Proposed EuCAIF Foundation Models Sub-Working Groups for Astro/Cosmo

Below are four project-focused “sub-WGs” that could run under the EuCAIF Foundation Models umbrella. The goal is to create action-oriented groups that (i) converge on shared datasets/benchmarks, (ii) define 1–2 reference tasks, and (iii) produce deliverables (i.e. datasets/benchmarks, model prototypes).

How to join: Under each project, add your **name + affiliation + research interests**. Feel free to join multiple.

Suggest a new sub-WG/project: If you have an additional idea, please add it at the end using the template below, including a short description and your name.

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1) GW-Focused Foundation Models WG

Theme: A dedicated group on gravitational-wave data foundation models.

General Direction: Build reusable representations and/or foundation models for GW time-series enabling transfer across detectors, runs, and tasks.

Interested participants (add yourself):

- Name, Affiliation, Research interests
- Waleed Esmail, University of Münster, Germany, GW Foundation Models, and developing AI methods for data analysis for 3G GW observatories (e.g., Einstein Telescope)
- Miguel Cárdenas-Montes, CIEMAT, Spain, Expertise in AI at large, from Evolutionary Algorithms to Machine Learning. Currently running Foundation Models in Oncology —in coordination with research groups at CIEMAT and hospital (real data)---, and GW.
- Nachiketa Chakraborty, University of Reading, UK, Expertise in AI and Causality, Time-series methods / signal processing, Time-domain solar and astrophysics. I would also be interested in design of foundation models for broader time-domain astrophysics/ transients problems
- Kyrill Blümer, University of Münster, Germany, development of AI methods for seismic noise suppression in GW observatories (e.g. Einstein Telescope)

- Shivam Rawat, University of Bonn, Germany, Physics Informed Machine Learning, LLMs and AI agents for astrophysics and cosmology, Foundation Models for Physics.
- Ik Siong Heng, University of Glasgow, machine learning for gravitational wave detection and inference
- John Veitch, University of Glasgow, gravitational wave astronomy - ML for inference from noisy time series data. Data compression/encoding for GW-ML.
- Hamza Hanif, Simon Fraser University, Expertise in AI , have experience applying AI in particle physics (ATLAS experiment), Neutrino Physics (TAMBO) and cosmology
- Roberto Ruiz (IFIC-CSIC), AI for GW detection and inference
- Ippocratis Saltas, Czech Academy of Sciences, AI for inference and detection (saltas@fzu.cz)
- Shahzaib Abbas, University of Karachi, ML for High Energy Physics, including surrogate modeling, neural network–based particle classification and neutrino physics (TAMBO)
- João A. Gonçalves, , Jet Quenching, Quark-Gluon Plasma, QCD, Deep Learning, Physics Informed Machine Learning, Uncertainty Quantification in ML, Foundation Models for Science
- Oscar J. Pellicer Valero, Universitat de València (UV), currently co-PI from UV at EU project ELLIOT, focused on the developing highly multimodal Foundation Models (FMs); expertise in developing FMs for Earth observation data.

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2) Multi-Messenger Astronomy Foundation Models for Neutron Star Mergers WG

Theme: Event-based multi-modal learning across GW + EM (and possibly neutrinos).

General Direction: Foundation models that understand *events* and their multi-modal signatures

Interested participants (add yourself):

- Vaibhav Chahar, Jagiellonina University, Poland,Deep Learning application in cosmology and particle physics.
- Ik Siong Heng, University of Glasgow, machine learning for gravitational wave detection and inference & multi-messenger analyses for GRB jet structure inference
- John Veitch, University of Glasgow, ML for gravitational wave binary neutron star analysis. PINNs for neutron star modelling.

- Pietro Vischia, Universidad de Oviedo: ultra high-energy tau neutrino detection (TAMBO), binary black hole mergers (joining Virgo). Interest in unified models across a vaster range of masses that may understand both BH and neutron star mergers
- Hamza Hanif, Simon Fraser University, Expertise in AI , have experience applying AI in particle physics (ATLAS experiment), Neutrino Physics (TAMBO) and cosmology
- Roberto Ruiz de Austri (IFIC-CSIC), machine learning for gravitational wave detection and inference
- Ippocratis Saltas, Czech Academy of Sciences, AI for inference and detection (saltas@fzu.cz)
- Michael Coughlin, University of Minnesota, multi-messenger brokering and analysis
- Nikhil Sarin, University of Cambridge, Simulations/Modelling/Inference of GW and EM transient data across any wavelength.
- Peter Pang, Nikhef, GW+EM multi-messenger analysis and simulation (NMMA). GPU-accelerated importance sampling EOS analysis on NS observations.
- João A. Gonçalves, , Jet Quenching, Quark-Gluon Plasma, QCD, Deep Learning, Physics Informed Machine Learning, Uncertainty Quantification in ML, Foundation Models for Science
- Shivam Rawat, University of Bonn, Germany, Physics Informed Machine Learning, LLMs and AI agents for astrophysics and cosmology, Foundation Models for Physics.
- Oscar J. Pellicer Valero, Universitat de València (UV), currently co-PI from UV at EU project ELLIOT, focused on the developing highly multimodal Foundation Models (FMs); expertise in developing FMs for Earth observation data.
- Carmen Misa Moreira, CERN, scientific ML, experience studying the dynamical and morphological evolution of barred galaxies (Illustris TNG).
- Nachiketa Chakraborty, University of Reading, UK, Expertise in AI and Causality, Time-series methods / signal processing, Time-domain solar and astrophysics. I would also be interested in design of foundation models for broader time-domain astrophysics/ transients problems

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3) Cosmology Cross-Correlation Foundation Models WG

Theme: Cross-correlating heterogeneous cosmology datasets (e.g., 21cm + CMB, CMB + LSST).

General Direction: Foundation models that learn robust representations of cosmological fields/maps and enable cross-survey, cross-tracer inference under realistic systematics.

Interested participants (add yourself):

- Name, Affiliation, Research interests
  Caroline Heneka, Heidelberg University, scientific ML for analysis and generative modelling of the LSS, FM-building for large radio interferometers (SKA), science goal: learn about cosmology and galaxy evolution jointly across cosmic time
- João A. Gonçalves, , Jet Quenching, Quark-Gluon Plasma, QCD, Deep Learning, Physics Informed Machine Learning, Uncertainty Quantification in ML, Foundation Models for Science
- Shivam Rawat, University of Bonn, Germany, Physics Informed Machine Learning, LLMs and AI agents for astrophysics and cosmology, Foundation Models for Physics.

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4) Neutrinos + Gamma-Rays Foundation Models WG

Theme: Spatio-temporal association, source identification, and anomaly/discovery tasks combining neutrino alerts with gamma-ray context.

General Direction: Unified models for sparse event streams (neutrino alerts) enriched by contextual gamma-ray/EM information to improve association, localization, and discovery potential.

Interested participants (add yourself):

- Tommaso Dorigo, INFN Padova & Lulea Technology University - High-energy Gamma-Ray astronomy (SWGO), ultra high-energy tau neutrino detection (TAMBO). Interested in combining information from multiple observatories.
- Gabrijela Zaharijas, UNG; I would be interested in a slightly enlarged topic, namely non thermal astro source identification (that would include radio/gamma rays/neutrinos, and among sources, also potential dark matter emitters)
- Judit Pérez Romero, UNG, high-energy gamma-ray astrophysics, neutrino astrophysics, multi-messenger modeling and detection, multi-wavelength (multi-messenger) source identification, anomaly detection (could be linked to detect new class of sources and exotic sources as DM)

- Troels Petersen (Univ. of Copenhagen). I'm working on event classification and reconstruction in IceCube, specifically on making transformers work efficiently on the very heterogeneous data size (10-100000 pulses per event). Anomaly detection and domain shift/adaptation is also of interest.
- Florian List, MPA Garching: high-energy gamma-ray physics, also connections / cross-correlation with cosmology; I work on ML & SBI methods for analysing gamma-ray maps, I'd also be interested in anomaly detection & domain adaptation
- Pietro Vischia, Universidad de Oviedo: ultra high-energy tau neutrino detection (TAMBO), binary black hole mergers (joining Virgo). Interest in unified models for end-to-end event description in a sparse, shower-based environment
- Johann Ioannou-Nikolaides, Niels Bohr Institute, ML for neutrino physics including hierarchical representation learning, domain adaptation / invariance using weakly/self-supervised approaches.
- Hamza Hanif, Simon Fraser University, Expertise in AI , have experience applying AI in particle physics (ATLAS experiment), Neutrino Physics (TAMBO) and cosmology
- Roberto Ruiz de Austri, (IFIC-CSIC), high-energy gamma-ray astrophysics
- Ippocratis Saltas, Czech Academy of Sciences, AI for inference and detection (saltas@fzu.cz)
- Shahzaib Abbas, University of Karachi, MLfor High Energy Physics, including surrogate modeling, neural network–based particle classification and neutrino physics (TAMBO)
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- Oscar J. Pellicer Valero, Universitat de València (UV), currently co-PI from UV at EU project ELLIOT, focused on the developing highly multimodal Foundation Models (FMs); expertise in developing FMs for Earth observation data.
- Shivam Rawat, University of Bonn, Germany, Physics Informed Machine Learning, LLMs and AI agents for astrophysics and cosmology, Foundation Models for Physics.
- Thomas Vuillaume, LAPP, Univerisity Savoie Mont-Blanc, CNRS, PI of the gammalearn project to use AI for event reconstruction in imaging cherenkov telescopes. <thomas.vuillaume@lapp.in2p3.fr>

Proposed by participants (add new ideas below)

5) Galaxy Evolution Foundation Models WG

Proposed by: Anna Scaife, University of Manchester

Theme: Multi/cross-modal/source representation learning across wavelengths for constraining models of galaxy evolution using large-scale survey data. Possibly to be combined with SBI.

General Direction: Building unified foundational representations from (diverse) large scale survey data including images, spectra, photometry etc. that can be queried and fine-tuned to efficiently address a variety of downstream scientific analysis tasks, as well as facilitate data discovery.

Interested participants:

- Name, Affiliation, Research interests
- Martin Eriksen, IFAE-PIC, Galaxy surveys, image analysis with AI
- Caroline Heneka, Heidelberg University, scientific ML for analysis and generative modelling of the LSS, FM-building for large radio interferometers (SKA), science goal: learn about cosmology and galaxy evolution jointly across cosmic time, WG lead 4MOST
- Carmen Misa Moreira, CERN, scientific ML, experience studying the dynamical and morphological evolution of barred galaxies (Illustris TNG).
- Shivam Rawat, University of Bonn, Germany, Physics Informed Machine Learning, LLMs and AI agents for astrophysics and cosmology, Foundation Models for Physics.
- João A. Gonçalves, , Jet Quenching, Quark-Gluon Plasma, QCD, Deep Learning, Physics Informed Machine Learning, Uncertainty Quantification in ML, Foundation Models for Science

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Proposed by participants (add new ideas below)

6) Foundation Models for Quark-Gluon Plasma Physics

Proposed by: João A. Gonçalves, University of Lisbon (in transition so affiliation will change)

Theme: Large muti-modal physics- and uncertainty-aware architectures, first with MC data and eventually with experimental data, that model the full QGP dynamics, from jet

quenching, to the underlying event, passing through heavy flavour and strangeness enhancement, with a connection to Cosmology through the QGP phase of the early universe.

General Direction: Through the use of SSL and other related techniques start by training on events from all available MC that are able to explain a *significant to good* portion of the experimental data. Ideally, a hierarchical representation from the softest to the hard scales is learned by the main backbone model; realistically an embedding approach across multiple tasks would be a more sensible starting point, where different objects are embedded in a lower-dimensional latent space, by different models, before applying SSL in a general model, and testing downstream tasks.

Interested participants (add yourself):

- Name, Affiliation, Research interests
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7) Generative Foundation Models for Detector Simulation & Fast Inference
Proposed by: Zhihua Liang, CERN/INFN
Theme: Building geometry-aware generative foundation models to replace or accelerate computationally expensive Monte Carlo simulations (e.g., Geant4) across HEP and Astro-particle detectors.
General Direction: Leveraging Large Language Models (LLMs) with Geometric Attention and HPC-optimized architectures (TPU/GPU) to learn detector responses from first principles. The goal is to achieve orders-of-magnitude speedup in simulation while maintaining high fidelity for downstream physics tasks.

Interested participants (add yourself):

- Hamza Hanif, Simon Fraser University, Expertise in AI , have experience applying AI in particle physics (ATLAS experiment), Neutrino Physics (TAMBO) and cosmolgy
- Shahzaib Abbas, University of Karachi, MLfor High Energy Physics, including surrogate modeling, neural network–based particle classification and neutrino physics (TAMBO)

- Soulaymane Loukili, Barcelona Supercomputing Center (BSC), AI/ML for scientific applications, including large language models and physics-informed neural networks.
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