

AI Initiatives in the Cosmic Frontier

Committee on Astronomy & Astrophysics

March 25, 2026

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Office of High Energy & Nuclear Physics

Cosmic Frontier Dream Team

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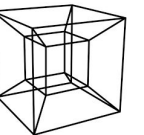
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U.S. DEPARTMENT
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[Energy.gov/science](https://www.energy.gov/science)



Outline

- AI/ML Strengthens HEP Science
- AI use by DESI
- AI use by Argonne
- AI use by LSST-DESC

- The Genesis Mission



AI/ML Strengthens HEP Science

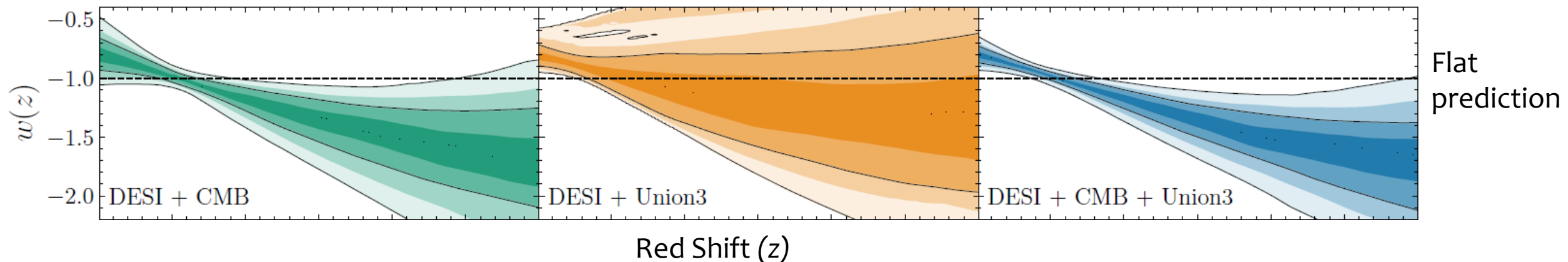
- Recent discovery by [DESI](#) that [Dark Energy](#) is not static but could evolve over time
 - Used ML to combine results from multiple experiments and for the first time determine in a model agnostic way, the Dark Energy behavior across the age of the universe (z)
 - This discovery received wide attention in global popular press with more than 1,500 articles in 35 languages
 - Use of AI/ML methods to process images and identify features

Cosmologists intrigued by signs the universe might stop expanding

The “dark energy” field that has fueled the expansion has been weakening over the past 4 billion to 5 billion years, new data shows.

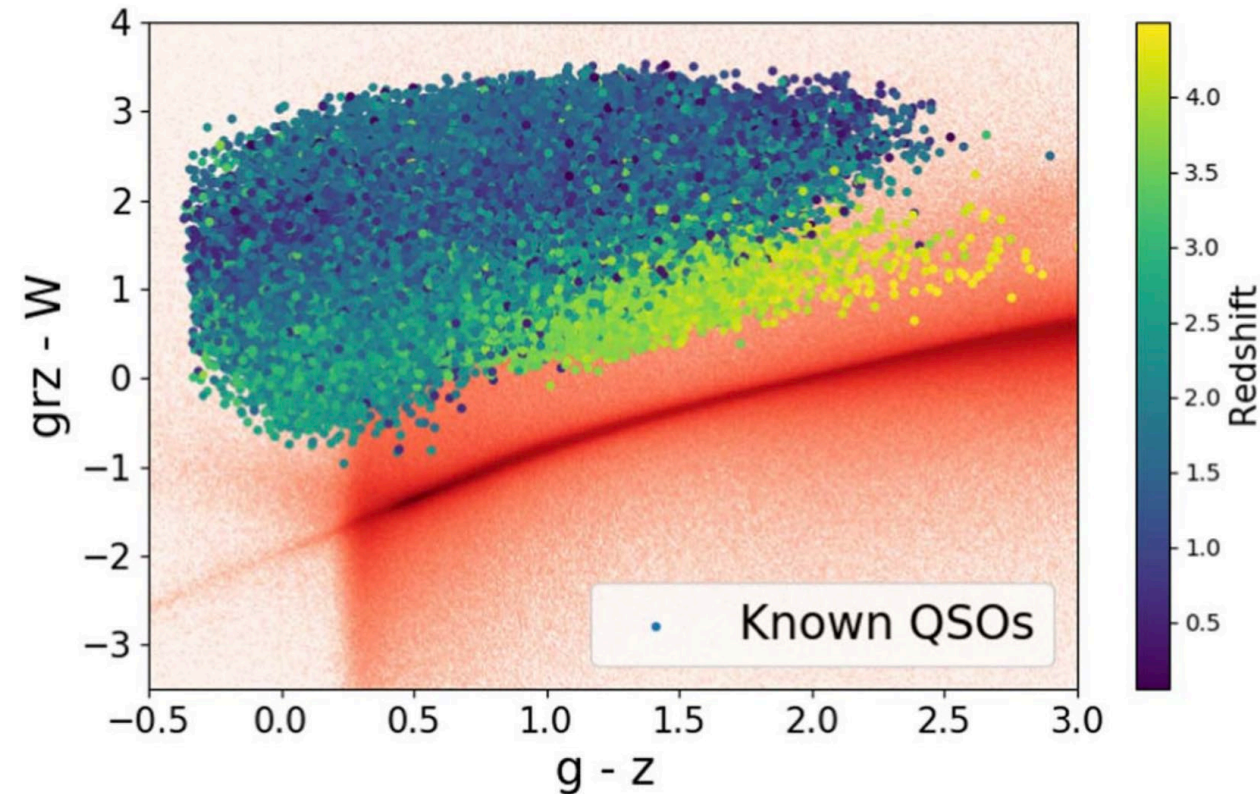
March 19, 2025

The Washington Post
Democracy Dies in Darkness



AI for DESI quasar selection

- DESI targets selected from flux in 3 optical bands and 2 near-IR bands + source size
- Traditional technique
 - Based on cuts on source color
 - How bright in IR vs. how bright in optical?
- ML approach
 - Using Random Forest trained on
 - known quasars from prior surveys (eBOSS)
 - known stars
 - Achieves 20% more quasars than color-cuts

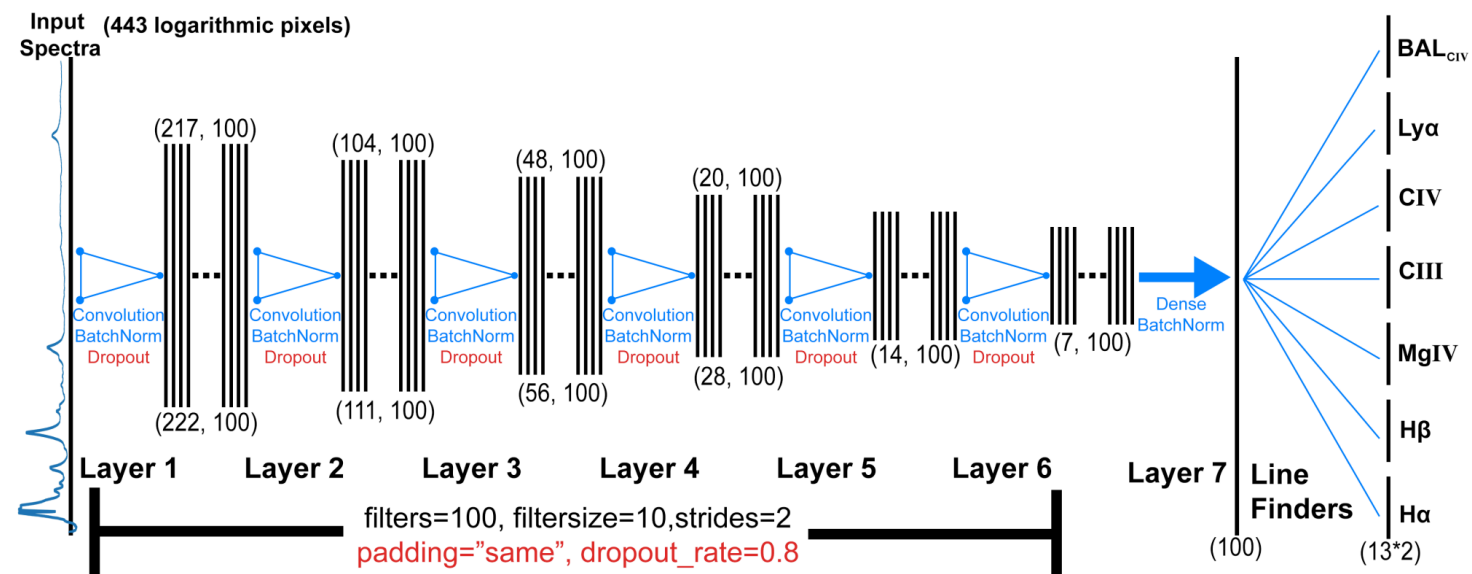


Thanks Nathalie Palanque-Delabrouille!

AI for classification of DESI spectra

Improved identification of quasars in DESI spectra thanks to AI

[arXiv:2505.01596](https://arxiv.org/abs/2505.01596)



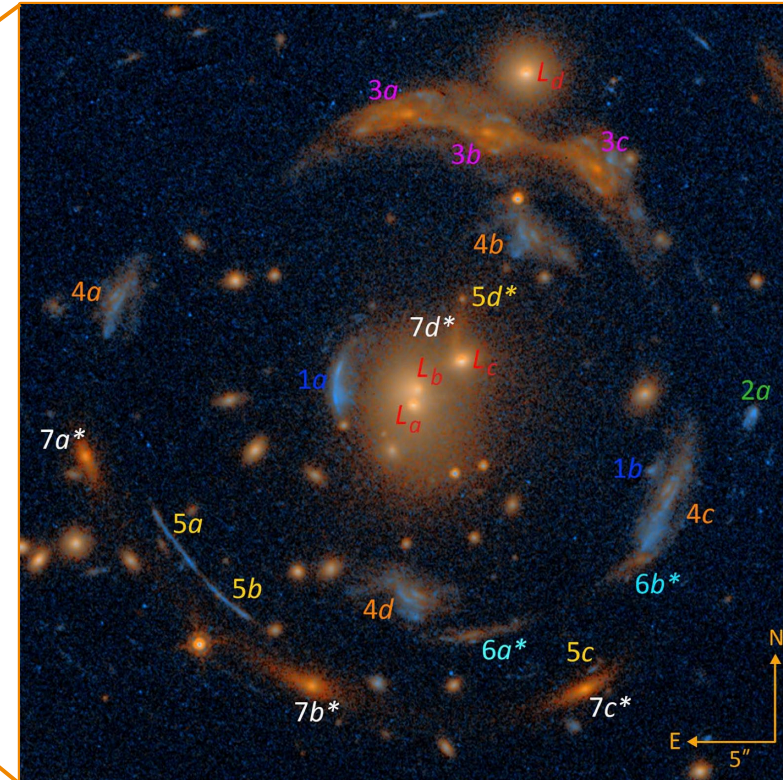
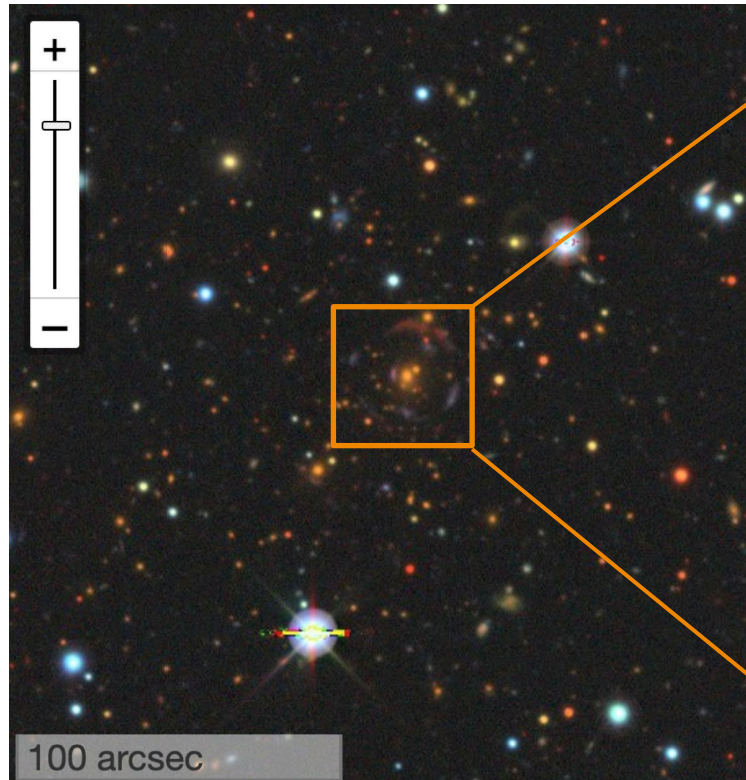
- DESI spectra automatically classified into emission-line galaxy, luminous red galaxy, star, quasar ...
- Traditional techniques have lower classification efficiency on quasars
- Significant improvement using two-step ML approach
 - 1/ Active learning algorithm (self-Organizing Map) as initial rejection to improve labeling of spectra to be used in training
→ 10% improvement of classification accuracy
 - 2/ Deep Convolutional Neural Network (CNN) to perform feature detection and identify emission peaks in spectra
→ 99.5% purity & 99.5% completeness, significantly better than traditional methods (which required visual inspection)

Gravitational lenses discovered with AI

Strong gravitational lenses offer new tools for **cosmology**
→ expansion rate & content of the Universe

- Predicted based upon General Relativity in 1937, first one discovered in 1979
- ~10,000 discovered applying **Convolutional Neural Networks** since 2018
- Including 2024 [Carousel Lens](#): 8 galaxies in near-perfect alignment across the Universe

Discovery
image
from DESI
imaging



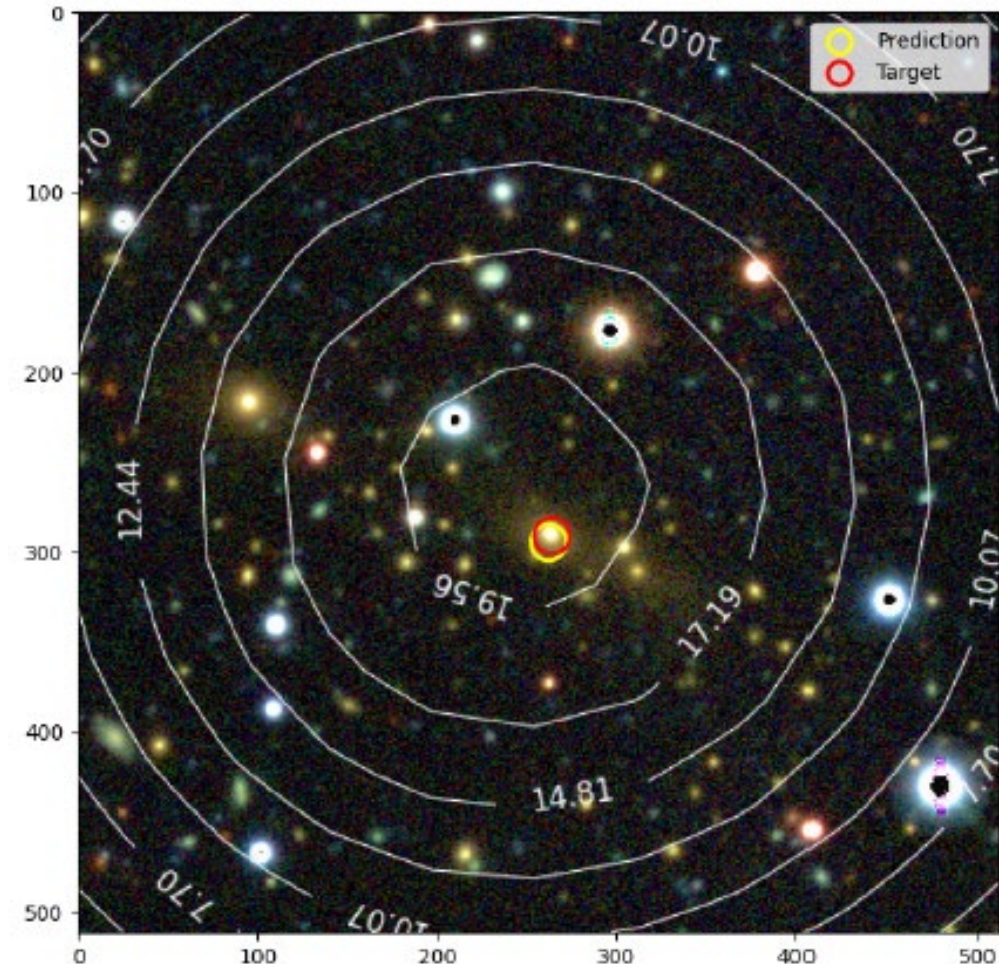
Follow-up image
from Hubble
Space Telescope

[ApJ 973, 3 \(2024\)](#)

AIML Driven Characterization of Galaxy Clusters for Cosmology

- Galaxy clusters are powerful probes of cosmology and with upcoming surveys, we expect sample sizes to grow by a factor of 10-100
- We need cluster centers, masses and cosmological distances to derive cosmological constraints
- Training data set based crowd-sourced image analysis using Argonne developed tool “Image Maker”
- Neural network approach to find cluster centers successful (though no calibrated uncertainties yet)
- Next steps will focus on masses and distances
- Future opportunities: Data driven AI methods

Thanks Kartin Heitmann, Lindsey Bleem,
Nesar Ramachandra, and Ryan Walker



Successful identifications of the cluster central galaxy using ResNet18 and a preliminary cluster dataset.

Dark Energy Science Collaboration (DESC) Early Rubin Science

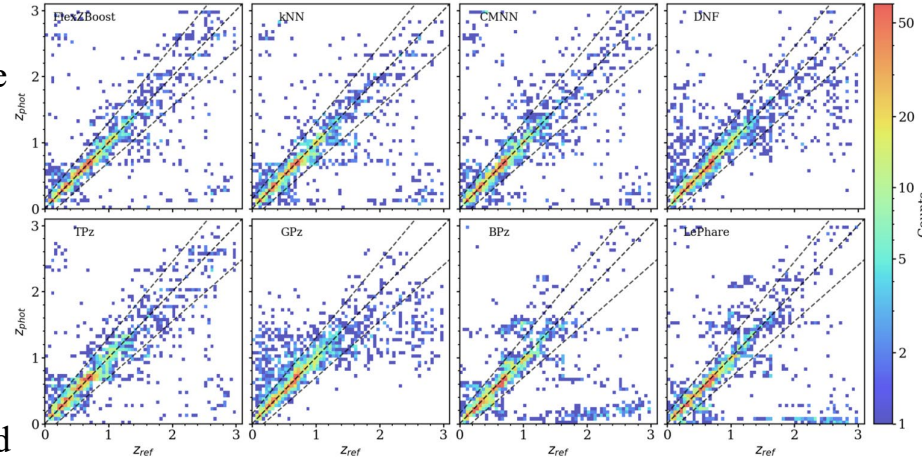
DESC is exercising its pipelines on Data Preview 1 (DP1) and leveraging AI/ML for cosmology to prepare for LSST Observations

Photometric Redshifts for DP1

DESC Photo-z software RAIL applied to the Rubin DP1 Extended Chandra Deep Field South. Eight algorithms, including 6 ML methods. Produced training galaxy catalogs, cross-matched with Euclid. (arXiv: [2510.07370](https://arxiv.org/abs/2510.07370))

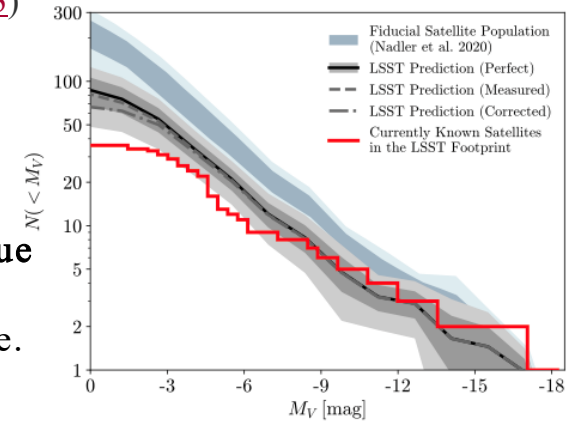
DP1 First weak-lensing measurement

Galaxy cluster Abell 360. DESC members led commissioning work on testing the data quality and measured the cluster mass with 3 shear algorithms (in prep).



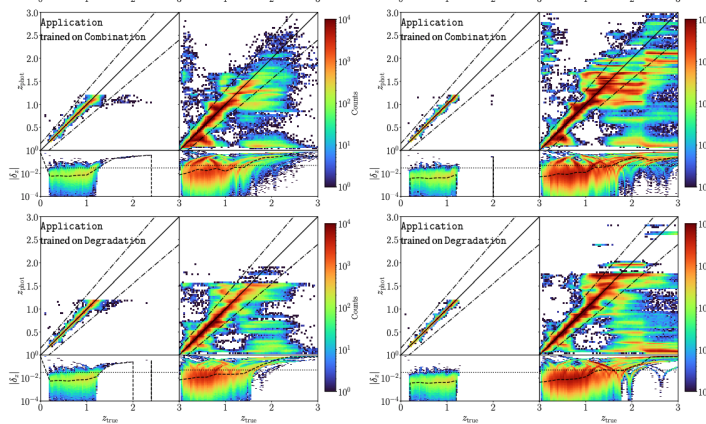
Satellite selection out to 250 kpc for dark matter demonstrated with simulations

Evaluated sensitivity to faint Milky Way satellite galaxies and outer-halo star clusters using simulated resolved stellar populations. With perfect star/galaxy separation, estimated >50% efficiency. (Tsiane et al., [2504.16203](https://arxiv.org/abs/2504.16203))



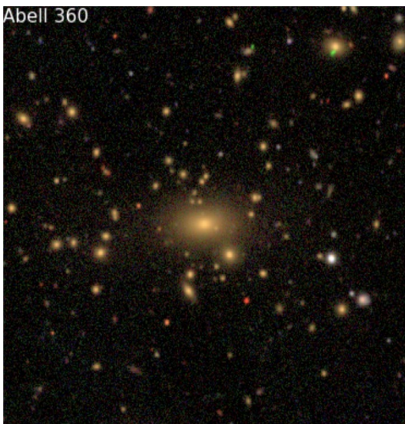
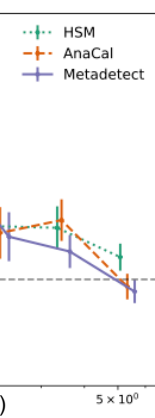
Augmenting samples for redshift calibration

Implemented machine learning “self-organizing map” technique to augment samples for photometric redshift calibration yields significant improvements. Tested in CosmoDC2 and OpenUniverse. (Zhang et al., [2508.20903](https://arxiv.org/abs/2508.20903))



Other AI/ML advances in 2025

- Hierarchical Inference for photometric classification of supernovae ([Shah+](#))
- Cataloging astronomical images via Neural Posterior Estimation ([Patel+](#))
- Identifying unrecognized blends with AI/ML ([Liang, Adari, von der Linden+](#))

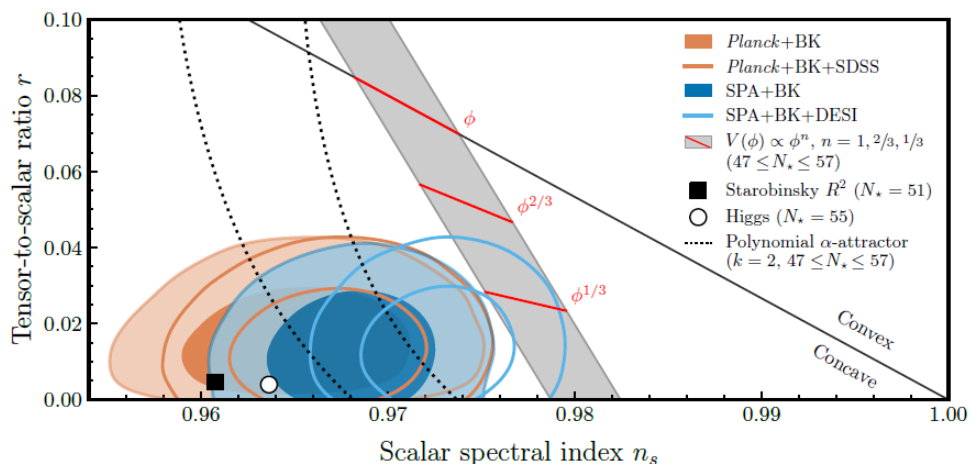


CMB Cosmology

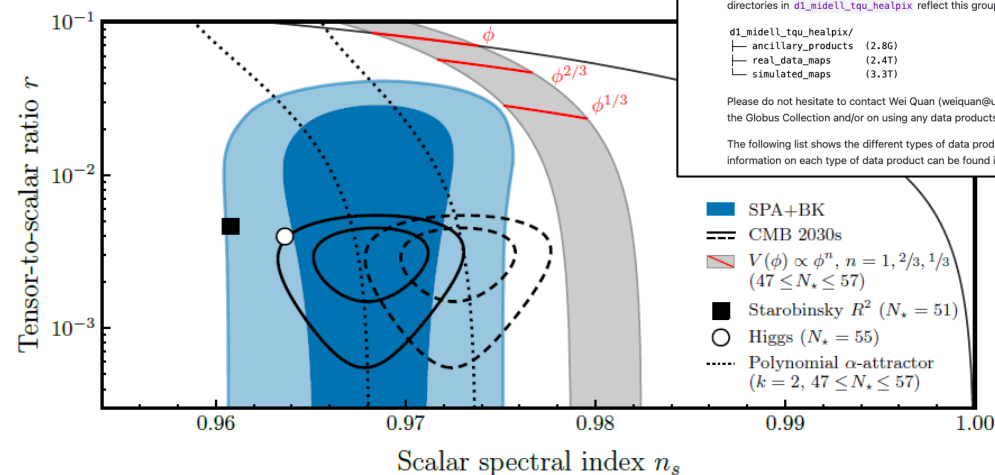
<https://arxiv.org/abs/2512.10613>



- SPT-3G has started its 7th year of the main survey (1500 sq deg) and the instrument continues to operate with high efficiency and stable sensitivity
- SPT-3G D1 Maps are Public



Addition of DESI data to CMB data shifts n_s to a different region of theoretical model space, disfavoring previously leading models of inflation



Information on an SPT-3G D1 data release

This page is linked from [the South Pole Telescope homepage](#) and was created using the tools [Jupyter Notebook](#) and [Quarto](#).

- 2026-03-23: Initial release

1 Introduction

This page provides information on a data release relevant to mainly the following two works:

- [Quan et al., SPT-3G D1: Maps of the millimeter-wave sky from 2019 and 2020 observations of the SPT-3G Main field \(hereafter Q26\)](#)
- [Camphuis et al., SPT-3G D1: CMB temperature and polarization power spectra and cosmology from 2019 and 2020 observations of the SPT-3G Main field \(hereafter C25\)](#)

The data products made available in this data release are stored in the directory `d1_midell_tqu_healpix` inside a [Globus Collection for SPT-3G public data releases](#) (Collection UUID: `0bf0cefa-568a-4b37-861d-32c9102ce7d6`). Information on how to transfer files on Globus can be found in the [final section](#) of this documentation.

The data products form three groups: real-data maps, simulated maps, and ancillary products. The directories in `d1_midell_tqu_healpix` reflect this grouping as follows:

```

d1_midell_tqu_healpix/
├── ancillary_products (2.8G)
├── real_data_maps (2.4T)
└── simulated_maps (3.3T)
    
```

Please do not hesitate to contact Wei Quan (weiquan@uchicago.edu) for any questions on accessing the Globus Collection and/or on using any data products provided in this data release.

The following list shows the different types of data products provided within each group, and more information on each type of data product can be found in a corresponding section.

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<https://pole.uchicago.edu/public/Data%20Releases.html>



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Transition to Genesis

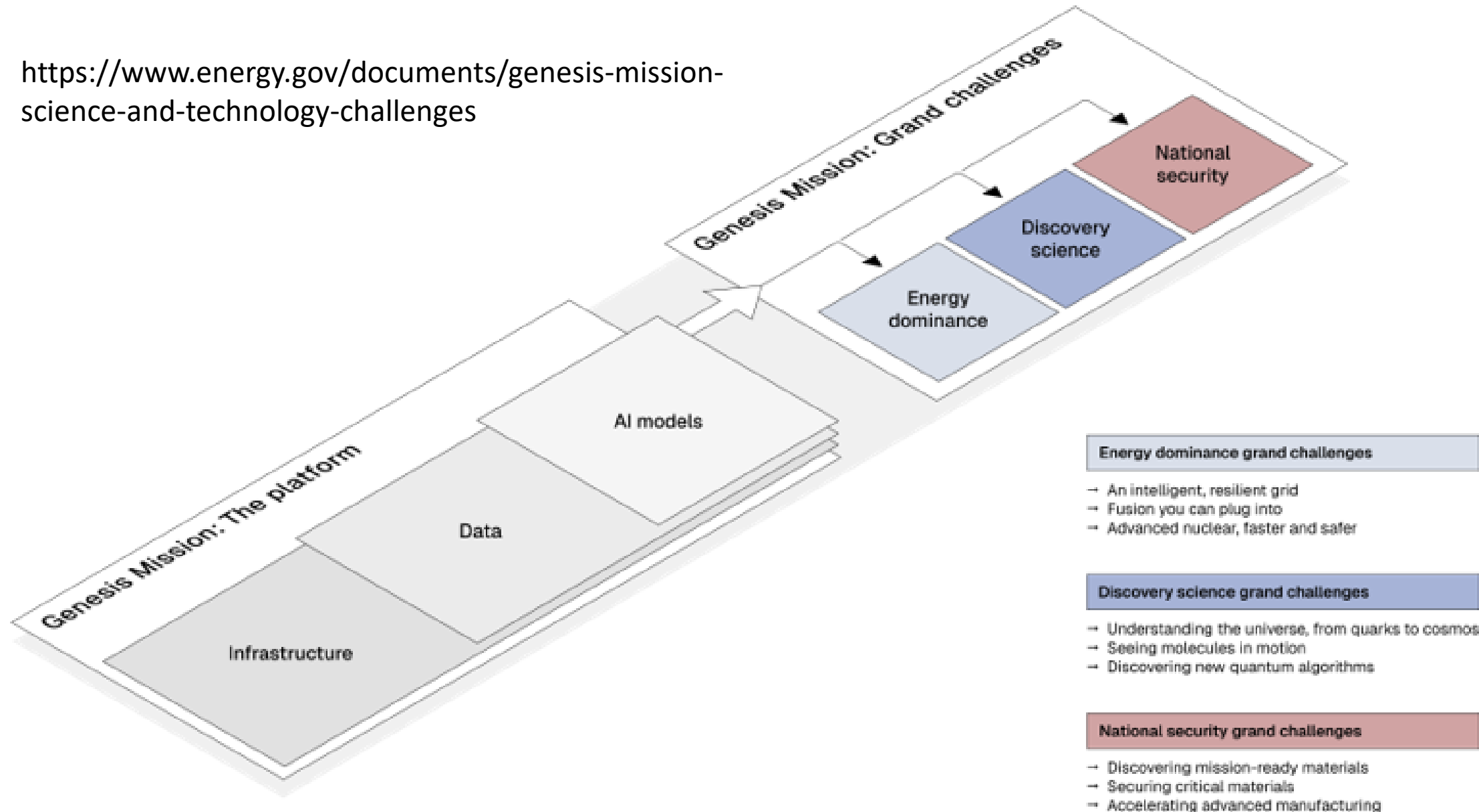


Genesis Mission will revolutionize American science and innovation

- Genesis Mission establishes the world's most powerful scientific platform to accelerate discovery, strengthen national security, and drive energy innovation.
- Integrates DOE's world-class supercomputing power, unique scientific data, and AI capabilities into a unified system to shrink discovery cycles from years to months
- Will harness scientific datasets to train scientific foundation models and create AI agents for testing hypotheses, automating research workflows, and accelerating scientific breakthroughs
- Recent collaborations with industry partners further underscore the commitment to unite government, industry, and academia to redefine American leadership in AI
- Supports American Science Cloud, (open platform for the Genesis Mission), as well as research on S&T challenges through the Transformational AI Models Consortium and program investments
- Investments in AI workforce development will grow the domestic talent to address the Nation's most challenging scientific problems



<https://www.energy.gov/documents/genesis-mission-science-and-technology-challenges>

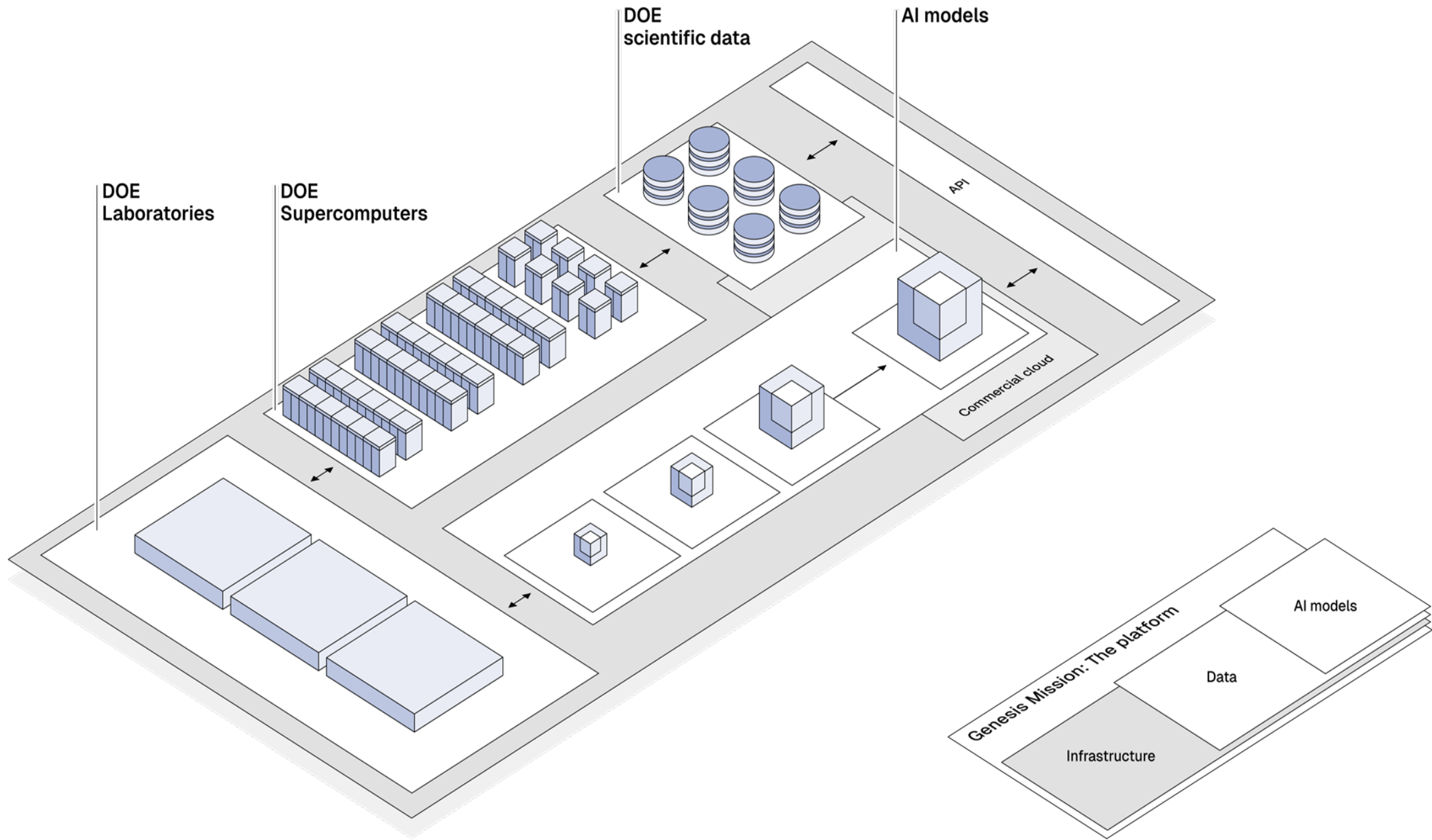


Infrastructure – American Science and Security Platform

- The Genesis Mission’s Platform infrastructure, hosting and distributing AI models and scientific data to the broader research community. The Platform will enable the 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 will meet the needs of the community

HEP IPs: BNL, SLAC, and FNAL computing services, LQCD, Scientific User-Facilities (SUF)



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 accomplish the HEP Mission

Supported three collaborative pilot projects for Intelligent Data Activities (IDAs)



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.

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.

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



Addressing a Portfolio of Key National Challenges

- Accelerating scientific discovery through AI-driven code development
- AI driven co-design for microelectronics
- AI for efficient quantum algorithms
- AI for planning and operation of the U.S. power grid
- AI for transforming combustion science and technology for energy applications
- AI for nuclear security and non-proliferation

Q2C Science at Scale: From Quarks to Cosmos

The Autonomous Microelectronics Consortium

R Accelerating Microelectronics Codesign (MTv2-Microelectronics)

R MOAT: Multi-Office Accelerator Operations & Controls

PROMETHEUS: Autonomous Power Plant Design (APPD)

SYNAPS-I: Light and Neutron Imaging FM

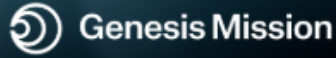
GRID-UNI: Agentic AI Foundation for the U.S. Power Grid

R MAIQMag: Multimodal AI for Quantum Magnets

OPAL-OMAHA: Bio/Autonomous Labs

Fusion-FM: Foundational Model for Magnetic Confinement Fusion





Correction: A previous version of this email used the submission deadline for Phase II Applications resulting from FY26 Phase I Awards as the closing date for applications. The correct dates for FY26 Phase I Applications and FY26 Phase II Letters of Intent are below.

Request for Applications Now Open for the Genesis Mission: Transforming Science and Energy with AI

On March 17, the U.S. Department of Energy (DOE) announced interest in receiving applications from interdisciplinary teams addressing the **Genesis Mission National Science and Technology Challenges** to accelerate scientific discovery and R&D workflow using novel AI models and frameworks. By achieving AI advantage, these teams will advance the DOE's mission and ensure America's security and prosperity by addressing energy, environmental, and nuclear challenges through science and technology.

Funding Details

- DOE expects to make multiple awards
- Total available program funding: \$293,760,000
- Submission Deadline for FY26 Phase I Applications: April 28, 2026
- Submission Deadline for FY26 Phase II Letters of Intent: April 28, 2026

[View Details](#)

Teams are encouraged to leverage the extensive scientific and data resources of the DOE, the National Laboratories, U.S. industry, and academia. Any resulting AI models, workflows, and data, will be integrated into the larger Genesis Mission capabilities.

For questions about this opportunity, please contact GenesisMissionNOFO@science.doe.gov.

More details, including the RFA text, templates, Frequently Asked Questions, and Public Webinar Registration can be found on <https://science.osti.gov/Funding-Opportunities>.

We plan to continue updating the FAQs (available on the funding opportunities page linked above) as we received questions from the community.

We plan to issue an amendment to the RFA in the near future to address how Phase II LOIs and Applications should be prepared and reviewed.

The public webinar is on March 26 from 3 – 4 pm ET.

The Genesis Mission Consortium “Partnership Exchange” is live. Applicants will be encouraged to consider this service as one of many ways they can form teams. They should also use their existing networks.

For questions about this opportunity, please contact GenesisMissionNOFO@science.doe.gov





U.S. DEPARTMENT of ENERGY

Office of Science (SC), Office of Critical Minerals and Energy Innovation (CMEI), Office of Environmental Management (EM), Office of Electricity (OE), Hydrocarbons and Geothermal Energy Office (HGEO), and Office of Nuclear Energy (NE)

Genesis Mission

The Genesis Mission: Transforming Science and Energy with AI

Notice of Request for Application (RFA) Number:
DE-FOA-0003612

RFA Type: Initial
Assistance Listings: 81.049

RFA Issue Date:	March 17, 2026
Submission Deadline for FY26 Phase I Applications:	April 28, 2026, at 11:59 PM Eastern
Submission Deadline for FY26 Phase II Letters of Intent:	April 28, 2026, at 5 PM Eastern
Submission Deadline for FY26 Phase II Applications:	May 19, 2026, at 11:59 PM Eastern
Submission Deadline for Phase II Applications resulting from FY26 Phase I Awards:	December 17, 2026, at 11:59 PM Eastern

- Genesis Mission has launched.
 - New DOE led multi-disciplinary multi-agency collaboration developing a computing ecosystem to host AI-ready datasets and train transformative AI models to address scientific grand challenges
- Beyond the initial phase DOE HEP expects scientists to continue integrating with the Genesis Mission
 - Infrastructure Partners contributing to the Platform’s software, interfaces, and computing resources
 - Collaborative Data and Model Teams using HEP expertise to prepare AI-ready datasets and to develop and adapt transformative AI models
 - HEP relevant grand challenges which will employ the Genesis Mission resources to deliver discovery science

<https://science.osti.gov/grants/FOAs/Open>

<https://science.osti.gov/-/media/grants/pdf/foas/2026/DE-FOA-0003612.pdf>



THANK YOU!

