

S2. Colab notebook — Two-arm PBS / folded implementation (Architecture A) under non-idealities

- **Purpose:** generate paper-ready figures and tables for Architecture A under realistic component non-idealities.
- **Modelled non-idealities:** finite PBS extinction/leakage, arm imbalance, HWP angle error $\Delta\theta$ and retardance error $\Delta\delta$ (per-arm), detector relative noise, 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 note (robust regime):** over some tolerance ranges the gate may operate in a regime where **BER remains ≈ 0** , making BER-based rankings appear flat. In such cases the **contrast-margin** metric ($\text{margin} = 1 - q_{0.05}(|C|)$, with $C = (I_H - I_V) / (I_H + I_V)$) provides an earlier and more sensitive robustness indicator; BER becomes informative once parameter variations drive the contrast distribution toward the decision threshold.

```
/tmp/ipython-input-591/2471434259.py:309: RuntimeWarning:
More than 20 figures have been opened. Figures created
through the pyplot interface (`matplotlib.pyplot.figure`)
are retained until explicitly closed and may consume too
much memory. (To control this warning, see the rcParam
`figure.max_open_warning`). Consider using
`matplotlib.pyplot.close()`.
```

```
fig = plt.figure()
```

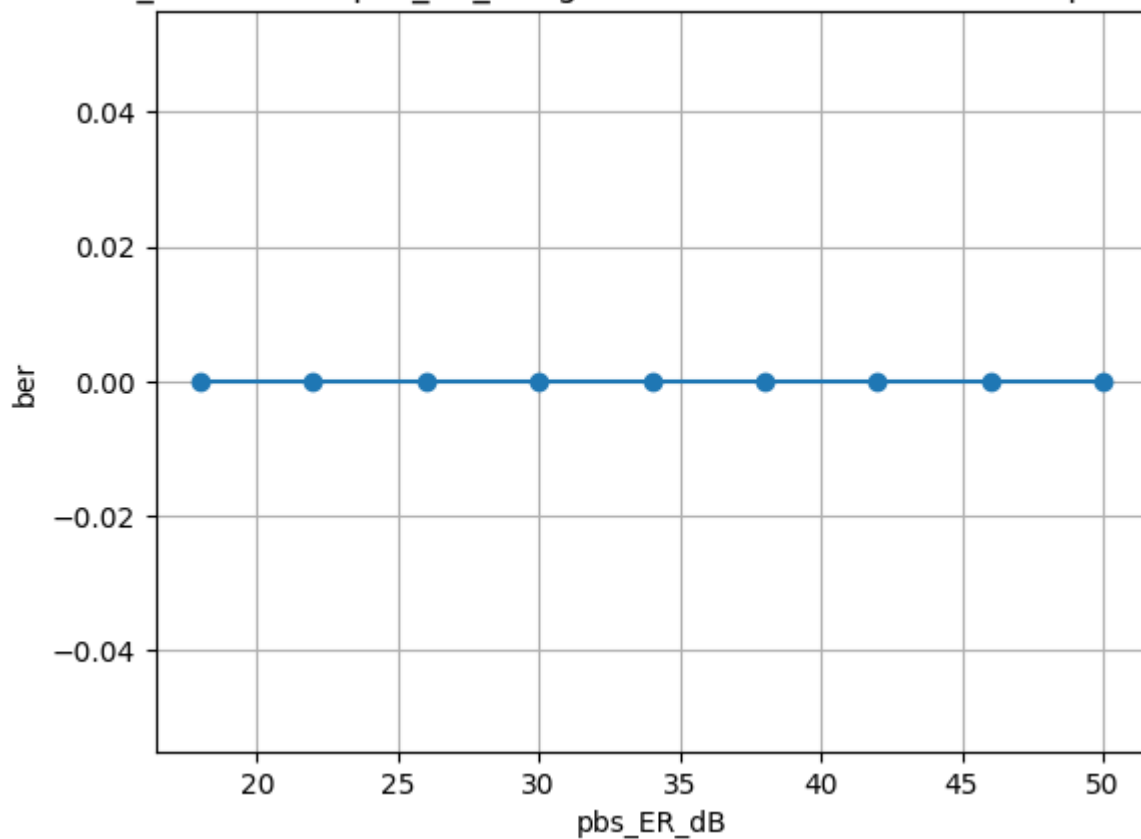
Sanity ranges on sweeps:

BER range: 0.0 0.0

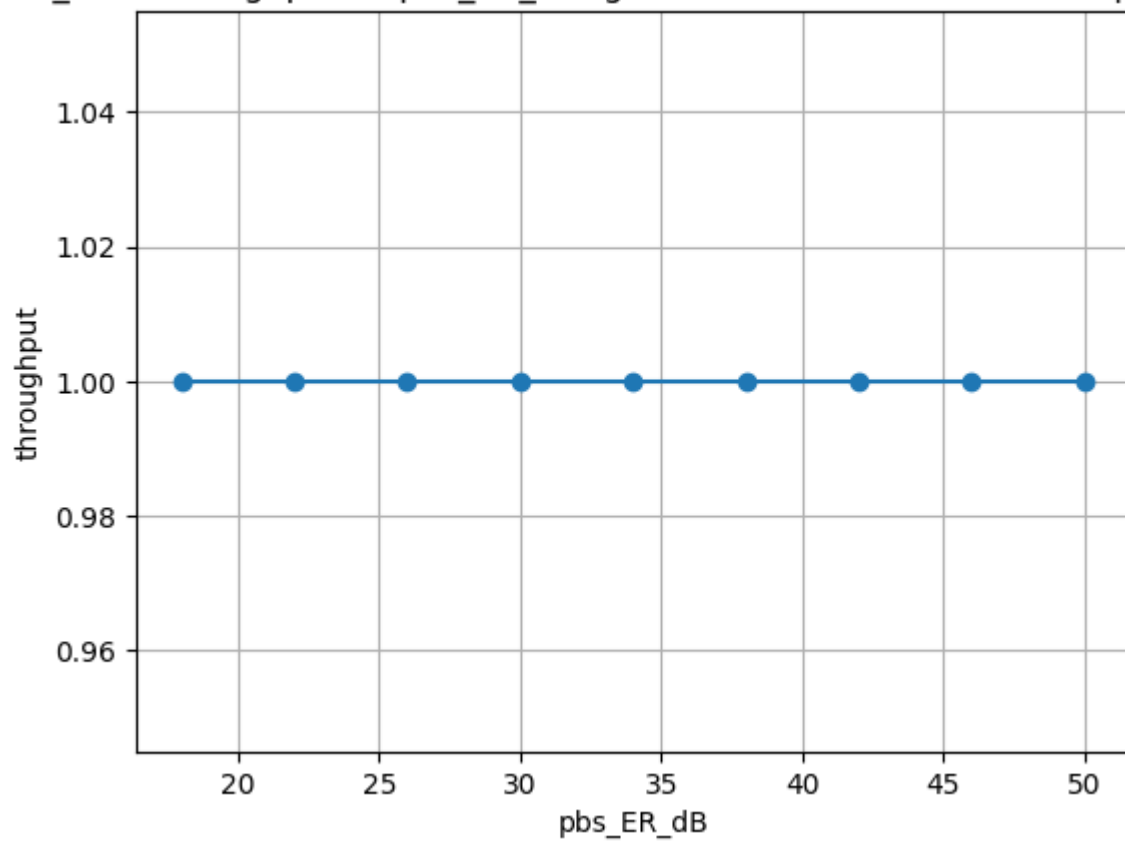
Throughput range: 1.0 1.0

Margin range: 0.00019547225334570761 0.24947725888711703

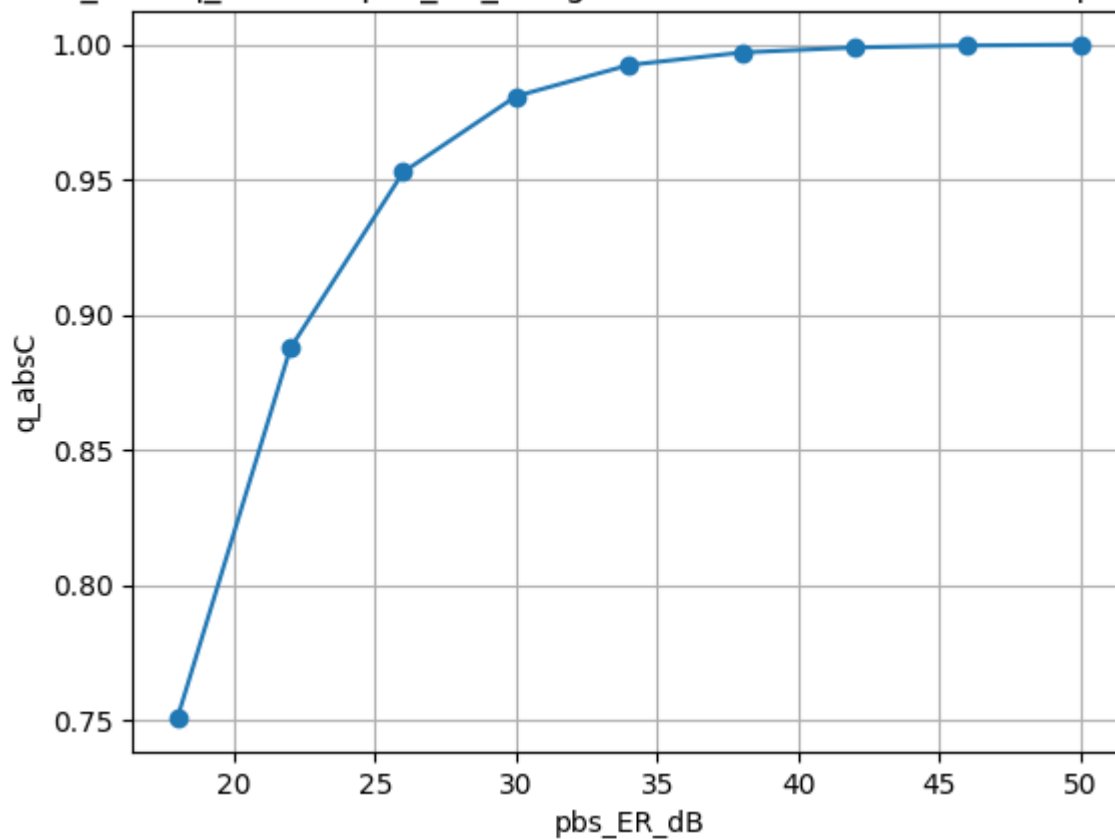
A_PBS: ber vs pbs_ER_dB (gamma=0.55, erasure=0.25, q=0.05)



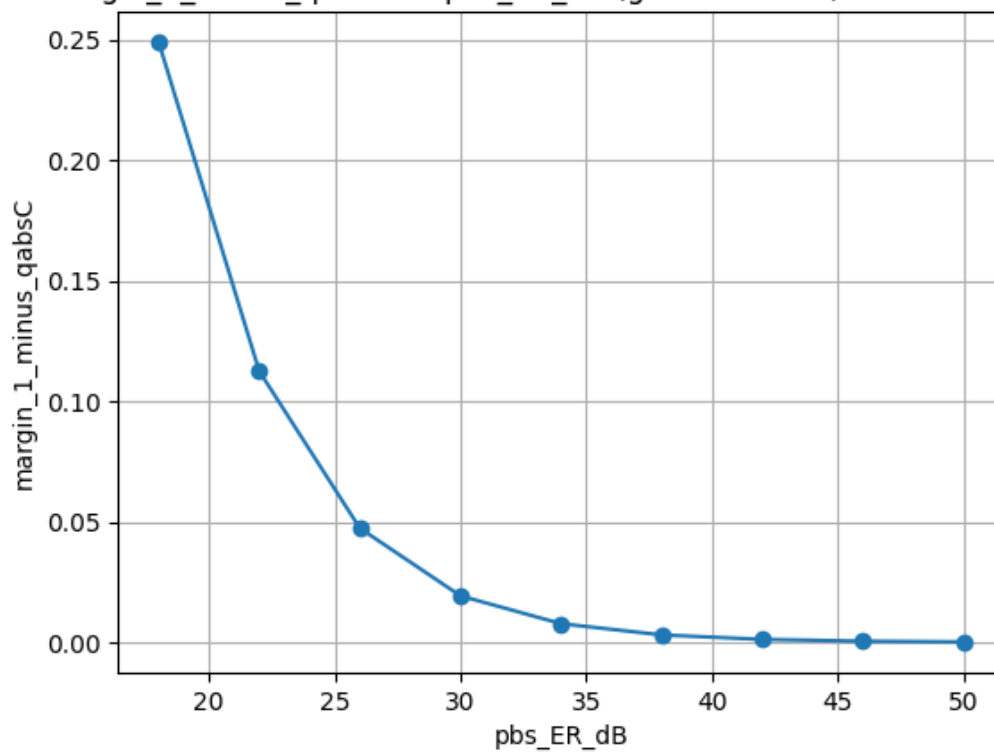
A_PBS: throughput vs pbs_ER_dB (gamma=0.55, erasure=0.25, q=0.05)



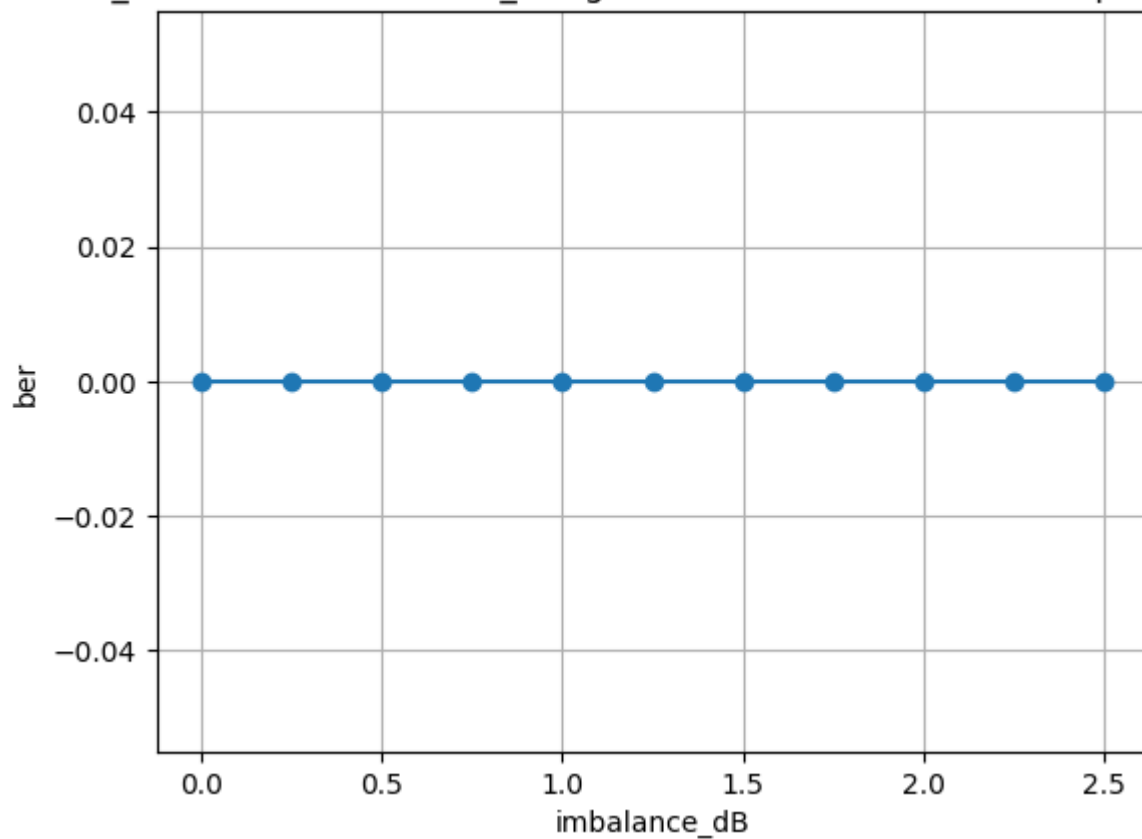
A_PBS: q_{absC} vs pbs_ER_dB ($\gamma=0.55$, erasure=0.25, $q=0.05$)



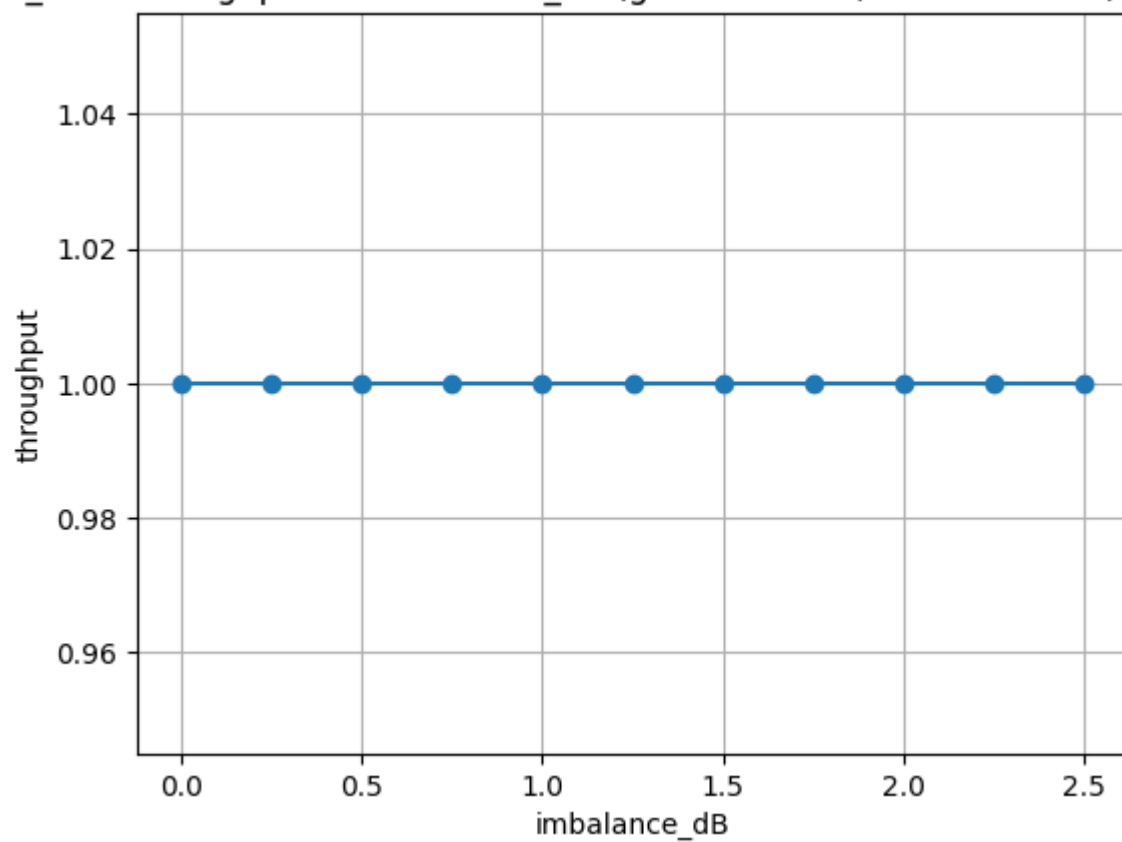
A_PBS: $\text{margin_1_minus_qabsC}$ vs pbs_ER_dB ($\gamma=0.55$, erasure=0.25, $q=0.05$)

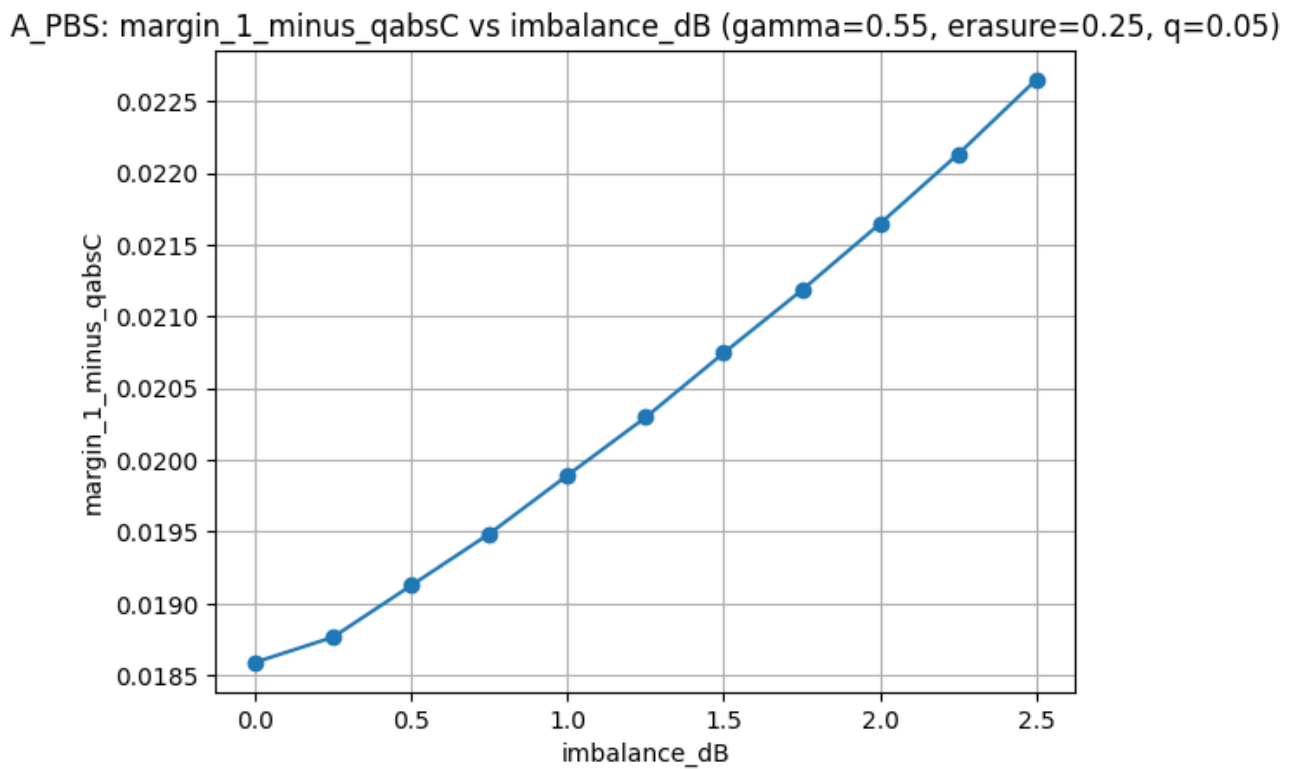
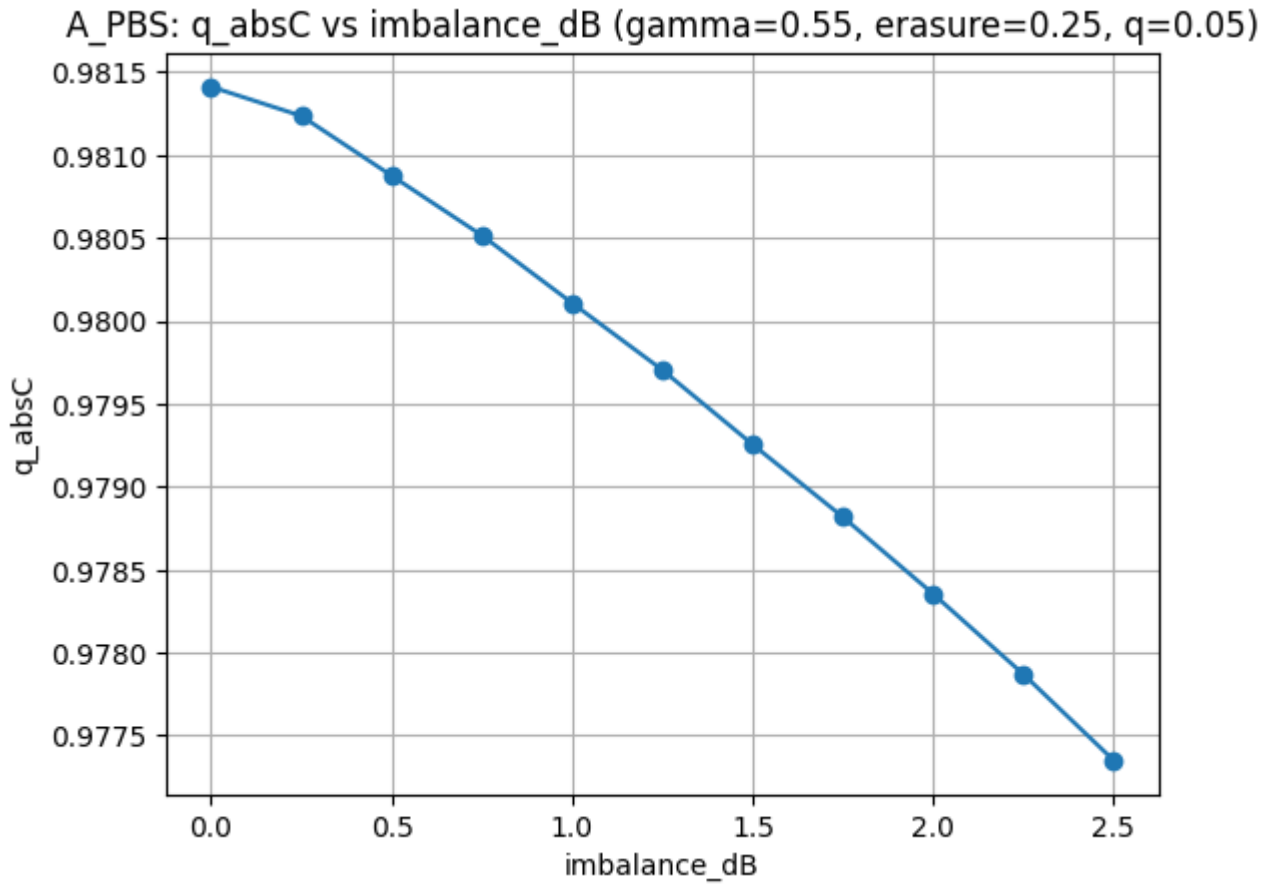


A_PBS: ber vs imbalance_dB (gamma=0.55, erasure=0.25, q=0.05)

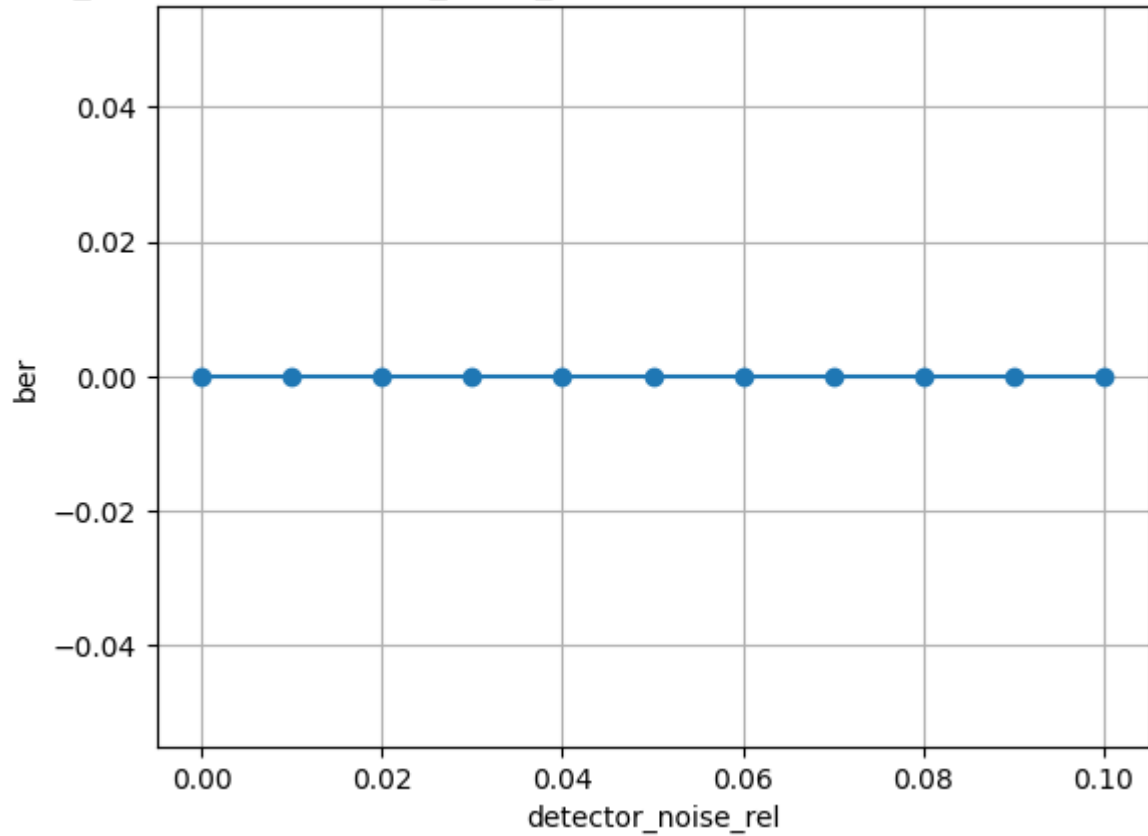


A_PBS: throughput vs imbalance_dB (gamma=0.55, erasure=0.25, q=0.05)

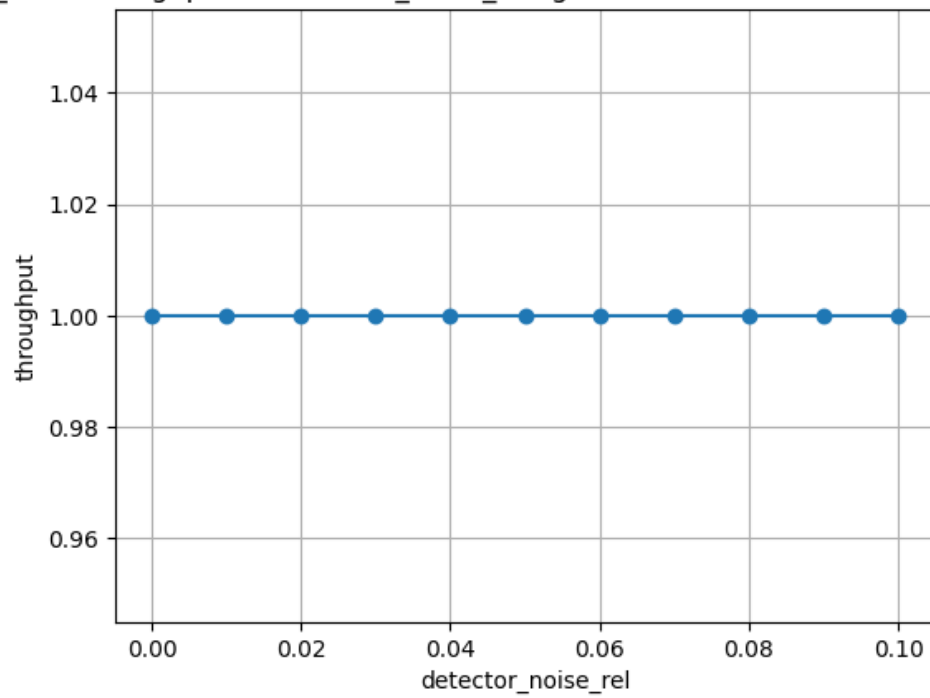




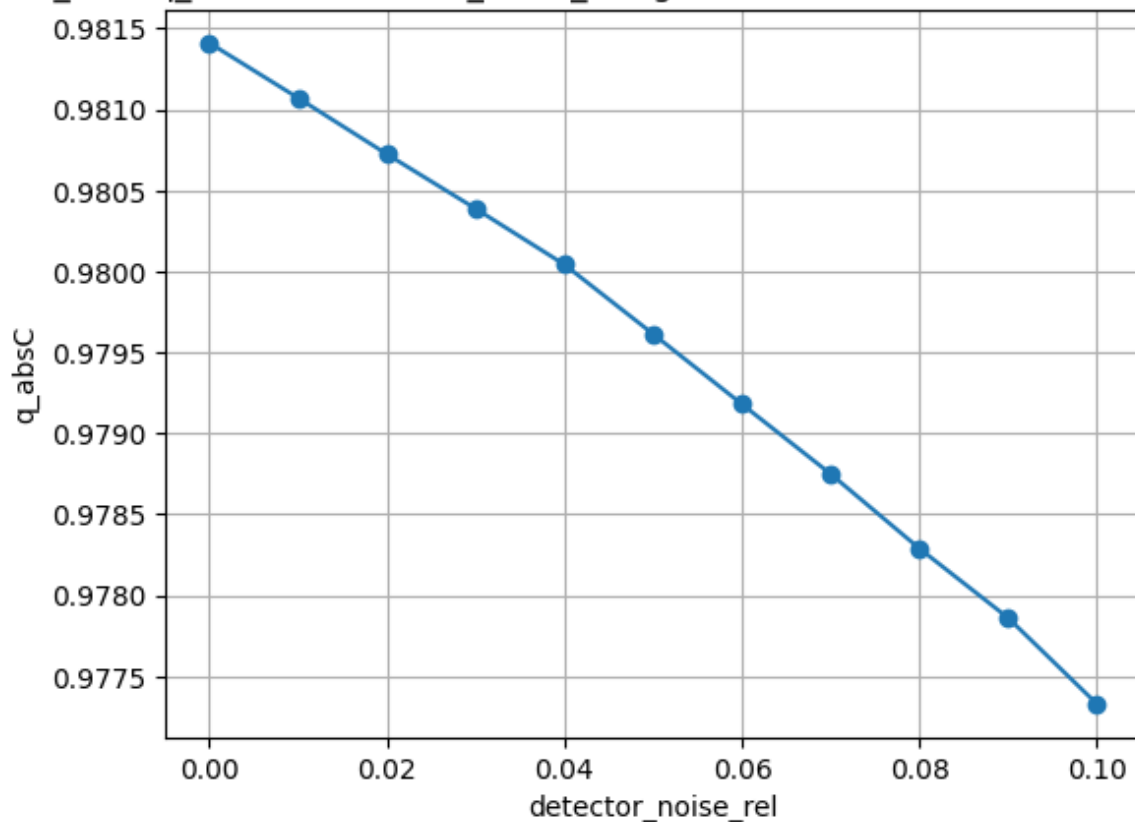
A_PBS: ber vs detector_noise_rel (gamma=0.55, erasure=0.25, q=0.05)



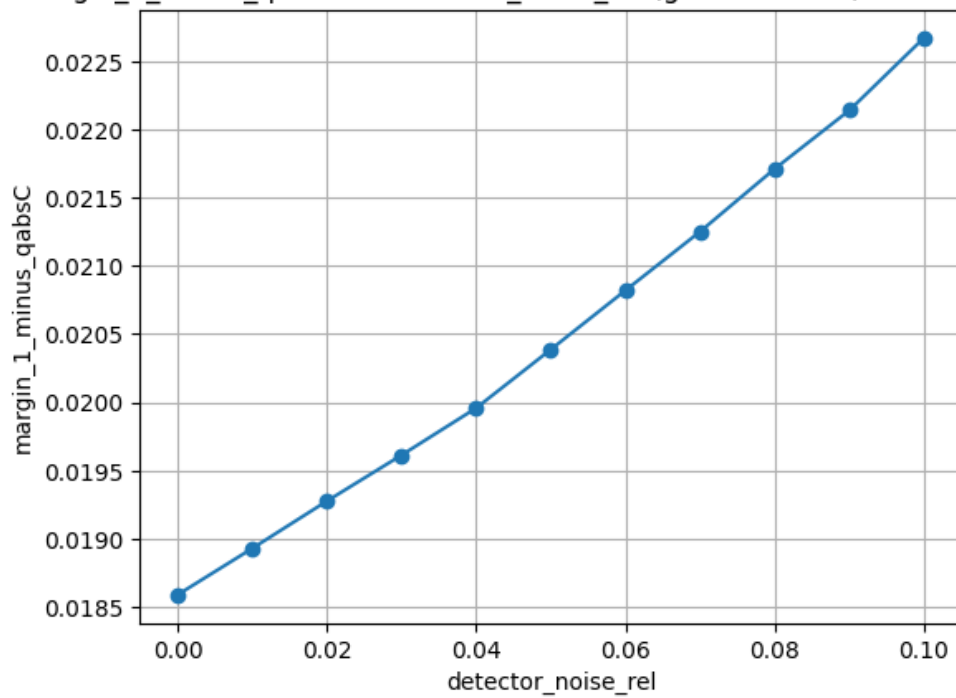
A_PBS: throughput vs detector_noise_rel (gamma=0.55, erasure=0.25, q=0.05)



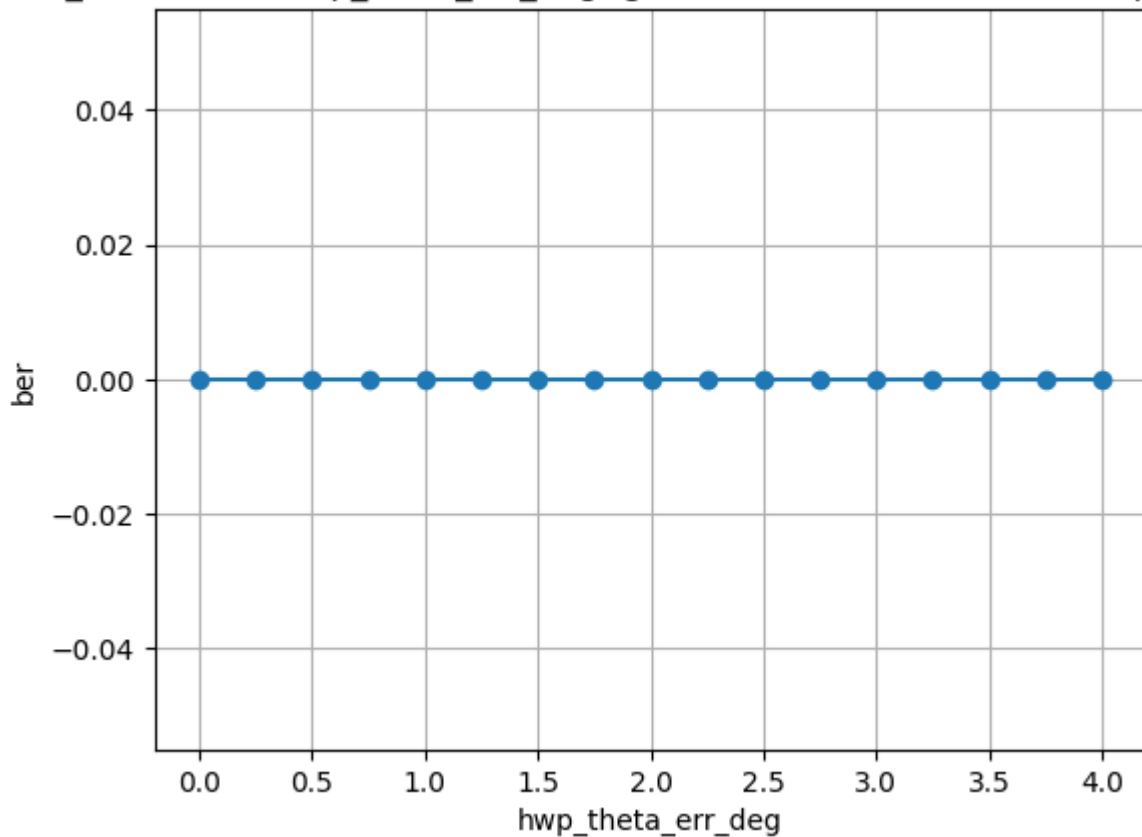
A_PBS: q_{absC} vs detector_noise_rel (gamma=0.55, erasure=0.25, q=0.05)



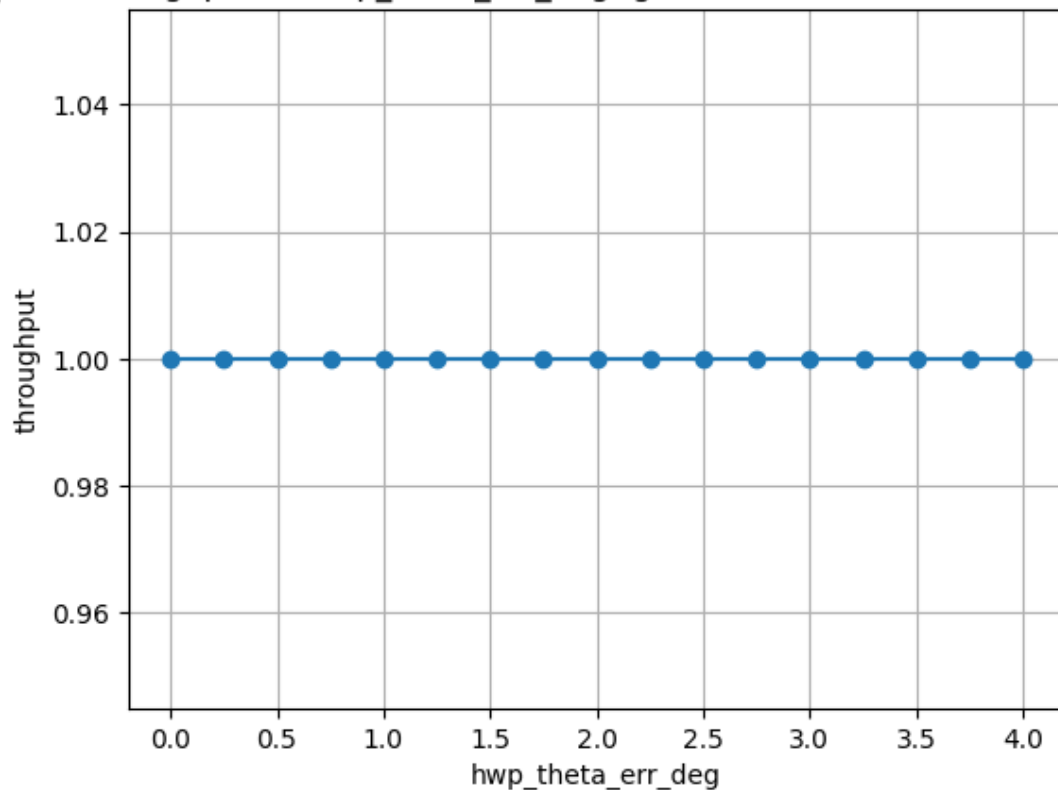
A_PBS: margin_1_minus_qabsC vs detector_noise_rel (gamma=0.55, erasure=0.25, q=0.05)



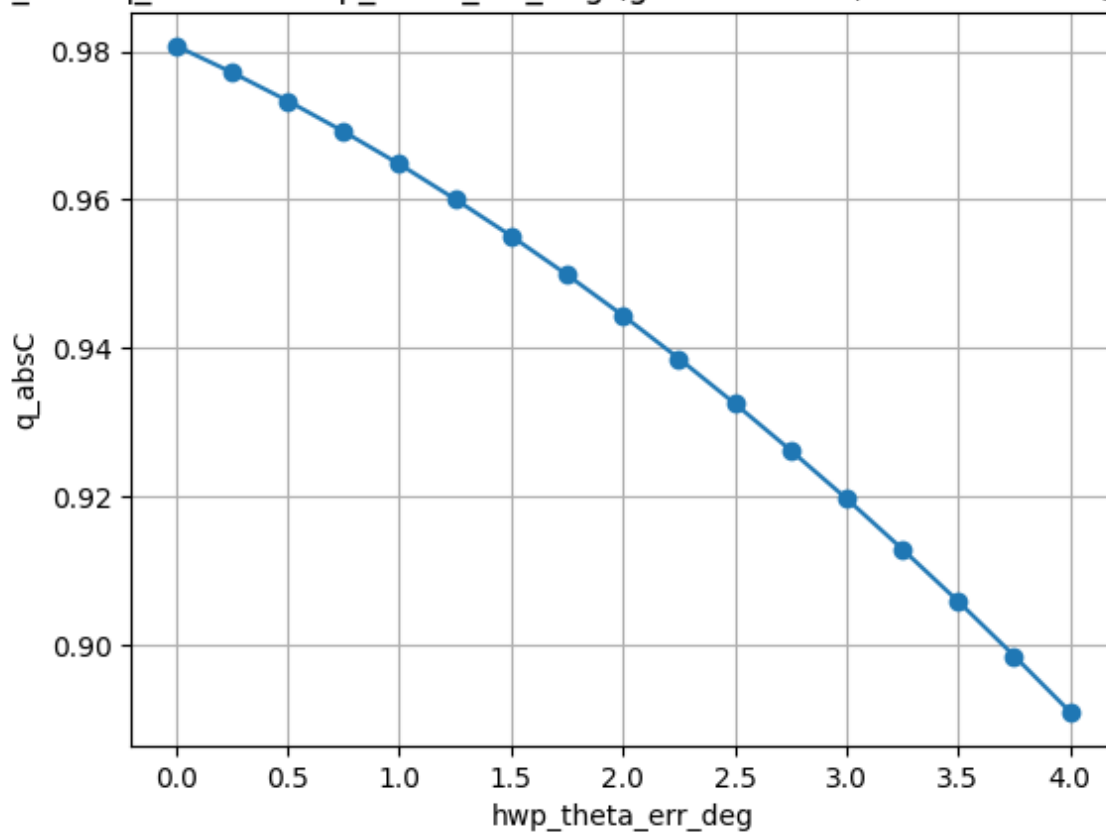
A_PBS: ber vs hwp_theta_err_deg (gamma=0.55, erasure=0.25, q=0.05)



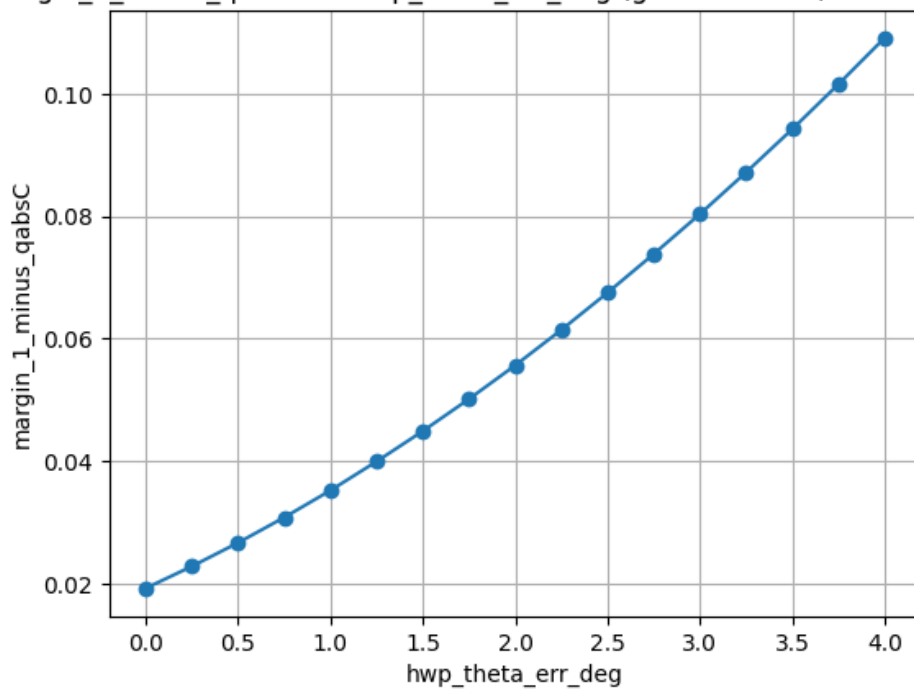
A_PBS: throughput vs hwp_theta_err_deg (gamma=0.55, erasure=0.25, q=0.05)



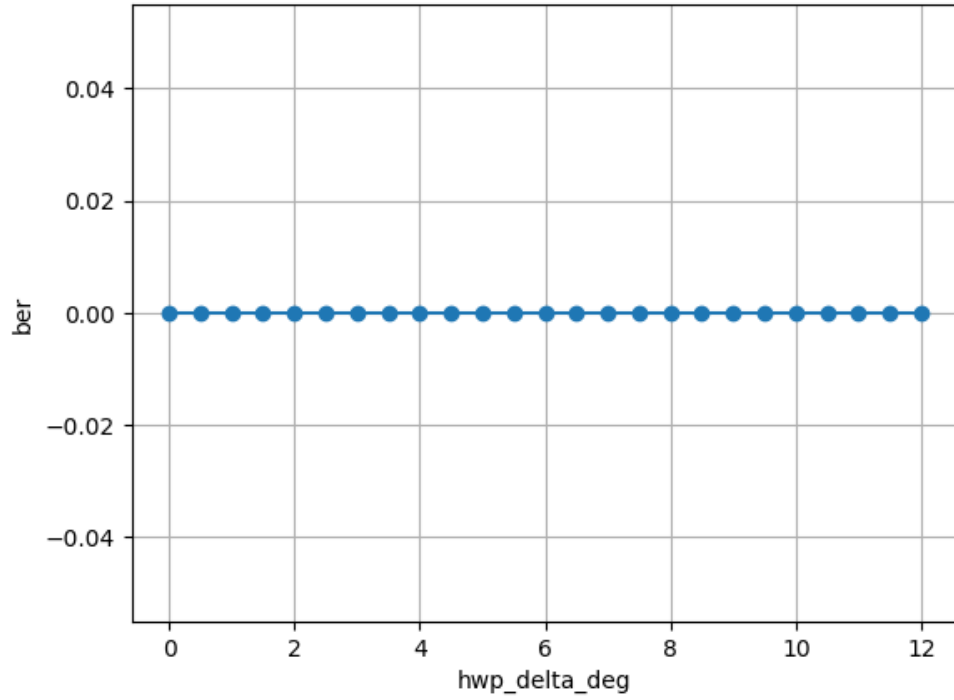
A_PBS: q_{absC} vs hwp_theta_err_deg ($\gamma=0.55$, erasure=0.25, $q=0.05$)



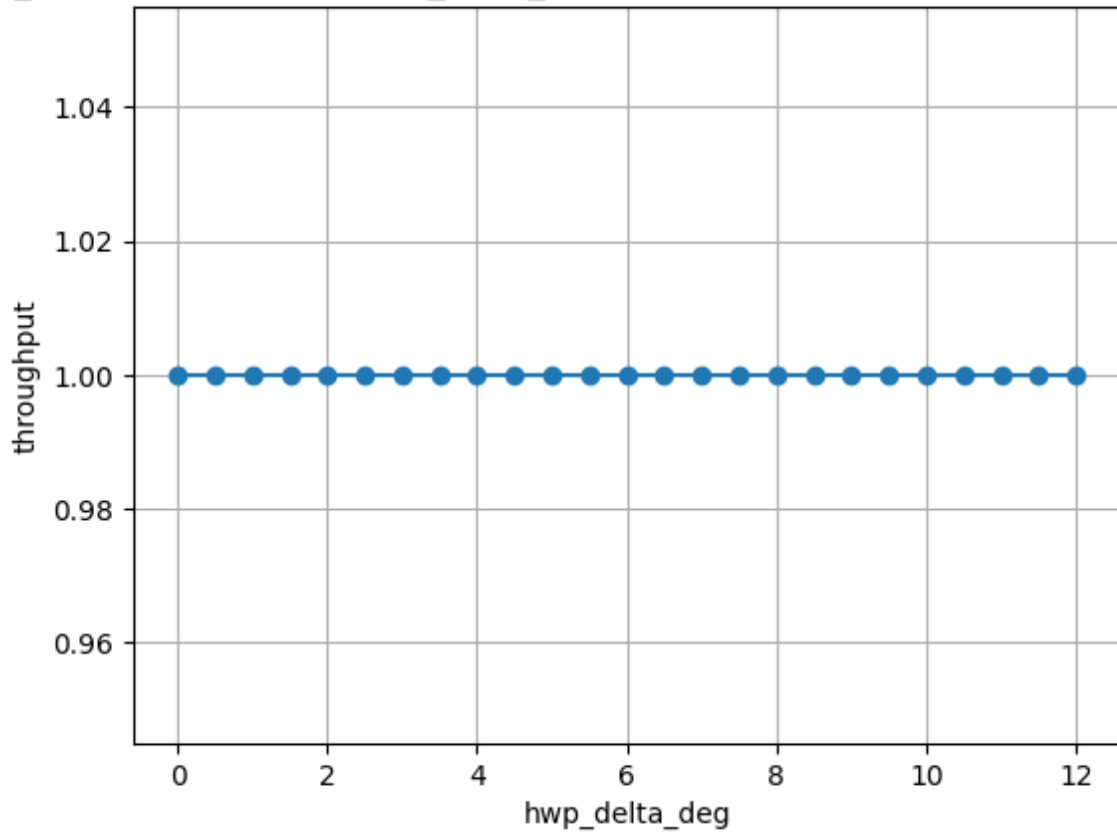
A_PBS: margin_1_minus_qabsC vs hwp_theta_err_deg ($\gamma=0.55$, erasure=0.25, $q=0.05$)



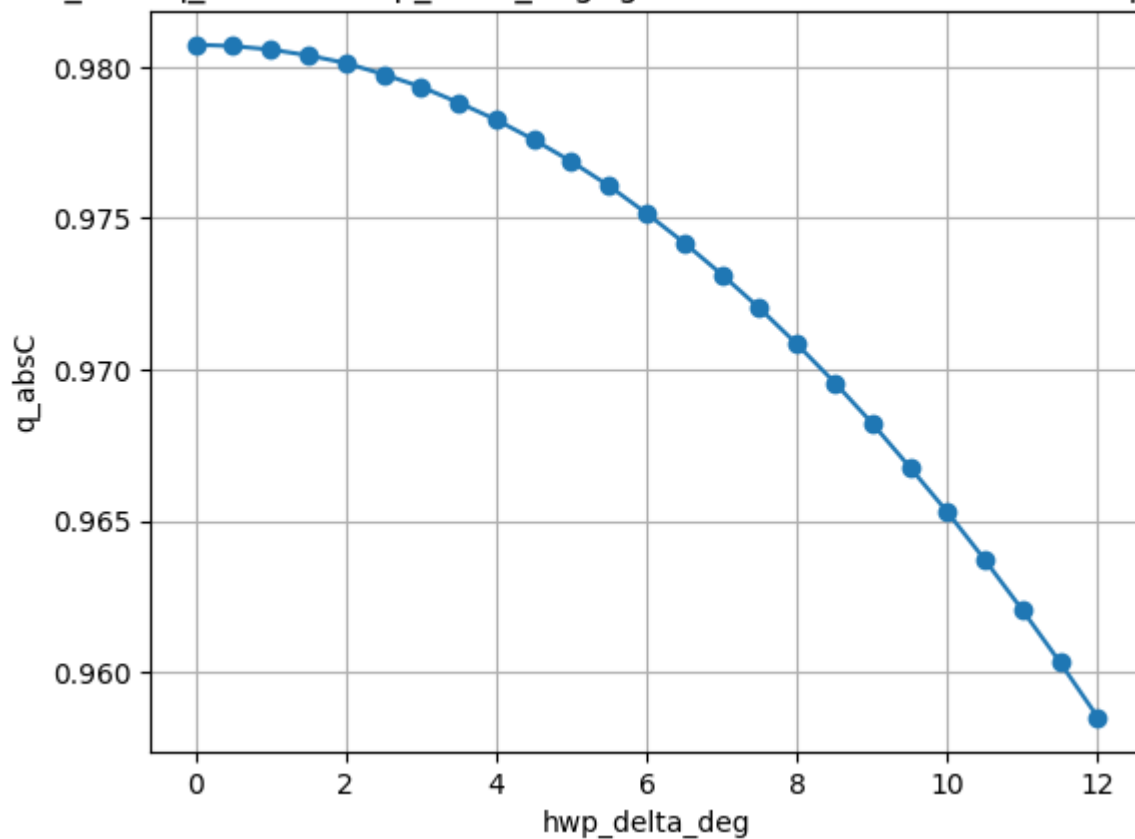
A_PBS: ber vs hwp_delta_deg (gamma=0.55, erasure=0.25, q=0.05)



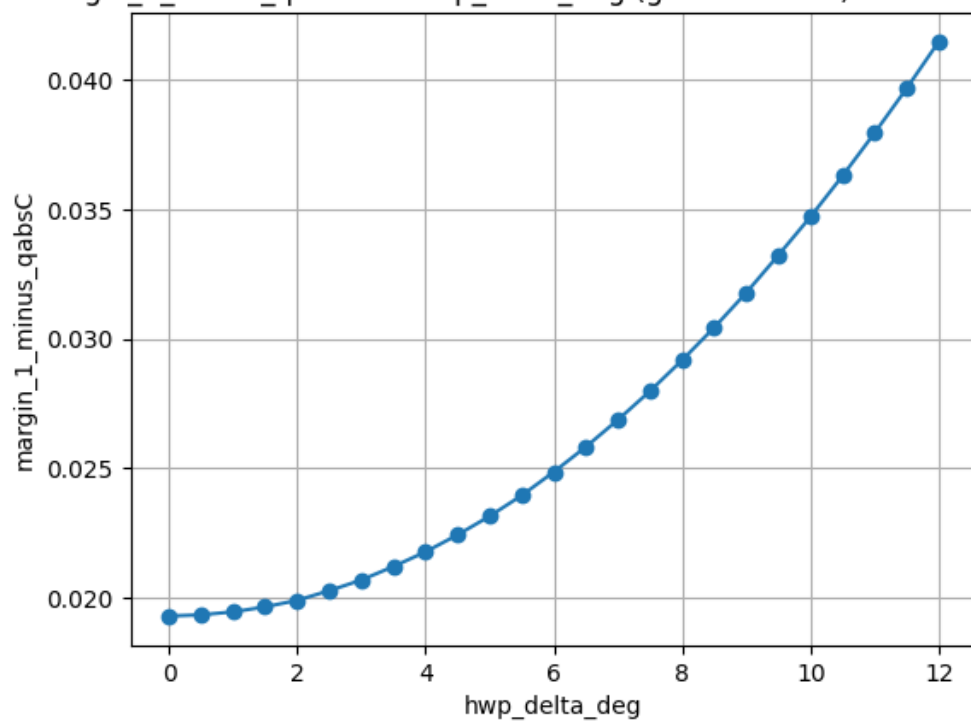
A_PBS: throughput vs hwp_delta_deg (gamma=0.55, erasure=0.25, q=0.05)



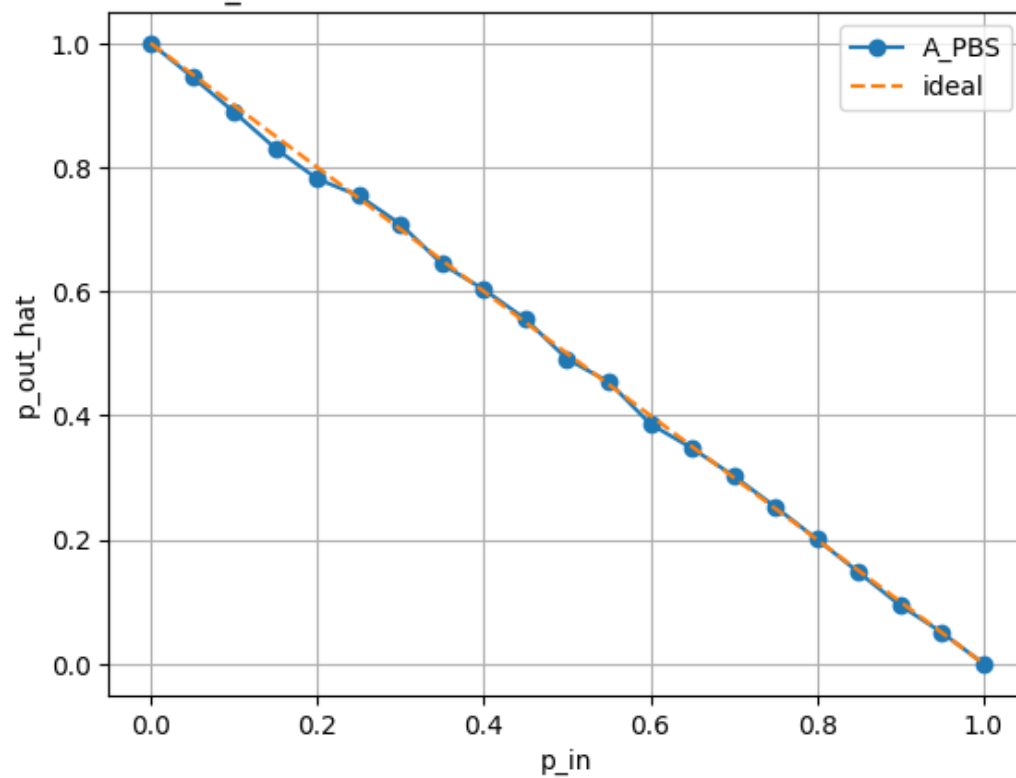
A_PBS: q_{absC} vs hwp_delta_deg ($\gamma=0.55$, erasure=0.25, $q=0.05$)



A_PBS: $\text{margin}_1 - q_{\text{absC}}$ vs hwp_delta_deg ($\gamma=0.55$, erasure=0.25, $q=0.05$)



A_PBS: Transfer curve under non-ideal baseline



A_PBS: Robustness margin vs p_{in} (non-ideal baseline)

