# ORN ECube Data Format Specification v1.0

## Authors

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## Citation

Cecconi, B., C Viou, A Coffre. **2022**. *ORN ECube Data Format Specification.* Version 1.0. PADC/CDN. https://doi.org/10.25935/NJWH-R040

## Version History

| Date | Version | Change record | Authors |
|---|---|---|---|
| **2022-09-25** | 0.1 | First draft | B. Cecconi |
| **2022-09-28** | 1.0 | First release | B. Cecconi |

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# Introduction

The *ECube data format* is the output format of the high resolution digital receivers developed at the Nançay Radio Observatory (ORN), and used for the Nançay Decameter Array (NDA) receivers: NDA/NewRoutine, NDA/MEFISTO and NDA/JunoN. The ECube files are composed of a header section followed by a series of ECube data records, as described in this document.

**NB:** *the JunoN dataset only uses the ECube data record structure, but has its own header specification.*

# File Header

The header section is composed of the following fields.

## Header structure

| Field Name | Offset (bytes) | Length (bytes) | Type |
|---|---|---|---|
| **length** | 0 | 4 | 1 x unsigned 32 bits integer |
| **corr_config** | 4 | 8 | 8 x unsigned 8 bits integer |
| **accum** | 12 | 4 | 1 x unsigned 32 bits integer |
| **freq_config** | 16 | 256 | 64 x unsigned 32 bits integer |
| **freq_length** | 272 | 4 | 1 x 32 bits integer |
| **freq_values** | 276 | 8192 | 2048 x 32 bits floating point |
| **freq_order** | 8468 | 8192 | 2048 x 32 bits integer |

## Header keyword description

### length

Definition — Length (in bytes) of the header section

### corr_config

Definition — Record correlation products configuration expressed as a bit mask. The following table explains the configuration, each pair of Left/Right columns or rows correspond to an instrumental or software configuration, depending on the setup and receiver.

| | bit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| byte | Array | Left | Right | Left | Right | Left | Right | Left | Right |
| 0 | Left | | | | | | | | |
| 1 | Right | | | | | | | | |
| 2 | Left | | | | | | | | |
| 3 | Right | | | | | | | | |
| 4 | Left | | | | | | | | |
| 5 | Right | | | | | | | | |
| 6 | Left | | | | | | | | |
| 7 | Right | | | | | | | | |

Color Coding

| | |
|---|---|
| | Autocorrelation |
| | Real part of cross-correlation |
| | Imag. part of cross-correlation |

accum

Definition: Accumulating factor: number of consecutive samples accumulated in each record.

freq_config

Definition: Frequency configuration: bit-mask of selected frequencies (2048 bits)

freq_length

Definition: Spectral axis length: number of spectral steps (set to 2048)

freq_values

Definition: Spectral axis: values of the 2048 spectral steps (frequencies in MHz)

freq_order

Definition: Spectral axis ordering: indices to sort the spectral axis (usually set to a simple ramp from 0 to 2047).

## ECube data record

The data section is composed of a series of ECube record. Each ECube record is composed of an *ECube data record header* and an *ECube record data*.

### ECube data record header

The length of the ECube record header is 32 bytes.

| Field Name | Offset (bytes) | Length (bytes) | Type |
|---|---|---|---|
| **magic_word** | 0 | 4 | 1 x unsigned 32 bits integer |
| **ecube_cnt** | 4 | 4 | 1 x unsigned 32 bits integer |
| **date_jd** | 8 | 4 | 1 x unsigned 32 bits integer |
| **date_sec** | 12 | 4 | 1 x unsigned 32 bits integer |
| **date_nsub** | 16 | 4 | 1 x unsigned 32 bits integer |
| **date_dsub** | 20 | 4 | 1 x unsigned 32 bits integer |
| **[unused]** | 24 | 8 | — |

magic_word

Definition: The value of this keyword is specific for each instrument/mode.
Values: 0x7F800000 = NewRoutine; MEFISTO; JunoN/Spectrum
0xFF800000 = JunoN/Waveform

ecube_cnt

Definition: ECube record number in observation session (may not start at 0 if the file has been extracted from the original observation data file)

date_jd

Definition: Julian day of observation.

date_sec

Definition: Second of current day

date_nsub

Definition: Fractional second numerator

date_dsub

Definition: Fractional second denominator

The date of the ECube record is reconstructed as:

- *ECube_date* = date_jd + (date_sec + date_nsub/date_dsub)/86400.

## ECube data record

The length of the ECube record data section depends on the number of selected correlation products (*nb_corr*) and number of steps of the spectral axis (*nfreq*).

- *nb_corr* = count of bits set to 1 in the *corr_config* header attribute.
- *nfreq* = *freq_length* header attribute.

NB: for JunoN/Spectrum data, *nb_corr* and *nfreq* are provided in the header.

The length of the ECube record data section is:

- *data_size* = 4 x *nb_corr* x (2 + *nfreq*) bytes

The *ECube record data* section is composed of a series of *nb_corr* correlation data vectors.

## ECube correlation vector

Each correlation data vectors is composed as follows

| Field Name | Offset (bytes) | Length (bytes) | Type |
|---|---|---|---|
| **magic_word** | 0 | 4 | 1 x unsigned 32 bits integer |
| **corr_cnt** | 4 | 4 | 1 x unsigned 32 bits integer |
| **corr_data** | 8 | nfreq x 4 | nfreq x 32 bits floating point |

### magic_word

Definition: The value of this keyword is specific for each instrument/mode.

Values: 0x7F800001 = MEFISTO
0xFF800001 = NewRoutine, JunoN/Spectrum

### corr_cnt

Definition: Correlation vector record number within ECube data record.

### corr_data

Definition: Correlation data vector (*nfreq* elements)