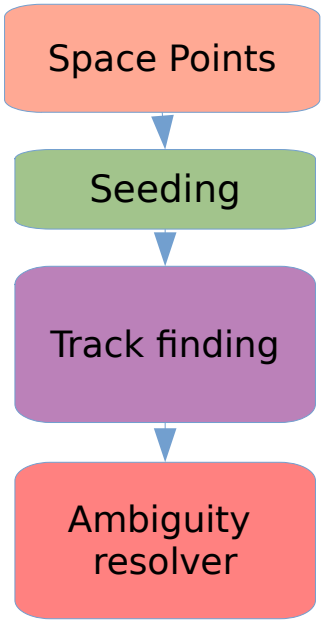
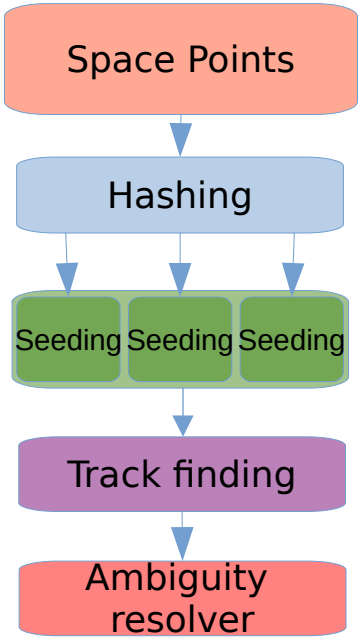
Plan

- **ACTS v29.1.0 + GEANT4 + ITk**

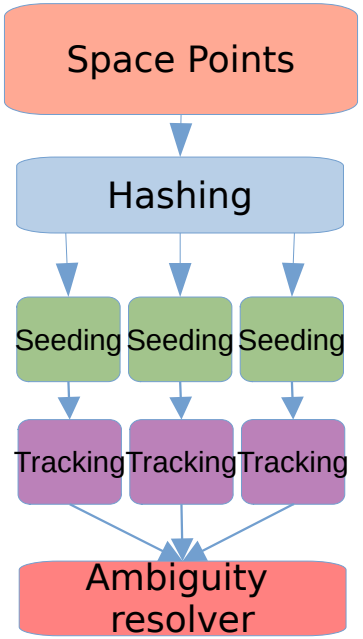
Default



Actual

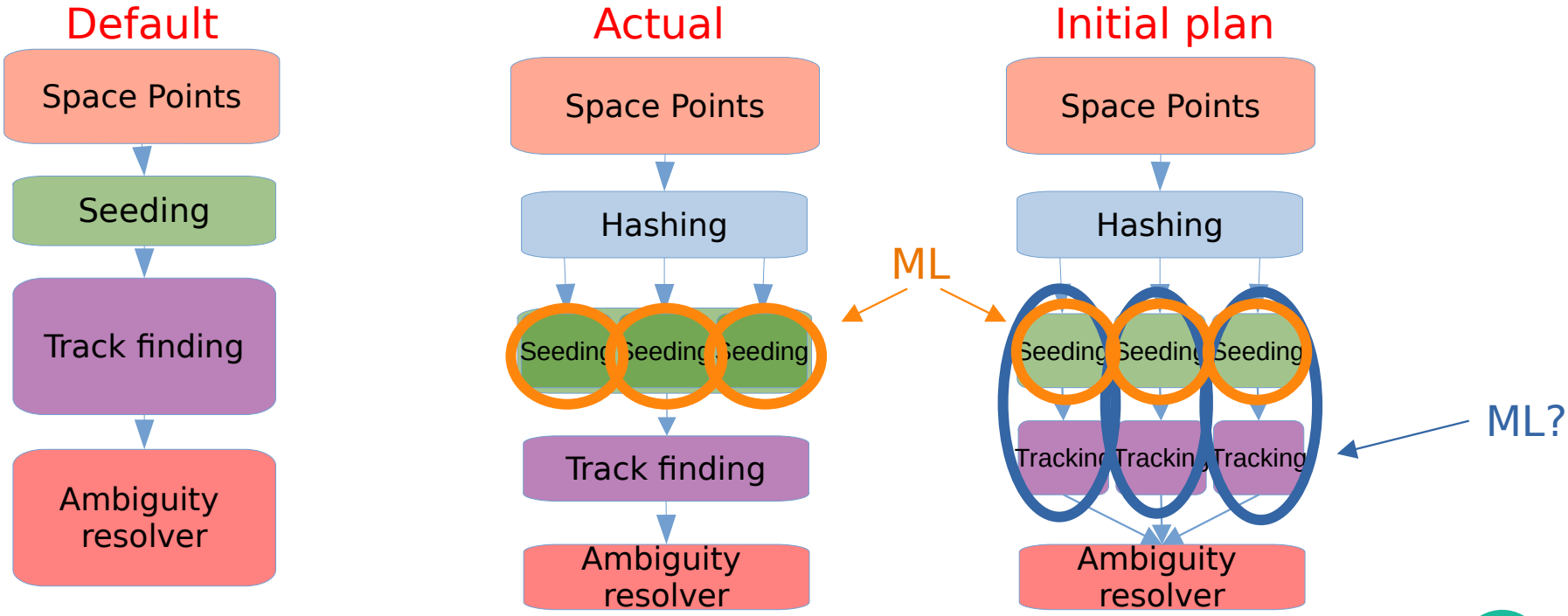


Initial plan



Plan for ML

- **ACTS v29.1.0 + GEANT4 + ITk**

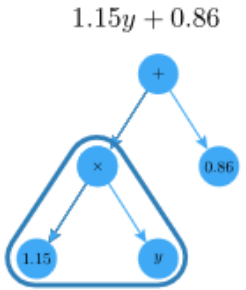


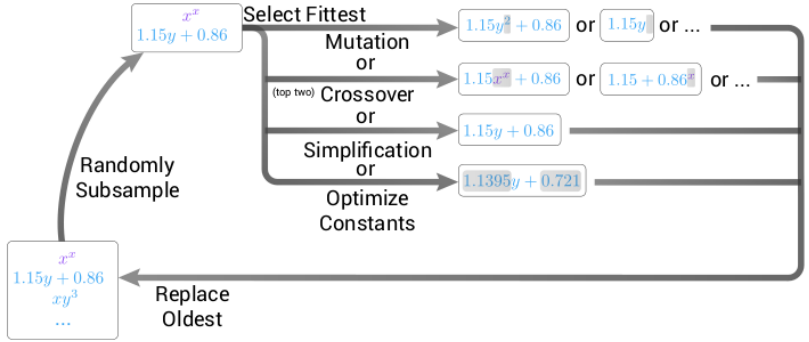
Workshops

- **Poster: Oct 10 – 13, CTD 2023**
- **Nov 6 – 10: ML4jets 2023**

Symbolic regression

PySR





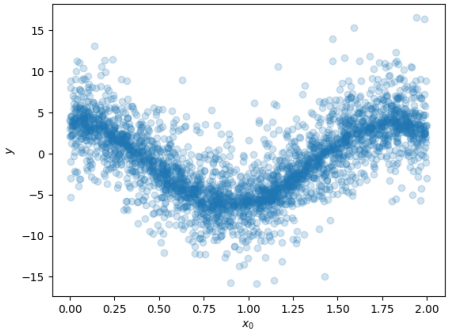
Genetic Algorithm

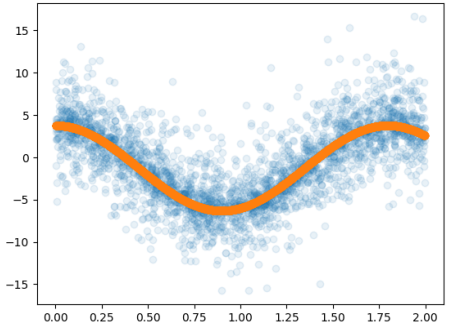
$$\sigma \sim U(0.1, 5.0)$$
$$\epsilon \sim N(0, \sigma^2)$$
$$y = 5\ \cos(3.5x_0) - 1.3 + \epsilon.$$

Truth

$$5.0337477 \cos(3.496164x_0) - 1.29099218487498$$

Learned





Neural Nets + Symbolic Regression

https://github.com/MilesCranmer/PySR

Analysis-by-Synthesis

Need a Differentiable Simulator

$$\mathcal{L} = \sum_i \left| F_i\left(S(\boldsymbol{x}, \theta)\right) - X_i \right|^2$$

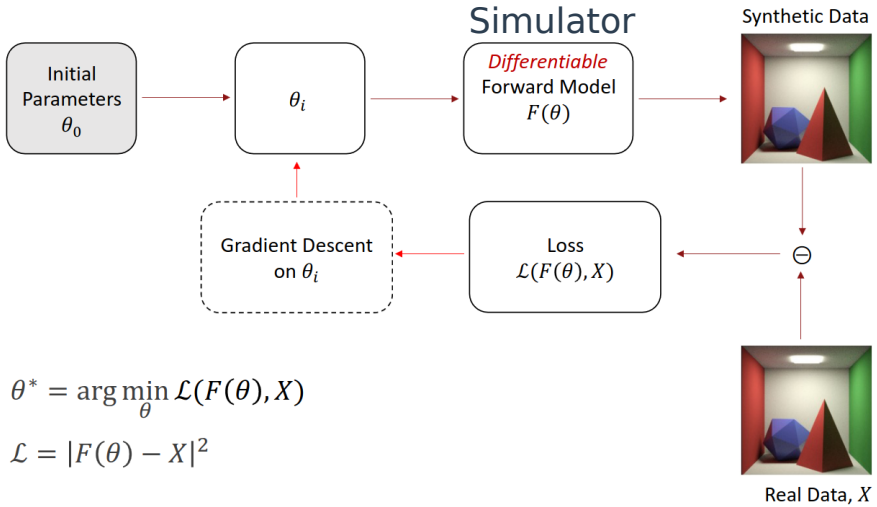
signal $(\cdot)$

$$\mathcal{L} = \sum_i \left| F_i\left(NN_\theta(\boldsymbol{x})\right) - X_i \right|^2$$

reconstruct a signal parameterized by a neural network

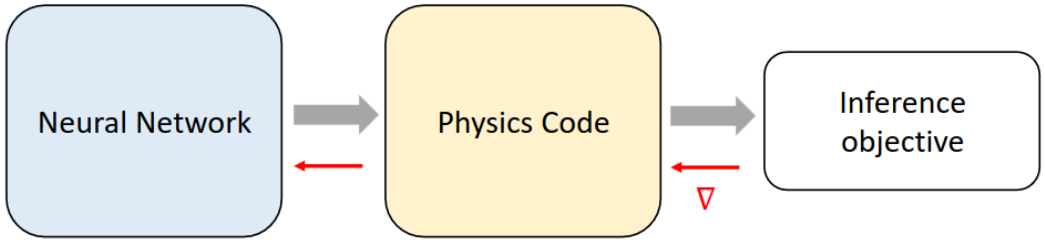
Combines physics knowledge (differentiable simulator) with neural networks to model complex signals

Physics guides learning & ensures we can make physical plausible predictions



$$\theta^* = \arg\min_\theta \mathcal{L}(F(\theta), X)$$

$$\mathcal{L} = |F(\theta) - X|^2$$



Learning Symmetries

Lax pairs

$$\frac{\mathrm{d}}{\mathrm{d}t} L = [L, M],$$

$$F_1 = 2\,\lambda,$$

$$F_2 = 2\,\lambda^2 + 4\,H,$$

$$F_3 = 2\,\lambda^3 + 12\,\lambda\,H,$$

$$F_4 = 2\,\lambda^4 + 24\,\lambda\,H + 4\,H^2.$$

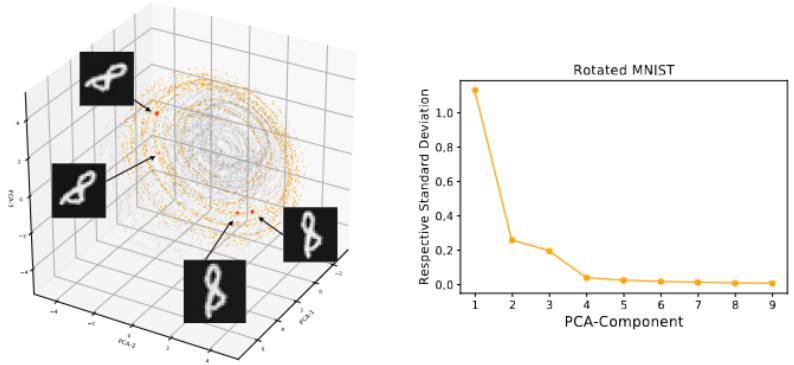


Figure 9: **Left:** Pointcloud of first three PCA components of our rotated MNIST dataset. Highlighted in orange are the orbits of multiple digits eight. Gray points correspond to the other digits present in this dataset. **Right:** The standard deviation on the generators identified from this pointcloud for the digit eight.