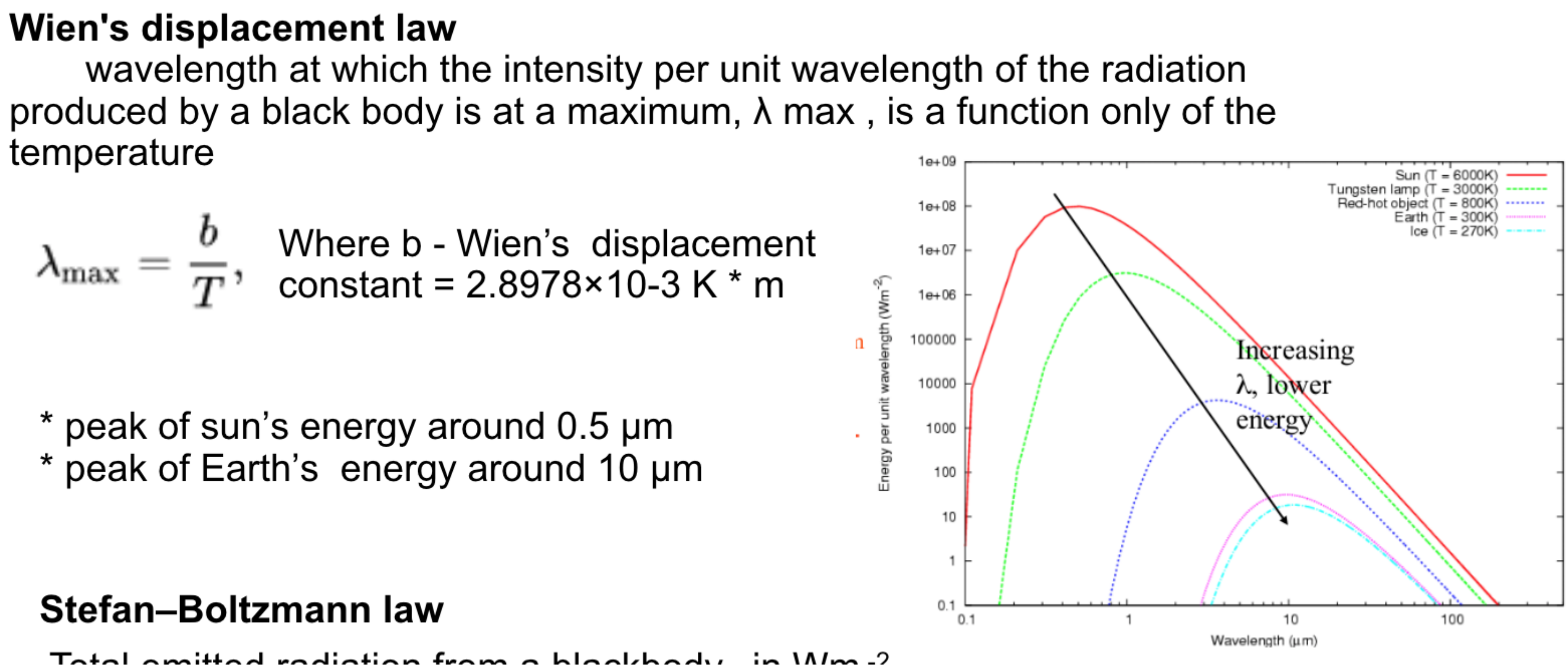
EMR. Sensors. Problems

```
In [1]: import numpy as np
```

3.1) Calculate wavelength of maximum of radiation from thermal source with T=600K



λpeak = 0.483x10^-5 m = 4830 nm = 4.83 microns.

3.2) Calculate ground pixel size for a CCD sensor with cell size 7µm. Focal length of the camera is 100cm. Platform height is 500км.

pixel_size = 7x10^-6 m

focal_length = 100 cm = 1 m

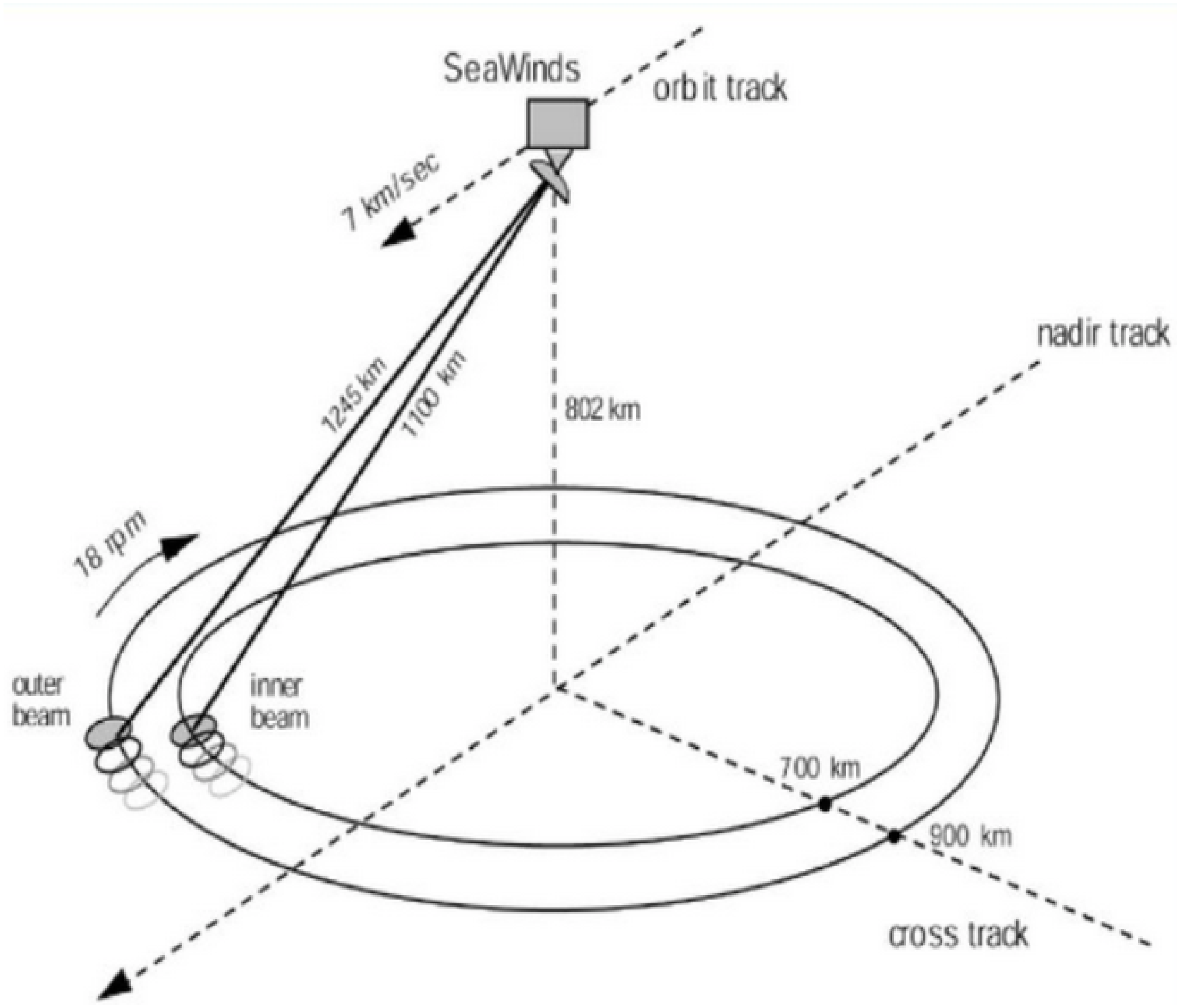
height = 500 km = 500000 m = 5x10^5 m

gr_pxl_size / pixel_size = height / focal_length

gr_pxl_size = (5x10^5 x 7x10^-6)/ 1x10^-1 = 3.5 m

Answer: ground pixel size is approx 3.5 m

3.3) What is the approximate resolution of a microwave antenna having an aperture of 1m(diameter) and orbiting at an altitude of 700 km. Working frequency 13.4GHz



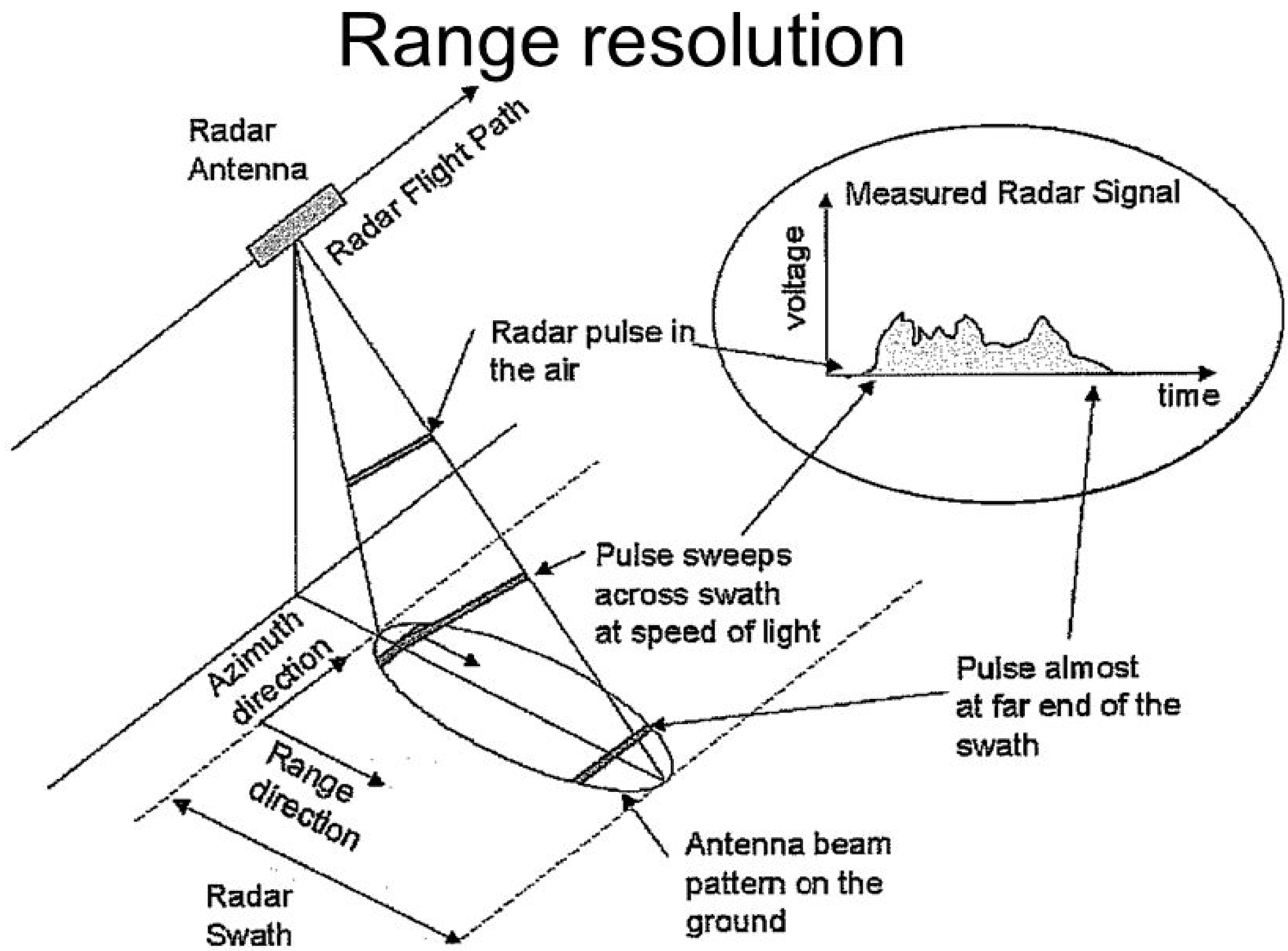


Figure 6-15. Imaging radars typically use antennas that have elongated gain patterns that are pointed to the side of the radar flight track. The pulse sweeps across the antenna beam spot, creating an echo as shown in this figure.

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SeaWinds used a rotating dish antenna with two spot beams that sweep in a circular pattern. The antenna consists of a 1-meter diameter rotating dish that produces two spot beams, sweeping in a circular pattern.[3] It radiates 110 W microwave pulses at a pulse repetition frequency (PRF) of 189 Hz. QuikSCAT operates at a frequency of 13.4 GHz, which is in the Ku-band of microwave frequencies. At this frequency, the atmosphere is mostly transparent to non-precipitating clouds and aerosols, although rain produces significant alteration of the signal.[4]

The spacecraft is in a sun-synchronous orbit, with equatorial crossing times of ascending swaths at about 06:00 LST ±30 minutes. Along the equator, consecutive swaths are separated by 2,800 km. QuikSCAT orbits Earth at an altitude of 802 km and at a speed of about 7 km per second.

Working frequency of 13.4 GHz means 0.02 m = 2*10^-2 m wavelength.

Assuming measurements are obtained at fixed incidence angles of 45° and pulse length is 1*10^-6 m

lambda / d 1000 m

In [2]:
```
wavelength = 0.022
height_sat = 700000
res = wavelength * height_sat / 1
print("resolution is", res/1000, "km")
```

```
resolution is 15.4 km
```

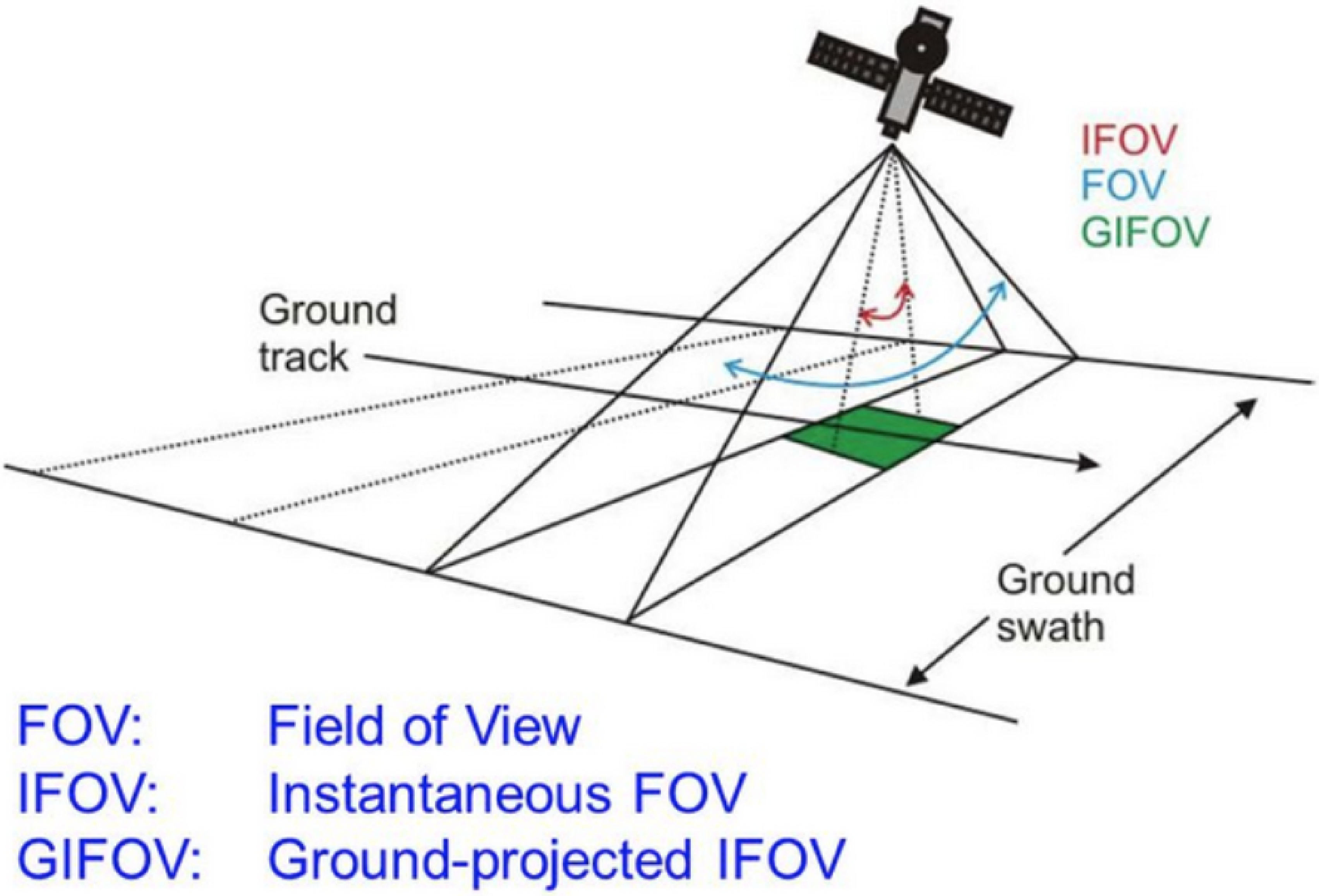
Considering diffraction through a circular aperture, this translates into:

$$\theta = 1.220\frac{\lambda}{D}$$

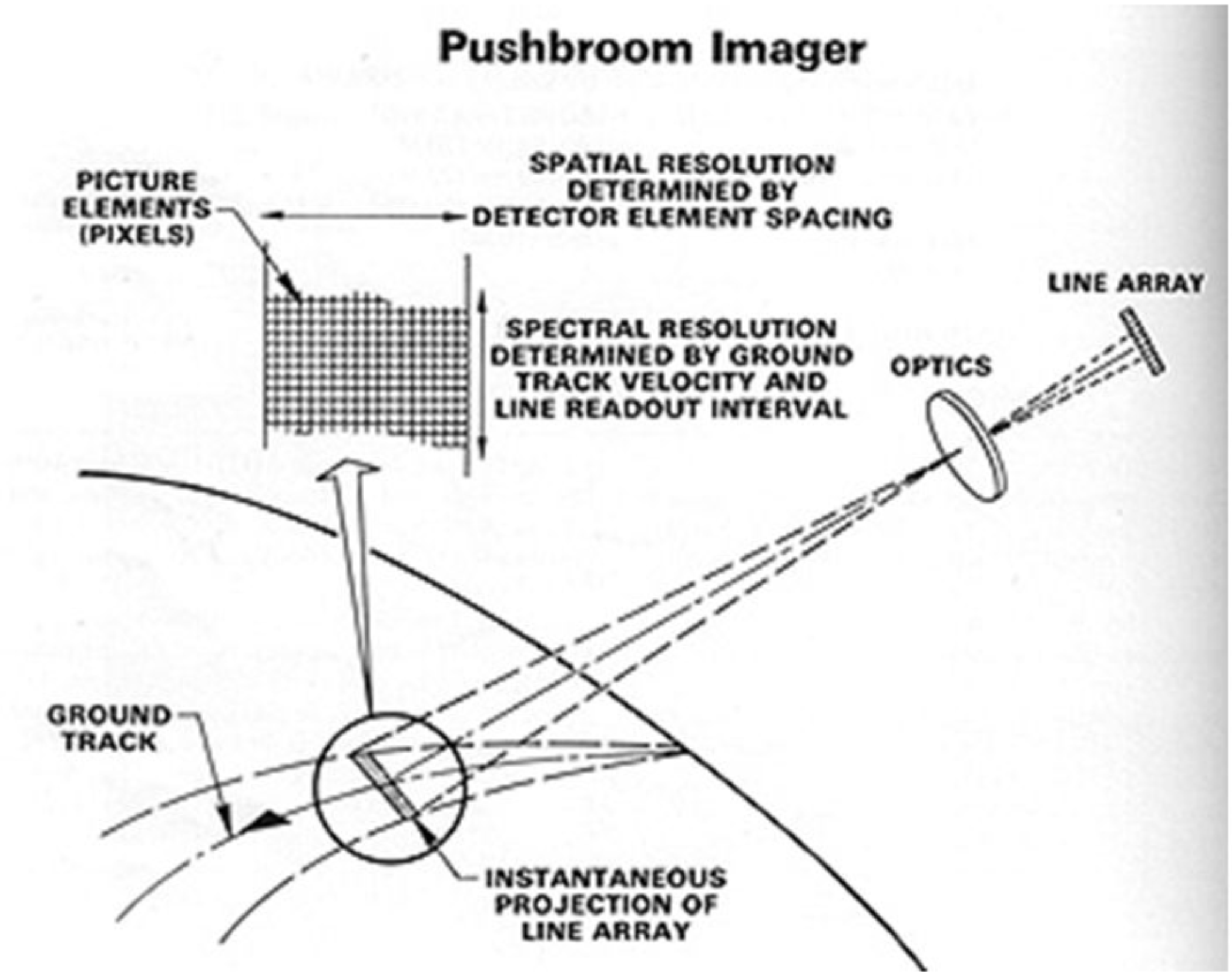
where θ is the *angular resolution* (radians), λ is the wavelength of light, and D is the diameter of the lens' aperture. The factor 1.220 is derived from a calculation of the position of the first dark circular ring surrounding the central Airy disc of the diffraction pattern. This number is more precisely 1.21966989... (OEIS: A245461), the first zero of the order-one Bessel function of the first kind $J_1(x)$ divided by π.

https://en.wikipedia.org/wiki/Angular_resolution (https://en.wikipedia.org/wiki/Angular_resolution)

3.4) Estimate rate of data stream generated from a pushbroom sensor having 8 spectral bands with 12bit radiometric resolution. Swath width is 150км, GIFOV 5m



Along-track scanner (pushbroom)



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https://crisp.nus.edu.sg/~research/tutorial/image.htm (https://crisp.nus.edu.sg/~research/tutorial/image.htm)

оценить скорость сканирвоания subsat_point_speed, m/sec 7253.5

скорость спутника известна из первого упр

In [3]:
```
num_bands = 8
res = 12  # bit radiometric
swath_width = 150000  # m
gifov = 5  # m
subsat_speed = 7253 # m/sec

coverage = swath_width * subsat_speed  # m^2 / s
print("coverage", coverage, "m^2 / s")
pixels_per_sec = int(coverage / gifov**2)
print("pixels_per_sec", pixels_per_sec)

data_rate = num_bands * res * pixels_per_sec
print("data rate per scan is", data_rate, "bits", " or ", "%.2f" % float(data_rate/8/1024/1024/1024), "GB/sec")
```

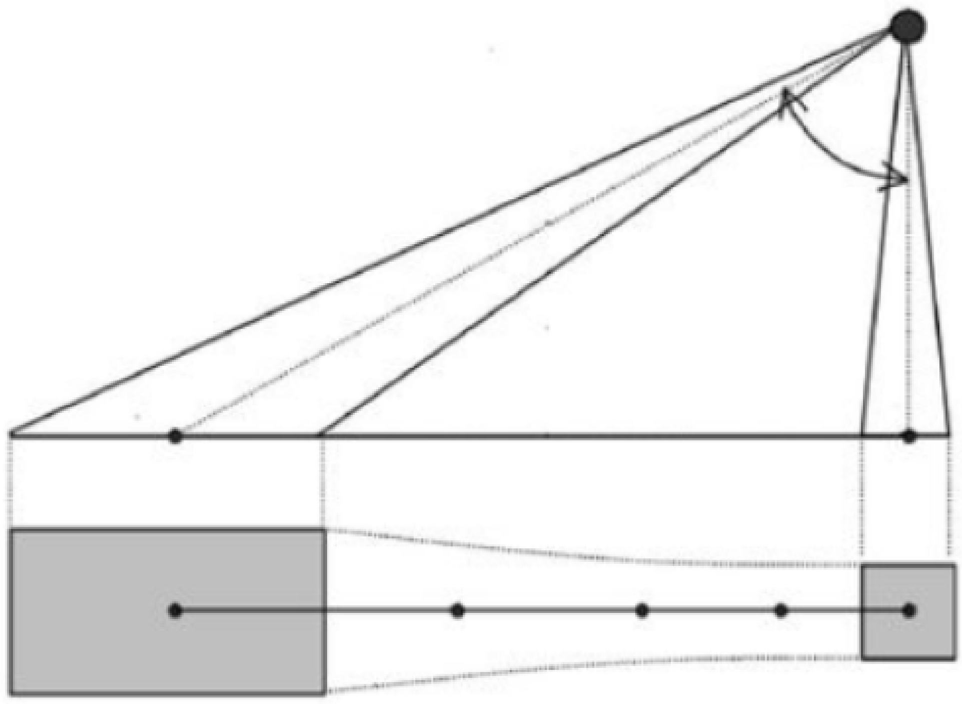
```
coverage 1087950000 m^2 / s
pixels_per_sec 43518000
data rate per scan is 4177728000 bits  or  0.49 GB/sec
```

3.5) Estimate temporal resolution of an imaging sensor with accessibility field of view 30 degrees. Orbit height ~ 500km

Temporal resolution provides information on the distance of time between the acquisitions of two images of the same area

Type *Markdown* and LaTeX: α^2

3.6) Ground pixel footprint in nadir is 1x1km. Estimate pixel size near the scan side (sensor scan half-angle 55degrees). Use either flat or spherical** Earth model.



In [23]:
```
h = 100
h_side = h/np.cos(55)
nadir_foot = 1  # km
# side_foot = x  to find
# from area correlation:
# side_foot / h_side = nadir_foot / h
# side_foot = nadir_foot * h_side / h
# cos(55) = 0.57
side_x_foot = nadir_foot /  0.57

print("side_x_foot", "%.2f" % side_x_foot, "km")
```

```
side_x_foot 1.75 km
```

In [26]:
```
# sin(35) = y/2 / dist
# sin(35) = 0,57
side_y_foot = 3.01 # km
print("pixel size near side is", "%.2f" % side_x_foot, "x", side_y_foot, "km**2")
```

```
pixel size near side is 1.75 x 3.01 km**2
```