# Background sources and synchrotron radiation issues at JLAB

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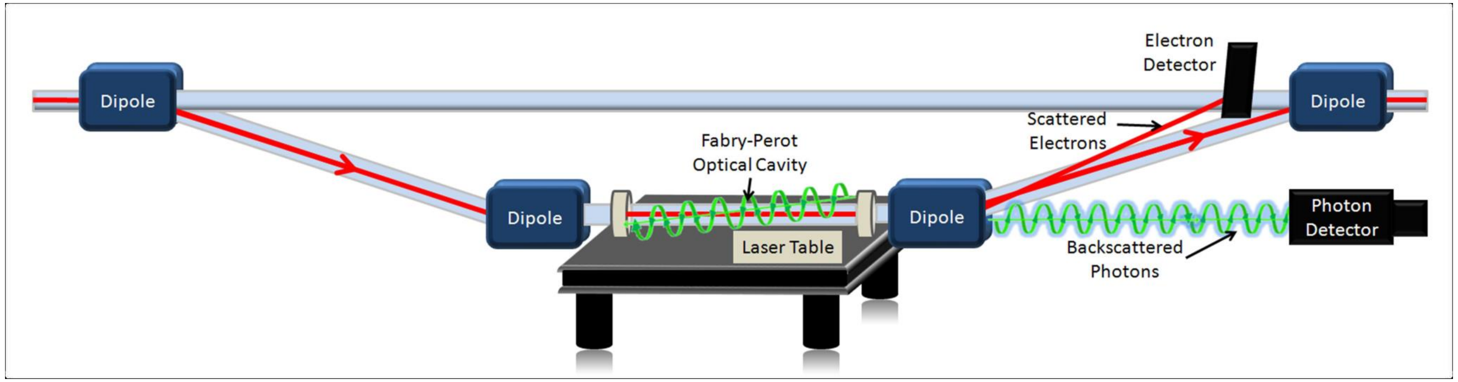
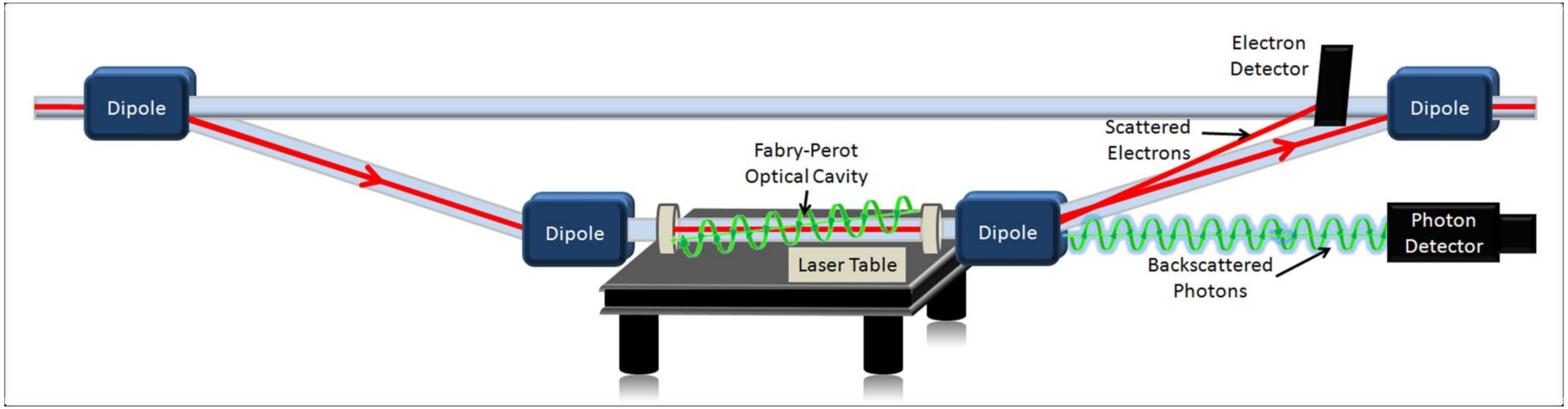
Jefferson Lab




FCC EPOL Workshop

September 19-30, 2022

# Compton Polarimeter Backgrounds




- Three primary sources of background
  - Bremsstrahlung
  - Synchrotron radiation
  - Beam halo interaction with beamline elements
- One special source of background (just for some experiments)
  - Neutrons from heavy targets (PREX)

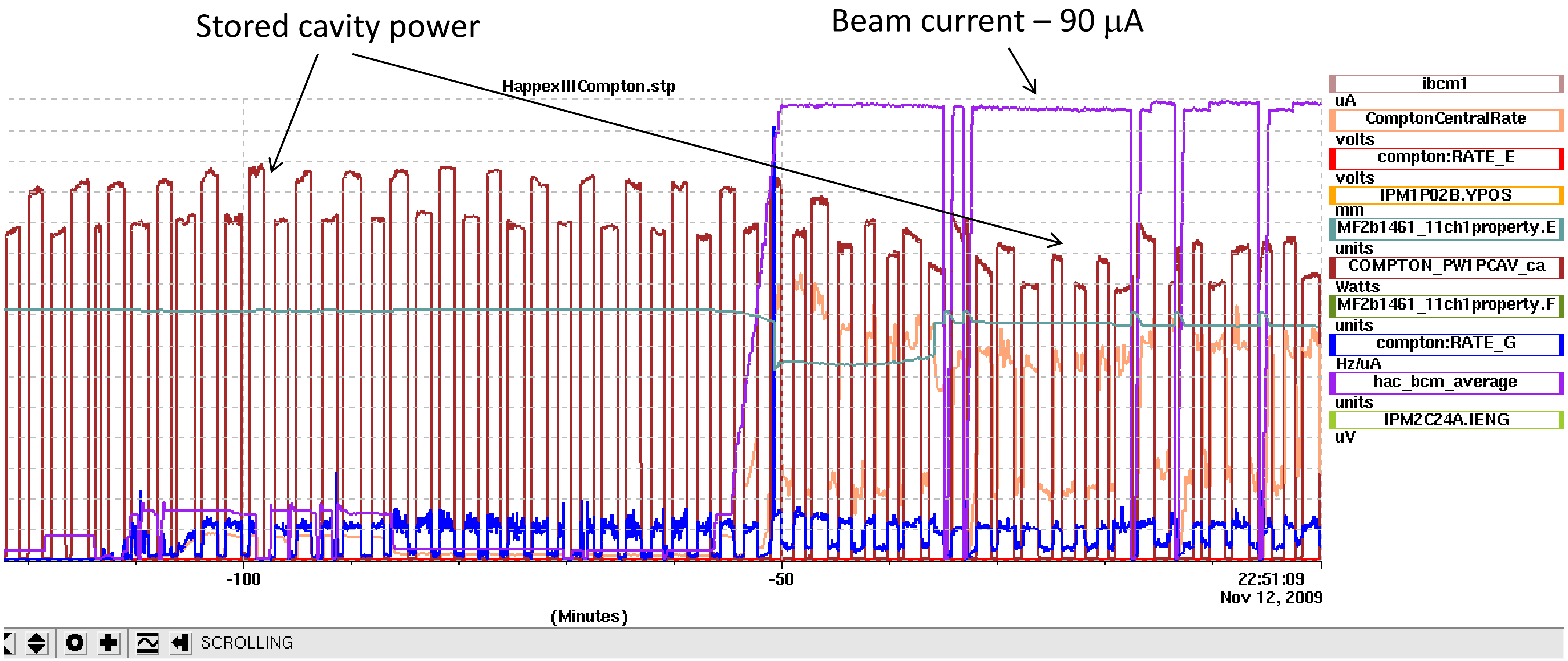
# Compton Operation Mode


Laser locks and unlocks regularly to allow measurement of backgrounds

→ Backgrounds highly dependent on beam quality

→ Sometimes extensive tuning is required to achieve good backgrounds – ***dominant background from beam interaction with apertures in beamline***

# Beam vs. Cavity




Example: stored cavity power droops at high e-beam currents

→ Source unknown: synch light or beam scraping heating and distorting mirrors?

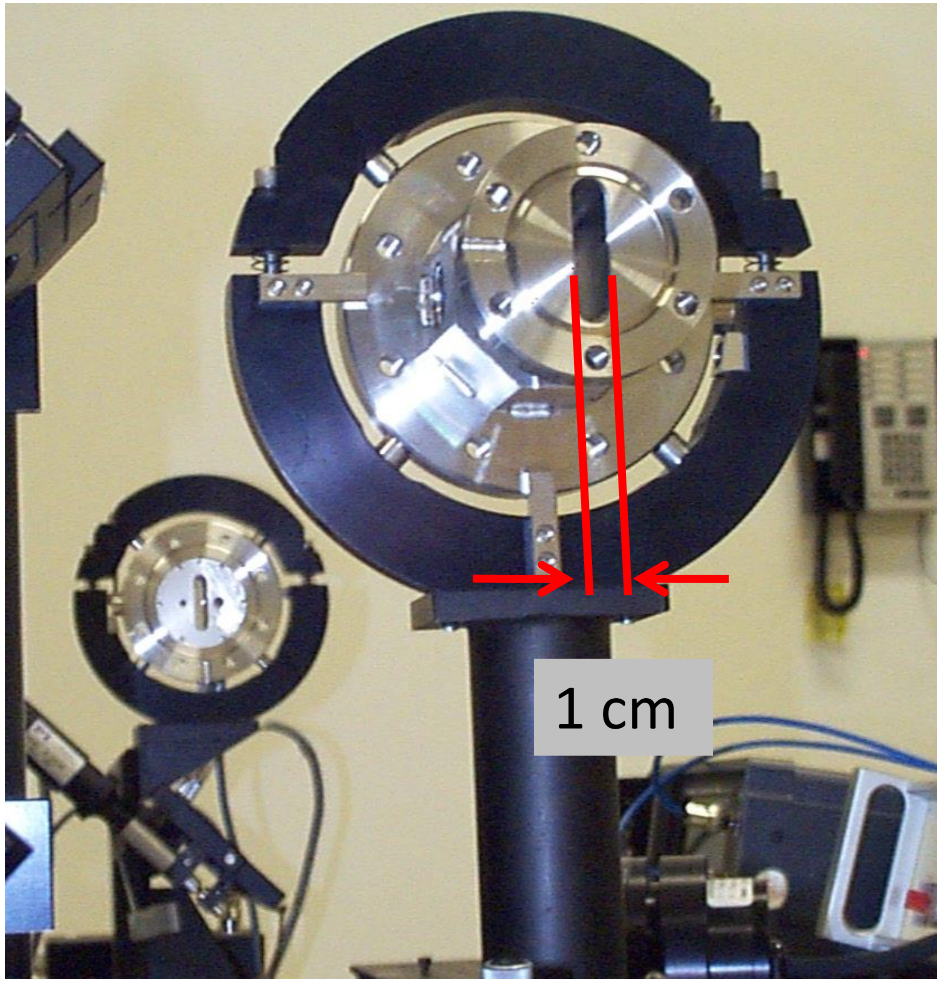
# Halo, small apertures and backgrounds

Hall A/C Compton polarimeters use narrow apertures to help protect cavity mirrors from
→Large beam related backgrounds
→Direct beam strikes

Large beam size, halo will result huge backgrounds from scraping on narrow apertures → ion chambers, machine protection system shuts off beam

This system has drawbacks → very small halos can still result in significant backgrounds

→ Halo may be small enough to run, but there still may be a lot of junk in your detectors





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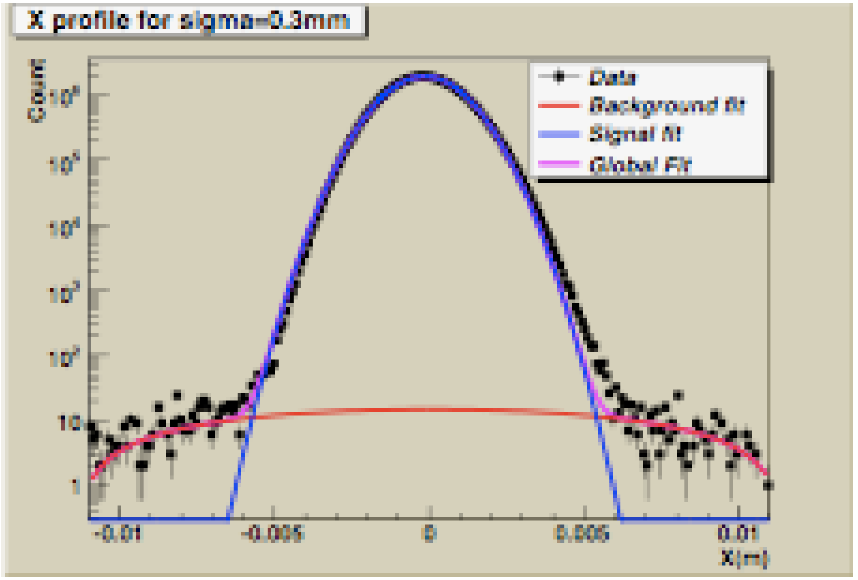
# Beam Halo and Backgrounds

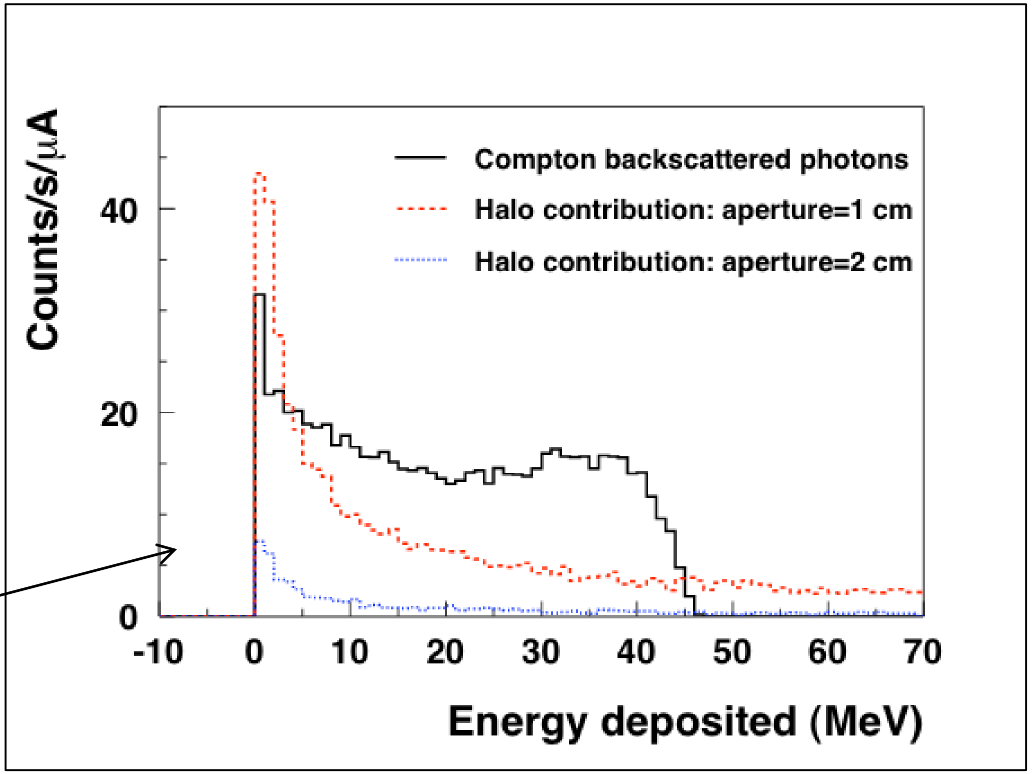



*Yves Roblin and Arne Freyberger*
*JLAB-TN-06-048*

Put model of JLab beam halo (11 GeV) in GEANT model
→ Halo forced to zero at edge of (1 inch) beam pipe

Sensitivity to beam halo makes us very sensitive to beam tune → it is sometimes not possible to achieve ideal tune for Compton and required parameters for experiment

Halo = 5 x $10^{-10}$





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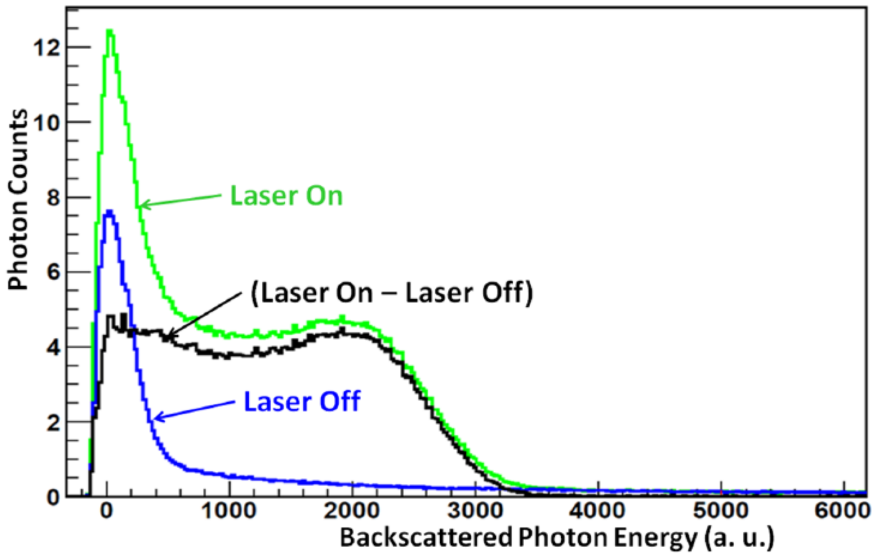
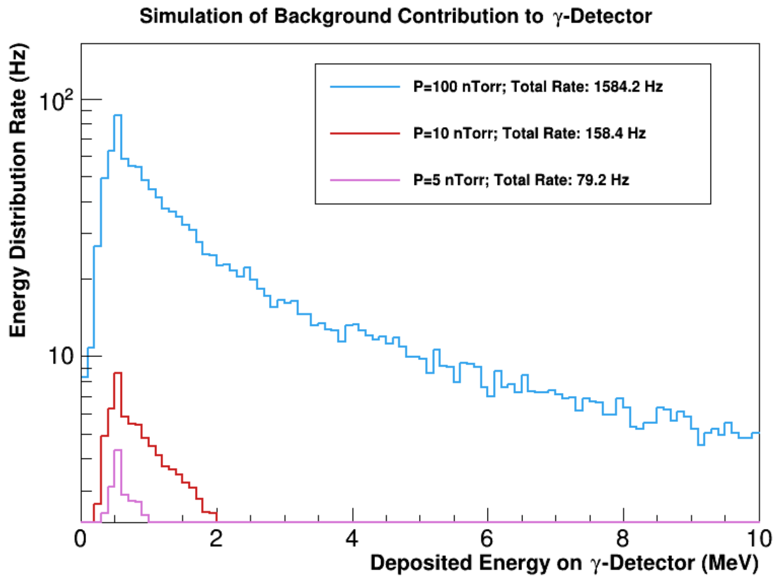
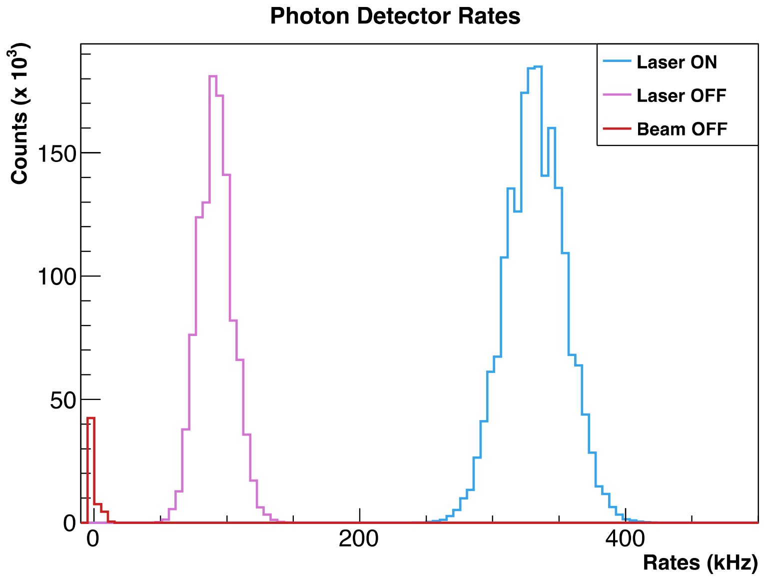
# Examples – Hall C Photon Detector

Hall C photon detector – measured energy spectrum
→ Beam energy=1.16 GeV, current = 180 μA
→ Laser (cavity) power ~ 1.7 kW




Simulation - Bremsstrahlung




Measured rates

Simulation including only Bremsstrahlung can't explain background

*Juan-Carlos Cornejo – PhD thesis*

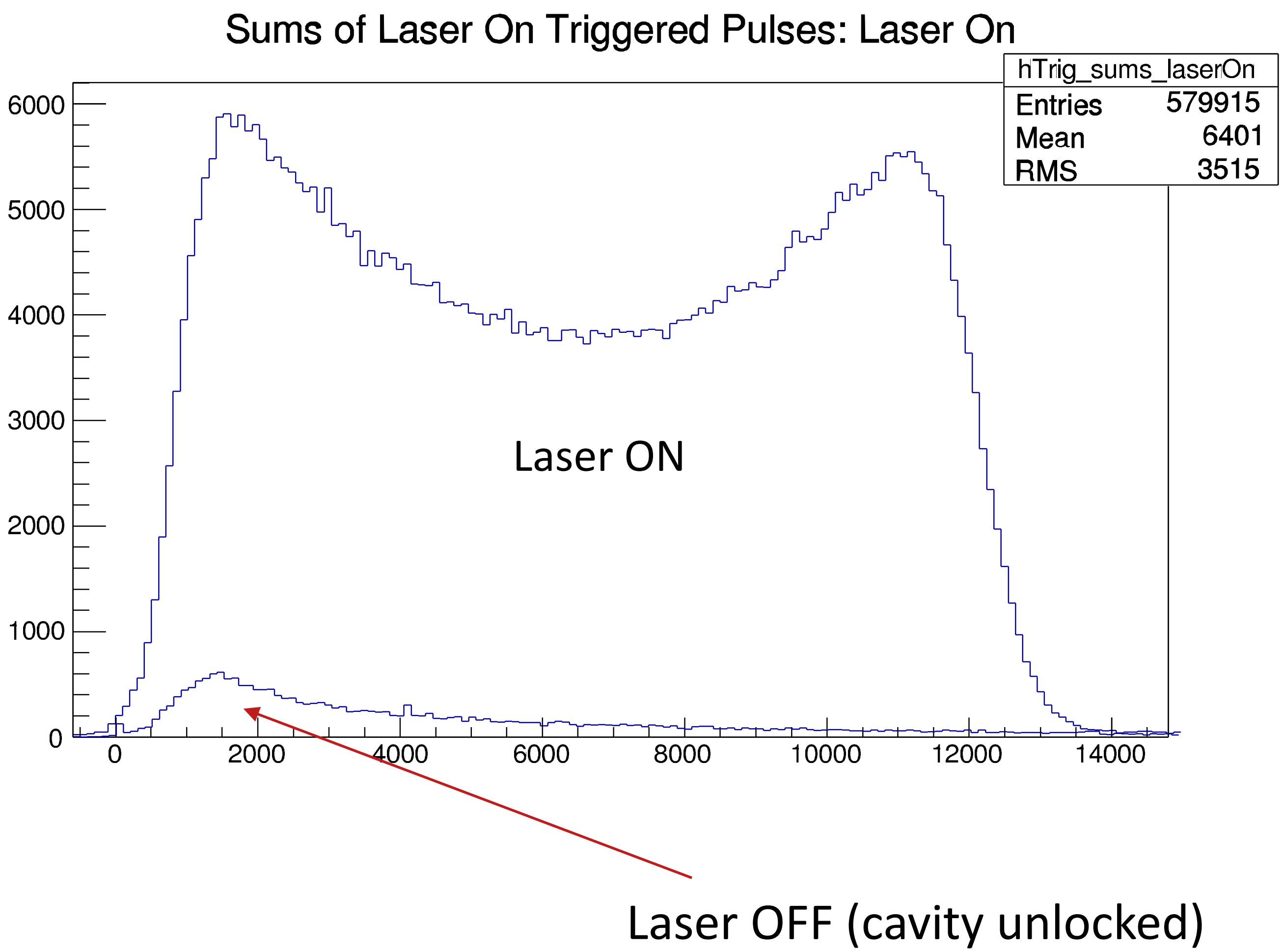
# Examples - Hall A Photon Detector

Energy spectrum from Hall A

→Beam energy = 8.8 GeV,
beam current = 20-50 μA

→Laser power ~ 2 kW

Low energy Bremsstrahlung contribution suppressed by discriminator threshold



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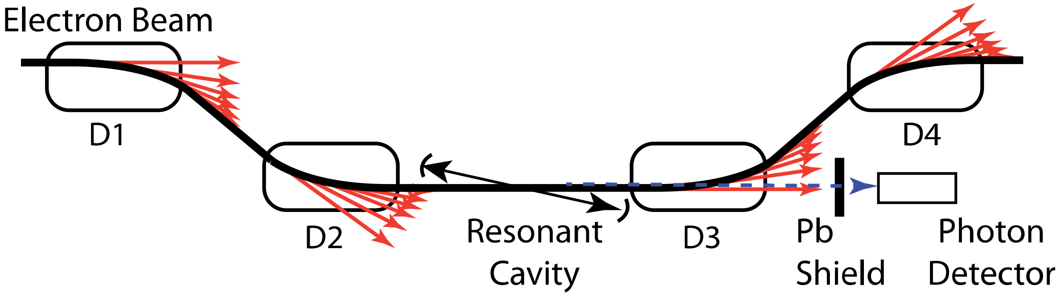
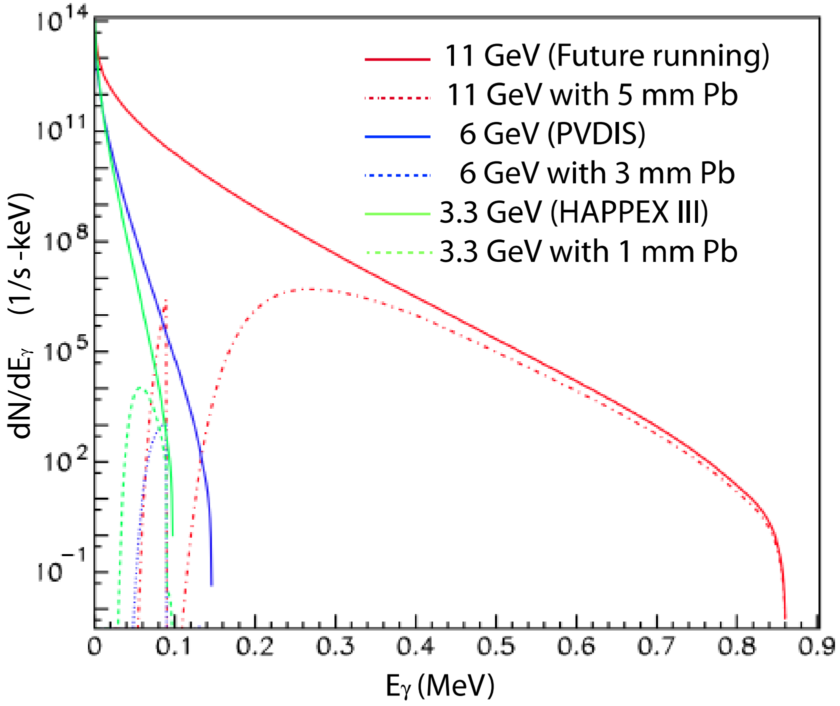
# Synchrotron Radiation at Higher Energies




Photon detector sees synchrotron radiation, primarily from dipoles 2 and 3




Before JLab 12 GeV Upgrade, synchrotron was mitigated with minimal shielding before detector
→ At 6 GeV, this was becoming less effective

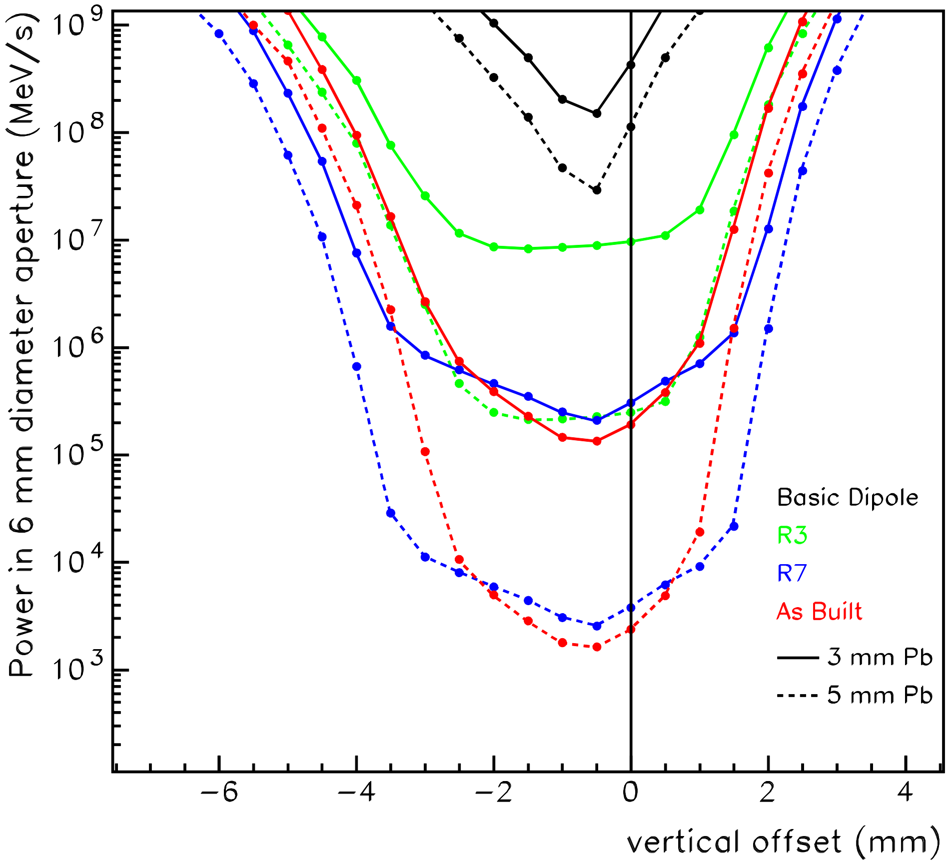
At higher energies, shielding alone not sufficient → need to mitigate source of synchrotron

J. Benesch *et al, Phys.Rev.ST Accel.Beams* 18 (2015) 11, 112401

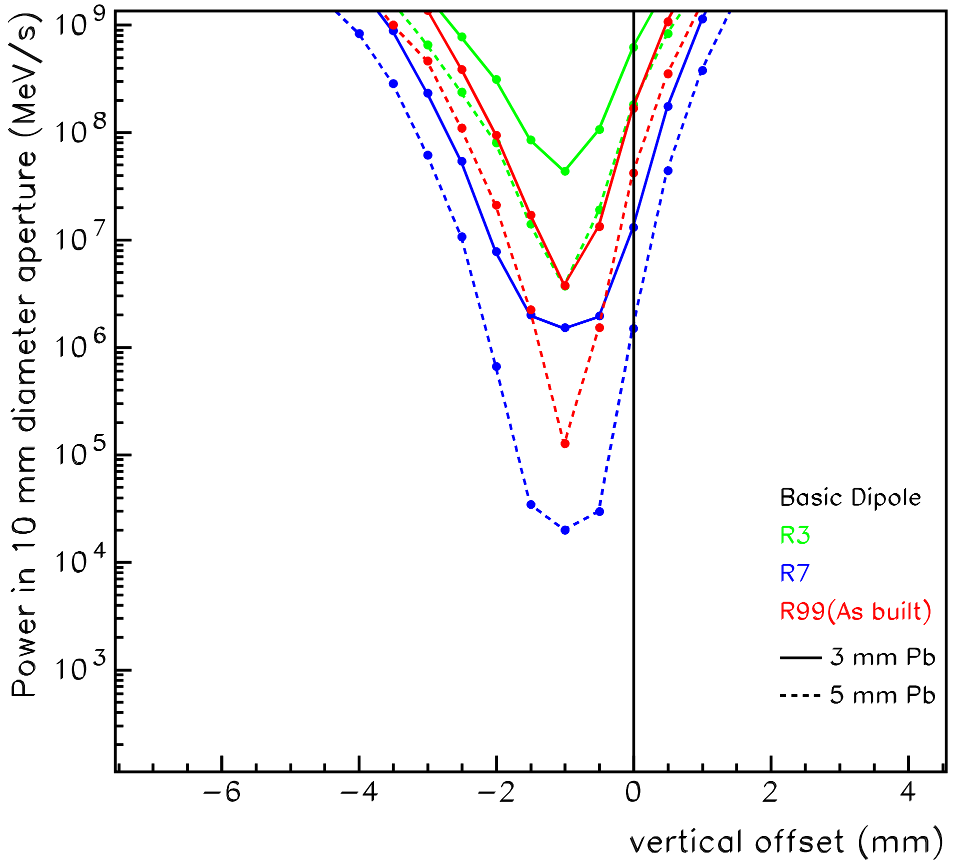
# Dipole Shims for Synchrotron Mitigation

Shims added to dipoles in chicane to extend effective length – reduce synchrotron contribution

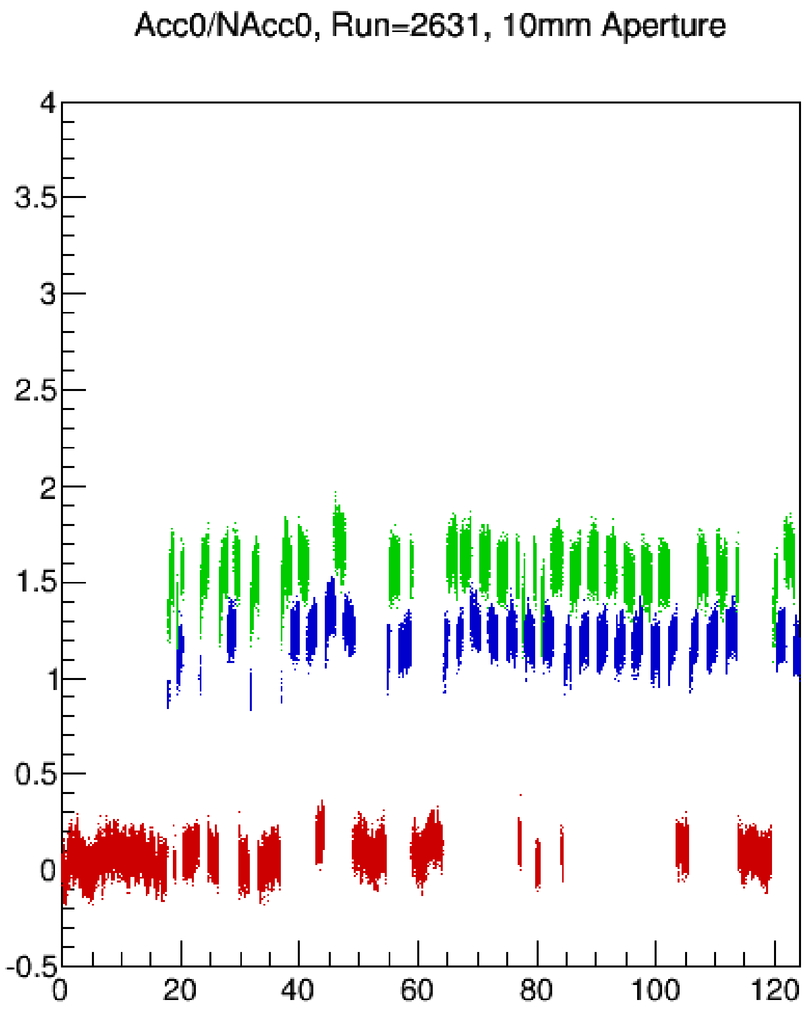
6 mm aperture

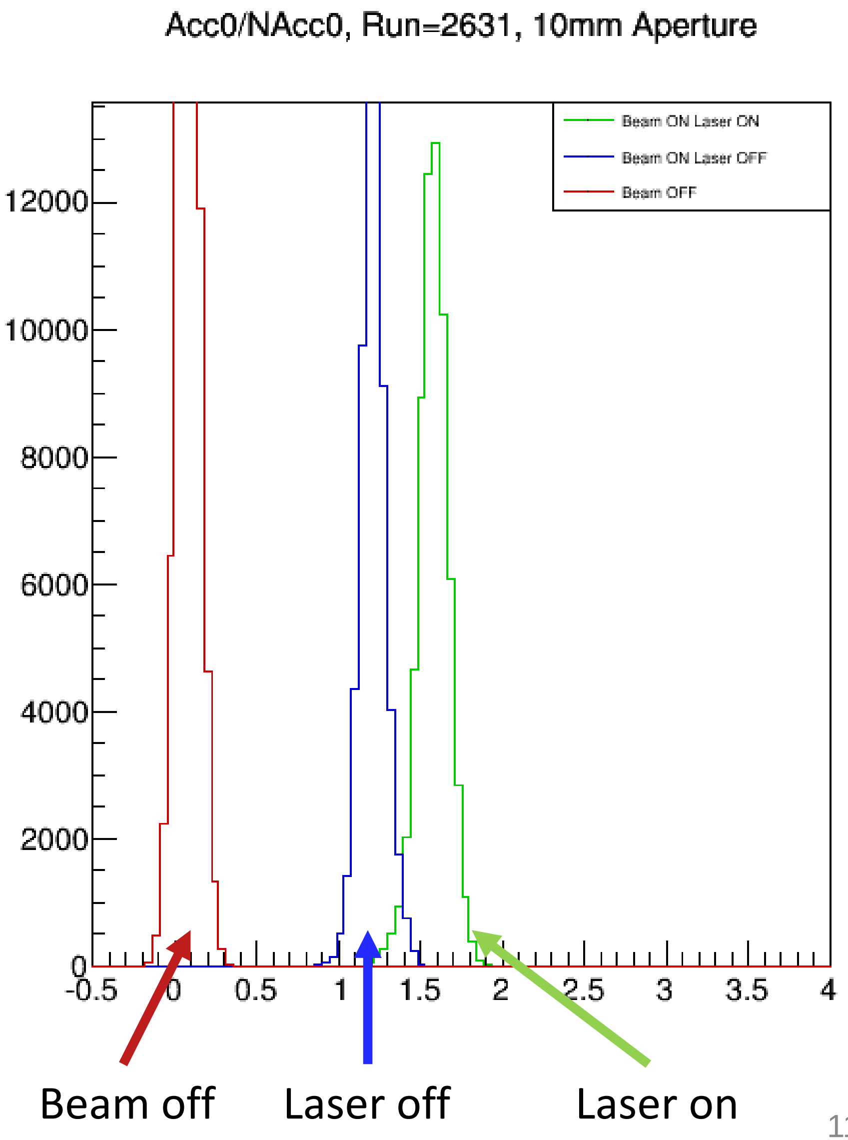



10 mm aperture

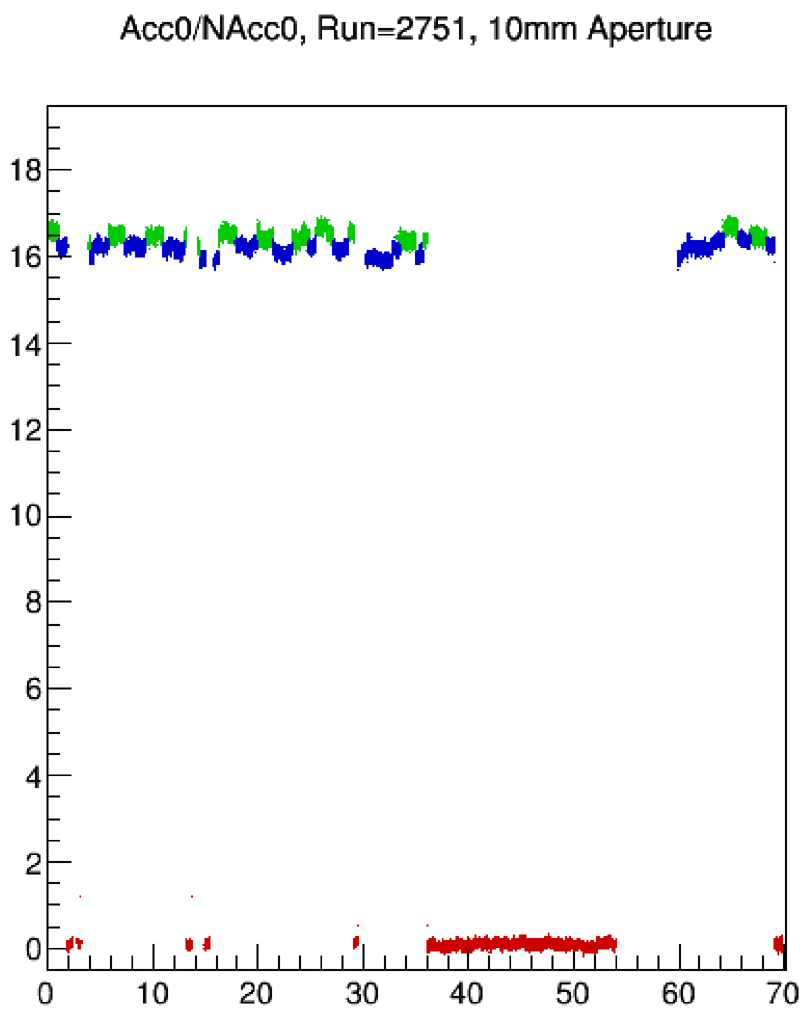


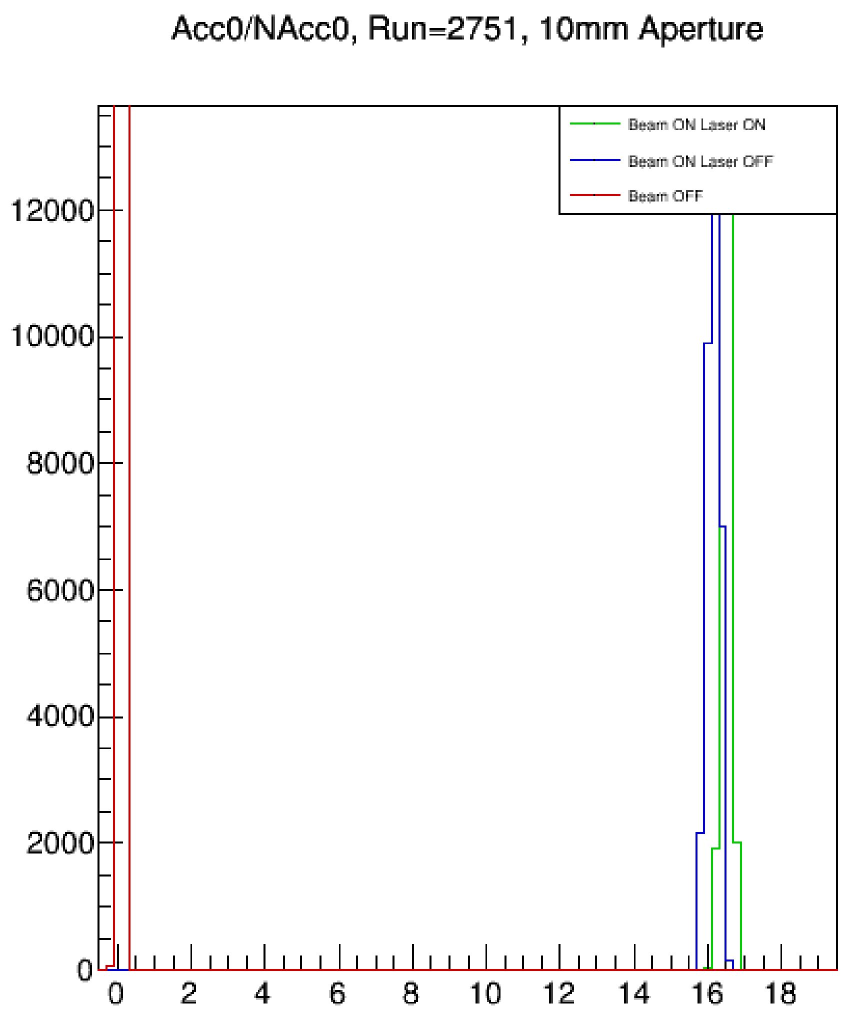
# Initial Higher Energy Running (8.5 GeV)



# Initial Higher Energy Running (10.6 GeV)

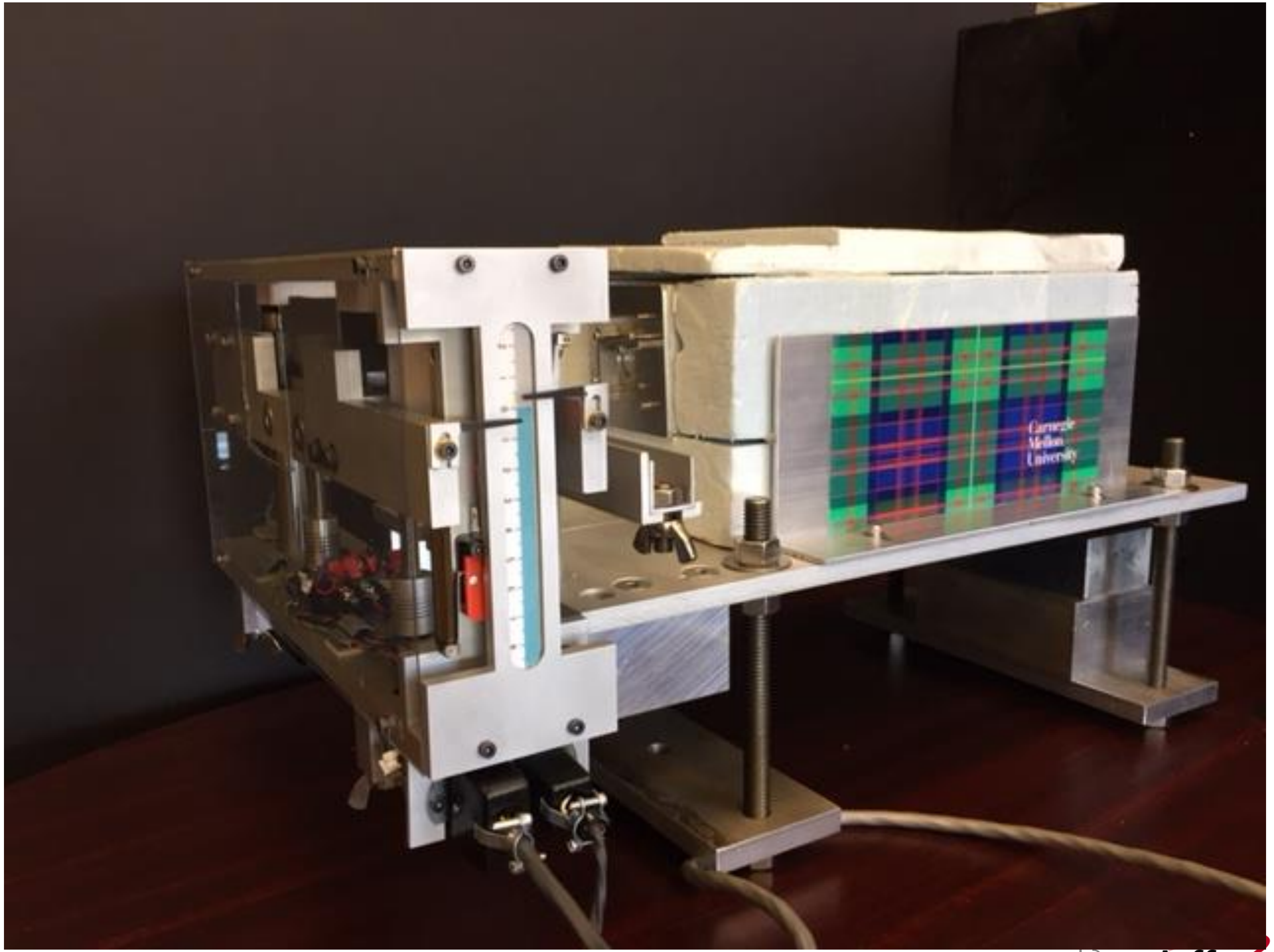



Difference between beam ON/OFF much larger → significant synchrotron radiation

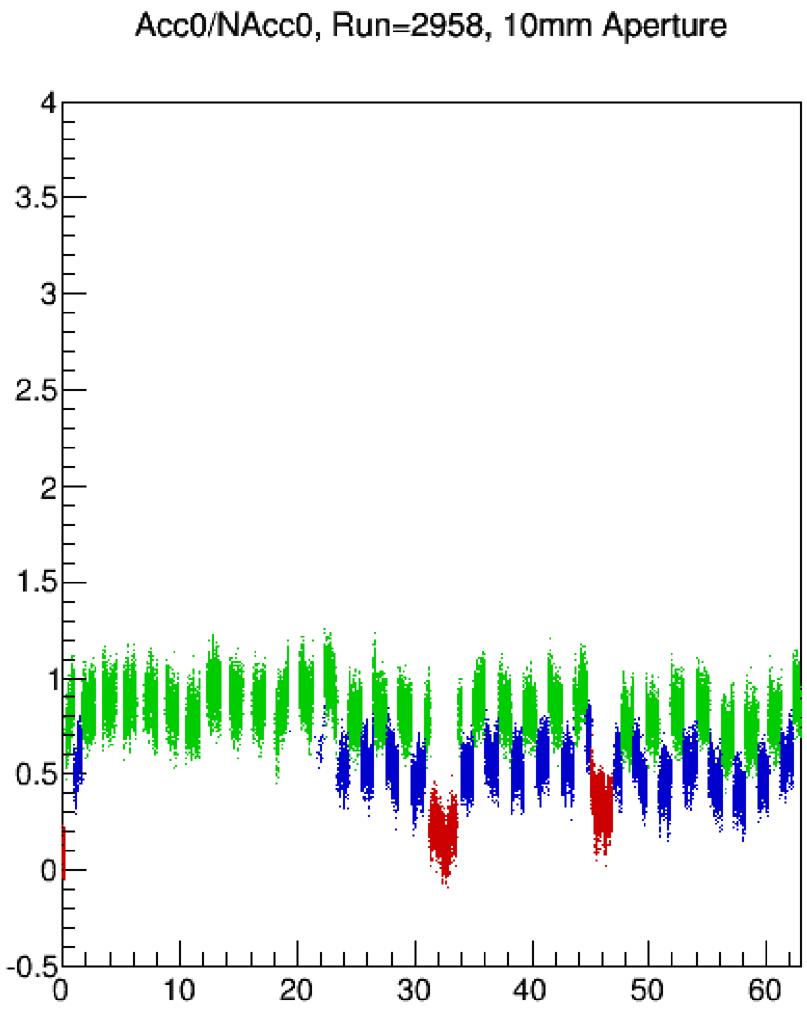
# Remotely Adjustable Collimator ("JAWS")

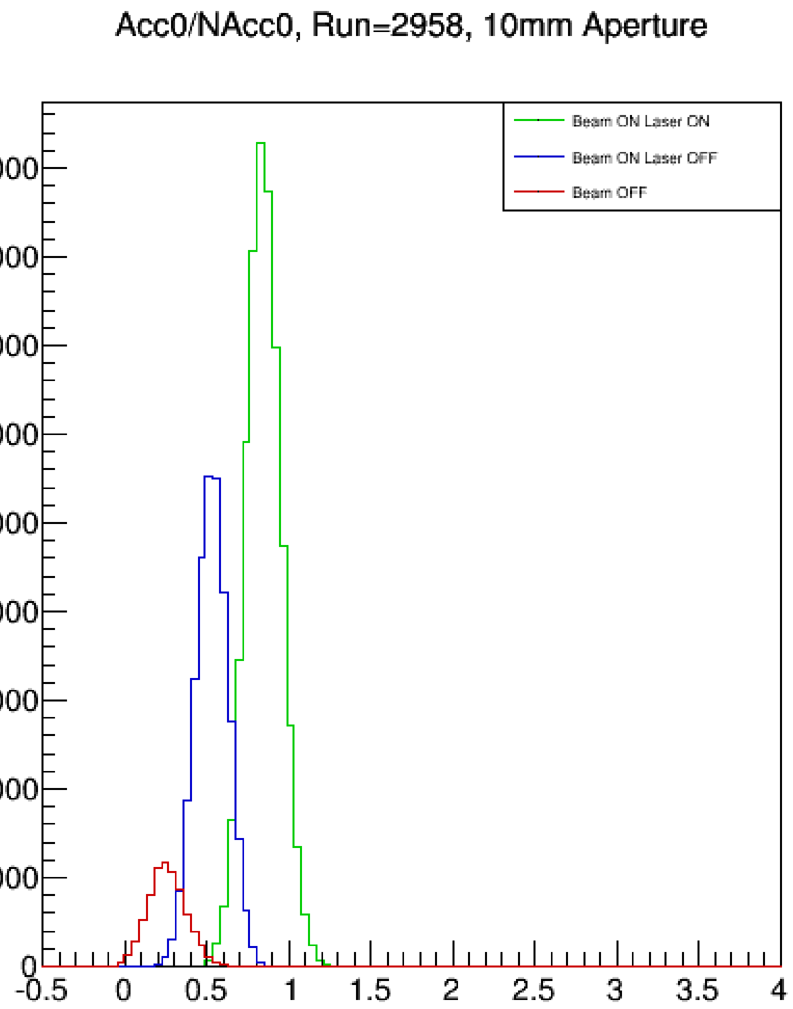
Synchrotron background primarily in vertical direction
→ Added remotely adjustable collimator to optimize signal/background



# Photon Detector with JAWS (8.8 GeV)

JAWS at 10 mm



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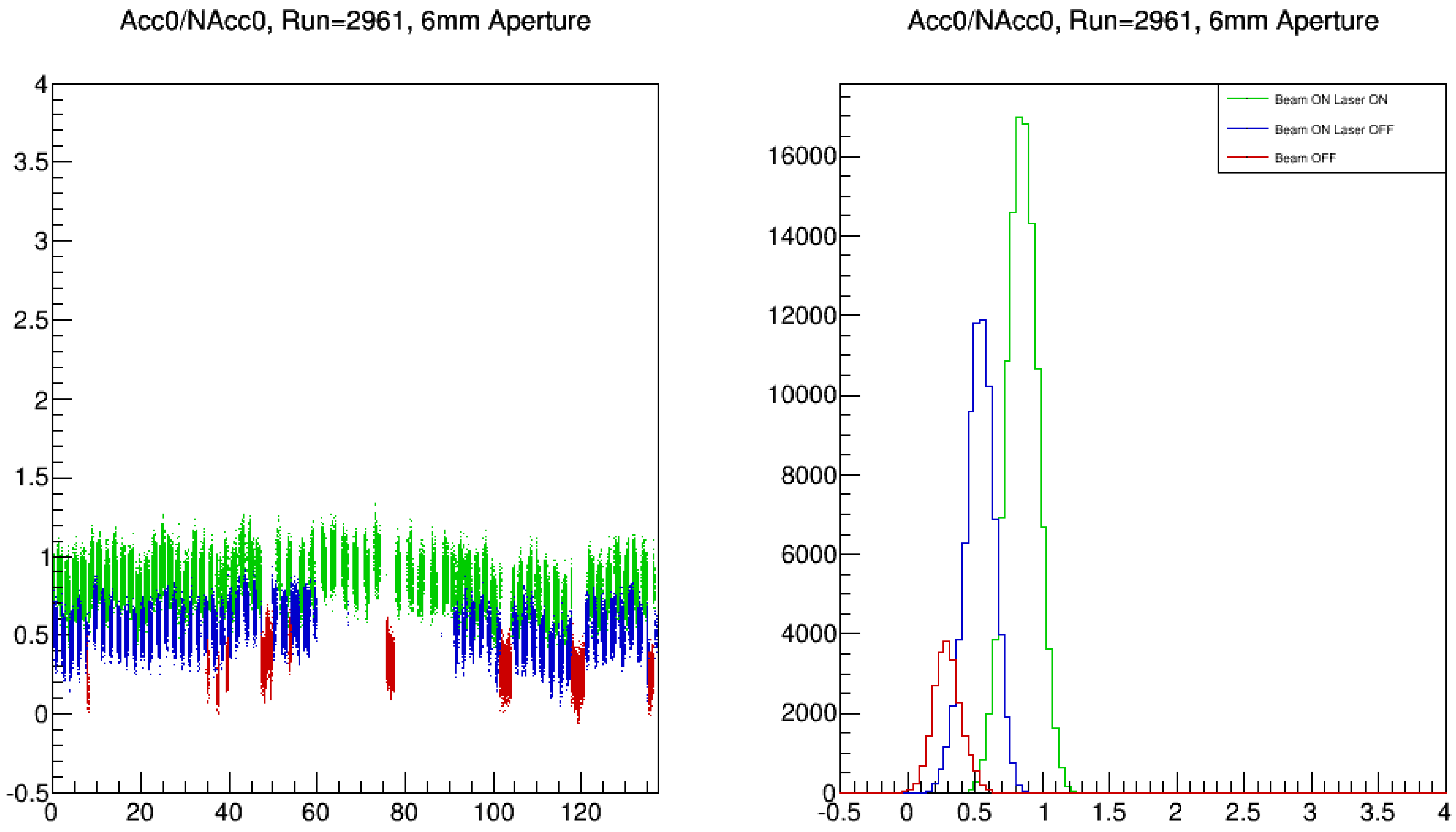
# Photon Detector with JAWS (8.8 GeV)

JAWS at 6 mm

→ Little change compared to 10 mm



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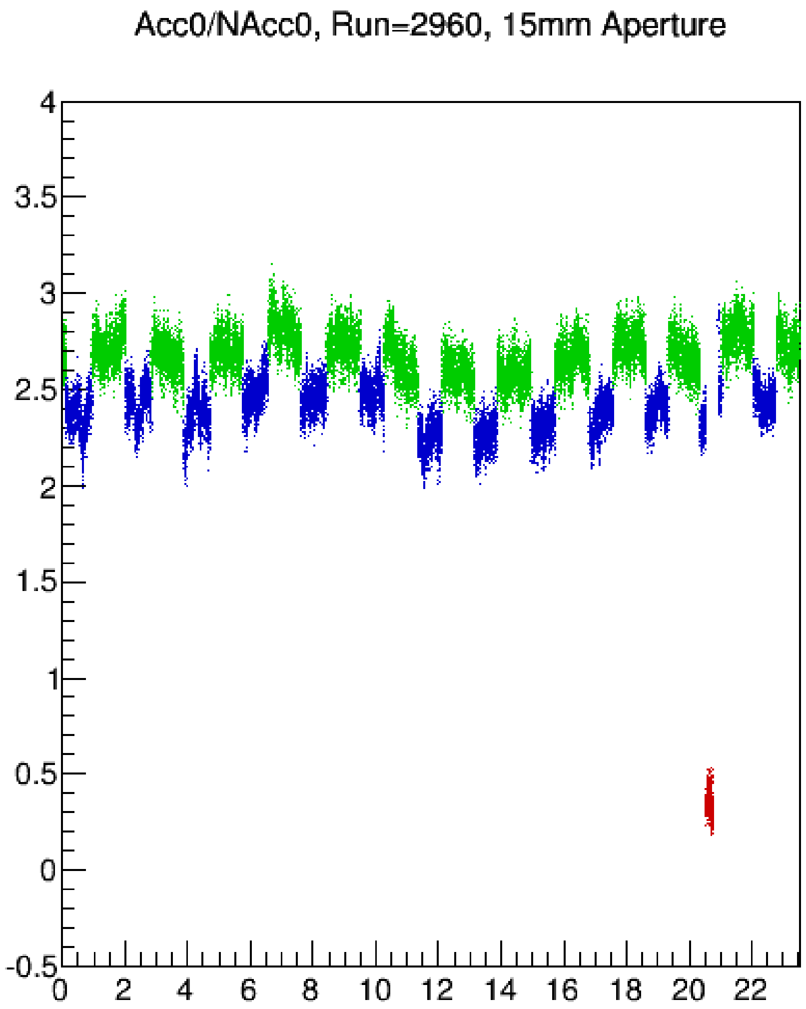
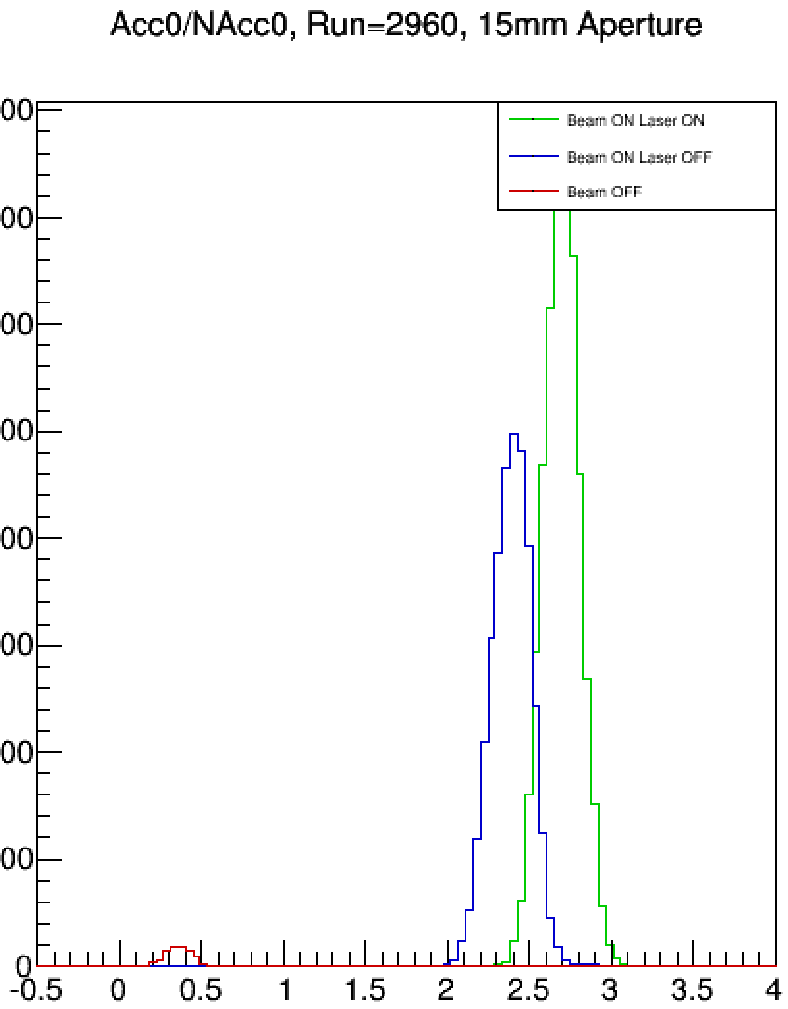
# Photon Detector with JAWS (8.8 GeV)

JAWS at 15 mm

→ Background significantly worse



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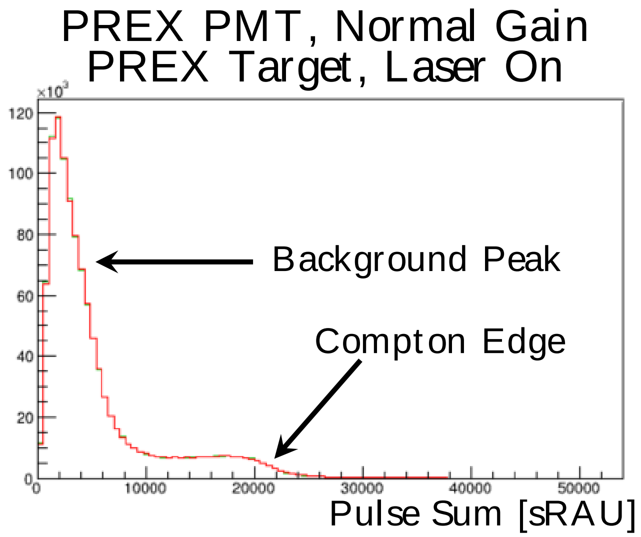
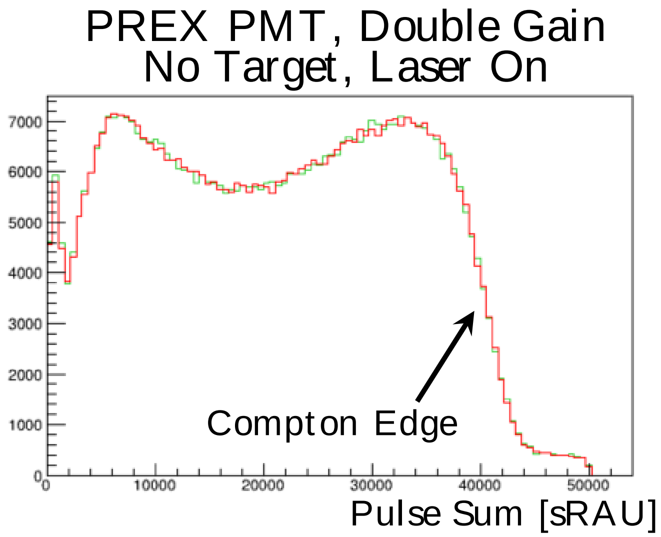
# Neutron Backgrounds

PREX experiment in Hall A used lead target to measure weak charge radius
→ Many thermal neutrons in hall when beam on target

Used Gd2SiO5:Ce (GSO) for photon detection → $^{157}$Gd has large thermal neutron capture cross section




*Allison Zec, Ph.D. thesis*

# Summary

- Dominant background at JLab Compton polarimeters due to beam interaction with material in beamline
  - Most likely small apertures in Fabry-Perot cavity
  - This background can be controlled with beam tuning – but sometimes requires much effort and time
- Bremsstrahlung not a significant issue – vacuum in Compton area generally at the few $10^{-8}$ level
- Synchrotron was not a major issue before 12 GeV Upgrade
  - Becomes a significantly worse at JLab's highest energies
  - Can be controlled with shielding and appropriate collimation (JAWS)
- In some unique circumstances, neutrons can be a problem
  - PREX experiment (lead target) and GSO detector