DPF/DNP Community Meeting May 2026

AmSC and Nuclear Physics at Jefferson Lab

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Friday, May 22, 2026

Jefferson Lab

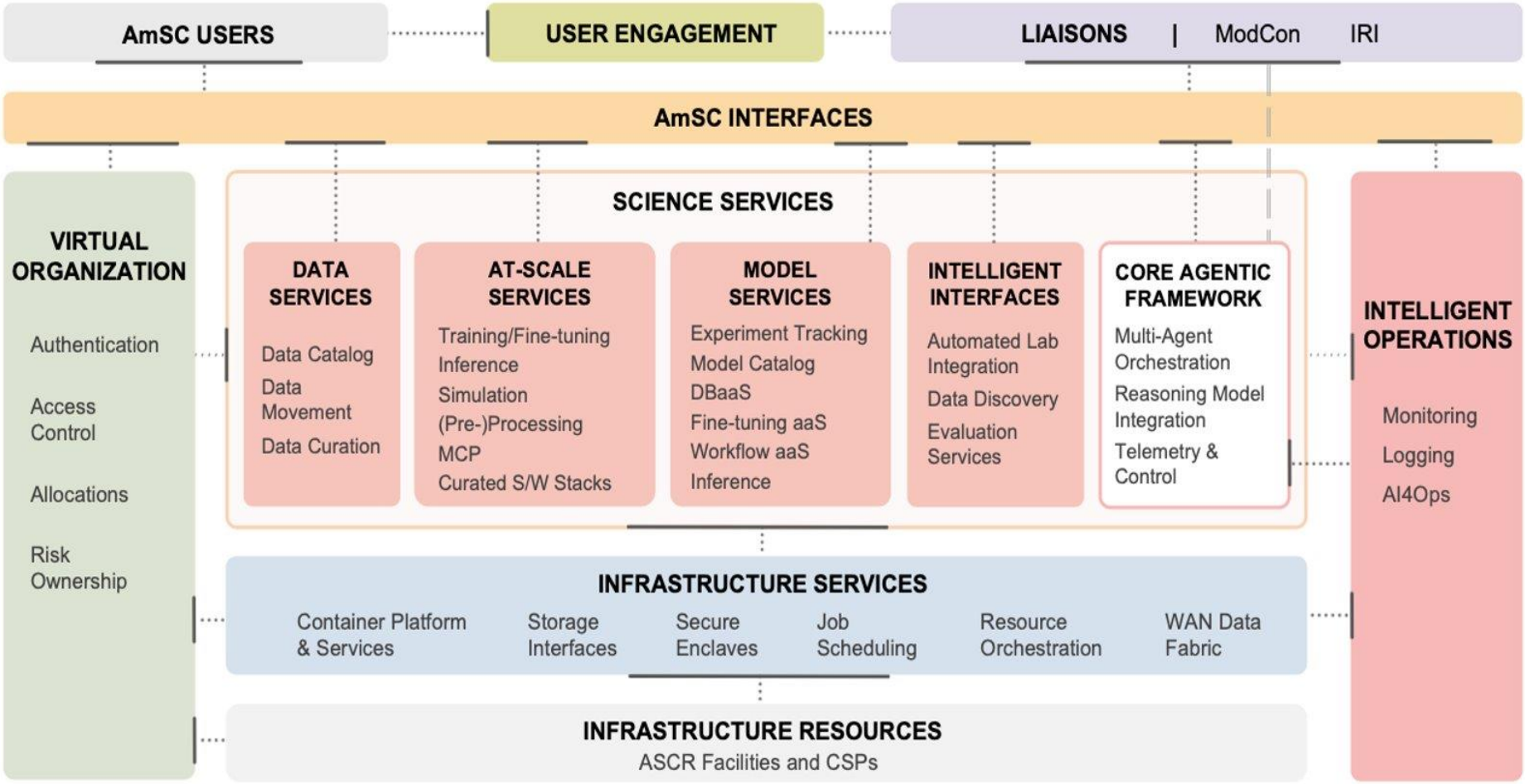
U.S. DEPARTMENT OF ENERGY | Office of Science

JSA

American Science Cloud - AmSC

- The American Science Cloud - AmSC part of the Genesis Mission
- What is AmSC ?
  - Secure, federated and science-optimized cloud environment
  - Synthesis of computing and experimental facilities, data resources and high performance networks
- AmSC goals:
  - Create, access and integrate AI-ready datasets
  - Deliver infrastructure for handling data and computing intensive science workflows
- **In a nutshell:** AmSC provides resources and services that enable scientists to run their workflows in a more collaborative, less siloed and standardized way

AmSC Resources and Services



AmSC at Jefferson Lab

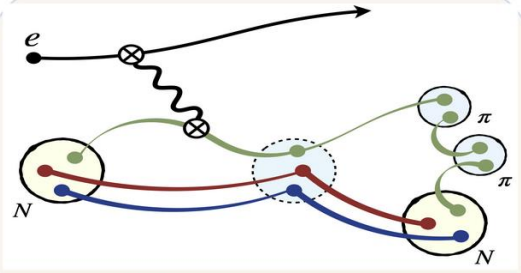
- All national labs contribute to AmSC
- Cover broad range of science and applications

  - Astronomy
  - Energy sciences (fusion, nuclear power,…)
  - Mineralogy
  - Plasma physics
  - High energy and nuclear physics
  - ….

- **Focus of this talk:** AmSC and Nuclear Physics at Jefferson Lab

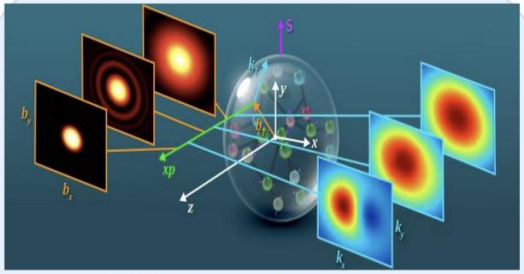
  - **FemtoMind:** Agentic AI for optimized QCD workflows (Nuclear Theory Group – Contact: Robert Edwards)
  - **Data streaming and data query:** Data movement between facilities (Scientific Computing and EPSCI group – Contact: David Lawrence)
  - **HAIDIS:** Inverse problem solving on streamlined nuclear physics data (Data Science group & GlueX Experiment – Contact: Ilya Baldin)

QCD Science Workflows



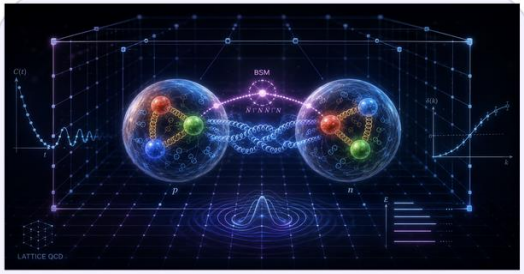
Hadron spectroscopy

Predicting dynamics of particles and resonances



3D femtoscale imaging

Understanding the quark/gluon structure of matter from QCD



BSM searches

Discovering new signals of rare processes beyond the Standard Model

QCD calculations connect experimental programs to the quark-and-gluon dynamics of matter: spectroscopy, imaging, neutrino interactions, and precision tests of the Standard Model

Spectroscopy | Femtoscale imaging | Neutrino interactions | Precision / BSM

Precision inputs

QCD results for nucleon / nuclear properties are **key inputs for experimental success**

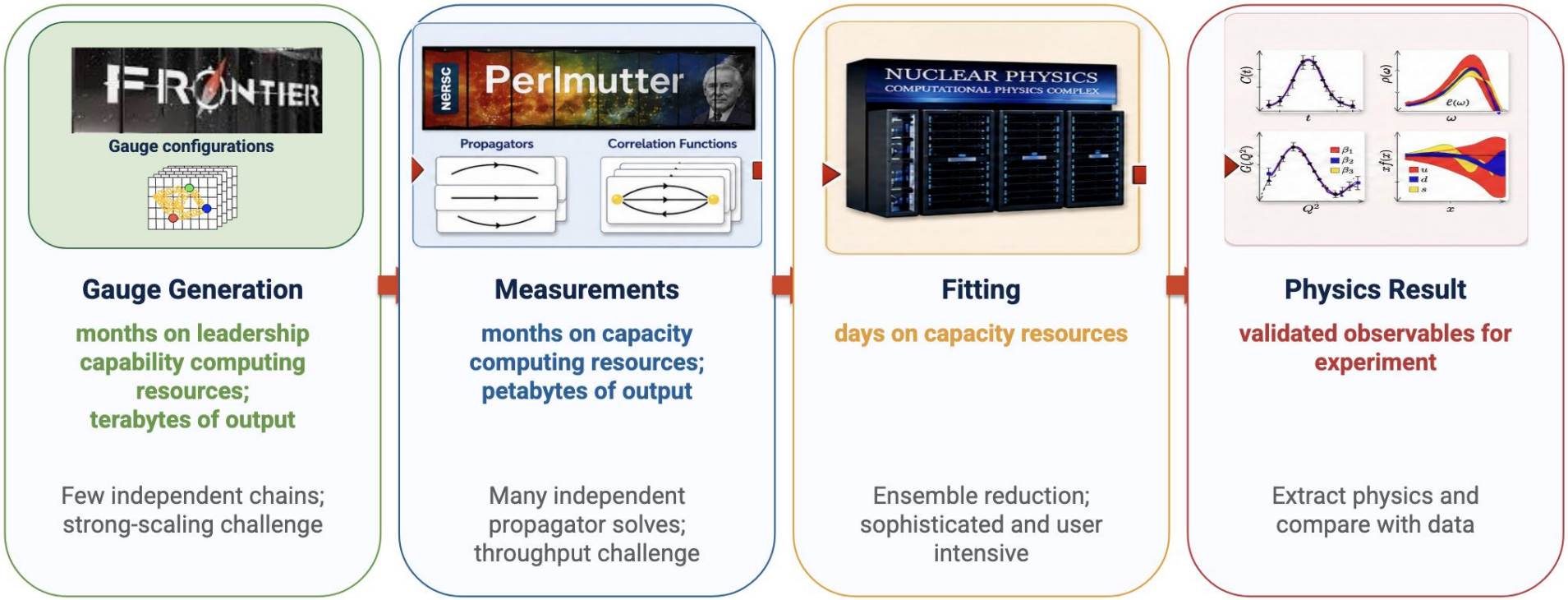
Data movement

QCD data is large (many PBs) and **reusable for multiple applications**, data transfer and provance critical

Automation

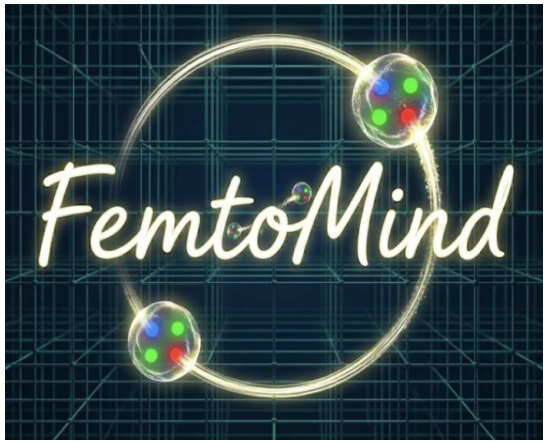
QCD workflows are complex – opportunity for **agentic orchestration**. Validation and reproducibility critical

Challenges in Lattice QCD



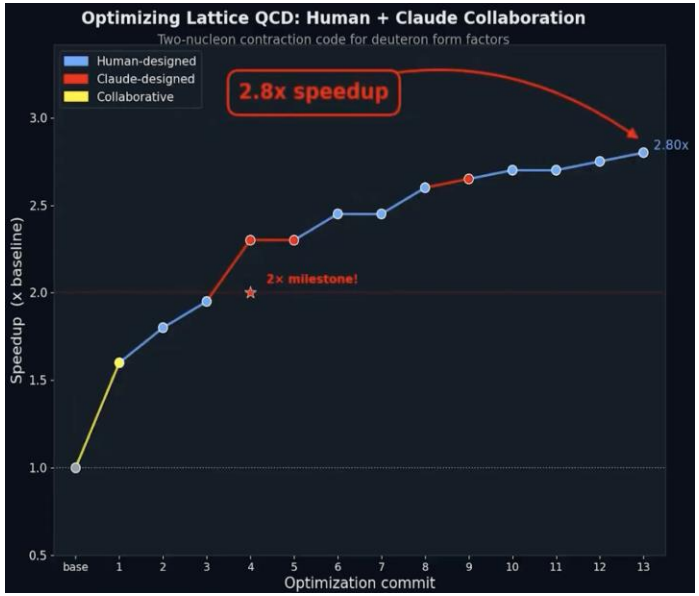
- Workflows typically span over multiple computing resources
- Need to coordinate: Data movement, compute utilization, provenance and expert decisions
- AmSC provides unified AI- and HPC-enabled infrastracture to accelerate and orchestrate scientific workflows

FemtoMind – AI assisted QCD Workflow Management



- Utilize AmSC infrastructure and agentic AI
- QCD code refactoring and optimization
- Manage slurm jobs across different machines and workflow configurations
- Visualization tools
- Connect applications for QCD science on experimental data

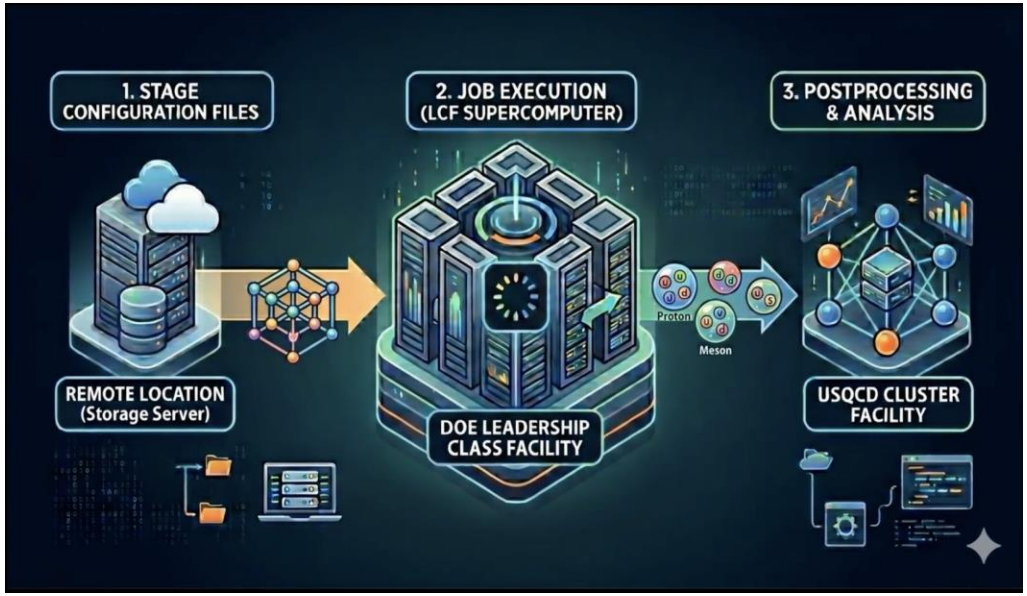
Lattice QCD Code Optimization



Speedup

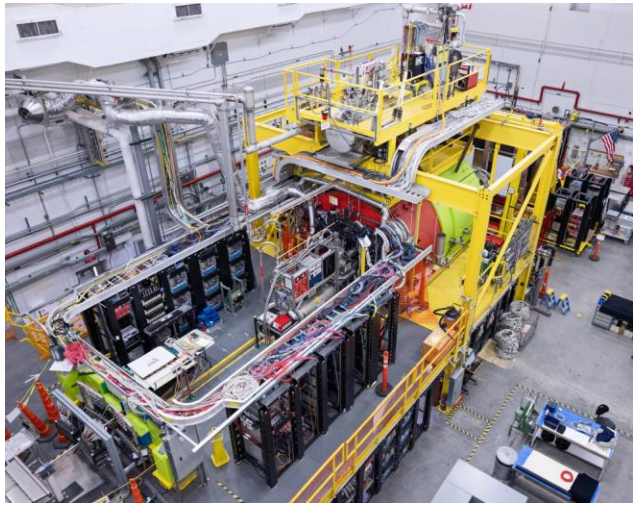
Optimization Commit

QCD Workflow Orchistration

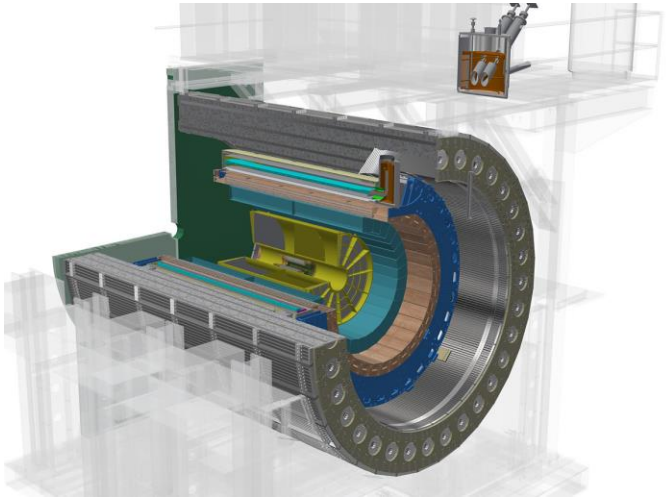


Data Handling for Experimental Nuclear Physics

- Large scale experiments (e.g. GlueX, sPHENIX) produce large-volume datasets (O(100) PB/yr)
- Heavily rely on fine-tuned accelerator operations
- Data storage and compute resource often spread across facilities
- Efficient data movement, curation and processing is a necessity to optimally drive scientific workflows
- Benefit from AmSC services
  - User authentification
  - Data catalogues and preprocesing tools
  - Model registry
  - Compute allocations

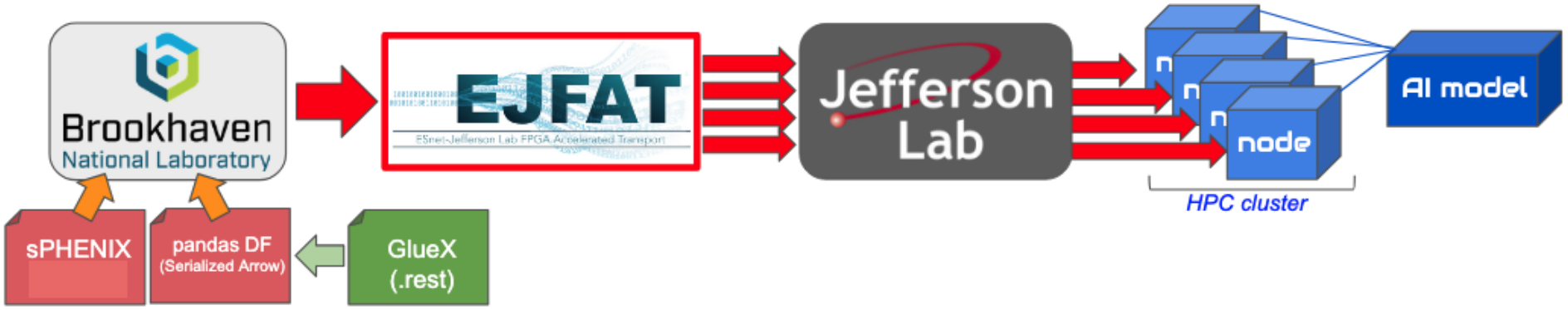


https://www.jlab.org/news/releases/pioneering-nuclear-glue-frontier-0

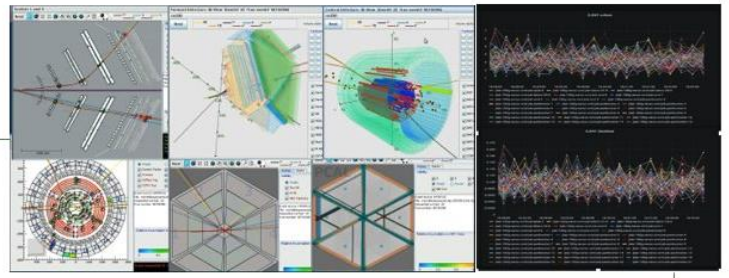


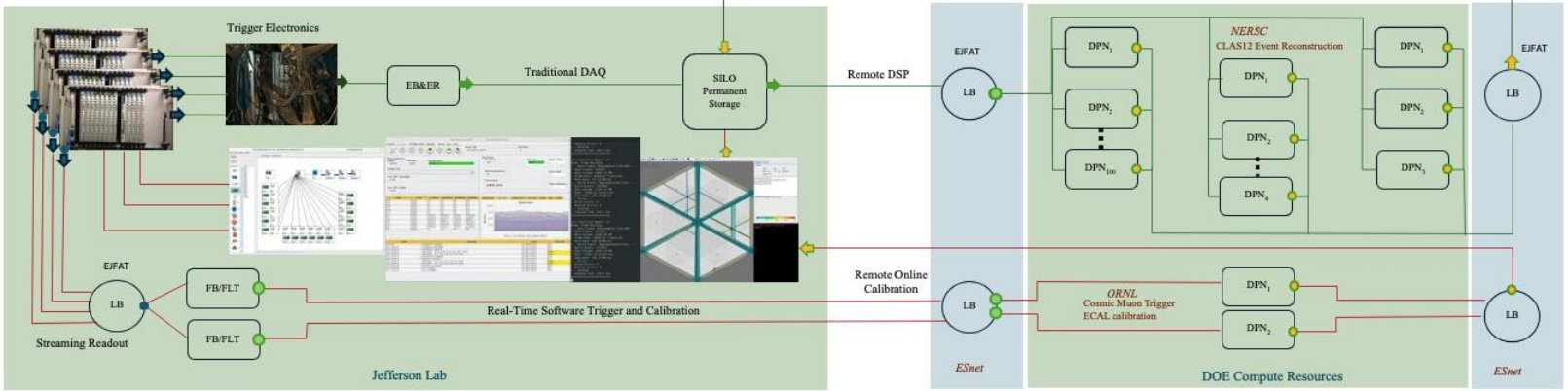
https://www.bnl.gov/rhic/sphenix.php

High Bandwidth Streaming of large-Volume Detector Data

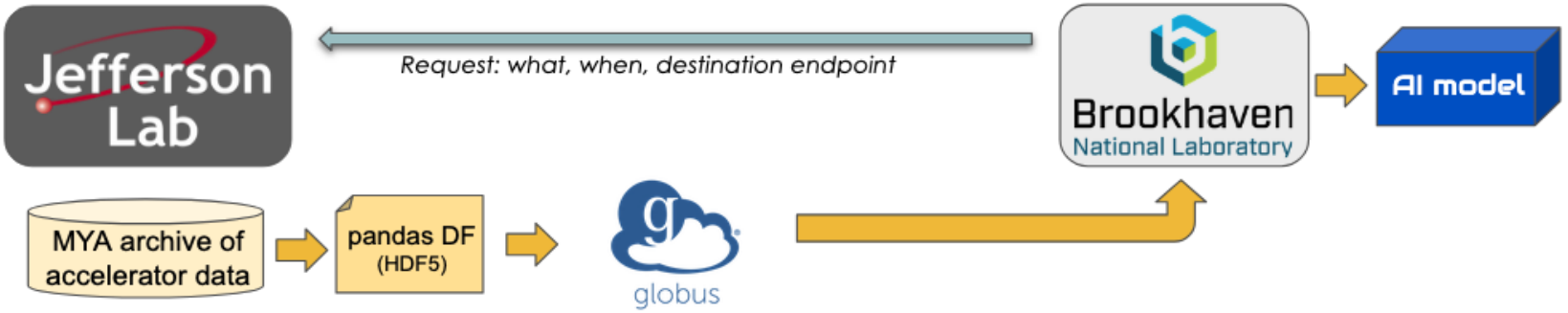


- Real time streaming of nuclear physics data across facilities with immediate feedback
- **EJFAT:** ESnet JLab FPGA Accelerated Data Transport
- Send large-volume data to distributed HPC nodes

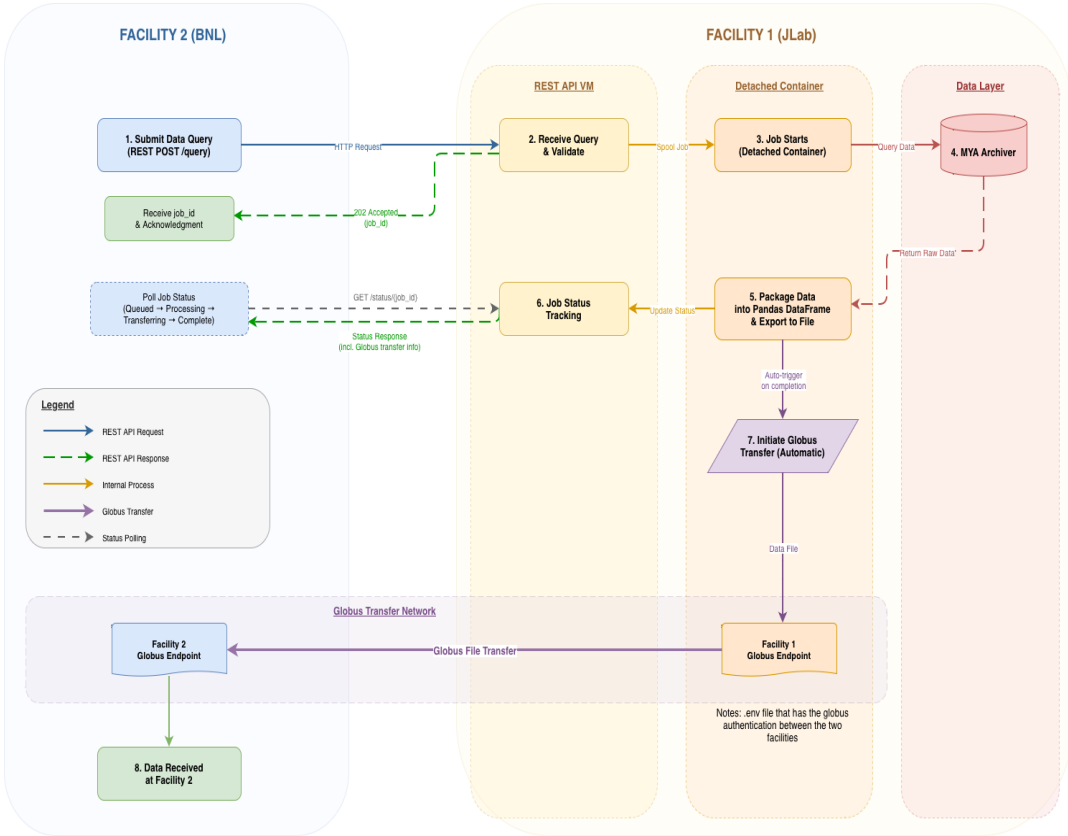




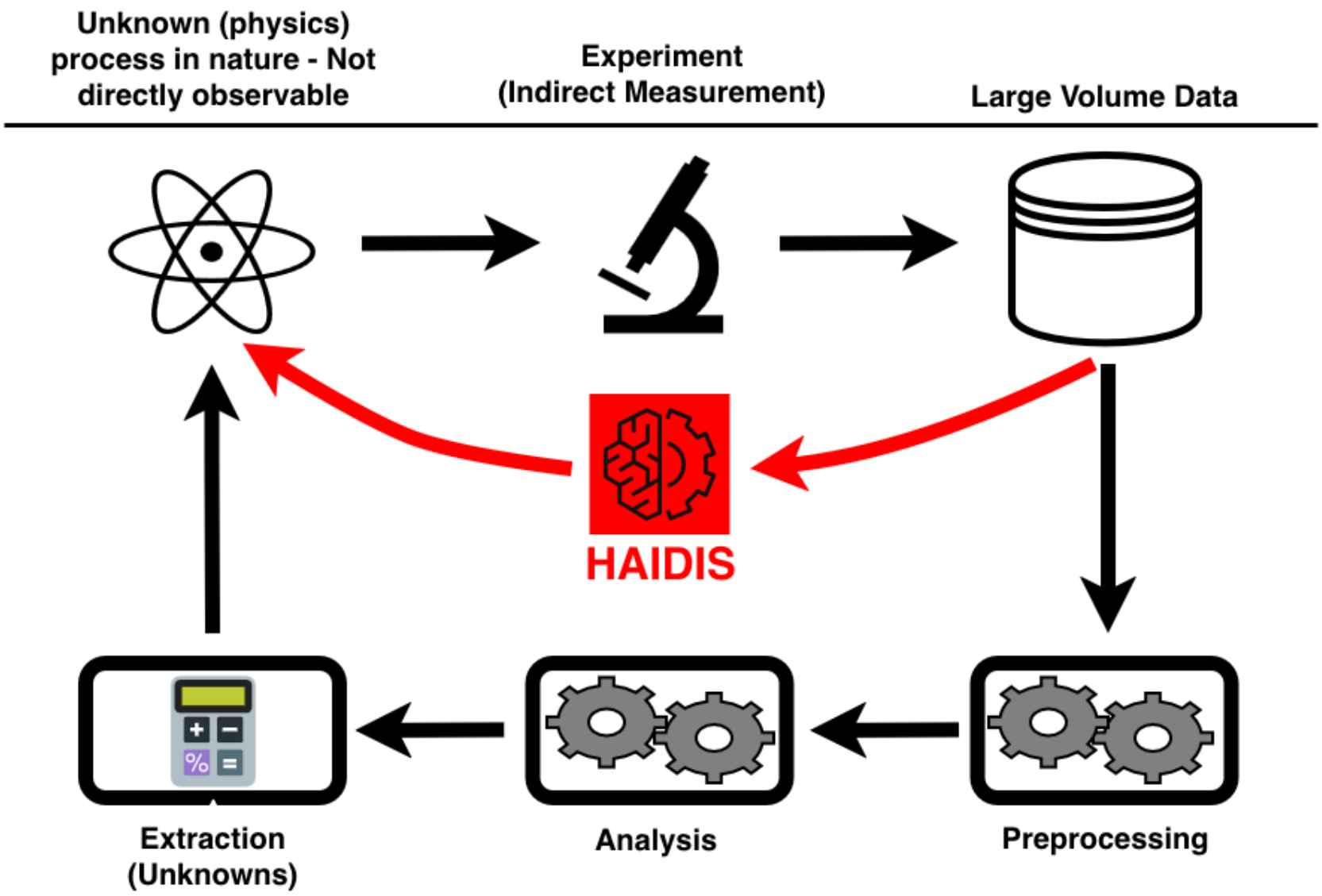
Low Bandwidth Query/Extraction of Accelerator Data



- Pull of accelerator data for offline analysis and accelerator design work
- Data translated into user / AI – friendly format
- Pipe directly into AI system for training and / or inference
- Run workflows across faciities



Hardware-enabled AI Distributed Inverse Solver - HAIDIS



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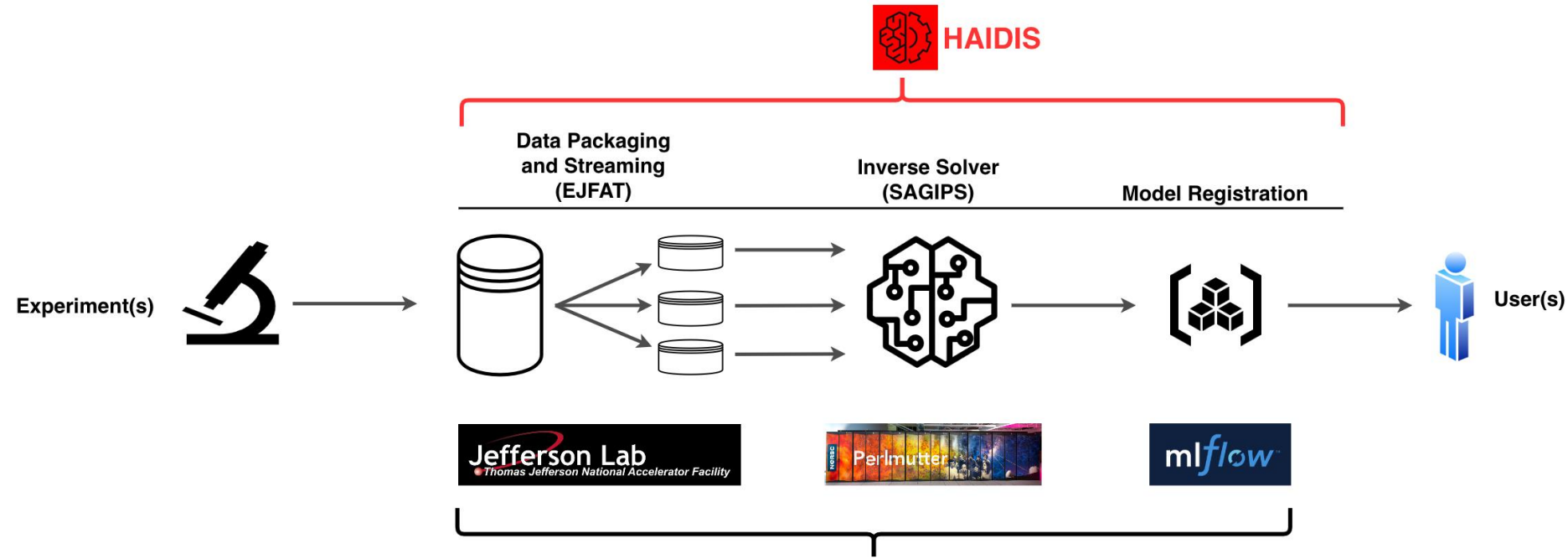
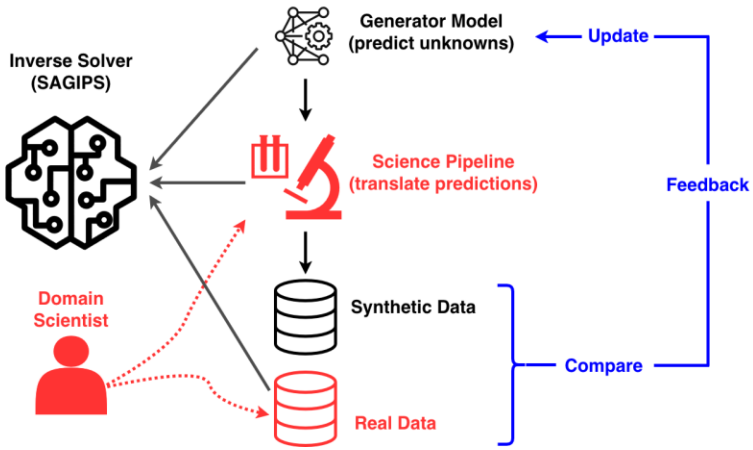
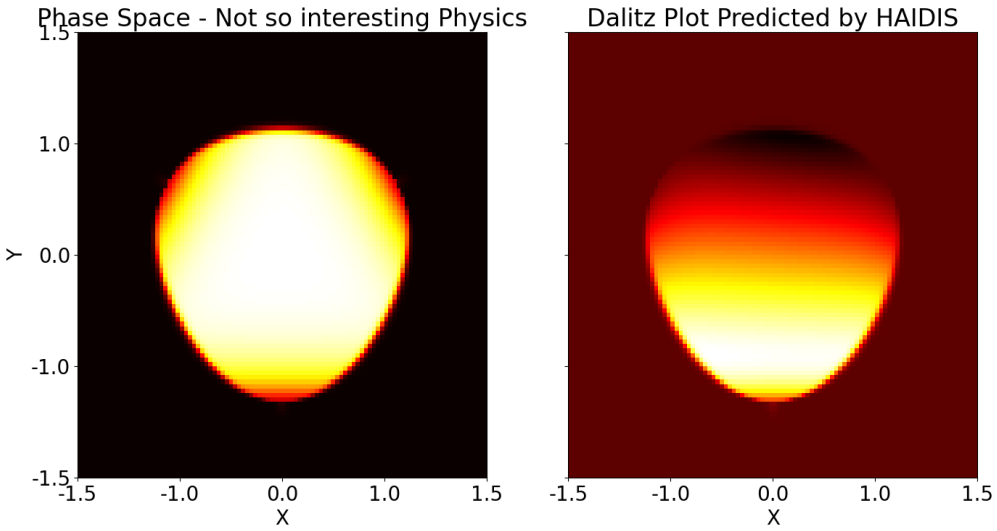


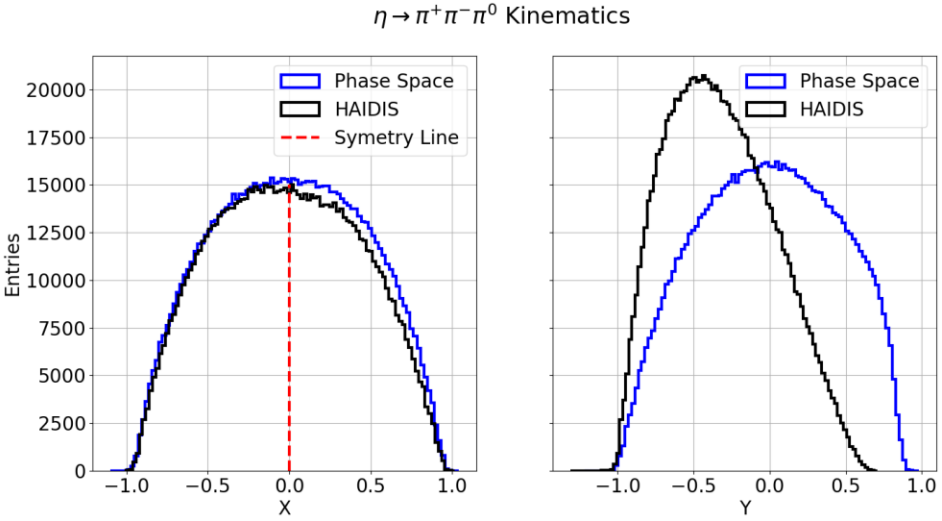


Genesis Mission
AMERICAN SCIENCE CLOUD

Dalitz Plot Analysis for $\eta \to \pi^+\pi^-\pi^0$ with HAIDIS



- Use Dalitz Plot analysis as benchmark
- Streamed event-level Dalitz plot analysis on experimental data
- Offline evaluation from tracked artifacts
- First results are promising – fine tuning of HAIDIS ongoing



$$A = \frac{N(X > 0.0) - N(X < 0.0)}{N(X > 0.0) + N(X < 0.0)} = \begin{cases} 0, & \text{C-symmetry conserved,} \\ \neq 0, & \text{C-symmetry broken} \end{cases}$$

HAIDIS found A consisten with 0