

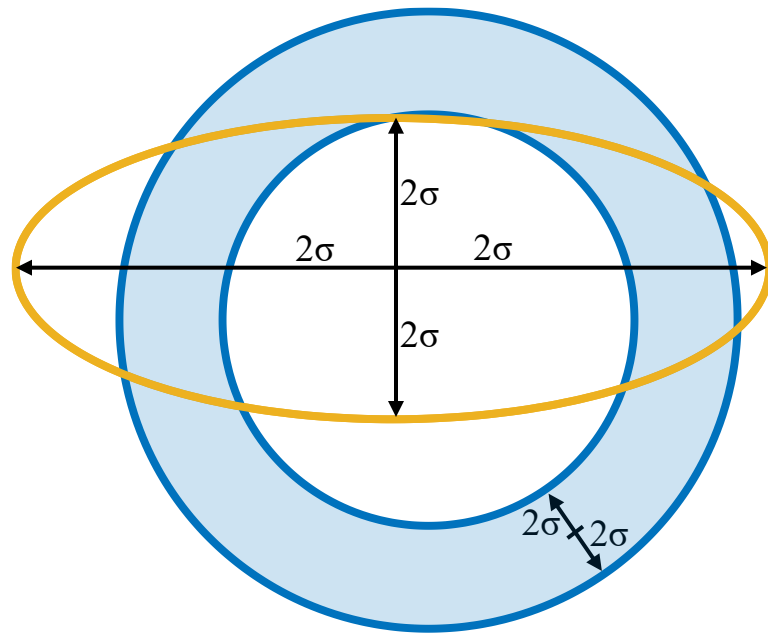
Progressive Bayesian Filtering with Coupled Gaussian and Dirac Mixtures

Daniel Frisch and Uwe D. Hanebeck

FUSION 2020 – Advanced Nonlinear Filtering 1

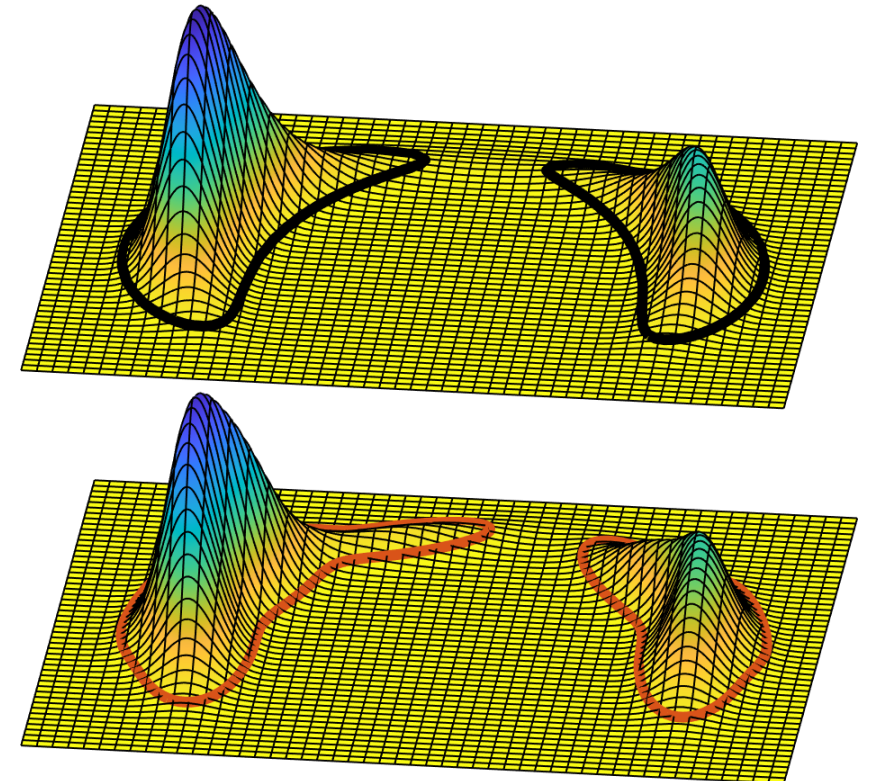
Intelligent Sensor-Actuator-Systems Laboratory (ISAS)
Institute for Anthropomatics and Robotics
Karlsruhe Institute of Technology (KIT)
Karlsruhe, Germany

Overview

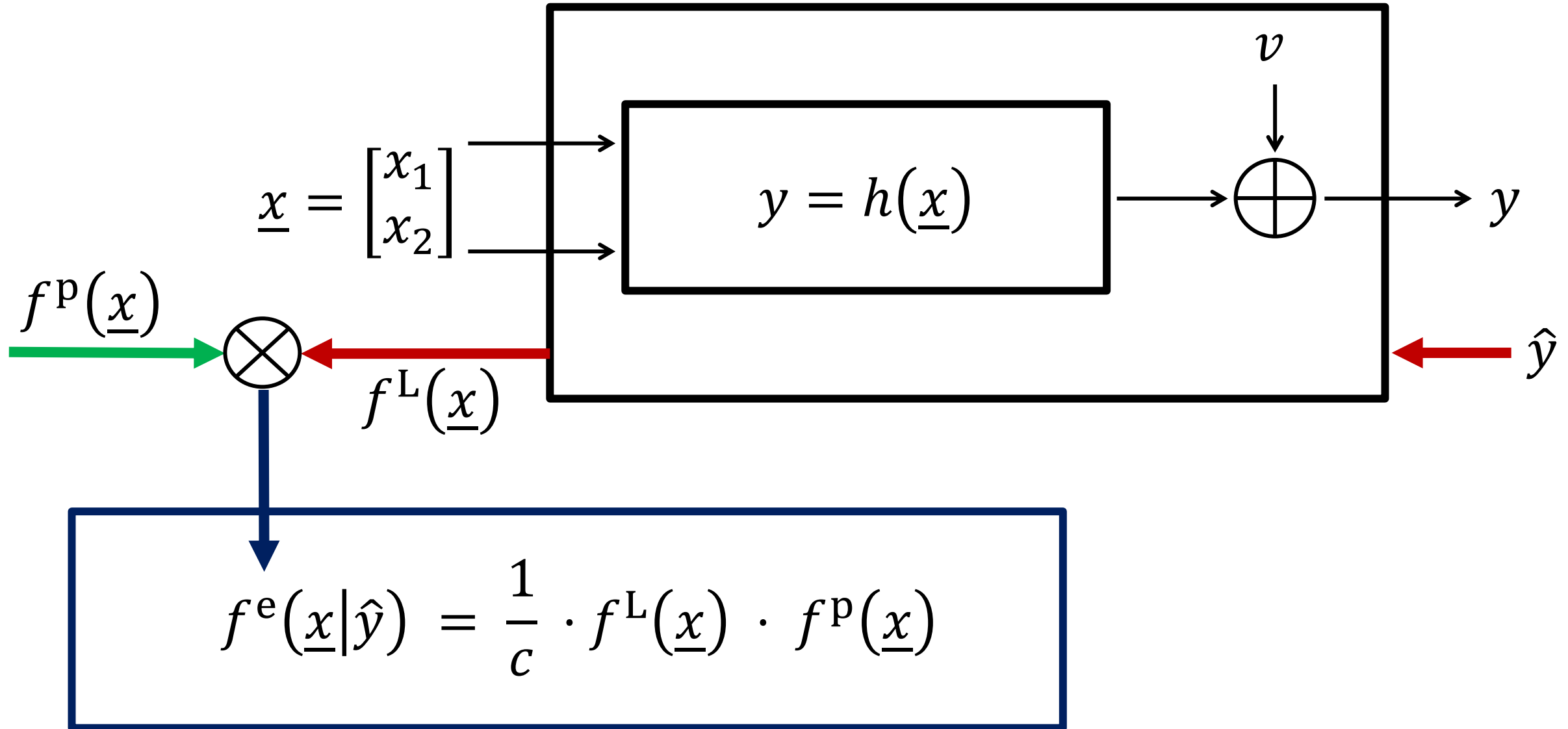


Methods

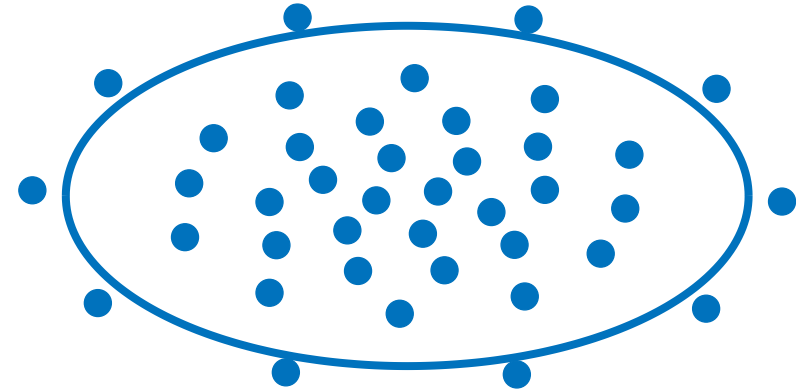
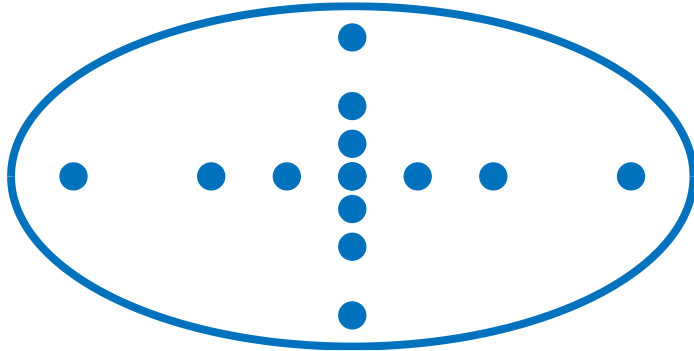
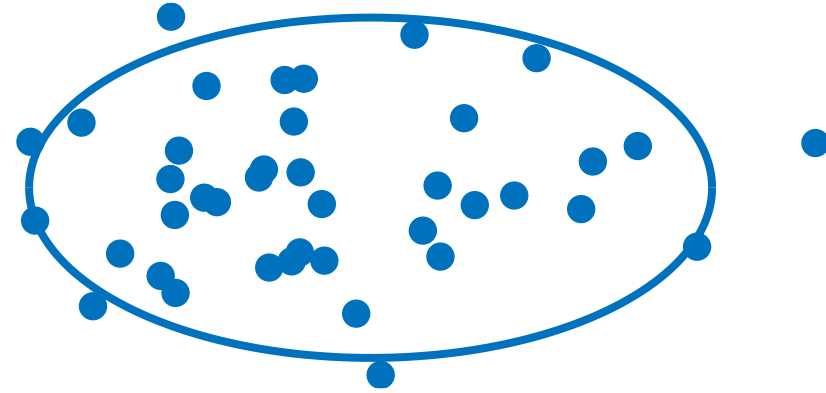
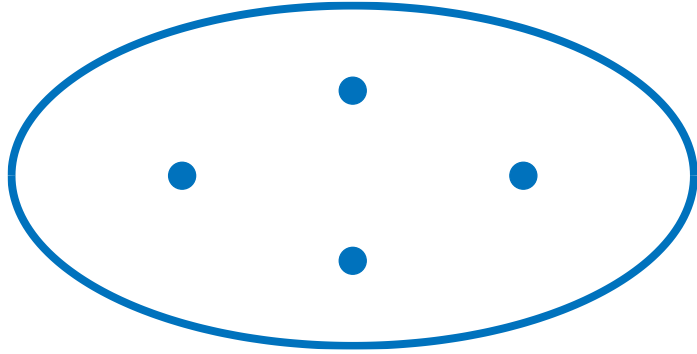
- **Progressive Update**
- Expectation Maximization
- Deterministic Gaussian Sampling
 - Localized Cumulative Distribution (LCD)
 - Modified Cramér-von Mises Distance



Nonlinear Filtering – Bayes Rule

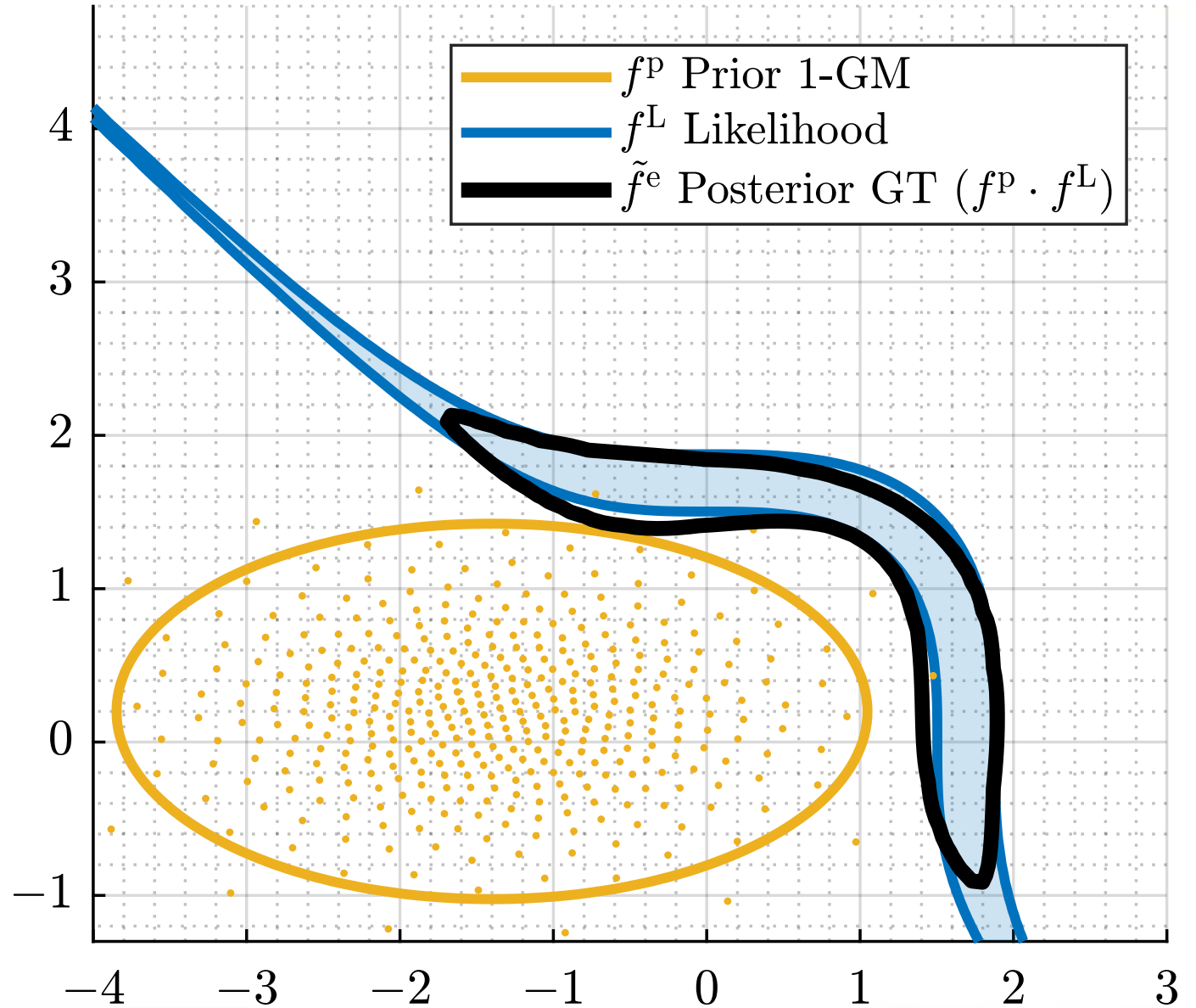


Sampling Methods



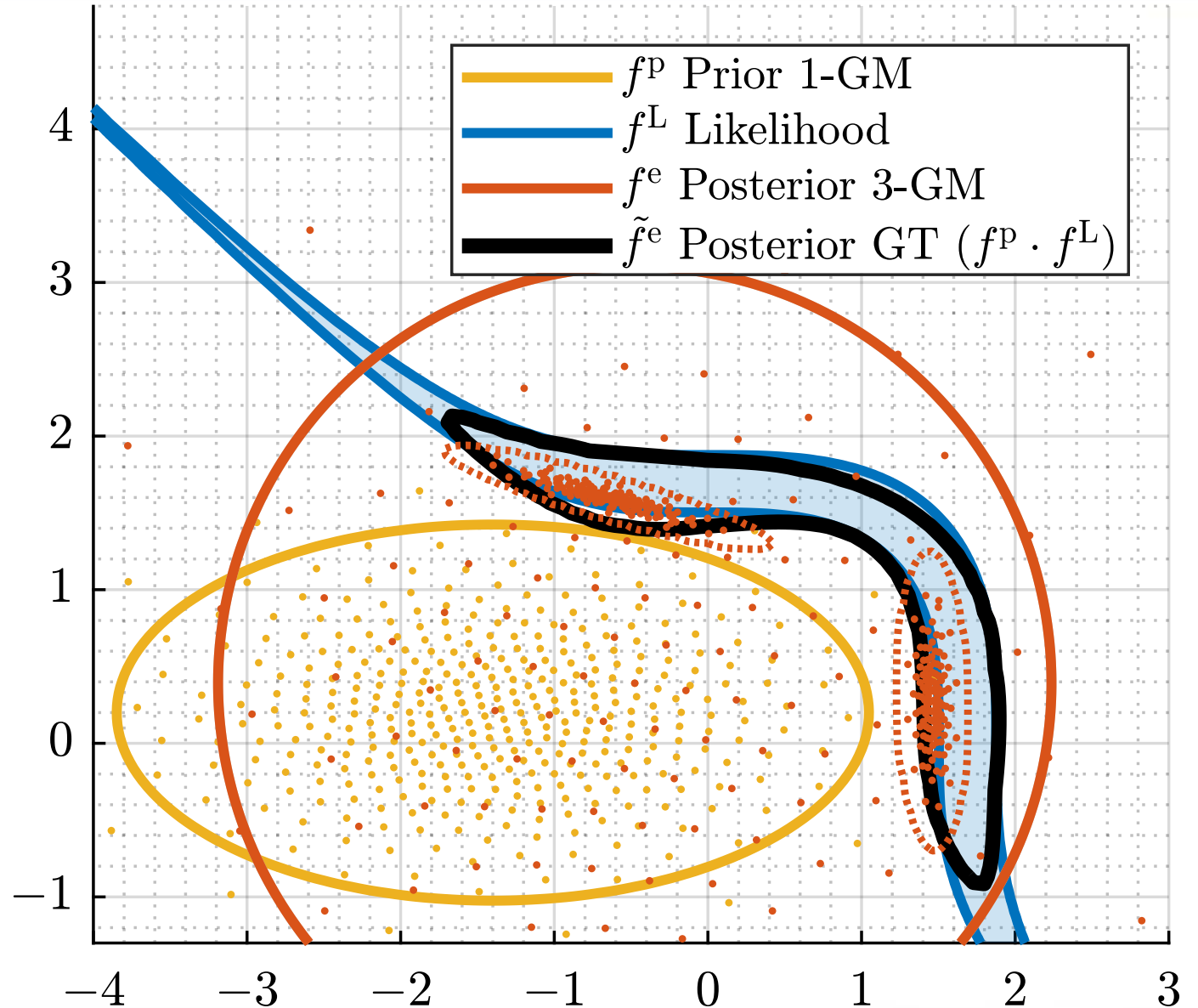
Sample Degeneration

- „Non-overlapping“
 - Prior
 - Likelihood
- Most samples are down-weighted to zero

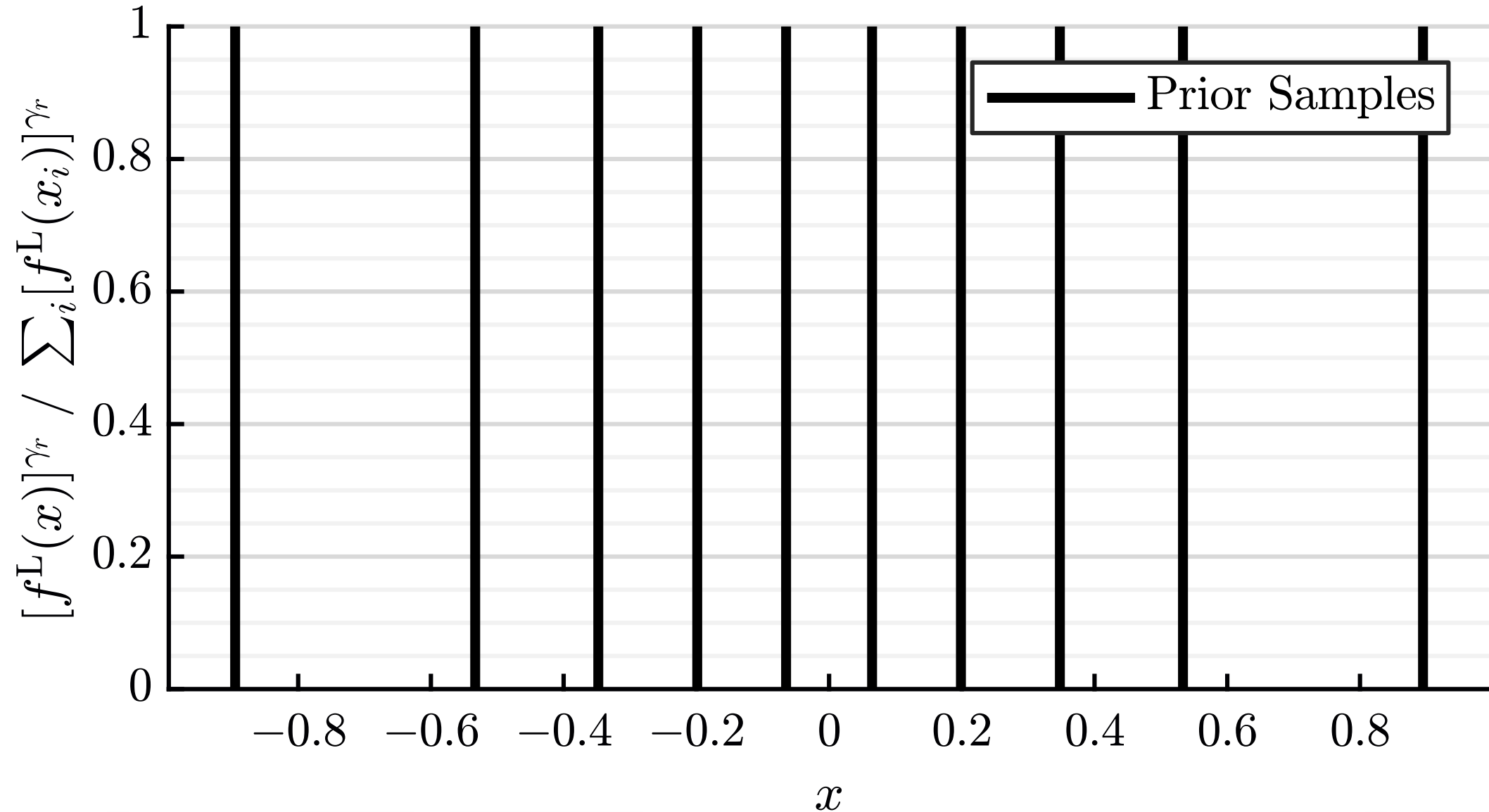


Sample Degeneration

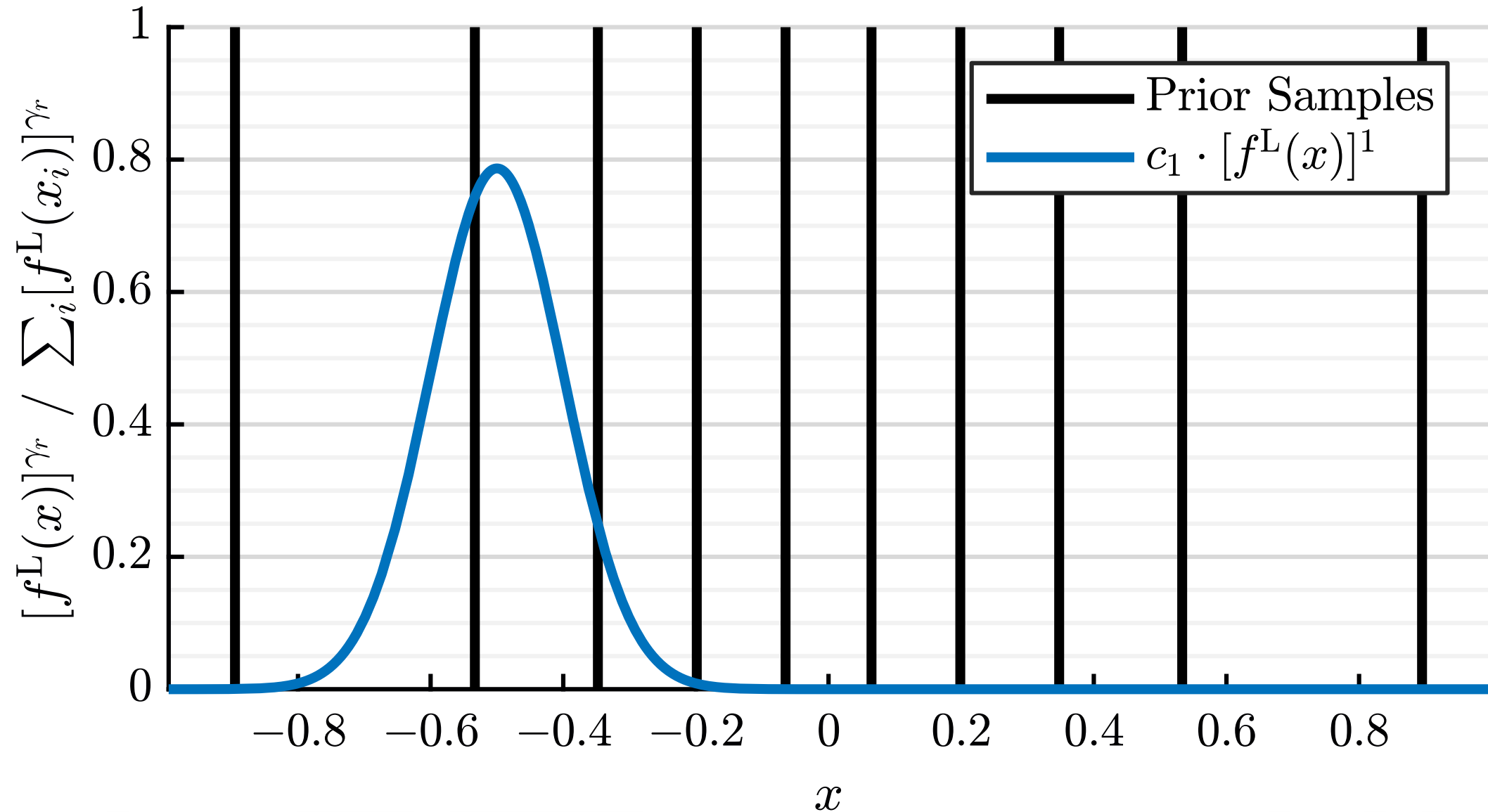
- „Non-overlapping“
 - Prior
 - Likelihood
- Most samples are down-weighted to zero
- Bad filter result



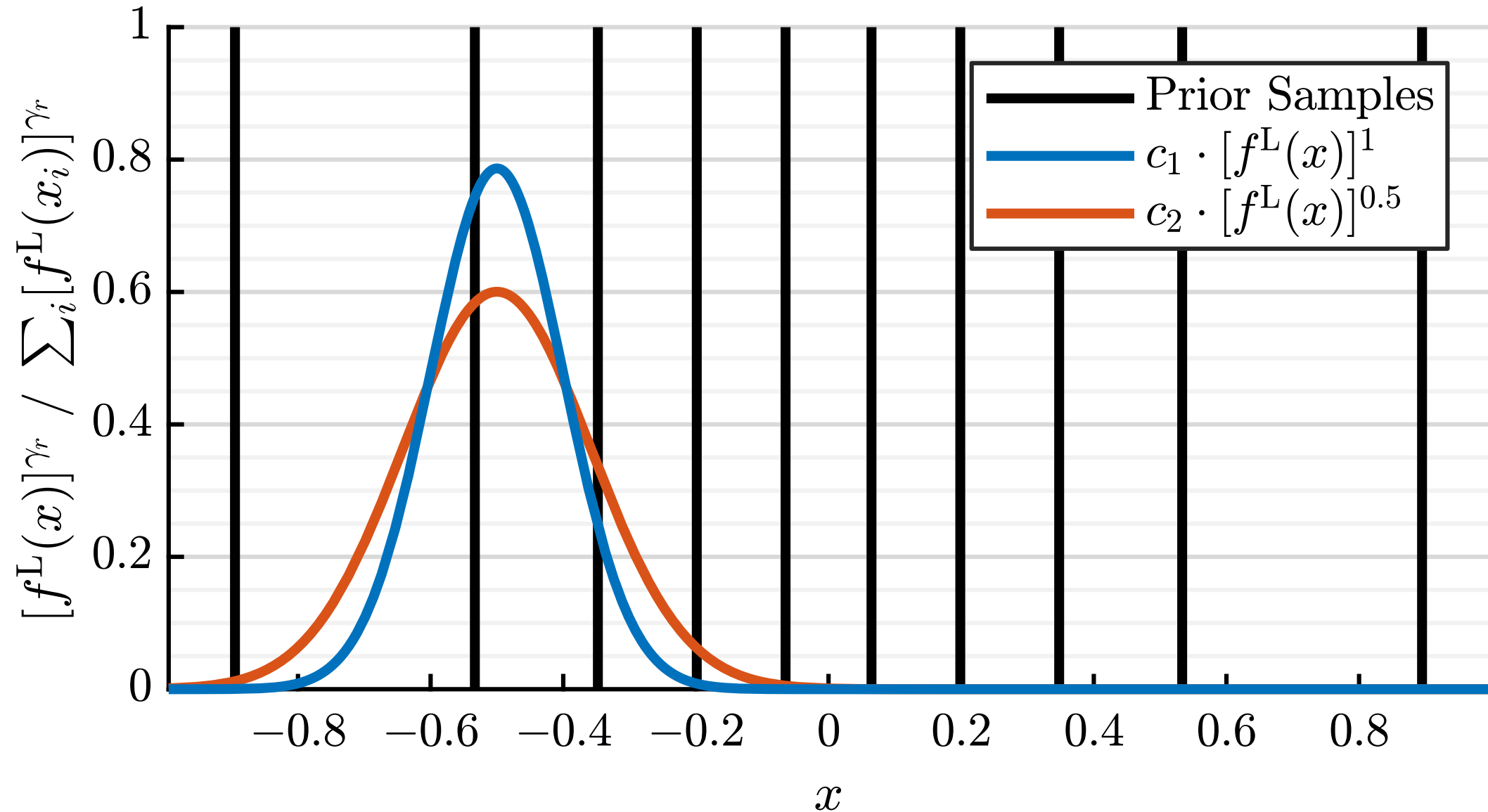
Likelihood „Flattening“



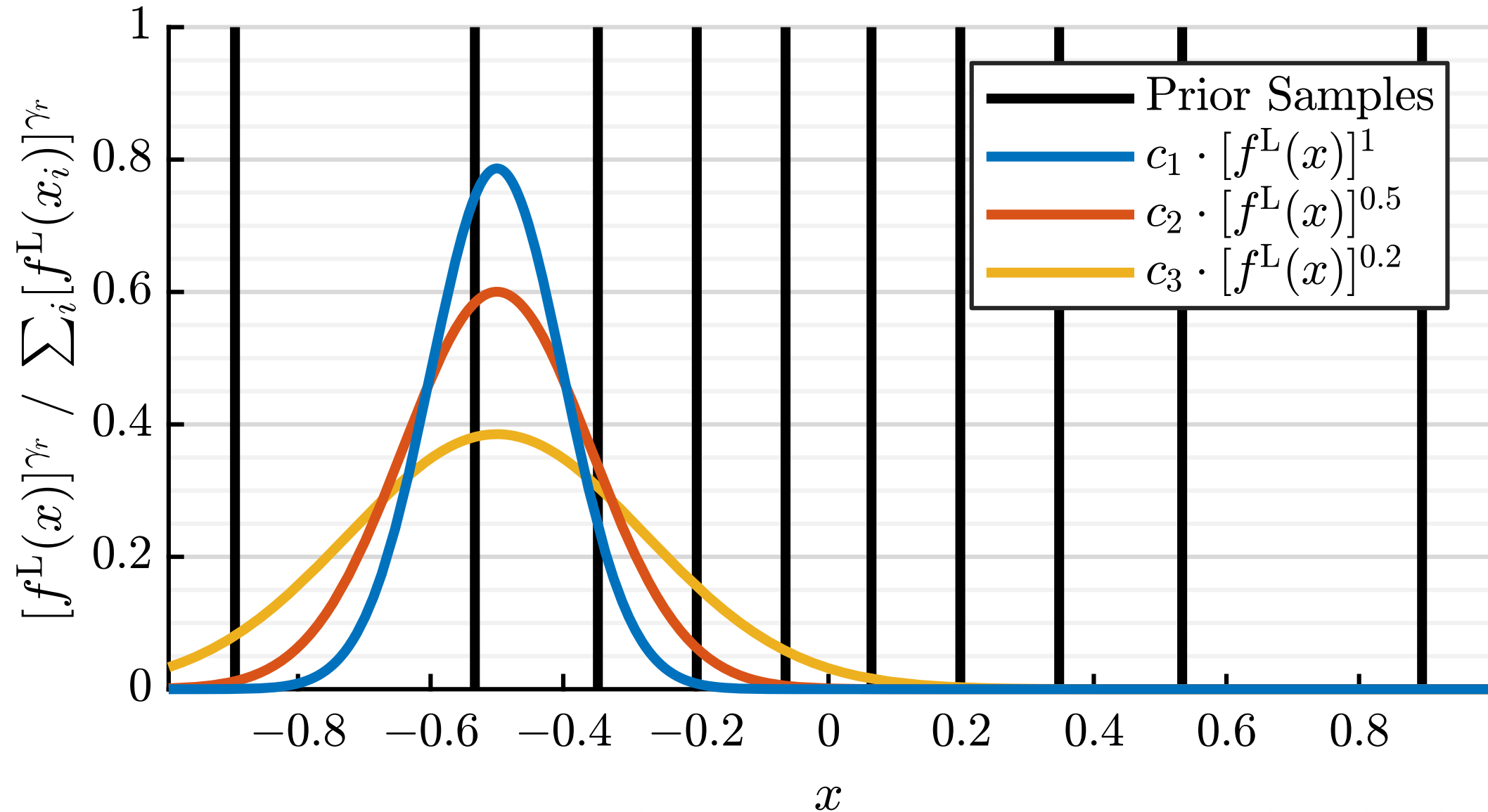
Likelihood „Flattening“



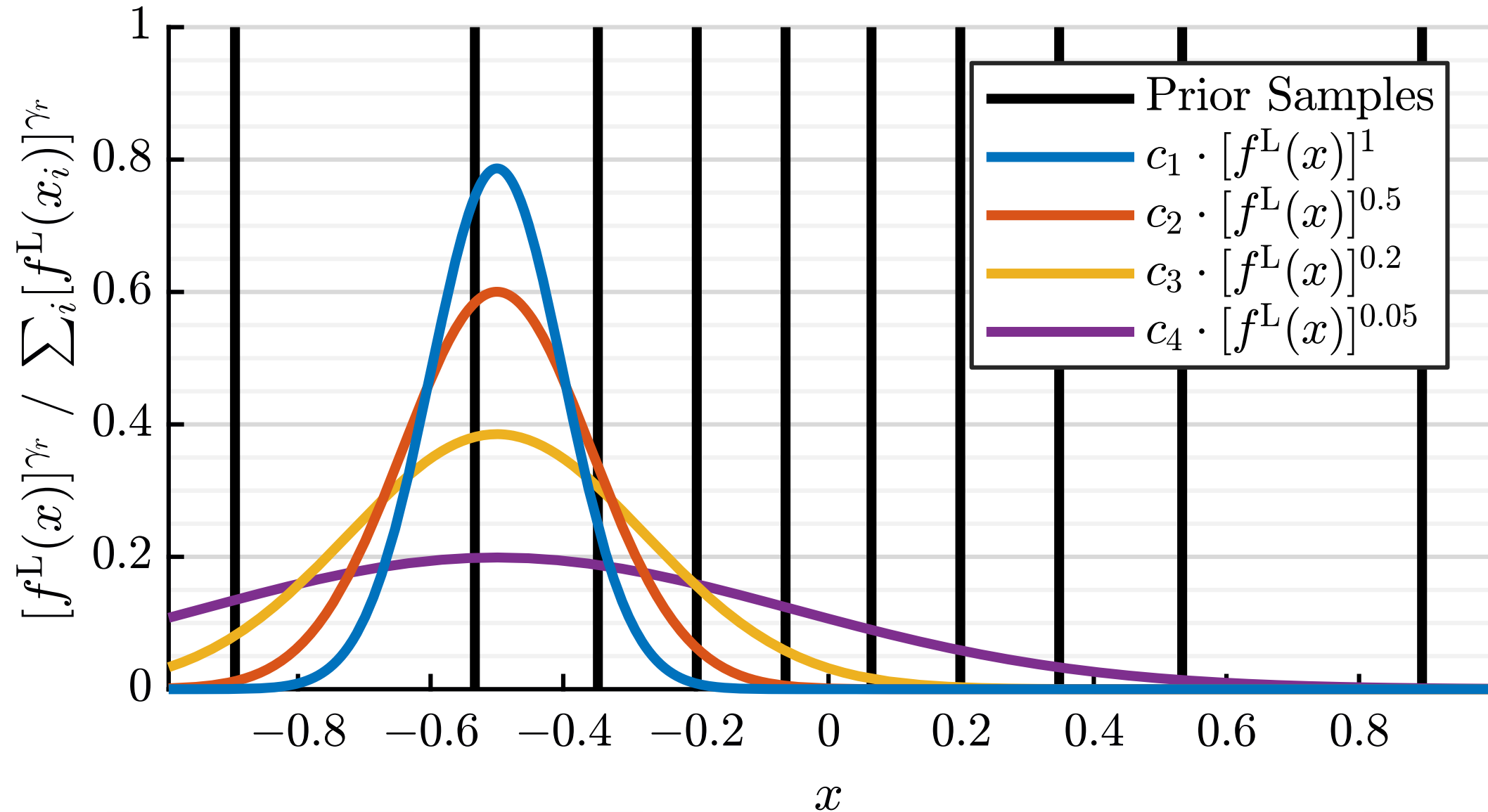
Likelihood „Flattening“



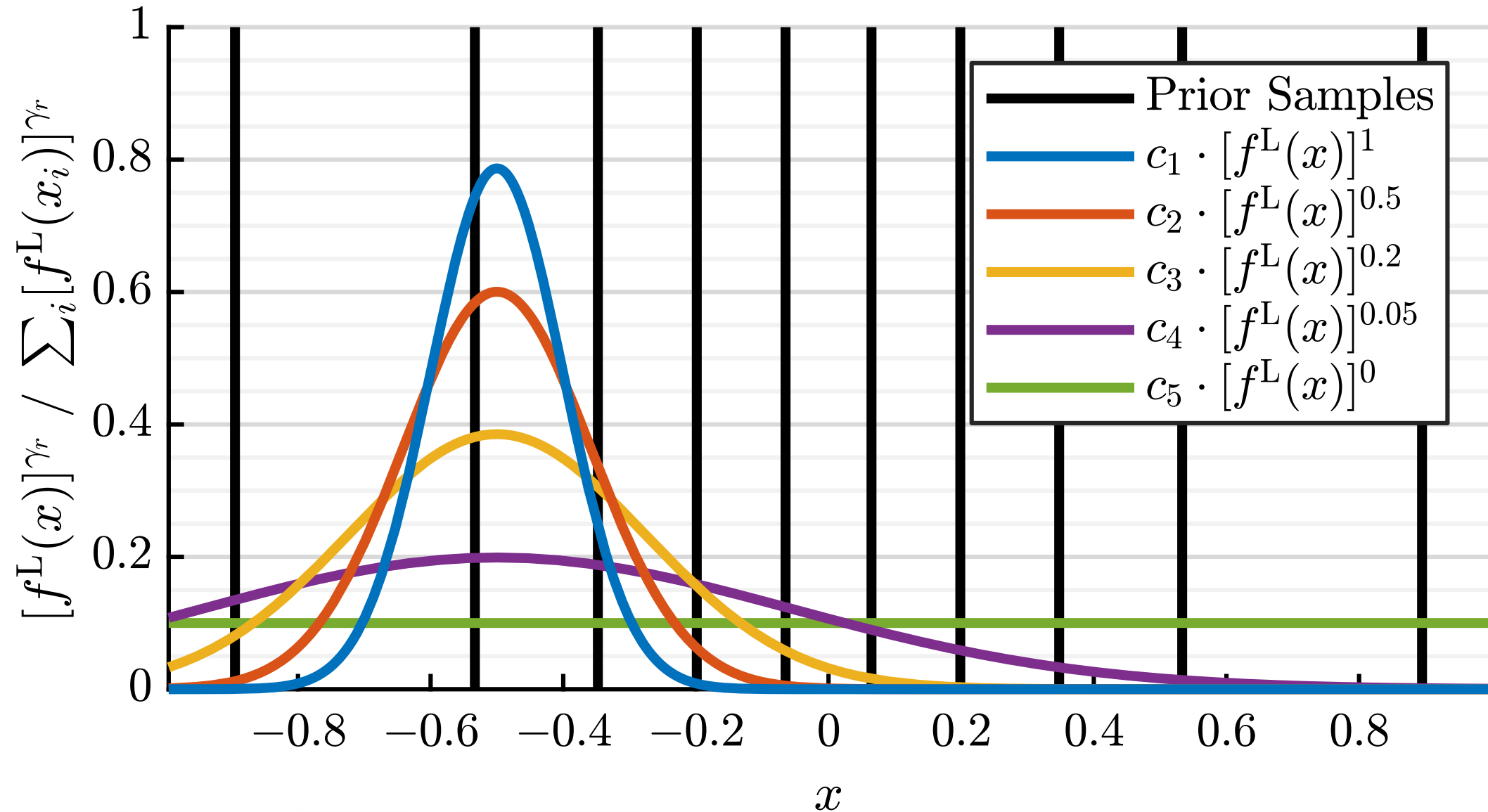
Likelihood „Flattening“



Likelihood „Flattening“



Likelihood „Flattening“

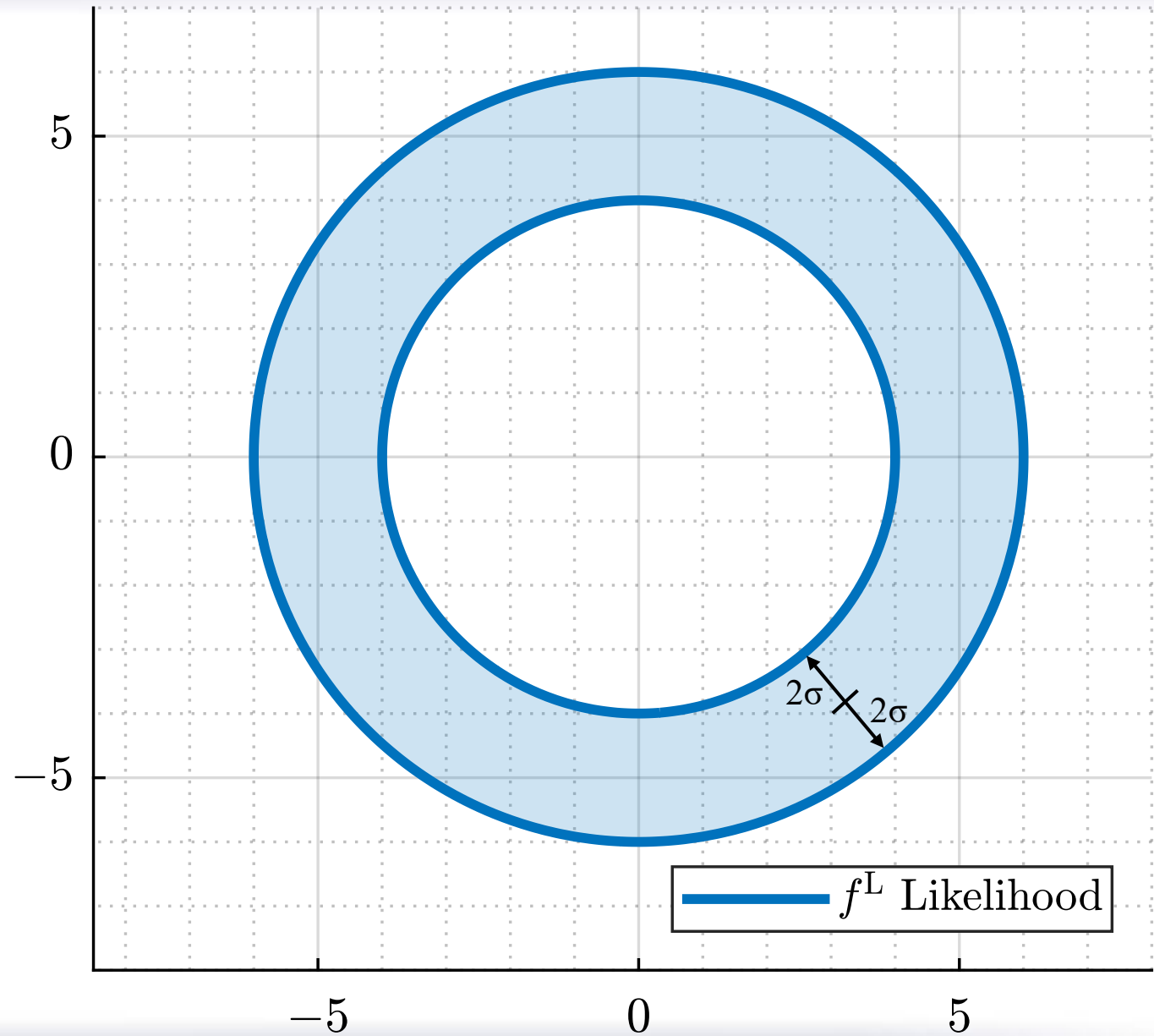


Likelihood „Splitting“

$$\begin{aligned} f^e(\underline{x}|\hat{y}) &= \underbrace{\frac{1}{c}}_{\text{const}} \cdot \underbrace{f^p(\underline{x})}_{\text{Prior}} \cdot \underbrace{f^L(\underline{x})}_{\text{Likelihood}} \\ &= \frac{1}{c} \cdot f^p(\underline{x}) \cdot \sqrt{f^L(\underline{x})} \cdot \underbrace{\sqrt{f^L(\underline{x})}}_{\text{Sub-Likelihood}} \\ &= \frac{1}{c} \cdot f^p(\underline{x}) \cdot \prod_{\substack{r=1 \\ \sum \lambda_r = 1}}^R \underbrace{[f^L(\underline{x})]^{\lambda_r}}_{\text{Sub-Likelihood}} \end{aligned}$$

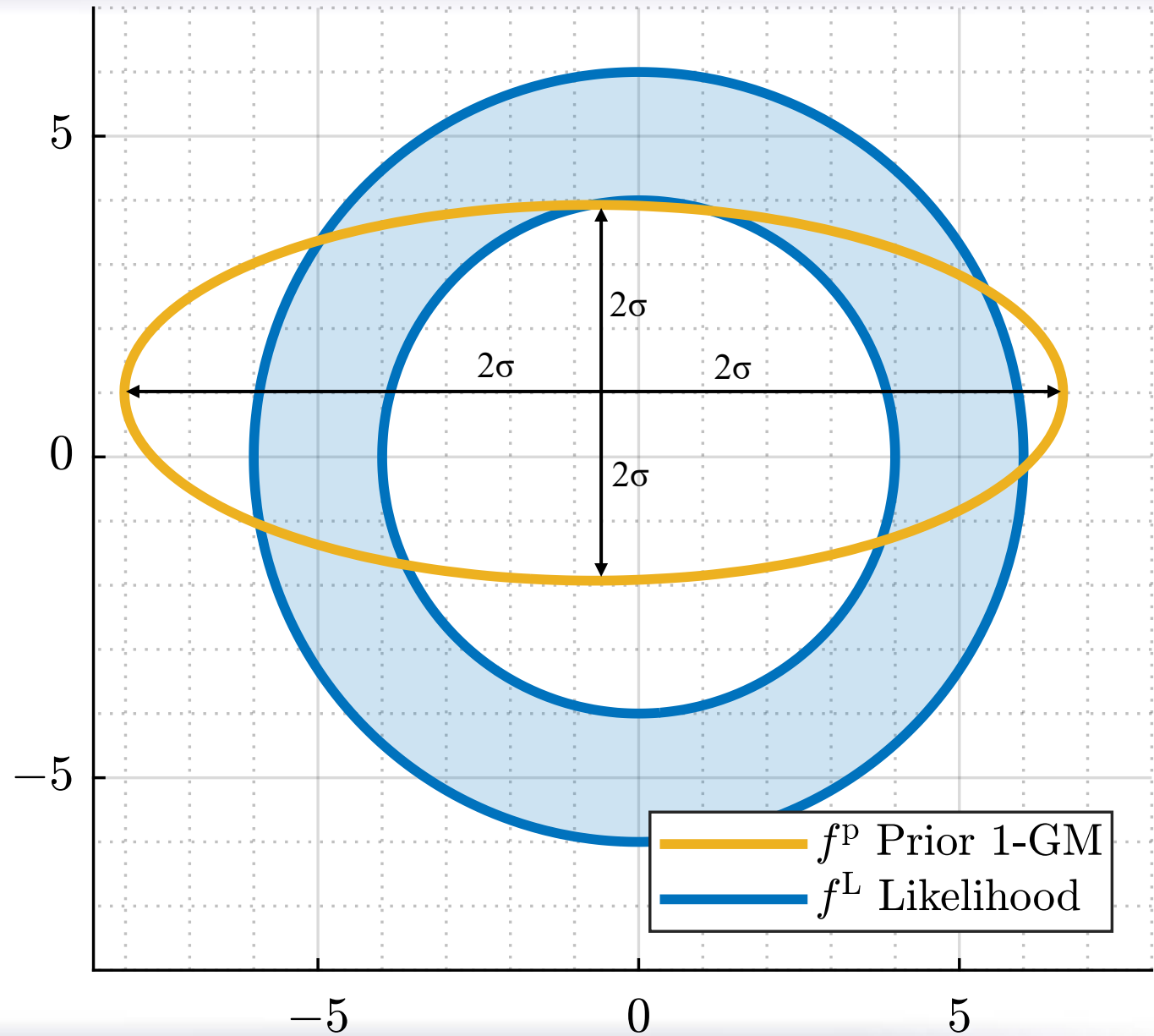
Progressive Update Example

- Likelihood (nonlinear)



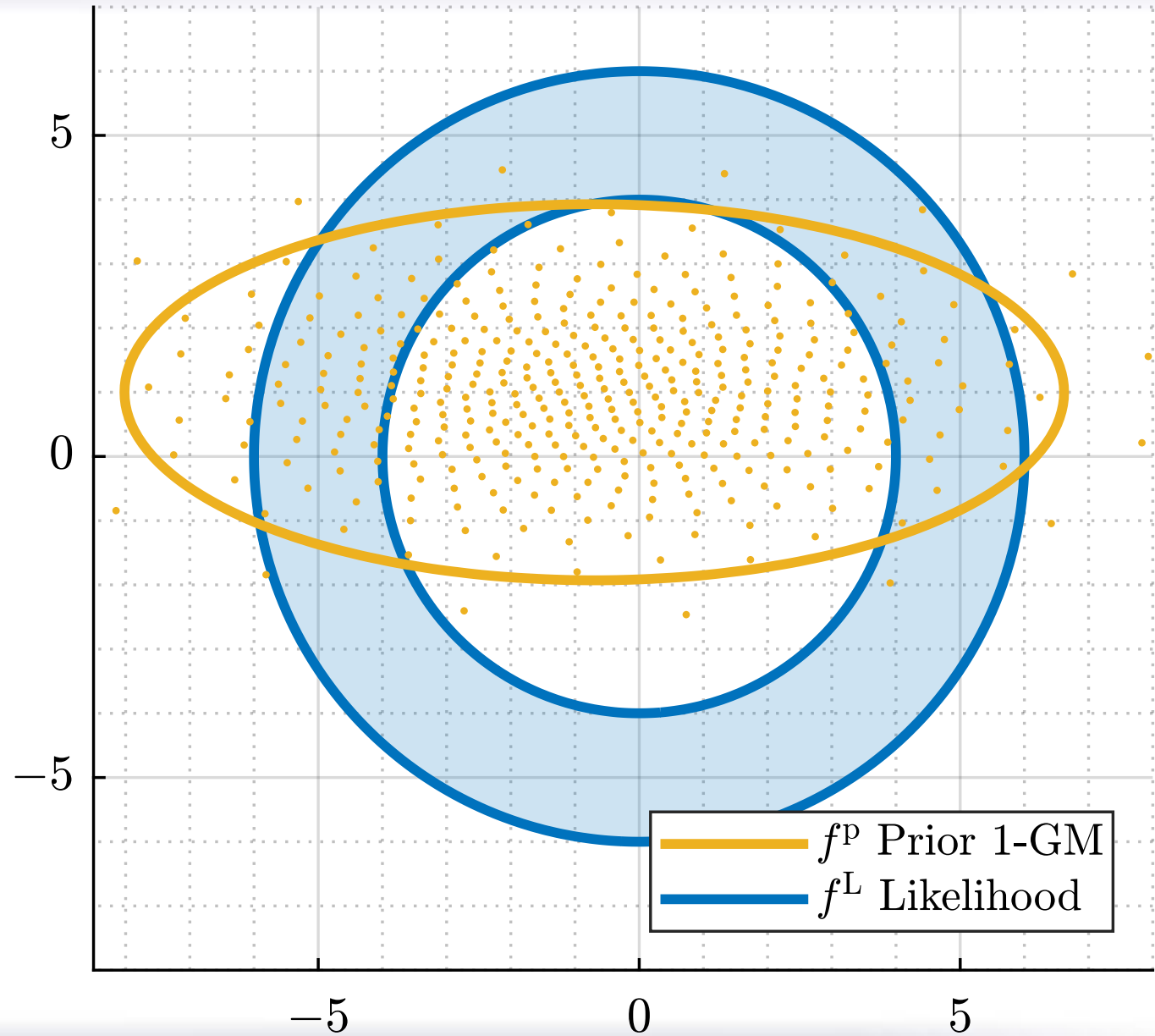
Progressive Update Example

- Likelihood (nonlinear)
- Prior Gaussian



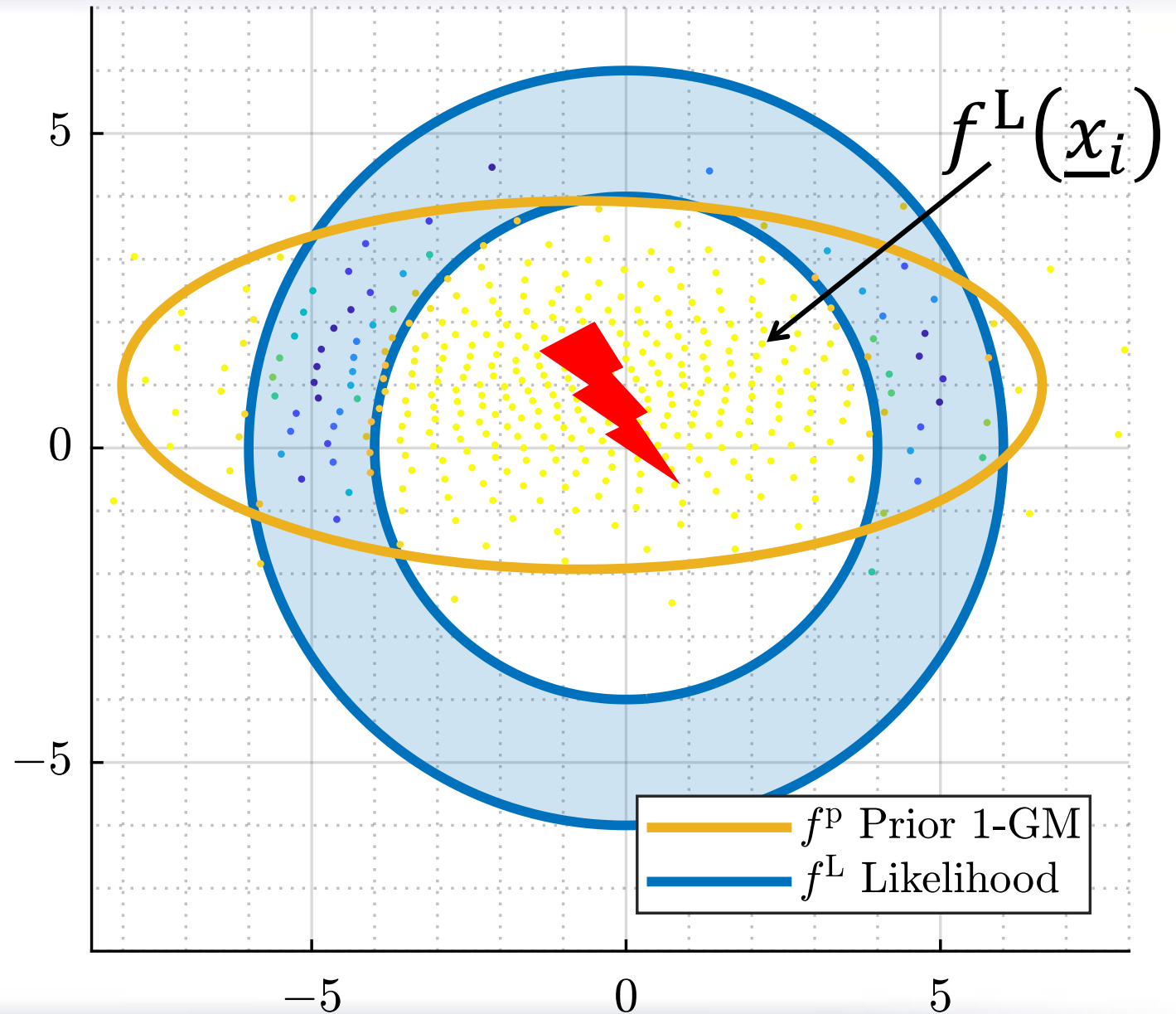
Progressive Update Example

- Likelihood (nonlinear)
- Prior Gaussian
- Deterministic sampling



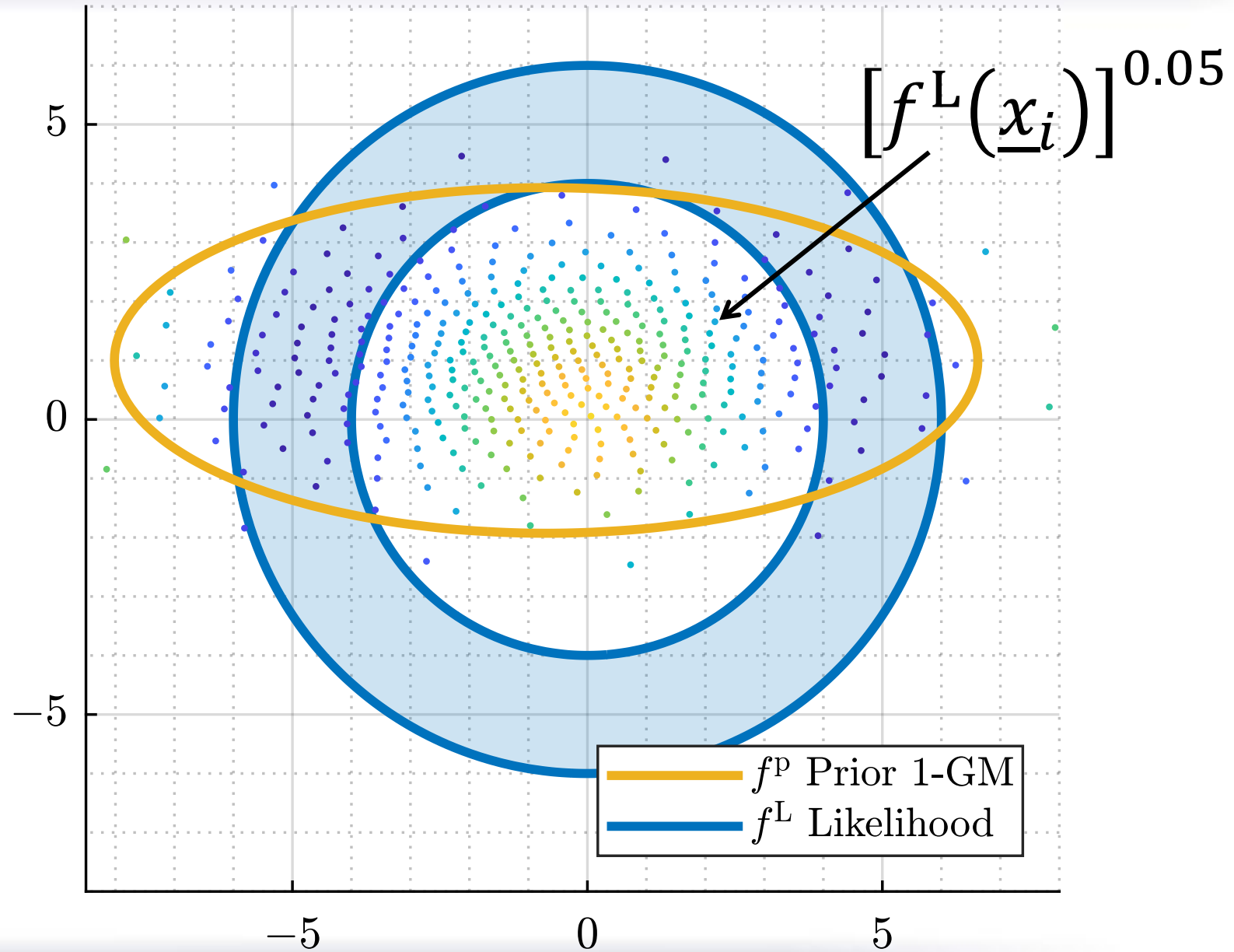
Progressive Update Example

- Likelihood (nonlinear)
- Prior Gaussian
- Deterministic sampling
- Full likelihood weighting:
Sample degeneration



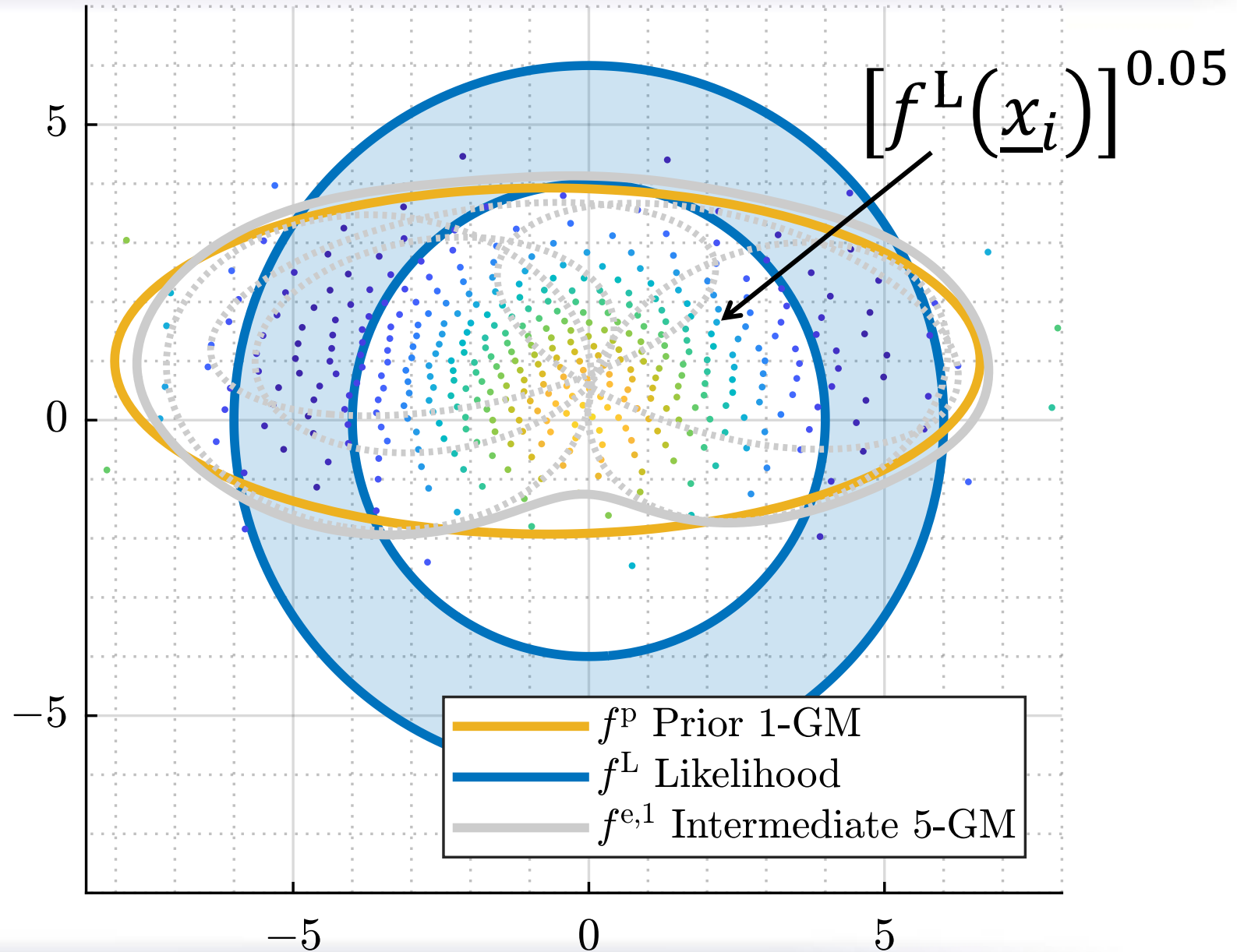
Progressive Update Example

- Likelihood (nonlinear)
- Prior Gaussian
- Deterministic sampling
- Flattened likelihood:
Homogeneous weights



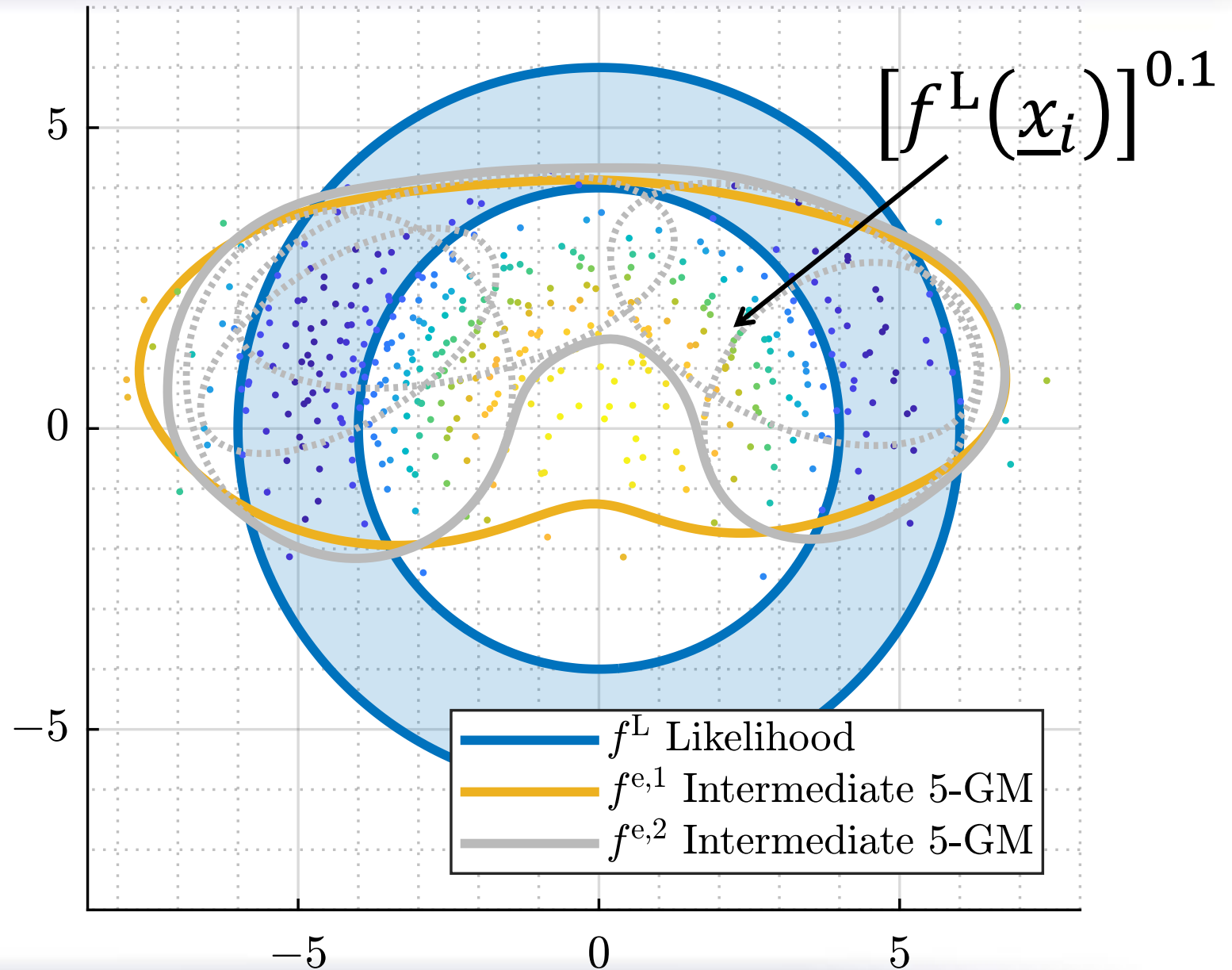
Progressive Update Example

- Likelihood (nonlinear)
- Prior Gaussian
- Deterministic sampling
- Flattened likelihood: Homogeneous weights
- Re-approximation DM2GM using EM
- 1st sub-posterior GM



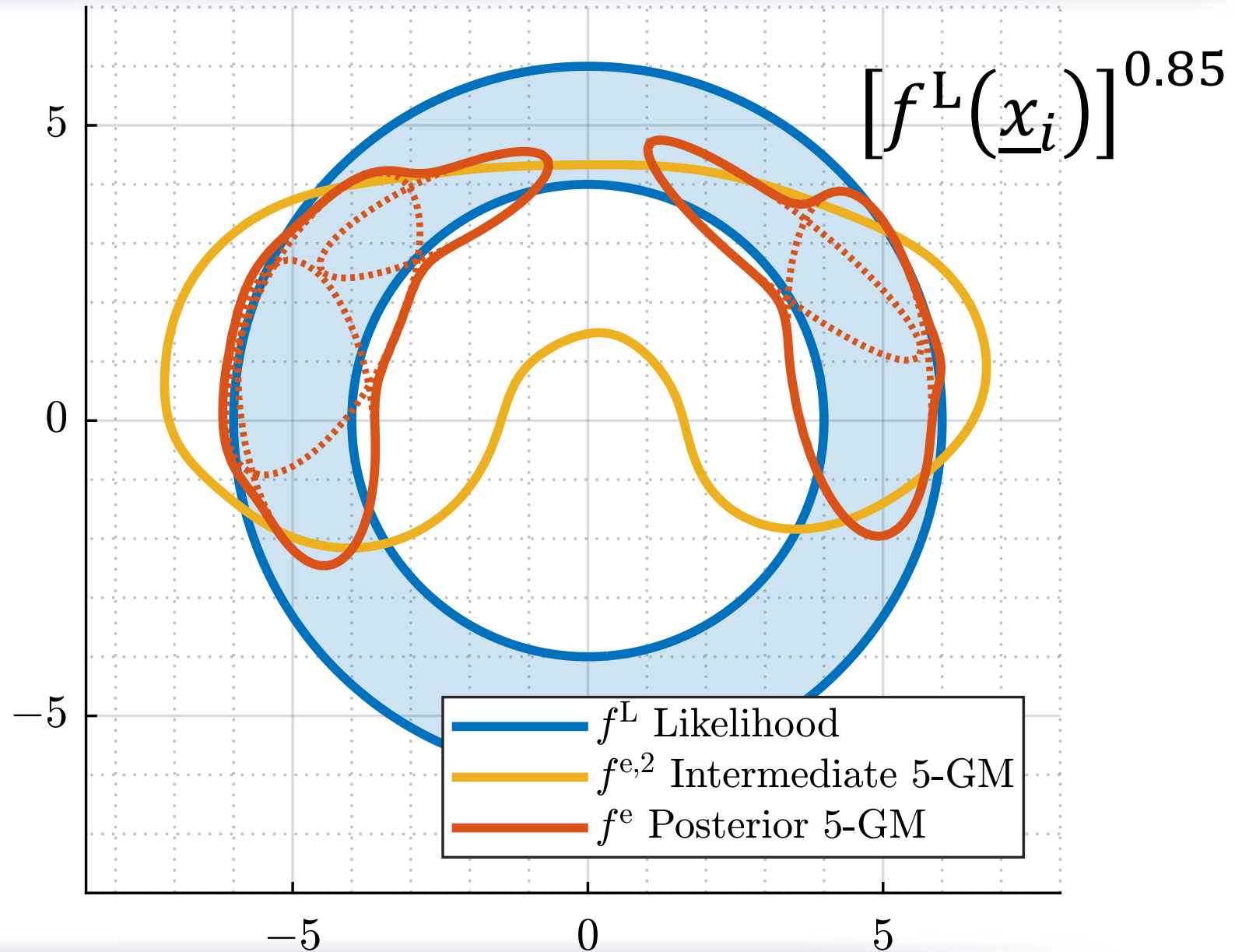
Progressive Update Example

- Likelihood (nonlinear)
- 1st sub-prior GM
- Deterministic sampling
- Flattened likelihood weighting
- Re-approximation DM2GM using EM
- 2nd sub-posterior GM

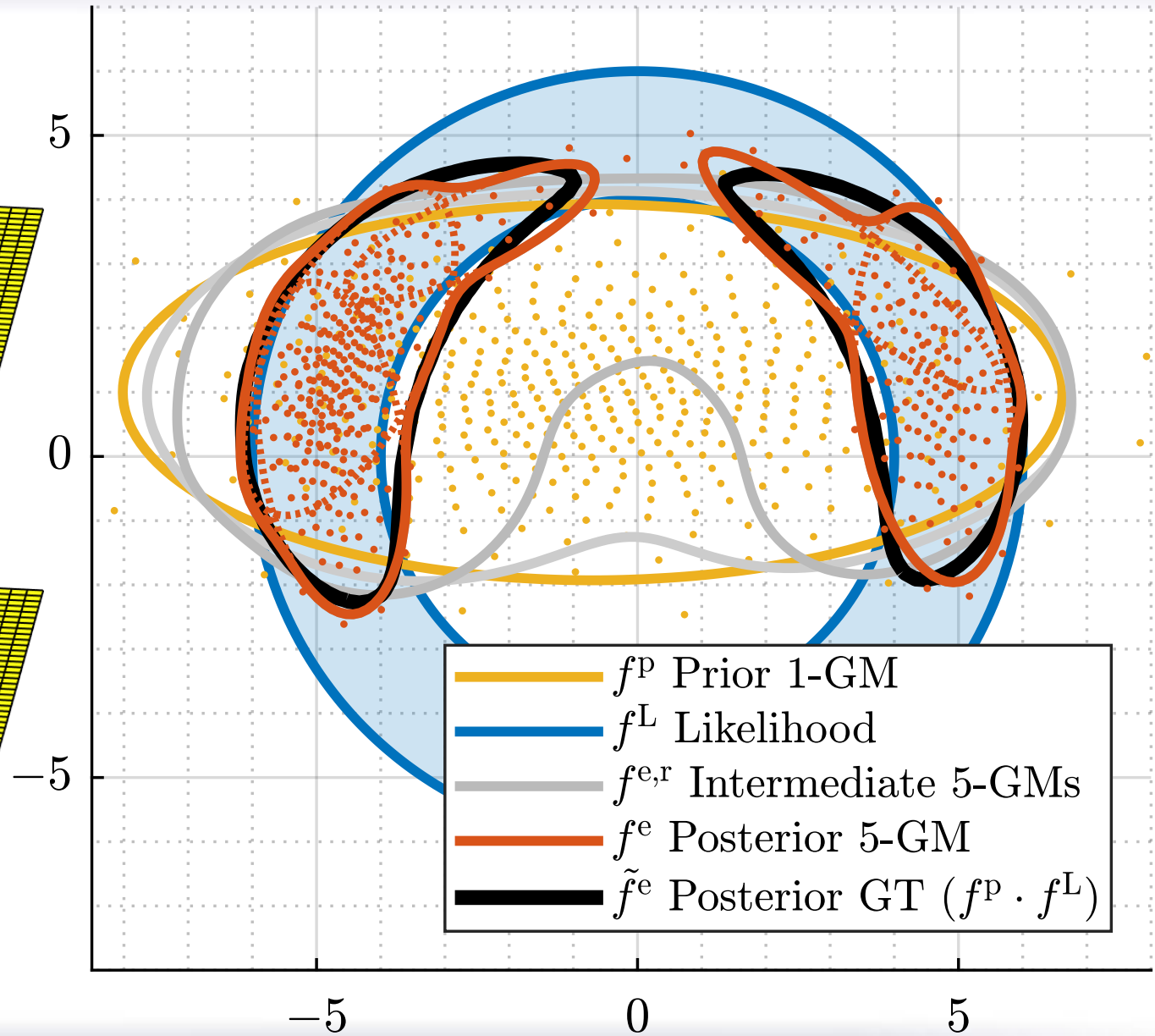
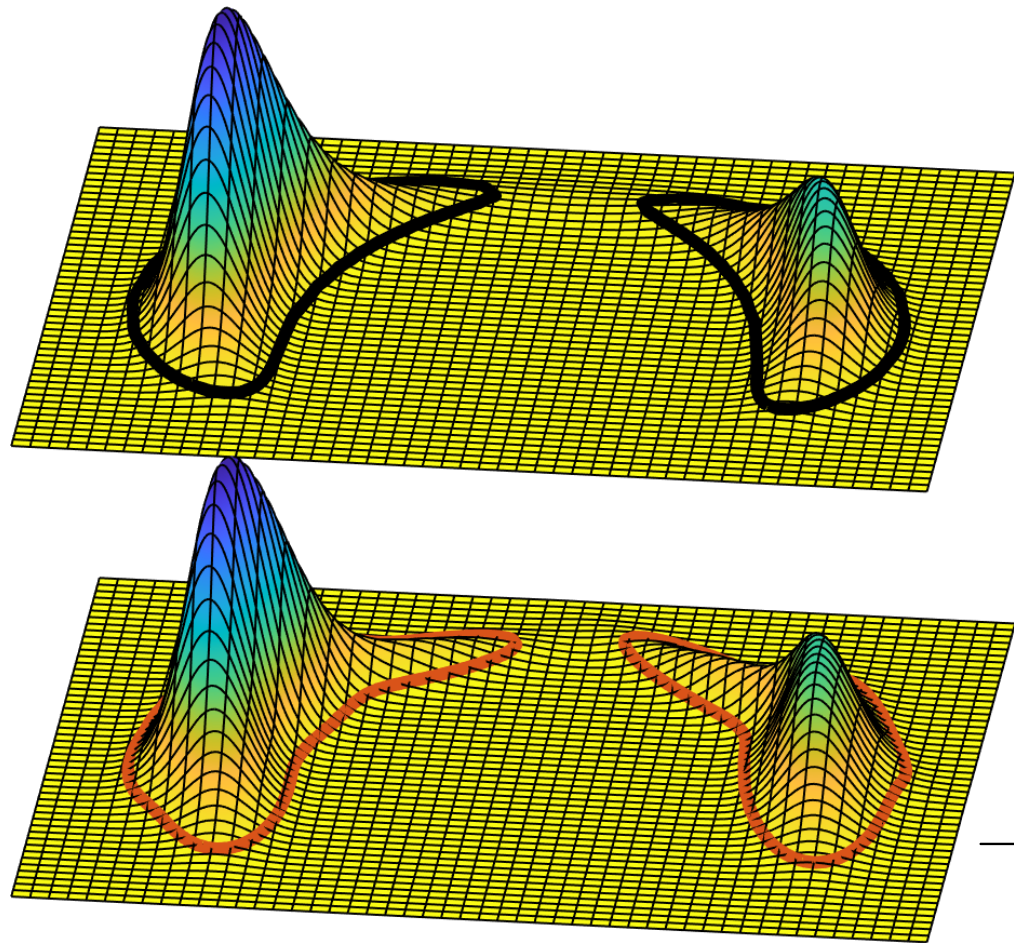


Progressive Update Example

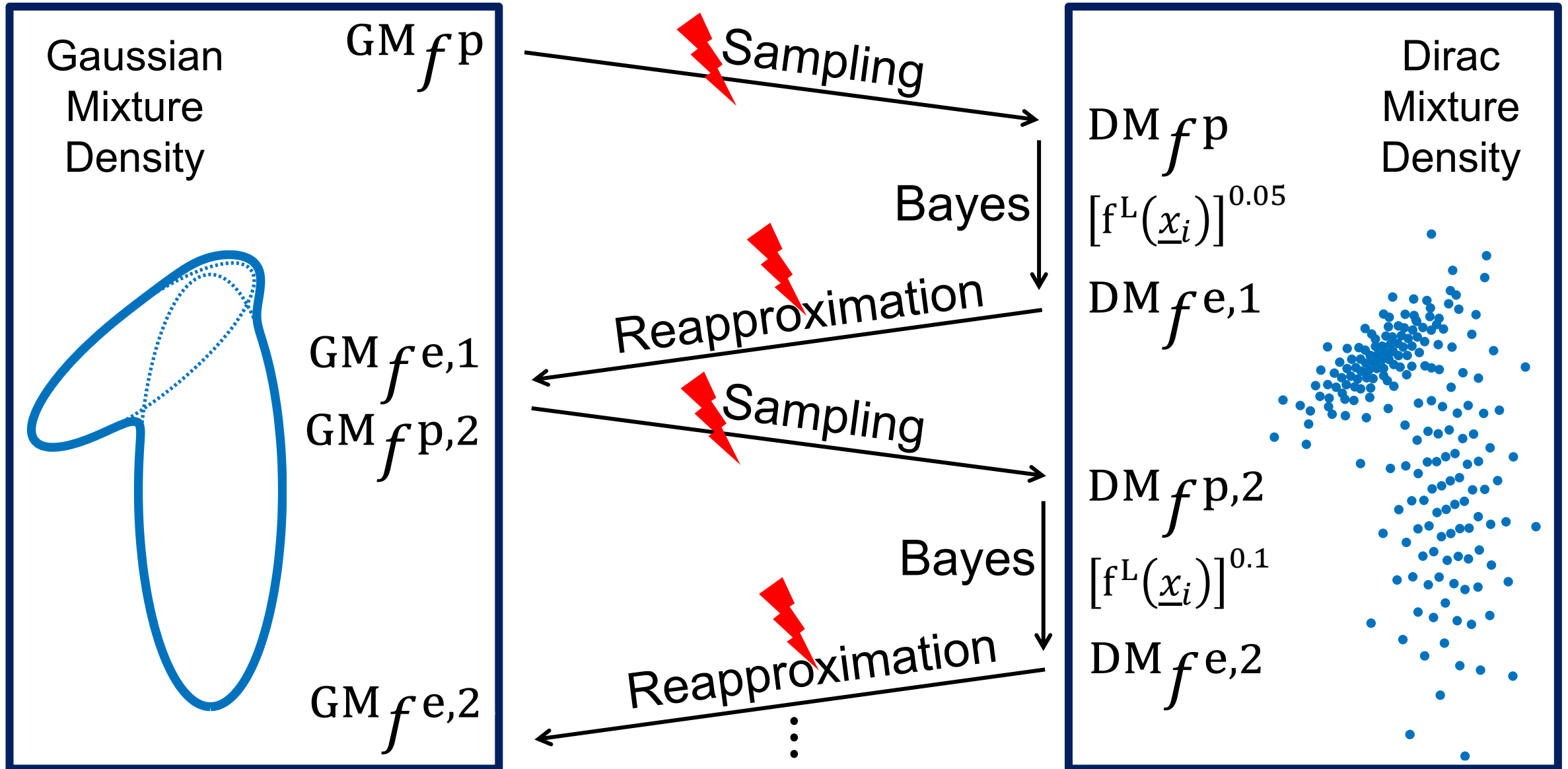
- Likelihood (nonlinear)
- 2nd sub-prior GM
- Deterministic sampling
- Flattened likelihood weighting
- Re-approximation DM2GM with EM
- Posterior GM



Progressive Update Example

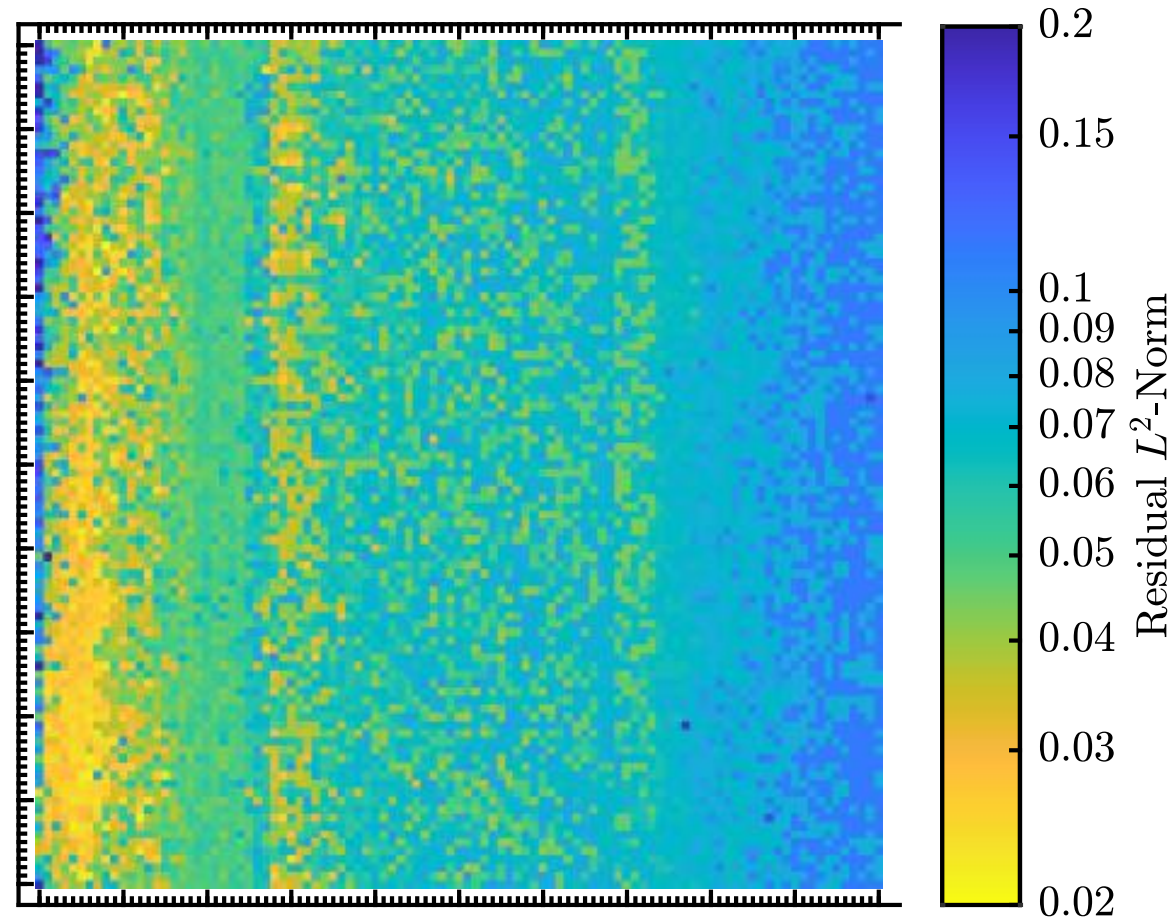


Progressive Update Overview



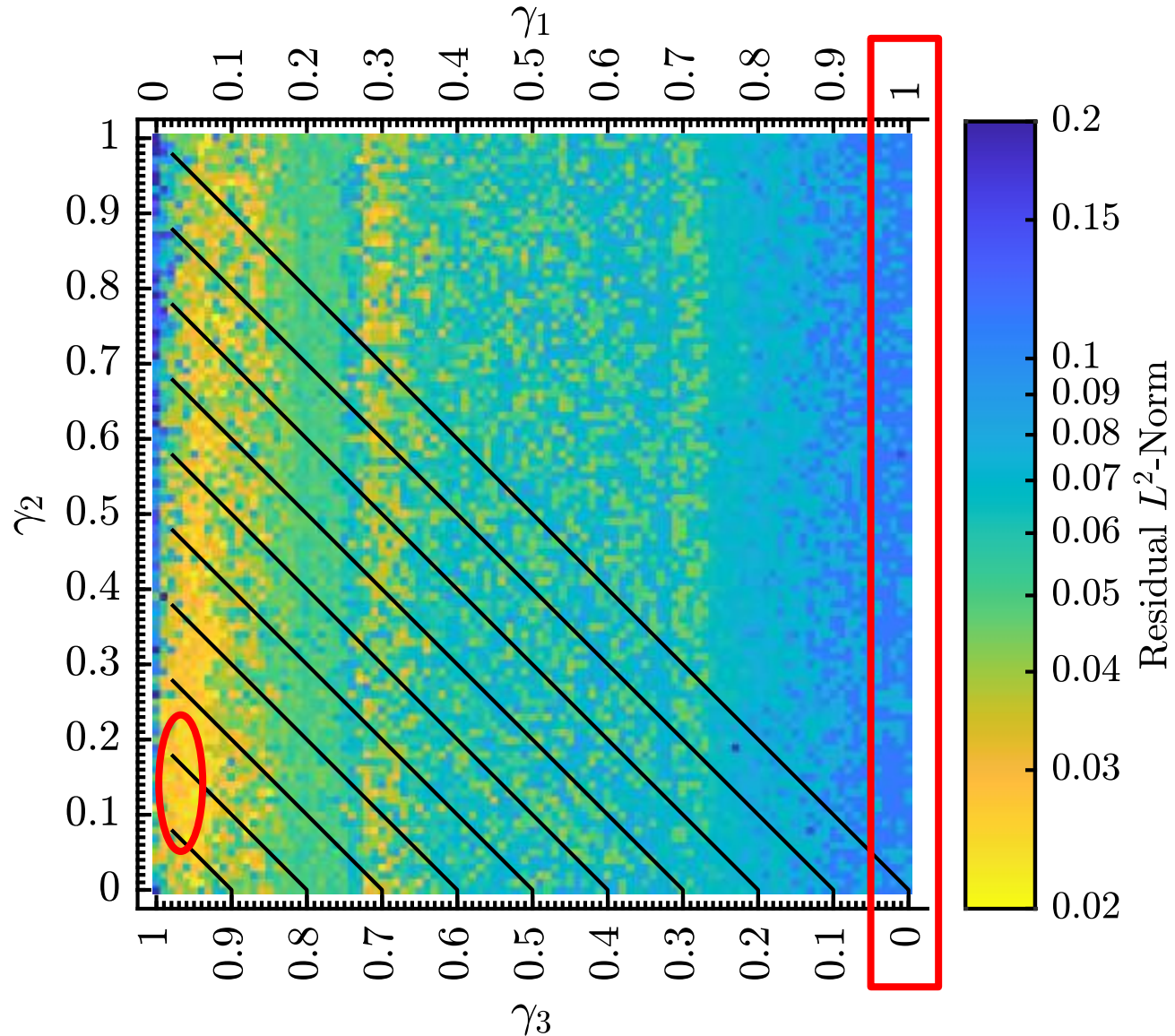
Evaluation

- All possible $\lambda_1, \lambda_2, \lambda_3$
- $\sum_{r=1}^R \lambda_r = 1; R \leq 3$



Evaluation

- All possible $\lambda_1, \lambda_2, \lambda_3$
- $\sum_{r=1}^R \lambda_r = 1; R \leq 3$
- No progression: bad
 $\lambda_1 = 1$
 $\lambda_2 = \lambda_3 = 0$
- „Sweet spot“
 $\lambda_1 = 0.01 \dots 0.06$
 $\lambda_2 = 0.1 \dots 0.2$
 $\lambda_3 = 1 - \lambda_1 - \lambda_2$

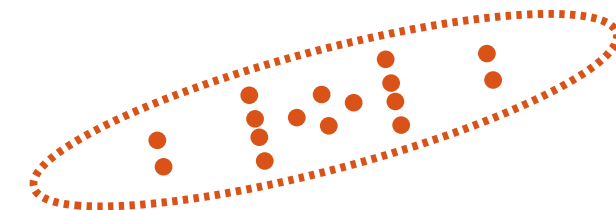
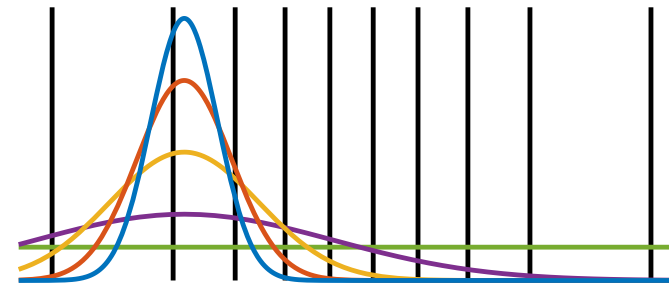
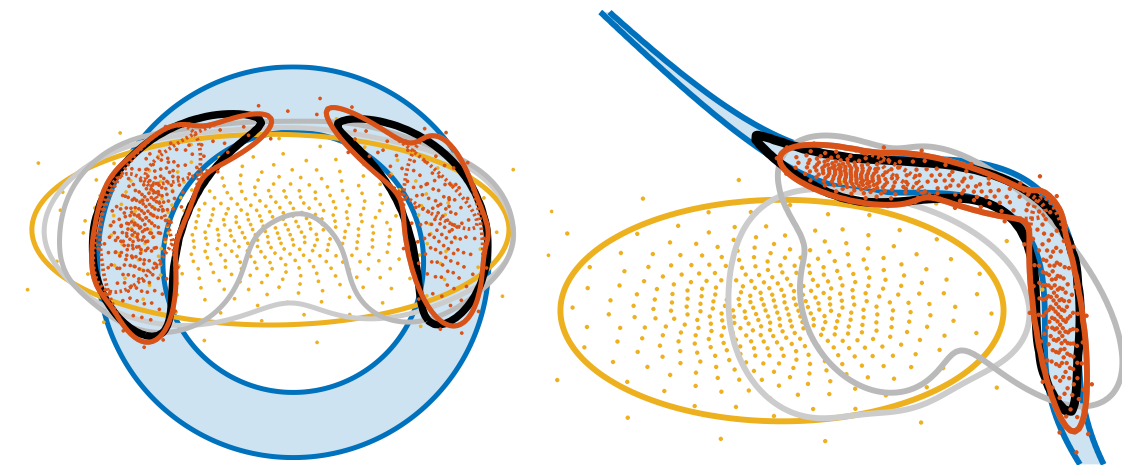


Nonlinear Bayesian Filter Step

- Universally applicable
 - GM or DM prior
 - Likelihood as arbitrary function
- Application Scenarios
 - Multimodal setups
 - „Non-overlapping“ prior & likelihood

Outlook

- Expectation Maximization
 - Adaptive number of GM components
 - Degenerated GM component handling
 - EM iterations stop conditions
- Progressive Update
 - Choice of likelihood exponent
 - Gaussian sampling scheme



Thank you for your attention

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