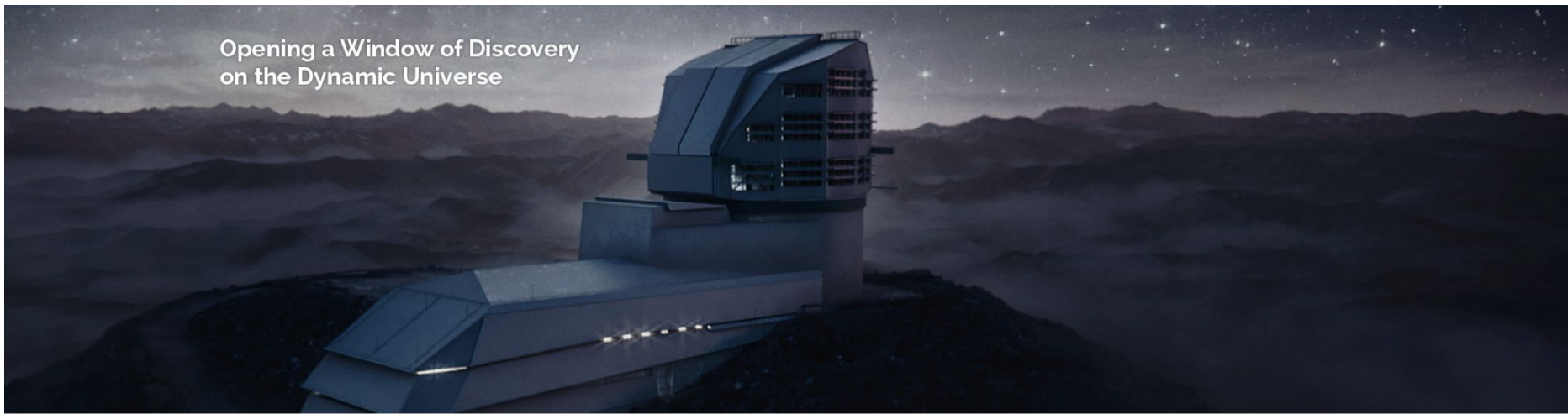


Opening a Window of Discovery
on the Dynamic Universe



LSST-MX: Mexican Participation in the Vera Rubin Observatory's Legacy Survey of Space and Time

Alma X. González Morales
Universidad de Guanajuato

On behalf of LSST-MX consortium



<https://rubinobservatory.org/es>

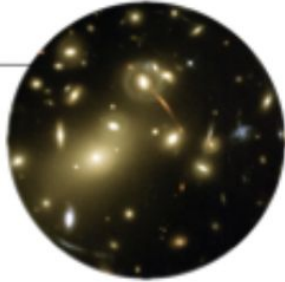
<http://fisica.ugto.mx/~lsstmx/>



Rubin/LSST Main Science Drivers (See Rogerio's talk)

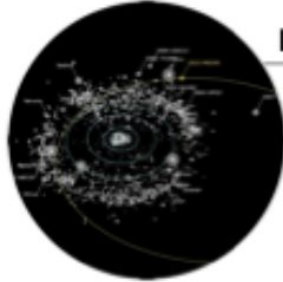
Probing Dark Matter & Dark Energy

- Strong & Weak Lensing
- Large Scale Structure
- Galaxy Clusters, Supernovae



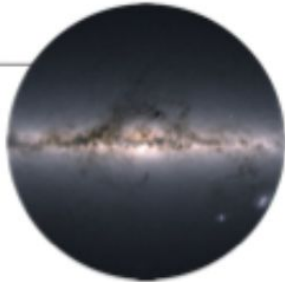
Inventory of the Solar System

- Comprehensive small body census
- Comets & ISOs
- Planetary defence



Mapping the Milky Way

- Structure and evolutionary history
- Spatial maps of stellar characteristics
- Reach well into the halo



Exploring the Transient Optical Sky

- Variable stars, Supernovae
- Fill in the variability phase-space
- Discovery of new classes of transients

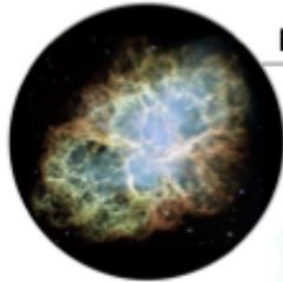


Image Credit: Rubin Observatory/Leanne Guy

Mexican Participation in Rubin/LSST

In-kind program

- A long road: First attempt to join LSST in 2015 (~40,000 USD per PI at that time).
- Sent in-kind proposal in 2019 and formally joined in 2021.
- LSST agreement in process of signature with DOE.
- In-kind project proposal leads: Alma González (U. de Guanajuato) and Octavio Valenzuela (IA-UNAM)
- Project Manager: Luis Ureña-López (U. de Guanajuato)
- Data rights (DR) for **20 PI (+ 4 JAs each)** in exchange of 6 in-kind project contributions. Mainly software development (3 directable, 2 non-directable) and a Lite-IDAC.
- List of DRH holders can be consulted at: <https://www.lsst.org/scientists/international-drh-list>

Mexican Participation

LSST-MX

Created to support the current in-kind program but also to extend it, to support scientific activities and foster collaboration, beyond current data rights (DR), and transfer knowledge in general.

- Collaborative agreement signed between UG and UNAM for the creation of LSST-MX consortium. UG and UNAM provides legal and institutional support to our activities.
- DRs assigned and overseen, annually, by LSST-MX membership committee.
- LSST-MX include participants with and without DR. 14 participant institutions: UG (Astronomy and Physics Department), UNAM (IA, ICN, ICF, IIMAS, IF,IRyA), CINVESTAV, ININ, BUAP, MCTP (Chiapas), UMSNH and UASLP
- Monthly e-meetings to share progress and activities report within the group.
- Current funding through individual grants from CONAHCYT and the different universities.

Full List of LSST-MX participants.

LSST-MX participants to date: Karla Alamo², Gabriela Alejandra Aguilar Argüello³, José Abraham Arvizu Valenzuela², Alejandro Aviles⁴, Alvaro Callejas Tavera³, Luis Eduardo Cantero Valadez², Jorge L. Cervantes-Cota⁵, Gabriel Efraín Condés Luna⁶, Julio César Clemente González⁷, Bolivia Teresa Cuevas Otahola⁸, Juan Carlos Cuevas Tello⁹, Axel de la Macorra¹⁰, Favio de Colle⁷, José Antonio de Diego Onsurbe⁷, Omar de Jesus Cabrera Rosas⁷, Josue de Santiago Sanabria¹¹, Miguel Enriquez Vargas⁷, Dailer Rolando Fontisiella Morell⁷, Sebastien Fromenteau⁴, Gibran Fuentes Pineda³, Gabriela García Arroyo⁴, Dante V. Gomez-Navarro¹⁰, Rosa Amelia Gonzalez Lopez Lira¹², Alma Xochitl González Morales^{2,13}, Héctor Hernández Toledo⁷, Juan Carlos Hidalgo Cuellar⁴, Luisa Guadalupe Jaime González⁶, Carlos Alejandro Ku Maldonado³, Luis Manuel León Anaya⁷, Francisco Xavier Linares Cedeño², Aditya Manuwal⁷, David Rogelio Márquez Castillo¹¹, Luis Alberto Martínez Medina⁷, Luis Artemio Martínez Vázquez⁷, Jorge Hiram Mastache de los Santos¹⁴, Daniel Esteban Montenegro Taborda¹², Rafael Morales Moreno⁴, Eladio Alonso Moreno Alcalá², José Salvador Negrete Serrato², Gustavo Niz², Hernán Enrique Noriega Barros⁴, René Parlange Chavarría⁷, Maria de los Angeles Pérez Villegas¹⁵, Sadi Ramírez Solano¹⁰, Mario Alberto Rodríguez-Meza⁵, Sofía del Pilar Samario Nava⁴, José Arturo Trelles Hernández⁸, Luis Arturo Ureña López², Lucero Uscanga¹⁶, José Octavio Valenzuela Tijerino⁷, Mariana Vargas Magaña¹⁰, Jose Alberto Vazquez Gonzalez⁴, Jose Antonio Vazquez Mata⁷, Tomás Verdugo¹⁵, Aida Hortensia Nava Bencheikh⁴.



<http://fisica.ugto.mx/~lsstmx/>

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Campus León

División de Ciencias e Ingenierías
Departamento de Física



UNIVERSIDAD AUTÓNOMA
DE SAN LUIS POTOSÍ



Campus Guanajuato

División de Ciencias Naturales y Exactas
Departamento de Astronomía



Current Projects

S1: Strong Lensing SC Directable Software Development

Project Lead: Alma González (UG)

Members: Luis León Anaya (postdoct, IA), Karla Alamo (UG, retired), Jorge Mastache (MCTP), Luis Ureña (UG), Octavio Valenzuela (IA), Julio Clemente (IA), Rosa Amelia González (IRyA), José Antonio De Diego Onsurbe (IA), Luis Cantero (undergraduate, UG), Salvador Negrete (PhD student, UG), Juan Carlos Cuevas-Tello (UASLP), René Parlante (PhD student, UG),
Recently Joined or in process: Tomás Verdugo (IA-UNAM) and Emmanuel Juda (MsC student, UG).

Goal: Explore and quantify image quality and identify metrics for how good are images for lens detection purpose, e.g single visit Vs (different) deep coadds.

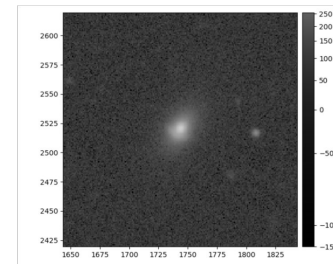
Current tasks on simulated data:

Identify best quality images from single visit exposures (best seeing, airmass, PSF variation, and other metrics)

Create custom coadded images for optimal lens detection.



Stack images, gri, for a galaxy-galaxy lens in LSST typical observation conditions. Credit: Collett 2015

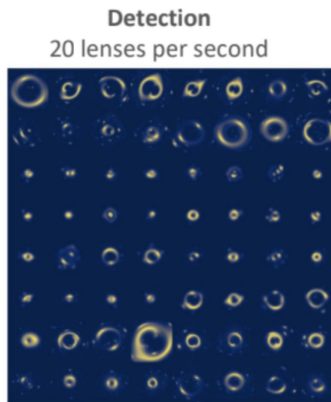


Example of a DP0.2 single exp visit with injected lens.

S1: Strong Lensing SC Directable Software Development

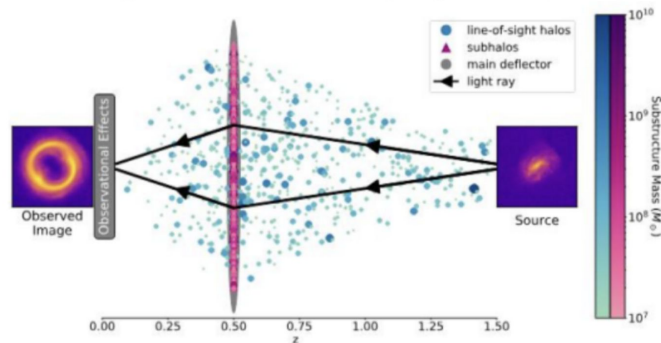
Non-inkind activities:

- SL modelling in Axion like Dark Matter models context (Salvador Negrete and Luis Ureña)
- Artificial intelligence algorithms for time delay estimation (See Juan Carlos Cuevas-Tello's talk in session VII of LSST@LATAM 2024) .
- Enhanced Time-Delay Estimation via Data Preprocessing (See Luis Leon's talk in session VII of LSST@LATAM 2024)
- Machine Learning for Strong Gravitational Lens Detection (See René Parlange's talk in session VII of LSST@LATAM 2024)



Credit: René Parlange

From Images to Dark Matter: End-To-End Inference of Substructure From Hundreds of Strong Gravitational Lenses (Wagner et al., 2023)



S2: DESC Directable Software Development

Members: Alberto Vazquez(ICF-UNAM), Gabriela Garcia (ICF-UNAM), Juan Carlos Hidalgo (ICF-UNAM).

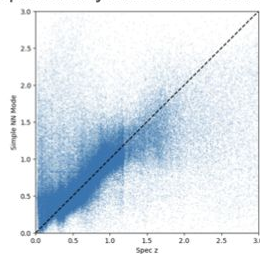
Contribution Lead: Josué de Santiago (CINVESTAV)



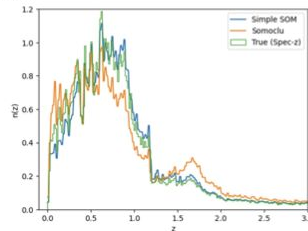
Non-in-kind project: Semi-supervised learning for Photo-z by Alvaro Callejas (PhD Student, UNAM), See Alvaro's talk at LSST@LATAM 2024.

E.g: Photo-z code parallelization by Josué de Santiago

Photometric redshifts **estimators** produce a redshift probability function for each galaxy.



Photometric redshift **summarizers** produce a redshift distribution $n(z)$ for a set of galaxies.



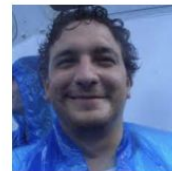
Since the quantity of galaxies in LSST will be too large to be processed by a single computer node, we need to parallelized the Photo-z codes to use all of the computer power available.

[RAIL](#) is the main photo-z engine for DESC, we have parallelized all of the estimators and most of the summarizers in RAIL

Algorithms parallelized as part of the in-kind contribution

- Estimation:
 - BPZ, Pzflow, train_z, random_gauss, k nearest neighbor, sklearn_neurmet, GPz, delightPZ, flexzboost
- Summarization:
 - NZDir, Somoclu, var_inf
- Creation:
 - FSPS

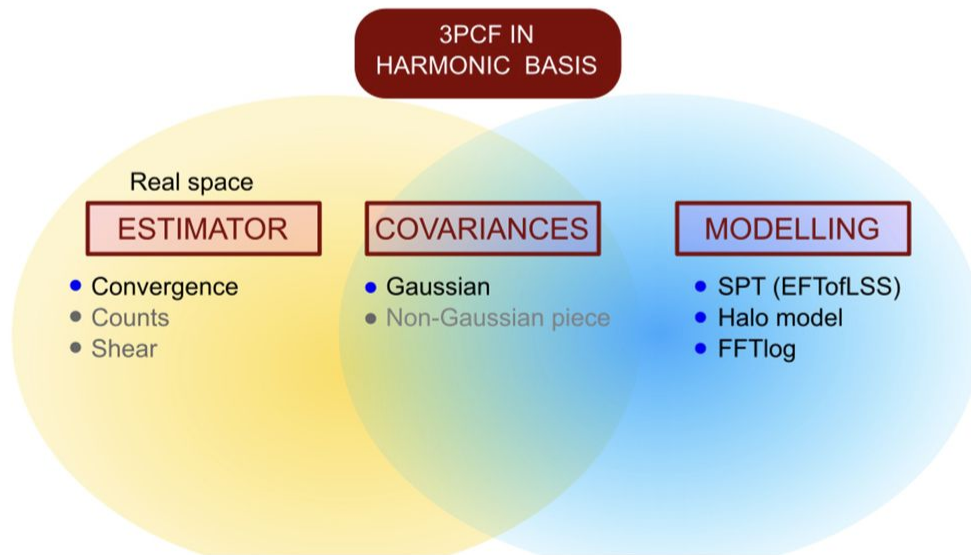
S3: DESC Non-Directable Software Development



Project Lead: Alejandro Aviles (ICF-UNAM)

Members: Sofia Samario (ICF-UNAM), Eladio Moreno (ICF-UNAM), Abraham Arvizu (UG), Francisco Linares (UMSNH), Juan Carlos Hidalgo (ICF-UNAM), Mario Rodríguez (ININ), Gustavo Niz (UG), Alejandro Aviles (ICF-UNAM)

Main idea: Expand 3 point correlation functions of weak lensing in plane waves



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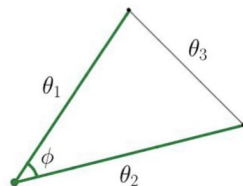
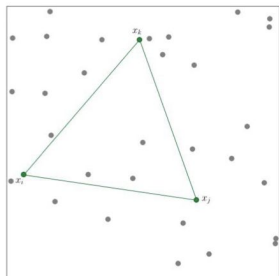
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S3: DESC Non-Directable Software Development

3PCF ζ :

$$\zeta(\theta_1, \theta_2) = \zeta(\theta_1, \theta_2, \phi) = \sum_{m=-\infty}^{\infty} \zeta_m(\theta_1, \theta_2) e^{im\phi}$$



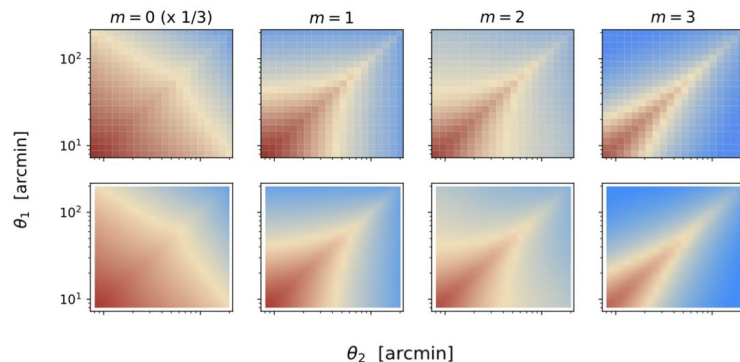
Modeling the 3-point correlation function of projected scalar fields on the sphere.

Arvizu et. al 2024, in prep.
(passed DESC internal review)

3PCF multipoles $\zeta_m(\theta_1, \theta_2)$

Counting triangles: complexity $\mathcal{O}(N^3)$

Harmonic basis: complexity $\mathcal{O}(N^2)$



Simulations

Theory

Scale: 8-200 arcmin

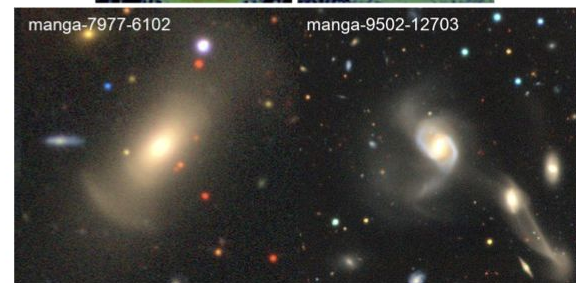
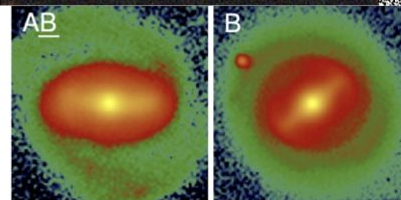
S4: Galaxies SC Non-Directable Software Development

Members

Gabriela Aguilar Argüello², Gibran Fuentes Pineda², Héctor Hernández Toledo¹, Luis A. Martínez¹, J Antonio Vazquez-Mata¹.

1. Instituto de Astronomía, UNAM
2. Instituto de Investigaciones en matemáticas aplicadas y sistemas, UNAM

- The automatic morphological classification of galaxies based on photometry and structural information (Vazquez-Mata talk, Aguilar-Argüello et al. in prep.)
- Detection of independent morphological structures like bars, rings, mergers of galaxies, etc., after applying image processing techniques and in combination with supervised/unsupervised CNN-based models.
- We are also working on automatic detection and classification of low surface brightness (LSB) structures, focusing mainly on tidal debris after applying image processing to enhance these structures.



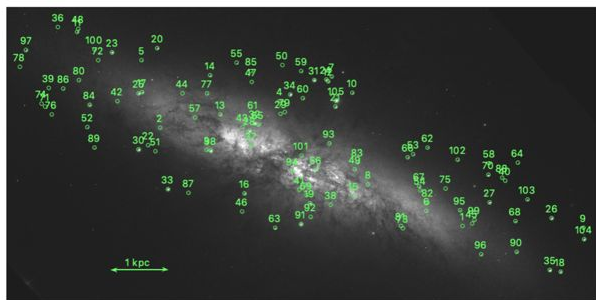
S5: SMWL Directable Software Development



Project Lead: Ángeles Perez Villegas (IA-UNAM)

Members: Rosa Amelia González (IRyA), Aida Wofford (IA), Bolivia Cuevas (BUAP), Luis Martínez (IRyA), Octavio Valenzuela (IA), Arturo Trellez (IA), Daniel Montenegro (IRyA), Aditya Manuwal (IA)

in-kind project: Studies of synthetic star clusters: Understand and quantify detectability of star clusters in Rubin data



nage. Bottom panels: zoom in of five (respectively). We show in the images .88 pc pixel⁻¹, which corresponds to

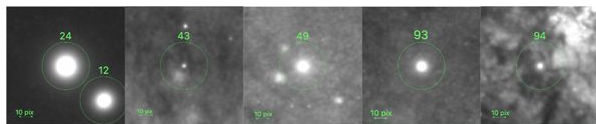
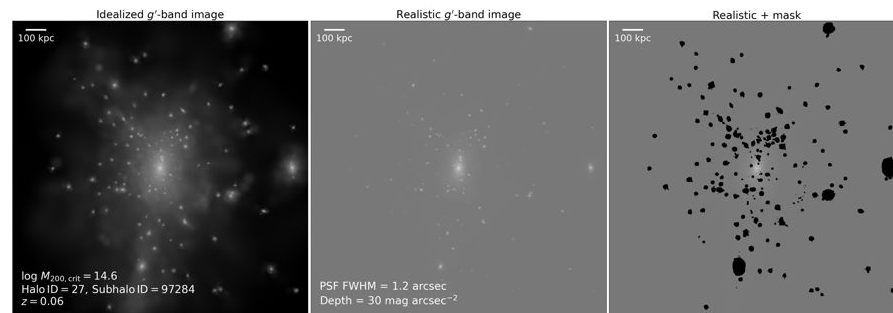


Figure 8. Top panel: Synthetic clusters (105 green circles) superposed on a real HST image, which corresponds to the F555W image. Bottom panels: zoom in of five clusters of the mock sample, in images of 10x10 pixels, centered in clusters S24, S43, S49, S93 and S94 (from left to right, respectively). We show in the images bars indicating 1 kpc and 10 pixels, in the top and bottom panels, respectively. Throughout this work we use an image scale of 0.88 pc pixel⁻¹, which corresponds to the physical size of the HST/ACS pixels at the distance of M82 (3.63 Mpc).

non-in-kind project: Hydrodynamical simulations from the IllustrisTNG to explore utility of intracluster light (ICL) as a tracer of structure and kinematics of dark matter (DM) haloes.



Daniel Montenegro's talk at LSST@LATAM 2024

This and other projects under definition.

S6: Lite IDAC



Project Lead: O. Valenzuela

- See O. Valenzuela talk at LSST@LATAM 2024 for more details...
- Approved: 2 Petabytes, 264 cores, 20 million CPU hours, GPUs, user front-end. Will likely support science collaborations activities, e.g. SLSC (in definition).



Participants: Julio Clemente, Luciano Diaz, Mauricio Morgado, JA De Diego, Juan Carlos Cuevas.

Other LSST-MX activities

- Broker activities
- One of the main drivers for MACSS (Mexican AstroCosmoStatistics School)
- Outreach events dedicated to Rubin, so far mostly in Guanajuato and Mexico City. We want to do it country wise, e.g Noche de las Estrellas (organized by IA-UNAM) events.
- National conferences and web presence. E.g National Astronomy Conference, National Physics Conference (Gravity section)
- We want to exploit different experiment synergies, e.g. DESI-LSST
- We want to make broader diffusion of Rubin EPO resources

Advanced topics in Cosmology

June 19-23, 2023

Location: Universidad de Guanajuato Sede Forum.

The main goal of this school is to prepare the next generation of students, postdocs, and researchers to perform statistical analysis over cosmological observations, such as present large scale surveys like DESI and VERA RUBIN C. OBSERVATORY.



Design credit: Luis Cantero (UG)

Programa de Educación del Observatorio Vera C. Rubin

<https://rubinobservatory.org/es/education>

Explore el Universo con datos reales

Explore datos auténticos con herramientas de análisis de fácil manejo. Diviértase aprendiendo ciencia haciendo ciencia.

CAPACITACIÓN EN LÍNEA PARA PROFESORAS(ES)

¿DÓNDE? Zoom
El link se enviará a los participantes registrados.

¿CUÁNDO? 23 de Agosto del 2024.

¿PARA QUIÉN? Profesoras(es) de educación media superior y superior.

HORA
10:00-12:00 hrs Ciudad de México
12:00-14:00hrs Santiago, Chile
13:00 to 15:00hrs Buenos Aires, Argentina y Brasilia, Brasil.

Conoce el Observatorio Vera Rubin, la forma en que revolucionará la astronomía y las actividades educativas desarrolladas por el observatorio, en particular la investigación "Expansión del Universo".

Registro: <https://forms.gle/Gn6LdQHyYehvY4UJ7>
Fecha límite: 20 de Agosto del 2024
Evento Gratuito

Más información en: <https://shorturl.at/1pnvz>
Contacto: gonzalez_alma@ujto.mx

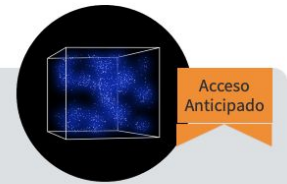
Campana LSST@LATAM NOIR Lab VERA C. RUBIN OBSERVATORY



Estudiando el Sistema Solar



Coloreando el Universo



Exploring the Observable Universe



Hazardous Asteroids



El Universo en Expansión



Exploding Stars

Acceso Anticipado

Acceso Anticipado

LSST-MX funding situation

- CONAHCYT: Participants regularly apply and obtain individual grants.
 - Thanks to
- Dirección de Apoyo al posgrado y la Investigación, UG individual grants (DAIP-MEXICO).
- PAPIIT-DGAPA-UNAM individual grants (UNAM-Mexico)

Non-financial support from

- Instituto Avanzado de Cosmología (México).
- División de Gravitación y Física Matemática, Sociedad Mexicana de Física (México)

mainly in the form of dissemination of the activities.

LSST-MX funding situation

The impact in Mexico of having a common fund for the LSST-MX would not only be local, it would allow us to have a better planning of activities towards strengthening and consolidating the humanistic, scientific, technological and innovation community, and activities for universal access to knowledge and its social benefits, it would also contribute to capacity, technological development, and scientific leadership in the region.

How to increase Mexican impact on Rubin/LSST** ...

- More postdocs and research focused staff (e.g. IxM) to support the in-kind program.
Permanency in LSST is subject to fulfill the in-kind commitments.
- Papers will take time to start flowing: **mindful evaluations (like the SNII, PRODEP, tenure) to our researchers will give some peace of mind to focus on the science, and the quality and not the quantity...**
- Mobility funds: Unlike DESI, LSST-MX is just starting so we would benefit from longer internships to learn the know how from groups that have been in Rubin for a longer time, to attend schools, the Community Workshop among other events. Those are great forums to foster collaborations.
- Common fund for LSST-MX could help the different efforts to advance more or least at the same pace...
- Transfer of knowledge: prepare the broader community for the exploitation of public data.
- Foster collaborations on key topics in Mexico and LATAM communities, e.g. the use of the IDACs
- Outreach programs to showcase astronomy, data science, IA, etc. etc. Make the society aware of big discoveries, and even bigger yet to come...

**This is my very own personal opinion and might not reflect the full LSST-MX views on the topic.



Thanks!