Panel on Science Center Coordination for Rubin, Roman, and Euclid

Phil Marshall (SLAC National Accelerator Laboratory), Josh Peek (Space Telescope Science Institute), Jason Rhodes (Jet Propulsion Laboratory, California Institute of Technology)

1. Survey coordination
2. Joint data processing
3. Joint simulations
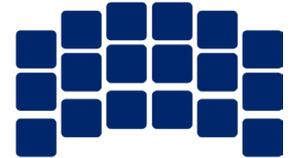4. Interoperability and accessibility of archives

The Golden Age

Mission Lifetime	2025 - 2034	2023 - 2030	2026 - 2032
Mirror size (m)	6.5 (effective diameter)	1.2	2.4
Survey size (sq deg)	~20,000	14,000	~2,000
Median z (WL)	0.9	0.9	1.2
Depth (5σ AB mag point source)	~27	~24 (NIR) ~26 (Vis)	>27
FoV (sq deg)	9.6	0.5 (Vis) 0.5 (NIR)	0.28
Filters	u-g-r-i-z-y	Y-J-H-Vis	R, Z, Y, J, F146, H, H/K, Ks
PSF Size	~0.8"	~0.2" (Vis)	~0.12" (NIR)
Mode	Photometry	Photometry/Grism	Photometry/Grism

A rough map of coordination activities

Roman

Euclid

Rubin

Josh

Fornax

Joint Simulations

Simultaneous Observations

Joint Derived Data Products

Footprint coordination
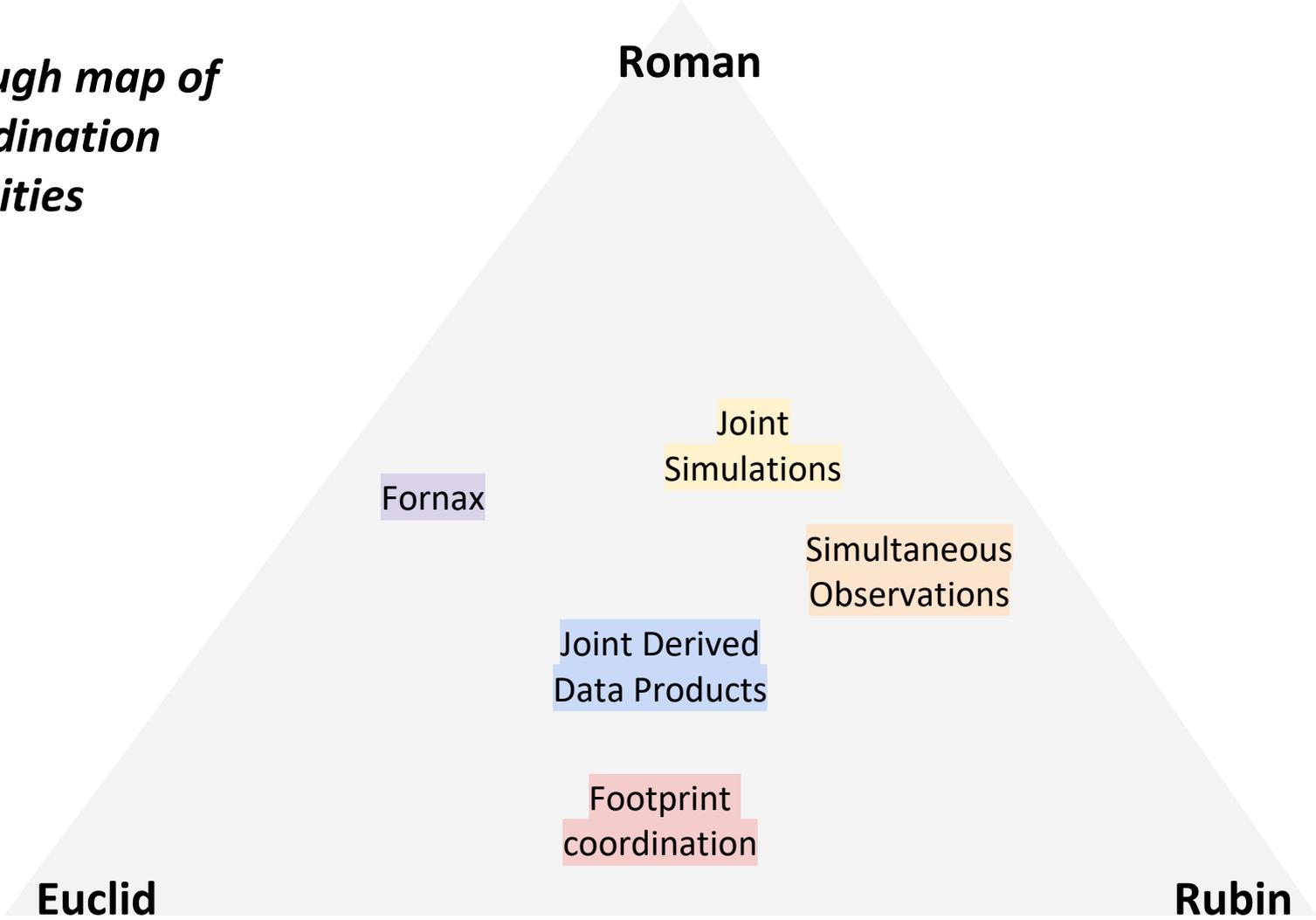
Survey Coordination

Jason

LSST W-F-D (dark green)
DES (light green)
UNIONS (blue)
Euclid ROI (yellow outline)
Euclid Deep (pink)

- A potential Roman/Euclid joint microlensing survey would allow better bound planet mass estimates and the only way to get rogue planet masses
- Euclid precursor observations of Roman galactic bulge field being considered by ESA
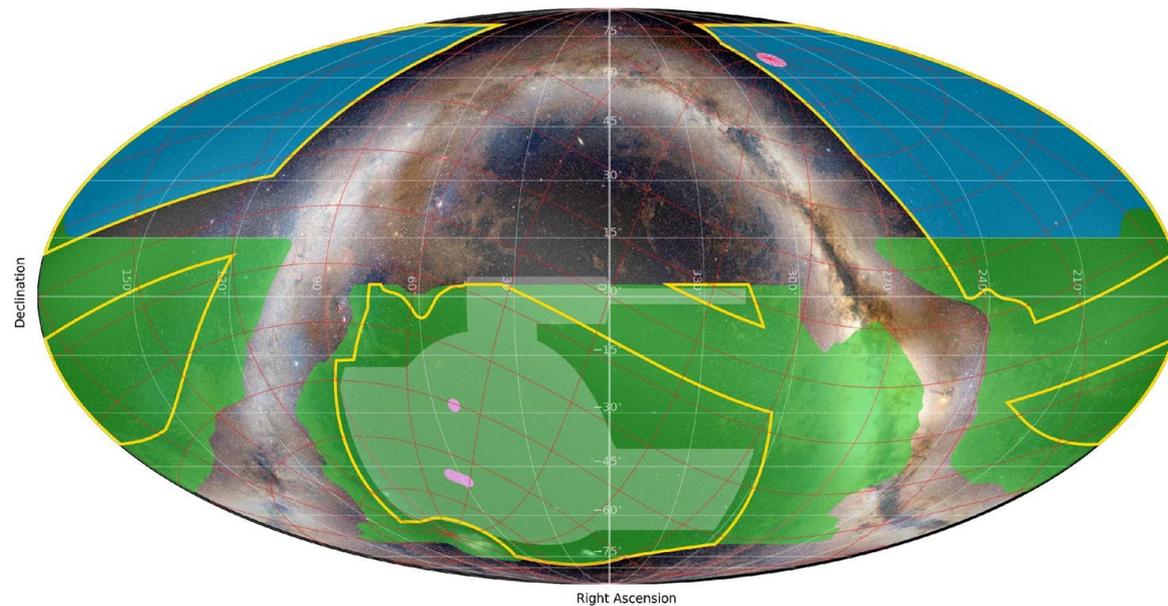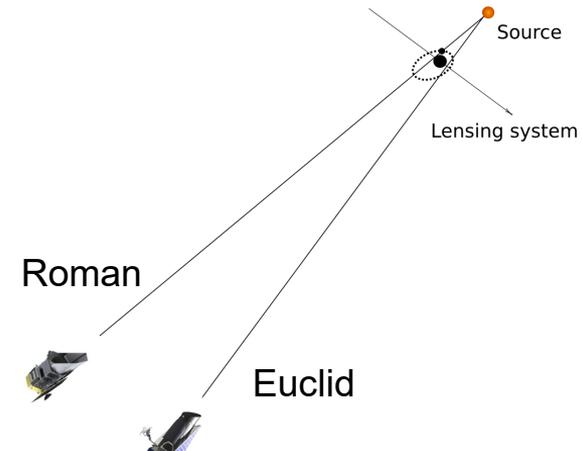

- Both Euclid & Rubin have tweaked survey footprints to maximize overlap
- Rubin-Euclid data-sharing MOU signed for Euclid Deep Field South (EDF-S; helps with Derived Data Products planning)
- Rubin ComCam early observations of EDF-S being explored (very soon)
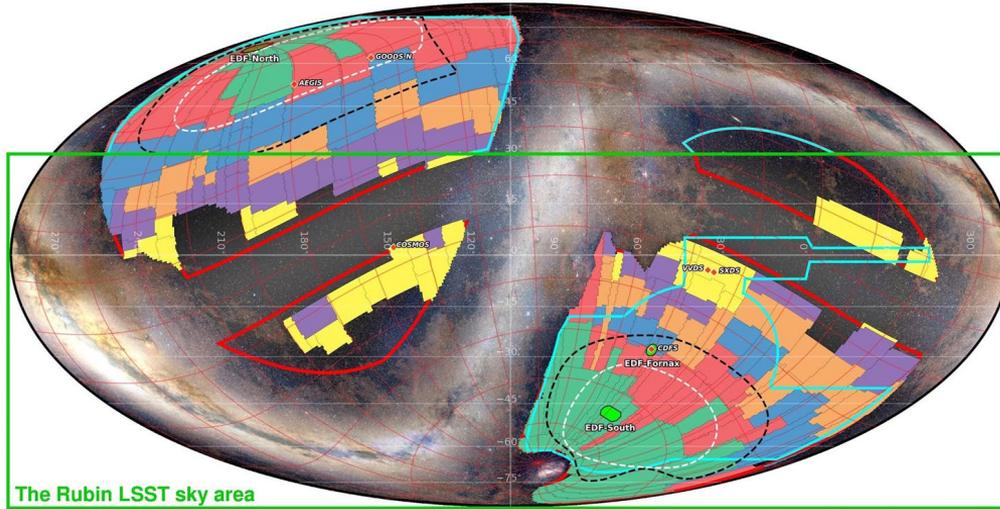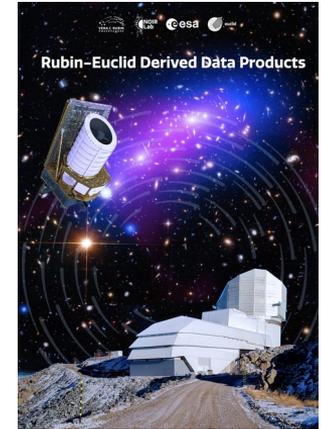- Roman & Rubin are exploring coordinating on simultaneous observations

Joint Processing and Science Driven Rubin-Euclid Derived Data Products (DDPs)

Effort to maximize science by generating products shared openly across the two consortia, while protecting science each individual project's unique science

The Rubin LSST sky area

R.A. (2000)

65% of the Euclid Region of Interest (17,354 square degrees)

RSD 2020c ECTile realization of a Euclid Wide Survey within the 17 Kdeg.² RoI : 14,668 deg.² over 6 years in 216 patches

- Euclid Wide Survey Region of Interest (RoI) : 17 Kdeg.² compliant with a 15 Kdeg.² survey
- Best 2600 deg.² (black) and 1300 deg.² (white) SNR areas per galactic cap
- Euclid Deep Fields (EDF, from north to south): 10+10+23 deg.²

Euclid Wide Survey chronology (2.5Kdeg.²/yr)
Year1 Year2 Year3 Year4 Year5 Year6

Background image: Euclid Consortium / Planck Collaboration / A. Mellinger

Science explored by the 350 Rubin and Euclid scientists during the open community 5-month long discussion on the forum:

Rubin–Euclid Derived Data Products

- Solar System
- Milky Way
- Transients
- Nearby Universe
- AGN & Galaxy Evolution
- Clusters of Galaxies
- Galaxy Clustering
- Strong Lensing
- Weak Lensing
- Primeval Universe

The great diversity in the complexity of the suggestions point to a tiered approach to developing DDPs : from simple catalog merging and cutouts exchange, enriching each side's catalog with provided algorithms, up to full blown joint pixel processing

Guy et al 2022, https://arxiv.org/pdf/2201.03862

R2D2: Rubin + Roman

- Joint STScI/NOIRLab initiative examined Rubin/Roman coordination in
  - Data processing
  - Survey coordination
  - Archival coordination
- Enhanced and enabled science across domains:
  - **Solar System Objects composition and morphology**
  - Sub-stellar demographics
  - Isolated Black Holes
  - Lensed Supernovae for H0 constraints
  - Extragalactic transient environments
  - 3D dwarf galaxy and stellar stream structure
  - Galaxy evolution and cosmic structure
- *Galactic Plane a new area of Rubin+Roman science with more sources than all previous surveys combined*
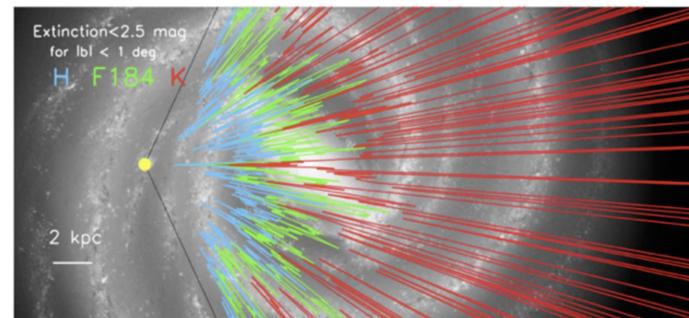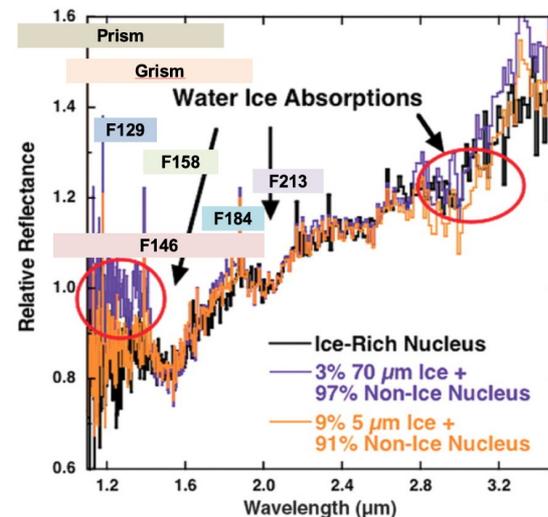
Joint Processing enables a Whole > ∑ (parts)

- The best dark energy constraints will come from a joint analysis of data from all three telescopes

- Deblending and photometric redshifts are prime examples

- Early (shallower) Euclid/Rubin will teach us to how to jointly process and analyze later (deeper) Roman and Rubin

- Benefits go beyond cosmology

4.5.1 Data Archiving, Curation, and Pipelines

The importance of joint analysis of observations from different facilities and wavelengths, and of sophisticated archiving with associated science platform tools, will grow dramatically over the next decade. A prime example is the measurement of cosmological constraints on dark energy and other parameters in the coming decade, which will rely heavily on the joint processing and analysis of data from the Euclid (ESA), Roman, and Rubin observatories.
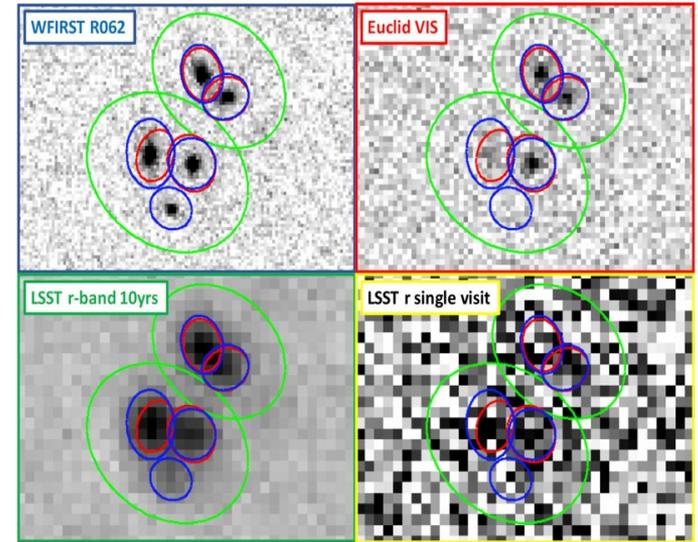

Figure from Ranga Chary
(Caltech/IPAC)

Joint processing and/or joint analysis of the **Golden Age** data will provide best results across many science areas.

Joint Processing and Science Driven Rubin-Euclid Derived Data Products (DDPs)

Effort to maximize science by generating products shared openly across the two consortia, while protecting science each individual project's unique science

- A Joint Implementation Working Group, co-led by NOIRLab and IPAC, has made progress towards a *roadmap* for joint DDP production

- Community surveyed for groups interested in, or already working on, this

- WG focused on the highest priority cross-cutting joint DDPs, as those that enable most science:

  - DDPs 1,2,3 joint photometry to varying degrees of sophistication (eg in support of photo-z's)

  - DDP 5: cross-queried image cutouts

- This approach can be a pathfinder for Roman/Rubin joint DDP creation.
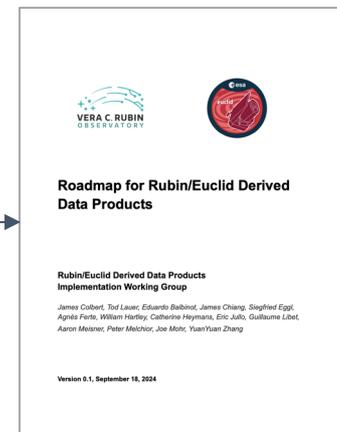
Rubin/Euclid Derived Data Products Implementation Working Group co-chairs:
James Colbert (IPAC), Tod Lauer (NOIRLab)

Joint Processing and Science Driven Rubin-Euclid Derived Data Products (DDPs)

Effort to maximize science by generating products shared openly across the two consortia, while protecting science each individual project's unique science

How and where will the Rubin-Euclid Joint DDPs be made?

- Expect each consortium to preprocess its own data to contribute to the early phase (eg aperture photometry, or image cutouts, at positions specified by the other consortium): science centers

- DDP3 is a multi-band Rubin+Euclid deblended photometry catalog. Making this will involve pixel-level joint processing, which will need

  - Co-hosting of all overlap region imaging or else very close coordination

  - Significant computing resources (storage, compute) plus mission & algorithm expertise

  - Successful joint DDP production will require *collaboration, between science centers and including the community.*

At some point additional resources (staff and computing) will be needed. What can we do in the margins to get started? *TBD but both consortia working on it.*

Simple sharing of Euclid DFS imaging should help emergent collaboration get started.

The OpenUniverse Joint Simulation Project

OpenUniverse is a directly funded NASA effort that began in FY20.

- Resources are focused on coordinating mock galaxy catalogs, image simulations, across surveys.
- All work is relevant to two or more of the surveys.
- All simulation products are made publicly available for worldwide usage.
- Leverages expertise from NASA and DOE communities.
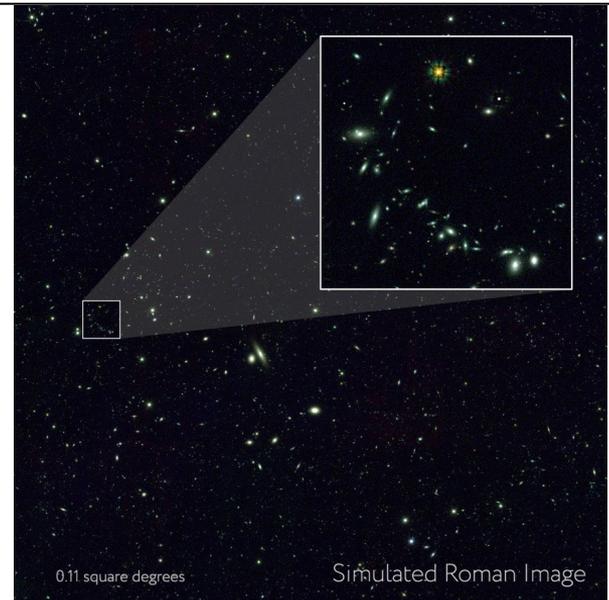- Initial focus and engagement Roman/Rubin.

Alina Kiessling (JPL, PI)
Vandana Desai (IPAC, Archives Lead)
Andrew Hearin (ANL, Mocks Lead)
Bhuv Jain (UPenn, Covariances Lead)
Michael Troxel (Duke, Images Lead)

0.11 square degrees   Simulated Roman Image

C. Hirata and K. Cao (OSU) and NASA's Goddard Space Flight Center

Same-sky Roman+Rubin+Euclid simulations

Team: Federico Berlfein (CMU), **Axel Guinot (CMU)**, Xiangchong Li (CMU), Andy Park (CMU), Rachel Mandelbaum (CMU), Jason Rhodes (JPL), Michael Troxel (Duke)

This work inherits from the huge effort on Roman+Rubin simulations and adds a Euclid-like component to make it Rubin+Roman+Euclid. Our goals:

- Provide same-sky public Euclid-like VIS image simulations & catalog-level NISP simulations
- Provide public tools to make Euclid-like VIS images
- Enable the broad community interested in studies of joint Rubin-Euclid processing and Derived Data Products (DDP)
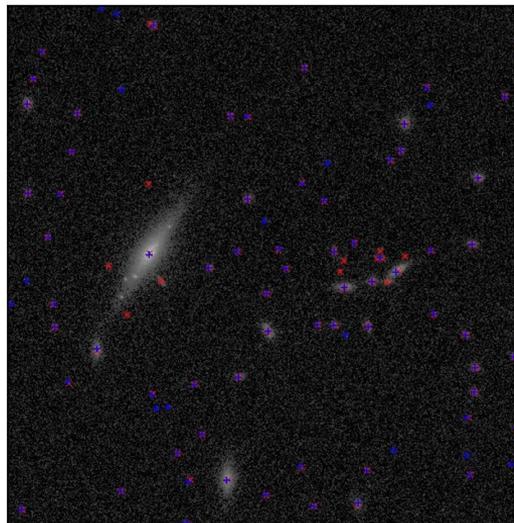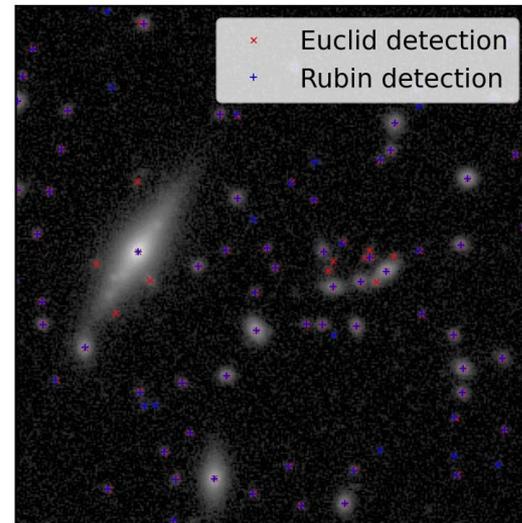
Preliminary detection comparison

Data Coordination is a top Decadal Recommendation

Josh

"NASA and the NSF should explore mechanisms to improve coordination among U.S. archive centers and to create a centralized nexus for interacting with the international archive communities. The goals of this effort should be informed by the broad scientific needs of the astronomical community."

*There is no active effort toward a **nexus** by either agency*

Archives as a tool for science and coordination

Josh

- *Experiments* can be closed and effective (e.g. *Planck*)
- *Surveys* and *Observatories* are much more impactful with open, integrated, accessible archives (e.g. *Gaia*, Hubble)
- Archives drive science today, even for pure Observatories
- Archives drive science *especially* for the broader science community (minority and undergraduate serving institutions, emerging economies)
- Archives can provide the ability for *anyone* to work with data with platforms and integrated services
- NASA pushing to use the cloud as a coordination location for archives (though still more SMD focused)

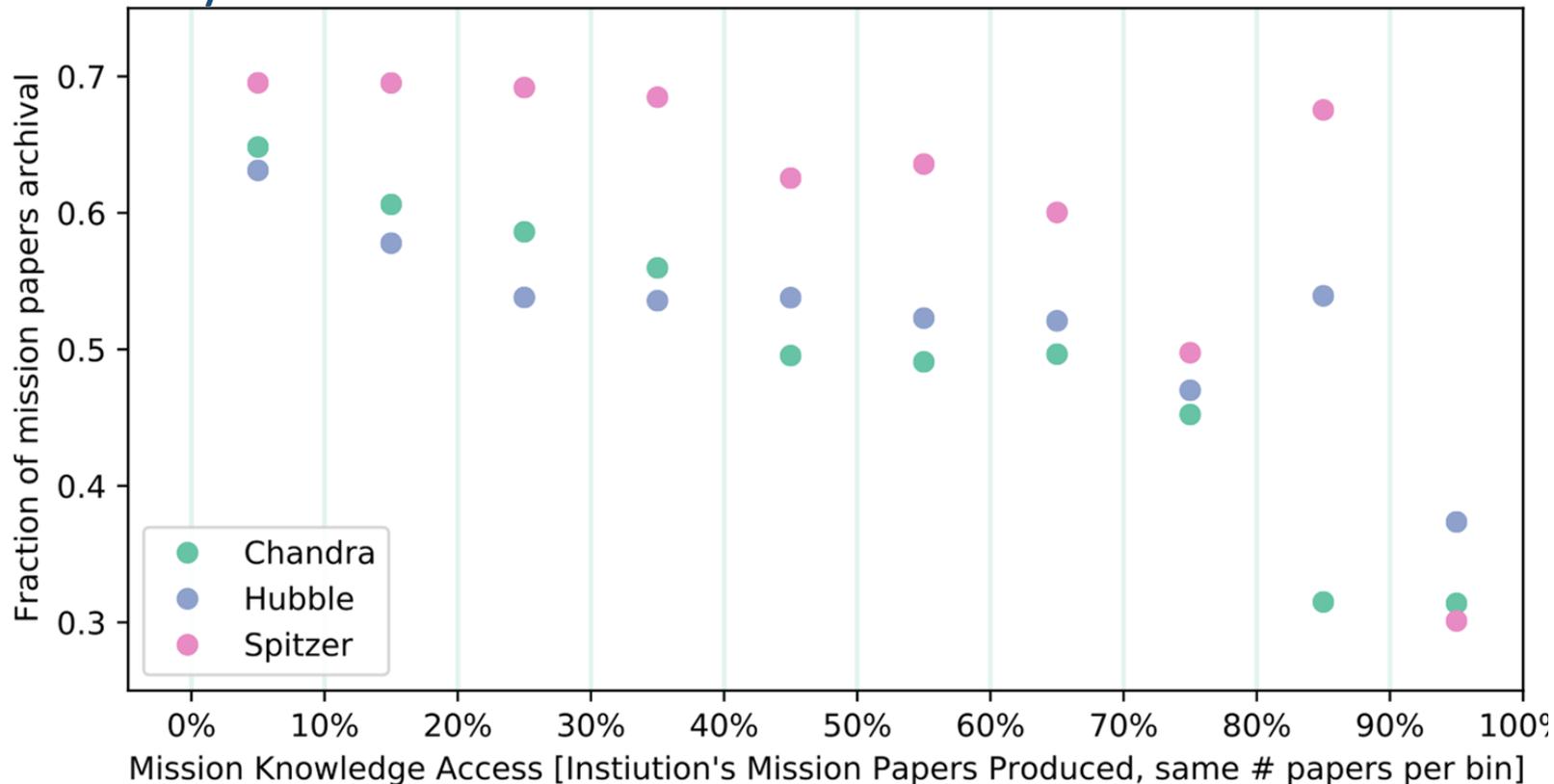# Archives drive science today, even for *pure Observatories*

Hubble Science Publications

Legend: Part, AR, None, GO
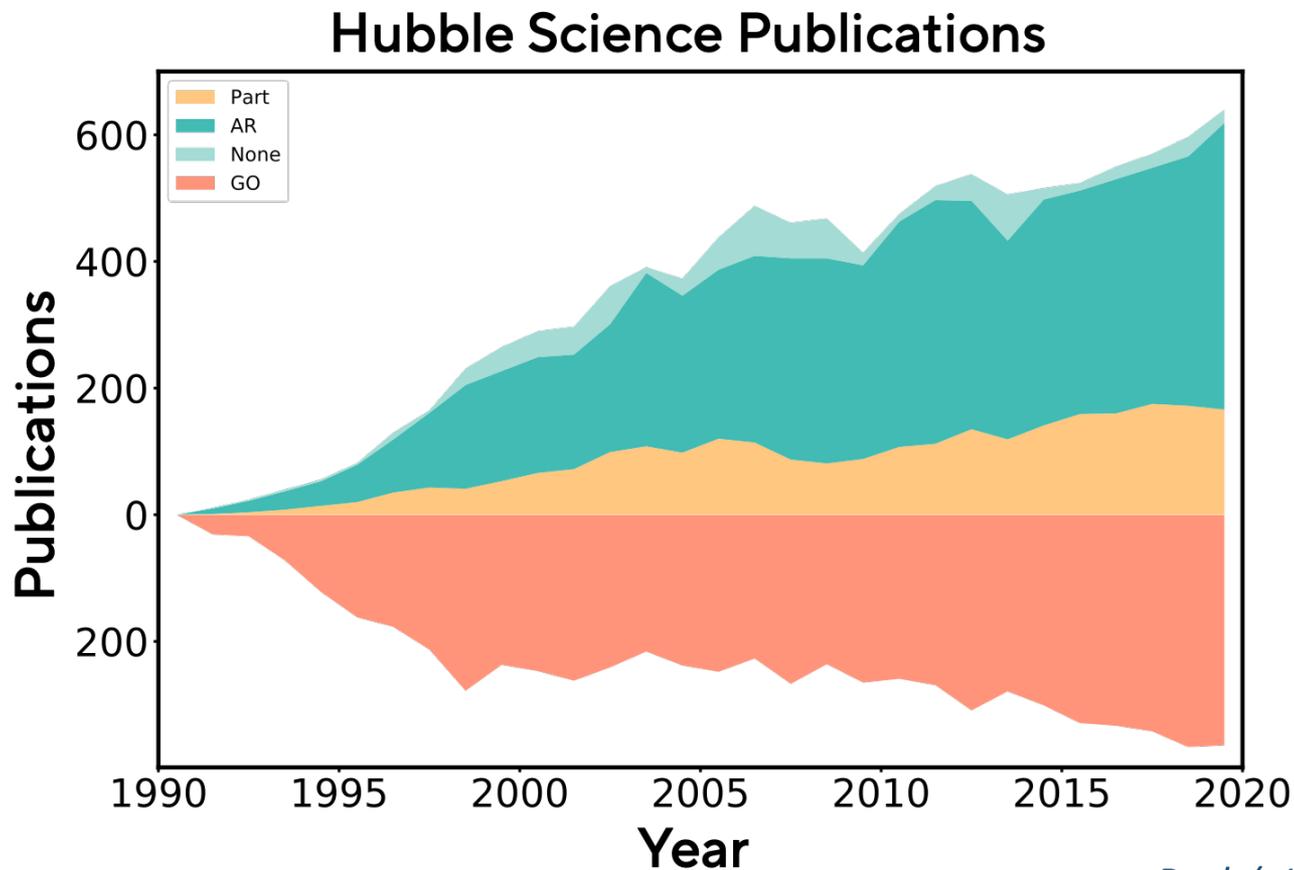
Peek (+IPAC, HEASARC)+2019

Archives drive science *especially* for the broader science community

Josh

Peek (+IPAC, HEASARC)+2019

The *Fornax* Project

Josh

- A cloud NASA project between IRSA, MAST, HEASARC, GSFC
- Coordinates MAST (Roman) and IRSA (Public Euclid in the US) in AWS, including a science platform
- Plans to put IRSA/Euclid data next to *Roman* data (though egress remains challenging for NASA today): aws-east-1
- A joint Euclid/Roman cutout service is planned
- Systems are being build to provide (some) joint access across these data sets that are harmonious with LSST/LINCC, including cloud-friendly, fast catalog cross-matching tech

Challenges

Josh

- Science Centers can create both *joint products* (e.g. Euclid/LSST DDP) and *joint systems* (e.g. Roman/Euclid *Fornax*) for creating these products, but **consensus** and **balance** remains challenging: *How do we best include the whole community?*
- NASA, NSF yet to identify a *Nexus* approach
- LSST and Euclid data rights initially limit ability to build open systems to enable science for all
- There is no plan at present to add public LSST data to a joint cloud science platform (Fornax)