Informal Guidelines for Instrument Scheduling: A Guide for the MPS Team

Instrument and Calibration Scientist Team

v3.1, 20 March 2012

Document Number: HERSCHEL-HSC-DOC-1298

Change Log

Version	Author	Notes
1.0	APM	First released version
2.0	LC	SPIRE chapter: • Revised "Photometer" and "Spectrometer" sections: prime instrument doesn't need to be "switch-off" if it is prime among 2 consecutive ODs (instrument remains "on" during DTCP) • Added the "Photometer – Spectrometer switching" section • Revised the "Parallel Mode" section: SPIRE commands to "switch on" and "off" the instruments must always be executed before the corresponding PACS ones • Added "SPIRE/PACS parallel mixed ODs" section: it explains how to change from (or to) PMODE to (or from) SPIRE or PACS only observations, as well as ToO treatment. In particular, it is not required to "switch off" both instruments PACS chapter: • Added the "Caveat" paragraph in the introductory part • Revised section 5.b: SPIRE must be "turned off" when PACS is prime, after a PMODE session • Revised section 6.b: PACS must be "turned off" when SPIRE is prime, after a PMODE session • Revised section 6.d: SPIRE must be "turned off" when PACS is prime, after a PMODE session
2.1	LC	Added Change Log
2.2	LC	Changes to Parallel mode sections for PACS prologue and epilogue naming convention: • From PacsEng_PHOT_orbit_prologue to SpirePacsEng_Parallel_PacsPrologue • From PacsEng_orbit_epilogue to SpirePacsEng_Parallel_PacsEpilogue
2.3	RV	Changes to PACS section based on input from U. Klaas
2.4	IV/LC	General update to SPIRE scheduling guidelines
2.5	LC	Changes to SPIRE section based on input from S. Leeks

2.6	APM	Combined parallel mode sections in SPIRE and PACS for clarity. Cooler hold time clarification in text, as per input from Ulrich Klaas.
2.7	DT	Update of HIFI section
2.8	APM	Update of information on placement of HIFI dissipative AOR within a DTCP (**HifiEngSetFromDissipative_I_IntoDissipative_II** see section on Mode Transitions). Update to information on SPIRE deliveries and switching between modes (see section on SPIRE).
2.9	APM	Added SPIRE checksum AOR usage (see first three items under SPIRE) Added SPIRE-S usage only on cooler-recycling days (see Spectrometer:). Also updated SPIRE sequences for example ODs.
3.0	APM	Updated to provide proper examples for routine phase names plus new scheme for prolog and epilogs for PACS where it is not required to have an epilog/prolog between successive PACS days.
3.1	APM	Added information on SPIRE-S dark sky usage (see SPIRE Spectrometer Dark Sky Calibrations:).

General

This set of informal guidelines is intended to provide advice for those who are planning schedules for observing days of Herschel observations.

In general -- if you are uncertain about a particular schedule you should ask the appropriate member(s) of the Instrument and Calibration Scientist team.

Some other caveats that should be noted at the start.

Warning: check instrument related manual activities planned for real time contact (DTCP).
Warning: don't use pool AORs for IST/PV unless the ICC provided them specifically for a given OD.

HIFI

General:

After the LCU failure of August 2nd, the scheduling rules have been adapted in order to provide more safety to the LCU and the LOU. The concept of standby mode remains, but it is named differently: Dissipative mode. As in the pre-LCU failure concept, there is a Dissipative-1 and a Dissipative-2 mode. There activation resembles the ones of the former Standby-1 and Standby-2 (see details thereafter).

Mode Description:

There are four modes applicable to HIFI:

- **Standby 1**: this mode is reserved for memory maintenance (LCU safety table upload, OBSW upload, SEU recovery). It is only entered in DTCP, and in manual commanding. As such, **one does not schedule the transition to and from this standby-1 mode.**
- **Dissipative 1**: this mode is used when HIFI is non-PRIME for long periods (long period here means: more than 2 consecutive days). In this mode, the WBS lasers are OFF, and the LOU chain is OFF.
- **Dissipative 2**: In this mode, the WBS lasers are ON, and one LOU chain is switched on with a very low output power level, this in order to warm up one of the SVM panels prior to observations. This mode is used in two circumstances:
  - In the day prior to HIFI becoming PRIME, HIFI transits to dissipative-2 in order to warm up both the WBS lasers and the LSU
  - In-between HIFI PRIME ODs (i.e. during DTCPs when HIFI is not operated), to keep the LSU warm
- **Normal**: this is the normal state when HIFI is PRIME instrument

Mode Transitions:

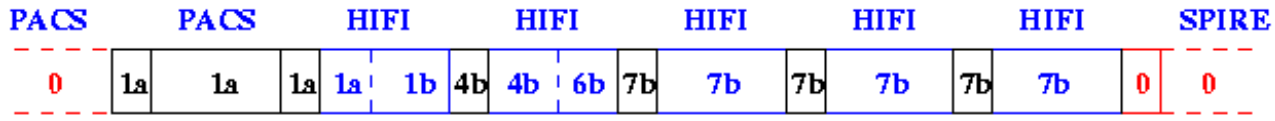
All engineering modes for mode transitions can be scheduled in the DTCP, however some should preferably be scheduled outside of the DTCP (see below). There are four mode transitions that can be scheduled:

- **HifiEngSetFromDissipative_I_IntoDissipative_II**: This is the engineering mode to schedule one day before HIFI ends a prolonged non-PRIME period. ***In order to leave room in the DTCP for potential contingency operations, this mode should be scheduled as late as possible in the DTCP – at the very end before observations that take place (with PACS) outside the DTCP.*** This mode transition requires the choice of an LOU band. This band should be the one that will be used first in the next day when HIFI becomes PRIME.
- **HifiEngSetIntoPrimary**: This is the engineering mode to schedule when HIFI becomes PRIME instrument. In order to leave room in the DTCP for potential contingency operations, this mode should be scheduled as late as possible in the DTCP.
- **HifiEngSetFromNormal_IntoDissipative_II**: This is the engineering mode to schedule at the end of an OD. It is preferable to have this outside of the DTCP, i.e. at the end of the MTL period. This mode transition requires the choice of an LOU band. Its choice differs depending on the situation:
  - if this is not the last HIFI PRIME OD of a given cycle, the band should be the one that will be used first in the next day when HIFI becomes PRIME again
  - if this is the last HIFI PRIME OD of a given cycle, the band should be "0".
- **HifiEngSetFromDissipative_II_IntoDissipative_I**: This is the engineering mode to schedule at the end of an HIFI PRIME cycle, i.e. it should come right after a **HifiEngSetFromNormal_IntoDissipative_II** with band "0". It is also preferable to have this outside of the DTCP.
  Note the dissipative-1 state is always equivalent to selecting band = "0". This is why there is no band selection in transitions to this mode.

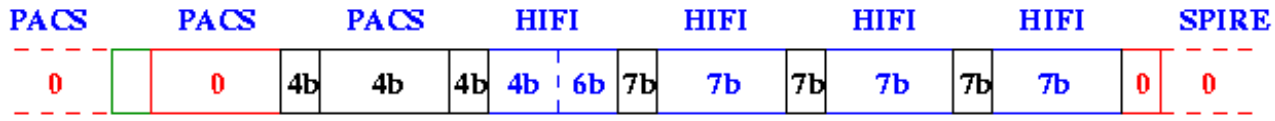
The figure below shows examples of typical mode sequences over several ODs. In black are the DTCP, periods, in blue the MTL periods.

- In the "ROUTINE" example, HIFI is preceded by two PACS days. At then end of the first PACS day, the transition to dissipative 2 is performed in band 1a, as this is the first band to be used on the first HIFI OD. During the whole second PACS day, HIFI is in dissipative-2 in band 1a (this is a passive state). On the first HIFI OD, HIFI starts in band 1a, then moves to 1b. At the end of that OD, HIFI goes into dissipative-2 in band 4b as this is the band to use at the start of the second OD. HIFI stays in this state over the DTCP. Etc. At the end of fifth OD, HIFI goes into dissipative-2 in band 0, then finally into dissipative-1 and let's SPIRE starts.
- In the "S/W MAINTENANCE" example the only difference is that one day before HIFI gets into dissipative-2 for warm-up, some LCU table upload take place. For this HIFI is put in standby-1 **in manual commanding**, then sets back to dissipative-1.

ROUTINE



S/W MAINTENANCE



Changing Local Oscillator Band/Subband:

When changing between bands (e.g. band 3b to band 5b) it is necessary to insert an engineering observation that both changes the band in use and allows time for thermal settling. This delays the scheduling of science observations so we would prefer to keep such transitions to a small number in an observing day. Note that this band switch is needed even though one may have set HIFI into a dissipative-2 mode in that same band prior to the start of the band use.

The engineering mode for this operation is called **HifiEngSwitchonLO**. It takes two input parameters:

- The LO band to switch
- A Boolean parameter driving the duration of the warm-up. The rationale behind this is that some AOTs are more robust against drift because they alternate relatively quickly between their respective ON and OFF phases.

- The **robust = false** option shall be used if the AOT following the switch-on is one of:
  - o **HifiPointModePositionSwitch**
  - o **HifiMappingModeOTF**
  - o **FSwitch**
- The **robust = true** option shall be used for any other of the AOTs (i.e. the **DBS** and **LoadChop** families of AORs).

- There are short and long versions of this switchover. For bands 6a to 7b you should **always use long. For bands 1a to 5b a short version only is needed IF robust = true.**

- IT IS NOT RECOMMENDED TO HAVE MORE THAN 3 BAND CHANGES PER HIFI OD.

Note: At present we recommend to not yet use the robust = true option for HEB bands (6a to 7b). So for those, regardless of the AOT to be scheduled after the switch-on, one should select robust = false. In the near future, HIFI is looking into optimizations consisting e.g. in combining the slew to the source and the warm-up of the switch-on.

A similar purpose can be met by running an engineering mode during the settling time. However, it should be indicated in the HIFI instruction that this engineering mode would substitute the **HifiEngSwitchonLO.**

The table below gives an order of magnitude of the durations involved for either case, per band:

Band	Duration if robust = true (sec)	Duration if robust = false (sec)
1a	324	1850
1b	323	1850
2a	358	1860
2b	358	1860
3a	373	1860
3b	372	1860
4a	395	1860
4b	395	1860
5a	234	1850
5b	234	1850
6a	970	3186
6b	858	3070
7a	858	3070
7b	857	3070

The above should also be used to get an idea of how many "robust" AORs should be scheduled before the first "non-robust" AOR should be scheduled. Indeed, say one chooses a "robust" switch-on, then schedules a 2 min *DBS* observation, followed by a *Position Switch* AOR, it is likely that not enough warm-up time has elapsed yet.

Recommended number of HIFI bands in an OD:

The scheduler should try to work with a maximum number of **2 LO bands per OD**. It is however understood that such a constraint may be difficult to respect for all visibility circumstances. If the planning of a given cycle (PSP or Routine) turns out to be to complex with this limitation, HIFI would like to be contacted and together with HSC look into ways to possibly relax this rule.

Recommended number of consecutive HIFI days in a cycle:

It is assumed that a typical Routine cycle will consist of 4 weeks (28 days) over which HIFI will be used during 7 days. From a safety viewpoint, there is no difference between having those 7 days consecutive, or spread over in two groups of 4 and 3 days respectively. However, from the perspective of the observatory operations, especially in the context of SEU contingency, HIFI believes that there is some advantage in working in two separate chunks, in particular if this can reduce e.g. the number of HIFI operation days falling on week-ends. From a statistical viewpoint however there is no indication that the sensibility to SEU really differs when working along one or the other scheme. When more statistics on the SEU occurrence is available we may revise the above.

SPIRE

SPIRE can work up to 48 hours after the cooler was recycled. That is why the optimal scheduling should include two days of SPIRE, so that the cooler hold time is efficiently used. The cooler recycle takes 2.5 hours and preferably should be done during the DTCP.

There are two special AORs that need to be run regularly to monitor and maintain the health of the SPIRE instrument – SMEC mechanism AOR (ensures regular use of the SMEC), and checksum AOR.

SMEC mechanism AOR usage:

If the SPIRE spectrometer is not to be used during a 2-week scheduling cycle, then a short SMEC scan is run using an engineering mode AOT (SpireEngSmecScanGen). This should follow any checksum AOR in the assigned operational day (see calibration delivery readme for details of when to schedule within a given scheduling cycle).

Checksum AOR usage:

In order to check for bitflips within the on-board software, it is necessary to always include an AOR that checks for possible problems at the beginning of each OD when SPIRE is in REDY mode.

1. **In practice this means the checksum AOR (currently called "SpireEngCheckPMGen") should be placed at the beginning of every OD when SPIRE is NOT the prime instrument, as well as the first OD (only) in a sequence of days in which SPIRE is prime (SPIRE-S, SPIRE-P or Parallel mode).**
2. **For the first OD in a sequence of SPIRE ODs, the checksum AOR should be placed at the very beginning of the OD and be followed by a 15 minute delay. Only after this should a cooler recycling [or SMEC scan AOR] be**

scheduled. In other words, when there is a cooler recycling there is always a 15 minute gap to follow. E.g.,

SpireEngCheckPMGen

15 minutes gap

SPIRE/Parallel mode cooler recycle

Calibration deliveries:

The guidelines given in the calibration deliveries "readme" file by the SPIRE ICC take precedence over the general guidelines. Even if not mentioned in the "readme" file, all calibration observations for a sub-instrument should be scheduled together in one block as much as possible (and obviously observations on the same target within a sub-instrument should be scheduled together) and towards the end of the 48 hours period (i.e., when the instrument temperature is stable). *Although the need to group calibrations or place them towards the end of a 48-hour period of sub-instrument usage is not an absolute requirement. See specific "readme" file for details of specific calibration deliveries.*

In order to handle checksum issues, SPIRE should provide at least one version of the checksum AOR (current base name "SpireEngCheckPMGen"). This will need to be cloned for each day of the cycle where it is required for usage (see above).

For the spectrometer – in cycles where there is no OD with SPIRE spectrometer measurements the calibration delivery from SPIRE will include information on usage of an AOR that exercises the SPIRE SMEC mechanism. This should be included in the planning as per the "readme" instructions provided and will always follow the checksum AOR noted above.

Photometer:

For the SPIRE Photometer, the instrument needs to be put into primary observing mode after a cooler recycle from a ready state (REDY) to standby mode (PHOT_STBY) to accept photometer observations. This is currently done by the engineering mode SpireEngREDYtoPHOT_STBY.

The non-slew part of the first SPIRE photometer observation should be no earlier than *10 minutes from the beginning* of the SpireEngREDYtoPHOT_STBY mode: since the latter takes 400s, it is 200s after its end.

The SpireEngREDYtoPHOT_STBY mode *should only be used for one period in an OD pair* (i.e. there should not be 2 REDY/STBY pairs during the period)

When to put the Photometer into REDY state:

- At the end of all SPIRE photometer observations
- Before the cooler recycling
- Before switching to SPIRE spectrometer
- Before switching to another instrument (PACS or HIFI)

When it is not necessary to make the transition from SPIRE Photometer to REDY state:

- At the end of an OD (before the DTCP) if the next OD (after the DTCP) is also SPIRE Photometer or SPIRE PACS Parallel Mode.
- At the end of an OD (before the DTCP) if the next OD (after the DTCP) is SPIRE PACS Parallel Mode.

This guideline is dictated by the requirement to have as few mode transition (REDY-to-STBY or STBY-to-REDY) as possible.

Example for 2 ODs of SPIRE PHOTOMETER:

```
      <DTCP 1st OD>
      SpireEngCheckPMGen
      Wait 15 minutes
      SpireEngCoolerRecycleGen (started during DTCP)
      SpireEngREDYtoPHOT_STBYGen
      ...
      <wait 10 minutes from the beginning of SpireEngREDYtoPHOT_STBYGen ==
      200s from the end of SpireEngREDYtoPHOT_STBYGen (which takes 400 seconds)>
            ...
            do the photometry AORs
            ...
      <DTCP 2nd OD>
            ...
            do the photometry AORs
            eventually finish the day with calibration AORs
            ...
      SpireEngPHOT_STBYtoREDYGen
```

Note: it is not absolutely necessary to finish a second OD with a set of sub-instrument calibration AORs. Neither is it necessary to group the calibration AORs.

Spectrometer:

For the SPIRE Spectrometer, the instrument needs to be put into primary observing mode after a cooler recycle from a ready state (REDY) to standby mode (SPEC_STBY) when it is ready then to accept spectrometer observations. This is currently done by the engineering mode SpireEngREDYtoSPEC_STBY. **NOTE: A spectrometer OD (or partial OD) should be done on the same OD as a cooler recycling.**

In addition – the SPIRE spectrometer SMEC scan should be exercised at least once per scheduling cycle (every 2 weeks). If the spectrometer is not to be used for a given observing day within a planning cycle, then a short AOR for exercising the SMEC mechanism should be provided within the SPIRE calibration delivery with information on the appropriate date for it to be run. Note that this AOR will always be after the checksum (see SMEC mechanism AOR usage:*).*

Preferably the SPIRE Spectrometer *should not be used for less than 6 hours at a time* (i.e. the time span between the engineering modes SpireEngREDYtoSPEC_STBY and SpireEngSPEC_STBYtoREDYGen must be more than 6 hours) **and *it should only be used once in an OD pair* (i.e. there should not be 2 REDY/STBY pairs).**

The non-slew part of the first SPIRE Spectrometer observation should be no earlier than *10 minutes after the end* of the SpireEngREDYtoSPEC_STBY mode transition.

When to put the Spectrometer into REDY state:

- At the end of all SPIRE spectrometer observations
- Before the cooler recycling
- Before switching to SPIRE photometer
- Before switching to another instrument (PACS or HIFI).

When it is not necessary to make the transition from SPIRE Spectrometer to REDY state:

- At the end of an OD (before the DTCP) if the next OD (after the DTCP) is also SPIRE Spectrometer.

This guideline is dictated by the requirement to have as few mode transition (REDY-to-STBY or STBY-to-REDY) as possible.

Example for 2 ODs of SPIRE SPECTROMETER:

```
      <DTCP 1st OD>
      SpireEngCheckPMGen
      Wait 15 minutes
      SpireEngCoolerRecycleGen (started during DTCP)
      SpireEngREDYtoSPEC_STBYGen
      ...
      <wait 10 minutes after the end of SpireEngREDYtoSPEC_STBYGen>
            ...
            do the spectrometer AORs
            ...
      <DTCP 2nd OD>
            ...
            do the spectrometer AORs
            eventually finish the day with calibration AORs
            ...
      SpireEngSPEC_STBYtoREDYGen
```

Note: it is not absolutely necessary to finish a second OD with a set of sub-instrument calibration AORs. Neither is it necessary to group the calibration AORs.

SPIRE Spectrometer Dark Sky Calibrations:

Spectrometer low resolution (LR) and medium resolution (MR) observations need dedicated dark sky observations done at the same spectral resolution and with as many repetitions as the highest number of repetitions of any of the planned observations for a given pair of the spectrometer days.

The long dark sky observation(s) are preferably to be planned close to the middle of the two spectrometer days.

One additional short dark sky observation, always at CR, should be planned in all pairs of spectrometer days. Preferably it should be planned as far in time from the long dark as possible. This implies that it is in the OD with no long dark. This also implies no short dark if only a single spectrometer day is planned.

Photometer – Spectrometer switching:

It must be noted that the photometer and spectrometer CANNOT be run at the same time and must not be turned on at the same time. There is also NO direct transition from photometer standby (PHOT_STBY) to spectrometer standby (SPEC_STBY) and vice versa: SPIRE must always be set into ready (REDY) mode when switching from one instrument to the other.

Example for 2 ODs with SPIRE instrument switching in 1st OD (starting with photometer, then switching to spectrometer: it would work the other way round too):

<DTCP 1st OD>
SpireEngCheckPMGen
Wait 15 minutes
SpireEngCoolerRecycleGen (started during DTCP)
SpireEngREDYtoPHOT_STBYGen
...
<*wait 10 minutes from the beginning of SpireEngREDYtoPHOT_STBYGen* ==
200s from the end of SpireEngREDYtoPHOT_STBYGen>
    ...
    do the photometry AORs
    eventually do the photometer calibration AORs
    ...
SpireEngPHOT_STBYtoREDYGen
SpireEngREDYtoSPEC_STBYGen
...
<*wait 10 minutes after the end of SpireEngREDYtoSPEC_STBYGen*>
    ...
    do the spectrometer AORs
    ...
<DTCP 2nd OD>
    ...
    do the spectrometer AORs
    eventually finish the day with spectrometer calibration AORs
    ...
SpireEngSPEC_STBYtoREDYGen

Example for 2 ODs with SPIRE instrument switching in 2nd OD (starting with spectrometer, then switching to photometer: it would work the other way round too):

<DTCP 1st OD>
SpireEngCheckPMGen
Wait 15 minutes
SpireEngCoolerRecycleGen (started during DTCP)
SpireEngREDYtoSPEC_STBYGen
...
<*wait 10 minutes after the end of SpireEngREDYtoSPEC_STBYGen*>
    ...
    do the spectrometer AORs
    ...
<DTCP 2nd OD>
    ...
    do the spectrometer AORs

```
            eventually do the spectrometer calibration AORs
            ...
      SpireEngSPEC_STBYtoREDYGen
      SpireEngREDYtoPHOT_STBYGen
      ...
      <wait 10 minutes from the beginning of SpireEngREDYtoPHOT_STBYGen ==
      200s from the end of SpireEngREDYtoPHOT_STBYGen>
            ...
            do the photometry AORs
            eventually finish the day with photometer calibration AORs
            ...
      SpireEngPHOT_STBYtoREDYGen
```

Example for 2 ODs with SPIRE instrument switching with DTCP in between (starting with spectrometer, then switching to photometer: it would work the other way round too):

```
      <DTCP 1st OD>
      SpireEngCheckPMGen
      Wait 15 minutes
      SpireEngCoolerRecycleGen (started during DTCP)
      SpireEngREDYtoSPEC_STBYGen
      ...
      <wait 10 minutes after the end of SpireEngREDYtoSPEC_STBYGen>
            ...
            do the spectrometer AORs
            eventually finish the day with spectrometer calibration AORs
            ...
      SpireEngSPEC_STBYtoREDYGen
      <DTCP 2nd OD>
      SpireEngREDYtoPHOT_STBYGen
      ...
      <wait 10 minutes from the beginning of SpireEngREDYtoPHOT_STBYGen ==
      200s from the end of SpireEngREDYtoPHOT_STBYGen>
            ...
            do the photometry AORs
            eventually finish the day with photometer calibration AORs
            ...
      SpireEngPHOT_STBYtoREDYGen
```

Note: it is not absolutely necessary to finish a second OD with a set of sub-instrument calibration AORs. Neither is it absolutely necessary to group the calibration AORs.

SPIRE/PACS Parallel Mode:

For the parallel mode (PMODE in the following), both the SPIRE and PACS photometers need to be switched on. For SPIRE this is the same set of commanding as for the photometer case noted above, i.e. first the SPIRE checksum should be done, then a cooler recycle for both instruments (SpireEngParallelCoolerRecycleGen), followed by the standard SPIRE photometer 'activation' (SpireEngREDYtoPHOT_STBYGen).

SPIRE commands must always be executed before the corresponding PACS ones, unless no SPIRE commands are needed (e.g., at the end of the first of a pair of PMODE ODs).

At the end of a PMODE OD (outside DTCP):

- Put SPIRE Photometer in its REDY state (SpireEngPHOT_STBYtoREDYGen) if the next OD requires a cooler recycle or does not start with SPIRE photometer observation or Parallel mode observation
- Do PACS orbit epilogue (SpirePacsEng_Parallel_PacsEpilogue)

Example for 2 ODs of SPIRE/PACS Parallel Mode:

```
<DTCP 1st OD>
SpireEngCheckPMGen
Wait 15 minutes
SpireEngParallelCoolerRecycleGen (started during DTCP)
SpireEngREDYtoPHOT_STBYGen
SpirePacsEng_Parallel_PacsPrologue
      ...
      do the PMODE AORs
      ...
SpirePacsEng_Parallel_PacsEpilogue
<DTCP 2nd OD>
SpirePacsEng_Parallel_PacsPrologue
      ...
      do the PMODE AORs
      ...
SpireEngPHOT_STBYtoREDYGen
SpirePacsEng_Parallel_PacsEpilogue
```

SPIRE/PACS and Parallel Mode mixed ODs:

In order to optimize the scheduling and because of the length of most of the parallel mode observations, parallel mode ODs are usually filled with either PACS or SPIRE photometry or both. PACS only and SPIRE only observations could be scheduled in one OD too.

The general guideline is:

- For the parallel part both SPIRE and PACS should be on (SPIRE in STBY mode, PACS after prologue), with SPIRE mode transition commands always executed before the PACS ones.
- To switch from Parallel mode to SPIRE-only or PACS-only, the other instrument should be put into 'off' mode (for SPIRE using in SpireEngPHOT_ STBYtoREDYGen; for PACS using SpirePacsEng_Parallel_PacsEpilogue) while the instrument to be prime next remains as it is.
- To switch to Parallel from SPIRE-only or PACS-only, the prime instrument remains as it is, the 'off' instrument is switch on (for SPIRE using in SpireEngREDYtoPHOT_STBYGen; for PACS using SpirePacsEng_Parallel_ PacsPrologue)

Example of PMODE + SPIRE OD (example OD214):

```
SpireEngCheckPMGen
```

```
      Wait 15 minutes
      SpireEngParallelCoolerRecycleGen (if needed, starting in DTCP)
      SpireEngREDYtoPHOT_STBYGen
      PacsEng_PHOT_orbit_prologue
            ...
            do the PMODE AORs
            ...
      PacsEng_orbit_epilogue
            ...
            do the SPIRE Phot AORs
            ...
      SpireEngPHOT_STBYtoREDYGen (required only if next OD starts with a cooler
recycle or does not start with SPIRE photometer or Parallel mode observation)
```

Example of SPIRE + PMODE OD:

```
      SpireEngCheckPMGen
      Wait 15 minutes
      SpireEngParallelCoolerRecycleGen (if needed, starting in DTCP)
      SpireEngREDYtoPHOT_STBYGen
      ...
      <wait 10 minutes from the begin of SpireEngREDYtoPHOT_STBYGen ==
      200s from the end of SpireEngREDYtoPHOT_STBYGen>
            ...
            do the SPIRE Phot AORs
            ...
      PacsEng_PHOT_orbit_prologue
            ...
            do the PMODE AORs
            ...
      PacsEng_orbit_epilogue
            ...
            do the SPIRE Phot AORs
            ...
      SpireEngPHOT_STBYtoREDYGen (required only if next OD starts with a cooler
recycle or does not start with SPIRE photometer or Parallel mode observation)
```

Applicability of PACS photometer orbit prologues to parallel mode science AORs and vice versa.

PACS photometer orbit prologues are used to
1) switch-on the optimum bias voltages for the photometer;
  Note that bias voltages for normal and parallel mode PACS
  photometer operations are identical;
2) to configure the mechanics, including enabling of the control loops,
  like e.g. the PACS chopper;
3) to switch on the PACS internal calibration sources and heat them
  in control loop to the defined level;

The SPU settings required for a specific type of measurement, and which are different between normal PACS photometry and SPIRE/PACS parallel mode photometry, are part of the AOT prologue and not of the orbit prologue. Therefore, the AOTs for normal PACS and SPIRE/PACS parallel mode are self-consistent regarding the correct SPU settings. The selection of the correct bus profile is taken care of by the SMPS.

This means that a normal PACS photometer orbit prologue is sufficient to configure PACS for SPIRE/PACS parallel mode science AORs as well as parallel mode PACS orbit prologue modules are sufficient to configure PACS for normal photometry.

DTCP/OD contains PACS Photometer and PARALLEL MODE AORs

Assuming condition 1.a is true

1.a - start with PHOTO -> end with PMODE observations

```
-- DTCP/OD:
SpireEngCheckPMGen
Wait 15 minutes
SpireEngParallelCoolerRecycleGen ->
PacsEng_PHOT_orbit_prologue ->
P_PACS activities ->
SpireEngREDYtoPHOT_STBY -> (so switch on SPIRE -- do not touch PACS)
PMODE activities ->  (start observations here)
SpireEngPHOT_STBYtoREDY ->
SpirePacsEng_Parallel_PacsEpilogue
```

1.b - start with PMODE -> end with PHOTO observations

```
-- DTCP/OD:
SpireEngCheckPMGen
Wait 15 minutes
SpireEngParallelCoolerRecycleGen ->
SpireEngREDYtoPHOT_STBY ->
SpirePacsEng_Parallel_PacsPrologue ->
PMODE activities ->
SpireEngPHOT_STBYtoREDY -> (so switch off SPIRE -- do not touch PACS)
P_PACS activities -> (do PACS PHOT observations)
PacsEng_orbit_epilogue
```

DTCP/OD contains PACS Photometer, SPIRE and/or PARALLEL MODE AORs

If PACS cryo-cooler recycling was 2 ODs or more ago, then schedule cooler recycle into DTCP or at earliest convenience in case of DTCP special activities: a photometer cooler recycle needs to take place followed by an orbit prologue, an epilogue completes the OD. Both prologue and epilogue can be in a DTCP:

2.a - start with PHOT -> then go to PMODE -> then SPIRE with parallel cooler recycling

```
-- DTCP/OD:
SpireEngCheckPMGen
Wait 15 minutes
SpireEngParallelCoolerRecycleGen -> (prepare SPIRE for later part)
PacsEng_PHOT_orbit_prologue ->
P_PACS activities ->
SpireEngREDYtoPHOT_STBY ->
PMODE activities ->
SpirePacsEng_Parallel_PacsEpilogue -> ("turn off" PACS)
SPIRE_PHOT activities ->
SpireEngPHOT_STBYtoREDY
```

NOTE: in routine operations this is likely to be updated with a need for an engineering block to change PACS bias settings between PHOT measurements and PMODE measurements. This does not exist yet!

2.b - start with PHOT -> go to PMODE -> then do SPIRE with two separate cooler recyclings. Only occurs if PACS cryo-cooler is recycled and the remaining hold time allows the scheduling of the required number of P_PHOT AORs
-- DTCP/OD:
SpireEngCheckPMGen
Wait 15 minutes
PacsEng_PHOT_orbit_prologue ->
P_PHOT activities ->
SpireEngCoolerRecycle ->
SpireEngREDYtoPHOT_STBY -> (prepare SPIRE for parallel mode)
PMODE activities ->
SpirePacsEng_Parallel_PacsEpilogue -> ("turn off" PACS)
P_SPIRE activities -> (do SPIRE PHOT observations)
SpireEngPHOT_STBYtoREDY

2.c - start with SPIRE -> go to PMODE -> then to PACS PHOT with parallel cooler recycling NOT recommended, loss of observing time.

2.d - start with SPIRE -> go to PMODE -> then go to PACS PHOT with two separate cooler recyclings. Only to be done if SPIRE cryo-cooler is recycled and the remaining hold time allows the scheduling of the required number of SPIRE AORs
-- DTCP/OD:
SpireEngCheckPMGen
Wait 15 minutes
SpireEngREDYtoPHOT_STBY -> (set up SPIRE -- observe as no cooler recycling needed in this case)
P_SPIRE activities ->
PacsEng_BOLO_cooler ->
SpirePacsEng_Parallel_PacsPrologue ->
PMODE activities ->
SpireEngPHOT_STBYtoREDY -> ("turn off" SPIRE)
P_PACS activities -> (observe with PACS)
PacsEng_orbit_epilogue

2.e - start with SPIRE -> go to PACS PHOT or vice versa.
NOT recommended. Loss of observing time.

PACS

The following are general PACS scheduling guidelines for a single OD, also shared ODs with HIFI or SPIRE.

Warning: In ODs including calibration activities the PACS prologue/epilogue blocks may have different names (alternative observing modes for test purposes).

Caveat: It was noticed that very low frequency oscillations have stronger power in the PACS photometer noise spectrum of those observations which are scheduled right after the cooler recycling. It is recommended to schedule AORs which are sensitive to extended emission (typically galactic plane or star formation

studies) further away (~at least 3 hours) from the cooler recycling. Further investigations will provide more precise timing estimate.

Pre-condition: general rules are applicable only if PACS is in safe mode from the previous PACS OD.

(1) DTCP/OD contains only PACS Photometer AORs

Check when last PACS cooler recycling (either PACS only or parallel cooler recycling) was.

1.a - If PACS cryo-cooler recycling was 2 ODs or more ago*, then schedule into DTCP or at earliest convenience in case of DTCP special activities: a photometer cooler recycle needs to take place followed by an orbit prologue, an epilogue completes the OD. Both prologue and epilogue can be in a DTCP:

0) PACS-SDPPhotCooler_117_nStd_Na_na_00nn 8542s
nn = 01 ....

This has to be followed immediately by the photometer orbit prologue (follow instructions as below in 1.b)

1.b - In case of no cooler recycling necessary, the photometer orbit prologue must be the first AOR on the OD and can be scheduled into the DTCP.

Until further notice, only 1 possible option of the orbit prologue has been delivered which is the "just wait" option. [The "VRL" and "40Hz" options need further follow-up wrt. signal stabilization due to variation of read-out modes.]

1) PACS-SDPPhotSetup_na_nStd_orbitproWait_na_00nn 2263s
nn = 01 ...

The orbit prologue modules set the bias voltages of the bolometer detectors. They include the necessary stabilization times for the detectors and the internal CSs.

Then science AORs can be scheduled.

Note 1 – In case of 1.b, the orbit prologue needs to be shifted as much as possible to the end of the DTCP in order to shorten the period when detectors are biased which counts with penalty factor 1.2 (instead of 1.0) in the cooler hold time calculation.

Note 2 – In case of 1.b, a slot of 1h without any pointing request has to be kept after the SOPS window in order to facilitate the gyro calibration activities. The orbit prologue covers only about 0.63h of that period, the remaining time slot needs to be ideally between the end of the SOPS window and the beginning of the orbit prologue (see Note 1 above).

Note 3 – In case of 1.a, the the gyro calibration window is provided by the sufficiently long duration (>1 hour) of the cooler recycling.

The last AOR of the OD must be the photometer orbit epilogue, putting PACS into safe mode:

2) PACS-SDPPhotSetup_na_nStd_orbitepi_na_00nn 13s
nn = 01 ...

(2) DTCP/OD contains only PACS Spectrometer AORs

The first 2 AORs on the OD must (unless the PACS-S was the last sub-instrument used on the previous day and no spectrometer epilog AOR was run) be the spectrometer orbit prologue, consisting of a module switching-on all necessary components and setting-up the detector bias voltages and a module taking data while detectors and internal calibration sources stabilise. These should be scheduled into the DTCP or at the earliest convenience in case of special DTCP activities. PACS should be in safe mode from the previous PACS OD.

1) Calibration-RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SetupFlexClassic_na_00nn 368s
2) Calibration_RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SpuSetupResetClass_na_00nn 3232s (minimum) to 8109s (filling DTCP; not usual)
nn = 01 ...

Calibration_RPSpecSetup….nn AORs have been delivered with a default length of 8109s and can be shortened to a minimum duration of 3233s, if science AORs with targets inside the DTCP area are available.

Then science AORs can be scheduled

Note 1 - The minimum duration orbit prologue covers exactly the required 1 hour of gyro calibration window.

The last AOR of the OD must be the spectrometer orbit epilogue UNLESS PACS-S is the first sub-instrument to be used on the following day (in which case it can be omitted). This puts PACS into safe mode:

3) Calibration_RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_orbitepi_na_00nn 13s
nn = 01 ...

(3) DTCP/OD contains PACS Photometer and PACS Spectrometer AORs

3.a - Start with PACS_PHOTO -> end with PACS_SPECTRO assuming condition 1.a is applicable and a cooler recycling is needed

Check when last PACS cooler recycling (either PACS only or parallel cooler recycling) was. If this was 2 ODs or more ago*, then schedule into DTCP or at earliest convenience in case of DTCP special activities:

0) PACS-SDPPhotCooler_117_nStd_Na_na_00nn 8542s
nn = 01 ...

This has to be followed immediately by the photometer orbit prologue (follow instructions as below in 3.b)

3.b - In case of no cooler recycling necessary, the photometer orbit prologue must be the first AOR on the OD and can be scheduled into the DTCP.

Until further notice, only 1 possible option of the orbit prologue has been delivered which is the "just wait" option. [The "VRL" and "40Hz" options need further follow-up w.r.t. signal stabilization due to variation of read-out modes.]

1) PACS-SDPPhotSetup_na_nStd_orbitproWait_na_00nn 2263s
nn = 01 ...

The orbit prologue modules set the bias voltages of the bolometer detectors. They include the necessary stabilization times for the detectors and the internal CSs.

Then science AORs of the photometer block can be scheduled

Note 1 – In case of 3.b, the orbit prologue needs to be shifted as much as possible to the end of the DTCP in order to shorten the period when detectors are biased which counts with penalty factor 1.2 (instead of 1.0) in the cooler hold time calculation.

Note 2 – In case of 3.b, a slot of 1h without any pointing request has to be kept after the SOPS window in order to facilitate the gyro calibration activities. The orbit prologue covers only about 0.63h of that period, the remaining time slot needs to be ideally between the end of the SOPS window and the beginning of the orbit prologue (see Note 1 above).

Note 3 – In case of 3.a, the gyro calibration window is provided by the sufficiently long duration (>1 hour) of the cooler recycling.

The last AOR of the photometer block must be the photometer orbit epilogue with internal calibration sources (CS) on, putting the photometer into safe mode:

2) PACS-SDPPhotSetup_na_nStd_orbitepiCSOn_na_00nn 13s
nn = 01 ...

This has to be followed immediately by the spectrometer orbit prologue with switched-on CSs:

3) Calibration-RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SetupFlexClassic_na_00nn 368s
4) Calibration_RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SpuSetupResetClass_na_00nn 3232s (minimum) to 8109s (filling DTCP; not usual)
nn = 01 ...

Then science AORs of the spectrometer block can be scheduled.

The last AOR of the OD must be the spectrometer orbit epilogue, putting PACS into safe mode:

5) Calibration_RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_orbitepi_na_00nn 13s
nn = 01 ...

3.c - Start with PACS_SPECTRO -> end with PACS_PHOTO assuming condition 1.a is applicable and a cooler recycling is needed

This sequence is generally NOT recommended (because cooler-recycling very likely is shifted to the OD what makes this scheme inefficient in terms of observatory time use)

The first 2 AORs on the OD must be the spectrometer orbit prologue, consisting of a module switching-on all necessary components and setting-up the detector bias voltages and a module taking data while detectors and internal calibration sources stabilise. These should be scheduled into the DTCP or at the earliest convenience in case of special DTCP activities.

Calibration-RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SetupFlexClassic_na_00nn 368s
Calibration_RPSpecSetup_1-PACS-RPSpecSetup_na_nStd_SpuSetupResetClass_na_00nn 3232s (minimum) to 8109s (filling DTCP; not usual)
nn = 01 ...

Calibration-RPSpecSetup_.... AORs have been delivered with a default length of 8109s and can be shortened to a minimum duration of 3233s, if science AORs with targets inside the DTCP area are available.

Then science AORs can be scheduled

Note 1 - The minimum duration orbit prologue covers exactly the required 1 hour of gyro calibration window.

The last AOR of the spectrometer block must be the spectrometer orbit epilogue with internal calibration sources (CS) on, putting the spectrometer into safe mode:

3) PACS-SDPSpecSetup_na_nStd_orbitepiCSOn_na_00nn 13s
nn = 01 ...

Check when last PACS cooler recycling (either PACS only or parallel cooler recycling) was. If this was 2 ODs or more ago*, then schedule

4) PACS-SDPPhotCooler_117_nStd_Na_na_00nn 8542s
nn = 01 ...

This has to be followed immediately by the photometer orbit prologue. In case of no cooler recycling necessary, the photometer orbit prologue must be the first AOR following the spectrometer orbit epilogue with internal calibration sources (CS) on. Since calibration sources are stable, the following photometer orbit prologue option is selected:

5) PACS-SDPPhotSetup_na_nStd_orbitproWaitCSon_na_00nn 2263s
nn = 01 ...

Then science AORs of the photometer block can be scheduled.

The last AOR of the OD must be the photometer orbit epilogue, putting PACS into safe mode:

6) PACS-SDPPhotSetup_na_nStd_orbitepi_na_00nn 13s
nn = 01 ...

(4) DTCP/OD contains PACS AORs in combination with HIFI and/or SPIRE.
4.1 - If rules 5, 6 & 7 are not applicable then rules 1 & 2 should be applied in a way that the relative positions of PACS blocks do not change

PACS cooler hold-time estimation formula

The cooler hold time after the end of the cooler recycling can be determined from the empirical formula:
T_hold = 73.11 - 0.22 x T_oper [h]
T_hold: cooler hold time
T_oper: operational time of the PACS photometer (all periods between photometer orbit prologues and orbit epilogues, in normal or parallel mode)
Note: T_hold = T_oper + T_idle
T_idle: PACS photometer in safe mode, e.g. during SOPS windows, or when PACS spectrometer is in operation

For a maximum T_oper with the bolometer on for the whole hold time, i.e. T_oper = T_hold, T_opermax = 59.93h