ING ionogram formats

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IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

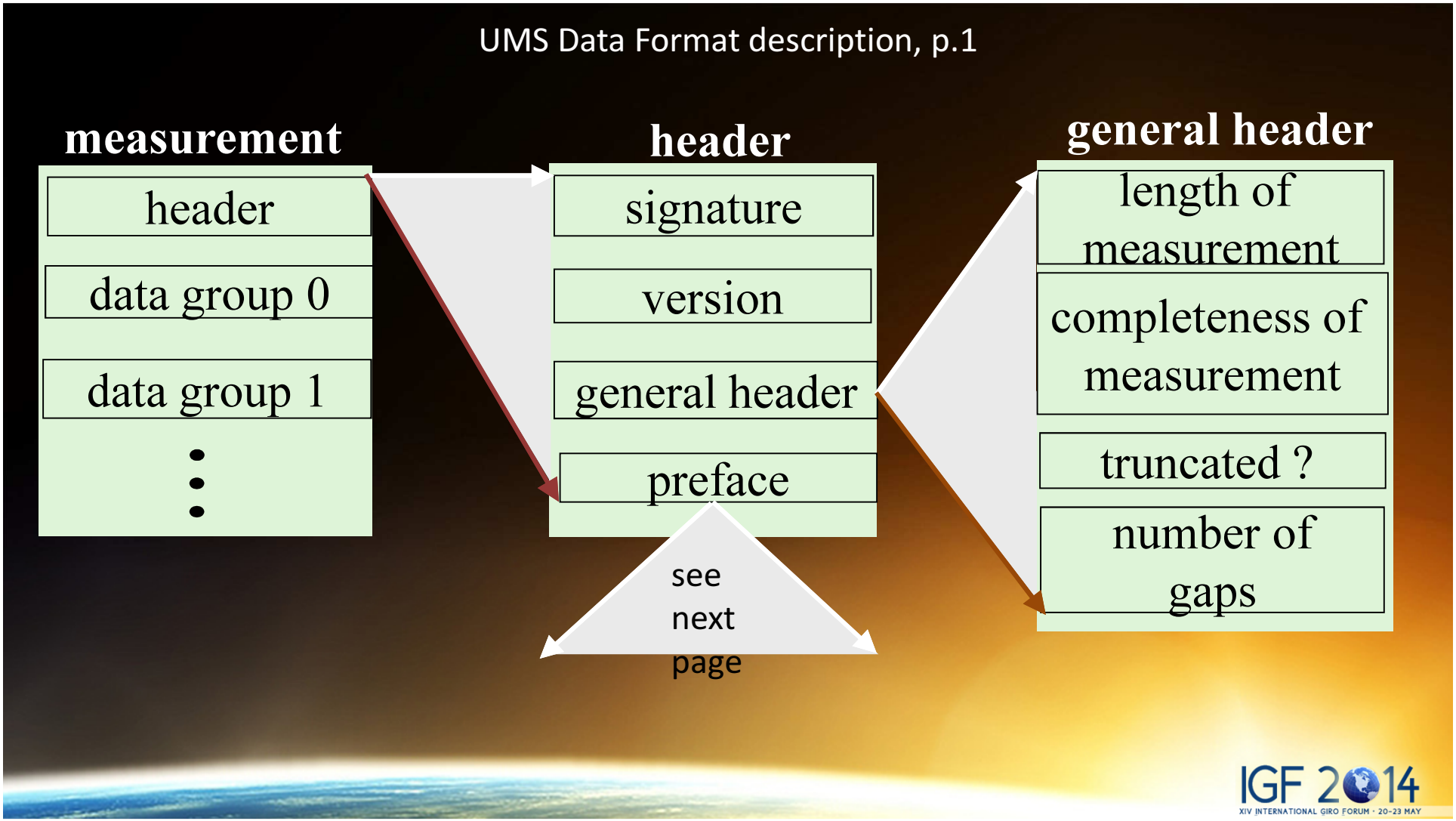
UMS (Uniform Measurement Storage) data format

- **Reusable data structures**
- **Mapping of memory structure**
- **Unified reader for all data types**
- **Versioning of data**

- **Program measurement** is the minimal data unit that can be addressed to UMS reader. Program measurement is uniquely identified by station and start time.
- Program measurement consists of Program header and number of Data Groups
- Data Group can be:

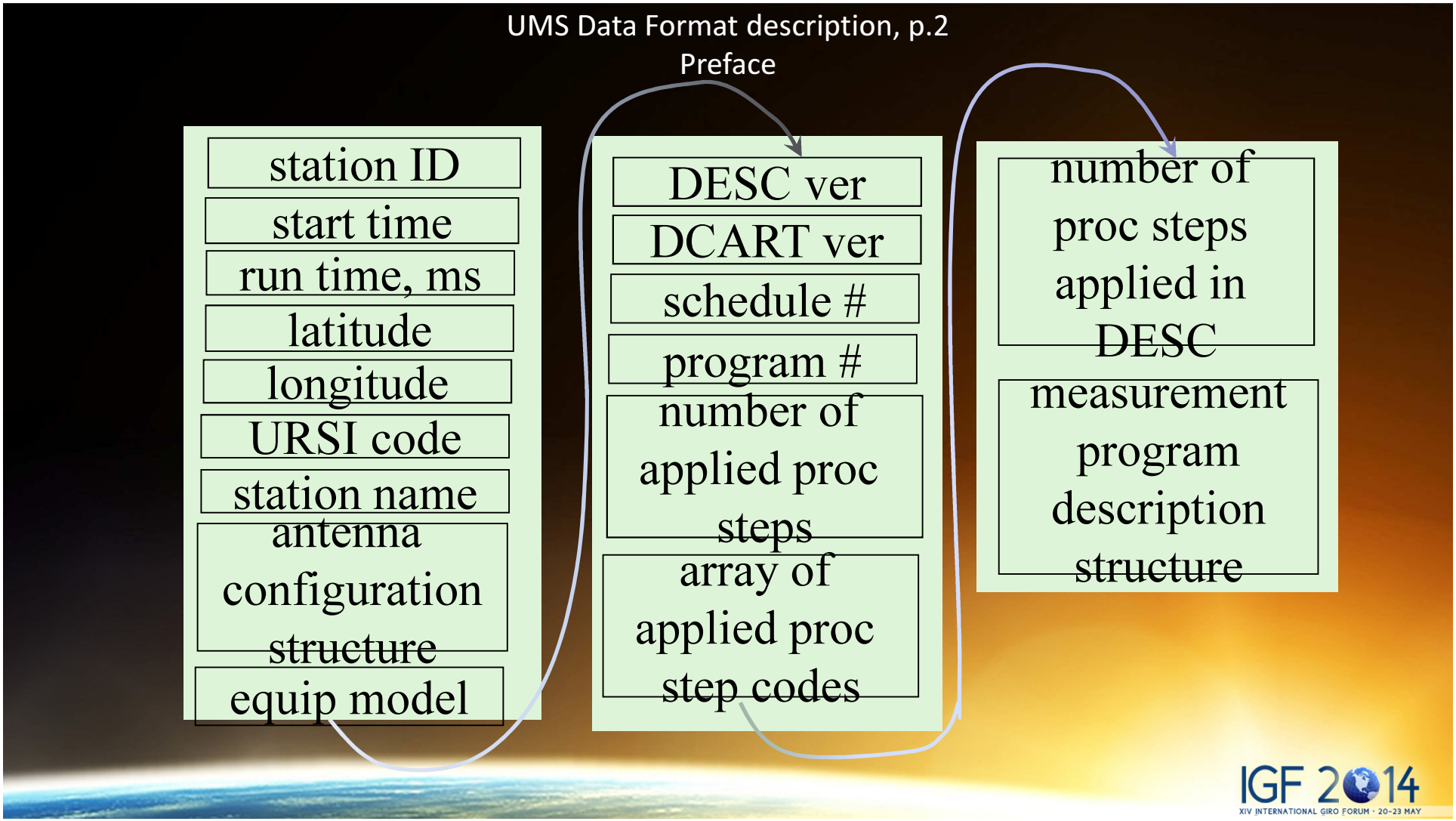
1. *Look*, corresponds to raw data acquired by DESC after one series of sampling (and it usually corresponds to one signal transmitting)
2. *Doppler Frequency Group*, corresponds to data unit after *Doppler Calculation Processing Step*
3. *Ionogram Frequency Group*, corresponds to data unit after *Ionogram Calculation Processing Step*

UMS Data Format description, p.1

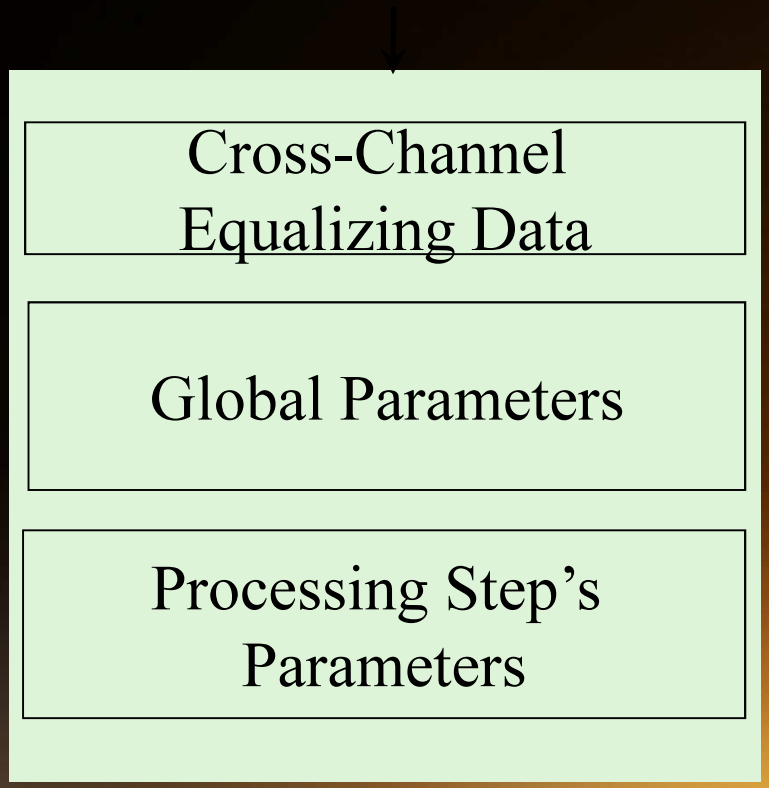


UMS Data Format description, p.2

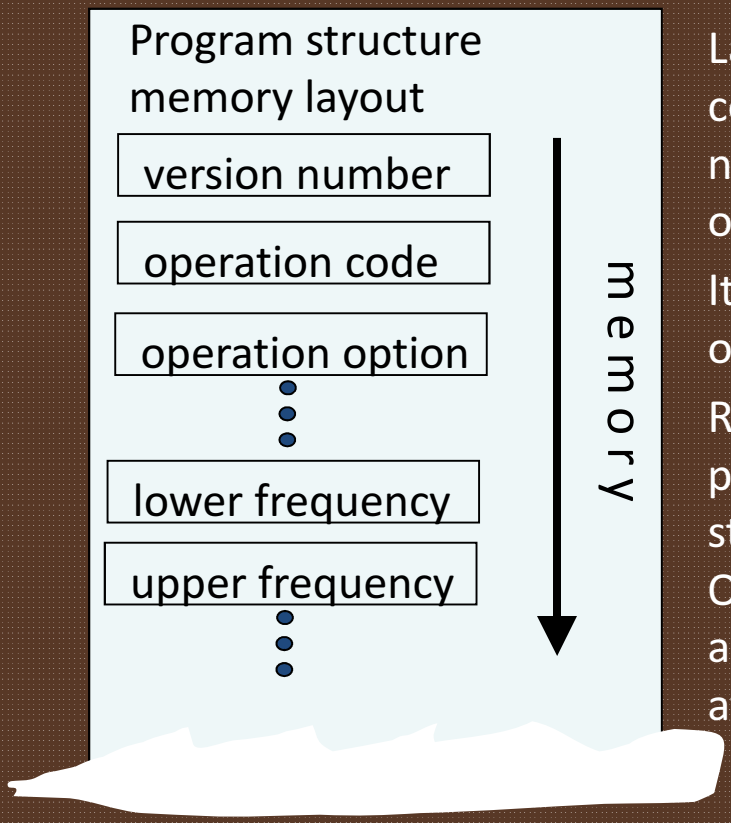
Preface



UMS Data Format description, p.3
Preface



Versioning mechanism example



Large data structures, like Program data structure, contain its version inside of its content and this version number saved on disk (serialized) as the first element of this data structure.

It gives possibility to tune-up software reading engine on-the-fly when data is retrieving.

Returning to this example, it leaves developers the possibility to change Program structure in the future still having backward compatibility of reading engine. Of course, maintenance of versioning mechanism for any structure requires quite a bit of developer's attention.

Databin formats

Databin is small piece of information that very often related with data sampling, and contains information of particular sample. The information it contains depends on data processing we already applied. For example, raw sample contains quadrature or amplitude-phase (2 values) for each of 4 antennas. Ionogram databin contains amplitude, doppler, angle of arrival.

Time domain databin formats

- Uncompressed databin, 4 bytes, format 0:

  Real part occupies 2 bytes, from -32768 to 32767;

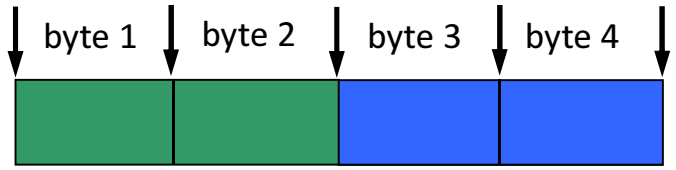
  Imaginary part occupies 2 bytes, from -32768 to 32767

- Compressed databin, 2 bytes, format 1:

  Amplitude, in dB, is mapped to 7-bit filed, from 0 to 127, with precision ≈ 96/127 = 0.76dB

  Phase, in degrees, is mapped to 9-bit field, from 0 to 511, with precision 360/512 ≈ 0.7 degree

Time domain databin format 0, 4 bytes

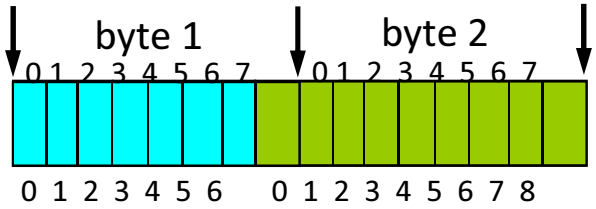


Real part,
16-bit field
to -32768 to 32767

Imaginary part,
16-bit field,
to -32768 to 32767

One databin for each look, height, and antenna

Time domain databin format 1, 2 bytes



amplitude,
7-bit field,
in ≈ 96/127
≈ 0.76 dB
units

phase,
9-bit field,
In 360/512
≈ 0.7 Deg
units

One databin for each look, height, and antenna

Doppler databin formats

- Uncompressed databin, 4 bytes, format 0:

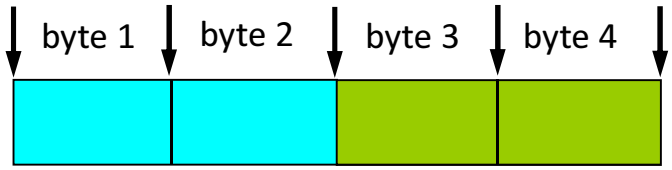
  Amplitude, in linear scale, occupies 2 bytes, from 0 to 65535;

  Phase, in degrees, is mapped to 16-bit field, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree
- Compressed databin, 2 bytes, format 1:

  Amplitude, in dB, is mapped to 7-bit field, from 0 to 127, with precision ≈ 96/127 dB

  Phase, in degrees, is mapped to 9-bit field, from 0 to 511, with precision 360/512 ≈ 0.7 degree

Doppler databin format 0, 4 bytes

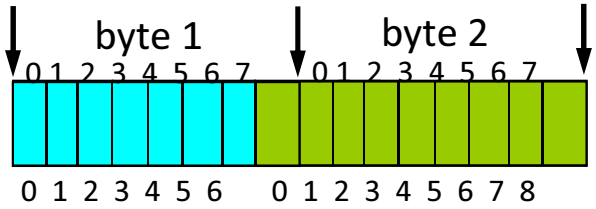


amplitude,
16-bit field,
in linear scale

phase,
16-bit field,
In 360/65536
≈ 0.006 deg
units

One databin for each frequency, polarization, height, antenna, and Doppler

Doppler databin format 1, 2 bytes



amplitude,	**phase,**
7-bit field,	9-bit field,
in ≈ 96/127	In 360/512
≈ 0.76 dB	≈ 0.7 Deg
units	units

One databin for each frequency, polarization, height, antenna, and Doppler

Ionogram databin format 0

- All-antennas uncompressed, 18 or 20 bytes:

  Sequential Doppler number is mapped to 8-bit field in such way that all Doppler numbers ≤ -128 are mapped to -128 and all Doppler numbers ≥ 128 are mapped to 128;

  For each antenna,

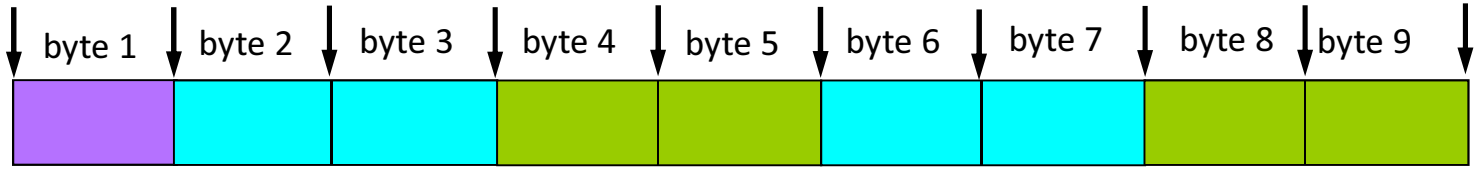
  Amplitude, in linear scale, occupies 2 bytes, from 0 to 65535, and

  Phase, in degrees, is mapped to 16-bit filed, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree

  For PGH mode:

  Phase difference, in degrees, is mapped to 16-bit field, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree

Ionogram databin format 0, not PGH mode, 17 bytes



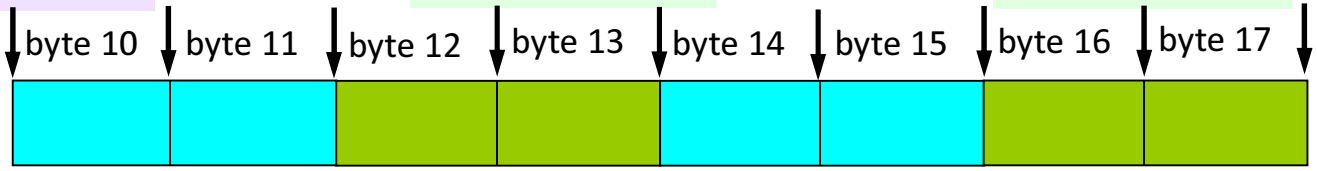
sequential number of **doppler**, 8-bit field, from 0 to 255

amplitude, antenna 1, 16-bit field, in linear scale

phase, antenna 1, 16-bit field, In 360/65536 ≈ 0.006 deg units

amplitude, antenna 2, 16-bit field, in linear scale

phase, antenna 2, 16-bit field, In 360/65536 ≈ 0.006 deg units



amplitude, antenna 3, 16-bit field, in linear scale

phase, antenna 3, 16-bit field, In 360/65536 ≈ 0.006 deg units

amplitude, antenna 4, 16-bit field, in linear scale

phase, antenna 4, 16-bit field, In 360/65536 ≈ 0.006 deg units

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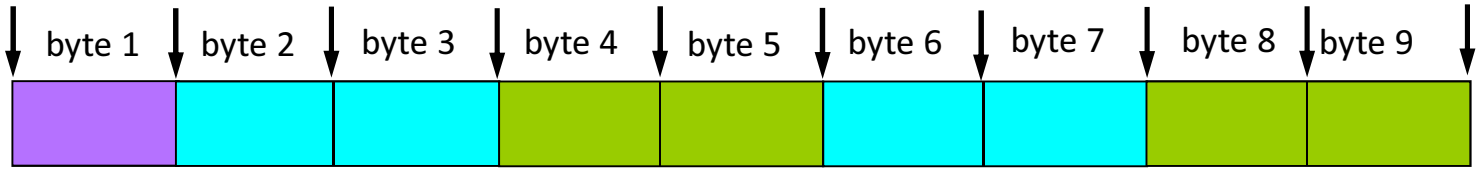
Ionogram databin format 0, PGH mode, 19 bytes



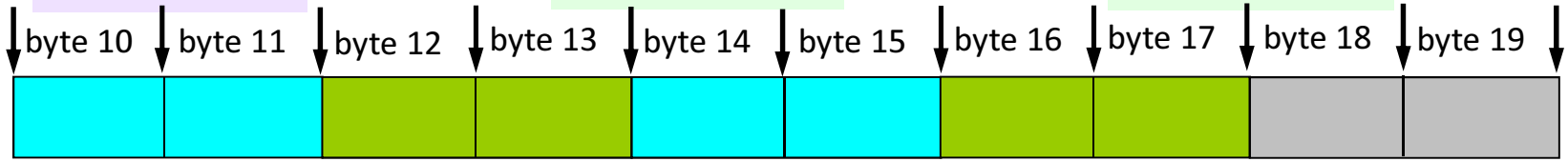
sequential number of **doppler**, 8-bit field, from 0 to 255

amplitude, antenna 1, 16-bit field, in linear scale

phase, antenna 1, 16-bit field, In 360/65536 ≈ 0.006 deg units

amplitude, antenna 2, 16-bit field, in linear scale

phase, antenna 2, 16-bit field, In 360/65536 ≈ 0.006 deg units



amplitude, antenna 3, 16-bit field, in linear scale

phase, antenna 3, 16-bit field, In 360/65536 ≈ 0.006 deg units

amplitude, antenna 4, 16-bit field, in linear scale

phase, antenna 4, 16-bit field, In 360/65536 ≈ 0.006 deg units

phase, difference, 16-bit field, In 360/65536 ≈ 0.006 deg units

Ionogram databin format 1

- All-antennas compressed, 9 or 10 bytes:

Sequential Doppler number is mapped to 8-bit field in such way that all Doppler numbers ≤ -128 are mapped to -128 and all Doppler numbers ≥ 128 are mapped to 128;

For each antenna:

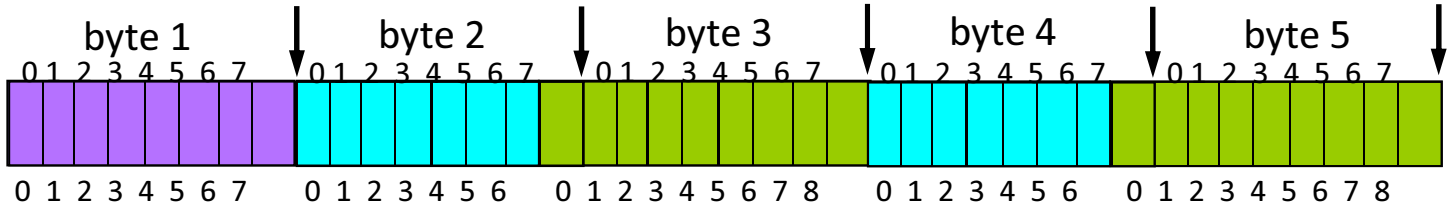
Amplitude, in dB, is mapped to 7-bit field, from 0 to 127, with precision ≈ 96/127 dB, and

Phase, in degrees, is mapped to 9-bit field, from 0 to 511, with precision 360/512 ≈ 0.7 degree

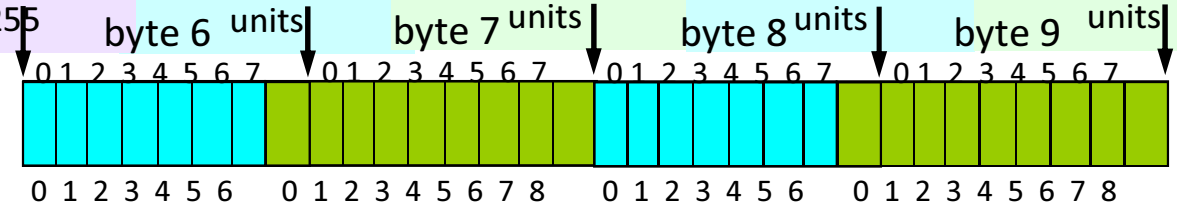
For PGH mode:

Phase Difference, in degrees, is mapped to 8-bit field, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree

Ionogram databin format 1, not PGH mode, 9 bytes



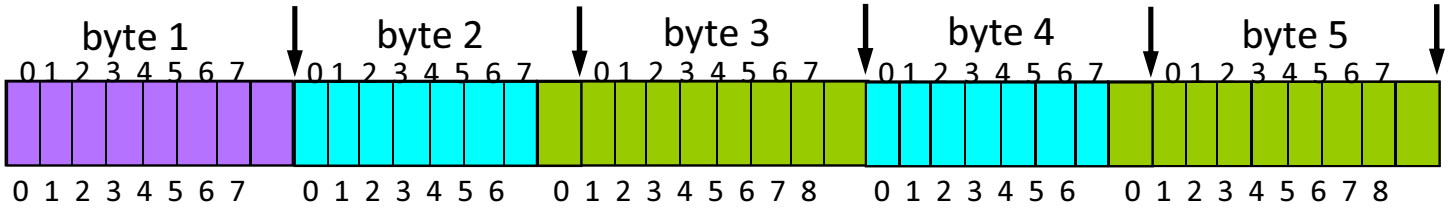
sequential number of **doppler**, 8-bit field, from 0 to 255	**amplitude, antenna 1**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 1**, 9-bit field, In 360/512 ≈ 0.7 Deg units	**amplitude, antenna 2**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 2**, 9-bit field, In 360/512 ≈ 0.7 Deg units



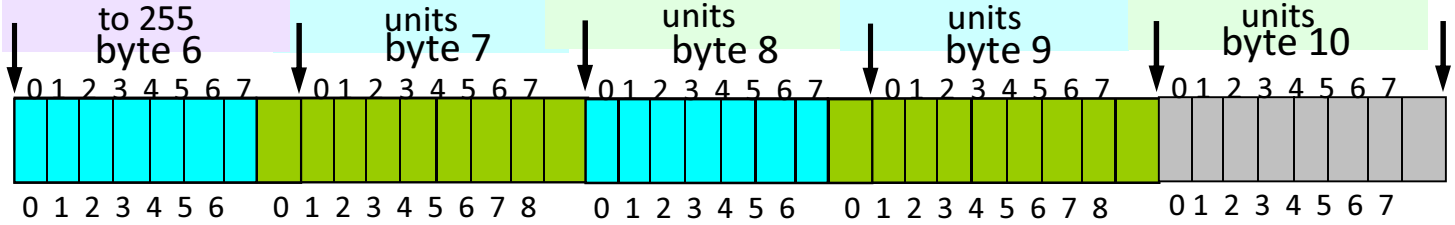
amplitude, antenna 3, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 3,** 9-bit field, In 360/512 ≈ 0.7 Deg units	**amplitude, antenna 4**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 4**, 9-bit field, In 360/512 ≈ 0.7 Deg units

For each frequency and polarization

Ionogram databin format 1, PGH mode, 10 bytes



byte 1	byte 2	byte 3	byte 4	byte 5
sequential number of **doppler**, 8-bit field, from 0 to 255	**amplitude, antenna 1,** 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 1**, 9-bit field, In 360/512 ≈ 0.7 Deg units	**amplitude, antenna 2**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 2**, 9-bit field, In 360/512 ≈ 0.7 Deg units



byte 6	byte 7	byte 8	byte 9	byte 10
amplitude, antenna 3, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 3**, 9-bit field, In 360/512 ≈ 0.7 Deg units	**amplitude, antenna 4**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**phase, antenna 4**, 9-bit field, In 360/512 ≈ 0.7 Deg units	**phase difference**, 8-bit field, In 360/256 ≈ 1.4 Deg units

For each frequency and polarization

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Ionogram databin format 2

- Convolved-antennas uncompressed, 8 or 10 bytes:

Sequential Doppler number, from 0 to *number_of_dopplers – 1*, occupies 2 bytes;

Amplitude, in linear scale, occupies 2 bytes, from 0 to 65535;

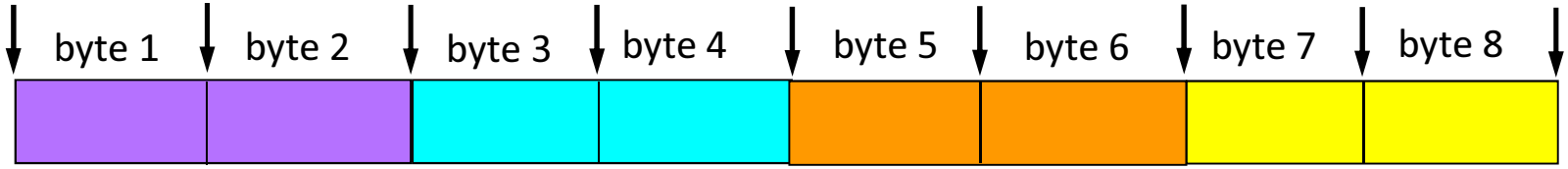
Zenith, in degrees, is mapped to 16-bit field, from 0 to 65535, with precision 90/65536 ≈ 0.002 degree. Value "65535" of this field signals 'zenith/azimuth values are not calculable';

Azimuth, in degrees, is mapped to 16-bit field, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree;

For PGH mode:

Phase difference, in degrees, is mapped to 16-bit field, from 0 to 65535, with precision 360/65536 ≈ 0.006 degree

Ionogram databin format 2, not PGH mode, 8 bytes



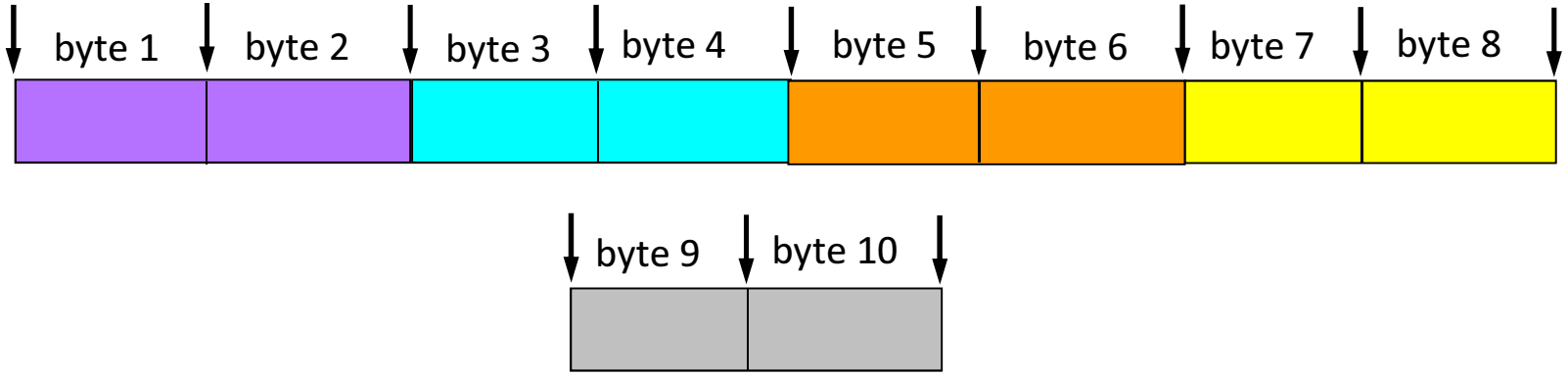
sequential number of **doppler**, 16-bit field, from 0 to 65535	**amplitude**, 16-bit field, in linear scale	**zenith**, 16-bit field, In 90/65535 ≈ 0.002 deg units[1,2]	**azimuth**, 16-bit field, in 360/65536 ≈ 0.006 deg units

For each frequency and polarization

[1] Value "65535" of this field signals 'zenith/azimuth values are not calculable'

[2] For better compression, all 1's will be put in azimuth field when zenith/azimuth values are not calculable

Ionogram databin format 2, PGH mode, 10 bytes



sequential number of **doppler**, 16-bit field, from 0 to 65535	**amplitude**, 16-bit field, in linear scale	**zenith**, 16-bit field, In 90/65535 ≈ 0.002 deg units[1,2]	**azimuth**, 16-bit field, in 360/65536 ≈ 0.006 deg units	**phase difference**, 16-bit field, in 360/65536 ≈ 0.006 deg units

For each frequency and polarization

[1] Value "65535" of this field signals 'zenith/azimuth values are not calculable'

[2] For better compression, all 1's will be put in azimuth field when zenith/azimuth values are not calculable

Ionogram databin format 3

- Convolved-antennas compressed, 4 or 5 bytes:

Sequential Doppler number is mapped to 8-bit field in such a way that all Doppler numbers ≤ -128 are mapped to -128, and all Doppler numbers ≥ 128 are mapped to 128;

Amplitude, in dB, is mapped to 7-bit field, from 0 to 127, with precision ≈ 96/127 dB;

Zenith, in degrees, is mapped to 7-bit field, from 0 to 127, with precision 90/128 ≈ 0.7 degree. Value "127" of this field signals 'zenith/azimuth values are not calculable';

not PGH mode:

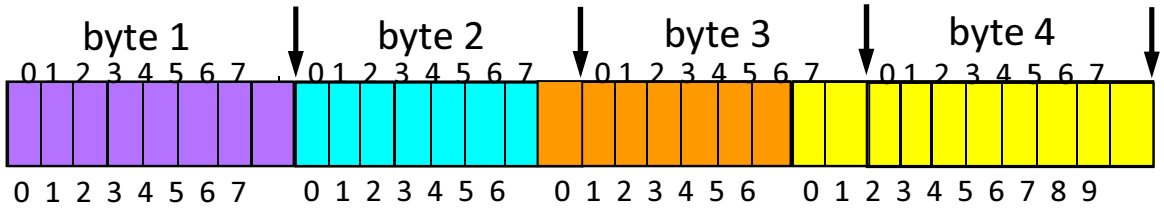
Azimuth, in degrees, is mapped to 10-bit field, from 0 to 1023, with precision 360/1024 ≈ 0.35 degree;

PGH mode:

Azimuth, in degrees, is mapped to 9-bit field, from 0 to 511, with precision 360/512 ≈ 0.7 degree;

Phase Difference, in degrees, is mapped to 9-bit field, from 0 to 511, with precision 360/512 ≈ 0.7 degree;

Ionogram databin format 3, not PGH mode, 4 bytes



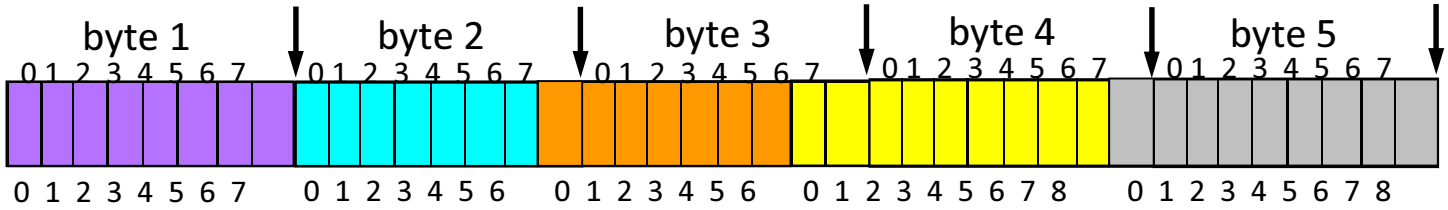
sequential number of **doppler**, 8-bit field, from 0 to 255	**amplitude**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**zenith**, 7-bit field, In 90/127 ≈ 0.7 Deg units[1,2]	**azimuth**, 10-bit field, in 360/1024 ≈ 0.35 Deg units

For each frequency and polarization

[1] Value "127" of this field signals 'zenith/azimuth values are not calculable'

[2] For supposedly better compression, all 1's will be put in azimuth field when zenith/azimuth values are not calculable

Ionogram databin format 3, PGH mode, 5 bytes



sequential number of **doppler**, 8-bit field, from 0 to 255	**amplitude**, 7-bit field, in ≈ 96/127 ≈ 0.76 dB units	**zenith,** 7-bit field, in 90/127 ≈ 0.7 Deg units[1,2]	**azimuth**, 9-bit field, in 360/512 ≈ 0.7 Deg units	**phase difference**, 9-bit field, In 360/512 ≈ 0.7 Deg units

For each frequency and polarization

[1] Value “127” of this field signals ‘zenith/azimuth values are not calculable’

[2] For supposedly better compression, all 1’s will be put in azimuth field when zenith/azimuth values are not calculable

Ionogram databin format 4

- Convolved-antennas RSF-like compressed, 2 bytes:

Sequential Doppler number is mapped to 3-bit field in such a way that all Doppler numbers ≤ -4 are mapped to -4, and all Doppler numbers ≥ 4 are mapped to 4;

Amplitude, in 3dB units, mapped to 5-bit field, from 0 to 31, with precision 3dB;

not PGH mode: Zenith, in degrees, is mapped to 3-bit field, from 0 to 6, with precision 90/7 ≈ 12.86 degree. Value "7" of this field signals 'zenith/azimuth values are not calculable';

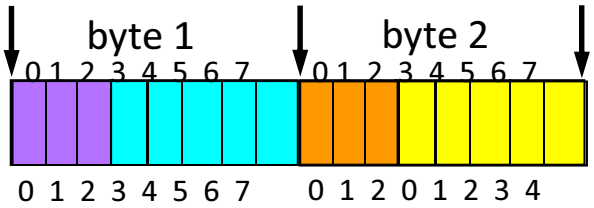
Azimuth, in degrees, is mapped to 5-bit field, from 0 to 31, with precision 360/32 ≈ 11.25 degree;

PGH mode: Zenith/Azimuth are coded in 3-bit field as follows:

0 - vertical
1 - oblique, azimuth is 0 degrees
2 - oblique, azimuth is 60 degrees
3 - oblique, azimuth is 120 degrees
4 - oblique, azimuth is 180 degrees
5 - oblique, azimuth is 240 degrees
6 - oblique, azimuth is 300 degrees
7 – signals 'zenith/azimuth values are not calculable'

Phase Difference, in degrees, is mapped to 5-bit field, from 0 to 31, with precision 360/32 ≈ 11.25 degree;

Ionogram databin format 4, not PGH mode, 2 bytes



sequential number of **doppler**, 3-bit field, from 0 to 7	**amplitude**, 5-bit field, in 3dB units	**zenith**, 3-bit field, In 48/6 = 8 Deg units[1'2'3]	**azimuth**, 5-bit field, in 360/32 = 11.25 Deg units

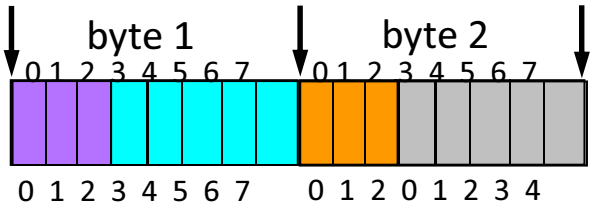
For each frequency and polarization

[1] Value "7" of this field signals 'zenith/azimuth values are not calculable'

[2] For supposedly better compression, all 1's will be put in azimuth field when zenith/azimuth values are not calculable

[3] Zenith values > 48 degrees will be mapped to 48 degrees

Ionogram databin format 4, PGH mode, 2 bytes



sequential number of **doppler**, 3-bit field, from 0 to 7	**amplitude**, 5-bit field, in 3dB units	coded value for **zenith/azimuth**, 3-bit field [1]	**phase difference**, 5-bit field, in 360/32 = 11.25 Deg units

[1] 0 - vertical
1 - oblique, azimuth is 0 degrees
2 - oblique, azimuth is 60 degrees
3 - oblique, azimuth is 120 degrees
4 - oblique, azimuth is 180 degrees
5 - oblique, azimuth is 240 degrees
6 - oblique, azimuth is 300 degrees

For each frequency and polarization


Dalu
감사합니다
Gracias
Danke
Ευχαριστίες
THANK YOU
Obrigado
Köszönöm
Grazie
Спасибо
Dank
Tack
谢谢
Merci
ありがとう
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