Genesis Mission

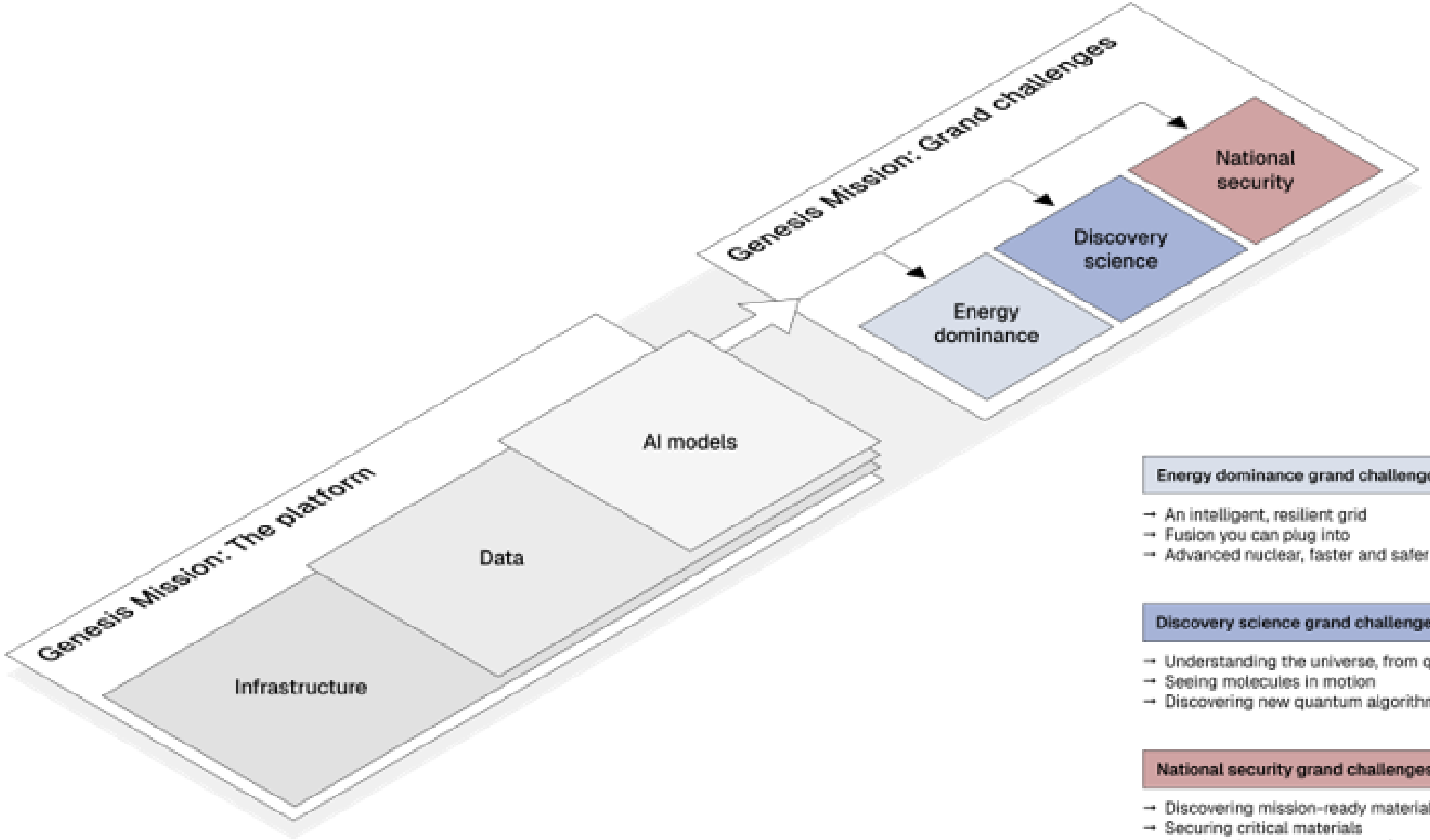
U.S. DEPARTMENT of ENERGY

The Genesis Mission

The **Genesis Mission** is a historic national effort to catalyze new industries, create high-skill jobs, and usher a new golden era of American discovery by fully embracing AI and the ongoing computing revolution.

The Genesis Mission's **American Science and Security Platform** will connect the world's best supercomputers, AI systems, and next-generation quantum computers with the most exquisite scientific instruments in the nation, and its intelligence layer will be trained with the singular scientific datasets and expertise housed in the National Laboratories. Once complete, it will be the world's most complex and powerful scientific instrument ever built.

Through the Genesis Mission's **National Science and Technology Challenges**, the scientific community will develop and deploy the technologies necessary to demonstrate true AI advantage for science and energy.



Energy dominance grand challenges

- An intelligent, resilient grid
- Fusion you can plug into
- Advanced nuclear, faster and safer

Discovery science grand challenges

- Understanding the universe, from quarks to cosmos
- Seeing molecules in motion
- Discovering new quantum algorithms

National security grand challenges

- Discovering mission-ready materials
- Securing critical materials
- Accelerating advanced manufacturing

Infrastructure – American Science and Security Platform

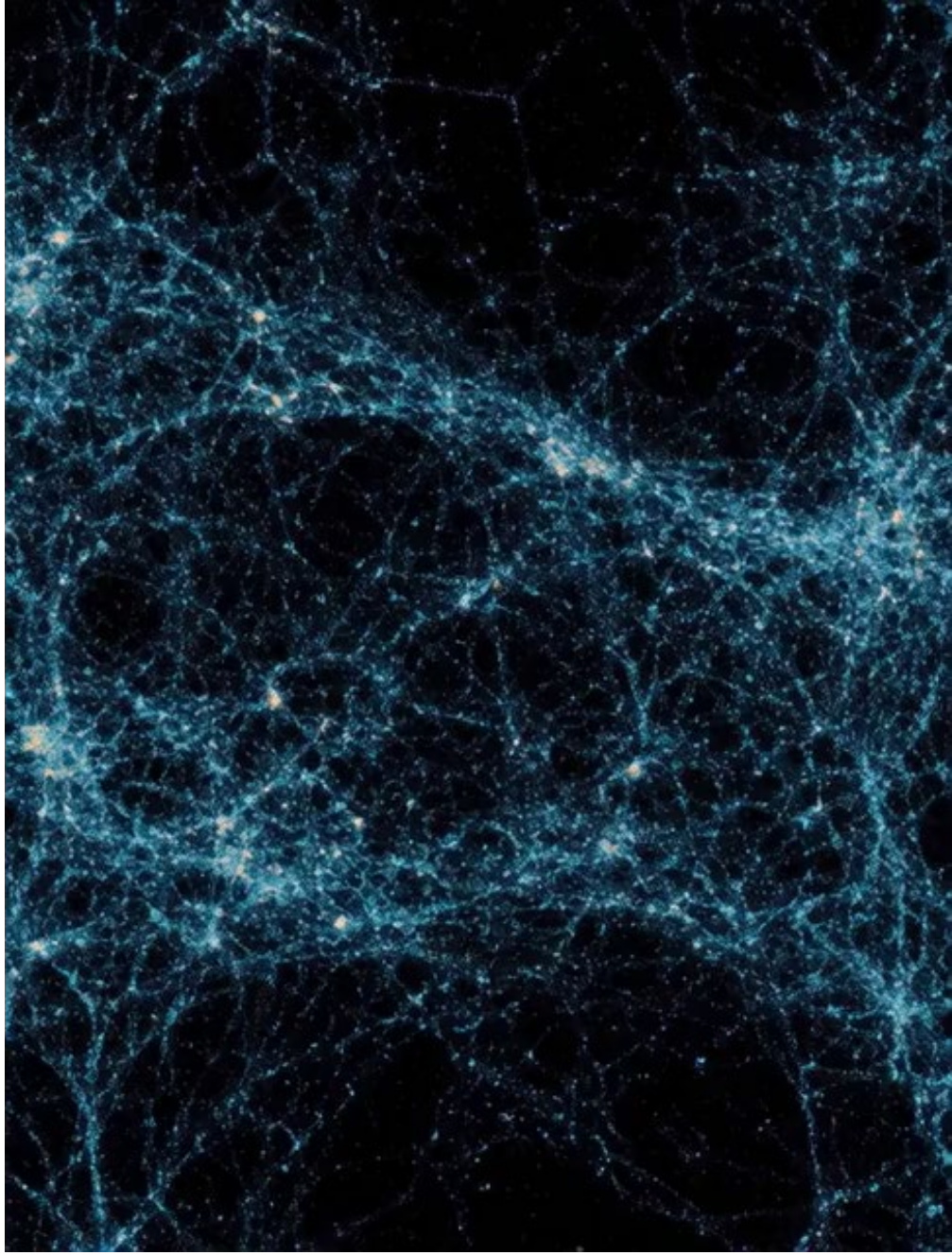
- The Genesis Mission's Platform infrastructure, hosting and distributing AI models and scientific data to the broader research community. The Platform enables National Labs, industry, and research partners to curate and apply DOE's extensive AI-ready scientific data.

- Infrastructure Partners (IPs) – contribute to, use, and integrate resources and shape capabilities to form the shared, integrated scientific and security platform
  - IPs ensure the Platform's services and interfaces meet the needs of the community
  - Through AmSC IPs for computing services at BNL, FNAL, and SLAC, LQCD, Scientific User-Facilities (SUF)
  - Experimental IPs help ensure the Platform serves the HEP Mission with IPs for ATLAS, CMS, and Rubin/DESC

AI-ready Data

- Scientific datasets collected, curated, and documented to be suitable for model training
  - AI models are as good as the data they are trained on, and scientific expertise is essential to produce the highest quality datasets and models

- HEP sought lab-led collaborative proposals to develop HEP AI-ready datasets and use them to advance the HEP Mission
  - Supported three collaborative pilot projects as **Intelligent Data Activities (IDAs)**



AI Models

- Genesis Mission's AI models and data efforts, will build and deploy self-improving AI models that advance science, engineering, and energy missions by harnessing DOE's unique data facilities, and expertise.
  - Create integrated AI technologies that reason within their domains, analyze and predict data, enable autonomous experimentation, and build modular, multimodal architectures that make data AI-ready for others

- **Data and Model Teams** – seedling model teams ready to take advantage of the tools being developed have worked on high priority research challenges
  - ModCon supported seedlings in HEP aligned topics: Microelectronics (AXESS), Multi-Office Accelerator Team (MOAT), and Quarks to Cosmos (Q2C)


Genesis Mission

HEP Activities and the Genesis Mission

- HEP activities that benefit from and contribute to the Genesis Mission are the DOE HEP AI R&D priority
  - Advance the HEP mission by using the best tools available, the frontier AI and computing of the Genesis Mission Platform
    - Requires a change in approach and a move toward larger multi-institution and multi-disciplinary collaborative efforts
- The Genesis Mission: Transforming Science and Energy with AI Request for Applications (RFA) provided the first opportunity to build these new collaborative activities
  - Received an overwhelming number of outstanding applications representing a massive community effort
  - From the RFA:
    This RFA will remain open and in FY27 DOE plans to amend the RFA or issue an alternative funding opportunity to update the topic and focus areas to allow a second competition of Phase-I small team applications and Phase-II large team applications.

HEP Genesis Mission RFA: 20 Awards from 381 Applications

- HEP's selected portfolio spans the HEP program utilizing existing and forging new collaborations for AI-driven scientific discoveries
  - Enabling science at HEP's flagship experiments ATLAS, CMS, DUNE, Rubin/DESC
    - Developing new AI methods for deeper insight from Exabyte-scale datasets
  - Accelerate the R&D cycle of technologies needed for the next generation of experiments
    - AI and agentic systems that can design, control, and realize more advanced technical solutions in QIS, Microelectronics, and particle accelerators
  - Partner with ARDAP, ASCR, and NP to pursue discoveries in areas of mutual interest beyond traditional stovepipes
    - International researchers from CERN and French, Japanese, and British institutions
    - Three Genesis Mission aligned awards through US-Japan Program further broadens international partnership
- Along with Phase-II applications HEP maintains some Phase-I alternates for future consideration

HEP Activities and the Genesis Mission

- DOE HEP expects a portfolio activities that develop the Platform and use it to accelerate HEP discovery science
  - Support facilitating activities through HEP relevant IPs, AI-ready Data activities, and AI Models that are then used for National Challenges

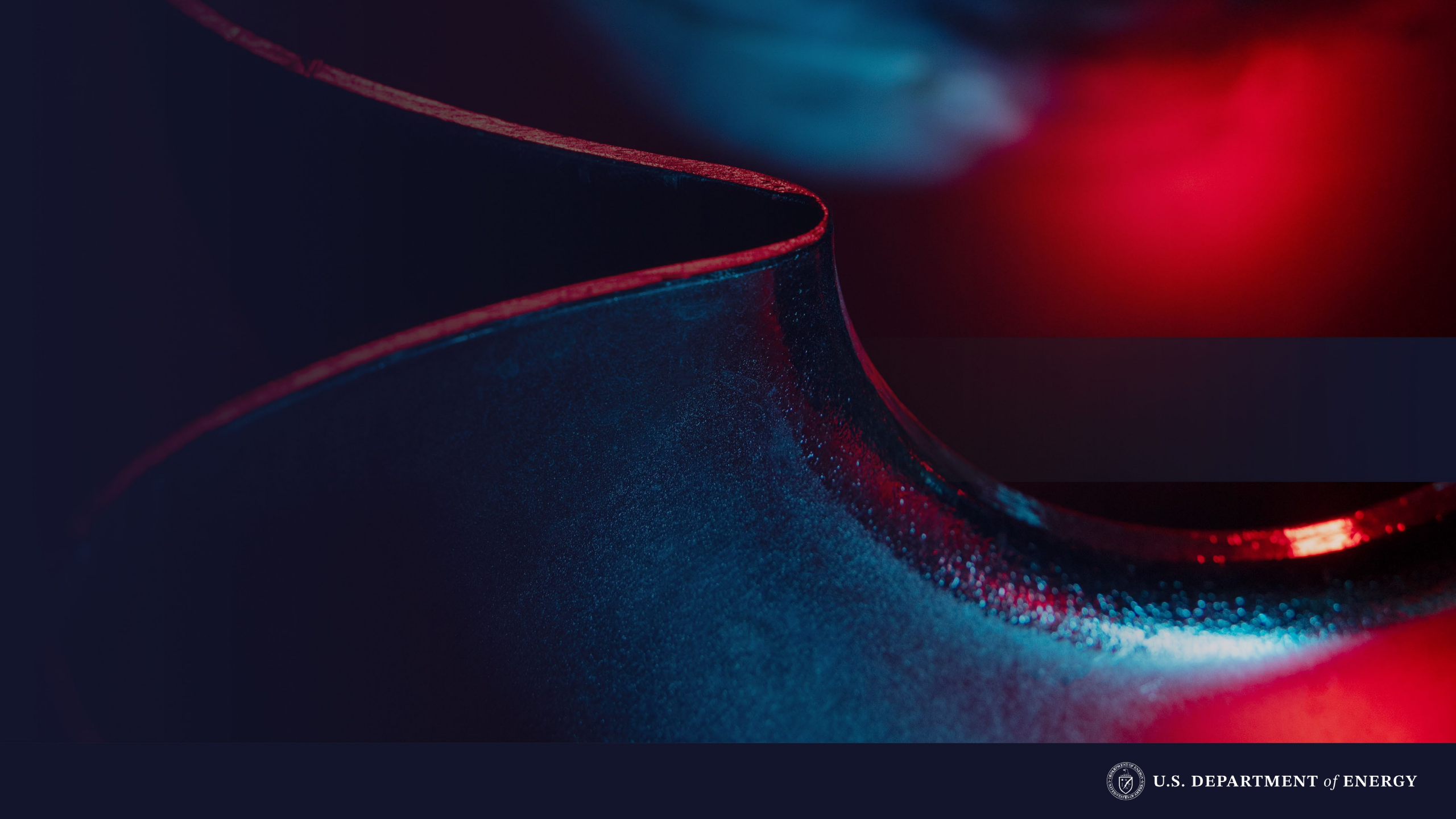
- PIs are strongly encouraged to seek support for existing and planned AI/ML R&D activities through Genesis Mission RFAs, NoFOs, lab calls, and other calls for proposals.
  - Existing research scope that can be aligned with Genesis Mission opportunities should be included in new proposals to future opportunities
  - PIs are encouraged to prepare by seeking out appropriate research partners at other institutions with shared research interests
    - These collaborations may leverage existing scientific collaborations, or develop new teaming arrangements

Summary

- The Genesis Mission has launched a new collaboration to understand the most challenging engineering and science challenges using cutting-edge AI tools and a modern computing ecosystem the unifies experiments, data, and computing.
  - HEP is already seeing the impact across many initial Genesis Mission activities
    - IPs have changed the way our facilities and experiments operate, IDAs have provided new ways to interact with HEP data, seedling model teams have brought together new collections of experts to enable discovery.

- To utilize the rapidly developing computing systems and frontier AI models of the Genesis Mission requires new collaborations and a shift in strategy for HEP research

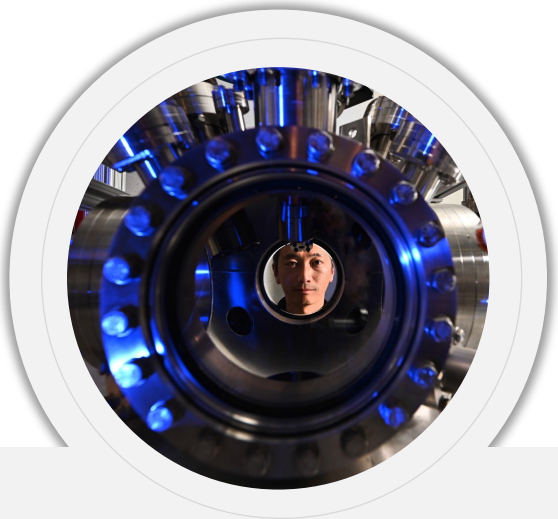
- DOE HEP looks forward to partnering with the community to ensure the Genesis Mission collaboration and tools developed accelerates HEP discovery science



U.S. DEPARTMENT *of* ENERGY

Genesis Mission: Transforming Science and Technology through AI

AI will be used to address grand challenges, ignite innovations, and drive unprecedented progress for national and global impact.



Energy Dominance

AI will be used to accelerate sustainable fusion power, optimize advanced nuclear reactor design and operation, and enable a more intelligent and resilient electrical grid.

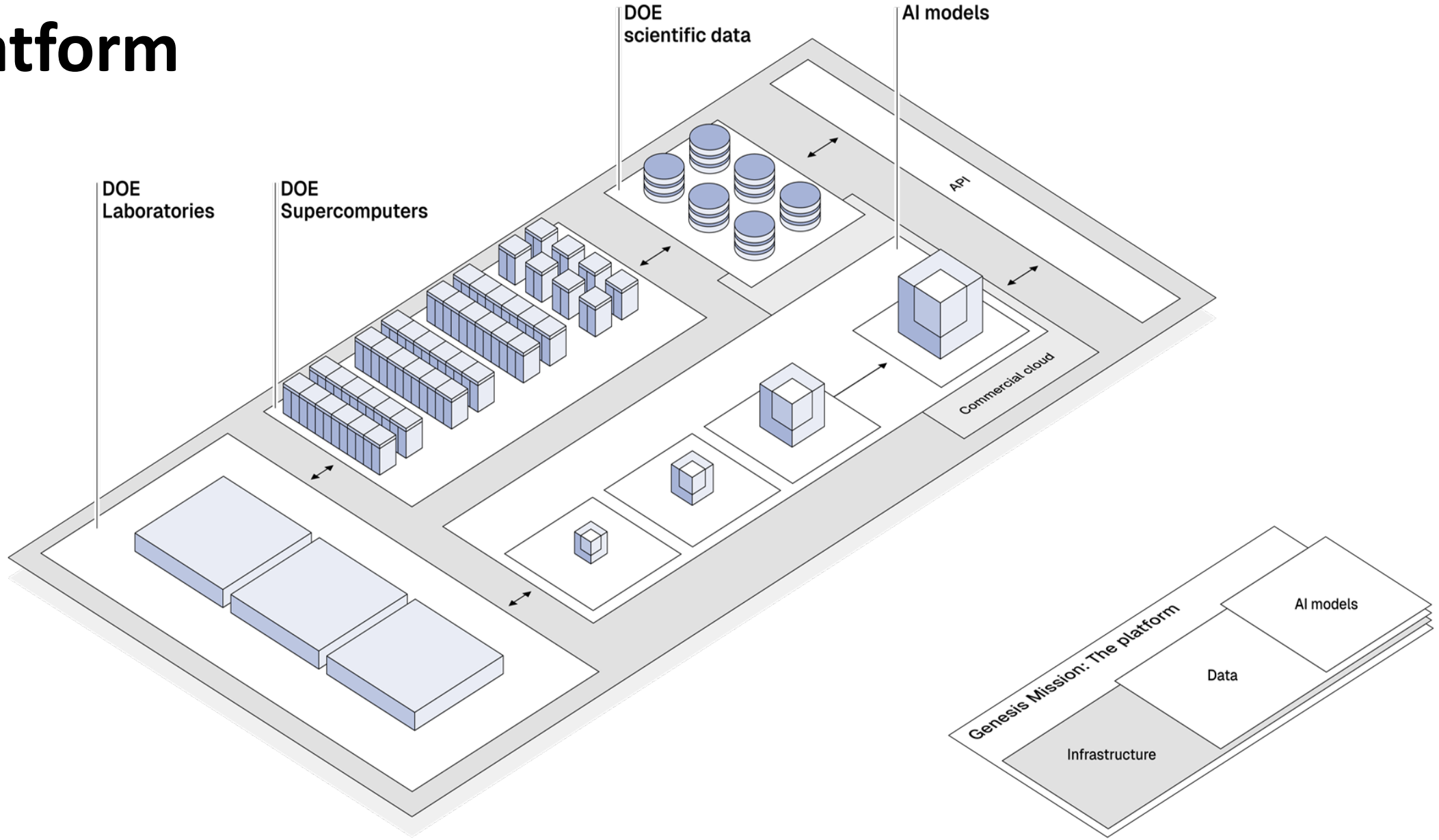
Discovery Science

AI will be used to illuminate molecular dynamics, unify data to understand the universe from quarks to cosmos, and generate new quantum algorithms.

National Security

AI will be used to secure critical materials, accelerate advanced manufacturing, and discover mission-ready materials for defense and industry.

The Platform



Executive Order: Launching the Genesis Mission for U.S. Leadership in AI

- Dedicated, coordinated national effort to unleash a new age of AI-accelerated innovation and discovery that can solve the most challenging problems of this century
- Synergistic effort to bring together U.S. research and development resources to achieve dramatic acceleration in AI development and utilization
- Development and operation of the American Science and Security Platform to serve as the infrastructure of the mission integrating high-performance computing, AI modeling and agents, computational and simulation tools, secure data access, and experimental and production tools
- Identification and prioritization of national science and technology challenges where AI will make the most significant impact (i.e., demonstrate AI advantage) on national security, economic competitiveness, and technological leadership

Links to Information

- **DOE Funding Opportunities Website**: https://science.osti.gov/Funding-Opportunities (Includes RFA; Templates; Frequently Asked Questions; Webinar Registration, Slides, and Recordings)
- **Genesis Mission Consortium - Partnership Exchange**: https://partnerships.genesismissionconsortium.org/user/login
- **Office of Science Updates:** https://public.govdelivery.com/accounts/USDOEOS/subscriber/new (including announcements about RFA updates)
- **Information about participating DOE offices:**
  - The Office of Science (SC): https://www.energy.gov/science/office-science
  - The Office of Critical Minerals and Energy Innovation (CMEI): https://www.energy.gov/cmei/office-critical-minerals-and-energy-innovation
  - The Office of Environmental Management (EM): https://www.energy.gov/em/office-environmental-management
  - The Office of Nuclear Energy (NE): https://www.energy.gov/ne/office-nuclear-energy
  - The Office of Electricity (OE): https://www.energy.gov/oe/office-electricity
  - The Hydrocarbons and Geothermal Office (HGEO): https://www.energy.gov/hgeo/about-hydrocarbons-and-geothermal-energy-office

HENP National Challenges and FY26 Focus Topics

7. Discovering Quantum Algorithms with AI

E. Quantum Advantage for Nuclear and Hadronic Systems (HEP, NP)

Use AI to determine the quantum computation advantage in nuclear and hadronic systems typically described through lattice quantum chromodynamics. Enable solutions using quantum algorithms that demand AI to tackle the challenges of chiral symmetry breaking, confinement, relativistic kinematics, and infinite degrees of freedom.

8. Realizing Quantum Systems for Discovery

B. AI for Control of Quantum Systems (HEP, NP)

Implement AI-based methods in control systems to dramatically improve the real-time control of practical quantum systems, including automating and optimizing calibration, tuning, noise mitigation, error correction, and readout processes, providing accurate, practical, and scalable quantum control to a wide variety of potential users.

C. AI for Quantum Imaging and Sensing (HEP, NP)

Integrate AI into multi-qubit quantum sensing applications for extreme sensitivity in both the laboratory and field environments to enhance and optimize the design, fabrication, and operation of sensors based on the quantum properties of superconductors, semiconductors, atoms, or other physical substrates.

HENP National Challenges and FY26 Focus Topics

9. Recentering Microelectronics in America

G. Microelectronics in Harsh Environments (HEP)

Integrate AI into the design and validation of robust devices and facilitate the efficient operation of devices that process high data volumes in harsh environments where there is no possibility of replacement or service.

J. Low-temperature Electronics for Sensors and Computation (ASCR, HEP)

Low-temperature (mK up to 120K) electronics, including cryogenic CMOS and superconducting logic, promises efficient, high-speed, and low-cost computing to address Genesis Mission needs in edge computing and AI accelerators, but bottlenecks in design, density, scaling, fabrication, and integration have prevented practical realization of these benefits. Research proposals may focus on EDA for superconducting digital logic, analog and digital superconducting electronics for sensors or for classical control of quantum computers, superconducting neuromorphic, AI, and control circuits, distributed superconducting computing architectures, or cryogenic CMOS.

HENP National Challenges and FY26 Focus Topics

13. Enhancing Particle Accelerators for Discovery

A. AI-driven Accelerator Facilities (BES, HEP, IRP, NP)

Enable and deploy AI systems that provide real-time operational advice, automate control functions, enhance beam stability, reduce beam tuning time, predict equipment failure, detect faults, and optimize performance for both large and small-scale accelerator facilities currently operating or under construction. Scope includes the development and deployment of high-fidelity AI-driven "digital twins" of these particle accelerators to enable a sophisticated simulation and design environment and AI systems that can mitigate cost and risk of accelerator facilities under construction.

HENP National Challenges and FY26 Focus Topics

14. Unifying Physics from Quarks to the Cosmos

A. Foundation Models of Particle Interactions and Cosmic Physics (HEP,NP)

Develop and curate the essential data of nuclear and particle experimental efforts, critical to train foundation models of particle interactions and cosmology to accelerate new breakthroughs in our understanding of the universe. Data and models may include the future Electron-Ion Collider, cosmic observations, underground and accelerator-based experiments as well as synthesizing different modalities of data from across multiple large-scale sky surveys to understand nuclear astrophysics, dark energy, dark matter, and the physics of the early Universe. Successful scope will seamlessly span experimental and theoretical inputs across the pinch points of analysis pipelines from detector-level through to final scientific artifacts, along with the output of advanced theoretical calculations. Discovery science potential will be maximized by addressing such technical challenges as sparse-data domains and real-time data acquisition of high-dimensional petabyte-scale datasets with associated scalability challenges and interpreting the experimental signals using theoretical knowledge.

HENP National Challenges and FY26 Focus Topics

14. Unifying Physics from Quarks to the Cosmos.

B. AI Accelerated DUNE Science (HEP)

Develop AI methods that significantly speed up and enhance the DUNE science program, reducing the time needed for the collaboration to publish neutrino oscillation measurements, significantly improving the sensitivity to neutrinos from core-collapse supernova, and developing new flagship measurements that will enhance the DUNE science goals.

C. Expedited Discovery from High Complexity and Petabyte-scale Datasets (HEP, NP)

Partner domain expertise with data science and industry to develop AI methods and techniques capable of drawing robust scientific insight from increasingly complex and/or petabyte-scale datasets. Enable deeper insights by directly connecting datasets with theoretical parameters for uncertainty-aware reasoning to leverage the high-dimensionality of particle physics datasets. Scope will address the critical slowdown problem in Lattice QCD, automate big-data analysis, achieve new levels of experimental precision and theoretical calculation, and significantly improve understanding of the universe and particle interactions. AI-assisted design to maximize experimental sensitivity to fundamental parameters of interest or that significantly reduces costs of proposed or current projects and can be implemented in the next three to five years, is also of interest.

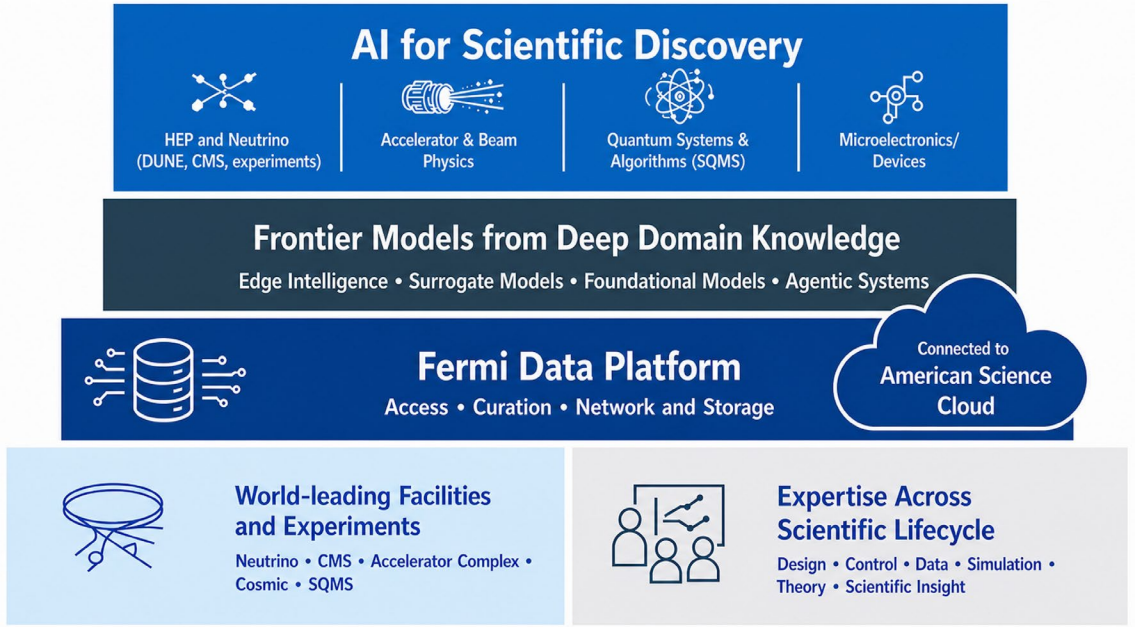
Bringing Together World-Class Innovators Across Sectors

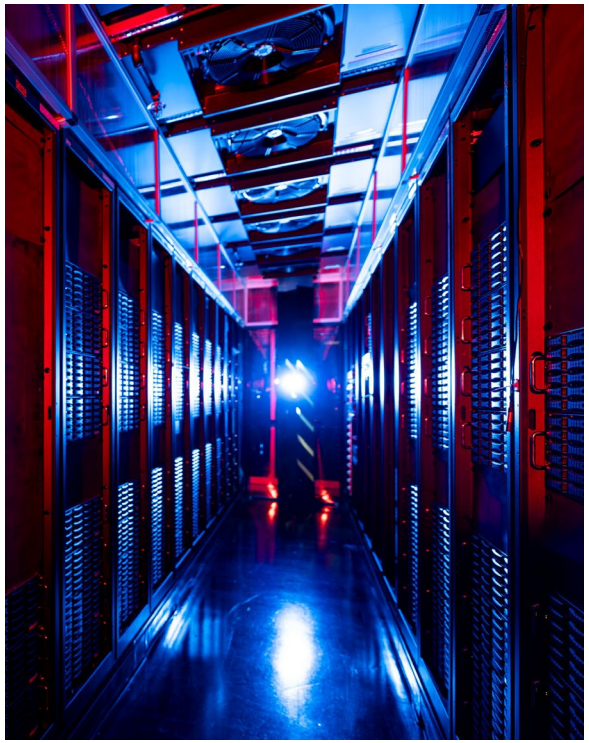
Under the leadership of DOE and the White House Office of Science and Technology Policy, the Genesis Mission brings together **DOE's National Laboratories** with America's **leading universities**, **non-profits**, and **industry**, including pioneers in artificial intelligence, computing, materials, and energy.

US-Japan Genesis Mission Partnership

Fermi Data Platform

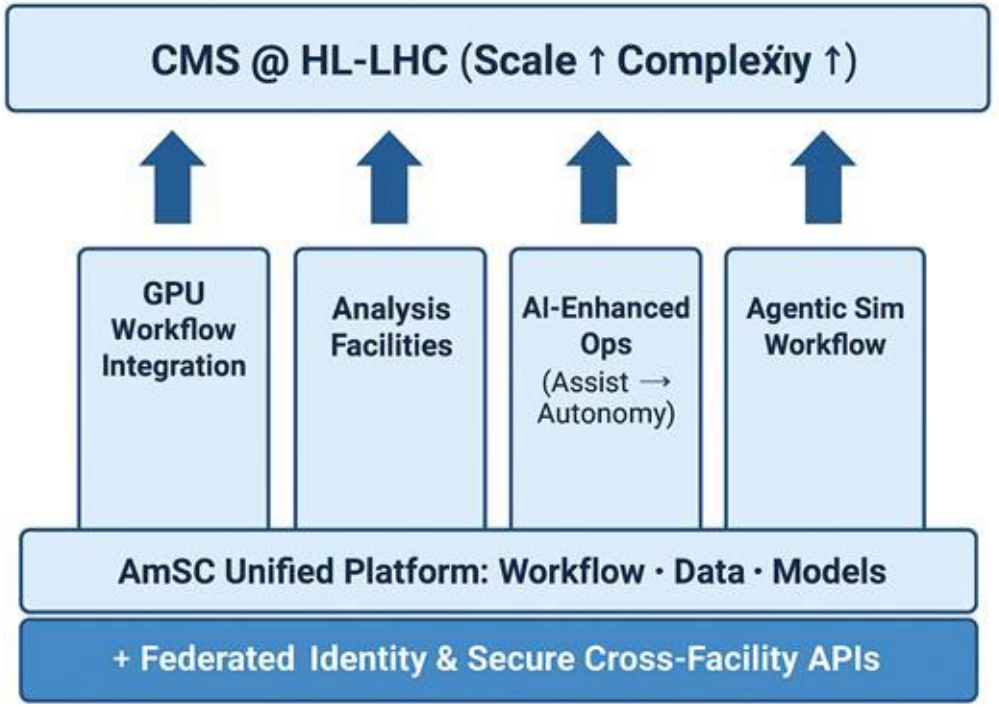
- Fermi Data Platform (FDP) provides the infrastructure to host and serve curated AI ready datasets
  - Including expert documented metadata to enable data discovery by agentic systems
  - Already serving a large and growing user community
  - Built on distributed computing tools like xRootD, and globus integrated with AmSC infrastructure





HEP IP Pilot CMS

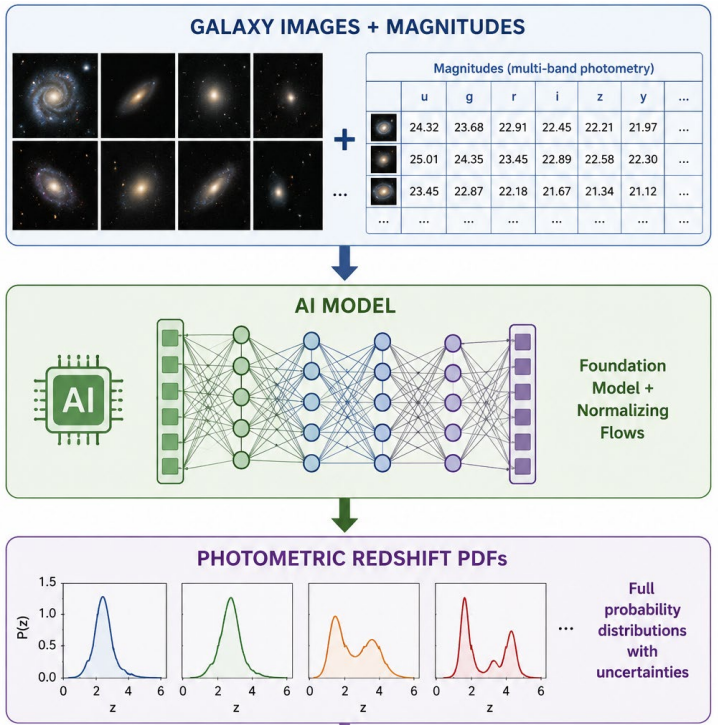
- CMS represents a complex globally distributed scientific workload
  - HL-LHC will bring order of magnitude increases in data volume and simulation throughput
- Utilize the Genesis Mission platform workflow and orchestration APIs, data services, model services, federated identity and security
- Focus on four initiatives:
  - GPU Enabled workflow integration with Genesis Mission
  - Analysis facilities on the Platform
  - AI enhanced computing operations
  - Agentic simulation workflow

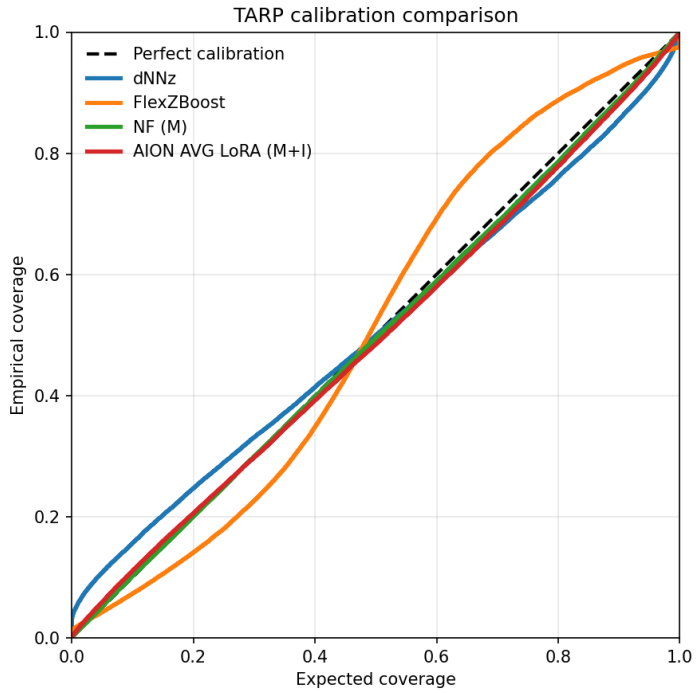


HEP IDA Pilots

- **AI Universe** – unites multiple national labs to build an integrated, AI-ready Cosmic Frontier data repository and use foundation models to advance discovery of dark energy, dark matter, and cosmic structure through multimodal astrophysical data analysis

- Foundation Model processes galaxy images and magnitudes to predict photo-z redshifts
  - Relative to HSC dNNz gives improvement of
    - 33% reduction in bias
    - 12% reduction in RMSE
    - 22% improvement in R^2





HEP IDA Pilots

- **Knowledge Extraction –** develop an HEP-focused framework for agentic AI that emphasizes specialization and modularity, where reasoning models orchestrate HEP foundation models, simulators, data sources, and analysis tools, with applications such as data resurrection and investigations of dark matter physics serving to ground and demonstrate the approach.

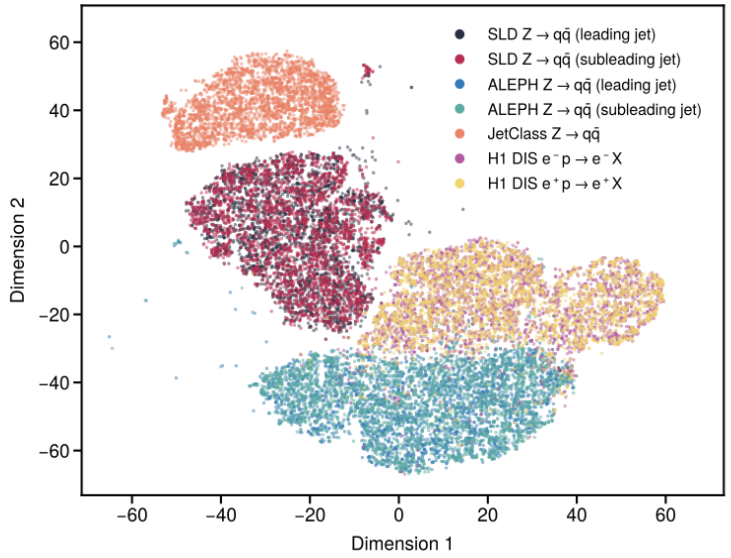
An AI-ready, Polarized Electron-Positron Collision Dataset

Chi Lung Cheng,[1,*] Simon Corrodi,[2,†] T. J. Hobbs,[2,‡] Alaettin Serhan Mete,[2,§] and Benjamin Nachman[1,¶]
[1]*SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA*
[2]*High Energy Physics Division, Argonne National Laboratory, Lemont, IL 60439, USA*

https://arxiv.org/pdf/2606.00224

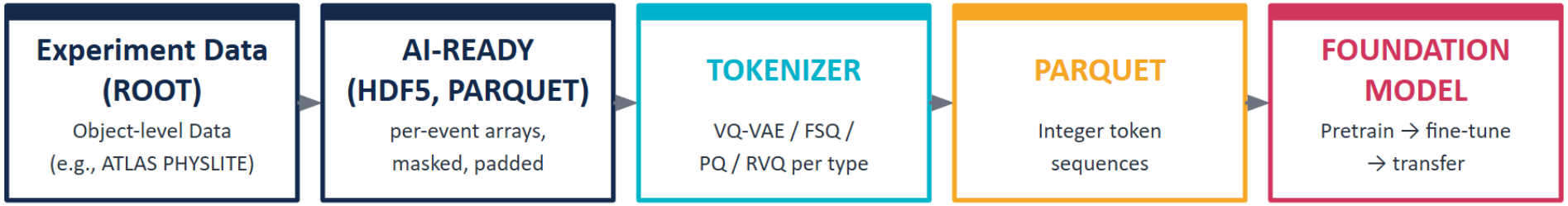
(includes links to data/documentation/code)

- Used LLMs to reverse engineer the SLD binary format to extract full physics content
- Reproduced legacy physics studies - basis for enhancing these with AI in the future
- Embedded data into OmniLearn foundation model latent space to demonstrate uniqueness and AI-readiness
- Published reconstructed data in modern format and expert knowledge from never-on-the-internet documents

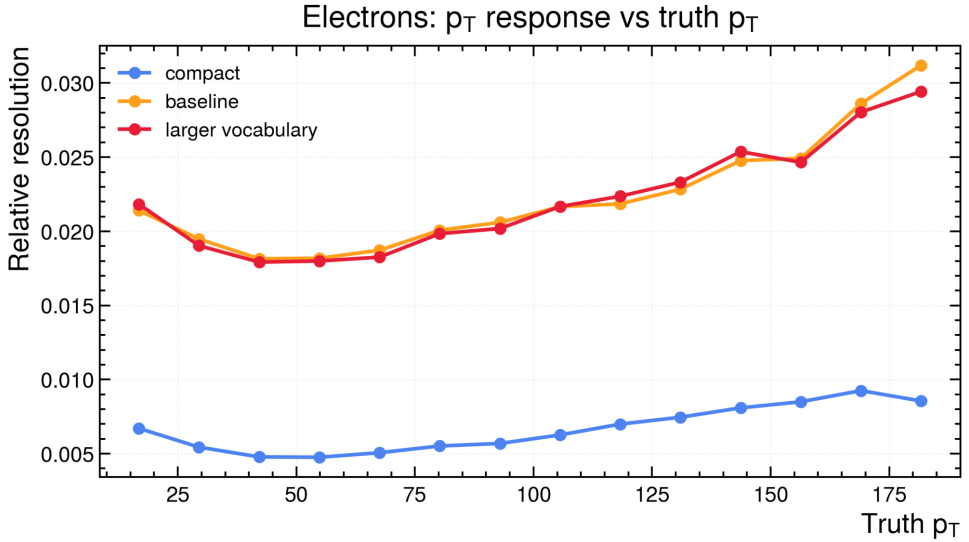


HEP IDA Pilots

- **TREASURE –** develop tokenized, AI-ready datasets from collider experiments and demonstrate cross-experiment foundation models that accelerate discovery in high-energy physics.

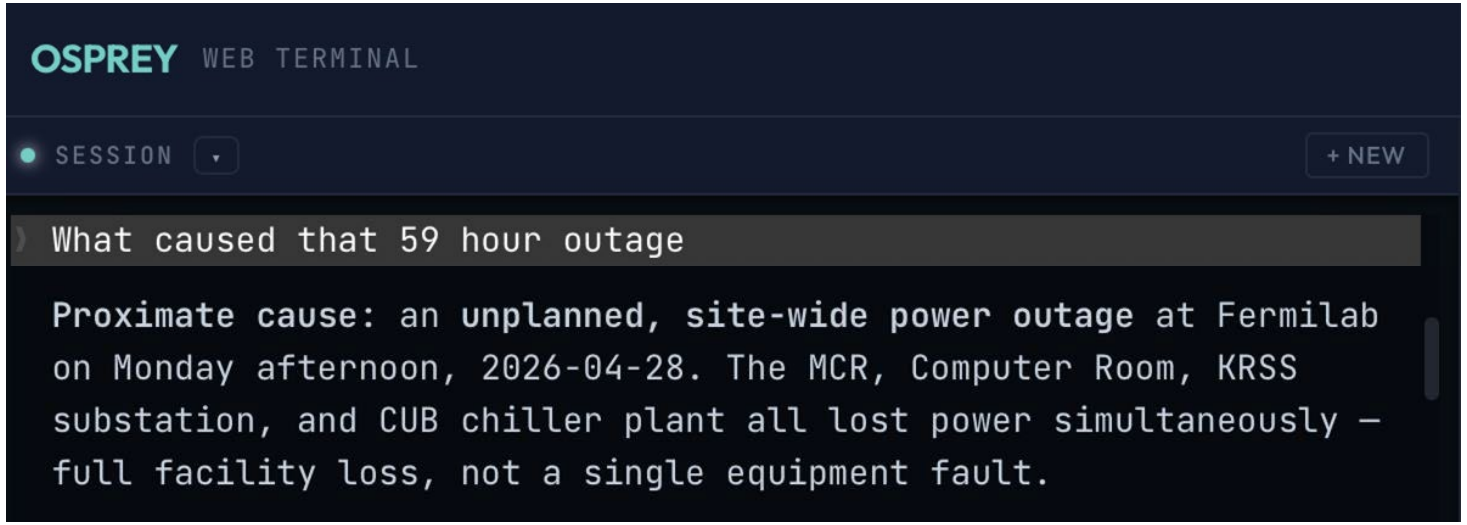


Resolution vs p_T: lower curves mean better reconstruction across the kinematic range



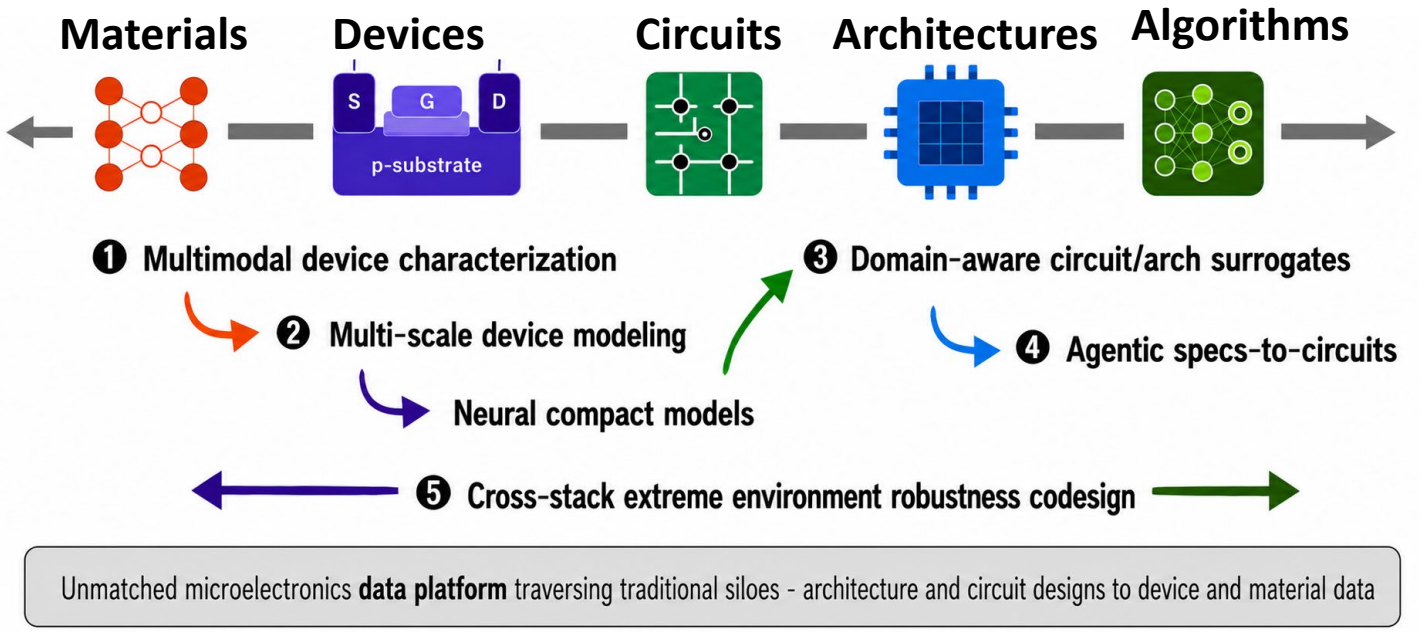
Multi-Office Accelerator Team

- Designed developed and deployed OSPREY agentic platform
  - Integrated with control system infrastructure, optimization packages, electronic logbooks, data archives, machine information databases, etc.
- Deployed at 11 accelerators across 6 DOE labs
- FNAL logbook integration allowed OSPREY to diagnose downtime 200x fast than shifter
  - Detected extended no-beam intervals and cross-referenced with elog



Accelerating eXtreme Environment Specs-to-Silicon (AXESS)

- Develop DOE-specific Microelectronics design tools to speed-up research and development in extreme environments where commercial tools fall short
  - Use decades of ASIC circuit designs from applications in extreme environments with characterization and testing data
  - Build foundational surrogate models across different levels of the microelectronics development workflow utilized by agentic orchestration
- Seed effort focused on qubit readout
  - Resulted in 500x faster circuit design



Genesis Mission

SC HEP Selections

Topic	Proposal #	Institutions (Lead, Partners)	PI	Proposal Title
9-F	298843	**Stony Brook**, BNL, Indiana	Salman, Emre	AI-Driven Autonomous and Self-Healing Readout Electronics for Radiation-Tolerant HEP Detectors
9-I	295110	**ANL**, SLAC, Illinois, Northwestern, Global Foundaries, Quantum Motion, Qo Lab, Quantum OPS, NIST	Miceli Antonino	CMOS + X: AI-Enabled Cross-Domain Co-Design for Low-Temperature Electronics, Sensors and Computation
13-A	295680	**FNAL**,LBNL, SLAC, ANL, Cornell, MSU, TTIC, Michigan, xLight Inc, *KEK*	Posen, Sam	AI/ML Resonance control for high-reliability, low-cost accelerator operations

Genesis Mission

SC HEP Selections

Topic	Proposal #	Institutions (Lead, Partners)	PI	Proposal Title
14-A	295960	**CMU**, U. of Wash., SLAC, *CNRS Research*	Mandelbaum, Rachel	A Unified Multimodal Data Service for AI-Driven Cosmology
14-A	298047	**Wisconsin**, ANL, CMU, Kentucky	Pettee, Mariel	Principles of Foundation Models for Particle and Nuclear Physics
14-A	296440	**Colorado**, FNAL, Johns Hopkins, UCSD, Adv. Micro Devices, *CERN*	Ulmer, Keith	AIDA-Scout: AI for Inclusive Real-Time Anomaly Detection and Accelerated Discovery in the CMS Level-1 Scouting System
14-B	298631	**Duke**, FNAL, Columbia, SuperMicro, NVidia	Scholberg, Kate	AI-Accelerated Supernova Burst Response with DUNE
14-B	301268	**Florida State**, FNAL	Sanchez, Mayly	Accelerating DUNE Physics with AI Discovery of Neutrino Interaction Uncertainties
14-B	297313	**Stanford**,SLAC, Tufts, Amazon Web Services	Darve, Eric	ORACLE: Observatory for Reasoning, Anomaly detection, and Causal Learning in Experiments

Genesis Mission

SC HEP Selections

Topic	Proposal #	Institutions (Lead, Partners)	PI	Proposal Title
14-C	297667	**BNL**, JLab, Pitt, Texas, Google	Klimentov, Alexei	Transforming Computing Cyber infrastructure for Collider Experiments to AI Based Computing and AI-ready Data
14-C	298569	**Columbia**, BNL, BU, UConn	Christ, Norman	AI-accelerated sampling for critical slowing down in lattice QCD
14-C	299058	**LLNL**,CMU	Schneider, Michael	Dynamical Learning for Fast, Uncertainty-Aware Cosmological Inference from Rubin Data
14-C	295928	**Oregon**, BNL, Brown	Majewski, Stephanie	MANGO - Monte Carlo Acceleration via Normalizing Flows Using GPU Optimization
14-C	298008	**South Carolina**, ANL, FNAL, Cal Tech, UVA, Yale	Tedeschi, David	Expedited Discovery by Leveraging Agentic Workflows for the Mu2e Charged Lepton Flavor Violation Search
14-C	300891	**Alabama**, FNAL, Google, NVidia, Orchestral AI	Matchev, Konstantin	AI Agents for HEP Simulations and Analysis Operations
14-C	298412	**UNM**, LANL, Rutherford Appleton Lab	Loomba, Dinesh	Learning Beyond Threshold: AI-Driven Signal Extraction for Rare-Event Searches