TITLE: **SPIRE Pipeline Mask Policy**

PREPARED BY: **Trevor Fulton**

DOCUMENT No: **SPIRE-BSS-DOC-003127**

ISSUE: **Issue 1.6** **Date:** **11 November 2009**

APPROVED BY: **Date:**

Distribution

Dave Clements	Imperial College
Trevor Fulton	Blue Sky Spectroscopy
Steve Guest	RAL
Ken King	RAL
Sarah Leeks	RAL
Tanya Lim	RAL
Pasquale Panuzzo	CEA
Julio Ramirez	HSC
Bernhard Schulz	IPAC
Sunil Sidher	RAL
Ivan Valtchanov	HSC

Change Record

ISSUE	DATE	Changes
Draft 0.1	23 July 2008	Consolidating the decisions from January 2008 and June 2008 ICC meetings, as well as the discussion from the Pipeline Integration workshop of April 2008.
Issue 1.1	08 October 2008	Added new mask, VOLTAGE_OOL. Added new developer's requierments relating to setting the a definition of the Mask in product Metadata. Added new requirement on SpireMask to provide a method to add mask definitions to metadata.
Issue 1.2	18 November 2008	Split GLITCH and GLITCH_UNCORR masks into: GLITCH_FIRST_LEVEL, GLITCH_FIRST_LEVEL_UNCORR and GLITCH_SECOND_LEVEL, GLITCH_SECOND_LEVEL_UNCORR.
Issue 1.3	28 January 2009	Changed the Metadata modification requirements to make it explicit that processing modules that could modify Sample Masks need to always add an applicable Metadata keyword (i.e. regardless of whether they actually set the Mask during processing)
Issue 1.4	16 April 2009	[SPIRE SCR-1060] Expanded the application of the GLITCH_FIRST_LEVEL sample masks to include neighbouring samples. [SPIRE SCR-1266] Added documentation for isSlow Channel Mask. [SPIRE SCR-1280] Added definitions for the VOLTAGE_BELOW_K3 and NO_RESP_DATA UNUSABLE sample masks.
Issue 1.5	31 July 2009	[SPIRE-1754] Added definition for the TSIGNAL_HDV sample mask.
Issue 1.6	11 November 2009	[SPIRE-2005] Added two new BSM related masks -- BSM_CHOP_OOL and BSM_JIGG_OOL Added a table that lists the bit numbers, bit values, and descriptions for all SPIRE Sample Masks. Clarified some descriptions.

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Glossary

BSM	Beam Steering Mirror
CCB	Configuration Control Board
NaN	Not a Number
SCR	System Change Request
SPIRE	Spectral and Photometric Imaging REceiver

1 Introduction

1.1 Purpose of this Document

The purpose of this document is to define masks and the policy for their usage in the SPIRE data processing pipelines. In addition, this document describes the procedure for adding new masks and for making changes to the definitions and/or usage of existing masks .

1.2 Scope

The following sections define the manner in which masks are to be handled within the SPIRE data processing pipelines. A list of general requirements for all SPIRE data processing modules with respect to masks is presented in Section 2 along with specific requirements for certain packages. The current list of masks are described in Section 3 and the procedure to make changes to the list of masks applicable to the SPIRE detector data products is described in Section 4.

1.3 Applicable Documents

AD01 SPIRE Pipeline Description (SPIRE-RAL-DOC-002437), Issue 1.0, 02 August 2008.

AD02 SPIRE Analogue Signal Chain and Photometer Detector Data Processing Pipeline (SPIRE-UCF-DOC-002890, Issue 5, 01 August 2008)

AD03 SPIRE Spectrometer Pipeline Description (SPIRE-BSS-DOC-002966), Issue 1.1, 04 August 2008.

AD04 SPIRE Product Definitions (http://www.spire.rl.ac.uk/consortium/icc/product_definitions/index.shtm).

1.4 Reference Documents

RD01 Trevor Fulton, Spire Spectrometer Data Products Description, draft 0.2, 07 June 2007.

RD02 Riccardo Cerulli-Irelli, Herschel SPIRE DPU Interface Control Document, SPIRE-IFS-PRJ-000650, Issue 1.4, 24 March 2003.

RD03 SpireMask Interface, Javadoc, herschel.spire.ia.util.SpireMask package.

2 Spire Masks

2.1 Definitions

2.1.1 General

In the context of the SPIRE data processing pipelines, masks are defined as indicators of a condition as it relates

to the data. Spire Masks shall be of type Boolean, meaning that they need to be defined in such a way so as to represent a given condition as being either true or false. For the sake of consistency, Spire Masks shall be defined in such a way that the Boolean false state represents that a mask condition is not applicable.

SPIRE-MASK-100 Spire masks shall be defined in such a way that mask conditions may be represented by a Boolean value.

SPIRE-MASK-110 Spire masks shall be defined in such a way that problematic conditions are represented by 1/True, while normal conditions are represented by 0/False.

2.1.2 Master

In order to provide for a quick reference as to whether a data sample is or is not scientifically valid, a Master mask has been defined. The Master mask represents the ultimate Go or No-go condition for a data sample. If the Master mask is set to 1/True, the data sample is not scientifically valid. In addition to provide for a level of redundancy within the SPIRE detector data products, data samples whose Master mask is set to 1/True should also be replaced by NaN.

SPIRE-MASK-120 The Master mask shall be set to 1/True for data samples that are not scientifically valid and set to 0/False otherwise.

SPIRE-MASK-121 Detector data samples whose Master mask is set to 1/True shall be replaced by NaN.

2.1.3 SpireMask() Interface

The SpireMask() interface [RD03] has been deemed as the single point of reference for all matters concerning Masks within the SPIRE data processing software system. SPIRE data processing modules that identify or make use of Mask information should do so via the SpireMask() interface.

SPIRE-MASK-130 All SPIRE data processing modules shall access Masks and, if necessary, update product Metadata with Mask definitions, via the SpireMask() interface.

2.2 Mask Representation

The SPIRE data processing pipelines are divided into a series of levels [AD01, AD02, AD03]. Within each of these levels, there are certain data products [AD04] that have been defined. The structure of the SPIRE data products at each level of the processing pipelines has an implication on the manner in which mask information is represented.

Level-0 – Level-0.5 Processing

The Level-0 data products do not contain placeholder in which mask information may be stored. As such, for the Level-0 to Level-0.5 stage of the SPIRE data processing pipelines, mask information must reside outside of the data products themselves. In the Level-0 to Level-0.5 stage of the SPIRE data processing pipelines, mask information is maintained in a set of calibration products [AD04]; the Channel Mask product and the Instrument Mode Mask product. Mask information in these calibration products applies to all samples for a given detector channel.

Level-0.5 – Level-2 Processing

The SPIRE detector data products used in the Level-0.5 to Level-2 stages for the SPIRE data processing pipelines all contain placeholders that may be used to store mask information. In each of these products, a 32-bit integer is reserved for each sample for each detector, referred to as a Sample Mask. Mask information is represented by bits in a Sample Mask, with different bits representing different mask conditions.

SPIRE-MASK-200 Processing modules that are responsible for translating the information in Channel or Instrument Mode Mask calibration products to detector data Sample Masks shall set the appropriate Sample Masks for all data samples within the resultant detector data product.

2.3 Mask Categories

The conditions that are represented by Sample Masks are divided into three categories: Unusable, Informational, and Correctable. The following sections provide definitions for these categories and discuss how the SPIRE pipeline modules should process data samples that fall into these categories.

2.3.1 Unusable

The masks in the *Unusable* category are reserved for samples that are afflicted with critical problems to the degree that the data samples should not be considered scientifically valid. Detector data samples that have been deemed Unusable should be ignored by the modules in the SPIRE data processing pipelines.

Given the definiton of the The Master mask, (Section 2.1) a data sample identified as Unusable should also have its Master mask set to 1/True and its data sample replaced by NaN.

SPIRE-MASK-210 Processing modules that are responsible for identifying Unusable conditions shall, for each sample identified as Unusable:

- set the Master Mask to 1/True;
- set the appropriate Mask corresponding to the condition to 1/True;
- change the signal sample to NaN;

Add a defintion of the Mask to the product Metadata for both the Master mask and the applicable Unuasble mask regardless of whether the Unusable mask is set during processing.

Since the conditions in the Unusable category are defined as critical, data processing modules that encounter an Unusable condition should not process the data sample but should simply propagate the Sample Mask information. In order to maintain consistency in the data products, one exception to the aforementioned is allowed. In the case of data processing modules that modify the units of the detector data samples, the value of the data sample should not be changed by the data processing module, but the unnits of the unusable data sample should be modified to conform with the units of the usable data samples in the detector data product.

SPIRE-MASK-211 Processing modules that encounter a data sample whose Sample Mask indicates an Unusable condition shall, for each sample identified as Unusable:

- not process the data sample;
- propagate the Sample Mask to the output data product;
- if the data processing module modifies the units of the samples in its input detector data product, it shall modify the units of the Unusable sample to conform with the usable samples for that detector.

2.3.2 Informational

Mask conditions defined as *Informational* represent non-critical problems with the detector data samples for which there exists no correcting data processing module. Data processing modules that encounter an Information condition should process the sample as normal and propagate the Sample Mask information.

SPIRE-MASK-220 Processing modules that are responsible for identifying Informational conditions shall, for each sample identified as Informational:

- set the appropriate Mask corresponding to the condition to 1/True;

Add a defintion of the Mask to the product Metadata regardless of whether the Informational mask is set during processing.

SPIRE-MASK-221 Processing modules that are encounter a data sample whose Sample Mask indicates an Informational condition shall, for each sample identified as Informational:

- process the data sample as normal;
- propagate the Sample Mask to the output data product.

2.3.3 Correctable

Samples in the *Correctable* category are those for which a potential problem has been noted and for which a data processing module exists that may be able to correct the condition. In order to maintain the knowledge that

a correctable condition was ever identified for a data sample, masks for Correctable conditions should always come in pairs: one mask will denote the identification of the condition; the second will denote whether the condition has been corrected. When a sample with a correctable problem is identified, the Sample Masks representing the condition and the Sample Mask denoted that the problem has not been corrected should both be set to 1/True simultaneously. If the problem is subsequently corrected the second bit of the pair should be set to 0/False.

SPIRE-MASK-230 Processing modules that are responsible for identifying Correctable conditions shall, for each sample identified as Correctable:

- concurrently et the appropriate Mask and UncorrectedMask corresponding to the condition to 1/True;

Add a defintion of the Mask to the product Metadata regardless of whether the Correctable mask is set during processing.

SPIRE-MASK-231 Processing modules that are responsible for correcting Correctable conditions shall, for each sample identified as Correctable:

- set the appropriate UncorrectedMask to 0/False when the condition is corrected;

Add a defintion of the Mask to the product Metadata regardless of whether the Correctable mask is set during processing.

SPIRE-MASK-232 Processing modules that are encounter a data sample whose Sample Mask indicates a Correctable condition but are not responsible for correcting such a condition shall, for each sample identified as Informational:

- process the data sample as normal;
- propagate the Sample Mask to the output data product.

2.4 Data processing module requirements

A summary of the general requirements for all SPIRE data processing modules with respect to masks is given below.

SPIRE-MASK-100 Spire masks shall be defined in such a way that mask conditions may be represented by a Boolean value.

SPIRE-MASK-110 Spire masks shall be defined in such a way that problematic conditions are represented by 1/True, while normal conditions are represented by 0/False.

SPIRE-MASK-120 The Master mask shall be set to 1/True for data samples that are not scientifically valid and set to 0/False otherwise.

SPIRE-MASK-121 Detector data samples whose Master mask is set to 1/True shall be replaced by NaN.

SPIRE-MASK-130 All SPIRE data processing modules shall access Masks and, if necessary, update product Metadata with Mask definitions, via the SpireMask() interface.

SPIRE-MASK-200 Processing modules that are responsible for translating the information in Channel or Instrument Mode Mask calibration products to detector data Sample Masks shall set the appropriate Sample Masks for all data samples within the resultant detector data product.

SPIRE-MASK-210 Processing modules that are responsible for identifying Unusable conditions shall, for each sample identified as Unusable:

- set the Master Mask to 1/True;
- set the appropriate Mask corresponding to the condition to 1/True;
- change the signal sample to NaN;

Add a defintion of the Mask to the product Metadata for both the Master mask and the applicable Unuasble mask regardless of whether the Unusable mask is set during processing.

SPIRE-MASK-211 Processing modules that encounter a data sample whose Sample Mask indicates an Unusable condition shall, for each sample identified as Unusable:

- not process the data sample;
- propagate the Sample Mask to the output data product;
- if the data processing module modifies the units of the samples in its input detector data product, it shall modify the units of the Unusable sample to conform with the usable samples for that detector.

SPIRE-MASK-220 Processing modules that are responsible for identifying Informational conditions shall, for each sample identified as Informational:

- set the appropriate Mask corresponding to the condition to 1/True;

Add a defintion of the Mask to the product MetaData regardless of whether the Informational mask is set during processing.

SPIRE-MASK-221 Processing modules that are encounter a data sample whose Sample Mask indicates an Informational condition shall, for each sample identified as Informational:

- process the data sample as normal;
- propagate the Sample Mask to the output data product.

SPIRE-MASK-230 Processing modules that are responsible for identifying Correctable conditions shall, for each sample identified as Correctable:

- concurrently set the appropriate Mask and UncorrectedMask corresponding to the condition to 1/True;

Add a defintion of the Mask to the product Metadata regardless of whether the Correctable mask is set during processing.

SPIRE-MASK-231 Processing modules that are responsible for correcting Correctable conditions shall, for each sample identified as Correctable:

- set the appropriate UncorrectedMask to 0/False when the condition is corrected;

Add a defintion of the Mask to the product Metadata regardless of whether the Correctable mask is set during processing.

SPIRE-MASK-232 Processing modules that are encounter a data sample whose Sample Mask indicates a Correctable condition but are not responsible for correcting such a condition shall, for each sample identified as Informational:

- process the data sample as normal;
- propagate the Sample Mask to the output data product.

3 Current Implementation

The following sections describe the Sample Masks that have been currently defined and implemented by the SpireMask interface.

3.1 Unusable sample masks

3.1.1 MASTER

The MASTER mask represents whether a data sample is scientifically valid and therefore indicates whether a data sample has been identified as Unusable.

3.1.2 ISDEAD

This mask indicates that the sample has been recorded on a channel that has been deemed as non-functional. This sample mask is directly transcribed from isDead in the Channel Mask product [AD01, AD04].

3.1.3 INVALID_TIME

If this bit is set, it indicates that the sample has an invalid time.

3.1.4 ADC_LATCH

If this bit is set, it indicates that there was an ADC latchup error [RD02].

3.1.5 VOLTAGE_BELOW_K3

If this bit is set, it indicates that Flux Converstion (Photometer) or Non-linearity Correction (Spectrometer) module encountered a Voltage sample whose value was less than the K_3 calibration factor.

3.1.6 NO_RESP_DATA

If this bit is set, it indicates that the VOLTAGE_OOL mask and/or the VOLTAGE_BELOW_K3 mask was set to

true for a given sample thereby signifying that no flux conversion (Photometer) or linearization (Spectrometer) is possible.

3.2 Informational sample masks

3.2.1 ISNOISY

This sample mask indicates that the sample has been recorded on a channel that has been deemed as noisy. This sample mask is directly transcribed from isNoisy in the Channel Mask product [AD01, AD04].

3.2.2 ISNOCHOPSKY

The ISNOCHOPSKY sample mask is directly transcribed from the notChoppedToSky flag for the instrument mode mask. This sample mask indicates that the sample has been recorded on a channel that did not view the astronomical sky during the particular instrument mode.

3.2.3 VOLTAGE_OOL

The VOLTAGE_OOL sample mask indicates that the resultant flux is not necessarily incorrect, it is just based on a voltage value that lies outside the range of the fitted portion of the bolometer responsivity curve. As such there may be a lower confidence in the resultant flux.

3.2.4 ISSLOW

This sample mask indicates that the sample has been recorded on a channel that has been deemed as slow but usable. This sample mask is directly transcribed from isSlow in the Channel Mask product [AD01, AD04].

3.2.5 TSIGNAL_HDV

This sample mask indicates that thermistor/DP signal deviations are larger than expected from temperature drift alone.

3.2.6 BSM_CHOP_OOL

This mask indicates that the recorded sample falls outside the BSM chop soft limits.

3.2.7 BSM_JIGG_OOL

This mask indicates that the recorded sample falls outside the BSM jiggle soft limits.

3.3 Correctable Conditions

The sample masks in this category all represent conditions that may be detected and corrected during data processing. The Sample Masks that relate to correctable conditions are always paired: one sample mask indicates that such a condition was detected during data processing; the other sample mask indicates whether this condition has been corrected during data processing.

3.3.1 Truncated Samples

The truncated condition refers to signal samples whose raw ADC values were recorded as either 0 or 65535 (2^{16}-1). Since these are the limits of the 16-bit read-out ADC, samples that were recorded with these values may be incorrect.

The two sample masks corresponding to this condition are: TRUNCATED and TRUNCATED_UNCORR.

3.3.2 Glitches

This condition refers to signal samples that have been identified during data processing as glitches [AD01].

There are two pairs of sample masks corresponding to this condition: the first pair, GLITCH_FIRST_LEVEL and GLITCH_FIRST_LEVEL_UNCORR correspond to first level glitch detection and correction; the second pair, GLITCH_SECOND_LEVEL and GLITCH_SECOND_LEVEL_UNCORR correspond to second level glitch detection and correction.

NB: The First Level Glitch Sample masks apply not only to the discontinuity (energy jump) but also the remaining exponential decreasing tail which correspond to the effects of the glitch on the detector.

3.4 Summary

A list of the sample masks that are currently defined is given in Table 1. Also indicated in Table 1 is the SpireMask() reserved word that corresponds to the sample mask, whether the sample mask was derived from a calibration product, the category into which the sample mask belongs and the data processing module that either sets or monitors the state of the sample mask.

Mask Condition	SpireMask [RD03] reserved word	Derived from Calibration Product?	Mask Category	Data Processing Module [AD01]
Master	MASTER	No	Unusable	
Dead Channel	ISDEAD	Yes	Unusable	Mask Bad Channels
Invalid sample time	INVALID_TIME	No	Unusable	Check ADC flags
ADC Latch	ADC_LATCH	No	Unusable	Check ADC flags
Voltage < K_3	VOLTAGE_BELOW_K3	No	Unusable	PhotFluxConversionTask, SpecNonlinearityCorrectionTask
VOLTAGE_OOL mask and/or VOLTAGE_BELOW_K3 mask == True	NO_RESP_DATA	Yes	Unusable	Check ADC flags
Noisy Channel	ISNOISY	Yes	Informational	Mask Bad Channels
Channel not chopped to sky	ISNOCHOPSKY	Yes	Informational	
Voltage Out Of Limit	VOLTAGE_OOL	No	Informational	PhotFluxConversionTask, SpecNonlinearityCorrectionTask
Slow Channel	ISSLOW	Yes	Informational	Mask Bad Channels
Thermistor/DP deviations	TSIGNAL_HDV	No	Informational	TemperatureDriftCorrectionTask
BSM Chopper Out Of Soft Limit	BSM_CHOP_OOL	No	Informational	CalcBsmAnglesTask
BSM Jiggle Out Of Soft Limit	BSM_JIGG_OOL	No	Informational	CalcBsmAnglesTask
ADC conversion truncation	TRUNCATED	No	Correctable	Check ADC flags
Uncorrected ADC conversion truncation	TRUNCATED_UNCORR	No	Correctable	Clipping Correction
First level glitch detected	GLITCH_FIRST_LEVEL	No	Correctable	Deglitch
First level glitch detected and corrected	GLITCH_FIRST_LEVEL_UNCORR	No	Correctable	Deglitch
Second level gllitch detected	GLITCH_SECOND_LEVEL	No	Correctable	GlitchFinder
Second level gllitch detected and removed	GLITCH_SECOND_LEVEL_UNCORR	No	Correctable	GlitchRemoval

Table 1: SPIRE detector data products Sample Masks.

The bit positions, bit values, and descriptions of the sample masks that are currently defined is given in Table 2.

SpireMask [RD03] reserved word	Bit Number	Bit Value	Description
MASTER	0	1	If the value is set, then the data should not be used
INVALID_TIME	1	2	indicates that the sample has an invalid time
ADC_LATCH	2	4	indicates that there was a possible ADC latchup error
TRUNCATED	3	8	indicates that the ADC conversion resulted in data being truncated
TRUNCATED_UNCORR	4	16	indicates that the ADC truncation is not corrected
ISDEAD	7	128	indicates that the channel is dead
ISNOISY	8	256	indicates that the channel is noisy
ISNOCHOPSKY	9	512	indicates that the channel is not chopped to sky
VOLTAGE_OOL	10	1024	indicates that a voltage value lies outside the range of the fitted portion of the bolometer responsivity curve
GLITCH_FIRST_LEVEL	11	2048	indicates that a glitch was detected in the sample during first level deglitching
GLITCH_FIRST_LEVEL_UNCORR	12	4096	indicates that a glitch was detected during first level deglitching and has not been removed from the sample
GLITCH_SECOND_LEVEL	13	8192	indicates that a glitch was detected in the sample during second level deglitching
GLITCH_SECOND_LEVEL_UNCORR	14	16384	indicates that a glitch was detected during first level deglitching and has not been removed from the sample
ISSLOW	15	32768	indicates that the sample has been recorded on a channel that has been deemed as slow
VOLTAGE_BELOW_K3	16	65536	indicates that Flux Converstion (Photometer) or Non-linearity Correction (Spectrometer) module encountered a Voltage sample whose value was less than the K3 calibration factor
NO_RESP_DATA	17	131072	indicates that VOLTAGE_OOL mask and/or the VOLTAGE_BELOW_K3 mask was set to true for a given sample thereby signifying that no flux conversion (Photometer) or linearization (Spectrometer) is possible
TSIGNAL_HDV	18	262144	indicates that thermistor/DP signal deviations are larger than expected from temperature drift alone
BSM_CHOP_OOL	19	524288	indicates that the recorded sample falls outside the BSM chop soft limits.
BSM_JIGG_OOL	20	1048576	indicates that the recorded sample falls outside the BSM jiggle soft limits.

Table 2: SPIRE Sample Mask bit numbers, bit values, and descriptions.

4 Future Modifications

The procedure to add or modify masks that are to be added should first be evaluated to see which of the three mask categories they belong. A System Change Request (SCR) should be issued (http://www.rssd.esa.int/herschel_webapps/servletsuite/ProblemReportServlet?area=spire&mode=displaysubmitpr) to the SPIRE software CCB which will then evaluate whether the change is feasible.

If a new mask is requested, the SCR should indicate the category in which this mask applies and should also identify the source of the mask information. In the case of correctable masks, the SCR should also describe the data processing module that will identify the condition as well as the module that will correct the condition.