

# Time Series Neutron Data from Subcritical Experiments for Validation of Radiation Transport Codes

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# Introduction

- 5 subcritical benchmark experiments
- Inherently Safe Subcritical Assembly (ISSA)
  - Existing asset as a training assembly
  - Modified to reduce uncertainties



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- 5 subcritical benchmark experiments
- Inherently Safe Subcritical Assembly (ISSA)
  - Existing asset as a training assembly
  - Modified to reduce uncertainties
- Motivation
  - Validation of radiation transport codes
  - Evaluation of nuclear data
  - Characterization of fissile material systems

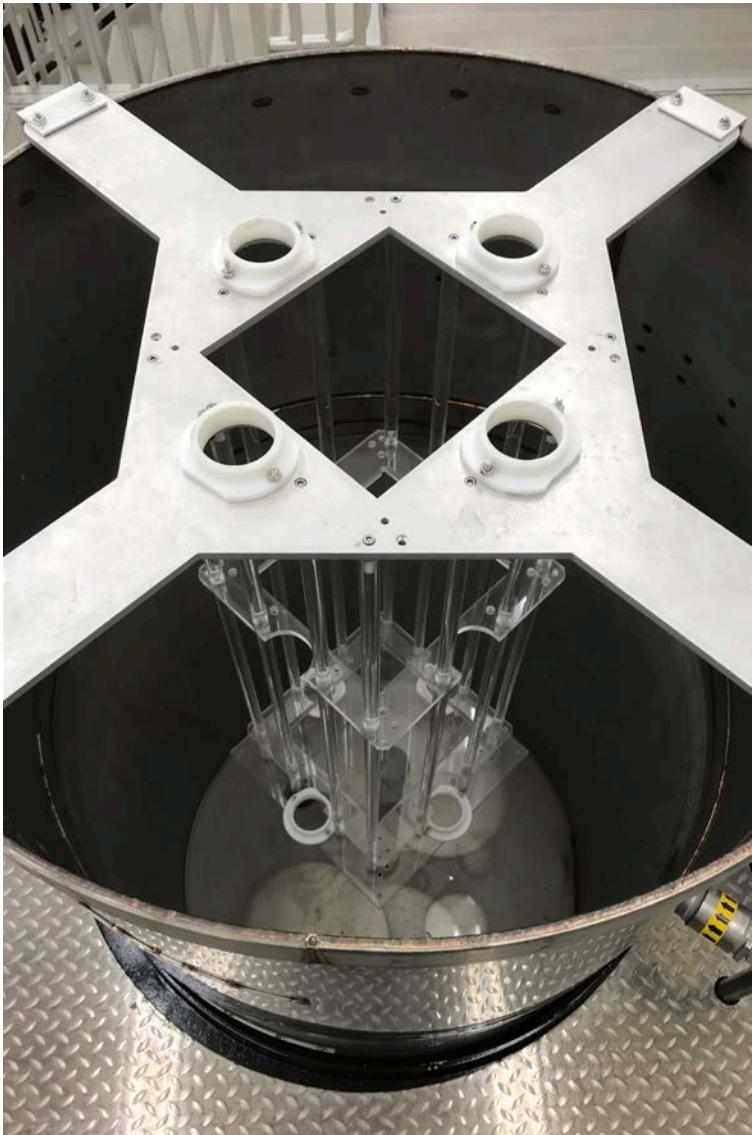


# ISSA Fuel Elements

- 93.16%  $^{235}\text{U}$
- $\text{U}_3\text{O}_8$  powder + aluminum powder
- Sandwiched between aluminum plates
- 19 curved plates per assembly
- 232 g  $^{235}\text{U}$  per assembly

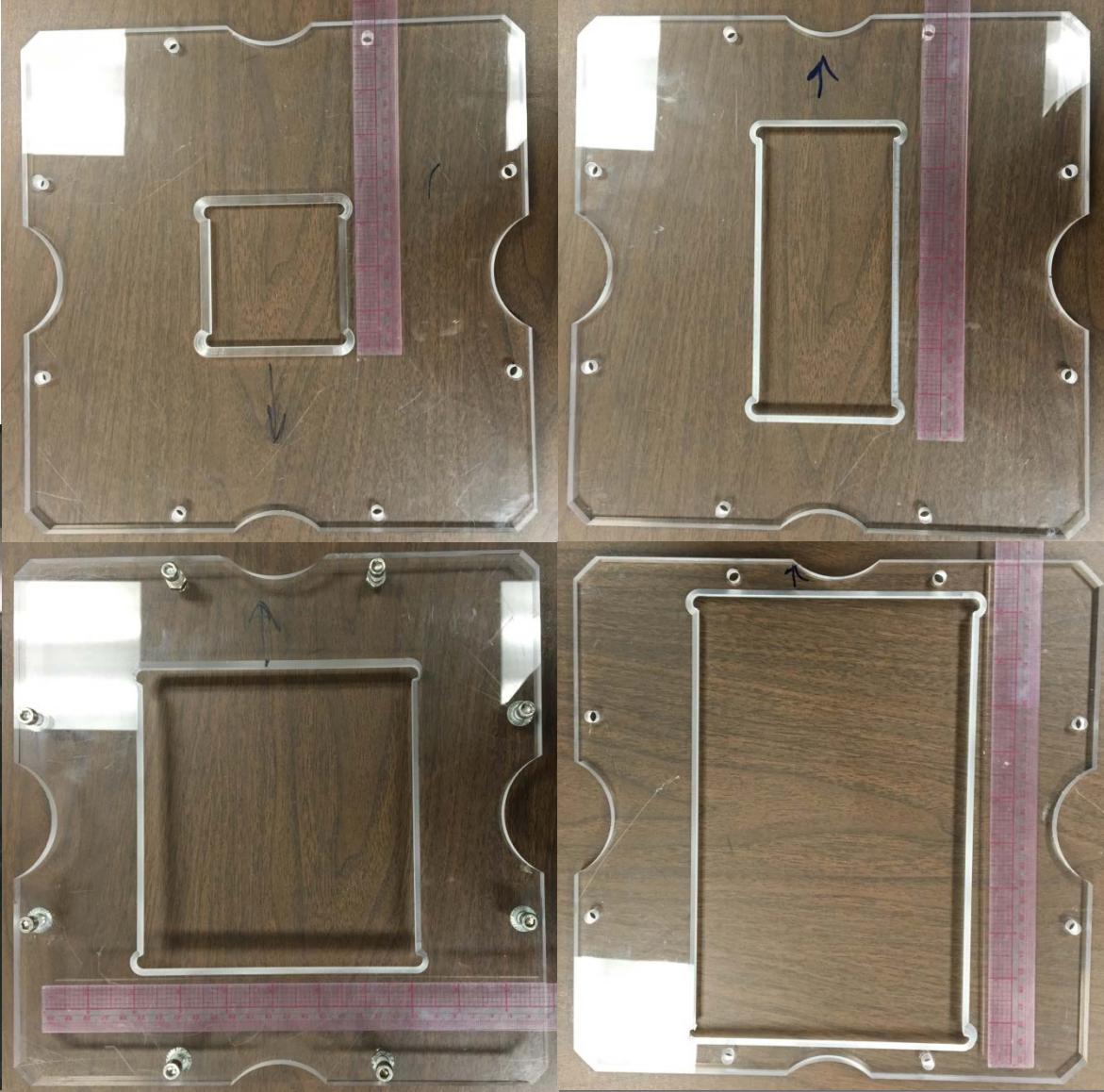
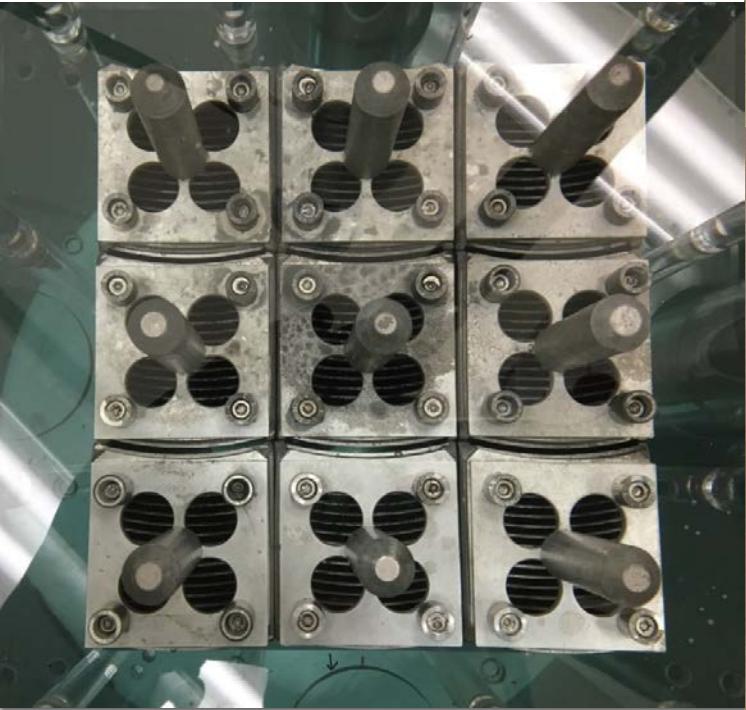


# Detectors and Alignment Fixture

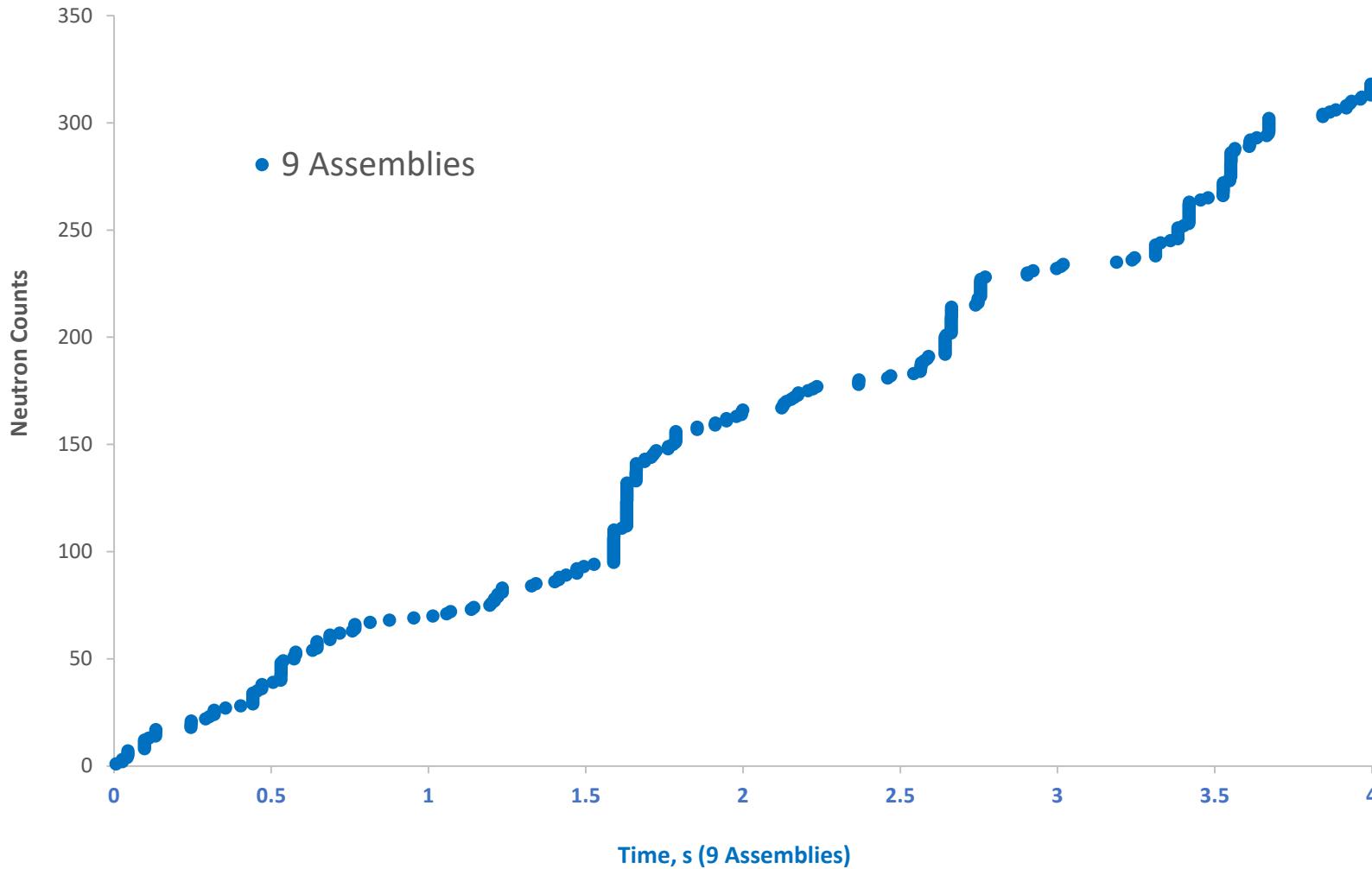


# Experimental Configurations

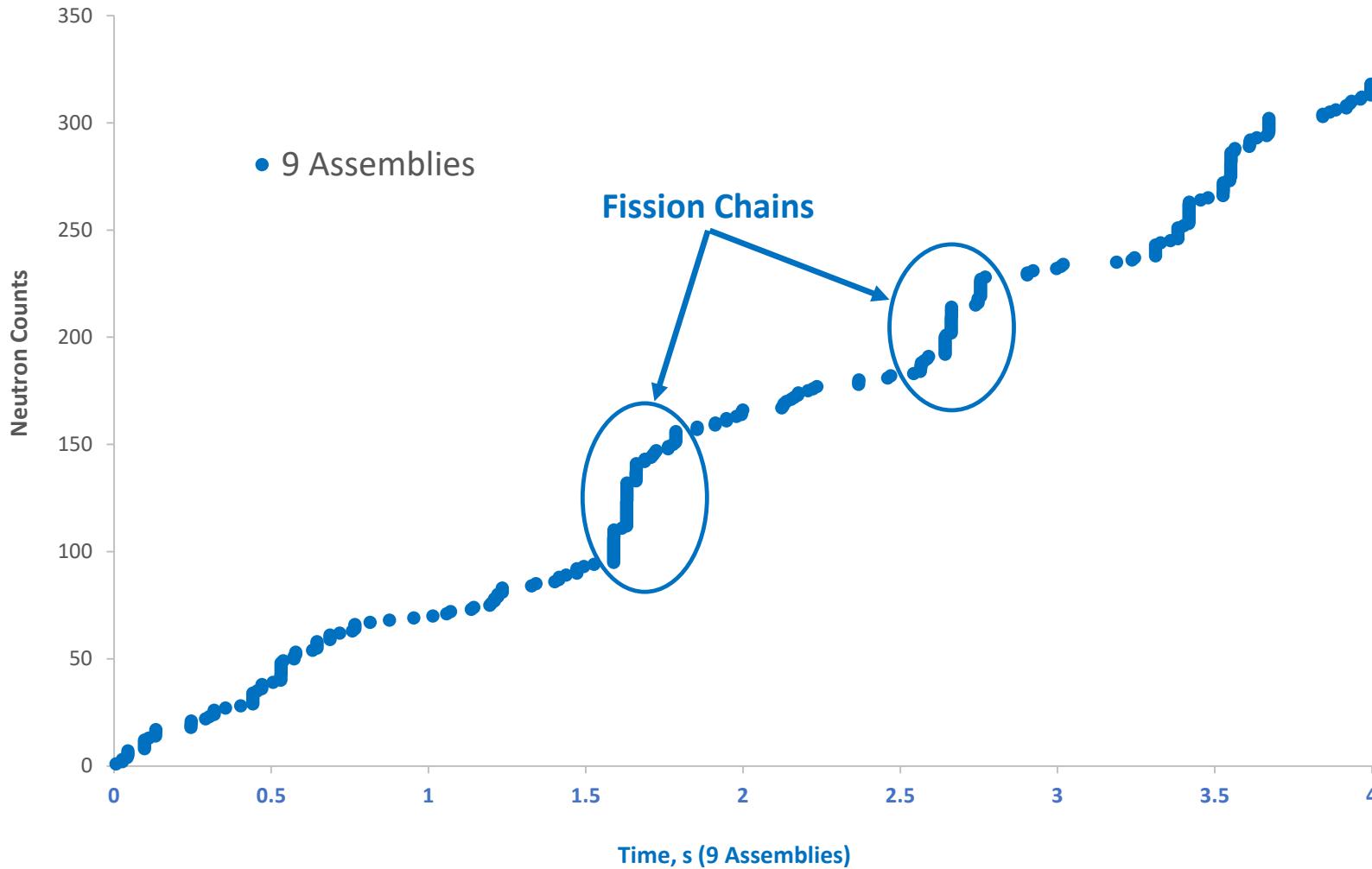
- 5 Experiments
  - 1, 2, 4, 6, and 9 assemblies
- Multiplication between 1.8 and 10.9



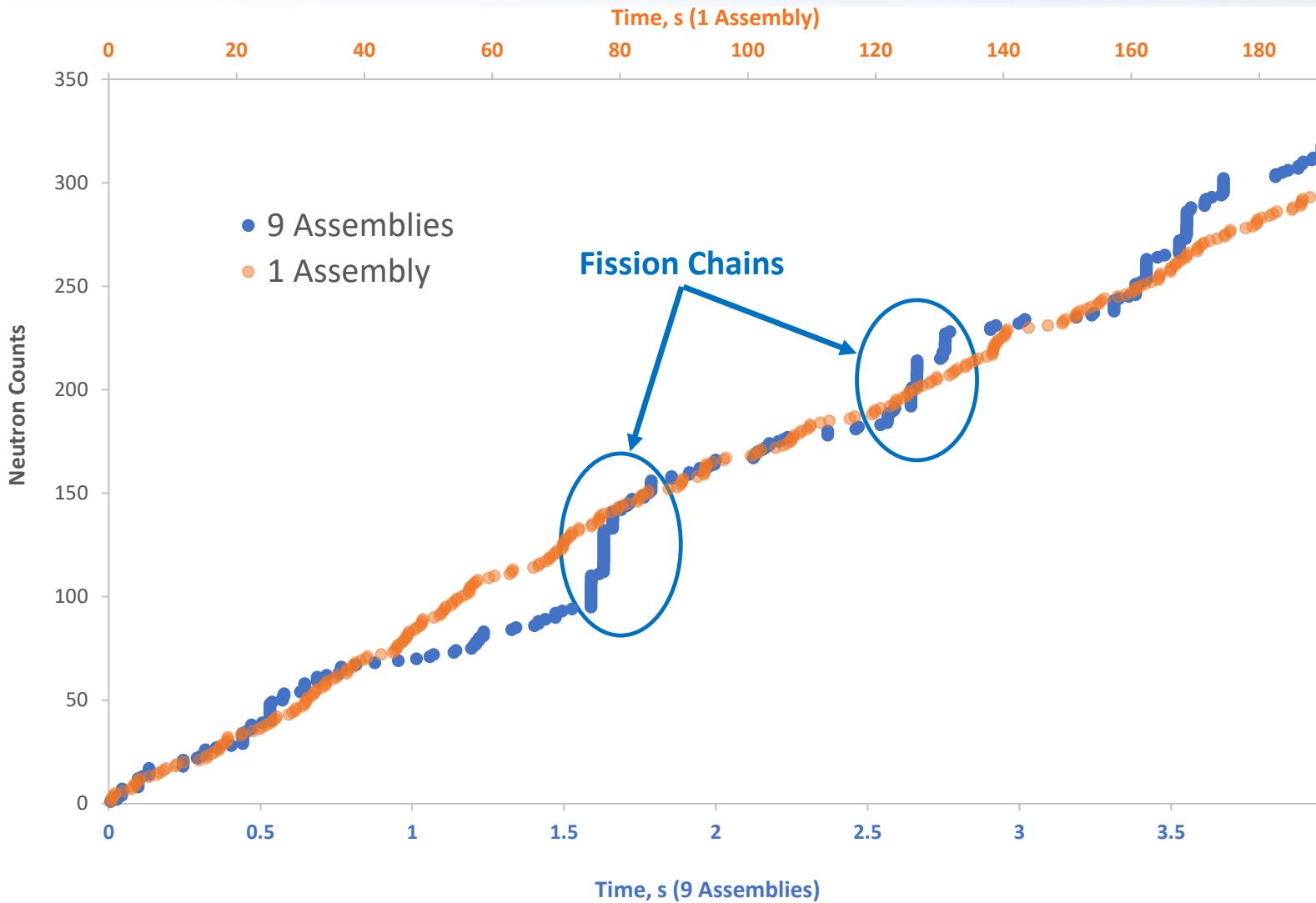
# Experimental Results



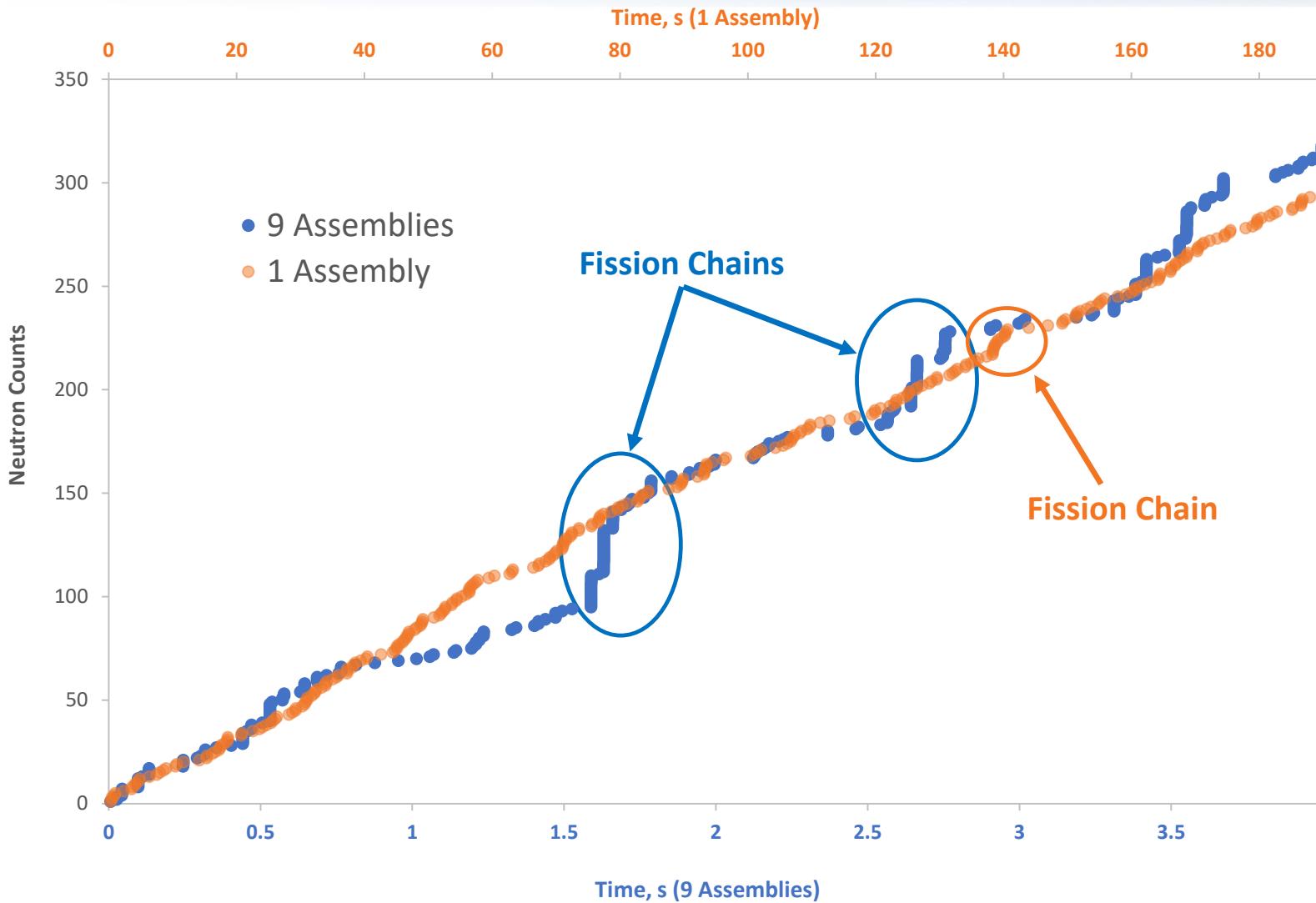
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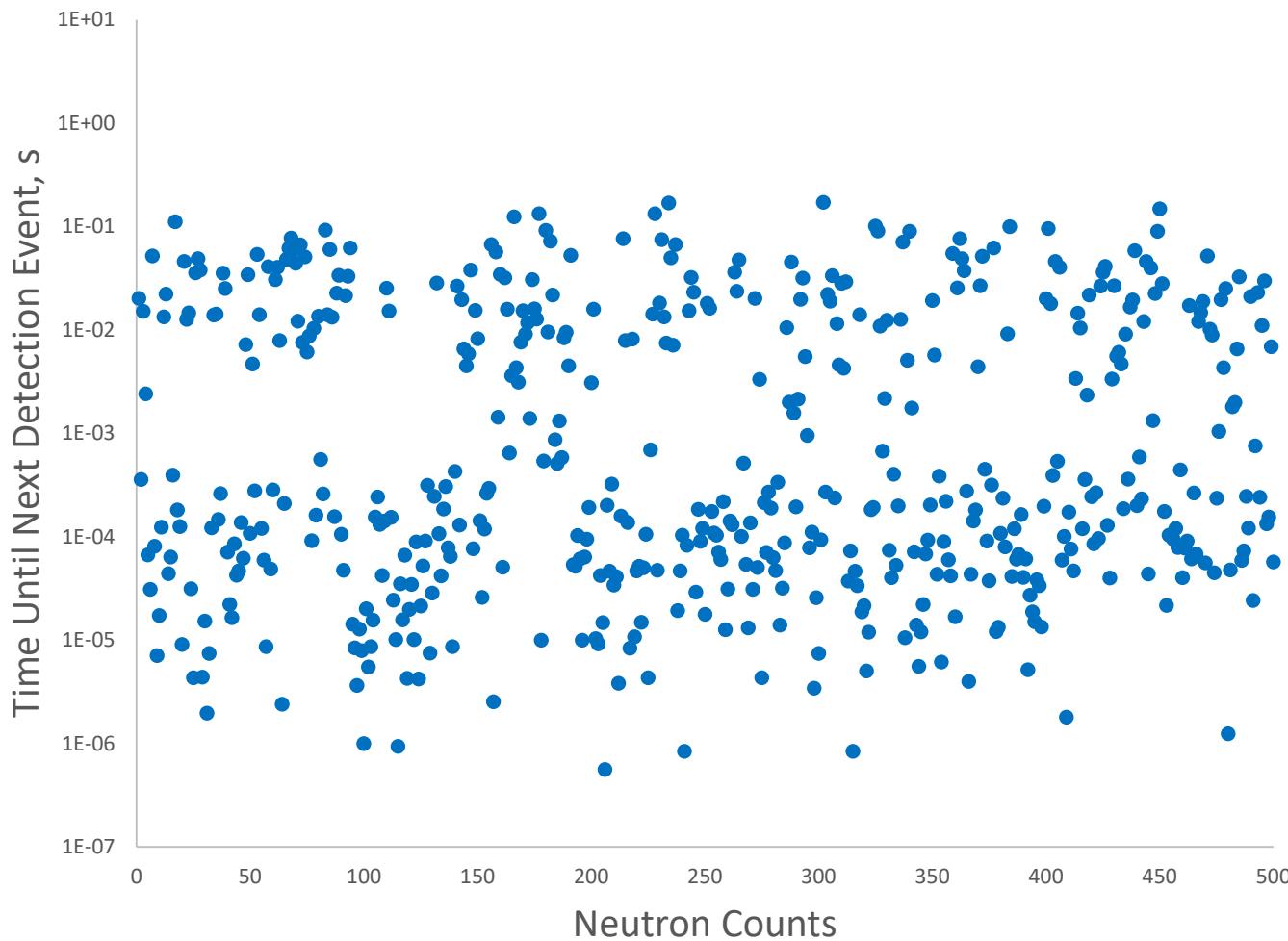


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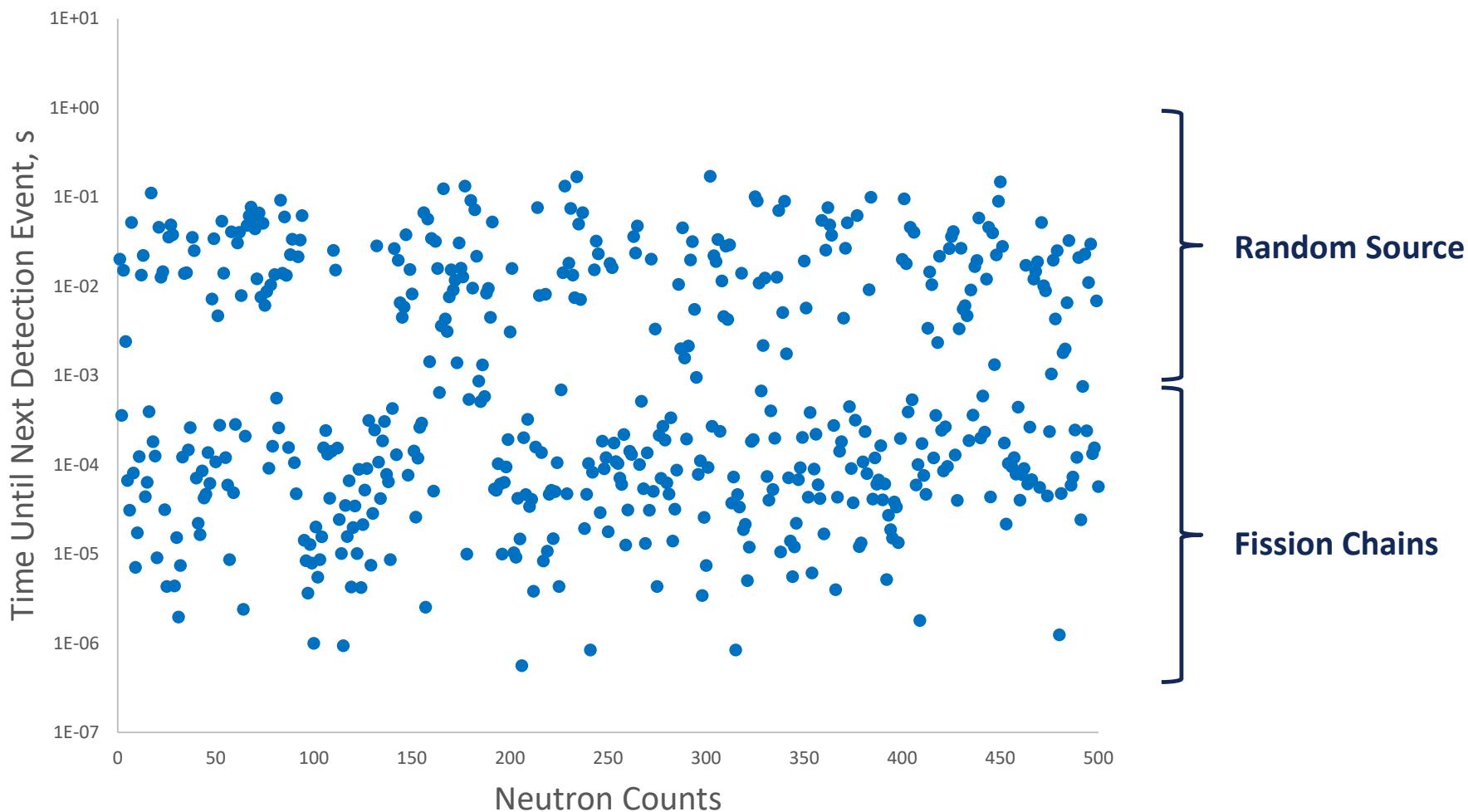
# Experimental Results

• 9 Assemblies

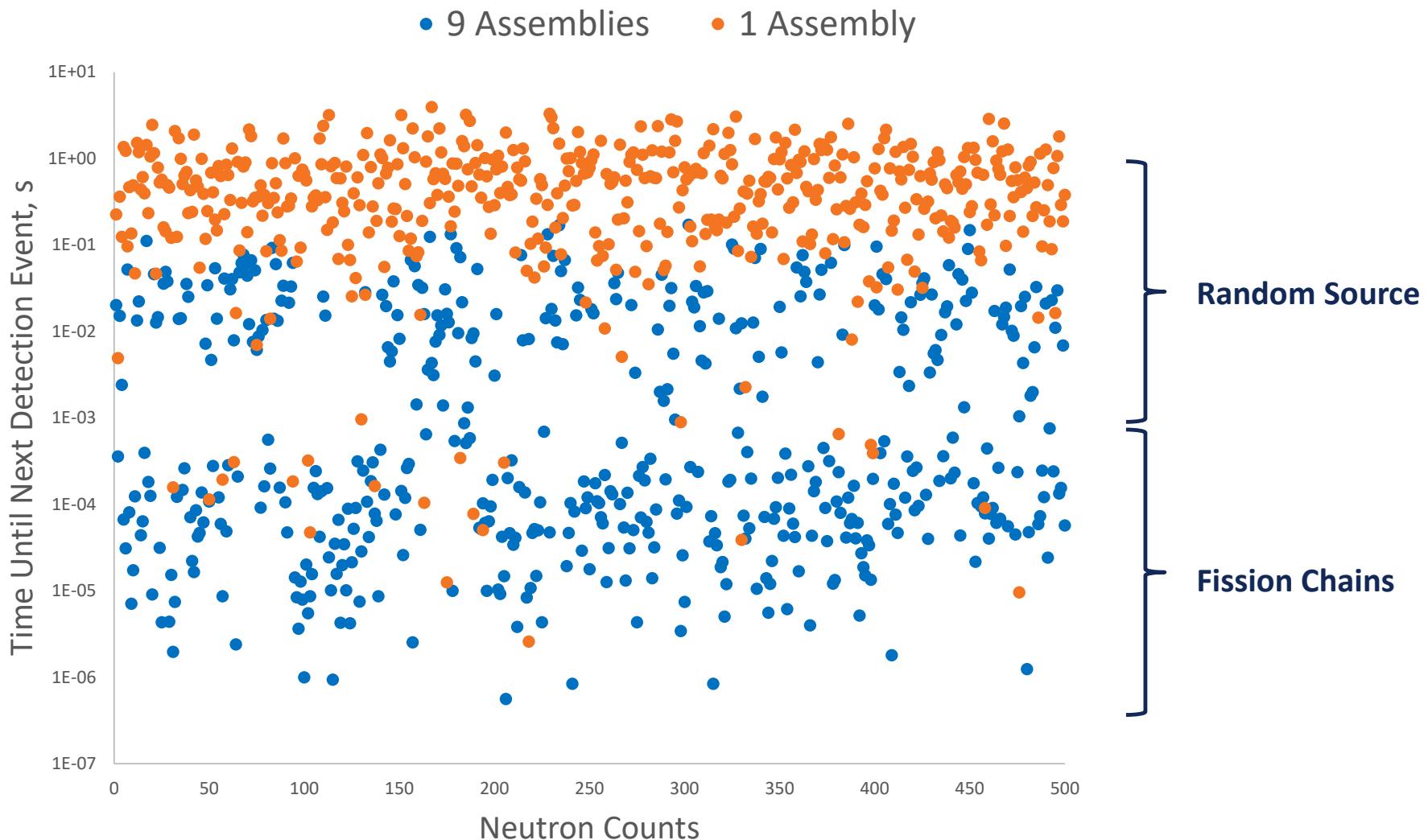


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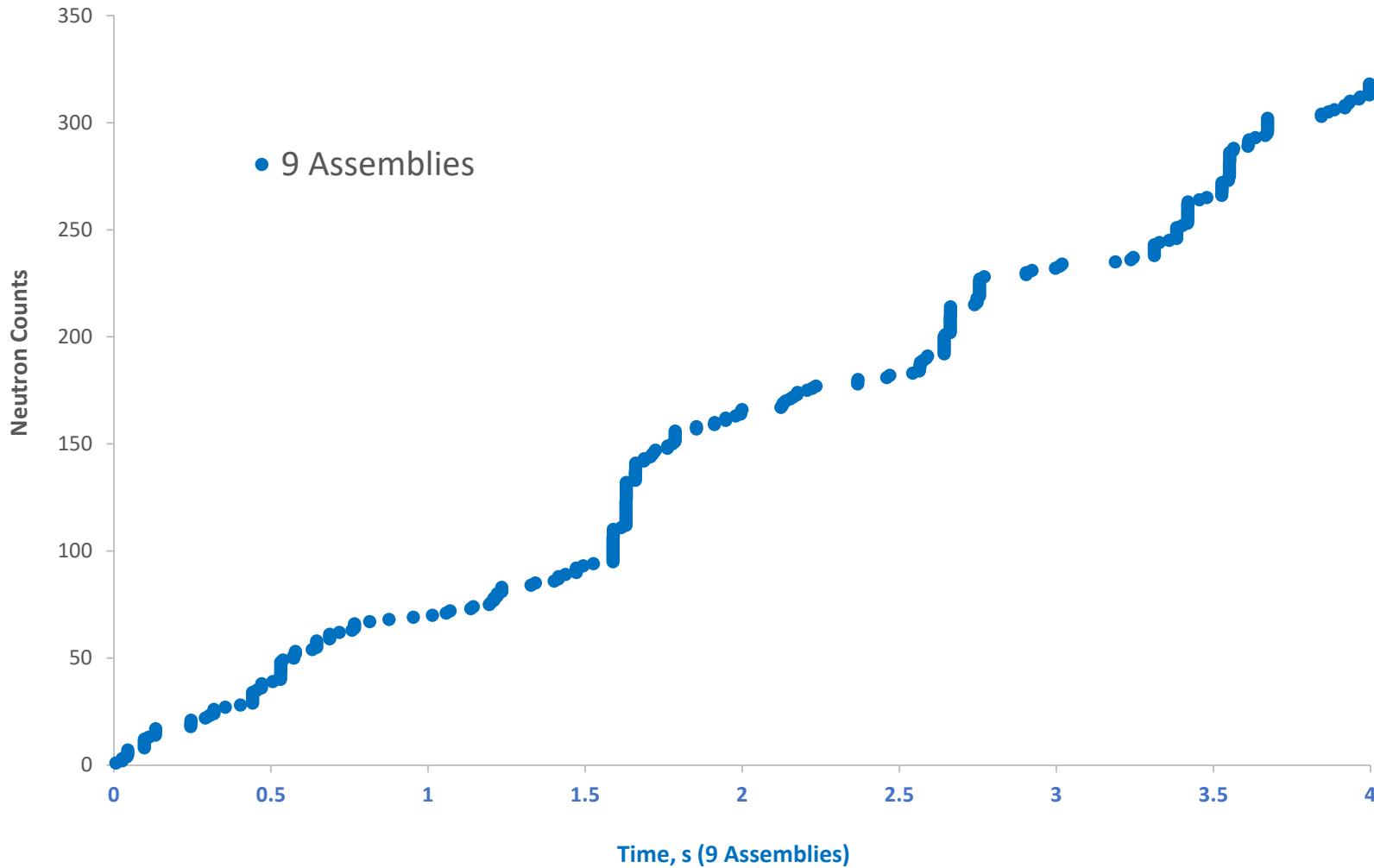
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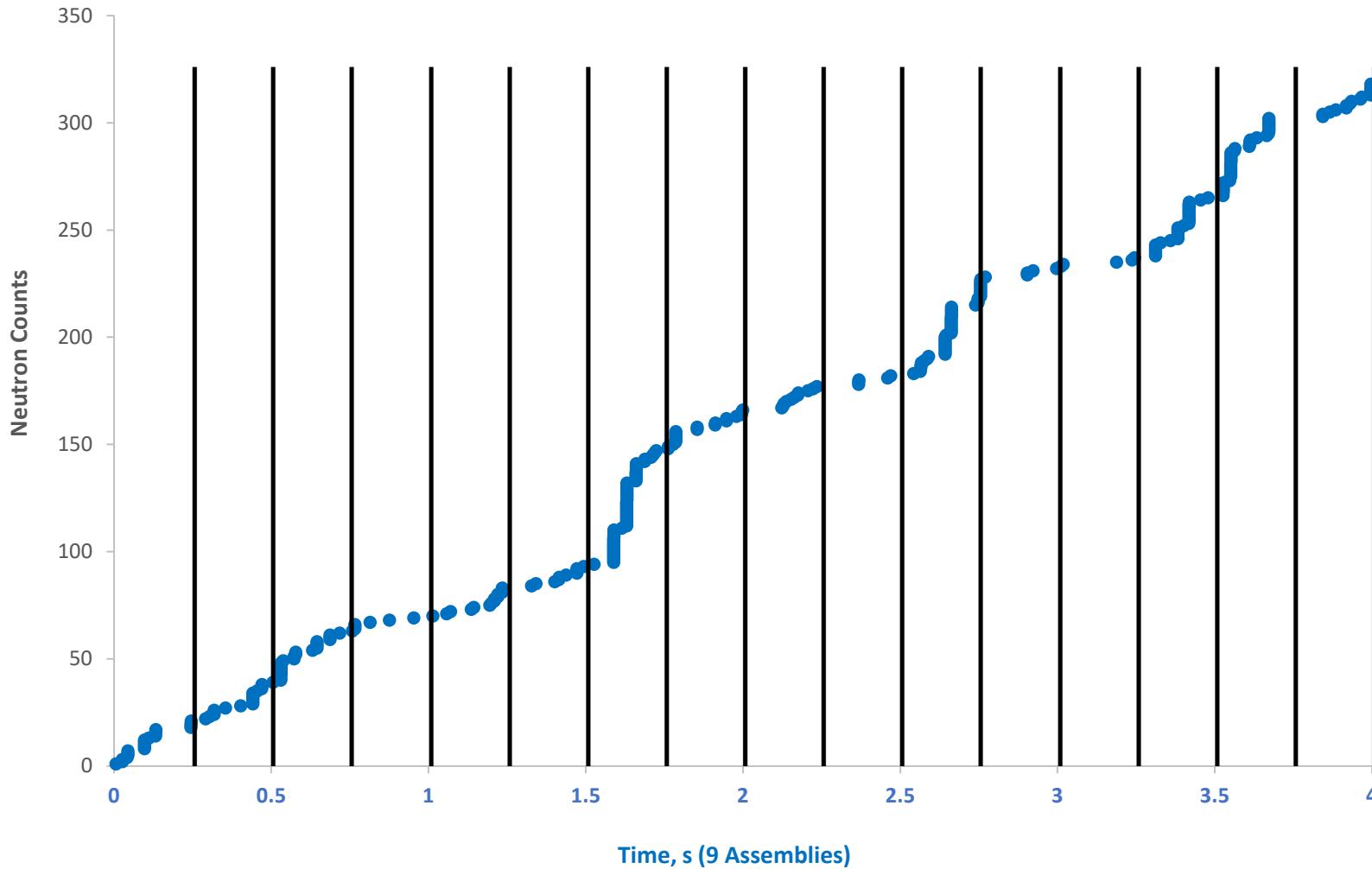
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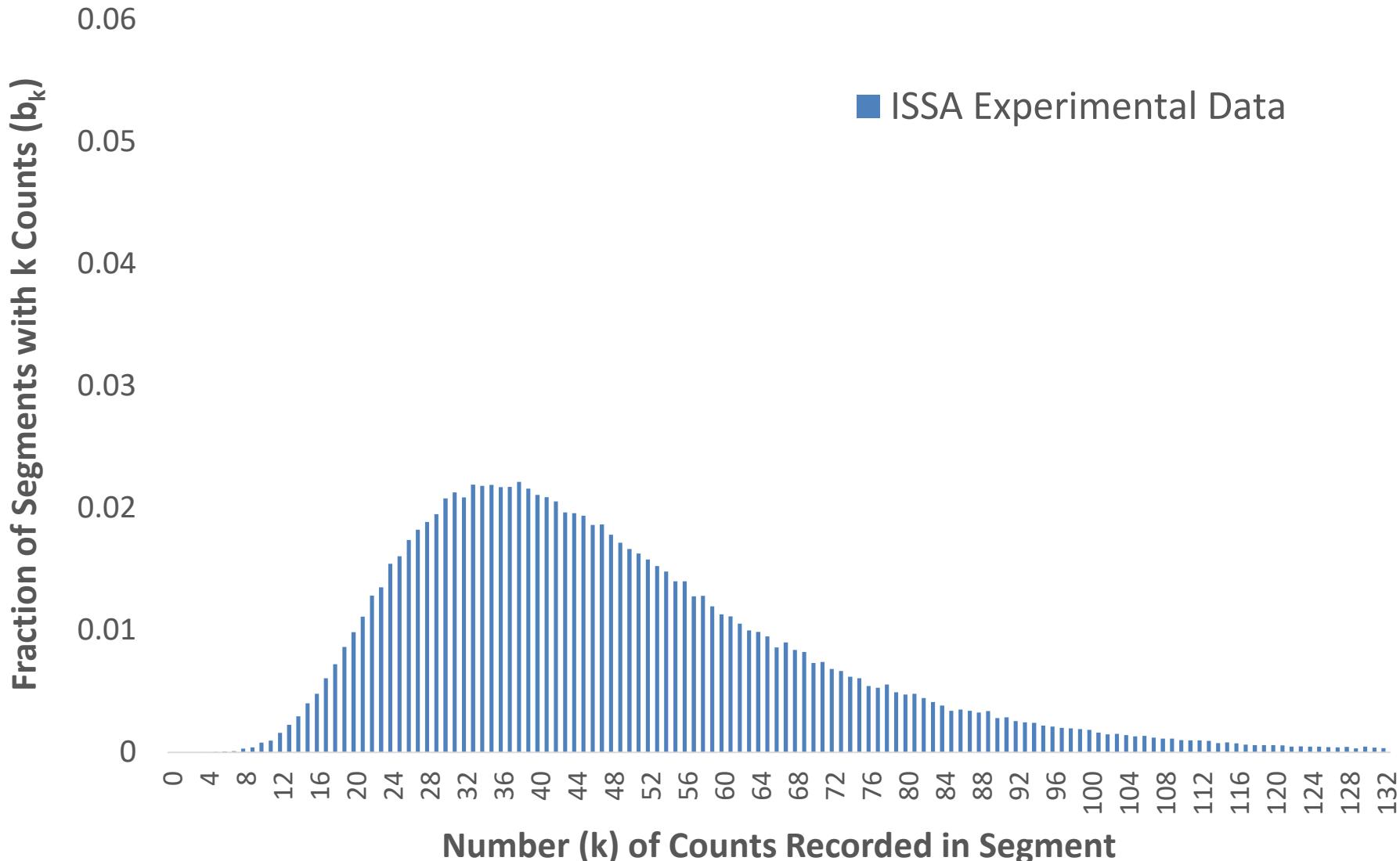
# Analysis



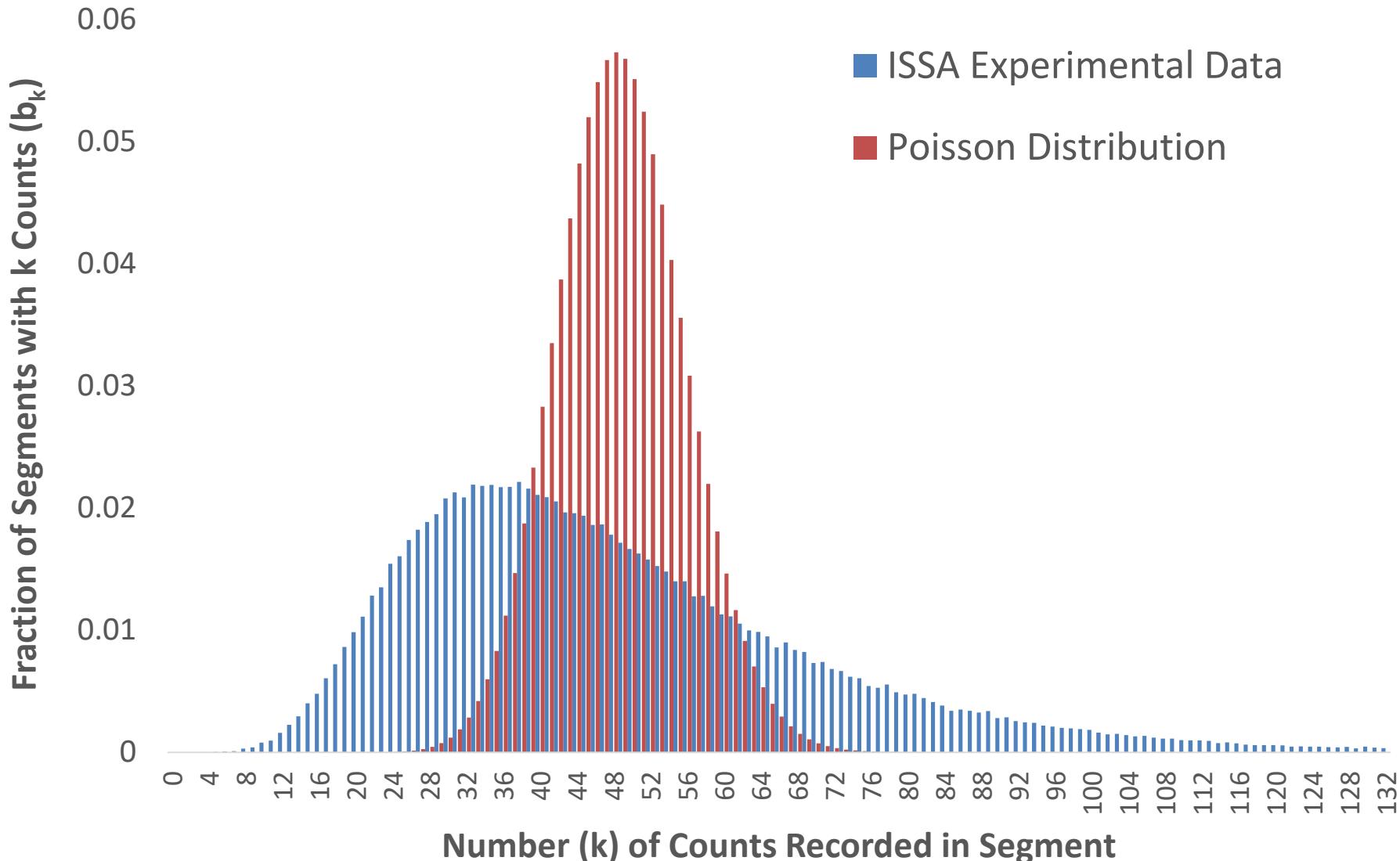
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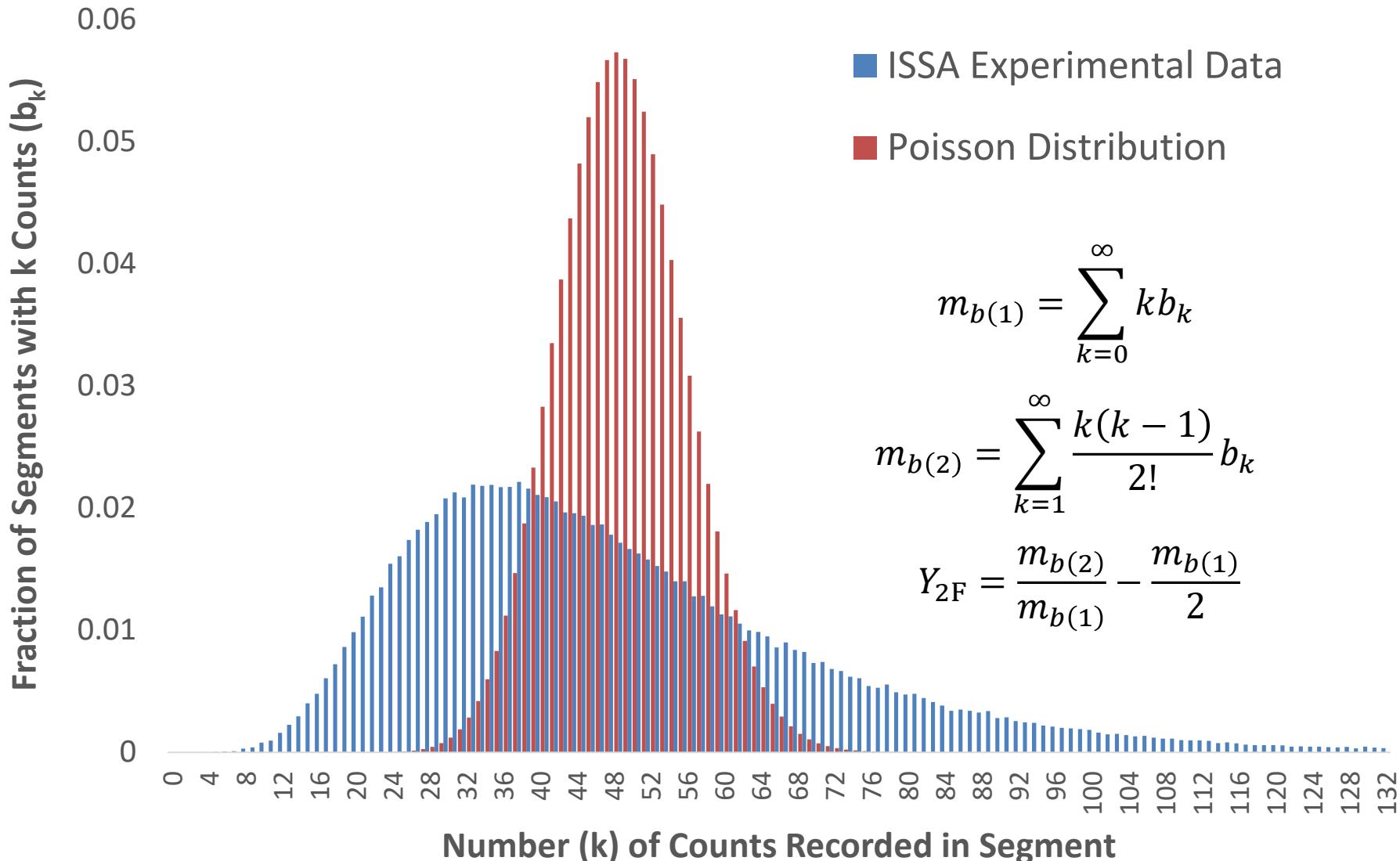
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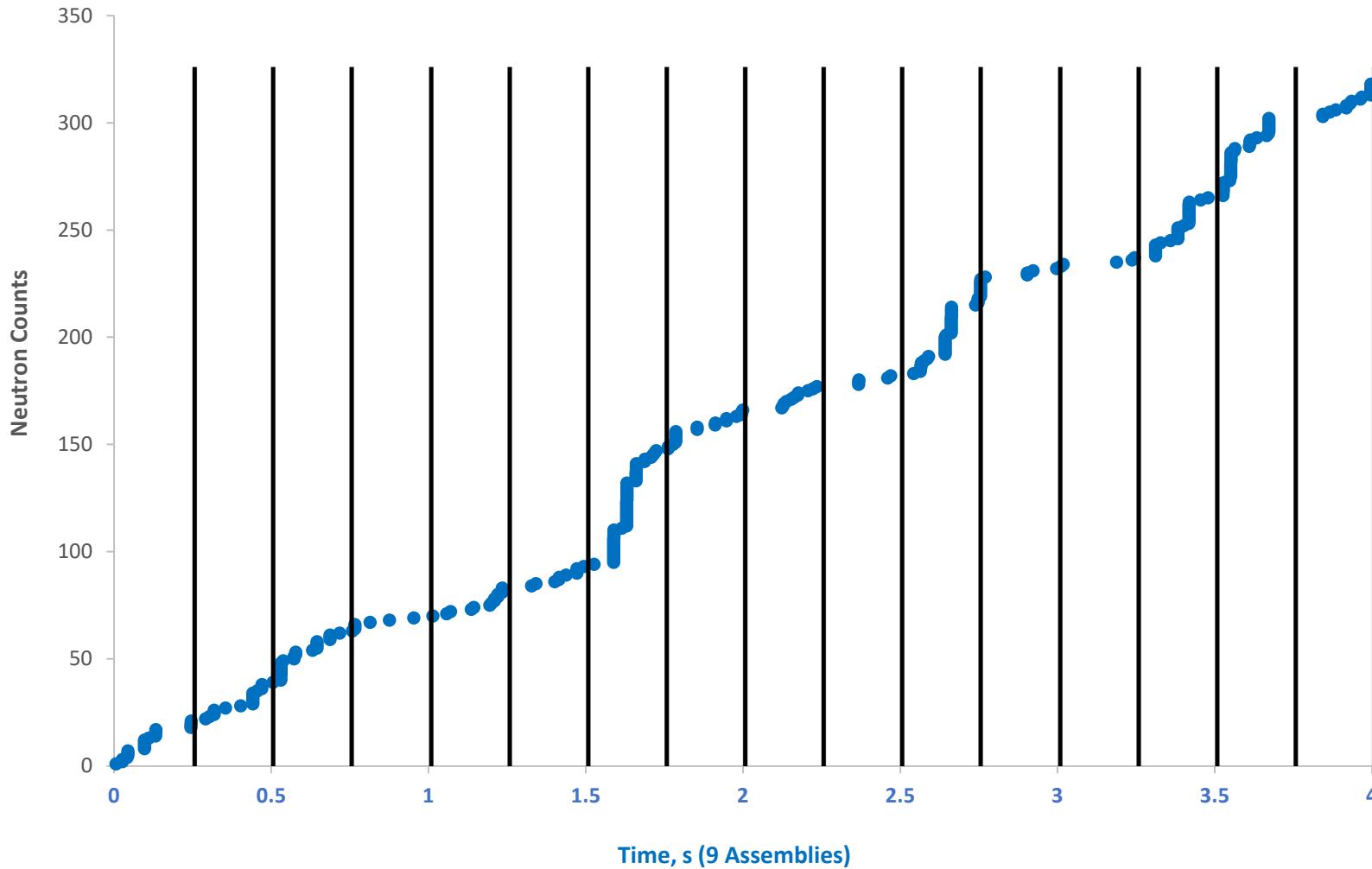
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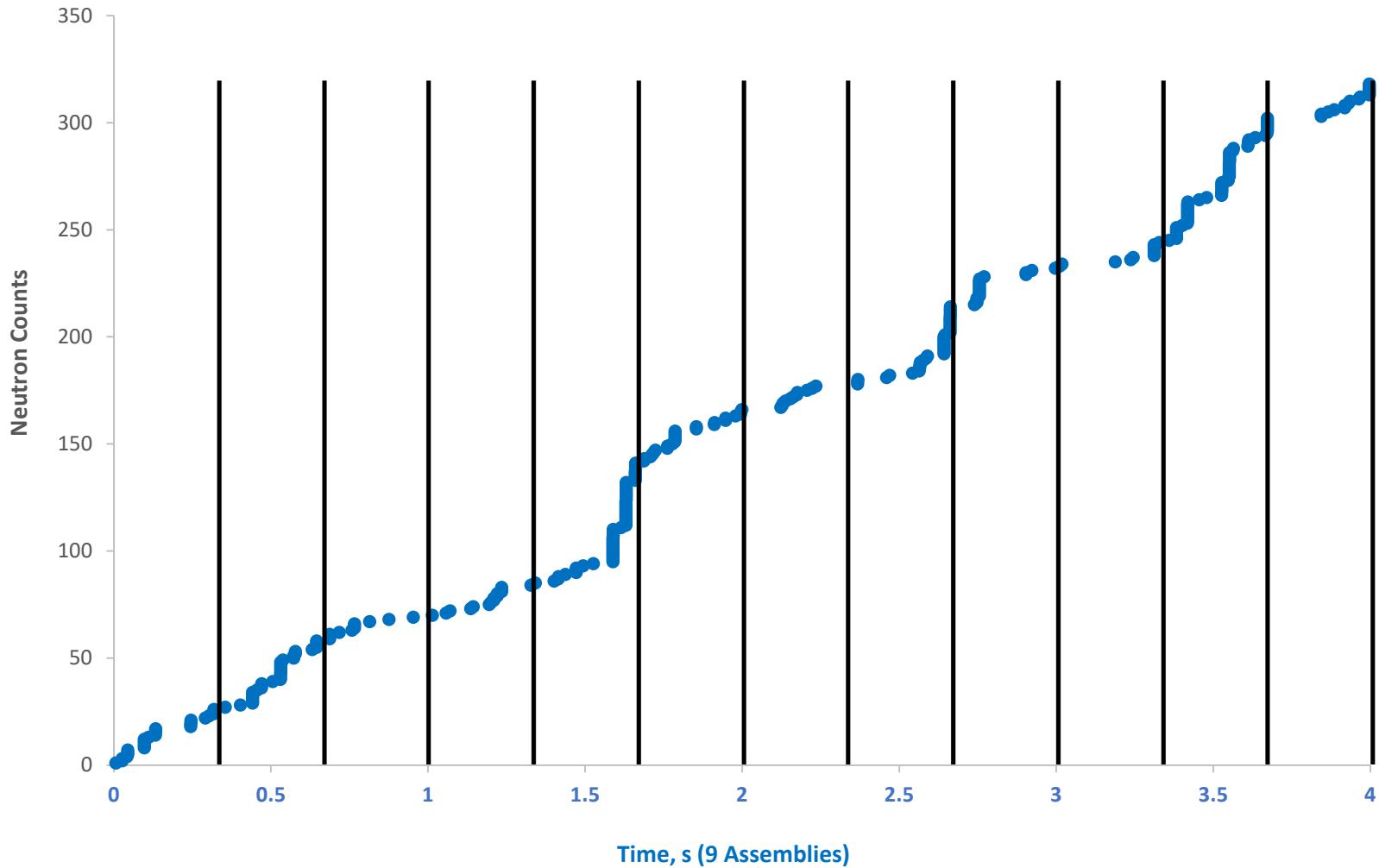
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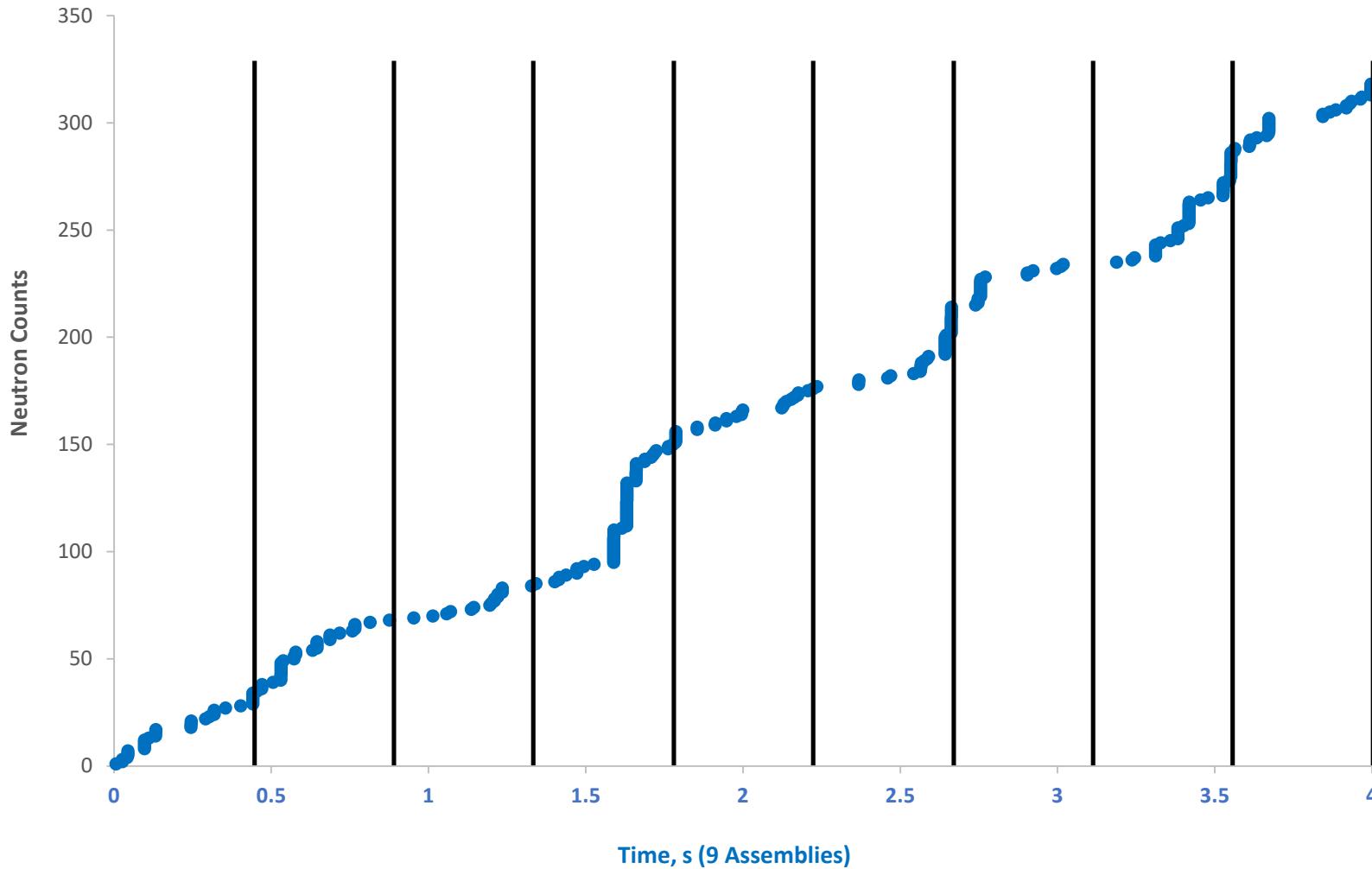
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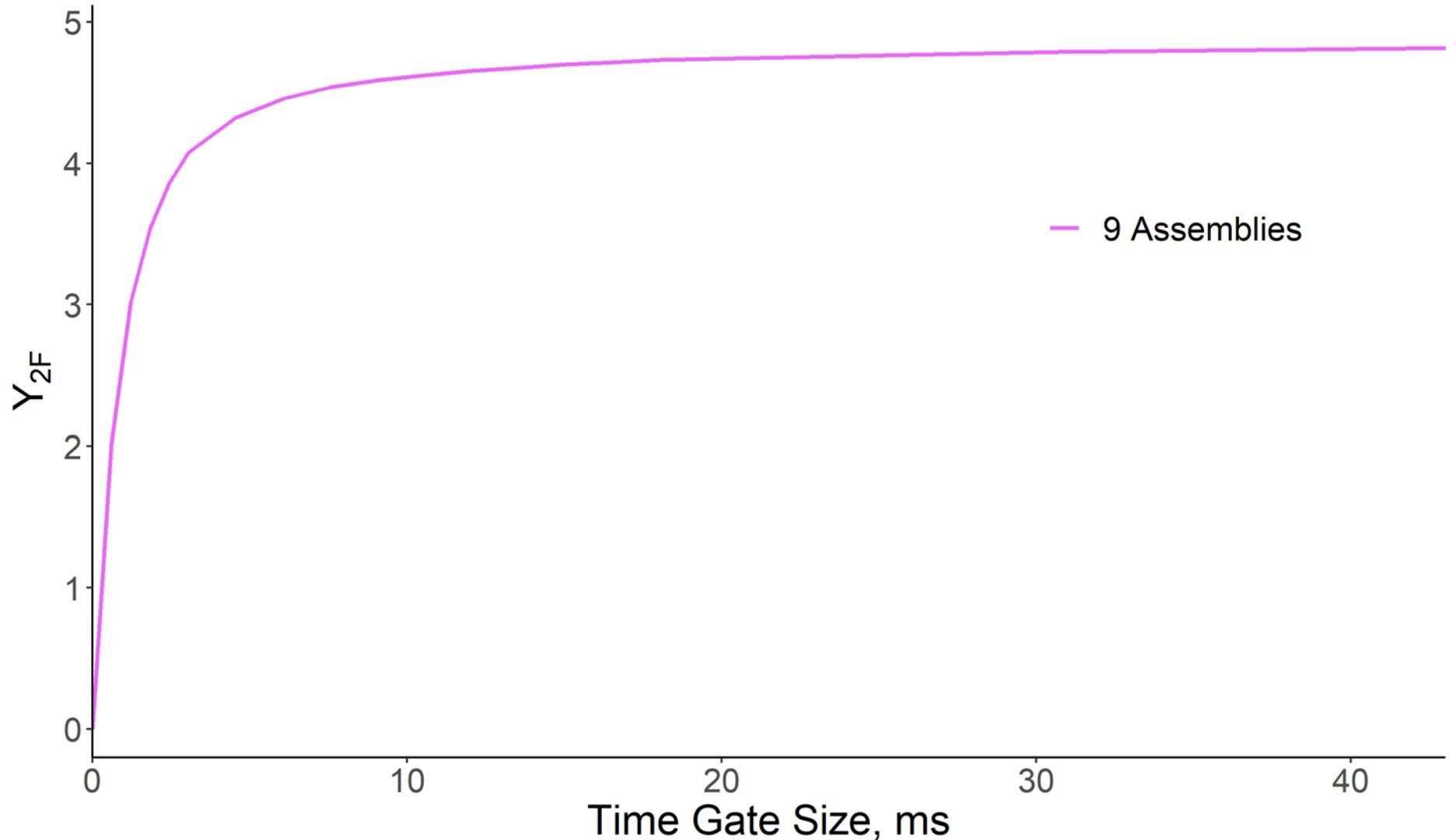
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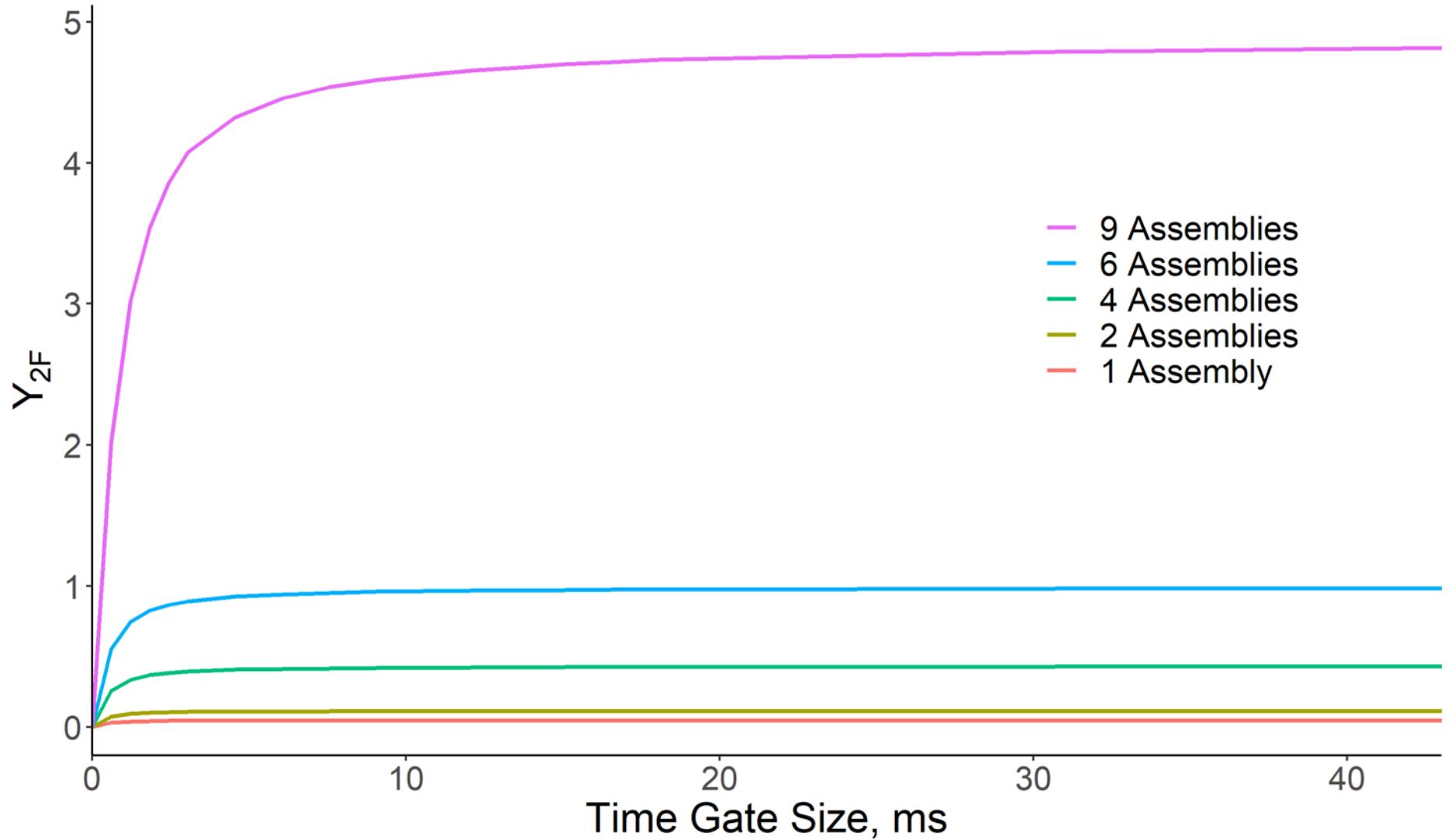
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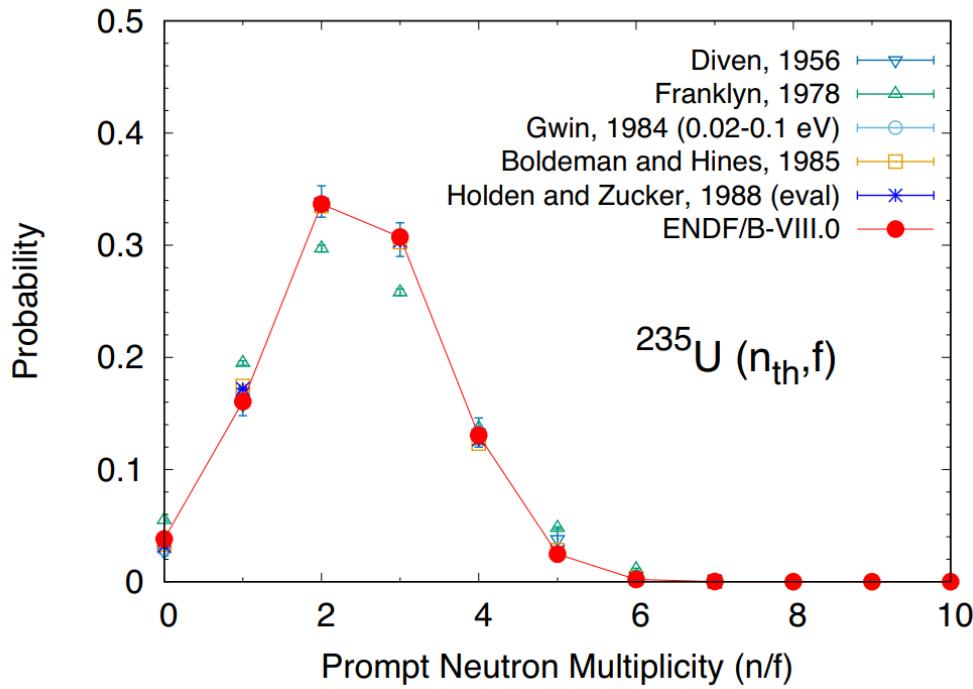


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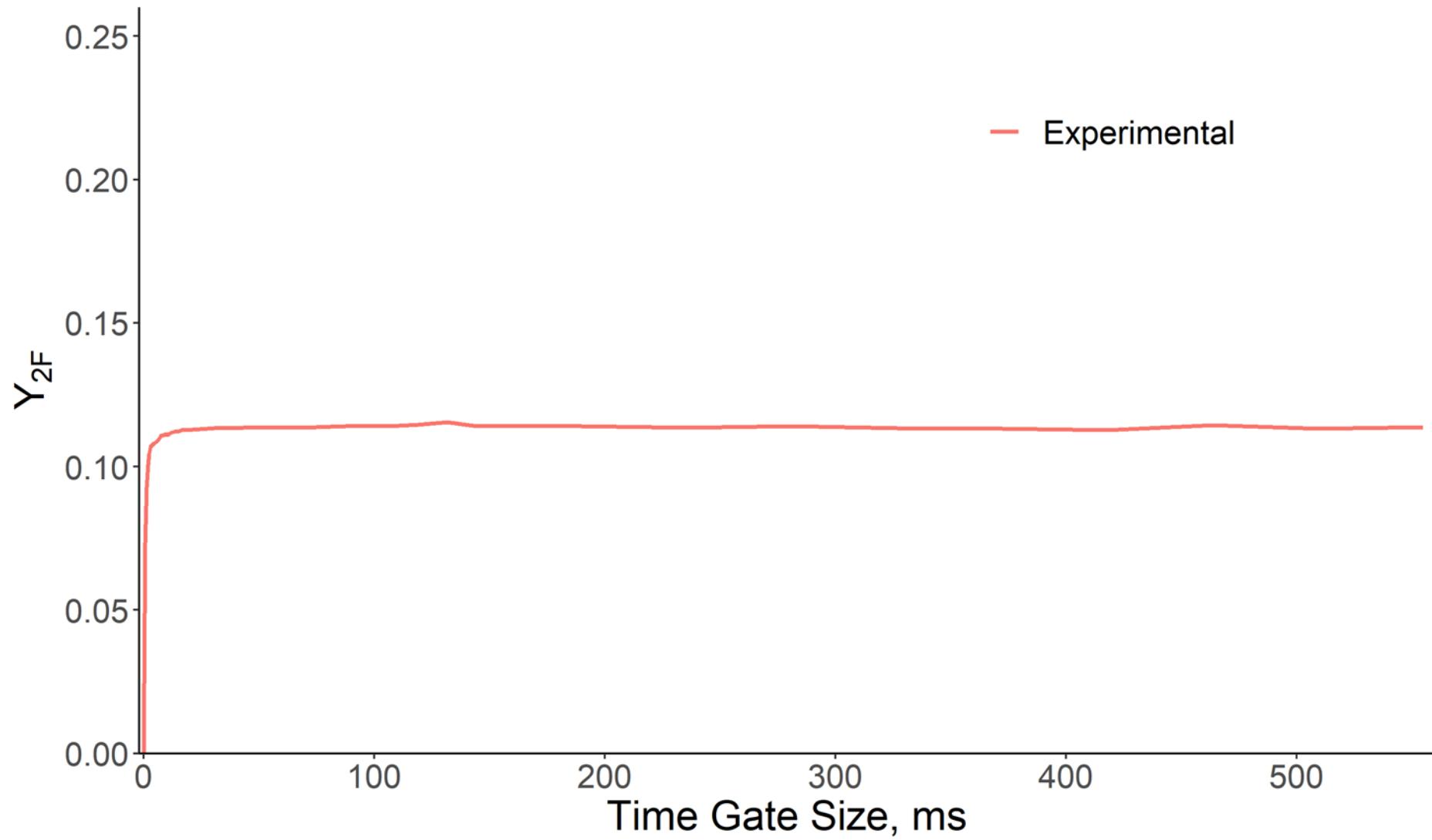
# Simulation - Model

- Modeled in 2 transport codes:
- COG Models (LLNL)
  - ENDF/B-VII.1 with Terrell's distribution
  - ENDF/B-VIII.0 (multiplicity included)
  - ENDF/B-VIII.0 with FREYA
- MORET Models (IRSN)
  - ENDF/B-VII.1 with Zucker and Holden
  - JEFF3.2 with Zucker and Holden
  - JEFF3.2 with FREYA

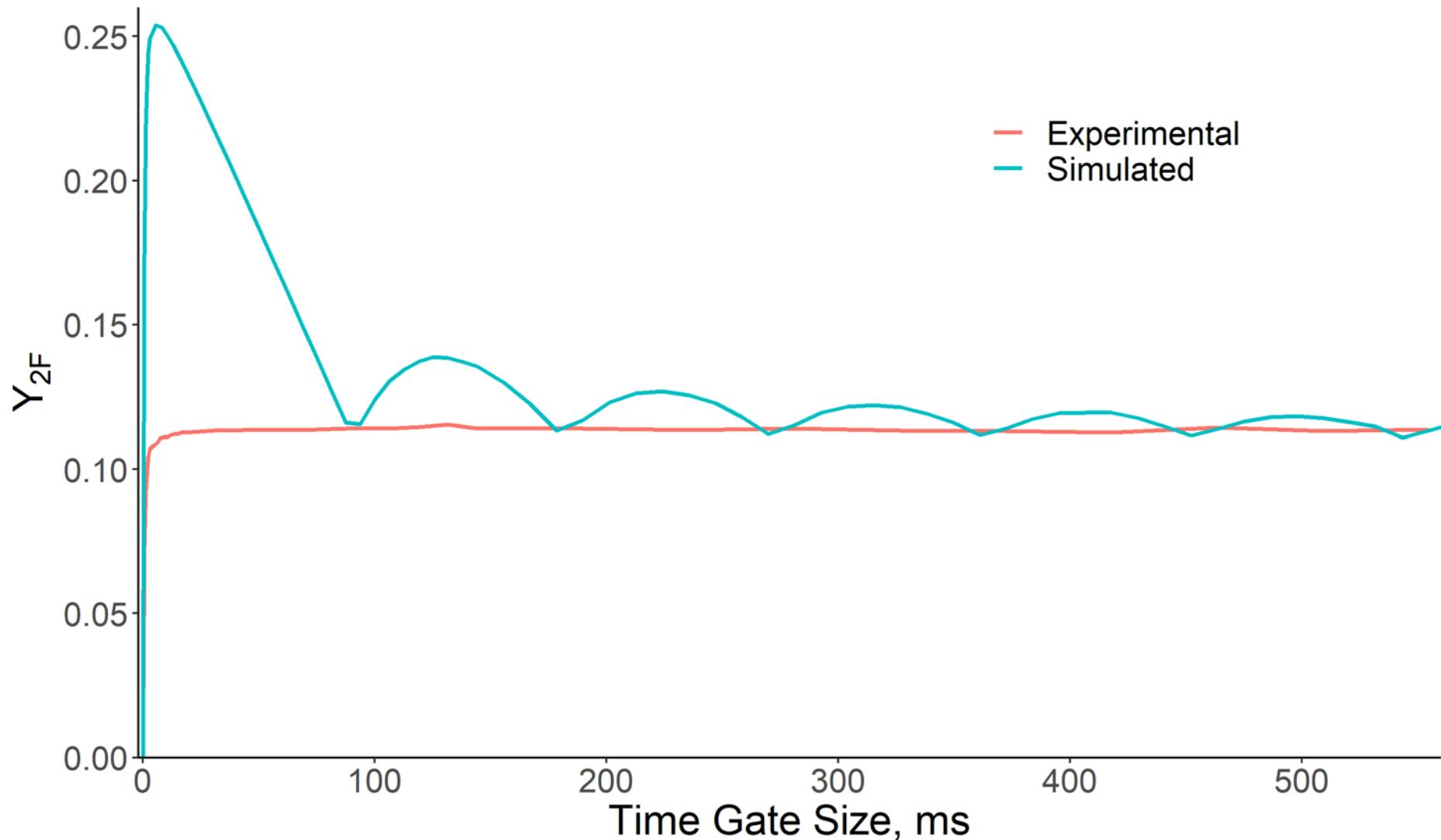


Brown, D. A., et al. "ENDF/B-VIII.0: The 8th Major Release of the Nuclear Reaction Data Library with CIELO-project Cross Sections, New Standards and Thermal Scattering Data," *Nuclear Data Sheets* 148 (2018) 1–142.

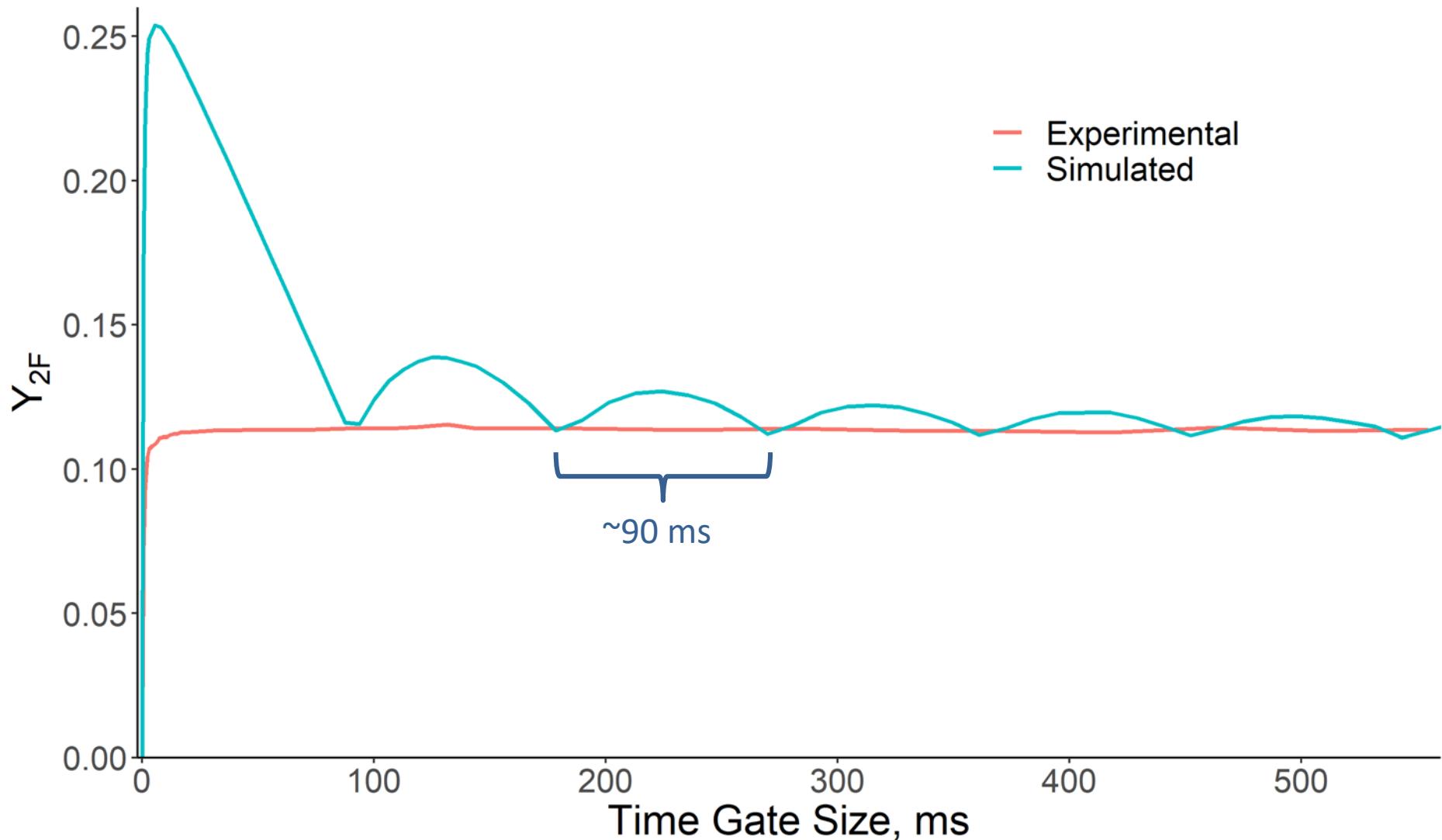
# Simulation Results



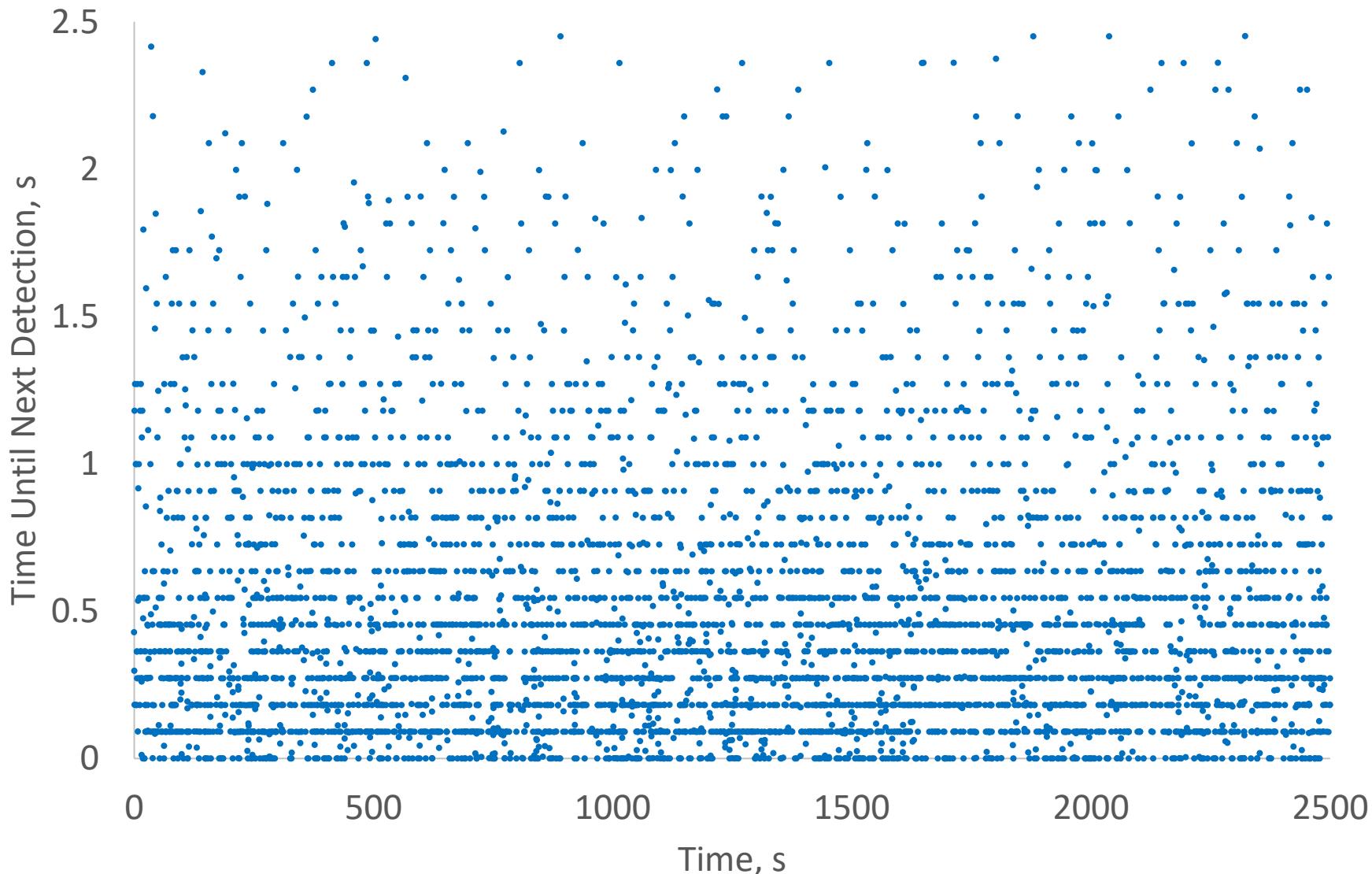
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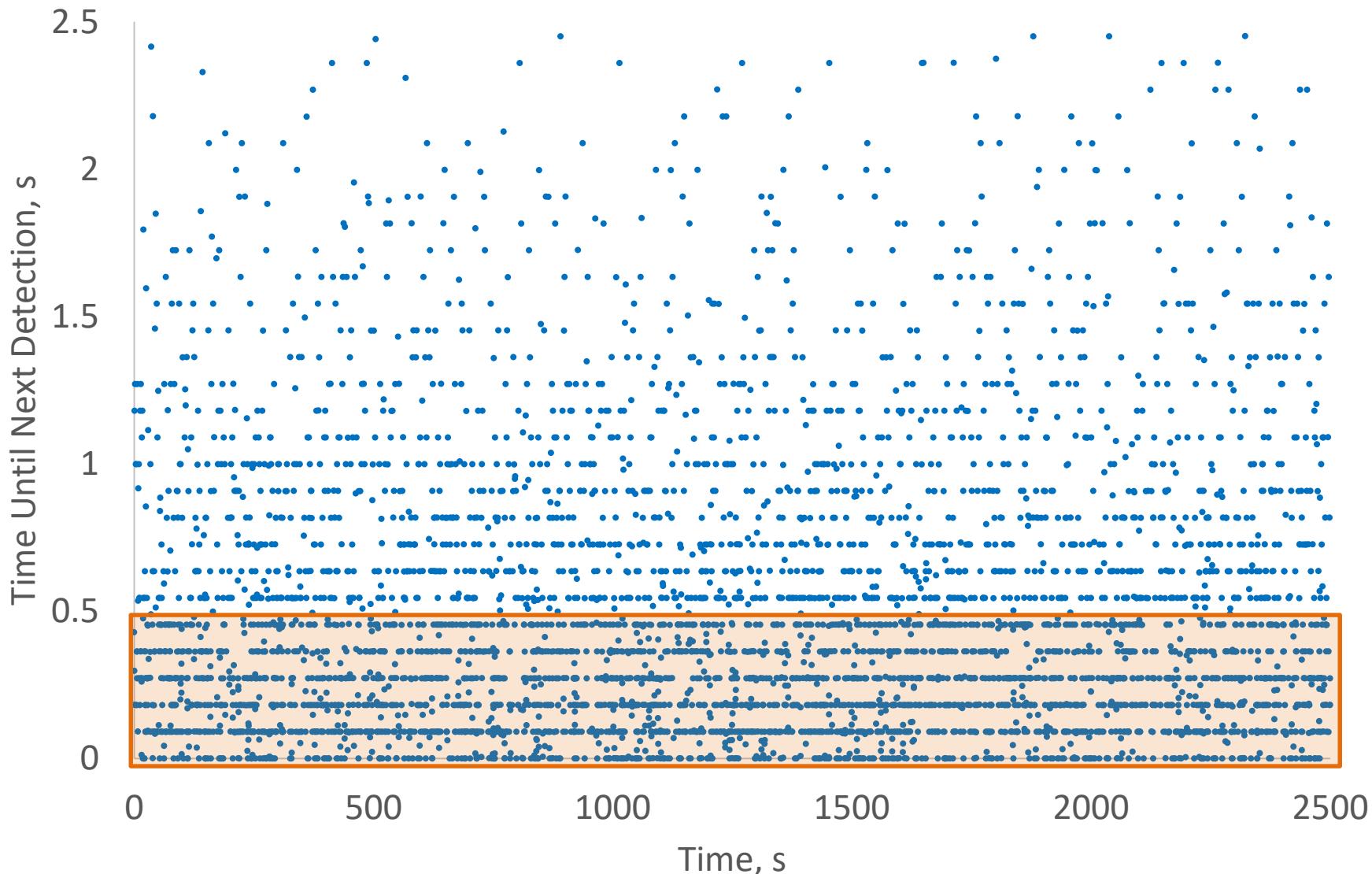
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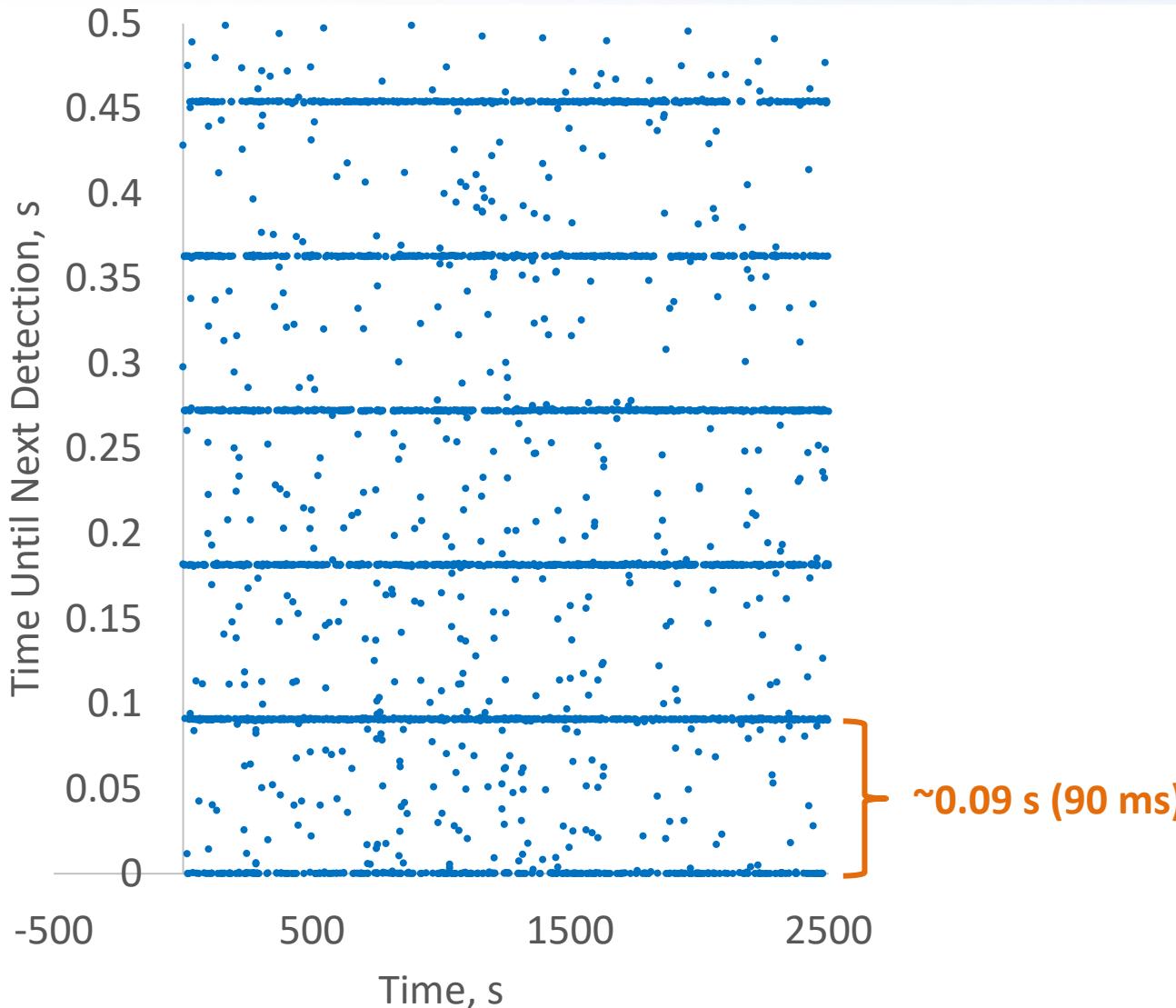
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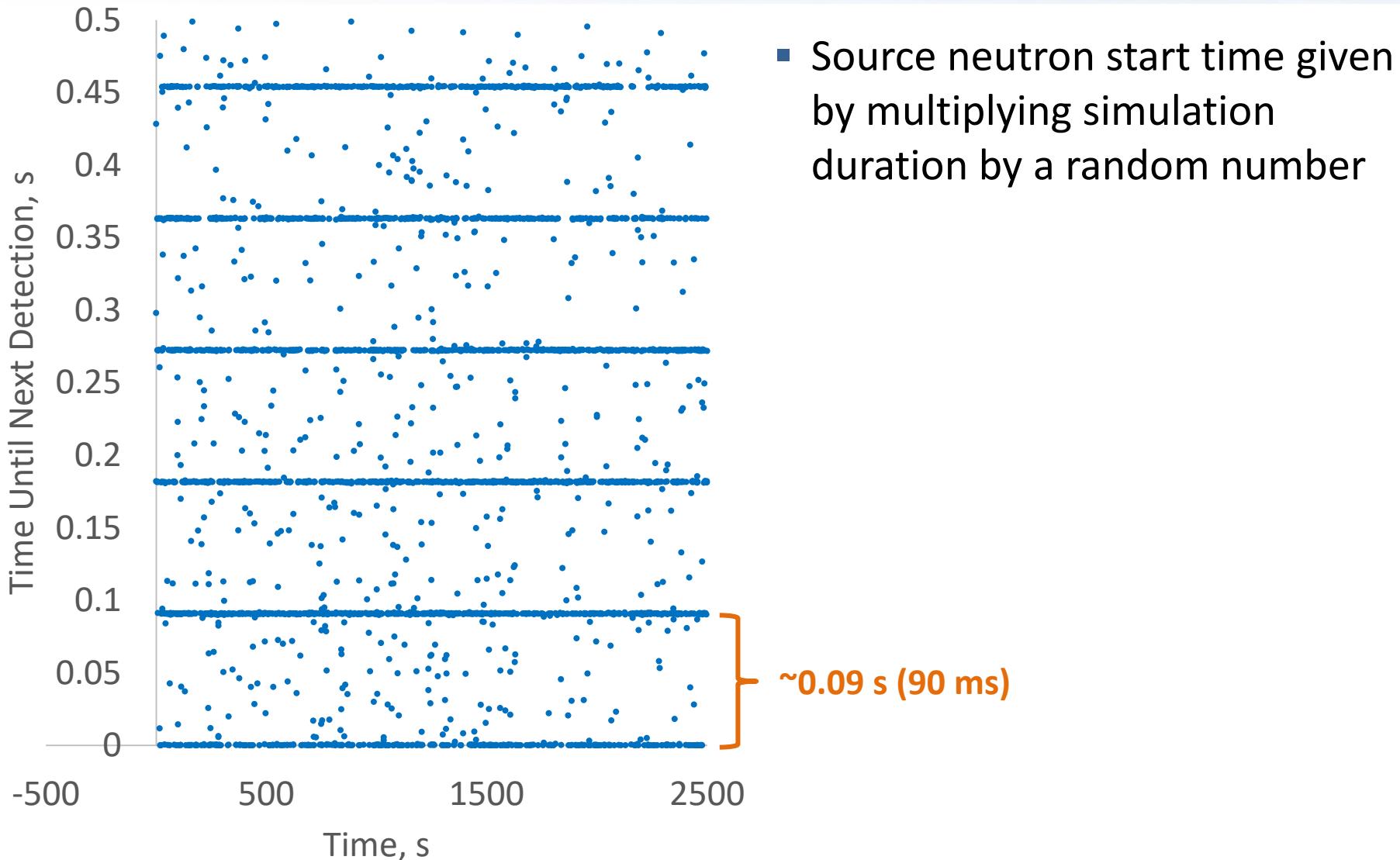
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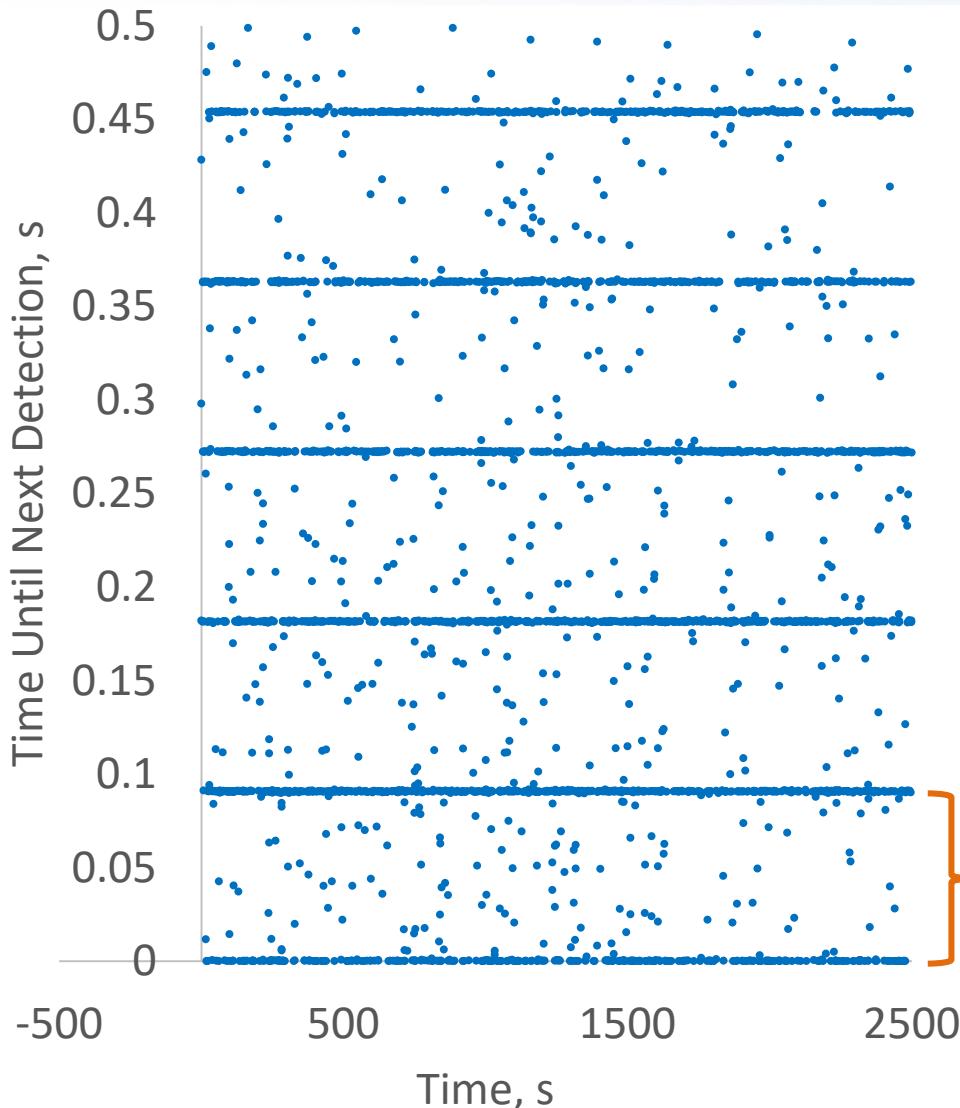
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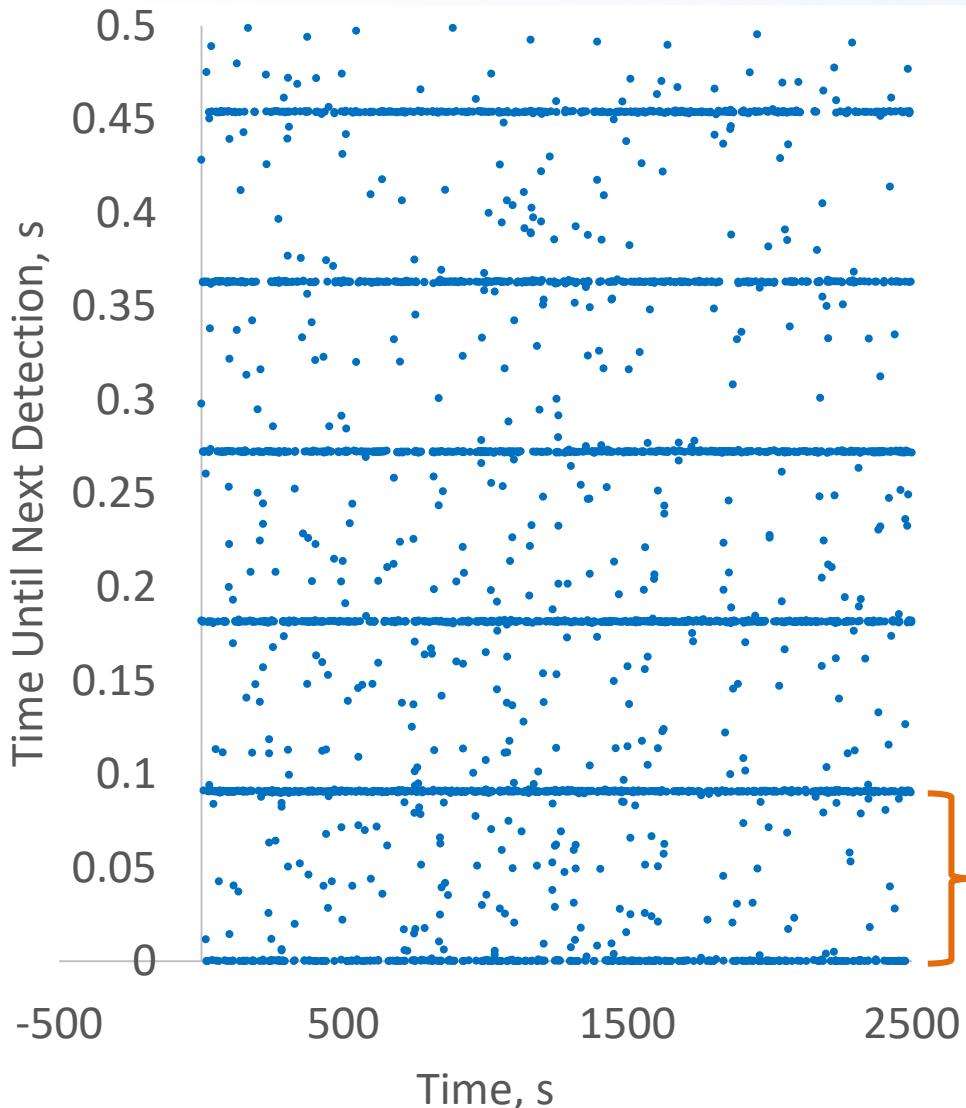


# Simulation Results



- Source neutron start time given by multiplying simulation duration by a random number
- Random number precision:
  - $5.96\text{E-}08$
- Simulation duration:
  - $1.52\text{E+}06$  seconds

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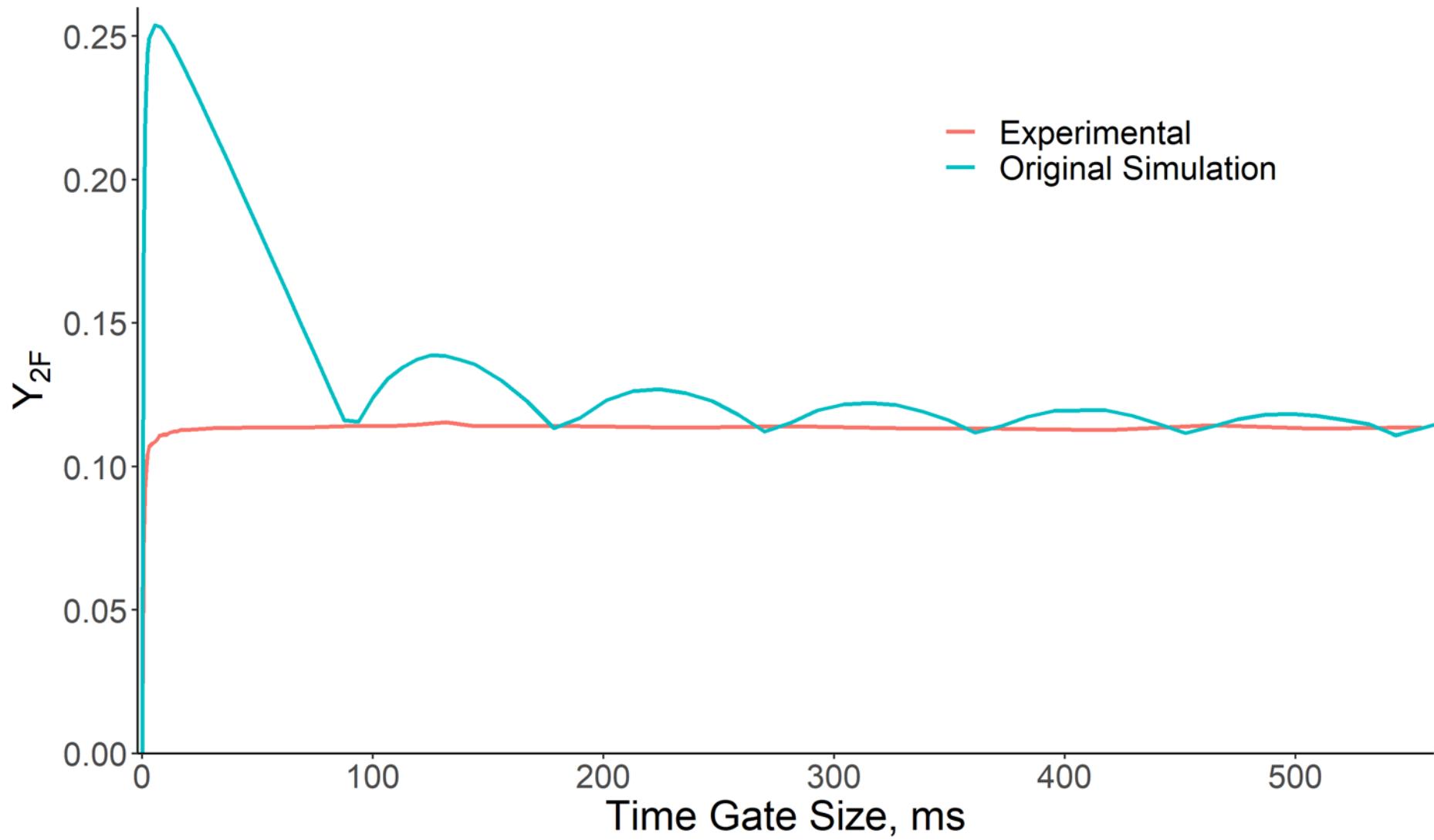


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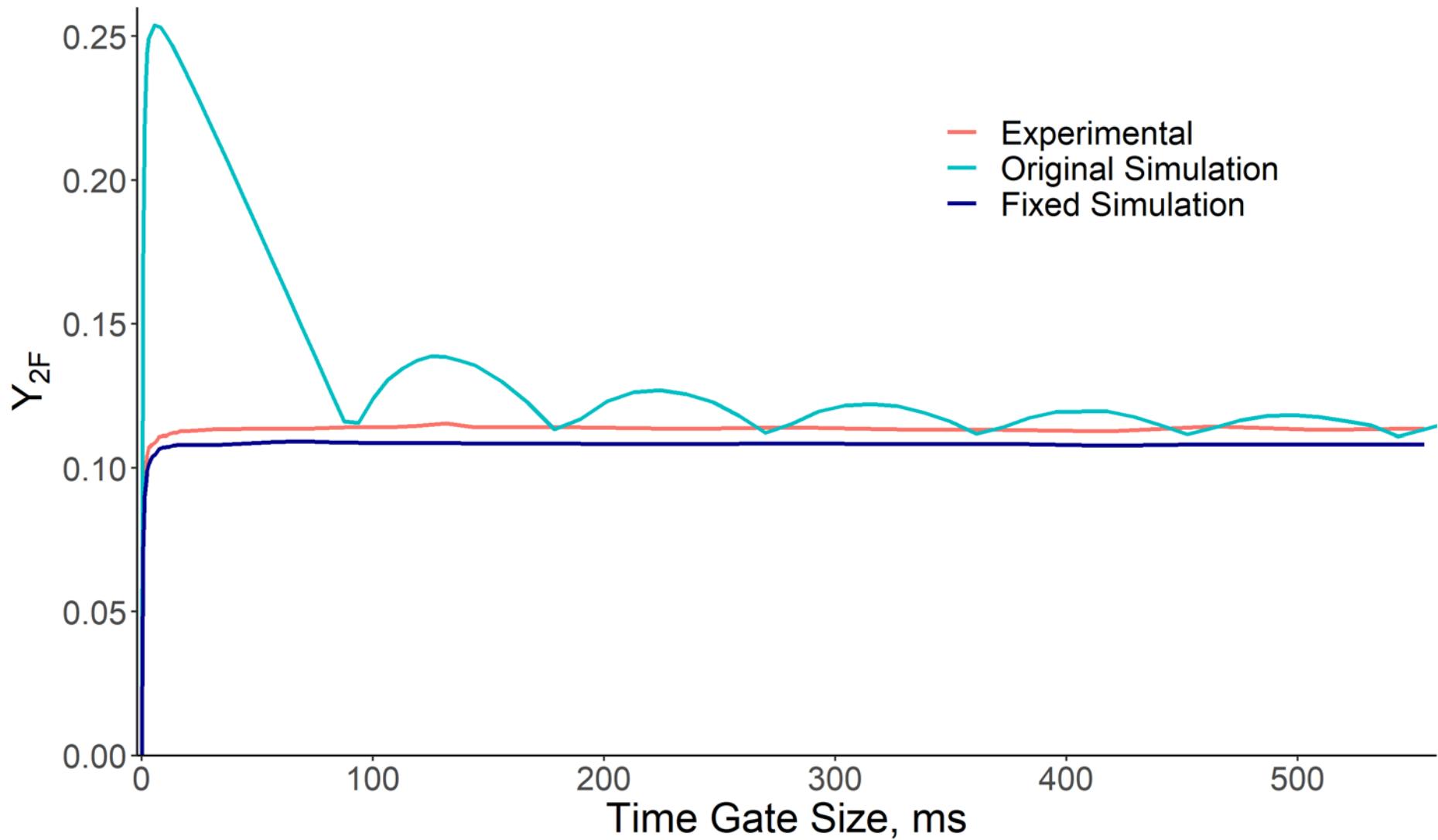
$$1.52(10)^6 \times 5.96(10)^{-8} = 0.09$$

$\sim 0.09 \text{ s (90 ms)}$

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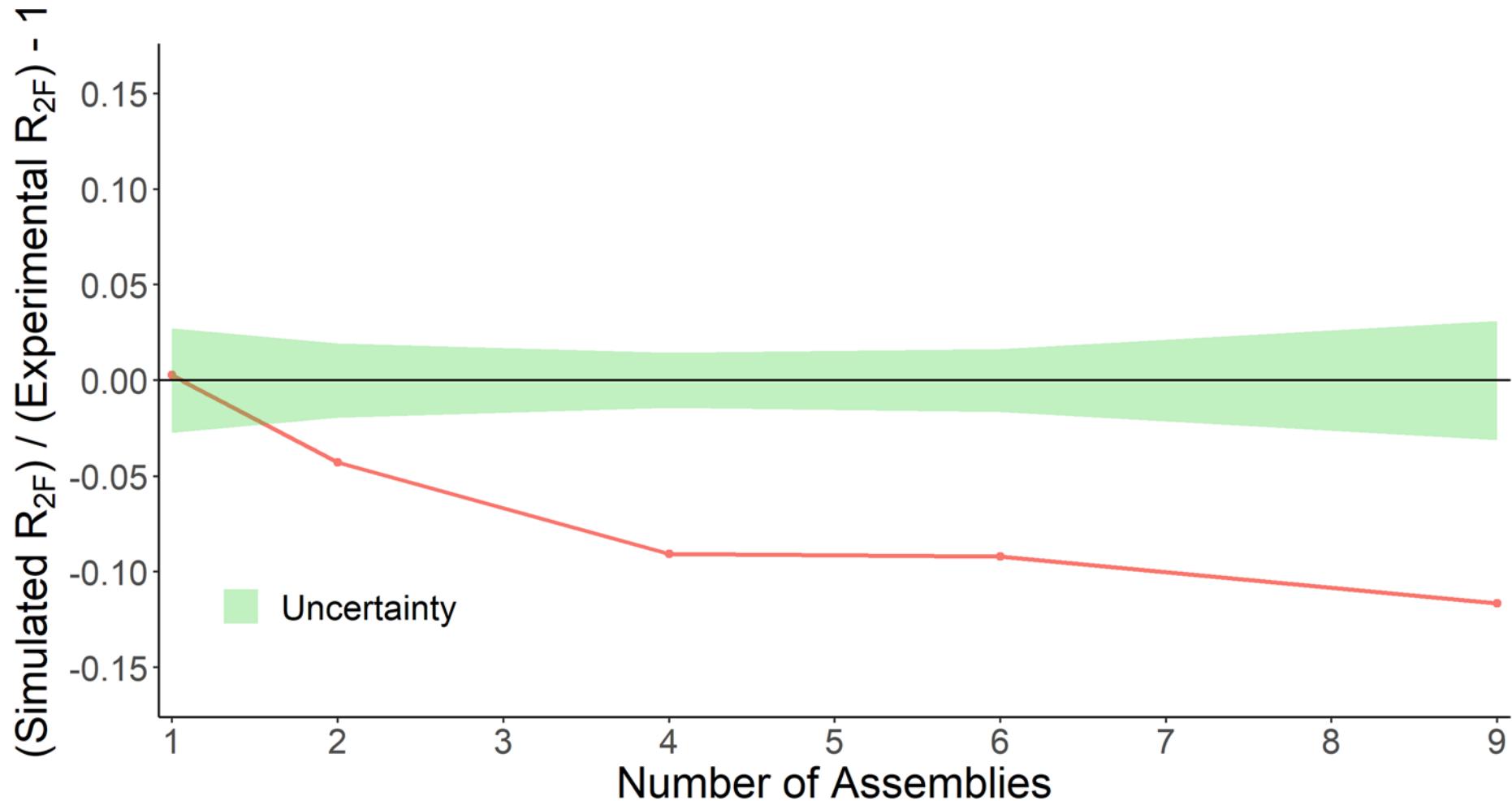


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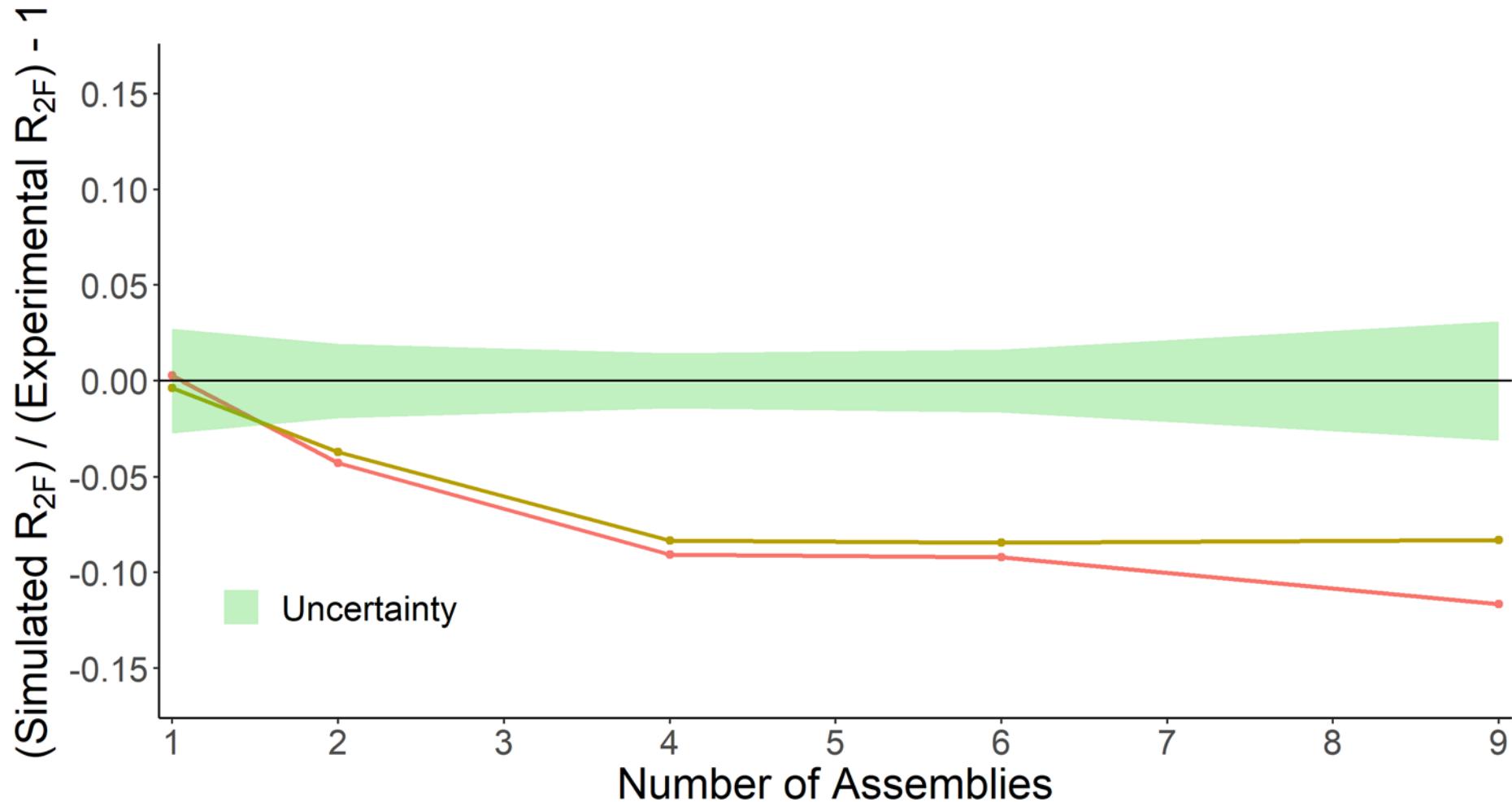
# Simulation Results

— COG with ENDF/B-VII.1

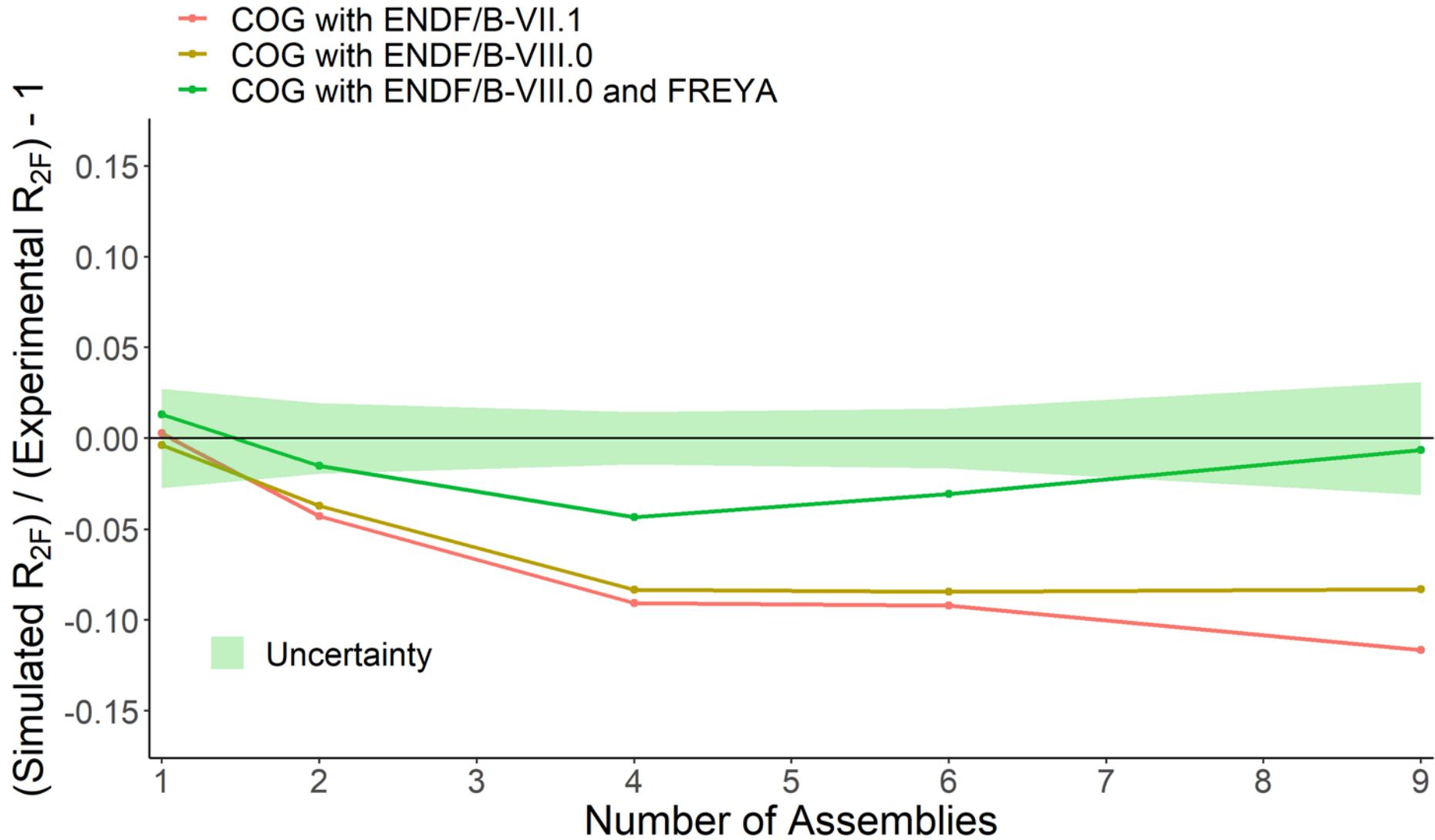


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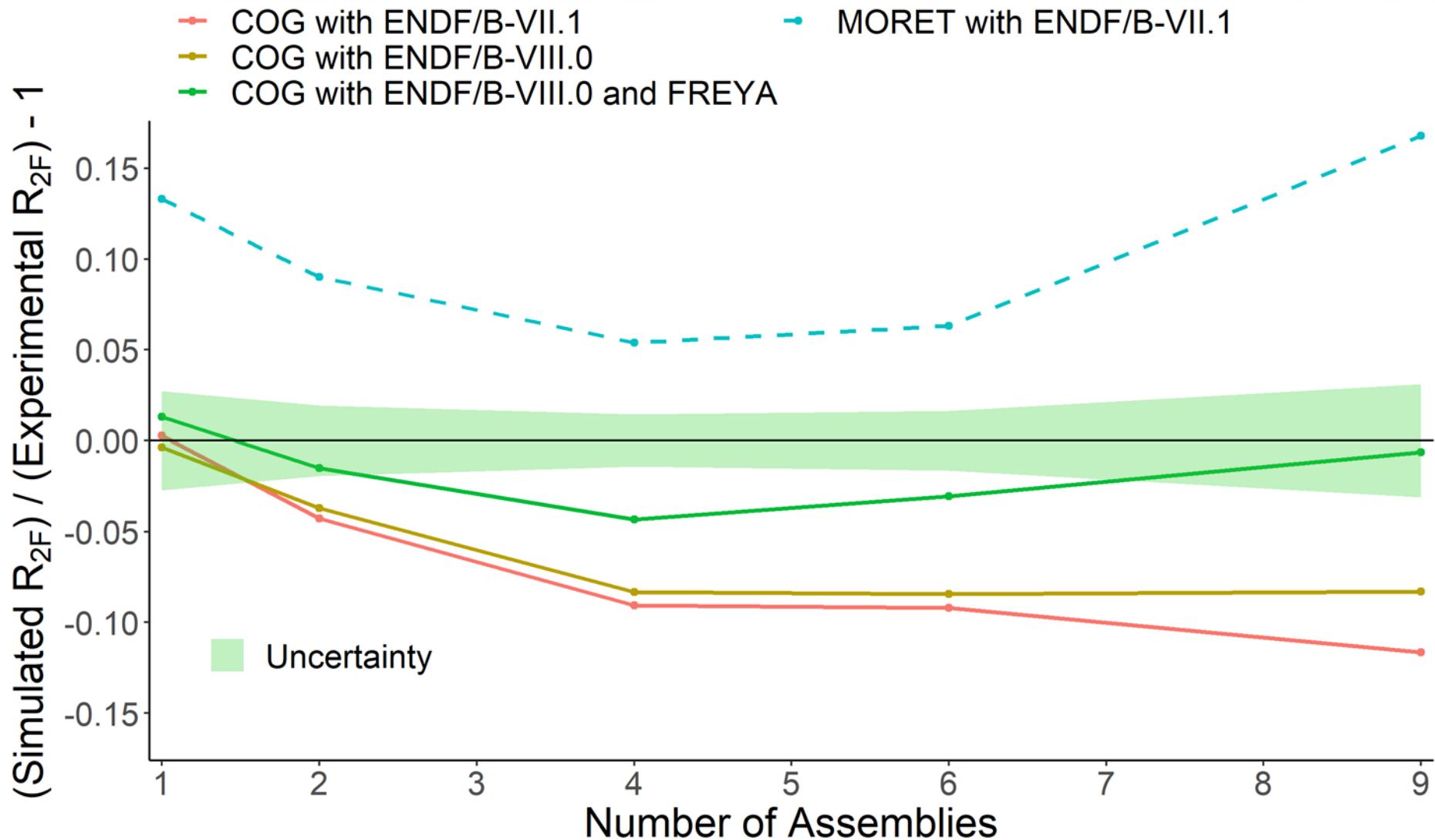
- COG with ENDF/B-VII.1
- COG with ENDF/B-VIII.0



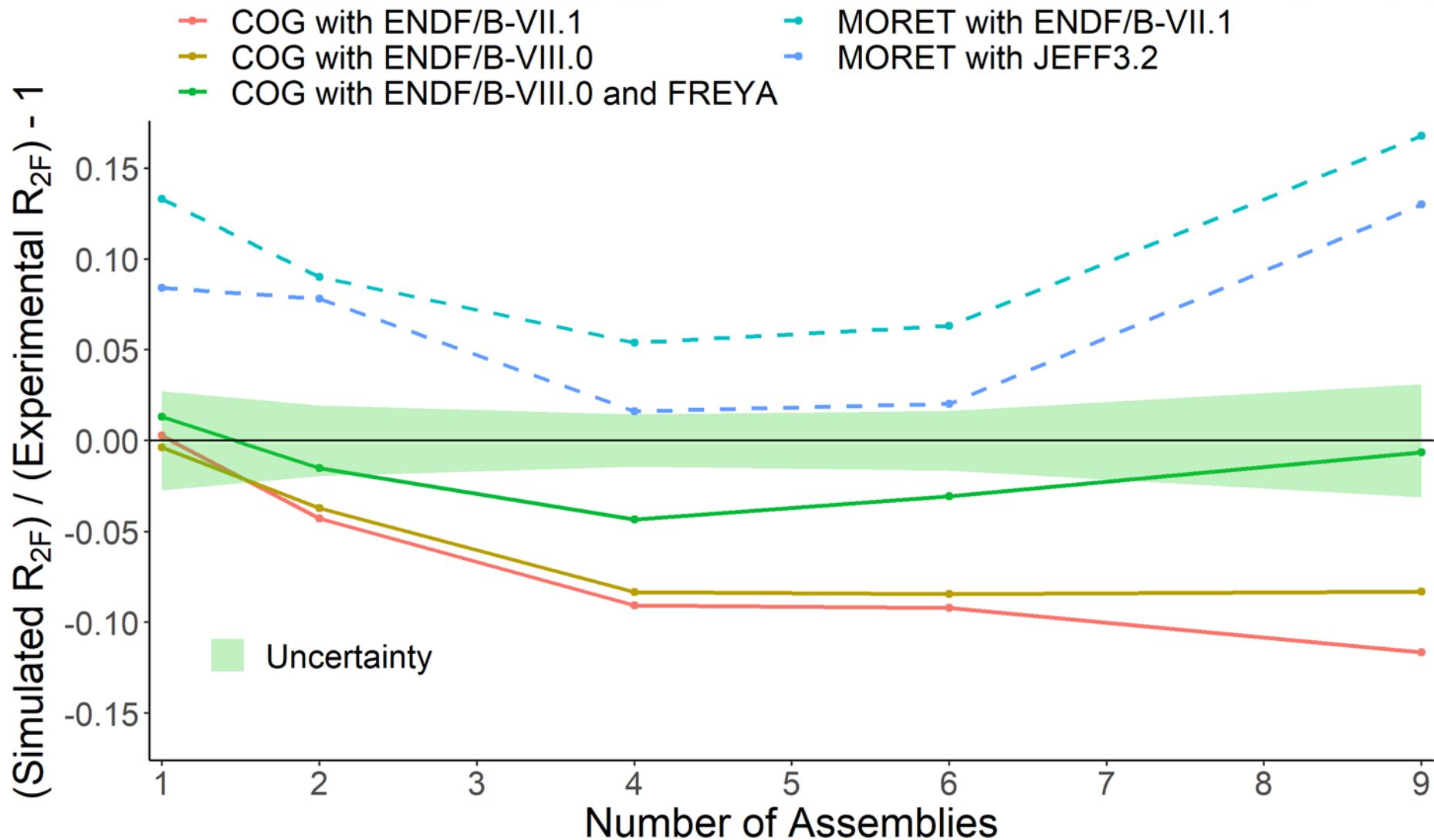
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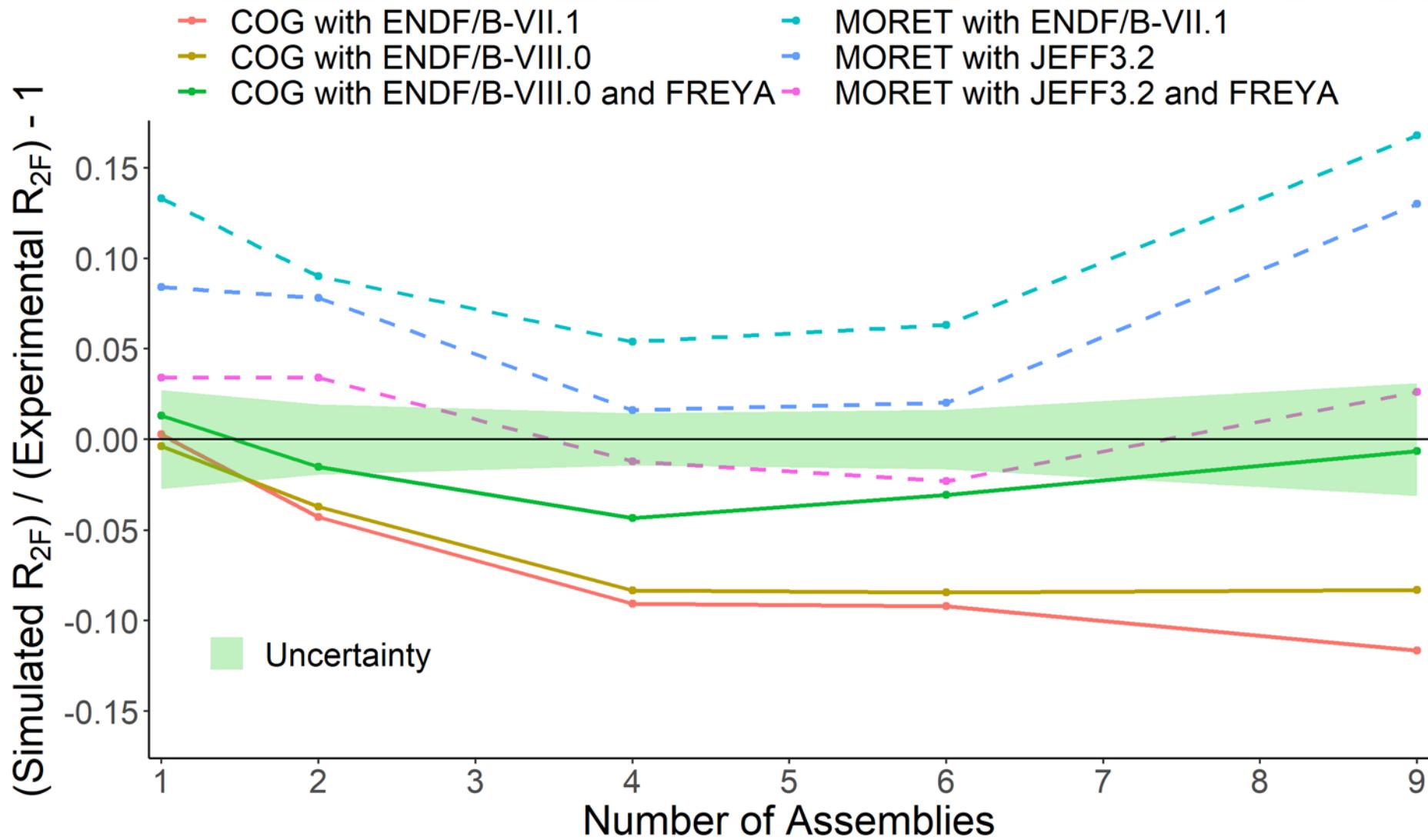
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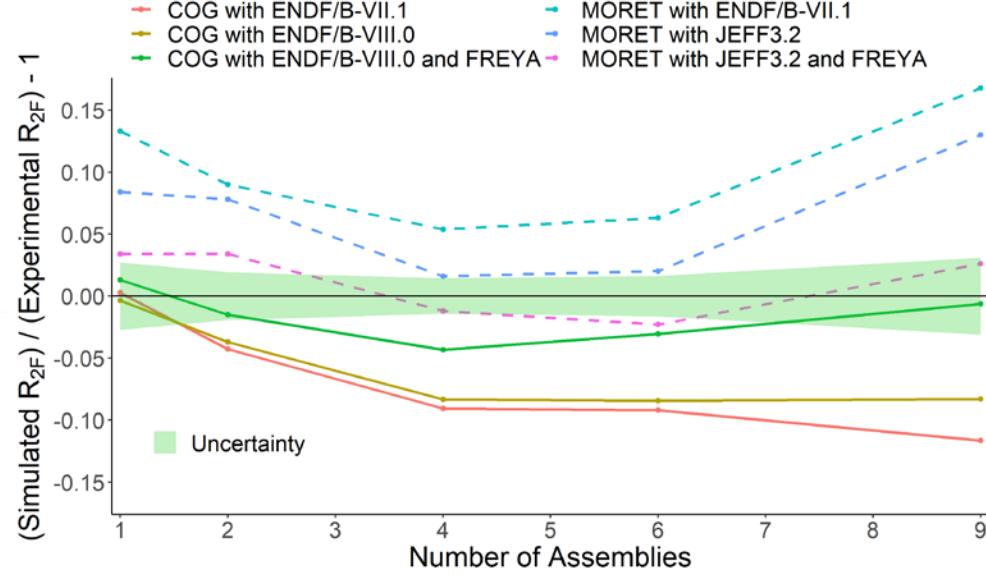
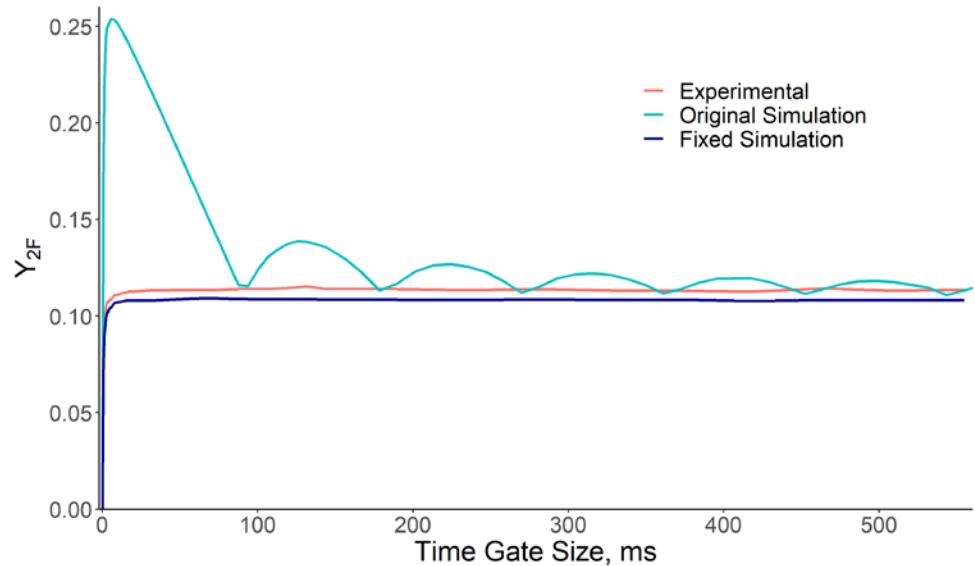
# Conclusions

- Identified and corrected a non-physical artifact in radiation transport code
- Demonstrated substantial improvement when using FREYA
- Provided a dataset for multiplicity community to validate new theories and techniques

# Acknowledgements

- This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA273444 and was made possible through the support of:
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- Jesson Hutchinson (LANL)
- Boukhmès Mechitoua (CEA)

# Questions





**Lawrence Livermore  
National Laboratory**

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# Simulation - Model

