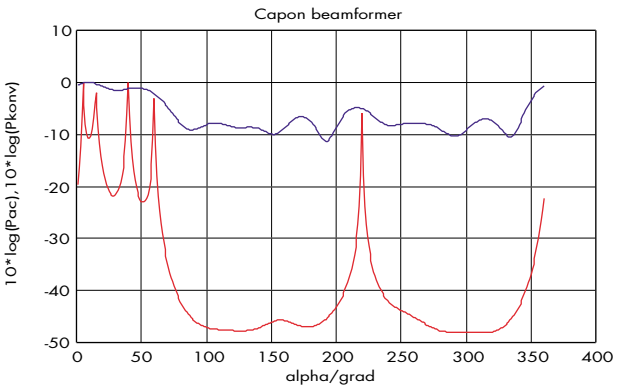

Fig. 24: DF function of Capon beamformers compared to conventional beamformer (S/N=100). Wave angle: 5°, 15°, 40°, 60°, 220°

Similar to a minimum-signal direction finder, the resolution strongly depends on the signal-to-noise ratio. Fig. 25 shows the same receiving scenario with noise increased by a factor of 10. The resolution of waves arriving at an angle of 5°and 10° is no longer possible.

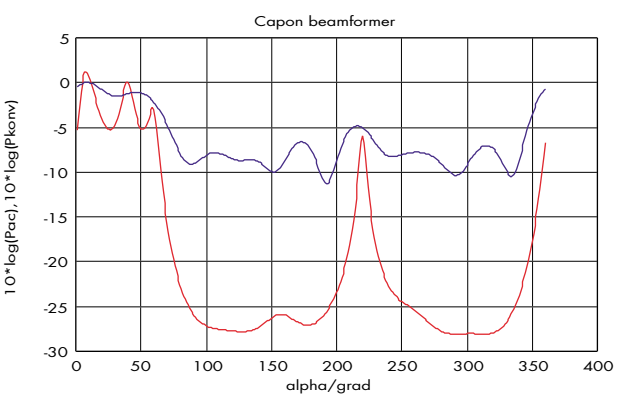

Fig. 25: DF function of Capon beamformer compared to conventional beamformer (S/N=10)

The socalled **subspace methods** are aimed at eliminating the effect of noise. This can be done by splitting up the N-dimensional space spanned by the element outputs into subspaces. The well-known MUSIC algorithm (**Mu**ltiple **Si**gnal **C**lassification) uses the fact that the signals lie perpendicular to the noise subspace. If the direction vectors are now projected to the noise subspace, nulls are obtained in the presence of signals that are independent of the noise level [16], [17], [24]. The reciprocal value is usually used as the DF function so that distinct peaks occur in the signal directions (Fig. 26).

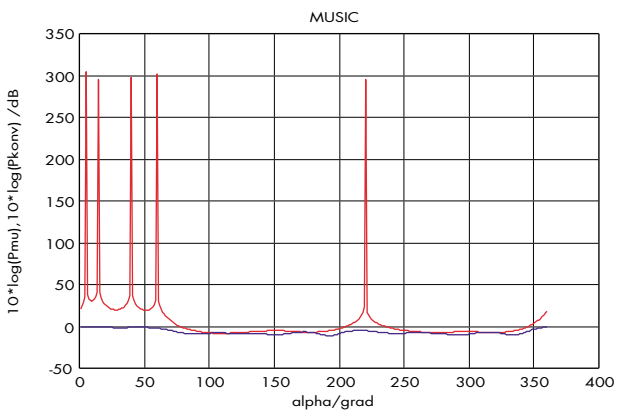

Fig. 26: DF function when using MUSIC algorithm (S/N=10)

5 Display of Bearings

The display of the DF results is of great importance as an interface to the operator. Basically, distinction is to be made whether the display is the DF result of a single channel or of a multichannel direction finder. In a single-channel display, the following parameters are usually indicated:

- Numeric DF value
- Azimuth in polar coordinates
- Elevation as bargraph or polar diagram (combined with azimuth display)
- DF quality
- Level
- Histogram of DF values
- DF values versus time (waterfall)

Fig. 27 shows a choice of possible displays.

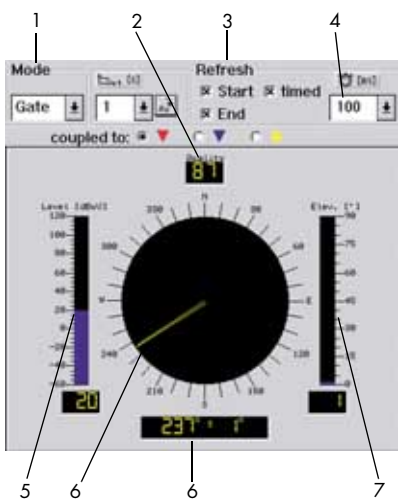

Fig. 27: Display of DF values with single-channel direction finding

1 = Averaging mode
2 = DF quality
3 = Output mode
4 = Averaging time
5 = Level
6 = Azimuth
7 = Elevation

Introduction into Theory of Direction Finding

In addition to the usual receiver settings such as frequency and bandwidth, the following settings and displays are made for direction finders:

- Averaging mode (if the signal level drops below the preset level threshold, averaging – depending on the averaging mode – is either stopped and restarted upon the next exceeding of the threshold or continued)
- Averaging time
- Output mode (refresh rate of display; output as a function of exceeding the signal threshold)

Multichannel direction finders are implemented with the aid of digital filter banks (FFT and polyphase filters). Depending on the outlay, these direction finders allow quasi-simultaneous direction finding in a frequency range from some 100 kHz up to a few MHz. Scan mode is additionally provided to cover larger frequency ranges (Fig. 28).

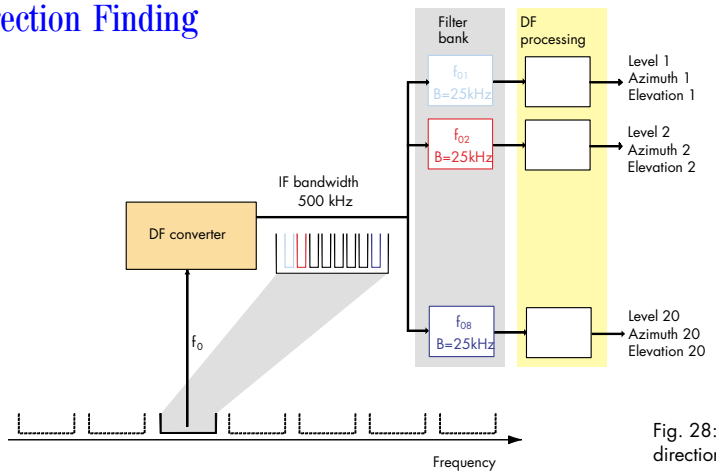

Fig. 28: Multichannel direction finder

With a multichannel direction finder it is essential that the individual events can quickly be recognized and the activities taking place in different channels correctly assigned. Usually the following display modes are therefore provided:

- DF values versus frequency
- DF values versus frequency and time (eg by using different colours for the DF values)
- Level versus frequency (power spectrum)
- Level versus time and frequency (using different colours for level values)
- Histograms

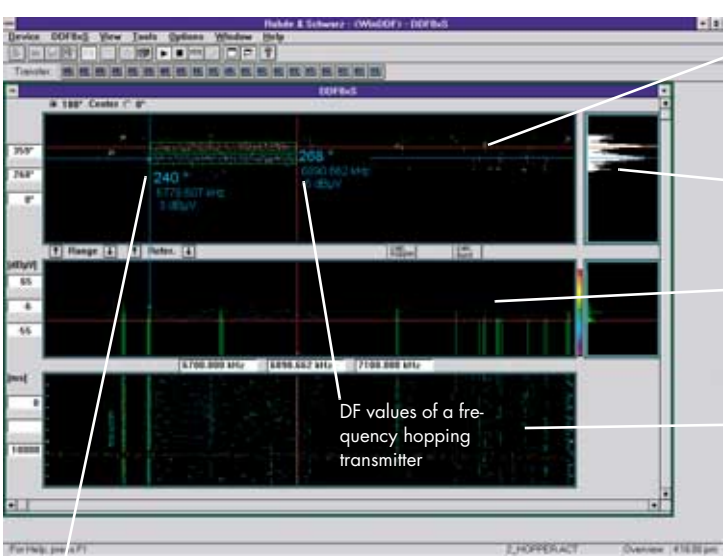

Fig. 29: Multichannel (broadband) display