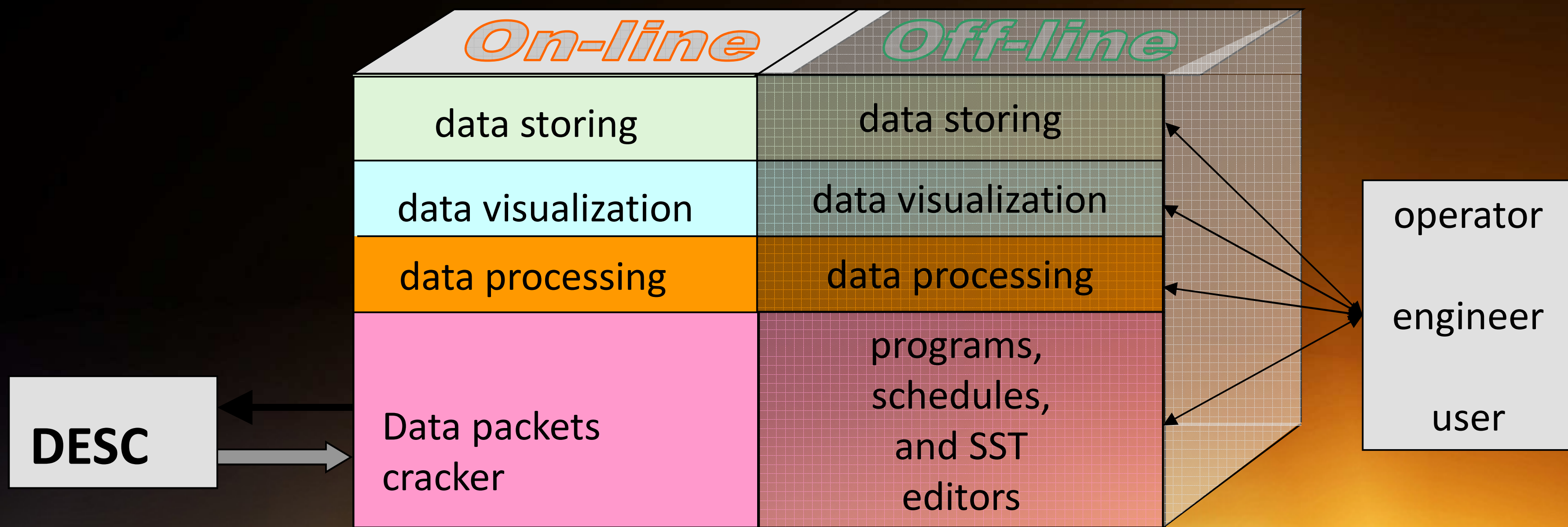
# Under the hood of the DCART project

**Alexander Kozlov**

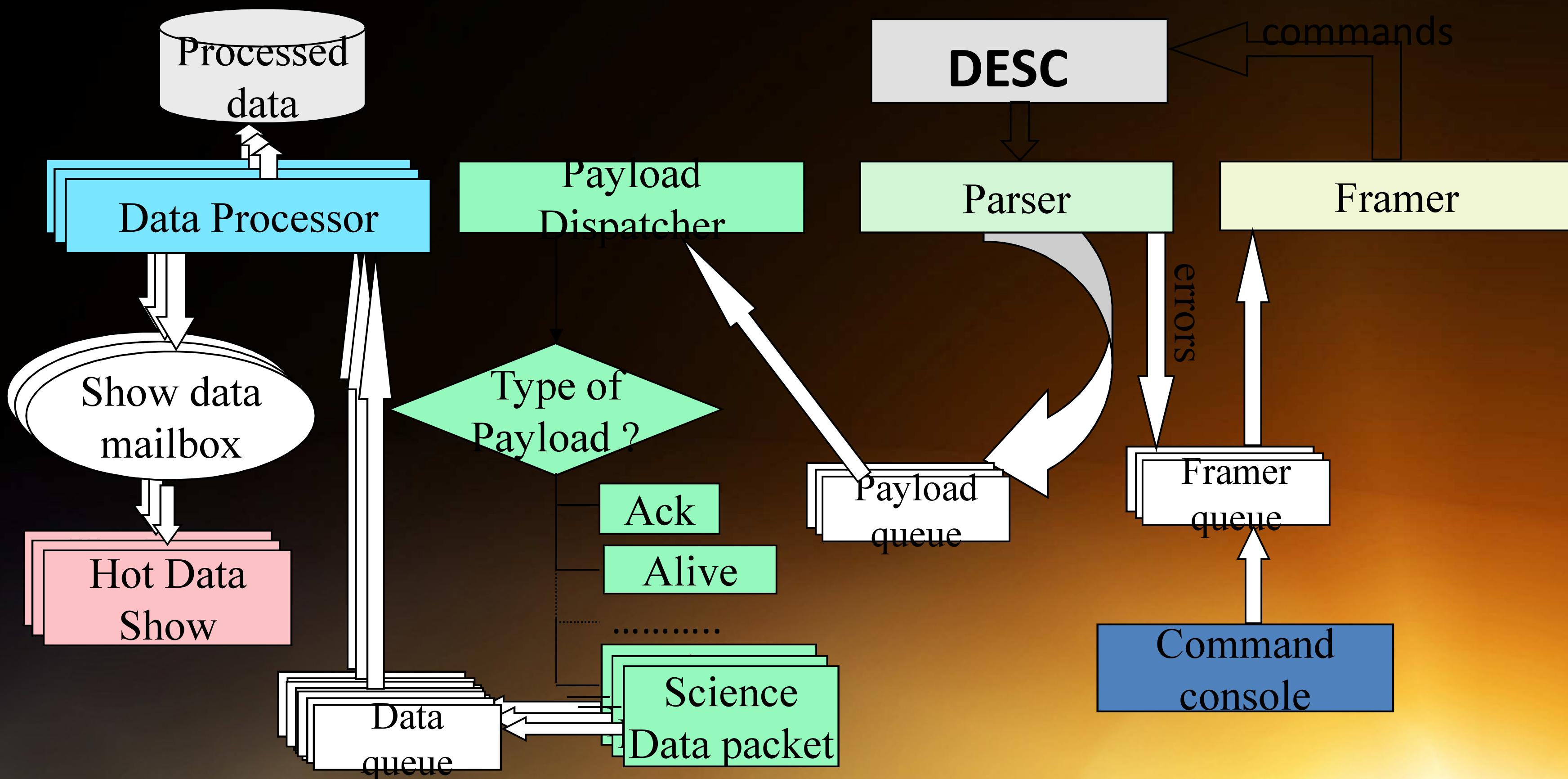
University of Massachusetts Lowell
Center for Atmospheric Research

XIV INTERNATIONAL GIRO FORUM · 20–23 MAY

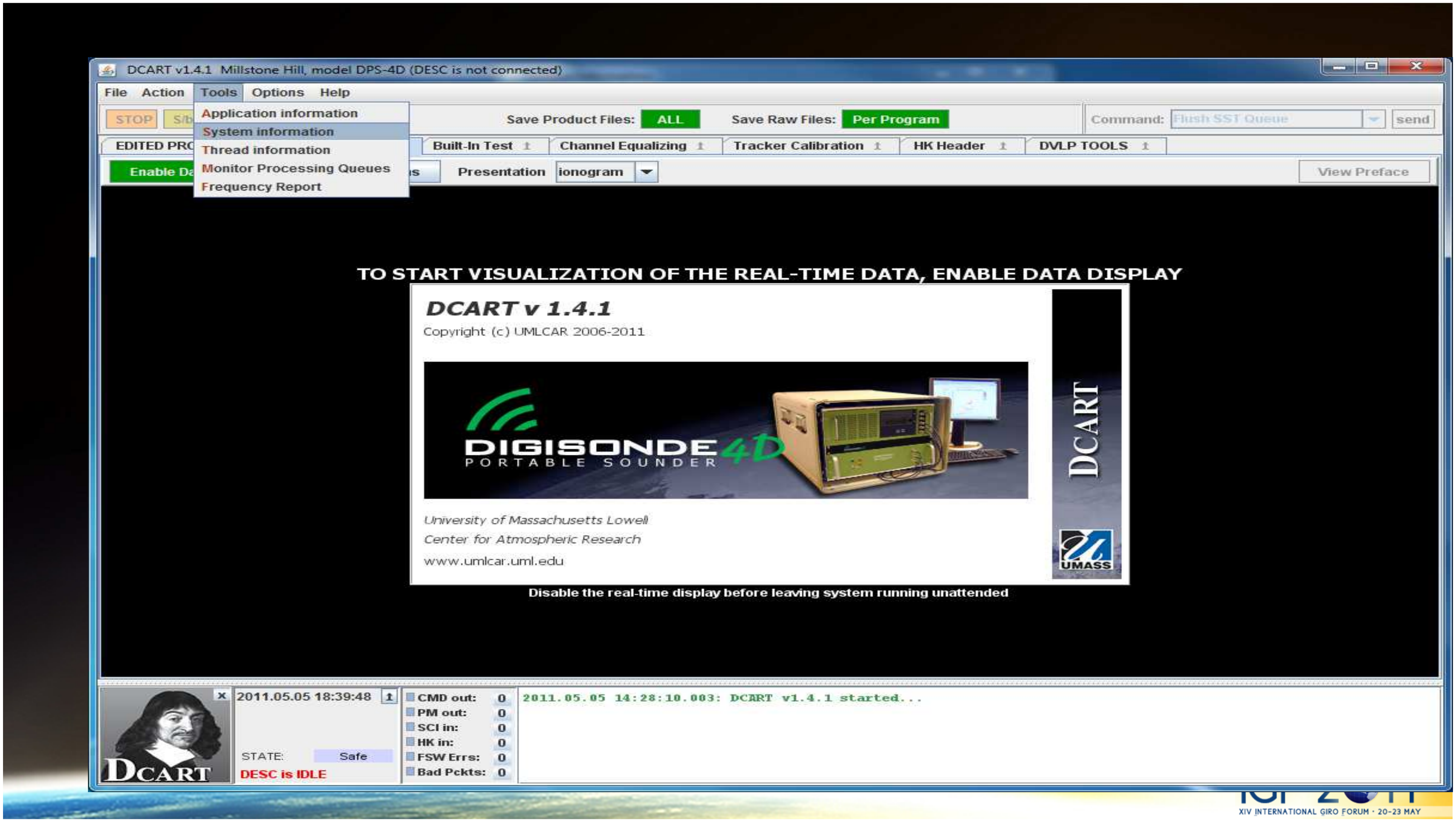
# DCART general layout



# On-line subsystem layout




IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY


DCART v1.4.1 Millstone Hill, model DPS-4D (DESC is not connected)
File Action Tools Options Help
Application information
System information
Thread information
Monitor Processing Queues
Frequency Report
Save Product Files: ALL
Save Raw Files: Per Program
Command:
send
Built-In Test
Channel Equalizing
Tracker Calibration
HK Header
DVLP TOOLS
Presentation ionogram
View Preface
TO START VISUALIZATION OF THE REAL-TIME DATA, ENABLE DATA DISPLAY
DCART v 1.4.1
Copyright (c) UMLCAR 2006-2011
DIGISONDE 4D
PORTABLE SOUNDER
University of Massachusetts Lowell
Center for Atmospheric Research
www.umlcar.uml.edu
DCART
UMASS
Disable the real-time display before leaving system running unattended
2011.05.05 18:39:48
STATE: Safe
DESC is IDLE
CMD out: 0
PM out: 0
SCI in: 0
HK in: 0
FSW Errs: 0
Bad Pckts: 0
2011.05.05 14:28:10.003: DCART v1.4.1 started...
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

System information

| | |
|---|---|
| OS name: | Windows 7 |
| OS version: | 6.1 |
| OS architecture | amd64 |
| Number of processors: | 4 |
| Running JVM name: | 4068@Sasha |
| JVM specification name: | Java Virtual Machine Specification |
| JVM specification vendor: | Sun Microsystems Inc. |
| JVM specification version: | 1.0 |
| Java Runtime name: | Java(TM) SE Runtime Environment |
| Java Runtime version: | 1.6.0_25-b06 |
| JVM implemention name: | Java HotSpot(TM) 64-Bit Server VM |
| JVM implemention vendor: | Sun Microsystems Inc. |
| JVM implemention version: | 20.0-b11 |
| Current thread count: | 26 |
| Peak thread count: | 29 |
| Total started thread count: | 33 |
| MX thread CPU time: | Supported |
| MX thread contention monitor: | Supported |
| Heap memory init: | 67,092,288 |
| Heap memory used: | 108,468,328 |
| Heap memory committed: | 192,610,304 |
| Heap memory max: | 652,476,416 |
| Non-heap memory init: | 24,313,856 |
| Non-heap memory used: | 32,644,320 |
| Non-heap memory committed: | 59,441,152 |
| NonHeap memory max: | 136,314,880 |

Refresh Close Run GC

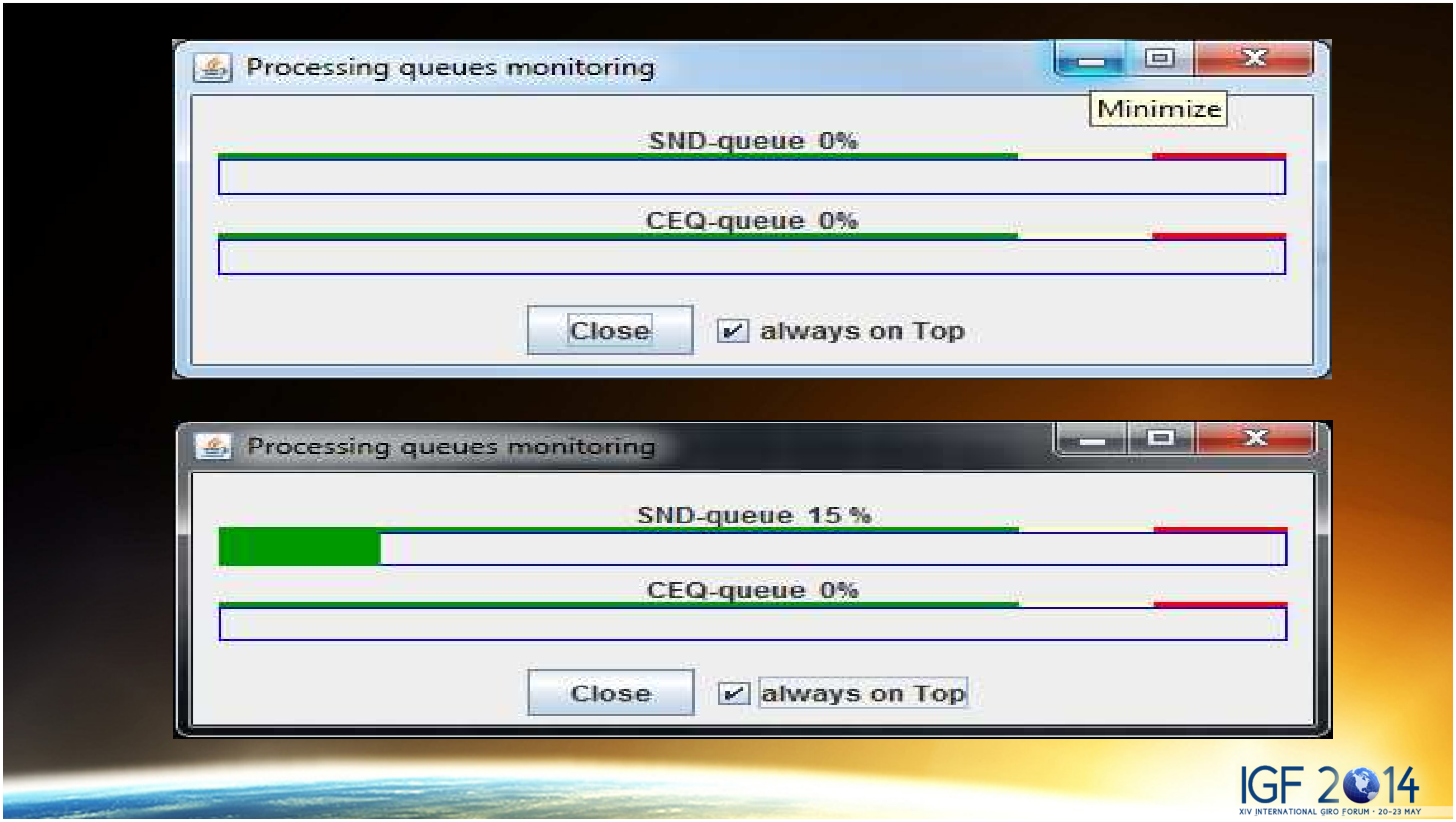
Thread information

Current thread count: 36   Peak thread count: 36   Total started thread count: 49

| TID | Name | State | ↓ CPU, ms | Blocked count | Waited count | Lock name | Lock owner name |
|---|---|---|---|---|---|---|---|
| 24 | RfrFromFiles | TIMED_WAITING | 45162 | 0 | 338 | | |
| 15 | AWT-EventQueue-0 | WAITING | 7129 | 19855 | 19560 | java.awt.EventQueue@4989... | |
| 43 | DestroyJavaVM | RUNNABLE | 6708 | 0 | 0 | | |
| 12 | AWT-Windows | RUNNABLE | 4134 | 16 | 0 | | |
| 45 | CommControl | TIMED_WAITING | 171 | 7 | 155 | General.Semaphore@a58b... | |
| 27 | Swing-Shell | WAITING | 171 | 0 | 508 | java.util.concurrent.locks.Abs... | |
| 40 | TimerQueue | WAITING | 93 | 6871 | 7178 | javax.swing.TimerQueue@4... | |
| 51 | PldDispatcher | TIMED_WAITING | 93 | 15 | 158 | General.Semaphore@7177... | |
| 33 | SSTRuleHelp0 | TIMED_WAITING | 46 | 5 | 247 | | |
| 59 | TM_refresh | RUNNABLE | 46 | 0 | 22 | | |
| 50 | Framer | WAITING | 46 | 17 | 16 | General.Semaphore@7817c... | |
| 49 | Parser | RUNNABLE | 31 | 0 | 0 | | |
| 18 | JCPipedOut | WAITING | 15 | 40 | 41 | General.Semaphore@7bc9d... | |
| 2 | Reference Handler | WAITING | 15 | 14 | 13 | java.lang.ref.Reference$Loc... | |
| 41 | CntMonitor | TIMED_WAITING | 15 | 3 | 436 | General.Semaphore@37df0... | |
| 3 | Finalizer | WAITING | 15 | 26 | 12 | java.lang.ref.ReferenceQueu... | |
| 20 | output | TIMED_WAITING | 0 | 0 | 1307 | java.io.PipedInputStream@1... | |
| 19 | JCPipedErr | WAITING | 0 | 1 | 2 | General.Semaphore@3bc12... | |
| 4 | Signal Dispatcher | RUNNABLE | 0 | 0 | 0 | | |
| 10 | Java2D Disposer | WAITING | 0 | 6 | 131 | java.lang.ref.ReferenceQueu... | |
| 11 | AWT-Shutdown | WAITING | 0 | 29 | 30 | java.lang.Object@7b5a9ad9 | |
| 17 | DCARTTimer | TIMED_WAITING | 0 | 3 | 1305 | java.util.TaskQueue@701afb... | |
| 5 | Attach Listener | RUNNABLE | 0 | 0 | 0 | | |
| 21 | error | TIMED_WAITING | 0 | 0 | 1307 | java.io.PipedInputStream@2... | |
| 47 | CEQ_watcher | WAITING | 0 | 0 | 1 | General.Semaphore@6214... | |
| 46 | SND_watcher | WAITING | 0 | 0 | 1 | General.Semaphore@1fe74... | |
| 39 | RefrCounters | TIMED_WAITING | 0 | 0 | 1302 | | |
| 55 | PMSender | TIMED_WAITING | 0 | 0 | 19 | | |
| 54 | CEQ_SDP | TIMED_WAITING | 0 | 0 | 153 | General.Semaphore@573cf... | |
| 53 | SND_SDP | TIMED_WAITING | 0 | 0 | 153 | General.Semaphore@64f48... | |
| 25 | Watchdog | TIMED_WAITING | 0 | 0 | 168 | | |
| 23 | FileChannel | TIMED_WAITING | 0 | 3 | 327 | | |
| 22 | CmdExecutor | WAITING | 0 | 0 | 1 | General.Semaphore@2c347... | |

Stop refresh   change period 4 sec   ☑ Show Accumulative   ☑ CPU monitoring   ☐ Contention monitoring   Stack

Refresh   Close


Processing queues monitoring
Minimize
SND-queue 0%
CEQ-queue 0%
Close
always on Top
Processing queues monitoring
SND-queue 15 %
CEQ-queue 0%
Close
always on Top
IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

# Data processing (DP) principles

- **Atomicity of processing and data**:

  Data Processing consists of several DP steps

  One step represents data processing algorithm

  One algorithm takes one or several *Data Groups* and produces one or several *Data Groups*

- **Conveyor:**

  Data Processing steps work in the same manner as conveyor where 'processing bricks' are Data Groups

- **Isolation**:

  Data Processing steps are isolated from each other

- **Developer obligation:**

  Coding of any Data Processing step has the mandatory conventions

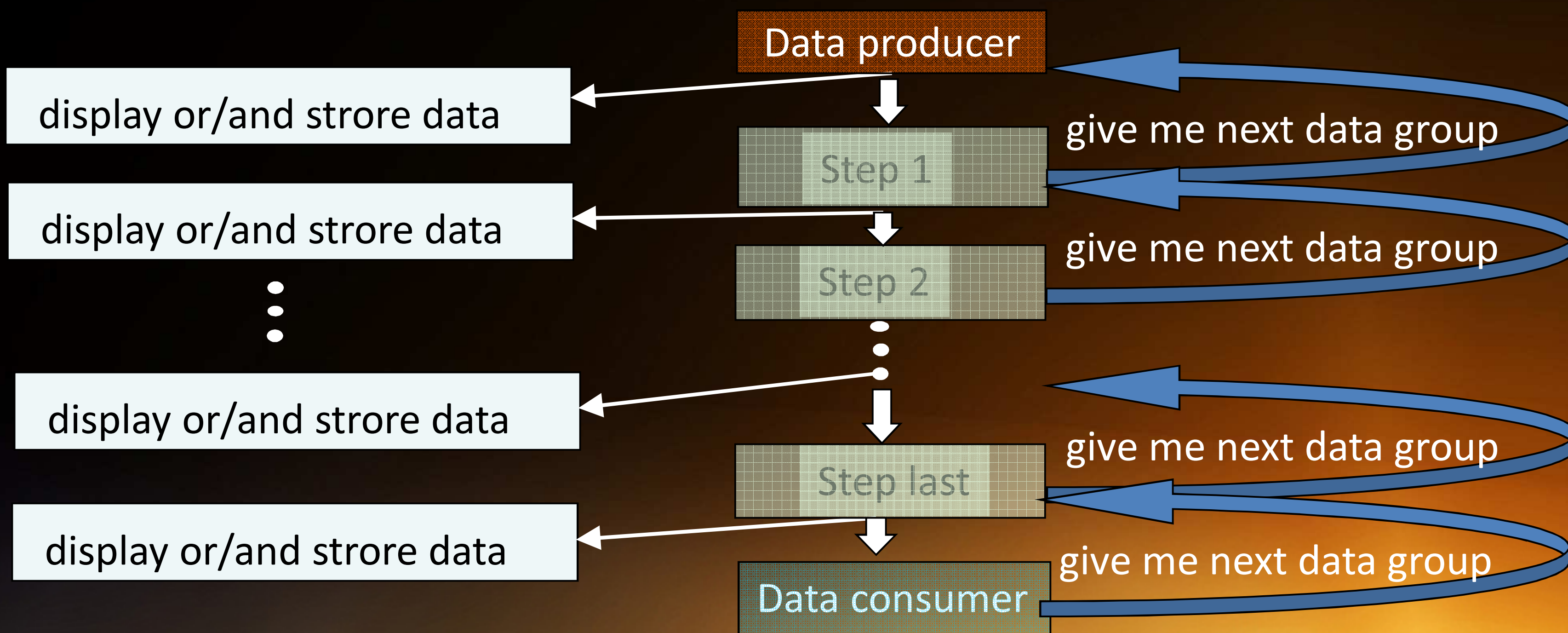
  These conventions are related with data processing

  DP step developer can concentrate on algorithm itself

- **Off-line debugging and testing:**

  having raw data developer can off-line debug and test data processing steps

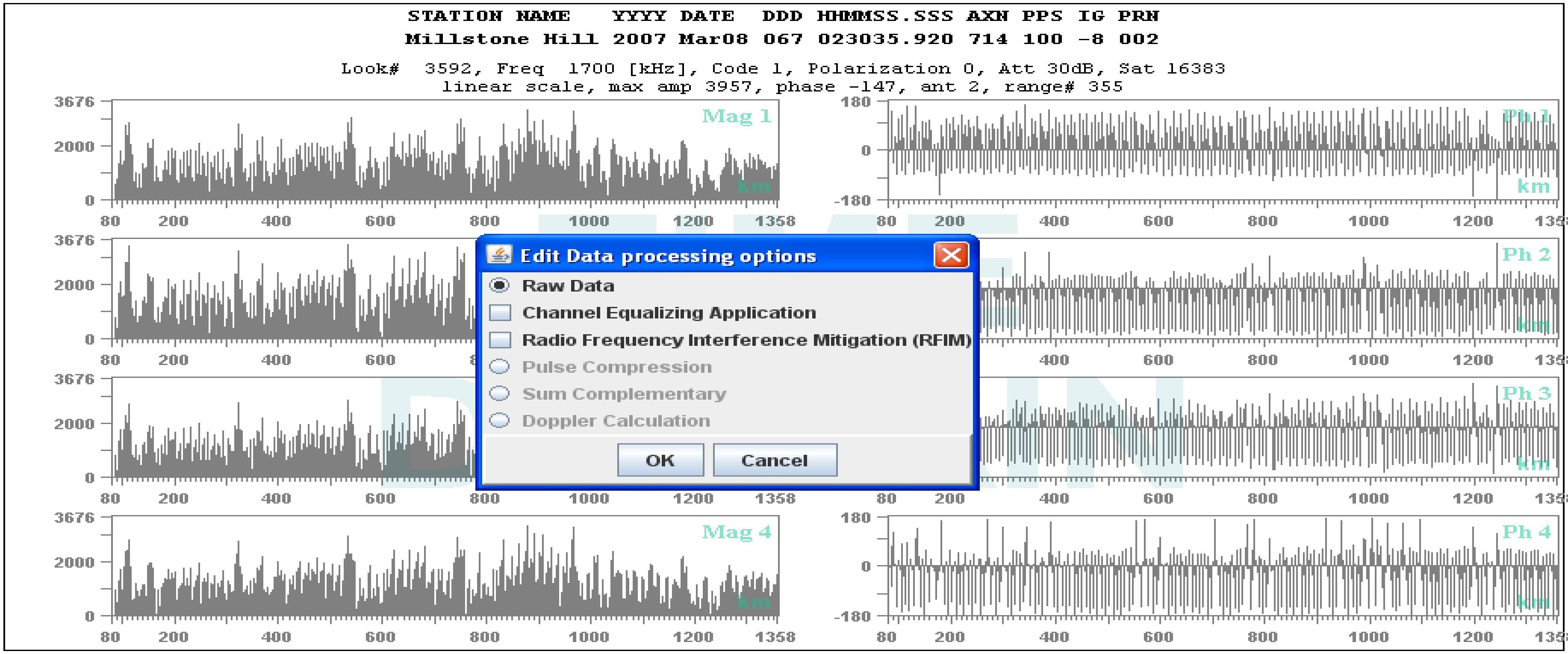
# DP Conveyor



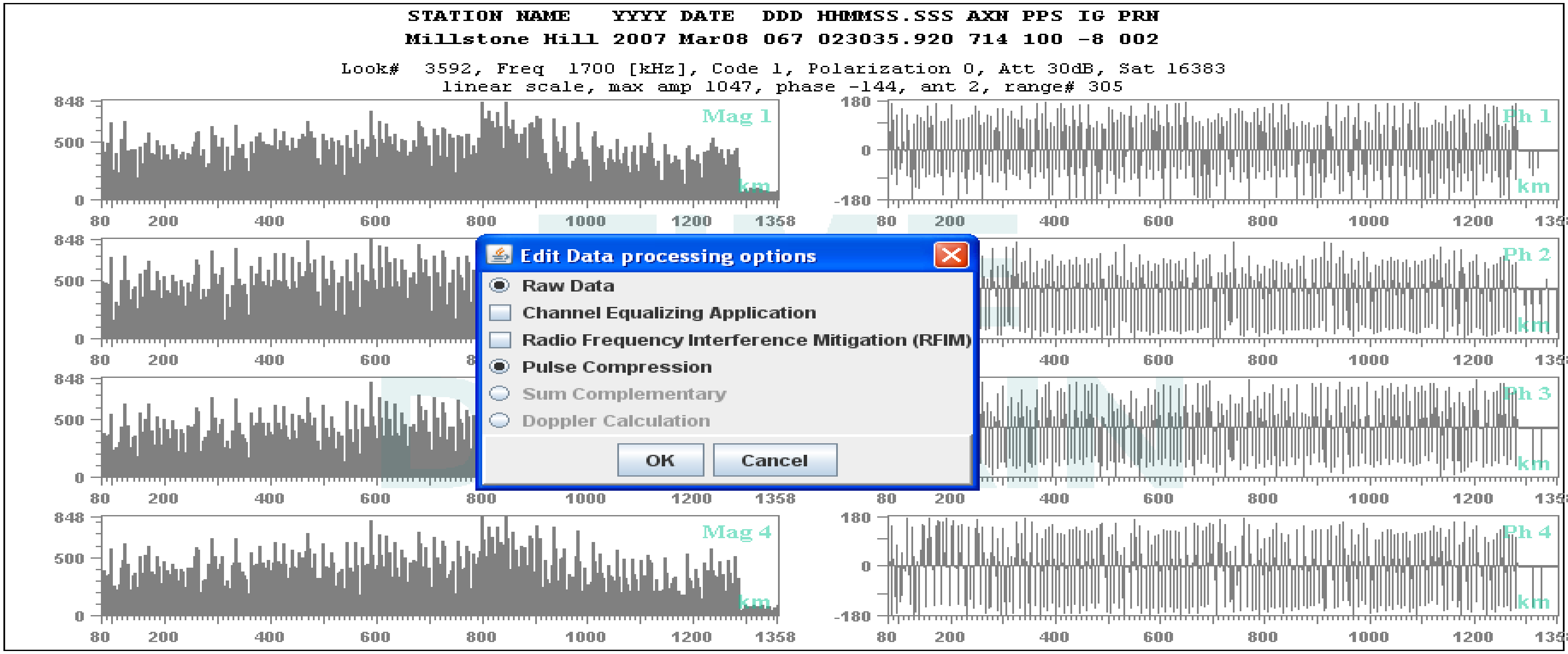

Data processing conveyor starts working from Data Consumer

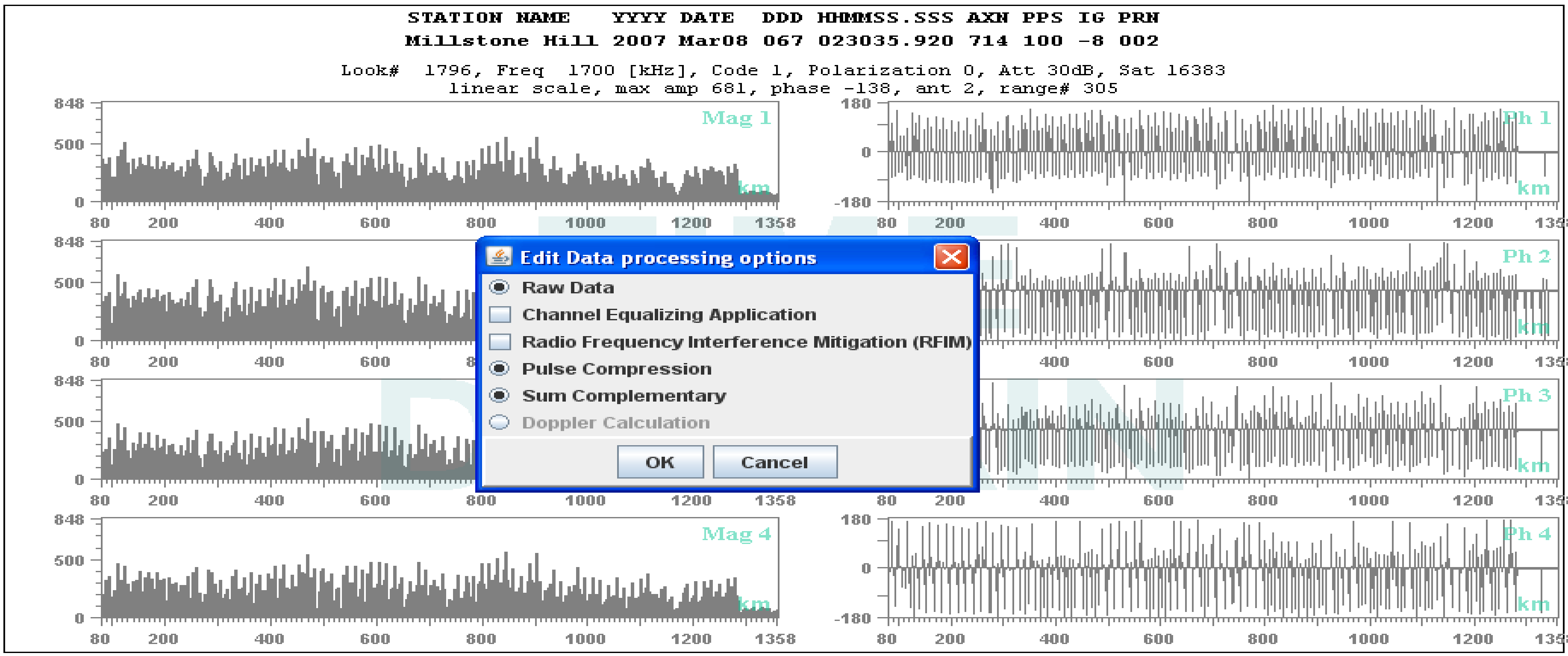
# Data Processing step properties

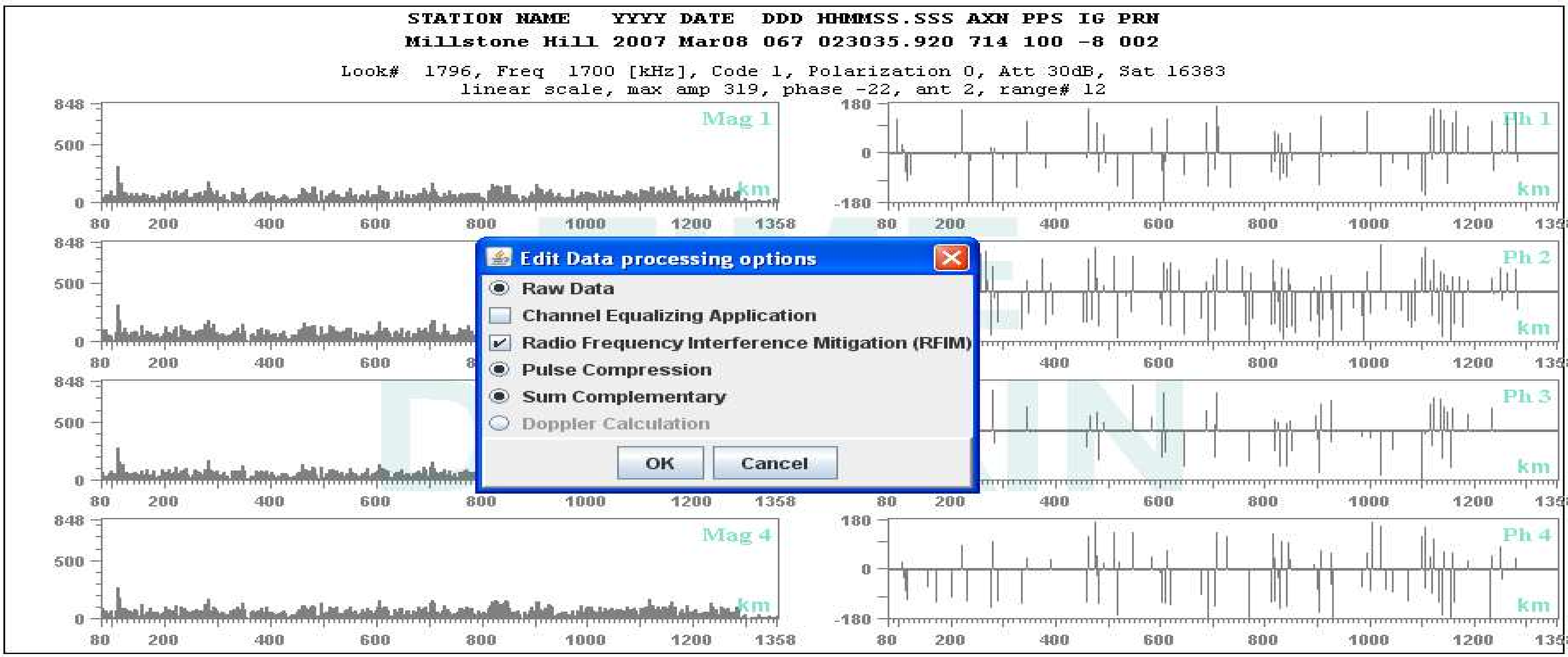
- **Get method**
- ***Accumulating* and *R*eduction *N*umbers**
  - *Accumulating number* says how many Data Groups DP step will accumulate before starting to process them
  - *Reduction number* says what times number of Data Groups will be reduced by applying this DP step
  - To get reduction number of DP you need just multiply reduction numbers of steps of this DP
  - Getting of accumulating number of DP is not so obvious
- **Modified in-place flag**




IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY


STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 3592, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 1047, phase -144, ant 2, range# 305
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel

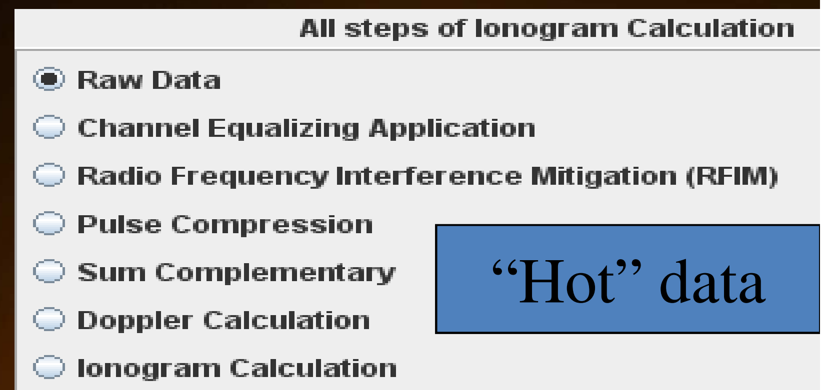

STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Mar08 067 023035.920 714 100 -8 002
Look# 1796, Freq 1700 [kHz], Code 1, Polarization 0, Att 30dB, Sat 16383
linear scale, max amp 681, phase -138, ant 2, range# 305
Mag 1
Ph 1
Ph 2
Ph 3
Mag 4
Ph 4
km
Edit Data processing options
Raw Data
Channel Equalizing Application
Radio Frequency Interference Mitigation (RFIM)
Pulse Compression
Sum Complementary
Doppler Calculation
OK
Cancel

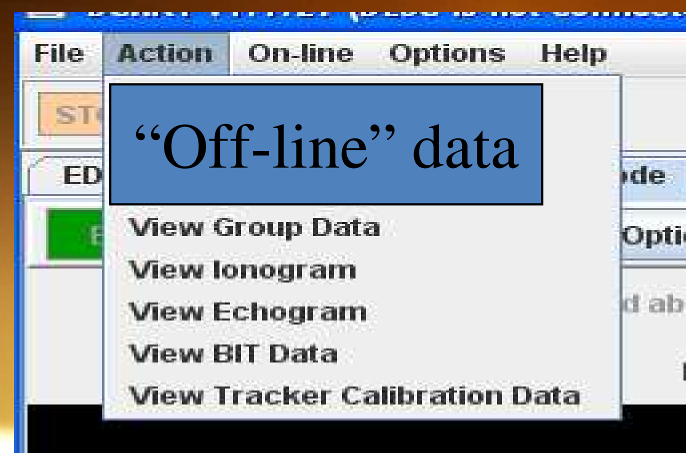



IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

# DCART Visualization Screens (1)

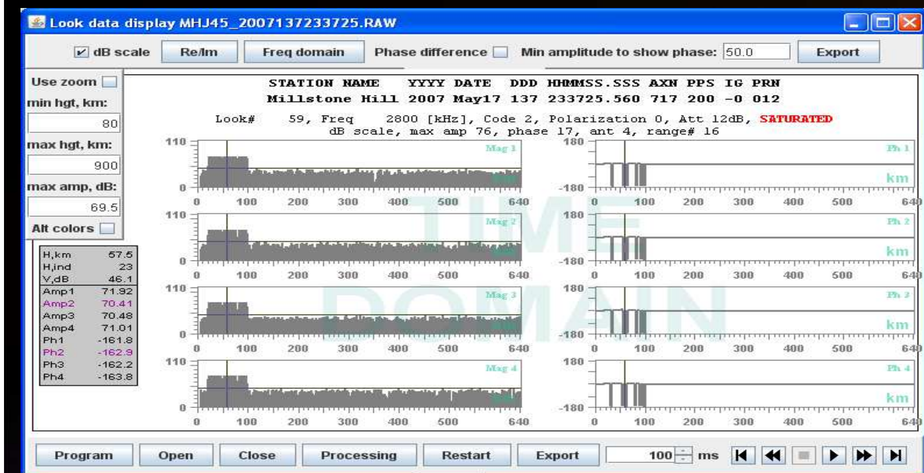
- Amplitude, Angle Of Arrival
  - Ionogram
- 4 antenna - Amplitude, Phase
  - Echogram
  - Group data
    - Original RAW
    - With RFIM
    - With channel equalizing
    - Pulse compression
    - Sum of complementary
    - Drift
- Housekeeping
  - BIT
  - Tracker Calibration

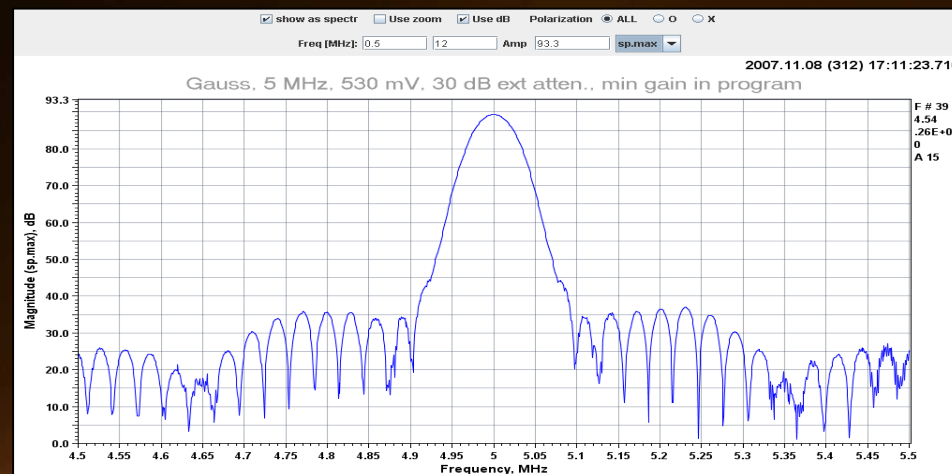



XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

# DCART Visualization Screens (2)




Raw data display showing phase code details

DCART in the spectrum analyzer mode showing Rx filter function

Step-by-step visualization of signal processing

IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

# Look data display

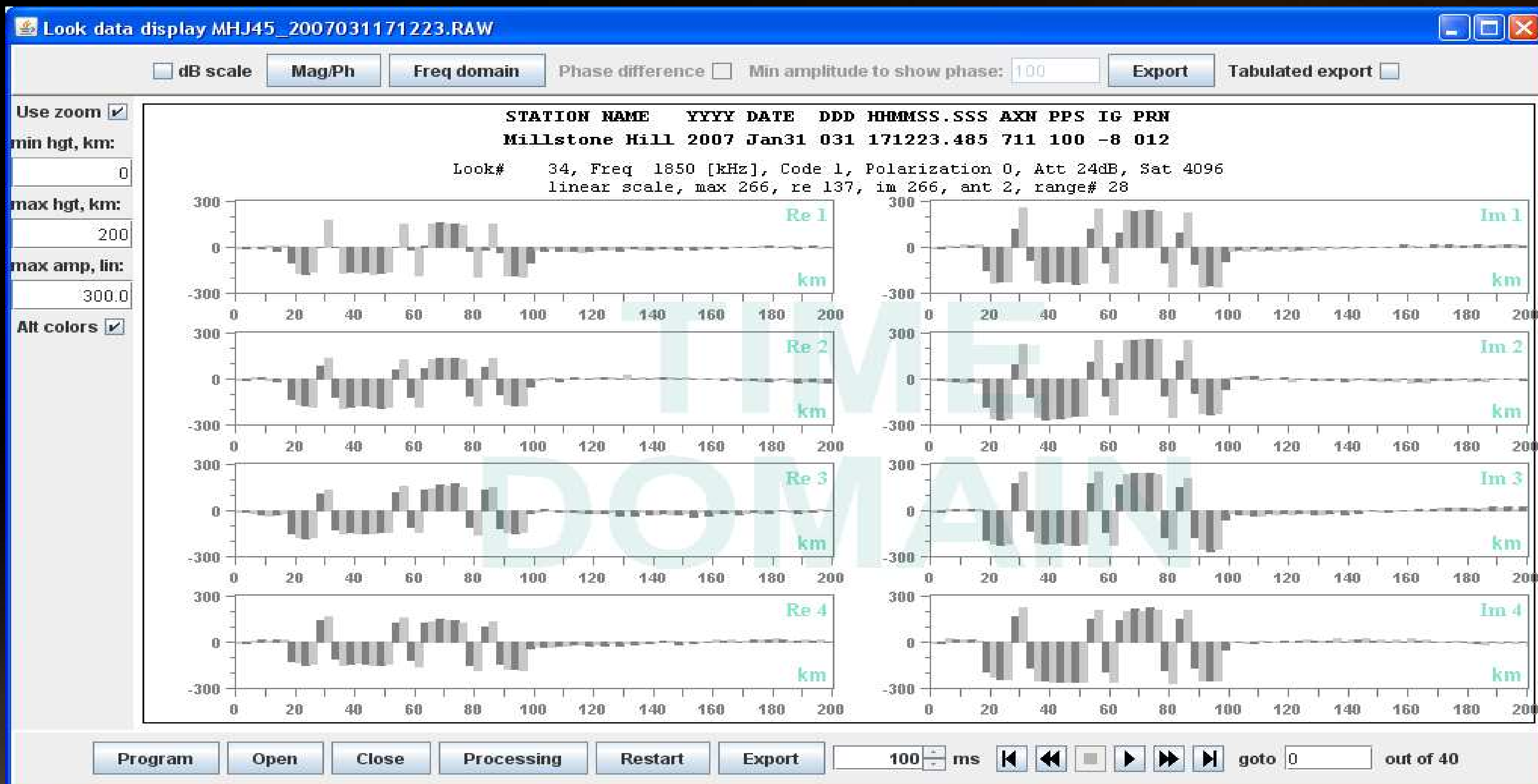
- Scale: db/linear
- Zoom: in/out
- Presentation:

  Frequency domain / Time domain

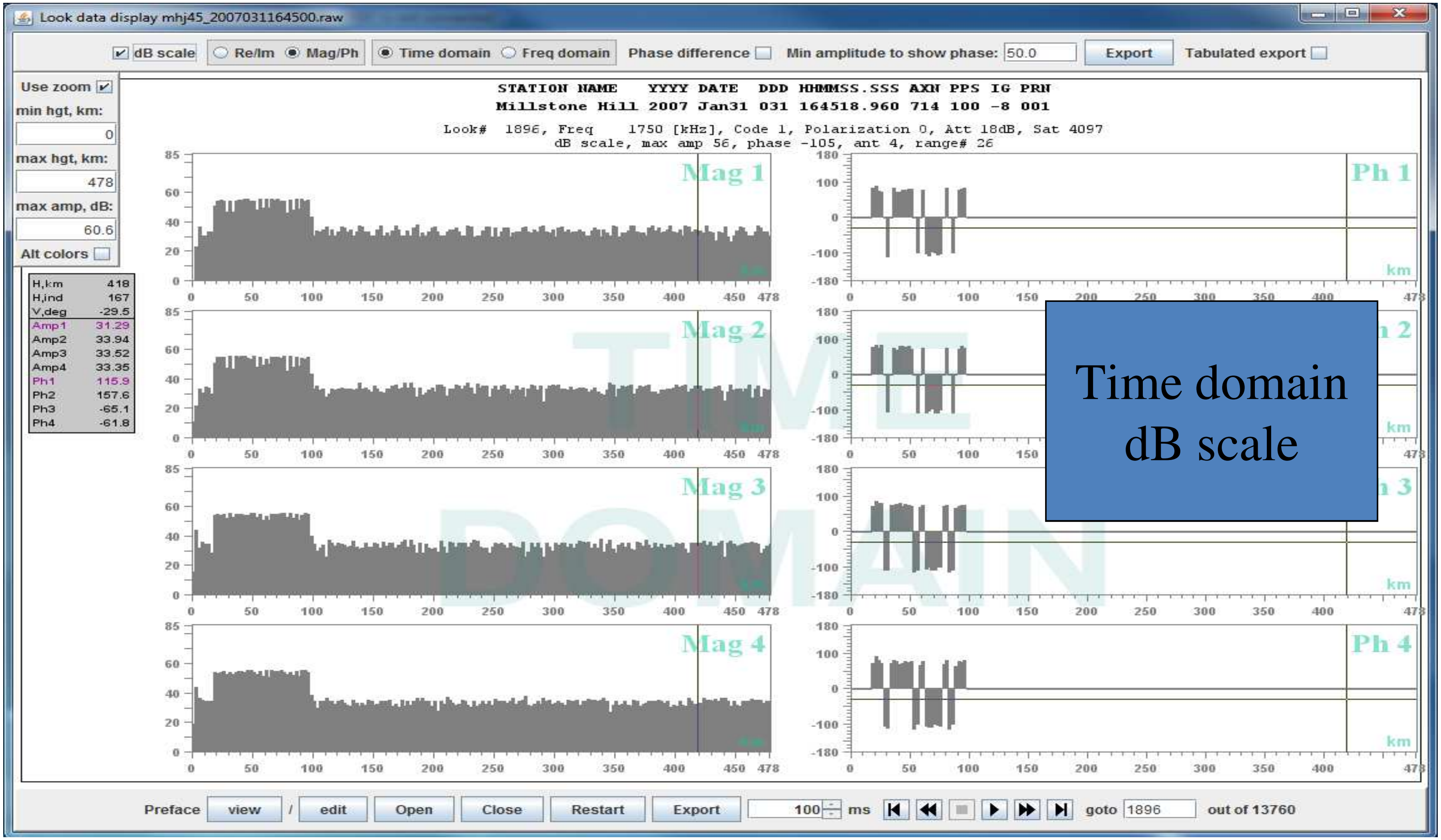
  Real + Imaginary / Amplitude + Phase
- Export:

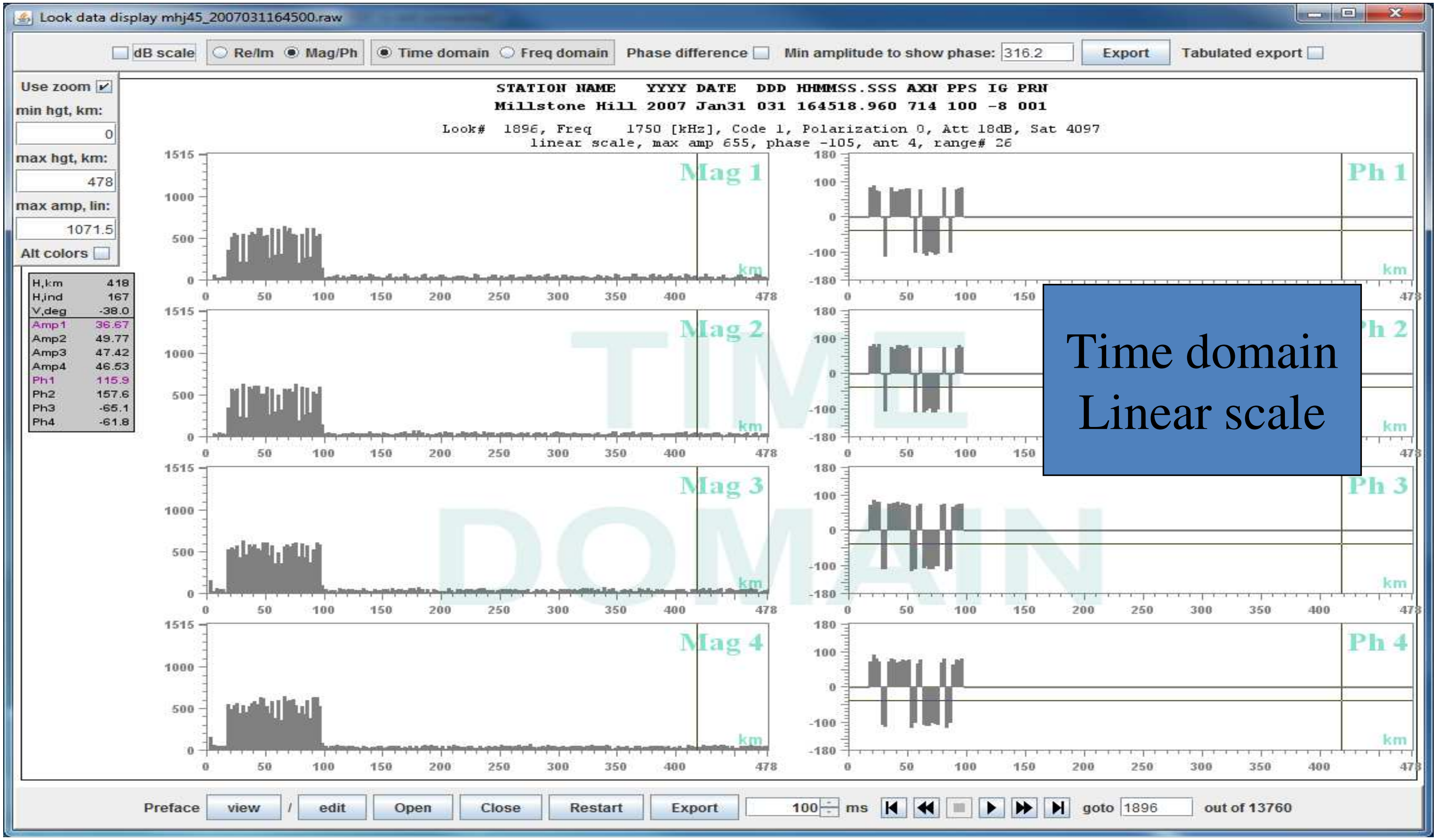
  one look

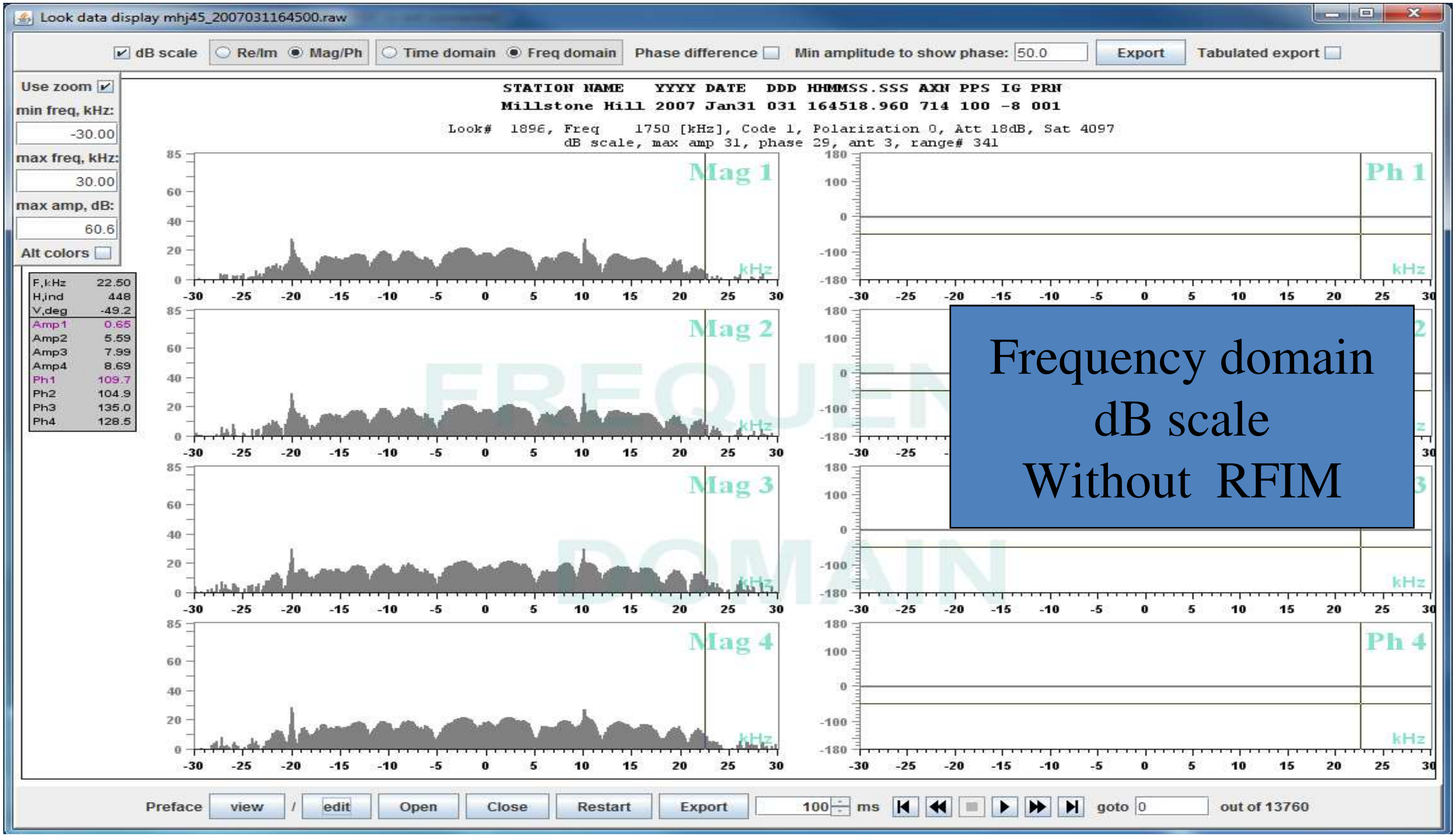
  all looks max/min/average



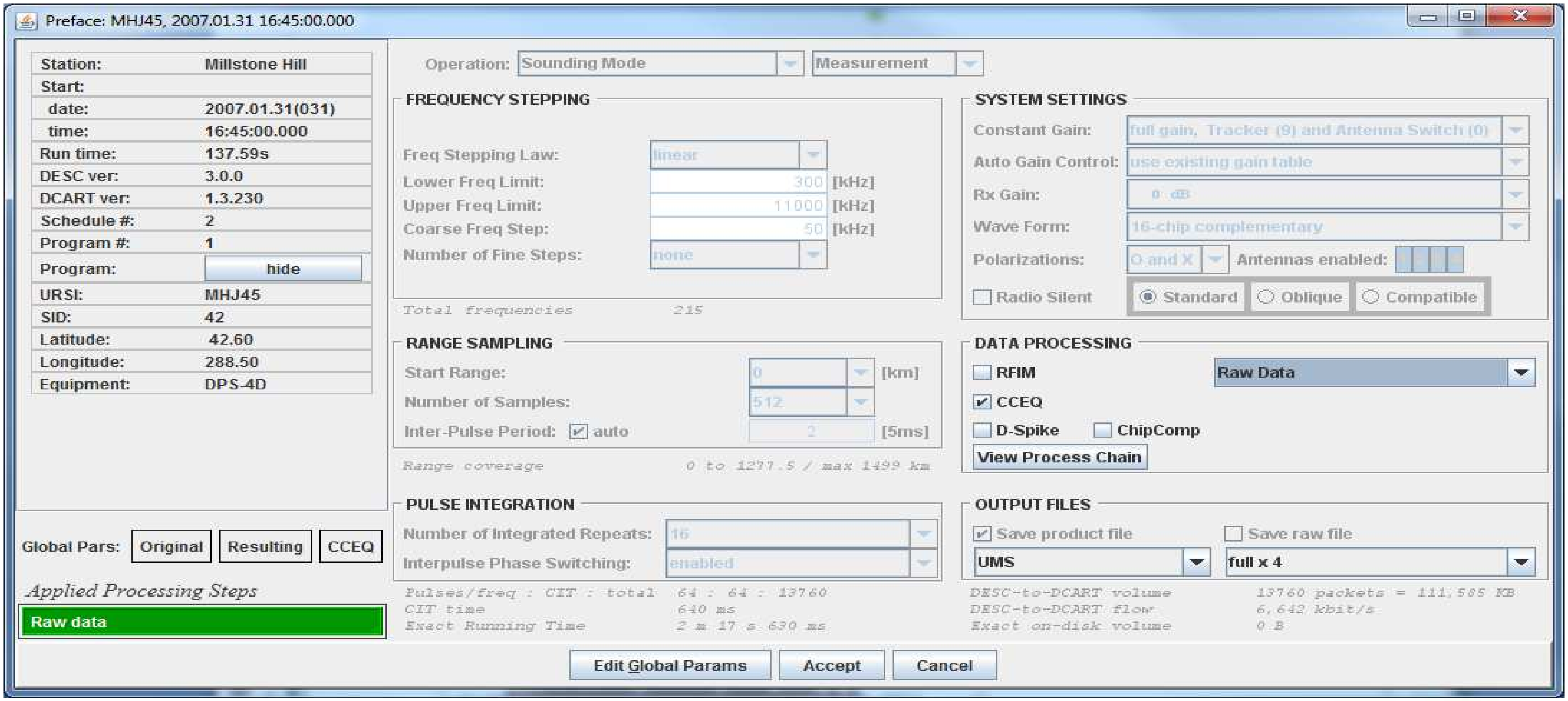
IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY


Look data display mhj45_2007031164500.raw
dB scale
Re/Im
Mag/Ph
Time domain
Freq domain
Phase difference
Min amplitude to show phase: 50.0
Export
Tabulated export
Use zoom
min hgt, km:
0
max hgt, km:
478
max amp, dB:
60.6
Alt colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
dB scale, max amp 56, phase -105, ant 4, range# 26
H,km 418
H,ind 167
V,deg -29.5
Amp1 31.29
Amp2 33.94
Amp3 33.52
Amp4 33.35
Ph1 115.9
Ph2 157.6
Ph3 -65.1
Ph4 -61.8
Mag 1
Mag 2
Mag 3
Mag 4
Ph 1
Ph 4
km
Preface
view
edit
Open
Close
Restart
Export
100 ms
goto 1896
out of 13760
Time domain
dB scale

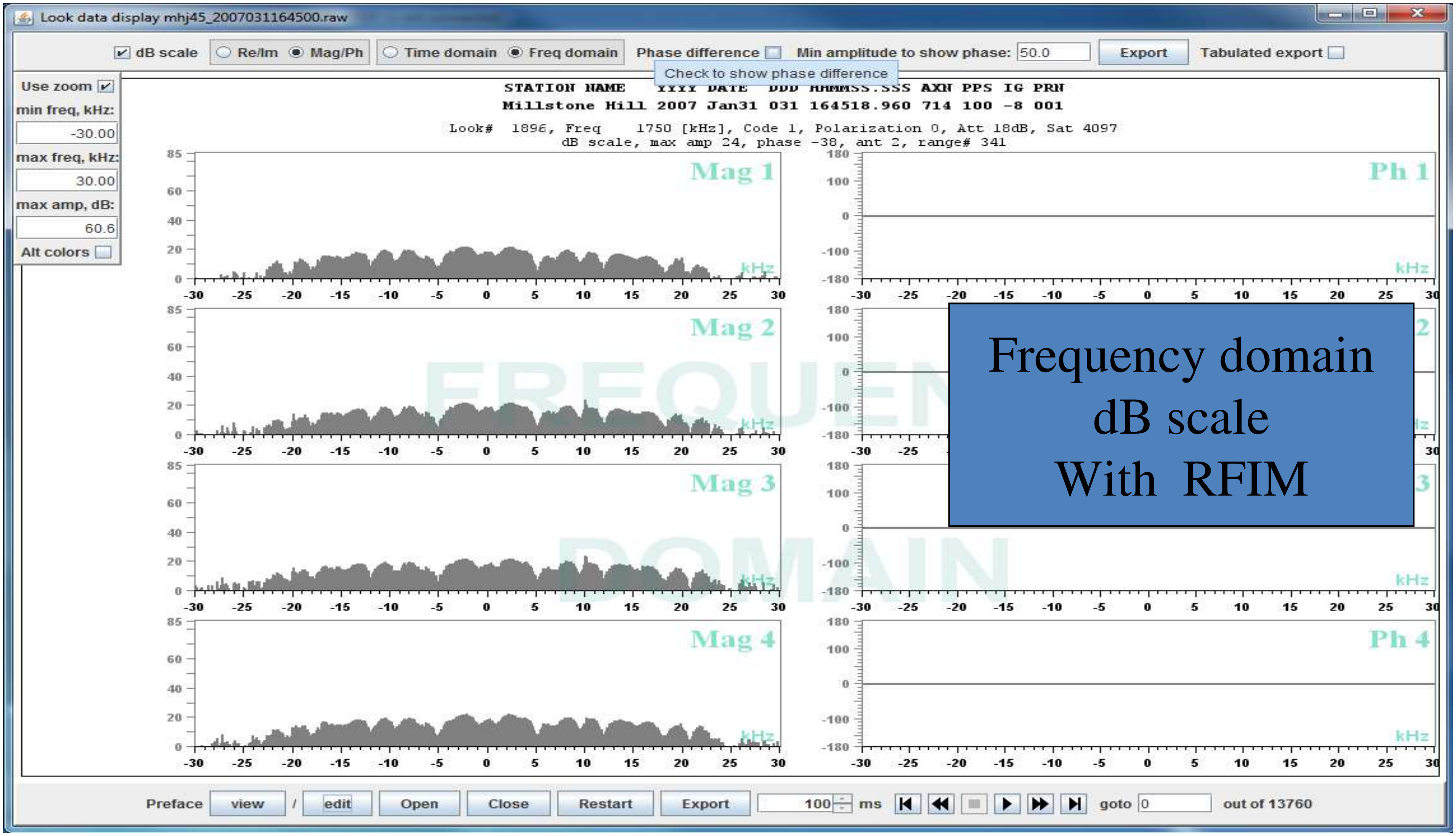

Look data display mhj45_2007031164500.raw
dB scale
Re/Im
Mag/Ph
Time domain
Freq domain
Phase difference
Min amplitude to show phase: 316.2
Export
Tabulated export
Use zoom
min hgt, km: 0
max hgt, km: 478
max amp, lin: 1071.5
Alt colors
H,km 418
H,ind 167
V,deg -38.0
Amp1 36.67
Amp2 49.77
Amp3 47.42
Amp4 46.53
Ph1 115.9
Ph2 157.6
Ph3 -65.1
Ph4 -61.8
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
linear scale, max amp 655, phase -105, ant 4, range# 26
Mag 1
Mag 2
Mag 3
Mag 4
Ph 1
Ph 2
Ph 3
Ph 4
km
TIME DOMAIN
Time domain
Linear scale
Preface
view
edit
Open
Close
Restart
Export
100 ms
goto 1896
out of 13760

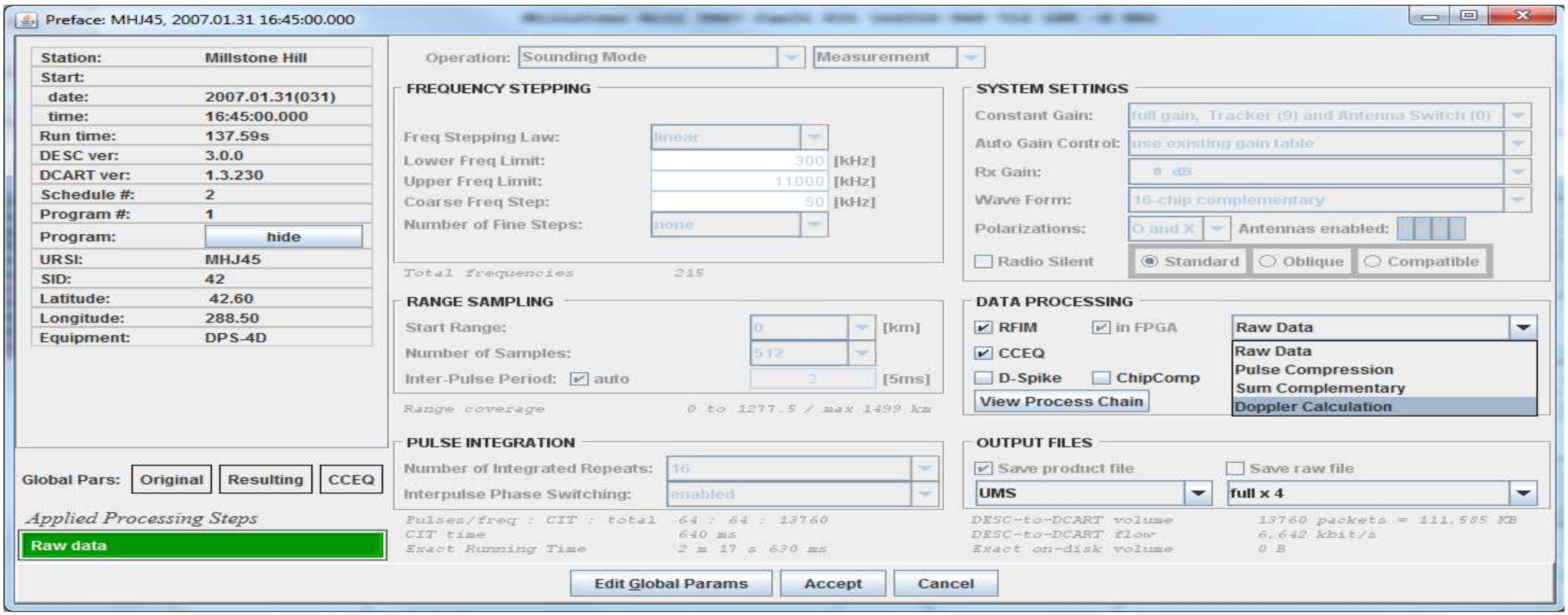


Look data display mhj45_2007031164500.raw
dB scale
Re/Im
Mag/Ph
Time domain
Freq domain
Phase difference
Min amplitude to show phase: 50.0
Export
Tabulated export
Use zoom
min freq, kHz: -30.00
max freq, kHz: 30.00
max amp, dB: 60.6
Alt colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
dB scale, max amp 31, phase 29, ant 3, range# 341
Mag 1
Mag 2
Mag 3
Mag 4
Ph 1
Ph 4
kHz
Frequency domain
dB scale
Without RFIM
Preface
view
edit
Open
Close
Restart
Export
100 ms
goto 0
out of 13760




IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY


Look data display mhj45_20070311164500.raw
dB scale
Re/Im
Mag/Ph
Time domain
Freq domain
Phase difference
Min amplitude to show phase: 50.0
Export
Tabulated export
Check to show phase difference
Use zoom
min freq, kHz:
-30.00
max freq, kHz:
30.00
max amp, dB:
60.6
Alt colors
STATION NAME YYYY DATE DDD HHMMSS.SSS AXN PPS IG PRN
Millstone Hill 2007 Jan31 031 164518.960 714 100 -8 001
Look# 1896, Freq 1750 [kHz], Code 1, Polarization 0, Att 18dB, Sat 4097
dB scale, max amp 24, phase -38, ant 2, range# 341
Mag 1
Mag 2
Mag 3
Mag 4
Ph 1
Ph 4
kHz
FREQUENCY
DOMAIN
Frequency domain
dB scale
With RFIM
Preface
view
edit
Open
Close
Restart
Export
100
ms
goto
out of 13760




IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

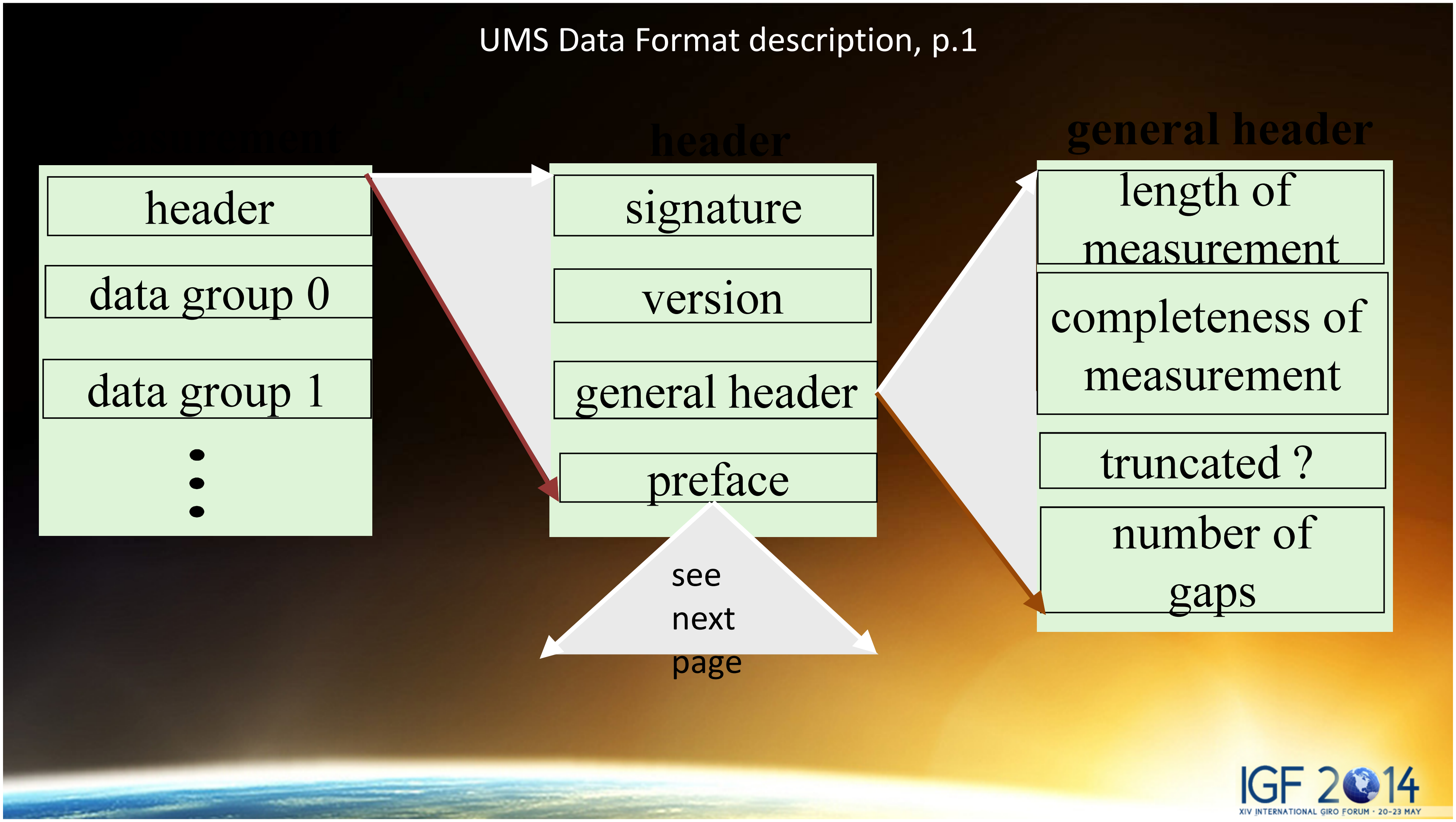
# UMS (Uniform Measurement Storage) data format

PRINCIPLES

- **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 read by UMS reader. Program measurement is uniquely identified by station and start time.
- Program measurement consists of Program header and number of Data Groups
- Data Groups:

  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
header
general header
header
data group 0
data group 1
signature
version
general header
preface
length of measurement
completeness of measurement
truncated ?
number of gaps
see next page
IGF 2014
XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

UMS Data Format description, p.2

Preface

- station ID
- start time
- run time, ms
- latitude
- longitude
- URSI code
- station name
- antenna configuration structure
- equip model

- DESC ver
- DCART ver
- schedule #
- program #
- number of applied proc steps
- array of applied proc step codes

- number of proc steps applied in DESC
- measurement program description structure

IGF 2014

XIV INTERNATIONAL GIRO FORUM · 20-23 MAY

UMS Data Format description, p.3

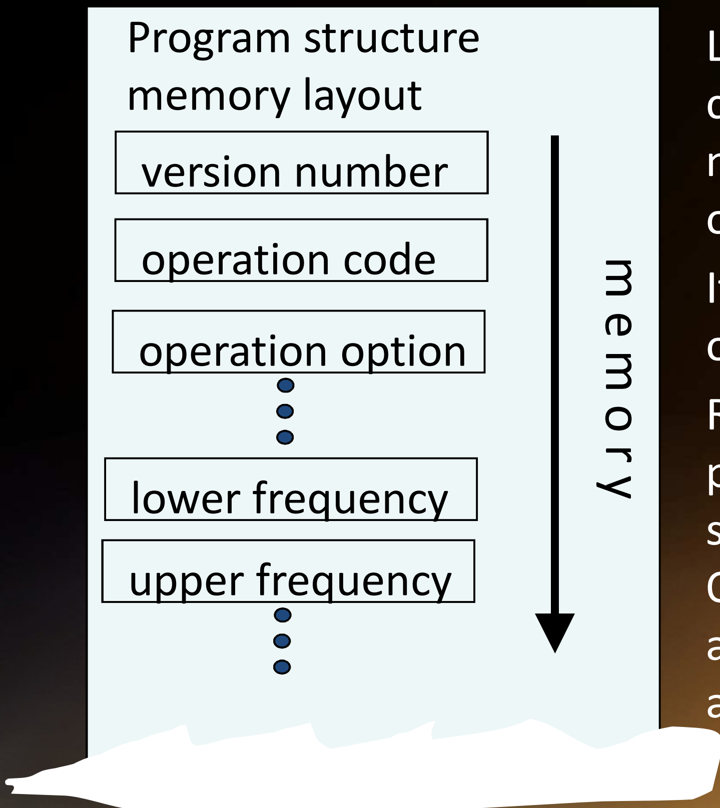
Preface

Cross-Channel Equalizing Data

Global Parameters

Processing Step’s Parameters

# 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.

Dalu

감사합니다

Gracias Danke Ευχαριστίες

Obrigado

THANK YOU

Köszönöm

Grazie Спасибо Dank

Tack 谢谢 Merci ありがとう

IGF 2014

XIV INTERNATIONAL GIRO FORUM · 20-23 MAY