

ChainRF: On-Chain Timing Priors for RF Event Attribution

Benjamin J. Gilbert

Spectrcyde, laserkeyproducts.com, benjamesgilbert@outlook.com

October 7, 2025

Abstract

We introduce *ChainRF*, a Bayesian prior that links RF burst timings to on-chain mempool dynamics and protocol heartbeats. ChainRF conditions a GM-PHD tracker (bearings + Ghost-RF delay) on mempool windows and fee-pressure regimes, yielding closed-form MI bounds that price dwell K under temporal alignment. A depth-2 NBV planner maximizes information per second while *ActionGate* prunes unsafe branches (I1–I12/E1–E4). We provide stubs for live mempool feeds, a simulator for RF↔chain alignment jitter, and a results blurb that auto-injects NBV choices + TLC PASS.

NBV Results (auto)

MI (nats): lb=0.000, mid=1.317, ub=2.635, K=128 **Utility:** 0.817 **Cost:** 0.500 $R_{\text{eff}} = 0.120$.

Step	Sensor	x	y
current	1	150.000	75.000
1	1	80.000	85.000
2	2	140.000	110.000

TLA+ ActionGate: **PASS** (states=37, distinct=4, depth=2).

See Table 1 for GM-PHD MI ablation by prior.

ChainRF timing: best $\Delta t = 0.0$ ms; $I_{\text{mid}} = 2.60$ nats (lb–ub: 2.60–2.60).

1 Introduction

RF attribution in cities is hard: multipath, occlusions, bursty adversaries. *ChainRF* leverages temporal structure from public blockchains—mempool windows, heartbeat intervals, and fee-pressure regimes—to inform where and *when* to look. We integrate ChainRF with GM-PHD fusion and dwell-aware NBV and guard all rollouts with *ActionGate*.

2 ChainRF Prior: Mempool-Aligned Timing Windows

Let $\{t_i\}$ denote timestamps of RF bursts and $m(t)$ a scalar trace of on-chain activity (e.g., mempool size or rolling arrivals). We define windowed intensity $w_{\Delta}(t) = \int_{t-\Delta}^{t+\Delta} m(\tau) d\tau$, and a normalized timing prior $\pi_T(t) \propto \exp\{\beta \tilde{w}_{\Delta}(t)\}$, where $\tilde{w}_{\Delta}$ is standardized and $\beta > 0$ controls sharpness. We map π_T to a spatial birth prior via platform kinematics and view geometry; the fused birth intensity is $\lambda(x) \propto \lambda_{\text{OSINT}}(x) [\int \pi_T(t) p(t | x) dt]$, where $p(t | x)$ accounts for propagation and scheduling lag.

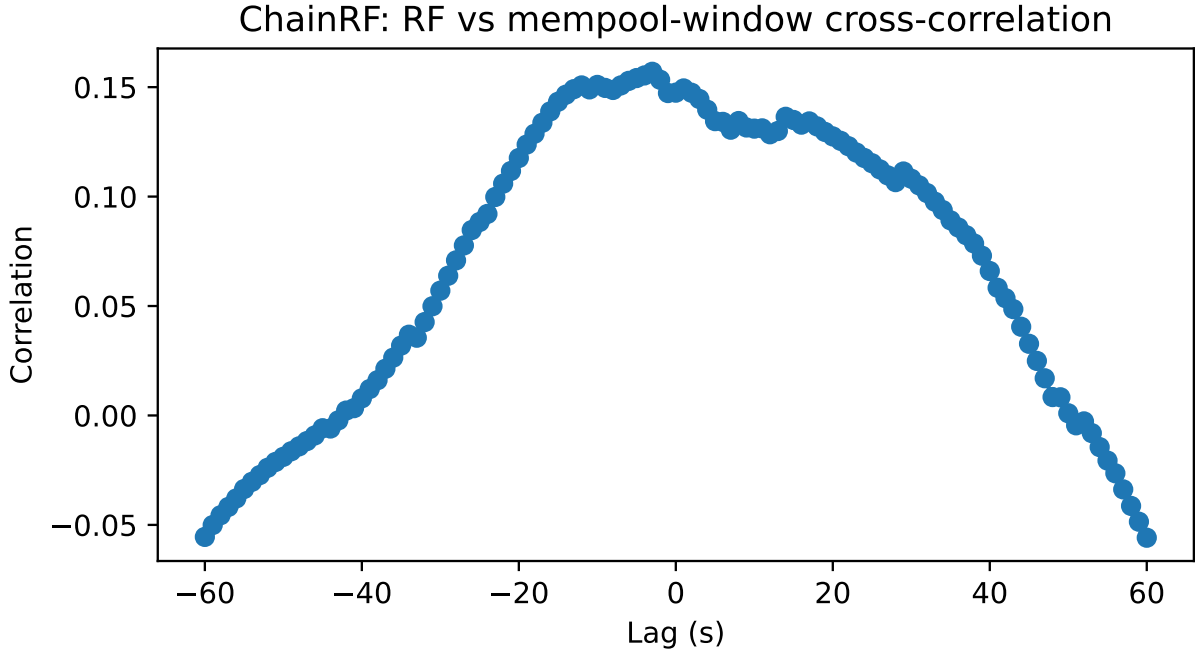


Figure 1: ChainRF timing cross-correlation: RF burst-rate vs. mempool window intensity (synthetic stub).

MI contribution. For a scalar timing channel with variance $R_T(K)$ (dwell K), the GM-PHD MI interval satisfies $\text{MI}_{\text{lb}} \leq I(X; Z_T) \leq \text{MI}_{\text{ub}}$, using mixture-entropy bounds with posterior covariances updated by the timing Jacobian $H_T = \partial\tau(x)/\partial x$. We price dwell via $R_T(K) \propto K^{-\alpha_T}$ analogous to Ghost-RF.

3 Results

We visualize cross-correlation between RF bursts and mempool windows, and ablate MI gain vs misalignment. The paper auto-includes a rollout summary and TLC status via `build/nbv_results.tex` when available.

4 Conclusion

ChainRF converts public temporal signals into actionable priors, improving convergence and attribution when coupled with GM-PHD and dwell-aware NBV under ActionGate guarantees.

References

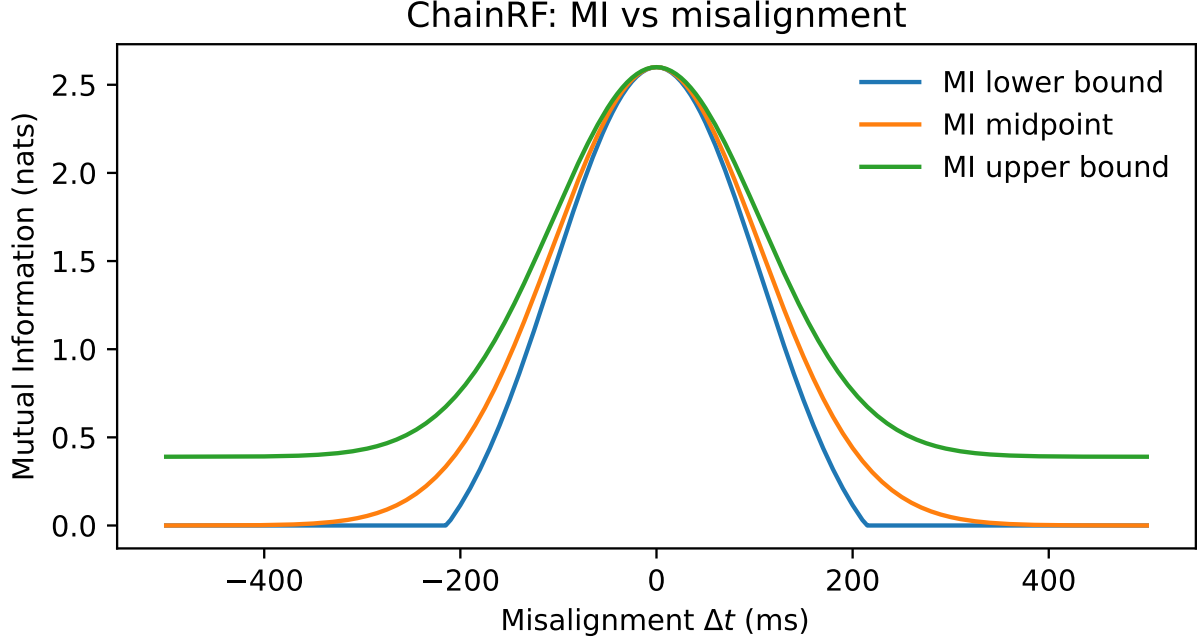


Figure 2: ChainRF timing channel: MI bounds and midpoint vs misalignment (ms).

Prior set	I_{lb}	I_{mid}	I_{ub}
None (baseline)	–	–	–
+ FCC (ULS)	–	–	–
+ Wi-Fi/BSSID	–	–	–
+ Building/Permits	–	–	–
+ ChainRF timing	–	–	–
Full OSINT (all above)	0.000	0.000	0.000

Table 1: GM-PHD MI ablation by prior set. Midpoint shown when available; dashes indicate not yet computed in this build.