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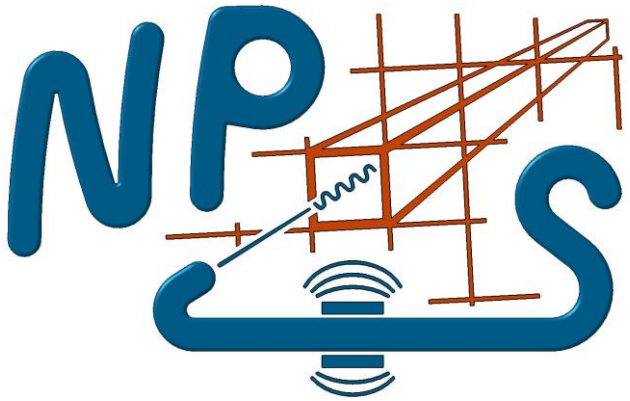
Jefferson Lab
Thomas Jefferson National Accelerator Facility



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# NPS RG1a: Validating Luminosity and HMS Acceptance via Analysis of DIS Yield

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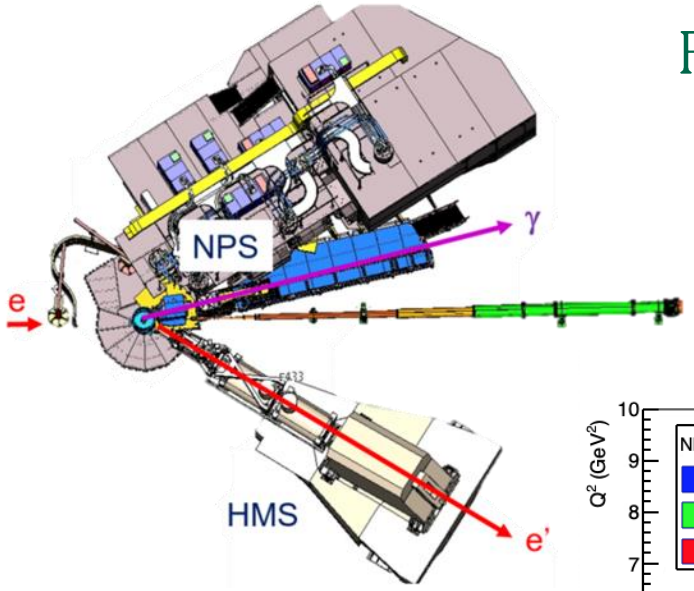
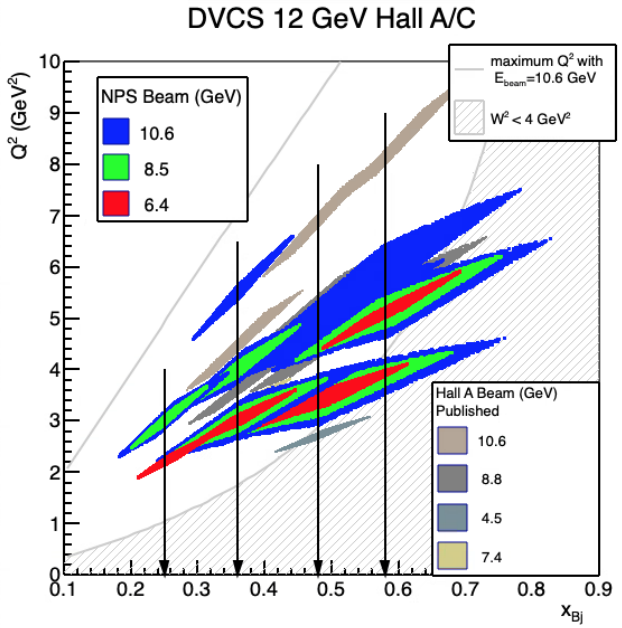
# The Neutral Particle Spectrometer (NPS) Experiments

- Normal DVCS runs triggered on recoil electron in HMS and photon in NPS
- Took DIS runs (HMS-only trigger) approximately every 12 hours throughout the experiment
- Analyzing DIS runs: Compare yields from data and MC simulation for 17 HMS settings




## Run Group 1a

E12-13-010
E12-13-007
E12-22-006
E12-23-014



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# DIS Data Comparison to MC Simulation

- Data:
  - Runs with HMS-only trigger
  - Data cuts:
    - Cerenkov: npeSum > 2
    - Calorimeter: etracknorm > 0.6
    - Delta between ± 8%
    - Beam current > 2uA
  - Normalize by charge
    - BCM calibration – Christine Ploen; Helicity scalers – Bob Michaels
  - Corrections for LT, detector efficiencies, prescaling, HMS acceptance
  - Target cell wall and charge-symmetric background contributions subtracted
- Simulation:
  - Generate events at vertex over a large phase space
  - Incorporate radiative corrections
  - Weight according to cross section model (F1F221)
  - Compute reconstructed event variables

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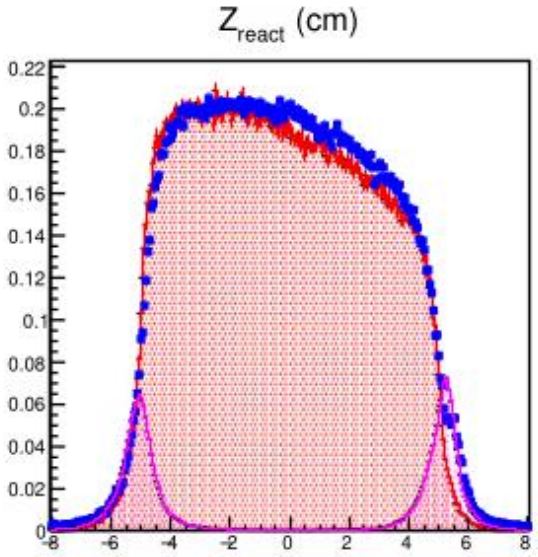
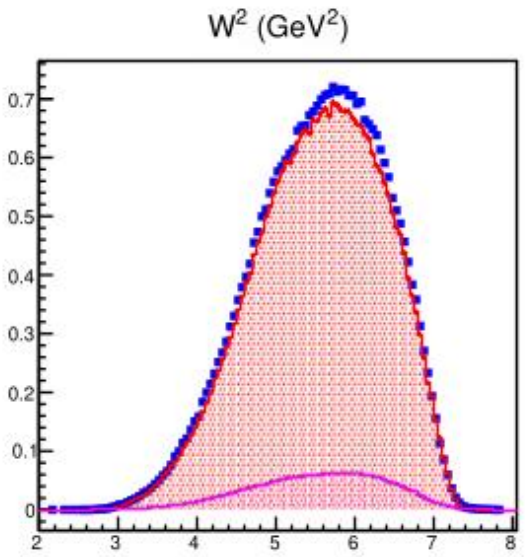
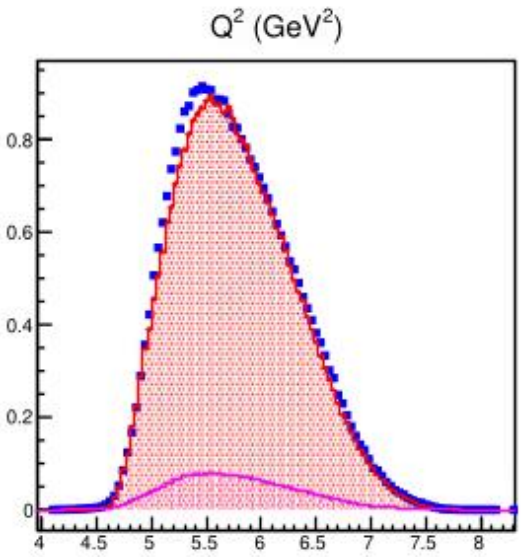
LD2 (loop 1)

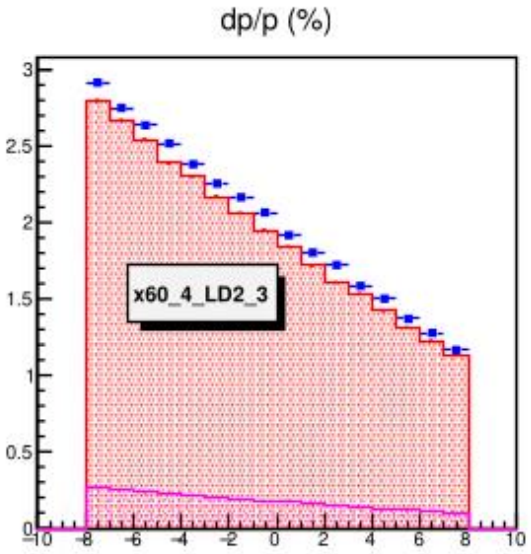
x60_4

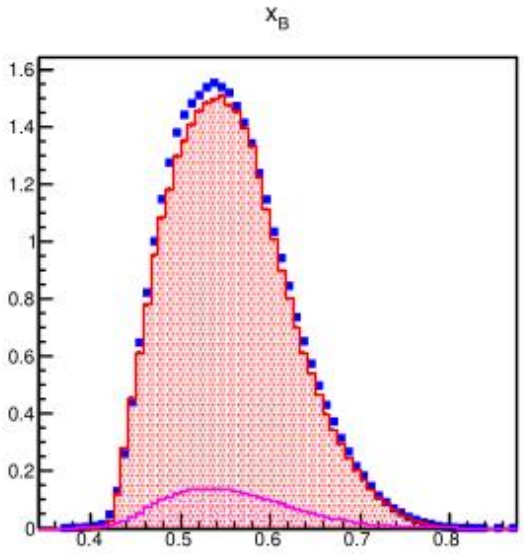
5/16/24 (day 216)

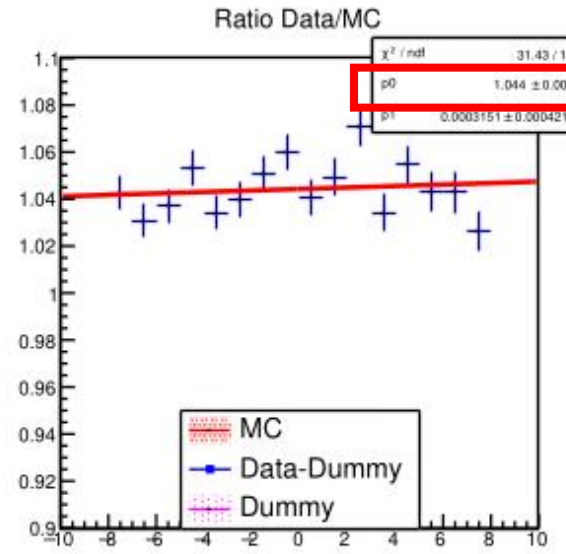


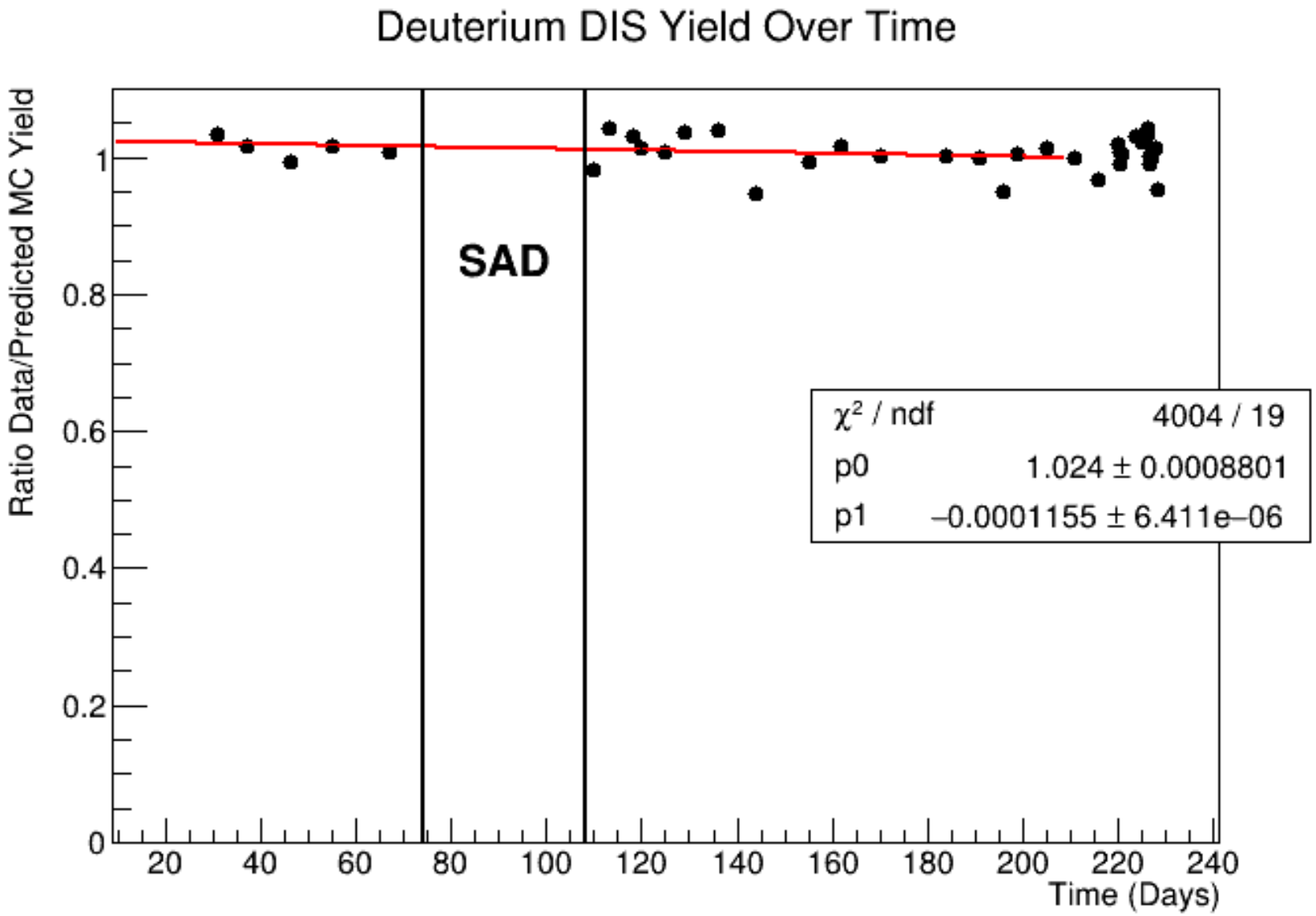



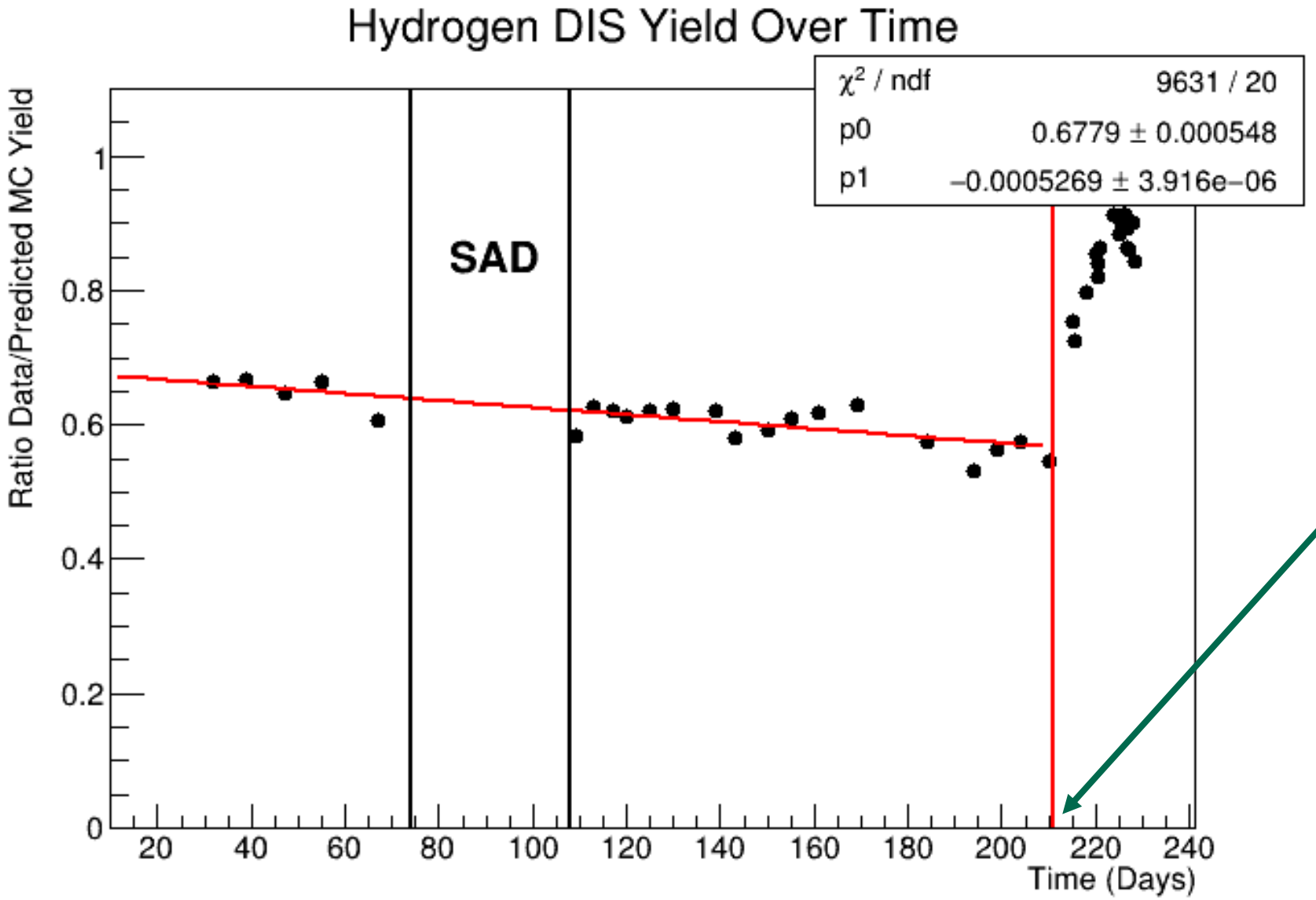

Data has 104.4% of MC yield

# DIS Yield Over Time

- Repeat analysis approximately once per week from beginning of run period until LH2 target adjustment period
- Post-LH2 target adjustment, took DIS runs at every kinematic
- Each kinematic has at least 2 data points
- Plot ratios of yield to MC prediction over time
  - Set October 3, 2023 as “Day 0”
  - LH2 target adjustment begins day 211




Simulation works well for all kinematics throughout the experiment




5/1/24 (day 211): Begin adjusting LH2 target conditions

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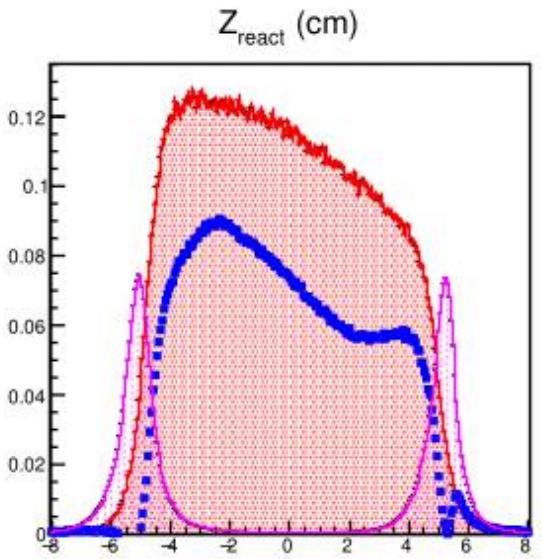
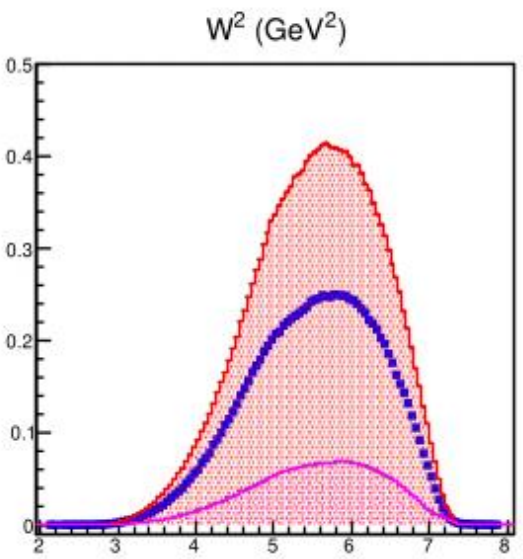
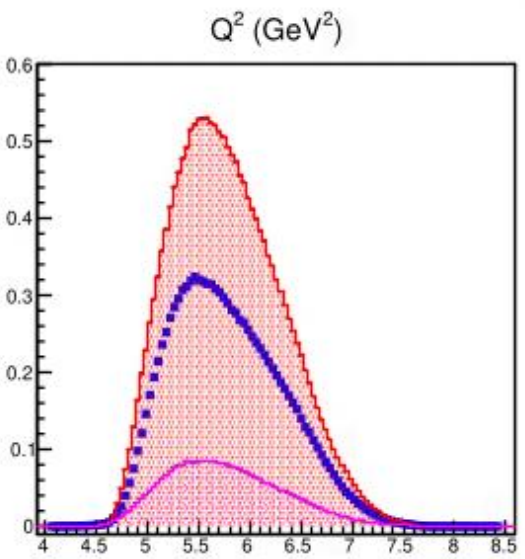
LH2 (loop 2)

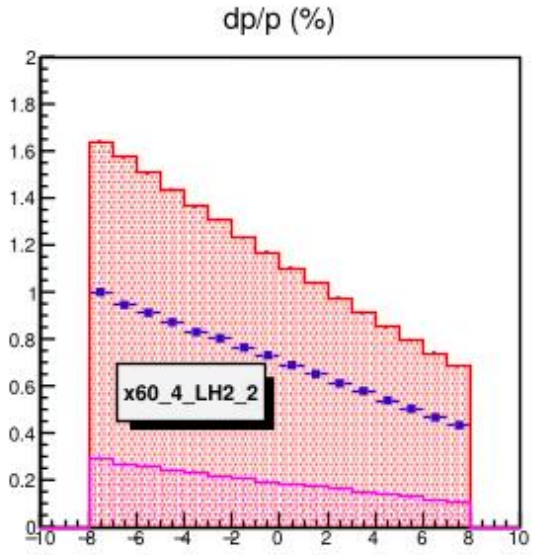
x60_4

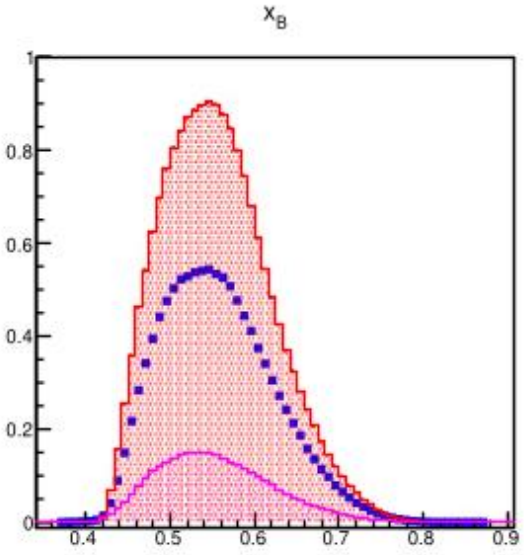
2/19/24 (day 139)

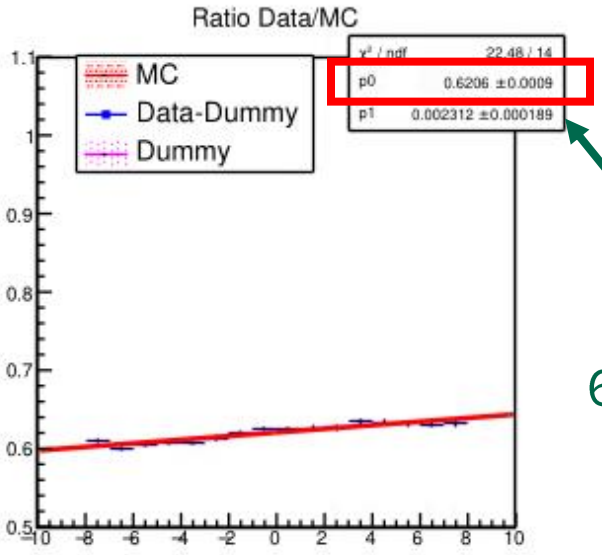



Data has 62.06% of MC yield

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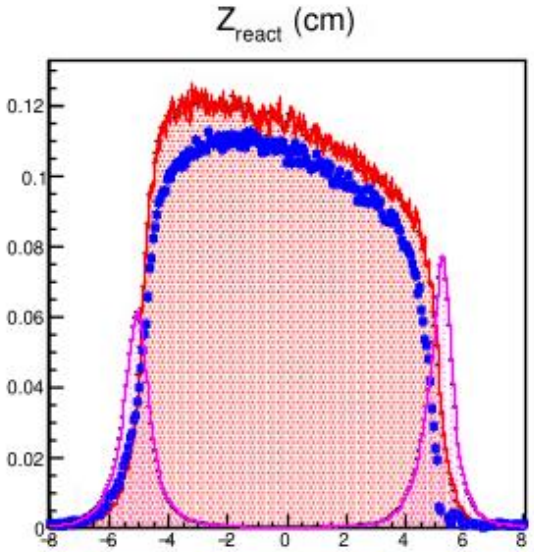
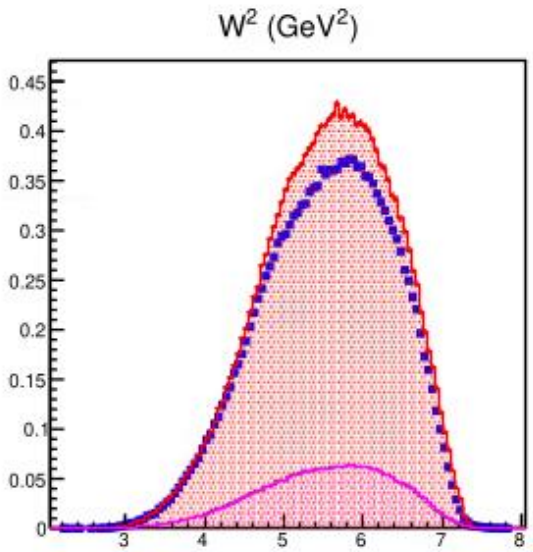
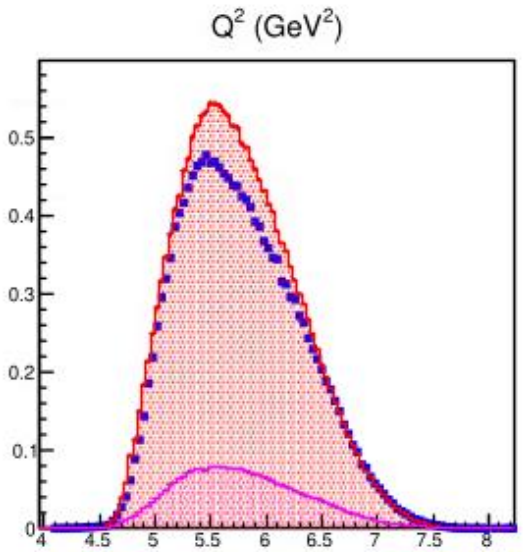
LH2 (loop 3)

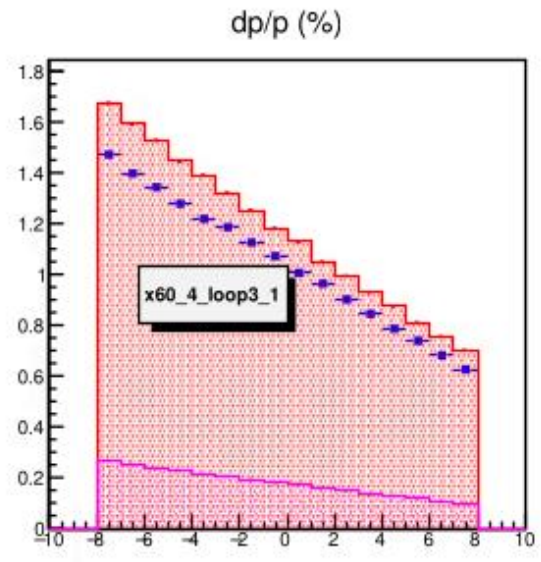
x60_4

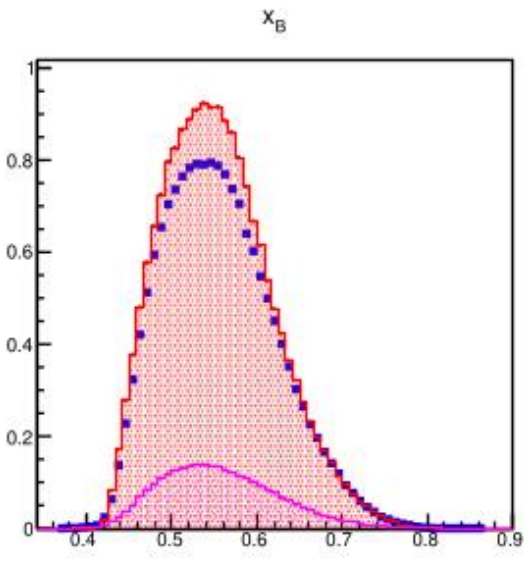
5/16/24 (day 216)

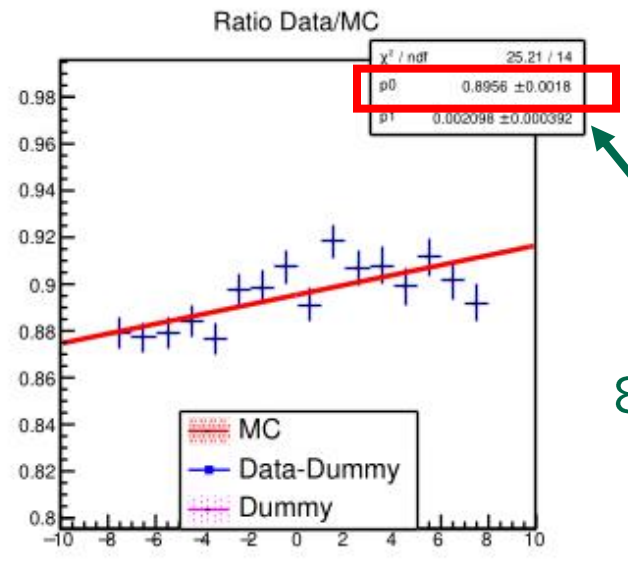



Data has 89.56% of MC yield

# Modifications to LH2 Target

- 2 primary hypotheses for the cause of target issues:
  - Atypical fan speed created bubbles
  - Helium contamination in LH2
- Measures taken:
  - Adjusted target fan speed (58Hz to 42Hz)
  - Replaced fan controller
  - Moved LH2 from loop 2 to loop 3
  - Increased pressure in target loop (25psia to 40psia)
- Each measure made small improvements

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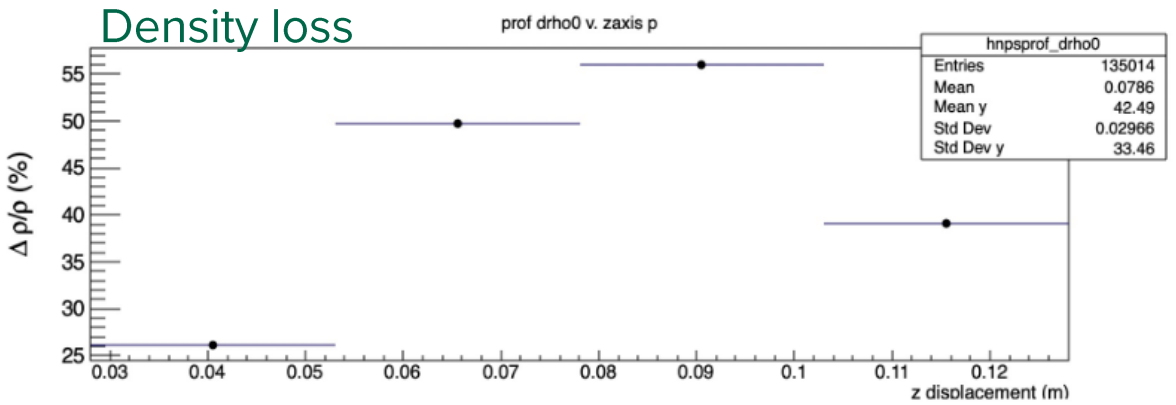
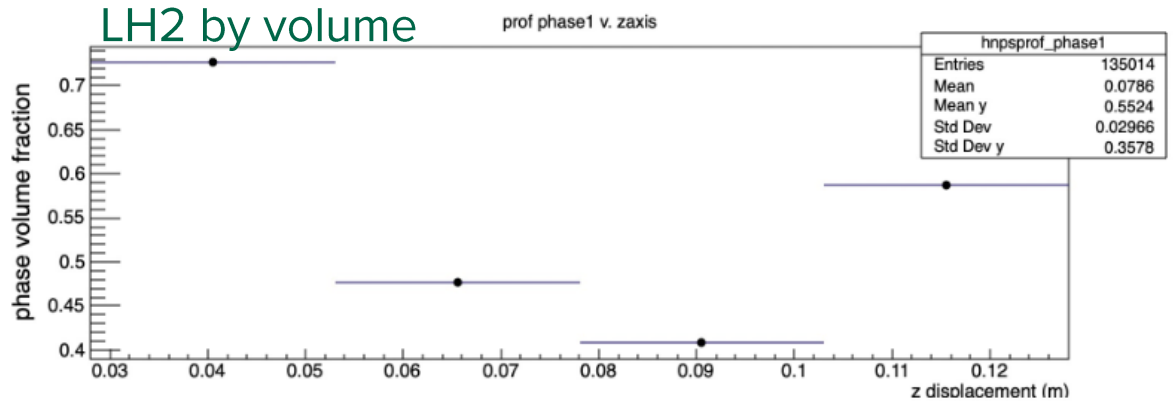
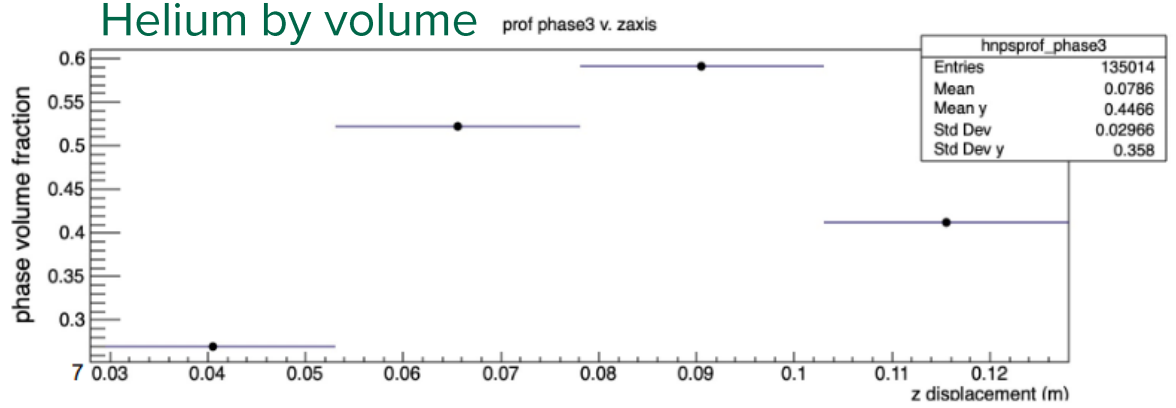
# Characterization of LH2 Target

- Helium contamination report from Dave Meekins: 0.5% He by volume in H2 tank
  - https://logbooks.jlab.org/entry/4324739
- Silviu Covrig Dusa conducted computational fluid dynamics (CFD) simulations of target cell
  - See Silviu's slides, NPS Collaboration Meeting, July 2024: https://indico.jlab.org/event/866/contributions/14977/subcontributions/255/attachments/11507/17809/nps_cdusa_targetcfd_17jul2024.pdf
  - If LH2 pump efficiency >80%, loss of target thickness not explained with only LH2
  - LH2-He mixture shows concentration of He in downstream half → He "bubble"
- Beam tests showed high power heater only sensed ~70% of LH2 target thickness




Plots: Silviu Covrig Dusa

# Improving the NPS DIS Analysis

- Removing minor inconsistencies between simulation and data
  - $y_{tar}$ to z mapping, HMS acceptance correction, etc.
- Dummy target contribution is not exactly the same as the contribution of aluminum foils in cryo targets
- How to correct for the discrepancy in LH2 DIS yield? Use an overall correction to luminosity or a z-dependent correction?
  - DVCS simulation in development and will help answer this question

# Summary and Outlook

- Deuterium DIS studies give reasonable results, so discrepancies in hydrogen seem to be coming from the target
  - Issues with hydrogen target were present from the start of the experiment and seemed to have gotten worse over time
  - Significant improvement with adjustment of hydrogen target conditions
- Refining consistency between data and simulation, improving aluminum cell wall subtraction
- Overall correction factor for LH2 target or z-dependent correction? DVCS simulation will help

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# Thank you for your time

## Questions?