Robot Physicist

Team = [Manoj Kumar, Michele Ceru, Phil Yeres]
Advisor = Kyle Cranmer

Project mentors

Professor Kyle Cranmer, NYU Physics

Brenden Lake, CDS (unofficial mentor)

The problem:

Particle physics experiments are expensive to perform

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Physicists optimize their experiments by running simulated experiments

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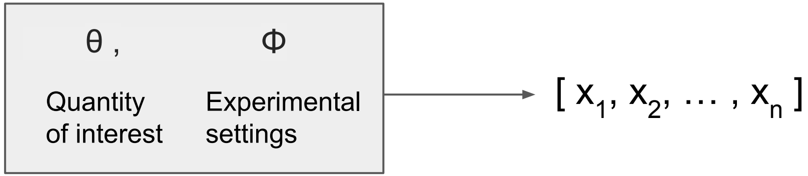
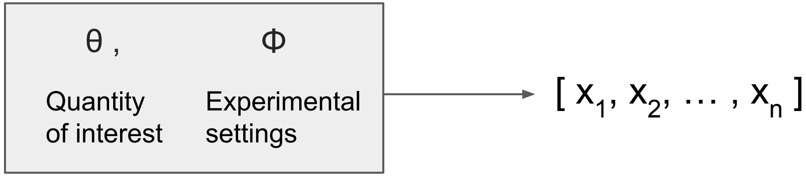
Our goal: design a proof of concept “robot physicist” that efficiently finds optimal experiment configurations

The black box



The Robot Physicist



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we use a list of possible values of the unobservable parameter, $\boldsymbol{\theta} = [\theta_1, \theta_2, ..., \theta_m]$

The Robot Physicist

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Quantity of interest — Experimental settings $\longrightarrow [\, x_1, x_2, \ldots , x_n \,]$

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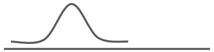
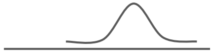
$\theta_2 , \Phi_j \longrightarrow \begin{bmatrix} \hat{x}_{1,\theta_2} & \hat{x}_{2,\theta_2} & \cdots & \hat{x}_{n,\theta_2} \end{bmatrix} \longrightarrow$  $\longrightarrow P(x_1, x_2, \dots , x_n \mid \theta_2) \times P(\theta_2 \mid \Phi)$

$\theta_m , \Phi_j \longrightarrow \begin{bmatrix} \hat{x}_{1,\theta_m} & \hat{x}_{2,\theta_m} & \cdots & \hat{x}_{n,\theta_m} \end{bmatrix} \longrightarrow$  $\longrightarrow P(x_1, x_2, \dots , x_n \mid \theta_m) \times P(\theta_m \mid \Phi)$

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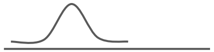
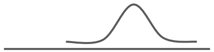
$\theta_2, \Phi_j \rightarrow \begin{bmatrix} \hat{x}_{1,\theta_2} & \hat{x}_{2,\theta_2} & \cdots & \hat{x}_{n,\theta_2} \end{bmatrix} \rightarrow$  $\rightarrow P(x_1, x_2, \dots, x_n \mid \theta_2) \times P(\theta_2 \mid \Phi)$

$\theta_m, \Phi_j \rightarrow \begin{bmatrix} \hat{x}_{1,\theta_m} & \hat{x}_{2,\theta_m} & \cdots & \hat{x}_{n,\theta_m} \end{bmatrix} \rightarrow$  $\rightarrow P(x_1, x_2, \dots, x_n \mid \theta_m) \times P(\theta_m \mid \Phi)$

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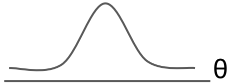
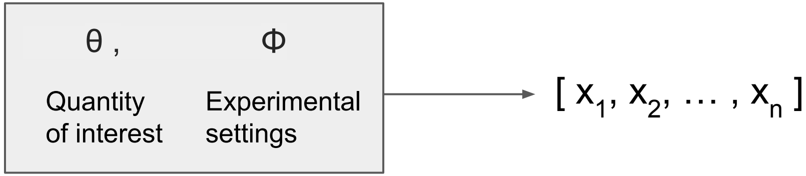


How likely were my experimental observations under different θ's ?

The Robot Physicist



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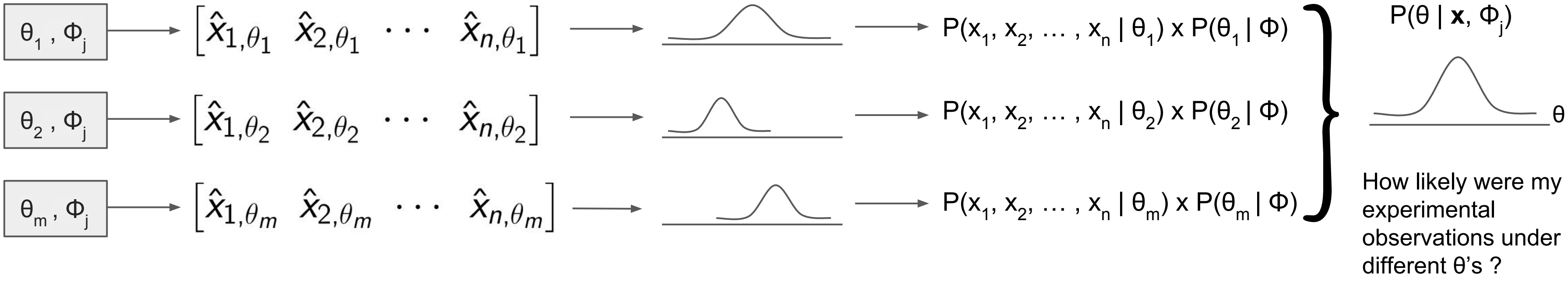

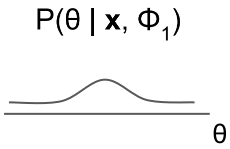

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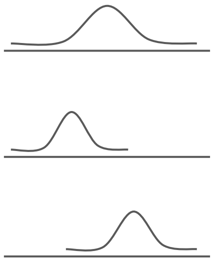

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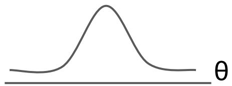

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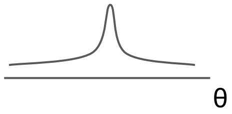

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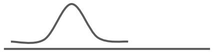
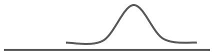
$\theta_2 , \Phi_j \rightarrow \begin{bmatrix} \hat{x}_{1,\theta_2} & \hat{x}_{2,\theta_2} & \cdots & \hat{x}_{n,\theta_2} \end{bmatrix} \rightarrow$  $\rightarrow P(x_1, x_2, \dots , x_n \mid \theta_2) \times P(\theta_2 \mid \Phi)$

$\theta_m , \Phi_j \rightarrow \begin{bmatrix} \hat{x}_{1,\theta_m} & \hat{x}_{2,\theta_m} & \cdots & \hat{x}_{n,\theta_m} \end{bmatrix} \rightarrow$  $\rightarrow P(x_1, x_2, \dots , x_n \mid \theta_m) \times P(\theta_m \mid \Phi)$

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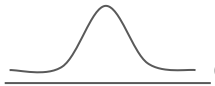

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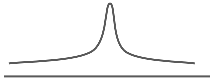

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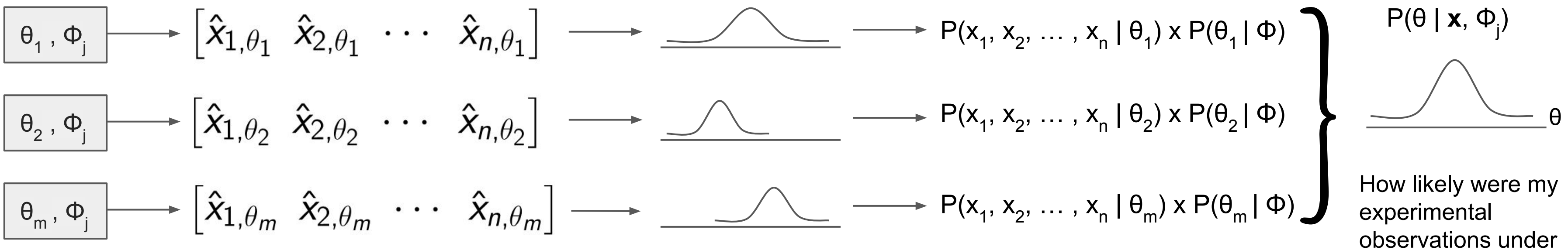

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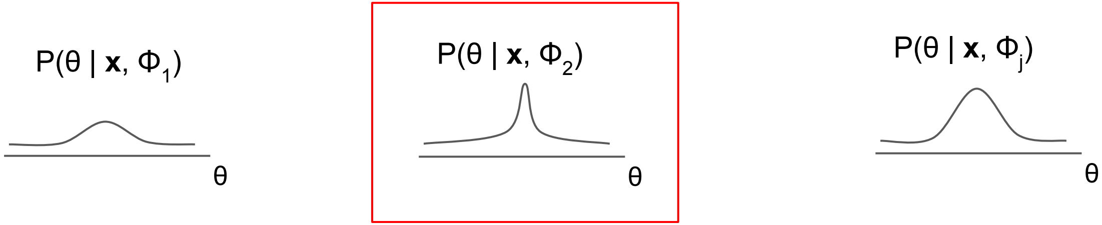
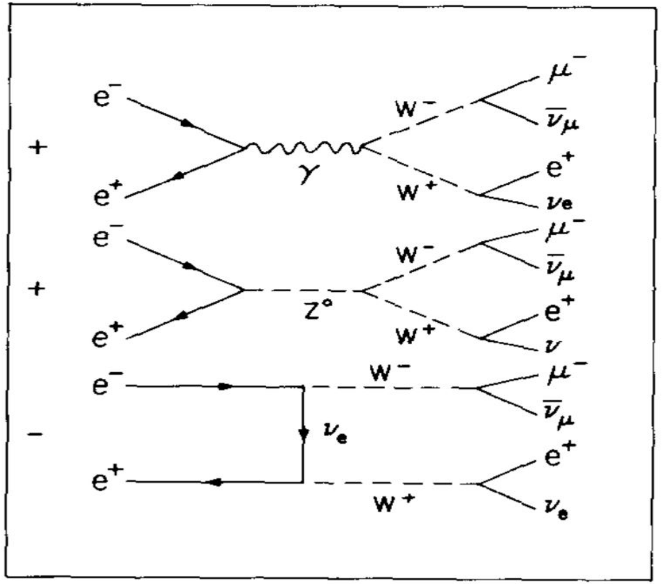


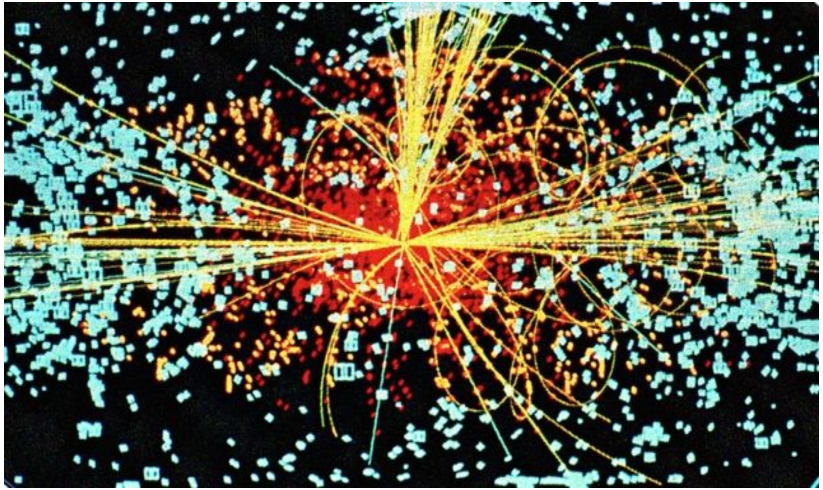
Project phase 2: physics data

Goal: choose the energy settings for an electron-positron collider in order to best measure the Weinberg angle parameter

Theory



Experiment



Project phase 2: physics data

- Run a simulated experiment, generating data with an unknown distribution

$$P(x \mid \theta, \Phi)$$

Outcome of the experiment — Weinberg angle — Experimental settings

- Estimate $P(\theta \mid x, \Phi)$

- Predict the experimental settings that measure the Weinberg angle with the least uncertainty

Thanks!