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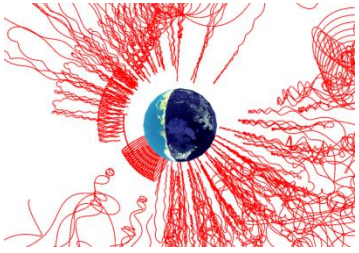
Geant4-based tools in SPENVIS

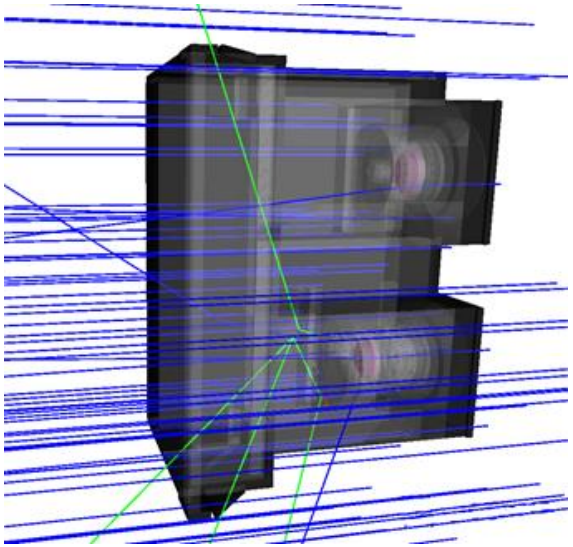
N. Messios , S. Calders, V. Letocart, M. Kruglanski
Royal Belgian Institute for Space Aeronomy (BIRA-IASB)

H. Evans
ESA Space Environments & Effects (ESTEC/TEC-EPS)



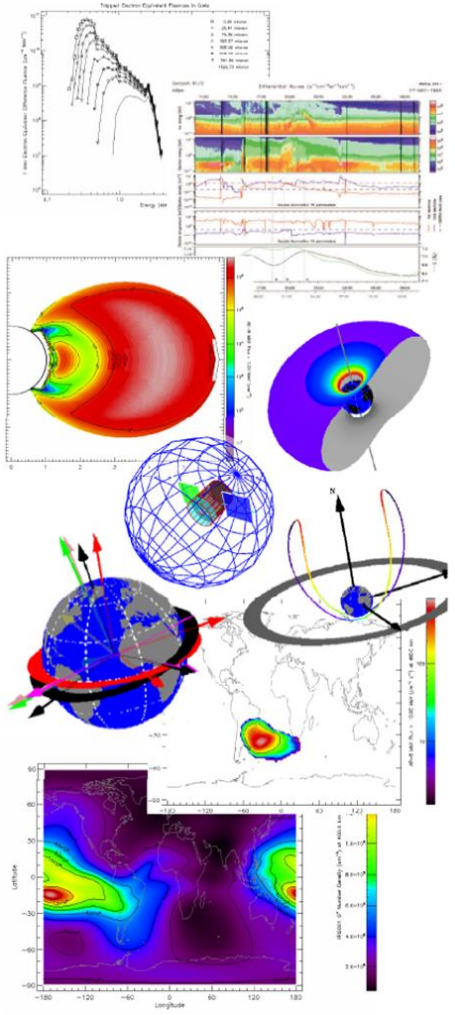
Outline

- A brief introduction to SPENVIS
- Geant4 and SPENVIS
  - motivation
  - overview of available Geant4 tools
- The SPENVIS Next Generation
  - basic concepts
  - model developers support
  - status
- Current & future developments



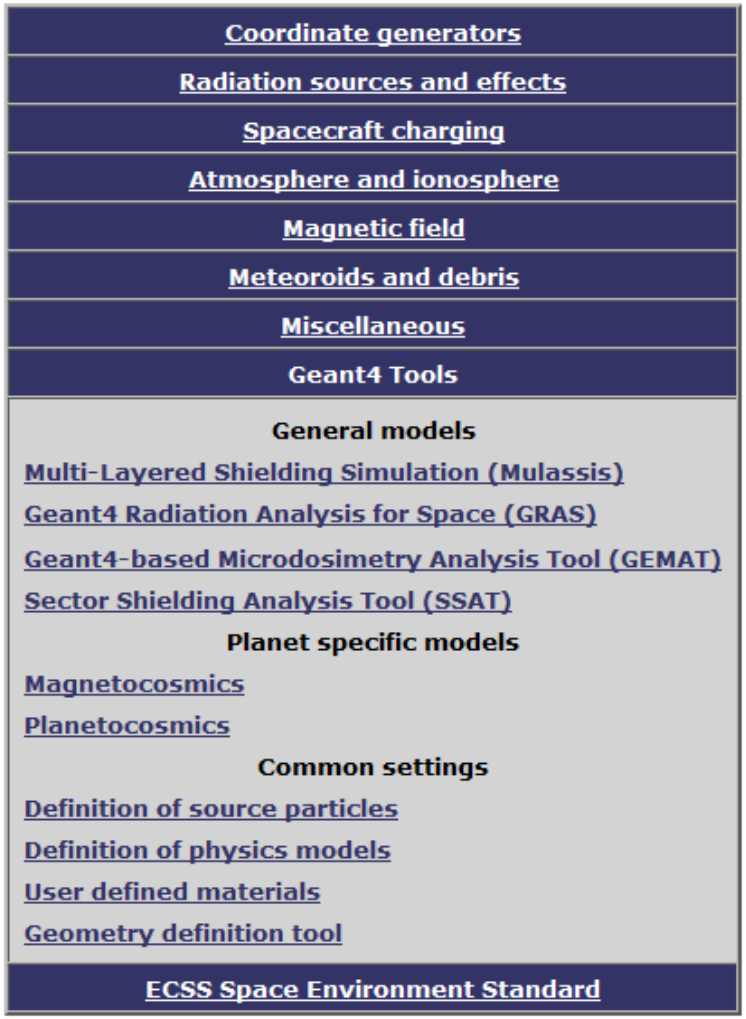
Space Environment Information System

- ESA Operational software with large user community, publicly available since 1998
- Developed & maintained by BIRA-IASB since 1996
- WWW interface to models of the space environment and its effects on spacecraft components and astronauts



Geant4 tools in SPENVIS

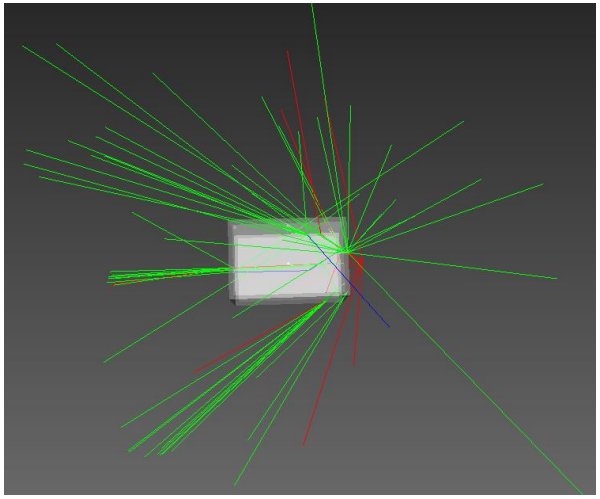
- Easy to use
  - ✓ User friendly interface
  - ✓ No prior knowledge of Geant4
- Interaction with other SPENVIS models & tools
- Macro files can be used outside SPENVIS

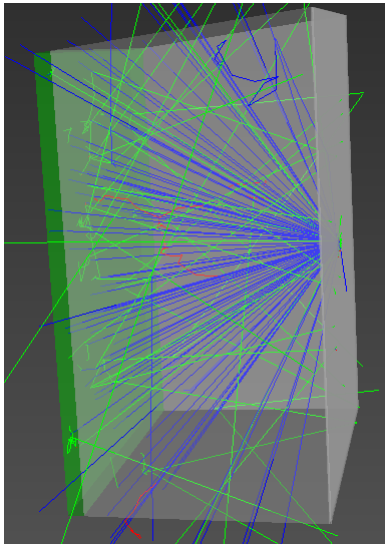


GRAS & MULASSIS

- Definition of a multi-layered (slab or sphere), one-dimensional geometry (MULASSIS & GRAS) or a multi-volume 3D (GDML) geometry (GRAS)

- Simulation of radiation transport through geometry, treating electromagnetic & nuclear interactions

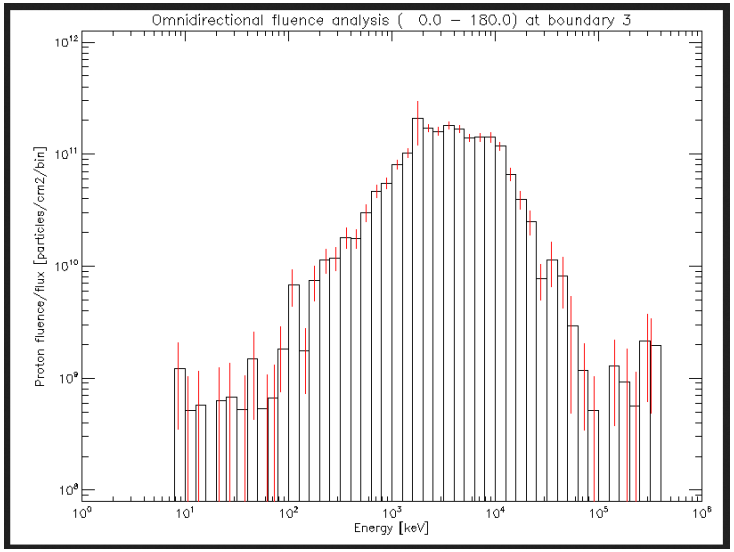




GRAS & MULASSIS

- Various analysis types:
  - Fluence analysis
  - Non ionizing dose/energy loss
  - Energy deposition/total ionizing dose
  - Dose equivalent & Equivalent dose analysis
  - Linear Energy Transfer (MeV/cm)

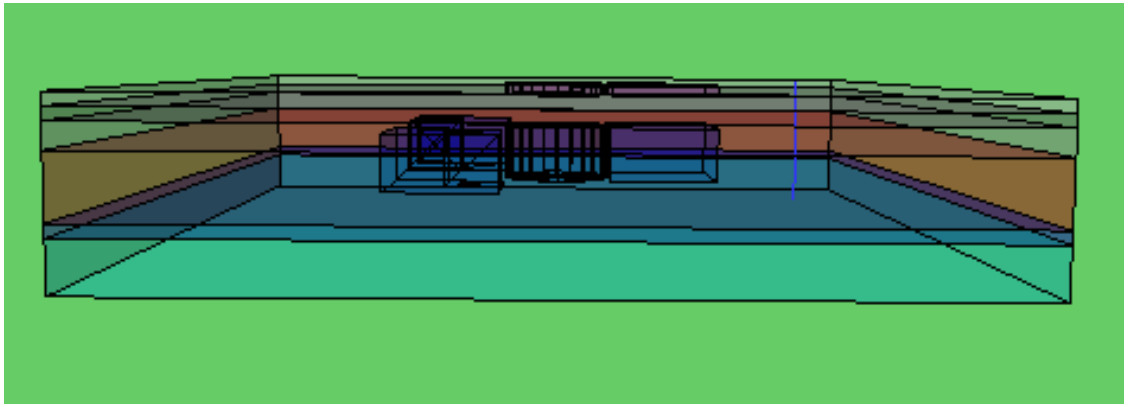
    → SEU rate estimates
  - Path length → useful for SEU analysis
  - Charging → total charge balance passing through user defined boundaries



GEMAT

- Geant4-based Micro-dosimetry Analysis Tool (GEMAT) is a computer code used for studying dosimetry effects of space radiation on micro-electronics and micro-sensors

- Has its own geometry builder → simulation geometry constructed in terms of layers, contact and depletion volumes



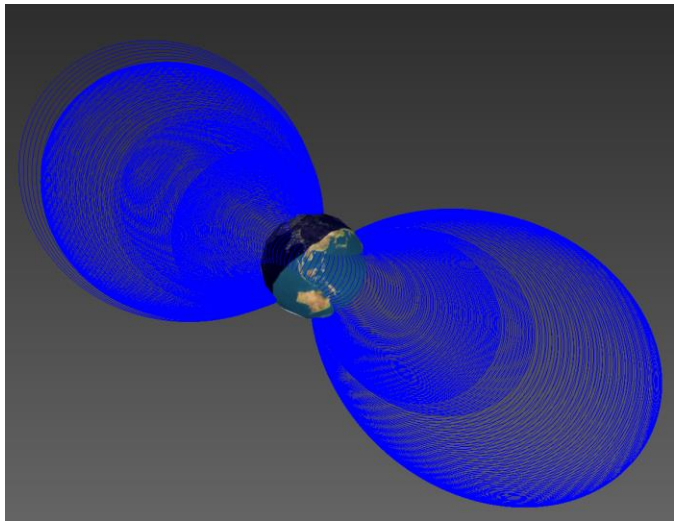
SSAT

- Sector Shielding Analysis Tool (SSAT) performs ray tracing from a user defined point within the geometry to determine
  - fraction of solid angle for which the shielding is within a defined interval (**shielding levels**)
  - mean shielding level as a function of look direction (**shielding distribution**)
- Geantino particle (no physical interactions) flags boundary crossings along its straight trajectory
- Positions of boundary crossings together with material density can be used to profile the shielding for given point within the geometry

MAGNETOCOSMICS

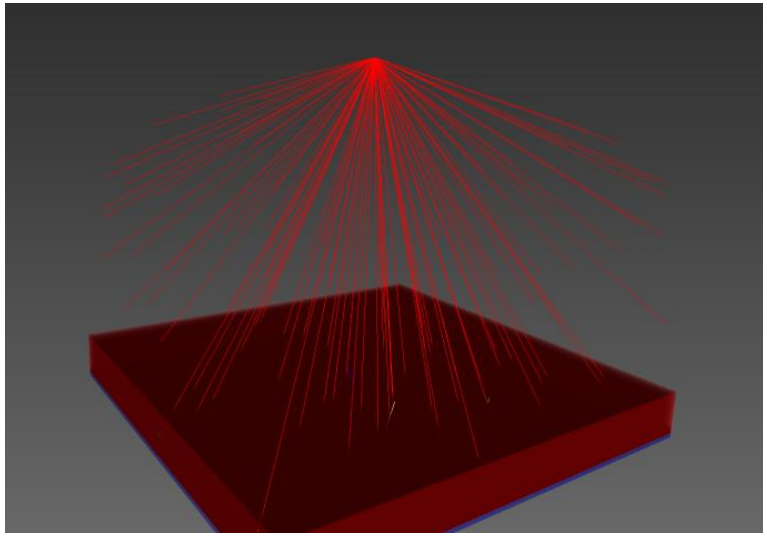
- Computation and visualisation of charged particle trajectories and magnetic field lines

- Computation of cut-off rigidities (min momentum per charge a particle must have in order to reach a certain location) as a function of position, for different types of magnetic field models



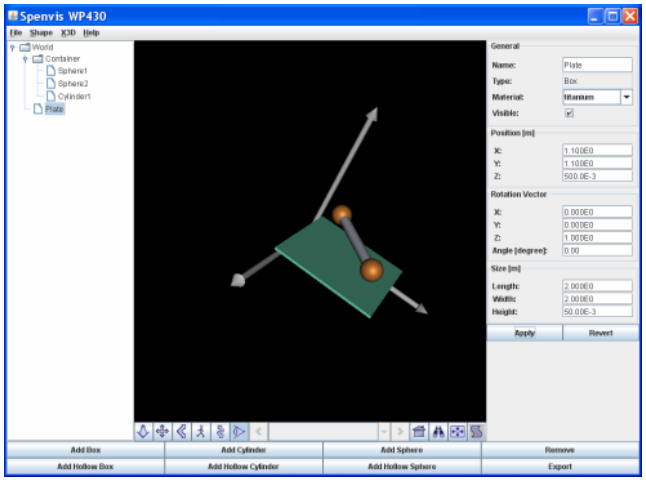
PLANETOCOSMICS

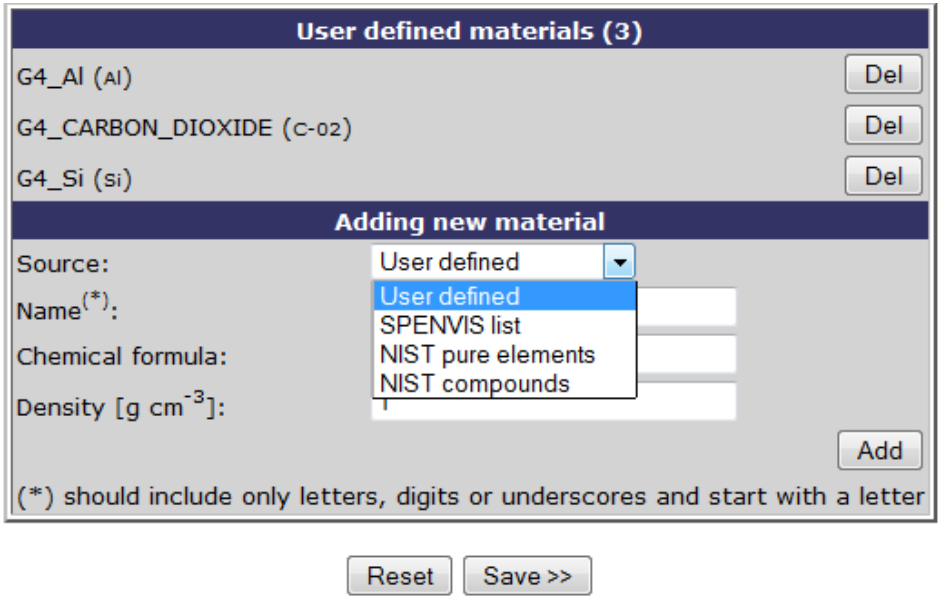
- Simulation of shielding effects of magnetic field, atmosphere and soil
  - Forward propagation: particle flux and energy deposition analysis
  - Backward propagation: rigidity cut-off analysis
- Geant4 particles & materials
- Mercury, Earth and Mars



Supporting tools

- Mission based Geant4 General Particle Source macros
- GDML (JAVA) geometry definition tool
- GDML analysis tool
- Material definition tool
  - ✓ user defined materials
  - ✓ selection from predefined lists





Other

- Detailed Mars Energetic Radiation Environment Model (dMEREM)

- PLANETOCOSMICS-J (update of PLANETOCOSMICS 2.0 code) and Genetic Algorithm Radiation Shield Optimiser (GARSO) for MULASSIS (JOREM)

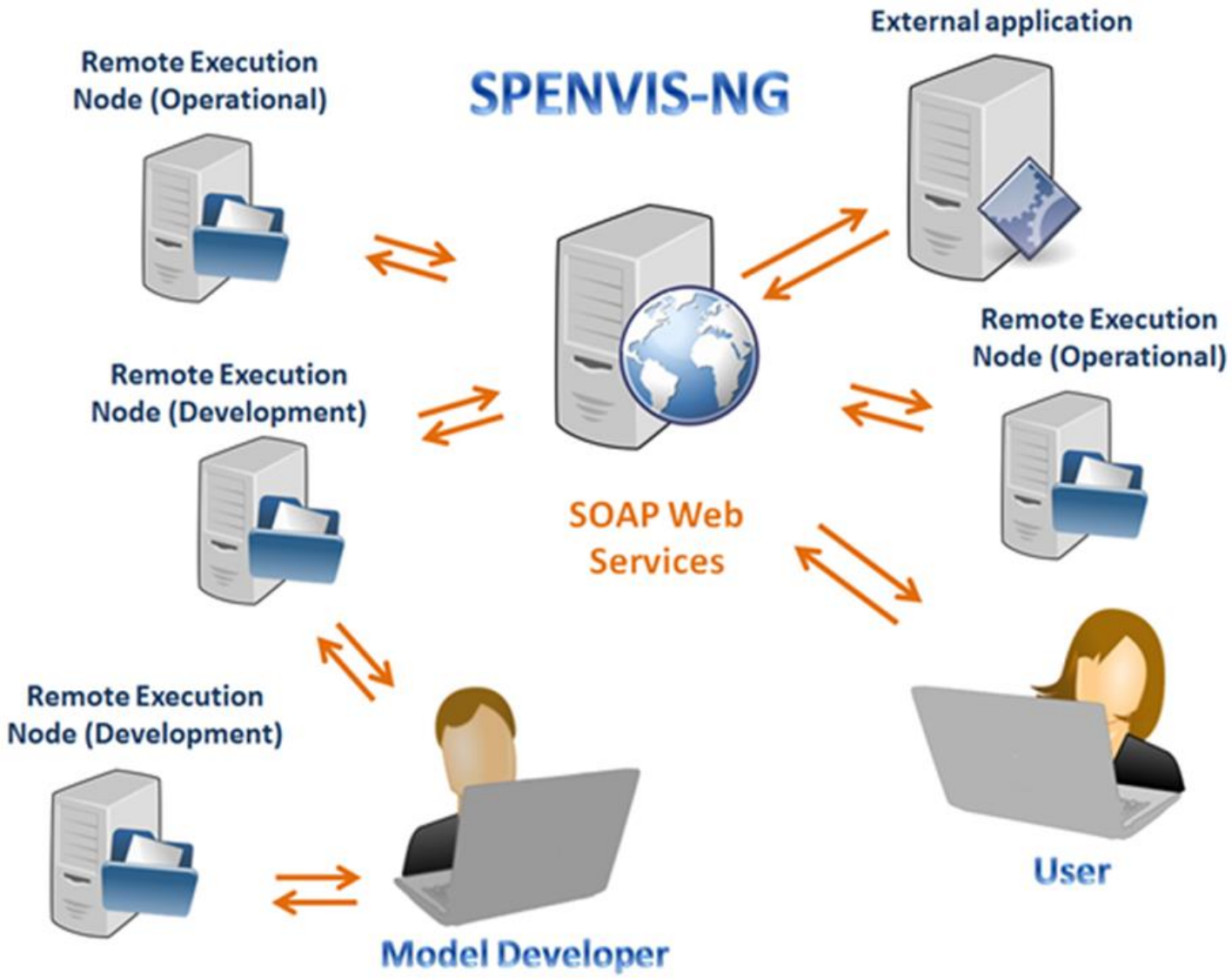
- MC-SCREAM: NIEL based damage equivalent fluences for solar cell (using MULASSIS)

The SPENVIS Next Generation

Complete re-design of the current SPENVIS system funded by ESA's General Support Technology Programme, GSTP-5

- ✓ web-based service oriented distributed framework supporting plug-in of models
- ✓ allows machine-to-machine interface for interoperability with other software

The SPENVIS Next Generation



The basic concepts

- Models and tools are embedded into **bundles**
  - ✓ binaries & execution script (ANT)
  - ✓ manifest
- Bundles can be easily plugged into the system (deployed on an execution node)
- Deployed models and tools are seen as consumers/producers of data streams (resources)

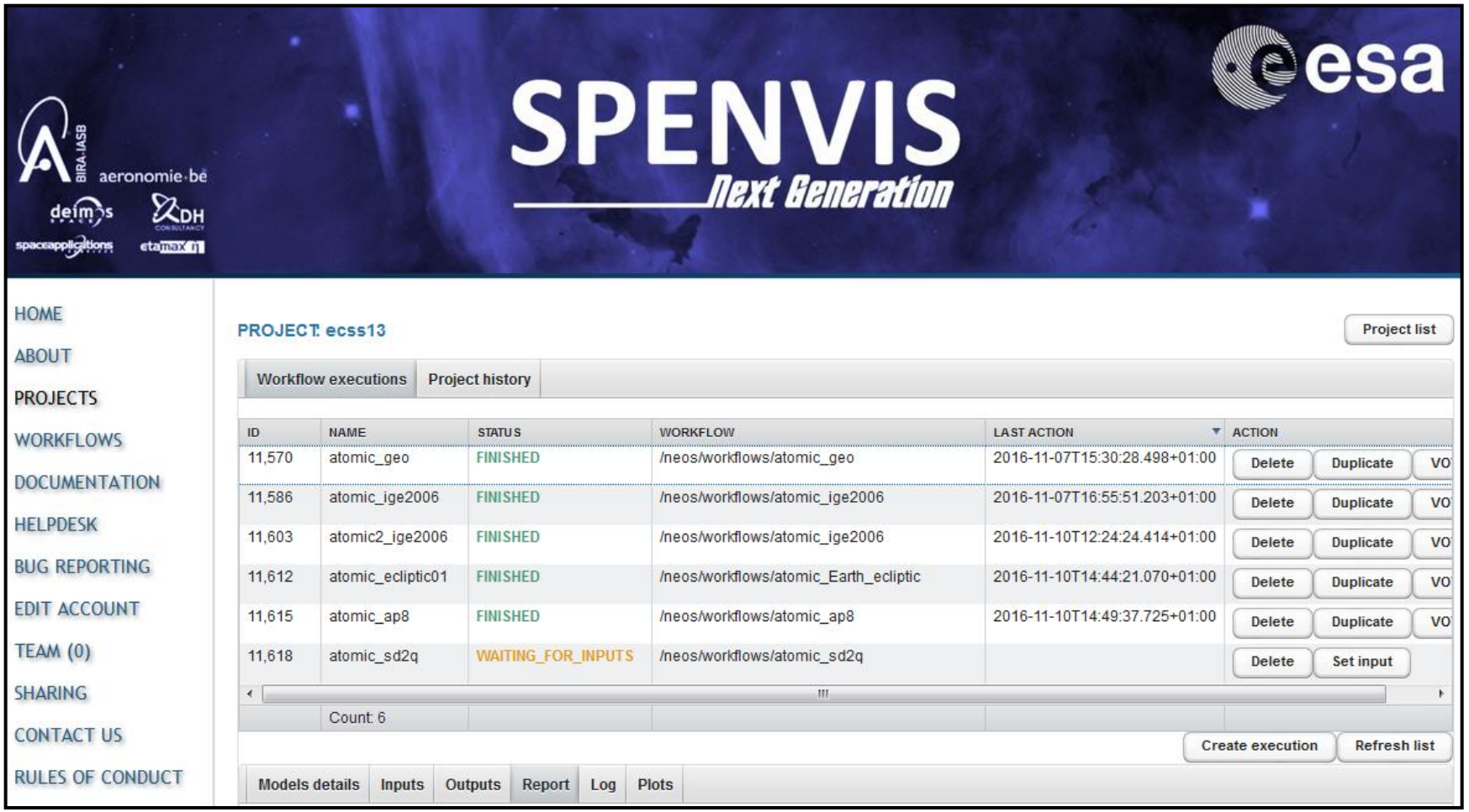
The basic concepts

- SPENVIS-NG is task oriented → **workflows**

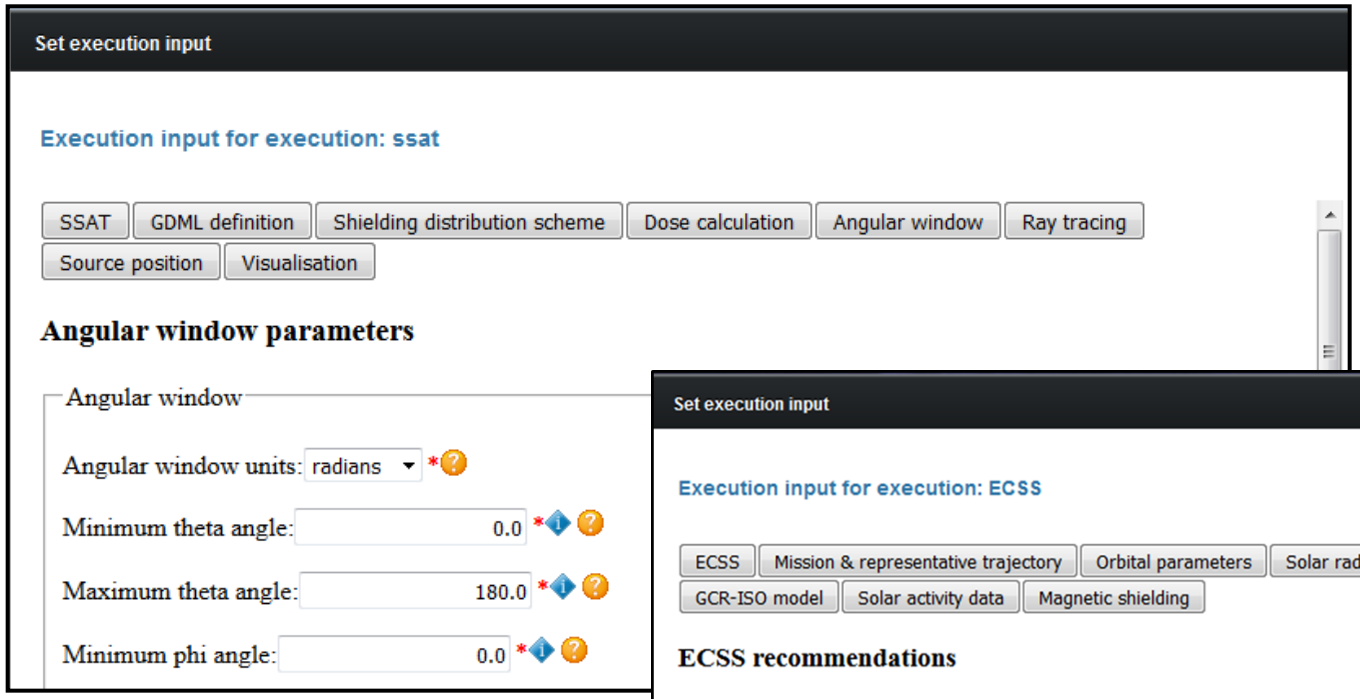
- A workflow describes how
  - ✓ the various models interact
  - ✓ the input interface shown to the user
  - ✓ the execution output is displayed

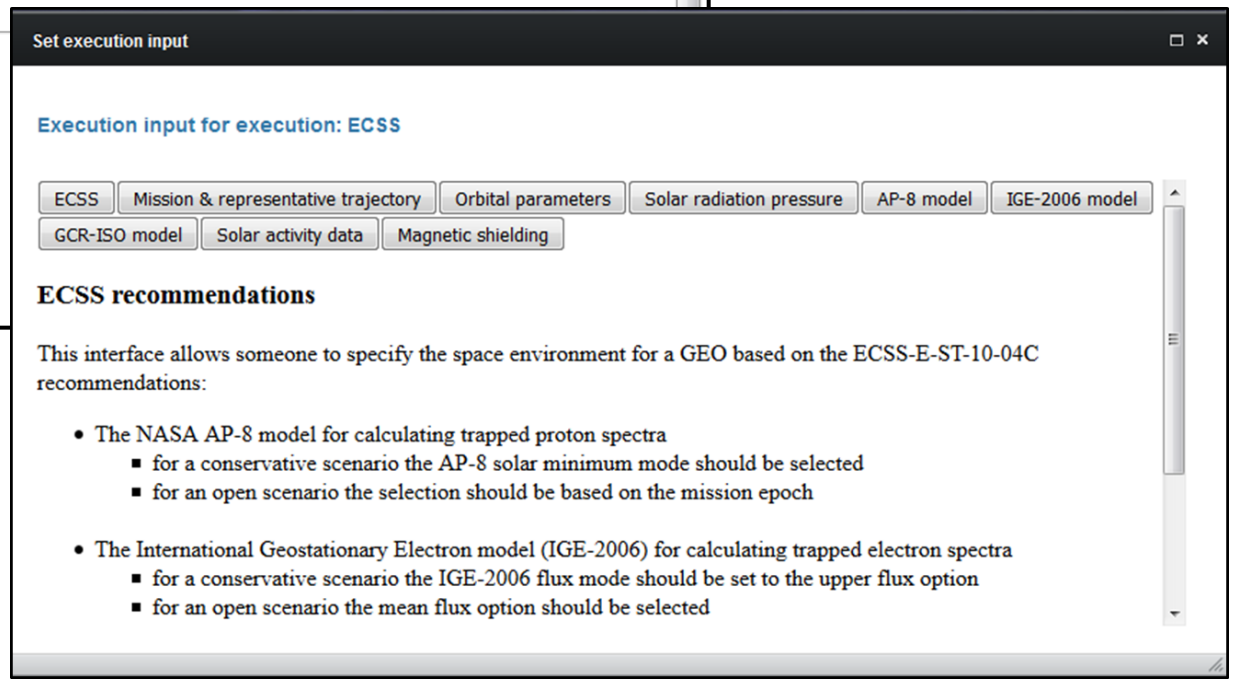
- Different types of workflows are supported
  - ✓ simple or complex (e.g. loops)
  - ✓ atomic: single model, parent/child
  - ✓ "All-in-one"
  - ✓ ECSS workflows

The SPENVIS-NG interface

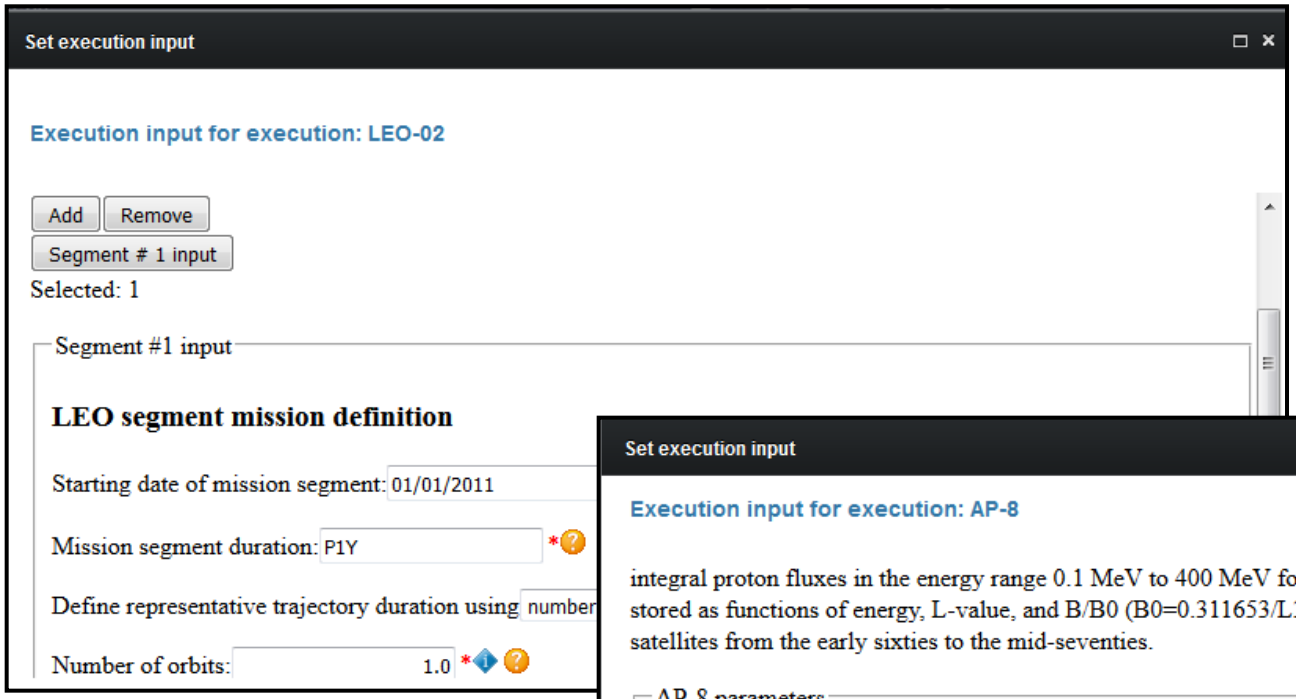


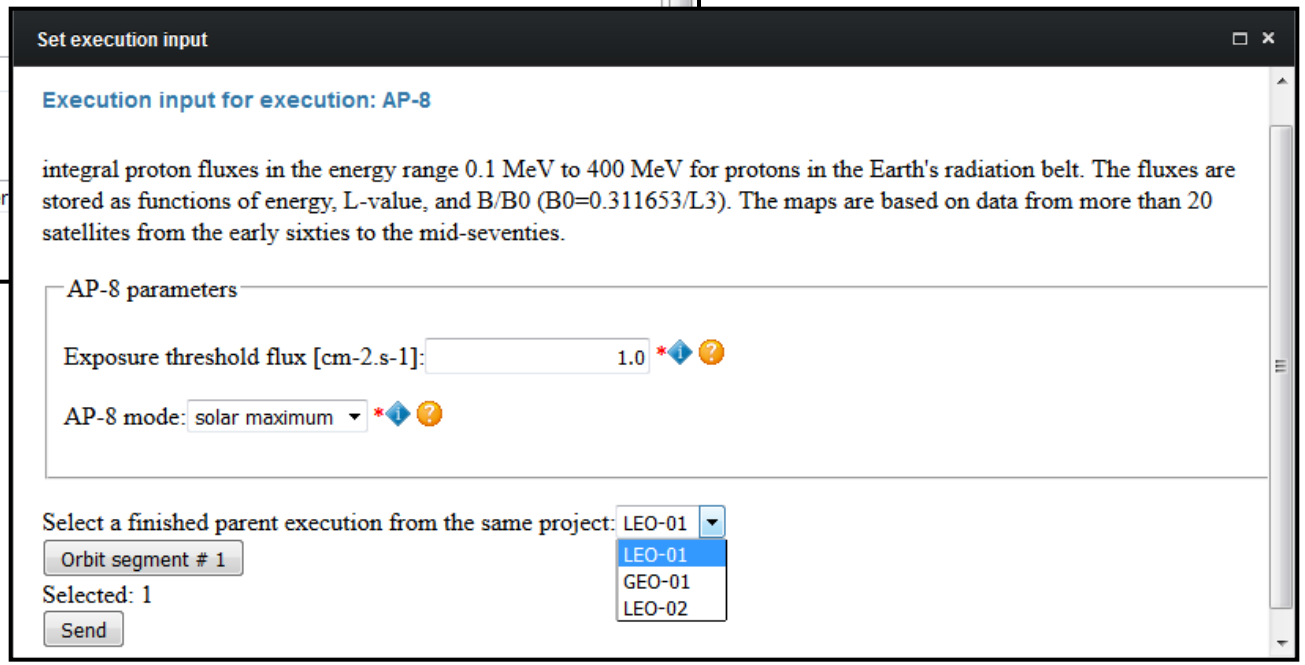
“All-in-one” workflows





Atomic workflows





Supporting the model developers

- Software Development Kit (SDK)
  - "Software Development Kit and Remote Execution Node Manual"
    - ✓ Tutorials & "Hints and tips" section
    - ✓ Installation & configuration of remote execution node
  - Tool for interacting with a remote execution node
  - Additional tools (extension): Saxon-HE package, STIL Tool Set (STILTS), wrappers for transforming CSV files into VOTables and vice versa, Python VOTable parser

Supporting the model developers

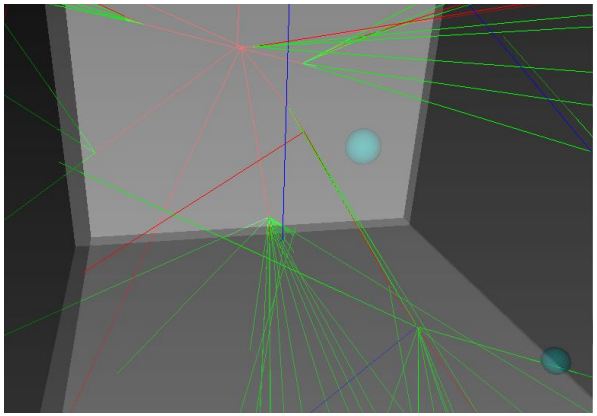
- XML Validation tool for manifests & workflows
- Semi-automatic creation of manifests (work in progress..)
- Python API

The status of SPENVIS-NG

- System development has been completed
- Busy with implementation of the model & tools (new + SPENVIS-4 migration)
- Some issues remain
  - ✓ not easy enough to implement models
    - ✓ user interface improvement
      - ✓ additional monitoring tools

Current & future developments

- Installation of Geant4.10 on a dedicated SPENVIS-NG execution node (geant4-10-01-patch-03)
- Successful compilation of MULASSIS (1.26) and GRAS (3.4) with Geant4.10 & SPENVIS-NG installation
- Installation of GEMAT and SSAT on SPENVIS-NG remote node



Current & future developments

- Complete the implementation of model in SPENVIS-NG
- Introduce a minimum set of public workflows
- Continue supporting SPENVIS users and model developers.

Geant4 tools in SPENVIS

Model	Version	Description
GRAS	3.1 (4.9.5p02), 2.3 (4.9.2)	Geant4 Radiation Analysis for Space →General space radiation analysis for 3D geometry models
MULASSIS	1.23 (4.9.5p02), 1.19 (4.9.2)	Multi-Layered Shielding Simulation Software → Radiation analysis for one-dimensional layered shield
GEMAT	2.8 (4.9.5p02), 2.4 (4.9.0)	Dosimetry effects of space radiation on micro-electronics and micro-sensors
SSAT	2.1 (4.9.0)	Ray tracing from user defined point within geometry to determine shielding levels and shielding distributions
MAGNETOCOSMICS	2.0 (4.7.1)	- Charged particle trajectories & magnetic field lines - Cut-off rigidities as a function of position
PLANETOCOSMICS	2.0 (4.8.1)	- Definition of a planetary magnetic field, atmosphere & soil - Interactions of cosmic rays with planetary environment

Geant4 tools in SPENVIS

Model	Version	Description
dMEREM	(4.9.1p03)	Detailed Mars Energetic Radiation Environment Model
PLANETOCOSMICS-J	(4.9.2p02)	Galilean Moon (Io, Europa, Ganymede & Callisto) Environment Tool → Update of version 2.0 of the PLANETOCOSMICS code
MC-SCREAM	MULASSIS 1.19 (4.9.2)	NIEL based damage equivalent fluences for solar cell (using MULASSIS)
SMUL	MULASSIS 1.19 (4.9.2)	Uses Pelliccioni conversion coefficients for converting the MULASSIS output into effective dose or ambient dose equivalent