Report from the 2014 International Space Development Conference

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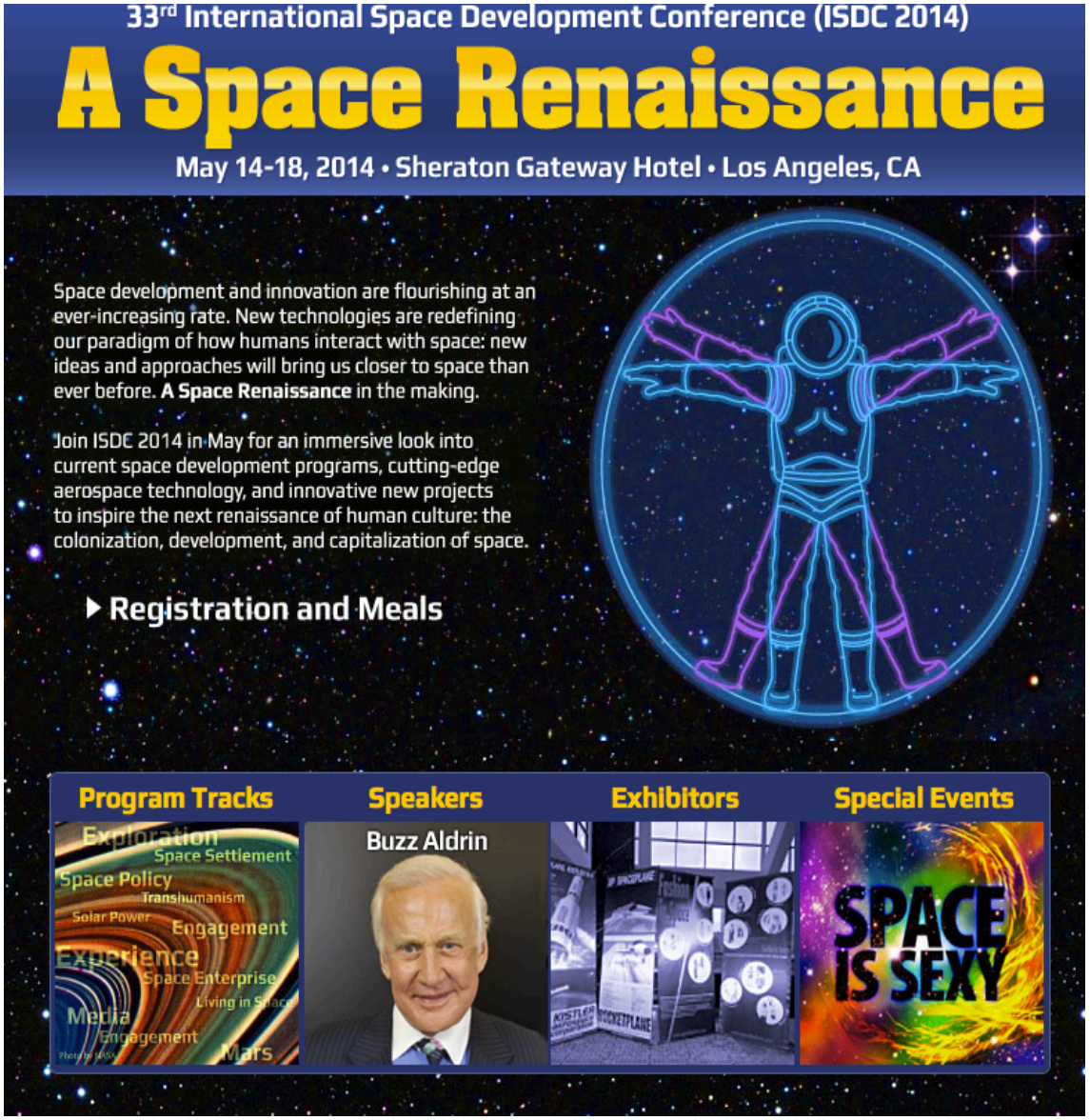
27 May 2014

ISDC 2014 (Los Angeles)



Annual conference of the National Space Society

- held in Huntsville in 2011

~1100 attendees

- scientists, engineers, entrepreneurs, students, space enthusiasts

General topics

- exploration, enterprise
- space solar power
- space policy, engagement/ outreach

Highlights

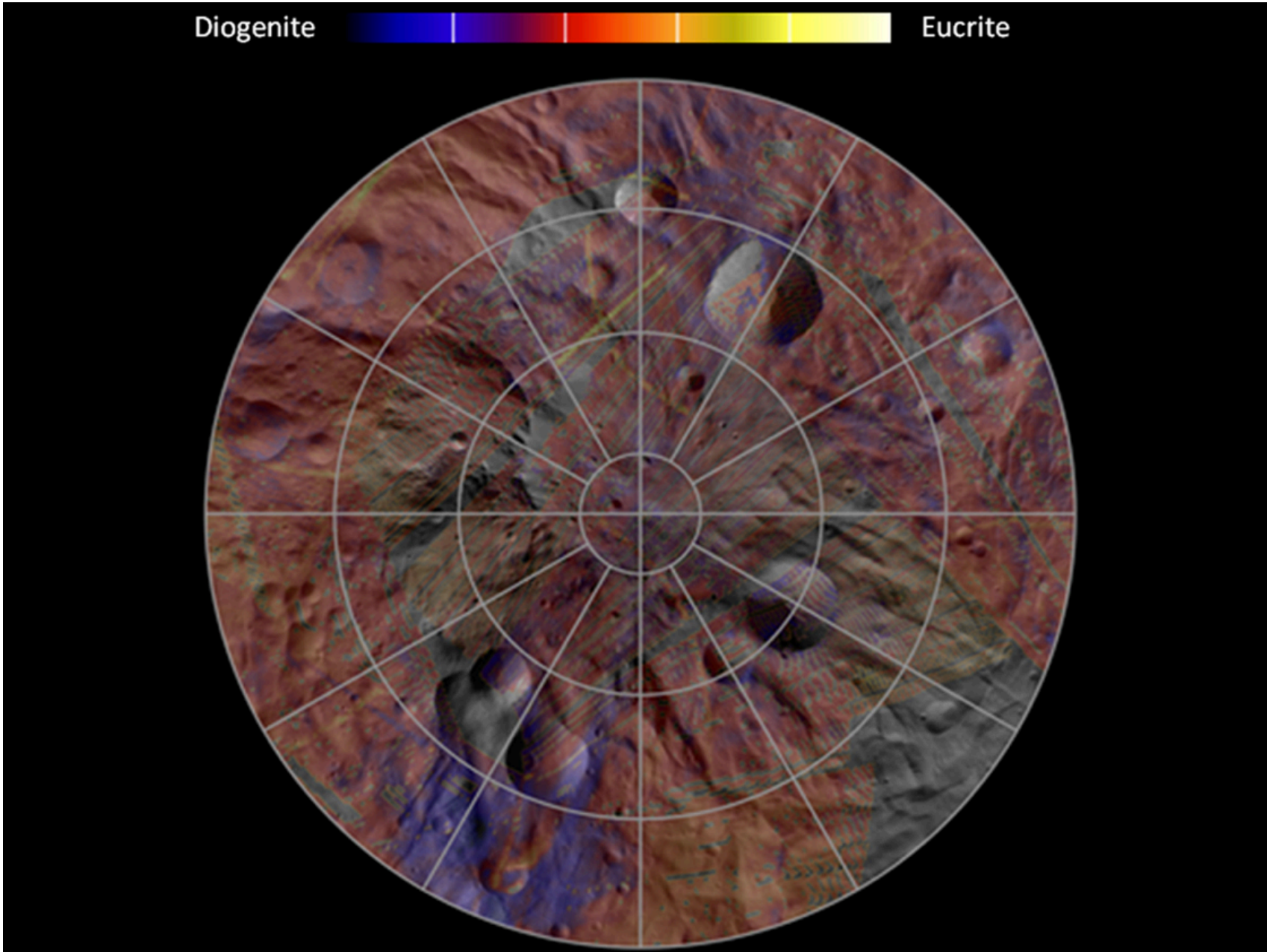
- Elon Musk awarded the Heinlein Prize

- Messenger team awarded the Space Pioneer Award
  - Messenger used Geant4 in their instrument design
- High school students from around the world presented their concepts of space settlement
  - poster session and video presentations
  - 1st prize to teams from India and Bulgaria
- Chance to meet some of the leaders in "New Space"
  - Rick Searfoss
  - Robert Zubrin
  - Richard Garriott

Summaries of Interesting Talks

- Messenger team
  - water ice at Mercury's poles, off-center magnetic field
- DAWN mission
  - Xenon ion propulsion, photos of Vesta, now en route to Ceres
- Panel discussion on NASA/private space cooperation
  - COTS (Commercial Orbital Transportation Services) was good, continue/extend it, commercial crew, lunar COTS
- Space solar power, space elevator

Mineral Survey of Vesta



Impressions

- Private space is “taking off”
  - SpaceX, XCOR, Deep Space Industries, Orbital Sciences, Boeing, …
- General dismay at lack of vision from government on manned missions
  - but some hope that there can be cooperation
  - can private space step in?
- There are investors looking to put money into space
  - good business plans required
- LOTS of young people wanting to get involved

The Space Radiation Environment: Physics and Software (45 attendees)

- Space radiation (not your father's space environment)
  - What is it?
  - Where does it come from?
- How to deal with it
  - not easy without good measurements
  - simulation is essential
    - design of shielding
    - calculation of dose
- The Geant4 simulation toolkit
  - description
  - CubeSat and inflatable habitat examples

The Importance of 3-D Modeling

Steadily increasing numbers of features on chips means that a single cosmic ray event can upset many bits

Simple 1-D models do not model this well

Many models do not take into account nuclear effects which can be significant

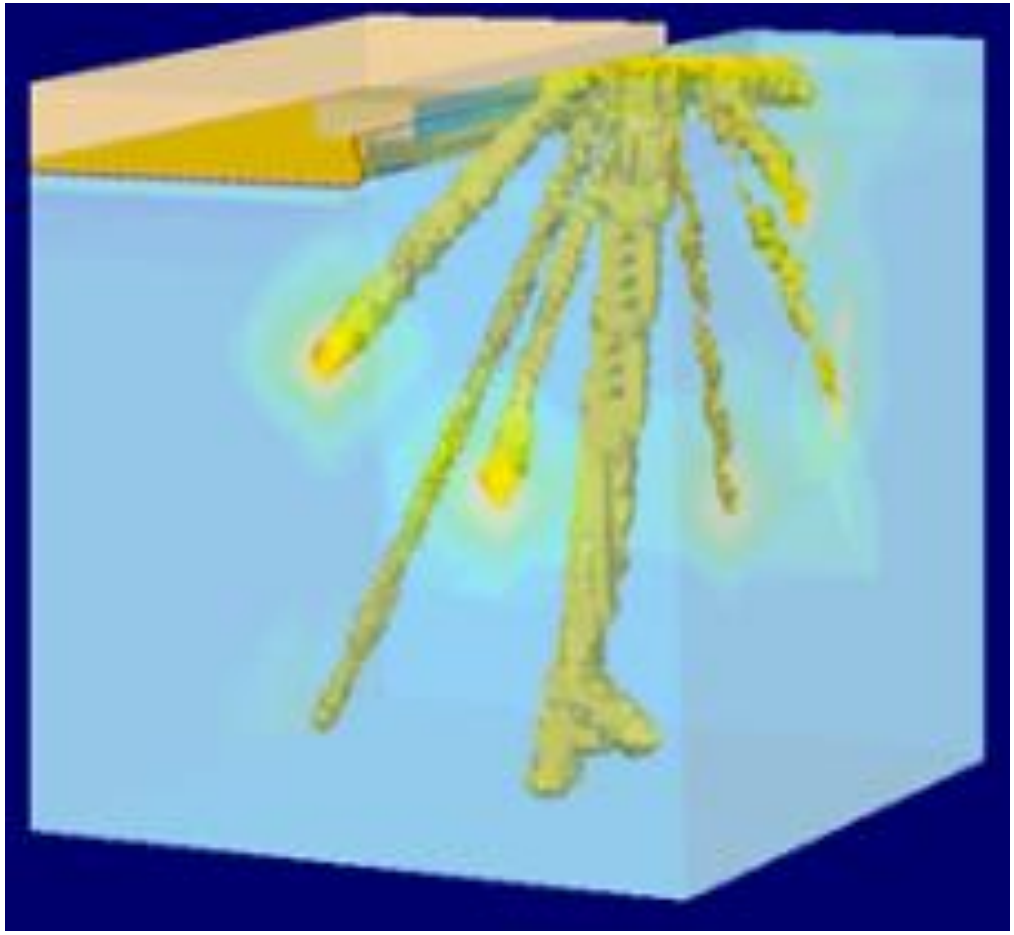
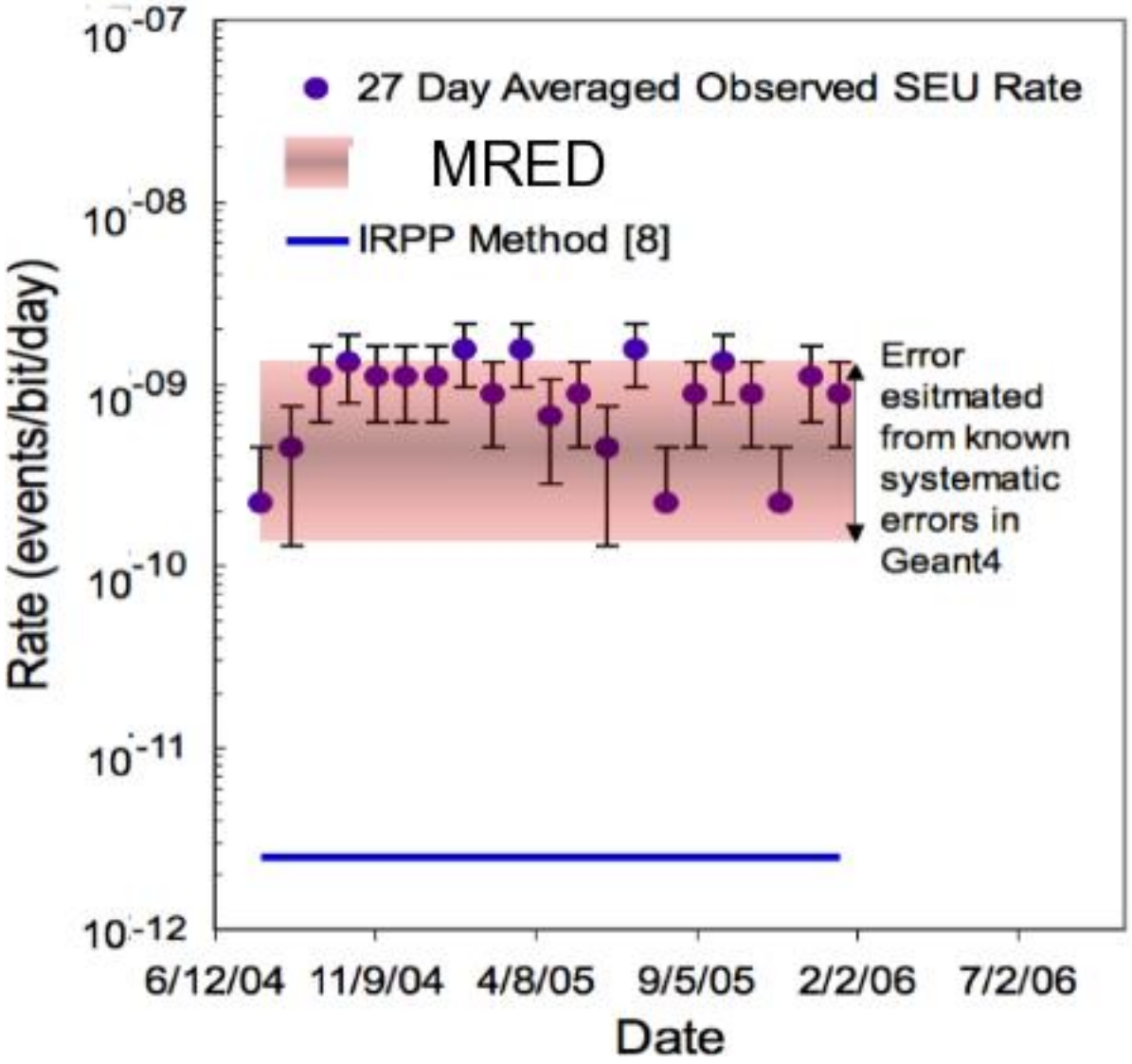


Figure courtesy of Robert Reed, Vanderbilt University

The Importance of 3-D Modeling

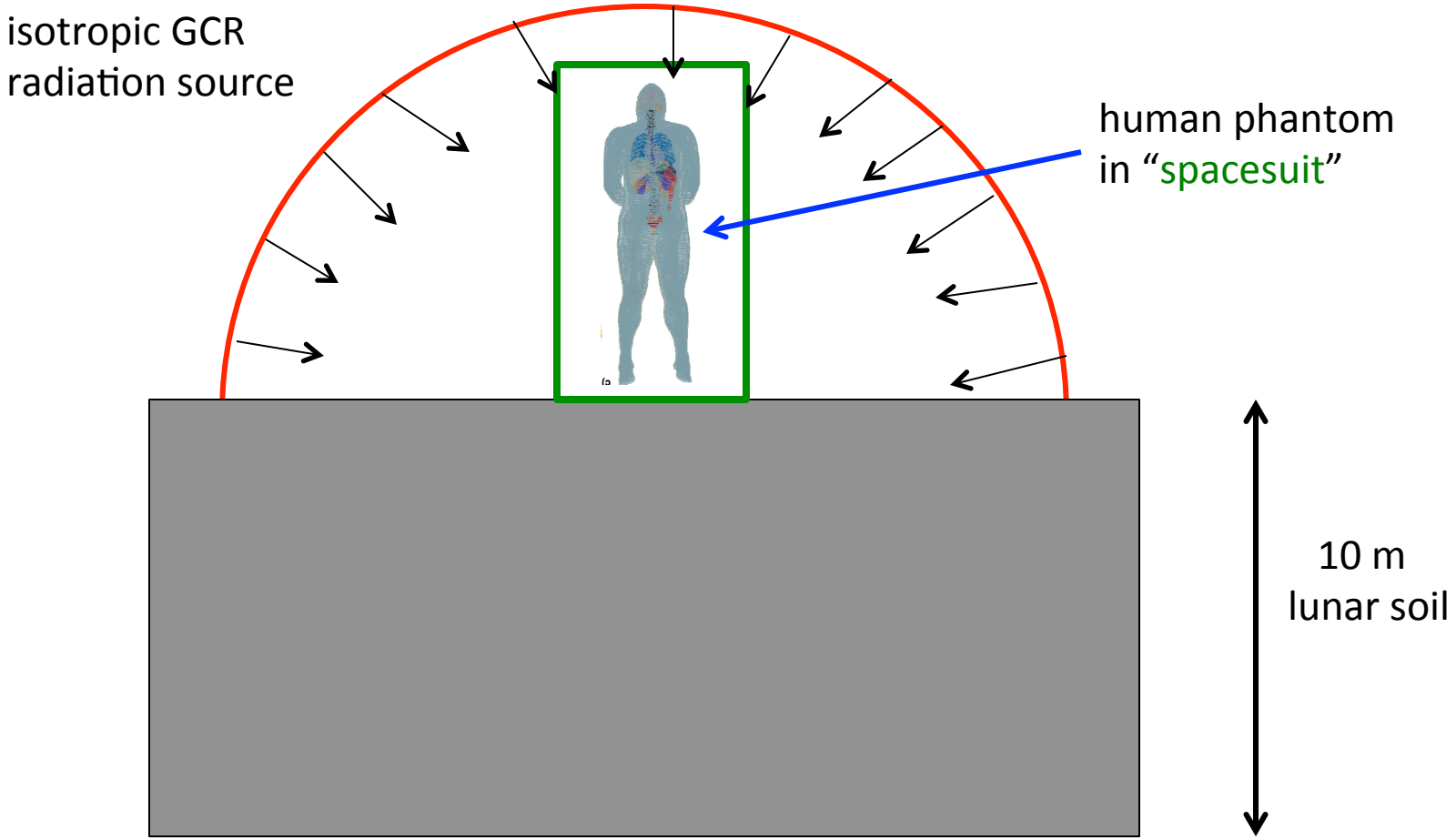


Data from Messenger spacecraft when en route to Mercury

Figure courtesy of Robert Reed, Vanderbilt University

Simulation of Dose at Lunar Surface

G. Reitz, T. Berger, D. Matthiae, Planetary and Space Science 74, 78-83 (2012)



Simulation of Dose at Lunar Surface

- Used Geant4 for calculation
  - human phantom with ~2 million voxels
  - spacesuit = 0.5 g/cm^2 polycarbonate cylindrical shell
  - cosmic ray spectrum 10 MeV/n to 100 GeV/n, consisting of nuclei from H up to Fe
- Calculated effect of
  - lunar soil albedo
  - cosmic rays at solar min (max GCR intensity)
  - natural radioactivity of lunar soil
  - spacesuit shielding
- Resulting effect: 0.6 mSv/day
  - after shadowing and quality factor corrections, consistent with dose to silicon measured in lunar orbit to be 0.26 mGy/day

Geant4

- A radiation simulation toolkit
  - 3-D transport of particles through complex geometry and fields
  - allows users to fully customize their apparatus, radiation and electromagnetic fields
  - provides a complete set of electromagnetic and hadronic physics
- Open
  - source code is available
  - expert users may contribute code to Geant4
- Free
  - no license fee
  - software developed on top of Geant4 may be sold without permission of Geant4 collaboration

www.geant4.org

Geant 4

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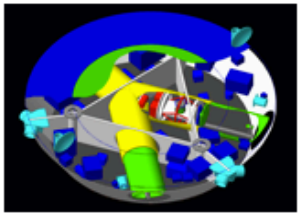
Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The two main reference papers for Geant4 are published in *Nuclear Instruments and Methods in Physics Research* A 506 (2003) 250-303, and *IEEE Transactions on Nuclear Science* 53 No. 1 (2006) 270-278.

Applications

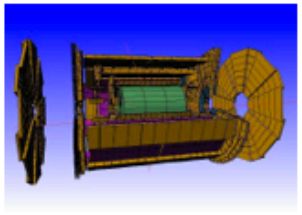
A sampling of applications, technology transfer and other uses of Geant4

User Support



Getting started, guides and information for users and developers

Publications



Validation of Geant4, results from experiments and publications

Collaboration

Who we are: collaborating institutions, members, organization and legal information

News

- *20 March 2014* - **Patch-03** to **release 9.6** is available from the source archive area.
- *19 March 2014* - 2014 planned developments.
- *28 February 2014* - **Patch-01** to **release 10.0** is available from the download area.

Events

- Geant4 Course at the 11th Seminar for Nuclear, Sub-nuclear and Applied Physics, Porto Conte, Alghero (Italy), **25-30 May 2014**.
- 10th Geant4 Space Users Workshop, at NASA/MSFC, Huntsville, Alabama (USA), **27-29 May 2014**.
- International Workshop on Monte Carlo Techniques in Medical Physics, Quebec City (Canada), **17-20 June 2014**.
- 19th Geant4 Collaboration Meeting, Okinawa (Japan), **29 September - 4 October 2014**.
- **Past events**

Do-It-Yourself Radiation Protection Design

- 3-D modeling with full physics is recommended
  - will likely result in substantially reduced shielding requirements
  - better estimates of component lifetime, upset rates
- Geant4 or similar Monte Carlo codes should be used
  - no longer need to settle for approximate geometry
  - can custom-design materials, particle sources
- Possible for individuals or small groups to do this
  - Geant4 toolkit is well-suited, although there is a significant learning curve (but lots of documentation)

A Geant4 Cubesat Application

1-unit Cubesat (10 x 10 x 10 cm)

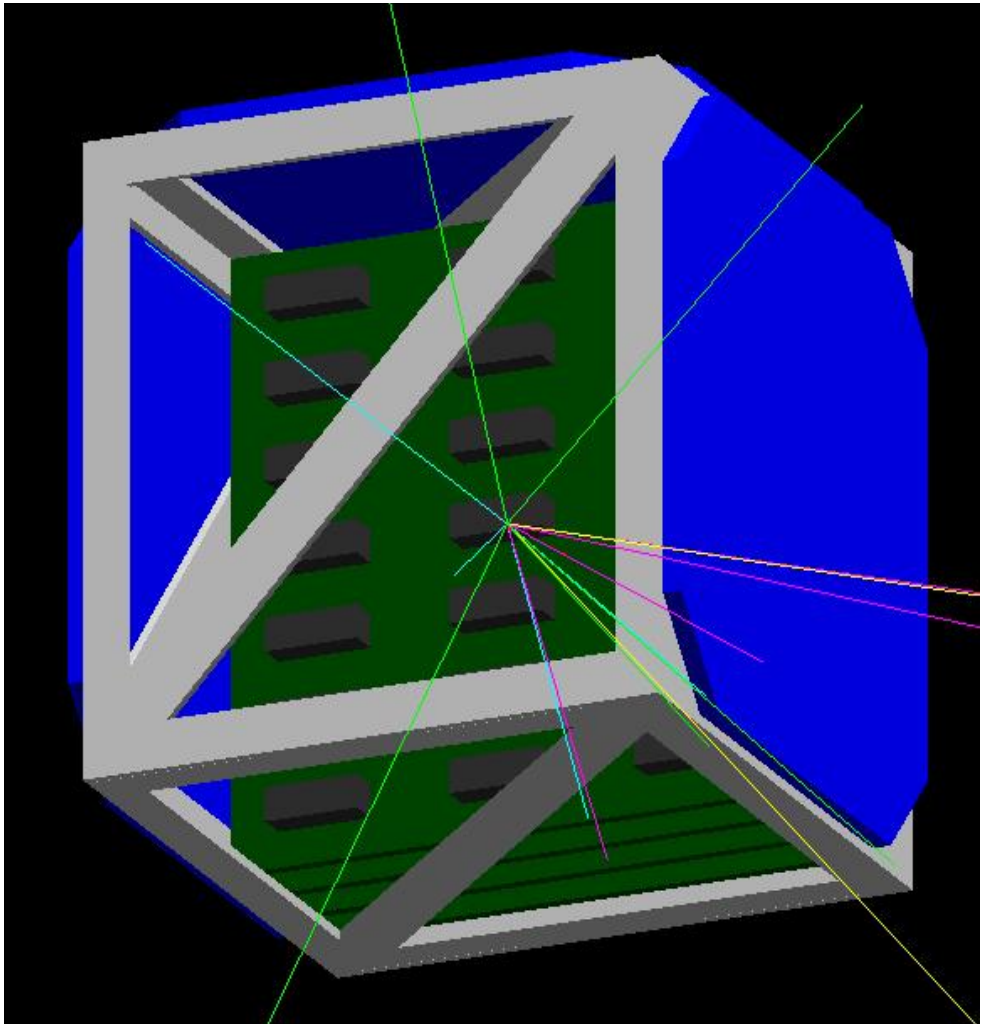
Aluminum chassis

Solar panels (blue)

Circuit boards

5 GeV proton incident on chip

Alphas, neutrons, protons, pions, gammas + recoil nucleus produced in reaction



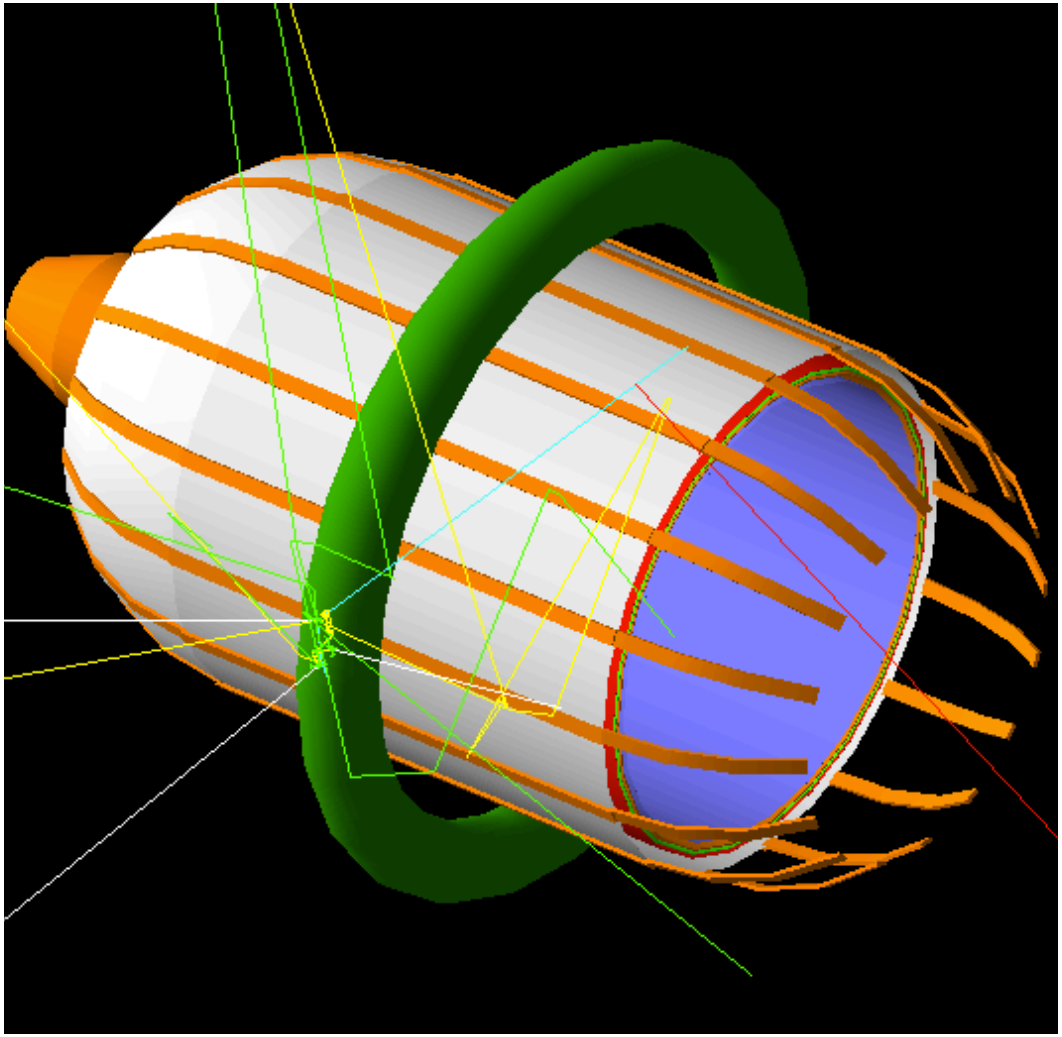
A Geant4 Inflatable Habitat Application

Similar to BA330 inflatable

Layers of beta cloth, Kevlar, mylar

Current loop for active shielding (green)

1 GeV proton incident from upper right



Do-It-Yourself Radiation Protection Design

- Steps to a working application
  - install Geant4
  - code your geometry (~ 2-day effort for Cubesat of inflatable)
  - design your particle source, or choose one of those provided
  - choose a physics package (14 provided, but 2 or 3 best for space applications)
  - identify sensitive regions for data collection and code data format and readout (~2-day effort)
  - code your C++ main() method (~ 0.5 day)
  - run the simulation and collect number of particles or energy deposited in sensitive regions
  - convert to dose and dose equivalent

Geant4 Talk Summary

- Energetic particles from the Sun, galaxy, radiation belts and surface sum to a substantial radiation environment
  - measurements are improving, but still not sufficient
- Simulation is required to estimate shielding, dose
  - traditional 1-D, single-material codes being replaced by 3-D, full physics codes
  - Geant4 is one such and is open source
- Cubesats or inflatables are an excellent application of Geant4
  - possible for individuals or small groups to use it for their own calculations

ISDC Summary

- Very worthwhile
  - broad interest, opportunity, enthusiasm
  - a good venue to get exposure in the "New Space" community
  - Geant4 should establish a presence

- Try it – you'll like it
  - next one in Toronto, May 2015

- Parting shot – simulated Vesta flyby with DAWN HR photos
  - http://dawn.jpl.nasa.gov/multimedia/video/dawn20120829-1280_h264.mov