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The Integrated TIGER Series

Version 5

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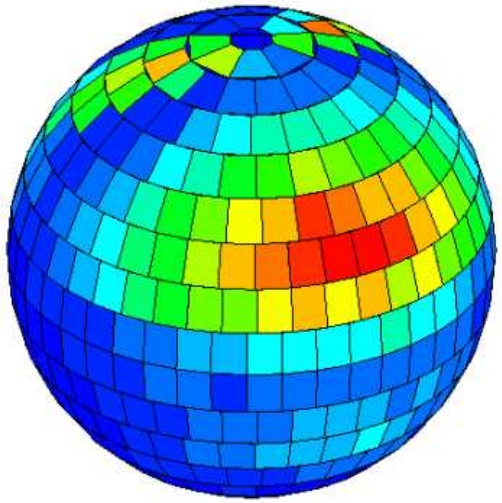
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Improvements Since Version 3.0

- Minor Physics Improvements to the ITS 3.0 continuous-energy codes.
- Multi-group codes with adjoint transport capabilities.
- Parallel implementations of all ITS codes.
- More automated subzoning options for combinatorial geometry.
- Additional source distributions, tallies, biasing options, and more CG primitives.
- Ability to output subzone energy and charge deposition in a finite-element-like format.
- Alternate geometry descriptions include CAD in the ACIS® format and faceted geometry (currently through CUBIT).
- Subzoning capabilities for alternate geometries.
- A ray-tracing capability for fast scoping calculations.

Multi-group Versions of the Codes

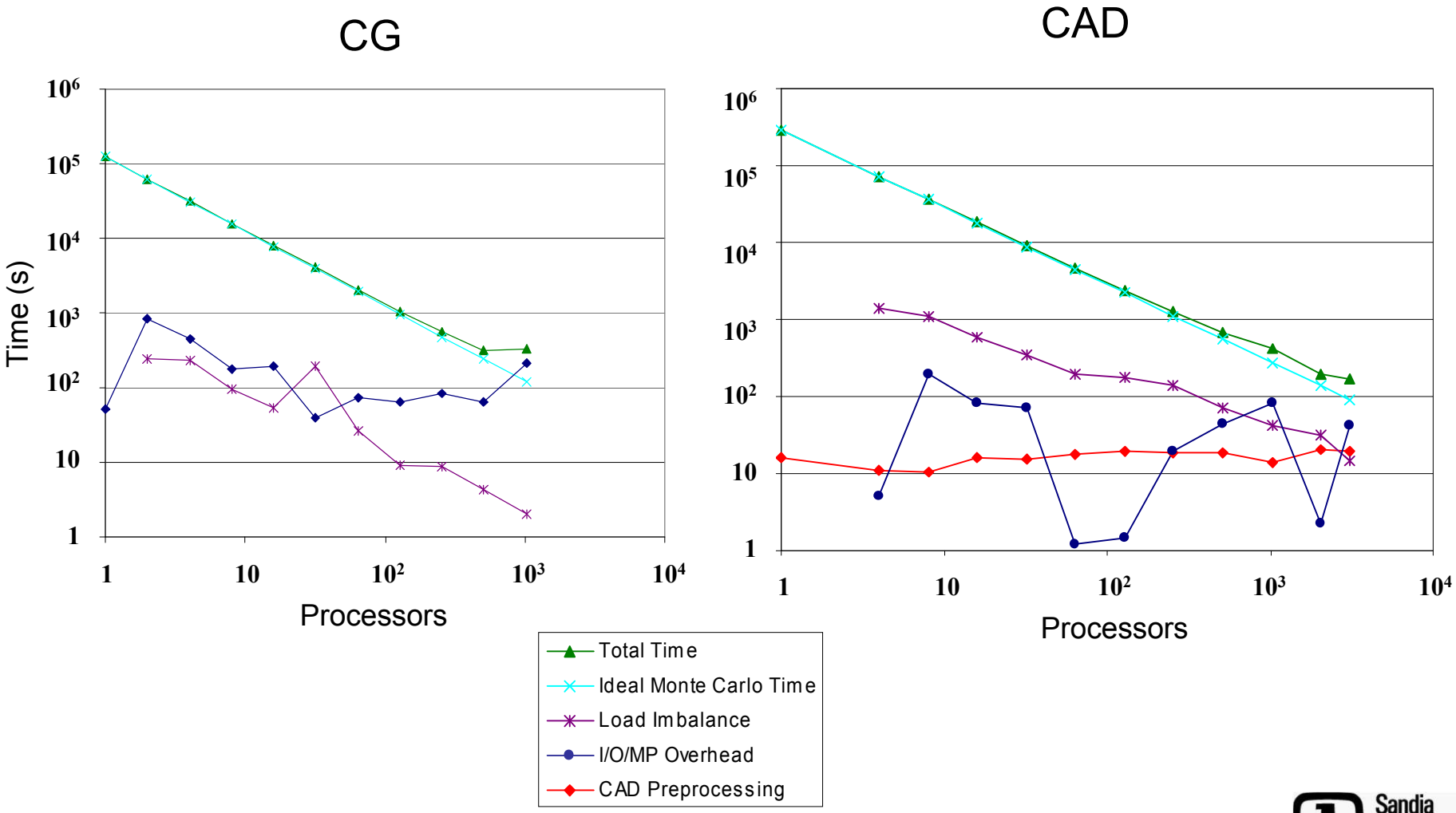
- The 1-D and 3-D codes (TIGER and ACCEPT) have been implemented in multi-group versions.
  - Uses CEPXS-generated cross sections
- Multi-group versions have adjoint capability.
- Adjoint advantages:
  - Assessing dose from many angles of attack in a single calculation.
  - Point detectors with electron transport
  - Assessing dose from multiple source spectra in a single calculation
- A ray-tracing feature for fast scoping of complex geometries was added to the multi-group codes.



Parallel Implementations Of All ITS Codes

- Parallel implementation uses MPI
- Based on domain replication
  - Embarrassingly parallel
  - Both static and dynamic load balancing
- Implementation shows good scaling
  - There is room for improvement (version 6)
- The following plots illustrate the parallel performance of ITS version 5

ITS Version 5 Parallel Efficiency



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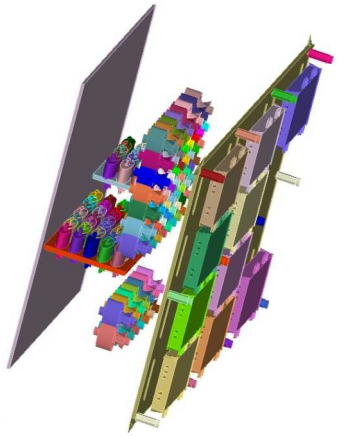
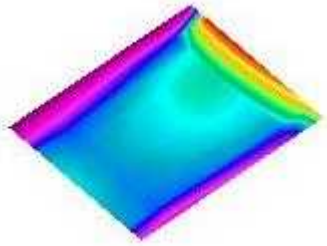
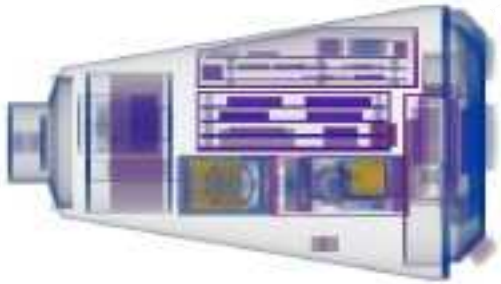
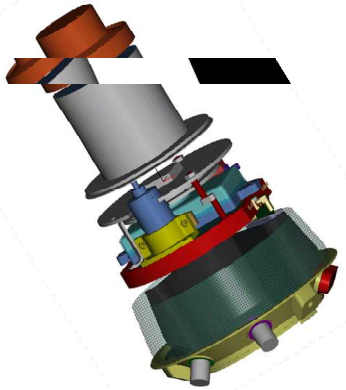
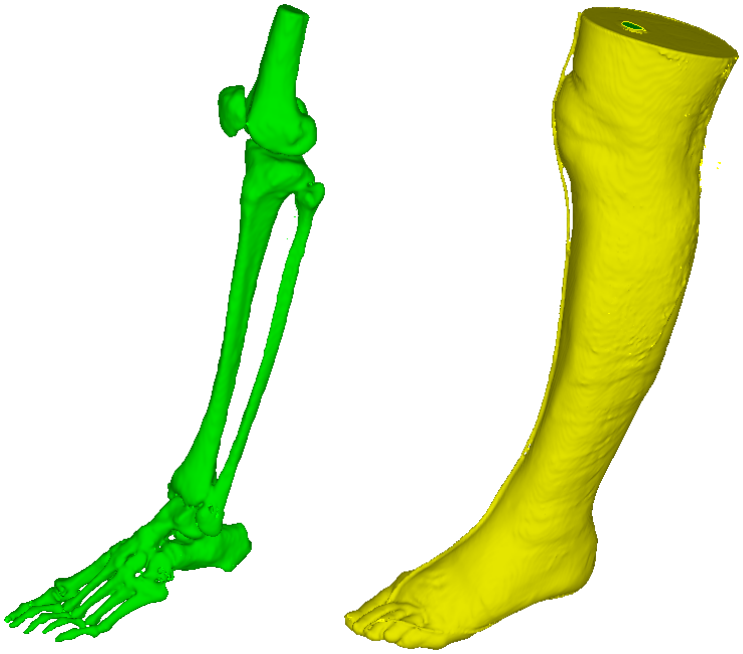
Ability To Transport on CAD Geometry

- Geometry descriptions in the ACIS® format can be used (separate purchase of ACIS license required).
- The CAD portions of the code are written in C++
- CAD incurs a penalty in computational speed
- Both CG and CAD can be used a single model

Use Of Facet-based Geometries

- Added facet-based geometry ability to deal with some CAD inefficiencies
  - Spline surface replacement
- Can combine all three geometries types in a single calculation
- Use the best representation for each part of the geometry



Computed Tomography Isosurface
Data from Visible Human Project™

Ongoing ITS Development Efforts

- Efficiency improvements.
- Generalized Boltzmann-Fokker-Planck (GBFP) moment-preserving transport of electrons.
- Extending some photon transport capability to sub 1-keV energies.
- Doppler broadening of Compton electrons.
- Implementation of the random hinge algorithm in ITS.
- Improvements in external electric and magnetic field descriptions.

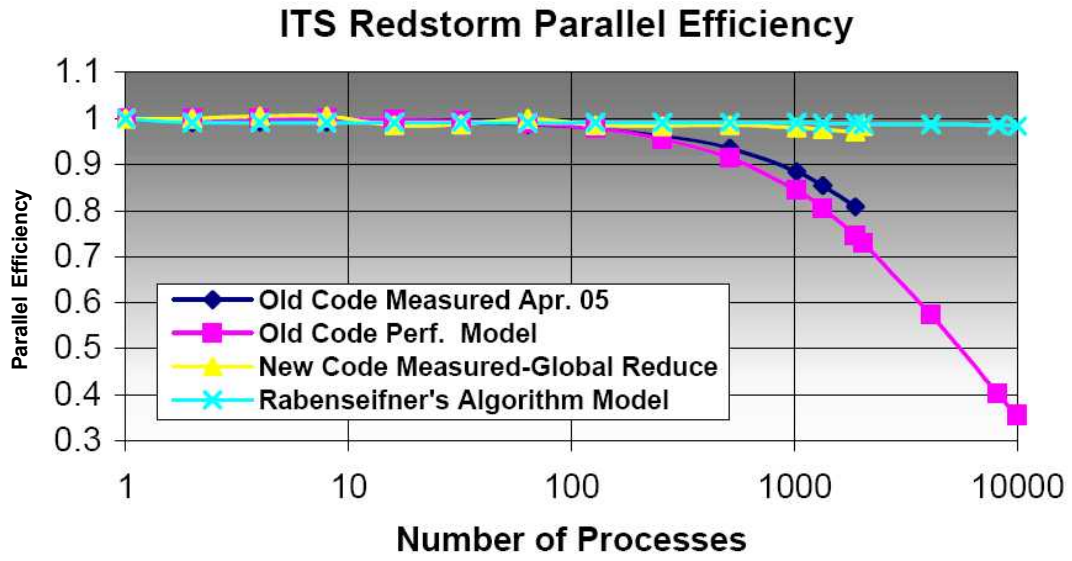
Efficiency Improvements

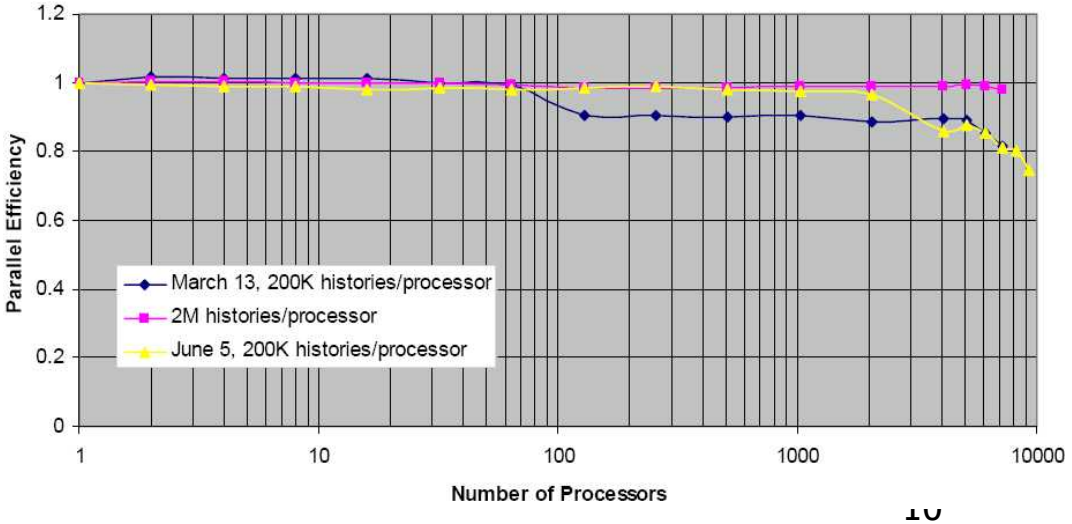
Ongoing ITS Development Efforts

- Path-length apportioning for photons in subzone structures
- Improvements in CAD geometry particle tracking efficiency
  - Use of tree structures
- ITS has been converted to Fortran 90
  - Allows dynamic memory management
  - Extends ability to rely on domain replication
- Parallel algorithm improvements

ITS Version 6 Parallel Efficiency

Ongoing ITS Development Efforts





- **Improvements in ITS version 5 have been obtained through parallel communication changes.**
- **ITS shows excellent parallel scaling out to 10000 processors.**

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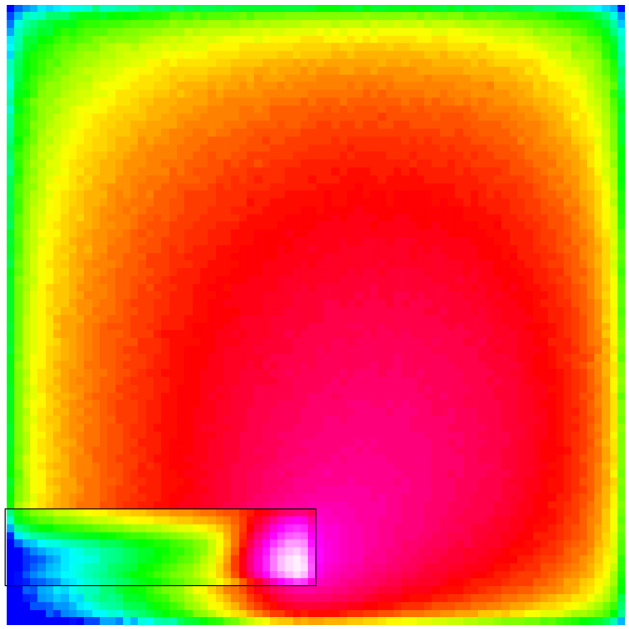
Generalized Boltzmann-Fokker-Planck

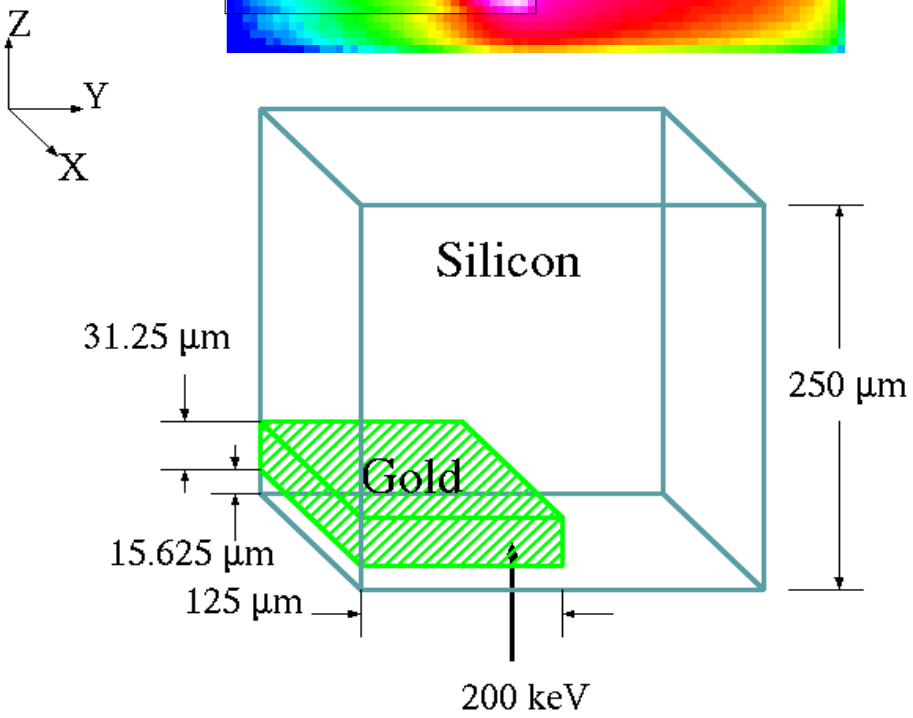
Ongoing ITS Development Efforts

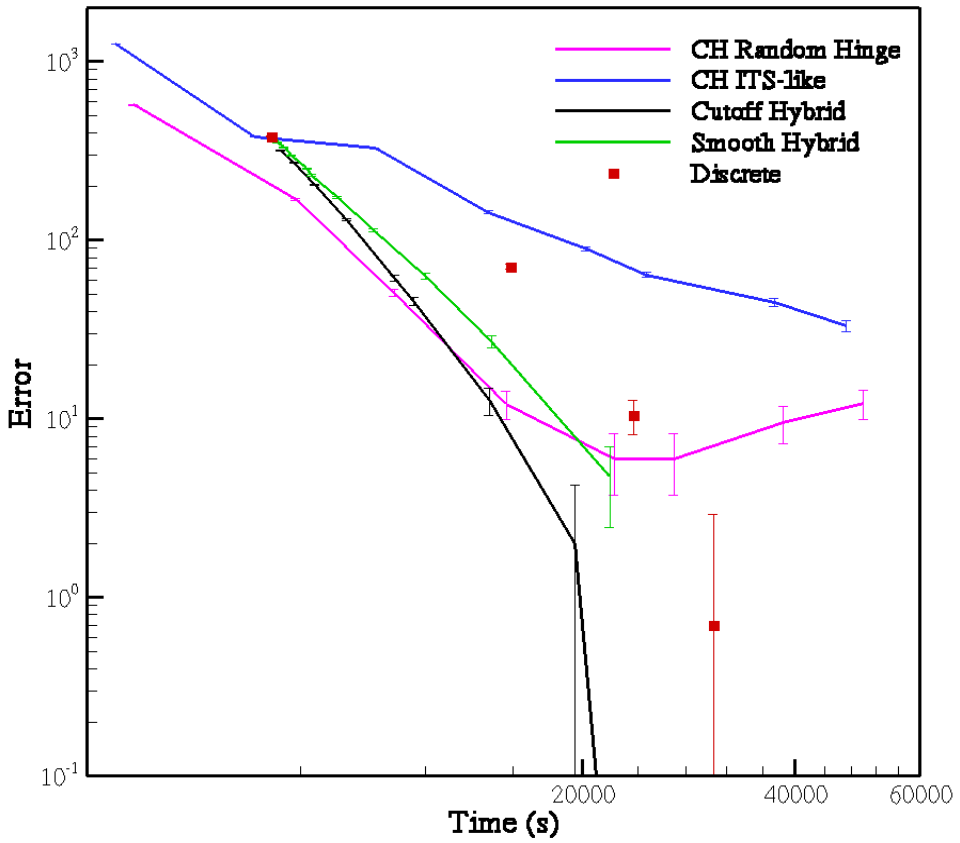
- A computationally efficient single-event method of Monte Carlo transport.
- Analog cross sections for electrons are converted into corresponding discrete cross sections that exactly preserve low order moments of the cross sections.
- Alleviates boundary crossing problems of condensed history.
- Will be offered as an alternative to condensed history in a future version of ITS.

GBFP Results

Analog Benchmark Dose







See Franke and Prinja, "Monte Carlo Electron Dose Calculations Using Discrete Scattering Angles and Discrete Energy Losses", NSE 149, 1–22 (2005) for a detailed discussion of this method

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Availability of ITS Version 5

- Currently ITS version 5 is only available for government use.
  - Contact Ron Kensek (rpkense@sandia.gov) or its-support@sandia.gov for license application procedures.
- Together with our legal department, we are pursuing:
  - Licensing for universities and research partners.
  - Distribution of ITS through RSICC.
  - Less restrictive distribution of ITS.