High Frequency High Spectral Resolution Focal Plane Arrays for AtLAST

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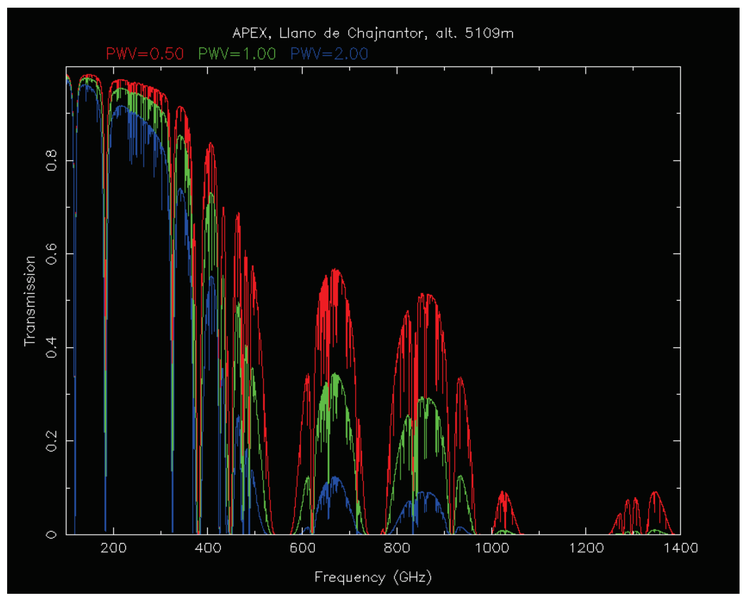
Abstract

Large collecting area single dish telescope such as ATLAST will be especially effective for medium (R~1000) and high (R~100000) spectral resolution observations. Large focal plane array is a natural solution to increase mapping speed. For medium resolution direct detectors with filter banks (KIDs) and or heterodyne technology can be employed. We will analyze performance limits of comparable KID and SIS focal plane array taking into account quantum limit and high background condition of terrestrial observing site. For large heterodyne focal plane arrays, a high current density AlN junctions open possibility of large instantaneous bandwidth >40%. This and possible multi frequency band FPSs presents a practical challenge for spatial sampling and scanning strategies. We will discuss phase array feeds as a possible solution, including a modular back-end system, which can be shared between KID and SIS based FPA. Finally we will discuss achievable sensitivities and pixel counts for a high frequency (>500 GHz) FPAs and address main technical challenges: LO distribution, wire counts, bias line multiplexing, and monolithic vs. discrete mixer component integration.

We are on the ground!

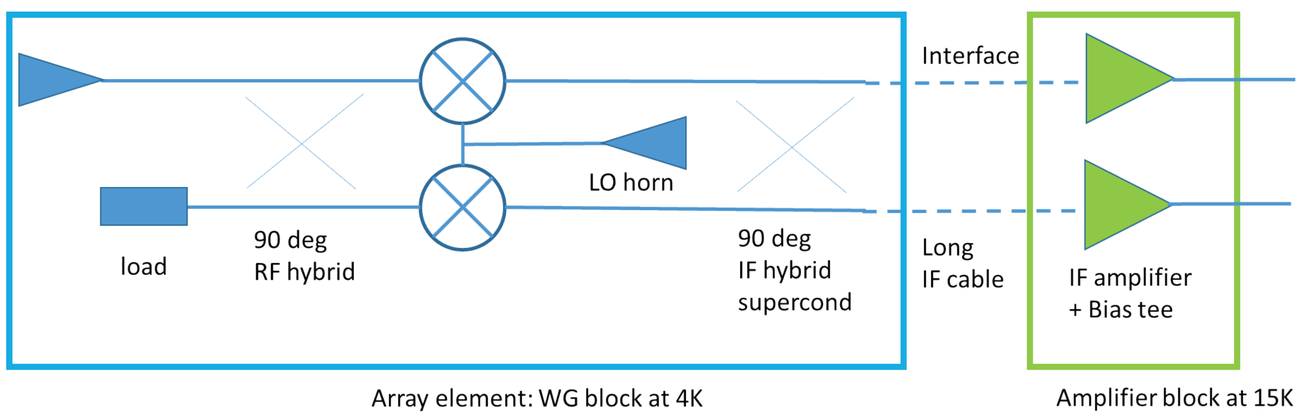
$T_{int} \sim T_{sys}^2/N$ is figure of merit

- Very important to have very good pixel noise
- Must have 2SB scheme for high frequencies

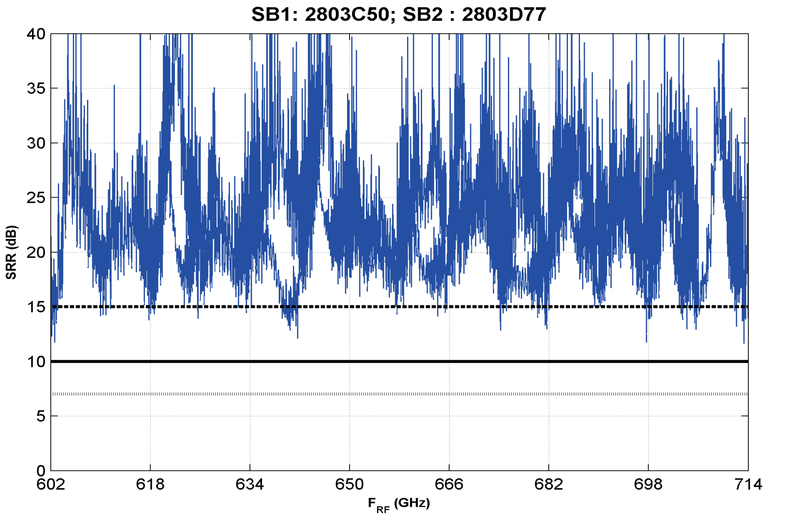


Because of square dependence of integration time from system noise temperature it is very important to maintain performance of single element array at the same level as good single pixel system where performance of ALMA front-end is good reference for AtLAST system. No compromises are acceptable. For the same reason, array pixel element at high frequency must deviate from simple DSB scheme and use 2SB or any other suitable SSB scheme.

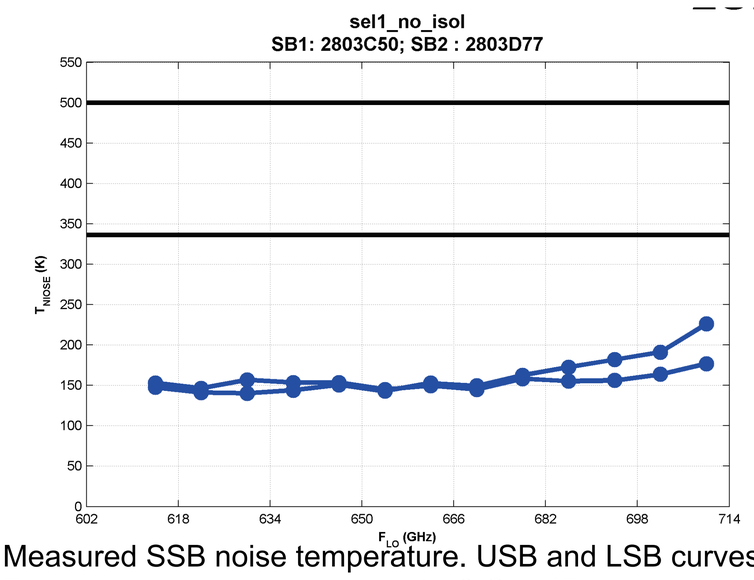
Single pixel module of high frequency FPA, 650 GHz band example



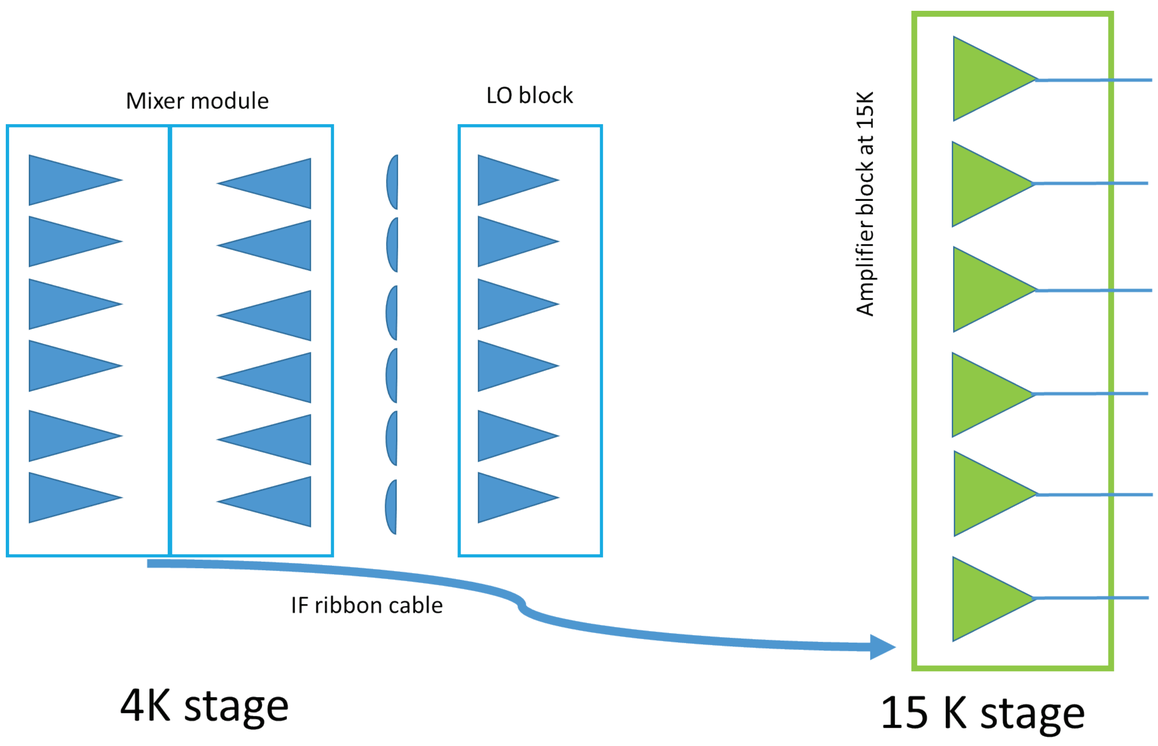
Principle mixer layout realized for ALMA band 9 2SB upgrade project and SEPIA 650 GHz channel at APEX telescope. Note absence of cryogenic isolator. This makes it possible to expand IF bandwidth to 32 GHz in this system (Measured is 3-12 GHz IF band). IF amplifiers can be located far from mixer and can even be on different temperature level, which is important for focal plane array implementation



Measured sideband ratio of the system. Note that average level of SBR is about 15dB which allows to reduce system noise



Measured SSB noise temperature. USB and LSB curves. Temperature is averaged over 4-12 GHz IF band.



Principle array layout based on building block above which allows to resolve major thermal and element placement problems. Especially IF amplifiers can be placed far away without affecting temperature of mixer module. The array can be built out single pixel mixer modules that can be tested separately to retain state of art performance. Current estimate that 128 pixel array in this configuration is feasible to build.

SUMMARY

- It is very important to maintain competitive mixer performance for array element. Performance is limited by atmosphere, not by quantum limit at high frequency.
- We demonstrated 2SB mixer that interfaces IF amplifier without cryogenic amplifier and through long IF line with very good performance.
- IF Bandwidth is now limited by IF amplifier bandwifdth and can be extended

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