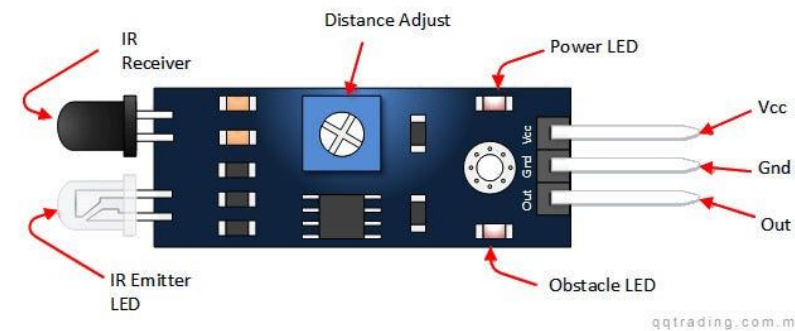
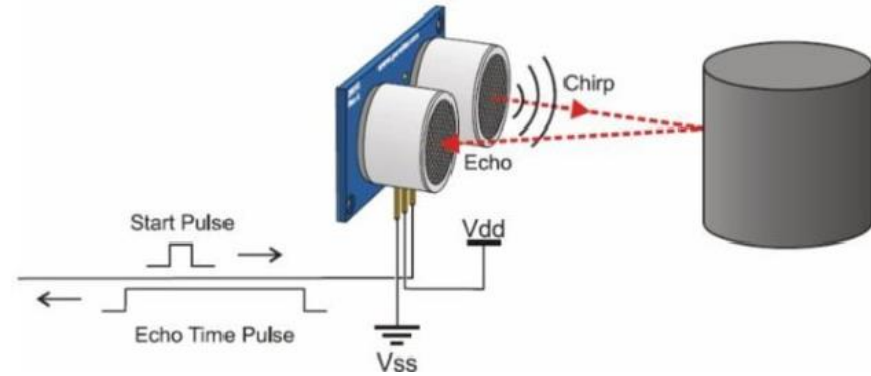

Sensing and Event Detection

Amitangshu Pal

Sensing and Event Detection



<https://easyelectronicsproject.com/mini-projects/motion-sensor-light-cd4017-ir/>

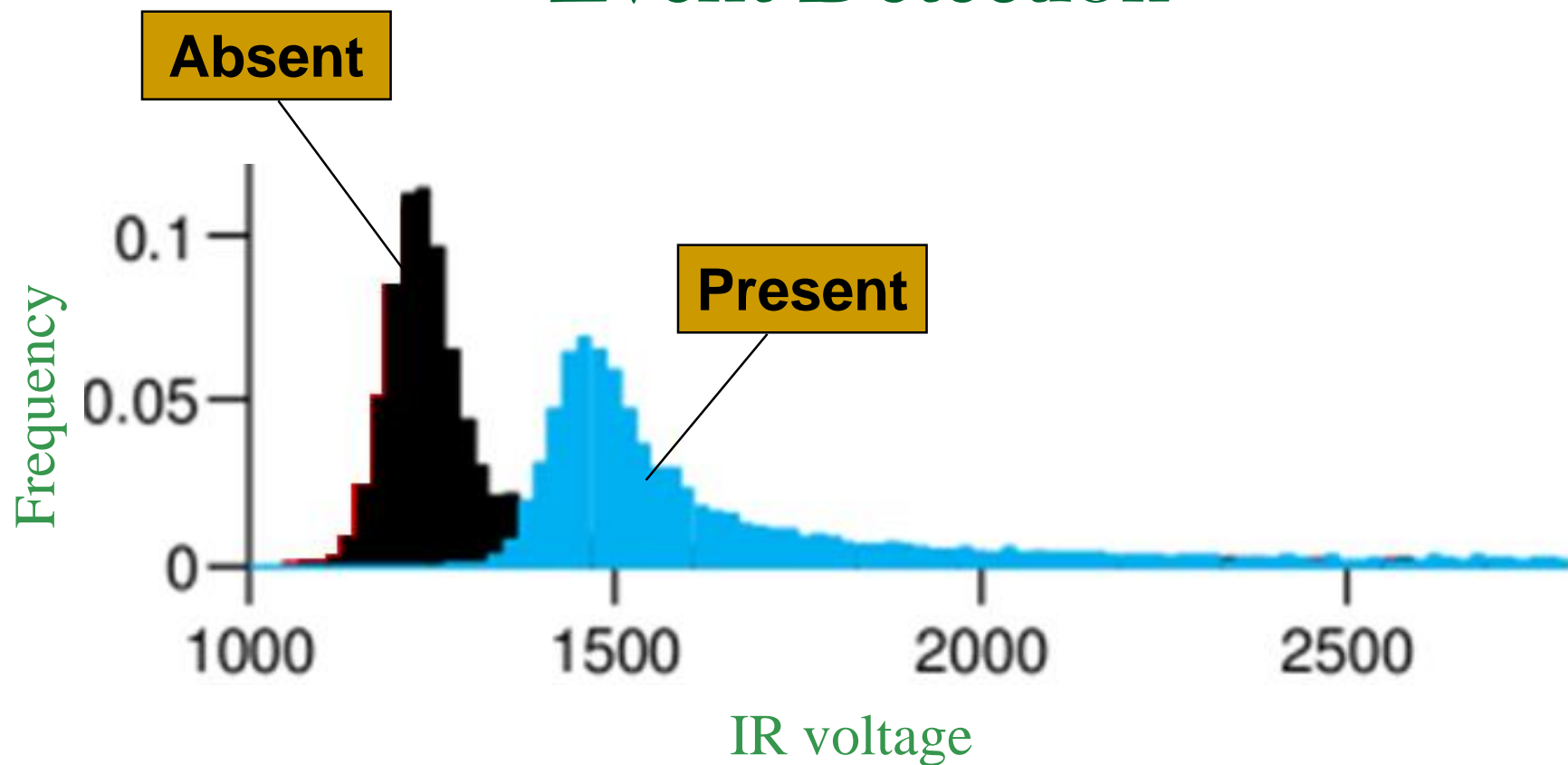
<https://medium.com/illumination/arduino-with-infrared-sensor-48ad4415f320>

https://www.researchgate.net/figure/Working-principle-of-ultrasonic-sensor-22_fig4_378534373

Event Detection: Confusion Matrix

		Ground truth		
		+	-	
Predicted	+	True positive (TP)	False positive (FP)	Precision = TP / (TP + FP)
	-	False negative (FN)	True negative (TN)	
		Recall = TP / (TP + FN)		Accuracy = (TP + TN) / (TP + FP + TN + FN)

Event Detection



Unbiased Estimators

$$L(\mu, \sigma | x_1, x_2, \dots, x_n) = \prod_{i=1}^n \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x_i - \mu)^2}{2\sigma^2}}$$
$$= \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x_1 - \mu)^2}{2\sigma^2}} \times \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x_2 - \mu)^2}{2\sigma^2}} \times \dots \times \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x_n - \mu)^2}{2\sigma^2}}$$

$$\ln L = \ln \left(\frac{1}{\sigma\sqrt{2\pi}} \right) - \frac{(x_1 - \mu)^2}{2\sigma^2} + \ln \left(\frac{1}{\sigma\sqrt{2\pi}} \right) - \frac{(x_2 - \mu)^2}{2\sigma^2} + \dots + \ln \left(\frac{1}{\sigma\sqrt{2\pi}} \right) - \frac{(x_n - \mu)^2}{2\sigma^2}$$

Lets maximize the log likelihood

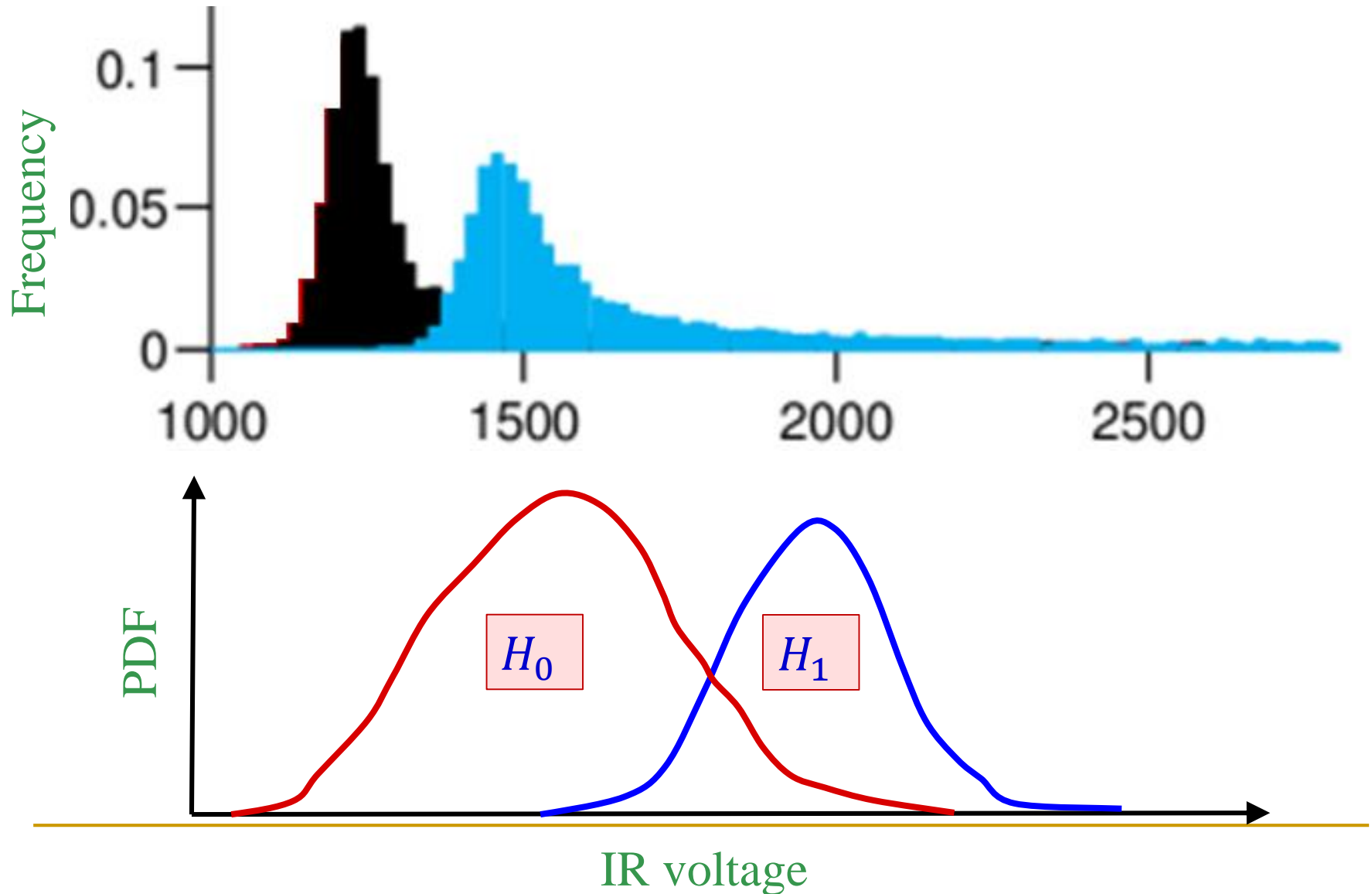
$$\frac{\partial \ln L}{\partial \mu} = \frac{2(x_1 - \mu)}{2\sigma^2} + \frac{2(x_2 - \mu)}{2\sigma^2} + \dots + \frac{2(x_n - \mu)}{2\sigma^2} = 0 \quad \therefore \mu = \frac{(x_1 + x_2 + \dots + x_n)}{n}$$

$$\ln L = n \ln \left(\frac{1}{\sigma} \right) + n \log \left(\frac{1}{\sqrt{2\pi}} \right) - \frac{(x_1 - \mu)^2}{2\sigma^2} - \frac{(x_2 - \mu)^2}{2\sigma^2} \dots - \frac{(x_n - \mu)^2}{2\sigma^2}$$

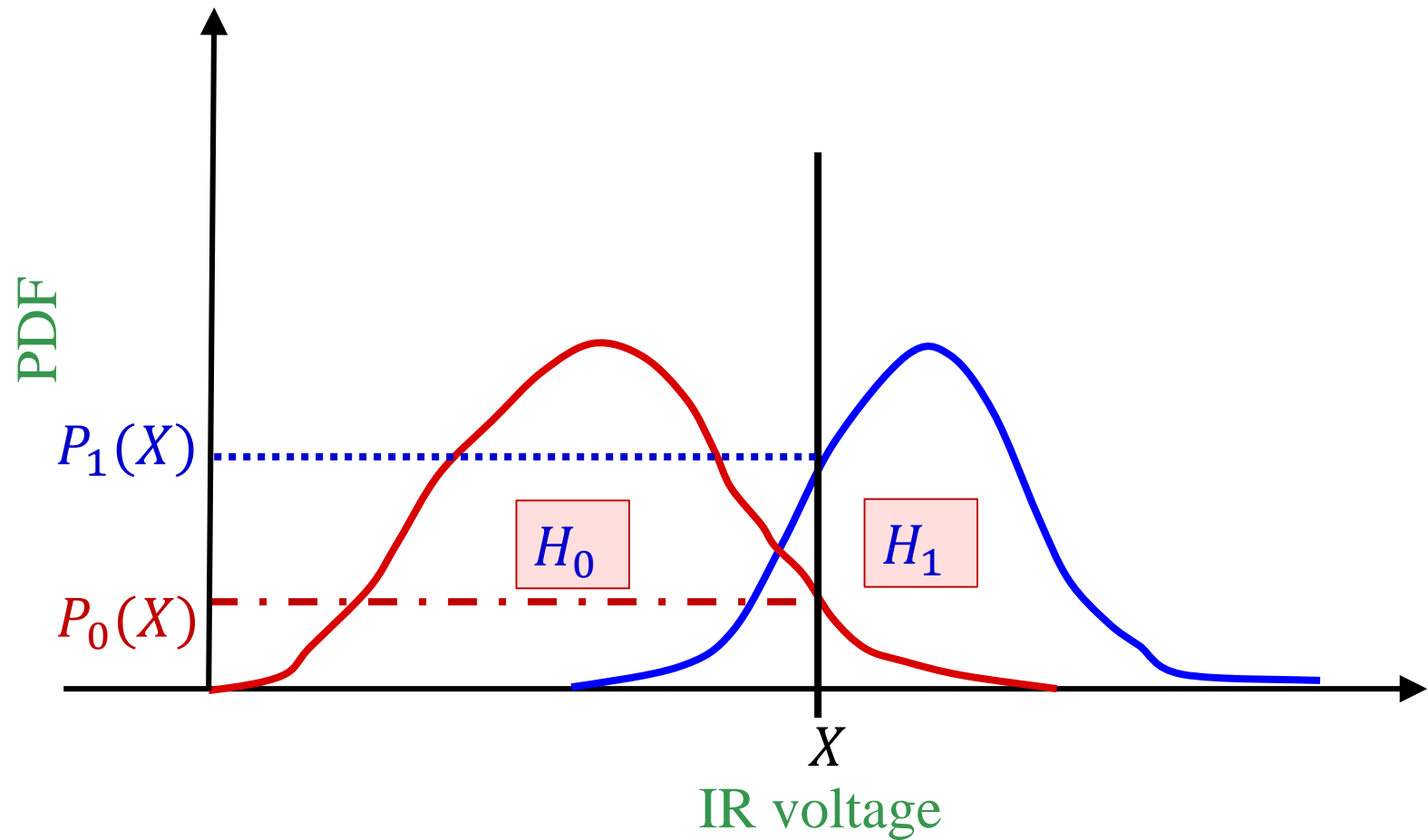
$$\frac{\partial \ln L}{\partial \sigma} = -\frac{n}{\sigma} + \frac{(x_1 - \mu)^2}{\sigma^3} + \frac{(x_2 - \mu)^2}{\sigma^3} \dots + \frac{(x_n - \mu)^2}{\sigma^3} = 0$$

$$\therefore \sigma^2 = \frac{(x_1 - \mu)^2 + (x_2 - \mu)^2 + \dots + (x_n - \mu)^2}{n} \quad \therefore \sigma = \sqrt{\frac{(x_1 - \mu)^2 + (x_2 - \mu)^2 + \dots + (x_n - \mu)^2}{n}}$$

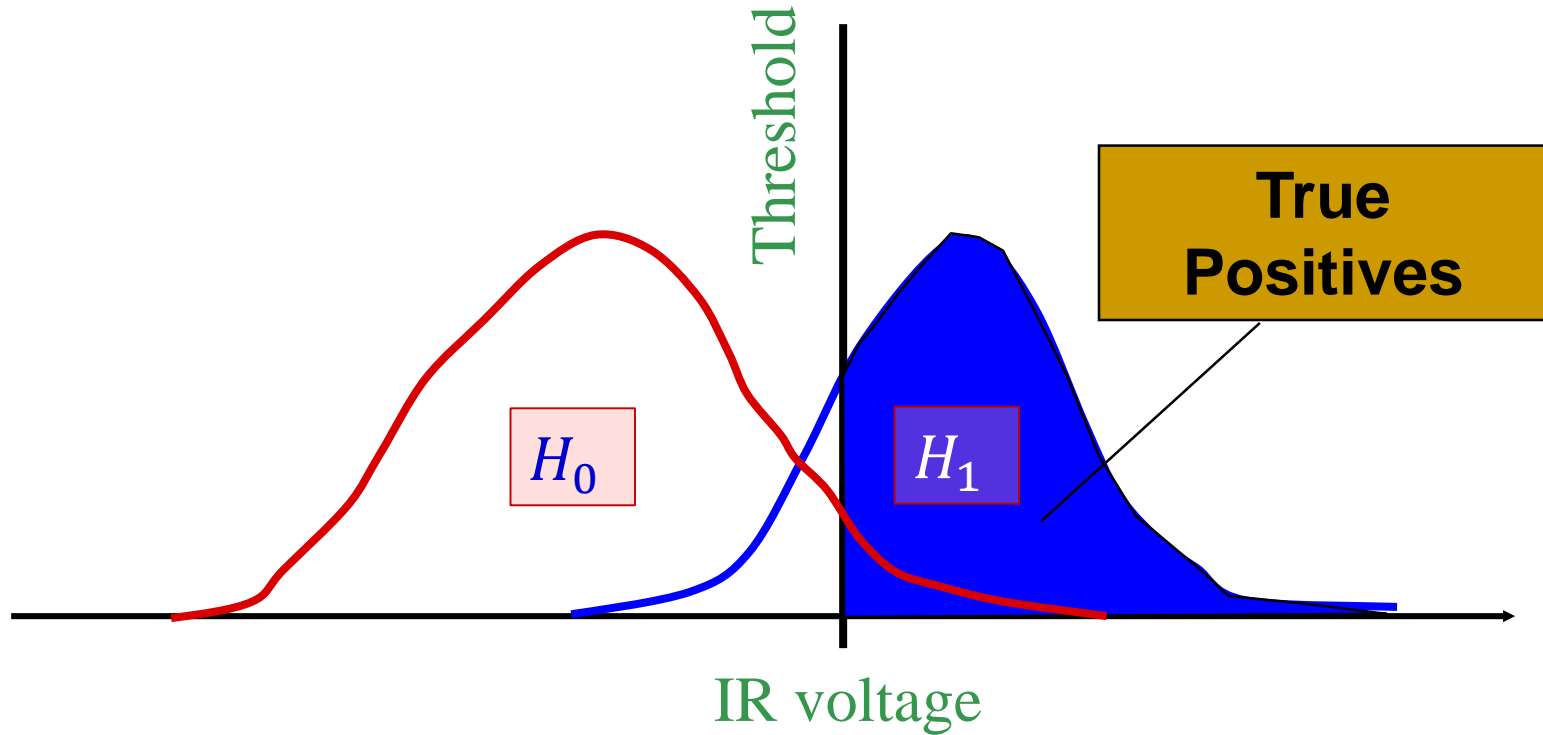
Event Detection \rightarrow Hypothesis Testing



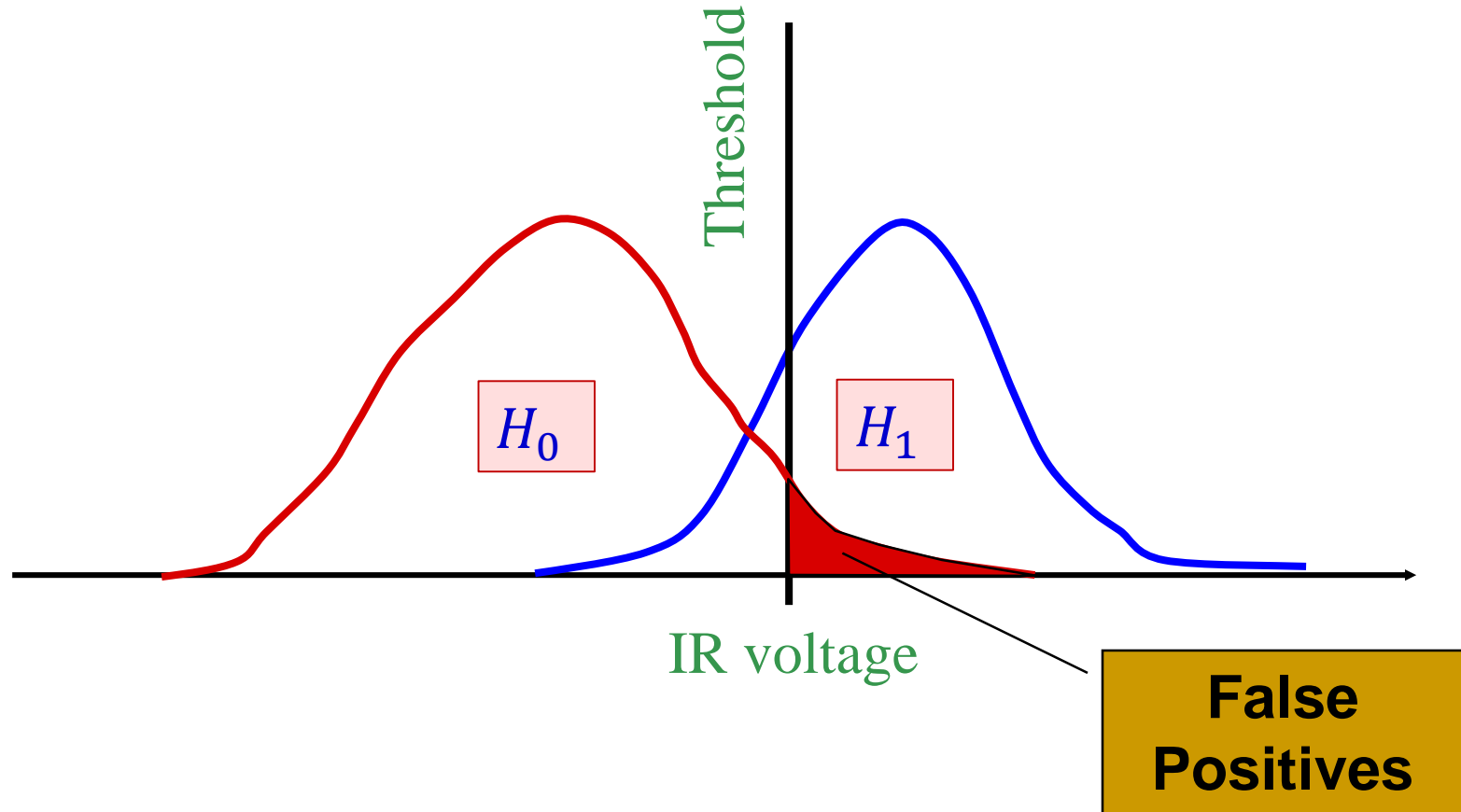
Event Detection as Hypothesis Testing



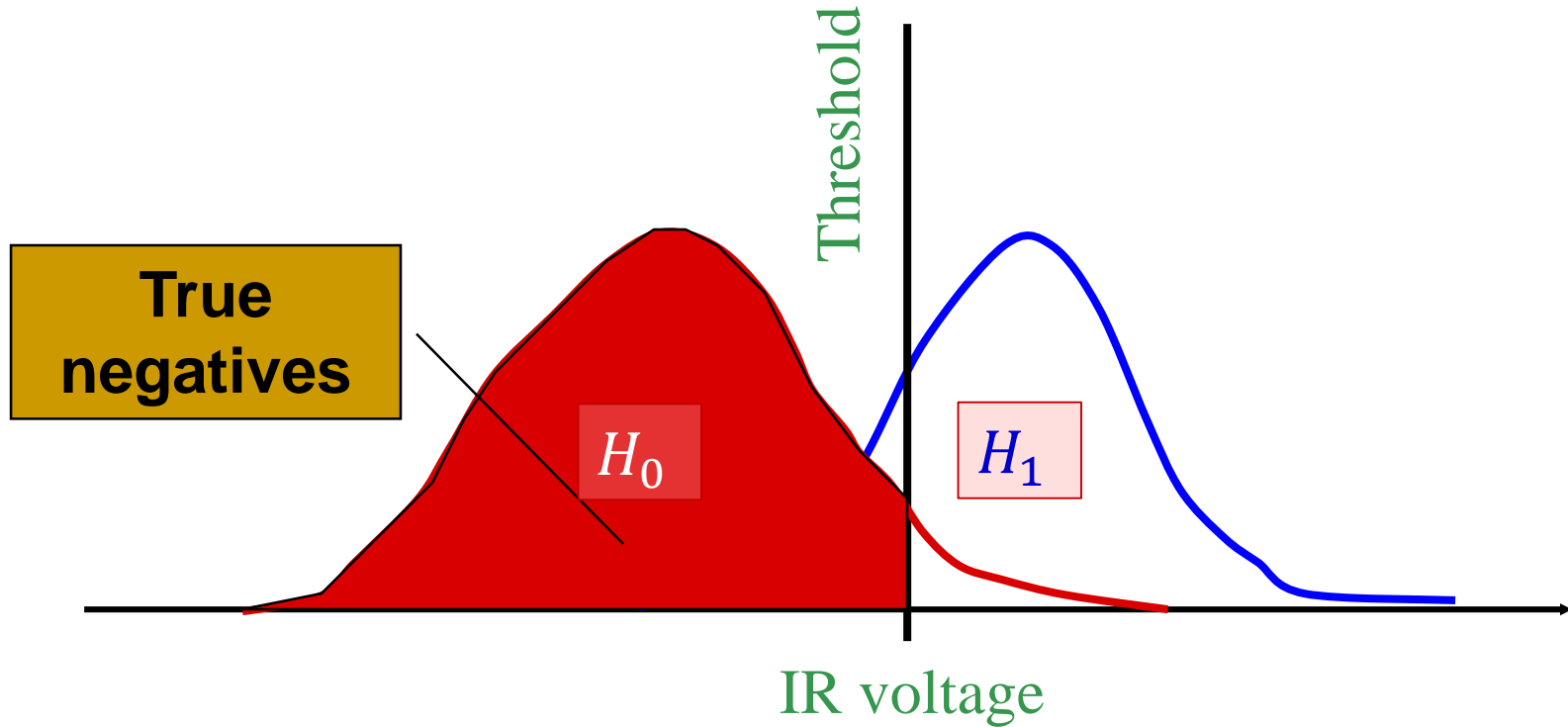
Event Detection \rightarrow Hypothesis Testing



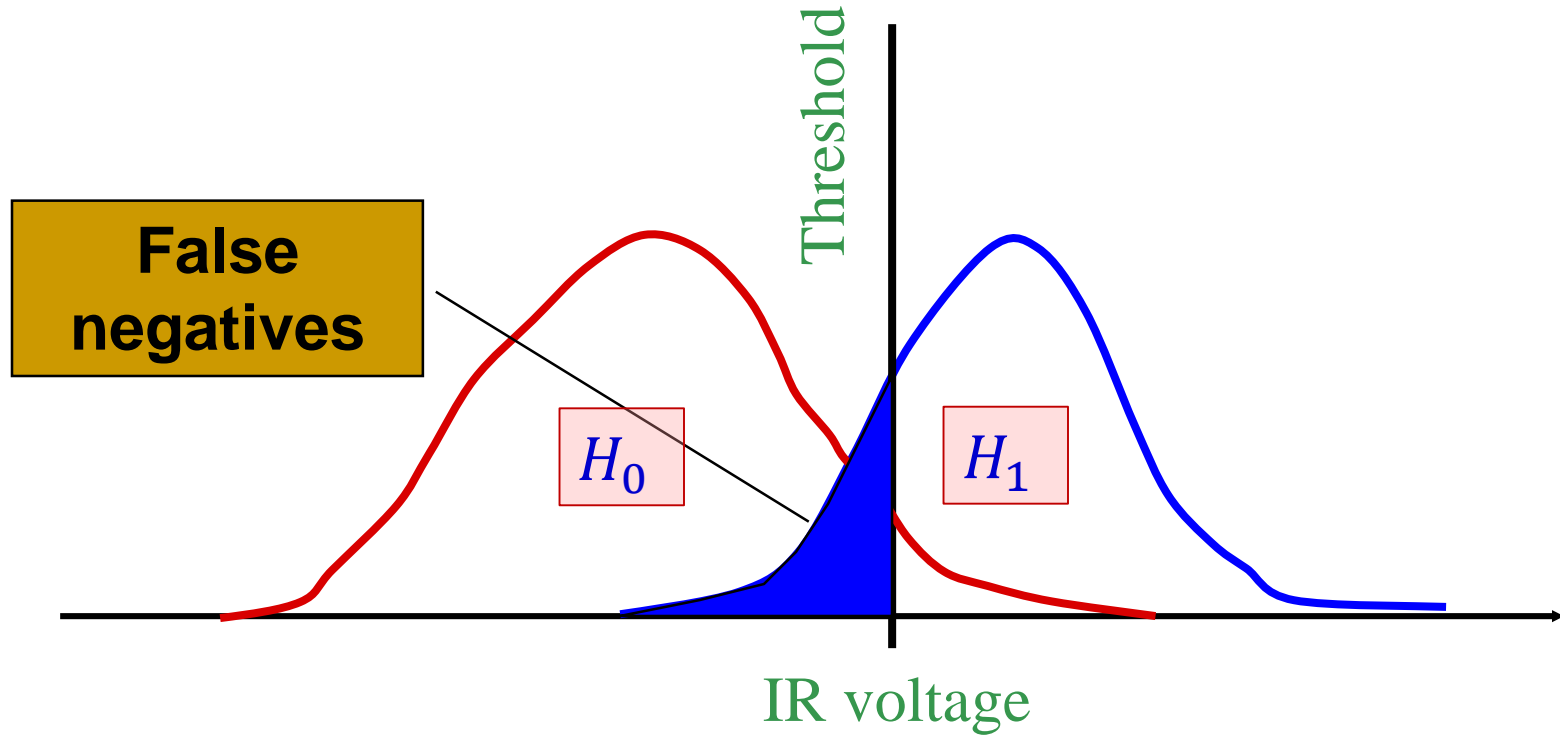
Event Detection → Hypothesis Testing



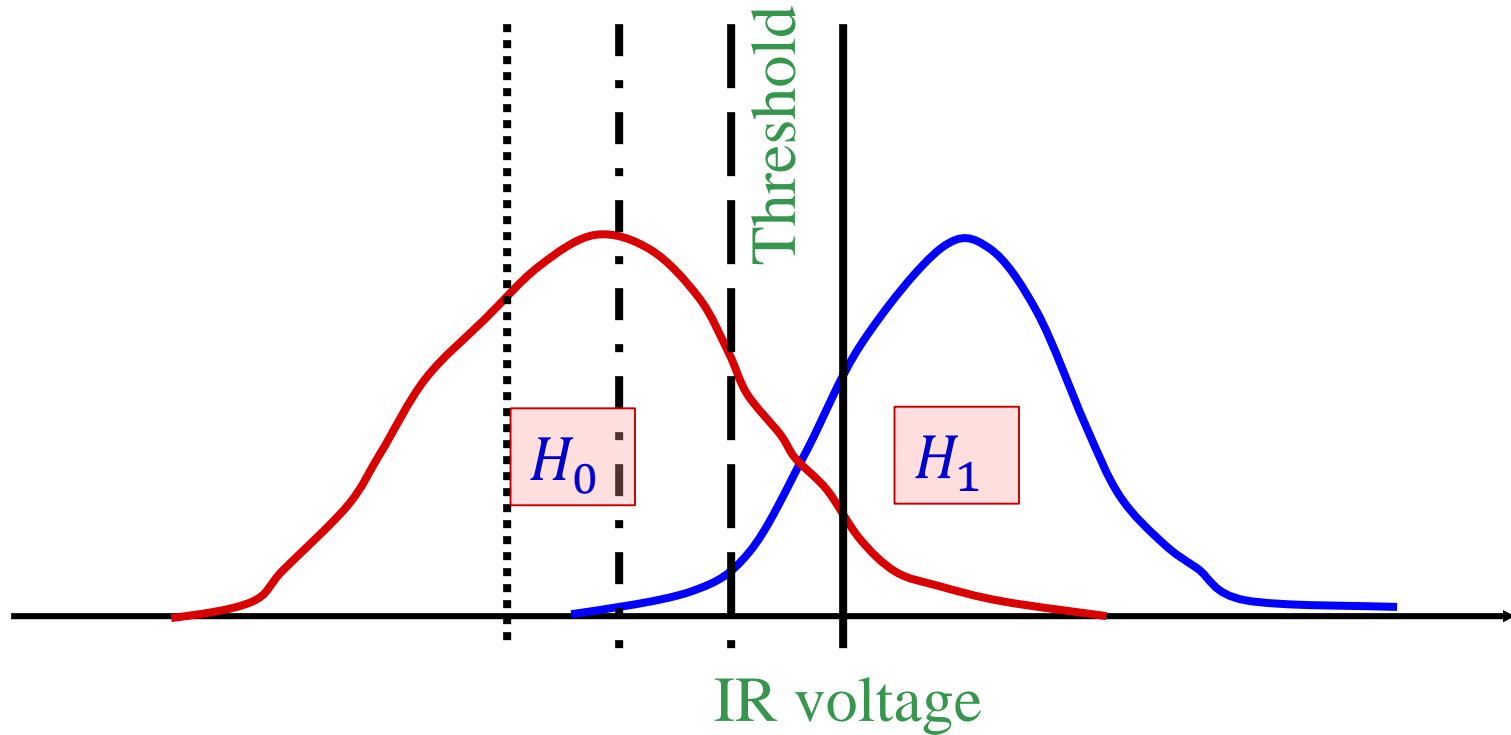
Event Detection → Hypothesis Testing



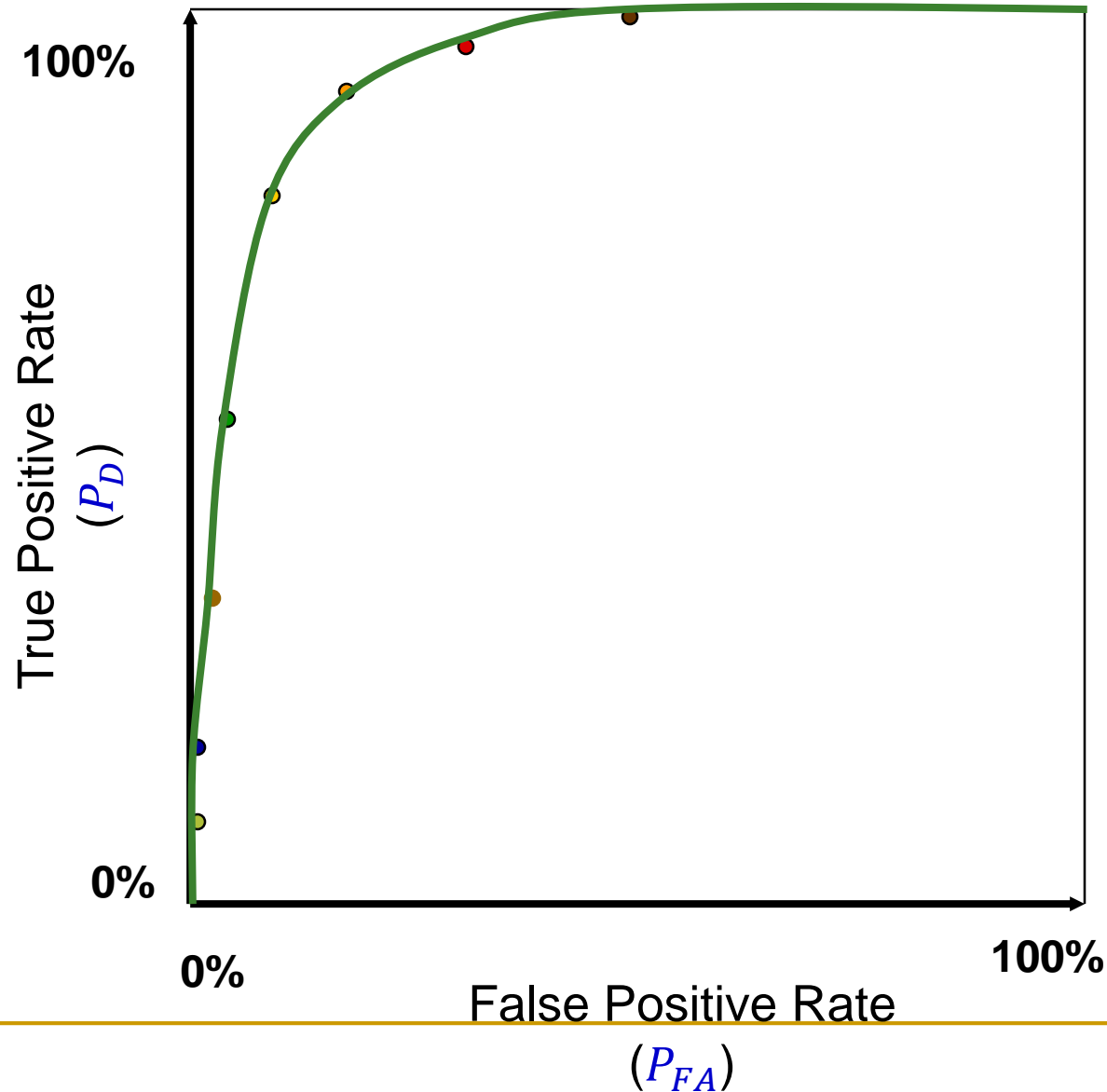
Event Detection → Hypothesis Testing



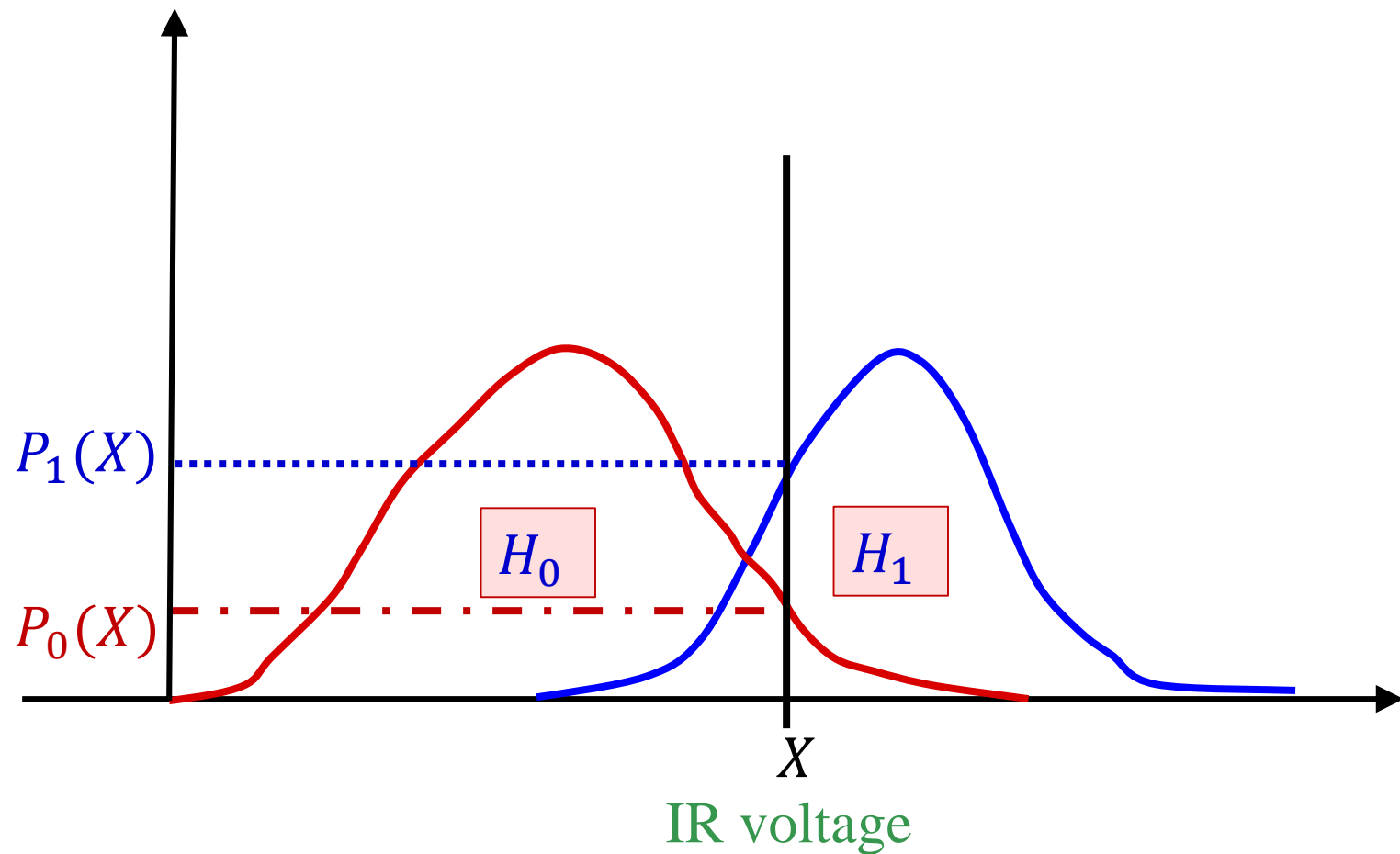
Moving the Threshold: left



Receiver Operating Characteristics (ROC) Curve



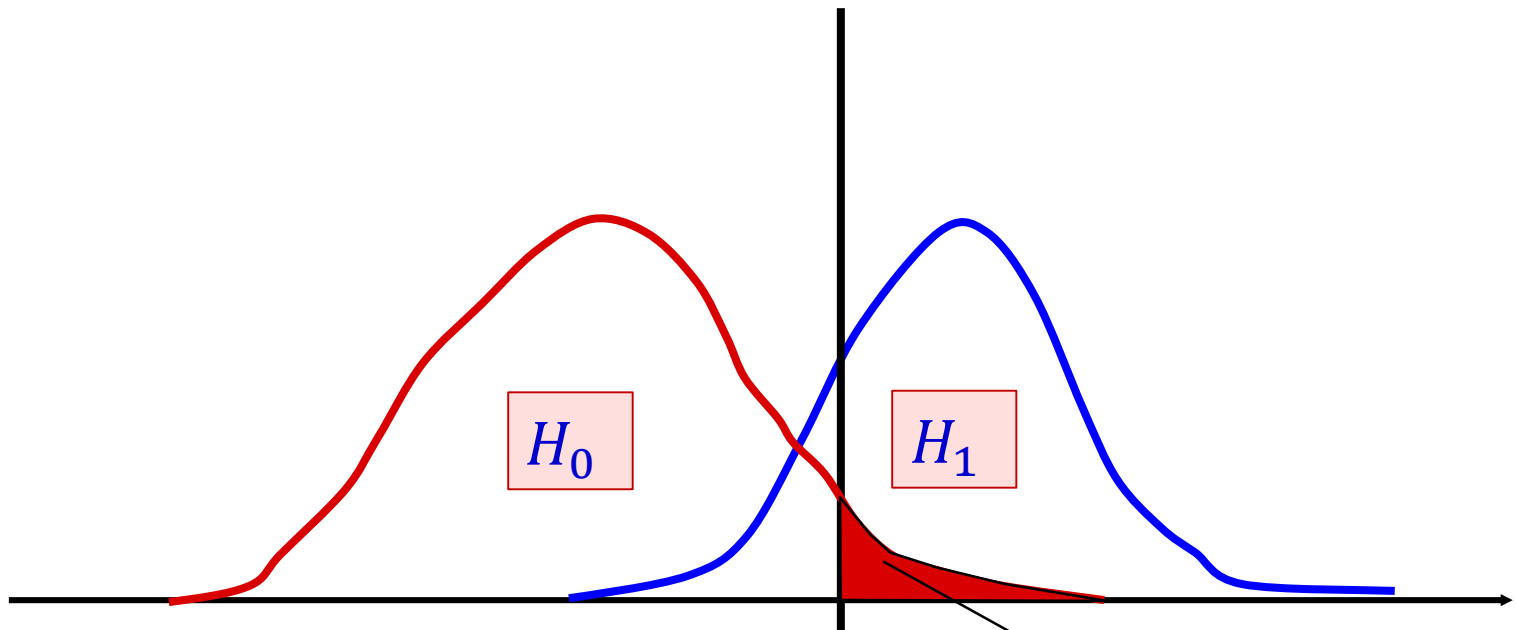
Event Detection as Likelihood Ratio Test



$$\frac{P_1(X)}{P_0(X)} \geq \lambda \quad \text{Choose } H_1$$

Event Detection as Likelihood Ratio Test

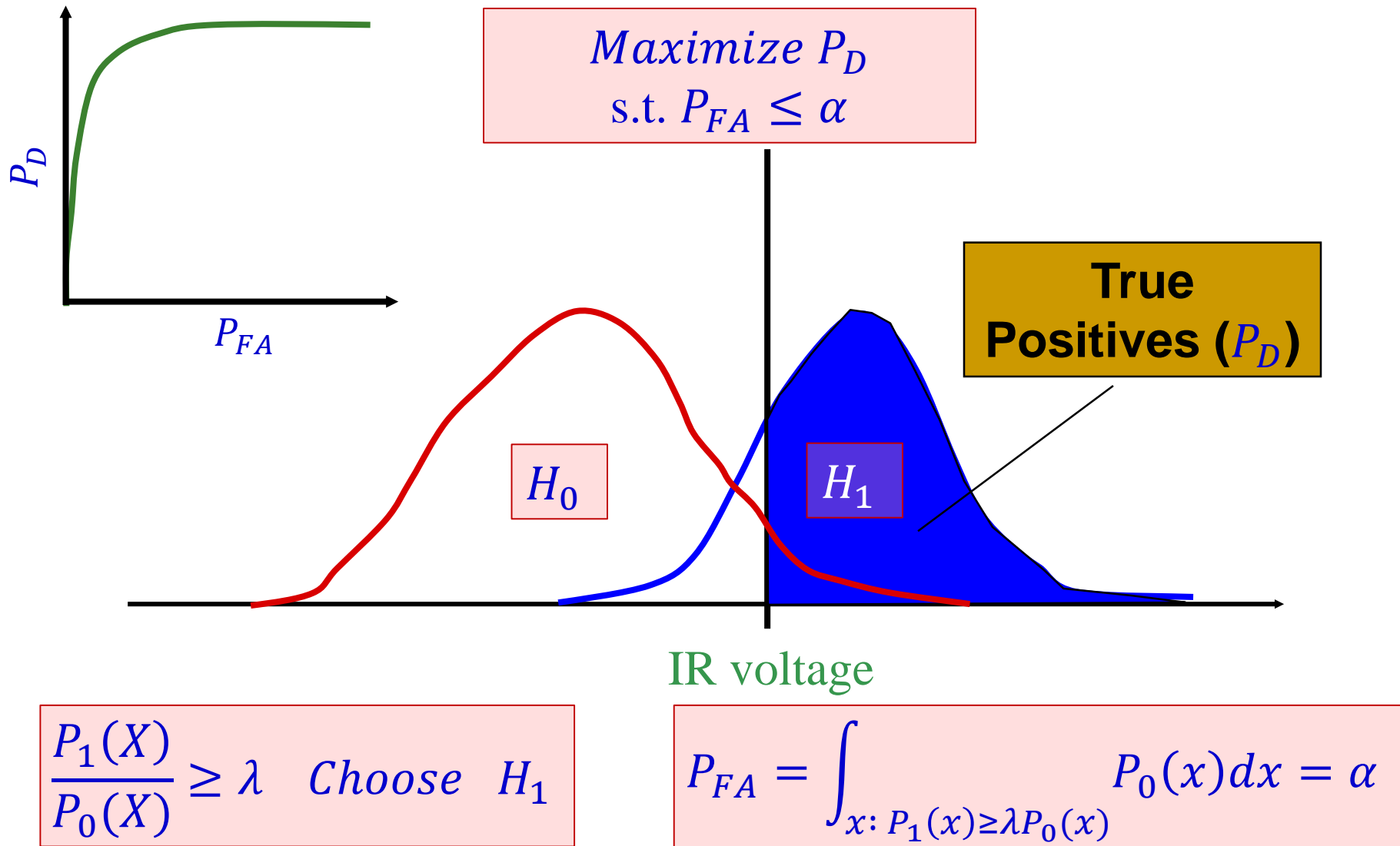
$$\begin{aligned} & \text{Maximize } P_D \\ & \text{s.t. } P_{FA} \leq \alpha \end{aligned}$$



IR voltage

**False
Positives**
(P_{FA})

Event Detection as Likelihood Ratio Test



Event Detection: Confusion Matrix

