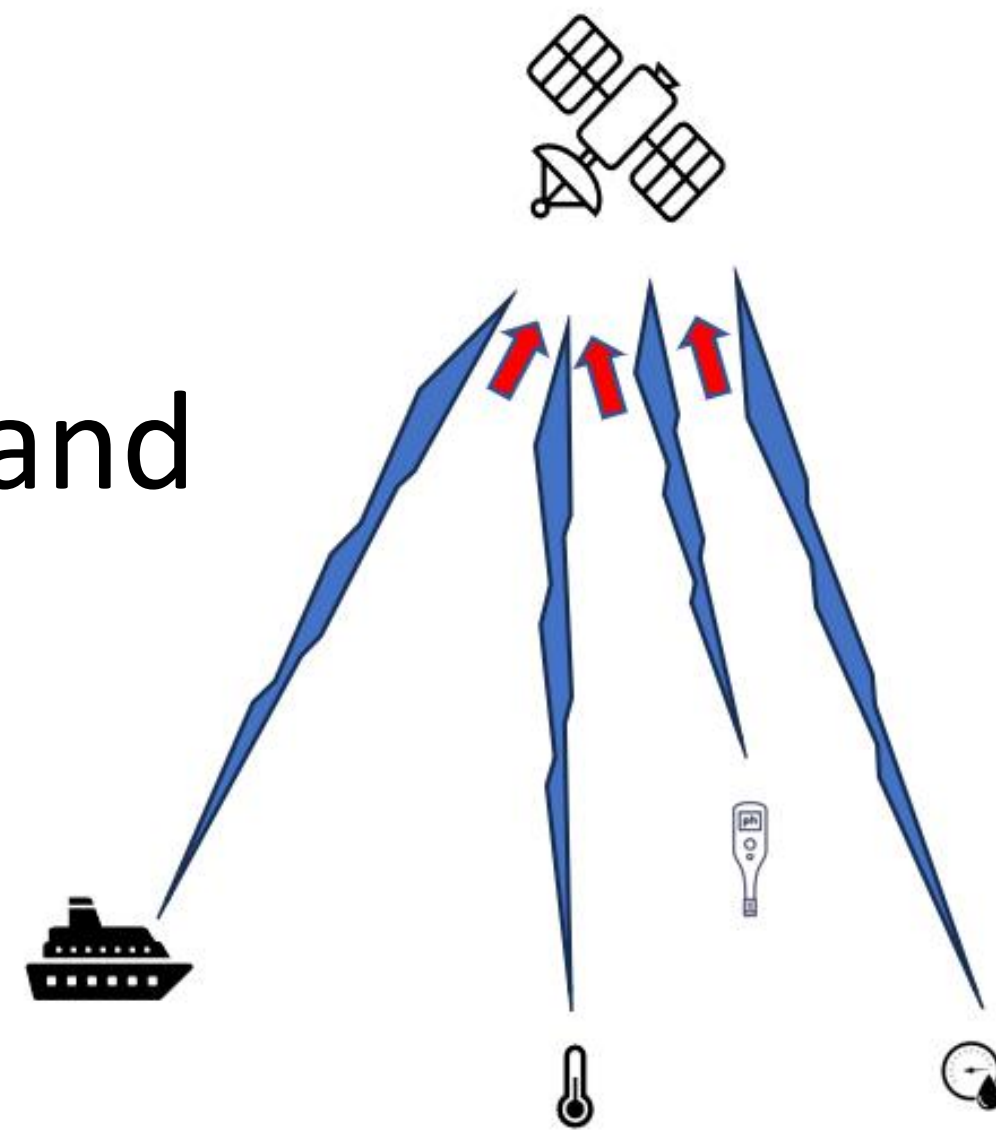


# Detection of Short Frames for Unslotted Multi-User Satellite-IoT Uplink Communications

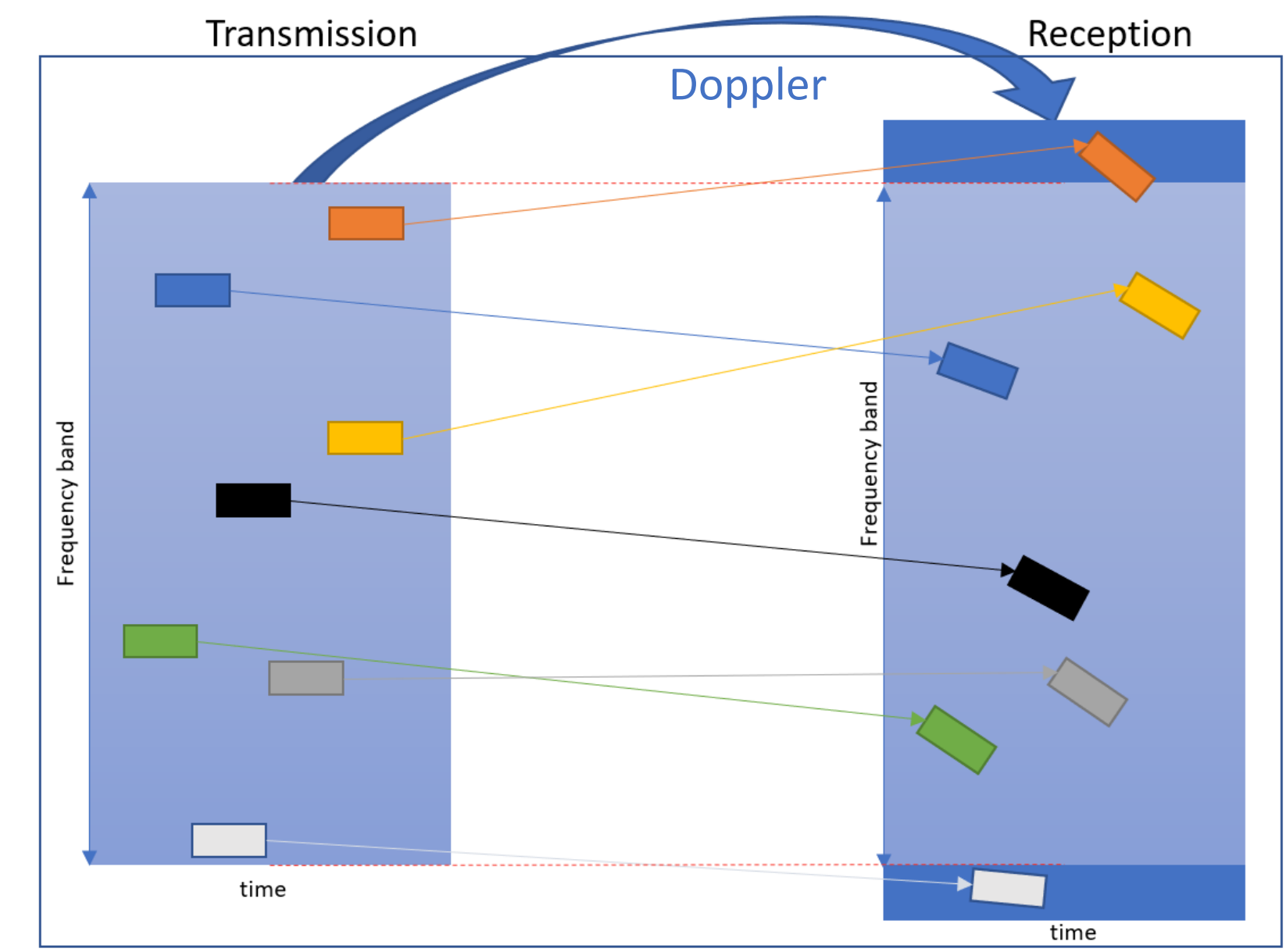
Samya TANNIR (UBS, INSAL), Maxime GUILLAUD (INRIA), Emmanuel BOUTILLON (UBS)

✓ QCSP (Quasi Cyclic Short Packets):  
Short Cyclic Code Shift Keying (CCSK)-LDPC based preamble less frame with efficient synchronization and detection capabilities. [1]

✓ TBM (Tensor-Based Modulation):  
blind signal separation via tensor algebraic considerations for random access. [2]



- Sporadic traffic
- Doppler effect
- Random access
- Short packets



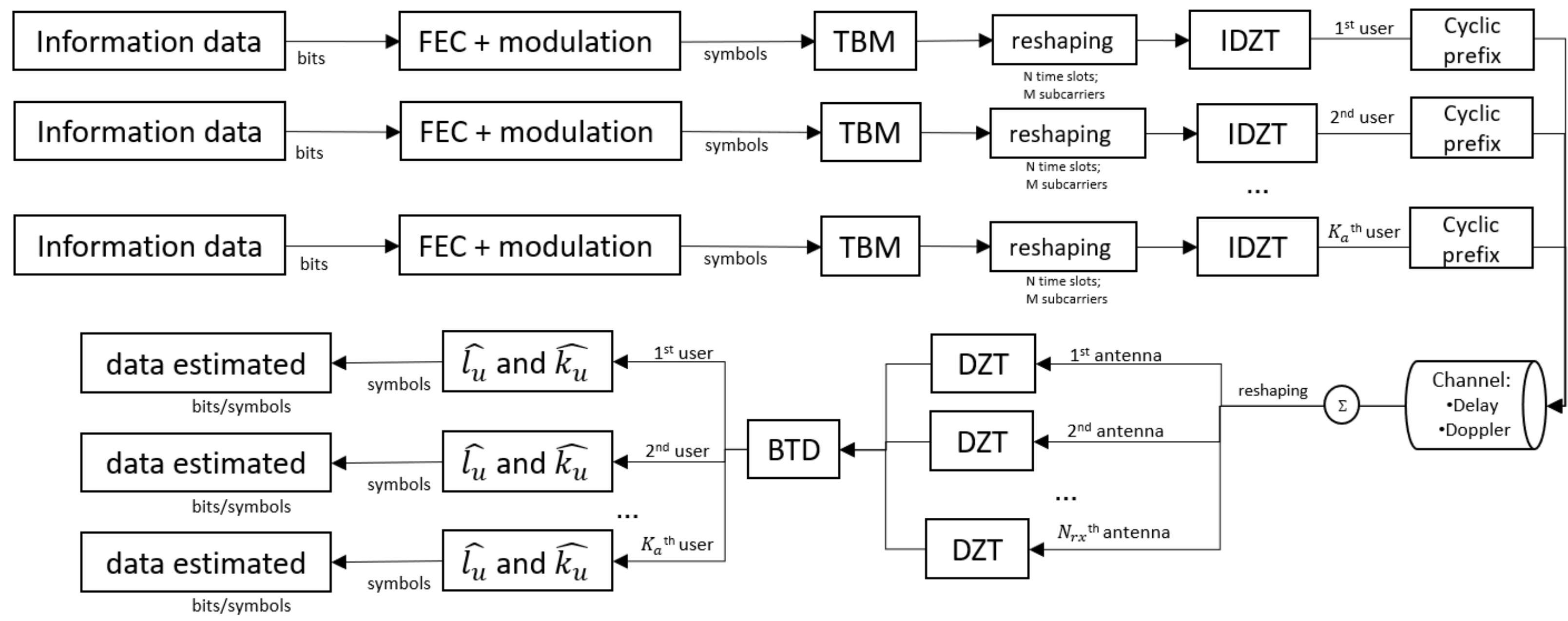
## TBM

Contributions:

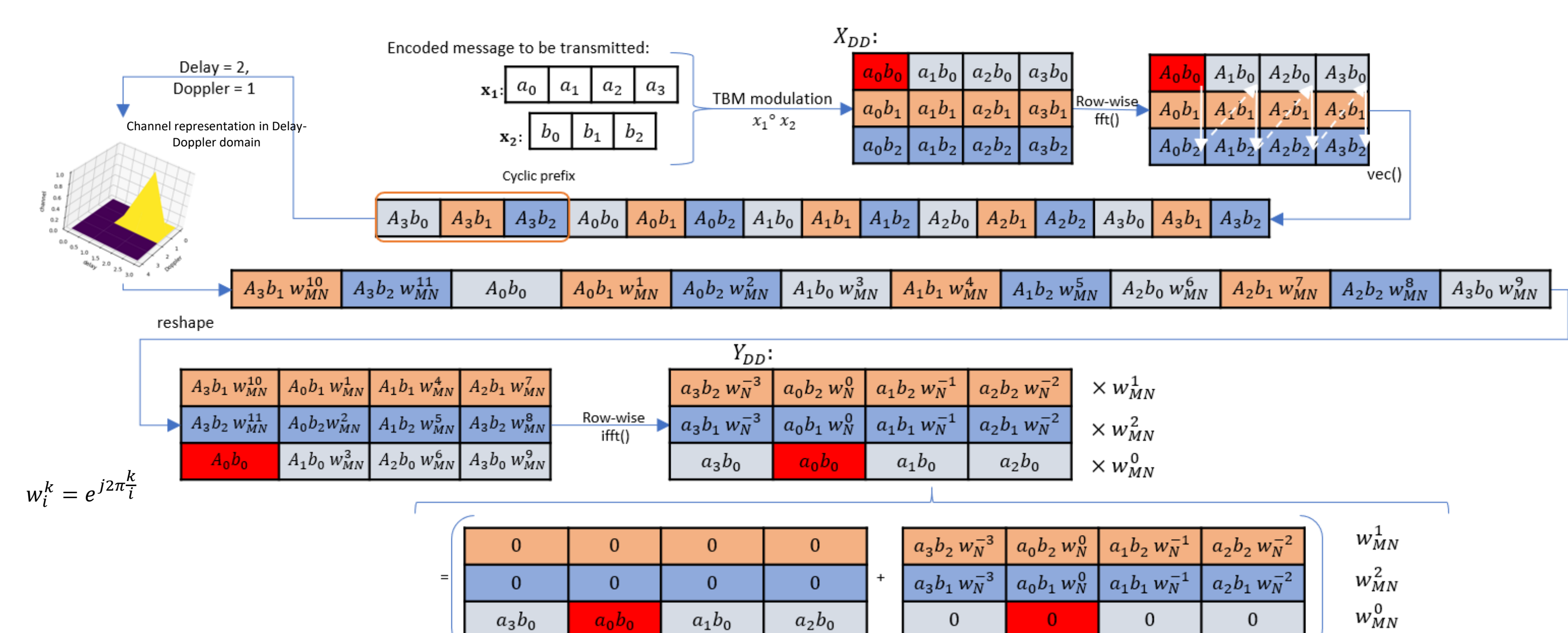
1. Combination of TBM and Orthogonal Time Frequency Space modulation (OTFS) [3]
2. Derivation of the Input-Output relationship for multiuser single path TBM-OTFS modulation

OTFS converts a time-varying, frequency-selective channel into a time-invariant, non-selective delay-Doppler channel

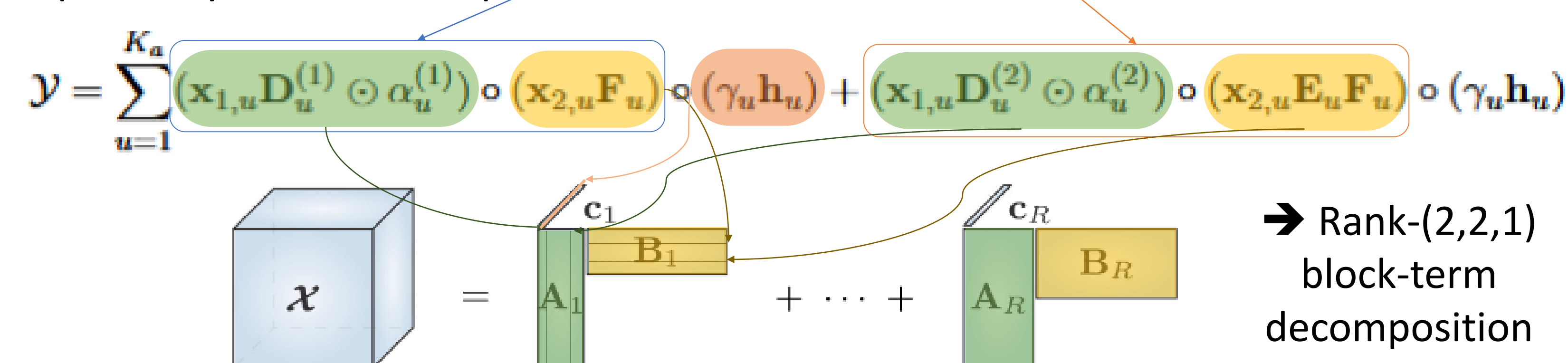
System model



Per-user delay-Doppler effects on a TBM-OTFS waveform: an example with  $N = 4$  and  $M = 3$ .

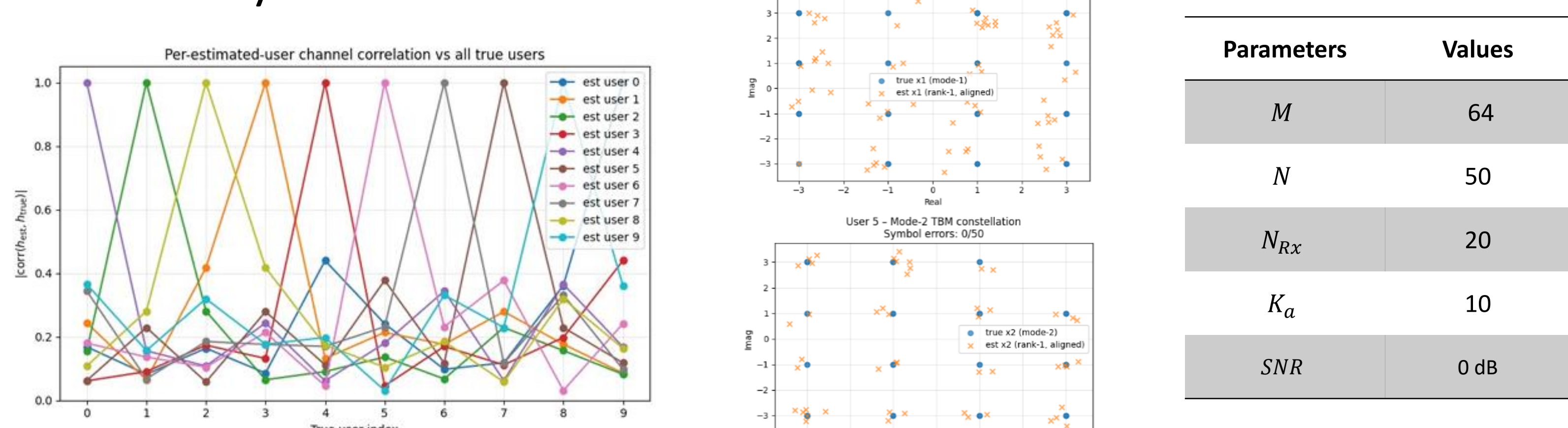


Input-Output relationship



Low rank tensor (per user) → Block-Term Decomposition for user separation [4]

Preliminary results

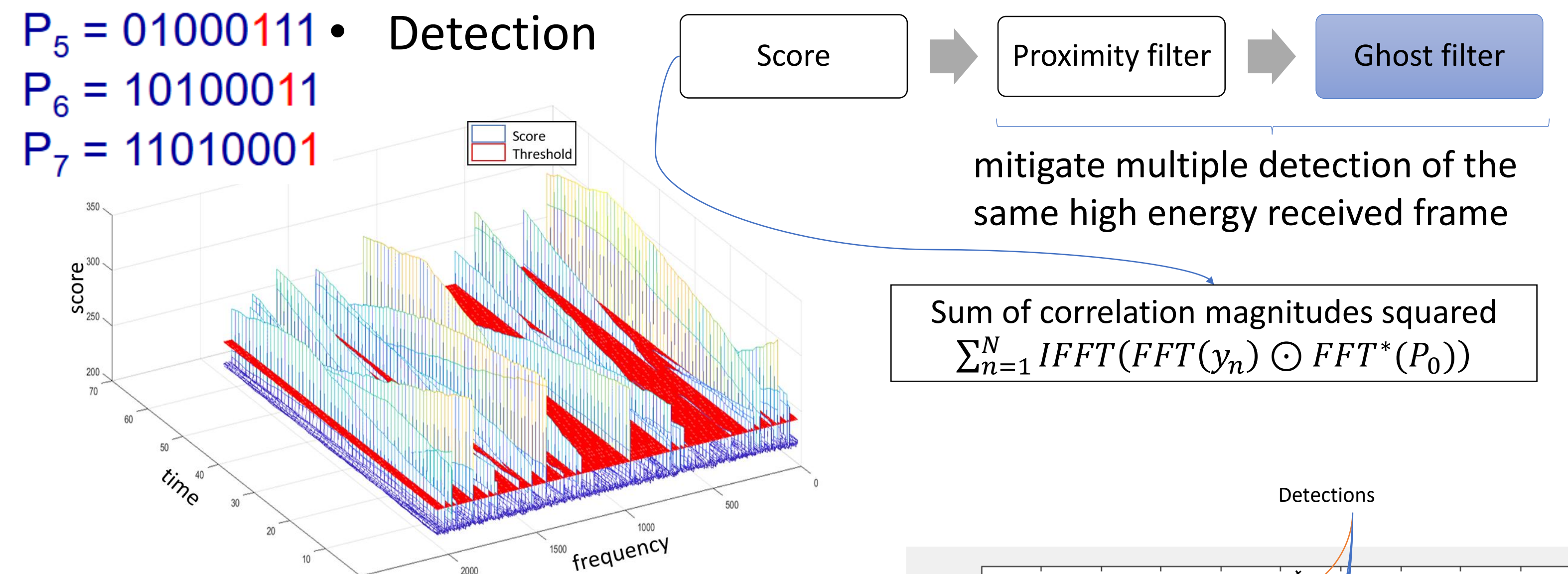


## QCSP

• CCSK

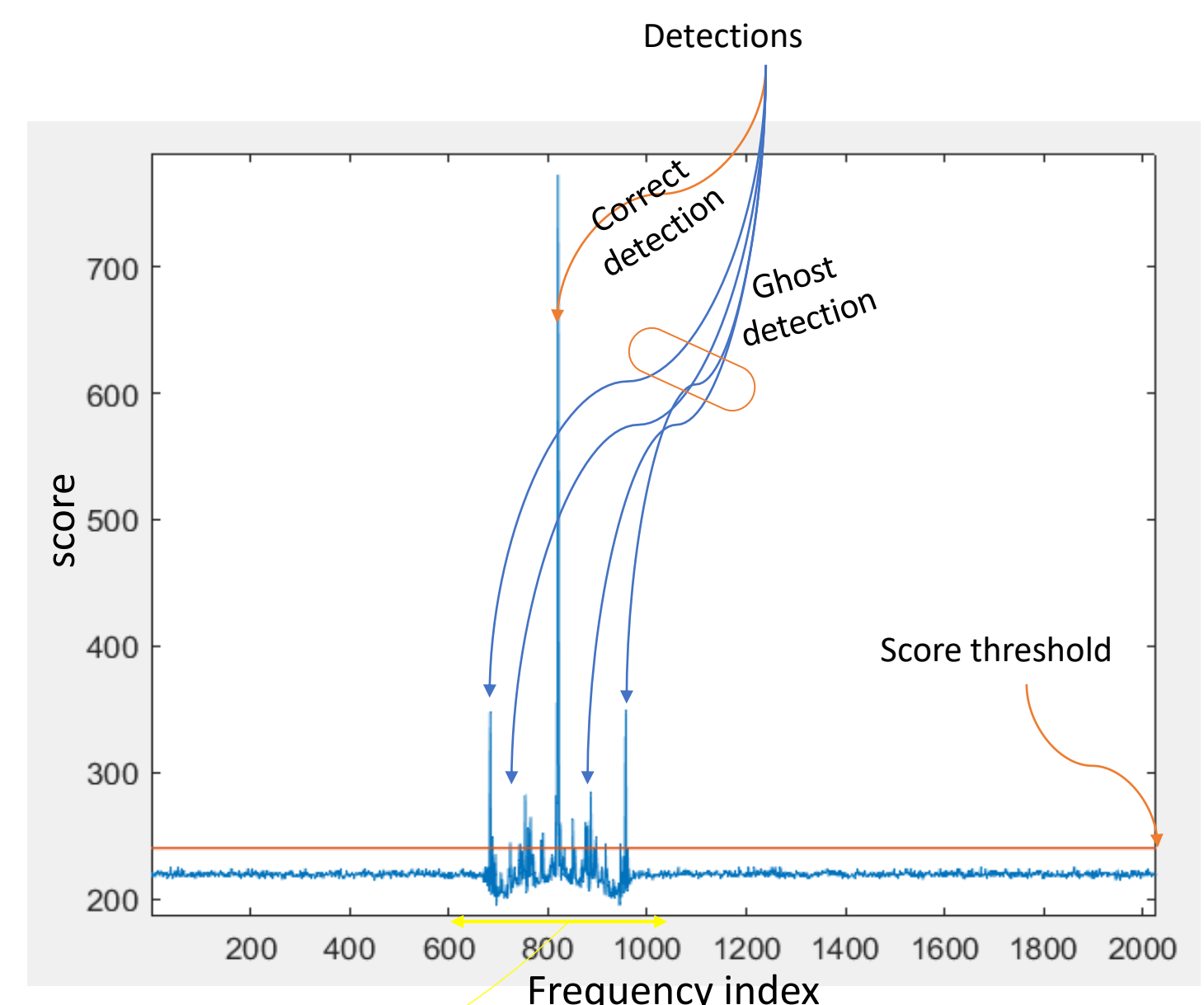
$P_0 = 11101000$   
 $P_1 = 01110100$   
 $P_2 = 00111010$   
 $P_3 = 00011101$   
 $P_4 = 10001110$   
 $P_5 = 01000111$   
 $P_6 = 10100011$   
 $P_7 = 11010001$

Symbol to transmit: 3 1 4  
 CCSK symbols:  $P_3$   $P_1$   $P_4$   
 QCSP transmitted frame: 00011101 11101001 10001110

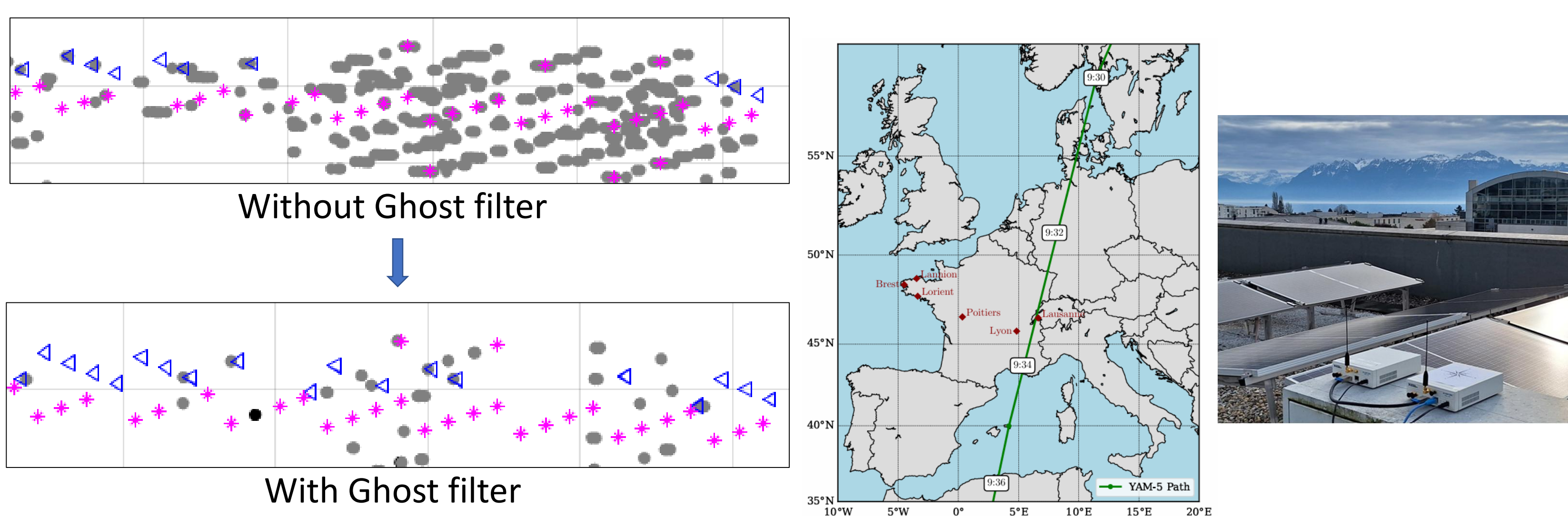


Problem: At high SNR, the side lobes of the Half Raised Cosine pulse shaping filter cause the same frame to be detected across multiple frequency bins, creating "ghost" detections.

Contribution: A ghost filter that keeps only the detection with the highest score within each frequency band, suppressing all others.



• Results for multi-user earth-to-satellite communication post processing real data (QCSP transmission to LEO Yam-5 satellite, ADONIS project) with 8 transmitters representing 128 virtual users. [5]



[1] K. Saied, A. Al Ghouwayel, and E. Boutillon, "Quasi Cyclic Short Packet for Asynchronous Preamble-Less Transmission in Very Low SNRs", IEEE TWC, 2022.  
 [2] A. Decurninge, I. Land, and M. Guillaud, "Tensor-based modulation for unsourced massive random access," IEEE Wireless Communications Letters 2021.  
 [3] Z. Wei, S. Li, et al, "Orthogonal time frequency space modulation—Part I: Fundamentals and challenges ahead", IEEE Communications Letters 2022.  
 [4] A. A. Rontogiannis, E. Kofidis and P. V. Giampouras, "Block-Term Tensor Decomposition: Model Selection and Computation," IEEE Journal of Selected Topics in Signal Processing 2021.  
 [5] L. Montoya Obeso, S. Tannir et al, "Proof of Concept of QCSP Frames in Earth-to-LEO Satellite Transmission," IEEE ICC 2026.

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