IceCube - Neutrinos in Deep Ice
Final Presentation

Group 13

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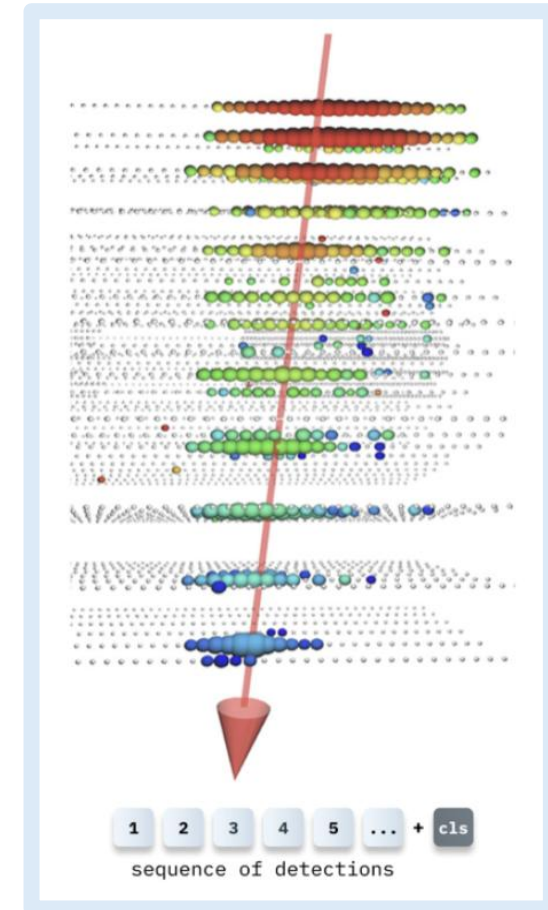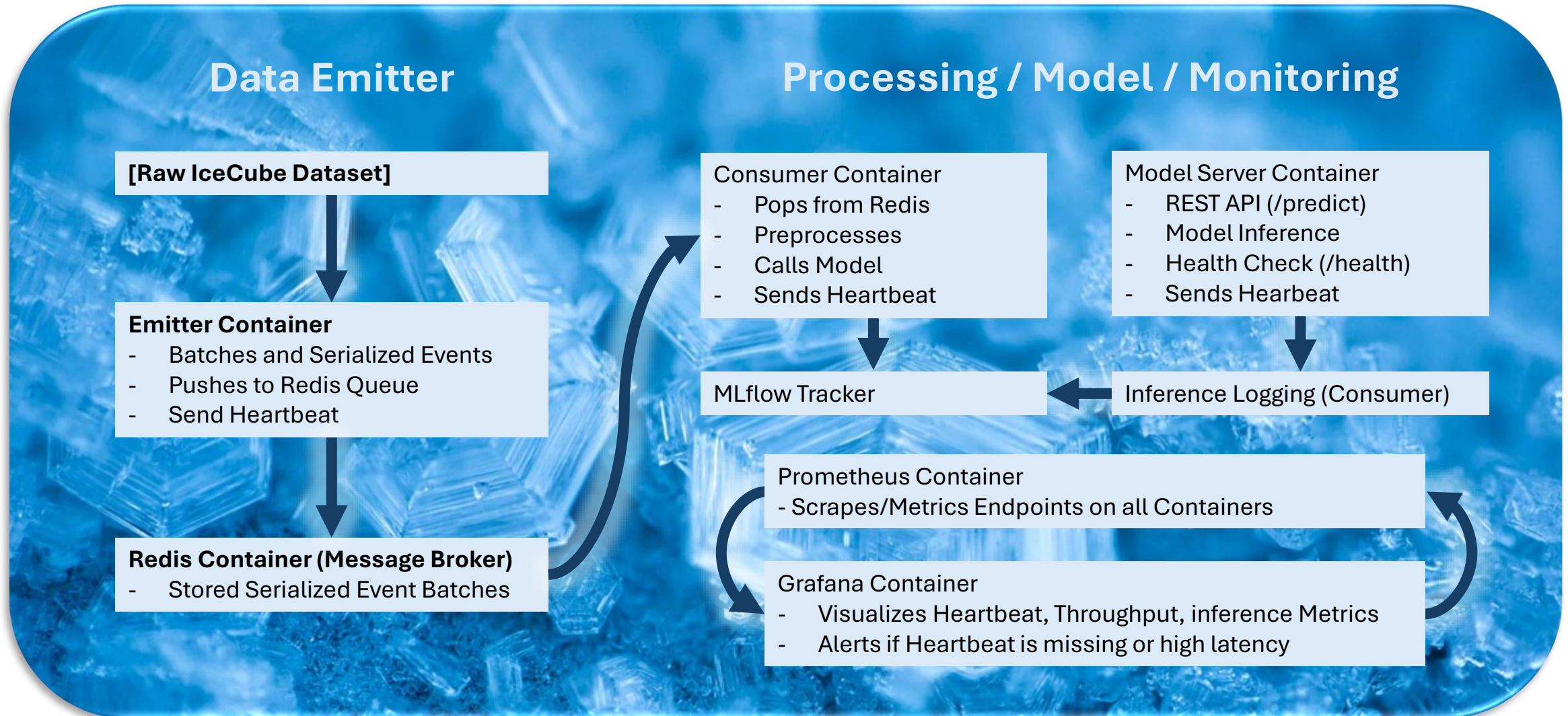Fabian Stepinski (stepifab)

Machine Learning Operations

FS 2025

Purpose/Task of the ML System

- Neutrinos are abundant particles in our universe emitted by violent astrophysical events

- Hard to dected since they rarely interact with matter

- The [IceCube Neutrino Observatory](#)

  - A detector array spanning a cubic kilometer of Antarctic ice
  - Detects the directions of neutrino traces using photon detections (3D Unit Vector)
  - Enables determination of the neutrinos' origin, thereby helping locate astrophysical events

- Disclaimer: Our aim is NOT to optimize ML performance, but to explore how the IceCube data processing might be structured
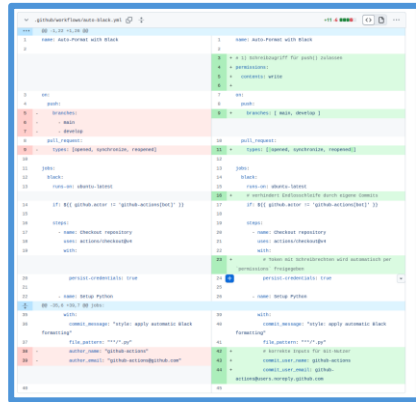

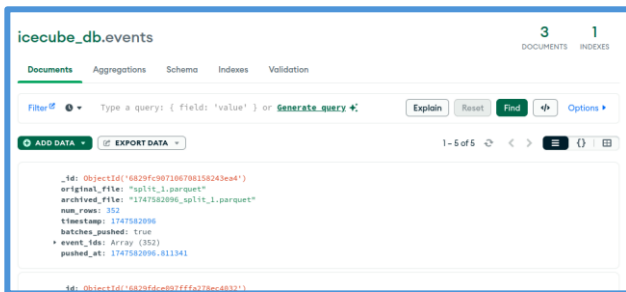3D Unit Vector

Overview of Components/Pipeline/System Setup

Data Emitter

Processing / Model / Monitoring

[Raw IceCube Dataset]

Emitter Container
- Batches and Serialized Events
- Pushes to Redis Queue
- Send Heartbeat

Redis Container (Message Broker)
- Stored Serialized Event Batches

Consumer Container
- Pops from Redis
- Preprocesses
- Calls Model
- Sends Heartbeat

Model Server Container
- REST API (/predict)
- Model Inference
- Health Check (/health)
- Sends Hearbeat

MLflow Tracker

Inference Logging (Consumer)

Prometheus Container
- Scrapes/Metrics Endpoints on all Containers

Grafana Container
- Visualizes Heartbeat, Throughput, inference Metrics
- Alerts if Heartbeat is missing or high latency

Key Features of the MLOps Pipeline [1/2]

| Tool	Raison d'être
GiHub Actions	• Automatic Checks of Code Quality • Automatic requirments.txt check and update • Automatic Container Build and upload to GHCR
Docker	• Easy to deploy • Ensures reproducibility • Allows containerization of each component
Redis Community Edition	• Easy to use and performant que system • Relatively fast deployment
MongoDB	Used to track Events
Promotheus	• Scrapes metrics (total requests, latency, etc.) from the different containers (including heartbeat) • Can define alert rules
Grafana	• Dashboard build upon Promotheus • Displays Real Time Metrics
Flask	Server used to serve the model via REST API

Key Features of the MLOps Pipeline [2/2]
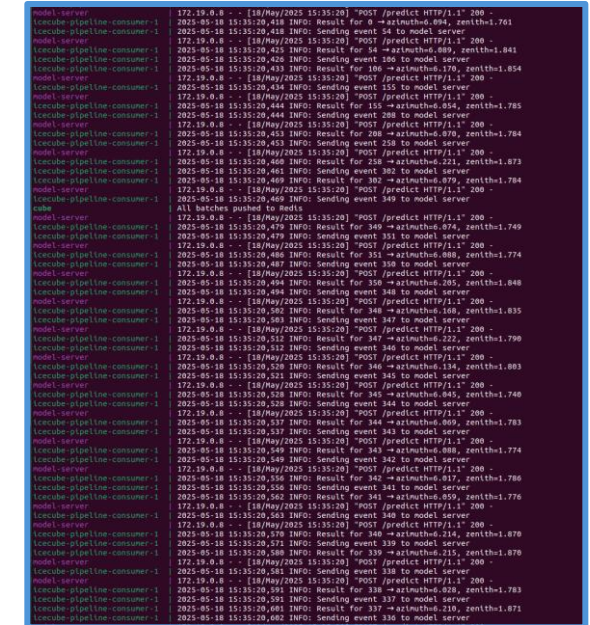

GitHub Actions

MongoDB for tracking Evenents

Grafana Dashboard with Real Time Insights
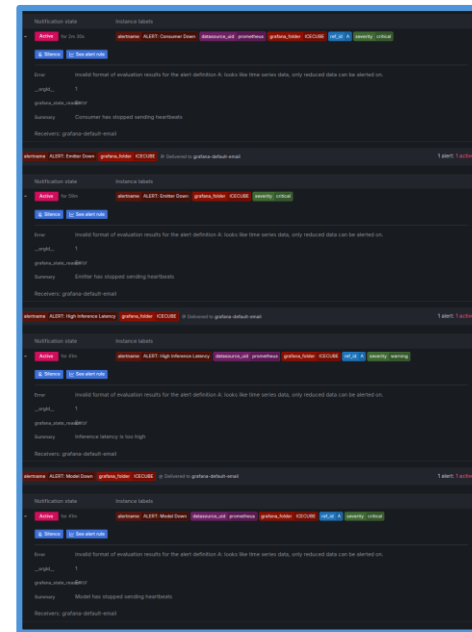
Promotheus (Eg. Automatic Alerts

«Behind the Scenes» Info Flow

Sources

- [Title Slide Picture](#) [Slide 1]
- [3D Unit Vector](#) [Slide 3]
- [Ice Pattern](#) [Slide 3]