Channel Measurement Campaign

RUTGERS
WINLAB | Wireless Information Network Laboratory

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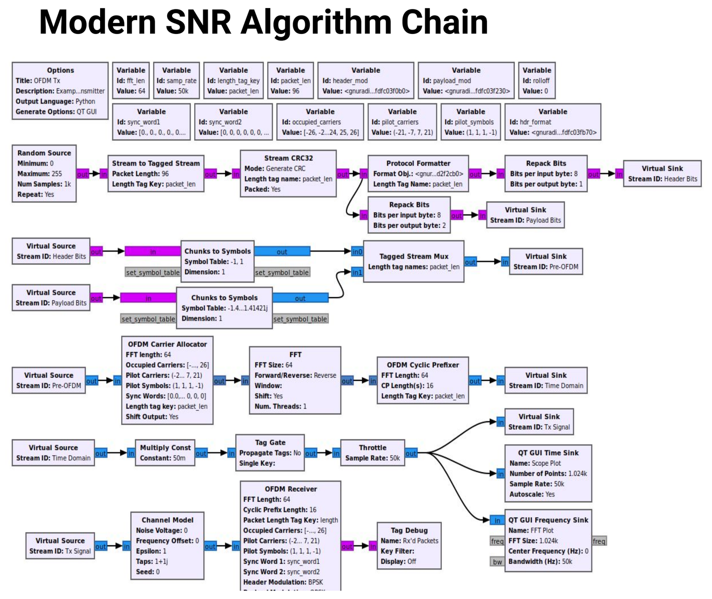
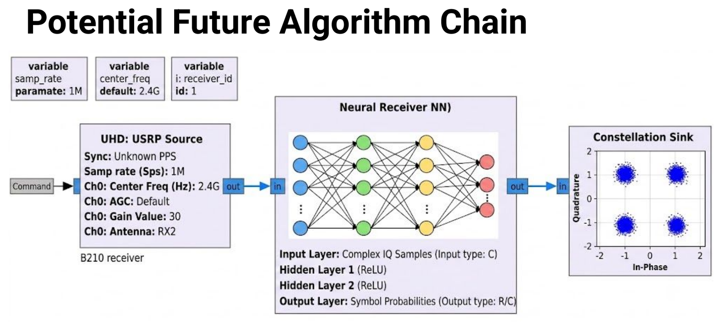
Background & Motivation

Modern SNR Algorithm Chain



Potential Future Algorithm Chain



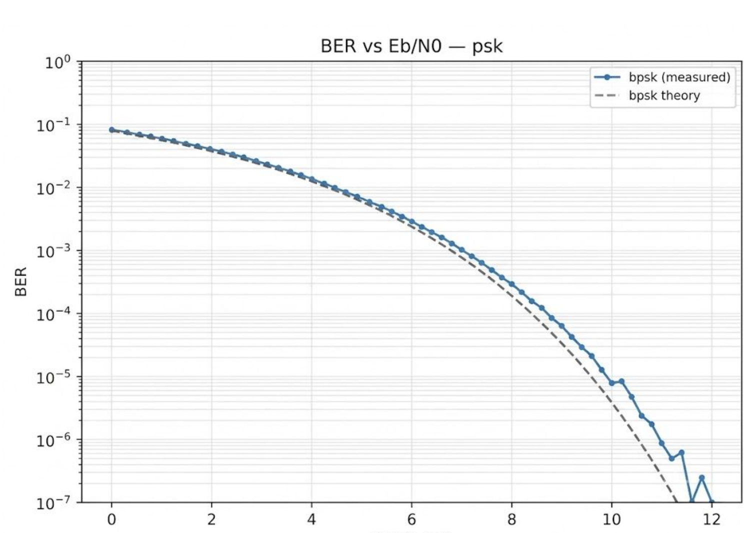
Modern radios use **hard-coded algorithms** to decode wireless signals, which break when real-world conditions don't match their assumptions. **Neural networks** can replace these algorithms, but require real, diverse, **over-the-air data**. This project builds an **automated pipeline** for capturing and labeling this data at scale.

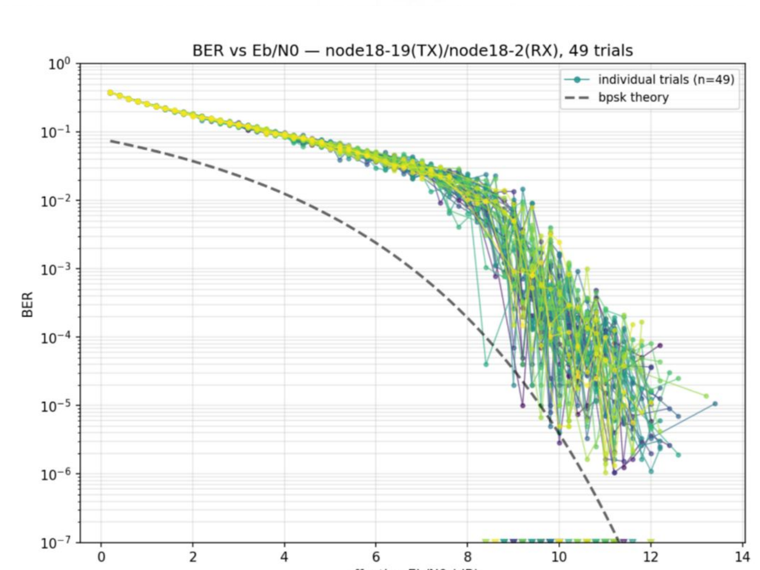
Baseline Importance

Every measurement campaign starts with a **baseline**. Before collecting usable data, we first validated that our **classical receiver** works correctly on real hardware — confirming our **signal chain, synchronization,** and **gain calibration** are trustworthy. Without this, no result that follows would be interpretable.

We chose **BPSK as our modulation** scheme because it is the simplest form of digital modulation, making it the ideal starting point **for validation**.

Baseline Testing

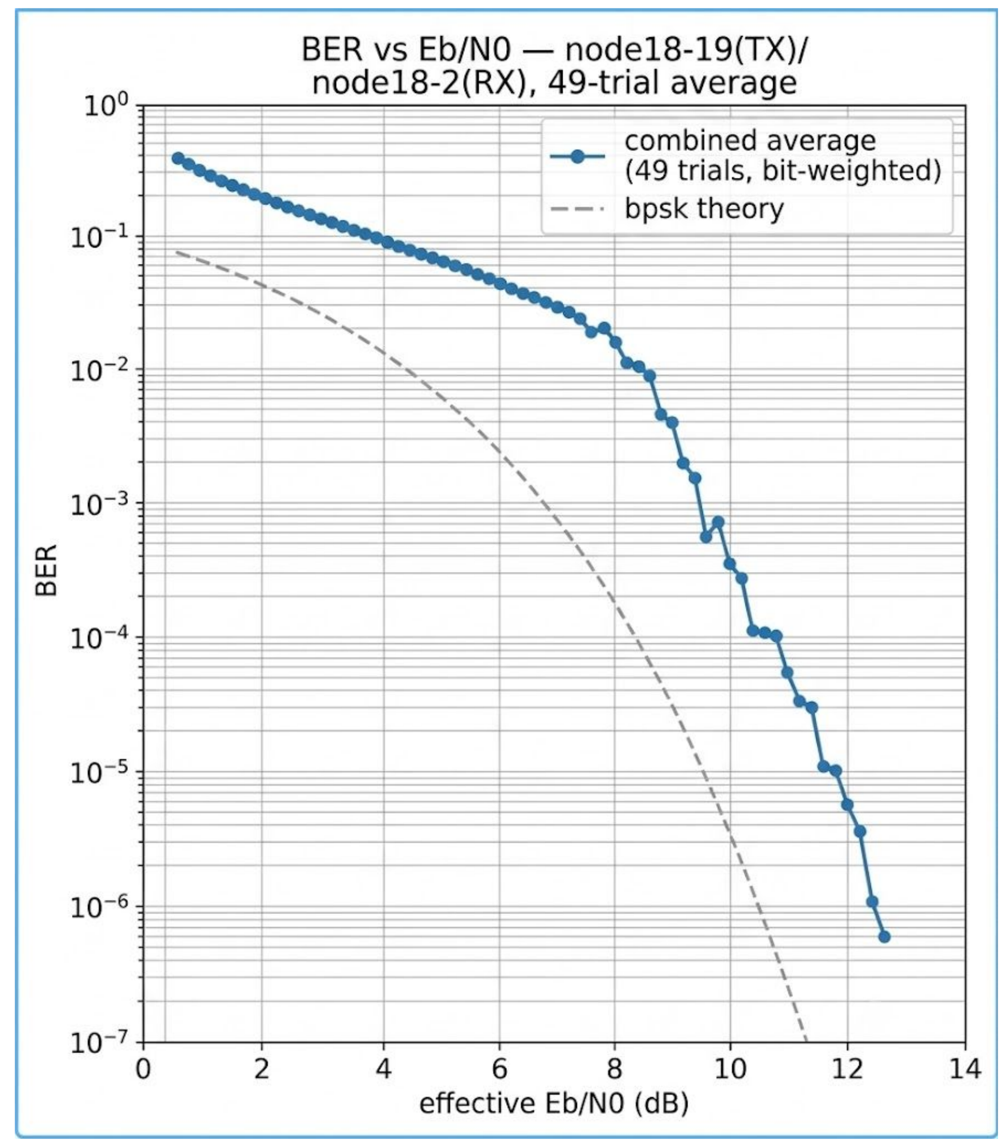




We tested multiple receiver architectures over wire, eventually settling on a **continuous-lock gain ramp** synchronizing at **high TX gain** then backing off into lower SNR ranges while maintaining lock.

That architecture was validated over the air across 49 trials on the **COSMOS** grid, producing curves within **3 dB** of theoretical BPSK, a trustworthy baseline for all data collection.

Pipeline Construction

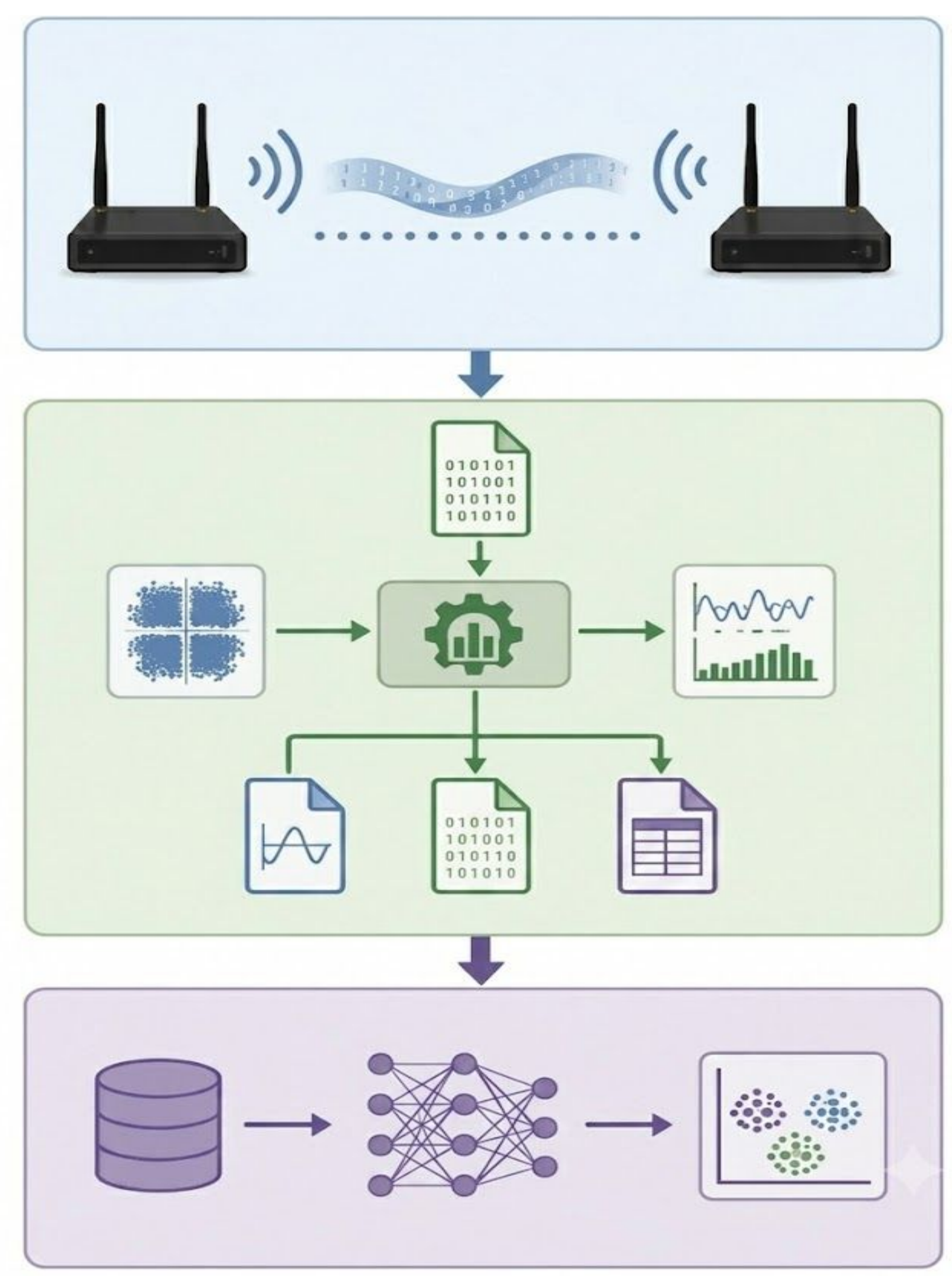


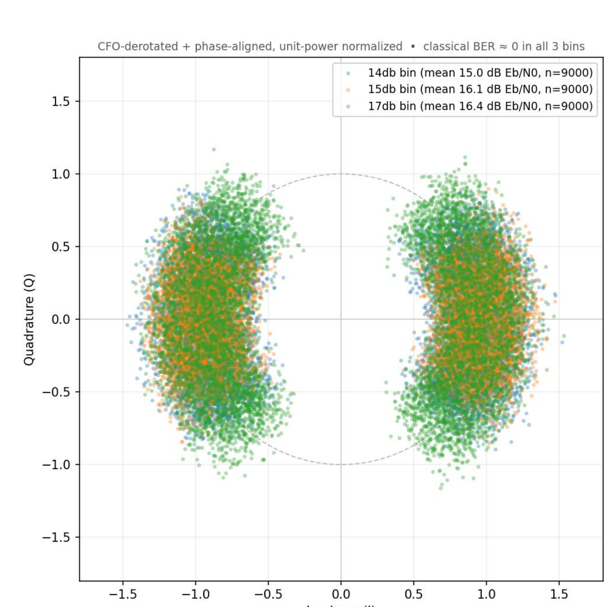
With the baseline accuracy verified, we built an **automated pipeline** capable of deploying and executing experiments across the entire **COSMOS** grid without human intervention. The backbone of that automation is **Ansible**. A single playbook handles all hardware configuration.

Each experiment produces **three output files**.

- Random Bit File
- IQ File
- SigMF Metadata File

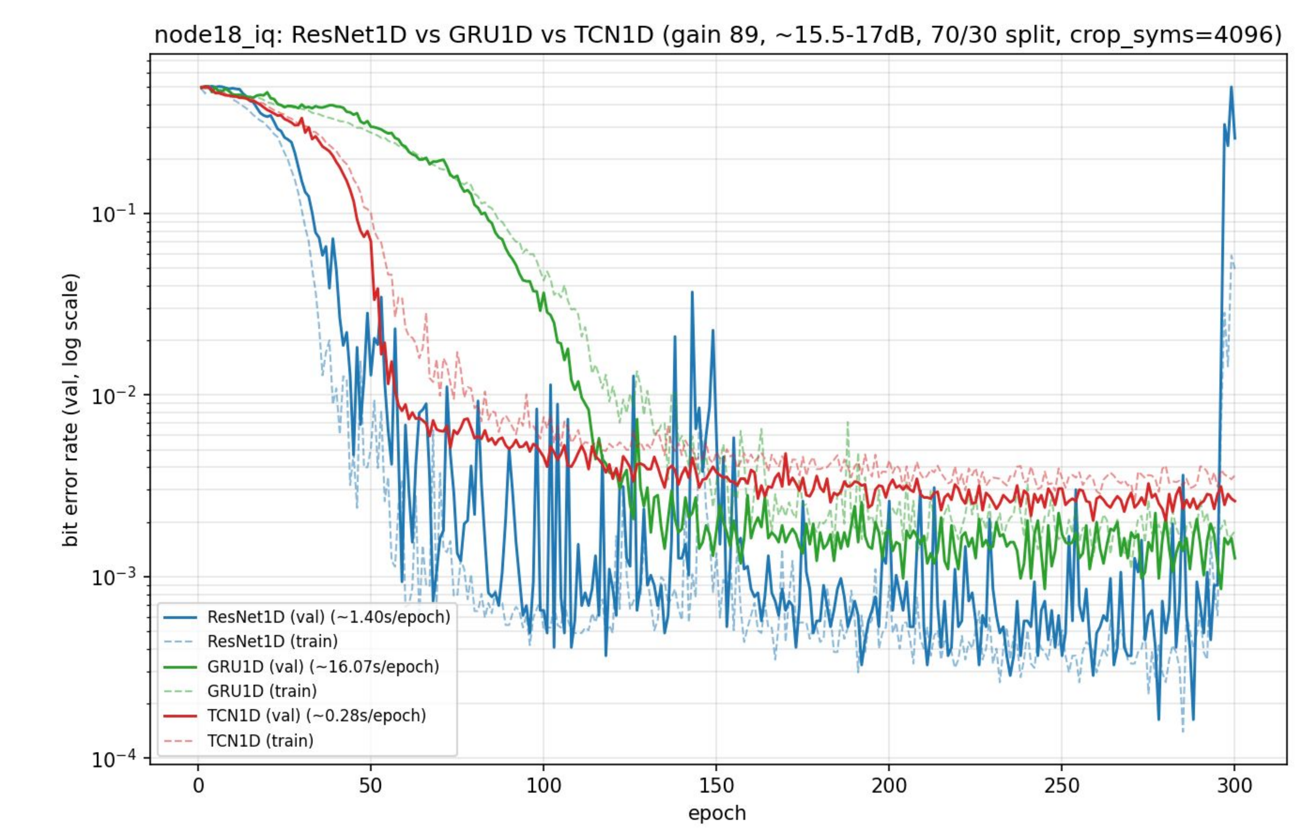
These three files travel together as a complete, **self-describing capture** immediately ready for storage and ML training.



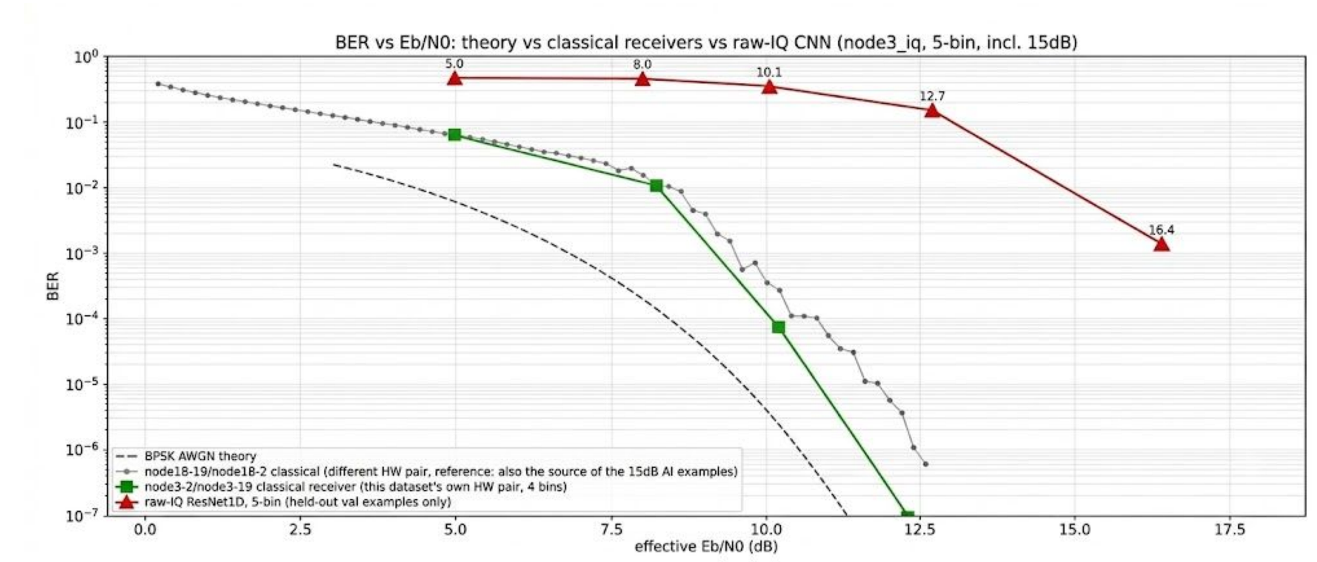


The beauty of the pipeline lies in **SigMF's** role as a **universal container**. No matter what modulation was used, what hardware pair captured it, or what channel conditions were present, every experiment produces the same structured output.

Machine Learning



With the pipeline producing labeled **IQ captures**, we trained and compared three architectures: **ResNet1D**, **GRU1D**, and **TCN1D**. ResNet achieved the lowest error rate while TCN trained significantly faster — making TCN ideal for **rapid iteration** and ResNet for accuracy.



With **ResNet** confirmed as our **strongest architecture**, we tested it against real IQ captures spanning five SNR bins from **5 to 15 dB**. The result was a waterfall curve strikingly similar in shape to the classical receiver, a promising first result showing the same **fundamental behavior** as classical DSP, just not yet as efficiently.

Acknowledgments

Special thank you to Ivan and Prasanthi for helping us with this project and sharing their wisdom.

There are a lot of disclaimers and important information that we could not include in this poster. To get a better understanding of our project, please visit our website by scanning the QR Code.

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