Callisto calibration

$$V = a + b \cdot \log(c)$$

General equation describing logarithmic detector, where

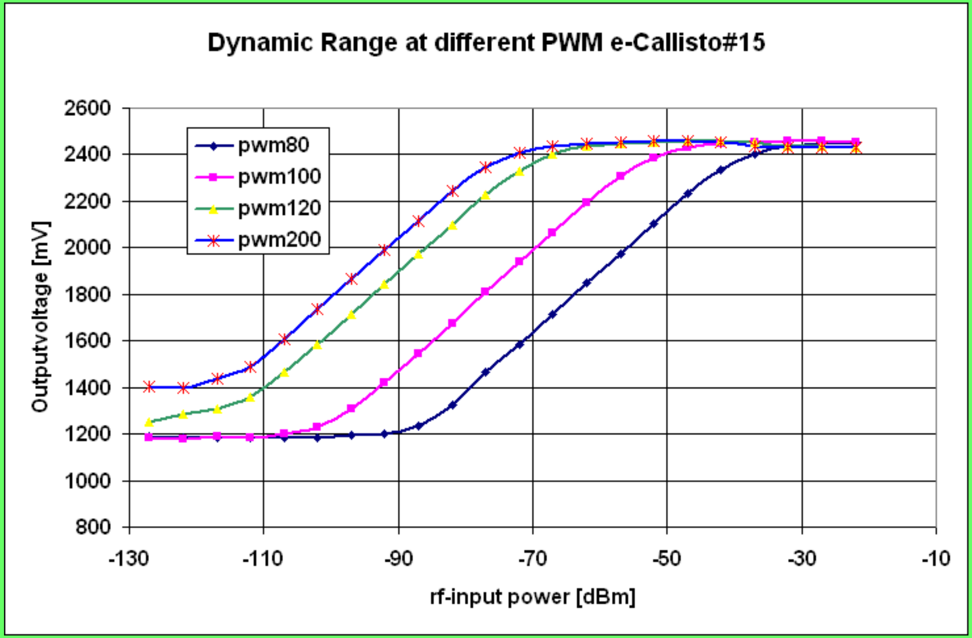
V = output voltage of the instrument -> FIT-file

a = offset voltage of the instrument

b = detector konversion constant (mV/dB)

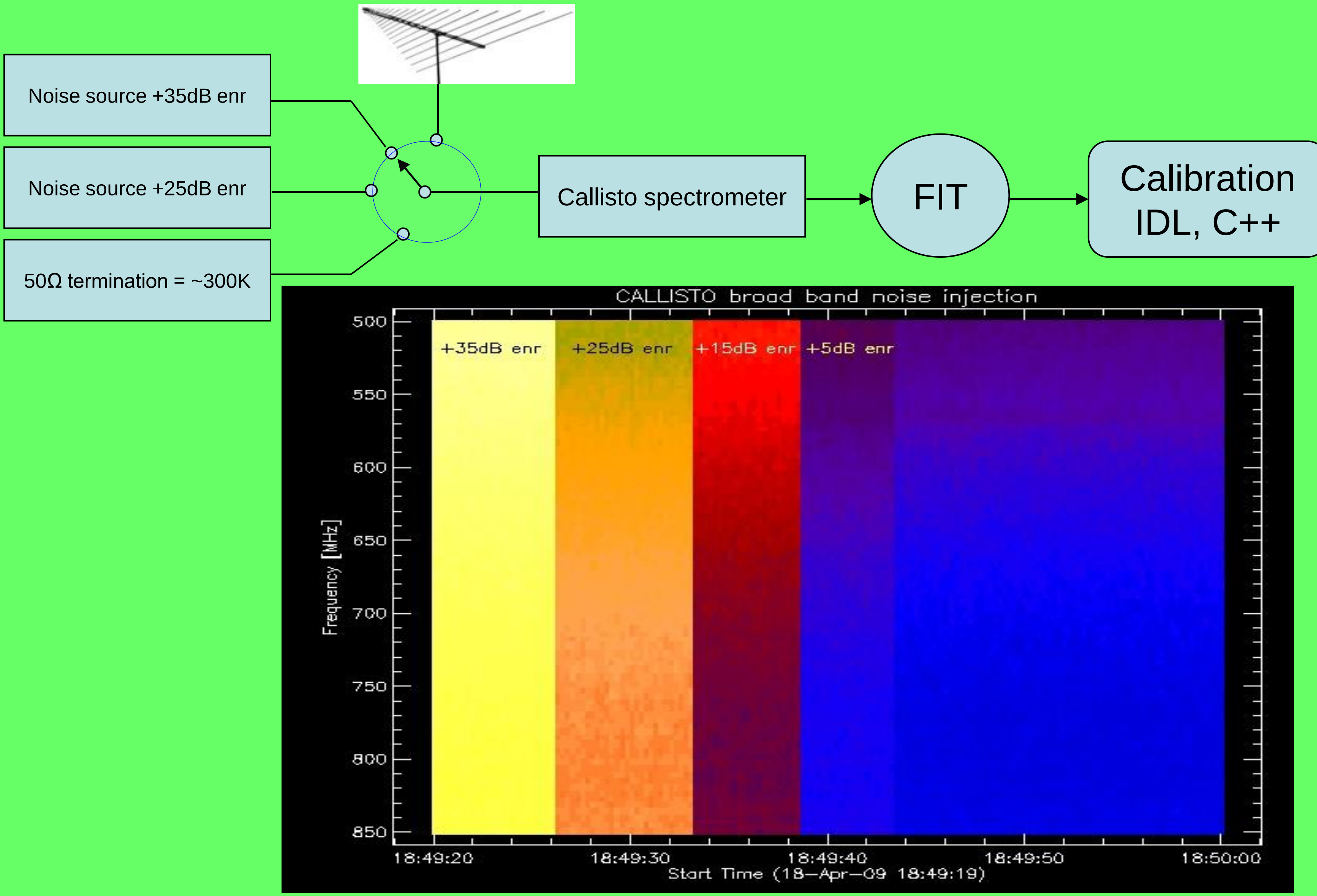
c = system temperature, where c = Trx+Ta = Trx + S*Aeff/(2*k) where Aeff=λ^2*G/(4*π)

$$c = 10^{\frac{(V-a)}{b}}$$



This equation above describes the function of the logarithmic detector.
To solve this equation, we need in principle 3 independent measurements

Callisto calibration



Callisto calibration

Given

$$\mathbf{Vcold = Vo + b \cdot log(Trx + Tcold)}$$

50 ohm termination = 300 K

$$\mathbf{Vwarm = Vo + b \cdot log(Trx + Twarm)}$$

Noise source 10% = 25 dB enr = 94'868 K

$$\mathbf{Vhot = Vo + b \cdot log(Trx + Thot)}$$

Noise source 100% = 35 dB enr = 948'683

Known: Vcold, Vwarm, Vhot, Tcold, Twarm and Thot
Unknown: Vo, b and Trx

This set of non-linear equations can not be solved mathematically correct,
it can only be solved numerically

But since Trx ~ Tcold << Twarm < Thot, the set of equations can be simplified.
This simplification leads to a set which can be solved straight forward.

Callisto calibration

Given

$$\mathbf{Vcold} = \mathbf{Vo} + \mathbf{b}\cdot\log(\mathbf{Trx} + \mathbf{Tcold})$$

50 ohm termination = 300 K

$$\mathbf{Vwarm} = \mathbf{Vo} + \mathbf{b}\cdot\log(\mathbf{Twarm})$$

Noise source 10% = 25 dB enr = 94'868 K

$$\mathbf{Vhot} = \mathbf{Vo} + \mathbf{b}\cdot\log(\mathbf{Thot})$$

Noise source 100% = 35 dB enr = 948'683 K

$$\mathbf{Find}(\mathbf{Vo},\mathbf{b},\mathbf{Trx}) \rightarrow \begin{bmatrix} \dfrac{(-\mathbf{Vwarm}\cdot\ln(\mathbf{Thot}) + \ln(\mathbf{Twarm})\cdot\mathbf{Vhot})}{(-\ln(\mathbf{Thot}) + \ln(\mathbf{Twarm}))} \\ \ln(10)\cdot\dfrac{(-\mathbf{Vhot} + \mathbf{Vwarm})}{(-\ln(\mathbf{Thot}) + \ln(\mathbf{Twarm}))} \\ \exp\left[\dfrac{-(\mathbf{Vcold}\cdot\ln(\mathbf{Thot}) - \mathbf{Vcold}\cdot\ln(\mathbf{Twarm}) - \mathbf{Vwarm}\cdot\ln(\mathbf{Thot}) + \ln(\mathbf{Twarm})\cdot\mathbf{Vhot})}{(-\mathbf{Vhot} + \mathbf{Vwarm})}\right] - \mathbf{Tcold} \end{bmatrix}$$

Callisto calibration

Final equation for calibration:

$$S_\lambda = \frac{2 \cdot k}{\lambda^2} \cdot \frac{4 \cdot \pi}{G_\lambda} \cdot \left[10^{\frac{(V_\lambda - Vo_\lambda)}{b_\lambda}} K - Trx_\lambda \right]$$

Still without taking into consideration second order effects like:
- Side lobes
- Spill over
- Cable loss (antenna – switch)
- Noise temperature enhancement by physical temperature of cables (antenna – switch)

To improve, do the same on the cold sky and take the difference S = S(sun) – S(sky)

k = Boltzmann constant
K = 1 Kelvin
λ = wavelength = c/f [m]
G = antenna gain
Trx = receiver noise temperature [K]

V = voltage at one frequency on the sky
Vo = offset voltage at the same frequency
b = detector coefficient at the same frequency
S = radio flux of sky/sun at the same frequency [sfu]