

ITA-INA-S2



AGILE: AGN In the LSST Era

An end-to-end simulation

of

AGN

Galaxies

and stars

Angela Bongiorno (INAF-OAR)

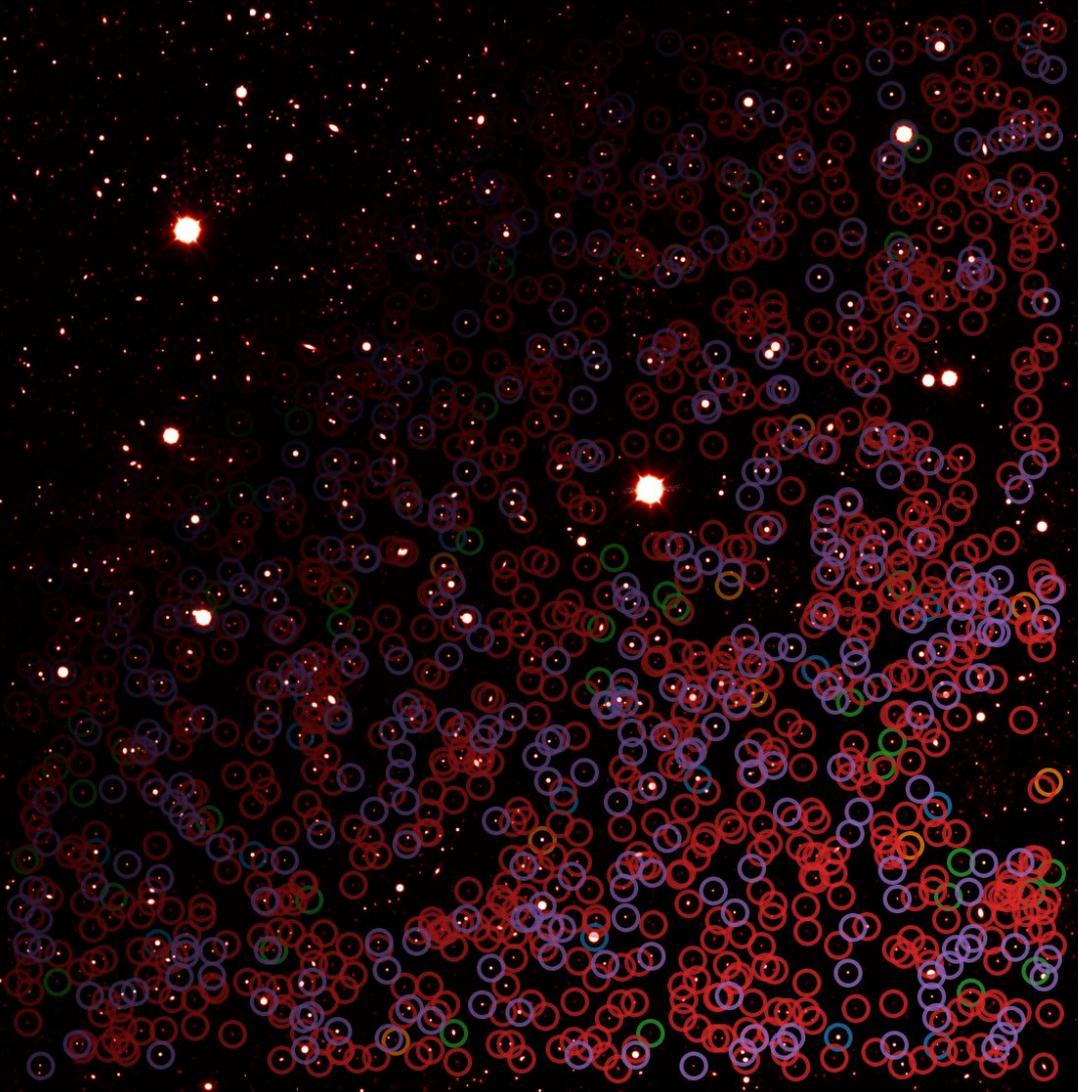
Akke Viitanen (UniGE, INAF-OAR), Ivano Saccheo (Univ. Bristol, INAF-OAR)

Collaborators: V. Petrecca, M. Paolillo, D. De Cicco, A. Kovacevic, D. Ilic, F. Shankar, D. Roberts, V. Allevalo, E. Merlin, A. Grazian, M. Di Criscienzo, M. Trabucchi, G. De Somma + INAF in-kind team

Aim

Create an LSST
end-to-end simulation
software capable of
simulating LSST
observations of the AGN
population (AGILE)

→ AGILE creates DP0-like
datasets (images and
photometric catalogs) **but
tailored specifically to
AGN.**



Motivation

DP0 has been fantastic for:

- End-to-end test of LSST pipelines and data-release machinery.
- Train the community on LSST-like images + catalogs *before* real data
- Benchmark for methods: selection, photo-z, image analysis, etc

But it contains no AGN!!

Thanks to AGILE data we can now test/perform:

- 1) **AGN identification** (morphology, colour–colour selection, variability) as function of survey progress
- 2) **AGN and host characterization** (variability parameters, AGN properties, morphology, host-galaxy properties, photometric redshifts)

Status of the in-kind contribution

Proposed in Feb 2020 → Got approved in March 2022

Official Starting date: October 2022

Official End date: October 2024

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Real

April 2023

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Real

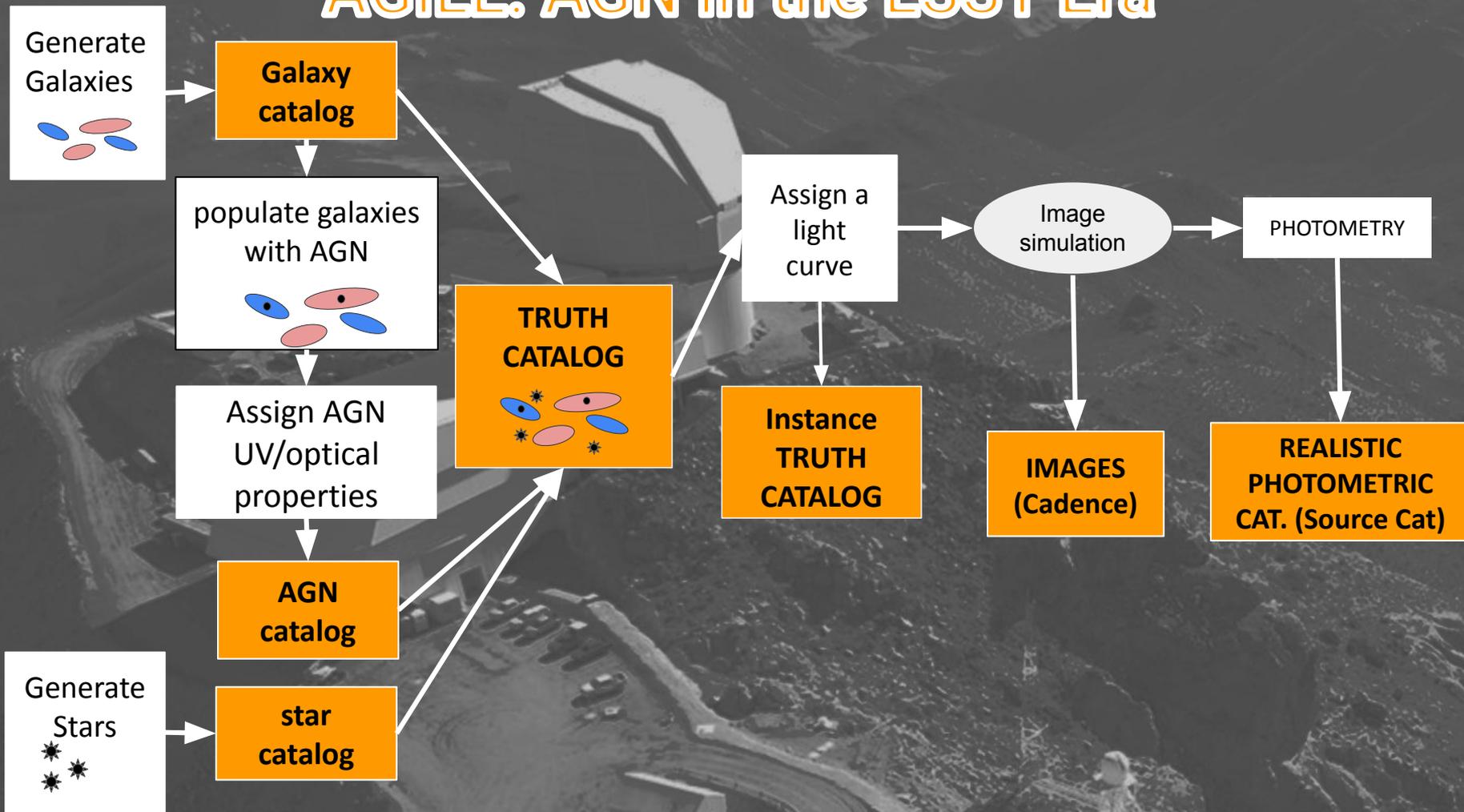
July 2025: AGILE DR1 unofficially released



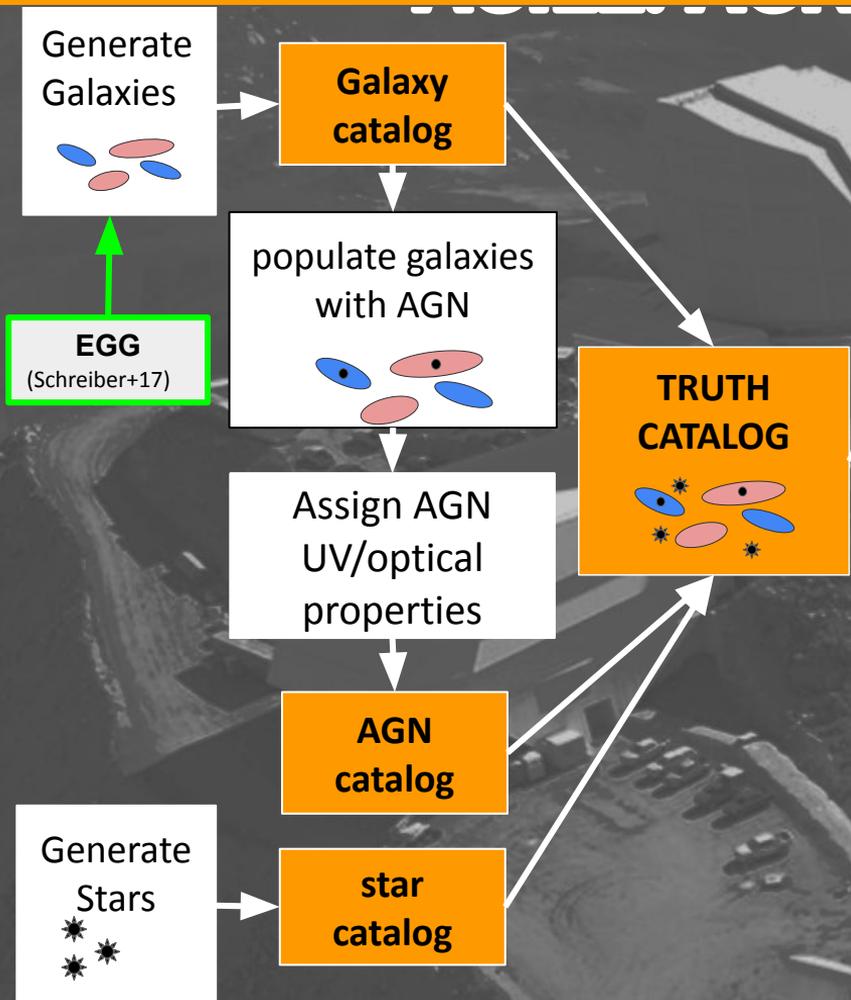
Paper (Viitanen, Bongiorno, Saccheo et al.) → referee report received (very positive)

Official in-kind release → End of Jan/Beginning of Feb. 2026 (finalizing the documentation)

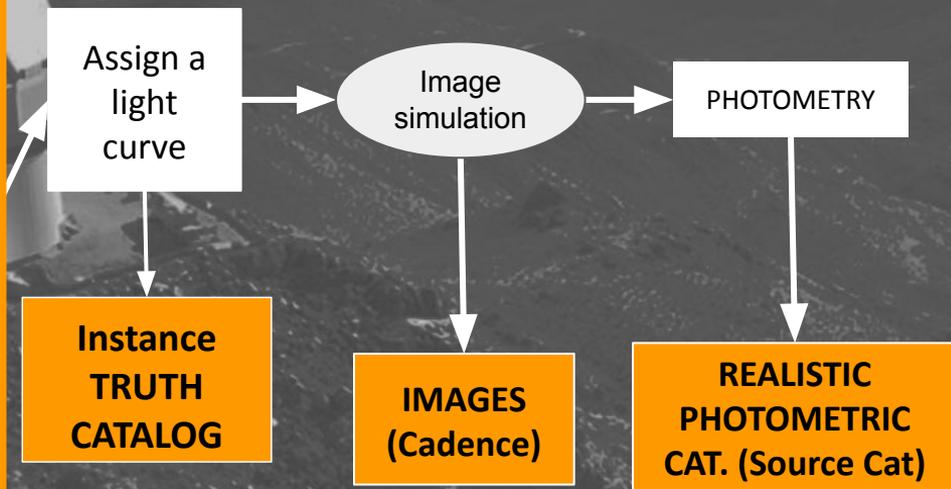
AGILE: AGN In the LSST Era



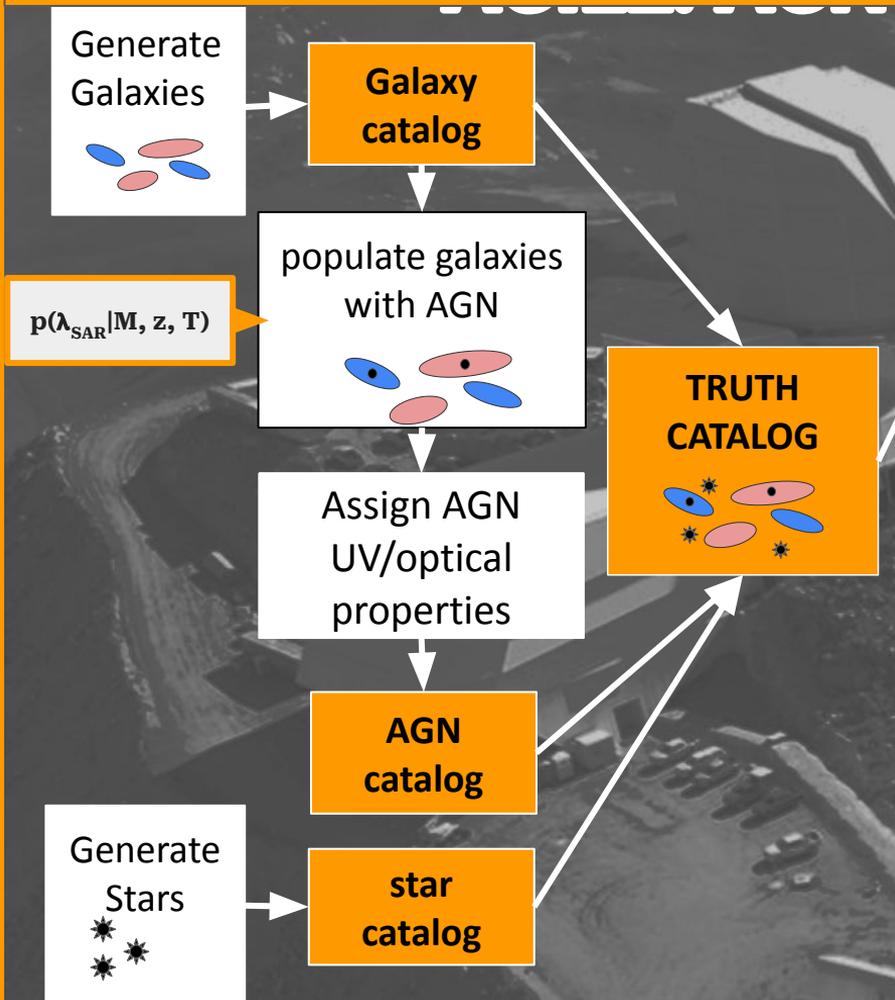
CREATION OF THE MOCK CATALOG



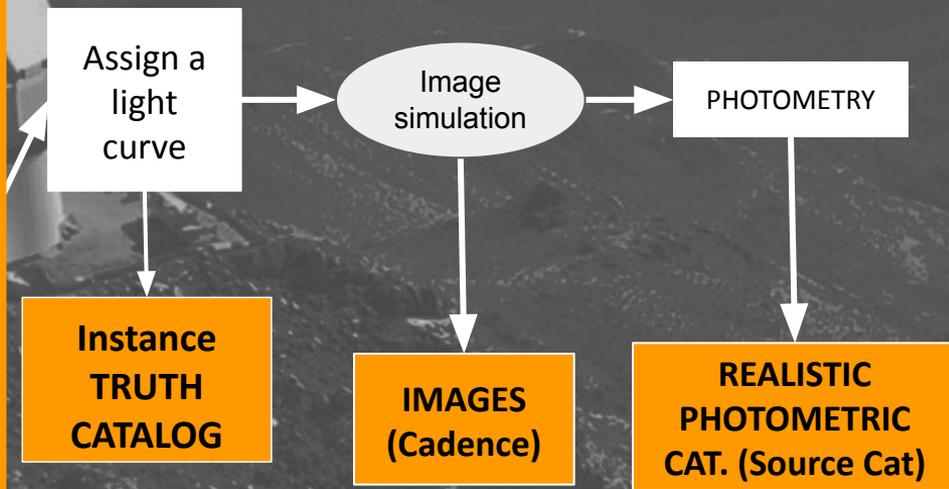
In the LSST Era



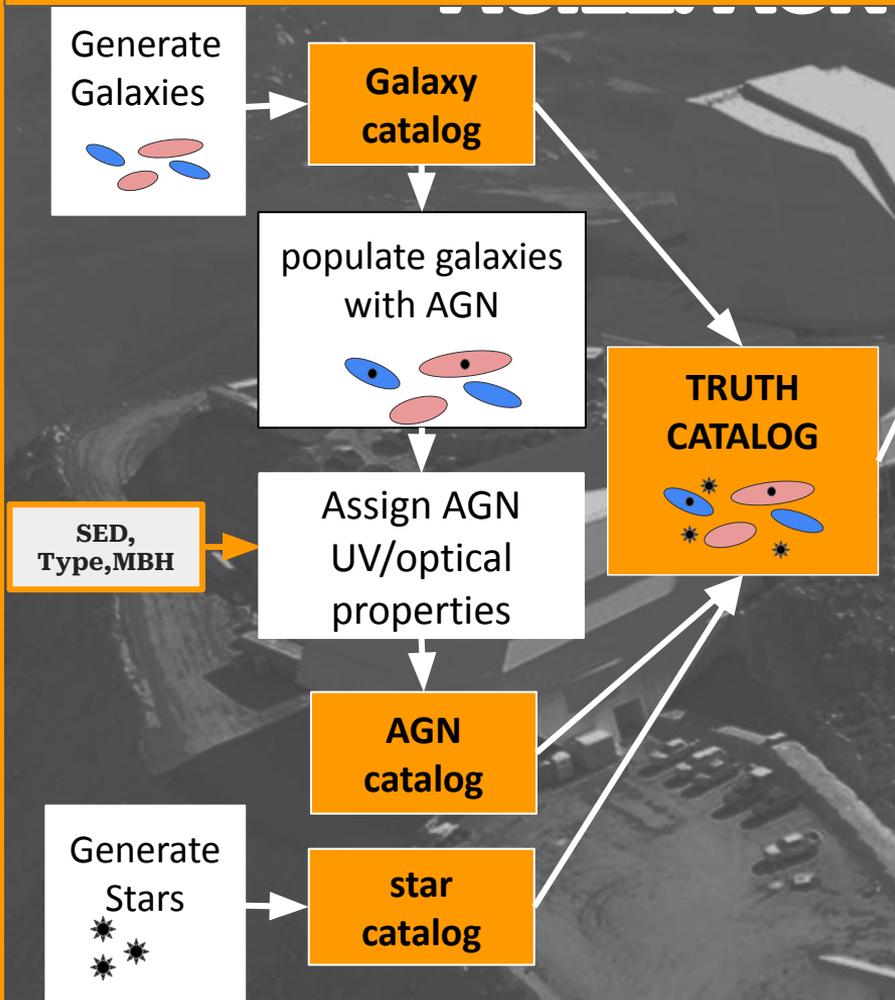
CREATION OF THE MOCK CATALOG



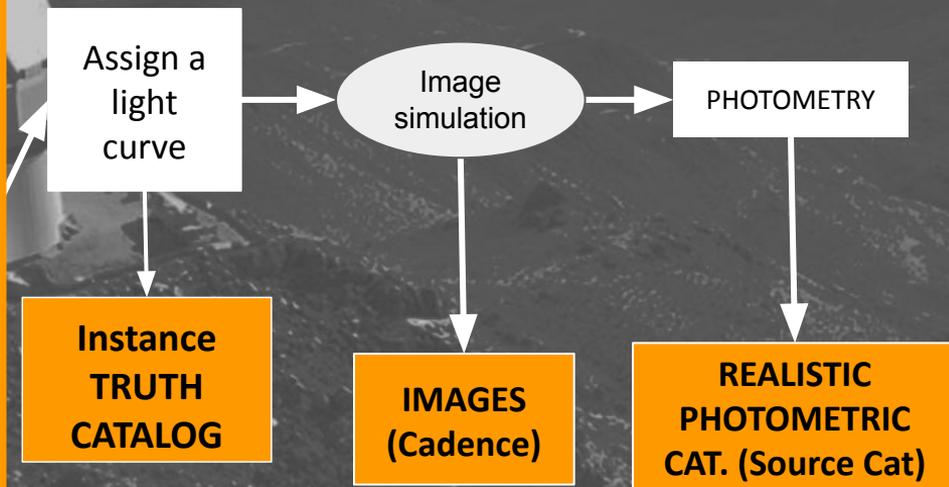
In the LSST Era



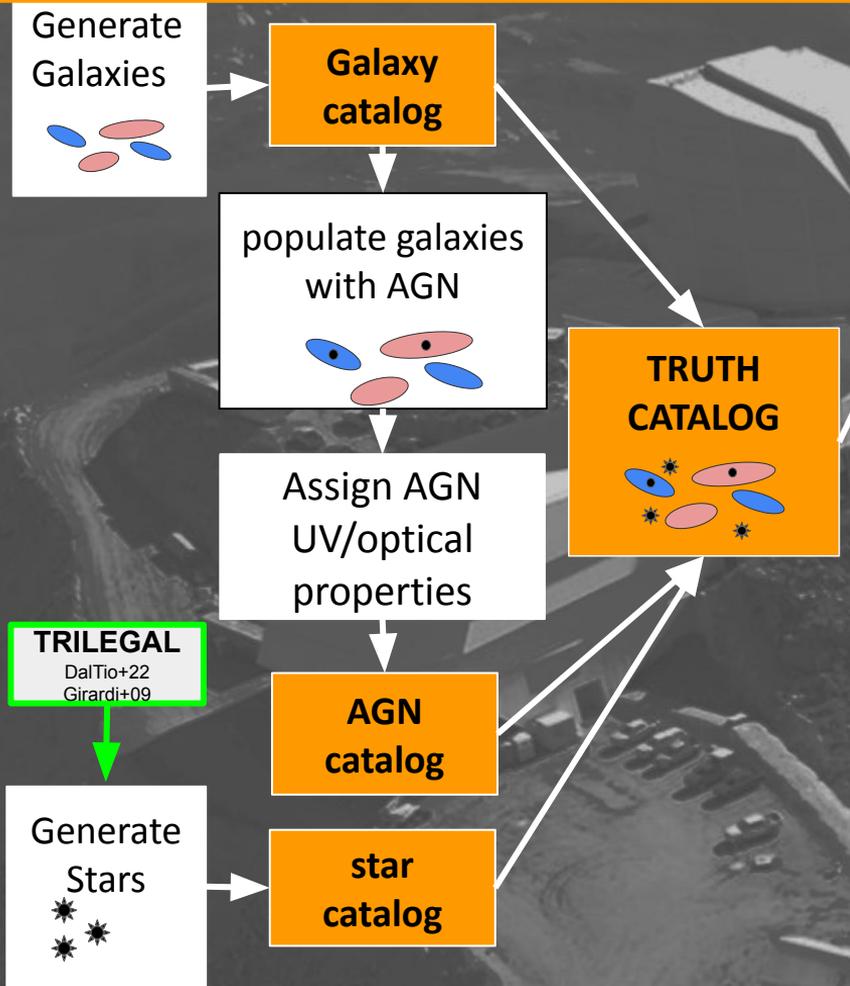
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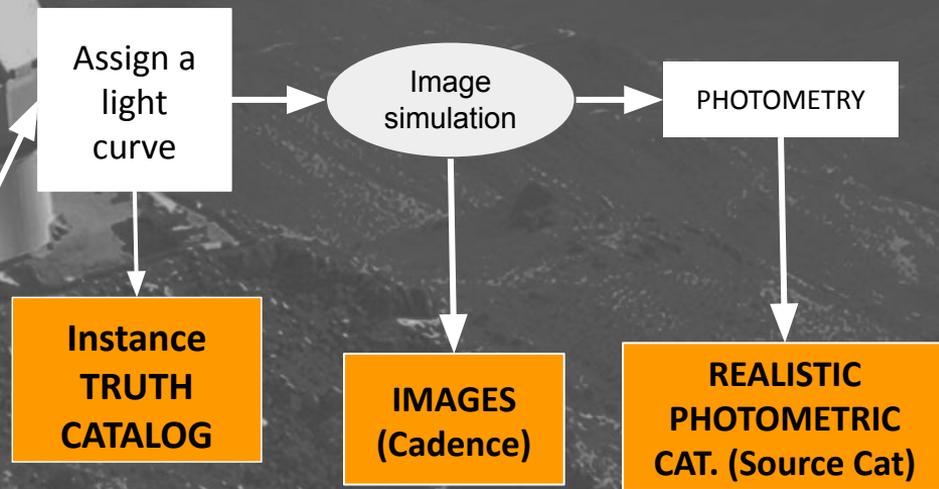
In the LSST Era



CREATION OF THE MOCK CATALOG



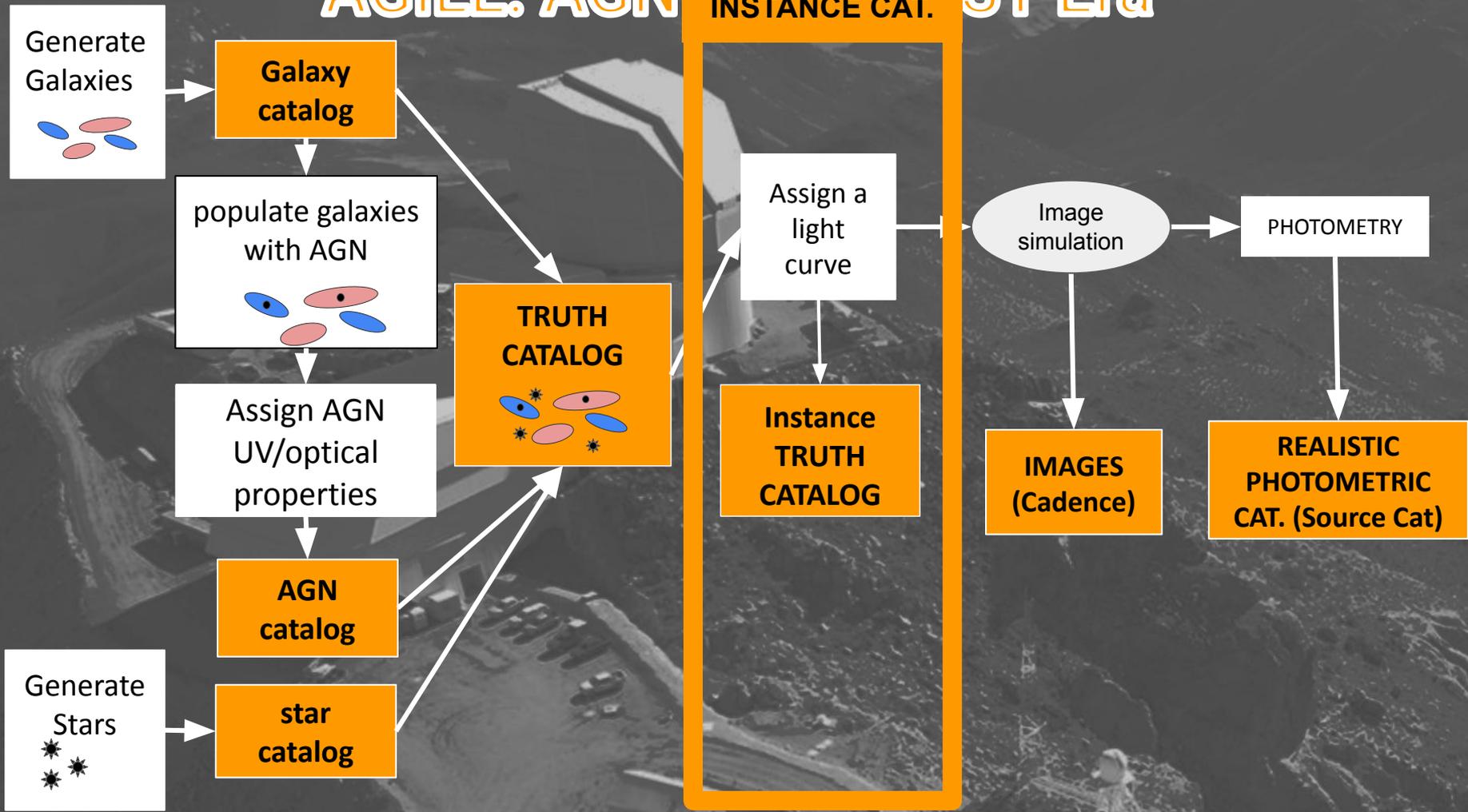
In the LSST Era



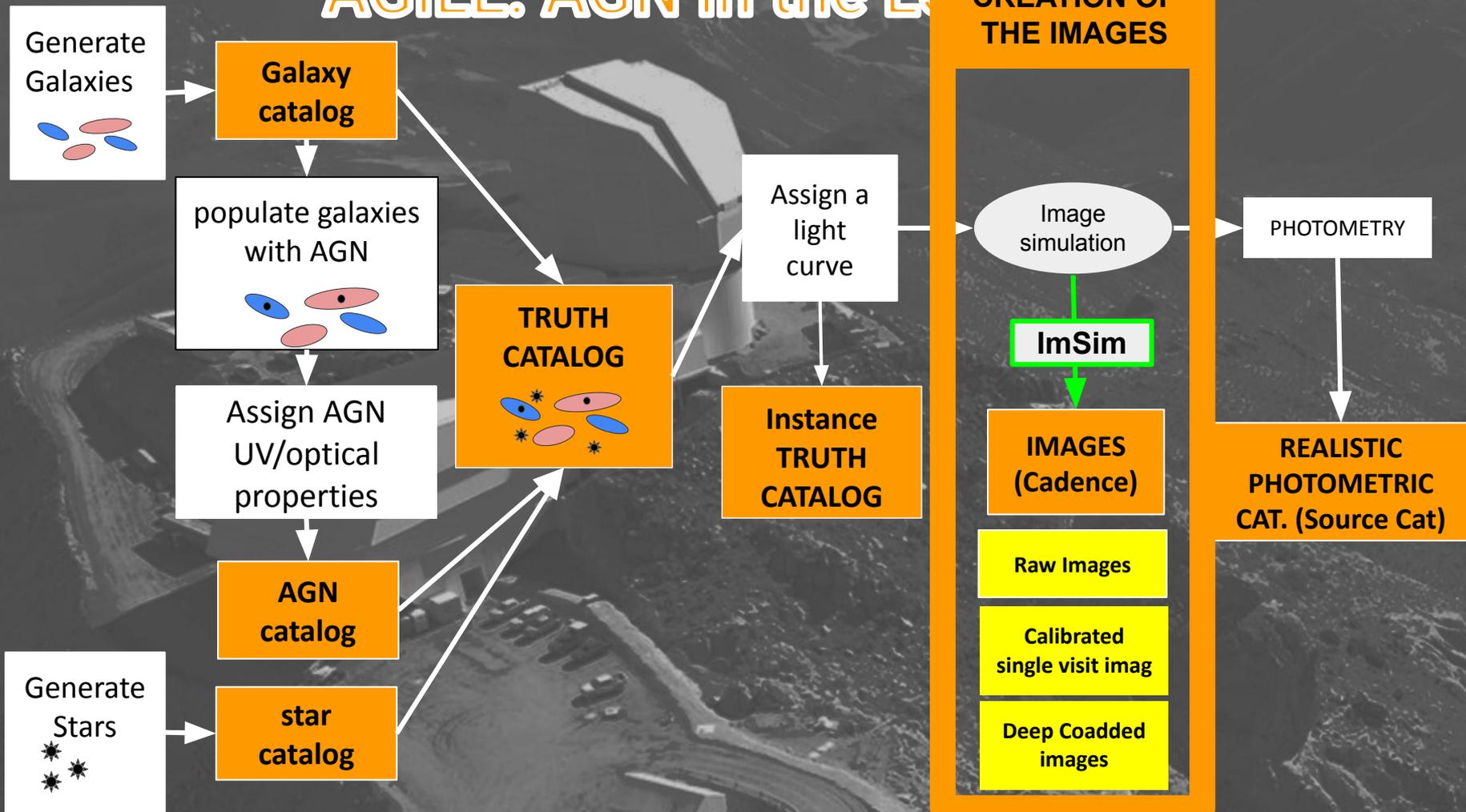
AGILE: AGN

CREATION INSTANCE CAT.

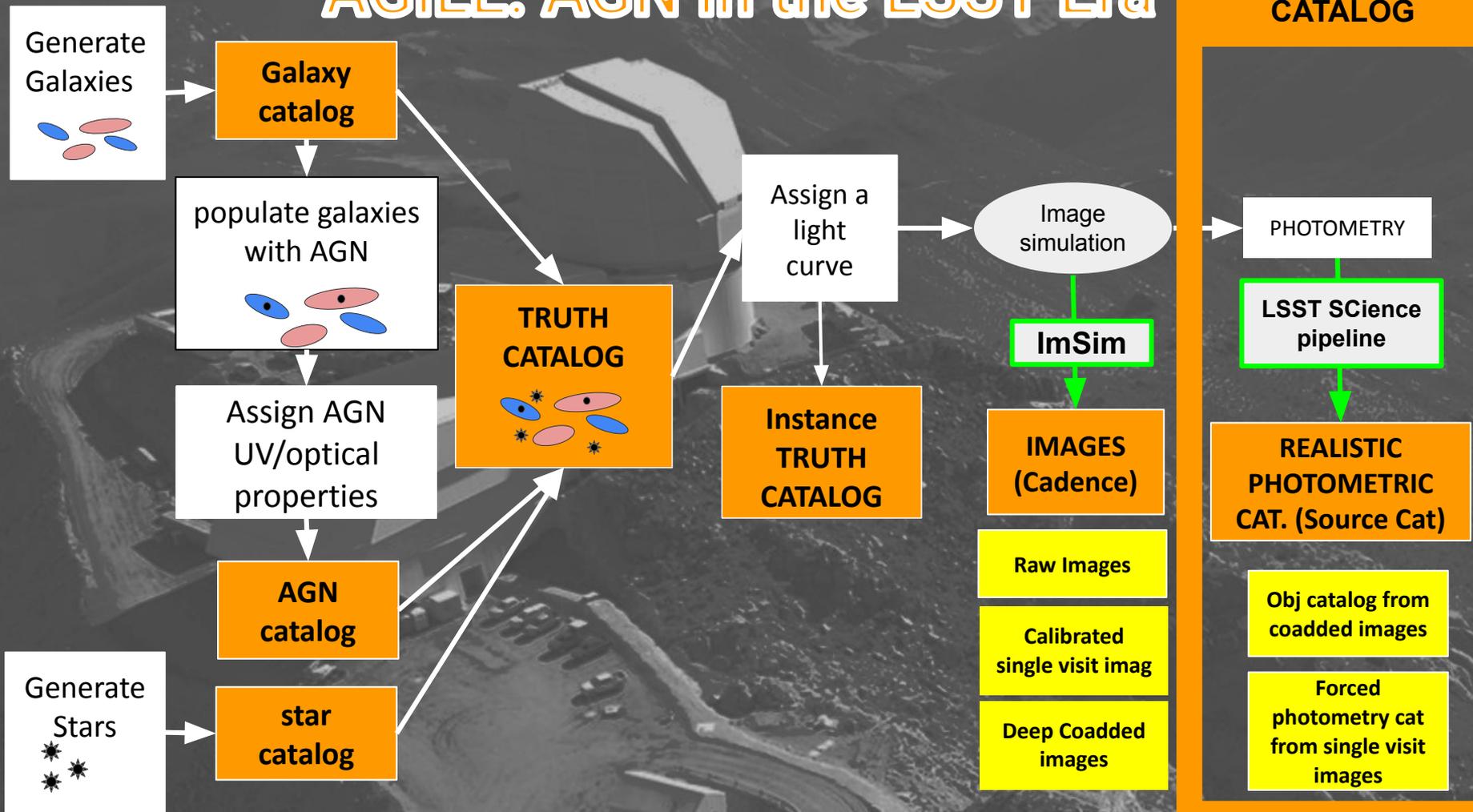
ST Era



AGILE: AGN In the LSST



AGILE: AGN In the LSST Era



AGILE DR1 dataset

Galaxies

Complete ($0.2 < z < 5.5$, $\log M/M_{\text{sun}} > 8.5$)
galaxy population based on COSMOS2020
stellar mass function (Weaver+23)

AGN

with UV-MIR SEDs

- X-ray AGN population (Zou+24) incl. CTK AGN (Ueda+14)
- Optical/UV properties (Temple+21, Merloni+14)
- Black hole masses from the continuity equation (Roberts, Shankar+, in prep.)
- Light Curves: Damped random Walk (Kelly+09)

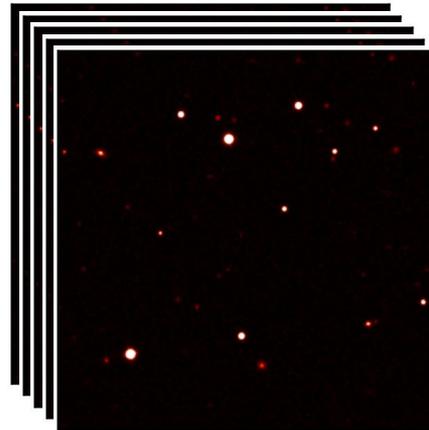
Stars

Milky Way and Magellanic cloud single binary
stars from LSST-SIM (dal Tio+ 22)

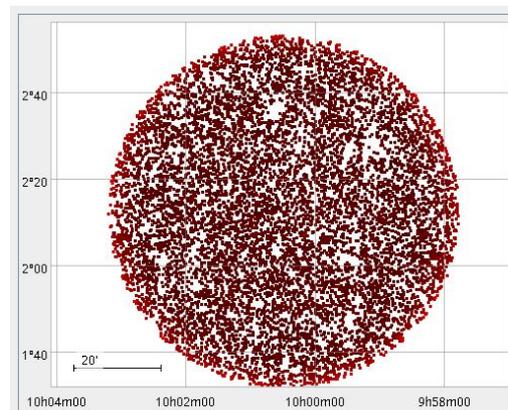
Truth catalog

ID	Name	Description
0	ID	unique ID
1	RA	Right ascension
2	DEC	Declination
3	Z	Cosmological redshift
4	D	Luminosity distance OR distance modulus for stars
5	M	\log_{10} of stellar mass
6	SFR	Star-formation rate
7	PASSIVE	Is passive (non-star-forming)
8	CLUSTERED	Is clustered
9	DISK_ANGLE	Galaxy disk rotation angle
10	DISK_RADIUS	Galaxy disk half-light radius
11	DISK_RATIO	Galaxy disk ratio of minor to major axis
12	BULGE_ANGLE	Galaxy bulge rotation angle
13	BULGE_RADIUS	Galaxy bulge half-light radius
14	BULGE_RATIO	Galaxy bulge ratio of minor to major axis
15	AVLINES_BULGE	Emission line extinction in the bulge
16	AVLINES_DISK	Emission line extinction in the disk
17 - 40	band_disk	Galaxy disk band flux
41 - 64	band_bulge	Galaxy bulge band flux
65 - 88	magabs_band	Galaxy band absolute magnitude
89	log_lambda_SAR	\log_{10} of specific accretion rate
90	is_agn_ctn	is Compton-thin AGN
91	is_agn_ctk	is Compton-thick AGN
92	is_agn	is Compton-thin or Compton-thick AGN

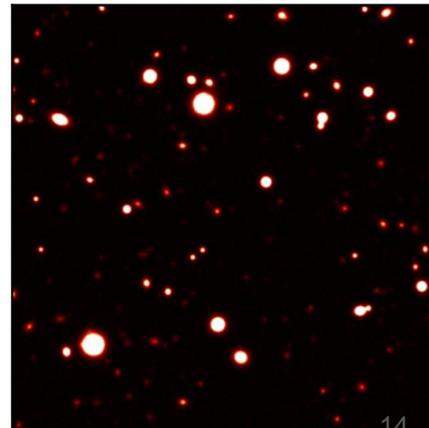
Single-visit images

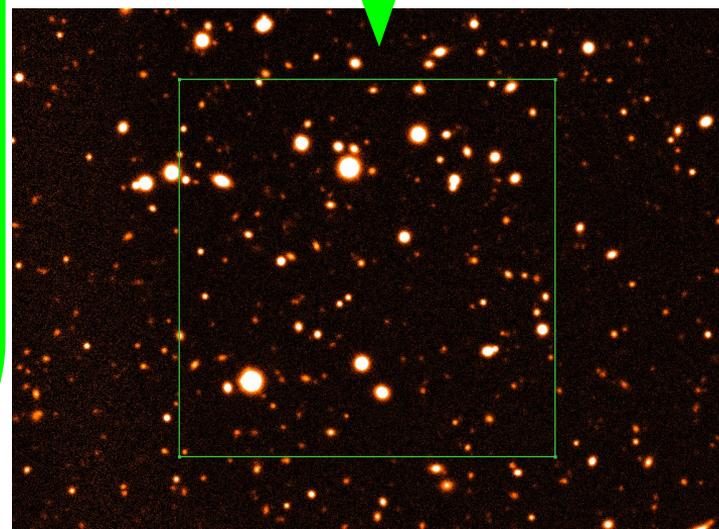
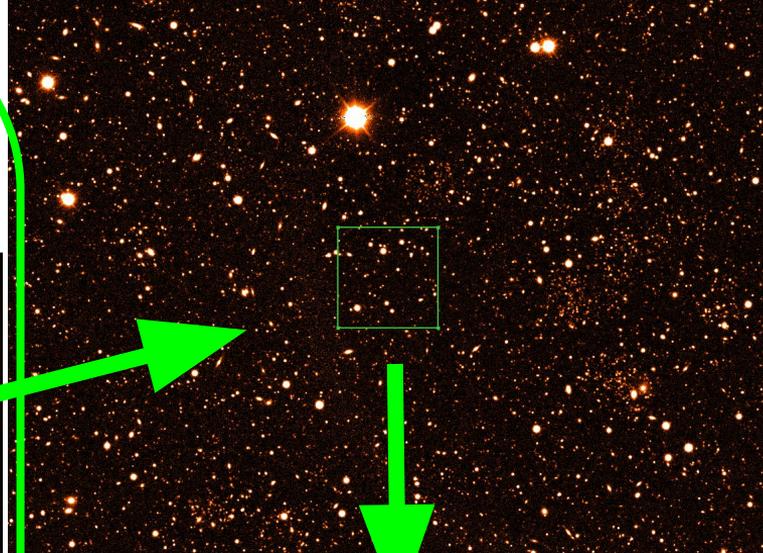
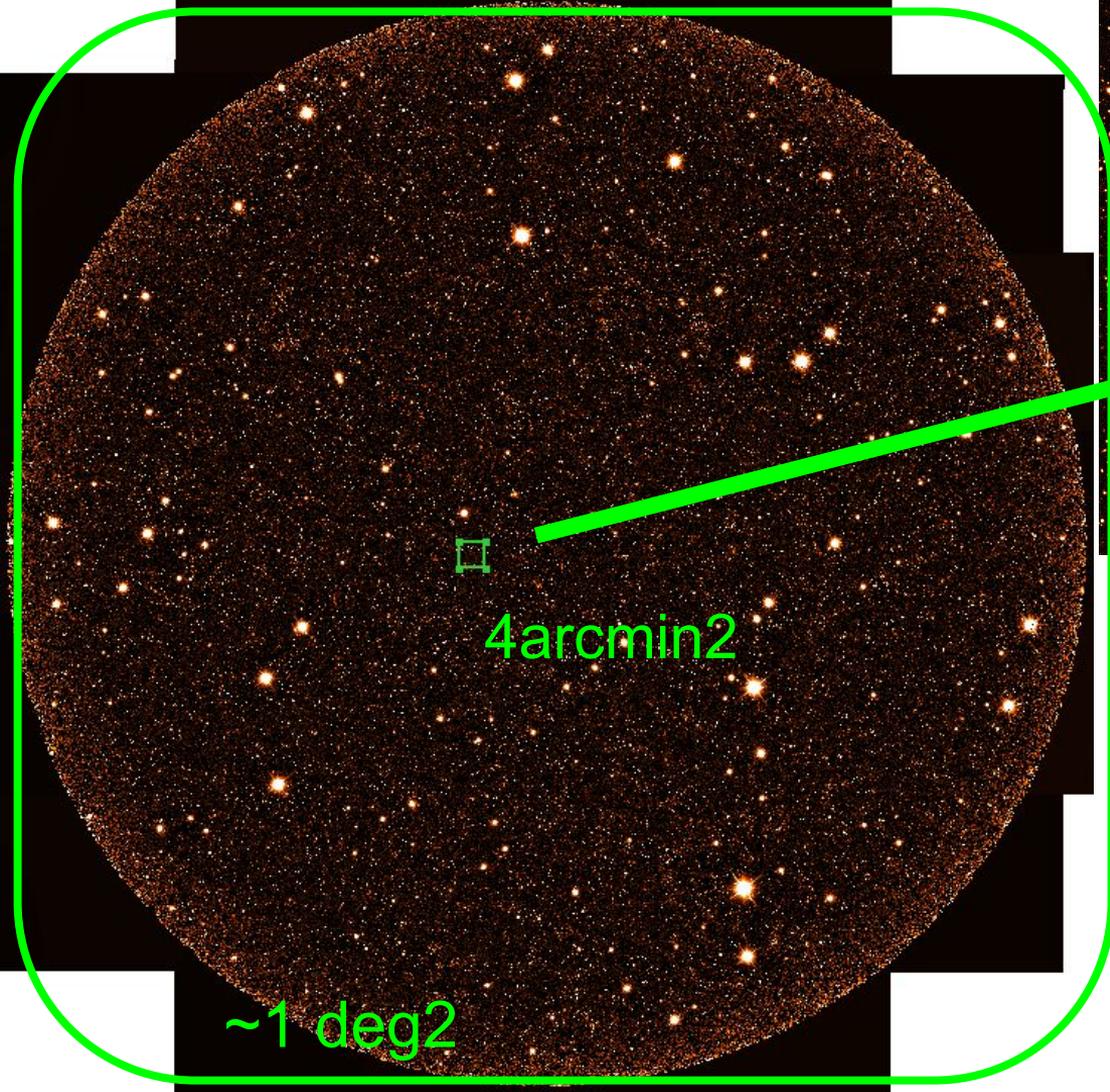


Photometric catalogs

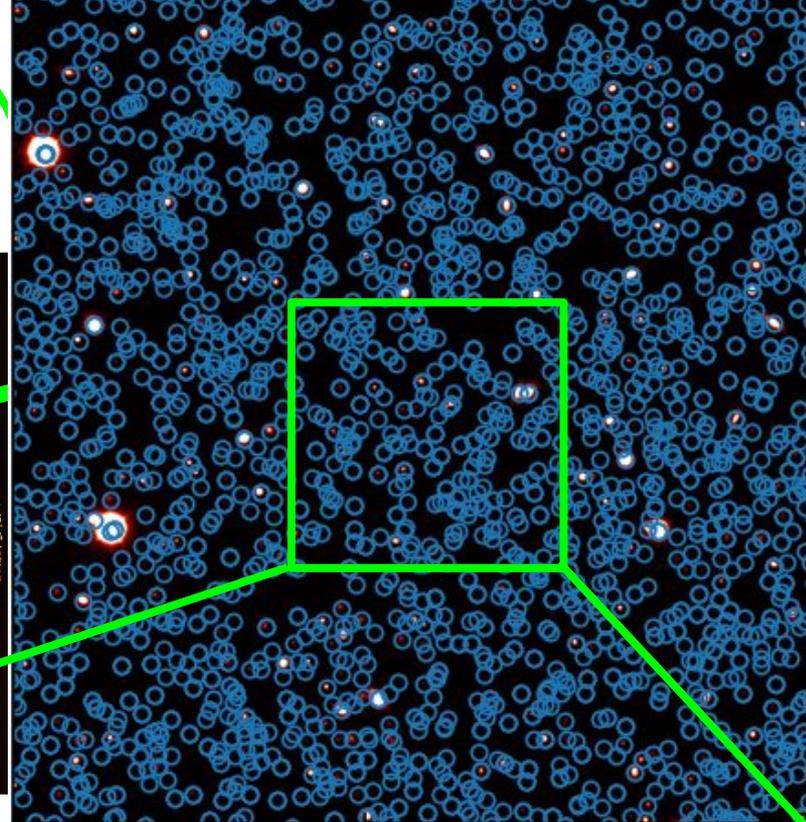


Coadded images



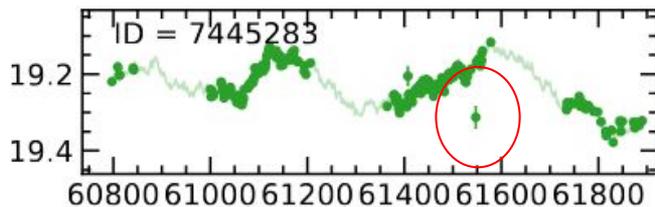
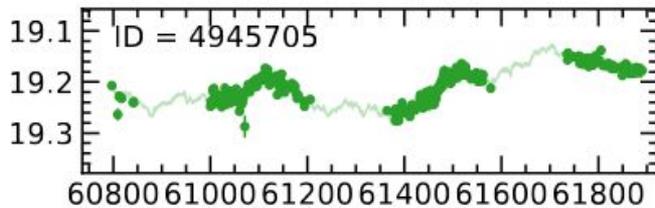
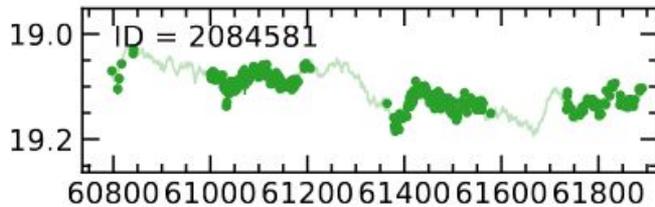
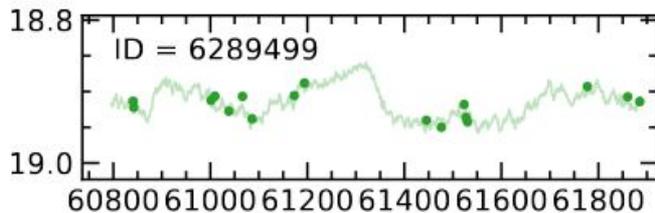
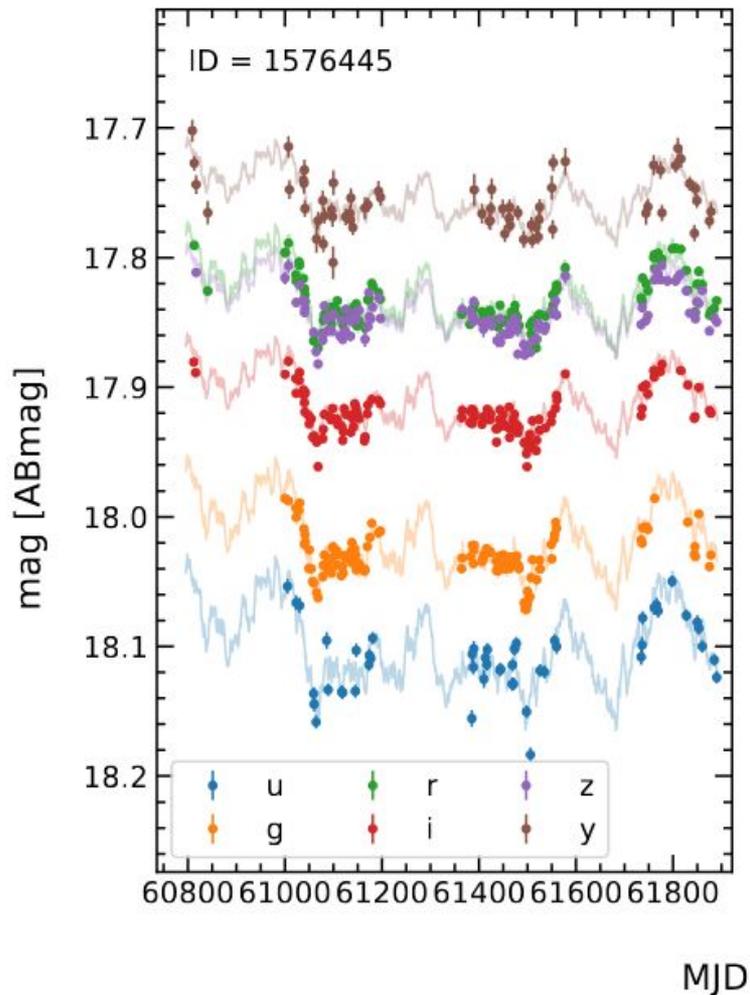


- **Source tables** – one per visit per detector
- **Object tables**– one per coadded image
- **ForcedSource tables** – Nobjects x Nvisits x Ndetectors
- **MatchesTruth** – x-match between Object and Truth



coord_ra	coord_dec	g_psfFlux	i_psfFlux	r_psfFlux	u_psfFlux	y_psfFlux	z_psfFlux
150.35769	2.11536	1116.61678	2343.69851	1552.84465	913.51278	2665.95582	2377.11034
150.33324	2.11601	267.50682	584.88535	475.10733	30.80897	710.36956	666.9564
150.29835	2.11603	1154.81855	16132.4848	4207.43841	61.90247	40263.57372	29976.01269
150.29638	2.11586	109.75589	178.71824	139.02539	123.8991	580.42405	250.30176
150.28728	2.11523	142.79915	255.48712	164.64102	92.48297	686.64076	318.44489
150.28467	2.11568	17493.68004	20477.58885	19657.52973	14644.40447	25253.53635	24549.83419
150.27621	2.11658	301.09698	2306.51761	796.61598	222.91218	4796.62832	3776.72296

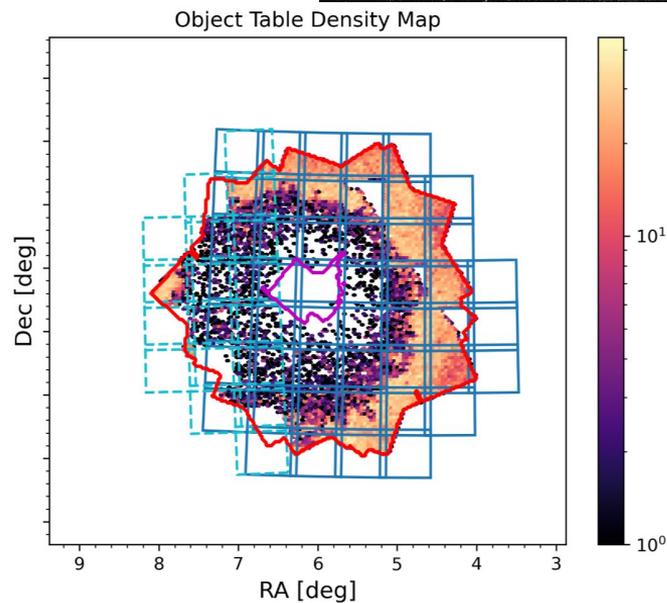
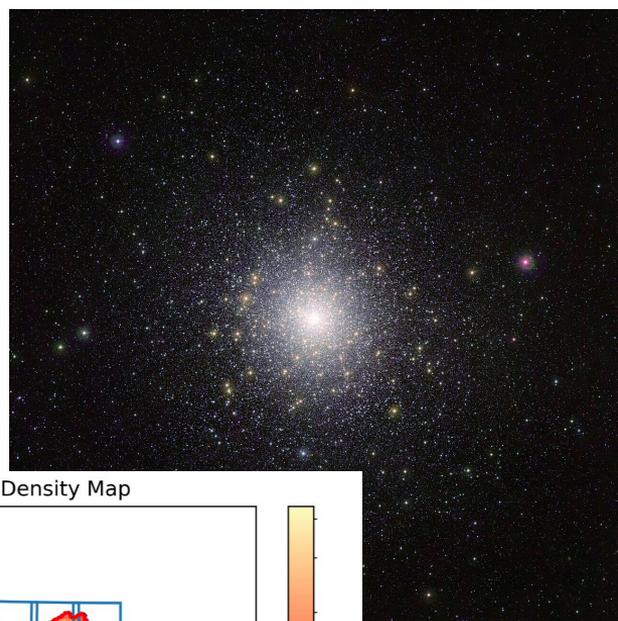
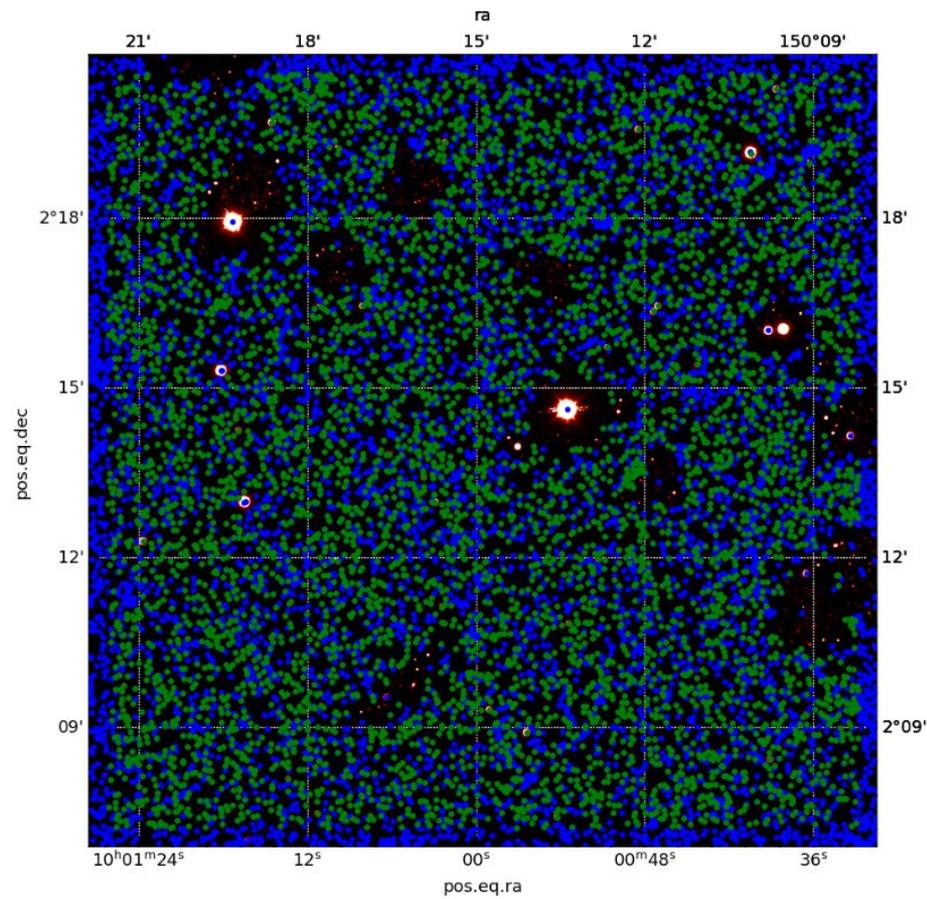
~1 deg²



AGN close to the edge of the detector

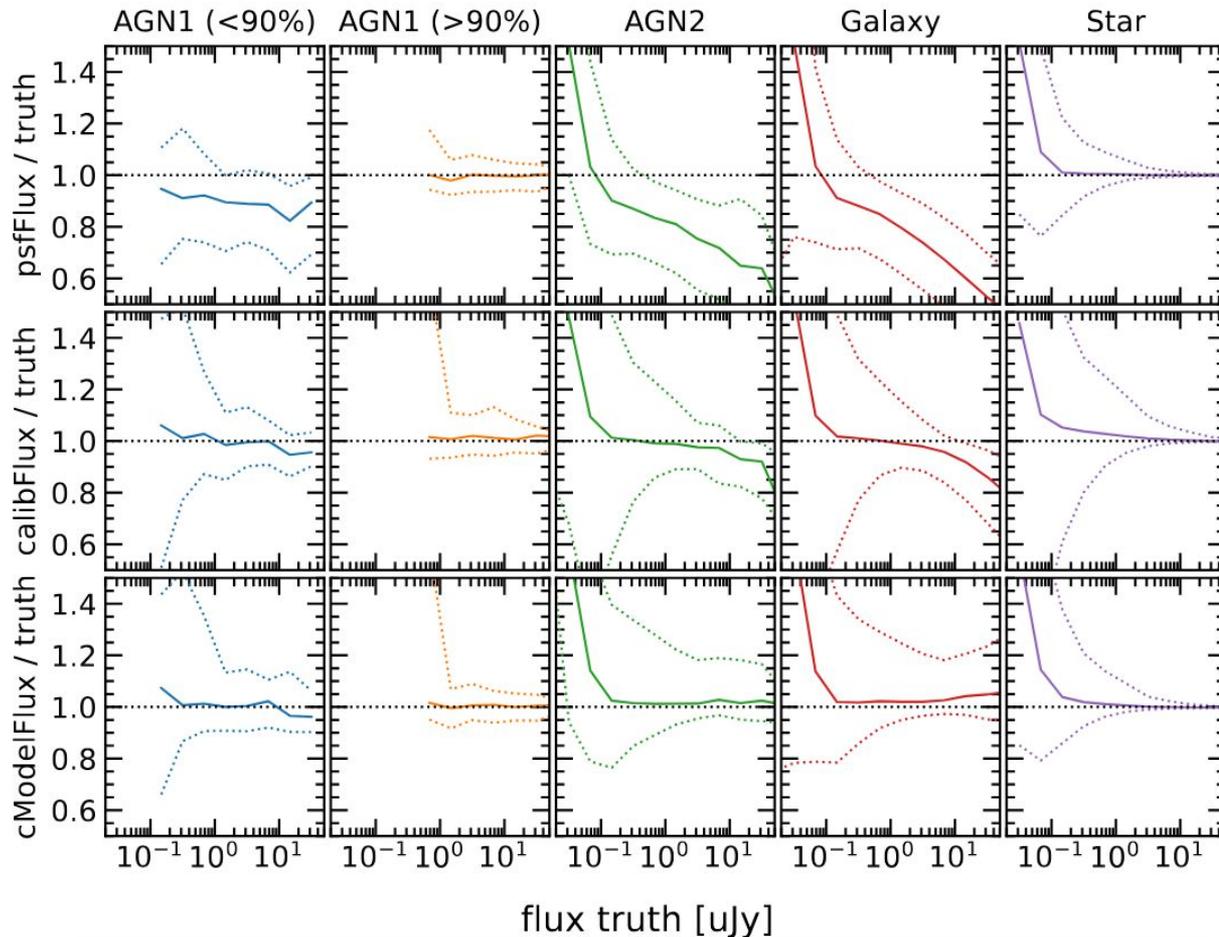
Outlier due to bad photometric calibration – most likely due to seeing and number of PSF stars

Deblending issues: AGILE vs. DP1



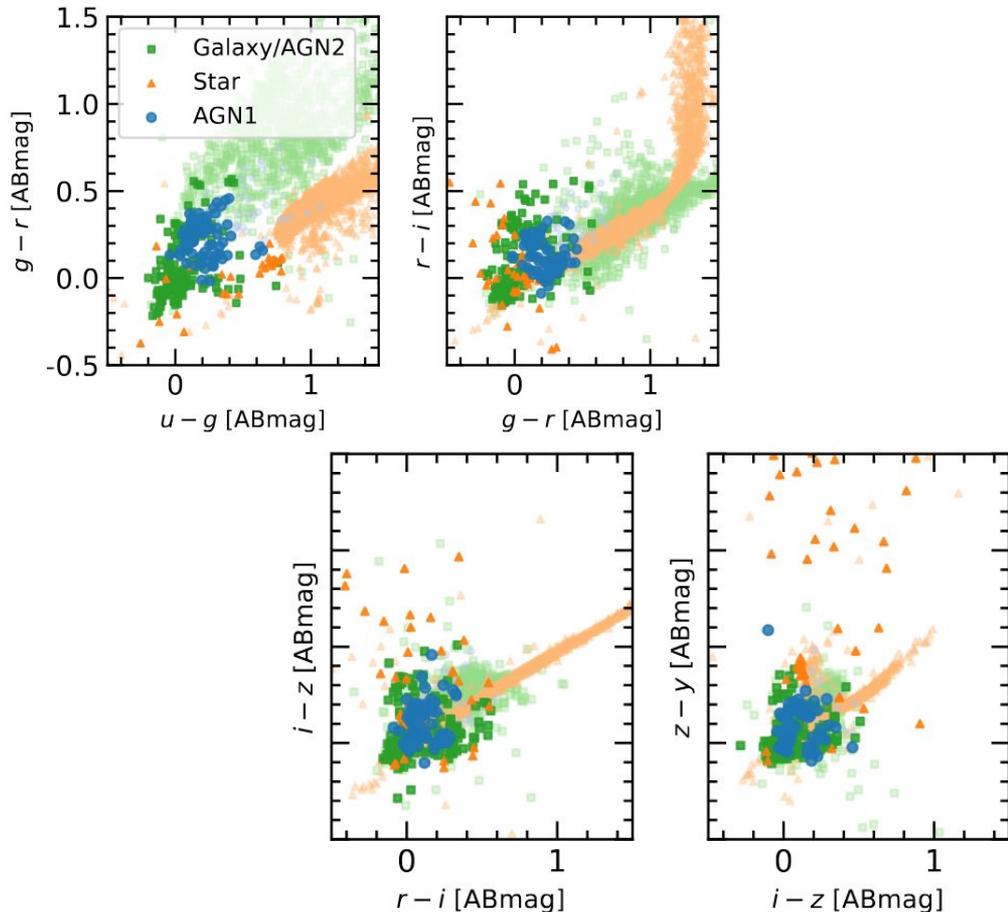
47 Tuc

AGILE DR1 applications – flux vs. flux



- no single flux estimator recovers the diverse AGN population
- minimal consideration: psfFlux for pointlike sources, cModelFlux for extended sources

AGILE DR1 applications – AGN color - color selection



AGN color-color selection (Croom+09)

- $g < 21.85, i < 22$
- $z < 2.6$

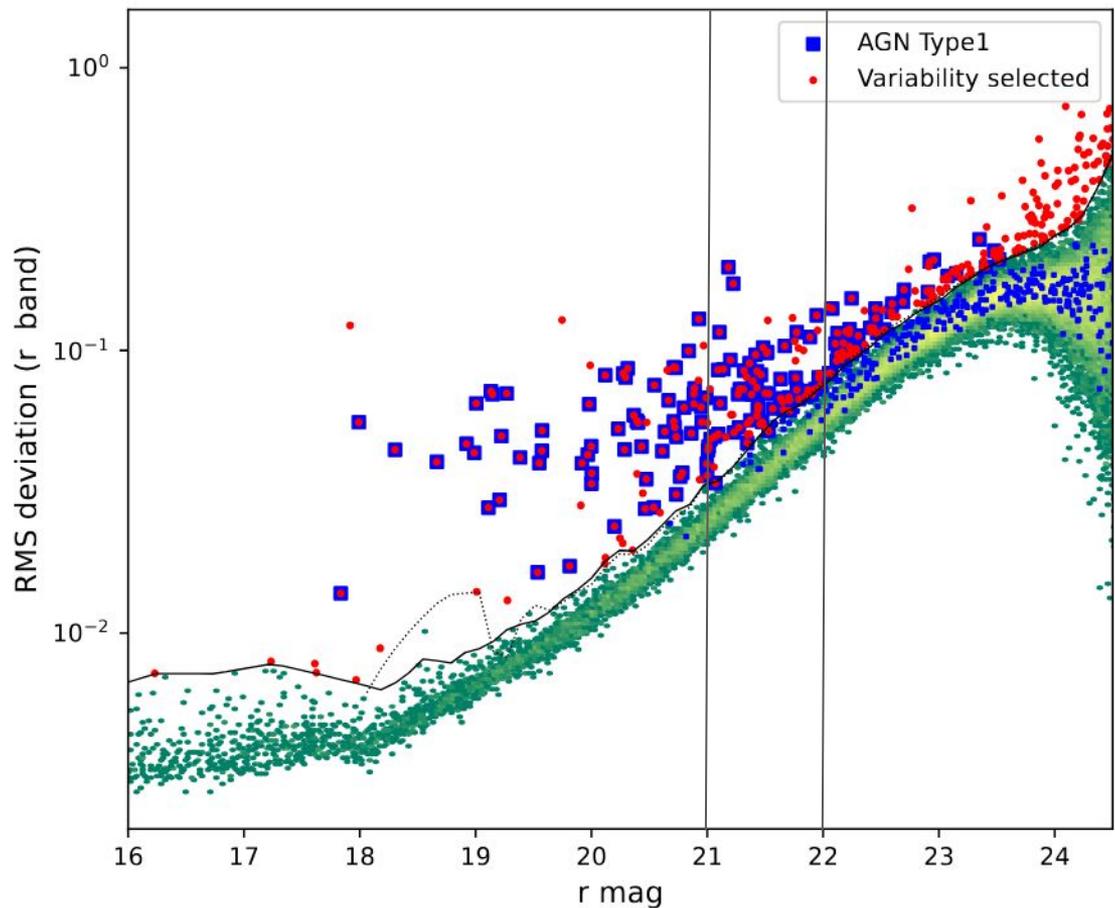
→ Completeness

- ~100% ($g < 20.5$)
- ~60% ($20.5 < g < 22$)

→ Contamination

- ~ 63% ($g < 20.5$)
- ~ 75% ($20.5 < g < 22$)

AGILE DR1 applications – AGN variability selection



Completeness

97% ($r < 21$)

75% ($21 < r < 22$)

13% ($r > 22$)

Contamination

28% ($r < 21$)

31% ($21 < r < 22$)

78% ($r > 22$)

Projects ongoing using AGILE DR1

1. **Testing different techniques to select AGN/Compute the LSST selection function**
2. **LSST DP1 vs AGILE DR1**
3. **Testing image decomposition tools vs SED fitting**
4. **Recovering variability parameters from lightcurve**
5. **Testing lensed AGN search methods**
6. **LSST + SPHEREx**
7. **Testing using LSST detected AGN variability as a distance scale measure**
8. **Testing photometric redshift software**
9. **Testing variability recipes:** random walk vs damped harmonic oscillator light curves

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4. Recoveri

5. Testing k

6. LSST + S

7. Testing u

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WARNING:

We have no dedicated personnel/budget to exploit AGILE

Large grant requested last year not approved

AGILE DR1 Data access

→ The **AGILE DR1** includes:

- ◆ Catalogs: We have created a **sqlite3 master database containing ALL the current catalogs (~130G)**
- ◆ **Single and coadded images (3T)**

→ **Access the DR1 dataset:**

- ◆ We have now stored the full DR1 dataset in ADHOC Newton in Naples but sharing the data remains a not fully solved problem
- ◆ Currently we are sharing the catalogs/SEDs/LCs through INAF Google Drive
- ◆ We have asked to officially release channel through some of the IDAC facilities w/o success
- ◆ Discussion about visibility and coordination of the in-kind products within LSST SC ecosystem are ongoing