PACS

PACS OBCPs and DMC Sequences

	Name	Function	Date	Signature
Prepared by	H. Feuchtgruber	CE	14-Apr-10	
Checked by				
Approved by				
Approved by				
Approved by				
Authorized by	E. Sturm	ICC		
Authorized by	A. Poglitsch	PI		

DISTRIBUTION RECORD

Issue / Revision	Draft 1.0	Draft 2.0	Draft 3.0	Draft 4.0	Draft 5.0	Draft 6.0
Distribution Date	16-Feb-01	11-Apr-01	15-May-01	20-Jun-01	15-Oct-01	21-Nov-01

Issue / Revision	Draft 7.0	Draft 8.0	Draft 9.0	Issue 1	Issue 1.1	Issue 1.2
Distribution Date	5-Feb-02	17-Feb-03	9-Oct-03	19-Dec-03	01-Feb-05	8-Mar-05

Issue / Revision	Issue 1.3	Issue 1.4	Issue 1.5	Issue 1.6	Issue 1.7	Issue 1.8
Distribution Date	06-Apr-06	11-Apr-06	25-Jul-06	15-Oct-07	9-Jul-08	28-Jan-09

Issue / Revision	Issue 1.9	Issue 2.0	Issue 2.1	Issue 2.2
Distribution Date	06-Feb-09	27-Apr-09	8-Jun-09	14-Apr-10

Intern			**Extern**		
Department	Name	Qty	Company	Name	Qty
MPE	Sturm				
MPE	Wieprecht		UVIE	Ottensamer	
MPE	Mueller		CEA	Cara	
MPE	Poglitsch		CSL	Gillis	
MPE	Wiezorrek		CSL	Mazy	
MPE			IFSI	Pezzuto	
MPE					
Electronic Archives at Leuven					

DOCUMENT CHANGE RECORD

Issue / Rev.	Date	Change Notice Number	Modified Pages or Paragraphs	Remarks / Nature of Change
Draft 0.0	19-Dec-00	Initial version		
Draft 1.0	16-Feb-01	Update for IIDR	All	Included updated set of documents by sub-units and changed format of document according to PACS-ME-GP-001
Draft 2.0	11-Apr-01	Update, sequences and autonomy functions	many	Initial thoughts about sequences and autonomy functions added. DMC packet counters added in HK. SPU LLSW command "stop" removed. Number of DMC loops increased to 5;
Draft 3.0	15-May-01	Based on meeting SP/HF, IFSI 19-Apr-01 and some minor updates		Included preliminary definition and contents of events, updated OBCP definition and relation to DMC sequences; adapted latest LLSW command parameters
Draft 4.0	20-Jun-01	Results and AIs from PACS OBSW meeting #5		URD update by IAC, note from17-May-01; AI-OBS5-02; AI-OBS5-10; AI-OBS5-11; AI-OBS5-13; 6 HK parameters added for SPU-HLSW; updated BOLA+BOLC HK parameters list; updated HLSW SSD; updated "are you alive ?" sec.
Draft 5.0	15-Oct-01	Inputs from several updated documents	many	DPU input by Stefano+Milena; BOLC ICD issue 0.4; appendix 8 of PACS OBSW#6; DEC/MEC User Manual draft 1.0; SAp-PACS-CCa-xx-01 issue 1.0 pseudo codes for cooler operations.
Draft 6.0	21-Nov-01		DMC Sequences Chapters; SPU-HLSW HK; BOLC HK and commands; DMC HK	All sequences written out in pseudo code. BOLC ICD issue 1.0; SPU-HLSW - DPU ICD issue 3.2; Updated DMC User manual; OBCP MOM;

Draft 7.0				Mail from SP on DPU HK changes; OTF is now confirmed to be service (20,4); update of DPU commands acc. to mail to SP 11-Dec-01; Time management commands removed; Changed description of TEMP_BOLA_ HK parameters. Changed "Are you alive?" strategy. Remove DMC TC/HK and replace by reference to DMC URD draft 0.2; BOLC-DMC ICD V1.1;
Draft 8.0	17-Feb-03	none	many	Restructured; specific sub-unit commands and HK are removed, since the respective manuals will be the reference. New OBCPs and DMC sequences are added.
Draft 9.0	27-Feb-03		many	Change title and remove information which is contained in the sub-unit user manuals; Parameter numbers and few comment lines added to DMC sequence descriptions.
Issue 1.0	20-Dec-03		many	Modified all OBCPs containing the DMC_WRT_SPU_TRAN_MODE command for 2 parameters. Adapted DMC command naming conventions in OBCPs. Included new BOLC OBCPs. Few typo corrections, Ge:Ga setup OBCP modified
Issue 1.1	01-Feb-05			Modified DMC sequence and OBCP for Freeze Frame Mode; Included SAFE mode OBCP; Included reference table for OBCP/DMC seq. numbering inside the DPU.
Issue 1.2	08-Mar-05			Added OBCP and DMC seq. numbers for each section and duration formulas (by PR); Removed sections on RECY, REGT, CALM, OFPU, OFWE, background cancelling and Cooler recycling; Removed OBCP for regulated state; Added new OBCP 3 for fixed-fixed chopping in photometry and the related DMC sequence. Modified the label for all grating scan

				DMC sequences to flag the down scan.
Issue 1.3	06-Apr-06			Introduced 2 new DMC sequences and the respective OBCPs (replacing 14 and 18) to call them for chopper FOV scans; Updated the SAFE mode OBCP;
Issue 1.4	11-Apr-06			Replaced OBCP 17: Equivalent to SAFE mode OBCP, but only the CSs are left on in order to shorten transitions from SPEC to PHOT and back;
Issue 1.5	25-Jul-06			Modified and changed purpose of OBCP 23; Added new DMC sequence #17 for faster grating scanning; some typo removal;
Issue 1.6	15-Oct-07			Added new wavelength switching OBCP (#32) and DMC sequence (#18). Removed code for SAFE mode, since it is contained in the DPU OBSW manual.
Issue 1.7	9-Jul-08			Adapted DMC sequences and OBCP list from DPU User Manual issue 3.0; Explanation for OBCP2 corrected
Issue 1.8	28-Jan-09			Added new DMC sequence and OBCP for spectroscopy to allow for “A-B-B-A” chopper patterns per grating position
Issue 1.9	6-Feb-09			Correct the label for down scan in DMC Sequence 19
Issue 2.0	27-Apr-09			Updated DMC sequence 18, wavelength switching 2
Issue 2.1	8-Jun-09			Updated DMC sequence 18
Issue 2.2	14-Apr-10			Updated DMC Sequence 18 by CUS upload to DPU

Table of Content

DISTRIBUTION RECORD 2
Intern 2
Extern 2
1 Scope 7
2 Applicable Documents 7
3 List of OBCPs 8
3.1 "Two" or "Three" - Position Chopping Photometry 10
3.1.1 Chopped Photometry (OBCP 4, DMC Seq. 1) 10
3.1.2 Chopped Photometry with Dither (OBCP 5, DMC Seq. 2) 11
3.1.3 Fixed-Fixed Chopped Photometry (OBCP 3, DMC Seq. 14) 11
3.2 "Freeze Frame" Chopping Photometry (OBCP 6, DMC Seq. 4) 12
3.3 Staring Photometry for Line Scans (OBCP 7, DMC Seq. 3) 12
3.4 Bolometer transition to IDLE state (OBCP 1) 12
3.5 Time synchronization 3 (OBCP 2) 13
3.6 Bolometer Set-up 13
3.6.1 ACWE (OBCP 34) 13
3.6.2 Wavelength Switch Grating 2 (OBCP 32; DMC Seq. 18) 14
3.6.3 OBMO (OBCP 33) 14
3.7 Grating Spectral Line Scan 15
3.7.1 Chopped (OBCP 8, DMC Seq. 8) 15
3.7.2 Chopped_2 (OBCP 27, DMC Seq. 12) 15
3.7.3 Chopped_2_Fast (OBCP 23, DMC Seq. 17) 16
3.7.4 No Chopping (OBCP 28, DMC Seq. 13) 16
3.7.5 Chopped with Dither (OBCP 9, DMC Seq. 9) 17
3.7.6 ABBA Chopping (OBCP 35, DMC Seq. 19) 17
3.8 Grating Range Scan 18
3.9 Internal Calibration Photometry 18
3.9.1 Photometry Calibration I (OBCP 10, DMC Seq. 5) 18
3.9.2 Photometry Calibration II (OBCP 11, DMC Seq. 6) 19
3.9.3 Photometry Calibration III (OBCP 12, DMC Seq. 7) 19
3.10 Internal Calibration Spectroscopy (OBCP 13, DMC Seq. 11) 19
3.11 Switch to SAFE (OBCP 24) 20
3.12 Chopper Up-Down Scan Photometry (OBCP 14, DMC Seq. 15) 20
3.13 Chopper Up-Down Scan Spectroscopy (OBCP 18, DMC Seq. 16) 21
3.14 Execute TEST Mode 21
3.14.1 DMC Test Mode (OBCP 15) 22
3.14.2 SPU Test Modes 22
3.15 Wavelength Switch Grating (OBCP 22, DMC Seq. 10) 22
3.16 Switch Spectroscopy to Photometry (OBCP 16) 23
3.17 SAFE with CSs left ON (OBCP 17) 23
3.18 Time Test 1 (OBCP 25) 24

3.19 Time Test 2 (OBCP 26) 24
4 List of DMC Sequences 24
4.1 Photometry 25
4.1.1 Two or Three Position Chopping (OBCP 4, DMC Seq. 1) 25
4.1.2 Two or Three Position Chopping with Dither (OBCP 5, DMC Seq. 2) 26
4.1.3 Staring Photometry (OBCP 7, DMC Seq. 3) 27
4.1.4 Freeze Frame Chopping (OBCP 6, DMC Seq. 4) 27
4.1.5 Chopping on Internal Cal. Sources I (variable-variable) (OBCP 10, DMC Seq. 5) 28
4.1.6 Chopping on Internal Cal. Sources II (fixed-variable) (OBCP 11, DMC Seq. 6) 29
4.1.7 Chopping on Internal Cal. Sources III (fixed-fixed) (OBCP 12, DMC Seq. 7) 30
4.1.8 Fixed-Fixed Chopping in Photometry (OBCP 3, DMC Seq. 14) 31
4.1.9 Chopper UP-Down Scan Photometry (OBCP 14, DMC Seq. 15) 32
4.2 Spectroscopy 33
4.2.1 Grating Line Scan with Two or Three Position Chopping (OBCP 8, DMC Seq. 8) 33
4.2.2 Grating Line Scan with Two position chopping (OBCP 27, DMC Seq. 12) 35
4.2.3 Grating Line Scan with Two position chopping fast (OBCP 23, DMC Seq. 17) 36
4.2.4 Grating Line Scan without chopping (OBCP 28, DMC Seq. 13) 37
4.2.5 Grating Line Scan with 2 or 3 Position Chop. with Dither (OBCP 9, DMC Seq. 9) 38
4.2.6 Grating Range Scan with Two or Three Position Chopping 40
4.2.7 Line Observation with Wavelength Switching (OBCP 22, DMC Seq. 10) 40
4.2.8 Chopped Grating Scans on Internal Calibration Sources (OBCP 13, DMC Seq. 11) 42
4.2.9 Chopper UP-Down Scan Spectroscopy (OBCP 18, DMC Seq. 16) 43
4.2.10 Line Observation with Wavelength Switching 2 (OBCP 32, DMC Seq. 18) 43
4.2.11 Grating Scan with ABBA Chopping (OBCP 35, DMC Seq. 19) 44

1 Scope

OBCPs and DMC sequences are the major components for PACS commanding. Both are stored inside the DPU for access via service 18. This document serves mainly as repository for pseudo code and description of all PACS OBCPs and DMC sequences and will therefore be subject to continuous changes throughout the early ILT phases. All individual commands contained in OBCPs and DMC sequences are described in the respective user manual (see applicable documents) of the involved sub-unit.

2 Applicable Documents

AD-1 DPU OBS User Manual issue 3.2, PACS-CR-UM-024, Feb-2009
AD-2 LFI-REBA and PACS-SPU Start-up SW and Low Level SW Drivers URD, PACS-IC-RD-001, Issue 1, 22-Jan-01 (+update note on 17-May-01)
AD-3 BOLC Electrical Interface Control Document, issue 1.3, 01-Oct-03
AD-4 SPU High Level Software User Manual, issue 13.95a, PACS-TW-HM-002, 5-Feb-06
AD-5 DEC/MEC User Manual, PACS-CL-SR-002, issue 4.5, 07-Jun-08
AD-6 Packet Structure-Interface Control Document, SCI-PT-ICD-7527, issue 5.0, 20-Jul-04
AD-7 Operations Interface Requirements Document, SCI-PT-RS-07360, issue 2.1, 31-Dec-01

3 List of OBCPs

The use of OBCPs within PACS operations originates from the limited uplink bandwidth, of on average only 50 bits/s and a maximum command rate of 2 commands per second. Combining few to many instrument commands, which logically belong together, into OBCPs solves this bandwidth problem and saves significant overheads, otherwise used for sending individual commands. OBCPs are called according to the rules of service 18 from AD-6.
OBCPs where chopper and/or grating movements are involved will consist of "DMC Sequences" and individual commands. However also in the cases without any move of a mechanism, where synchronised detector readouts are required (ex.: 3.3), "DMC sequences" within these OBCPs will be required. Other OBCPs as for example 3.6, 3.7.3 etc. will in principle not require the execution of dedicated "DMC Sequences".

The following rules concerning the relation between OBCPs and sequences, to ease their handling within the DPU, have been established:

- Every OBCP can call a maximum of 1 DMC sequence
- The first parameter of every OBCP defines the DMC sequence
- An OBCP is always called with all its parameters, there will be default values and the last called parameters will be remembered by the procedure.
- Every "ground load" of a DMC sequence which resides inside the DPU has to be done by a call to the respective OBCP, which contains the DMC_WRITE_SEQ_BUF statement.
- DMC sequences, which do not reside inside the DPU, will be uploaded by the respective DMC_WRITE_SEQ_BUF_x command to DMC and can therefore also be started outside of OBCPs

The list of presently known DMC sequences is provided in section 4.

Note: In general, at the time an OBCP is actually started, the parameters have to be filled in already, it is assumed here that this is already done by the DEC_WRITE_SEQ_BUF command with its parameters. Activities like "Issue TM(1,8)" are no instrument commands, but concern other actions the DPU has to perform within such OBCPs. The actual identifiers of the OBCPs and DMC sequences called by them are listed in AD-1. There are also few DPU specific OBCPs concerning lower level functions, which are not listed here, but are described in AD-1 (WRITE_EEPROM, START SPU HLSW, START 1355,…)

The OBCP assignment in the DPU user manual nomenclature is reproduced below for convenience:

The related DMC sequences assignment in the DPU user manual nomenclature is as follows:

Name	ID	NoP	Sequence	NoP
Bolometer transition to IDLE state	1	0	NO	
Time Synchronization III	2	0	NO	
Fixed-Fixed Chopped Photometry	3	12	YES	8
Chopped Photometry	4	14	YES	9
Chopped Photometry with Dither	5	15	YES	9
"Freeze Frame" Chopping Photometry	6	9	YES	4
Staring Photometry for Line Scans	7	5	YES	1
Grating Line Scan Chopped	8	22	YES	12
Grating Line Scan Chopped with Dither	9	23	YES	12
Photometry Calibration I	10	11	YES	6
Photometry Calibration II	11	15	YES	10
Photometry Calibration III	12	13	YES	8
Internal Calibration Spectroscopy	13	19	YES	9
Chopper Up-Down Scan Photometry	14	13	YES	6
DMC Test Mode	15	3	NO	
Switch Spectroscopy to Photometry	16	1	NO	
Enter SAFE mode 2	17	0	NO	
Chopper Up-Down Scan Spectroscopy	18	17	YES	6
Start 1355 link	19	2	NO	
Write in EEPROM	20	25	NO	
Start HLSW	21	3	NO	
Wavelength Switch Grating	22	20	YES	11
Grating Line Scan Chopped 2 Fast	23	21	YES	11
Enter SAFE mode	24	0	NO	
Time Synchronization I	25	0	NO	
Time Synchronization II	26	0	NO	
Grating Line Scan Chopped 2	27	21	YES	11
Grating Line Scan Without Chopping	28	20	YES	11
Generate dummy science packets	29	2	NO	
SPU test mode spec	30	2	NO	
SPU test mode phot	31	2	NO	
Wavelength Switch Grating 2	32	19	YES	8
OBMO	33	0	NO	
ACWE	34	1	NO	
Grating Line Scan Chopped 3	35	21	YES	11

Name	ID	NoP	Length
Two or Three Position Chopping Photometry	1	9	72
Two or Three Position Chopping Photometry with Dither	2	9	72
Staring Photometry	3	1	18
Freeze Frame Chopping Photometry	4	4	30
Chopping on Internal Calibration Sources I	5	6	44
Chopping on Internal Calibration Sources II	6	10	96
Chopping on Internal Calibration Sources III	7	8	54
Grating Line Scan with Two or Three Position Chopping	8	12	142
Grating Line Scan with Two or Three Position Chopping with Dither	9	12	142
Line Observation with Wavelength Switching	10	11	112
Chopped Grating Scan on Internal Calibration Sources	11	9	74
Grating Line Scan with Two Position Chopping	12	11	110
Grating Line Scan without Chopping	13	11	82
Fixed-Fixed Chopping	14	8	100
Chopper Up-Down Scan Photometry	15	6	38
Chopper Up-Down Scan Spectroscopy	16	6	38
Grating Line Scan with Two Position Chopping Fast	17	11	88
Line Observation with Wavelength Switching 2	18	8	48
Grating Line Scan with Two Position Chopping (on-off-off-on)	19	11	108

3.1 "Two" or "Three" - Position Chopping Photometry

The respective sequence (sec. 4.1.1) could be used for both, 2 position and 3 position chopping. If P#4 = P#5 there are just two positions, otherwise three. One assumption is of course, that the bolometer detectors have been set up already by previous commands. The sequence contains 3 loops for chopping after every specified number of observation cycles to the internal calibrations sources. The main loop determines the number of repetitions.

3.1.1 Chopped Photometry (OBCP 4, DMC Seq. 1)

```
OBCP_CHOPPED_PHOTOMETRY(seq, seq_time, P#1,…, P#9, cmp_par_blue, cmp_par_red,
chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
```

```
                        ; failure stop OBCP and issue TM(1,8) + event
DMC_MOV_CHOP_ABS(chop_def)
Issue TM(1,7)
End
```

Duration: 9 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec. 4.1.1.

3.1.2 Chopped Photometry with Dither (OBCP 5, DMC Seq. 2)

```
OBCP_CHOPPED_PHOTOMETRY_DITH(seq, seq_time, P#1,…, P#9, cmp_par_blue,
cmp_par_red, chop_def, max_dith)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_MAX_DITHER(max_dith)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
Issue TM(1,7)
end
```

Duration: 10 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec.4.1.2.

3.1.3 Fixed-Fixed Chopped Photometry (OBCP 3, DMC Seq. 14)

```
OBCP_Fixed_Fixed_PHOTOMETRY(seq, seq_time, P#1,…,P#8, cmp_par_blue, cmp_par_red)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DEC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
Issue TM(1,7)
End
```

Duration: 8 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec. 4.1.8

3.2 "Freeze Frame" Chopping Photometry (OBCP 6, DMC Seq. 4)

Set the chopping sequence such that the sky remains fixed on the array for a certain time, as given via the slew speed.

```
OBCP_FREEZE_FRAME_CHOPPING(seq, seq_time, P#1,…, P#4, cmp_par_blue, cmp_par_red,
chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
Issue TM(1,7)
End
```

Duration: 9 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec. 4.1.4.

3.3 Staring Photometry for Line Scans (OBCP 7, DMC Seq. 3)

```
OBCP_STARING_PHOTOMETRY(seq, seq_time, P#1, cmp_par_blue, cmp_par_red)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DEC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
Issue TM(1,7)
End
```

Duration: 8 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec.4.1.3.

3.4 Bolometer transition to IDLE state (OBCP 1)

Within the flow diagram of the cooler operations this OBCP serves to initiate the transition to the IDLE state.
Suggested implementation (TBC):

```
OBCP_IDLE
Begin
DMC_SWOF_BOL_TEMP_REG
DMC_SEND_COMMAND_TO_BOLC(0x07020000)
DMC_SEND_COMMAND_TO_BOLC(0x07030000)
DMC_SEND_COMMAND_TO_BOLC(0x07010000)
End
```

Duration: 4 x 200ms + 0.5s = 1.3s

3.5 Time synchronization 3 (OBCP 2)

This is a simple OBCP, which serves the only purpose to transfer and set the actual time into the DMC. After execution of this OBCP all science data shall be stamped with synchronized time.

```
OBCP_TimeSynch3()
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
End
```

Duration: 2 x 200ms + 0.5s

AFID represents the identifier of the autonomous function which is being activated. This function has to carry out the following task every 2 seconds when new HK values are available:

```
Begin
If TEMP_EV > 1 Kelvin then
      begin
      TM(5,2) ; DPU to send event with OBSID, BBID, TEMP_EV ID and
              ; TEMP_EV value
      IDLE_OBCP
endif
End
```

The actual comparison of TEMP_EV is done against a digital value which corresponds to 1 K, since there will be no on-board stored conversion tables.

3.6 Bolometer Set-up

3.6.1 ACWE (OBCP 34)

For a description of this OBCP see AD-3.

```
ACWE_OBCP(0,P#1)
```

```
Begin
DMC_SEND_COMMAND_TO_BOLC(P#1) ; P#1=Set_ON_OFF_GROUP
DMC_SEND_COMMAND_TO_BOLC(0x070000FF)
End
```

Remarks: BOLC will be in HK mode only when this OBCP is sent.

Duration: 2 x 200ms + 0.5s = 0.9s

3.6.2 Wavelength Switch Grating 2 (OBCP 32; DMC Seq. 18)

```
OBCP_WAVELENGTH_SWITCHING2(seq, seq_time, P#1,…, P#15, detector, cmp_par_blue,
cmp_par_red, grat_pos, chop_pos, grat_time, grat_def, grat_def_time)
begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_MOVE_CHOP_ABS(chop_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_GRAT_ABS(grat_def)
WAIT(grat_def_time)
Issue TM(1,7)
end
```

Duration: 9 x 200ms + grat_time + grat_def_time + 0.5s

Note that it is somewhat non-trivial to compute the grating start position grat_pos, since the first move in the DMC sequence is the relative move to advance the switch-pattern.

This procedure calls the sequence described in sec. 4.2.10

3.6.3 OBMO (OBCP 33)

```
OBCP_OBMO
Begin
DMC_SEND_COMMAND_TO_BOLC(0x09000000)
DMC_SEND_COMMAND_TO_BOLC(0x0C000014)
DMC_SEND_COMMAND_TO_BOLC(0x0C0111B4)
DMC_SEND_COMMAND_TO_BOLC(0x0C024134)
DMC_SEND_COMMAND_TO_BOLC(0x0C034CE4)
DMC_SEND_COMMAND_TO_BOLC(0x0C044FEC)
DMC_SEND_COMMAND_TO_BOLC(0x0C0590EC)
DMC_SEND_COMMAND_TO_BOLC(0x0C0694AC)
DMC_SEND_COMMAND_TO_BOLC(0x0C0799B4)
DMC_SEND_COMMAND_TO_BOLC(0x0C08A100)
```

```
DMC_SEND_COMMAND_TO_BOLC(0x09000001)
End
```

Remarks: BOLC will be in HK + data in compressed mode when this OBCP is sent.

Duration: 11 x 200ms + 0.5s = 2.7s

3.7 Grating Spectral Line Scan

Consists mainly of a sequence with repetitive up- and down-scans with the grating around a given center position, while the chopper is operating as well on either two- or three-positions.

3.7.1 Chopped (OBCP 8, DMC Seq. 8)

```
OBCP_GRATING_LINE_SCAN_CHOPPED(seq,  seq_time,  P#1,…,P#12,  detector,  grat_pos,
grat_time, cmp_par_blue, cmp_par_red, grat_def, chop_def, grat_def_time)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
End
```

Duration: 13 x 200ms + grat_time + seq_time + grat_def_time + 0.5s

This procedure calls the sequence described in sec. 4.2.1.

3.7.2 Chopped_2 (OBCP 27, DMC Seq. 12)

```
OBCP_GRATING_LINE_SCAN_CHOPPED_2(seq, seq_time, P#1,…,P#11, detector, grat_pos,
grat_time, cmp_par_blue, cmp_par_red, grat_def, chop_def, grat_def_time)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
```

```
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
End

Duration: 13 x 200ms + grat_time + seq_time + grat_def_time + 0.5s
```

This procedure calls the sequence described in sec.4.2.2.

3.7.3 Chopped_2_Fast (OBCP 23, DMC Seq. 17)

```
OBCP_GRATING_LINE_SCAN_CHOPPED_2_Fast(seq, seq_time, P#1,…,P#11, detector,
grat_pos, grat_time, cmp_par_blue, cmp_par_red, grat_def, chop_def,
grat_def_time)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
End

Duration: 13 x 200ms + grat_time + seq_time + grat_def_time + 0.5s
```

This procedure calls the sequence described in sec.4.2.3

3.7.4 No Chopping (OBCP 28, DMC Seq. 13)

```
OBCP_GRATING_SCAN_NOCHOP(seq, seq_time, P#1,...,P#11, detector, grat_pos,
grat_time, cmp_par_blue, cmp_par_red, grat_def, grat_def_time)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_MOVE_CHOP_ABS(P#11)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
```

```
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                       ; Check execution status of the sequence and in case of
                         failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(P#11)
WAIT(grat_def_time)
Issue TM(1,7)
End

Duration: 13 x 200ms + grat_time + seq_time + grat_def_time + 0.5s
```

This procedure calls the sequence described in sec.4.2.4.

3.7.5 Chopped with Dither (OBCP 9, DMC Seq. 9)

```
OBCP_GRATING_LINE_SCAN_CHOPPED_DITH(seq,   seq_time,   P#1,…,   P#12,   detector,
grat_pos,    grat_time,    cmp_par_blue,    cmp_par_red,    grat_def,    chop_def,
grat_def_time, max_dith)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_WRT_MAX_DITHER(max_dith)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
End
```

Duration: 14 x 200ms + grat_time + seq_time + grat_def_time + 0.5s

This procedure calls the sequence described in sec.4.2.5.

3.7.6 ABBA Chopping (OBCP 35, DMC Seq. 19)

```
OBCP_GRATING_LINE_SCAN_CHOPPED_3(seq, seq_time, P#1,…,P#11, detector, grat_pos,
grat_time, cmp_par_blue, cmp_par_red, grat_def, chop_def, grat_def_time)
Begin
 DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
 DMC_SET_TIME
 DMC_MOVE_GRAT_ABS(grat_pos)
```

```
 DMC_MOVE_CHOP_ABS(P#5)
 DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
 DMC_SYNCHRONIZE_ON_DET(detector)
 DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
 WAIT(grat_time)
 DMC_START_SEQUENCE
 WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
 DMC_MOVE_GRAT_ABS(grat_def)
 DMC_MOVE_CHOP_ABS(chop_def)
 WAIT(grat_def_time)
 Issue TM(1,7)
End
```

Duration: 14 x 200ms + grat_time + seq_time + grat_def_time + 0.5s

This procedure calls the sequence described in sec.

3.8 Grating Range Scan

Consists mainly of a sequence with one to few up- and down-scans across a given grating position range, while the chopper is operating as well on either two- or three- positions. Right now there is no principle difference to 3.7.1.

3.9 Internal Calibration Photometry

Detailed measurements on the internal calibration sources. The wheel will be moved outside the OBCP. Since the best strategy for calibration is not yet known, three different scenarios will be available.

3.9.1 Photometry Calibration I (OBCP 10, DMC Seq. 5)

```
OBCP_PHOT_CAL_I(seq, seq_time, P#1,…, P#6, cmp_par_blue, cmp_par_red, chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
SYNCHRONIZE_ON_DETECTOR(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
```

```
Issue TM(1,7)
End
```

Duration: 9 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec.4.1.5.

3.9.2 Photometry Calibration II (OBCP 11, DMC Seq. 6)

```
OBCP_PHOT_CAL_II(seq,seq_time,P#1,…, P#10,cmp_par_blue,cmp_par_red, chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
Issue TM(1,7)
End
```

Duration: 9 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec.4.1.6.

3.9.3 Photometry Calibration III (OBCP 12, DMC Seq. 7)

```
OBCP_PHOT_CAL_III(seq, seq_time, P#1,…, P#8, cmp_par_blue_cmp_par_red, chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_SPU_TRAN_MODE(ID, 1, cmp_par, CHHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
Issue TM(1,7)
end
```

Duration: 9 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec.4.1.7.

3.10 Internal Calibration Spectroscopy (OBCP 13, DMC Seq. 11)

Some chopping to the two internal BB sources will be done and the grating will be moved, such that a certain number of readouts are taken for every specified wavelength range. The wheel will be moved outside the OBCP.

```
OBCP_CHOPPED_GRATING_SCANS_CALIBRATION(seq,  seq_time,  P#1,…,  P#9,  detector,
grat_pos, grat_time, cmp_par_blue,cmp_par_red,grat_def, chop_def, grat_def_time)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
end
```

Duration: 13 x 200ms + grat_time + seq_time + grat_def_time + 0.5s

This procedure calls the sequence described in sec.4.2.8.

3.11 Switch to SAFE (OBCP 24)

Involves all commands to set mechanisms, calibration sources, detectors and all configuration parameters to this mode. This OBCP will check whether another OBCP is already running and if yes will stop that one before executing. Among other things it will also stop any running DMC sequence. The actual code of this OBCP is listed in the DPU OBSW User Manual.

Duration: few seconds

3.12 Chopper Up-Down Scan Photometry (OBCP 14, DMC Seq. 15)

This procedure is required to execute chopper scans across the PACS field of view. The filter wheel must commanded outside this OBCP.

```
OBCP_CHOP_SCAN_PHOT   (seq,   seq_time,   P#1,…,P#6,   detector,   cmp_par_blue,
cmp_par_red, chop_start_pos, chop_def)
begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_CHOP_ABS(chop_start_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
```

```
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHKSUM)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_CHOP_ABS(chop_def)
Issue TM(1,7)
End
```

Duration: 8 x 200ms + seq_time + 0.5s

This procedure calls the sequence described in sec. 4.1.9

3.13 Chopper Up-Down Scan Spectroscopy (OBCP 18, DMC Seq. 16)

This procedure is required to execute chopper scans across the PACS field of view at a given grating position. The filter wheel must commanded outside this OBCP.

```
OBCP_CHOP_SCAN_SPEC(seq, seq_time, P#1,...,P#6, detector, grat_pos, cho-
_start_pos, grat_time, cmp_par_blue, cmp_par_red, grat_def, grat_def_time,
chop_def)
Begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(grat_pos)
DMC_MOVE_CHOP_ABS(chop_start_pos)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; Check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8)+event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
End
```

Duration: 10 x 200ms + seq_time + grat_def_time + grat_time+0.5s

This procedure calls the sequence described in sec. 4.2.9

3.14 Execute TEST Mode

These OBCPs provide the tools to obtain simulated data from SPU or simulated data from DMC etc. for test purposes.

3.14.1 DMC Test Mode (OBCP 15)

```
OBCP_DMC_TEST_START(det_sim, cmp_par_blue, cmp_par_red)
Begin
DMC_INVAL_SCI_DATA_BOTH
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue,cmp_par_red, CHHKSUM)
DMC_START_DET_SIMULATOR(det_sim)
                        ; check where we can see this status in the DMC HK
DMC_VAL_SCI_DATA_BOTH
End
```

Duration: 4 x 200ms + 0.5s = 1.3s

Note that there is no dedicated "Stop" procedure, just the STOP_DET_SIMULATOR command.

3.14.2 SPU Test Modes

```
OBCP_SPU_TEST_SPEC(sim_data_r, sim_data_b)                    (OBCP 30)
Begin
STOP_REDUCTION/COMPRESSION_RED
STOP_REDUCTION/COMPRESSION_BLUE
WRITE_SIM_DATA_RED(ID, LENGTH, sim_data_r, CHKSUM)
WRITE_SIM_DATA_BLUE(ID, LENGTH, sim_data_b, CHKSUM)
ACTIVATE_SPU_TEST_RED_SPEC
ACTIVATE_SPU_TEST_BLUE_SPEC
End
```

Duration: 6 x 200ms + 0.5s = 1.7s

```
OBCP_SPU_TEST_PHOT(sim_data_r, sim_data_b)                    (OBCP 31)
Begin
STOP_REDUCTION/COMPRESSION_RED
STOP_REDUCTION/COMPRESSION_BLUE
WRITE_SIM_DATA_RED(ID, LENGTH, sim_data_r, CHKSUM)
WRITE_SIM_DATA_BLUE(ID, LENGTH, sim_data_b, CHKSUM)
ACTIVATE_SPU_TEST_RED_PHOT
ACTIVATE_SPU_TEST_BLUE_PHOT
End
```

Duration: 6 x 200ms + 0.5s = 1.7s

3.15 Wavelength Switch Grating (OBCP 22, DMC Seq. 10)

```
OBCP_WAVELENGTH_SWITCHING(seq,  seq_time,  P#1,…,  P#11,  detector,  grat_time,
cmp_par_blue, cmp_par_red, grat_def, chop_def, grat_def_time)
begin
DMC_WRT_TIME (DPU_TIME in standard 48 bit format according to PS-ICD)
DMC_SET_TIME
DMC_MOVE_GRAT_ABS(P#4)
DMC_WRT_SEQ_BUFFER(ID, LENGTH, DATA, CHECKSUM)
                        ; (all parameters filled by DPU based on seq parameter)
```

```
DMC_SYNCHRONIZE_ON_DET(detector)
DMC_WRT_SPU_TRAN_MODE(ID, 2, cmp_par_blue, cmp_par_red, CHHKSUM)
WAIT(grat_time)
DMC_START_SEQUENCE
WAIT(seq_time)
                        ; check execution status of the sequence and in case of
                          failure stop OBCP and issue TM(1,8) + event
DMC_MOVE_GRAT_ABS(grat_def)
DMC_MOVE_CHOP_ABS(chop_def)
WAIT(grat_def_time)
Issue TM(1,7)
end
```

Duration: 13 x 200ms + grat_time + grat_def_time + 0.5s

This procedure calls the sequence described in sec. 4.2.7.

3.16 Switch Spectroscopy to Photometry (OBCP 16)

Preliminary, the WAIT parameters and the actual sequence of actions is probably not yet final.

```
OBCP_SWITCH_SPEC_TO_PHOT(grat_def)
Begin
STOP_REDUCTION/COMPRESSION_RED
STOP_REDUCTION/COMPRESSION_BLUE
DMC_WRT_R_DEC_REC_OPT(ID, 1, 0, CHKSUM)
DMC_WRT_B_DEC_REC_OPT(ID, 1, 0, CHKSUM)
DMC_SWOF_R_SPEC
DMC_SWOF_B_SPEC
WAIT(2000)
DMC_SWOF_R_DEC
DMC_SWOF_B_DEC
DMC_MOVE_GRAT_ABSO(grat_def)
DMC_MOVE_SPEC_FW_LOC(TBD)
WAIT(10000)
DPU_N_SET_HK_LIST(2)
                        ; 1=spectroscopy, 2=photometry, 3=non-prime
DMC_SYNCHRONIZE_ON_DET(4)
DMC_WRT_BOL_REC_OPT(ID, 1, 4, CHKSUM)
DMC_WRT_SPU_TRAN_MODE(ID, 2, 0, 0, CHKSUM)
START_REDUCTION/COMPRESSION_RED
START_REDUCTION/COMPRESSION_BLUE
End
```

Duration: 18 x 200ms + 12000 ms + 0.5s = 16.1s

3.17 SAFE with CSs left ON (OBCP 17)

Involves all commands to set mechanisms, detectors and all configuration parameters to this mode. This OBCP will check whether another OBCP is already running and if yes will stop that one before executing. Among other things it will also stop any running DMC sequence. The only differ-

ence to the actual SAFE mode OBCP 24 is, that the internal calibration sources are left on. The actual code of this OBCP is listed in the DPU OBSW User Manual.

Duration: few seconds

3.18 Time Test 1 (OBCP 25)

The purpose is to measure the duration of the "write" and "set" commands for the time, which may be characteristic for each model of PACS.

```
OBCP_TIMESYNC1
Begin
For i=0,99 do
  DMC_WRT_TIME(DPU_TIME in standard 48 bit format acc. to PS-ICD)
  DMC_SET_TIME
WAIT(3 sec)
endfor
End
```

Duration: 200 x 200ms + 300s+ 0.5s

3.19 Time Test 2 (OBCP 26)

The purpose is to measure the duration of the "set" commands for the time, which may be characteristic for each model of PACS.

```
OBCP_TIMESYNC2
Begin
For i=0,99 do
  DMC_SET_TIME
WAIT(3 sec)
endfor
End
```

Duration: 100 x 200ms + 300s+ 0.5s

4 List of DMC Sequences

The sequences may still be refined once they have been tested together with real detector data.

Note that if the number of loops is specified to be zero via the LOOP statement inside the sequences, this means that the loop is not done.

General rules for sequences:

- Loop, Validate, Invalidate, Label statements are much faster than readouts
- Move a mechanism only after a "Wait"
- Start a sequence with a "Wait" to start with a defined timing

Presently no invalid readouts will be flagged, once real PACS FPU data is available, we will be able to specify this much better.
The "Label" statement is meant to indicate to the SPU-HLSW across which "quadruples" it has to average in photometry. It is further used also to indicate the number of discrete chopper steps within a sequence. In spectroscopy the meaning of the Label statement will be slightly different (see 4.2).
Hereafter, the following conventions for the LABEL will be used in photometry:

Bit 1 = set if start of quadruple, no sequence active otherwise
Bit 2-6 = counts chopper positions within sequence
Bit 7 = signal from BB1
Bit 8 = signal from BB2
63 = has a special meaning and indicates "freeze frame mode"
193 = chopper scan up
225 = chopper scan down

4.1 Photometry

4.1.1 Two or Three Position Chopping (OBCP 4, DMC Seq. 1)

```
Command                         Parameter        Comment

WAIT                                 1           ; have a defined start
LABEL                                0           ; set Label to 0
WAIT                                 1           ; have a defined start
LOOP                                 P#6         ; main loop obs. + cal.
LOOP                                 P#1         ; do it P#1 times
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#2         ; move chopper to P#2
  LABEL                              1           ; start quadruple
  WAIT                               P#3         ; take P#3 images
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#4         ; move chopper to P#4
  LABEL                              3           ; next chopper position
  WAIT                               P#3         ; take P#3 images
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#2         ; move chopper to P#2
  LABEL                              1           ; first chopper position
  WAIT                               P#3         ; take P#3 images
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#5         ; move chopper to P#5
  LABEL                              5           ; chopper position 3
  WAIT                               P#3         ; take P#3 images
END_LOOP                                         ; end loop measurement
LOOP                                 P#7         ; calibration loop
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#8         ; move chopper to BB1
  LABEL                              65          ; chopper to BB1
  WAIT                               P#3         ; take P#3 images
  WAIT                               1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE              P#9         ; move chopper to BB2
  LABEL                              129         ; chopper to BB2
  WAIT                               P#3         ; take P#3 images
```

```
END_LOOP                                        ; end loop calibration
END_LOOP                                        ; end main loop
WAIT                                  1         ; complete last plateau
LABEL                                 0         ; no sequence anymore
END_SEQUENCE
```

9 Parameters: # of main loops (P#6); # of chopper/readout cycles on target (P#1); 3 chopper positions (P#2, P#4, P#5); # of readouts per chopper position (P#3); # of calibration cycles (P#7); position of BB1 (P#8); position of BB2 (P#9)

Note: If P#4 = P#5 the sequence chops between two positions, otherwise three. P#3 must be defined such that: (P#3 + 1) mod 4 = 0 (in order to have an integer number of quadruples)

Sequence duration, in readouts :
3 + P#6 * (1 + P#3) * (4*P#1 + 2*P#7)

4.1.2 Two or Three Position Chopping with Dither (OBCP 5, DMC Seq. 2)

```
Command                           Parameter         Comment

WAIT                                  1         ; have a defined start
LABEL                                 0         ; set Label to 0
WAIT                                  1         ; have a defined start
LOOP                                  P#6       ; main loop obs. + cal.
LOOP                                  P#1       ; do it P#1 times
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE               P#2       ; move chopper to P#2 = on
  LABEL                               1         ; start quadruple
  WAIT                                P#3       ; take P#3 images
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE_DITHER        P#4       ; move chopper to P#4 = off1
  LABEL                               3         ; next chopper position
  WAIT                                P#3       ; take P#3 images
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE               P#2       ; move chopper to P#2 = on
  LABEL                               1         ; first chopper position
  WAIT                                P#3       ; take P#3 images
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE_DITHER        P#5       ; move chopper to P#5 = off2
  LABEL                               5         ; chopper position 3
  WAIT                                P#3       ; take P#3 images
END_LOOP                                        ; end loop measurement
LOOP                                  P#7       ; calibration loop
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE               P#8       ; move chopper to BB1
  LABEL                               65        ; chopper to BB1
  WAIT                                P#3       ; take P#3 images
  WAIT                                1         ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE               P#9       ; move chopper to BB2
  LABEL                               129       ; chopper to BB2
  WAIT                                P#3       ; take P#3 images
END_LOOP                                        ; end loop calibration
END_LOOP                                        ; end main loop
```

```
WAIT                                1           ; complete last plateau
LABEL                               0           ; no sequence anymore
END_SEQUENCE
```

9 Parameters: # of main loops (P#6); # of chopper/readout cycles on target (P#1); 3 chopper positions (P#2, P#4, P#5); # of readouts per chopper position (P#3); # of calibration cycles (P#7); position of BB1 (P#8); position of BB2 (P#9)

Note: The dither amplitude has to be specified outside the sequence, possibly by the calling OBCP. If P#4 = P#5 the sequence chops between two positions, otherwise three.
P#3 must be defined such that: (P#3 + 1) mod 4 = 0

Sequence duration, in readouts :
3 + P#6 * (1 + P#3) * (4*P#1 + 2*P#7)

4.1.3 Staring Photometry (OBCP 7, DMC Seq. 3)

No operation of mechanisms, only a defined loop through a specified number of bolometer readouts. Therefore this is composed of a rather trivial and short sequence code. This sequence will be used during nominal Line Scan observations. Calibration cycles on the internal calibration sources may be done before, after and at the turn-over points of the spacecraft scans, by 4.1.5.

```
Command                         Parameter         Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; set Label to 0
WAIT                                1           ; have a defined start
LOOP                                P#1
  LABEL                             1           ; start of quadruple
  WAIT                              40          ; shortest time = 1 sec
END_LOOP
LABEL                               0           ; no sequence anymore
END_SEQUENCE
```

1 Parameter: # of loops (P#1)

Sequence duration, in readouts :
2 + P#1 * 40

4.1.4 Freeze Frame Chopping (OBCP 6, DMC Seq. 4)

In case the bolometer bandwidth does not reach the goal, freeze frame chopping may be required for photometric spatial Line Scan observations. The dedicated sequence will consist of a saw tooth like chopper movement to compensate the satellite slew for a fraction of a second. Calibration cycles on the internal calibration sources may be done before, after and at the turn-over points of the spacecraft scans, by 4.1.5.

```
Command                        Parameter        Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; set Label to 0
WAIT                                1           ; have a defined start
LOOP                                P#1         ; main loop observation
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; start position of chopper
  LABEL                             63          ; start quadruple
  LOOP                              P#3         ; do a P#3 step saw tooth
    WAIT                            1           ; sync. for chopper
    MOVE_CHOPPER_RELATIVE           P#4         ; increment chopper position
  END_LOOP                                      ; end of a saw tooth
END_LOOP                                        ; end main loop
WAIT                                1           ; complete last plateau
LABEL                               0           ; no sequence anymore
END_SEQUENCE
```

4 Parameters: # of loops (P#1); start position of chopper (P#2); # of chopper increments (P#3); chopper relative increment (P4);

Sequence duration, in readouts :
3 + P#1 * (1 + P#3)

4.1.5 Chopping on Internal Cal. Sources I (variable-variable) (OBCP 10, DMC Seq. 5)

Detailed calibration sequence on the internal sources, version I. Chopping is done to both sources and the positions on each source may be incremented by a few small steps.

```
Command                        Parameter        Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; set Label to 0
WAIT                                1           ; have a defined start
LOOP                                P#1         ; main loop measurement
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; start pos. chopper BB1
  LABEL                             65          ; start quadruple on BB1
  WAIT                              P#3         ; take P#3 images
  LOOP                              P#4         ; do P#4 steps on BBs
    WAIT                            1           ; sync. for chopper
    MOVE_CHOPPER_RELATIVE           P#5         ; go to BB2
    LABEL                           129         ; start quadruple on BB2
    WAIT                            P#3         ; take P#3 images
    WAIT                            1           ; sync. for chopper
    MOVE_CHOPPER_RELATIVE           P#6         ; go back to BB1
    LABEL                           65          ; start quadruple on BB1
    WAIT                            P#3         ; take P#3 images
  END_LOOP                                      ; end of a saw tooth
END_LOOP                                        ; end main loop
WAIT                                1           ; complete last plateau
LABEL                               0           ; no sequence anymore
END_SEQUENCE
```

6 Parameters: # of main loops (P#1); Chopper start position on BB1 (P#2); Size of Relative chopper move BB1-BB2 (P#6); Size of relative chopper move BB2-BB1 (P#5); # of BB1-BB2 incremental steps (P#4); # of readouts per chopper plateau (P#3)

Note: P#3 must be defined such that: (P#3 + 1) mod 4 = 0. Setting P#4 = 1 and P#5 = P#6 one may obtain a sequence which just chops BB1-center to BB2-center.

Sequence duration, in readouts :
3 + P#1 * (1 + P#3) * [1 + (2 * P#4 + 1)]

4.1.6 Chopping on Internal Cal. Sources II (fixed-variable) (OBCP 11, DMC Seq. 6)

Detailed calibration sequence on the internal sources, version II. Chopping is done to both sources, however the initial start position on a BB source remains fixed, while the position on the other source loops through 5 increments. The number of 5 is chosen arbitrarily and can be changed only by modifying the sequence, since it cannot be parameterised.

```
Command                        Parameter        Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; set Label to 0
WAIT                                1           ; have a defined start
LOOP                                P#1         ; main loop measurement
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; define fixed start pos.
  LABEL                             P#4         ; start quadruple on P#4
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE             P#6         ; go to other BB
  LABEL                             P#5         ; start quadruple on P#5
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; go back to BB1
  LABEL                             P#4         ; start quadruple on P#4
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE             P#7         ; go to other BB
  LABEL                             P#5         ; start quadruple on P#5
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; go back to BB1
  LABEL                             P#4         ; start quadruple on P#4
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE             P#8         ; go to other BB
  LABEL                             P#5         ; start quadruple on P#5
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; go back to BB1
  LABEL                             P#4         ; start quadruple on P#4
  WAIT                              P#3         ; take P#3 images
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE             P#9         ; go to other BB
  LABEL                             P#5         ; start quadruple on P#5
```

```
  WAIT                          P#3         ; take P#3 images
  WAIT                          1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE         P#2         ; go back to BB1
  LABEL                         P#4         ; start quadruple on P#4
  WAIT                          P#3         ; take P#3 images
  WAIT                          1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE         P#10        ; go to other BB
  LABEL                         P#5         ; start quadruple on P#5
  WAIT                          P#3         ; take P#3 images
END_LOOP                                    ; end main loop
WAIT                            1           ; complete last plateau
LABEL                           0           ; no sequence anymore
END_SEQUENCE
```

10 Parameters: # of main loops (P#1); Chopper start position (P#2); # readouts per chopper plateau (P#3); 2 Labels to indicate BB position (P#4, P#5); 5 chopper positions on the "variable BB" (from P#6 to P#10)

Note: P#3 must be defined such that: (P#3 + 1) mod 4 = 0. Setting P#6 = P#7 = P#8 = P#9 = P#10 one may obtain a sequence which just chops between 2 fixed positions.

Sequence duration, in readouts :
3 + P#1 * 10 * (1 + P#3)

4.1.7 Chopping on Internal Cal. Sources III (fixed-fixed) (OBCP 12, DMC Seq. 7)

Detailed calibration sequence on the internal sources, version III. Chopping is done to a set of positions on both sources, where the distance between 2 respective positions stays constant for a while and then the next position is being measured.

```
Command                         Parameter       Comment

WAIT                            1           ; have a defined start
LABEL                           0           ; set Label to 0
WAIT                            1           ; have a defined start
LOOP                            P#1             ; main loop measurement
  WAIT                          1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE         P#2         ; start pos. chopper on BB1
  LABEL                         65          ; start quadruple on BB1
  WAIT                          P#3         ; take P#3 images
  LOOP                          P#8         ; loop through increments
    LOOP                        P#4         ; do P#4 chops per step
      WAIT                      1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE     P#5         ; go to BB2
      LABEL                     129         ; start quadruple on BB2
      WAIT                      P#3         ; take P#3 images
      WAIT                      1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE     P#6         ; go back to BB1
      LABEL                     65          ; start quadruple on BB1
      WAIT                      P#3         ; take P#3 images
    END_LOOP                                          ; end of chop
  WAIT                          1           ; sync. for chopper
  MOVE_CHOPPER_RELATIVE         P#7         ; incr. chop position on BB1
  WAIT                          P#3         ; take P#3 images
```

```
  END_LOOP                                  ; end of increments loop
END_LOOP                                    ; end main loop
WAIT                              1         ; complete last plateau
LABEL                             0         ; no sequence anymore
END_SEQUENCE
```

8 Parameters: # of main loops (P#1); Chopper start position on BB1 (P#2); Size of Relative chopper move on BB1 (P#7); Size of relative chopper move BB2-BB1 (P#6); Size of relative chopper move BB1-BB2 (P#5); # of incremental steps (P#8); # of chops per incremental step (P#4); # of readouts per chopper plateau (P#3)

Note: P#3 must be defined such that: (P#3 + 1) mod 4 = 0; P#5 = -P#6;

Sequence duration, in readouts :
3 + P#1 * (1 + P#3) * {1 + [P#8 * (2 * P#4 + 1)]}

4.1.8 Fixed-Fixed Chopping in Photometry (OBCP 3, DMC Seq. 14)

Chopping is done to a set (3 pairs) of positions in order to place positive and negative beams on different pixels on the array, where the distance between 2 respective positions stays constant for a while and then the next position pair is being measured.

```
Command                         Parameter         Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; set Label to 0
WAIT                                1           ; have a defined start
LOOP                                P#1         ; main loop measurement
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2         ; start pos. chopper
  LABEL                             3           ; 1st chopper position
  WAIT                              P#3         ; take P#3 images
    LOOP                            P#4         ; do P#4 chops per step
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#5         ; go to other chop position
      LABEL                         5           ; 2nd chopper position
      WAIT                          P#3         ; take P#3 images
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#6         ; go back to previous position
      LABEL                         3           ; 1st chopper position
      WAIT                          P#3         ; take P#3 images
    END_LOOP                                    ; end of chop
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#7         ; go to next position pair
  LABEL                             7           ; 3rd chopper position
  WAIT                              P#3         ; take P#3 images
    LOOP                            P#4         ; do P#4 chops per step
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#5         ; go to other chop position
      LABEL                         9           ; 4th chopper position
      WAIT                          P#3         ; take P#3 images
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#6         ; go back to previous position
      LABEL                         7           ; 3rd chopper position
```

```
      WAIT                          P#3         ; take P#3 images
    END_LOOP                                    ; end of chop
  WAIT                              1           ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#8         ; go to next position pair
  LABEL                             11          ; 5th chopper position
  WAIT                              P#3         ; take P#3 images
    LOOP                            P#4         ; do P#4 chops per step
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#5         ; go to other chop position
      LABEL                         13          ; 6th chopper position
      WAIT                          P#3         ; take P#3 images
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_RELATIVE         P#6         ; go back to previous position
      LABEL                         11          ; 5th chopper position
      WAIT                          P#3         ; take P#3 images
    END_LOOP                                    ; end of chop
END_LOOP                                        ; end main loop
WAIT                                1           ; complete last plateau
LABEL                               0           ; no sequence anymore
END_SEQUENCE
```

8 Parameters: # of main loops (P#1); Chopper start positions P#2, P#7, P#8; Size of Relative chopper moves P#5, P#6; # of chops per incremental step (P#4); # of readouts per chopper plateau (P#3)

Note: P#3 must be defined such that: (P#3 + 1) mod 4 = 0; P#5 = -P#6;

Sequence duration, in readouts :
3 + P#1 * 3 * {(1 + P#3) + P#4 * (2 * (1+P#3))}

4.1.9 Chopper UP-Down Scan Photometry (OBCP 14, DMC Seq. 15)

Parameterized up and down scan with the PACS chopper.

```
Command                         Parameter         Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; ensure LABEL 0
WAIT                                1
LOOP                                P#1         ; number of up-down seqs.
  LABEL                             193         ; special LABEL up
  LOOP                              P#3         ; number of steps up
    WAIT                            P#2         ; number of readouts on step
    MOVE_CHOPPER_RELATIVE           P#5         ; relative move up
  END_LOOP
  LOOP                              P#4         ; number of steps down
    WAIT                            P#2         ; number of readouts on step
    MOVE_CHOPPER_RELATIVE           P#6         ; relative move down
    LABEL                           225         ; special LABEL down
  END_LOOP
END_LOOP
WAIT                                P#2         ; integrate on last step
WAIT                                1
LABEL                               0
END_SEQUENCE
```

6 parameters: # of up-down sequences (P#1); number of readouts per chopper position (P#2); number of steps up (P#3); number of steps down (P#4); step size of chopper up (P#5); step size of chopper down (P#6);

Sequence duration in Bolometer readouts:
3 + P#1* { P#3 * P#2 + P#4*P#2 } + P#2

4.2 Spectroscopy

Hereafter, the following conventions for the LABEL will be used in spectroscopy:

Bit 1	= set if a sequence is active, 0 otherwise
Bit 2-4	= counts chopper positions within sequence
Bit 5	= up=0, down=1 indicates scan direction
Bit 6	= set if wavelength switching is active
Bit 7	= signal from BB1
Bit 8	= signal from BB2
193	= chopper scan up
225	= chopper scan down

4.2.1 Grating Line Scan with Two or Three Position Chopping (OBCP 8, DMC Seq. 8)

Default sequence for spectral line observations. The chopping pattern is identical to the analogous photometry case, however the number of chopper/readout cycles per grating step can be given as a parameter. Currently it is assumed that we do internal calibration measurements inside this sequence on every grating position. Alternatively or additionally we can start dedicated internal calibration measurements just before and/or after such a line observation. "Up" and "Down" scans will cover the same absolute grating positions in equidistant steps, commanded by MOVE_GRATING_RELATIVE. The initial absolute start position of the grating will be commanded before, from within the OBCP (3.7). The number of grating steps for a line scan is determined by P#2. The sequence may therefore consist of at least 7 LOOPs:

```
Command                          Parameter        Comment

WAIT                                   1          ; have a defined start
LABEL                                  0          ; set Label to 0
LOOP                                   P#1        ; main loop measurement
  LOOP                                 P#2        ; grating loop up
    WAIT                               1          ; sync. for grating
    MOVE_GRATING_RELATIVE              P#11       ; increment grating position
    LOOP                               P#3        ; chop readout cycle
      WAIT                             1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE            P#4        ; chopper to P#4
      LABEL                            3          ; first chopper pos.
      WAIT                             P#5        ; take P#5 ramps
      WAIT                             1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE            P#6        ; chopper to P#6
```

```
      LABEL                        5          ; next chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#4        ; chopper to P#4
      LABEL                        3          ; first chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#7        ; chopper to P#7
      LABEL                        7          ; last chopper pos.
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; chop readout cycle done
    LOOP                           P#8        ; calibration loop
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#9        ; chop to BB1
      LABEL                        65         ; BB1
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#10       ; chop to BB2
      LABEL                        129        ; BB2
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; calibration done
  END_LOOP                                    ; grating scan up done
  LOOP                             P#2        ; grating loop down
    WAIT                           1          ; sync. for grating
    MOVE_GRATING_RELATIVE          P#12       ; decrement grating position
    LOOP                           P#3        ; chop readout cycle
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#4        ; chopper to P#4
      LABEL                        19         ; first chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#6        ; chopper to P#6
      LABEL                        21         ; next chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#4        ; chopper to P#4
      LABEL                        19         ; first chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#7        ; chopper to P#7
      LABEL                        23         ; last chopper pos.
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; chop readout cycle done
    LOOP                           P#8        ; calibration loop
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#9        ; chop to BB1
      LABEL                        81         ; BB1
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#10       ; chop to BB2
      LABEL                        145        ; BB2
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; calibration done
  END_LOOP                                    ; grating scan down done
END_LOOP                                      ; main loop done
WAIT                               1          ; complete last plateau
LABEL                              0          ; reset LABEL to 0
END_SEQUENCE
```

12 Parameters: # of "up-down" sequences (P#1); 3 chopper positions (P#4, P#6, P#7); # of readouts per chopper position (P#5); # of cycles per grating position (P#3); size of relative grating move up (P#11); size of relative grating move down (P#12); # of cycles on the internal calibration sources (P#8); position of BB1 (P#9); position of BB2 (P#10); # of grating steps (P#2)

Note: - If P#6 = P#7 the sequence chops between 2 positions, otherwise three.
- The first MOVE_GRATING_RELATIVE has the effect that no measurement is performed at the initial grating position of any up- or down-scan within the sequence itself.

Sequence duration, in ramps :
2 + P#1 * 2 * P#2 * {1 + (4*P#3 + 2*P#8) * (1 + P#5)}

4.2.2 Grating Line Scan with Two position chopping (OBCP 27, DMC Seq. 12)

Similar to 4.2.1 but with only two chopping positions. It is meant to allow for faster execution once only two chopping positions are used on bright targets.

```
Command                          Parameter        Comment

WAIT                                  1           ; have a defined start
LABEL                                 0           ; set Label to 0
LOOP                                  P#1         ; main loop measurement
  LOOP                                P#2         ; grating loop up
    WAIT                              1           ; sync. for grating
    MOVE_GRATING_RELATIVE             P#10        ; increment grating position
    LOOP                              P#3         ; chop readout cycle
      WAIT                            1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE           P#4         ; chopper to P#4
      LABEL                           3           ; first chopper pos.
      WAIT                            P#5         ; take P#5 ramps
      WAIT                            1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE           P#6         ; chopper to P#6
      LABEL                           5           ; next chopper pos.
      WAIT                            P#5         ; take P#5 ramps
    END_LOOP                                      ; chop readout cycle done
    LOOP                              P#7         ; calibration loop
      WAIT                            1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE           P#8         ; chop to BB1
      LABEL                           65          ; BB1
      WAIT                            P#5         ; take P#5 ramps
      WAIT                            1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE           P#9         ; chop to BB2
      LABEL                           129         ; BB2
      WAIT                            P#5         ; take P#5 ramps
    END_LOOP                                      ; calibration done
  END_LOOP                                        ; grating scan up done
  LOOP                                P#2         ; grating loop down
    WAIT                              1           ; sync. for grating
    MOVE_GRATING_RELATIVE             P#11        ; decrement grating position
    LOOP                              P#3         ; chop readout cycle
      WAIT                            1           ; sync. for chopper
```

```
      MOVE_CHOPPER_ABSOLUTE        P#4        ; chopper to P#4
      LABEL                        19         ; first chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#6        ; chopper to P#6
      LABEL                        21         ; next chopper pos.
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; chop readout cycle done
    LOOP                           P#7        ; calibration loop
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#8        ; chop to BB1
      LABEL                        81         ; BB1
      WAIT                         P#5        ; take P#5 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#9        ; chop to BB2
      LABEL                        145        ; BB2
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; calibration done
  END_LOOP                                    ; grating scan down done
END_LOOP                                      ; main loop done
WAIT                               1          ; complete last plateau
LABEL                              0          ; reset LABEL to 0
END_SEQUENCE
```

11 Parameters: # of "up-down" sequences (P#1); 2 chopper positions (P#4, P#6); # of readouts per chopper position (P#5); # of cycles per grating position (P#3); size of relative grating move up (P#10); size of relative grating move down (P#11); # of cycles on the internal calibration sources (P#7); position of BB1 (P#8); position of BB2 (P#9); # of grating steps (P#2)

Sequence duration, in ramps :
2 + P#1 * 2 * P#2 * {1 + (P#3 + P#7) * (1 + P#5)}

4.2.3 Grating Line Scan with Two position chopping fast (OBCP 23, DMC Seq. 17)

Similar to 4.2.2 but without dedicated "wait 1" for mechanism synchronization. It is meant to allow for faster execution, but mechanism/readout synchronization might not be perfect.

```
Command                          Parameter        Comment

WAIT                                1             ; have a defined start
LABEL                               0             ; set Label to 0
LOOP                                P#1           ; main loop measurement
  LOOP                              P#2           ; grating loop up
    MOVE_GRATING_RELATIVE           P#10          ; increment grating position
    LOOP                            P#3           ; chop readout cycle
      MOVE_CHOPPER_ABSOLUTE         P#4           ; chopper to P#4
      LABEL                         3             ; first chopper pos.
      WAIT                          P#5           ; take P#5 ramps
      MOVE_CHOPPER_ABSOLUTE         P#6           ; chopper to P#6
      LABEL                         5             ; next chopper pos.
      WAIT                          P#5           ; take P#5 ramps
    END_LOOP                                      ; chop readout cycle done
    LOOP                            P#7           ; calibration loop
```

```
      MOVE_CHOPPER_ABSOLUTE        P#8        ; chop to BB1
      LABEL                        65         ; BB1
      WAIT                         P#5        ; take P#5 ramps
      MOVE_CHOPPER_ABSOLUTE        P#9        ; chop to BB2
      LABEL                        129        ; BB2
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; calibration done
  END_LOOP                                    ; grating scan up done
  LOOP                             P#2        ; grating loop down
    MOVE_GRATING_RELATIVE          P#11       ; decrement grating position
    LOOP                           P#3        ; chop readout cycle
      MOVE_CHOPPER_ABSOLUTE        P#4        ; chopper to P#4
      LABEL                        19         ; first chopper pos.
      WAIT                         P#5        ; take P#5 ramps
      MOVE_CHOPPER_ABSOLUTE        P#6        ; chopper to P#6
      LABEL                        21         ; next chopper pos.
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; chop readout cycle done
    LOOP                           P#7        ; calibration loop
      MOVE_CHOPPER_ABSOLUTE        P#8        ; chop to BB1
      LABEL                        81         ; BB1
      WAIT                         P#5        ; take P#5 ramps
      MOVE_CHOPPER_ABSOLUTE        P#9        ; chop to BB2
      LABEL                        145        ; BB2
      WAIT                         P#5        ; take P#5 ramps
    END_LOOP                                  ; calibration done
  END_LOOP                                    ; grating scan down done
END_LOOP                                      ; main loop done
LABEL                              0          ; reset LABEL to 0
END_SEQUENCE
```

11 Parameters: # of "up-down" sequences (P#1); 2 chopper positions (P#4, P#6); # of readouts per chopper position (P#5); # of cycles per grating position (P#3); size of relative grating move up (P#10); size of relative grating move down (P#11); # of cycles on the internal calibration sources (P#7); position of BB1 (P#8); position of BB2 (P#9); # of grating steps (P#2)

Sequence duration, in ramps :
1 + P#1 * 2* P#2 * {(P#3 + P#7) * (2 * P#5)}

4.2.4 Grating Line Scan without chopping (OBCP 28, DMC Seq. 13)

Similar to 4.2.1 but with no chopping positions on target. It is meant for ILT to allow for fast execution of measurements on "absolute" flux sources.

```
Command                          Parameter        Comment

WAIT                                 1            ; have a defined start
LABEL                                0            ; set Label to 0
LOOP                                 P#1          ; main loop measurement
  LOOP                               P#2          ; grating loop up
    WAIT                             1            ; sync. for grating
    MOVE_GRATING_RELATIVE            P#3          ; increment grating position
```

```
    LABEL                          3          ; first chopper pos.
    WAIT                           P#5        ; take P#5 ramps
    LOOP                           P#6        ; calibration loop
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#7        ; chop to BB1
      LABEL                        65         ; BB1
      WAIT                         P#9        ; take P#9 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#8        ; chop to BB2
      LABEL                        129        ; BB2
      WAIT                         P#9        ; take P#9 ramps
    END_LOOP                                  ; calibration done
    MOVE_CHOPPER_ABSOLUTE          P#11       ; chopper to default
  END_LOOP                                    ; grating scan up done
  LOOP                             P#10       ; grating loop down
    WAIT                           1          ; sync. for grating
    MOVE_GRATING_RELATIVE          P#4        ; decrement grating position
    LABEL                          19         ; first chopper pos.
    WAIT                           P#5        ; take P#5 ramps
    LOOP                           P#6        ; calibration loop
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#7        ; chop to BB1
      LABEL                        81         ; BB1
      WAIT                         P#9        ; take P#9 ramps
      WAIT                         1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE        P#8        ; chop to BB2
      LABEL                        145        ; BB2
      WAIT                         P#9        ; take P#9 ramps
    END_LOOP                                  ; calibration done
    MOVE_CHOPPER_ABSOLUTE          P#11       ; chopper to default
  END_LOOP                                    ; grating scan down done
END_LOOP                                      ; main loop done
WAIT                               1          ; complete last plateau
LABEL                              0          ; reset LABEL to 0
END_SEQUENCE
```

11 Parameters: # of "up-down" scans (P#1); # of steps up (P#2); # of steps down (P#10); # of ramps per grating position (P#5); size of relative grating move up (P#3); size of relative grating move down (P#4); # of cycles on the internal calibration sources (P#6); position of BB1 (P#7); position of BB2 (P#8); # ramps on the calibration sources (P#9); chopper default position (P#11)

Sequence duration, in ramps :
2 + P#1 * {(P#2+P#10) * [1+ P#5 + P#6 * 2 * (1 + P#9)]}

4.2.5 Grating Line Scan with 2 or 3 Position Chop. with Dither (OBCP 9, DMC Seq. 9)

Similar to previous sequence, but with MOVE_CHOPPER_ABSOLUTE_DITHER to both off positions. The cycle on the internal calibration sources is identical to 4.2.1.

```
Command                        Parameter        Comment

WAIT                               1          ; have a defined start
LABEL                              0          ; set Label to 0
```

```
LOOP                                P#1         ; main loop measurement
  LOOP                              P#2         ; grating loop up
    WAIT                            1           ; sync. for grating
    MOVE_GRATING_RELATIVE           P#11        ; increment grating position
    LOOP                            P#3         ; chop readout cycle
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#4         ; chopper to P#4
      LABEL                         3           ; first chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE_DITHER  P#6         ; chopper to P#6
      LABEL                         5           ; next chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#4         ; chopper to P#4
      LABEL                         3           ; first chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE_DITHER  P#7         ; chopper to P#7
      LABEL                         7           ; last chopper pos.
      WAIT                          P#5         ; take P#5 ramps
    END_LOOP                                    ; chop readout cycle done
    LOOP                            P#8         ; calibration loop
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#9         ; chop to BB1
      LABEL                         65          ; BB1
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#10        ; chop to BB2
      LABEL                         129         ; BB2
      WAIT                          P#5         ; take P#5 ramps
    END_LOOP                                    ; calibration done
  END_LOOP                                      ; grating scan up done
  LOOP                              P#2         ; grating loop down
    WAIT                            1           ; sync. for grating
    MOVE_GRATING_RELATIVE           P#12        ; decrement grating position
    LOOP                            P#3         ; chop readout cycle
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#4         ; chopper to P#4
      LABEL                         19          ; first chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE_DITHER  P#6         ; chopper to P#6
      LABEL                         21          ; next chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#4         ; chopper to P#4
      LABEL                         19          ; first chopper pos.
      WAIT                          P#5         ; take P#5 ramps
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE_DITHER  P#7         ; chopper to P#7
      LABEL                         23          ; last chopper pos.
      WAIT                          P#5         ; take P#5 ramps
    END_LOOP                                    ; chop readout cycle done
    LOOP                            P#8         ; calibration loop
      WAIT                          1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#9         ; chop to BB1
      LABEL                         81          ; BB1
      WAIT                          P#5         ; take P#5 ramps
```

```
      WAIT                          1          ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE         P#10       ; chop to BB2
      LABEL                         145        ; BB2
      WAIT                          P#5        ; take P#5 ramps
    END_LOOP                                   ; calibration done
  END_LOOP                                     ; grating scan down done
END_LOOP                                       ; main loop done
WAIT                                1          ; complete last plateau
LABEL                               0          ; reset LABEL to 0
END_SEQUENCE
```

12 Parameters: # of "up-down" sequences (P#1); 3 chopper positions (P#4, P#6, P#7); # of readouts per chopper position (P#5); # of cycles per grating position (P#3); size of relative grating move up (P#11); size of relative grating move down (P#12); # of cycles on the internal calibration sources (P#8); position of BB1 (P#9); position of BB2 (P#10); # of grating steps (P#2)

Note: If P#6 = P#7 the sequence chops between 2 positions (one with dither), otherwise three (two with dither).

Sequence duration, in ramps :
2 + P#1 * { 2 * P#2 * [1+ (4*P#3 + 2*P#8) * (1 + P#5)]}

4.2.6 Grating Range Scan with Two or Three Position Chopping

Basically the same as 4.2.1, all differences of this mode are handled within the parameter space.

4.2.7 Line Observation with Wavelength Switching (OBCP 22, DMC Seq. 10)

Wavelength switching will be required on extended sources. No chopping will be done. Instead, the grating will be moved in a 2 or 3 position pattern around the spectral line to be observed. The frequency of internal calibrations is adjusted by the top loop around observation and calibration loops. It is of course possible to have also calibrations outside the sequence, just before and/or after.

```
Command                         Parameter        Comment

WAIT                                1          ; have a defined start
LABEL                               0          ; set Label to 0
LOOP                                P#1        ; main loop obs. + cal.
  WAIT                              1          ; sync. for chopper
  MOVE_CHOPPER_ABSOLUTE             P#2        ; chopper to "on"
  LOOP                              P#3        ; do it P#3 times
    WAIT                            1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE           P#4        ; move grating to P#4
    LABEL                           33         ; wavelength switching
    WAIT                            P#5        ; take P#5 ramps
    WAIT                            1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE           P#6        ; move grating to P#6
    WAIT                            P#5        ; take P#5 ramps
    WAIT                            1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE           P#4        ; move grating to P#4
    WAIT                            P#5        ; take P#5 ramps
```

```
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#7        ; move grating to P#7
    WAIT                          P#5        ; take P#5 ramps
  END_LOOP                                   ; end loop measurement
  LOOP                            P#8        ; calibration loop1
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#4        ; move grating to P#4
    MOVE_CHOPPER_ABSOLUTE         P#9        ; chop to BB1
    LABEL                         97         ; indicate BB1
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#6        ; move grating to P#6
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#4        ; move grating to P#4
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#7        ; move grating to P#7
    WAIT                          P#5        ; take P#5 ramps
  END_LOOP                                   ; end loop calibration1
  LOOP                            P#10       ; calibration loop2
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#4        ; move grating to P#4
    MOVE_CHOPPER_ABSOLUTE         P#11       ; chop to BB2
    LABEL                         161        ; indicate BB2
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#6        ; move grating to P#6
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#4        ; move grating to P#4
    WAIT                          P#5        ; take P#5 ramps
    WAIT                          1          ; sync. for grating
    MOVE_GRATING_ABSOLUTE         P#7        ; move grating to P#7
    WAIT                          P#5        ; take P#5 ramps
  END_LOOP                                   ; end loop calibration2
END_LOOP                                     ; end main loop
WAIT                              1          ; complete last plateau
LABEL                             0          ; no sequence anymore
END_SEQUENCE
```

11 Parameters: # of full sequences (P#1); # of grating/readout cycles on the line (P#3); 3 grating positions (P#4, P#6, P#7); # of readouts per grating position (P#5); # of cycles on the internal calibration BB 1 (P#8); # of cycles on calibration BB 2 (P#10); position of BB1 (P#9); position of BB2 (P#11); initial position of chopper (P#2)

Note: If P#6 = P#7 the wavelength will switch only between 2 positions, otherwise 3. By setting the respective number of calibration loops to zero, one may also decide to use only one BB source or even no calibration at all, rather than both in order to save time.

Sequence duration, in ramps :
2 + P#1 * { 1+ (P#3 + P#8 + P#10) * 4 * (1+ P#5)}

4.2.8 Chopped Grating Scans on Internal Calibration Sources (OBCP 13, DMC Seq. 11)

Detailed calibration sequence on the internal sources. The nominal use of this sequence may be to move the grating at rough (few micron) step sizes through the PACS spectral ranges and perform small, chopped up-down scans at fine grating step sizes on the internal calibration sources. Note that the spectroscopy field of view fits ~3 times into the calibration sources field of view. Therefore this sequence may be called with different absolute chopper positions for the two internal PACS calibration sources in order to obtain averaging of possible inhomogeneities of the calibration sources field of views.

```
Command                         Parameter        Comment

WAIT                                 1           ; have a defined start
LABEL                                0           ; set Label to 0
LOOP                                 P#1         ; main loop
  WAIT                               1           ; wait for grating
  MOVE_GRATING_RELATIVE              P#2         ; incr. grating rough
  LOOP                               P#3         ; grating loop up
    WAIT                             1           ; sync. for grating
    MOVE_GRATING_RELATIVE            P#4         ; incr. grating fine
    LOOP                             P#5         ; chop readout cycle
      WAIT                           1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE          P#6         ; chopper to BB1
      LABEL                          65          ; indicate BB1
      WAIT                           P#7         ; take P#7 ramps
      WAIT                           1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE          P#8         ; chopper to BB2
      LABEL                          129         ; indicate BB2
      WAIT                           P#7         ; take P#7 ramps
    END_LOOP                                     ; chop readout cycle done
  END_LOOP                                       ; grating scan up done
  LOOP                               P#3         ; grating loop down
    WAIT                             1           ; sync. for grating
    MOVE_GRATING_RELATIVE            P#9         ; decr. grating fine
    LOOP                             P#5         ; chop readout cycle
      WAIT                           1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE          P#6         ; chopper to BB1
      LABEL                          81          ; indicate BB1
      WAIT                           P#7         ; take P#7 ramps
      WAIT                           1           ; sync. for chopper
      MOVE_CHOPPER_ABSOLUTE          P#8         ; chopper to BB2
      LABEL                          145         ; indicate BB2
      WAIT                           P#7         ; take P#7 ramps
    END_LOOP                                     ; chop readout cycle done
  END_LOOP                                       ; grating scan down done
END_LOOP                                         ; main loop done
WAIT                                 1           ; complete last plateau
LABEL                                0           ; no sequence anymore
END_SEQUENCE
```

9 Parameters: # of "up-down" sequences (P#1); rough grating step size (P#2); 2 chopper positions for internal calibration sources (P#6, P#8); # of readouts per chopper position (P#7); # of cycles per grating position (P#5); size of relative grating move up (P#4); size of relative grating move down (P#9); # of grating steps fine (P#3)

Note: Usually P#4 = -P#9 (P#3 is unique for loops up and down. Hence, P#4 ≠ -P#9 corresponds not to cover the same wavelength range during up- and down-scans)

Sequence duration, in ramps :
2 + P#1 * { 1+ 2 * P#3 * [1+ 2 * P#5 * (1+ P#7)]}

4.2.9 Chopper UP-Down Scan Spectroscopy (OBCP 18, DMC Seq. 16)

Parameterized up and down scan with the PACS chopper in spectroscopy.

```
Command                        Parameter        Comment

WAIT                                1           ; have a defined start
LABEL                               0           ; ensure LABEL 0
WAIT                                1
LOOP                                P#1         ; number of up-down seqs.
  LABEL                             193         ; special LABEL up
  LOOP                              P#3         ; number of steps up
    WAIT                            P#2         ; number of readouts on step
    MOVE_CHOPPER_RELATIVE           P#5         ; relative move up
  END_LOOP
  LOOP                              P#4         ; number of steps down
    WAIT                            P#2         ; number of readouts on step
    MOVE_CHOPPER_RELATIVE           P#6         ; relative move down
    LABEL                           225         ; special LABEL down
  END_LOOP
END_LOOP
WAIT                                P#2         ; integrate on last step
WAIT                                1
LABEL                               0
END_SEQUENCE
```

6 parameters: # of up-down sequences (P#1); number of destructive readouts per chopper position (P#2); number of steps up (P#3); number of steps down (P#4); step size of chopper up (P#5); step size of chopper down (P#6);

Sequence duration in destructive readouts:
3 + P#1* { P#3 * P#2 + P#4*P#2 } + P#2

4.2.10 Line Observation with Wavelength Switching 2 (OBCP 32, DMC Seq. 18)

Wavelength switching will be required on extended sources. No chopping will be done. Instead, the grating will be moved in a programmable pattern around the spectral line to be observed. This version of the wavelength switching DMC sequence does not contain any internal calibration block. Internal calibrations are thought to be done outside the sequence in a dedicated calibration block. This version allows for more shifts of the grating pattern with at the same time smaller overheads.

```
Command                          Parameter        Comment

WAIT                                  1           ; have a defined start
LABEL                                 0           ; set Label to 0
LOOP                                  P#1         ; number of up-down patterns
  LOOP                                P#2         ; number of shifts up
    MOVE_GRATING_RELATIVE             P#3         ; shift grating by P#3 (up)
    WAIT                              1           ; wait for grating move
    LOOP                              P#4         ; P#4 times core loop
      MOVE_GRATING_RELATIVE           P#5         ; move grating by P#5
      LABEL                           33          ; wavelength switching
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#7         ; move grating by P#7
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#8         ; move grating by P#8
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#9         ; move grating by P#9
      WAIT                            P#6         ; take P#6 ramps
    END_LOOP                                      ; end core loop
  END_LOOP                                        ; end loop up
  LOOP                                P#10        ; number of shifts down
    WAIT                              1           ; wait for grating move
    LOOP                              P#4         ; P#4 times core loop
      MOVE_GRATING_RELATIVE           P#12        ; move grating by P#12
      LABEL                           49          ; wavelength switching
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#13        ; move grating by P#13
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#14        ; move grating by P#14
      WAIT                            P#6         ; take P#6 ramps
      MOVE_GRATING_RELATIVE           P#15        ; move grating by P#15
      WAIT                            P#6         ; take P#6 ramps
    END_LOOP                                      ; end core loop
    MOVE_GRATING_RELATIVE             P#11        ; shift grating by P#11 (down)
  END_LOOP                                        ; end loop down
  WAIT                                1           ; wait for grating move
END_LOOP                                          ; end up-down loop
LABEL                                 0           ; no sequence anymore
END_SEQUENCE
```

15 Parameters: # of up-down patterns (P#1); # shifts up (P#2); # of A-B-B-A loops (P#4); # of shifts down (P#10); grating relative moves (P#3, P#5, P#7, P#8, P#9, P#11, P#12, P#13, P#14, P#15); # of readouts per grating position (P#6);

Sequence duration, in ramps :
1 + P#1 * [P#2 * (P#4*4*P#6 +1) +P#10*(P#4*4*P#6+1)]

4.2.11 Grating Scan with ABBA Chopping (OBCP 35, DMC Seq. 19)

In order to improve on spectroscopy signal determination in case of frequent cosmic radiation hits on Ge:Ga detectors and sub-sequent response changes and drifts, a new DMC sequence has been required. In contrast to existing and implemented chopper patterns, determining the signals for each

grating position by chopper patterns which follow an "on-off-on-off" scheme the new sequence will do "on-off-off-on" signal acquisitions. Since the grating move is slow as compared to the chopper move, an extra detector reset interval, inserted for each grating step, shall allow to stabilize the grating prior to the "on-off-off-on" chopper pattern.

The following parameters will allow for a flexible implementation:

P#1: main loop, number of repetitions of everything
P#2: number of grating steps up and down
P#3: grating stepsize up
P#4: number of "A-B-B-A" chopper patterns per grating position
P#5: chopper position "A"
P#6: number of reset intervals per chopper position
P#7: chopper position "B"
P#8: number of calibrations per grating position
P#9: chopper position for CS1
P#10: chopper position for CS2
P#11: grating stepsize down

```
Command                          Parameter         Comment

WAIT                                     1           ; have a defined start
LABEL                                    0           ; set Label to 0
LOOP                                     P#1         ; main loop measurement
  LOOP                                   P#2         ; grating loop up
    MOVE_GRATING_RELATIVE                P#3         ; increment grat. position
    WAIT                                 1           ; stabilization of grating
    LOOP                                 P#4         ; chop readout cycle
        MOVE_CHOPPER_ABSOLUTE            P#5         ; chopper to P#5 "A"
        LABEL                            3           ; first chopper pos.
        WAIT                             P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE            P#7         ; chopper to P#7 "B"
        LABEL                            5           ; next chopper pos.
        WAIT                             P#6         ; take P#6 ramps
        WAIT                             P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE            P#5         ; chopper to P#5 "A"
        LABEL                            3           ; first chopper pos.
        WAIT                             P#6         ; take P#6 ramps
    END_LOOP                                         ; chop readout cycle done
    LOOP                                 P#8         ; calibration loop
        MOVE_CHOPPER_ABSOLUTE            P#9         ; chop to BB1
        LABEL                            65          ; BB1
        WAIT                             P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE            P#10        ; chop to BB2
        LABEL                            129         ; BB2
        WAIT                             P#6         ; take P#6 ramps
    END_LOOP                                         ; calibration done
  END_LOOP                                         ; grating scan up done
  LOOP                                   P#2         ; grating loop down
    MOVE_GRATING_RELATIVE                P#11        ; increment grat. position
    WAIT                                 1           ; stabilization of grating
    LOOP                                 P#4         ; chop readout cycle
        MOVE_CHOPPER_ABSOLUTE            P#5         ; chopper to P#5 "A"
```

```
        LABEL                           19          ; first chopper pos.
        WAIT                            P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE           P#7         ; chopper to P#7 "B"
        LABEL                           21          ; next chopper pos.
        WAIT                            P#6         ; take P#6 ramps
        WAIT                            P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE           P#5         ; chopper to P#5 "A"
        LABEL                           19          ; first chopper pos.
        WAIT                            P#6         ; take P#6 ramps
    END_LOOP                                        ; chop readout cycle done
    LOOP                                P#8         ; calibration loop
        MOVE_CHOPPER_ABSOLUTE           P#9         ; chop to BB1
        LABEL                           81          ; BB1
        WAIT                            P#6         ; take P#6 ramps
        MOVE_CHOPPER_ABSOLUTE           P#10        ; chop to BB2
        LABEL                           145         ; BB2
        WAIT                            P#6         ; take P#6 ramps
    END_LOOP                                        ; calibration done
  END_LOOP                                          ; grating scan down done
END_LOOP                                            ; main loop done
LABEL                                   0           ; reset LABEL to 0
END_SEQUENCE
```

Sequence duration, in ramps :
1 + P#1 * 2 * P#2 * {1 + (P#4 * P#6 * 4)+ (P#8 * P#6 * 2)}

Example duration: 1 Grating updown scan 50 steps, no internal calibration, 1 reset interval per chopper position --> 501 resets; for 1/4sec reset this gives 125.25sec