# IER 538: International Dosimetry Intercomparison Exercise with Godiva-IV

NCSP Technical Program Review

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# DOE Requirements

- 10 CFR §835.1304
  - *"an individual SHALL be issued a personal NAD if there is a possibility for a nuclear accident to occur resulting in excessive exposure of radiation to the individual"*

- DOE-STD-1098-2017 part 515

| particle | absorbed dose in or on a phantom (Gy) | required accuracy (%) |
|---|---|---|
| neutron | 0.1 — 10 | 30 |
| photon | 0.1 — 10 | 20 |

- ANSI/HPS N13.3 2013 (R2019)

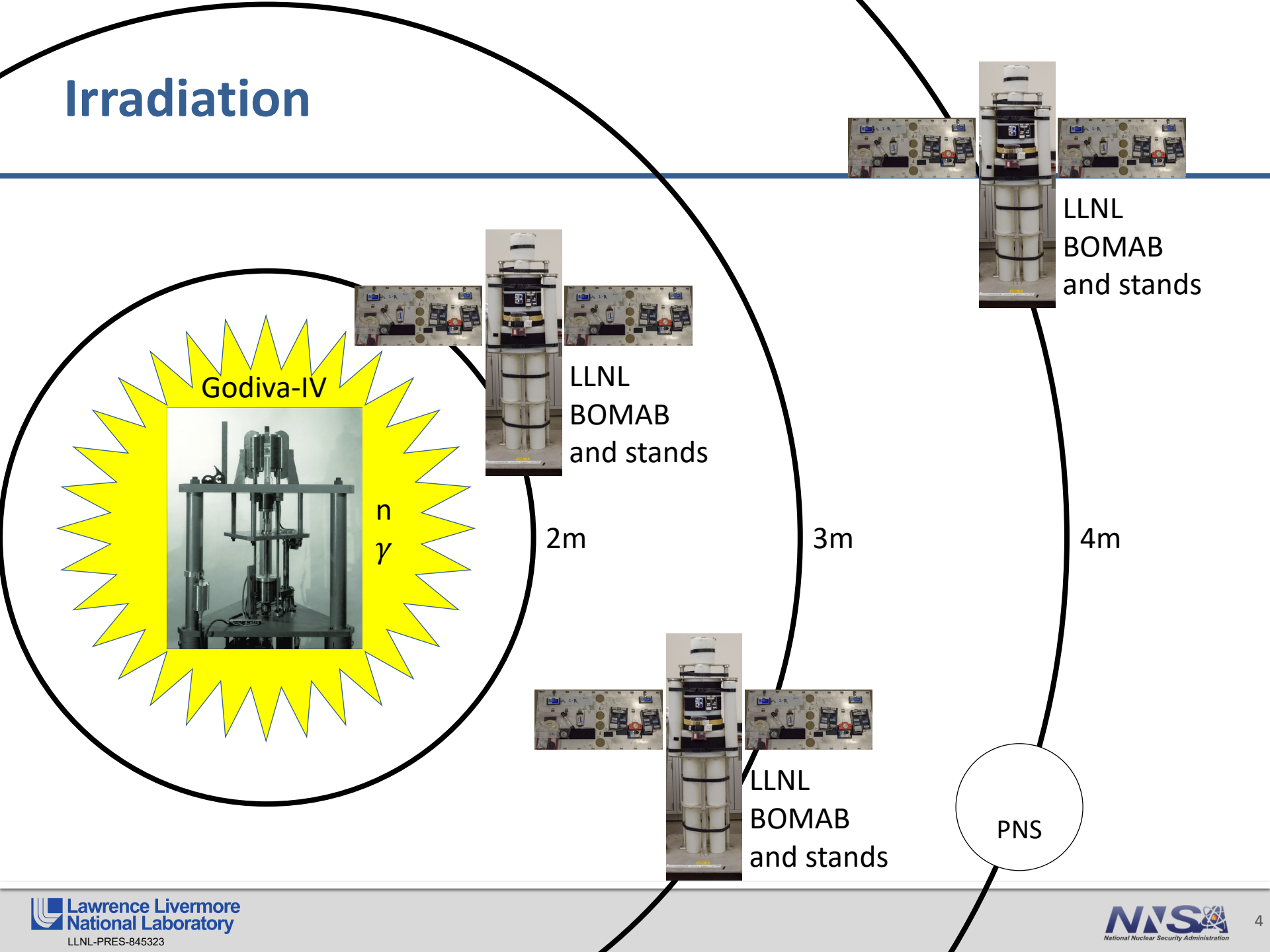
| total dose (Gy) | requried accuracy (%) |
|---|---|
| 0.1 — 1 | 50 |
| 1 — 10 | 25 |
| >10 | positive indication |

# DOE NCSP

- DOE NCSP series of dose characterization and dosimetry exercises
  - IER-147 (Godiva-IV dose characterization, 2014)
  - IER-148 (Godiva-IV intercomparison exercise, 2016)
  - IER-252 (Flattop dose characterization, 2017)
  - IER-253 (Flattop intercomparison exercise, 2018)
  - **IER-538 (Godiva-IV intercomparison exercise, 2022)**

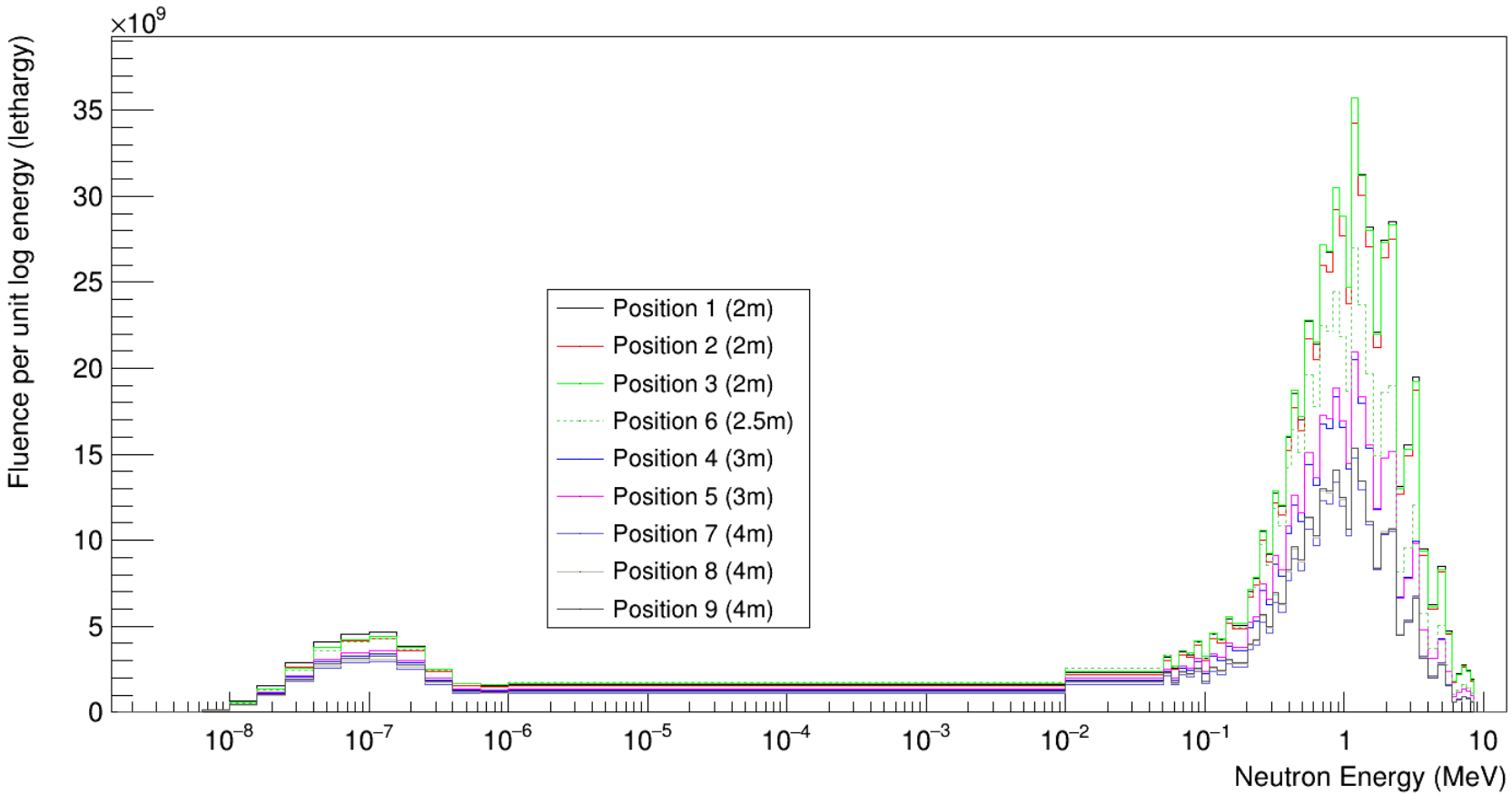
- Participating institutions:
  - LLNL, LANL, SNL, SRS, Hanford, MSTS, Y-12, NDC, AWE, and IRSN
    - 7 DOE labs
    - 1 from U.S. Navy
    - 1 from U.K.
    - 1 from France

# Irradiation



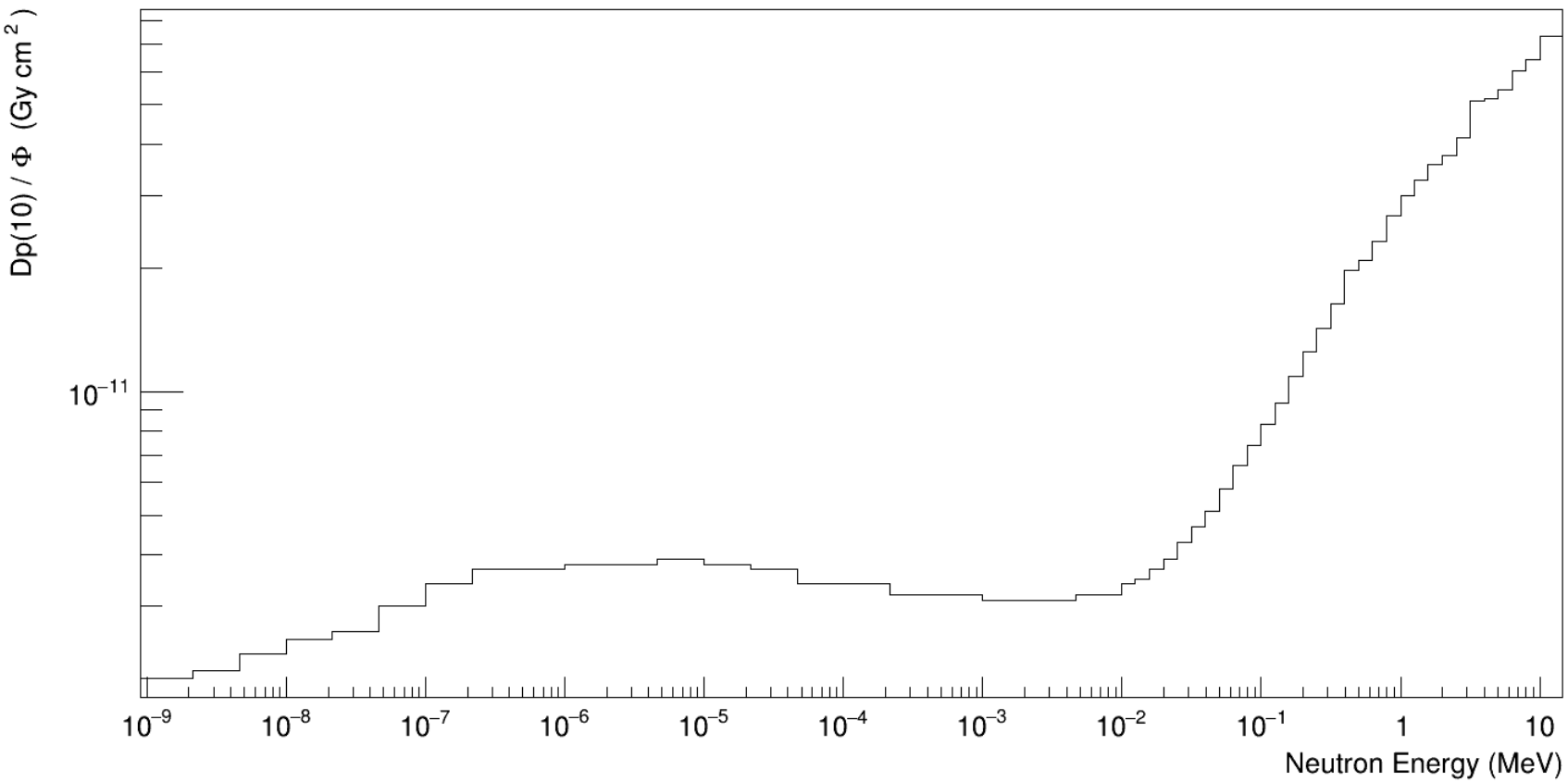
# Neutron Fluence

Neutron spectra at different distances measured by AWE for a burst change in temperature = 68.6°C (from Godiva dose characterization)



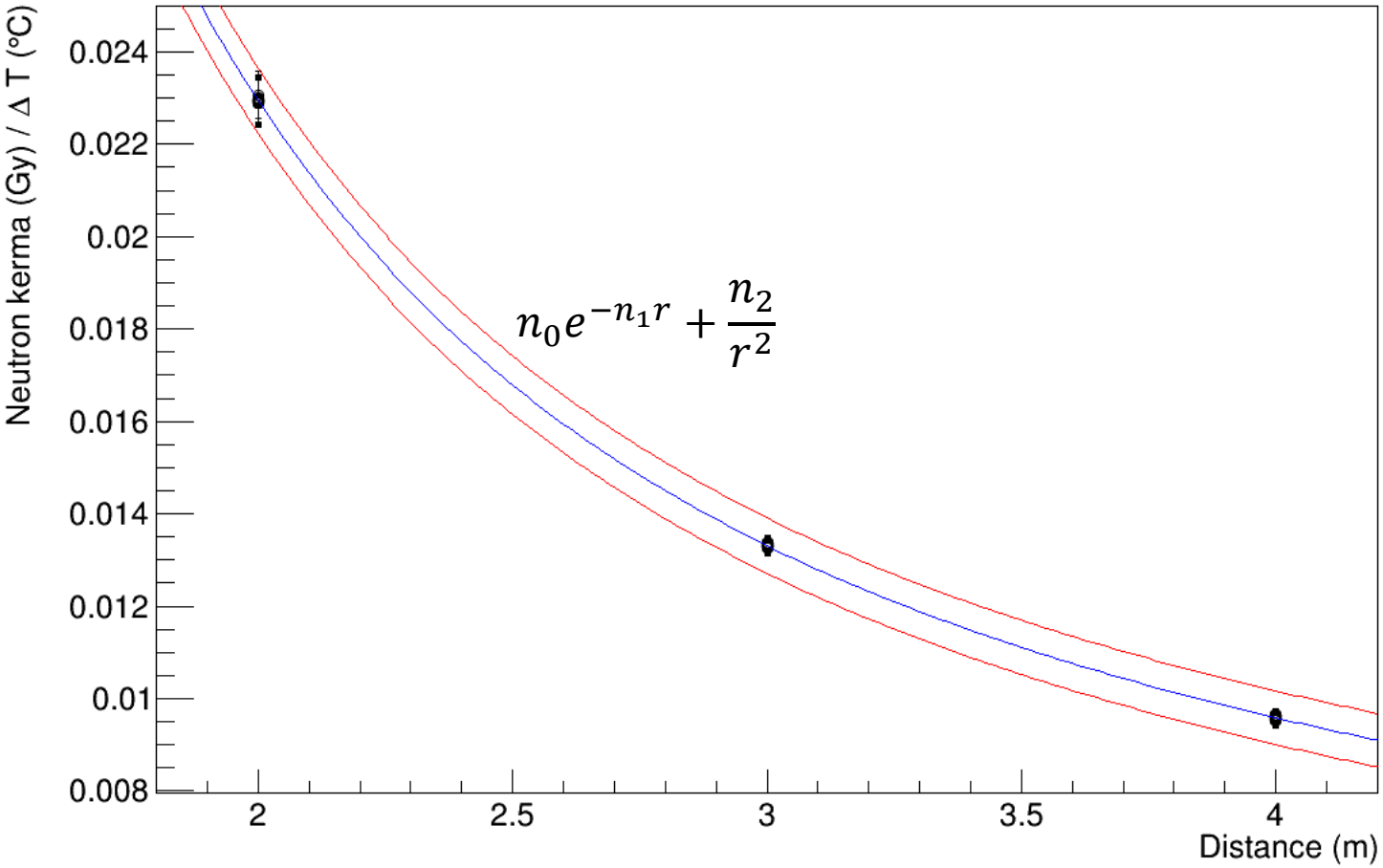
# Neutron Dose Conversion Factors

Provided in the ANSI/HPS N13.3-2013 (R2019)



# Neutron dose characterization

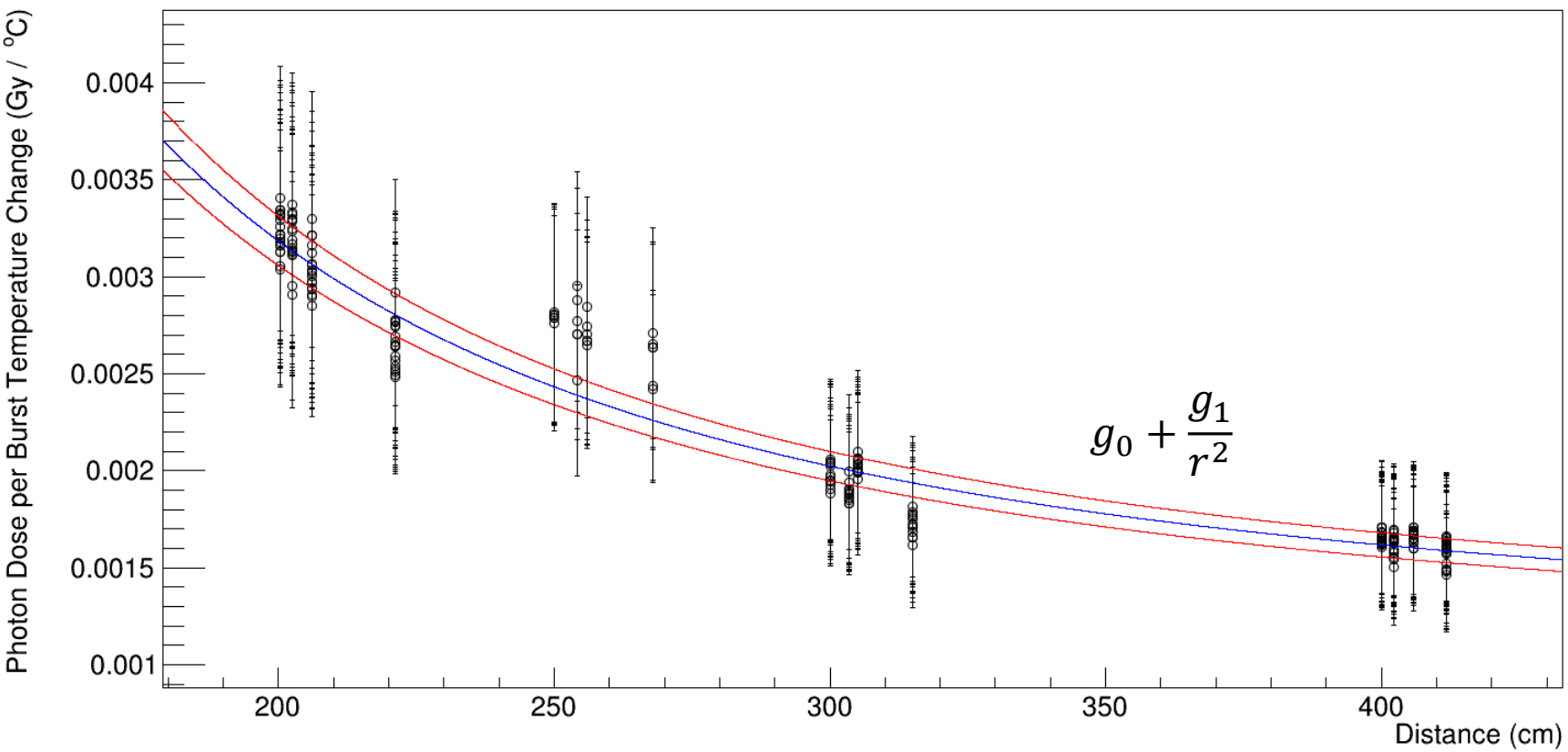
Data points are from IER-443 measurements (a more recent measurement)



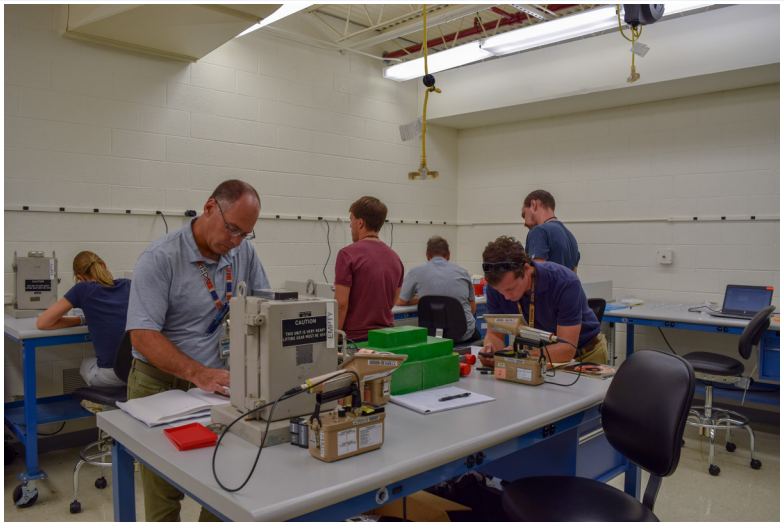

This is rescaled to the reference measurement at 68.6°C to get neutron dose.

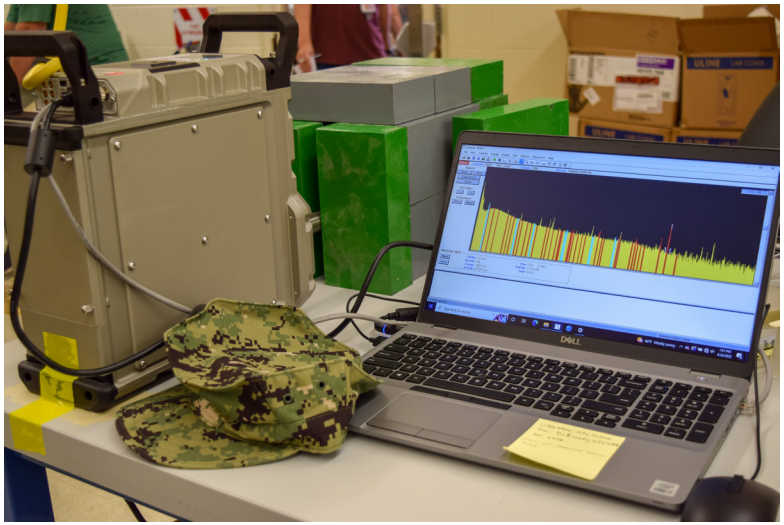
# Photon Dose Characterization

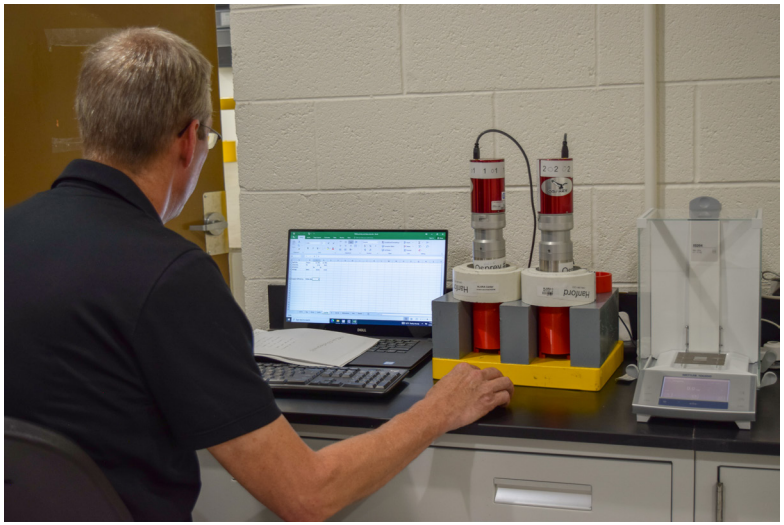
Compilation of multiple photon dose measurements for multiple bursts



# Measurement



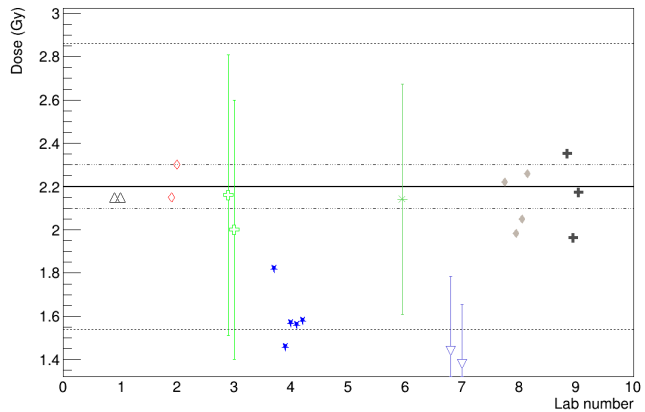



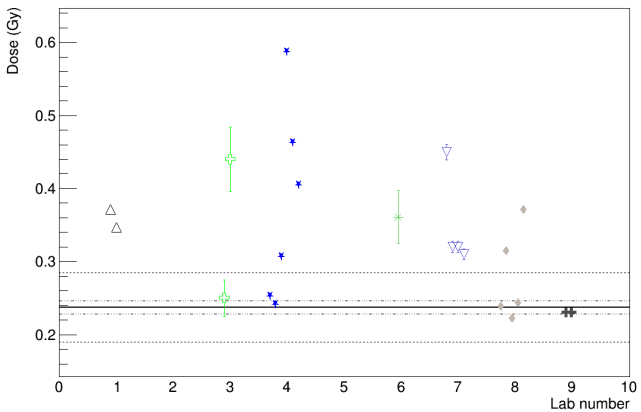


# Final Results at 2m compared to DOE standards

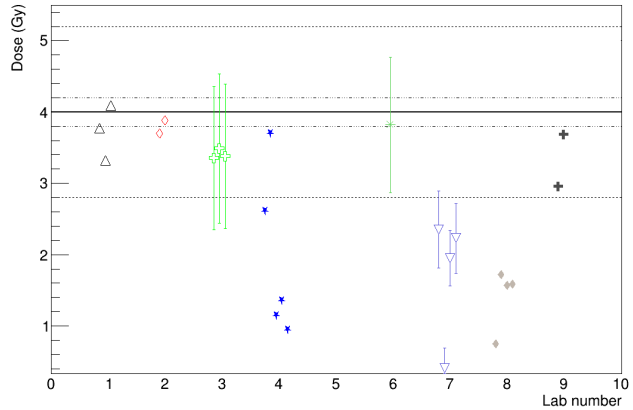
- Neutron
- Photon

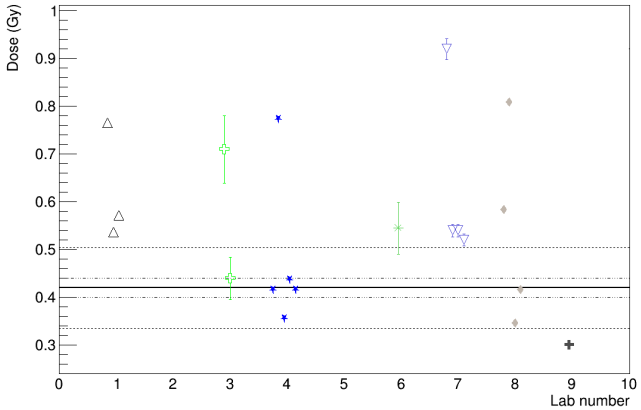
Day 1




Day 2

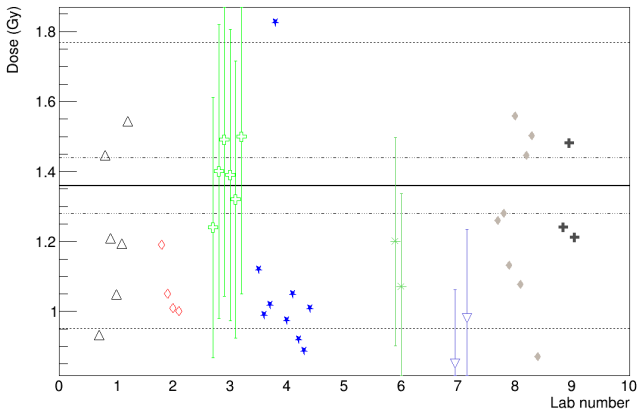


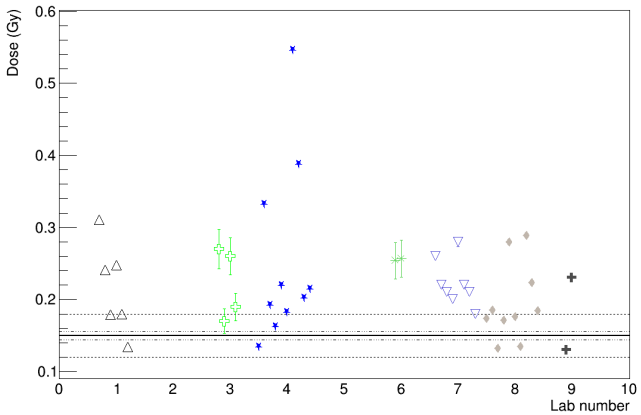



# Final Results at 3m compared to DOE standards

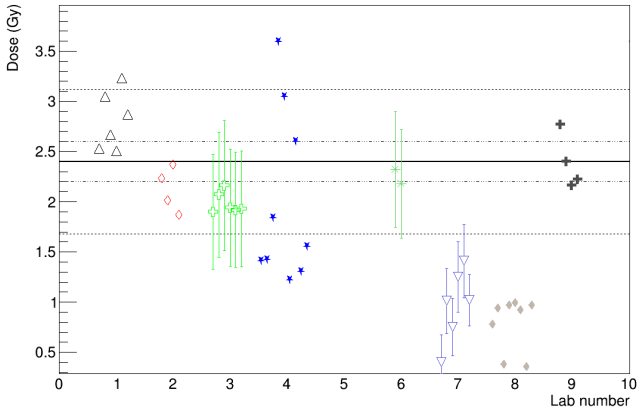
- Neutron
- Photon

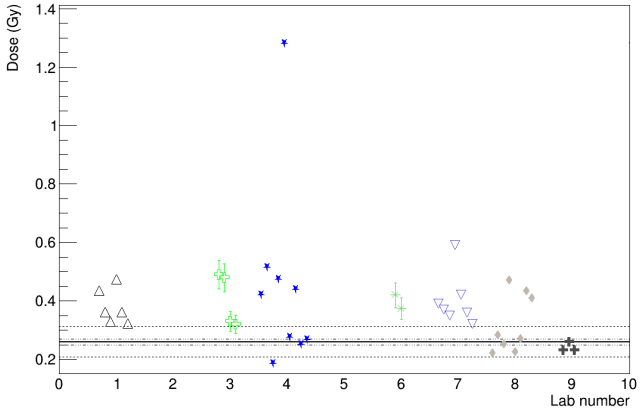
Day 1




Day 2

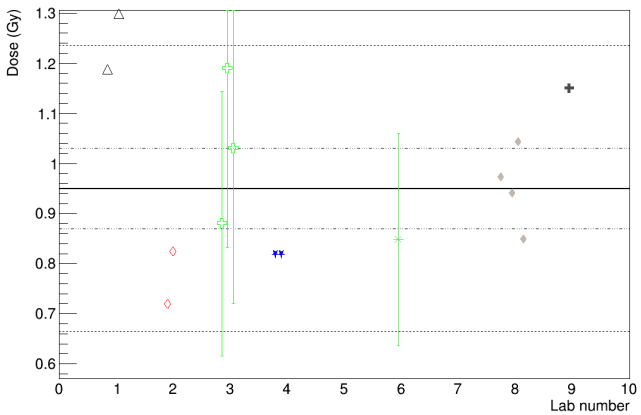


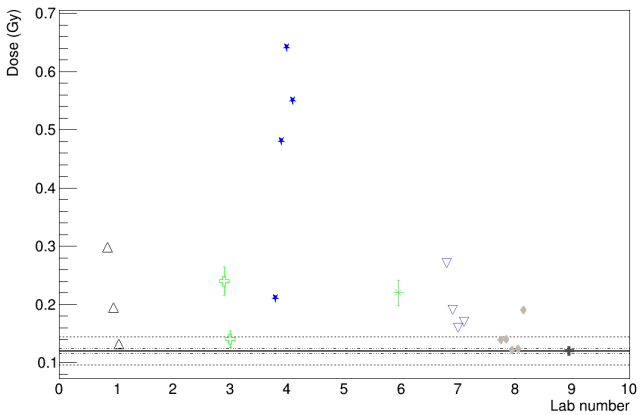



# Final Results at 4m compared to DOE standards

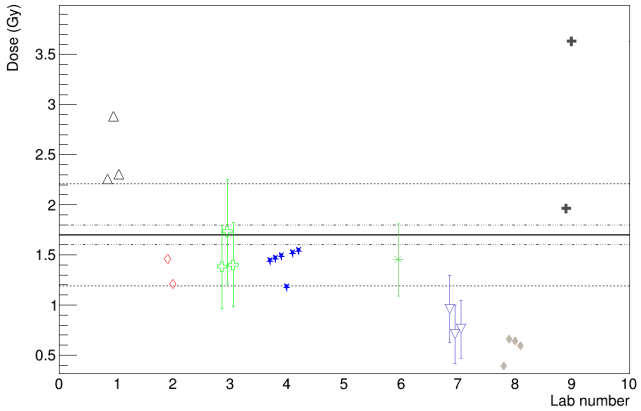
- Neutron
- Photon

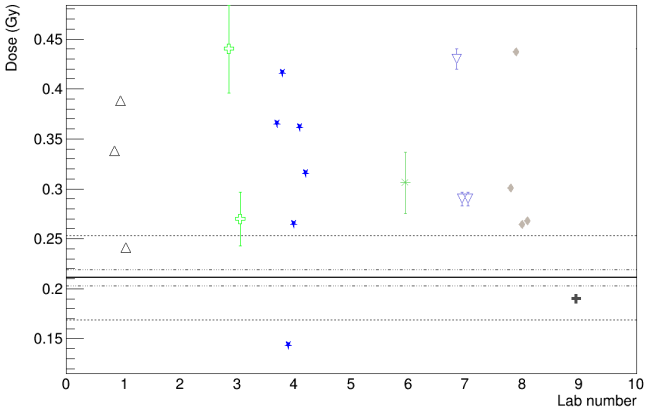
Day 1




Day 2



# Summary

| Lab | Provided Uncertainties | Below Neutron Dose Standard (%) | Above Neutron Dose Standard (%) | Outside Neutron Dose Standard (%) | Below photon Dose Standard (%) | Above photon Dose Standard (%) | Outside photon Dose Standard (%) |
|---|---|---|---|---|---|---|---|
| 1 | – | 8 | 25 | 33 | 4 | 75 | 79 |
| 2 | – | 11 | 0 | 11 | 100 | 0 | 100 |
| 3 | ✓ | 0 | 0 | 0 | 30 | 52 | 83 |
| 4 | – | 43 | 5 | 48 | 5 | 68 | 73 |
| 5 | – | – | – | – | – | – | – |
| 6 | ✓ | 0 | 0 | 0 | 0 | 100 | 100 |
| 7 | ✓ | 0 | 96 | 96 | 0 | 97 | 97 |
| 8 | – | 58 | 0 | 58 | 0 | 47 | 47 |
| 9 | – | 0 | 7 | 7 | 40 | 7 | 47 |
| Average | 33% | 27 | 5 | 32 | 22 | 56 | 78 |

Bias for lower neutron dose

Bias for higher photon dose

Not a criteria to provide uncertainty, but 1/3 of the labs provided

This is may be due to prolonged exposure of activated photons from the BOMABs (dosimeters retrieved 4 hours after irradiation)

# Conclusion

- Photon dose measurements were limited by instrumentation not available (hard to ship TLD readers)
- There has been a turnover of staff in dosimetry
  - Knowledge gaps
- DOE NSR&D is funding development of a universal nuclear accident dosimeter (U-NAD)
- Characterization of the AFRRI radiation field is scheduled for August 2023 with an exercise to follow in 2024

# Auspice


- This work was supported by the Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.
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