Using SPENVIS within Space Mission Operations

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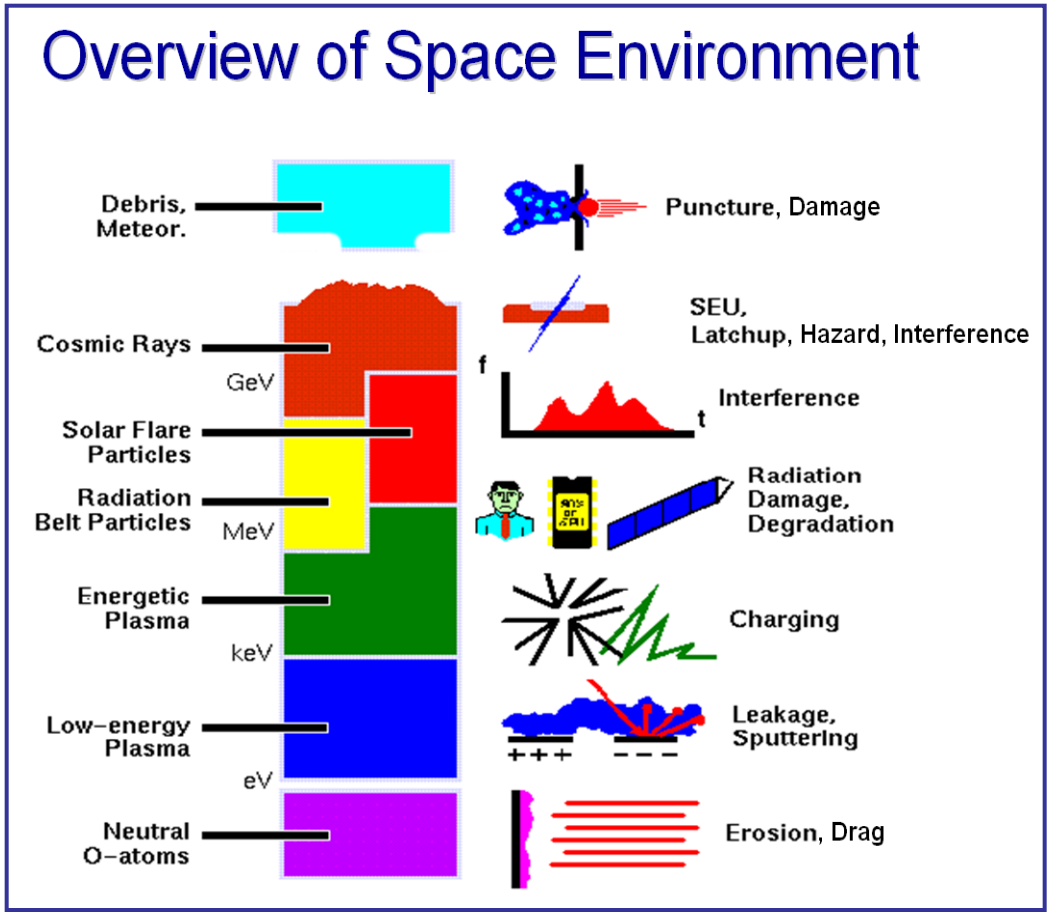
*Supporting material courtesy **Eamonn Daly** (ESA-ESTEC)*

28th April 2010 – SWW2010

Space Environments Effects: Project Support



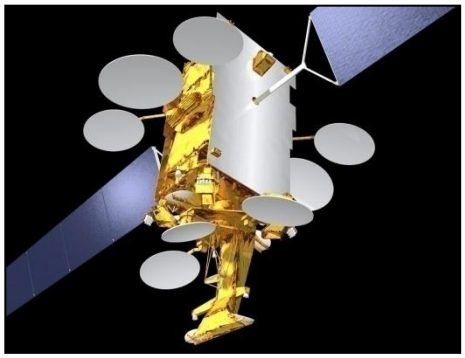
Evaluation of space environments and effects

- Starts pre-phase A
  - Environment specifications
  - Tailoring of standards
  - Concurrent Design
- More detailed support in later phases
- In-orbit behaviour evaluations

Supporting activities

- R&D
- Standardisation
- Collaboration

Commercial, Applications & Earth Obs Missions



Telecommunications spacecraft in GEO:
- environment dominated by energetic e^- of the outer radiation belt;
- High lifetime dose

Low altitude constellations (e.g. Globalstar at 1400km)
- Mixed environment; High lifetime dose

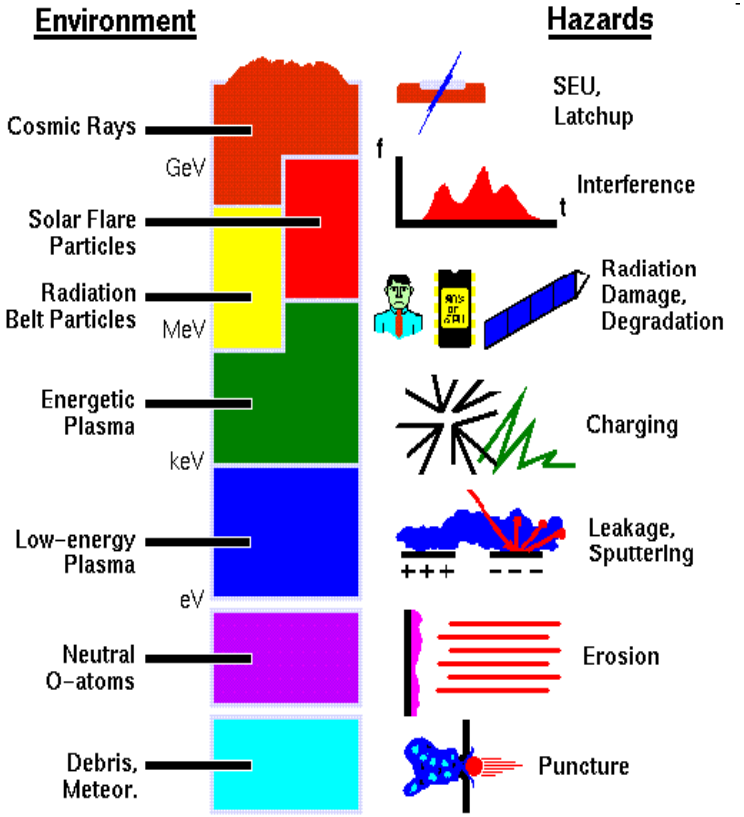
Earth observation and Earth science:
- "sun-synchronous" polar orbit ~600-900 km; Mixed environment
- Many ESA Earth Science and "Sentinel" projects

Navigation systems
- medium altitude, highly inclined, circular orbits.
- Galileo at ~25000km and ~55º incl. → heart of the radiation belts.

Trends have major radiation implications:
- ↑complexity of on-board systems;
- ↑spacecraft size in GEO;
- ↑ power in GEO -> large lightweight solar arrays,
- ↓ procurement costs;
- minimization of operations;
- ↑ on-board processing;
- long-term reliability;
- extensive use of commercial off-the-shelf components (COTS):
  - ↓ radiation hard or poorly characterized
  - ↑ on-chip complexity.

SPENVIS in short

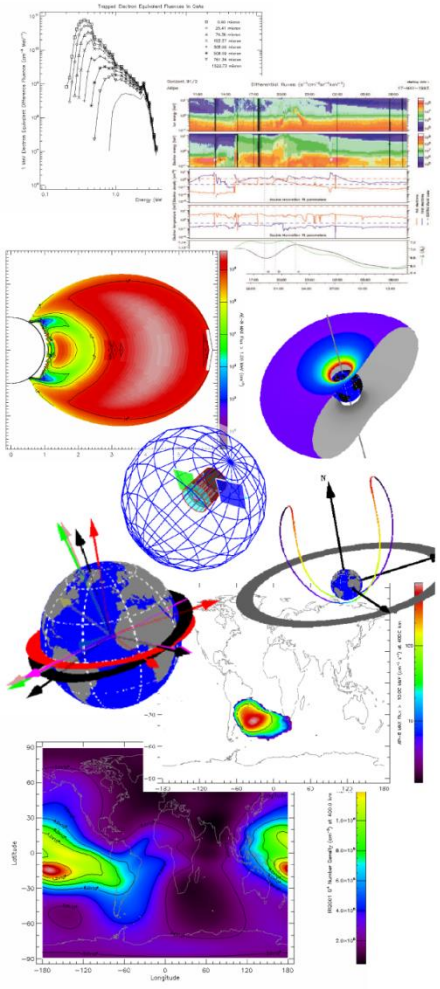
- ESA operational software
  - developed and maintained at BIRA-IASB from 1996
  - Support through ESA GSTP programme
  - H Evans TEC-EES, ESA responsible
- User-friendly human interface to models of the space environment and its effects
  - web interface,
    default values, contextual help,
    user workspace (inputs, outputs),
    reports, graphical utilities,…
- Allows rapid analysis of
  - cosmic rays
  - solar energetic particles
  - natural radiation belts
  - magnetic fields
  - space plasmas
  - upper atmosphere
  - meteoroids and debris



(TEC-ESS http://space-env.esa.int)

SPENVIS Overview

- Tour of SPENVIS models
  (including focus on new and upcoming items)
  - Coordinate generators
  - Space environment
  - Environment effects
- Geant4-based tools (GRAS, Mulassis, GEMAT)
- Current developments
  - Planetary environment
  - Third party development toolkit
  - On-line help; user forum; bug-tracker
- Conclusions

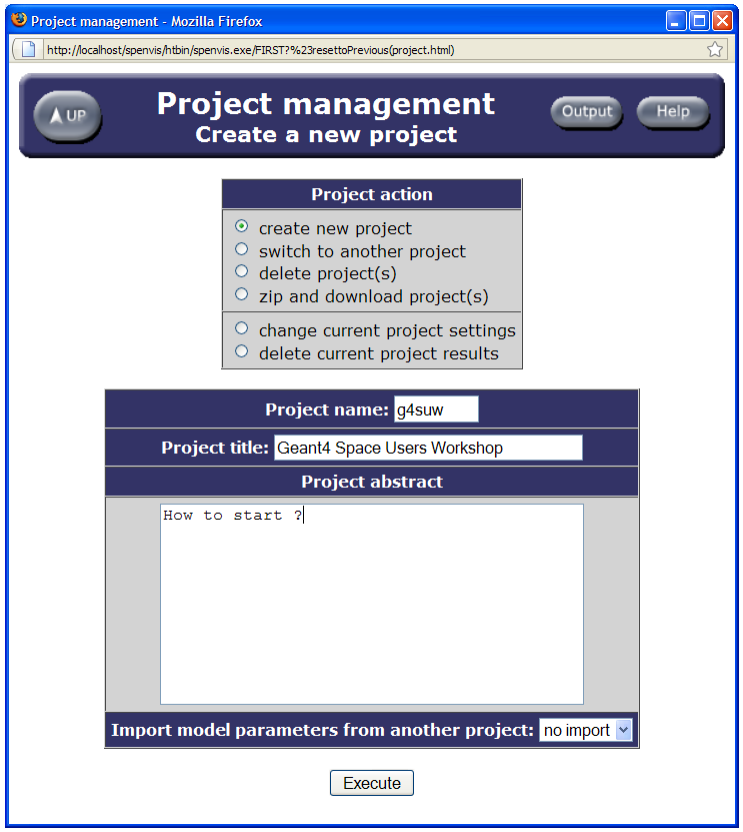


SPENVIS: Space Environment Information System

www.spenvis.oma.be

Introduction > How to start?

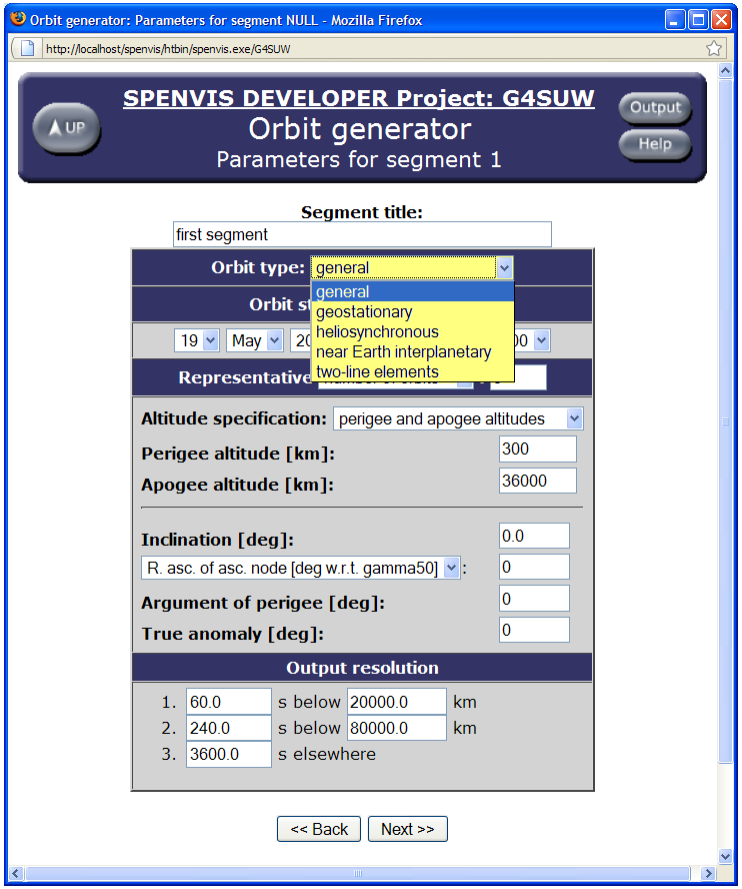
1. Create an account → Register
2. Login in → Access
3. Create a new project (user workspace)
4. "Coordinate generators"



Coordinate generators

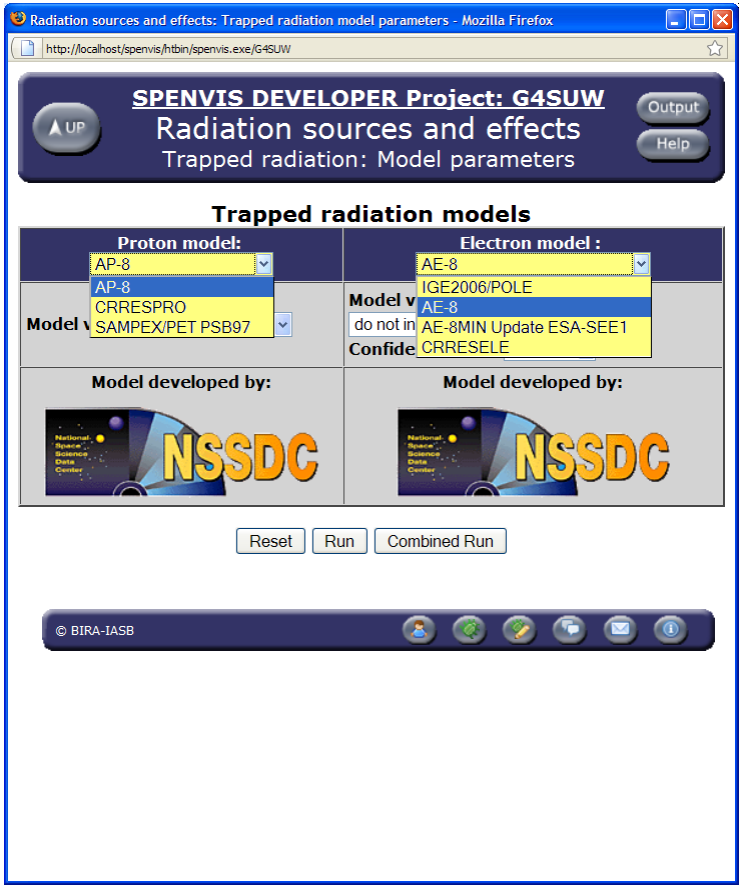
- Coordinate grid
- Spacecraft trajectories

  Next Release → other trajectories
  (hyperbolic, user upload)

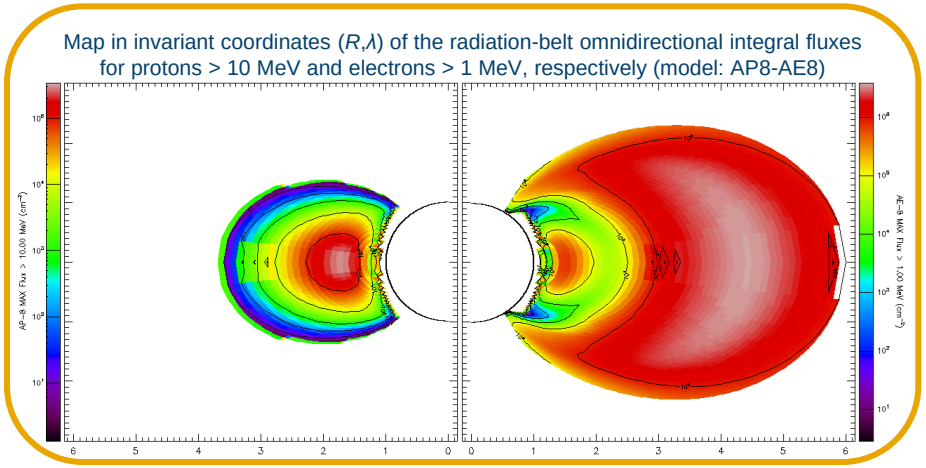


> Space environment > Radiation belts

- Trapped electron/proton fluxes along spacecraft trajectories or maps (coordinate grids)
- new → IGE2006/POLE (e^- geostationary orbit)
- new → Sampex/PET (p^+ low altitudes)
- next → Jovian models (Divine and Garret, JIRE, ONERA/Salammbô)



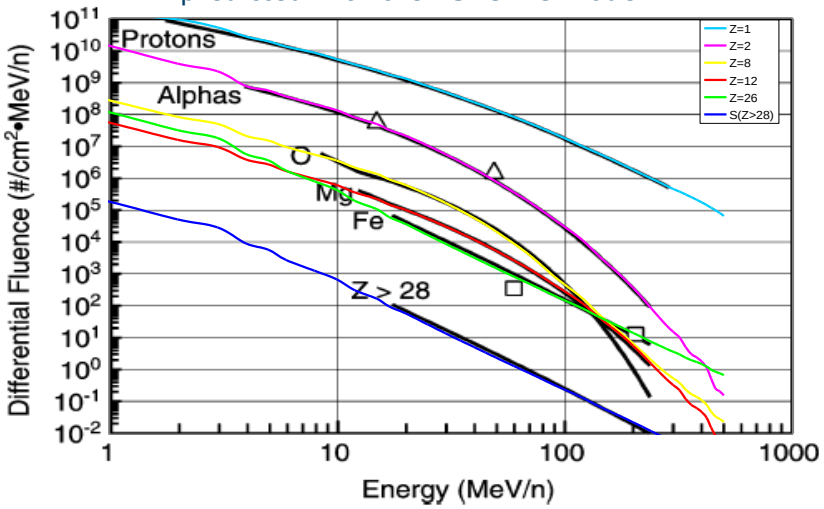
Map in invariant coordinates (R,λ) of the radiation-belt omnidirectional integral fluxes for protons > 10 MeV and electrons > 1 MeV, respectively (model: AP8-AE8)

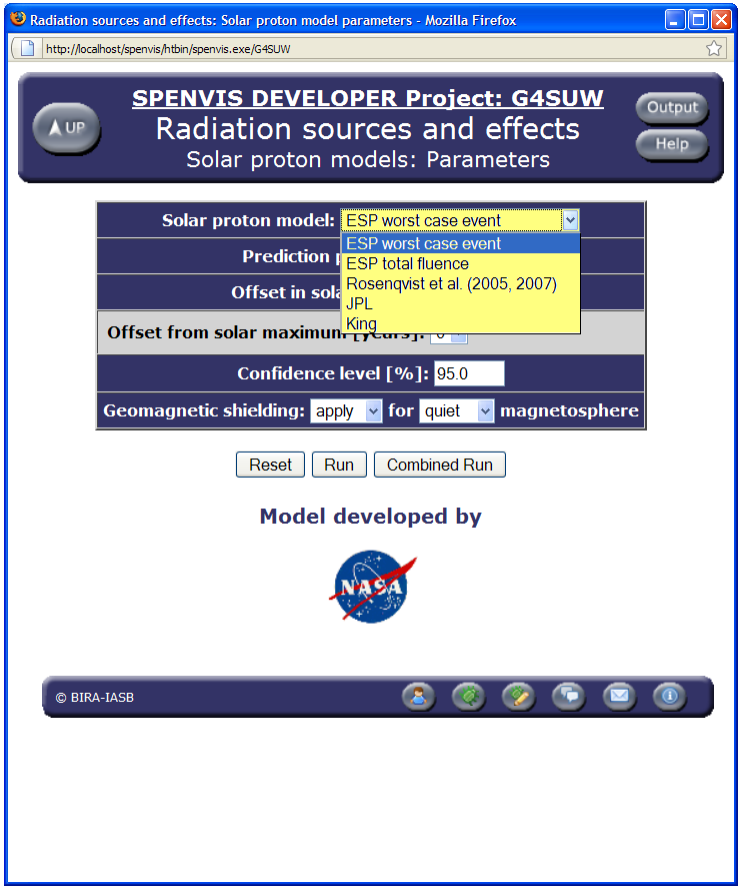


> Space environment > Solar Energetic Particles

- new → Particle fluence
- new → PSYCHIC incl. ions
  (Xapsos et al. 2007)

Differential fluences for Z = 1, 2, 8, 12, 26 and >28 predicted with the PSYCHIC model





> Space environment > GCR

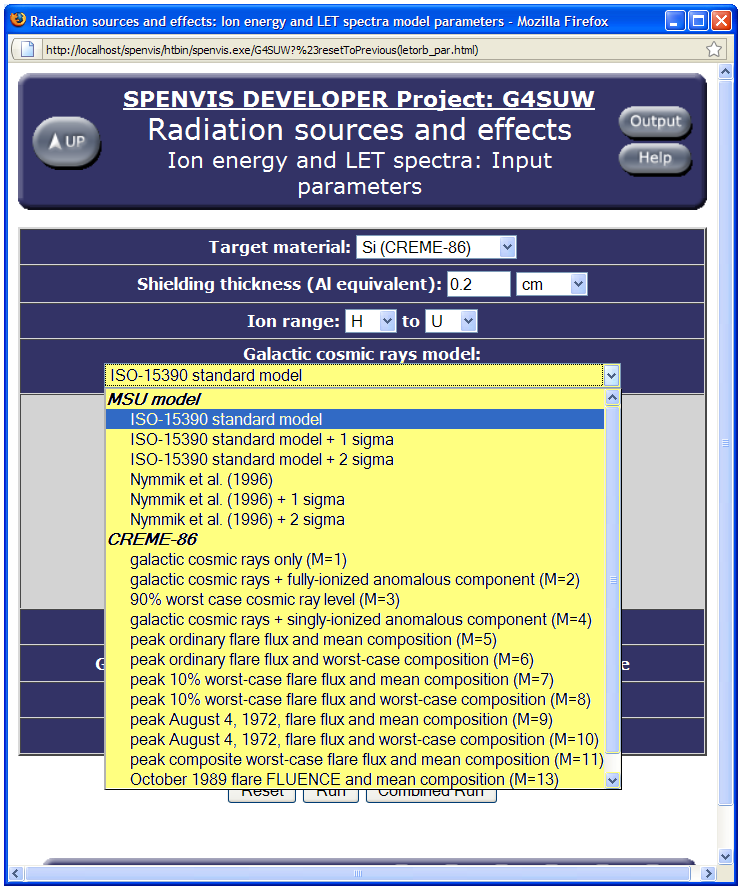
Cosmic rays

(inside LET spectrum model)

- new → ISO-15390
- new → Nymmik et al 1996

SEP & GCR > Magnetic shielding

- Størmer approach (= dipole)
- new → Upgrade based on Magnetocosmics



> Environment effects > Solar cell

Solar cell damage equivalent fluences

← trapped e^-, trapped & solar p^+

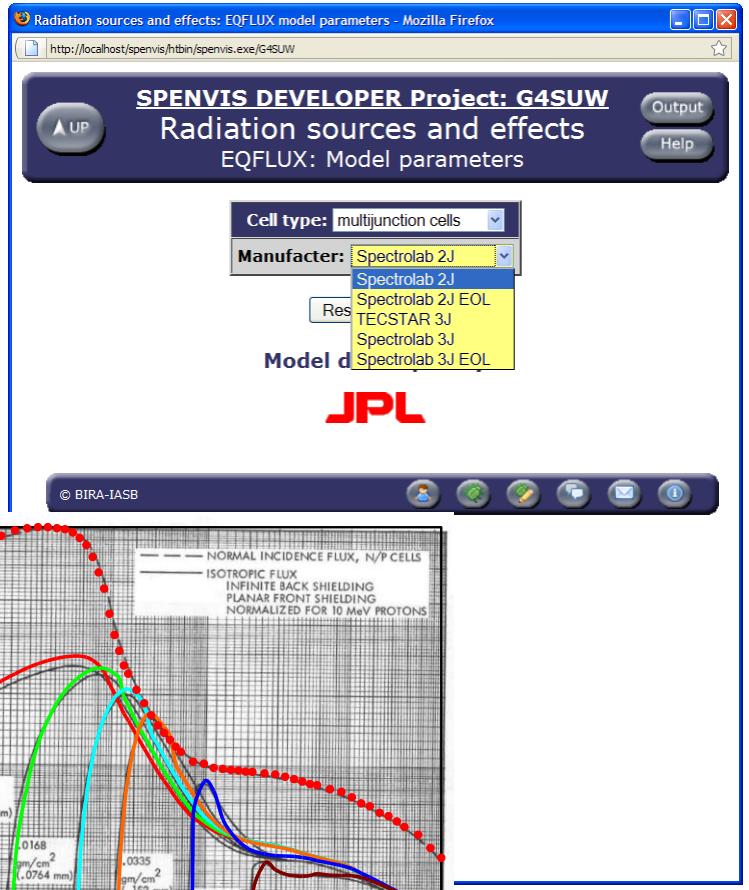
- new → RDC (Relative Damage Coefficient) converter Tada et al. (1982)

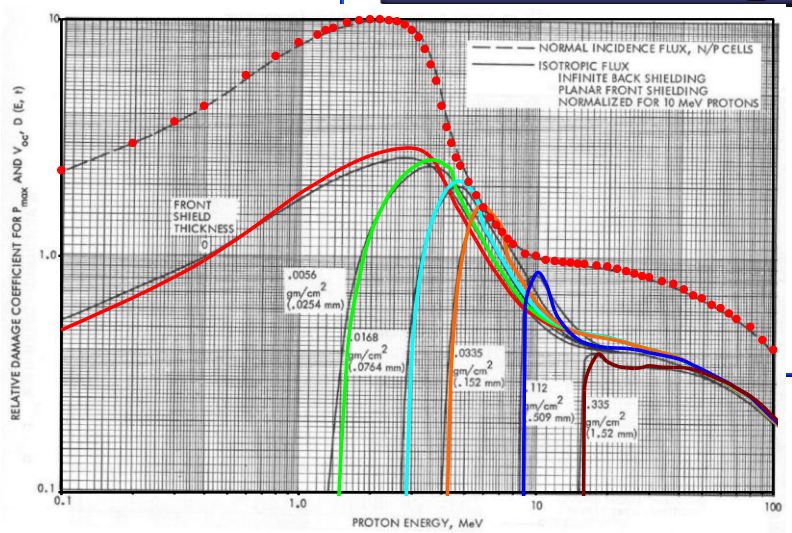
  Input= uncovered unidirectional RDC

  Output= covered omnidirectional RDC

- next→ additional RDC data (Emcore, Azur solar cells)

- new → NIEL-based degradation calculations (MC-SCREAM)

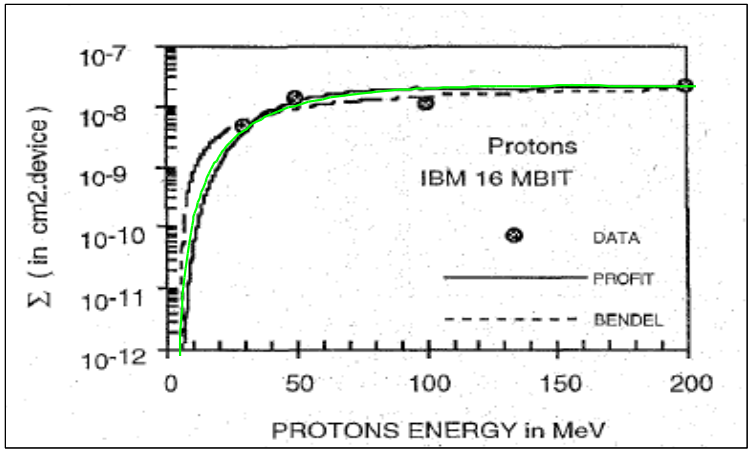




Single Event Upset

← LET spectra ← trapped p^+ & GCR

- new → GaAs device
- new → Profit algorithm
  Multiple devices
  Path length distr.

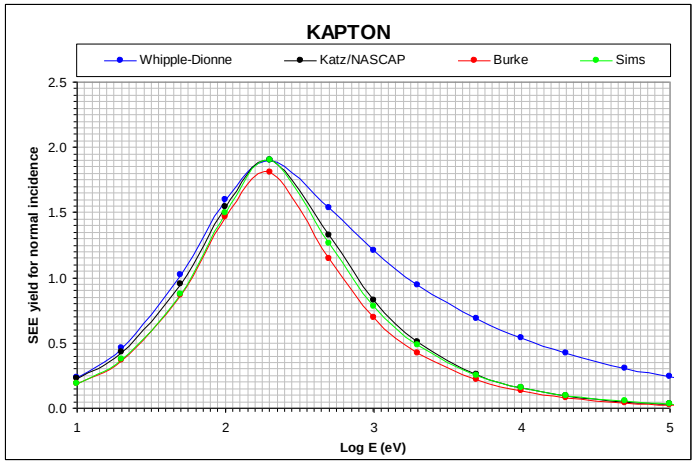


- next → Upgrade of
  slowing/stopping ions

Surface charging

← space plasma

- new → Burke's equation (1980)
  (secondary electron emission)

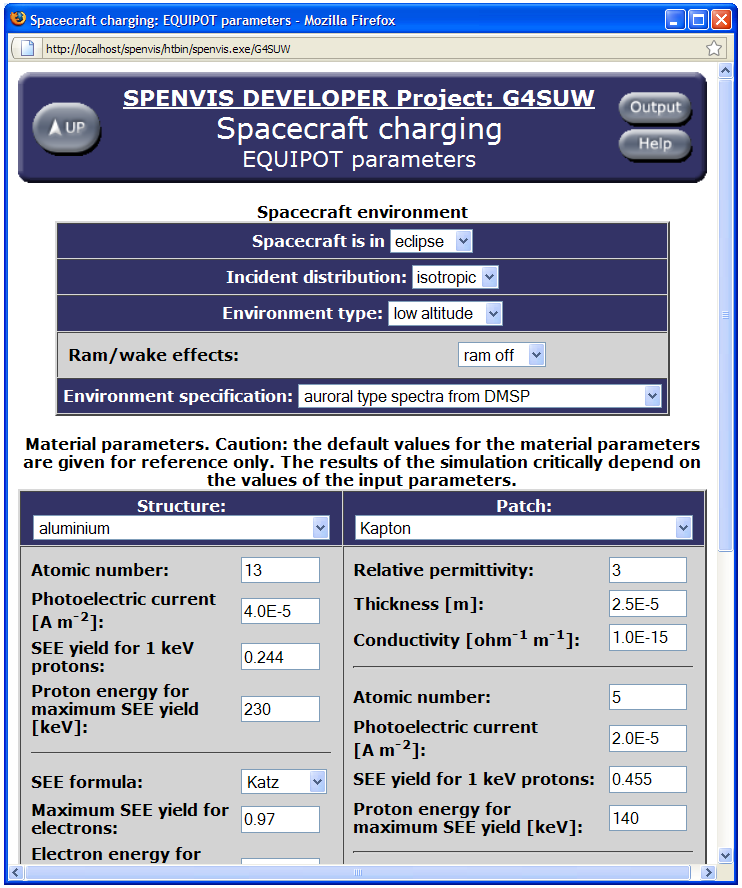


- new → auroral environment
  (Davis & Duncan, 1992)

Deep dielectric charging

← trapped e^-

- new → DICTAT v3



GEANT-4 Tools

- Geant4 Library Developed by the Geant4 Collaboration, members include CERN, SLAC, ESA, ...
- Physics-based and semi-empirical
- Study interactions of Radiation and Matter at all scales and energies
- Subset relevant to Space Science optimised to reflect nature of problem:
  - Omni-directional radiation
  - Specific species (e^-, p^+, He ions, heavier ions etc ...)
  - Materials commonly used
  - Typical geometries
  - Shielding
- Applications (Mulassis, SSAT, GEMAT) fully integrated within SPENVIS (user friendly!)

Current developments

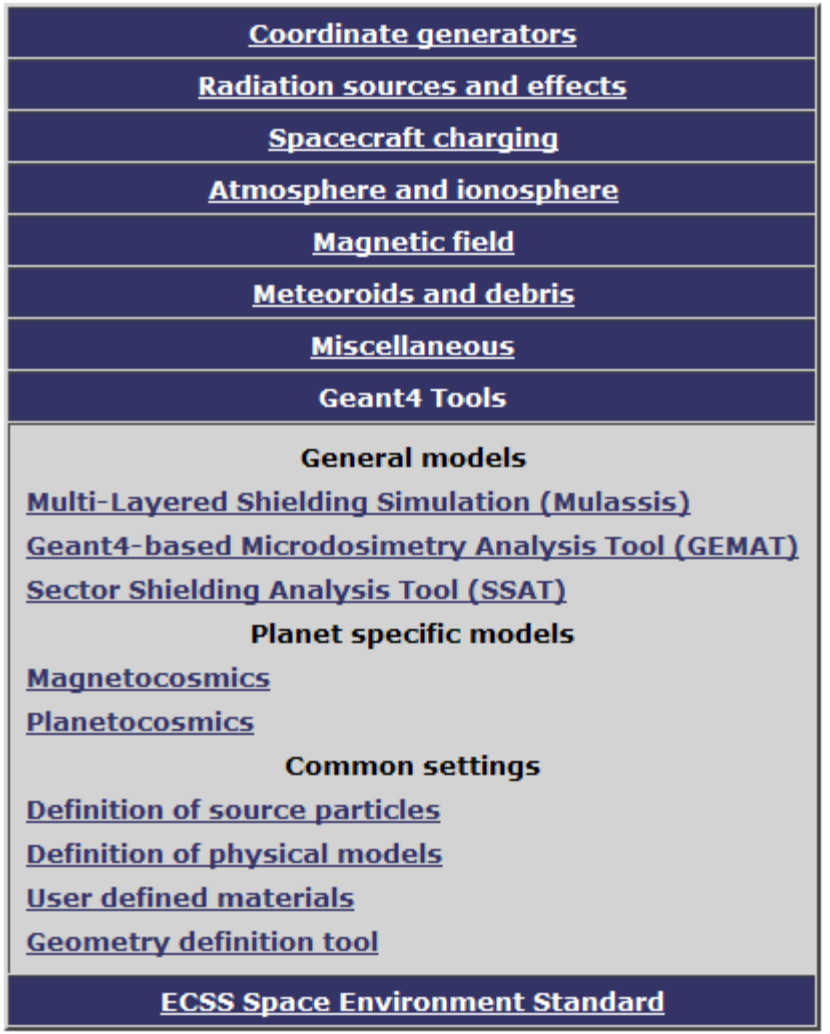
Geant4-based tools

New Applications

new → Magnetocosmics
Planetocosmics
MC-SCREAM
GRAS (later)

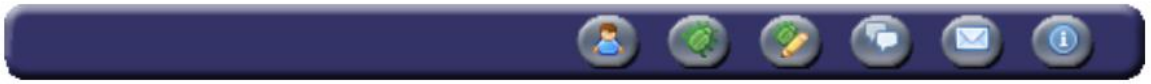
Existing Applications

now → GEMAT, Mulassis, SSAT



User Support: Bug Tracker

New → Tool bar:



- Tracking of issues reported by users (bug, feature,…)

0000058: SHIELDOSE returns zeroes when given only one thickness - SPENVIS Bug Tracker - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dev.spenvis.oma.be/tracker/view.php?id=58

spenvis-tracker

Logged in as: *michel* (Michel Kruglanski - developer) 2009-05-18 19:03 CEST Space Environment I

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Viewing Issue Simple Details [Jump to Notes] [>>] [Issue

ID	Category	Severity	Reproducibility	Date Submitted	
0000058	[SPENVIS] Package: Radiation Doses	minor	always	2009-05-15 21:12	200
Reporter	Christopher Dieck	**View Status**	public		
Assigned To	Michel Kruglanski				
Priority	normal	**Resolution**	fixed		
Status	resolved			**Product Version**	4.6
Summary	0000058: SHIELDOSE returns zeroes when given only one thickness				
Description	In SHIELDOSE and SHIELDOSE-2, when including only one value in the user input table of values, the outpu regardless of the value of the single input, is 0.00 for all calculated columns.				
Additional Information	The problem only appears in the case of the "solid sphere" geometry for which the both models require at l thicknesses (the spherical results are derived from the planar results). The problem has been fixed by adding some thicknesses to the user values. These additional values are no model outputs. See note for an example how the results are affected by the number of thicknesses.				
Tags	No tags attached.				
Attach Tags	(Separate by ',') Existing tags Attach				
Attached Files					

Change Status To: new Reopen Issue

Relationships

There are no users monitoring this issue.

Find: neop Next Previous Highlight all Match case

View Issues - SPENVIS Bug Tracker - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://dev.spenvis.oma.be/tracker/view_all_bug_page.php

spenvis-tracker esa

Logged in as: *michel* (Michel Kruglanski - developer) 2009-05-18 19:01 CEST Space Environment Information System

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Recently Visited: 0000058, 0000052

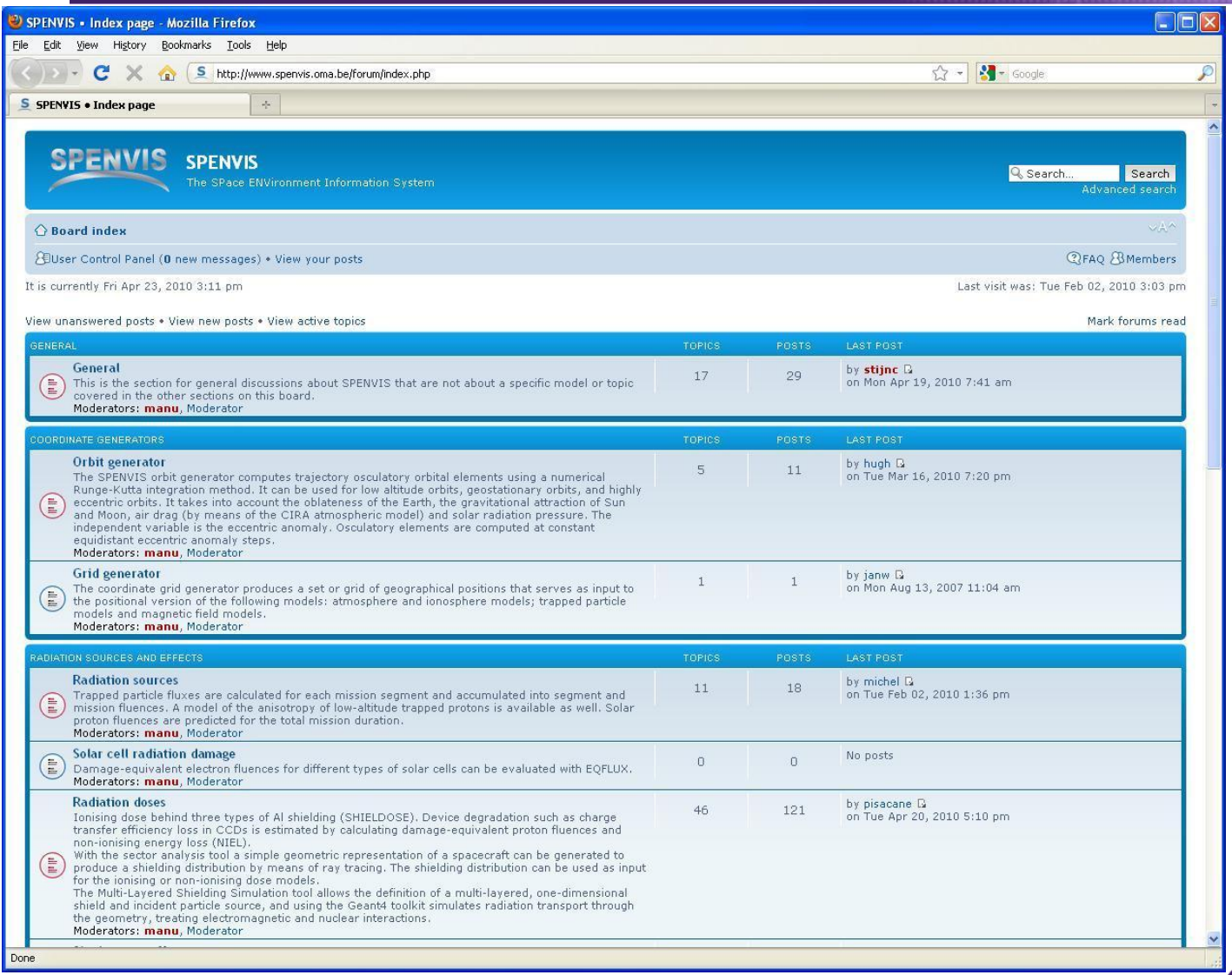
Search: Apply Filter Reset Filter Save Current Filter

Viewing Issues (1 - 34 / 34) [Print Reports] [CSV Export]

P	ID	#	Category	Severity	Status	Updated	Summary
	0000058	1	Package: Radiation Doses	minor	resolved (Michel Kruglanski)	2009-05-18	SHIELDOSE returns zeroes when given only one thickness
	0000057		Package: Radiation Sources	feature	new	2009-05-15	Add input for threshold flux for exposure
	0000056		Add-on: Development Tools	feature	new	2009-03-31	Would be nice to have ViewVC integrated into the SVN as an http based source code browser
	0000054	1	Package: Spacecraft Charging	minor	resolved (Michel Kruglanski)	2009-03-30	Fraction of solar cycle
	0000055		System: Documentation	text	assigned (Michel Kruglanski)	2009-03-30	Links to TREND-3 web site point to http://www.magnet.oma.be/trend4/public/trend3/index.html
	0000052	2	Package: Radiation Sources	major	resolved (Erwin De Donder)	2009-03-19	results from IGE-2006 model are several orders of magnitude too high
	0000053	4	Package: Radiation Sources	minor	resolved (Michel Kruglanski)	2009-03-19	TREP: Differential fluence to be checked
	0000051	2	Package: Radiation Sources	major	resolved (Erwin De Donder)	2009-03-17	No results obtained from the IGE-2006 model
	0000001	1	Package: Coordinate Generators	crash	resolved (Michel Kruglanski)	2009-03-06	Orbit Generator, Two Line Elements
	0000019		Other	feature	resolved	2009-03-06	(Technical: Kernel) changing behaviour the #runModel() action
	0000032		Package: Spacecraft Charging	minor	resolved	2009-03-06	DICTAT: compilation warning (version 3)
			Package: Spacecraft				number of input lines of DICTAT user-defined

Find: neop Next Previous Highlight all Match case

User Support: User Forum



Response by SPENVIS team member normally within 3 working days.

All advanced users are encouraged to use the forum particularly as respondents to posted questions.

Third Party Development

New → **Third party development toolkit**

Development of SPENVIS applications by third parties

1. Dedicated repository (SVN)

@ developer side:(win32 or linux)

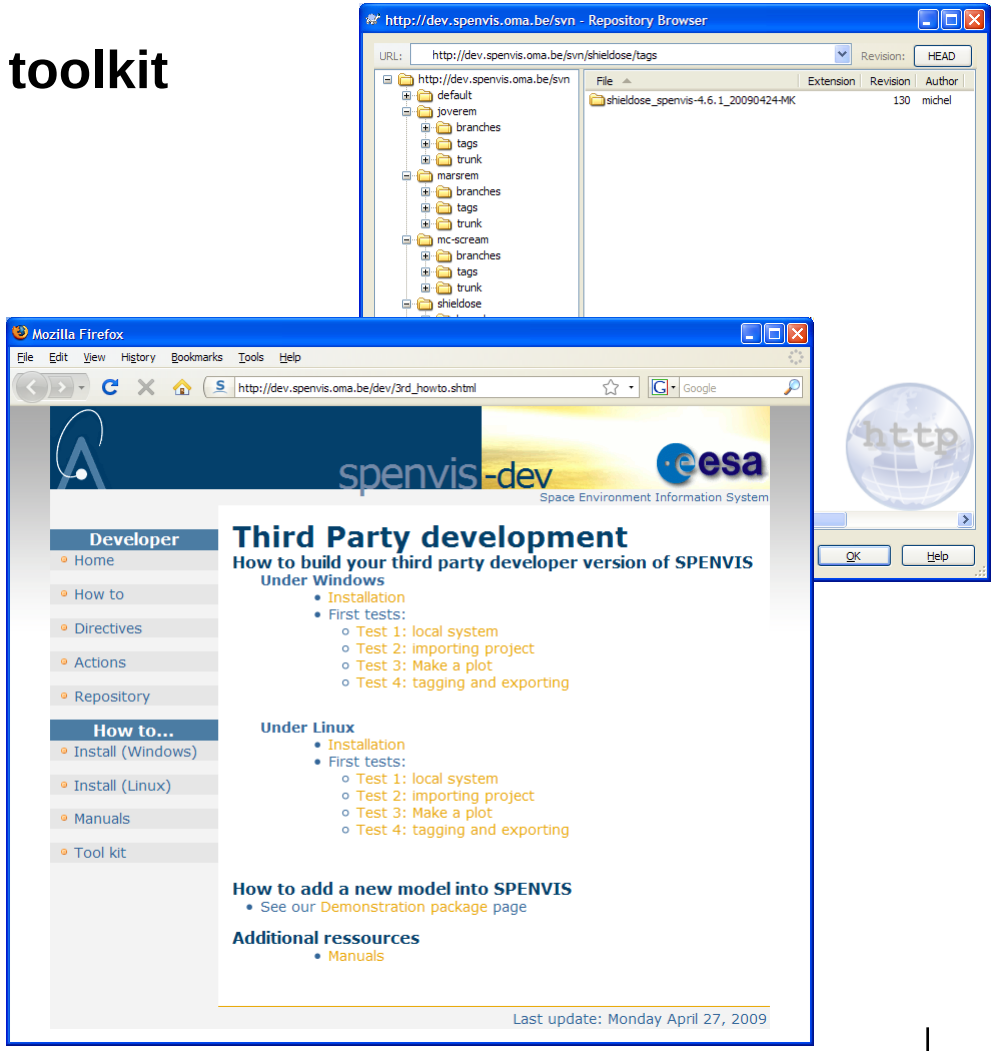
2. Reduced version of SPENVIS
3. Application development
4. Testing on reduced version

@ dev.spenvis.oma.be:

5. Export & installation of the application on full version
6. Testing & demonstration

SPENVIS team:

7. Final integration in SPENVIS



SPENVIS for S/C Design

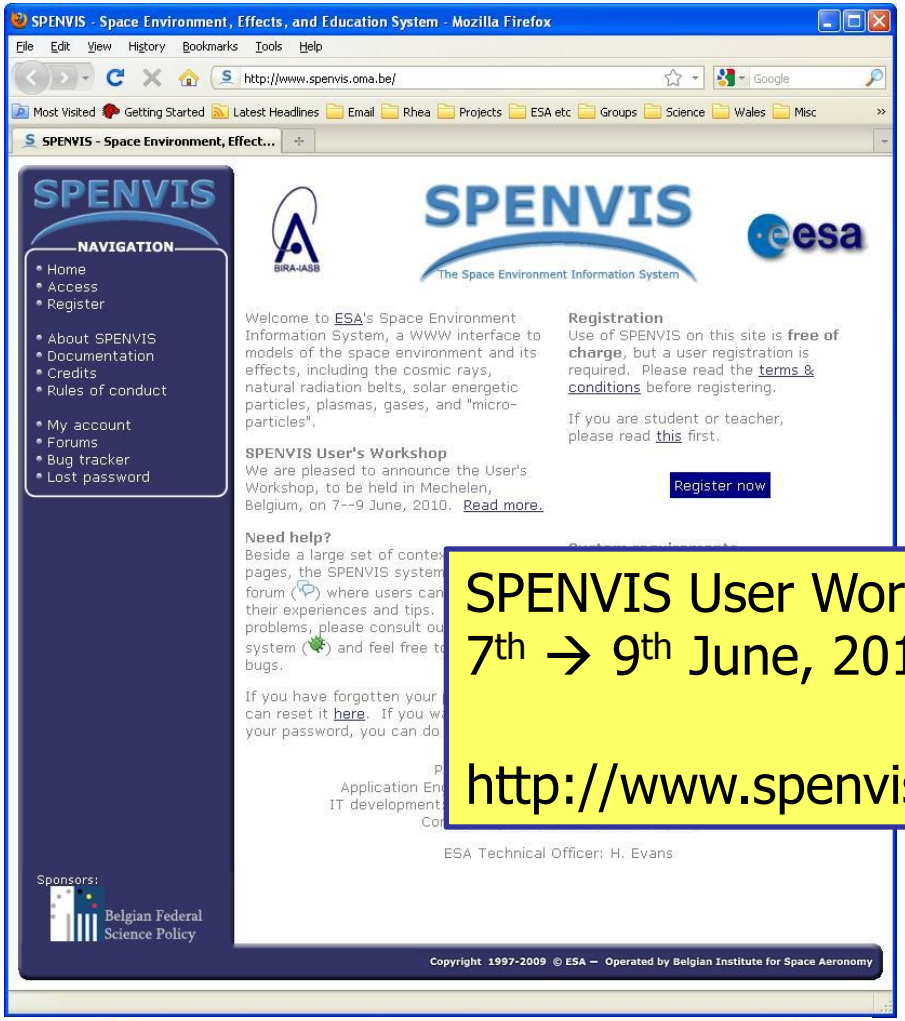
- Study radiation environments and likely effects during mission design
- Analyse long term radiation dose for the final orbit, especially for sensitive components (eg., processors, detectors, solar panels)
- Optimise shielding – materials and quantity – to reduce margins

SPENVIS for S/C Operations

- Core applications are used with other SWE products (eg SWENET, SEISOP …) to routinely describe space environment for a given mission and orbit
- often used alongside in-situ data from INTEGRAL, XMM, PROBA, Giove-A, Giove-B, etc..
- Predict likely impact from anticipated SWE events
- Use pre-launch to define thresholds etc to reduce both failures and safe downtime during routine operations

- Under consideration for redeployment within ESA's SSA framework in 2010

SPENVIS: Further Information



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SPENVIS User Workshop to be held on the 7th → 9th June, 2010 in Mechelen, Belgium.

http://www.spenvis.oma.be/workshop2010.php