CAPABILITIES OF THE IRKUTSK INCOHERENT SCATTERING RADAR FOR SPACE DEBRIS STUDIES

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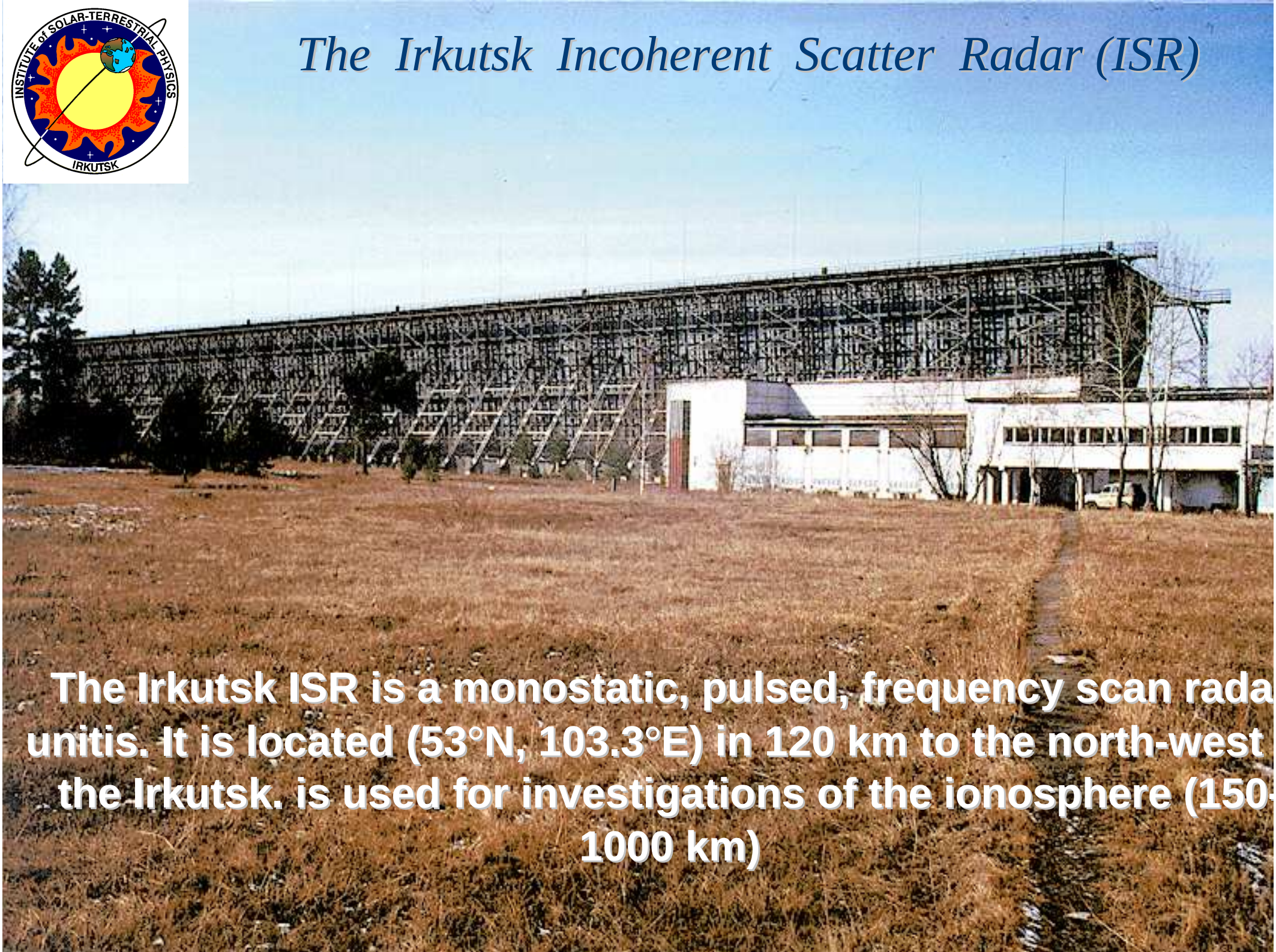
The Irkutsk Incoherent Scatter Radar (ISR)



The Irkutsk ISR is a monostatic, pulsed, frequency scan rada unitis. It is located (53°N, 103.3°E) in 120 km to the north-west the Irkutsk. is used for investigations of the ionosphere (150- 1000 km)

The Irkutsk ISR consists of :

- doubly sectionalized antenna system with antenna switch;
- transmitters;
- multichannel receiving system;
- radar control and signal recording devices.

The Irkutsk ISR is used to measure:

- ***electron densities;***
- ***electron and ion temperatures;***
- ***ion composition;***
- ***plasma drift velocities.***

Furthermore the Irkutsk ISR can be used for spacecraft (SC) and space debris (SD) detection and determination of their motion parameters:

range;

Doppler velocity;

antenna azimuth;

elevation;

radar cross section (RCS)

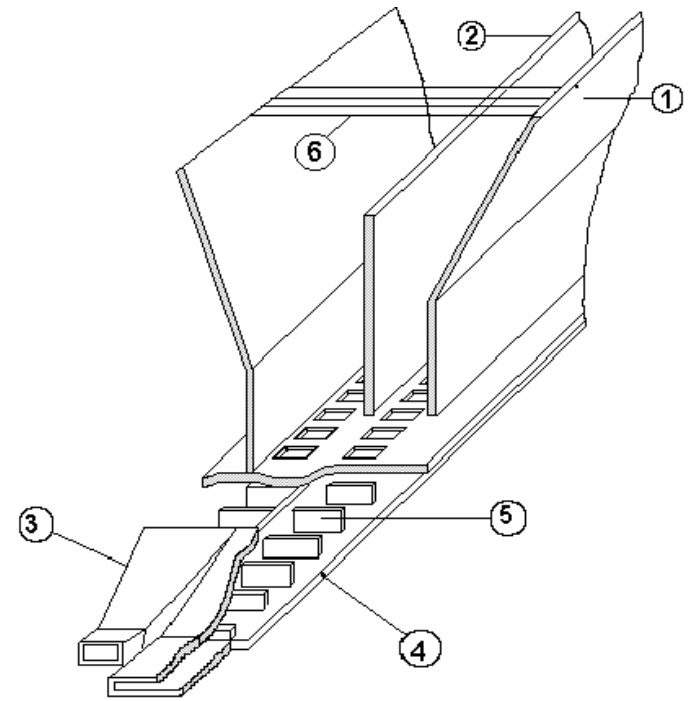
From six elements of the Kepler orbit two are more precisely defined: an inclination and right ascension of the ascending node observed space object (SO).

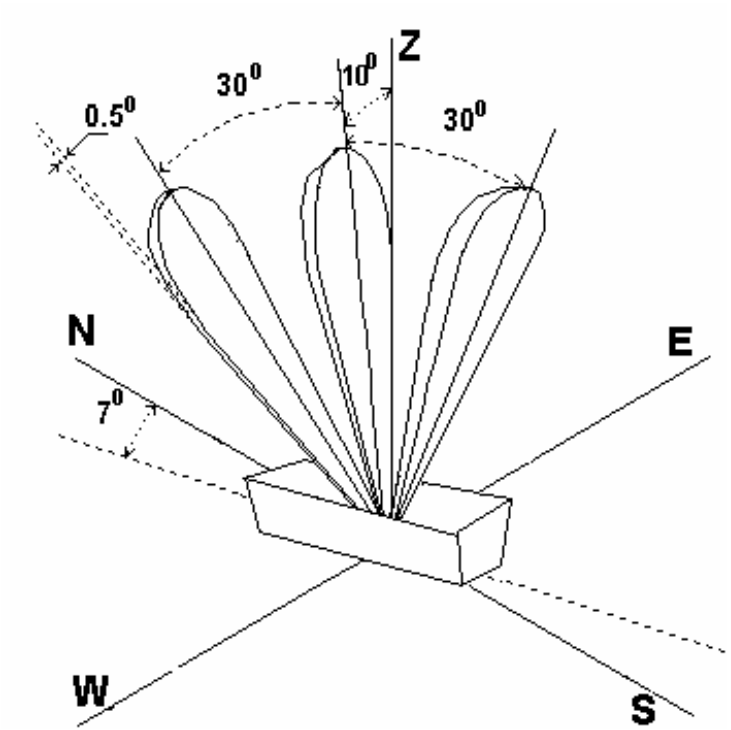
Basic parameters of Irkutsk IS radar

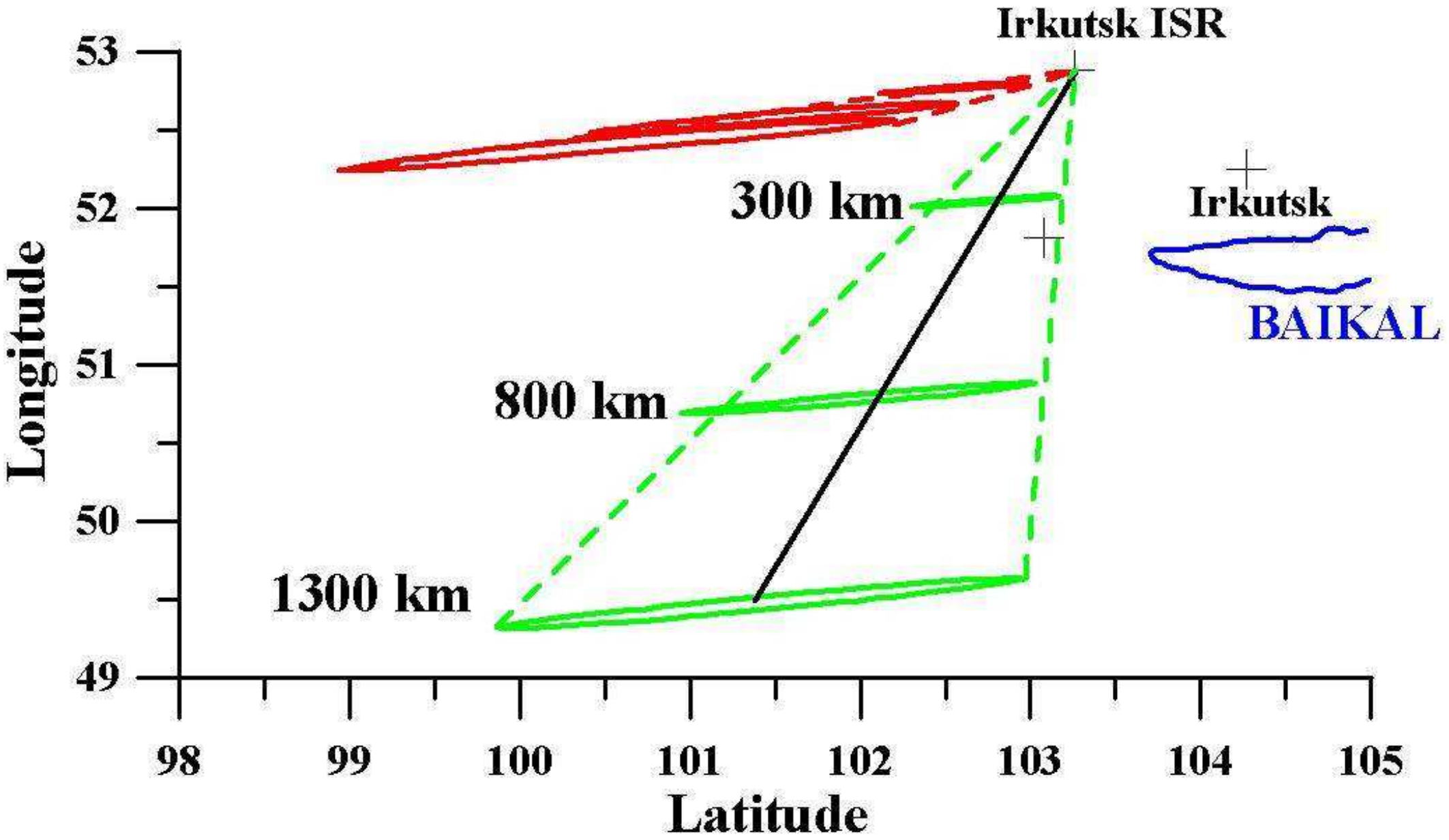
Range of frequencies	(154 - 162) MHz
Peak output power	3,2 MW
Pulse duration	70 - 860 μs
Type of antenna	Sectoral horn
Antenna gain	38 dB
Angular size of the beam	0.5^0 x 10^0
Scan sector	$\pm 30^0$
Polarization	Linear

The uniqueness of the Irkutsk ISR is in its antenna design

1 - external horn;
2 - partition separating the antenna into two sections;
3 - feed horn;
4 - waveguide-slot system;
5 - ribbed retarding structure.
6 – polarization filter







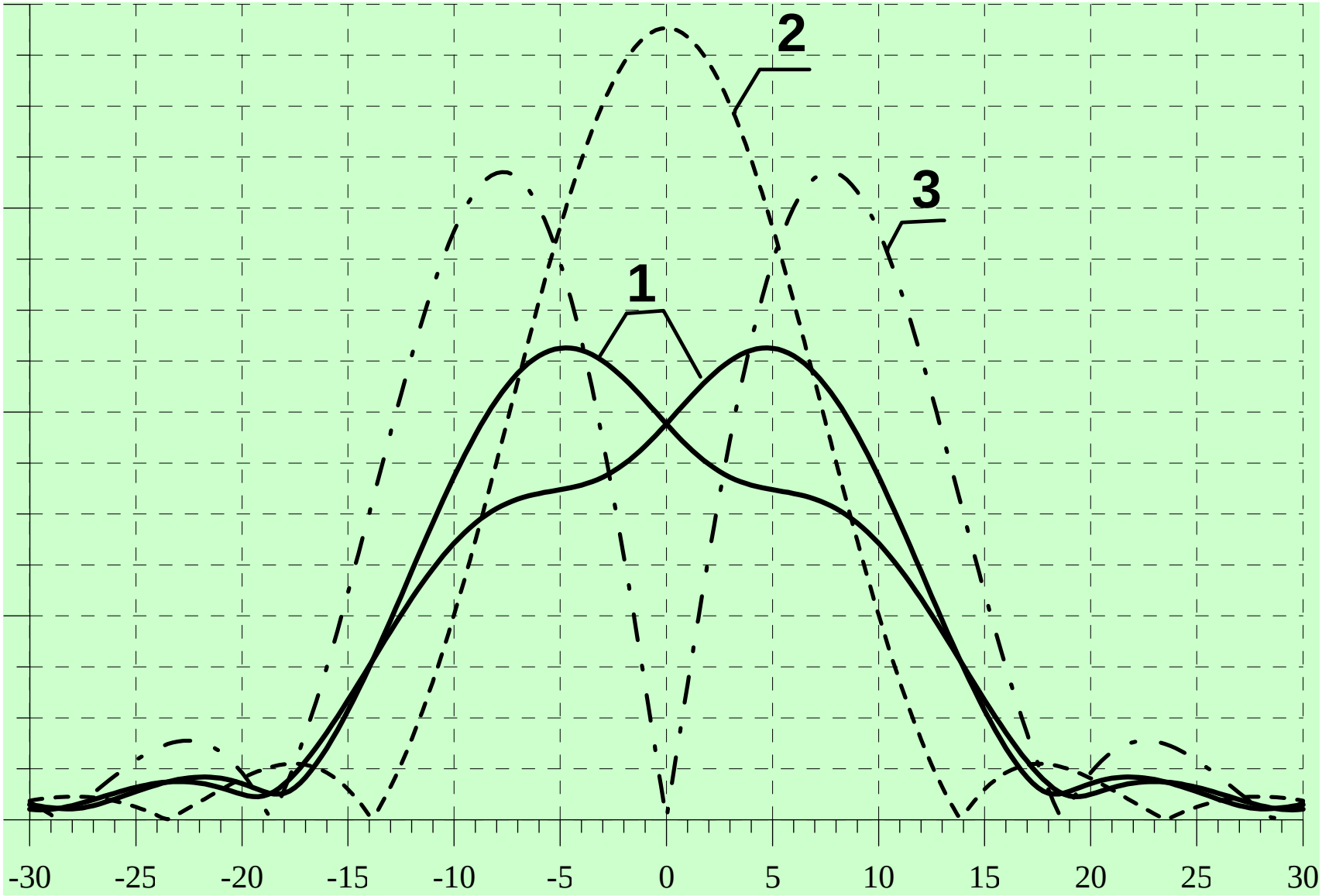
Standard beam directions used for the IS ionospheric measurements

Diagram Pattern (DP) shape along the antenna's minor axis.

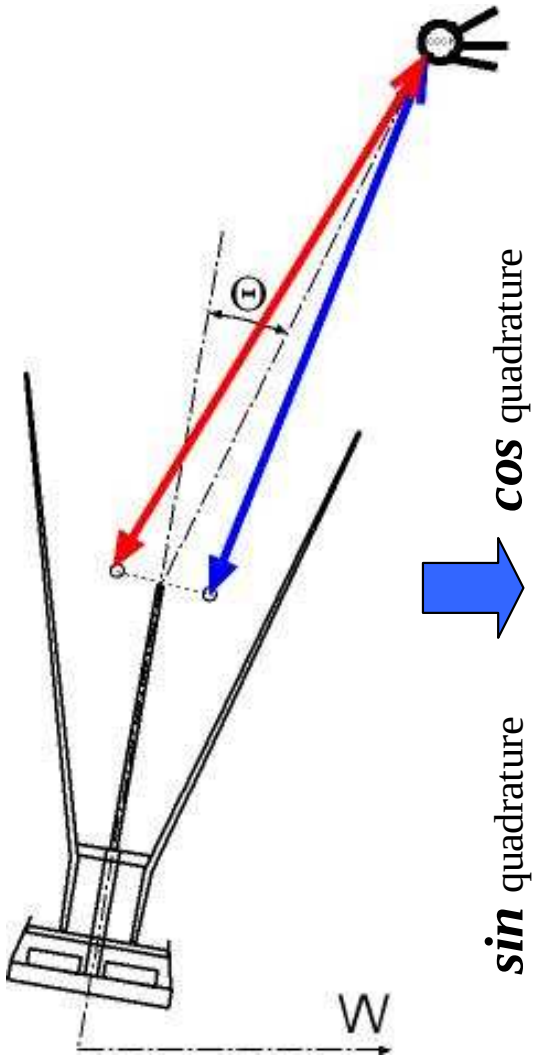
1 - DP (degrees) of two independent half-horns;

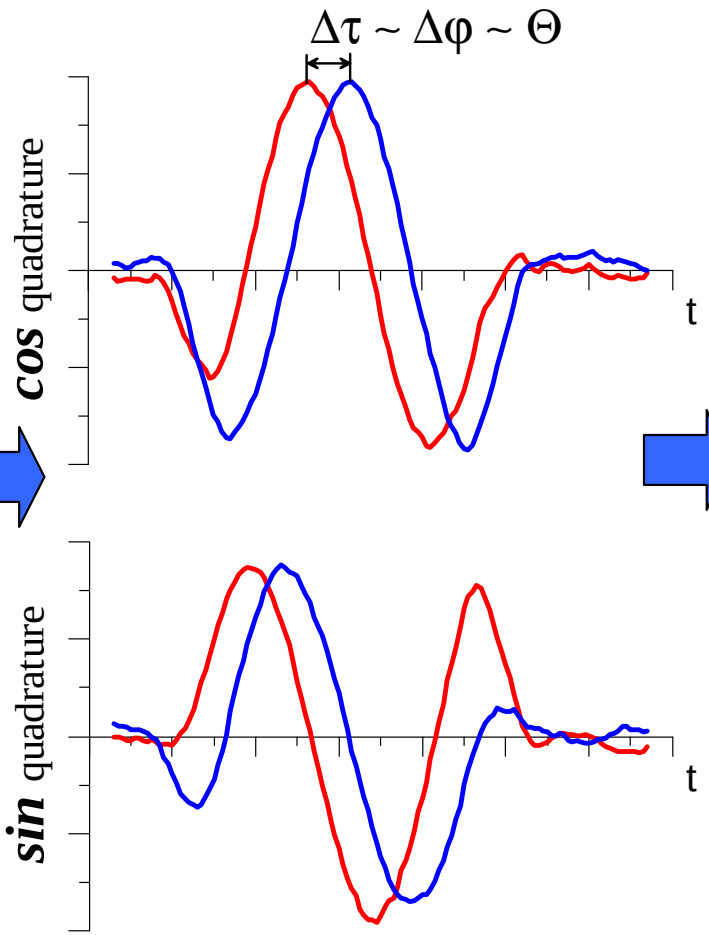
2 - total DP;

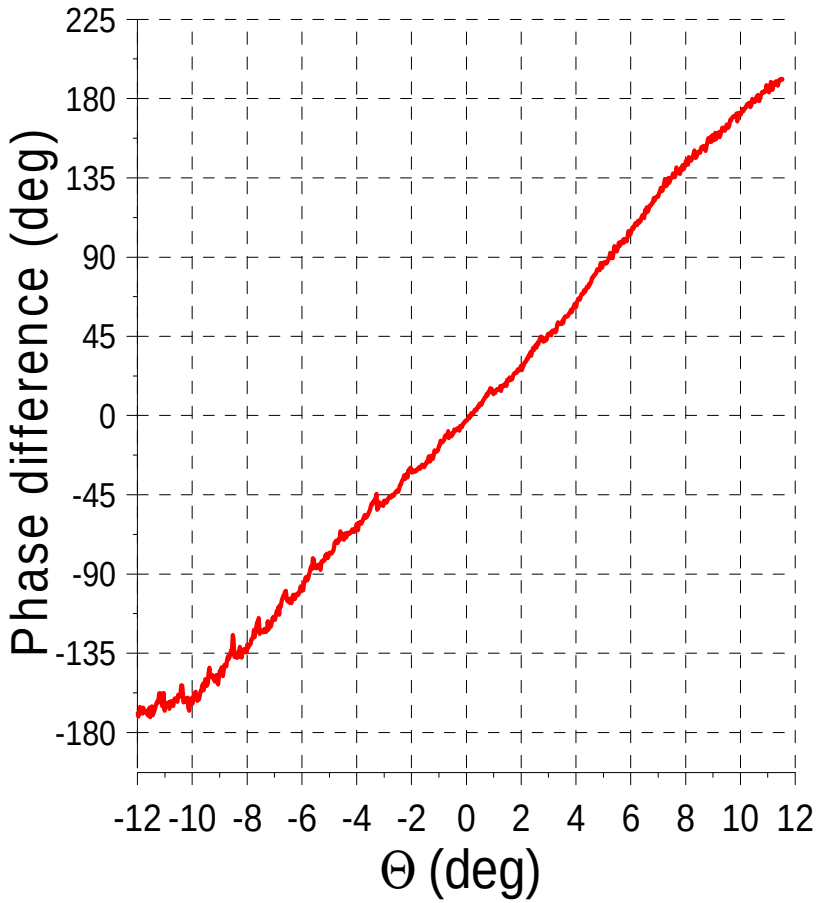
3 - difference DP.



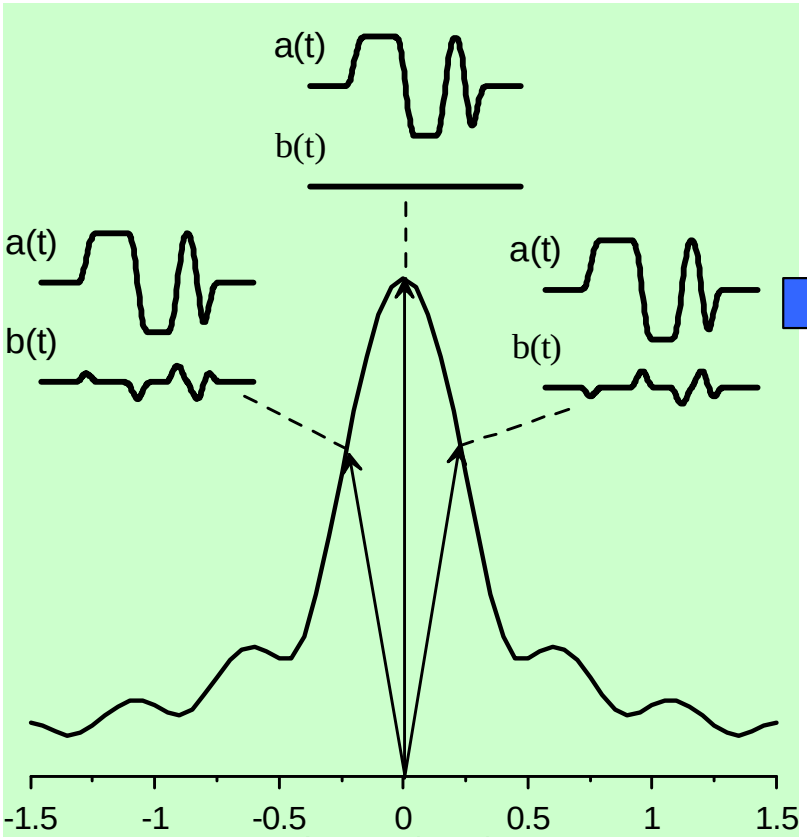
Simultaneous registration of signals in two antenna half-horns allows to carry out interferometry measurements and refine angular coordinates







DP shape along the antenna's major axis (degr.) and refining angular coordinates technique



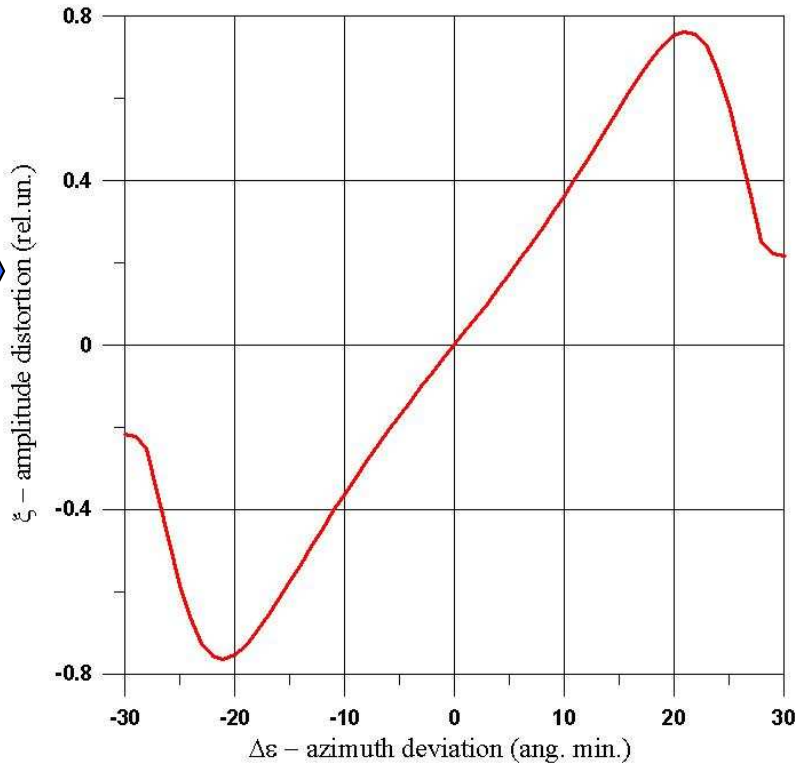
$$\xi = \frac{dF(\Delta\varepsilon)}{d(\Delta\varepsilon)} \frac{d\varepsilon_0}{df_0} \frac{dq}{dt}$$

$dF(\Delta\varepsilon)$ – DP form

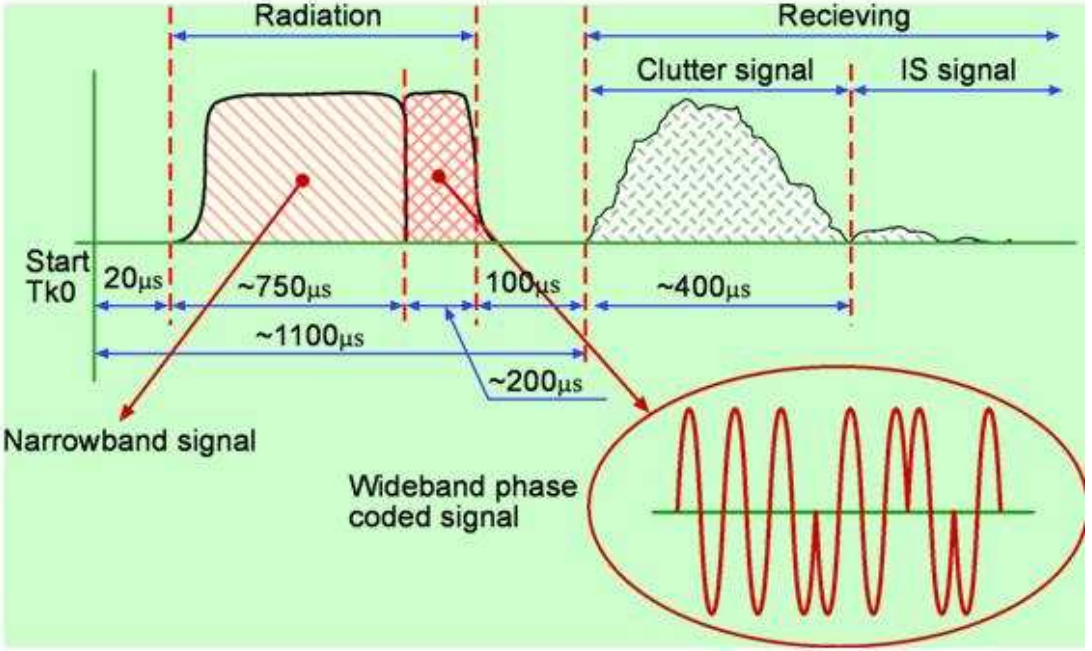
ε_0 – antenn azimuth at car. freq. f_0

ξ – signal distortion amplitude

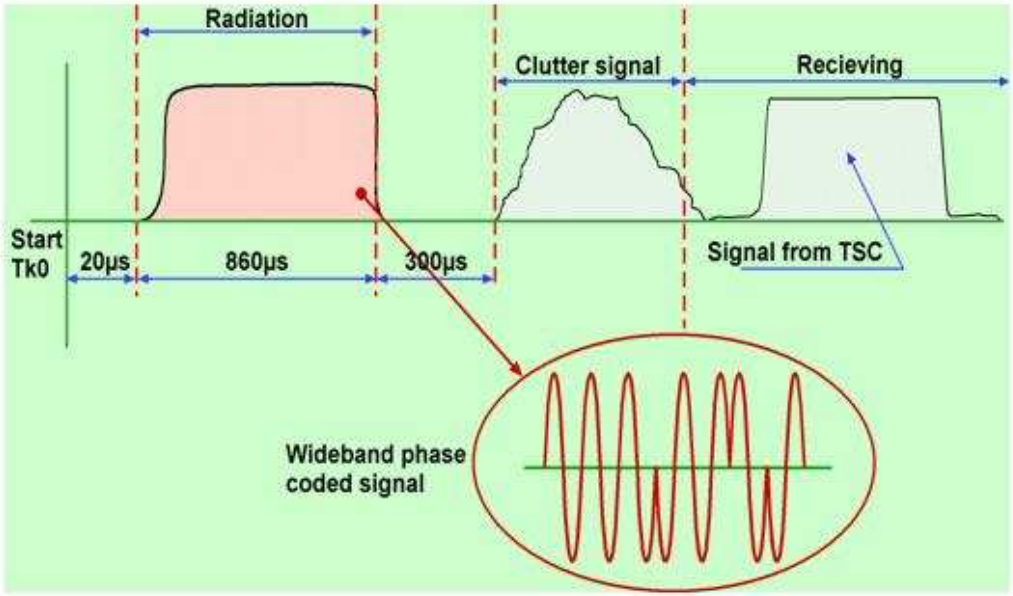
q – complex envelope of radar signal



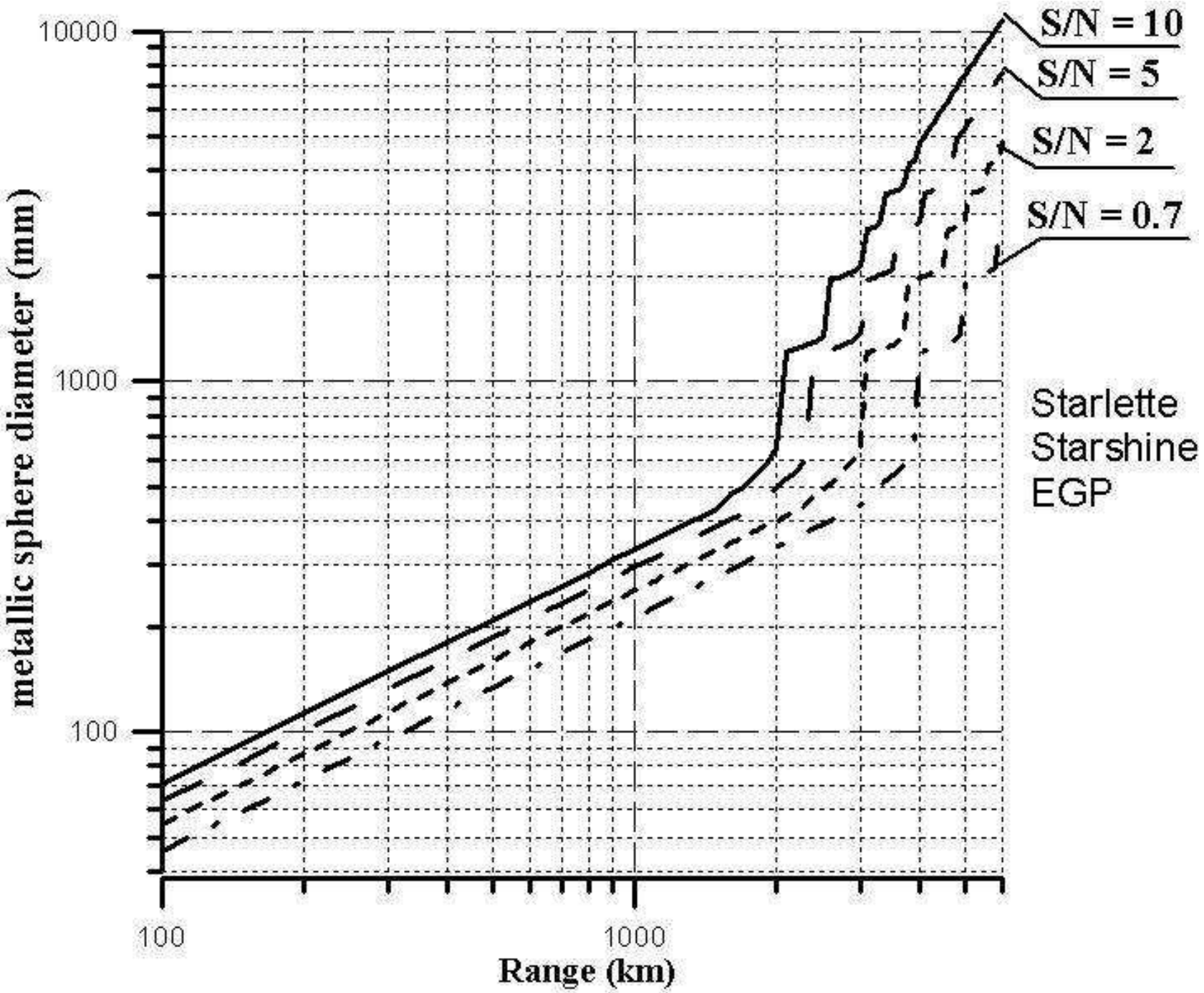
Incoherent scattering mode



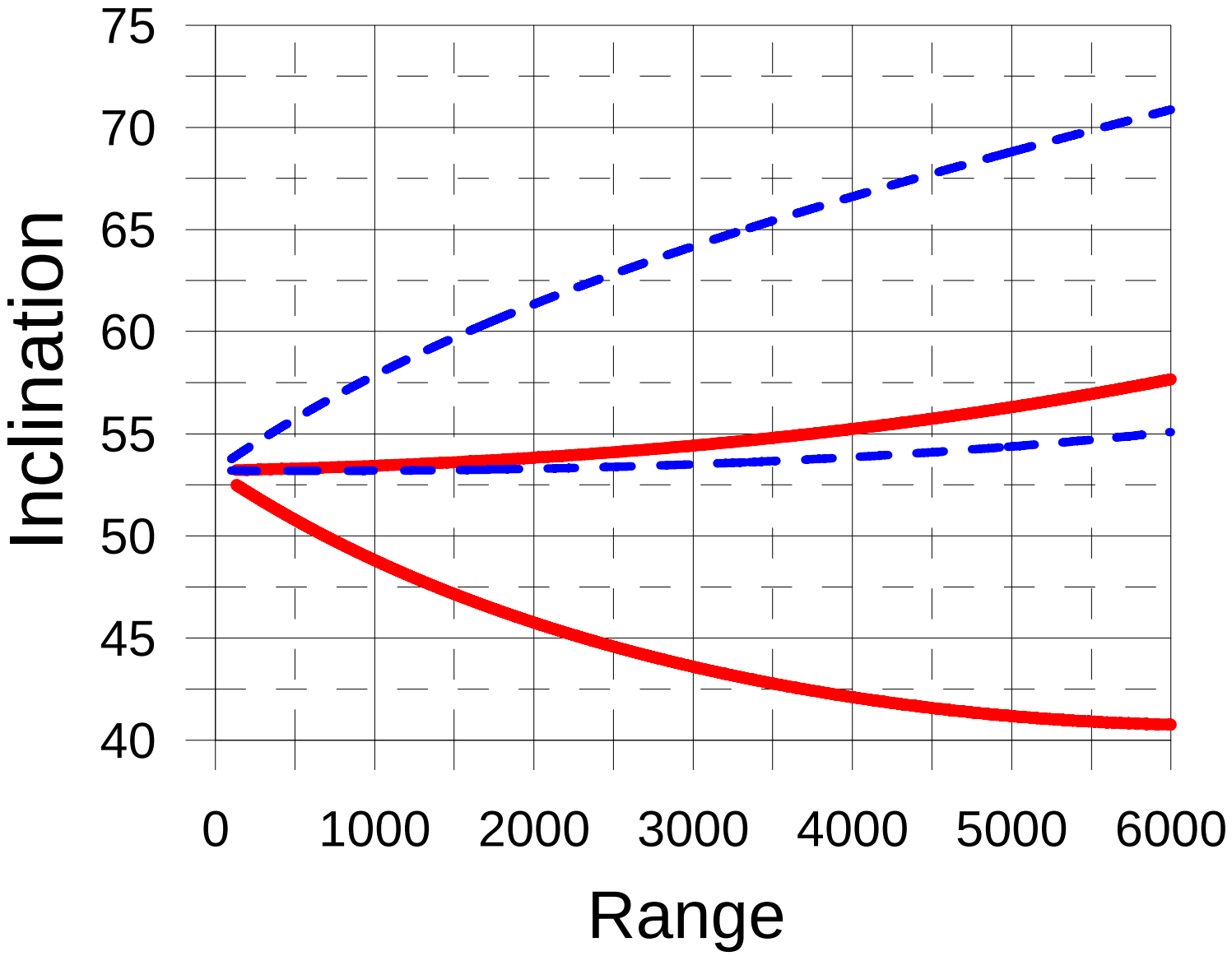
Radar mode



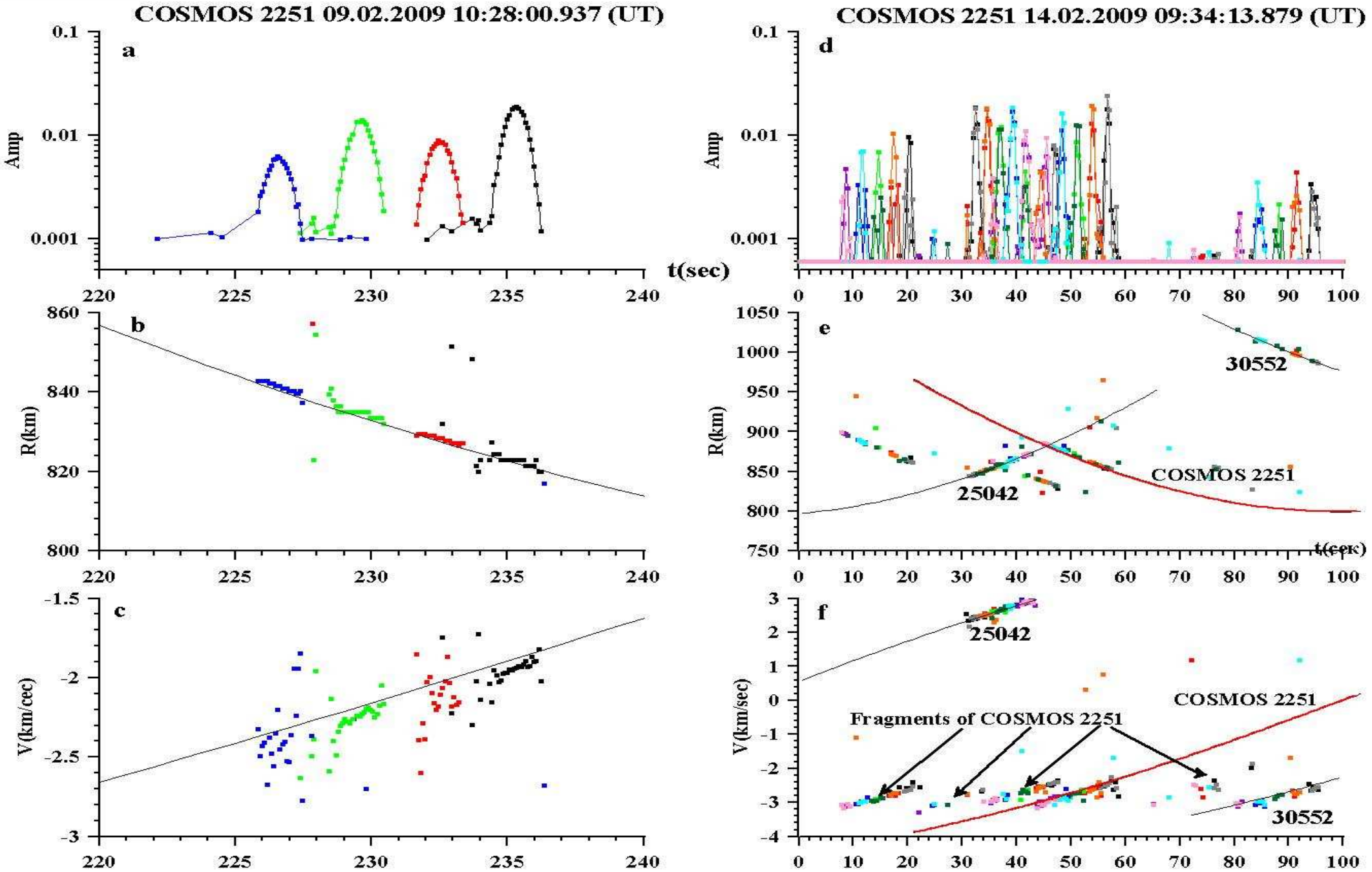
Dependence of the metallic sphere detection range versus its diameter for different signal/noise factors



Orbit class of the satellites which we can observe on the nearby turns

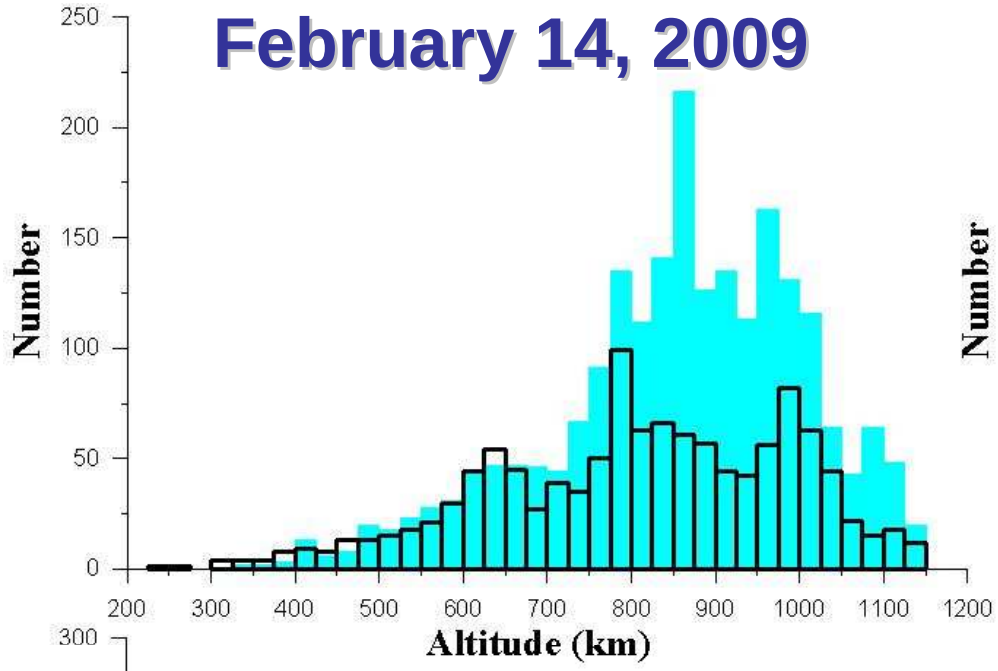


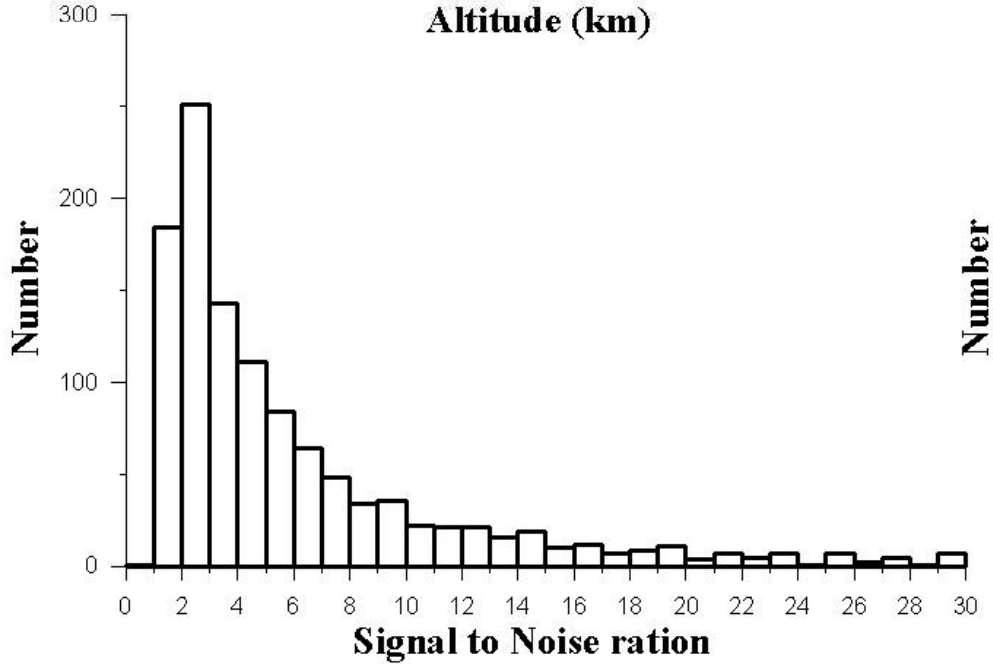
The Irkutsk ISR observations of COSMOS 2251 before and after collision with IRIDIUM 33



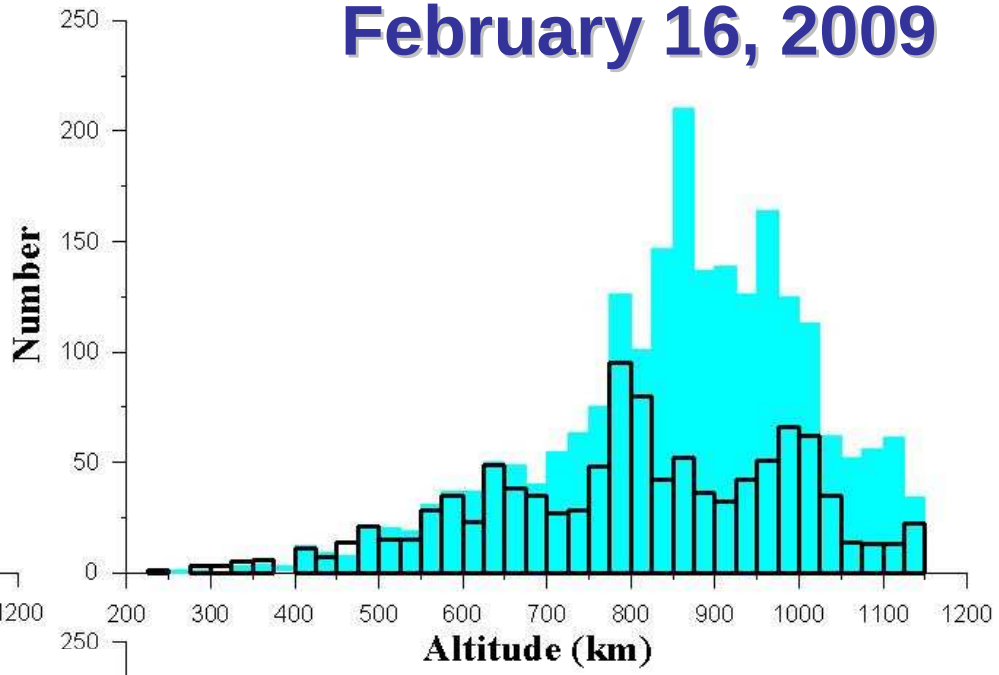
Comparison Irkutsk ISR data on space debris with space object catalogue (www.space-track.org)

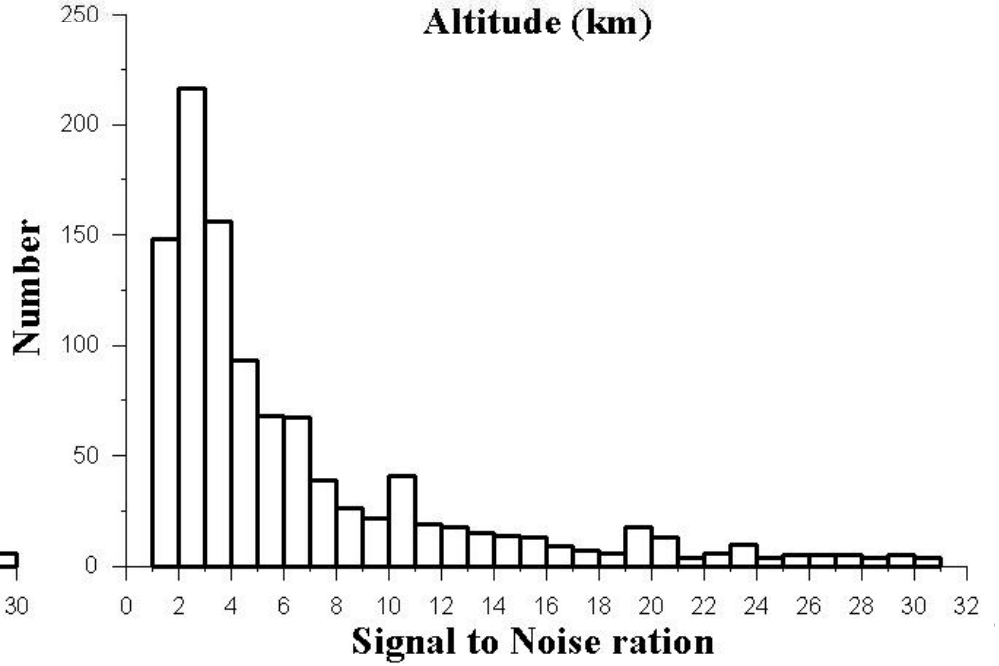
February 14, 2009





February 16, 2009





Summary

The Irkutsk ISR's potential is sufficient for detection of the existing spacecraft and large SD and determination of their parameters of motion.

Some non-coordinate information about SD can be obtained with help of the radar.

The Irkutsk ISR is located favourable site for space debris studies.