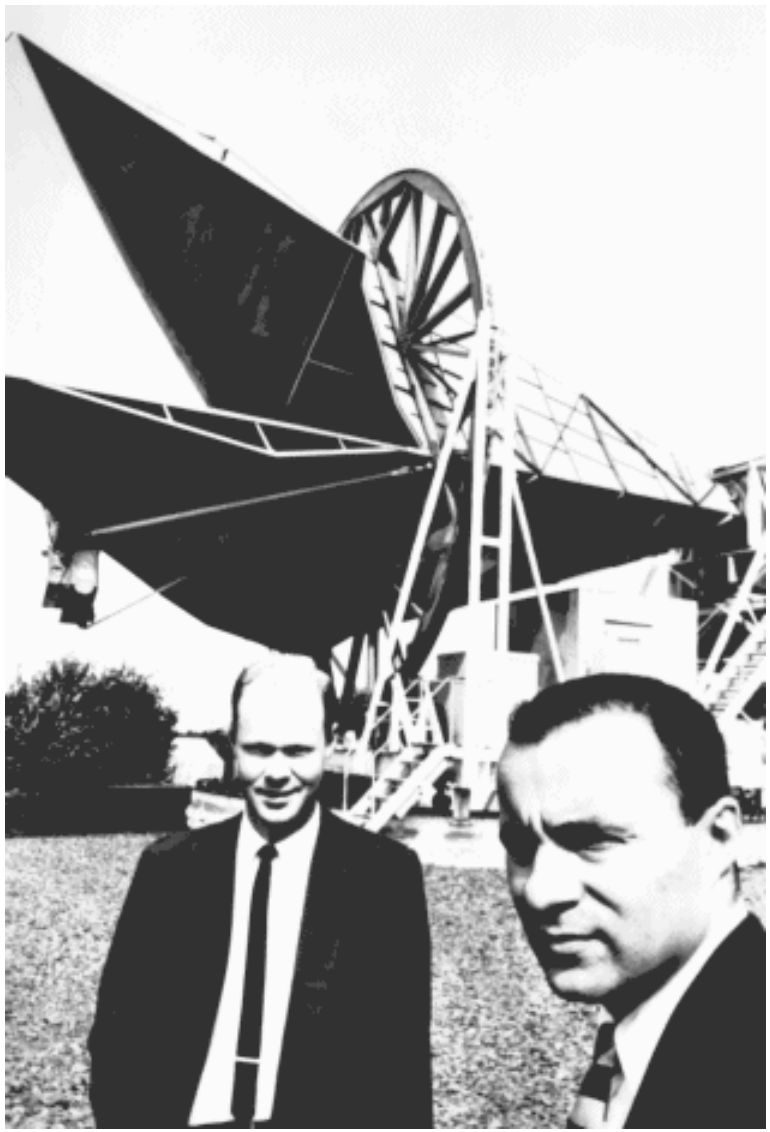
Calibration

You never know – it might be important.



Equivalent noise temperature

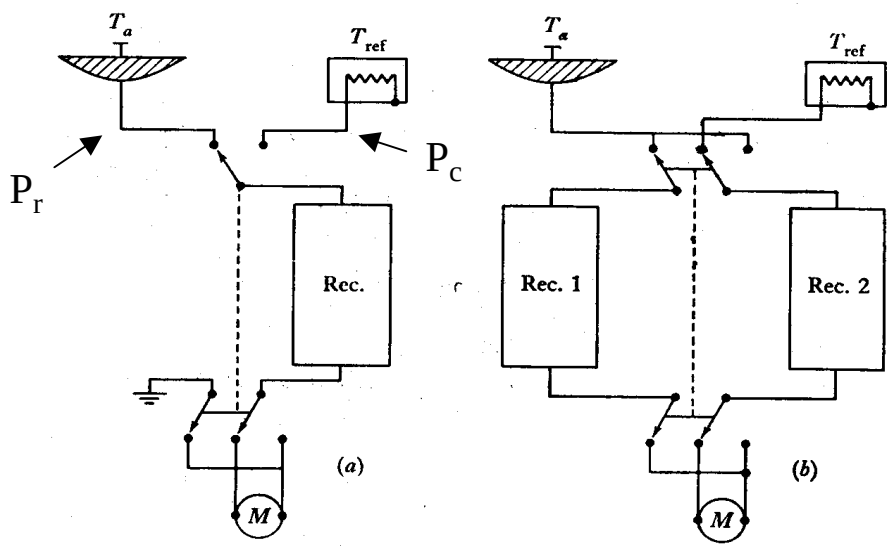
Flux density : 1 Jansky = 10^{-26} W/m^2/Hz

$P_r = ½ A_{eff} S d\nu$ (A_{eff}:= collecting area, S:=flux density)

$P_c = kT_{ref} d\nu$

$kT_A = ½ A_{eff}.S$

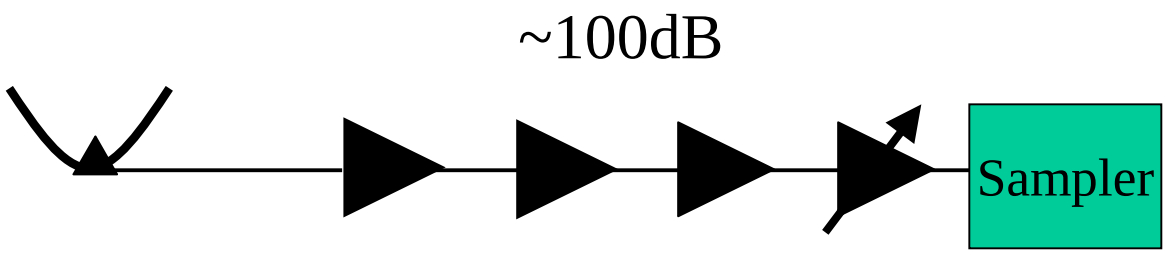
$T_{sys} = T_A + T_{spill} + T_{sky} + T_{rx}$



What are we measuring?

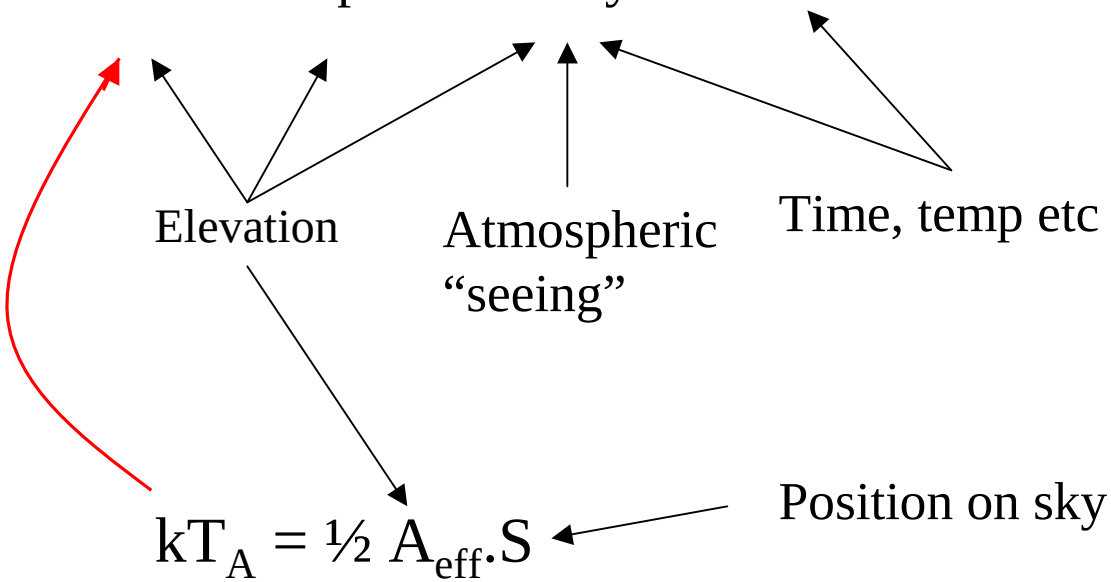
- Typical receiver systems have large gain which varies with time.

Abandon detected power for calibration: use only equivalent noise temperatures.



The noise equation

$$T_{sys} = T_A + T_{spill} + T_{sky} + T_{rx} + T_{2.7K}$$



NAR – noise-adding radiometer

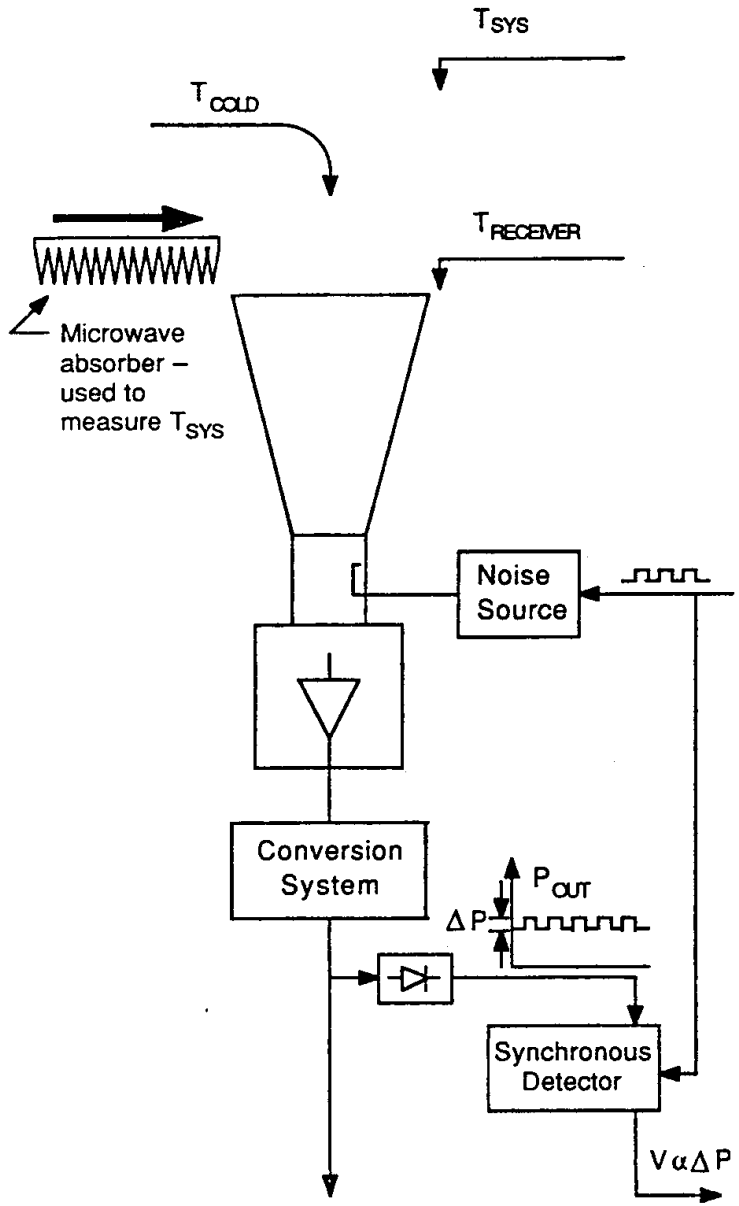
Jargon:

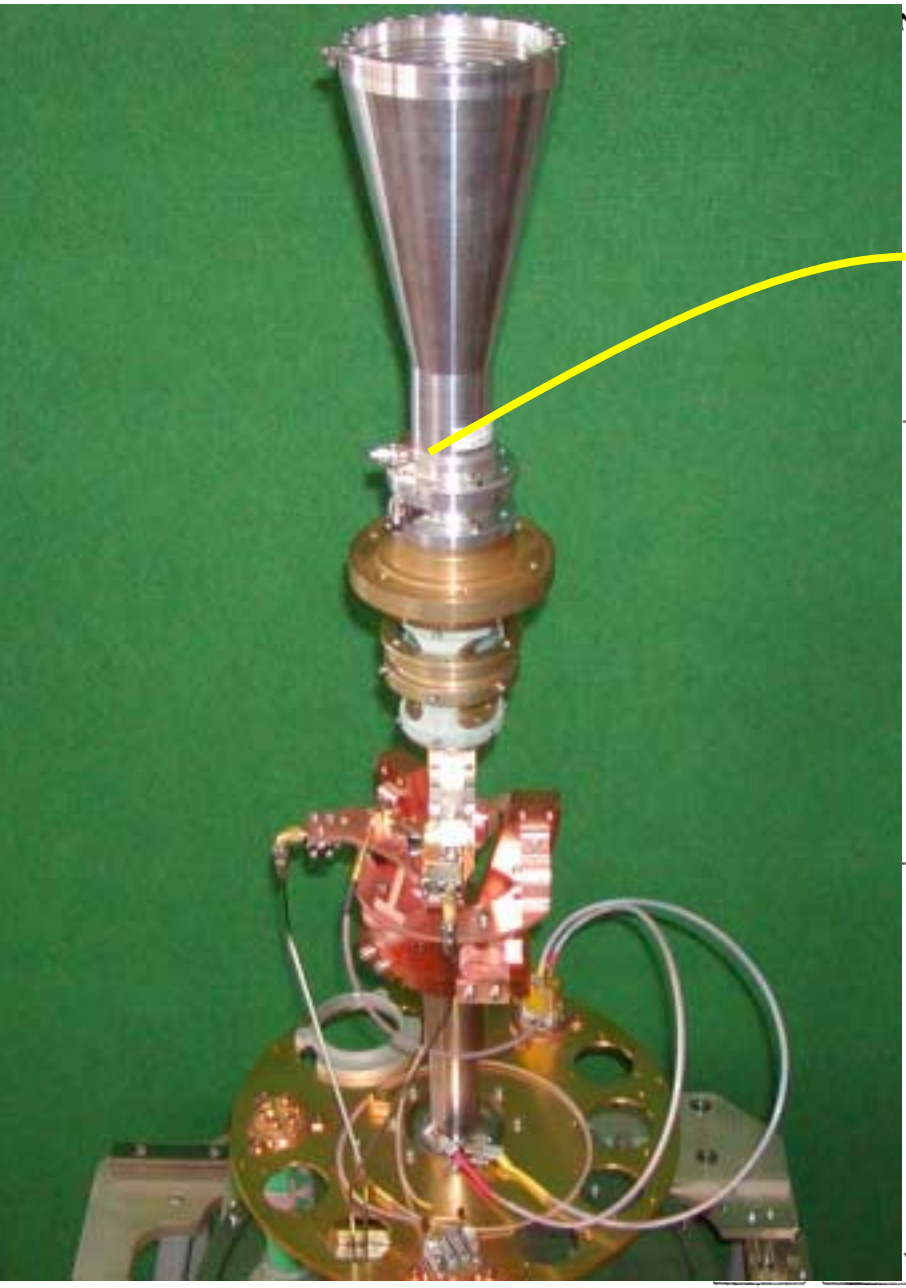
"noise tube"

="noise diode"

="noise source"

="cal"





NAL PATH - THE RECEIVER SYSTEM - *Sinclair, et al*

COMPACT ARRAY FRONT END

1.2-2.5 GHz HORN

(4.5-9.2 GHz HORN)

CLOSED CYCLE REFRIGERATOR

NOISE SOURCE

VACUUM WINDOW

VACUUM DEWAR

THERMAL GAP

A

WIDE BAND OMT

B

1.2-1.8 GHz

DIPLEXER

2.2-2.5 GHz

(4.5-6.1 GHz)

(8.0-9.2 GHz)

+30 dB FET AMP

R.F. MODULE

PRESSURE TRANSDUCERS

RETURN

SUPPLY

EARTH

NEUTRAL

ACTIVE

20V

MONITOR & CONTROL

POWER SUPPLY VOLTAGE

R.F. OUTPUT

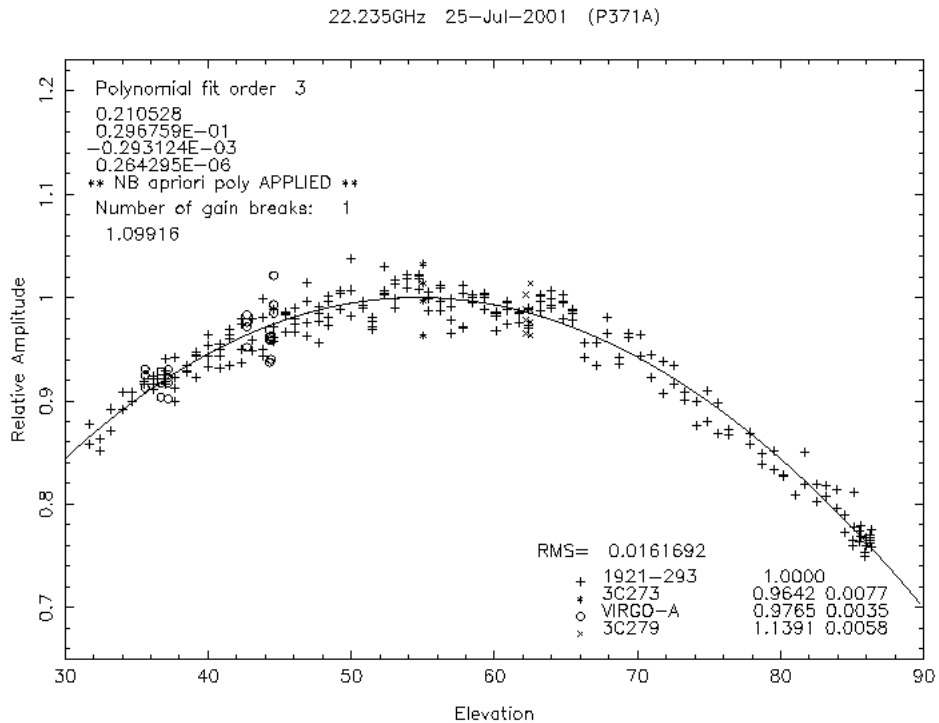
240V A.C.

HELIUM SUPPLY

Antenna gain

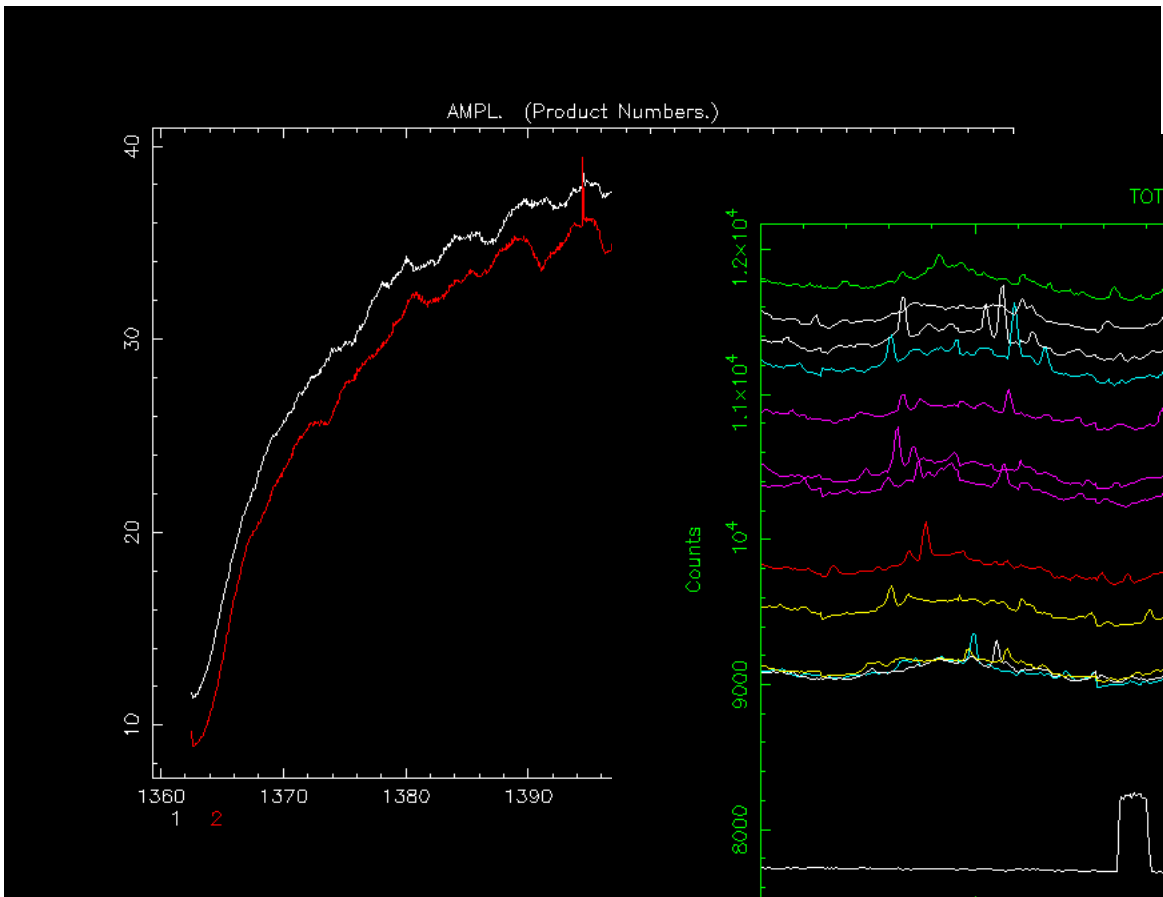
$kT_A = ½\ A_{eff}.S$

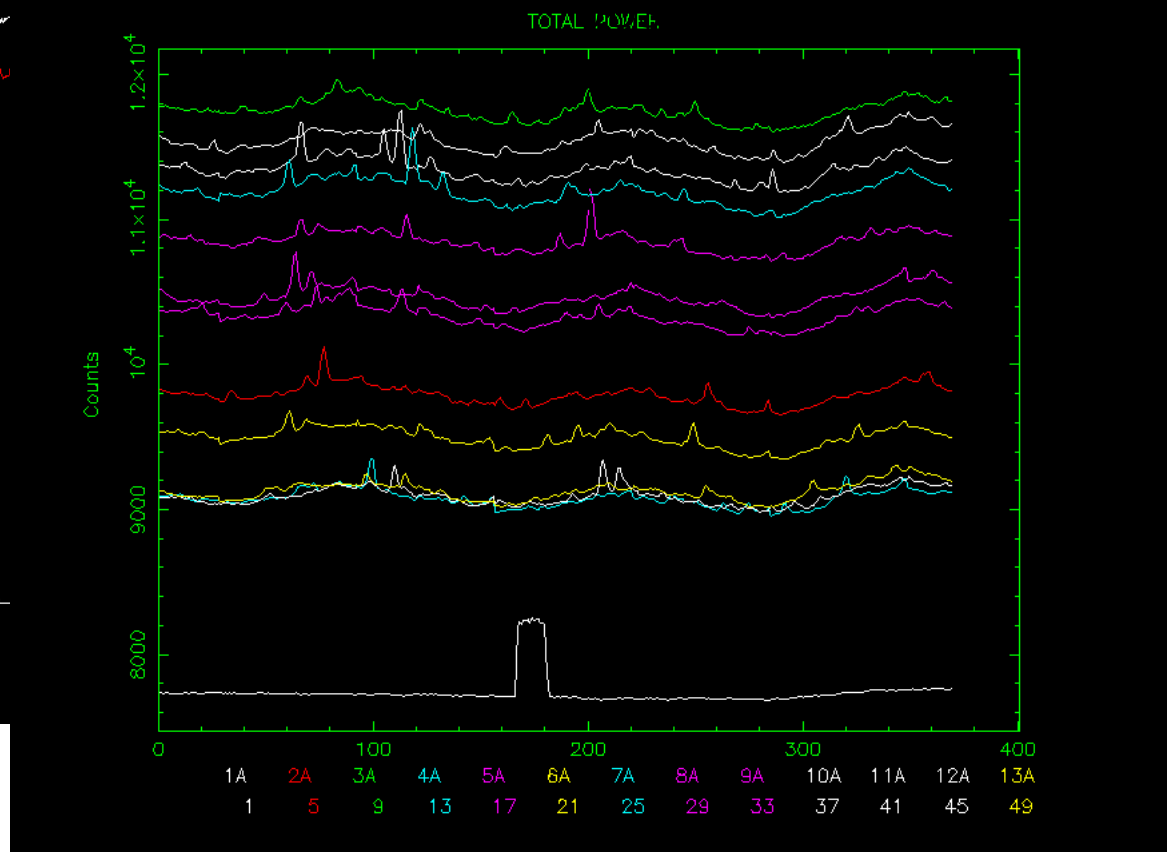
$T_A/S = 1/2k\ .\ A_{eff}$



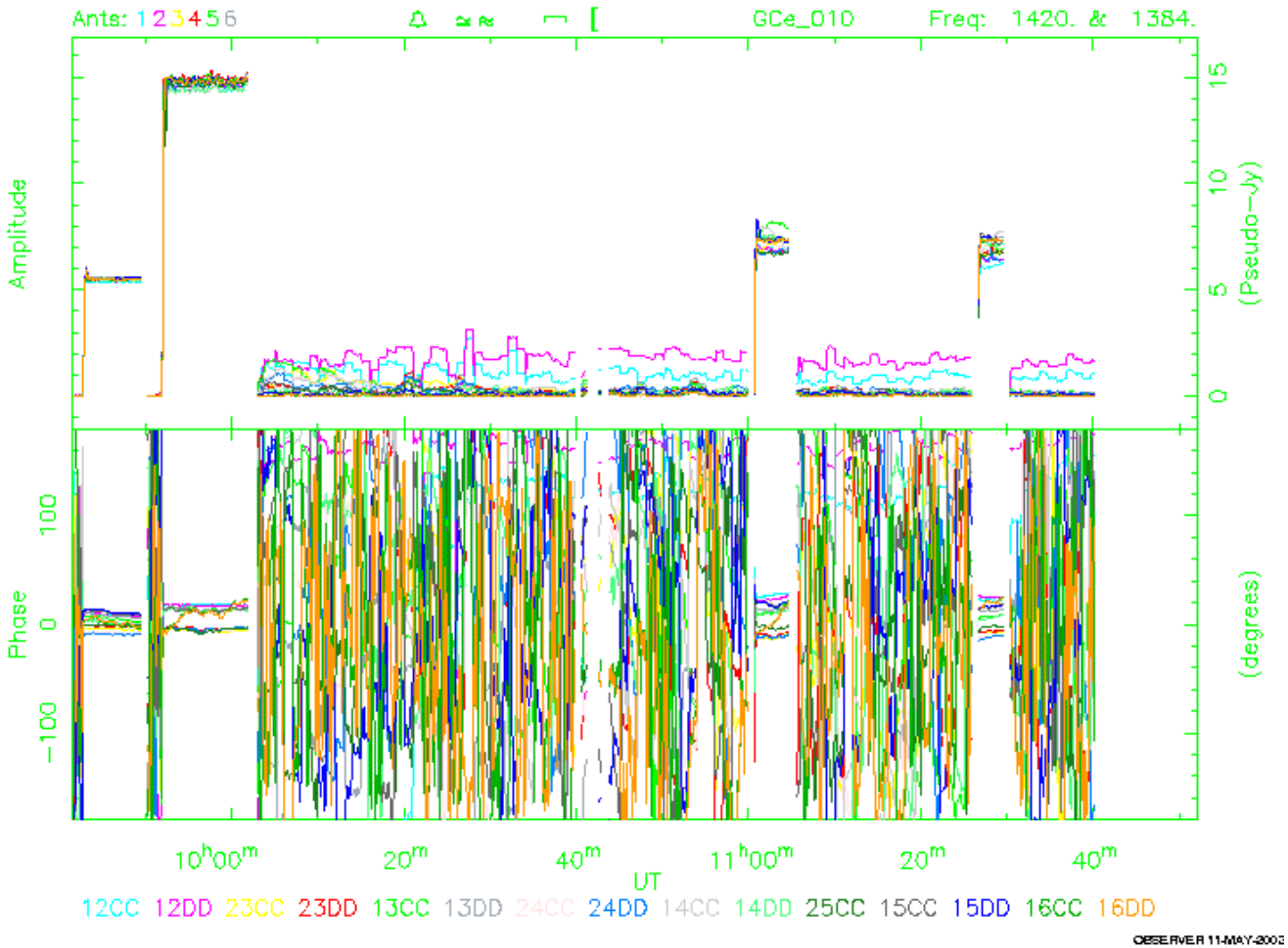
Bandpass calibration

Calibrate bandpass by





Interferometers…. at last



ATCA calibration practice

- Fiducial calibrator (delays, amplitude)
  once per ~12 hour observation

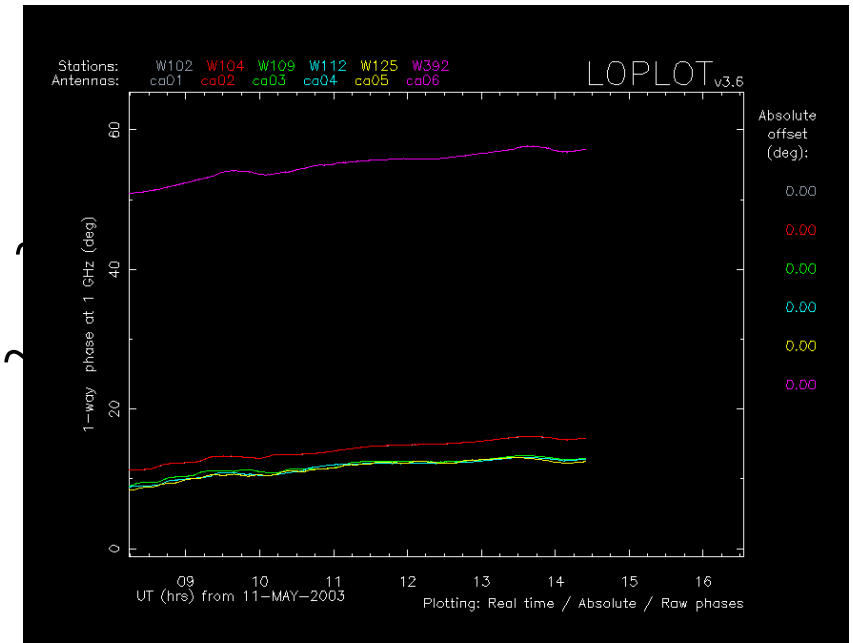
- Secondary calibrators (phase, amplitude)
  once per 10 minutes ~ 2 hours
  linear interpolation of amp, phase

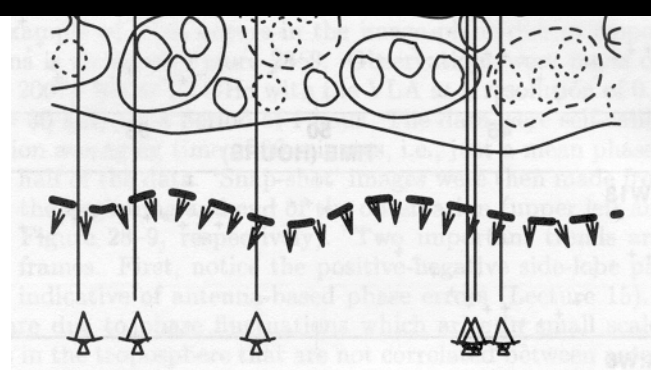
Phase errors

Atmosphere

- Ionosphere dominant < ~
- Neutral atmosphere , ϕ ~
- ”Outer-scale” ~ 30km

Instrumental effects





Interferometer calibration

- Measured visibility *vs* true visibility:

$$V'_{ij} = V_{ij} \bullet G_i \bullet G^*_j$$

- Assume errors small:

$$G_j \approx (1 + \varepsilon_j + i\phi_j)$$

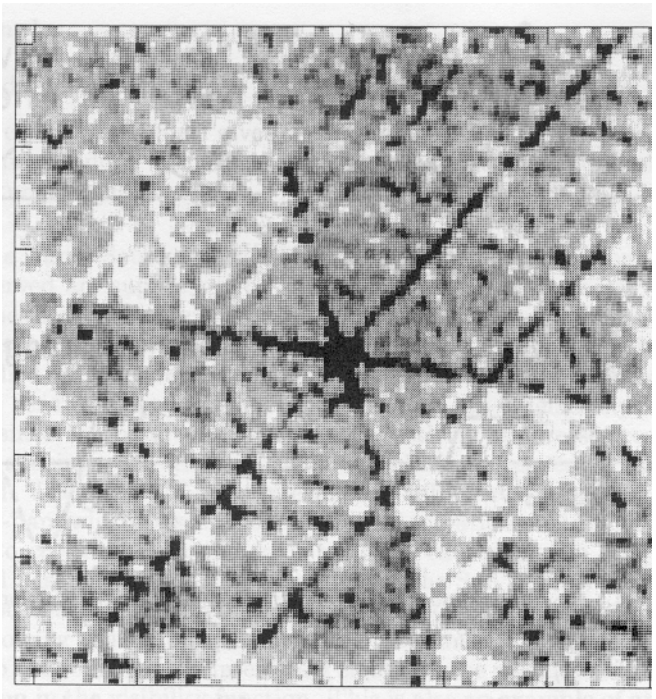
$$G_i \bullet G_j^* \approx 1 + \varepsilon_i + \varepsilon_j + i(\phi_i - \phi_j)$$

Perfect response

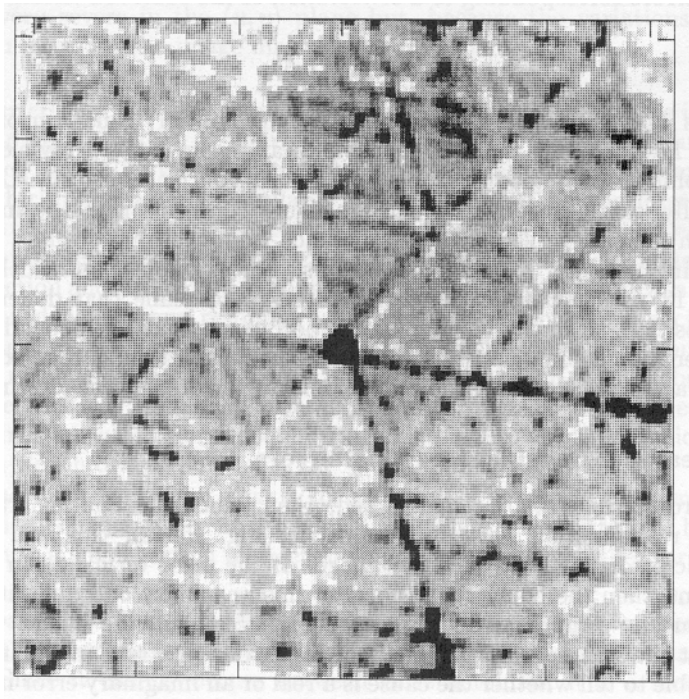
Real = amplitude

Imaginary=phase

Image distortion



Amplitude errors
(symmetric)



Phase errors
(antisymmetric)

Self-calibration

- Standard calibration : image quality ~100:1
- Self-calibration:

  G_i : N complex gains

  N*(N-1)/2 visibilities (complex constraints)

  ➔Can solve for the G_i

  ➔Image quality >> 1000:1

More to think about

- Self-calibration
- Polarization calibration: online XY phases
- Spectral-line (bandpass) calibration
- Data flagging/editing
- Absolute flux calibration
- Pointing calibration
- RFI
- Astrometry (milli-arcsecond positions)