Carnegie Mellon University

GlueX

AI for experiment control and calibration
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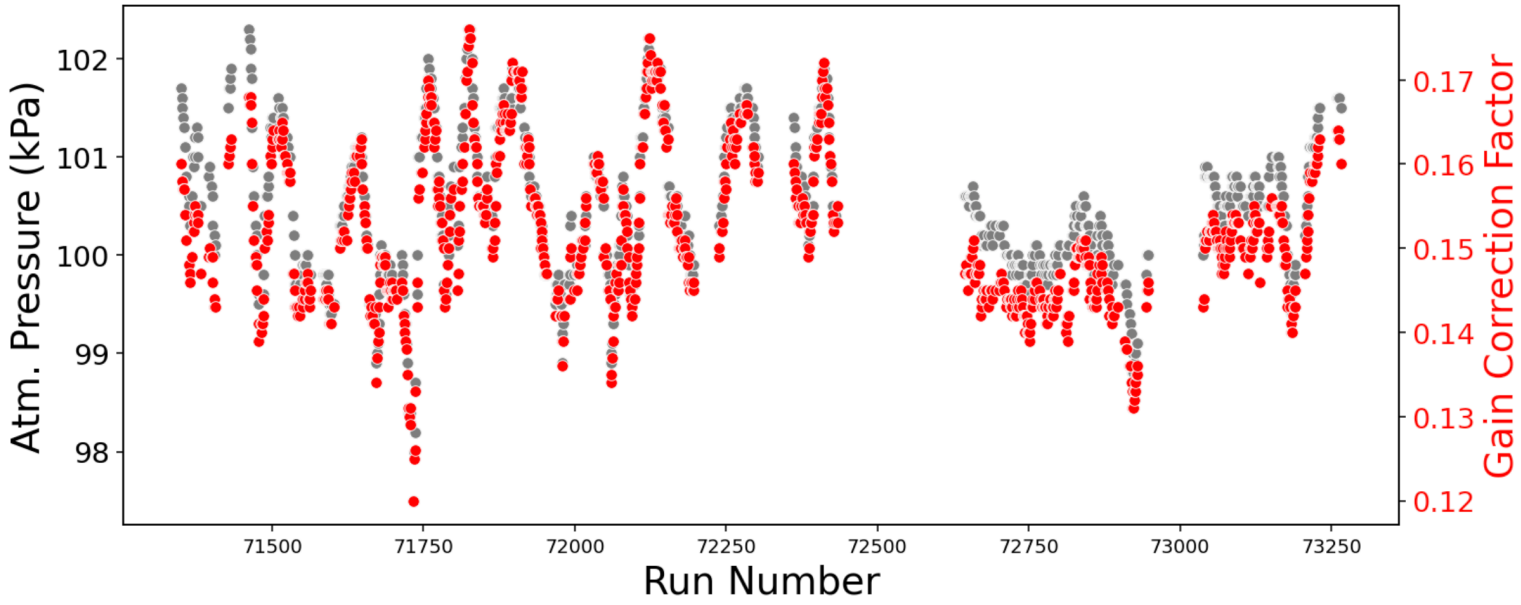
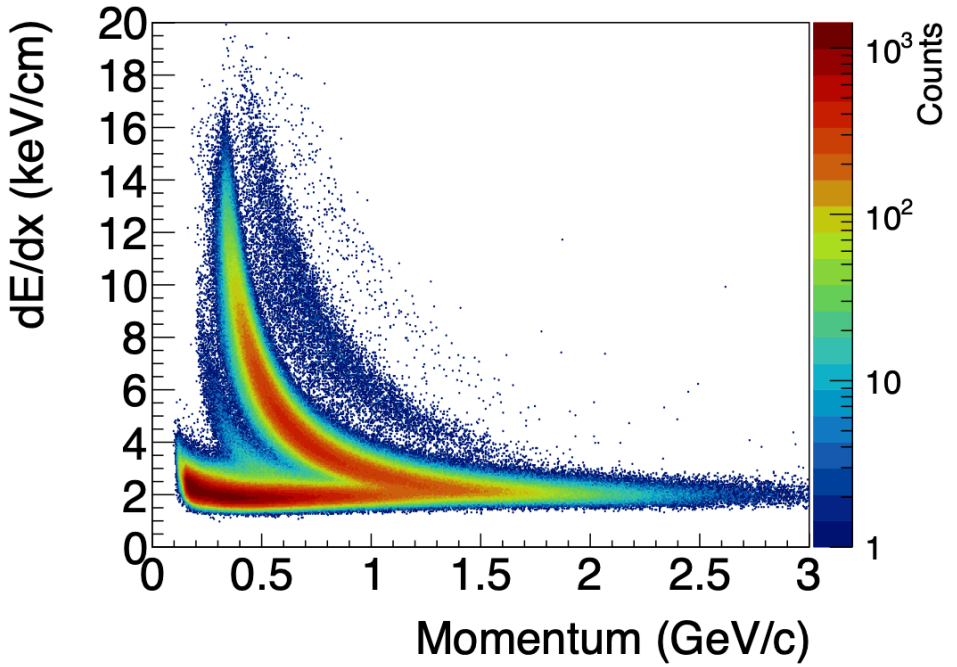
GlueX Central Drift Chamber (CDC) – charged particle tracking and identification

- CDC: Straw tube drift chamber, measures drift time and deposited charge NIM A962, 163727 (2020)
- Time to distance calibration -> track-fitting, vertex resolution and dE/dx resolution
- Gain calibration -> stable dE/dx throughout the run, affects PID selections in analysis. Focusing on this.

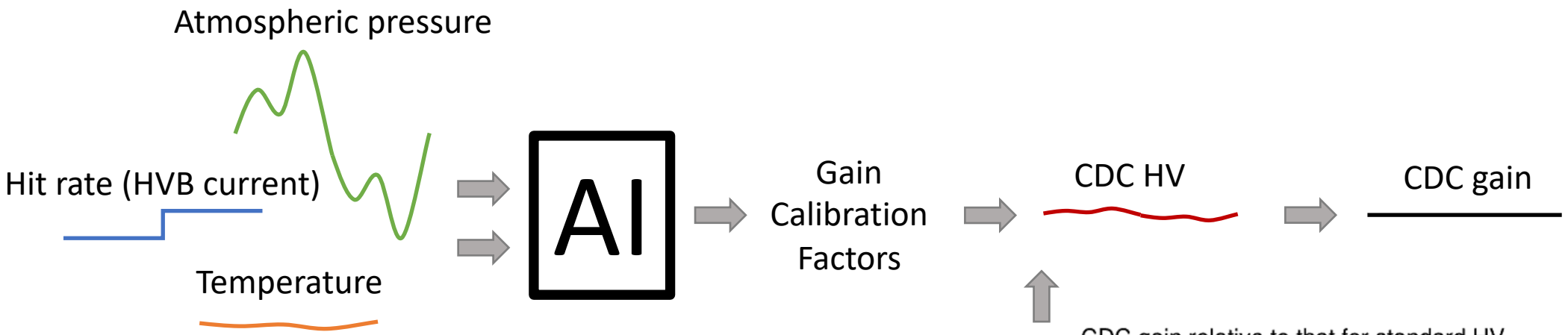
Pressure and gain correction factor vs run number (time)



CDC dE/dx vs momentum



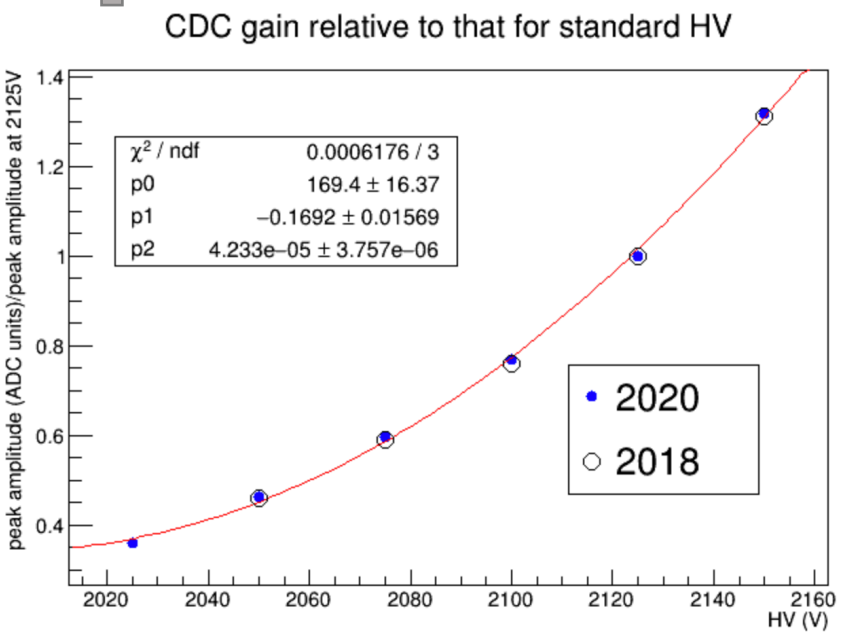
Using the AI to control the CDC for stable gain and quicker calibration



AI model: Gaussian Process Regression

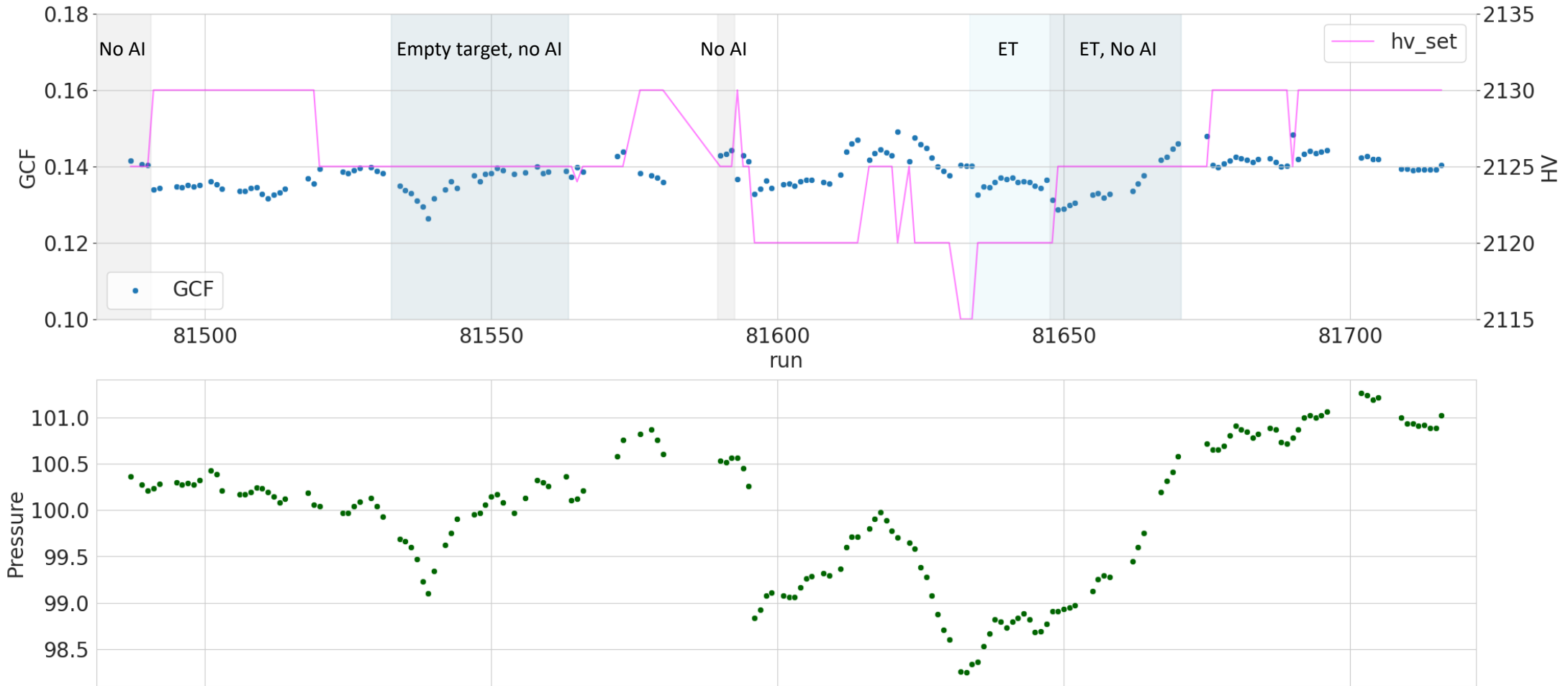
Trained using environmental data + conventional GCFs
Main dataset has 984 runs, divided 80:20 for train/test

The model uses environmental data to predict GCF in a few seconds



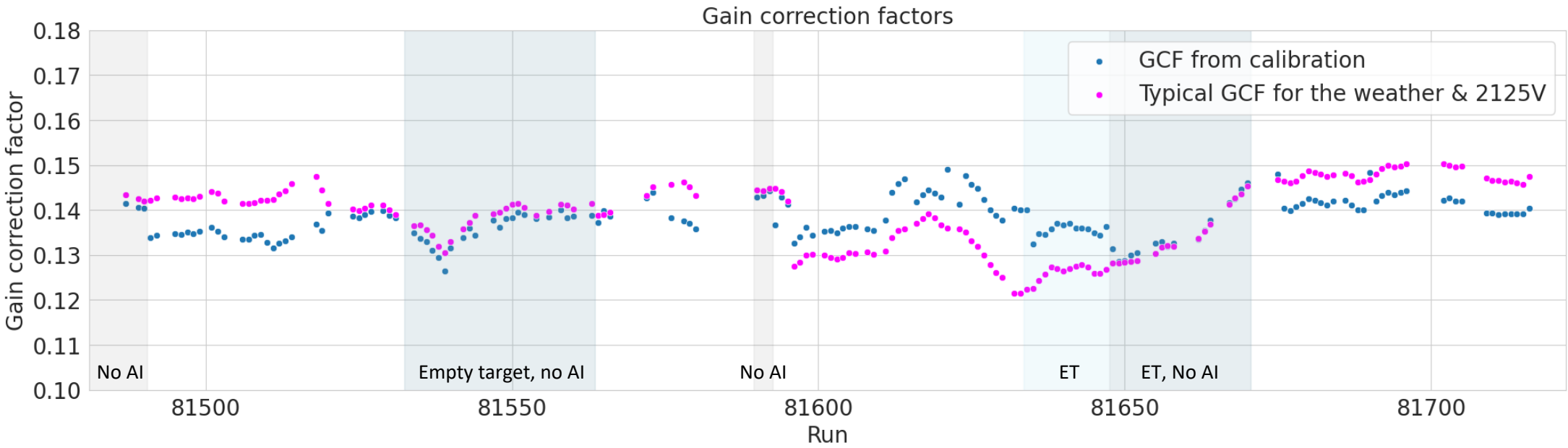
Operational testing during PrimEx Nov 2021

The AI-tuned HV was rounded to the nearest 5V and set manually by the shift-taker. It was constrained to 2125 +/- 20V. GCFs were obtained from dE/dx later on. The AI was not used for some runs.

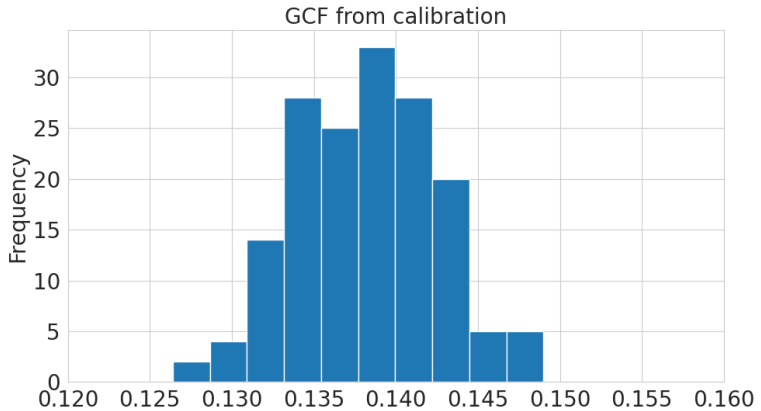


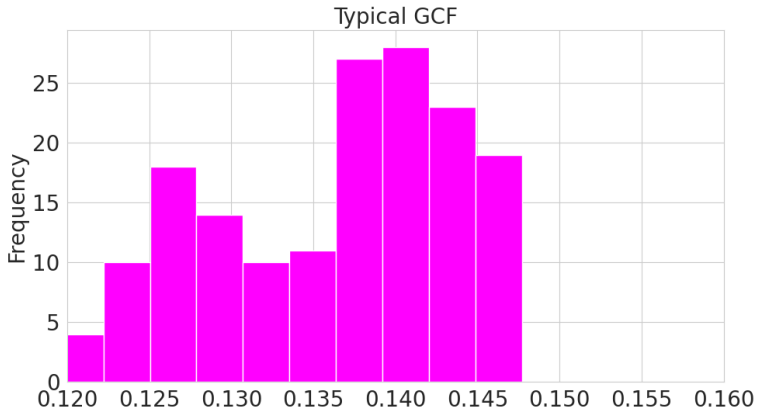
Operational testing - estimated GCFs likely for constant HV

Used 2018's fitted gain vs P/T, scaled to match 2021's mean GCF for runs at mean pressure (x 0.138/0.1475)



Gain was more stable with AI-tuned HV





Summary

- Trained an AI with drift chamber environmental values – pressure, gas temperature, HVB current.
- It takes just a few seconds to run the AI.
- Gained practical experience using this in fall 2021.
- The data-taking team was cooperative and enthusiastic.
- The results look good.
- Next operational experience will be in June 2022, with improved user interface.

References

GlueX Detector NIM A**987**, 164807 (2021)

GlueX Central Drift Chamber NIM A962, 163727 (2020)

Experimental Physics and Industrial Control System https://epics.anl.gov/

Garfield – Simulation of Gaseous Detectors https://garfield.web.cern.ch/garfield/

Acknowledgements

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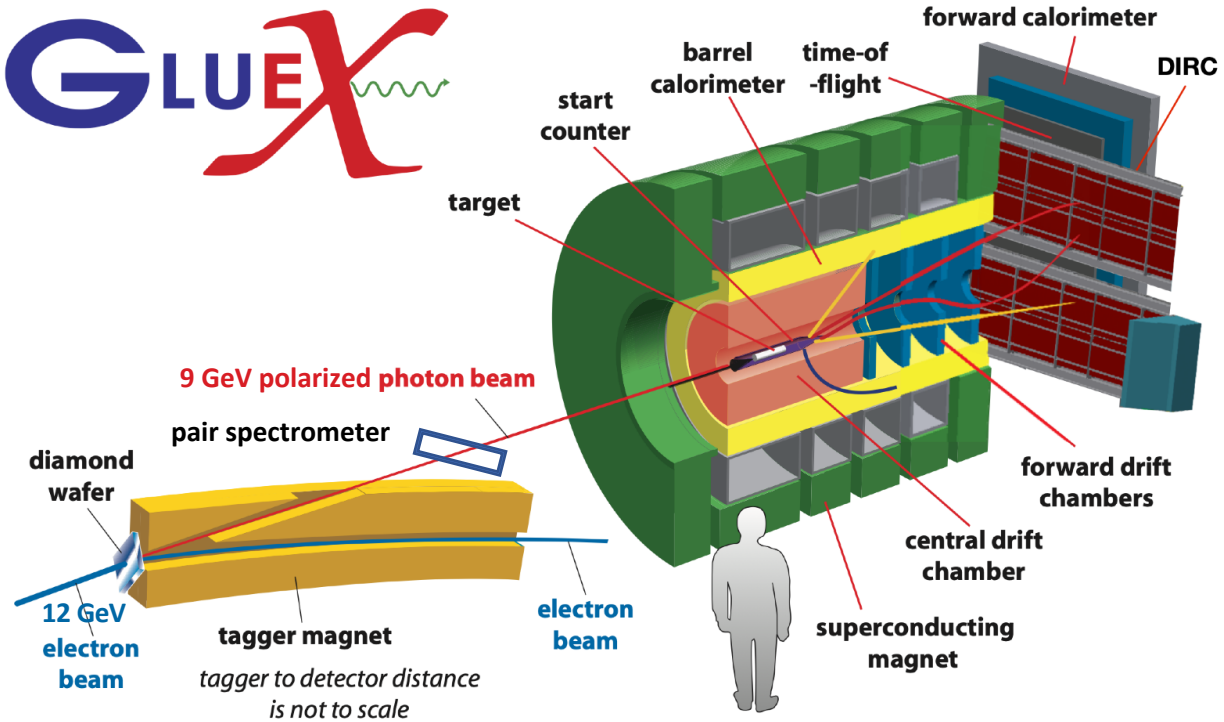
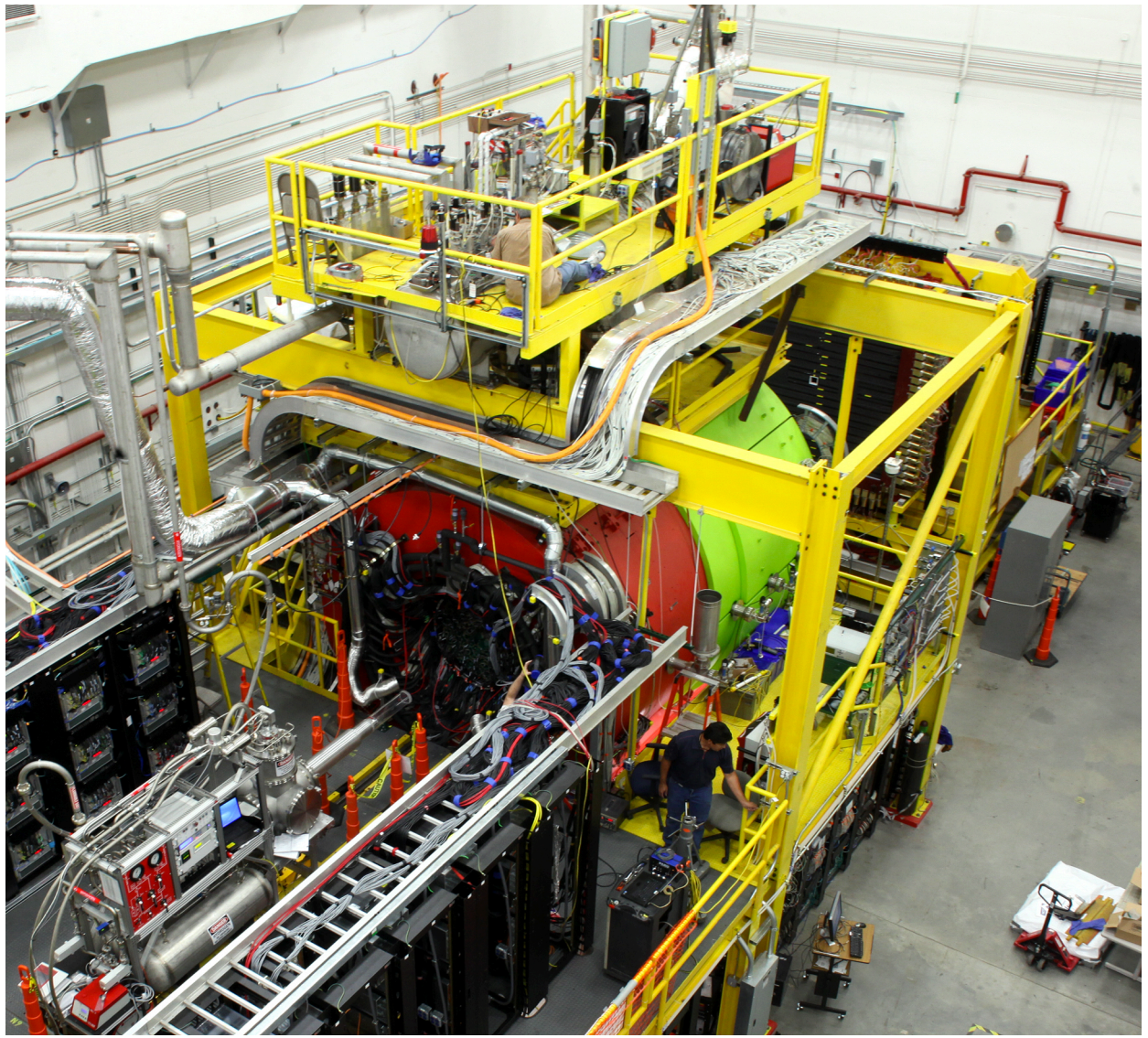
GlueX acknowledges the support of several funding agencies and computing facilities: www.gluex.org/thanks

Backup slides

GlueX: meson photoproduction experiment, searching for exotics

GlueX detector located in Hall D at Jefferson Lab, VA





Estimate of the range of HV needed

- Obtained new HV values for several runs spanning the pressure range from 2018

Run	GCF	Pressure from EPICS	Calibrated Pressure (mmHg)	GCF/ideal_GCF	New HV
51687	0.173	102.067	776	1.146	2137
51570	0.160	101.042	768	1.060	2129
51762	**0.151**	**100.016**	**760**	**1.000**	**2125**
51287	0.139	99.1262	753	0.921	2116
51160	0.132	98.4129	747	0.874	2111

New HV obtained from fit to relative GCF as function of HV

- Range of HV needed is within 12V of standard HV

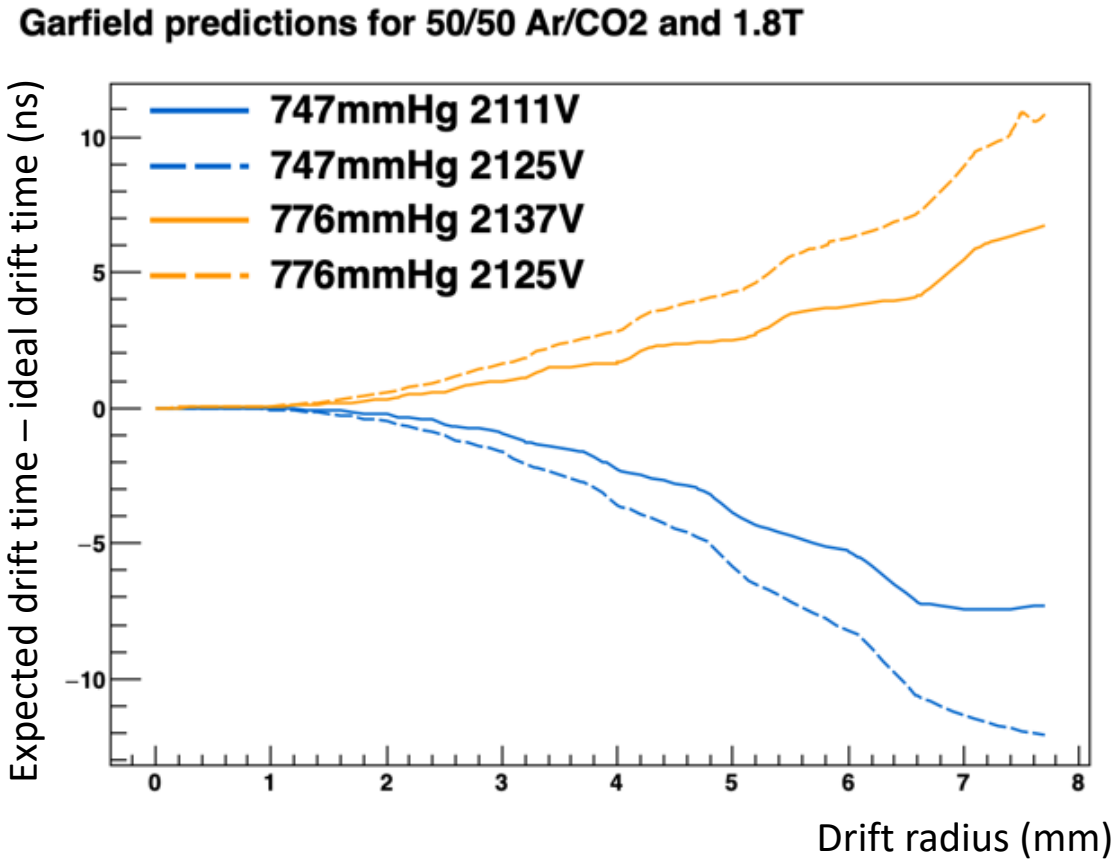
Drift times simulated for HV tuned to the pressure

- Drift time to distance conversion uses a table of ideal drift times simulated for standard pressure and nominal HV 2125V (GARFIELD). Calibration accounts for imperfect straws and pressure.

- Calculated difference between expected and ideal drift times at extreme pressure values
  - Faint lines: 2125V
  - Solid lines: tuned HV

- Differences are small, smaller for tuned HV

- Tuned HV should improve the position resolution



Operational testing during PrimEx Nov-Dec 2021 – Environmental data

All runs
after HV scan