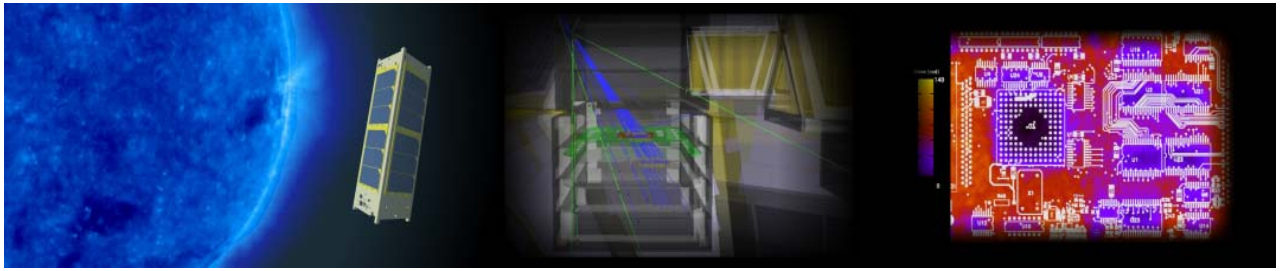
7th Geant4 Space User's Workshop

Seattle, 18-20 Aug 2010



G4MRES

A Geant4-based operational tool to evaluate space weather effects on satellites

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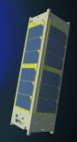
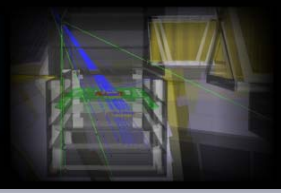
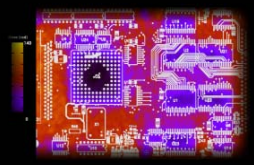
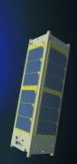
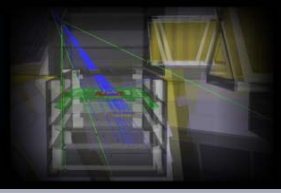
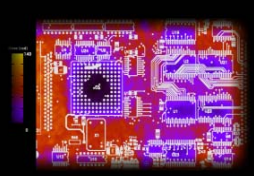




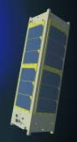
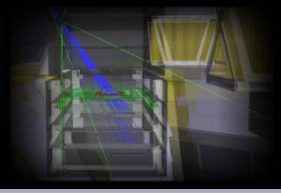
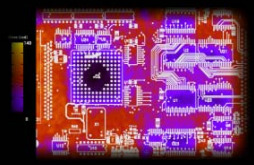
OUTLINE

- MOTIVATION
- SEISOP: An operational SW information system
  - OVERVIEW
  - PLUGIN Capability
- G4MRES
  - CONCEPT
  - ARQUITECTURE
  - FUNCTIONALITY / MODULES
  - DEMO
- SUMMARY, STATUS & FUTURE

MOTIVATION

- Lack of available tools linking SW real-time conditions and direct effects on S/C
  - Lot of SW data providers (NOAA/SWPC, SWENET, On-board monitors)
  - No useful information for operators (TID,etc)
  - No real-time correlation with S/C anomalies
- S/C geometry and materials properties are not enough reflected in existing tools
  - Only very simple geometry cases are available to satellite operators
- Several radiation transport codes (MCNPX, Geant4, FLUKA, etc) can provide very precise results
  - they are not adapted to fulfil operation reqs
  - they are not operations-oriented
- In case of an Event ¿can we quantify its effects? ¿TID rate? ¿Power drop? Etc,…

MOTIVATION

PROPOSED SOLUTION:

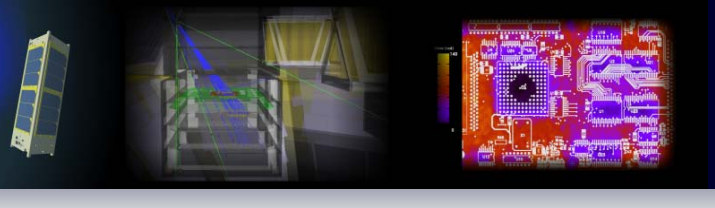
Use SW real-time data and Monte-Carlo capabilities

Precursors: SESS & G4SESS

G4MRES

Geant4 for Mission Radiation Effects Simulation

- Mission: It is oriented to support mission operations…
- Radiation: … propagates real-time radiation conditions …
- Effects: … and calculates radiation damages on S/C parts …
- Simulation: … by means of Geant4 simulation adn SW analysis

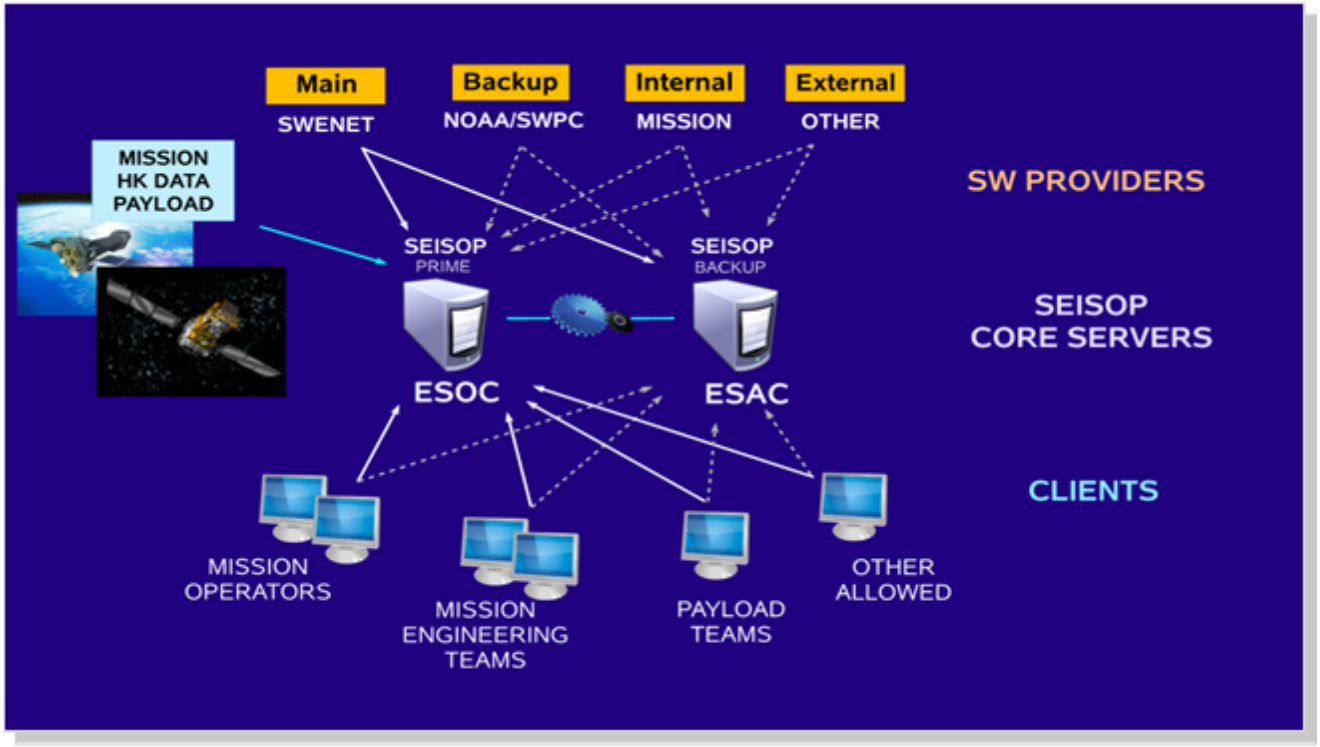


SEISOP

Space Environment Information System for Operations

"provides satellite operators, mission teams and scientists with a multi-mission environment, modular and expandable, capable to supply, in a structured manner, information and extracted knowledge related to the space environment and its effects on the monitored spacecraft"

SEISOP: An operational SW system



Heritage

- **SEIS** (Space Environment Information System) In operation at ESOC for INTEGRAL
- **SESS** (Space Environment Support System) Precursor of SEISOP

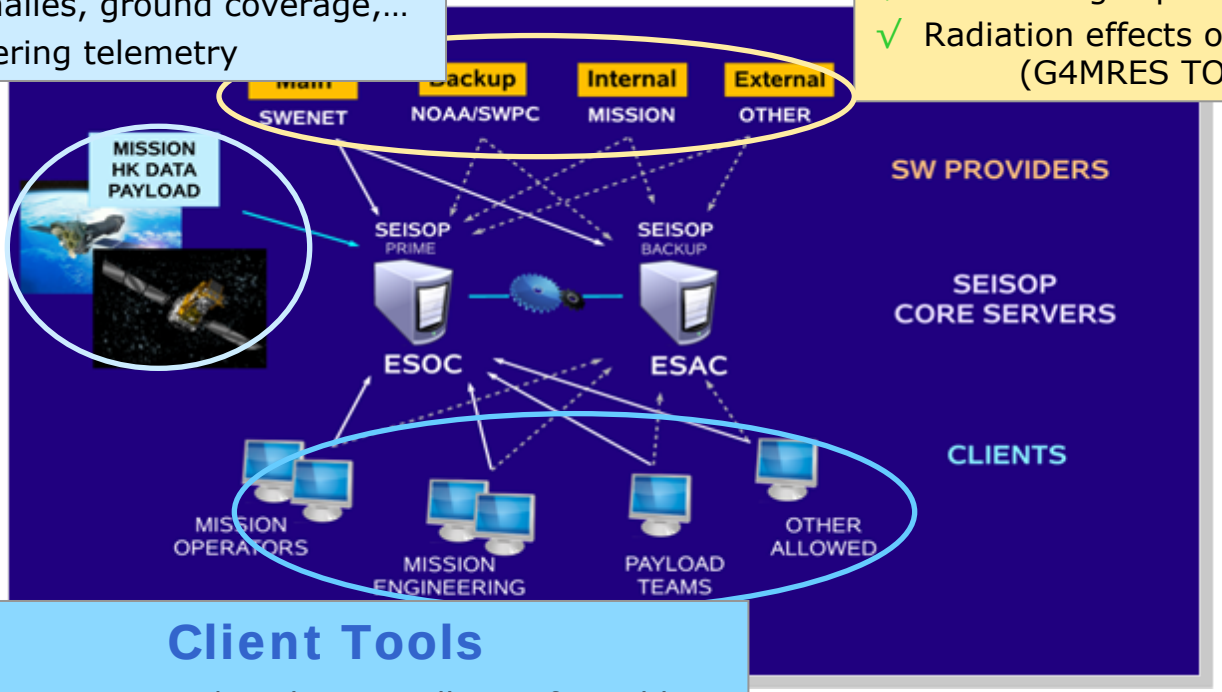
SEISOP: An operational SW system

Mission Data

- √ Archiving HK data
- √ Archiving Payload data
- √ Mission orbital information
- √ S/C events, anomalies, ground coverage,…
- √ Any other engineering telemetry

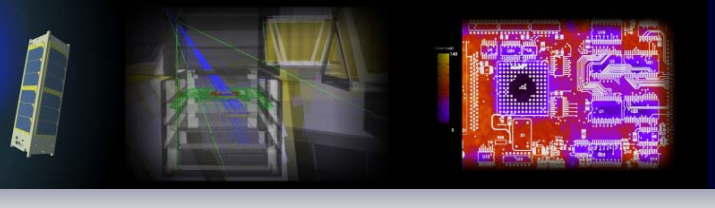
Space Weather

- √ Monitoring SW real-time data
- √ Structured archiving of SW data
- √ Retriving data from any provider
- √ Forecasting capabilities models
- √ Radiation effects on 3D S/C models (G4MRES TOOL)

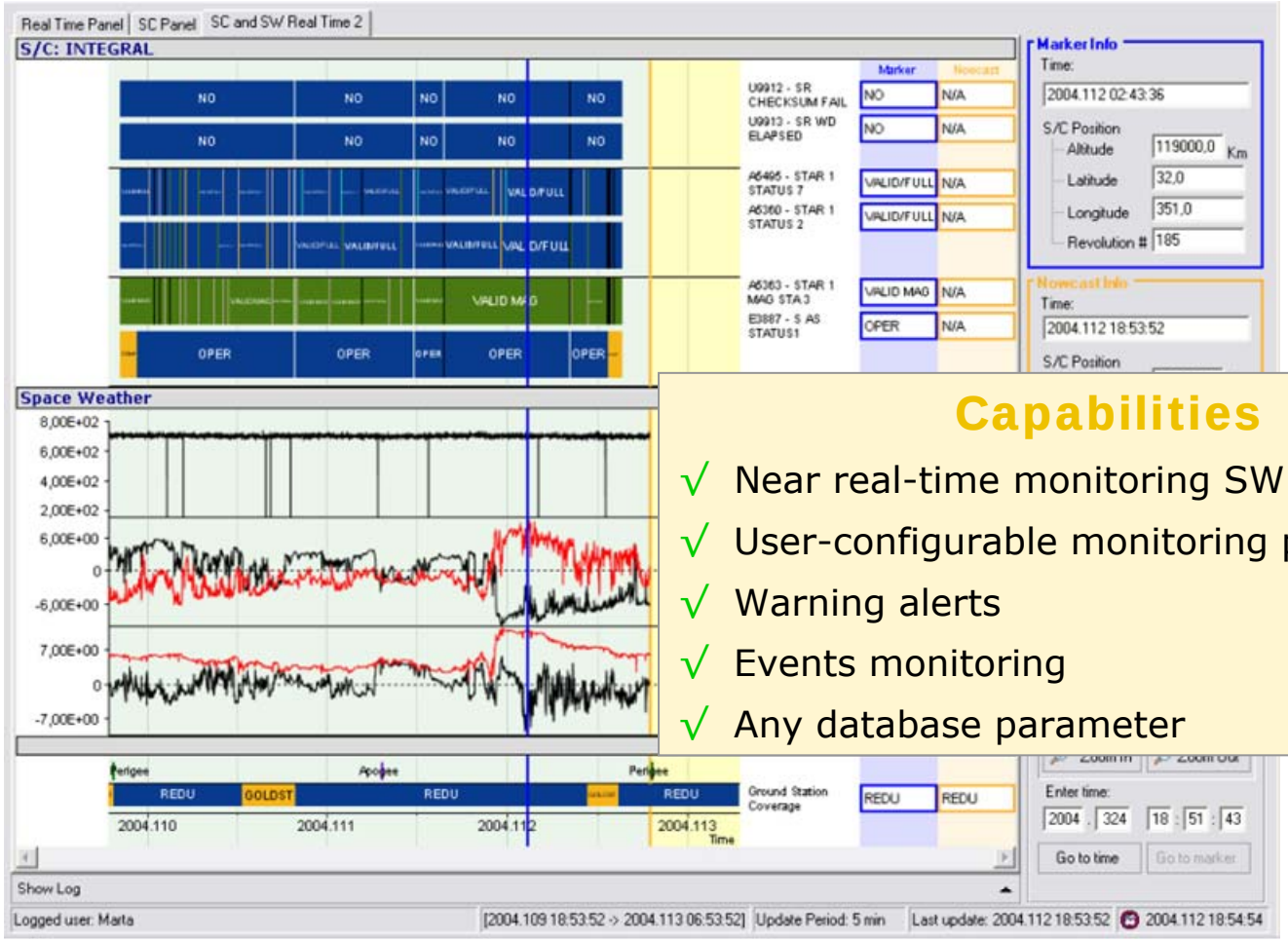


Client Tools

- √ Monitoring SW/HK data - Fully Configurable
- √ Automatic anomalies reporting
- √ Warning/Alarm defintion
- √ Correlation SW Event vs. HK anomaly



CLIENT MONITORING TOOL



Capabilities

- √ Near real-time monitoring SW and S/C
- √ User-configurable monitoring panels
- √ Warning alerts
- √ Events monitoring
- √ Any database parameter

SEISOP: An operational SW system

CLIENT MONITORING TOOL

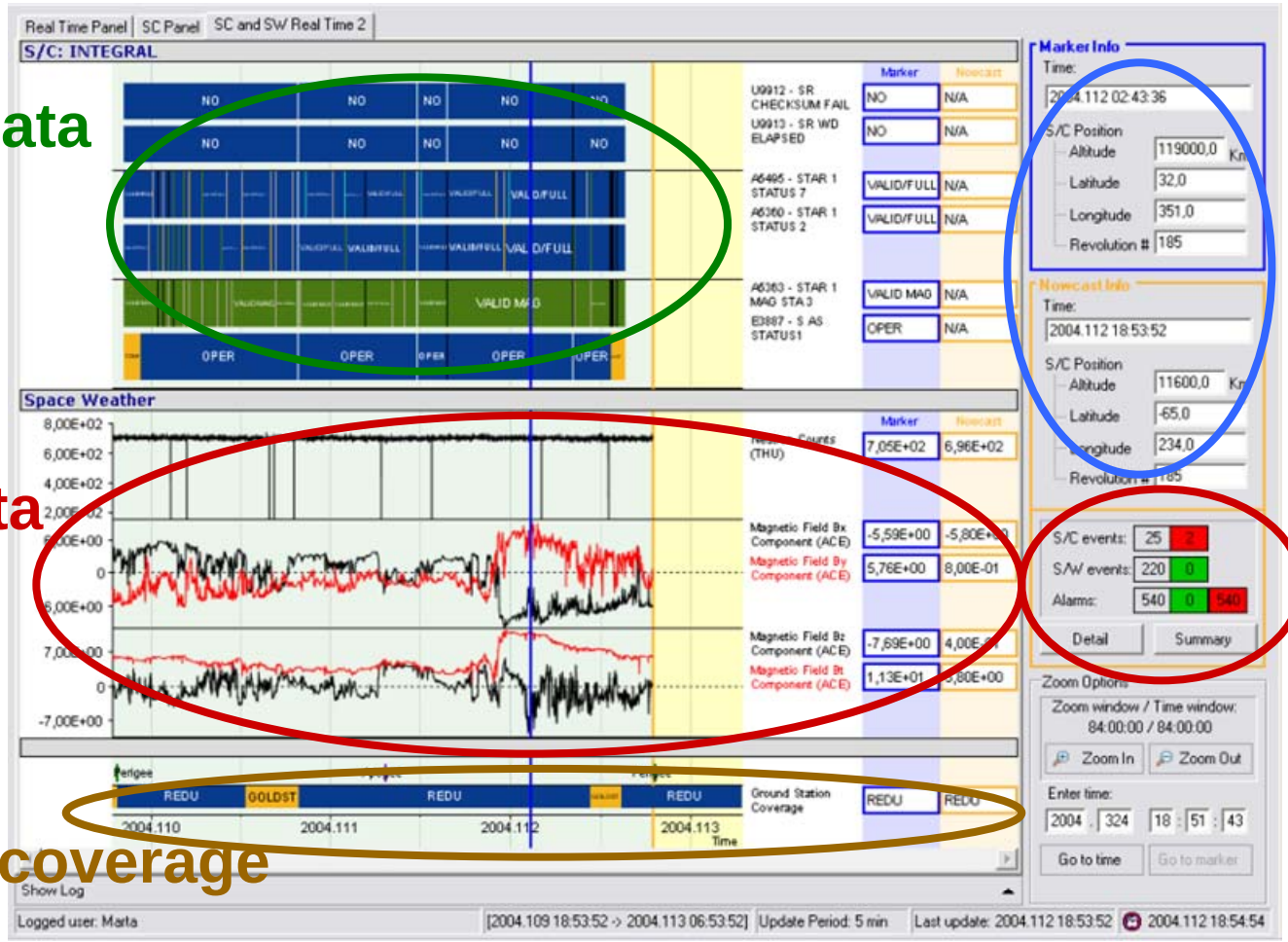
HK Data

SW Data

Station coverage

Orbital Info

Events Alarms

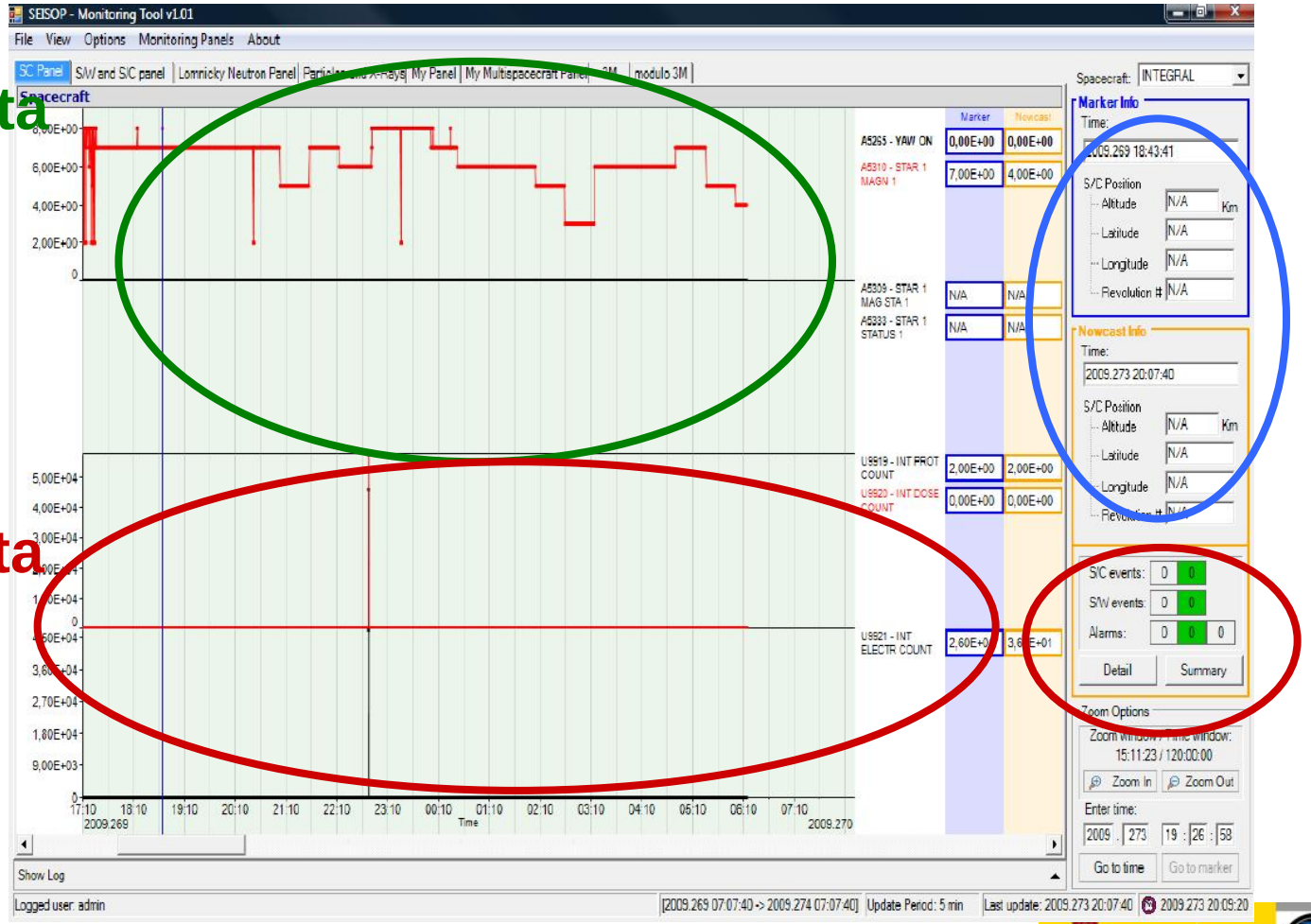


SEISOP: An operational SW system

CLIENT MONITORING TOOL

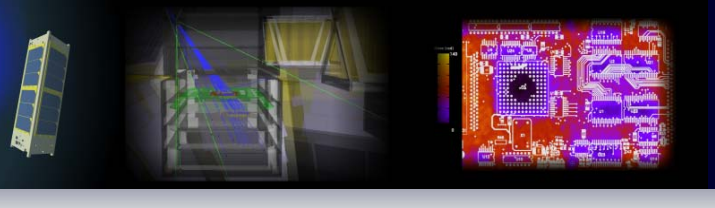
HK Data

SW Data

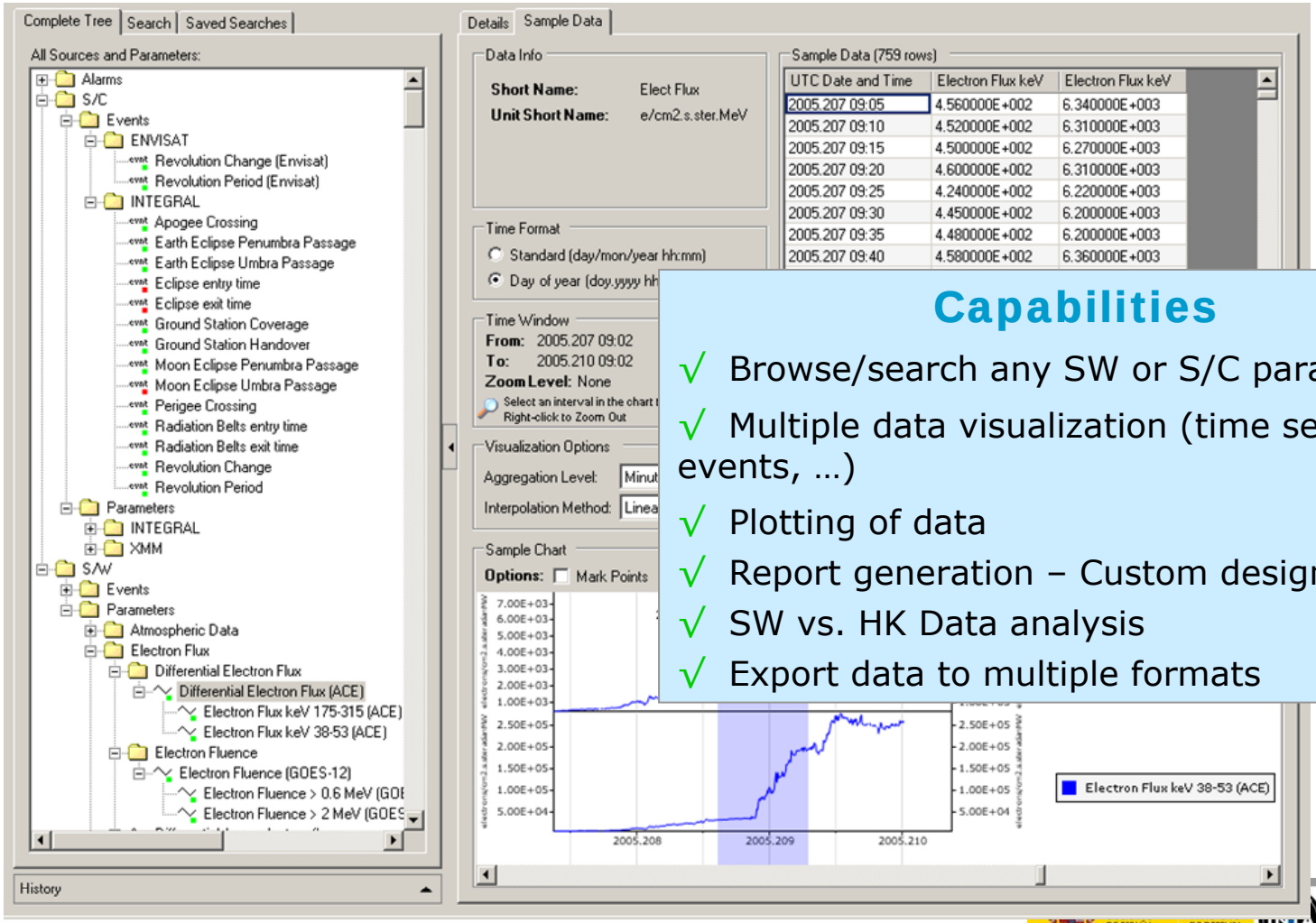


Orbital Info

Events Alarms

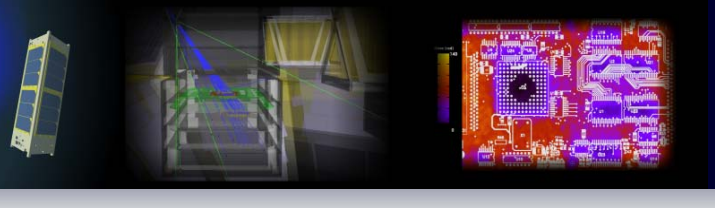


CLIENT REPORT and ANALYSIS TOOL



Capabilities

- √ Browse/search any SW or S/C parameter
- √ Multiple data visualization (time series, events, …)
- √ Plotting of data
- √ Report generation – Custom design
- √ SW vs. HK Data analysis
- √ Export data to multiple formats



SEISOP: An operational SW system

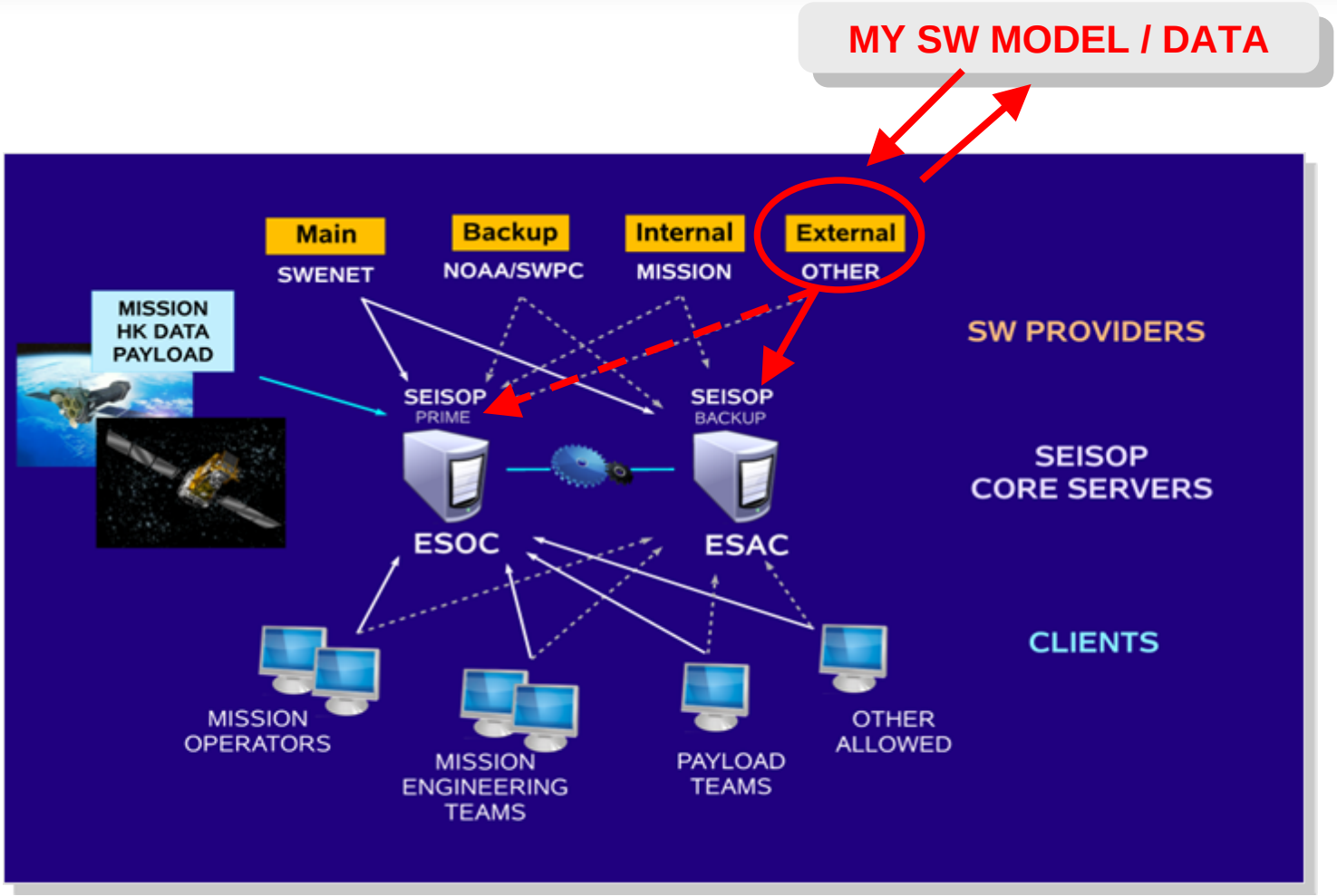
SEISOP Plugin Architecture

- SEISOP is a framework that unifies HK data, SW data, forecasting models and tools
  - Advanced data warehousing techniques to integrate the huge amounts of heterogeneous data (multi-mission)
- SEISOP imports data from any of data source, including
  - ESA mission's telemetry
  - SW data available from other sources (e.g. NOAA, SIDC, SWENET)
  - Ground-based measurements or relevant physical/numerical data from models
- SEISOP's design is based on a Service Oriented Architecture (SOA)
  - provides a flexible and modular environment
  - easy to plug-in new components to the existing "core"
  - well-defined web service interfaces

ANY USER CAN "PLUG-IN" ITS OWN

- SW DATA
- MODEL RESULTS, etc

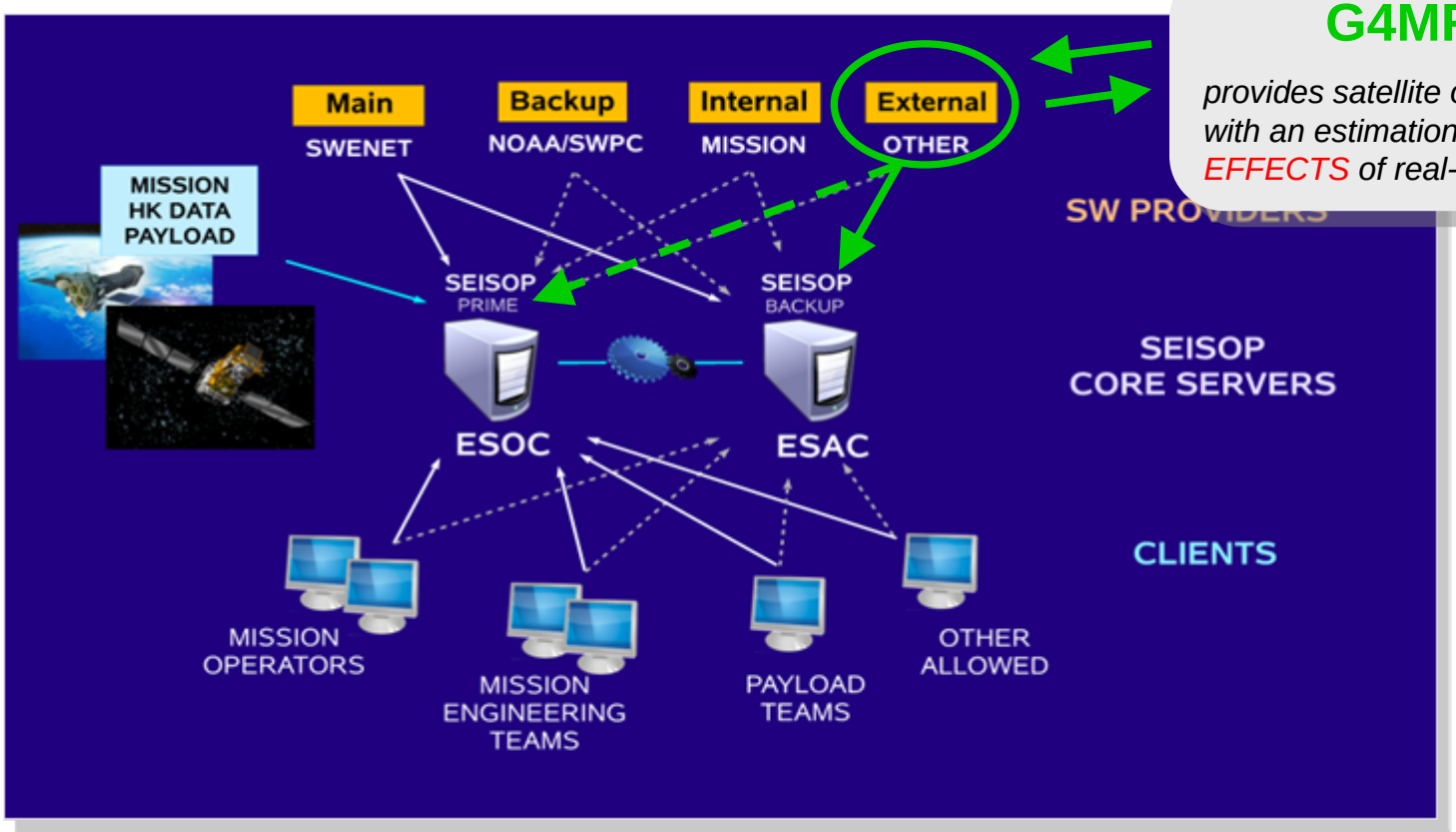
SEISOP: An operational SW system



SEISOP: An operational SW system

G4MRES

"A Monte-Carlo plug-in to estimate radiation effects on any S/C part"



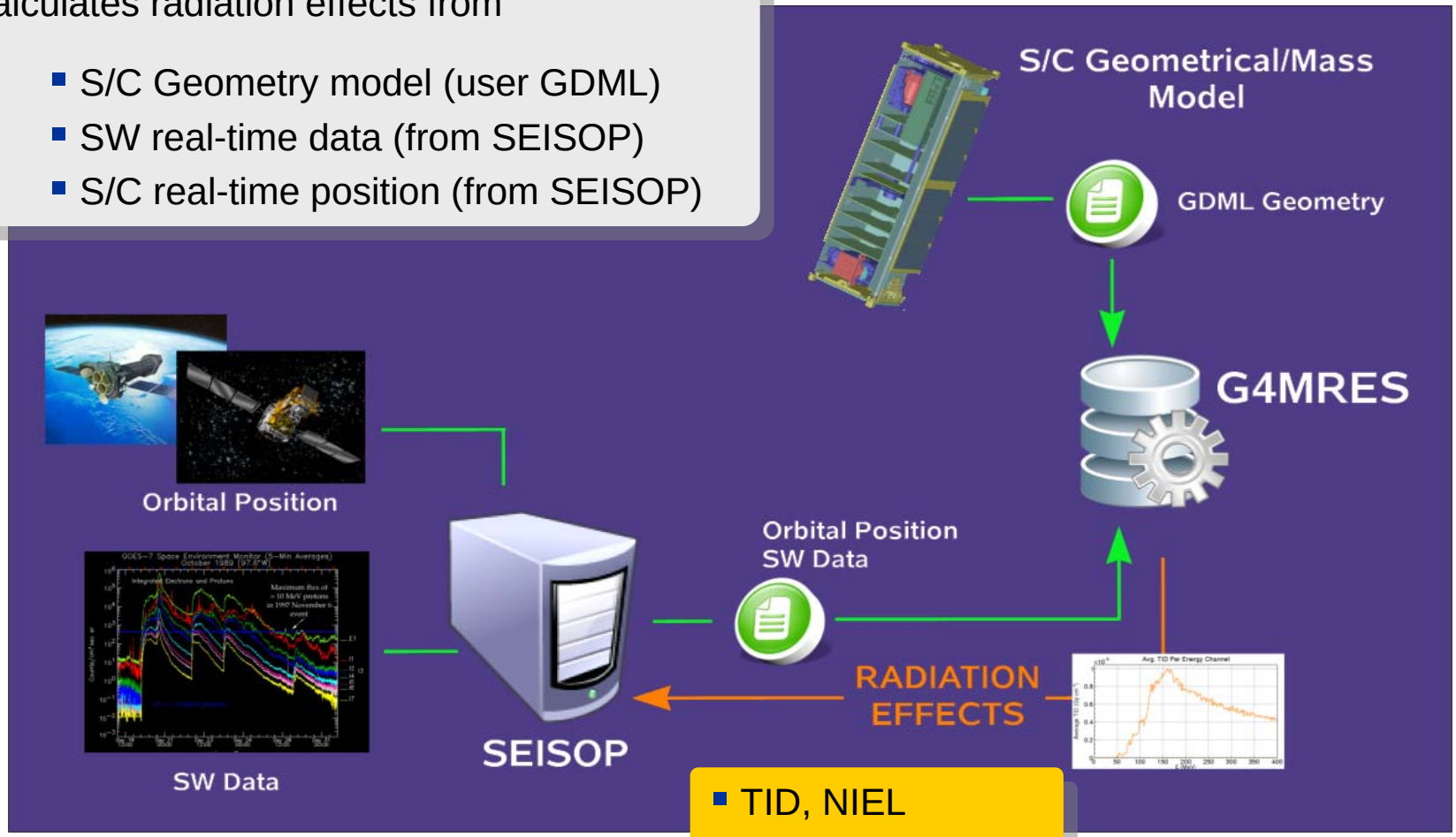
G4MRES

provides satellite operators,.. with an estimation of the EFFECTS of real-time SW

G4MRES: A G4 plug-in for SEISOP

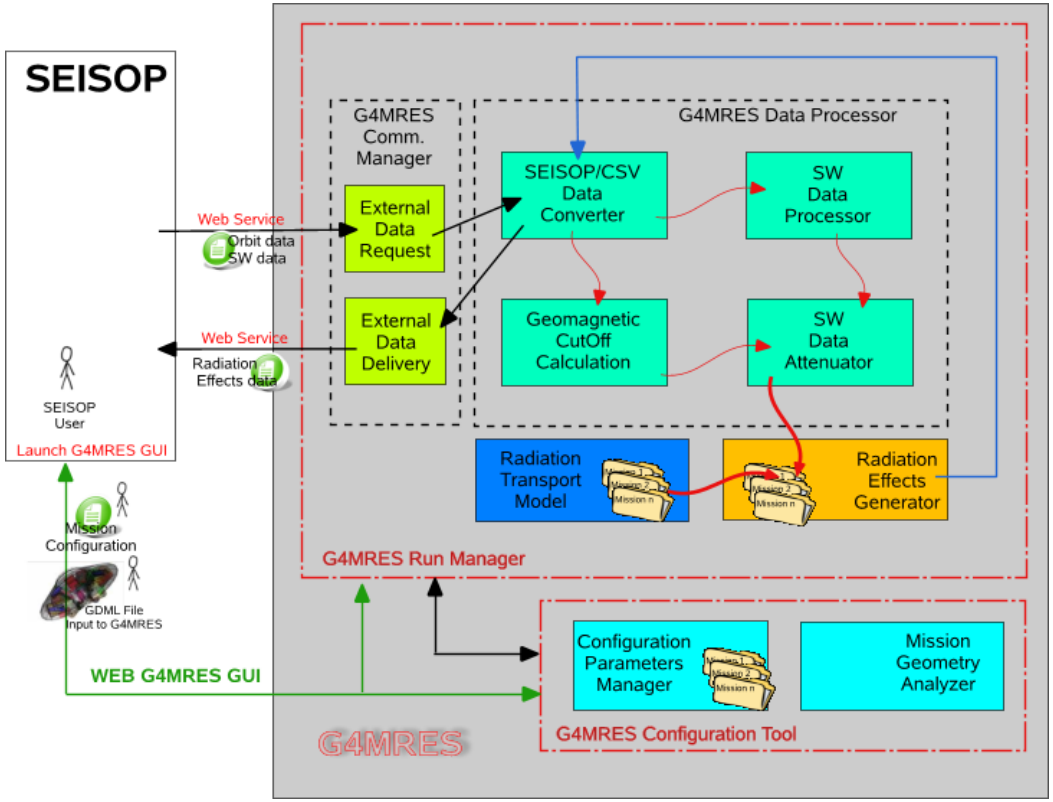
Calculates radiation effects from

- S/C Geometry model (user GDML)
- SW real-time data (from SEISOP)
- S/C real-time position (from SEISOP)



- TID, NIEL
- Particle Fluxes

G4MRES: A G4 plug-in for SEISOP



ARCHITECTURE

Main Modules

- **COMM**

Communication with SEISOP

- **DP**

SW & Orbital data processing

- **REG**

Radiation effects calculation

- **RTM**

Radiation Model of S/C

- **CT**

Configuration and control

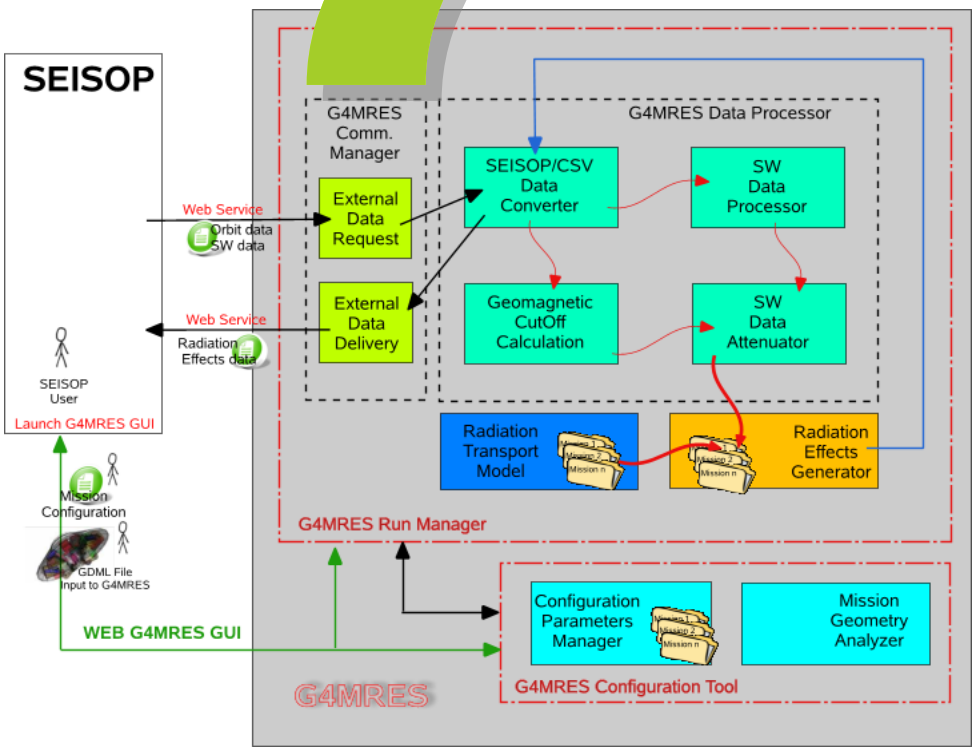
- **GUI**

Graphical IF for control & monitoring

Implementation

- Geant4/GRAS
- MAGNETOCOSMICS
- Python
- Django

G4MRES: A G4 plug-in for SEISOP



COMM

Manages communication with SEISOP via web-services

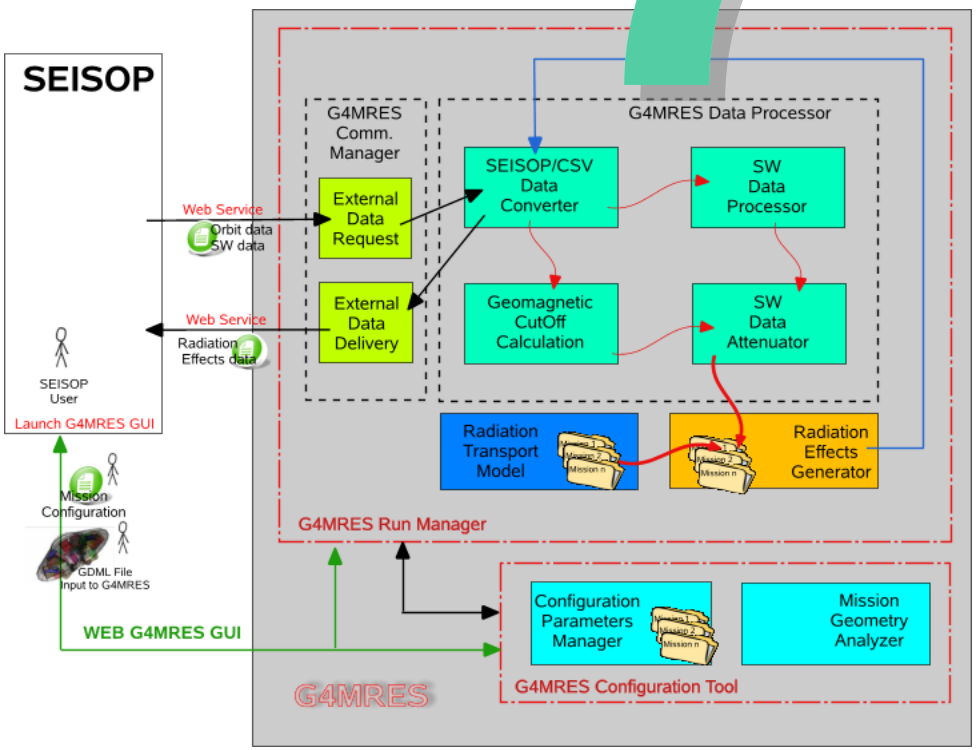
- SW data retrieving from SEISOP
- Orbital data retrieving from SEISOP

- Delivering of final radiation products to SEISOP

ARCHITECTURE

G4MRES: A G4 plug-in for SEISOP

ARCHITECTUR

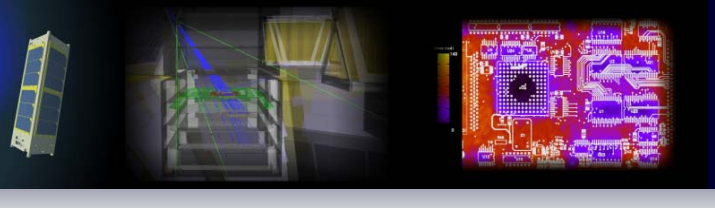


DP

Processing of SW and Orbital data

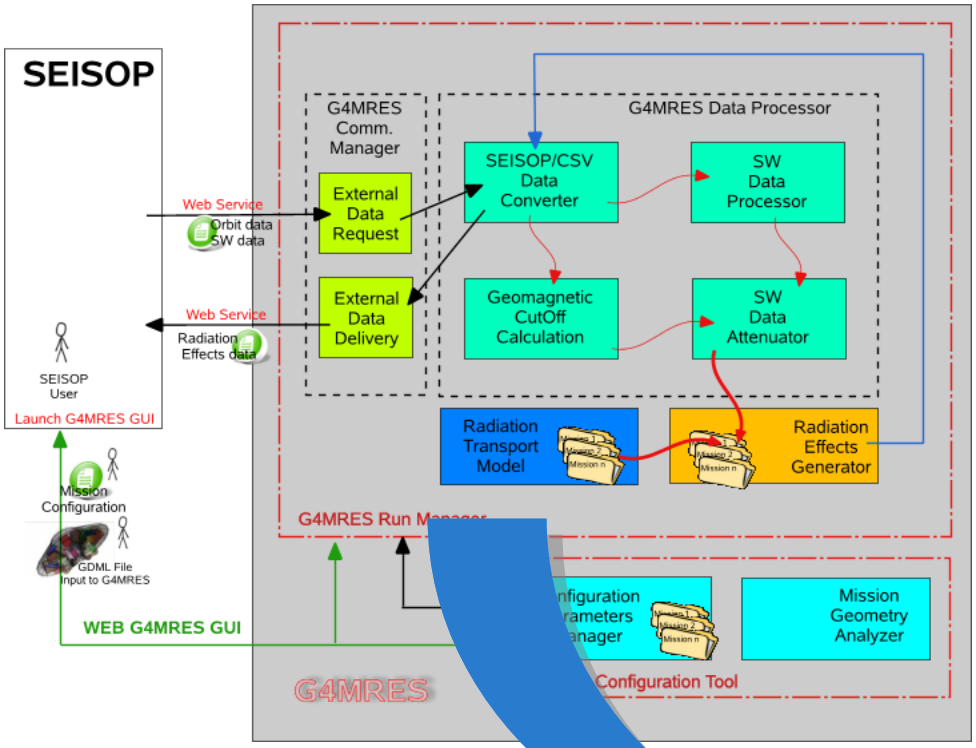
- Particle spectrum building
- Geomagnetic cutoff at S/C location
- Spectrum geomagnetic attenuation

- Parsing & formatting of data



G4MRES: A G4 plug-in for SEISOP

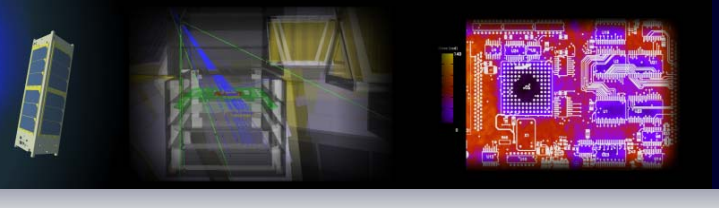
ARCHITECTURE



RTM

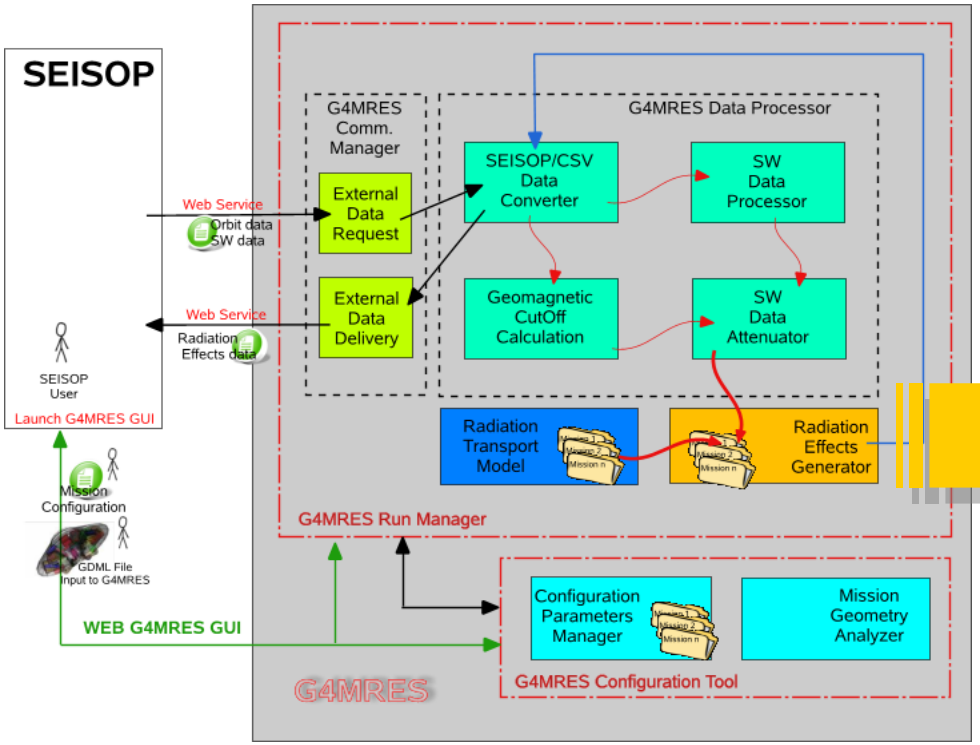
Radiation response of S/C

- Performs detailed G4 simulation
- Characterizes each sensor response
  - per energy channel
  - per particle
  - per omnidirectional flux unit



G4MRES: A G4 plug-in for SEISOP

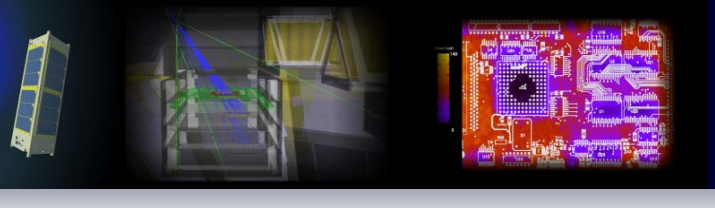
ARCHITECTURE



REG

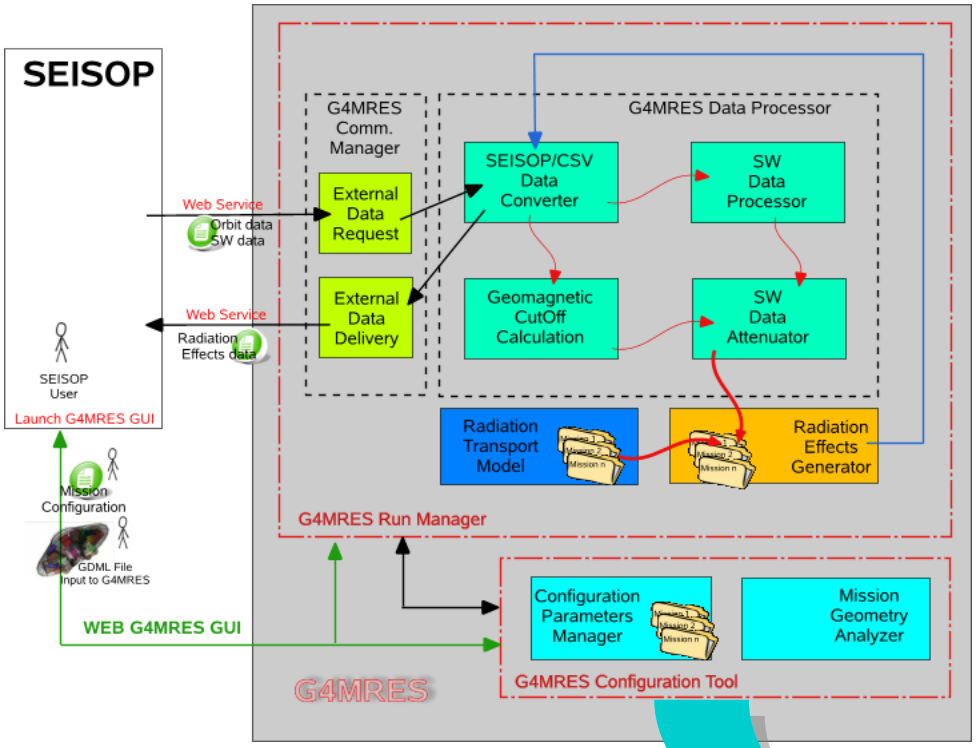
Generates real-time effects for each sensor from

- Real-time spectrum (from DP)
- Effects matrix (from RTM)



G4MRES: A G4 plug-in for SEISOP

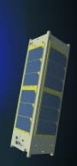
ARCHITECTURE

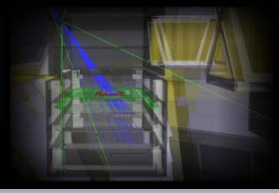


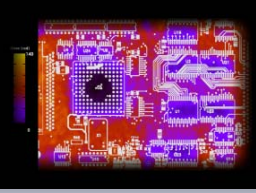
CT & GUI

Control, configuration and running of the tool

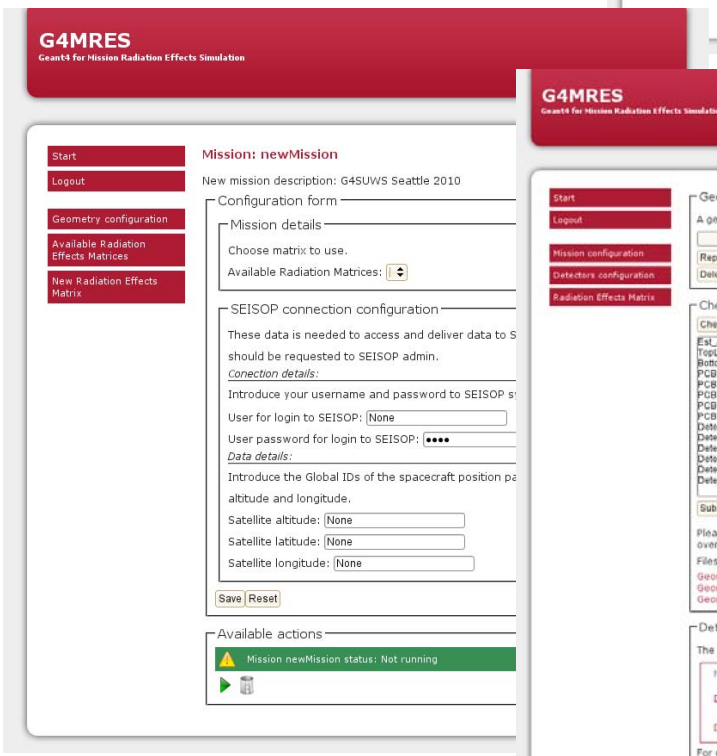
- Define users, missions
- Load Geometry
- Define Geant4 settings for RTM
- Define SW/Orbital parameters
- Define SEISOP comm. Settings
- Monitor tool status
- Launch/stop tool

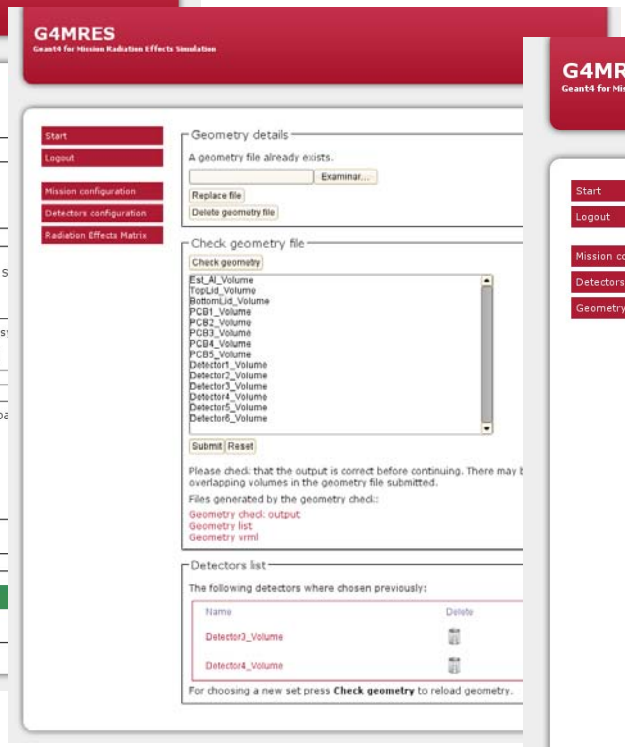


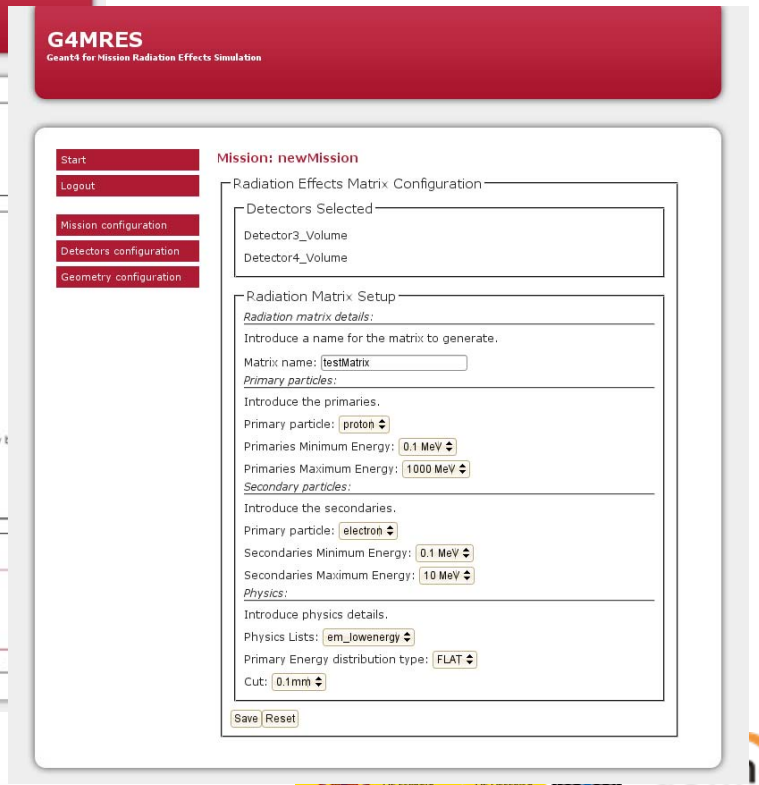


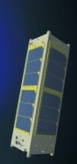
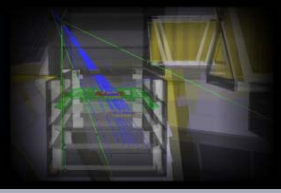
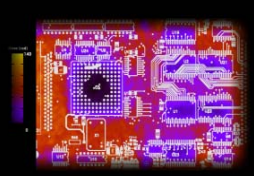


G4MRES: A G4 plug-in for SEISOP







SUMMARY, STATUS & FUTURE

- G4MRES provides operators an esy-to-use tool to
  - Get an estimation of SW events impact…
  - … in real-time!!
  - Mission oriented and designed to support operations
- It takes advantage of
  - SEISOP as advanced SW data system
  - Geant4 as reliable and accurate particle propagator
- Current status
  - Delivery to ESA and installationat ESOC
  - First tests with INTEGRAL mission are on-going