**Introduction and Motivation**

- **Co-located MIMO systems**: Transmit antennas use a single oscillator and receiver antennas share a common oscillator. Thus, due to the single CFO, compensation schemes for SISO systems.
- **Distributed MIMO systems**: Transmitters cannot utilize a common oscillator and multiple CFOs and multiple TOs are observed, and thus, compensation schemes for SISO systems cannot be applied.
- **Multiple CFOs**: Different CFOs cause different symbol-energy attenuation on the matched filter output, which hasn’t been well studied.
- **Multiple TOs**: Different transmission paths exhibit different propagation delays which implies different TOs at each receive antenna.

**System Model**

- **Distributed MIMO system**: $M_t$ Tx and $M_r$ Rx;
- $g(t)$: symbol sent by $i$th Tx at $t$th time slot;
- $f_c(t)$: pulse shaping;
- $T_s$: symbol duration;
- $T_c$: target carrier frequency;
- $\mu$: carrier drift rate of $i$th Tx.

The lowpass equivalent signal at the $j$th Rx output is given by:

$$y_j(t) = \frac{1}{2} \sum_{m=1}^{M_t} \sum_{n=1}^{N} h_{ij} e^{-j2\pi f_c n (m+1) T_s} g(t - n T_s - \tau_{ij}) + n_j(t).$$

- $h_{ij}$: channel coefficient from $i$th Tx to $j$th Rx;
- $\tau_{ij}$: propagation delay between $i$th Tx and $j$th Rx;
- $f_c(t)$: CFO between $i$th Tx and $j$th Rx;
- $n_j(t)$: lowpass noise.

**Proposed Receiver structure and Optimal Detection**

The discrete sample output from the $m$th branch matched filter with sampling at $t = k T_s + t_m$ is given by:

$$y_j(m) = \sum_{n=1}^{N} h_{ij} e^{-j2\pi f_c (m+1) T_s} g(t - n T_s - \tau_{ij}) + n_j(m).$$

- $h_{ij}$: channel coefficient from $i$th Tx to $j$th Rx;
- $g(t)$: pulse shaping;
- $T_s$: symbol duration;
- $T_c$: target carrier frequency;
- $\mu$: carrier drift rate of $i$th Tx.

We consider pulse shape within one symbol duration and the difference of the TOs is within one symbol duration. Compact expression of $y_j(m):$

$$y_j(m) = \Psi_j y_j(m) S + N_j(m),$$

where $\Psi_j = \psi_j e^{j2\pi f_c T_s}.$

**Simulation Results**

We propose a novel receiver design for distributed MIMO systems that accounts for multiple CFOs and multiple TOs. The proposed structure utilizes a bank of pulse matched filters (one per effective CFO) at each receive antenna, followed by ML information symbol detection. Each filter in the bank is sampled at the symbol rate with sampling timing selected according to the corresponding TO. For the proposed receiver configuration, we derive the ML detector. Simulation results show that the proposed receiver structure together with the optimal ML detection offers significant performance gains in presence of multiple CFOs and multiple TOs.