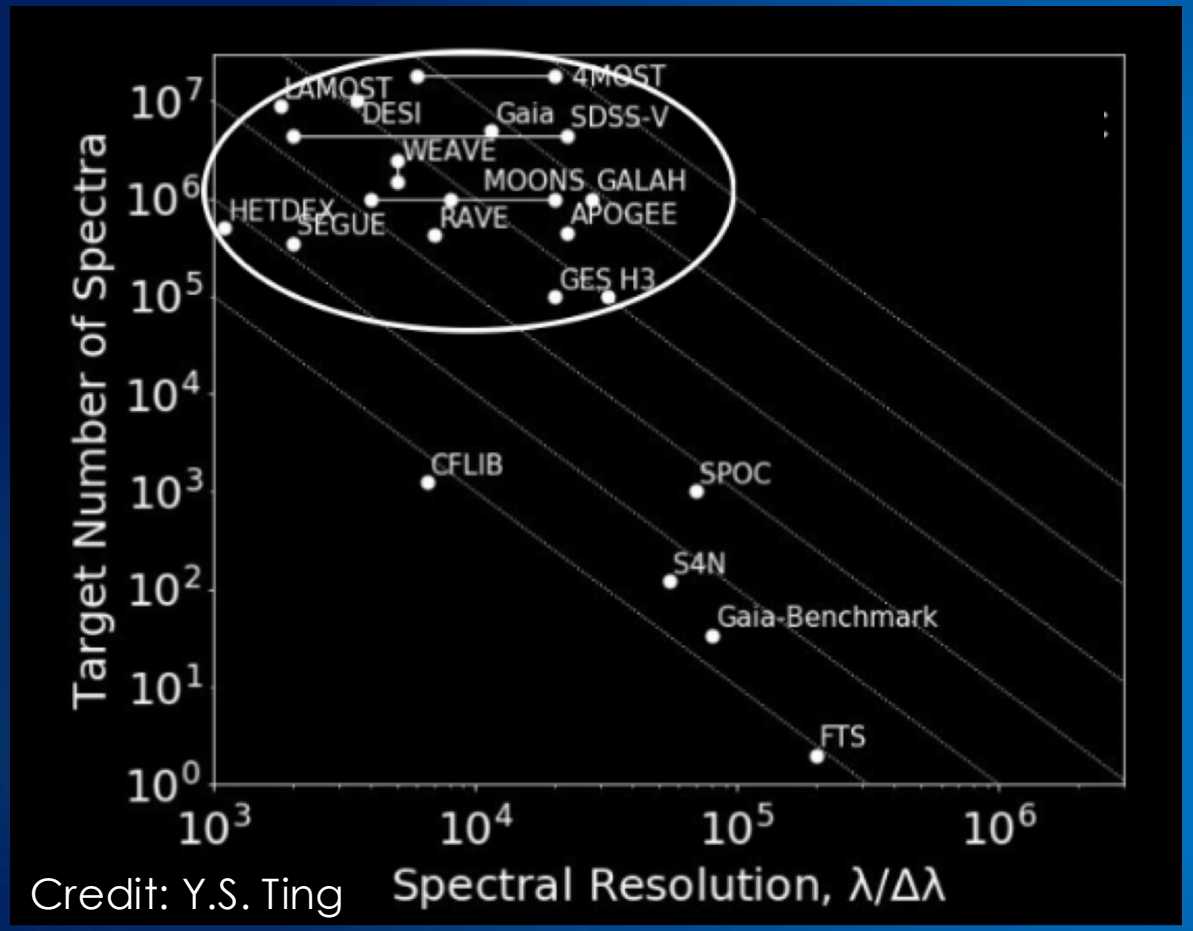
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

OSSERVATORIO ASTROFISICO DI ARCETRI

The evolving role of AI in astronomical spectroscopy and future telescope

G. SACCO, N. CANDEBAT, F. BELFIORE, M. GINOLFI, S. ZIBETTI

The need of AI for astronomical spectroscopy



Large amount of data

+

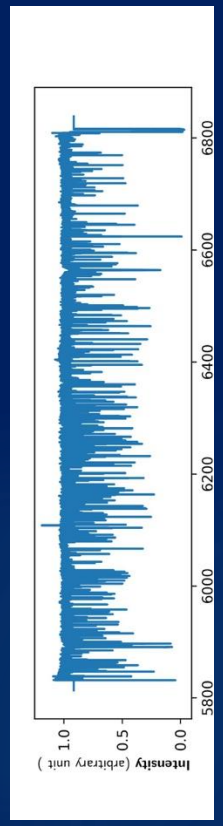
Complex physical models and multiple parameters

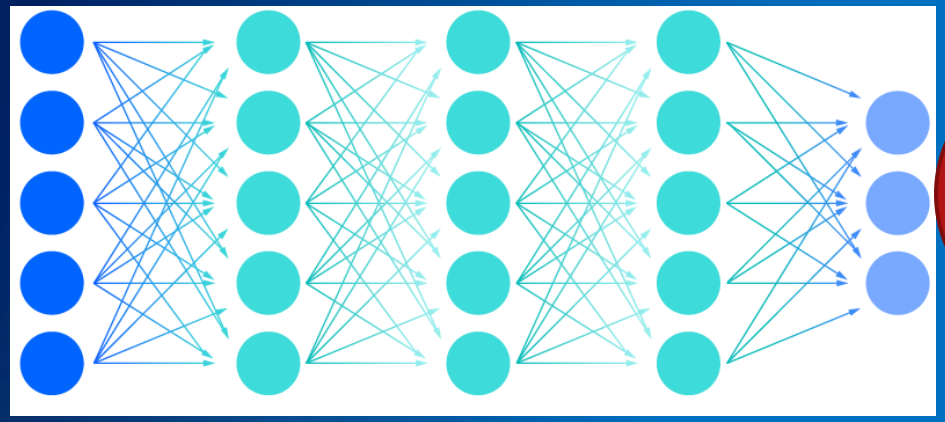
+

Effects of atmosphere and instruments

Traditional methods for spectral analysis are not adequate

First steps of AI in astronomical spectroscopy





Teff, Logg, [Fe/H], etc..

(e.g. Ness+2015, Ting+2019, Keown+2019, Ambrosch+2023)

Strengths

- Much faster
- Better with low res spectra
- Better with Low SNR spectra

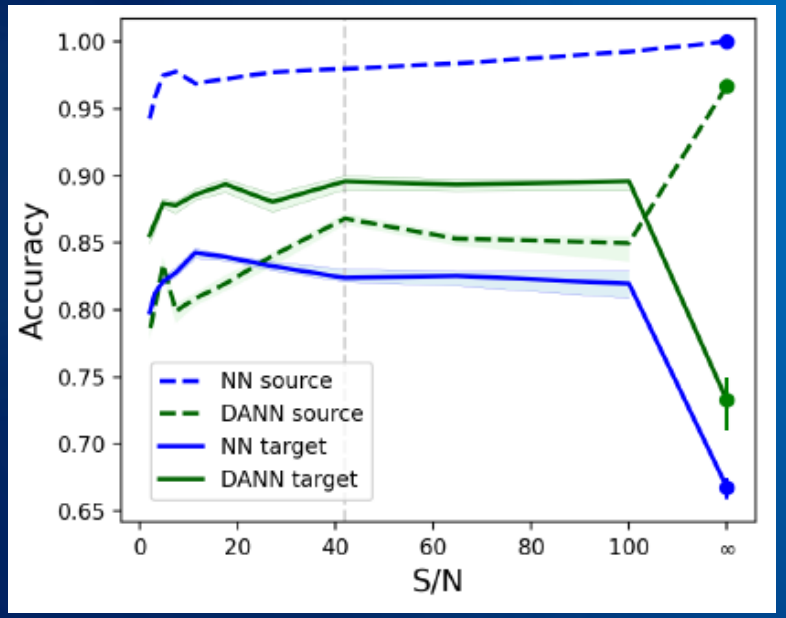
Weaknesses

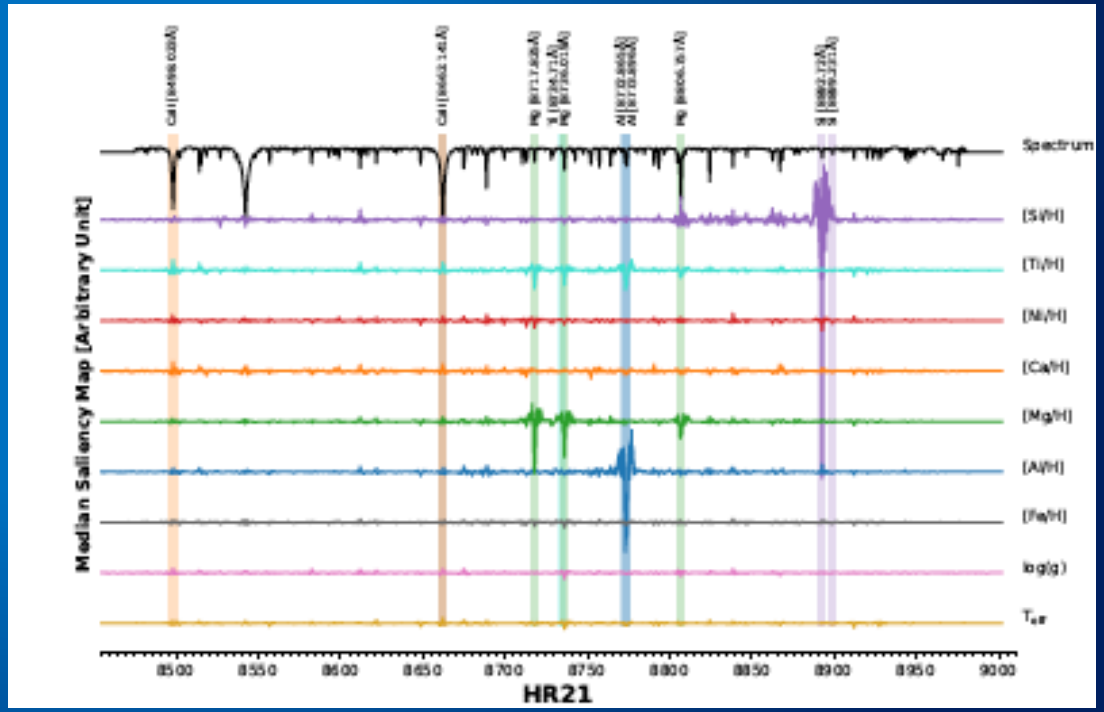
- Error estimates
- Interpretability
- Results depend on the training sample

Scientific AI for astronomical spectroscopy

Domain adaptation to use models for training (E.g. O'Brian+2021, Belfiore+2025)

New tools for interpretability (e. g., Ambrosch+2023, Candebat, Sacco+2024)

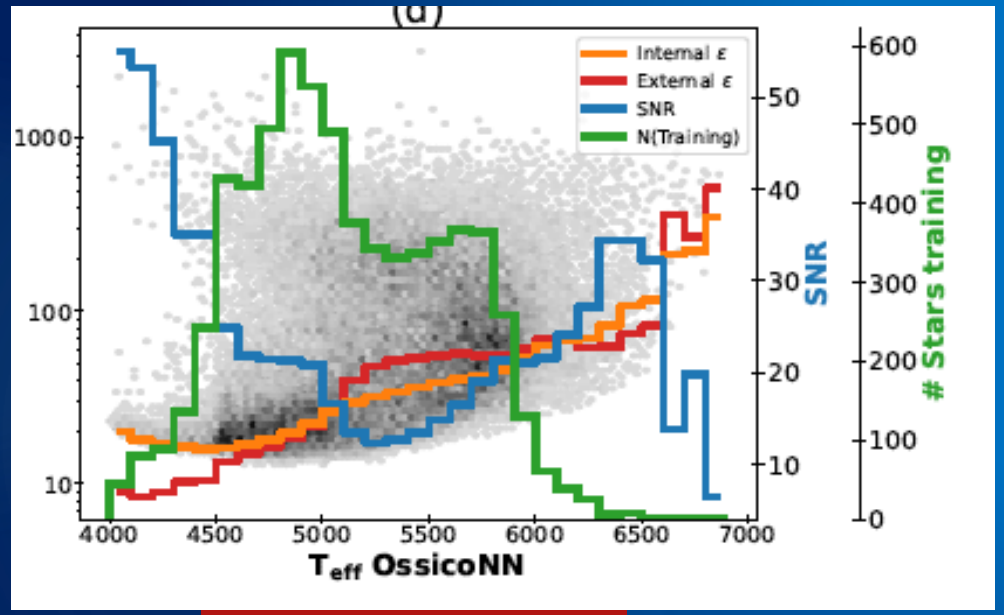




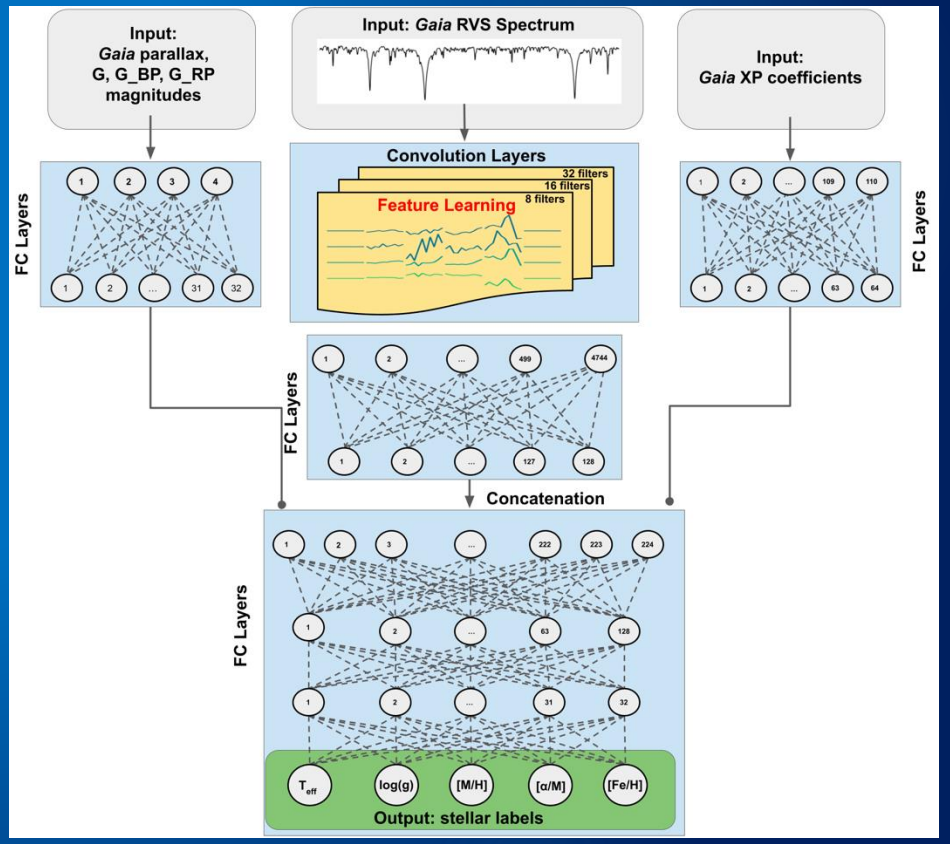
Scientific AI for astronomical spectroscopy

Normalizing flows to calculate posterior distribution (e.g. Kang+2022, 2023, Iglesias-Navarro+2024 Candebat+ 2024)

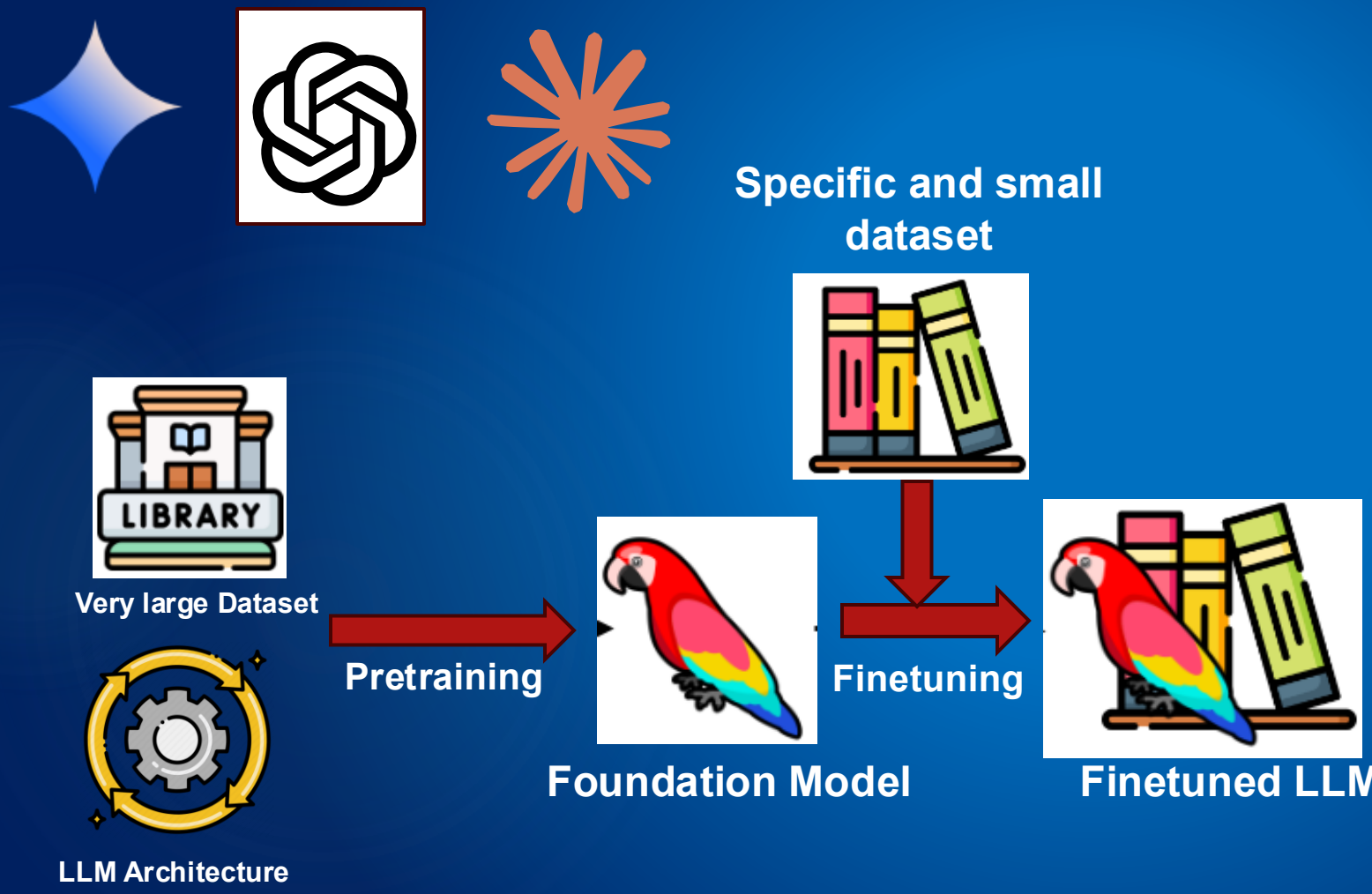
Combination of photometry and spectrosopy (Guiglion+2024, Candebat+,in prep)



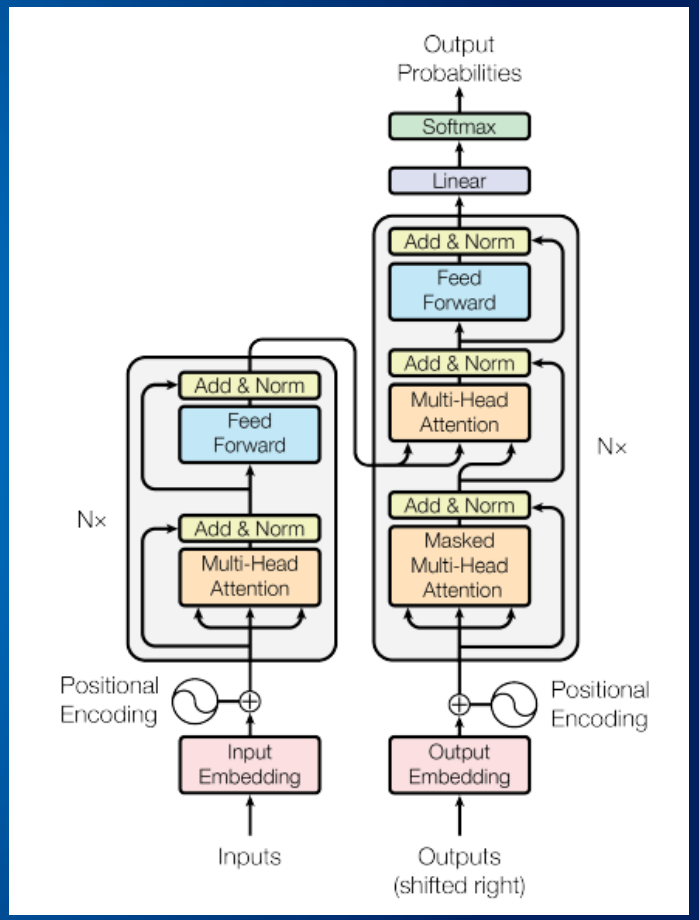
Candebat+2024



AI 2.0: foundation models



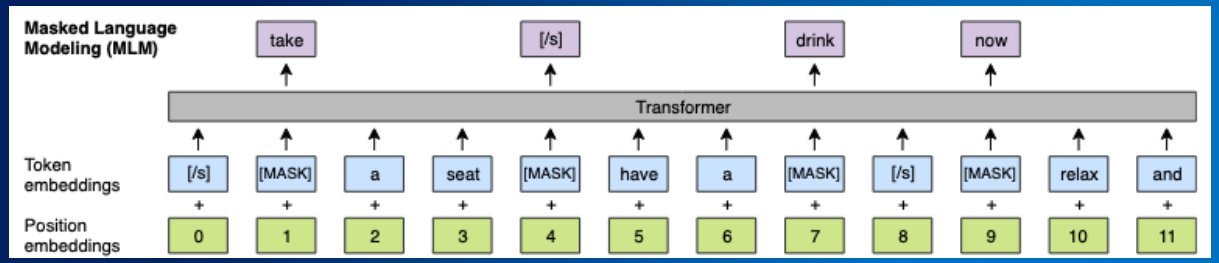
Attention is all you need



Vaswani+2017

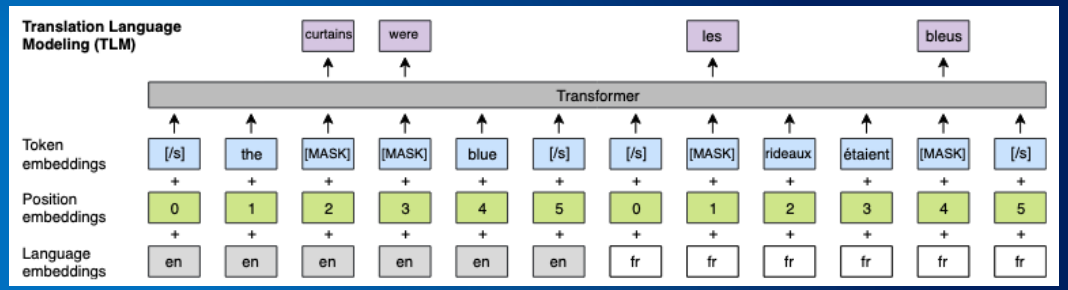
AI 2.0: foundation models

Self-Supervised Learning pre-training

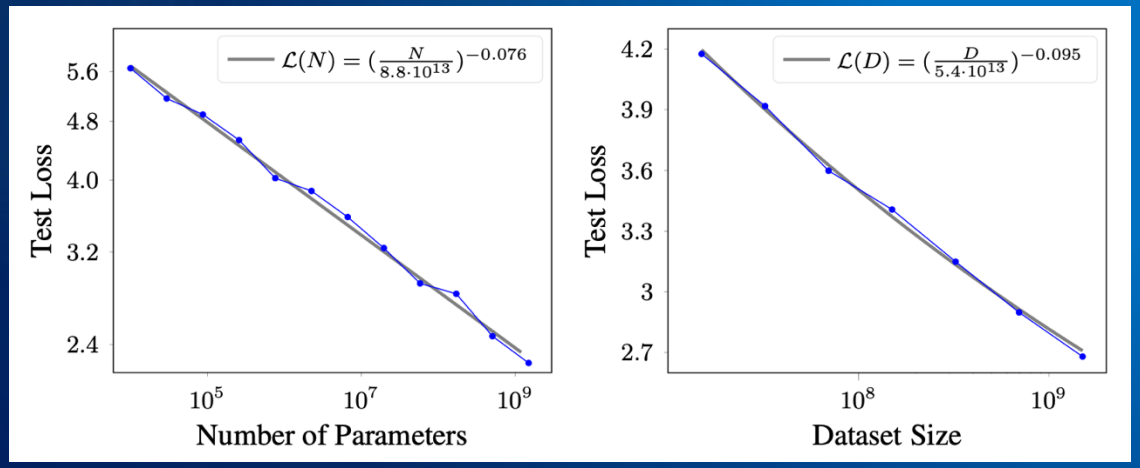


Lample & Conneau 2019

Cross-Domain Generalization

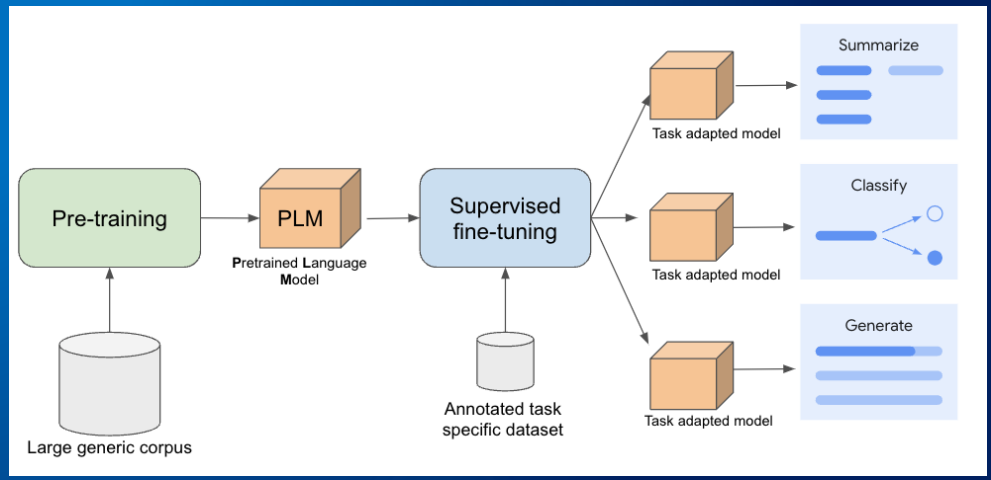


Scalling Law



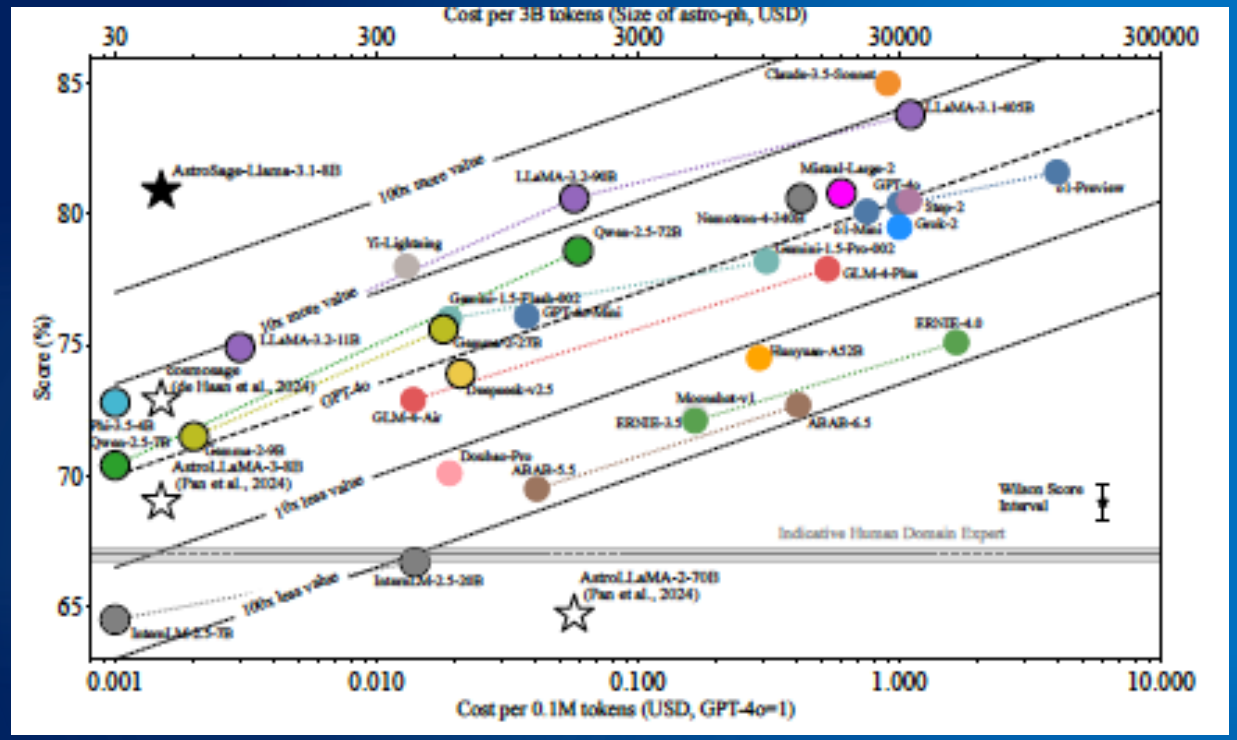
Xio&Zhu 2025

Versatility

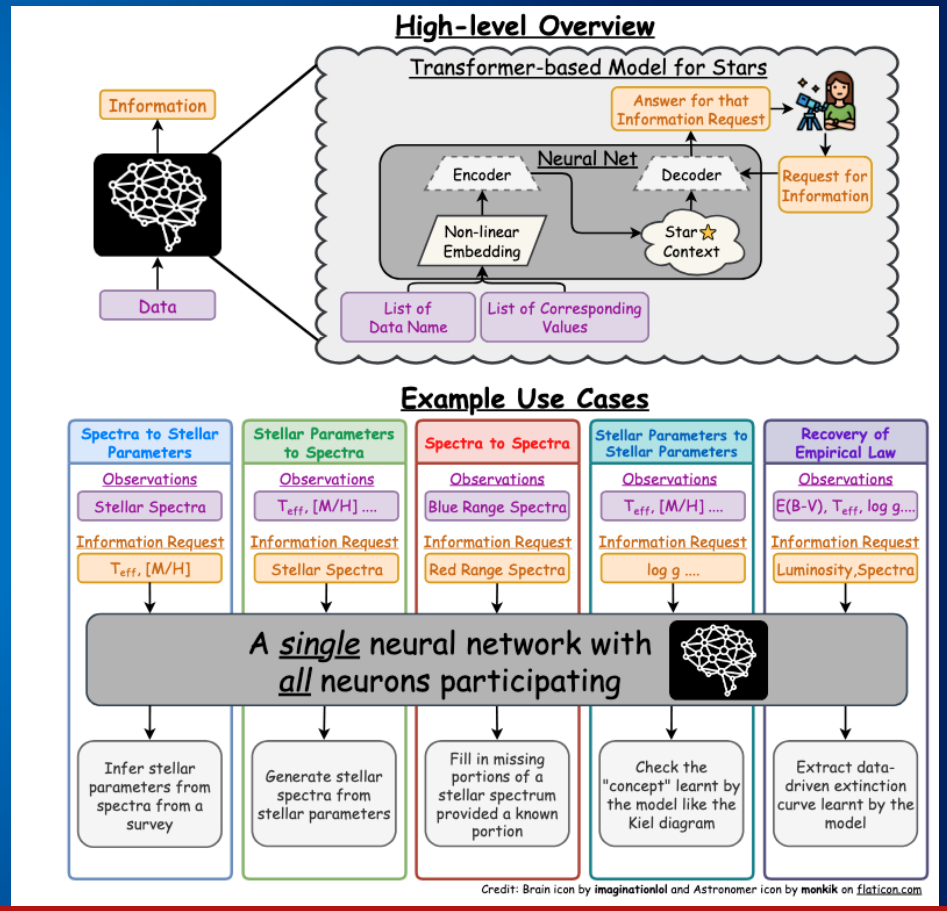


Foundation models in astronomy

Astronomy based LLMs.

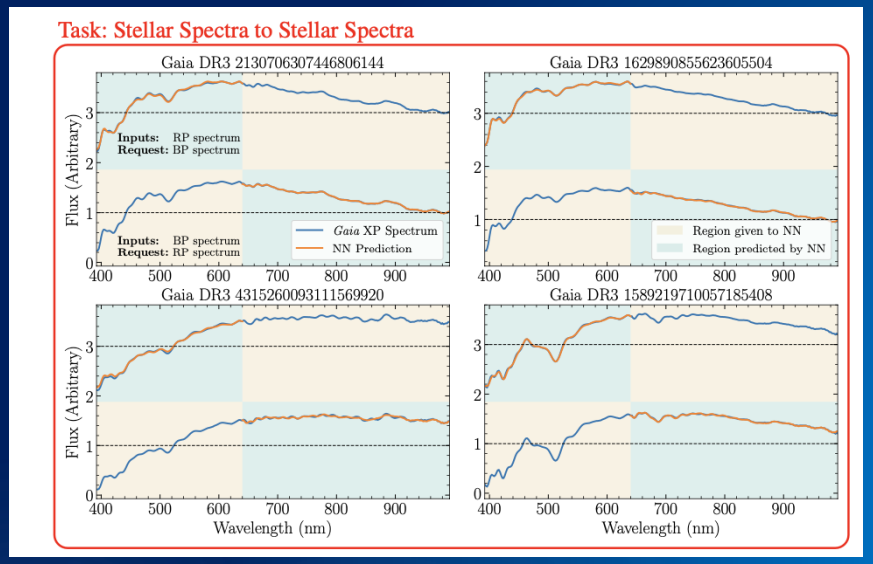


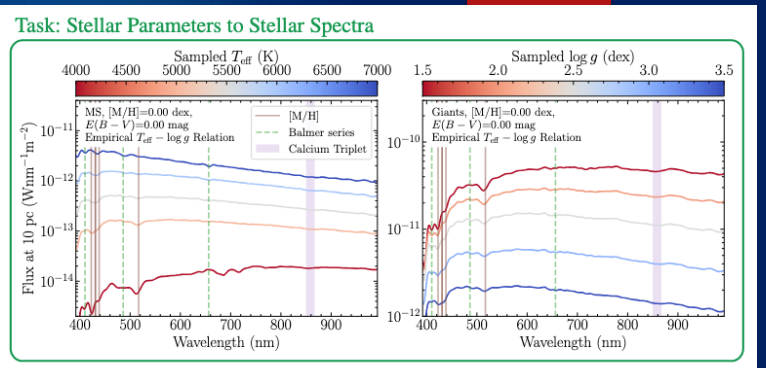
de Haan et al. 2025

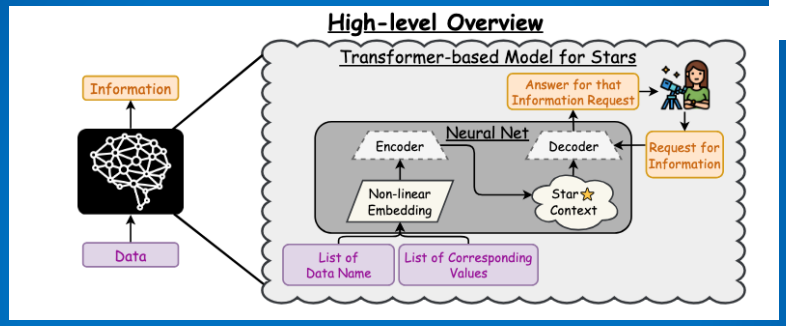


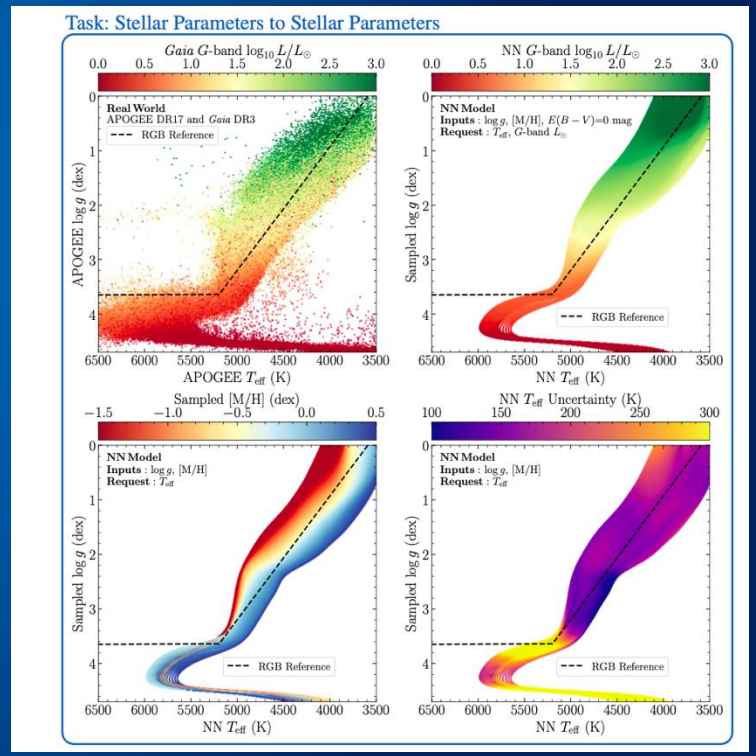
(Leung & Bovy 2023, Koblishche & Bovy 2024)

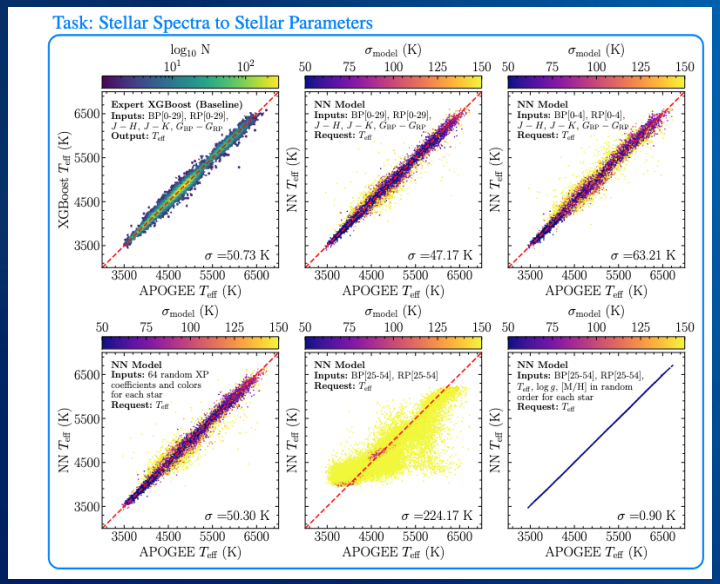
Foundation models in astronomy

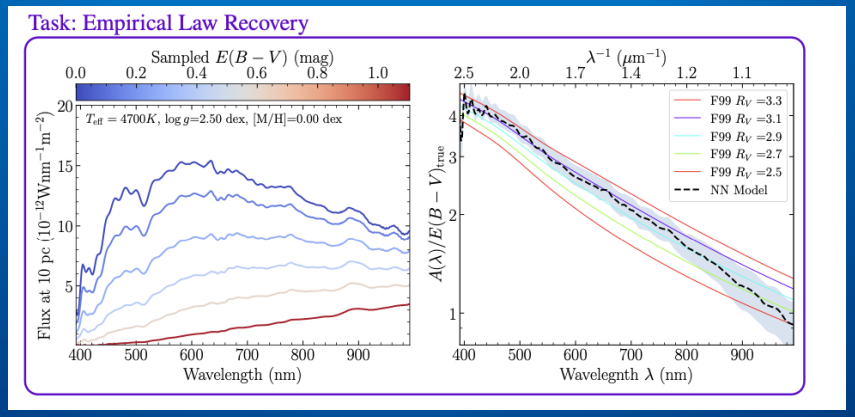




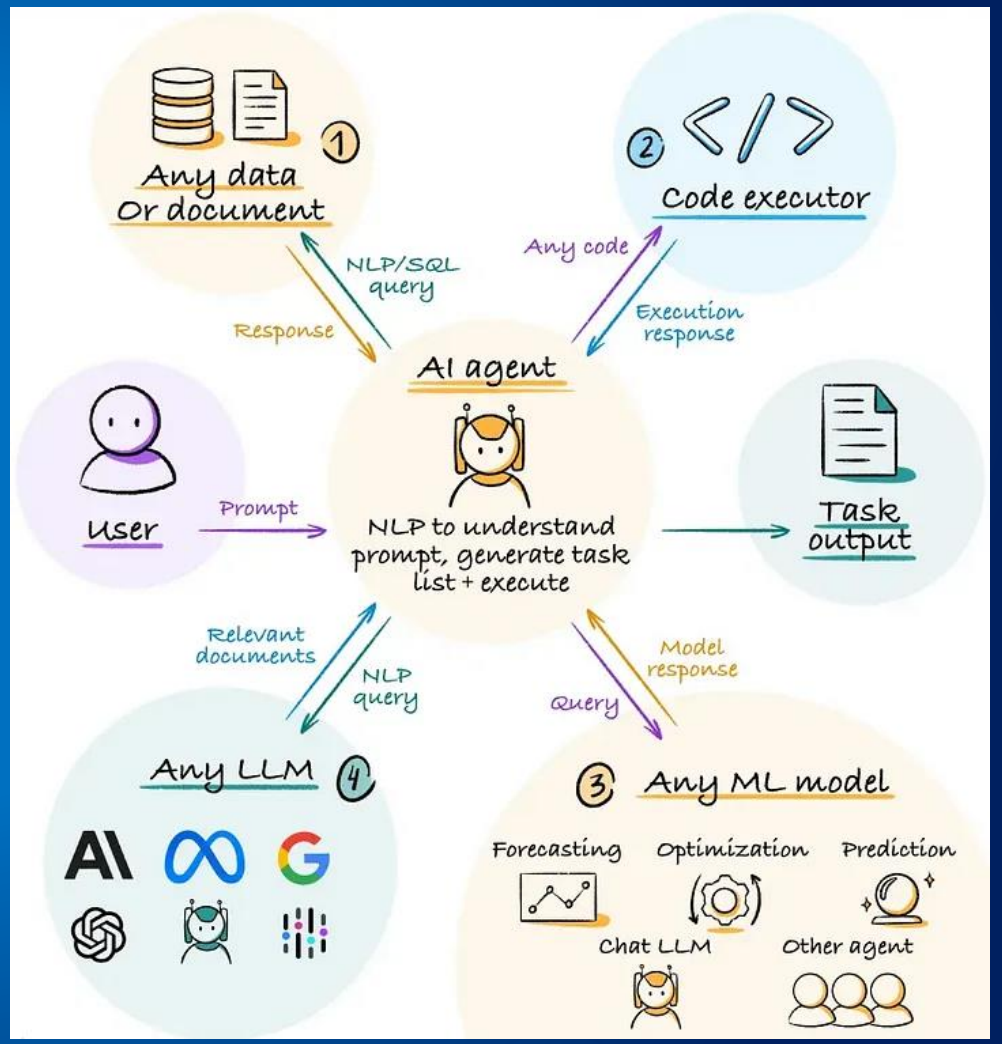






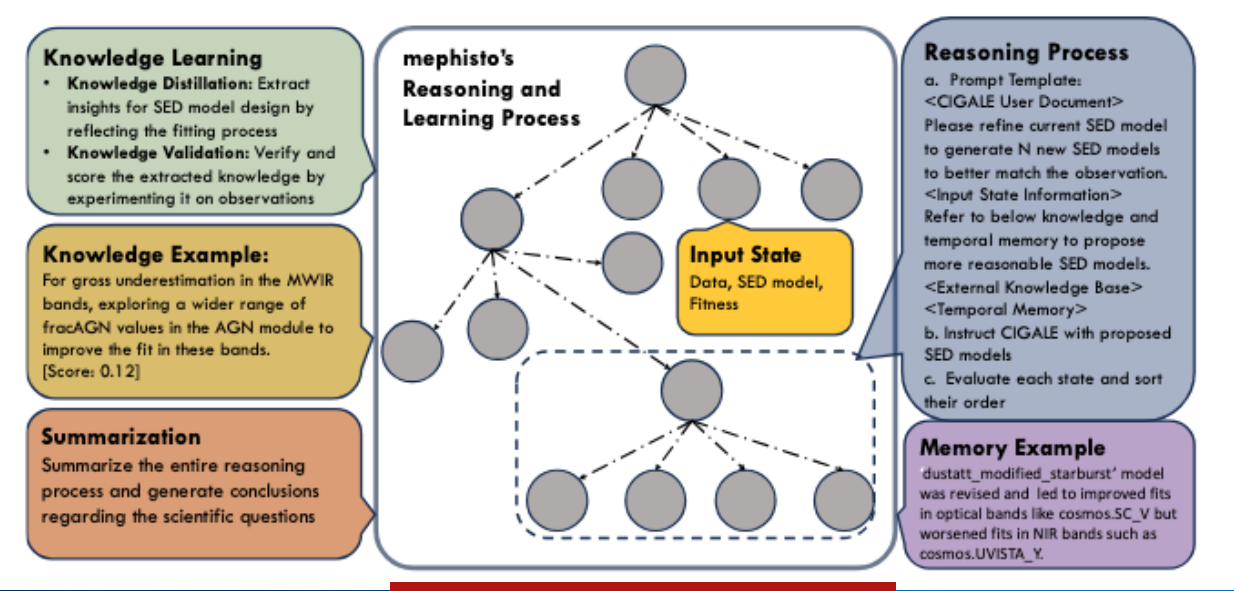


AI 2.0: AI agents



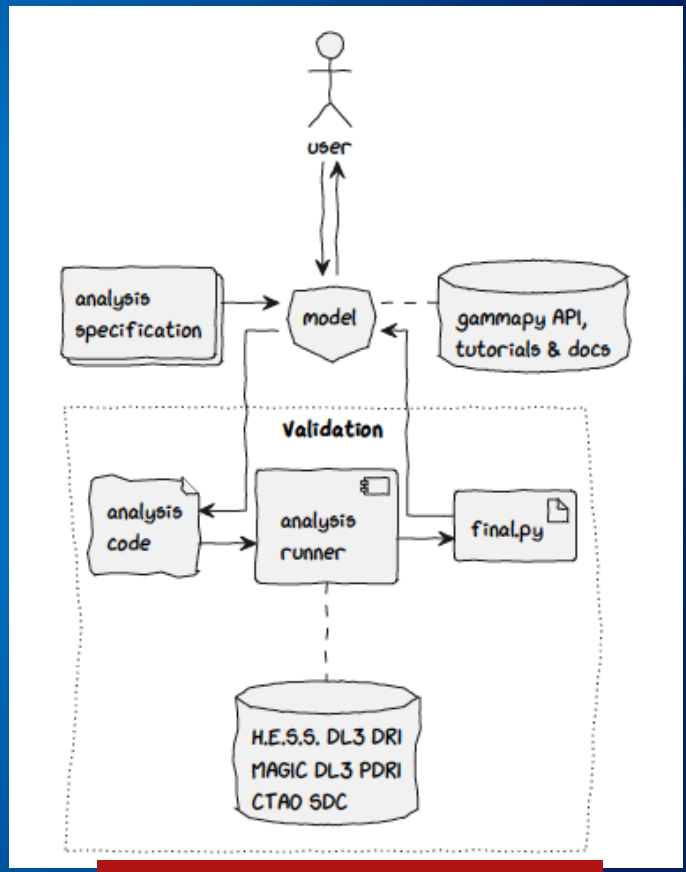
AI agents in Astronomy

An AI agent able to use CIGALE to fit SED



Sun+2024

AI agent for Gamma ray astronomy



Kostunin+2024

AI and spectroscopy towards 2040+

Deploy current AI tools for the next generation of IFU and MOS

Develop new tools for data reduction, survey strategy, scheduling

Foundation models and Agents for Astronomy?

An INAF data analysis hub for the next ESO facility