Genesis Mission

AMERICAN SCIENCE CLOUD

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Intro to AmSC for HEP

PRESENTED BY

J. Taylor Childers

Argonne National Laboratory

AmSC PR Page

AmSC Documentation

U.S. DEPARTMENT of ENERGY

THE AI-NATIVE RESEARCH WORKFLOW ON AmSC: PHYSICIST INQUIRY TO INSIGHT

AmSC Interface

PHYSICIST INTERACTION

"i2-chat" ChatUI

Question

Evaluate tungsten absorber thickness effects (2.0, 2.5, 3.0mm) on $A' \to e^+e^-$ tracking/clustering efficiency vs. L_{xy} (cx=10-100mm). Search HL-LHC data, stage to NERSC, run Geant4 sweep, GNN reco, analysis, return plots.
Project: genesis_hep

① INGRESS & ORCHESTRATION (THE BRAINS)

CLOUD MANAGEMENT PLANE (AmSC)

i2-mag (Model Access Gateway)
Manage project soist context
LLM Router | OPA Policy | OIDC Auth

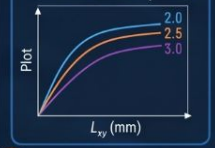
Model Orchestrator Agent
Manage project context
Project: genesis_hep

② DATA & NETWORK FABRIC

Data Discovery (ds-catalog)
Apache Polaris metadata
urn:iri.science:lbnl:nersc:hep-data:hl-lhc-14tev-minbias

Data Transfer (ds-transfer)
ESnet L3VPN (Secure WAN Data Fabric)
Move data efficiently

"i2-chat" ChatUI



③ FinOps Wallet

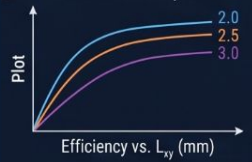
Data managed: 4.2TB (ESnet managed)

FinOps Wallet Summary (genesis_hep):
Data: 4.2TB (ESnet managed)
Compute: 48 GPU-hrs
Tokens: 14.2k

Project: genesis_hep

ChatUI (Updated)

① Efficiency vs. L_{sy} (mm)



② Energy Resolution

③ FinOps Wallet Summary (genesis_hep):
Data: 4.2TB (ESnet managed)
Compute: 48 GPU-hrs
Tokens: 14.2k

SOURCE DATA CENTER
HL-LHC Min-Bias BKG

HPC FACILITY (NERSC PERLMUTTER)

③ SIMULATION & COMPUTATION (THE MUSCLE)

Secure machine identity (SPIFFE) and Vaulted credentials

INFRA-RIG
Secure machine identity (SPIFFE)

SLURM Batch Job Array

NERSC PERLMUTTER (HPC)

GNN
Key4hep / Geant4 (Geometry Sweep: 2.0mm, 2.5mm, 3.0mm Tungsten)

Generate data

AI Reco Pipeline (GNN Track Reconstruction on GPUs)

ExaTrkX | ROOT files

MCP Server (The Wormhole)
Real-time steering/monitoring

Analysis Scripts (Python/uproot)

PERLMUTTER

Output files processed

④ ANALYSIS & SYNTHESIS

The Wormhole (MCP/WebSocket)

Results & back *outbound*

Output files

Currently Available

Login:
- Globus + White List (Access Is Currently Limited to DOE Labs)

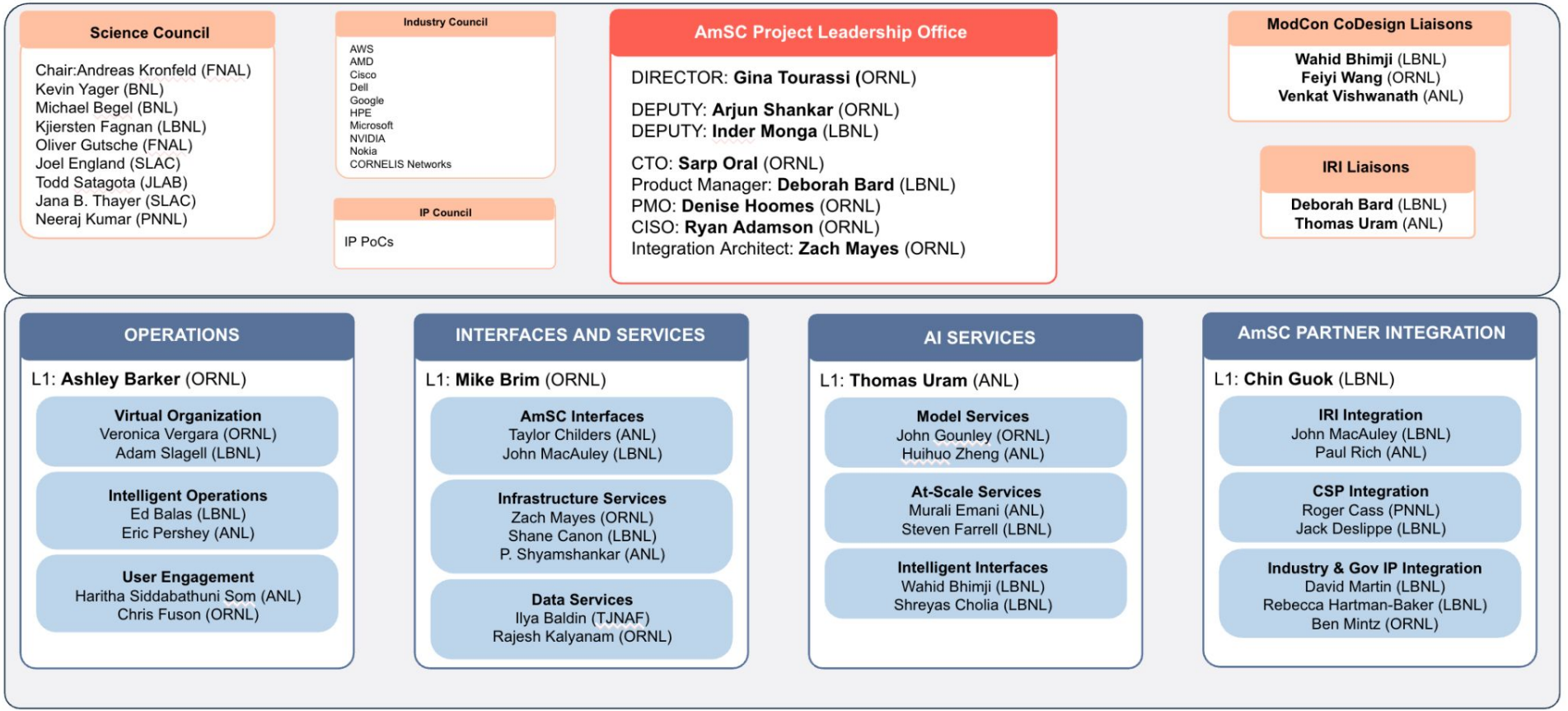
Data Management:
- OpenMetaData as a central register for all DOE data
- Globus/EJFAT for data transfer

Compute:
- IRI REST API enables remote job submission at NERSC/OLCF/ALCF as well as limited filesystem operations

Inference:
- LiteLLM/MAG (Model Access Gateway)
- Backed by industry models and latest open source models served by DOE HPC sites

Tools:
- MLFlow
- ClearML
- REST & Python API

ORG Chart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CSP Integration
Roger Cass (PNNL)
Jack Deslippe (LBNL)
Industry & Gov IP Integration
David Martin (LBNL)
Rebecca Hartman-Baker (LBNL)
Ben Mintz (ORNL)

Our milestones will build towards our MVP

3-MONTHS
FEDERATED ACCESS DEMONSTRATION

✓ Unified login across multiple DOE HPC sites; first operational **REST API and Python client** enabling authentication, dataset discovery, and workflow execution

6-MONTHS
SCIENCE TEAM ONBOARDING

✓ Two to three research teams execute **end-to-end workflows** (data search → transfer → model fine-tuning) on **Frontier**, **Perlmutter**, or **Aurora** using the AmSC Data Catalog

9-MONTHS
INTELLIGENT WORKFLOW MILESTONE

✓ First early **agentic workflow framework** autonomously discovers data, trains, fine-tunes, and performs **reasoning-based inference** across federated DOE and cloud resources

12-MONTHS
MINIMUM VIABLE PRODUCT

✓ Link IPs and CSPs into a **unified pre-production environment** to support AI-ready data services, agentic frameworks, large-scale model training/inference and advanced simulation. Establish a **foundation for future expansion** to additional partners and services.

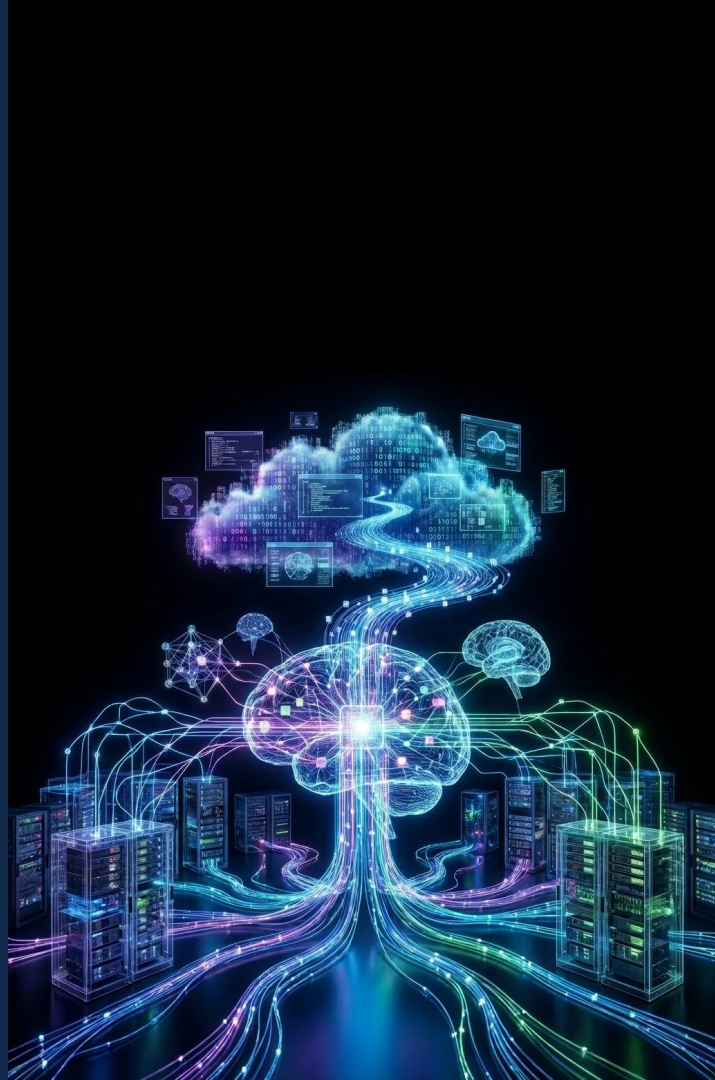
LONG-TERM VISION

Accelerate discovery cycles by building the world's most integrated scientific platform

Infrastructure Partners (IPs) are a necessary component in the success of AmSC

IPs leverage AmSC to provide enhanced capabilities for the scientific workflows they currently support.

IPs integrate resources into the AmSC ecosystem to offer additional capabilities for all AmSC scientific workflows. Resources include physical infrastructure (e.g., compute, storage, network), services (e.g., data curation, inference), and data.



BES/HEP/NP Scientific User Facilities Infrastructure Partnership (AmSC SUF IP)

Establish **AmSC** as a **shared platform for the research communities** of multiple (accelerator-based) **BES**, **HEP**, and **NP Scientific User Facilities (SUFs)**, along with their industry and research partners, to **reduce the time to science** and **unlock challenging measurements and experiments**

SUFs power the DOE SC mission by advancing discovery

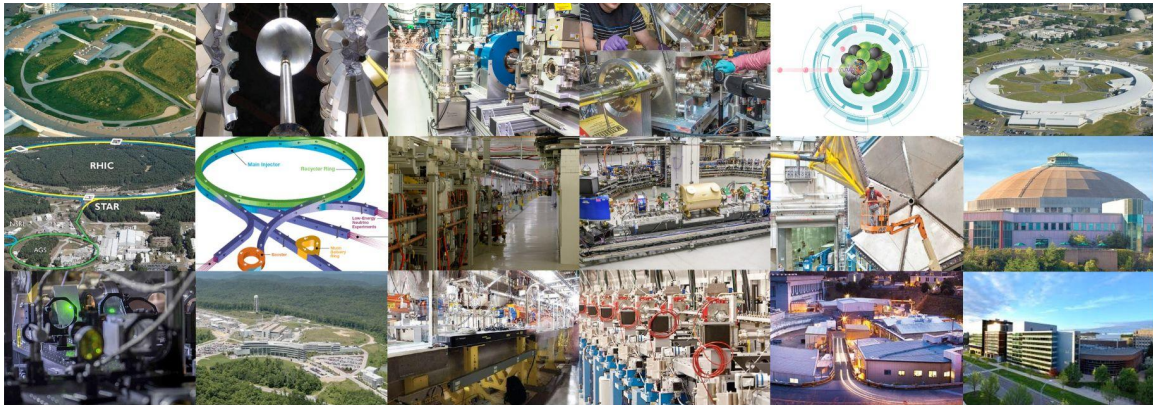
- >> 10,000 users per year, producing thousands of publication annually

Pose complex computing challenges and opportunities

- Exabytes of high-quality scientific data
- Multiple petabytes of curated data
- Hundreds of production workflows and AI models

AmSC Capabilities

- Federated identity and virtual organizations
- AI services: IaaS, training, model catalogs, agentic AI
- Robust data services
- Operations services / IRI foundation



1. Agentic Accelerator Controls

Real-time guidance and optimization of particle accelerators
(LBNL, SLAC, ANL, BNL, …)

2. Cross-Facility Data Ingestion and AI Workflows for NP

Automated AI pipelines
(JLAB, BNL)

3. Inference as a Service for HEP and NP Data Analysis

Distributed IaaS for data analysis
(FNAL, LBNL)

4. Light and Neutron Source AmSC Demonstrator

AI-enabled workflows across 6 facilities
(ANL, BNL, LBNL, ORNL, SLAC)

5. OpenCosmo on AmSC

Seamless access to peta-scale cosmological data
(DOE Computing Facilities)

Aligned with: MOAT, SYNAPS-I, MAIQMag, NARAD, ISAAC, LAMBDA

APS, ATLAS, AWA at ANL, ATF, EIC, NSLS-II, RHIC at BNL, the Accelerator Complex, FAST, IOTA at FNAL, CEBAF at JLAB, ALS, BELLA at LBNL, SNS at ORNL, FACET-II, LCLS, SSRL, NLCTA at SLAC, and FRIB at MSU

Paolo Calafiura (LBNL, PI), Nicholas Schwarz (ANL, co-PI) - POCs: Salman Habib (ANL), David Lawrence (JLAB), Meifeng Lin (BNL), Auralee Edelen (SLAC), Jonathan Taylor (ORNL), Nhan Tran (FNAL), Remi Lehe (LBNL)

Genesis Mission | AMERICAN SCIENCE CLOUD

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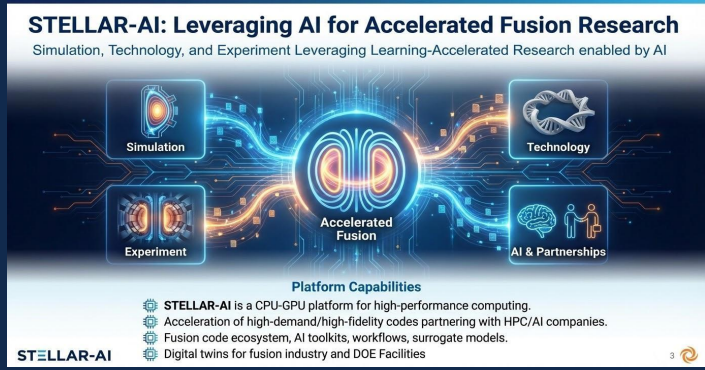
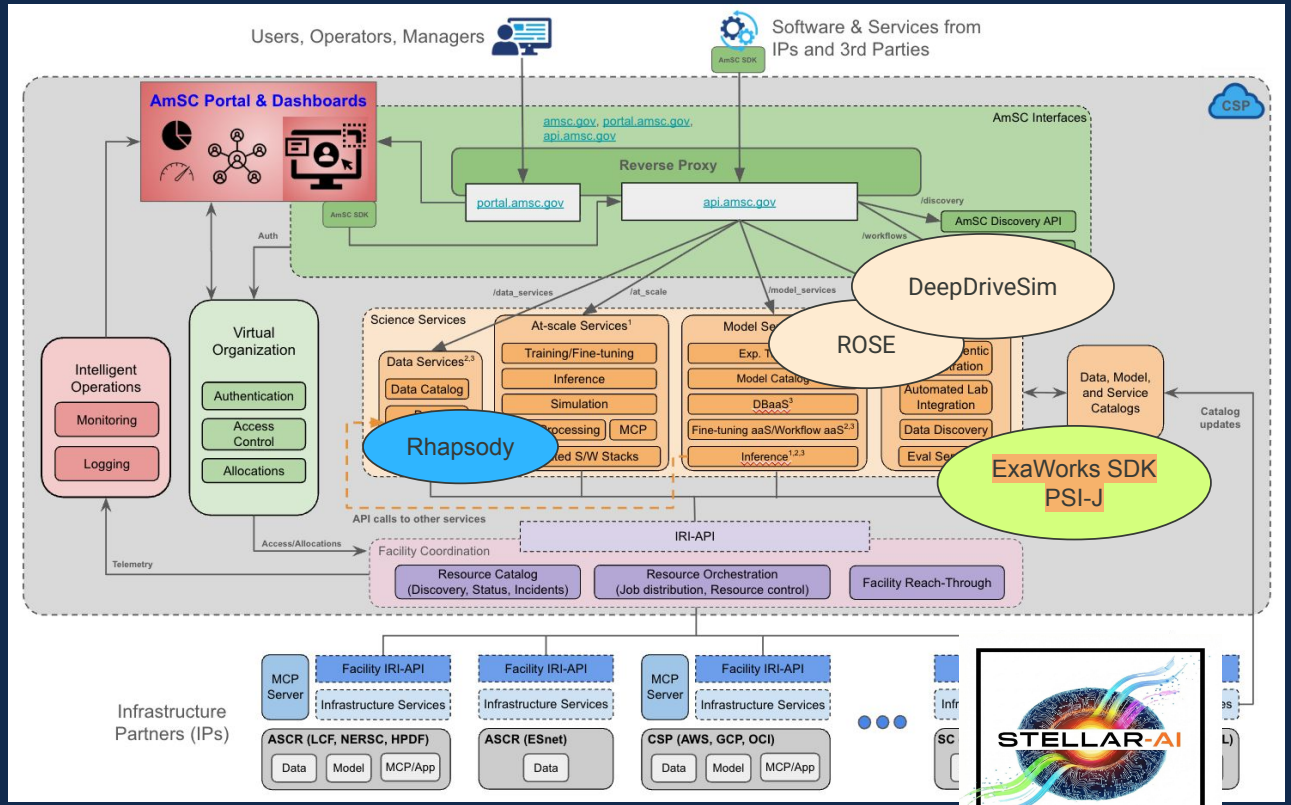
STELLAR-AI: Contribution to AmSC

Deployment, Development, and Integration/Usage



- **Deployment** of AmSC Software and Services
  - Accelerated Fusion requires Learning Everywhere: AI toolkits, workflows, surrogate models
- **Development** of AmSC Services
  - Consumers and producers of scalable software and services
  - Provides baseline ECP ExaWorks SDK and associated capabilities
- **Integration** into production computational campaigns
  - NSTX-U Digital Twin: A FES AmSC Project

STELLAR-AI: Contribution to AmSC Development



AI Model Consortium Project
AI4HPC
AI-Microelecronics
AI-QuantumAlgo
AXES
CM2US
CombustionFM
FAMOUS-OPAL
GRID-UNI
Fusion-FM
ISAAC
MAIQMag
MOAT
PROMETHEUS
Q2C
SYNAPS-I