

Luca Defect Regime Map (Cross-Report, Fixed Full-FPT Fairness)

Automated benchmark in valley-k-small

March 9, 2026

1 Scope and Fairness

Main winner metric compares only full-FPT competitors: sparse exact recursion vs Luca defect-reduced route. Linear systems are recorded as MFPT reference only. All claims use fixed-horizon fairness and ratio metric $R = \text{sparse}/\text{luca}$. Cross-family claims do not mix absolute seconds.

2 Methods

Timing protocol: warm-up 1 run, then 3 measured runs with median. Luca mode rule: full when defect pairs ≤ 120 , otherwise sampled- z extrapolated estimate. Estimator form: $t_{\text{est}} = t_{\text{setup}} + (t_{\text{eval}}/n_z)m + t_{\text{fft}}$.

3 Main Findings

Pooled median R : 0.0005 (mean 0.0198); Luca-win probability $P(R > 1)$: 0.000. Global regime decision: No Luca winning region under fixed-T full-FPT fairness. Estimation anchors: $n=8$, median relative error=0.126 (PASS against 25% threshold).

4 Figures

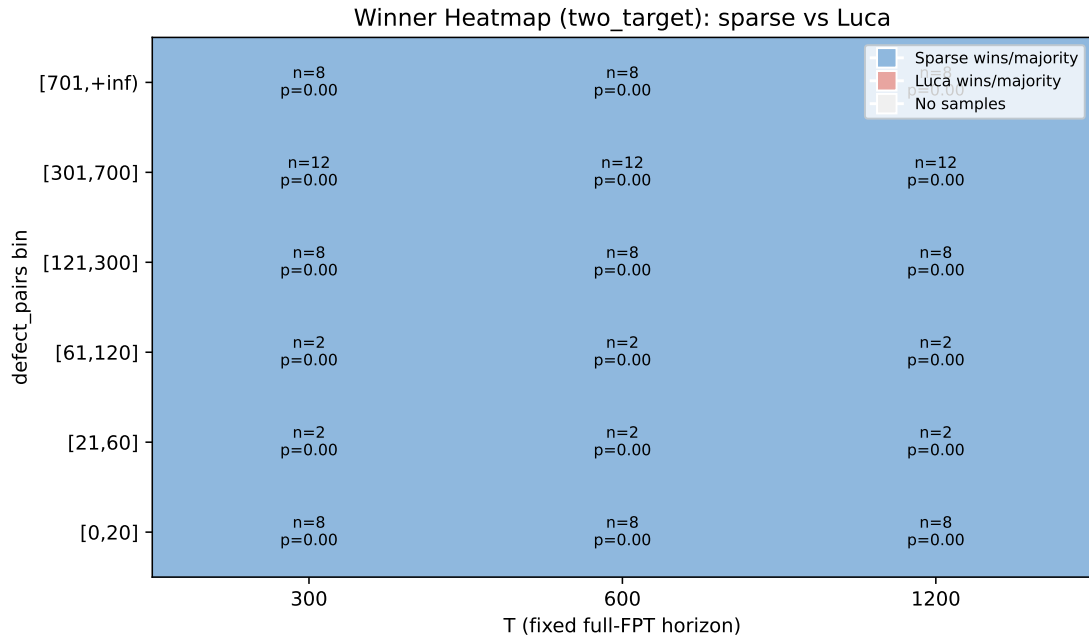


Figure 1: Winner heatmap on two-target workloads.

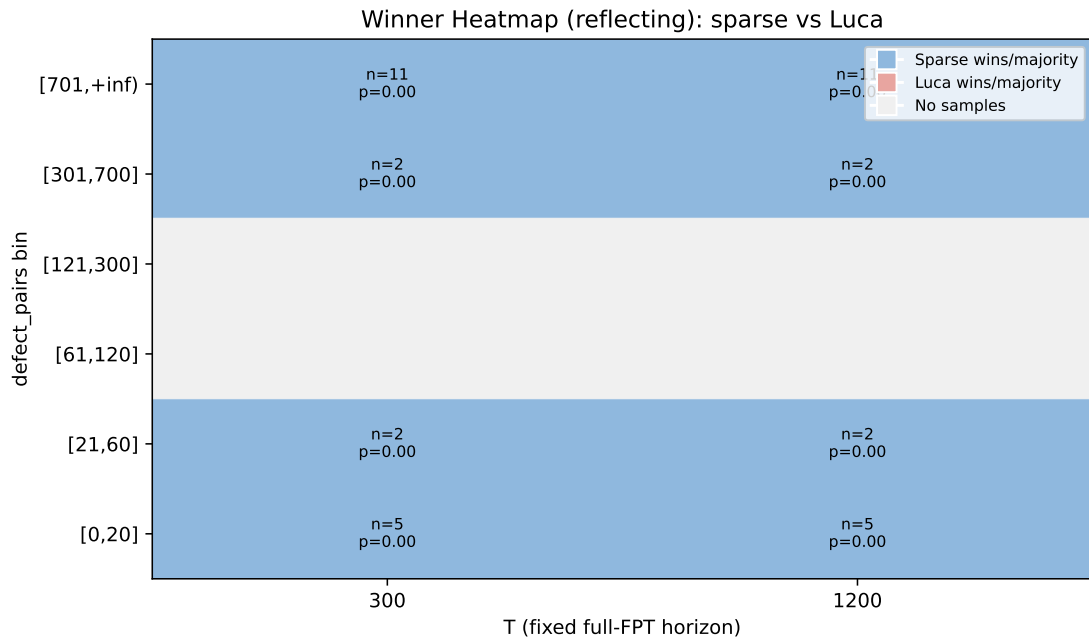


Figure 2: Winner heatmap on reflecting workloads.

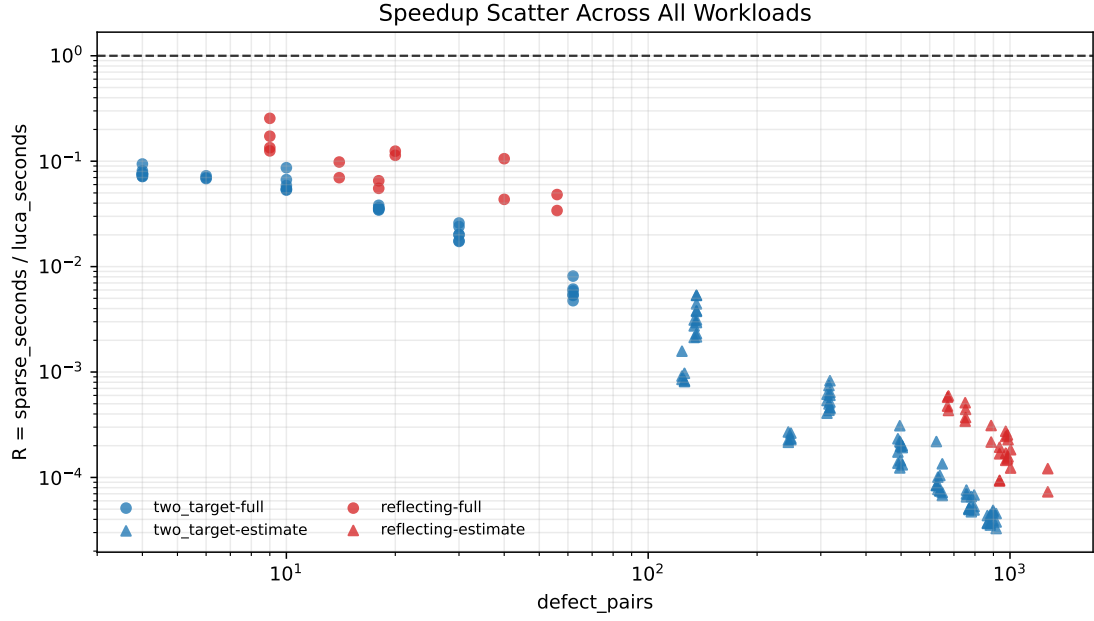


Figure 3: Speedup ratio scatter with full/estimate mode markers.

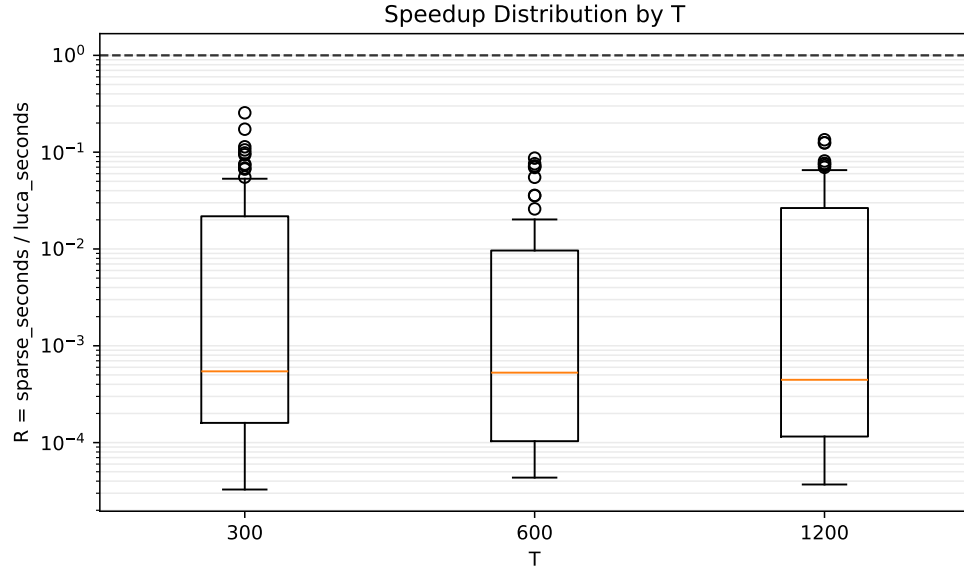


Figure 4: Distribution of R by fixed horizon T .

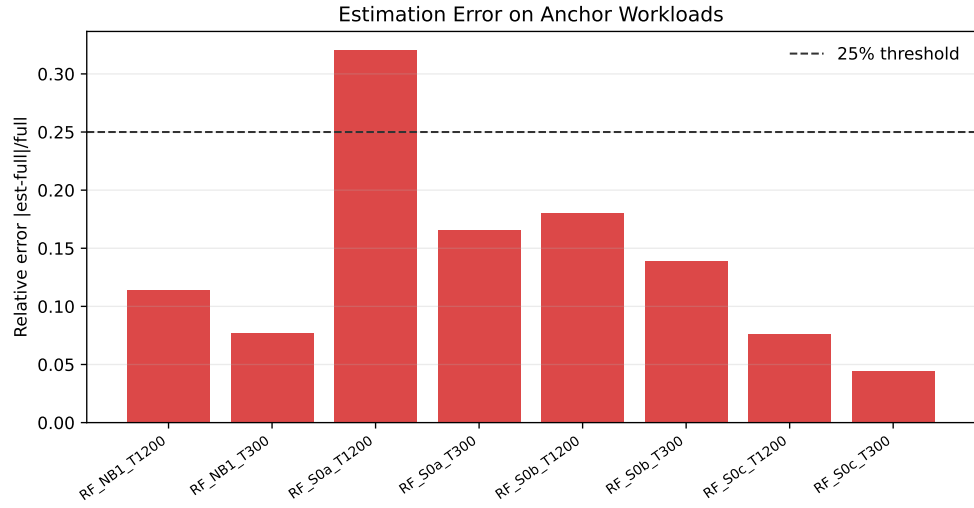


Figure 5: Full vs estimate relative error on anchor workloads.

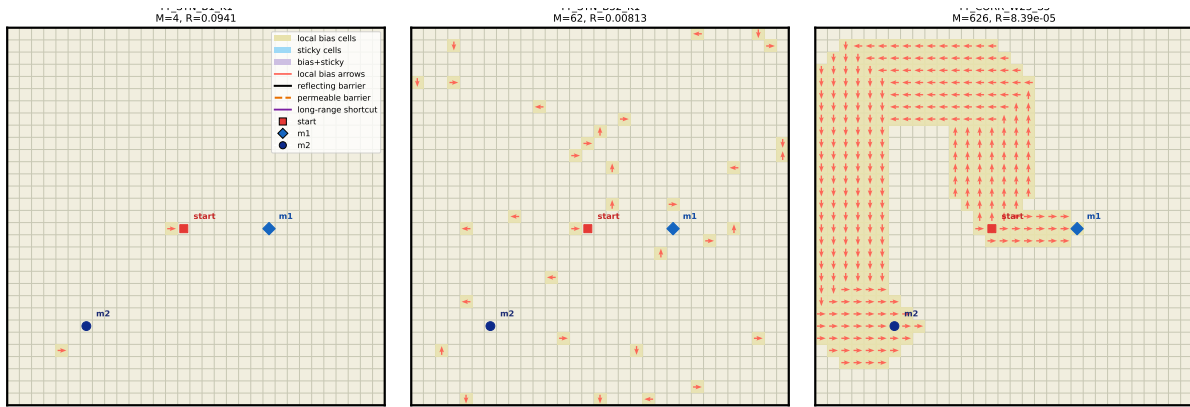


Figure 6: Representative low/medium/high-defect configuration examples.

5 Tables

Table 1: Runtime ratio summary by defect bin and horizon.

Defect bin	T	n	Median R	Mean R	$P(R > 1)$
[0,20]	300	13	0.0734	0.0919	0.000
[0,20]	600	8	0.0705	0.0628	0.000
[0,20]	1200	13	0.0727	0.0779	0.000
[121,300]	300	8	0.0019	0.0021	0.000
[121,300]	600	8	0.0015	0.0019	0.000
[121,300]	1200	8	0.0020	0.0021	0.000
[21,60]	300	4	0.0329	0.0472	0.000
[21,60]	600	2	0.0231	0.0231	0.000
[21,60]	1200	4	0.0290	0.0304	0.000
[301,700]	300	14	0.0002	0.0003	0.000
[301,700]	600	12	0.0002	0.0003	0.000
[301,700]	1200	14	0.0003	0.0003	0.000
[61,120]	300	2	0.0068	0.0068	0.000
[61,120]	600	2	0.0057	0.0057	0.000
[61,120]	1200	2	0.0053	0.0053	0.000
[701,+inf)	300	19	0.0002	0.0002	0.000
[701,+inf)	600	8	0.0000	0.0001	0.000
[701,+inf)	1200	19	0.0001	0.0001	0.000

Table 2: Anchor workload runtime baselines.

Anchor	Defects	Sparse(s)	Dense(s)	Full AW(s)	Luca(s)	Linear(s)
low_defect (TT_SYN_B1_K1-T300)	4	0.0029	0.0050	22.9998	0.0416	0.0147
high_defect (TT_CORR_W23_S2-T300)	632	0.0034	0.0065	22.2596	36.4872	0.0168

6 Practical Recommendation Matrix

Task Type	Recommended Method
Full FPT under fixed finite horizon	Sparse exact recursion as default baseline; Luca only when defect support is very small and validated on anchors.
MFPT/splitting only	Linear systems (do not use as full-FPT winner metric).
Transform-domain analysis with sparse defects	Luca defect-reduced AW, but keep estimation/full calibration checks.
High-defect corridor-like regimes	Prefer sparse recursion; Luca often loses after setup/evaluation overhead is counted.

7 Reproducibility

Core data files: `data/manifest.csv`, `data/runtime_raw.csv`, `data/runtime_summary.json`.