Operational Performance Envelope of the PULSE-A SDR Ground Station

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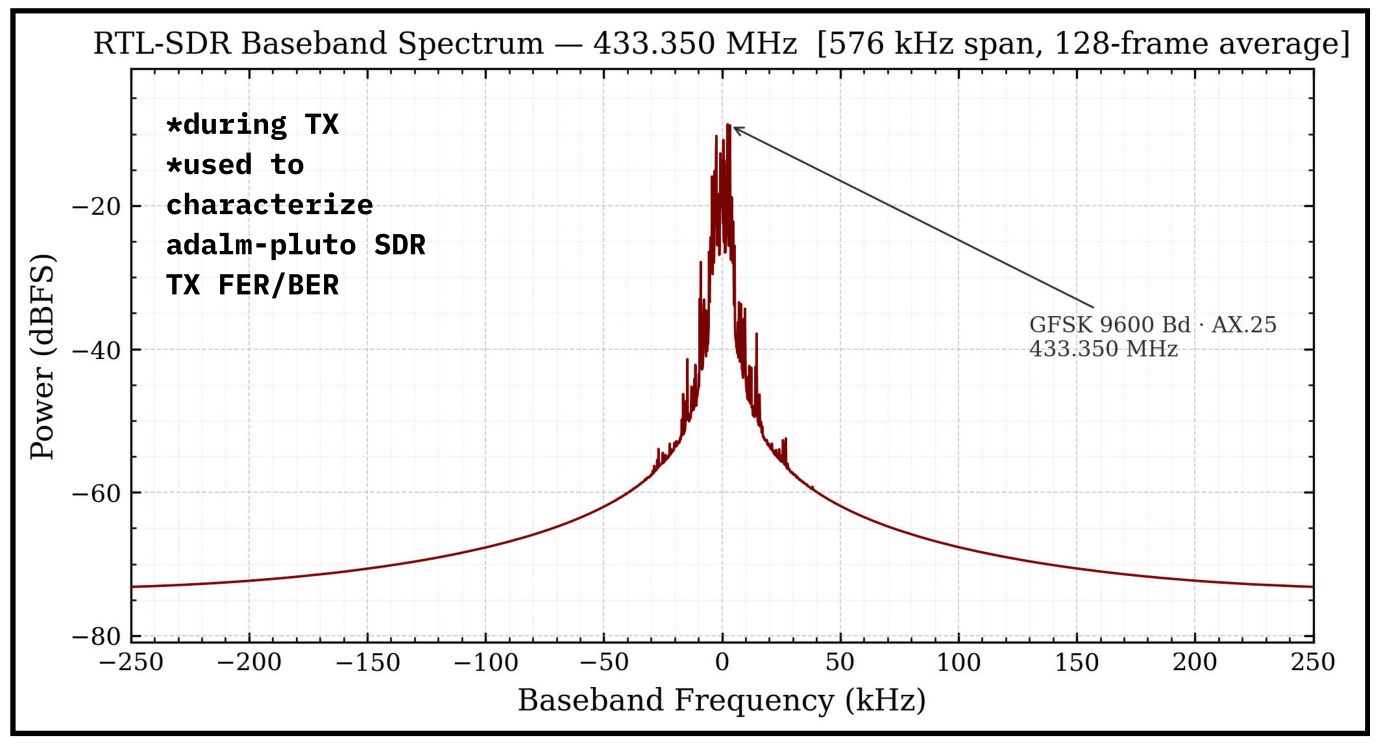
PURPOSE

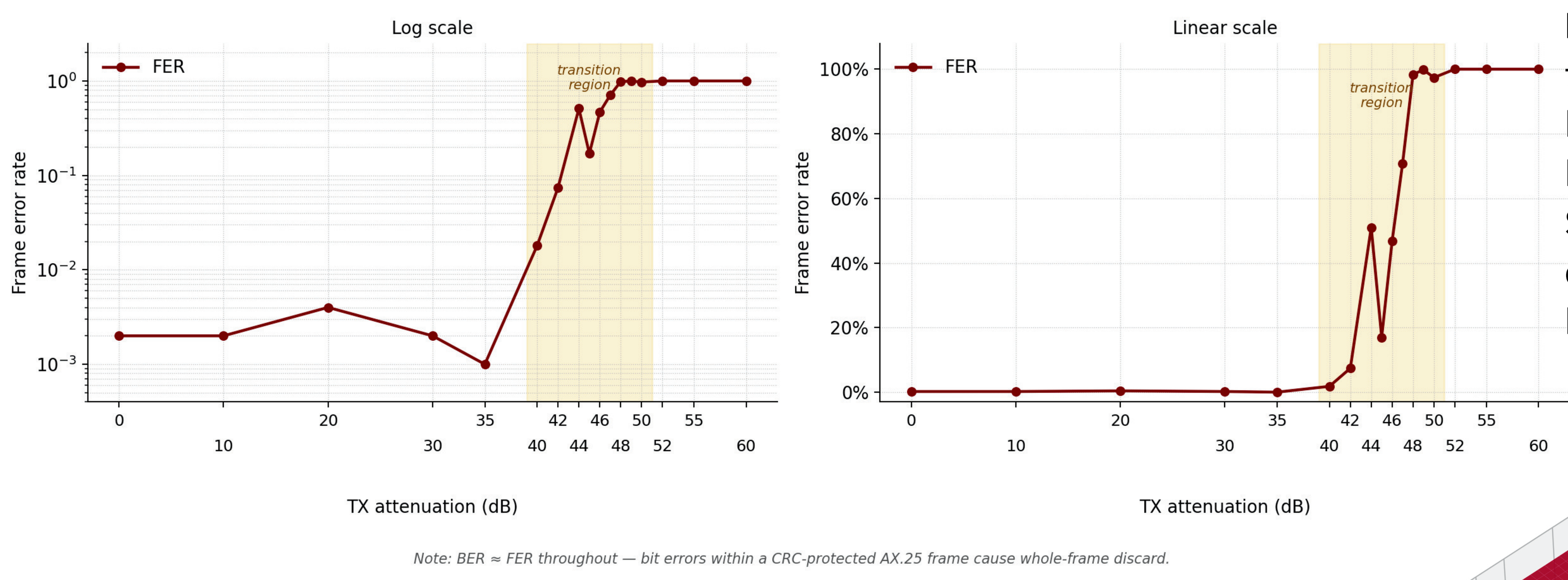
The RFGS will communicate with the **PULSE-A CubeSat** through radio signals. It will receive critical telemetry at **9600 bps**, which will be used to evaluate the health diagnostics of the satellite, ranging from thermal data to link quality. It also transmits mission and maintenance commands to the satellite, enabling function of the laser and avionics systems.



ABOUT PULSE-A

PULSE-A is a UChicago student-led **3U** CubeSat mission. It is designed to demonstrate space-to-ground optical downlink at **1-10 Mbps data rate** using an infrared laser, encoding data using **Circular Polarization Shift Keying** (CPolSK). This demonstration will be enabled by commands sent over amateur **UHF (435-438 MHz)** frequencies by radio to space from the Radio Frequency Ground Station (RFGS) to the payload and onboard computer, and critical telemetry sent from space to the RFGS by the satellite radio module.

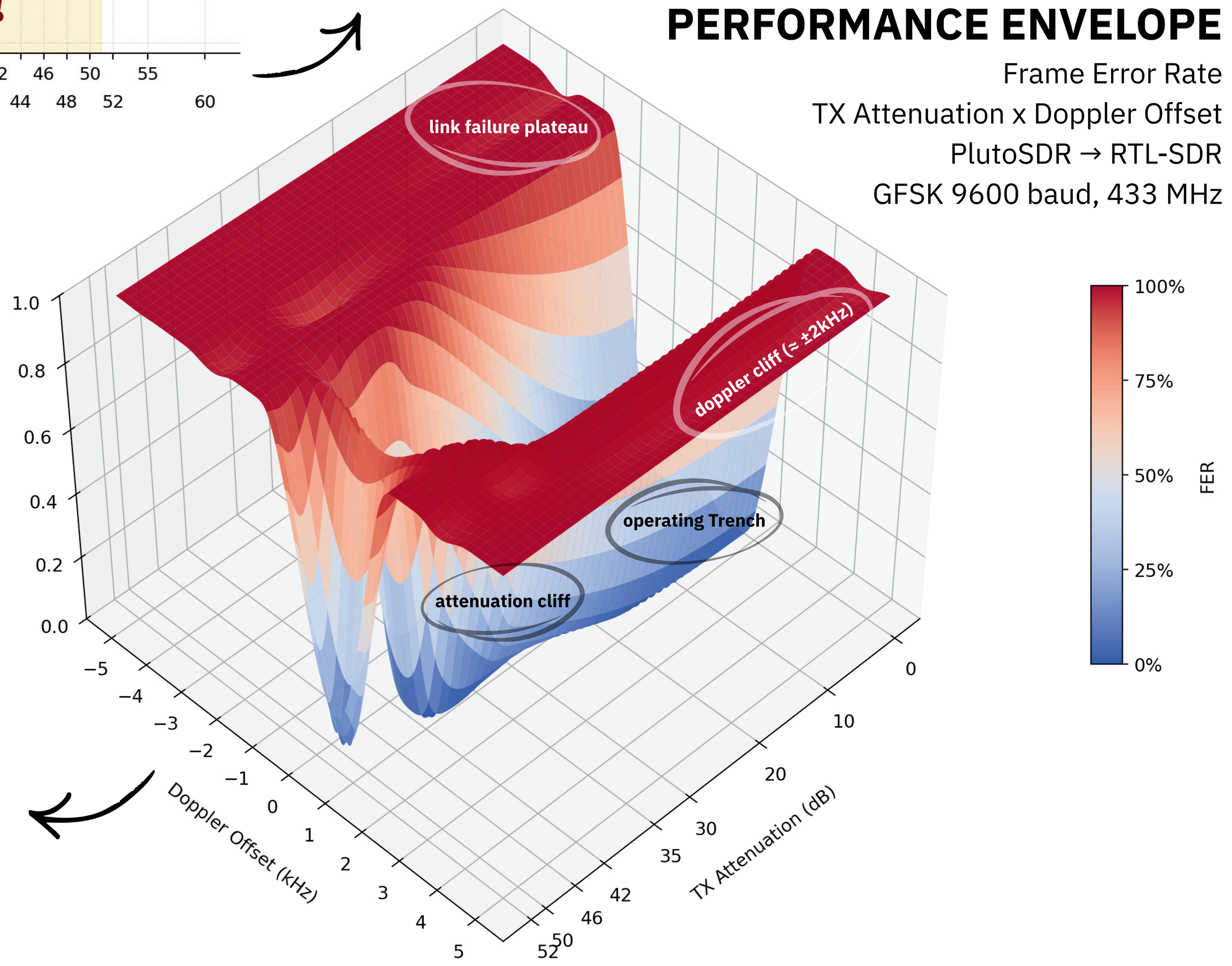
FER vs TX Attenuation – PlutoSDR → RTL-SDR, GFSK 9600 baud, 433 MHz



The **1D attenuation sweep** isolates the power-dependent behaviour of the link at **zero simulated Doppler offset**. Frame recovery remains stable across the low-attenuation region, followed by a comparatively broad transition window in which FER rises rapidly before reaching complete failure at higher attenuation. Small irregularities within this transition region are consistent with setup-dependent variation in the indoor bench configuration.

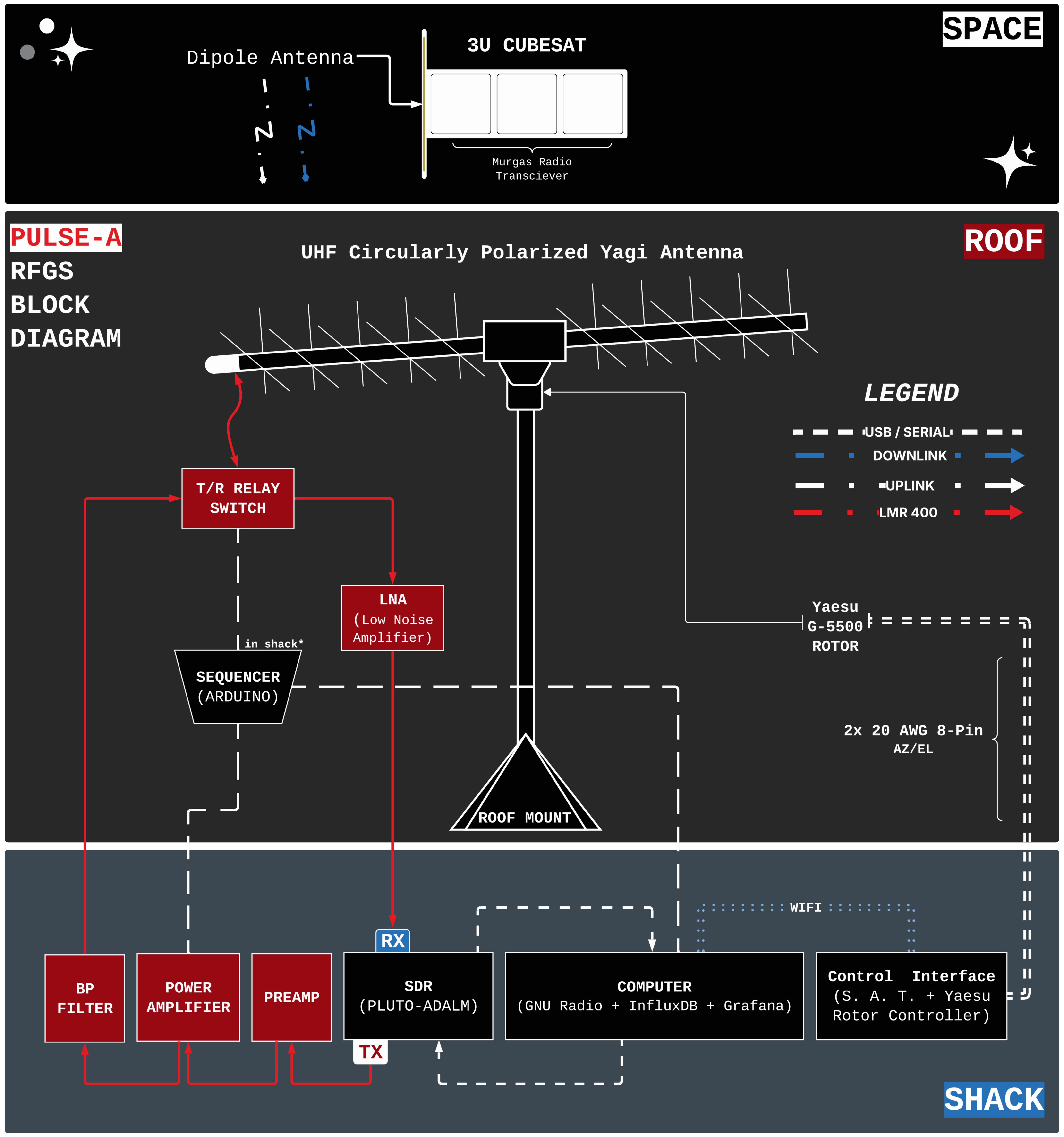
PERFORMANCE ENVELOPE

Frame Error Rate
TX Attenuation x Doppler Offset
PlutoSDR → RTL-SDR
GFSK 9600 baud, 433 MHz

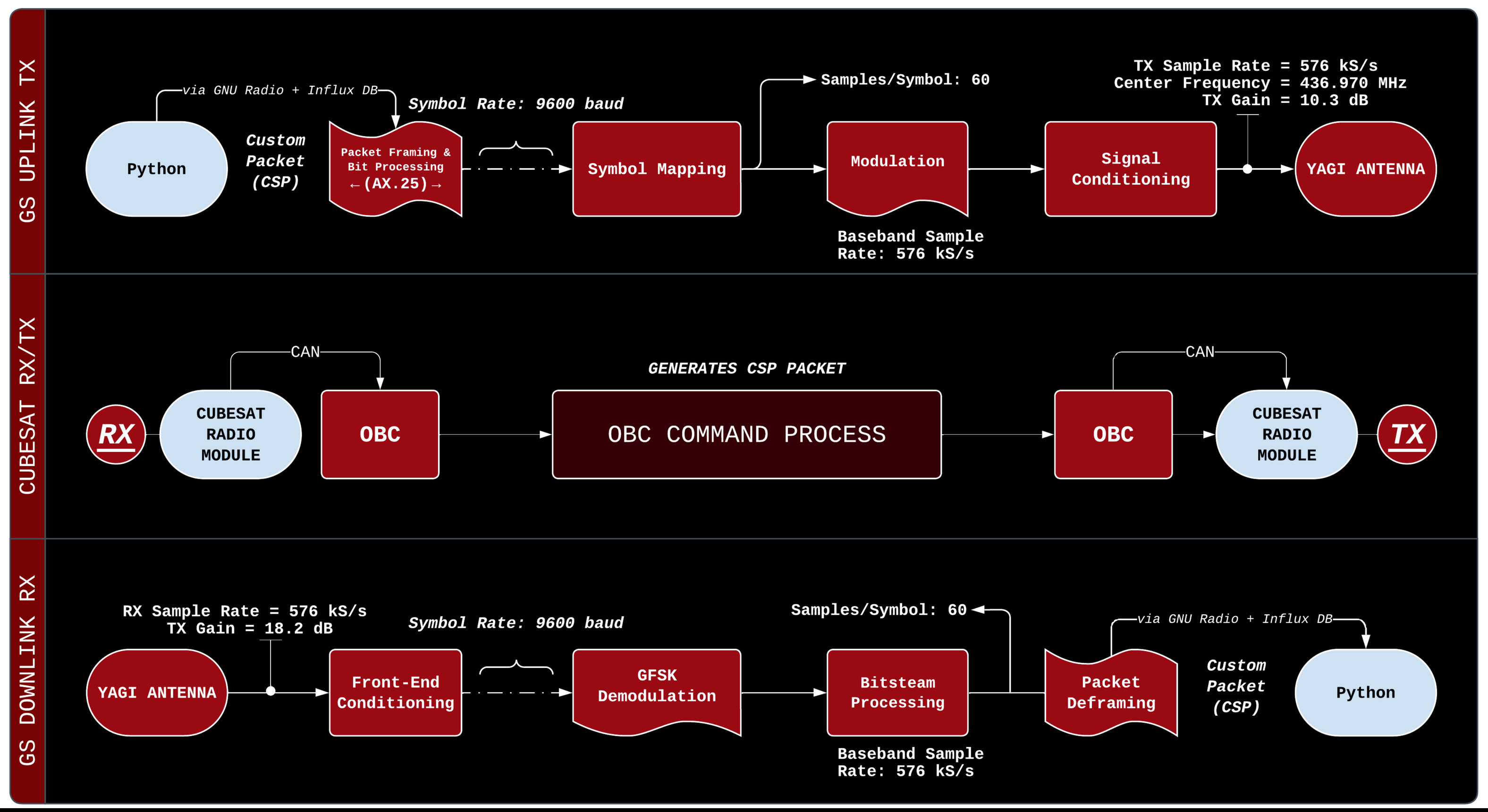


The joint **Frame Error Rate** (FER) **performance envelope** surface shows that simulated **Doppler offset** degrades the receiver much more strongly than **attenuation** in the present chain. Reliable decoding was confined to a narrow region near the nominal carrier frequency, while attenuation produced a more gradual transition. BER and FER tracked closely across the trials, consistent with **AX.25 frame rejection** after **decoding errors**.

RFGS BLOCK DIAGRAM



SOFTWARE DEFINED RADIO COMM-CHAIN



GNU Radio Implementation of the PlutoSDR Communication Chain. A **Python** control layer manages the GNU Radio transmit and receive flowgraphs and records telemetry and experiment results in **InfluxDB** for visualization through **Grafana**. The transmit chain performs **AX.25/HDLC framing**, **PDU-to-stream** conversion, bit unpacking, and **GFSK modulation**. The receive chain performs **front-end conditioning**, GFSK demodulation, **clock and symbol recovery**, and AX.25/HDLC deframing.

PULSE-A is designed and developed by undergraduate students at The University of Chicago. Previously selected for Call 15 of NASA's CubeSat Launch Initiative, covering launch and integration costs up to $300,000. PULSE-A hopes to launch and be deployed from the ISS no earlier than 2026.
www.uchicagospaceprogram.org