New Spectrum: Interferers in our midst

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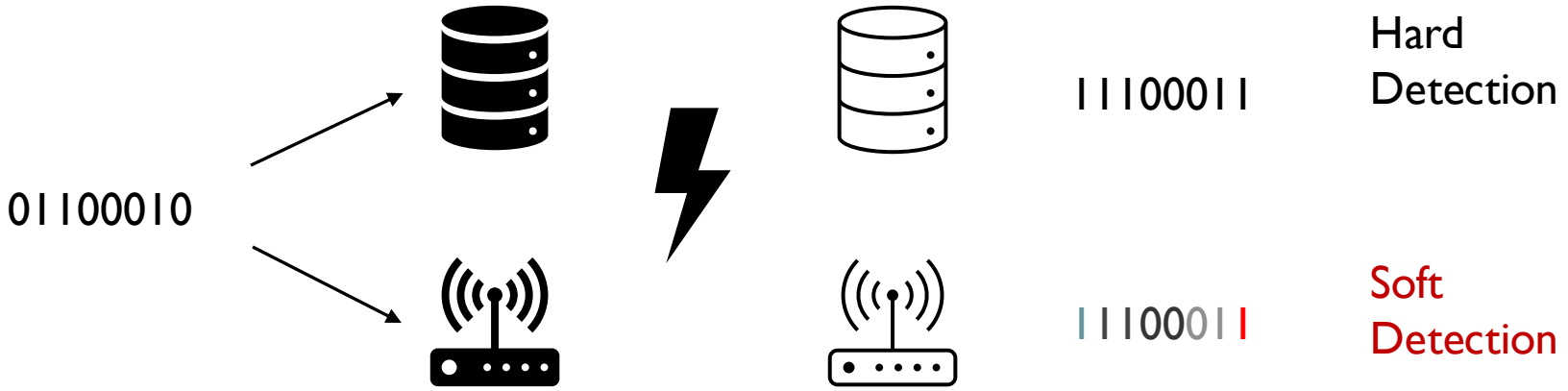
Error correction code (ECC)



- Decoding is a bottleneck: must be lower latency than data reception (i.e. in hardware).
- More corrupt channel implies lower code rate and more challenging error correction
- Soft detection decoders assume bits have been impacted independently by the channel
- Long, powerful codes constructed by concatenating shorter ones & decoding iteratively

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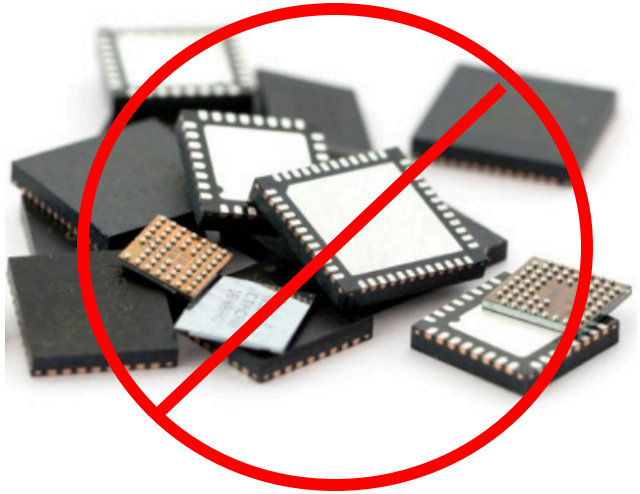
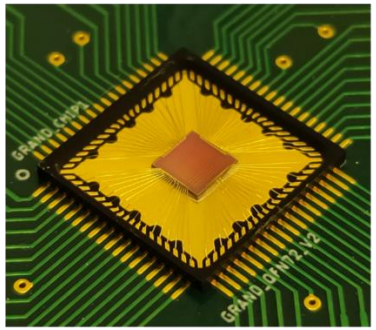
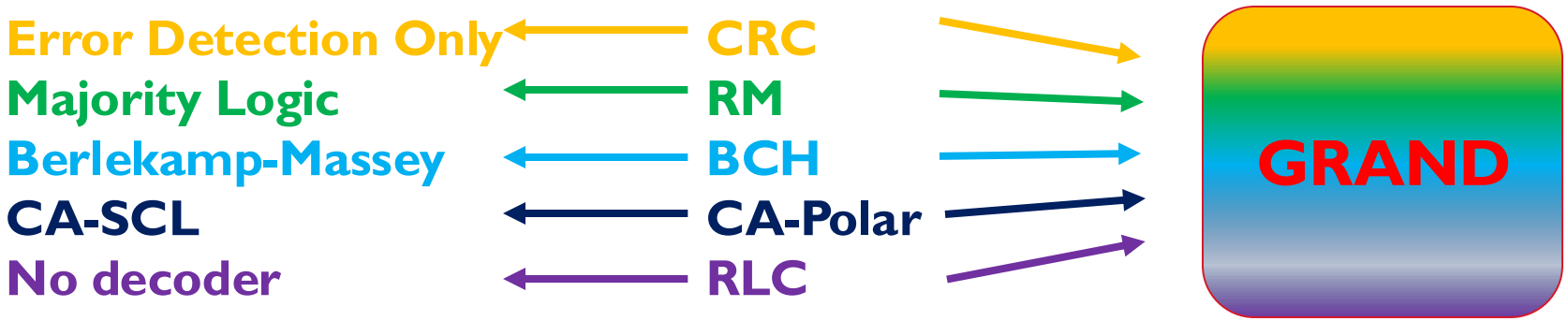
Guessing Random Additive Noise Decoding







Efficiently decode **any** moderate redundancy code & generate soft output

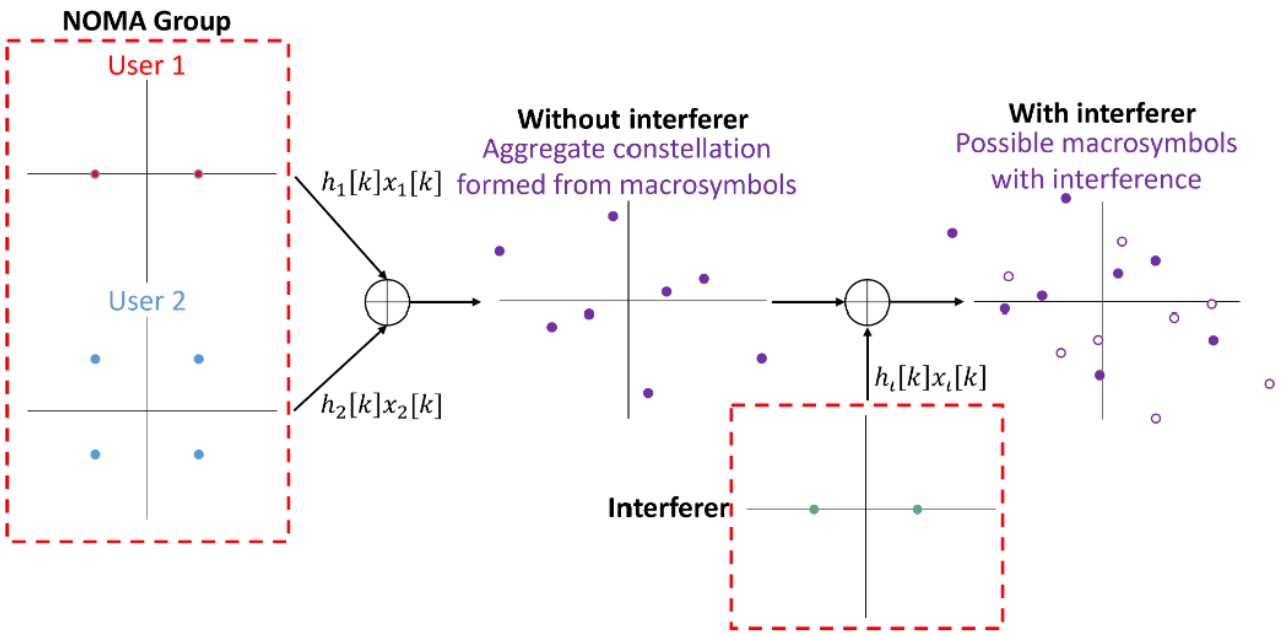
Duffy, Li, Médard, *IEEE Tran. Inf. Theory*, 19. Duffy, An, Médard, *IEEE Trans. Sig. Proc.*, 22. Yuan, Medard, Galligan, Duffy, *IEEE Trans. Wireless Commun.*, 25.

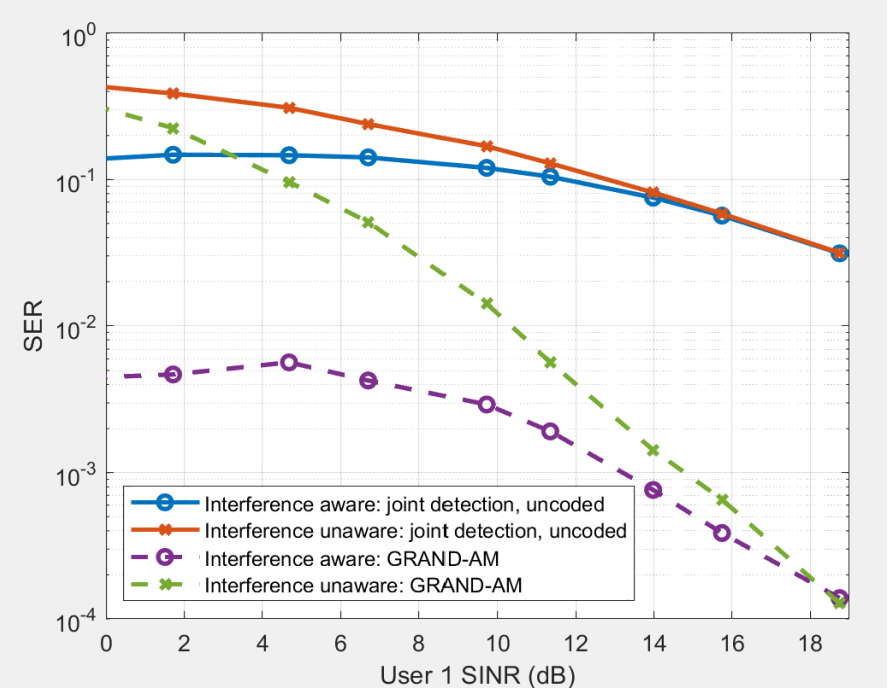
Riaz et al., *IEEE ESSCIRC*, 21. Riaz et al., *IEEE ISSCC*, 23. Riaz et al., *IEEE JSSC*, 25.

Decoding knowing that interference ≠ noise

- **Thrust (1):** Guessing random interference and noise decoding (GRIND)
- **Thrust (2):** Interference-Inflected-noise (IIN) GRAND
- **Thrust (3):** Interference discovery and subtraction

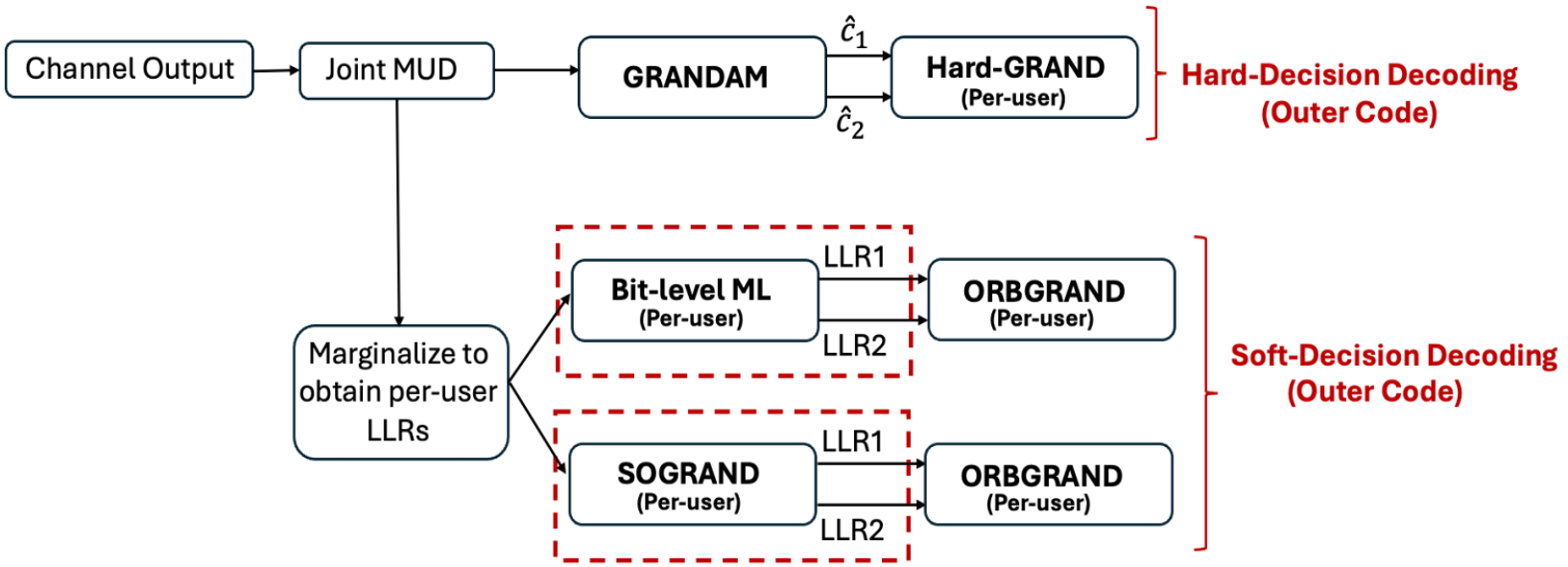
GRAND-AM (aided macrosymbol) with Interference





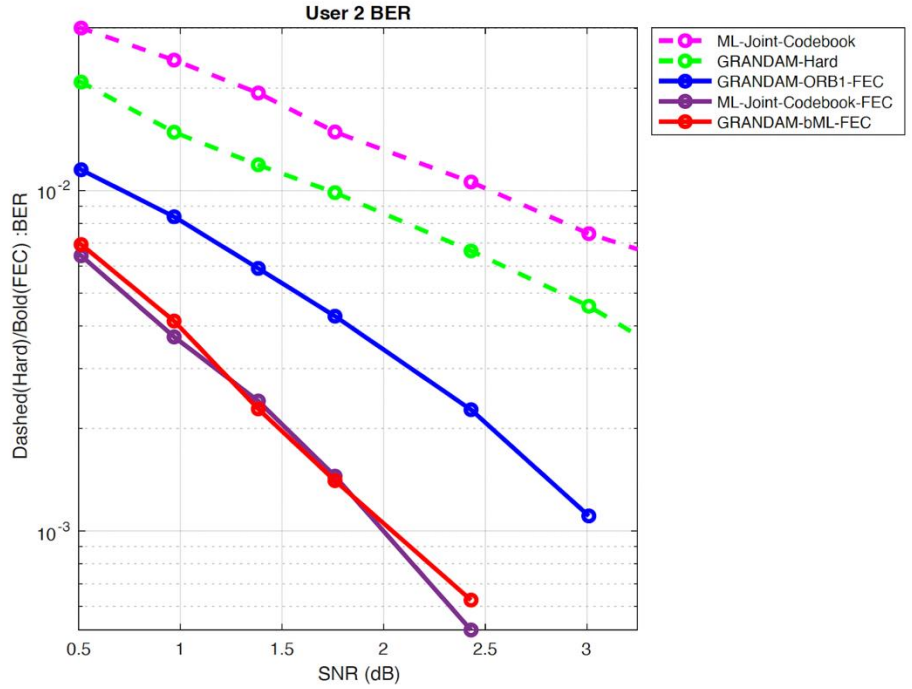
- Multiple Access Channel (MAC) codes to handle multiple access interference
- **Joint detection of macrosymbols:** combinations of all user symbols
- **Joint universal decoding:** symbol-level GRAND
- At the receiver:
  - **Interference-aware**: remove the effect of interferer for each aggregate constellation point
  - **Interference-ignorant:** treat interferer signal as noise

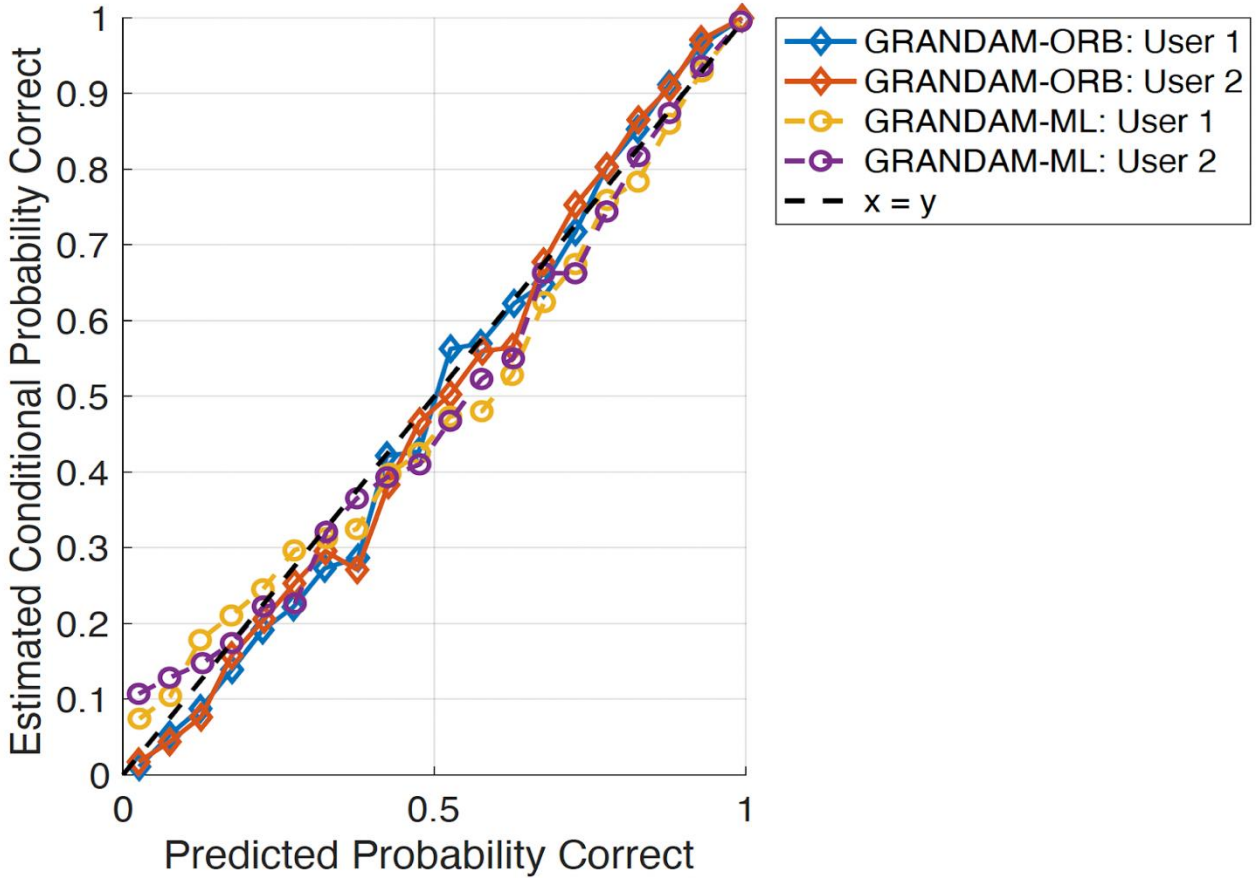
Soft-output GRAND-AM (Aided Macrosymbol)



- GRAND's ability to generate accurate a posteriori probabilities (APPs) for decoding
- Codes considered:
  - **Outer code:** error correcting code (ECC)
  - **Inner code:** short MAC codes
- **SO-GRANDAM:** enable soft decision decoding of the ECC
- Convert blockwise SO to bitwise LLRs → soft-information for decoding ECC

Soft-output GRAND-AM (Aided Macrosymbol)

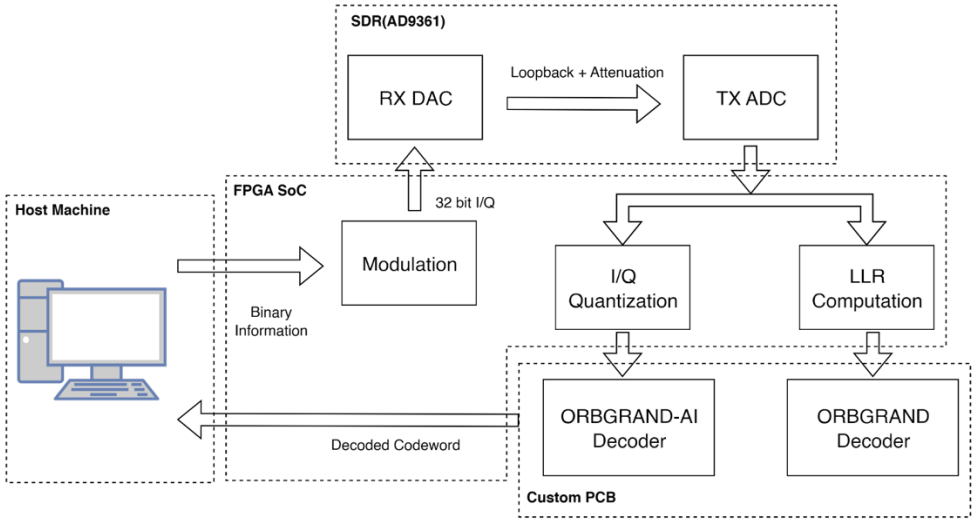


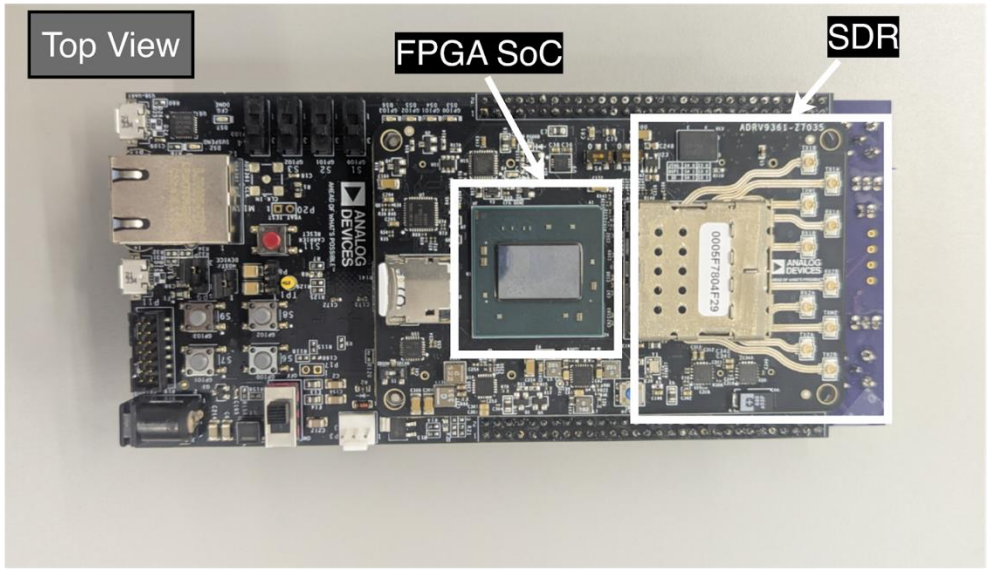


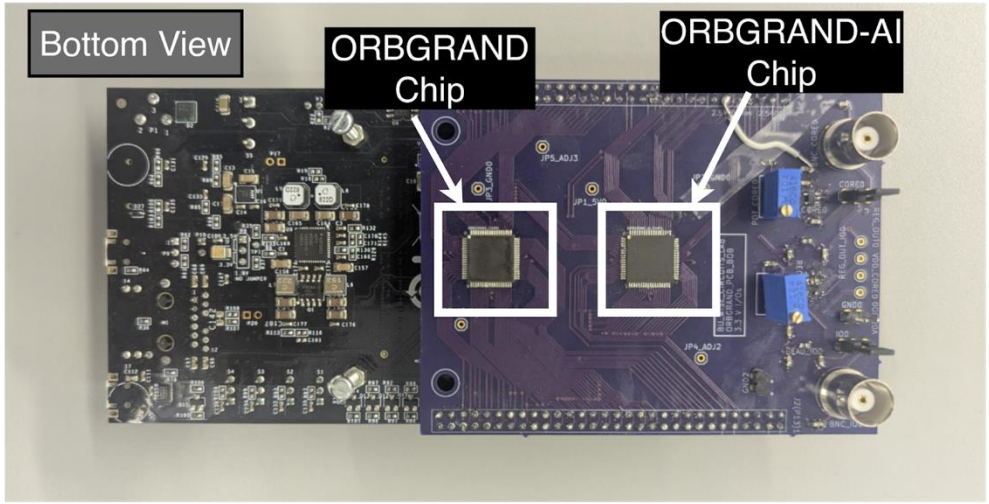
- Consider two decoders for blockwise SO:
  - Bitwise-ML decoding
  - SOGRAND
- Blockwise SO is a forecast that the decoding is correct
- Well-calibrated: if conditional likelihood given the forecast corresponds to the forecast itself (data aligns with x=y)

Experimental evaluation

- Evaluate the performance in a real channel
- Multiple ORBGRAND chips
- Enable low-latency and energy efficiency
- Hardware-based system:
  - SoC-based FPGA
  - SDR
  - Custom Hardware Attached on Top (HAT)







Bali, Kizilates, Riaz, Medard, Duffy, Yazicigil, Asilomar Conference on Signals, Systems, and Computers, 2025