Enabling Time-Domain Science for Roman with RAPID

Jacob Jencson (IPAC, RAPID Testing and Validation Scientist)

Pasadena, CA – July 15, 2026

Shifting Landscapes in Astrophysics: New Frontiers to Explore with Roman

Mansi Kasliwal (PI; Caltech)
Ben Rusholme (Pipeline Development Lead; IPAC)
Lin Yan (Testing and Validation Lead; Caltech)
Ashish Mahabal (Machine Learning Lead; Caltech)
Roberta Paladini (Galactic transients, Inclusion Lead; IPAC)
Joe Masiero (Solar System Objects Lead; IPAC)
Russ Laher (Applications Developer; IPAC)
Amalia Rivera (Database Administrator; IPAC)
Ryan Lau (Coordination Scientist; IPAC)
Azalee Bostroem (Applications Developer; IPAC)
Emily Everetts (Applications Developer; IPAC)

Current and Former Students and Post-baccs:
Joseph Santana, Aayush Kulor
Alice Ciobanu, Karan Gandhi,
Manaswi Kondapally, Hebu Patil,
Anushka Paulchoudhury

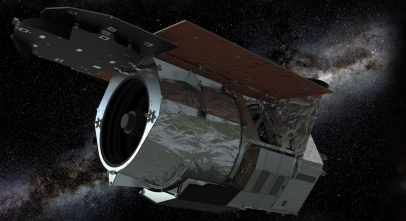
ipac Caltech

The Nancy Grace Roman Space Telescope

NASA flagship observatory - Field of View >100 times that of Hubble

Primary Instrument - Wide-Field Instrument (WFI)

- Wavelength coverage: 0.48 – 2.30 μm
- Eighteen H4RG-10 Detectors (300 Mpix); 0.28 deg^2 FoV
- Prism and grism for full-field, slitless spectroscopy from 0.75 – 1.93 μm



Launch by May 2027 and a 5+5 year nominal/extended mission

3 Core Community Surveys (CCS) + General Astrophysics Survey (GAS) + Coronagraph Survey

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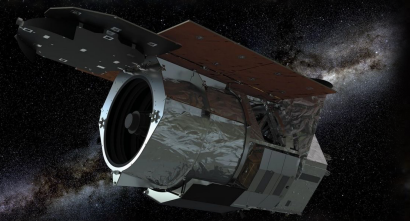

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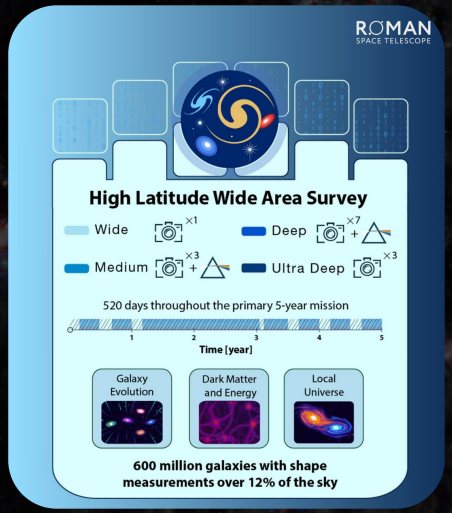

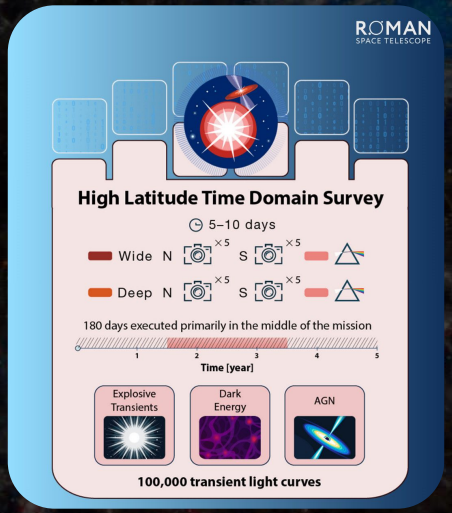

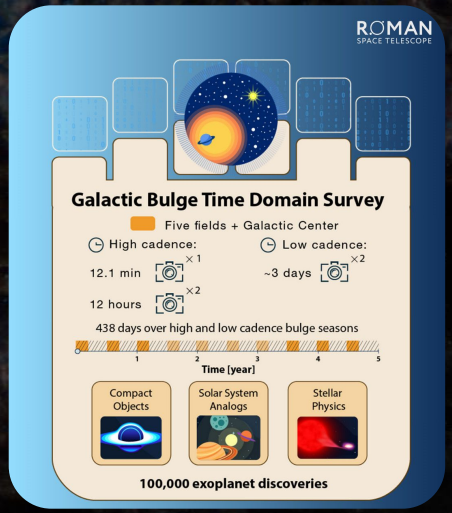

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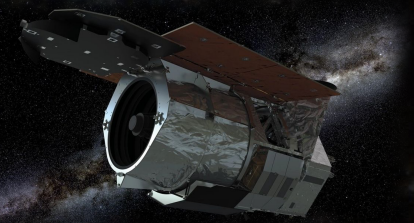

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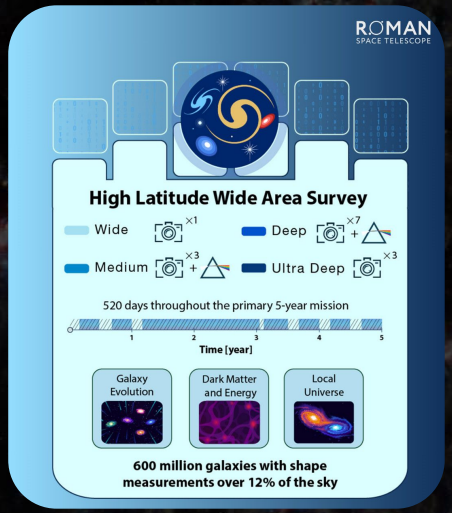

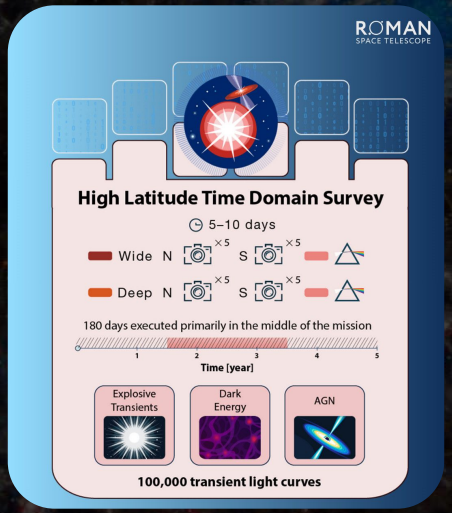

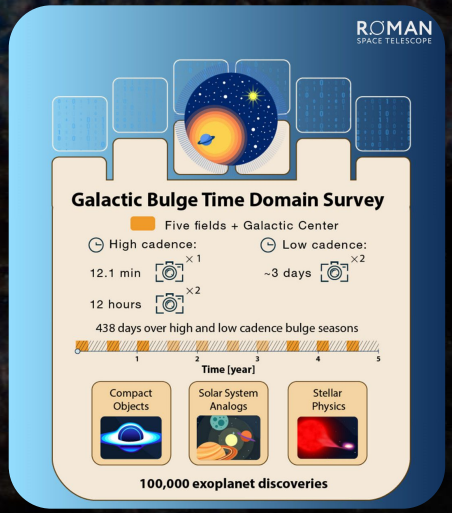

Galactic Plane Survey*

- ★ Includes time-domain science element (19 deg^2, 130 hrs) of six fields in seven filters
- ★ Repeat observations with cadences from ~11 minutes to weeks
- ★ Survey Definition report available!

Enthusiasm for Time-domain Science in Cycle 1

16 Analysis Programs with significant time-domain goals spanning a large breadth of science: TDEs and exotic SNe, cosmology with lensed SNe, transient hosts, stellar/AGN variability, searches for free-floating planets

GAS Programs:
Roman eXtreme Deep Field (Program 2001, PI H. Yan):
9 epochs over 3 years over ~1000 sq. arcmin in 7 filters

A Legacy Survey of Andromeda and Triangulum with Roman
(Program 2002, PI K. Gilbert):
4 epochs per year of entire disk (1.7 sq. deg.) plus a high-cadence pointing

How do we enable prompt transient discoveries with Roman?

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What is RAPID? (Roman Alerts Promptly from Image Differencing)

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A ***Project Infrastructure Team*** for the Roman Space Telescope

Role of Project Infrastructure Teams (PITs)
Provide comprehensive and sustained support to Roman and the science community for research areas that require long-term scientific infrastructure development.

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RAPID *will deliver*

- ***Rapid image differencing*** of every new Roman image
- A ***prompt public alert stream*** of all transient and variable candidates in difference images
- Source match-files recording ***candidate light curves***
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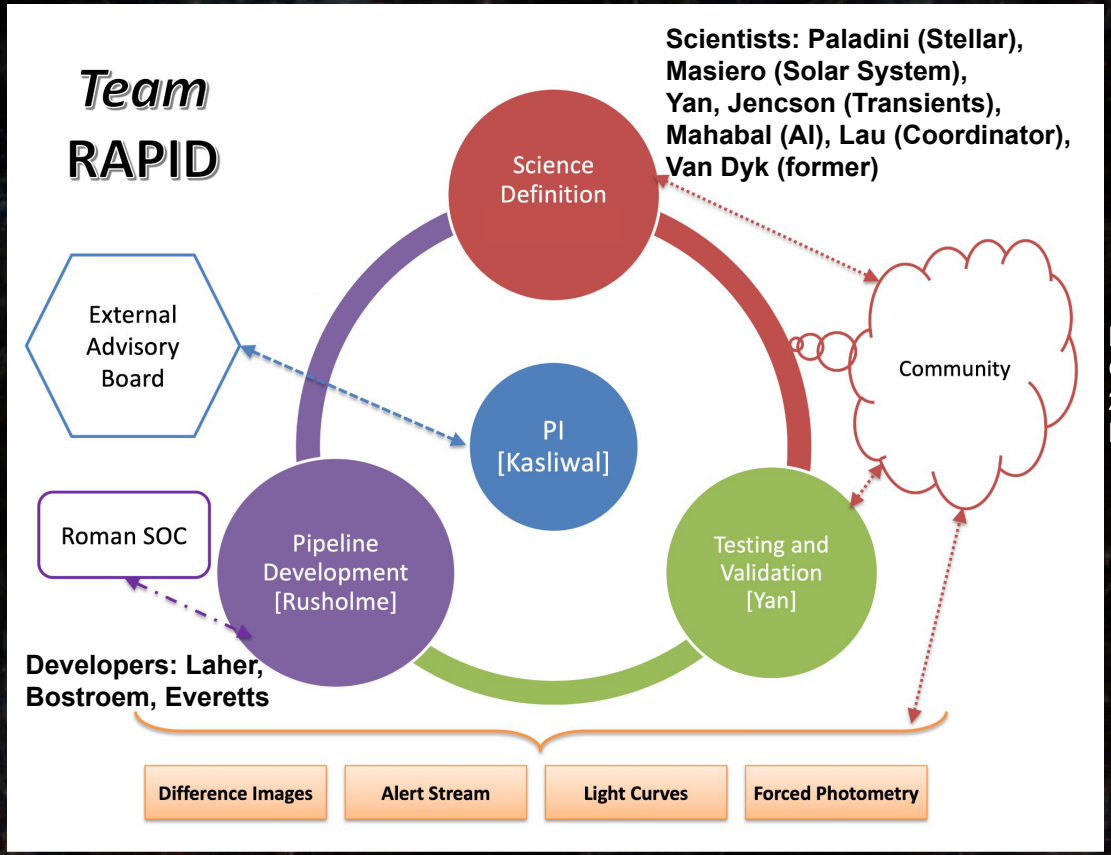


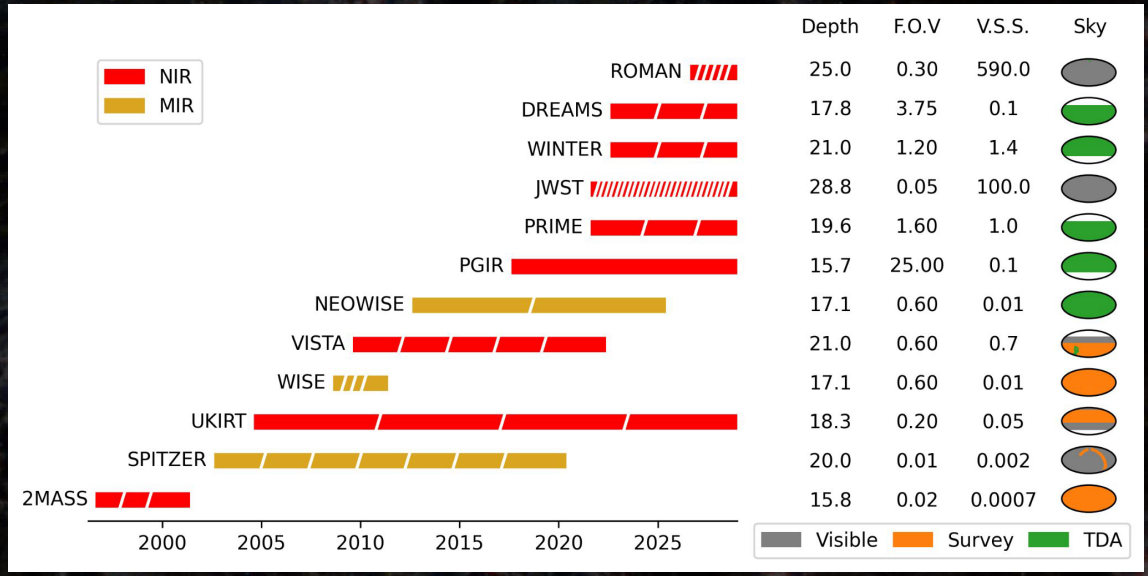
Bellm (Chair), Rest, Fox, De, Moller, Trilling

Mailing List, Github, Slack, 2026 Workshop, Meeting Breakouts

Science Enabled by RAPID

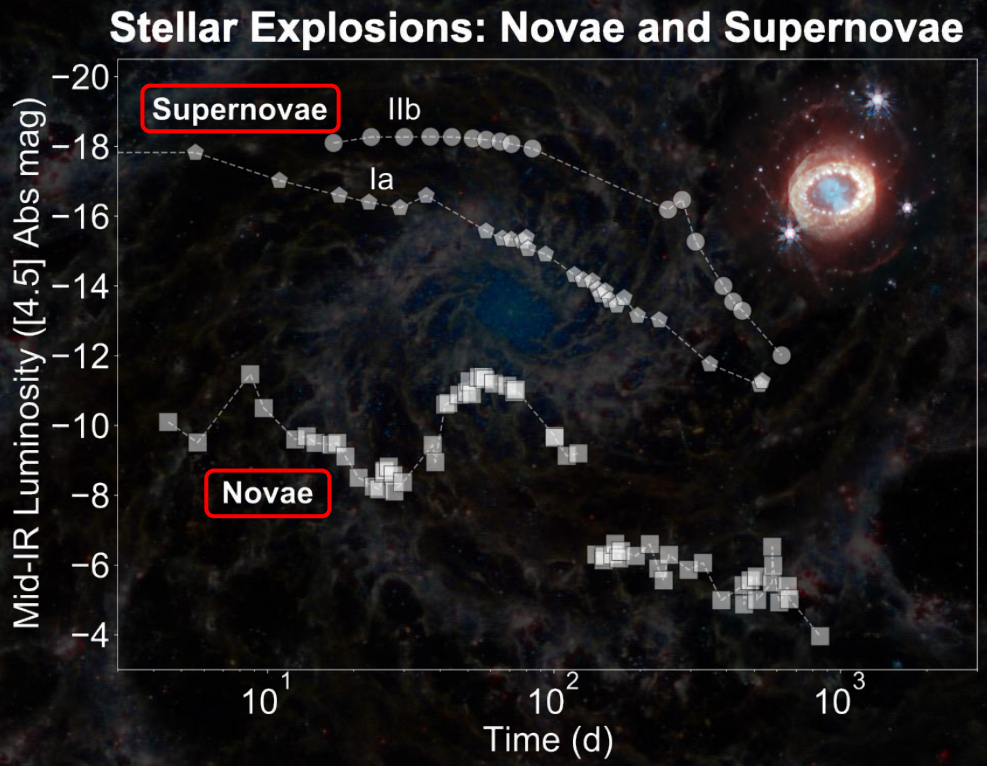
Infrared Time-domain Potential for Roman:

- **High opacity from synthesis of heavy elements**
- **Self-enshrouding by dust**
- **Milky Way extinction**
- **Host obscuration**
- **High redshift events**



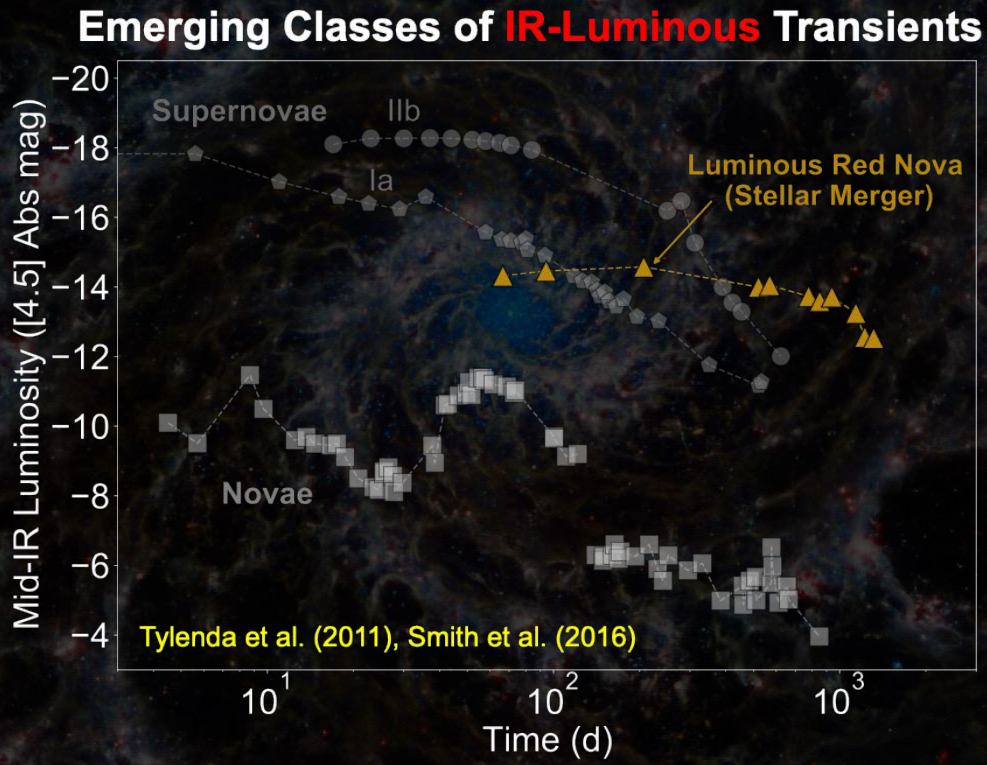
V.S.S. = volumetric survey speed (normalized to PRIME*)
(*PRIME = PRime-focus IR Microlensing Experiment)

Science Enabled by RAPID



Science Enabled by RAPID

Stellar Mergers



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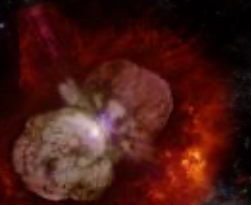
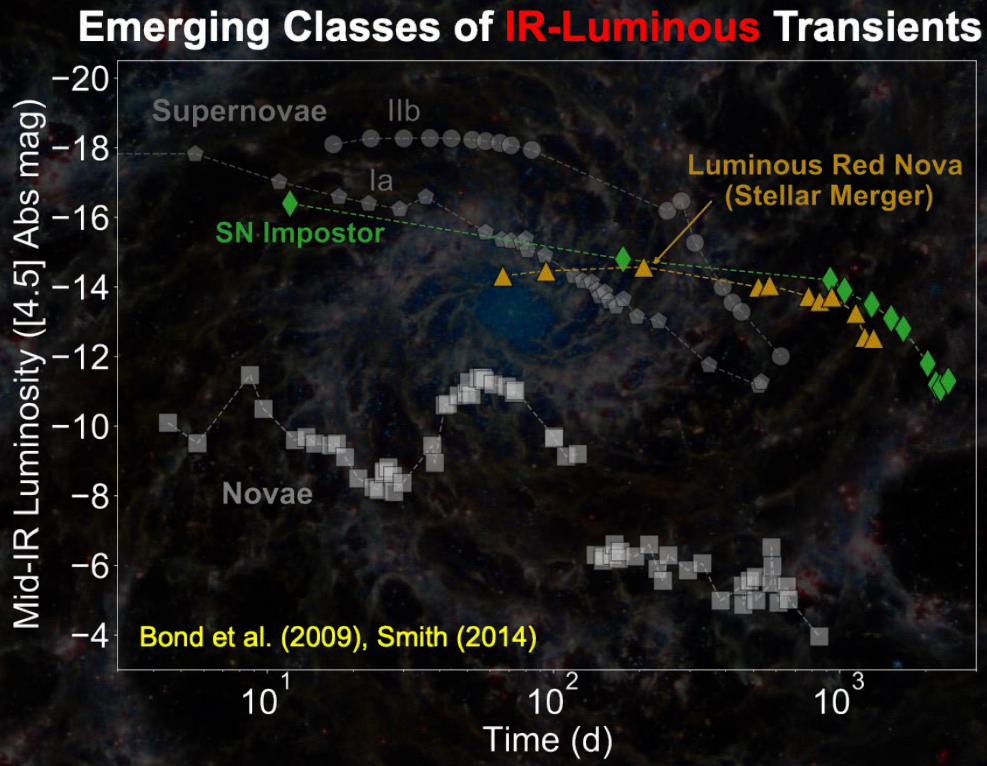


SN Impostors
(LBV eruption)



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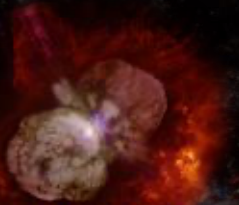

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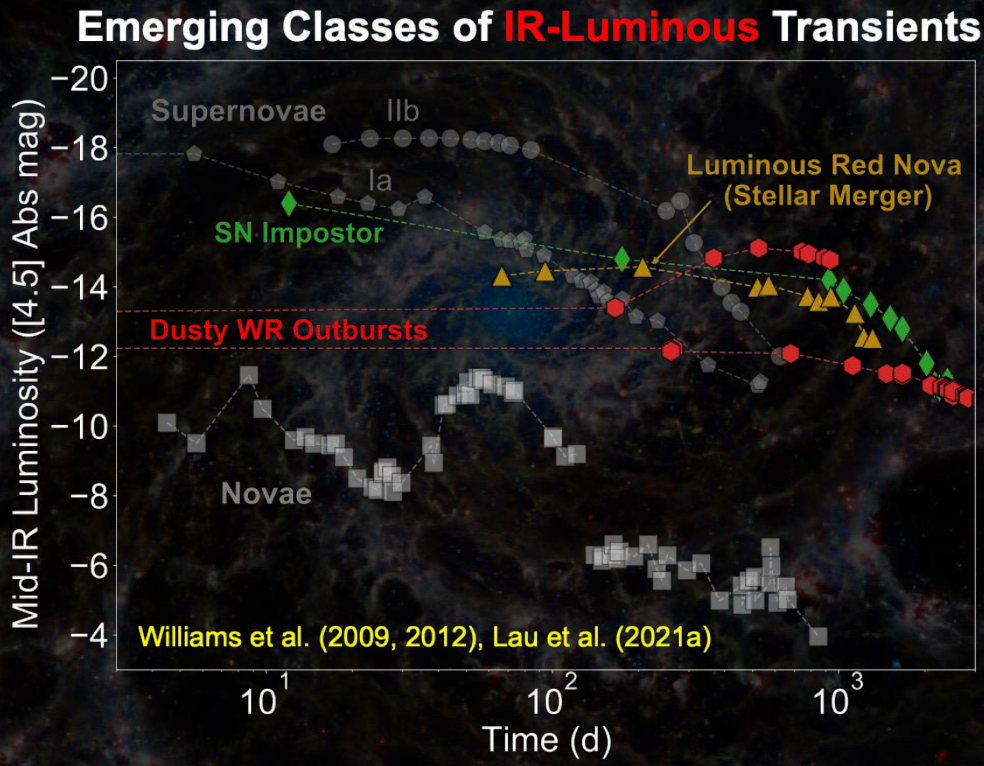

WR Outbursts

ipac Caltech

Science Enabled by RAPID

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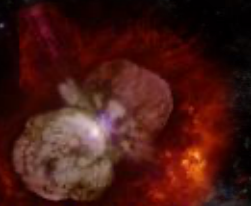

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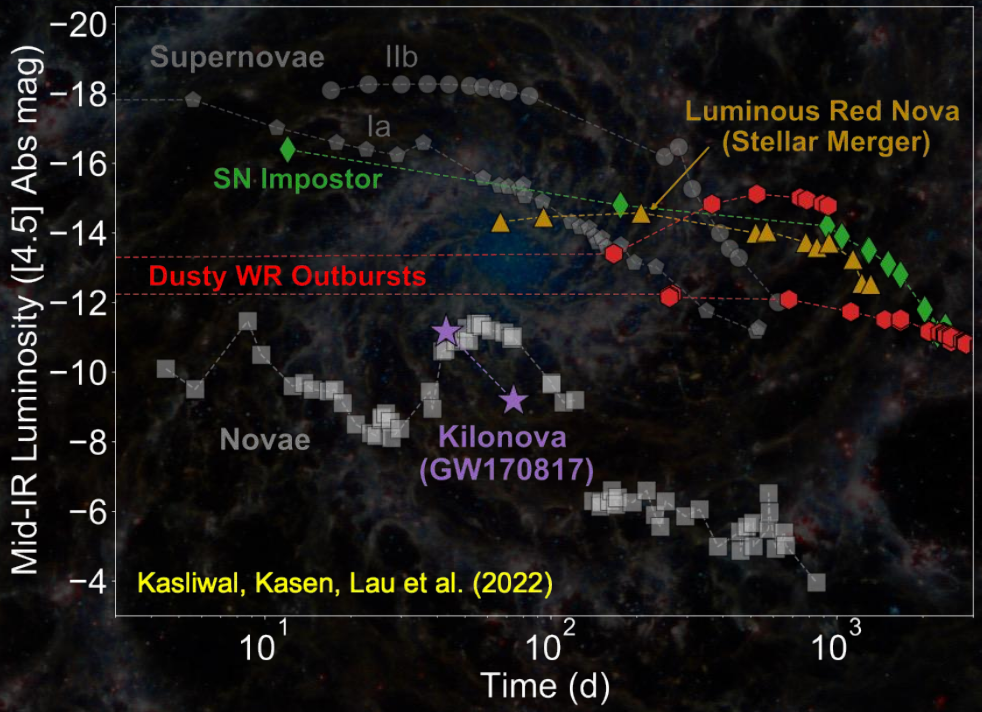

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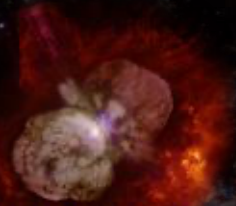

SN Impostors
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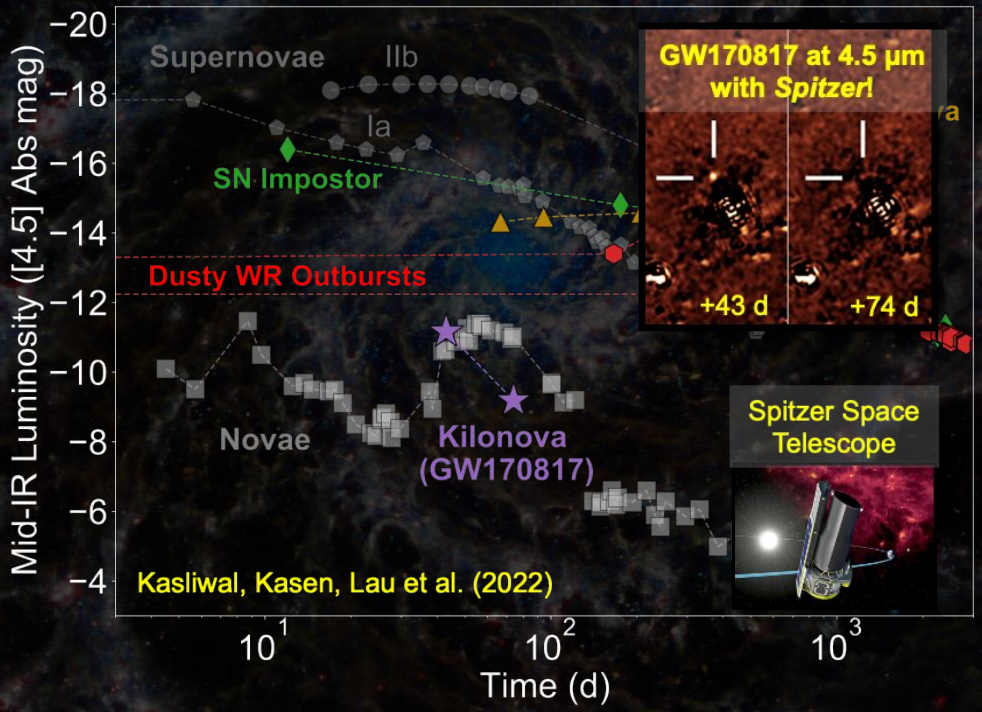
Emerging Classes of IR-Luminous Transients



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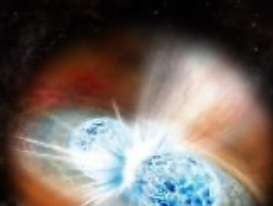

NS Mergers
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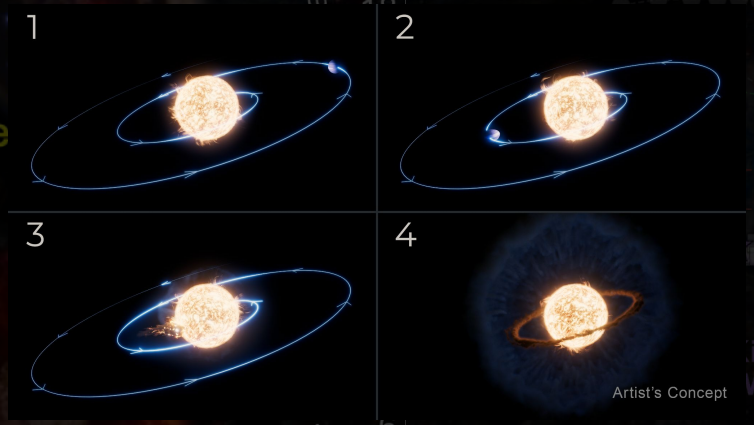
Science Enabled by RAPID

Galactic Transients



NASA, ESA, CSA, Ralf Crawford (STScI); Lau et al. (2025)

(LBV eruption)

Tidal Disruption Events

NASA/CXC/M.Weiss

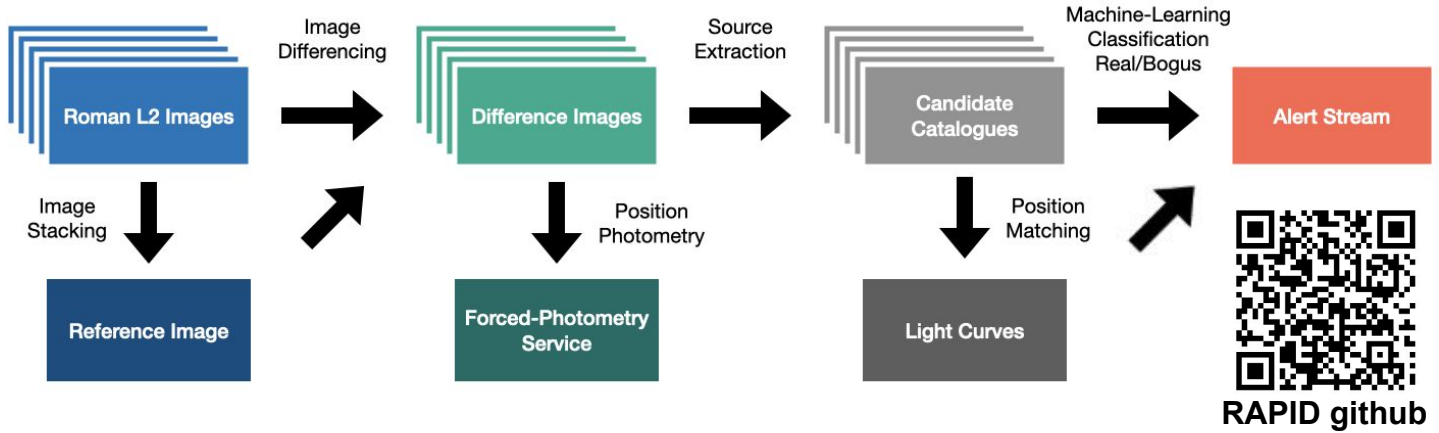
NS Mergers
(Kilonovae)

Low-latency is high priority for RAPID

- Receive calibrated Level-2 WFI data from the SOC
  <48 hour turnaround requirement
- Execute fully-automated reference building, image differencing and prompt public alert broadcasting **within < 1 hour**
- Forced-photometry on difference images and appended source-matched light curves available **within < 24 hours** (goal)
- Archived public alerts and difference images (TBC) via STScI MAST

★ “Beta” alerts available ASAP during ~6 month Early Science Operations

Building the RAPID pipeline



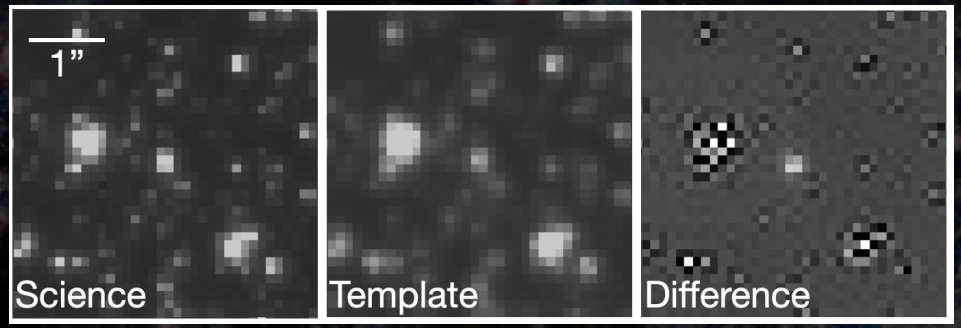
On-going development – feedback is welcome!

rapid@ipac.caltech.edu

Building the RAPID pipeline

- Leveraging significant experience at Caltech/IPAC from ZTF
  - Image-differencing pipeline, products and real-time alerts are well understood
  - Offering consistent products to established broker community (see also Arandu talk Thu by A. Mahabal)
- Roman introduces important operational differences:
  - No repeated observation on fixed grid (e.g., HLTDS will roll)
  - Variable depths and cadence in core surveys and GAS programs
- Need to generate reference images
  - Can improve with new observations, but balanced with traceability and stability

What to expect from RAPID



Example detection of injected variable source in RAPID difference imaging cutouts from SOC simulations of GBTDS

1. Rapid image differencing of every new Roman image

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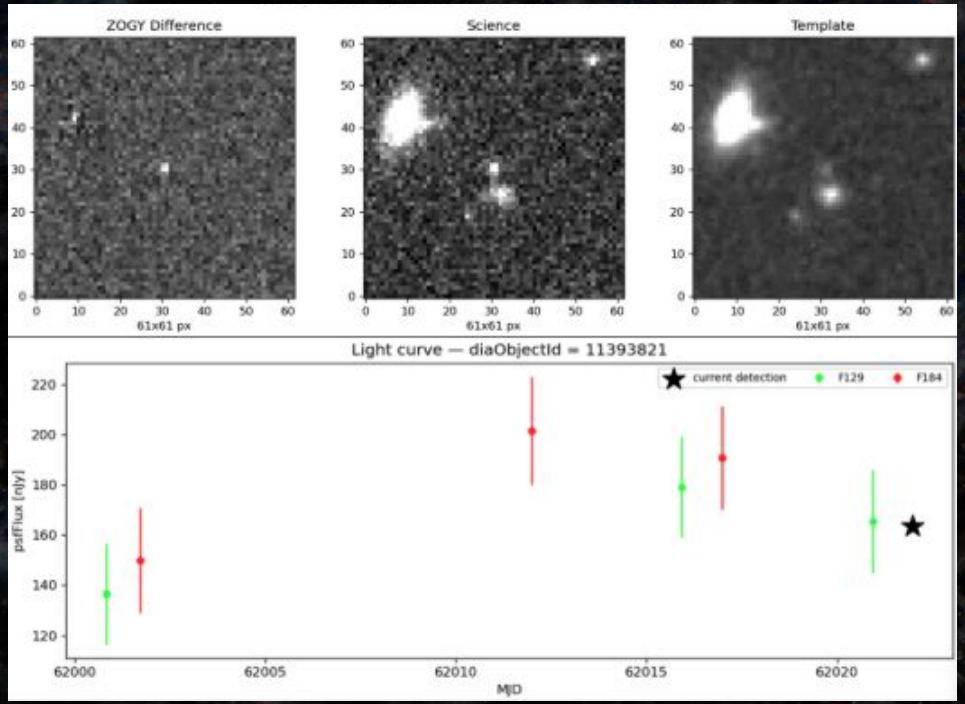

Prototype alert generated from RAPID differencing of OpenUniverse2024 simulated HLTDS images

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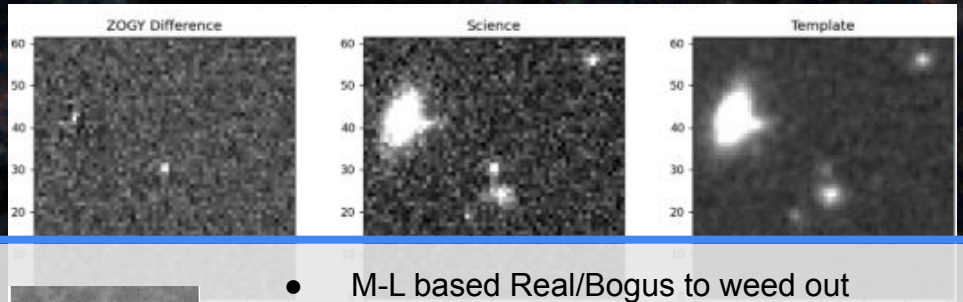

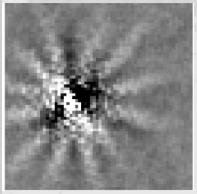

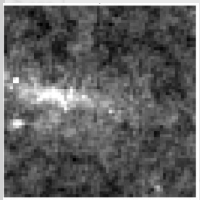

- M-L based Real/Bogus to weed out false positives
- Template-based star-galaxy separation
- Cross-matches to e.g., GAIA, NED, and Rubin/Euclid as available
- Roman-based host photo-z (see last talk by A. Nugent)
- Initial light curve classifications
- Detections/Alerts from deep co-adds with RISE (see next talk by L. Yan)

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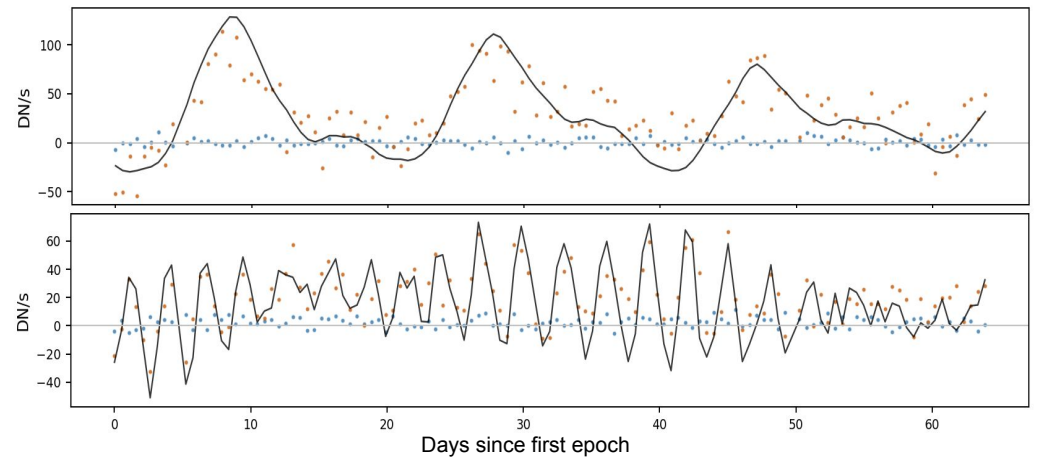

RAPID forced-PSF photometry on difference images from RimTimSim GBTDS simulations for **static** and **variable** stars

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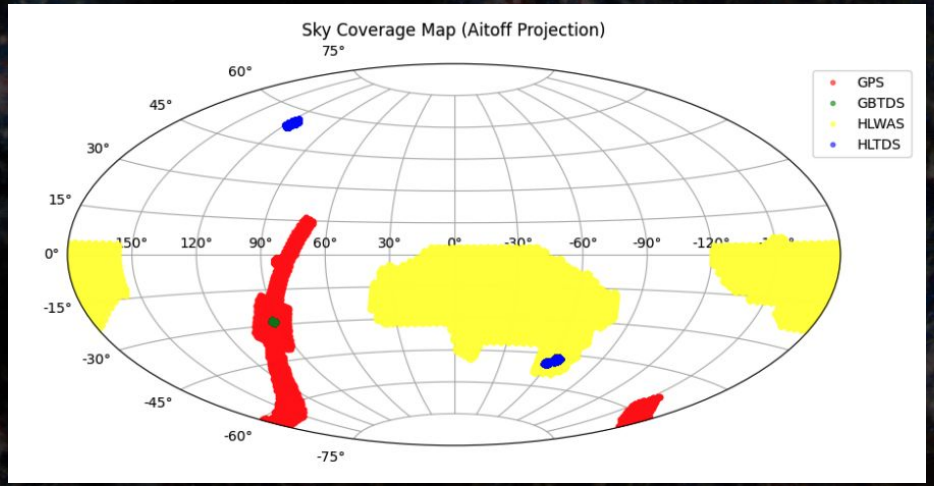
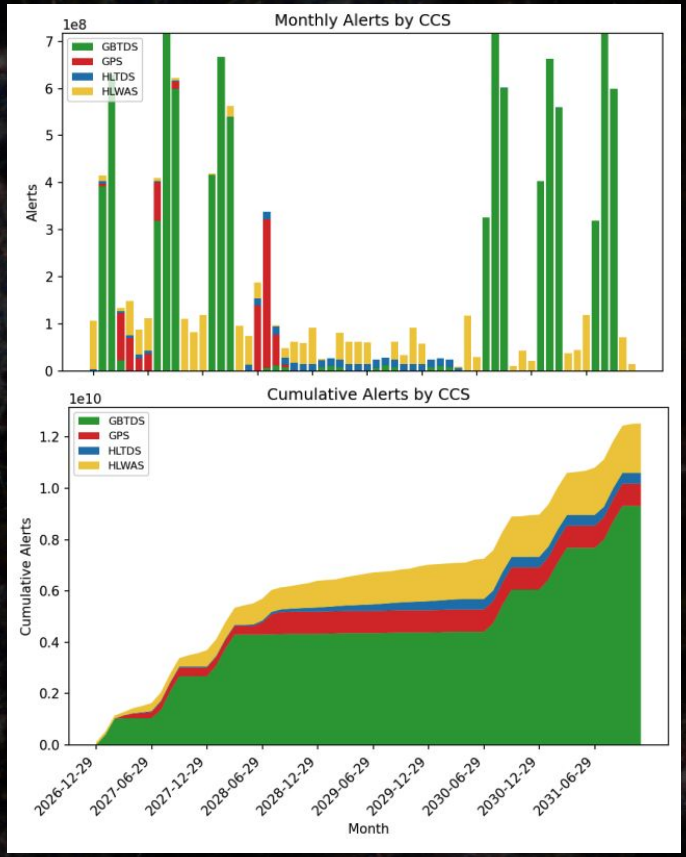


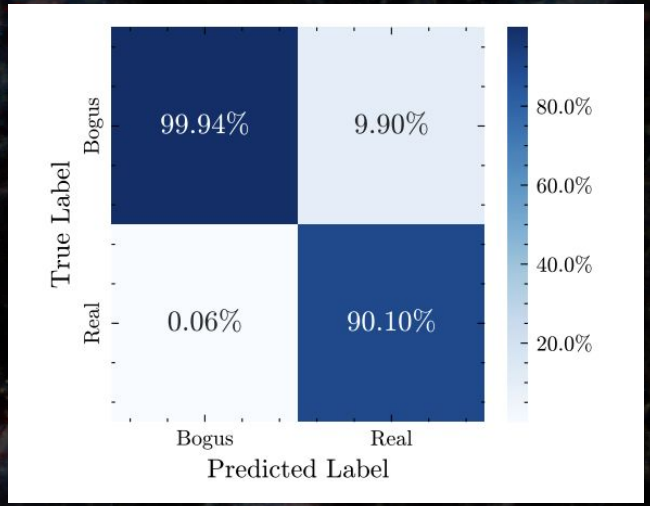


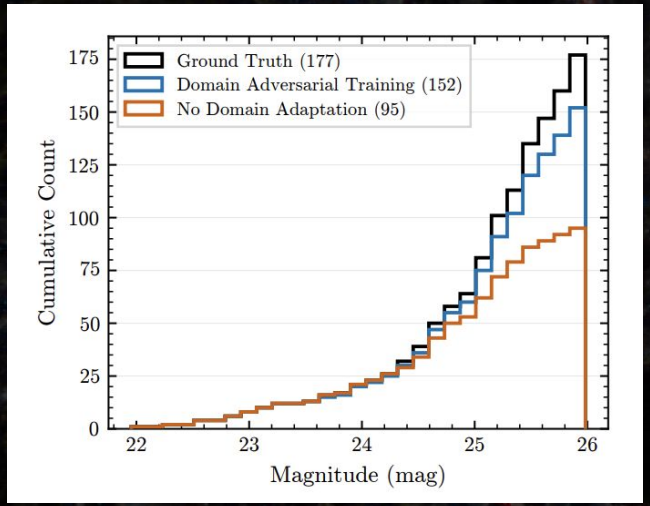
Naive Alert Rates:

12.5 billion alerts totaling 0.75 PB at 60 KB per AVRO packet

GBTDS alone accounts for 74% of all alerts

Real-Bogus classification for RAPID

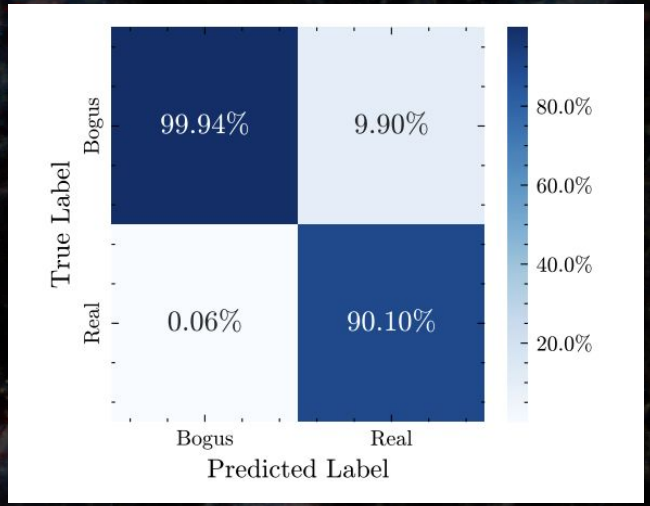


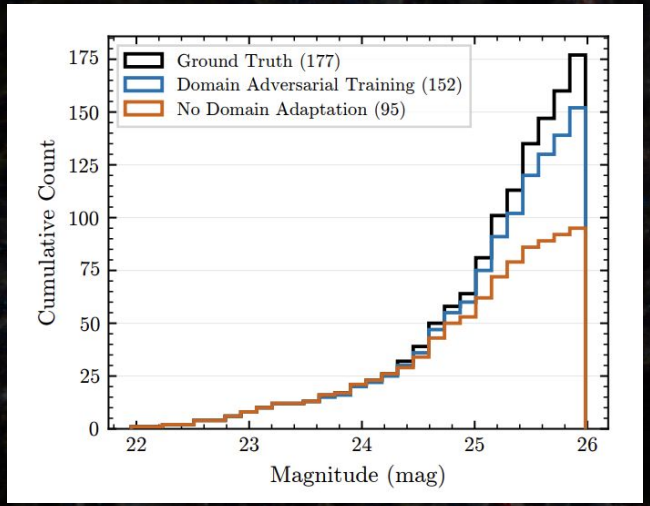


K. Gandhi, A. Mahabal, +RAPID team, 2026 PASP 138

Uses Domain Adversarial Training to improve performance at fainter mags

Real-Bogus classification for RAPID





For latest improvements utilizing transformers/attention mechanisms and Real/Real classification see poster by A. Kuloor!

K. Gandhi, A. Mahabal, +RAPID team, 2026 PASP 138

Uses Domain Adversarial Training to improve performance at fainter mags

Summary and keeping up with RAPID

Roman is launching soon and has tremendous potential for prompt multi-messenger and time-domain astronomy.

RAPID will fully realize this potential by delivering:

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RAPID Docs

Join the RAPID Slack!

Email Us!
rapid@ipac.caltech.edu

RAPID github