

Jefferson Lab

GlueX/Hall D Overview

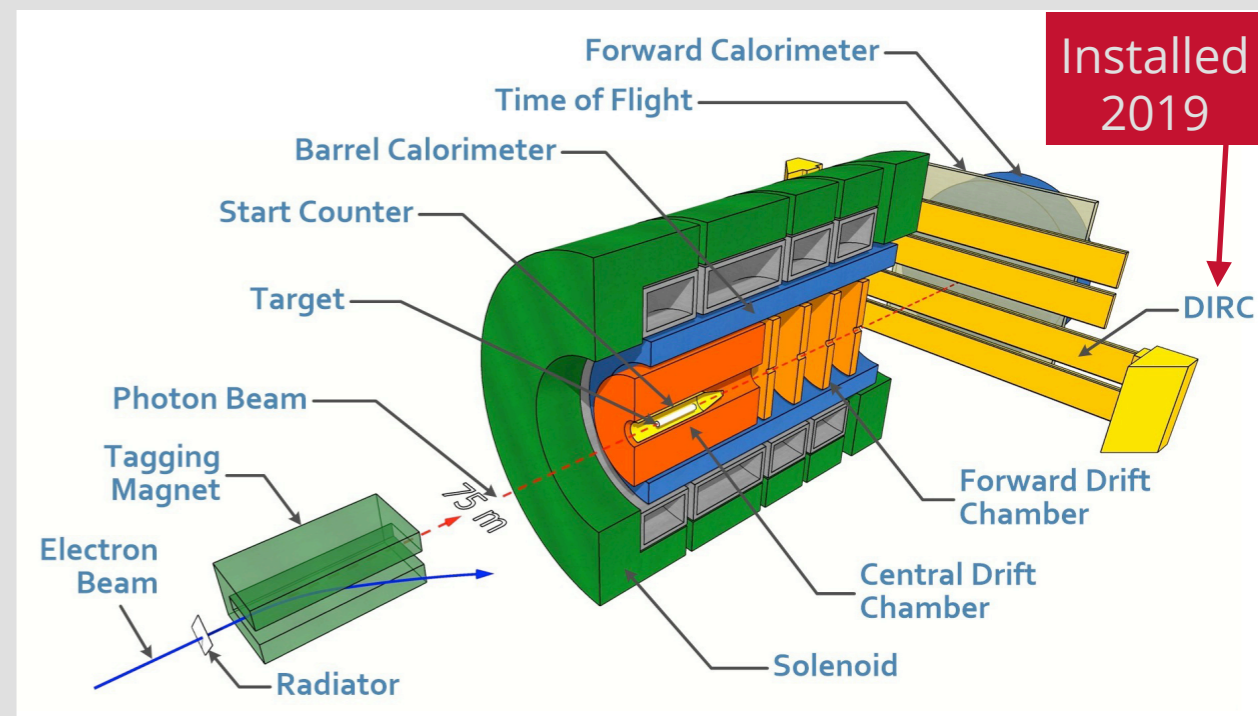
**JLUO Satellite Meeting
APS 2023 Spring Meeting**



Nathaniel Dene Hoffman — April 16th, 2023
Carnegie Mellon University

Overview

1. GlueX-I (2017-2018) and GlueX-II (2020+)
 - J/ψ cross-section near threshold
 - $\rho(770)$ Spin Density Matrix Elements (SDMEs)
 - $\pi_1(1600)$ upper limit
 - Other analyses
2. PrimeX- η
3. Charged/Neutral Pion Polarizability (CPP/NPP)
4. FCAL-II/JEF



J/ψ Cross-Section

Data from 2017-2018 GlueX-I runs

- 4x more statistics than previous paper
- Near-threshold measurement is related to several fundamental properties:
 - Trace anomaly contribution to proton mass
 - J/ψ p scattering length
 - Gravitational form factors of the proton (related to proton mass radius)
- Possible evidence of open-charm exchange in total cross-section
- Important in $P_c^+ \rightarrow J/\psi p$ pentaquark search

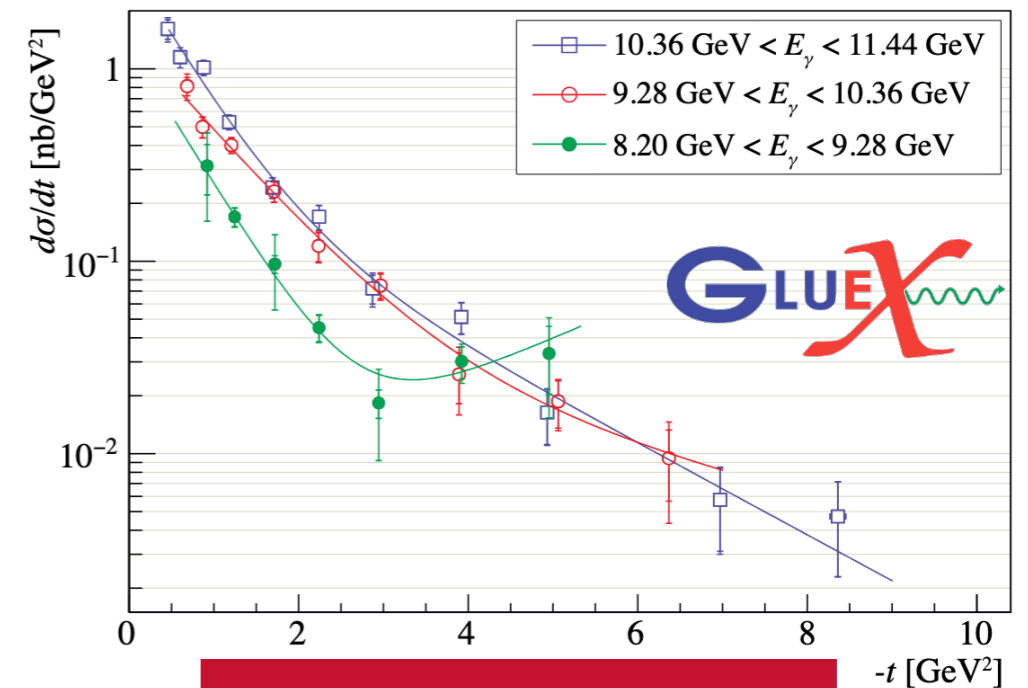
Previous Measurement

Phys. Rev. Lett. 123, 072001 (2019)

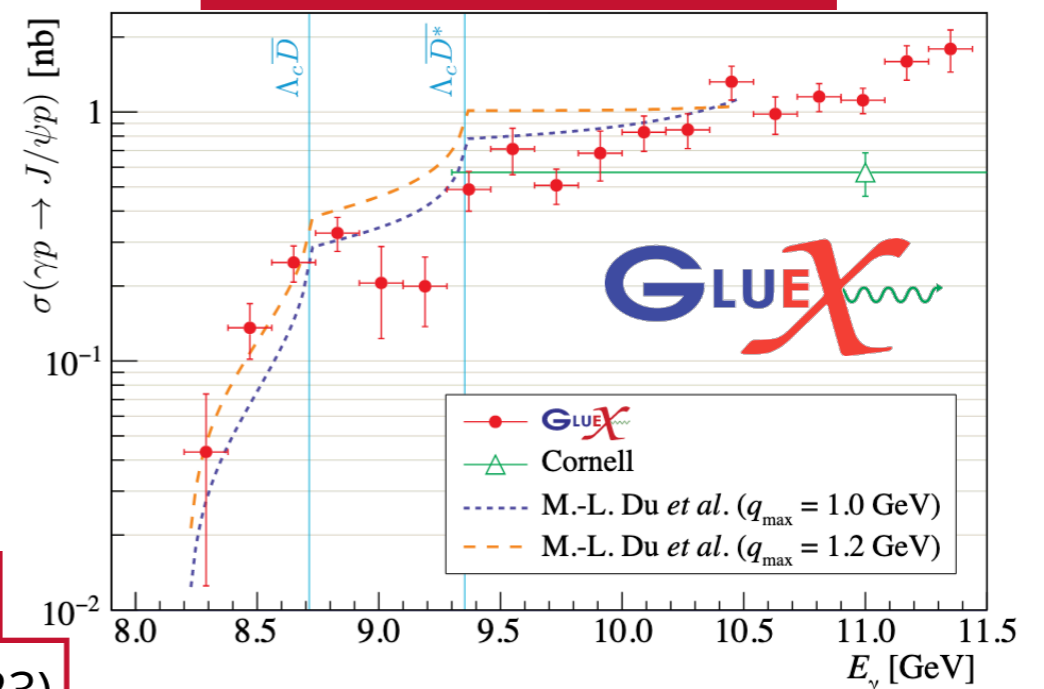
This Measurement

arXiv:2304.03845 (2023)

Differential Cross-Section



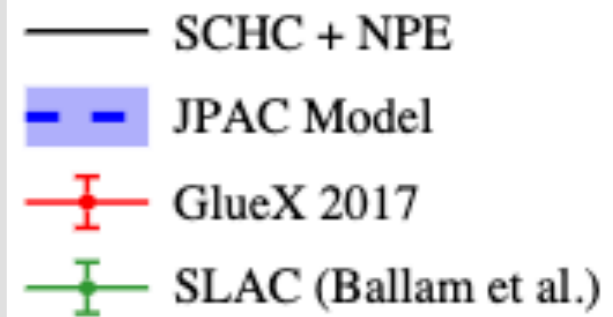
Total Cross-Section



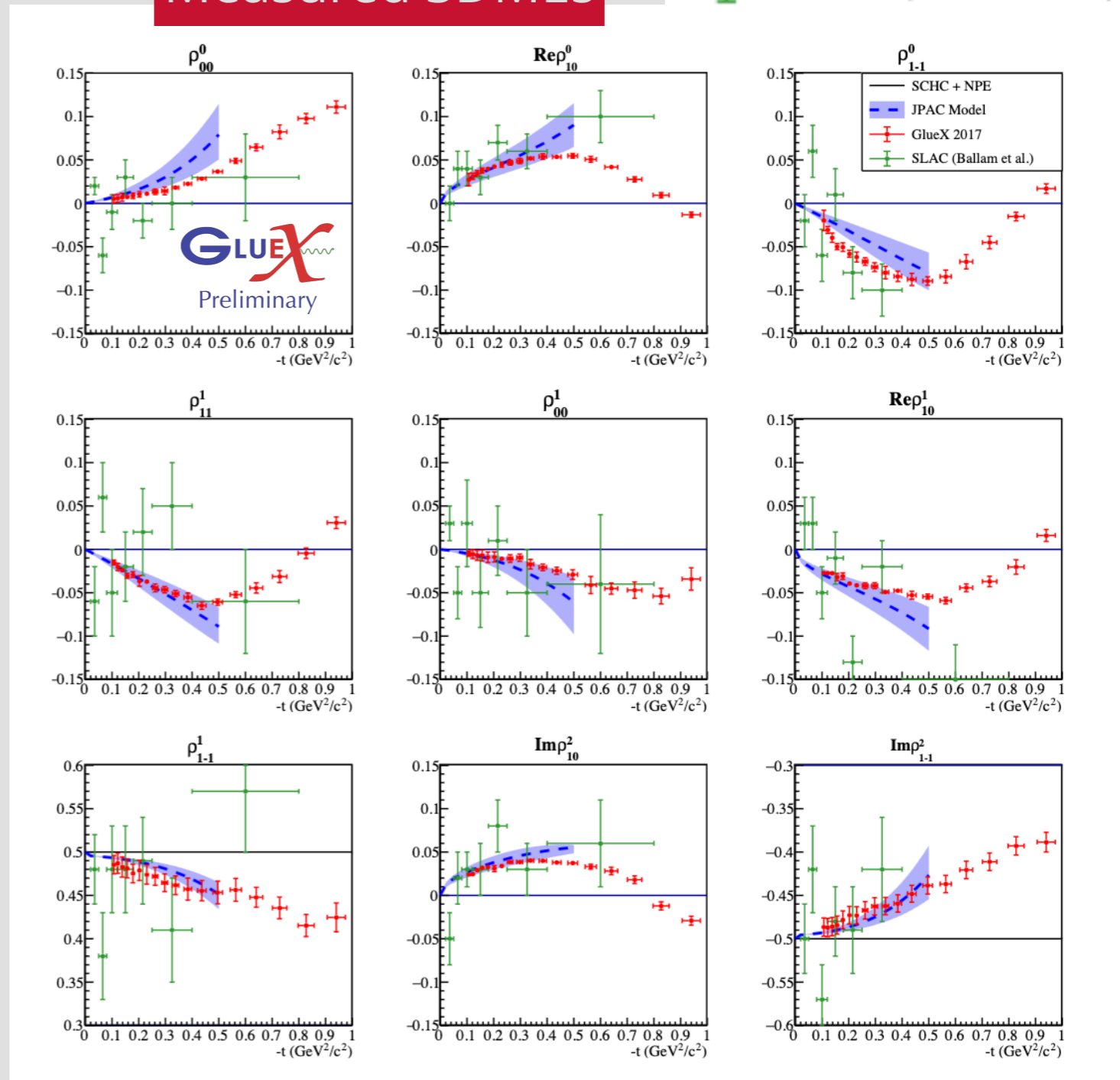
$\rho(770)$ Spin Density Matrix Elements

Data from 2017 GlueX-I runs

Measured SDMEs



- Input for theoretical description of vector meson production
- Much higher precision than previous measurements
- Demonstration of GlueX's amplitude analysis capabilities
- Paper is under internal review

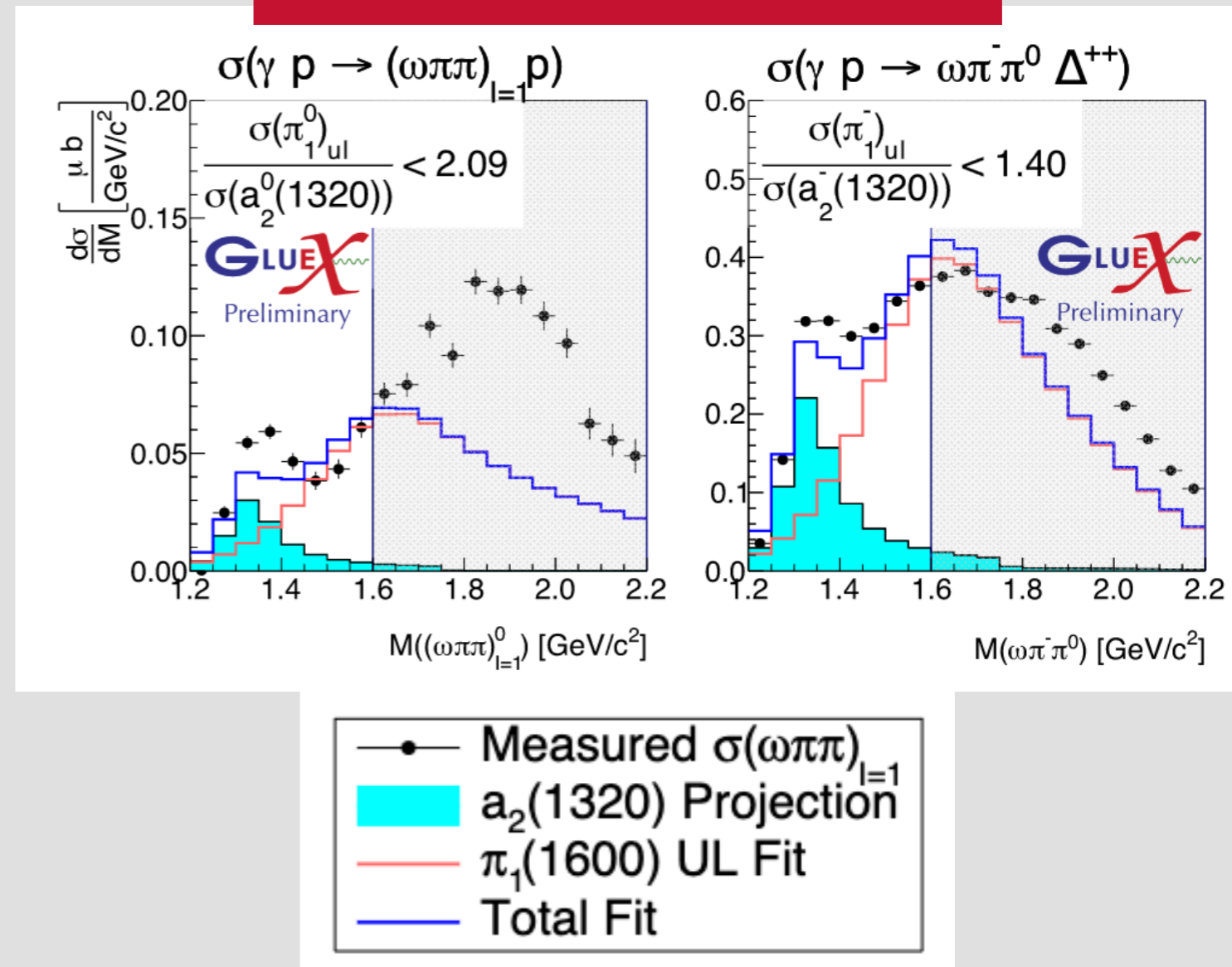


$\pi_1(1600)$ Upper Limit

Data from 2017-2018 GlueX-I runs

- The $\pi_1(1600)$ is the lightest predicted spin-exotic hybrid meson ($J^{PC} = 1^{-+}$)
- $\pi_1(1600) \rightarrow b_1\pi \rightarrow \omega\pi\pi$ has largest predicted branching fraction from LQCD; use this channel for an upper limit in photoproduction
- Future work in $\eta(\prime)\pi$ channels will seek to confirm COMPASS observation

Fits of GlueX Data to Model

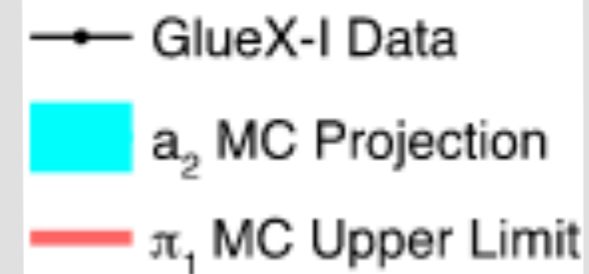
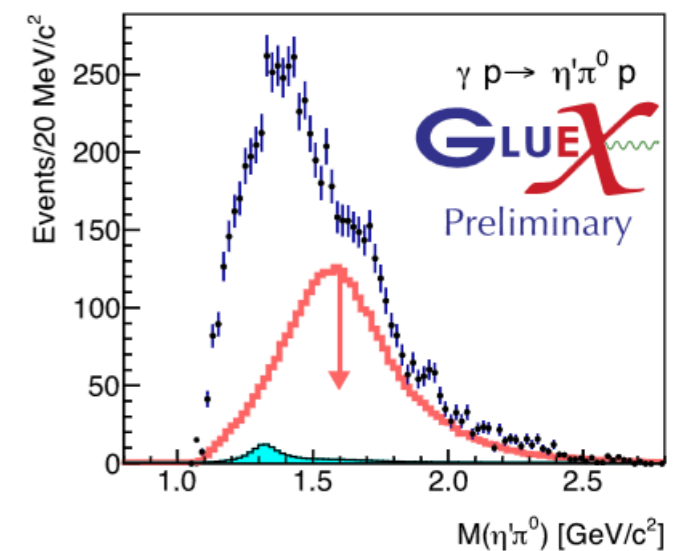
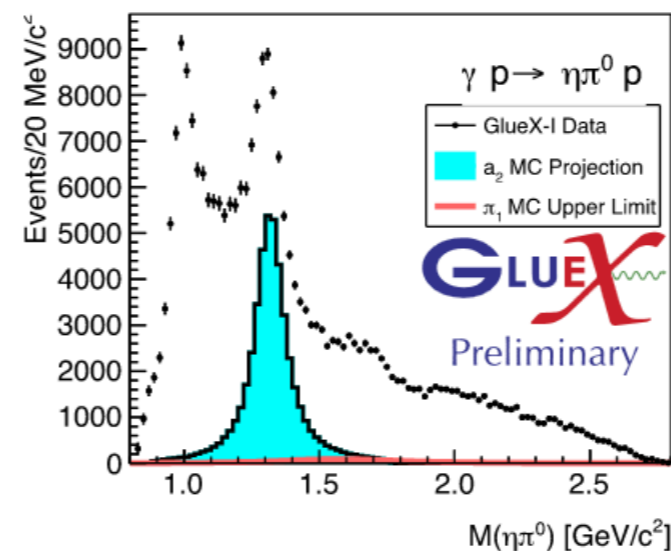


$\pi_1(1600)$ Upper Limit

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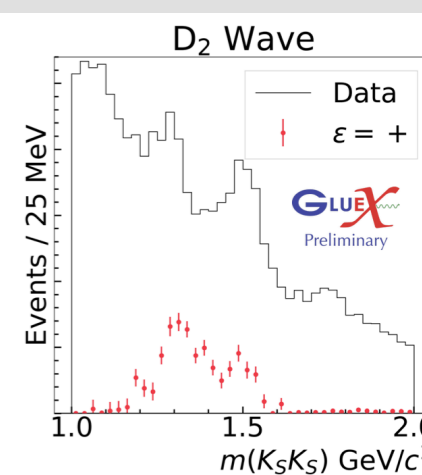
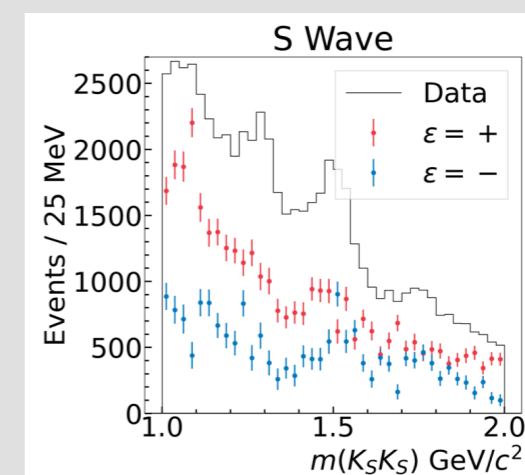
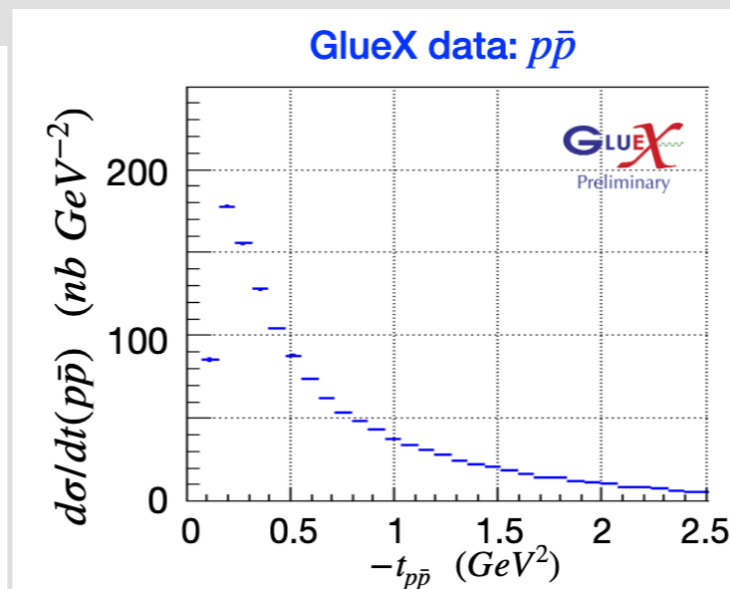
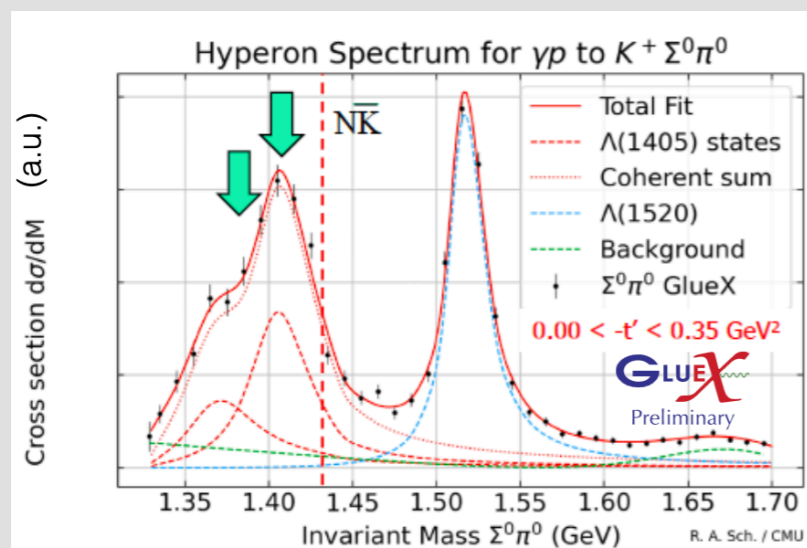
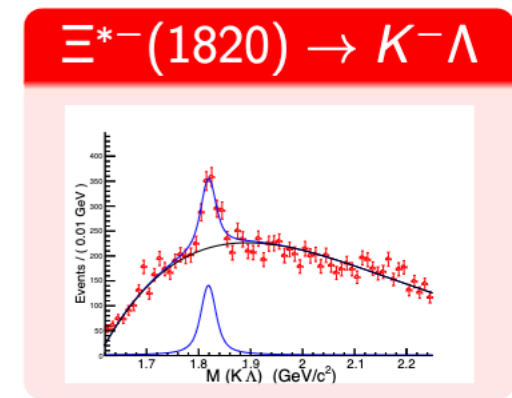
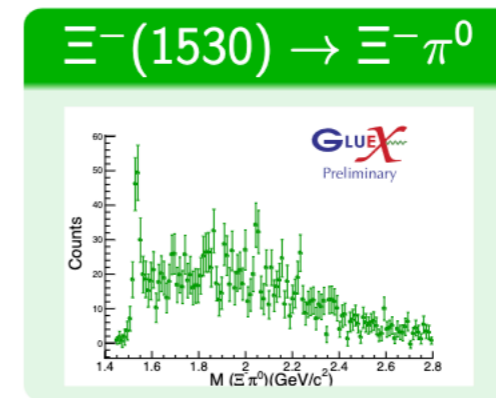
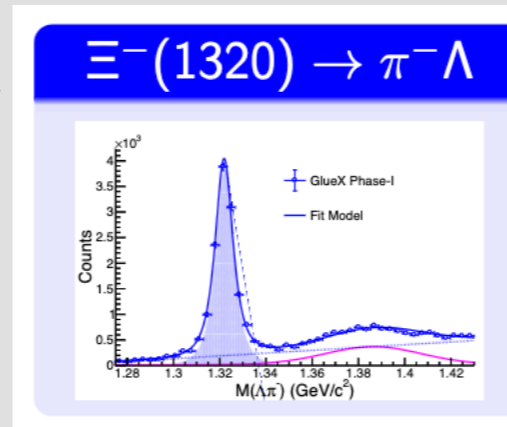
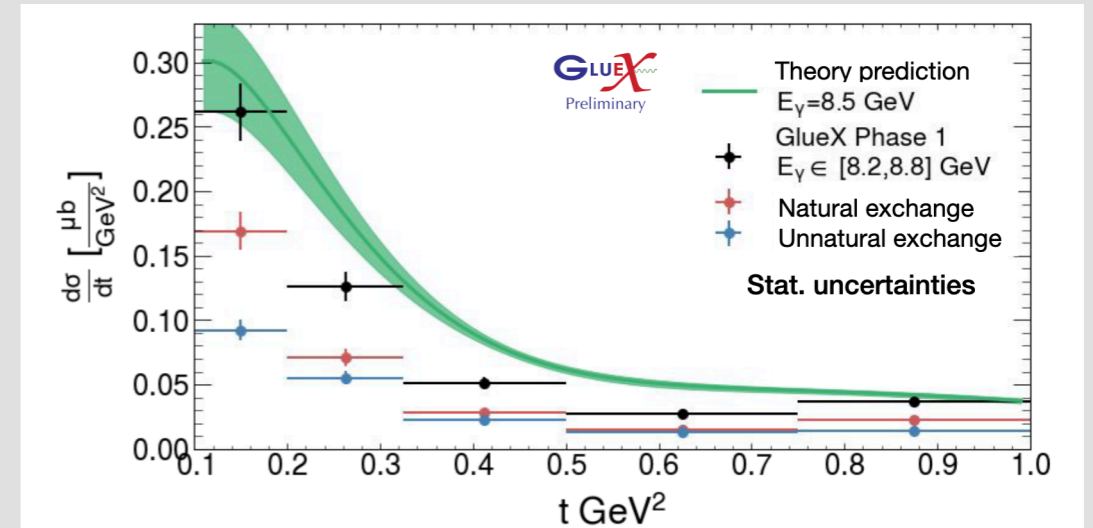
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Projections of Upper Limit onto $\eta\pi^0$ and $\eta'\pi^0$



Other Ongoing Analyses

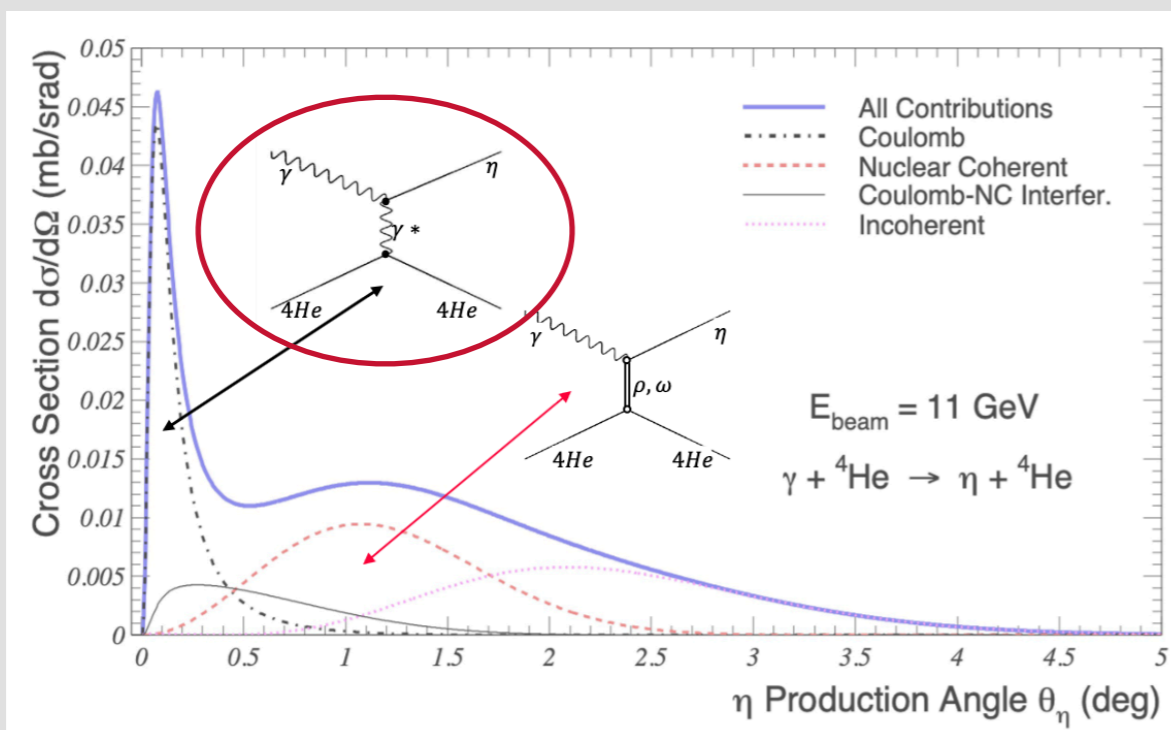
- $a_2(1320)$ cross-section
- Excited Ξ searches
- $p\bar{p}$ and $\Lambda\bar{\Lambda}$ cross-sections and polarization studies
- Modeling $\Lambda(1405)$ decay to $\Sigma^0\pi^0$
- $K_S K_S$ photoproduction (see my talk tomorrow!)
- **Many, many more!**



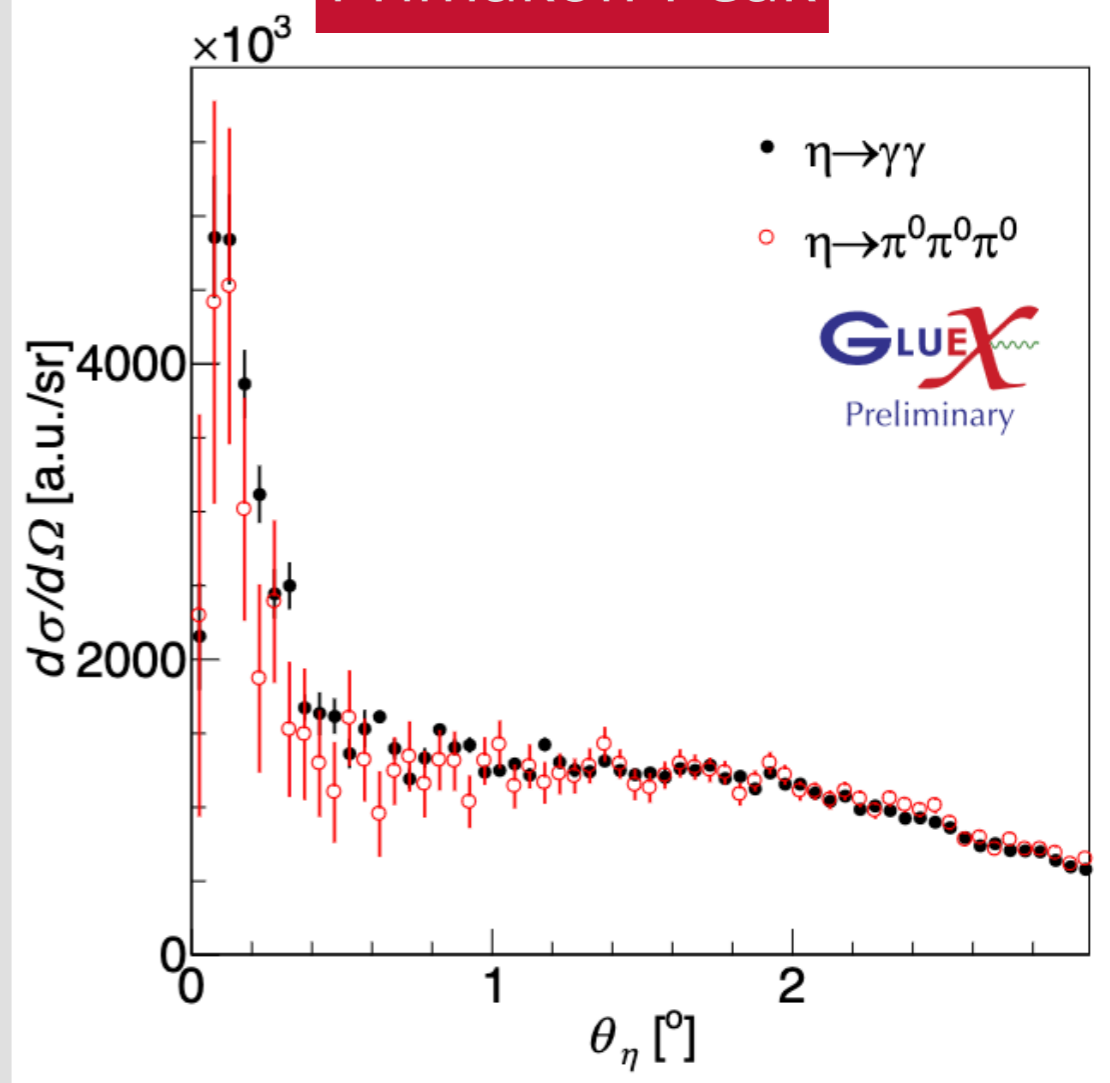
PrimeX- η

Spring 2019, Fall 2021, and Fall 2022

- Precise measurement of $\Gamma_{\eta \rightarrow \gamma\gamma}$ via the Primakoff effect
 - Mixing angle of $\eta - \eta'$ eigenstates
 - Improves measurements of other decay channels like $\Gamma_{\eta \rightarrow \pi\pi\pi}$ and light quark mass ratio
- All data has been collected and is under analysis, we expect $\sim 4\text{-}6\%$ precision in the final measurement



Primakoff Peak



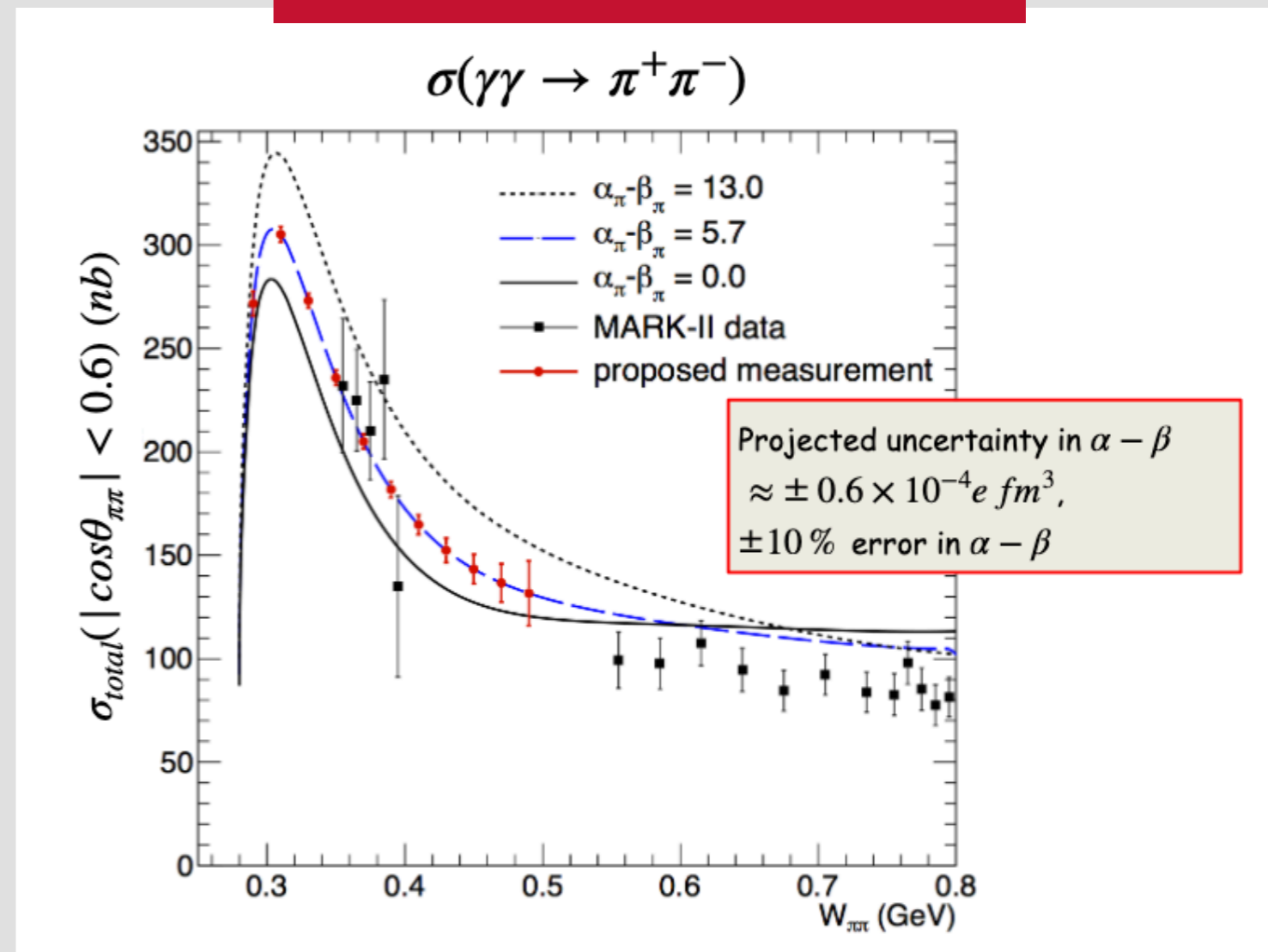
PrimEX \rightarrow D^{5.5}

Charged/Neutral Pion Polarizabilities

Summer 2022

- Precise measurement of charged and neutral pion polarizability
- Hall D measurement utilizes Primakoff photoproduction
 - Added forward μ detector
- NPP has no prior measurement
- Data collection in Summer 2022 was a success, analysis is underway!

Predicted $\pi\pi$ Cross-Section

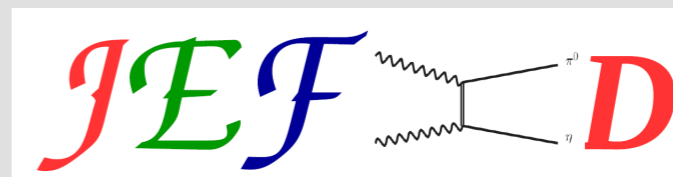
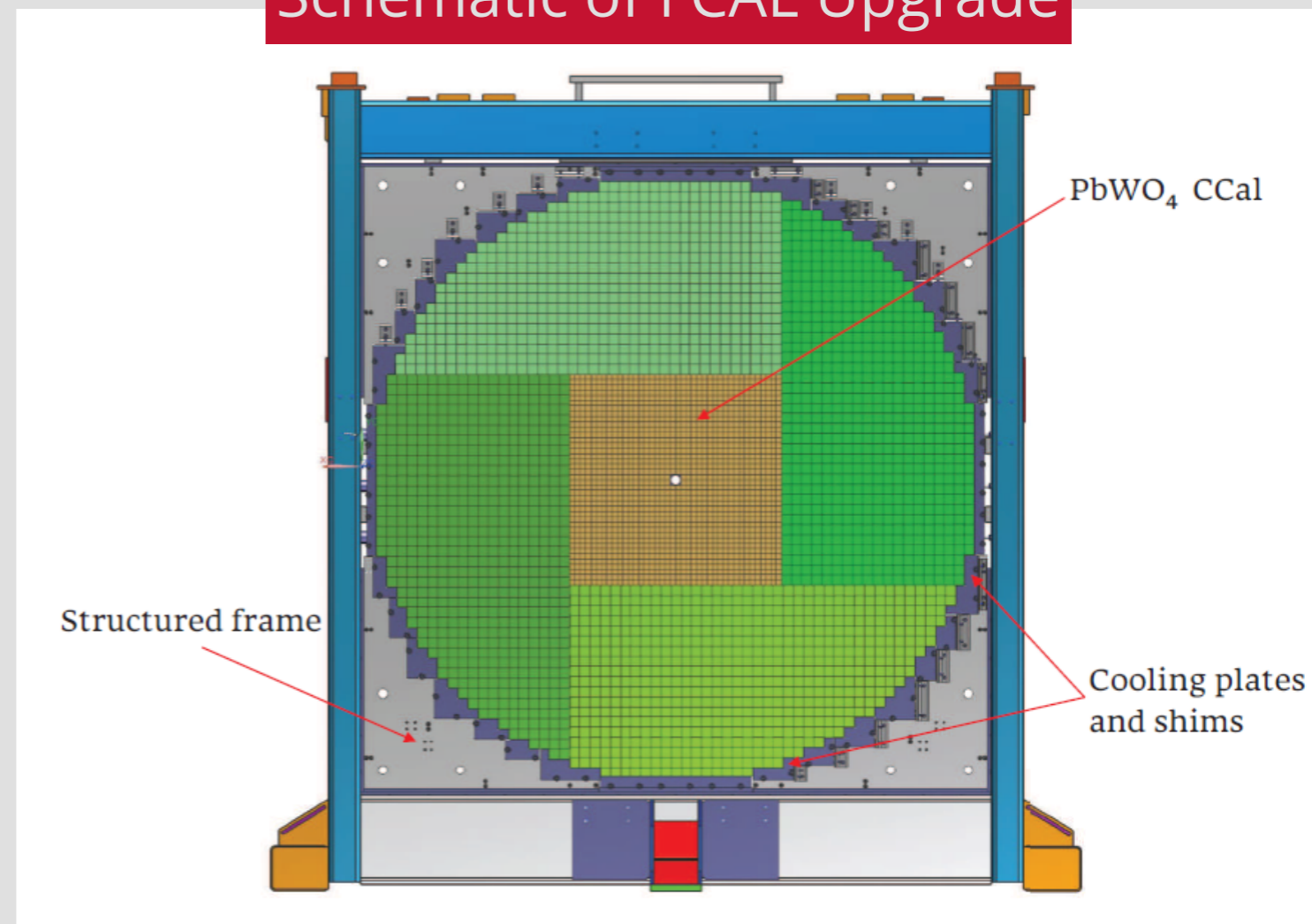


FCAL-II and JEF

Summer 2023+

- Upgrade the Forward Calorimeter (FCAL) for higher granularity/precision with PbWO_4 crystals inserted into center of existing detector
 - Installation started a couple of weeks ago, aiming for operation in July 2024
- Goal: Improved reconstruction of multi-photon final states
- Jefferson Lab η Factory (JEF) experiment will run in parallel to GlueX-II
 - JEF will utilize FCAL-II to produce large $\eta(\prime)$ dataset
 - Goal: Study rare decays of $\eta(\prime)$
 - Dark matter ($\eta(\prime) \rightarrow B'\gamma \rightarrow \pi^0\gamma\gamma$ and others)

Schematic of FCAL Upgrade



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