

Quantifying Aleatoric and Epistemic Dynamics Uncertainty via Local Conformal Calibration


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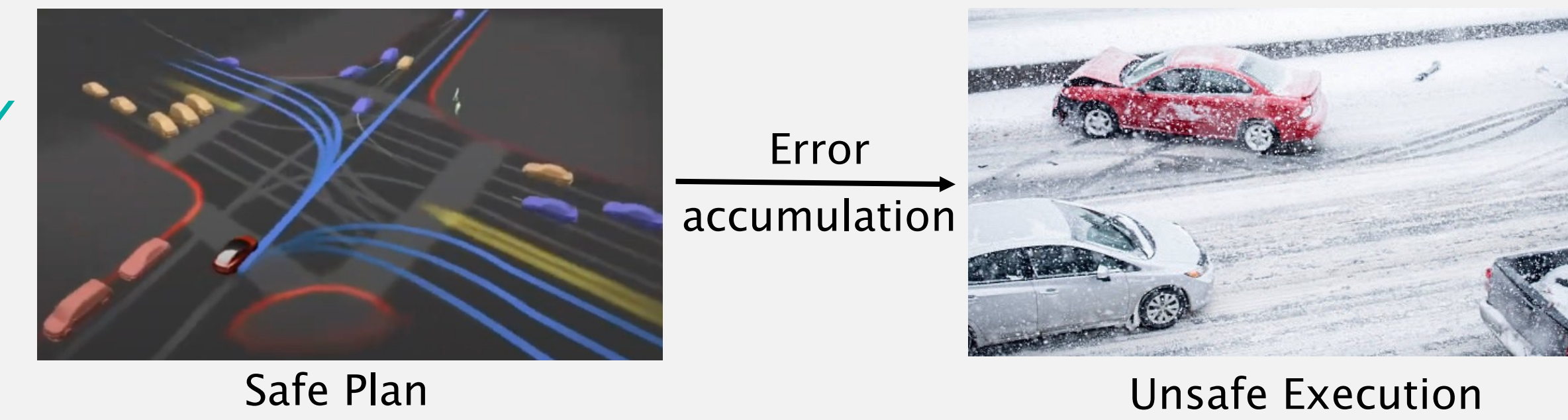
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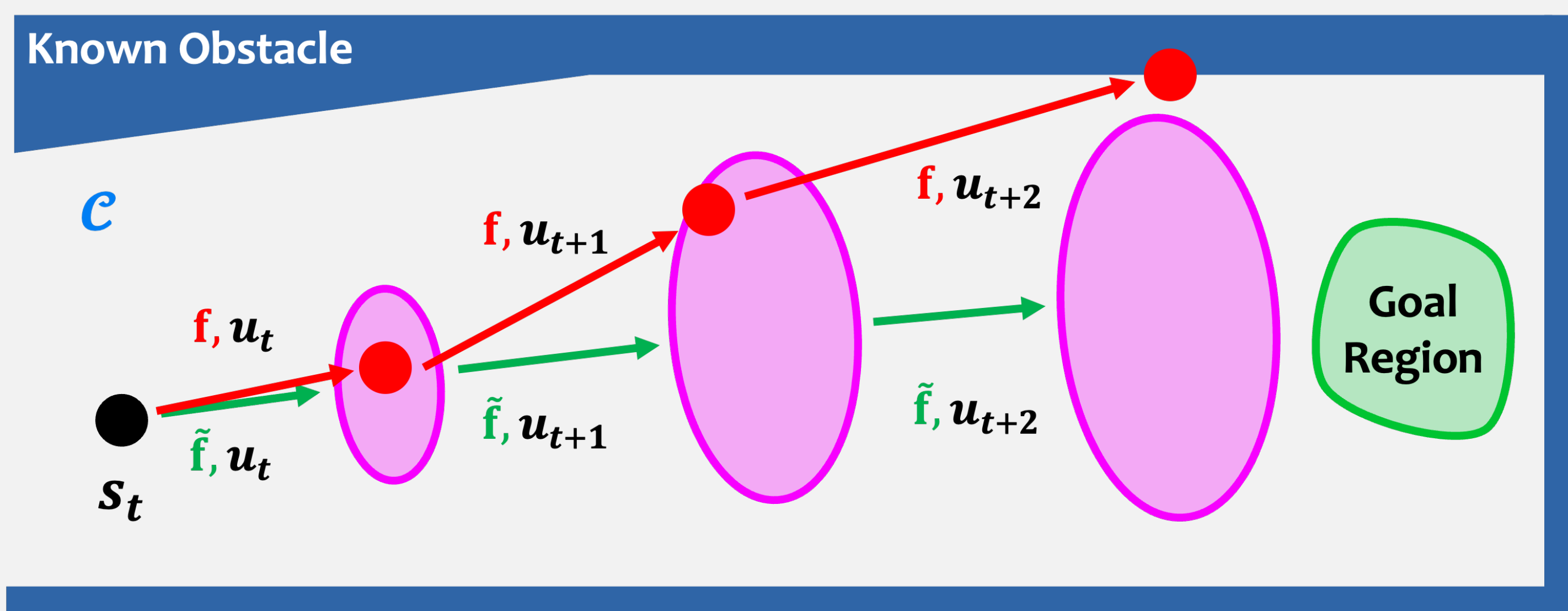
1. Motivation

- Safety-critical autonomous systems () act under *uncertainty*
- We provide **probabilistically valid prediction regions** for any *finite calibration dataset*, *dynamics predictors* (outputting Gaussians), *unknown true dynamics*, and *aleatoric perturbations*



Can **guarantee safety** at a user-defined **reliability rate** $\in (0,1)$

2. Problem



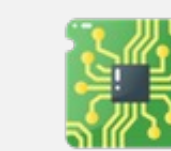
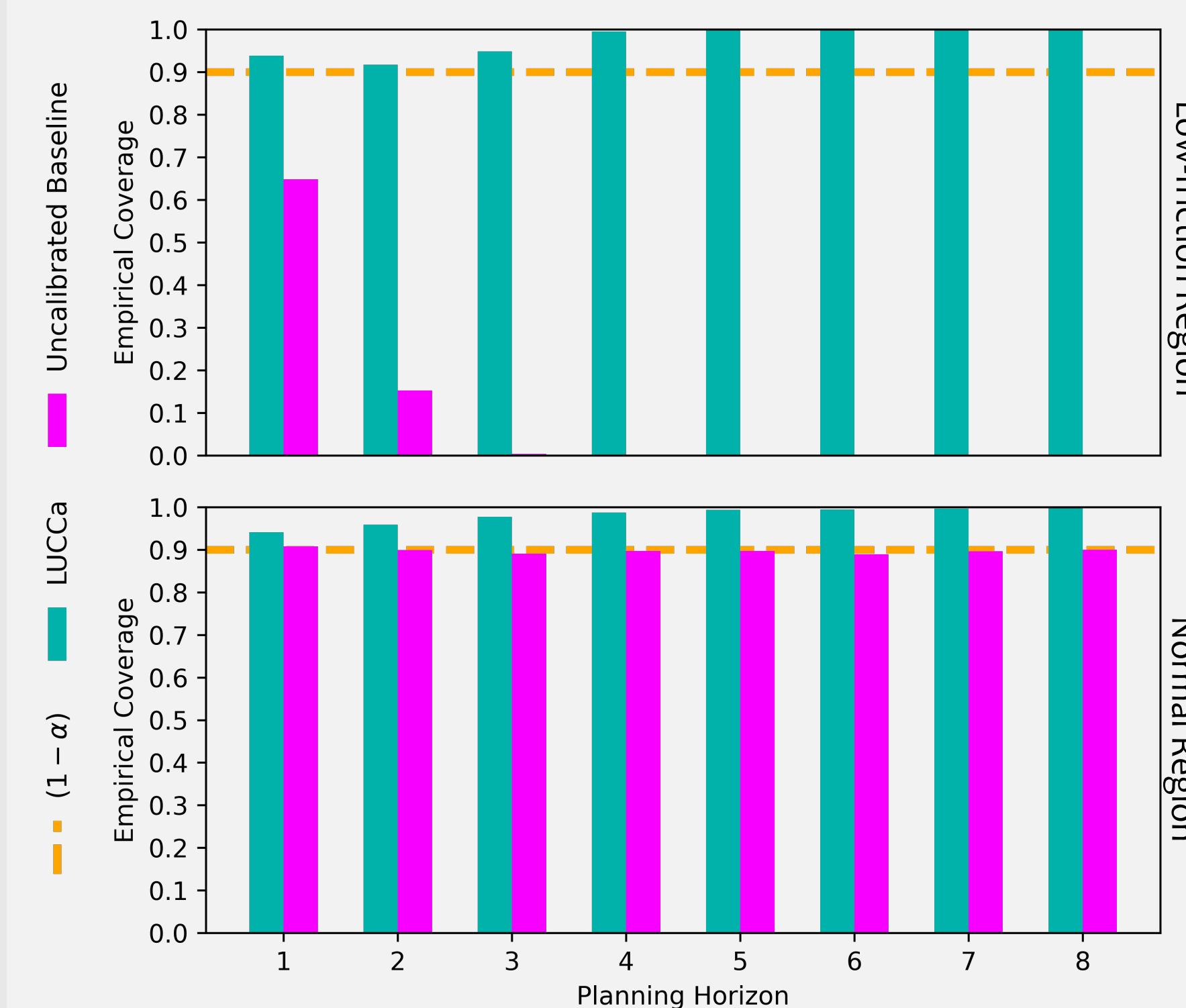
$$\min_{u_{t:t+H-1}} J(s, u) \quad \text{s: Robot State } \quad \text{u: Control Input}$$

$$\text{s.t.} \quad \mathbb{P}(s_{\tau+1} \in \mathcal{C}) \geq (1 - \alpha), \quad \forall \tau \in \{t, \dots, t + H - 1\}$$

$$s_{\tau+1} \sim \tilde{f}(s_{\tau}, u_{\tau}), \quad \forall \tau \in \{t, \dots, t + H - 1\}$$

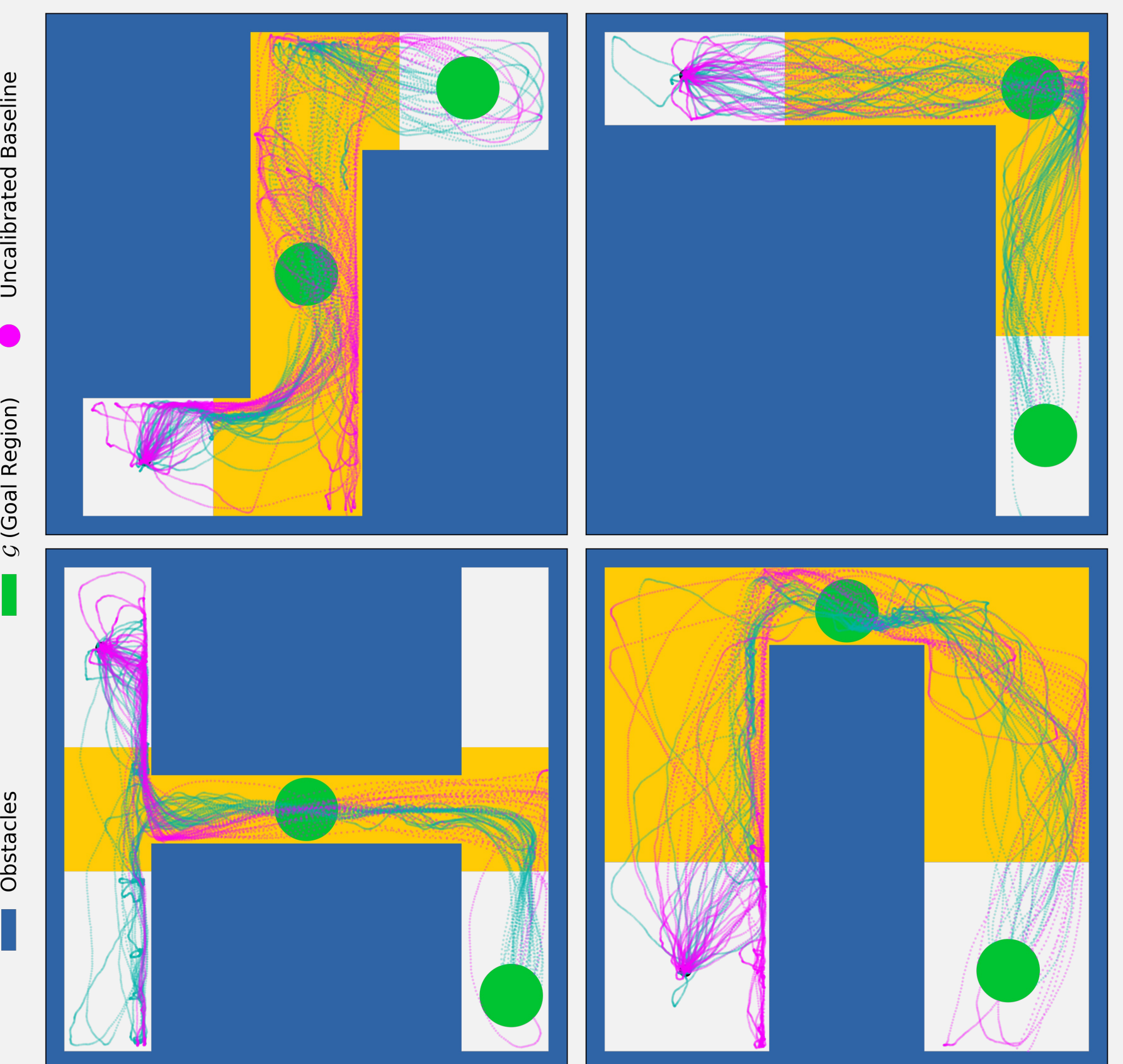
4. Results

- Metrics on double integrator:
- Collision-rate ↓
 - Success rate ↑
 - Avg Duration ↑



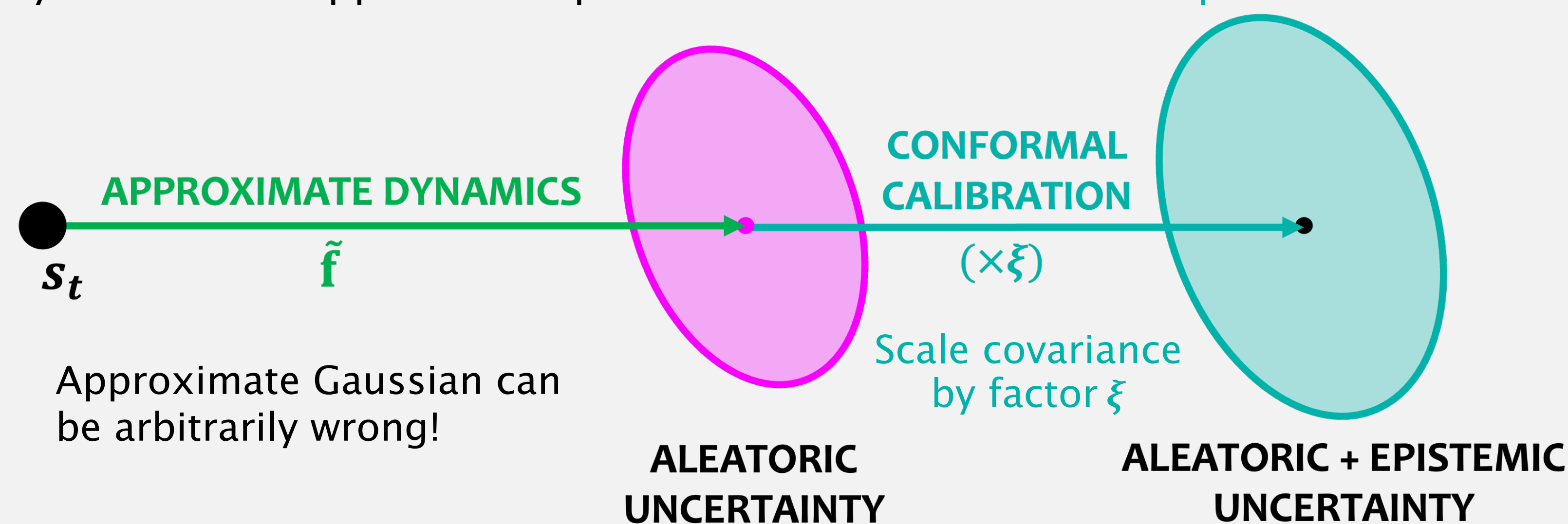
Computational Cost

- Offline: full process takes 0.17 secs
- Online: overhead of 0.3 ms/planning step

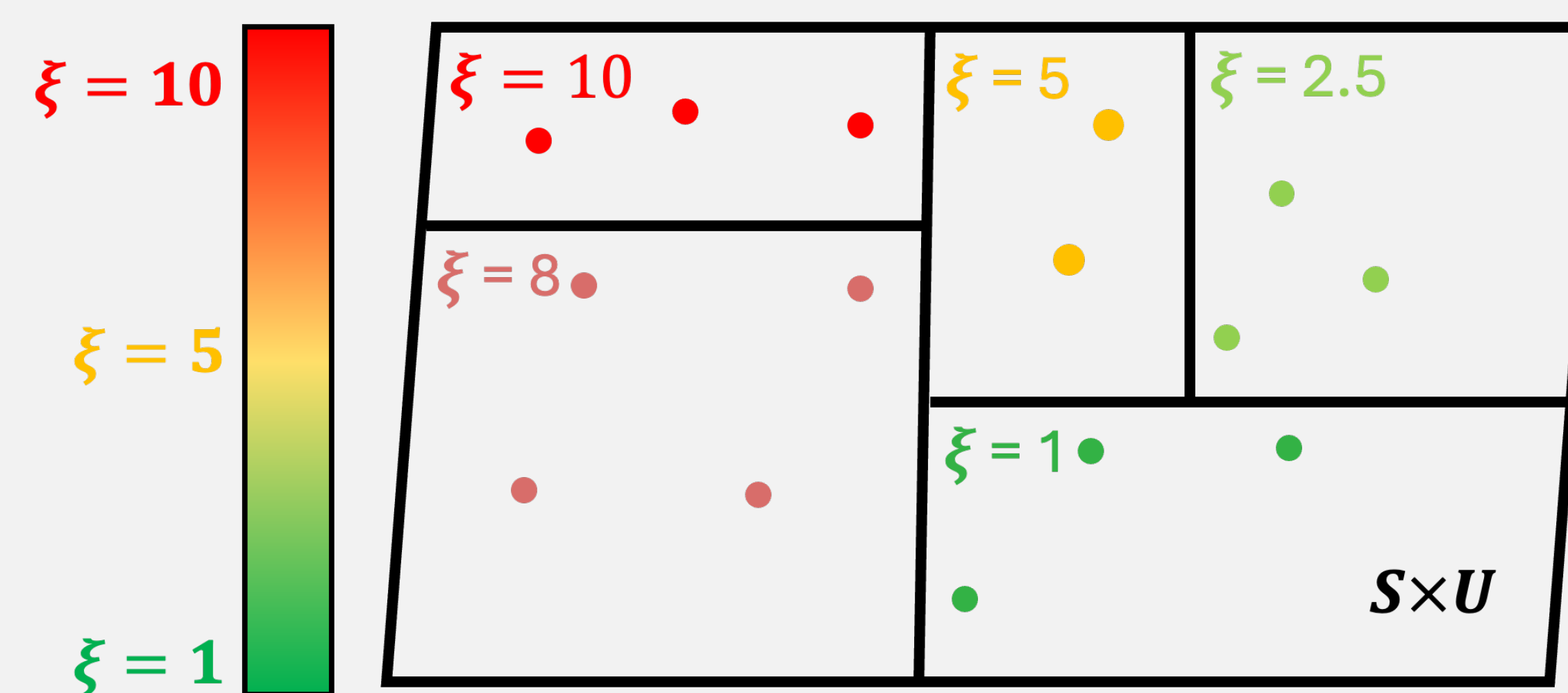


3. Method

Key idea: Chain approximate predictions with **calibration step**



Model accuracy might vary along state-action space



5. Conclusion

- Calibrated predictors of *arbitrary performance*
- Performed *state-action dependent calibration*
- *Reduced collision rate* on all four maps to below user-set rate

Sponsors



f: True Dynamics f-tilde: Approximate Dynamics J: Objective Function alpha: Acceptable Failure-rate H: Planning Horizon C: Safe Region