Evaluation of Measured and Simulated List-Mode Data for Subcritical Systems

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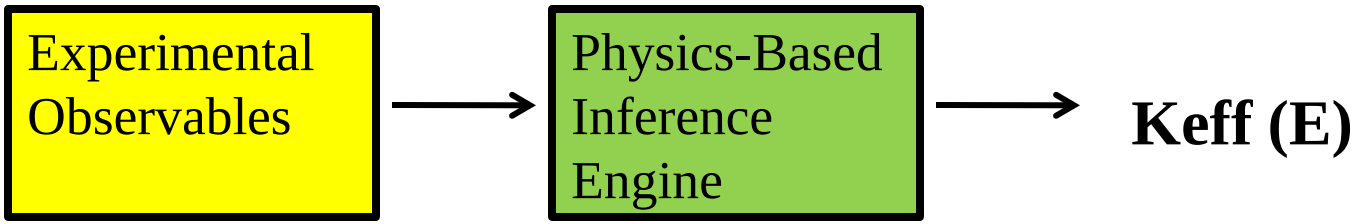
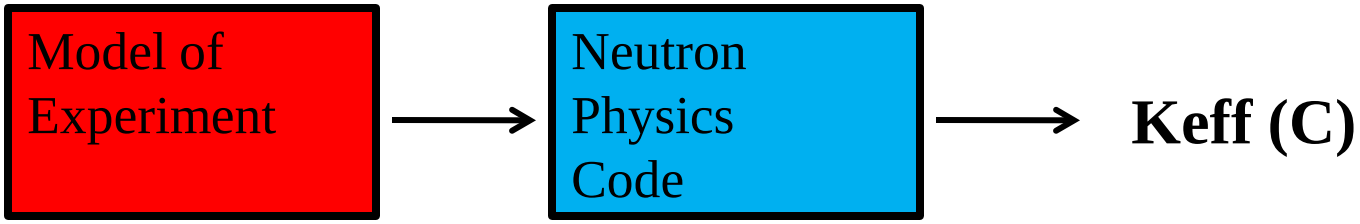
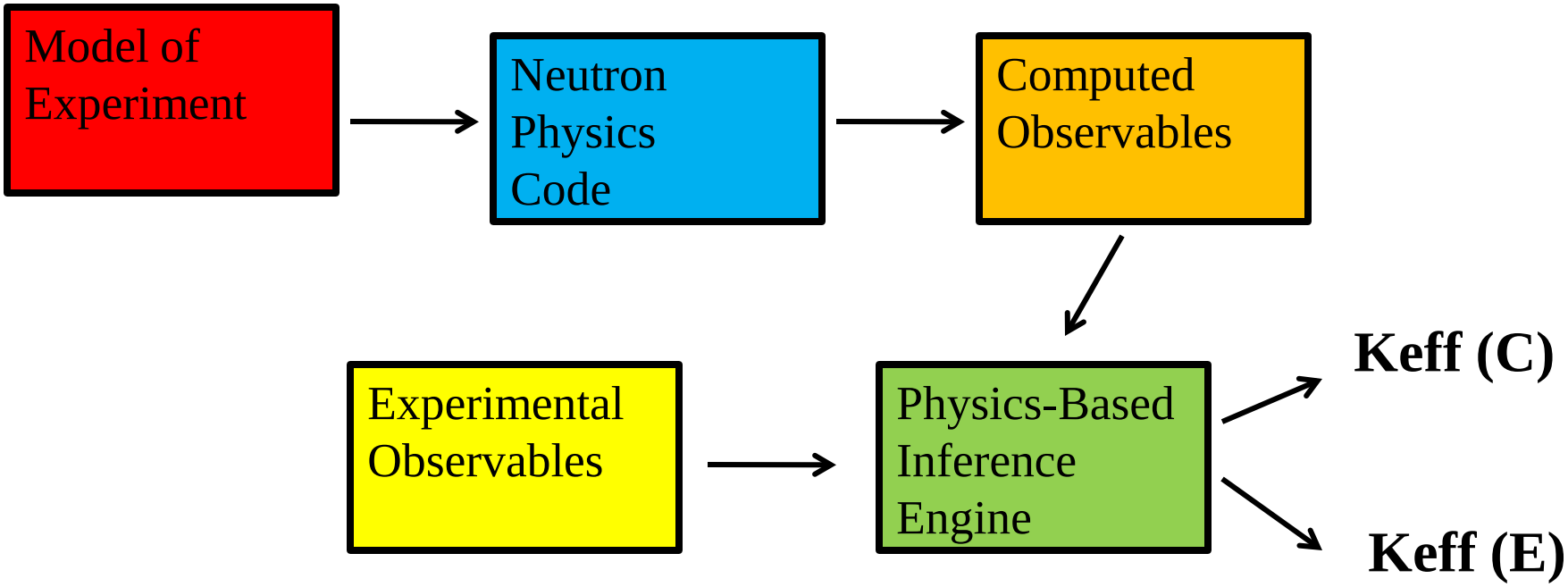
Measured and simulated analysis (1)





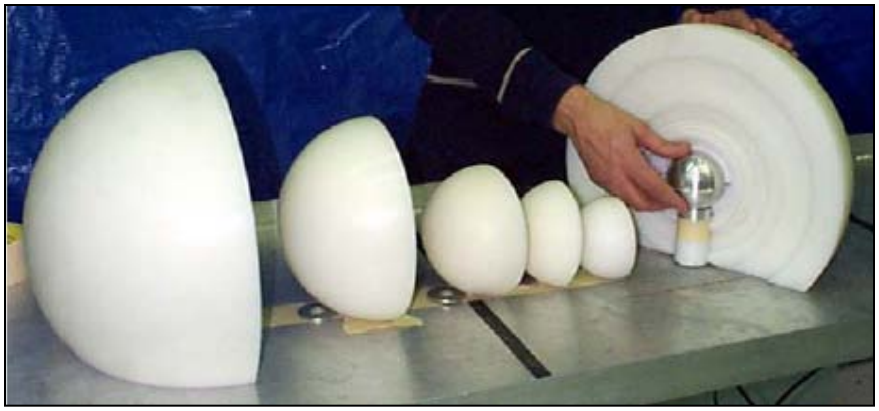
W. Myers, “The Reality of Subcritical Neutron Measurements and How They Can Differ with What Your Favorite Neutron Physics Code is Telling You”

Measured and simulated analysis (2)

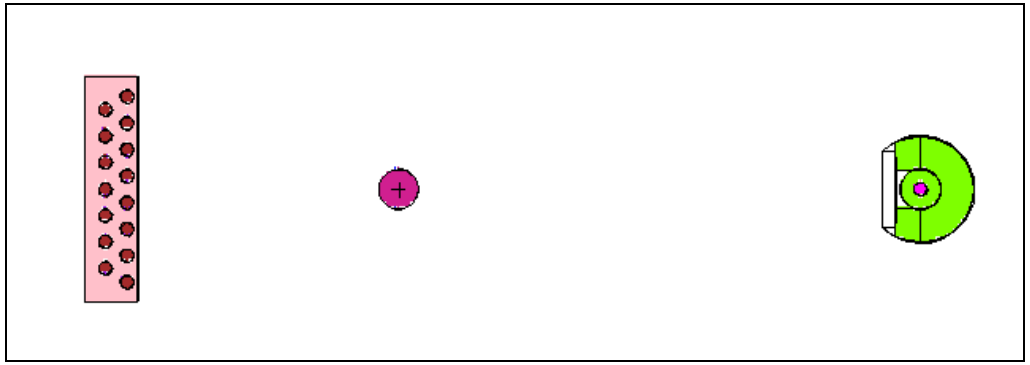


Configurations

- Data of the BeRP ball reflected by polyethylene.
- Measured data were reduced to match the simulation time (300 sec).



Measurement Setup and Model



Parameters

- NSS (neutron source strength)
  - Measured: SNAP detector.
  - Simulated: Outgoing F1 current tally (at outermost reflector surface) times the BeRP ball emission rate (2.83e5 n/s).
- Transmission
  - Measured: Reflected count rate divided by bare count rate using ^{252}Cf replacement measurements.
  - Simulated: Outgoing F1 current tally at reflector surface divided by outgoing F1 current tally at SNM surface

$$\varepsilon = \frac{\overline{C}}{T}\frac{\psi}{NSS}$$

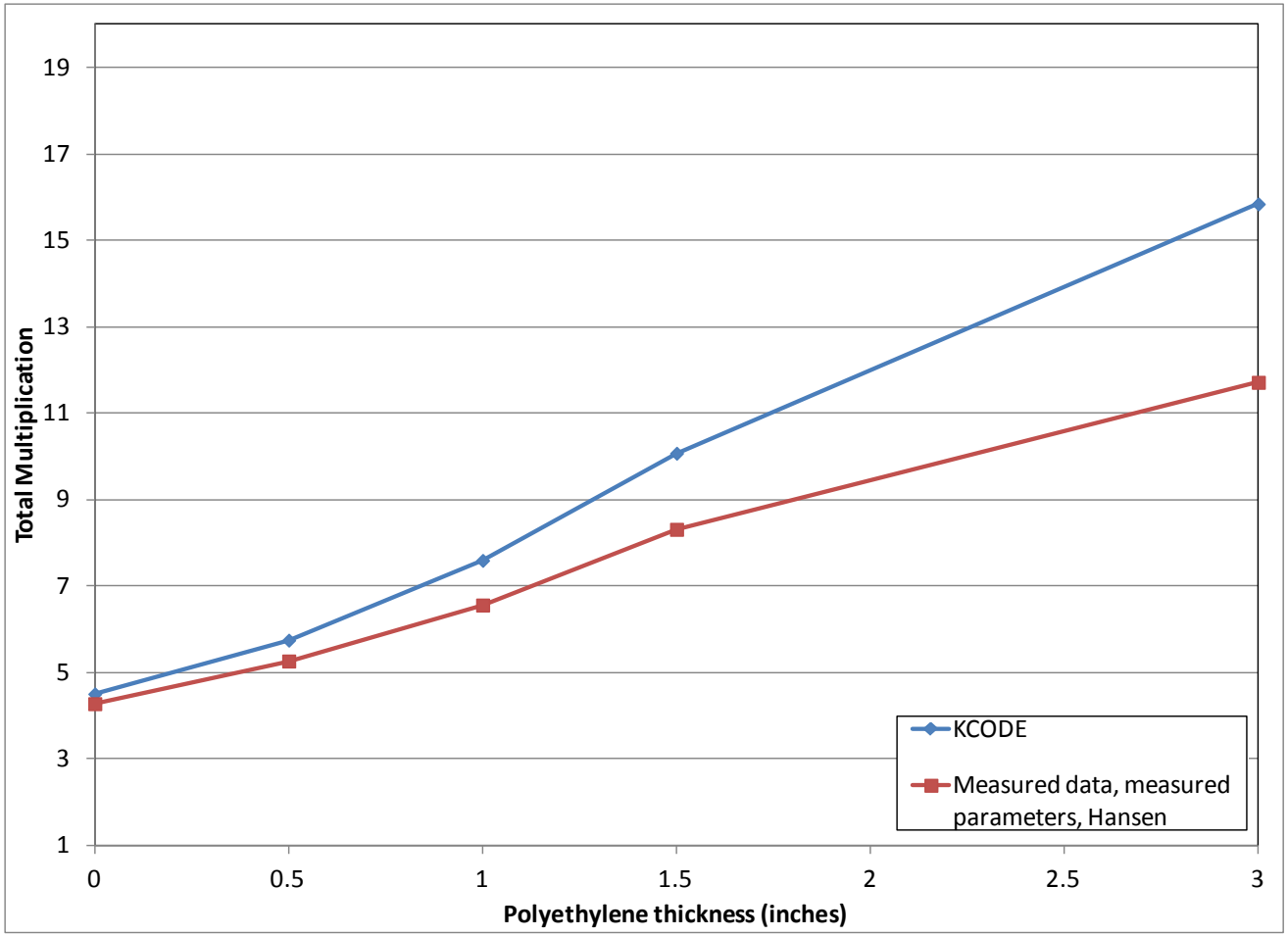
Parameters

Polyethylene Thickness (inches)	0	0.5	1	1.5	3
D_0	1.774				
D_1	2.352				
$\bar{\nu}_{S(1)}$	2.153				
$\bar{\nu}_{S(2)}$	1.904				
$\bar{\nu}_{I(1)}$	2.879				
$\bar{\nu}_{I(2)}$	3.388				
σ_c / σ_f	4.08E-03				
(α,n)	0.0015				
τ	0.1667				
NSS (measured)	9.964E+05	1.328E+06	1.697E+06	2.008E+06	1.687E+06
NSS (simulated)	8.860E+05	1.039E+06	1.361E+06	1.731E+06	1.829E+06
ψ (measured)	1.00	1.06	1.12	1.04	0.62
ψ (simulated)	1.00	0.87	0.83	0.77	0.50

Data comparison

- Previously we were comparing two data sets:
  - MCNP KCODE
  - Measured data using measured parameters
- This is similar to the first flowchart.

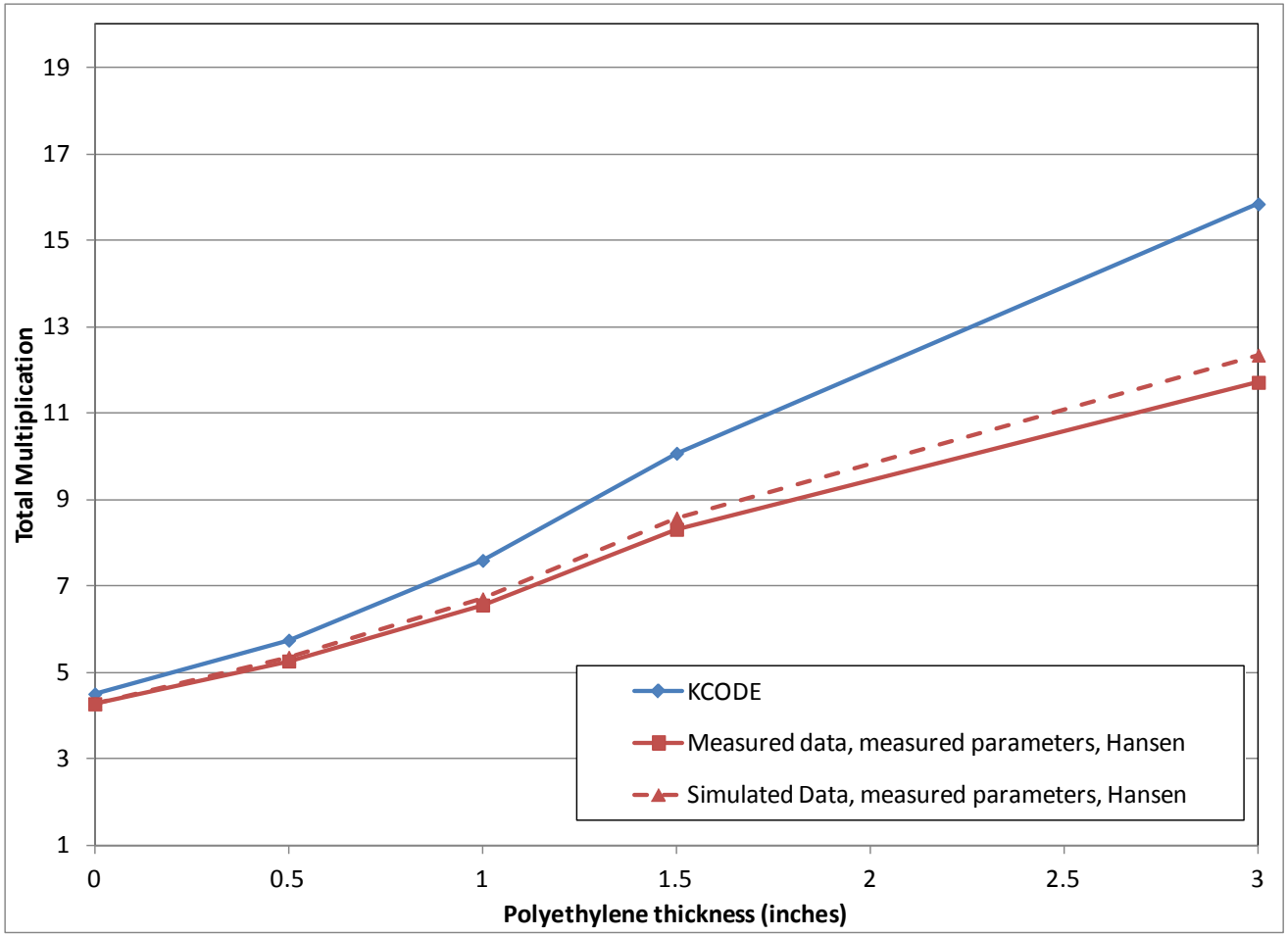
Data comparison (256 micro-sec)



Data comparison

- Now we can compare similar data sets:
  - Measured data using measured parameters
  - Simulated data using measured parameters
- This is similar to the second flowchart.

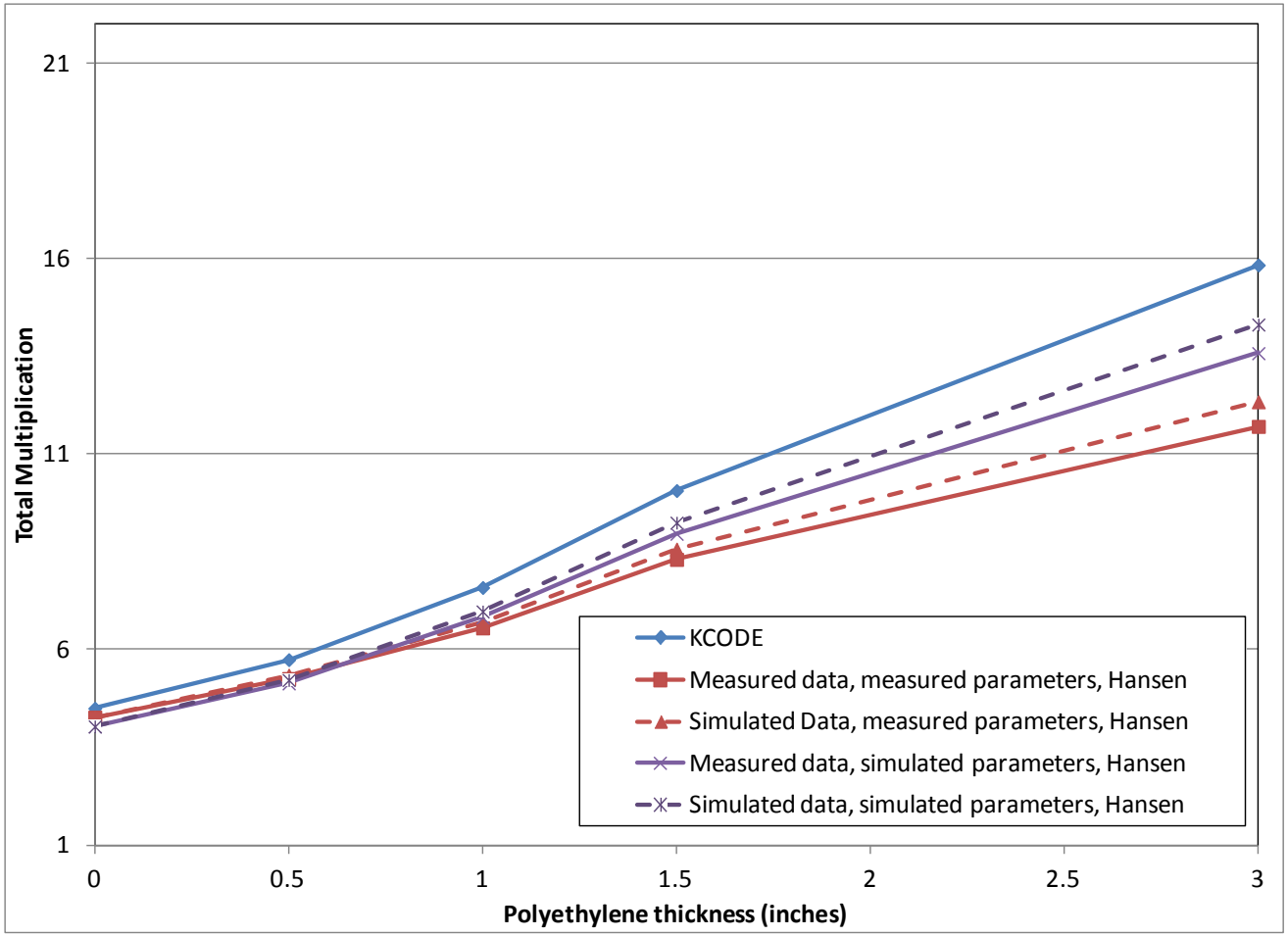
Data comparison (256 micro-sec)



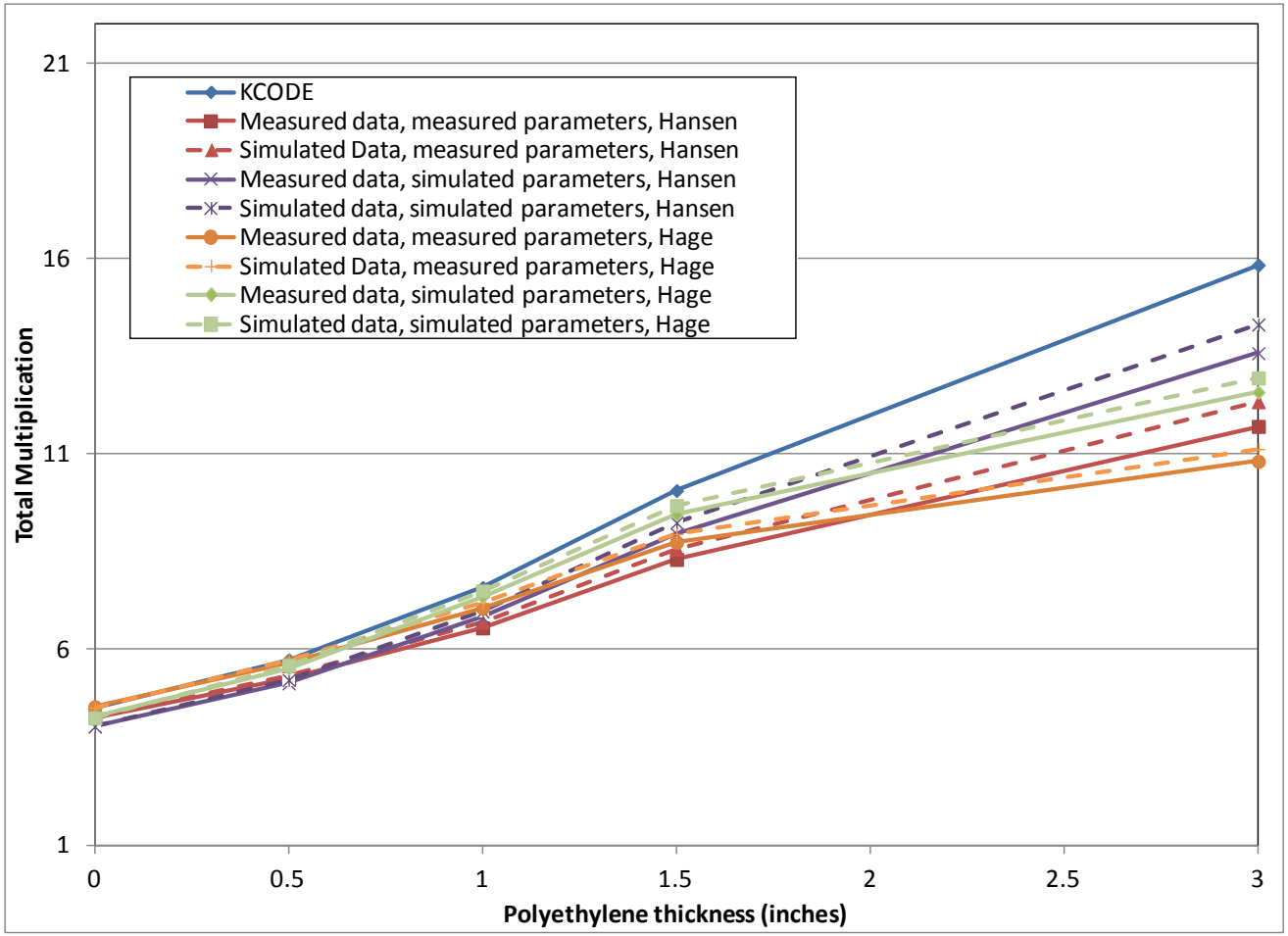
Data comparison

- Now we can compare similar data sets:
  - Measured data using measured parameters
  - Simulated data using measured parameters
  - Measured data using simulated parameters
  - Simulated data using simulated parameters

Data comparison (256 micro-sec)



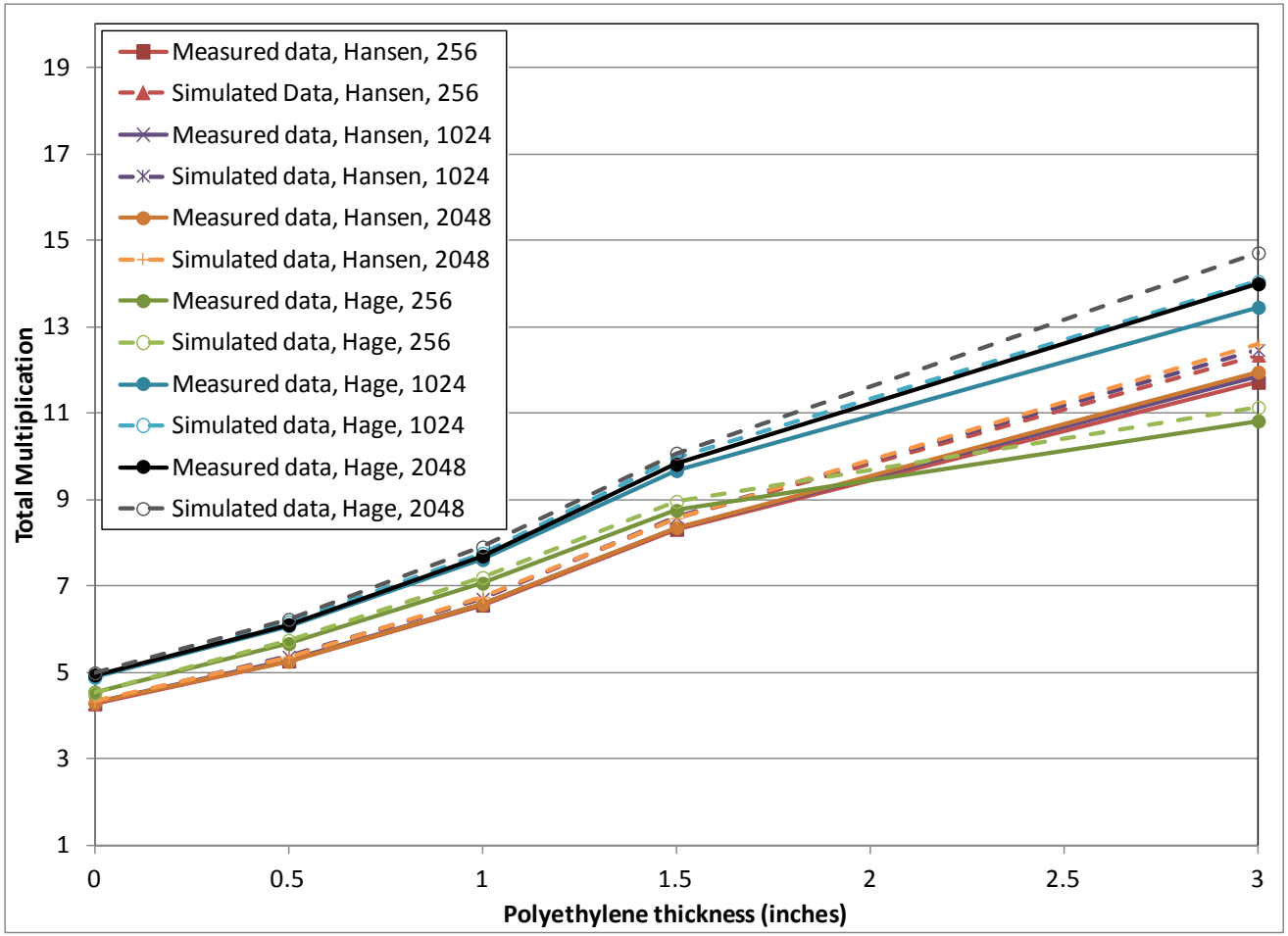
Data comparison (256 micro-sec)



Data comparison (256 micro-sec)

Poly	Gate Width	Method	Parameters	Measured Data	Simulated Data	C/E
0	256	Hansen-Dowdy	Measured	4.27	4.27	1.00
0.5				5.26	5.35	1.02
1				6.56	6.70	1.02
1.5				8.31	8.57	1.03
3				11.71	12.34	1.05
0			Simulated	4.04	4.04	1.00
0.5				5.14	5.22	1.02
1				6.83	6.98	1.02
1.5				8.97	9.25	1.03
3				13.59	14.32	1.05
0		Hage-Cifarelli	Measured	4.54	4.52	0.99
0.5				5.66	5.74	1.01
1				7.06	7.20	1.02
1.5				8.75	8.96	1.02
3				10.82	11.13	1.03
0			Simulated	4.28	4.25	0.99
0.5				5.53	5.60	1.01
1				7.36	7.50	1.02
1.5				9.46	9.69	1.02
3				12.59	12.95	1.03

Gate Width Comparison (measured parameters)



Other Results

	gate width	analysis method	data	paramaters	0	0.5	1	1.5	3
lifetime	-	-	measured	-	40.640	39.616	43.257	56.316	118.196
lifetime	-	-	simulated	-	42.888	41.268	44.803	59.591	129.948
$\overline{C}$	256 micro-seconds	Hansen-Dowdy	measured	-	2.176	2.936	3.799	4.496	3.706
$\overline{C}$			simulated	-	2.248	3.077	4.066	4.888	4.098
$\overline{C^2}$			measured	-	7.533	12.934	21.181	29.644	21.058
$\overline{C^2}$			simulated	-	7.956	14.100	24.099	34.894	25.579
Y_m			measured	-	0.285	0.470	0.775	1.097	0.977
Y_m			simulated	-	0.291	0.506	0.861	1.251	1.143
R_1		Hage-Cifarelli	measured	-	2.176	2.936	3.799	4.496	3.706
R_1			simulated	-	2.248	3.077	4.066	4.888	4.098
R_2			measured	-	0.310	0.690	1.473	2.467	1.810
R_2			simulated	-	0.327	0.778	1.750	3.056	2.342
ε		-	measured	measured	0.009	0.009	0.010	0.009	0.005
ε		-	simulated		0.009	0.010	0.010	0.010	0.006
ε		-	measured	simulated	0.010	0.010	0.009	0.008	0.004
ε		-	simulated		0.010	0.010	0.010	0.008	0.004

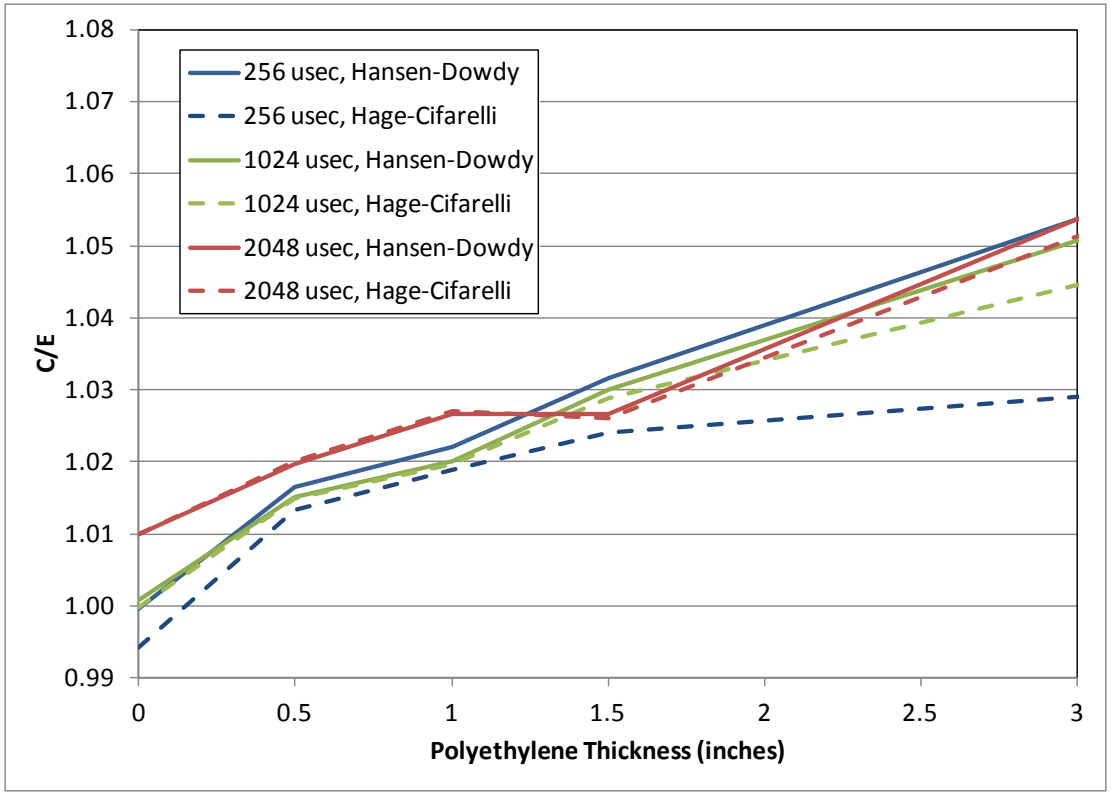
Results

- Table below shows C/E for $\overline{C}$, R_1, count rate, and efficiency.
- It is independent of the gate width.
- Simulated data yields higher values for all polyethylene thicknesses.

Poly Thickness	C/E
0.00	1.03
0.50	1.05
1.00	1.07
1.50	1.09
3.00	1.11

Results

- Figure shows C/E for total multiplication.
- It is independent of parameters (measured vs. simulated).



Conclusions

- Measured and simulated data were compared for the BeRP ball reflected by polyethylene.
- Simulated data gives higher count rate and multiplication than measured data.
- The data differ more as reflector thickness increases.
  - The maximum difference in count rates was 10%.
  - The maximum difference in both total and leakage multiplication was 5.5%.

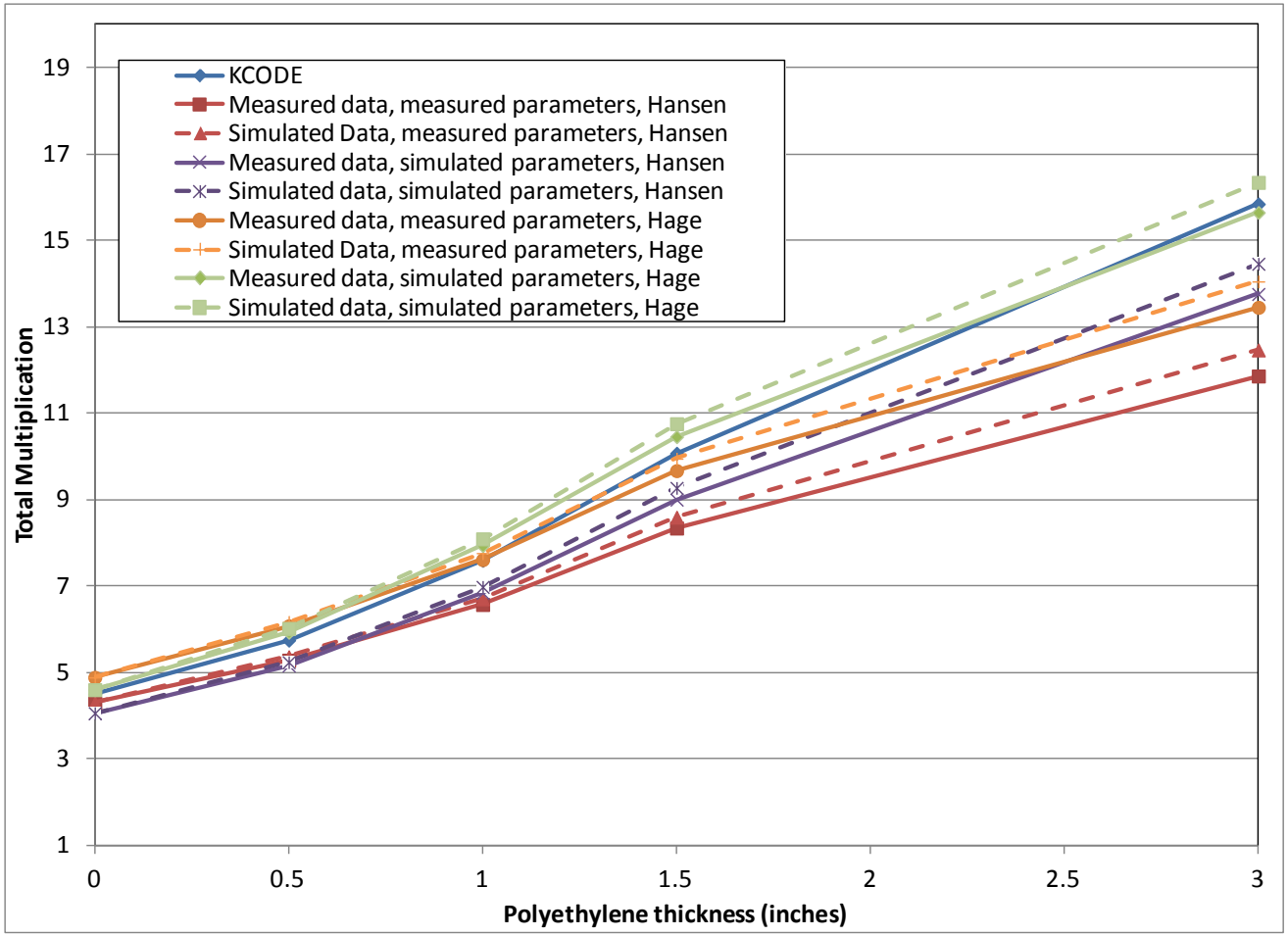
Future Work

- Perform additional comparisons with measured data (both existing and new data).
- Determine the optimal parameter set(s) for use in future subcritical benchmarks.
- Perform measurements and simulations at greater ranges of multiplication.
  - This is particularly useful on known/benchmarked assemblies such as CALIBAN.
  - Measurements will be performed on CALIBAN in summer 2012 ($0.88 < k_{eff} < 1$).
  - Measurements will be performed with US and French neutron detectors.

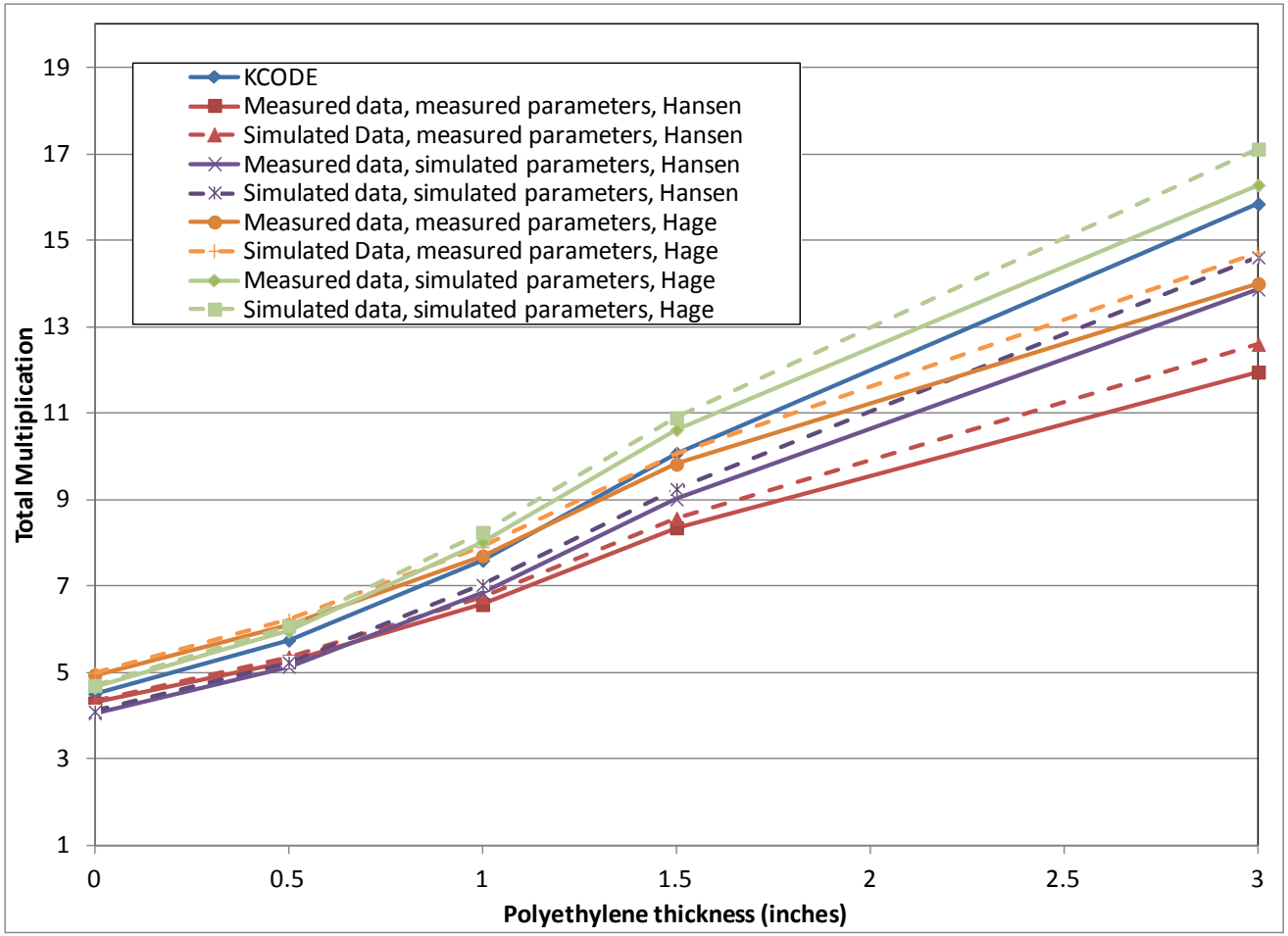
Related Works

- W. Myers, “The Reality of Subcritical Neutron Measurements and How They Can Differ with What Your Favorite Neutron Physics Code is Telling You,” Nuclear Criticality Safety Program Technical Seminar, Oak Ridge National Laboratory, March 1-2, 2011.
- A. Sood, J. Hutchinson, W. Myers, C. Solomon, R. Little, “Current Capabilities for Generating List-Mode Data for Simulated Subcritical Neutron Measurements Using MCNP,” Nuclear Criticality Safety Program (NCSP) Subcritical Measurement Workshop, Los Alamos National Laboratory, July 14th, 2011.
- C. Solomon, “Polyethylene Reflected Plutonium Multiplication Inference Simulations,” Nuclear Criticality Safety Program (NCSP) Subcritical Measurement Workshop, Los Alamos National Laboratory, July 14th, 2011.
- K. Clark, D. Beller, A. Liu, L. Lakeotes, “Current Status of NCSP Subtask 7 Subcritical Modeling,” Nuclear Criticality Safety Program (NCSP) Subcritical Measurement Workshop, Los Alamos National Laboratory, July 14th, 2011.
- J. Hutchinson, M. Smith-Nelson, C. Solomon, W. Myers, A. Sood, “Comparison of Measured and Simulated Data using the Feynman Variance-to-Mean Method,” Nuclear Criticality Safety Program (NCSP) Subcritical Measurement Workshop, Los Alamos National Laboratory, July 14th, 2011.
- A. Sood, et. al., “Direct Calculation of Measured Observables in a Multiplying Sub-Critical System,” International Conference on Nuclear Criticality, Edinburgh, Scotland, 19-22 September 2011.
- J. Hutchinson, C. Solomon, A. Sood, W. Myers, M. Smith-Nelson, “Comparison Of Feynman Variance-To-Mean Measurements Using Measured And Simulated Data,” International Conference on Nuclear Criticality, Edinburgh, Scotland, 19-22 September 2011.

Data comparison (1024 micro-sec)



Data comparison (2048 micro-sec)



Gate Width Comparison (simulated parameters)