HERSCHEL / PLANCK

Planck Cleanliness Control Plan

Product Code : 200000

Rédigé par/*Written by*	**Responsabilité-Service-Société** ***Responsibility-Office -Company***	**Date**	**Signature**
M. Giordanengo	Cleanliness System Engineer		
Vérifié par/*Verified by*			
T. Banos	Planck PLM manager	21/07/04	
P Rideau	Herschel/Planck System Engineer	21/07/04	
Approbation/*Approved*			
C Masse	Herschel/Planck PA Manager	19/07/04	
Released by			
JJ Juillet	Herschel/Planck Program Manager	21.07.04	

Data management : G. SERRA

Entité Emettrice : Alcatel Space - Cannes
(détentrice de l'original)

HERSCHEL/PLANCK	DISTRIBUTION RECORD

DOCUMENT NUMBER : H-P-1-ASPI-PL-0253

Issue 03/ Rev. : 00

Date: 16-07-2004

EXTERNAL DISTRIBUTION		INTERNAL DISTRIBUTION	
ESA		**HP team**	**X**
ASTRIUM			
ALENIA			
CONTRAVES			
TICRA			
TECNOLOGICA			
		Clt Documentation	**Orig.**

ENREGISTREMENT DES EVOLUTIONS / *CHANGE RECORDS*

ISSUE	DATE	§ : DESCRIPTION DES EVOLUTIONS *§ : CHANGE RECORD*	REDACTEUR *AUTHOR*
01	15/06/2002	Initial Issue	M. Giordanengo
02	09/04/2004	Update of the document for the CDR PPLM : • Implementation of the witnesses for the hardware and the cleanroom (§ 9.2) • Detailed flow chart of the CQM according to the CQM AIT plan (§ 9.4)	M. Giordanengo
03	16/07/2004	Update of the document following the CDR PPLM RIDs for the CQM : • Text correction (§ 6, 9.1.6) • Hypotheses for mechanical tests (§ 9.1.1) • Witnesses for the CQM and the FM (§ 9.2.1) • FPU budget (hypothesis : § 9.4.1; CQM budget : § 9.4.3) • Hypotheses for the contamination redistribution in the optical cavity (§ 9.1.1) Update of the document for the FM contamination budget : • Integration of the new AIT inputs (§ 9.5) • Discussion on the PPLM cleaning efficiency and on the FPU cover (§ 11.3)	M. Giordanengo

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

This document presents the dispositions taken during the AIT sequence of Planck satellite to guarantee that the contamination level reached after the launch is compliant with the optical performances specifications. More over, it gives a detailed contamination synoptic that covers all the AIT sequences, from the beginning of the satellite integration to the delivery to Arianespace.
As it concerns AIT sequence, only the on ground contaminants, particulate and molecular, are studied. The other contaminants (NH_3, H_2O …) are taken into account in the flight analyses ([RD04]).

In § 10, PFM contamination budgets are calculated, considering the impact of the AIT sequence detailed in § 9.3. They are then compared to the needs.

This document is applicable to the CQM and the PFM.
Compared to the issue 2 of the document, the hypotheses have not been updated for the PFM.

2. DOCUMENTATION

2.1 Reference documents

[RD01] : ECSS-Q-70-01 : "Contamination and cleanliness control"

[RD02] : ESA PSS 01 204 : "Particulate contamination control in cleanrooms by particle fallout measurements "

[RD03] : ESA PSS 01 705 : "The detection of organic contamination of surfaces by infrared spectroscopy"

[RD04] : H-P-1-ASPI-AN-0269 :"Contamination Analysis"

[RD05] : H-P-1-ASPI-MN-1488 :"Cleanliness Team MoM N°7"

[RD06] : ASPI-02-PM/PT-0409 :"caractérisation du nettoyage de Nida Aluminium"

[RD07] : H-P-3-ASPI-TS-0051 :"Requirement specification for the Planck cryogenic facility"

[RD08] : ICU 623 : "Evaluation de la contamination moléculaire"

[RD09] :	ICU 625 :	" Evaluation de la contamination particulaire surfacique par compteur de particules en milieu liquide: METONE 211"
[RD10] :	ICU 626 :	" Evaluation de la contamination particulaire surfacique par microscope BHSM-NL "
[RD11] :	ICU 904 :	" Contrôle et suivi des salles à ambiance contrôlée "
[RD12] :	ICU 906 :	" Contrôle de pollution particulaire en lumière UV "
[RD13] :	IFCA 250.000 :	"Conditionnement des pièces spatiales"
[RD14] :	IFCA 291.000 :	"Nettoyage, emballage, déballage des pièces de types Classe 100"
[RD15] :	IFCA 341.000 :	"Procédure de travail en salle V01 Nord"
[RD16] :	IFCA 428.000 :	" travail en salle à empoussièrement contrôlé de cl 10000 et 100 000"
[RD17] :	REF-ASP-PN-93-F :	"salles propres à ambiance contrôlée"

2.2 Applicable documents

[AD01] : H-P-1-ASPI-SP-0035 :"Cleanliness requirements specifications"

[AD02] : H-P-3-ASP-PL-0668 :"Planck CQM AIT Plan"

3. ACRONYMS

AD	Applicable Document
AIT	Assembly, Integration and Test
CVCM	Collected Volatile Condensable Material
EOL	End Of Life
GSE	Ground Support Equipment
MLI	MultiLayer Insulation
NRB	Non-Conformance Review Board
PA	Product Assurance
PLM	PayLoad Module
PPM	Parts Per Million
QA	Quality Assurance

RD	Reference Document
RF	Radio Frequency
RML	Recovered Mass Loss
S/C	Spacecraft
SVM	Service Module
TBC	To Be Confirmed
TBD	To Be Defined

4. LIST OF SENSITIVE ELEMENTS

Planck sensitive elements (in term of contamination) are :

- the focal plane unit
- the reflectors
- the V-grooves low emissivity surfaces
- the V-grooves high emissivity surfaces
- the external side of the baffle
- the inner side of the baffle.

5. AIT CONTAMINATION ALLOCATIONS

All the contamination allocations for the AIT sequence (till encapsulation) are given in [AD01].
They are applicable to the PFM :

element	particulate contamination allocation for S/C AIT till encapsulation
Focal plane unit	800 ppm
Primary and secondary reflectors	800 ppm
Baffle inner side	2400 ppm
External parts of the PPLM	1500 ppm
External surfaces of the SVM	3400 ppm

Table 5.1 : particulate contamination allocations for S/C AIT till encapsulation

element	molecular contamination allocation for S/C AIT till encapsulation
Focal plane unit	$3\ 10^{-7}$ g/cm^2
Primary and secondary reflectors	$3\ 10^{-7}$ g/cm^2
Baffle inner side	$4\ 10^{-7}$ g/cm^2
External parts of the PPLM	$6\ 10^{-7}$ g/cm^2
External surfaces of the SVM	$2\ 10^{-6}$ g/cm^2

Table 5.2 : molecular contamination allocations for S/C AIT till encapsulation

6. GENERAL RULES FOR PREVENTION OF CONTAMINATION

6.1 Design

The materials near the sensitive surfaces shall be compliant with the outgassing specifications (RML < 1% ; CVCM < 0.1%). This criterion is necessary but may not be sufficient. So, due to the potential outgassing that shall not affect the cleanliness level, a conditioning may be realised considering the needs coming from the cleanliness analyses.

Generally, the following kinds of materials will undergo a bake out :

- the materials that have a view factor with the optical surfaces
- the materials that are near the optical surfaces
- the materials that are in the optical cavity
- the materials that have a high mass and an important temperature difference with the optical surfaces.

The materials used for the sensitive elements shall not induce scraps . They must be inert with regards to the creation of particles.

The metal pieces shall not have pointed edges that could create particles during integration.

Open holes will be avoided.

6.2 Manufacturing

All items manufactured in non-clean conditions shall be subject to cleaning to the required cleanliness level and packaged for delivery to the classified clean area according to [RD14]. Such cleaning and packaging shall be supervised and certified by the PA Engineer.

For the lubrication during manufacturing, no oil with paraffin will be used. Oils cleanable with usual solvents will be preferred. After each operation, the pieces will be degreased.

The metal pieces shall not have barbs that could create particles during integration. This point has to be checked at their arrival.

6.3 Assembly and test

6.3.1 Clean rooms

The cleanliness of Assembly, Integration and tests areas must be compatible w.r.t. equipment/subsystem/system required cleanliness level.

Certification of the facilities in accordance with the cleanroom standards shall be done by the QA Department. PA shall also check the facilities compliance to project requirements and review the operating controls implemented in the facilities.

All hardware not pre-packaged must be cleaned before entering the controlled areas up to the required cleanliness levels.

Written operational guides are established to avoid contamination and degradation of the cleanrooms cleanliness level.
This guide shall deal with :

- rules to be applied
- cleanroom constraint and monitoring
- cleanroom cleaning
- garments
- personnel entrance …

All these requirements are included in the document [RD17].

The critical elements are protected most of the time during activities according to § 9. During exposure of these elements, the time duration shall be controlled and recorded.

For specific tests or facilities:

1. Acoustic and vibrations facilities
   - The responsible shall take measures to reduce or eliminate the contamination hazards by keeping the exposure time to the minimum, using additional enclosure, clean walls, clean tent...
   - The cleanliness constraints defined in the cleanliness control plan shall be integrated in the AIT plan and procedures shall be approved by the PA Engineer.

2. Thermal vacuum facilities

Just prior any application to hardware, it shall be demonstrated that the test facilities will not induce unacceptable contamination to the hardware. A blank test shall be performed to check this.

6.3.2 Personnel

The personnel have to respect the specifications of [RD17] and of [RD15].

All personnel working in clean areas shall receive training about the purpose and practice of clean area operations. Only those trained people shall be authorised for area access.
The clothes (cap, gloves, mask …) must be compatible with the 100000 or 10000 cleanroom.

Only personnel trained in precision cleaning process shall be involved in special hardware cleaning.

Any manipulation of flight hardware and the associated set of tools must be done with clean and lint-free gloves.

Personnel assignment and entry into a clean area shall be under the responsibility of the AIT manager.

For occasional visitors who might need to enter the clean room the right of access shall be given by the AIT manager. He has the responsibility for visitor briefing in compliance with cleanroom procedures.

6.3.3 GSE

For all GSE :

- a cleaning to meet the required cleanliness level has to be performed
- packaging has to be implemented before delivery to the classified clean area

according to [RD14] and [RD16].

The GSE submitted to the same constraints as the hardware shall meet the same requirements.

For uncleanable means, the cleanliness of manufacturing area must be compatible w.r.t. equipment/subsystem/system required cleanliness level. If not, covers shall be implemented not to contaminate the hardware.

Special attention has to be taken for GSE and means used under vacuum.

6.3.4 Cleaning process

The cleaning processes used to clean integration means (as screws, nuts, washers …) are defined in [RD13] and [RD14].

6.3.5 Harnesses

All manipulations that create particles after wiring are forbidden.

Interventions as soldering, splice, crimping, stripping … are not authorised in cleanroom. In case of need, specific procedures will be defined in the frame of NRB.

All the wiring activities will be done with a special care and will be treated individually.

6.4 Handling, packaging, transport

The packaging processes are defined in [RD13] and [RD14].

Handling of components and units shall be minimised and shall be controlled in accordance with the respective handling and safety procedures. A protection of sensitive elements and cleanliness volumes must be used as often as possible. Clean items shall be protected from contamination by proper preservation, packaging or storage prior to further handling as assembly and integration.

Packaging requirements shall be defined in written procedures. Their content shall be reviewed for contamination aspects by the PA Engineer. The requirements of ECSS-Q-70-01 § 6.5. shall be met by these procedures (packing materials shall not release corrosive vapours or containing corrosive constituents. The contamination level of the packed item shall not increase the specified cleanliness level…).

Transportation containers shall be designed such as the contamination of the components contained therein is not degraded. Consequently, materials used in the construction of the container shall not induce contamination. Entry of contamination from external sources shall not be possible. Purging gas system shall contain appropriate filtration.

Monitoring of contamination during transportation shall be carried out by the provision of particulate and molecular witnesses and visual inspection as a minimum. Cleaning procedures for the transport containers shall be developed and applied prior to use it for flight hardware.

6.5 Storage

The storage shall be performed:

- either in clean packaging (see [RD14])
- or in clean container.

In any case, the cleanliness conditions during storage have to meet the equipment/subsystem/system cleanliness requirements.

Cleanliness during storage shall be controlled with at least a pair of particulate and molecular witnesses and recorded.

6.6 Launch activities

The cleanliness during launch activities shall be compatible w.r.t. required cleanliness level.

A monitoring of cleanliness during these phases has to be implemented to control contamination. This monitoring consists in :

- registrating the exposure duration
- controlling the room area under UV light (TBC).

7. CLEANLINESS CONTROL

7.1 Method of control

7.1.1 Molecular control

The molecular contamination must be checked by I.R. spectrometry method according to [RD08]. This method is compatible with ESA PSS 01 705.

7.1.2 Particulate control

The particulate contamination can be controlled by 3 methods :

- counting the particles in a volume using a particle counter functioning on a light diffusion (MET ONE, HIAC-ROYCO) according to [RD11]
- the indirect method which consists in counting in the rinsing solvent the dust grains of different sizes, with the help of a microscope ([RD10]) or a liquid laser counter ([RD09]) which answers to the specifications listed in ESA PSS 01 204
- counting the contamination under UV light as described in [RD12].

7.2 Hardware monitoring

Monitoring of the hardware shall be performed during manufacturing (if necessary), AIT, transportation, storage... at equipment, subsystem or system level by the company responsible of the hardware, in compliance with cleanliness flow chart.

Due to contamination risks during handling and inability to clean some optical elements (which may cause performance degradation) monitoring by witnesses is recommended and wiping process shall be strictly limited.

At least one pair of molecular / particulate witnesses will be placed in the equipment (TBC), or subsystem or system near the sensitive elements. They can be useful either for specific activities (vibrations, etc...) or for cumulating the pollution until final measurements.

- They will be exposed in an environment representative of the sensitive elements one.
- All the measurements shall be recorded and sent to the QA Engineer.

The policy hold for Planck critical elements is :

- to protect them each time it's possible
- to clean them (in case of cleanable elements) in order to decrease their contamination level.

For each critical element, when no cleaning is scheduled any more, the contamination level will be followed using witnesses. Their types, positions and the frequency of controls are defined in § 9.2.

7.3 Cleanroom monitoring

The cleanroom shall respect the rules defined in [RD17].

Within an environmentally controlled area, only the equipment which is specifically needed for the work in progress shall be stored. Equipment to be used in a clean room shall be cleaned before entering the clean area. Special care shall be taken so that volatile materials (e.g. oil) are not stored or used near the equipment.

Prior to the entry of flight hardware into a clean area, the cleanliness of this area shall be checked.

7.4 Treatment of the non-conformance

Each non-conformance will be treated as specified in PA plan H-P-1-ASPI-PL-0055.

In a first step, no cleaning or decontamination are scheduled for the optical surfaces (reflectors and FPU) : it is considered as an exceptional case. In case of accidental contamination of these critical surfaces, dispositions will be taken according to NRB.

7.5 Documentation

The applicable documents for the usual information (cleaning processes, working procedures, bake out …) are listed in the § 2.2.

All the cleaning processes developed especially for Planck will be listed in the « Declared Process List ».

All the results concerning the cleanliness levels reached on the satellite will be gathered by the QA Engineer and checked with the Cleanliness Engineer.

At the end of the AIT phase, a summary of the cleanliness levels reached will be provided by the QA Engineer in the ADP.

8. CLEANLINESS CONTROL PLAN FOR THE SUB-SYSTEMS

8.1 Cleanliness control plan

All the ASPI cleanliness specifications will be applicable to the subcontractors.

Each subcontractor will answer to this specification by a cleanliness control plan. He must indicate the location of activities, the time exposure duration, the moment of protections, the moment of cleaning, the cleaning and preventive actions, the tests procedures (whether the test could have an effect on cleanliness level), the cleanliness flow chart, the cleanliness and inspection procedures.

The Prime Contractor has to check the conformance between the specifications and the specific provisions scheduled in the subcontractors Cleanliness Control Plans.

When this plan, after comments and negotiation, is in accordance with the specifications, it is approved by the Cleanliness Engineer and it becomes prior to the specifications.

8.2 Audit

- In case of non-conformance or repeated problems concerning the cleanliness level of a Subcontractor delivery, a cleanliness audit will be performed by PA Engineer, in order

⇨ to check the application of the Cleanliness Control Plan
⇨ to determine the potential lacuna of this plan
⇨ to determine the preventive and corrective necessary actions to reach the cleanliness specification.

- The Subcontractor shall conduct audits of his own and of his lower Subcontractors or Suppliers facilities, equipment, personnel, procedures, services and operations to check if this Cleanliness Control Plan is well applied.

- An audit can also be conducted to estimate the available means of a new supplier that has no space references.

It is recommended that the "cleanliness audits" are performed by a team of personnel trained with the cleanliness activities; Planck Cleanliness Engineer shall participate to such audits.

These audits shall be conducted early in the program to minimize the effects of the eventual corrective actions. The results of these audits shall be documented in a report and the follow-up of the required corrections must be performed by the concerned Contractor.

ASPI and its Customer shall be invited to participate to such audits, and shall receive a copy of these reports.

8.3 Documentation

At delivery, each Subcontractor summarises the reached cleanliness levels.
This cleanliness report will be included in the End Item Data Package.

8.4 Contractors cleanliness control plan

All the subsystems for which ASPI expects a cleanliness control plan are listed here after.

8.4.1 Cryostructure

8.4.2 Telescope

8.4.3 FPU

8.4.4 SVM

9. AIT/AIV SEQUENCE

9.1 Hypotheses

9.1.1 Contamination during AIT (except cryogenic tests)

All the AIT, except cryogenic tests, is done in Cannes, in a cleanroom 100000. The following expected contamination levels are given considering the standard particles size distribution MIL-STD-1246-B.

- 1 day in class 100000 : 225 ppm
- 1 year in class 100000 : 1.10^{-6} g/cm^2

These values correspond to 24 working hours. To take into account the real exposure time, if the material is protected during the non-working hours, a correction coefficient has to be applied.
The normal work corresponds to 8 working hours per day.

- If the hardware is protected otherwise, the coefficient to be applied on the number of days will be taken equal to 0.5 (and not 8/24 = 0.33) to keep a margin.
- If not, the coefficient is equal to 1.

According to the Cleanliness Team Report (see [RD05]), for the specific phases (vibration or acoustic tests, transport),the assumptions are :

- Particulate : 25 ppm
- Molecular : 1.10^{-9} g/cm^2 /day (equivalent to contamination in cleanroom 100).

Note 1 : the values of contamination for the mechanical tests correspond to the means of Alcatel Cannes. In particular, a tent is attached on the top of the chamber and covers the satellite.

Note 2 : Concerning the redistribution,

- For the CQM model, the mirrors or the FPU are not present during the test (see § 9.4.2), so the impact of redistribution has not to be considered
- For the FM model, the redistribution inside the optical cavity is considered in the "cleanliness end of life analysis" (H-P-1-ASPI-AN-0269) considering the ratio of the optical cavity inner surfaces.

9.1.2 Contamination during cryogenic tests

These tests take place in CSL in a cleanroom 10000. The following expected contamination levels are given considering the standard particles size distribution MIL-STD-1246-B.

- 1 day in class 10000 : 60 ppm
- 1 year in class 10000 : 1.10^{-6} g/cm^2

These values correspond to 24 working hours.
The spacecraft arrives in CSL with its protections. As long as they are not put away, the particulate and molecular contamination are not considered for the corresponding elements.

1 thermal vacuum test (according to the cleanliness working team – see [RD05]) :
- Particulate : 25 ppm
- Molecular : 1.10^{-9} g/cm^2 /day

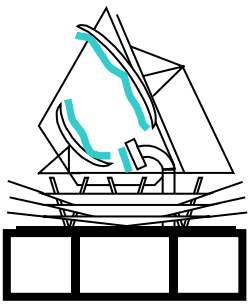
9.1.3 Protections

The protections only concern the PPLM : the SVM is not supposed to be protected.

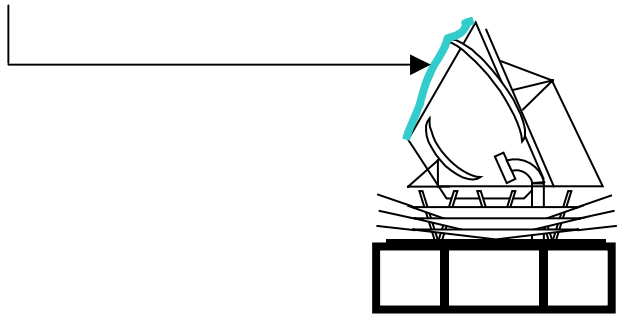
During non-working periods, the PPLM is protected as far as possible. In that case, it is supposed that the particulate and the molecular contamination are null (see [RD05]).

5 different protection configurations are defined for Planck.

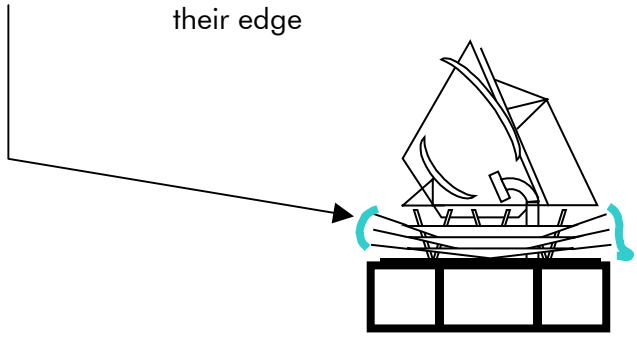
- Protection 0 : no covers on the whole PPLM (including the optics)
- Protection 1 : covers on the 2 mirrors and the FPU



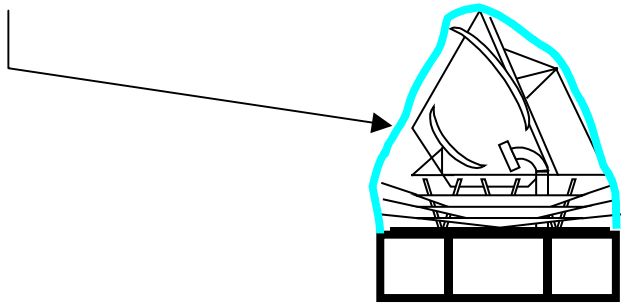
- Protection 2 : the optical cavity is covered with a film



- Protection 3 : the upper and lower faces of the grooves are protected with a film on their edge



- Protection 4 : the whole PPLM is covered



9.1.4 Cleanliness budget

For each critical subsystem in term of contamination, the duration of each phase is divided between :

- the periods without protection
- the periods with protection.

The total amount of exposed hours is then multiplied by the contamination per hour linked to the cleanroom class.

For the specific phases (thermal vacuum, mechanical tests and transports), the budget defined in § 9.1.1 and 9.1.2 is then added.

9.1.5 Hypotheses for the cleanings

The cleanings only concern the particulate contamination, as the molecular contamination has been shown as non critical (see budget in § 11.1).

The assembly really begins with the RAA mounting. For the earlier activities (WU preparation), the panels are supposed to be cleaned after their preparation, before their assembly. As it concerns plane surfaces, they are supposed to reach 300 ppm after this cleaning.
The electronics, the piping and the He tank are supposed to be integrated at 300 ppm - 2 10^{-7} g/cm^2. Concerning the harness, the cleaning is supposed to decrease the contamination down to 1000 ppm - 10^{-6} g/cm^2

If a cleaning is scheduled on the SVM, it is supposed that not all the surfaces are accessible (due to external elements such as antennas …). The final contamination level is calculated supposing that :

- 90 % of the surface reaches a level of 1000 ppm
- 10% of the surface keeps the initial level Ci.

So the final level is equal to : (Ci * 0.1) + (1000 * 0.9).

If a cleaning is scheduled on the PPLM, as it can concern non plane surfaces, it is supposed that the particulate contamination can decrease down to 1000 ppm.
If this cleaning happens once the baffle is mounted, the optical cavity is not accessible anymore. So its particulate contamination is not improved by the cleaning.

9.1.6 Preventive actions

9.1.6.1 Global preventive actions

During the assembly / integration, if no activities are scheduled on the PPLM, it is protected, whatever its integration status.

A cleaning of the PPLM is scheduled just before the baffle mounting : it corresponds to the last moment when the telescope is accessible. During this phase, the PPLM and the baffle are cleaned. It takes 2 days to install the baffle and close the optical cavity. So the optical cavity can be exposed 2 days to the environment 100 000 after its cleaning, before its protection.

In the AIT sequence, for the shrouds installation (or the shrouds removal) in CSL, the optical cavity cover can be put away very late (or put in very early) in the phase. So the optical cavity, the mirrors and the FPU are non protected only one day during the shrouds installation or the shrouds removal.

9.1.6.2 Specific preventive actions for the CQM

The CQM will be used to qualify the PPLM cleaning procedures at S/C level. The implementation of this cleaning in the CQM flow chart depends on the expected contamination level, in order to be representative of the ones estimated on the PFM level before the S/C cleanings (se § 9.5).

The following cleanings are scheduled on the CQM :

- at the end of the acoustic test, once the model is dismounted, the different parts of the PPLM (telescope, baffle, grooves) will be cleaned separately. A level of 1000 ppm is expected on these elements. A cleaning will also be applied on the different panels of the SVM : as they are cleaned individually, a level of 1000 ppm is expected too.
- at the end of the cryo test, the external sides of the baffle and the grooves will be cleaned before the model dismounting. The dismounting allows to control the reached particulate level on the different parts of the grooves (extension and centre).

Concerning the cleanings, as for the PFM, a spacecraft cleaning is scheduled in Cannes before the transport to CSL. According to the CSL AIT activities duration, this cleaning guarantees a particulate contamination before the cryo test in accordance with the one expected for the PFM.

9.1.6.3 Specific preventive actions for the PFM

Three cleanings are scheduled on the whole spacecraft :

- one at the end of the assembly / integration phase
- one in CSL before the first thermal vacuum test
- one before encapsulation.

During the RF tests, the optical cavity will be protected with a specific film that is RF transparent. The associated assumption for the decontamination is that it takes half a day to :

- remove the protections to have access to the optics
- remove the mirrors and the FPU covers
- put the optical cavity film in position.

So the optical cavity, the mirrors and the FPU are supposed to be non protected only half a day.
Note : the necessity of this protection during the RF test will be confirmed during the update of the FM contamination budget.

The thermal vacuum instrumentation scheduled for the optical cavity induces only one day of work, so only one day without cover for this cavity.

9.2 Control / witnesses

9.2.1 Witnesses on the hardware

The policy for the contamination control is defined as follows :

- step witnesses will be scheduled for the environmental tests and RF tests
- cumulative witnesses will be implemented to guarantee a contamination level at delivery.

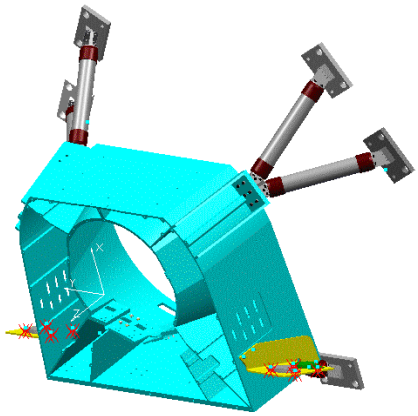
In the following description of the witnesses, the term “set” includes :

- 2 cumulative witnesses (1 molecular and 1 particulate)
- 2 step witnesses (1 molecular and 1 particulate).

9.2.1.1 Witnesses for the CQM

The following sets of witnesses will be implemented on the CQM :

- one set is positioned inside the optical cavity. It will be linked on the FPU (see next figure)

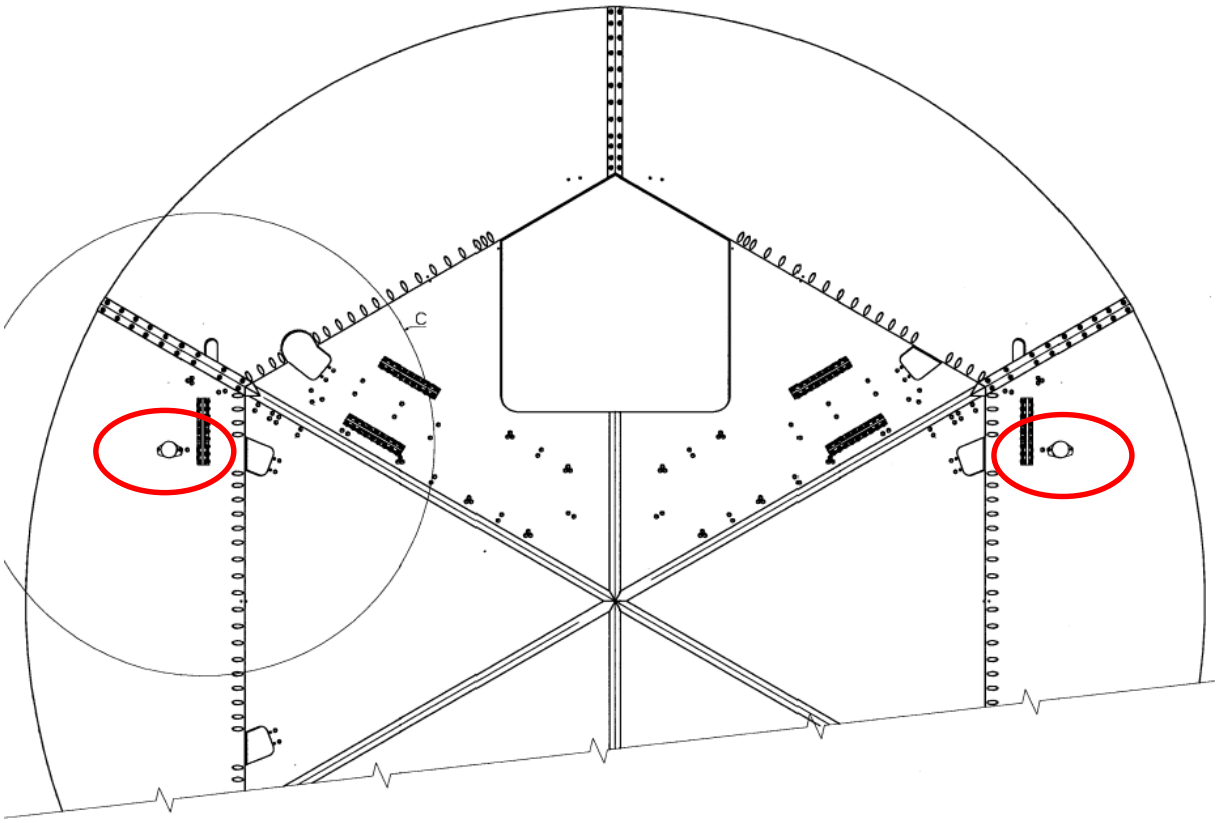


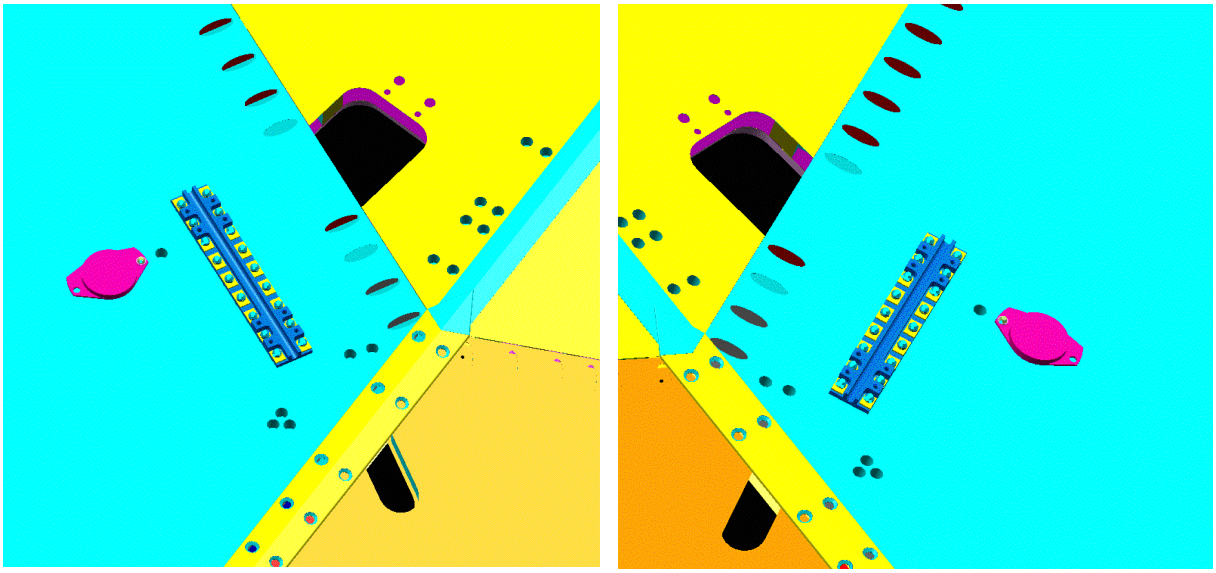
- one set is positioned on the upper face of the groove 2 extensions or the lower face of the groove 3.

Molecular Cumulative and Step witnesses location on Cryo-Structure :

These 2 witnesses are directly attached with one screw each on the lower side of Groove 3 (-X face), definition of the link for 1 piece :

- 1 screw RSAT M4x10
- 1 Spring washer CuBe2, Dia int 4.2 mm, Dia ext 8 mm, thickness 0.4 mm
- 1 large washer, Dia int 4.25 mm, Dia ext 14 mm, thickness 0.8 mm

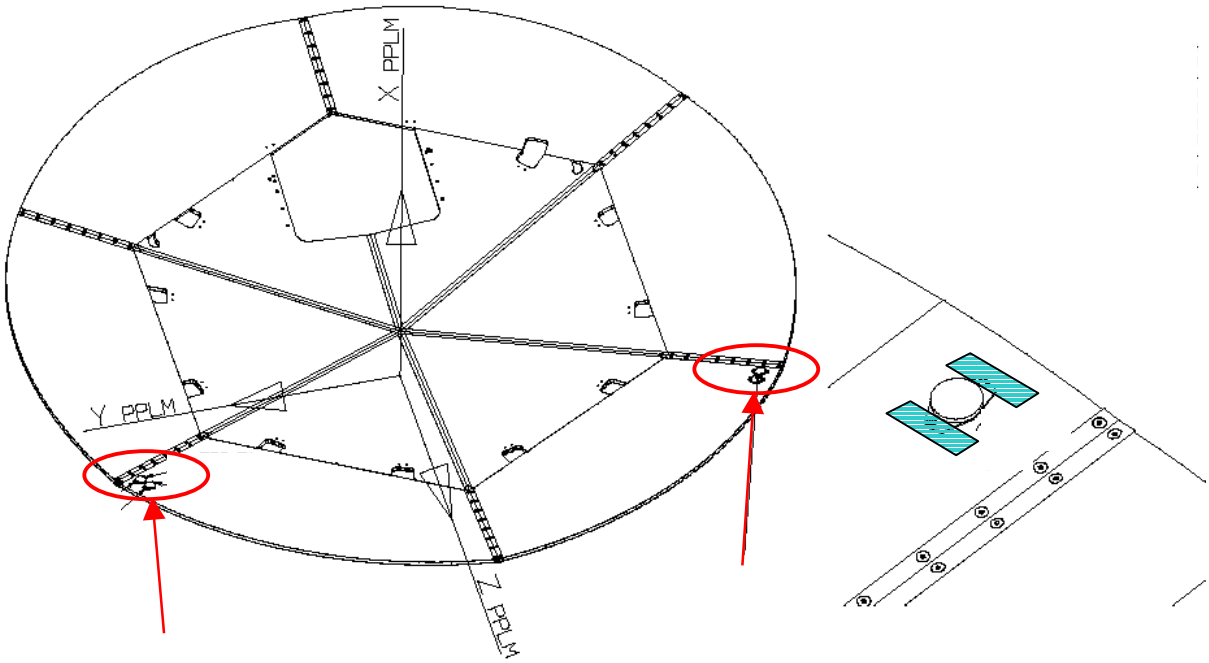




Particular Cumulative and Step witnesses location :

- For the particulate ones, this position opposite to the gravity is not the best one. So these witnesses will be stickled on the upper face of the groove 2. During the thermal vacuum itself, in order to avoid any risk of hardware damage, the witnesses will be moved and stickled on the GSE around the cryostructure (and not the grooves themselves). This policy is not the best one, but it is acceptable as it only concerns the particulate contamination (which is not the critical contamination expected during a TV test).

During integration or stocking phases : these 2 witnesses are attached with adhesive strips on the upper side of Groove 2 (+X face), Definition of the link : Kapton adhesive strips 8901.



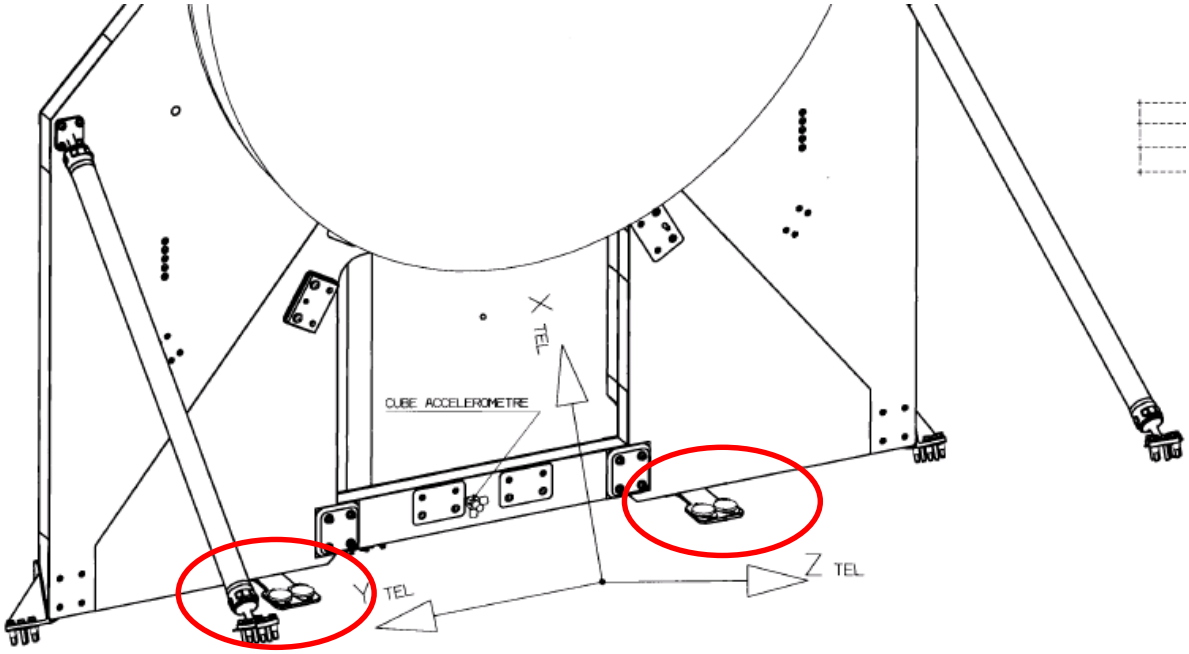
These sets are not designed to support all the mechanical tests (acoustic and vibration). This constraint is taken into account in the detailed CQM flow chart (see § 9.4).

9.2.1.2 Witnesses for the PFM

The following sets of witnesses will be implemented on the PFM :

- one set is positioned inside the optical cavity. It will be linked to the PR panel.

Particular and Molecular Cumulative and Step witnesses location in the optical cavity :
These 4 witnesses are attached on specific support plates. These 2 support plates are attached on free shurlock at the back of the PR Panel, bottom side (-X).
The attachment of these support plates is detailed in the FM model integration drawings.

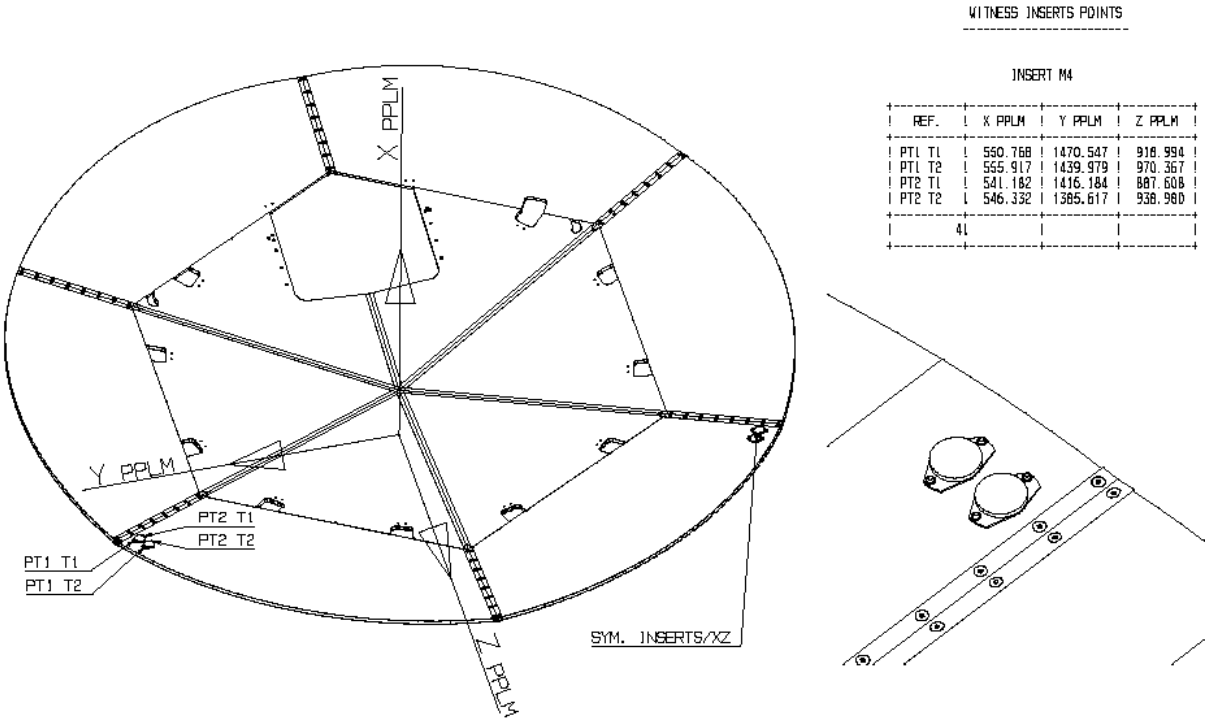


- one set is positioned on the upper face of the groove 2 extensions.

These sets will be designed in order to support all the environmental tests.

Particular and Molecular Cumulative and Step witnesses location on Cryo-Structure :
These 4 witnesses are directly attached with two screws each on the upper side of Groove 2 (+X face), definition of the link for 1 attachment point :

- 1 screw RSAT M4x10
- 1 Spring washer CuBe2, Dia int 4.2 mm, Dia ext 8 mm, thickness 0.4 mm
- 1 large washer, Dia int 4.25 mm, Dia ext 14 mm, thickness 0.8 mm



9.2.2 Control of the cleanroom

To guarantee the environment cleanliness level, the cleanroom chosen for Planck AIT activities will be controlled 2 months before the arrival of the hardware. More over, during the AIT activities :

- according to [RD17], the particulate contamination will be controlled at least once a week (continuously depending on the cleanroom). This control consists in an airborne particles counting (no Obscuration Factor calculation) : the counter is calibrated for particles sizes of 0.5 µm and 5 µm.
- concerning the molecular contamination, it will be measured once per month (instead of once per trimester as precised in [RD17]). For this control, 3 molecular witnesses will be added in the cleanroom, near the AIT activities and will be analysed each month.

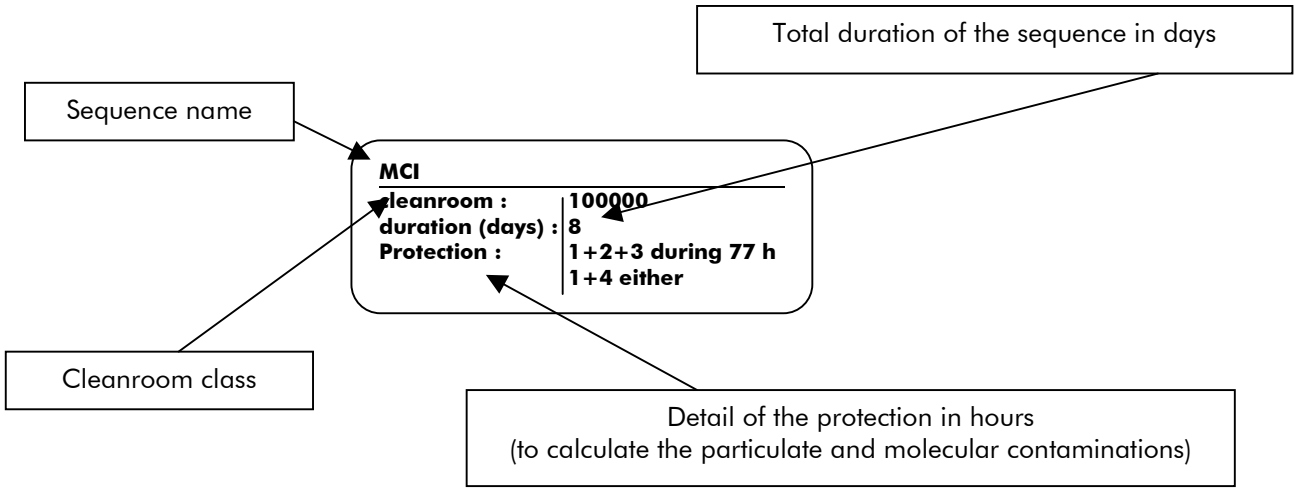
These cleanroom controls will be applied for the CQM and the PFM.

9.3 Flow chart description

9.3.1 Information available

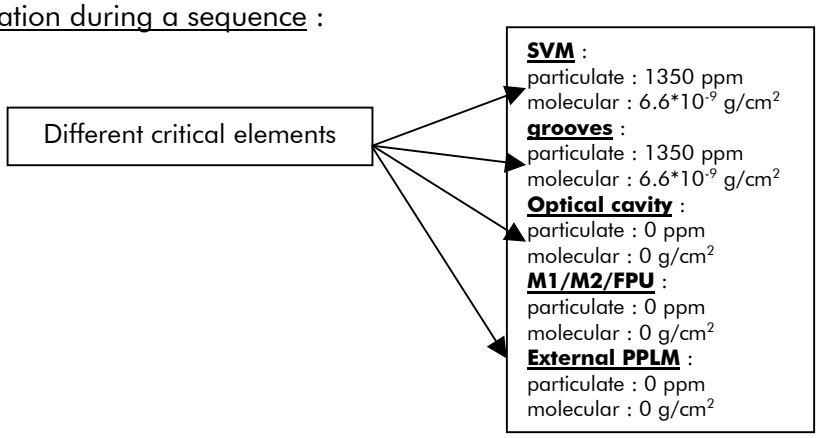
In the flow chart, the following information is given :

AIT sequence :



Nota : if there is no detail in « hours » for the protection, that means that it is kept during the whole phase duration (in days).

Contamination during a sequence :



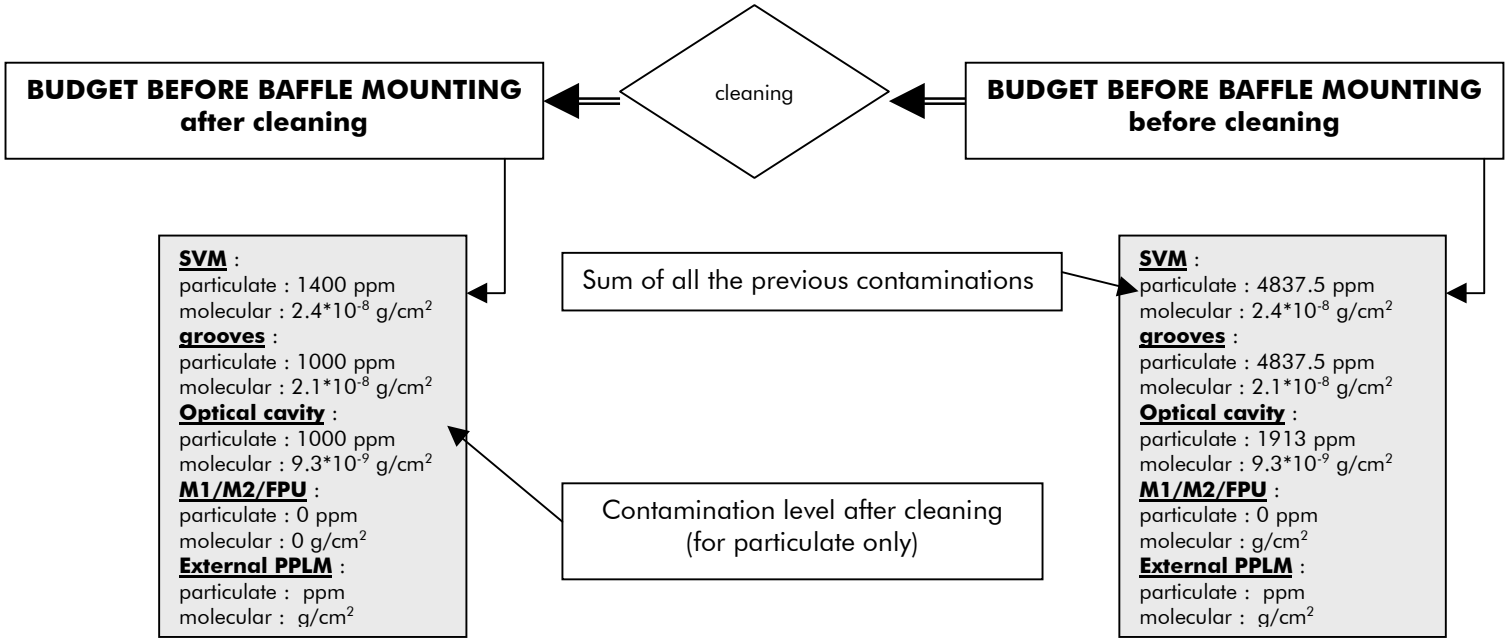
⇨ The particulate contamination is calculated as follows for a 100000 cleanroom :

$$(\text{number of exposed hours}) \times \frac{225\ \text{ppm}}{24}$$

⇨ The molecular contamination is calculated as follow for a 100000 cleanroom :

$$(\text{number of exposed hours}) \times \frac{1.10^{-6}\ \text{g/cm}^2}{365 \times 24}$$

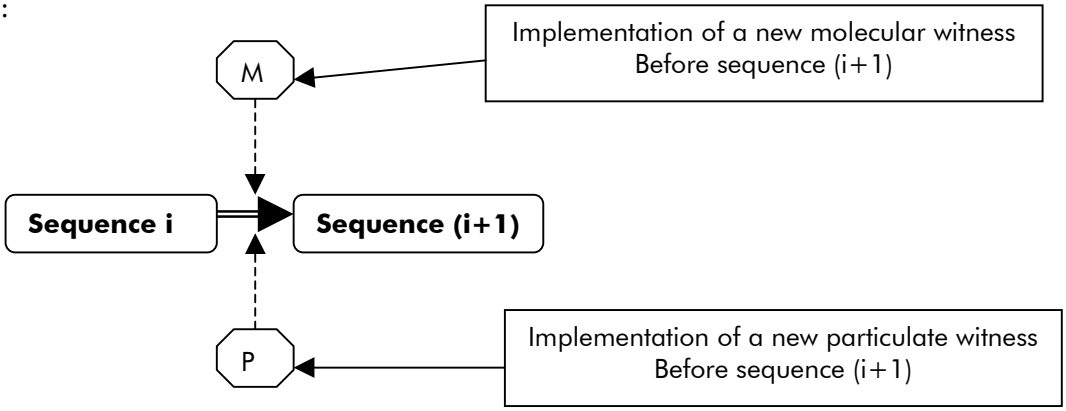
Total contamination before and after a cleaning :



Note 1 : the decrease of the particulate contamination after a cleaning is calculated as described in § 9.1.5.

Note 2 : for the S/C cleaning, the baffle is not dismounted. So it is supposed that, after the baffle mounting, the optical cavity is not cleanable because of accessibility problems (see § 9.1.5).

Witnesses :



Note : the witnesses are named M/P_{FPU} for the one on the FPU and M/P_{VG} for the one on the groove 2 extensions (see § 9.2.1.1).

9.4 Flow chart for the CQM

The aim of this model on a cleanliness point of view is essentially to validate :

- the cleaning procedures at satellite level
- the manipulation of the different protections that are scheduled.

The major objective of the CQM detailed contamination budget is to place the PPLM cleaning:

- before a dismounting in order to be able to measure the reached contamination level after cleaning
- at the more representative phase in terms levels expected for the FM (to apply the cleaning at a level equivalent to the one estimated on the PFM before cleaning).

These two constraints will allow to validate the cleaning procedures that will be applied on the PFM.

The detailed CQM flow chart is based on the document [AD02].

9.4.1 Definition of the groups for the CQM

In the flow chart, the contamination levels are calculated for the following « groups » :

- grooves : it concerns the areas between the internal grooves
- optical cavity : it includes the telescope (structural parts) and the inner side of the baffle. As a cleaning of the telescope is scheduled before the baffle mounting, the contamination of the telescope and the inner side of the baffle can be considered as equal, even if they are not integrated at the same moment.
- M1/M2 : they have the same policy for covers, so they are submitted to the same contamination
- FPU : detailed information of the FPU cover are TBC. In particular, this cover may protect only the hornes, and its compatibility with the different activities scheduled on the FPU is not completely defined. So, for this first CQM budget, the FPU contamination level corresponds to the FPU parts without protection : the FPU is protected only once it is integrated in the telescope and the optical cavity is closed. This corresponds to a worst case. According to the FPU position (parallel to the gravity) only 10% of the particulate contamination is considered (and the total value for the molecular one).

- external PPLM : it concerns the external side of the baffle and the grooves extensions (as they are integrated rather at the same moment in the AIT sequences)
- SVM : it is not supposed to be protected (see § 9.1.3). More over, no distinction is done between the different panels, according to their integration in the AIT sequence : the contamination budget provided is a worst one.

9.4.2 Acoustic test

For the acoustic test, no contamination budgets are done on the FPU or the mirrors, as they only consist in STM or dummies.

During this test, no specific protections or hardware witnesses are scheduled. Indeed :

- the CQM witnesses are not sized to support the mechanical test (see § 9.2.1.1)
- at the end of the acoustic test, the different parts of the model are dismounted and cleaned.

PACE CQM (AI1)

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**/**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
NOT INTEGRATED

Optical cavity :
NOT INTEGRATED

M1/M2 :
NA

FPU :
NA

External PPLM :
NOT INTEGRATED

Cryostr. mounting (AI2)

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**/**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
M1/M2 :
NA

FPU :
NA

External PPLM :
NOT INTEGRATED

mounting on SVM (AI3)

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**/**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
Optical cavity :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
M1/M2 :
NA

FPU :
NA

External PPLM :
NOT INTEGRATED

FPU mounting (AI4)

cleanroom :	**100000**
duration (days) :	**7**
Protection :	**/**

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
Optical cavity :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
M1/M2 :
NA

FPU :
NA

External PPLM :
NOT INTEGRATED

Tel. finalisation (AI5)

cleanroom :	**100000**
duration (days) :	**2**
Protection :	**/**

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
Optical cavity :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
M1/M2 :
NA

FPU :
NA

External PPLM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2

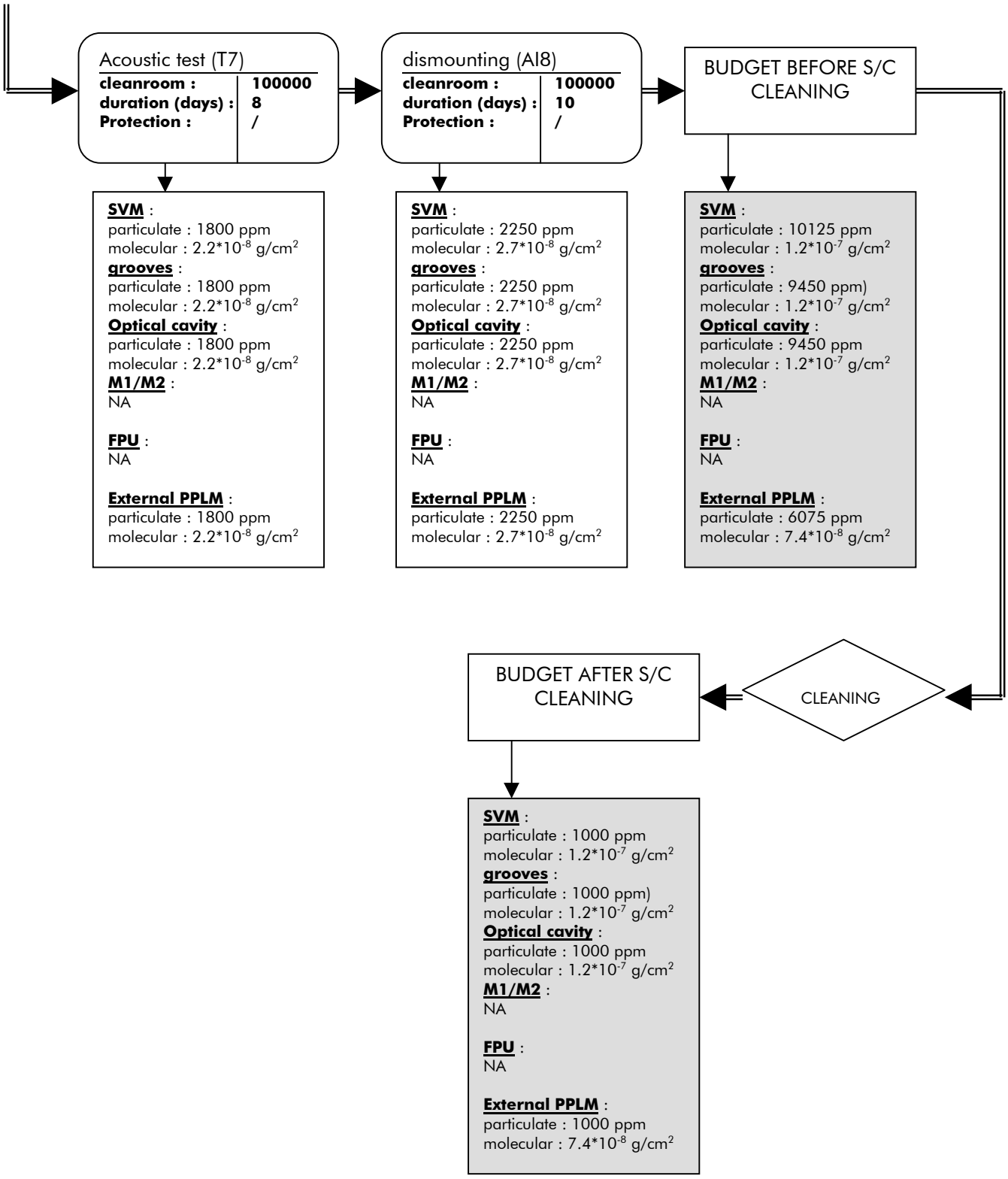
S/C QCM. finalisation (AI6)

cleanroom :	**100000**
duration (days) :	**7**
Protection :	**/**

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
Optical cavity :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
M1/M2 :
NA

FPU :
NA

External PPLM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2



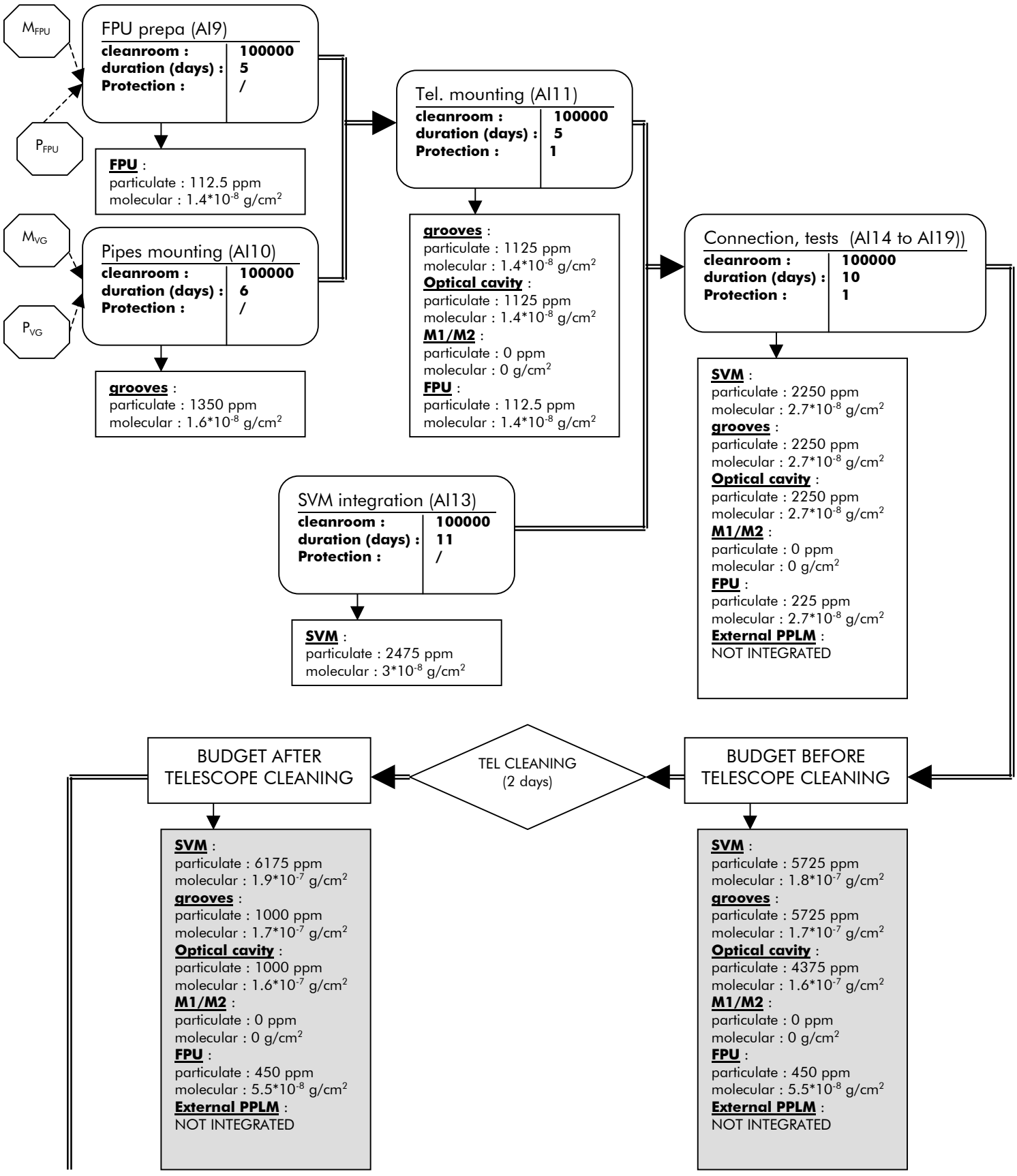
9.4.3 Cryo test

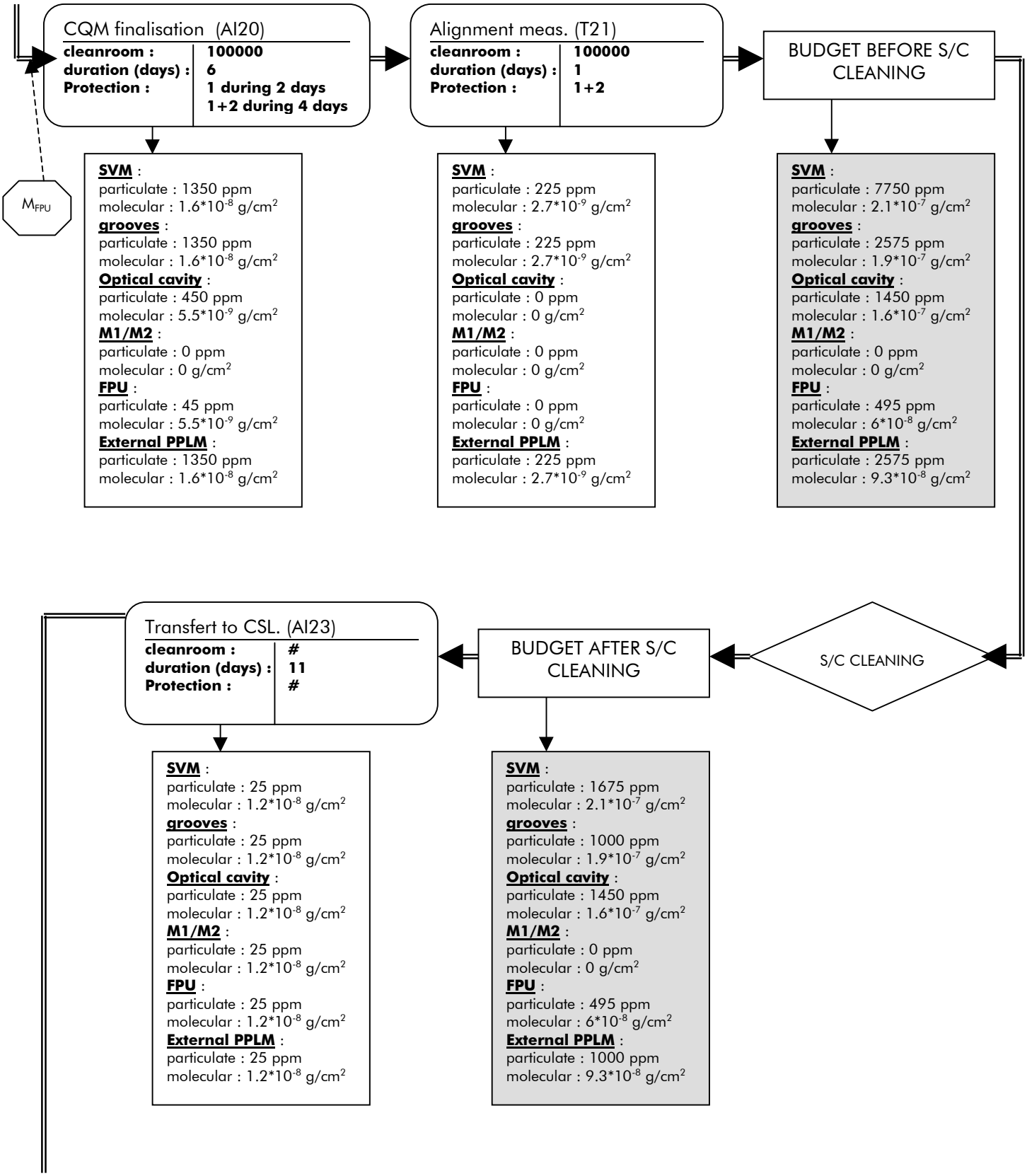
For the cryo test, the contamination witnesses listed in § 9.2.1.1 and some protections described in § 9.1.3 are implemented.

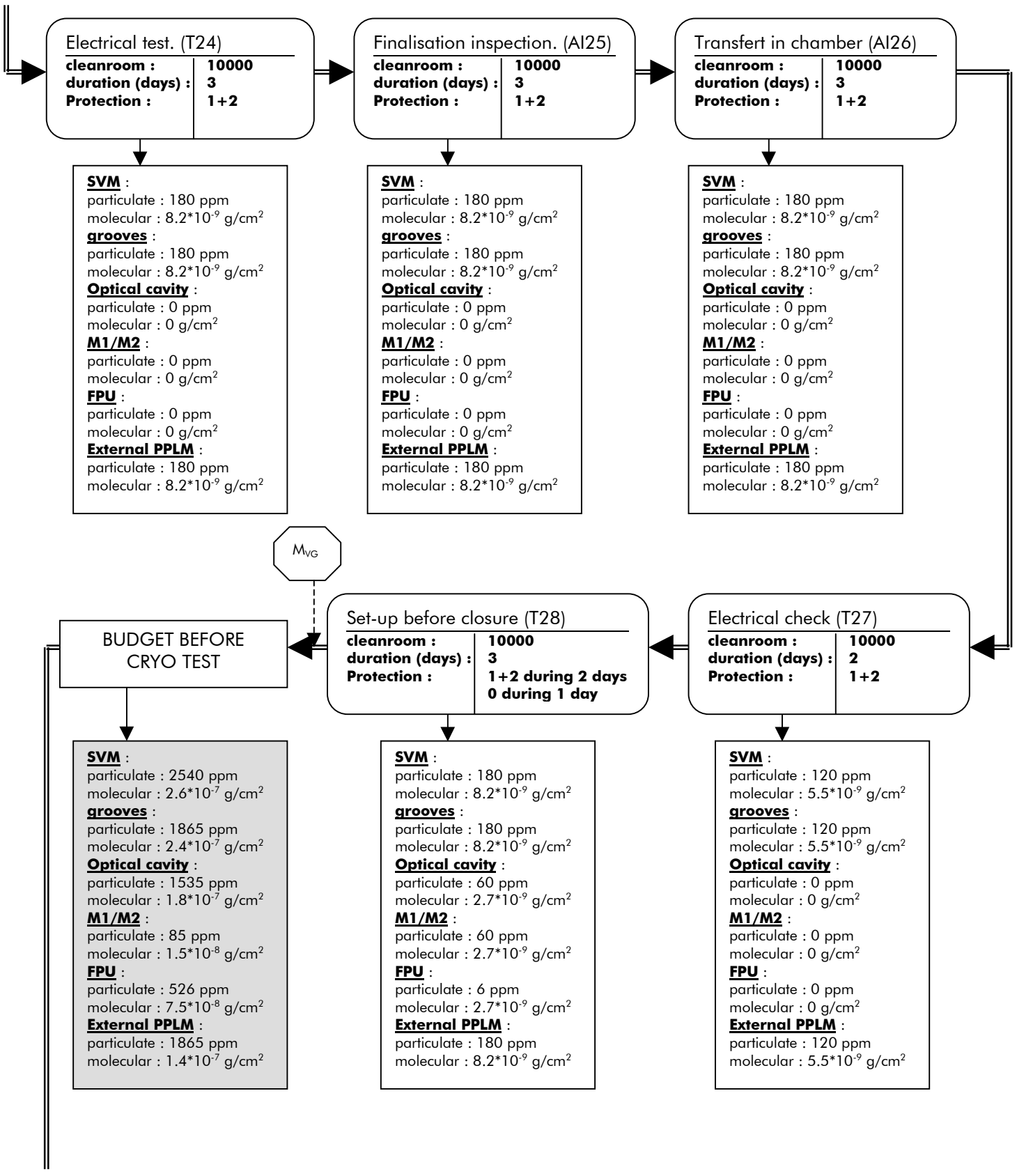
- The cumulative witnesses will be implemented from the beginning of the cryo test sequence to the end. Concerning the step witnesses, the change is defined in the flow chart.
- Concerning the witnesses that are implemented on the grooves extension, as this structural part is not integrated since the beginning of the activities, they will placed :
  - near the PPLM during the AIT sequences without the extension (precised position TBC)
  - on their scheduled position once the extensions are mounted on the CQM.

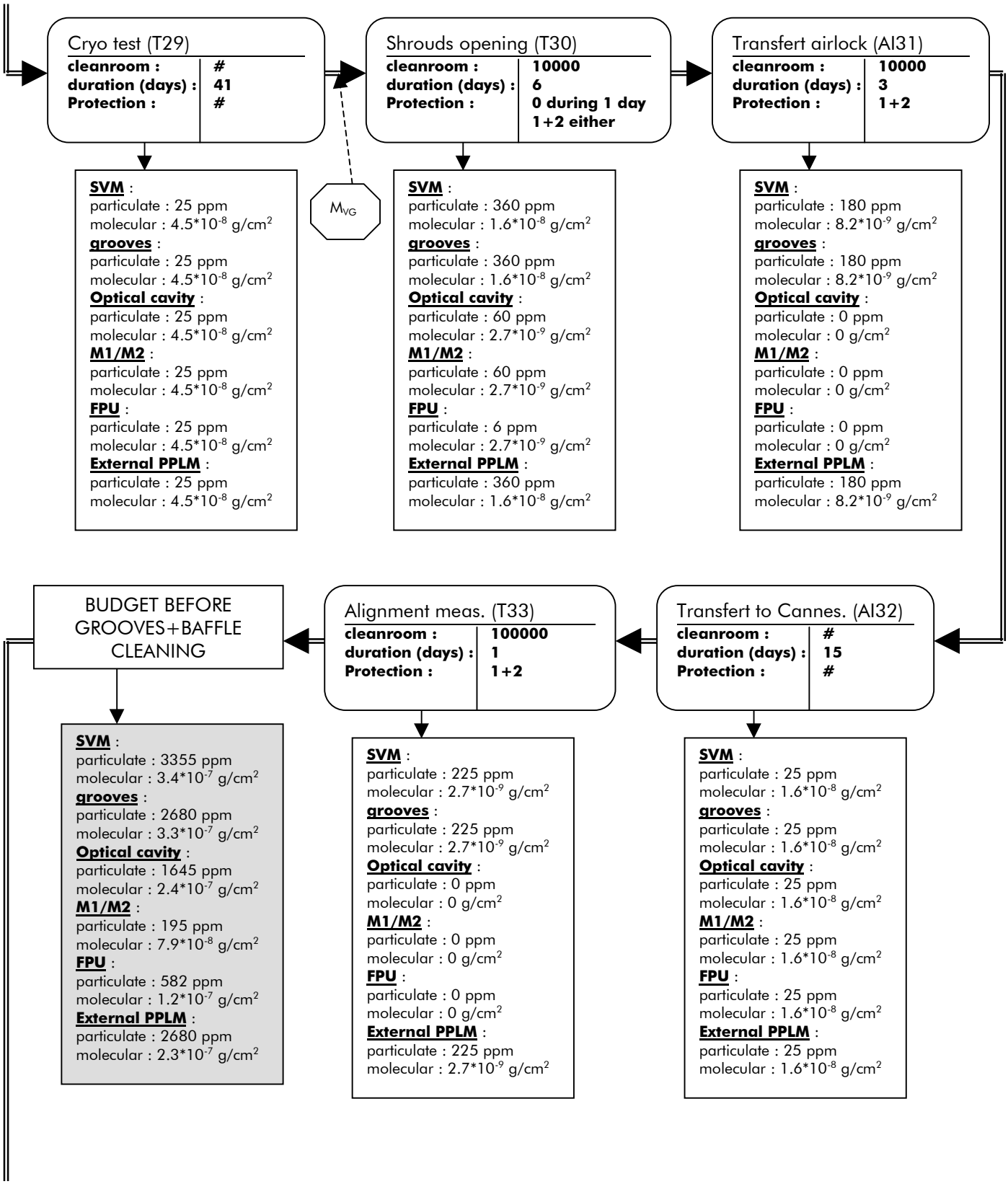
Concerning the activities :

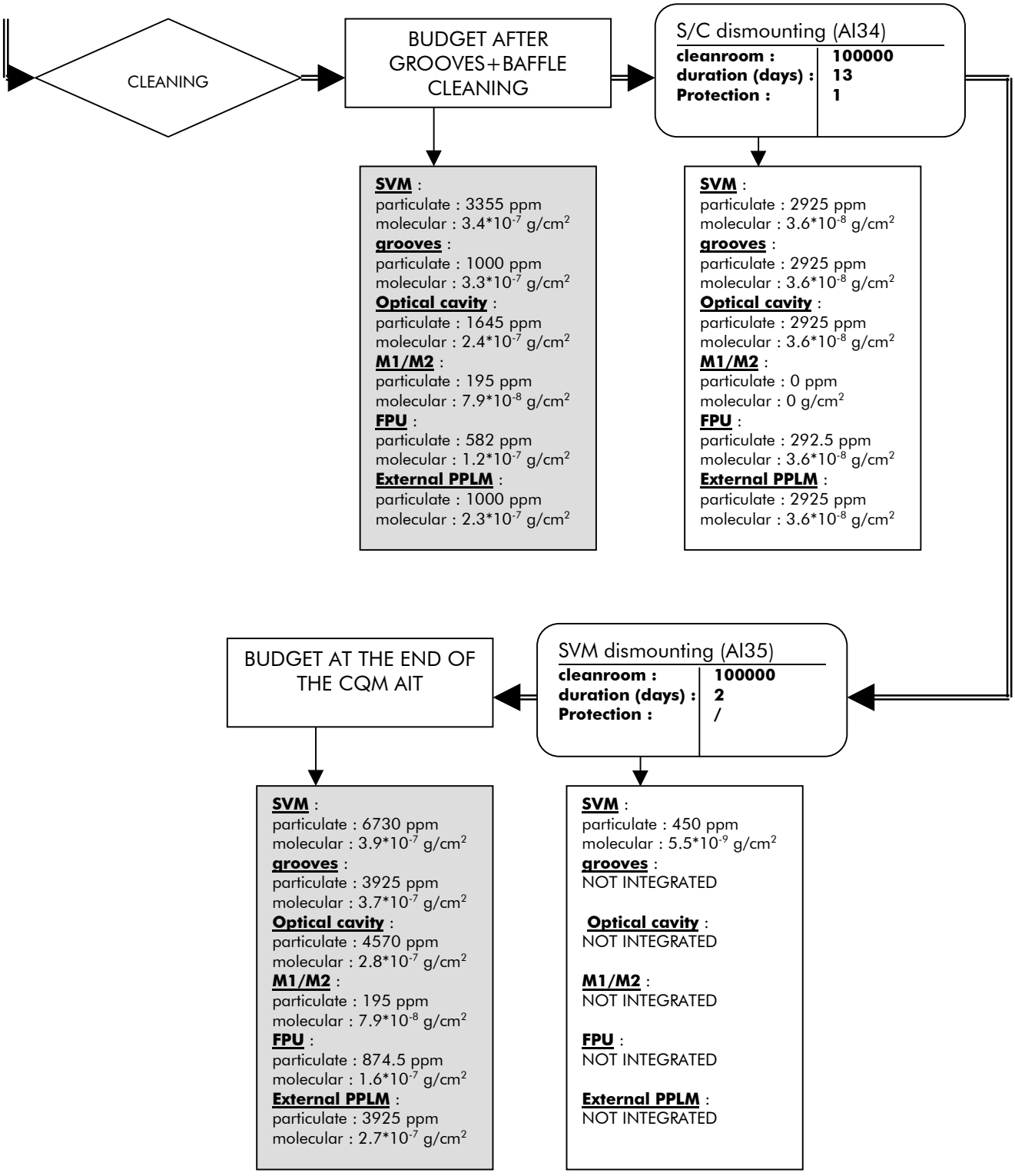
- AI9 and AI10 are made in parallel
- (AI10 + AI11), AI12 and AI13 are made in parallel
- for the set of activities from AI14 to AI19 (electronic integration, connection check …), that are made during the same period, the budget is done considering the sum of the AI14 and T16 durations (so 10 days)











9.5 Flow chart for the PFM

The FM flow chart has been updated according to the new AIT inputs. The frequence of the step witnesses change is not defined yet.

9.5.1 Definition of the groups for the PFM

In the flow chart, the contamination levels are calculated for the following « groups » :

- grooves : it concerns the areas between the grooves. No distinction is done between the low emissivity and the high emissivity parts as they have the same protection policy
- optical cavity : it includes the telescope (structural parts) and the inner side of the baffle. As a cleaning of the telescope is scheduled before the baffle mounting, the contaminations of the telescope and the inner side of the baffle can be considered as equal, even if they are not integrated at the same moment.
- M1/M2/FPU : they have the same policy for covers, so they are submitted to the same contamination
- external PPLM : it concerns the external side of the baffle and the upper part of the groove 3 extension
- SVM : it is not supposed to be protected (see § 9.1.3).

9.5.2 Assembly / Integration

WU preparation
cleanroom : 100000
duration (days) : 37
Protection : /

SVM :
particulate : 300 ppm (*)
molecular : $1.0*10^{-7}$ g/cm^2
grooves :
NOT INTEGRATED

Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

(*) : cleaning

RAA mounting
cleanroom : 100000
duration (days) : 4
Protection : /

SVM :
particulate : 300 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
NOT INTEGRATED

Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

Cryo structure preparation
cleanroom : 100000
duration (days) : 15
Protection : 0

SVM :
particulate : 3375 ppm
molecular : $4.1*10^{-8}$ g/cm^2
grooves :
particulate : 3375 ppm
molecular : $4.1*10^{-8}$ g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

Cryo structure assembly
cleanroom : 100000
duration (days) : 10
Protection : 0

SVM :
particulate : 2250 ppm
molecular : $2.7*10^{-8}$ g/cm^2
grooves :
particulate : 2250 ppm
molecular : $2.7*10^{-8}$ g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

Grooves piping, TC routing
cleanroom : 100000
duration (days) : 7
Protection : 0

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

DCCU mounting on SVM
cleanroom : 100000
duration (days) : 2
Protection : 4

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

SVM (He tank, 0.1 K piping mounting)
cleanroom : 100000
duration (days) : 8
Protection : 4

SVM :
particulate : 1800 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

SVM (He tank, 0.1 K leak test)
cleanroom : 100000
duration (days) : 7
Protection : 4

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

EGSE SVM set-up
cleanroom : 100000
duration (days) : 5
Protection : 4

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

Upper panels removal
cleanroom : 100000
duration (days) : 3
Protection : 4

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

4K CRU & REBA & DPU mounting
cleanroom : 100000
duration (days) : 3
Protection : 4

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

SVM PFM / cryostructure mating
cleanroom : 100000
duration (days) : 5
Protection : 4

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

HFI/LFI WU connection

cleanroom :	**100000**
duration (days) :	**4**
Protection :	**4**

SVM :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
NOT INTEGRATED

M1/M2/FPU :
NOT INTEGRATED

External PPLM :
NOT INTEGRATED

FM telescope mounting

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
Optical cavity :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

RAA adjustement

cleanroom :	**100000**
duration (days) :	**10**
Protection :	**1**

SVM :
particulate : 2250 ppm
molecular : $2.7*10^{-8}$ g/cm^2
grooves :
particulate : 2250 ppm
molecular : $2.7*10^{-8}$ g/cm^2
Optical cavity :
particulate : 2250 ppm
molecular : $2.7*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

PAU/bellow/J-FET mounting

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

Pipes (I/F mounting & connection)

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**4**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

FPU connection

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

0,1 K/4 K leak & purge test

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g /cm^2
Optical cavity :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g /cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :

NOT INTEGRATED

0,1 K/4 K cryo-harness

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

0,1 K/4 K electrical check

cleanroom :	**100000**
duration (days) :	**4**
Protection :	**4**

SVM :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

HF/LFI electrical integration

cleanroom :	**100000**
duration (days) :	**10**
Protection :	**4**

SVM :
particulate : 2250 ppm
molecular : $2.8*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

TC check / rounting

cleanroom :	**100000**
duration (days) :	**4**
Protection :	**1**

SVM :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
Optical cavity :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

PLM SIT

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 1125 ppm
molecular : : $1.4*10^{-8}$ g/cm^2
Optical cavity :
particulate : 1125 ppm
molecular : : $1.4*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

SVM/PLM MLI

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :

NOT INTEGRATED

STM solar arrays

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

Upper panels closure mounting

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

Antennaes integration

cleanroom :	**100000**
duration (days) :	**4**
Protection :	**4**

SVM :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

External STM SA fit ceck

cleanroom :	**100000**
duration (days) :	**2**
Protection :	**4**

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
NOT INTEGRATED

BUDGET BEFORE BAFFLE MOUNTING
before PPLM cleaning

SVM :
particulate : 32925 ppm
molecular : $5.0*10^{-7}$ g/cm^2
grooves :
particulate : 16425 ppm
molecular : $2.0*10^{-7}$ g/cm^2
Optical cavity :
particulate : 9225 ppm
molecular : $1.1*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

PPLM Cleaning (1 day)

BUDGET BEFORE BAFFLE MOUNTING after PPLM cleaning

SVM :
particulate : 33150 ppm
molecular : $5.0*10^{-7}$ g/cm^2
grooves :
particulate : 1000 ppm
molecular : $2.0*10^{-7}$ g/cm^2
Optical cavity :
particulate : 1000 ppm
molecular : $1.1*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
NOT INTEGRATED

Baffle mounting

cleanroom :	**100000**
duration (days) :	**2**
Protection :	**1**

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
Optical cavity :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2

External grooves & MLI mounting

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+2**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2

Alignment check

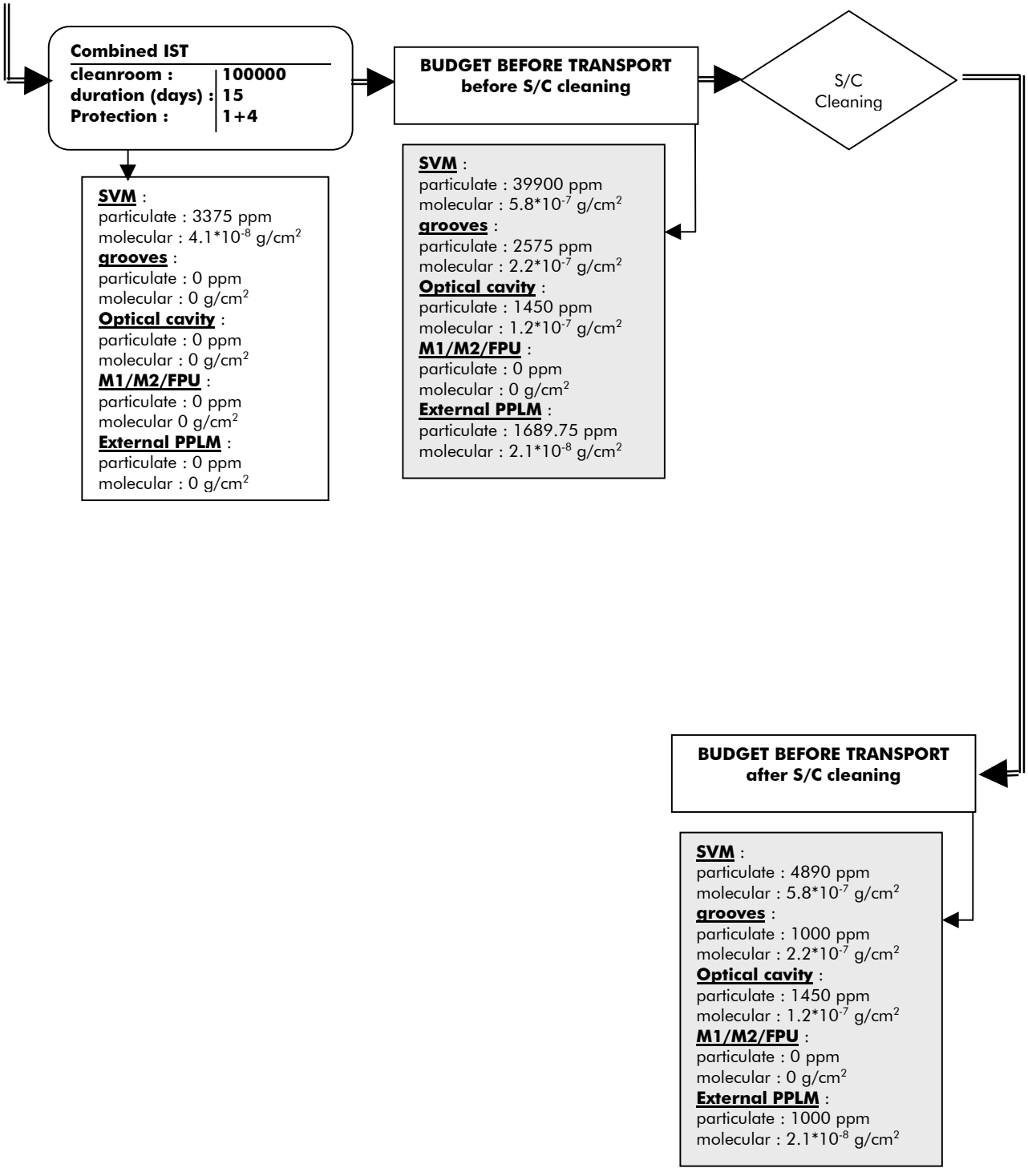
cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+2+3 during 12 h** **1+4 either**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : $1.9*10^{-8}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : $1.9*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 114.75 ppm
molecular : $1.4*10^{-9}$ g/cm^2

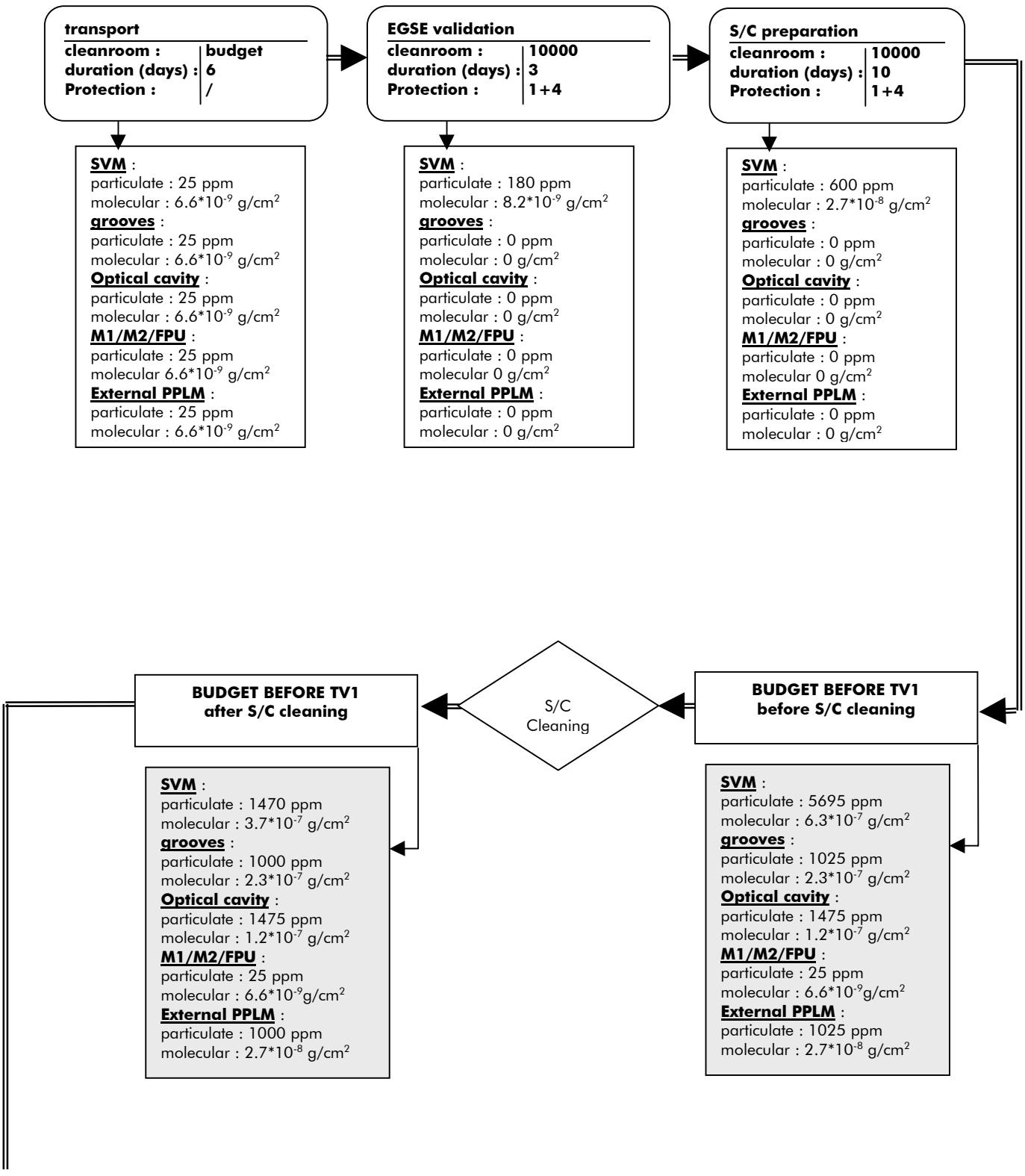
Final external MLI mounting

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+4**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2



9.5.3 System tests



Shrouds installation

cleanroom :	**10000**
duration (days) :	**10**
Protection :	**1+2**

SVM :
particulate : 600 ppm
molecular : $2.7*10^{-8}$ g/cm^2
grooves :
particulate : 600 ppm
molecular : $2.7*10^{-8}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 600 ppm
molecular : $2.7*10^{-8}$ g/cm^2

S/C check

cleanroom :	**10000**
duration (days) :	**8**
Protection :	**0 during 1 day**
	1+2 either

SVM :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2
Optical cavity :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
External PPLM :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2

BUDGET BEFORE TV1

SVM :
particulate : 2550 ppm
molecular : $6.8*10^{-7}$ g/cm^2
grooves :
particulate : 2080 ppm
molecular : $2.8*10^{-7}$ g/cm^2
Optical cavity :
particulate : 1535 ppm
molecular : $1.3*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 85 ppm
molecular : $9.3*10^{-9}$ g/cm^2
External PPLM :
particulate : 2080 ppm
molecular : $7.6*10^{-8}$ g/cm^2

Thermal Vacuum 1

cleanroom :	**budget**
duration (days) :	**20**
Protection :	**0**

SVM :
particulate : 25 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $2.2*10^{-8}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $2.2*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular $2.2*10^{-8}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $2.2*10^{-8}$ g/cm^2

Shrouds removal

cleanroom :	**10000**
duration (days) :	**3**
Protection :	**0 during 1 day**
	1+2 either

SVM :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
External PPLM :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2

S/C exit

cleanroom :	**10000**
duration (days) :	**2**
Protection :	**1+2**

SVM :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2

S/C functional tests

cleanroom :	**10000**
duration (days) :	**7**
Protection :	**1+2**

SVM :
particulate : 420 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 420 ppm
molecular : $1.9*10^{-8}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 420 ppm
molecular : $1.9*10^{-8}$ g/cm^2

packing

cleanroom :	**10000**
duration (days) :	**4**
Protection :	**1+4**

SVM :
particulate : 240 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

transport

cleanroom :	**budget**
duration (days) :	**9**
Protection :	**/**

SVM :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2

Alignment stability check

cleanroom :	**10000**
duration (days) :	**3**
Protection :	**1+2+3 during 12 h** **1+4 either**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 114.75 ppm
molecular : $1.4*10^{-9}$ g/cm^2

EMC test set-up

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

EMC tests

cleanroom :	**100000**
duration (days) :	**15**
Protection :	**1+4**

SVM :
particulate : 3375 ppm
molecular : $4.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

LFI RF test

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+2+3 half a day**
	1+4 half a day

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 115 ppm
molecular : $1.4*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 115 ppm
molecular $1.4*10^{-9}$ g/cm^2
External PPLM :
particulate : 562.5 ppm
molecular : $6.8*10^{-9}$ g/cm^2

(*) : half a day to put away the mirrors and FPU covers and to protect the optical cavity with the film RF transparent

SVT1

cleanroom :	**100000**
duration (days) :	**15**
Protection :	**1+4**

SVM :
particulate : 3375 ppm
molecular : $4.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

SA FM mounting

cleanroom :	**100000**
duration (days) :	**4**
Protection :	**1+4**

SVM :
particulate : 900 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves : particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

MCI

cleanroom :	**100000**
duration (days) :	**8**
Protection :	**1+2+3 : 77 h**
	1+4 either

SVM :
particulate : 1800 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 720 ppm
molecular : $8.8*10^{-9}$ g/cm^2

balancing

cleanroom :	**100000**
duration (days) :	**6**
Protection :	**1+2+3 half a day**
	1+4 half a day

SVM :
particulate : 1350 ppm
molecular : $1.6*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2

Balancing mass/align. check

cleanroom :	**100000**
duration (days) :	**7**
Protection :	**1+4**

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Vibration set-up

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+2+3 during 36 h** **1+4 either**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 115 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 115 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 337.5 ppm
molecular : $4.1*10^{-9}$ g/cm^2

RCS filling

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Vibration & acoustic

cleanroom :	**budget**
duration (days) :	**20**
Protection :	**/**

SVM :
particulate : 50 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 50 ppm
molecular : $2.2*10^{-8}$ g/cm^2
Optical cavity :
particulate : 50 ppm
molecular : $2.2*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 50 ppm
molecular : $2.2*10^{-8}$ g/cm^2
External PPLM :
particulate : 50 ppm
molecular : $2.2*10^{-8}$ g/cm^2

Fit check

cleanroom :	**100000**
duration (days) :	**2**
Protection :	**1+4**

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Leak test 0.1 K/4 K

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+2+3 during 36 h** **1+4 either**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 337.5 ppm
molecular : $4.1*10^{-9}$ g/cm^2

RCS draining & drying & leak test

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+4**

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Fit check

cleanroom :	**100000**
duration (days) :	**2**
Protection :	**1+4**

SVM :
particulate : 450 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

S/C functional tests

cleanroom :	**100000**
duration (days) :	**7**
Protection :	**1+4**

SVM :
particulate : 1575 ppm
molecular : $1.9*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Alignment check

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+2+3 during 12 h** **1+4 either**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 114.75 ppm
molecular : $1.4*10^{-9}$ g/cm^2

FM SA dismount., instr. replace

cleanroom :	**100000**
duration (days) :	**10**
Protection :	**1 during 1 day** **1+2+3 either**

SVM :
particulate : 2250 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 225 ppm
molecular : $2.7*10^{-9}$ g/cm^2
Optical cavity :
particulate : 225 ppm
molecular : $2.7*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 2250 ppm
molecular : $2.2*10^{-8}$ g/cm^2

transport

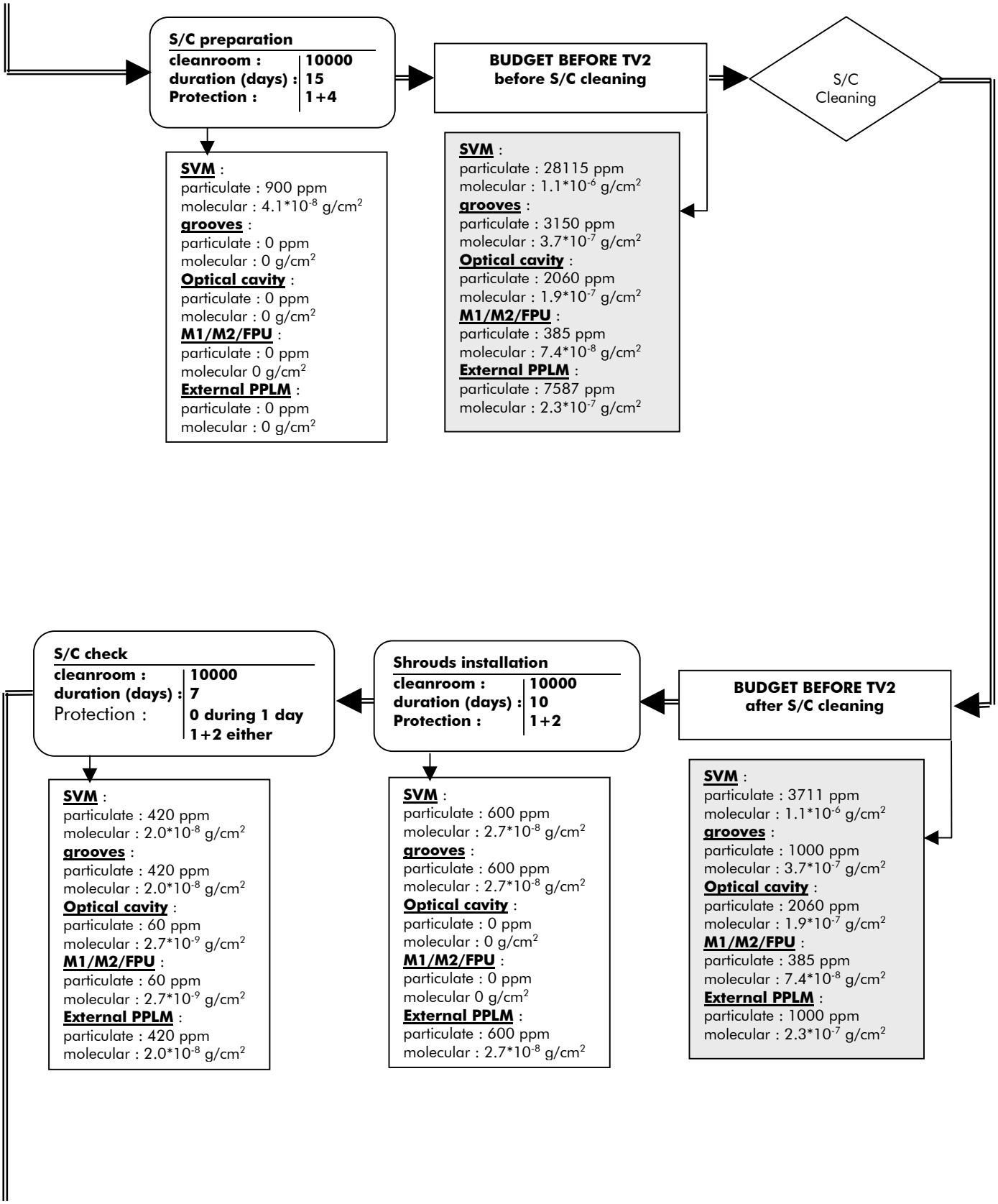
cleanroom :	**budget**
duration (days) :	**6**
Protection :	**/**

SVM :
particulate : 25 ppm
molecular : $6.6*10^{-9}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $6.6*10^{-9}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $6.6*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular : $6.6*10^{-9}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $6.6*10^{-9}$ g/cm^2

EGSE validation

cleanroom :	**10000**
duration (days) :	**3**
Protection :	**1+4**

SVM :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2



BUDGET BEFORE TV2

SVM :
particulate : 4731 ppm
molecular : $1.2*10^{-6}$ g/cm^2
grooves :
particulate : 2020 ppm
molecular : $4.2*10^{-7}$ g/cm^2
Optical cavity :
particulate : 2120 ppm
molecular : $2.0*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 445 ppm
molecular : $7.6*10^{-8}$ g/cm^2
External PPLM :
particulate : 2020 ppm
molecular : $2.7*10^{-7}$ g/cm^2

Thermal Vacuum 2

cleanroom :	**budget**
duration (days) :	**36**
Protection :	**0**

SVM :
particulate : 25 ppm
molecular : $3.9*10^{-8}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $3.9*10^{-8}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $3.9*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular : $3.9*10^{-8}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $3.9*10^{-8}$ g/cm^2

Shrouds removal

cleanroom :	**10000**
duration (days) :	**3**
Protection :	**0 during 1 day**
	1+2 either

SVM :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2
Optical cavity :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 60 ppm
molecular : $2.7*10^{-9}$ g/cm^2
External PPLM :
particulate : 180 ppm
molecular : $8.2*10^{-9}$ g/cm^2

S/C exit

cleanroom :	**10000**
duration (days) :	**2**
Protection :	**1+2**

SVM :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2
grooves :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 120 ppm
molecular : $5.5*10^{-9}$ g/cm^2

S/C functional tests

cleanroom :	**10000**
duration (days) :	**8**
Protection :	**1+2**

SVM :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2
grooves :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 480 ppm
molecular : $2.2*10^{-8}$ g/cm^2

packing

cleanroom :	**10000**
duration (days) :	**4**
Protection :	**1+4**

SVM :
particulate : 240 ppm
molecular : $1.1*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

transport

cleanroom :	**budget**
duration (days) :	**9**
Protection :	**/**

SVM :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $9.9*10^{-9}$ g/cm^2

Alignment check

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+2+3 during 12 h**
	1+4 either

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 114.75 ppm
molecular : $1.4*10^{-9}$ g/cm^2

EGSE validation

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

S/C functional tests IST2

cleanroom :	**100000**
duration (days) :	**25**
Protection :	**1+4**

SVM :
particulate : 5625 ppm
molecular : $6.8*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

SA mounting

cleanroom :	**100000**
duration (days) :	**3**
Protection :	**1+4**

SVM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular : 0 g/cm^2
External PPLM :
particulate : 0 ppm
molecular : 0 g/cm^2

Final balancing

cleanroom :	**100000**
duration (days) :	**6**
Protection :	**1+2+3 half a day**
	1+4 half a day

SVM :
particulate : 1350 ppm
molecular : $1.6*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 675 ppm
molecular : $8.2*10^{-9}$ g/cm^2

Global leak test

cleanroom :	**100000**
duration (days) :	**5**
Protection :	**1+2+3 half a day** **1+4 half a day**

storage & transport to Kourou

cleanroom :	**budget**
duration (days) :	**15**
Protection :	/

SVM :
particulate : 1125 ppm
molecular : $1.4*10^{-8}$ g/cm^2
grooves :
particulate : 0 ppm
molecular : 0 g/cm^2
Optical cavity :
particulate : 0 ppm
molecular : 0 g/cm^2
M1/M2/FPU :
particulate : 0 ppm
molecular 0 g/cm^2
External PPLM :
particulate : 562.5 ppm
molecular : $6.8*10^{-9}$ g/cm^2

SVM :
particulate : 25 ppm
molecular : $1.6*10^{-8}$ g/cm^2
grooves :
particulate : 25 ppm
molecular : $1.6*10^{-8}$ g/cm^2
Optical cavity :
particulate : 25 ppm
molecular : $1.6*10^{-8}$ g/cm^2
M1/M2/FPU :
particulate : 25 ppm
molecular : $1.6*10^{-8}$ g/cm^2
External PPLM :
particulate : 25 ppm
molecular : $1.6*10^{-8}$ g/cm^2

BUDGET
after S/C cleaning in Kourou
before encapsulation

S/C
Cleaning

BUDGET
before S/C cleaning in Kourou

SVM :
particulate : 2495 ppm
molecular : $1.4*10^{-6}$ g/cm^2
grooves :
particulate : 1000 ppm
molecular : $5.2*10^{-7}$ g/cm^2
Optical cavity :
particulate : 2255 ppm
molecular : $2.7*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 580 ppm
molecular : $1.4*10^{-7}$ g/cm^2
External PPLM :
particulate : 1000 ppm
molecular : $3.9*10^{-7}$ g/cm^2

SVM :
particulate : 15951 ppm
molecular : $1.4*10^{-6}$ g/cm^2
grooves :
particulate : 2875 ppm
molecular : $5.2*10^{-7}$ g/cm^2
Optical cavity :
particulate : 2255 ppm
molecular : $2.7*10^{-7}$ g/cm^2
M1/M2/FPU :
particulate : 580 ppm
molecular : $1.4*10^{-7}$ g/cm^2
External PPLM :
particulate : 4227 ppm
molecular : $3.9*10^{-7}$ g/cm^2

10. PFM BUDGET

The flow charts of § 9.5.2 and § 9.5.3 give the particulate and molecular contamination due to the AIT sequence, from the beginning of the integration up to the last cleaning in Kourou, before the launch campaign.
The results are summarised hereafter :

	FPU	mirrors	V-grooves	Baffle inner side	Baffle outer side	SVM External surfaces
AIT sequence	580	580	1000	2255	1000	2495
allocations	**800**	**800**	**1500**	**2400**	**1500**	**3400**

Table 10.1 : particulate contamination due to the AIT sequence (ppm)

	FPU	mirrors	V-grooves	Baffle inner side	Baffle outer side	SVM External surfaces
AIT sequence	$1.4\ 10^{-7}$	$1.4\ 10^{-7}$	$5.2\ 10^{-7}$	$2.7\ 10^{-7}$	$3.9\ 10^{-7}$	$1.4\ 10^{-6}$
allocations	$3\ 10^{-7}$	$3\ 10^{-7}$	$6\ 10^{-7}$	$4\ 10^{-7}$	$6\ 10^{-7}$	$2\ 10^{-6}$

Table 10.2 : molecular contamination due to the AIT sequence (g/cm^2)

11. CONCLUSION FOR THE PFM

11.1 Molecular contamination

The molecular contamination due to the AIT sequence on the whole spacecraft is within the needs, with margins.
In particular, the level before the thermal vacuum test induces no problem.

The global contribution of the CSL activities, taking into account the duration planned in § 9.5.3 and the hypotheses described in § 9.1.2, correspond to $3.3\ 10^{-7}$ g/cm^2. Concerning the specific phases with no protection on the whole spacecraft, and with the preventive action defined in § 9.1.6, the molecular contamination is around $4\ 10^{-8}$ g/cm^2 for each thermal vacuum test ($2.7\ 10^{-8}$ g/cm^2 for te first one and $4.5\ 10^{-8}$ g/cm^2 for the second one).

11.2 Particulate contamination

The particulate contamination due to the AIT sequence on the whole spacecraft is within the needs, with margins.

Moreover, the flow charts show that, before the thermal vacuum test, all the subsystems are within the EOL needs.

Concerning the specific phases in CSL with no protection on the whole spacecraft, and with the preventive action defined in § 9.1.6 and the hypotheses listed in § 9.1.2, the particulate contamination is equal to 145 ppm for each thermal vacuum test.

11.3 Discussion on hypotheses

This paragraph gives a sensitivity on the values found in § 9.5.3 according to the hypothesis that have been done.

The flow chart described in § 9.5.3 has been issued assuming that :

1. the cleaning of the PPLM (except the optics) can decrease its particulate contamination down to 1000 ppm

All the data concerning this input (results already available and activities to be performed) are presented in a specific technical note (ASP-04-OS/I/IA-53).

2. Additionnaly to the optical cavity protection, the FPU has its own protection that can be put away/put back even once the baffle is integrated

This hypothesis will be validated during the CQM AIT. However, in order to underline any criticity, the contamination budget has been reassessed on the FPU, considering that :

- the FPU has its own protection as long as the baffle is not integrated
- once the PPLM baffle is integrated, this protection is not reachable any more; so it has to be retired after the telescope cleaning, before the baffle mounting
- after this sequence, the FPU is protected only when the optical cavity is closed
- as the FPU is parallel to the gravity, only 10% of the contamination is considered (and 100% for the molecular one).

With these hypotheses, the estimated contamination on the FPU for the FM AIT sequence desccribed in § 9.5 is :

Particulate (ppm)	648
Molecular (g/cm^2)	1.5 10^{-7}

These values are still compatible with the requirements. So, in case of accessibility problem of the FPU cover detected during the CQM AIT activities, it could be put put away just before mounting the baffle, without any risk of performances degradation.

3. The film that protects the optical cavity is RF transparent and so can be kept during the RF tests.

This hypothesis is scheduled to be checked during the test on the RFQM. Moreover, following the PPLM CDR, actions are on-going with RF experts to check the characteristics of the protective film used and their compatibility with the Planck frequencies.

Anyway this test could be removed or configuration may change by the implementation of a RF test horn. In both case the budget will be updated accordingly.

4. the thermal vacuum instrumentation can be installed in 1 day

Realistic hypothesis according to Alcatel experience

5. for the shrouds installation or the shrouds removal, CSL can nearly perform all their activities with the optical cavity film. So it has to be put away only 1 day for each phase

The constraints of optical cavity accessibility has already been integrated in the Planck cryogenic facility requirements (see [RD07])

6. the budget is calculated without considering the geometry

This is a sizing hypothesis as : no surface is considered to be hidden, a vertical or an horizontal plane collect the same contaminants quantity.

END OF DOCUMENT