AGILE	ITE

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PREPARED BY: C. LABANTI, E. CELESTI

CHECKED BY: C. LABANTI

APPROVED BY:

SUBSYSTEM LEADER:	G. DI COCCO	**DATE:**
PRINCIPAL INVESTIGATOR:	M. TAVANI	**DATE:**
PROGRAM MANAGER:	A. ZAMBRA	**DATE:**
PAPM:	R. A. BERNABEO	**DATE:**
CONFIGURATION:	C. MANGILI	**DATE:**

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CHANGE RECORD

ISSUE	DATE	PAGE	DESCRIPTION OF CHANGES	RELEASE
3	Feb 2003	2	Details on the scope of the document	
3	Feb 2003	3	Updated acronyms	
3	Feb 2003	4	Updated applicable and reference docs	
3	Feb 2003	5	Number of bar detectors	
3	Feb 2003	6	CsI bar dimension and weight	
3	Feb 2003	6	MCAL mechanical design compliance with AGILE	
3	Feb 2003	6	Position of MCAL items in AGILE lower structure	
3	Feb 2003	7	Details on the power supply filtering	
3	Feb 2003	8	Details on bar housing	
3	Feb 2003	8	Redundancy of MCAL power supply removed	
3	Feb 2003	9	Updated bar number	
3	Feb 2003	10	GRID gain ranges	
3	Feb 2003	10	Details on GRID ADC conversion time	
3	Feb 2003	10	Number of bar detectors	
3	Feb 2003	10	Details on FIFO depth GRID mode	
3	Feb 2003	10	Details on FEE max data handling GRID mode	
3	Feb 2003	10	GRID transmission data speed	
3	Feb 2003	11	Details on RTP GRID mode	
3	Feb 2003	12	Details on FIFO depht Burst mode	
3	Feb 2003	14	Details in ADC performances	
3	Feb 2003	15	Defined center of gravity	

3	Feb 2003	15	Defined momentum of inertia	
3	Feb 2003	15	Defined temperature gradients	
3	Feb 2003	15	Details on general vibration requirements	
3	Feb 2003	16	Bar ratemeter grouping moved to DH	
3	Feb 2003	17	HK reviewed	

TABLE OF CONTENTS

1. INTRODUCTION

1.1 *SCOPE OF THE DOCUMENT*

This document summarises AGILE Mini-Calorimeter (MCAL) subsystem requirements specifications for its design, implementation, development, production and qualification.
The current document includes the result of the discussion held during the Phase B of the project and consolidated on June 2000 at the time of the Phase C definition. It represents the best understandment of AGILE MCAL requirements updated at June 2000; optimisation of the subsystem can be foreseen during the final design phase.
The further adjustment added in the issue 3 are derived from the descoping on AGILE payload required to fulfil the launcher requirements and from discussions held with LABEN during the manufacturing of the MCAL SEM. However, at the moment of the editing of issue 3, the MCAL SEM has not been delivered so than the full test sequence on it has not been completed and the possible feedback on this document not considered.

1.2 ACRONYMS

ADC	**Analogue to Digital Conversion**
AFEE	**Analogue Front End Electronics**
AGILE	**Astrorivelatore Gamma a Immagini LEggero**
CSA	**Charge Sensitive Preamplifier**
DH	**Data Handling**
DP	**Calorimeter Detector Plane**
EB	**Calorimeter Electronic Board**
EM	**Electro Magnetic**
FEE	**Front End Electronics**
GRID	**Gamma Ray Imaging Detector (referred to Agile system)**
HK	**HouseKeeping**
I/F	**Interface**
LIT	**Long Integration Time**
MCAL	**Mini Calorimeter**
MUX	**Multiplexer**
P&H	**Peak and Hold**
PD	**PhotoDiode**
PDHU	**Payload Data Handling Unit**
PIN	**Positive Intrinsic Negative**
PSU	**Power Supply Unit**
RTP	**Rise Time Protection**
SDL	**Serial Data Line**
SEM	**Simplified Engineering Model**
SIT	**Short Integration Time**
SSL	**Service Serial Line**
TBC	**To Be Confirmed**
TBD	**To Be Defined**
TC	**TeleCommands**

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 *APPLICABLE DOCUMENTS*

AD1: Calorimeter specification and requirements: AGILE-ITE-SS-001 Is. 2.3
AD2: AGILE Minicalorimeter Architectural Design LABEN TL 16067 Is. 3
AD3: AGILE Scientific Requirements: AGILE-IFC-SR-008
AD4: AGILE Data Handling Requirements: AGILE-DWG-SS-001 Issue 7
AD5: AGILE P/L System Requirements, AGILE-AST-SR-002, Issue 4
AD6: AGILE Mechanical Subsystem Specification: AGILE-AST-SS-002
AD7: AGILE EMC P/L SPECIFICATION REQUIREMENTS AGILE-AST-SR-003_Issue_2

2.2 *REFERENCE DOCUMENTS*

RD1 AGILE Phase A Report
RD2 AGILE Payload Data Handling architectural design TL 16066
RD3 Payload power supply architectural design TL 16064
RD4 AGILE Payload TE and EGSE design Concept TL 16369
RD5 AGILE MINICALORIMETER design report TL 17716
RD6 AGILE P/L Detector Reference System AGILE-AST-TN-009

2.3 *DOCUMENT PRIORITY*

A priority in the applicability of documents is established as follows:

1. AGILE Scientific Requirements
2. P/L System Requirements
3. Current Document
4. Applicable Documents
5. Minutes of Meeting

In case of conflict among technical material contained in these documents, the highest rank document shall have the precedence.

3. UNIT DEFINITION

AGILE is an ASI Small Scientific Mission dedicated to high-energy astrophysics in the range 30 MeV to 50 GeV with an extension band between 10 and 40 keV.
MCAL is one of the AGILE detectors subsystem designed to:

- measure the energy of nuclear radiation produced in the Silicon-Tungsten tracker placed above the MCAL and
- independently detect impulsive events and background variation of gamma rays interacting with the single bars.

3.1 MCAL MAJOR COMPONENTS

The MCAL (Ref. AD1, AD2) is made of the Detection Plane, DP, an Electronic Board, EB, and the harness between the two elements.

The Detection Plane is made 30 of CsI(Tl) scintillator bars placed in two orthogonal layers. Each bar is wrapped with a light diffusive material and glued to PhotoDiodes, a PD in each of to the two smallest sides to collect the scintillation light. The Detection Plane includes the first stage of the AFEE (the PD' s pre-amps) and the relative EM shield.

The EB contains the electronics of the system with the following functions:
Detector and Electronic Board power supply conditioning circuits.
Processing of detector signals
HK generation and TC servicing

4. MCAL BUDGET REQUIREMENTS

4.1 *DIMENSIONS*

URS-4.1.1 The overall MCAL size (detector plane and electronics) is :

Lenght	440	± 0.1 mm
width	440	± 0.1 mm
thickness	87.0	± 0.1 mm

In any case the MCAL overall design should be compliant with AD5

URS-4.1.2 The size of each CsI(Tl) bar without coating and PD is

Lenght	375	± 0.1 mm
width	23	± 0.2 mm
thickness	15	± 0.2 mm

URS-4.1.3 The board with CSA for PD read-out shall be contiguous to the PD.

URS-4.1.4 The MCAL FEE board is realised in a single or double board located below the CsI detector block and has equal dimensions.

URS-4.1.5 The MCAL mechanics shall be compatible with the mounting on AGILE lower frame the dimension of which are

Lenght	490	± 0.1 mm
width	490	± 0.2 mm
thickness	136	± 0.2 mm

The position of MCAL items inside this block should be such than the CsI bars bottom is at least at 91 mm from the bottom of the AGILE lower frame and the PA boards are at least at 77 mm from the bottom of the AGILE lower frame

4.2 *WEIGTH*

URS-4.2.1 The weight of the MCAL shall be as represented in the following table:

	Kg (no contingency)	Contingency
CsI(Tl)	17.5	0
Bar Housing	5.0	0.5
Mechanics including electronic boards	1.0	0.15
Harness	1.0	0.15
Total	24.5	0.8

4.3 *POWER SUPPLY*

URS-4.3.1 The power supply of MCAL shall be as represented in the following table:

	Voltage (V)	Nom Power (mW)	Max Power (mW)	Cleanness Level
PhotoDiodes	-28 *	0.1	0.1	1 mV rms
Analog FEE	± 5	3120	3500	1 mV peak .to.peak
Digital FEE	+ 5	1600	1800	5 mV peak .to.peak
Total (secondary)		4720	5100	

* Heavy local filtering to ensure the fulfilment of the overall noise requirements for the PD + pre-amp system when powered with the AGILE PSU system and with the EMC criteria described in AD7

URS-4.3.2 The power supply of MCAL shall be protected against overloads at PSU level.

5. MCAL INTERFACES

5.1 *MECHANICAL INTERFACE*

URS-5.1.1 The MCAL mechanical interface shall comply with the Interface Control Drawing of the AGILE payload system (ref AD5)

URS-5.1.2 Provision shall be made for the Calorimeter mechanical design in order to shield the PDs from stray light. The PD leakage current is assumed as a parameter to evaluate the light tightness. In any case the PD leakage current shall NOT exceed the 3 nA value at 25 °C.

URS-5.1.3 The bars should be assembled in an individual mechanical frame (bar housing) to give stiffness and rigidity to each detector and to allow individual detector testing.

5.2 *ELECTRICAL INTERFACE*

5.2.1 GENERAL

The MCAL as a subsystem, i. e. detector and electronics is interfaced with the payload Power Supply Unit PSU (RD3) and with PDHU (AD4)

URS-5.2.1 The MCAL electrical interface with the payload power supply unit shall ensure the powering of the subsystem.

URS-5-2-3 The following signal lines are required among MCAL and DH

- 1 AC top line
- 1 AC lateral line

For the MCAL GRID mode

- Fast Trigger to DH (to indicate energy release in MCAL greater than 10 MeV)
- Trigger In bus from DH will all the needed lines to begin and validate GRID operations in MCAL
- 1 monodirectional serial link bus for GRID data transmission

For the MCAL Burst mode

- Fast timing to DH (used in DH to time marking of events)
- 1 monodirectional serial link bus for Burst data transmission
- 1 service line for data time tagging

For HouseKeeping and TC

- Bidirectional service serial link bus (for transmission of HK and TC)
- Analog HK line to DH (for transmission of multiplexed analog HK)
- LVDS line for HK read out clock
- One survival HK line to monitor MCAL temperature

URS-5-2-4 A test line shall be available to stimulate the MCAL CSA from the external for testing and during AIV

6. MCAL OPERATION REQUIREMENTS

6.1 *MCAL OPERATIONS*

The Calorimeter operates in two modes:

GRID mode: acting as GRID' s calorimeter. The FEE shall process the signals so that:

- Trigger pulses are generated when an high energy deposit (greater than 10 MeV) is detected on the whole Calorimeter.
- The two signals of each bars are ADC converted after receiving a command from Agile DH.

Burst Monitor mode: To detect strong γ transient events.

In this mode each side of each bar (total 60) will act as individual γ-ray detector. The calorimeter FEE performs the ADConversion of signals from triggered detectors and sends data do Agile DH. The events detected by the Burst electronics will be used to determine the address of counters in the AGILE DH to be incremented; these counters will be used in AGILE burst search process

URS-6.1.1	The MCAL shall simultaneously process event of GRID and Burst mode at the same time
URS 6.1.2	An exclusion circuit shall allow the killing of each PD circuit that became for any reason too noisy
URS 6.1.3	A ratemeter on each discriminator shall be implemented. The ratemeter integration time is defined via TC. Ratemeters shall be multiplexed.
URS 6.1.4	The threshold of each discriminator shall be settled with a value defined via TC

6.2 *GRID MODE*

URS-6.2.1 In GRID mode, each bar shall detect an individual energy deposit between: 1 to 500 MeV

URS-6.2.2 In GRID mode the MCAL shall detect energy deposit on the whole MCAL greater than 10 MeV (considering as each energy deposit is at the center of the bars) in less than 1 μsec from gamma interaction (Fast Trigger).

URS-6.2.3 In GRID mode the MCAL shall operate in sample mode on AGILE DH command

URS-6.2.4 In GRID mode all the 60 PD channels are converted on AGILE DH command

URS-6.2.5 The ADC for GRID operation shall be 12 bit

URS-6.2.6 The ADC operates in two ranges, the first covering 1 ÷ 2.5 MeV the second covering 2.5 ÷ 500 MeV; the first of the 12 data bit will mark the range.
In case of technical difficulties in the implementation of this requirements an alternative solution can be negotiate
In a possible alternative the ADC will operate in 4 ranges selectables via telecommand
The first range will cover the interval 0 ÷ 50 MeV
The second range will cover the interval 0 ÷ 100 MeV
The third range will cover the interval 0 ÷ 250 MeV
The fourth range will cover the interval 0 ÷ 500 MeV

URS-6.2.7 In GRID mode the analysis (ADC conversion, etc.) of all the data shall be finished before the Tracker of AGILE finished to convert its data. All the PD signals (60) should be converted; that implies that the ADC conversion time should be less than 330 nsec.

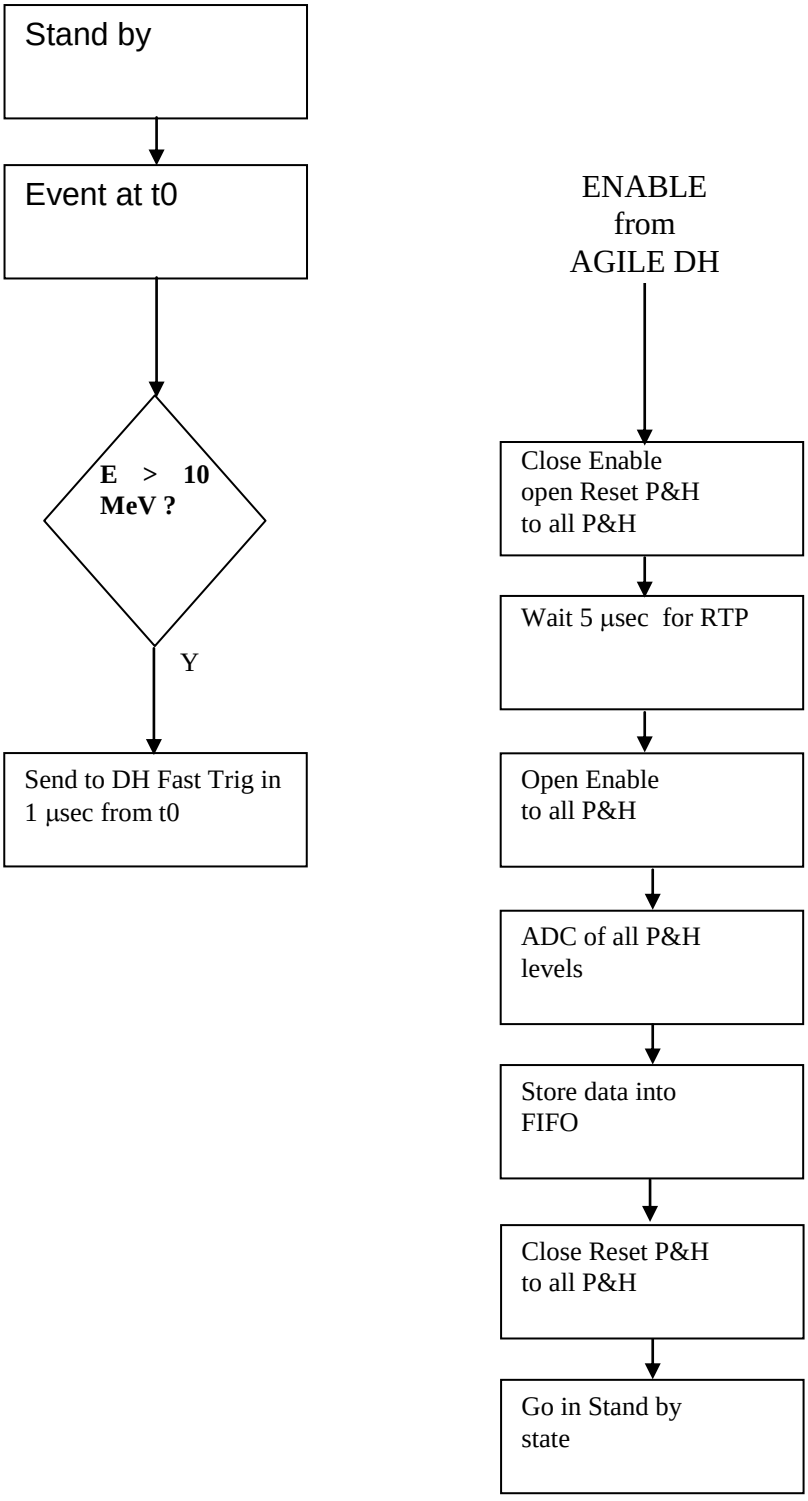
URS-6.2.8 A derandomizing FIFO buffer with at least 2 kword depth shall be included in the GRID circuitery.

URS-6.2.9 The MCAL GRID FEE shall be able to handle GRID events until a maximum rate of 5500 events/sec

URS-6.2.10 The MCAL GRID I/F to AGILE DH shall be able to send GRID events until a maximum rate of 5500 events/sec

URS-6.2.11 The logical of GRID mode shall be as described in Fig 6.2.1

Fig. 6.2.1 GRID Calorimeter logic



6.3 *BURST MODE*

URS-6.3.1	In Burst Monitor mode, each side of each bar shall be considered as an individual detector
URS-6.3.2	In Burst Monitor mode, each side of each bar shall detect an energy deposit between: 0.250 to 250 MeV
URS-6.3.3	The threshold of a detected event in a bar shall be made both on single PD signal and on the sum of the signals from both PD of the bar.
URS-6.3.4	The discriminators of the signals shall ehxibit a walking time less than 300 nsec on the whole signal ranges and a jitter less than 0.75 μsec RMS. AGILE DH shall use a flag related to this signal to mark the time of occurence of the event
URS-6.3.5	The AGILE AC signal shall inhibits data acquisition.
URS-6.3.6	The read out logic provides ADC conversion at 12 bit for the signal of each PD
URS-6.3.7	The read out logic provides detector (PD) address
URS-6.3.8	A derandomizing FIFO buffer with at least 2 kword depth shall be included in the Burst circuitery
URS-6.3.9	In Burst mode the time required to analysis a data of each detection (signal processing, ADC conversion etc) shall be less than 10 μsec
URS-6.3.10	The MCAL Burst FEE shall be able to handle events up to a peak rate of 500 kHz
URS-6.3.11	The MCAL Burst I/F to AGILE DH shall be able to the maximum rate allowed by the I/F clock of 5 Mhz.
URS-6.3.12	The read out logic provides the time marking of the signals
URS-6.3.13	The incertitude of the events time marking shall be dominated by the jitter of the signal (URS-6.3.4) and shall not be increased by the logic circuits used to define the time.
URS-6.3.14	MCAL burst data shall be organised in such a way to implement in DH a Counter Address Logic (12 addresses) that will be used by the DH in the Burst Search Logic.

URS-6.3.15 MCAL burst data shall be organised in such a way that the Counter Address Logic can distinguish between single event (one bar fired) and multiple event (more than one bar fired)

7. MCAL PERFORMANCE REQUIREMENTS

7.1 *ELECTRONICS*

URS-7.1.1 The bar detectors shall be screened so to exhibit a ligth output at one PD end of 15.000 e^-/MeV

URS-7.1.2 The bar detectors shall be screened so to exhibit a light attenuation coefficient in the range $\alpha = 0.035 \div 0.045$ cm^{-1}.

URS-7.1.3 The noise level of a PD and its electronic chain (up to the shaping amp) shall be less than 800 e^- rms

URS-7.1.4 The linearity of the system shall be less than 1 %

URS-7.1.5 The integral non linearity of the GRID ADC shall be less than ± 1 LSB

URS-7.1.6 The differential non linearity of the GRID ADC shall be less than ± 0.5 LSB

URS-7.1.7 The integral non linearity of the Burst ADC shall be less than ± 1 LSB

URS-7.1.8 The differential non linearity of the Burst ADC shall be less than ± 0.5 LSB

7.2 *DETECTOR*

URS-7.2.1 In both GRID and Burst mode the energy resolution (each detector) shall comply to:

$(\Delta E/E)_{FWHM}$ ~ 22 - 24 % @ 1 MeV

$(\Delta E/E)_{FWHM}$ ~ 0.7 % @ 100 MeV

URS-7.2.2 In both GRID and Busrt mode the spatial resolution of reconstructed event i each detector shall comply to:

σ_x ~ 15 mm @ 1 MeV

σ_x ~ 2 mm @ 100 MeV

8. MCAL PHYSICAL REQUIREMENTS

8.1 *MECHANICALS*

URS-8.1.1 The MCAL center of gravity shall be at the center of the MCAL plane in the x and z directions and at –30.6 mm with respect to the MCAL top surface

URS-8.1.2 The MCAL momentum of inertia shall be

$Ix = 3.91$ E+06 kg/mm^2

$I_y = 1.99$ E+06 kg/mm^2

$Iz = 1.99$ E+06 kg/mm^2

.

URS-8.1.3 The MCAL reference system co-ordinate shall be as described in AD6.

8.2 *THERMAL*

URS-8.2.1 The MCAL thermal requirements shall comply with the following table:

Operating	**-20 +40 °C**
Max rate of change (operating)	**3 °C/h**
Non operating	**-20 + 45 °C**
Start up (cold)	**-20 °C**
Start up (hot)	**+ 40 °C**
Max rate of change (non operating)	**3°C/h**
Max spatial gradient on whole MCAL	**5°C**

8.3 *ENVIRONMENTAL REQUIREMENTS.*

8.3.1 VIBRATION REQUIREMENTS

Two vibration levels are defined, the first is qualification level; the second is acceptance level. The levels to be applied to different models or prototypes depends from Agile model philosophy; the design of MCAL should be implemented considering the load applied by a Pegasus launcher + 20%

URS-8.3.1 The MCAL random vibration level requirements shall be TBD

URS-8.3.2 The MCAL sine vibration level requirements shall be TBD

9. MCAL TELECOMMANDS

9.1 *GENERAL*

URS-9.1.1 AGILE MCAL receiving and verification rules shall conform to AGILE general requirements (AD4)

9.2 *MCAL TASK MANAGEMENT TELECOMMANDS*

URS-9.2.1 Enable/Disable discriminators. This TC is used to enable/disable side A, side B and bar sum discriminators. It is also used to kill noisy elements

URS-9.2.2 Load integration time. This TC is used to load the integration time of the discriminator ratemeters

URS-9.2.3 Load threshold. This TC is used to load threshold values of the discriminators

URS-9.2.4 General reset. This TC is used set MCAL parameter at defualt values

URS-9.2.6 PD Power on/off. This TC is used to switch on/off PD

URS-9.2.7 MCAL Power on/off. This TC is used to switch on/off MCAL

URS-9.2.8 In flight calibration. This TC is used to enter calibration testing mode

URS-9.2.9 Coincidence window for multiple events . This TC is used to define the width of the time window that defines multiple events

10. MCAL HOUSEKEEPINGS

10.1 *ANALOGUE HK*

URS-10.1.1 The following list of analogue HK shall be implemented

		N.
Detector:	Temperature Detector	4
Voltages PD	2	
Electronic Board	Temperature	2
	Voltages (AFEE & DFEE)	6
	(+5 An, -5 An , +5 Dig, for both boards y and z)	

10.2 *DIGITAL HK*

URS-10.2.1 The following list of digital HK shall be implemented

	N°
Ratemeters Thr sum bar signal	30
Ratemeters Thr single side (A –B)	60
Ratemeters Fast triggers	1
Live time meter each layer GRID mode	2
Live time meter each layer Burst Mode	2

10.3 *SURVIVAL HK*

URS-10.3.1 When the Calorimeter is switched off the following HK shall be monitored (at satellite level) Temperature levels on the detector 1

11. MCAL OPERATIONAL MODES

11.1 *GENERAL*

URS-11.1.1 MCAL shall comply to AGILE general requirements (AD4) for operational modes.

URS-11.1.2 A calibration of each PD channel will be done in a dedicated AGILE mode The calibration will allow to monitor the time variation due to ageing of signal levels produced by the detectors and the gain and offset variations of the electronic.
Calibration is done jointly by AGILE Tracker and Calorimeter and will use the charge particles entering the whole GRID detector from the top.
In that case AGILE top AC will be used to mark the passing of a charge particle.
During calibration the Calorimeter will act as in GRID mode.

12. MCAL TESTING

12.1 *GENERAL*

AGILE MCAL functional test are performed at various level:

a) Detector unit level
b) MCAL FEE level
c) MCAL unit level

12.2 *DETECTOR UNIT TEST*

URS-12.2.1 To perform AGILE MCALdetector unit (bar) test the CAL-CSI test equipment will be used (RD 3)

URS-12.2.2 Each detector unit shall be tested to measure its light output characteristics

URS-12.2.3 Each detector unit shall be tested to measure its light attenuation characteristics

URS-12.2.3 Modality of the test. The PD shall be illuminated with an X-ray source (Am-241) the detector shall be illuminated with relevant collimated gamma sources at fixed points

12.3 *MCAL FEE TEST*

URS-12.3.1 To perform AGILE MCAL FEE test standard laboratory equipment will be used

URS-12.3.2 The functional performances test shall verify the functionality of MCAL FEE i.e:

b1-1) Correct operation of the GRID chain
b1-2) Correct operation of the Burst chain
b1-3) Correct operation of GRID and Burst chain in parallel
b1-4) Correct triggers generation
b1-5) Correct generation of burst counter addresses for DH burst search
b1-6) Correct I/Fs management
b1-7) Correct TC reception and execution
b1-8) Correct HK (analog and digital) generation

URS-12.3.3 The functional performances test shall verify the performances of MCAL FEE like:

b2-1) PD+pre+amp etc noise level measure
b2-2) Pre-amp + amp range and linearity
b2-3) Minimum signal level for triggers (slow on the PD and bars and fast) generation
b2-4) Measure of discriminators jitter (in Burst chain)
b2-5) ADC performances (integral and differencial non linearity etc)
b2-6) Max count rate evaluation
b2-7) Dead time evaluation for GRID chain
b2-8) Dead time evaluation for Burst chain

URS-12.3.4 Modality of the test. Pulse generators both with fixed and random period will be used to stimulate MCAL FEE. Data will be collected with standard laboratory equipments (Scopes, MCA etc).

12.4 *MCAL UNIT TESTS*

URS-12.4.1 To perform AGILE MCAL system test the CAL-DFE test equipment will be used (RD 3)

URS-12.4.2 The functional performance AGILE MCAL test shall verify the functionality of MCAL FEE i.e: As for b1-1) to b1-8) of URS 12.3.2 but with the detector as signal input

Plus C1-9) Correct operation in calibration mode

URS-12.4.3 The performance AGILE MCAL test shall be tested i.e.:
As for b2-6) to b2-8) of URS 12.3.3 but with the detector as signal input plus
C2-4) Bar resolution (GRID and Burst)
C2-5) Bar Minimun Threshold (GRID and Burst)

URS-12.4.4 The functionality and the performance AGILE MCAL in Burst mode should be tested with a TBD procedure