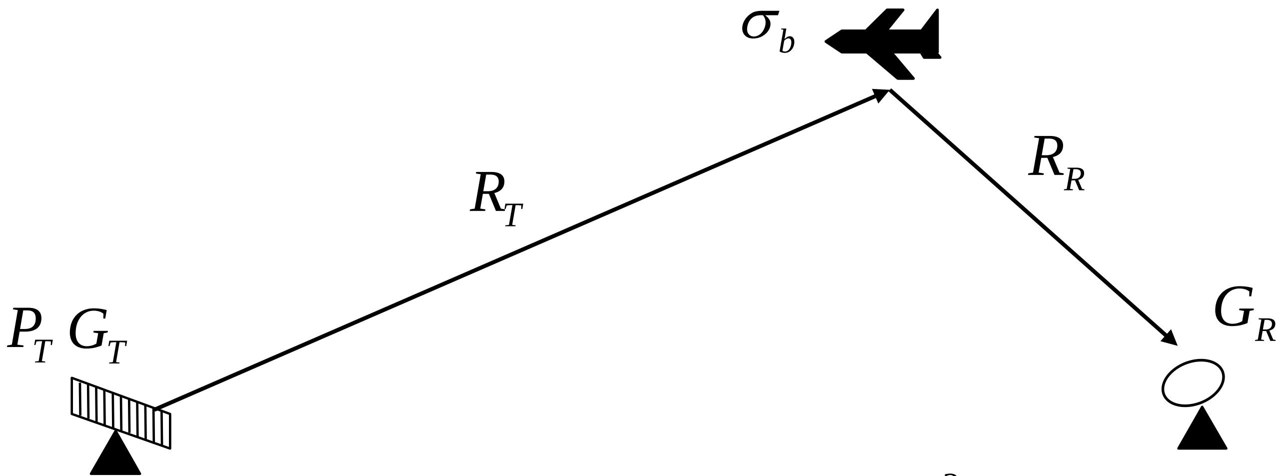
3.3 *Effective volume of detection*

1. Detection range
2. Vertical plane coverage of illuminators
3. Optimum position of nodes

Bistatic radar equation

This is derived in the same way as the monostatic radar equation :



$$\frac{P_R}{P_N} = \frac{P_T G_T}{4\pi R_T^2} . \sigma_b . \frac{1}{4\pi R_R^2} . \frac{G_R \lambda^2}{4\pi} . \frac{1}{L} . \frac{1}{k T_0 B F}$$

$$= \frac{P_T G_T G_R \lambda^2 \sigma_b}{(4\pi)^3 R_T^2 R_R^2 \ L \ k T_0 B F}$$

The dynamic range of signals to be handled is reduced, because of the defined minimum range.

Integration gain

Maximum integration dwell time is approximately

$$T_{MAX} = \left(\frac{\lambda}{A_R}\right)^{1/2}$$

For a VHF waveform with a bandwidth of 50 kHz and a dwell time of 1 second, processing gain is $G_p \approx 47$ dB.

Cast bistatic radar equation in the form:

$$\left(R_R\right)_{max} = \left(\frac{\Phi\ \sigma_b G_R \lambda^2 G_p}{(4\pi)^2 \left(S/N\right)_{min} L\, kT_0 BF}\right)^{1/2}$$

allows prediction of coverage around transmitters and receivers

Passive Bistatic Radar (PBR)

In general, bistatic radar systems will use dedicated radar transmitters with explicit control over location, modulation, scan pattern, etc.

However, it is also possible to use other transmissions that just happen to be there. These are known as *illuminators of opportunity*, and the technique is sometimes known as *passive bistatic radar* (PBR), *hitchhiking*, *parasitic radar* or *passive coherent location* (PCL)

Such transmissions may be other radars, or they may be communications, broadcast or navigation signals. In these days of spectral congestion there are more and more such transmissions, and they are often high-power and favourably sited.

They also allow use of parts of the spectrum (VHF, UHF, …) that are not normally available for radar purposes – where there may be a counter-stealth advantage (in addition to the potential counter-stealth advantage that comes from the bistatic geometry)

As well as that, no transmitting licence is needed

And the radar is potentially completely covert, so countermeasures against it may be very difficult

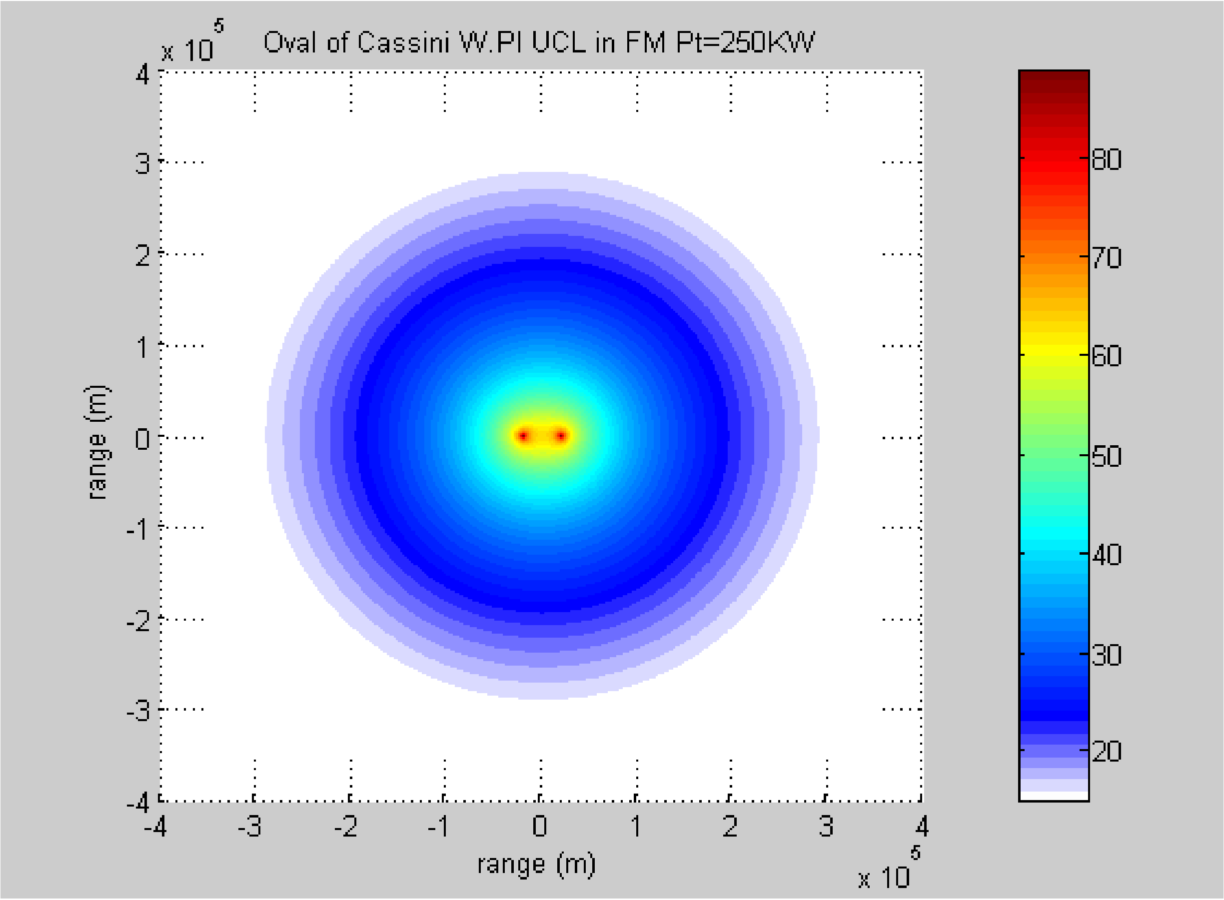
But ….

We need to understand the correct parameter values to use. In particular:

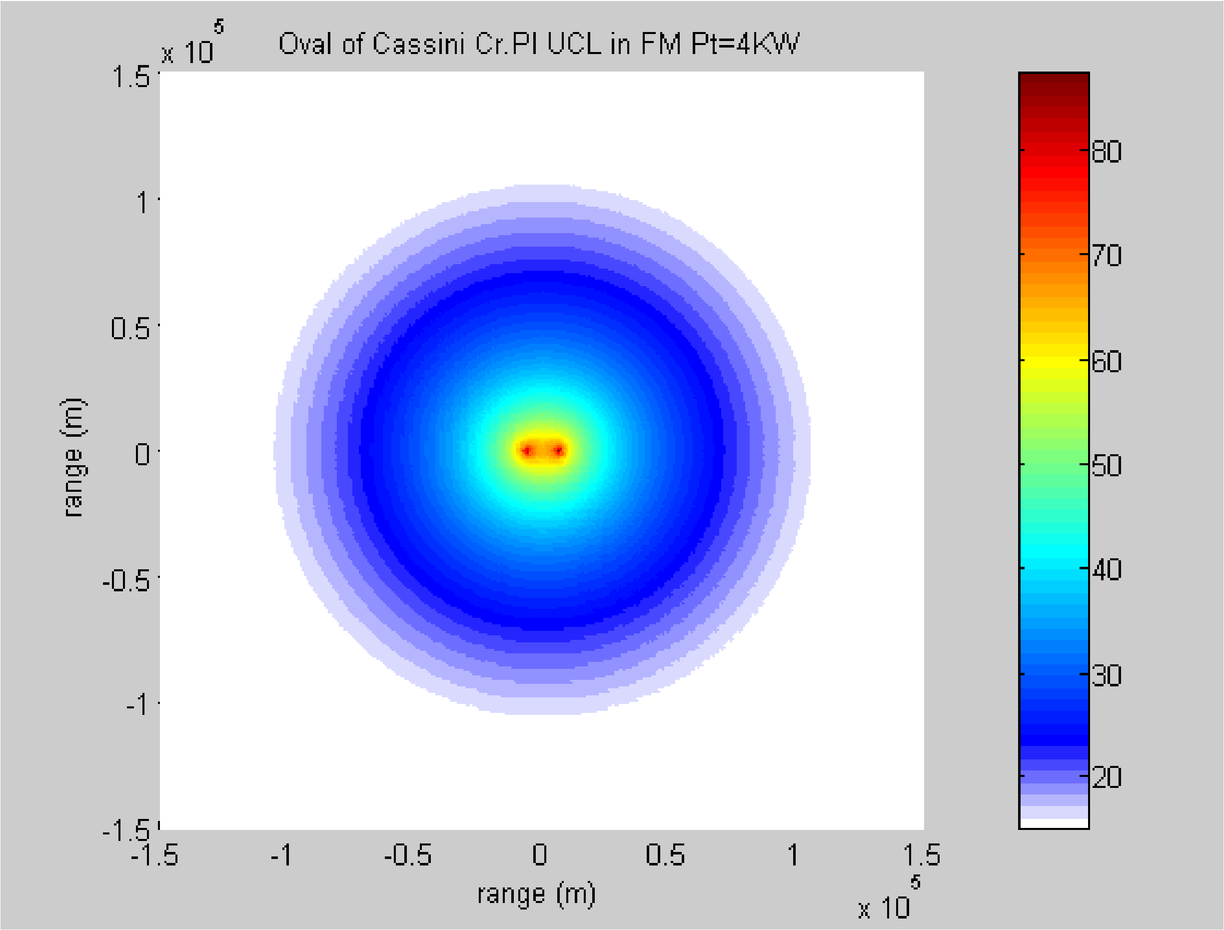
- σ_b
- integration gain
- noise level
- losses
- receive antenna gain

:
:

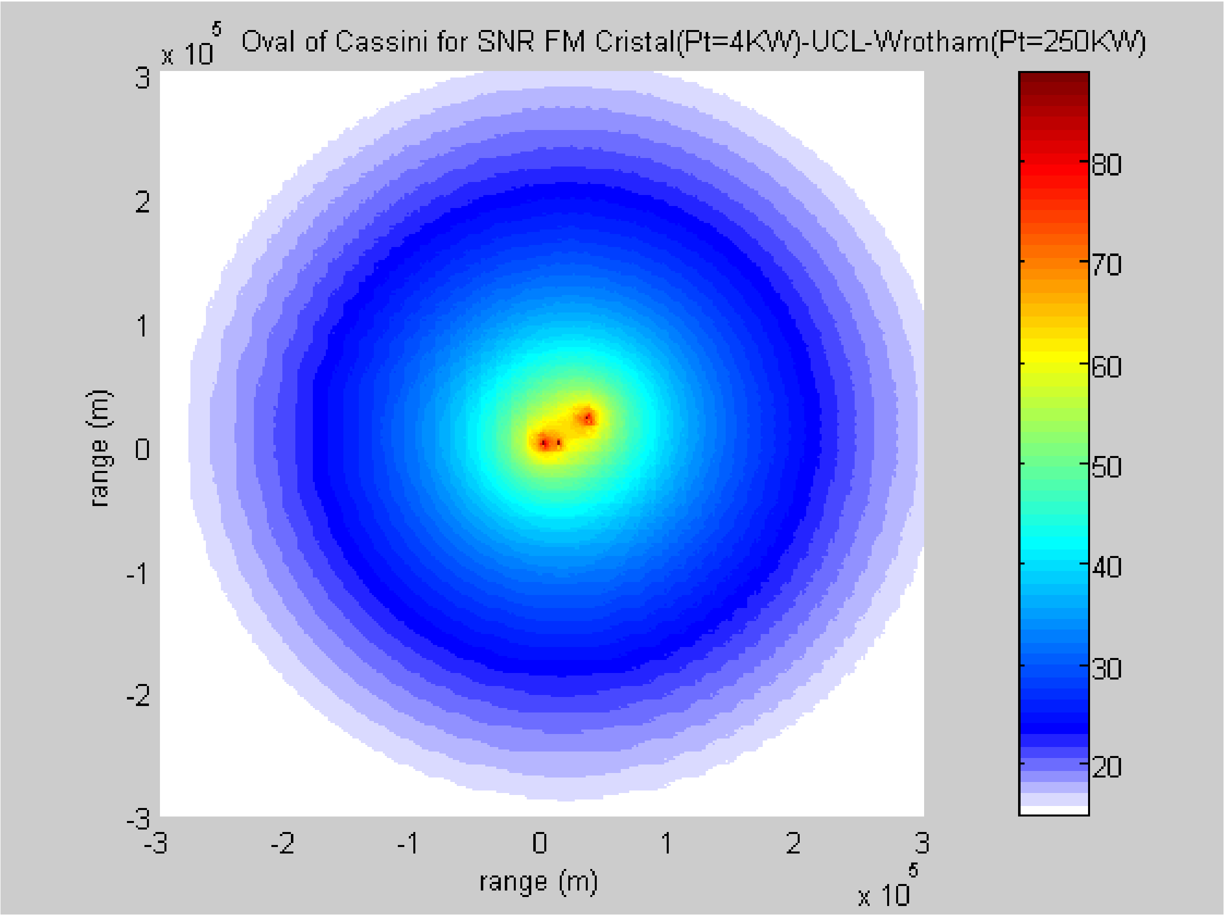
Detection range



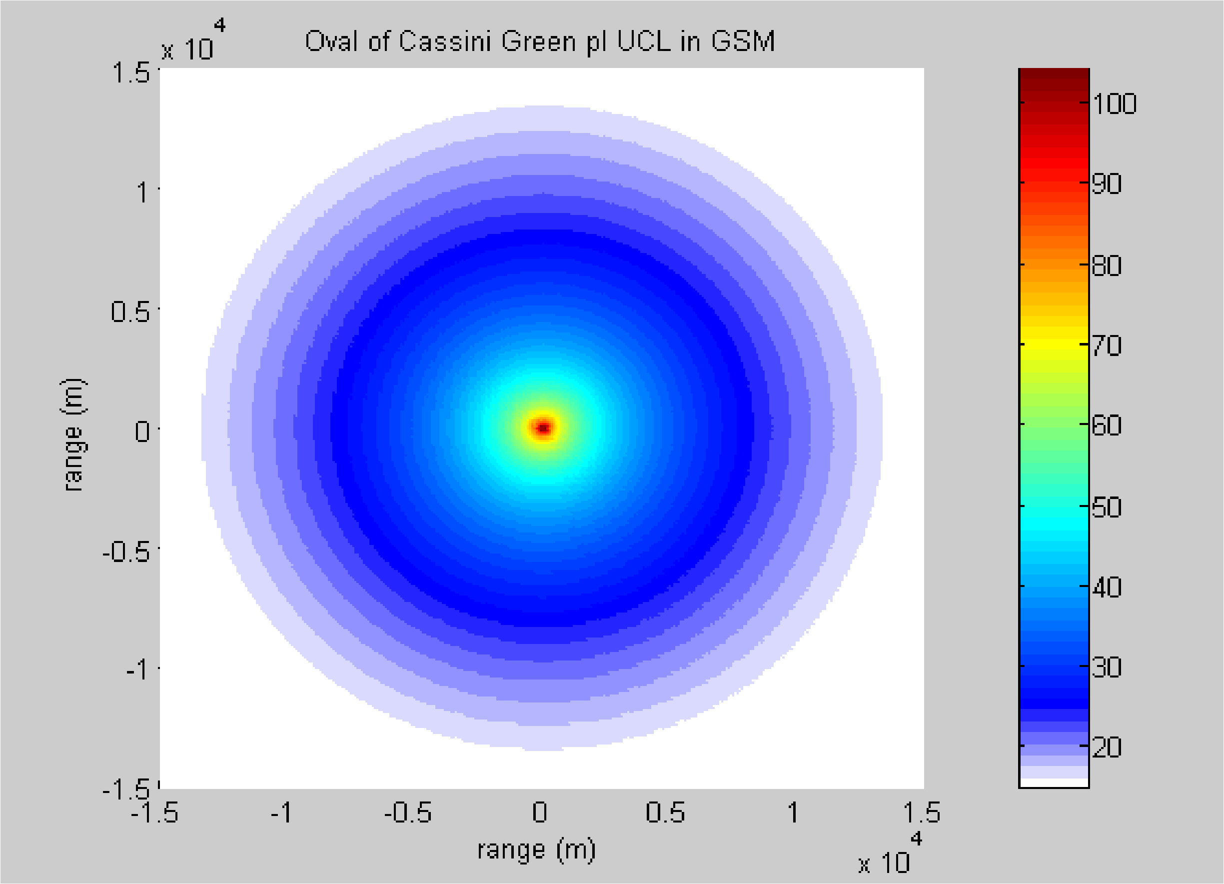
Detection range



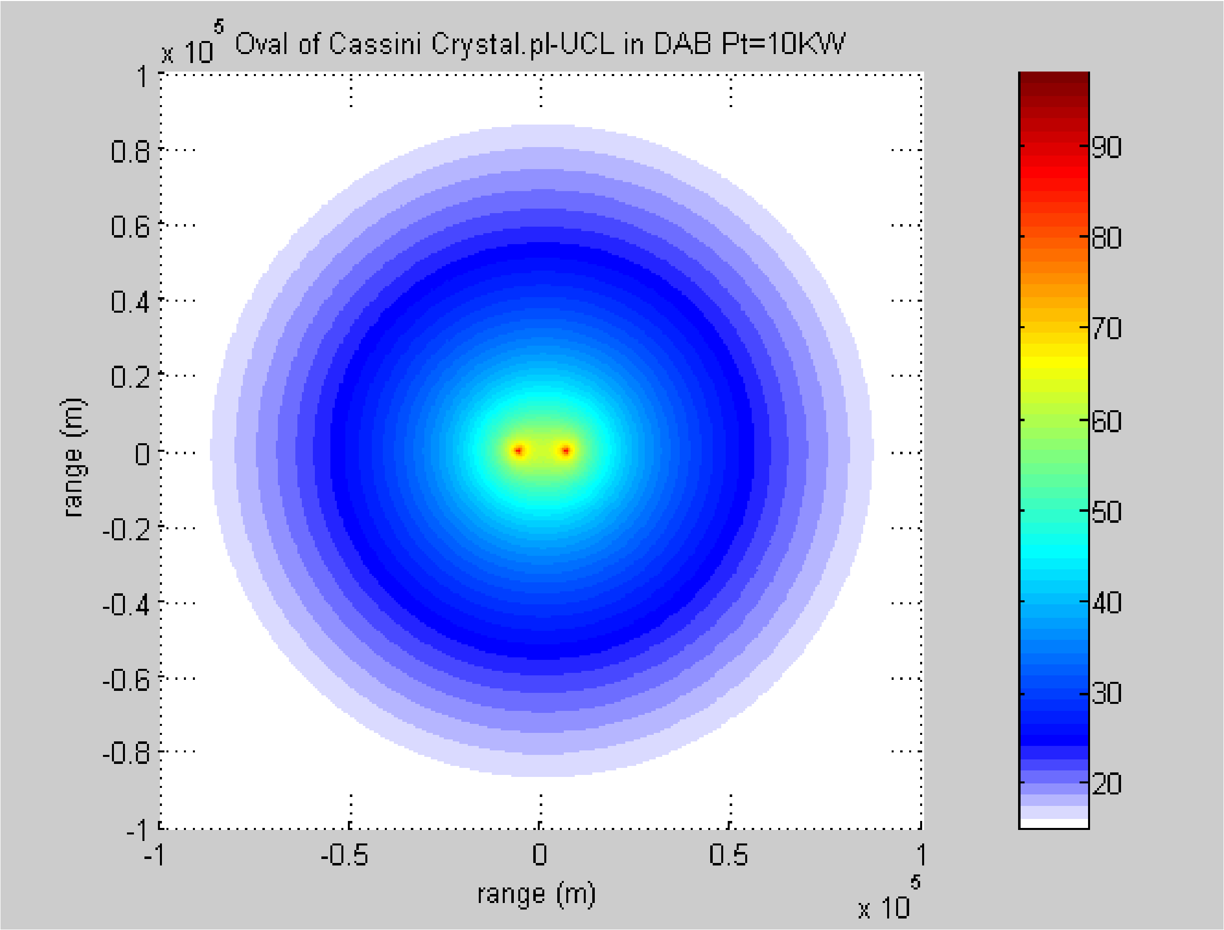
Detection range



Detection range



Detection range



Optimum location of nodes

- Will depend on the quantities being measured (range, Doppler, angle of arrival)
- But we know that range and Doppler resolution are degraded for targets on or close to the baseline (cf ambiguity function)
- This suggests arranging the receive nodes so that the degradation is only substantial for one transmit-receive pair, so the information from the others is to first order unaffected.

Degradation of resolution

We can also calculate how the spatial resolution varies as a function of target position.

The area, A_M, of a monostatic radar's spatial resolution cell is, to first order, the product of the cross-range width of the beam at the target and the thickness of the annulus defining its range resolution:

$$A_M = \frac{c\tau}{2} R \sin\Theta_2$$

where Θ_2 is the two-way –3 dB beamwidth of the monostatic radar.

Similarly, the area, A_B, of the bistatic radar's spatial resolution cell is the product of the cross-range width of the receiver beam at the target and the thickness of its annulus:

$$A_B = \left[\frac{c\tau}{2}\cos\left(\frac{\beta}{2}\right)\right] R_R \sin\Theta_1$$

where Θ_1 is the –3 dB beamwidth of the bistatic receive antenna.

Degradation of resolution

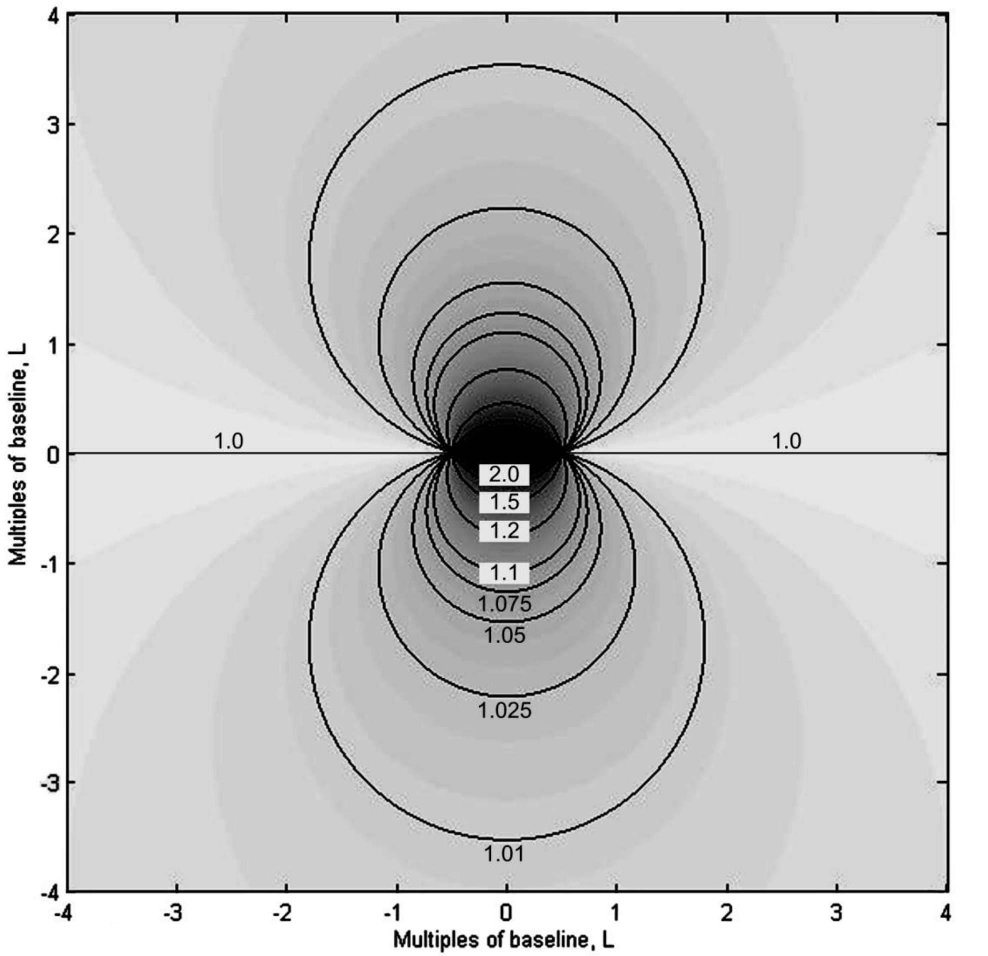
The normalized spatial resolution of the bistatic receiver with respect to a comparable (host) monostatic radar is then:

$$\frac{A_B}{A_M} = \frac{\sin\Theta_1 / \sin\Theta_2}{\cos(\beta/2)}$$

Note that $\sin\Theta_1 > \sin\Theta_2$

and $\cos(\beta/2) \leq 1$,

so that $A_B > A_M$ for all β.



Plot: James Brown, UCL