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EVALUATION OF ATOMIC RECOIL SPECTRA FOR STUDIES OF DEGRADATION IN SEMICONDUCTOR DEVICES

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Joint ICTP-IAEA Workshop on Simulation of Nuclear Reaction Data with the TALYS Code

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Sandia National Laboratories
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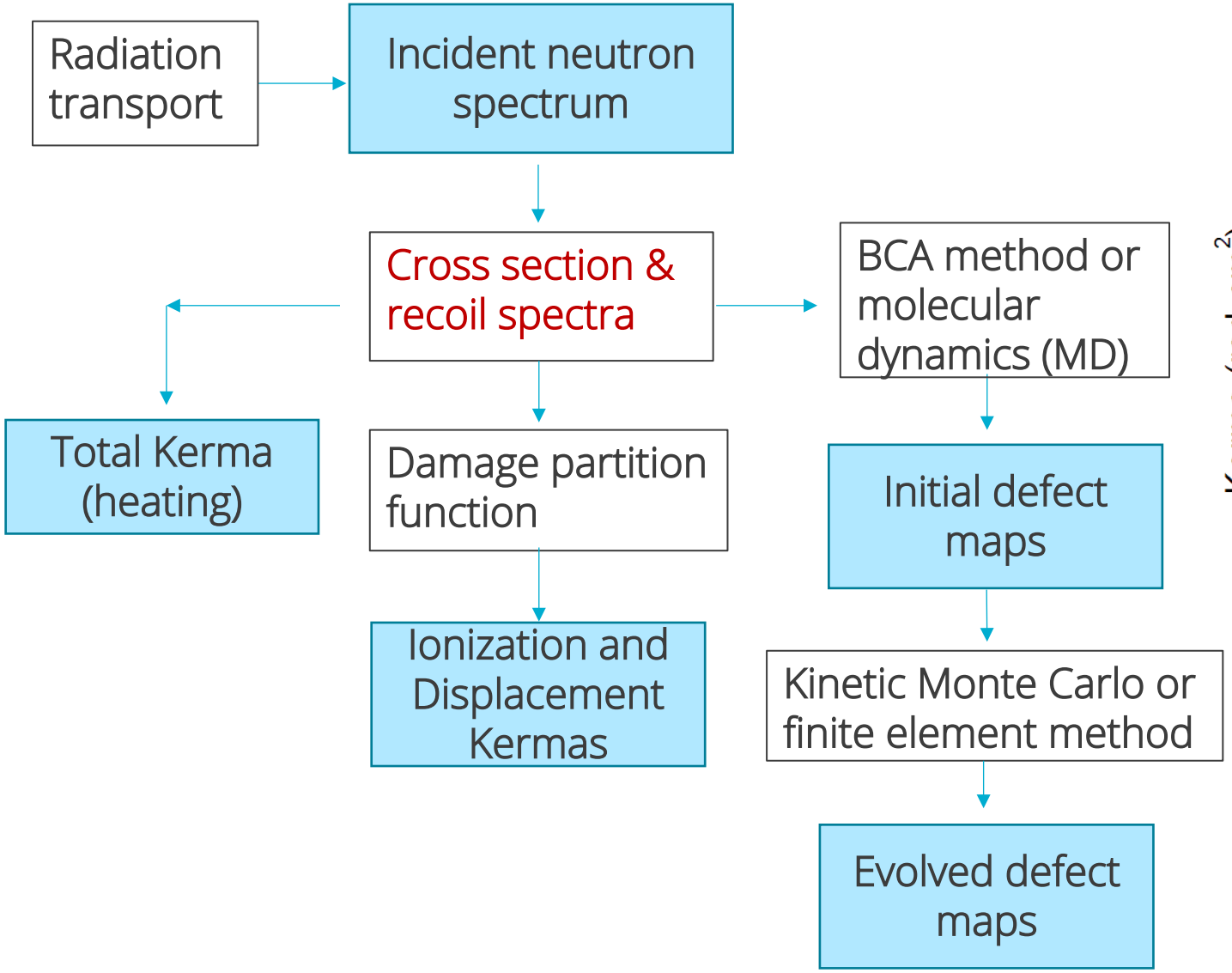
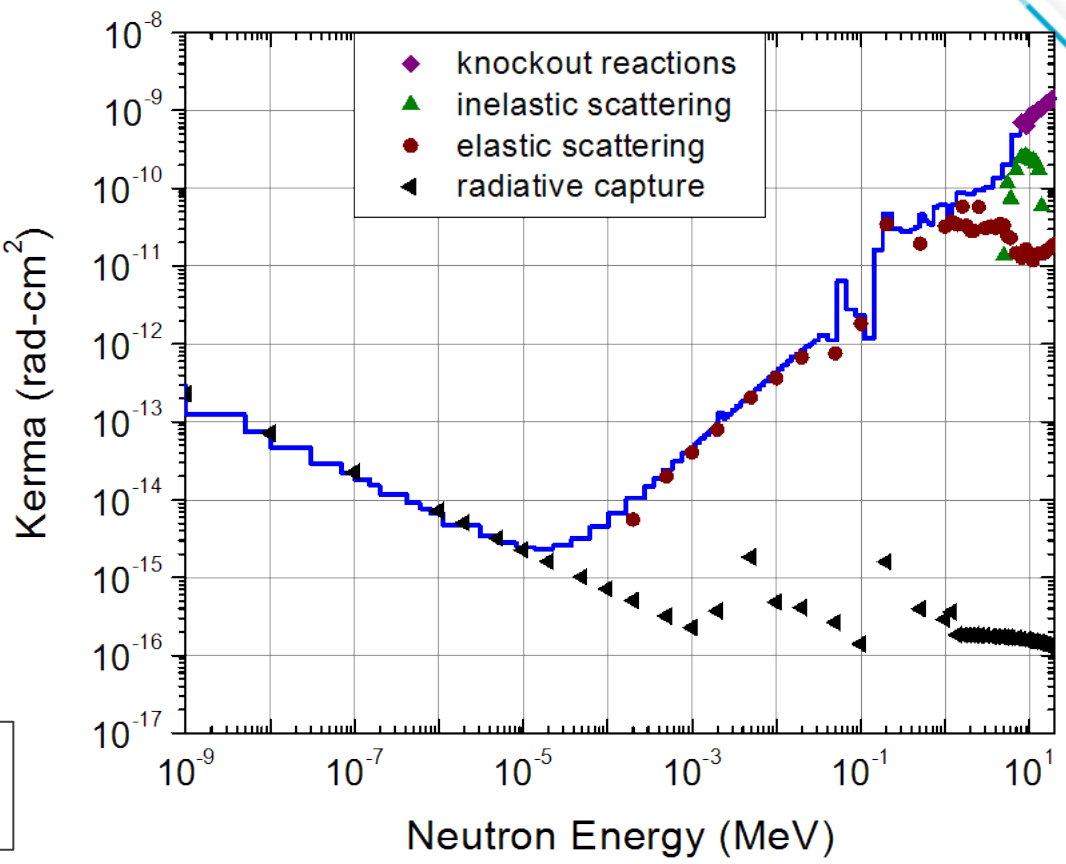
DAMAGE MODELING

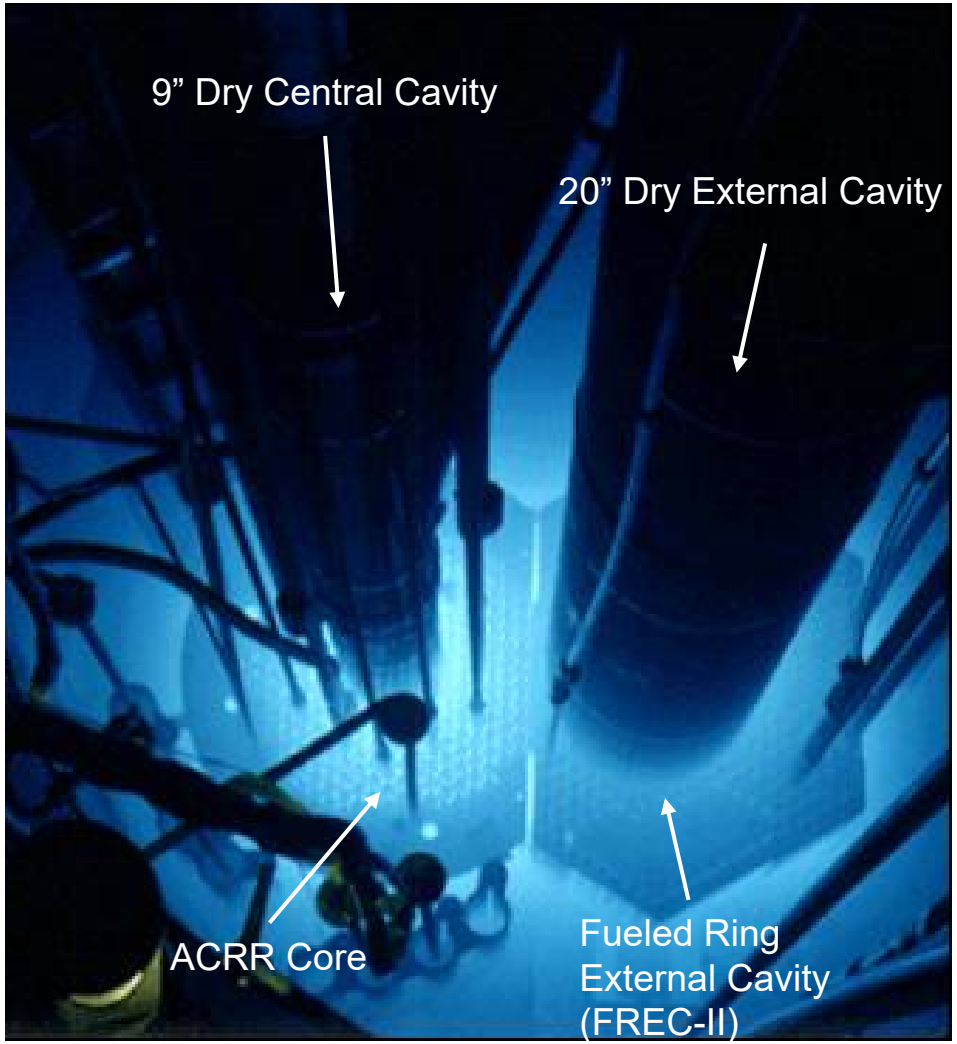




Breakdown of the components of total kerma in silicon, by reaction type

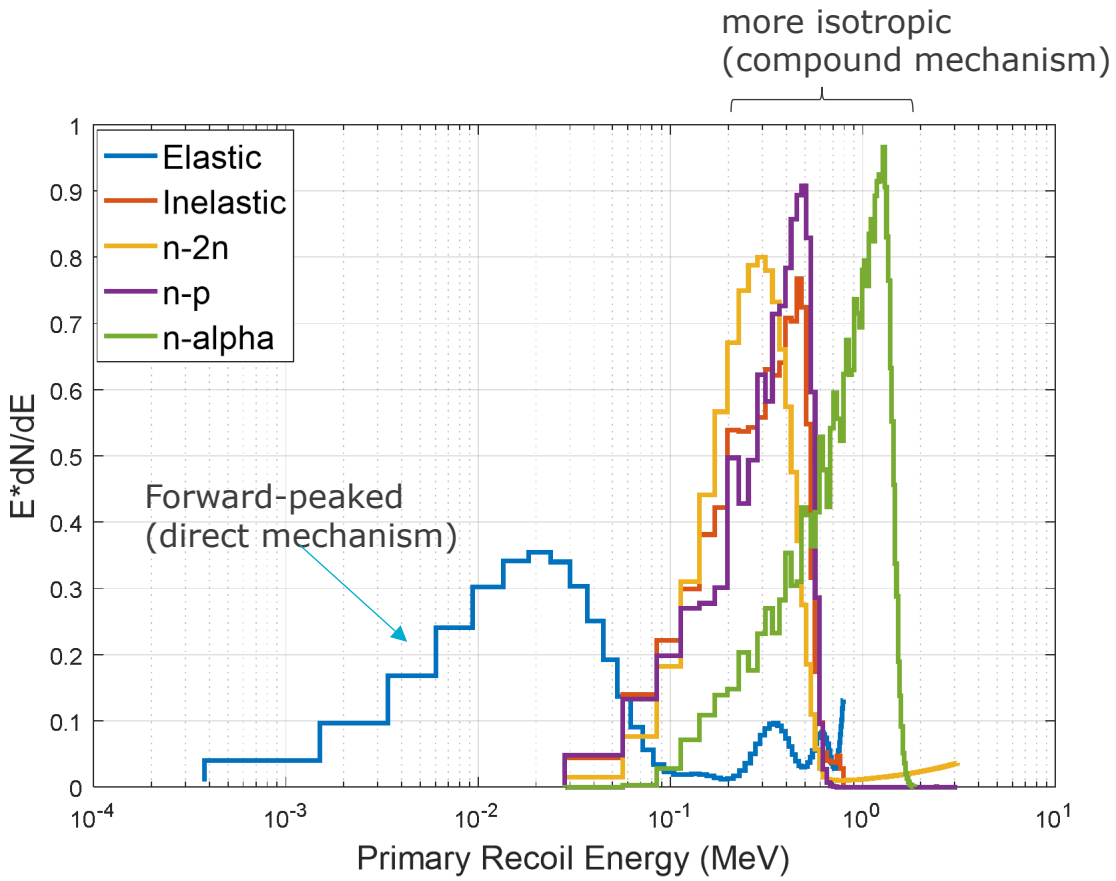
RADIATION ENVIRONMENTS OF CONCERN

- **Fission sources:** Typically reactor-type spectra: Watt fission spectrum peaked 1 – 2 MeV; possible down-scattering to thermal energies (Maxwellian)
- **Fusion sources:** D-T (14.1 MeV) and D-D (2.45 MeV) are most notable; many other reactions exist
- **Atmospheric neutrons:** Varies with altitude, but spectrum extends up to hundreds of MeV
- **Surrogate sources:**
  - Protons
  - Heavy ions



ACRR and FREC-II (Sandia Tech Area V)

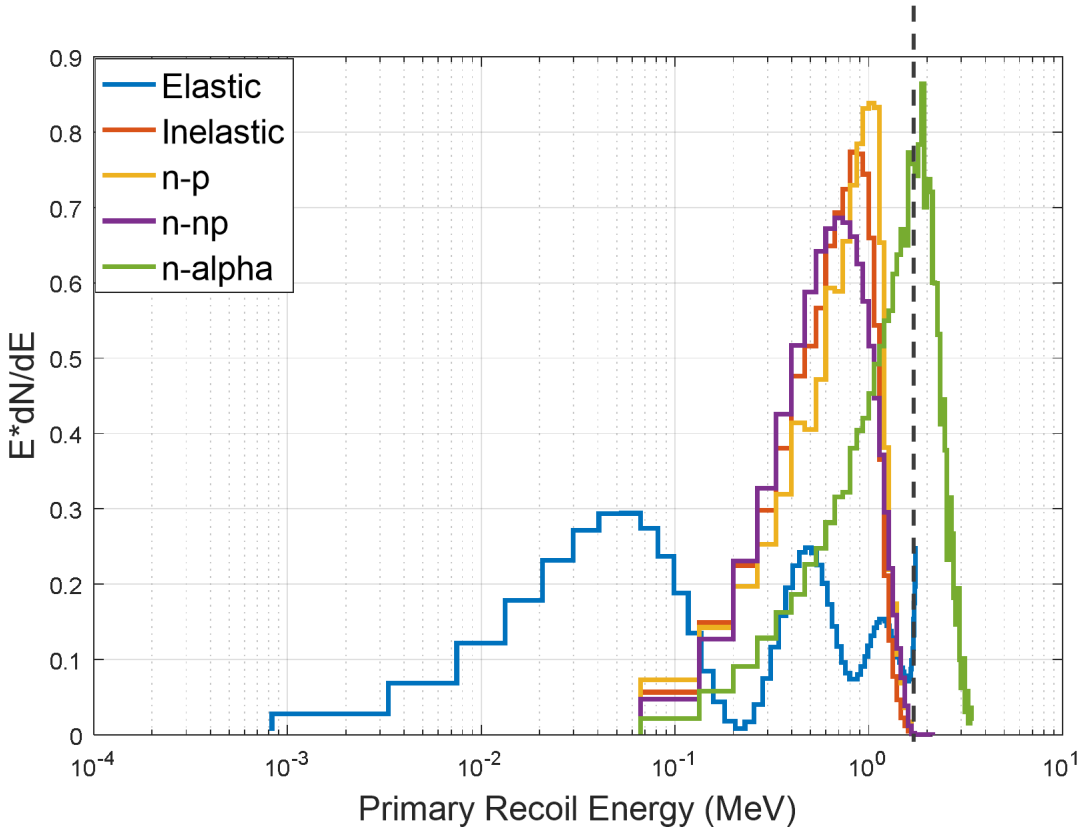
RECOIL SPECTRA



Recoil spectrum from 14-MeV neutrons, by reaction type, in Ga-71

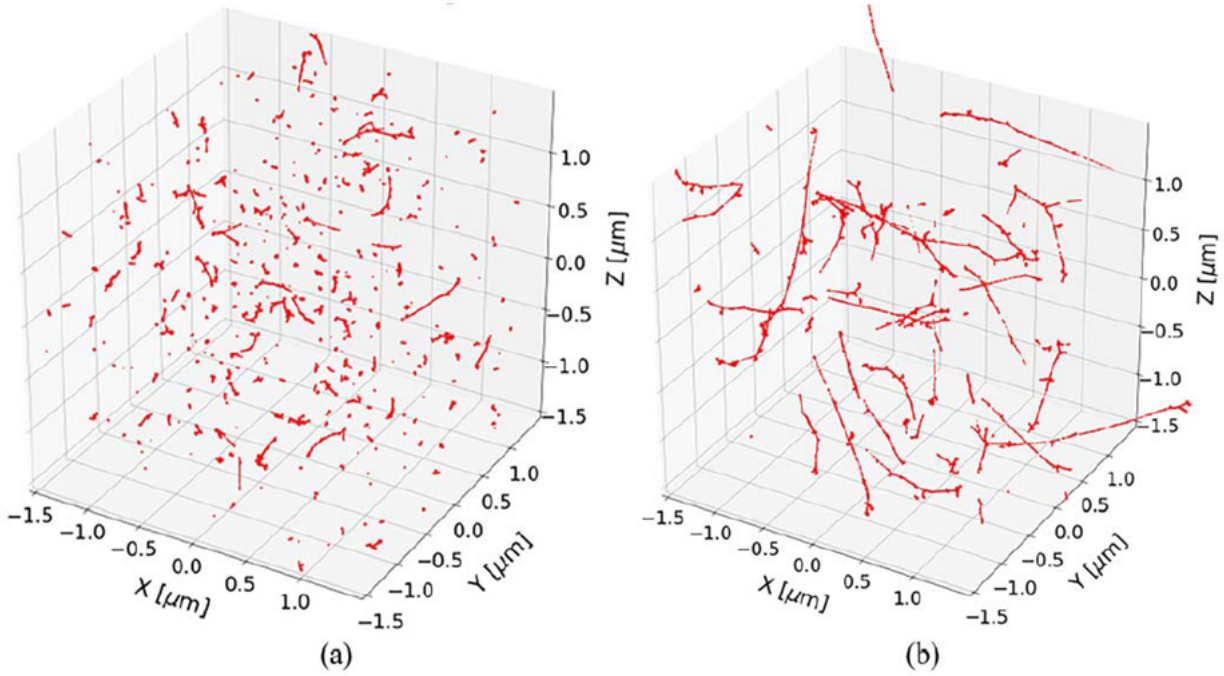
Elastic limit

$$E_{rec} = E_n \frac{4A}{(A+1)^2}$$

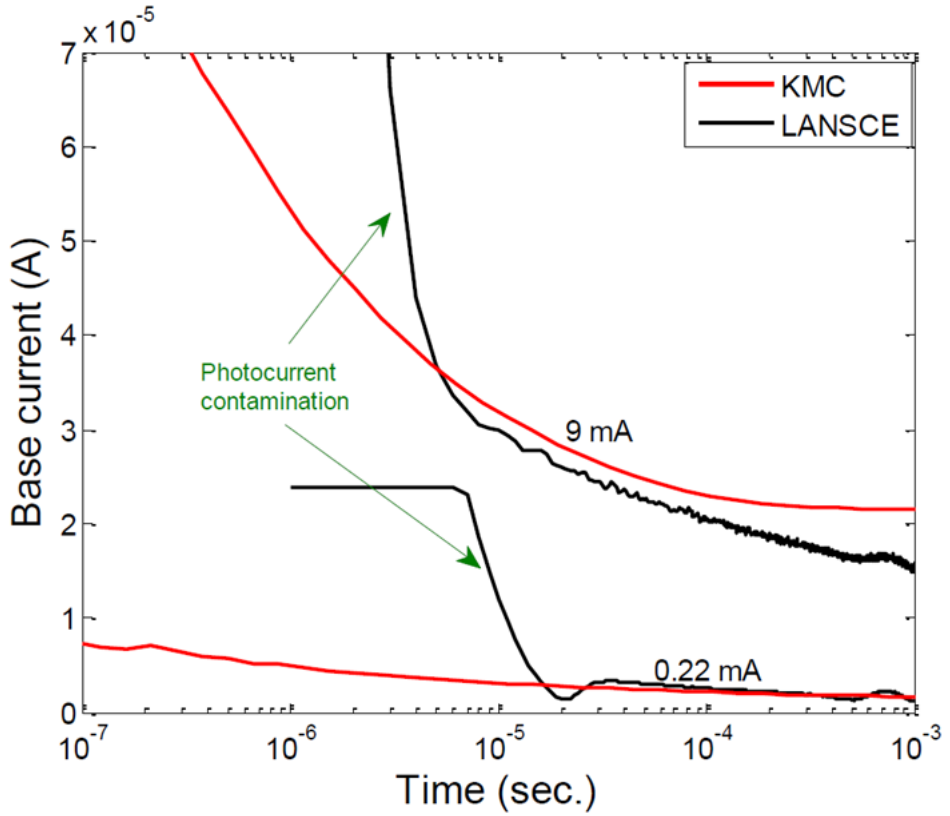


Recoil spectrum from 14-MeV neutrons, by reaction type, in P-31

SEMICONDUCTOR DEGRADATION FROM RADIATION



Damage cascade maps* calculated using MARLOWE for (a) ACRR fission reactor and (b) 14-MeV neutrons.



Current at the transistor base terminal versus time**, adjusted by subtracting out the steady-state, pre-irradiation current.

***Source:** M. J. Jasica, W. R. Wampler, G. Vizkelethy, B. D. Hehr, and E. S. Bielejec. "Photocurrent from Single Collision 14-MeV Neutrons in GaN and GaAs", *IEEE Trans. Nucl. Sci.*, vol. 67, no. 1, pp. 221-227, (2020).

****Source:** B. D. Hehr. "Analysis of Radiation Effects in Silicon using Kinetic Monte Carlo Methods", *IEEE Trans. Nucl. Sci.*, vol. 61, no. 6, pp. 2847-2854, (2014).