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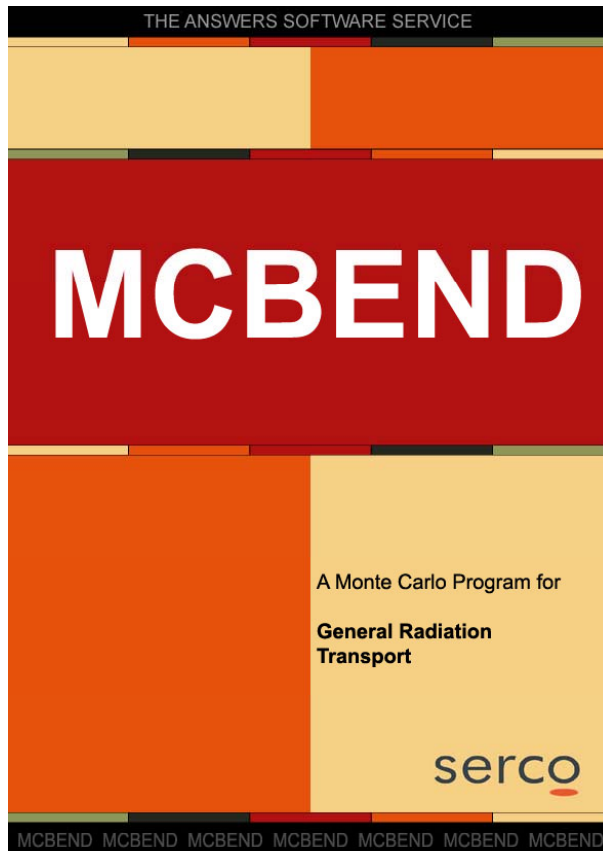**An Overview of the Monte Carlo Code MCBEND**

Presentation to
NPL Workshop on Monte Carlo codes

by
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The ANSWERS Software Service
Serco Assurance

- – 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.

MCBEND Attributes

- 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

- – Nuclear Data and Collision Processing
  - Neutron, gamma ray, electron and coupled calculations are possible
  - Hyperfine 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

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- 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

MCBEND Geometry Modelling Package

- The MCBEND geometry modelling and tracking package comprises:

    – A <u>simple body</u> component (Fractal Geometry or FG) using conventional 'ray tracing'

    – The additional power of <u>hole geometries</u> employing Woodcock tracking

- Fractal Geometry is a system of solid geometry modelling.

- The problem geometry is subdivided into zones of uniform material.

Source

- 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.

Source Ring

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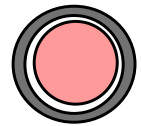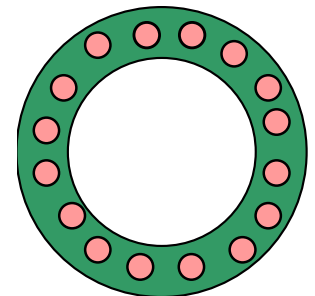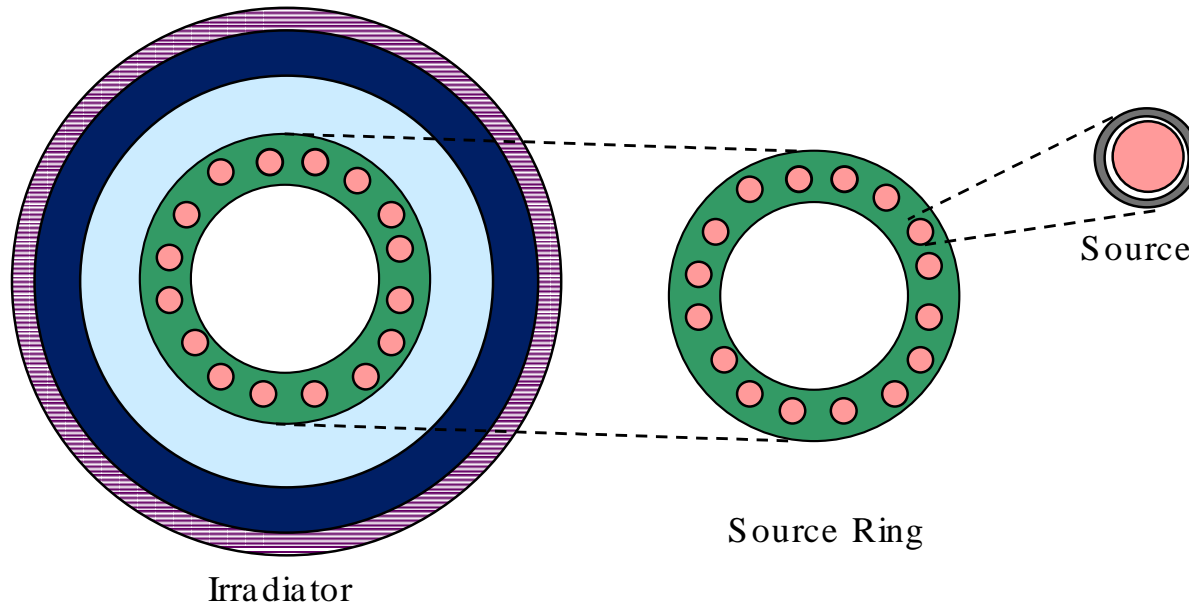
- The ability to break down complex models into parts, each separately described in its own local co-ordinate system, simplifies the preparation and checking of the input data.

Source

Source Ring

Irradiator

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

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Geometry Visualisation and Checking

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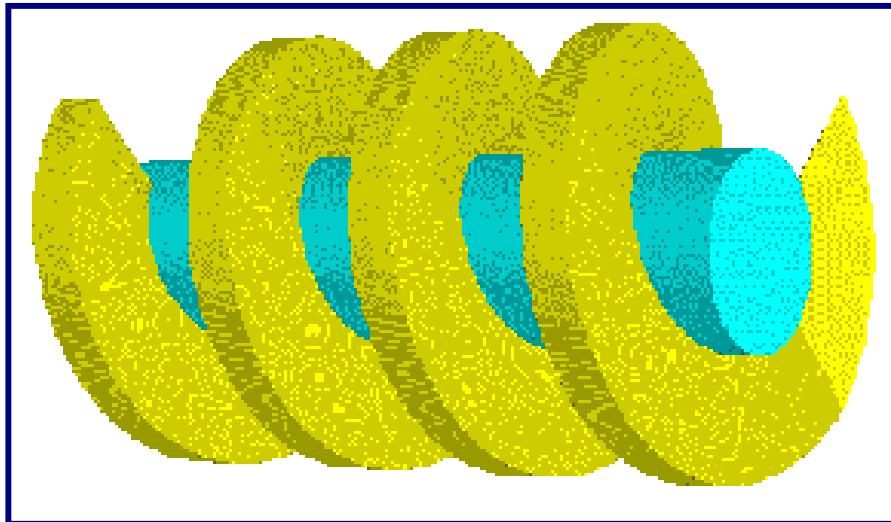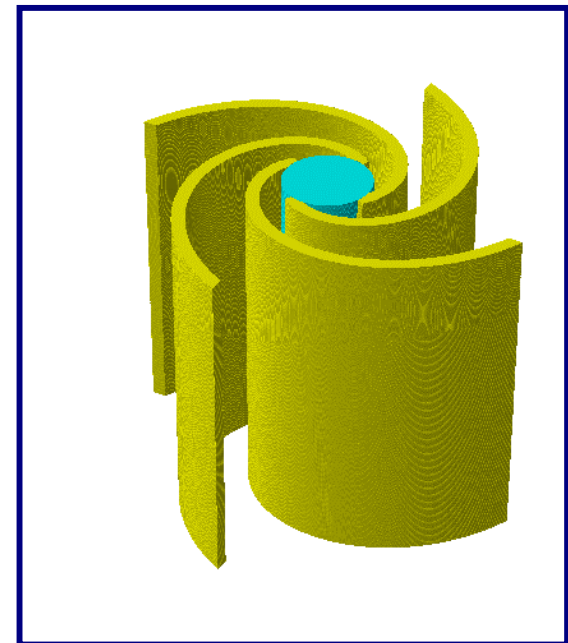
- A fundamental part of the geometry checking in MCBEND are the visualisation codes VISAGE and VISTA which are used to diagnose errors in the user's specification.

- 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
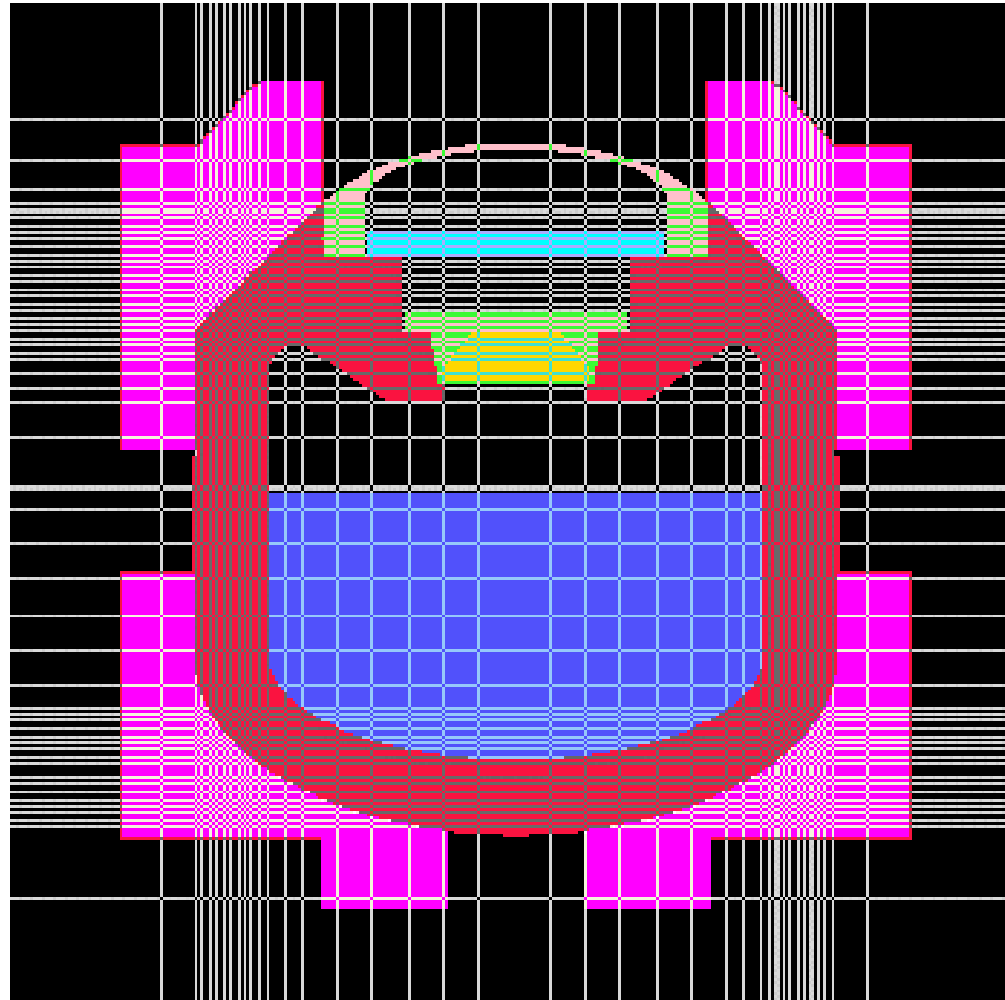
VISAGE

- Interactive viewing of 2-D slices through the model
- Use mouse to check co-ordinates, dimensions of components and material identification etc.
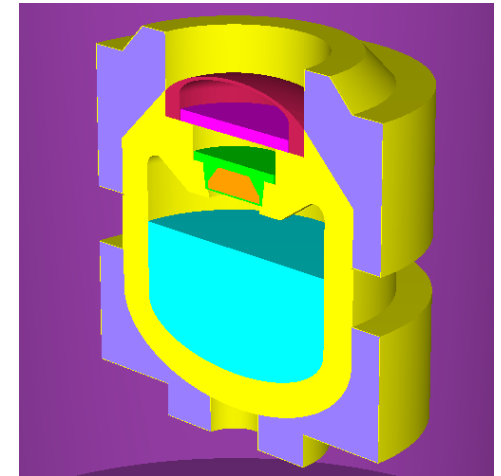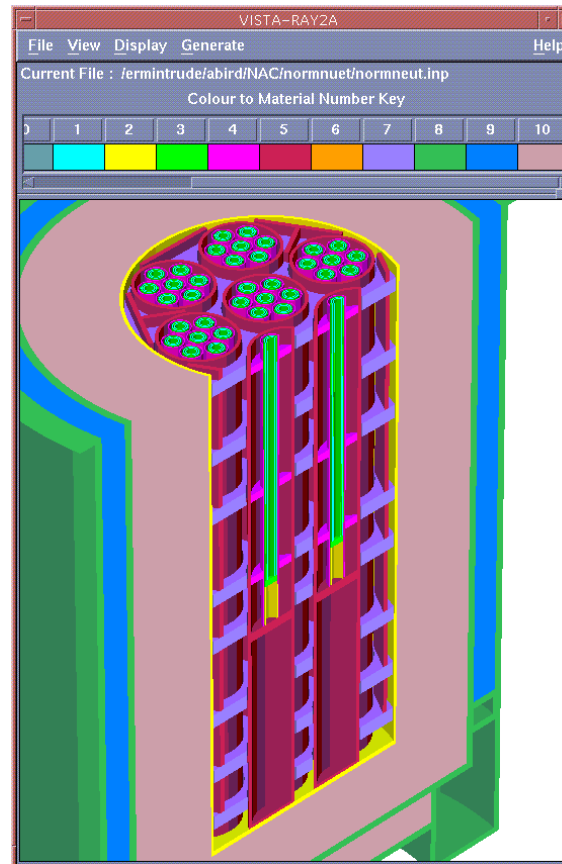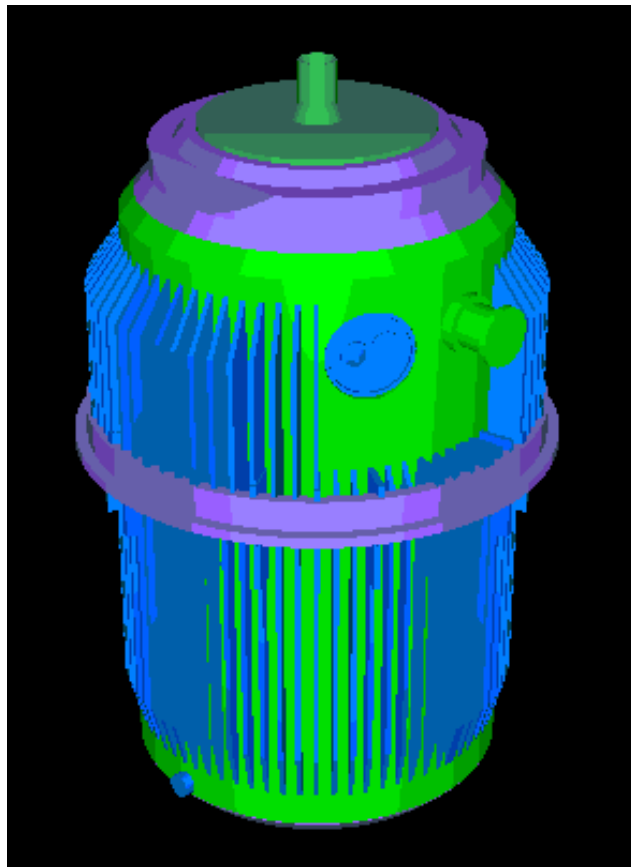
VISAGE
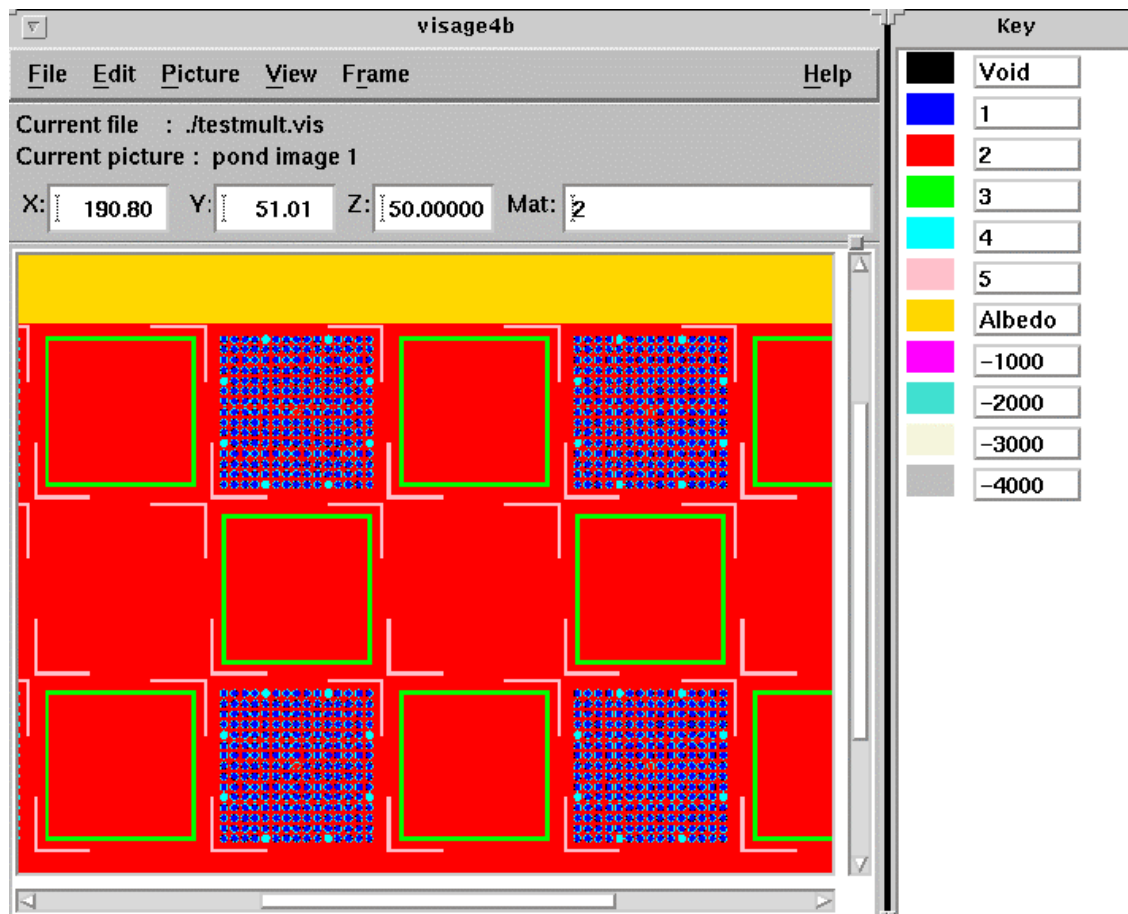
- The image is generated using identical tracking routines to those used in MCBEND

- Tracking identifies undefined or multiply defined volumes
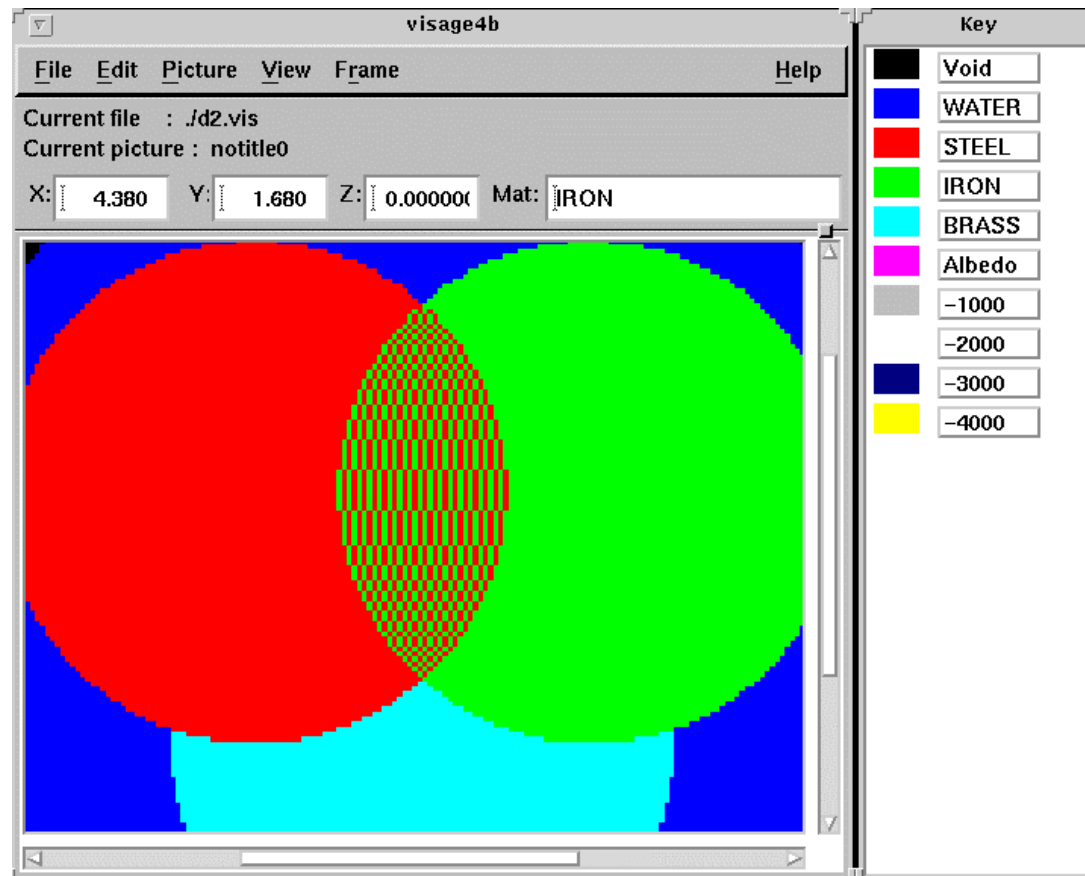
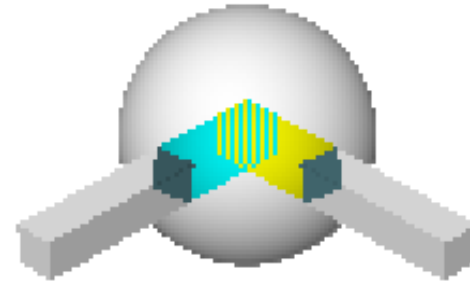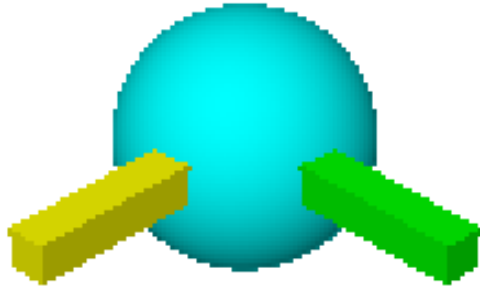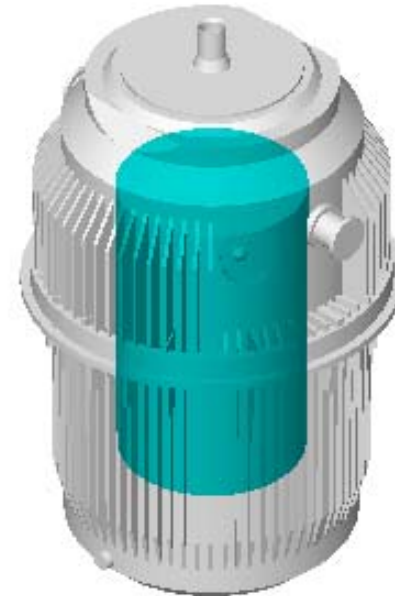- Display independent splitting/roulette mesh

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

- Detection of Multiple Definitions

- Display of Source Bodies

MCBEND Acceleration Options

- 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.

MCBEND Acceleration Options
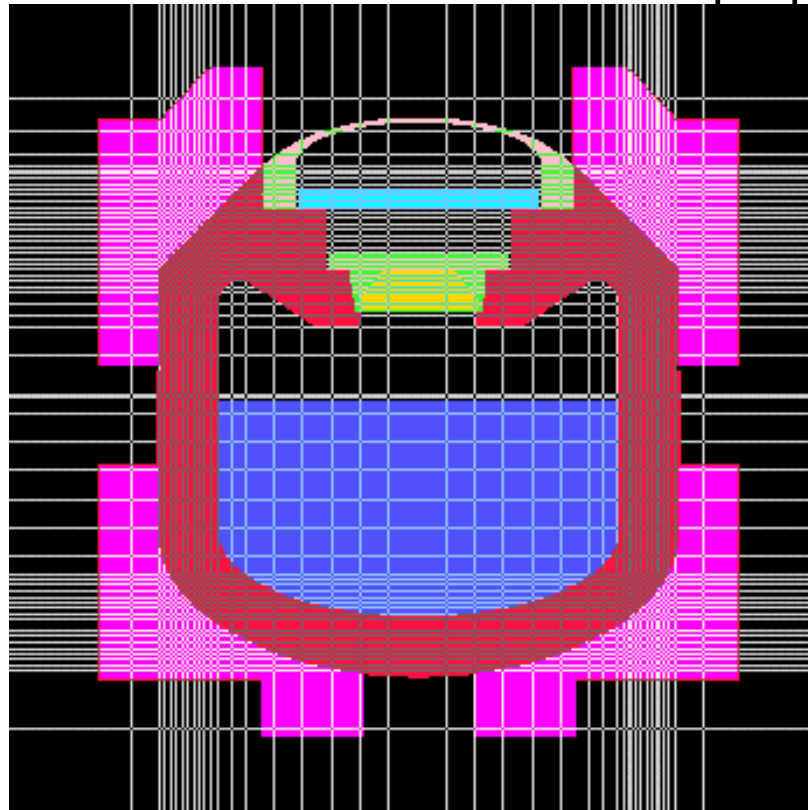
- Some difficult radiation transport problems required additional help with variance reduction.

- 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.

User Interface - Input Data Syntax

- 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
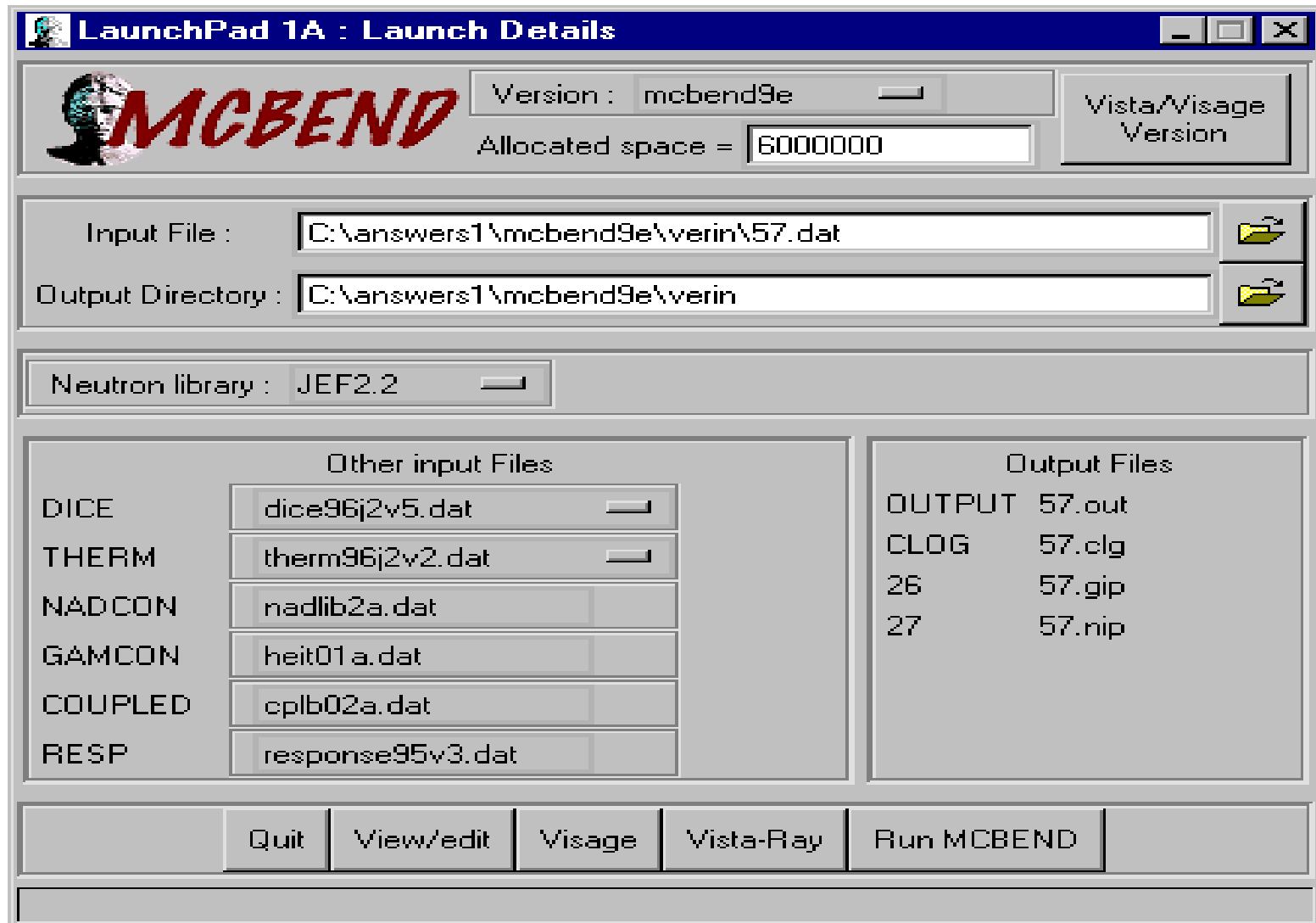
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- Results Display using VISTA-Ray

MCBEND Development Strategy
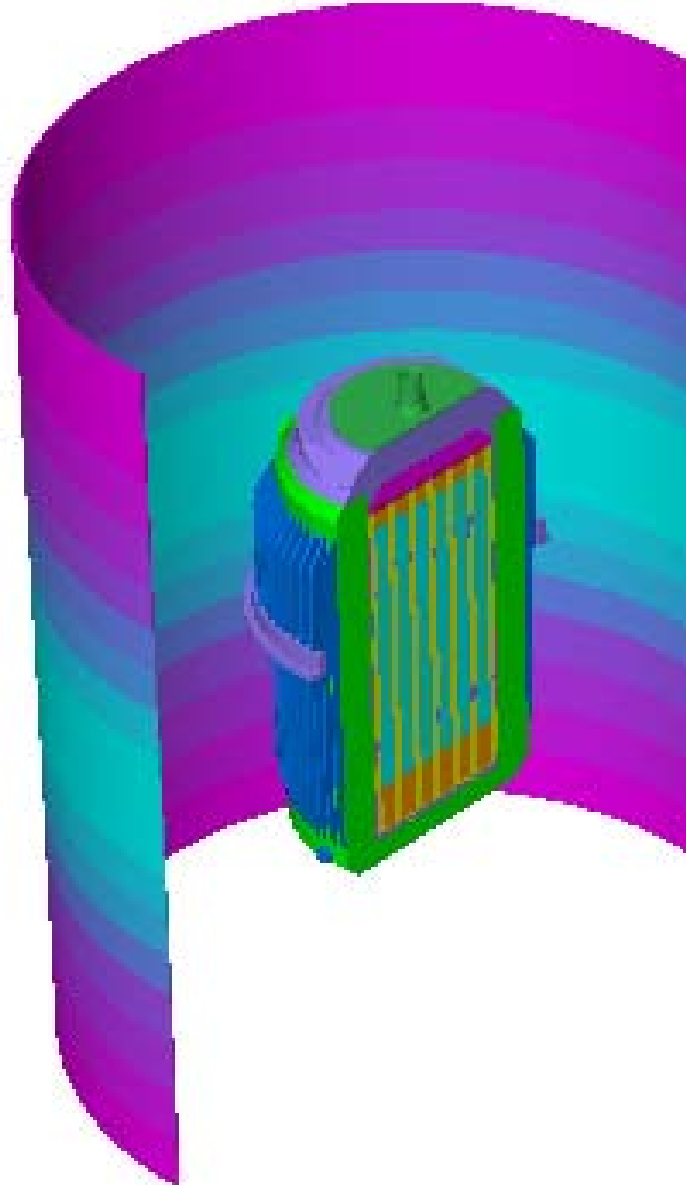
- The ANSWERS code development strategy is:

  - *'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

Current MCBEND Developments

- 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

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– **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.

- Supporting tools - Enhanced 3D visualisation:

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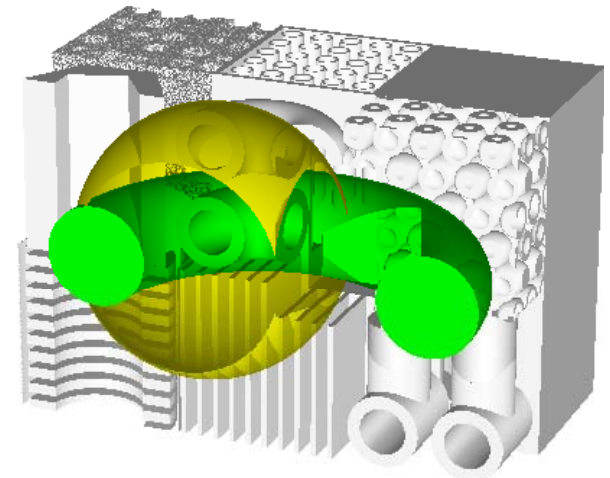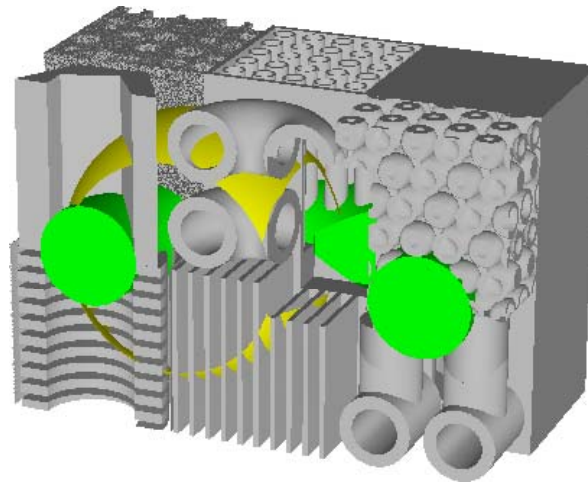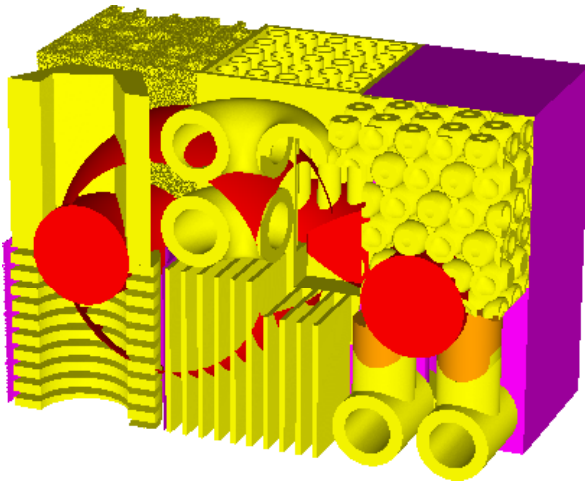
- MCBEND is a well-established and proven tool for shielding and dose analysis.

- 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.

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