

The NSF AI Institute for Artificial Intelligence and Fundamental Interactions

Jesse Thaler

Director, IAI



AI Institutes Panel, AAAI-2022 — February 26, 2022



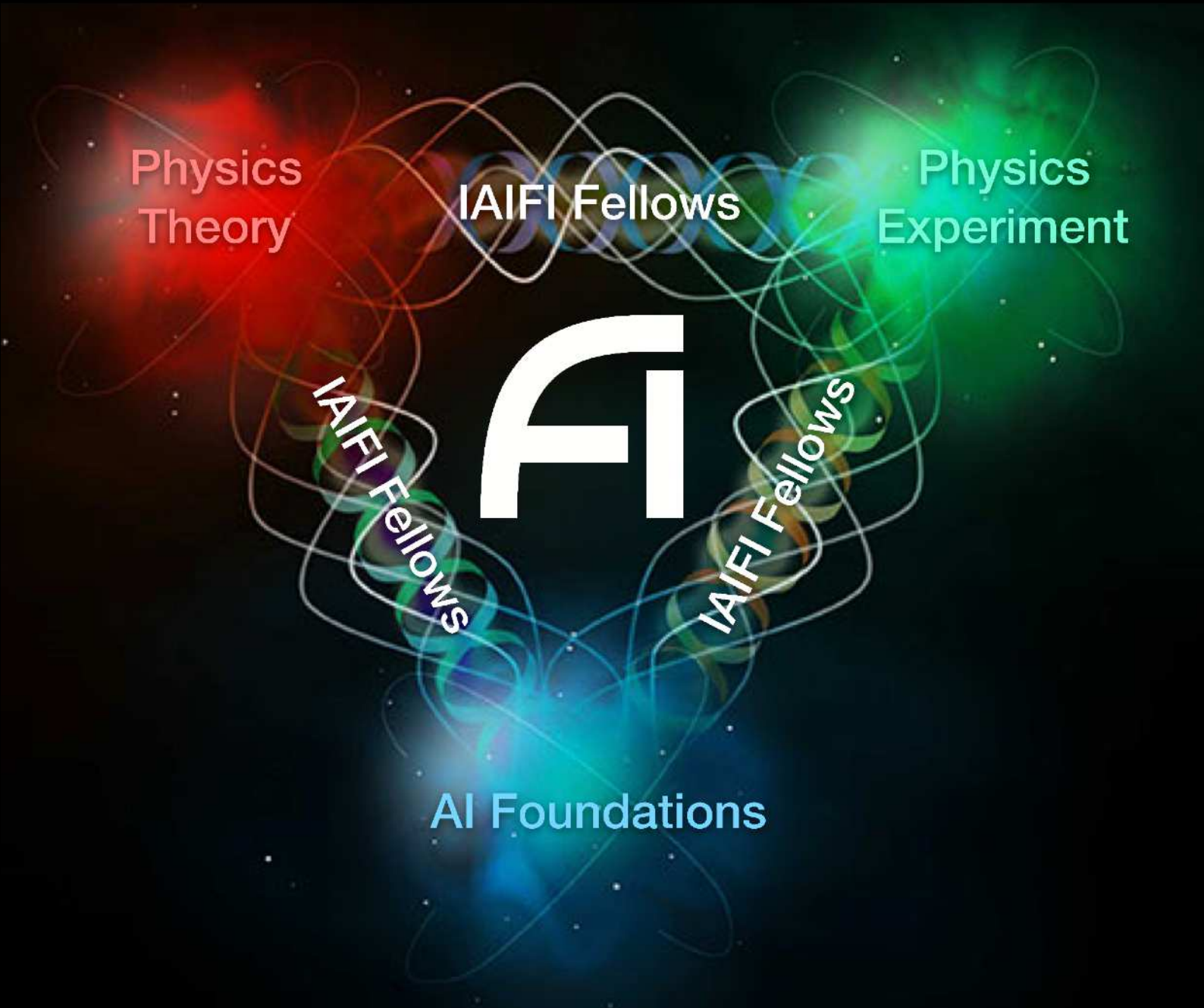
The NSF AI Institute for Artificial Intelligence and Fundamental Interactions (IAIFI /ai-fai/ iaifi.org)



AI

Advance physics knowledge — from the smallest building blocks of nature to the largest structures in the universe — and galvanize AI research innovation

IAIFI at a Glance:



2021-2024

2022-2025

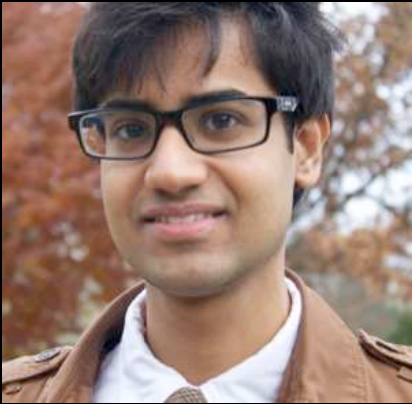
IAIFI
Postdoctoral
Fellows:



Anna Golubeva



Di Luo



Siddharth Mishra-Sharma



Ge Yang



Denis Boyda



Carolina Cuesta



Jessie Micallef

AI Foundations:

Power of machine learning to process large, rich data sets

Ai

AI

fi

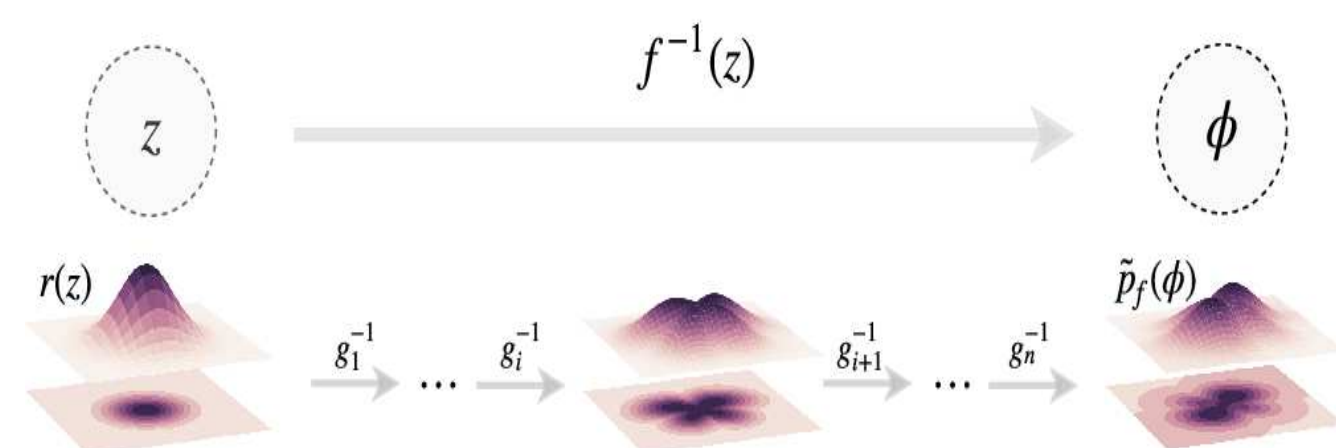
Physics Theory & Experiment:

First principles and best practices from fundamental interactions

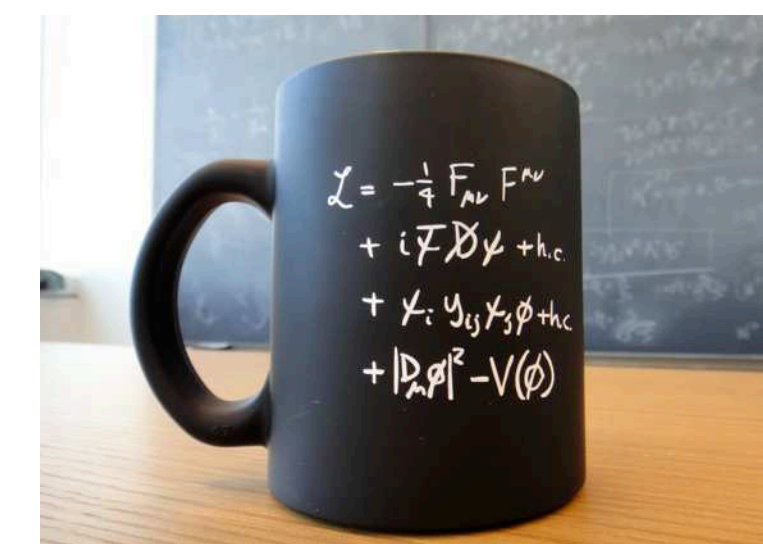
Enable physics discoveries by developing and deploying the next generation of AI technologies

Galvanize AI research innovation by incorporating physics intelligence into artificial intelligence

Generative Models from Normalizing Flows



Symmetries of Standard Model of Particle Physics



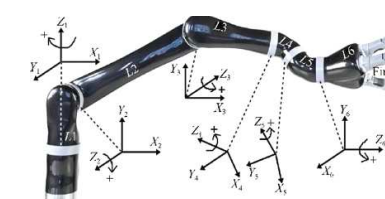
Efficient Computations in Lattice Field Theory

Currently: >10% of open supercomputing in US

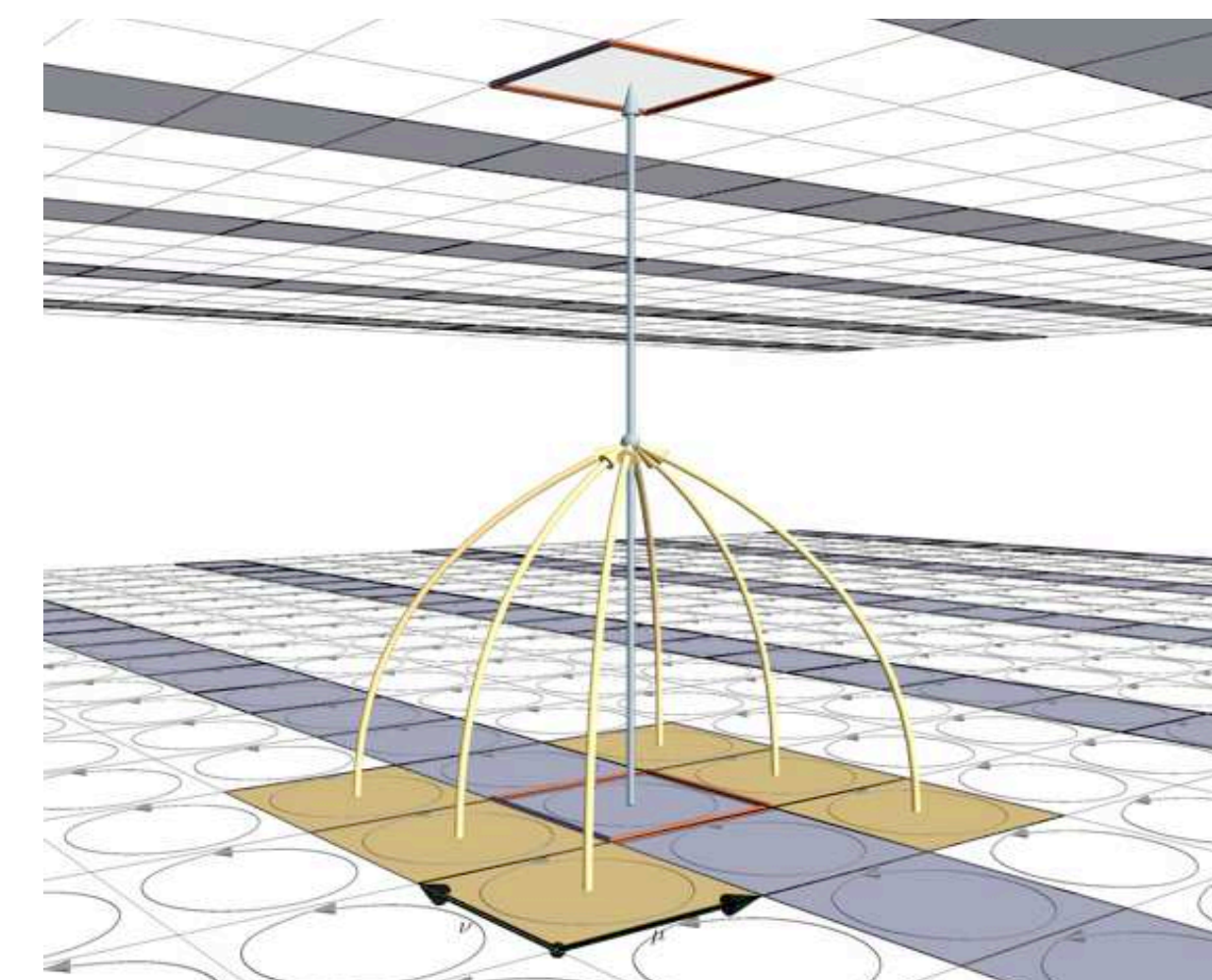
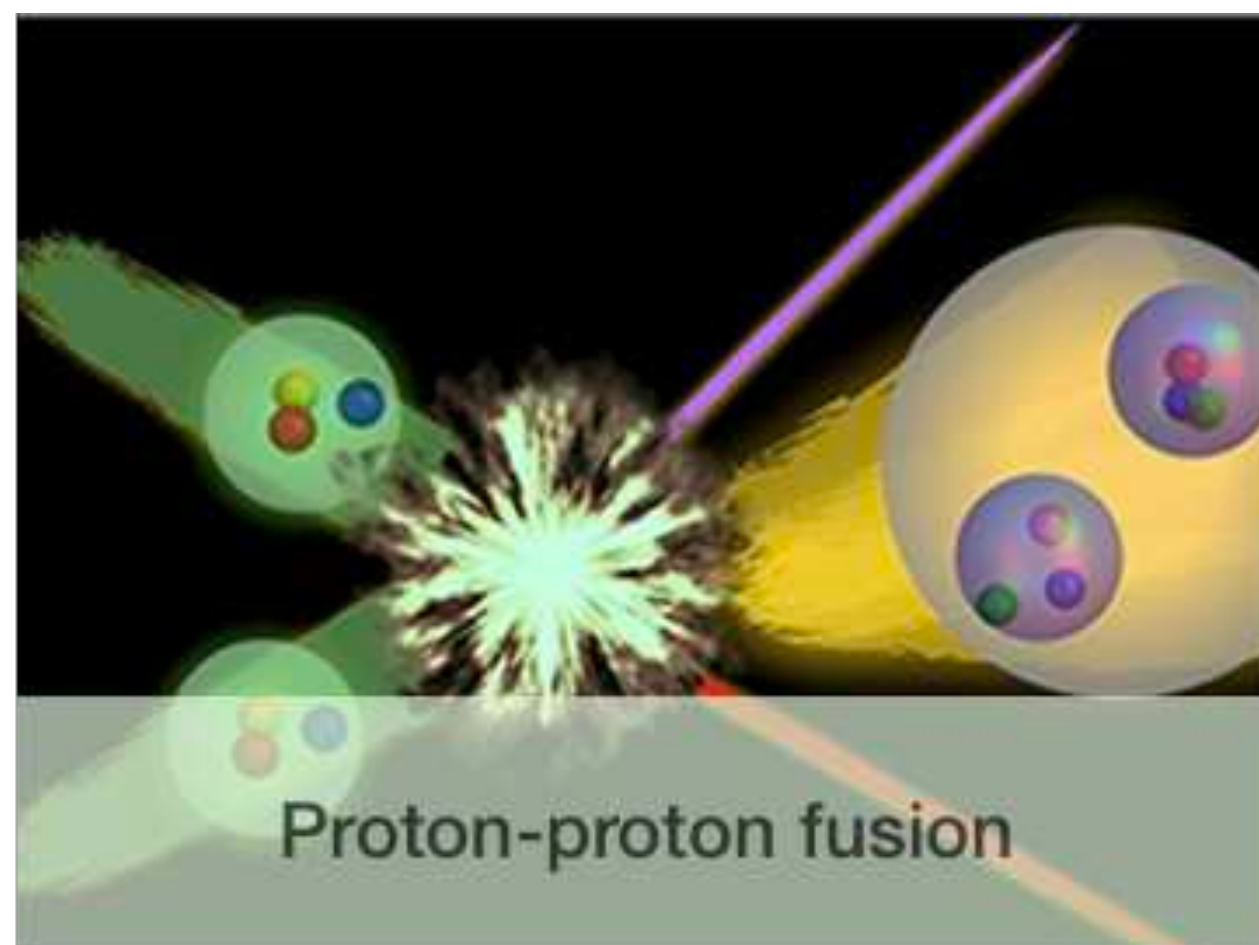
Industry collaboration for 1000-fold speedup:



Tools designed for physics find interdisciplinary applications:



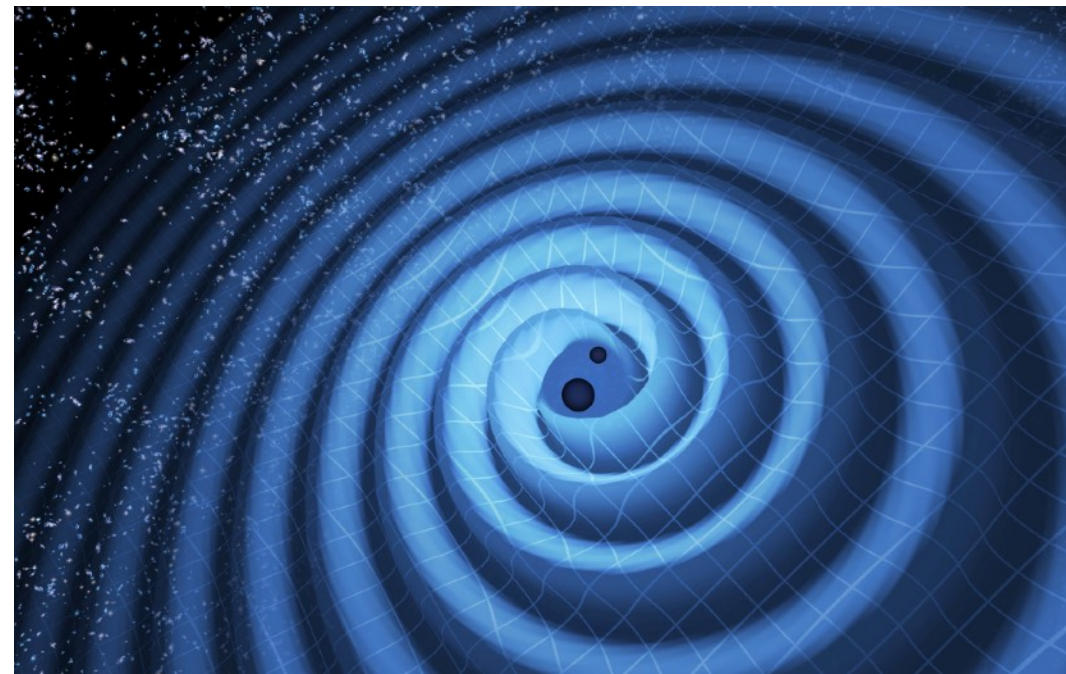
Shanahan Group: [PRD 103, 074504 \(2020\)](#), [PRL 125, 121601 \(2020\)](#), [ICML, PMLR 8083-8092 \(2020\)](#), [2107.00734 \(2021\)](#), [2106.05934 \(2021\)](#), [2101.08176 \(2021\)](#)



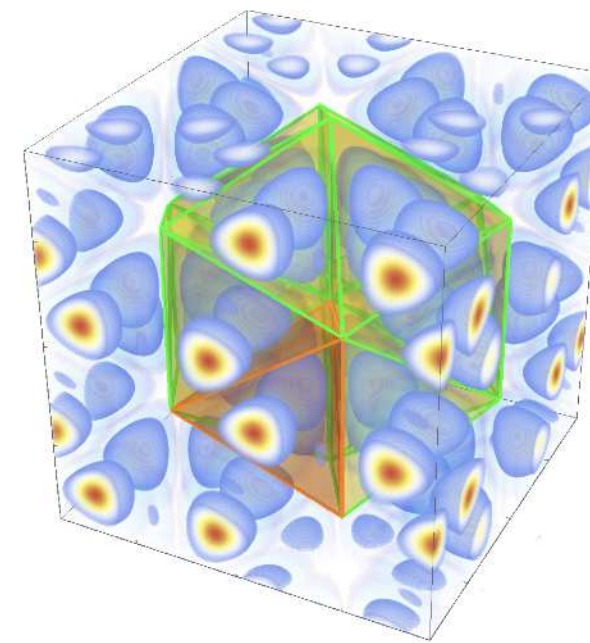
Artificial Intelligence \Leftrightarrow Fundamental Physics



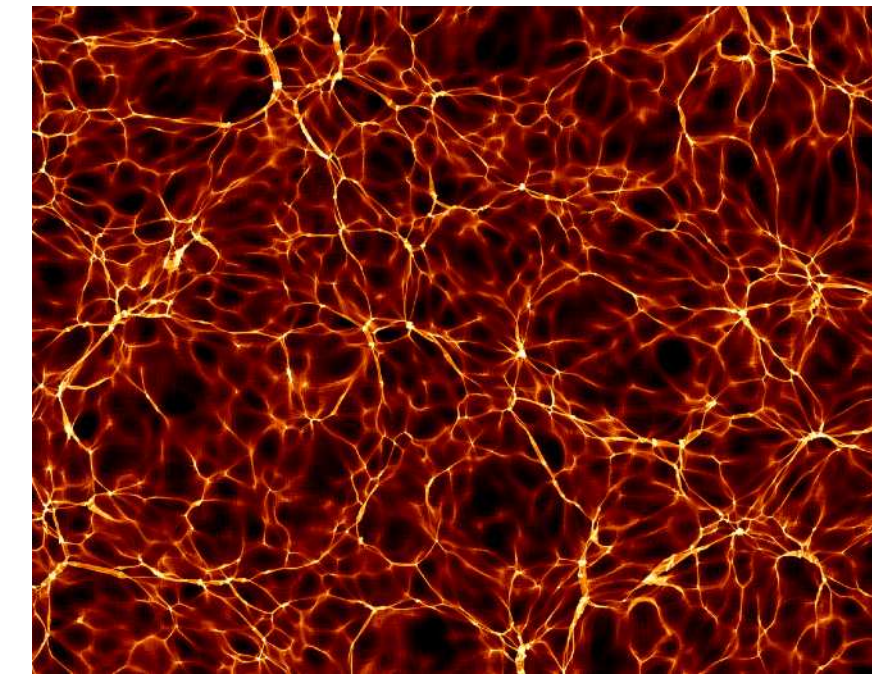
Gravitational Waves



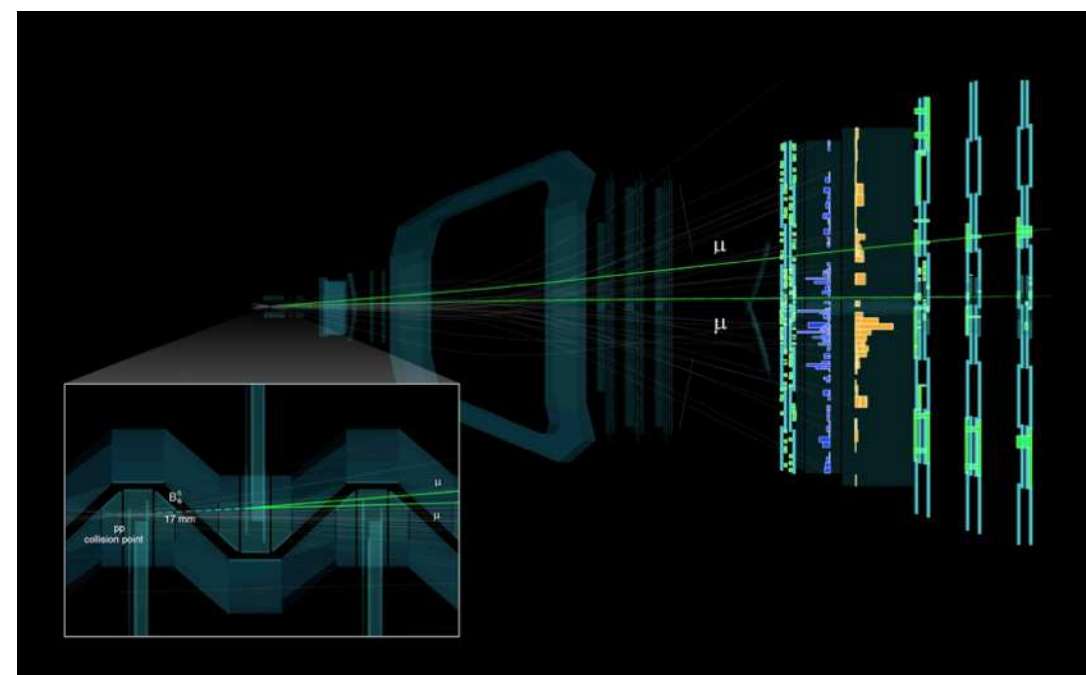
Nuclear Physics



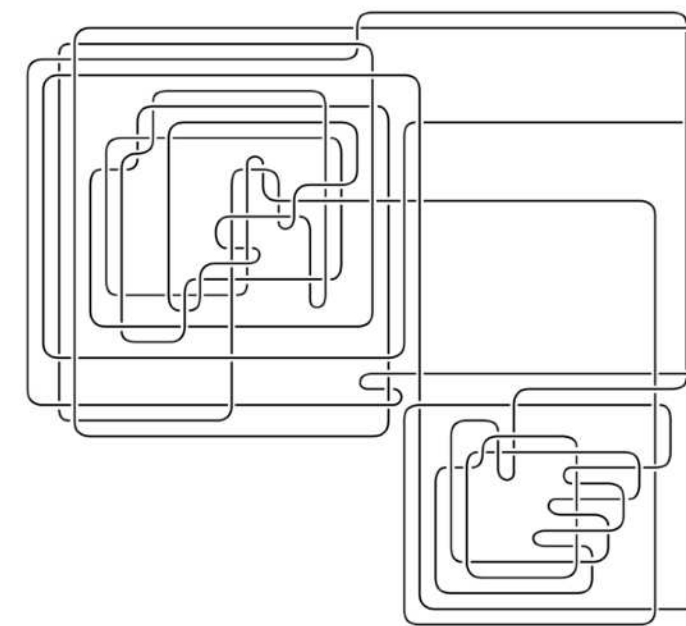
Dark Matter



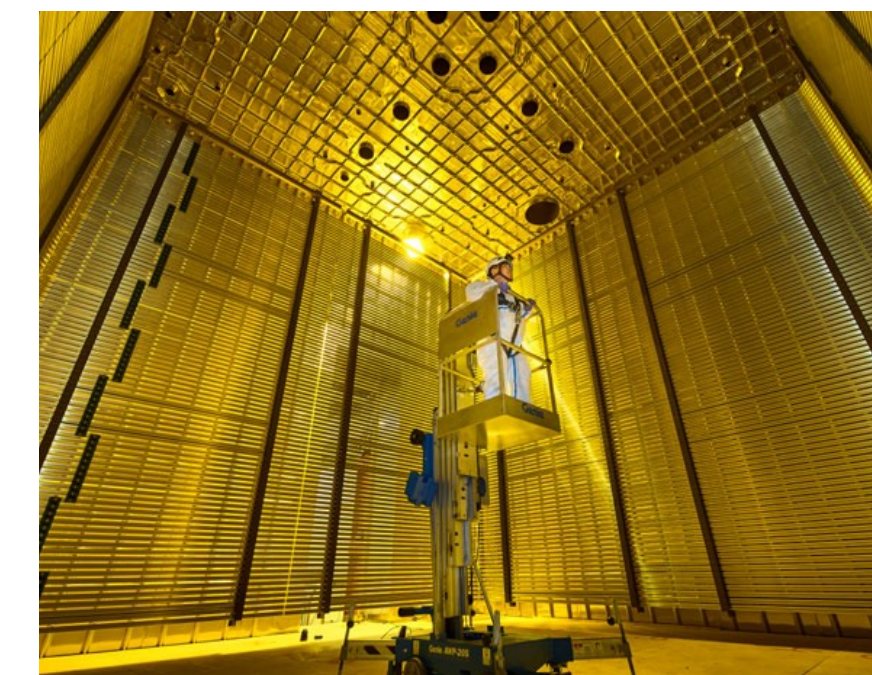
Particle Colliders



Mathematical Physics

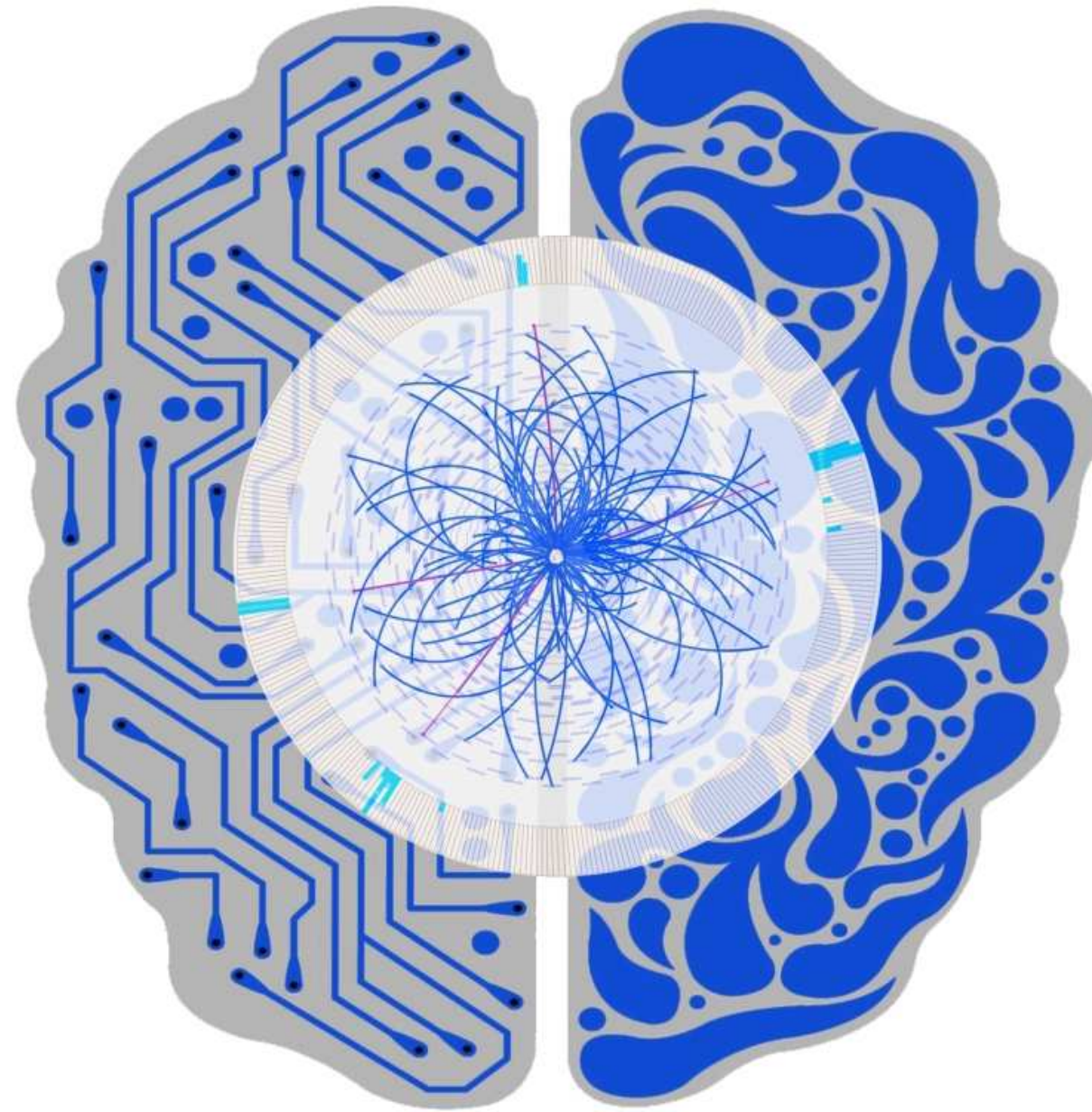
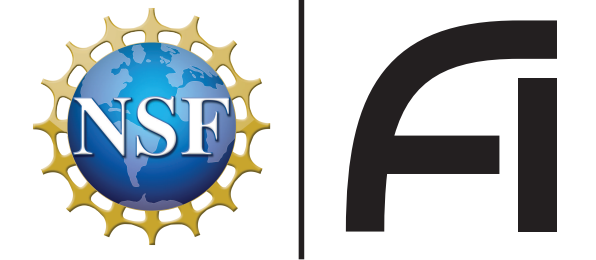


Neutrino Detection



...

Towards **AI²**: **Ab Initio** Artificial Intelligence



Machine learning that incorporates first principles, best practices, and domain knowledge from fundamental physics

Symmetries, conservation laws, scaling relations, limiting behaviors, locality, causality, unitarity, gauge invariance, entropy, least action, factorization, unit tests, exactness, systematic uncertainties, reproducibility, verifiability, ...

*Key Goal of IAI: Cultivate **Early-Career Talent** with **Cross-Disciplinary Expertise***