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ON THE FUTURE OF MONTE CARLO SIMULATION FOR NUCLEAR LOGS

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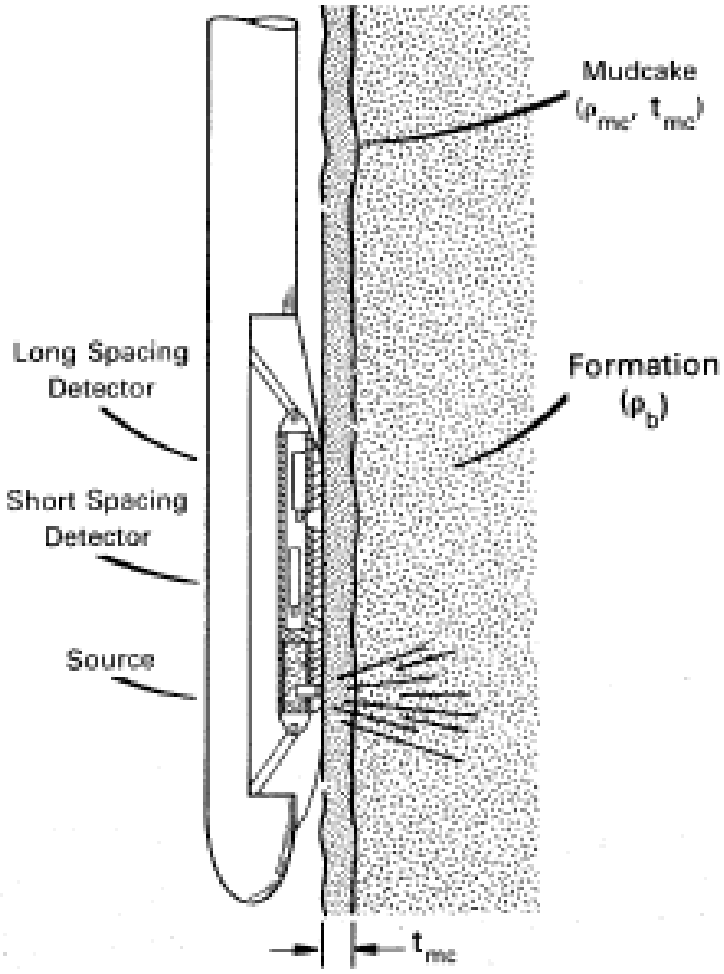
TOPICS

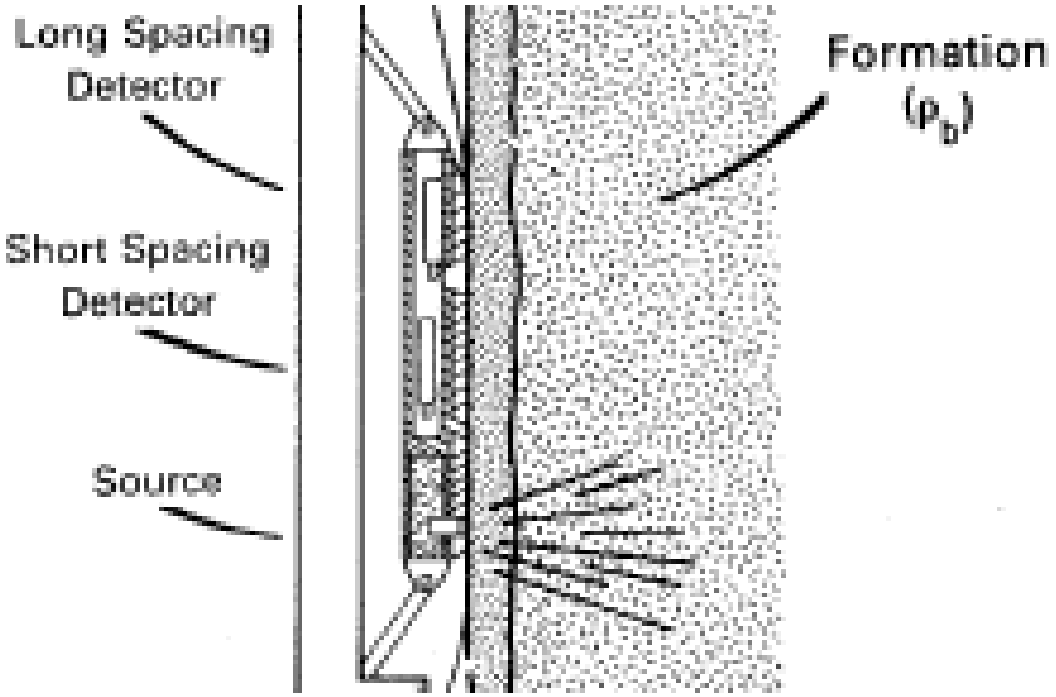
- INTRODUCTION
- CHARACTERISTICS OF NUCLEAR LOGS
- PAST WORK AND MILESTONES
- RECENT WORK AND MILESTONES
- DISCUSSION, FUTURE WORK, AND CONCLUSIONS

CHARACTERISTICS OF NUCLEAR LOGS

- LOG TYPES: Natural Gamma, Gamma Density, Neutron Porosity, Neutron Absorption Cross Section, Neutron C/O, and Neutron Elemental Analyzer
- GEOMETRY: Point Sources and Finite Detectors (often two) at Different Distances from Source
- Gamma-Ray Sources: Natural Radioisotopes (K-40 and U and Th Chains) and Cs-137
- Neutron Sources: ^{241}Am-Be, 14-MeV D-T, and Cf-252
- Elemental analyzer logs are becoming more important

A GAMMA-RAY DENSITY LOG





PAST WORK AND MILESTONES, 1

The work referred to here is mostly that of CEAR or Ex-CEAR personnel.

- Booth and Hendricks (1983) published their paper on use of importance estimation with the weight windows variance reduction approach.
- Gardner and Co-workers (1985) designed a number of specific purpose Monte Carlo codes for the nuclear oil well logging tools.
- Mickael (1992) used simple diffusion models to obtain adjoint solutions for providing importance maps for Monte Carlo weight windows.
- Liu and Gardner (1997) developed a "patch" for MCNP that provided a geometry-independent importance mesh for MCNP
- Gardner and Liu (1999) combined the approaches of Mickael (1992) and Liu and Gardner (1997).

PAST WORK AND MILESTONES, 2

- MCNP personnel (1998) incorporated the work of Liu and Gardner into MCNP5.
- Pat Soran was hired by Schlumberger to head up a Monte Carlo modeling group – he started a CRADA (1998?) on this topic with members including Baker Atlas, Halliburton, Chevron, and CEAR (NCSU).
- Gardner and Verghese (1990) held a workshop to investigate Monte Carlo accuracy for nuclear well logs. Specific purpose, MCNP, and McBEND were studied.

PAST WORK AND MILESTONES, 3

- Gardner, Mickael, and others (1989-90) published three papers on correlated sampling used in specific purpose (CEAR) Monte Carlo codes. This probably led to MCNP adding Differential Operators in v. 5.
- John Butler and Co-Workers (from leads by Clayton and Sanders) developed the Monte Carlo code McBEND, which was later leased to oil and oil well logging companies.
- Mickael (1992) designed a logging tool entirely by Monte Carlo simulation – no experiments until design was tested.
- Mickael developed the technique of using company computers in off-work hours for parallel computing (1994).

PAST WORK AND MILESTONES, 4

- Gardner, Sood, and others developed:
  + the Detector Response Function (DRF) approach for Monte Carlo simulation of radiation detector spectral responses,
  + a Monte Carlo code called CEARPPU for correcting pulse pile-up distorted spectra, and
  + the Monte Carlo – Library Least-Squares (MCLLS) approach for treating the inverse problem for non-linear radiation analyzers.

RECENT WORK AND MILESTONES

- Gardner and Co-Workers recently developed the use of Differential Operators (DO's) in Monte Carlo codes, which now makes the MCLLS approach practical.
- Sood and Co-workers at LANL have initiated work on methods to extend the weight-windows approach in MCNP to multiple detectors.
- Peplow and Co-workers at ORNL have initiated work on techniques for a new Monte Carlo code that can use weight windows for multiple detectors and is self-optimizing.

RECENT WORK AND MILESTONES, 2

- Oil and oil well logging companies have begun to routinely use computer clusters for Monte Carlo calculations to generate logging correction factors and new log designs.
- MCNP has become very user-friendly – perhaps too user-friendly!
- Computers are still getting cheaper and faster – problems that were once difficult to handle are becoming easier and easier!

DISCUSSION, FUTURE WORK, AND CONCLUSIONS

- Automatic methods for optimizing Weight Windows and other similar variance reduction techniques are being introduced for applications of interest. These things are becoming automatic in some codes.
- One very promising idea (CEAR) is to pre-calculate many cases of interest with Monte Carlo codes that contain differential operators. This allows one to use the excellent accuracy of Monte Carlo simulation with the linear or quadratic interpolation afforded by the differential operators to yield very fast or essentially real time solutions for log interpretation purposes.

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