An Overview of the Monte Carlo Code MCBEND

Presentation to
NPL Workshop on Monte Carlo codes

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Overview

– Introduction to MCBEND
– MCBEND Attributes
  • Geometry Modelling Package
  • Geometry Visualisation Codes
  • Acceleration Options
  • User Interfaces
– MCBEND Developments
– Summary
Introduction to MCBEND

• MCBEND is a generalised 3D Monte Carlo code for all radiation shielding and dosimetry applications

• MCBEND is distributed and actively supported in use by the ANSWERS Software Service of Serco Assurance.
The main attributes of MCBEND are:

- **Powerful Geometry Modelling Package**
  - Flexible and easy-to-use geometry modelling package
  - Simple bodies, structured parts and hole geometries
  - Models of any required complexity can be readily created
  - Supporting visualisation and checking tools to verify geometry models

- **Advanced Acceleration options**
  - A general purpose and easy-to-use automatic acceleration option is available
  - Splitting and roulette, source weighting, self-adjusting importance maps
  - Additional special purpose capabilities
MCBEND Attributes

– Nuclear Data and Collision Processing
  • Neutron, gamma ray, electron and coupled calculations are possible
  • Hyperrne energy nuclear data/collision processing
  • Diversity of nuclear data sources (JEFF, ENDF/B, JENDL, UKNDL)
  • Multigroup and continuous energy adjoint options
  • Cross section sensitivity analysis

– Easy-to-use Input Data Syntax
  • Structured yet flexible input data units
  • Allows easy checking
  • Sophisticated parameterisation, looping and formulae input options
MCBEND Attributes

– User Friendly
  • User-oriented documentation - User Guide and Applications Guides
  • Launchpad - Simple user interface for submitting and controlling calculations, with a common user image across all systems

– Customer Support
  • Dedicated support team - expert help-desk support via telephone, email, fax covering all aspects of code usage
  • Provision of Introductory and Advanced Training courses, that can be tailored to individual requirements

– Quality Assurance
  • All codes distributed by ANSWERS have a strict version control and an audit trail from developer to user
The MCBEND geometry modelling and tracking package comprises:

- A simple body component (Fractal Geometry or FG) using conventional ‘ray tracing’

- The additional power of hole geometries employing Woodcock tracking
Fractal Geometry

- Fractal Geometry is a system of solid geometry modelling.
- The problem geometry is subdivided into zones of uniform material.
- These zones are defined as the intersections and differences of simple mathematical BODIES such as cuboids, cylinders and spheres.
- The bodies are assembled into structures called PARTS. Parts are self contained to simplify the construction and to take advantage of any replication which may be present.
- Parts may be included within other parts to any depth of nesting and a given part may be included more than once within the geometry.
Fractal Geometry

- The ability to break down complex models into parts, each separately described in its own local co-ordinate system, simplifies the preparation and checking of the input data.
Hole Geometries

- Hole geometries are used in conjunction with simple body geometries by placing a hole geometry inside a zone (taking the place of a physical material or a subsidiary part).

- Hole geometries can be used to model common replicating arrangements and simple intersecting configurations in a short-cut form.

HELIX

SPIRAL
Geometry Visualisation and Checking

- A fundamental part of the geometry checking in MCBEND are the visualisation codes VISAGE and VISTA which are used to diagnose errors in the user's specification.

- These codes can:
  - Draw two- or three-dimensional pictures of the geometry
  - Check for undefined or doubly defined zones
  - Display source bodies, to verify that they are correctly positioned
  - Display splitting mesh, to verify that it is correctly positioned
  - Verify the model, by comparing it with the technical drawings
VISAGE

- Interactive viewing of 2-D slices through the model
- Use mouse to check co-ordinates, dimensions of components and material identification etc.
VISAGE

- The image is generated using identical tracking routines to those used in MCBEND
- Tracking identifies undefined or multiply defined volumes
• Display independent splitting/roulette mesh
VISTA-RAY

- Interactive 3-D rendering of model geometry
- Cutaway planes and boxes can be used to view inside model
VISTA-RAY

- Detection of Multiple Definitions

- Display of Source Bodies
The major MCBEND variance reduction technique is splitting/roulette.

A splitting mesh (independent of the actual geometry) is overlaid onto the MCBEND model - splitting or Russian roulette takes place if appropriate when particles cross the mesh boundaries.

Importance values are assigned to each mesh, usually via the automatic in-built adjoint deterministic calculation MAGIC.
MCBEND Acceleration Options

• Just tell it where and what you wish to score and an optimized 3D importance map in space, energy and time is generated.

• As the importance grid is separate from the geometry model you don't have to complicate your geometry by splitting material regions into cells for acceleration purposes.
Some difficult radiation transport problems required additional help with variance reduction.

MCBEND provides options for automatic self-improving the importance map as the calculation proceeds and for deriving an importance map based on Monte Carlo sampling, rather than deterministic methods.

MCBEND also has a forced flight method of variance reduction, particularly applicable to situations where particles pass through narrow openings.
MCBEND has structured input units with a readable keyword-driven syntax.

Simple input formats meet common needs.

Flexibility provided for by:

- parameters  @Height = 10.5
- input formulae  @Deltad = [@R*TAN(30)+15.0]
- calculation looping  @RADIUS= 2.1; 2.2; 2.3; 2.4
User Interface - LaunchPad

- Provides a Graphical means to start a MCBEND calculation
- Provides a common interface on all computer platforms
- Provides links to visualisation tools VISTA-RAY and VISAGE
- Provides a Tool to run the standard verification tests shipped with the ANSWERS codes
User Interface - LaunchPad

LaunchPad 1A : Launch Details

**MCBEND**

- **Version**: mcbend9e
- **Allocated space**: 6000000

**Input File**: C:\answers1\mcbend9e\verin\57.dat

**Output Directory**: C:\answers1\mcbend9e\verin

**Neutron library**: JEF2.2

**Other input Files**
- DICE: dice96j2v5.dat
- THERM: therm96j2v2.dat
- NADCON: nadlib2a.dat
- GAMCON: heit01a.dat
- COUPLED: cplb02a.dat
- RESP: response95v3.dat

**Output Files**
- OUTPUT: 57.out
- CLOG: 57.clg
- 26: 57.gip
- 27: 57.nip

Buttons:
- Quit
- View/edit
- Visage
- Vista-Ray
- Run MCBEND
User Interface - Output File Display

- Results Display using VISTA-Ray
The ANSWERS code development strategy is:

- ‘Provision of easy-to-use software that meets the needs of the user community’

focussing for MCBEND on the key areas of **accuracy, understanding of uncertainties, efficiency and user-friendliness**
The current MCBEND development programme is aimed at meeting identified customer needs in the four key areas:

- **Accuracy**
  - BINGO - a replacement neutron nuclear data and collision processing package for MCBEND offering new capabilities and better data representation.
  - Point energy adjoint - An innovative method aimed at improving the accuracy of adjoint calculations.

- **Understanding of uncertainties**
  - Uncertainty module - Automatic folding of sensitivities to produce an estimate of the uncertainty on the result due to those on the nuclear data.
  - Geometrical sensitivities - Further expansion of this method, again aimed at improving the understanding of the true uncertainty on the result.
Current MCBEND Developments

– **Efficiency**
  - Automatic splitting mesh placement - A pioneering step along the road to completely ‘hands-off’ calculation acceleration.
  - Geometry modelling - Taking the geometry modelling package further ahead of the competition.
  - Unified source module - Improved user image and options.

– **User Friendliness**
  - Extensions to formula, iteration and encoding options.
  - Further development of LaunchPad, to improve the interface for submitting and controlling calculation submission.
Current Developments

• Supporting tools - Enhanced 3D visualisation:
Summary

- MCBEND is a well-established and proven tool for shielding and dose analysis.

- The main attributes of MCBEND are:
  - Powerful geometry modelling package
  - Supporting visualisation and checking tools
  - Advanced acceleration options
  - Easy-to-use user interfaces

- As part of the ANSWERS suite of codes, it has a number of attributes that translate directly to customer benefits.
  - On-going support and Quality Assurance provide confidence in use and productivity benefits.

- Development is planned in partnership with customers to ensure their requirements are met.