

Meteor scatter on 432 MHz ++

&

Why not to try something truly challenging? ;-)

*22 Zjazd Techniczny UKF
Zieleniec 2023*

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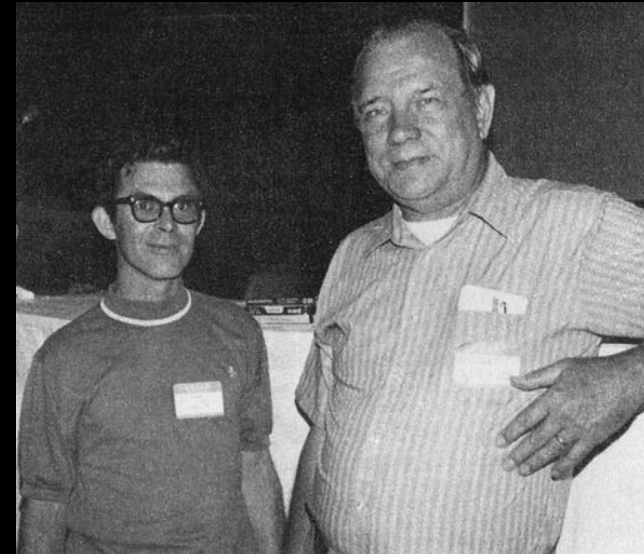
www.ok2kkw.com

Meteor scatter on 70cm – few words about history..

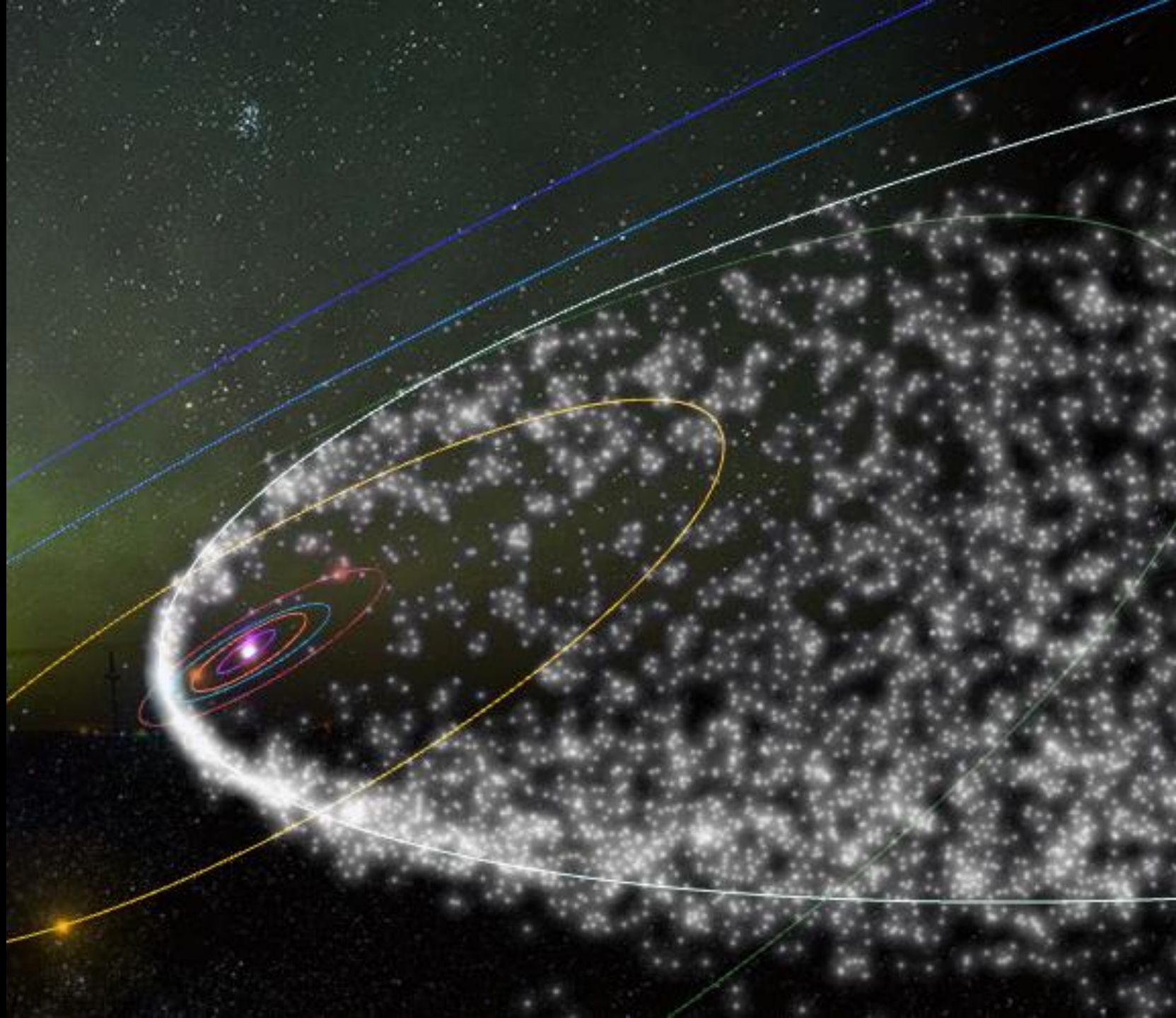
The first tests of 70cm MS were held by G3HBW during early 60's. During 1967 K4QIF has heard first reflections from W4GJO on 70cm. On August 9 1968, after two months of daily schedules, Mel Baer, W6WSQ, and Don Hilliard, W0EYE, completed the first 220 MHz contact. Further tests on UHF continued and the first ever 70cm MS QSO was finished by W2AZL, Holmdel, New Jersey, and W0LER, Minneapolis on 12th August 1972 and it required 5 hours and 4 minutes to complete.

First 70cm MS QSO in Europe was completed exactly 5 years later on 12th August 1977 between SK6AB and SM2AID - more about these tests can be seen at [ok2kkw web](#). The biggest positive step forward in 70's was the new LNA generation based on gallium arsenide field-effect transistors (GaAsFET) which allowed suppress the Noise Figure from 2 - 3dB well below 0,5dB which was quite remarkable especially on UHF, where the sky background temperature is very low. During end of 70's further MS tests were rolled by Chris GW4DGU, Karl, SM3AKW, Claus, DL7QY and ON5FF.

In OK the first 70cm MS QSO was established already in year 1986 on 11th August by Josef, OK1MDK & OK1KKH club with Carl, SM3AKW during Perseids shower. The contact took to finish about 3 hours + 15 minutes and OK1MDK heard 4 bursts (the best was 6s long) and about 16 pings.



W0LER (left) and W2AZL made the first 432 MHz meteor scatter contact August 12 1972. The exchange required 5 hours(!) to complete, on infrequent short bursts.



Meteor, Meteorite, Meteoroid

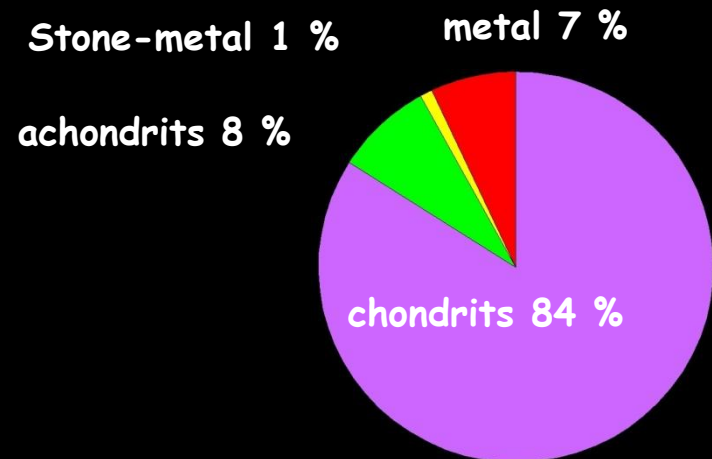
Meteoroid – mostly microscopic particle usually created by fragmentation of the main asteroid belt (>Yarkovsky effect) between Mars and Jupiter and comets, which moves in the interplanetary space. Usual mass/size 0,1g –1g “grains of sand–pea sized rocks”. Usual velocity 10 –100 km/s. Over 100 000 t of meteoroids hits Earth per 1 year.

Meteor - light (ionized) trace caused by passage of meteoroid atmosphere of the planet, usually Earth.

Meteorite - body from the interplanetary space (a remnant of a meteoroid) that collided with the planet (Earth, Mars,...), survived through the atmosphere and hit the surface.

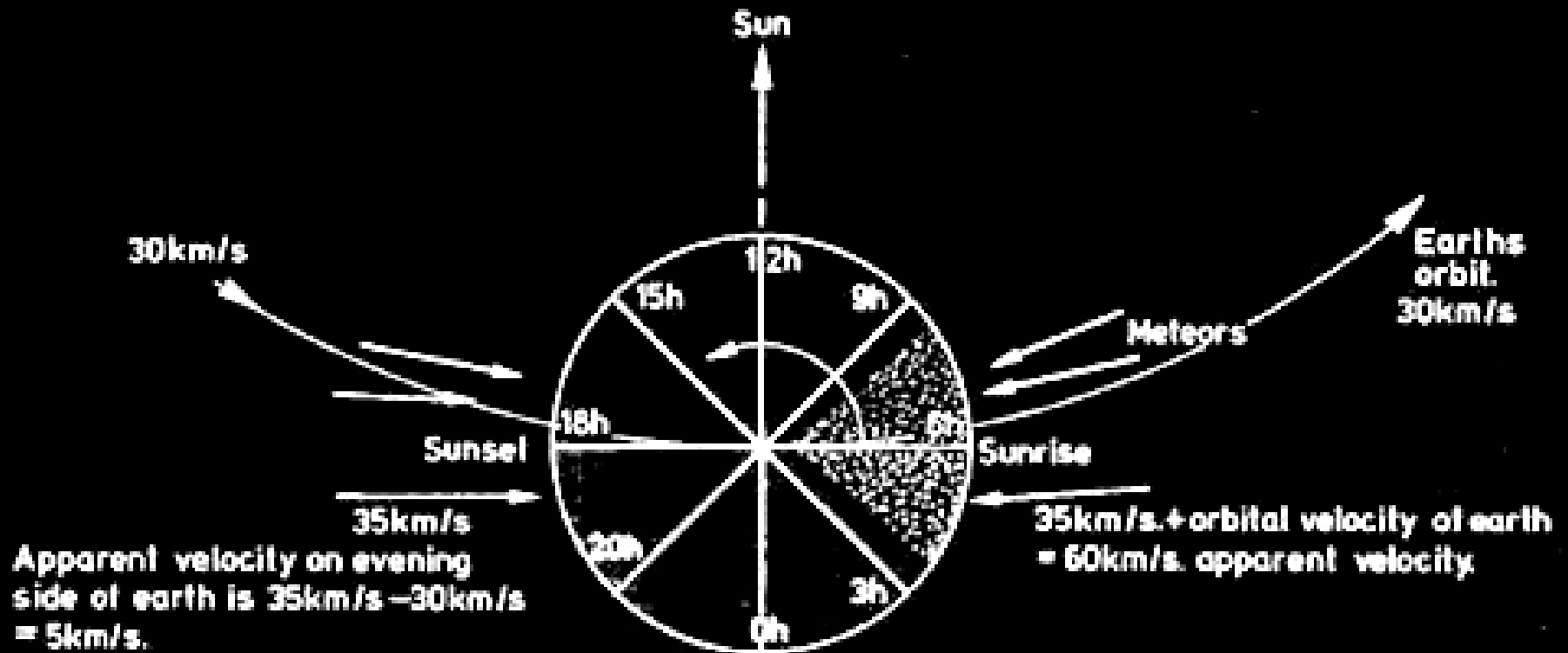
Main division of meteors

- Sporadic meteors
- Meteors showers



Sporadic rocks & speed of meteoroids

- All day –Every Day of the year, Peak just before dawn
- with well known speeds between 5 to 100 km/s we can prove that meteoroids came from Solar system
- Sporadic rocks with higher ionization are so rare for 432 MHz contacts in reasonable time :- (



The path of the earth intercepts more sporadic meteors at sunrise than it does at sunset.

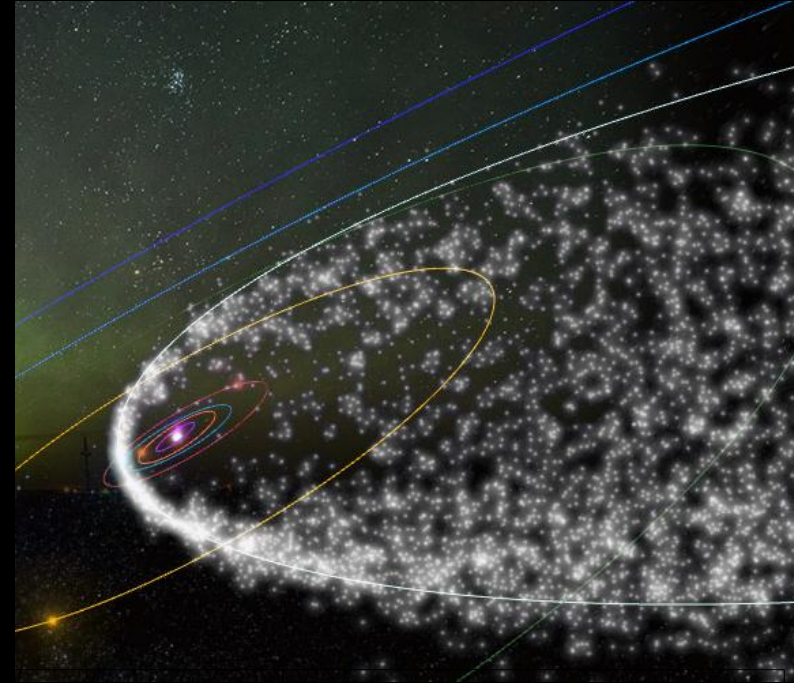
Meteoric showers

Meteoric shower – it's basically a dust's clouds which is orbiting the Sun by elliptic orbit and it's crossing orbit of the Earth. Meteors used to be coming from the single point at sky which is known as a radiant and this radiant is always known by the constellation which is at the background.

For Meteor-scatter is important to make QSO 90deg off the radiant position (+-15deg). Some meteor showers are circumpolar (like Perseids) which means that the radiant is always above the horizon which is perfect for QSOs into UA6 or EA8.

Faster meteors are converting it's velocity's energy into higher ionization which is very important especially on 70cm.

> <https://www.imo.net>

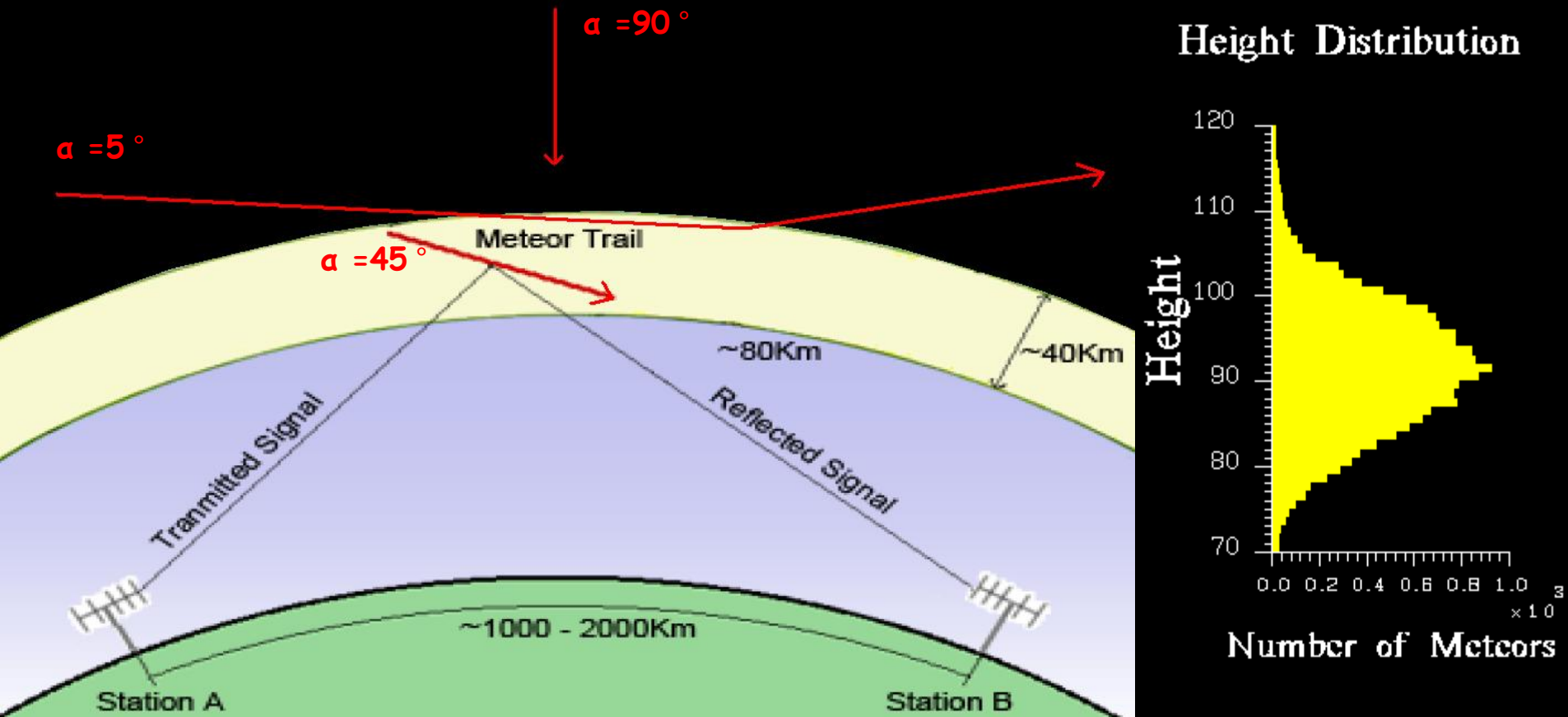


good showers for 70cm MS	Date of maximum	Constellation	ZHR	v [m/s]	Source (comet)
Quadrantids	3 rd January ^{***}	Boots	120	41	96P/Machholz 1
Lyrids	22 nd April	Lyra	20	48	Tchatcher 1861 I
eta Aquarids	4 th May	Aquarius	30	66	<u>1P/Halley</u>
Perseids	12th August	Perseus	70	58	109P/Swift-Tuttle
Orionids	21 st October	Orion	30	66	<u>1P/Halley</u>
Leonids (2031) ^{**}	18 th November	Lion	10-1000	71	55P/Tempel-Tuttle
Geminids	14 th December	Gemini	100	35	<i>(3200) Phaeton (asteroid)</i>

Entry into the atmosphere

When meteoroid enters the atmosphere, it's starting to disintegrating and ablating, the ionization trace is created. If it enter the atmosphere in 90deg, it will burn out fast, so the total count of reflections is big but this is producing very short and weak pings and so low ionization. However when the angle is low, the meteoroid will be burning longer but some of them will reflect from atmosphere back into the space so the reflections are strong and longer but rare. While on 70cm band you need the highest as possible ionization, based on my practical experiments I found that it's nonsense to try UHF contacts when the radiant is higher than about 60degrees of elevation.

The burning height vary with Solar cycle (!) so around Solar minimum you can make longer contacts.



What's the radiant's actual position?

Virgo

Meteor Sky View

2006-10-09

04:42:00 UTC

DL1DBC

JO31oj

Your call sign:

DL1DBC

Your locator:

JO31oj

GO

☐ Save data

Sky display

☐ W - E

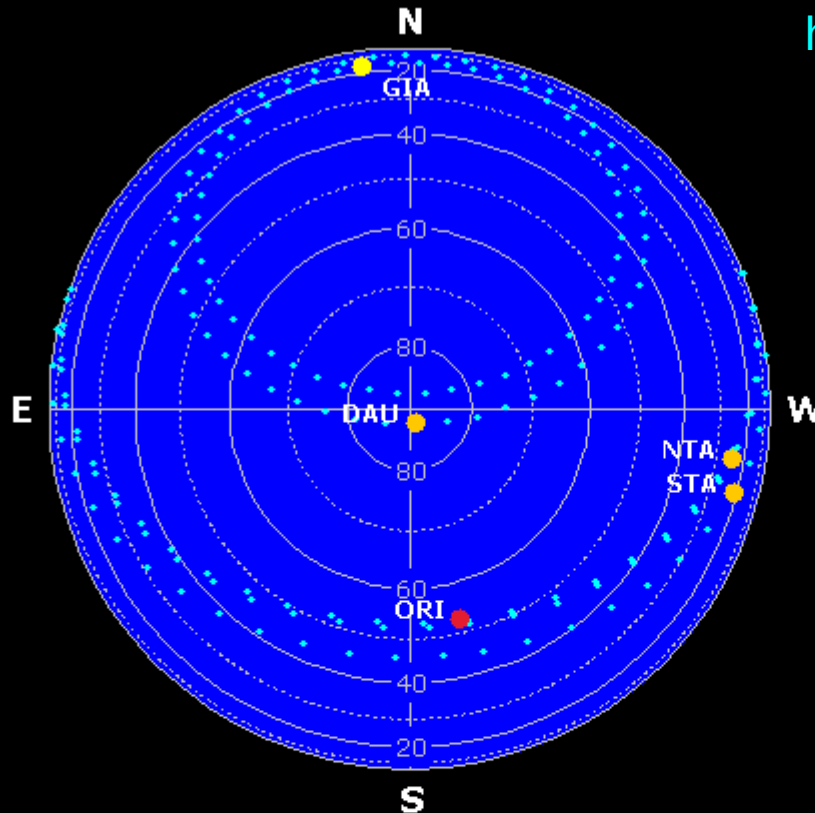
☒ Ticks

☒ Labels

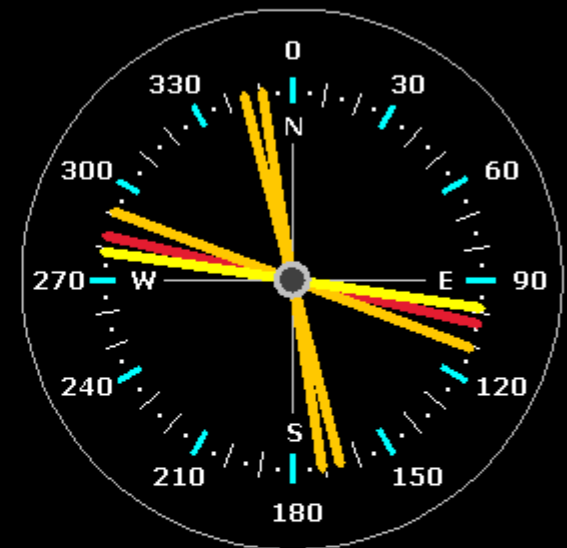
Azimuth indicator

☒ Antenna

☒ Meteor trails



<http://www.dl1dbc.net/Meteorscatter>



Meteor Shower	Ref.	Rise	Set	RA	Decl.	ZHR	Class	Visual Activity Peak
Orionids	ORI	20:43	11:29	87	15	23	1 ●	2006-10-21 15:26
South. Taurids	STA	17:34	07:04	30	8	5	2 ●	2006-11-05 15:55
Delta-Aurigids	DAU	circumpolar		94	49	5	2 ●	2006-09-09 14:56
North. Taurids	NTA	16:53	07:28	28	14	5	2 ●	2006-11-12 15:11
Draconids	GIA	circumpolar		262	54	var	3 ●	2006-10-08 22:18

What's the radiant's actual position?

The screenshot shows two windows from a ham radio software interface. The 'Options' window on the left has a 'Miscellaneous' tab with 'Source RA' set to 7.5 and 'Source DEC' set to +32.6. The 'Astronomical data' window on the right displays a table of celestial data. Red arrows point from the 'Source RA' and 'Source DEC' fields in the 'Options' window to the 'Moon' row in the 'Astronomical data' window, specifically to the RA and DEC columns.

	AZ	EL
Moon:	34.86	-10.86
Moon/DX:	51.94	-12.01
Sun:	256.17	-18.80
Source:	47.05	7.96
	Doppler	df/dt
DX:	218	0.83
Self:	159	0.87
	RA	DEC
Moon:	08:58	21.83

RA/DEC for some major showers (tnx to PA5DD):

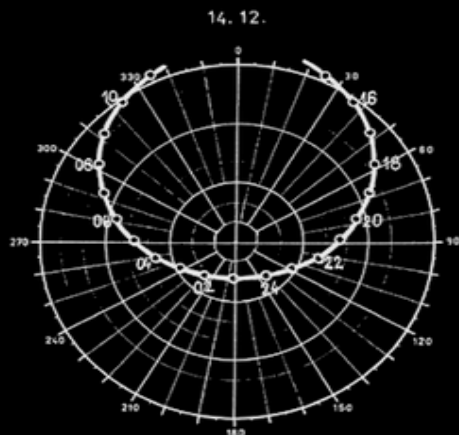
Quadrantids RA= 15.3 hrs DEC= 49°

Perseids RA= 3.1 hrs DEC= 58°

Leonids RA= 10.2 hrs DEC= 22°

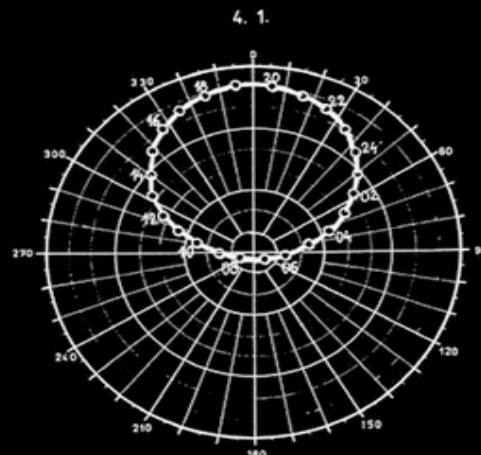
Geminids RA= 7.5 hrs DEC= 32.6°

Radiant – when to set skeds?



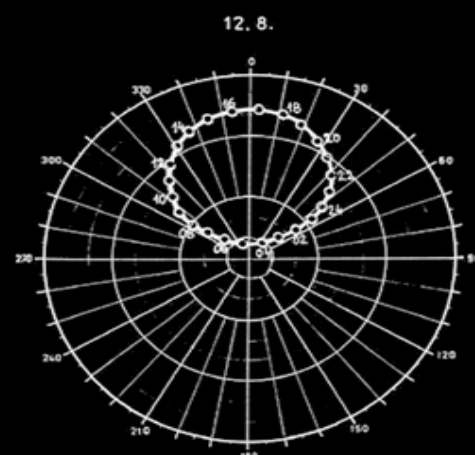
Geminids in JO70FD

UTC	AZ	RAD	AZ+90	AZ-90	RAD	EL	OK1>DXCC
00:00	138	228	48	68	EL	EA2	
01:00	174	264	84	72	EL	F6, UA6	
02:00	214	304	124	70	EL	US7, G	
03:00	241	331	151	63	EL	LZ, OY	
04:00	258	348	168	54	EL	IK7	
05:00	270	0	180	44	EL	SM4	
06:00	281	11	191	35	EL	SM5, IK0	
07:00	291	21	201	25	EL	OH, EA6	
08:00	301	31	211	17	EL	OH, YL, ES	
09:00	311	41	221	9	EL	UA3	
10:00	322	52	232	2	EL	UA3	
11:00	333	63	243	-3			
12:00	346	76	256	-6			
13:00	359	89	269	-7			
14:00	11	101	281	-6			
15:00	23	113	293	-3			
16:00	36	126	306	1	EL	YO, G	
17:00	46	136	316	8	EL	LZ, GM	
18:00	57	147	327	15	EL	SV2	
19:00	67	157	337	24	EL	LZ, OY	
20:00	77	167	347	33	EL	Z35, LA	
21:00	87	177	357	42	EL	IK7, SM3	
22:00	100	190	10	52	EL	IK0, OH0	
23:00	115	205	25	61	EL	UA3, EA6	
00:00	138	228	48	68	EL	EA2	



Quadrantids in JO70FD

UTC	AZ	RAD	AZ+90	AZ-90	RAD	EL	OK1>DXCC
00:00	42	132	312	25	EL	YO, G	
01:00	50	140	320	31	EL	LZ, GM	
02:00	57	147	327	40	EL	LZ, GM	
03:00	65	155	335	48	EL	LZ, OY	
04:00	71	161	341	57	EL	Z35, LA	
05:00	78	168	348	66	EL	IK7	
06:00	86	176	356	76	EL	IK7, SM3	
07:00	101	191	11	85	EL		
08:00	260	350	170	85	EL		
09:00	274	4	184	75	EL		
10:00	282	12	192	66	EL		
11:00	289	19	199	56	EL	OH, EA6	
12:00	296	26	206	47	EL	OH, YL, ES	
13:00	303	33	213	39	EL	UA1, YL, EA6	
14:00	310	40	220	31	EL	UA3, EA6	
15:00	319	49	229	24	EL	UA3, EA5	
16:00	327	57	237	18	EL	UA3, EA5	
17:00	336	66	246	14	EL	UA4, EA2	
18:00	345	75	255	11	EL	UA4, F	
19:00	356	86	266	9	EL	UA4, F	
20:00	6	96	276	9	EL	UA6, G, F	
21:00	15	105	285	11	EL	UA6, G	
22:00	25	115	295	15	EL	UA6, G	
23:00	34	124	304	19	EL	YO, G	
00:00	42	132	312	25	EL	YO, GM	

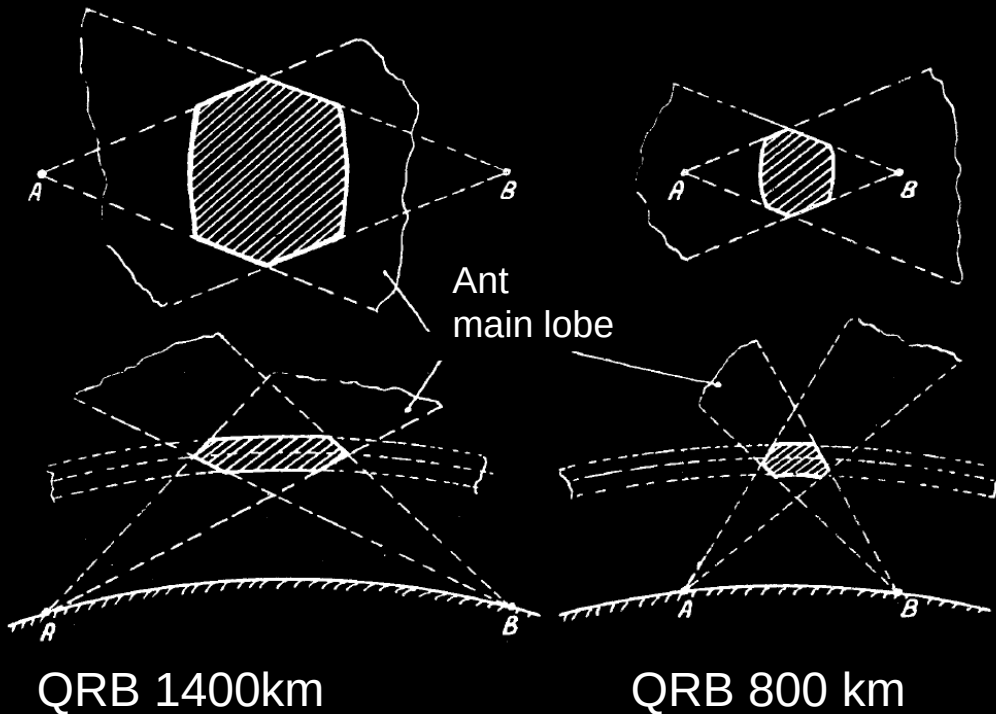
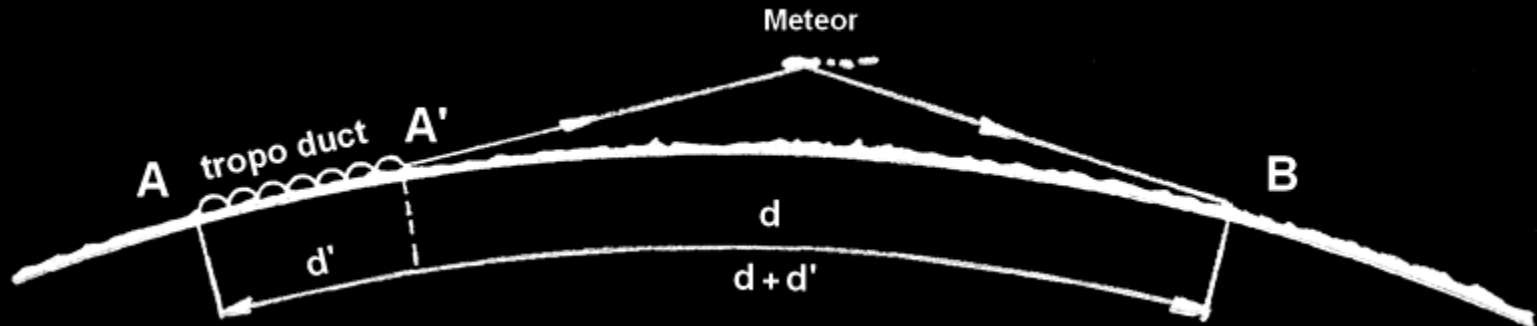


Perseids in JO70FD

UTC	AZ	RAD	AZ+90	AZ-90	RAD	EL	OK1>DXCC
00:00	39	129	309	35	EL		
01:00	50	140	320	49	EL	LZ, GM	
02:00	54	144	324	57	EL		
03:00	55	145	325	65	EL		
04:00	53	143	323	73	EL		
05:00	35	125	305	80	EL		
06:00	345	75	255	82	EL		
07:00	312	42	222	76	EL		
08:00	305	35	215	69	EL		
09:00	304	34	214	61	EL		
10:00	307	37	217	53	EL		
11:00	312	42	222	46	EL		
12:00	317	47	227	39	EL		
13:00	323	53	233	33	EL		
14:00	330	60	240	27	EL		
15:00	338	68	248	23	EL		
16:00	346	76	256	20	EL		
17:00	354	84	264	19	EL		
18:00	2	92	272	18	EL		
19:00	11	101	281	19	EL		
20:00	19	109	289	22	EL		
21:00	26	116	296	25	EL		
22:00	34	124	304	30	EL		
23:00	40	130	310	36	EL		
00:00	45	135	315	42	EL		

Maximal QRB for MS & elevation

While usually meteor trails are reflecting elmag. waves on VHF in height of 80-110km, the maximum possible distance is limited to ~2300km. However sometimes large contacts are possible thanks to tropo duct extension (like DL – EA8). While the maximum ionization usable for 70cm scattering in reasonable strength is always caused at lower altitude, so 70cm MS isn't working well above 2000 km (unless you use big dish).

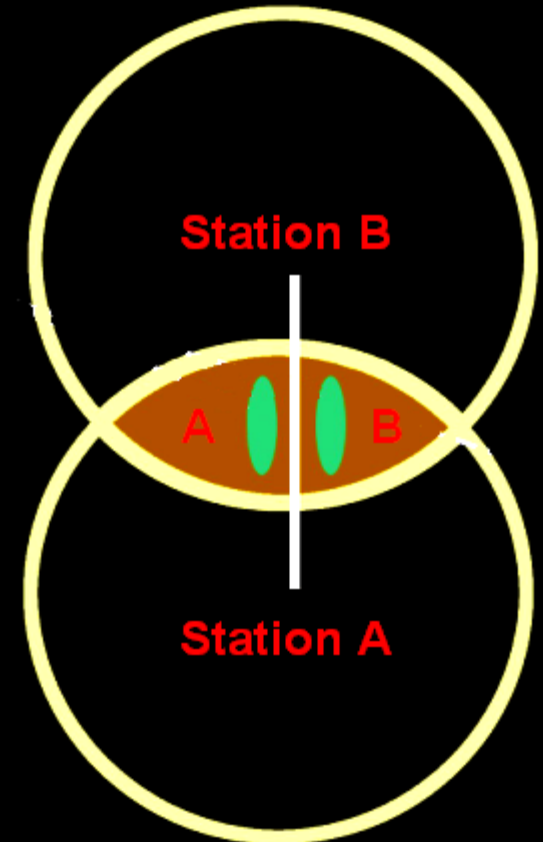


Optimal antenna beaming – HOT SPOTS

The reflecting surface for all meteorites can be anywhere in the intersection of the antennas, but it is preferable to direct the antennas to areas called "HOT POINTS". Which are elliptical regions close to a straight line, between stations, where sporadic meteors cause the most reflections. The location of the regions is not so much related to the radiant from where the sporadic meteors are arriving, but rather to the simple rule of the shortest possible signal path, or the best reflection angle. For meteor shower this is true if the meteors arrive perpendicular to the stations and as close to the middle of their distance as possible, then the shower cause reflection in the "HOT POINTS" areas just like the sporadic meteors.

For example, for a station distance of 1000km, the ideal offset is 13 degrees to one side or the other. Ideal for sporadic meteors would be if we could irradiate both areas simultaneously including the correct elevation. For showers this is not the case, as meteors seem to come from one place (the radiant), and the radiant is usually on the side of the route between stations during skeds, so simple geometry implies that we must use a more distant reflection point from the radiant to make the connection and that's why WSJT is recommending HOT-A or HOT-B.

Over distance of 1700km is the "probability region" so far that it's recommended to use direct AZ.

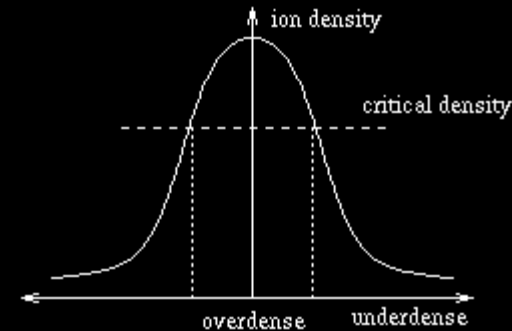


Signal characteristics

In classical meteor radar terminology, trails are classified as underdense (pings) or overdense (bursts), depending on the volume density of electrons in the wake trail. If the density is sufficiently low, radio waves can penetrate the trail and scattering occurs independently from the free electrons within the trail. If the density is large enough, secondary scattering from electron to electron becomes important. Hence the electrons no longer behave as independent scatterers and the incident wave cannot penetrate the column freely. The dielectric constant (K) of an ionized gas differs from the vacuum value of unity due to the number of electrons per m^3 (N) according to

$$\kappa = 1 - \frac{N\lambda^2}{\pi} r_e \simeq 1 - 81 \frac{N}{f^2},$$

where λ is the wavelength of the incident radiation (m), f the corresponding frequency (Hz) and $r_e = e^2 / (e_0 m_0 c^2) = 2,8 * 10^{-15}$ m the electron radius. A trail is defined as overdense when $K < 0$ throughout an appreciable volume of the ionized gas, which means that the radio waves are reflected from the surface of the meteor trail as from a metallic surface. At commonly-used meteor radar frequencies of 30-50MHz, this happens if the initial electron line density exceeds $\sim 10^{14}$ m). The axial dielectric constant can, however, be highly negative in the center of an underdense trail without resulting in total reflection; the transition from underdense to overdense scattering is not distinct.



VHF vs UHF characteristics

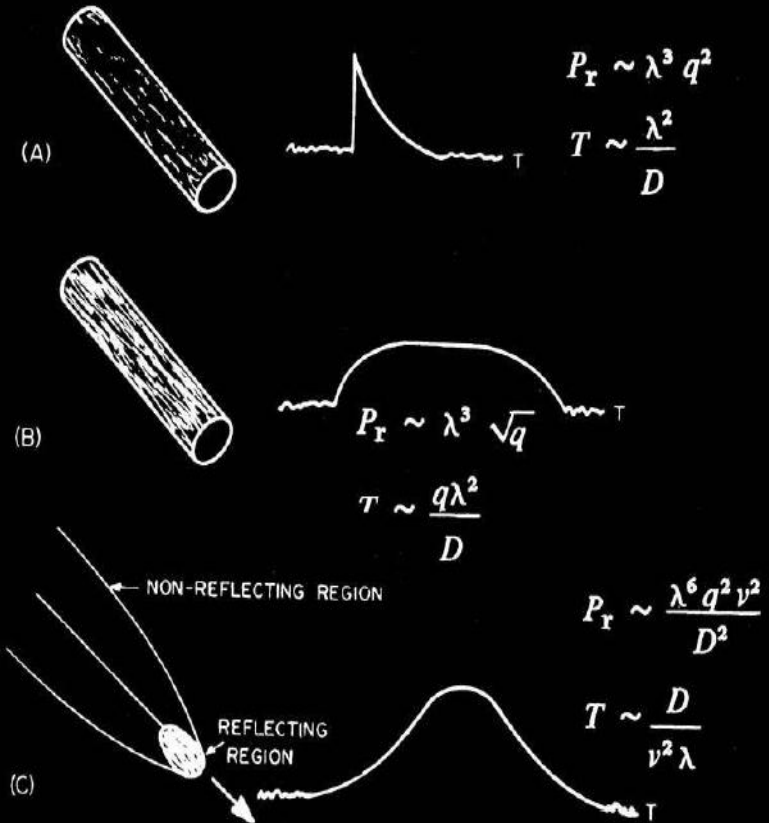
It was determined that for the most common underdense pings we can assume

Reflection duration:

$$\propto \lambda^2 (1/9^{\text{th}} \text{ of } 144 \text{ MHz})$$

Signal strength:

$$\propto \lambda^3 (1/27 \text{ of } 144 \text{ MHz } -15\text{dB})$$



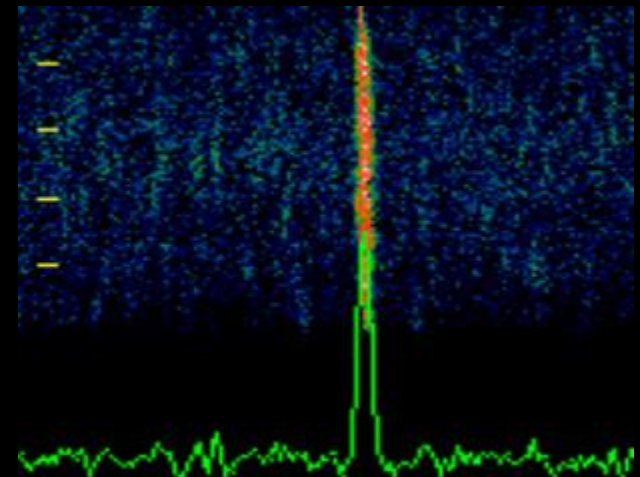
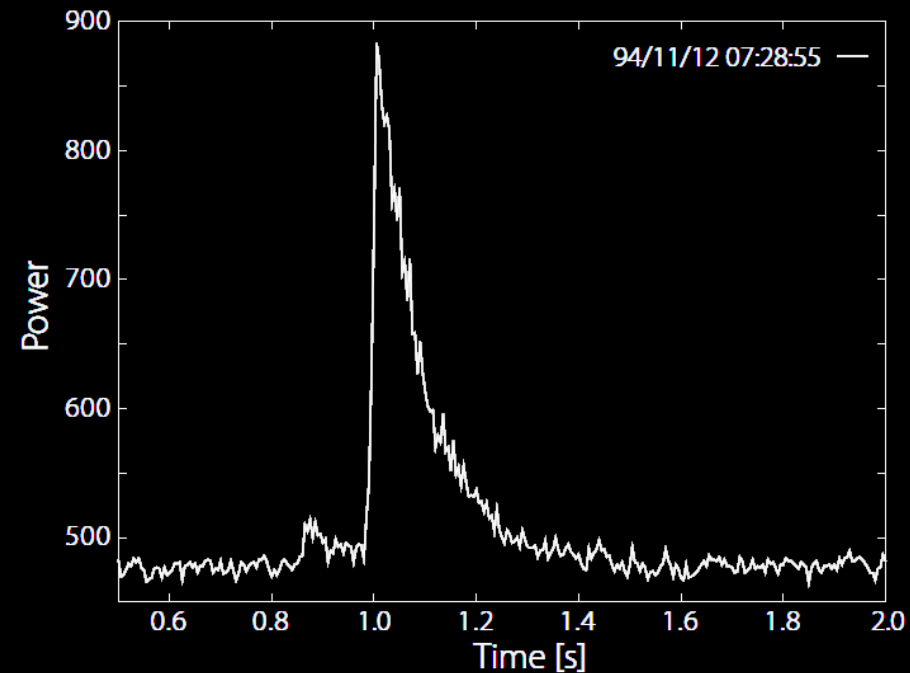
CONCLUSION:

Signal strength isn't so big problem as the length of reflection, in real practice most of 70cm reflections are very short around 50-100ms so therefore MSK144 isn't recommended!

Signal characteristics: underdense ping

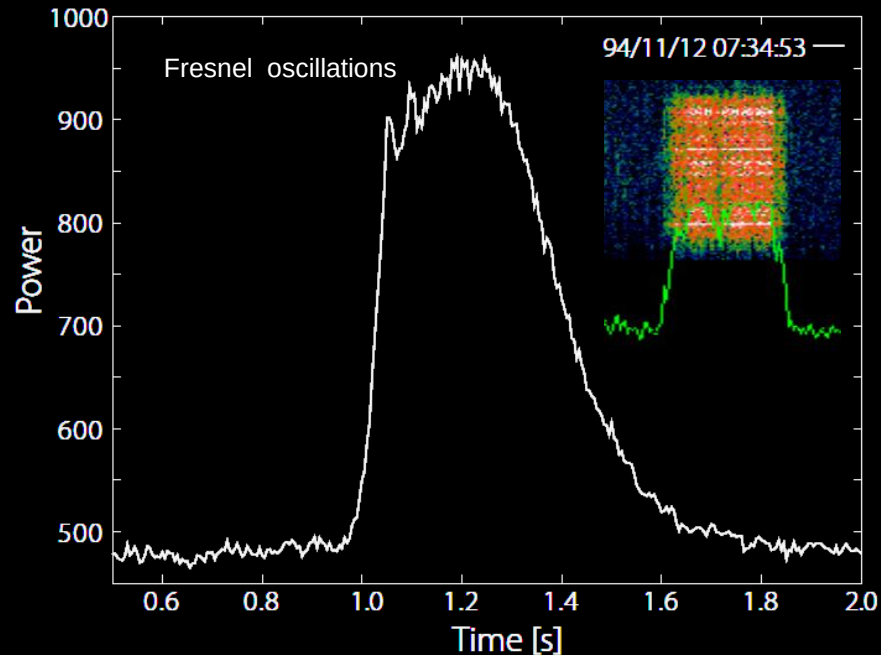
Underdense meteors of course correspond to faint meteors. Theory sets an upper limit on the line density for underdense reflection, approximately corresponding to 2×10^{14} electrons per meter. This is a line density generally associated with 5th magnitude meteors. Observations of underdense reflections cover a meteoroid mass range that is not observable with the naked eye.

The signal received from reflection on underdense trails is shown at picture: a very steep rise of a few hundreds of a second is followed by an exponential decay of the received power. The evolution of the signal power with time is called the profile of the meteor. Signals from underdense meteors last no more than a few tenths of a second. Apart from the simplicity of the received power profile, underdense meteors have two other qualities in favor of a good reduction: they are very numerous (enabling the use of statistical reduction techniques) and they strictly obey the specularly rules. This last property creates a link between the position of the meteor reflection point in the sky and the meteor path in the atmosphere. This is especially useful in all kinds of techniques associated with the radio observation of meteor streams.

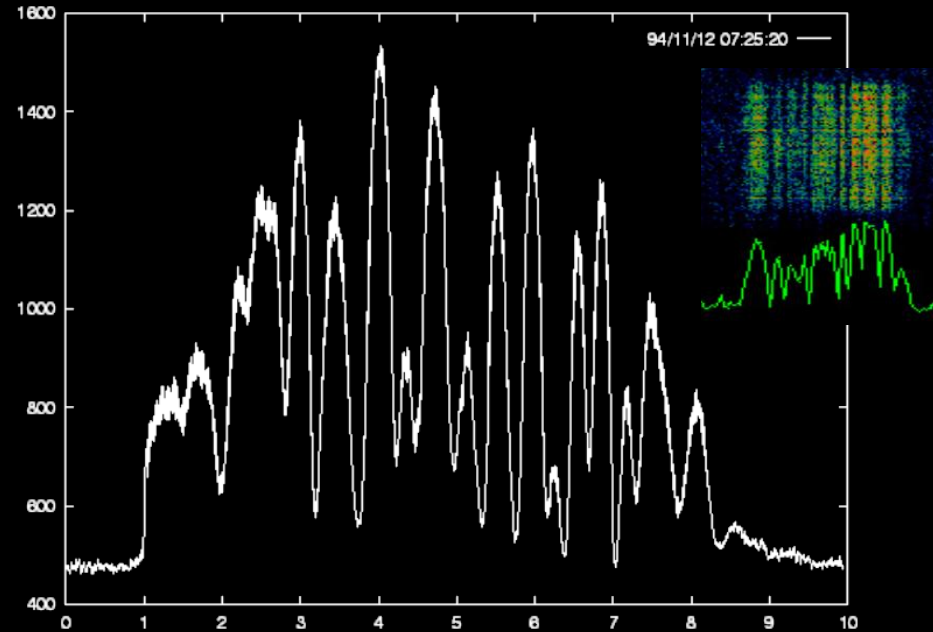


Signal characteristics: overdense burst

Overdense (saturated) reflection - less common than underdense pings (reddening). In these trails, the electron density is greater - supercritical and reflects the radio wave as a continuous reflection. The reflection onset and extinction is continuous and the maximum level can last up to tens of seconds. In general, Overdensesse "bursts" are caused by meteors that are already visible to the naked eye.



Shorter burst



Several seconds long bursts

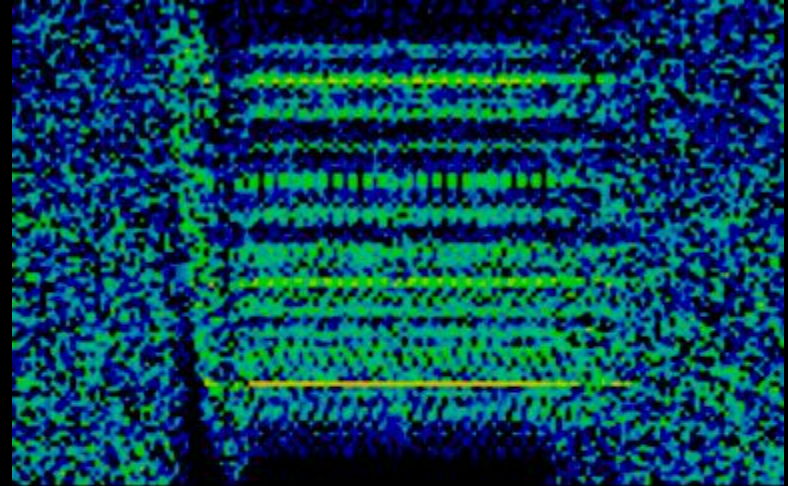
Longer bursts: In the upper atmosphere, strong winds distort the meteor trail, thus "breaking" the "meteor mirror". As a consequence, multiple reflection points can appear on the trail. Radio waves from different reflection points interfere. As the reflection points are not stationary due to the wind, fast oscillations are observed in the received signal power. This feature can only be observed in meteors after a few seconds. Consequently, it does not affect underdense meteors, as these rarely last more than a few tenths of a second. The usual frequency of the oscillations is 5 to 10 Hz. These oscillations are sometimes called "deep fading".

Signal characteristics – head-echo

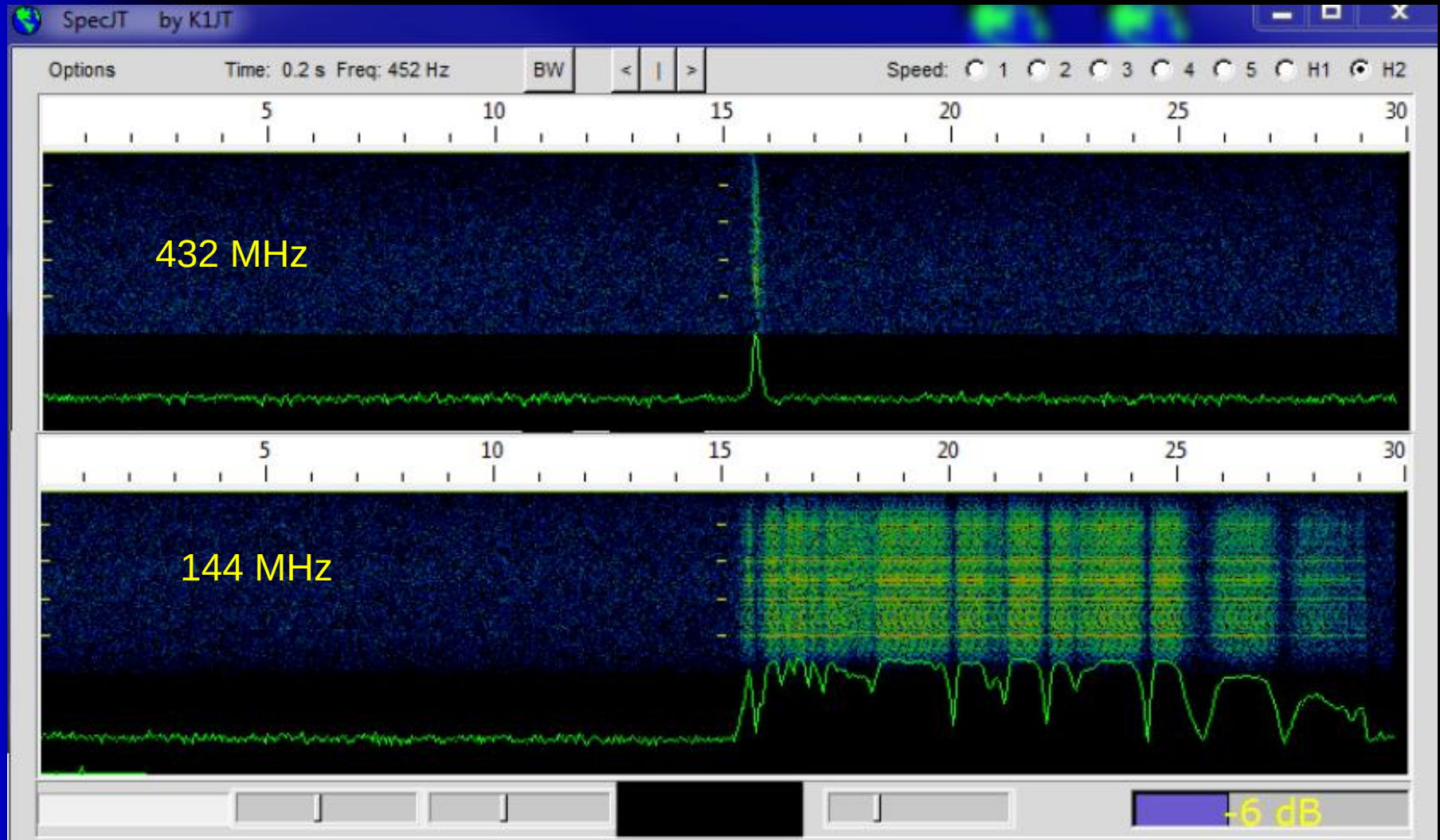
Head echo - Often a short frequency traveling whistle is heard from the main echo of the meteorite. The sound is reminiscent of the sound of a falling bomb, this is caused by the compression and rapid expansion of ionization around the head of the meteor track. The frequency shift itself is caused by Doppler shift as the meteor descends through the atmosphere and changes speed, it can reach 12-76 KHz depending on the frequency and speed of the meteor. Often the Head echo is accompanied by an Underdense ping, or Overdense burst.

Head echoes occur when meteorites have a very low inclination of their trajectory to the Earth's atmosphere; they reflect higher frequencies more often than lower frequencies, as has been observed by radar observations of multiple frequencies simultaneously (the first Fresnel zone required for higher frequencies is smaller). They last briefly for a larger zone of about 100ms. There is no 100% explanation for the Head echo, but it is thought that there is cooling and rapid recombination of ions with water vapor (which takes about 1 millisecond) at the high density front ahead of the meteorite.

Decoding of head-echo on 2m and 70cm is possible but usually very difficult.



Difference between 144 and 432 MHz



(Credits: Matt Bowman VK1MT & Dr. Kevin Johnston VK4UH, TNX)

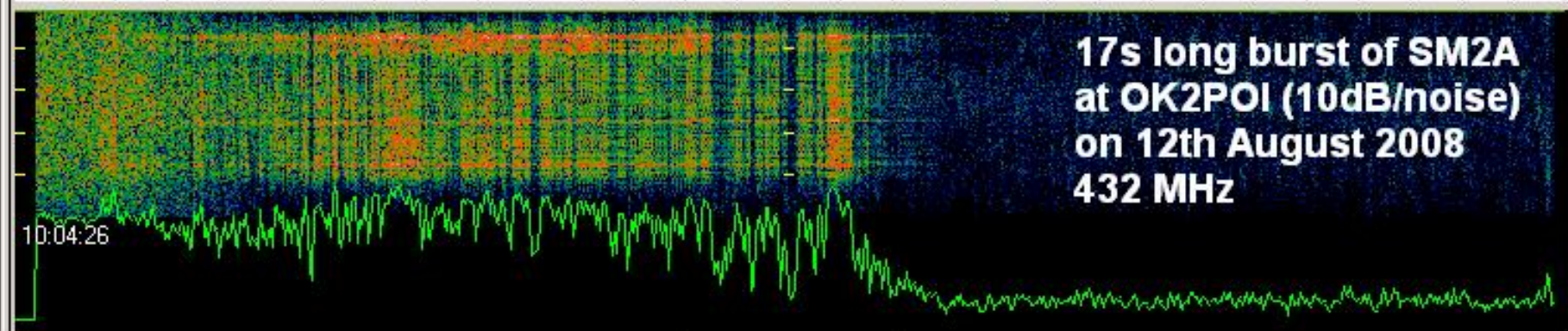
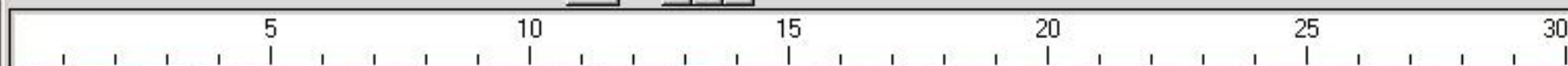
Options

Time: 30.0 s Freq: 559 Hz

BW



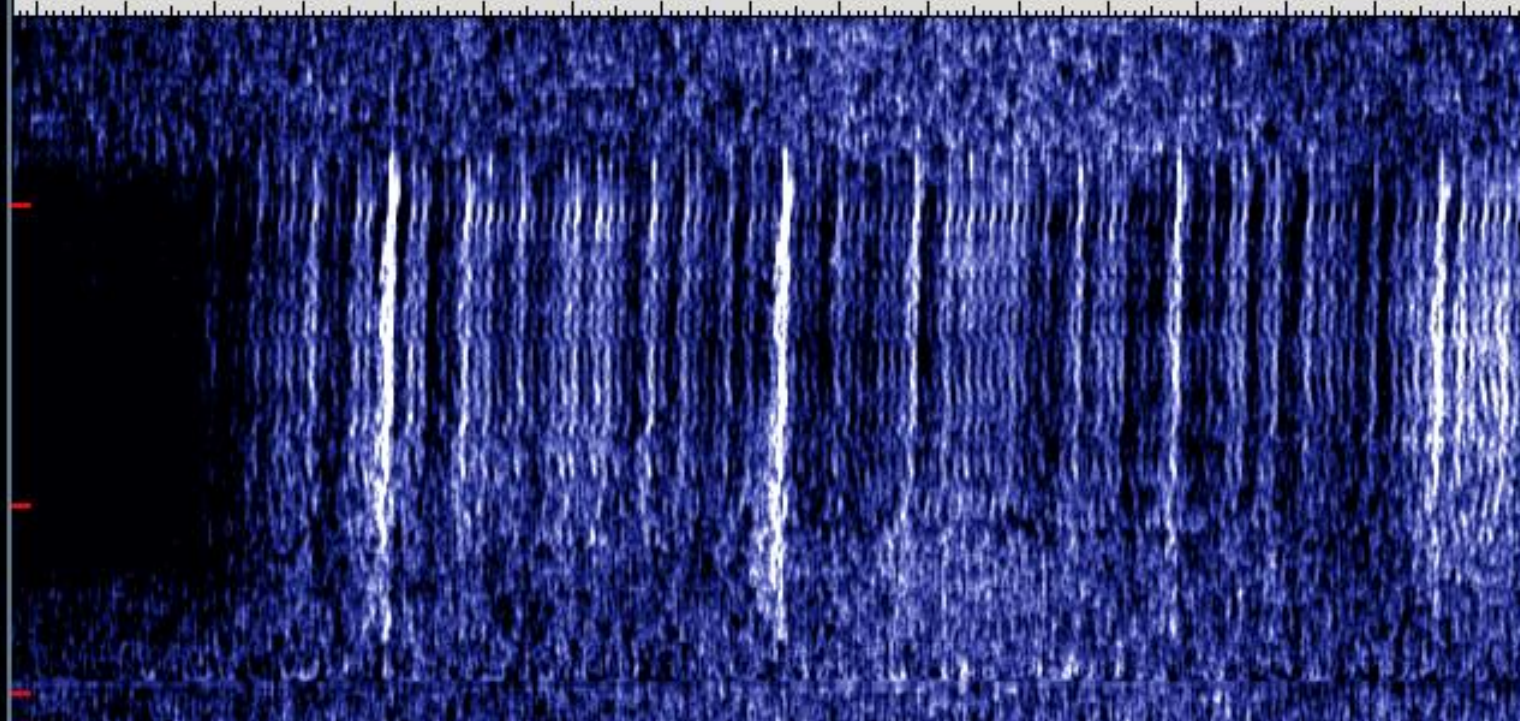
Speed: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☒ H1 ☐ H2



**17s long burst of SM2A
at OK2POL (10dB/noise)
on 12th August 2008
432 MHz**



600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 Hz



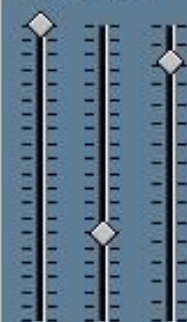
Spectran Setup Mode Palette Filters Capture About

11:05:27

13.08.2008



Ticks : 1 10 30 60 seconds



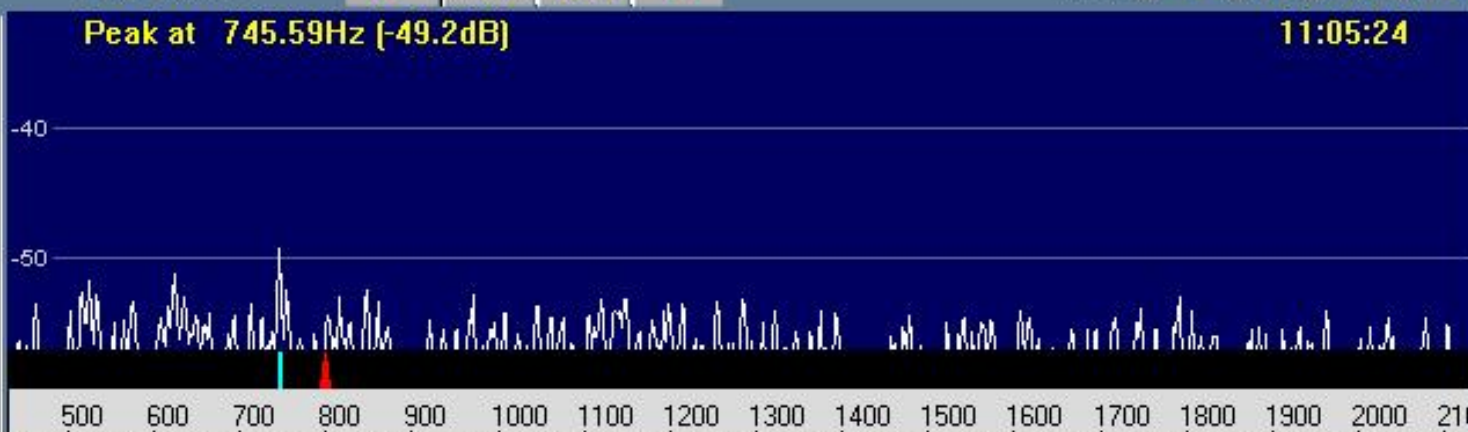
Vol Gain
Speed

- ☒ Average
- ☐ Humid
- ☒ Denoiser
- ☒ BandPass
- ☐ BandRej.
- ☐ CW Peak
- ☒ Auto brig.
- ☒ PassThru



Contrast

Freeze



Base
Hz

About 3s long burst of RK3WWF 5dB/noise
with R26 reports on 12th August 2008 on 432 MHz

Optimal MS equipment

CONCLUSIONS:

- For shorter distance like 1000km with higher elevation is better to use shorter antenna with wider main lobe. This antenna should have good F/B ration and suppressed side lobes to minimize noise.
- While due to distance of reflection point between two stations at around 400-1000km and the height of MS trail around 90km and optimal distance for maximum probability around 1400km the antenna diagram should be narrow in vertical plane and wide in horizontal plane so big advantage is to use more shorter yagies in vertical stacking with full working elevation.
- High gain antennas like 4xLY or big dish can be very useful at longer distance above 1800km.
- UHF bands compared to VHF or HF bands aren't that noisy so on 70cm it really pay off to take care of minimal antenna temperature and LNA as close to the feed or combiner as possible just like on EME. That's why it's good to use the latest antenna designs like from DG7YBN, antenna at optimal height above the roof or ground.
- Quiet countryside QTH compared to the noisy city can improve your reception up to 5dB (!)
- FSK441 or JTMS work with maximal filter width of 400Hz therefore you must be sure about your QRG!
- Due to noise temperature of the background and other factors it's still possible to make 70cm MS QSO with simple barefoot station like IC9700 and some 15el yagi while working some QRO station however more power & better antenna will result in shorter waiting and so:

70cm MS proves that LIFE IS TOO SHORT FOR QRP!

23cm Meteor Scatter – SciFi or real?

• CLOSE, HUNT, MINARDI, AND MCKEEN
Meteor Shower Characterization at Kwajalein Missile Range

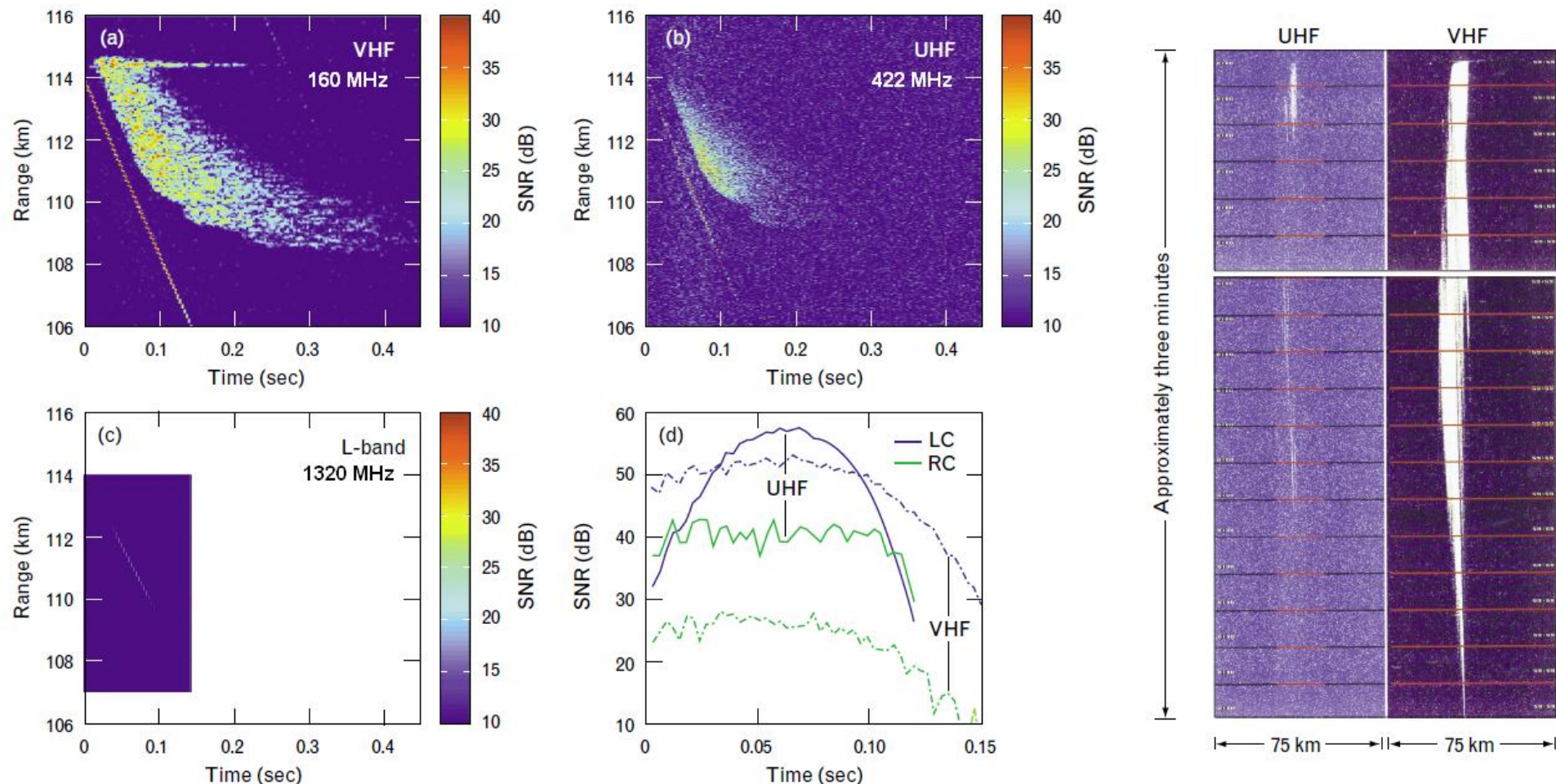
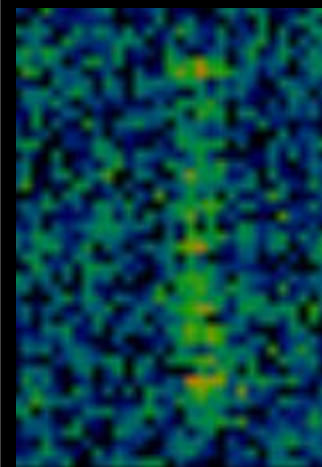
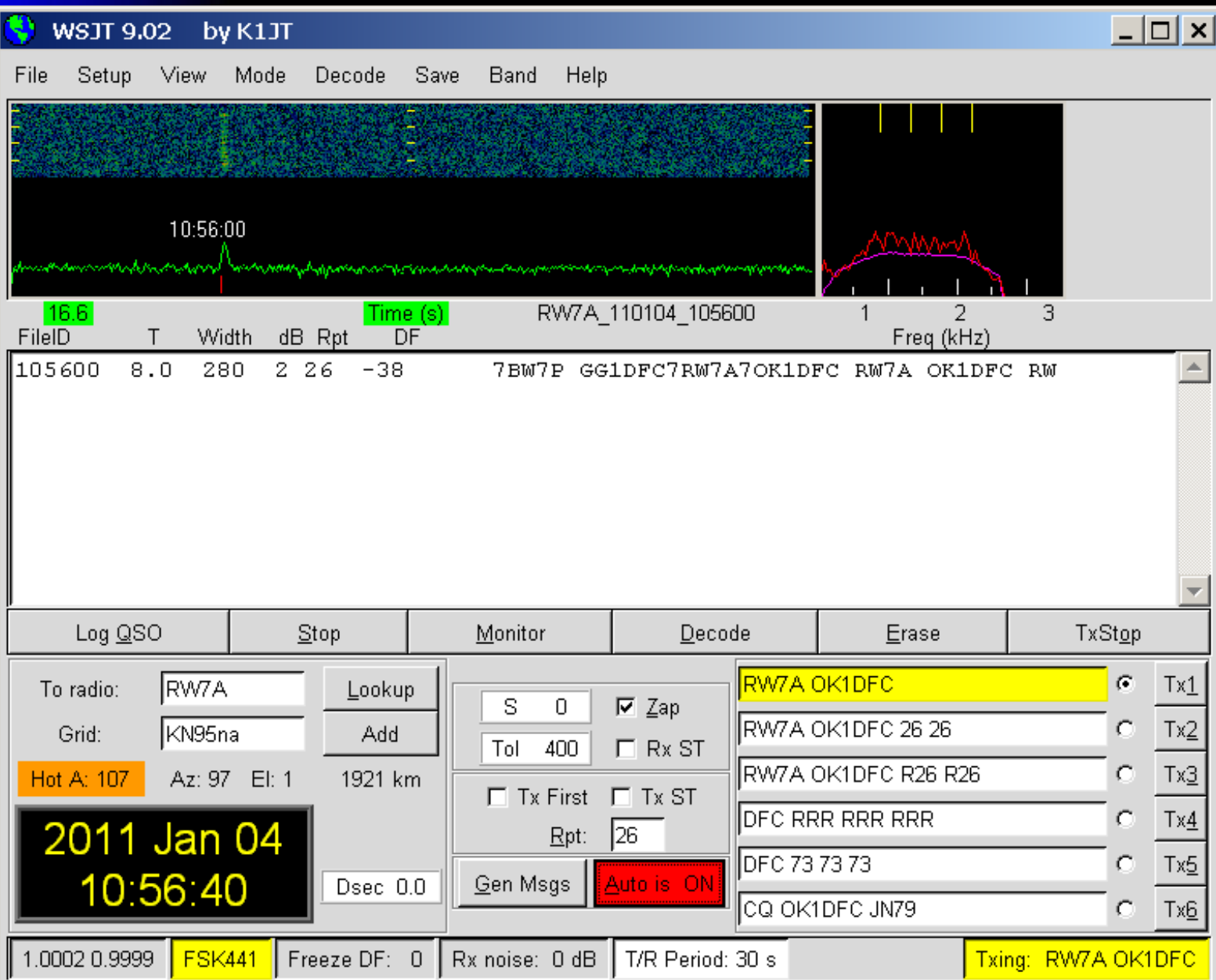


FIGURE 9. RTI images for left circular (LC) data at (a) VHF, (b) UHF, and (c) L-band. (d) The signal-to-noise ratio (SNR) of the head echo was extracted at UHF and VHF for both LC and right circular (RC) data and is plotted as a function of time.

23cm Meteor Scatter – SciFi or real?



FSK441/JTMS/MSK144, robots, chats – Operation ethics ;-)

- Every valid contacts must fit rules written at IARU's R1 VHF Manager handbook like exchange the both callsigns, reports and QSO is valid if one side receive the final RRRR. More at: <https://rudius.net/oz2m/ms.htm>
- The most important is patience, patience, **patience**... QRO, and good cooling of PA to be able to survive up to 2h long torture
- 70cm MS is far better with FSK441/JTMS than with MSK because of shorter reflections with length around 60ms however this presentations isn't primarily focused to digital modes
- 23cm MS – good to wait for Leonids 2032 (?!)



Any questions?

73 & GL!

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