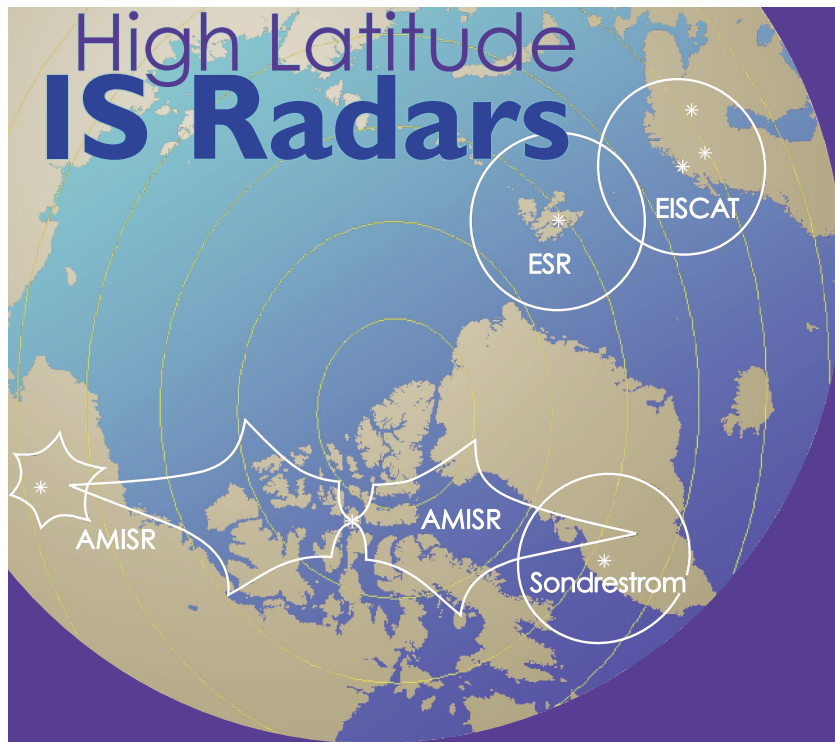


High Latitude IS Radars

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

Tromsø

| | |
|--------------------|--|
| 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

Poker Flat*

Resolute Bay*

| | | |
|--------------------|--------------------------------|---------------------------------|
| 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

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

$$\text{Plasma frequency, } \omega_p = \left(\frac{n_e e^2}{\mu_0 m_e} \right)^{1/2} = 2\pi \sqrt{80.6 n_e}$$

$$\text{Debye length, } \lambda_D = \left(\frac{\mu_0 k_B T_e}{n_e e^2} \right)^{1/2} = 69 \sqrt{\frac{T_e}{n_e}}$$

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

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

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

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

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

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

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

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:

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

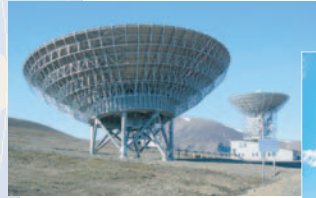
$$\text{Noise, } P_n = k_b T_{\text{sys}} \cdot \text{BW} : \text{BW} - \text{bandwidth}$$

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

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

ESR

| | |
|--------------------------------------|---|
| Center transmit frequency, f | 500 MHz |
| Wavenumber, k | 10.48 m ⁻¹ (2k = 20.96 m ⁻¹) |
| Wavelength, λ | 0.5996 m (λ/2 = 0.2998 m) |
| Peak power, P _t | 1 MW |
| Max duty cycle | 25% |
| Pulse length, λ _p | <1 – 2000 μs |
| 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 * |



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 (λ/2 = 0.1615 m) |
| Peak power, P _t | 2 MW |
| Max duty cycle | 12.5% |
| Pulse length, λ _p | 1-2000 μs |
| 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

| | |
|--------------------------------------|--|
| Center transmit frequency, f | – |
| Wavenumber, k | 220 km ^{**} , 2k sin λ = 36 m ⁻¹ |
| Wavelength, λ | 220 km ^{**} , λ/2 = 0.17 m |
| Peak power, P _t | – |
| Max duty cycle | – |
| Pulse length, λ _p | – |
| Antenna size (dia.) | 32 m |
| Antenna gain, G | 48 dBi |
| Antenna beamwidth* | 0.5° |
| System temperature, T _{sys} | 30 – 35 K |
| Antenna type | Parabolic dish |
| Feed system | Cassegrain |
| Polarization | Any |

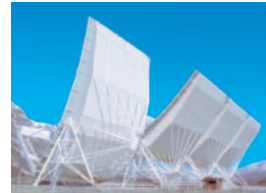
| | |
|--------------------------------------|--|
| Center transmit frequency, f | – |
| Wavenumber, k | 220 km ^{**} , 2k sin λ = 33 m ⁻¹ |
| Wavelength, λ | 220 km ^{**} , λ/2 = 0.19 m |
| Peak power, P _t | – |
| Max duty cycle | – |
| Pulse length, λ _p | – |
| Antenna size (dia.) | 32 m |
| Antenna gain, G | 48 dBi |
| Antenna beamwidth* | 0.5° |
| System temperature, T _{sys} | 30 – 35 K |
| Antenna type | Parabolic dish |
| Feed system | Cassegrain |
| Polarization | 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 (λ/2 = 0.6692 m) |
| Peak power, P _t | 2 x 1.5 MW |
| Max duty cycle | 12.5% |
| Pulse length, λ _p | 1 – 2000 μs |
| 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 (λ/2 = 0.3338 m) |
| Peak power, P _t | 2 MW |
| Max duty cycle | 10% |
| Pulse length, λ _p | 1 – 2000 μs |
| 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 (λ/2=0.1162 m) |
| Peak power, P _t | 3.5 MW |
| Max duty cycle | 3% |
| Pulse length, λ _p | 2 – 500 μs |
| 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

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E I S C A T