User Manual 2-Element Total Power Radio-Interferometer

General Description

The instrument is a simple 2-element, total power, swept frequency interferometer covering S-Band 2200 MHz – 2700 MHz. The instrument based on two Celestron advanced GoTo mounts can track the source or it can be used just as a transit-meridian instrument. Antenna, mount and notebook are commercial systems while the frontend, down-converter and the backend are special designed products of the Institute of Astronomy. The instrument can be saved in several transport containers and it can be used in the field as well as on a building like the terrace of HPP.

Operating Information

When using the interferometer it is important to utilize interconnecting cables and connectors having a characteristic impedance of 50Ω. Also the antenna, receiver and spectrometer must properly match the impedance. Take care that connectors, components and cables are not laying on ground avoiding water penetrating into components. Especially at high altitudes take also care about electrostatic discharges due to low humidity. Before touching an instrument or a component, discharge your body by touching first central heating or any other infrastructure device which is connected to ground potential. Select observation place such that you 'see' the source as long as possible (low horizon). Try to stay away from strong transmitters like mobile phone, WiFi, TV- or Radio transmitters. Check and edit carefully longitude, latitude, altitude, time and date in parameter files and notebook. Don't install antennas outside during thunderstorms because we don't have lightning protection. When you expect strong winds or a storm you need to weight the tripod with stones or any other heavy stuff (e.g. rocks or blocks of ice).

Installation and configuration:

1. Setup Celestron tripod in north-south direction on a horizontal baseline separated by a few meters, e.g. 4m. Align both mounts properly according to Celestron handbook. Electrical power can be taken from 2 separate accumulators or any other dc-source delivering 12V.
2. Install both antennas and align them in the same (!) polarization, either H or V.
3. Connect both antennas with frontend (preamplifier) and connect them with receiver.
4. Connect receiver via DC-injector to Callisto spectrometer.
5. Connect DC-injector with power supply 12V 0.5A
6. Connect Callisto with coaxial cable
7. Connect Callisto via RS232 with Notebook (directly or via RS232/USB-adapter)
8. Switch every supply on and start Notebook and then start application callisto.exe
9. Start also application 'lightcurve' to observe up to 5 light curves

Figure 1: Antenna mounted on tripod

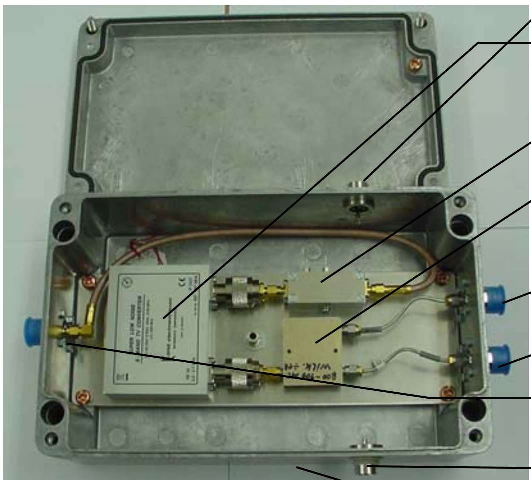


Figure 2: Heterodyne down-converter/receiver

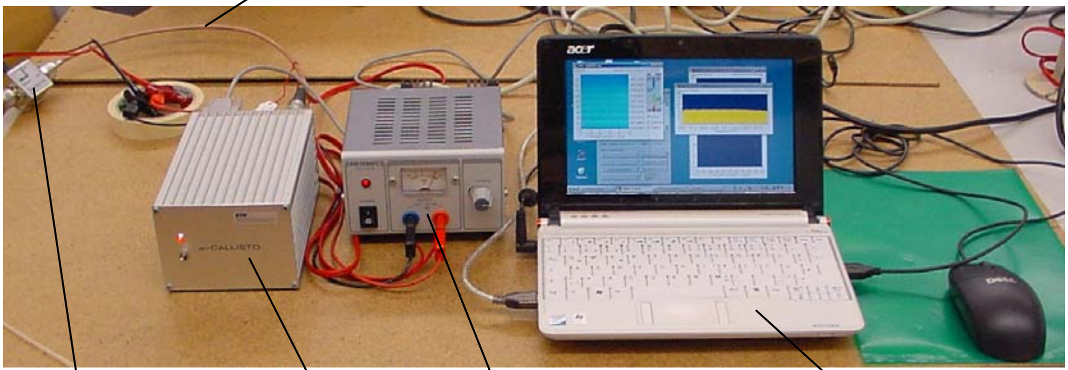


Figure 3: Backend

Specification

Parameter	Value
Parabolic Grid-Antenna	21 dB versus isotropic radiator
Frequency range	2200 MHz – 2700 MHz, LO = 1833.0 MHz
Noise figure	< 1.5 dB
Beam angle	14° x 10°
Polarization	Linear V/H
Mount	Parallactic, computer controllable
Spectrometer	Frequency agile (Callisto)
Radiometric bandwidth	300 KHz
Integration time	(1, 10, 140, 300, 660,3000) msec (switchable)
Number of channels	1... 400, nominal 200
Spurious free dynamic range SFDR	> 45 dB
Output	FIT-file (spectrum) per 15 minutes ASCII-file (1...5 light curves) per day ASCII-file (logfile)per day ASCII-file (spectral overview)on demand
Inputs	Configuration files callisto.cfg Frequency file FRQnnnnn.cfg Calibration file CALnnnnn.cfg (Optional)

Table 1: Specifications

Typical applications

- Measuring the disc diameter of the sun
- Measuring the declination of the sun by knowing antenna separation and wavelength
- Measuring tangential velocity of satellite down link transponders
- Comparing different high frequency components by measuring Y-factor

Maintenance

Maintenance will normally be limited to replacement of components damaged by overload, static discharges or simply lost/theft. The items lending themselves to field replacement are connectors, bolts, adapters etc. Ensure to take notebooks with updated operating system and virus scanner according to ETH roles and regulations. Measure the noise figure once per year in the laboratory.

Schematic

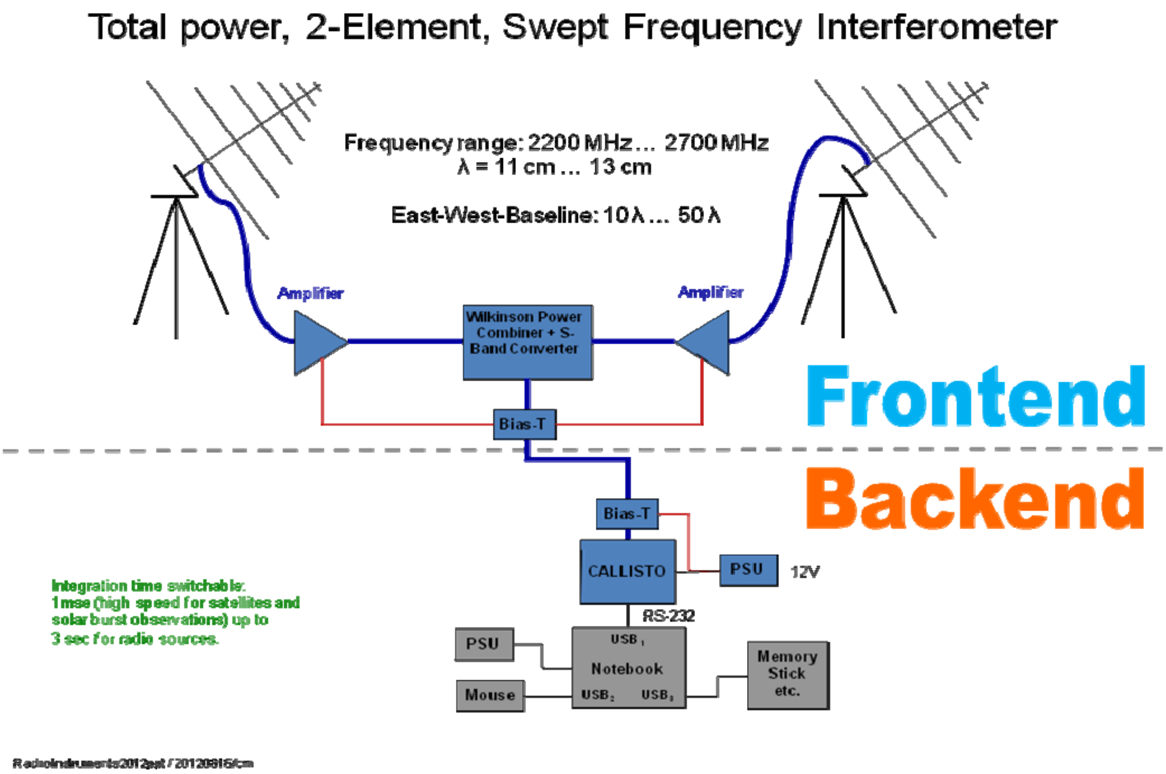


Figure 4: Schematic configuration of the interferometer.

Components list

2	Parabolic grid antenna with mounting platform and bolts
2	Adapter N-connector male/male for antenna cable
2	Parallactic mount with hand control, cables and power supply
2	Low noise pre-amplifier in box
2	DC supply cables for preamplifier xxm
1	Receiver down-converter 2200 MHz-2700MHz down to 367 MHz-867MHz LO = 1833.0 MHz
2	Coaxial cable ~3m for antenna
1	Coaxial cable converter → Observatory ~10m
1	Coaxial cable ~50 cm from DC coupler → Callisto
1	Power supply 12V for spectrometer
1	Frequency agile spectrometer Callisto eC22
1	Notebook IBM Thinkpad (kallistor.ethz.ch) with Callisto-Software installed
1	Serial cable and USB/RS232 adapter for Callisto

Table 2: Components list, for more details see parts-list in transport container.

Example of single antenna beam power pattern

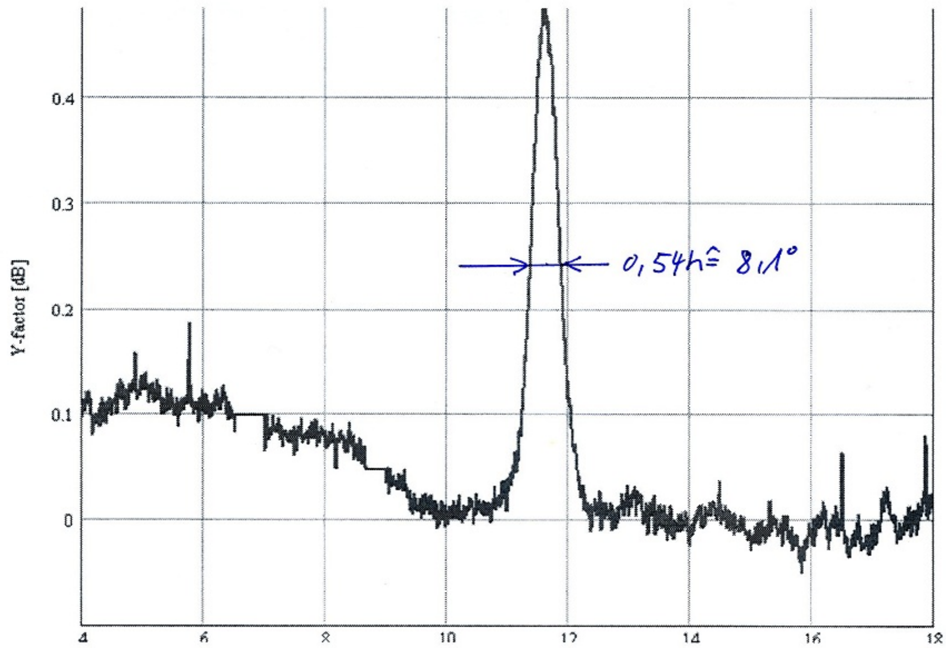


Figure 5: Beam power pattern of a single antenna while observing the sun.
Observation-method: transit meridian

Example of solar fringes

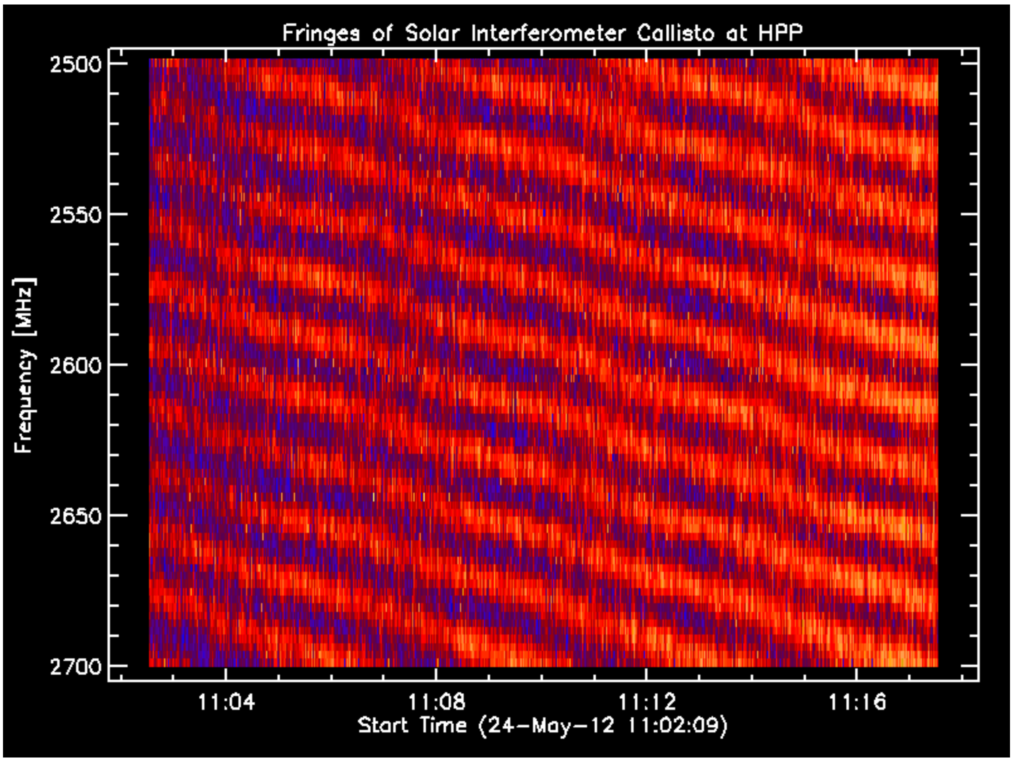


Figure 6: Fringe pattern collected during D-day demonstration on terrace of HPP.
Plot is slightly smoothed with IDL-function: zz = LeeFilt(zz,1).

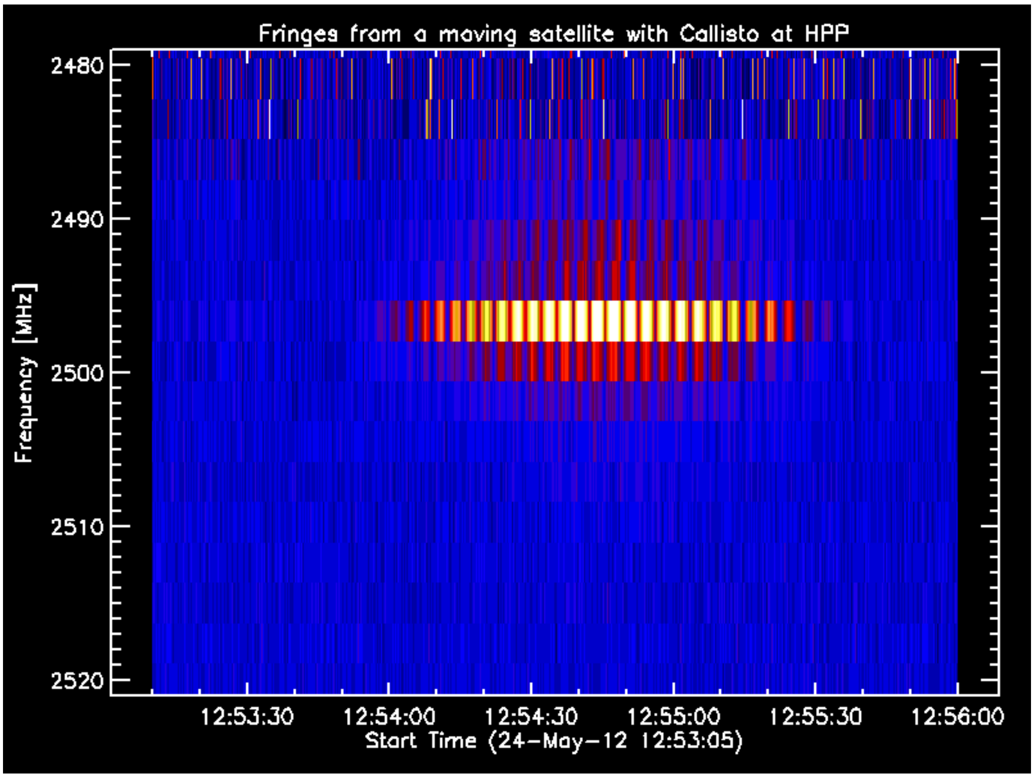


Figure 7: Fringes from a fast moving satellite in S-band. Satellite show a very good SNR, so there is no smoothing or filtering necessary.

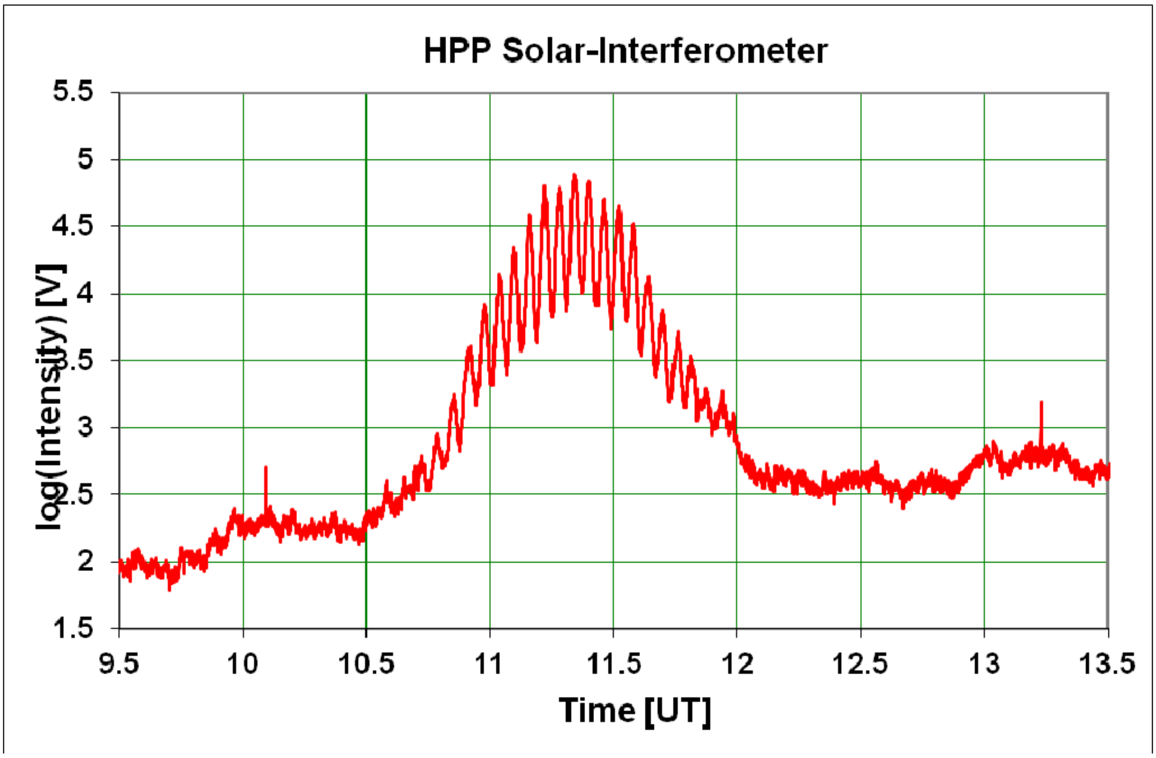
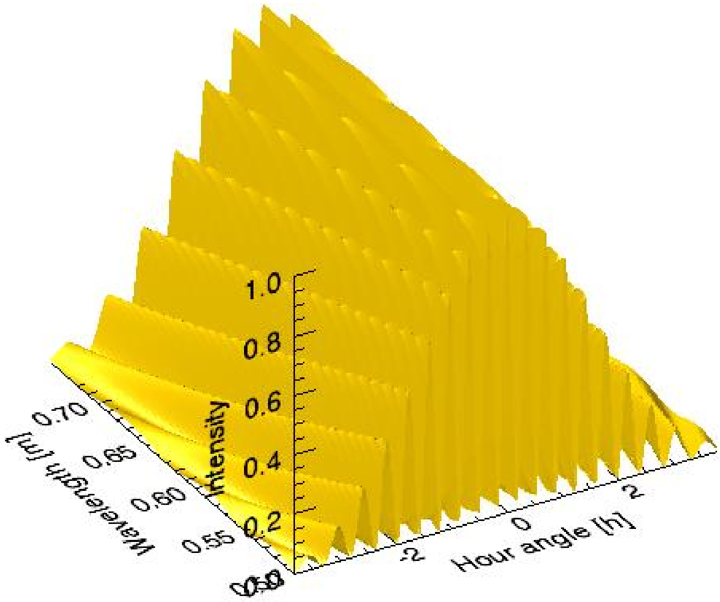


Figure 8: Integrated light curves (over 10 MHz bandwidth!) showing solar fringes and fringe broadening due to sun diameter and due to too high integration in bandwidth.

Simulation of fringe pattern of a point-source at the position of the sun




```
PRO Interfero

Nrows = 200.0
Ncols = 200.0
pi      = 3.1415
D       = 3.0 ; East-West separation of antennas
phi     = 5.0/180.0*pi ; instrumental phase shift 5°
declination =  58.8/180.0*pi ; Cas A
declination =  40.7/180.0*pi ; Cyg A
declination = -21.4/180.0*pi ; Sun

lambda      = fltarr(Nrows)
hourangle  = fltarr(Ncols)
att             = fltarr(Ncols)

F = fltarr(Ncols,Nrows)

FOR row = 0, Nrows-1 DO  BEGIN
  lambda[row] = 0.5 + 0.25*row/Nrows ; 0.50 m .. 0.75m = 400 MHz ... 600 MHz
  FOR col = 0, Ncols-1 DO BEGIN
    hourangle  [col] = (col/Ncols -0.5)*2.0 ; +/-1.0rad = +/-3.8h
    att[col] = cos(hourangle[col])^6 ; rough estimation of beam pattern
    F0 = cos((2*pi*D/lambda[row])*cos(declination)*sin(hourangle[col]-phi))
    F[col,row] = att[col]*F0^2 ; interferometer power normalized to max
  ENDFOR
ENDFOR

isurface,F,hourangle/pi*12.0,lambda,$
xtitle = 'Hour angle [h]',$
ytitle = 'Wavelength [m]',$
ztitle = 'Intensity',$
title='Simulation of total power 2-element interferometer'

end
```

Figure 9: IDL-simulation of the sun as a point source and IDL script

Ideal frequency range for satellite observations: 2480 MHz – 2520 MHz
Ideal frequency range for solar fringe observations: 2310 MHz – 2400 MHz and 2500 MHz – 2700 MHz. The range in between is interfered by WiFi-systems.

Interferometer angular resolution and fringe frequency

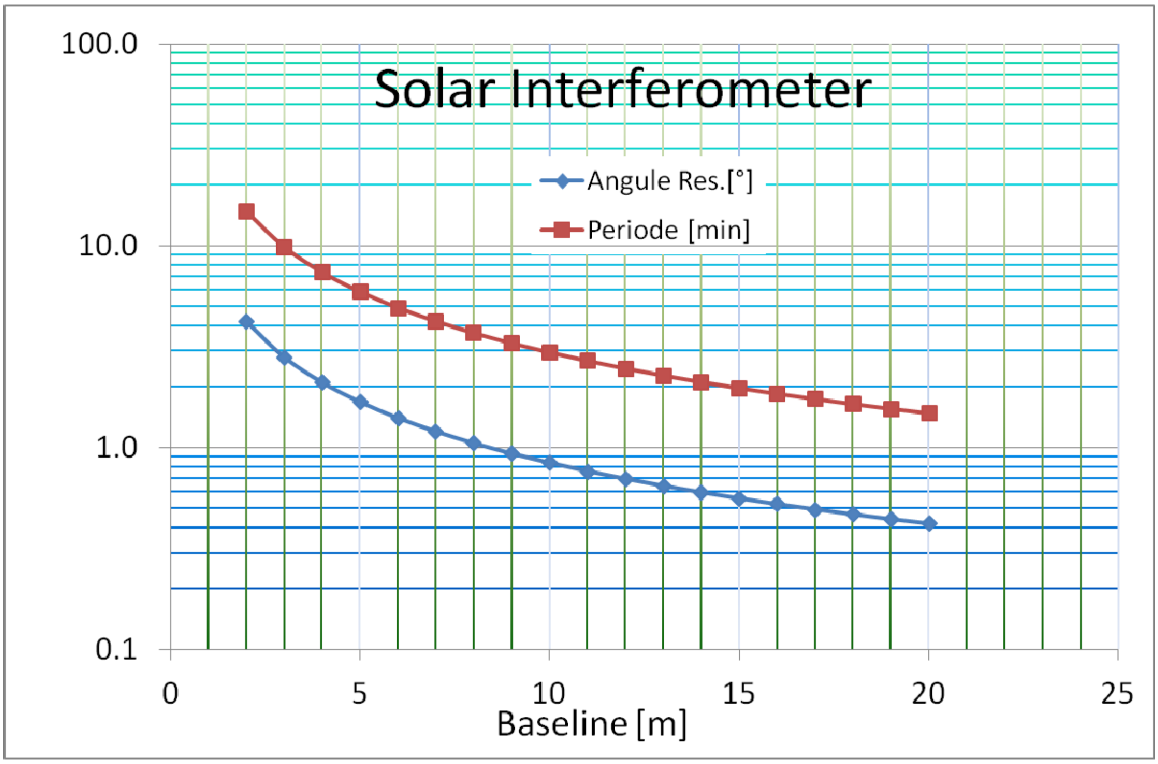


Figure 10: Angular resolution and fringe period of 2-element interferometer at 2.2 to 2.7 GHz.

PC-Application needed

Callisto.exe + libraries and DLL Handbook online here:	Spectrometer software to control instrument http://www.reeve.com/Documents/CALLISTO/CALLISTOSoftwareSetup.pdf
FGeni.exe + libraries and DLL	Tool to generate frequency programs
Jv-20070909.jar	Tool to visualize FIT-files
Option: ALAVAR.exe	Tool to evaluate Allan-time variance
Option: SSWIDL	Scientific spreadsheet to plot FIT-files
Option: EXCEL, Mat-Lab, Math-Cad, Maple, Mathematica etc.	

Document info:

Version:	*Draft: 2010-10-15 Monstein* *V1.5, 2012-10-22 Monstein*
Filename:	*Instruction Manual_V15.doc*
Distribution:	*Astrowoche, VP (HPP)*