

Jean-Luc Vay

**Advanced Modeling Program
Accelerator Technology &
Applied Physics Division**

Overview of AI for accelerators within the US DOE Genesis Mission

**Artificial Intelligence for Muon Colliders (AI4MuC)
Virtual Mini-Workshop**

June 29-30, 2026

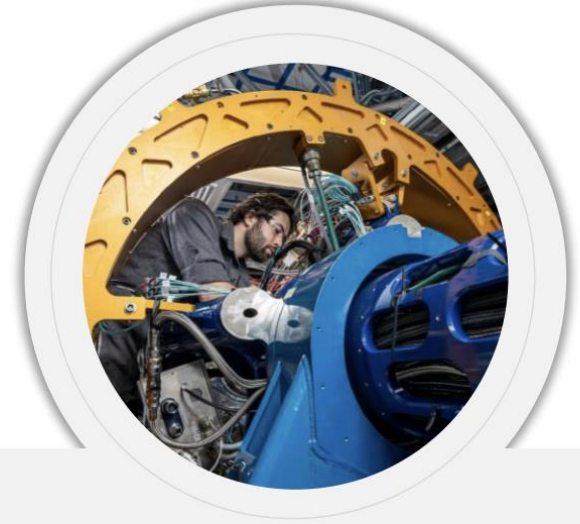
Genesis Mission: A National Mission to Accelerate Science Through AI



Energy



Discovery Science

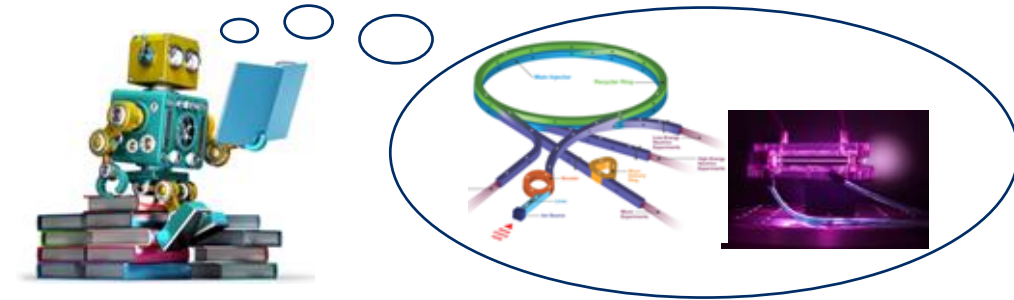


National Security

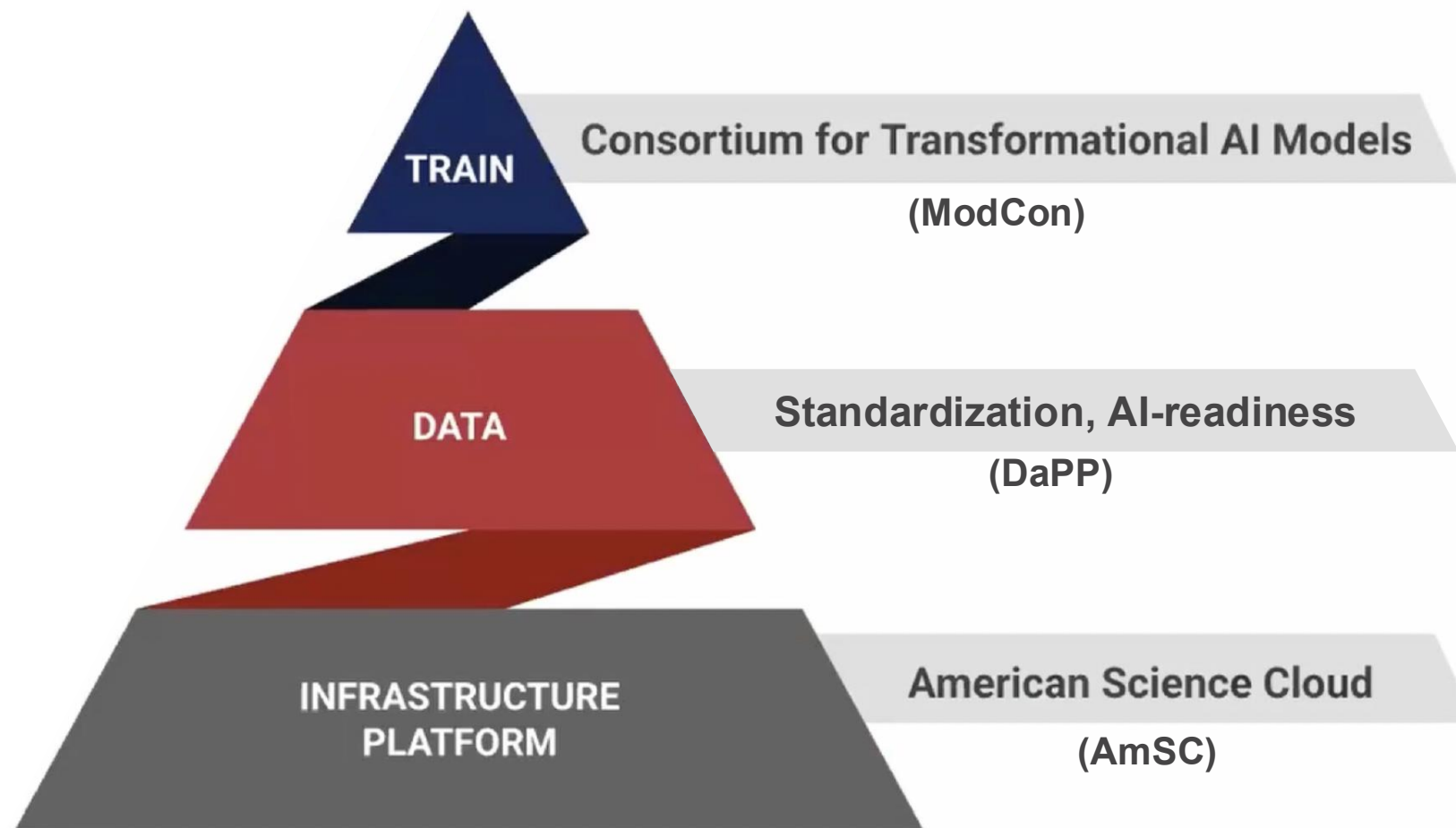
<https://genesis.energy.gov>

AI is Ideally Suited to Transform Accelerators and Applications

- **Long-term vision: AI becomes indispensable partner in accelerators**
 - Full lifecycle, from design to operation to R&D and workforce development
 - **Many benefits expected to come from AI assistance and control, e.g.:**
 - Novel designs with integrated optimization
 - Including end-to-end, detailed physics, cost, safety, etc
 - Faster designs (spans years for largest accelerators, which are among the most complex machines)
 - Higher efficiency and performance
 - Unprecedented on-demand beam customization and beam quality
 - Higher precision (control, pointing, etc)
 - Automated failure prediction and prevention
 - AI-assisted to fully autonomous operation
- **Better colliders, light sources & accelerators for many applications, e.g.:**
- DOE accelerator-based science
 - Nuclear waste transmutation
 - Advanced reactor and fusion concepts
 - EUV lithography
 - Advanced manufacturing
 - Ultracompact accelerators for medical and industrial use



Genesis simplified structure*



*From "Introduction to the American Science Cloud (AmSC) : Part One" – 11/13/2025
4 <https://vimeo.com/1137699305>



Initial accelerator projects embedded at all levels of Genesis

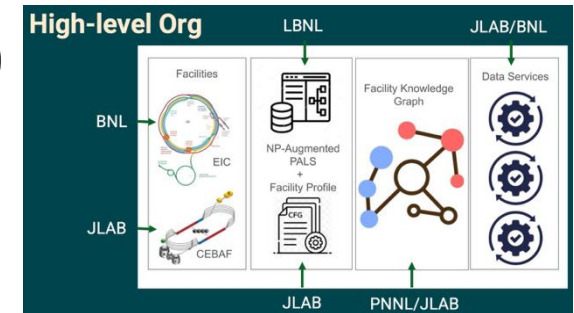
Multi-Office Accelerator Team (MOAT-seed)

- LBNL, ANL, BNL, FNAL, JLAB, ORNL, SLAC (BES+HENP)
- Deployment of shared accelerator agentic AI software across facilities (8 to date)
- Deployment of digital twin prototypes across facilities (3 to date)



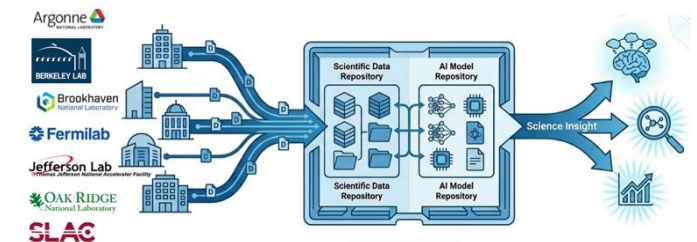
Nuclear Physics AI-Ready Accelerator Data (NARAD)

- JLAB, BNL, LBNL, PNNL; (HE)NP-focused, but coordinating with all US accelerators
- Augments the Particle Accelerator Language Standard (PALS) with facility-specific profiles and a shared ontology; Delivers cross-facility knowledge graph tools that supports subgraph extraction for diagnostics/optimization tasks



AmSC Scientific User Facility IP

- LBNL, ANL, BNL, FNAL, JLAB, ORNL, SLAC
- Establish Genesis as a shared platform to host and distribute AI models and scientific data for (mostly) accelerator-based BES, HEP, and NP Scientific User Facilities (SUFs), along with their industry and research partners



March Demo(s): MOAT in coordination with AmSC SUF

Deployment of agentic platform at 8 sites (MOAT), digital twins at 3 sites (MOAT+AmSC SUF IP)

Deployed agentic platform Osprey at multiple facilities

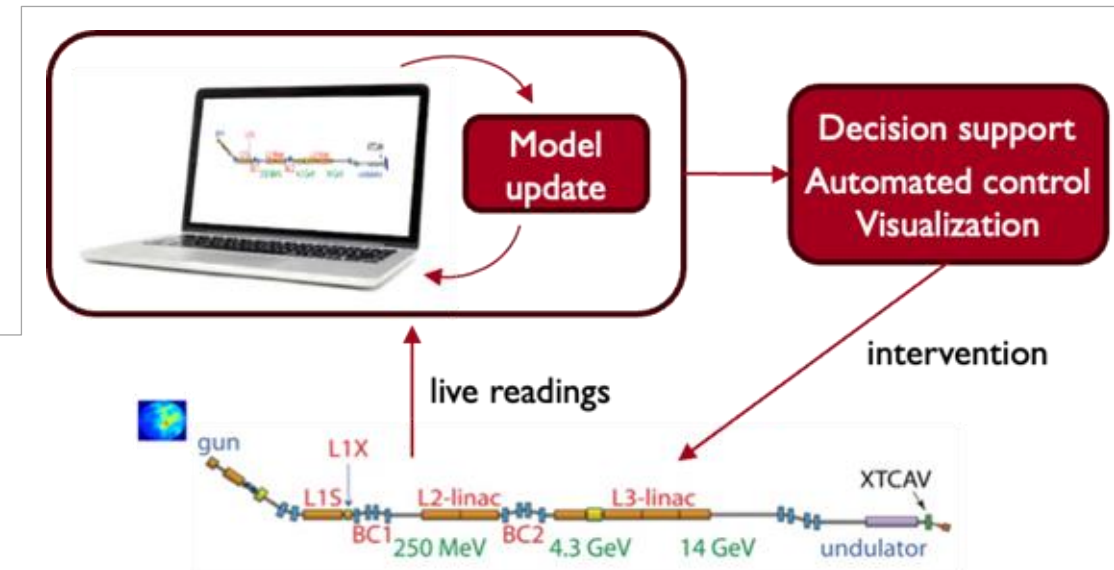
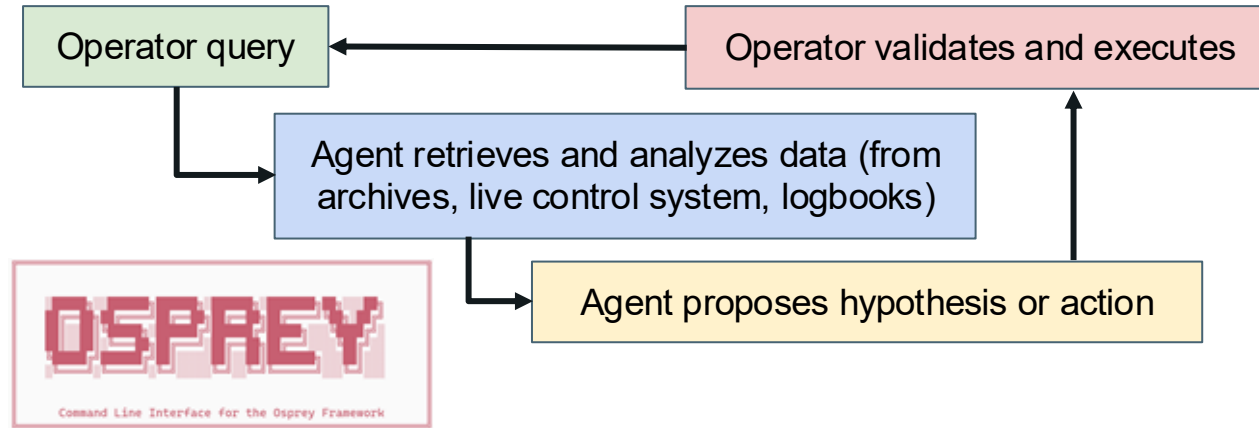
Supports accelerator operations @ LBNL (ALS, BELLA), FNAL (Accelerator Complex, FAST), ORNL (SNS), ANL (APS), SLAC (LCLS), JLab (CEBAF, UITF), BNL (RHIC/EIC)

Uses MOAT's Osprey framework (initially developed at LBNL/ALS)
⇒ outperform ad-hoc workflows based on fragmented institutional knowledge that operators currently rely on*

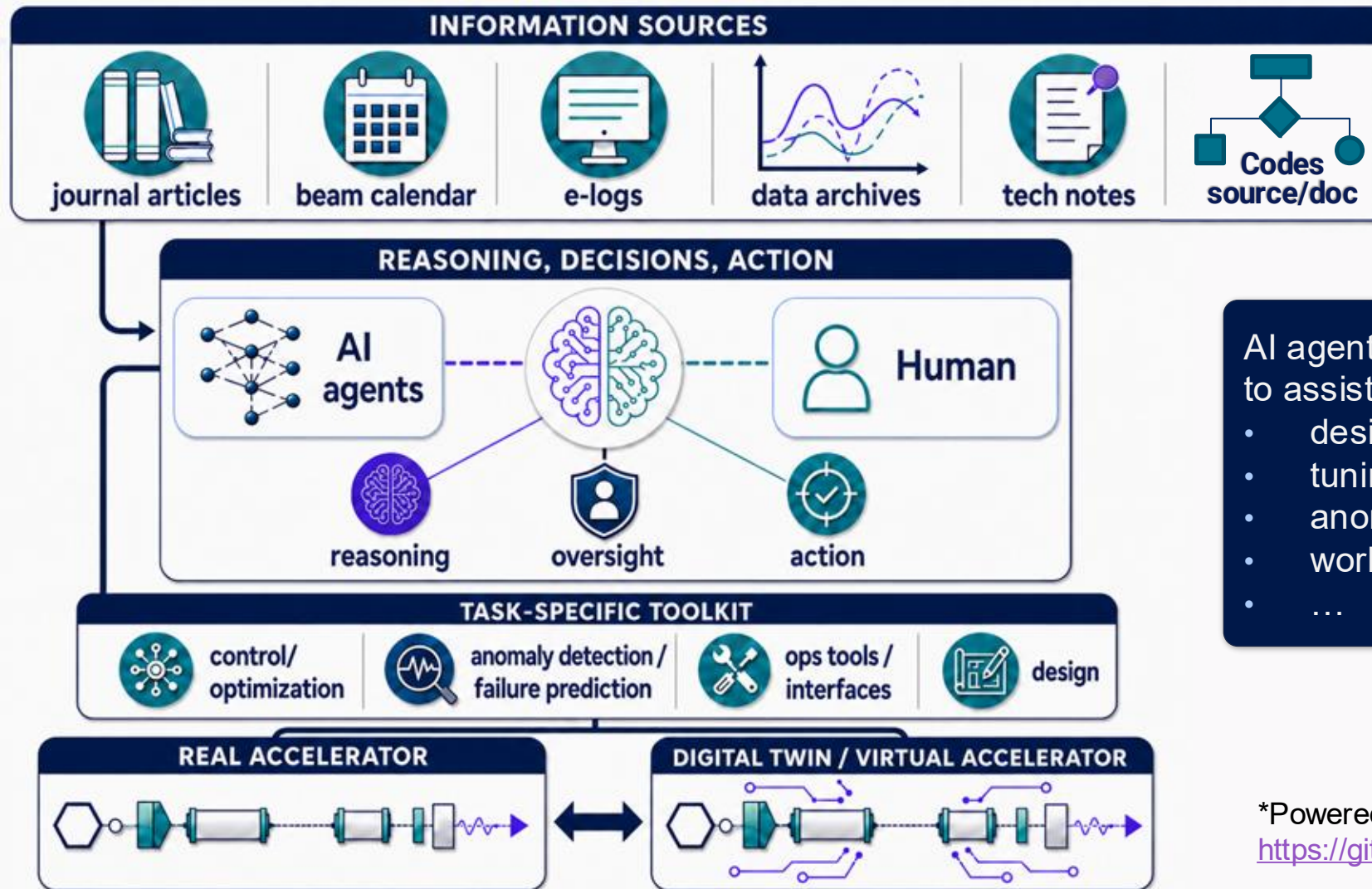
"the preparation effort is reduced from what would typically take several hours of manual scripting and debugging to only a few minutes from a single natural language prompt—a **speedup of 2 orders of magnitude."*
T. Hellert, PRR 8, L012017 (2026).

Digital twin demos at subset of facilities (collab. AmSC SUF IP)

- HPC integration (e.g., IRI, Perlmutter@NERSC)
- Deploying at LBNL (BELLA), FNAL (FAST), SLAC (LCLS)
- Ongoing: ML model retraining (coord. w/ ModCon BASE SIM)
- Ongoing: Linking digital twin to Osprey agents



MOAT plans to expand scope of AI framework around Agentic AI



AI agents use information sources and tools to assist accelerator activities:

- design
- tuning
- anomaly detection & prevention
- workforce development
- ...

*Powered by the LBNL-led Osprey agentic framework
<https://github.com/als-apg/osprey>

MOAT is expanding into a cross-projects, cross-facility collaboration extending to additional labs, universities and industry

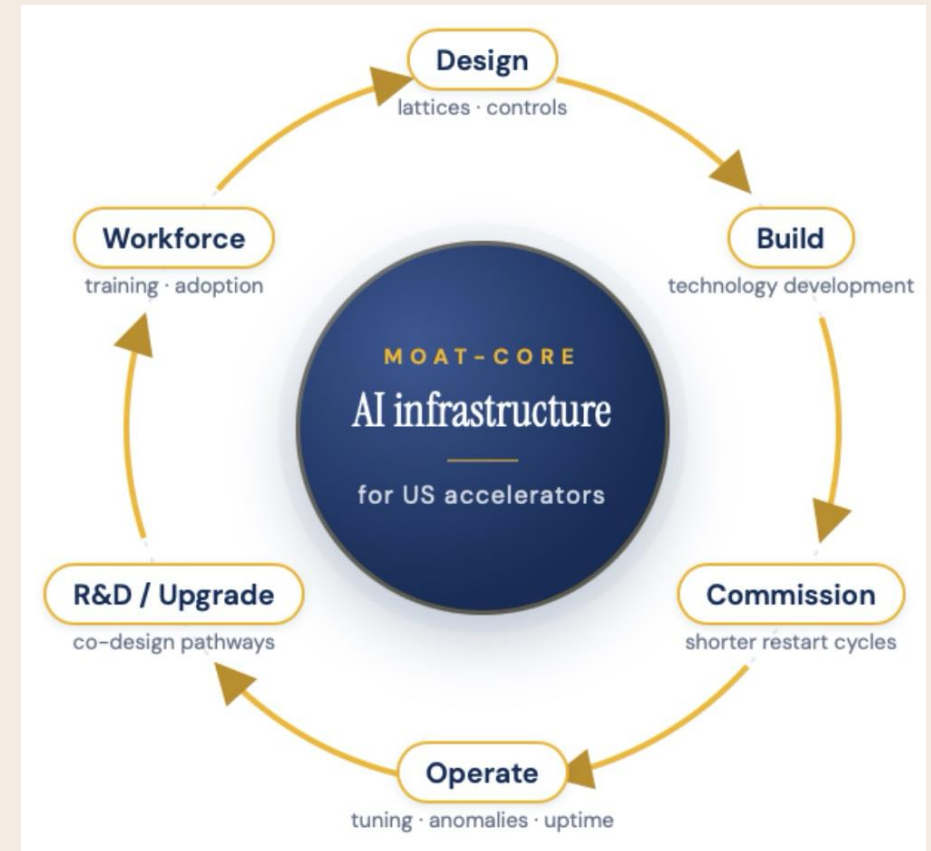
The MOAT Collaboration

**Collaboration focus: shared infrastructure
& coordination of AI-enabled accelerator work**



MOAT connects institutions, workflows, tools, technical knowledge so progress can be reused across facilities

More info: <https://moat-ai.github.io>
moat@lbl.gov





Thank You!