

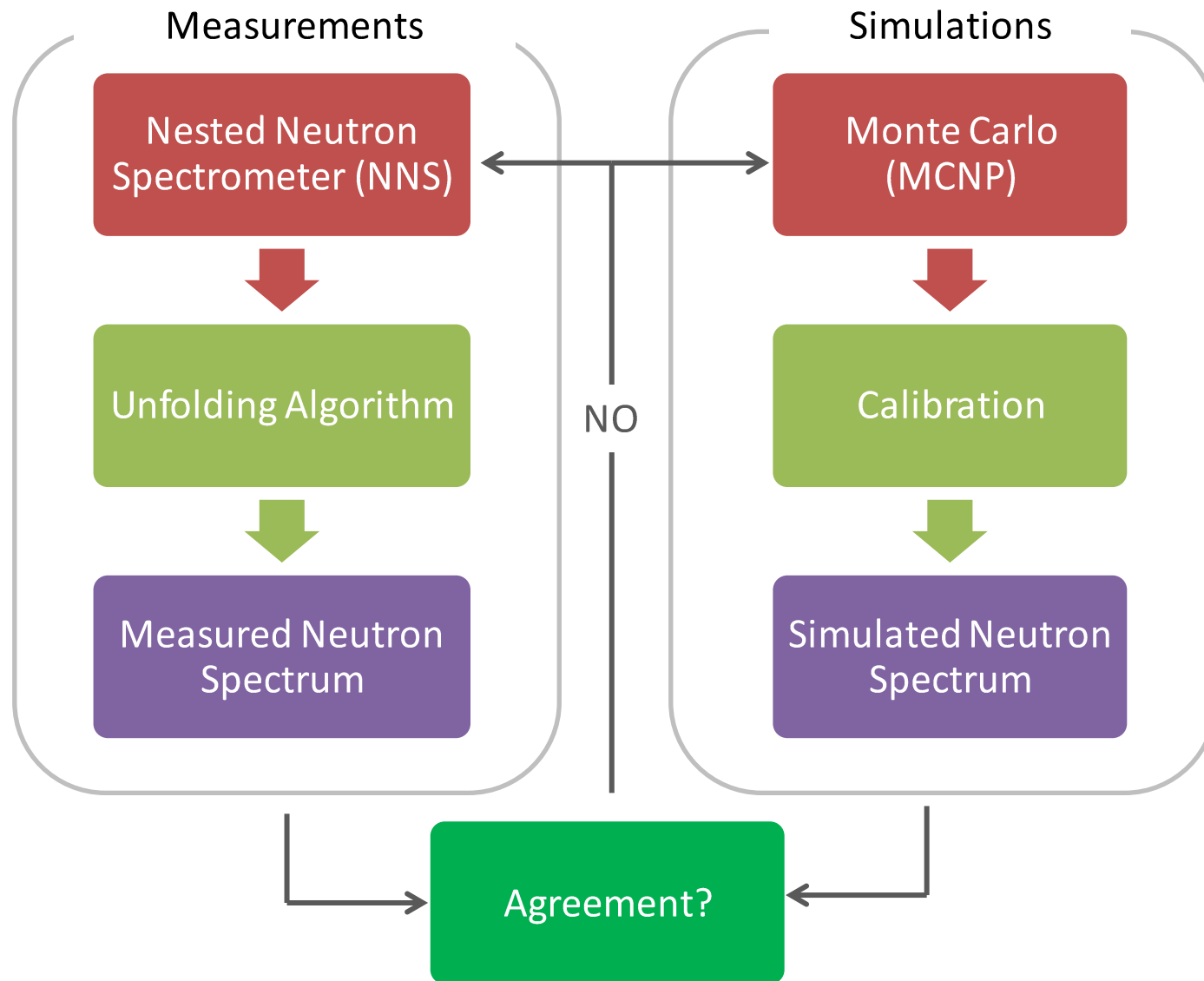


Measuring Neutron Spectra in Radiotherapy Using the Nested Neutron Spectrometer

R. Maglieri*, A. Licea, J. Seuntjens, J. Kildea

McGill University
Medical Physics

Objectives



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Evaluate the suitability of the Nested Neutron Spectrometer (NNS) for measuring neutron spectra in radiotherapy

1. Determine the performance of NNS for measurements around a Varian linac
2. Compare equivalent doses measured by the NNS and bubble detectors
3. Compare Monte Carlo simulated neutron spectra with those measured by the NNS

A New Neutron Detector

Nested Neutron Spectrometer

- Thermal neutron He-3 detector with HDPE shells
- Current mode (possible due to Kr mixed with He-3)
- Similar but more practical than Bonner sphere system



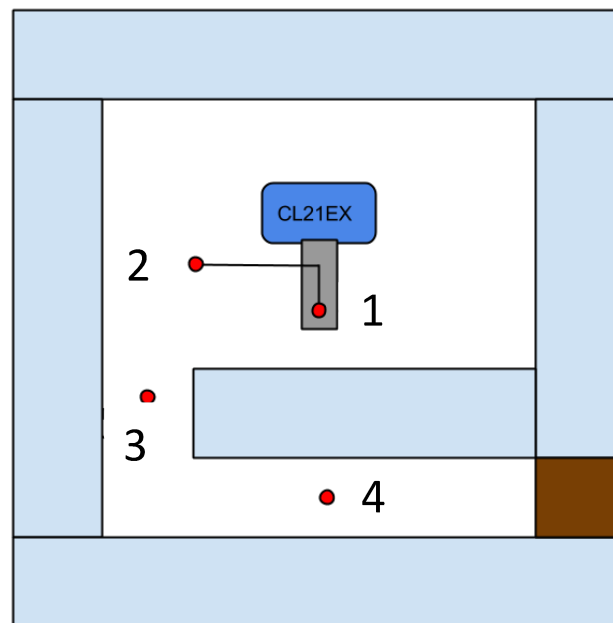
Dubeau, J., et al. "A neutron spectrometer using nested moderators."
Radiation protection dosimetry 150.2 (2012): 217-222.

Methods

Experimental Setup

- Varian Clinac 21EX with gantry at 0° , jaws closed, energy at 18 MV and dose rate at 600 MU/min
- NNS positioned at 40 cm and 140 cm from the isocenter, at the maze-room junction and in the maze (operated in current mode)

No pulse pile up in current mode



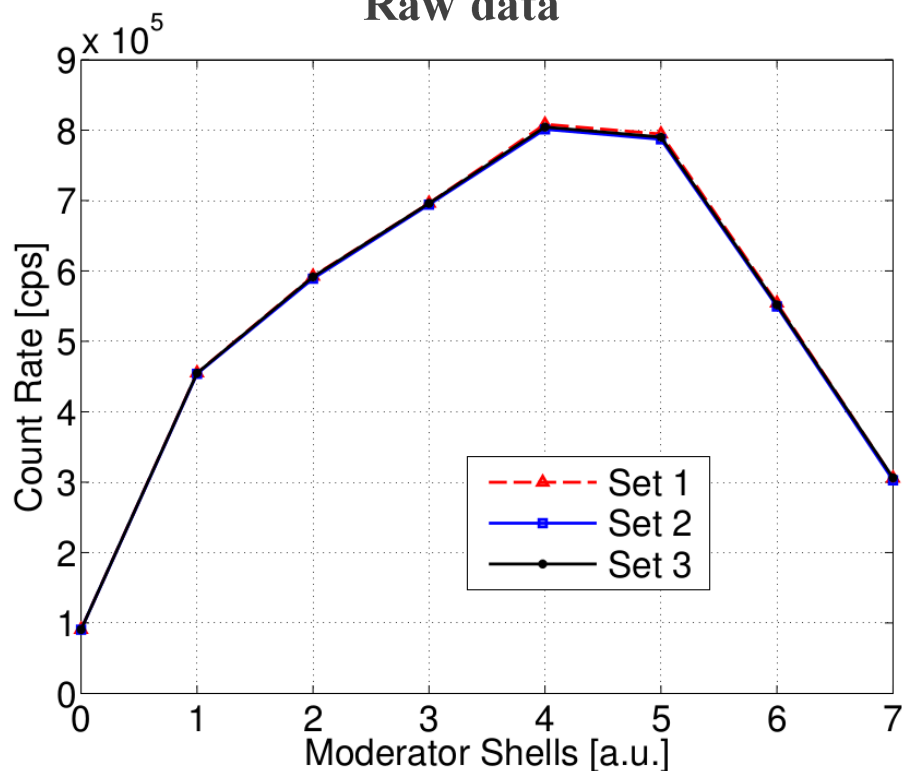
- 1) 40 cm
- 2) 140 cm
- 3) Maze-Room Junction
- 4) Maze

Performance Tests

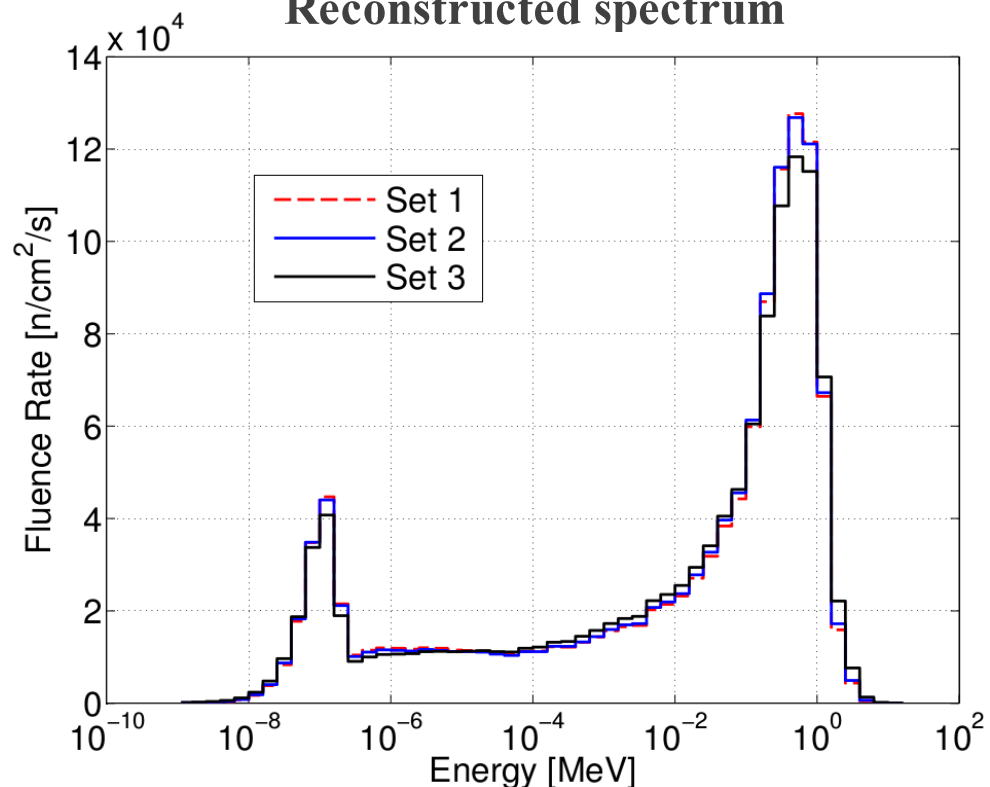
Reproducibility

- Measurement repeated 3 times at 40 cm from isocenter
- Total fluence rate was 1.205×10^6 n/cm²/s; COV: **0.4 %**

Raw data



Reconstructed spectrum



Performance Tests

Linearity

- Three measurements: 600 MU, 1200 MU, 1800 MU
- Total fluence rate was 1.209×10^6 n/cm²/s; COV: **0.1 %**

Dose Rate

- Changing the dose rate from 400 MU/min to 600 MU/min

	Dose Rate (MU/min)	Total Fluence Rate ($\times 10^6$ n/cm ² /s)
	400	0.81
	600	1.21
Ratio	0.67	0.67

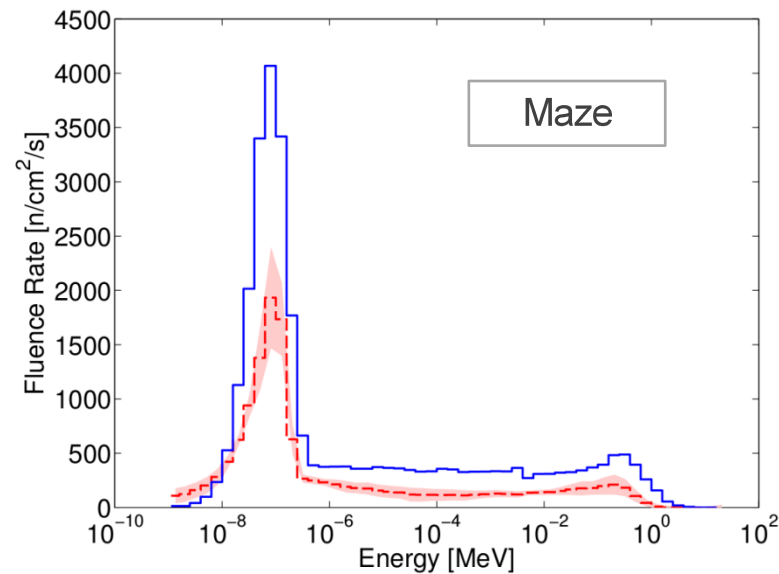
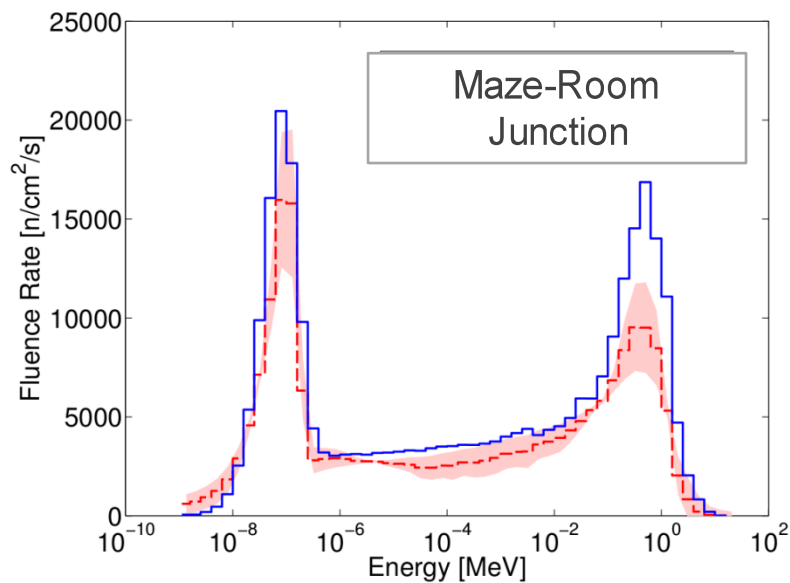
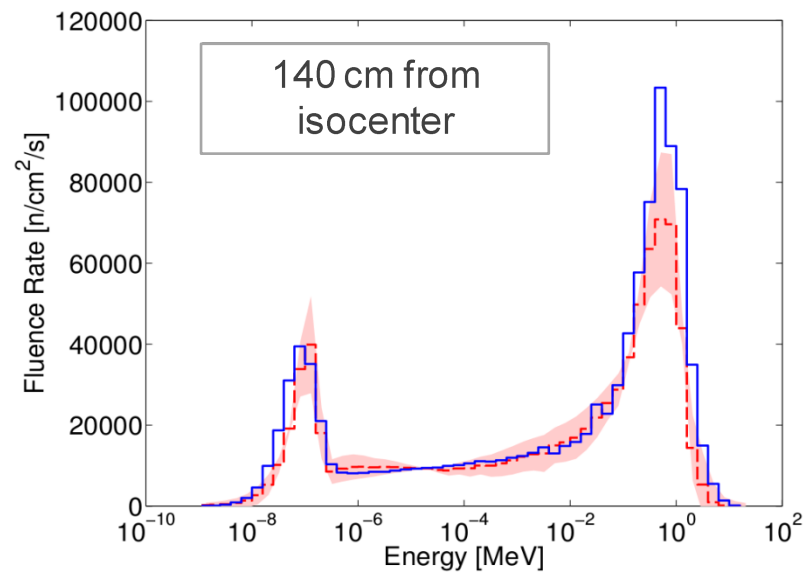
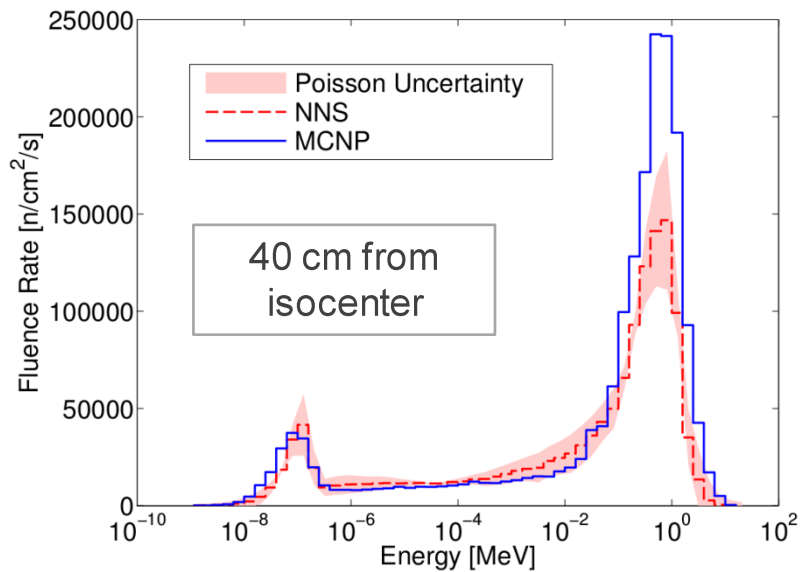
Equivalent Doses

NNS compared to bubble detectors

- Measurements at 140 cm from the isocenter, at the maze-room junction and in the maze
- Equivalent dose from BDT (thermal to epithermal) summed with PND (200 keV to ~15 MeV)
- ICRP-74 conversion coefficients used to convert fluence to equivalent dose

	140 cm	M-R Junction	Maze
NNS (mSv/hr)	383.0	56.7	1.1
PND+BDT (mSv/hr)	387.9	61.9	2.2
Difference (%)	1.25	8.45	50

MCNP vs NNS



Conclusions

NNS measurements in current mode are possible around a linac

- Reproducibility and linearity tests yield total fluence rates with COVs less than 1 %
- Total fluence rate ratios follow dose rate ratios

Equivalent doses measured by bubble detectors and NNS are in agreement

- Differences range from 1 % in the room to 50 % in the maze

Good overall agreement between NNS measured and MC simulated neutron spectra

- Spectral characteristics preserved
- Discrepancies in the thermal and fast neutron peaks

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