ELBARA: Low altitude L-band radiometer for soil moisture retrieval

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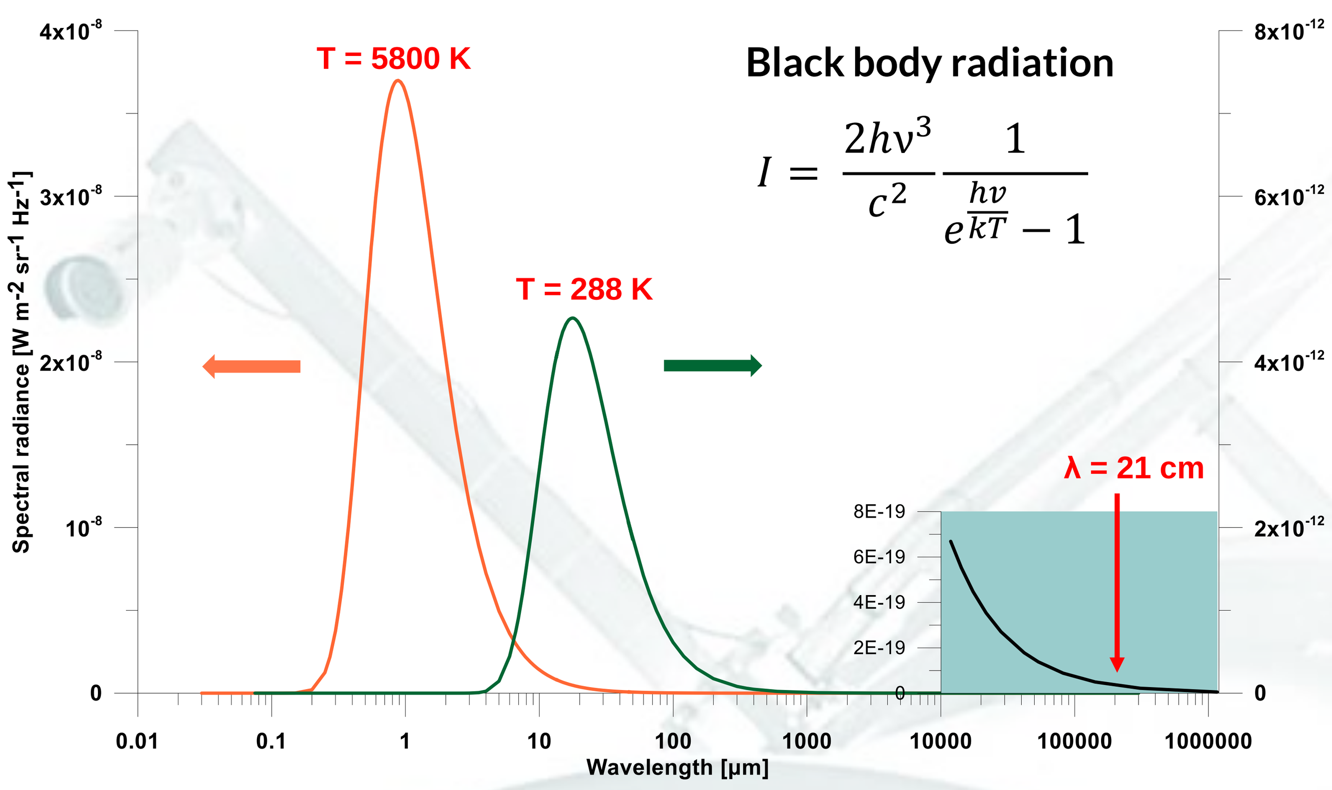
ELBARA (ESA L-Band Radiometer) is passive radiometer localized in Sekow, near Bubnow Wetland. Measured frequency (1420 MHz) has stritce scientific purpose in radioastronomy, so this band is officially protected. For this reason, ELBARA measurements (theoretically) should be clean of various radio frequency interferences (RFI) or other artificial emitters. The L-band is also sensitive to changes in soil moisture, and that's why we can use ELBARA in agrophysics. Radiometer has unique feature that allows it to rotate full circle on 6.5 m and study four different test-sites (meadow, wetland, fallow and cultivated field).

PRINCIPLE OF OPERATION

ELBARA uses passive remote-sensing technique that measures thermal radiation based on Planck law. Radiometer collect radiance, called brightness temeprature (T_B), emitted from a terrestrial surface at both horizontal and vertical polarizations. This value depends on the surface temperature T_S, and its reflectivity R^p what can be described by equation:

$$T_B^p = (1 - R^p)T_s + R^p T_{sky}$$

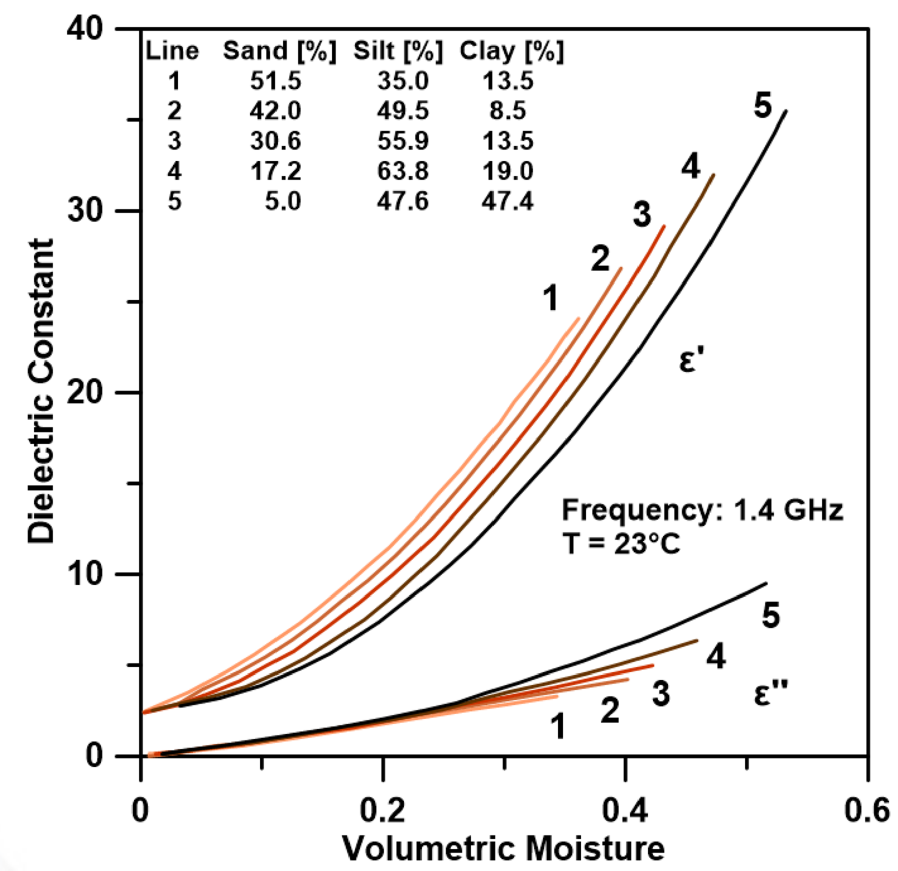
T_{sky} is constant value (4.2 K), which is important to radiometer calibration. To calculate reflectivity parameter, in simplest approach, we can use Fresnel equations for flat, homogeneous surface. In these formulas, incident angle and dielectric constant for soil are revealed:



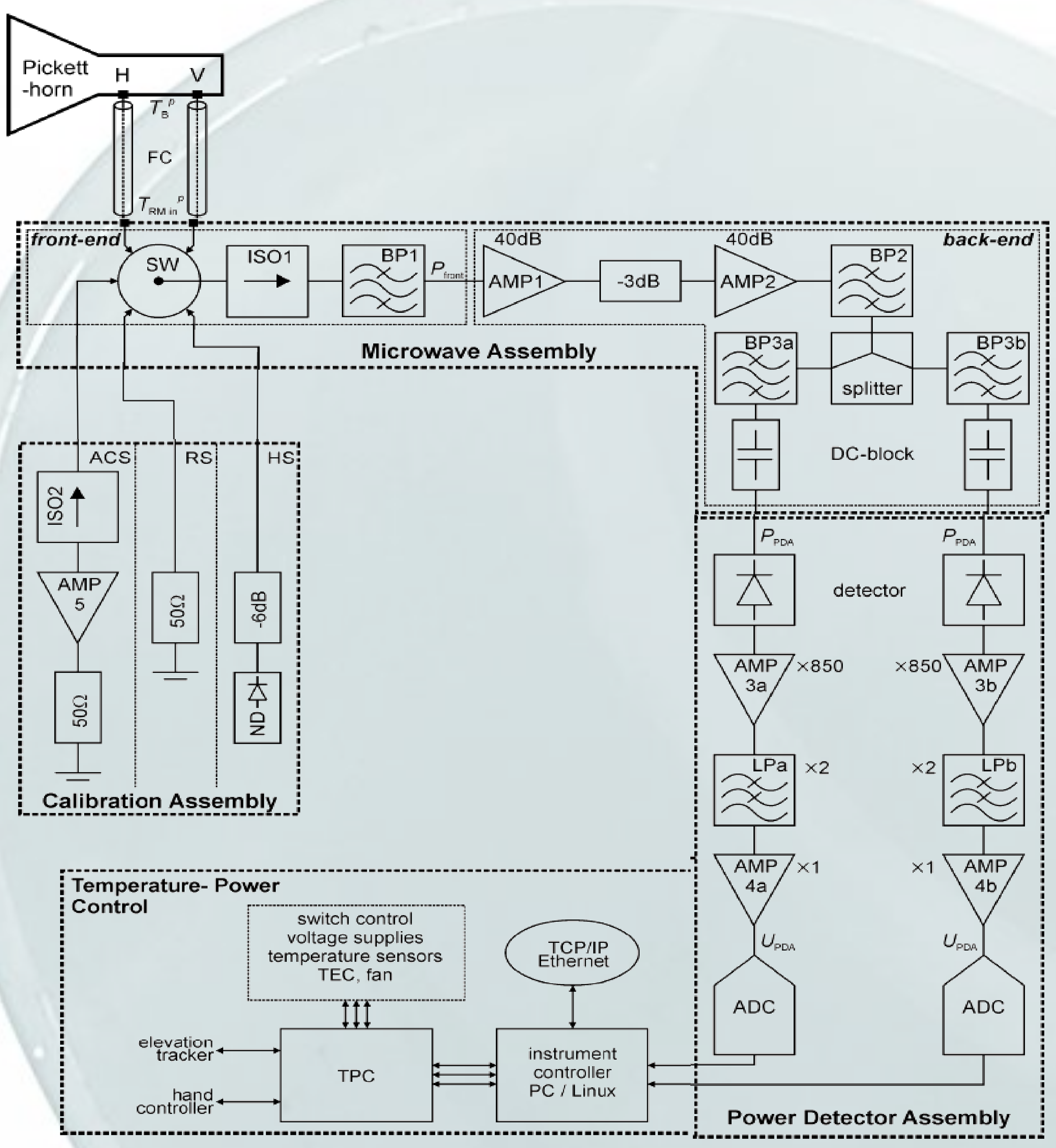
$$R(H,\Theta) = \left|\frac{\cos\Theta - \sqrt{\varepsilon_{soil} - \sin^2\Theta}}{\cos\Theta + \sqrt{\varepsilon_{soil} - \sin^2\Theta}}\right|^2$$

$$R(V,\Theta) = \left|\frac{\varepsilon_{soil}\cos\Theta - \sqrt{\varepsilon_{soil} - \sin^2\Theta}}{\varepsilon_{soil}\cos\Theta + \sqrt{\varepsilon_{soil} - \sin^2\Theta}}\right|^2$$

Because soil is composed of minerals, organic matter, air and water, and water contributes most to soil dielectric constant, there is a relationship beetwen soil moisture and brightness temperature. In addition, parameters such as surface porosity or vegetation cover are taken into consideration.

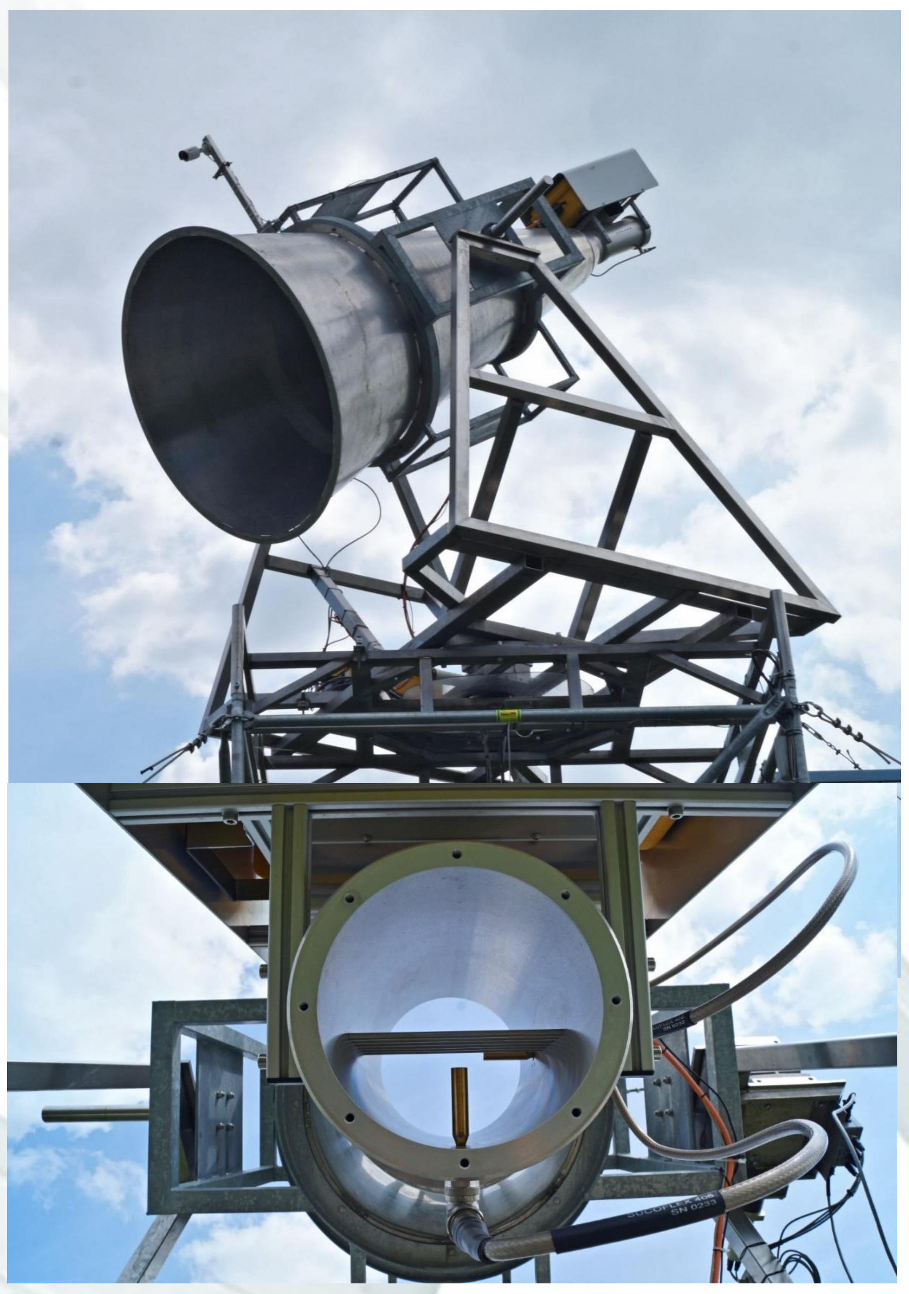


RADIOMETER DESIGN

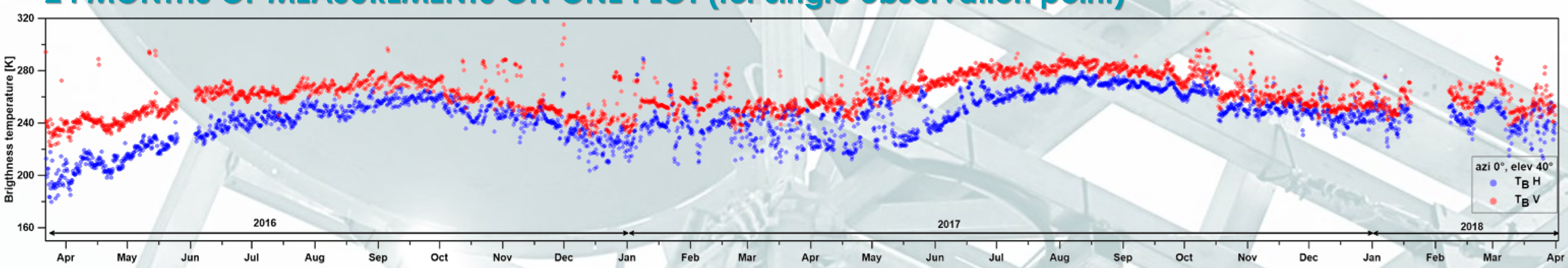


1. Antenna: Picket-horn type, collecting signal at horizontal nad vertical polarizations.
2. Microwave assembly: signal selection from the noise, split to two channels
3. Power detector assembly: amplifiyng and filtering signal, convert from analog to digital
4. Temperature-power control: uses Peltier module to very precise control temperature at calibration assembly and radiometer management
5. Calibration assembly: internal calibration sources to determine the absolute value of noise signals

Channel 1: 1400-1418 MHz
Channel 2: 1409-1427 MHz
Attenuation: -3 dB beamwidth of ± 6°
Detection sensitivity ~10^{-13} W



24 MONTHS OF MEASUREMENTS ON ONE PLOT (for single observation point)



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