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How fast can we go in digitizing analogue signals for future radio observatories?

Contemporary radio telescopes increasingly rely on advanced digital signal processing. A continuing tendency to replace traditional analogue functions in the signal chain like frequency-conversion and filtering in, astronomical, receiver systems to the digital domain can be observed. In general, it can be stated that over the past decades the analogue to digital conversion function in the signal chain of radio telescope has been moving closer and closer to the antenna. This development in receiver architecture is very much driven by the technological advances in analogue-to-digital converters (ADC) and this trend is also illustrated by the system architecture of the Atacama Large Millimeter/submillimeter Array (ALMA).

The initial ALMA architecture used two heterodyne stages resulting in an Intermediate Frequency (IF) range of 2 – 4 GHz. This analogue IF signal is then digitized by a 3-bit ADC operating at a sampling frequency of 4 GHz. The ongoing Wideband Sensitivity Upgrade (WSU) of ALMA has removed the second, analogue, heterodyne stage and uses an IF range of 2 – 20 GHz. This wideband IF is digitized by a 6-bit ADC running at a sample frequency of 40 GHz. The WSU architecture will offer a 16 GHz instantaneous bandwidth to the astronomical user.

The astronomical user community of ALMA has a large interest in further increasing the observed bandwidth beyond the 16 GHz offered by the WSU. Ideally the RF signal available from the antenna, after ample amplification, would be directly digitized. An instantaneous bandwidth of 100 GHz or more with at least 6-bit quantization is an objective. The highest RF signal frequency for ALMA is 950 GHz.

Questions and ideas that are on our mind and we are very interested in exploring with you are:
- How far can ADCs based on electronics be pushed to reach our objective?
- Can ADCs based on photonic technology, for example photonic samplers, be an alternative solution to reach our objective?
- In case that photonic ADCs are a possible option would it be feasible to move other signal processing functions from the electronic domain to the optical domain? One example could be to have the time delay function, need to phase up signals from different antennas, implemented as an optical delay.