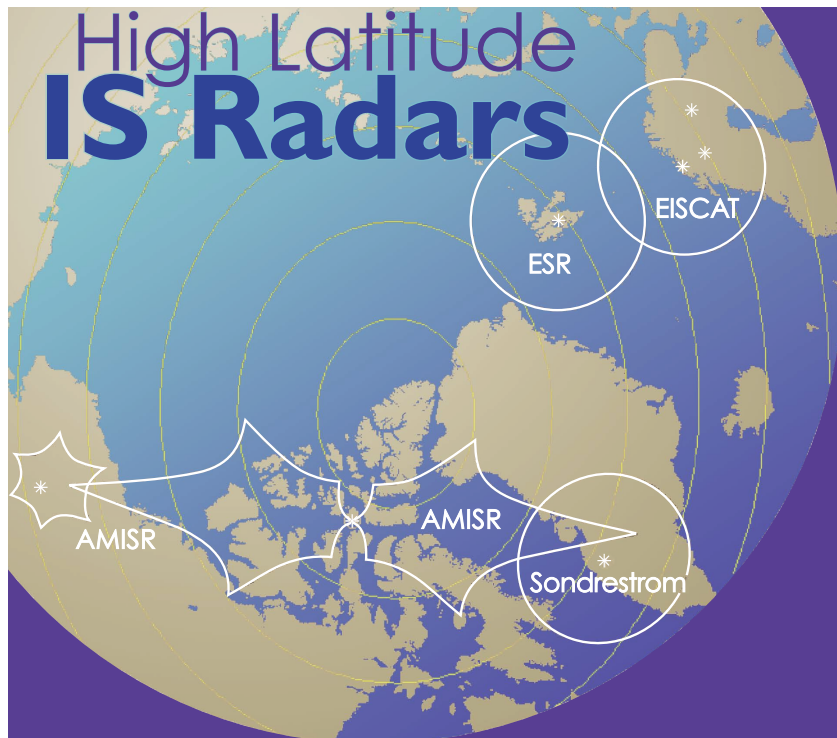


High Latitude IS Radars

EISCAT2003



ESR

Geographic coord.	78° 09' 11" N 16° 01' 44" E
Geomag. dip angle	82° 06'
Invariant latitude	75° 10' 48" N
Local time	UT + 1 (UT + 2 summer)
Magnetic time	UT + 2:45
Elevation	445 m
Coverage	360° az., above 30° elev.*

*No transmission below this elevation.

EISCAT

Geographic coord.	69° 35' 11" N 19° 13' 38" E
Geomag. dip angle	77° 30'
Invariant latitude	66° 12' N
Local time	UT+1 (UT + 2 summer)
Magnetic time	UT + 2:30
Elevation	86 m
Coverage	UHF: 360° az., above 20°–22° elev.* VHF: ±15° az., 30°–90° elev. (north only)

*Dependent on azimuth. No transmission below this elevation.

AMISR

Geographic coord.	65° 7' 12" N 147° 25' 48" W	74° 43' 46" N, 94° 54' 16" W
Geomag. dip angle	77° 32'	88° 47'
Invariant latitude	66° 7' N	83° 37' N
Local time	UT – 9 (Alaska)	UT – 6 (central)
Magnetic time	UT – 11:20	UT – 7:45
Elevation	–	–
Coverage	±25°	±25°

*Initial locations. Poker Flat (one face) operational Spring 2005. Resolute Bay (two faces) operational Winter 2006. One face = 128 panels.

Useful Constants

$c_0 = 2.99792458 \times 10^8 \text{ ms}^{-1}$	$m_e = 9.10938188 \times 10^{-31} \text{ kg}$
$\mu_0 = 4\pi \times 10^{-7} \text{ NA}^{-2}$	$e = 1.602176462 \times 10^{-19} \text{ C}$
$\epsilon_0 = 1/\mu_0 c_0^2$	$r_e = 2.817940285 \times 10^{-15} \text{ m}$
$\mu_B = 8.854187817 \times 10^{-12} \text{ Fm}^{-1}$	$u = 1.66053873 \times 10^{-27} \text{ kg}$
$k_B = 1.3806503 \times 10^{-23} \text{ JK}^{-1}$	$G = 6.673 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$

$$\text{Plasma frequency, } \omega_p = \left(\frac{n_e e^2}{\epsilon_0 m_e} \right)^{1/2} = 2\pi \sqrt{80.6 n_e}$$

$$\text{Debye length, } \lambda_D = \left(\frac{\epsilon_0 k_B T_e}{n_e e^2} \right)^{1/2} = 69 \sqrt{\frac{T_e}{n_e}}$$

$$\text{Electron thermal speed, } v_{the} = \left(\frac{2k_B T_e}{m_e} \right)^{1/2} = 5506 \sqrt{T_e}$$

$$\text{Ion thermal speed, } v_{thi} = \left(\frac{2k_B T_i}{m_i} \right)^{1/2} = 129.1 \sqrt{\frac{T_i}{W}}$$

$$\text{Ion-acoustic speed, } c_s = \left(\frac{k_B (T_e + T_i)}{m_i} \right)^{1/2} = 91.2 \sqrt{\frac{T_e + T_i}{W}}$$

$$\text{Electron gyro frequency, } \omega_e = \frac{eB}{m_e} = 1.759 \times 10^{11} \text{ B}$$

$$\text{Ion gyro frequency, } \omega_i = \frac{eB}{m_i} = 9.649 \times 10^7 \frac{B}{W}$$

$$\text{Electron gyroradius, } r_{Le} = \frac{v_{the}}{\omega_e} = 3.13 \times 10^{-8} \sqrt{\frac{T_e}{B}}$$

$$\text{Ion gyroradius, } r_{Li} = \frac{v_{thi}}{\omega_i} = r_{Le} \sqrt{\frac{1827 W}{T_e / T_i}}$$

W: molecular weight; $m_i = W \cdot u$

Kiruna

67° 51' 38" N
20° 26' 07" E
76° 48'
64° 27' N
UT + 1 (UT + 2 summer)
–
418 m
Fully steerable

Sodankylä

67° 21' 49" N
26° 37' 37" E
76° 43'
63° 34' N
UT + 2 (UT + 3 summer)
–
197 m
Fully steerable

Sondrestrom

Geographic coord.	66° 59' 12" N 309° 03' 02" E
Geomag. dip angle	80° 24'
Invariant latitude	74° 11' 24" N
Local time	UT – 3 (UT – 2 summer)
Magnetic time	UT – 1:58
Elevation	177 m
Coverage	360° az., above 25°–30° elev.*

*Dependent on azimuth. No transmission below this elevation.

The Incoherent Scatter

RADAR Equation:

ESR

Center transmit frequency, f	500 MHz
Wavenumber, k	10.48 m ⁻¹ (2k = 20.96 m ⁻¹)
Wavelength, λ	0.5996 m ($\lambda/2 = 0.2998$ m)
Peak power, P _t	1 MW
Max duty cycle	25%
Pulse length, τ_p	<1 – 2000 μ s
Antenna size (dia.)	32 m / 42 m
Antenna gain, G	42.5 dBi / 45 dBi
Antenna beamwidth*	0.6°
System temperature, T _{sys}	55 – 65 K
Antenna type	Parabolic dish
Feed system	Cassegrain
Polarization	Circular

$$\text{Signal, } P_r = \frac{C C_0 G^2}{2 (4\pi)^2} \frac{P_t \lambda}{r^2} \frac{\sigma_e n_e(r)}{(1 + k^2 \lambda_D^2)(1 + k^2 \lambda_D^2 + T_r)}$$

$$\text{Noise, } P_n = k_b T_{\text{sys}} \cdot \text{BW} : \text{BW} - \text{bandwidth}$$

$$\sigma_e = 4\pi r_e^2 \approx 9.98 \times 10^{-29} \text{ m}^2 \quad \text{Radar cross section of a free electron}$$

C = Constant containing antenna shape and illumination (~0.4)



ESR



Tromsø



Kiruna



Sodankylä

EISCAT

Center transmit frequency, f	928.4 MHz
Wavenumber, k	19.46 m ⁻¹ (2k = 38.92 m ⁻¹)
Wavelength, λ	0.3229 m ($\lambda/2 = 0.1615$ m)
Peak power, P _t	2 MW
Max duty cycle	12.5%
Pulse length, τ_p	1-2000 μ s
Antenna size (dia.)	32 m
Antenna gain, G	48 dBi
Antenna beamwidth*	0.5°
System temperature, T _{sys}	70 – 80 K
Antenna type	Parabolic dish
Feed system	Cassegrain
Polarization	Circular

Tromsø UHF

Kiruna UHF

Sodankylä UHF

–
220 km**, 2k sin θ = 36 m ⁻¹
220 km**, $\lambda/2 = 0.17$ m
–
–
–
32 m
48 dBi
0.5°
30 – 35 K
Parabolic dish
Cassegrain
Any

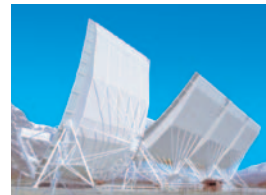
–
220 km**, 2k sin θ = 33 m ⁻¹
220 km**, $\lambda/2 = 0.19$ m
–
–
–
32 m
48 dBi
0.5°
30 – 35 K
Parabolic dish
Cassegrain
Any

Sondrestrom



EISCAT VHF

Center transmit frequency, f	224 MHz
Wavenumber, k	4.695 m ⁻¹ (2k = 9.389 m ⁻¹)
Wavelength, λ	1.3384 m ($\lambda/2 = 0.6692$ m)
Peak power, P _t	2 x 1.5 MW
Max duty cycle	12.5%
Pulse length, τ_p	1 – 2000 μ s
Antenna size	120x40 m (4 x (30mx40m))
Antenna gain, G	46 dBi
Antenna beamwidth*	Whole antenna: 0.6° EW x 1.7° NS; Half antenna: 1.2° EW x 1.7° NS
System temperature, T _{sys}	250 – 350 K
Antenna type	Offset parabolic cylinder
Feed system	Line feed
Polarization	Circular



Tromsø VHF



AMISR



Sondrestrom

AMISR

Center transmit frequency, f	449 MHz
Wavenumber, k	9.4 m ⁻¹ (2k = 18.82 m ⁻¹)
Wavelength, λ	0.6677 m ($\lambda/2 = 0.3338$ m)
Peak power, P _t	2 MW
Max duty cycle	10%
Pulse length, τ_p	1 – 2000 μ s
Antenna size	128 x (1.5 x 3.5 m)
Antenna gain, G	43 dBi
Antenna beamwidth*	1°
System temperature, T _{sys}	120 K
Antenna type	Crossed dipole phased array
Feed system	Distributed amplifiers
Polarization	Circular

Sondrestrom

Center transmit frequency, f	1290 MHz
Wavenumber, k	27.04 m ⁻¹ (2k = 54.07 m ⁻¹)
Wavelength, λ	0.2323 m ($\lambda/2 = 0.1162$ m)
Peak power, P _t	3.5 MW
Max duty cycle	3%
Pulse length, τ_p	2 – 500 μ s
Antenna size (dia.)	32 m
Antenna gain, G	49 dBi
Antenna beamwidth*	0.5°
System temperature, T _{sys}	85 K
Antenna type	Parabolic dish
Feed system	Cassegrain
Polarization	Circular

* Full width, half power ** Tromsø field line

Useful Constants on front page from Physics Today, Vol 85, No 8, Aug 2003.
All data, equations and illustrations in this handout are provided as-is. No warranty is expressed or implied. The printer, furthermore, does not warrant the suitability of these data for any user applications. Use at your own risk. (v.1)

EISCAT2003



E I S C A T