

# Foundation Model

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Structured data



Text



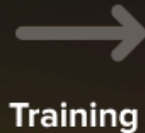
Voice



3D signals



Images



## Foundation Model



Information extraction



Instruction following



Object recognition



Image captioning



Q&A



Sentiment analysis

*"A **foundation model (FM)**, also known as **large AI model**, is a machine learning or deep learning model that is trained on broad data such that it can be applied across a wide range of use cases." - wikipedia (e.g. ChatGPT-n)*

How about data in HEP domain?

# Goals & Challenges of HEP-domain FM

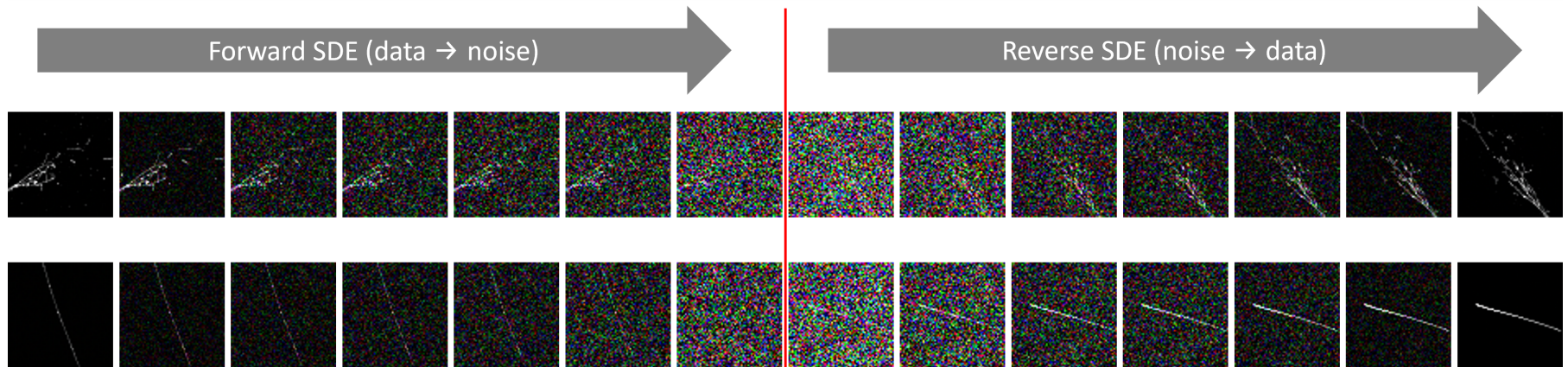
1. develop *self-supervised* training / optimization methods for HEP-domain data
2. build an open ecosystem for HEP data generation, curation and model optimization
3. adapt the pre-trained models to multiple tasks and multiple data modalities
4. solve physics problems

Let's start with something we are familiar with, i.e. LArTPC

Yeon-Jae, Jiaqi (Stanford CS student), Hiro, Kazu, Patrick

# Diffusion Model on LArTPC Image

**Challenge:** generate high fidelity LArTPC images w/ AI/ML model



$$d\vec{X}_t = \mathbf{f}(\vec{X}_t, t)dt + g(t)d\mathbf{W}_t$$

$$d\vec{X}_s = [-\mathbf{f}(\vec{X}_s, s) + g^2(s) \overset{\text{score function}}{\nabla \log p(\vec{X}_s)}]ds + g(s)d\mathbf{W}_s$$

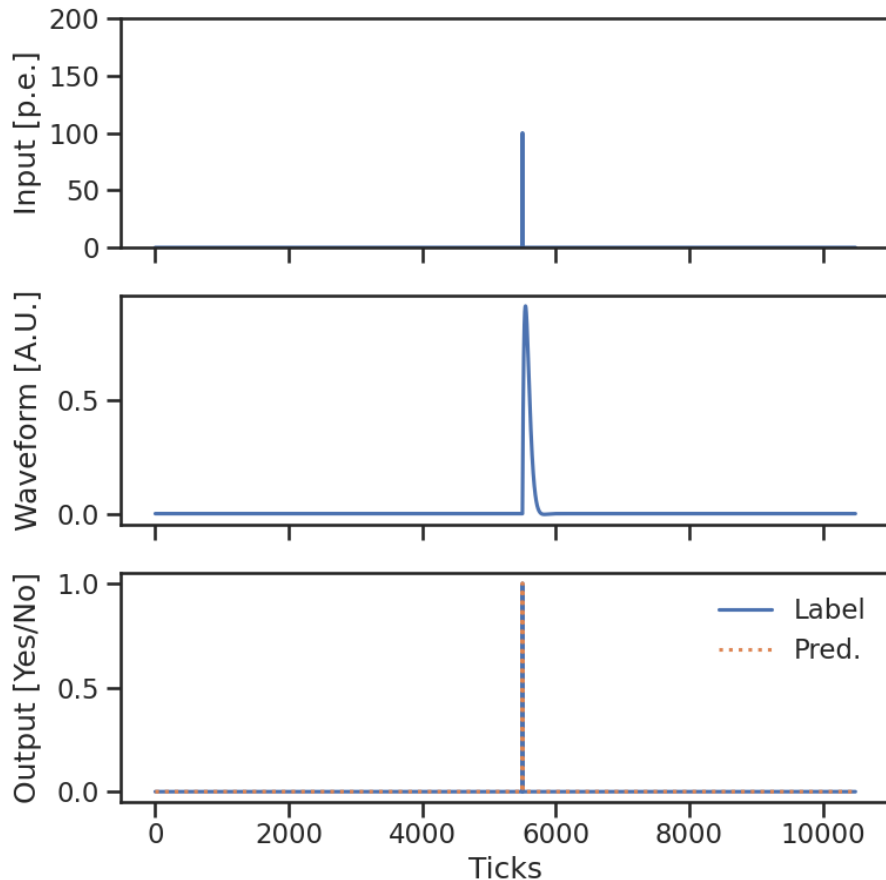
*Diffusion model by Taritree's group on 64x64 2D image*

## Goals

- generate 3D images in large scale
- perform physics tasks, e.g. pixel-level track/shower classification
- compare to the simulated data

# Learning from Raw Waveform

## Waveform simulation & unfolding



## Goals

- explore alternative ML models (e.g. state space model) for *long* sequence modeling
- demonstrate feasibility of self-supervised learning

# What's Next

- manpower
  - SLAC: Francois, new hired postdoc
  - Stanford CS: Stefano Ermo's and Chris Re's group
- what kind of data input?
  - 3D LArTPC image, charge / light raw waveforms
- model architecture & adaption
  - what tasks / physics problems to be solved?
- foundation model beyond LArTPC
  - neutrino physics => HEP in general