NOEMA DATA REDUCTION PIPELINE

Arancha Castro-Carrizo

Three different pipelines at the Observatory

- Visualization of ongoing observations - Check data and observing conditions

- Data reduction pipeline at the end of the observations :
  1. Analysis of observing conditions
  2. Calibration
  3. Visibility Assessment
  4. Table creation and imaging is also happening at Bure

- Instrument monitoring

NOEMA data reduction PIPELINE

- The assessment of the obtained data is a task of the Science Operations Group (SOG). The NOEMA data-reduction pipeline is developed within the SOG to use their expertise at the service of data and SOG duties (AoDs and Local Contacts)

- Two main uses:
  a. Support the AoD at the observatory to decide on data quality and project completion
  b. Provide correctly reduced data to the user

- “Intelligent” software scripts

- Based on CLIC (and SIC) language

Data analysis at the observatory

- Little differences exist between the pipeline version used by the AoD at the observatory and that used by the user at Grenoble

- At the Observatory, the pipeline is launched automatically at the end of each observed track

- Imaging tools are also launched by the “data reduction pipeline”, which will help to assess the obtained data. Also new data are automatically added to all previous observations to decide on the status of the science project

Data analysis at Grenoble by the user

- A detailed data analysis is performed by the PI with the help of the Local Contact
- Notes written by the AoDs are delivered with data, and should help to understand certain issues or to take decisions
- Even if the calibrated data in the archive (=AoD reduction) must be good, we advice to repeat the calibration at Grenoble with the PI

- A document exists in GILDAS web (Documentation link, Data calibration section)
- It will be updated to PolyFiX soon. Otherwise, the main information remains valid today

IRAM NOEMA
Data Reduction CookBook

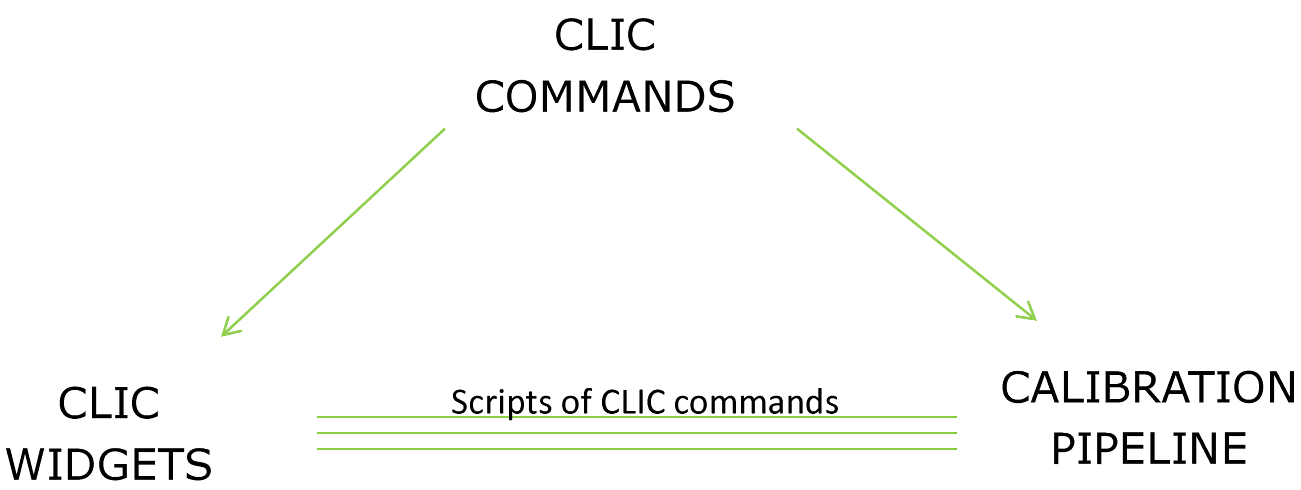
September 2010

Version 5.0

This document describes how to reduce NOEMA observations and gives some ideas to perform first analysis and imaging. Sect. 1 explains how to get started, from planning your trip to Grenoble to having a project account. The standard procedure to calibrate NOEMA data with the CLIC software package is described in Sect. 2. A few instructions to start the data analysis with the MAPPING software package are given in Sect. 3. A theoretical description of the calibration as well as a description of the extended pipeline (or AoD) `First Look` report are annexed in Apps. A and B respectively.

Documentation
In charge: A. Castro-Carrizo[1], R. Neri[1].

Generalities about NOEMA data calibration



Little differences between widgets and pipeline

- Pipeline must take good and robust decisions
- Widgets propose decisions, but they are launched step by step
  Widgets assume the user knows, less elaborated than the pipeline

Generalities about NOEMA data calibration

CLIC COMMANDS: The logic of commands is very simple

Visualize data

```
CLIC> set y amplitude
CLIC> set x time
CLIC> plot
```

Store calibration solutions

```
CLIC> store phase
```

Search calibration solutions

```
CLIC> set y phase
CLIC> set x time
CLIC> solve phase /plot
```

Visualize applied calibration

```
CLIC> set phase relative
CLIC> plot
```

However the pipeline is made of ~ 40.000 CLIC line commands.
Having the best calibration for all projects is sometimes more difficult than few simple commands
Simple actions or verifications can easily be done with CLIC commands (btw, sometimes proposed by the AoD)

Data calibration with commands

1

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
say "RF CALIBRATION"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

set bin 5
set drop 0.005 0
find /proc corr flux /sou 3c84

store phase /self
set phase rel atm

set x i_f
set y amp phase /lim 0 * * *

set band lsb
for ibb 1 2 5 6
   set bband 'ibb'
   plot
   solve rf 40 50 /plot
next ibb

set band usb
for ibb 3 4 7 8
   set bband 'ibb'
   plot
   solve rf 40 50 /plot
next ibb

find /proc corr flux
store rf
```

2

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
say "PHASE CALIBRATION"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

set phase abs atm
set rf on
set y phase /lim * *
set x time
set spw line
find /proc corr flux /typ ph

set polar h
set band lsb
plot /id col
solve phase /plot

set band usb
plot /id col
solve phase /plot

set polar v
set band lsb
plot /id col
solve phase /plot

set band usb
plot /id col
solve phase /plot

find append /proc corr /typ o
store phase
```

3

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
say "FLUX CALIBRATION"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

set rf on
set phase relative atm
set amplitude scale
set y amplitude
set x time
set spw line
find /proc corr flux /ty ph

set polar both
plot /id col

set flux all /reset
set flux mwc349 1.35
show flux

solve flux
store flux

set rf on
set phase relative atm
set amplitude scale
set y amplitude
set x time
set spw line
plot /id col
```

4

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
say "AMPLITUDE CALIBRATION"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

find /proc corr flux /typ ph

set polar h
set band lsb
plot /id col
solve amplitude /plot

set band usb
plot /id col
solve amplitude /plot

set polar v
set band lsb
plot /id col
solve amplitude /plot

set band usb
plot /id col
solve amplitude /plot

find append /proc corr /typ o
store amp
```

5

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
say "DATA CALIBRATION ASSESSMENT"
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

set rf on
set phase relative atm
set amplitude scale relative
set spw line
set polar both

set y amplitude
set x time

find /proc corr flux
plot /id col

pause CALIBRATED_AMPLUTUDES

set y phase

find /proc corr flux /typ ph
plot /id col

say "CALIBRATED_PHASES"
```

Data calibration with pipeline

- A **pipeline** helps however to gain time, and is important if :
  - Not enough expertise
  - Problems or characteristics are identified (e.g. polarized calibrator, non-optimum wvr-correction, different solutions for diff polars, etc)
  - Verifications and decisions are needed (e.g. for flux calibration, flags, etc)

- Every astronomer should start with a pipeline calibration
- Experienced astronomers may be able to improve the pipeline calibration after verification of pipeline plots, choices and results
- Less experienced astronomers should follow the advice (training) of the Local Contact

Generalities about NOEMA data calibration

From raw data to image: IPB > hpb > uvt > lmv-clean

- IPB (filename.IPB) = raw NOEMA data (with real-time calibration, Tsys and Ta*, see Pietu presentation)
- hpb (filename.hpb) = calibration information obtained offline by last calibration in CLIC
- uvt (filename.uvt) = source data in the uv-plane (=visibilities; see Herrera presentation)
- lmv-clean (filename.lmv-clean) = cleaned image maps ; lmv = dirty image maps (see Pety presentations)

Generalities about NOEMA data calibration

From raw data to image: IPB > hpb > uvt > lmv-clean

- IPB should not be modified (readable by CLIC) - large files
- hpb created by CLIC, modified at each calibration, but no data are in - moderate files

IPB and hpb are both needed for calibration and uv-tables creation

- uvt contain calibrated data (with few records about the original visibilities), created by CLIC and processed by MAPPING - small files
- lmv-clean resulting images (grid+FT+cleaning), processed by MAPPING - moderate files

Generalities about NOEMA data calibration

Comparison with ALMA

NOEMA	PIPELINEs	ALMA
IPB : raw data with Tsys calibration, readable by CLIC	↓	ASDM : raw data without Tsys calibration, not readable by CASA
hpb : calibration solutions		ms : data + calibration solutions
uvt : calibrated visibilities on a source (one per position)		ms : every data format = calibrated and uncalibrated visibilities, every source, offset, depending on your choice
lmv-clean : images (gdf format, like lmv)		ms : it also include image format

Different files contain different things

To you to keep order between different "ms" files

Generalities about NOEMA data calibration

Comparison with ALMA

NOEMA

ALMA

PIPELINEs

IPB : raw data with Tsys calibration, readable by CLIC

ASDM : raw data without Tsys calibration, not readable by CASA

hpb : calibration solutions

ms : data + calibration solutions

uvt : calibrated visibilities on a source (one per position)

ms : CASA pipeline produces a final ms with calibrated visibilities on all sources and offsets (*split.cal file)

lmv-clean : images (gdf format, like lmv)

ms : it also include image format

Different files contain different things

To you to keep order between different "ms" files

NOEMA data calibration with the Pipeline

With @pipeline 'project' 'date' in CLIC three blocks of scripts are executed, in the following order :

1. Observing conditions
2. Data calibration
3. Visibility assessment

IPB >> IPB+hpb

A document of ~ 70-80 pages is created to show at first data calibration (2), secondly a complete review of observing conditions (1), and at third a visibility assessment (3)

The uv-table is to be created at the end with a widget or a dedicated script at Grenoble (at Bure also made by the pipeline) IPB+hpb >> uvt

NOEMA data calibration with the Pipeline

OBSERVING CONDITIONS

CALIBRATION

Project TINTSV97 Data File 20-sep-2018-tintsv97
Observed on 20-SEP-2018 Configuration 10D
(N17W08W12N05E10E04N13N09W05N02)

Automatic calibration report by CLIC @ x_calib

September 20, 2018

Scan range:	0 to 10000
Use phase correction:	YES (22GHz)
Minimum quality:	AVERAGE
Auto. flag procedure:	YES (0 scans)
WVR interference check:	NO
Averaged polarization mode for amplitude calibration:	YES

	Receiver 3
Bandpass:	Excellent
Phase:	Correct
Seeing HOR:	0.27″
Seeing VER:	0.27″
Amplitude:	Good

1 Summary

1.1 Calibrators

Name	Flux (Jy) @209.8 GHz		Calibration	
3C84	14.56	*Computed*	*RF*	
LKHA101	0.51	*Fixed (model = 0.51)*		
3C273	11.89	*Computed*		
1418+546	2.54	*Computed*	*phase/amp*	*(detected polarization)*
MWC349	1.81	*Fixed (model = 1.81)*		

1.2 Efficiencies

Antenna 1 (A 1)	25.5	Jy/K	(20.1 / 0.79)
Antenna 2 (A 2)	28.8	Jy/K	(20.1 / 0.70)
Antenna 3 (A 3)	25.1	Jy/K	(20.1 / 0.80)
Antenna 4 (A 4)	23.8	Jy/K	(20.1 / 0.84)
Antenna 5 (A 5)	24.1	Jy/K	(20.1 / 0.83)
Antenna 6 (A 6)	24.0	Jy/K	(20.1 / 0.84)
Antenna 7 (A 7)	26.8	Jy/K	(20.1 / 0.75)
Antenna 8 (A 8)	24.3	Jy/K	(20.1 / 0.83)
Antenna 9 (A 9)	24.8	Jy/K	(20.1 / 0.81)
Antenna 10 (A10)	23.8	Jy/K	(20.1 / 0.84)

1.3 Observed Source(s)

IC10-B11 was observed for Hour Angles from -5.8 to -4.3 h for a total of 1.1 h (90 scans)

1

Project S1 TINTSV97 ata File 15-sep-2018-s18tintsv97
Observed on 15-SEP-2018 configuration 8D+N17N05
(N17W08W12N05E10E04N13N09W05N02)

Automatic Summary Report by CLIC @ x_show

September 16, 2018

1 Summary

1.1 Spectral Configuration

Sky Frequency 78.6 GHz, at 3903 MHz in the receiver IF in the LSB

Correlator configuration:

unit	width	resolution	unit location in IF1	Rest Sky	Polar	Sideband	PolyFiX Baseband
		MHz	*MHz*	*GHz*			
L01	4064	2.00	9775	72.728	H	LSB	HLO
L02	4064	2.00	5713	76.790	H	LSB	HLI
L03	4064	2.00	5713	88.215	H	USB	HUI
L04	4064	2.00	9775	92.277	H	USB	HUO
L05	4064	2.00	9775	72.728	V	LSB	VLO
L06	4064	2.00	5713	76.790	V	LSB	VLI
L07	4064	2.00	5713	88.215	V	USB	VUI
L08	4064	2.00	9775	92.277	V	USB	VUO
L09	192	0.06	10432	72.071	H	LSB	HLO
L10	128	0.06	10080	72.423	H	LSB	HLO
L11	320	0.06	9664	72.839	H	LSB	HLO
L12	128	0.06	8928	73.575	H	LSB	HLO
L13	64	0.06	8384	74.119	H	LSB	HLO
L14	128	0.06	8032	74.471	H	LSB	HLO
L15	448	0.06	6208	76.295	H	LSB	HLI
L16	128	0.06	5408	77.095	H	LSB	HLI
L17	320	0.06	4224	86.726	H	USB	HUI
L18	64	0.06	4800	87.302	H	USB	HUI
L19	64	0.06	4928	87.430	H	USB	HUI
L20	128	0.06	5088	87.590	H	USB	HUI
L21	192	0.06	6144	88.646	H	USB	HUI
L22	256	0.06	6624	89.126	H	USB	HUI
L23	256	0.06	8160	90.662	H	USB	HUO
L24	128	0.06	8480	90.982	H	USB	HUO

DATA ASSESSMENT

Project S18AL001
Observed on 15-SEP-2018

Automatic Visibility Quality Assessment Report
by CLIC @ x_visi

September 16, 2018

Project type:	MAPPING
Seeing limit:	$\leq 1.5''$
Amplitude loss:	$\leq 21.6\%$
Pointing error:	$\leq 30\%$ (FOV) $\simeq 19.2''$
Focus error:	$\leq 30\%$ (λ) $\simeq 1.1$ mm
Tracking error:	$\leq 10\%$ (FOV) $\simeq 6.4''$
Configuration(s):	1. N17W08W12N05E10E04N13N09W05N02

The three documents are compiled in pipeline-‘date’-‘project’.pdf

NOEMA data calibration with the Pipeline

Three sections in the pipeline report :

1. Data calibration : displays calibration solutions
   a. RF/bandpass: Amp and phases vs frequency, one per BaseBand (pages 6-13 in report)
   b. Phases in time, one per IF, or per SB (pages 14-17)
   c. Absolute flux (page 5)
   d. Amplitude in time, one per IF, or per SB (pages 18-21)

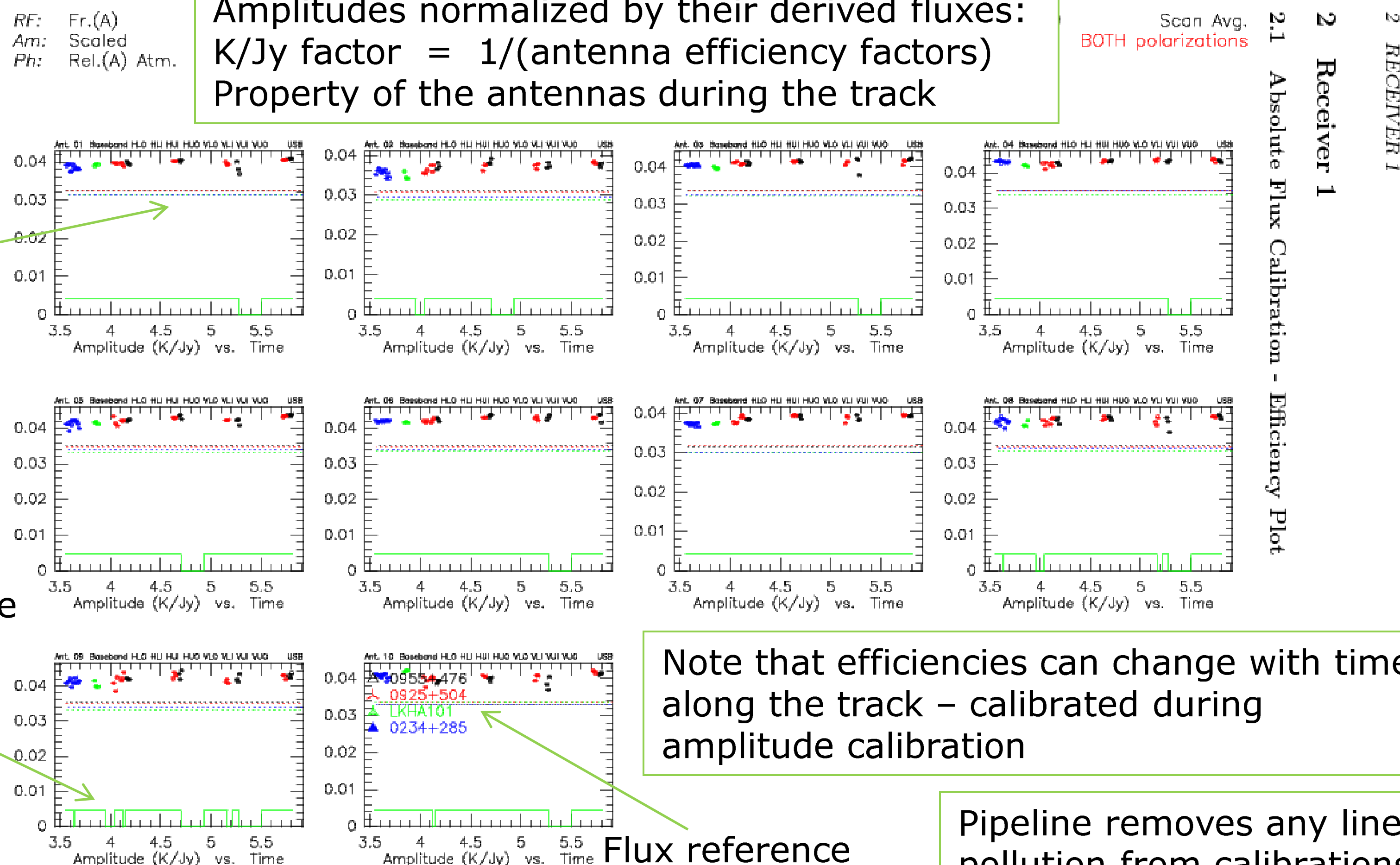
2. Observing Conditions : displays conditions during the observations, and detect possible problems (about 40 pages)

3. Visibility assessment : evaluates the data quality relative to predefined inputs, and propose data flagging (introduced by the pipeline)

NOEMA pipeline: data calibration

NOEMA pipeline: data calibration

Absolute flux calibration – shown at first to give a track overview



Amplitudes normalized by their derived fluxes:
K/Jy factor = 1/(antenna efficiency factors)
Property of the antennas during the track

Limits of considered data for flux calibration

Where the WVR phase correction is applied

Note that efficiencies can change with time along the track – calibrated during amplitude calibration

Flux reference

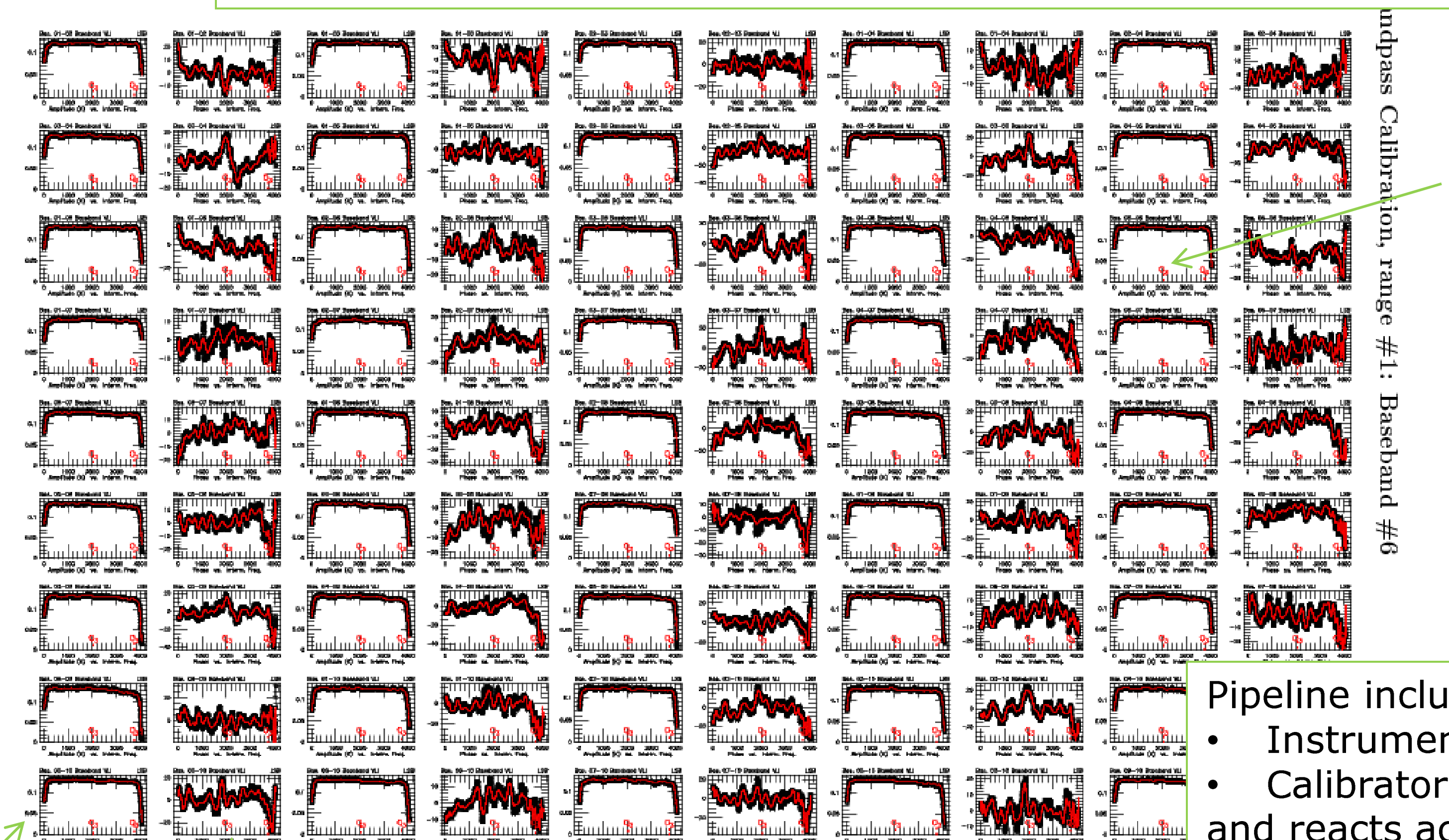
Pipeline removes any line pollution from calibrations

NOEMA pipeline: data calibration

RF/Bandpass calibration – one per Correlator BaseBand (there are 8)
Calibrates Amplitudes and Phases vs. frequency

- A high polynomial degree is used for the calibration solution
- It can be increased for a source with very strong continuum
- Other solutions are being considered for future (interpolations)

RF: 40/50
Am: Abs.
Ph: Rel.(A) Atm.



We take care if strong O3 lines

Amplitudes

Phases

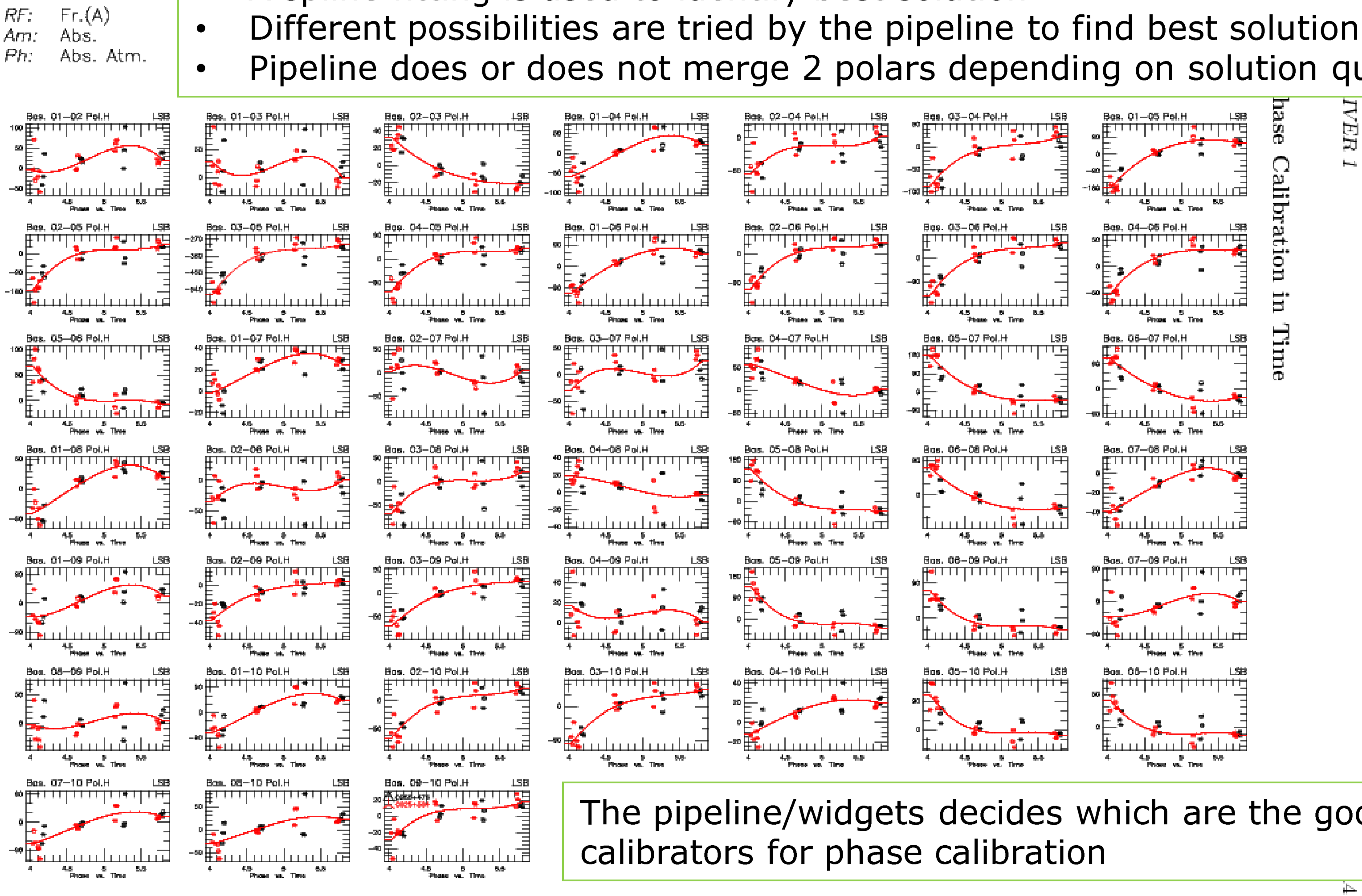
Pipeline includes a check of:
- Instrumental parasites
- Calibrator emission

and reacts accordingly to avoid affecting calibration

NOEMA pipeline: data calibration

Phase calibration in time – one per polar and sideband, but verify if solutions are close (soon we may average 2 polars by default)

- A spline fitting is used to identify best solution
- Different possibilities are tried by the pipeline to find best solution
- Pipeline does or does not merge 2 polars depending on solution quality



The pipeline/widgets decides which are the good calibrators for phase calibration

NOEMA pipeline: data calibration

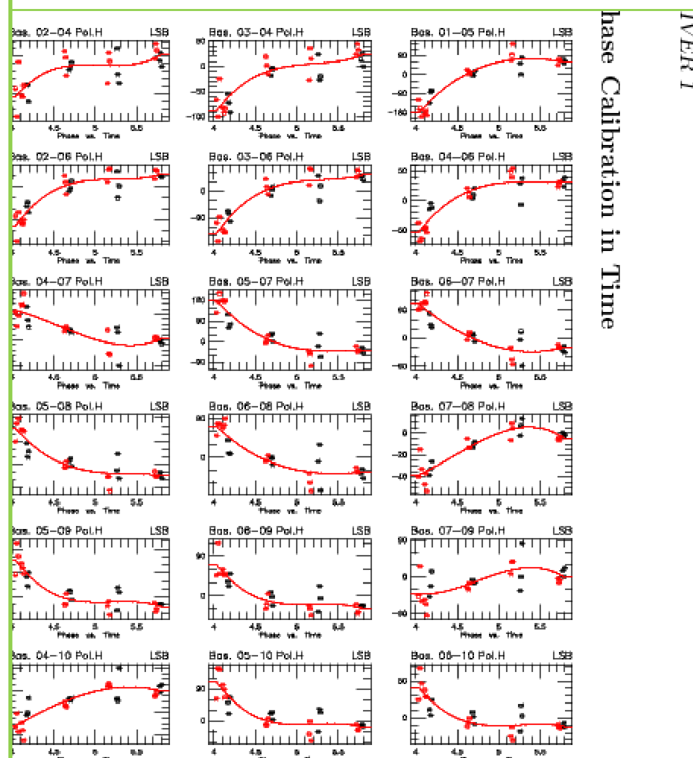
lar and sideband, but verify if solutions
olars by default)

tify best solution
d by the pipeline to find best solution
ge 2 polars depending on solution quality

Default Phase calibration is ok

1.6 Time Calibration:

Receiver Band 1		Phase r.m.s. Polar H deg.	Phase r.m.s. Polar V deg.	H–V Mean deg.	H–V Max. deg.	Ampl. Polar H %	Ampl. Polar V %
Base 01-02	(134.0 m)	27.4	27.3	-0.3	√	6.2	5.1
Base 01-03	(145.0 m)	27.0	27.0	5.9	√	6.0	5.3
Base 02-03	(32.0 m)	9.1	9.2	6.1	√	6.6	4.6
Base 01-04	(96.0 m)	20.9	20.7	5.0	√	5.7	5.0
Base 02-04	(66.0 m)	16.4	16.4	5.2	√	6.4	4.8
Base 03-04	(94.0 m)	21.6	21.7	-0.9	√	6.2	4.8
Base 01-05	(175.0 m)	31.1	31.1	1.9	√	5.9	5.1
Base 02-05	(144.0 m)	31.8	31.9	2.1	√	6.4	5.0
Base 03-05	(176.0 m)	34.8	34.9	-4.0	√	6.1	5.8
Base 04-05	(98.0 m)	26.7	26.7	-3.1	√	5.9	5.3
Base 01-06	(148.0 m)	26.3	26.1	3.5	√	5.7	4.9
Base 02-06	(96.0 m)	21.5	21.5	3.8	√	6.0	4.7
Base 03-06	(128.0 m)	26.6	26.5	-2.3	√	5.9	4.8
Base 04-06	(57.0 m)	14.3	14.6	-1.4	√	5.7	4.8
Base 05-06	(48.0 m)	15.7	15.6	1.7	√	5.7	5.1
Base 01-07	(32.0 m)	9.0	8.9	3.4	√	6.2	5.0
Base 02-07	(107.0 m)	26.6	26.5	3.7	√	6.5	4.8
Base 03-07	(122.0 m)	27.8	27.8	-2.5	√	6.5	4.7
Base 04-07	(64.0 m)	18.3	18.3	-1.5	√	5.8	4.9
Base 05-07	(147.0 m)	32.8	32.9	1.5	√	6.1	4.9
Base 06-07	(116.0 m)	26.6	26.7	-0.1	√	5.7	4.7
Base 01-08	(64.0 m)	13.4	13.3	2.0	√	5.8	5.5
Base 02-08	(83.0 m)	22.4	22.5	2.3	√	6.7	4.6
Base 03-08	(104.0 m)	24.8	25.0	-3.9	√	6.5	4.6
Base 04-08	(32.0 m)	13.1	13.2	-2.9	√	5.9	4.9
Base 05-08	(121.0 m)	31.8	31.7	0.1	√	6.1	5.9
Base 06-08	(86.0 m)	23.6	23.6	-1.5	√	6.0	4.8
Base 07-08	(32.0 m)	7.4	7.1	-1.4	√	6.1	4.8
Base 01-09	(131.0 m)	29.2	29.2	3.3	√	5.9	5.2
Base 02-09	(24.0 m)	8.0	8.0	3.6	√	6.8	5.4
Base 03-09	(56.0 m)	15.3	15.5	-2.5	√	6.4	5.0
Base 04-09	(49.0 m)	14.4	14.6	-1.6	√	6.2	5.1
Base 05-09	(120.0 m)	30.1	30.2	1.5	√	6.1	5.3
Base 06-09	(72.0 m)	18.3	18.4	-0.2	√	6.0	4.8
Base 07-09	(101.0 m)	28.2	28.3	-0.1	√	6.4	5.0
Base 08-09	(73.0 m)	23.3	23.3	1.3	√	5.9	5.3
Base 01-10	(120.0 m)	26.4	26.2	1.7	√	5.3	5.5
Base 02-10	(62.0 m)	14.3	14.3	1.9	√	5.8	5.4
Base 03-10	(93.0 m)	20.8	20.8	-4.2	√	5.9	5.2
Base 04-10	(24.0 m)	7.9	8.0	-3.3	√	5.6	5.4
Base 05-10	(86.0 m)	25.9	25.9	-0.2	√	5.3	5.5
Base 06-10	(39.0 m)	11.9	12.1	-1.8	√	5.1	5.2
Base 07-10	(88.0 m)	25.2	25.0	-1.7	√	5.4	5.2
Base 08-10	(56.0 m)	20.0	20.0	-0.3	√	5.7	5.4
Base 09-10	(39.0 m)	9.8	9.8	-1.6	√	5.6	5.5



ne/widgets decides which are the good
s for phase calibration

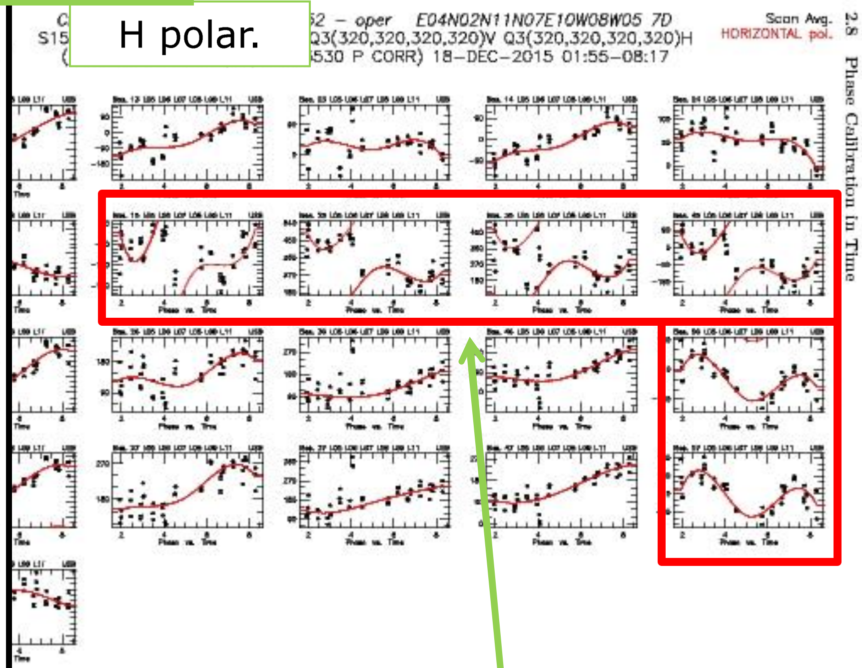
Default Phase H & V calibration is NOT ok

1.7 Time Calibration:[†]

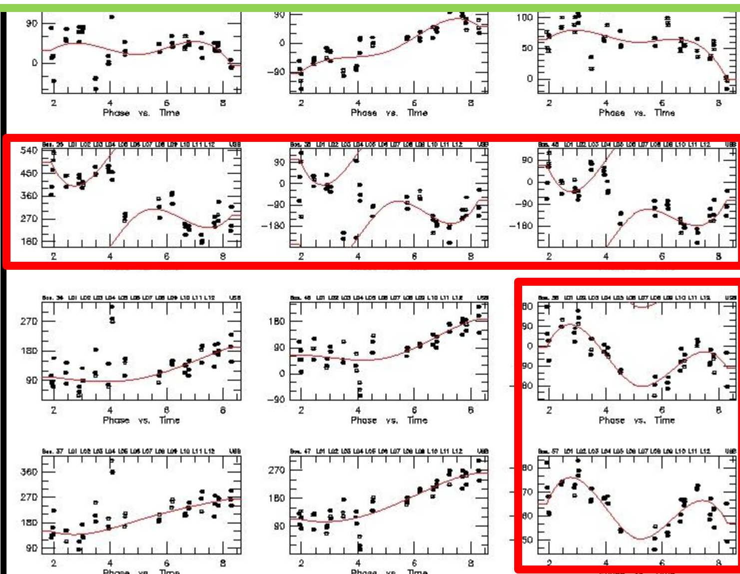
Receiver 3		Phase r.m.s. Polar H (deg.)	Phase r.m.s. Polar V (deg.)	H−V Mean (deg.)	H−V Max. (deg.)	Ampl. Polar H (%)	Ampl. Polar V (%)
Base 12	(39.0 m)	26.0	26.1	7.	√	11.2	11.4
Base 13	(101.0 m)	49.4	49.0	-1.	√	9.3	9.1
Base 23	(72.0 m)	38.3	38.5	-9.	√	12.1	11.2
Base 14	(71.0 m)	30.5	30.0	-6.	√	9.6	11.8
Base 24	(40.0 m)	21.4	21.5	-13.	√	12.5	11.9
Base 34	(32.0 m)	24.1	23.4	-4.	√	12.0	11.9
Base 15	(48.0 m)	46.8	37.4	14.	170.2	8.7	9.5
Base 25	(86.0 m)	48.4	53.3	6.	179.1	14.8	16.1
Base 35	(133.0 m)	65.2	70.9	-20.	169.0	12.6	12.0
Base 45	(109.0 m)	52.1	56.1	20.	165.1	13.0	13.7
Base 16	(96.0 m)	47.6	47.3	0.	√	10.3	11.0
Base 26	(62.0 m)	35.4	36.1	-6.	√	14.5	14.8
Base 36	(94.0 m)	49.9	50.1	2.	√	10.6	11.5
Base 46	(73.0 m)	38.4	38.6	6.	√	11.4	11.7
Base 56	(144.0 m)	50.9	69.1	-27.	176.6	11.2	12.8
Base 17	(72.0 m)	36.2	36.2	-42.	√	10.7	10.2
Base 27	(39.0 m)	26.9	26.4	-50.	51.7	11.7	11.4
Base 37	(87.0 m)	47.7	47.7	-41.	√	10.8	10.4
Base 47	(60.0 m)	31.1	31.4	-36.	√	10.3	11.1
Base 57	(120.0 m)	46.5	63.6	-57.	157.2	11.8	13.1
Base 67	(24.0 m)	16.1	15.7	-43.	46.1	8.3	8.9

[†] Phase calibration averaged on H- and V-phases

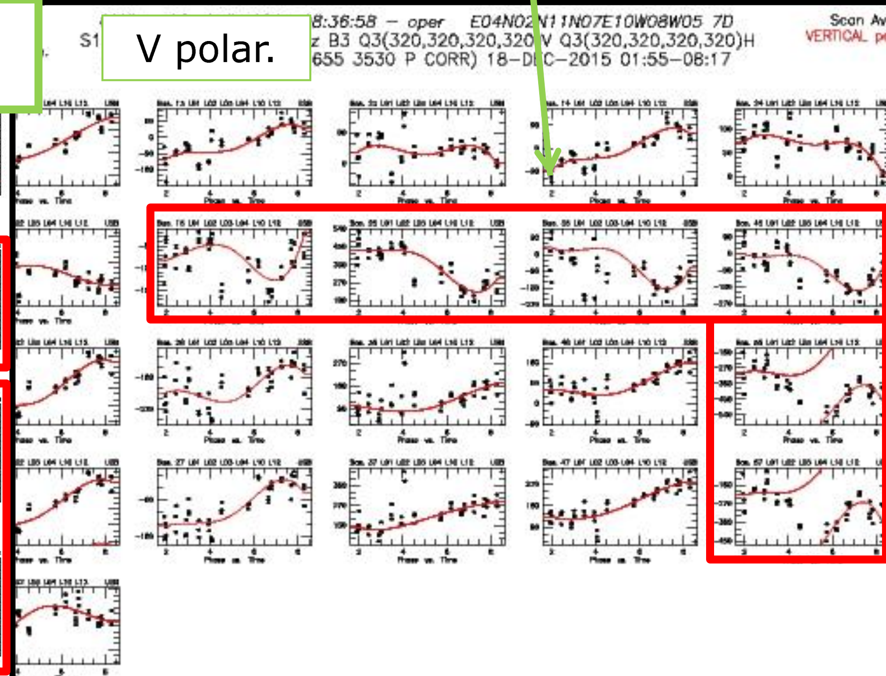
H polar.



Average polar solution is then used by the pipeline



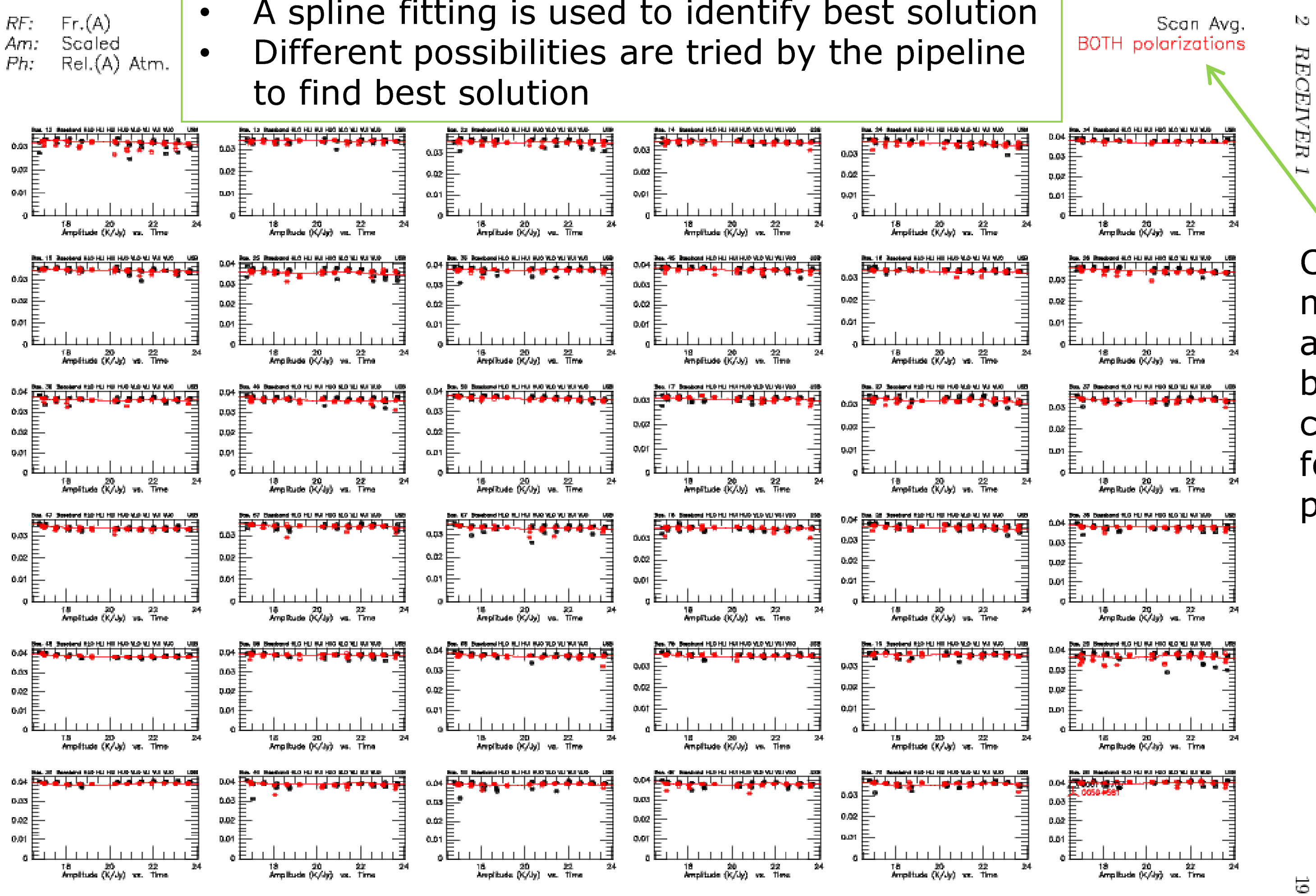
V polar.



NOEMA pipeline: data calibration

Amplitude calibration in time – how antenna efficiencies change on time - one calibration per polar and sideband by default, but verify if calibrator is polarized to average if needed (Soon we may average 2 polars by default)

- A spline fitting is used to identify best solution
- Different possibilities are tried by the pipeline to find best solution



Calibration is made on H+V average data because a calibrator was found to be polarized

NOEMA pipeline: data calibration

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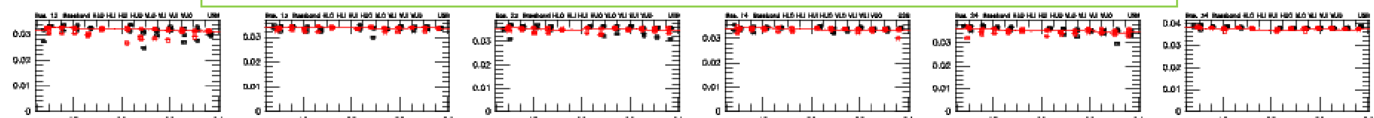

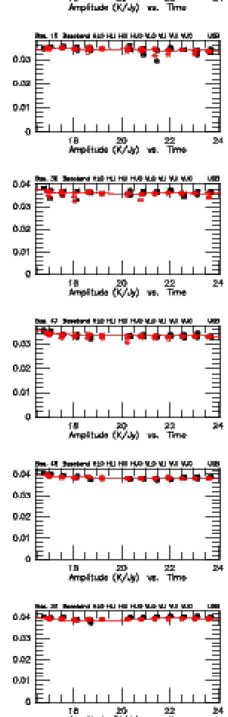

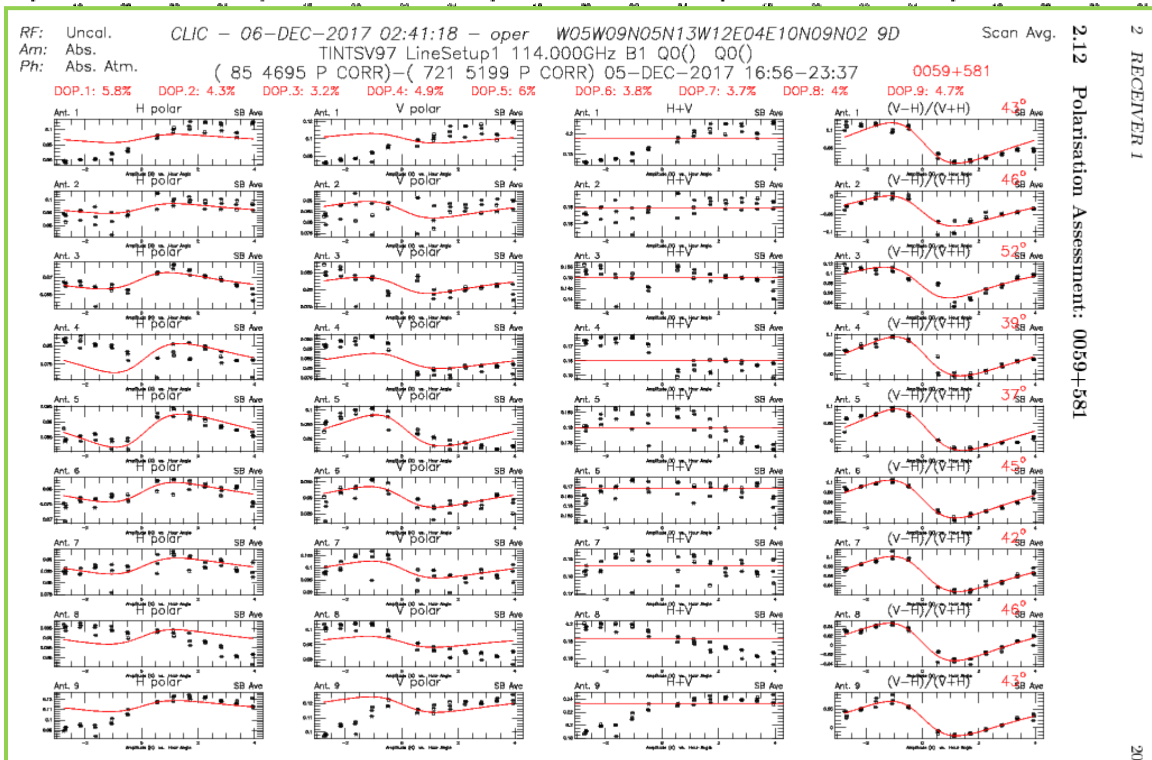

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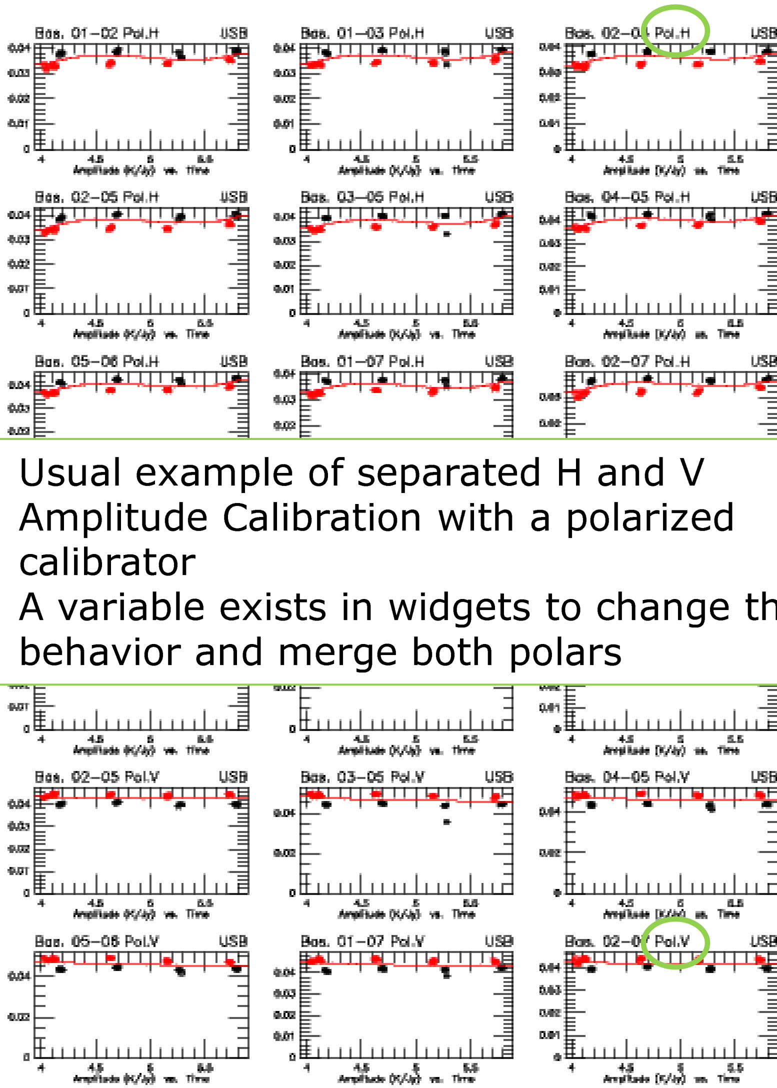
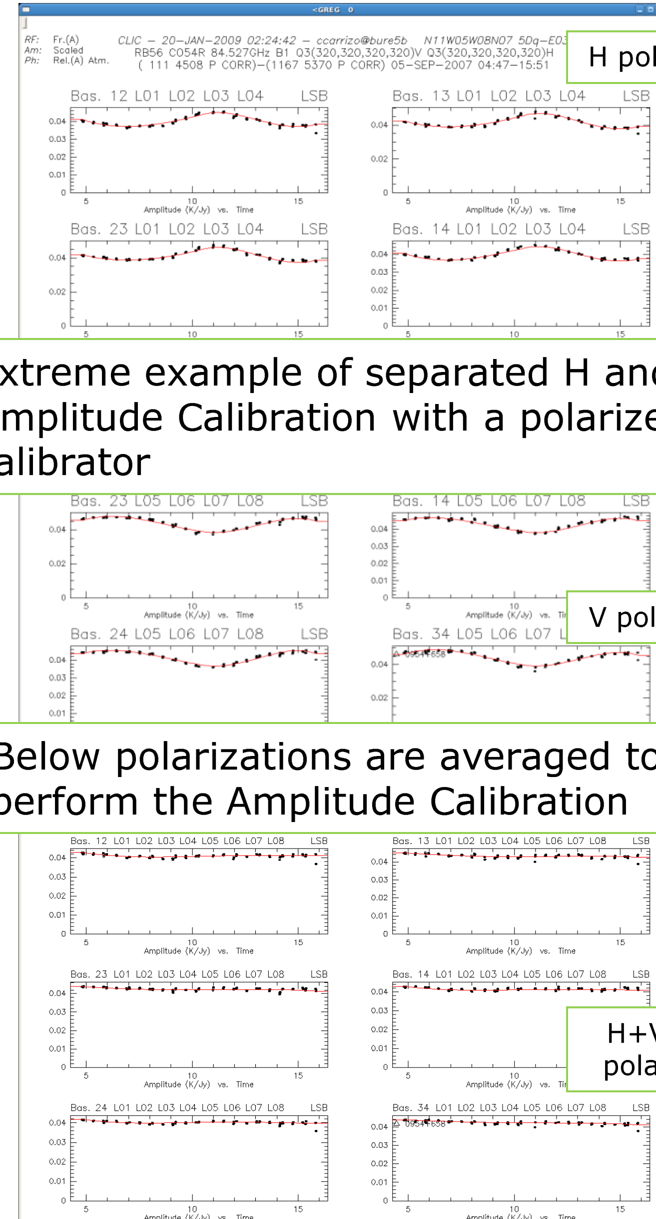
NOEMA pipeline: data calibration



- Usual example of separated H and V Amplitude Calibration with a polarized calibrator
- A variable exists in widgets to change the behavior and merge both polars



Extreme example of separated H and V Amplitude Calibration with a polarized calibrator

Below polarizations are averaged to perform the Amplitude Calibration

NOEMA data calibration with the Pipeline

CALIBRATION: report first page

Project TINTSV97 Data File 20-sep-2018--tintsv97
Observed on 20-SEP-2018 Configuration 10D
(N17W08W12N05E10E04N13N09W05N02)

Automatic calibration report by CLIC @ x_calib

September 20, 2018

Scan range:	0 to 10000
Use phase correction:	YES (22GHz)
Minimum quality:	AVERAGE
Auto. flag procedure:	YES (0 scans)
WVR interference check:	NO
Averaged polarization mode for amplitude calibration:	YES

	Receiver 3
Bandpass:	Excellent
Phase:	Correct
Seeing HOR:	0.27″
Seeing VER:	0.27″
Amplitude:	Good

Calibration quality

Amplitude Calibration

1 Summary

1.1 Calibrators

Name	Flux (Jy) @209.8 GHz		Calibration	
3C84	14.56	*Computed*	*RF*	
LKHA101	0.51	*Fixed (model = 0.51)*		
3C273	11.89	*Computed*		
1418+546	2.54	*Computed*	*phase/amp*	*(detected polarization)*
MWC349	1.81	*Fixed (model = 1.81)*		

Flux Calibration

1.2 Efficiencies

Antenna 1 (A 1)	25.5	Jy/K
Antenna 2 (A 2)	28.8	Jy/K
Antenna 3 (A 3)	25.1	Jy/K
Antenna 4 (A 4)	23.8	Jy/K
Antenna 5 (A 5)	24.1	Jy/K
Antenna 6 (A 6)	24.0	Jy/K
Antenna 7 (A 7)	26.8	Jy/K
Antenna 8 (A 8)	24.3	Jy/K
Antenna 9 (A 9)	24.8	Jy/K
Antenna 10 (A10)	23.8	Jy/K

1.3 Observed Source(s)

IC10-B11 was observed for Hour Angles from -5.8 to -4.3 h
for a total of 1.1 h (90 scans)

NOEMA pipeline: check Observing Conditions

NOEMA pipeline: check Observing Conditions

Aimed to

- 1) identify possible problems that could condition the data reduction,
- 2) prevent that those are reproduced in future observations (for AoDs)

The analysis of ‘Observing Conditions’ can influence the calibration

→ executed before Calibration (reported after calibration)

NOEMA pipeline: check Observing Conditions

unit	width	resolution	unit location in IF1	Rest Sky	Polar	Sideband	PolyFiX Baseband
		MHz	MHz	GHz			
L25	64	0.06	8704	91.206	H	USB	HUO
L26	192	0.06	9472	91.974	H	USB	HUO
L27	64	0.06	9984	92.486	H	USB	HUO
L28	192	0.06	10624	93.126	H	USB	HUO
L29	128	0.06	11360	93.862	H	USB	HUO
L30	192	0.06	10432	72.071	V	LSB	VLO
L31	128	0.06	10080	72.423	V	LSB	VLO
L32	320	0.06	9664	72.839	V	LSB	VLO
L33	128	0.06	8928	73.575	V	LSB	VLO
L34	64	0.06	8384	74.119	V	LSB	VLO
L35	128	0.06	8032	74.471	V	LSB	VLO
L36	448	0.06	6208	76.295	V	LSB	VLI
L37	128	0.06	5408	77.095	V	LSB	VLI
L47	192	0.06	9472	91.974	V	USB	VUO
L48	64	0.06	9984	92.486	V	USB	VUO
L49	192	0.06	10624	93.126	V	USB	VUO
L50	128	0.06	11360	93.862	V	USB	VUO

It shows the spectral config, spectral windows definitions as they are in data

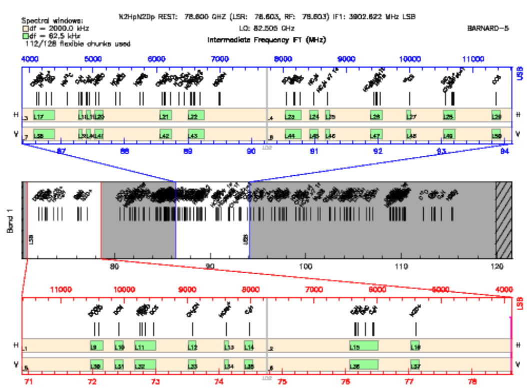


Figure: PolyFiX Correlator configuration, units L01 to L50

Plots are created to visualize:

- Observed sequence (calibrators and sources)
- Flagged data by the real-time software
- Weather conditions
- Antenna movements
- Tracking errors
- Pointing errors
- Stability of the correlator
- Power at the correlator entry
- Stability of calibration data
- Derived receiver Trec and sideband rejection
- Stability of the receiver
- Receiver power exit
- Sky total power
- Derived and used Tsys
- Derived water vapor amount
- Monitoring of WVR performance
- Monitoring of cable phase correction
- Monitoring of delay presence
- Monitoring of instrumental phase drift (need for baseline model?)
- Monitoring of amplitude differences between different correlator units

NOEMA pipeline: check Observing Conditions

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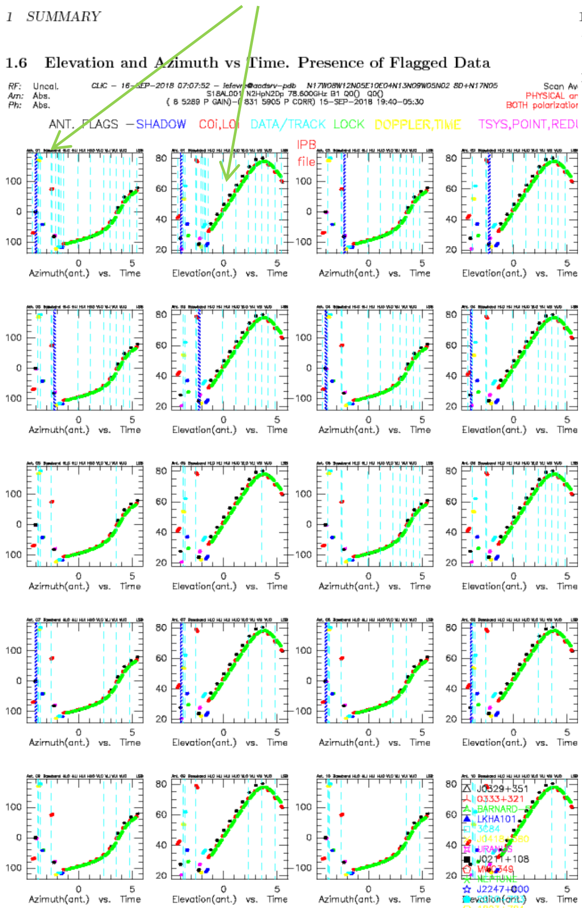
- Only experienced astronomers can interpret those plots, but they can be very important to understand
- We want to keep this visualization for every project and user, to be able to judge data quality and characteristics. AoD notes and L.C. are helping normal users.
- In the mid-term, to reduce pipeline time, we plan to remove the creation of those plots in Grenoble, and copy them from Bure. Architectural changes should then happen because pipelines extract information from some of them

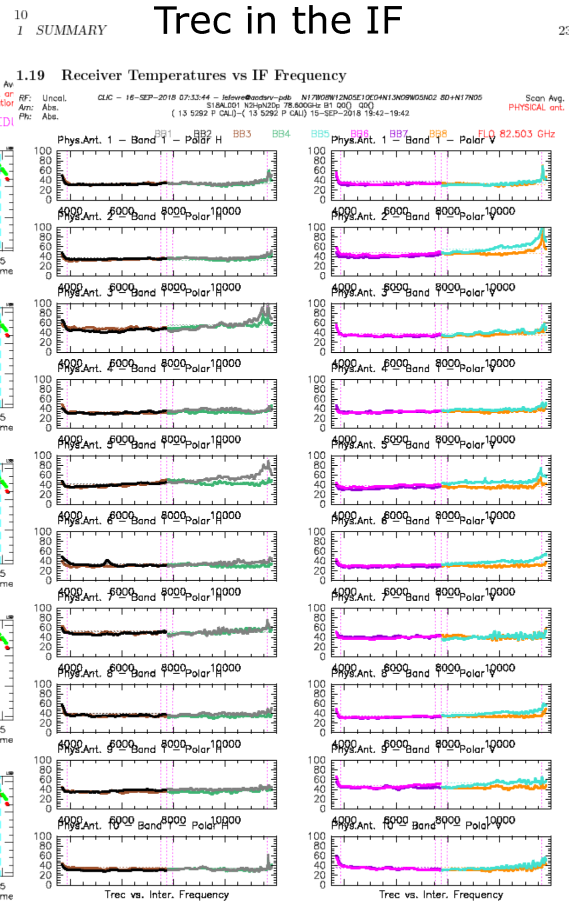
NOEMA pipeline: check Observing Conditions

Few examples:

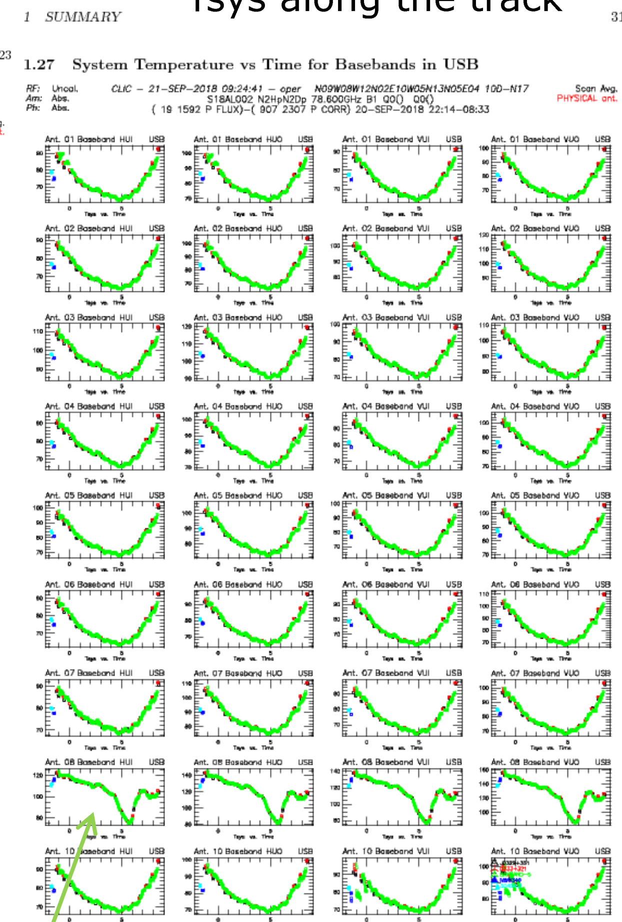
Real-time flags



Trec in the IF



Tsys along the track



From the plot we identified a deicing problem
Technitians intervened following this track

NOEMA pipeline: Visibility Assessment

NOEMA pipeline: Visibility Assessment

- Evaluation of the data quality in the UV plane by checking the calibrated visibilities on calibrators

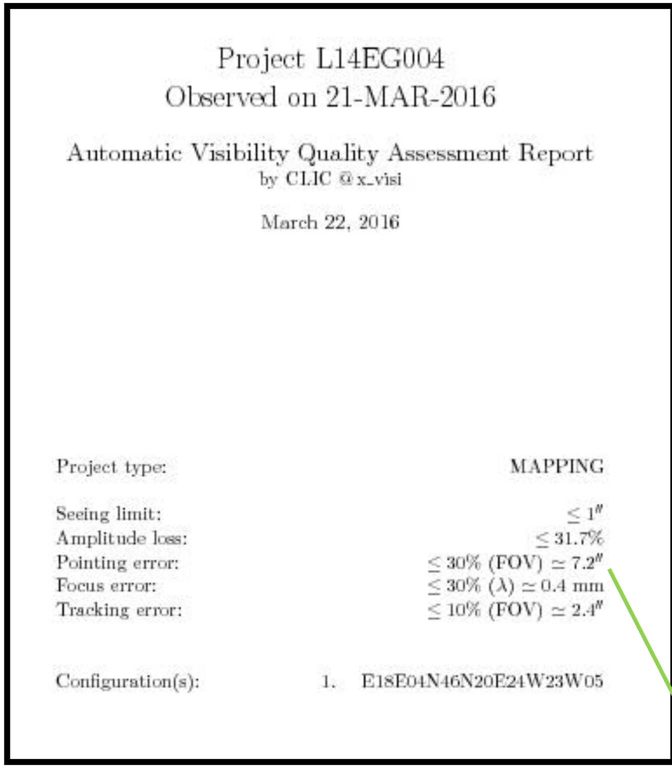
- Data worse than pre-defined quality limits are flagged. Limits are defined for phase, amplitudes, pointing, focus, tracking quality

- Criteria are different for Detection and Mapping projects
  - Detection : based on phase rms
  - Mapping : phase rms is weighted by baselines, so that visibilities are flagged if they introduced relevant mistakes compared to the aimed resolution (a “seeing” criteria is defined)

- Don’t hesitate to adapt the default parameters to the needs of your project. <u>Pipeline default is too restrictive</u>
  The best choice depends on the amount of data you have, and the aims of the project

- A detailed report is created by the pipeline

NOEMA pipeline: Visibility Assessment



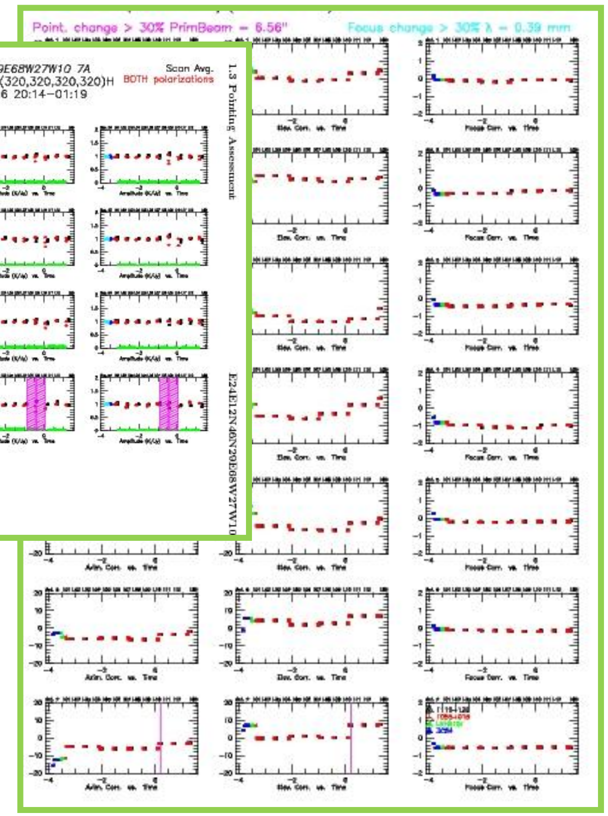
Project L14EG004
Observed on 21-MAR-2016

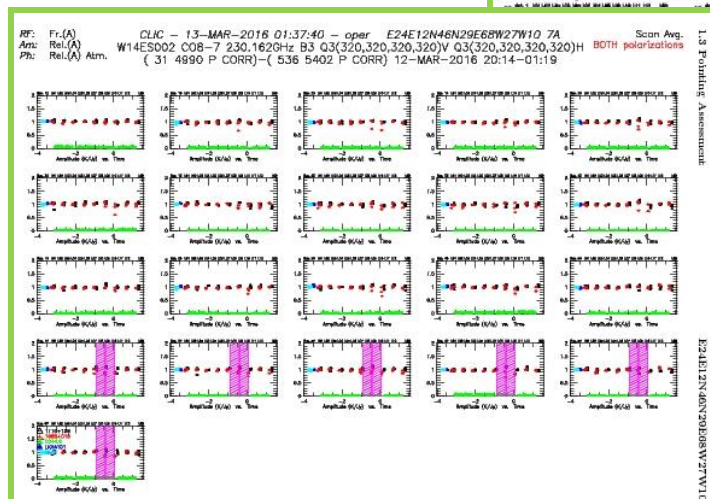
Automatic Visibility Quality Assessment Report
by CLIC @x_visi

March 22, 2016

Project type:	MAPPING
Seeing limit:	$\leq 1''$
Amplitude loss:	$\leq 31.7\%$
Pointing error:	$\leq 30\%$ (FOV) $\simeq 7.2''$
Focus error:	$\leq 30\%$ (λ) $\simeq 0.4$ mm
Tracking error:	$\leq 10\%$ (FOV) $\simeq 2.4''$
Configuration(s):	1. E18E04N46N20E24W23W05

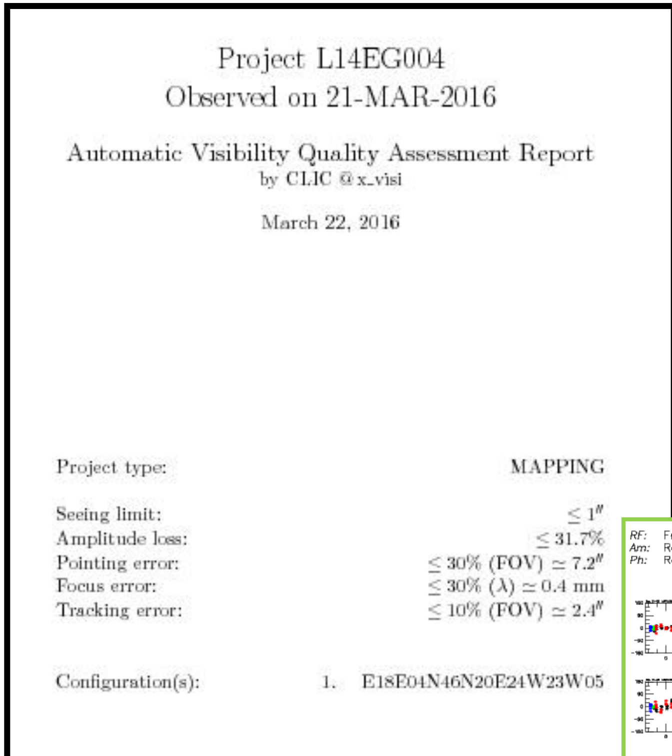
Flagging criteria given in the 1st page





Flagged by pointing considerations

NOEMA pipeline: Visibility Assessment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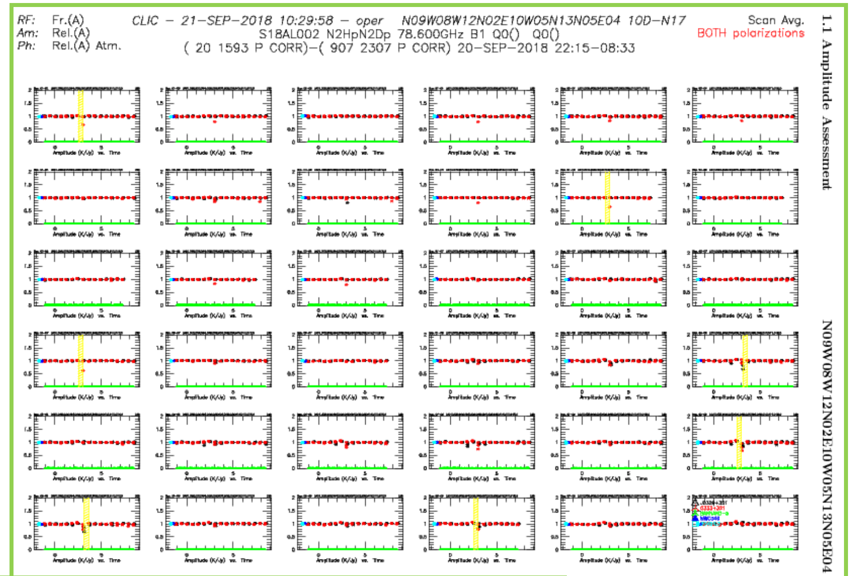
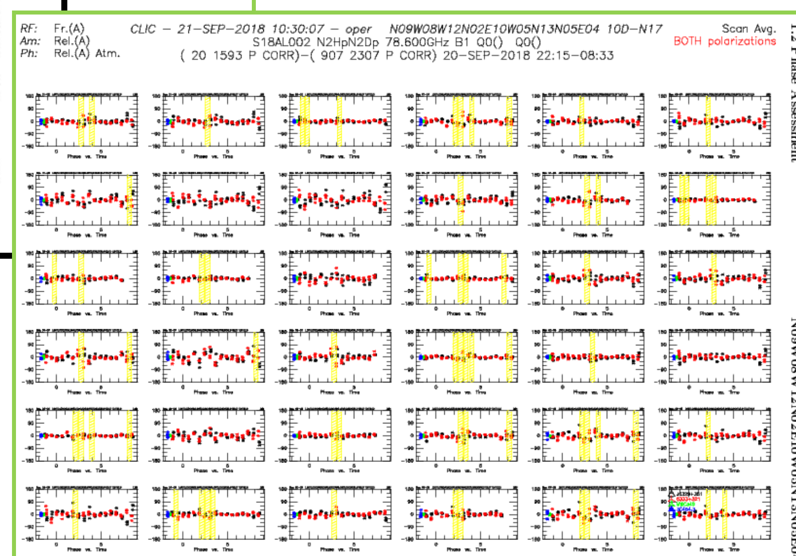
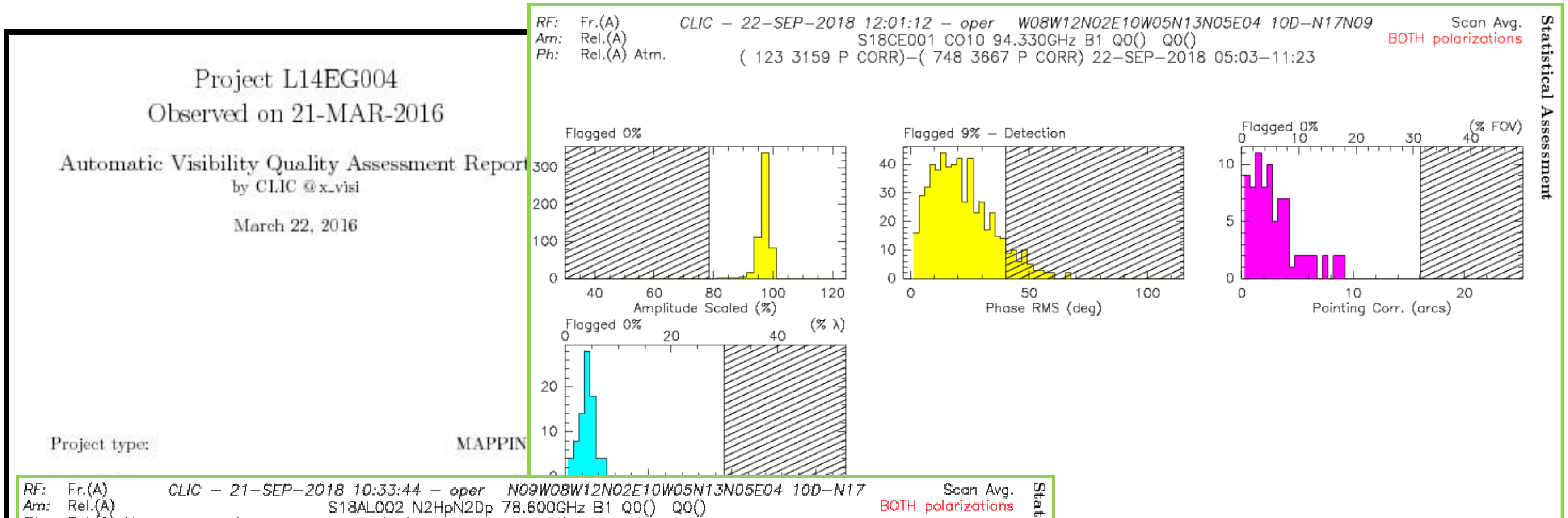


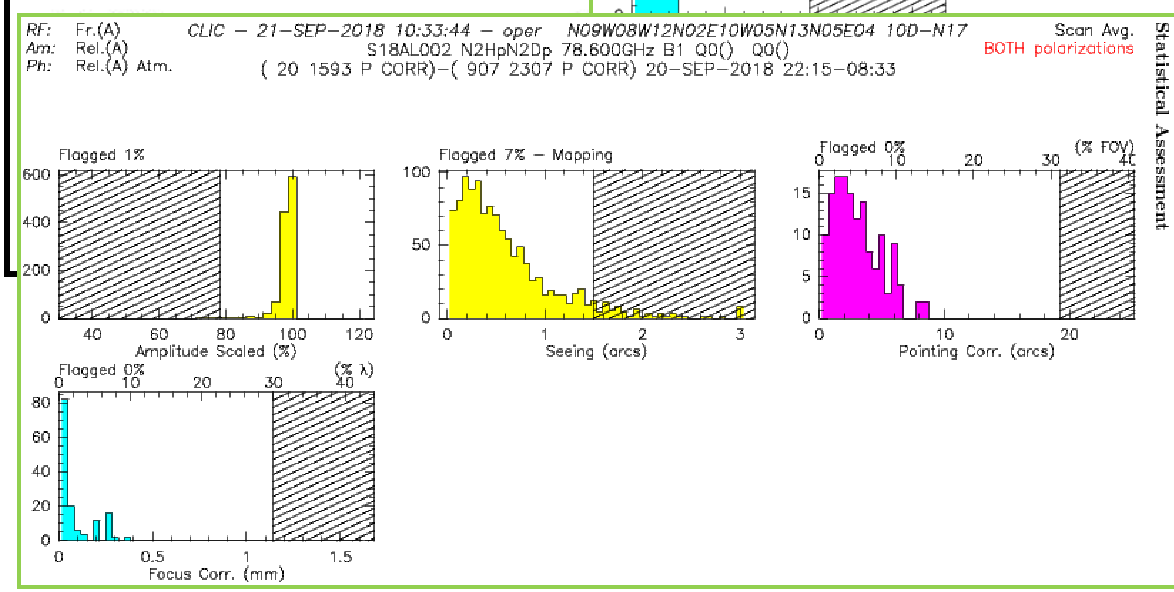
Amplitude rms



Phase / Seeing criteria

NOEMA pipeline: Visibility Assessment





Histogram of introduced flags at the end

NOEMA pipeline calibration done

NOEMA data calibration with the Pipeline

In practice…

Usual practice 1:

1) Check AoD notes
2) Run the pipeline
3) Look at the pipeline report
4) Create tables

Usual practice 2:

1) Check AoD notes
2) Run the pipeline
3) Look at the pipeline report
4) Introduce some correction according to AoD notes or L.C. advice
5) Create tables

Usual practice 3:

1) Check AoD notes
2) Run the pipeline
3) Look at the pipeline report
4) Introduce some correction according to AoD notes or L.C. advice
5) Recalibrate some step with widgets
6) Create tables

Usual practice 4:

If several tracks, we may verify the flux calibration consistency between tracks

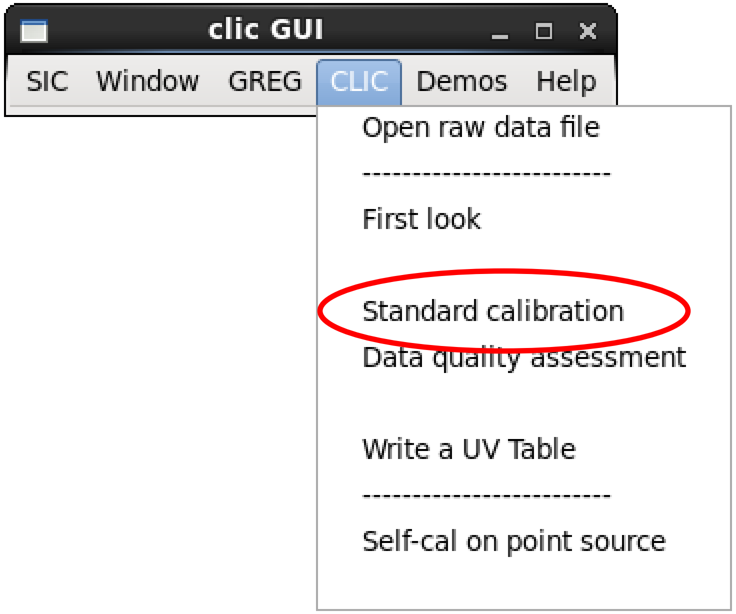
Calibration with Widgets

If we are not happy with pipeline calibration, we can repeat it partially or entirely from the same hpb file (this overwrites previous calibration)

Certain rules are to be followed however

Widgets : main menu

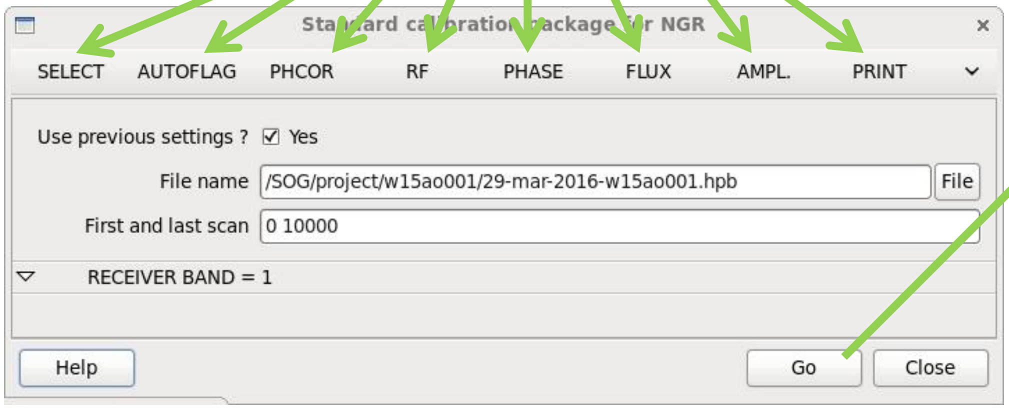
With widgets we can partially or entirely repeat the calibration of our project



Widgets: data calibration

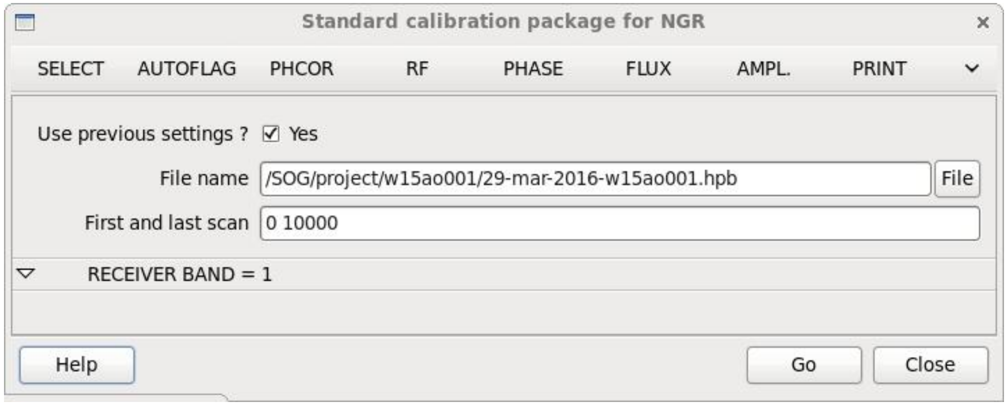
The Standard Calibration widget uses a logic similar to that of the pipeline (same scripts), widgets giving to the user the possibility of interact. @pipeline often uses more advanced solutions

Step by step, interacting by hand with semi-pipeline approach



GO: executes the entire data calibration **like the pipeline** does
(without the analysis of observing conditions)

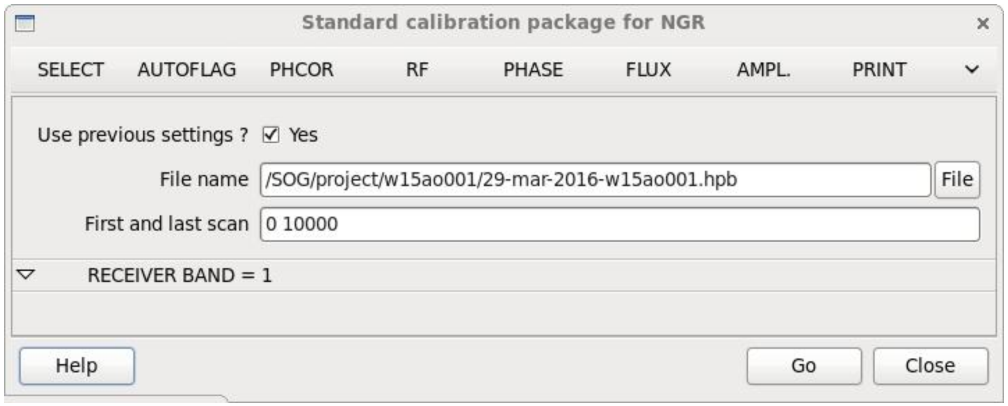
Widgets: to repeat a calibration step



Repetition of a step after the Pipeline Calibration:

- Click on Select at first
- Click on the Calibration Step to repeat
- Go one by one through all the following steps
  (from left to right, for example if we repeat the flux calibration, then we must repeat amplitude and print to save the new report)

Widgets: to introduce some change in the hpb file

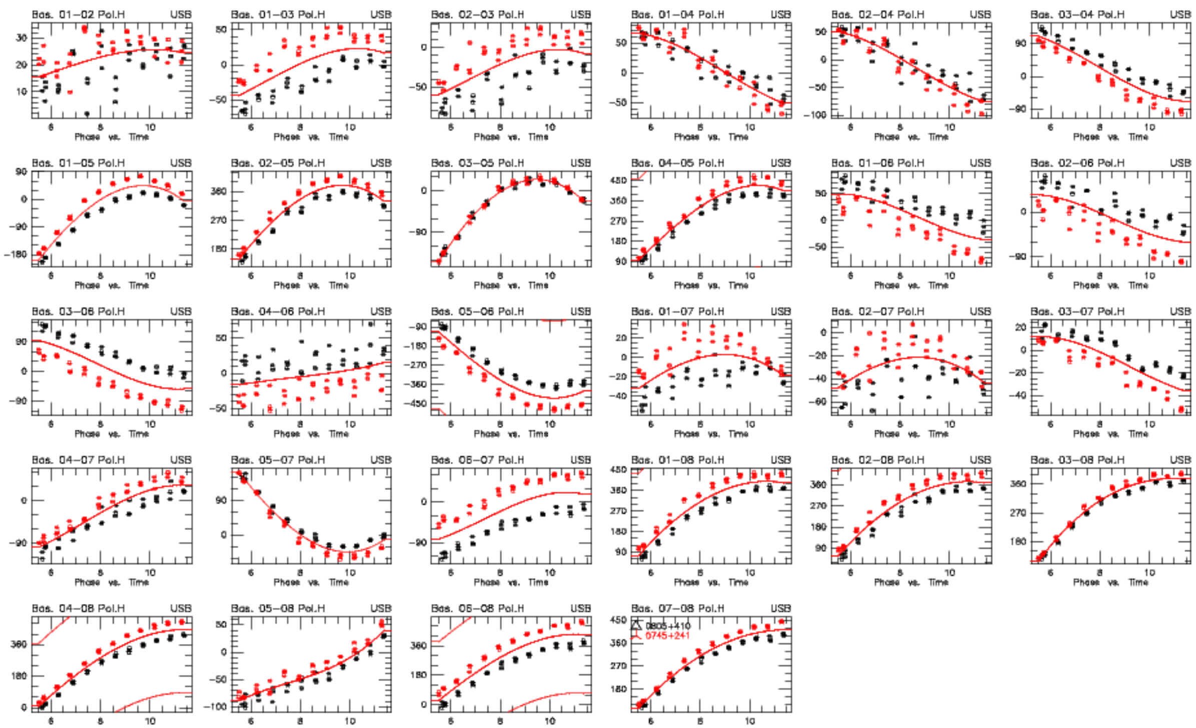


If some data are corrupted:

- Create a new hpb without those, or erase the corrupted data in the previous hpb file (ex: find /scan #, store quality 9)

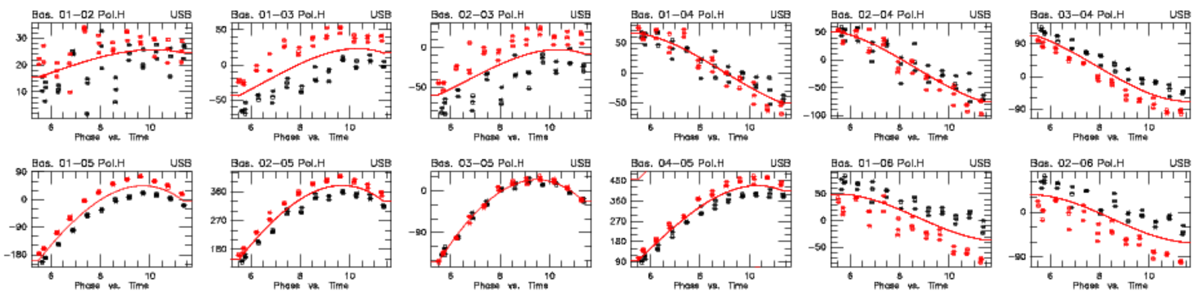
- Launch the “Pipeline” on the same track, or click on GO in the Standard Calibration

Widgets: to introduce a global correction into the hpb (ex: baseline model)



Example of phases affected by a “baseline” problem.
The separation of phases between two close calibrators and the large phase drifts are characteristics of a wrong baseline model. The position of the antennas must be re-determined This is an usual problem following a change of configuration until a new baseline model is obtained

Widgets: to introduce a global correction into the hpb (ex: baseline model)

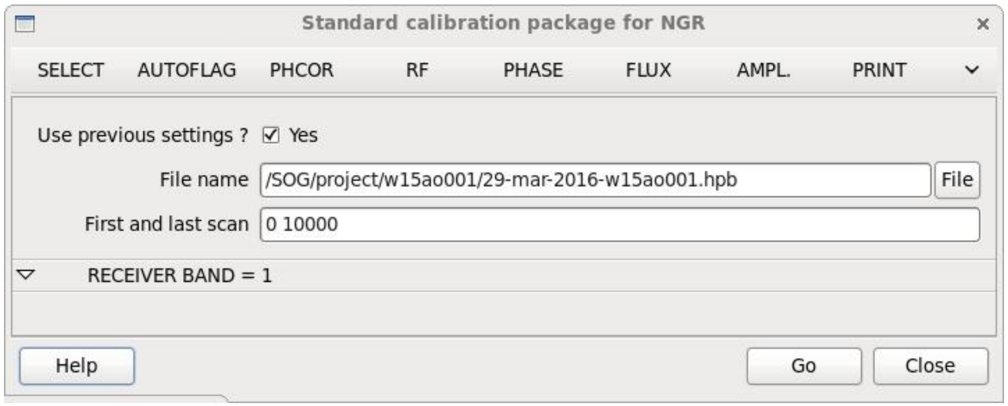


If a new baseline model is to be applied :

- Introduce the new baseline model in the hpb (in CLIC, following instructions of AoD or L.C.)
- Launch again the “Pipeline” on the same hpb file (no need of widgets if no other iteration is needed by hand)

close calibrators and the large phase drifts are characteristics of a wrong baseline model.
The position of the antennas must be re-determined
Usual problem following a change of configuration until a new baseline model is obtained

Widgets: to repeat calibration with different settings



Examples, if changes in the:

- Choice of Rf calibrator
- Choice of flux calibrator
- Choice of phase calibrator
- Change in the average of polarizations during calibration

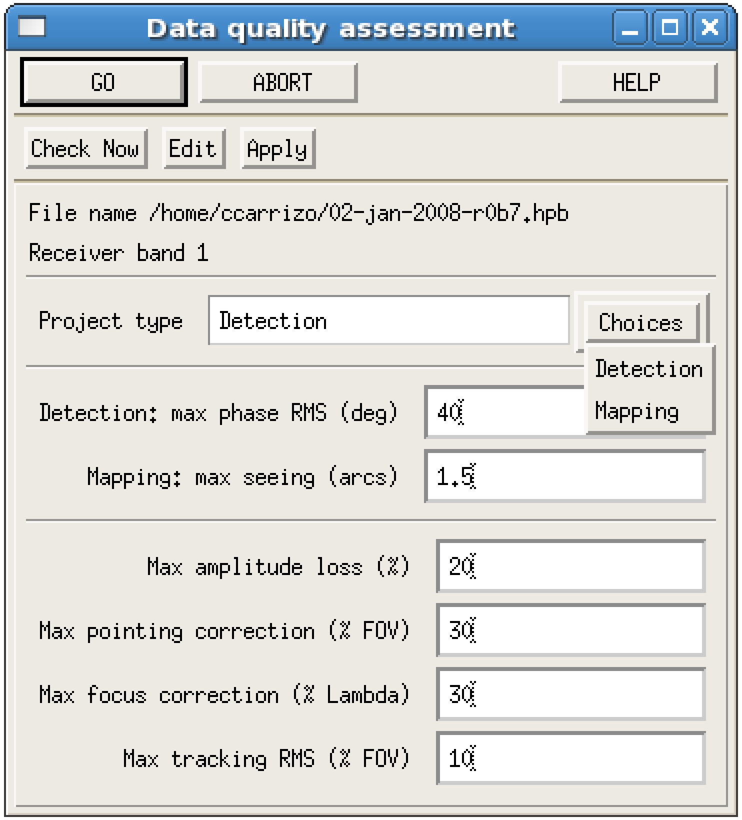
The pipeline can also be executed with new Settings:

- Repeat @pipeline

  or
- GO in Standard Calibration widget

Widgets: Visibility Assessment

Always evaluate the need/reasons for flagging following the Pipeline



- Pipeline is very restrictive for many projects (particularly for mapping projects, where a good UV-coverage is needed)
- With the widget, a report is created, and proposed flags can then be applied

advice

If the pipeline is running :

do not stop it, or exit CLIC if you did it

PIPELINEs in the future:

- The pipeline is a project in continuous evolution, getting adapted to new findings or changes

- With the arrival of new antennas (baselines from 45 to 66), a new data visualization may be implemented

- Many other optimizations are also foreseen in the years to come (example: integral flux consistency check for a project)

- A new architecture, likely different between Bure and Grenoble, will have to be defined

ADDITIONAL INFORMATION:

If several tracks :

Check the flux-calibration consistency

Check the flux-calibration consistency

Observed on 08-JUL-2018

Name	Flux (Jy) @152.8 GHz in LSB		Calibration
2013+370	2.38	*Computed*	
MWC349	1.50	*Fixed (model = 1.5)*	
1418+546	0.77	*Computed*	*phase/amp*
J1439+499	0.25	*Computed*	*phase/amp*
2230+114	5.04	*Computed*	*RF*

Observed on 09-JUL-2018

Name	Flux (Jy) @152.8 GHz in LSB		Calibration
3C279	8.01	*Computed*	*RF*
1418+546	0.78	*Computed*	*phase/amp*
J1439+499	0.26	*Computed*	*phase/amp*
3C454.3	7.68	*Computed*	
MWC349	1.50	*Fixed (model = 1.5)*	

Observed on 10-JUL-2018

Name	Flux (Jy) @152.8 GHz in LSB		Calibration
3C345	3.28	*Computed*	*RF*
MWC349	1.50	*Fixed (model = 1.5)*	
1418+546	0.72	*Computed*	*phase/amp*
J1439+499	0.24	*Computed*	*phase/amp*

Observed on 27-JUL-2018

Name	Flux (Jy) @152.8 GHz in LSB		Calibration
3C454.3	9.79	*Computed*	*RF*
MWC349	1.50	*Fixed (model = 1.5)*	
1418+546	0.66	*Computed*	*phase/amp*
J1439+499	0.24	*Computed*	*phase/amp*

Four different tracks: it is important to check the flux calibration consistency

We extract the derived flux for each calibrator from the first page of the calibration report

Check the flux-calibration consistency

	08/07	09/07	10/07	27/07
MWC349	1.5 F	1.5 F	1.5 F	1.5 F
1418+546	0.77	↗ +1% 0.78	↘ -8% 0.72	↘ -8% 0.66
J1439+499	0.25	↗ +4% 0.26	↘ -8% 0.24	0.24
3C454.3	-	7.68	-	9.79
3C345	-	-	3.28	-
3C279	-	8.01	-	-
2013+370	2.28	-	-	-
2230+114	5.04	-	-	-

5 other calibrators (3C454.3, 3C345, 3C279, etc) were observed in some tracks. We have regular monitorings of their fluxes, which could be used if we want to make some checks, but our flux-calibration accuracy would not be very high

The antenna efficiency values (or Jy/K factors) shown in the 1st page of calibration are related to the obtained fluxes. Checking those efficiencies (according to weather conditions) can only help to double-check flux consistency in case of doubts – this evaluation should only be made by experts (SOG)

Close dates = simpler interpretation
The flux of calibrators is known to change, but it should change less in short time scales

Our reference calibrator is marked in green, which was fixed (F) for every track

In red the phase calibrators are shown; if dates are close, we can check how estimated fluxes change in time to detect a possible common patterns

If MWC349 or LKHa101 would not be, those checks could help to fix a flux for the phase calibrators

In 09/07 track we can doubt if this common flux increase for phase calibrators is true. If we can identify in the data of MWC349 in 09/07 an explanation for a wrong estimate based on MWC349, we could fix the flux of a phase calibrator (likely the brightest and stable enough; check with SOG).
This is important if differences > 10%

Identify between all tracks those with more reliable flux calibration, i.e. better acquisitions, constant and reliable efficiencies and phase rms between MWC349/LKHa101 and phase calibrators

Check the flux-calibration consistency

	08/07	09/07	10/07	27/07
MWC349	1.5 F	Ignored	1.5 F	1.5 F
1418+546	0.77	(-2%) 0.75 F	(-4%) 0.72	(-8%) 0.66
J1439+499	0.25	0.25	(-4%) 0.24	0.24
3C454.3	-	7.38	-	9.79
3C345	-	-	3.28	-
3C279	-	7.70	-	-
2013+370	2.28	-	-	-
2230+114	5.04	-	-	-

We repeat with widgets this flux calibration

Identify between all tracks those with more reliable flux calibration, for instance

- better acquisitions,
- constant or reliable efficiencies (considering time changes),
- phase rms consistency between different used calibrators

After checking the track in 09/07, the acquisitions on MWC349 were not considered to be very representative of the conditions of the track (higher phase noise, increased decorrelation).
It was so decided to fix the flux of 1418+546 (the strongest) to an interpolated value between both surrounding days.
The calibrations on 08/07 and 10/07 were identified to be very good.

This change is also consistent with the values monitored for other calibrators in the table (to be checked with SOG)

We may have corrected for a possible error of ~ 4% in our relative flux calibration between tracks

If you are not an expert, avoid introducing big changes without SOG support

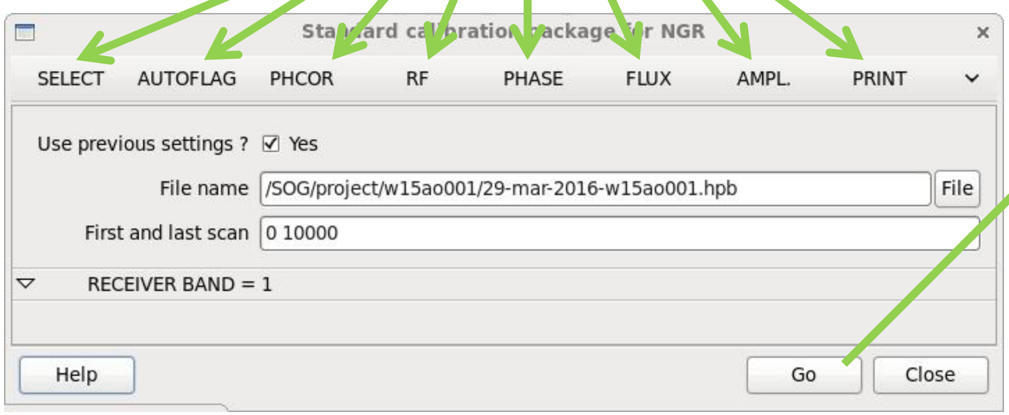
Widgets: data calibration

Some more explanations about the use of widgets…

Widgets: data calibration

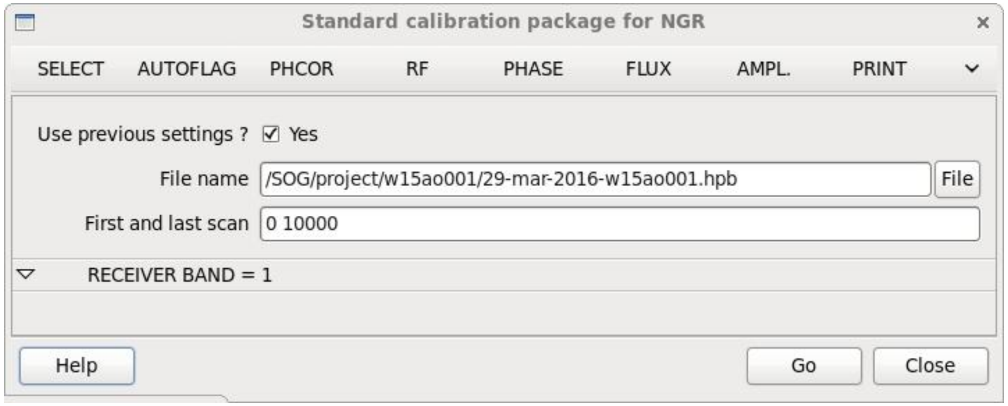
The Standard Calibration widget uses a logic similar to that of the pipeline (same scripts), widgets giving to the user the possibility of interact.
@pipeline often uses more advanced solutions

Step by step, interacting by hand with semi-pipeline approach



GO: executes the entire data calibration **like the pipeline** does
(without the analysis of observing conditions)

Widgets: data calibration

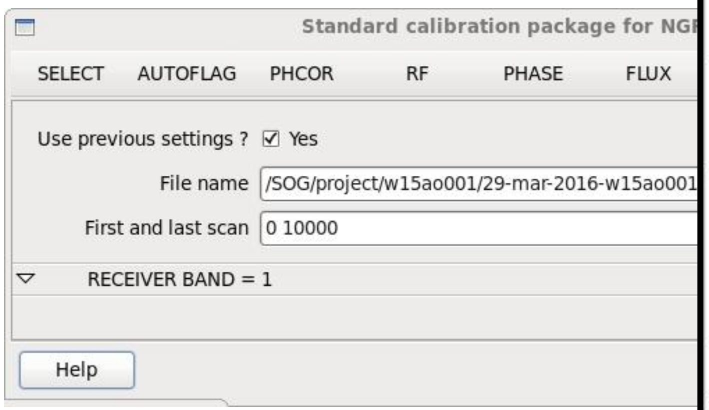


SELECT: to define needed variables at start, identify all calibrators, diff tuning ranges, and adopt previous settings if applicable.

Attention to messages in the prompt !!

Different variables to change the calibration default (“*do_atm*”, “*phcal*”, “*band_source*”, “*do_avpha*”, “*do_avpol*”)

Widgets: data cali

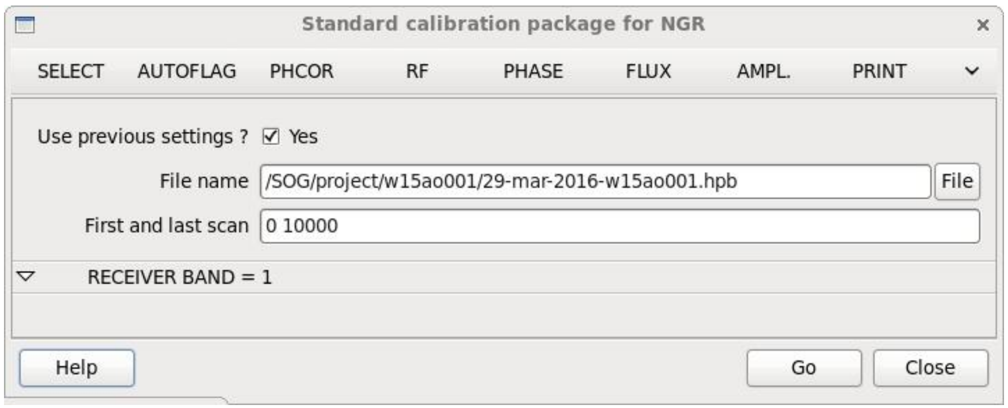


SELECT: to define needed var
tuning ranges, and adopt previ

Attention to <u>messages in the p</u>
Different variables to chang
(*"do_atm"*, *"phcal"*, *"band_*

```
---------------------------------------------------------
Atmospheric phase correction is applied according to
the PHCOR evaluation
After SELECT you can disable it with: let do_atm no
Phases are Degrees Continuous 10
---------------------------------------------------------
The minimum quality required for data selection is
AVERAGE. After SELECT you can change it with:
let min_qual "quality_flag"
---------------------------------------------------------
If no phase calibrator is found to be polarized, average
polarization mode is not selected for amplitude calibration
You can also change it with: let do_avpol yes
---------------------------------------------------------
After a first phase calibration, the pipeline script may change the
default phase calibration to happen in average polarization mode
You can also change it with: let do_avpha yes
---------------------------------------------------------
You can decide on the way to calibrate the phases and amplitudes
of the FLUX and RF calibrators by introducing their names in the
variable PHCAL (with 'let phcal "*"') and clicking again on SELECT
This is important if the phases of the data obtained with H and V
receivers are different (see last plots of the "FirstLook" report)
---------------------------------------------------------

Building the flux list...
I-LISTE,[3106] Source #  1    3C84           7 Observations
I-LISTE,[3106] Source #  2    LKHA101       11 Observations
I-LISTE,[3106] Source #  3    1222+216      50 Observations
Source  1        3C84 Fluxes   0.00  0.00 12.96  0.00 Jy
Source  2     LKHA101 Fluxes   0.00  0.00  0.65  0.00 Jy
Source  3    1222+216 Fluxes   0.00  0.00  0.97  0.00 Jy
I-LISTE,[3530] Source #  1    3C84           7 Observations
I-LISTE,[3530] Source #  2    LKHA101       11 Observations
I-LISTE,[3530] Source #  3    1222+216      50 Observations

Recommended bandpass calibrator 3C84 in scan range 1
Selected bandpass calibrator 3C84 in scan range 1

Selecting calibrators for phase and amplitude calibration...
Sources :
I-LISTE,[3103] Source #  1    NC           300 Observations
Calibrators :
I-LISTE,[3524] Source #  1    1222+216      42 Observations
The recommended calibrator is   1222+216
which has been adopted for phase and amplitude calibration

USB tuning for receiver 3

CLIC>
```

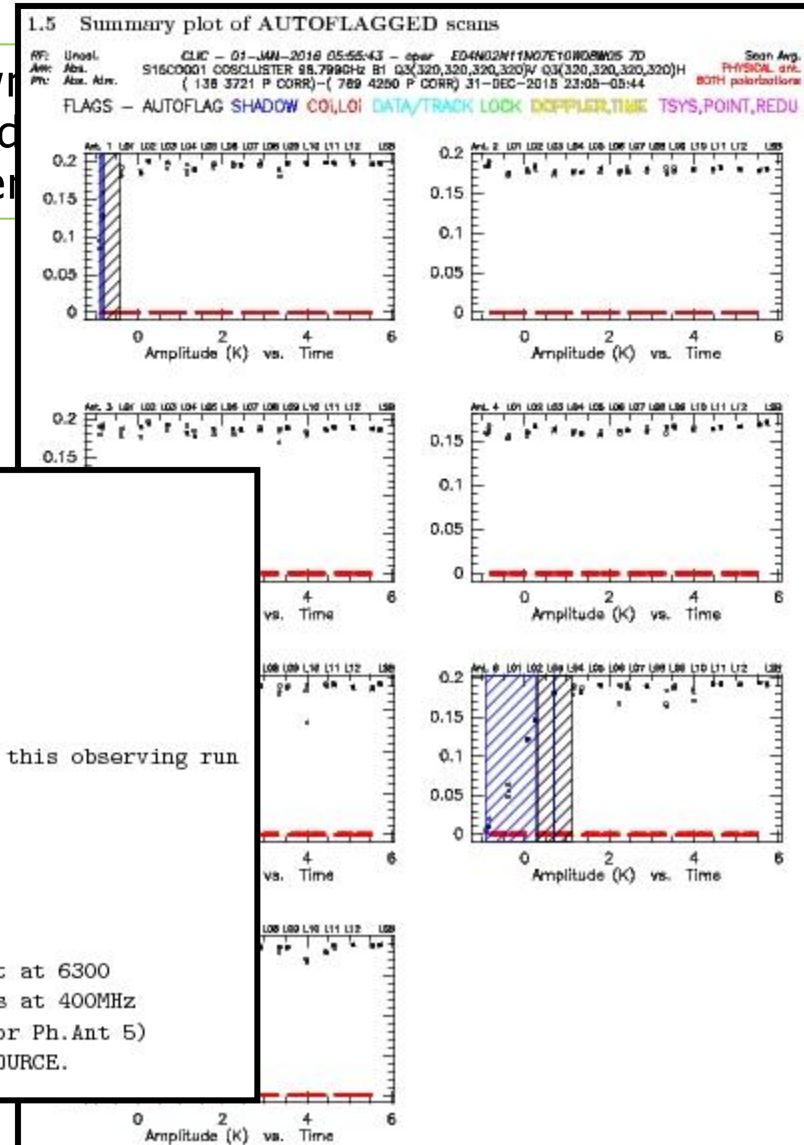
Widgets: data calibration



AUTOFLAG: Verify in a database if known problems exist in the project and if other features are identified (source not surrounded by calibrators, spectral config change, presence of parasites, etc)

Widgets: data calibration

AUTOFLAG: Verify in a database if known
project and if other features are identified
calibrators, spectral config change, preser



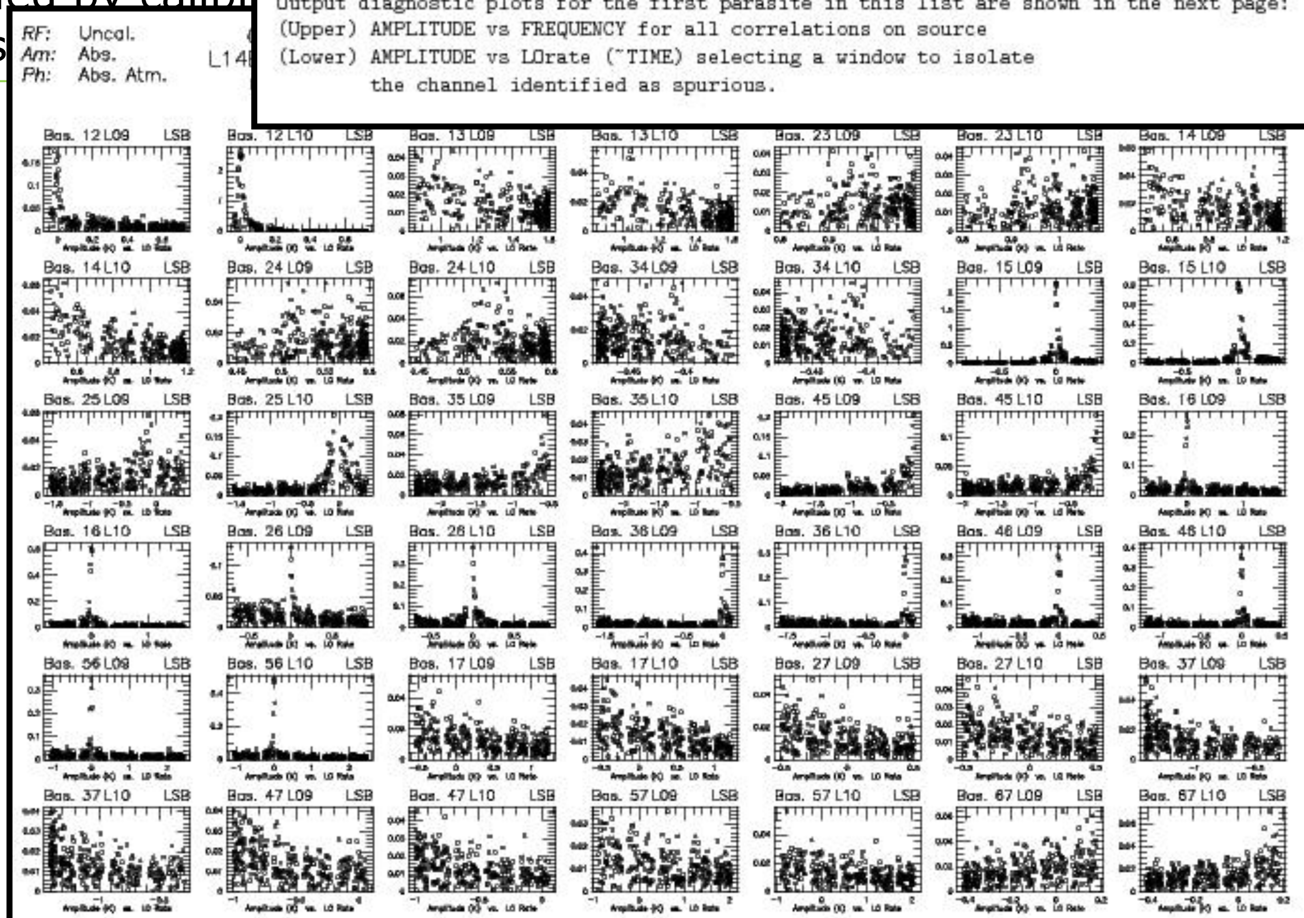
1.4 Calibration warnings:

```
! Spurious lines of unknown origin are detected in:
! Ant Nar/Wid  I_F freq   SKY freq   IF1 freq  IF2 freq  IF3 freq
!  #  cor_unit    MHz        MHz        MHz       MHz       MHz
   6   W  2     2868.16   134411.69   5231.84   2868.16   2868.16
   6   W  2     2870.12   134413.64   5229.88   2870.12   2870.12

 Possible spurious signals are identified in AUTOCORRELATIONS during this observing run
   6   W  2     2870.12   134413.64   5229.88   2870.12   2870.12
   6   W  2     2872.07   134415.59   5227.93   2872.07   2872.07
   6   W  2     2874.02   134417.55   5225.98   2874.02   2874.02
   3   W  4     2221.68   131965.20   7678.32   2221.68   2221.68
   3   W  4     2223.63   131967.16   7676.37   2223.63   2223.63
!
! Also, some known spurious lines triggered by the IF processor exist at 6300
! & 4500MHz IF1 freqs (at ~  133343.19 & 135143.19MHz), and sometimes at 400MHz
! from those (eg. at 6700MHZ IF1 freq [~ 132943.19 MHz in the sky] for Ph.Ant 5)
 NO spurious signals are identified in the average CORRELATIONS ON SOURCE.
```

Widgets: data calibration

AUTOFLAG: Verify i
project and if other p
surrounded by calibr
parasites

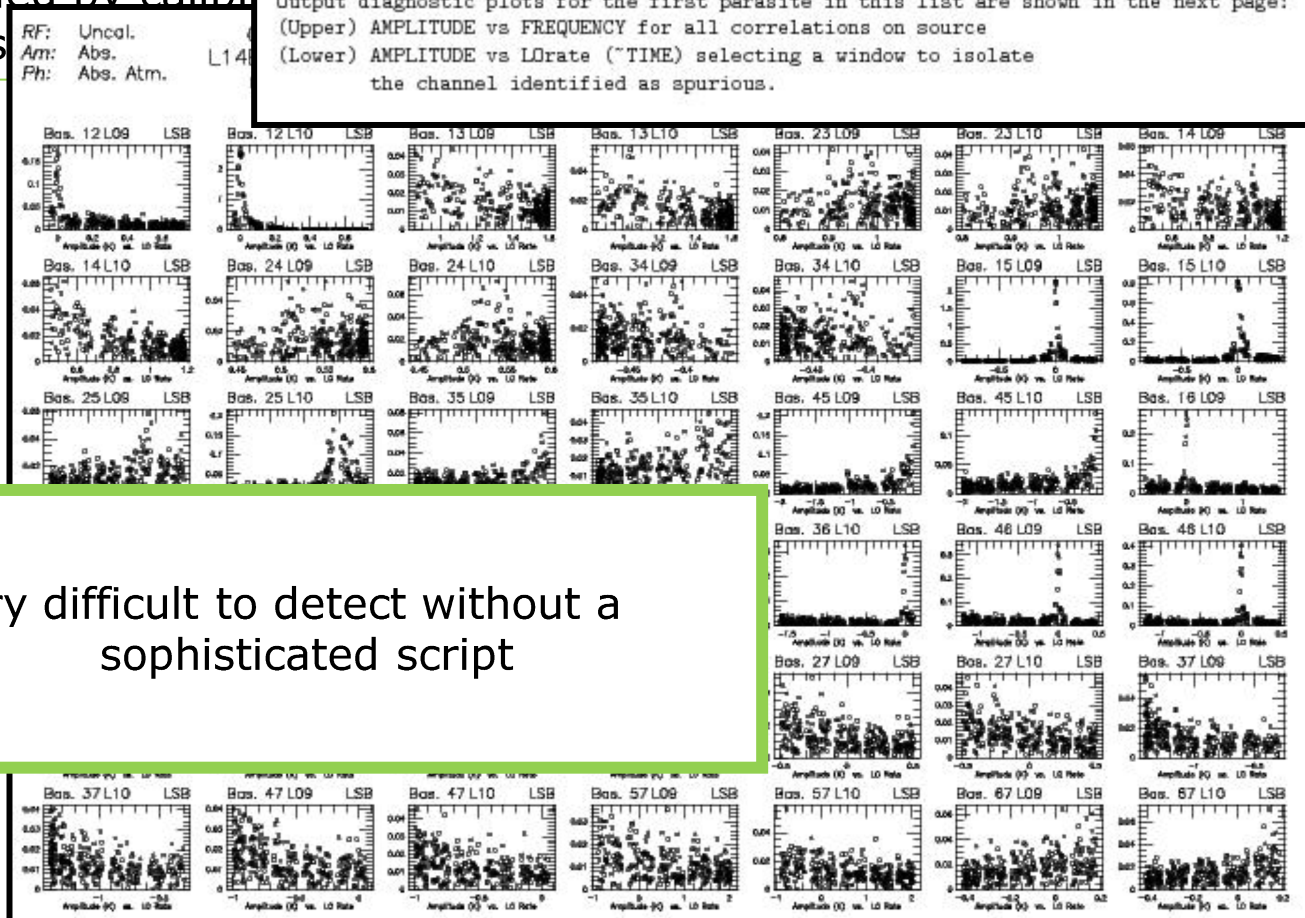
```
 Spurious signals are identified in the average CORRELATIONS ON SOURCE.
 Lines falling at the parasites frequencies should be carefully checked.
! Parasite search ONLY in WIDEX units (may be seen in other subbands)
!WIDEX  CHAN  IF1 freq    SKY freq   AMPvsFREQ  S/N AMPvsLORATE  S/N   LO_RATE(MAX)
!               MHz          MHz      # found          #found
L09L10   179   5751.37   138748.81          4   24           12  269           0.00
 Output diagnostic plots for the first parasite in this list are shown in the next page:
 (Upper) AMPLITUDE vs FREQUENCY for all correlations on source
 (Lower) AMPLITUDE vs LOrate (~TIME) selecting a window to isolate
         the channel identified as spurious.
```



Widgets: data calibration

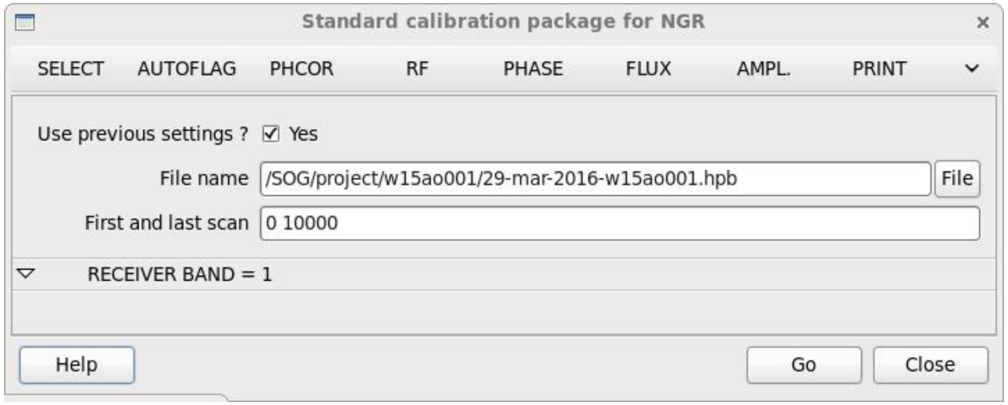
AUTOFLAG: Verify i
project and if other p
surrounded by calibr
parasites

```
 Spurious signals are identified in the average CORRELATIONS ON SOURCE.
 Lines falling at the parasites frequencies should be carefully checked.
! Parasite search ONLY in WIDEX units (may be seen in other subbands)
!WIDEX  CHAN  IF1 freq    SKY freq    AMPvsFREQ  S/N AMPvsLORATE  S/N   LO_RATE(MAX)
!              MHz          MHz       # found         #found
L09L10   179   5751.37   138748.81          4   24            12  269           0.00
 Output diagnostic plots for the first parasite in this list are shown in the next page:
 (Upper) AMPLITUDE vs FREQUENCY for all correlations on source
 (Lower) AMPLITUDE vs LOrate (~TIME) selecting a window to isolate
         the channel identified as spurious.
```



Very difficult to detect without a sophisticated script

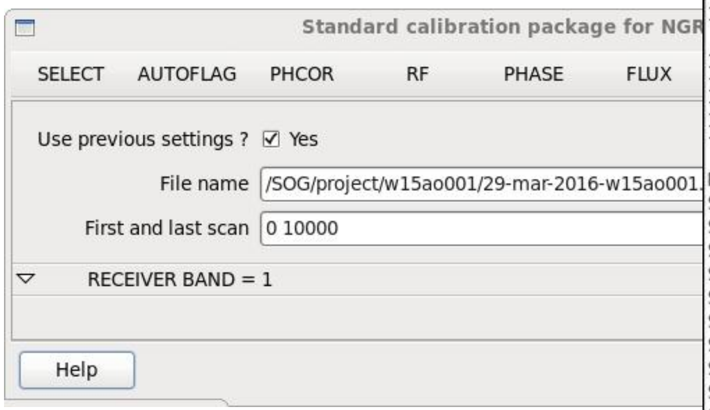
Widgets: data calibration



PHCOR: Verify the quality of the WVR correction

Also, a polarization assessment is made for the phase calibrators, which will determine the mode for the Amplitude calibration

Widgets: data calibration



PHCOR: Verify the quality of th

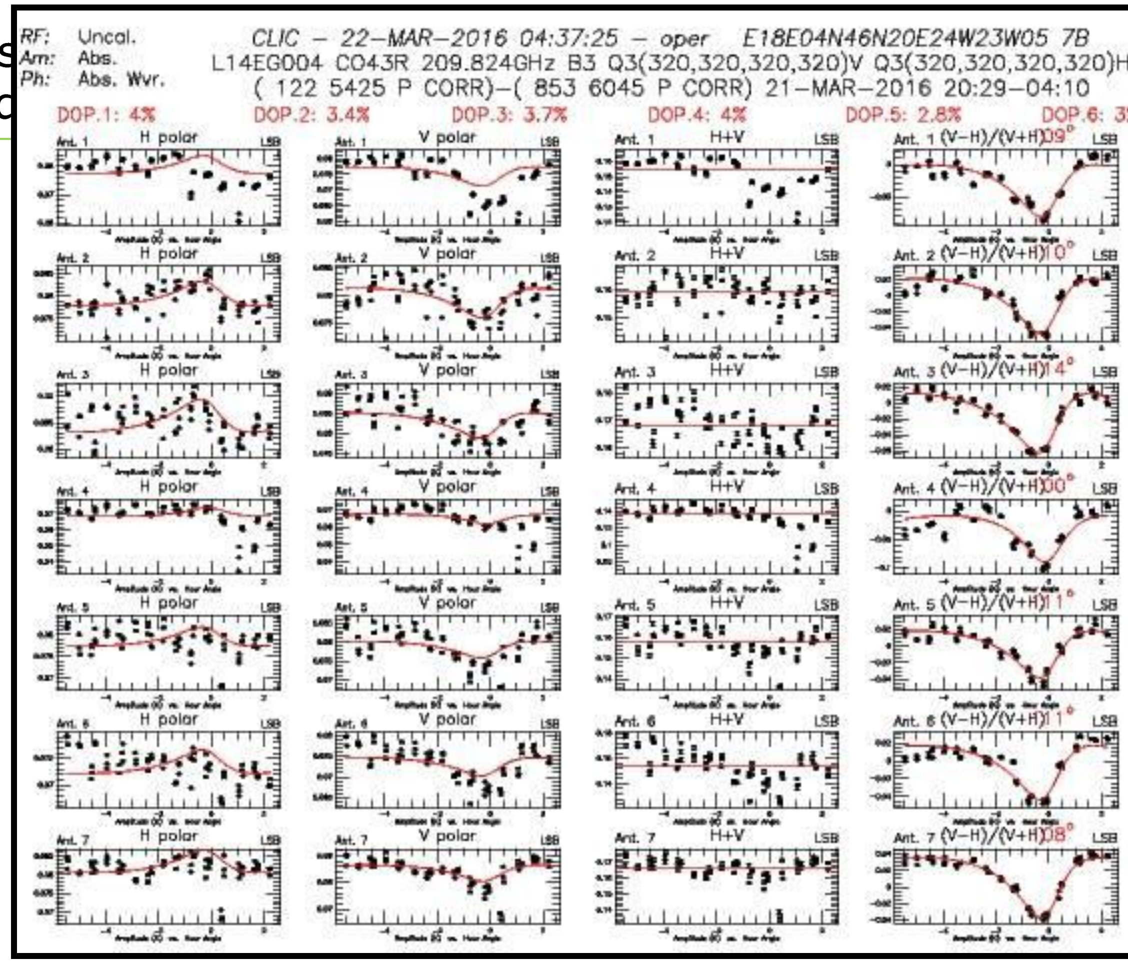
Also, a polarization assessment
will determine the mode for the

```
CLIC>
I-CLIC_SET,[3038] Polarization mode: BOTH
 Selected data quality is   8 (Worst)
I-CLIC_MASK,[3530] Masked - Ant 1: SATURATI SHADOW, Ant 2: SATURATI SHADOW, Ant
I-CLIC_MASK,[3530] 5: SATURATI SHADOW, Ant 6: SATURATI SHADOW, Ant 7: SATURATI
I-STORE_CORRECTION,[3530] Using 0.050 as a fraction of amplitude for threshold
I-CLIC_MASK,[3524] Masked - no flags

Real-time atmospheric phase correction
Scans 3050 to 3050 : phase correction disabled (ant  1 2 3)
Scans 3051 to 3051 : phase correction disabled (ant  2 5 6 7)
Scans 3052 to 3052 : phase correction disabled (ant  1 2 3 4)
Scans 3054 to 3054 : phase correction disabled (ant  1 2 3 4 6 7)
Scans 3055 to 3055 : phase correction disabled (ant  6 7)
Scans 3056 to 3056 : phase correction disabled (ant  2 3 4 6 7)
Scans 3066 to 3066 : phase correction disabled (ant  2 7)
Scans 3069 to 3069 : phase correction disabled (ant  2 3 7)
Scans 3100 to 3100 : phase correction disabled (ant  1 2 3)
Scans 3106 to 3111 : phase correction disabled (ant  1 2 3)
Scans 3112 to 3112 : phase correction disabled (ant  1 2 3 6 7)
Scans 3113 to 3135 : phase correction disabled (ant  1 2 3 4 6 7)
Scans 3139 to 3139 : phase correction disabled (ant  1 2 6 7)
Scans 3140 to 3140 : phase correction disabled (ant  2 3 4 6 7)
Scans 3530 to 3530 : phase correction disabled (ant  2 7)

Ant. 1: real-time phase correction based on 22 GHz WVR
Ant. 2: real-time phase correction based on 22 GHz WVR
Ant. 3: real-time phase correction based on 22 GHz WVR
Ant. 4: real-time phase correction based on 22 GHz WVR
Ant. 5: real-time phase correction based on 22 GHz WVR
Ant. 6: real-time phase correction based on 22 GHz WVR
Ant. 7: real-time phase correction based on 22 GHz WVR
Checking for interference in WVR channels ...
 Y axis  : DH_WVR1 (CTS)       , * to  *
 Y axis  : DH_WVR2 (CTS)       , * to  *
 Y axis  : DH_WVR3 (CTS)       , * to  *
 All antennas selected:
 Logical | Physical | Station |  X Offset  |  Y Offset  |  Z Offset /99
    1    |    1     |   E04   | -0.000000 |  0.000000 |  0.000000
    2    |    2     |   N02   | -0.000692 | -0.001628 |  0.001929
    3    |    3     |   N11   |  0.001134 |  0.001636 | -0.000213
    4    |    4     |   N07   |  0.001731 | -0.000648 | -0.000923
    5    |    5     |   E10   |  0.001597 |  0.002325 |  0.001269
    6    |    6     |   W08   |  0.001015 |  0.001247 | -0.002045
    7    |    7     |   W05   |  0.000740 |  0.001418 | -0.000059
   0 in  364 scans
```

Widgets: data calibration

PHCOR: Verify the quality of the WVR correction

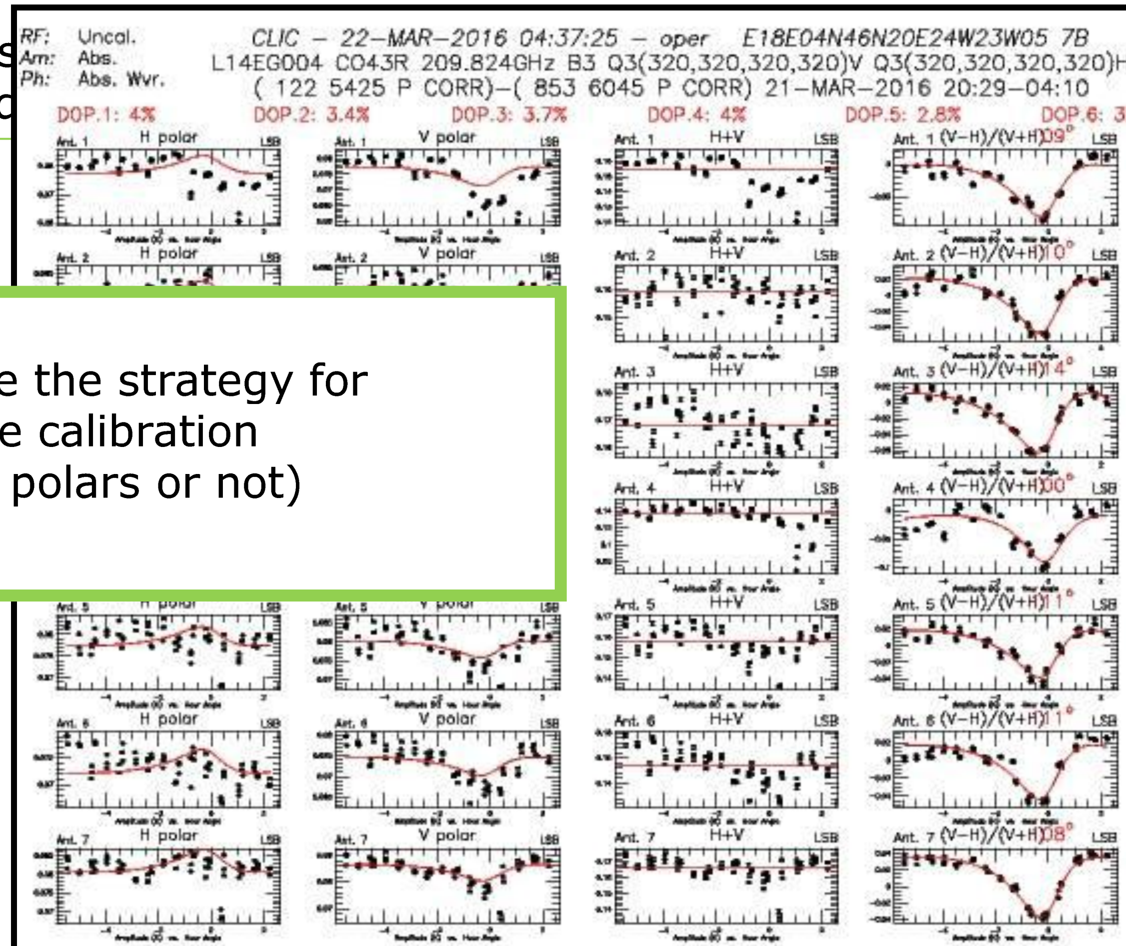
Also, a polarization ass
will determine the mod



Widgets: data calibration

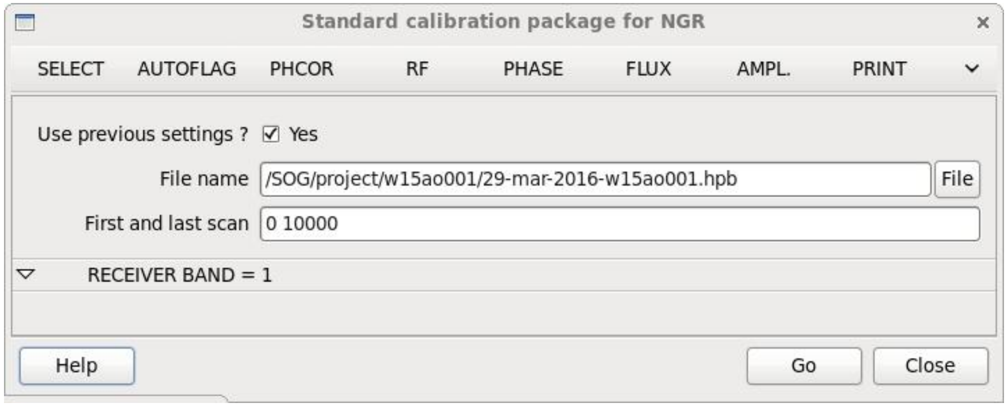
PHCOR: Verify the quality of the WVR correction

Also, a polarization ass
will determine the mod



This will define the strategy for
amplitude calibration
(averaging polars or not)

Widgets: data calibration



RF: Measure the receiver bandpass (RF) to calibrate the source data, for every spectral calibration unit (narrow and widex) and tuning (gain) range.

The selected RF calibrator in variable “band_source".

Possible parasites (instrumental or lines from calibrators) are searched and removed from calibration .

Widgets: data calibration

RF: I
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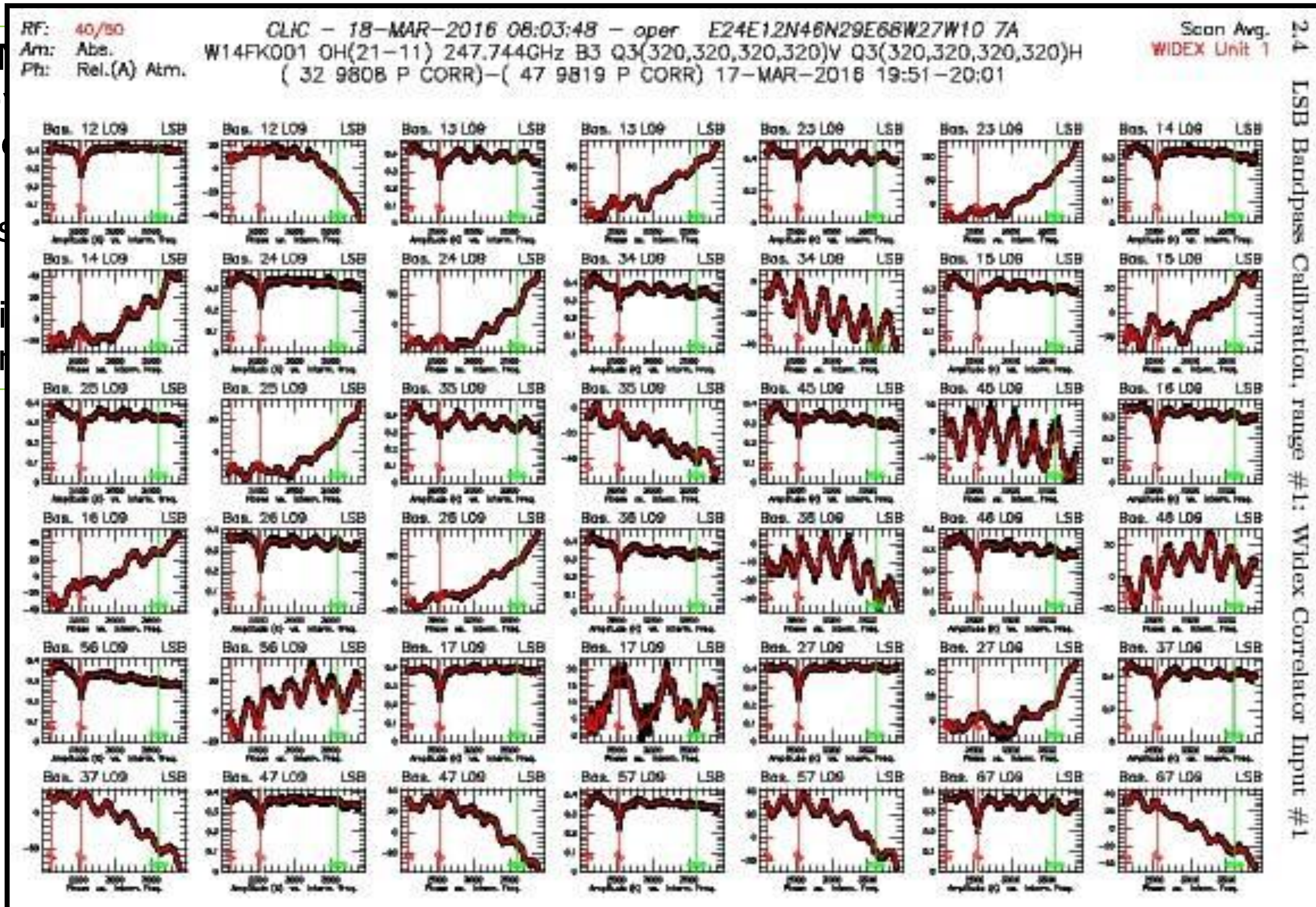
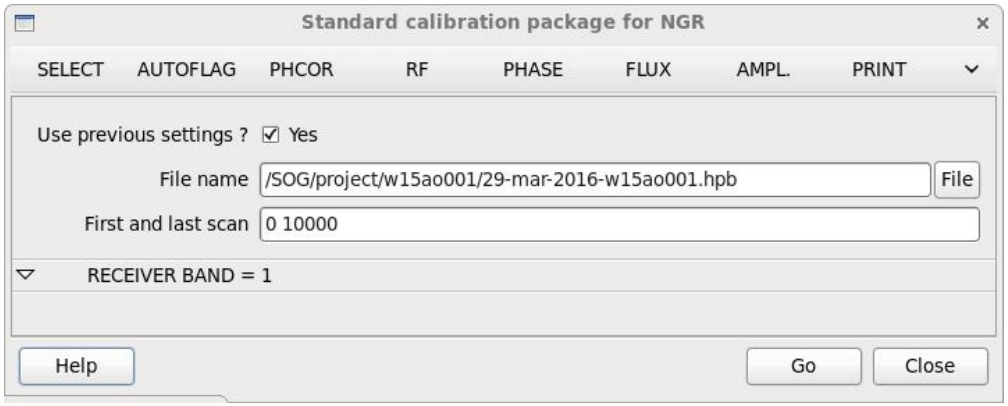


Widgets: data calibration



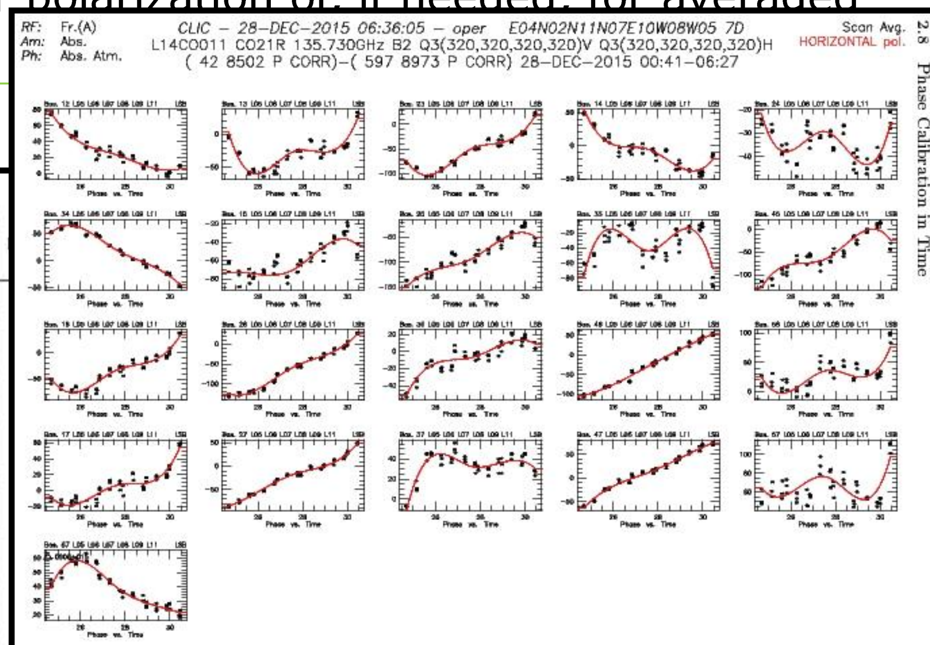
Phase: Remove instrumental phases in time by observing a close point-like source (phase=0).

A solution is searched per polarization or, if not satisfactory, for averaged polarizations

Widgets: data calibration

Phase: Remove instrumental phases in time by observing a close point-like source (phase=0).

A solution is searched per polarization or, if needed, for averaged polarizations



1.6 Time Calibration:

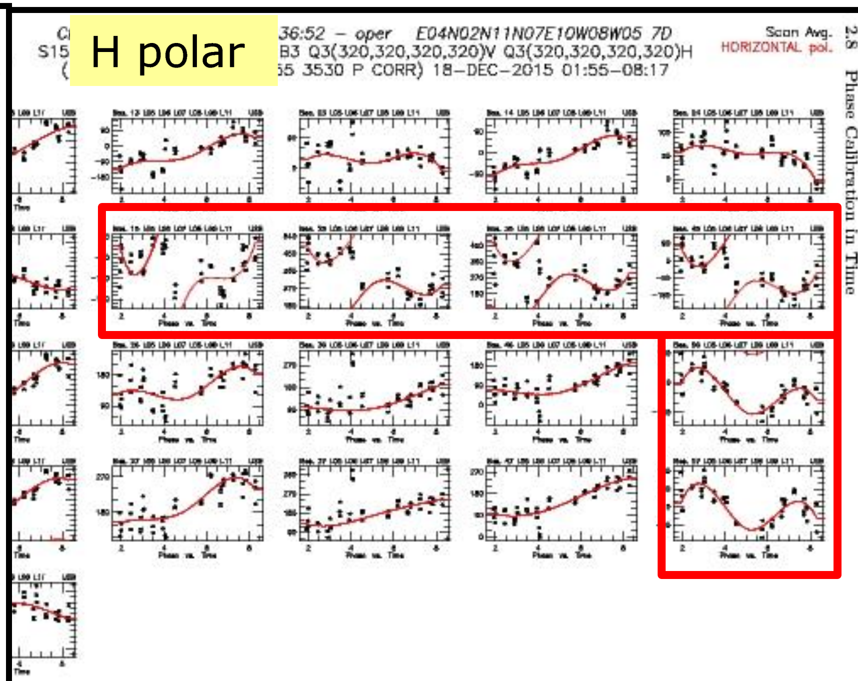
Receiver 3		Phase r.m.s.		H−V			
		Polar H (deg.)	Polar V (deg.)	Mean (deg.)	Max. (deg.)		
Base 12	(112.0 m)	23.5	23.1	1.2	√		
Base 13	(428.0 m)	39.6	39.6	2.6	√		
Base 23	(378.0 m)	41.0	41.2	1.3	√		
Base 14	(241.0 m)	26.3	26.2	-0.2	√		
Base 24	(171.0 m)	22.9	22.9	-1.4	√		
Base 34	(208.0 m)	30.0	29.9	-2.7	√		
Base 15	(48.0 m)	13.6	13.8	-3.2	√		
Base 25	(160.0 m)	30.9	30.9	-4.5	√		
Base 35	(457.0 m)	40.9	40.9	-5.8	√		
Base 45	(280.0 m)	30.7	30.8	-3.0	√		
Base 16	(328.0 m)	37.7	37.8	0.5	√		
Base 26	(216.0 m)	31.3	31.4	-0.8	√		
Base 36	(366.0 m)	47.2	47.2	-2.1	√		
Base 46	(210.0 m)	29.7	29.8	0.7	√		
Base 56	(376.0 m)	43.4	43.8	3.7	√		
Base 17	(184.0 m)	25.5	25.4	-3.2	√		
Base 27	(72.0 m)	13.1	13.1	-4.4	√	2.9	2.9
Base 37	(360.0 m)	37.7	37.6	-5.8	√	3.2	3.2
Base 47	(155.0 m)	20.0	20.1	-3.0	√	4.3	4.3
Base 57	(232.0 m)	32.3	32.3	0.0	√	3.6	3.6
Base 67	(144.0 m)	23.4	23.6	-3.7	√	3.2	3.2

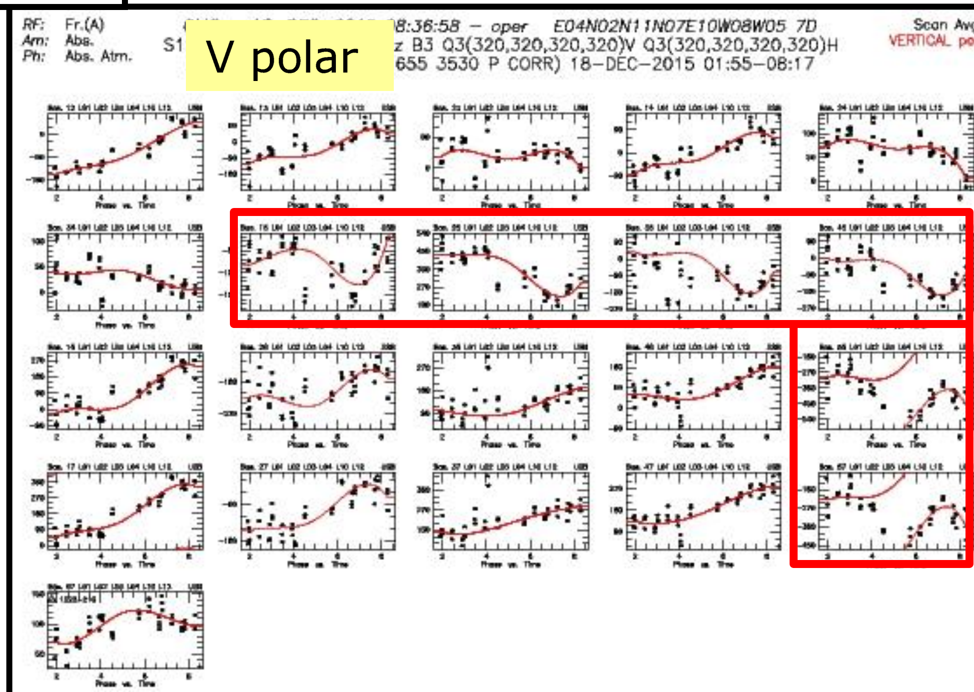
* Average of the H- and V-amplitudes

1.7 Time Calibration:†

Receiver 3		Phase r.m.s. Polar H (deg.)	Phase r.m.s. Polar V (deg.)	H−V Mean (deg.)	H−V Max. (deg.)	Ampl. Polar H (%)	Ampl. Polar V (%)
Base 12	(39.0 m)	26.0	26.1	7.	√	11.2	11.4
Base 13	(101.0 m)	49.4	49.0	-1.	√	9.3	9.1
Base 23	(72.0 m)	38.3	38.5	-9.	√	12.1	11.2
Base 14	(71.0 m)	30.5	30.0	-6.	√	9.6	11.8
Base 24	(40.0 m)	21.4	21.5	-13.	√	12.5	11.9
Base 34	(32.0 m)	24.1	23.4	-4.	√	12.0	11.9
Base 15	(48.0 m)	46.8	37.4	14.	170.2	8.7	9.5
Base 25	(86.0 m)	48.4	53.3	6.	179.1	14.8	16.1
Base 35	(133.0 m)	65.2	70.9	-20.	169.0	12.6	12.0
Base 45	(109.0 m)	52.1	56.1	20.	165.1	13.0	13.7
Base 16	(96.0 m)	47.6	47.3	0.	√	10.3	11.0
Base 26	(62.0 m)	35.4	36.1	-6.	√	14.5	14.8
Base 36	(94.0 m)	49.9	50.1	2.	√	10.6	11.5
Base 46	(73.0 m)	38.4	38.6	6.	√	11.4	11.7
Base 56	(144.0 m)	50.9	69.1	-27.	176.6	11.2	12.8
Base 17	(72.0 m)	36.2	36.2	-42.	√	10.7	10.2
Base 27	(39.0 m)	26.9	26.4	-50.	51.7	11.7	11.4
Base 37	(87.0 m)	47.7	47.7	-41.	√	10.8	10.4
Base 47	(60.0 m)	31.1	31.4	-36.	√	10.3	11.1
Base 57	(120.0 m)	46.5	63.6	-57.	157.2	11.8	13.1
Base 67	(24.0 m)	16.1	15.7	-43.	46.1	8.3	8.9

† Phase calibration averaged on H- and V-phases

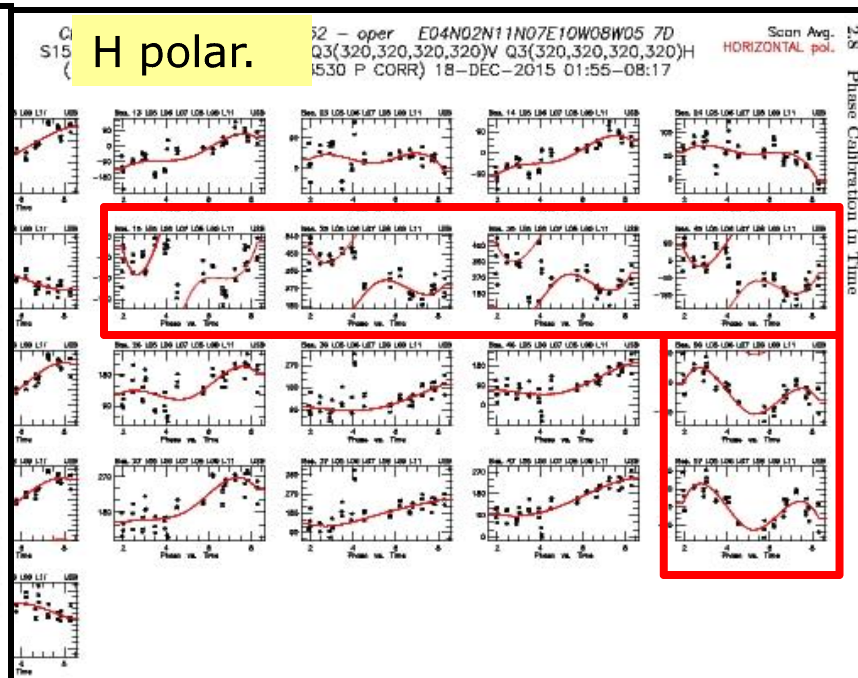


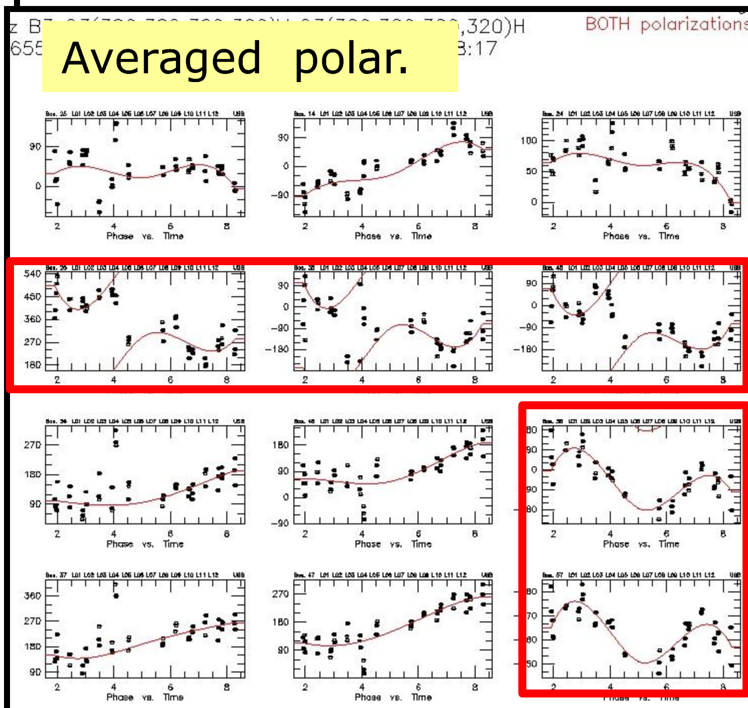


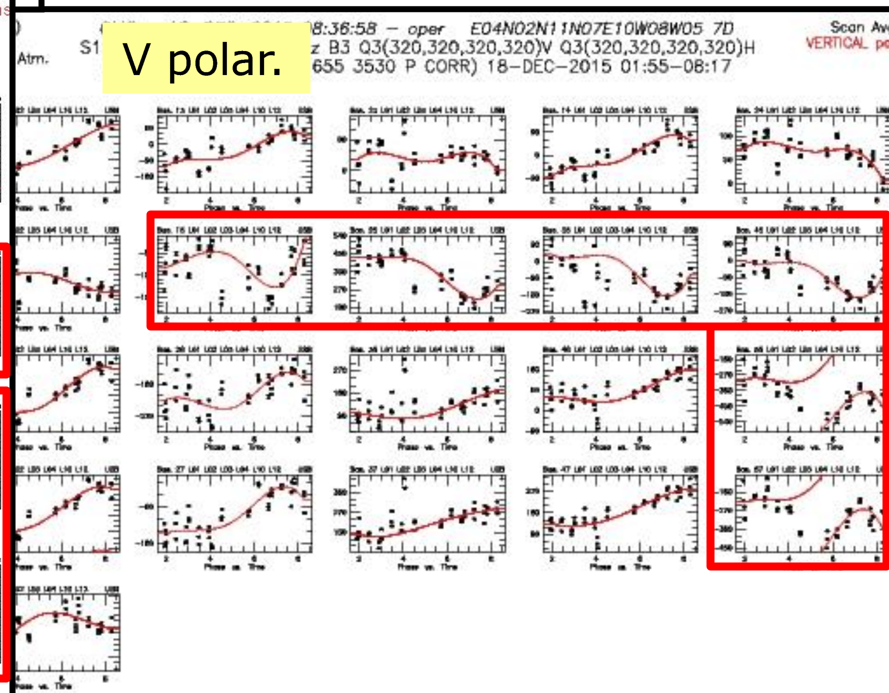
1.7 Time Calibration:†

Receiver 3		Phase r.m.s. Polar H (deg.)	Phase r.m.s. Polar V (deg.)	H−V Mean (deg.)	H−V Max. (deg.)	Ampl. Polar H (%)	Ampl. Polar V (%)
Base 12	(39.0 m)	26.0	26.1	7.[illegible]	√	11.2	11.4
Base 13	(101.0 m)	49.4	49.0	-1.[illegible]	√	9.3	9.1
Base 23	(72.0 m)	38.3	38.5	-9.[illegible]	√	12.1	11.2
Base 14	(71.0 m)	30.5	30.0	-6.[illegible]	√	9.6	11.8
Base 24	(40.0 m)	21.4	21.5	-13.[illegible]	√	12.5	11.9
Base 34	(32.0 m)	24.1	23.4	-4.[illegible]	√	12.0	11.9
Base 15	(48.0 m)	46.8	37.4	14.[illegible]	170.2	8.7	9.5
Base 25	(86.0 m)	48.4	53.3	6.[illegible]	179.1	14.8	16.1
Base 35	(133.0 m)	65.2	70.9	-20.[illegible]	169.0	12.6	12.0
Base 45	(109.0 m)	52.1	56.1	20.[illegible]	165.1	13.0	13.7
Base 16	(96.0 m)	47.6	47.3	0.[illegible]	√	10.3	11.0
Base 26	(62.0 m)	35.4	36.1	-6.[illegible]	√	14.5	14.8
Base 36	(94.0 m)	49.9	50.1	2.[illegible]	√	10.6	11.5
Base 46	(73.0 m)	38.4	38.6	6.[illegible]	√	11.4	11.7
Base 56	(144.0 m)	50.9	69.1	-27.[illegible]	176.6	11.2	12.8
Base 17	(72.0 m)	36.2	36.2	-42.[illegible]	√	10.7	10.2
Base 27	(39.0 m)	26.9	26.4	-50.[illegible]	51.7	11.7	11.4
Base 37	(87.0 m)	47.7	47.7	-41.[illegible]	√	10.8	10.4
Base 47	(60.0 m)	31.1	31.4	-36.[illegible]	√	10.3	11.1
Base 57	(120.0 m)	46.5	63.6	-57.[illegible]	157.2	11.8	13.1
Base 67	(24.0 m)	16.1	15.7	-43.[illegible]	46.1	8.3	8.9

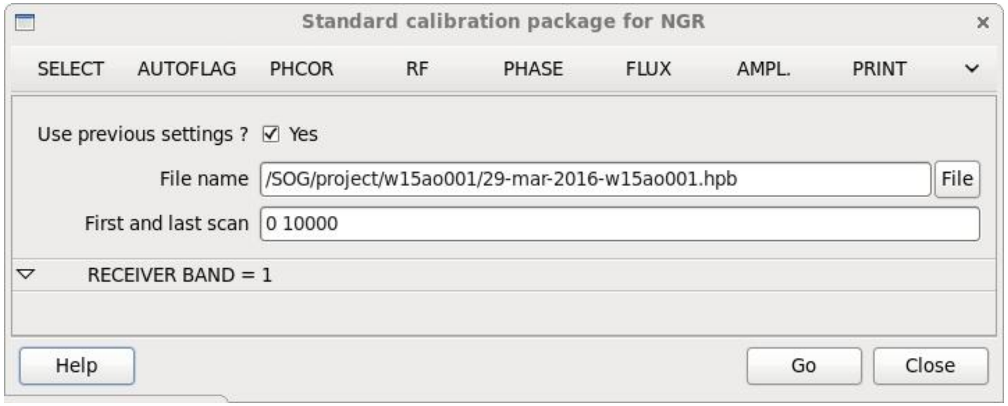
† Phase calibration averaged on H- and V-phases







Widgets: data calibration



Flux: MWC349 and LKH401 are the current absolute references for NOEMA.

The acquisitions with less decorrelation are used as reference for flux calibration, removing possible contaminating lines

A monitoring of efficiencies is made to evaluate the validity of the flux calibration.

Widgets: data calibration

Flux: MWC349 and LKH401 are the current absolute references for NOEMA.

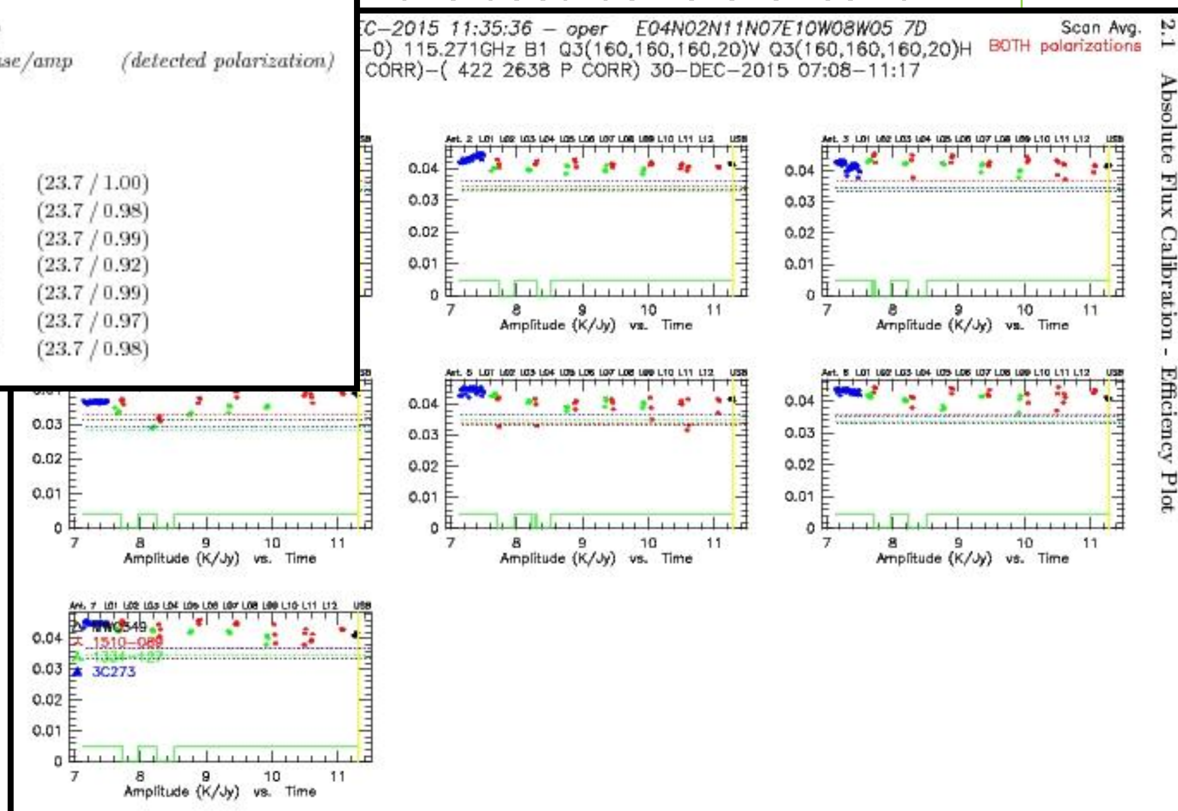
n are used as reference for

1.1 Calibrators

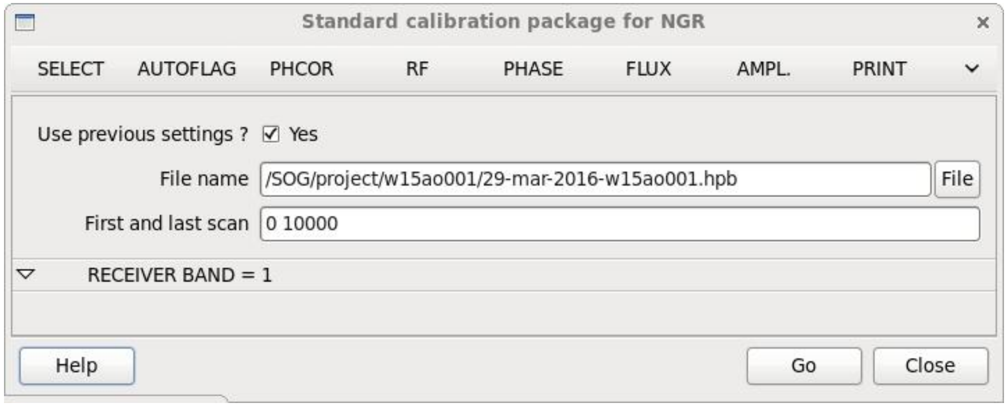
Name	Flux (Jy) @115.3 GHz		Calibration	
3C273	13.99	*Computed*		
1334-127	3.18	*Computed*	*RF*	
1510-089	4.83	*Computed*	*phase/amp*	*(detected polarization)*
MWC349	1.26	*Fixed (model = 1.26)*		

1.2 Efficiencies

Antenna 1 (A1)	23.6	Jy/K	(23.7 / 1.00)
Antenna 2 (A2)	24.1	Jy/K	(23.7 / 0.98)
Antenna 3 (A3)	23.9	Jy/K	(23.7 / 0.99)
Antenna 4 (A4)	25.7	Jy/K	(23.7 / 0.92)
Antenna 5 (A5)	24.0	Jy/K	(23.7 / 0.99)
Antenna 6 (A6)	24.4	Jy/K	(23.7 / 0.97)
Antenna 7 (A7)	24.2	Jy/K	(23.7 / 0.98)



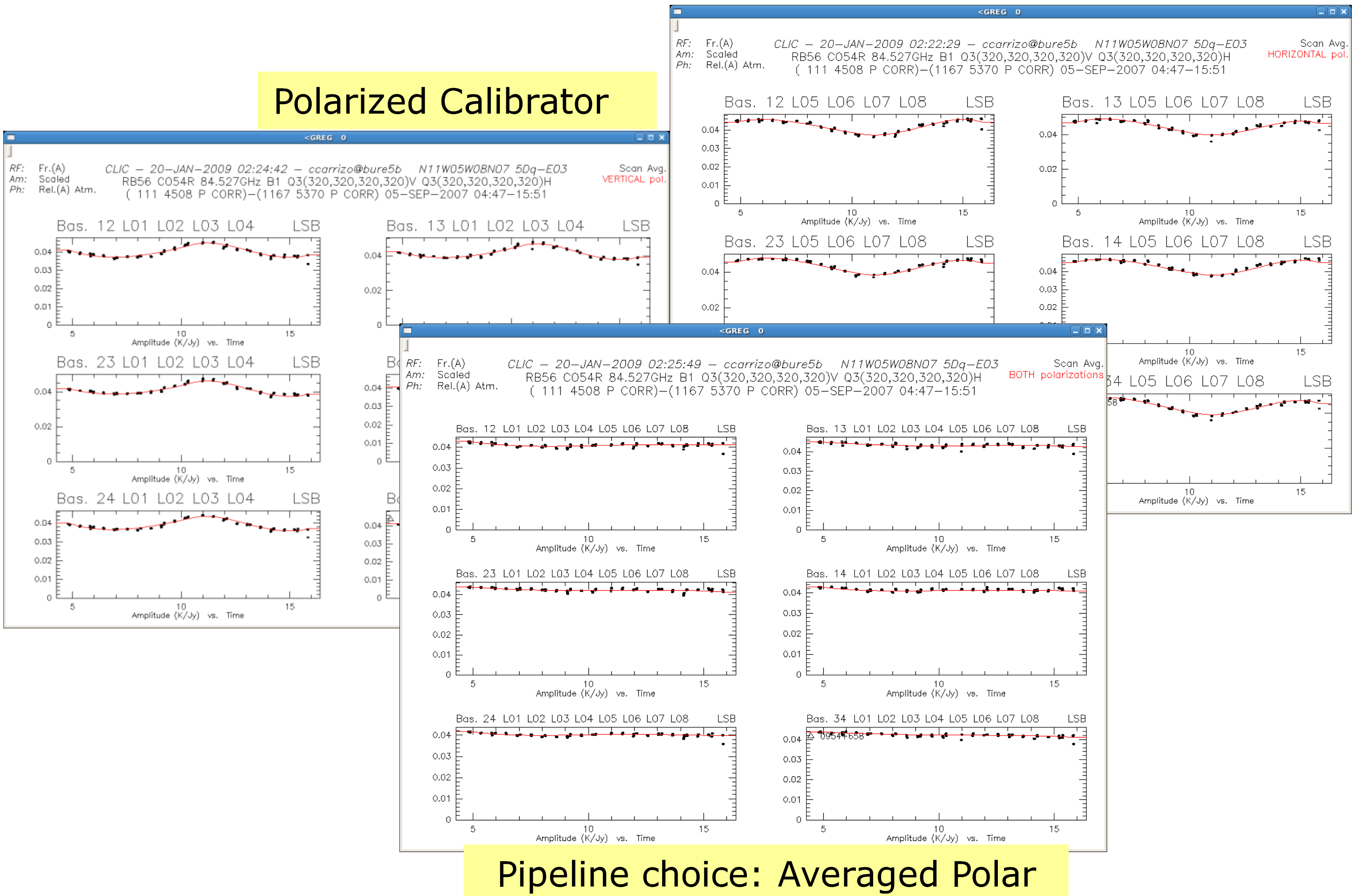
Widgets: data calibration



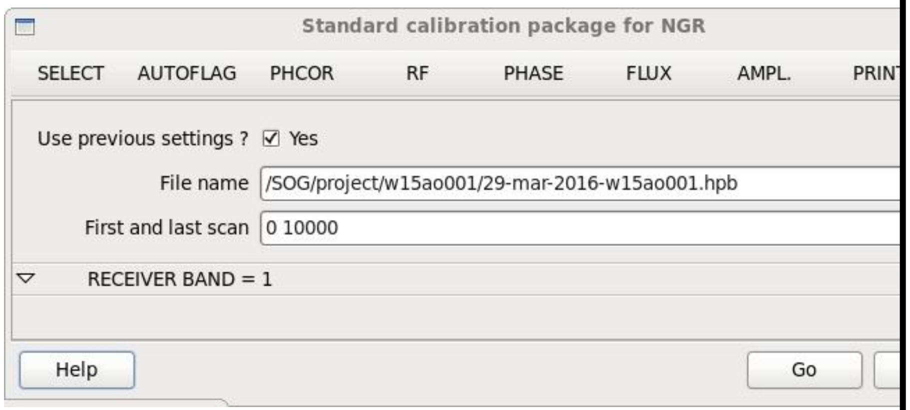
Ampl: Remove instrumental amplitudes in time by observing a close point-like source (constant amplitude).

Polarizations are averaged if phase calibrators are found to be polarized.

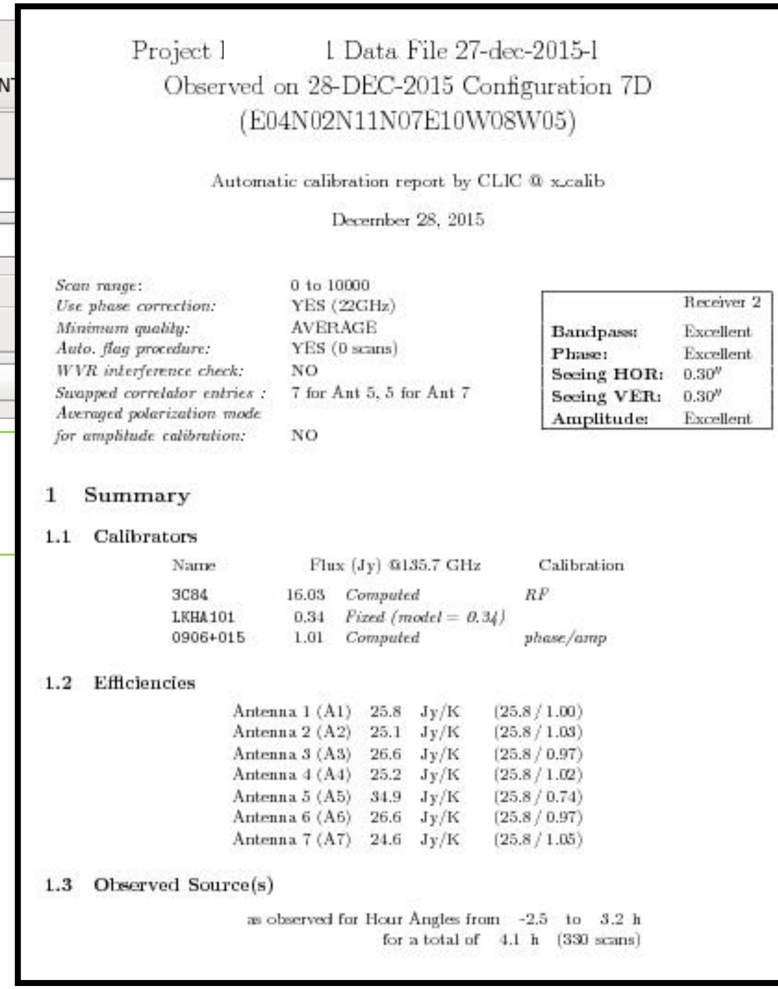
Widgets: data calibration



Widgets: data calibration



Print: Print in a report the summary of choices and results



Project l l Data File 27-dec-2015-l
Observed on 28-DEC-2015 Configuration 7D
(E04N02N11N07E10W08W05)

Automatic calibration report by CLIC @ x_calib

December 28, 2015

Scan range:	0 to 10000
Use phase correction:	YES (22GHz)
Minimum quality:	AVERAGE
Auto. flag procedure:	YES (0 scans)
WVR interference check:	NO
Swapped correlator entries :	7 for Ant 5, 5 for Ant 7
Averaged polarization mode for amplitude calibration:	NO

	Receiver 2
Bandpass:	Excellent
Phase:	Excellent
Seeing HOR:	0.30″
Seeing VER:	0.30″
Amplitude:	Excellent

1 Summary

1.1 Calibrators

Name	Flux (Jy) @135.7 GHz		Calibration
3C84	16.03	*Computed*	*RF*
1KHA101	0.34	*Fixed (model = 0.34)*	
0906+015	1.01	*Computed*	*phase/amp*

1.2 Efficiencies

Antenna 1 (A1)	25.8	Jy/K	(25.8 / 1.00)
Antenna 2 (A2)	25.1	Jy/K	(25.8 / 1.03)
Antenna 3 (A3)	26.6	Jy/K	(25.8 / 0.97)
Antenna 4 (A4)	25.2	Jy/K	(25.8 / 1.02)
Antenna 5 (A5)	34.9	Jy/K	(25.8 / 0.74)
Antenna 6 (A6)	26.6	Jy/K	(25.8 / 0.97)
Antenna 7 (A7)	24.6	Jy/K	(25.8 / 1.05)

1.3 Observed Source(s)

as observed for Hour Angles from -2.5 to 3.2 h
for a total of 4.1 h (330 scans)