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### Towards sideband-separation for ALMA's highest bands

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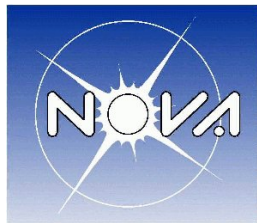
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# Towards sideband-separation for ALMA's highest bands



NOVA Sub-mm  
Instrumentation  
Group

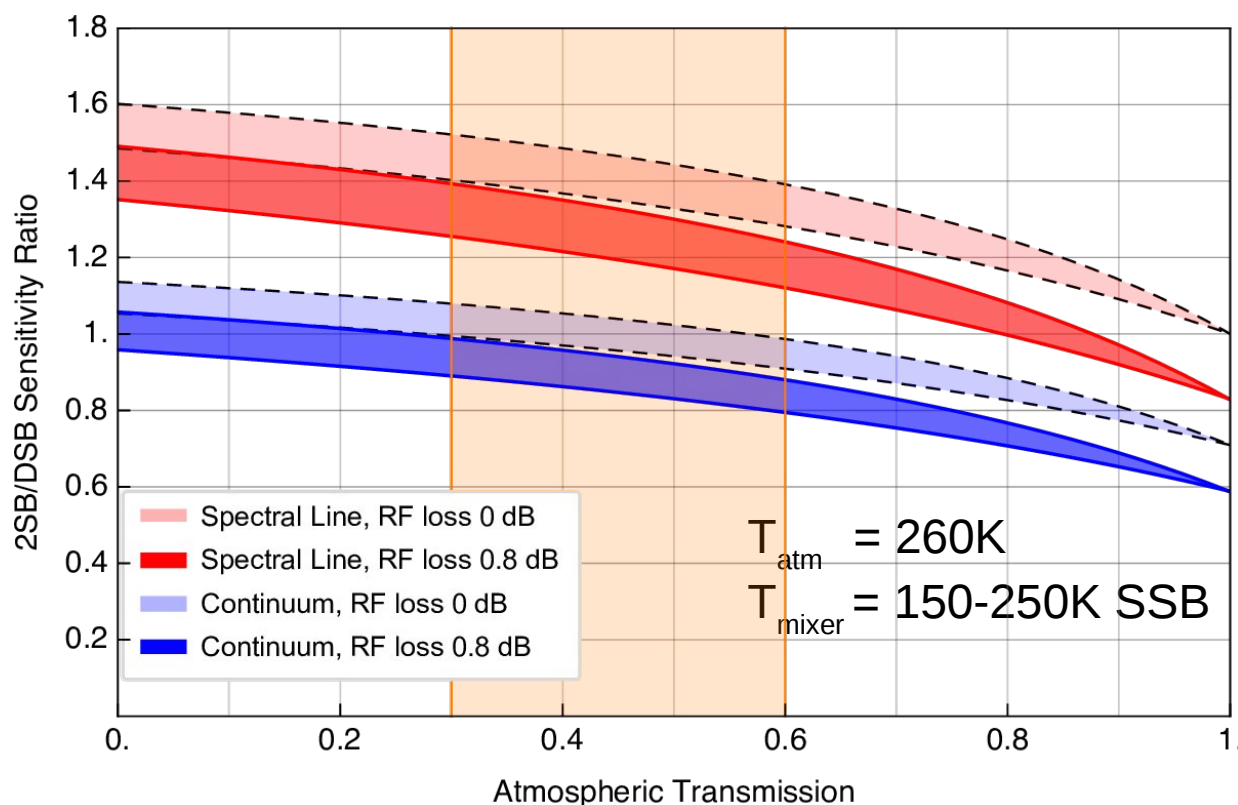


kapteyn astronomical  
institute

Ronald Hesper  
Andrey Khudchenko  
Andrey Baryshev  
Jan Barkhof  
Mariëlle Bekema  
Rob de Haan-Stijkel

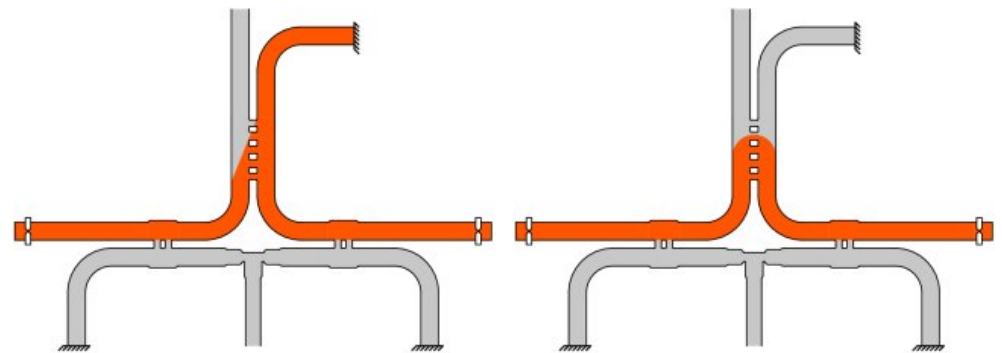
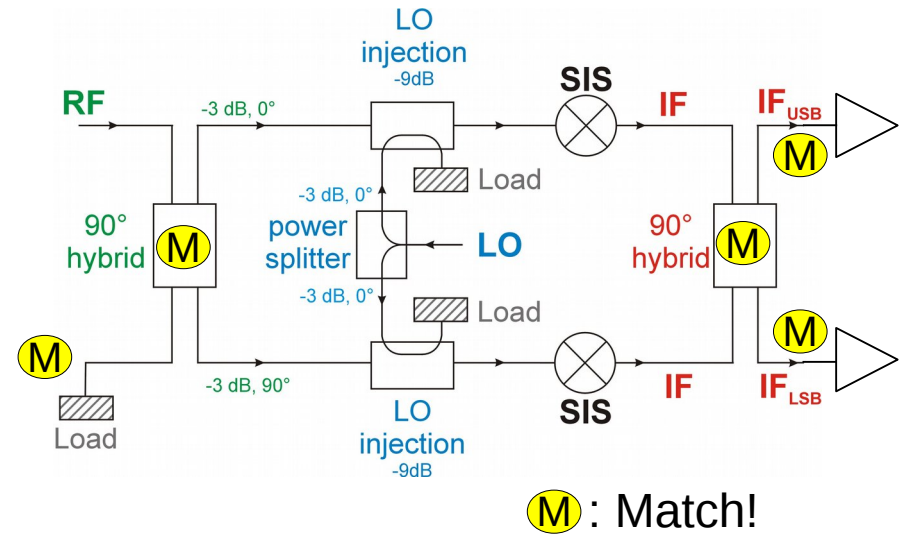
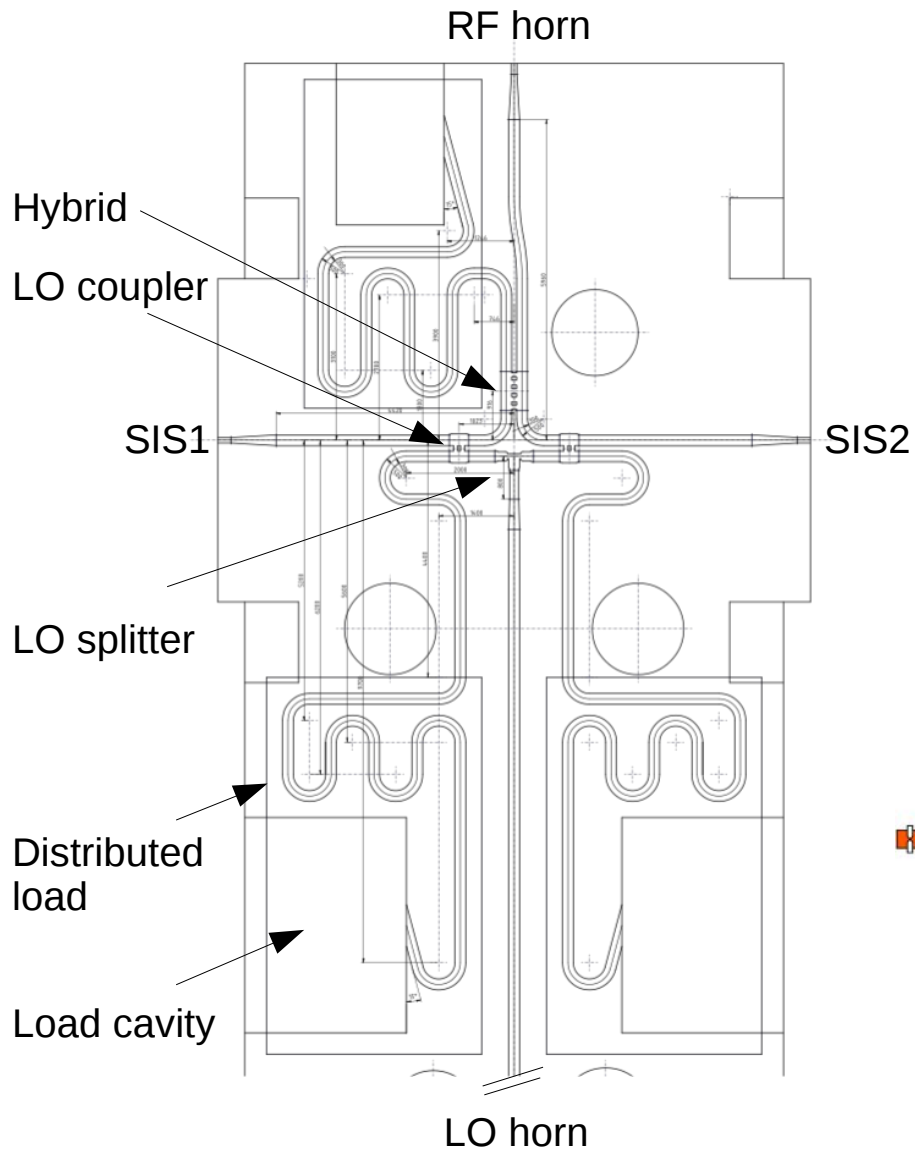
# Benefits of sideband-separation

1: Improved spectral line sensitivity for atmosphere-limited bands



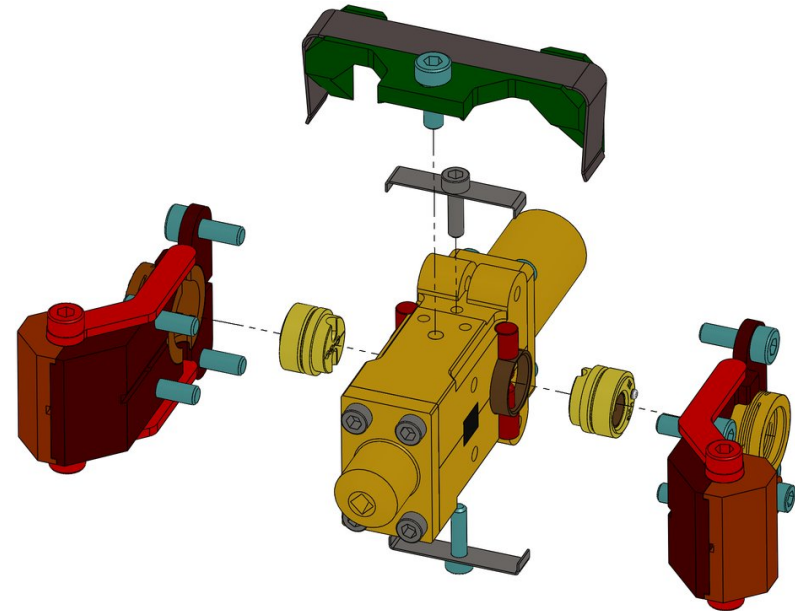
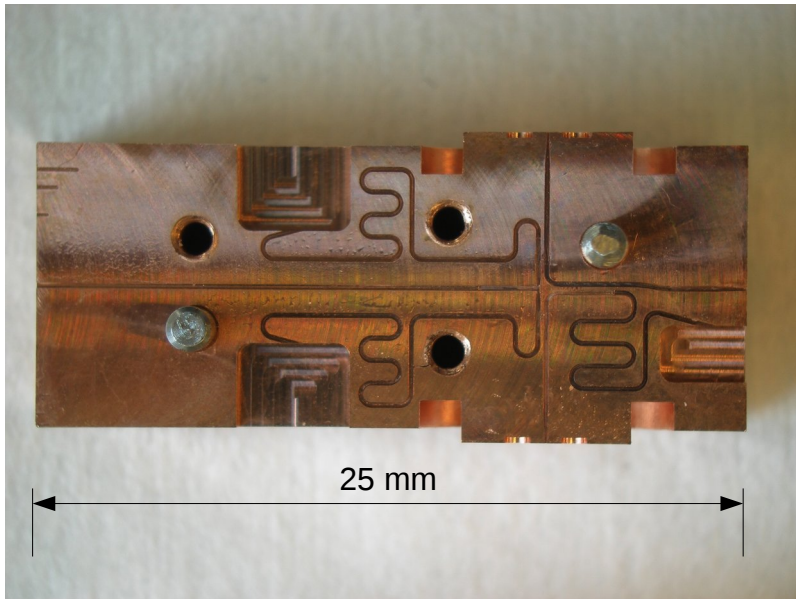
2: Avoiding line-confusion; can partially be solved in the correlator, at the cost of longer integration time

# An optimized Band 9 2SB mixer



Key: avoid multiple reflection paths

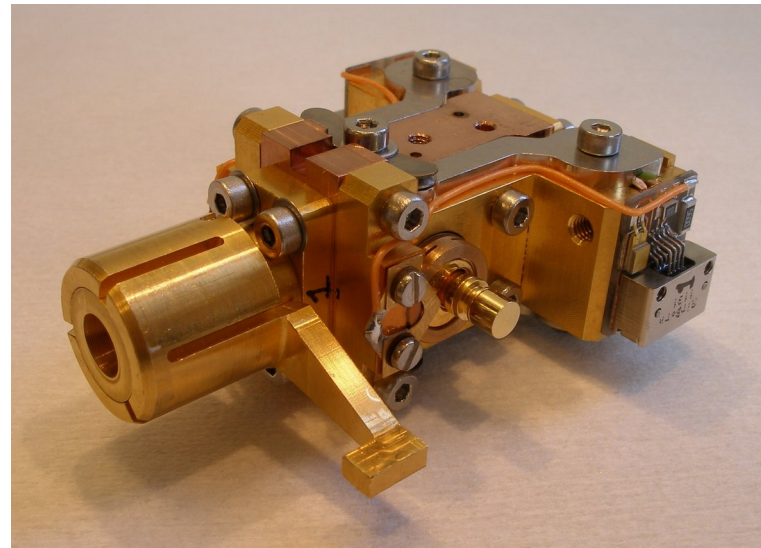
# Modularity



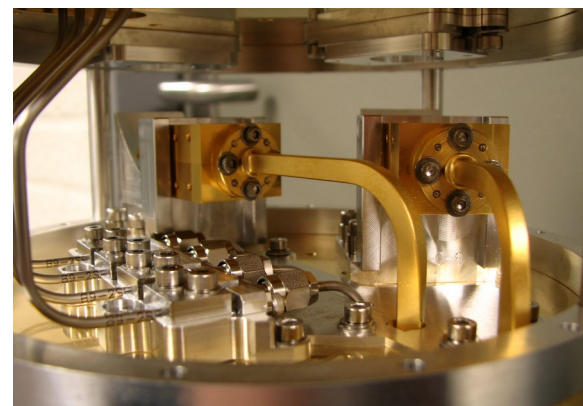
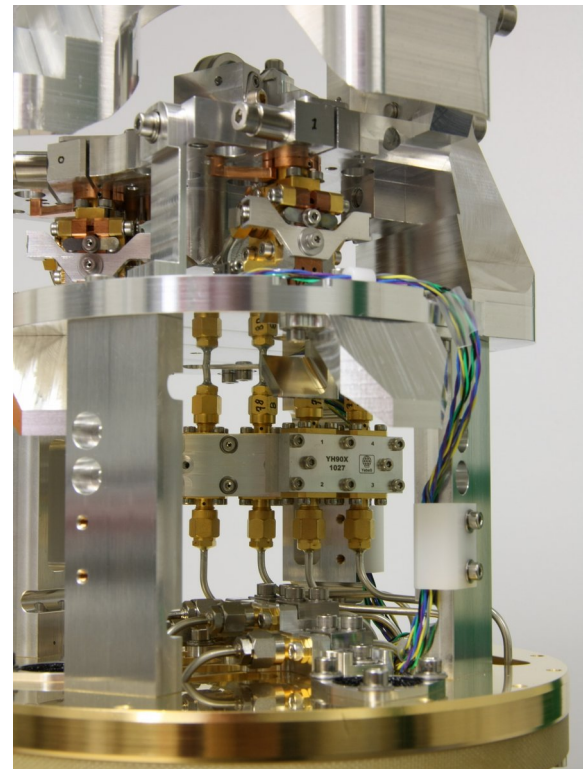
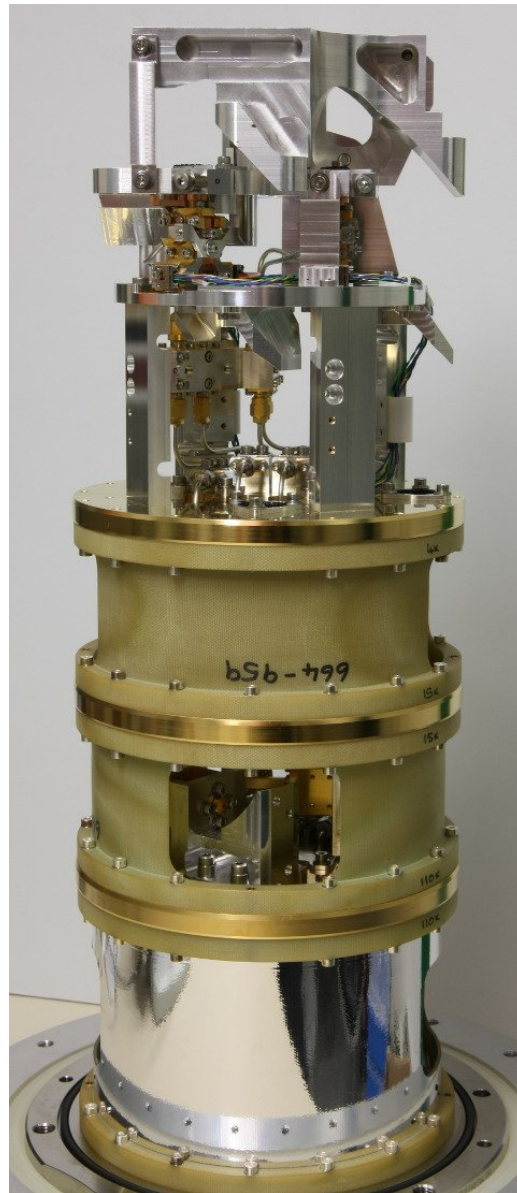
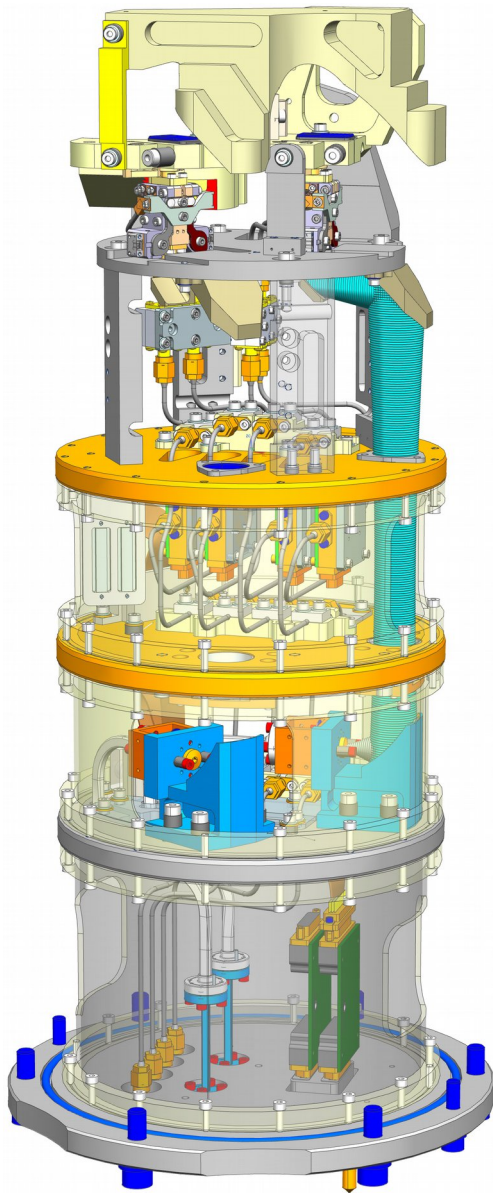
Mixer is modular

- Less critical for manufacturing
- Testable at component-level
- Mix & Match of SIS devices

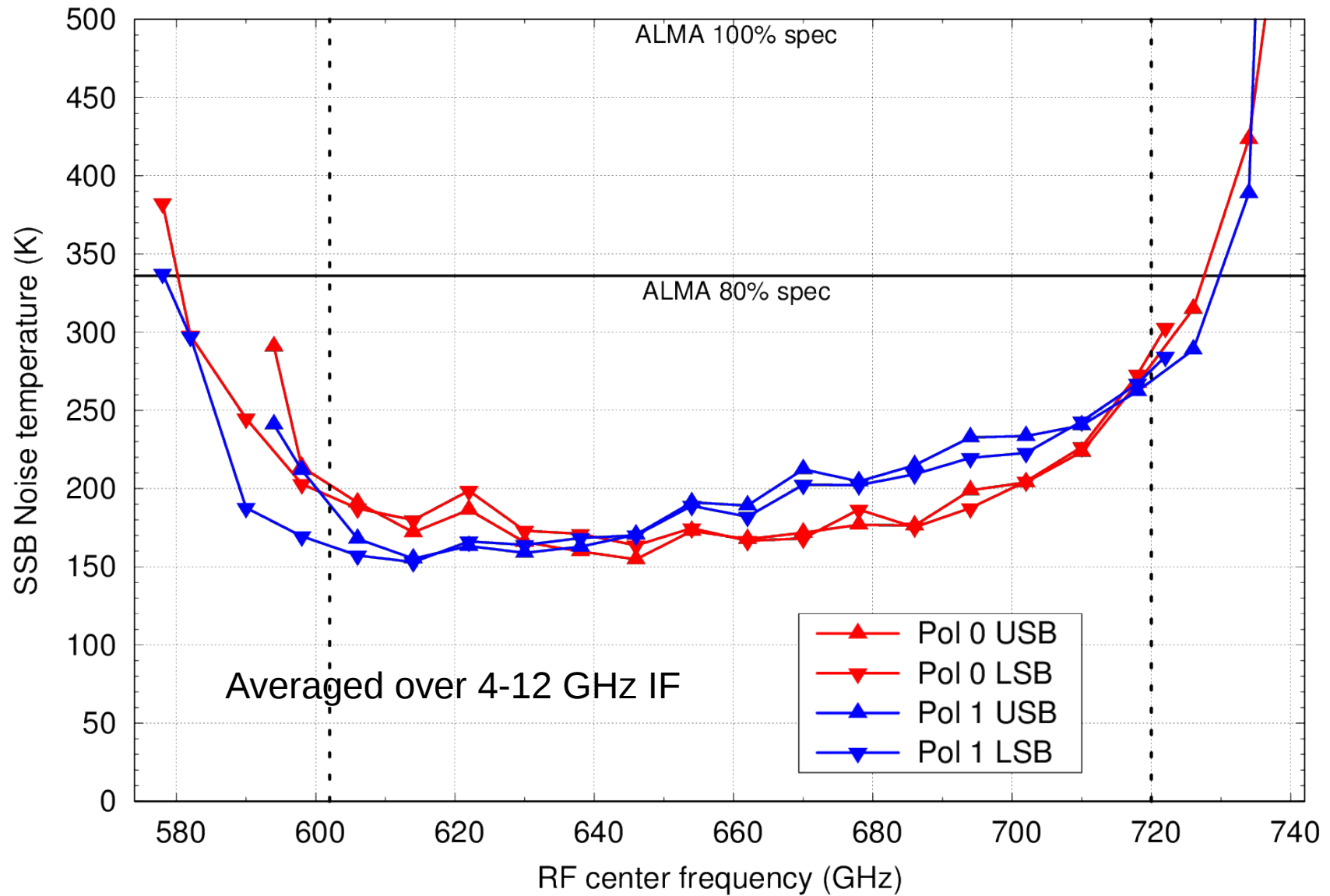
Mixer backpieces are identical to existing Band 9 DSB ones



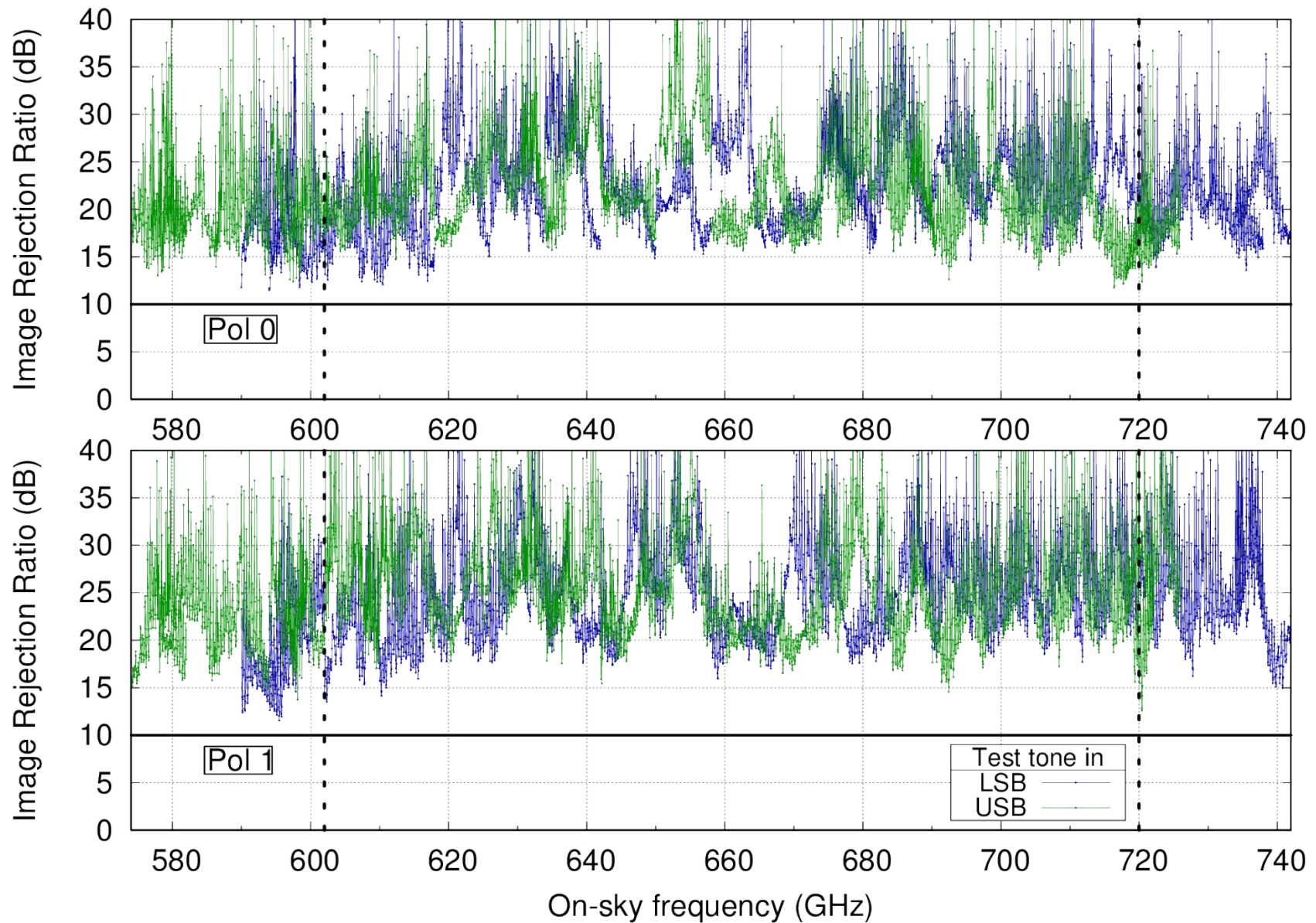
# The SEPIA660 cartridge



# Lab results: noise temperature

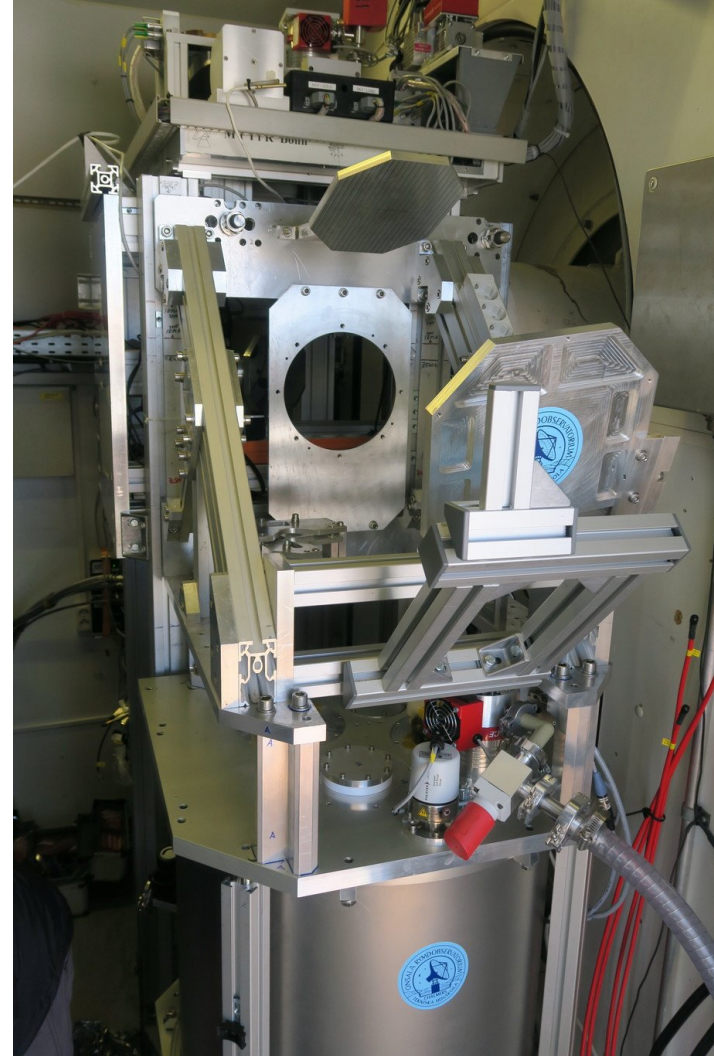
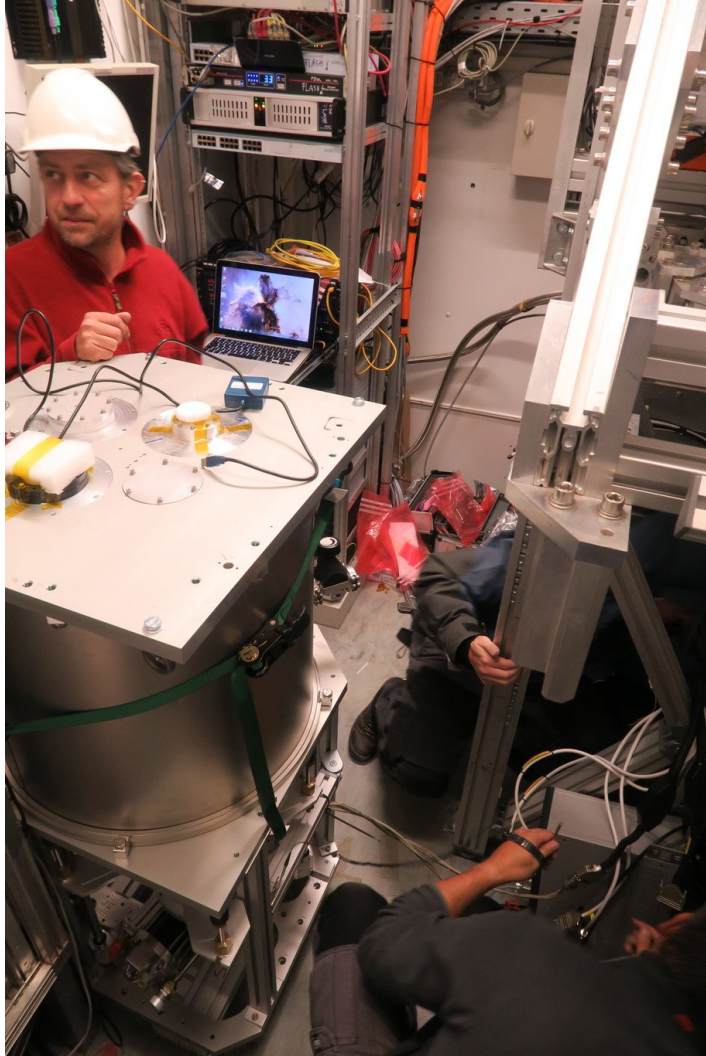


# Lab results: image rejection



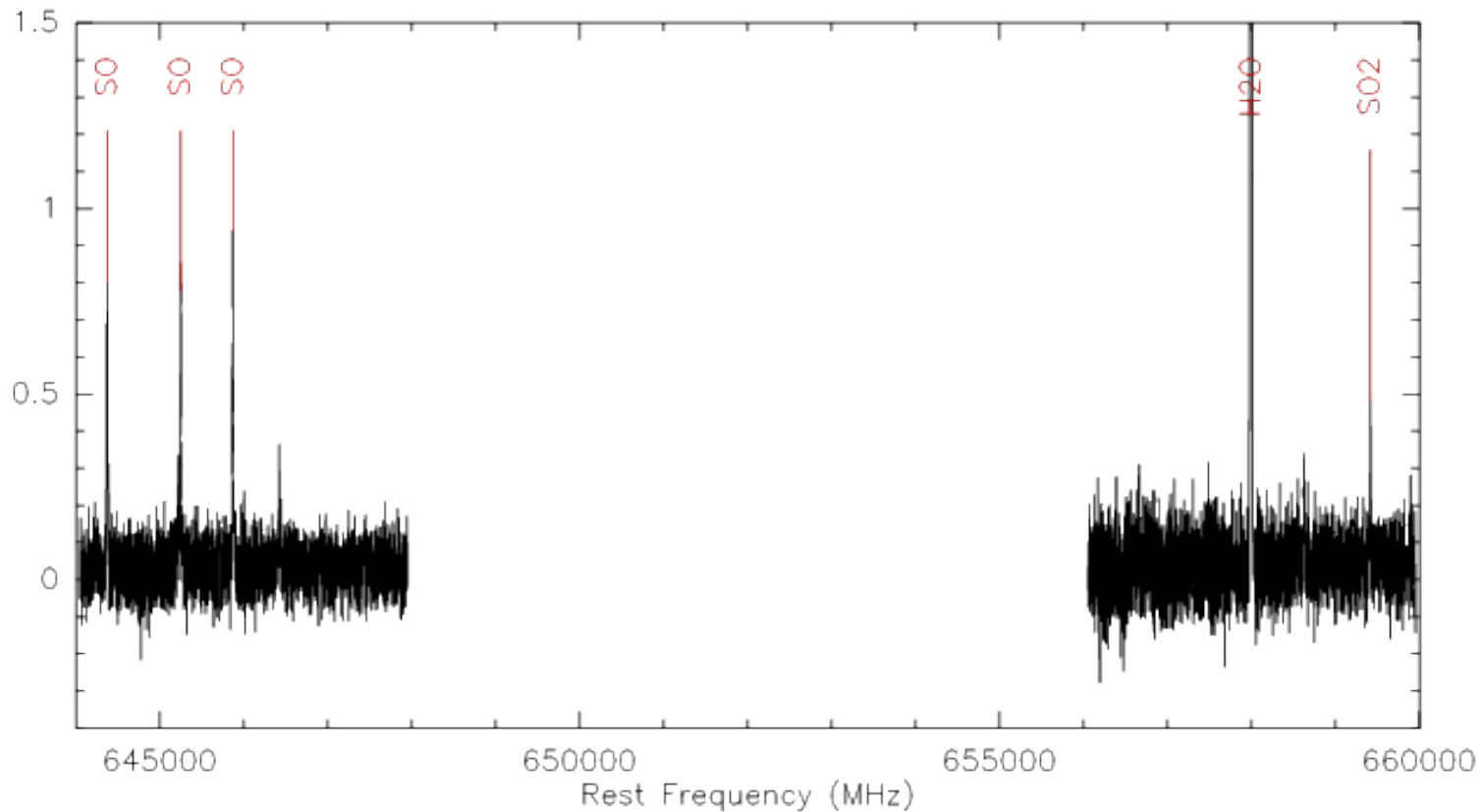


# Into SEPIA...



# First light – R-Dor

0;0 R-DOR      H2Ov1      AP-S60--XF0-    O:19-AUG-2018 R:20-AUG-2018  
RA: 04:36:45.49 DEC: -62:04:38.5 Eq 2000.0 Rad. 0.0° Offs: -0.3 -0.2  
Unknown    tau: 0.784    Tsys: 1392.    Time: 5.9min    El: 36.6  
N: 14581    I0: 1823.14      V0: 7.000      Dv: 0.5000      LSR  
FO: 658006.000      Df: -1.097      Fi: 646005.214  
Bef: 1.0      Fef: 0.95      Gim: 3.1620E-02  
Scan:                    47001    Subscan:            1

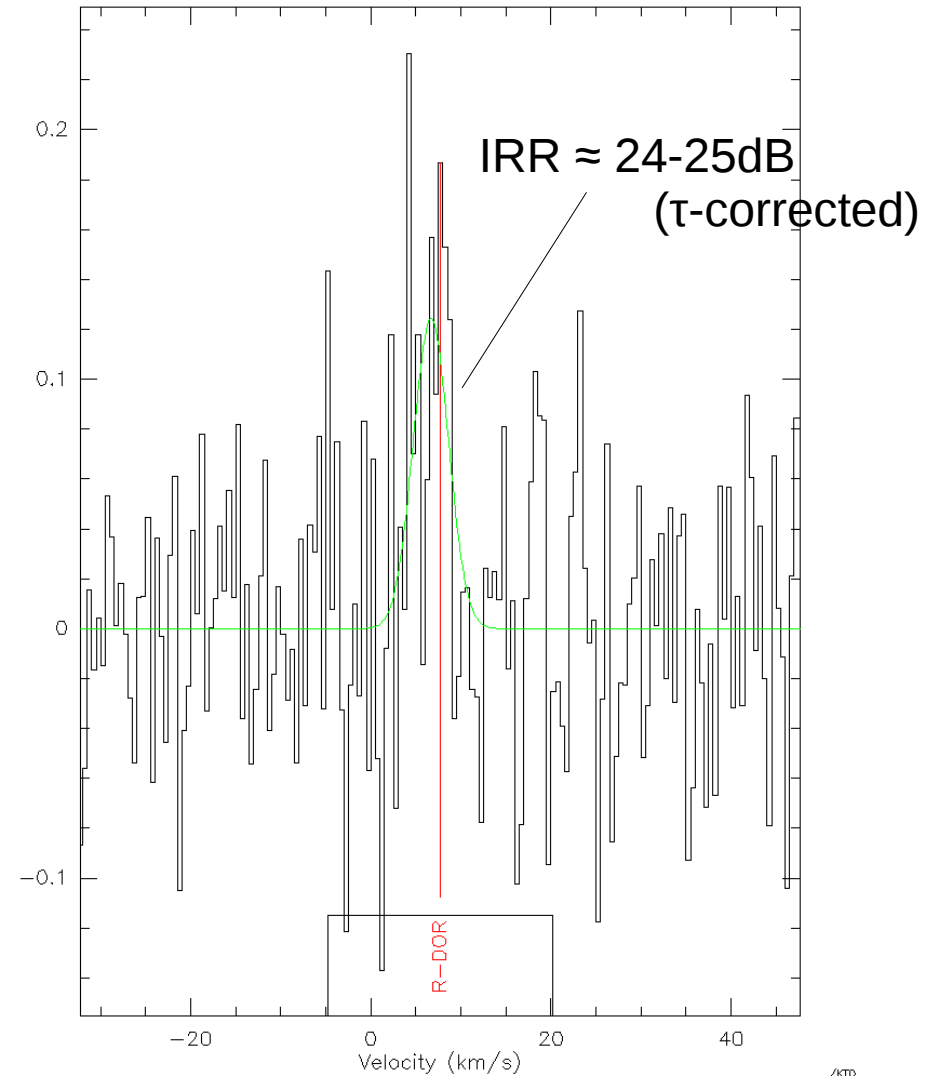
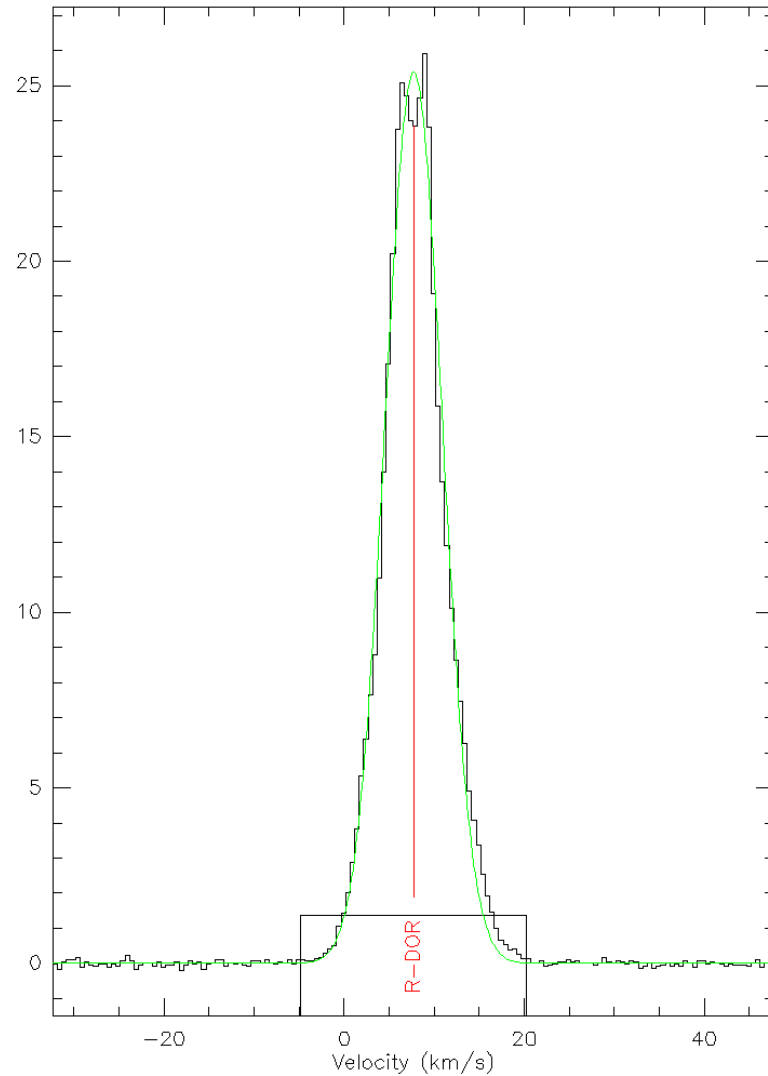


# Image rejection - H<sub>2</sub>O maser

Source: R-DOR v0: 7.7 km/s dv: 0.5 km/s t: 5.9 min

H<sub>2</sub>O @ 658 GHz

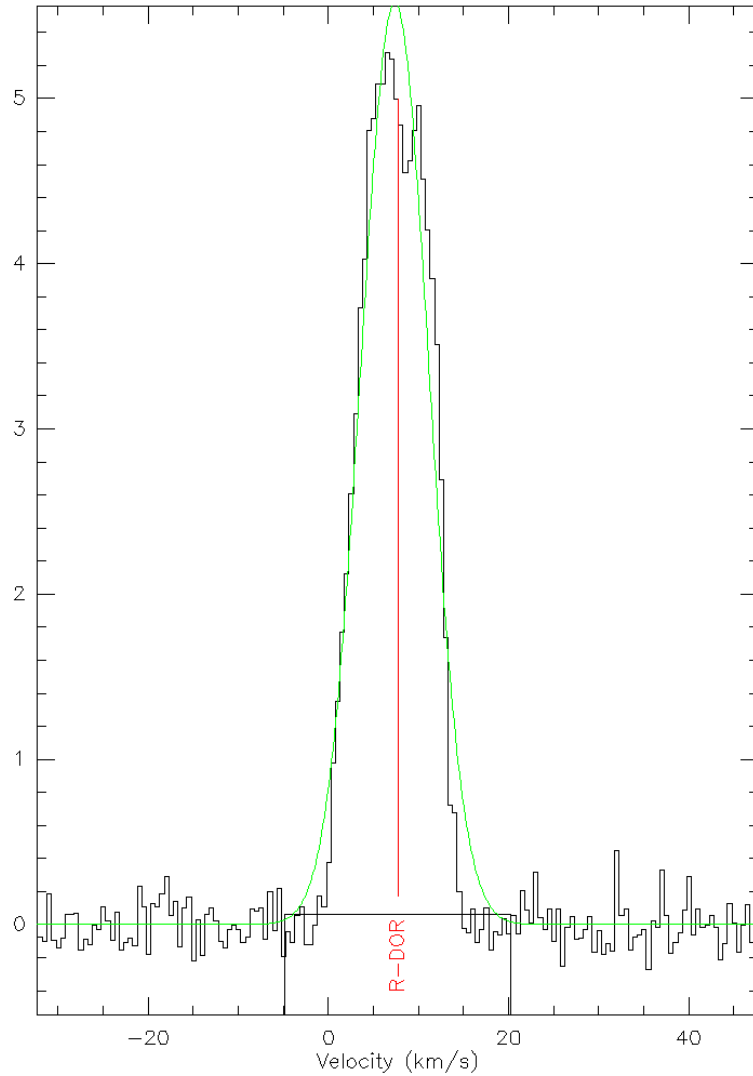
H<sub>2</sub>O im @ 646 GHz



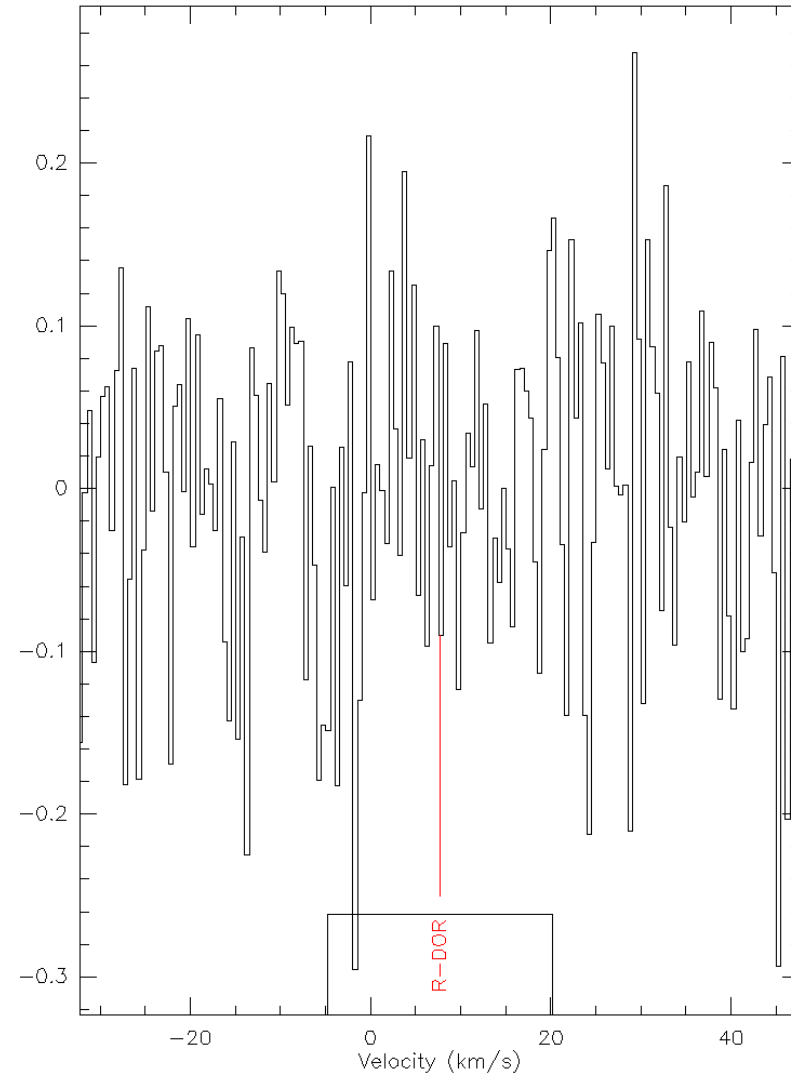
# Image rejection - CO 6-5

Source: R-DOR v0: 7.7 km/s dv: 0.5 km/s t: 2.9 min

CO @ 691.5 GHz



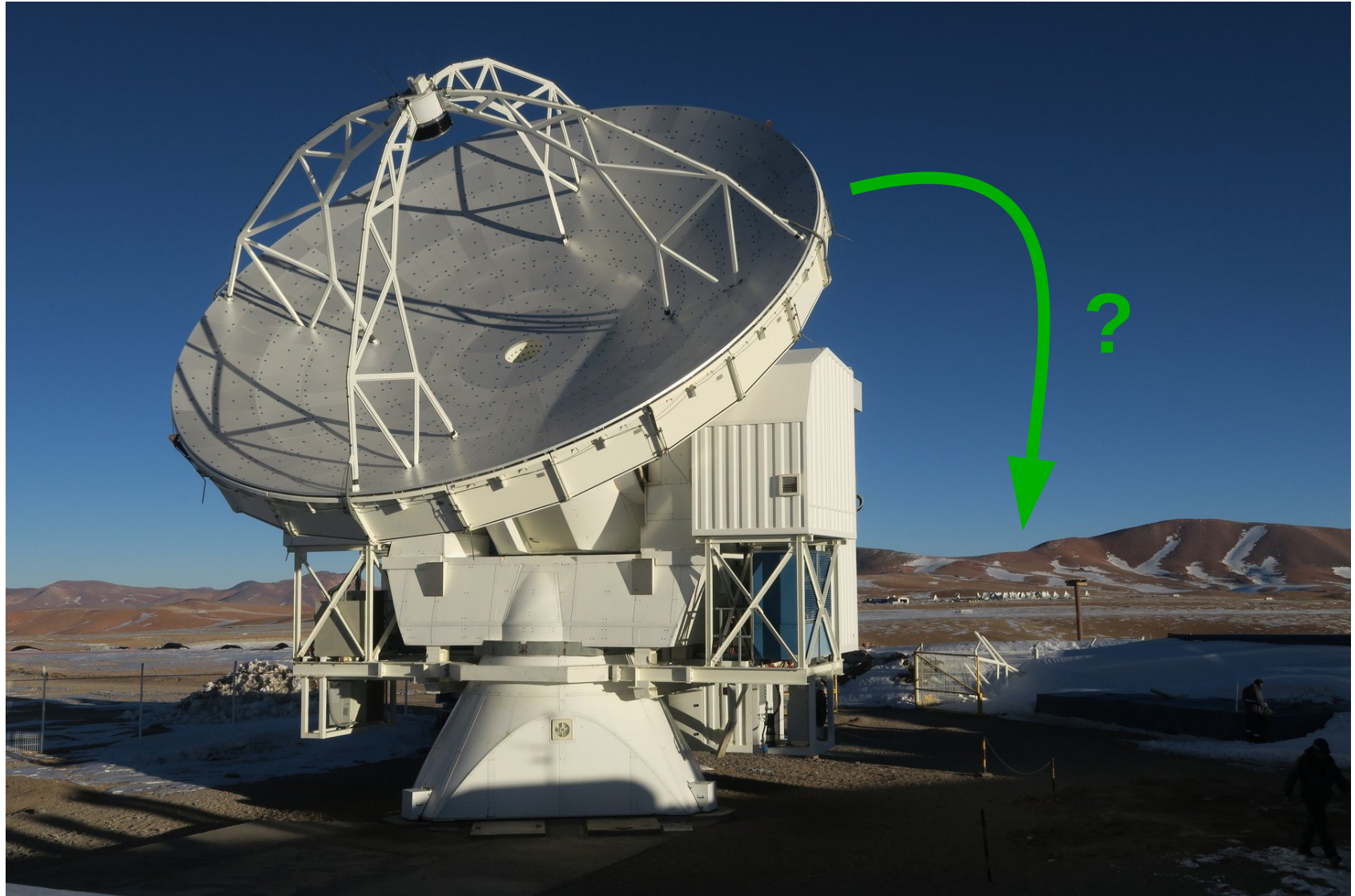
CO im @ 679.5 GHz



/KTO

For CO  $J = 6-5$ : no image detectable - IRR better than 24dB

# From APEX to ALMA

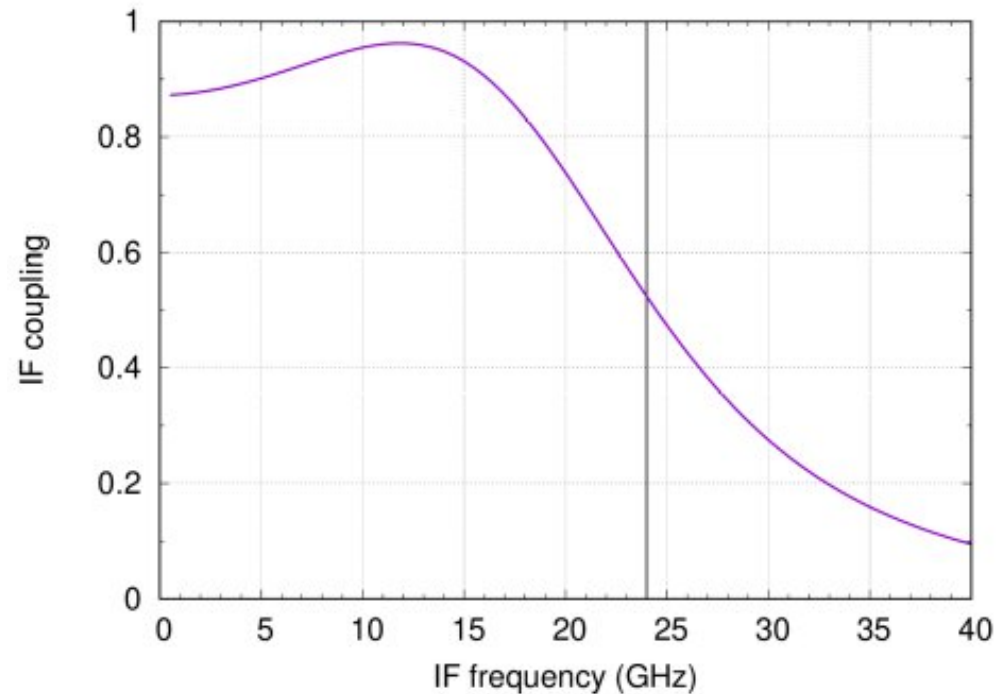


# Goals of the study

- 1. Further extension of the IF bandwidth to 4x12 GHz or even more (SEPIA660 has 4x8 GHz)**
2. Extension of RF bandwidth beyond 600-720 GHz
3. The availability of a sufficient number of SIS mixer devices to enable a full upgrade
4. Optionally, the improvement of the optical cross-polarization performance
5. The expected cost for all existing ALMA Band 9 receivers to be upgraded
6. The expected cost for a limited number of pre-production receiver modules
7. The upgrade strategy, especially the possibility to allow continued Band 9 operations during upgrade

# Increasing the IF bandwidth

New simulations show that current Band 9 SIS devices may have an IF bandwidth up to 24 GHz



K. Rudakov

Provided that the IF infrastructure can accommodate this, it would mean a total IF coverage of 80 GHz!

Challenges:

- cryogenic IF LNAs
- cryogenic IF hybrids

# Conclusions

A dual-pol sideband-separating Band 9 ALMA-class receiver has been demonstrated and commissioned on-sky, with a total IF bandwidth of 32 GHz and image rejection in excess of 20dB on average (better than 15dB everywhere)

RF BW extension to 580-732 GHz was demonstrated.

The technology to implement this in ALMA is ready; expensive components like SIS devices (probably) and LOs (certainly) can be re-used.

Extension of the total IF BW to 48 GHz looks quite feasible, 64 GHz possibly so.

And...

For the Flash receiver (MPIfR) on APEX, we have a 2SB 790-950 GHz mixer with similar performance

→ poster Andrey Khudchenko