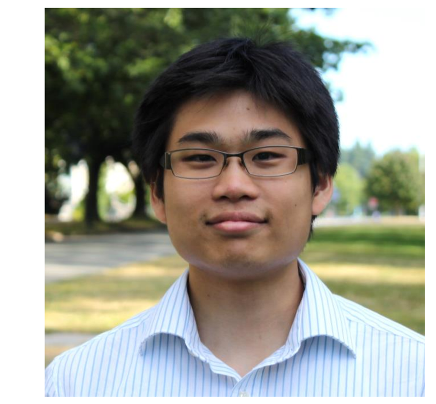
Optical Compressive Sensing of Ultra-wideband RF Spectra



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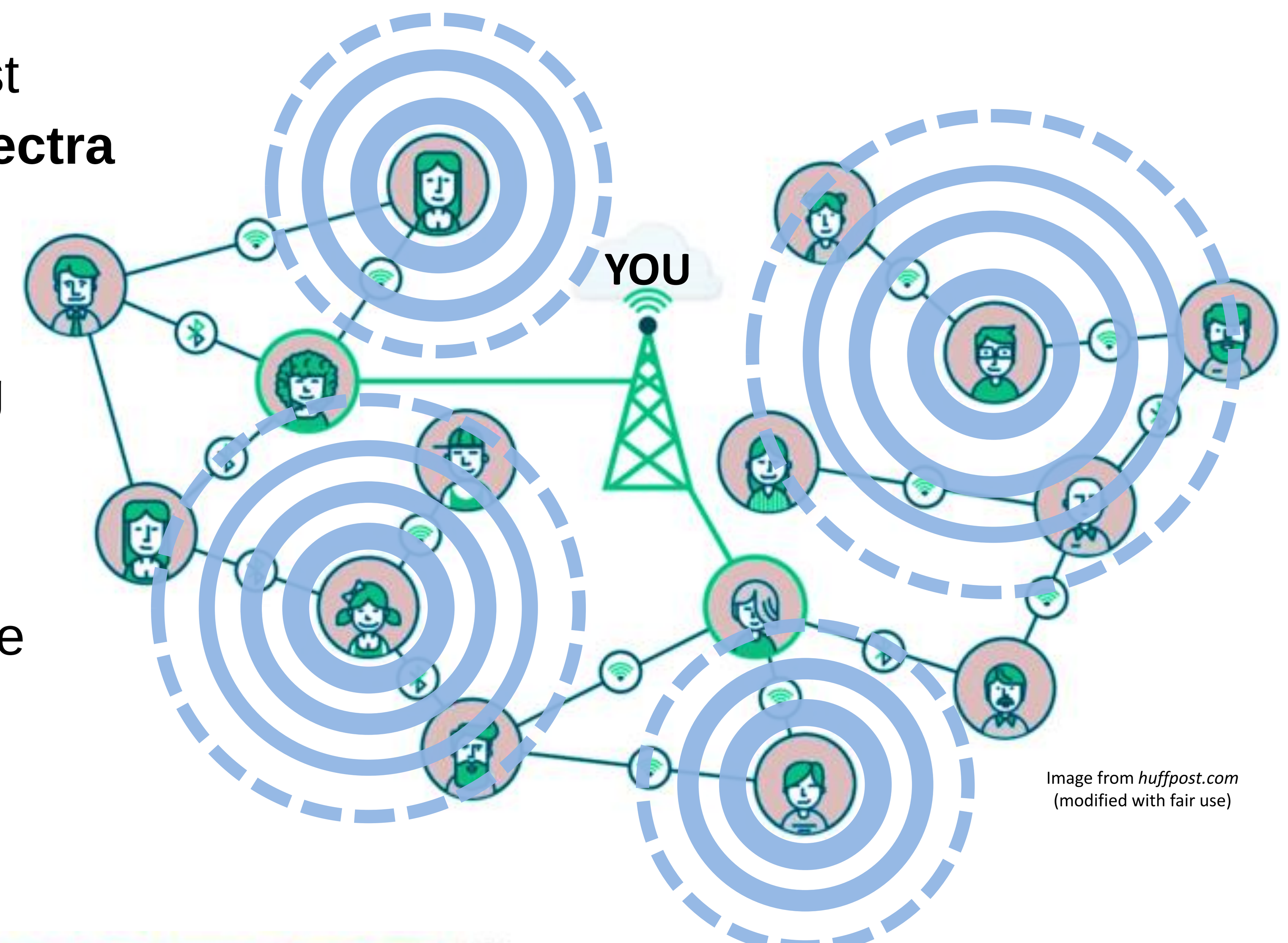
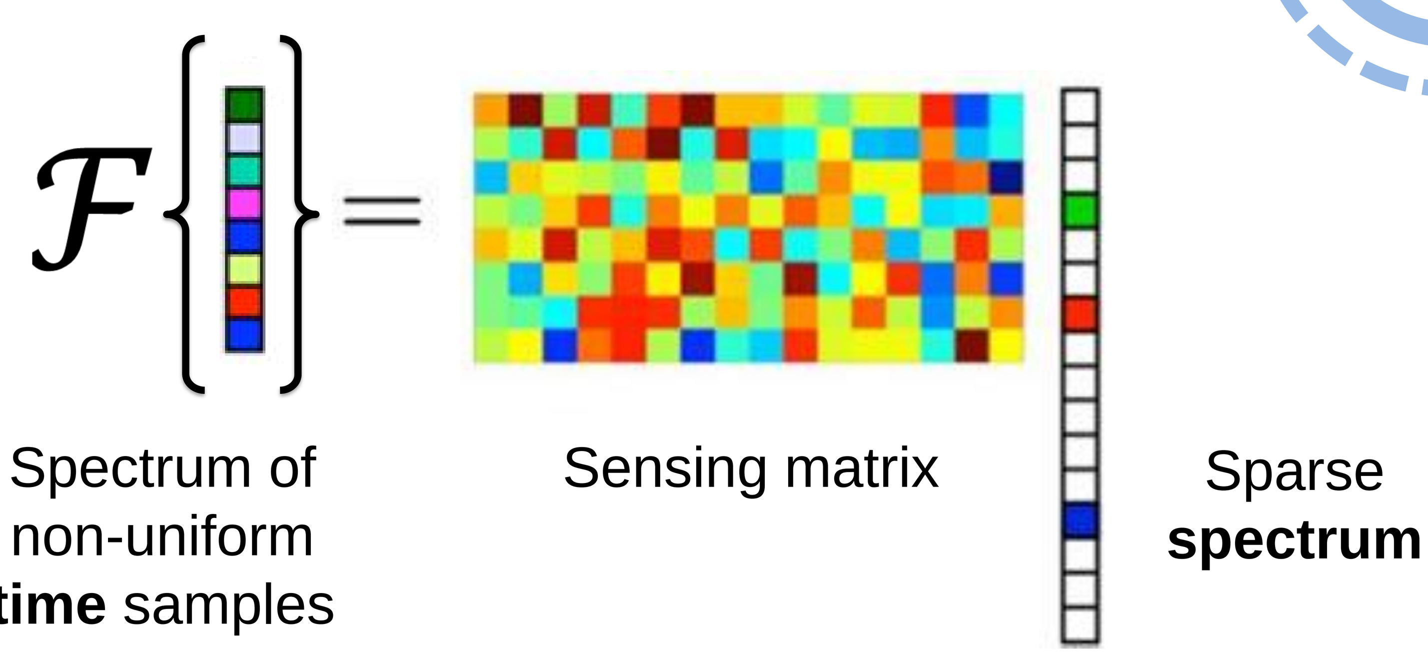
We investigate novel photonic architectures capable of measuring extremely wide bandwidth radio-frequency (RF) signals more efficiently than traditionally possible. This combines optical sampling, which uses optics to alleviate the bandwidth limitations of traditional electronic sampling, with compressive sensing, a new signal processing theory which seeks to recover signals measured with far fewer samples than typically necessary. This has the potential to both increase accuracy and reduce cost over current state-of-the-art sampling devices.

Introduction

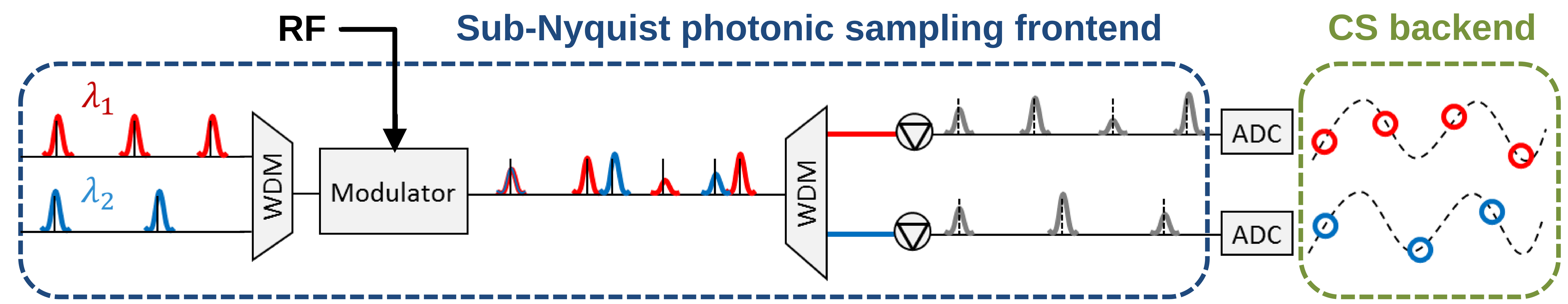
- Many RF sensing applications must monitor **extremely broadband spectra** of 50 GHz or higher
- For real-time operation, traditional Nyquist samplers are limited by big data bottlenecks both in **signal fidelity** and **data volume**
- Current designs typical compromise with **slower scanning t**echniques





- Recent developments in **compressive sensing (CS)** theory demonstrate that sparsely occupied RF spectra can be recovered from undersampled data with high fidelity after appropriate signal post-processing
- Our research aims to investigate and build an hardware implementation of a compressive sensing in an RF photonic system. We evaluate the performance and limitations of different optical sampling architectures via simulations

Methods

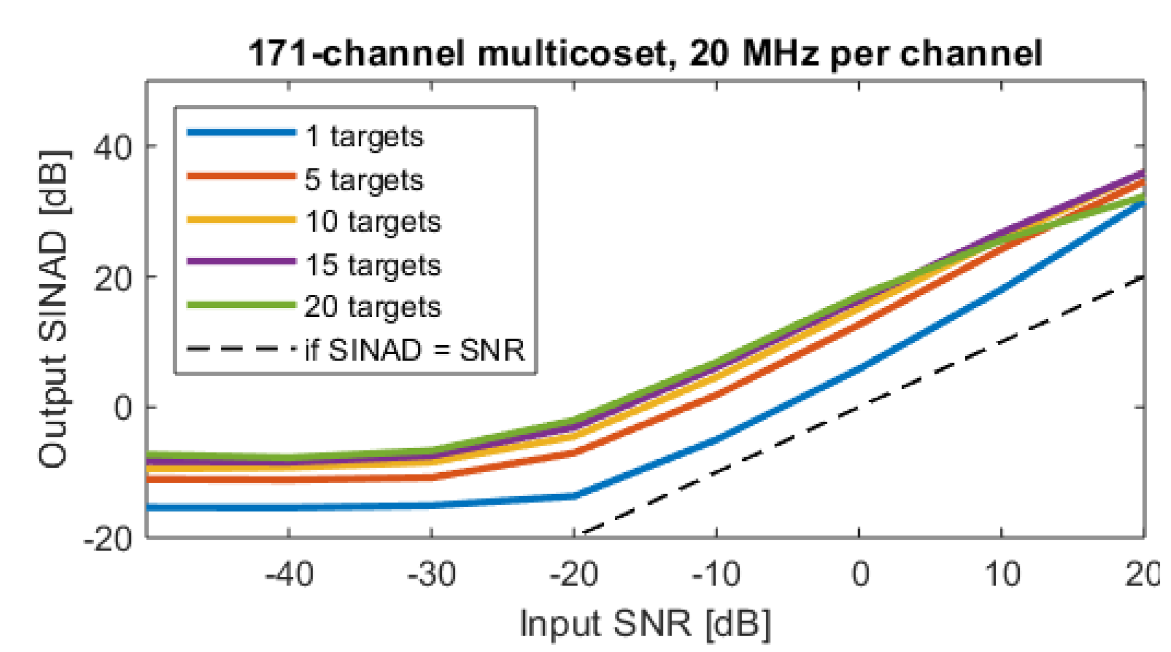


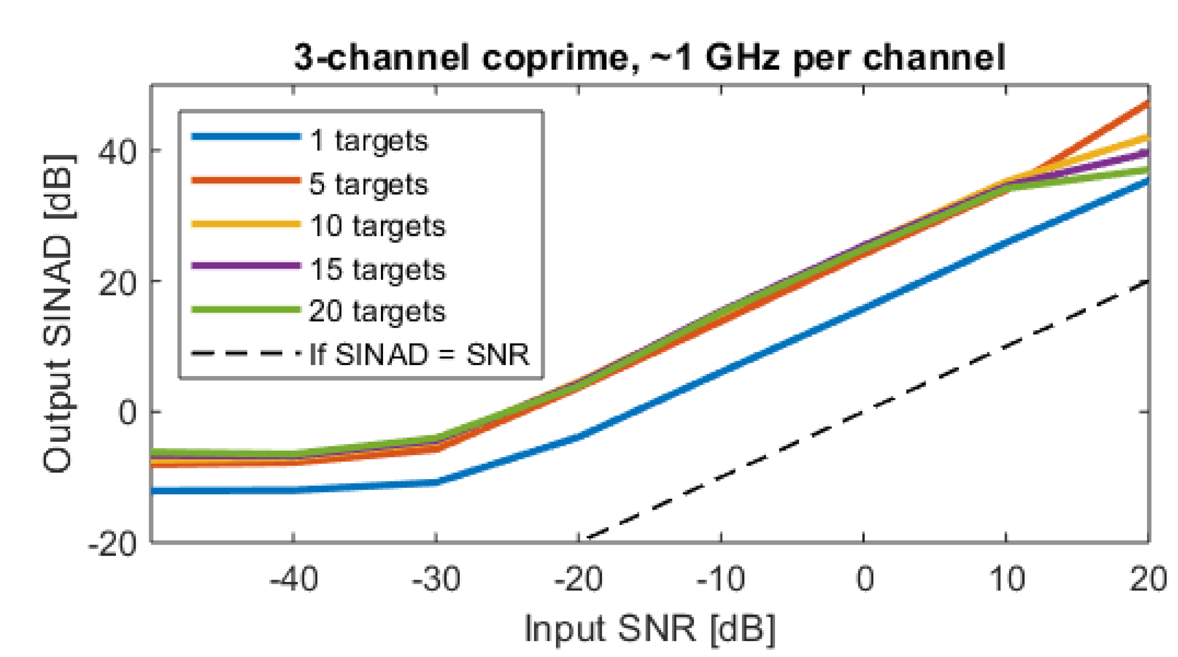
Non-uniform RF sampling in time is achieved photonically by electro-optically modulating optical pulses at multiple wavelengths, each wavelength representing one RF channel sampled at its laser repetition rate

- We simulate two compressed sensing photonic ADC architectures with 20-MHz narrowband signals at increasing total occupied bandwidths:

1) **Multi-coset sampling:** p channels, each at the same sampling rate p/L
2) **Coprime sampling:** p channels at different sampling rates $\{r_i\}$, $\{r_i, r_j\}$ all coprime

Results and Discussion





- Both methods demonstrated high fidelity reconstruction
- 3 channels already sufficient for coprime sampling, superior to multi-coset sampling in minimizing SWAP-C when implemented as a photonic ADC
- Future work: building experimental prototype for undersampled photonic ADC

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