EISCAT Experiments

Anders Tjulin
EISCAT Scientific Association

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Cover art: Visualisation of the alternating code used in the manda VHF experiment.

Contents

1 Introduction

This document is created in order to give a brief overview of the measurement capabilities of the EISCAT radar systems. It describes standard experiments, that is experiments that are used in the common programmes, and other supported experiments to aid the understanding of their differences.

2 Overview

Before making a measurement campaign with EISCAT, there are some choices that the experimenter has to make: the geographic/geomagnetic location, the time of day and year, the ionospheric region, the resolutions in time and space, the antenna scan patterns, and so on. These choices naturally depend on the scientific objectives of the measurements, but for some of the choices knowledge of the radar systems is needed.

2.1 The radar systems

EISCAT Scientific Association operates three radar systems (UHF, VHF and ESR) with transmitters on two geographical locations, working in three different radio frequency ranges.

2.1.1 UHF system

The UHF (Ultra High Frequency) system operates at a frequency range around 929 MHz with a transmitter and receiver on the Ramfjordmoen site near Tromsø (see Table 1). The antenna is a 32 m steerable parabolic dish. The lowest elevation that is allowed to be used for radio transmissions from the UHF antenna is $25°$.

2.1.2 VHF system

The VHF (Very High Frequency) system operates at a frequency range around 224 MHz with a transmitter and receiver on the same site as the UHF system (Ramfjordmoen near Tromsø). The antenna consists of four 30 m × 40 m tiltable rectangular dishes. The VHF antenna is allowed to be used for radio transmissions from the zenith direction, and northward down to $25°$, No transmissions are allowed in any southward direction.

Table 1: Geographic location of the EISCAT radar facilities.

Location	Country	Coordinates	
Tromsø	Norway	69°35′ N	19°14′ E
Longyearbyen	Svalbard	78°9′ N	16°1′ E
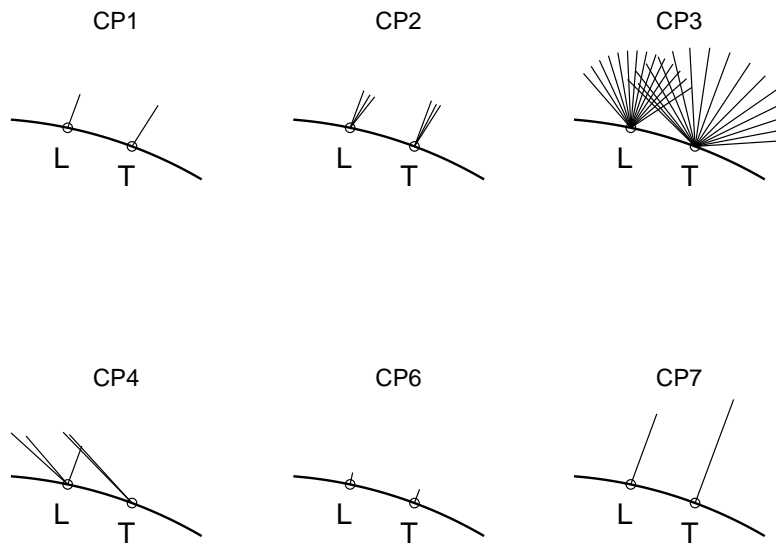
Figure 1: Illustration of the different standard scan patterns used by the EISCAT radar systems. L is indicating the EISCAT Svalbard Radar (Longyearbyen), and T the mainland systems (Tromsø).

2.1.3 ESR system

The ESR (EISCAT Svalbard Radar) system operates at a frequency range around 500 MHz with a transmitter and receiver at Longyearbyen on Svalbard. The system consists of two antennas: one fully steerable 32 m parabolic dish, and one fixed 42 m parabolic dish pointing in the direction of the local magnetic field. This set-up enables simultaneous measurements in two different directions.

2.2 Radar modes

The EISCAT radar systems operate in two basic modes, using approximately half the available observing time for each. In the Special Programme (SP) mode, users from EISCAT members countries conduct individual campaigns dedicated to specific research objectives, with the resulting data reserved for that user for some time. Common Programmes are conducted by EISCAT for the benefit of the entire user community and the resulting data are immediately available to all EISCAT members.

2.3 Antenna scan patterns

EISCAT has a set of pre-defined antenna scan patterns that should be useful for most scientific measurements. They are named after the Common Programme in which they are used. An illustration of the antenna scan patterns is shown in Figure 1.

The different common programmes are usually run using a specific experiment, as denoted in Table 2. See next section for a brief overview of the different experiments.

2.3.1 Mainland systems

The UHF and VHF radars can be operated simultaneously during the Common Programme experiments. Such observations offer comprehensive data sets for atmospheric, ionospheric, and magnetospheric studies.

Common Programme One, CP-1

Common Programme One, CP-1, uses a fixed transmitting antenna, pointing along the geomagnetic field direction. The antenna scan pattern connected to this programme is called *cp1*.

CP-1 is capable of providing results with very good time resolution and is suitable for the study of substorm phenomena, particularly auroral processes where conditions might change rapidly. On longer time scales, CP-1 measurements support studies of diurnal changes, such as atmospheric tides, as well as seasonal and solar-cycle variations.

Common Programme Two, CP-2

Common Programme Two, CP-2 does small antenna scan. The scan uses three positions, vertical, field-aligned and west (east), and a full scan takes 4 min. The antenna scan pattern connected to this programme is called *ip2*. A variation of this scan pattern is *cp2*, which is a 6 min scan to four directions: vertical, field-aligned, south and west (east).

One aim of the scan is to identify wave-like phenomena with length and time scales comparable with, or larger than, the scan (a few tens of kilometers and about ten minutes).

Common Programme Three, CP-3

Common Programme Three, CP-3, covers a 10° latitudinal range in the F-region with a 16-position scan up to 74°N in a 24 min cycle. The observations are made in a plane defined by the magnetic meridian through Tromsø. The antenna scan pattern connected to this programme is called *cp3*. A variation of this scan pattern is *ip3*, which is a 15 position scan that takes 24 min.

The main aim of CP-3 is the mapping of ionospheric and electrodynamic parameters over a broad latitude range.

Common Programme Four, CP-4

Common Programme Four, CP-4, covers geographic latitudes up to almost

Table 2: Common programmes and their connected experiments. Experiment names in italic indicates common programmes not normally run.

	UHF	VHF	ESR
CP-1	beata	*beata*	ipy
CP-2	beata	-	tyko
CP-3	bella	-	folke
CP-4	*bella*	bella	folke
CP-6	*manda*	manda	manda
CP-7	-	othia	othia

80°N (77°N invariant latitude) using a low elevation, with a possible split-beam configuration. The antenna scan patterns connected to this programme are called *cp4* for UHF and *lowel* for VHF.

CP-4 is particularly suitable for studies of high latitude plasma convection and polar cap phenomena. However, with the present one-beam configuration of the VHF radar, CP-4 is run with either simultaneous UHF and VHF radars, or with UHF only in a two position scan taking 4 min.

Common Programme Six, CP-6

Common Programme Six, CP-6, is designed for low altitude studies, providing spectral measurements at mesospheric heights. Velocity and electron density are derived from the measurements and the spectra contain information on the aeronomy of the mesosphere. Vertical antenna pointing is used. The antenna scan pattern connected to this programme is called *zenith*.

Common Programme Seven, CP-7

Common Programme Seven, CP-7, probes high altitudes and is particularly aimed at polar wind studies. The present version, with only one of the VHF klystrons running, is designed to cover altitudes up to 1500 km vertically above Ramfjordmoen. The antenna scan pattern connected to this programme is called *zenith*.

Other scan patterns

There are many variations of the already mentioned scan patterns, and the user can provide their own patterns as well as adjust one of the standard ones to fit for their purposes.

It is worth mentioning the antenna scan pattern called *fixed*. This is indicating that the antenna will not be moved during the experiment, and is used whenever the experimenter wishes a stationary experiment pointing in a direction different from the ones used in the common programmes.

2.3.2 The EISCAT Svalbard Radar

Equivalent Common Programme modes are available for the EISCAT Svalbard Radar.

Common Programme One, CP-1

CP-1 is directed along the local geomagnetic field (81.6° inclination). The antenna scan pattern connected to this programme is called *cp1*, but some variation of this, using the fact that the the ESR system has two antennas, are *fixed32m*, *fixed42m* and *fixed42p*.

Common Programme Two, CP-2

CP-2 uses a two position scan with the 32 m antenna, with the 42 m antenna measuring while the 32 m antenna is moving. The full scan takes 3 min. The antenna scan pattern connected to this programme is called *ip2*. A commonly used variation is the *cp2* scan pattern, which takes 6 min and has three pointing directions for the 32 m antenna.

Common Programme Three, CP-3

CP-3 is a 14 position elevation scan with south beam swinging positions of the 32 m antenna, with the 42 m antenna measuring during the motion. The full scan takes 24 min. The antenna scan pattern connected to this programme is called *cp3*.

Common Programme Four, CP-4

CP-4 combines observations in the F-region (42 m antenna) with a two low-elevation direction scan (32 m antenna), which can be either northward or southward. The full scan takes 4 min. The antenna scan pattern connected to this programme is called *ip4*.

Common Programme Six, CP-6

CP-6 is similar to the mainland radar CP-6. The antenna scan pattern connected to this programme is called *zenith*.

Common Programme Seven, CP-7

CP-7 is similar to the mainland radar CP-7.

Other scan patterns

There is a large number of variations of these scan patterns also at the ESR system. The user can provide their own scan patterns but also adjust one of the standard ones to fit for their purposes.

A special antenna scan pattern is called *any*. This is used if the experimenter wishes to freely move the 32 m during the experiment, or if they want a stationary antenna pointing in a non-standard direction.

2.4 Overview of EISCAT experiments

An EISCAT "experiment" is a set of instructions telling the transmitters, receivers and digital signal processing units what to do at what time. In order to considerably simplify for the users of the radar systems a set of standard experiments have been created. They differ in range coverage, range resolution, time resolution and spectral resolution so that they are fitted for studies of different regions of the ionosphere. Some experiments are usable when the antenna is scanning while others are best used at fixed antenna positions. Some experiments provide plasma line data in addition to the standard ion line data, and some experiments, in addition, collect raw voltage level data to be analysed by the more experienced user. Expert users can modify the standard experiments, or even create their own ones.

All supported EISCAT experiments are based on alternating codes, but the codes are of (very) different lengths.

The names of the different EISCAT experiments come from the imagination of the experiment original designers.

When reading the overview tables that follow, we can also get quick estimates of range resolution (from baud length), spectral resolution (from the inversion of the multiplication of code length and baud length) and spectral range

(inverse of sampling rate). However, the actual numbers may differ from these estimates depending on what is done during the digital signal processing.

2.4.1 UHF system

Some parameters describing the standard experiments used by the EISCAT UHF radar are collected in Table 3. The experiments used when running Common Programmes are beata, bella and manda. The main difference between these experiments lies in the range coverage, as is illustrated in Figure 2 and resolution. More details about these experiments are found in Section 3.1.

Other supported experiments on the UHF radar are arc1 (good time resolution, for auroral studies), lace (very high range resoltion), leo (optimised for meteor and space debris studies) and tau1 (older experiment comparable to bella). More details on these specialised experiments are found in section Section 4.1.

2.4.2 VHF system

Parameters describing the standard experiments used by the EISCAT VHF radar are collected in Table 4. The experiments used when running Common Programmes are beata, bella, manda and othia. Similar to the UHF experiments, the main difference between these experiments is in the range coverage, as is illustrated in Figure 3, and resolution. More details about these experiments are found in Section 3.2.

Other supported experiments on the VHF radar are arc_dlayer (optimised for D-region measurements), lace (very high range resoltion), leo (optimised for meteor and space debris studies), tau7 (older experiment comparable with othia) and tau8 (older experiment comparable with bella). More details on these specialised experiments are found in section Section 4.2.

2.4.3 ESR system

Parameters describing the standard experiments used by the EISCAT Svalbard Radar (ESR) are collected in Table 5. The experiments used when running Common Programmes are ipy, tyko, folke, manda and othia. The main difference is once again in the range coverage, and is illustrated in Figure 4. The folke experiment is using both the 32 m and the 42 m antennas, and can thus by default make observations in two directions at the same time. More details about these experiments are found in Section 3.3.

Other supported experiments on the ESR radar are arc_slice (good time resolution, for auroral studies), beata (an alternative to ipy or tyko), hare (very long ranges), leo (for meteor or space debris studies), steffe (different range resolution for different range intervals), taro (both antennas are used over a large range interval, but with different duty cycles)and tau 7 (alternative to othia). More details on these specialised experiments are found in section Section 4.3. The experiments using both antennas for transmissions are folke and taro.

Figure 2: Overview of the ranges covered at the EISCAT UHF radar by the experiments used in the common programmes.

Table 3: EISCAT UHF radar standard experiments.

Name	Code length [bit]	Baud length [µs]	Sam- pling [µs]	Range span [km]	Time resolution [s]	Plasma line	Raw data
beata	32	20	10	51–696	5.0	Yes	-
bella	30	45	15	51–1431	3.6	Yes	-
manda	61	2.4	1.2	19–209	4.8	-	Yes
arc1	64	6	6	96–422	0.44	-	-
lace	256	2	2	47–579	4.6	Yes	Yes
leo	64	30	1	2844–5844	12.8	-	Yes
tau1	16	60	12	53–1360	5.0	-	Yes
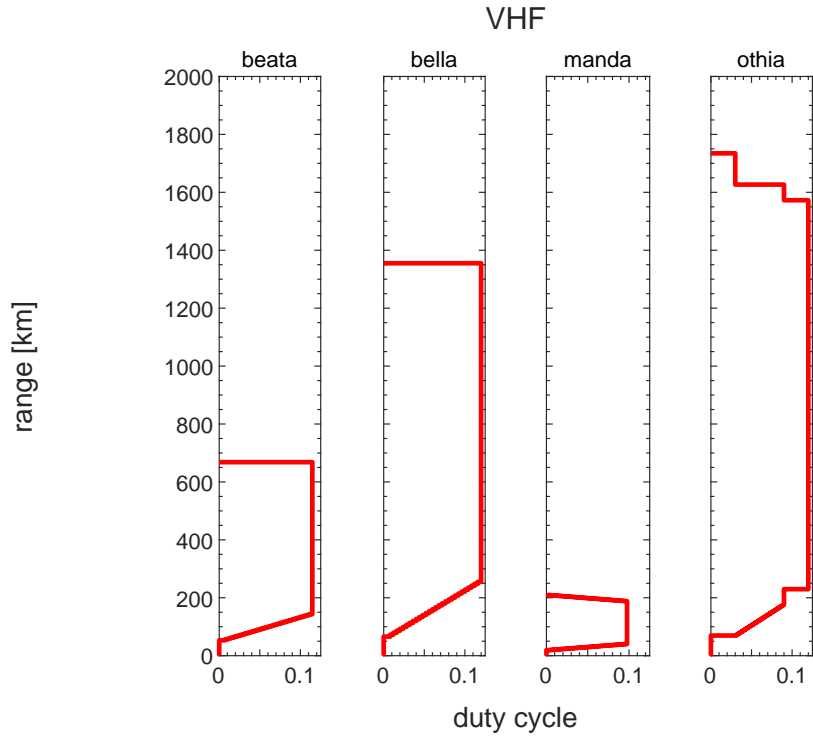
Figure 3: Overview of the ranges covered at the EISCAT VHF radar by the experiments used in the common programmes.

Table 4: EISCAT VHF radar standard experiments.

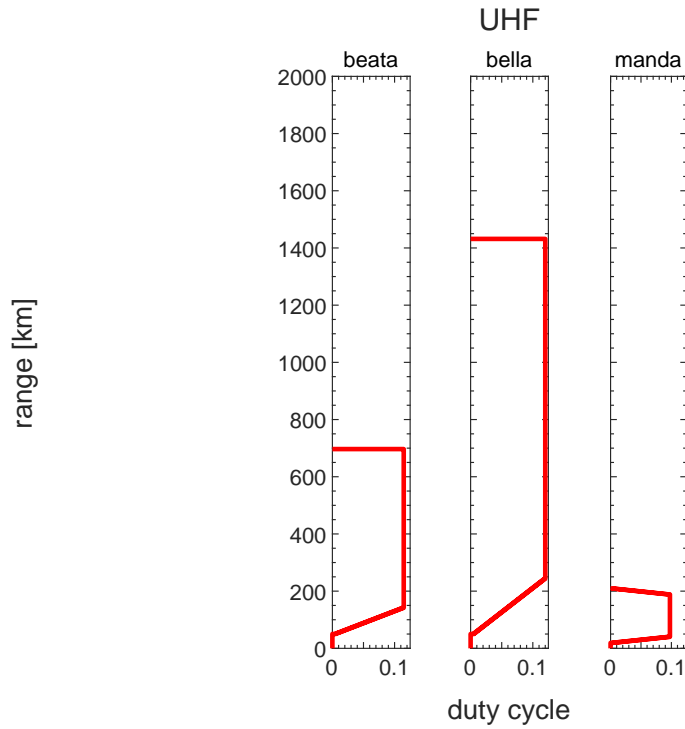| Name	Code length [bit]	Baud length [µs]	Sam- pling [µs]	Range span [km]	Time resolution [s]	Plasma line	Raw data
beata	32	20	20	55–667	5.0	Yes	-
bella	30	45	45	69–1352	3.6	Yes	-
manda	61	2.4	1.2	19–209	4.8	-	Yes
othia	3	360	12	71–1734	3.6	-	-
arc_dlayer	64	2	2	60–140	5.0	-	-
lace	242	3	3	47–792	6.3	Yes	Yes
leo	64	30	1	2844–5844	12.8	-	Yes
tau7	16	120	15	81–2061	3.6	Yes	-
tau8	16	84	14	60–1316	5.0	Yes	-
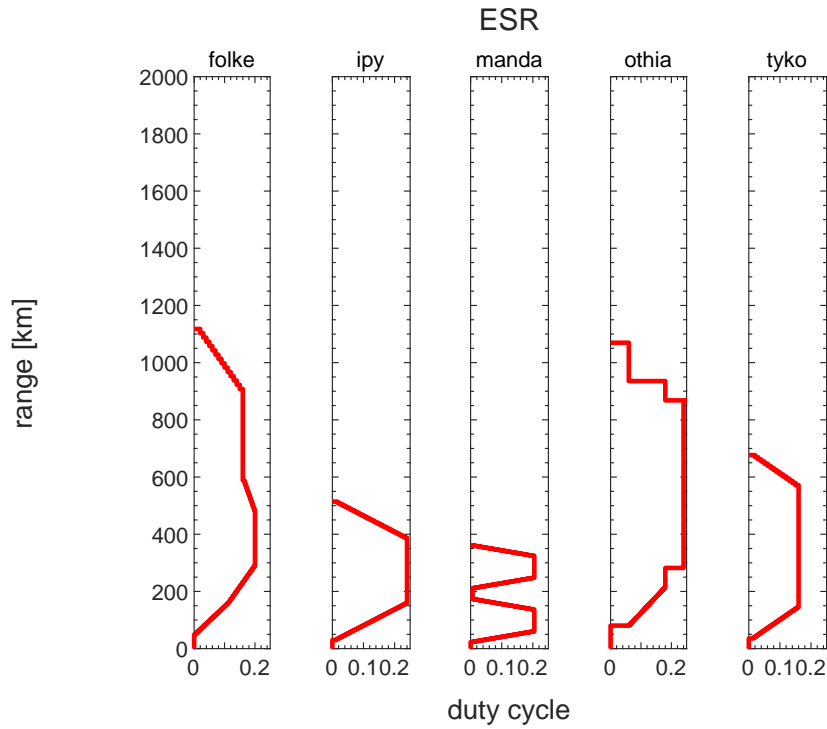
Figure 4: Overview of the ranges covered at the EISCAT ESR radar by the experiments used in the common programmes.

Table 5: EISCAT ESR radar standard experiments.

Name	Code length [bit]	Baud length [µs]	Sam-pling [µs]	Range span [km]	Time resolution [s]	Plasma line	Raw data
folke	16	100	25	51–1110	6.4	Yes	-
(dual)	16	50	25	51–585	6.4	Yes	-
ipy	30	30	15	31–512	6.0	Yes	Yes
manda	64	4	2	24–174	4.0	Yes	Yes
	64	4	2	211–361	4.0	Yes	Yes
othia	3	450	6	81–1069	4.5	Yes	-
tyko	16	50	25	37–673	4.0	Yes	Yes
arc_slice	64	6	6	86–482	0.5	-	-
beata	30	50	25	51–651	6.0	Yes	Yes
hare	3	660	5	278–6614	3.0	-	-
leo	64	30	1	2844–5844	6.0	-	Yes
steffe	16	30	15	38–287	6.4	-	-
	16	30	15	517–1037	6.4	-	-
	16	105	15	43–1024	6.4	Yes	-
taro	16	50	25	49–836	6.4	-	-
(dual)	16	50	25	49–836	6.4	-	-
tau7	16	120	5	49–1353	6.0	Yes	-

2.5   Explanation of terms in the overview

Sections 3 and 4 contain a rather detailed overview of the different experiments that are run at the EISCAT radar systems. The experiments are sorted first by the radar system (UHF, followed by VHF and finally ESR) and then alphabetically.

2.5.1   General description

The general description of the experiment contains a number of terms explained below:

Version The number of the version of the experiment that is used at the present.

Antenna Only used at ESR. Dual if both the 32 m and the 42 m antennas are used for the radio transmissions, otherwise single.

Raw data available Availability of raw samples for the ion line data.

Plasma line Availability of plasma line data.

Transmitter frequency The transmitter frequency/frequencies used for transmission.

Integration time The time length of the individual data dumps.

Duty cycle The time ratio the radar is transmitting.

Code The type of radar code.

Length of code The number of bits per pulse in the radar code.

Baud length The time length of the individual bits of the radar code.

Subcycle length The time it takes from the start of one pulse to the start of next pulse.

Number of subcycles The total number of different subcycles in the radar code.

Number of loops The total number the full code is repeated in one data dump.

Sampling The time interval between each data sample.

2.5.2   Most relevant data types

Data from the experiments contain different data types. Following the general overview described above are descriptions of the most relevant data types for a normal user, and they contain the following terms:

Time resolution The time resolution of the data type.

Ranges covered The span of the centre points of the range gates covered by the data type.

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Range gate size The size of the range interval covered by the individual range gate of the data type.

Range gate step The distance between two consecutive range gates for the data type.

Spectral range The spectral range of the data type.

Spectral resolution The spectral resolution of the data type.

Lag step The size of the lags in the lag profiles of the data type.

Maximum lag The maximum lag for the data type.

2.5.3 Figures

The detailed overview of each experiment contains two figures.

1. The range coverage of the most relevant data types for the experiment.

2. The timing of the radar for one, or a few, subcycles of the radar experiment. It shows when the transmitter is active, and which frequency is used. Furthermore, it shows when the calibration signal is on, and when each of the receiver channels are in use (colour-coded by which frequency it is tuned to).

2.5.4 Tables

The detailed overview of each experiment contains the following tables.

1. Short explanation of the receiver channels used in the experiments (and displayed in one of the overview figures).

2. The layout of the `d_raw` vector in the data dumps from the experiment.

3. The layout of the `d_data` vector in the data dumps from the experiment.

The figures and tables are repeated for the plasma line data for the experiments on the Svalbard radar utilising the separate plasma line receiver.

3   Experiments used in common programmes

3.1   UHF

3.1.1   beata

Version	2.3
Raw data available	No
Plasma line	Yes
Transmitter frequency	927.2 MHz
Integration time	5.0 s
Duty cycle	0.1147
Code	Alternating
Length of code	32 bit
Baud length	20 µs
Subcycle length	5580 µs
Number of subcycles	64
Number of loops	14
Sampling	10 µs (0.266 67 µs plasma line)

Ion line

Time resolution	5.0 s
Ranges covered	51 km to 696 km
Range gate size	4.5 km
Range gate step	1.5 km
Spectral range	±50 kHz
Spectral resolution	1.2195 kHz
Lag step	10 µs
Maximum lag	41 (410 µs)

Ion line   Slices

Time resolution	0.357 12 s
Ranges covered	51 km to 696 km
Range gate size	4.5 km
Range gate step	1.5 km
Spectral range	±50 kHz
Spectral resolution	50 kHz
Lag step	10 µs
Maximum lag	1 (10 µs)

Plasma line   One down-shifted frequency range

Time resolution	5.0 s
Ranges covered	95.25 km to 695.25 km
Range gate size	6.0 km
Range gate step	3.0 km
Spectral range	±1.875 MHz
Spectral resolution	1.4648 kHz
Lag step	0.266 67 µs
Maximum lag	1280 (341.33 µs)
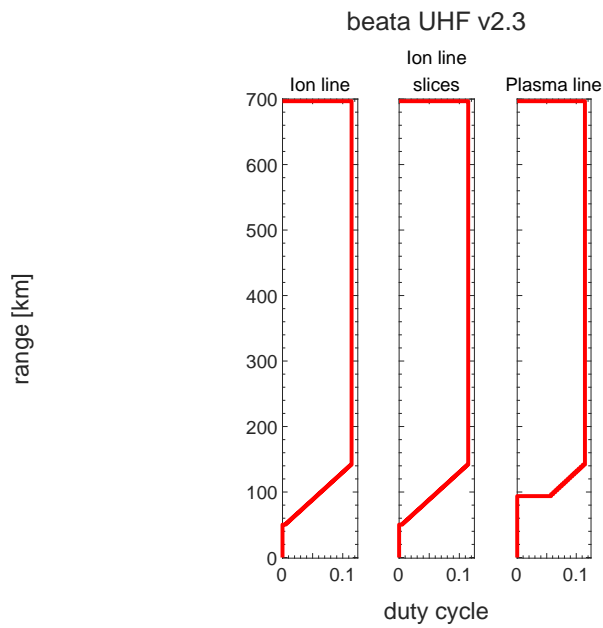
beata UHF v2.3

Range coverage for the most relevant data obtained by beata UHF.

Illustration of timing for transmission and the receiver channels for beata UHF.

Channel setup for beata UHF.

Channel	Description
1	Ion line data
2	Gain
4	Plasma line data (−3.85 MHz)

Layout of the `d_raw` vector for beata UHF (level 1 data).

Start address	Size	Channel	Description
0	4352	1	Transmitter samples
4352			

Layout of the `d_data` vector for beata UHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	432	1	Power profile
480	25051	1	Lag profiles
25531	6034	1	14 slices
31565	16	2	Background
31581	16	2	Calibration
31797	432	2	Power profile
32029	30	4	Background
32059	30	4	Calibration
32089	15150	4	Lag profiles (short)
47239	257280	4	Lag profiles
304519	600	4	Lag profiles (undecoded)
305119	16200	4	Power profile
321319			

3.1.2 bella

Version	1.1
Raw data available	No
Plasma line	Yes
Transmitter frequency	927.2 MHz
Integration time	3.6 s
Duty cycle	0.12
Code	Alternating
Length of code	30 bit
Baud length	45 µs
Subcycle length	11 250 µs
Number of subcycles	64
Number of loops	5
Sampling	15 µs (0.6 µs plasma line)

Ion line

Time resolution	3.6 s
Ranges covered	51.3 km to 1430.5 km
Range gate size	9 km
Range gate step	2.25 km
Spectral range	±33.33 kHz
Spectral resolution	1.0417 kHz
Lag step	15 µs
Maximum lag	32 (480 µs)

Plasma line Two down-shifted frequency ranges

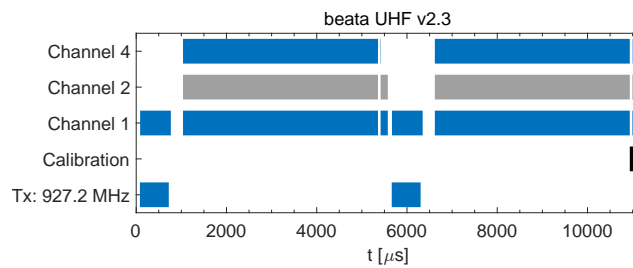|	
Time resolution	3.6 s
Ranges covered	214.92 km to 767.88 km
Range gate size	340.74 km
Range gate step	138.24 km
Spectral range	±0.833 33 MHz
Spectral resolution	11.261 kHz
Lag step	0.6 µs
Maximum lag	74 (44.4 µs)
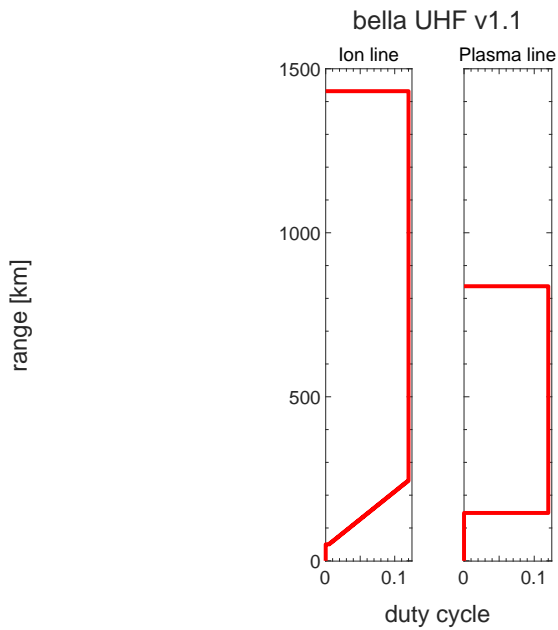
Range coverage for the most relevant data obtained by bella UHF.

Illustration of timing for transmission and the receiver channels for bella UHF.

Channel setup for bella UHF.

Channel	Description
1	Ion line data
2	Gain
3	Plasma line data (−2.9 MHz)
4	Plasma line data (−4.5 MHz)

Layout of the `d_raw` vector for bella UHF (level 1 data).

Start address	Size	Channel	Description
0	6016	1	Transmitter samples
6016			

Layout of the `d_data` vector for bella UHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	615	1	Power profile
663	31092	1	Lag profiles
31755	16	2	Background
31771	16	2	Calibration
31787	615	2	Power profile
32402	16	3	Background
32418	16	3	Calibration
32434	7680	3	Power profile
40114	375	3	Lag profiles (undecoded)
40489	16	4	Background
40505	16	4	Calibration
40521	7680	4	Power profile
48201	375	4	Lag profiles (undecoded)
48576			

3.1.3 manda

Version	4.0
Raw data available	Yes
Plasma line	No
Transmitter frequency	927.5 MHz
Integration time	4.8 s
Duty cycle	0.0976
Code	Alternating
Length of code	61 bit
Baud length	2.4 µs
Subcycle length	1500 µs
Number of subcycles	128
Number of loops	25
Sampling	1.2 µs

Ion line

Time resolution	4.8 s
Ranges covered	19.26 km to 209.34 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±416.67 kHz
Spectral resolution	3.4722 kHz
Lag step	1.2 µs
Maximum lag	120 (144 µs)

Ion line D region, shorter lags

Time resolution	4.8 s
Ranges covered	19.26 km to 108.9 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±333.33 Hz
Spectral resolution	2.6247 Hz
Lag step	1.5 ms
Maximum lag	127 (190.5 ms)

Ion line D region, longer lags

Time resolution	4.8 s
Ranges covered	19.26 km to 108.9 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±2.6042 Hz
Spectral resolution	0.173 61 Hz
Lag step	192 ms
Maximum lag	15 (2.88 s)

Range coverage for the most relevant data obtained by manda UHF.
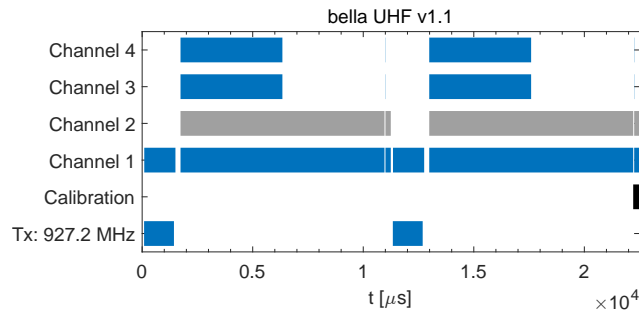

Illustration of timing for transmission and the receiver channels for manda UHF.

Channel setup for manda UHF.

Channel	Description
1	Ion line data

Layout of the `d_raw` vector for manda UHF (level 1 data).

Start address	Size	Channel	Description
0	32768	1	Transmitter samples
32768	3014400	1	Raw data time series
3047168			

Layout of the `d_data` vector for manda UHF (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	1060	1	Lag profiles (short)
1080	63480	1	Lag profiles
64560	942	1	Power profile
65502	31750	1	Lag profiles (D short)
97252	3750	1	Lag profiles (D long)
101002	250	1	Coherent profile (D)
101252			

3.2   VHF

3.2.1   beata

Version	2.1
Raw data available	No
Plasma line	Yes
Transmitter frequency	223.6 MHz
Integration time	5.0 s
Duty cycle	0.1147
Code	Alternating
Length of code	32 bit
Baud length	20 µs
Subcycle length	5580 µs
Number of subcycles	64
Number of loops	14
Sampling	20 µs (0.4 µs plasma line)

Ion line

Time resolution	5.0 s
Ranges covered	54.75 km to 666.75 km
Range gate size	6 km
Range gate step	3 km
Spectral range	±25 kHz
Spectral resolution	0.781 25 kHz
Lag step	20 µs
Maximum lag	32 (640 µs)

Plasma line   Two down-shifted frequency ranges

Time resolution	5.0 s
Ranges covered	108.75 km to 375.75 km
Range gate size	6.0 km
Range gate step	3.0 km
Spectral range	±1.25 MHz
Spectral resolution	1.5625 kHz
Lag step	0.4 µs
Maximum lag	800 (320 µs)
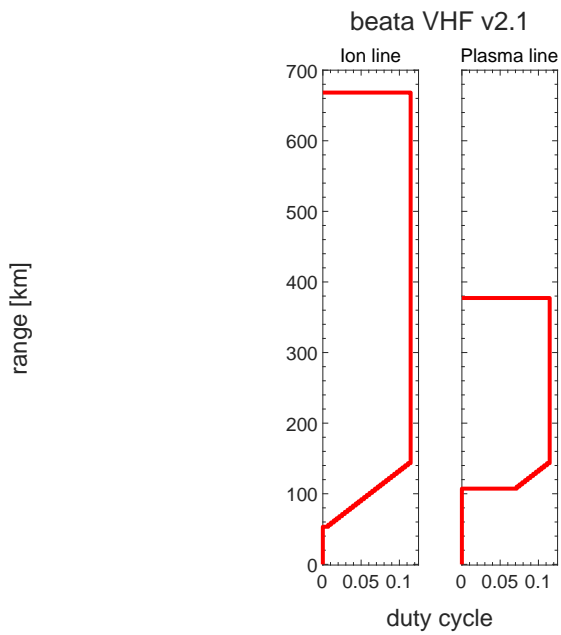
beata VHF v2.1

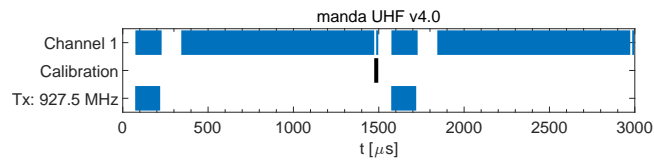

Range coverage for the most relevant data obtained by beata VHF.
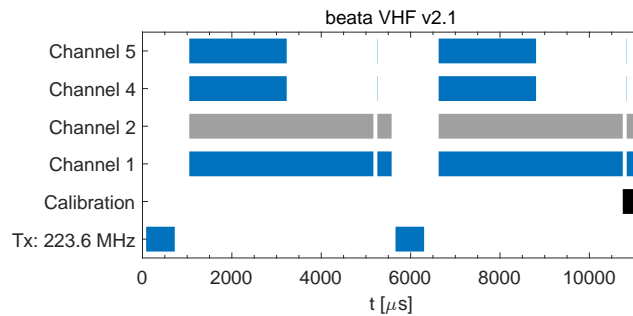
Illustration of timing for transmission and the receiver channels for beata VHF.

Channel setup for beata VHF.

Channel	Description
1	Ion line data
2	Gain
4	Plasma line data (−3.6 MHz)
5	Plasma line data (−6.0 MHz)

Layout of the `d_raw` vector for beata VHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
	0		

Layout of the `d_data` vector for beata VHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	206	1	Lag profiles (short)
254	6560	1	Lag profiles
6814	206	1	Power profile
7020	16	2	Background
7036	16	2	Calibration
7052	206	2	Power profile
7258	16	4	Background
7274	16	4	Calibration
7290	4550	4	Lag profiles (short)
11840	72000	4	Lag profiles
83840	200	4	Lag profiles (undecoded)
84040	5450	4	Power profile
89590	16	5	Background
89606	16	5	Calibration
89522	4550	5	Lag profiles (short)
94072	72000	5	Lag profiles
166072	200	5	Lag profiles (undecoded)
166272	5450	5	Power profile
171722			

3.2.2 bella

Version   1.0
Raw data available   No
Plasma line   Yes
Transmitter frequency   223.6 MHz
Integration time   3.6 s
Duty cycle   0.12
Code   Alternating
Length of code   30 bit
Baud length   45 µs
Subcycle length   11 250 µs
Number of subcycles   64
Number of loops   5
Sampling   45 µs (0.6 µs plasma line)

Ion line   Two signals, one per antenna half
Time resolution   3.6 s
Ranges covered   69.3 km to 1351.8 km
Range gate size   13.5 km
Range gate step   6.75 km
Spectral range   ±11.11 kHz
Spectral resolution   0.370 37 kHz
Lag step   45 µs
Maximum lag   30 (1350 µs)

Plasma line   Two down-shifted frequency ranges, one per antenna half
Time resolution   3.6 s
Ranges covered   226.17 km to 779.13 km
Range gate size   340.74 km
Range gate step   138.24 km
Spectral range   ±0.833 33 MHz
Spectral resolution   11.261 kHz
Lag step   0.6 µs
Maximum lag   74 (44.4 µs)
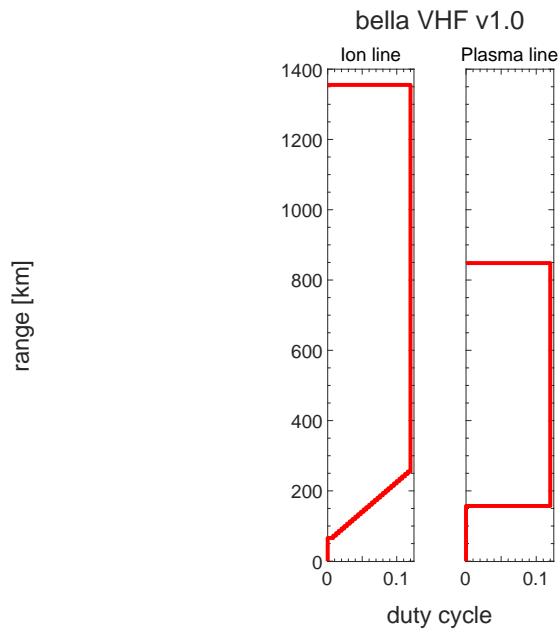
bella VHF v1.0

Range coverage for the most relevant data obtained by bella VHF.

Channel setup for bella VHF.

Channel	Description
1	Ion line data, antenna half 1
2	Gain, antenna half 1
3	Plasma line data, antenna half 1 (−5.2 MHz)
4	Ion line data, antenna half 2
5	Gain, antenna half 2
6	Plasma line data, antenna half 2 (−3.6 MHz)
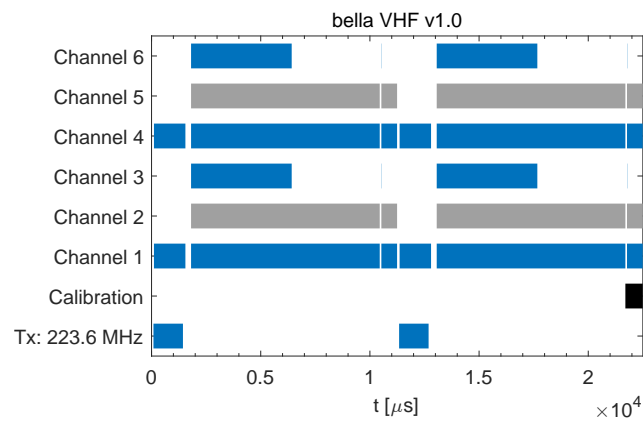
Illustration of timing for transmission and the receiver channels for bella VHF.

Layout of the `d_raw` vector for bella VHF (level 1 data).

Start address	Size	Channel	Description
0	2048	1	Transmitter samples
2048	2048	4	Transmitter samples
4096			

Layout of the `d_data` vector for bella VHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	192	1	Lag profiles (short)
240	5730	1	Lag profiles
5970	192	1	Power profile
6162	16	2	Background
6178	16	2	Calibration
6194	192	2	Power profile
6386	16	3	Background
6402	16	3	Calibration
6418	7680	3	Power profile
14098	375	3	Lag profiles (undecoded)
14473	16	4	Background
14489	16	4	Calibration
14505	16	4	FFT
14521	192	4	Lag profiles (short)
14713	5730	4	Lag profiles
20443	192	4	Power profile
20635	16	5	Background
20651	16	5	Calibration
20667	192	5	Power profile
20859	16	6	Background
20875	16	6	Calibration
20891	7680	6	Power profile
28571	375	6	Lag profiles (undecoded)
28946			

3.2.3 manda

Version	4.0
Raw data available	Yes
Plasma line	No
Transmitter frequency	223.4 MHz
Integration time	4.8 s
Duty cycle	0.0976
Code	Alternating
Length of code	61 bit
Baud length	2.4 µs
Subcycle length	1500 µs
Number of subcycles	128
Number of loops	25
Sampling	1.2 µs

Ion line   Two signals, one per antenna half

Time resolution	4.8 s
Ranges covered	19.26 km to 209.34 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±416.67 kHz
Spectral resolution	3.4722 kHz
Lag step	1.2 µs
Maximum lag	120 (144 µs)

Ion line   D region, shorter lags, two signals, one per antenna half

Time resolution	4.8 s
Ranges covered	19.26 km to 108.9 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±333.33 Hz
Spectral resolution	2.6247 Hz
Lag step	1.5 ms
Maximum lag	127 (190.5 ms)

Ion line   D region, longer lags, two signals, one per antenna half

Time resolution	4.8 s
Ranges covered	19.26 km to 108.9 km
Range gate size	0.72 km
Range gate step	0.36 km
Spectral range	±2.6042 Hz
Spectral resolution	0.173 61 Hz
Lag step	192 ms
Maximum lag	15 (2.88 s)
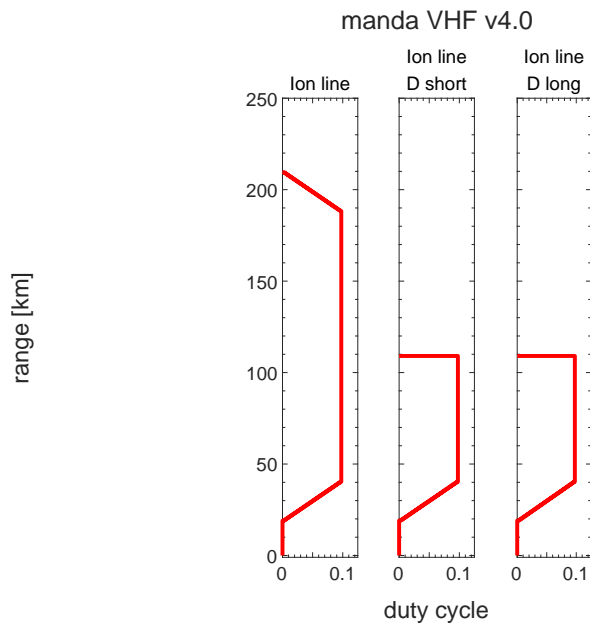
Range coverage for the most relevant data obtained by manda VHF.
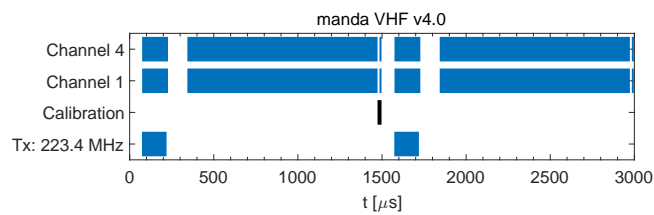
Illustration of timing for transmission and the receiver channels for manda VHF.

Channel setup for manda VHF.

Channel	Description
1	Ion line data, antenna half 1
4	Ion line data, antenna half 2

Layout of the `d_raw` vector for manda VHF (level 1 data).

Start address	Size	Channel	Description
0	32768	1	Transmitter samples
32768	3014400	1	Raw data time series
3047168	32768	4	Transmitter samples
3079936	3014400	4	Raw data time series
6094336			

Layout of the `d_data` vector for manda VHF (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	1060	1	Lag profiles (short)
1080	63480	1	Lag profiles
64560	942	1	Power profile
65502	31750	1	Lag profiles (D short)
97252	3750	1	Lag profiles (D long)
101002	250	1	Coherent profile (D)
101252	10	4	Background
101262	10	4	Calibration
101272	1060	4	Lag profiles (short)
102332	63480	4	Lag profiles
165812	942	4	Power profile
166754	31750	4	Lag profiles (D short)
198504	3750	4	Lag profiles (D long)
202254	250	4	Coherent profile (D)
202504			

3.2.4 othia

Version	1.0
Raw data available	No
Plasma line	No
Transmitter frequency	223.4 MHz, 223.6 MHz and 224.4 MHz
Integration time	3.6 s
Duty cycle	0.12
Code	Single pulse and alternating
Length of code	1 bit and 3 bit
Baud length	360 µs
Subcycle length	12 000 µs
Number of subcycles	12
Number of loops	25
Sampling	12 µs

Ion line   Single pulse, two signals, one per antenna half

Time resolution	3.6 s
Ranges covered	230.7 km to 1733.7 km
Range gate size	55.8 km
Range gate step	1.8 km
Spectral range	±41.667 kHz
Spectral resolution	1.4368 kHz
Lag step	12 µs
Maximum lag	29 (348 µs)

Ion line   Two signals, one per antenna half

Time resolution	3.6 s
Ranges covered	70.5 km to 1571.7 km
Range gate size	55.8 km
Range gate step	1.8 km
Spectral range	±41.667 kHz
Spectral resolution	0.468 16 kHz
Lag step	12 µs
Maximum lag	89 (1068 µs)

Ion line   Top end, two signals, one per antenna half

Time resolution	3.6 s
Ranges covered	1545.6 km to 1599.6 km
Range gate size	108 km
Range gate step	54 km
Spectral range	±41.667 kHz
Spectral resolution	1.4368 kHz
Lag step	12 µs
Maximum lag	29 (348 µs)
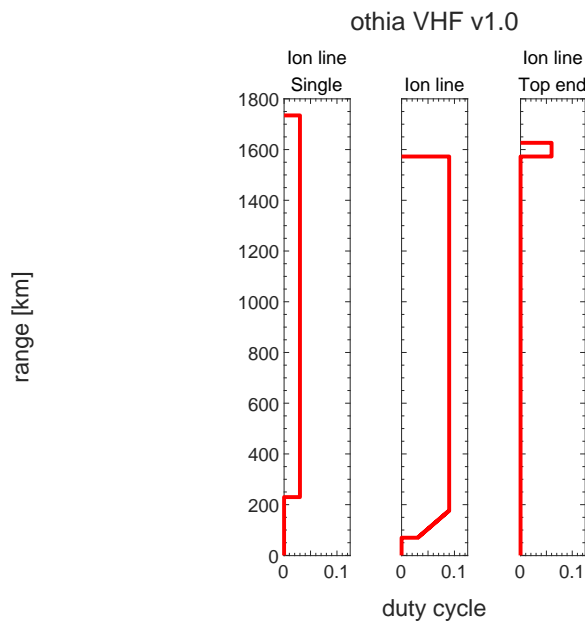
othia VHF v1.0

Range coverage for the most relevant data obtained by othia VHF.

Channel setup for othia VHF.

Channel	Description
1	Ion line data, single pulse, antenna half 1
2	Ion line data, antenna half 1
3	Gain, antenna half 1
4	Ion line data, single pulse, antenna half 2
5	Ion line data, antenna half 2
6	Gain, antenna half 2
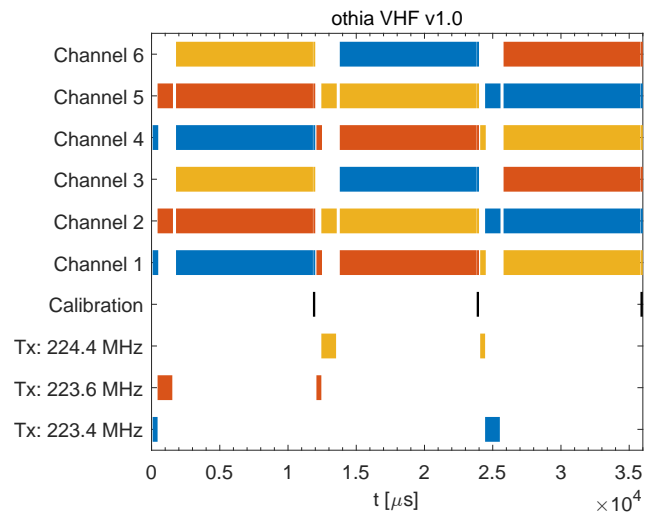
Illustration of timing for transmission and the receiver channels for othia VHF.

Layout of the `d_raw` vector for othia VHF (level 1 data).

Start address	Size	Channel	Description
0	408	1	Transmitter samples
408	1128	2	Transmitter samples
1536	408	4	Transmitter samples
1944	1128	5	Transmitter samples
3072			

Layout of the `d_data` vector for othia VHF (level 2 data).

Start address	Size	Channel	Description
0	12	1	Calibration
12	836	1	Power profile
848	23809	1	Lag profiles
24657	12	2	Calibration
24669	836	2	Power profile
25505	23809	2	Lag profiles
49314	93338	2	Lag profiles
142652	60	2	Lag profiles, top end (short)
142712	45	2	Lag profiles, top end
142757	12	3	Calibration
142769	836	3	Power profile
143605	23809	3	Lag profiles
167414	12	4	Calibration
167426	836	4	Power profile
168262	23809	4	Lag profiles
192071	12	5	Calibration
192083	836	5	Power profile
192919	23809	5	Lag profiles
216728	93338	5	Lag profiles
310066	60	5	Lag profiles, top end (short)
310126	45	5	Lag profiles, top end
310171	12	6	Calibration
310183	836	6	Power profile
311019	23809	6	Lag profiles
334828			

3.3 ESR

3.3.1 folke

Version	2.0
Antenna	Dual, four parts 32 m, one part 42 m
Raw data available	No
Plasma line	Yes
Transmitter frequency	499.85 MHz and 500.15 MHz
Integration time	6.4 s
Duty cycle	0.2
Code	Alternating
Length of code	16 bit
Baud length	100 µs (32 m) and 50 µs (42 m)
Subcycle length	20 000 µs
Number of subcycles	32
Number of loops	10
Sampling	25 µs (0.4 µs plasma line)

Ion line   32 m

Time resolution	6.4 s
Ranges covered	50.925 km to 905.92 km
Range gate size	18.75 km
Range gate step	3.75 km
Spectral range	±20 kHz
Spectral resolution	0.645 16 kHz
Lag step	25 µs
Maximum lag	31 (775 µs)

Ion line   32 m top end

Time resolution	6.4 s
Ranges covered	915.3 km to 1110.3 km
Range gate size	30 km
Range gate step	15 km
Spectral range	±20 kHz
Spectral resolution	0.625 kHz
Lag step	25 µs
Maximum lag	32 (800 µs)

Ion line   42 m

Time resolution	6.4 s
Ranges covered	50.925 km to 482.17 km
Range gate size	11.25 km
Range gate step	3.75 km
Spectral range	±20 kHz
Spectral resolution	0.645 16 kHz
Lag step	25 µs
Maximum lag	31 (775 µs)

Ion line 42 m top end

Time resolution	6.4 s
Ranges covered	487.8 km to 585.3 km
Range gate size	15 km
Range gate step	7.5 km
Spectral range	±20 kHz
Spectral resolution	1.25 kHz
Lag step	25 µs
Maximum lag	16 (400 µs)

Plasma line 32 m two down-shifted and two up-shifted frequency ranges

Time resolution	6.4 s
Ranges covered	229.99 km to 714.41 km
Range gate size	362.88 km
Range gate step	122.88 km
Spectral range	±1.25 MHz
Spectral resolution	5.0201 kHz
Lag step	0.4 µs
Maximum lag	249 (99.6 µs)

Plasma line 42 m two down-shifted and two up-shifted frequency ranges

Time resolution	6.4 s
Ranges covered	132.27 km to 378.03 km
Range gate size	181.44 km
Range gate step	61.44 km
Spectral range	±1.25 MHz
Spectral resolution	10.081 kHz
Lag step	0.4 µs
Maximum lag	124 (49.6 µs)
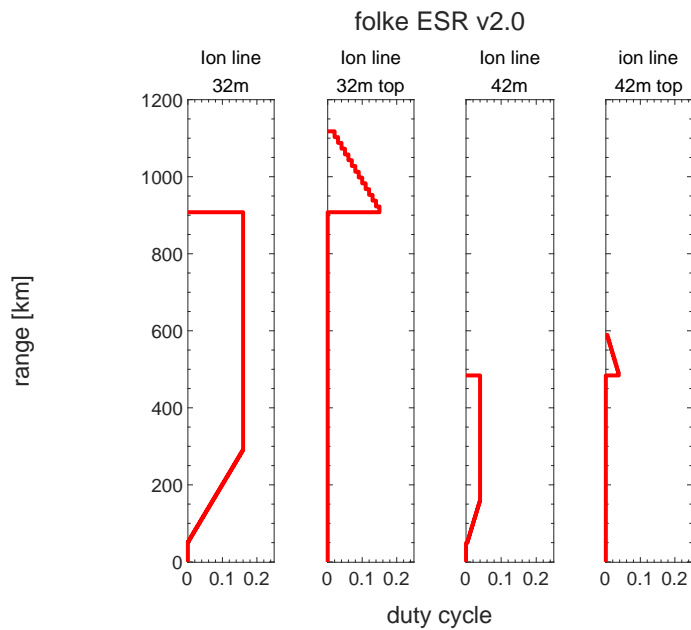
Range coverage for the most relevant data obtained by folke ESR.
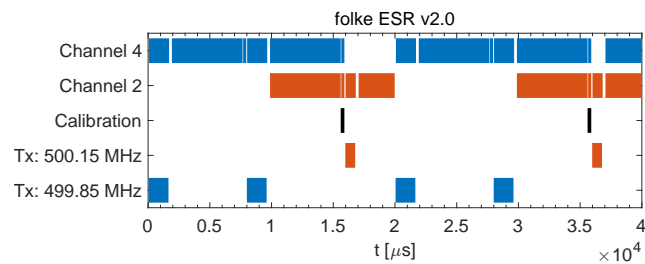
Illustration of timing for transmission and the receiver channels for folke ESR.

Channel setup for folke ESR.

Channel	Description
2	Ion line data, 42 m
4	Ion line data, 32 m

Layout of the `d_raw` vector for folke ESR (level 1 data).

Start address	Size	Channel	Description
0	2080	4	Transmitter samples, 32 m
2080	1056	2	Transmitter samples, 42 m
3136			

Layout of the `d_data` vector for folke ESR (level 2 data).

Start address	Size	Channel	Description
0	117	4	Background
117	108	4	FFT
225	10	4	Background
235	10	4	Calibration
245	229	4	Power profile
474	11034	4	Lag profiles
11508	60	4	Lag profiles, top end (short)
11568	448	4	Lag profiles, top end
12016	229	2	Background
12245	10	2	Calibration
12255	216	2	FFT
12471	117	2	Power profile
12588	4545	2	Lag profiles
17133	30	2	Lag profiles, top end (short)
17163	224	2	Lag profiles
17387			

folke ESR v2.0

Plasma line 32m — Plasma line 42m

range [km]

duty cycle
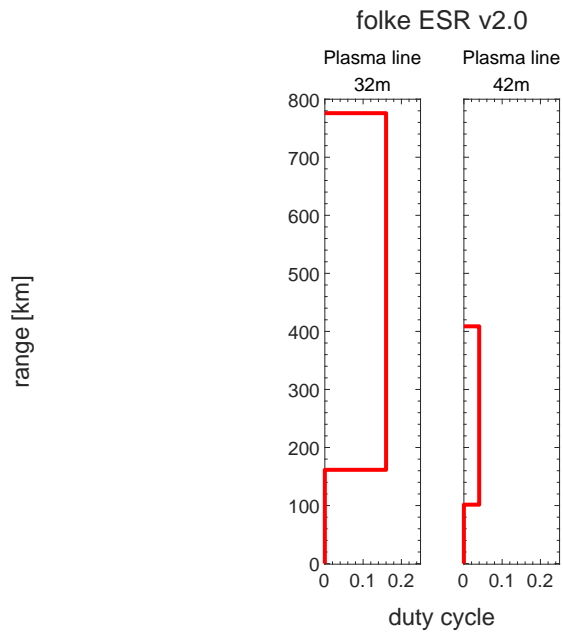
Range coverage for the most relevant data obtained by folke ESR plasma line receiver.

Channel setup for folke ESR plasma line receiver.

Channel	Description
1	Plasma line data ($-4.25\,$MHz)
2	Plasma line data ($-6.75\,$MHz)
4	Plasma line data ($+4.25\,$MHz)
5	Plasma line data ($+6.75\,$MHz)

folke plasmaline ESR v2.0

Illustration of timing for transmission and the receiver channels for folke ESR plasma line receiver.
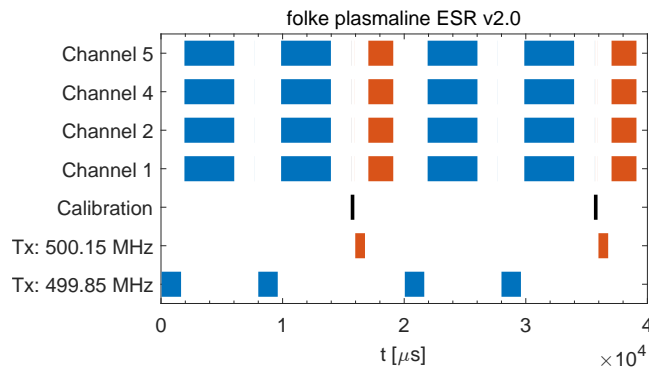
Layout of the `d_raw` vector for folke ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for folke ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	10	1	Calibration, 32 m
10	10	1	Background, 32 m
20	1250	1	Lag profiles (undecoded), 32 m
1270	10	1	Calibration, 42 m
1280	10	1	Background, 42 m
1290	625	1	Lag profiles (undecoded), 42 m
1915	10	2	Calibration, 32 m
1925	10	2	Background, 32 m
1935	1250	2	Lag profiles (undecoded), 32 m
3185	10	2	Calibration, 42 m
3195	10	2	Background, 42 m
3205	625	2	Lag profiles (undecoded), 42 m
3830	10	4	Calibration, 32 m
3840	10	4	Background, 32 m
3850	1250	4	Lag profiles (undecoded), 32 m
5100	10	4	Calibration, 42 m
5110	10	4	Background, 42 m
5120	625	4	Lag profiles (undecoded), 42 m
5745	10	5	Calibration, 32 m
5755	10	5	Background, 32 m
5765	1250	5	Lag profiles (undecoded), 32 m
7015	10	5	Calibration, 42 m
7025	10	5	Background, 42 m
7035	625	5	Lag profiles (undecoded), 42 m
7660			

3.3.2 ipy

Version	4.3
Antenna	Single
Raw data available	Yes
Plasma line	Yes
Transmitter frequency	499.85 MHz
Integration time	6.0 s
Duty cycle	0.24
Code	Alternating
Length of code	30 bit
Baud length	30 µs
Subcycle length	3750 µs
Number of subcycles	64
Number of loops	25
Sampling	15 µs (0.333 33 µs plasma line)

Ion line

Time resolution	6.0 s
Ranges covered	31.425 km to 386.93 km
Range gate size	6.75 km
Range gate step	2.25 km
Spectral range	±33.333 kHz
Spectral resolution	0.813 01 kHz
Lag step	15 µs
Maximum lag	41 (615 µs)

Ion line   Top end

Time resolution	6.0 s
Ranges covered	390.3 km to 511.8 km
Range gate size	9 km
Range gate step	4.5 km
Spectral range	±33.333 kHz
Spectral resolution	0.5556 kHz
Lag step	15 µs
Maximum lag	60 (900 µs)

Plasma line   Two down-shifted and two up-shifted frequency ranges

Time resolution	6.0 s
Ranges covered	93.3 km to 439.8 km
Range gate size	9 km
Range gate step	4.5 km
Spectral range	±1.5 MHz
Spectral resolution	1.0417 kHz
Lag step	0.333 33 µs
Maximum lag	1440 (480 µs)

ipy ESR v4.3
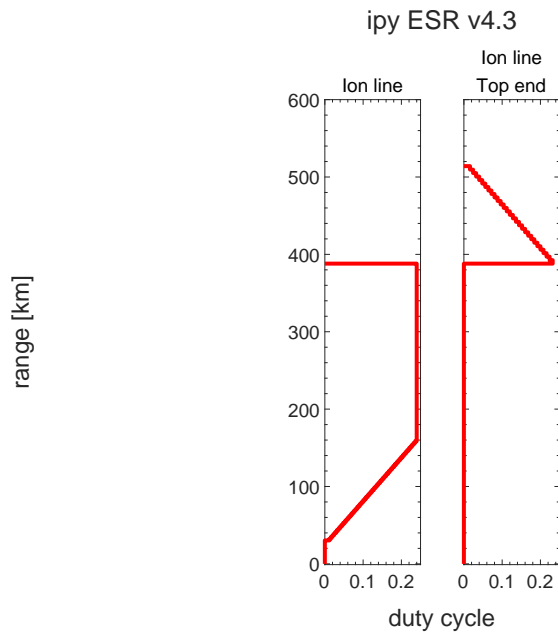
Range coverage for the most relevant data obtained by ipy ESR.

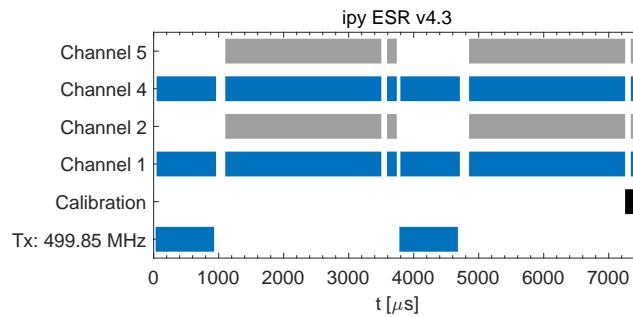Illustration of timing for transmission and the receiver channels for ipy ESR.

Channel setup for ipy ESR. Channels 4 and 5 are only used when the fixed42p scan is applied. In that case channels 1 and 2 are for the 42 m antenna and channels 4 and 5 for the 32 m antenna.

Channel	Description
1	Ion line data
2	Gain
4	*Ion line data*
5	*Gain*

Layout of the `d_raw` vector for ipy ESR (level 1 data).

Start address	Size	Channel	Description
0	3904	1	Transmitter samples
3904	256000	1	Raw data time series
259904	*3904*	*4*	*Transmitter samples*
263808	*256000*	*4*	*Raw data time series*
519808			

Layout of the `d_data` vector for ipy ESR (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	10	1	FFT
30	160	1	Power profile
190	8459	1	Lag profiles
8649	58	1	Lag profiles, top end (short)
8707	1680	1	Lag profiles, top end
10387	10	2	Background
10397	10	2	Calibration
10407	160	2	Power profile
10567	*10*	*4*	*Background*
10577	*10*	*4*	*Calibration*
10587	*10*	*4*	*FFT*
10597	*160*	*4*	*Power profile*
10757	*8459*	*4*	*Lag profiles*
19216	*58*	*4*	*Lag profiles, top end (short)*
19274	*1680*	*4*	*Lag profiles, top end*
20954	*10*	*5*	*Background*
20964	*10*	*5*	*Calibration*
20974	*160*	*5*	*Power profile*
21134			

45

ipy ESR v4.3
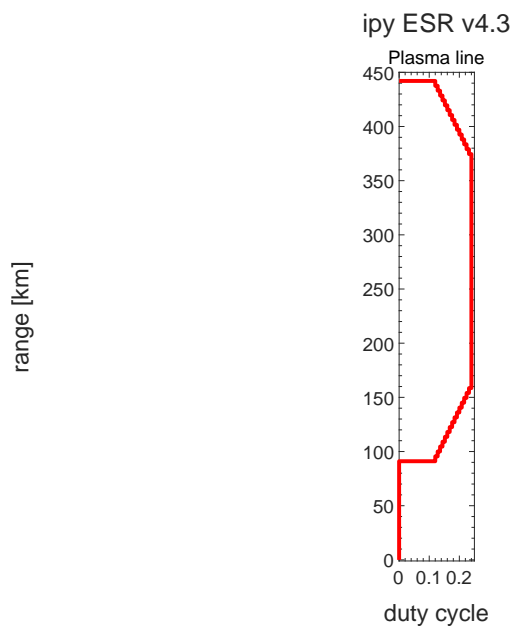
Plasma line

Range coverage for the most relevant data obtained by ipy ESR plasma line receiver.

Channel setup for ipy ESR plasma line receiver. In case of fixed42p scan, the 32 m antenna is used. Otherwise it is the single antenna of choice.

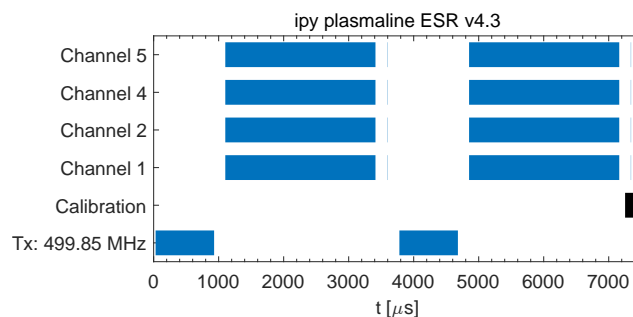| Channel	Description
1	Plasma line data (−3.45 MHz)
2	Plasma line data (−6.35 MHz)
4	Plasma line data (+3.45 MHz)
5	Plasma line data (+6.35 MHz)

ipy plasmaline ESR v4.3

Illustration of timing for transmission and the receiver channels for ipy ESR plasma line receiver.

Layout of the `d_raw` vector for ipy ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for ipy ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	12	1	Background
12	12	1	Calibration
24	7110	1	Lag profiles (short)
7134	112320	1	Lag profiles
119454	360	1	Lag profiles (undecoded)
119814	6930	1	Power profile
126744	12	2	Background
126756	12	2	Calibration
126768	7110	2	Lag profiles (short)
133878	112320	2	Lag profiles
246198	360	2	Lag profiles (undecoded)
246558	6930	2	Power profile
253488	12	4	Background
253500	12	4	Calibration
253512	7110	4	Lag profiles (short)
260622	112320	4	Lag profiles
372942	360	4	Lag profiles (undecoded)
373302	6930	4	Power profile
380232	12	5	Background
380244	12	5	Calibration
380256	7110	5	Lag profiles (short)
387366	112320	5	Lag profiles
499686	360	5	Lag profiles (undecoded)
500046	6930	5	Power profile
506976			

3.3.3 manda

Version	4.1
Antenna	Single
Raw data available	Yes
Plasma line	Yes
Transmitter frequency	500.3 MHz
Integration time	4.0 s
Duty cycle	0.2048
Code	Alternating
Length of code	64 bit
Baud length	4 µs
Subcycle length	1250 µs
Number of subcycles	128
Number of loops	25
Sampling	2 µs (0.4 µs plasma line)

Ion line

Time resolution	4.0 s
Ranges covered	23.55 km to 173.55 km
Range gate size	1.2 km
Range gate step	0.6 km
Spectral range	±250 kHz
Spectral resolution	1.9531 kHz
Lag step	2 µs
Maximum lag	128 (256 µs)

Ion line   D region, shorter lags

Time resolution	4.0 s
Ranges covered	23.55 km to 112.95 km
Range gate size	1.2 km
Range gate step	0.6 km
Spectral range	±400 Hz
Spectral resolution	3.1496 Hz
Lag step	1.25 ms
Maximum lag	127 (158.75 ms)

Ion line   D region, longer lags

Time resolution	4.0 s
Ranges covered	23.55 km to 112.95 km
Range gate size	1.2 km
Range gate step	0.6 km
Spectral range	±3.125 Hz
Spectral resolution	0.208 33 Hz
Lag step	160 ms
Maximum lag	15 (2.4 s)

Ion line   F region

Time resolution   4.0 s
Ranges covered   211.05 km to 361.05 km
Range gate size   1.2 km
Range gate step   0.6 km
Spectral range   ±250 kHz
Spectral resolution   1.9531 kHz
Lag step   2 μs
Maximum lag   128 (256 μs)

Plasma line   Two down-shifted and two up-shifted frequency ranges
Time resolution   4.0 s
Ranges covered   60.75 km to 155.55 km
Range gate size   1.2 km
Range gate step   0.6 km
Spectral range   ±1.25 MHz
Spectral resolution   3.9062 kHz
Lag step   0.4 μs
Maximum lag   320 (128 μs)

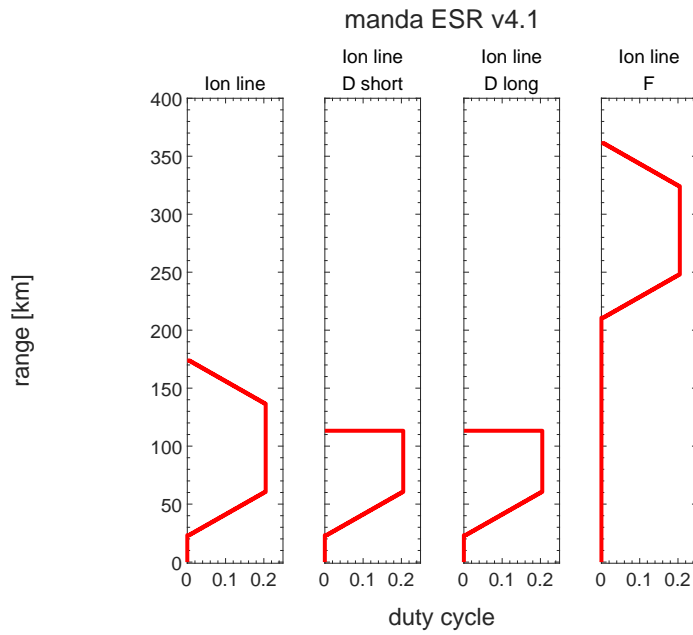**Plasma line**   F region, two down-shifted and two up-shifted frequency ranges
Time resolution   4.0 s
Ranges covered   229.05 km to 343.05 km
Range gate size   1.2 km
Range gate step   0.6 km
Spectral range   ±1.25 MHz
Spectral resolution   3.9062 kHz
Lag step   0.4 μs
Maximum lag   320 (128 μs)

Range coverage for the most relevant data obtained by manda ESR.
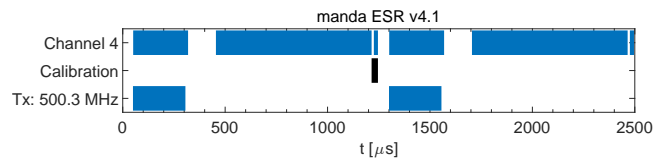
Illustration of timing for transmission and the receiver channels for manda ESR.

Channel setup for manda ESR.

Channel	Description
4	Ion line data

Layout of the `d_raw` vector for manda ESR (level 1 data).

Start address	Size	Channel	Description
0	34304	4	Transmitter samples
3404	1216000	4	Raw data time series
1250304			

Layout of the `d_data` vector for manda ESR (level 2 data).

Start address	Size	Channel	Description
0	10	4	Background
10	10	4	Calibration
20	504	4	Lag profiles (short)
524	32128	4	Lag profiles
32652	380	4	Power profile
33032	19050	4	Lag profiles (D short)
52082	2250	4	Lag profiles (D long)
54332	150	4	Coherent profile (D)
54482	504	4	Lag profiles (short F)
54986	32128	4	Lag profiles (F)
87114			
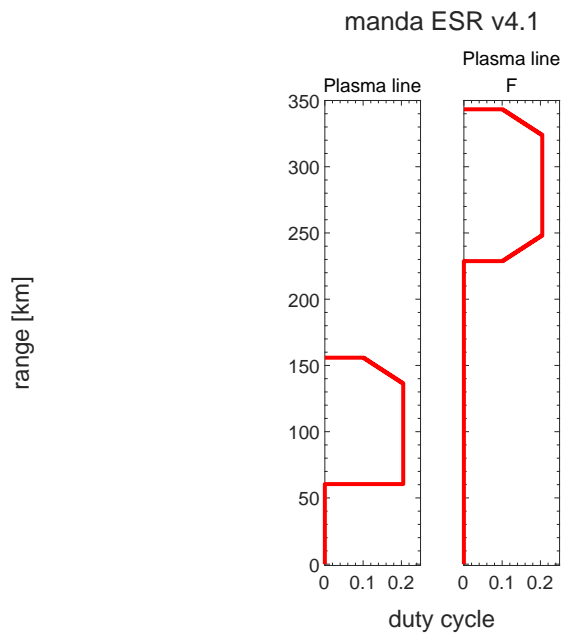
Range coverage for the most relevant data obtained by manda ESR plasma line receiver.

Channel setup for manda ESR plasma line receiver.

Channel	Description
1	Plasma line data (−6.4 MHz)
2	Plasma line data (−4.0 MHz)
4	Plasma line data (+4.0 MHz)
5	Plasma line data (+6.4 MHz)

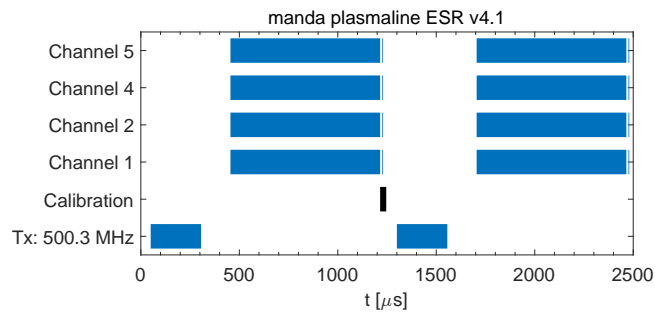Illustration of timing for transmission and the receiver channels for manda ESR plasma line receiver.

Layout of the `d_raw` vector for manda ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for manda ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	1600	1	Lag profiles (short)
1620	50880	1	Lag profiles
52500	20	1	Lag profiles (undecoded)
52520	1900	1	Power profile
54420	1920	1	Lag profiles (short F)
56340	61120	1	Lag profiles (F)
117460	10	2	Background
117470	10	2	Calibration
117480	1600	2	Lag profiles (short)
119080	50880	2	Lag profiles
169960	20	2	Lag profiles (undecoded)
169980	1900	2	Power profile
171880	1920	2	Lag profiles (short F)
173000	61120	2	Lag profiles (F)
234920	10	4	Background
234930	10	4	Calibration
234940	1600	4	Lag profiles (short)
236540	50880	4	Lag profiles
287420	20	4	Lag profiles (undecoded)
287440	1900	4	Power profile
289340	1920	4	Lag profiles (short F)
291260	61120	4	Lag profiles (F)
352380	10	5	Background
352390	10	5	Calibration
352400	1600	5	Lag profiles (short)
354000	50880	5	Lag profiles
404880	20	5	Lag profiles (undecoded)
404900	1900	5	Power profile
406800	1920	5	Lag profiles (short F)
408720	61120	5	Lag profiles (F)
469840			

3.3.4 othia

Version	1.0
Antenna	Single / Dual
Raw data available	No
Plasma line	Yes
Transmitter frequency	498.75 MHz, 499.75 MHz and 500.75 MHz
Integration time	4.5 s
Duty cycle	0.24
Code	Single pulse and alternating
Length of code	1 bit and 3 bit
Baud length	450 μs
Subcycle length	7500 μs
Number of subcycles	12
Number of loops	50
Sampling	6 μs (0.4 μs plasma line)

Ion line   Single pulse

Time resolution	4.5 s
Ranges covered	282.6 km to 1069.2 km
Range gate size	68.4 km
Range gate step	0.9 km
Spectral range	±83.333 kHz
Spectral resolution	1.1261 kHz
Lag step	6 μs
Maximum lag	74 (444 μs)

Ion line

Time resolution	4.5 s
Ranges covered	81.0 km to 866.7 km
Range gate size	68.4 km
Range gate step	0.9 km
Spectral range	±83.333 kHz
Spectral resolution	0.559 28 kHz
Lag step	6 μs
Maximum lag	149 (894 μs)

Ion line   Top end

Time resolution	4.5 s
Ranges covered	833.4 km to 900.9 km
Range gate size	135.0 km
Range gate step	67.5 km
Spectral range	±83.333 kHz
Spectral resolution	1.1261 kHz
Lag step	6 μs
Maximum lag	74 (444 μs)

Plasma line   Two down-shifted and two up-shifted frequency ranges

Time resolution	4.5 s
Ranges covered	250.83 km to 458.19 km
Range gate size	409.86 km
Range gate step	207.36 km
Spectral range	±1.25 MHz
Spectral resolution	1.1121 kHz
Lag step	0.4 µs
Maximum lag	1124 (449.6 µs)
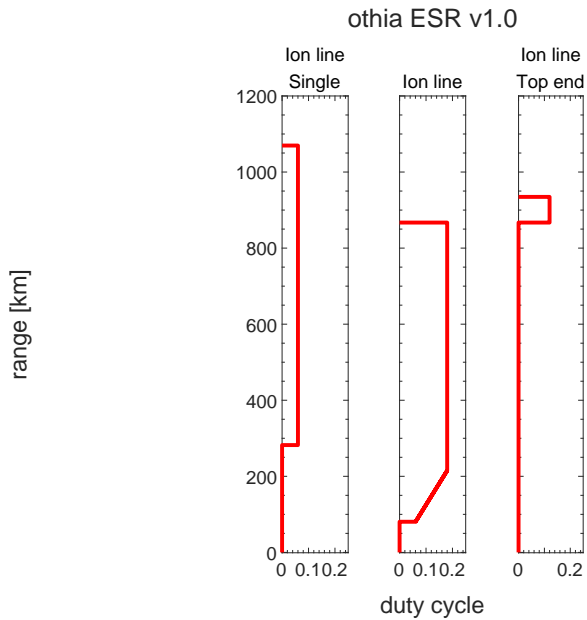
othia ESR v1.0

Range coverage for the most relevant data obtained by othia ESR.

Channel setup for othia ESR. Channels 4, 5 and 6 are only used when the fixed42p scan is applied. In that case channels 1, 2 and 3 are for the 42 m antenna and channels 4, 5 and 6 for the 32 m antenna.

Channel	Description
1	Ion line data, single pulse
2	Ion line data
3	Gain
4	*Ion line data, single pulse*
5	*Ion line data*
6	*Gain*

Layout of the `d_raw` vector for othia ESR (level 1 data).

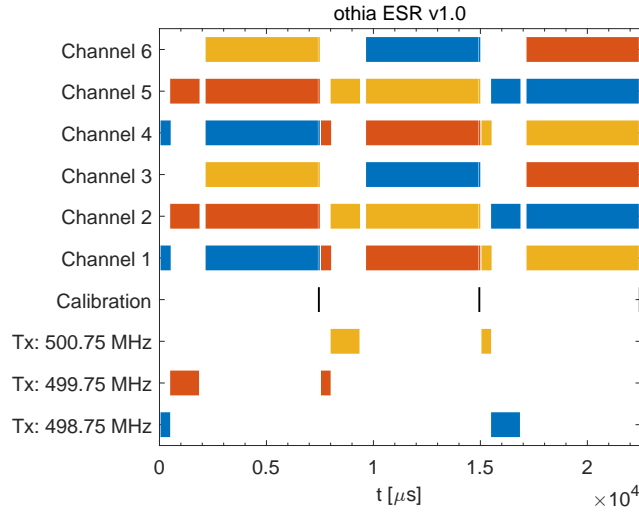| Start address	Size	Channel	Description
0	948	1	Transmitter samples
948	2748	2	Transmitter samples
3696	*948*	*4*	*Transmitter samples*
4644	*2748*	*5*	*Transmitter samples*
7392			

Illustration of timing for transmission and the receiver channels for othia ESR.

Layout of the `d_data` vector for othia ESR (level 2 data).

Start address	Size	Channel	Description
0	12	1	Calibration
12	875	1	Power profile
887	61975	1	Lag profiles
62862	12	2	Calibration
62874	875	2	Power profile
63749	61975	2	Lag profiles
125724	175625	2	Lag profiles
301349	150	2	Lag profiles, top end (short)
301499	120	2	Lag profiles, top end
301619	12	3	Calibration
301631	875	3	Power profile
302506	61975	3	Lag profiles
364481	12	4	Calibration
364493	875	4	Power profile
365368	61975	4	Lag profiles
427343	12	5	Calibration
427355	875	5	Power profile
428230	61975	5	Lag profiles
490205	175625	5	Lag profiles
665830	150	5	Lag profiles, top end (short)
665980	120	5	Lag profiles, top end
666100	12	6	Calibration
666112	875	6	Power profile
666987	61975	6	Lag profiles
728962			
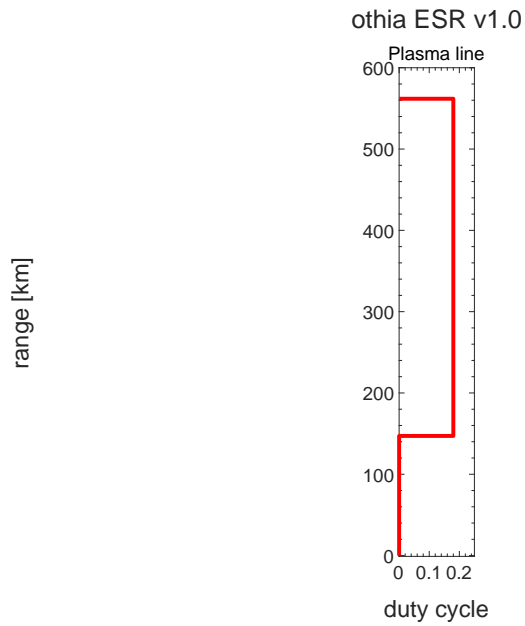
othia ESR v1.0

Range coverage for the most relevant data obtained by othia ESR plasma line receiver.

Channel setup for othia ESR plasma line receiver. In case of fixed42p scan, the 42 m antenna is used. Otherwise it is the single antenna of choice.

Channel	Description
1	Plasma line data (−3.6 MHz)
2	Plasma line data (−6.0 MHz)
4	Plasma line data (+3.6 MHz)
5	Plasma line data (+6.0 MHz)

Illustration of timing for transmission and the receiver channels for othia ESR plasma line receiver.

Layout of the `d_raw` vector for othia ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for othia ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	12	1	Calibration
12	2250	1	Lag profiles (undecoded)
2262	12	2	Calibration
2274	2250	2	Lag profiles (undecoded)
4524	12	4	Calibration
4536	2250	4	Lag profiles (undecoded)
6786	12	5	Calibration
6798	2250	5	Lag profiles (undecoded)
9048			

3.3.5 tyko

Version	1.0
Antenna	Single
Raw data available	No / Yes (with fixed42p scan)
Plasma line	Yes
Transmitter frequency	499.9 MHz
Integration time	4.0 s
Duty cycle	0.16
Code	Alternating
Length of code	16 bit
Baud length	50 µs
Subcycle length	5000 µs
Number of subcycles	32
Number of loops	25
Sampling	25 µs (0.4 µs plasma line)

Ion line

Time resolution	4.0 s
Ranges covered	37.425 km to 569.92 km
Range gate size	11.25 km
Range gate step	3.75 km
Spectral range	±20.0 kHz
Spectral resolution	0.645 16 kHz
Lag step	25 µs
Maximum lag	31 (775 µs)

Ion line   Top end

Time resolution	4.0 s
Ranges covered	575.55 km to 673.05 km
Range gate size	15 km
Range gate step	7.5 km
Spectral range	±20.0 kHz
Spectral resolution	1.25 kHz
Lag step	25 µs
Maximum lag	16 (400 µs)

Plasma line   Two down-shifted and two up-shifted frequency ranges

Time resolution	4.0 s
Ranges covered	118.77 km to 364.53 km
Range gate size	181.44 km
Range gate step	61.44 km
Spectral range	±1.25 MHz
Spectral resolution	10.081 kHz
Lag step	0.4 µs
Maximum lag	124 (49.6 µs)

tyko ESR v1.0
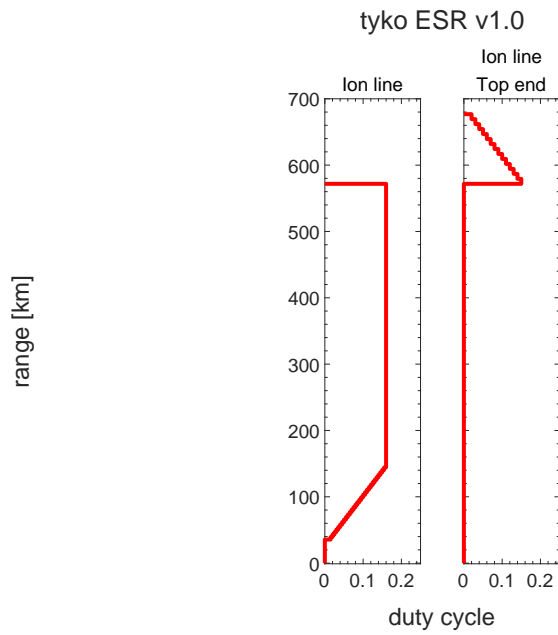
Range coverage for the most relevant data obtained by tyko ESR.

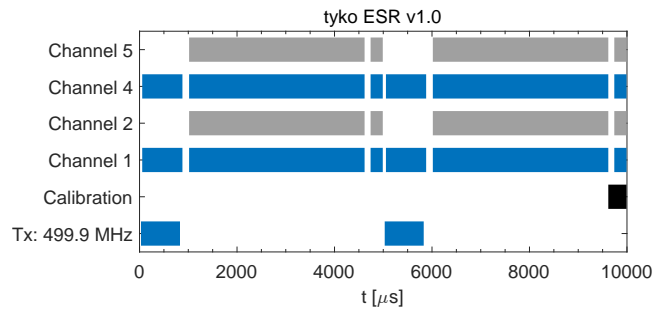Illustration of timing for transmission and the receiver channels for tyko ESR.

Channel setup for tyko ESR. Channels 4 and 5 are only used when the fixed42p scan is applied. In that case channels 1 and 2 are for the 42 m antenna and channels 4 and 5 for the 32 m antenna.
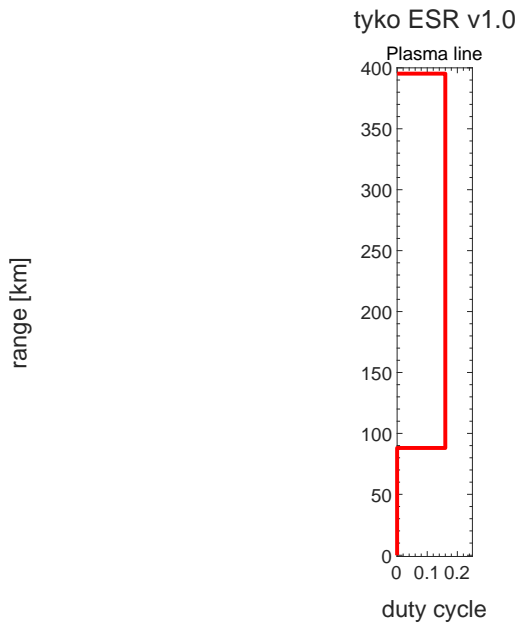
Channel	Description
1	Ion line data
2	Gain
4	*Ion line data*
5	*Gain*

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Layout of the `d_raw` vector for tyko ESR (level 1 data).

Start address	Size	Channel	Description
0	1056	1	Transmitter samples
1056	*115200*	*1*	*Raw data time series*
116256	*1056*	*4*	*Transmitter samples*
117312	*115200*	*4*	*Raw data time series*
232512			

Layout of the `d_data` vector for tyko ESR (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	10	1	FFT
30	144	1	Power profile
174	5760	1	Lag profiles
5934	30	1	Lag profiles, top end (short)
5964	224	1	Lag profiles, top end
6188	10	2	Background
6198	10	2	Calibration
6208	144	2	Power profile
6352	*10*	*4*	*Background*
6362	*10*	*4*	*Calibration*
6372	*10*	*4*	*FFT*
6382	*144*	*4*	*Power profile*
6526	*5760*	*4*	*Lag profiles*
12286	*30*	*4*	*Lag profiles, top end (short)*
12316	*224*	*4*	*Lag profiles, top end*
12540	*10*	*5*	*Background*
12550	*10*	*5*	*Calibration*
12560	*144*	*5*	*Power profile*
12704			

Range coverage for the most relevant data obtained by tyko ESR plasma line receiver.
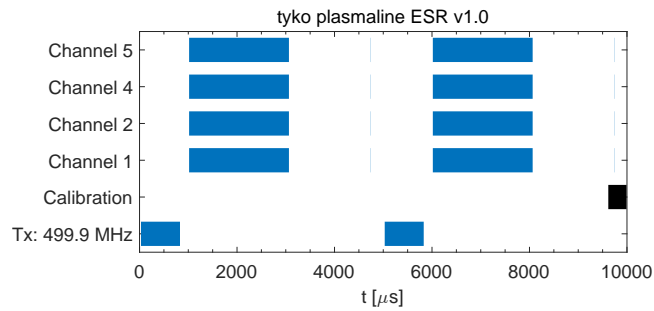
Illustration of timing for transmission and the receiver channels for tyko ESR plasma line receiver.

Channel setup for tyko ESR plasma line receiver.

Channel	Description
1	Plasma line data (−4.2 MHz)
2	Plasma line data (−6.6 MHz)
4	Plasma line data (+4.2 MHz)
5	Plasma line data (+6.6 MHz)

Layout of the `d_raw` vector for tyko ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
	0		

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Layout of the `d_data` vector for tyko ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	625	1	Lag profiles (undecoded)
645	10	2	Background
655	10	2	Calibration
665	625	2	Lag profiles (undecoded)
1290	10	3	Background
1300	10	3	Calibration
1310	625	3	Lag profiles (undecoded)
1935	10	4	Background
1945	10	4	Calibration
1955	625	4	Lag profiles (undecoded)
2580			

4 Other supported experiments

4.1 UHF

4.1.1 arc1

Version	1.0
Raw data available	No
Plasma line	No
Transmitter frequency	927.5 MHz
Integration time	4.0 s
Duty cycle	0.11073
Code	Alternating
Length of code	64 bit
Baud length	6 µs
Subcycle length	3468 µs
Number of subcycles	128
Number of loops	9
Sampling	6 µs

Ion line

Time resolution	0.4439 s
Ranges covered	95.7 km to 421.5 km
Range gate size	1.8 km
Range gate step	0.9 km
Spectral range	±20.833 kHz
Spectral resolution	1.3889 kHz
Lag step	24 µs
Maximum lag	15 (360 µs)

arc1 UHF v1.0
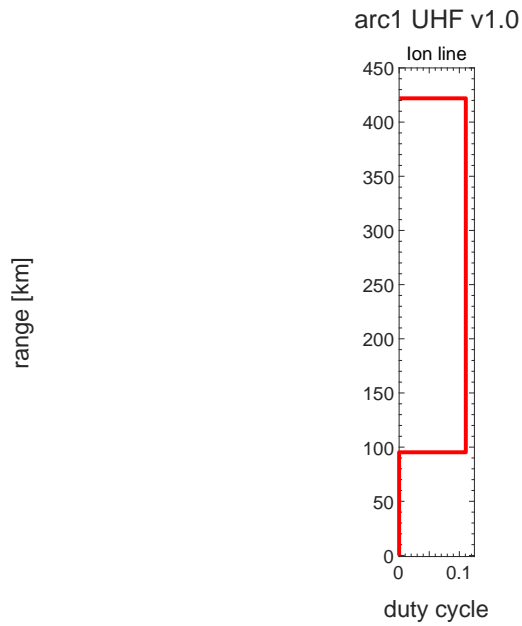
Range coverage for the most relevant data obtained by arc1 UHF.

Illustration of timing for transmission and the receiver channels for arc1 UHF.

Channel setup for arc1 UHF.

Channel	Description
1	Ion line data
2	Calibration

Layout of the `d_raw` vector for arc1 UHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for arc1 UHF (level 2 data).

Start address	Size	Channel	Description
0	3834	1	9 slices, power profile)
3834	52272	1	9 slices, lag profiles
56106	20	2	Background
56126	20	2	Calibration
56146			

66

4.1.2 lace

Version	1.1
Raw data available	Yes
Plasma line	Yes
Transmitter frequency	927.5 MHz
Integration time	4.6 s
Duty cycle	0.11398
Code	Alternating
Length of code	256 bit
Baud length	2 µs
Subcycle length	4492 µs
Number of subcycles	512
Number of loops	2
Sampling	2 µs (0.666 67 µs plasma line)

Ion line

Time resolution	4.6 s
Ranges covered	46.65 km to 579.45 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±250 kHz
Spectral resolution	0.976 56 kHz
Lag step	2 µs
Maximum lag	256 (512 µs)

Plasma line   One down-shifted frequency range

Time resolution	5.0 s
Ranges covered	95.25 km to 695.25 km
Range gate size	6.0 km
Range gate step	3.0 km
Spectral range	±1.875 MHz
Spectral resolution	1.4648 kHz
Lag step	0.266 67 µs
Maximum lag	1280 (341.33 µs)

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lace UHF v1.1
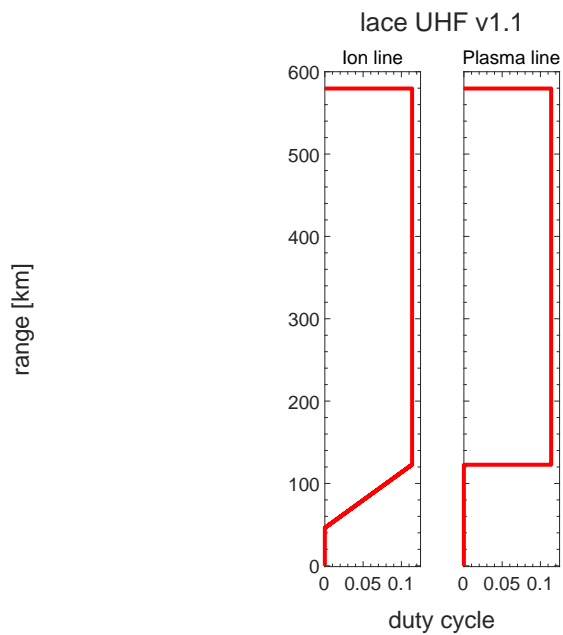
Range coverage for the most relevant data obtained by lace UHF.
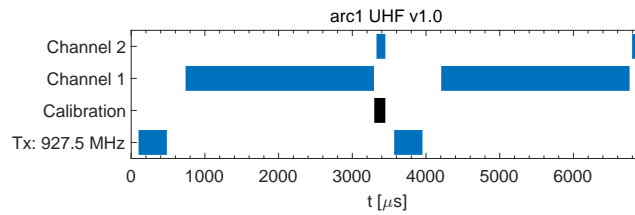

Illustration of timing for transmission and the receiver channels for lace UHF.

Channel setup for lace UHF.

Channel	Description
1	Ion line data
2	Gain
4	Plasma line data (−3.85 MHz)
5	Plasma line data (−3.85 MHz), ion line time resolution

Layout of the `d_raw` vector for lace UHF (level 1 data).

Start address	Size	Channel	Description
0	133120	1	Transmitter samples
133120	1820672	1	Raw data time series
1953792	1820672	5	Raw data time series
3774464			

Layout of the `d_data` vector for lace UHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	1778	1	Lag profiles (short)
1826	454912	1	Lag profiles
456738	1778	1	Power profile
458516	16	2	Background
458532	16	2	Calibration
458548	1778	2	Power profile
460326	16	4	Background
460342	16	4	Calibration
460358	4572	4	Lag profiles (short)
464930	584832	4	Lag profiles
1049762	5334	4	Power profile
1055096	16	5	Background
1055112	16	5	Calibration
1055128			

4.1.3 leo

Version	2.1
Raw data available	Yes
Plasma line	No
Transmitter frequency	927.2 MHz
Integration time	12.8 s
Duty cycle	0.096
Code	Alternating
Length of code	64 bit
Baud length	30 µs
Subcycle length	20 000 µs
Number of subcycles	128
Number of loops	5
Sampling	1 µs

Power profile

Time resolution	12.8 s
Ranges covered	2843.8 km to 5843.6 km
Range gate size	288.15 km
Range gate step	0.15 km
Spectral range	0 kHz
Spectral resolution	0 kHz
Lag step	0 µs
Maximum lag	0 (0 µs)

leo UHF v2.1

Power profile

Range coverage for the most relevant data obtained by leo UHF.

Illustration of timing for transmission and the receiver channels for leo UHF.

Channel setup for leo UHF.

Channel	Description
4	Signal

Layout of the `d_raw` vector for leo UHF (level 1 data).

Start address	Size	Channel	Description
0	12800000	4	Raw data time series
12800000			

Layout of the `d_data` vector for leo UHF (level 2 data).

Start address	Size	Channel	Description
0	20000	4	Power profile
20000			

4.1.4 tau1

Version   1.3
Raw data available   Yes
Plasma line   No
Transmitter frequency   929.3 MHz and 929.6 MHz
Integration time   5.0 s
Duty cycle   0.086022
Code   Alternating
Length of code   16 bit
Baud length   60 µs
Subcycle length   22 320 µs
Number of subcycles   32
Number of loops   7
Sampling   12 µs

Ion line

Time resolution   5.0 s
Ranges covered   52.95 km to 1359.8 km
Range gate size   10.8 km
Range gate step   1.8 km
Spectral range   ±41.667 kHz
Spectral resolution   1.4368 kHz
Lag step   12 µs
Maximum lag   29 (348 µs)

tau1 UHF v1.3
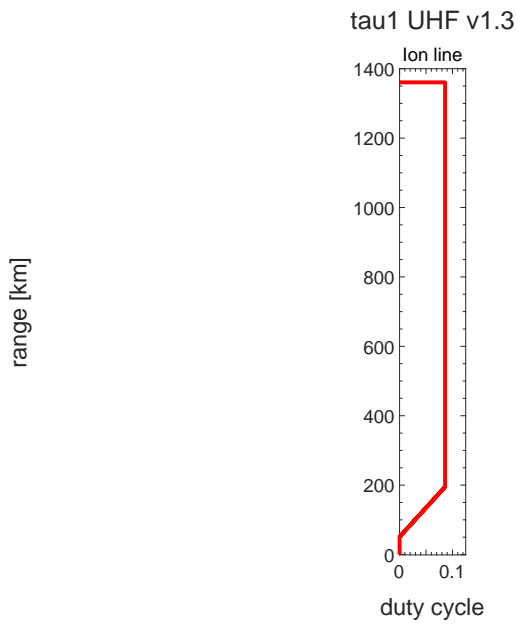
Range coverage for the most relevant data obtained by tau1 UHF.
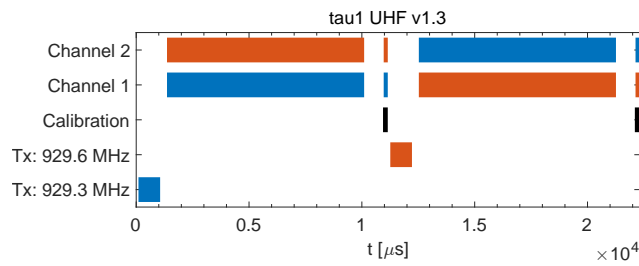
Illustration of timing for transmission and the receiver channels for tau1 UHF.

Channel setup for tau1 UHF.

Channel	Description
1	Ion line data
2	Gain

Layout of the `d_raw` vector for tau1 UHF (level 1 data).

Start address	Size	Channel	Description
0	326144	1	Raw data time series
326144			

Layout of the `d_data` vector for tau1 UHF (level 2 data).

Start address	Size	Channel	Description
0	728	1	Power profile (929.3 MHz)
728	728	1	Power profile (929.6 MHz)
1456	34887	1	Lag profiles
36343	15	1	Calibration
36358	728	2	Power profile
37086	15	2	Calibration
37101			

4.2 VHF

4.2.1 arc_dlayer

Version	1.11
Raw data available	No
Plasma line	No
Transmitter frequency	224.2 MHz
Integration time	5.0 s
Duty cycle	0.095097
Code	Alternating
Length of code	64 bit
Baud length	2 µs
Subcycle length	1346 µs
Number of subcycles	128
Number of loops	29
Sampling	2 µs

Ion line D region

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±371.47 Hz
Spectral resolution	2.925 Hz
Lag step	1.346 ms
Maximum lag	127 (170.942 ms)

Ion line E region

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±15.625 kHz
Spectral resolution	5.208 kHz
Lag step	32 µs
Maximum lag	3 (96 µs)

Ion line D region, longer lags (Here the max lag is uncertain)

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±2.9021 Hz
Spectral resolution	0.103 647 Hz
Lag step	172.288 ms
Maximum lag	28 (4.824 s)

arc_dlayer VHF v1.11

Range coverage for the most relevant data obtained by arc_dlayer VHF.

Illustration of timing for transmission and the receiver channels for arc_dlayer VHF.

Channel setup for arc_dlayer VHF.

Channel	Description
1	Ion line data
2	Calibration

Layout of the `d_raw` vector for arc_dlayer VHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for arc_dlayer VHF (level 2 data).

Start address	Size	Channel	Description
0	45	2	Background
45	45	2	Calibration
90	330	1	Power profile
420	34176	1	Lag profiles (D)
34596	1068	1	Lag profiles (E)
35664	7743	1	Lag profiles (D, longer)
43407			

4.2.2 lace

Version	1.0
Raw data available	Yes
Plasma line	Yes
Transmitter frequency	223.6 MHz
Integration time	6.3 s
Duty cycle	0.11816
Code	Alternating
Length of code	242 bit
Baud length	3 µs
Subcycle length	6144 µs
Number of subcycles	512
Number of loops	2
Sampling	3 µs (1 µs plasma line)

Ion line

Time resolution	6.3 s
Ranges covered	47.1 km to 791.85 km
Range gate size	0.9 km
Range gate step	0.45 km
Spectral range	±166.67 kHz
Spectral resolution	0.7716 kHz
Lag step	3 µs
Maximum lag	216 (648 µs)

Plasma line

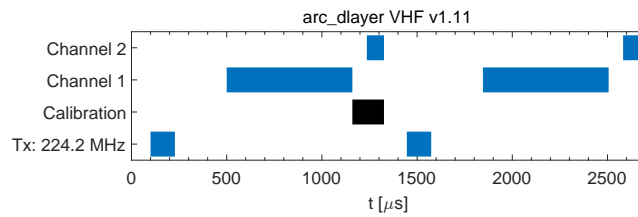|	
Time resolution	6.3 s
Ranges covered	110.1 km to 791.85 km
Range gate size	0.9 km
Range gate step	0.45 km
Spectral range	±0.5 MHz
Spectral resolution	1.3021 kHz
Lag step	1 µs
Maximum lag	384 (384 µs)
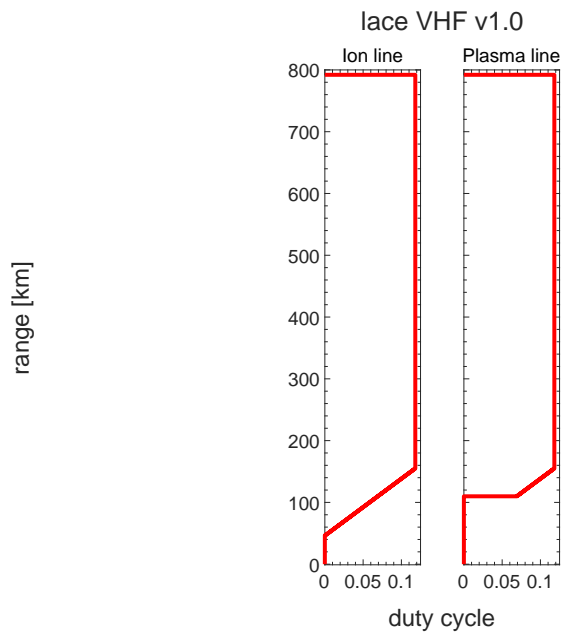
Range coverage for the most relevant data obtained by lace VHF.
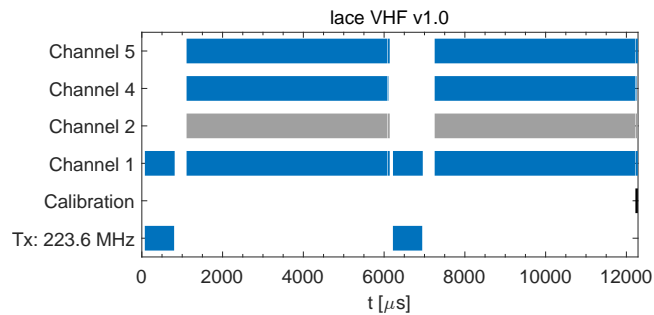
Illustration of timing for transmission and the receiver channels for lace VHF.

Channel setup for lace VHF.

Channel	Description
1	Ion line data
2	Gain
4	Plasma line data ($-4.15\,\mathrm{MHz}$)
5	Plasma line data ($-4.15\,\mathrm{MHz}$), ion line time resolution

Layout of the `d_raw` vector for lace VHF (level 1 data).

Start address	Size	Channel	Description
0	125952	1	Transmitter samples
125952	1696768	1	Raw data time series
1822720	1696768	5	Raw data time series
3519488			

Layout of the `d_data` vector for lace VHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	1657	1	Lag profiles (short)
1705	357696	1	Lag profiles
359401	1657	1	Power profile
361058	16	2	Background
361074	16	2	Calibration
361090	1657	2	Power profile
362747	16	4	Background
362763	16	4	Calibration
361779	4551	4	Lag profiles (short)
367330	582144	4	Lag profiles
949474	4971	4	Power profile
954445	16	5	Background
954461	16	5	Calibration
954477			

4.2.3   leo

Version	2.3
Raw data available	Yes
Plasma line	No
Transmitter frequency	223.6 MHz
Integration time	12.8 s
Duty cycle	0.096
Code	Alternating
Length of code	64 bit
Baud length	30 µs
Subcycle length	20 000 µs
Number of subcycles	128
Number of loops	5
Sampling	1 µs

Power profile   Two signals, one per antenna half

Time resolution	12.8 s
Ranges covered	2843.8 km to 5843.6 km
Range gate size	288.15 km
Range gate step	0.15 km
Spectral range	0 kHz
Spectral resolution	0 kHz
Lag step	0 µs
Maximum lag	0 (0 µs)

leo VHF v2.3

Power profile
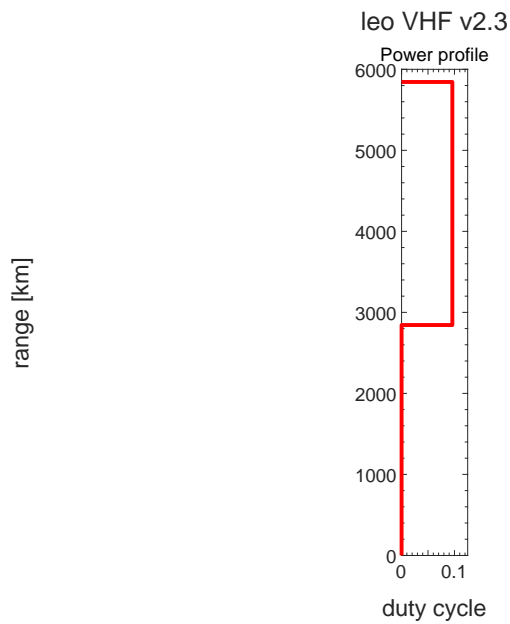
Range coverage for the most relevant data obtained by leo VHF.
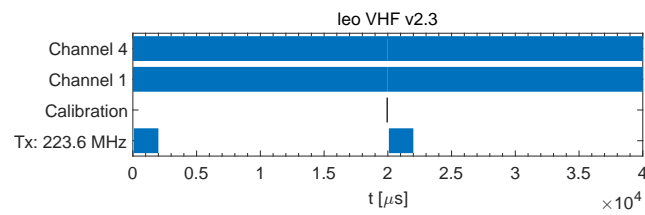
Illustration of timing for transmission and the receiver channels for leo VHF.

Channel setup for leo VHF.

Channel	Description
1	Signal, antenna half 1
4	Signal, antenna half 2

Layout of the `d_raw` vector for leo VHF (level 1 data).

Start address	Size	Channel	Description
0	12800000	1	Raw data time samples
12800000	12800000	4	Raw data time samples
25600000			

Layout of the `d_data` vector for leo VHF (level 2 data).

Start address	Size	Channel	Description
0	20000	1	Power profile
20000	20000	4	Power profile
40000			

4.2.4 tau7

Version	2.0
Raw data available	No
Plasma line	Yes
Transmitter frequency	223.6 MHz
Integration time	3.6 s
Duty cycle	0.11951
Code	Alternating
Length of code	16 bit
Baud length	120 µs
Subcycle length	16 065 µs
Number of subcycles	32
Number of loops	7
Sampling	15 µs (0.6 µs plasma line)

Ion line   Two signals, one per antenna half

Time resolution	3.6 s
Ranges covered	80.55 km to 2060.5 km
Range gate size	36 km
Range gate step	18 km
Spectral range	±33.333 kHz
Spectral resolution	0.260 42 kHz
Lag step	15 µs
Maximum lag	128 (1920 µs)

Plasma line   Two down-shifted frequency ranges, one per antenna half

Time resolution	3.6 s
Ranges covered	257.67 km to 810.63 km
Range gate size	426.24 km
Range gate step	138.24 km
Spectral range	±0.833 33 MHz
Spectral resolution	4.1876 kHz
Lag step	0.6 µs
Maximum lag	199 (119.4 µs)

tau7 VHF v2.0
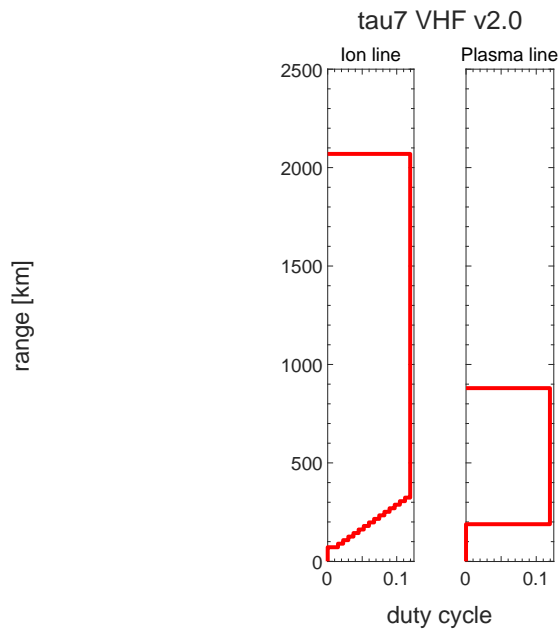
Range coverage for the most relevant data obtained by tau7 VHF.

Channel setup for tau7 VHF.

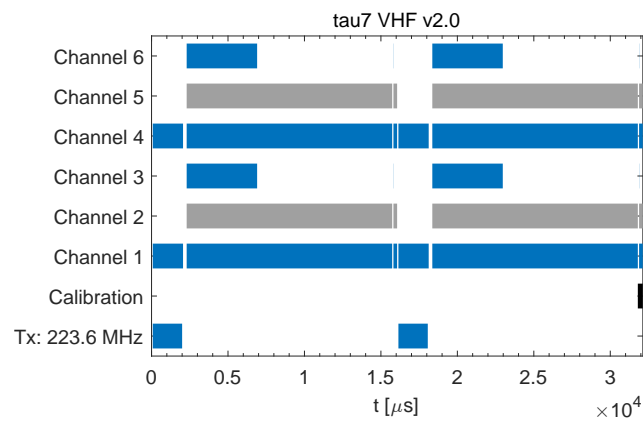| Channel	Description
1	Ion line data, antenna half 1
2	Gain, antenna half 1
3	Plasma line data, antenna half 1 (−5.2 MHz)
4	Ion line data, antenna half 2
5	Gain, antenna half 2
6	Plasma line data, antenna half 2 (−3.6 MHz)

Illustration of timing for transmission and the receiver channels for tau7 VHF.

Layout of the `d_raw` vector for tau7 VHF (level 1 data).

Start address	Size	Channel	Description
0	4224	1	Transmitter samples
4224	4224	4	Transmitter samples
8448			

Layout of the `d_data` vector for tau7 VHF (level 2 data).

Start address	Size	Channel	Description
0	16	1	Background
16	16	1	Calibration
32	16	1	FFT
48	896	1	Lag profiles (short)
944	14208	1	Lag profiles
15152	896	1	Power profile
16048	16	2	Background
16064	16	2	Calibration
16080	896	2	Power profile
16976	16	3	Background
16992	16	3	Calibration
17008	7680	3	Power profile
24688	1000	3	Lag profiles (undecoded)
25688	16	4	Background
25704	16	4	Calibration
25720	16	4	FFT
25736	896	4	Lag profiles (short)
26632	14208	4	Lag profiles
40840	896	4	Power profile
41736	16	5	Background
41752	16	5	Calibration
41768	896	5	Power profile
42664	16	6	Background
42680	16	6	Calibration
42696	7680	6	Power profile
50376	1000	6	Lag profiles (undecoded)
51376			

85

4.2.5 tau8

Version	1.0
Raw data available	No
Plasma line	Yes
Transmitter frequency	223.4 MHz and 223.6 MHz
Integration time	5.0 s
Duty cycle	0.12045
Code	Alternating
Length of code	16 bit
Baud length	84 μs
Subcycle length	11 158 μs
Number of subcycles	64
Number of loops	7
Sampling	14 μs (0.6 μs plasma line)

Ion line Two signals, one per antenna half

Time resolution	5.0 s
Ranges covered	59.85 km to 1315.7 km
Range gate size	14.7 km
Range gate step	2.1 km
Spectral range	±35.714 kHz
Spectral resolution	0.759 88 kHz
Lag step	14 μs
Maximum lag	47 (658 μs)

Plasma line One up-shifted frequency range, two signals, one per antenna half, spectral domain only

Time resolution	5.0 s
Ranges covered	159.96 km to 579.96 km
Range gate size	213.12 km
Range gate step	139.95 km
Spectral range	±0.833 33 MHz
Spectral resolution	13.0 kHz
Lag step	0 μs
Maximum lag	0 (0 μs)
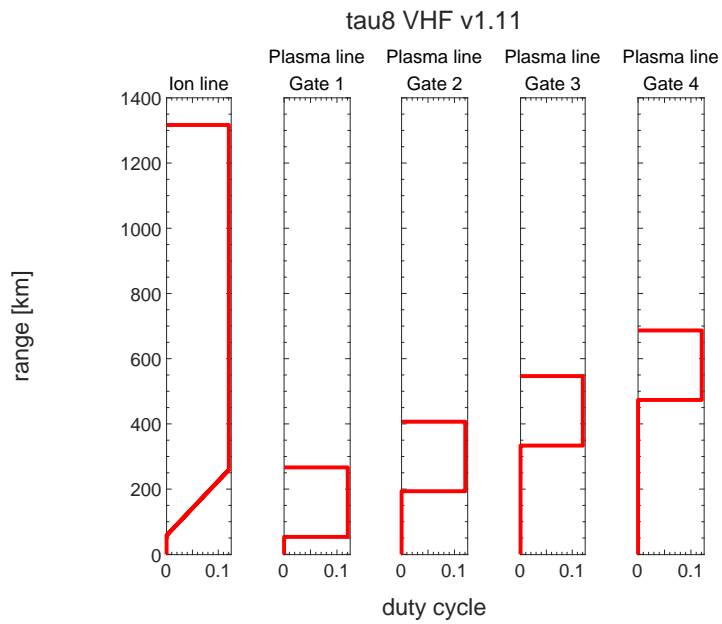
Range coverage for the most relevant data obtained by tau8 VHF.

Channel setup for tau8 VHF.

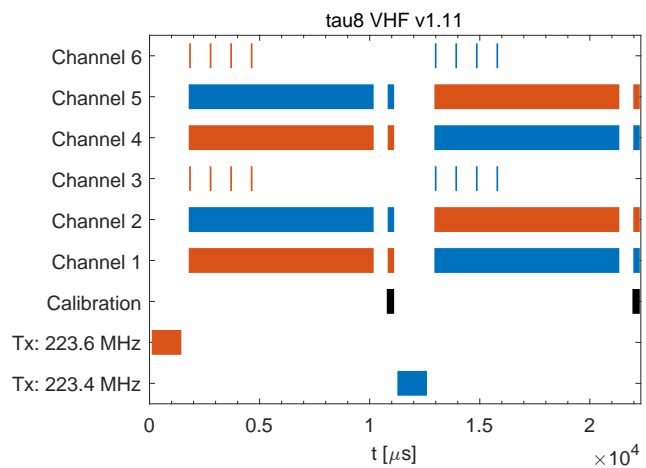| Channel	Description
1	Ion line data, antenna half 1
2	Gain, antenna half 1
3	Plasma line data, antenna half 1 (+4.1 MHz)
4	Ion line data, antenna half 2
5	Gain, antenna half 2
6	Plasma line data, antenna half 2 (+4.1 MHz)

Illustration of timing for transmission and the receiver channels for tau8 VHF.

Layout of the `d_raw` vector for tau8 VHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for tau8 VHF (level 2 data).

Start address	Size	Channel	Description
0	600	1	Power profile
600	2985	1	Lag profiles (undecoded)
3585	47127	1	Lag profiles
50712	21	1	Calibration
50733	600	2	Power profile
51333	2985	2	Lag profiles (undecoded)
54318	21	2	Calibration
54339	600	4	Power profile
54939	2985	4	Lag profiles (undecoded)
57924	47127	4	Lag profiles
105051	21	4	Calibration
105072	600	5	Power profile
105672	2985	5	Lag profiles (undecoded)
108657	21	5	Calibration
108678	128	3	FFT (range 1)
108806	128	3	FFT (range 2)
108934	128	3	FFT (range 3)
109062	128	3	FFT (range 4)
109190	128	6	FFT (range 1)
109318	128	6	FFT (range 2)
109446	128	6	FFT (range 3)
109574	128	6	FFT (range 4)
109702			

4.3 ESR

4.3.1 arc_slice

Version	1.1
Antenna	Single
Raw data available	No
Plasma line	No
Transmitter frequency	500.95 MHz
Integration time	5.0 s
Duty cycle	0.09831
Code	Alternating
Length of code	64 bit
Baud length	6 μs
Subcycle length	3906 μs
Number of subcycles	128
Number of loops	10
Sampling	6 μs

Ion line Slices

Time resolution	0.499 97 s
Ranges covered	85.5 km to 482.4 km
Range gate size	1.8 km
Range gate step	0.9 km
Spectral range	±20.833 kHz
Spectral resolution	1.3889 kHz
Lag step	24 μs
Maximum lag	15 (360 μs)

arc_slice ESR v1.1
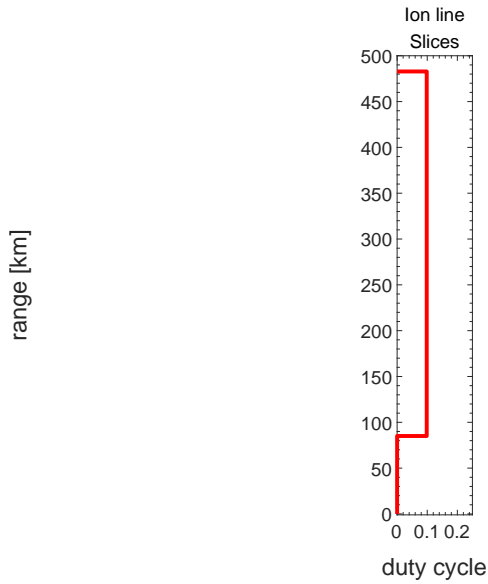
Ion line
Slices

Range coverage for the most relevant data obtained by arc_slice ESR.
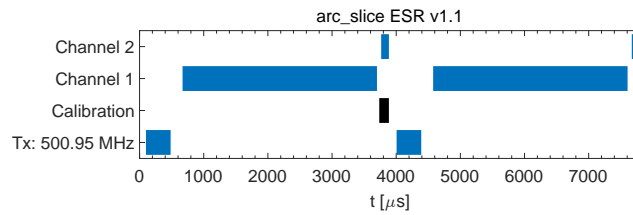
arc_slice ESR v1.1

Illustration of timing for transmission and the receiver channels for arc_slice ESR.

Channel setup for arc_slice ESR.

Channel	Description
1	Ion line data
2	Calibration

Layout of the `d_raw` vector for arc_slice ESR (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for arc_slice ESR (level 2 data).

Start address	Size	Channel	Description
0	5050	1	10 power profiles
5050	70720	1	10 slices
75770	20	2	Background
75790	20	2	Calibration
75810			

4.3.2   beata

Version	1.0
Antenna	Single
Raw data available	No / Yes (with fixed42p scan)
Plasma line	Yes
Transmitter frequency	500.3 MHz
Integration time	6.0 s
Duty cycle	0.24
Code	Alternating
Length of code	30 bit
Baud length	50 µs
Subcycle length	6250 µs
Number of subcycles	64
Number of loops	15
Sampling	25 µs (0.4 µs plasma line)

Ion line

Time resolution	6.0 s
Ranges covered	50.925 km to 650.92 km
Range gate size	11.25 km
Range gate step	3.75 km
Spectral range	±20 kHz
Spectral resolution	0.4878 kHz
Lag step	25 µs
Maximum lag	41 (1025 µs)

Ion line   Slices

Time resolution	0.4 s
Ranges covered	50.925 km to 650.92 km
Range gate size	11.25 km
Range gate step	3.75 km
Spectral range	±20 kHz
Spectral resolution	20 kHz
Lag step	25 µs
Maximum lag	1 (25 µs)

Plasma line   One down-shifted and one up-shifted frequency ranges

Time resolution	6.0 s
Ranges covered	154.05 km to 281.55 km
Range gate size	15 km
Range gate step	7.5 km
Spectral range	±1.25 MHz
Spectral resolution	0.610 35 kHz
Lag step	0.4 µs
Maximum lag	2048 (819.2 µs)
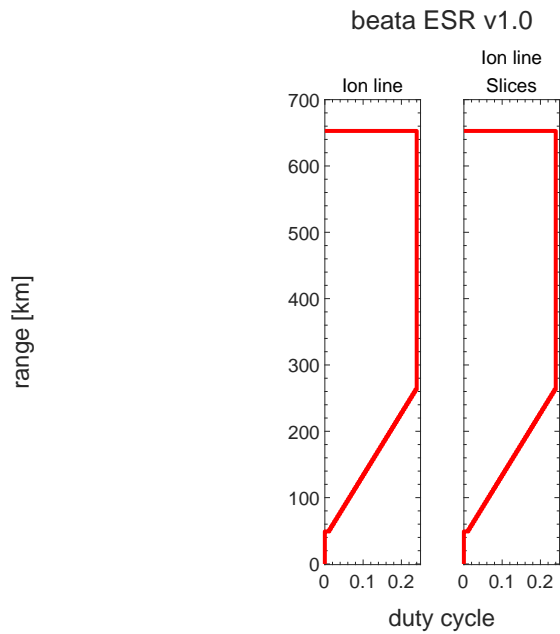
Range coverage for the most relevant data obtained by beata ESR.

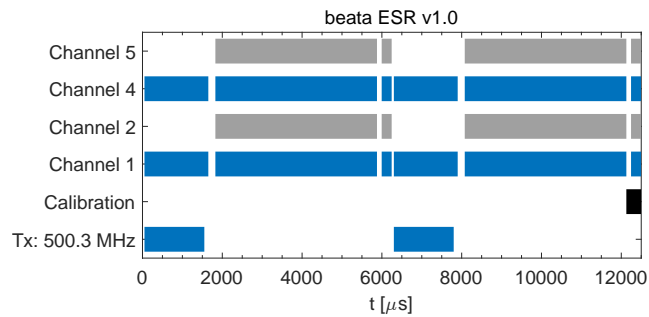Illustration of timing for transmission and the receiver channels for beata ESR.

Channel setup for beata ESR. Channels 4 and 5 are only used when the fixed42p scan is applied. In that case channels 1 and 2 are for the 42 m antenna and channels 4 and 5 for the 32 m antenna.
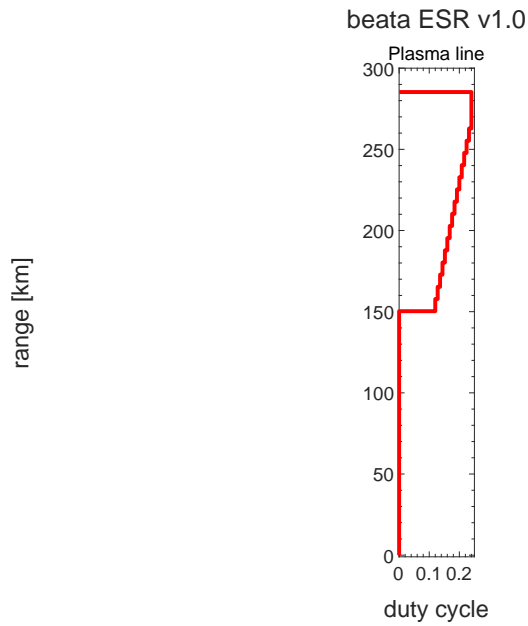
Channel	Description
1	Ion line data
2	Gain
4	*Ion line data*
5	*Gain*

Layout of the `d_raw` vector for beata ESR (level 1 data).

Start address	Size	Channel	Description
0	4096	1	Transmitter samples
4096	*155520*	*1*	*Raw data time series*
159616	*4096*	*4*	*Transmitter samples*
163712	*155520*	*4*	*Raw data time series*
319232			

Layout of the `d_data` vector for beata ESR (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	10	1	FFT
30	162	1	Power profile
192	8581	1	Lag profiles
8773	2415	1	15 slices
11188	10	2	Background
11198	10	2	Calibration
11208	162	2	Power profile
11370	*10*	*4*	*Background*
11380	*10*	*4*	*Calibration*
11390	*10*	*4*	*FFT*
11400	*162*	*4*	*Power profile*
11562	*8581*	*4*	*Lag profiles*
20143	*2415*	*4*	*15 slices*
22558	*10*	*5*	*Background*
22568	*10*	*5*	*Calibration*
22578	*162*	*5*	*Power profile*
22740			

beata ESR v1.0

Plasma line

Range coverage for the most relevant data obtained by beata ESR plasma line receiver.

Channel setup for beata ESR plasma line receiver. In case of fixed42p scan, the 32 m antenna is used. Otherwise it is the single antenna of choice.

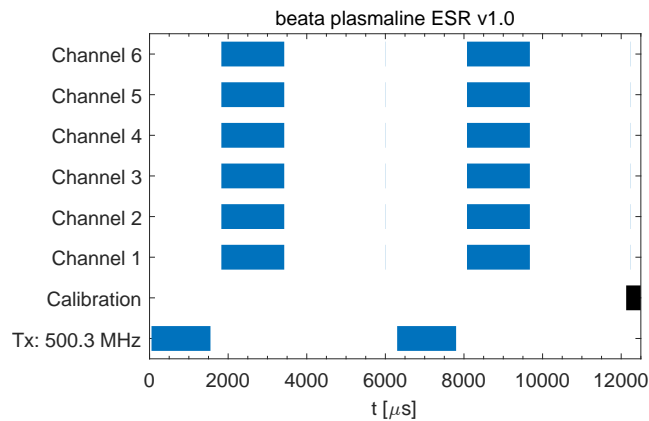| Channel	Description
1	No data stored
2	Plasma line data (−5.5 MHz)
3	No data stored
4	Plasma line data (+5.5 MHz)
5	No data stored
6	No data stored

Illustration of timing for transmission and the receiver channels for beata ESR plasma line receiver.

Layout of the `d_raw` vector for beata ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for beata ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	10	4	Background
10	10	4	Calibration
20	2375	4	Lag profiles (short)
2395	36864	4	Lag profiles
39259	250	4	Lag profiles (undecoded)
39509	4000	4	Power profile
43509	10	2	Background
43519	10	2	Calibration
43529	2375	2	Lag profiles (short)
45904	36864	2	Lag profiles
82768	250	2	Lag profiles (undecoded)
83018	4000	2	Power profile
87018			

4.3.3   hare

Version	2.1
Antenna	Single
Raw data available	No
Plasma line	No
Transmitter frequency	499.75 MHz and 500.25 MHz
Integration time	3.0 s
Duty cycle	0.04224
Code	Alternating
Length of code	3 bit
Baud length	660 μs
Subcycle length	46 875 μs
Number of subcycles	8
Number of loops	8
Sampling	5 μs

Ion line

Time resolution	3.0 s
Ranges covered	277.5 km to 6613.5 km
Range gate size	198 km
Range gate step	99 km
Spectral range	±100 kHz
Spectral resolution	0.5 kHz
Lag step	5 μs
Maximum lag	200 (1000 μs)

hare ESR v2.1
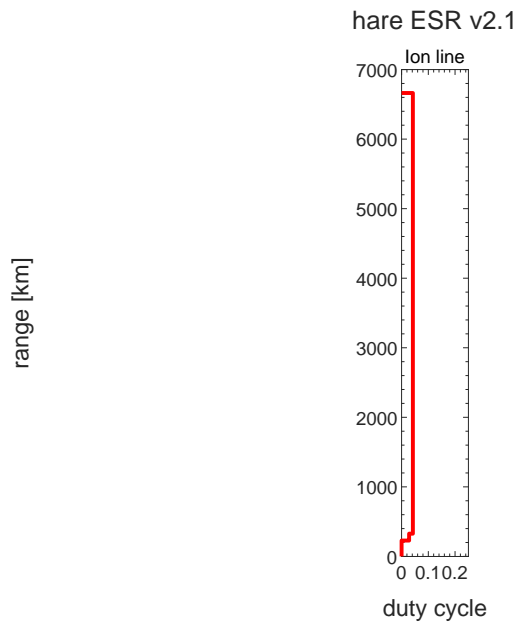
Range coverage for the most relevant data obtained by hare ESR.

Illustration of timing for transmission and the receiver channels for hare ESR.

Channel setup for hare ESR.

Channel	Description
1	Ion line data
2	Gain

Layout of the `d_raw` vector for hare ESR (level 1 data).

Start address	Size	Channel	Description
0	3176	1	Transmitter samples
3176			

Layout of the `d_data` vector for hare ESR (level 2 data).

Start address	Size	Channel	Description
0	8712	1	Lag profiles (short)
8712	13000	1	Lag profiles
21712	8712	1	Lag profiles (undecoded)
30424	8712	1	Power profile
39136	8712	2	Power profile
47848	134	2	Calibration
47982	1024	2	FFT
49006			

4.3.4   leo

Version	2.2
Antenna	Single
Raw data available	Yes
Plasma line	No
Transmitter frequency	500.5 MHz
Integration time	12.8 s
Duty cycle	0.096
Code	Alternating
Length of code	64 bit
Baud length	30 µs
Subcycle length	20 000 µs
Number of subcycles	128
Number of loops	5
Sampling	1 µs

Power profile

Time resolution	12.8 s
Ranges covered	2843.8 km to 5843.6 km
Range gate size	288.15 km
Range gate step	0.15 km
Spectral range	0 kHz
Spectral resolution	0 kHz
Lag step	0 µs
Maximum lag	0 (0 µs)

leo ESR v2.2
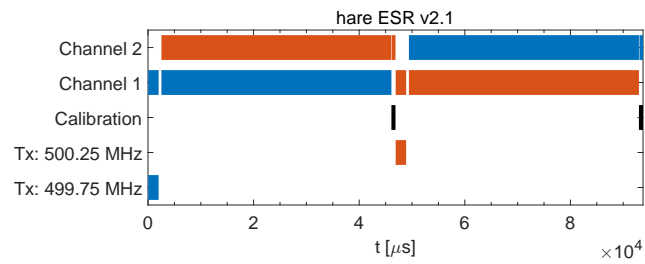

Range coverage for the most relevant data obtained by leo ESR.

Illustration of timing for transmission and the receiver channels for leo ESR.

Channel setup for leo ESR.

Channel	Description
1	Signal

Layout of the `d_raw` vector for leo ESR (level 1 data).

Start address	Size	Channel	Description
0	12800000	1	Raw data time samples
12800000			

Layout of the `d_data` vector for leo ESR (level 2 data).

Start address	Size	Channel	Description
0	20000	1	Power profile
20000			

4.3.5   steffe

Version   2.0
Antenna   Single
Raw data available   No
Plasma line   Yes
Transmitter frequency 499.7 MHz and 500.1 MHz
Integration time   6.0 s
Duty cycle   0.2304
Code   Alternating
Length of code   16 bit
Baud length   30 µs and 105 µs
Subcycle length   9375 µs
Number of subcycles   32
Number of loops   20
Sampling   15 µs (0.6 µs plasma line)

Ion line   F region
Time resolution   6.0 s
Ranges covered   42.75 km to 810 km
Range gate size   18 km
Range gate step   2.25 km
Spectral range   ±33.333 kHz
Spectral resolution 0.813 01 kHz
Lag step   15 µs
Maximum lag   41 (615 µs)

Ion line   F region, top end
Time resolution   6.0 s
Ranges covered   819 km to 1023.8 km
Range gate size   31.5 km
Range gate step   15.75 km
Spectral range   ±33.333 kHz
Spectral resolution 0.520 83 kHz
Lag step   15 µs
Maximum lag   64 (960 µs)

Ion line   E region
Time resolution   6.0 s
Ranges covered   37.875 km to 224.62 km
Range gate size   6.75 km
Range gate step   2.25 km
Spectral range   ±33.333 kHz
Spectral resolution 1.0753 kHz
Lag step   15 µs
Maximum lag   31 (465 µs)

Ion line   E region, top end

Time resolution   6.0 s
Ranges covered   228 km to 286.5 km
Range gate size   9 km
Range gate step   4.5 km
Spectral range   ±33.333 kHz
Spectral resolution   1.0417 kHz
Lag step   15 µs
Maximum lag   32 (480 µs)

Ion line   High ranges
Time resolution   6.0 s
Ranges covered   517.12 km to 1036.9 km
Range gate size   6.75 km
Range gate step   2.25 km
Spectral range   ±33.333 kHz
Spectral resolution   1.9608 kHz
Lag step   15 µs
Maximum lag   17 (255 µs)

Plasma line   Two down-shifted and two up-shifted frequency ranges
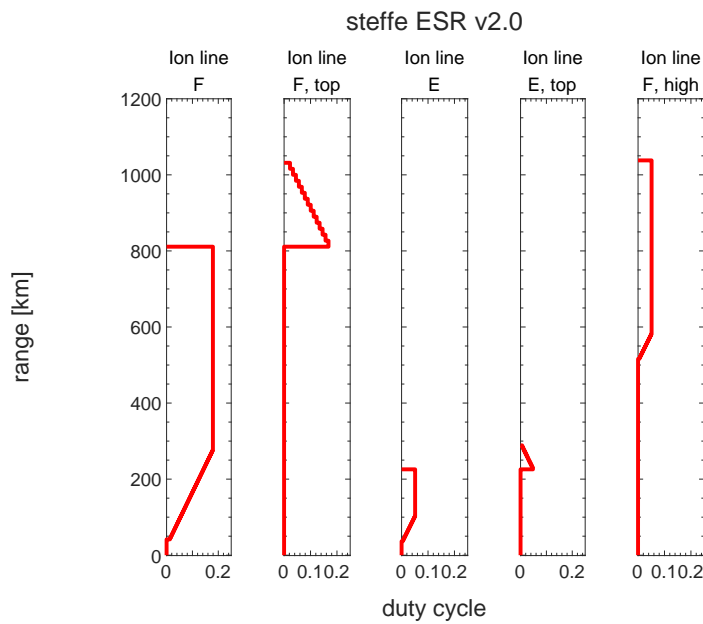Time resolution   6.0 s
Ranges covered   235.5 km to 361.5 km
Range gate size   31.5 km
Range gate step   15.75 km
Spectral range   ±0.833 33 MHz
Spectral resolution   0.542 53 kHz
Lag step   0.6 µs
Maximum lag   1536 (921.6 µs)

steffe ESR v2.0

Range coverage for the most relevant data obtained by steffe ESR.

Channel setup for steffe ESR. Channels 4, 5 and 6 are only used when the fixed42p scan is applied. In that case channels 1, 2 and 3 are for the 42 m antenna and channels 4, 5 and 6 for the 32 m antenna.

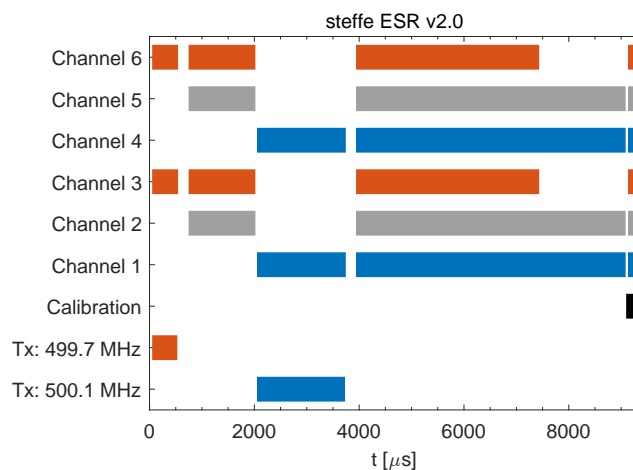| Channel	Description
1	Ion line data, F region
2	Gain
3	Ion line data, E region
4	*Ion line data, F region*
5	*Gain*
6	*Ion line data, E region*

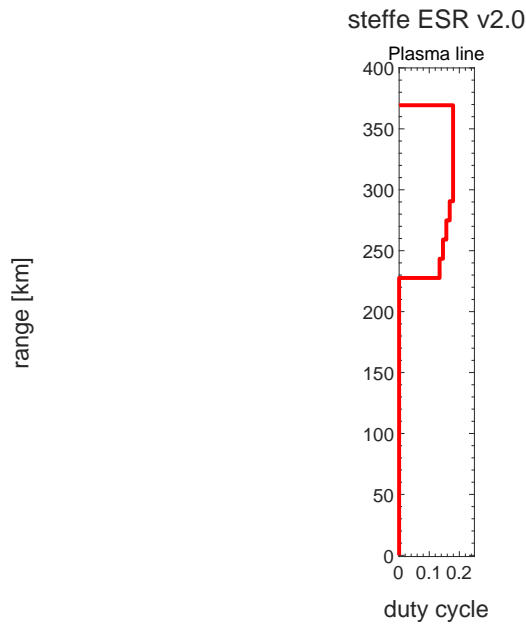Illustration of timing for transmission and the receiver channels for steffe ESR.

Layout of the `d_raw` vector for steffe ESR (level 1 data).

Start address	Size	Channel	Description
0	3616	1	Transmitter samples
3616	1056	3	Transmitter samples
4672	*3616*	*4*	*Transmitter samples*
8288	*1056*	*6*	*Transmitter samples*
9344			

Layout of the `d_data` vector for steffe ESR (level 2 data).

Start address	Size	Channel	Description
0	343	1	Background
343	15	1	Calibration
358	343	1	Power profile
701	22757	1	Lag profiles
23458	105	1	Lag profiles, top end (short)
23563	896	1	Lag profiles, top end
24459	105	1	Empty
24564	428	2	Background
24992	15	2	Calibration
25007	318	3	Background
25325	15	3	Calibration
25340	85	3	Power profile
25425	3105	3	Lag profiles
28530	30	3	Lag profiles, top end (short)
20560	448	3	Lag profiles, top end
29008	30	3	Empty
29038	233	3	Power profile (high)
29271	5592	3	Lag profiles (high)
34863	*343*	*4*	*Background*
35206	*15*	*4*	*Calibration*
35221	*343*	*4*	*Power profile*
35564	*22757*	*4*	*Lag profiles*
58321	*105*	*4*	*Lag profiles, top end (short)*
58426	*896*	*4*	*Lag profiles, top end*
59322	*105*	*4*	*Empty*
59427	*428*	*5*	*Background*
59855	*15*	*5*	*Calibration*
59870	*318*	*6*	*Background*
60188	*15*	*6*	*Calibration*
60203	*85*	*6*	*Power profile*
60288	*3105*	*6*	*Lag profiles*
63393	*30*	*6*	*Lag profiles, top end (short)*
63423	*448*	*6*	*Lag profiles, top end*
63871	*30*	*6*	*Empty*
63901	*233*	*6*	*Power profile (high)*
64134	*5592*	*6*	*Lag profiles (high)*
69726			

steffe ESR v2.0

Plasma line

Range coverage for the most relevant data obtained by steffe ESR plasma line receiver.

Channel setup for steffe ESR plasma line receiver. In case of fixed42p scan, the 42 m antenna is used. Otherwise it is the single antenna of choice.

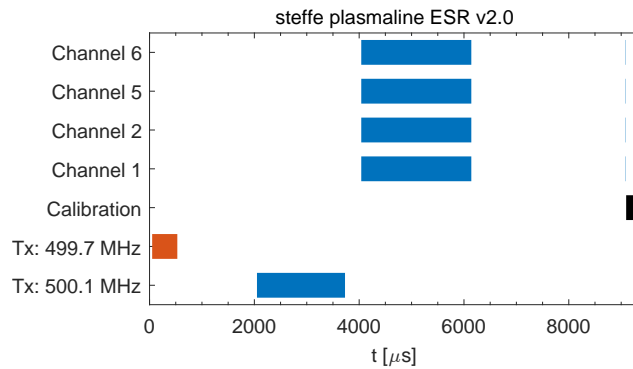| Channel	Description
1	Plasma line data (−3.8 MHz)
2	Plasma line data (−5.4 MHz)
5	Plasma line data (+3.8 MHz)
6	Plasma line data (+5.4 MHz)

Illustration of timing for transmission and the receiver channels for steffe ESR plasma line receiver.

Layout of the `d_raw` vector for steffe ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for steffe ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	1750	1	Lag profiles (short)
1750	13824	1	Lag profiles
15574	525	1	Lag profiles (undecoded)
16099	3500	1	Power profile
19599	10	1	Background
19609	10	1	Calibration
19619	1750	2	Lag profiles (short)
21369	13824	2	Lag profiles
35193	525	2	Lag profiles (undecoded)
35718	3500	2	Power profile
39218	10	2	Background
39228	10	2	Calibration
39238	1750	5	Lag profiles (short)
40988	13824	5	Lag profiles
54812	525	5	Lag profiles (undecoded)
55337	3500	5	Power profile
58837	10	5	Background
58847	10	5	Calibration
58857	1750	6	Lag profiles (short)
60607	13824	6	Lag profiles
74431	525	6	Lag profiles (undecoded)
74956	3500	6	Power profile
78456	10	6	Background
78466	10	6	Calibration
78476			

4.3.6 taro

Version   1.0
Antenna   Dual, two parts 32 m, one part 42 m
Raw data available   No
Plasma line   No
Transmitter frequency   499.5 MHz, 499.8 MHz, 500.1 MHz and 500.4 MHz
Integration time   6.4 s
Duty cycle   0.24
Code   Alternating
Length of code   16 bit
Baud length   50 µs
Subcycle length   20 000 µs
Number of subcycles   32
Number of loops   10
Sampling   25 µs

Ion line   32 m and 42 m higher ranges
   Time resolution   6.4 s
    Ranges covered   172.42 km to 836.17 km
    Range gate size   11.25 km
    Range gate step   3.75 km
    Spectral range   ±20 kHz
    Spectral resolution   0.645 16 kHz
    Lag step   25 µs
    Maximum lag   31 (775 µs)

Ion line   32 m and 42 m lower ranges
    Time resolution   6.4 s
    Ranges covered   48.675 km to 712.42 km
    Range gate size   11.25 km
    Range gate step   3.75 km
    Spectral range   ±20 kHz
    Spectral resolution   0.645 16 kHz
    Lag step   25 µs
    Maximum lag   31 (775 µs)

Ion line   32 m and 42 m lower ranges, top end
    Time resolution   6.4 s
    Ranges covered   718.05 km to 815.55 km
    Range gate size   15 km
    Range gate step   7.5 km
    Spectral range   ±20 kHz
    Spectral resolution   1.25 kHz
    Lag step   25 µs
    Maximum lag   16 (400 µs)
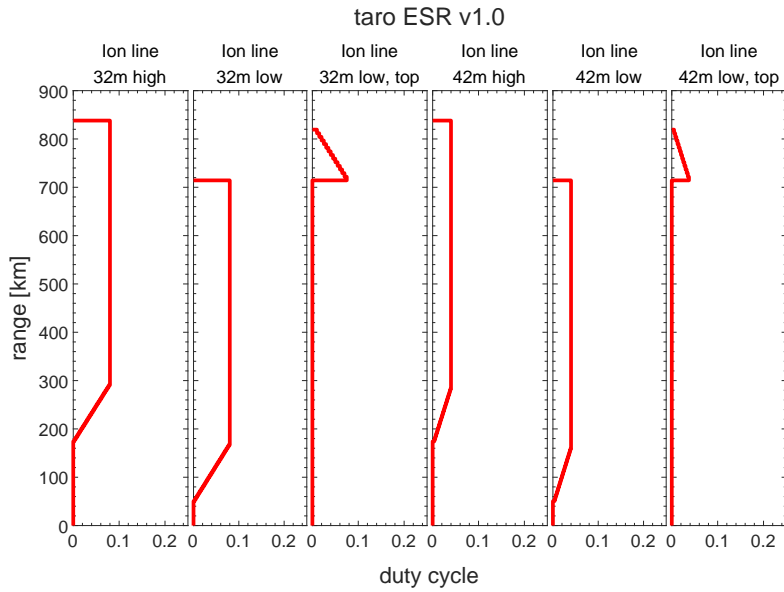
Range coverage for the most relevant data obtained by taro ESR.

Channel setup for taro ESR.

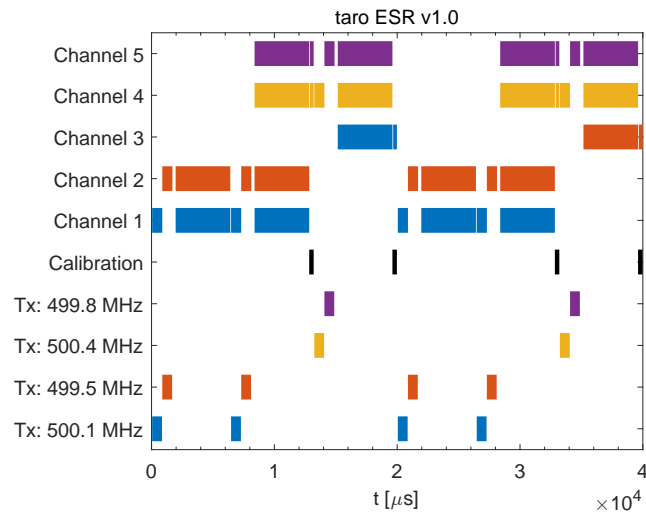| Channel	Description
1	Ion line data, higher ranges (32 m)
2	Ion line data, lower ranges (32 m)
3	Gain (32 m)
4	Ion line data, lower ranges (42 m)
5	Ion line data, higher ranges (42 m)

Illustration of timing for transmission and the receiver channels for taro ESR.

Layout of the `d_raw` vector for taro ESR (level 1 data).

Start address	Size	Channel	Description
0	2112	1	Transmitter samples
2112	2112	2	Transmitter samples
4224	1056	4	Transmitter samples
5280	1056	5	Transmitter samples
6336			

Layout of the `d_data` vector for taro ESR (level 2 data).

Start address	Size	Channel	Description
0	178	1	Power profile
178	7290	1	Lag profiles
7468	178	2	Power profile
7646	7290	2	Lag profiles
14936	30	2	Lag profiles, top end (short)
14966	224	2	Lag profiles, top end
15190	178	3	Background 1
15368	12	3	Calibration 1
15380	178	3	Background 2
15558	12	3	Calibration 2
15570	128	3	FFT 1
15698	128	3	FFT 2
15826	178	4	Background
16004	12	4	Calibration
16016	128	4	FFT
16144	178	4	Power profile
16322	7290	4	Lag profiles
23612	178	5	Background
23790	12	5	Calibration
23802	128	5	FFT
23931	178	5	Power profile
24108	7290	5	Lag profiles
31398	30	5	Lag profiles, top end (short)
31428	224	5	Lag profiles, top end
31652			

4.3.7 tau7

Version	1.0
Antenna	Single
Raw data available	No
Plasma line	Yes
Transmitter frequency	499.7 MHz
Integration time	6.0 s
Duty cycle	0.2048
Code	Alternating
Length of code	16 bit
Baud length	120 μs
Subcycle length	9375 μs
Number of subcycles	32
Number of loops	20
Sampling	5 μs (0.4 μs plasma line)

Ion line

Time resolution	6.0 s
Ranges covered	48.675 km to 1109.2 km
Range gate size	18.75 km
Range gate step	0.75 km
Spectral range	±100 kHz
Spectral resolution	0.840 34 kHz
Lag step	5 μs
Maximum lag	119 (595 μs)

Ion line   Top end

Time resolution	6.0 s
Ranges covered	1118.5 km to 1352.5 km
Range gate size	36 km
Range gate step	18 km
Spectral range	±100 kHz
Spectral resolution	0.520 83 kHz
Lag step	5 μs
Maximum lag	192 (960 μs)

Plasma line   One down-shifted and one up-shifted frequency range, spectral domain only

Time resolution	6.0 s
Range covered	250.23 km
Range gate size	303.36 km
Range gate step	0 km
Spectral range	±1.25 MHz
Spectral resolution	4.8828 kHz
Lag step	0 μs
Maximum lag	0 (0 μs)
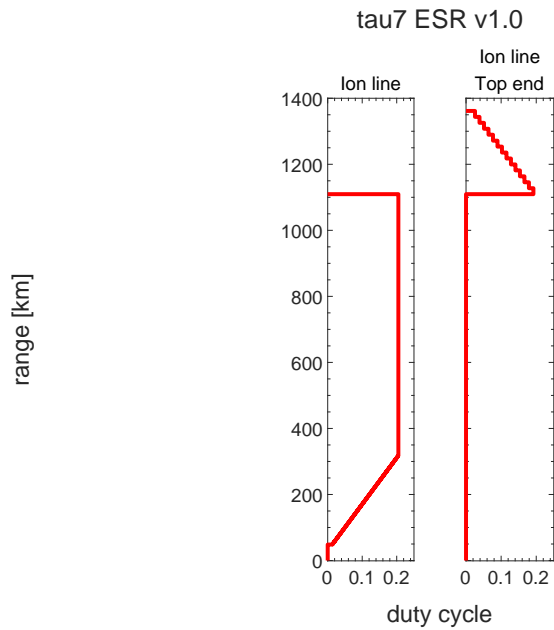
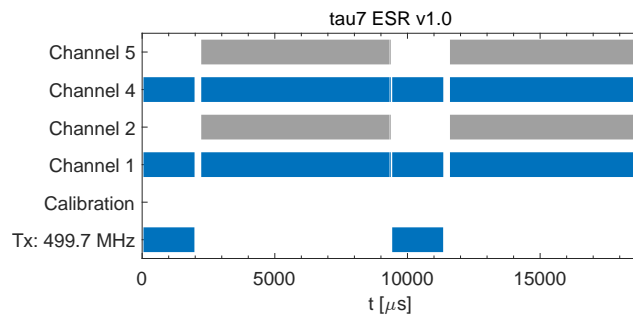Range coverage for the most relevant data obtained by tau7 ESR.

Illustration of timing for transmission and the receiver channels for tau7 ESR.

Channel setup for tau7 ESR. Channels 4 and 5 are only used when the fixed42p scan is applied. In that case channels 1 and 2 are for the 42 m antenna and channels 4 and 5 for the 32 m antenna.

Channel	Description
1	Ion line data
2	Gain
4	*Ion line data*
5	*Gain*

Layout of the `d_raw` vector for tau7 ESR (level 1 data).

Start address	Size || Channel	Description
0	12320	1	Transmitter samples
12320	*12320*	*4*	*Transmitter samples*
24640			

Layout of the `d_data` vector for tau7 ESR (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	10	1	Calibration
20	10	1	FFT
30	1416	1	Power profile
1446	285012	1	Lag profiles
286458	360	1	Lag profiles, top end (short)
286818	2688	1	Lag profiles, top end
289506	10	2	Background
289516	10	2	Calibration
289526	1416	2	Power profile
290942	*10*	*4*	*Background*
290952	*10*	*4*	*Calibration*
290962	*10*	*4*	*FFT*
290972	*1416*	*4*	*Power profile*
292388	*285012*	*4*	*Lag profiles*
577400	*360*	*4*	*Lag profiles, top end (short)*
577760	*2688*	*4*	*Lag profiles, top end*
580448	*10*	*5*	*Background*
580458	*10*	*5*	*Calibration*
580468	*1416*	*5*	*Power profile*
581884			

tau7 ESR v1.0
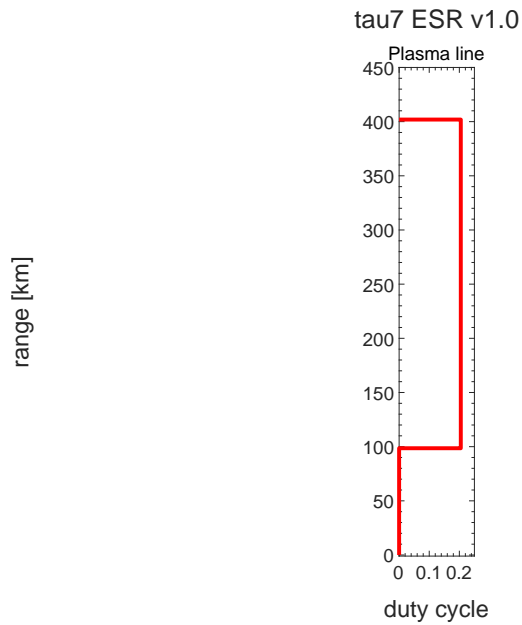
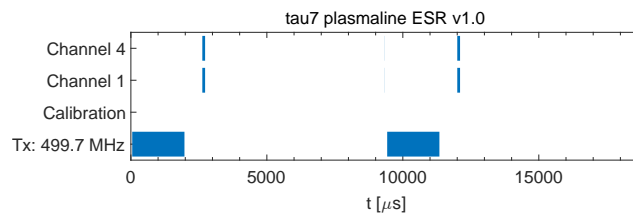Range coverage for the most relevant data obtained by tau7 ESR plasma line receiver.

Illustration of timing for transmission and the receiver channels for tau7 ESR plasma line receiver.

Channel setup for tau7 ESR plasma line receiver. In case of fixed42p scan, the 42 m antenna is used. Otherwise it is the single antenna of choice.

Channel	Description
1	Plasma line data (−4.2 MHz)
4	Plasma line data (+4.2 MHz)

Layout of the `d_raw` vector for tau7 ESR plasma line receiver (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for tau7 ESR plasma line receiver (level 2 data).

Start address	Size	Channel	Description
0	10	1	Background
10	20	1	Calibration
20	256	1	FFT
276	10	4	Background
286	10	4	Calibration
296	256	4	FFT
552			

5 Experiments not used the last 10 years

5.1 UHF

5.1.1 arc_dlayer

Version	1.11
Raw data available	No
Plasma line	No
Transmitter frequency	929.6 MHz
Integration time	5.0 s
Duty cycle	0.095097
Code	Alternating
Length of code	64 bit
Baud length	2 µs
Subcycle length	1346 µs
Number of subcycles	128
Number of loops	29
Sampling	2 µs

Ion line   D region

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±341.47 Hz
Spectral resolution	2.925 kHz
Lag step	1.346 ms
Maximum lag	127 (170.942 ms)

Ion line   E region

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±15.625 kHz
Spectral resolution	5.208 kHz
Lag step	32 ms
Maximum lag	3 (96 ms)

Ion line   D region, longer lags (Here the max lag is uncertain)

Time resolution	5.0 s
Ranges covered	60.0 km to 139.8 km
Range gate size	0.6 km
Range gate step	0.3 km
Spectral range	±2.9021 Hz
Spectral resolution	0.103 647 Hz
Lag step	172.288 ms
Maximum lag	28 (4.824 s)
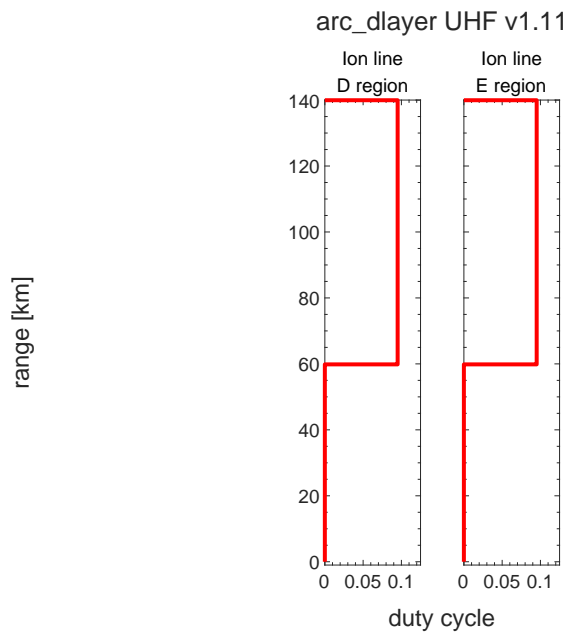
arc_dlayer UHF v1.11

Range coverage for the most relevant data obtained by arc_dlayer UHF.
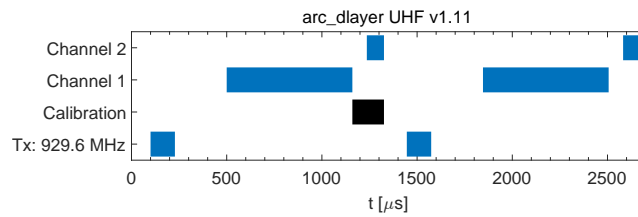

Illustration of timing for transmission and the receiver channels for arc_dlayer UHF.

Channel setup for arc_dlayer UHF.

Channel	Description
1	Ion line data
2	Calibration

Layout of the `d_raw` vector for arc_dlayer UHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
0			

Layout of the `d_data` vector for arc_dlayer VHF (level 2 data).

Start address	Size	Channel	Description
0	45	2	Background
45	45	2	Calibration
90	330	1	Power profile
420	34176	1	Lag profiles (D)
34596	1068	1	Lag profiles (E)
35664	7743	1	Lag profiles (D, longer)
43407			

5.2 VHF

5.2.1 tau1

Version	1.3
Raw data available	No
Plasma line	Yes
Transmitter frequency	223.6 MHz and 224.2 MHz
Integration time	5.0 s
Duty cycle	0.073846
Code	Alternating
Length of code	16 bit
Baud length	72 μs
Subcycle length	15 600 μs
Number of subcycles	64
Number of loops	5
Sampling	24 μs

Ion line Two signals, one per antenna half

Time resolution	5.0 s
Ranges covered	110.85 km to 2069.2 km
Range gate size	14.4 km
Range gate step	3.6 km
Spectral range	±20.833 kHz
Spectral resolution	0.718 39 kHz
Lag step	24 μs
Maximum lag	29 (696 μs)

tau1 VHF v1.3
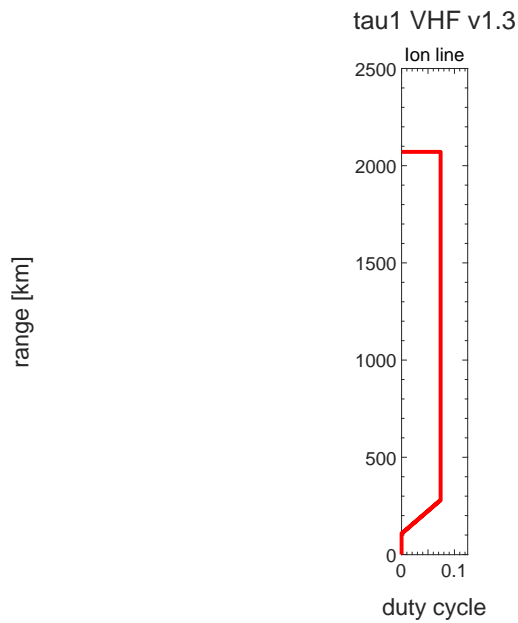
Ion line

Range coverage for the most relevant data obtained by tau1 VHF.

Channel setup for tau1 VHF.

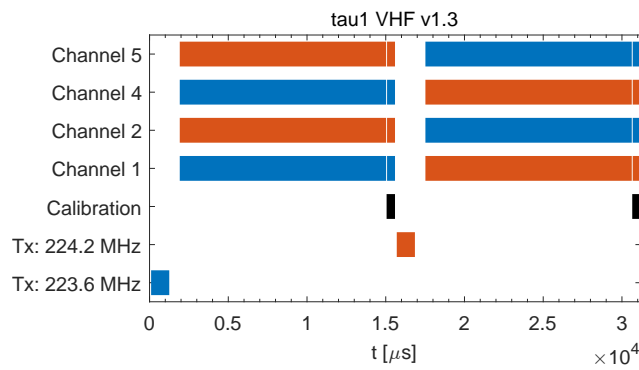| Channel	Description
1	Ion line data, antenna half 1
2	Gain, antenna half 1
4	Ion line data, antenna half 2
5	Gain, antenna half 2

Illustration of timing for transmission and the receiver channels for tau1 VHF.

Layout of the `d_raw` vector for tau1 VHF (level 1 data).

Start address	Size	Channel	Description
0	0	0	No `d_raw` vector
	0		

Layout of the `d_data` vector for tau1 VHF (level 2 data).

Start address	Size	Channel	Description
0	546	1	Power profile (223.6 MHz)
546	546	1	Power profile (224.2 MHz)
1092	24930	1	Lag profiles
26022	21	1	Calibration
26043	546	2	Power profile
26589	21	2	Calibration
26610	546	4	Power profile (223.6 MHz)
27156	546	4	Power profile (224.2 MHz)
27702	24930	4	Lag profiles
52632	21	4	Calibration
52653	546	5	Power profile
53199	21	5	Calibration
53220			

5.3 ESR

5.3.1 hilde

Version	1.01
Antenna	Dual, one part 32 m, one part 42 m
Raw data available	No
Plasma line	No
Transmitter frequency	499.5 MHz, 499.8 MHz, 500.1 MHz and 500.4 MHz
Integration time	5.1 s
Duty cycle	0.1992
Code	Alternating
Length of code	16 bit
Baud length	32 μs and 96 μs (42 m), and 60 μs (32 m)
Subcycle length	19 920 μs
Number of subcycles	64
Number of loops	4
Sampling	16 μs (42 m), 20 μs (42 m)

Ion line 42 m, undecoded range 1

Time resolution	5.1 s
Ranges covered	225.3 km to 1034.1 km
Range gate size	232.8 km
Range gate step	2.4 km
Spectral range	±31.25 kHz
Spectral resolution	5.2083 kHz
Lag step	16 μs
Maximum lag	6 (96 μs)

Ion line 42 m, undecoded range 2

Time resolution	5.1 s
Ranges covered	1449.3 km to 2519.7 km
Range gate size	232.8 km
Range gate step	2.4 km
Spectral range	±31.25 kHz
Spectral resolution	5.2083 kHz
Lag step	16 μs
Maximum lag	6 (96 μs)

Ion line 42 m, F region

Time resolution	5.1 s
Ranges covered	40.5 km to 926.1 km
Range gate size	16.8 km
Range gate step	2.4 km
Spectral range	±31.25 kHz
Spectral resolution	0.892 86 kHz
Lag step	16 μs
Maximum lag	35 (560 μs)

Ion line 42 m, E region
    Time resolution   5.1 s
    Ranges covered   35.7 km to 220.5 km
    Range gate size   7.2 km
    Range gate step   2.4 km
    Spectral range   ±31.25 kHz
    Spectral resolution   1.0081 kHz
    Lag step   16 µs
    Maximum lag   31 (496 µs)

Ion line 42 m, F region, E channel
   Time resolution   5.1 s
    Ranges covered   489.3 km to 966.9 km
    Range gate size   7.2 km
    Range gate step   2.4 km
    Spectral range   ±31.25 kHz
    Spectral resolution   1.8382 kHz
    Lag step   16 µs
    Maximum lag   17 (272 µs)

Ion line 32 m, upper ranges
    Time resolution   5.1 s
    Ranges covered   185.1 km to 1295.1 km
    Range gate size   12 km
    Range gate step   3 km
    Spectral range   ±25 kHz
    Spectral resolution   0.862 07 kHz
    Lag step   20 µs
    Maximum lag   29 (580 µs)

Ion line 32 m, lower ranges
    Time resolution   5.1 s
    Ranges covered   38.1 km to 1148.1 km
    Range gate size   12 km
    Range gate step   3 km
    Spectral range   ±25 kHz
    Spectral resolution   0.862 07 kHz
    Lag step   20 µs
    Maximum lag   29 (580 µs)

hilde ESR v1.01
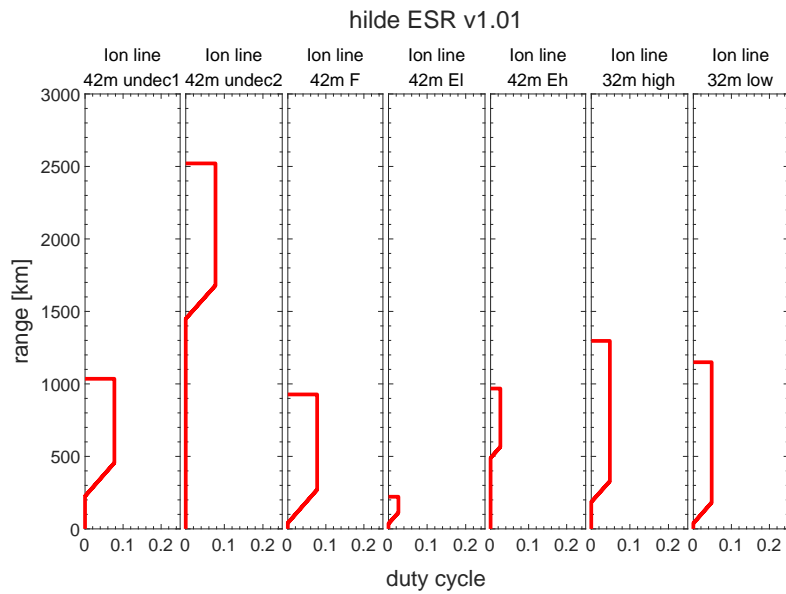
Range coverage for the most relevant data obtained by hilde ESR.

Channel setup for hilde ESR.

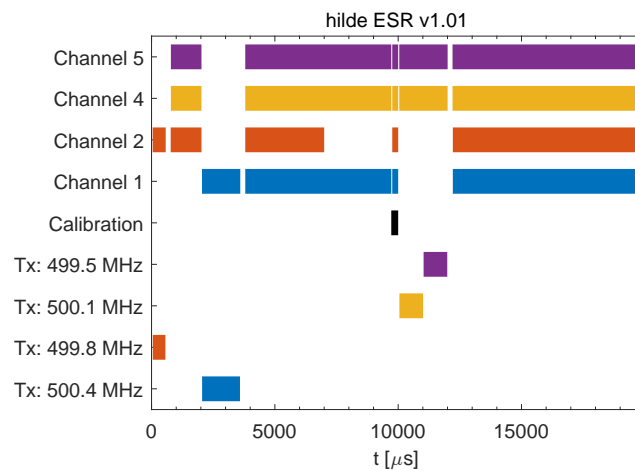| Channel	Description
1	Ion line data, 42 m, F
2	Ion line data, 42 m, E
4	Ion line data, 32 m, upper
5	Ion line data, 32 m, lower

hilde ESR v1.01

Illustration of timing for transmission and the receiver channels for folke ESR.

Layout of the `d_raw` vector for hilde ESR (level 1 data).

Start address	Size	Channel	Description
0	6208	1	Transmitter samples, 42 m, F
6208	2112	2	Transmitter samples, 42 m, E
8320	6272	4	Transmitter samples, 32 m, upper
14592	6272	5	Transmitter samples, 32 m, lower
20864			

Layout of the `d_data` vector for hilde ESR (level 2 data).

Start address	Size	Channel	Description
0	15	1	Calibration 1
15	15	1	Calibration 2
30	370	1	Power profile (low ranges)
400	2007	1	Lag profiles (low ranges, undecoded)
2407	463	1	Power profile (high ranges)
2870	2661	1	Lag profiles (high ranges, undecoded)
5531	370	1	Power profile (low ranges)
5901	21045	1	Lag profiles (low ranges)
26946	256	1	FFT
27202	256	2	FFT
27458	78	2	Power profile (low ranges)
27536	200	2	Power profile (middle ranges)
27736	15	2	Calibration 1
27751	463	2	Power profile (high ranges)
28214	15	2	Calibration 2
28229	78	2	Power profile (low ranges)
28307	2790	2	Lag profiles (low ranges)
31097	200	2	Power profile (middle ranges)
31297	4767	2	Lag profiles (middle ranges)
36064	62	4	Power profile (middle ranges)
36126	296	4	Power profile (high ranges)
36422	12	4	Calibration 1
36434	371	4	Power profile (low ranges)
36805	12	4	Calibration 2
36817	371	4	Power profile (low ranges)
37188	16705	4	Lag profiles (low ranges)
53893	256	4	FFT
54149	256	5	FFT
54405	62	5	Power profile (middle ranges)
54467	296	5	Power profile (high ranges)
54763	12	5	Calibration 1
54775	371	5	Power profile (low ranges)
55146	12	5	Calibration 2
55158	371	5	Power profile (low ranges)
55529	16705	5	Lag profiles (low ranges)
72234			

5.3.2 tau0

Version	6.4
Antenna	Single
Raw data available	No
Plasma line	No
Transmitter frequency	499.875 MHz and 500.125 MHz
Integration time	8.0 s
Duty cycle	0.0384
Code	Alternating
Length of code	16 bit
Baud length	60 µs
Subcycle length	50 000 µs
Number of subcycles	5
Number of loops	20
Sampling	20 µs

Ion line   Upper ranges

Time resolution	8.0 s
Ranges covered	209.1 km to 6806.1 km
Range gate size	12 km
Range gate step	3 km
Spectral range	±25 kHz
Spectral resolution	0.961 54 kHz
Lag step	20 µs
Maximum lag	26 (520 µs)

Ion line   Lower ranges

Time resolution	8.0 s
Ranges covered	56.1 km to 6653.1 km
Range gate size	12 km
Range gate step	3 km
Spectral range	±25 kHz
Spectral resolution	0.961 54 kHz
Lag step	20 µs
Maximum lag	26 (520 µs)

tau0 ESR v6.4
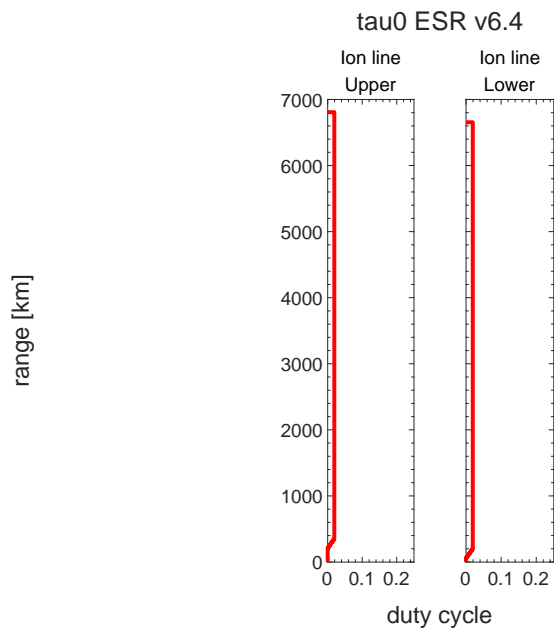
Range coverage for the most relevant data obtained by tau0 ESR.

Channel setup for tau0 ESR.

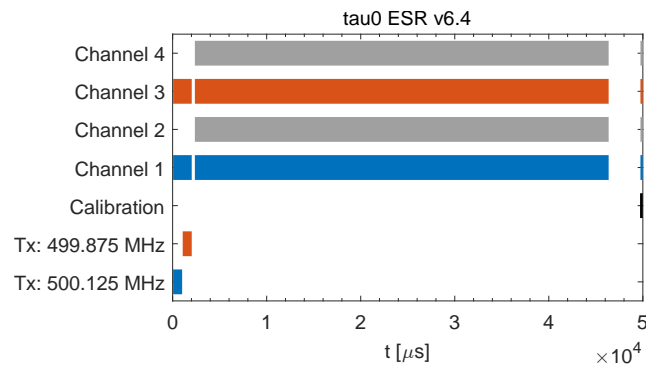| Channel	Description
1	Ion line data (upper)
2	Gain
3	Ion line data (lower)
4	Gain

Illustration of timing for transmission and the receiver channels for tau0 ESR.

Layout of the `d_raw` vector for tau0 ESR (level 1 data).

Start address	Size	Channel	Description
0	3168	1	Transmitter samples
3168	3168	3	Transmitter samples
6336			

Layout of the `d_data` vector for tau0 ESR (level 2 data).

Start address	Size	Channel	Description
0	2200	1	Power profile
2200	91809	1	Lag profiles
94009	12	1	Calibration
94021	2200	2	Power profile
96221	12	2	Calibration
96233	2200	3	Power profile
98433	91809	3	Lag profiles
190242	12	3	Calibration
190254	2200	4	Power profile
192454	12	4	Calibration
192466			