Application of COG to Deuteron Transport Benchmarks

S. Kim, D. Heinrichs, and E. Lent

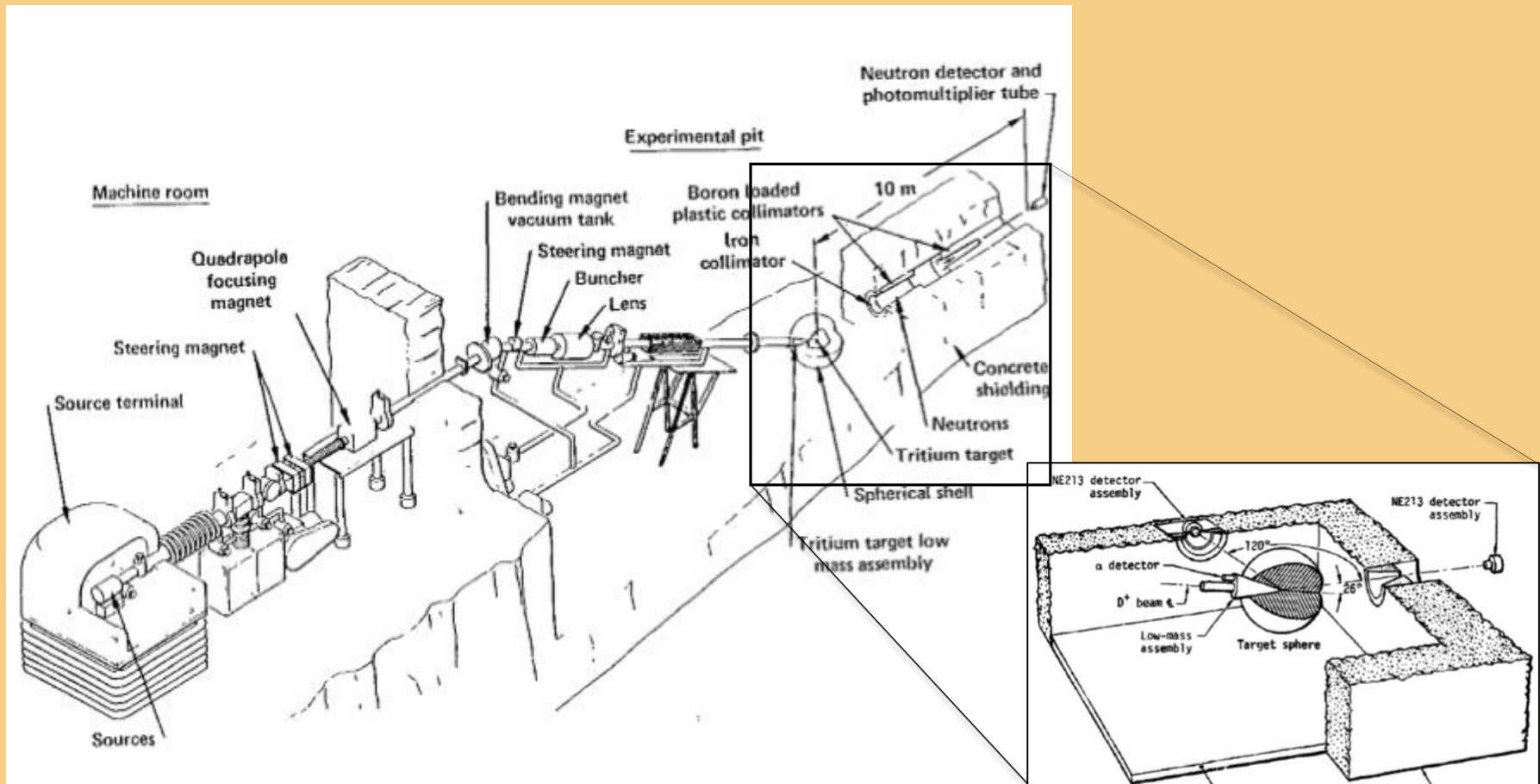**Lawrence Livermore National Laboratory**

Acknowledgements

- DOE Nuclear Criticality Safety Program (NCSP) for supporting this work.

- Dr. Luisa Hansen, principal investigator of this project, for assistance provided with invaluable original experimental data information.
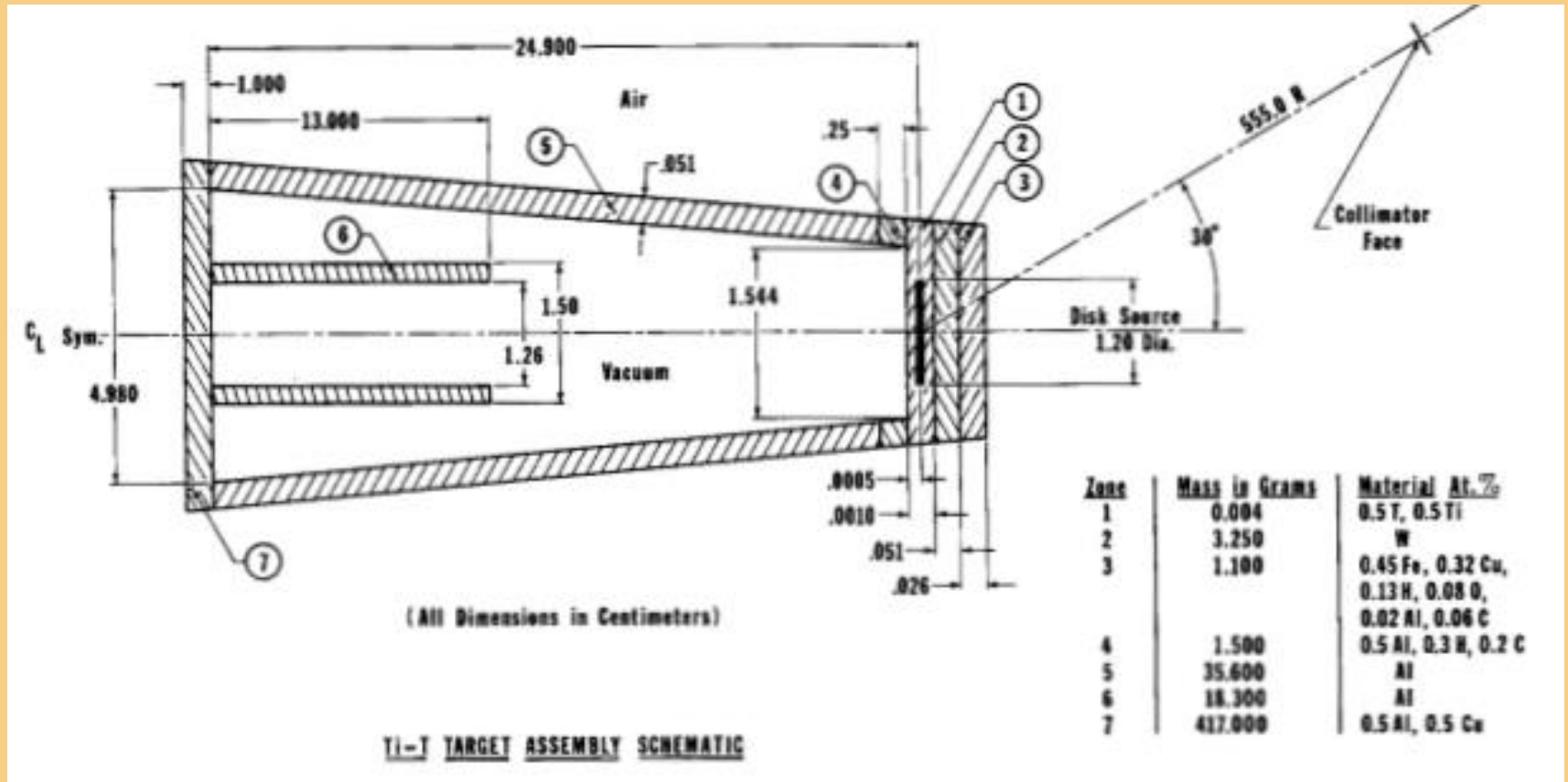
Background

- From the late 1960s to about 1985, a series of Pulsed Sphere experiments performed for 32 materials involving 148 different experiments using 75 different spheres,

- To measure neutron leakage spectra from 14 MeV neutrons generated by by $^3H(d,n)^4He$ reactions induced by an incident D+ beam from the Insulated Core Transformer (ICT) accelerator,

- Used conventional fixed neutron source approximations for experiments using $^3H(d,n)^4He$ 'source' reaction, and solved for neutron transport problem,

- Recent addition to COG 11.3 includes deuteron particle transport in order to directly calculate $^3H(d,n)^4He$ reactions, and resulting neutron emission spectra.

ICT and Pulsed Sphere

Target Assembly

Ti-T TARGET ASSEMBLY SCHEMATIC

(All Dimensions in Centimeters)

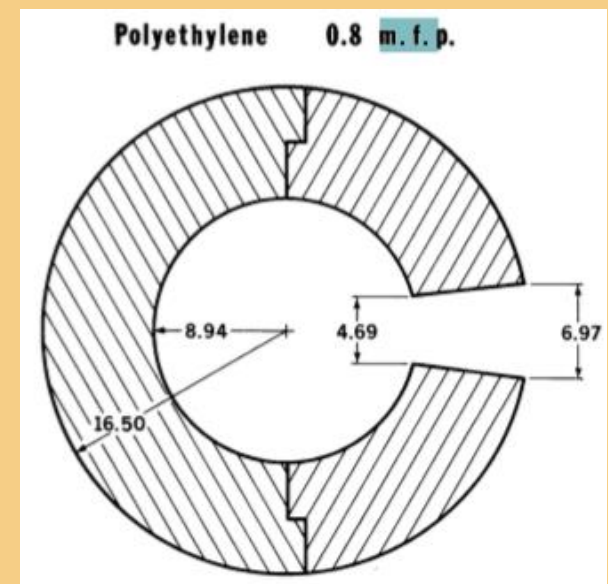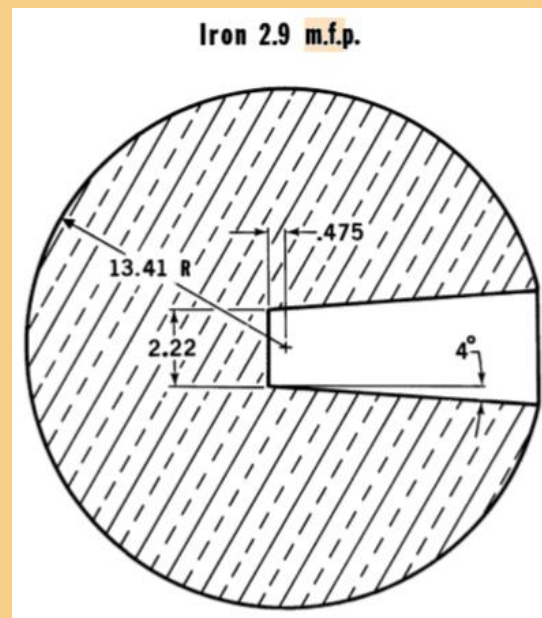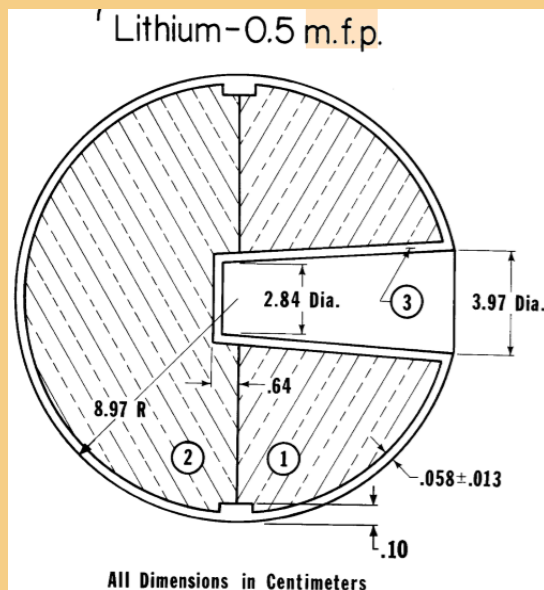| Zone	Mass in Grams	Material At.%
1	0.004	0.5 T, 0.5 Ti
2	3.250	W
3	1.100	0.45 Fe, 0.32 Cu, 0.13 H, 0.08 O, 0.02 Al, 0.06 C
4	1.500	0.5 Al, 0.3 H, 0.2 C
5	35.600	Al
6	18.300	Al
7	417.000	0.5 Al, 0.5 Cu

Testing Materials

Li-6, Li-7, LiD, LiH, Be, Mg, C, N, O, Al, Ti, U-235, U-238, Th-232, Pu-239, Fe, Cu, Mo, Nb, Sn, Ho, Ta, Au, Pb, W, Teflon, Polyethylene, Light Water, Heavy Water, Air, Concrete, Fiberglass

COG11

- Modern, general purpose, high-fidelity, multi-particle, Monte Carlo transport code,

- Can solve complex 3-D particle transport problems applicable to reactor physics, criticality safety, radiation shielding, and activation analyses,

- Alpha and Deuteron transport in COG based on the continuous slowing down approximation (CSDA) used in the AlfaMC Monte Carlo code,

  - NIST ASTAR database used for electronic and nuclear stopping power,
  - Gaussian, Vavilov, or Landau distributed energy straggling performed,
  - Fermi small-angle multiple scattering model adapted.

Pulsed Sphere Model

- Hollow Polyethylene Sphere, 0.8 mean free paths (MFP) or 7.56 cm thick. The inner and the outer diameters of the sphere are 17.88 and 33 cm, respectively.

- Angle between beam direction and detector: 30°,

- Distance to Pilot B detector from target center: 754 cm,
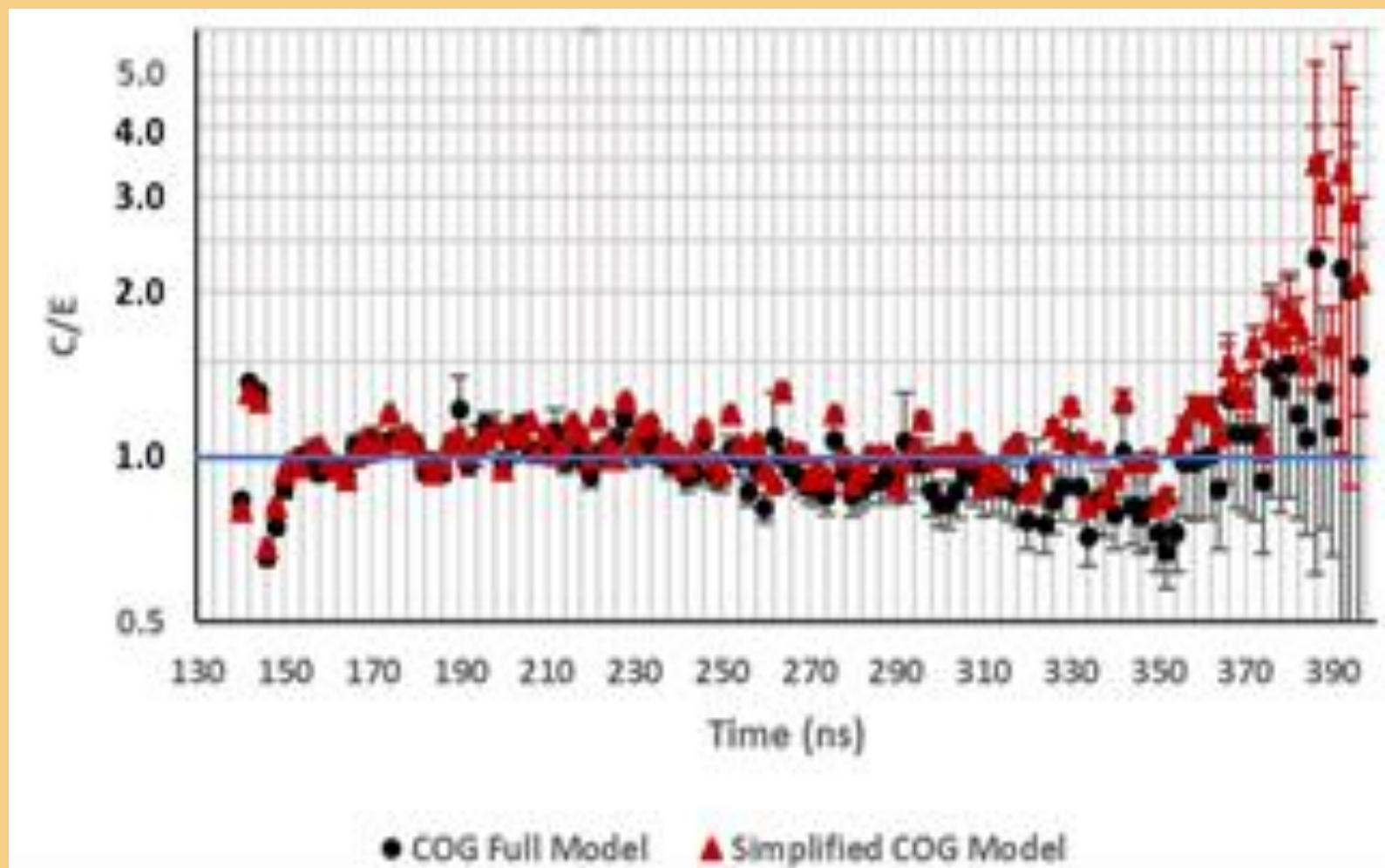
- Simplified and Full models considered,

Simplified Model
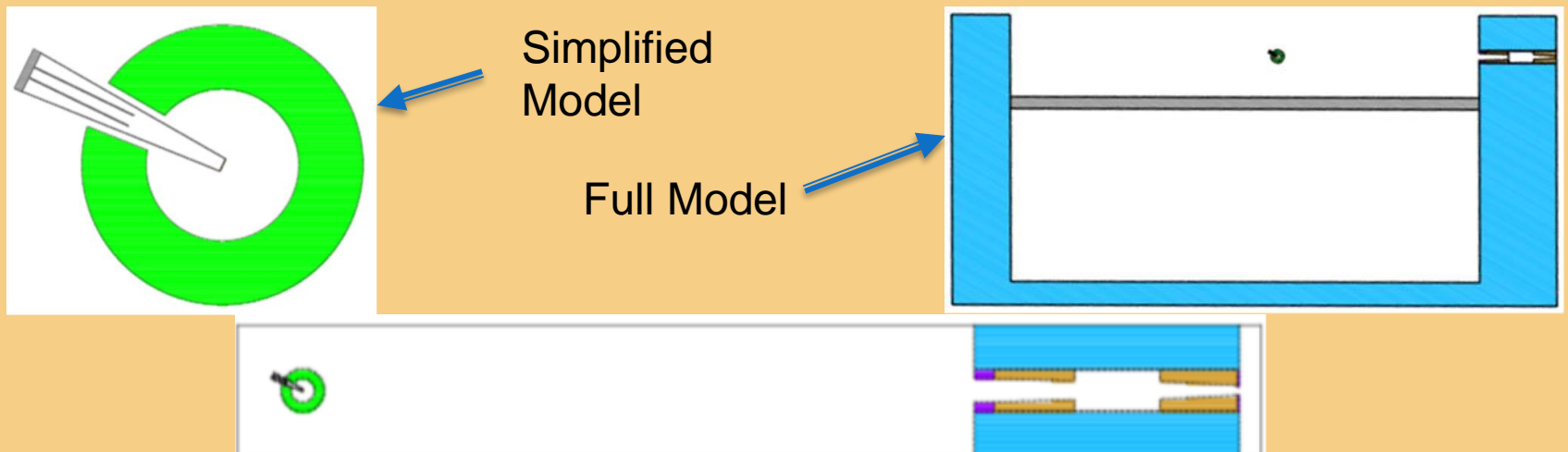
Full Model

Fixed Neutron Source and D+ Transport Results
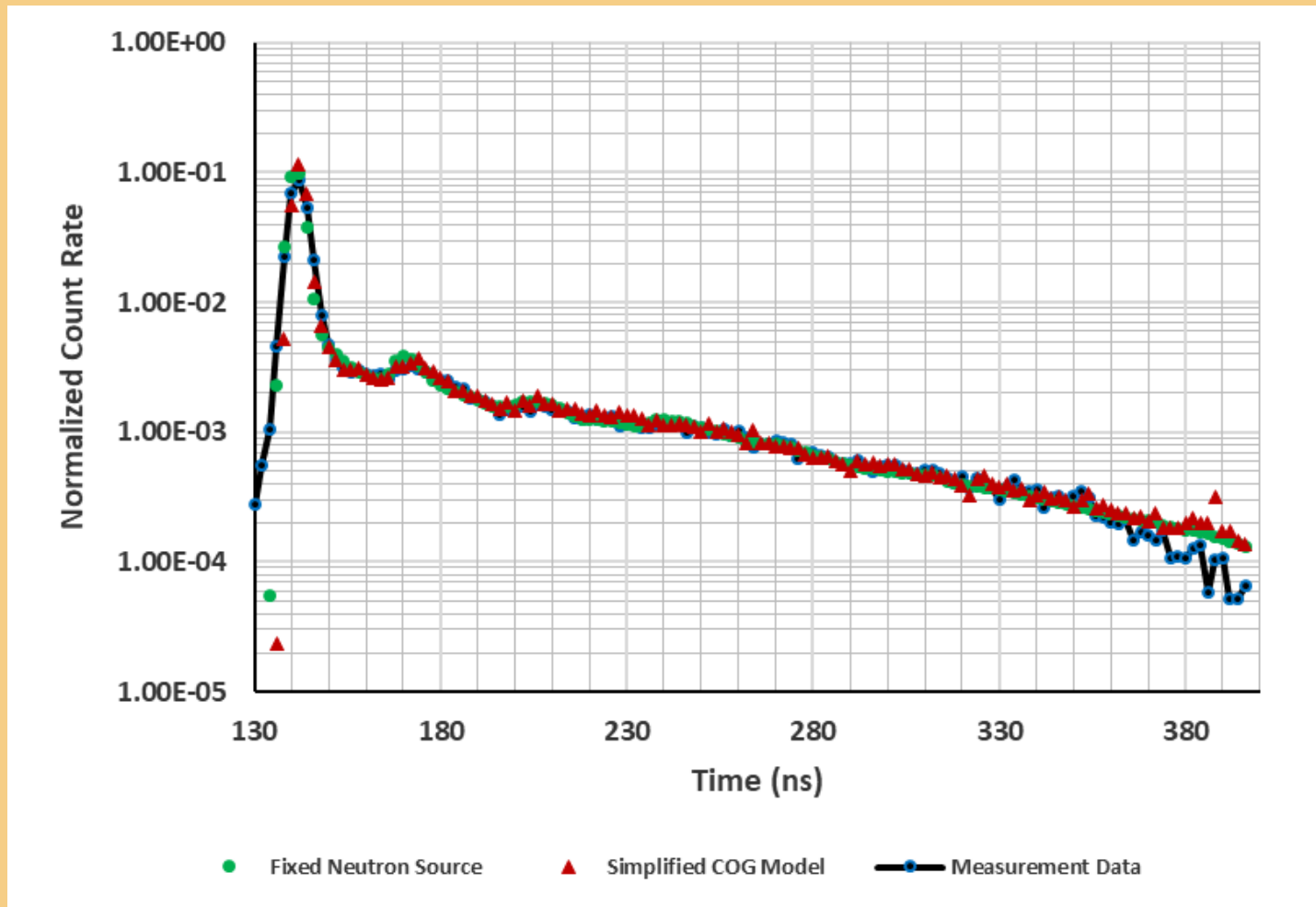
D+ Transport Results
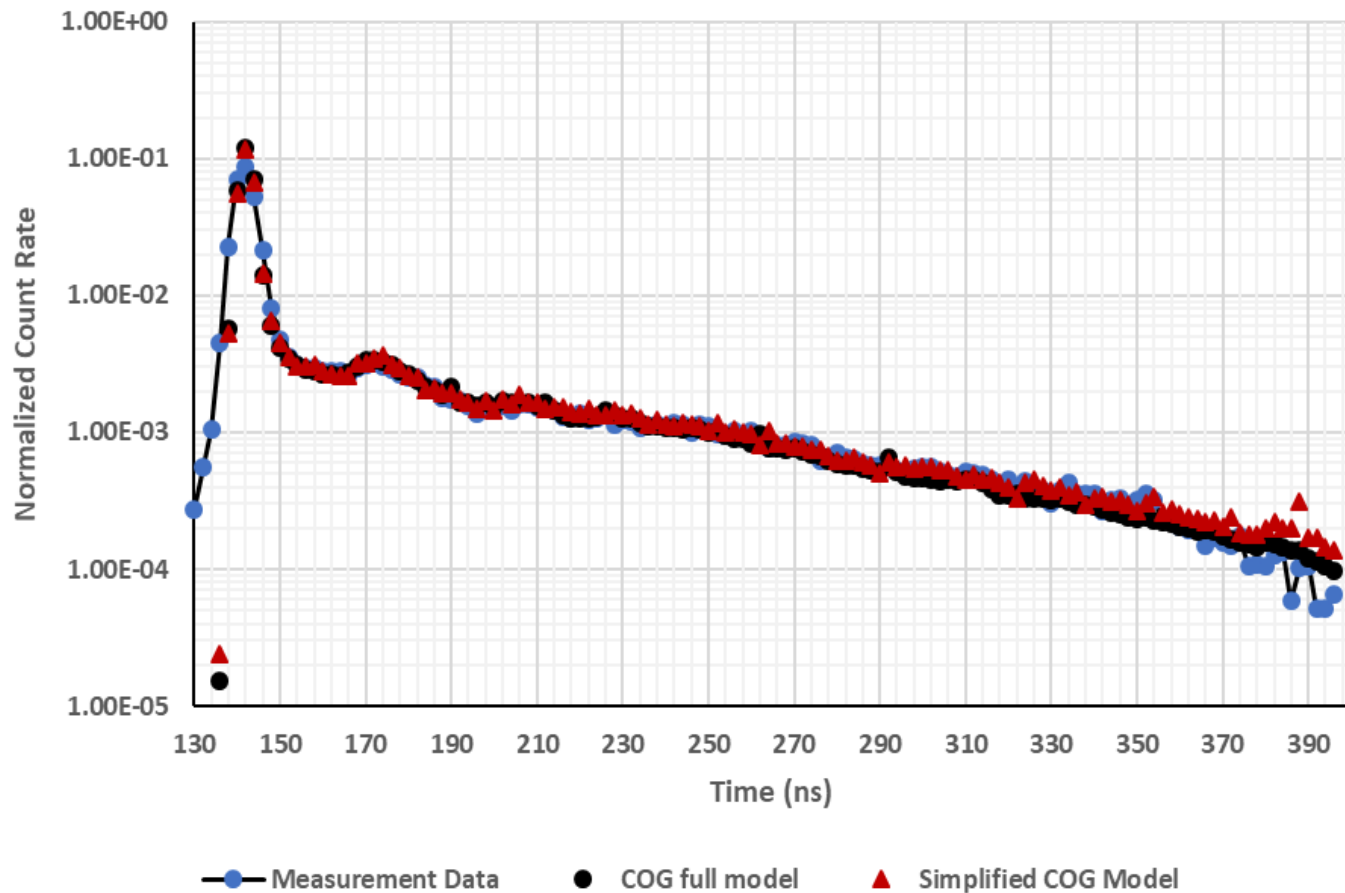
C/E for Simplified and Full Model

Summary

- New COG results demonstrate that high-fidelity D+ transport simulate can replace conventional fixed neutron source approximations,

- Evaluation of the other experiments including 1.8 mfp thick polyethylene and blank run with the same NE213 detector efficiency, is in progress,

- Plan to publish COG and other code results in a future edition of International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook and Shielding Integral Benchmarks Archive and Database (SINBAD) for information preservation and the international user community.