EDGES MEMO #490

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To: EDGES group

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Subject: Study of FM reflections in data from Adak

The data from Adak has only very weak FM reflections as it is the most remote site from which EDGES data has been obtained. While studies of FM reflections have been made using the EDGES data from WA in memos 250, 424 and 468 and from Devon Island in memo 400 it has not been possible to determine the origin of the reflections except on the days when they are clearly associated with meteor showers listed in memo 469.

The calculated loss for reflections required to meet the ITU RA769-1 recommendation for Radio Astronomy (RA769-1) were made in memo 53 and the geometry of meteor scatter is shown in memo 54. These calculations show that line of sight reflections from meteors that produce ionization no higher than 100 km altitude will be blocked by the curvature of the earth at sites more than about 2000 km from the FM transmitter.

Figure 1 shows the spectra from Adak averaged over 24 hours with no RFI excision and no smoothing and in Figure 2 with the moon below the horizon. The average over all days is shown on a scale expanded by a factor of 10. The FM stations which can be identified as being in Anchorage are 92.9 KFAT 93.7 KATZ and 94.7 KZND. The signal at 93.7 MHz is clearly present each day and since Anchorage is about 2000 km from Adak it is probably due to reflections from satellites which orbit the earth well above 100 km like the space station at about 400 km and starlink at about 550 km. The starlink V2 satellites are the largest objects in orbit over Adak as the space station orbit is all south of Adak and consequently reflections from the space station are probably not in the Adak data. Also no strong reflections like those shown in the “waterfall” plots of memo 469 are seen in the Adak data.

Figures 1 and 2 show that the reflections at 93.7 MHz are present each day at about 1 K averaged over each day and average to about 1 K over all days. Also there is little difference when data with the moon is above the horizon. This is consistent with the peak FM reflections expected from the moon of about 0.25 K estimated in memo 244.

Figure 3 shows that 93.7 MHz peaks to about 10K in the 3 minute blocks at 4.40 and 5.15 hours and averages down to about 2K over the full data span of 1.15 hours. This reduction of a factor of about 5 in the average implies that the peak reflections at 93.7 MHz last for about 20% of the time or about 12 minutes out of the hour. The V2 satellites orbit the earth in about 90 minutes and the reflected signal strength depends on the radar cross-section of the satellite as well as its location and orientation. Repeating the test used in figure 3 with 6 minute blocks also gives factor of about 5 and going to 1.5 minute blocks gives the same average of 2K but is too noisy to measure any peaks in the 1.5 minute blocks.

The expected peak strength for the reflection of 100 kw FM signal from a starlink satellite is calculated to be about 10 K with 6 kHz resolution shown in the figures assuming:

distance FM transmitter to satellite = 550 km
distance of EDGES to satellite = 1000 km
radar cross-section 100 square m (most are now V2)
EDGES gain 6
transmitter gain 1
FM transmitter 100 kw at 100 MHz
EDGES resolution 6 kHz (as shown in the figures)

The Adak site is probably one of the very best available on the earth for observations of the global 21-cm signal and is probably better than can be achieved in lunar orbit as described in memo 279 or on the lunar surface without a large ground plane as described in memo 422.

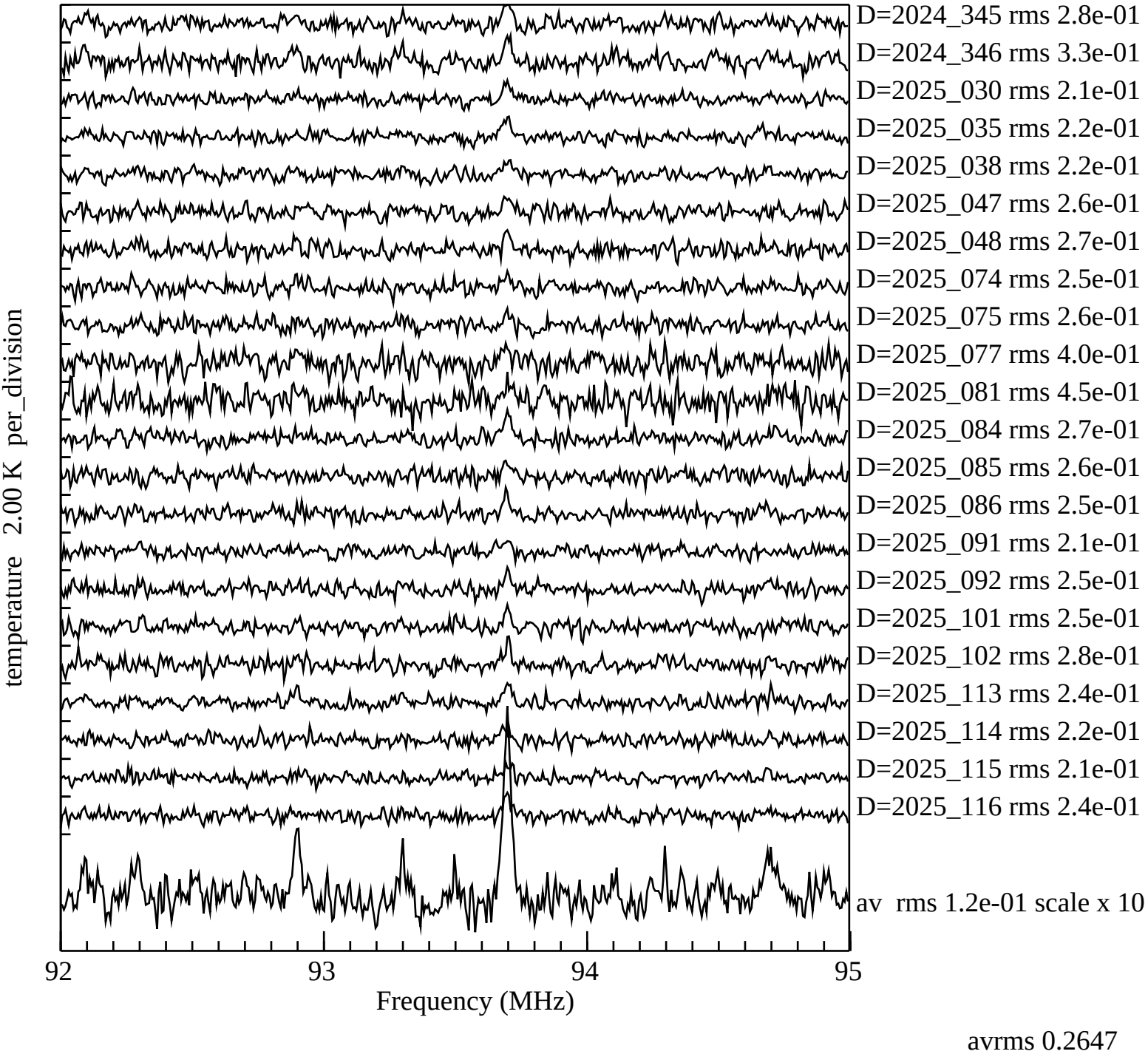


Figure 1. Spectra from each day at Adak averaged over all hours without rfi filtering

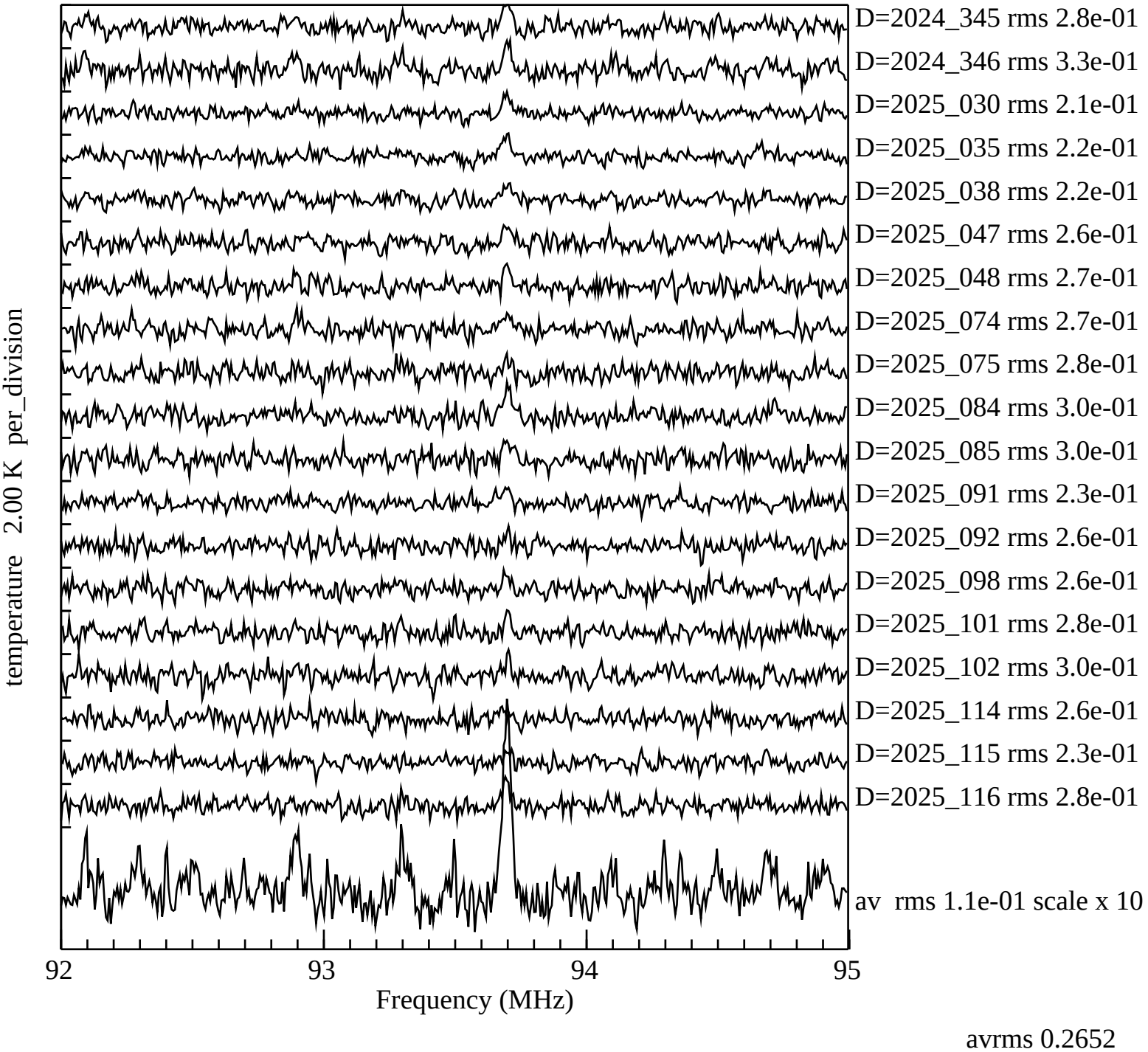
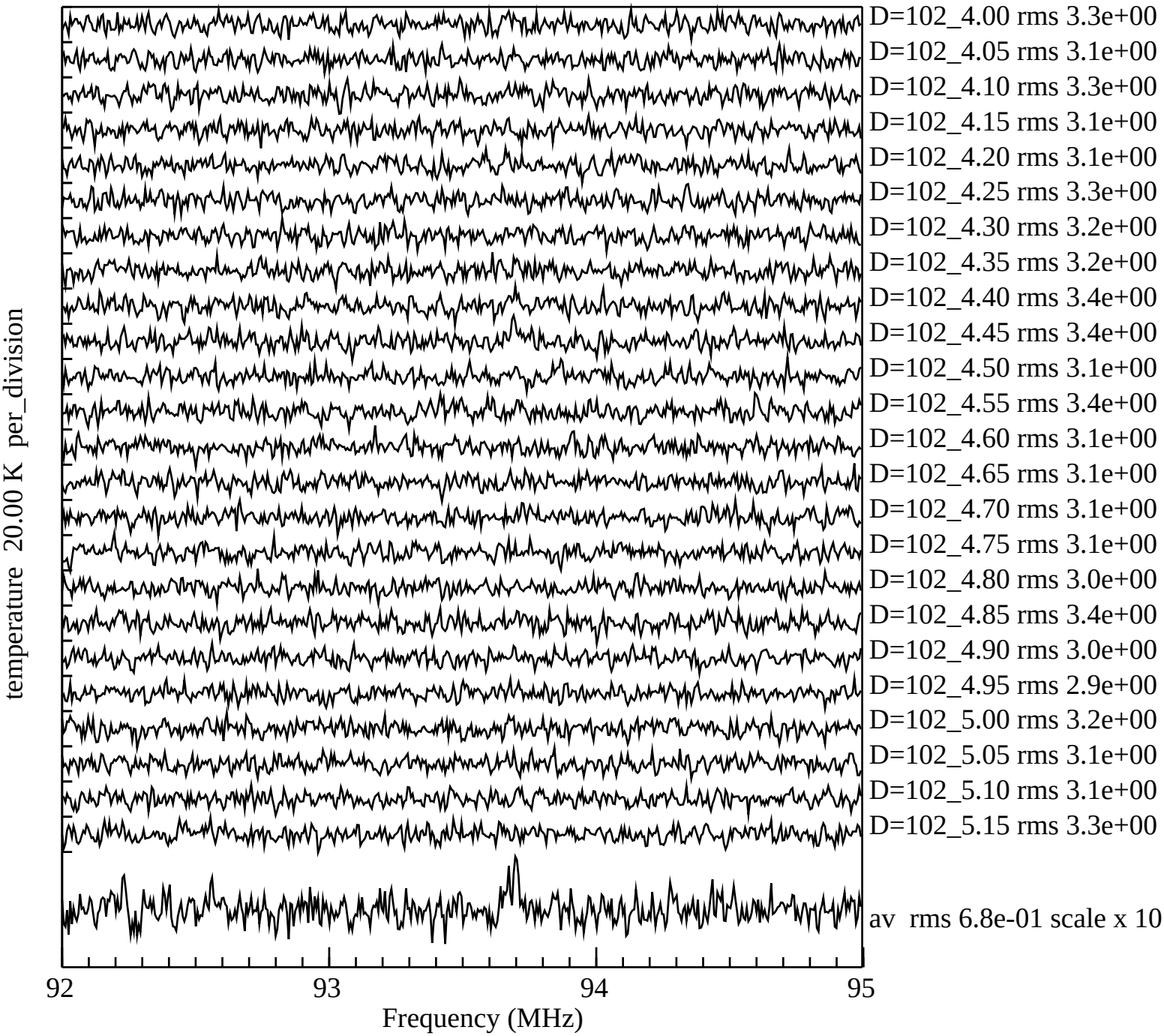


Figure 2. Spectra averaged over all hours with the moon below the horizon



avrms 3.1754

Figure 3. Spectra averaged over 3 minute (0.05 hr) blocks on 2025 day 4:00 to 5:09 UT