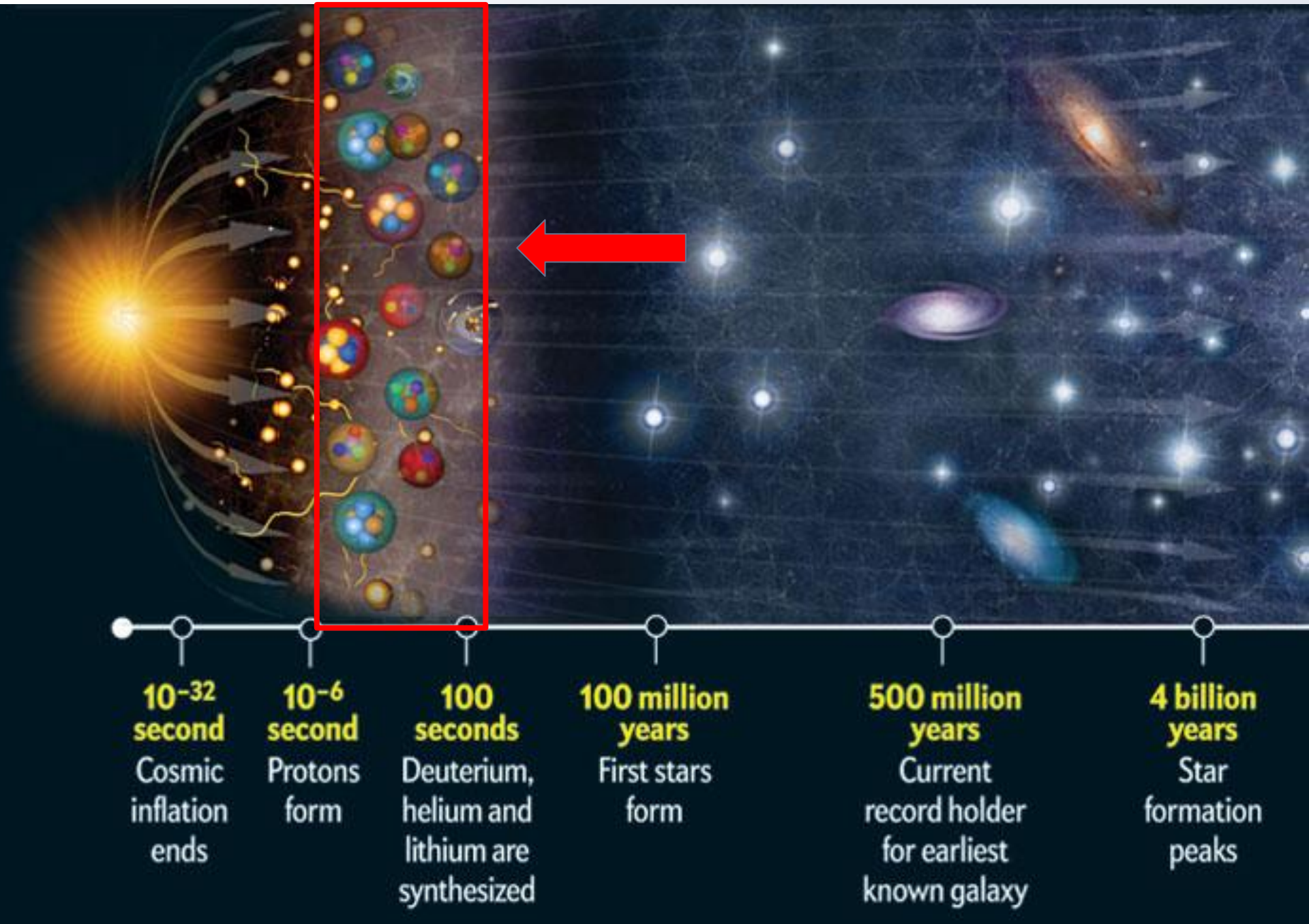
Catalyzing Interdisciplinarity

Rafael S. de Souza

Shanghai Astronomical Observatory

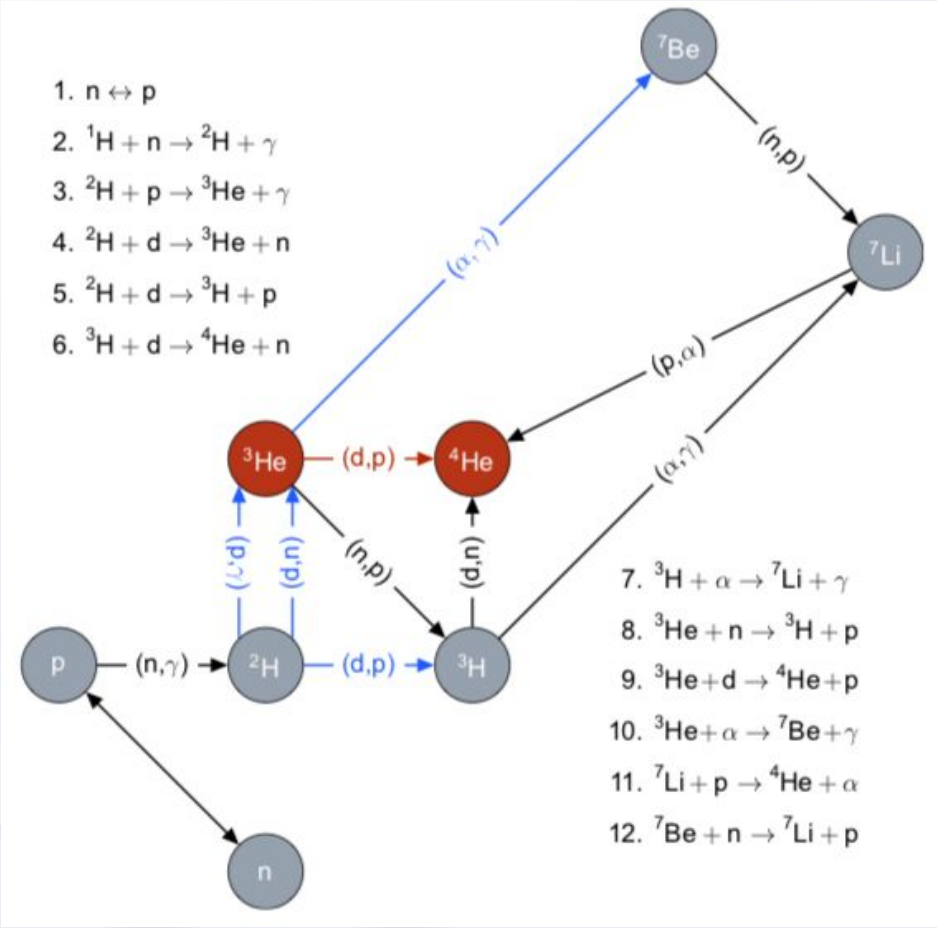
Cosmostatistics Initiative

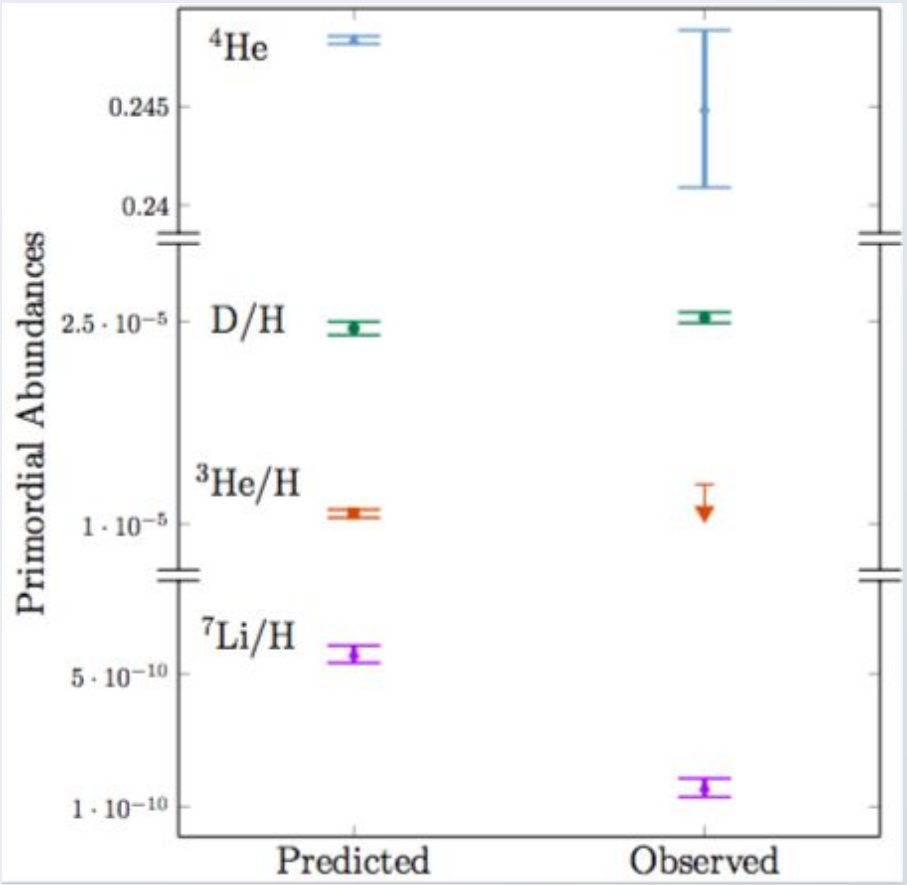
context
risk
opportunity
data
process
plan
resources
treatment
strategy
research
complex
customer
assessment
identification
impact
planning
analysis
retention
management
sales
project
performance
cost
evaluation
important
scope
organization
probability
implementation
monitor


10⁻³² second
Cosmic inflation ends
10⁻⁶ second
Protons form
100 seconds
Deuterium, helium and lithium are synthesized
100 million years
First stars form
500 million years
Current record holder for earliest known galaxy
4 billion years
Star formation peaks

The Big-Bang Nucleosynthesis

Reaction rates → Primordial Abundances





Common sources of uncertainties in Nuclear Astrophysics

- Plasma in laboratory differs from Astrophysical Plasma
- Unknown stochastic scatter;
- Errors-in-measurements
- Systematic effects - unknown normalization factors from different experiments

Hierarchical Bayesian Thermonuclear Rate for the $^{7}Be(n,p)^{7}Li$ Big Bang Nucleosynthesis Reaction

Rafael S. de Souza[1,2], Tan Hong Kiat[3], Alain Coc[4], and Christian Iliadis[1,2]

Published 2020 May 15 • © 2020. The American Astronomical Society. All rights reserved.
The Astrophysical Journal, Volume 894, Number 2

Astrophysical *S*-factors, Thermonuclear Rates, and Electron Screening Potential for the $^{3}He(d,p)^{4}He$ Big Bang Reaction via a Hierarchical Bayesian Model

Rafael S. de Souza[1], Christian Iliadis[1,2], and Alain Coc[3]

Published 2019 February 12 • © 2019. The American Astronomical Society. All rights reserved.
The Astrophysical Journal, Volume 872, Number 1

PHYSICAL REVIEW C
covering nuclear physics

Highlights Recent Accepted Authors Referees Search Press About

Accepted Paper

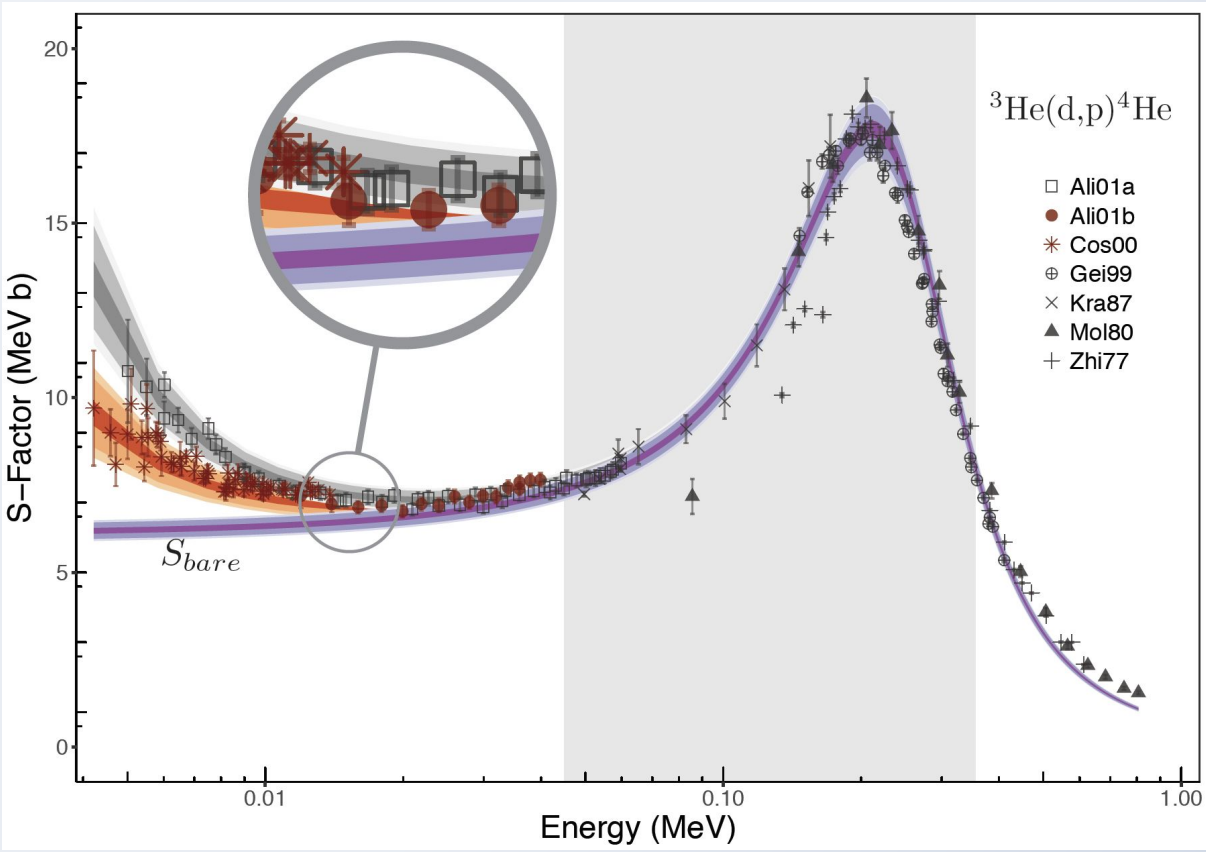
Thermonuclear fusion rates for tritium + deuterium using Bayesian methods

Phys. Rev. C

Rafael S. de Souza, S. Reece Boston, Alain Coc, and Christian Iliadis

Accepted 2 January 2019

Uncertainty quantification for Nuclear Astrophysics via Bayesian Hierarchical Models

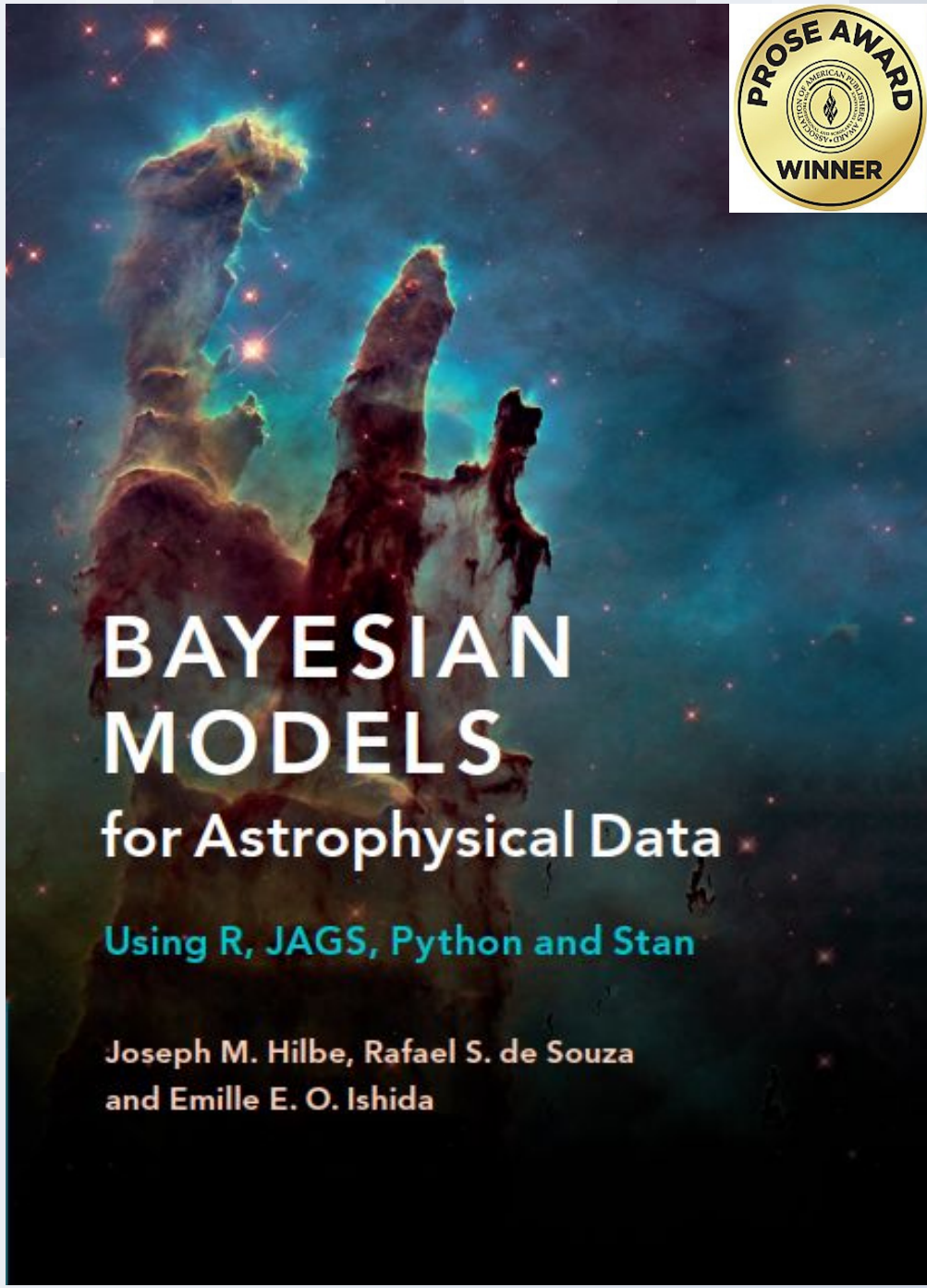


COSMOLOGY & ASTRONOMY

Cambridge University Press

Bayesian Models for Astrophysical Data Using R, JAGS, Python, and Stan

By Joseph M. Hilbe, Rafael S. de Souza, and Emille E. O. Ishida



Cambridge Elements

Astrostatistics

The development of new statistical methods and their application in the quest to answer astronomical endeavours has given rise, in the past few decades, to the field of Astrostatistics. This exciting area, that emerges at the intersection of Statistics and Astronomy, provides a fertile ground for both communities to grow. This innovative series from Cambridge University Press is a new medium to communicate advances in Astrostatistics to enable a steady astronomical–statistical dialogue, to develop a common language for the benefit of both communities, and to catalyse the synergy between them.

Elements are short, timely, broadly accessible papers that will appeal to both astronomical and statistical communities, highlighting cutting-edge developments for graduate students and researchers. This Elements series offers a unique platform where statistical methods and their potential applications may be demonstrated, for example, in advance of an important astronomical data release, as well as reviews and tutorials on more general topics in Astrostatistics, accepting both invited and unsolicited contributions, both subject to suitable peer review by astronomers and statisticians. The series also encourages best practice in software/code archiving and distribution through appropriate repositories to ensure their long-term access and scientific reproducibility.

Forthcoming topics in the series

(among many others planned over the coming few years):

- Sparsity in Astronomical Data Analysis and Acquisition
- Astronomical Inference via Forward Modelling and Template Libraries
- Bayesian Inference for Astrophysics
- Poisson Statistics in High-Energy Astrophysics

Series Editors

Rafael de Souza, *University of North Carolina at Chapel Hill*

Emille Ishida, *Université d'Auvergne*

Alberto Krone-Martins, *Universidade de Lisboa*

Jianhua Huang, *Texas A&M University*

Alan Heavens, *Imperial College London*

Benjamin Wandelt, *Université de Paris*

CAMBRIDGE UNIVERSITY PRESS

Cambridge Elements

Cambridge Elements are original, concise, authoritative, and peer-reviewed collections of scholarly and scientific research. Organised into focused series edited by leading scholars, they provide comprehensive coverage of key topics in disciplines spanning the arts and sciences.

Flexibility

With lengths of approx. 20,000 to 30,000 words (~40-70pp.), Elements offer an opportunity to publish concise overviews of techniques and their applications not typically found in the traditional book and journal literature.

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Functionality

The digital-first format allows:

- Enhanced search
- Linked references
- Citation export
- Ability to link to a variety of associated formats – audio, video
- Richer content – social media, debates, resources for teaching, links to data repositories

Content will be hosted on Cambridge Core, which means Elements will benefit from launch marketing as well as increased discoverability. Functionality will be updated on a regular basis.

Want to find out more?

To write an Element for this series or to find out more information about it, contact:
Rafael de Souza (rafael@cosmostatistics-initiative.org)

For more information about the Cambridge Elements publishing model, contact Vince Higgs (vhiggs@cambridge.org)

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CAMBRIDGE UNIVERSITY PRESS

A worldwide endeavour aimed to foster interdisciplinary collaborations around Astronomy.

Team Science Learning

STATISTICAL CHALLENGES in 21st CENTURY COSMOLOGY

IAU SYMPOSIUM 306 Lisbon Portugal 25-29 May 2014

COIN
Cosmostatistics Initiative

Session: CMB (Chair: Graca Rocha)

16h15 – Anomalies – Hiranya Peiris

16h50 – Transforming Data into Science: Planck data and the CMB non-Gaussianity – Anna Mangilli

17h10 – Applications of the Gaussian Kinematic Formula in Cosmology – Yabebal Fantaye

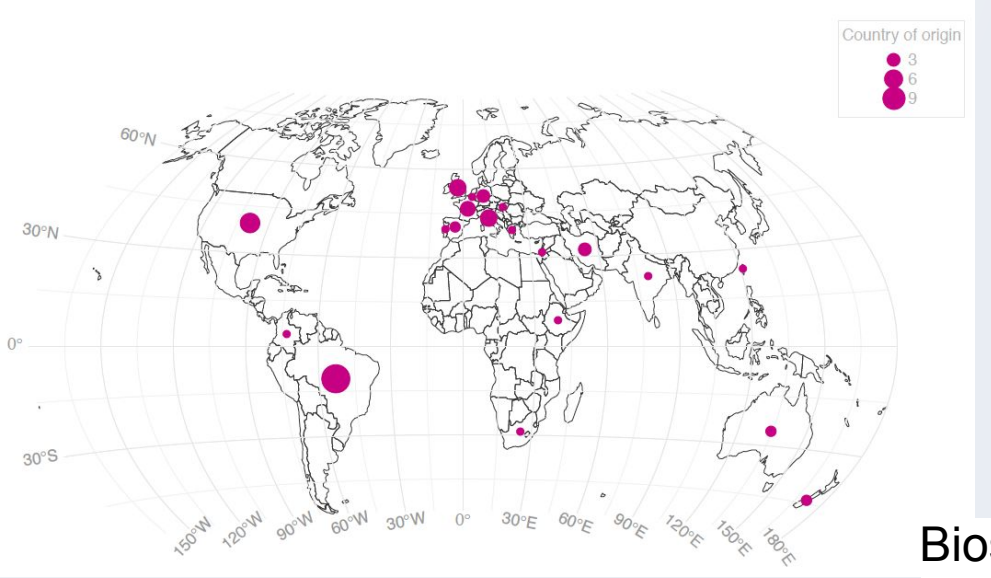
17h30 – Detectability of multi-connected topologies – Ophélia Fabre

17h50 – Cosmology with photometric quasars – Boris Leistedt

18h10 – Session ends

18h10 to 18h40 – *Meeting of the IAA Working Group on Cosmostatistics* – *Hosted by Rafael de Souza*

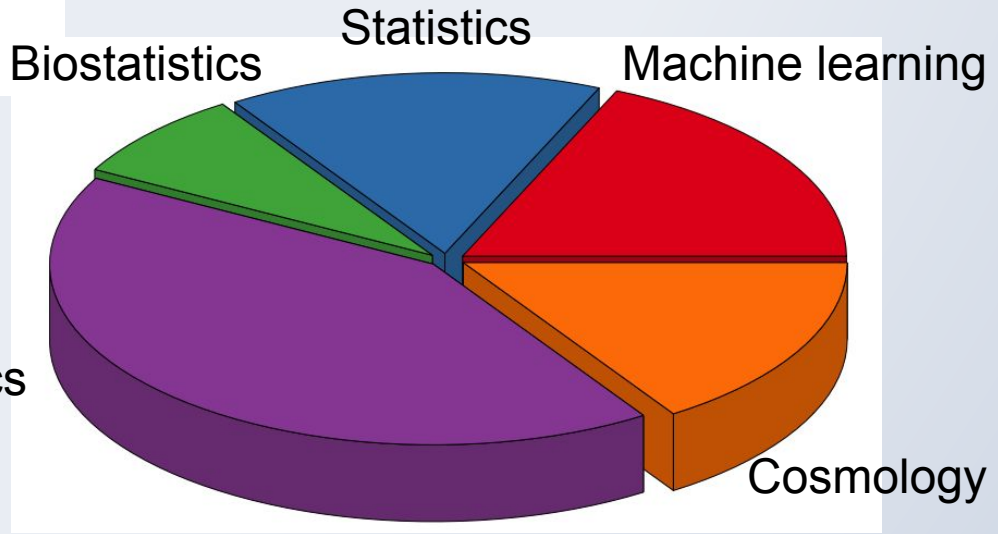
A worldwide task force



Over **60** researchers from **15** countries

Management model utilizes concepts of startups and meta-studies of interdisciplinary teams.

Projects, and the structure of the venue, are designed to optimize the contribution of each participant



See e.g. Am J Prev Med. 2008, 35, S96-115. *The ecology of team science understanding contextual influences on transdisciplinary collaboration*


COIN
Cosmostatistics Initiative
COIN
https://cosmostatistics-initiative.org
About
Chairs
Projects
Residence Programs
Focus
Community
Highlights
Partners

CRP#4: Clermont-Ferrand, France 2017

CRP#5: Chania, Greece 2018

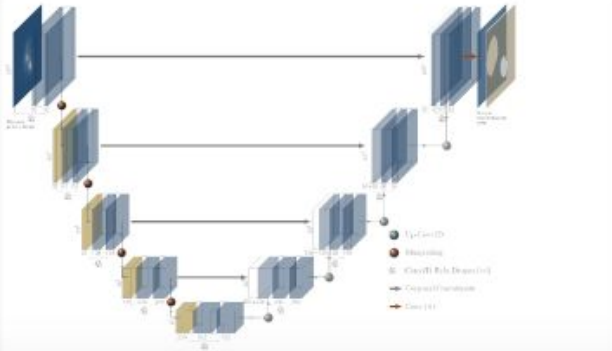

COIN Residence Program #6
Chamonix - France, 24 - 31 August 2019

COIN-Focus : TOLIMAN mission

Read more

COIN and LSST-DESC join forces in astro-wise machine learning research

Read more

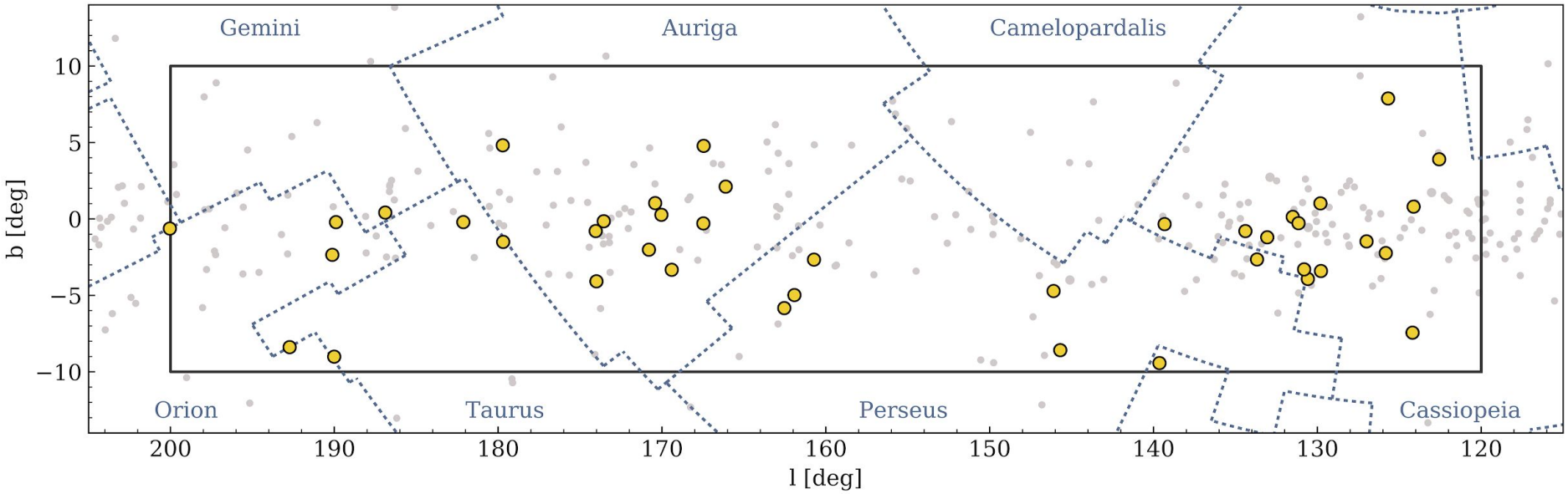


Sight beyond sight: Teasing Galaxies Apart with Deep Learning

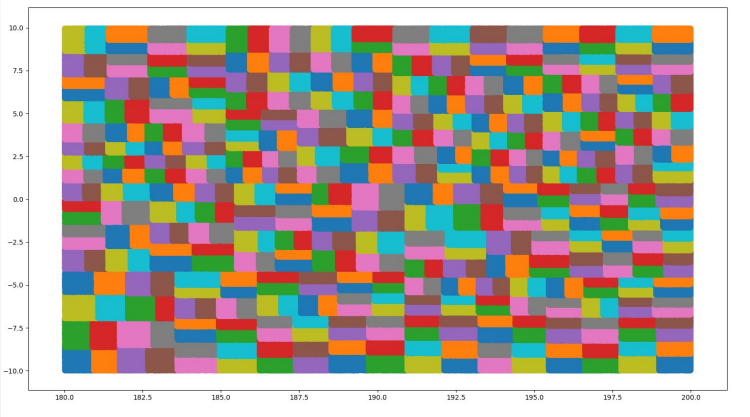
Read more

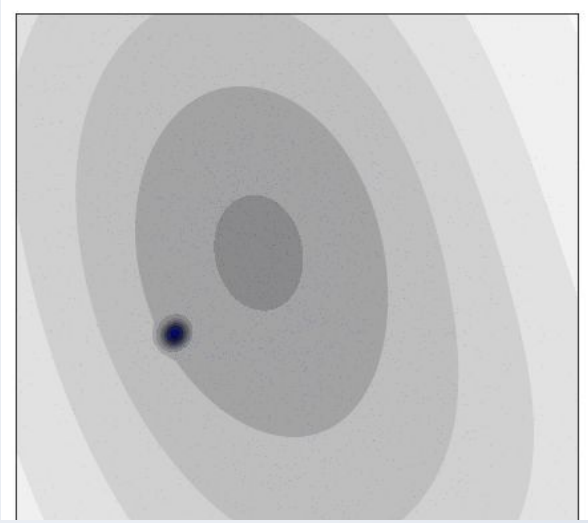
Now you see me: COIN extends the open cluster census in the solar neighborhood with Gaia DR2

A&A, 624, A126, 17, 2019



Astro-aware statistical learning



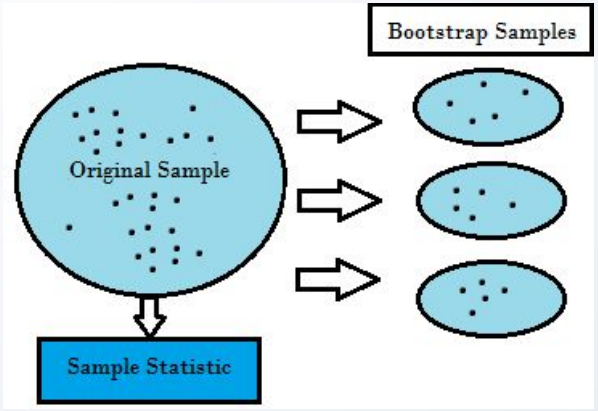


Fast density-aware partitioning of the sky via a *k*-d tree in the spatial domain of Galactic coordinates.

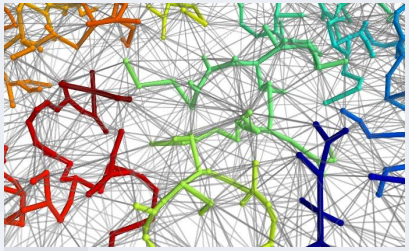
Only meaningful cases are further scrutinized, i.e. low variance in proper motion.

Recommender system

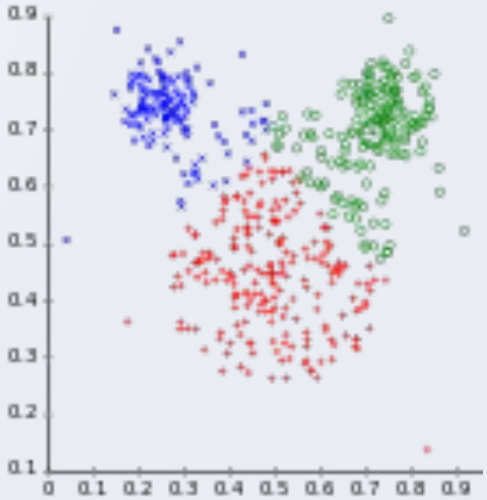
Astro-aware statistical learning



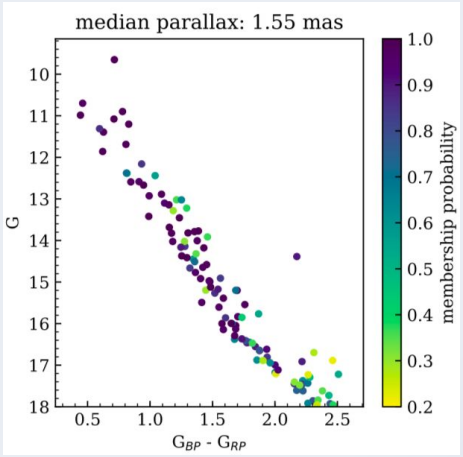
Bootstrap for measurement uncertainty



Sanity check against a random field via minimum spanning trees

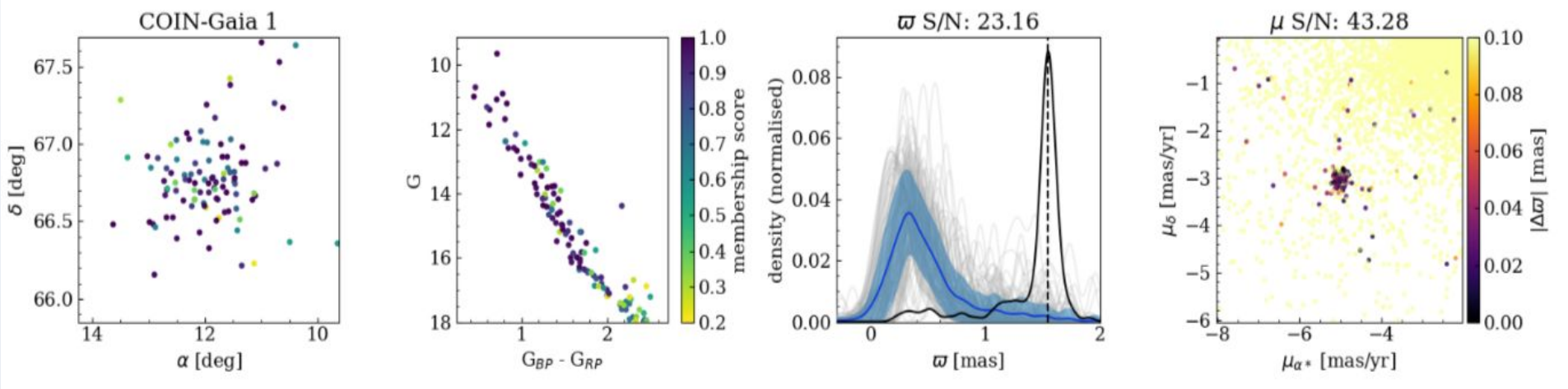


Iterative K-means in the space of proper motions.



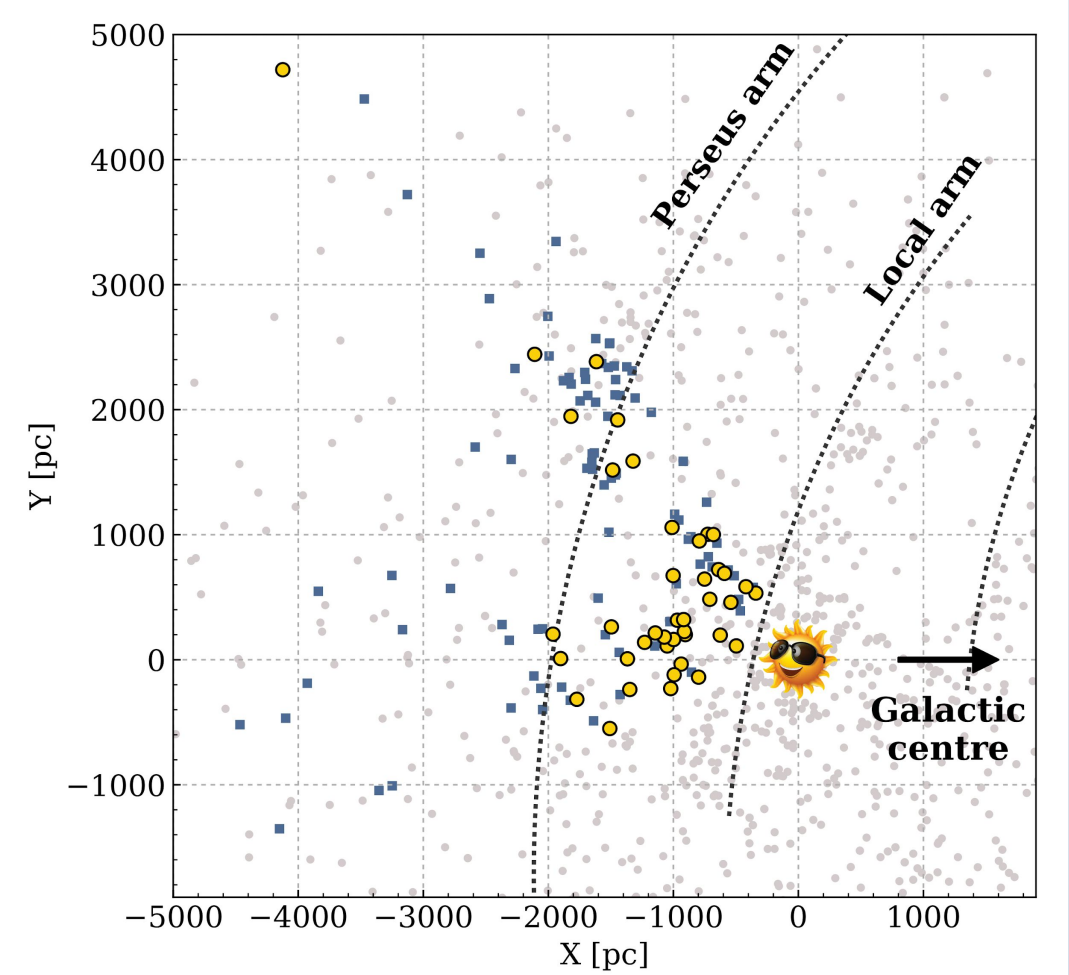
Independent expert validation

COIN-Gaia 1


COIN-Gaia 1
δ [deg]
α [deg]
G
G_BP - G_RP
membership score
ϖ S/N: 23.16
density (normalised)
ϖ [mas]
μ S/N: 43.28
μ_δ [mas/yr]
μ_α* [mas/yr]
|Δϖ| [mas]

COIN extends the open cluster census in the solar neighborhood with Gaia DR2

We reported the discovery of 45 new stellar clusters

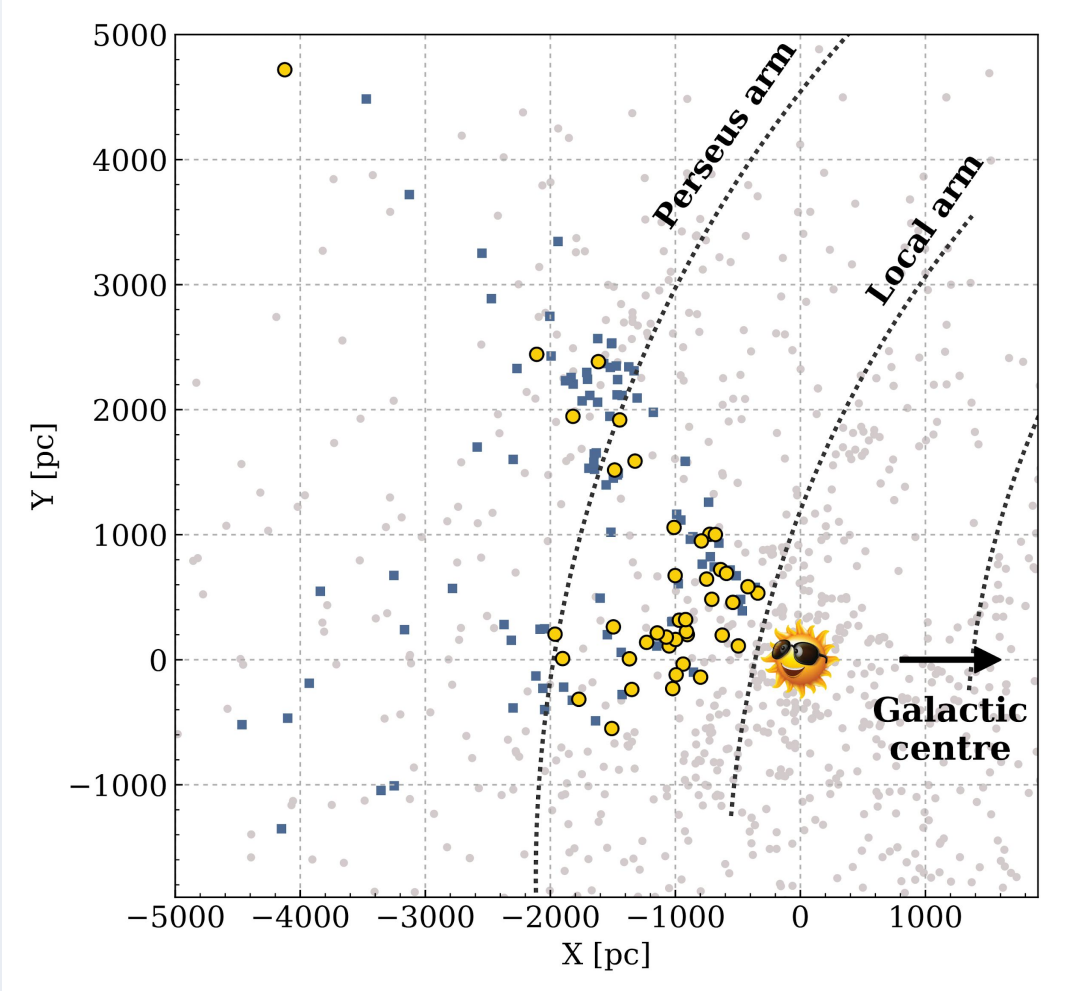


An increment of at least 20% of the previously known OC population in this volume of the Milky Way.

Potential follow-up project-

GAIA DR3 + LAMOST:

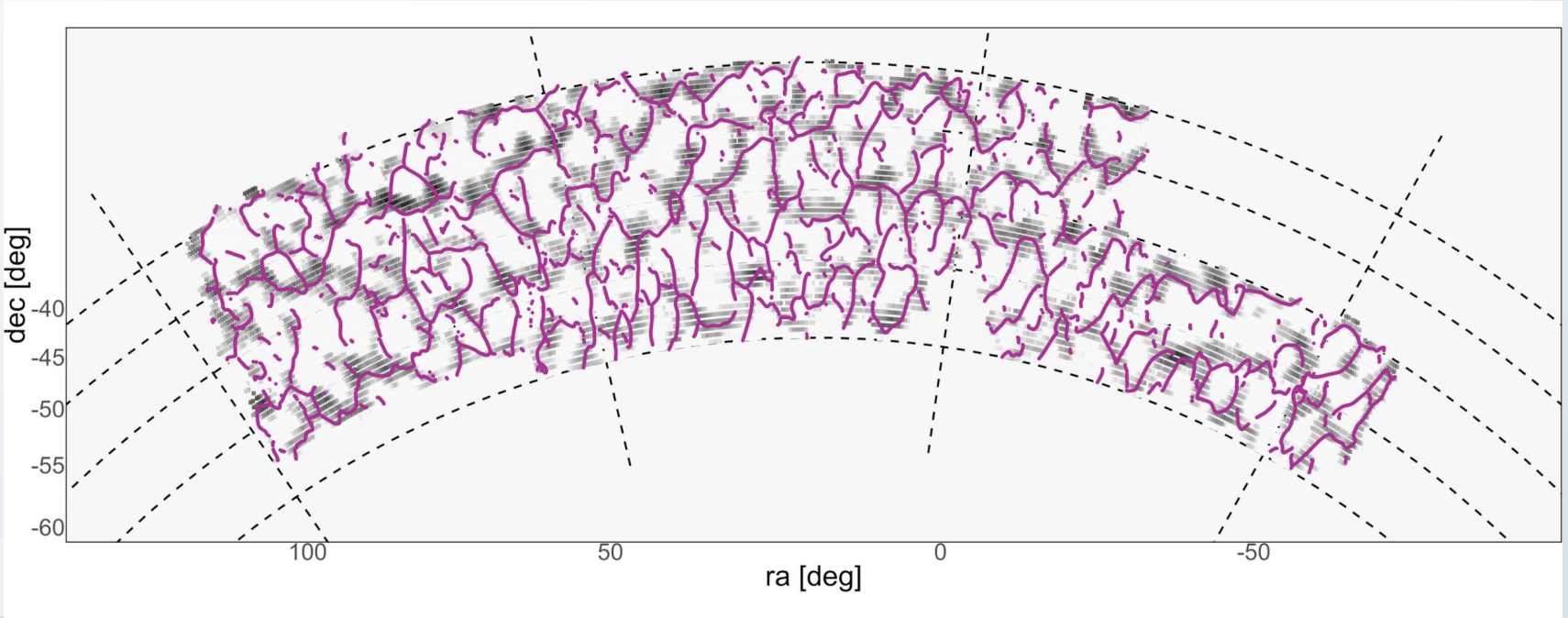
Full sky search with Gaia DR3 and cross-match the newly discovered with **LAMOST-LEGUE and related spectroscopic surveys** to produce the largest OC catalog of OC properties.



An increment of at least 20% of the previously known OC population in this volume of the Milky Way.

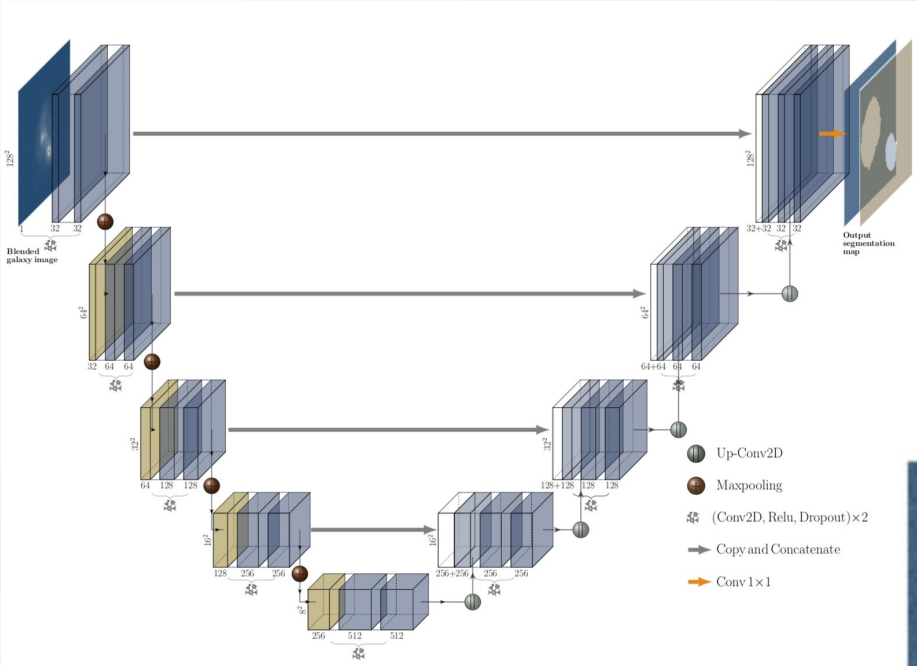
Ridges in the Dark Energy Survey for cosmic voids/trough identification

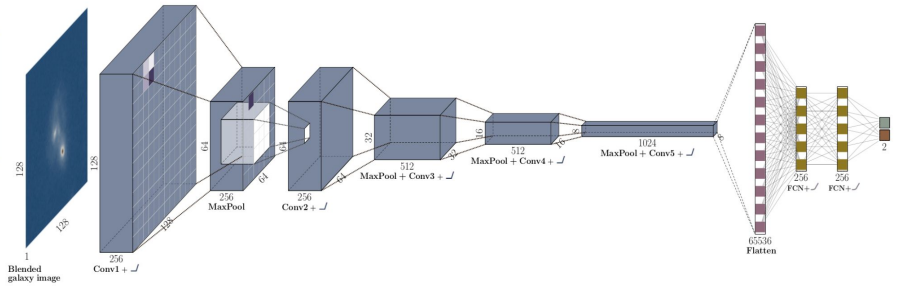
Cosmic voids/troughs play an important role in our attempt to model the large-scale structure of the Universe. They are probes to alternative cosmologies, and dark energy equation of state.



Extension of the subspace-constrained mean shift algorithm applied to 2D weak-lensing density maps from the DES DR1 arXiv:2005.08583.

Deep Learning for Galaxy Deblending





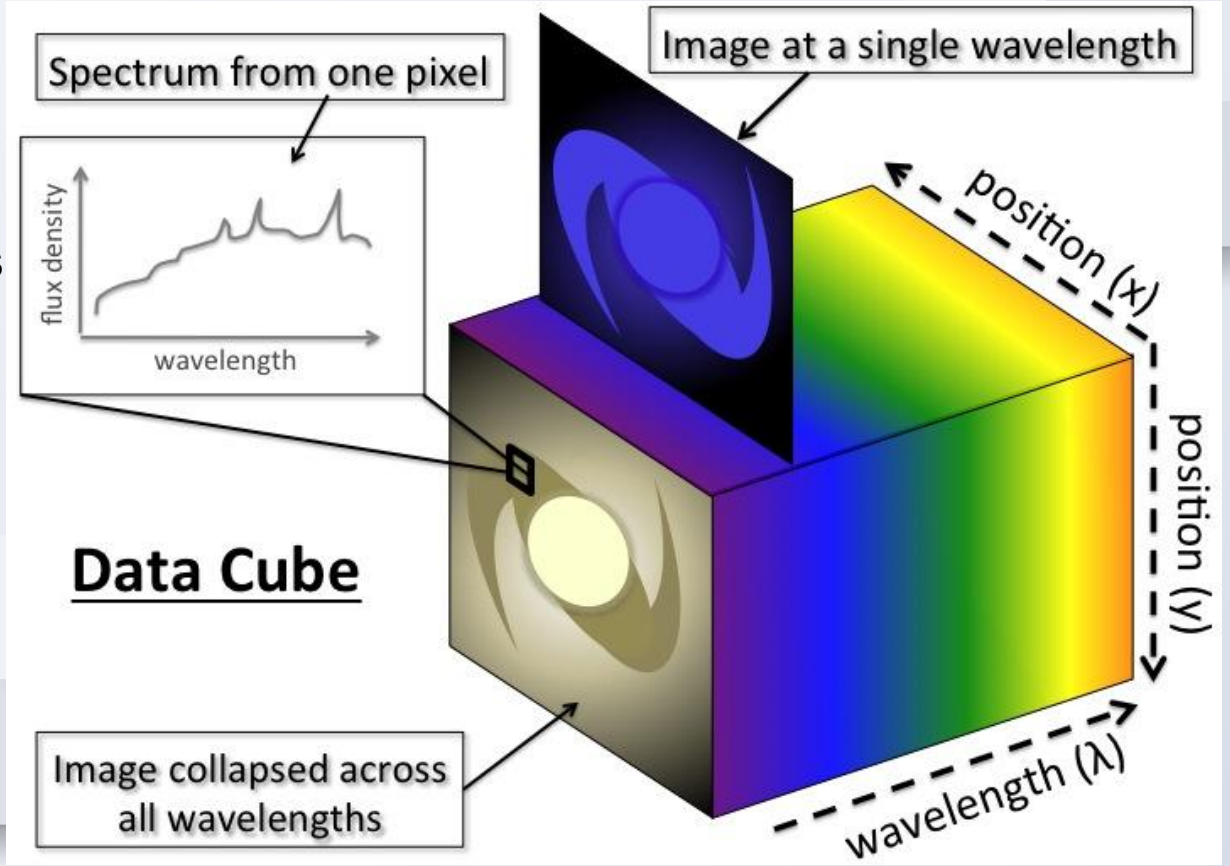
*From **COIN Residence Program #5**, MNRAS, 491, 2481 (2020)*

Spatial field reconstruction with INLA: application to IFU galaxy data

S González-Gaitán ✉, R S de Souza, A Krone-Martins, E Cameron, P Coelho, L Galbany, E E O Ishida, COIN collaboration

Monthly Notices of the Royal Astronomical Society, Volume 482, Issue 3, 21 January 2019, Pages 3880–3891, https://doi.org/10.1093/mnras/sty2881

Spatially aware techniques to better exploit spatial information



Spatial field reconstruction with INLA: application to IFU galaxy data

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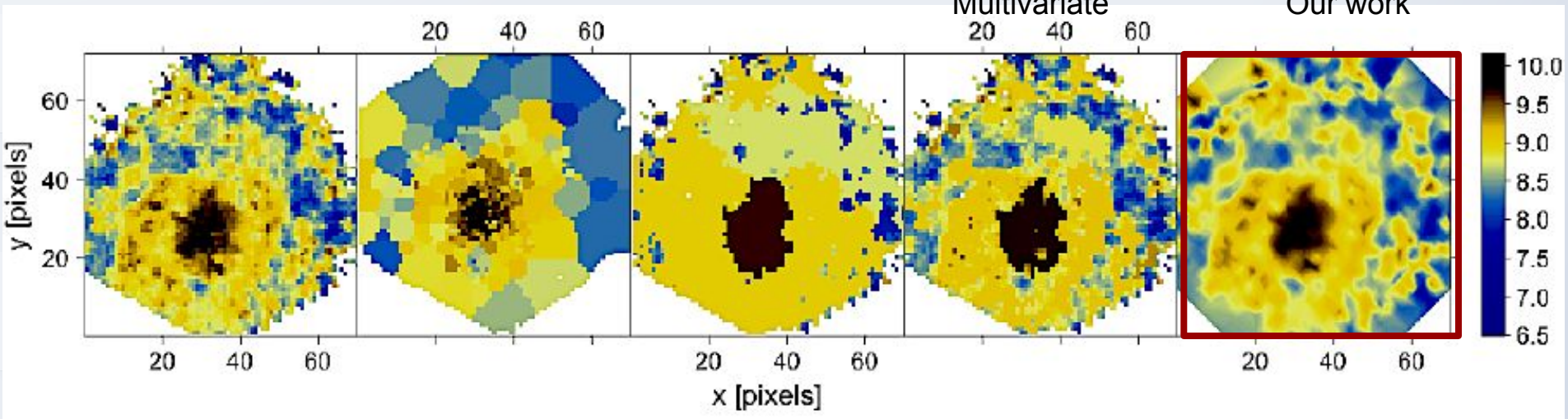
Monthly Notices of the Royal Astronomical Society, Volume 482, Issue 3, 21 January 2019, Pages 3880–3891, https://doi.org/10.1093/mnras/sty2881

The proposed Bayesian approach enables the recovery of areas with bad pixels, and an increased power to detect structures in data sets subject to substantial noise and/or sparsity of sampling.



The Cosmostatistics Initiative

The Cosmostatistics Initiative (COIN) is an international network which aims to create an interdisciplinary environment where collaborations between astronomers, statisticians and machine learning experts can flourish. The group utilizes a management model which can find parallel in technological start-ups: based on a dynamic, non-hierarchical and people-centric approach.

The LSST Dark Energy Science Collaboration

The LSST Dark Energy Science Collaboration (DESC) is an international collaboration preparing for a variety of cosmological analyses with the Large Synoptic Survey Telescope (LSST) data. In advance of LSST's first observations, DESC will help prepare for LSST science analysis, make synergistic connections with ongoing cosmological surveys and provide the dark energy community with state of the art analysis tools.

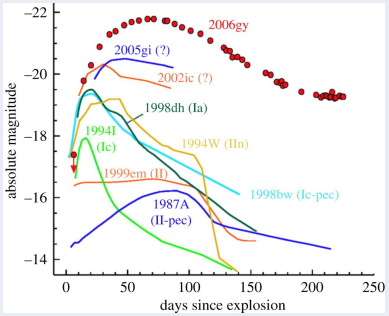
RESSPECT

The REcommendation System for SPECTroscopic follow-up (RESSPECT) is a collaboration between COIN and LSST-DESC which aims to adapt active learning strategies for the construction of optimized training samples for supernova photometric classifcation in the context of LSST.

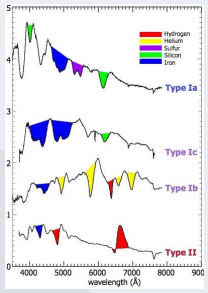
The team is formed by researchers from both collaborations who are working together in the development of a recommendation system which will enable informed decisions regarding the allocation of spectroscopic follow-up resources and consequent optimized scientific results from purely photometric samples.

Spectroscopy vs Photometry
(high-resolution) (low-resolution)

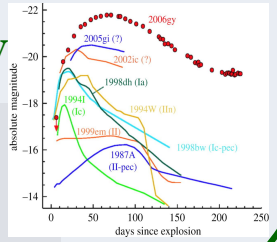
Apply it here



Learn from here



Photometry
+
Spectra

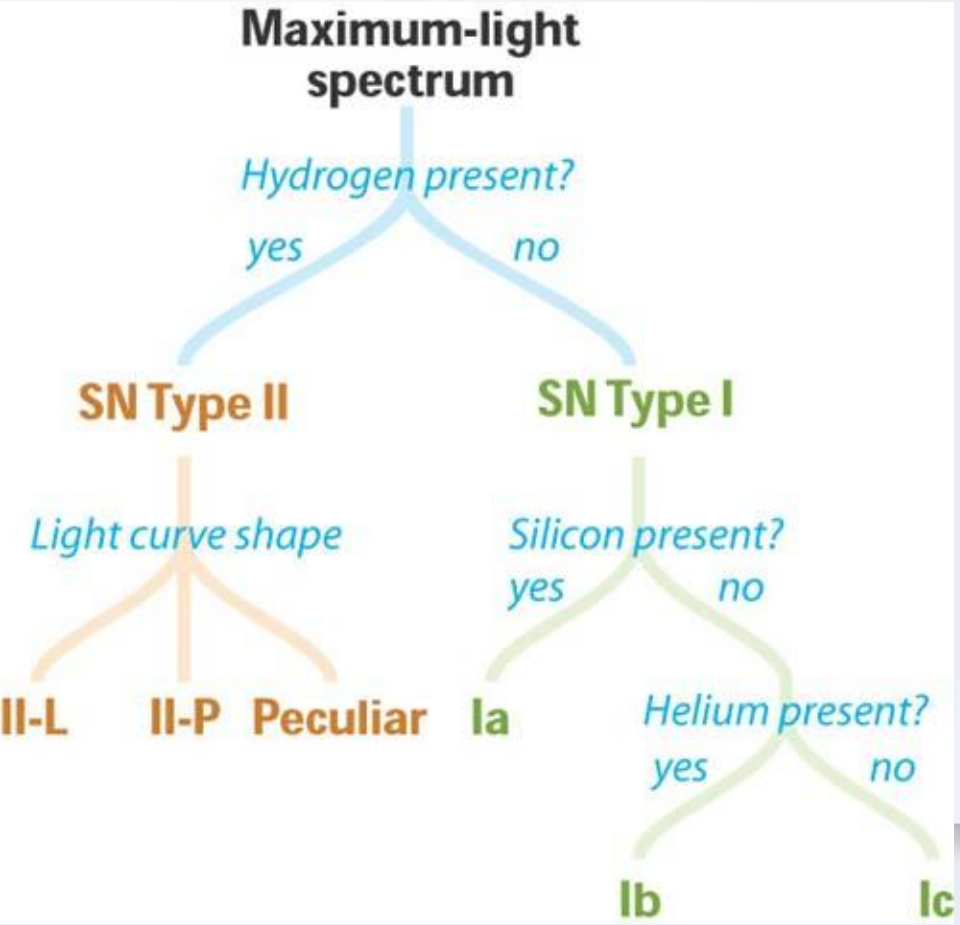


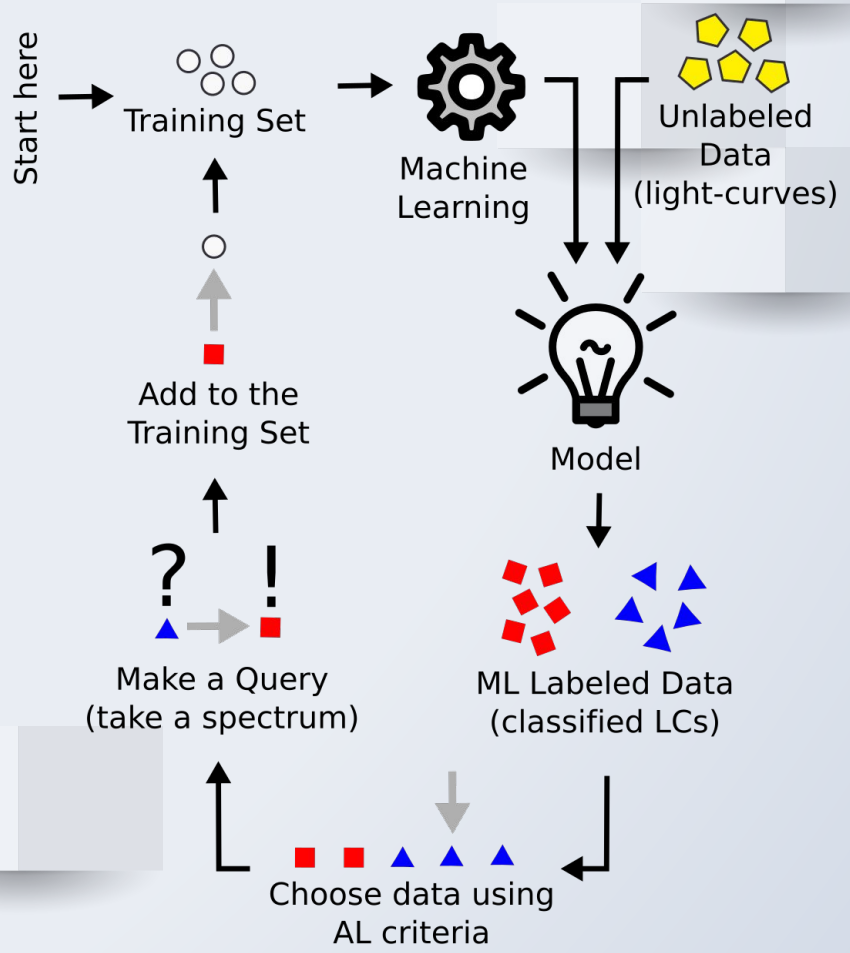
Photometry only

Optimizing spectroscopic follow-up strategies for supernova photometric classification with active learning

E E O Ishida ✉, R Beck, S González-Gaitán, R S de Souza, A Krone-Martins, J W Barrett, N Kennamer, R Vilalta, J M Burgess, B Quint, ... Show more

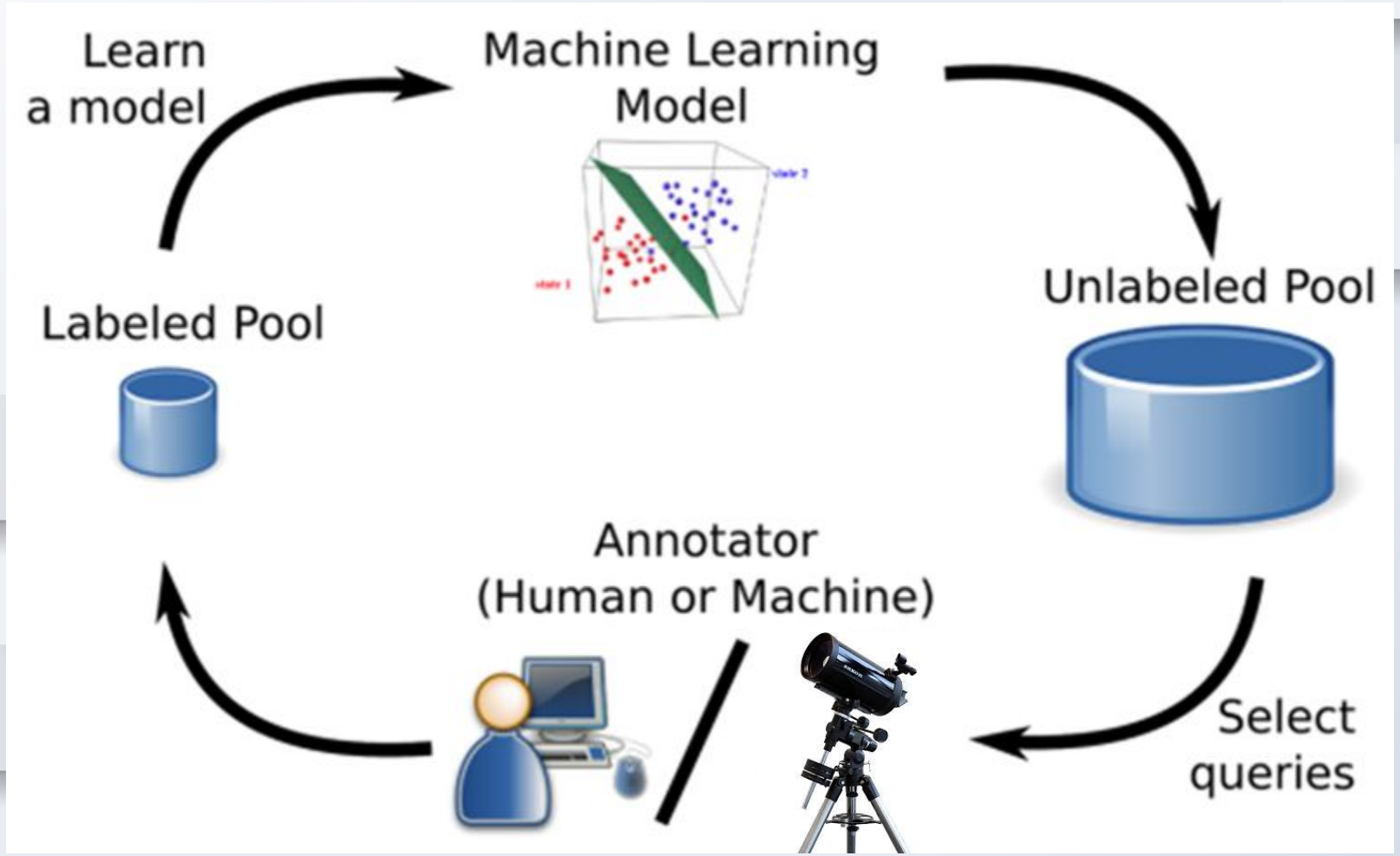
Monthly Notices of the Royal Astronomical Society, Volume 483, Issue 1, 11 February 2019, Pages 2–18,





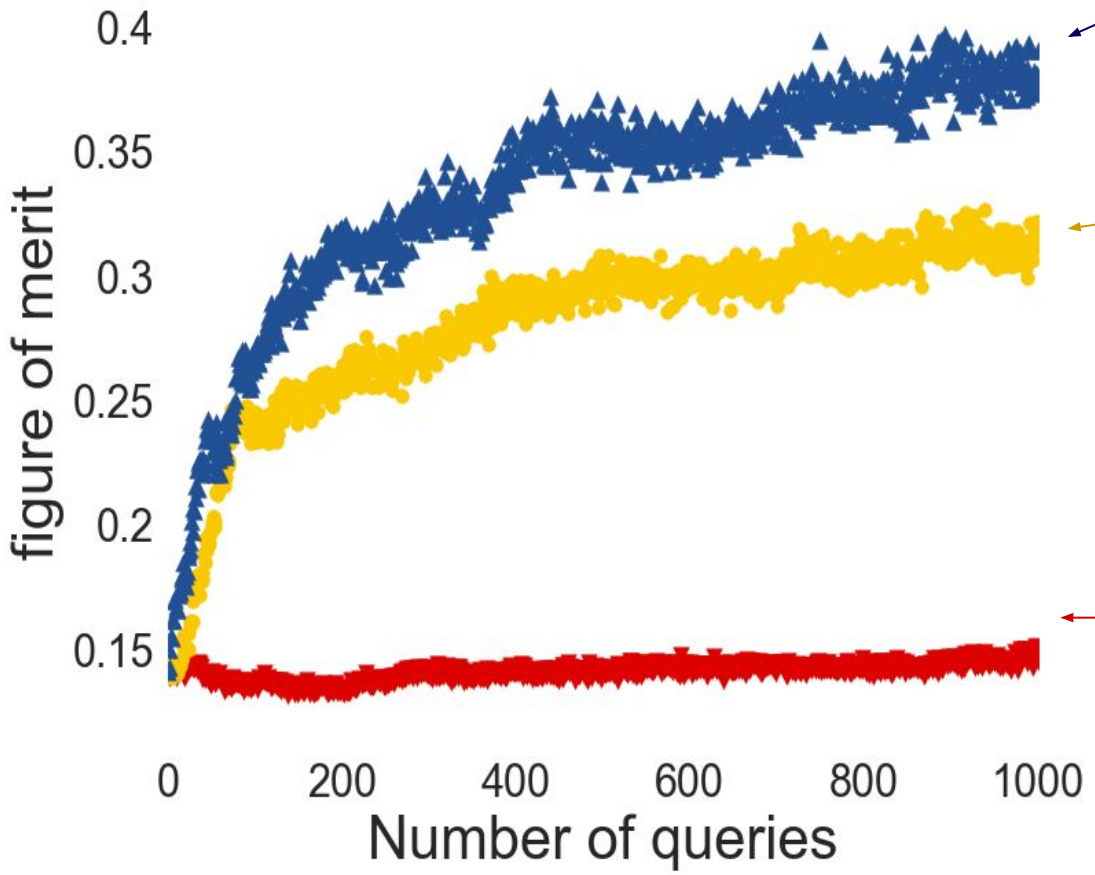
Active Learning

Optimal classification, minimum training



AL for Supernova Classification

Diagnostic plots



Active Learning

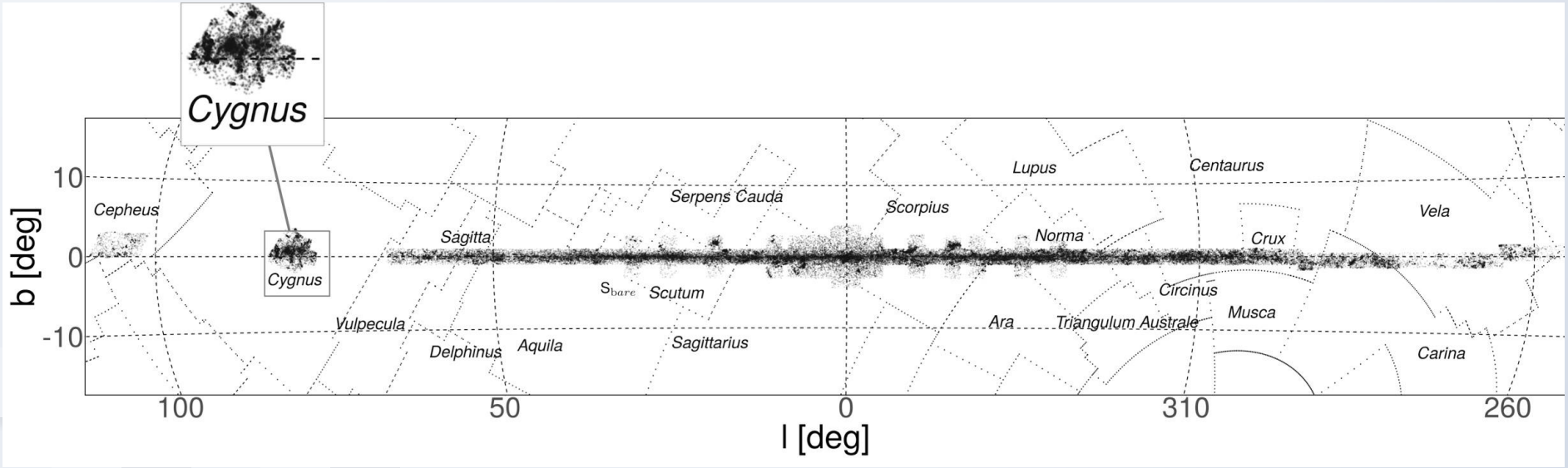
Passive Learning

Current strategy

CYMES - Candidate YSOs with Mid-IR Excess from Spitzer

We perform an automated search for young stellar objects (YSOs) using the public IRAC catalogs from Spitzer legacy surveys (GLIMPSE I/II, 3D, Vela-Carina, Cygnus X, and SMOG). They are augmented by near-infrared (NIR) catalogs from 2MASS, UKIDSS, and VVV.

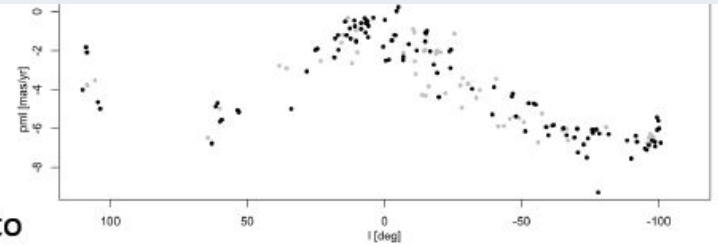
We identify ~150,000 YSOs candidates.
More than twice the previously known objects.

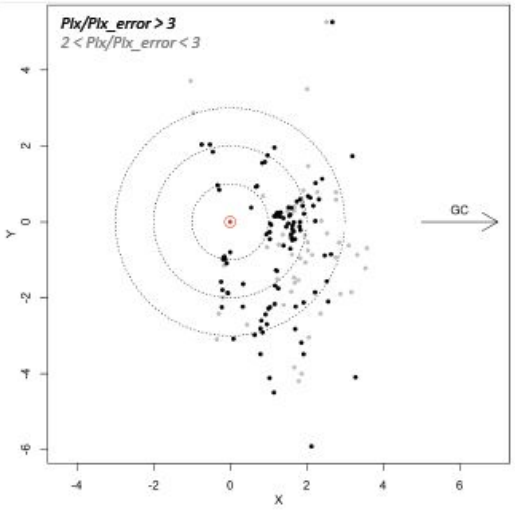


IRAC catalogs → Cross match •2MASS •UKIDSS •VVV → Color cuts → SED Fitting → Creation of training sets → Imputation → YSO Classifier

Gaia cross match → Remove duplicates → Cluster Analysis on Spatial Distributions → Validate groups using clustering in PM/Plx → Obtain mean astrometric properties of groups

- About one third of YSO candidates have *Gaia* astrometry
- We expect YSOs that are members of associations to cluster in parallax/proper-motions space, while contaminants are not expected to be clustered
- *Gaia* can be used to validate which groups are real and which YSO candidates are likely members of these groups





Mean proper motions (top) and distances (left) for groups of stars clustered in pos-plx-pm space.

Estimating Contamination Rate for YSO Candidates in the Galactic Plane

Michael A. Kuhn (CIT), Lynne Hillenbrand (CIT), Alberto Krone-Martins (UC Irvine), Rafael S. de Souza (SHAO), Emille E. O. Ishida (CNRS), Alfred Castro-Ginard (U Barcelona)

We request three nights for observations with the P200/DBSP to spectroscopically classify a sample of candidate young stellar objects (YSOs).

Some potential collaboration with SHAO to use local facilities?

2020B Palomar Cover Sheet 4/15/20, 4:41 PM

COO/Palomar Observatory

Cover Sheet - Semester 2020B

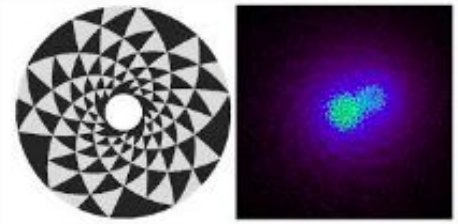
200-inch Telescope

COIN-Focus

Toliman

The TOLIMAN space telescope is a low-cost, agile mission concept dedicated to astrometric detection of exoplanets in the near-solar environment, and particularly targeting the Alpha Cen system.

COIN
Cosmostatistics Initiative



BREAKTHROUGH
INITIATIVES

CRP#7?

- COIN was constructed under the lemma *people come first*.
- The scientific project emerges from a shared group interest.
- They are a product of the interaction between a unique group of people, whose materialisation is only possible in an environment which profoundly respects the diversity of their scientific backgrounds, gender, career stages and nationalities.


THANK
YOU
PEACE