

S3. Colab notebook — 3×HWP chain implementation (Architecture B) under non-idealities

- **Purpose:** generate paper-ready figures and tables for Architecture B, including per-plate (3×) HWP tolerances and wavelength mis-tuning (retardance detuning).
- **Modelled non-idealities:** per-plate HWP angle errors $\Delta\theta_i$ and retardance errors $\Delta\delta_i$ (with an additional λ -dependent detuning term), detector relative noise, finite analyser ER (leakage), and contrast-threshold decision settings (γ , optional erasure window).
- **Outputs:** automated one-parameter sweeps + joint Monte-Carlo sampling + **impact $\pm 1\sigma$** rankings (primary) + correlation-based rankings (secondary) + exported CSV/JSON datasets and 300-dpi figures.
- **Interpretation notes:** (i) In some regimes the erasure rule may not activate ($|C|$ stays above the erasure window), yielding throughput ≈ 1 ; this indicates the contrast distribution remains well separated. (ii) BER-based rankings can appear flat in a robust regime or when $\pm 1\sigma$ perturbations do not cross the decision threshold; in such cases the **contrast-margin** metric ($\text{margin} = 1 - q_{0.05}(|C|)$, with $C=(I_H-I_V)/(I_H+I_V)$) is a more sensitive early-warning indicator.
- **Implementation detail:** for clarity, several sweeps use common-mode settings ($\Delta\theta_i=\Delta\theta$, $\Delta\delta_i=\Delta\delta$), while Monte-Carlo sampling can draw independent per-plate errors.
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Sanity (sweeps):

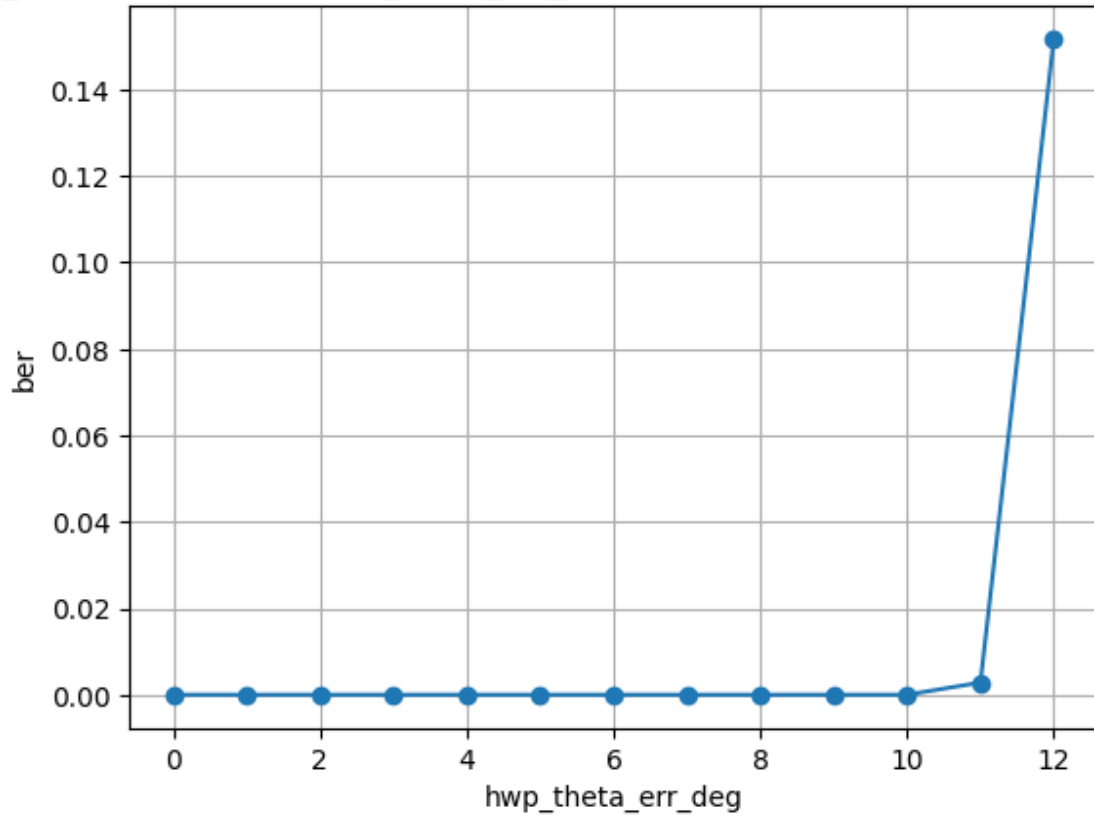
BER range: 0.0 0.15966796875

Throughput range: 1.0 1.0

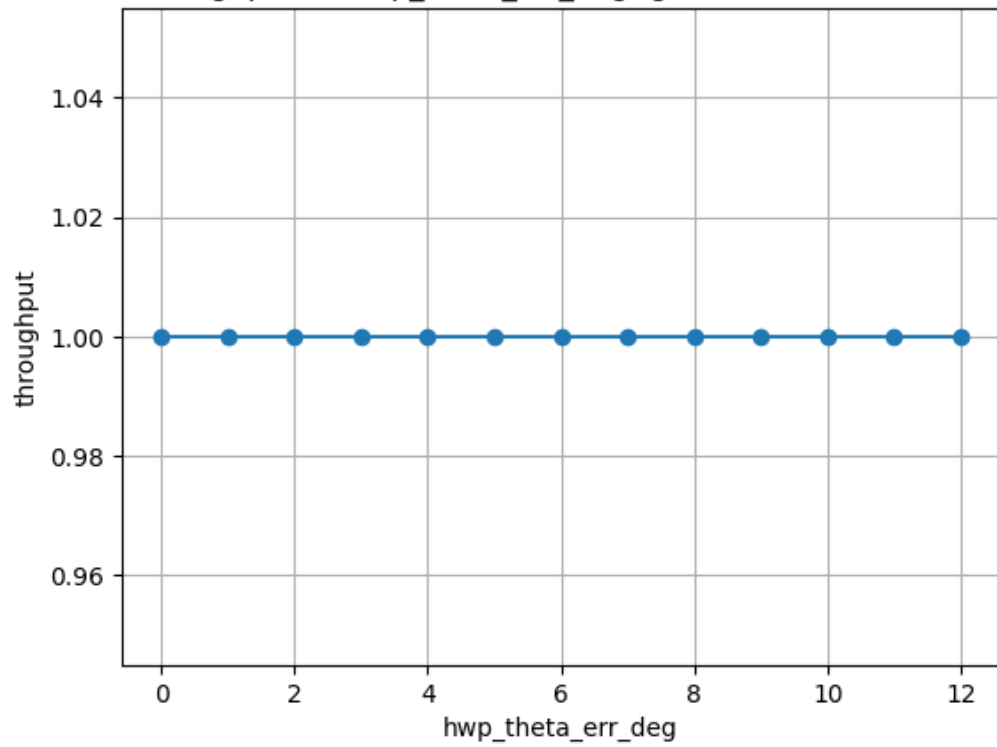
Margin range: 2.2895815627643756e-05 0.4233007968147511

Outputs in: S3_outputs_B_lambda_final

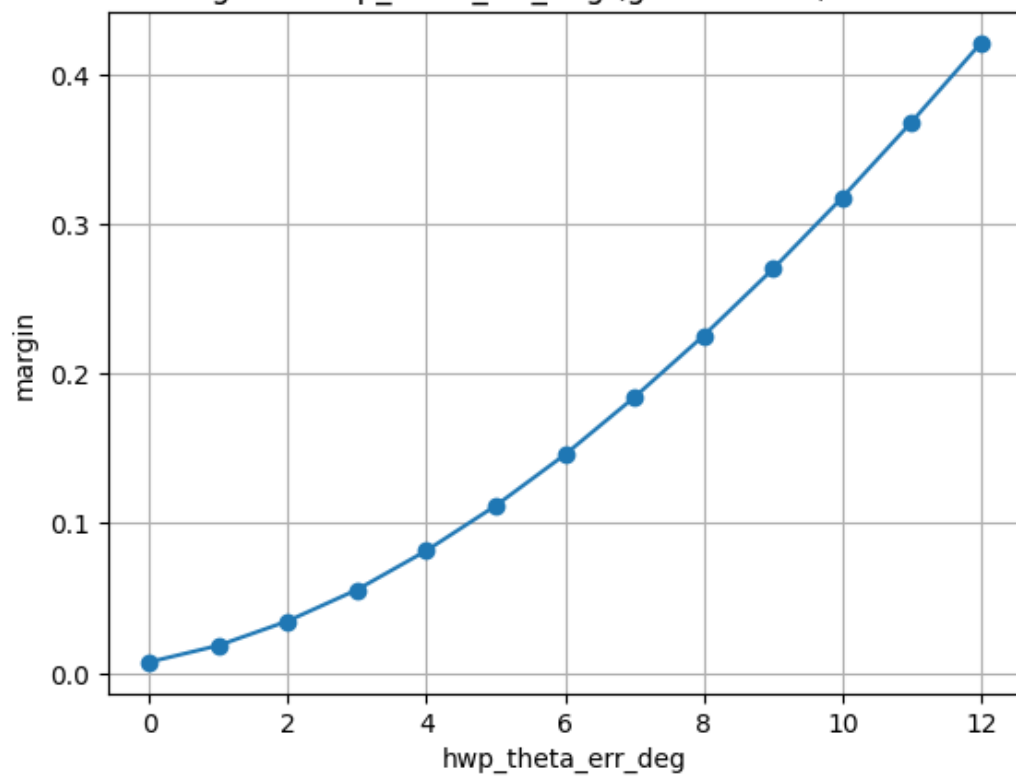
B_HWPchain: ber vs hwp_theta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



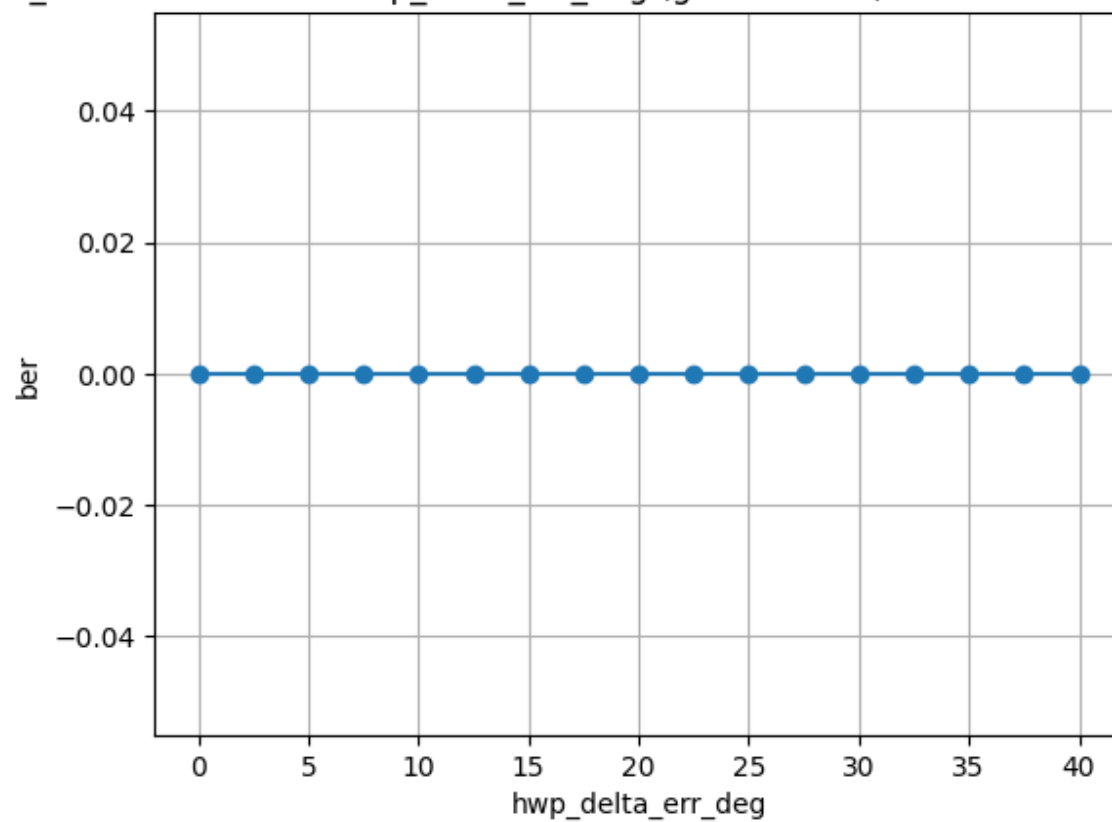
B_HWPchain: throughput vs hwp_theta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



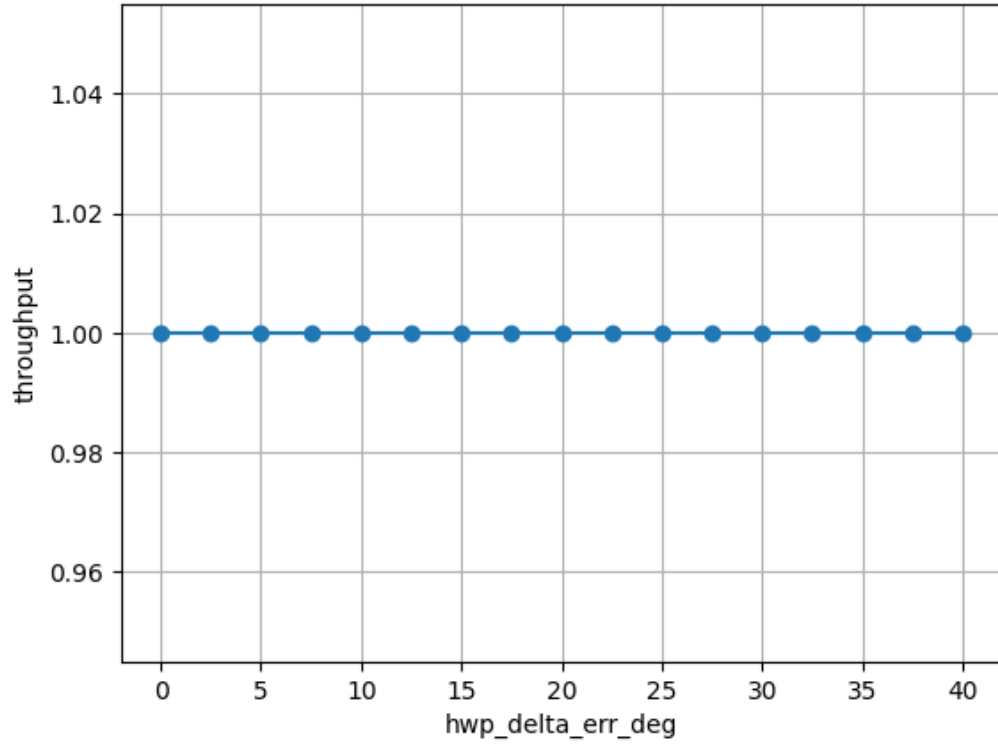
B_HWPchain: margin vs hwp_theta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



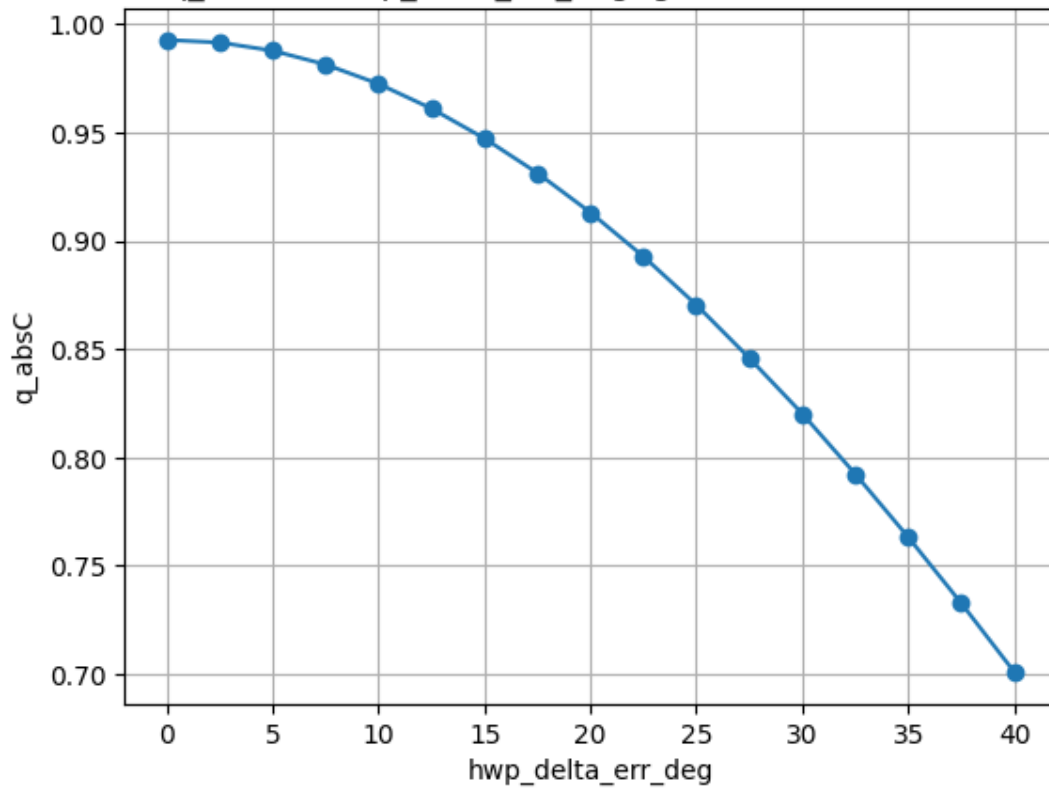
B_HWPchain: ber vs hwp_delta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



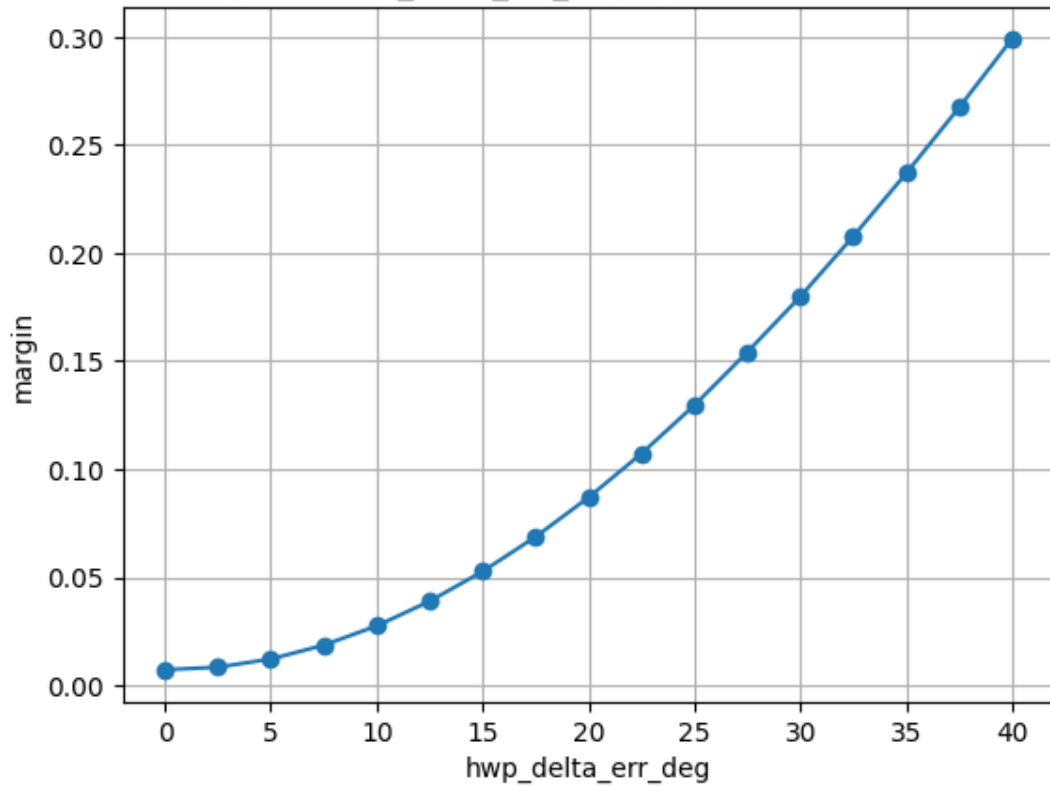
B_HWPchain: throughput vs hwp_delta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



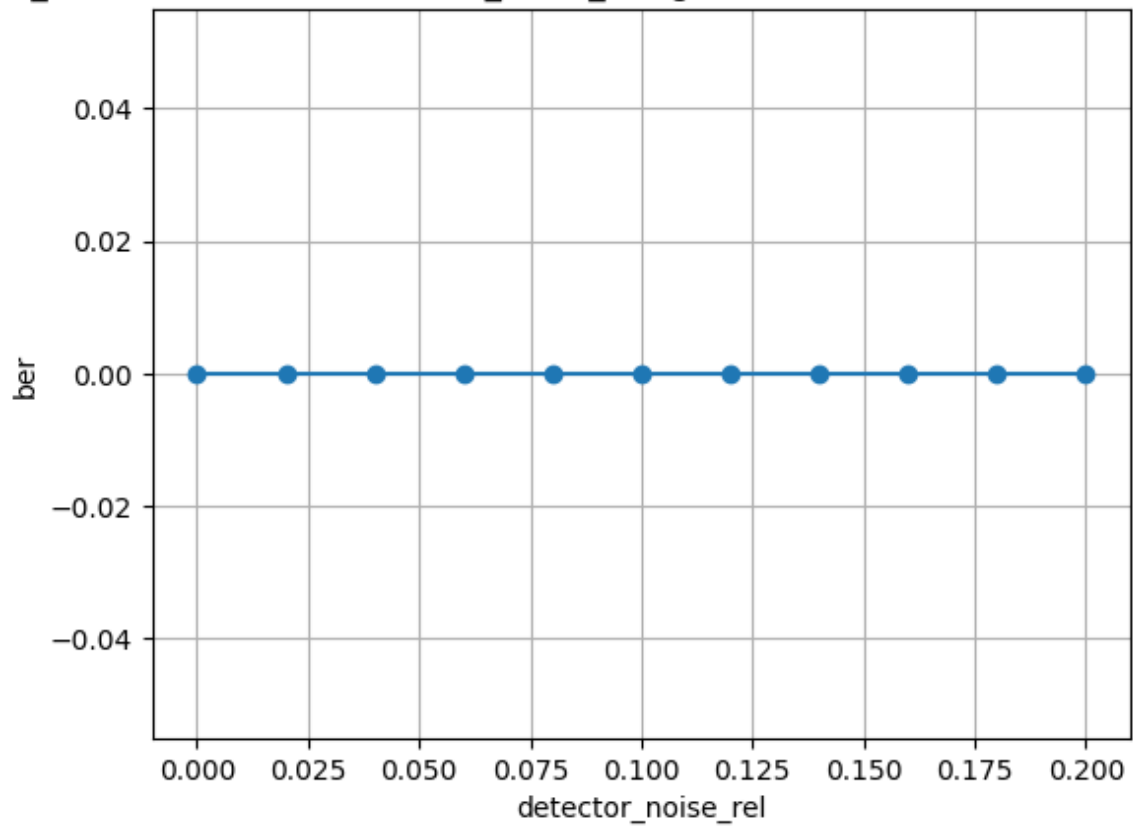
B_HWPchain: q_absC vs hwp_delta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



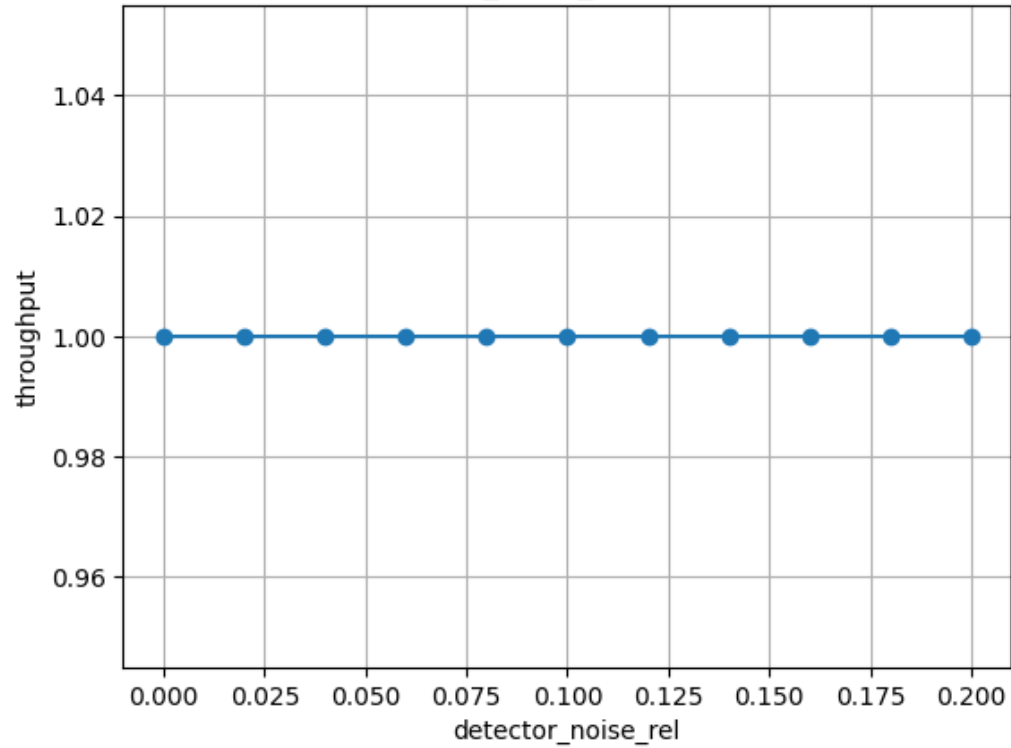
B_HWPchain: margin vs hwp_delta_err_deg (gamma=0.6, erasure=0.35, q=0.05)



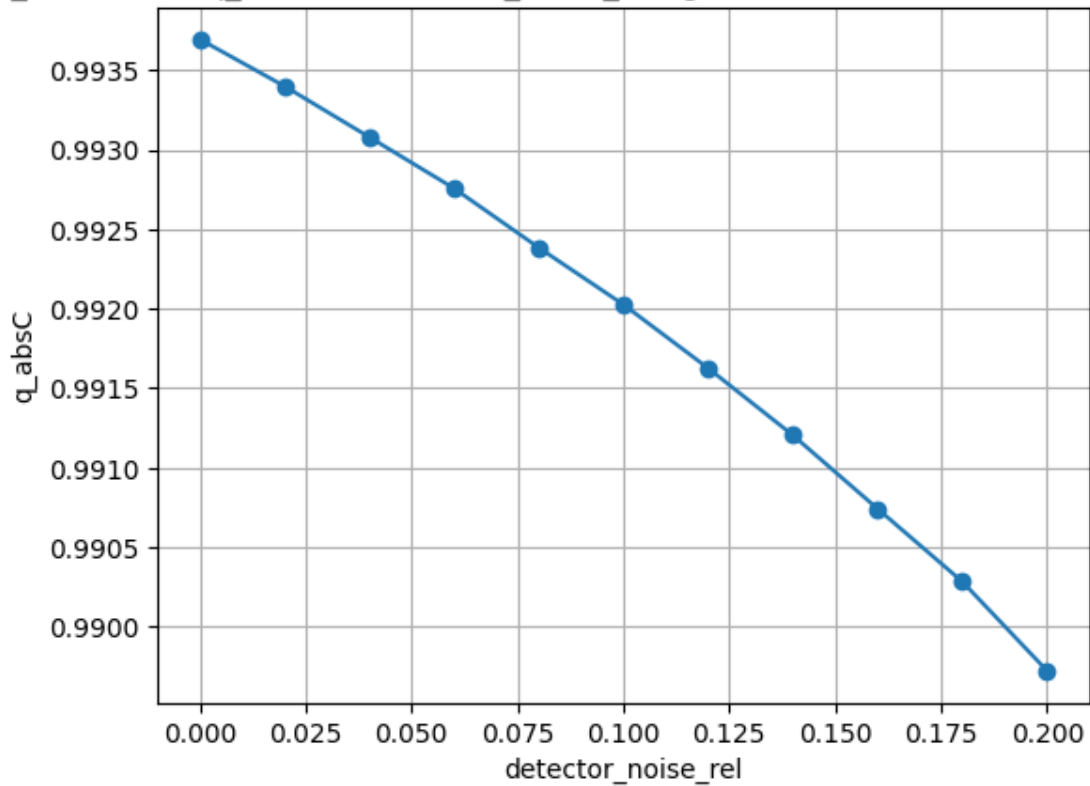
B_HWPchain: ber vs detector_noise_rel (gamma=0.6, erasure=0.35, q=0.05)



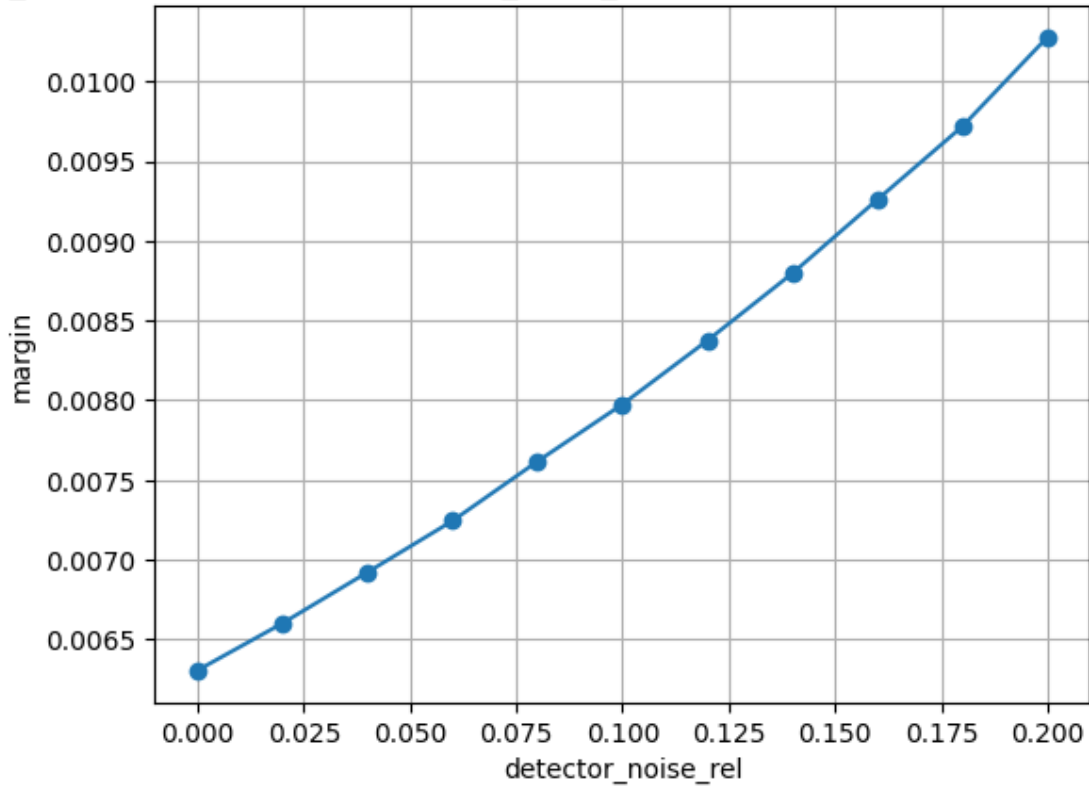
B_HWPchain: throughput vs detector_noise_rel (gamma=0.6, erasure=0.35, q=0.05)



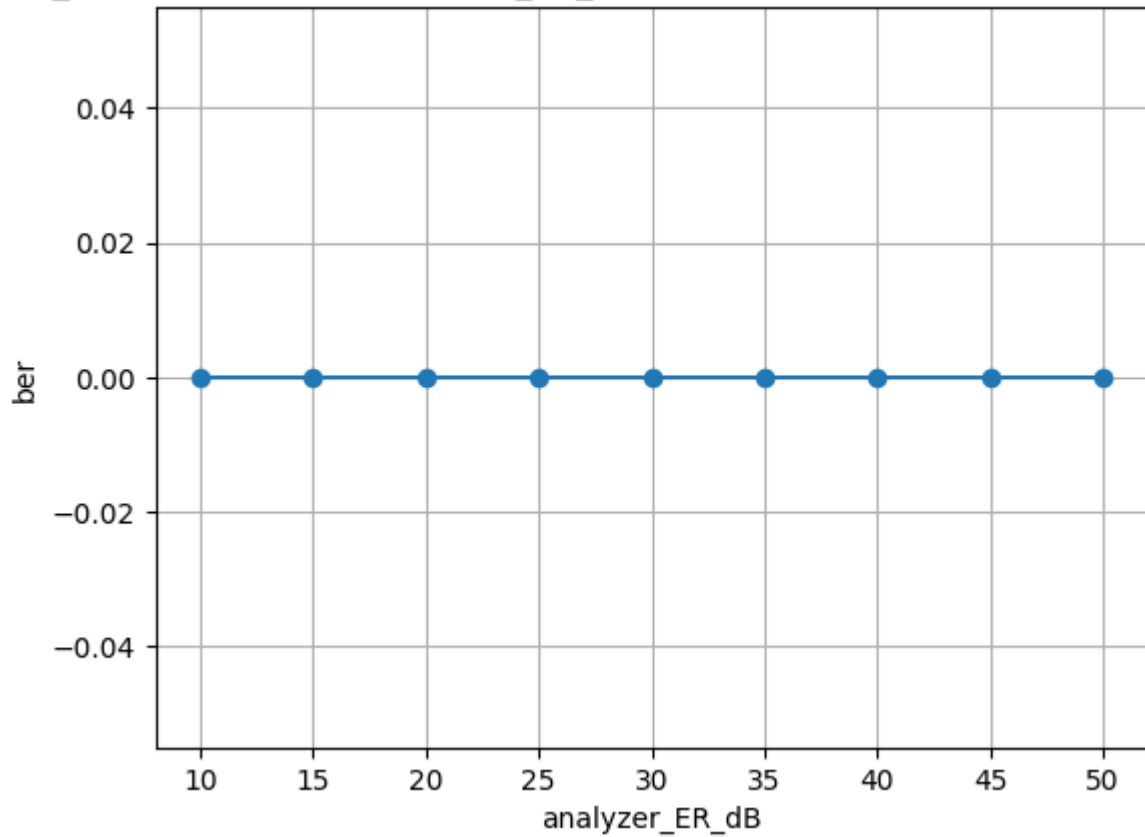
B_HWPchain: q_absC vs detector_noise_rel (gamma=0.6, erasure=0.35, q=0.05)



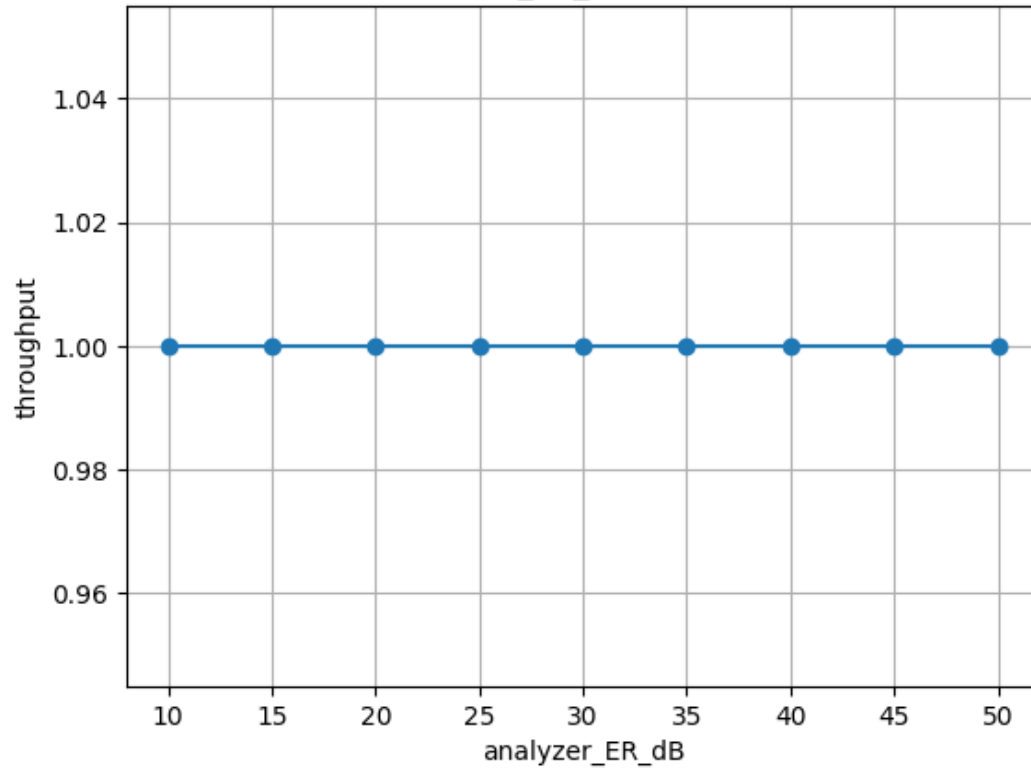
B_HWPchain: margin vs detector_noise_rel (gamma=0.6, erasure=0.35, q=0.05)



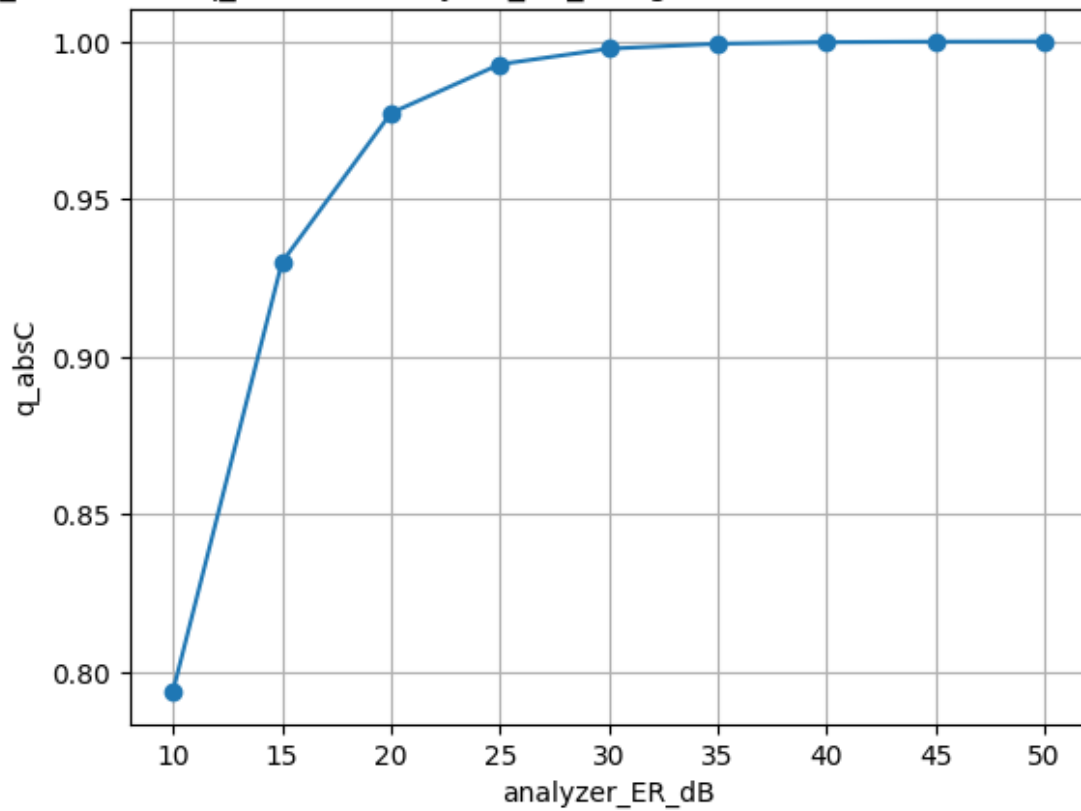
B_HWPchain: ber vs analyzer_ER_dB (gamma=0.6, erasure=0.35, q=0.05)



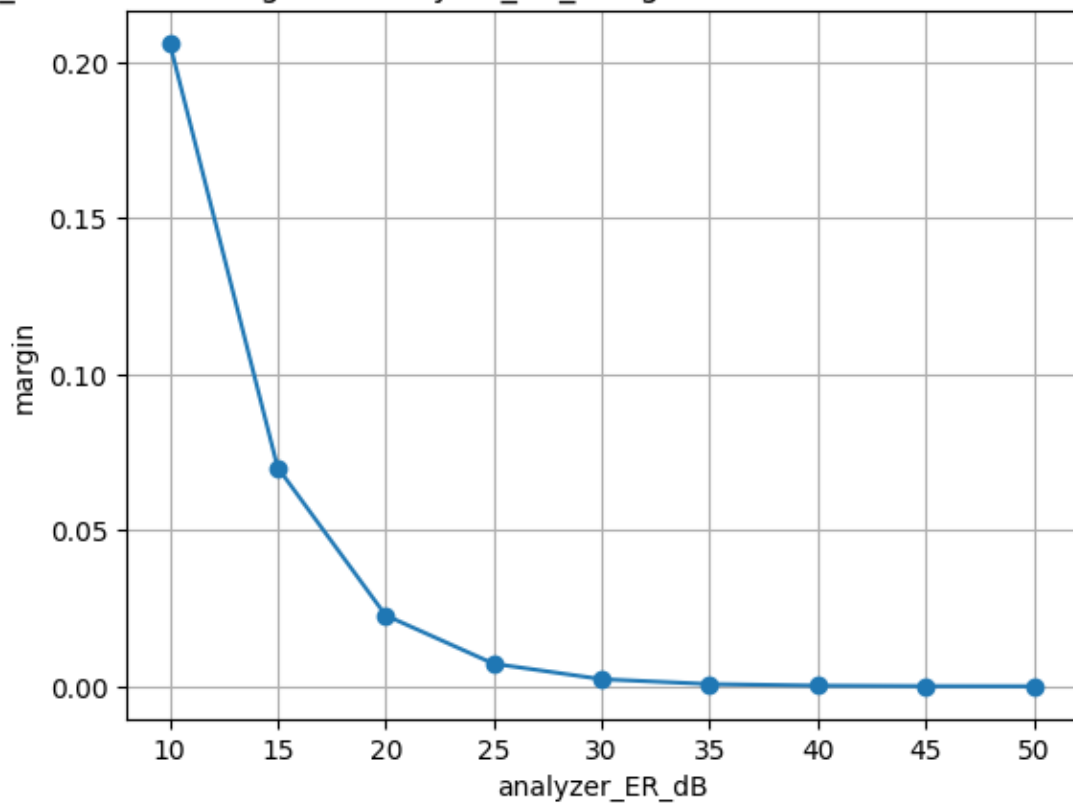
B_HWPchain: throughput vs analyzer_ER_dB (gamma=0.6, erasure=0.35, q=0.05)



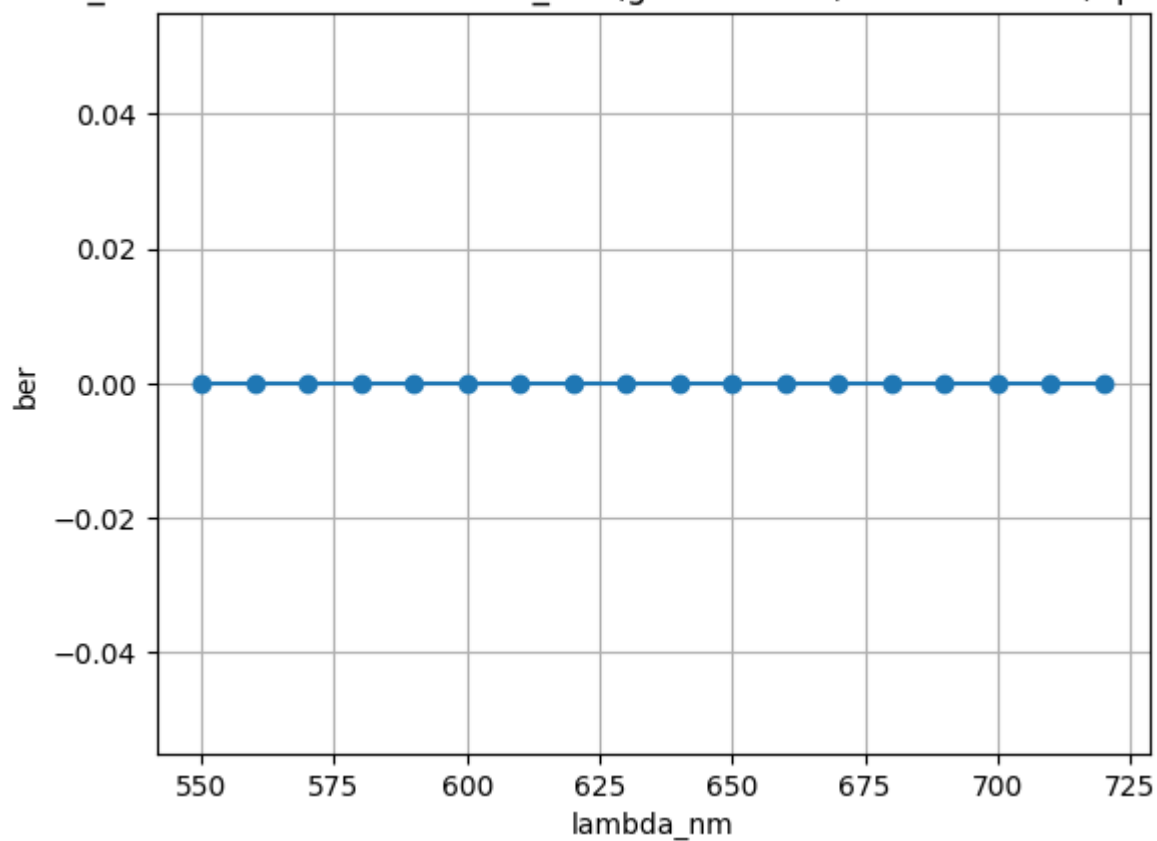
B_HWPchain: q_absC vs analyzer_ER_dB (gamma=0.6, erasure=0.35, q=0.05)



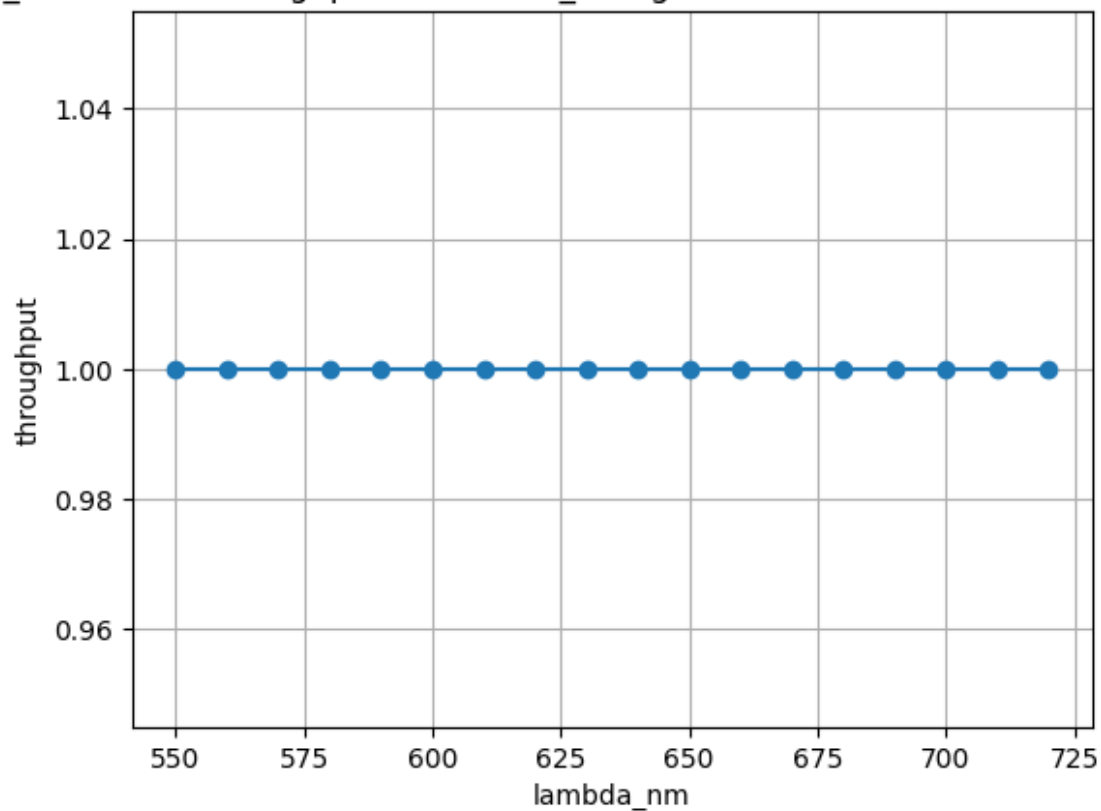
B_HWPchain: margin vs analyzer_ER_dB (gamma=0.6, erasure=0.35, q=0.05)



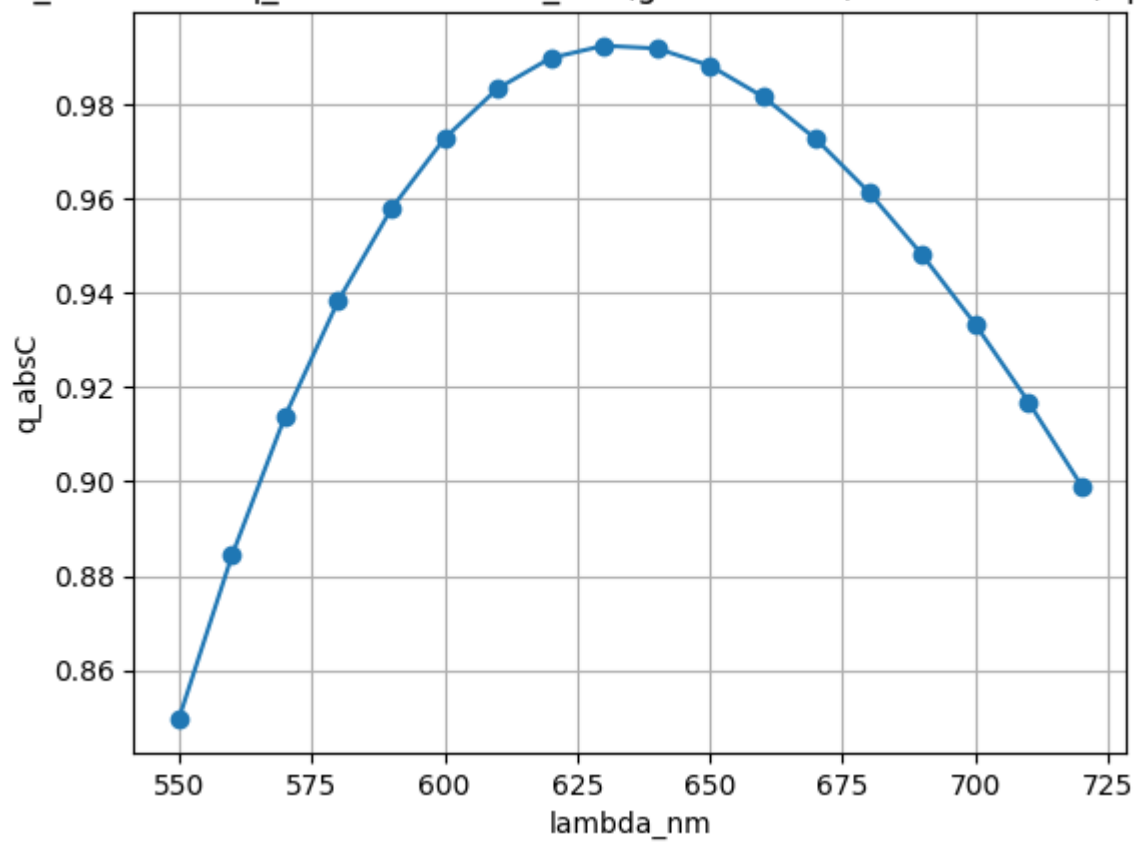
B_HWPchain: ber vs lambda_nm (gamma=0.6, erasure=0.35, q=0.05)



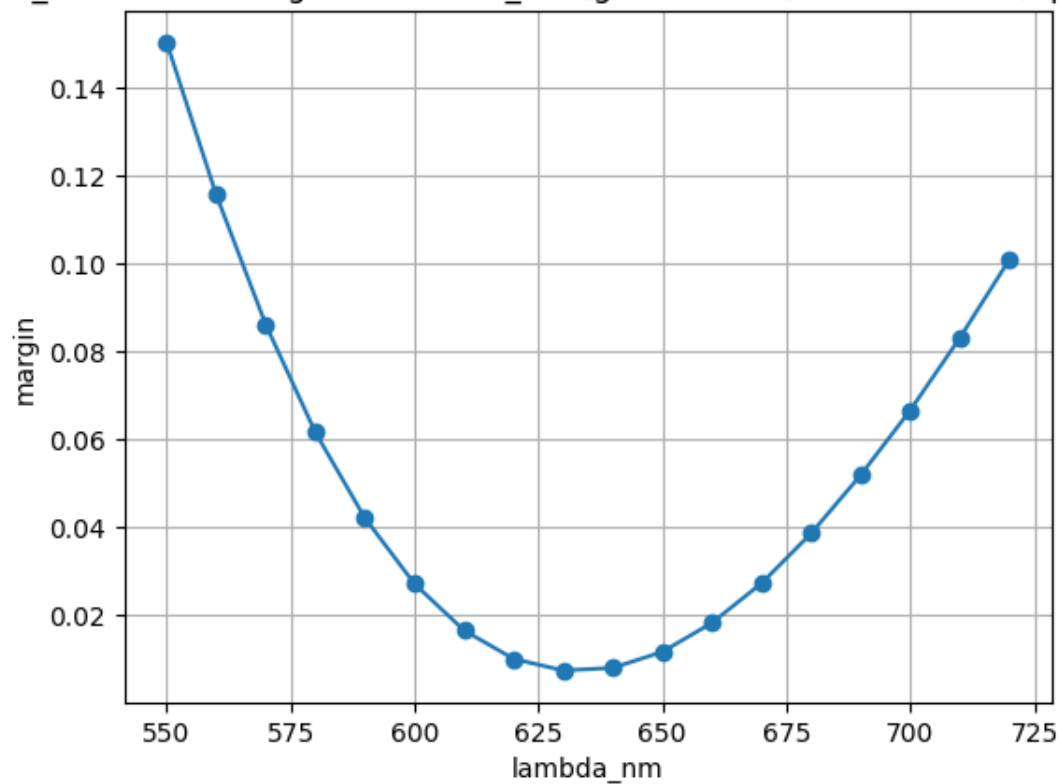
B_HWPchain: throughput vs lambda_nm (gamma=0.6, erasure=0.35, q=0.05)



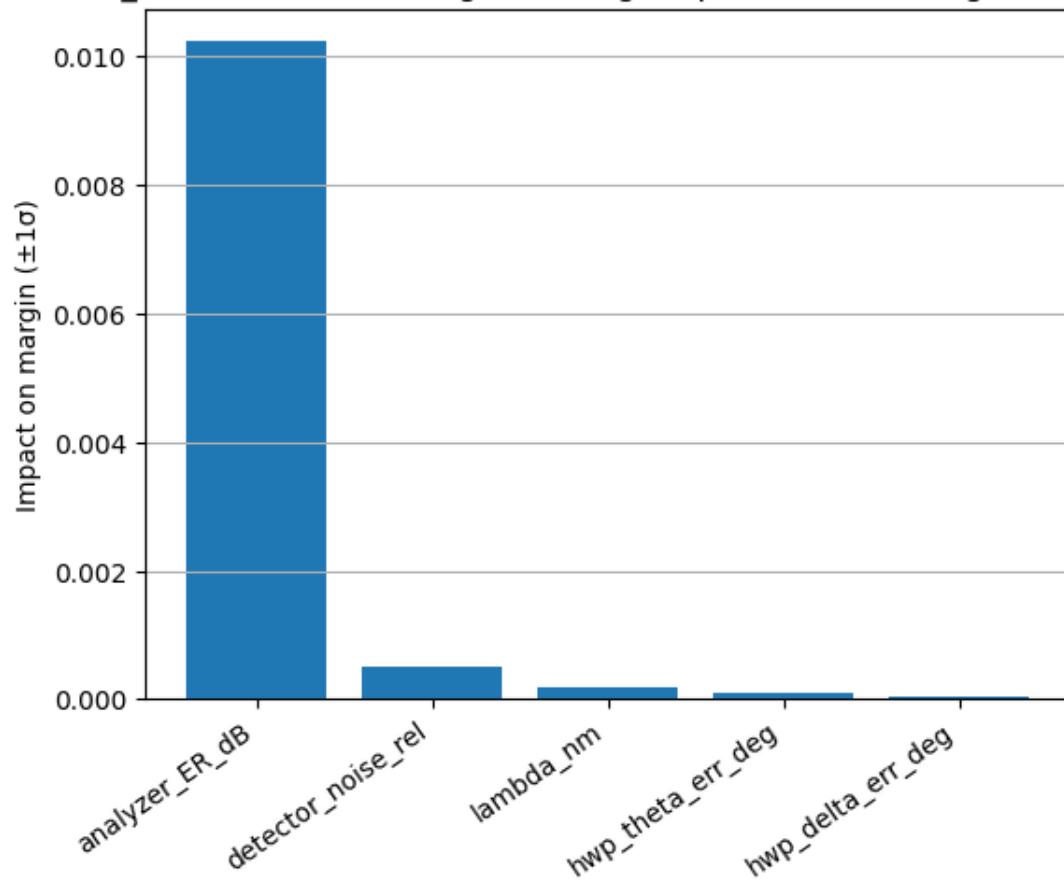
B_HWPchain: q_absC vs lambda_nm (gamma=0.6, erasure=0.35, q=0.05)



B_HWPchain: margin vs lambda_nm (gamma=0.6, erasure=0.35, q=0.05)



B_HWPchain: Error-budget ranking (impact $\pm 1\sigma$) — margin target



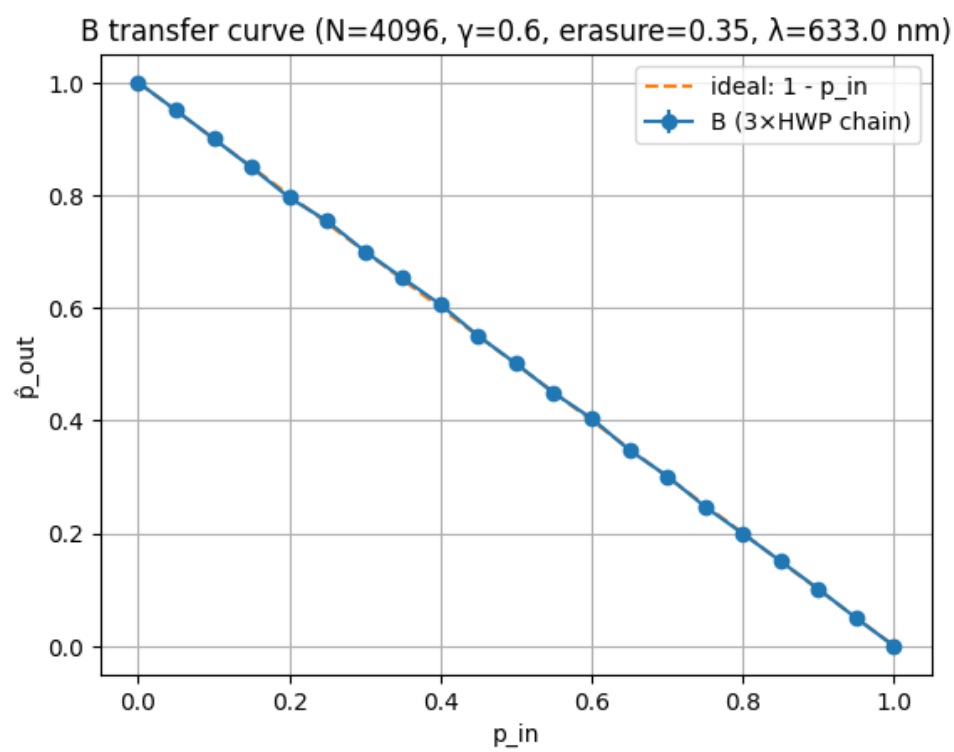
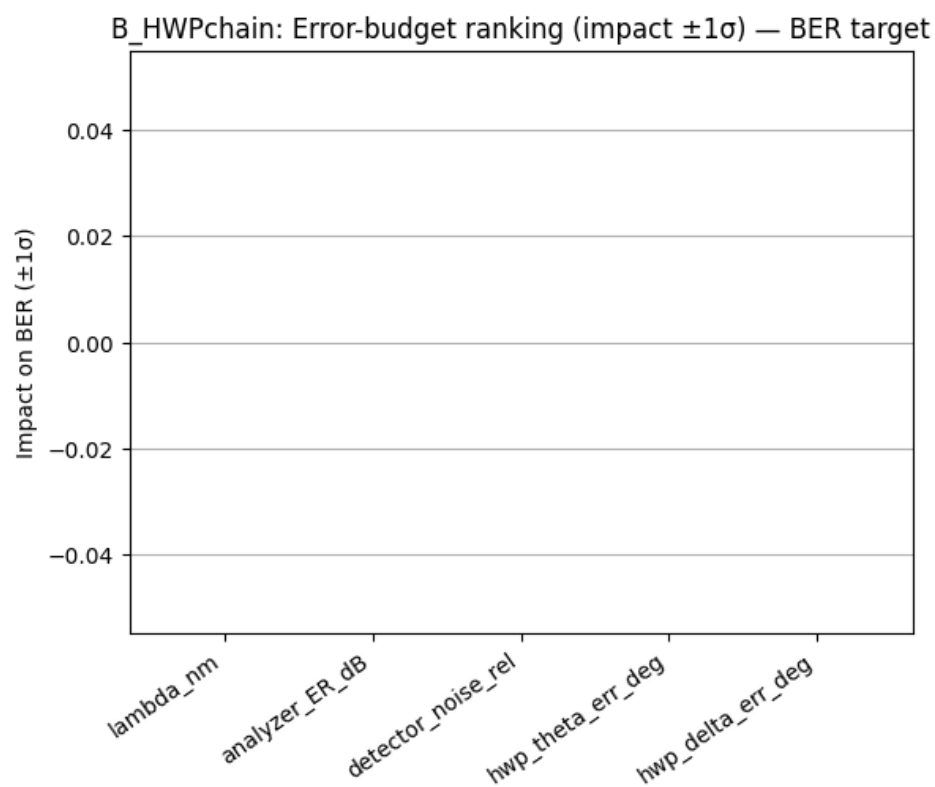


Figure 6.1 — Probability transfer curves (A vs B)

