# $F_{10.7}$

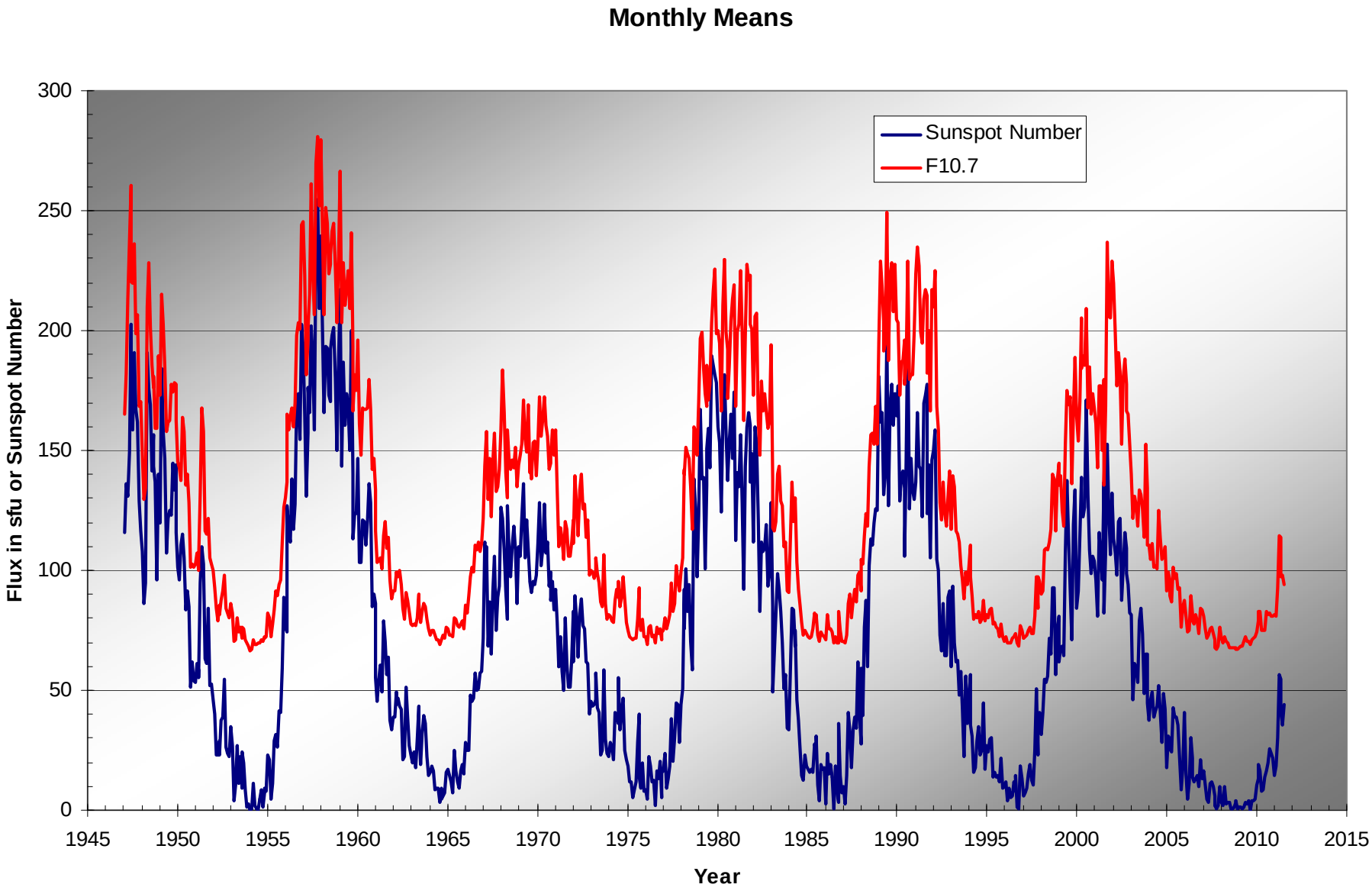
*Ken Tapping*

*ken.tapping@nrc-cnrc.gc.ca*


Natural Resources Canada | Ressources naturelles Canada

NRC · CNRC

# F10.7

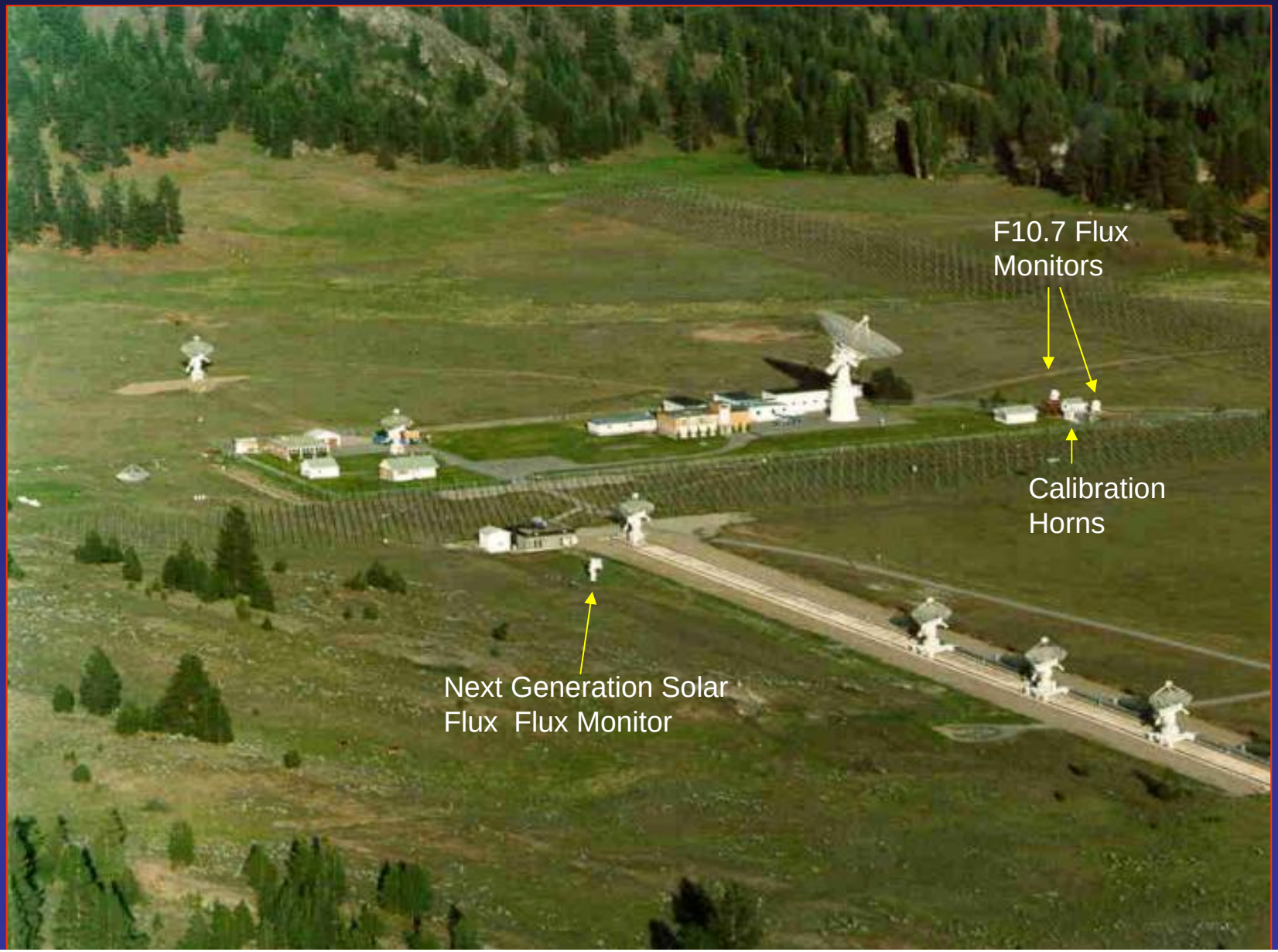

Monthly Means
Sunspot Number
F10.7
Flux in sfu or Sunspot Number
300
250
200
150
100
50
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year

# Data Products

- Three flux values a day: morning, noon and afternoon (1700, 2000 and 2300 UT in summer; 1800, 2000 and 2200 in winter). Noon measurement is the primary datum.
- “Continuous Record” or “CR” files: recordings of the receiver outputs sampled at 1 sample/sec, from sunrise to sunset.
- (“High-Speed” or “HS” files: essentially CR files with sampling rates of 1000 samples/sec.)


British
Columbia,
Canada
Vancouver
DRAO

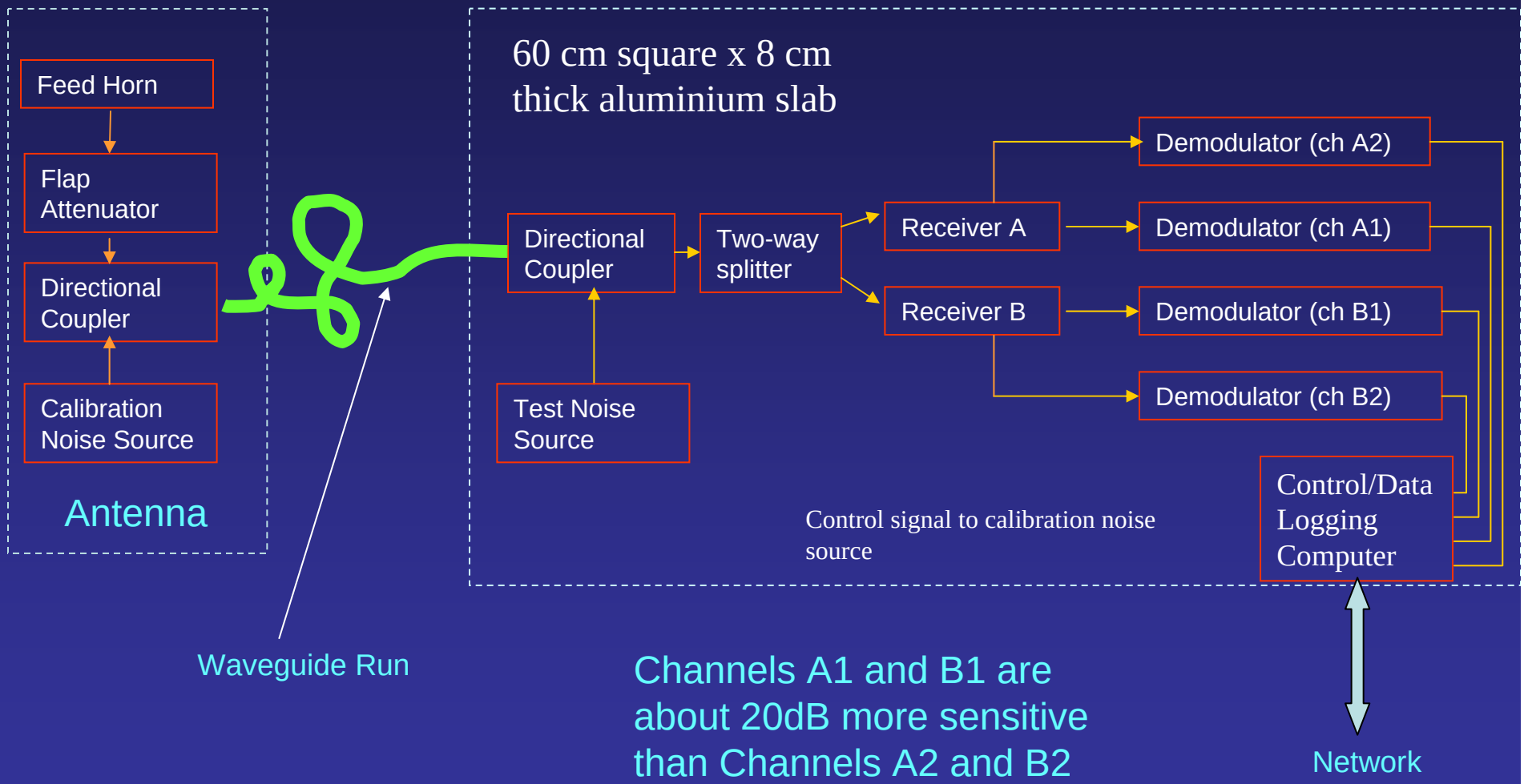
# DRAO


F10.7 Flux
Monitors
Calibration
Horns
Next Generation Solar
Flux  Flux Monitor

# DRAO

# Solar Radio Monitoring Programme
# DRAO, Penticton, Canada

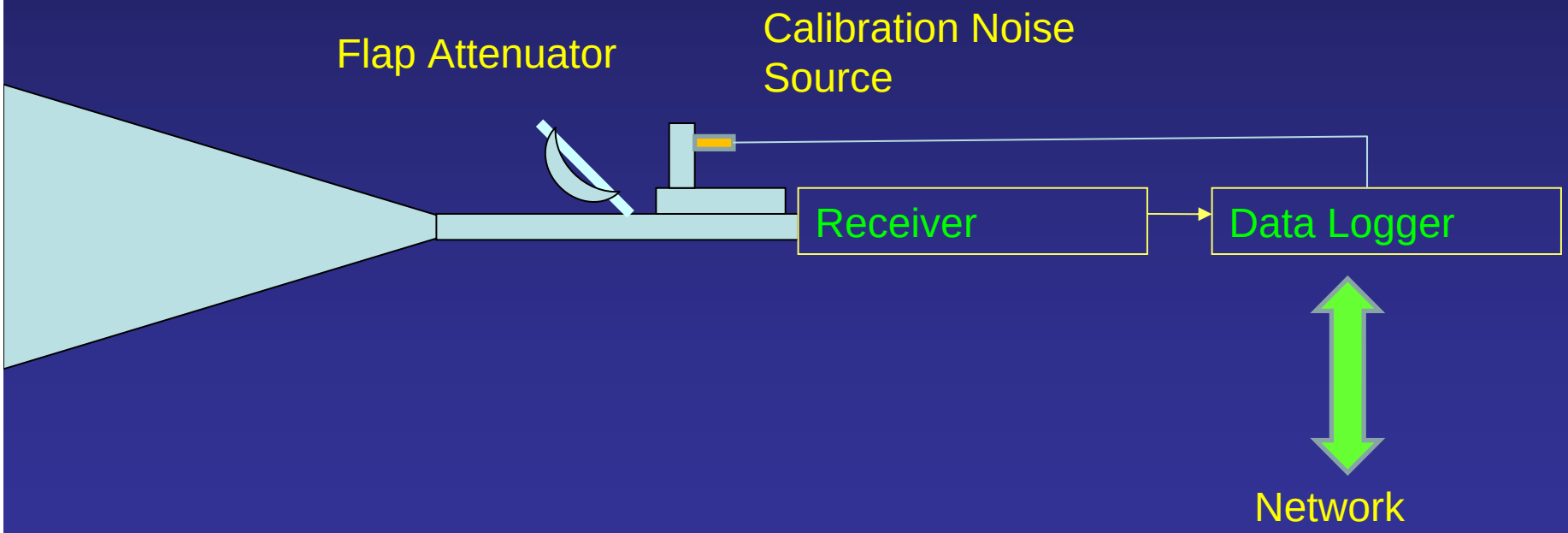
# One of the Flux Monitors



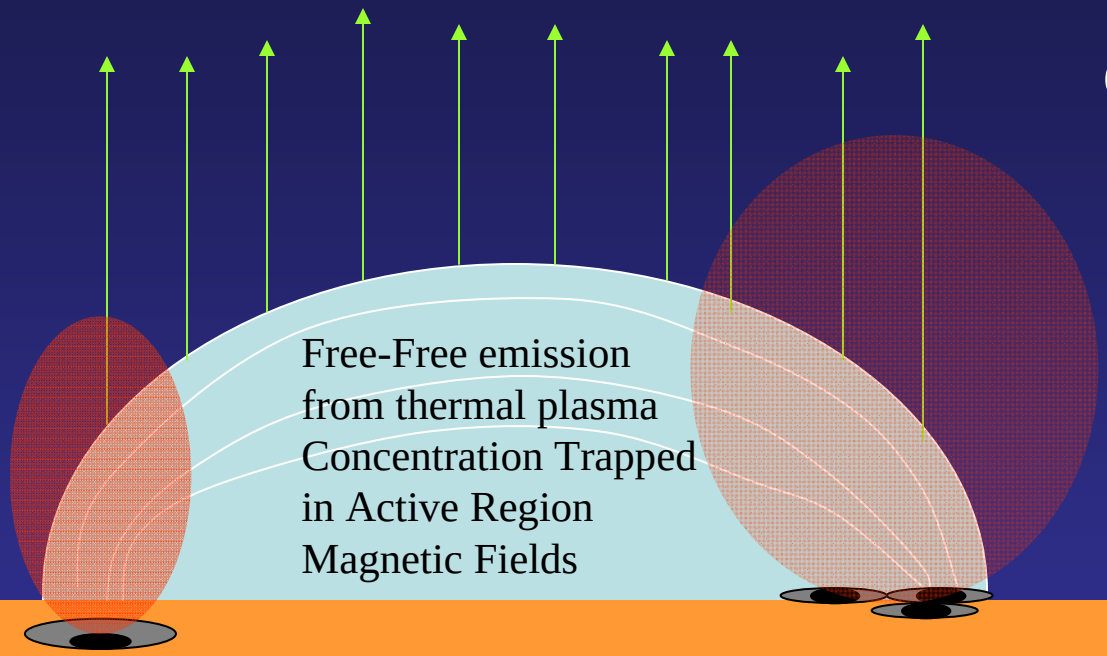

Channels A1 and B1 are about 20dB more sensitive than Channels A2 and B2

# Dual Horn Calibration System

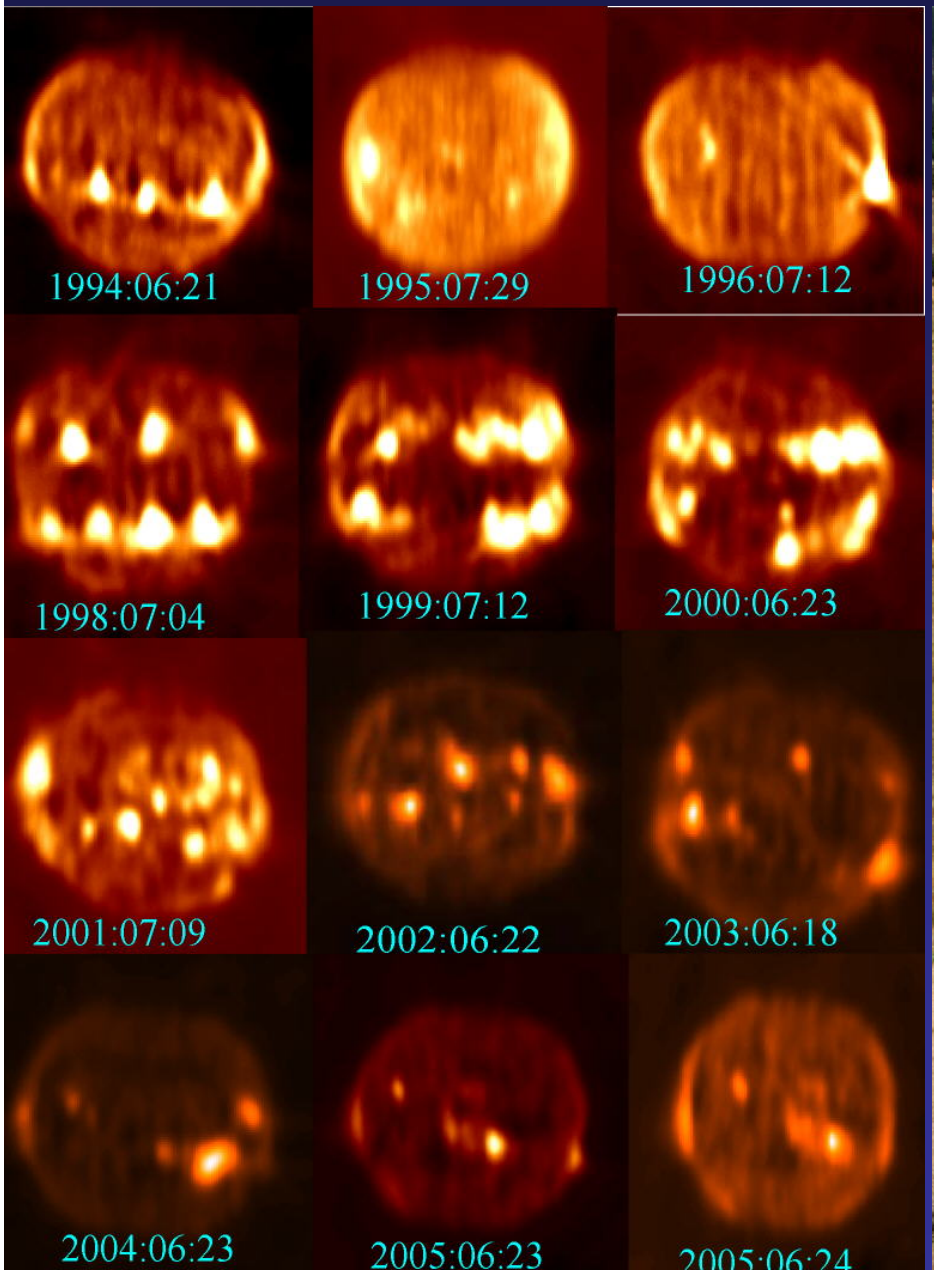
# Calibration Horn System

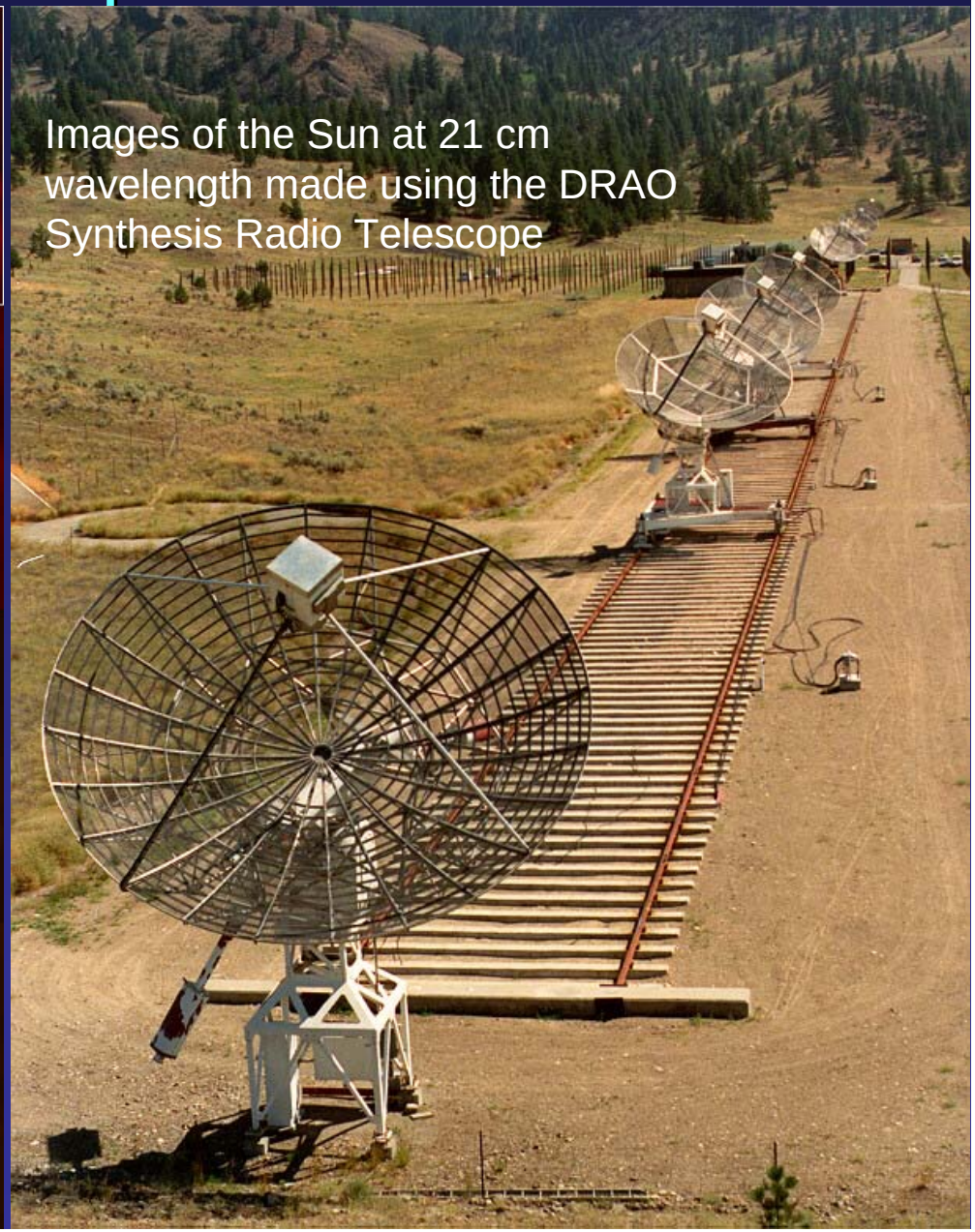


# Where Does F10.7 Come From?



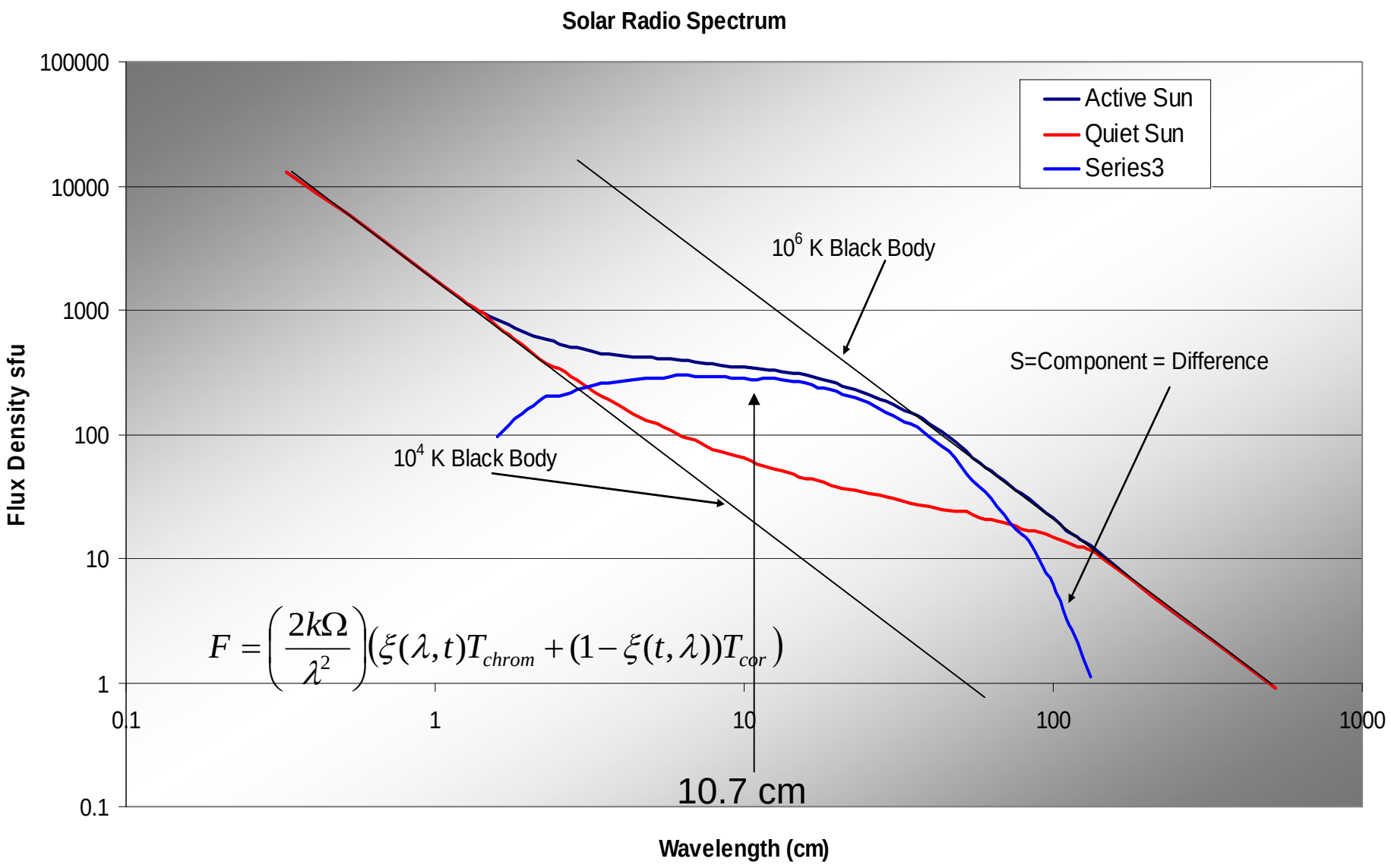
# Where Does the S-Component Come From?



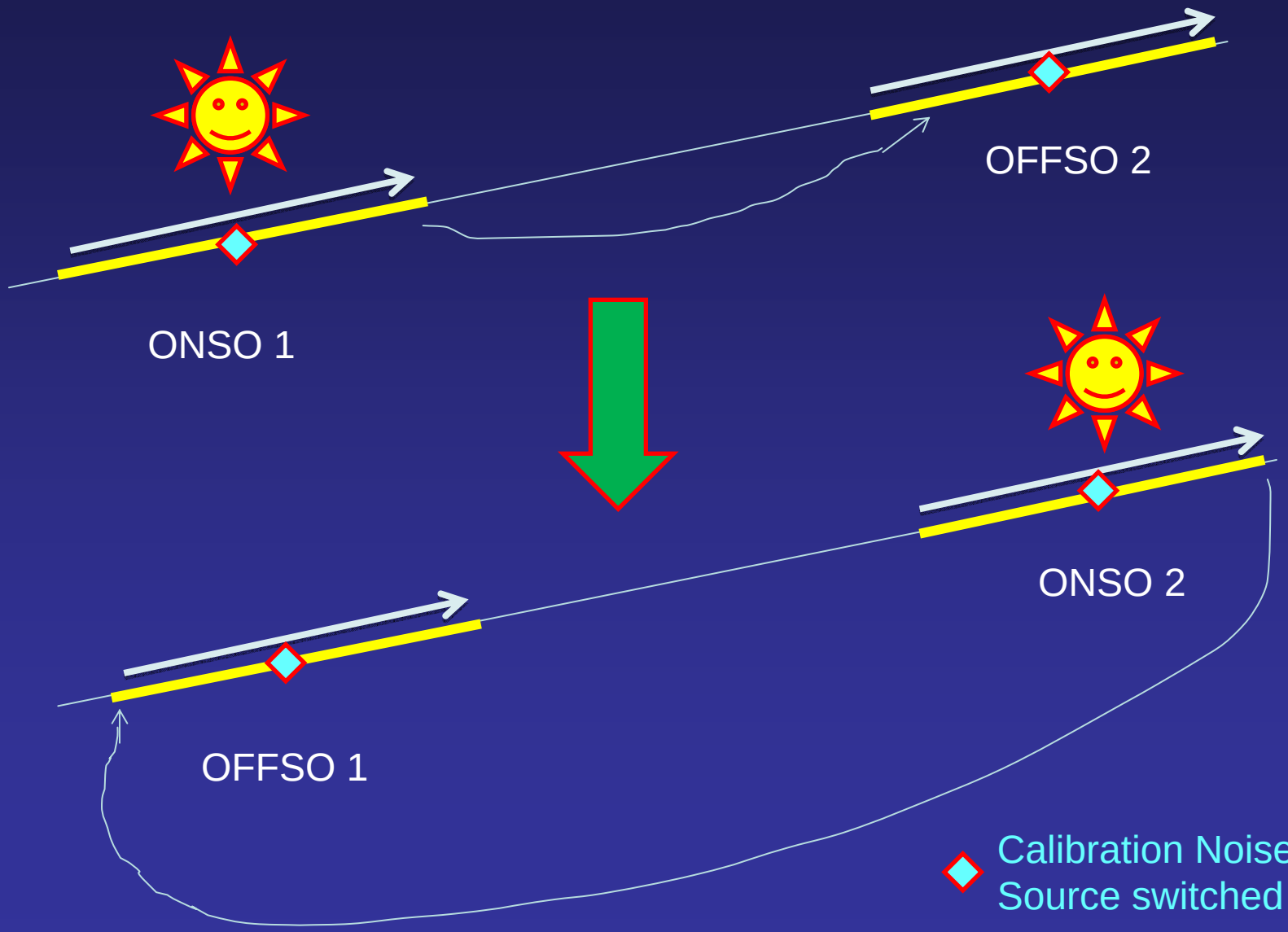
Images of the Sun at 21 cm wavelength made using the DRAO Synthesis Radio Telescope

# The S-Component Spectrum



# Flux Determination Method

(Shown for 2 Sub-Arcs Only. We Use 4 Sub-Arcs)

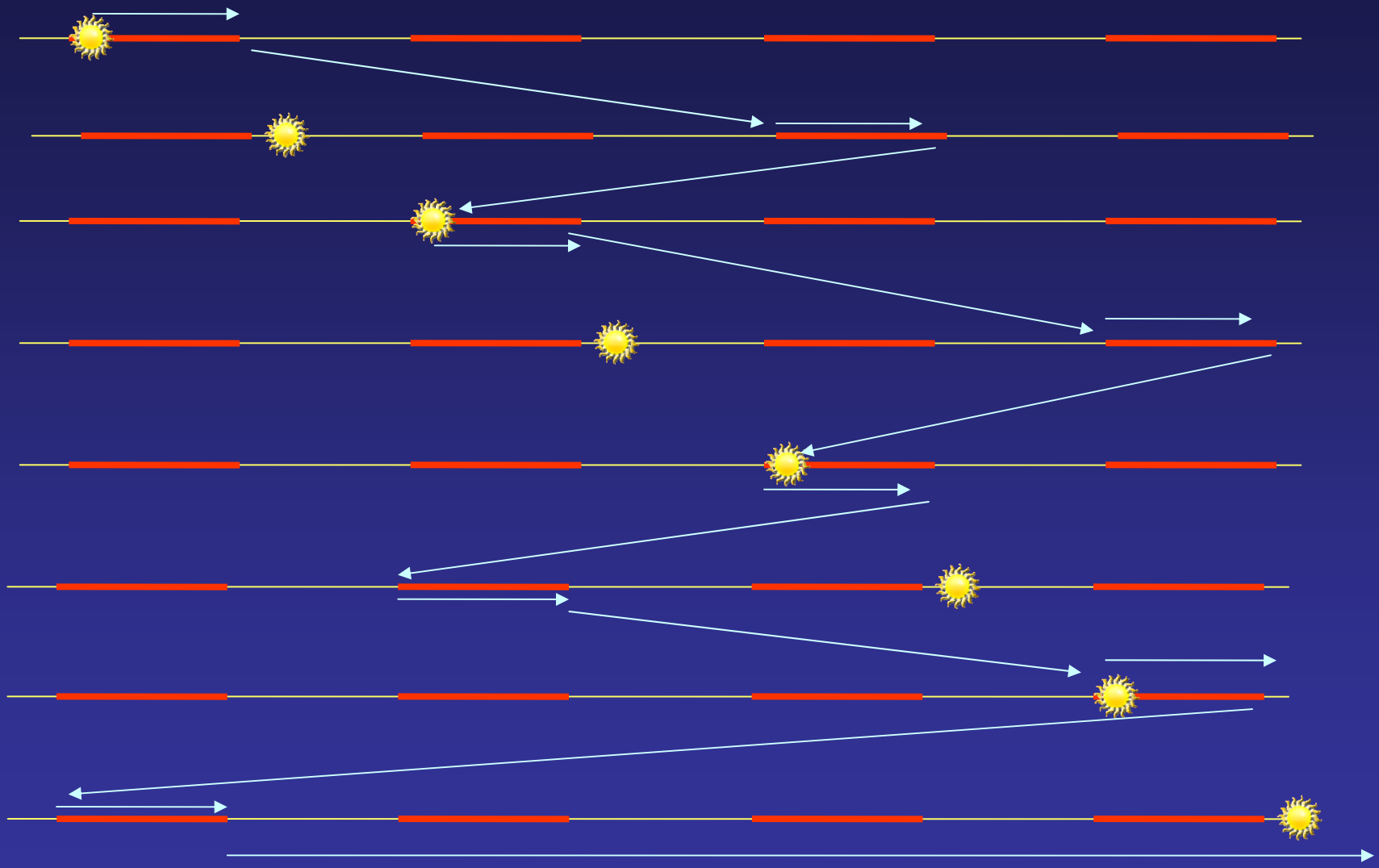


# Sad But True

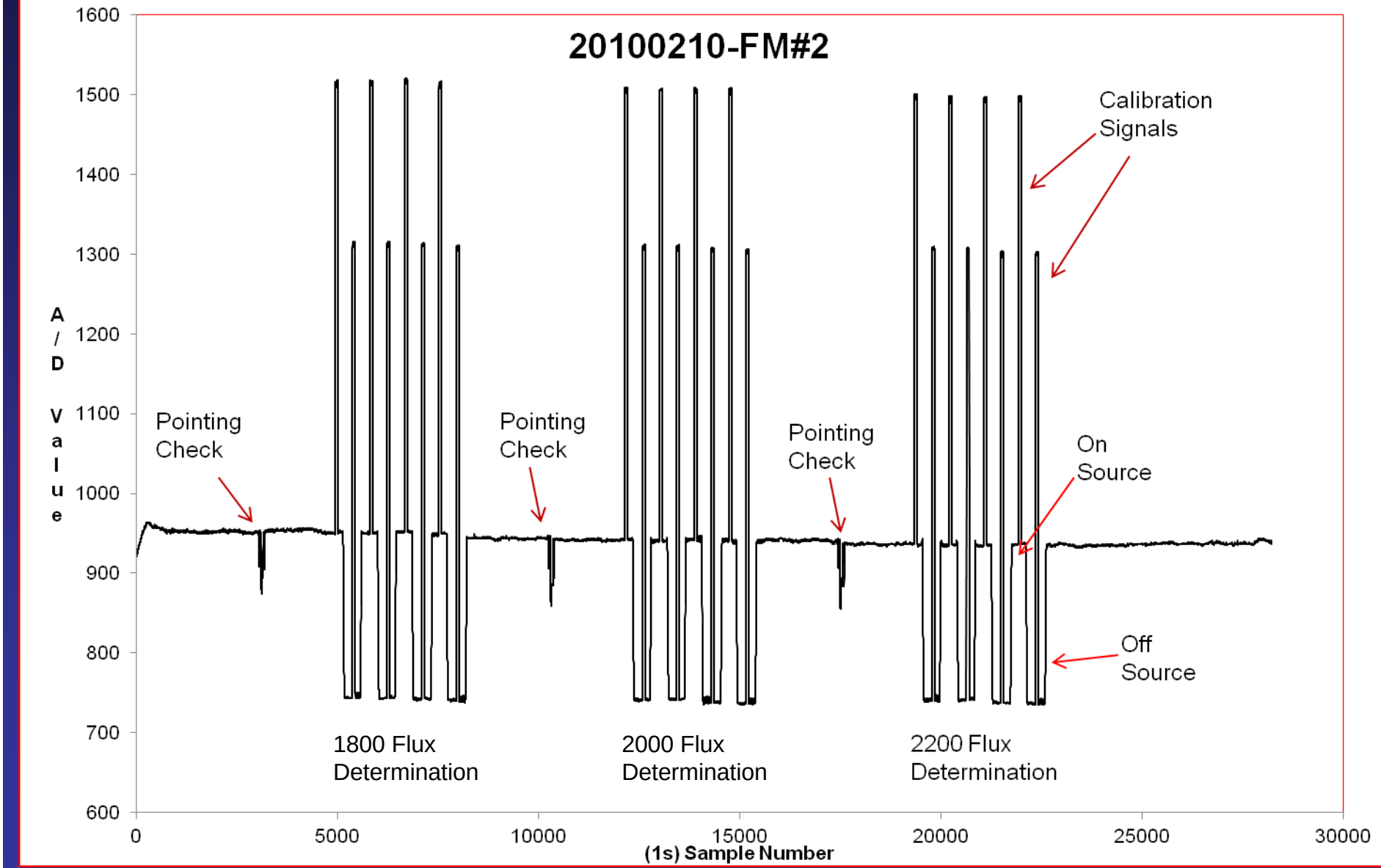
- Originally we could use six sub-arcs, with a pause in the middle of the flux determination to ensure the process always took one hour.
- Hardware and software obsolescence issues required that we did an upgrade (new computers, new A/D cards, new computer language and adapting the software. This included adding remote monitoring and diagnosis, which was necessary to accommodate changes in operational support.
- The result was a slower system, which required our reducing the number of sub-arcs to four.

**THE ENEMY OF "GOOD" IS "BETTER"!**

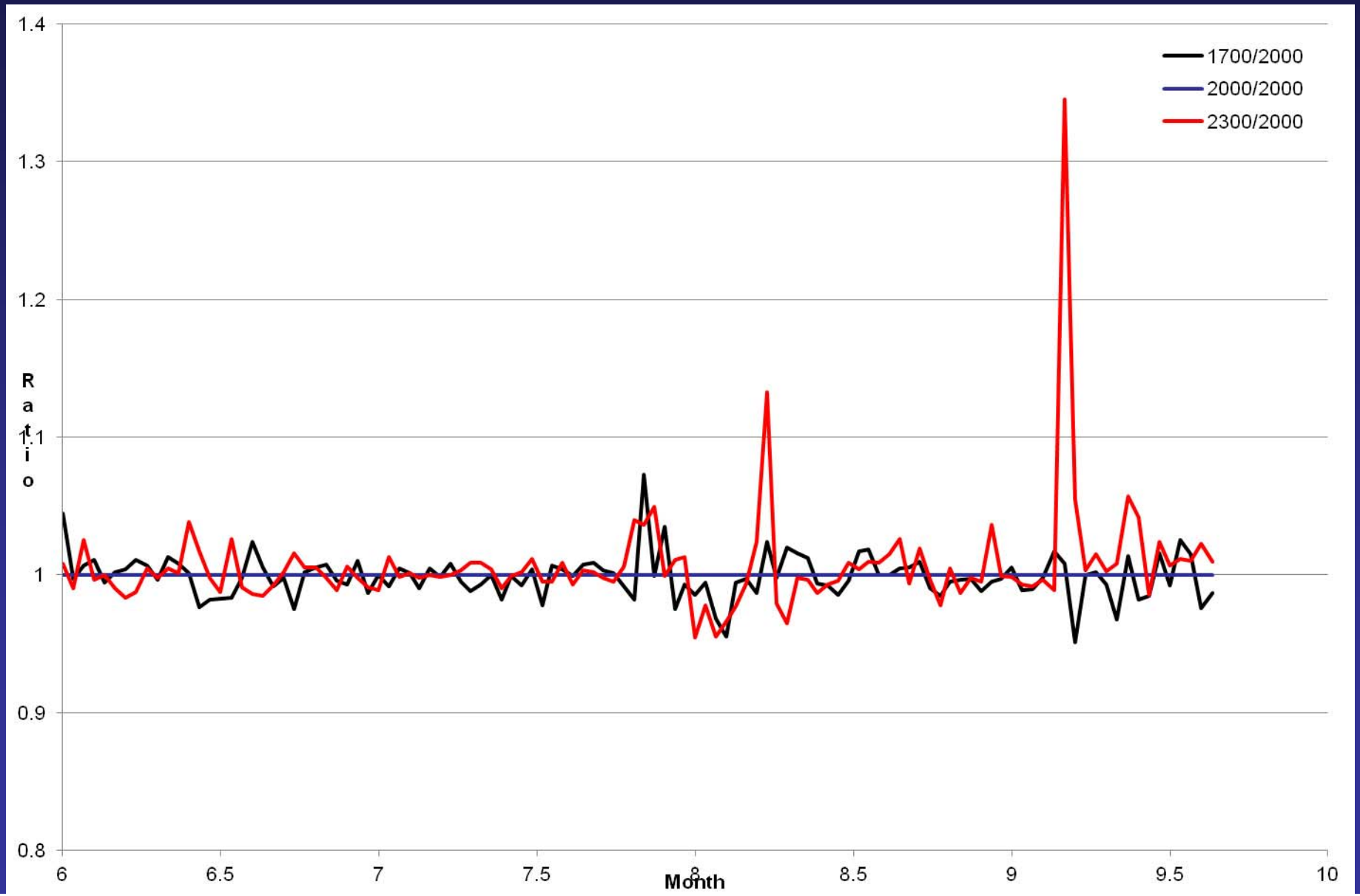
# Calibration Procedure



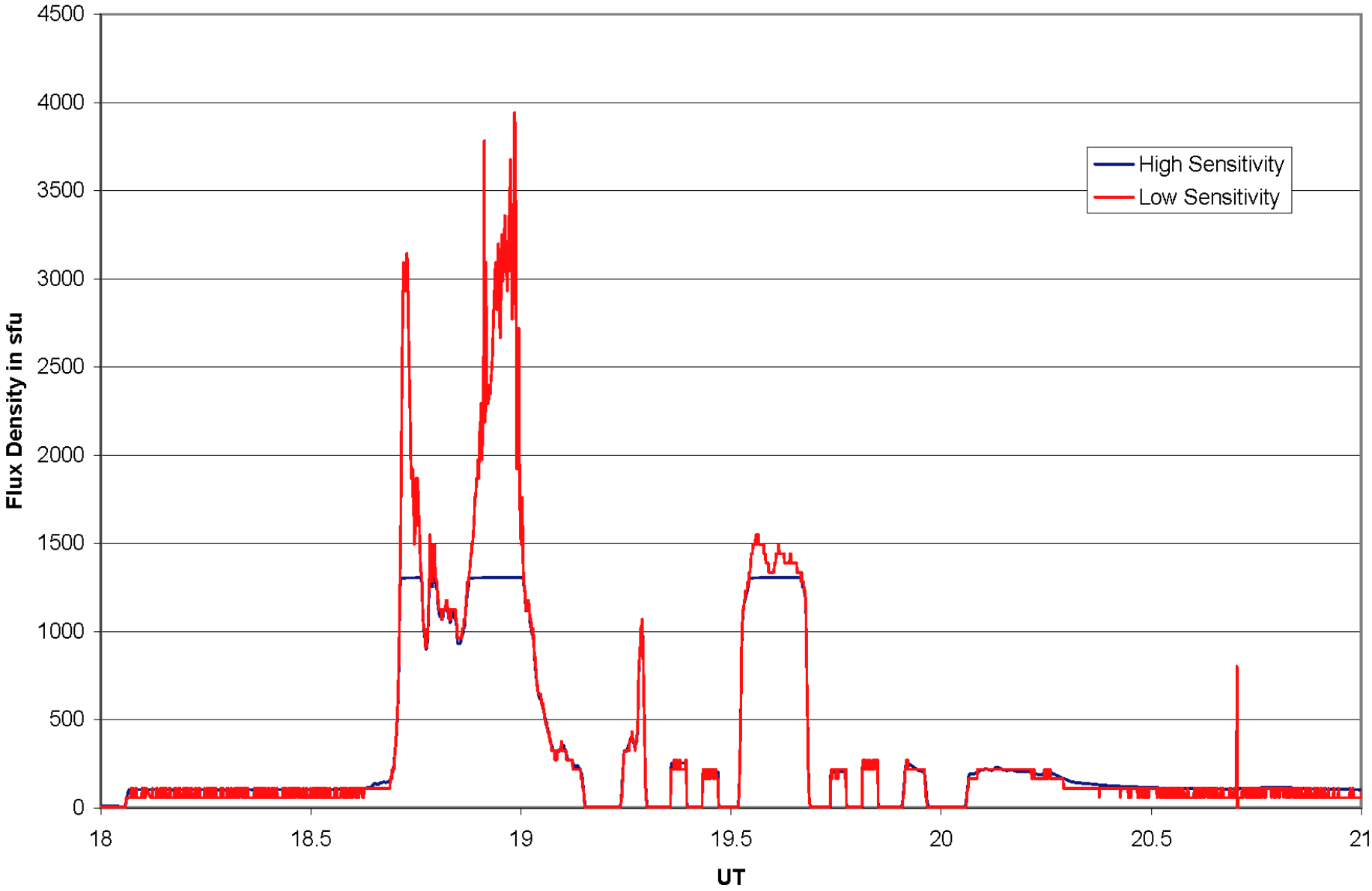
# Daily CR File



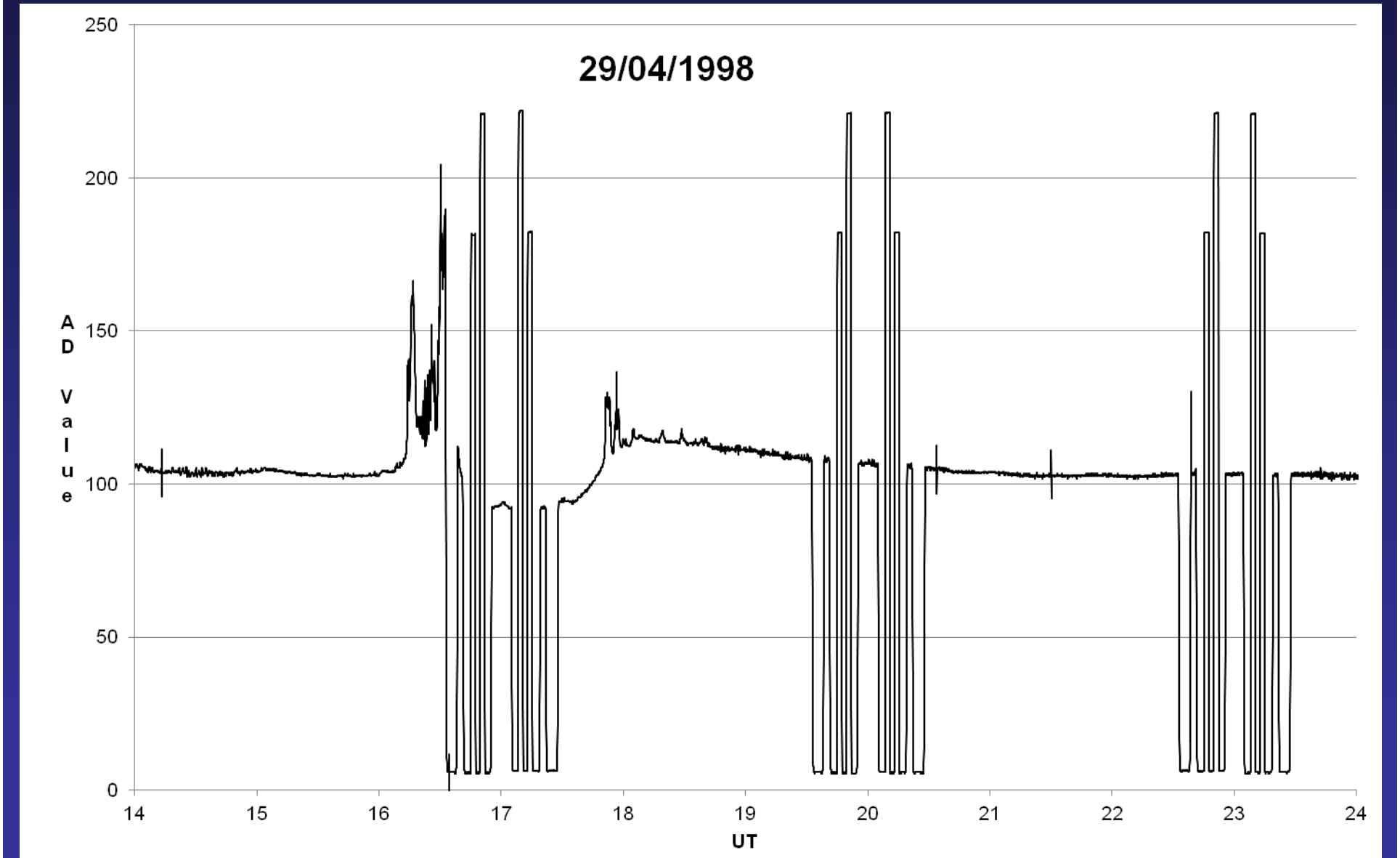
# Comparison of AM/ Noon and PM Flux Values



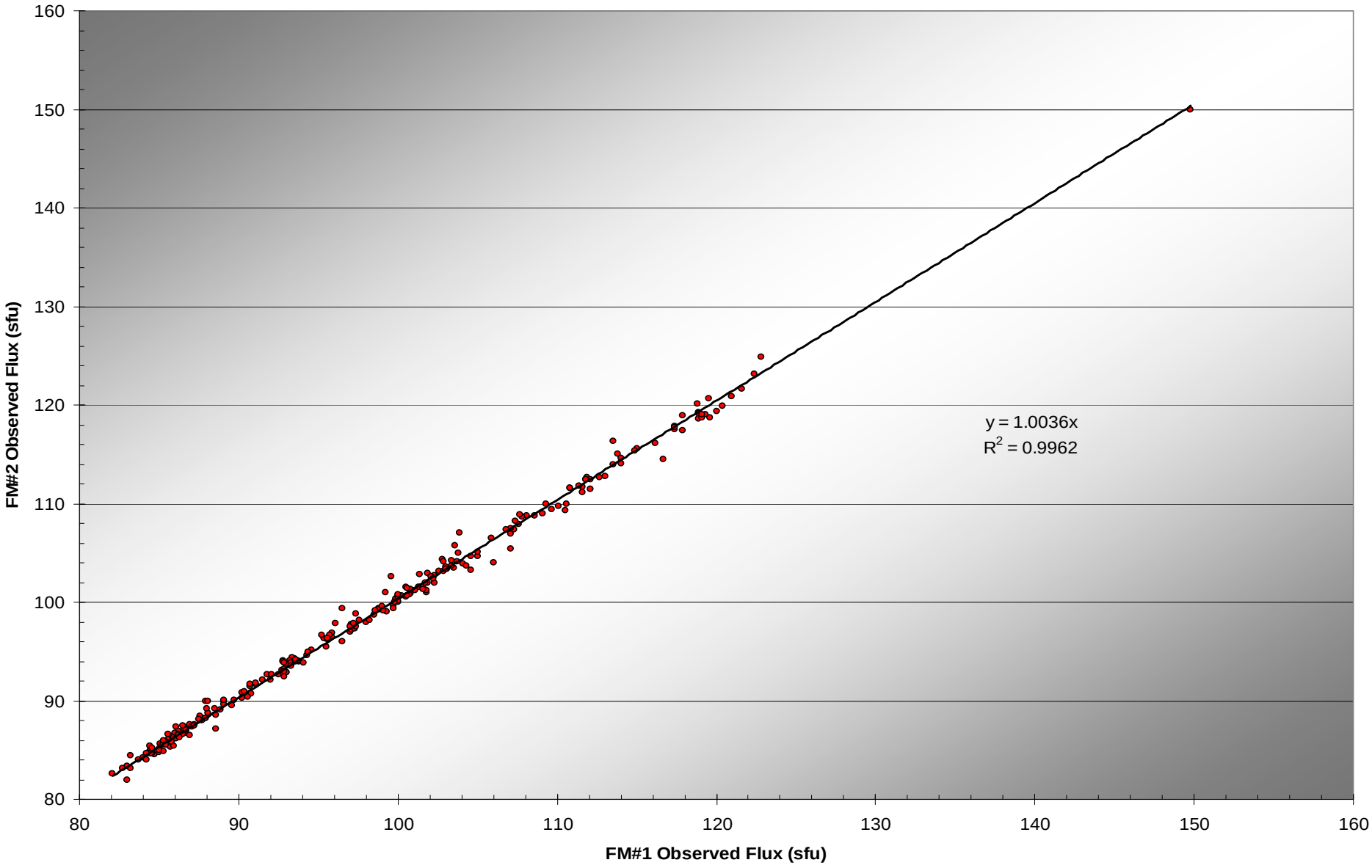
# 2006/12/06 Event: Value of Low-Sensitivity Channels



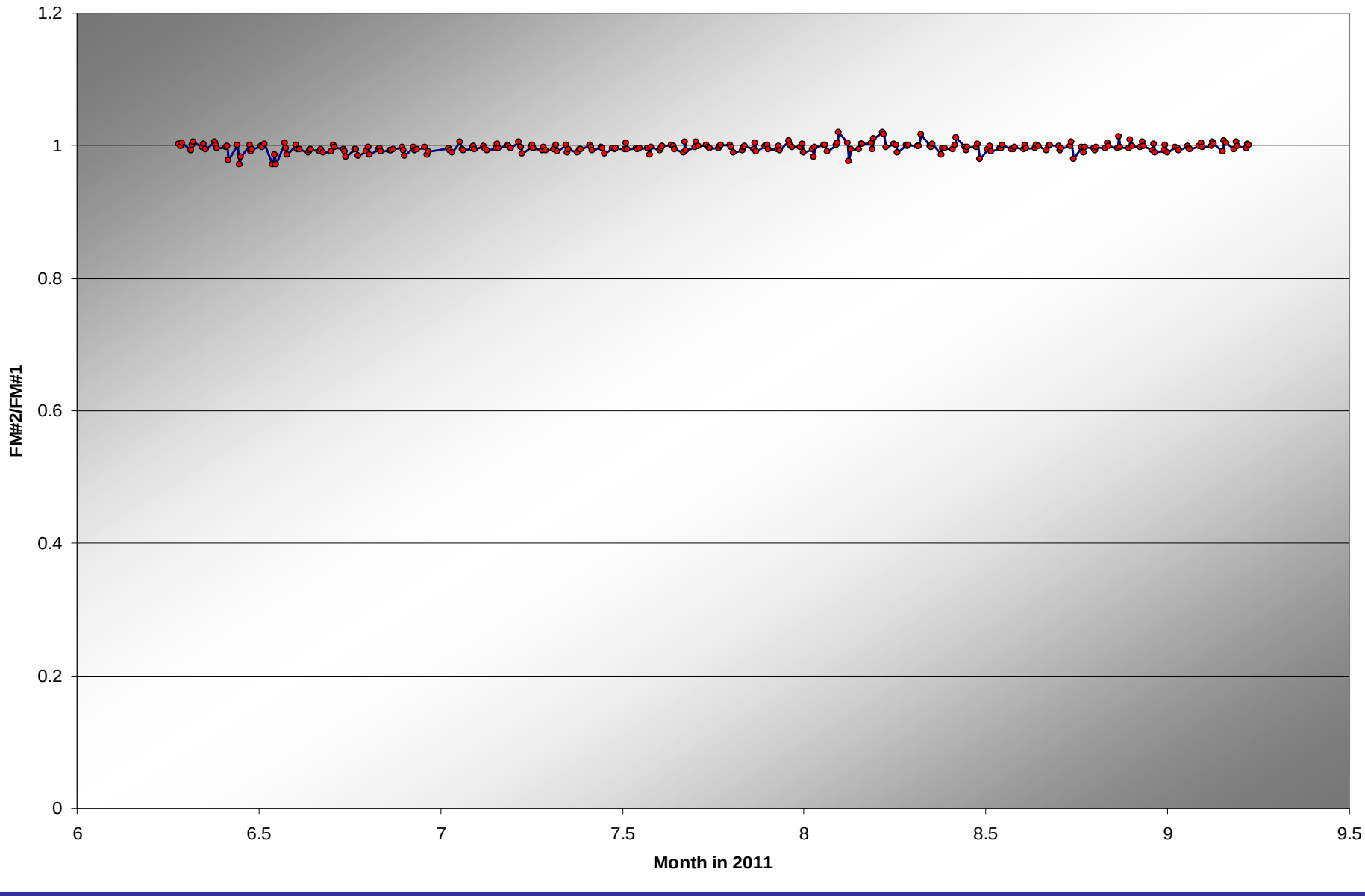
# Effects of Flares (2)



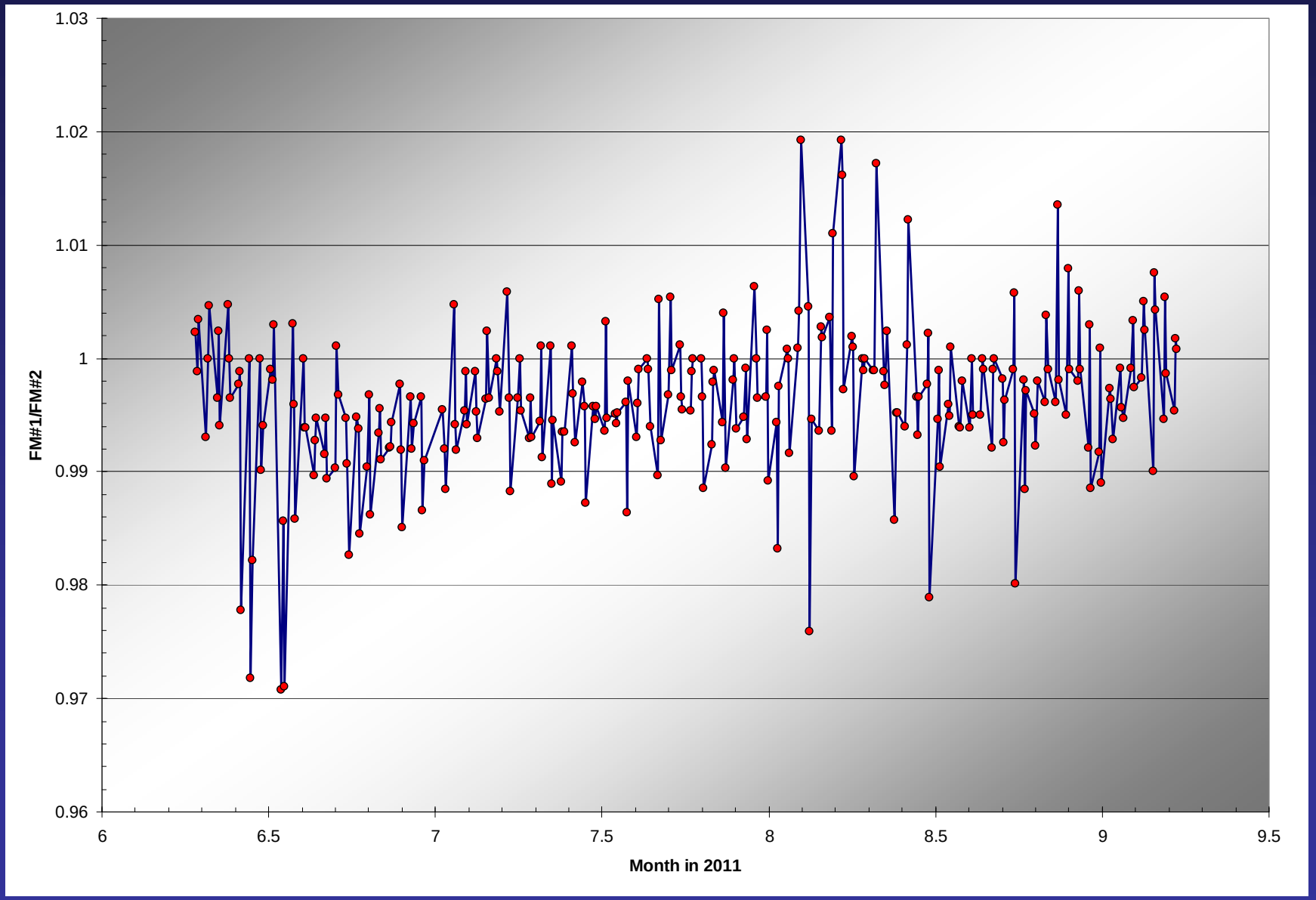
# FM#2 v. FM#1 Values



# FM#1/FM#2 Flux Ratio



# FM#1/FM#2 Flux Ratio



# F10.7

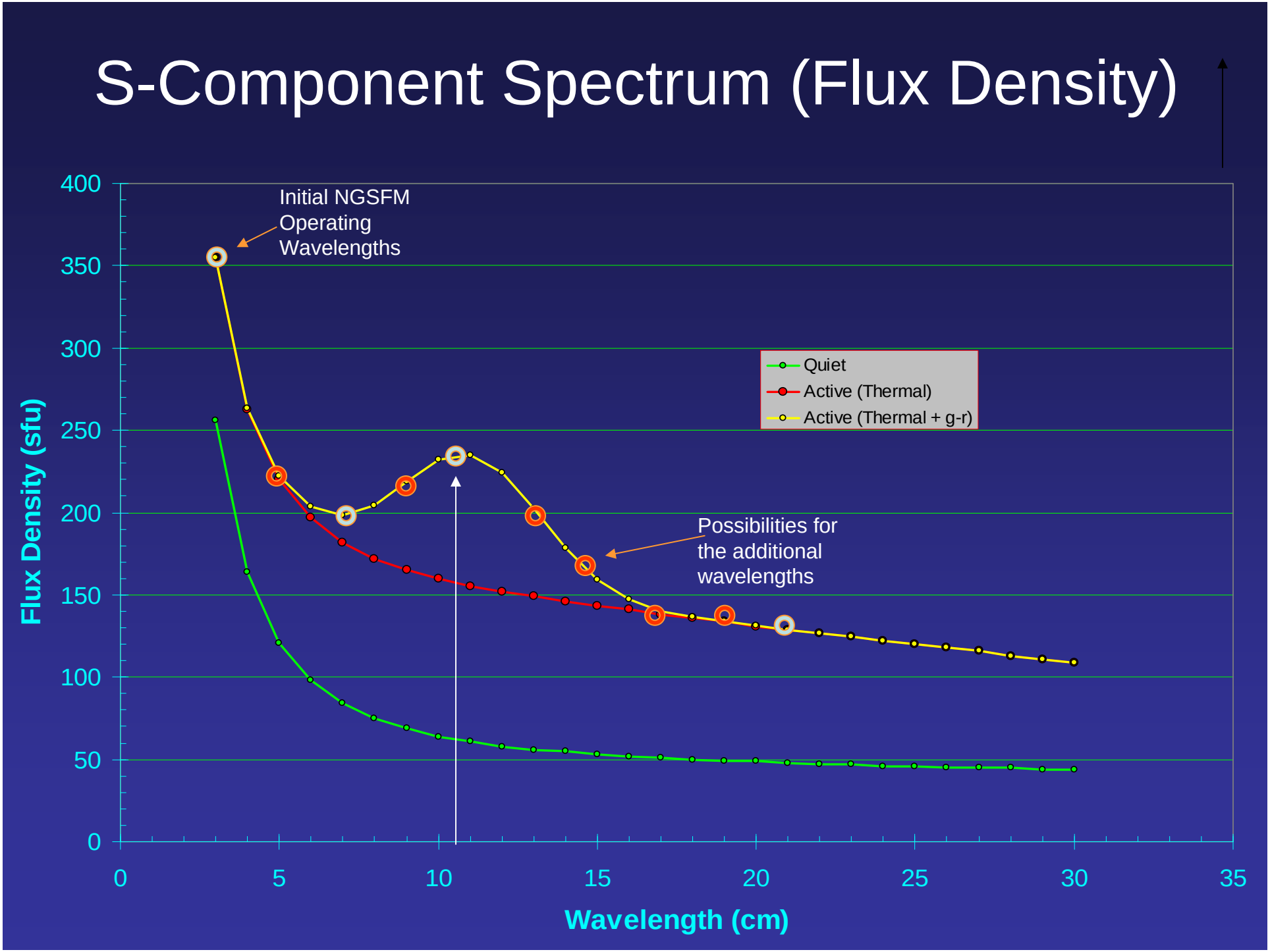
## What's Right About It

- It is a very good indicator of the general level of solar magnetic activity.
- It is a successful basis for proxies for various solar emission components and solar parameters.
- It is easy to measure and monitor with high objectivity. It is highly but not totally observer-independent.
- We have a consistent, continuous database covering more than 60 years.

## What's Wrong With It

- It contains contributions from at least two emission components (thermal free-free and thermal gyroresonance). The former is related to plage and the latter to sunspots.
- It is not therefore a pure index.
- An increase in F10.7 with number/area of sunspots makes it a poorer proxy for irradiance components subject to sunspot blocking.
- Since sunspot and plage area are not consistently proportional to one another, this can degrade its applicability to proxies (as our needs get tighter and tighter).

# S-Component Spectrum (Flux Density)



# Next Generation Solar Flux Monitor - Requirements

- To make precise flux determinations at enough wavelengths for the spectrum of the S-component to be obtained.
- *What would happen if we integrated over the whole spectrum, accommodating all the amplitude and peak frequency variations? Is that even possible in the DRAO electromagnetic environment?*
- To monitor the Sun with high time resolution for identification of bursts and perhaps reconnection events associated with the lift-off of coronal mass ejections.
- To provide a degree of redundancy for on-going data checks and to increase fault tolerance.
- To reach at least the calibration and data quality standards currently used with F10.7.

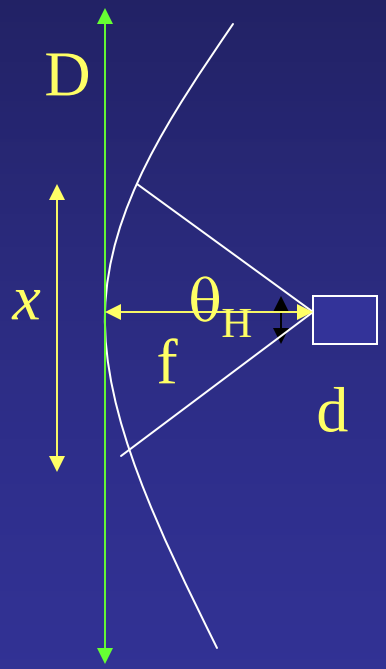
# Next Generation Solar Flux Monitor - Requirements

- The changes we want to monitor can be quite subtle. The best way to monitor them would be to use a single antenna for all the wavelengths, with an antenna beamwidth that is (fairly) independent of observing wavelength. This will make it more likely that any small perturbation would apply to all wavelengths, so that the ratios are less likely to be affected.
- We need to apply a common approach to calibration for all wavelengths. Again this is best met using a single system for all wavelengths.
- Assuming there are always some sort of linearity/dynamic range issue somewhere, a common design theme for all wavelengths would make it easier to identify deviations.

# Antenna Arrangement

Angular diameter of the patch of dish "seen" by the horn (horn diameter is *d*:

$$\theta_H = 57\frac{\lambda}{d}$$




Diameter of patch of dish seen by the horn:

$$x \approx f\frac{\theta_H}{57}$$

Beamwidth of antenna at that wavelength:

$$\theta_D = 57\frac{\lambda}{x} = 57\frac{d}{f}$$

Beamwidth is independent of wavelength until $x => D$

We want a beamwidth of about 5 degrees. This will require $d/f = 0.09$ ($f \approx 10d$). For a feed 10cm in diameter, we want a dish with a 1m focal length and to give a 5-degree beam at the longest wavelength (30cm), a diameter of more than 3.6m

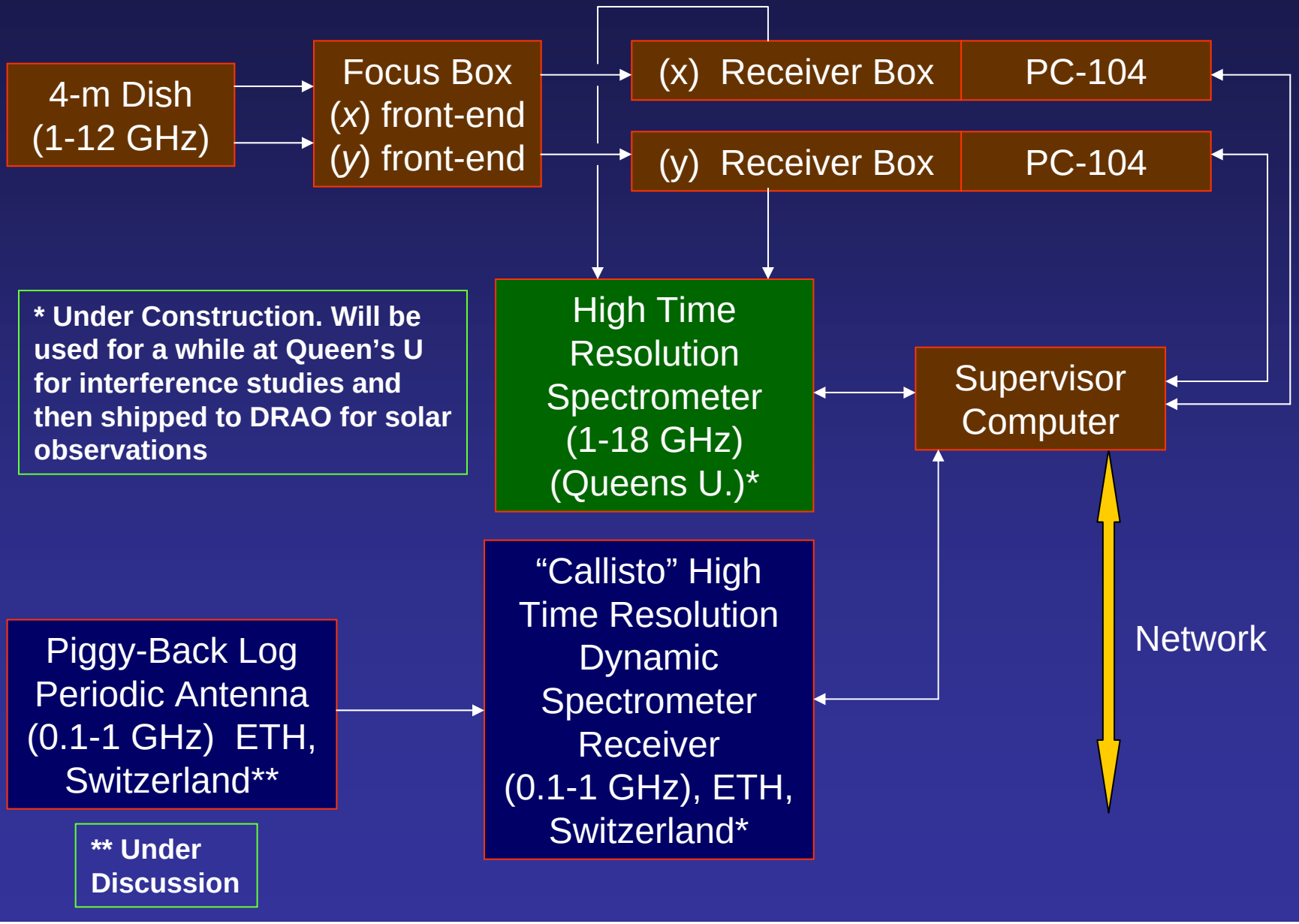
# NGSFM Antenna

4-m Altazimuth Dish In this picture it is being tested using an S-Band test receiver.

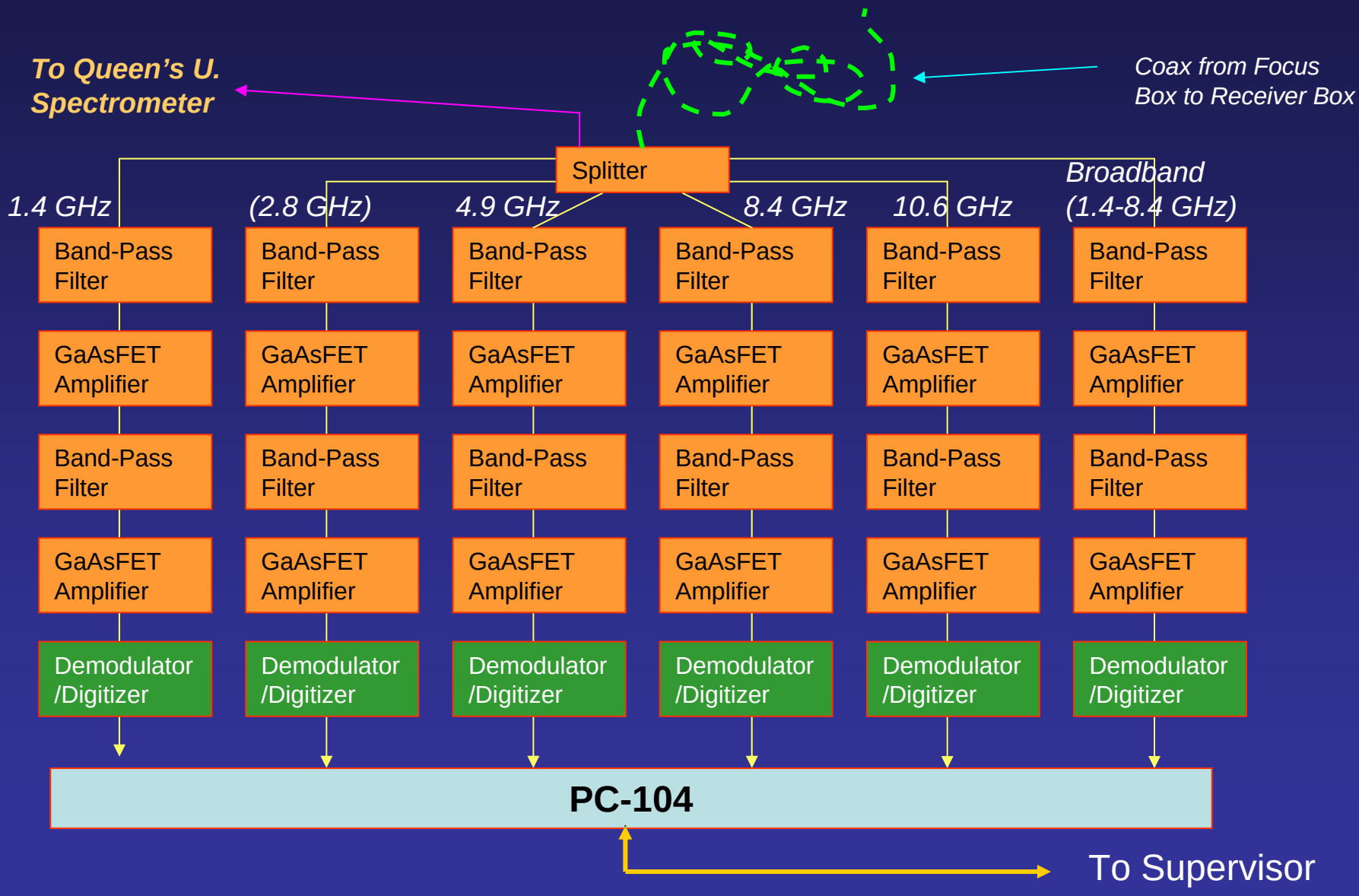
# Specification for the NGSFM

- Antenna half-power beamwidth to stay in the range 3 – 5 degrees over the wavelength range 21 – 3 cm (1.4 – 10 GHz).
- Multi-wavelength operations: 21cm, 10.7 cm, 6cm, 4 cm, 2.8 cm and “broadband”.
- Dual orthogonal linear polarization (not primarily for science, for redundancy and backup).
- Three precise flux determinations a day plus a “continuous record” from sunrise to sunset, for each polarization and wavelength.
- Time resolution in continuous record better than 10ms, target is 1ms.
- Modular system that can be duplicated totally or in part in the construction of other instruments.
- 7 calibration levels, so that the degree of extrapolation is reduced and we can monitor linearity and dynamic range. *We achieve this by using three noise sources that can be switched on and off in various combinations (no switches or other moving parts).*

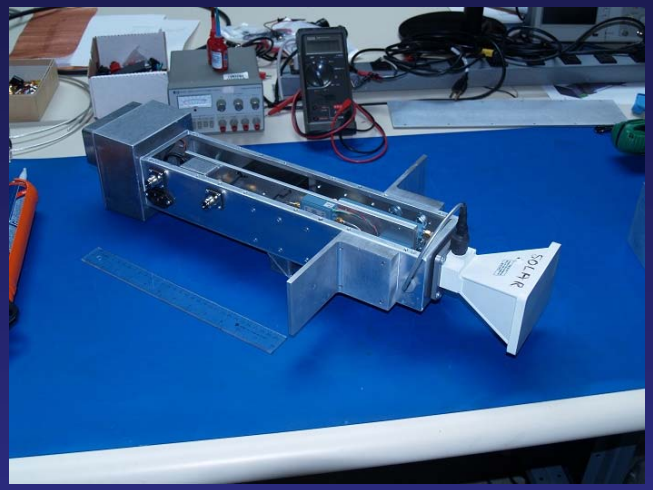
# Ultimate Objective

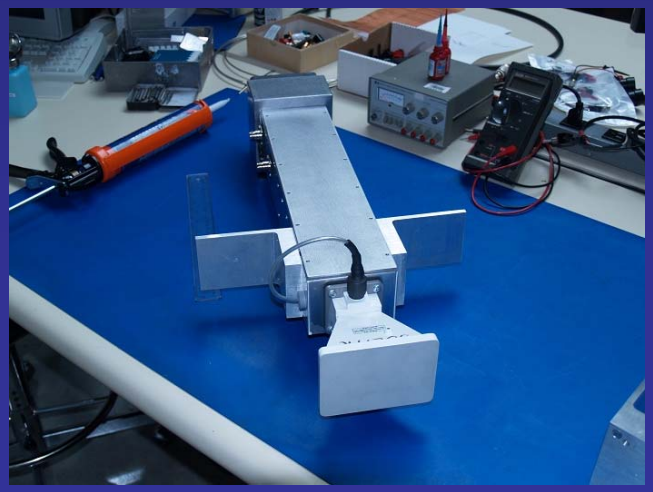


# NGSFM-RX (One Polarization)

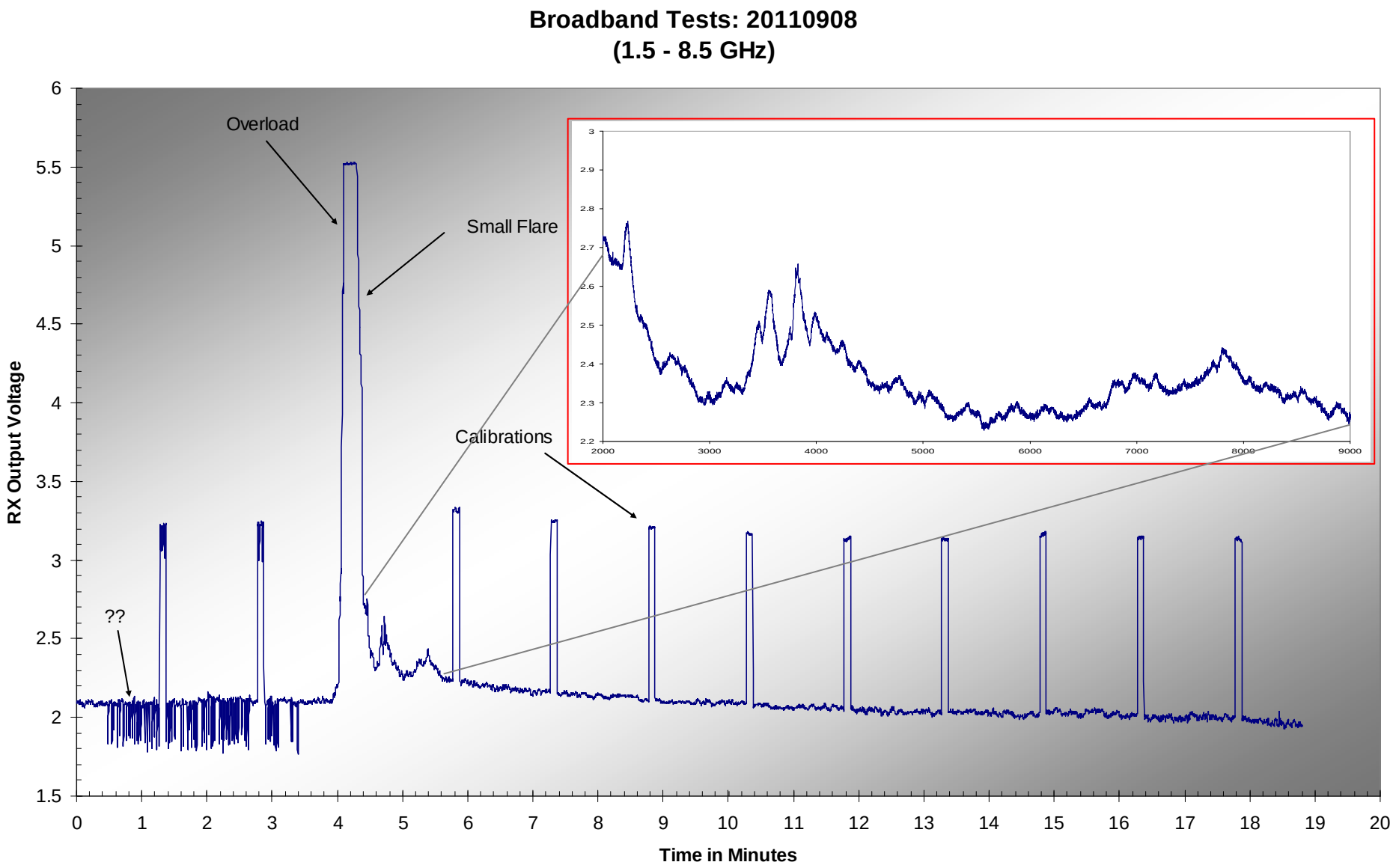


# Trials Using the Broadband Test Receiver



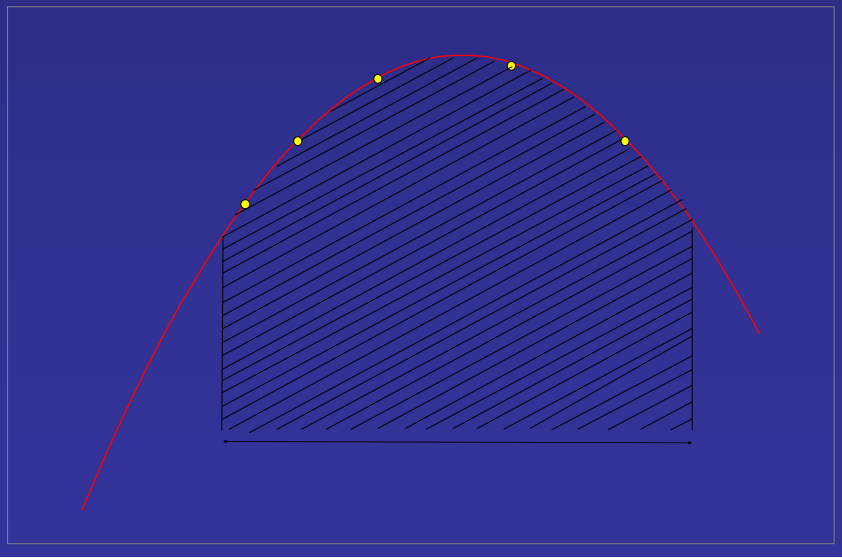


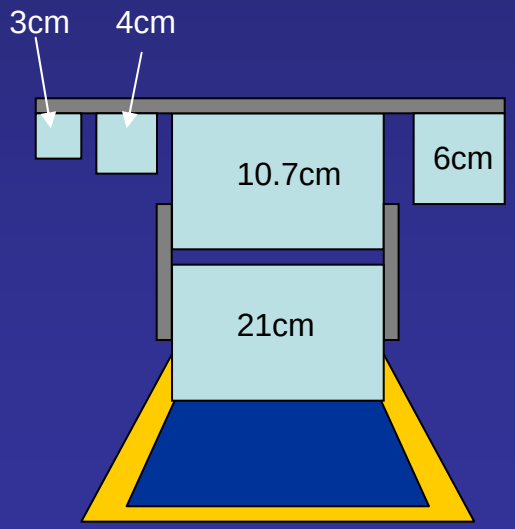
# NGSFM – First Light: 20110908



# Calibration

- The NGSFM cannot be intrinsically calibrated. An absolute calibration standard is needed for each wavelength. This can be handled using separate calibration horns attached as outriggers to the existing horns. The 21cm calibration will be using the lower, spare horn, which means its beam will be a bit fat.
- Calibrating the broadband measurements is more problematic. The current idea is to take the spot measurements made using the horns, fit a curve, integrate under it and use that to calibrate the broadband flux.





# Data Products

- F21.1, F10.7, F6.0, F3.6, F2.8(?), FBB
- CR files (1 sec sampling) for each of the above wavelengths.
- HS files (1 ms sampling) for each of the above wavelengths.
- 1 – 11 GHz spectra.
- Possibly, eventually, 0.1 – 1 GHz spectra.

# Finally…

- Operations with the NGSFM are due to start in 2013.
- The existing flux monitors, producing F10.7, will continue to operate. The F10.7 capability of the NGSFM will be a backup and an additional fixing point for cross-calibration.
- The NGSFM will become FM#3