

Jefferson Laboratory Hadron and Nuclear Physics

Universities of Glasgow and York



University
of Glasgow



UNIVERSITY
of York

Our Discovery Machine: Advancing Nuclear Physics Research

The **Continuous Electron Beam Accelerator Facility** is the highest throughput research accelerator in the world.



Supporting LRP priorities for the user communities in NP.



The Continuous Electron Beam Accelerator Facility (CEBAF) superconducting machine, is unique in the world – the only high-energy accelerator for nuclear physics for the next several years (RHIC, CERN LS3, 2026-30).



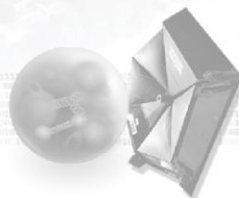
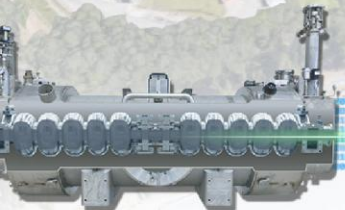
Half-million accelerator control points monitored by AI, improving operation & reliability (86.7% in 2025).



Largest pair of 2 Kelvin cryogenics refrigerators in the world, unique capabilities for the DOE complex.

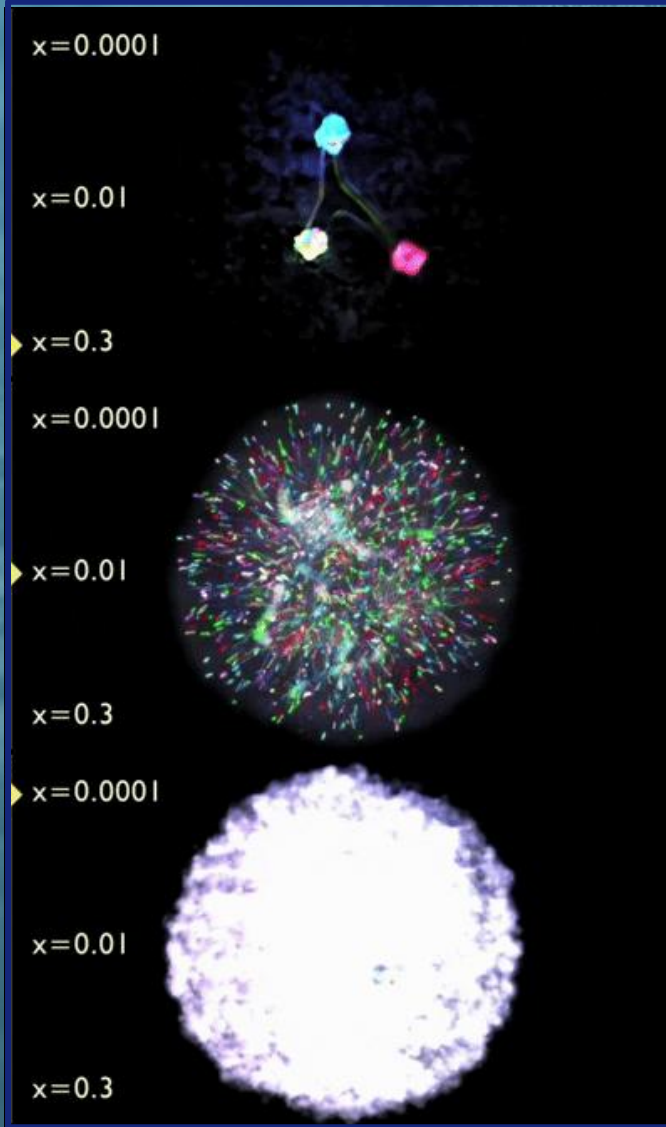


12 GeV electron beams at up 10^{39} electrons/second/cm², making it the highest luminosity electron accelerator in the world. We use polarized beams and targets.



Future : Smarter Particle Accelerators & Nuclear Physics

nucleon visualization at different Bjorken x values

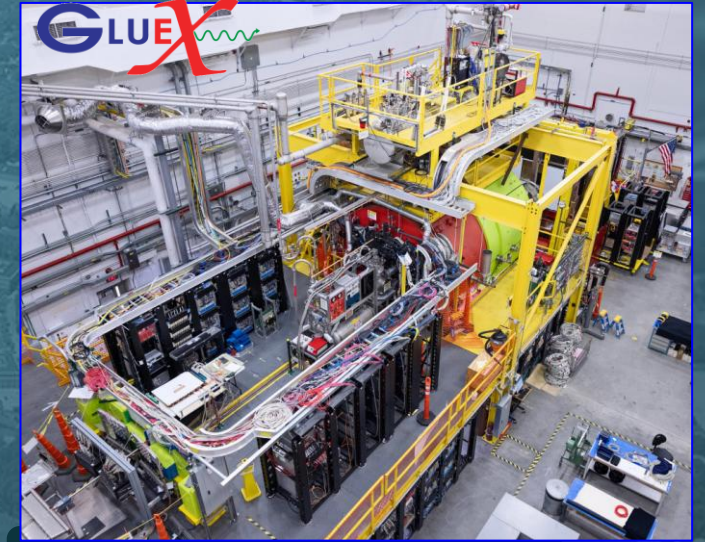


Experimental Nuclear Physics (NP) seeks to understand the internal structure and dynamics of nucleons

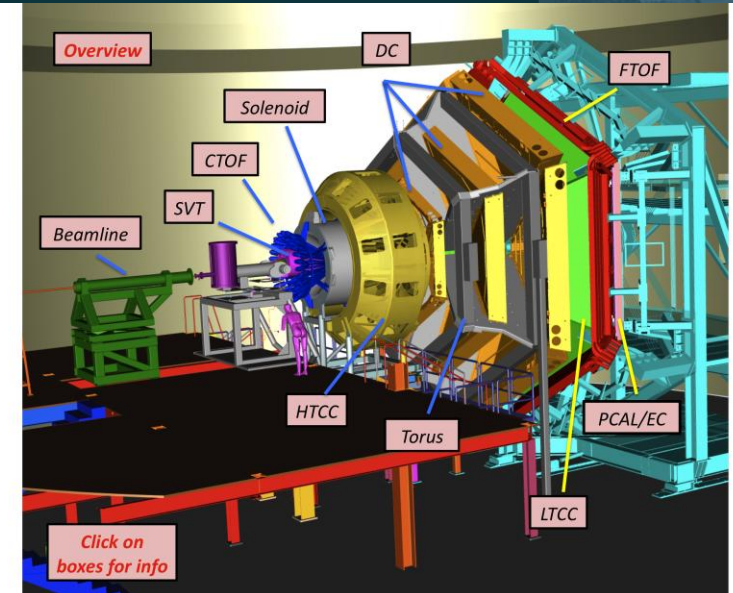
Large detectors with high sensor density produce increasingly larger datasets ($O(10)$ PB/yr for a single experiment) which are needed to search for increasingly rare reactions

Workflows that match large datasets with large compute and advanced analysis techniques enable faster, more efficient insight to the science

Accelerator operation with high intensity, precision, and reliability is required to obtain clean signals for next-gen subatomic discovery



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



General Visualizations of a Nucleon

3D Partonic Imaging : Hadron Femtography

- Deeply Virtual Compton Scattering
- Timelike Compton Scattering
- Deeply Virtual Meson Production
- Light Meson Structure
- Gluonic Gravitational Form Factors (J/ψ Production)

Properties of Hadrons : Spectroscopy and Structure

- Exotic Hadron Spectroscopy
- Strange Spectroscopy
- Transverse Hadron Structure
- Hadronic Form Factors

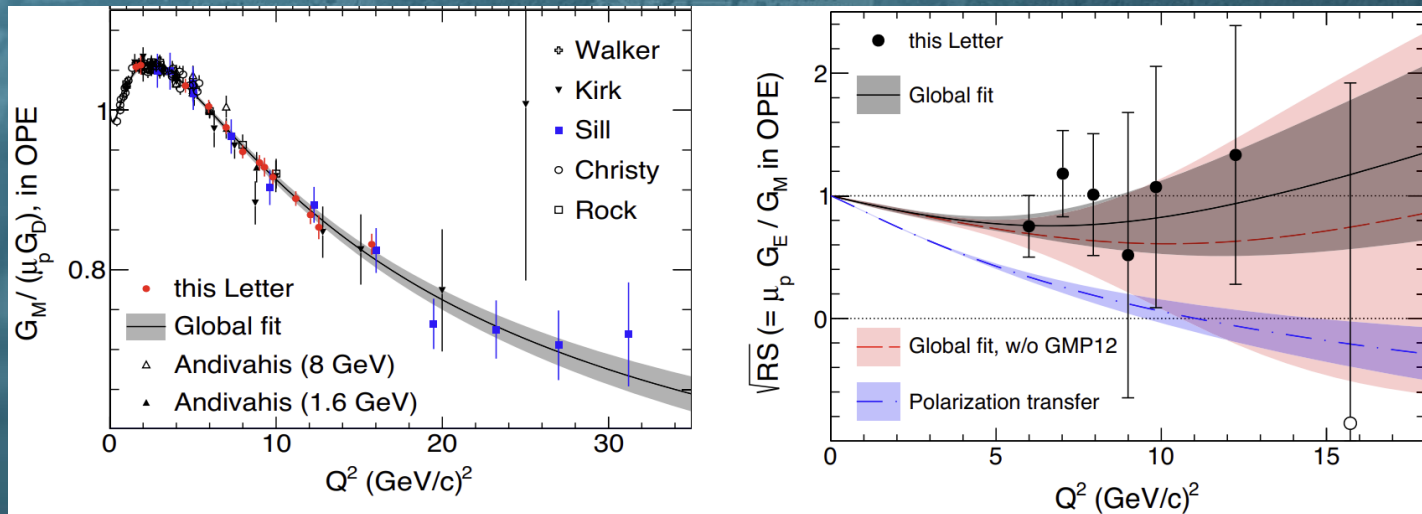
Nuclear Physics

- Short-Range Correlations (SRC)
- Electrons for Neutrinos (e4nu)
- Color Transparency

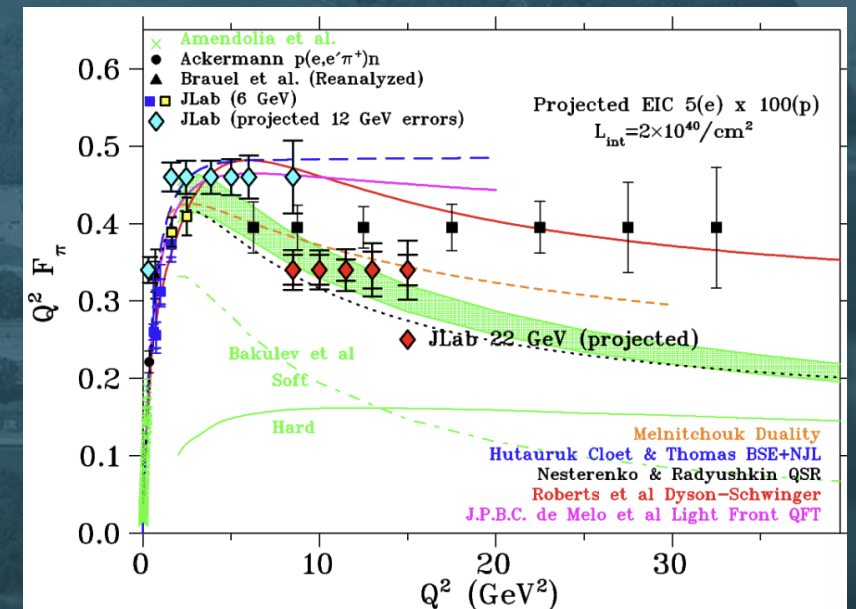
Halls A/C - High Resolution Magnetic Spectrometers, BIGBITE

- Precision Nucleon Form Factors
- The Strange Form Factor of the Proton
- Reaction Mechanisms via GPDs
- Wide-Angle Compton Scattering (WACS)
- Meson Structure

Detailed measurements of two photon exchange via nucleon form factors



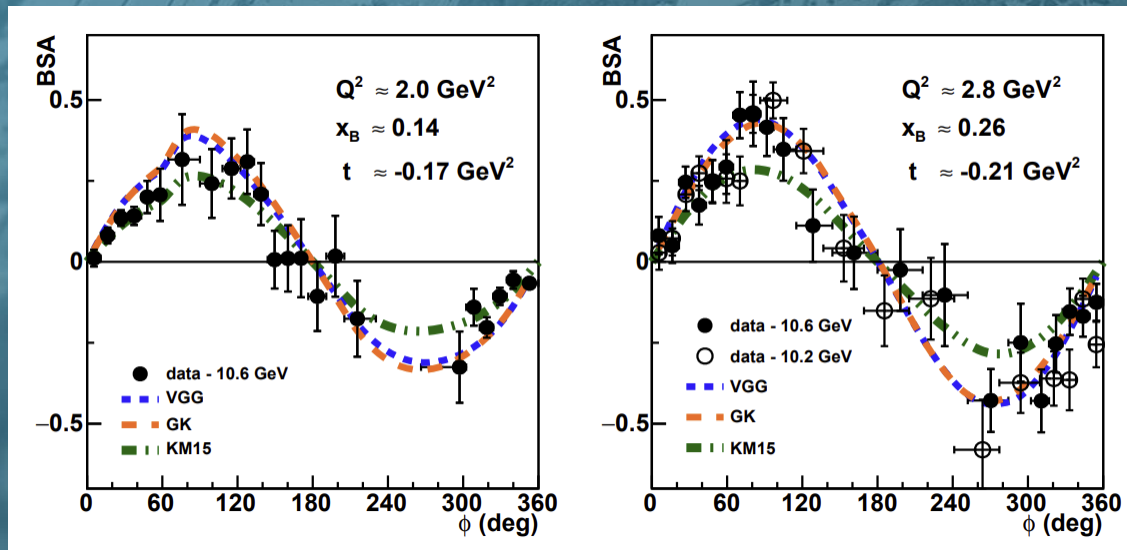
Pion (and soon kaon) form factor experiments



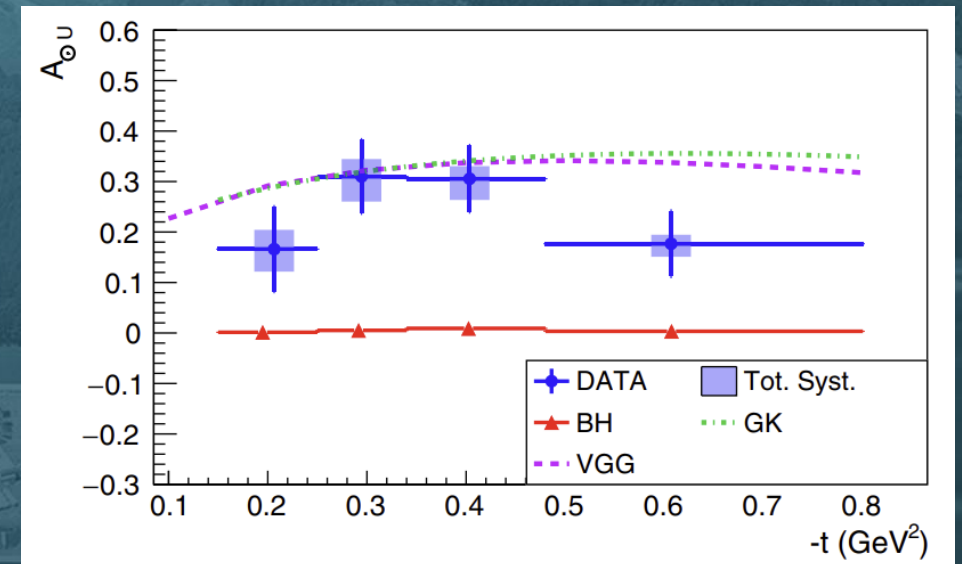
Hall B : CLAS12 Large Angle Spectrometer

- 3D Quark Tomography via Deeply Virtual Compton Scattering
- Timelike Compton Scattering
- Deeply Virtual Meson Production
- Hadron Transition Form Factors
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- Gluonic Form Factors and Mass Radius Mapping
- Lepton-Nucleus Benchmarking for Neutrino Oscillations
- High-Density Short-Range Correlations
- Color Transparency and the Quark-Hadron Transition

First polarisation observables in DVCS for GPDs



First polarisation observables in TCS for GPDs

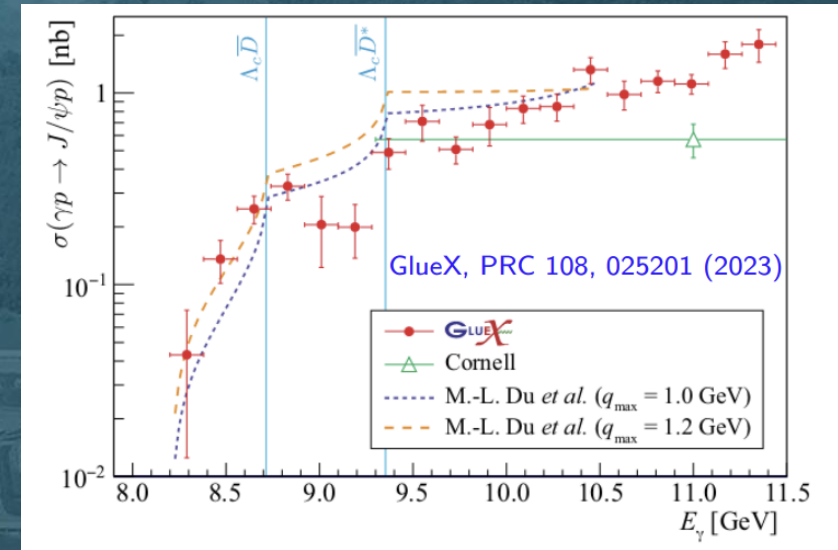
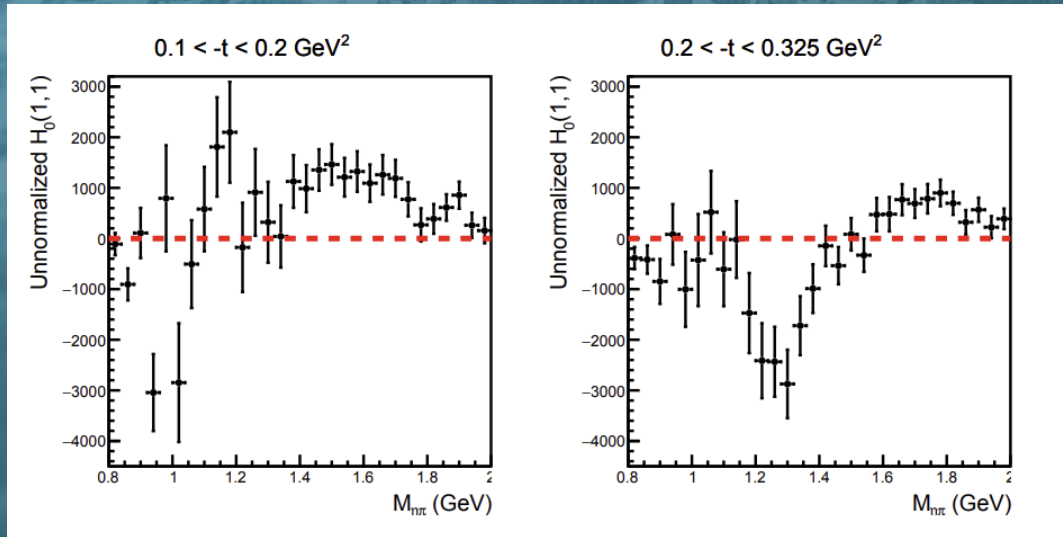


Hall D : Hermetic GlueX Spectrometer / Calorimeter

- Exotic Meson Spectroscopy (GlueX)
- Precision Hyperon Weak Decays (Elliptical GlueX)
- Gluonic Structure and the EMC Effect in Nuclei (Nuclear GlueX)
- J/ψ and Charmonium Production (GlueX III)

First Exotic hybrid signals in Photoproduction
Only exotics contribute to these Spherical harmonics

Largest statistics and coverage for J/ψ photoproduction

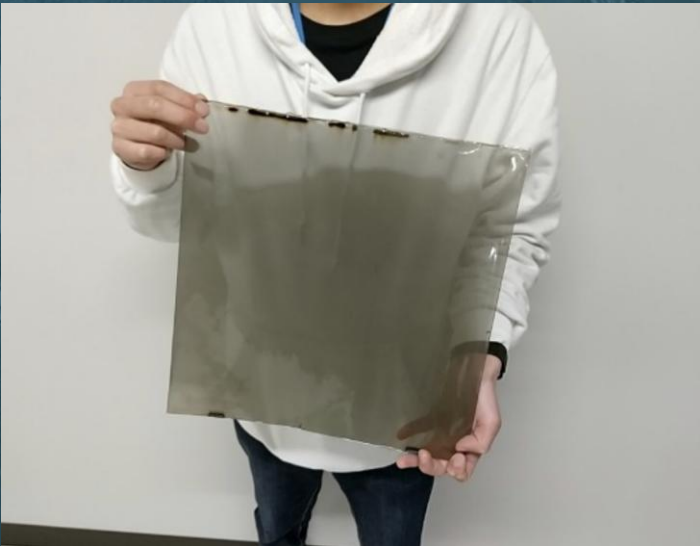
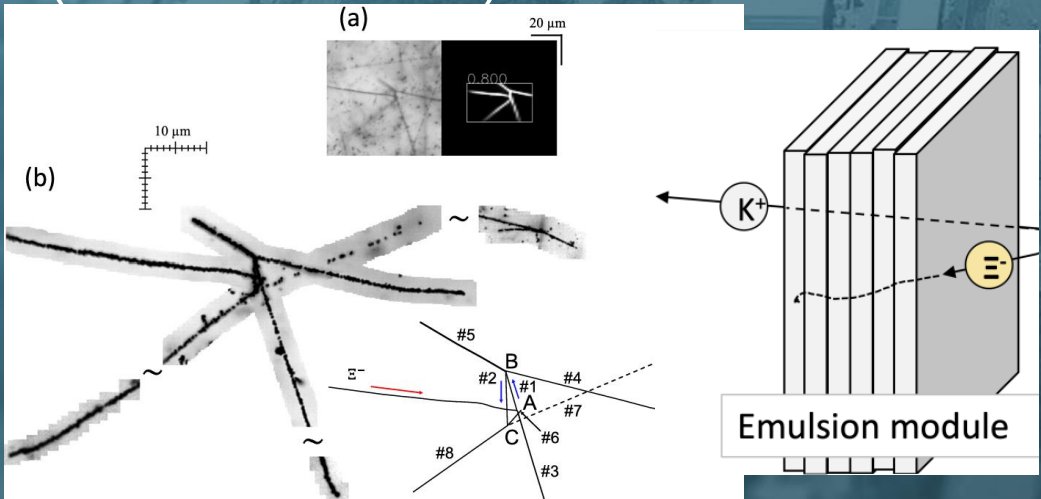


Hall D : K-Long Facility

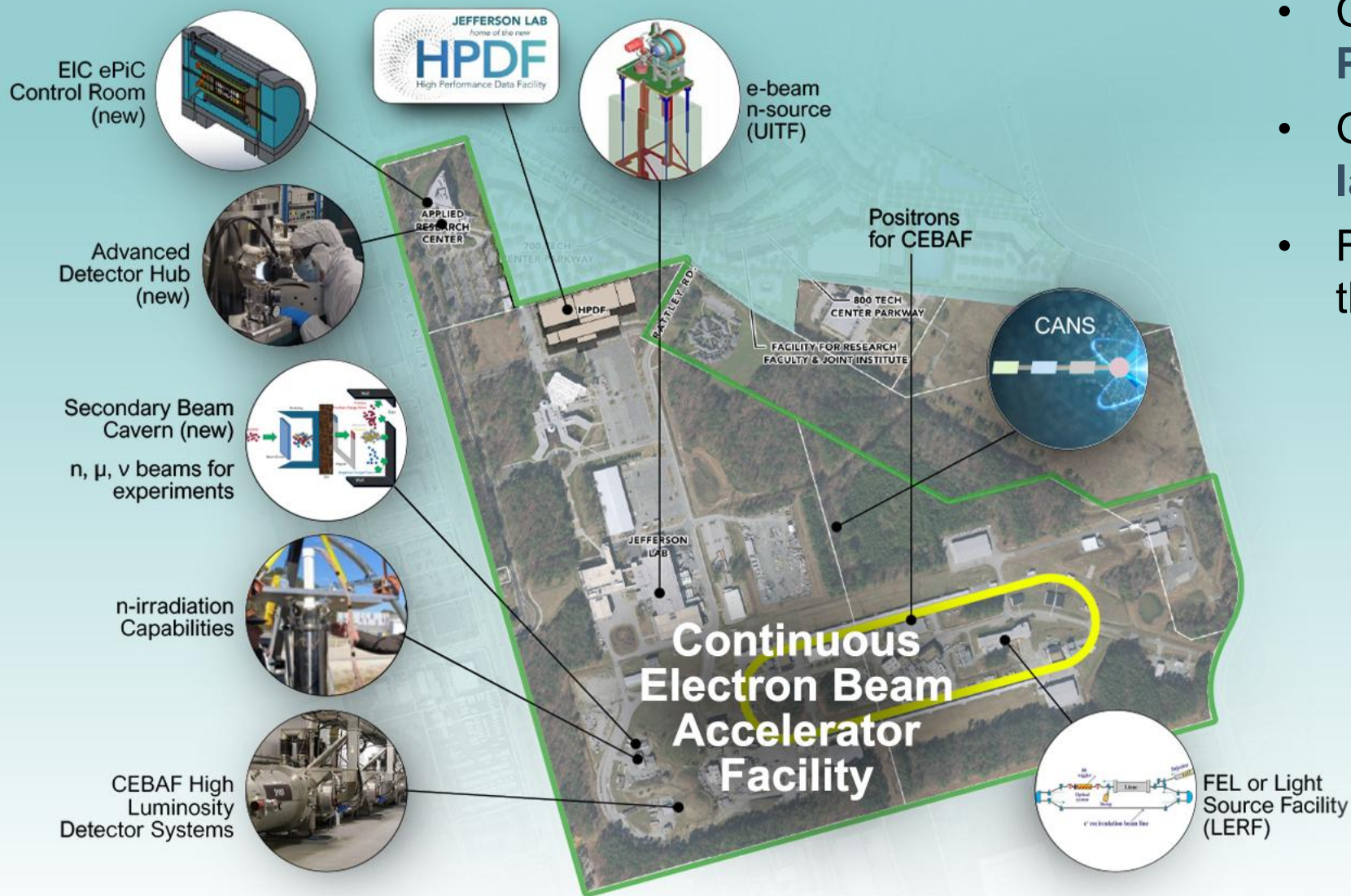
Strange Baryon Spectroscopy

- Equipment for the Flux monitor
 - UoY responsibility, to be shipped from Juelich
 - took 26 months to sign all contracts Sweden-Germany-UK-USA
 - First new KLF equipment
- Successful intermediate readiness review (Summer 2025)
- Final readiness review (Summer 2027)
- New proposal UoY-RIKEN – Hypernuclear station at KLF (PAC on 07.07.2026)

	FY-2026	FY-2027	FY-2028	FY-2029	FY-2030	FY-2031
Experimental Hall A						
Experimental Hall D						
E12-25-005: GlueX Low Energy Runs						
E12-12-002 & 12-002A: GlueX Phase II with DIRC and JEF						
E12-24-006 & 25-002: GlueX-III & Nuclear Target Runs						
K-long Installation						
E12-19-001: K-long experiment						



Jefferson Lab: 10/20-Year Outlook



- Continuation of **CEBAF Nuclear Physics Program**
- Growing to a **multi-program laboratory**
- Future expansions proposed over the next 20 years supported by:
 - › working with the scientific **user community** for buy in on priorities
 - › We are planning community-oriented strategy planning exercises, for CEBAF and other sectors
 - › CEBAF 2037 and beyond
 - › Beam Dump opportunities
 - › 22 GeV ? Positron beams ?
 - › FEL, n-sources...