

Calibration in Radio Astronomy

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What is Calibration ?

Calibration typically involves measuring some parameter of a system using a known Input and the measured Output.

$$O = P.I \text{ or } P = I^{-1}O$$

($P \rightarrow$ unknown parameter, I known, O measured).

Measured versus True visibilities

$$V'_{ij} = G_{ij}(t, \nu).V_{ij} + \epsilon_{ij} + \eta_{ij}$$

where, $G_{ij} = g_i \cdot g_j^*$

$\epsilon_{ij} \rightarrow$ Offset, $\eta_{ij} \rightarrow$ Noise

Determining Calibrations

Make sense when $\epsilon_{ij}, \eta_{ij} \ll G_{ij}.V_{ij}$

Interested in V_{ij} .

$$G_{ij}(t, \nu) \approx G_{ij}(t).G_{ij}(\nu)$$

Interested in lesser no. of variables.
Antenna based solutions.

Bandpass Calibration (g_ν)

Observe a strong Calibrator (flux= S).

$$V'_{ij}(t, \nu) = (g_i(t).g_i(\nu)).(g_j(t).g_j(\nu))^*.S \quad (1)$$

$$V'_{ij}(t, \nu_0) = (g_i(t).g_i(\nu_0)).(g_j(t).g_j(\nu_0))^*.S \quad (2)$$

→ Ref. Chan.

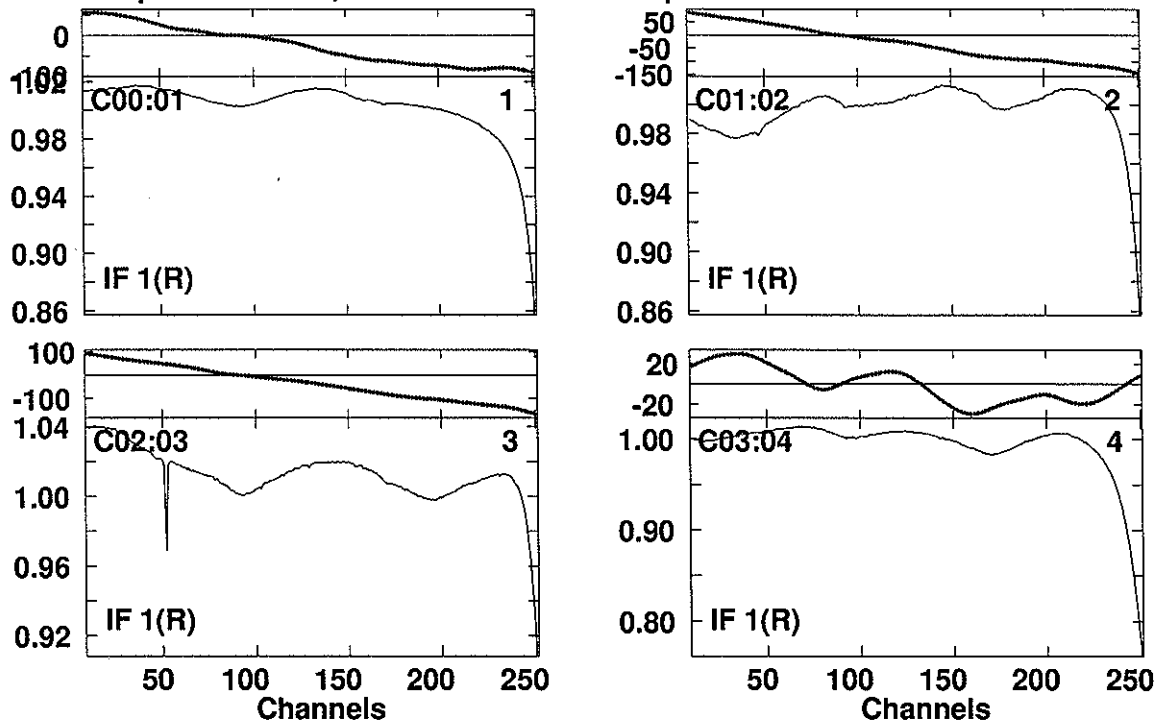
$$(1) \div (2) :$$

Visibilities normalised w.r.t. a frequency channel.

$$V'_{ij}(t, \nu) \div V'_{ij}(t, \nu_0) = (g_i(\nu)/g_i(\nu_0)).(g_j(\nu)/g_j(\nu_0))^*$$

$g_i(\nu)/g_i(\nu_0) \rightarrow$ Bandpass calibration.

Plot file version 12 created 02-JUN-2009 10:51:33
 21MAR.GSB.NE.FITLD.1
 Freq = 1.2800 GHz, Bw = 16.667 MH Bandpass table # 1



Lower frame: BP ampl Top frame: BP phase
 Bandpass table spectrum Antenna: *
 Timerange: 00/19:23:39 to 01/03:54:45

Figure 1. Typical Bandshape for GMRT antennas.

All the Freq. channels have prop.
 similar to ν_0 .
 Collapse Channels.

Calibration $g(t)$

$$\text{Now } g(t) = g(t) \cdot g(\nu_0)$$

$$V'_{ij}(t) = g_i(t) \cdot g_j^*(t) \cdot S$$

Primary and Secondary calibrator:

Ionospheric phase Direction dependent.

Observe calibrator close to source.

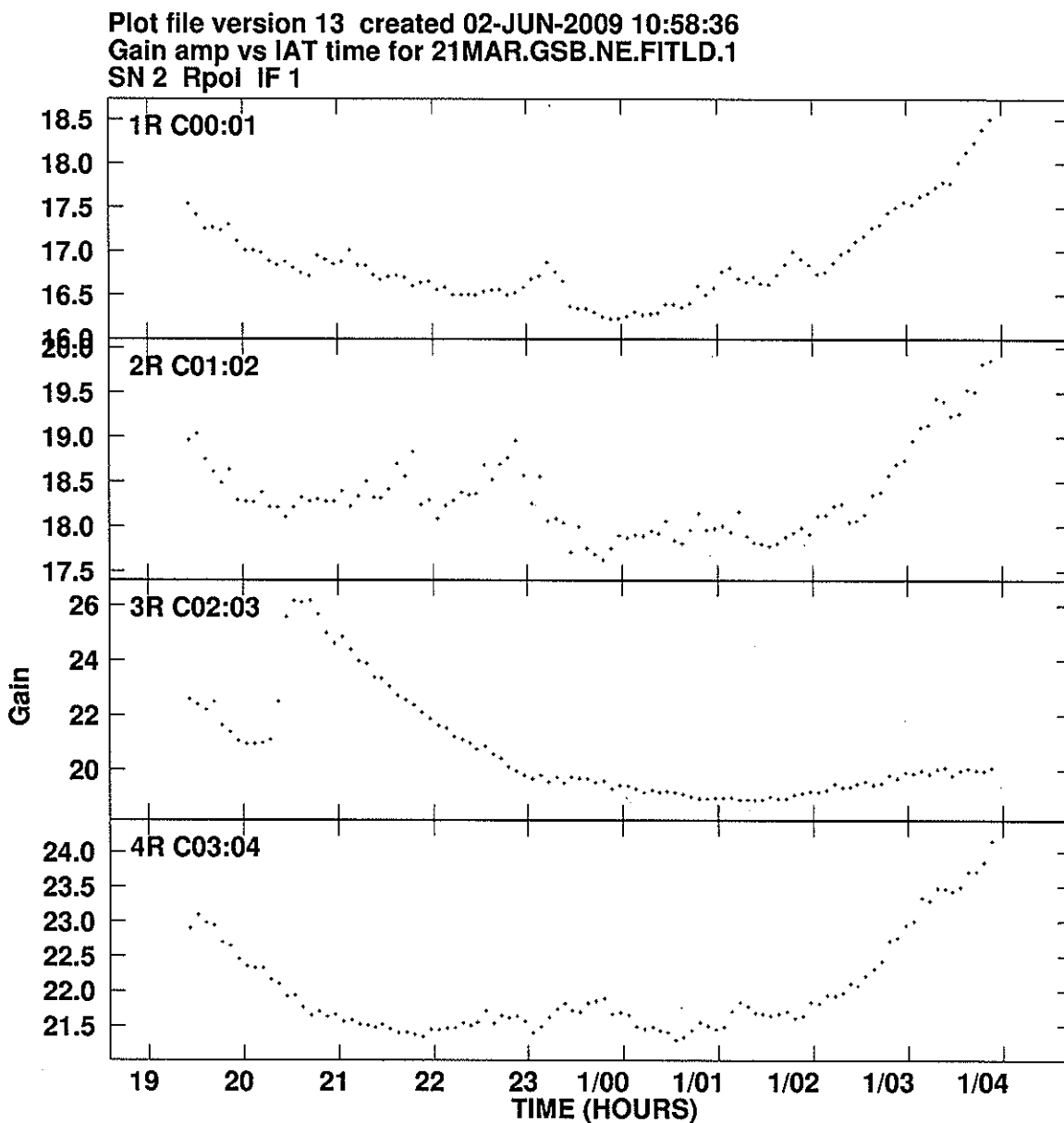


Figure 2. Gain amplitude of Antennas

Plot file version 14 created 02-JUN-2009 11:02:15
Gain phs vs IAT time for 21MAR.GSB.NE.FITLD.1
SN 2 Rpol IF 1

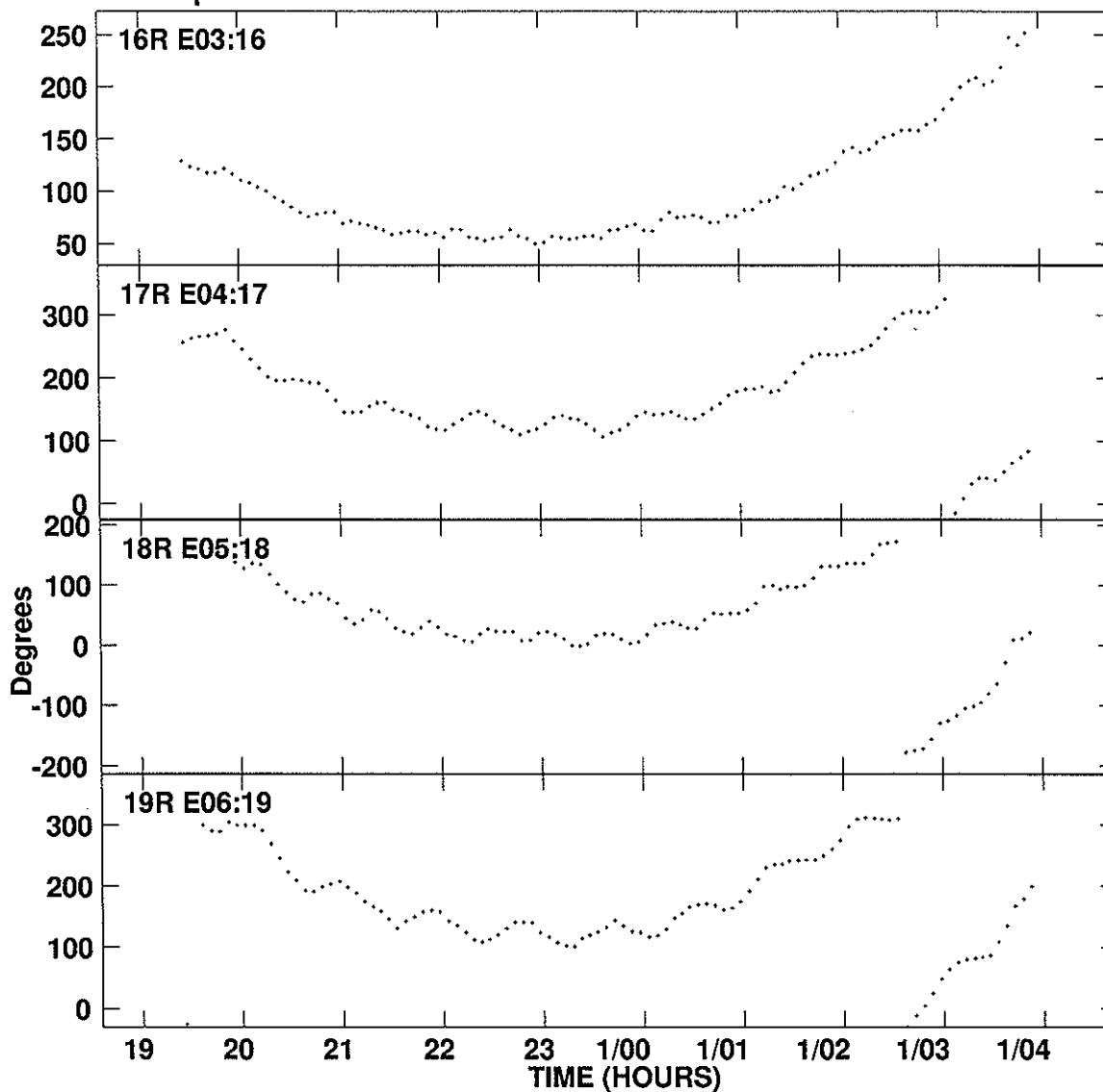


Figure 3. Antenna based Phases

Most calibrators Variable.

Determine Secondary flux densities
using non-variable cal. (Primary).

PLot file version 15 created 02-JUN-2009 11:31:15
Amplitude vs Time for 21MAR.GSB.NE.FITLD.1
IF 1 CHAN 150 STK RR

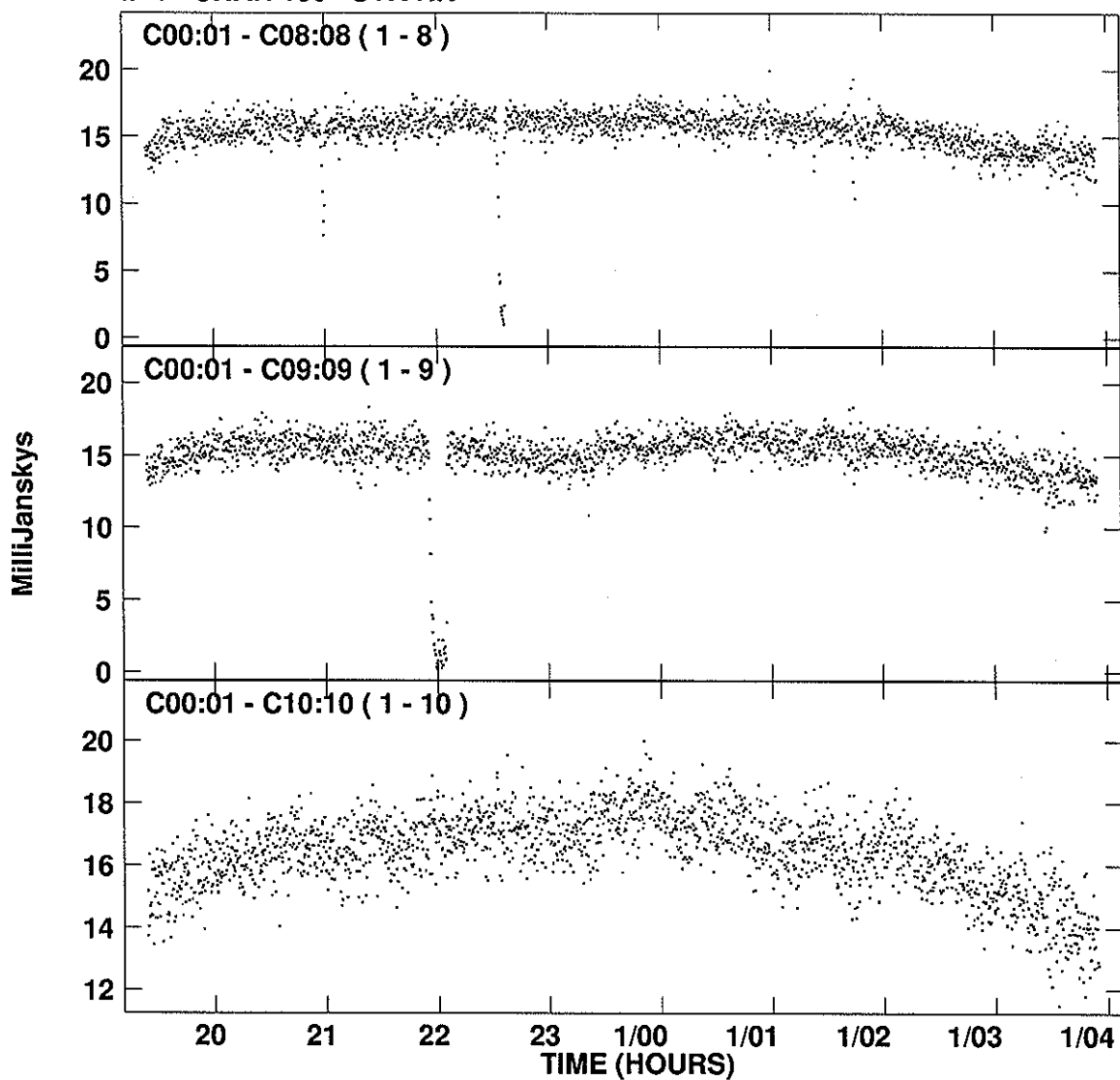


Figure 4. Actual data on a Cal. (t, ν_0)

Editing data

Certain techniques

Amplitude check.

(i) Stability of Phases(t) for calibrator.

(ii) Smooth variation of Amplitude and Phase for Source in time and frequency.

(iii) Visibility Amp. and Ph. for parallel handed Stokes should be close.

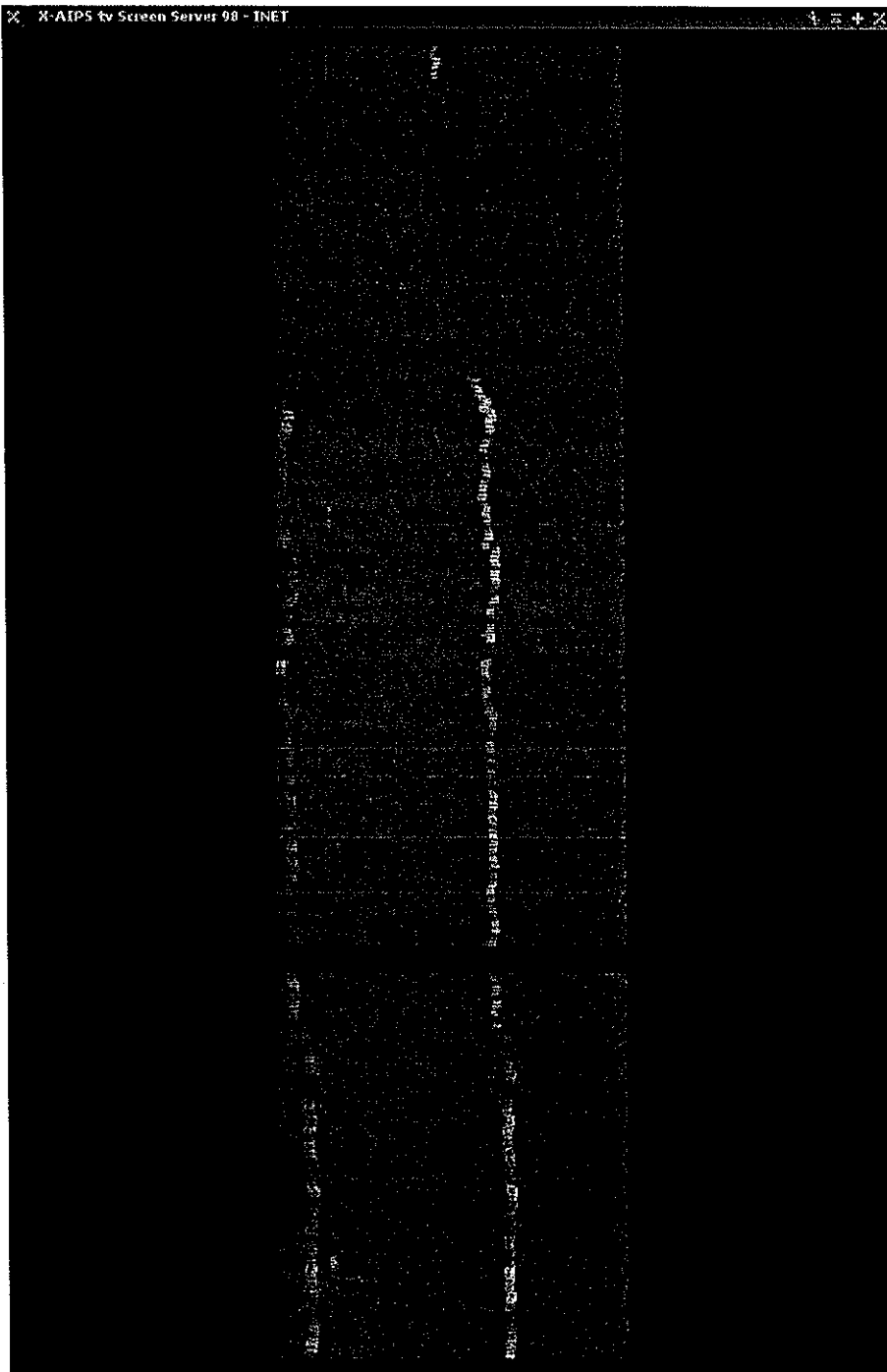


Figure 5. RFI across the band.

