

Status of the LOFAR Data Formats (aka ICDs)

Anastasia Alexov

On behalf of the LOFAR Data Formats Group

LSM: May 18, 2011

Previously known as: LOFAR Interface LOFAR Data Formats Group Control Documents (ICDs) Group

- **New name:** LOFAR Data Formats Group (under LCCG umbrella)
- **Responsibilities:** define, create, update, and track all LOFAR data formats (i.e. raw data packets, measurement sets, images, etc.)
- **Long term goal:** moderating body for format changes in the system; collect and manage suggested/needed changes and present them at the staff meetings for approval
- **Members:** Anastasia Alexov, Lars Bähren, Mike Bell, Sven Duscha, Jean-Mathias Griessmeier, Clancy James, Adriaan Renting, Michael Wise (advisory)
- **Meetings:** bi-weekly (minutes are posted to the LOFAR User Forum)
- **Documents:** 7 released ICDs + MeasurementSet Definition
- **Software:** Data Access Library (DAL) + Python bindings (PyDAL)

ICD #001: TBB Time-Series Data

- Clancy James (and Arthur Corstanje) [CR KSP]

LOFAR Data Format ICD TBB Time-Series Data

Document ID: LOFAR-USG-ICD-001

Version 2.01.05

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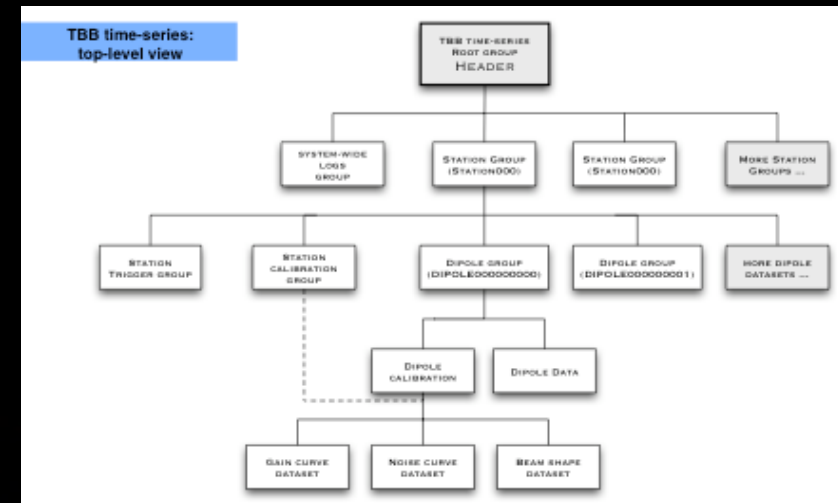
L. Bähren, K. Anderson, A. Corstanje, A. Horneffer, J. Masters

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ICD #003: Beam Formed Data

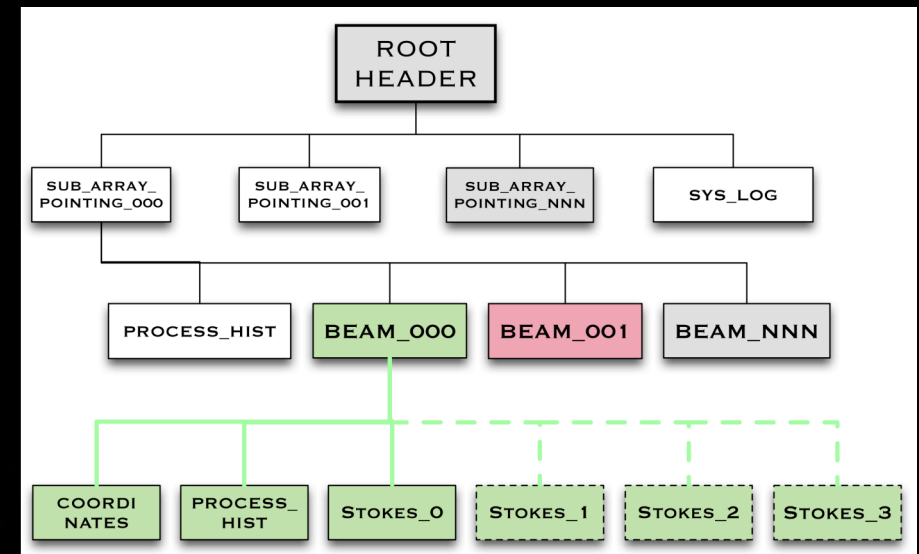
- Anastasia Alexov [Transients (Pulsars) KSP]

LOFAR Data Format ICD
Beam-Formed Data
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A. Alexov, K. Anderson, L. Bähren, J.-M. Grießmeier, J.W.T. Hessels,
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ICD #004: Radio Sky Image Cubes

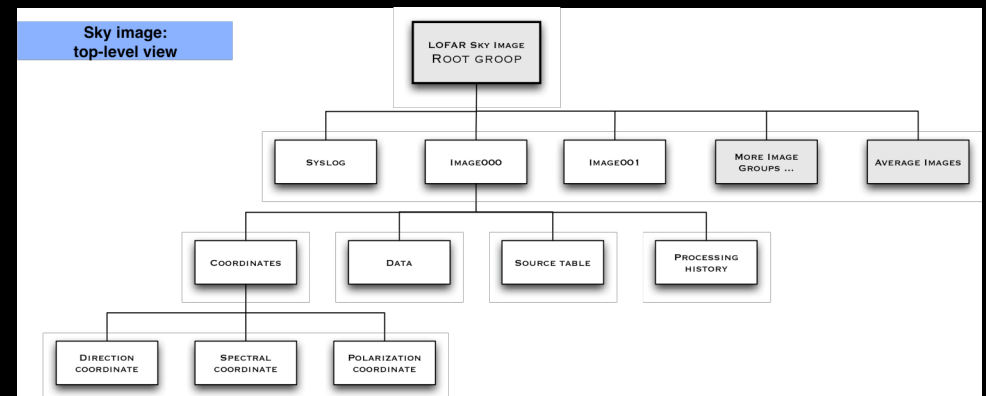
- Lars Bühren [Transients (AARTFAAC) KSP]

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Radio Sky Image Cubes
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L. Bühren, K. Anderson, J. Masters
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ICD #006: Dynamic Spectrum Data

- Jean-Mathias Griessmeier [Transients (Planets) KSP]

LOFAR Data Format ICD
Dynamic Spectrum Data

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Version 2.03.01

SVN Repository Revision: 7681

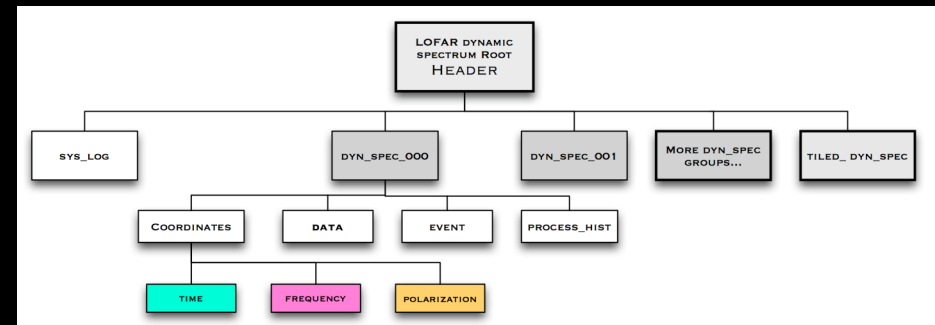
J.-M. Griessmeier, A. Alexov, K. Anderson, L. Bähren

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ICD #008: Rotation Measure Synthesis Cubes

- Mike Bell [Magnetism KSP]

LOFAR Data Format ICD
Rotation Measure Synthesis Cubes

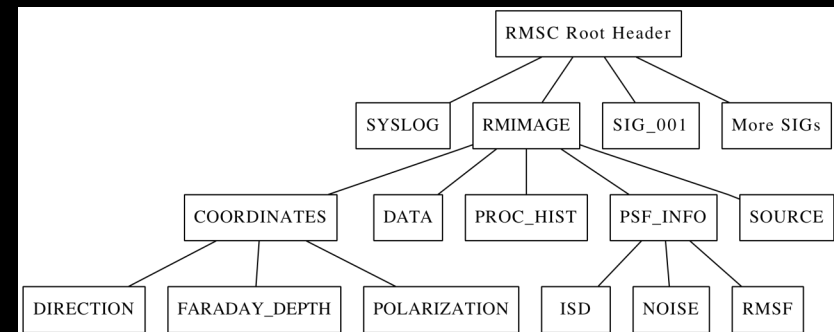
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J. Anderson, L. Bähren, M. Bell, T. Riller, K. Anderson
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ICD #002: Representations of World Coordinates

- Lars Bähren [Transients (AARTFAAC) KSP]

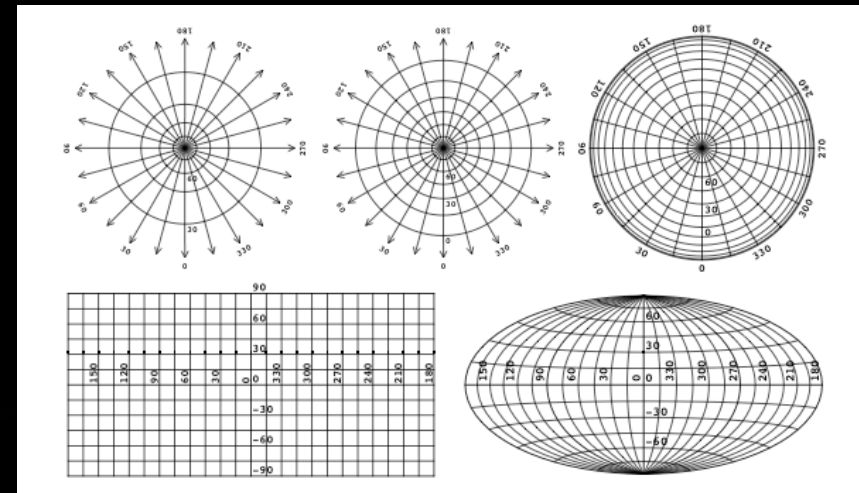
LOFAR Data Format ICD
Representations of World Coordinates

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L. Bähren, A. Alexov, K. Anderson, J.-M. Grießmeier
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ICD #005: File Naming Conventions

- Anastasia Alexov, Adriaan Renting

**LOFAR Data Format ICD
File Naming Conventions**

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A. Alexov, K. Anderson, L. Bähren, J.-M. Grieffmeier,
A. Gunst, H. Holties, M. Wise, G. A. Renting

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Description	Format	Example
Sub-Array Pointing (SAP)	3 digits	SAPxxx
Subband (SB)	3 digits	SBxxx
Beam (B)	3 digits	Bxxx
Part (P)	3 digits	Pxxx
Stokes (S)	1 digit	Sx
Date (D)	8 digits	D<yyyymmdd>
Date (D) & Time	8+6 digits	D<yyyymmdd>T<hhmmss>

File Type	Value	Description
UV Vis	'uv'	LOFAR visibility file w/correlation UV information.
Sky cube	'sky'	LOFAR Image cube w/RA, Dec, frequency and polarization
RM cube	'rm'	Rotation Measure Synthesis Cube w/ axes of RA, Dec, Faraday Depth, polarization.
Near-field image	'nfi'	Near Field Sky Image w/ axes of position on the sky (x, y, z), frequency time, polarization.
Dynamic Spectra	'dynspec'	Dynamic Spectra w/ axes of time, frequency, polarization.
Beamformed data	'bf'	Beam-Formed file w/ time series data with axes of frequency vs time.
TBB dump	'tbb'	TBB dump file, raw time-series: (1) intensity as a function of frequency, or (2) voltage vs time.

Extension	Type of data
.MS	CASA/casacore MeasurementSet
.h5	HDF5 file
.fits	FITS file
.log	Logfile
.parset	A parset file
.lsm	Local sky model
.IM	CASA/casacore image file (PagedImage)
.PD	ParmDB file generated by BBS
.vds	Dataset description file
.gds	Dataset description file
.conf	Configuration file (mostly local to station)
.raw	Raw Beam-Formed (non-Incoherentstokes) file written from the Blue Gene/P
.incoherentstokes	Raw Beam-Formed incoherent Stokes file written from the Blue Gene/P

MeasurementSet Definition (v 2.07.01)


- Adriaan Renting (LTA)

MeasurementSet description for LOFAR
Version 2.07.01

NETHERLANDS FOUNDATION FOR RESEARCH IN ASTRONOMY

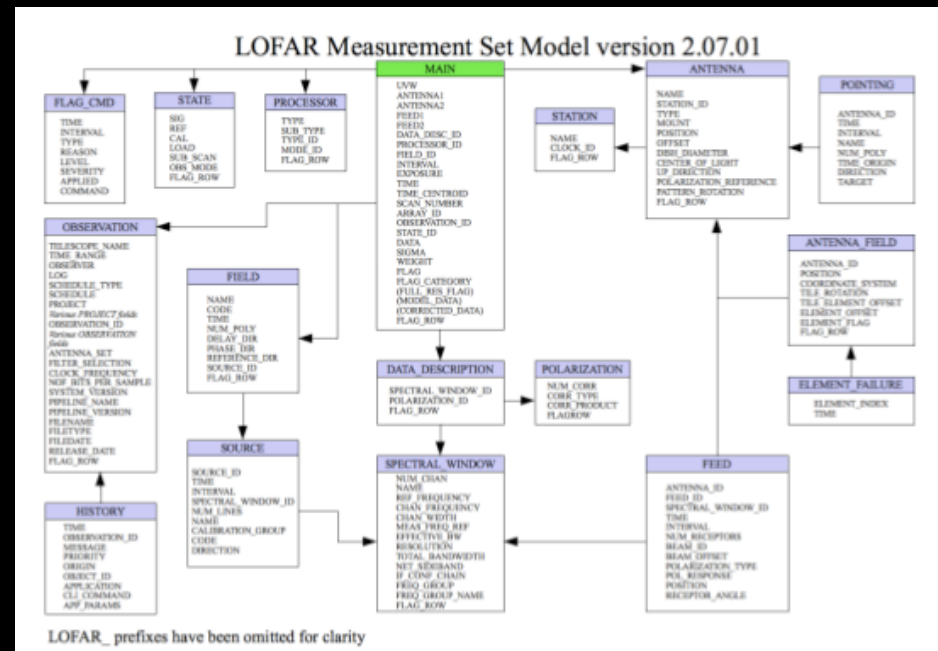
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A.P. Schoenmakers, G.A.Renting	ASTRON	24-03-2011
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Autorisatie / Authorisation:	ASTRON	
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**LOFAR/
USG/
Data Formats**

Doc.nr.:
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Date:
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1 of 32



TBD: Convert to TeX

ICD List

http://usg.lofar.org/wiki/doku.php?id=documents:lofar_data_products

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- ICD #002: Representations of World Coordinates
- ICD #003: Beam Formed Data
- ICD #004: Radio Sky Image Cubes
- ICD #005: File Naming Conventions
- ICD #006: Dynamic Spectrum Data
- ICD #007: Visibility Data
- ICD #008: Rotation Measure Synthesis Cubes
- ICD #009: Near Field Sky Image
- MeasurementSet Definition

ICD Cross-Check

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Dynamic Spectrum Data**
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MeasurementSet description for LOFAR
Version 2.07.01

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LOFAR-USG Data Formats

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LOFAR Data Access Software

- LOFAR User Software (LUS) available in SVN repository or as Daily Build:
 - LOFAR offline processing tools, pipelines, etc. (C, C++, Python, etc)

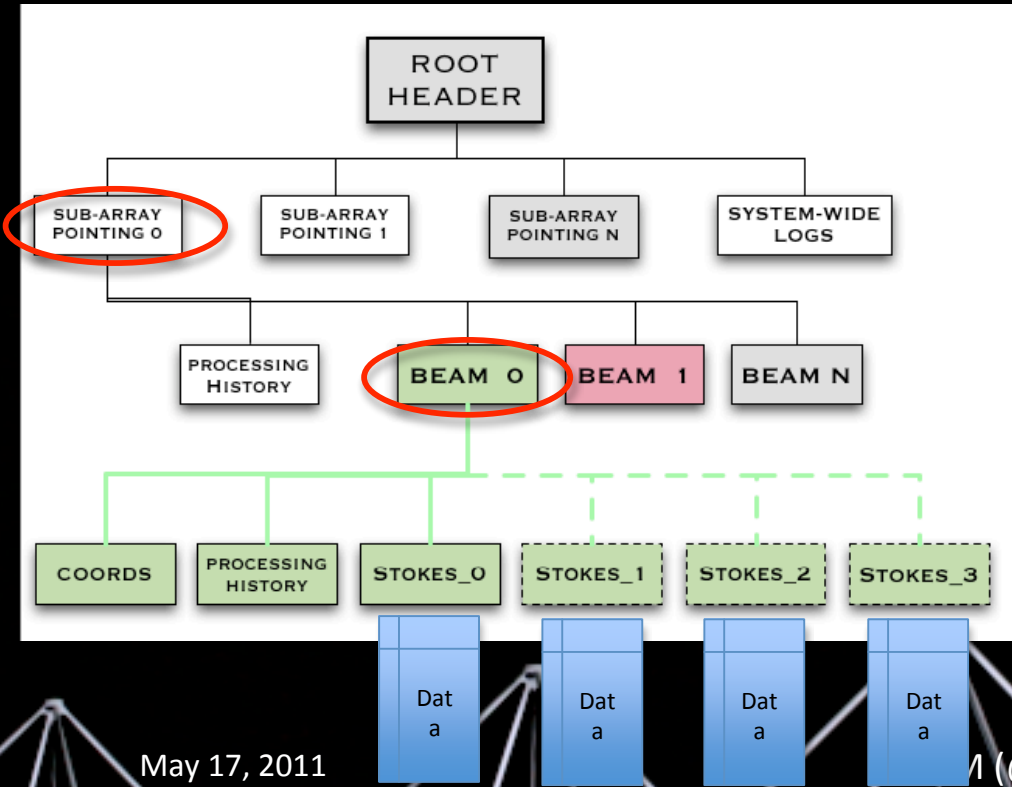
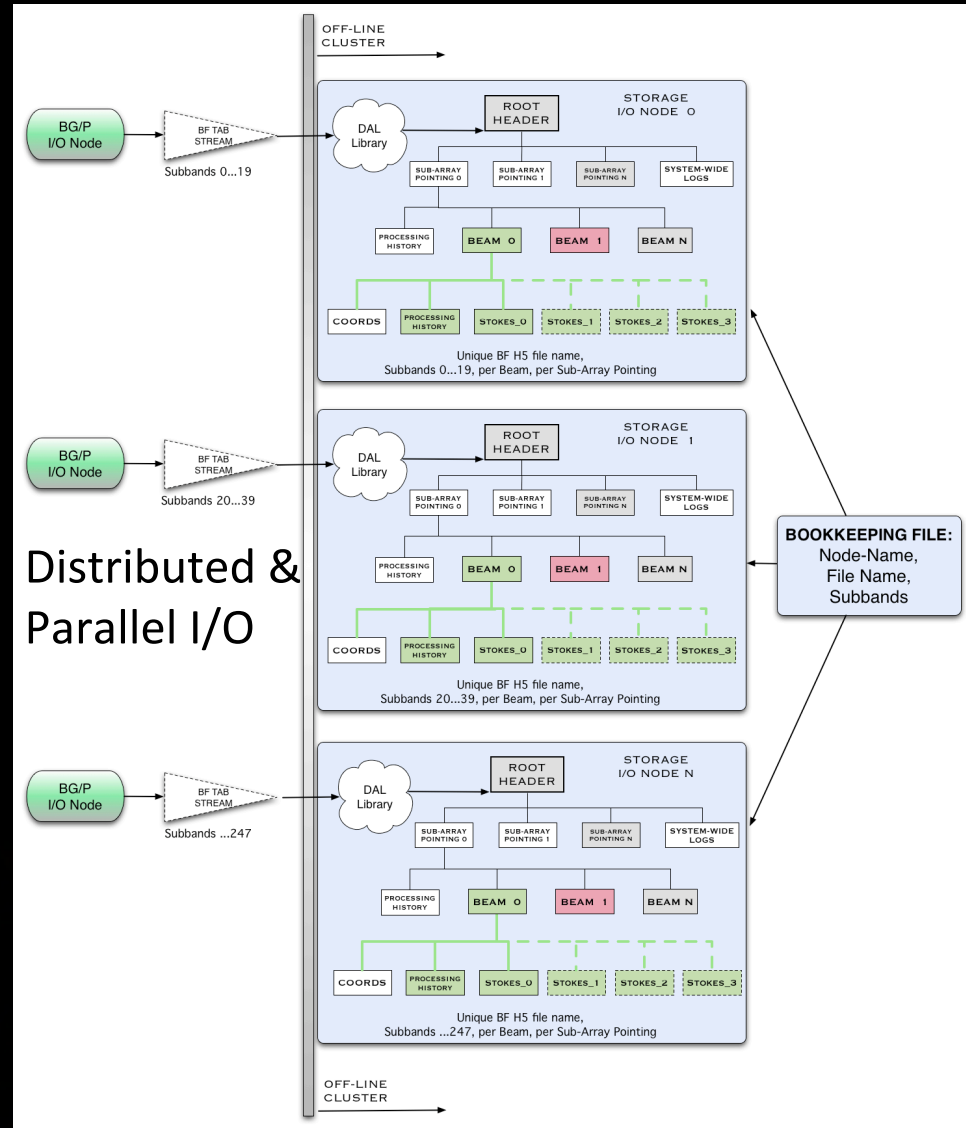
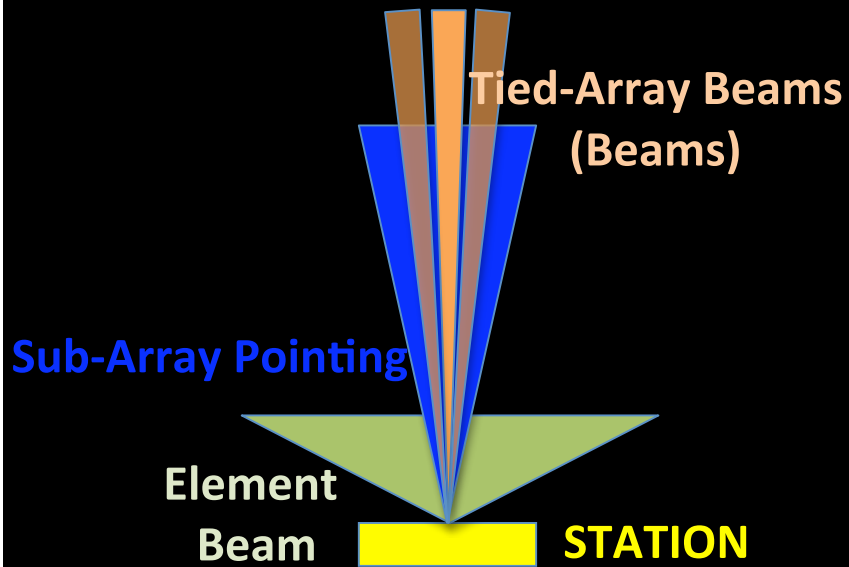
- C++ Data Access Layer (DAL) Library (intermediate layer on top of HDF5)
- DAL Python wrapper (PyDAL)

<https://github.com/nextgen-astrodata/DAL>

- C++ Classes are based on LOFAR data format ICDs [Beam Formed, Sky Image, Dynamic Spectra, Transient Buffer Board]

- Active developers: Lars Bähren, Sven Duscha, Pim Schellart, Jan David Mol
- Work in process:
 - LOFAR HDF5 Data writers & python bindings
 - HDF5 Data I/O benchmarking
 - Choosing optimum HDF5 data containers [dim, cache, chunk] (adjust ICDs as needed)
 - Plan on visualization tool: plugin for VisIt
 - Plan on HDF5 Sky Cube -> FITS converter for DS9

Beam-Formed Data Format in HDF5:



Next Generation Astronomical Data Formats?

- Current and future telescopes and missions have similar data size and complexity challenges:
 - Radio: EVLA, ALMA, ASKAP, MeerKAT, MWA, LWA, eMERLIN and SKA!
 - Non-Radio: Pan-Starrs, LSST, TMT, GMT, ELT, JWST
- MeerKat project is writing raw visibilities in HDF5; evaluating LOFAR ICDs
- Collaborations are forming to work on HDF5-usage as tool-set in astronomy:
 - NRAO (Charlottesville) + LOFAR + HDF Group writing NSF Grant
 - Oak Ridge National Laboratory + NRAO (Socorro) working on FITS/CASA/HDF5 + WCS-friendly VisIt plugin for large data visualization
- Discussion on moderated mailing list: nextgen-astrodata@astron.nl
Email to: majordomo@astron.nl
Text in message body: [subscribe nextgen-astrodata](#)
- Web page coming soon! (www.nextgen-astrodata.org)
- Time is ripe to solve this issue across wavelengths and projects; HDF5 is mature and used extensively in science for over 20 years: NASA's earth observing system (EOS), Simulation community uses HDF5 (GADGET, ENZO, FLASH); netCDF-4: scientific data format, Computational Fluid Dynamics, EXPRESS (data modeling language) soon to be ISO standard for product data, HDF5-iRODS Grid project... Field 3D: visual effects in film production, and the Oil and Gas Industry (RESQML)
- This is NOT just a “Radio-problem”, it’s an astronomical problem!