

Methods in Using a Novel ^3He Target During GEN-II

Jack Jackson

*on behalf of the SBS Collaboration
and the ^3He Target Group*



WILLIAM & MARY

CHARTERED 1693



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Outline

- Quick Overview of GEn-II Neutron Magnetic Form Factor Experiment
- Target Sub-Systems Needed for the Novel Target
- Effects on the ^3He Target Performance



EXPERIMENTAL HALL A

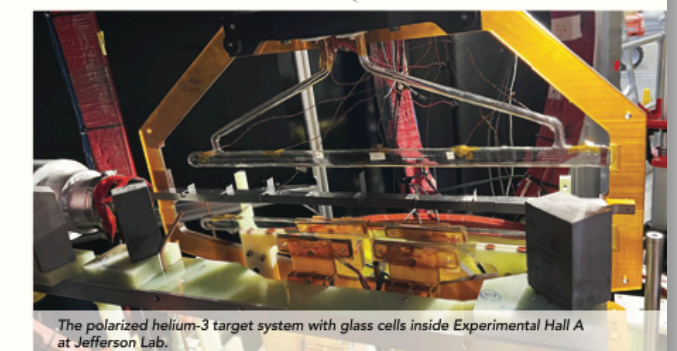
at Thomas Jefferson National Accelerator Facility

The unique capability to install large, diverse experimental setups allows scientists to explore:

- Nucleon charge and magnetic structure
- Precision 3D momentum imaging of the neutron
- Precision tests of the Standard Model
- Nuclear constraints on dense astrophysical systems
- Nuclear structure at short distances
- Origins of mass from dynamical nuclear interactions

Hall A's international collaboration of scientists represents more than 70 institutions and 17 countries.

17 COUNTRIES
Armenia, Brazil, Canada, China, Croatia, Egypt, Eswatini, France, Italy, Japan, Saudi Arabia, Slovenia, South Korea, Tunisia, Ukraine, United Kingdom, and United States

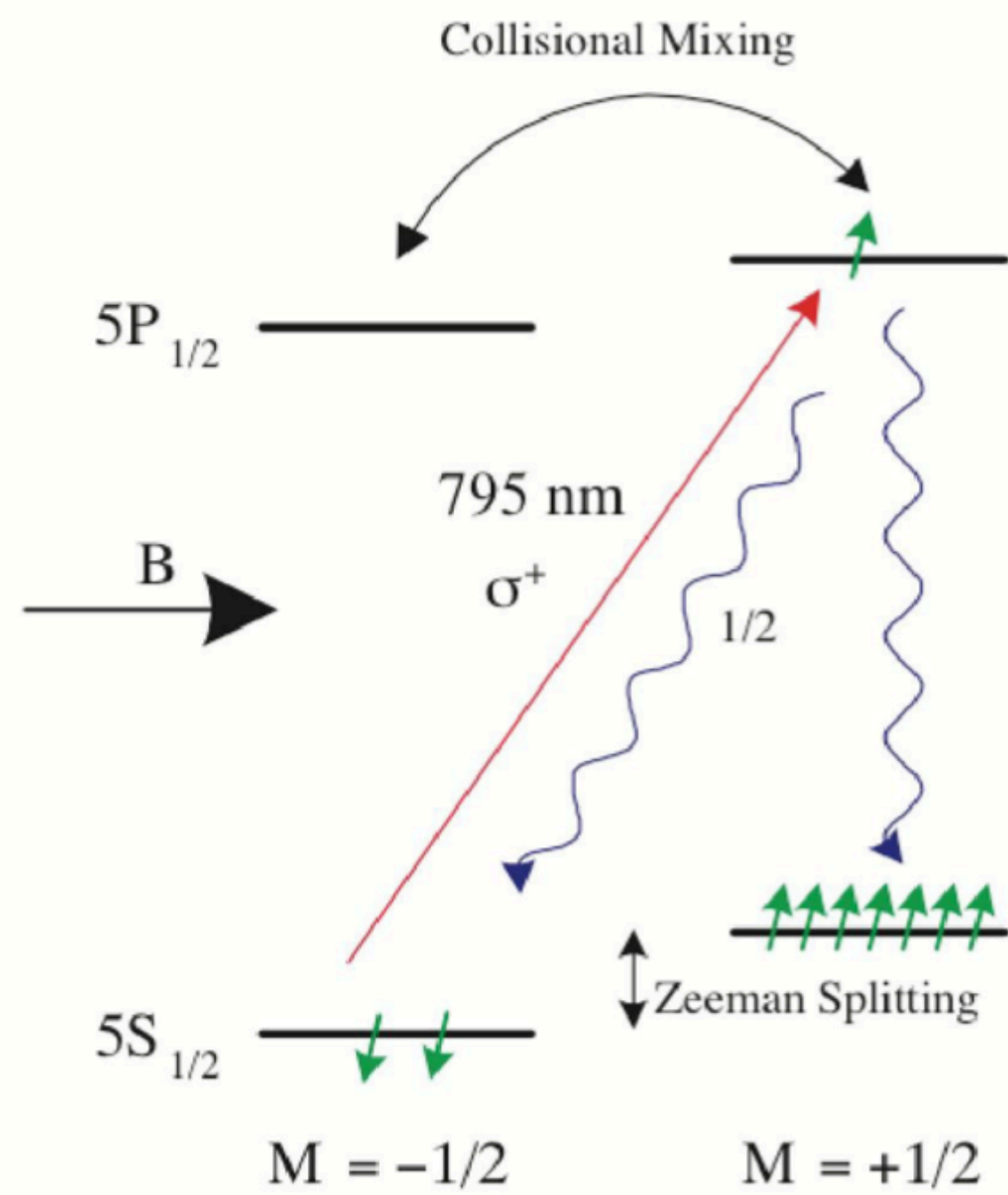


70+ INSTITUTIONS
A.I. Alkharjyan National Science Laboratory (Yerevan Physics Institute); Argonne National Laboratory; Bluffton University; Cairo University; California State University, Los Angeles*; Canon U.S.A.; Carnegie Mellon University; CEA Paris-Saclay; Christopher Newport University; Chubu University; Department of Homeland Security; Duke University; Duquesne University; Faculté des Sciences de Monastir; Florida International University*; Hampton University*; Harvard University; Idaho State University; Indiana University; Istituto Nazionale di Fisica Nucleare (INFN) – Sezione di Bari, Sezione di Catania, Sezione di Genova, Sezione di Roma; James Madison University; Jazan University; Jozef Stefan Institute; Kent State University; Kharkov Institute of Physics and Technology; King Saud University; Kyoto University; Laboratoire de Physique des 2 Infinis Irène Joliot-Curie (JCLab); Lawrence Berkeley National Laboratory; Lawrence Livermore National Laboratory; Longwood University; Los Alamos National Laboratory; Louisiana Tech University; Massachusetts Institute of Technology; Michigan State University; Mississippi State University; Norfolk State University*; Ohio University; Old Dominion University; Rutgers University; St. Mary's University (Canada); Seoul National University; Shandong University; Stony Brook; State University of New York; Syracuse University; Temple University; The Catholic University of America; The George Washington University; Tohoku University; Tsinghua University; Universidade de São Paulo; Università di Catania; Université Clermont Auvergne; Université Paris-Saclay; University of California, Riverside*; University of Connecticut; University of Eswatini; University of Glasgow; University of Illinois Chicago; University of Ljubljana; University of Manitoba; University of Massachusetts, Amherst; University of New Hampshire; University of Regina; University of South Carolina; University of Tennessee, Knoxville; University of Tokyo; University of Virginia; University of Zagreb; Virginia Military Institute; Virginia Tech; William & Mary

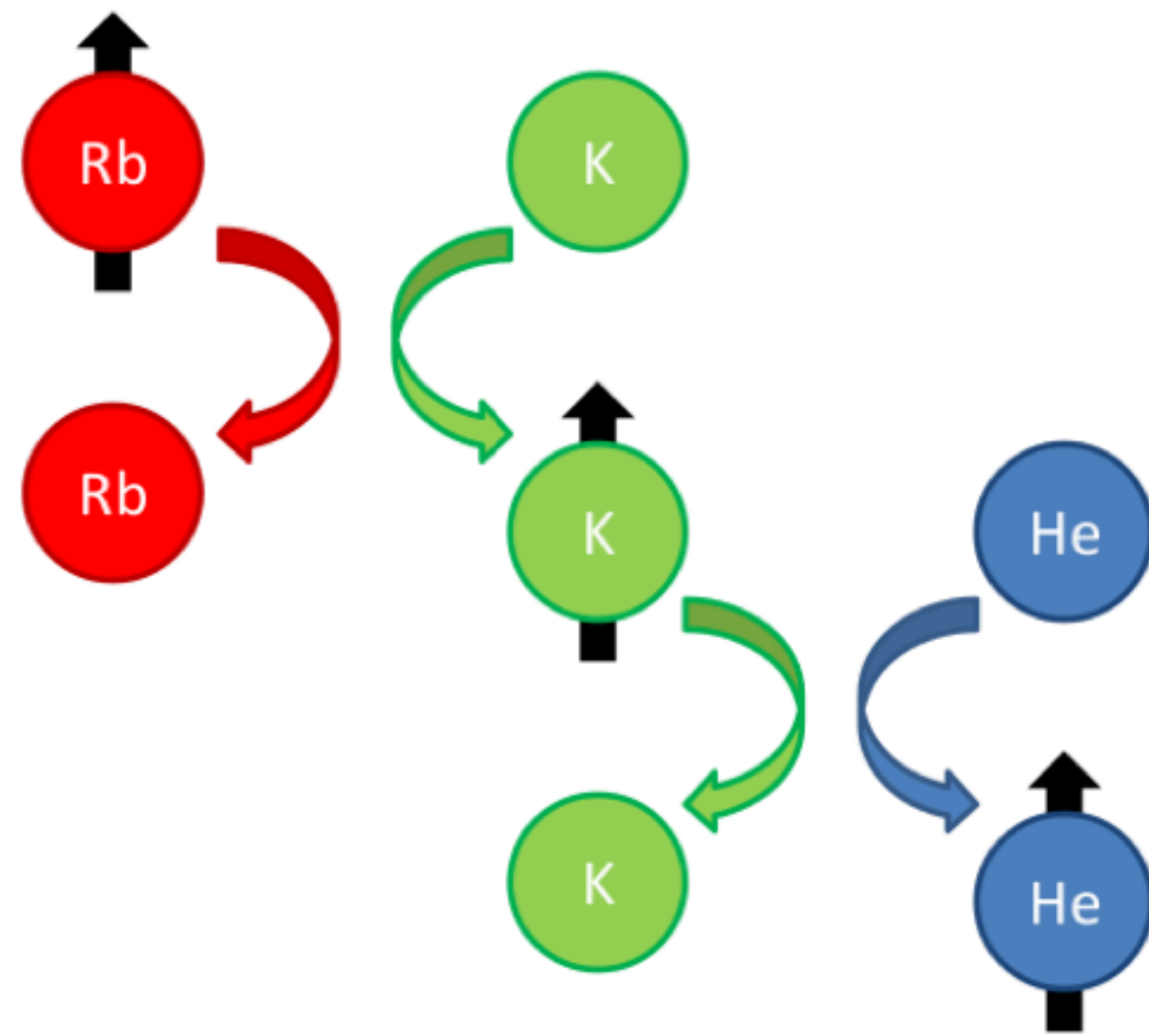
* U.S. Historically Black Colleges and Universities
* U.S. Hispanic-Serving Institutions

SEOP in a Nutshell

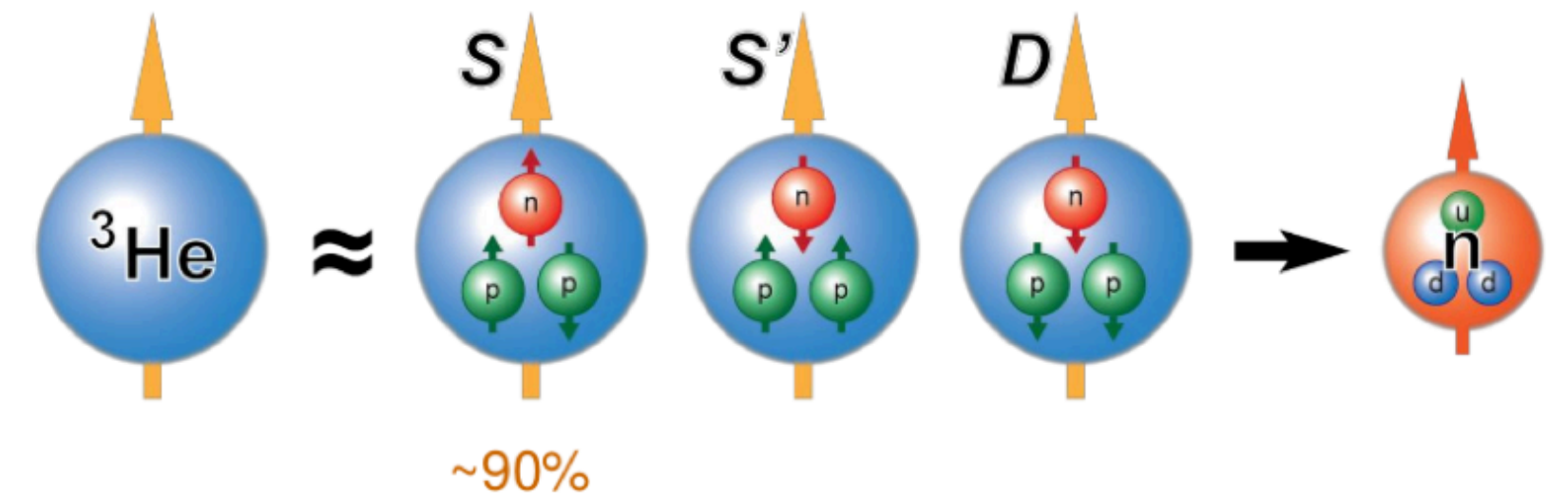
Optical pumping of Rb vapor at 794.7 nm circularly polarized light



Spin exchange optical pumping



Collisional mixing

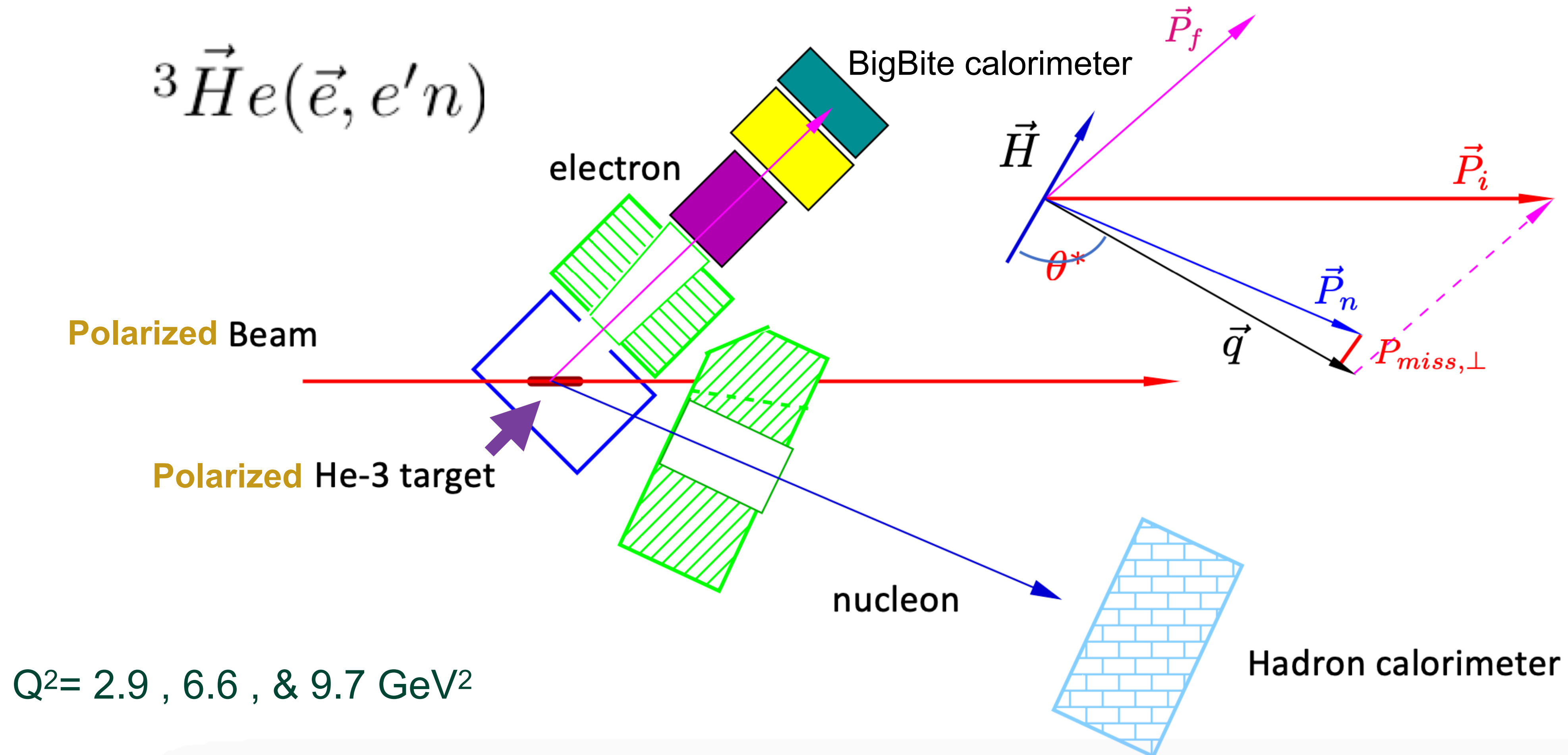


Effective neutron target

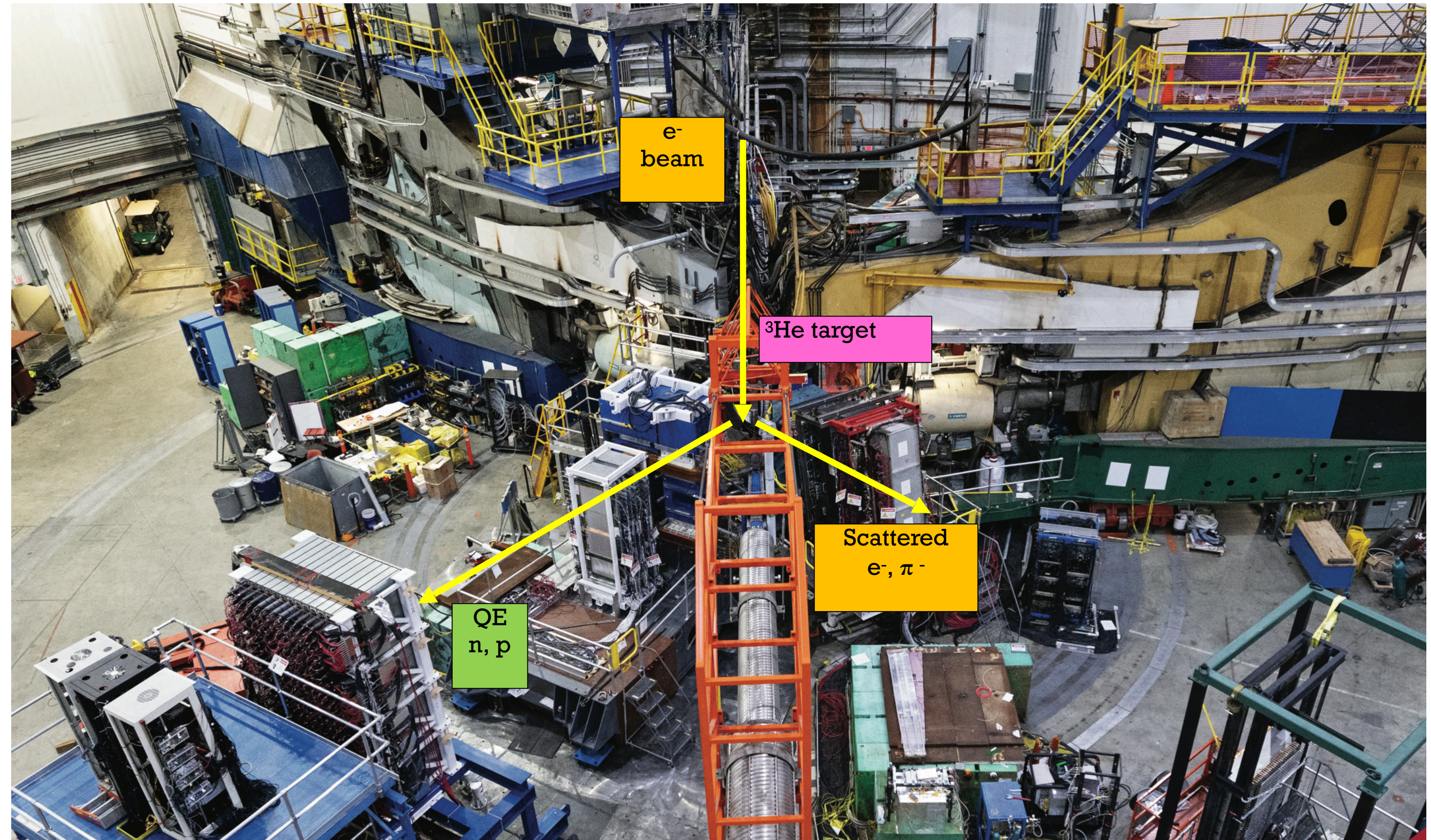
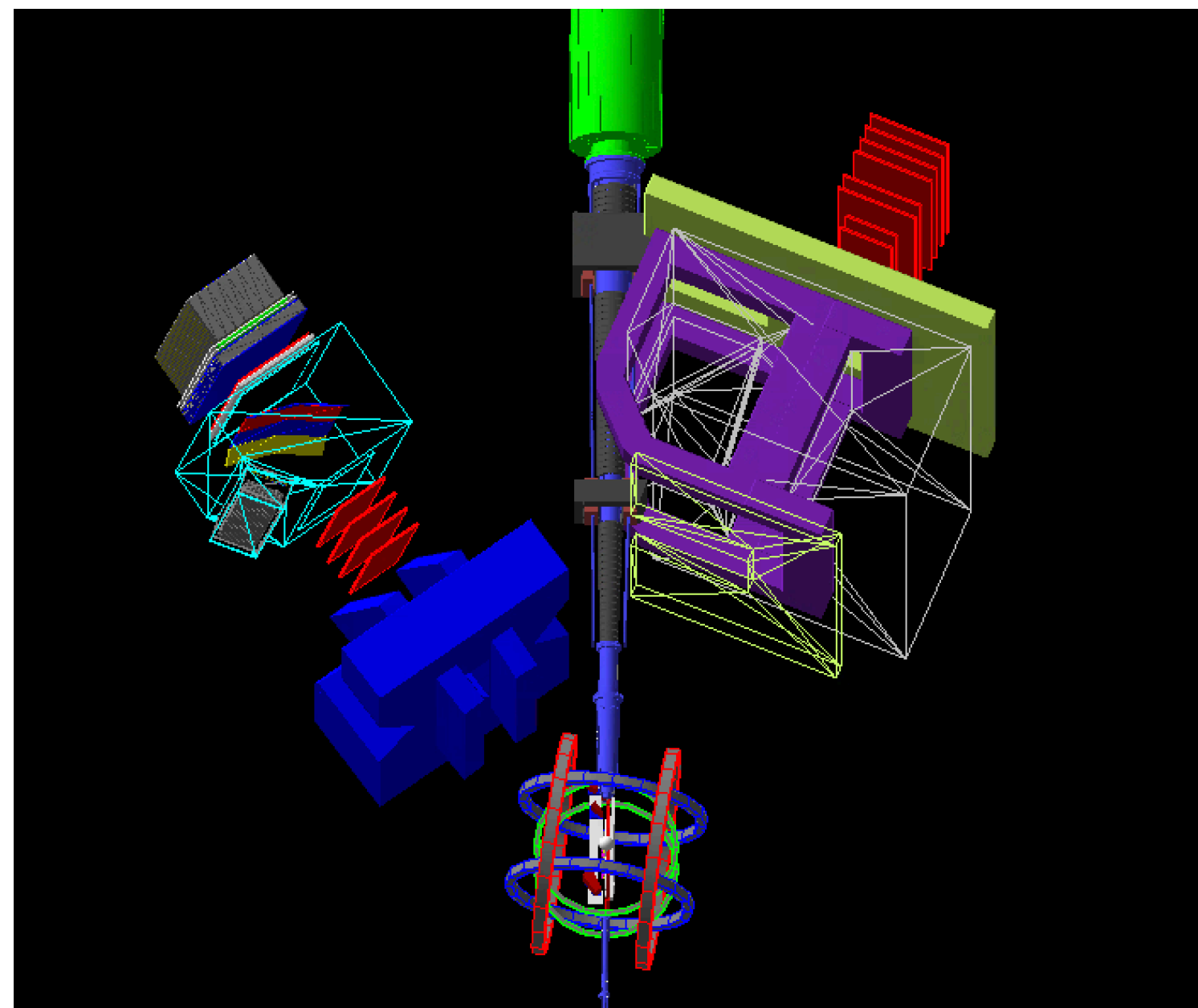
A Look at GEn-II

Double Polarization Method

$${}^3\vec{H}e(\vec{e}, e'n)$$



GEn-II On The Floor



Complicated

Laser Enclosure

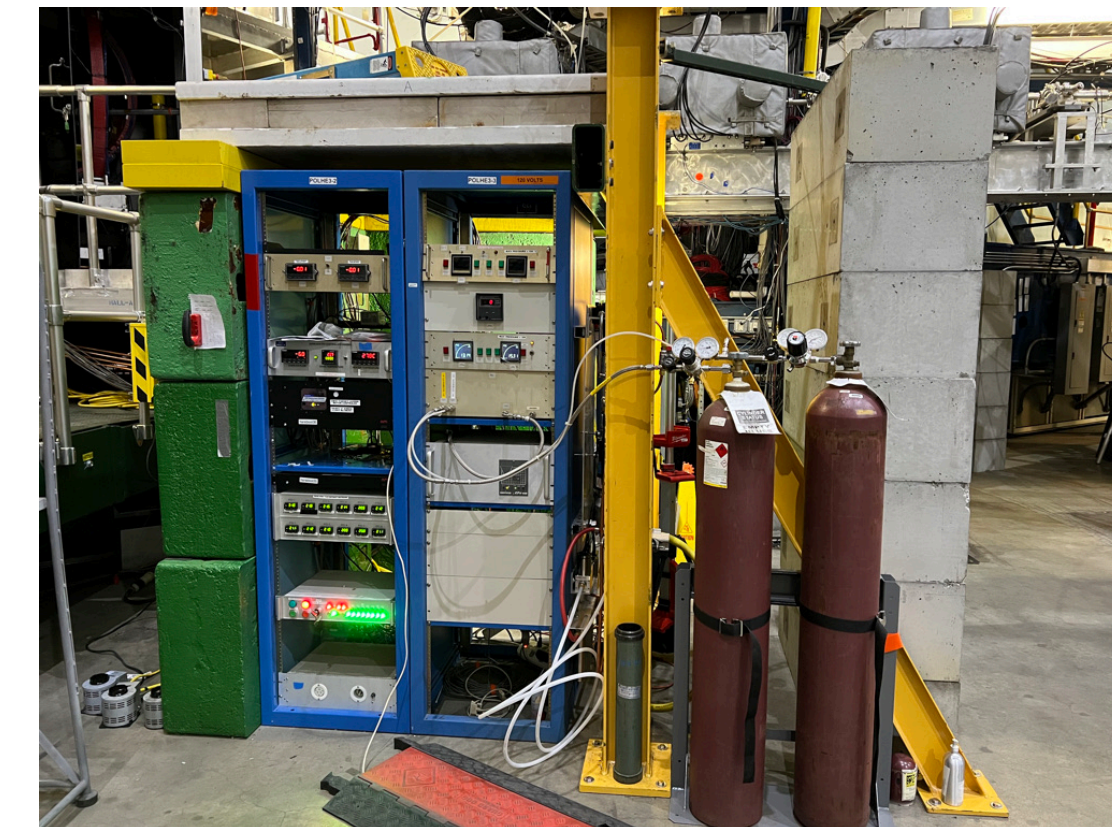


Laser Room

Target enclosure



HH coils electronics



Ref Cell and Oven Controls

Counting house electronics



Target Area

- Laser fibers enter (grey box)
- Upper Periscope Mirrors & Heating system (cyan)
- Helmholtz Coils, Oven, & Targets (rust)
- Beam enters W-SW to E-NE

Enclosure



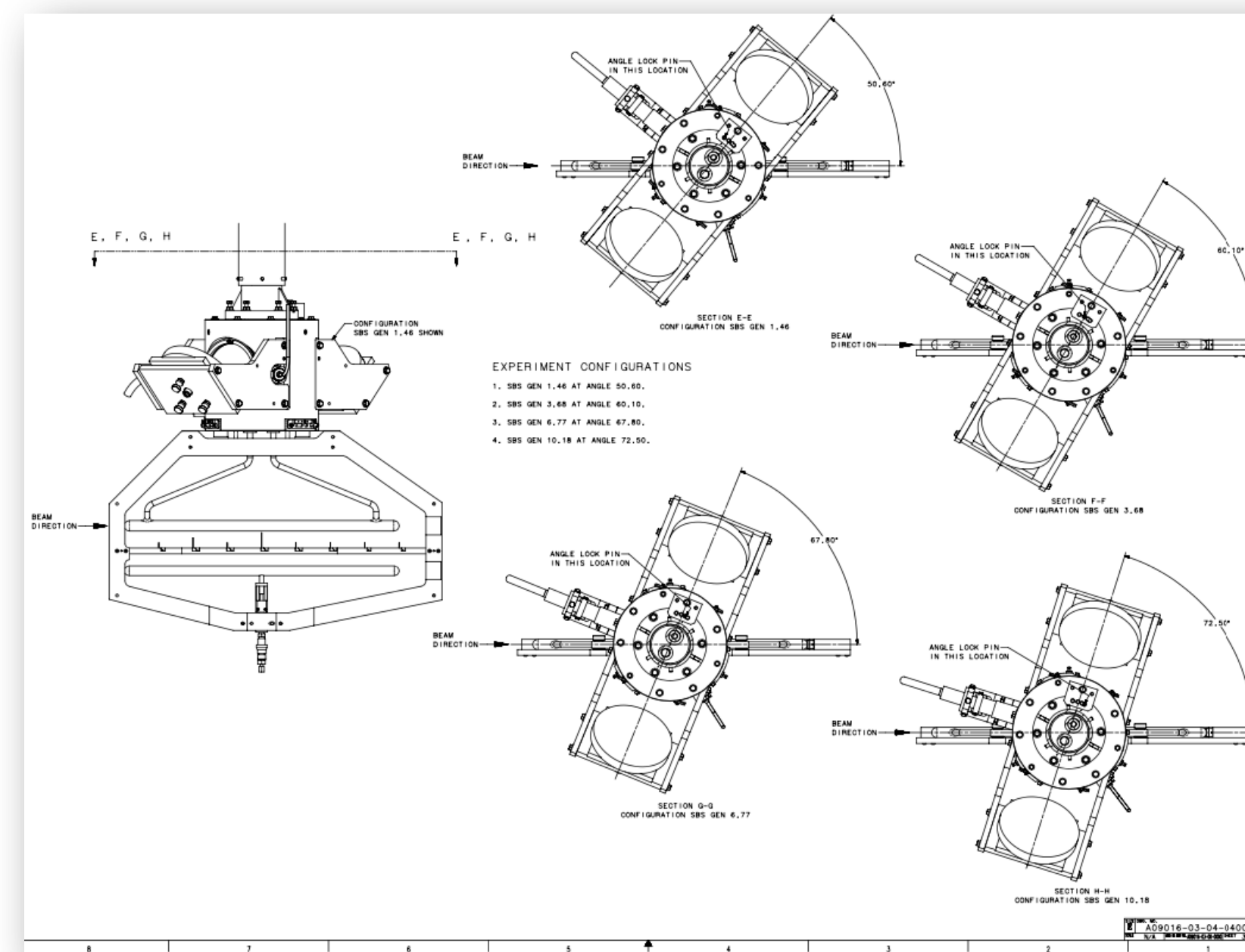
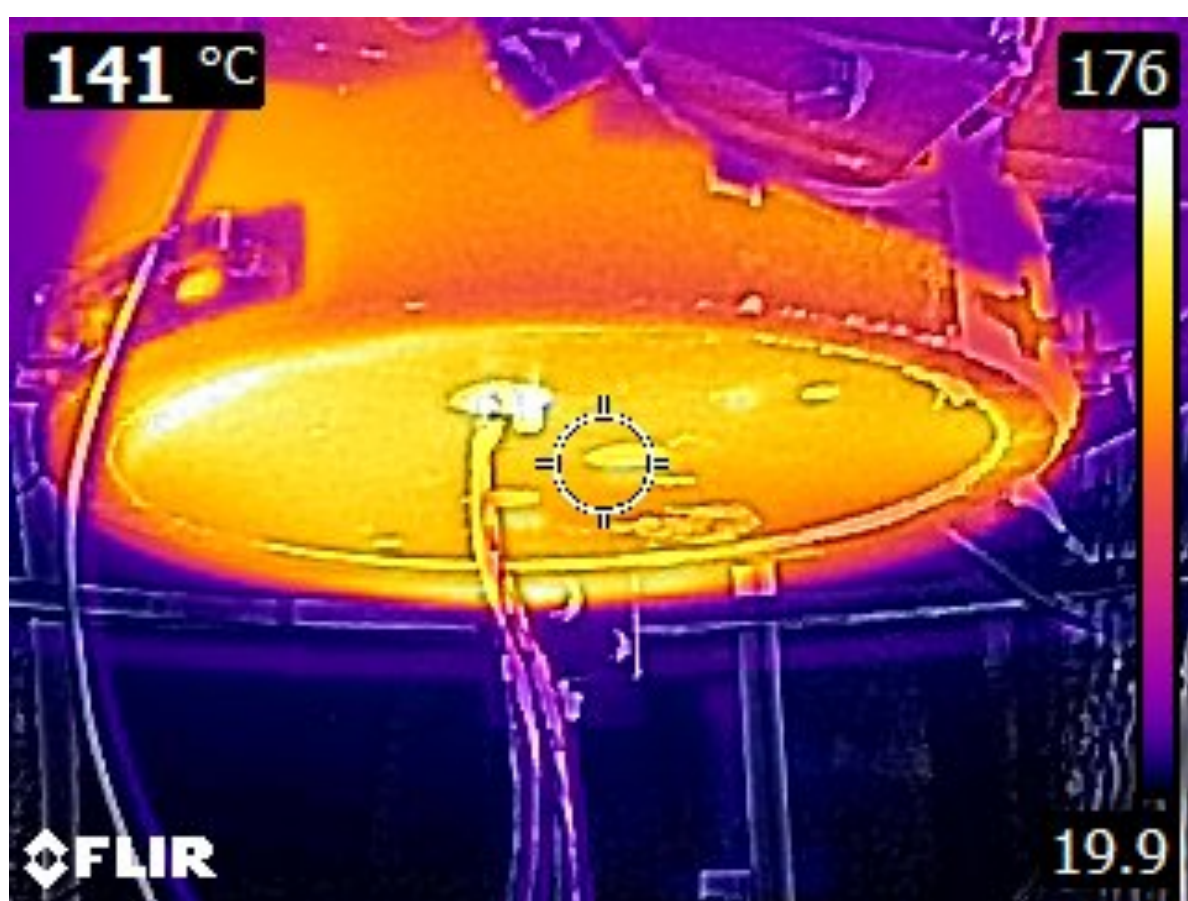
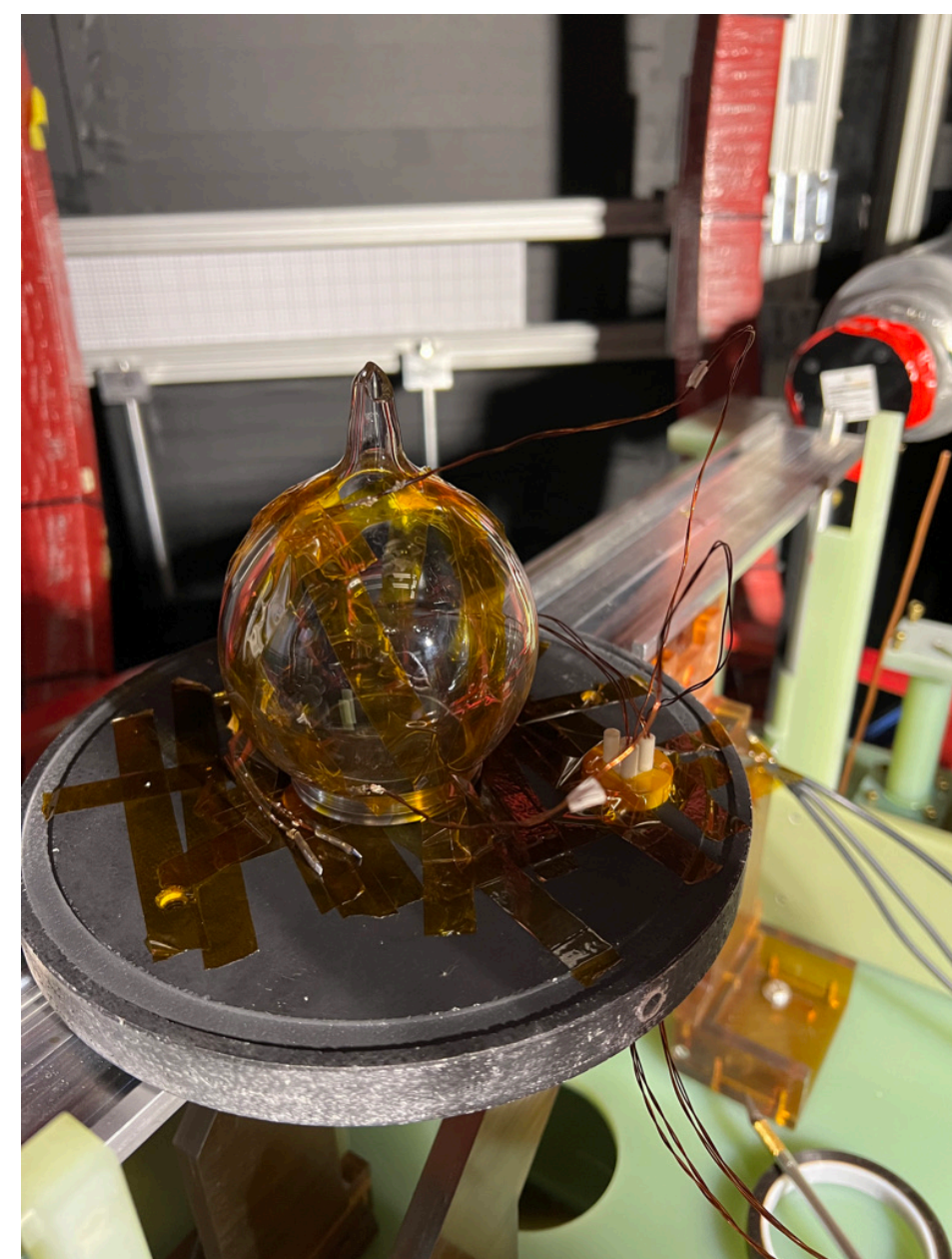
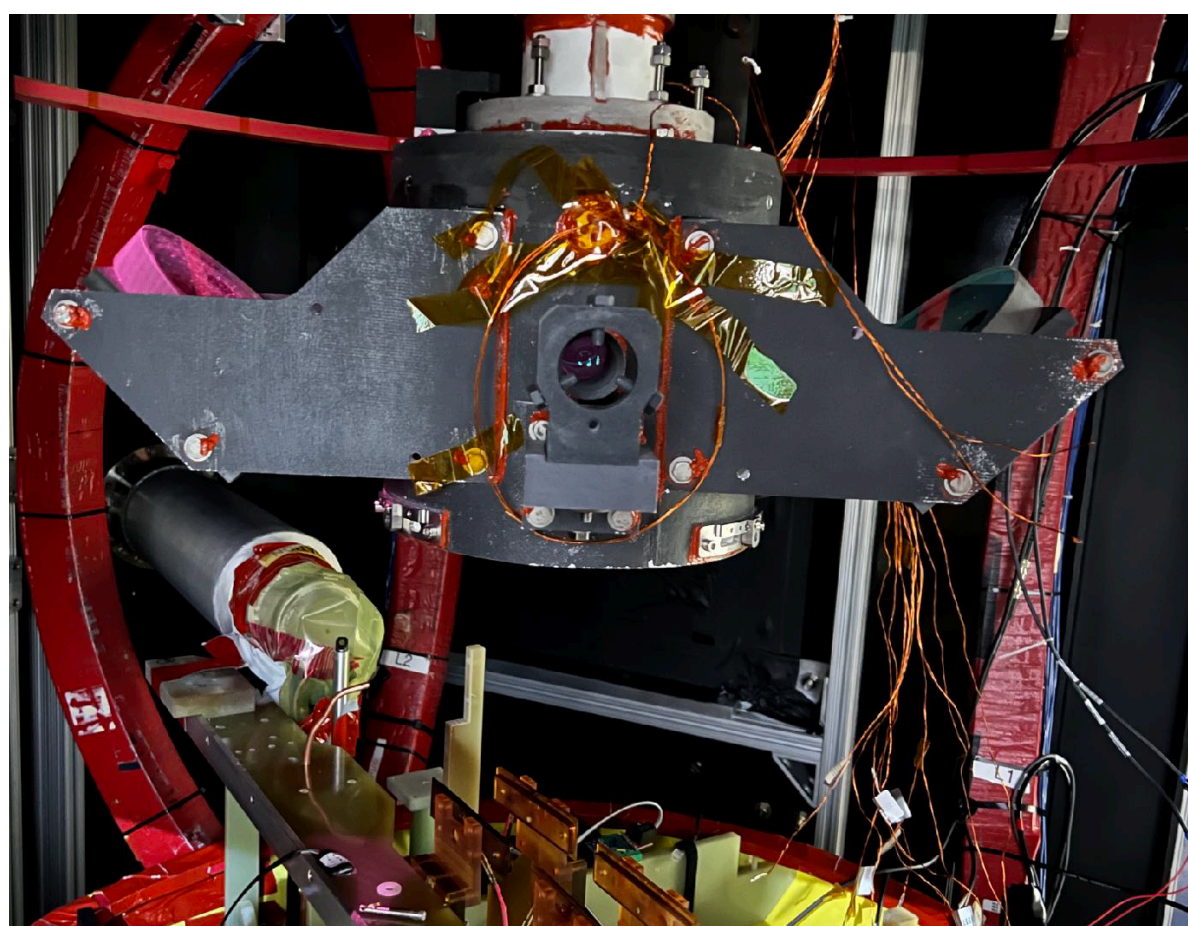
Enclosure

- Helmholtz Coils
 - 25G Net Holding Field
 - RF Field
- Target Ladder
 - Heater Column
 - Oven
 - ^3He Target
 - Carbon Foils
 - Reference Cell
- Cooling Jets / Lines
- Beam Pipe
- Tungsten Collimators



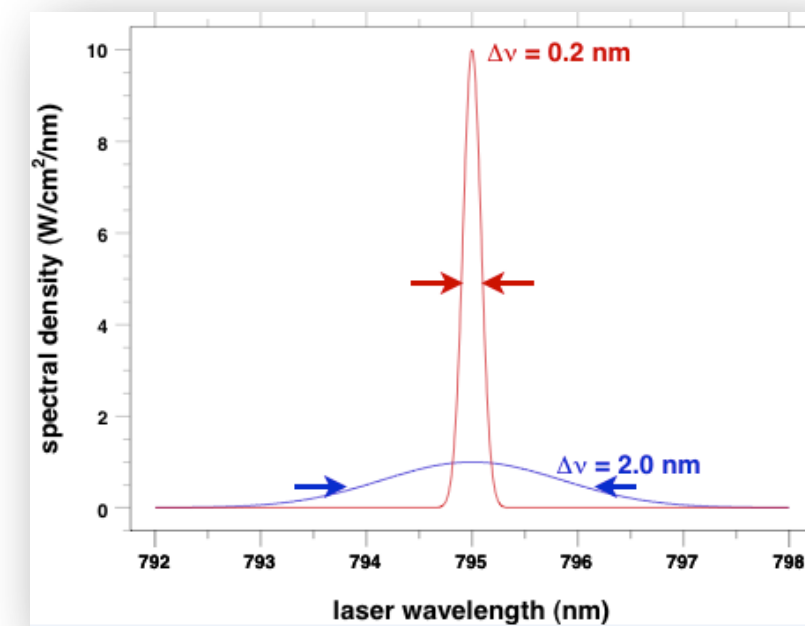
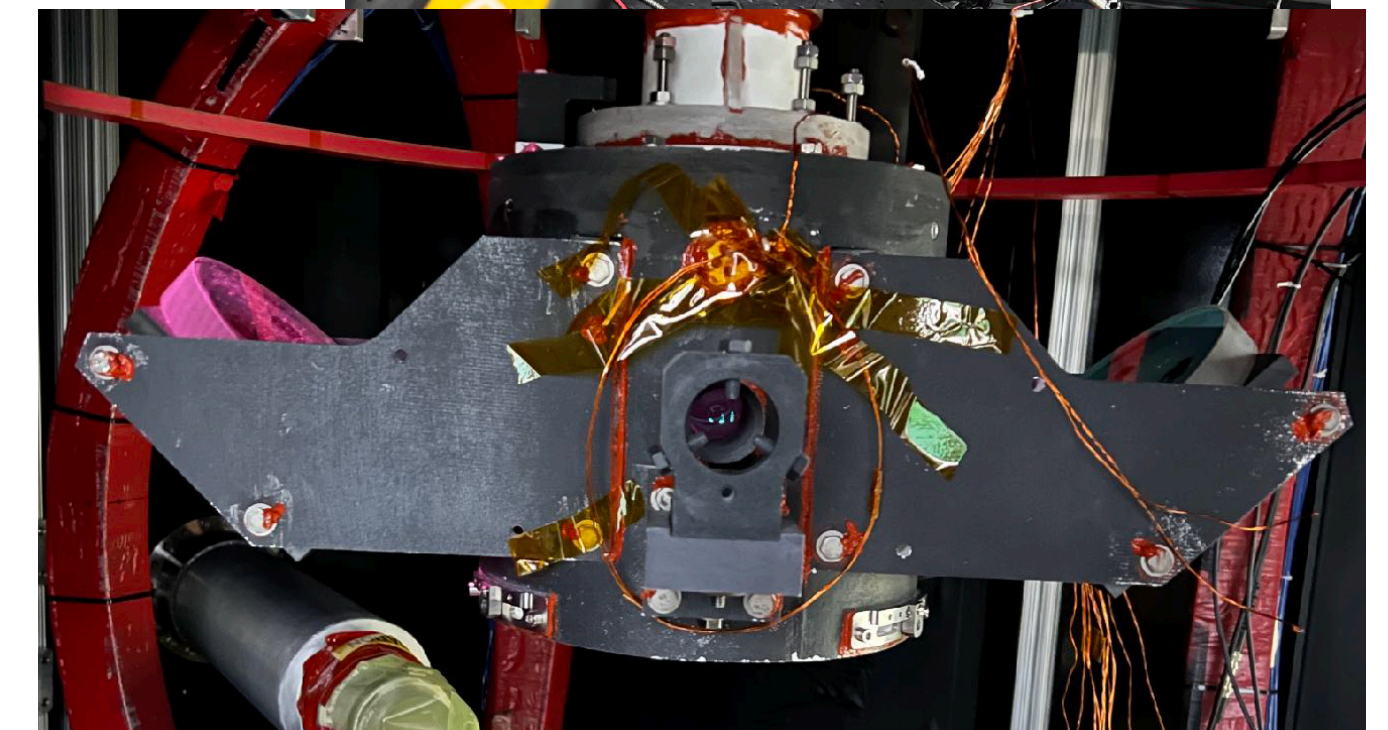
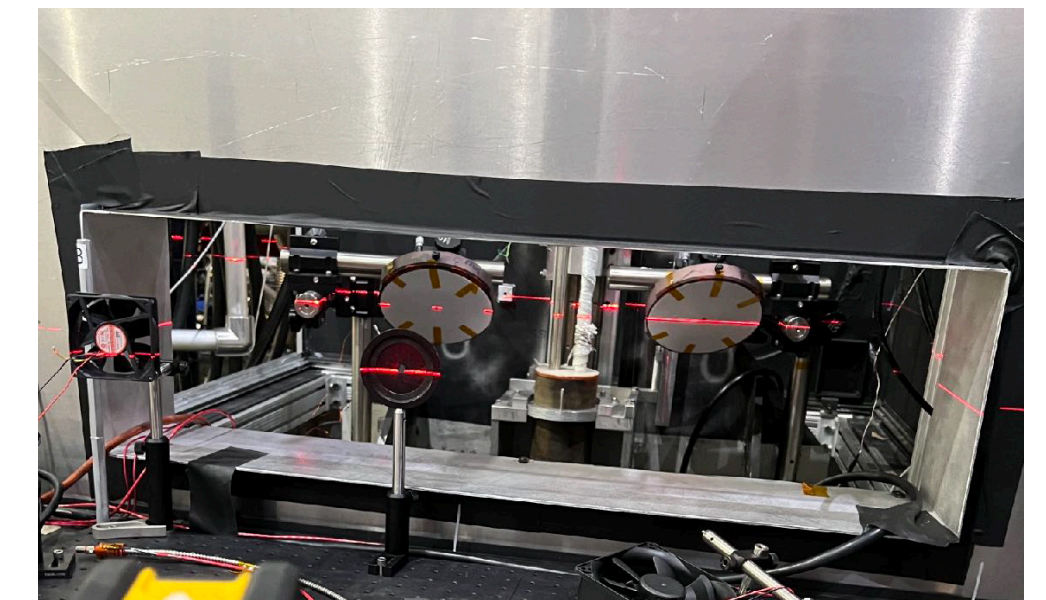
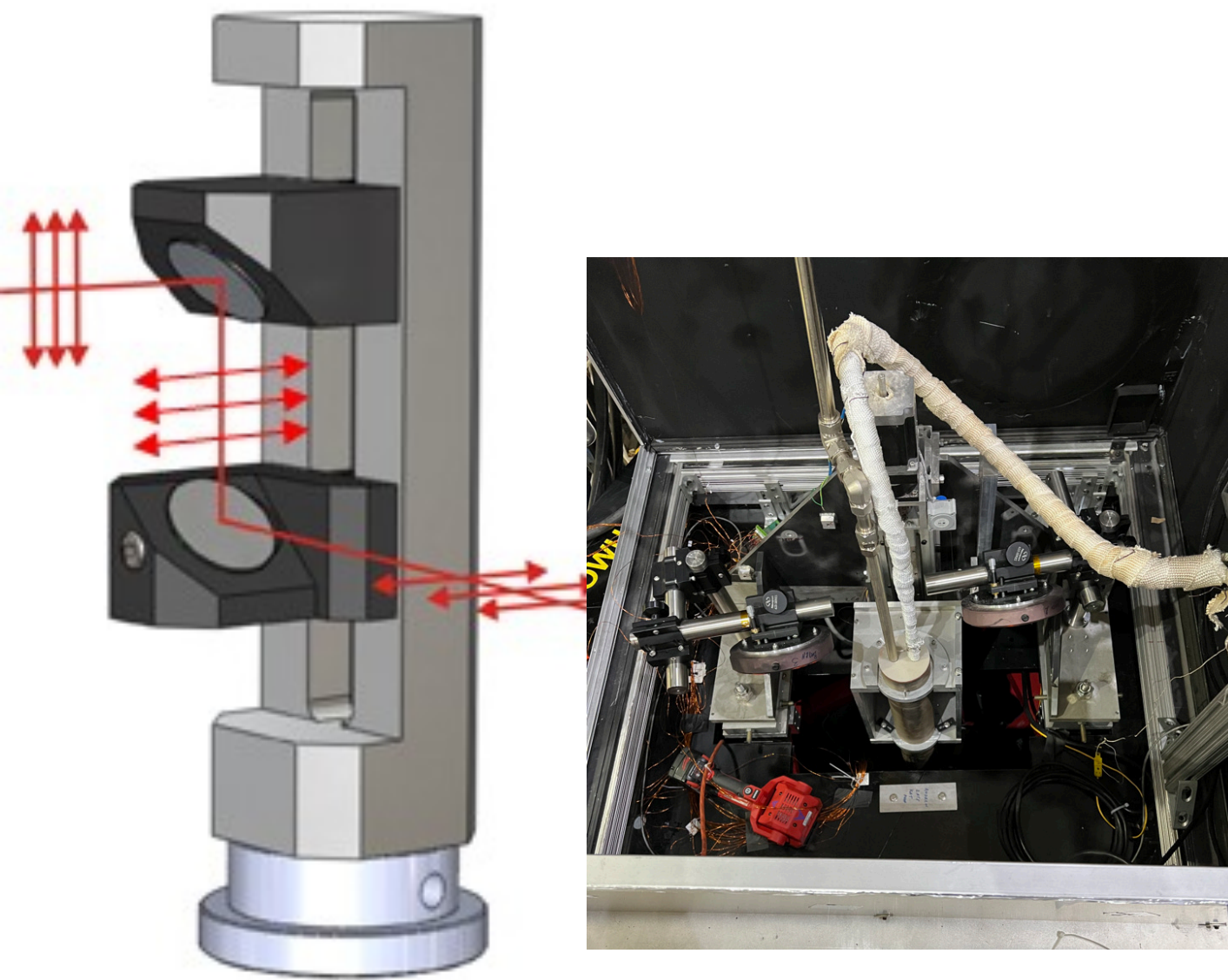
Oven Configurations for the GEn-II Kinematics

- Target oven rotated for each kinematic setting
- 3/8" spacer included to accommodate cell pull offs inside the oven
- Oven checked for alignment after rotation at each setting and the position was repeatable within noise of the survey and alignment device



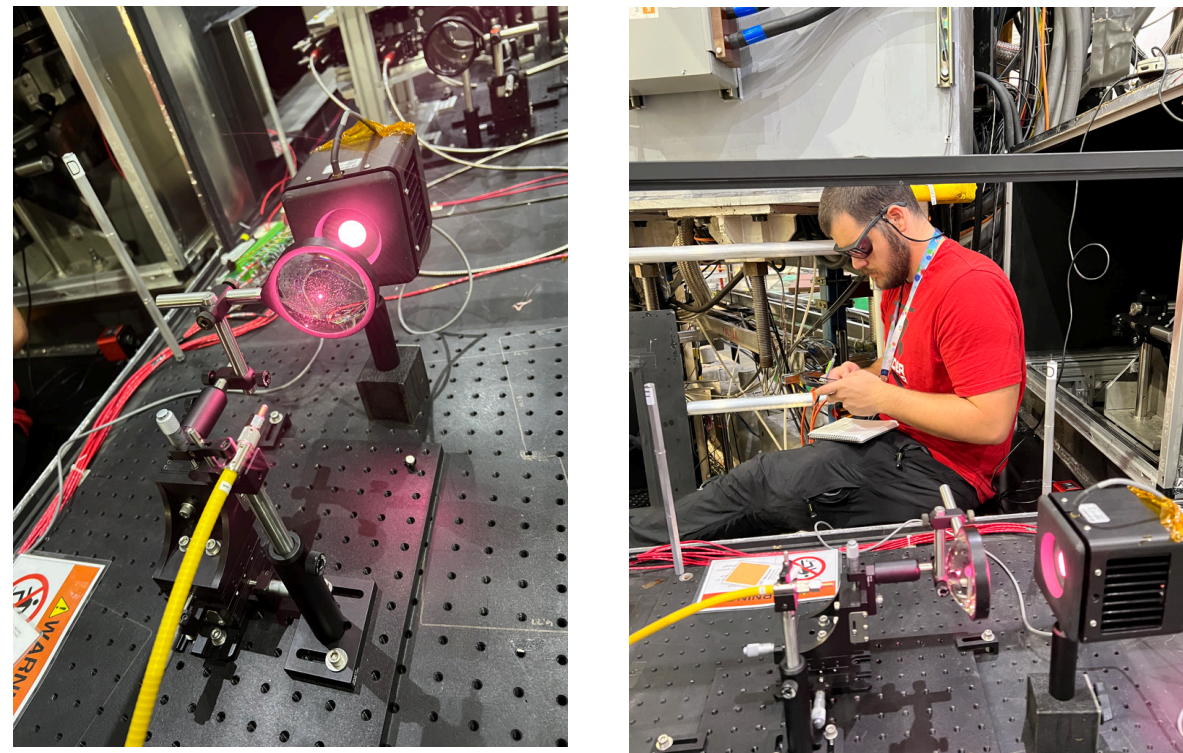
Laser System

- Needed Circular Polarization >99.5%
- Linewidth Requirement < 0.2nm
- Setup required LHP down one & RHP down opposite periscope
- Allowed for up to 100W per side
 - Limits heating & improves photon absorption through cell

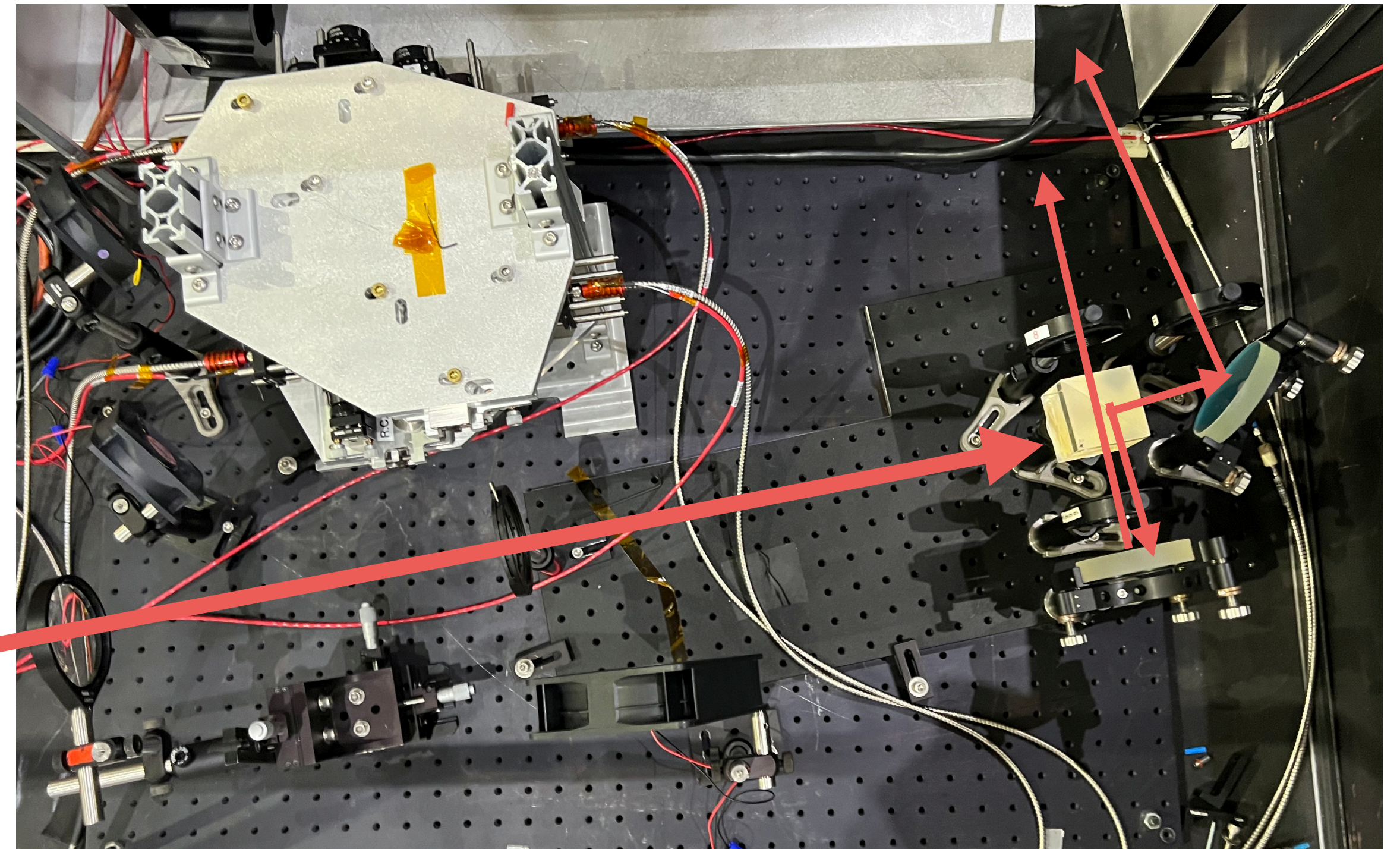
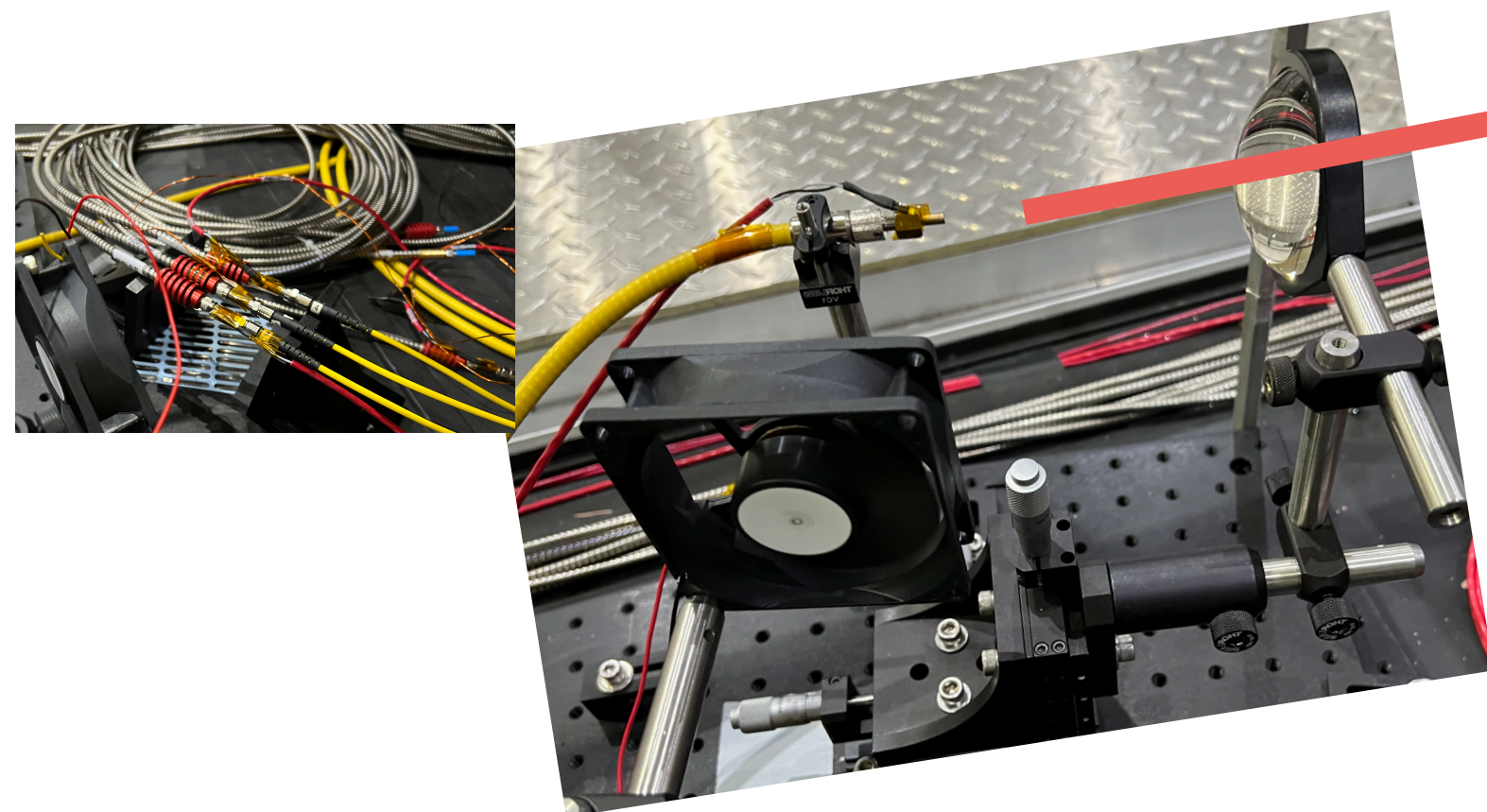
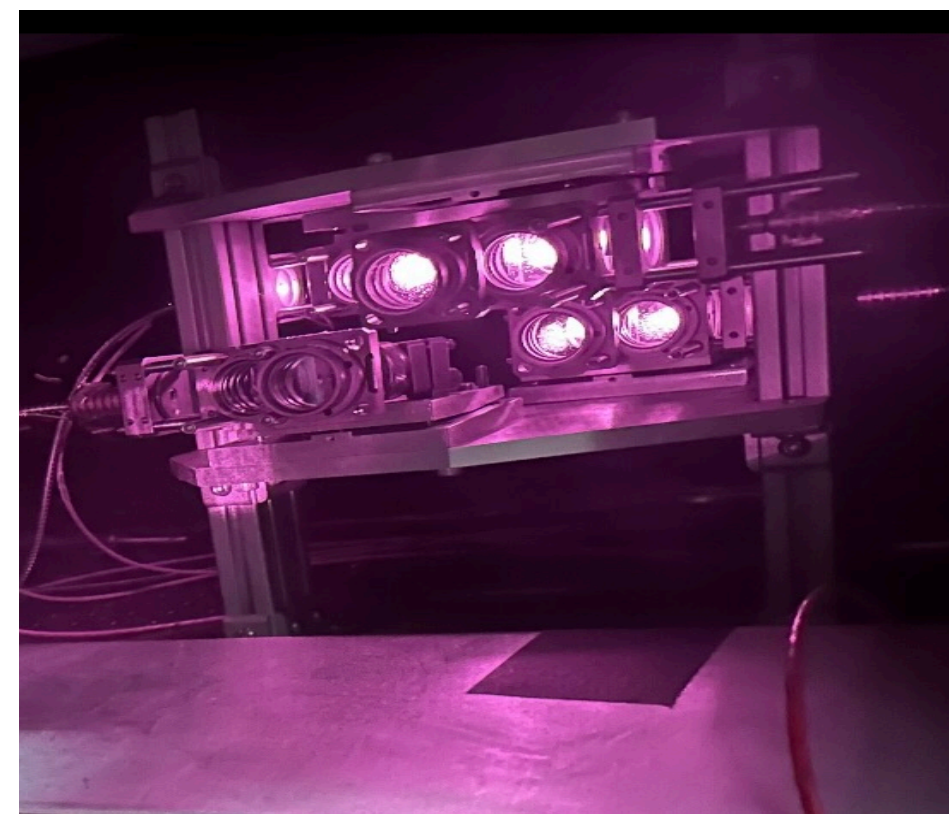


SEOP Laser Optics

Laser Power Tests

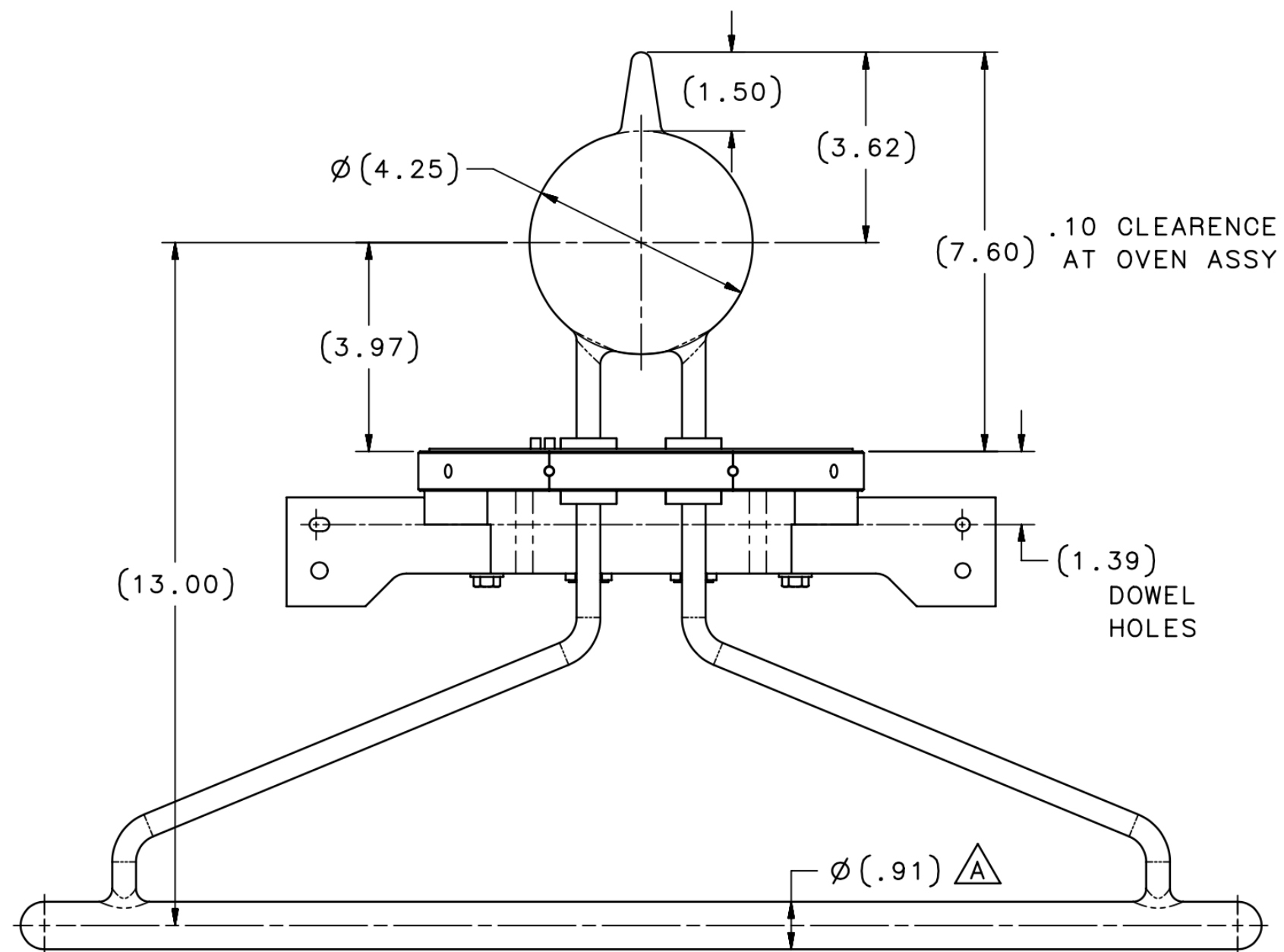


“UVA” Optics



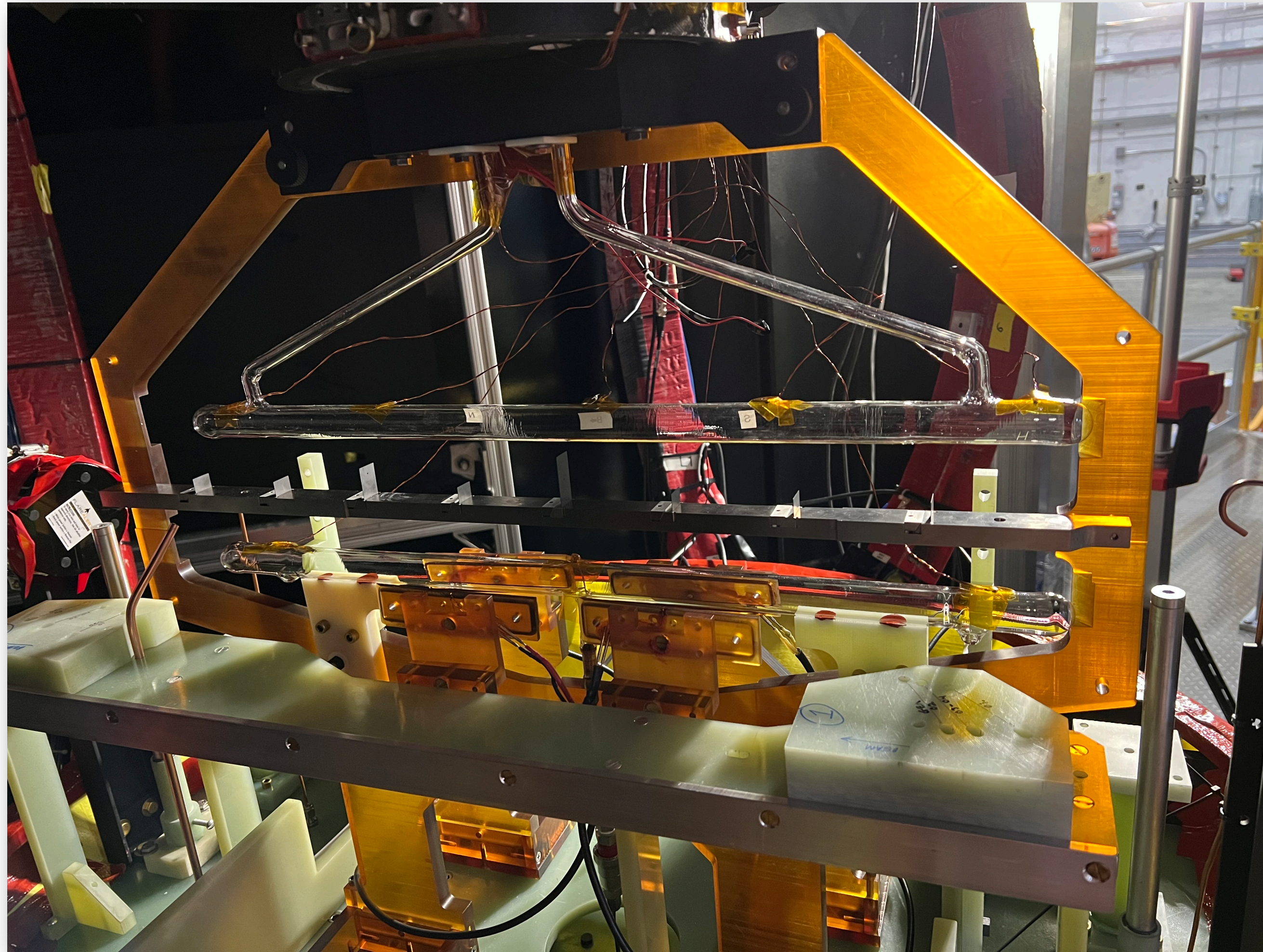
Laser Path Through “JLab” Optics

Preparing the Target Cell

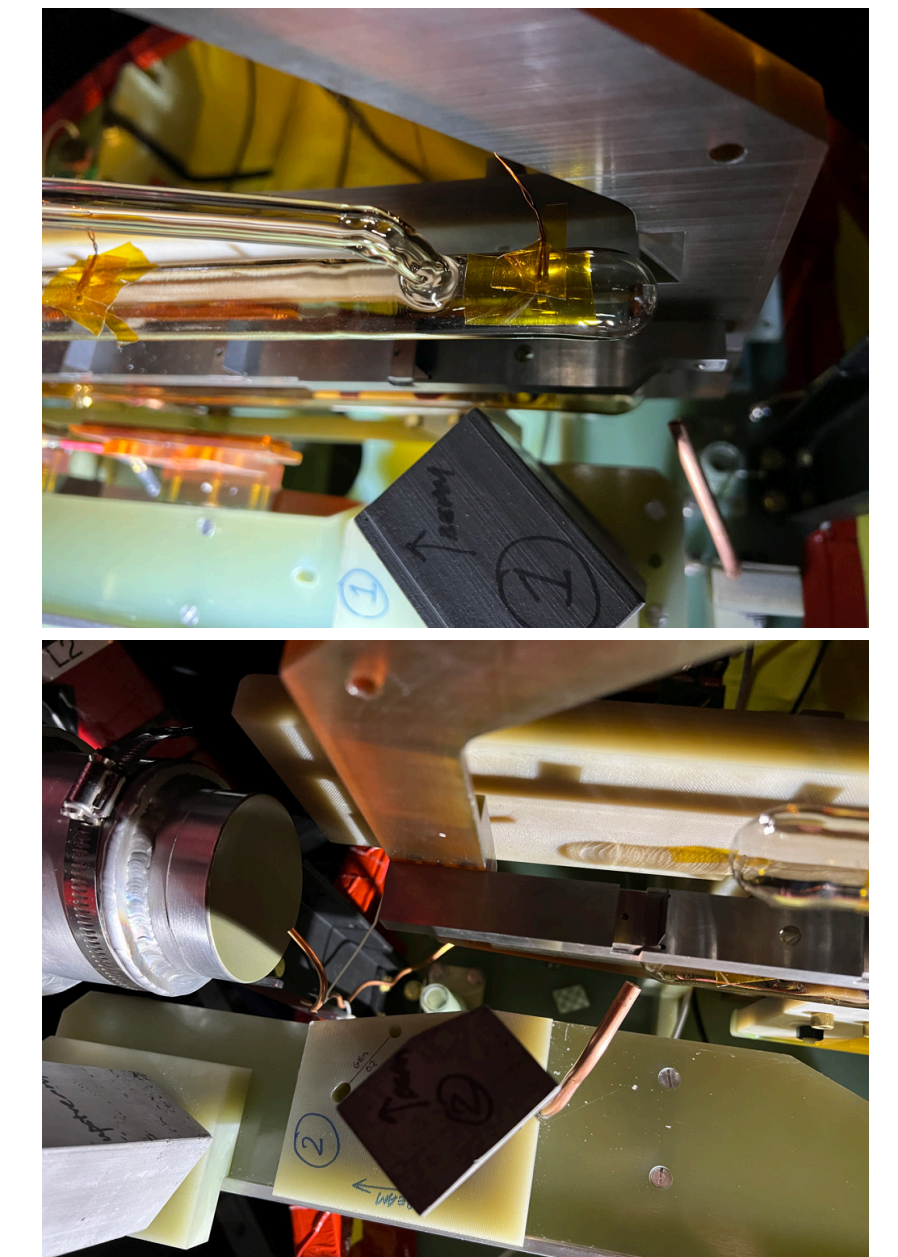
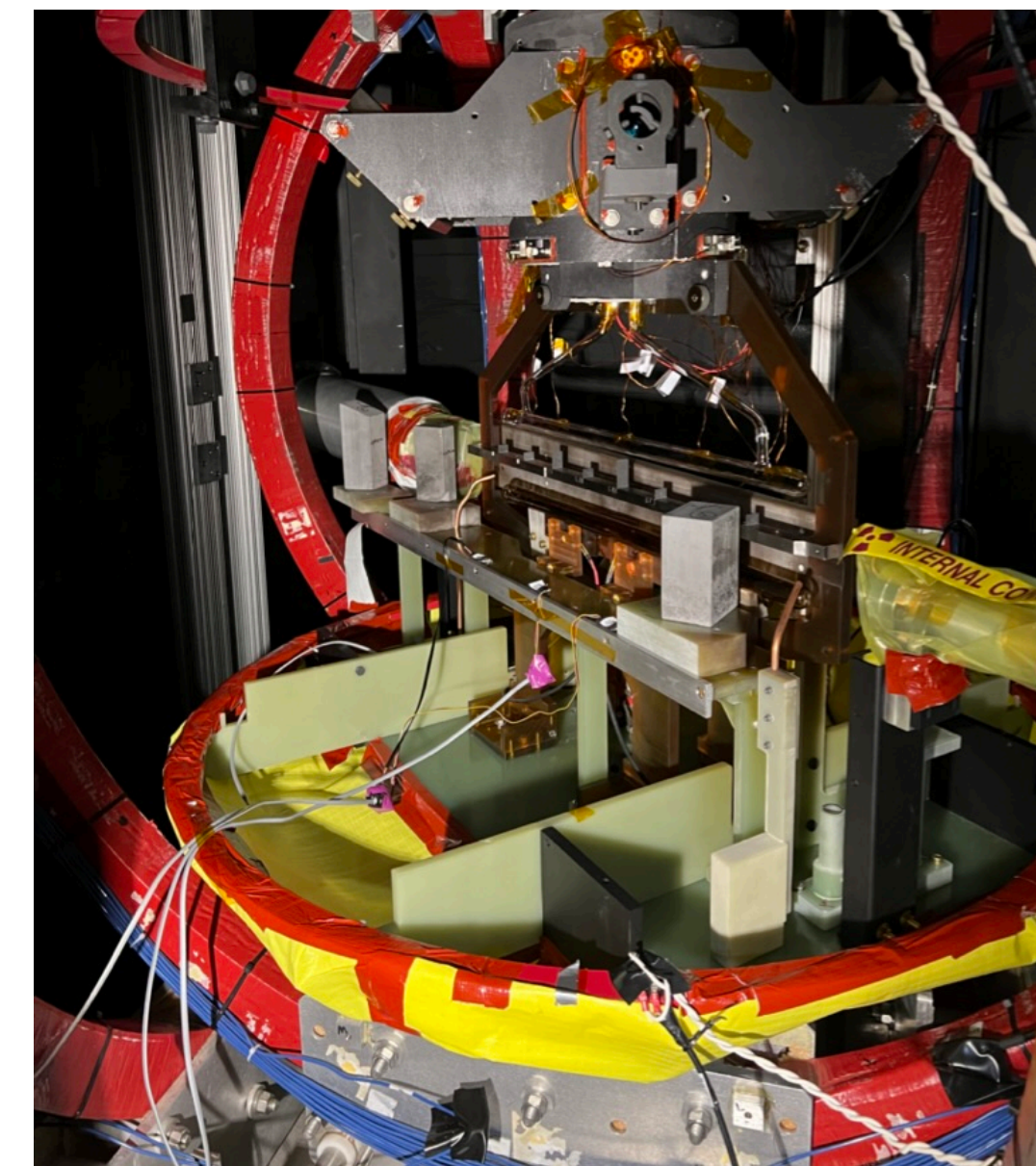


- Cell mounting jig in EEL building used to mount bottom plate onto each cell
- TC chamber aligned carefully in V-shape slots of the mounting jig for alignment with beam axis in the hall

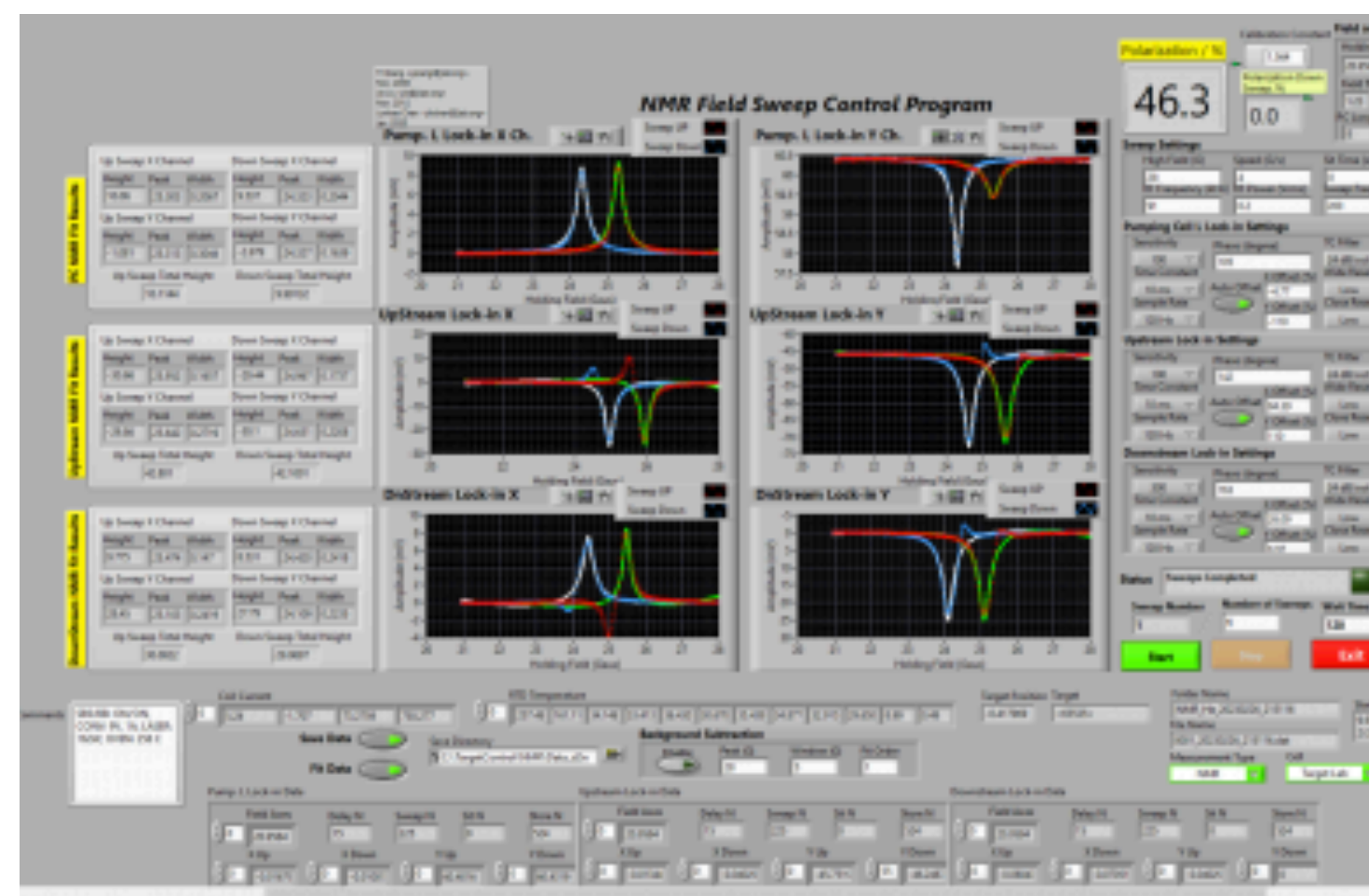
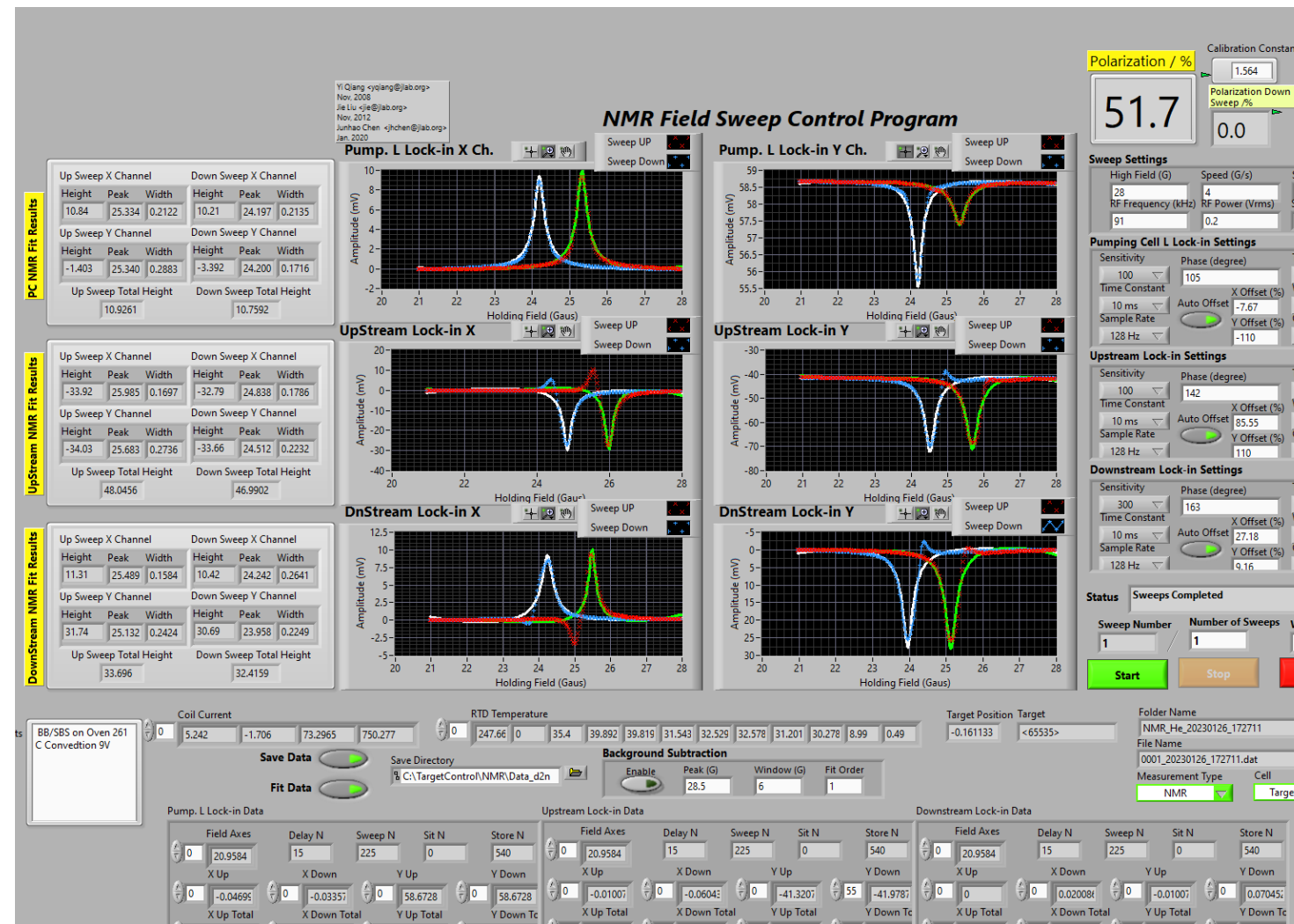
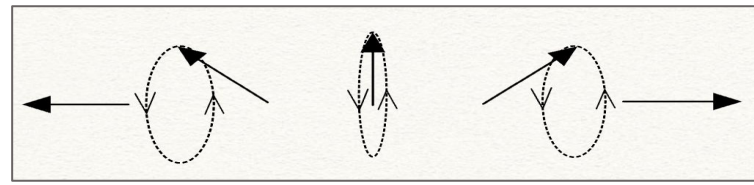
All Targets Installed



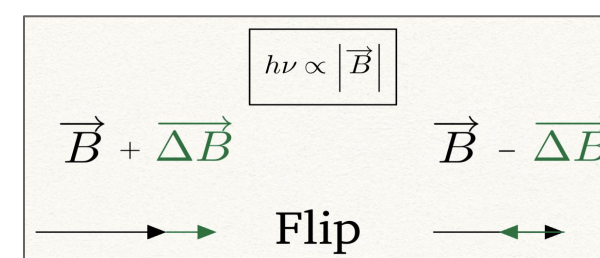
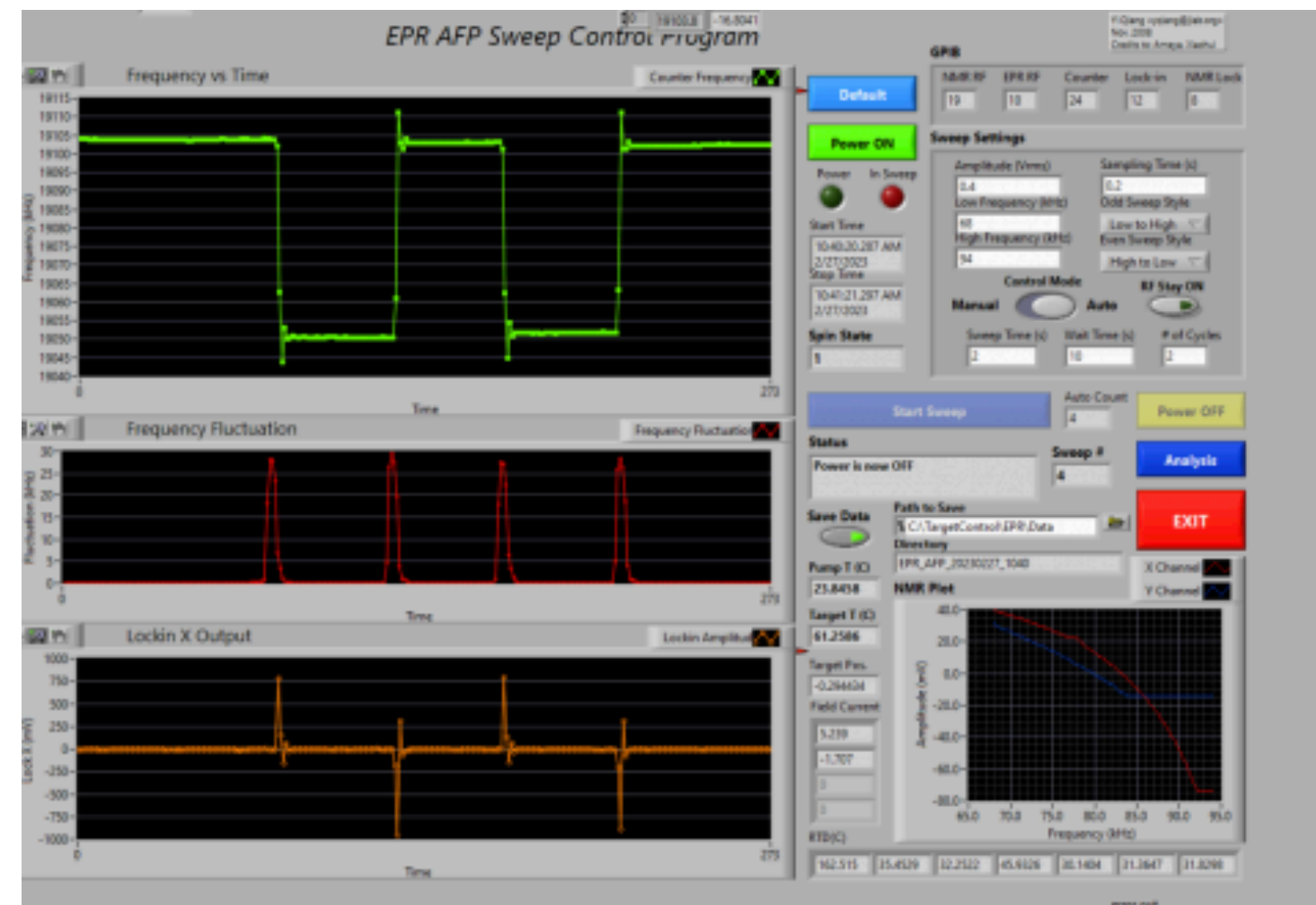
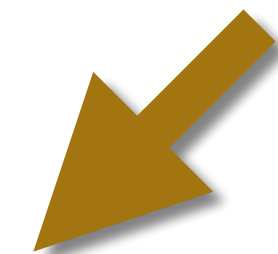
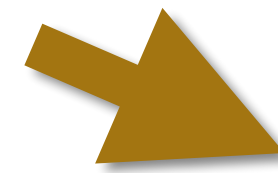
- SEOP ^3He Target
 - Heater tape for convection
- Carbon Foils
- Reference Cell
- Target Chamber NMR Coils



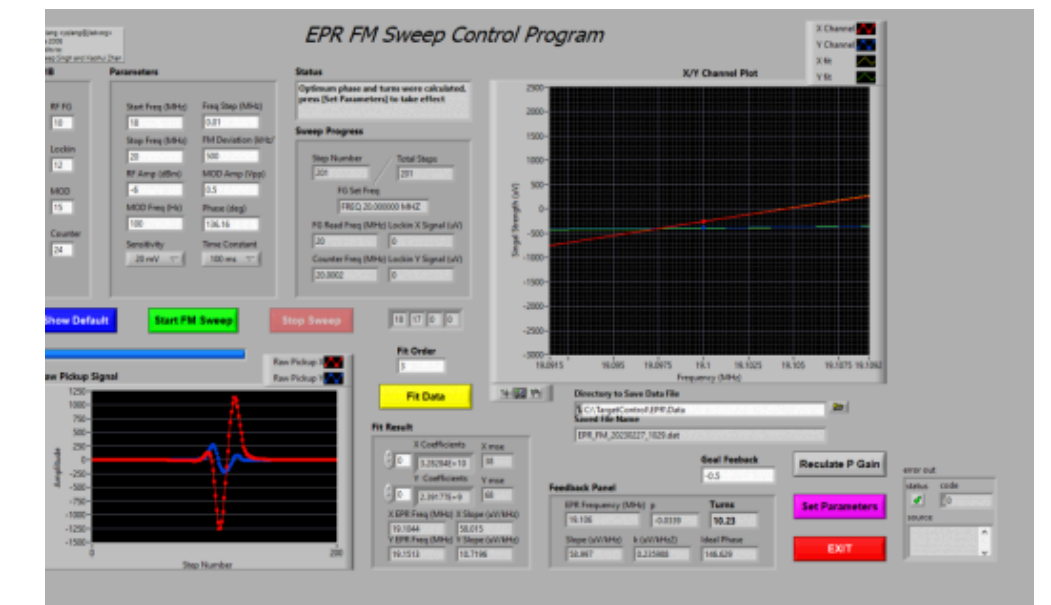
Polarimetry



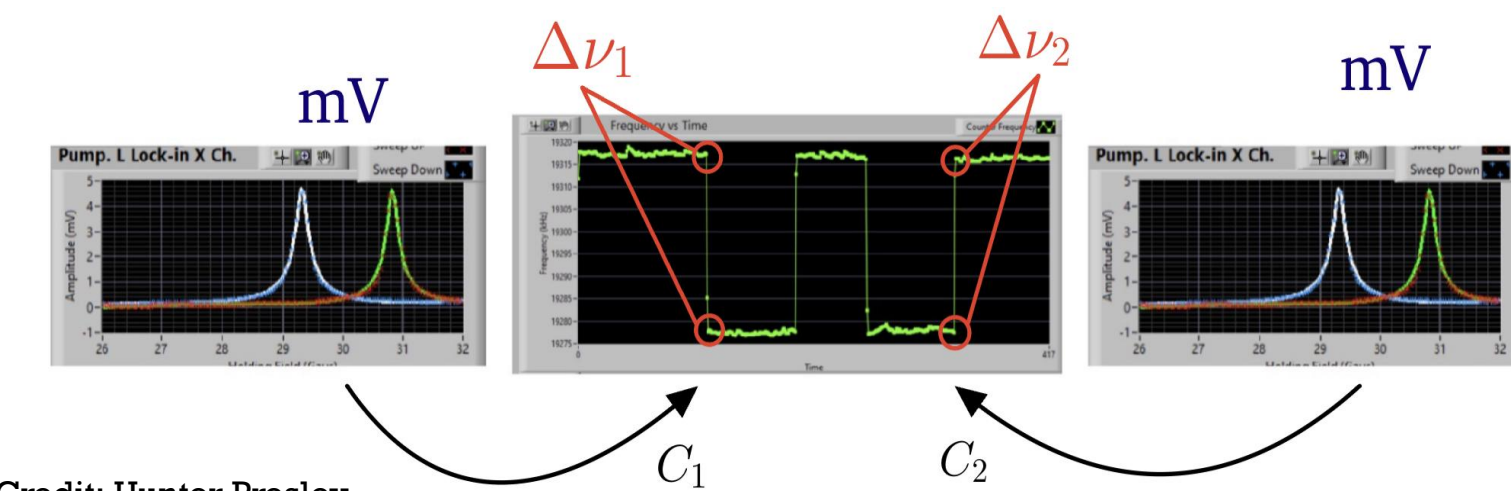
- Completed during production running of each cell opportunistically (~3 Hours)
- Gives a generally accurate % / mV value to apply to NMR data in real time



Calibrations



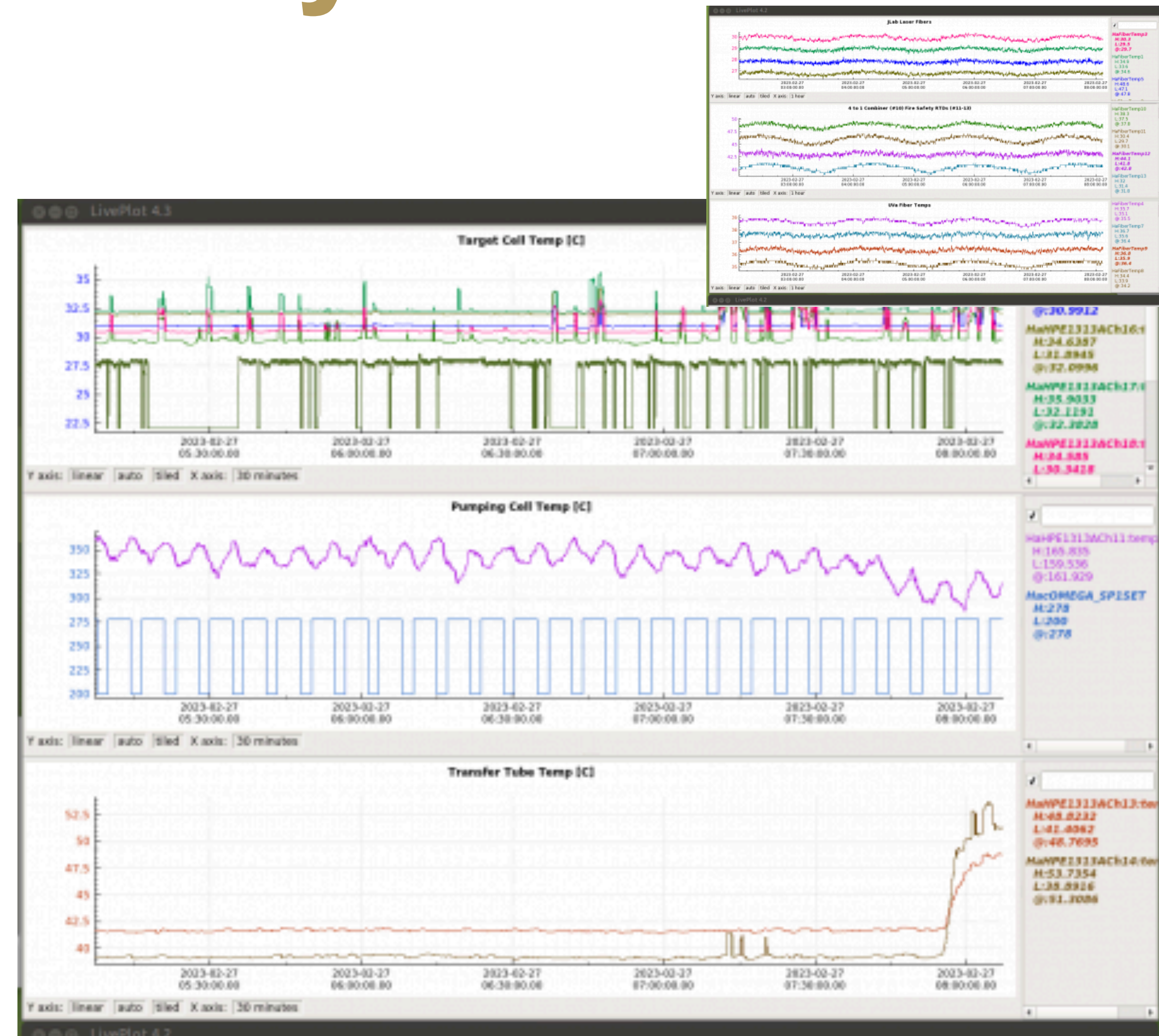
1. Set Convection to 25V
2. Wait 30 minutes for mixing
3. Find EPR frequency through FM sweep
4. NMR -> EPR -> NMR
5. Reset Convection to 9V



Credit: Hunter Presley

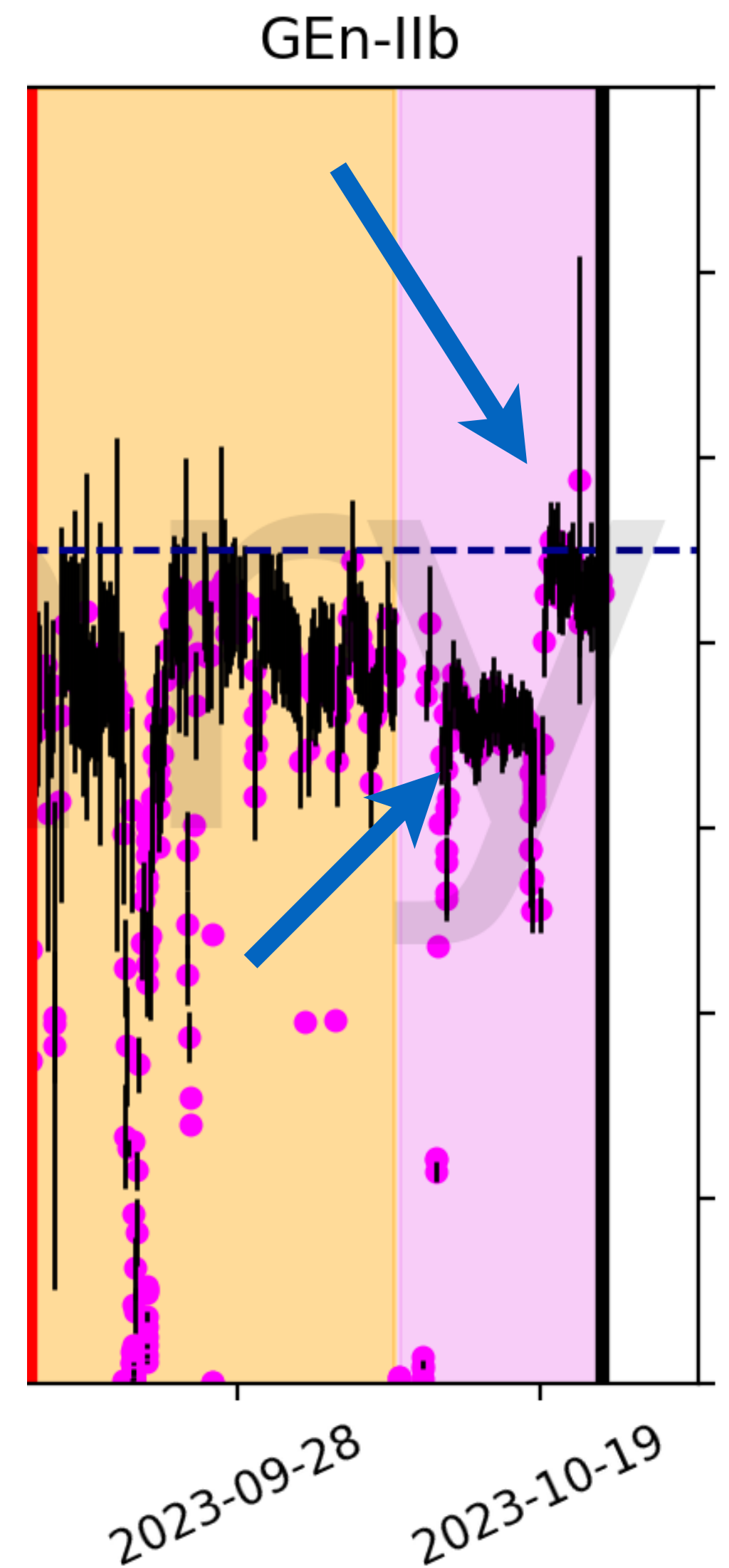
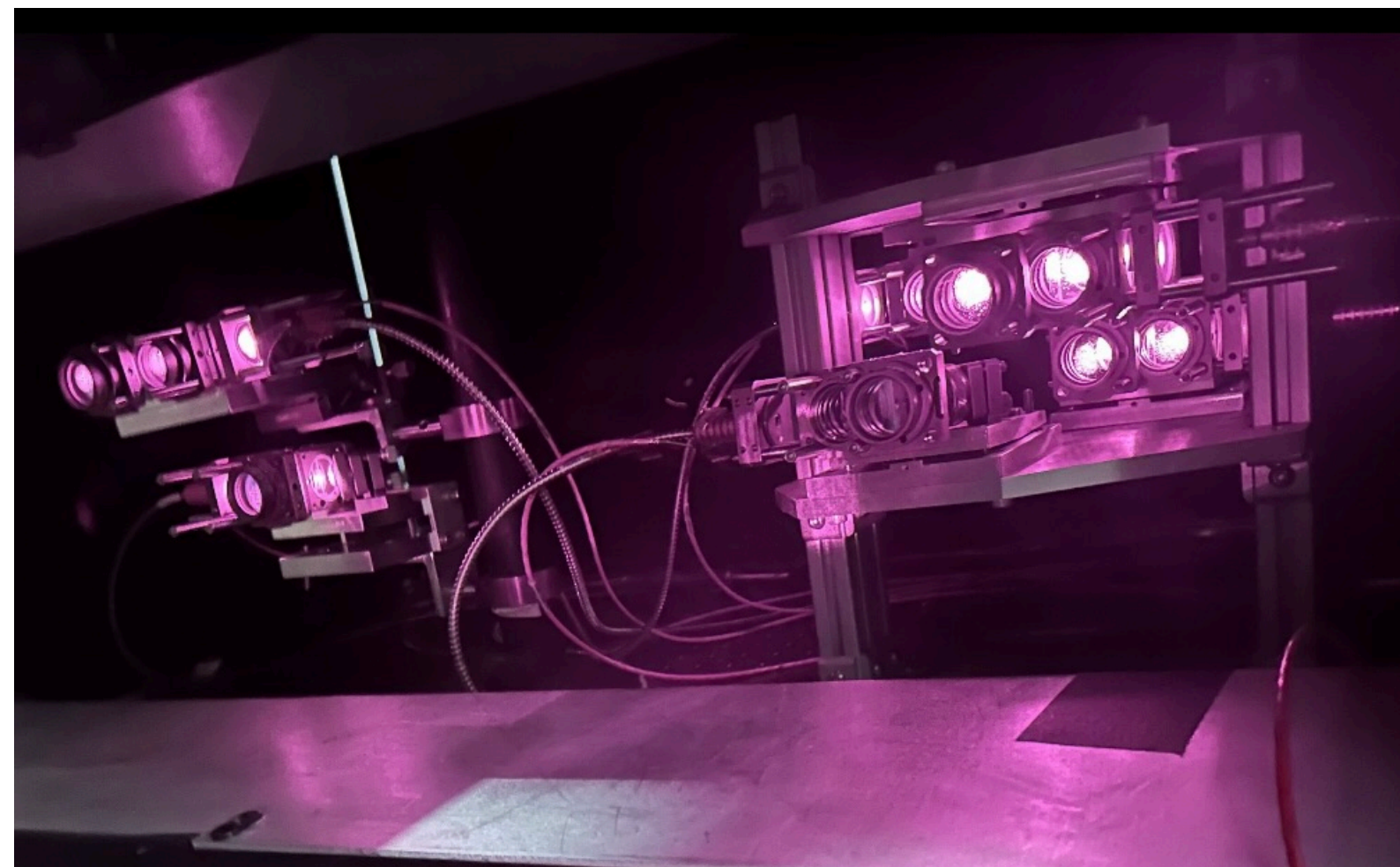
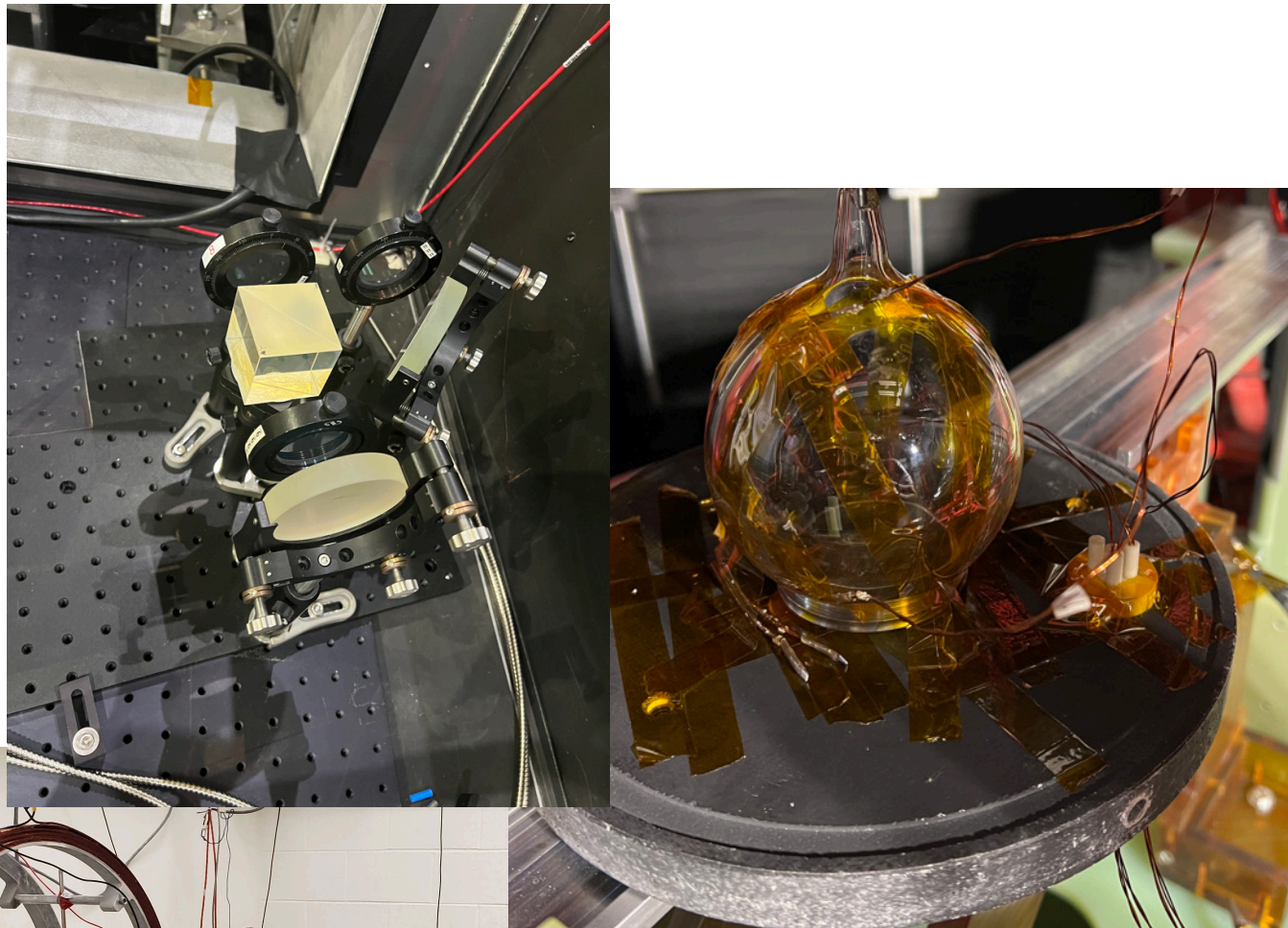
Monitoring the System

- Laser Fiber Temp. Monitored for equipment / fire safety
- Cell temperatures initially monitored for “Polarization Dance” and density corrections
- Dance between Laser Power & Oven Temp.



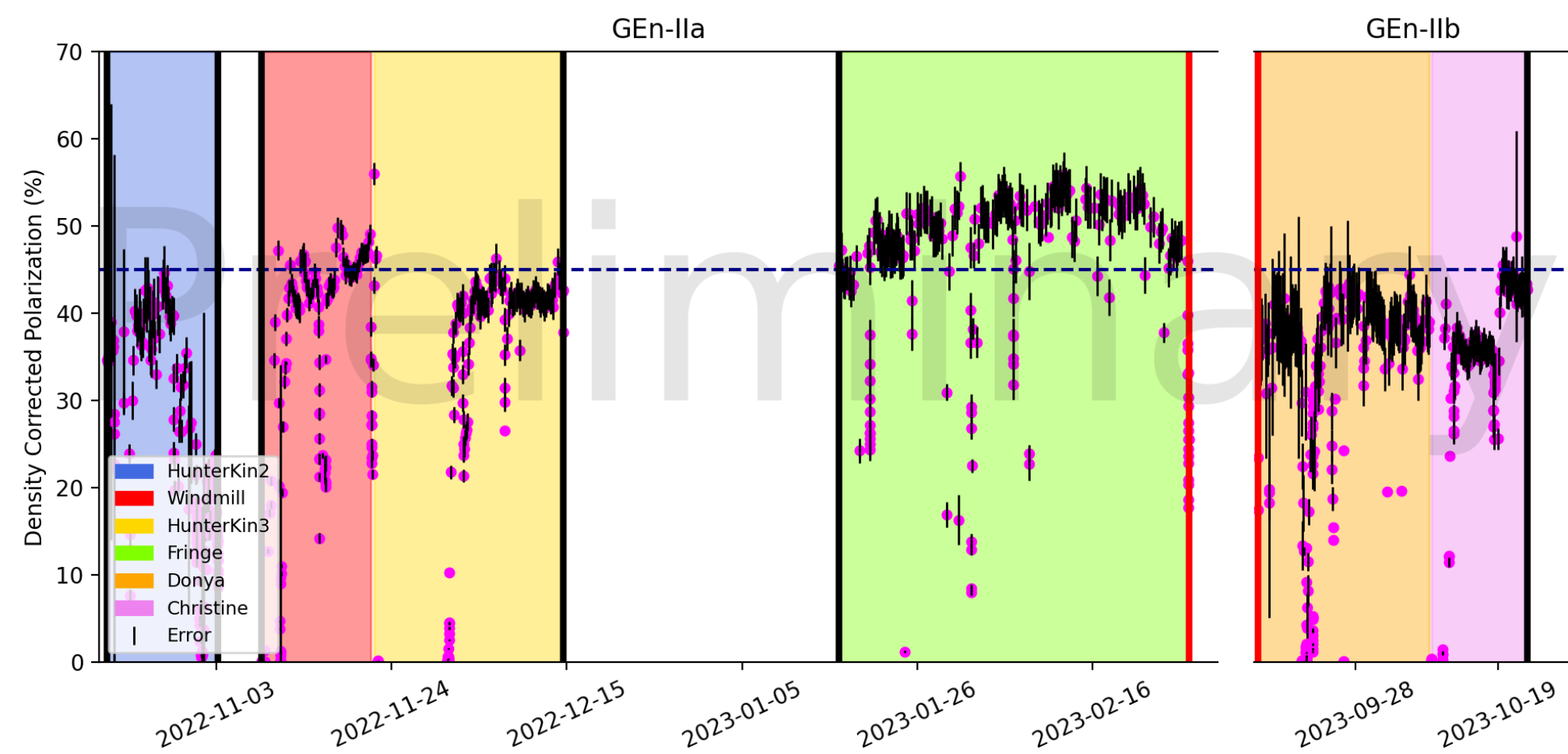
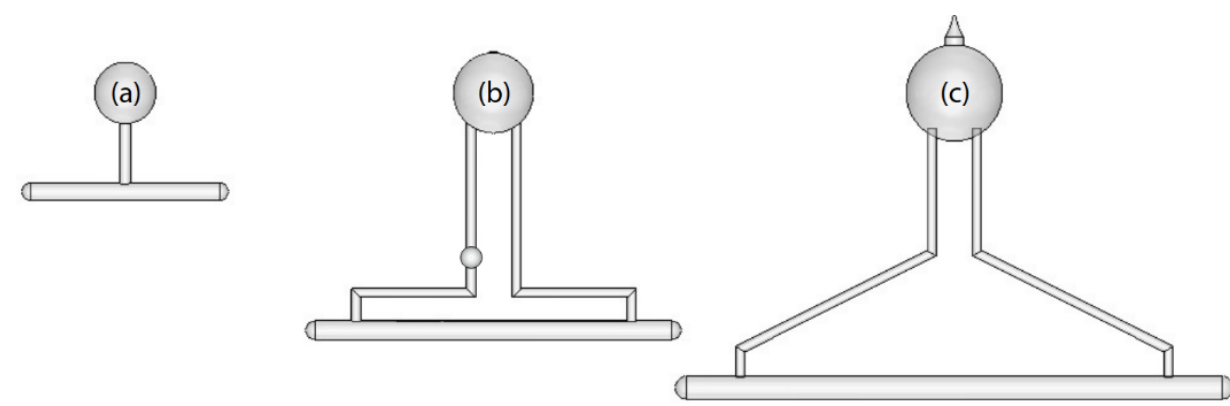
GEN4B Issues

- Low Target Polarization
- Tests for Magnetic field anomalies
- Laser issues (alignment & power losses)
- Nominal increase from 35% to 45% polarization after fix

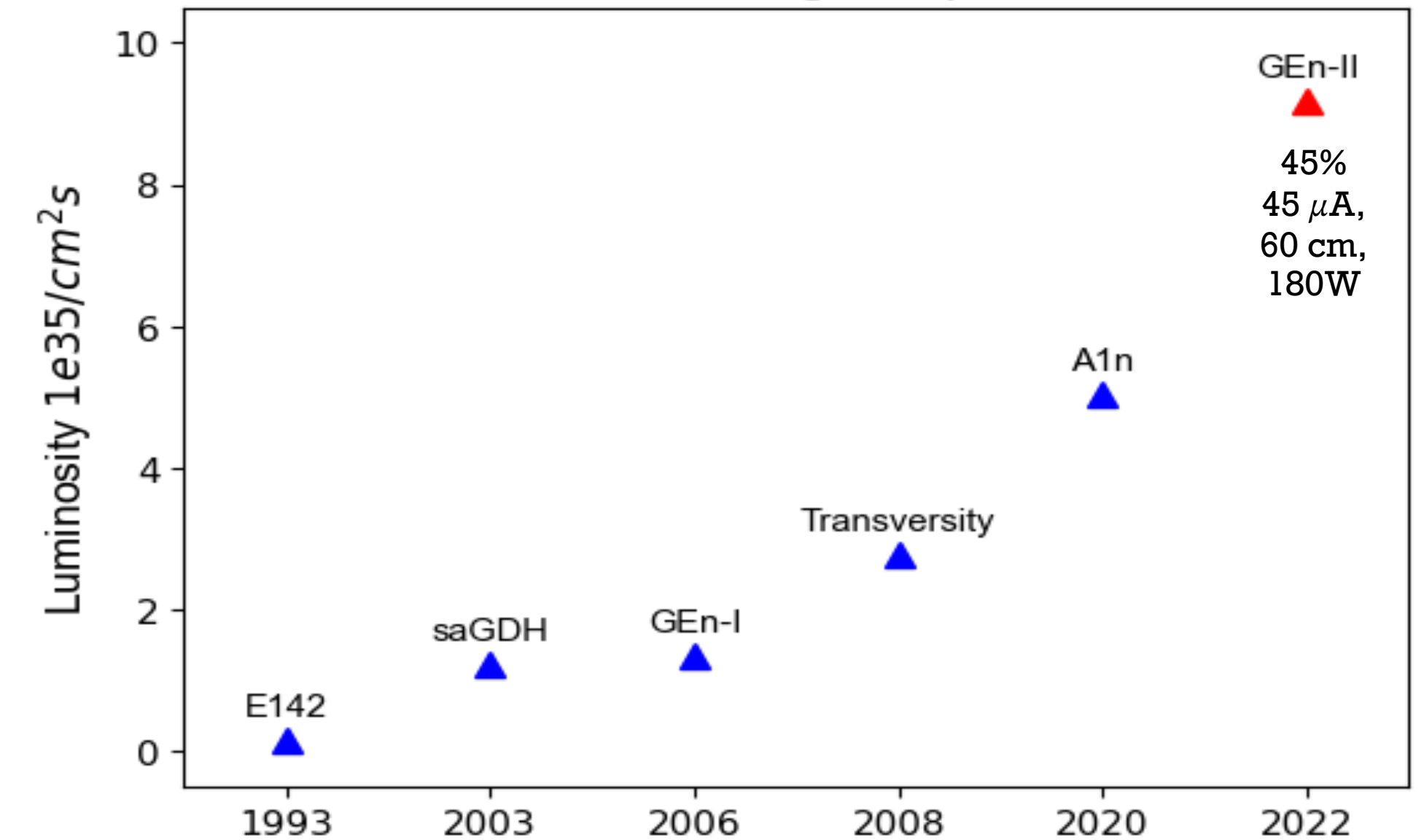


Summary

- Larger Volume Convection Cells
- Very Good Polarization for SEOP Cells
- Record Breaking Luminosity for SEOP ^3He Target



Polarization-Weighted Luminosity for Various ^3He Target Experiments



	Cell Name	Average Polarization	Max Polarization	Duration Installed
Kinematic 2	Hunter	40%	46.08%	20 days
	Windmill	45%	49.80%	14 days
Kinematic 3	Hunter	42%	46.32	24 days
	Fringe	53%	55.92%	60 days
Kinematic 4	Chicago	n/a	43.60%	12 days
	Donya	40%	44.49%	31 days
	Christin	40%	45.57%	20 days

Credit: Hunter Presley

Thank You.

