cursor Radiation Activities for the ESA Exploration Programme

P. Nieminen

ESA-ESTEC Space Environments and Effects Section

http://www.estec.esa.nl/wmwww/wma/R_and_D/PN-Radiation.html

DESIRE: http://gluon.particle.kth.se/desire/

DESIRE RadVIS:
http://www.external.hrp.no/vr/products/radvis/info/index.html

SOLPENCO: http://www.am.ub.es/~blai/grupospacew_UB.html

MAGNETOCOSMICS:
http://reat.space.qinetiq.com/septimess/magcos/

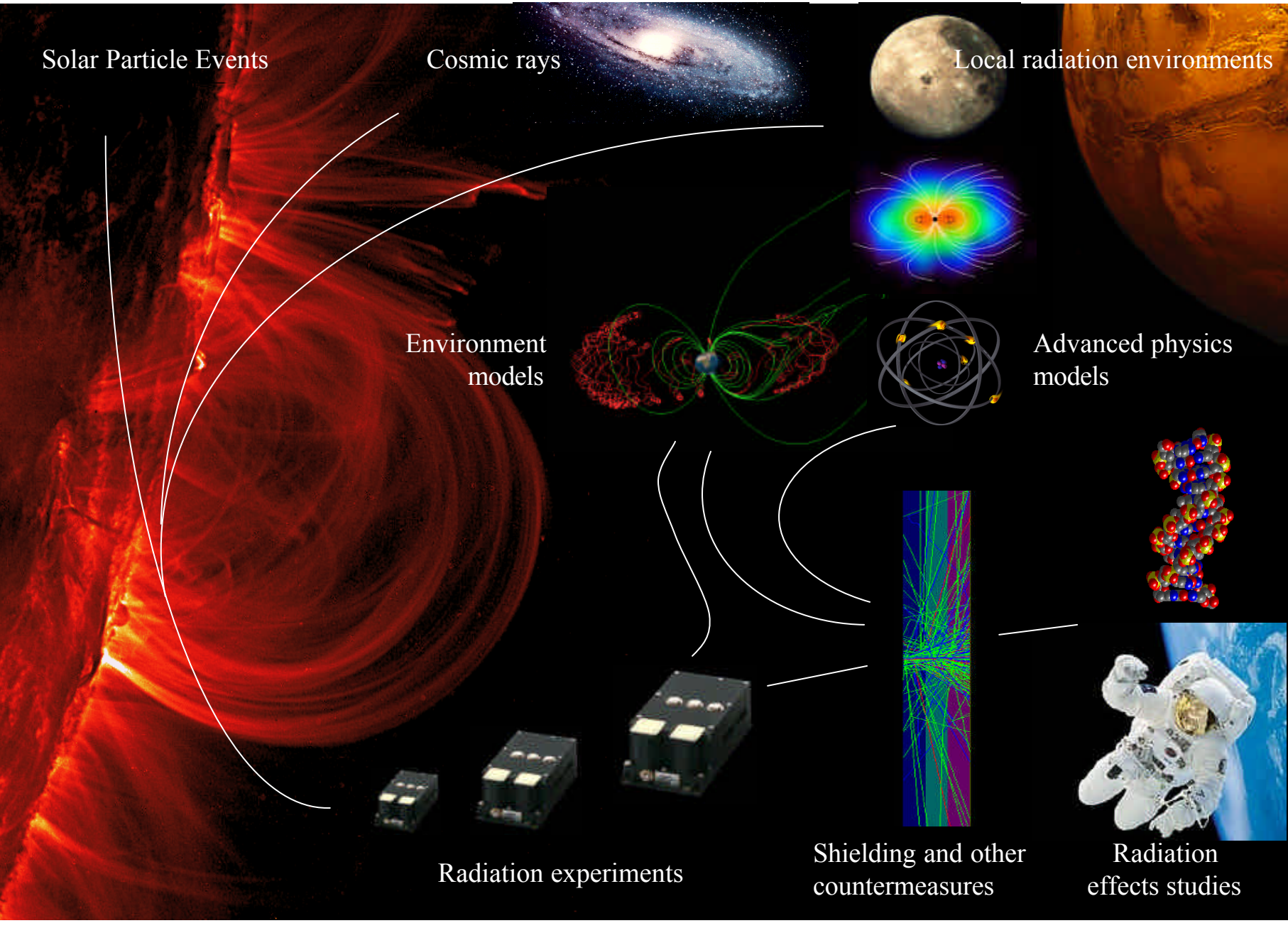
RESTEC: http://www.lip.pt/experiments/esa/

REMSIM:
http://ewand.to.alespazio.it/programs/programs_page.aspx?PID=59

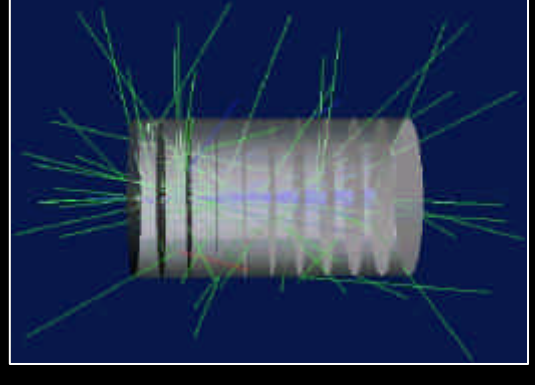
IONMARSE: http://reat.space.qinetiq.com/ionmarse/ionmarse.htm

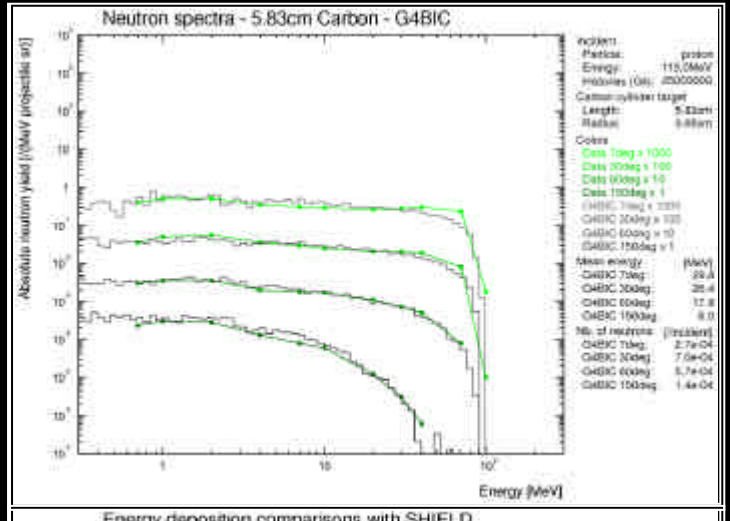
GEANT4-DNA: http://www.ge.infn.it/geant4/dna/index.html

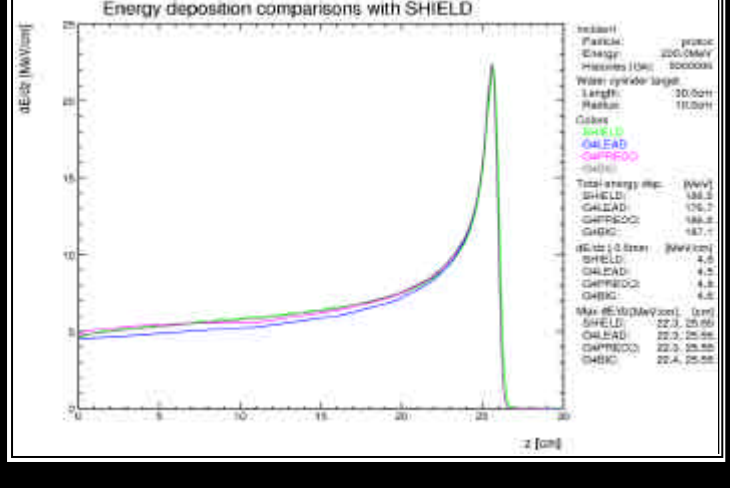
RERMM: http://www.magnet.oma.be/mrm/


Solar Particle Events
Cosmic rays
Local radiation environments
Environment models
Advanced physics models
Radiation experiments
Shielding and other countermeasures
Radiation effects studies

ISS Columbus Radiation Doses (DESIRE project)

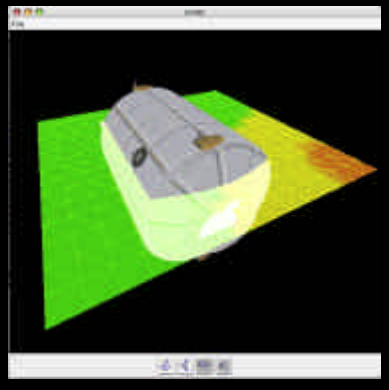


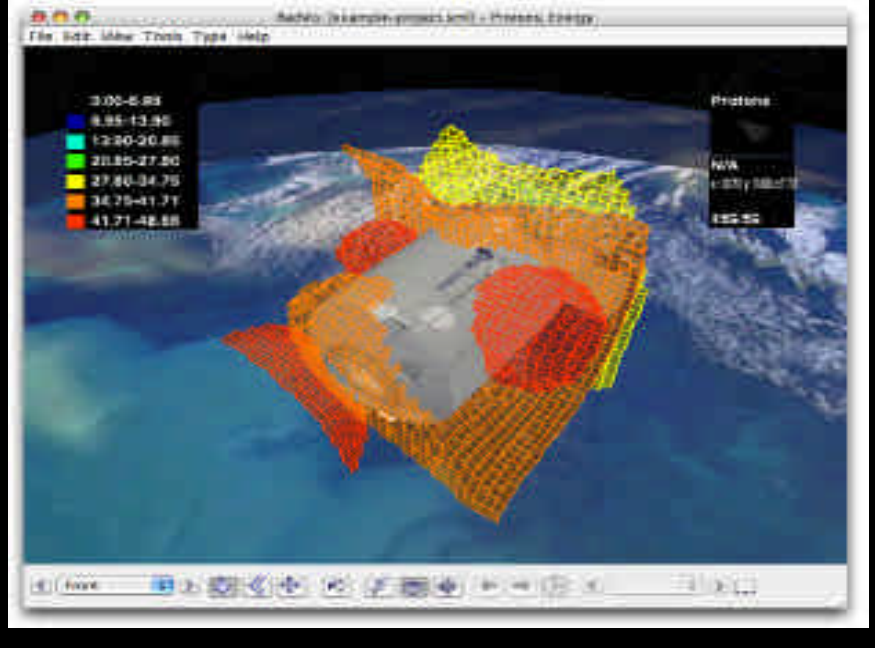


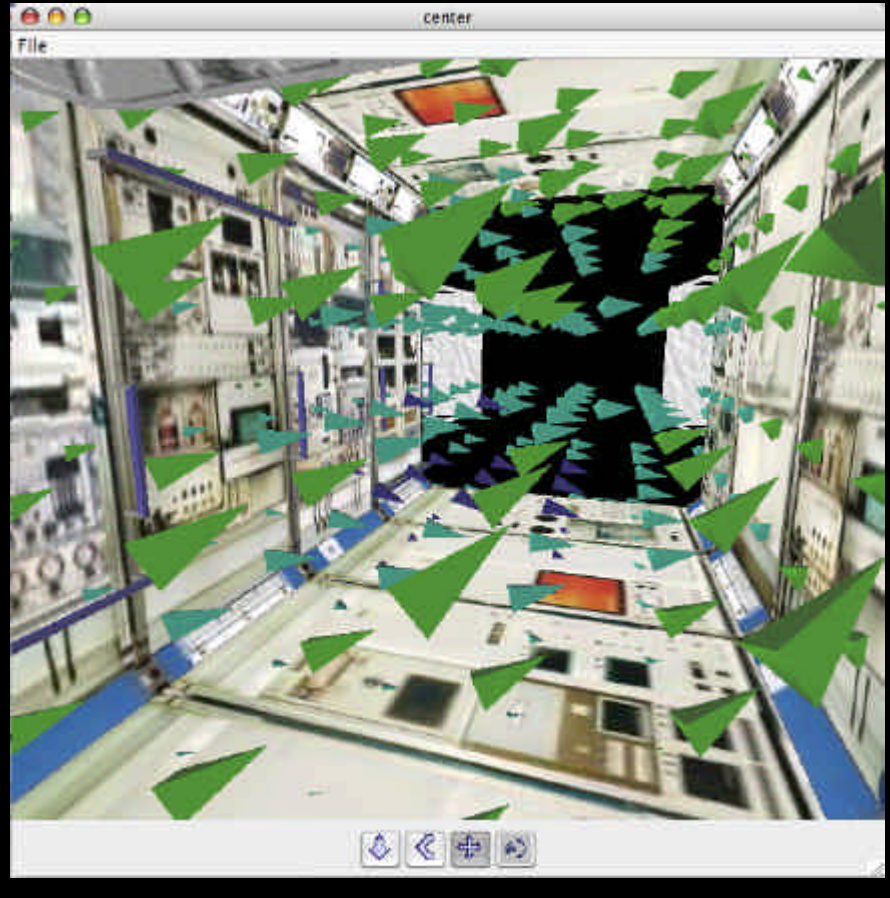


KTH Fysik

DESIRE RadVIS



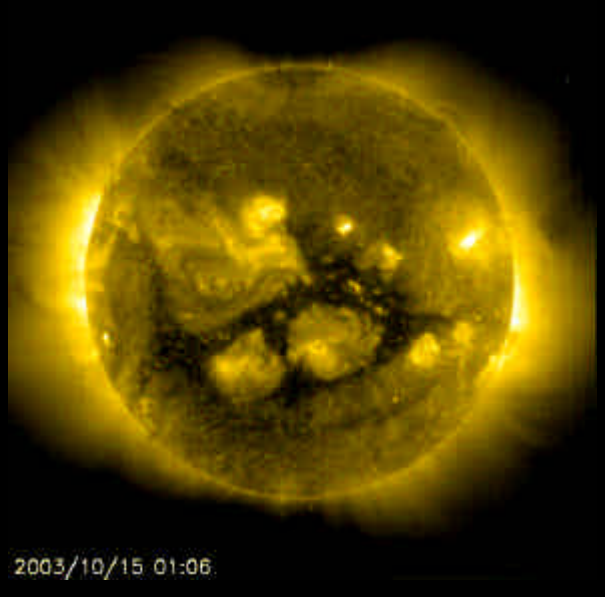


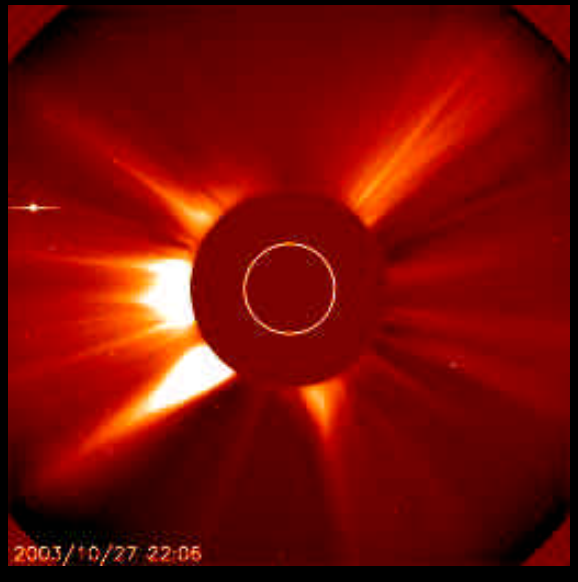


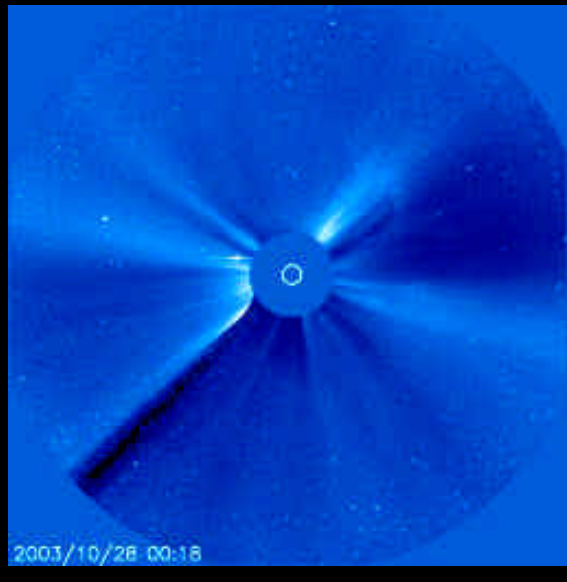
http://www.external.hrp.no/vr/products/radvis/info/index.html

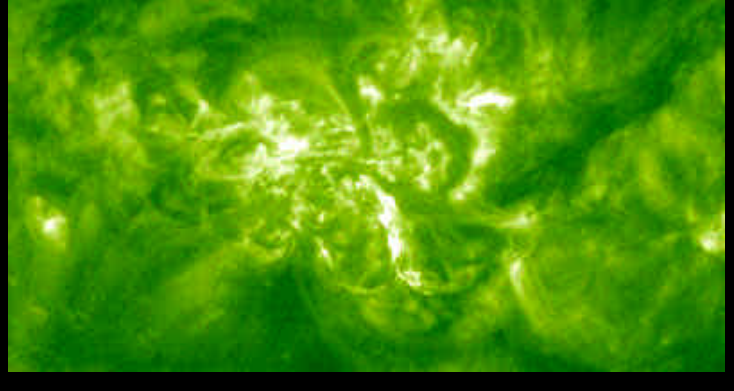
ife Institutt for energiteknikk

Space Radiation: Solar Events of October-November 2003



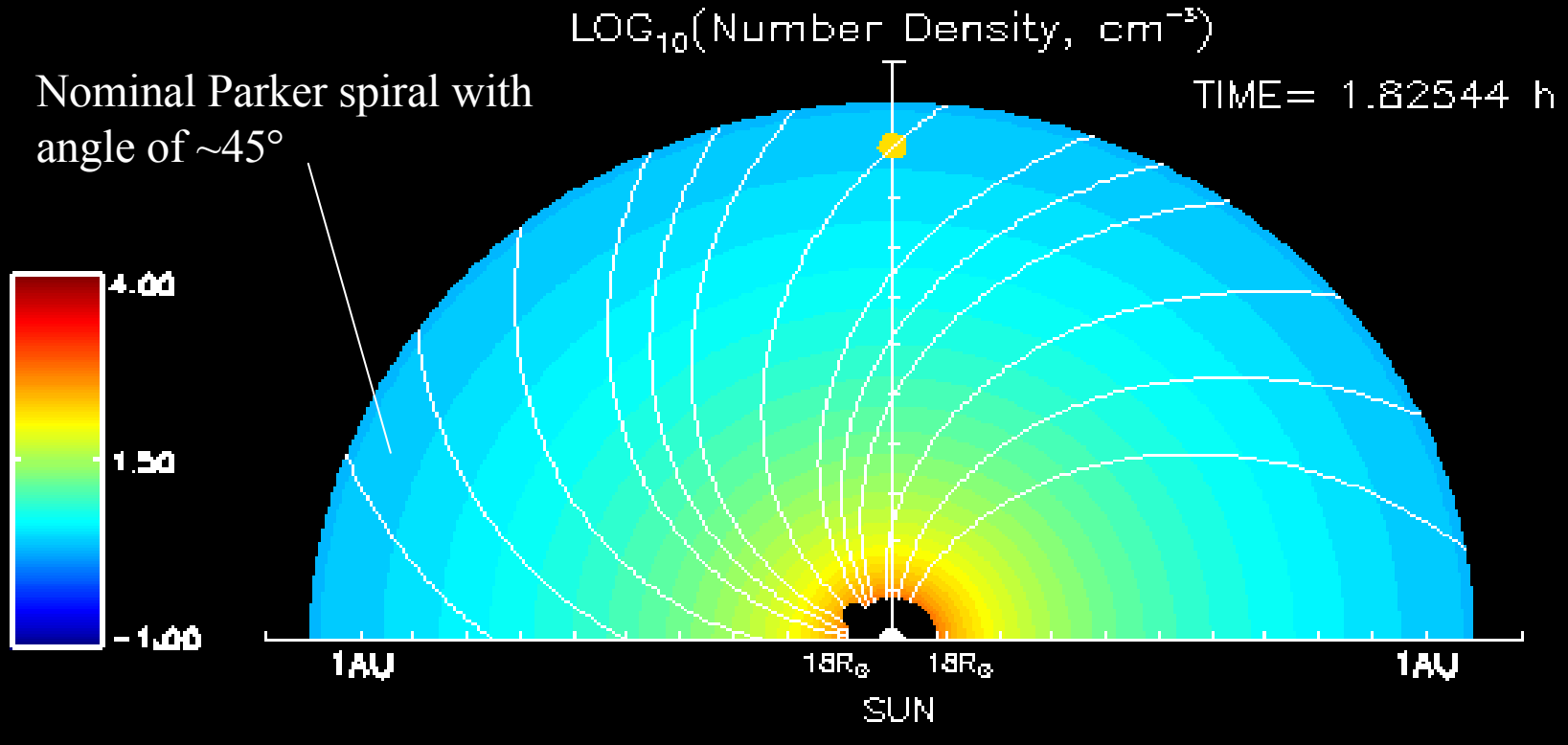






Images by the ESA/NASA SOHO spacecraft

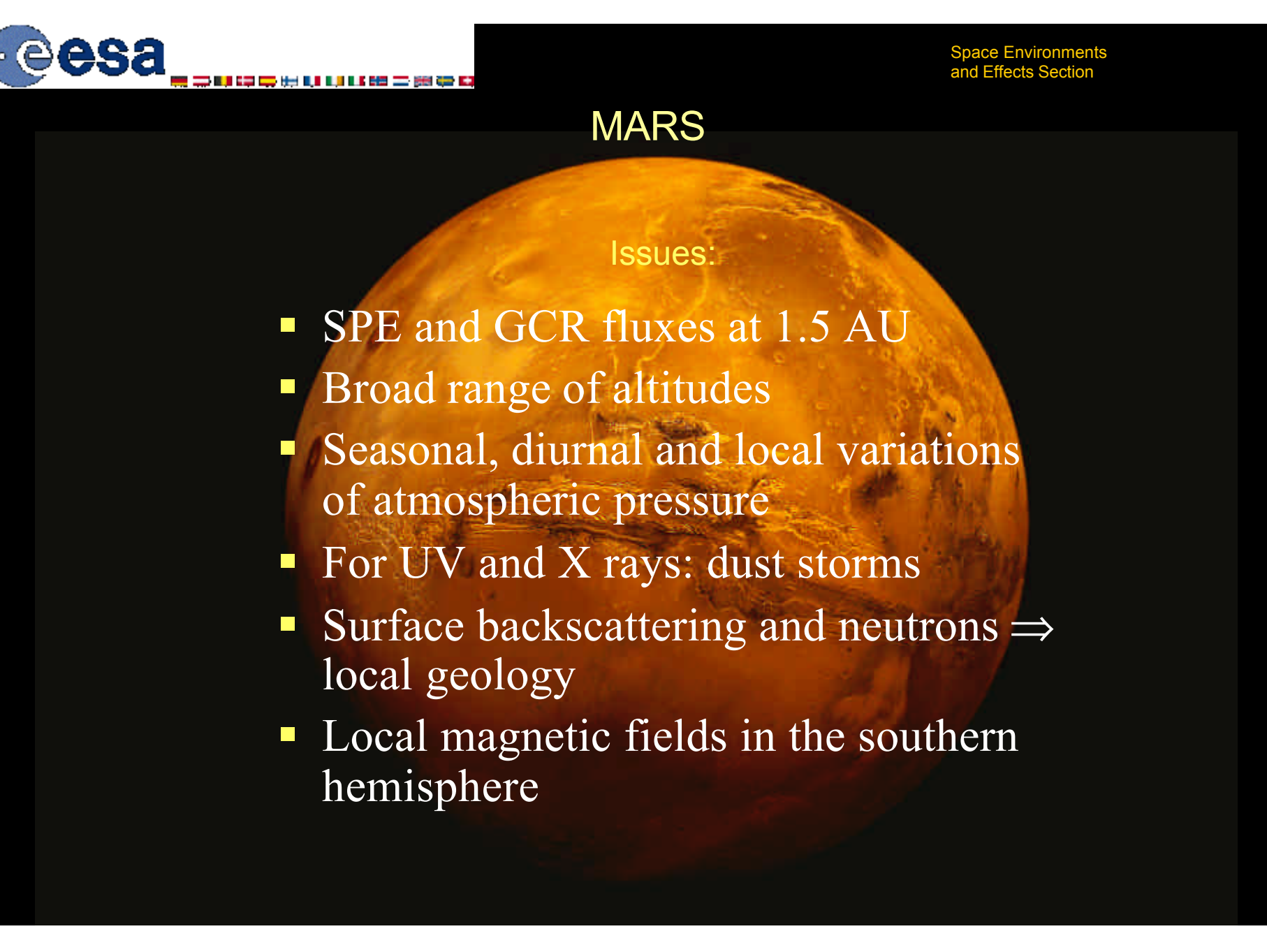
SOLPENCO: Solar Particle Event Propagation



http://www.am.ub.es/~blai/grupospacew_UB.html

UNIVERSITAT DE BARCELONA

MARS

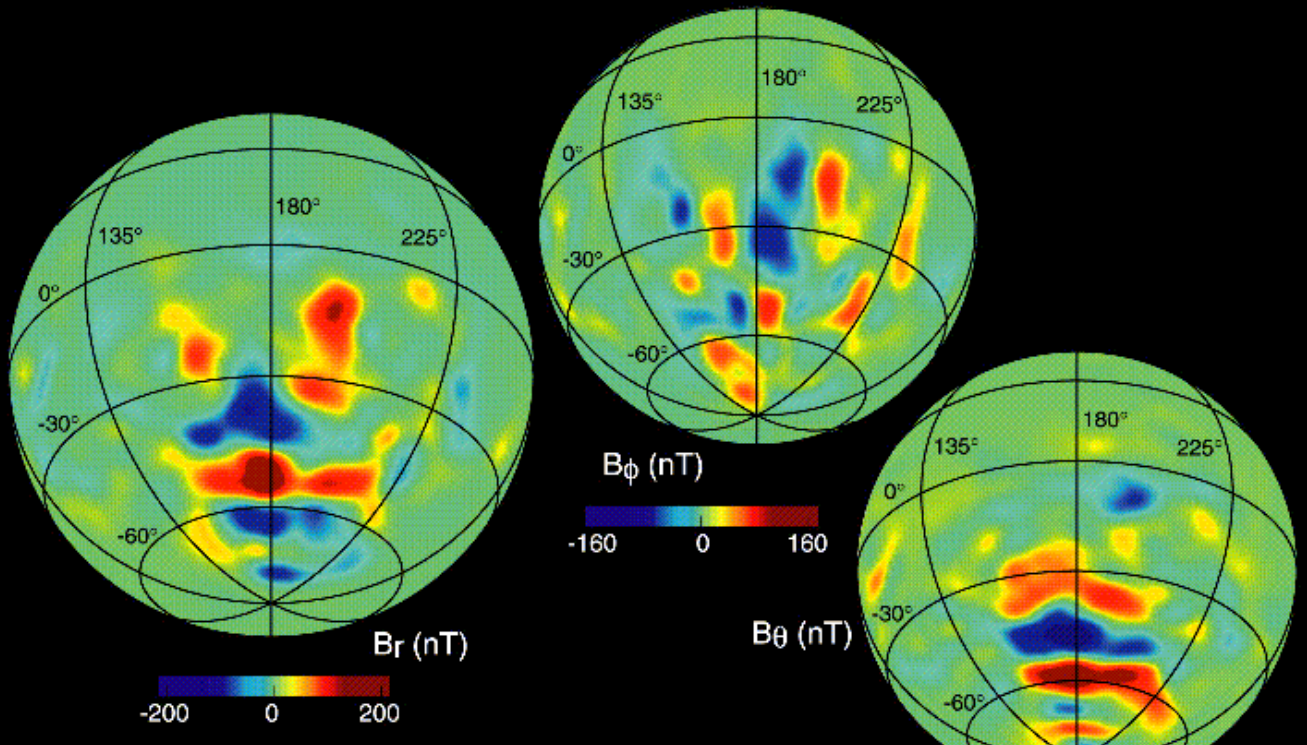


Issues:

- SPE and GCR fluxes at 1.5 AU
- Broad range of altitudes
- Seasonal, diurnal and local variations of atmospheric pressure
- For UV and X rays: dust storms
- Surface backscattering and neutrons ⇒ local geology
- Local magnetic fields in the southern hemisphere

MARS CRUSTAL MAGNETISM

MGS MAG/ER

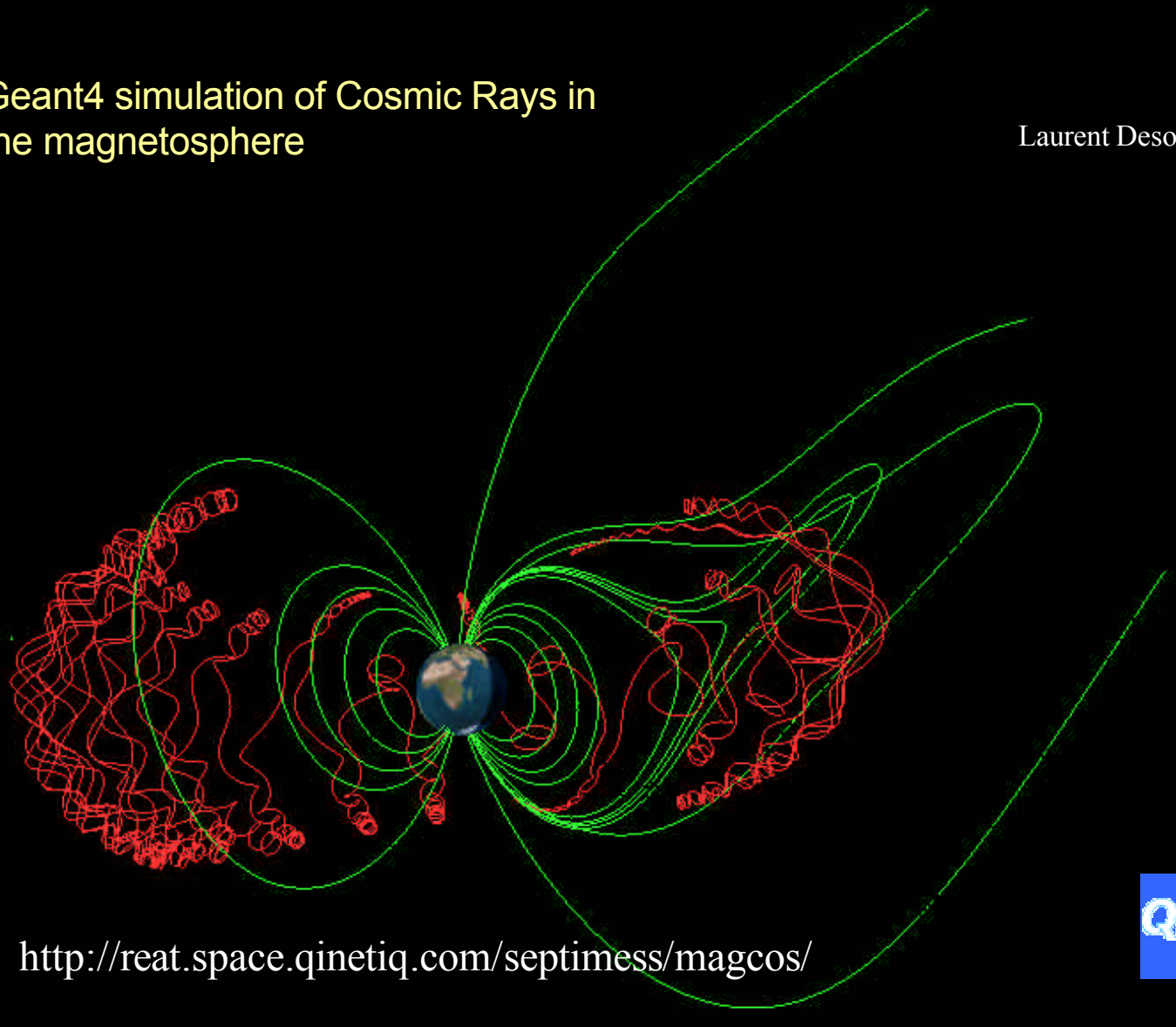


MGS at mapping orbit altitude ~400 km
1° by 1° resolution

Connerney et al., *Geophys.Res. Lett., 28,* 4015-4018, 2001.

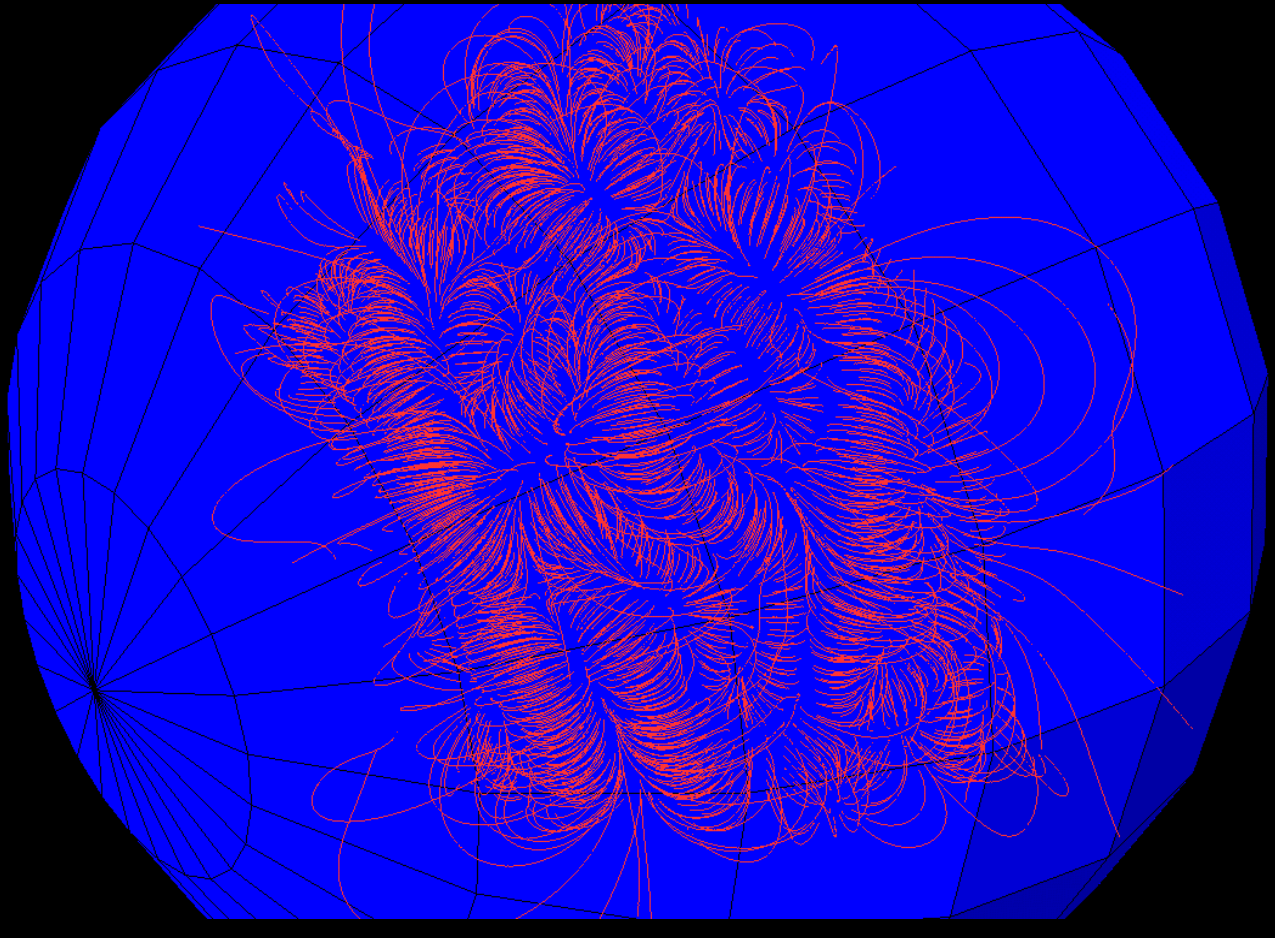
Geant4 simulation of Cosmic Rays in the magnetosphere

Laurent Desorgher, University of Bern



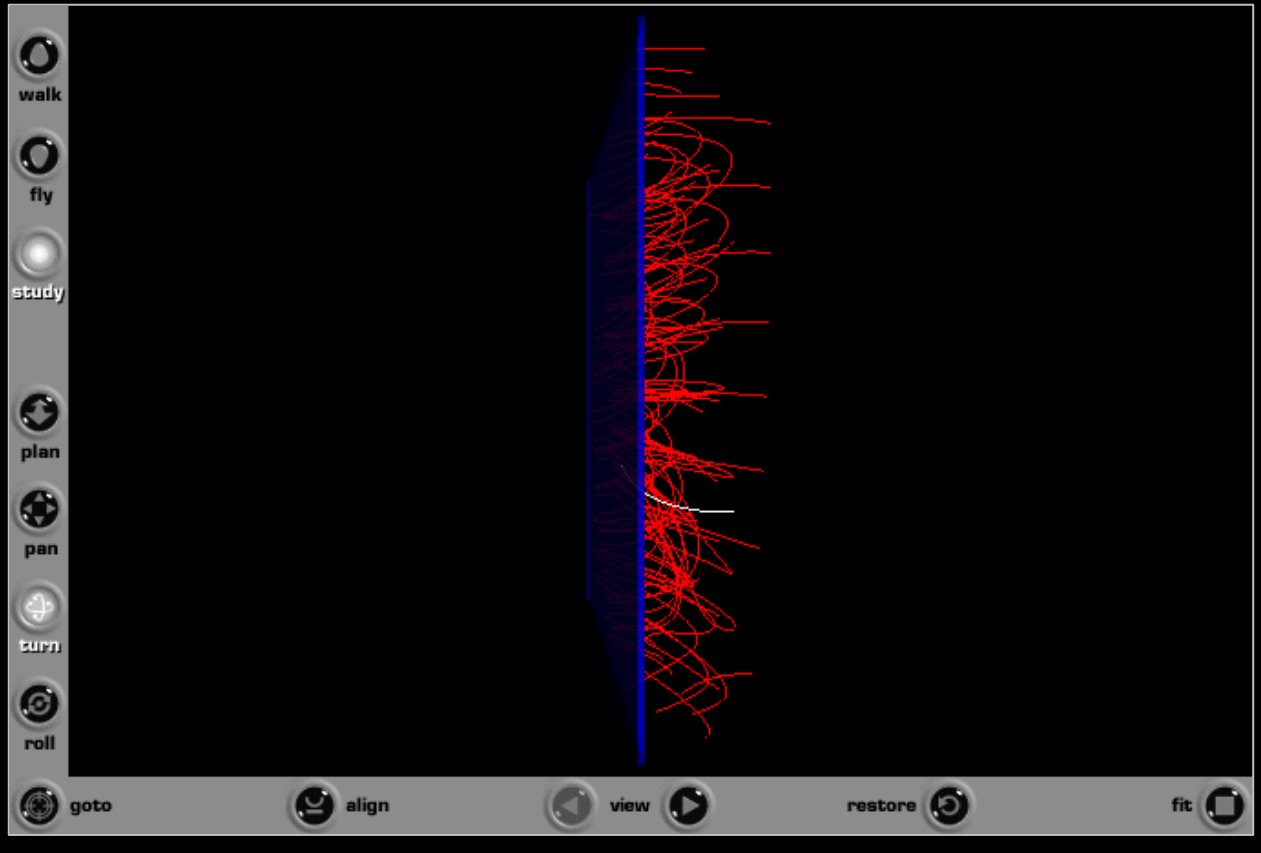
http://reat.space.qinetiq.com/septimess/magcos/

MAGNETOCOSMICS for Mars



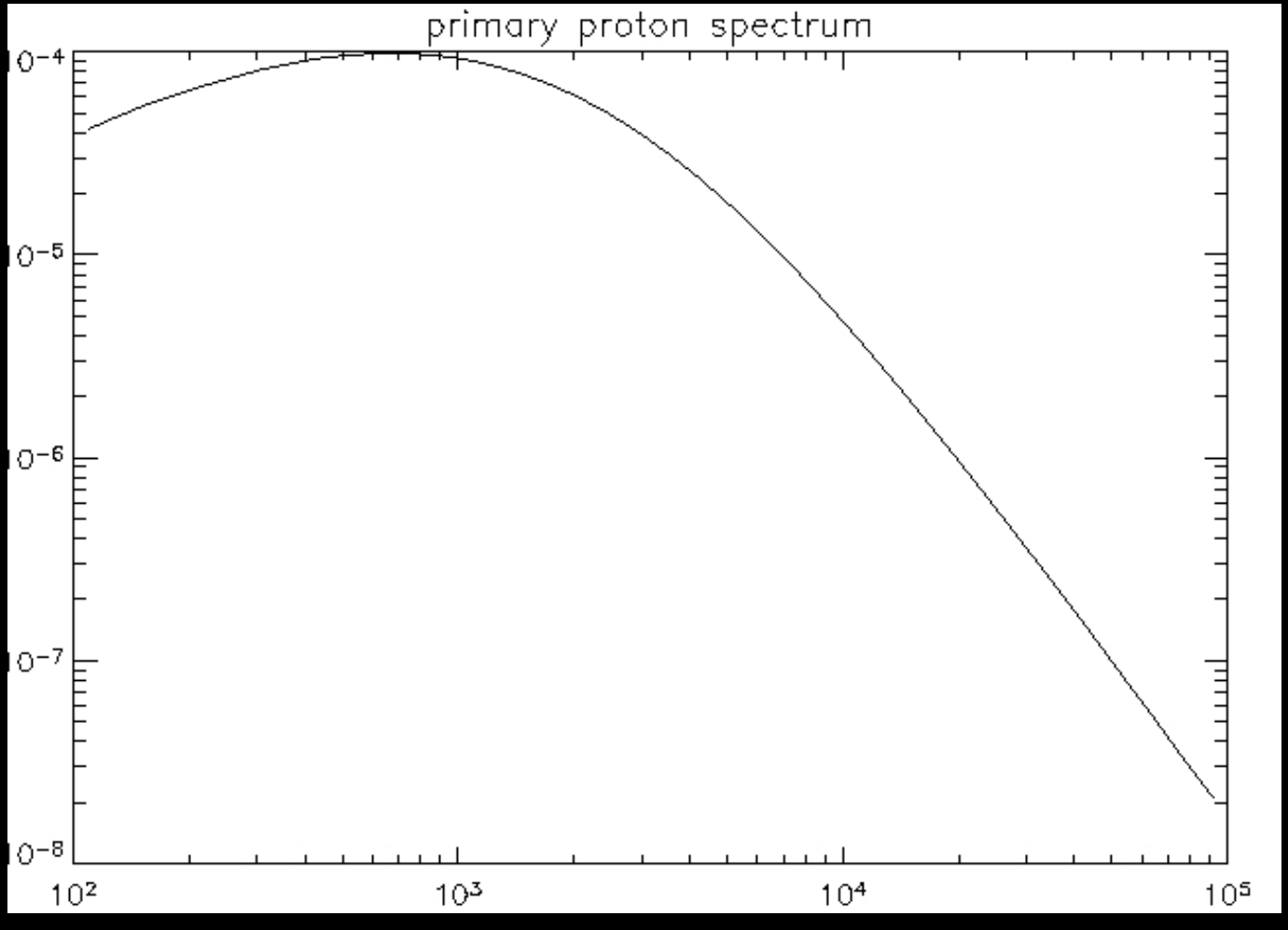
Cain 50-degree spherical harmonic model (2003),
Geant4 implementation courtesy L. Desorgher, University of Bern

MAGNETOCOSMICS for Mars



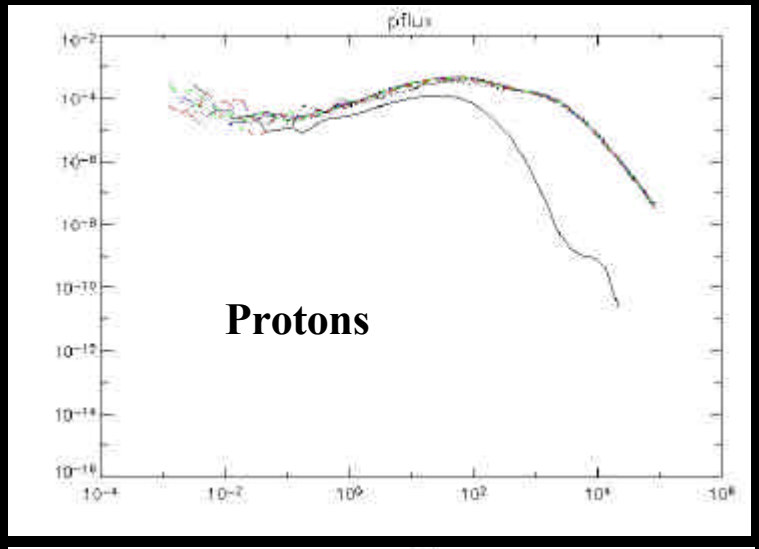
Courtesy L. Desorgher, University of Bern

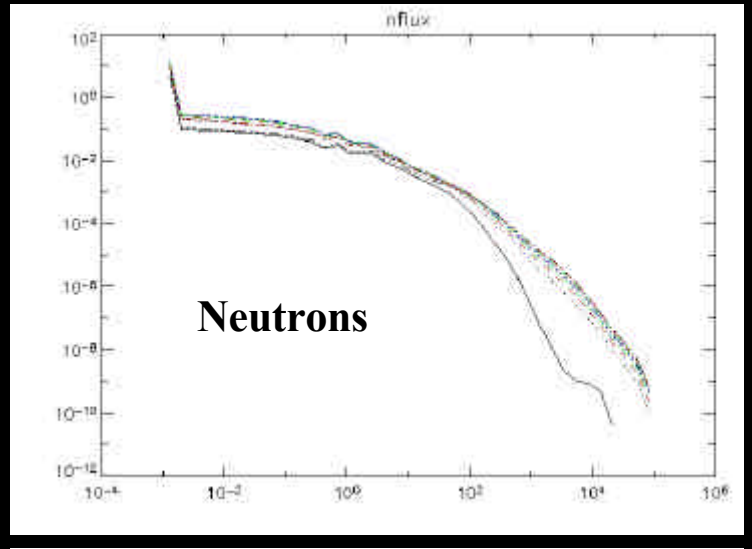
ATMOCOSMICS for Mars



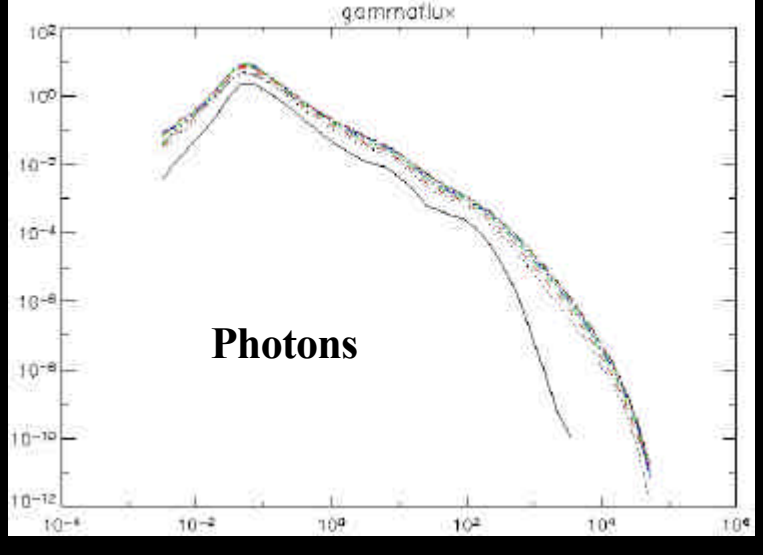
Courtesy L. Desorgher, University of Bern

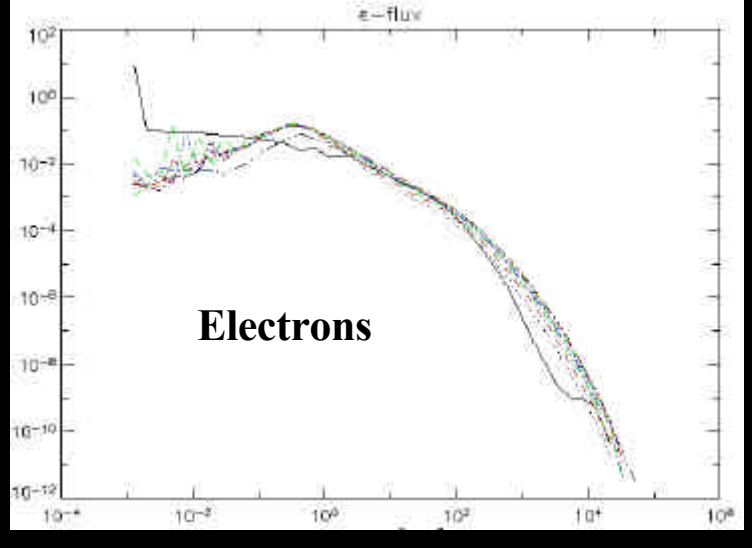
Flux [#/MeV/cm²/s]





Flux [#/MeV/cm²/s]



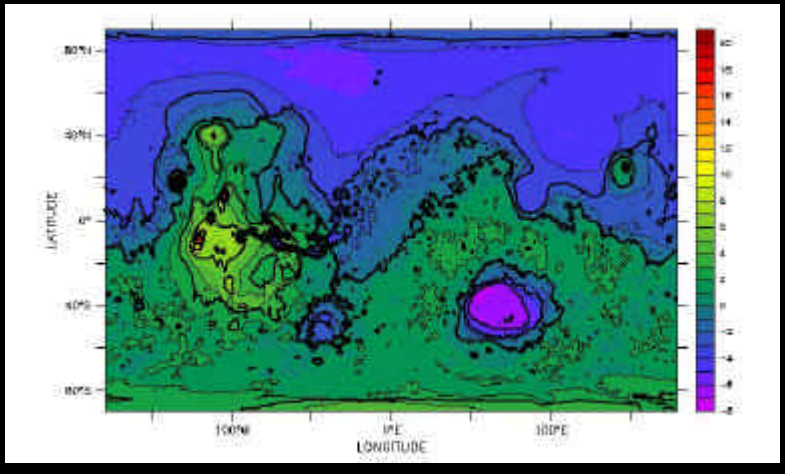


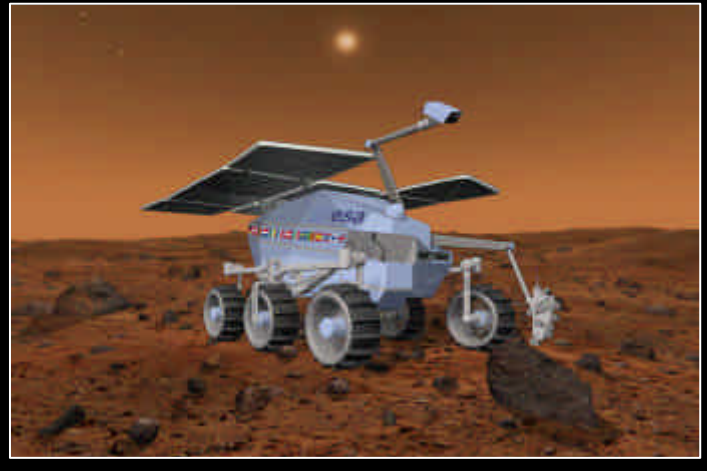
E_{kin} [MeV]

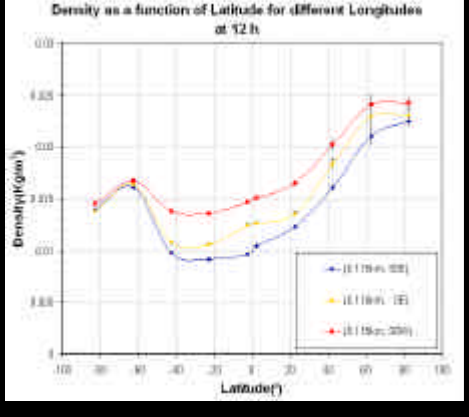
E_{kin} [MeV]

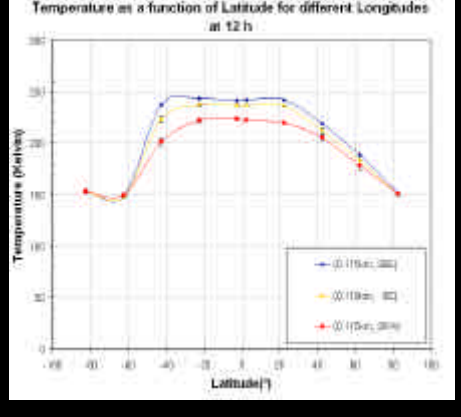
Courtesy L. Desorgher, University of Bern

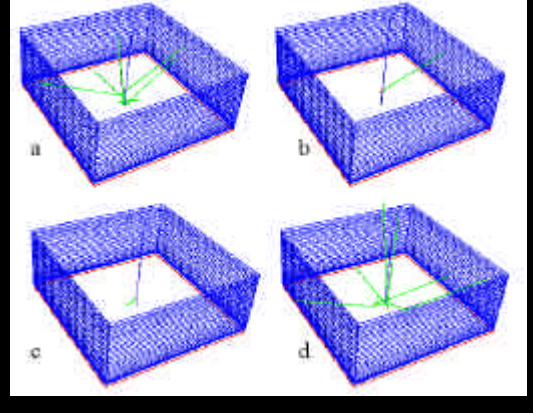
Integrated Radiation Environment, Effects and Component Degradation Tool











http://www.lip.pt/experiments/esa/

REMSIM –

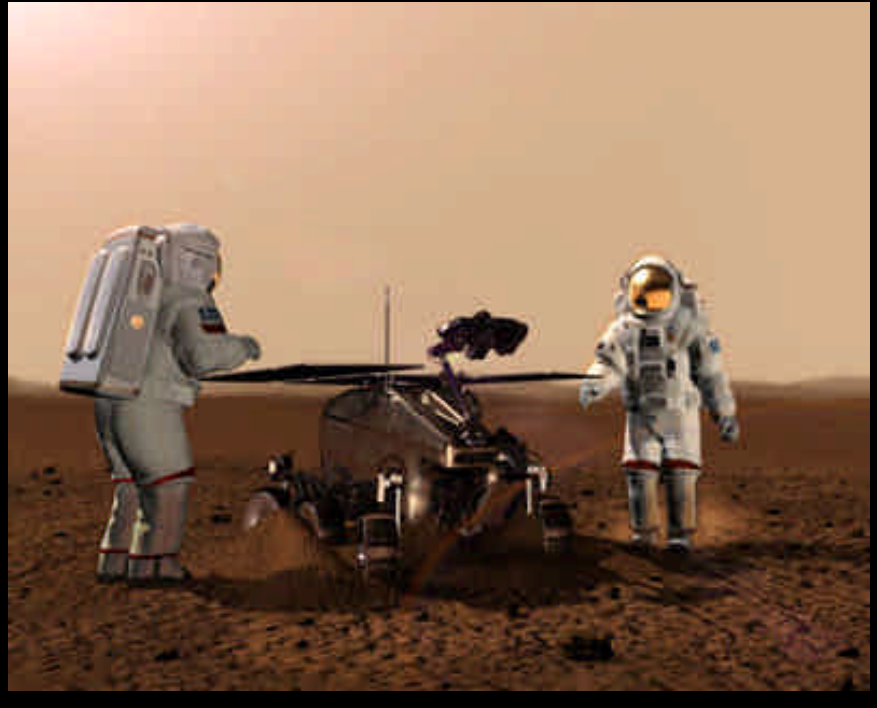
Radiation Exposure and Mission Strategies for Interplanetary Manned Missions

http://ewand.to.alespazio.it/programs/programs_page.aspx?PID=59

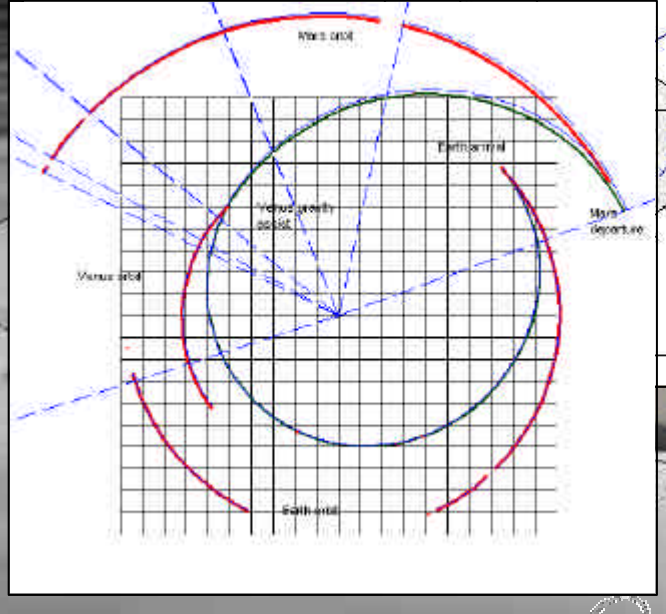
http://www.ge.infn.it/geant4/space/remsim/

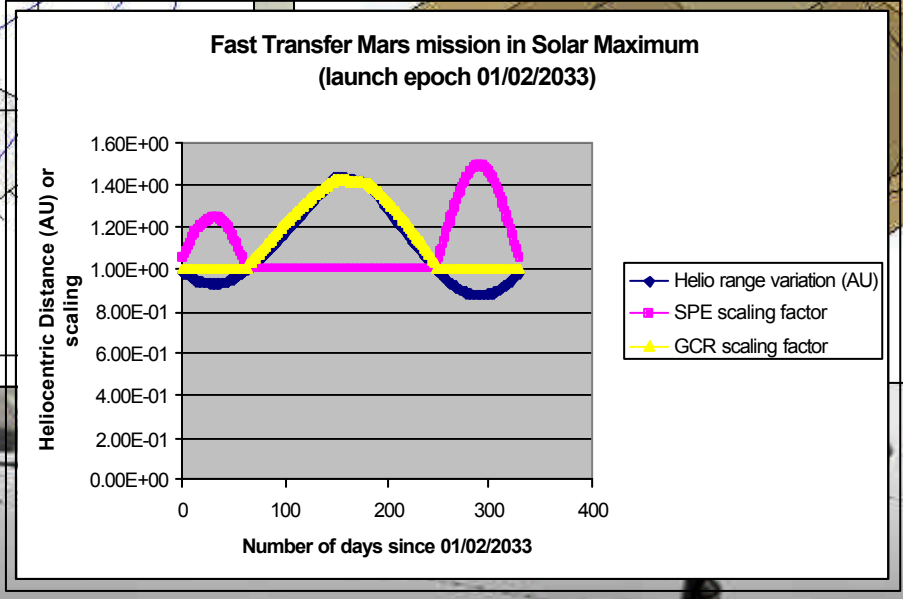
REMSIM

- Review of space radiation hazards
- Review and analysis of transfer trajectories
- Vehicle and habitat concepts and preliminary simulations
- Radiation hazards and warning systems
- FP planned 15-16.11. -04



Data	Long stay Solar max	Long stay Solar min	Fast Transfer Solar max	Fast Transfer Solar min	VGA Solar max	VGA Solar min	Lunar Solar max	Lunar Solar min
Epoch Start	19/04/33	25/03/48	01/02/33	01/01/48	11/04/33	08/02/48	01/09/24	01/09/27
Earth to Mars (or Moon) duration	200	201	150	150	184	172	5	5
Epoch start at Mars (or Moon)	05/11/33	12/10/48	01/07/33	30/05/48	12/10/33	29/07/48	06/09/24	06/09/27
Duration around Mars (or on Moon)	553	539	30	30	35	39	170	170
Epoch Start Mars (or Moon) to Earth	12/05/35	04/04/50	31/07/33	29/06/48	16/11/33	06/09/48	23/02/25	23/02/28
Mars (or Moon) to Earth Duration	198	212	150	150	397	373	5	5
Epoch End	26/11/35	02/11/50	28/12/33	26/11/48	18/12/34	14/09/49	28/02/25	28/02/28
Total Mission Duration (days)	951	952	330	330	616	584	180	180
Total Mission Duration (years)	2.604	2.606	0.903	0.903	1.687	1.599	0.493	0.493





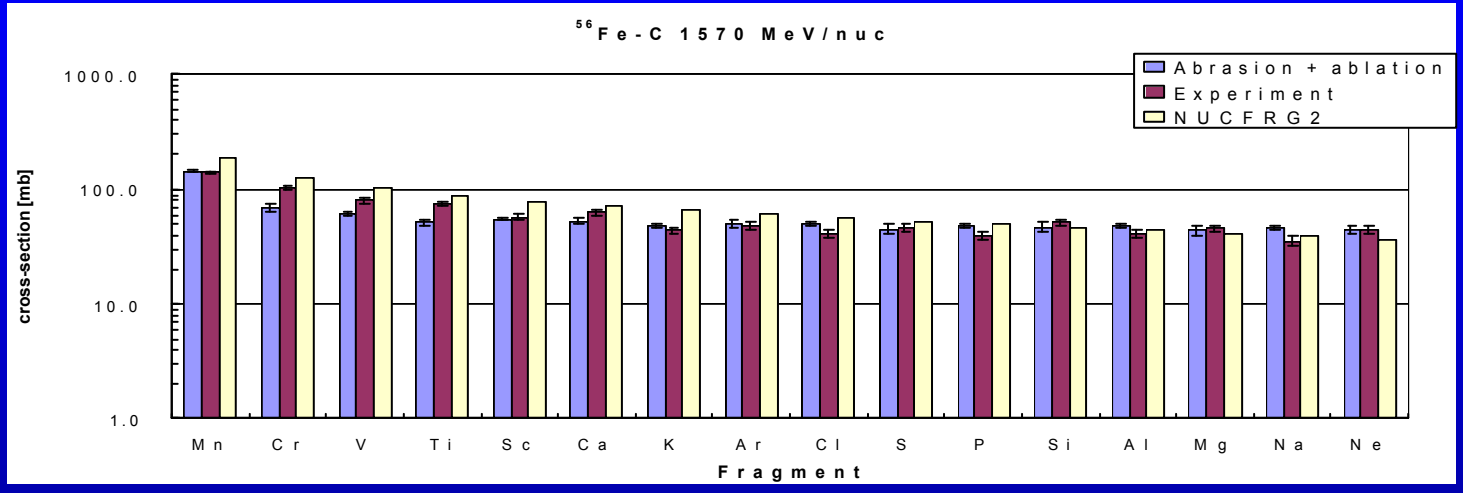
Alenia SPAZIO

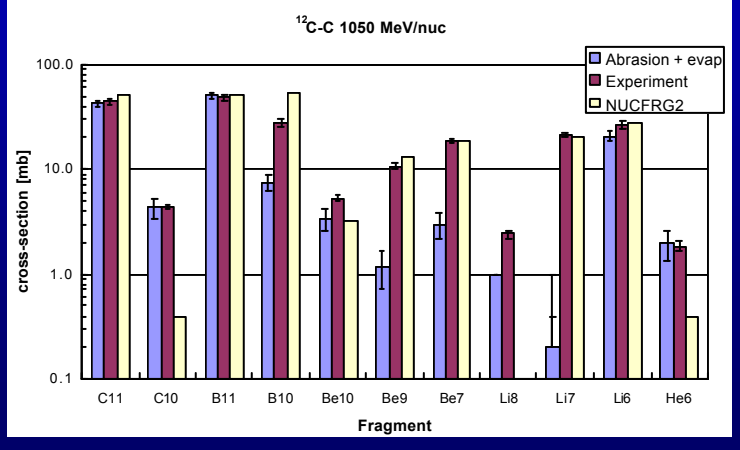
INFN ISTITUTO NAZIONALE DI FISICA NUCLEARE

EADS ASTRIUM

RxTec

IONMARSE – Heavy ion hadronic physics in GEANT4



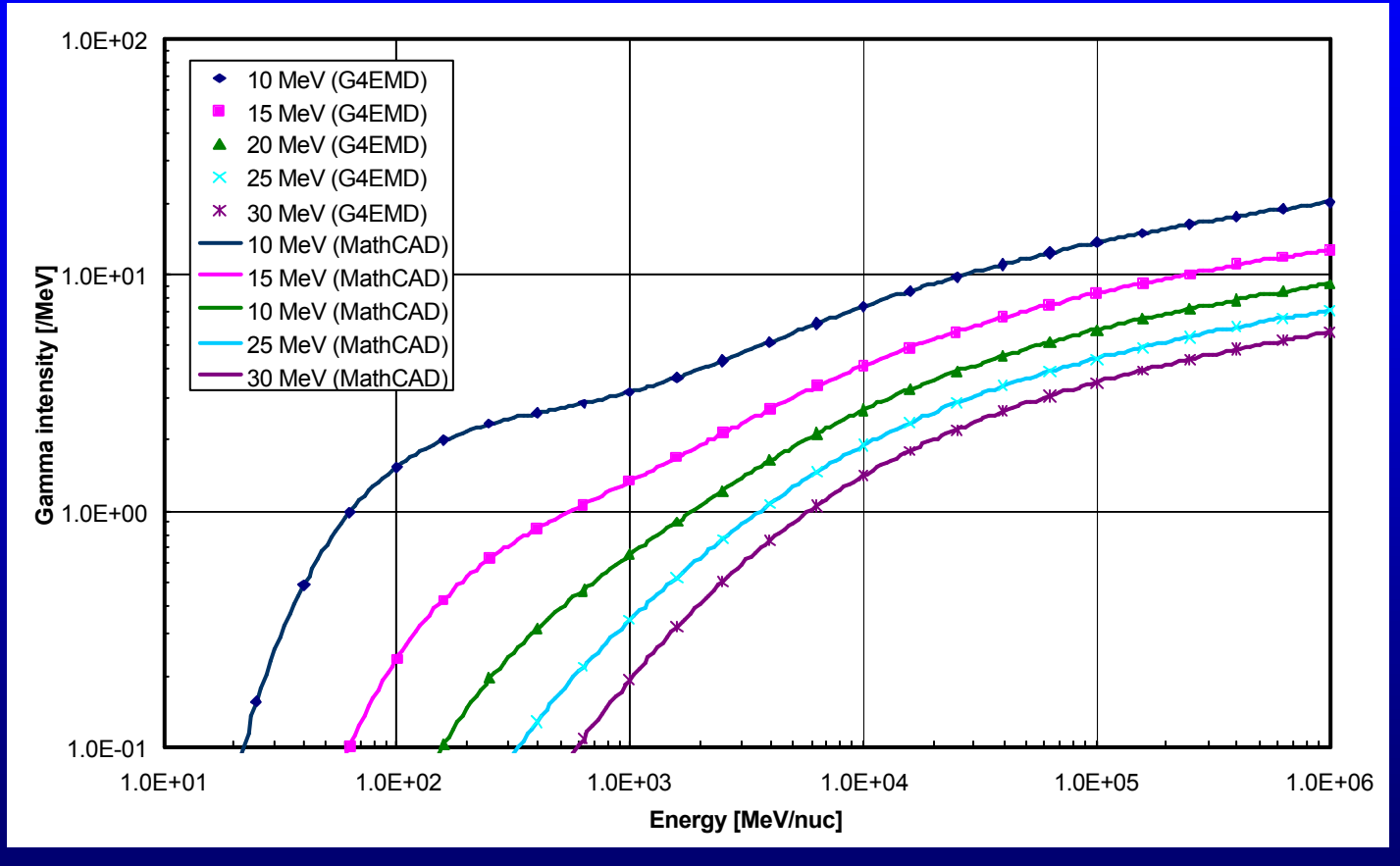


Truscott, P., "*Ion-Nuclear Models for the Analysis of Radiation Shielding and Effects (IONMARSE)*", ESA Contract 17191/03/NL/LvH Final Report, June 3, 2004]

http://reat.space.qinetiq.com/ionmarse/ionmarse.htm

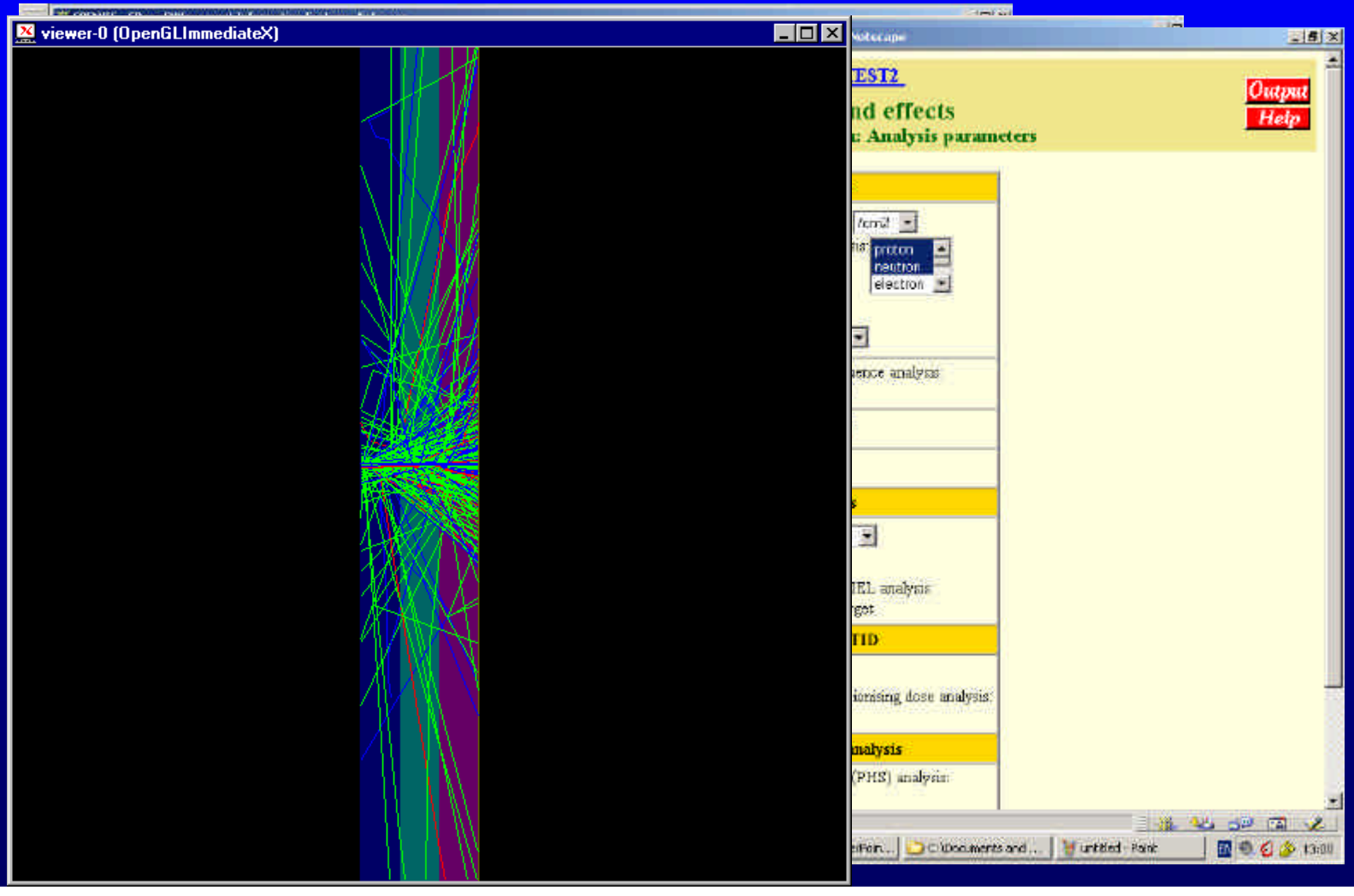
Independent developments also by SLAC/KEK

IONMARSE

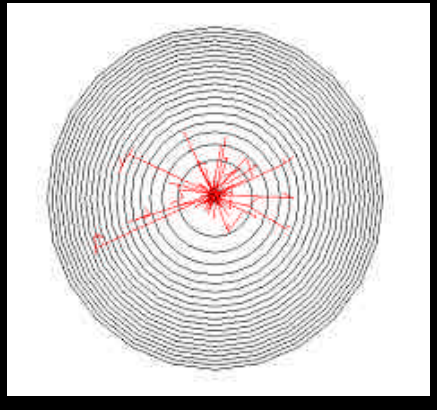


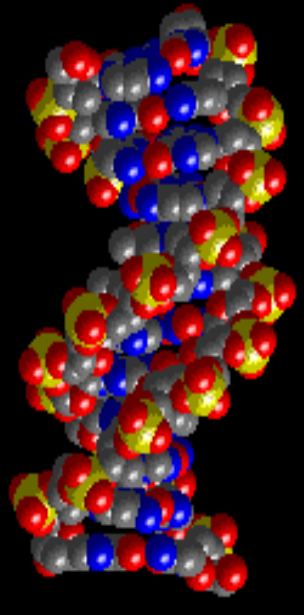
http://reat.space.qinetiq.com/ionmarse/ionmarse.htm

MULASSIS in SPENVIS
(www.spenvis.oma.be/spenvis/



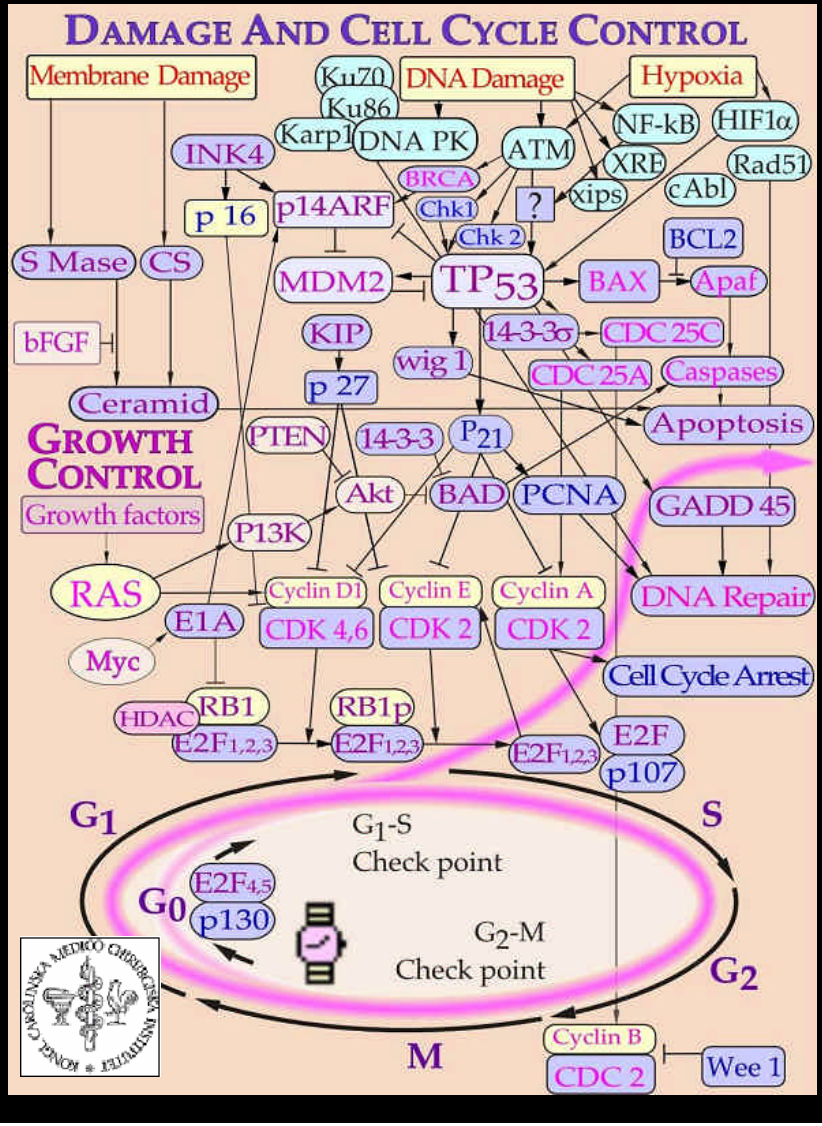
GEANT4-DNA Project





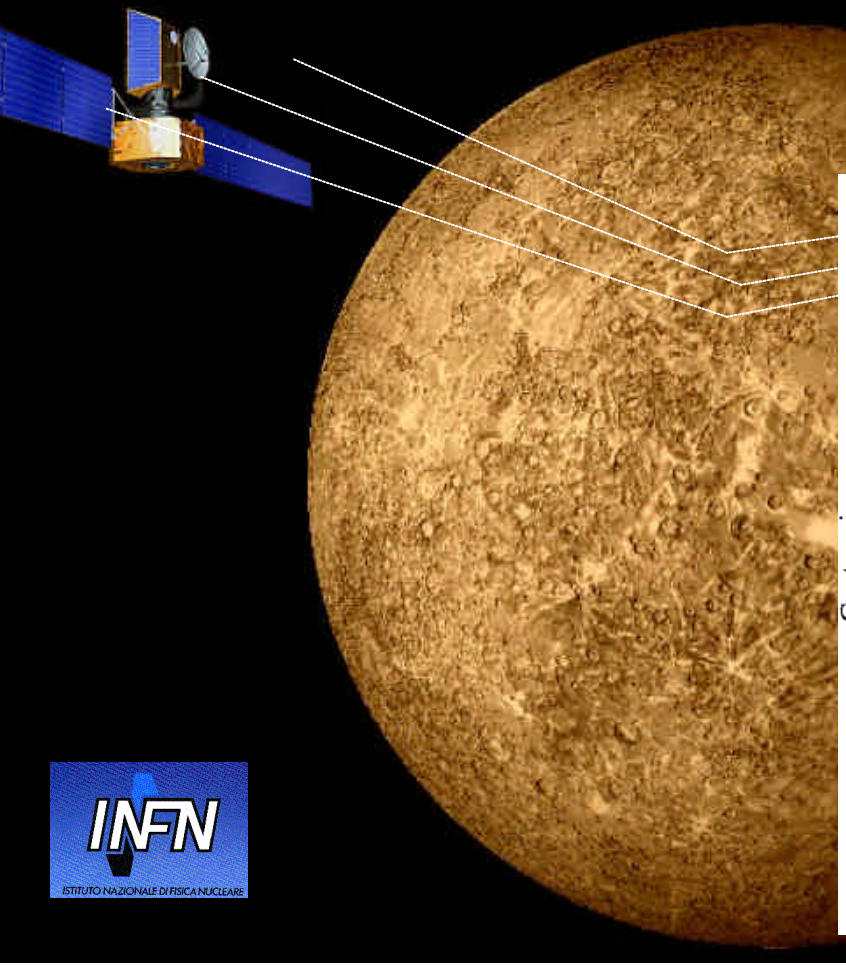
Prototyping: 5.3 MeV alpha particle in a cylindrical volume inside cell nucleus. The inner cylinder has a radius of 50 nm.

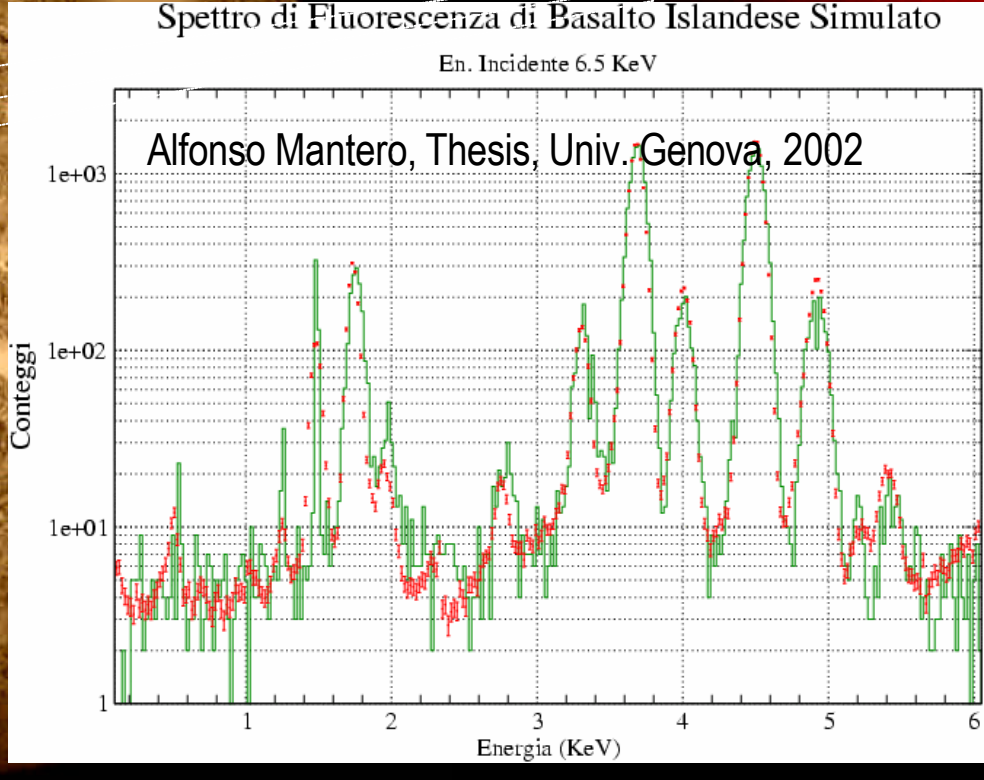
http://www.ge.infn.it/
geant4/dna/index.html



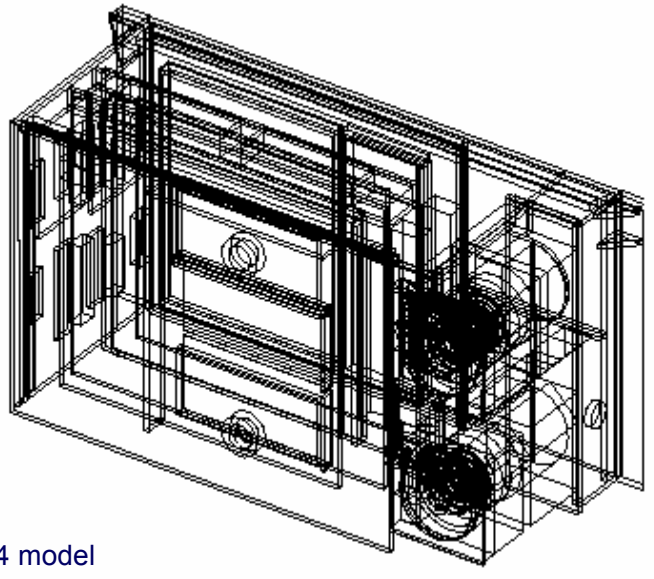
Space Environments
and Effects Section

Bepi Colombo: X-Ray Mineralogical Survey of Mercury





ESA Standard Radiation Environment Monitor (SREM)



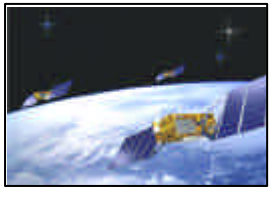
SREM
Geant4 model

INTEGRAL

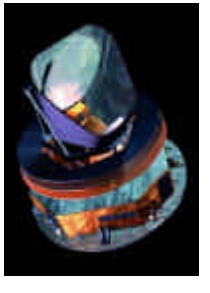
ROSETTA

PROBA-1

HERSCHEL



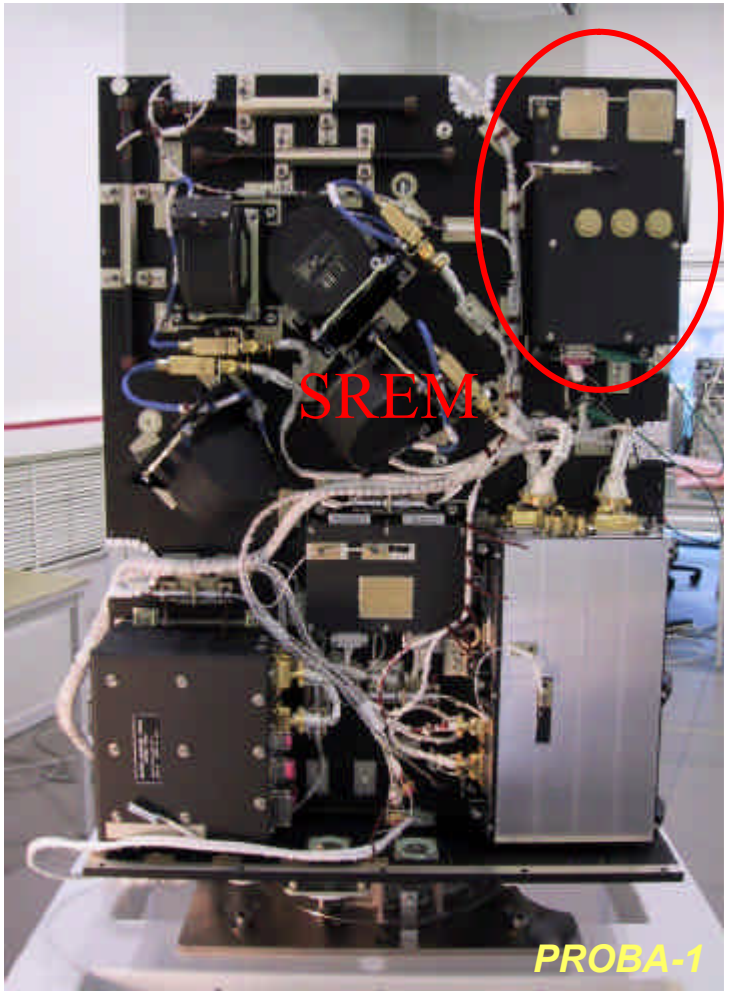
GSTB V2

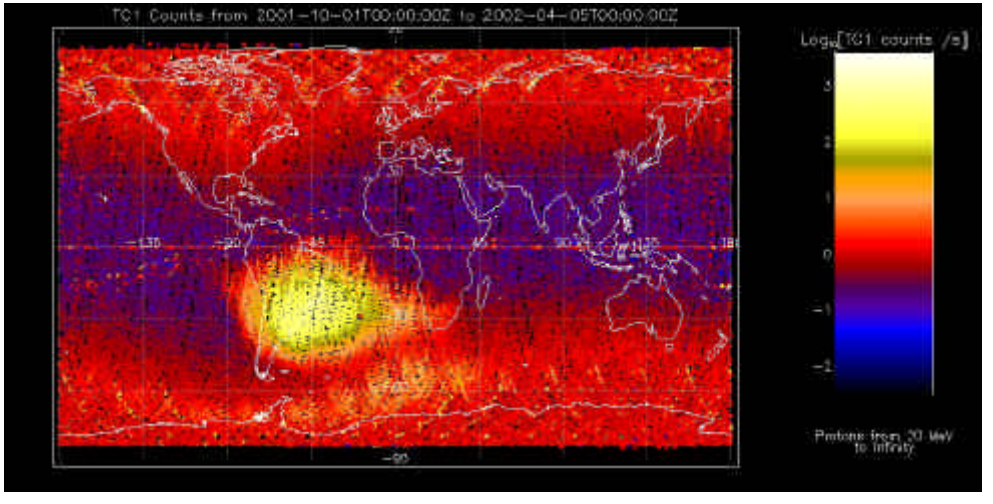


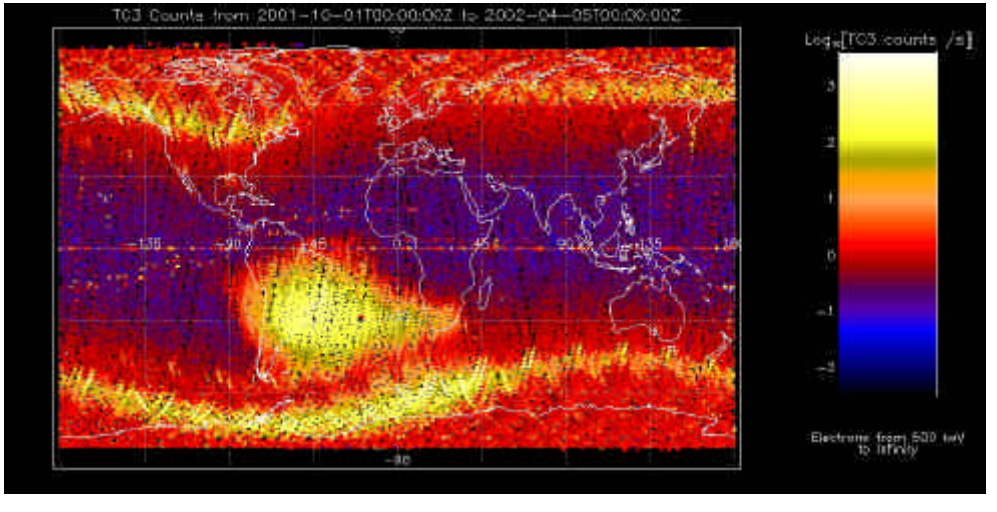
PLANCK

GAIA

ESA Standard Radiation Environment Monitor (SREM)

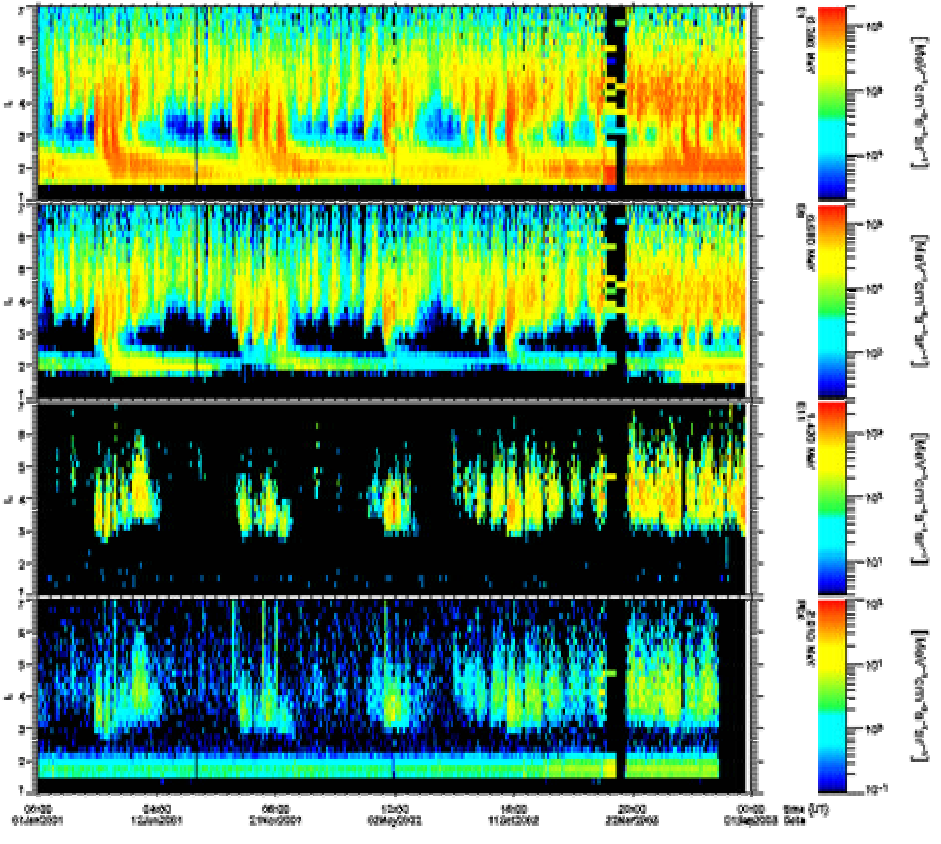




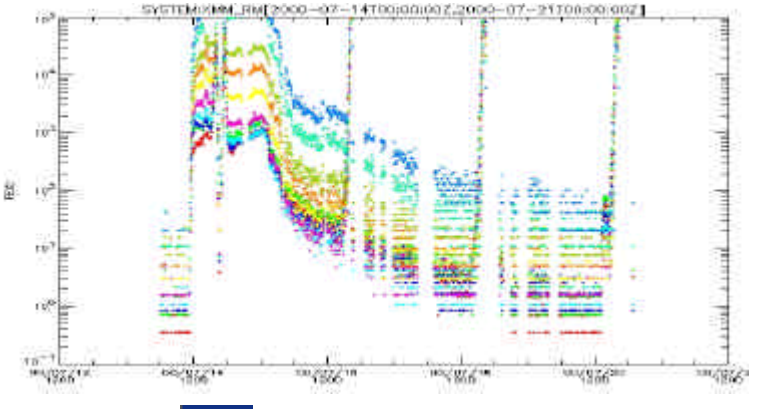


SREM on Rosetta

Radiation Environment Research from Multiple Monitors (RERMM)



- Data analysis from PROBA, XMM-Newton, SAC-C, Oersted, INTEGRAL, MPTB, LANL radiation monitors
- Interpolation of heterogeneous measurements of ionising particles
- Development of new, public domain community tools and models for near-Earth radiation environment



Paul Buehler

GEANT4

- Open-source and free
- Available for community development and model inclusion
- Web documentation & HyperNews help system
- Supported by a World-Wide Collaboration (CERN, ESA, SLAC, INFN, IN2P3, KEK, HIP, …)
- Heavy ion hadronic physics developed and available

Others:

- Cosmic Ray Shielding Topical Team report finalised
- Further Exploration-related radiation environments and effects activities planned in ESA Aurora and TRP programmes for 2004-05 (Mars radiation models, SPE modelling, radiation transport and effects treatment, radiobiology/accelerator experiment preparation)
- European Radiobiology and Accelerator Utilisation Workshop planned for 2nd half of 2005 (ESOC/GSI)
- Flight of *radiation monitors* strongly recommended whenever possible, for ISS, Mars missions and other interplanetary spacecraft