DAQ data structure for the Muon g-2 experiment

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January 5, 2017

Abstract

This document outlines the DAQ data structure of the Muon g-2 experiment. A detailed list of the MIDAS data bank will be shown and their contents will described.

Contents

1 MIDAS DAQ output in a nutshell

The main DAQ framework for the Muon g-2 experiment is based on MIDAS [cite]. MIDAS event structure is as depicted in Fig. 1.

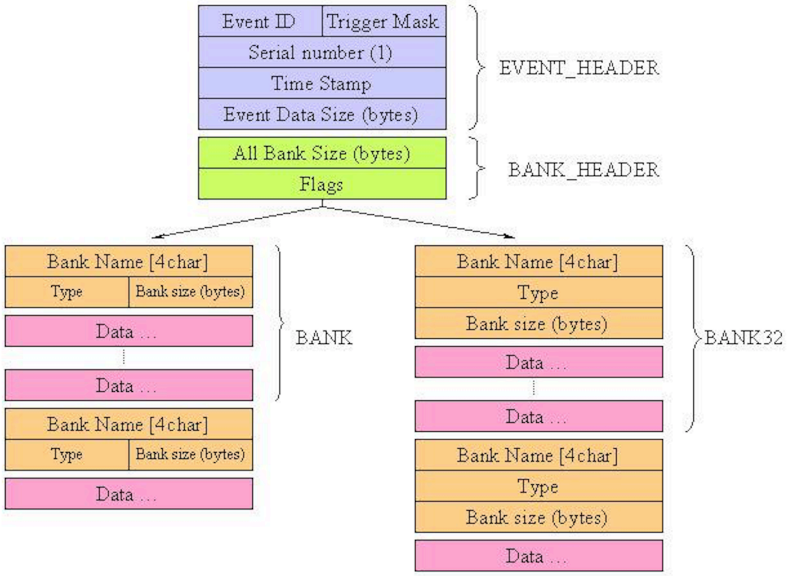


Figure 1: *MIDAS event structure. Each event has its header that is followed by the bank header. Then all the banks will appear according the defined order.*

2 MIDAS Bank list

Hundred of banks will be stored in each MIDAS event and it is very important to classify them properly. At the moment they can be grouped into 4 categories: calorimeter, auxiliary detector, CCC and magnetic field. Naming of these banks will be described in this section and their contents will be explained in the next section.

2.1 Calorimeter-related banks

There are 3 fill types for the calorimeter. `Muon` fill is the typical muon events, laser fill is event dedicated for laser calibration and monitoring events and pedestal fill is trivia from its name. Data from each fill type is identified from the bank name. The muon fill is denoted by "**C**", the laser fill is denoted by "**L**" and the pedestal fill is denoted by "**P**". A summary of the banks is listed in Tab. 1.

Table 1: *MIDAS bank list for the calorimetry data.*

muon fill	laser fill	pedestal fill	Description
Bank name			
CA	LA	PA	AMC13 Header
CB	LB	PB	WFD5 header
CC	LC	PC	GPU timing data
CF	LF	PF	GPU fitted data
CH	LH	PH	per-crystal Q-method data (N-th event, end of run)
CL	LL	PL	Clock data
CP	LP	PP	Pedestal
CQ	LQ	PQ	per-calo Q-method data (every event)
CR	LR	PR	WFD5 raw data
CT	LT	PT	T-method islands
CZ	LZ	PZ	AMC13 CDF trailers

Since each bank has to be named exactly four characters, the last 2 characters denoted the calorimeter number, e.g. **CT03** means the T-method bank from calorimeter number 3.

2.2 Auxiliary detector-related banks

A separate T/Q-method is needed for auxiliary detectors. Their data banks are denoted with the initial "**K**". A list of these banks are summarized in Tab. 2.

Table 2: *MIDAS bank list for auxiliary T/Q data. This is mainly for the fiber harps, quads and kickers.*

Bank name	Description
KH	Per aux. detector channel Q-method data (N-th event, end of run)
KQ	Per aux. detector Q-method data (every event)
KT	T-method data

The last 2 characters of the bank name will be decided soon.

2.3 CCC related banks

This is the bank storing the information regarding the CCC system based on FC7. A list of these banks are summarized in Tab. 3.

Table 3: *MIDAS bank list for the CCC data.*

TTCA	AMC13 Header
TTCR	CCC AMC13 Payload
TTCZ	AMC13 Trailer

2.4 Field related banks

All field-team banks are filled once per event and the definition of an event is different from the one of the ω_a related banks. For many field-team banks, a c struct is defined in the `field_struct.hh` file, accessible for all frontends and unpackers. Programmers should able to cast the read-out bank (array of bytes) onto a pointer of the corresponding struct. A midas bank can be an entire struct (like **TLNP**, **ABPR**, etc) or a array of structs (like **GALI**). A list of these banks are summarized in Tab. 4.

Table 4: *MIDAS bank list for the magnetic field related data.*

System	Name	Description
Fixed probe	FXPR	Fixed probe, header + NMR waveforms
Trolley	TLNP	Trolley NMR Pulse, header + NMR waveforms
	TLBC	Trolley Barcode, header + Barcode waveforms
	TLMN	Trolley Monitors (temperatures, voltages and pressure), header + voltage waveforms
	GALI	Galil (trolley and garage) data, positions + velocities + control voltages + tensions
Absolute probes	ABPR	Absolute probe (spherical probe and plunging probe are using the same bank), header + NMR waveforms
Flux gate	FLUX	Flux gate, fluxgate waveforms
Surface coil	SFCL	Surface coil, current readouts

3 Bank contents

This section details contents of each MIDAS bank. All the banks are packed in 32-bit word integer regardless of the original format.

3.1 Calorimeter-related banks

CA (LA, PA) banks

This is the bank for the AMC13 to DAQ header information. The first 64-bit word is the CDF header and the next 64-bit word is the payload header as shown in Fig. 2.

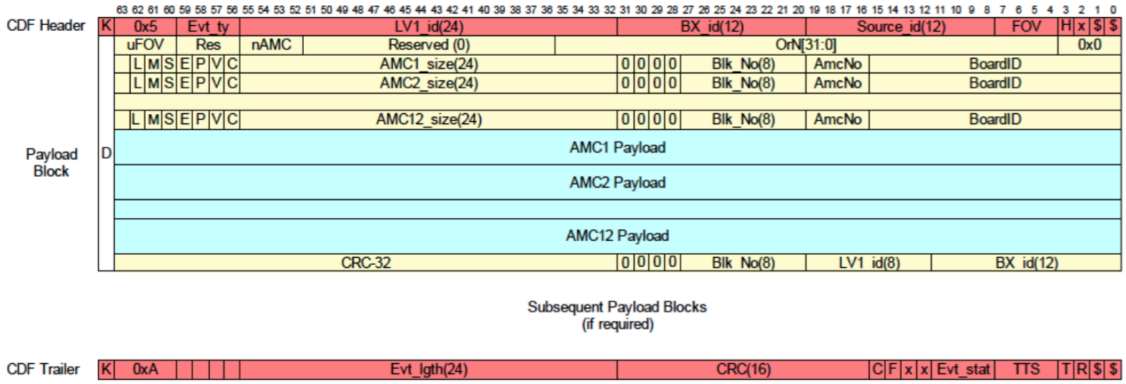


Figure 2: *Data structure for AMC13 to DAQ. The first 2 64-bit words are stored in the CA (LA, PA) bank.*

CZ (LZ, PZ) banks

This is the bank for the AMC13 to DAQ trailer information. The first 64-bit word is the last 64-bit word of the payload block and the next 64-bit word is the CDF trailer as shown in Fig. 2.

CB (LB, PB) banks

This is the bank for the WFD5 to AMC13 header information as shown in Fig. 3.

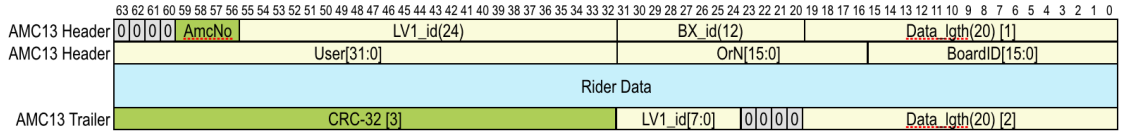


Figure 3: *Data structure for Rider to AMC13.*

CR (LR, PR) banks

This is the bank for the full WFD5 payload as shown in Fig. 4. Due to the huge data size of raw payload, a pre-scale of about 1000 event is usually being set in the MIDAS ODB.

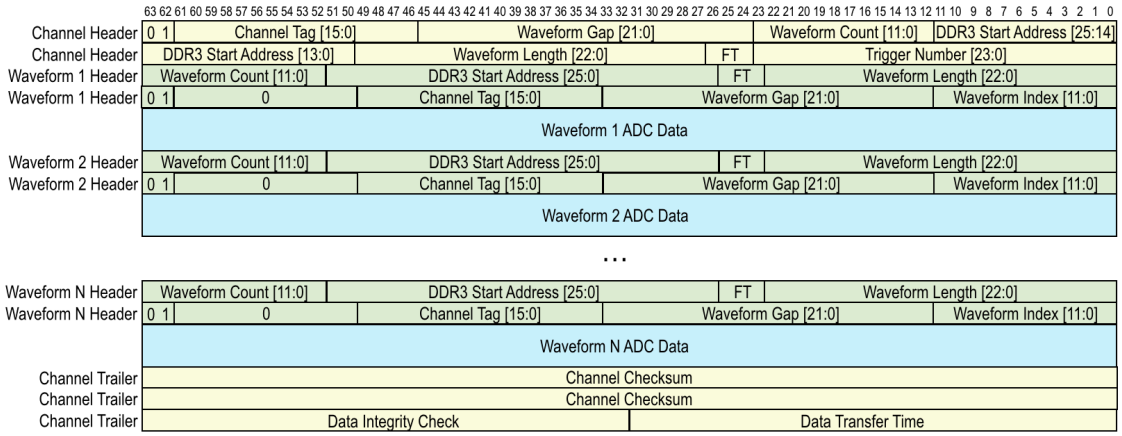


Figure 4: *Data structure for the WFD5 raw payload.*

CT (LT, PT) banks

This is the bank for calorimeter T-method chopped islands. A collection of 54 islands from 54 crystals/segments are extracted per trigger. The detailed structure is shown in Fig. 5.

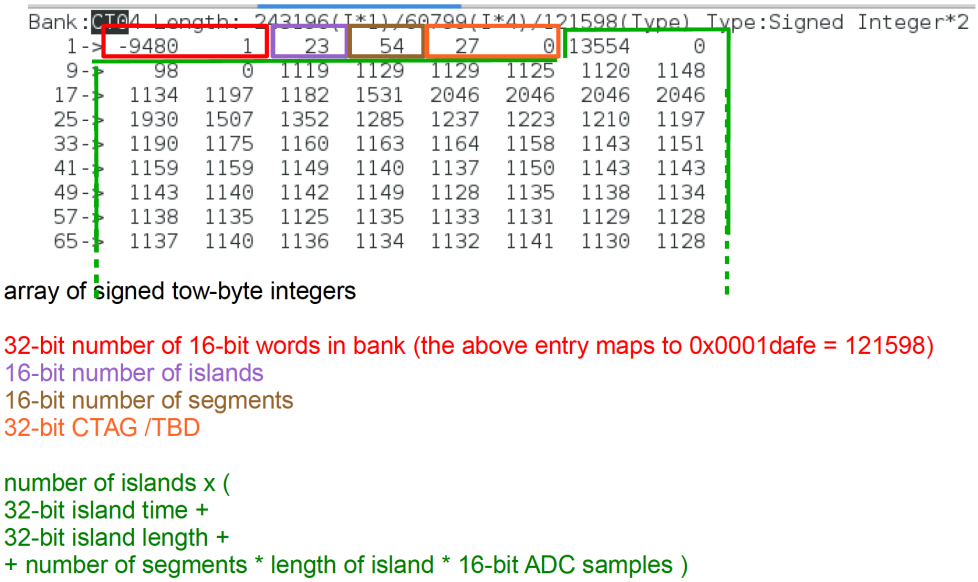


Figure 5: *Data structure for the CT bank (T-method chopped islands).*

CH (LH, PH) banks

This is the bank for calorimeter segment histograms. Histogram from each segment is being summed to itself each fill and is flushed out every N-th event. The detailed structure is shown in Fig. 6.

CQ (LQ, PQ) banks

This is the bank for calorimeter sum histograms. Histograms from all segments are summed together and decimated, and then are being flushed out every fill. The detailed structure is

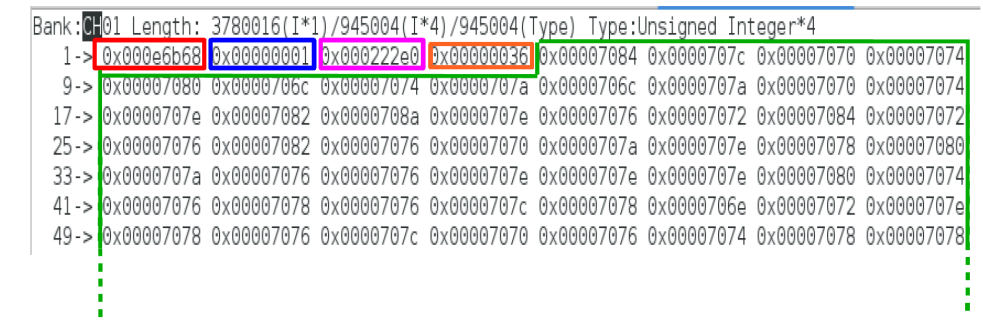


Figure 6: *Data structure for the CH bank (calo segment histograms).*

shown in Fig. 7.

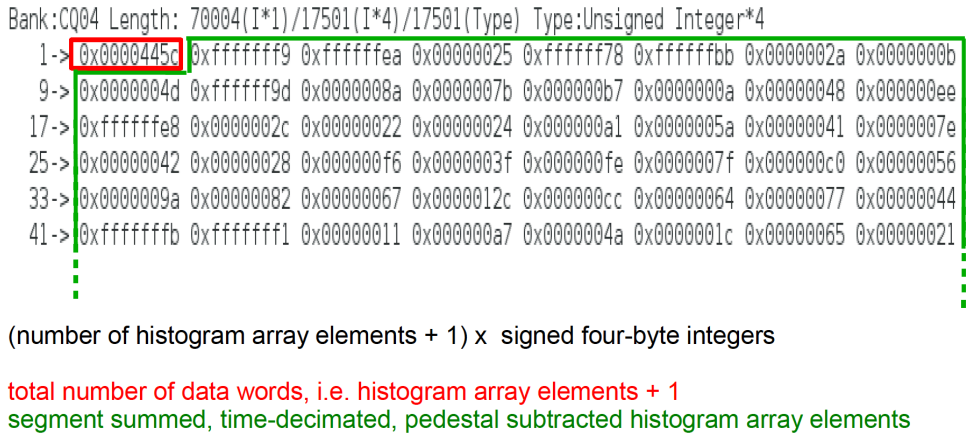


Figure 7: *Data structure for the CQ bank (calo sum histograms).*

CP (LP, PP) banks

This is the bank for calorimeter pedestals. The detailed structure is shown in Fig. 8.

CC (LC, PC) banks

This is the bank for the calorimeter DAQ performance related information. It has information like tcp timing and gpu timing. The detailed structure is shown in Fig. 9.

CR (LR, PR) banks, asynchronous

This is the bank for the WFD5 payload in the asynchronous mode. The detailed structure is shown in Fig. 10.

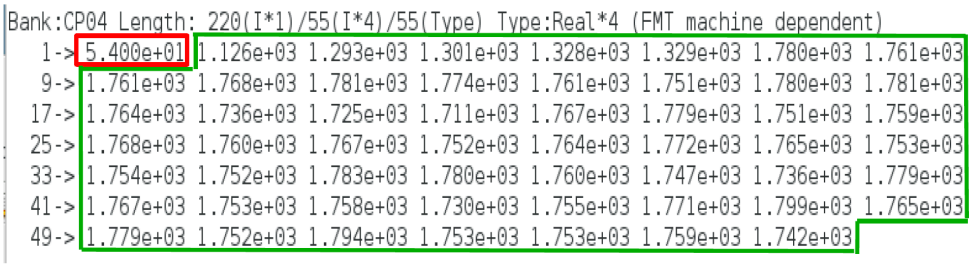
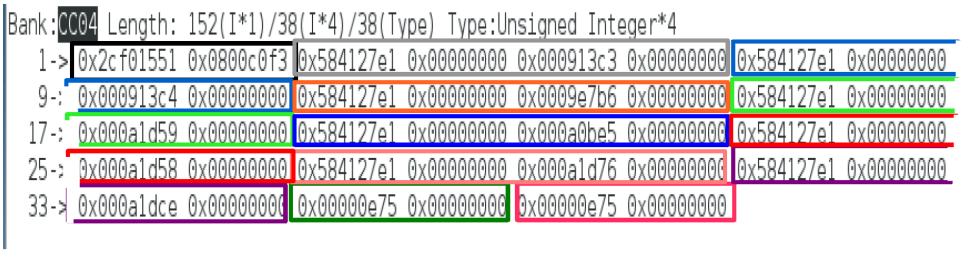


Figure 8: *Data structure for the CP bank (T-method pedestals).*



array of 64-bit words (sec, usecs are obtained from gettimeofday() and struct timeval in sys/time.h

64-bit CDF header word
TCP proc unlocked / started, first 64-bit word is seconds, second 64-bit word is usecs
got TCP header word, first 64-bit word is seconds, second 64-bit word is usecs
got TCP header word, first 64-bit word is seconds, second 64-bit word is usecs
GPU proc unlocked / started , first 64-bit word is seconds, second 64-bit word is usecs
GPU copy done , first 64-bit word is seconds, second 64-bit word is usecs
GPU proc done , first 64-bit word is seconds, second 64-bit word is usecs
MFE proc unlocked, first 64-bit word is seconds, second 64-bit word is usecs
MFE banks made, first 64-bit word is seconds, second 64-bit word is usecs
current TCP fill number
current GPU fill number

Figure 9: *Data structure for the CC bank (calo performance).*

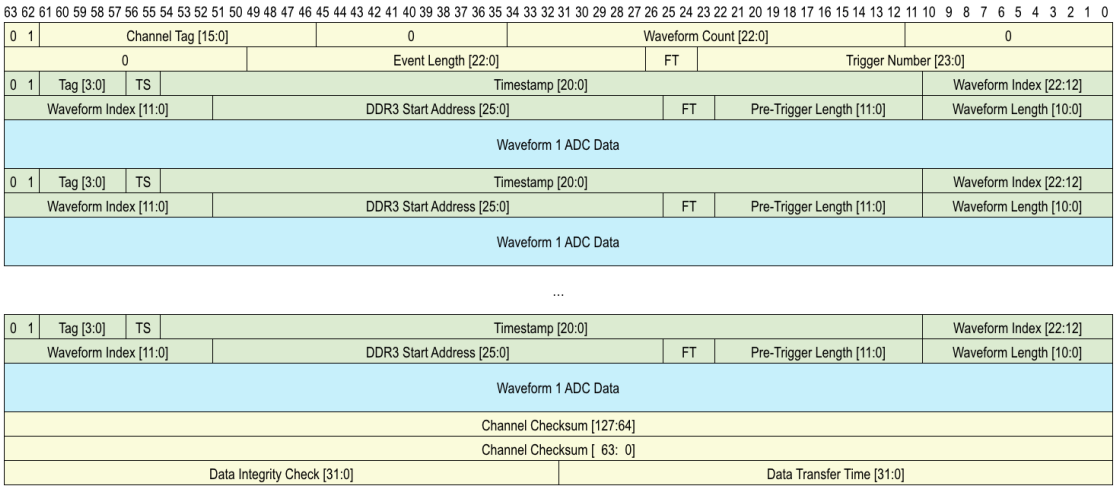


Figure 10: *Data structure for asynchronous mode for Rider.*

3.2 Auxiliary detector-related banks

KH and KQ banks

These two banks have the same format as the CH and CQ banks.

KT bank

This bank has the same format as the CT bank.

3.3 CCC related banks

TTCA, TTCR, TTCZ banks

TTCA bank will have the same format as the CA bank in the calorimeter-related data since the uTCA crate has the same data format. TTCZ on the other hand will have the same format as the CZ bank.

There are two types of TTCR banks for the FC7 - encoder and fanout. The data format of the encoder and fanout FC7 are shown in Fig. 11 and Fig. 12. respectively.

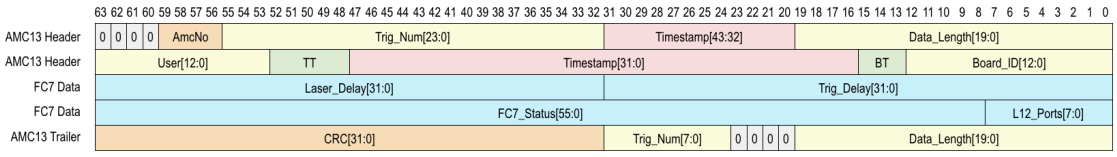


Figure 11: *Data structure for encoder FC7.*

3.4 Field related banks

FXPR bank

This is the bank for fixed probes. It consists of a header and NMR waveforms.

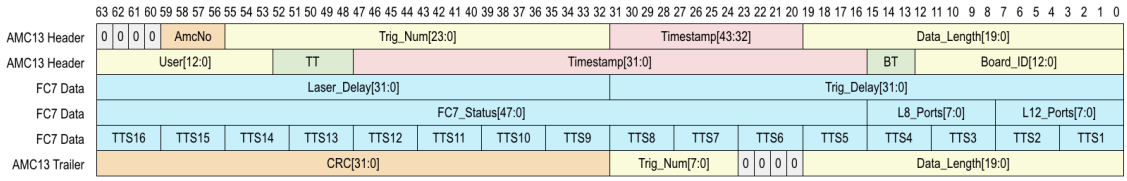


Figure 12: *Data structure for fanout FC7.*

Table 5: *MIDAS bank structure for the FXPR bank.*

start word index	type	array length	field name	content	struct name
0	Double_t	num_ch	sys_clock	system clock	fixed_t
4*num_ch	Double_t	num_ch	gps_clock	gps clock	
8*num_ch	Double_t	num_ch	dev_clock	device clock	
12*num_ch	Double_t	num_ch	snr	signal to noise ratio	
16*num_ch	Double_t	num_ch	len	length of each wave form	
20*num_ch	Double_t	num_ch	freq	frequency extracted	
24*num_ch	Double_t	num_ch	ferr	frequency error	
28*num_ch	Double_t	num_ch	freq_zc	frequency extracted, zero crossing	
32*num_ch	Double_t	num_ch	ferr_zc	frequency error, zero crossing	
36*num_ch	UShort_t	num_ch	health	health indicator of probes	
37*num_ch	UShort_t	num_ch	method	frequency extraction method	
38*num_ch	UShort_t	num_ch * rec_len	trace	NMR waveforms: Waveform_Ch1 + Waveform_Ch2 + ... + Waveform_Ch6	

Table 6: *Hard-coded macros in the FXPR bank.*

Name in the code	Name in this doc	Value
NMR_NUM_FIXED_PROBES	num_ch	378
NMR_FID_LENGTH_RECORD	rec_len	10000

TLNP bank

This is the bank for Trolley NMR pulses. It consists of a header and NMR waveforms.

Table 7: *MIDAS bank structure for the TLNP bank.*

start word index	type	array length	field name	content	struct name
0	ULong64_t	1	gps_clock	Time stamp of the first NMR sample	trolley_nmr_t
4	UShort_t	1	probe_index	probe index	
5	UShort_t	1	length	length of the NMR waveform	
6	Short_t	nmr_len	trace	Trolley Probe NMR wavefrom	

Table 8: *Hard-coded macros in the TLNP bank.*

Name in the code	Name in this doc	Value
TRLY_NMR_LENGTH	nmr_len	24000

TLBC bank

This is the bank for Trolley barcode readers. It consists of a header and barcode waveforms.

Table 9: *MIDAS bank structure for the TLBC bank.*

start word	index	type	array length	field name content	struct name
0	ULong64_t	1	gps_clock	Time stamp of the first barcode sample	trolley_barcode_t
4	UShort_t	1	length_per_ch	length of the barcode waveform per channel	
5	UShort_t	bc_ch*bc_len	traces	Barcode wavefroms: Waveform_Ch1 + Waveform_Ch2 + ... + Waveform_Ch6	

4 Parsers for MIDAS bank data

Muon g-2 offline analysis framework relies on parsers in the gm2parser namespace hosted under repository gm2unpackers to decode the data. To checkout the codes,

```
git clone ssh://p-gm2dqm@cdcvs.fnal.gov/cvs/projects/gm2unpackers
```

Alternatively, you can also use

```
mrb g gm2dqm
```

in our g-2 environment. These parsers are written in C++ and are being used in the *art* producer modules. They can also be used in your standalone C++ codes, if you wish to. The parsers are located at

```
gm2unpackers/calo/parsers
```

at the moment for both calorimeter and CCC related information. This document will be updated accordingly once they are reorganized.