

# Graph Analytics for CEBAF Operations

- **Goal:** express the state of CEBAF as a graph, find a suitable low-dimensional, whole-graph embedding such that the result can be visualized
- graphs are a general language for describing and analyzing entities with relations/interactions

Social networks (Advertisement)

Drug/Material molecules (Chemistry)

3D Meshes (Computer Graphics)

Brain connectivity (Neuroscience)

Transportation networks

Words relationships (NLP)

Knowledge graphs

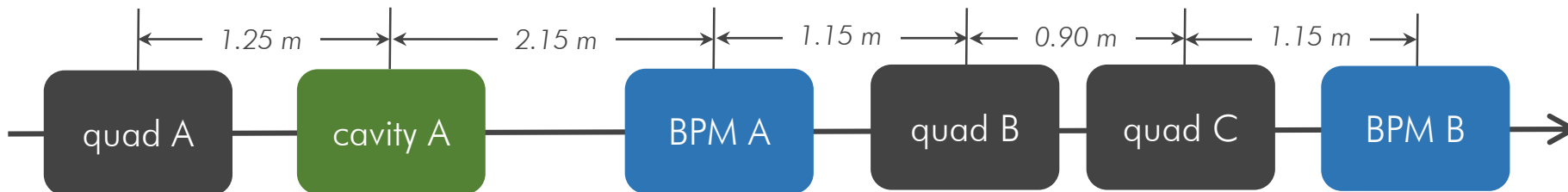
Scene understanding

Recommender systems (Amazon, Netflix)

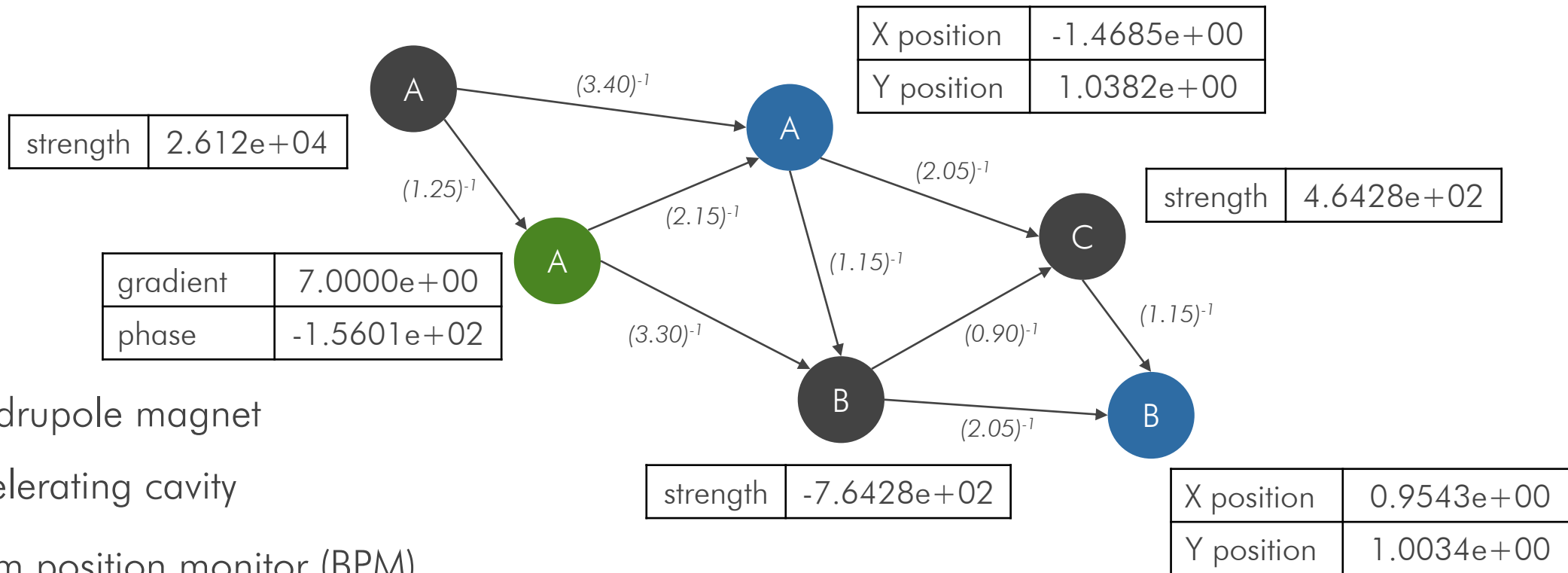
Neutrino detection (High-energy Physics) (courtesy X. Bresson)

**Graph**

# Representing a Beamline as a Graph

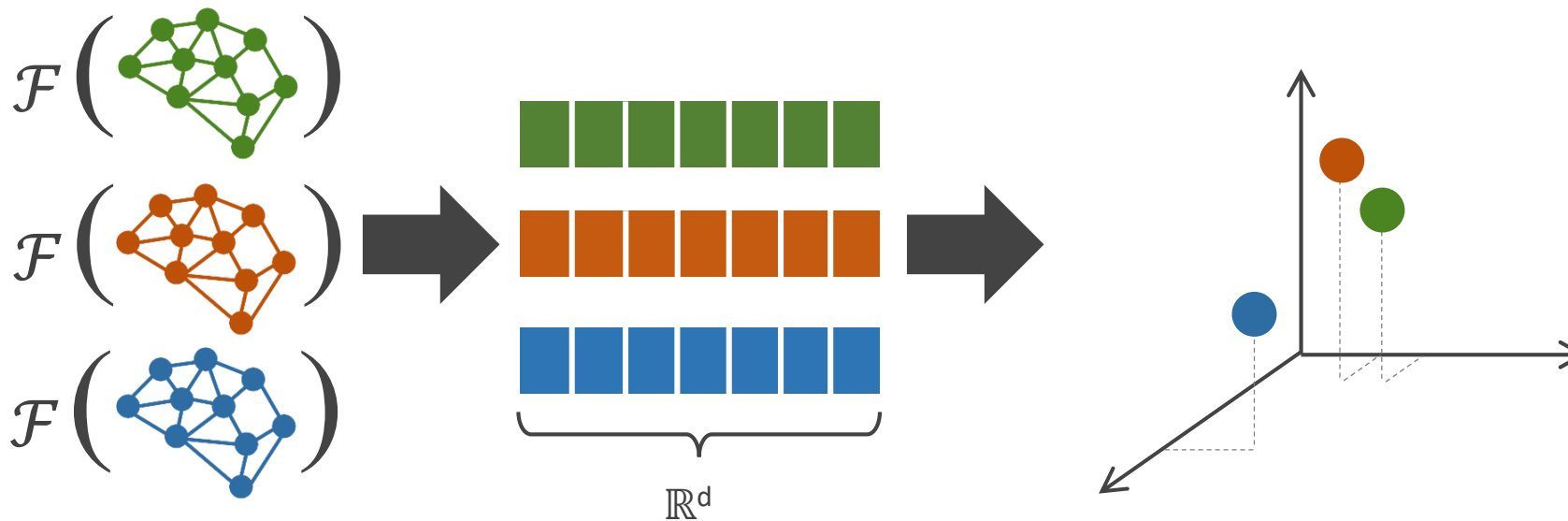


GRAPH



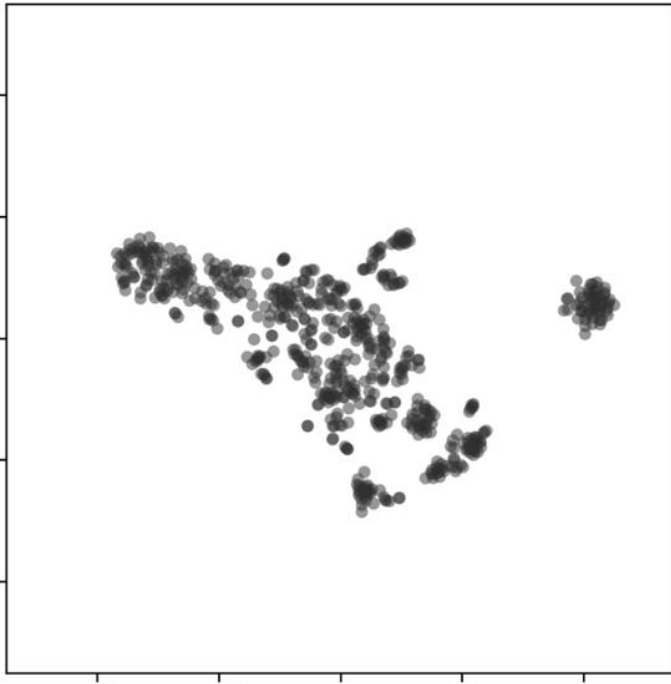
# Whole-Graph Embedding

- goal: summarize/embed the graph into 2- or 3-dimensions
- assume the machine state can be represented as a graph
  - ✓ the graph structure would remain the same for every all-save, only node/edge features would change



# Application for Beam Operations

- visualize the underlying distribution/pattern of machine states
- use cluster analysis to identify regions of parameter space
- make changes to machine, analyze state, and see where you move in parameter space



- provides a data-driven approach to the operation of an accelerator
  - ✓ bridges the gap between idealized simulations and the real-world implementation

# Project Benefits

- leverages years of under-utilized operational data of accelerator facilities
- data collection is passive
  - ✓ does not require dedicated beam studies time or investment in additional diagnostics
- a graph framework can incorporate critical accelerator components which are neglected in conventional beamline models and simulations
  - ✓ includes standard beamline components (RF cavities, magnetic elements, diagnostics) but can also include their associated power supplies, vacuum readbacks, information from beam loss and radiation monitors, cryogenics information, environmental conditions, cooling water properties, etc.