MM-wave issues -- Myth and reality

Harvey Liszt
ALMA & NRAO, CHARLOTTESVILLE

mm-waves

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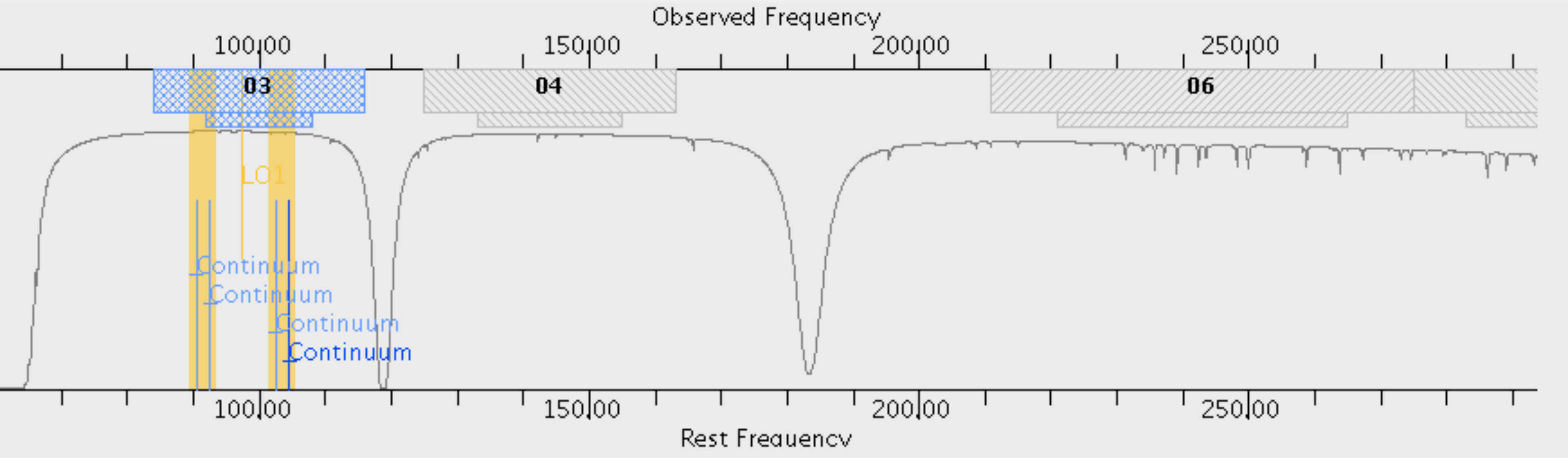
- The spectrum is allocated up to 275 GHz
- ALMA works up to 950 GHz, soon beyond

Myth: Air absorbs stray mm radiation

MM-wave transmission at median ALMA weather



Plots have linear vertical scale for transmission

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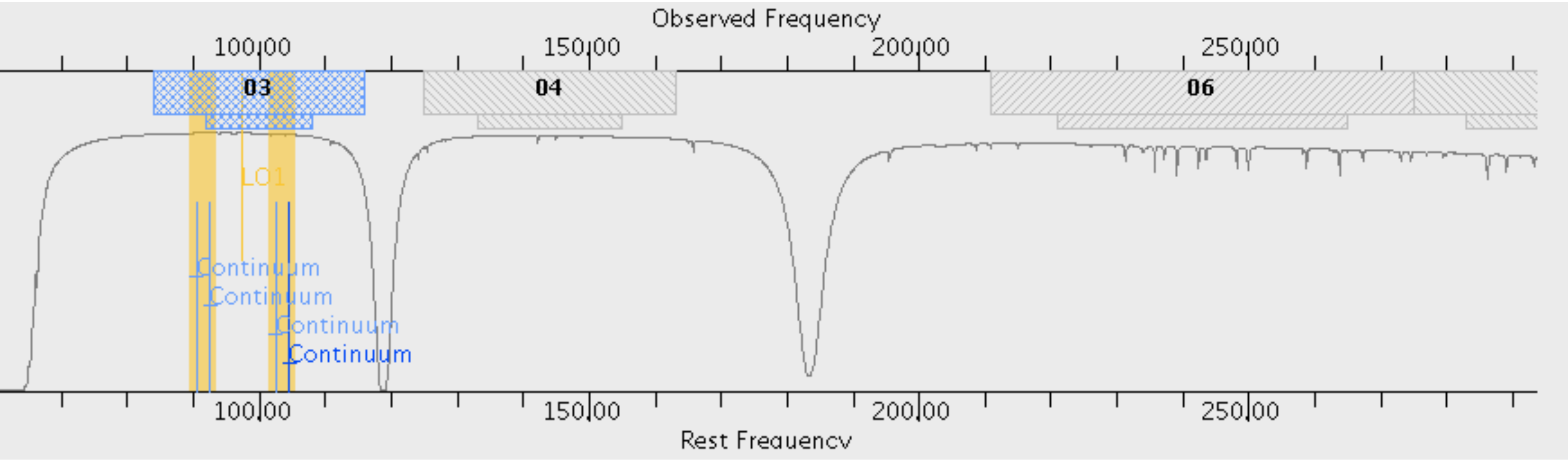

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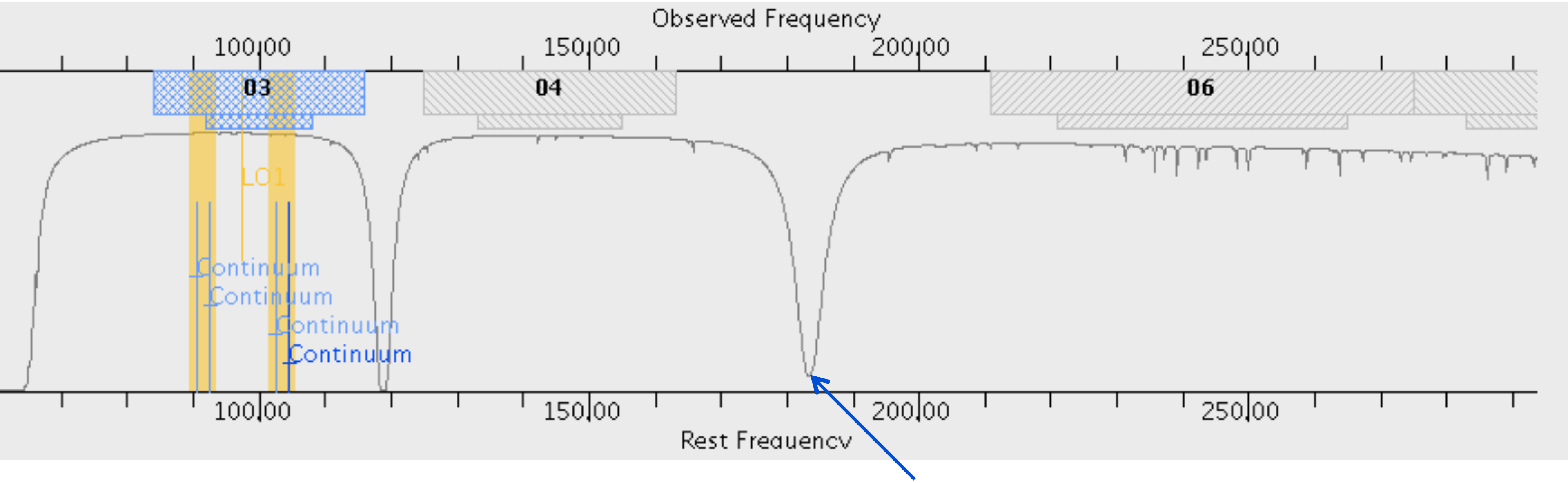

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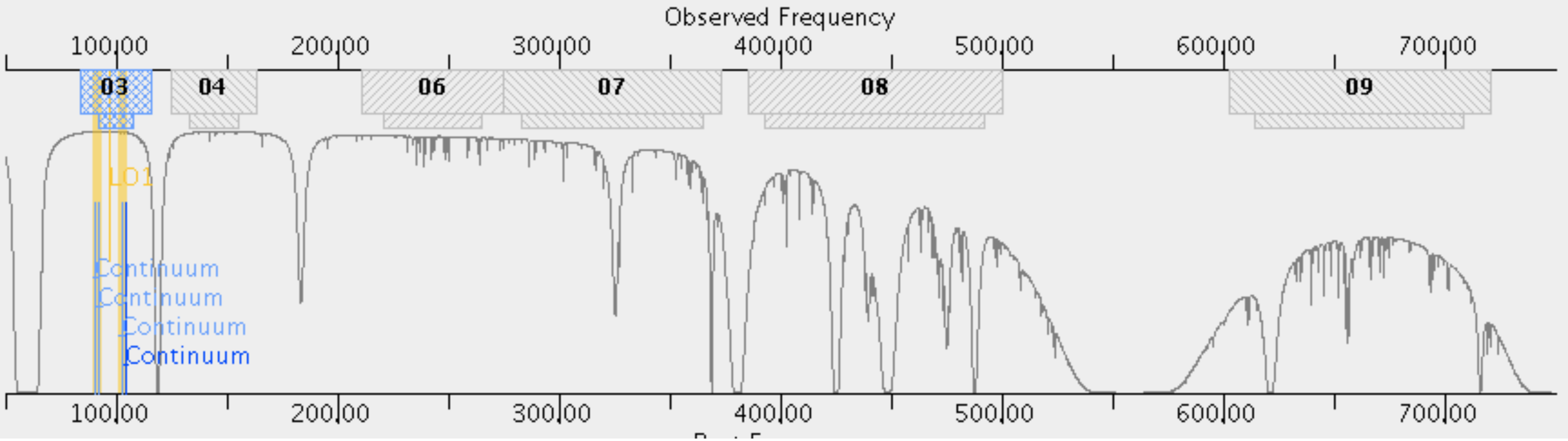
A broader view in the 1st octile of ALMA weather



ALMA is currently taking band 10 test data (787-950 GHz) and band 11 (1000-1600 GHz) is under development

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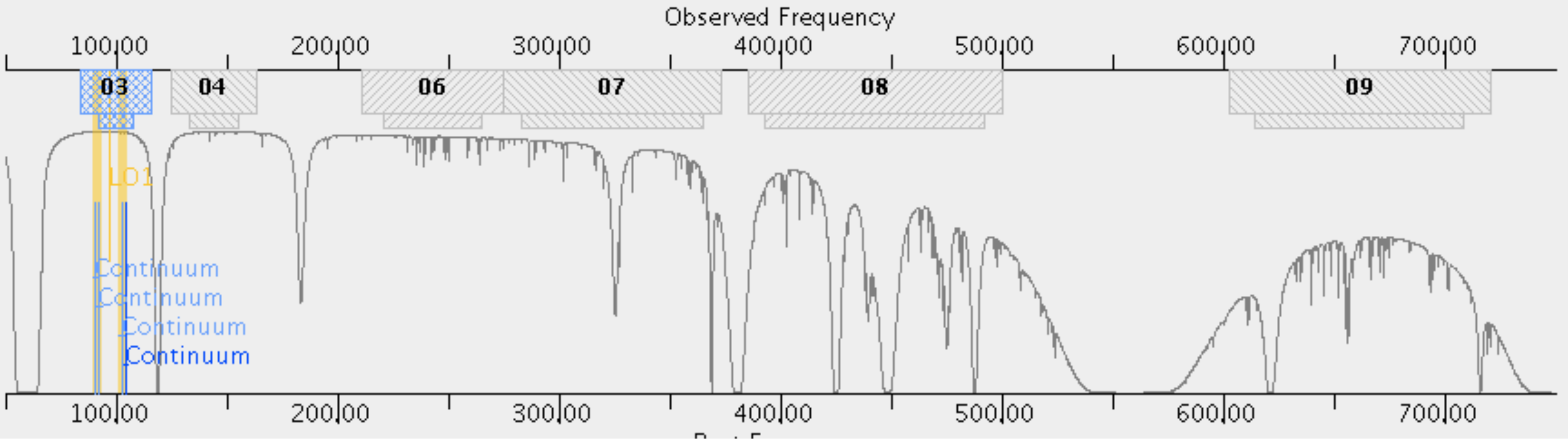

Things get pretty choppy above 350 GHz

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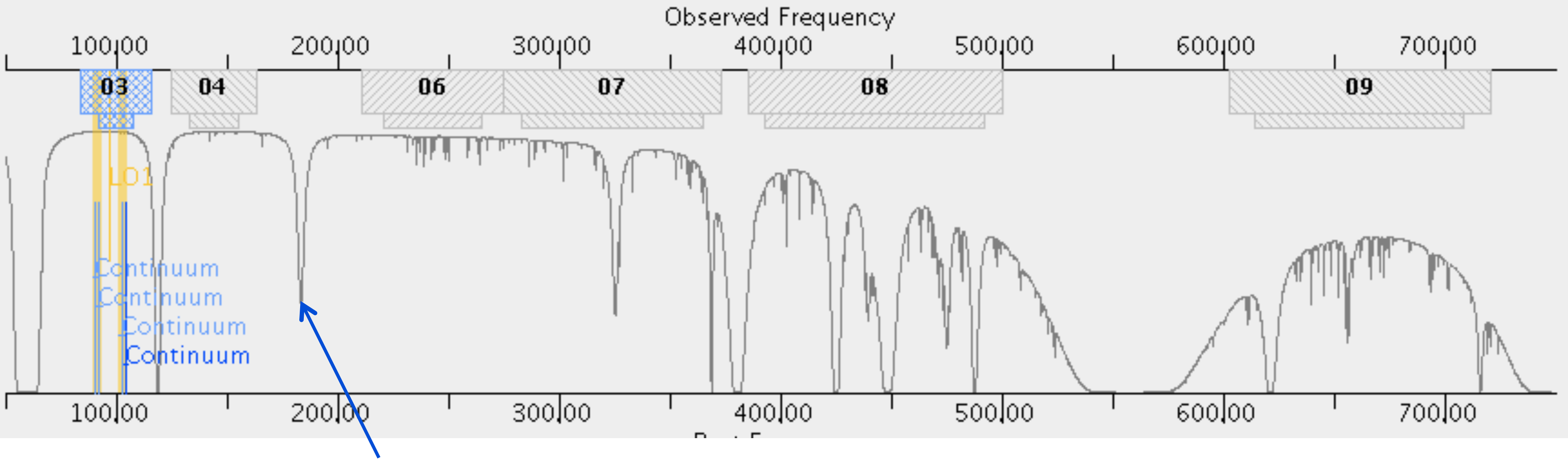

Things get pretty choppy above 350 GHz
but look how much things improved at 183 GHz

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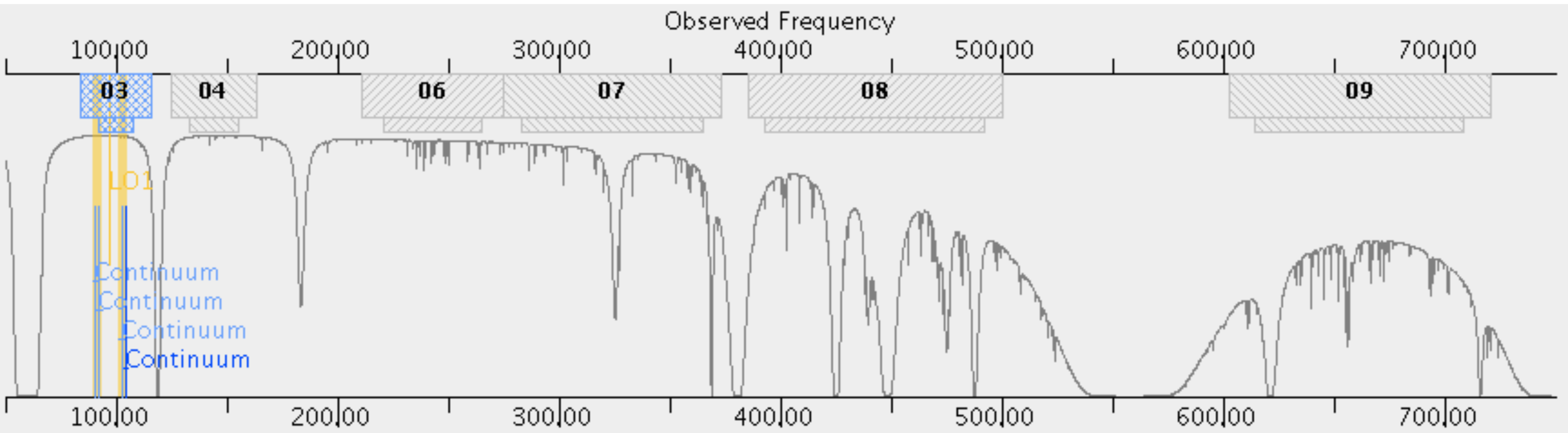
A broader view in the 1st octile of ALMA weather



Things get pretty choppy above 350 GHz

There is abundant spectrum for use by short-range high frequency applications in non-interfering spectral regions

Some numbers

ITU-R 79 GHz radar studies use 6 dB/km in "wet" air when doing studies against most services

ITU-R 79 GHz studies use ~0.15 dB/km vs RAS

ITU-R 230 GHz studies would use 0.34 dB/km vs RAS

(based on median 230/79 GHz conditions at ALMA)

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The pigeons are now coming home to roost

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CloudSat 94.05 GHz radar

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EarthCare 94.05 GHz radar

35.5-36, 133.5-134 GHz

Myth: MM band structure protects RAS

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Case study Level Probing Radar

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If one of these things interfered with your telescope it could be there *forever*

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regulators acting badly

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Ohmart/VEGA has a nice radar primer!

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James Clerk Maxwell - predicted the existence of radio waves in his theory of electromagnetism (Pic. 1.1 - J.C.M.F)

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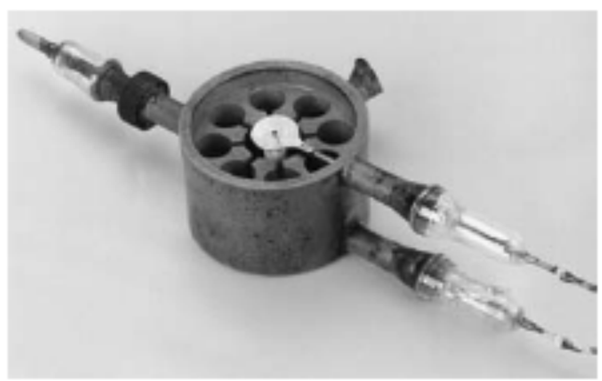

Cavity Magnetron - the world changing invention by John Randall and Harry Boot invented in 1940 (Pic. 1.11 - GEC)

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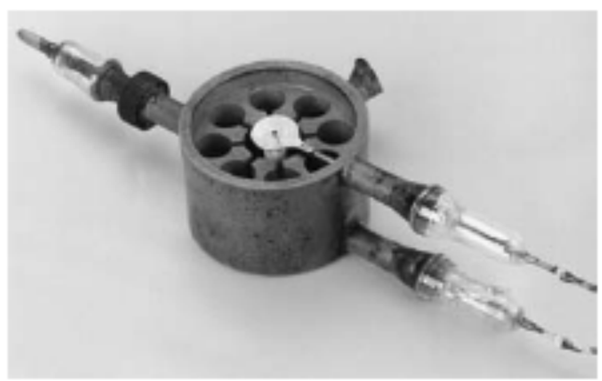

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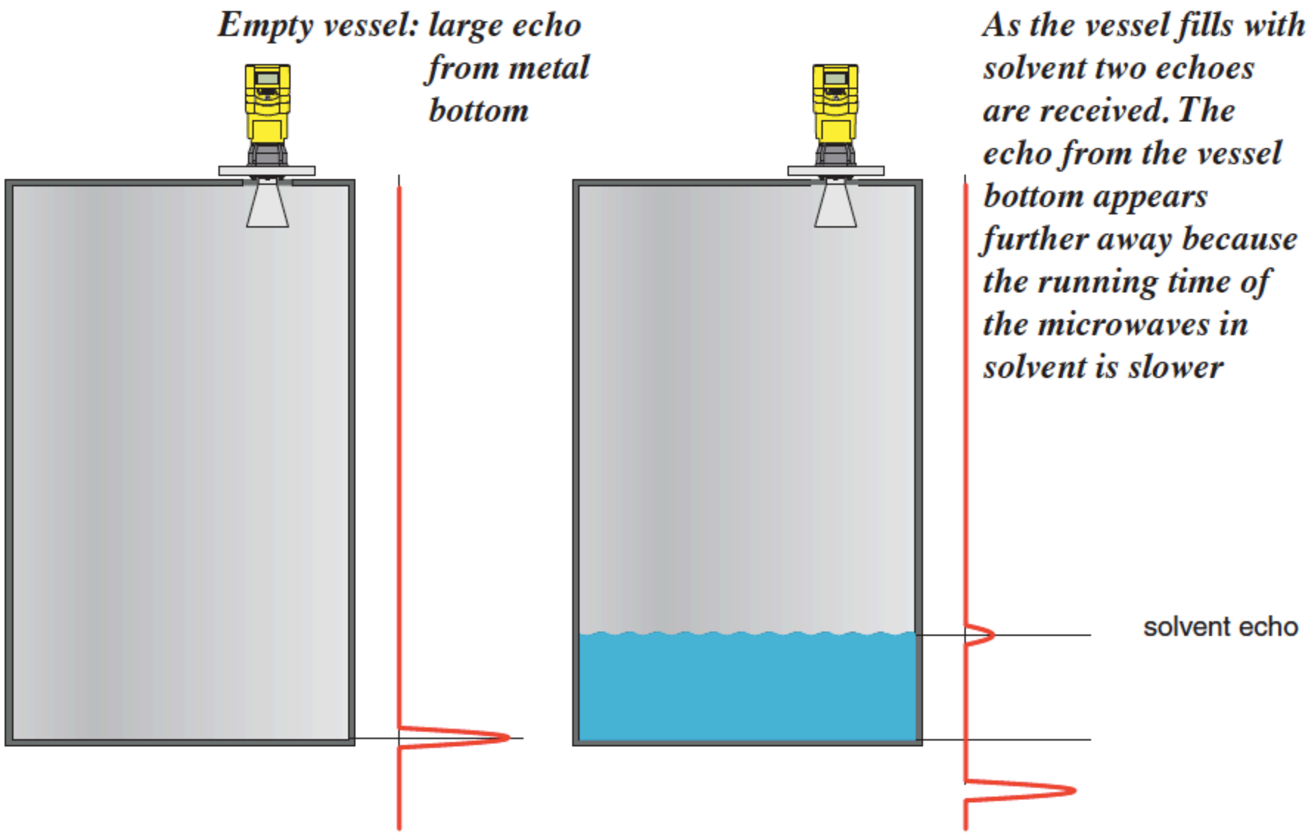

Fig 2.3 - Effect of dielectric constant on the running time of a microwave radar

Myth: MM band structure protects RAS

Federal Communications Commission FCC 14-2

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
Amendment of Part 15 of the Commission's Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz	)	ET Docket No. 10-23
Amendment of Part 15 of the Commission's Rules To Establish Regulations for Level Probing Radars and Tank Level Probing Radars in the Frequency Bands 5.925-7.250 GHz, 24.05-29.00 GHz and 75-85 GHz	)	
Ohmart/VEGA Corp., Request for Waiver of Section 15.252 to Permit Marketing of Level Probing Radars in the 26 GHz Band	)	ET Docket No. 10-27

REPORT AND ORDER and ORDER

Adopted: January 15, 2014 **Released: January 15, 2014**

Myth: MM band structure protects RAS

The Commission stated its belief that LPR operation in the 75-85 GHz band would not adversely affect incumbent authorized users, because this band is currently sparsely used and the propagation losses are significant at these frequencies, making harmful interference unlikely beyond a short distance from the LPR device.[79]

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b. Additional Protection for the Radio Astronomy Service (RAS)

59. *Distance Separation and Height Restrictions.* As noted above,[168] CORF notes that RAS has primary allocations at 76-77.5 GHz and 78-85 GHz and does not oppose sharing these bands with LPRs provided the Commission adopts certain protections designed to ensure that RAS can operate in the interference-free environment that the service requires for picking up extremely weak signals.[169] More specifically, CORF and NRAO request that these protections include exclusion zones around RAS stations, restrictions on the height of LPR antennas, requirements for antenna installation, a restriction of operations to fixed installations only, and the deployment of a publicly accessible database of all LPR installations. CORF and NRAO state that the ECC Report 139 recommends a geographical region in which LPRs cannot be installed within 4 km from RAS locations and a limit of 15 meters above ground level on LPR antenna height within 40 km of these locations.[170] They request that the Commission require the same distance separation and height restrictions to protect RAS stations, particularly in the 6650-6675.2 MHz[171] (part of the 5.925-7.250GHz band) and 75-85 GHz bands.[172] MCAA, which represents the LPR industry, agrees with the separation distance and height restrictions to protect RAS sites.[173]

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Myth: MM band structure protects RAS

60. The Commission did not propose these restrictions in the *FNPRM* because interference to RAS observatories from downward-looking LPRs is unlikely. First, the ETSI/ECC distance and antenna height limitation requirements are based on the RAS operating environment in Europe where RAS sites are typically found in urban areas; this is a different environment than in the United States, where RAS receivers are commonly located in remote or rural areas, not the industrial areas where LPRs are likely to be found.

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Third, RAS receivers discriminate against off-beam signals and are pointed skyward, discriminating against reflected signals that would be reflected from the side or below. Even in the case of LPRs installed over waterways in remote areas, because the radio astronomy observatories typically have control over access to a distance of one kilometer from the telescopes to provide protection from interference caused by uncontrolled RFI sources,[174] the potential for interference caused by LPRs at that distance (one kilometer) would be infinitesimal, when also taking into account the variability in uses.

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While the MCAA does not oppose the restrictions proposed by CORF and NRAO, MCAA represents only a segment of current LPR users of the band and does not necessarily anticipate future uses. Accordingly, we are denying CORF and NRAO's requests for separation distances from radio astronomy observatories and for a limitation on LPR antenna height within certain distances of the line of sight of RAS stations.

Myth: MM-wave radio astronomy …

76-77.5
RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
Space research (space-to-Earth)
5.149

77.5-78
AMATEUR
AMATEUR-SATELLITE
Radio astronomy
Space research (space-to-Earth
5.149

78-79
RADIOLOCATION
Amateur
Amateur-satellite
Radio astronomy
Space research (space-to-Earth
5.149 5.560

79-81
RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
Space research (space-to-Earth)
5.149

81-84
FIXED
FIXED-SATELLITE (Earth-to-space)
MOBILE
MOBILE-SATELLITE (Earth-to-space)
RADIO ASTRONOMY
Space research (space-to-Earth)
5.149 5.561A

84-86
FIXED
FIXED-SATELLITE (Earth-to-space) 5.561E
MOBILE
RADIO ASTRONOMY
5.149

86-92
EARTH EXPLORATION-SATELLITE (passi
RADIO ASTRONOMY
SPACE RESEARCH (passive)
5.340

92-94
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

94-94.1
EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
SPACE RESEARCH (active)
Radio astronomy
5.562 5.562A

94.1-95
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

95-100
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
RADIONAVIGATION
RADIONAVIGATION-SATEL
5.149 5.554

100-102
EARTH EXPLORATION-SA
RADIO ASTRONOMY
SPACE RESEARCH (passi
5.340 5.341

136-141
RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
5.149

141-148.5
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

148.5-151.5
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)
5.340

151.5-155.5
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

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RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
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5.149

78-79
RADIOLOCATION
Amateur
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Radio astronomy
Space research (space-to-Earth)
5.149 5.560

79-81
RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
Space research (space-to-Earth)
5.149

92-94
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

94-94.1
EARTH EXPLORATION-SATELLITE (active)
RADIOLOCATION
SPACE RESEARCH (active)
Radio astronomy
5.562 5.562A

94.1-95
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

95-100
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
RADIONAVIGATION
RADIONAVIGATION-SATEL
5.149 5.554

136-141
RADIO ASTRONOMY
RADIOLOCATION
Amateur
Amateur-satellite
5.149

141-148.5
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

151.5-155.5
FIXED
MOBILE
RADIO ASTRONOMY
RADIOLOCATION
5.149

Myth: MM-wave radio astronomy …

226-231.5
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340

Myth: MM-wave radio astronomy …

226-231.5
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340

Divide 231 GHz/3 = 77 GHz

Myth: MM-wave radio astronomy …

226-231.5
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340

Myth: MM-wave radio astronomy …

226-231.5 EARTH EXPLORATION-SATELLITE (passive) RADIO ASTRONOMY SPACE RESEARCH (passive) 5.340
231.5-232 FIXED MOBILE Radiolocation
232-235 FIXED FIXED-SATELLITE (space-to-Earth) MOBILE Radiolocation

Myth: MM-wave radio astronomy …

226-231.5
EARTH EXPLORATION-SATELLITE (passive)
RADIO ASTRONOMY
SPACE RESEARCH (passive)

5.340

231.5-232
FIXED
MOBILE
Radiolocation

232-235
FIXED
FIXED-SATELLITE (space-to-Earth)
MOBILE
Radiolocation

DARPA Video Synthetic Aperture Radar (ViSAR)

The U.S. Defense Advanced Research Projects Agency (DARPA) has launched a program to develop a millimeter wave synthetic aperture radar system that can image at a rate of at least 5 frames per second. Such a system would allow essentially real-time surveillance through clouds and dust, from aerial platforms. The initial platform is planned to be the Lockheed Martin AC-130J. Existing synthetic aperture radar systems require too much backend processing to provide real-time video data.

Status: Proposed Use

Frequency Bands

Band	Use	Service	Table
231.5 - 235 GHz	DARPA ViSAR	Radiolocation	-

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Myth: ALMA is the only major radio astronomy observatory without a spectrum management program

Myth: “Sandy” is a real person

Sandy is a real person

National Radio Astronomy Observatory
A facility of the National Science Foundation

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Monday, April 7, 2014

2011 Jansky Lecturer

Dr. Sander Weinreb Awarded the 2011 Jansky Lectureship

The 46th Annual Jansky Lecture will be given by Dr. Sander Weinreb of NASA's Jet Propulsion Laboratory and the California Institute of Technology and is entitled **"Radio Astronomy from Jansky to the Future - An Engineer's Point of View".** Dr. Weinreb is being honored for his pioneering developments of novel techniques and instrumentation over nearly half a century which have helped to define modern radio astronomy.

Dr. Sander Weinreb

The first lecture will take place in Charlottesville on **Tuesday, September 20, at 7:00 pm** at Cramer Auditorium at the NRAO Technology Center (NTC) with an informal reception held at 6 pm prior to the lecture.
Green Bank will host Dr. Weinreb on **Wednesday, September 21 at 3:30 pm** in the Green Bank Science Center Auditorium.
The final Lecture of the series will be held in Socorro on **Friday, October 14, 2011 at 8:00 pm** at the Workman Center on campus at New Mexico Tech.

Weinreb received his PhD degree in electrical engineering from the Massachusetts Institute of Technology in 1963. While he was still a graduate student at MIT, he developed the world's first digital autocorrelation spectrometer which he then used to place a new upper limit to the Galactic deuterium to hydrogen ratio, and with Al Barrett, Lit Meeks, and J. C. Henry, he detected the OH ion, which was the first radio observation of an interstellar

Harvey Liszt

Myth: It is possible to convert from Jy to μV/m

REPORT ITU-R RA.2131

Supplementary information on the detrimental threshold levels of interference to radio astronomy observations in Recommendation ITU-R RA.769

(2008)

TABLE 2a

Threshold levels of interference detrimental to radio astronomy spectral-line observations
Entries common to Recommendations ITU-R RA.769-1 and ITU-R RA.769-2*

Centre frequency (MHz)	Bandwidth (kHz)	pfd (dB(W/m²))	Spectral pfd (dB(W/m² · Hz))	Electric field (dB(μV/m))
327	10	−204	−244	−58.2
1 420	20	−196	−239	−50.2
1 612	20	−194	−238	−48.2
1 665	20	−194	−237	−48.2
4 830	50	−183	−230	−37.2
14 488	150	−169	−221	−23.2
22 200	250	−162	−216	−16.2
23 700	250	−161	−215	−15.2
43 000	500	−153	−210	−07.2
48 000	500	−152	−209	−06.2

* Arrows have been used to indicate changes in the sense Recommendations ITU-R RA.769-1 → ITU-R RA.769-2