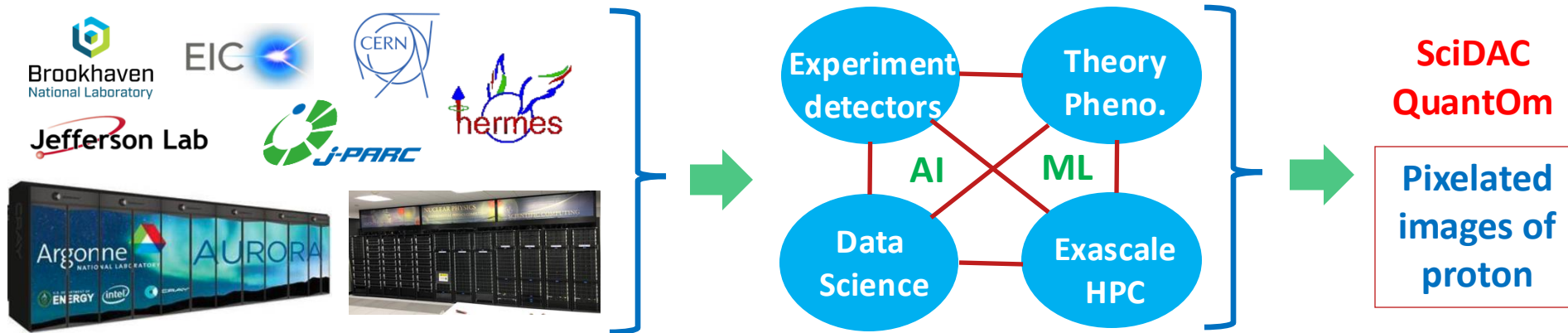


Samples of Major on-going Collaborative Theory Efforts

□ Help discover new exotic hadrons at GlueX/CLAS12 at JLab & future EIC:

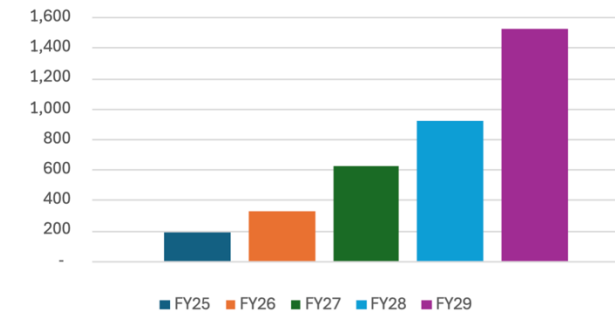
- LQCD calculation of decay branching ratios of exotics & Dalitz plots – **where to look!**
- Develop AI/ML tools for searching Exotics from data of JLab & future EIC (JPAC)

□ Develop the most advanced tools to “see” quarks & gluons from data:

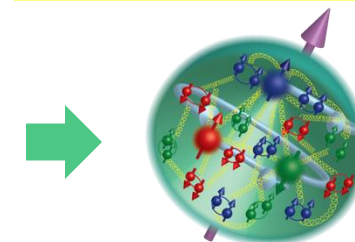


LQCD capability

JLab Integrated TFlop-year



3D Hadron Structure at Femtoscale

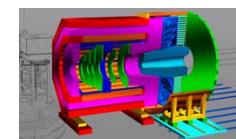


Unique capability & synergy at JLab

□ EW & BSM at JLab & future EIC:

- Treating QCD and QED **equally** with all-order factorizations for lepton-hadron DIS and SIDIS at JLab & future EIC!
- Precision **NLO PVDIS** (EW+QCD+SoLID) & explore BSM signatures at SoLID-JLab & future EIC, ...

Intensity Frontier



Jefferson Lab

Joint Faculty Program for Theory & Computation

□ Joint Faculty/Staff leads or plays key role – Spectroscopy:

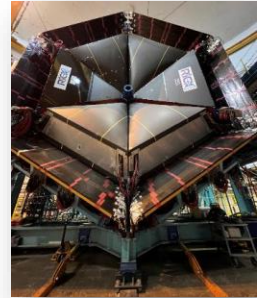
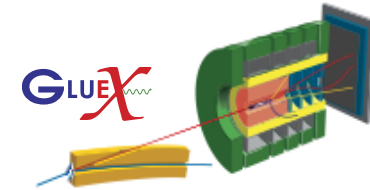


Led by **A. Szczepaniak** (Director) to support the spectroscopy analysis at



Hadron Spectrum Collaboration

Locally led by **J. Dudek + A. Rodas** to provide LQCD predictions for spectroscopy and search for exotics, ...

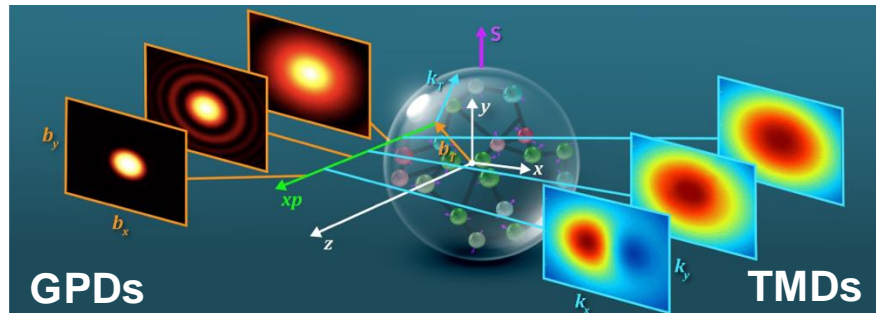


Directed/organized by **A. Accardi**, supported by JLab postdocs, provided training to hundreds of students in nuclear physics
Many former students now hold prestigious faculty or staff positions!

□ Joint Faculty/Staff leads or plays key role – Hadron/Nuclear Structure:

A. Radyushkin (4/1992)
Theory - Matching

K. Orginos (8/2005)
LQCD



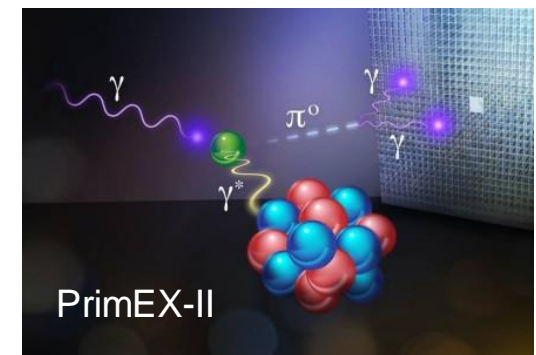
I. Balitsky (9/1996) , **T. Rogers** (1/2015) - TMD - Theory

Program Uncertainty: R. Briceno to UC-Berkeley/LBNL (2023)

Major Risk

F. Ringer to Stony Brook U. (2024)

R. Schiavilla
(8/1993-1/2024)
Nuclear structure
($A > 1$)



J. Goity (1993) - EFTs

Joint Faculty Program for Theory & Computation – Uncertainty

□ Uncertainty of the Joint Faculty/Staff program:

- 3/2023: DOE/NP intended to terminate JLab's Theory joint faculty/staff program
- 7/2023: DOE/NP's effort was put on hold – waiting for a new policy (not available yet)
- 2/2024: DOE/NP PM asked JLab/Thy to cut its budget by \$200K/yr for 4 years starting FY25 on top of a Flat/Flat base

□ Budget impact on the JLab/Theory program:

- JLab Theory DOE/NP base budget has been Flat-Flat since FY2021: \$4,222K for FY2021-2024
Resulted in a reduction of bridge faculty staff from 4 to 1 and a loss of 1 post-doc
- Further \$200K reduction for FY2025 and the future: \$4,022K for FY2025
Reduction of 1 more post-doc (from Flat/Flat – inflation)
Not be able to replace R. Schiavilla (phased retired) and F. Ringer (to Stony Brook U)
- FY2026: DOE/NP/PM asked JLab/Thy not to search for any replacement hire
Not even postdocs who are leaving (3) – 1st year we did not have any search for over 10 years!
Expected to lose 3 more PDs & 4-5 more Joint Staff/Faculty members by FY2028!

□ Major risks:

- **Not be able to provide the needed theory support to CEBAF program (PAC, T.E.D., ...)**
- **Losing good young staff: R. Briceno to UC Berkeley/LBNL as a joint, F. Ringer to Stony Brook U, ...**
- **Hurting our ability to recruit good people (all young staff/joint staff received DOE ECAs so far!)**

Joint Faculty Program for Theory & Computation – Mitigation Efforts

□ Writing proposals in response to LDRD, DOE/NSF Funding Opportunities:

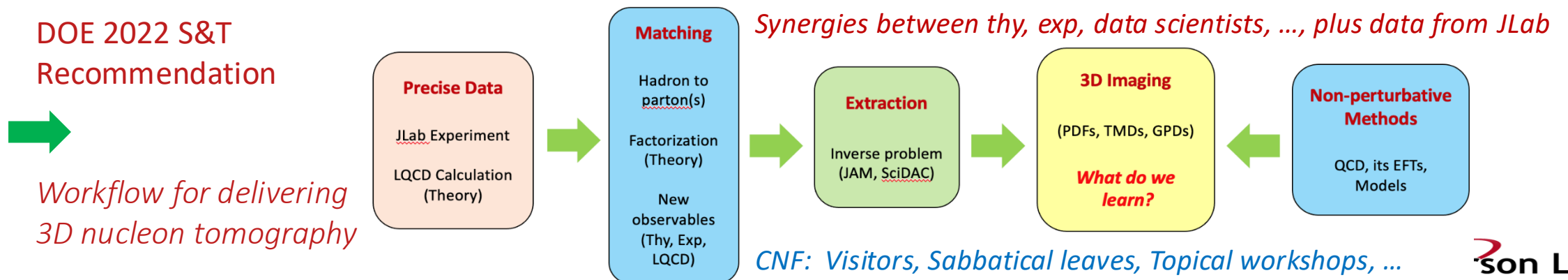
- FY2024: Received more than \$3.2M beyond DOE/NP Theory base funding
(SciDACs, Topical Groups, HEP, NSF, QIS/QC, AI/ML, LDRD, ...)
- Continue making efforts to get more supports – *But, Not stable & less FTEs to support CEBAF programs!*

□ Developing/updating our 5-year Strategic Plan – Priority and Focuses (on-going):

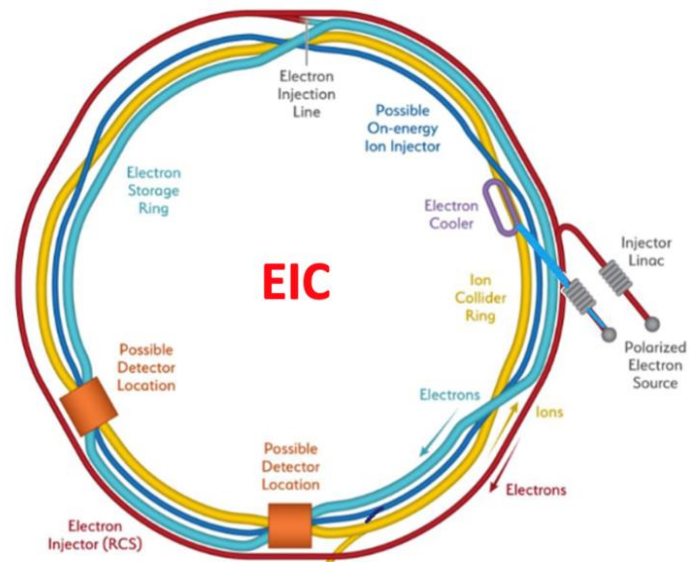
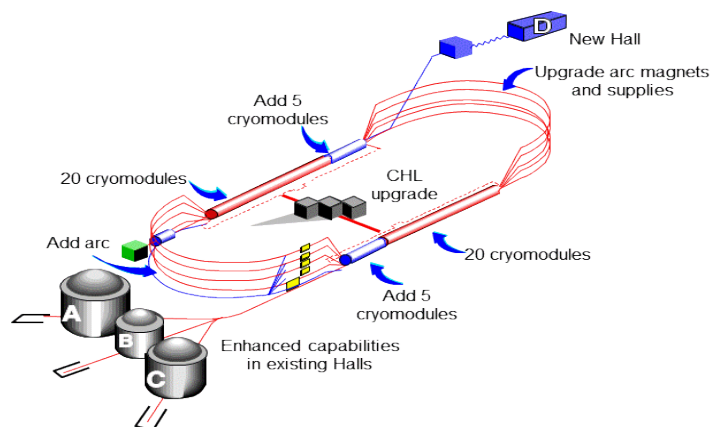
How should the Theory Center and its physics focuses look like in FY2028?

- NP Science (LRP) – identify what is relevant to us?
- Our strength – QCD and hadron physics, ...
- Our role for the future of JLab and NP community?
- Realistic goals, milestones, priority, and the need for achieving them?

□ Center for 3D hadron tomography:



Division of Theoretical & Computational Physics @ JLab



- Deliver the physics results from the JLab 12 GeV experimental and theoretical program, especially in the meson spectrum (GlueX), and nucleon structure (partonic structure, spin, 3D imaging, energy-momentum tensor)
- Provide intellectual and programmatic leadership in a range of areas in nuclear theory, and in future programs at JLab (SoLID, positron beam, CEBAF energy upgrade)

- Develop and help strengthen the EIC physics program, especially in jet physics, heavy flavor physics, and nuclear processes
- Explore opportunities in artificial intelligence/machine learning (AI/ML) and quantum computing for nuclear physics.

- Continue to engage in a range of outreach activities
- Disseminate the specific knowledge and research to the broader academic community, attract and train future generations of scientists, and promote awareness and understanding of science in society at large
- Recruit and nurture the best young researchers, providing the best workforce training

AL/ML: & QC for Nuclear Physics