Rubin Observatory and Satellite Constellations

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with contributions from many wonderful colleagues!

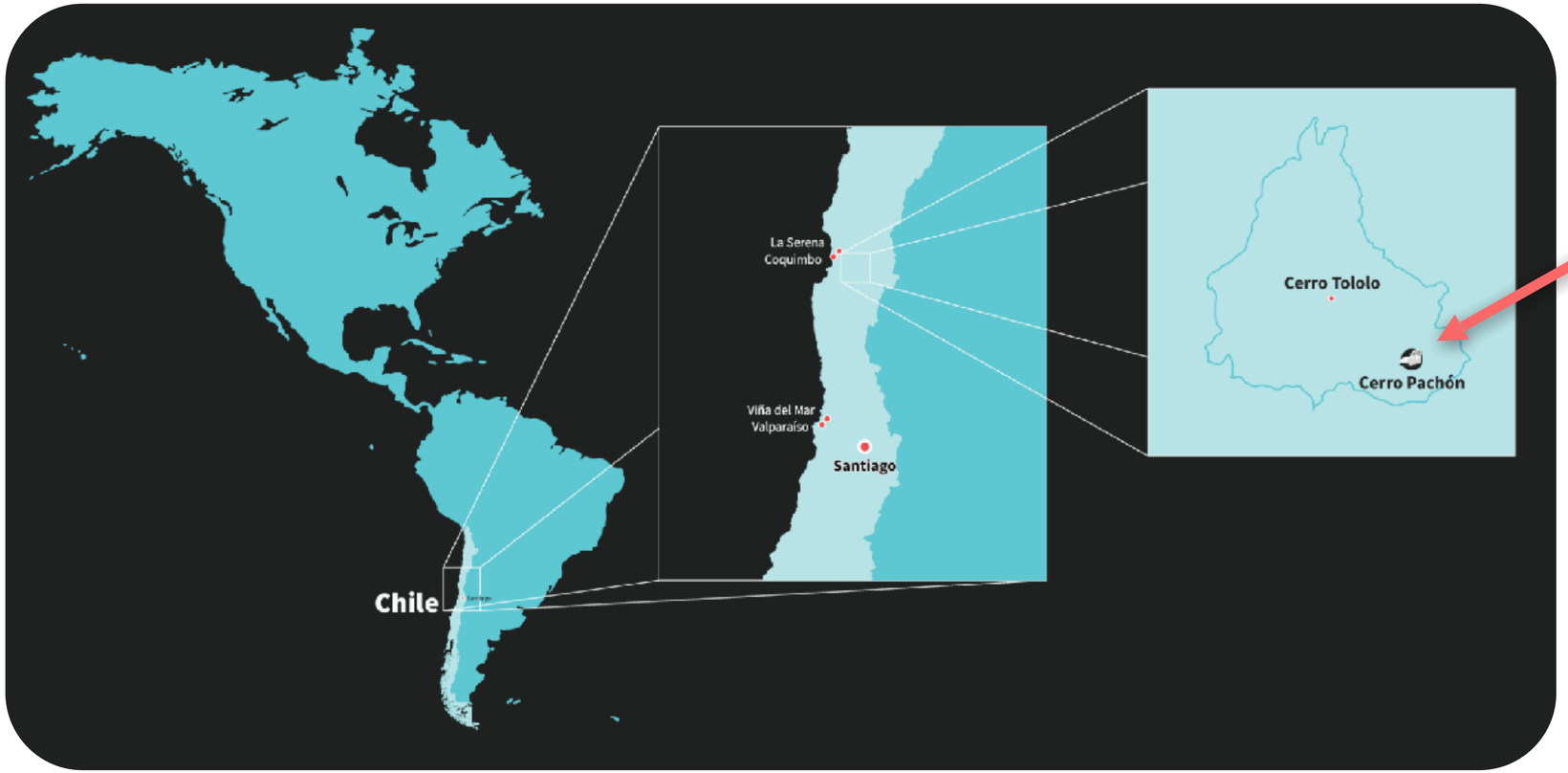
9 Dec 2025

#DarkAndQuietSkies for Science and Society

U.S. National Science Foundation

U.S. DEPARTMENT of ENERGY | Office of Science

Meet Rubin Observatory



Located on **Cerro Pachón**, in the Coquimbo region of Chile

Jointly funded by the **U.S. National Science Foundation** and the **U.S. Department of Energy, Office of Science**

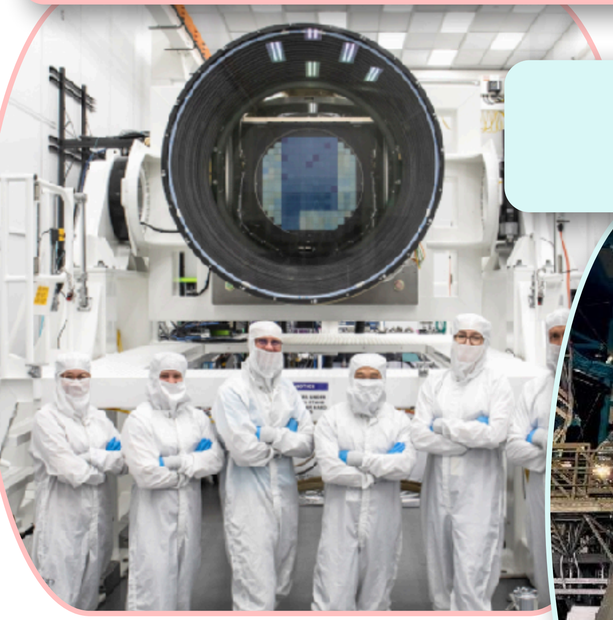
VERA C. RUBIN OBSERVATORY · U.S. National Science Foundation · U.S. DEPARTMENT of ENERGY | Office of Science

NOIRLab · AURA · SLAC NATIONAL ACCELERATOR LABORATORY

Mission: Capture the Cosmos

The greatest astronomical movie of all time

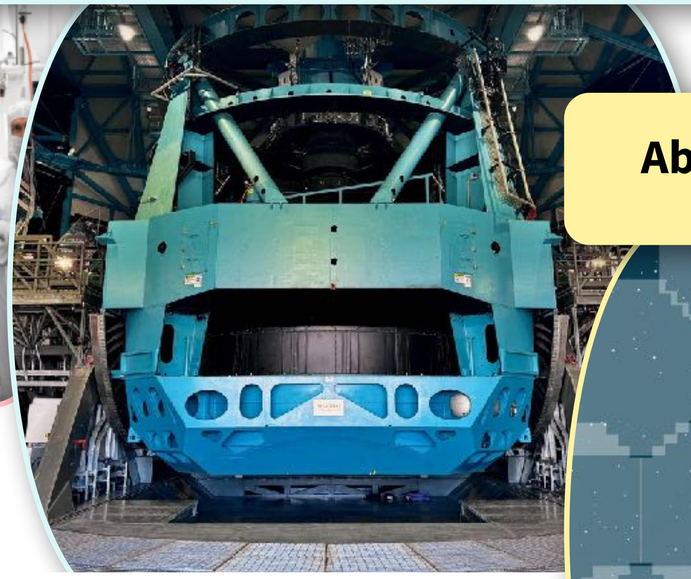
Wide Field of View
Largest digital camera ever built



J. Orrell/SLAC National Accelerator Lab

+

Speed
Novel three-mirror design



RubinObs/NOIRLab/SLAC/NSF/DOE/AURA

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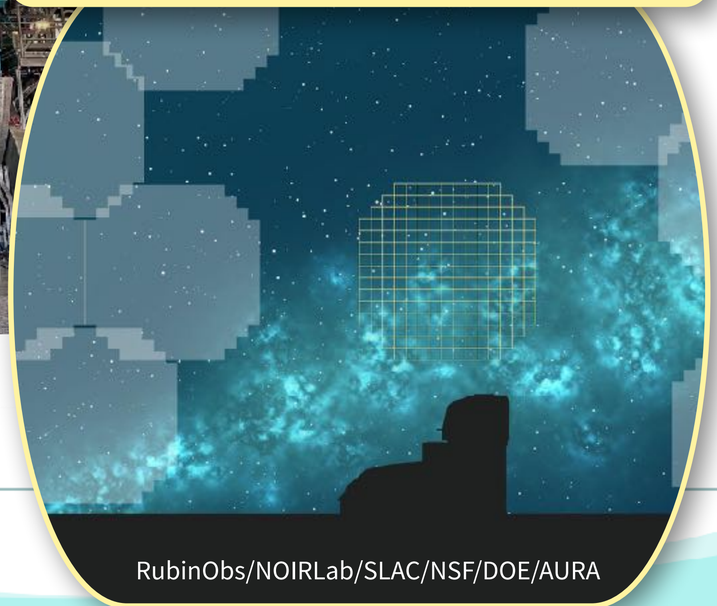
Ability to see faint objects
Across the entire Southern sky



RubinObs/NOIRLab/SLAC/NSF/DOE/AURA

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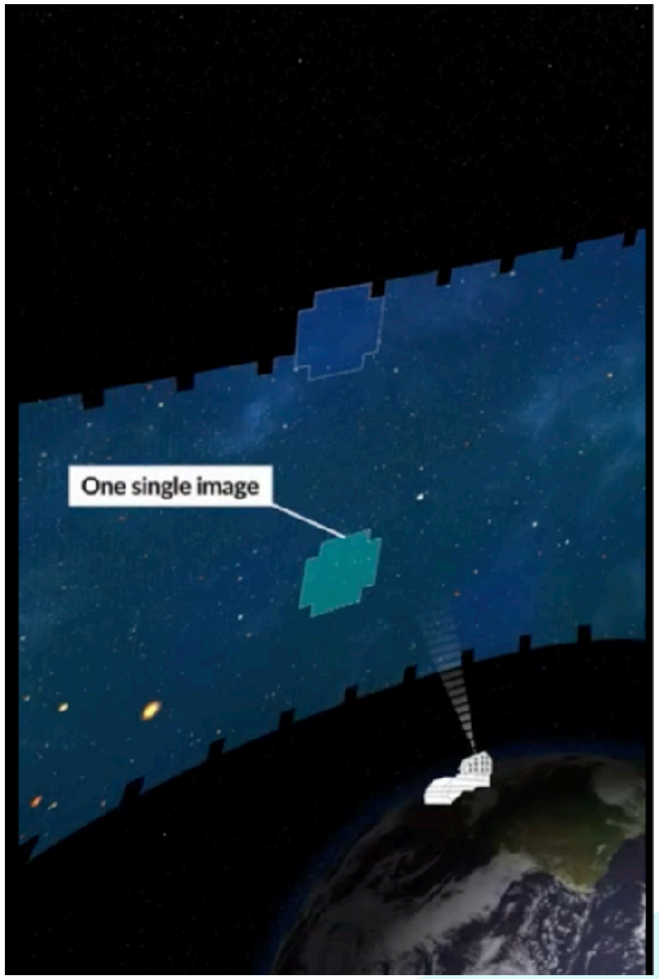
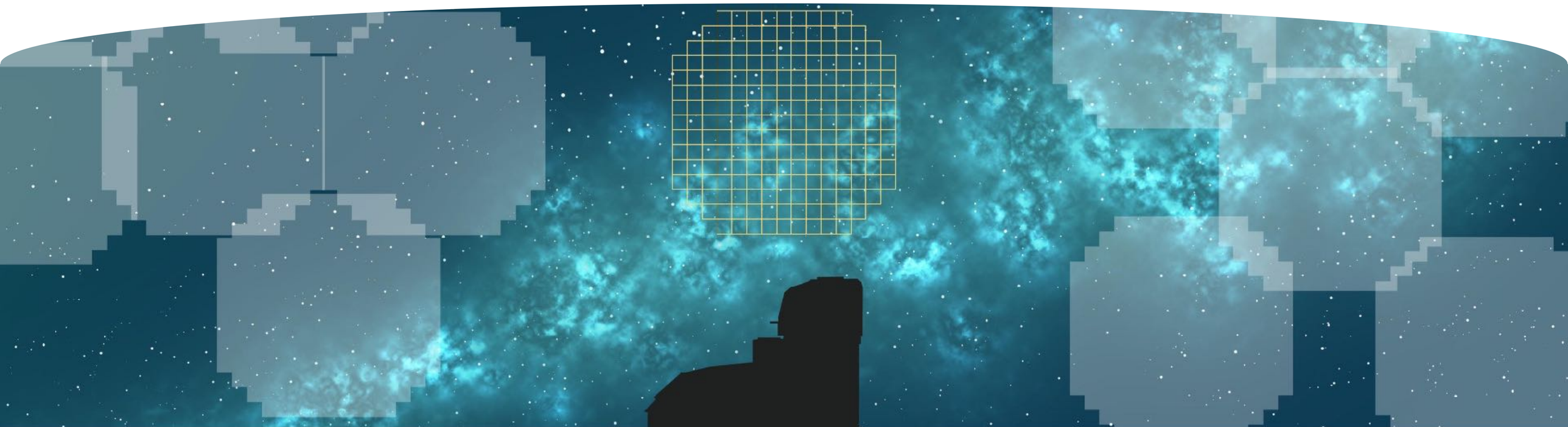


Rubin’s Legacy Survey of Space and Time (LSST)

Repeatedly scan the southern sky every ~3 nights for 10 years

Wide-field survey with a fast cadence in 6 color filters

LSST will build the most detailed time-lapse view of the cosmos ever generated



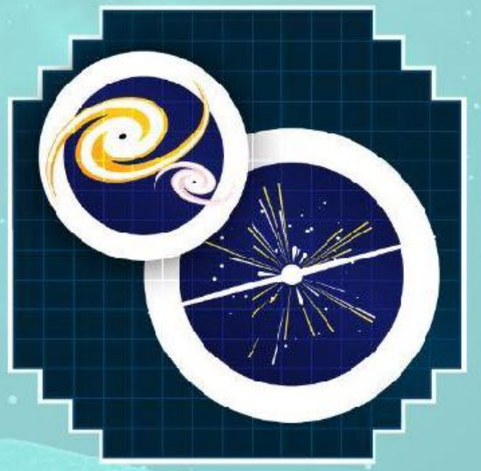
Four Science Areas

Milky Way Structure & Formation

Rubin will help us make the best map of our home galaxy yet.

Solar System Census

Rubin will show us millions of new asteroids and comets, and so much more.

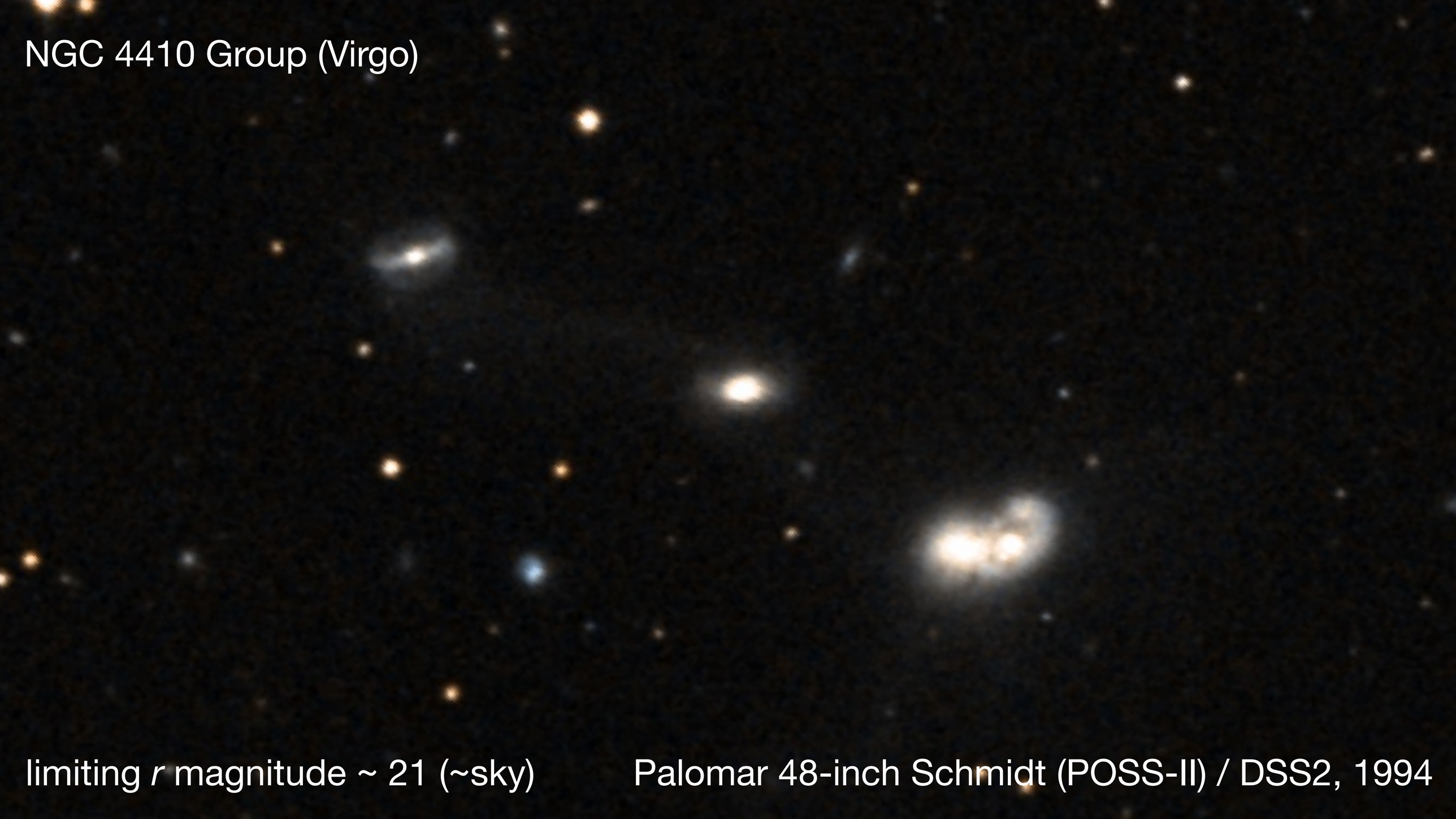


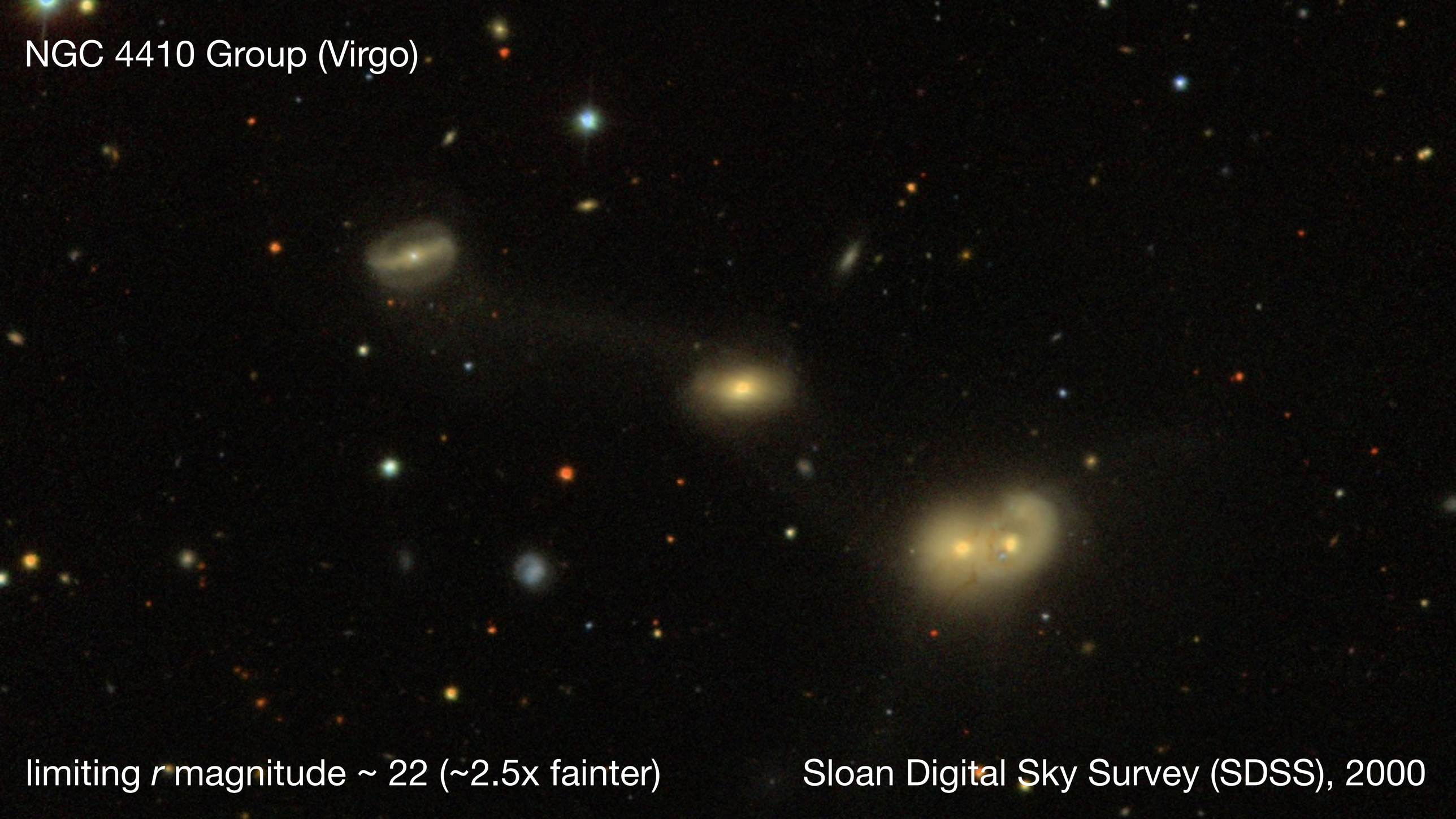
Dark Matter & Dark Energy

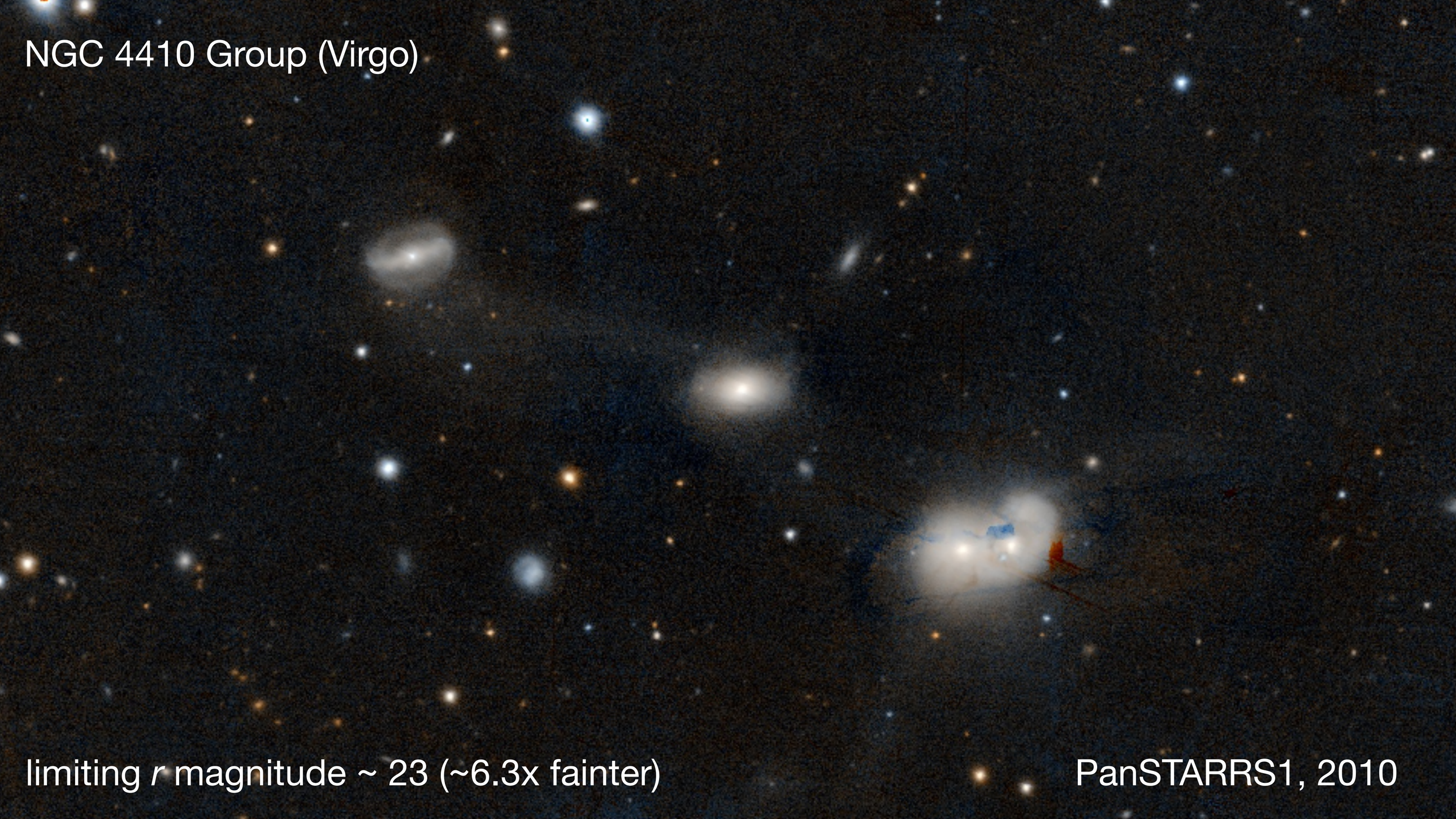
Rubin is a brand new tool to help us learn more about their nature & behavior.

The Changing Sky

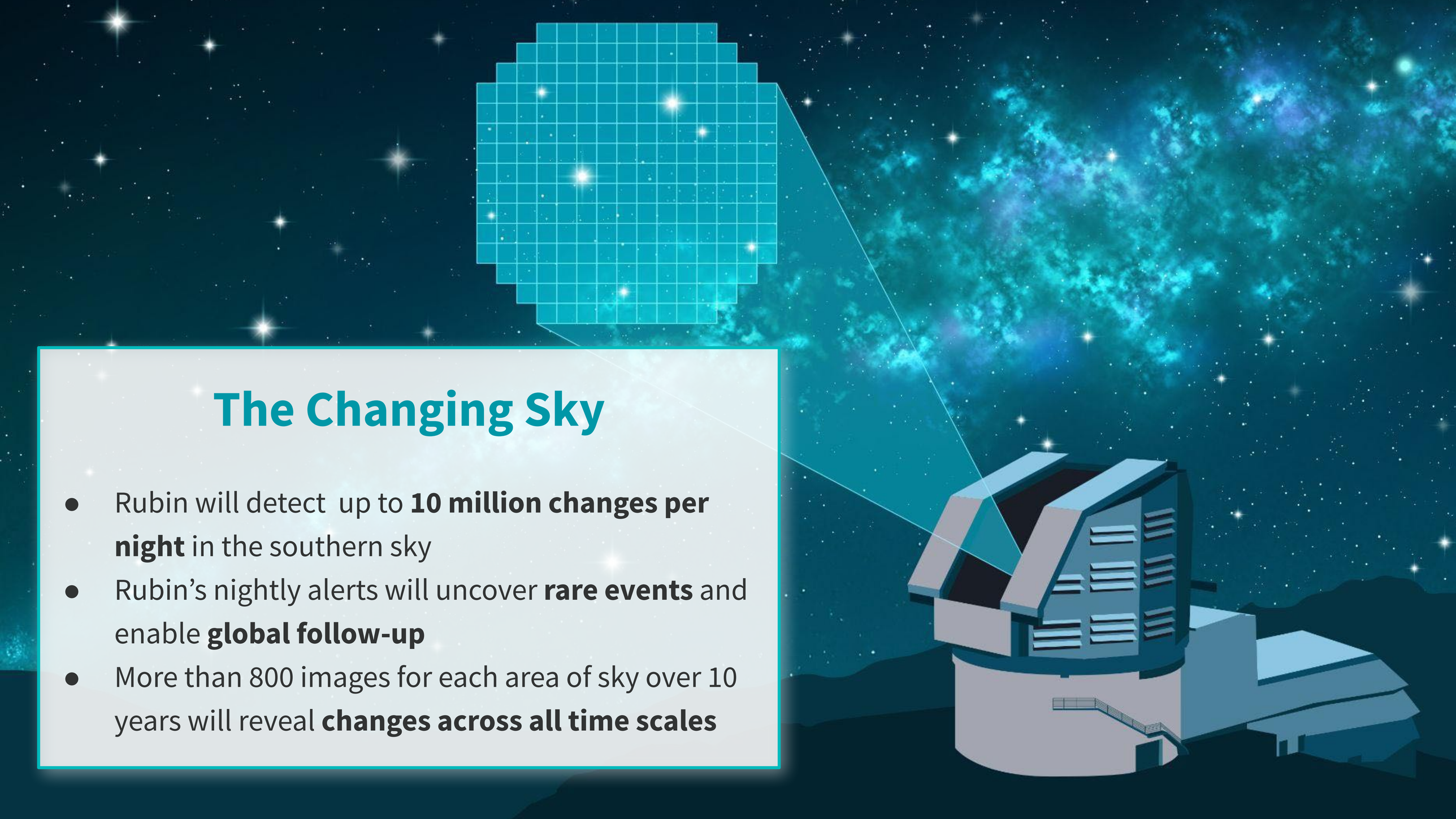
Rubin will bring the night sky to life, yielding a treasure trove of discoveries.


NGC 4410 Group (Virgo)
limiting *r* magnitude ~ 21 (~sky)
Palomar 48-inch Schmidt (POSS-II) / DSS2, 1994


NGC 4410 Group (Virgo)
limiting *r* magnitude ~ 22 (~2.5x fainter)
Sloan Digital Sky Survey (SDSS), 2000


NGC 4410 Group (Virgo)
limiting *r* magnitude ~ 23 (~6.3x fainter)
PanSTARRS1, 2010

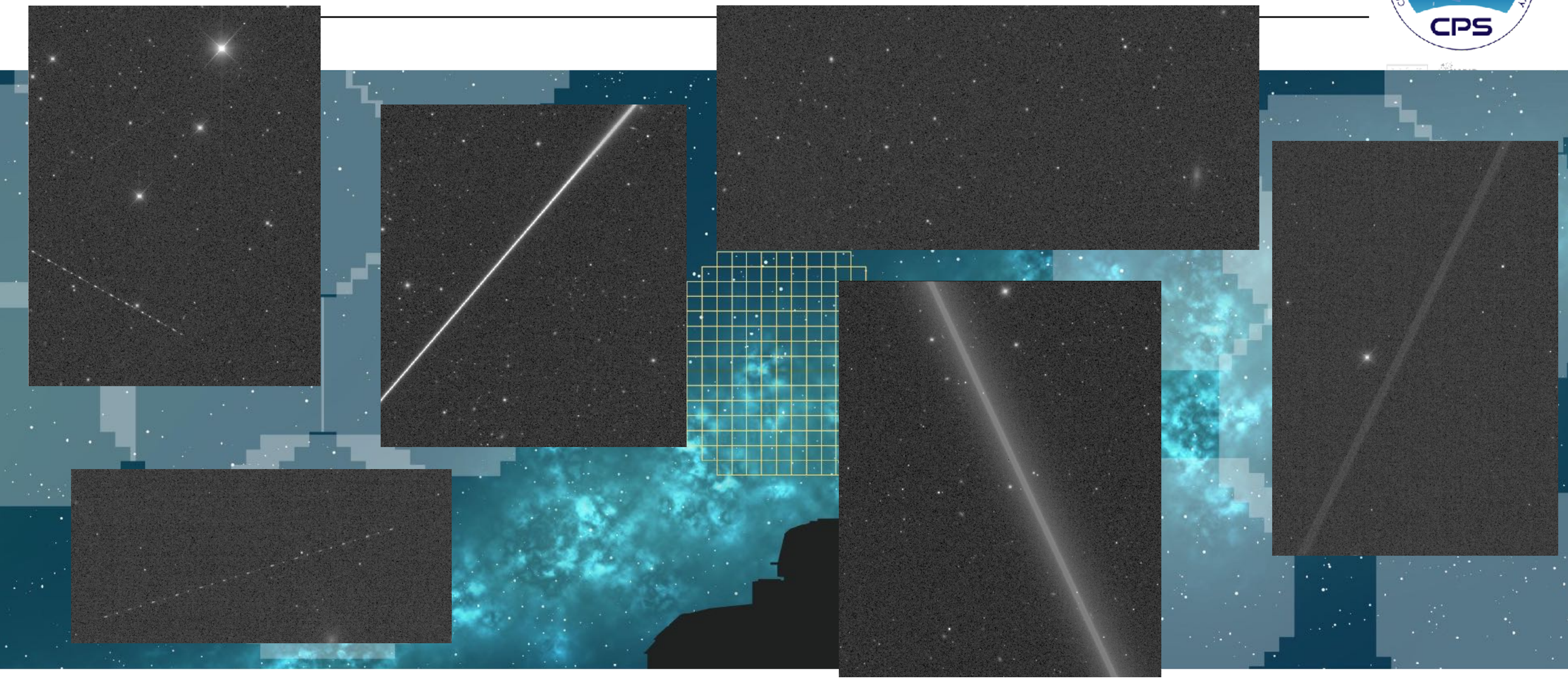

NGC 4410 Group (Virgo)
limiting *r* magnitude ~ 27 (~250x fainter)
Rubin First Look, 2025



The Changing Sky

- Rubin will detect up to **10 million changes per night** in the southern sky
- Rubin’s nightly alerts will uncover **rare events** and enable **global follow-up**
- More than 800 images for each area of sky over 10 years will reveal **changes across all time scales**

Also the Changing Sky



Impacts to Rubin LSST science

- Depends on **imperfectly known** quantities:
  - Number of satellites and their orbits 📈
  - The satellite brightness distribution 🛰️
  - How the LSST Camera responds 📷
  - Image processing algorithms and pipelines 🔁

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- **Rubin's potential for discovery is also its vulnerability to satellites**

- Huge field of view means low pixel loss fraction

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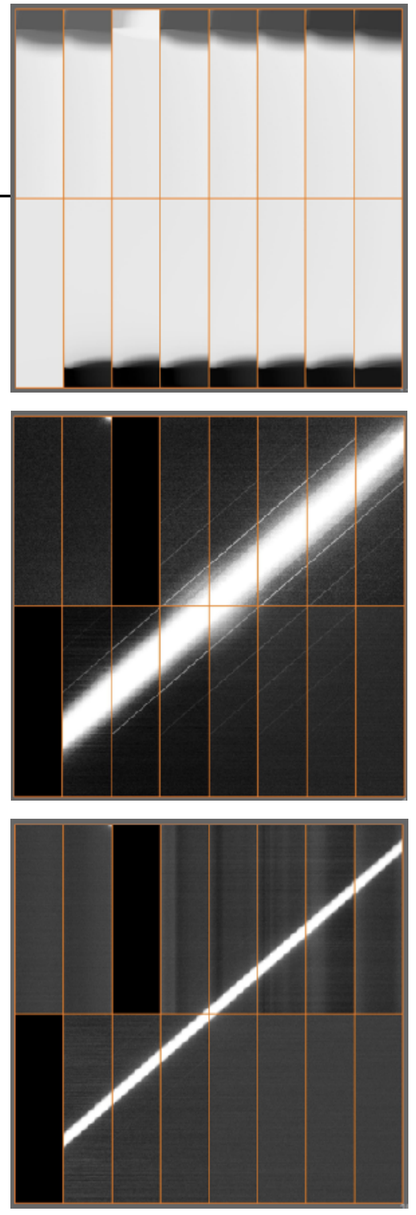
0–1 mag
BlueBird

4–5 mag
Starlink DTC
Guowang

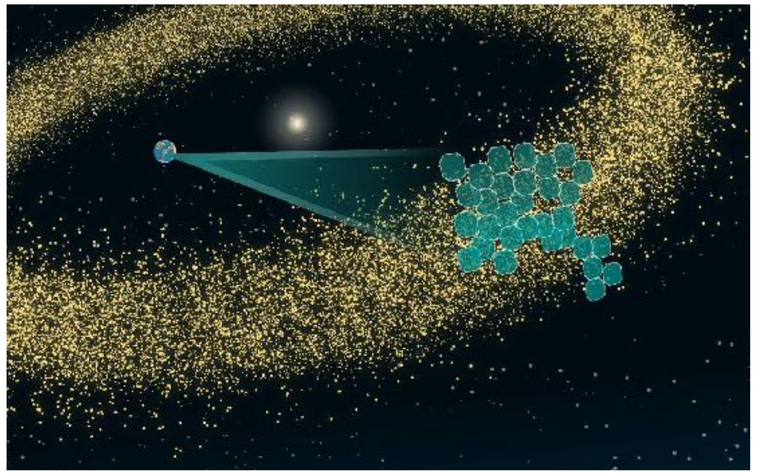
6–7 mag
Starlink
Leo (Kuiper)
*Qianfan**
*OneWeb**

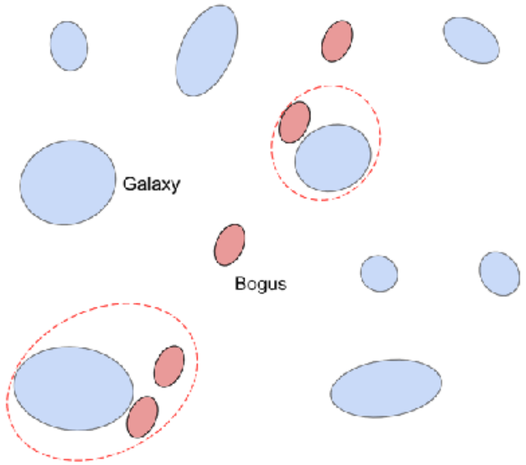


**higher altitude ~1000 km*

Fewer discoveries, more systematic errors

- **Solar System**
  Fewer asteroids discovered
- **Cosmology**
  Errors from spurious signals





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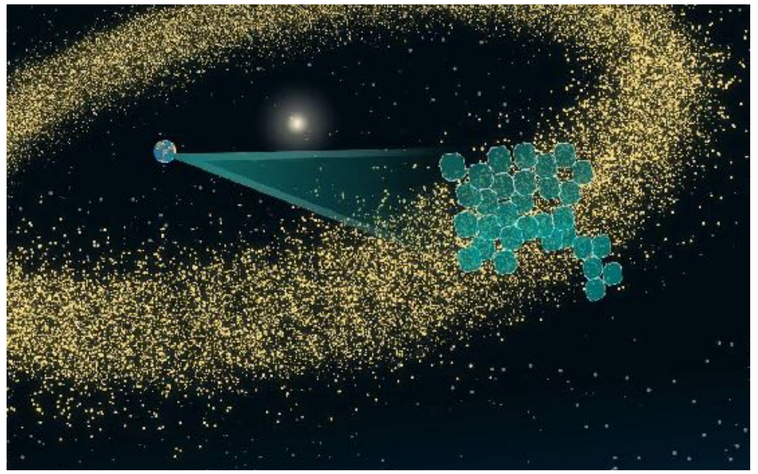
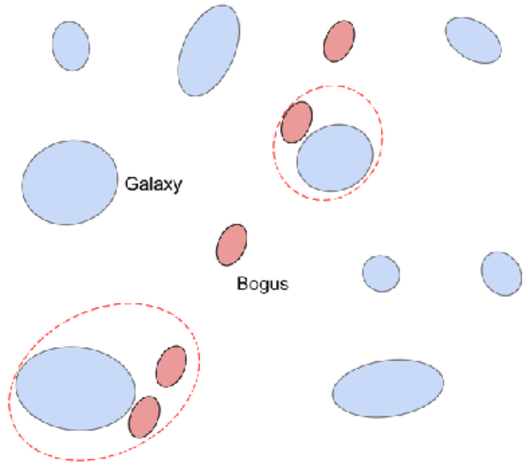
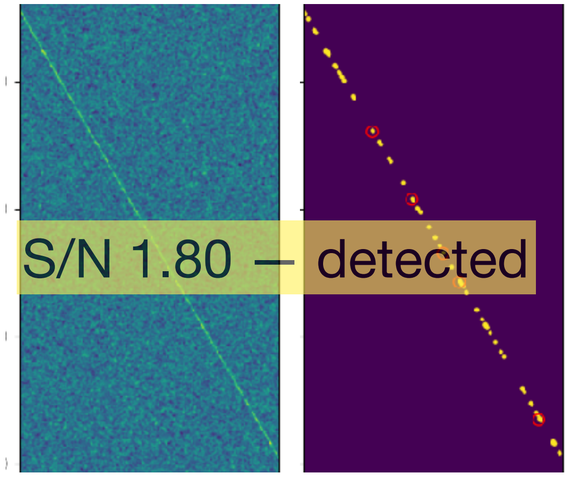
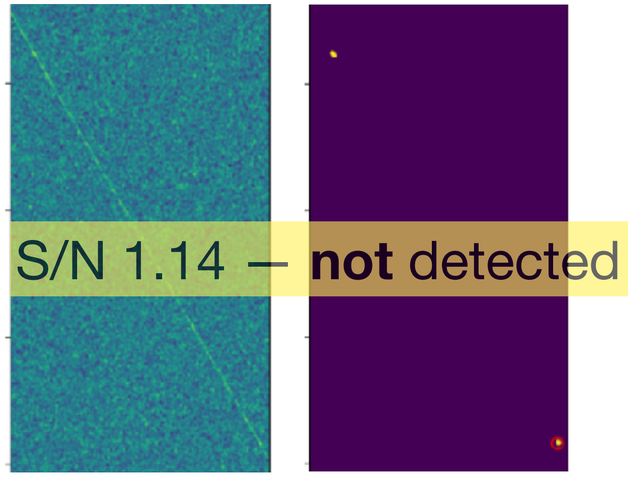


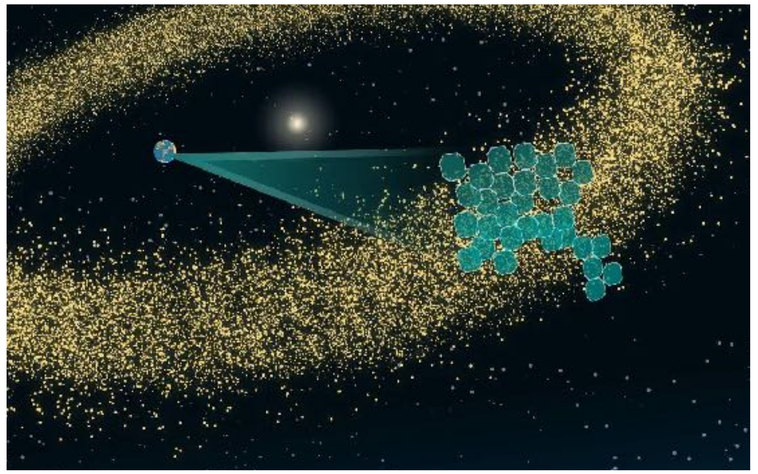


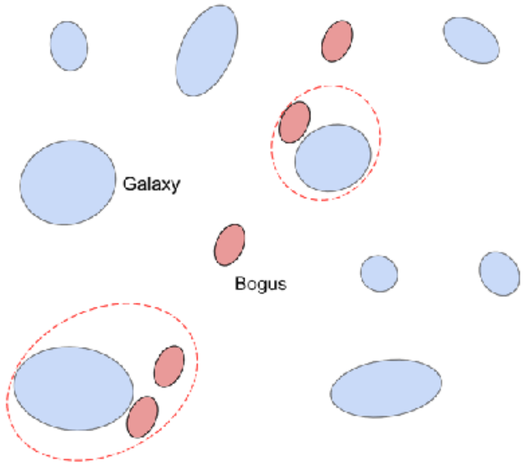


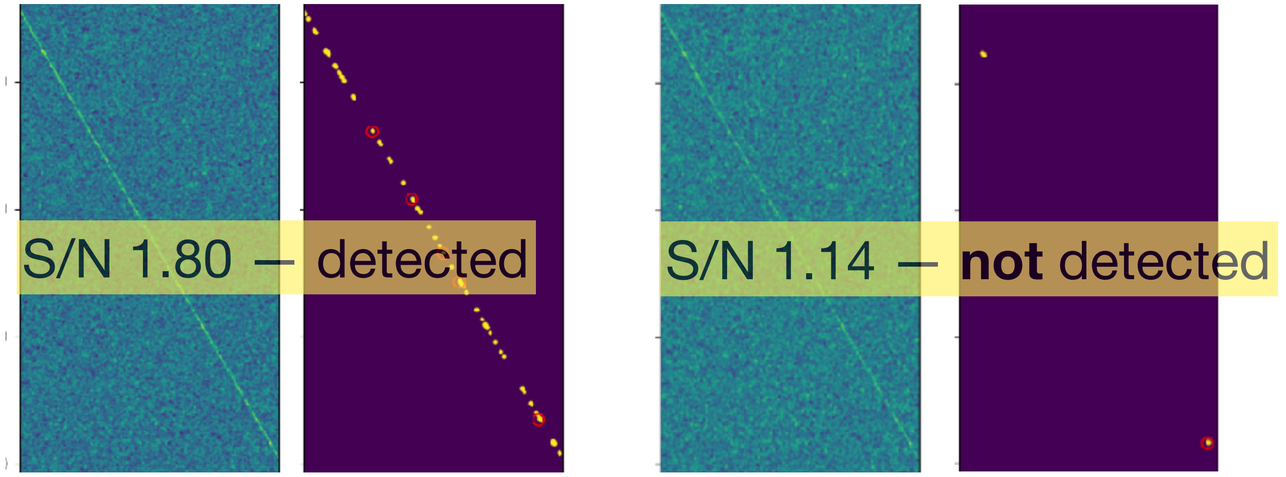


Fewer discoveries, more systematic errors

- **Solar System**
  Fewer asteroids discovered
- **Cosmology**
  Errors from spurious signals
- **Faint Universe**
  Susceptible to contamination
- **All science**
  Need more time to complete LSST







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How to maximize Rubin science?

- *Already happening, still improving*
  - **Reject outliers** when building deep image stacks
  - Exclude known satellites and long trails from **Alerts**
  - Find and **label streaks and glints** in difference images

Credit: Alysha Shugart

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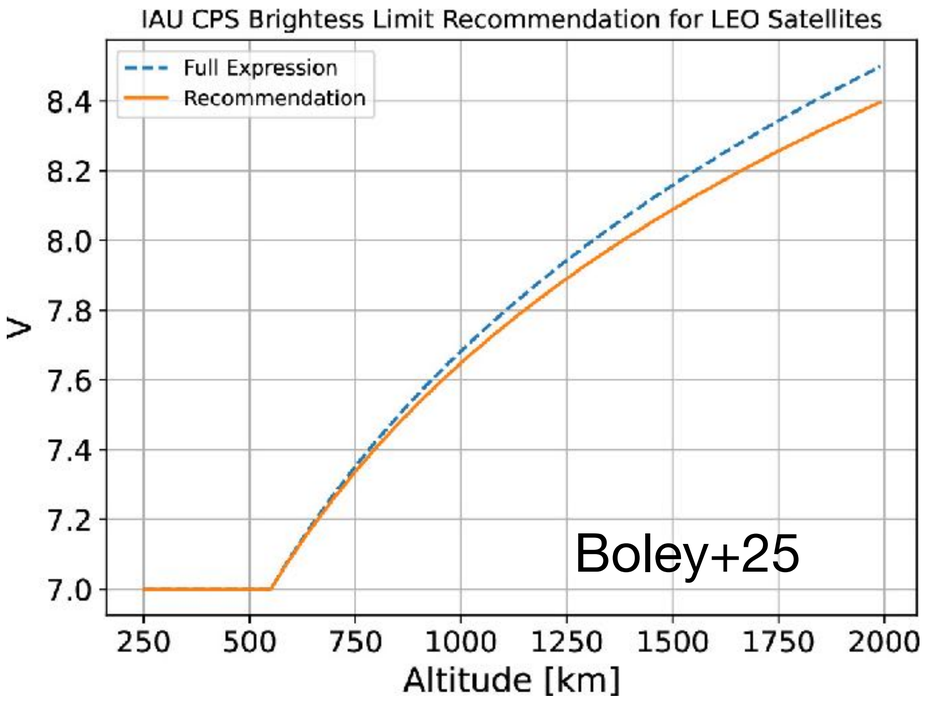
- *Already happening, still improving*
  - **Reject outliers** when building deep image stacks
  - Exclude known satellites and long trails from **Alerts**
  - Find and **label streaks and glints** in difference images
- *Goals for Rubin's decade of operations*
  - Use the LSST scheduler to **avoid observing** satellites or trigger operator **attitude adjustments**
  - Quantify impacts from faint streaks or sky background brightness **below the detection threshold**
  - Build a database of **all** satellite signatures in LSST

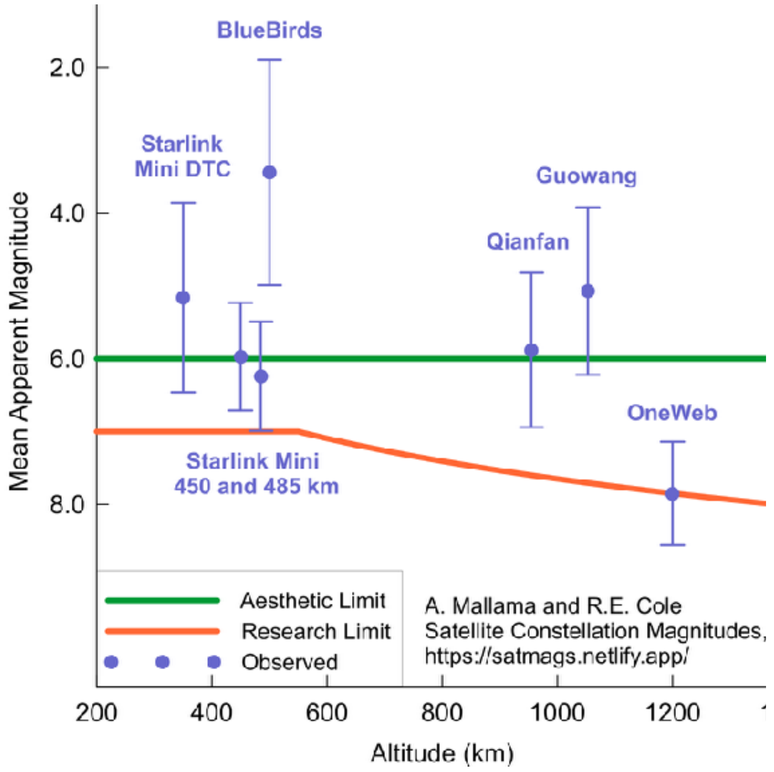
Credit: Alysha Shugart

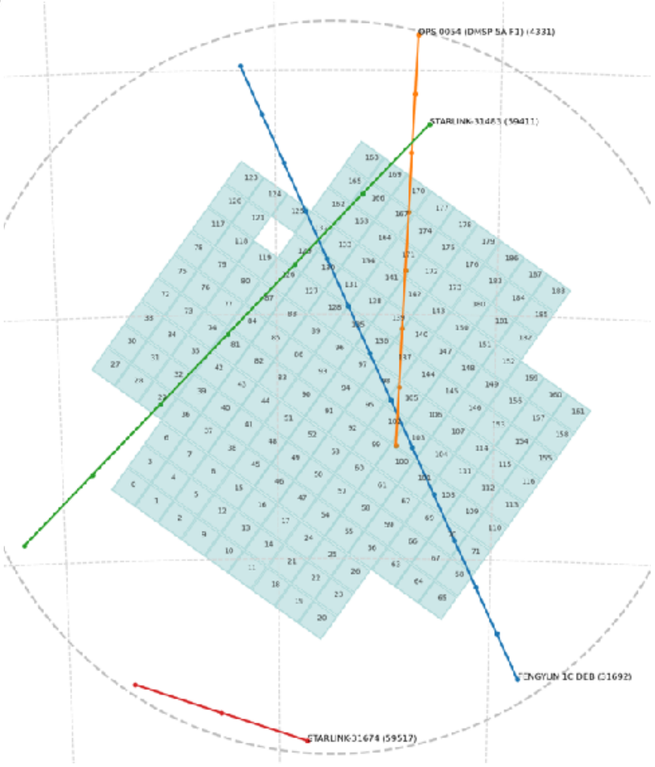
2025 Aug **Workshop Report**
https://arxiv.org/abs/2509.19758

No observatory can do this work alone

- **SatHub** at the IAU CPS coordinates satellite observations, provides feedback to operators, shares technical expertise, builds software, and develops recommendations



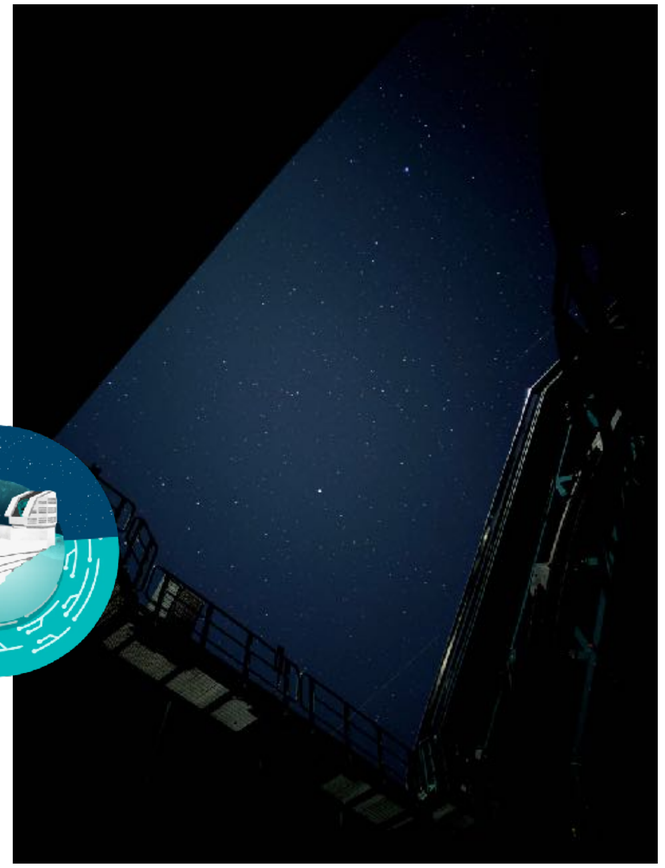




satchecker.readthedocs.io

Welcome to Rubin's Operations Era ✨

- Rubin's ten-year LSST will see lots of satellites, but will still do ground-breaking science
- To ensure this, **operators** can:
  - Share timely ephemerides, coordinate launches and de-orbits, darken satellites, explore hardware sharing, collaborate
- To ensure this, **astronomers** can:
  - Develop metrics and standards, quantify impacts to science, catalog observed satellite signatures to faint levels, expect pernicious contamination, collaborate
- The IAU CPS welcomes you: [cps.iau.org](cps.iau.org)



Credit: Alexandre Boucaud

Astronomers' favorite satellites

Fewer
Smaller
Darker
Lower*
Predictable
Long-lived
Shared

**it's complicated*