	Istituto di Astrofisica e Planetologia Spaziali **Institute For Space Astrophysics and Planetology**	

SERENA
Power Constraints

SERENA NPA-IS
(Neutral Particle Analyzer- Ion Spectrometer)

prepared by	Alessandro Mura (alessandro.mura@iaps.inaf.it) , Francesco Lazzarotto (francesco.lazzarotto@iaps.inaf.it) (INAF/IAPS)		
checked by	Anna Milillo (anna.milillo@iaps.inaf.it) (INAF/IAPS)		
approved by	Stefano Orsini, Principal Investigator (stefano.orsini@iaps.inaf.it) (INAF/IAPS)		
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INAF IAPS – SERENA Project
Area Ricerca Tor Vergata, Via del Fosso del Cavaliere 100, 00133 Rome - ITALY
Tel (+39) 06 4993 4612 - Fax (+39) 06 4993 4383
http://www.iaps.inaf.it/serena/

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name	organisation
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CHANGE LOG

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15/10/2015	2	0		Merged with Science Operations Review in a new deliverable.
30/10/2015	2	1		Splitted again, now only Science Operations. Science Operations againg in another document

Contents

A C R O N Y M S

TBW

1 Introduction

This document describes the power limitations to the operation scenarios of the SERENA experiment on-board the Bepicolombo space mission to Mercury. Here are also introduced the global set of operative rules, constraints, features and top level procedures for the execution of SERENA operations, and some description of the scientific rationale behind the optimal observing strategy. The SERENA instrument is composed by four units, ELENA, STROFIO and PICAM may operate independently, SERENA has a good flexibility in order to operate in different modes and configurations that could fit the allocated power and telemetry budget. Nevertheless for reaching the full science goals, the four units should operate at the same time, when compatible with system constraints. The scientific objectives of SERENA are listed in Table 1.

2 Applicable Documents

- AD 1 SERENA Calibration Plan
  BC-SRN-RP-00028_03_4_SERENA_Science_Perf_Report

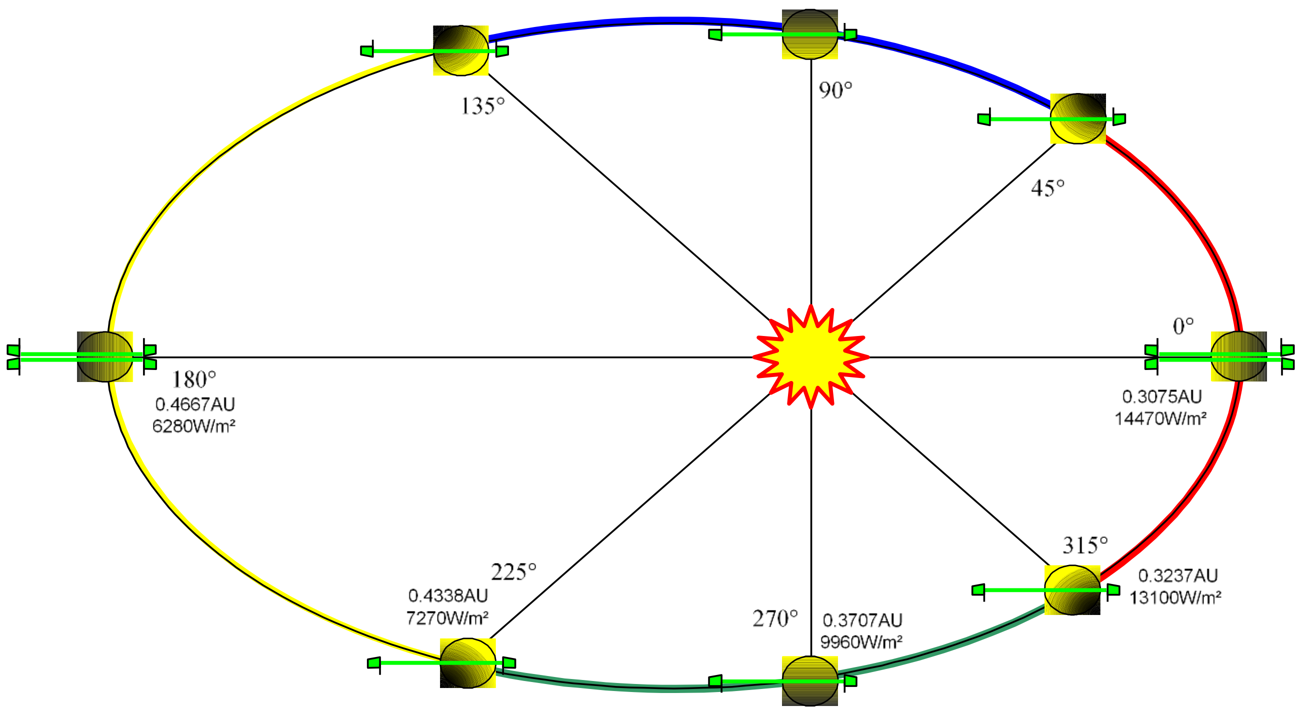
- AD 2 Tech.note - BepiColombo Radiation Analysis
  BC-ASD-TN-00027   EADS Astrium GmbH

  INPUTS:

- AD 3 ASI Contract
- AD 4 Scientific Requirements (WP 2200)
- AD 5 ELENA layout (SEE SERENA EID-B)
- AD 6 Strofio layout (SEE SERENA EID-B)
- AD 7 PICAM layout (SEE SERENA EID-B)
- AD 8 MIPA layout (SEE SERENA EID-B)

3 Mission Phases.

The mission phases for SERENA are defined by dividing the orbit of Mercury around the Sun into 4 parts of 90 degrees each: A, Summer (from -45° to 45° of TAA); B, Fall (45° to 135°), C, Winter (135° to 225°); D, Spring (225° to 315°). Phase A lasts 14.5 days, phase B and D last 21 days, phase C lasts 31 days. Figure 1 shows the four Mercury phases. For each Mercury phase, 2 mission phases are defined based on the MPO position along its orbit: phase "p" (periherm) from -90° to 90° of true anomaly angle (TAA); phase "a" (apoherm) from 90° to 270°. Hence, a total of 8 phases are defined: Aa, Ap, Ba, Bp, Ca, Cp, Da, Dp. Additionally, phases B and D may be subdivided into "early" (first half) and "late" (second half) B and D; in this way, there is a correlation between the mission phase and whether the MPO is in the day side or not. MPO is in the dayside in phases Aa, EBa,



LBp, Cp, EDp, LDa, and it is in the nightside in the other phases.

Figure 1 MPO configurations during 1 Mercurian year. Red: A; Blue: B; Yellow: C; Green: D

4 SERENA Experiment Operations

SERENA is an instrument composed of 4 units devoted to neutral and ionized particles detection, plus a System Control Unit (SCU) to provide whole package instrument functionality control, memory and computational capability

Following the power-up of the instrument, the HW-SW initialisations and tests are carried out. The test results can be provided by requesting specific boot report TM. The Main IFE controller is put into STAND-BY state. The reception of dedicated ON/OFF command from the S/C SpaceWire I/F to the power control register will allow to control and power any sub-unit. Compressor unit is a specific sub-unit residing in the SCU itself and it can be powered on as any other Sensor unit. Boot behaviour is described in paragraph 3.7.1.4 of EIDB. The default logic for the SERENA state transitions is that any automatism can be disabled and the modes trajectory is defined by a sequence of ground commands. The transition from one state to another (except power off /on) always goes via STAND-BY state.

4.1 SERENA Modes Summary

Regardless of the Compression/DPU SCU state, the following SERENA operational modes can be commanded:

- INIT & TEST
- DIAGNOSTIC
- STAND-BY
- CALIBRATION
- SCIENCE

When automatism are enabled the default logic for the SCU mode transitions is that they can be operated with no human action, but the control logic may be bypassed all the time by ground control. The transition from one mode to another mode (except power off /on) always goes via STAND-BY Mode.
SCU System will switch mode by first closing current acquisition mode and dumping all complete information, then switching into standby mode, then setting up the new mode necessary configuration parameters and then finally switching it into the target mode.
The transition:
SCI-Mode_X -> STAND-BY -> SCI-Mode_Y
Is the normal commanding sequence required to go from one mode science Mode_X to another. By the way the instrument can accept a direct SCI-Mode_X -> SCI-Mode_Y command directly and in which the passage to the STAND-BY is made transparent for the User.

4.2 INIT & TEST

This mode is automatically entered by power-on/reset.
INIT & TEST concerns the SCU HW-SW initialisation performed at the boot. The result of the initialization is made available in a specific RAM table. If the booting test procedures success, SCU switches autonomously to STAND-BY mode and the test results can be provided by requesting specific boot report TM. Conversely if errors are detected SCU goes automatically in DIAGNOSTIC mode.

4.3 DIAGNOSTIC MODE

This mode is used for diagnostic purposes, only housekeeping packets are transmitted.

Regardless of the Sensor head powering condition, the “diagnostic” mode is the basic mode for performing checks and testing operation on power-up. SCU will be switched into a survival mode with minimum performances and operability of the unit. Only H/K and diagnostic dumps for health monitoring will be provided and transmitted.

4.4 STAND-BY MODE

This is the default mode, in which SCU is switched following a reset or a power-up. From this mode, the DPU SCU can be switched to any other scientific or diagnostic mode by means of dedicated TCs. Only housekeeping telemetry will be supported while in this mode.

4.5 CALIBRATION

The complete calibration of the whole package at LBR TM budget. TM bandwidth will be dedicated to the data produced by collecting from a specific sensor in turn, the maximum quantity of data fixed according to the predefined TM allocation table. This mode can benefit of the DSP Compressor. Other sensor must stay in STAND-BY or being OFF.

4.6 SCIENCE MODE

The SCIENCE mode is the native mode for returning science products for the SERENA suite. It provides one or more science modes with different power and telemetry budget defined for each unit. It foresees several categories of science returning modes each providing different sorted list of products according to the output TM regime. They may be grouped in some sub-modes.

4.6.1 Nominal Science

This scientific sub-mode is a combination of modes for the 4 units that stays inside the nominal TM budget. It’s the nominal one and shall be normally used for all types of scientific observations. All or a few sensor units can be active and producing science data. TM will be produced by collecting from the sensor head fixed quantity of data according to the predefined TM allocation table.

4.6.2 High Science

This scientific sub-mode is an upgrade of the nominal science case. It’s a combination of modes of the units that exceeds the nominal TM budget. It’s reserved for specific and time-limited science cases. It takes into account of specific condition in which a more relevant bandwidth of the S/C is made available for SCU. All or a few sensor units can be active and produce science data.
TM will be produced collecting from the sensor heads fixed quantity of data according to the predefined TM allocation table.

4.6.3 Full Science (Nominal/High Science Compression)

These scientific modes for the 4 SERENA units take full benefit of the availability of the compression functionality and they can provide a considerable larger amount of science even with the same TM allocation bandwidth (LBR/HBR) of the nominal /high science modes.

4.6.4 SUB-SyS CAL

This scientific mode is fully devoted to support calibration or diagnostic purposes.
Multi sensors calibration may be accounted as standard Nominal/High and Full Science modes by tailoring their calibration bandwidth to those of the related scientific modes.

4.7 Mode Transition Table

Present_Mode / Next_Mode	INIT & TEST	DIAG	STAND-BY	SCIENCE	COMPR. NOM. SCI	COMPR. HI. SCI	CAL
INIT&TEST	RST	RST	RST	RST	RST	RST	RST
DIAGNOSTIC	TC AE	X	TC AEC	AEC	AEC	AEC	AEC
STAND_BY	TC AN	TC	X	TC AN AE	TC AN AE	TC AN AE	TC AN AE
SCIENCE	X	X	TC AN	X	X	X	X
COMP. NOM-SCI	X	X	TC AN	X	X	AN	X
COMP. HI-SCI	X	X	TC AN	X	AN	X	X
CALIBRATION	X	X	TC AN	X	X	X	X

Table 1

TC = Commanded by TeleCommand
AN = Autonomous Nominal
AE = Autonomous due to Error
AEC = Autonomous due to Critical Error
RST = ReSeT (autonomous or commanded)
X = not allowed

Note that:

(1) The Autonomous Nominal transitions “Standby to Science or Standby to Calibration” occur when instrument is commanded to go to a specific science mode when is NOT in standby. In this case the control system performs first a transition to Stand-by then to the required mode.

(2) The Autonomous Nominal transitions “Science Compressed Nom to Science Compressed High” (and back), when this automatism has been enabled, occurs without affecting the TM bandwidth allocated for SERENA.
(3) The Autonomous Nominal transitions “Science to Standby” occurs in the presence of a major fault or in the end of acquisition (single or multiple sequences snapshots).
(4) A Critical error transition condition AEC is originated by a detection of a critical error like program memory corruption (checksum), or anomalous power consumption detection of some module (latch-up). All the other less severe error conditions maps to A

4.7.1 S/W Memory Allocation

Table 2

MEM ID	UNIT	TYPE	MEM OFFSET (Byte)	MEM SIZE (Bytes)	Comment
200	SCU	16b	0x0000	256k	Prog Mem Area
201	SCU	16b	0x0000	456k	SRAM Prog & Data Area
202	SCU	16b	0x72000	568k	SRAM Scratch Data Area
203	SCU-DSP	16b	0x00000	2M	Prog Mem Area
204	SCU-DSP	16b	0x00000	320k	SRAM Prog & Data Area
205	SCU-DSP	16b	0x00000	1M	SRAM Scratch Data Area
206	PICAM	8b	0x00000	768k	Prog & Data Area**
207	ELENA	8b	0x00000	256k	SRAM Prog & Data Area*
208	MIPA	8b	0x00000	8k	SRAM Prog & Data Area
209	STROFIO	16b	0x00000	16k	SRAM Prog & Data Area

*ELENA Note:
Three types of ELENA memory are accessible:

Memory Type	Size	Memory Access	Address Range
Program RAM	64kx8	Check/Dump/Load	0x00000 - 0x0FFFF
Extended RAM	64kx8	Check/Dump/Load	0x10000 - 0x1FFFF
EEPROM	128kx8	Check/Dump	0x20000 - 0x3FFFF

**PICAM Note:
Four types of PICAM memory are accessible:

Memory Type	Size	Memory Access	Address Range
Program RAM	32kx8	Check/Dump/Load	0x00000 - 0x07FFF
Extended RAM	**8kx8**	**Check/Dump/Load**	**0x0C000 - 0x0DFFF**
EEPROM	128kx8	Check/Dump	0x20000 - 0x3FFFF
Mass RAM	512kx8	Check/Dump	0x40000 - 0xBFFFF

Boot Behaviour

After power up, the SCU operates as follows.

“Stand-by state” is the default mode in which SERENA is switched on following a reset or a power-up. From this mode, the unit can be switched into any other scientific or diagnostic mode by means of dedicated TCs. Only housekeeping telemetry will be supported while in this mode.

If a “Diagnostic TM” SCU mode is commanded, the unit will be switched into a survival mode with minimum performances and operability. In this condition, no usual science telemetry will be provided by the experiment even if any sensor head would be put in ON state. Only H/K and diagnostic dumps for health checking will be provided and transmitted.

If a “Low TM” SCU mode is commanded, the unit will be kept into its nominal state to provide science support. Science data will be collected from the activated sensor heads, and according the normal operations TM polling tables, eventually Loss-Less data compressed, organized into science packets and transmitted to S/C.

If a “Burst TM” SCU mode is commanded, the system will power up and initialize the DSP compressor. In this mode the nominal performances of the IFE will be increased taking benefit of the DSP performances to support also Lossy data compression. However, if during burst the booting procedure problems in the health checking of the DSP are identified the DSP is put in a partial mode in which a limited set of functionality is available for diagnostic, while the main IFE system will be left into its nominal state for autonomous S/C I/F and TM dumping.

4.7.2 S/W Maintenance Concept

The SERENA on-board software maintenance (OBSM) capability provides a means of adapting the real mission conditions scenario to the real-time status of the hardware and to any operational difficulties that instrument might encounter during its operating lifetimes. The need for On-Board Software Maintenance can arise at any time, from immediately after launch if the spacecraft's post-launch status calls for operational adaptations, until the end of the mission when ageing of the in-orbit hardware leads to a greater probability of failures. Even if the need of OBSM services are not used regularly, an adequate infrastructure must be available on the ground throughout the mission to correct, add to or re-design the on-board software whenever the need arises.

The re-programmable SERENA on-board S/W on SCU, ELENA and PICAM resides on EEPROMs as listed in table 3.7.1.3. Such blocks contain XORCRC 16 checksum tables for each of their 1kbytes content. Re-programmability may occur only in the so-called DIAGNOSTIC Mode.

5 Scientific modes

5.1 SERENA Objectives

Table 3

Observation	Instrument-Level Science Objective	Mission-Level Science Objective
Neutrals mass 1	1. Chemical and elemental composition of the exosphere	Determination of the composition of Mercury's vestigial atmosphere (exosphere) Characterisation of the composition of the planet's surface
Neutrals mass 2	2a. Neutral gas density asymmetries Latitude	Determination of the exosphere and magnetosphere structures Identification of the composition of the radar bright spots in the Polar Regions
Neutrals mass 3	2b, 2c. Neutral gas density asymmetries Day/night Dawn/dusk	Determination of the exosphere and magnetosphere structures
Neutrals mass 1	2d, 2e. Neutral gas density asymmetries Altitude Local Time	Determination of the exosphere and magnetosphere structures
Exo-ionosphere	3. Exo-ionosphere composition	Determination of the composition of Mercury's vestigial atmosphere (exosphere) Study of the planet's magnetic field interaction with the solar wind
Exo-ionosphere	4. Exo-ionosphere spatial and energy distribution	Determination of the exosphere and magnetosphere structures Study of particle energisation mechanisms in Mercury's environment Study of the planet's magnetic field interaction with the solar wind
Plasma precipitation	5a. Plasma precipitation rate SW	Study of the planet's magnetic field interaction with the solar wind Study of particle energisation mechanisms in Mercury's environment
Plasma precipitation	5b. Plasma precipitation rate Heavy ions	Study of particle energisation mechanisms in Mercury's environment Study of the planet's magnetic field interaction with the solar wind Determination of the exosphere and magnetosphere structures
Low-Energy Neutral Atoms	6a. Surface emission rate and release processes. Localized surface emissivity induced by ion-sputtering	Determination of the source/sink processes of the exosphere Study of the planet's magnetic field interaction with the solar wind
Particle release	6b. Surface emission rate and release processes.	Determination of the source/sink processes of the exosphere

	Localised surface emissivity induced by back-scattering	Study of the planet's magnetic field interaction with the solar wind
Particle release	6c. Surface emission rate and release processes: Average SW sputtering emission rate	Determination of the source/sink processes of the exosphere
Particle release	6d. Surface emission rate and release processes: Surface MIV	Determination of the source/sink processes of the exosphere
Particle release	6e. Surface emission rate and release processes: PSD	Determination of the source/sink processes of the exosphere
Escape	7a. Particle loss rate from Mercury's environment: SW sputtering	Determination of the source/sink processes of the exosphere
Escape	7b. Particle loss rate from Mercury's environment: Exospheric charge-exchange	Determination of the source/sink processes of the exosphere
Escape	7c. Particle loss rate from Mercury's environment: Loss of planetary ions	Determination of the source/sink processes of the exosphere

5.2 ELENA

(To be updated) ELENA instrument has 7 telemetry modes, depending on ToF and Mass resolution:

Table 4

Name	Info	ToF channels	Azimuth channels	Mass channels	Time resolution	TLMR
N	Nominal	64	32	1	15	2184
L	Low resolution	32	32	1	15	1092
M	Mass resolution	32	32	4	15	4370
HT	High ToF resolution	128	32	1	15	4370
F	Full mode	128	32	4	15	17476
S	Survey	32	8	1	15	273
R	Raw, event by event	128	32	16	15	16000

In addition to scientific TM, ELENA instrument H/K Telemetry is 128 b/s.

5.3 MIPA

MIPA scientific modes foresee constant power and data rate

Table 5

NAME	INFO	ANG	ENE	MASS	COUNTERS	CYCLES	TIME	TLM UNC	TLM COMP	POWER BOL	POWER EOL
N	Full	24	96	32	3	1	18	35840	17920	2.9	3.5
Mode1	full_slow	24	96	32	3	6	108	5973	2987	2.9	3.5
Mode2	Monitoring	24	32	2	3	4	24	1280	640	2.9	3.5
Mode3	Minimum	2	32	2	3	1	72	36	18	2.9	3.5
Mode4	Mass resolution 1	1	32	128	3	4	72	466	233	2.9	3.5
Mode5	Plasma dynamics 1 (basic)	24	32	2	3	1	18	1707	853	2.9	3.5
Mode6	Mass resolution 2	6	32	128	3	4	72	2795	1397	2.9	3.5
Mode7	Mass spectrum from a single pixel	1	96	128	3	NaN	96	1048	524	2.9	3.5
Mode8	Plasma dynamics 2 (slow)	24	32	2	3	4	72	427	213	2.9	3.5
Mode9	Plasma dynamics 3 (fast)	24	64	2	3	1	12	5120	2560	2.9	3.5
Mode10	Plasma dynamics 4 (ultra fast)	24	32	2	3	1	6	5120	2560	2.9	3.5
Mode11	Plasma dynamics 5	24	32	8	3	3	24	2816	1408	2.9	3.5
Mode12	Mass resolution 3	1	32	64	3	4	72	238	119	2.9	3.5
Mode13	Calibration	1	1	128	3	NaN	0.125	8384	4192	2.9	3.5
Mode14	Raw	NaN	NaN	NaN	NaN	NaN	NaN	16000	8000	2.9	3.5

5.4 PICAM

PICAM foresees the following modes for operating the optics:
Mode 1 :Energy
Mode 2 : TOF
Mode 3 : Hadamard

Mode 4 : Diagnostic

Telemetry Traffic

Housekeeping packets rate (min, max, peak, average) b/s:

Table 6

UNIT	MIN (Rate 120s)	MAX (Rate 4s)	PEAK (Rate 1s)	AVG (Rate 30s)
PICAM	17.1	512	2048	68.3

Science packets rate (maximum length, peak, average):

The uncompressed rates refer to the rates at the PICAM-SCU interface and include data binning and selection within PICAM. Data compression proper is done by the SCU. In this table, a compression factor of 10 is assumed for count rates, and a factor 4 for other information. All rates are given in bit/s.

Table 7

NAME	INFO	TIME	TLM_UNC	TLM_COMP	POWER_BOL	POWER_EOL
IM_HR	High Resolution Image, Single Pulse	64	2163	1082	4.1	4.9
IM_NR_AR	Normal Resolution Image, Angular Focus, Single Pulse	64	580	290	4.1	4.9
IM_NR_ER	Normal Resolution Image, Energy Focus, Single Pulse	64	517	259	4.1	4.9
IM_LR	Low Resolution Image, Single Pulse	64	129	65	4.1	4.9
MC_HR_HE_S	High Resolution TOF, High Energy Resol., Single Pulse	64	4441	2220	4.1	4.9
MC_HR_HE_H	High Resolution TOF, High Energy Resol., Hadamard	64	4441	2220	6.5	7.8
MC_HR_LE_S	High Resolution TOF, Low Energy Resol., Single Pulse	64	1110	555	4.1	4.9
MC_HR_LE_H	High Resolution TOF, Low Energy Resol., Hadamard	64	1110	555	6.5	7.8
MC_NR_HE_S	Normal Resol. TOF, High Energy Res., Single Pulse	64	1312	656	4.1	4.9
MC_NR_HE_H	Normal Resol. TOF, High Energy Res., Hadamard	64	1312	656	6.5	7.8
MC_NR_LE_S	Normal Resol. TOF, Low Energy Res., Single Pulse	64	328	164	4.1	4.9
MC_NR_LE_H	Normal Resol. TOF, Low Energy Res., Hadamard	64	328	164	6.5	7.8

MC_LR_HE_S	Low Resolution TOF, High Energy Res., Single Pulse	64	790	395	4.1	4.9
MC_LR_HE_H	Low Resolution TOF, High Energy Res., Hadamard	64	790	395	6.5	7.8
MC_LR_LE_S	Low Resolution TOF, High Energy Res., Single Pulse	64	198	99	4.1	4.9
MC_LR_LE_H	Low Resolution TOF, High Energy Res., Hadamard	64	198	99	6.5	7.8
MD_HE_S	High Energy Resolution, Single Pulse	64	7271	3636	4.1	4.9
MD_HE_H	High Energy Resolution, Hadamard	64	7271	3636	6.5	7.8
MD_LE_S	Low Energy Resolution, Single Pulse	64	3636	1818	4.1	4.9
MD_LE_H	Low Energy Resolution, Hadamard	64	3636	1818	6.5	7.8

5.5 STROFIO

Table 8

NAME	INFO	TLM_UNC	TLM_COMP	POWER_BOL	POWER_EOL	TIME
N	nominal	600	200	4.2	5	100%

6 Observing strategy: SCIENCE ACTIVITY PLAN (SAP)

Given the SERENA objectives (table 3) and the single sensor capabilities, the planning of SERENA operation can be optimized by assuming the following strategy:

Table 9

Objective	Observation (Sensor)	Observing Strategy/Measurement Requirement
1. Chemical and elemental composition of the exosphere with a continuous coverage in the mass to charge range from m/q=3 (He) up to m/q=56 (Fe)	CHEM. COMP. (STROFIO)	spatial sampling of at least 120 samples or 200 km along the orbit for 1 Mercury's year uncertainty of less than 70% for all atomic species with a density greater than 100 particles/cm3
2a Neutral gas density latitude asymmetries	NEUTRAL ASYM (STROFIO)	Complete observation for 1 year of mission
2b, c. Neutral gas density asymmetries Day/night Dawn/dusk	NEUTRAL ASYM (STROFIO)	Complete observation for 1 year of mission
2d, e. Neutral gas density asymmetries Altitude LT	NEUTRAL ASYM (STROFIO)	Complete observation for 1 year of mission

3. Exo-ionosphere composition	ION COMP (PICAM)	spatial sampling at high mass resolution mode of at least 120 samples or 200 km along the orbit for 1 Mercury's year
4. Exo-ionosphere spatial and energy distribution	ION DISTRIB. (PICAM)	Complete observation for 1 year of mission in survey mode
5a. Plasma precipitation rate SW	SW PRECIPITATION (MIPA)	Phase Aa and Cp: survey mode all orbits for 1 year high res. mode in few selected periods Other phases: survey mode
5b. Plasma precipitation rate Heavy ions	HEAVY PRECIPITATION (MIPA+PICAM)	Phases Ap and EBp and Ca (mainly night side) in survey mode for 1 Mercury year
6a. Surface emission rate and release processes. SW - sputtering emission	ION SPUTTERING (ELENA+MIPA+ STROFIO)	Each surface element of 100 km x 100 km should be sampled with at least 5000 counts. According to expected countrates, ELENA should be in H or N mode every time ELENA looks to the dayside (even partially) and MIPA in survey mode for 1 year of mission. STROFIO should be on, as well
6b. Surface emission rate and release processes. SW - back-scattering emission	BACKSCATTERING FLUX (ELENA+MIPA)	ELENA should be in H or N mode every time ELENA looks to the dayside (even partially) and MIPA in survey mode for 1 year of mission
6c. Surface emission rate and release processes. Time averaged ion-sputtering emissivity of surface features	SURFACE ION SPUTTERING EFFICIENCY (ELENA)	Same as point 6a, except surface resolution should be enhanced to 50 km x 50 km or less. Some at least 20 passages over the same region are required to have enough statistics
6d. Surface emission rate and release processes. Surface MIV	MIV FLUX (STROFIO)	STROFIO should be always on in the night side
6e. Surface emission rate and release processes. PSD	PSD FLUX (STROFIO)	STROFIO should be always on in the day side
7a. Particle loss rate from Mercury's environment SW sputtering	NEUTRAL SPUTTERING LOSS RATE (ELENA)	Average over time of measurements every time ELENA looks to the dayside (even partially) in different Mercury configuration for at least 2 Mercury years
7b. Particle loss rate from Mercury's environment Exospheric charge-exchange	CHARGE-EXCHANGE FLUX (ELENA)	Current modeling of Hermean environment indicates that charge-exchange is detectable only if ELENA FoV is partially external to planet and not pointing toward the tail. This is possible for some time around apocenter.
7c. Particle loss rate from Mercury's environment Loss of planetary ions	ION LOSS RATE (PICAM)	Ca phase: survey mode all orbits for 1 Earth's year All apoherm phases in the nightside

The strategy in table 11 results in the following flight operation table (SAP)

Mercury Year 1	AA				AP				BA				BP			
	Orbits		Obj.	Mode	Orbits		Obj.	Mode	Orbits		Obj.	Mode	Orbits		Obj.	Mode
STROFIO	all	100	2a, 2b, 2c, 2d, 2e, 6a, 6c, 6d, 6e	**N**	all	100	1, 2a, 2b, 2c, 2e, 2d, 6a, 6c, 6d	N	all	100	2a, 2d, 2e, 6d, 6e	N	all	100	1, 2a, 2d, 2e, 6a, 6c, 6d, 6e	N
ELENA	all	100	6a, 6b, 6c, 7a	**H**	all	50	6a, 6b, 6c, 7a	**N**	50% 50%	80	7a	N L	50% 50%	95	6a, 6b, 6c, 7a	N L
PICAM	all	65	4, 5b	IM_HT_HR	5/6 1/6	75	3, 4, 5b	MC_HR_LE MD_MR_HE	all	70	4, 5b,7c	IM_HT_HR	5/6 1/6	90	3, 4, 5b	MC_HR_LE MD_MR_HE
MIPA	all	100	5a, 5b, 6a, 6b	5	3/6	60	5a, 5b, 6a, 6b	5	3/6	70	5b, 7c	6	3/6	80	5a, 5b, 6a, 6b	5

Mercury Year 1	CA				CP				DA				DP			
	Orbits		Obj.	Mode	Orbits		Obj.	Mode	Orbits		Obj.	Mode	Orbits		Obj.	Mode
STROFIO	all	100	2a, 2b, 2c, 2d, 2e, 6d	N	all	100	1, 2a, 2b, 2c, 2d, 2e, 6a, 6c, 6d, 6e	N	all	100	2a, 2d, 2e, 6d, 6e	N	all	100	1, 2a, 2d, 2e, 6a, 6c, 6d, 6e	N
ELENA	all	60	7b	H	all	100	6a, 6b, 6c, 7a	H	50% 50%	80	7b	N L	50% 50%	95	6a, 6b, 6c, 7a	L N
PICAM	5/6 1/6	80	4, 5b, 7c	IM_HR_HT MC_HR_LE	5/6 1/6	100	3, 4, 5b	MC_HR_LE MD_MR_HE	all	80	4, 5b,7c	**IM_HT_HR**	5/6 1/6	90	3, 4, 5b	MC_HR_LE MD_MR_HE
MIPA	all	65	5b, 7c	6	all	80	5a, 5b, 6a, 6b	5	3/6	80	5b, 7c	6	3/6	80	5a, 5b, 6a, 6b	5

7 BEPICOLOMBO available power profile

Extracted from: BC-SGS-TN-047_1_0_Science_Planning_Concept_2013Dec17.doc:

During the perihelion period there are power-limitations, such that not all experiments can be switched-on at the same time.

That constraint has to be taken into account when planning the observations around perihelion, taking into account the thermal aspect, which together will drive the experiments that can be on in this season.

Figure 1 shows the power availability at perihelion currently provided in Astrium documentation (see BC-ASD-TN-00424 [RD.05] for details).

8 SERENA POWER BUDGETS

8.1 February 23rd, 2012

Revision: 23th february 2012

ALL VALUES in tables are AVERAGE power consumption

SCU ELENA

Notes:

EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU	4,6	4,2	4,6	4,2	4,6	4,2	4,6	4,2
ELENA	15,2	13,85	10,8	9,8	15,2	13,85	6,8	6,2
ELENA with SCU	19,8	18,05	15,4	14	19,8	18,05	11,4	10,4

STROFIO

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
STROFIO	7,5	6,58	7,5	6,58	8,44	7,52	5,5	5

PICAM

Notes

EOL = BOL +10%, H = Hadamard mode, S = Single pulse mode

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
PICAM H orbits (around 50% of orbits)	10,2	9,3	6,7	6,1	10,2	9,3	4,4	4
PICAM S orbits (around 50% of orbits)	8,1	7,4						

MIPA

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
MIPA	3,5	2,6	3,5	2,6	3,5	2,6	3,5	2,6

TOTAL

Note
Picam H orbits considered

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU + All units	**41**	**36,5**	**33,1**	**29,3**	**41,9**	**37,5**	**24,8**	**22**

8.2 February 27th, 2012

Revision: 27th february 2012

ALL VALUES in tables are AVERAGE power consumption

SCU ELENA

Notes:

EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU	4,6	4,2	4,6	4,2	4,6	4,2	4,6	4,2
ELENA	15,2	13,85	10,8	9,8	15,2	13,85	10,8	9,8
ELENA with SCU	19,8	18,05	15,4	14	19,8	18,05	15,4	14

STROFIO

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
STROFIO	7,5	6,58	7,5	6,58	8,44	7,52	5,5	5

PICAM

Notes

EOL = BOL +10%, H = Hadamard mode, S = Single pulse mode

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
PICAM H orbits (around 50% of orbits)	10,2	9,3	6,7	6,1	10,2	9,3	7,3	6,6
PICAM S orbits (around 50% of orbits)	8,1	7,4						

MIPA

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
MIPA	3,5	2,6	3,5	2,6	3,5	2,6	3,5	2,6

TOTAL

Note
Picam average orbits considered

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU + All units	**40**	**35,6**	**33,1**	**29,3**	**41,9**	**37,5**	**31,7**	**28,2**

8.3 April 24th, 2012

Revision: 24 April 2012

ALL VALUES in tables are AVERAGE power consumption

SCU ELENA

Notes:

DCDC for MIPA is hosted on Elena Main Board
EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU	4,6	4,2	4,6	4,2	4,6	4,2	4,6	4,2
ELENA with MIPA OFF	15,7	14,29	10,8	9,8	15,7	14,29	10,8	9,8
ELENA with MIPA ON	16,7	15,2	11,8	10,71	16,7	15,2	11,8	10,71
ELENA with SCU and MIPA OFF	20,3	18,49	15,4	14	20,3	18,49	15,4	14
ELENA with SCU and MIPA ON	21,3	19,4	16,4	14,91	21,3	19,4	16,4	14,91

STROFIO

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
STROFIO	7,5	6,58	7,5	6,58	8,44	7,52	5,5	5

PICAM

Notes

EOL = BOL +10%, H = Hadamard mode, S = Single pulse mode

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
PICAM H orbits (around 50% of orbits)	10,2	9,3	6,7	6,1	10,2	9,3	7,3	6,6
PICAM S orbits (around 50% of orbits)	8,1	7,4						

MIPA

Elena Main Board
EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
MIPA	3,5	2,6	3,5	2,6	3,5	2,6	3,5	2,6

TOTAL

Note
Picam S orbits considered
Picam H orbits considered

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU + All units (Picam S orbits)	40,4	36	34,1	30,2	43,4	38,8	32,7	29,1
SCU + All units (Picam H orbits)	42,5	37,9						

8.4 May 18th , 2012

Revision: 24 April 2012

ALL VALUES in tables are AVERAGE power consumption

SCU ELENA

Notes:

DCDC for MIPA is hosted on Elena Main Board
EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU	4,6	4,2	4,6	4,2	4,6	4,2	4,6	4,2
ELENA with MIPA OFF	14,9	13,54	10,8	9,8	14,9	13,54	10,8	9,8
ELENA with MIPA ON	15,9	14,45	11,8	10,71	15,9	14,45	11,8	10,71
ELENA with SCU and MIPA OFF	19,5	17,74	15,4	14	19,5	17,74	15,4	14
ELENA with SCU and MIPA ON	20,5	18,65	16,4	14,91	20,5	18,65	16,4	14,91

STROFIO

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
STROFIO	7,5	6,58	7,5	6,58	8,44	7,52	5,5	5

PICAM

Notes

EOL = BOL +10%, H = Hadamard mode, S = Single pulse mode

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
PICAM H orbits (around 50% of orbits)	10,2	9,3	6,7	6,1	10,2	9,3	7,3	6,6
PICAM S orbits (around 50% of orbits)	8,1	7,4						

MIPA

Elena Main Board
EOL = BOL +10%

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
MIPA	3,5	2,6	3,5	2,6	3,5	2,6	3,5	2,6

TOTAL

Note
Picam S orbits considered
Picam H orbits considered

Unit	Nominal (EOL/BOL) [W]		Calibration (EOL/BOL) [W]		Burst [W] (EOL/BOL)		Diagnostic (EOL/BOL) [W]	
SCU + All units (Picam S orbits)	39,6	35,2	34,1	30,2	42,6	38,1	32,7	29,1
SCU + All units (Picam H orbits)	41,7	37,1						

8.5 January, 28th 2013

Revision: 28 January 2013

ALL VALUES in tables are AVERAGE power consumption

SCU ELENA

Notes:

DCDC for MIPA is hosted on Elena Main Board
EOL = BOL +10%

Unit	Nominal	(EOL/BOL) [W]	Calibration (EOL/BOL) [W]		Burst [W]	(EOL/BOL)	Diagnostic (EOL/BOL) [W]	
SCU	4,6	4,2	4,6	4,2	4,6	4,2	4,6	4,2
ELENA with MIPA OFF	14,8	13,49	10,8	9,8	14,8	13,49	10,8	9,8
ELENA with MIPA ON	15,8	14,4	11,8	10,71	15,8	14,4	11,8	10,71
ELENA with SCU and MIPA OFF	19,4	17,69	15,4	14	19,4	17,69	15,4	14
ELENA with SCU and MIPA ON	20,4	18,6	16,4	14,91	20,4	18,6	16,4	14,91

STROFIO

Unit	Nominal	(EOL/BOL) [W]	Calibration (EOL/BOL) [W]		Burst [W]	(EOL/BOL)	Diagnostic (EOL/BOL) [W]	
STROFIO	7,5	6,58	7,5	6,58	8,44	7,52	5,5	5

PICAM

Notes

EOL = BOL +10%, H = Hadamard mode, S = Single pulse mode

Unit	Nominal	(EOL/BOL) [W]	Calibration (EOL/BOL) [W]		Burst [W]	(EOL/BOL)	Diagnostic (EOL/BOL) [W]	
PICAM H orbits (around 50% of orbits)	9,5	8,6	6,7	6,1	9,5	8,6	4,4	4
PICAM S orbits (around 50% of orbits)	7,5	6,8						

MIPA

Elena Main Board
EOL = BOL +10%

Unit	Nominal	(EOL/BOL) [W]	Calibration (EOL/BOL) [W]		Burst [W]	(EOL/BOL)	Diagnostic (EOL/BOL) [W]	
MIPA	3,5	2,6	3,5	2,6	3,5	2,6	3,5	2,6

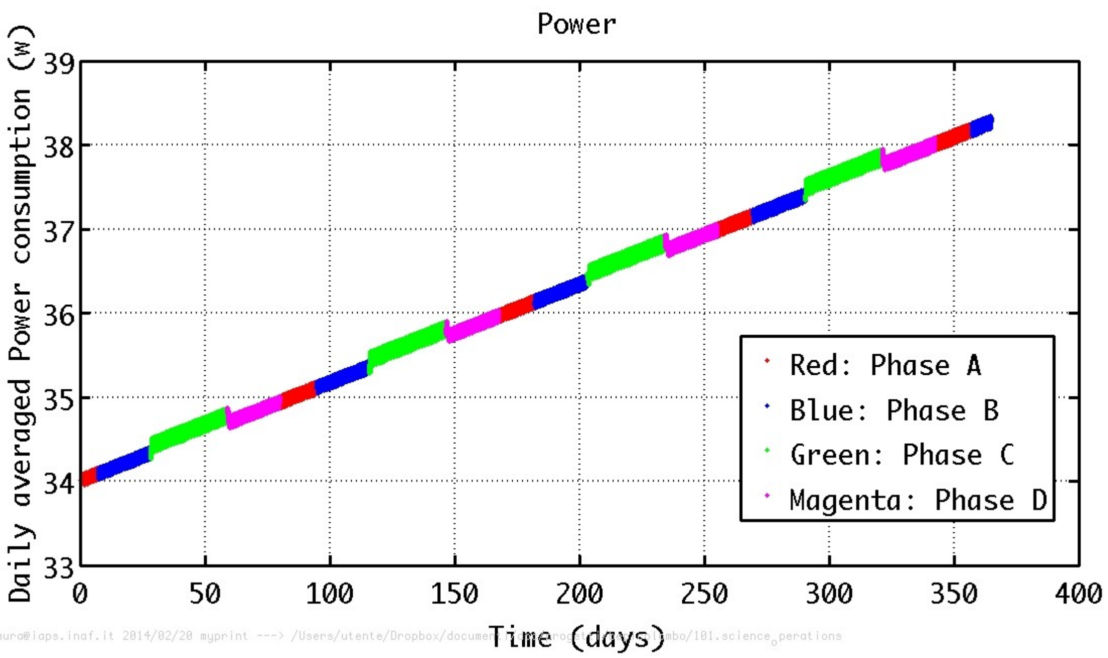
TOTAL

Note	Unit	Nominal	(EOL/BOL) [W]	Calibration (EOL/BOL) [W]		Burst [W]	(EOL/BOL)	Diagnostic (EOL/BOL) [W]	
Picam S orbits considered	SCU + All units	**38,9**	**34,6**	**34,1**	**30,2**	**41,8**	**37,3**	**29,8**	**26,5**
Picam H orbits considered		**40,9**	**36,4**						

9 Power profiles

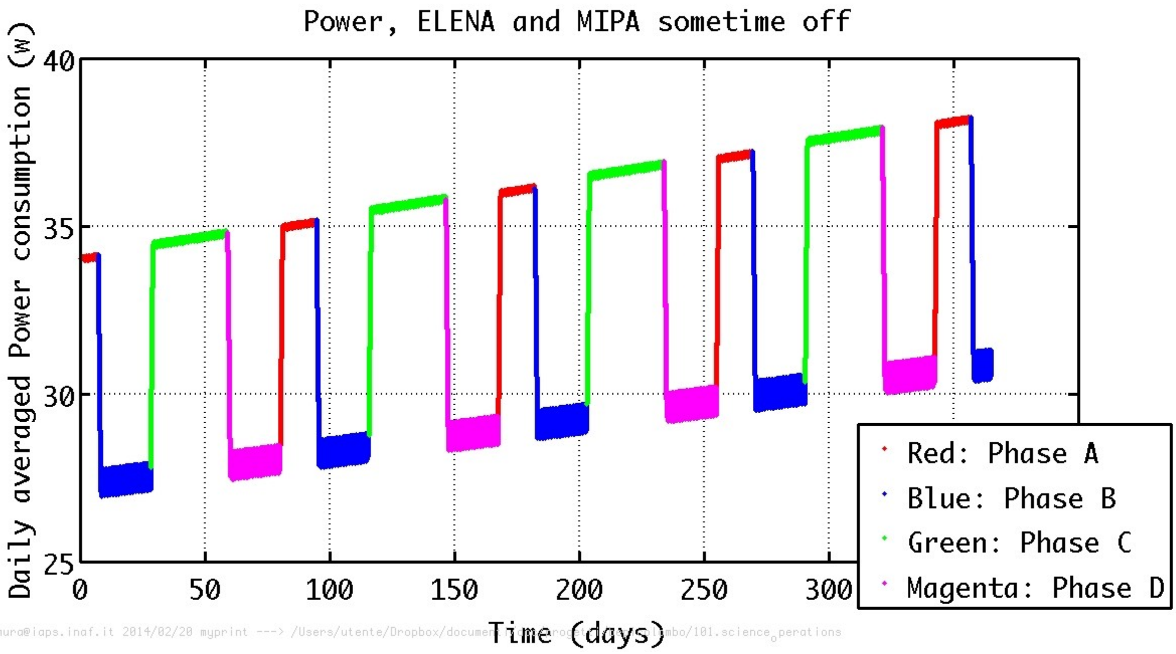
9.1 Daily average power consumption

By using the above SAP and power tables, it is possible to estimate the SERENA power consumption during the whole mission.



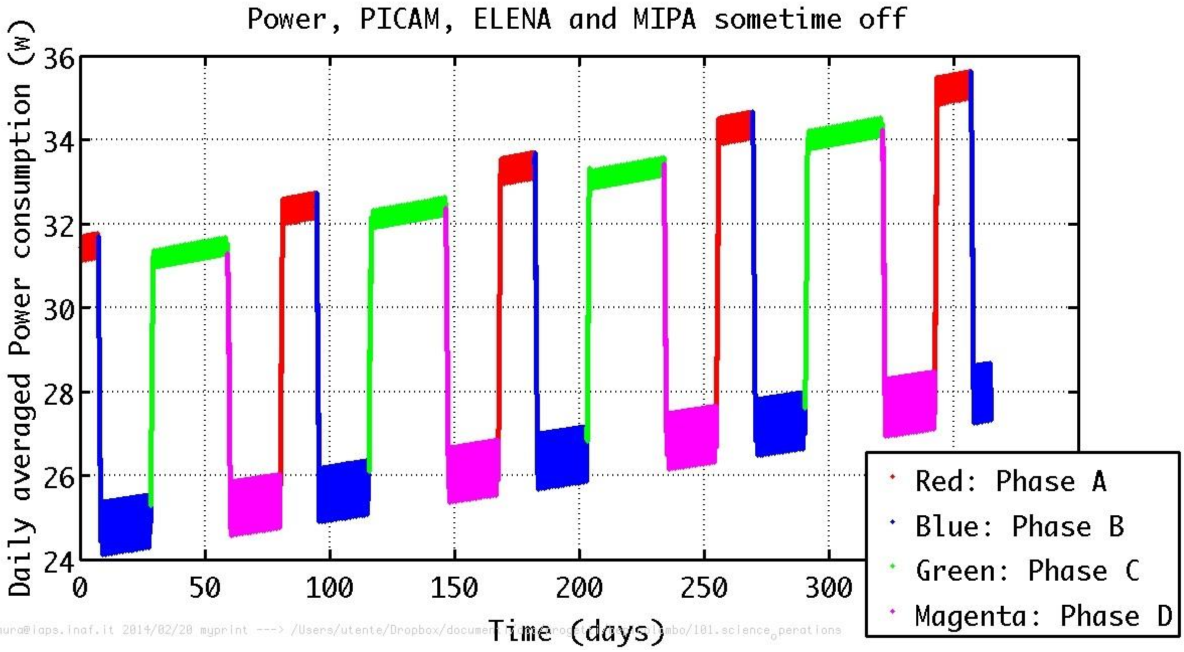
9.2 Reduced power consumption strategy, example.

It is possible to reduce the SERENA average power consumption by switching off some instruments when they are not at high priority. In the following example, instead of switching ELENA and MIPA to low data rate, they are switched off.



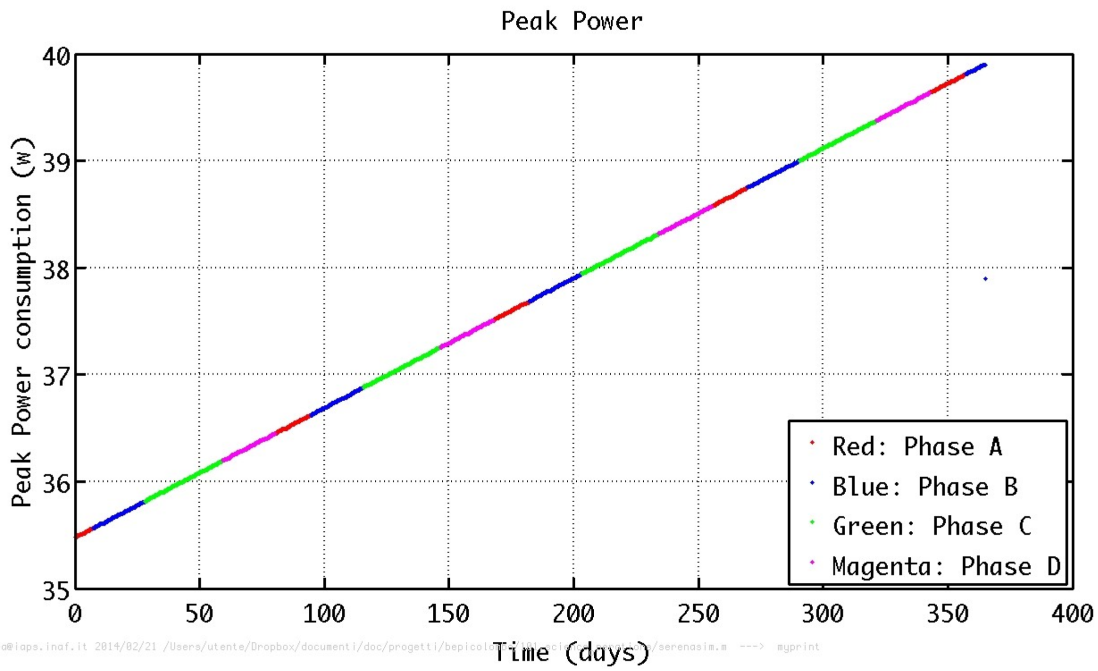
9.3 Reduced power consumption strategy, 2nd example

It is possible to reduce the SERENA average power consumption by switching off some instruments when they are not at high priority. In the following example, instead of switching ELENA PICAM and MIPA to low data rate, they are switched off.



9.4 Peak power consumption

The maximum power needed by SERENA is shown in the following figure.



10 References

TBW

Appendix A: SAP table in different format (TBC)

Table 10

Phase		STROFIO	ELENA	PICAM	MIPA
AA	Orbits	all	all	all	all
	Time (%)	100	100	65	100
	Obj.	2a, 2b, 2c, 2d, 2e, 6a, 6c, 6d, 6e	6a, 6b, 6c, 7a	4, 5b	5a, 5b, 6a, 6b
	Mode	**N**	**H**	IM_HT_HR	5
AP	Orbits	all	all	5/6 1/6	3/6
		100	50	75	60
	Obj.	1, 2a, 2b, 2c, 2e, 2d, 6a, 6c, 6d	6a, 6b, 6c, 7a	3, 4, 5b	5a, 5b, 6a, 6b
	Mode	N	**N**	MC_HR_LE MD_MR_HE	5
BA	Orbits	all	50% 50%	all	3/6
		100	80	70	70
	Obj.	2a, 2d, 2e, 6d, 6e	7a	4, 5b,7c	5b, 7c
	Mode	N	N L	IM_HT_HR	6
BP	Orbits	all	50% 50%	5/6 1/6	3/6
		100	95	90	80

	Obj.	1, 2a, 2d, 2e, 6a, 6c, 6d, 6e	6a, 6b, 6c, 7a	3, 4, 5b	5a, 5b, 6a, 6b
	Mode	N	N L	MC_HR_LE MD_MR_HE	5
CA	Orbits	all	all	5/6 1/6	all
		100	60	80	65
	Obj.	2a, 2b, 2c, 2d, 2e, 6d	7b	4, 5b, 7c	5b, 7c
	Mode	N	H	IM_HR_HT MC_HR_LE	6
CP	Orbits	all	all	5/6 1/6	all
		100	100	100	80
	Obj.	1, 2a, 2b, 2c, 2d, 2e, 6a, 6c, 6d, 6e	6a, 6b, 6c, 7a	3, 4, 5b	5a, 5b, 6a, 6b
	Mode	N	H	MC_HR_LE MD_MR_HE	5
DA	Orbits	all	50% 50%	all	3/6
		100	80	80	80
	Obj.	2a, 2d, 2e, 6d, 6e	7b	4, 5b,7c	5b, 7c
	Mode	N	N L	**IM_HT_HR**	6
DP	Orbits	all	50% 50%	5/6 1/6	3/6
		100	95	90	80

	Obj.	1, 2a, 2d, 2e, 6a, 6c, 6d, 6e	6a, 6b, 6c, 7a	3, 4, 5b	5a, 5b, 6a, 6b
	Mode	N	L N	MC_HR_LE MD_MR_HE	5