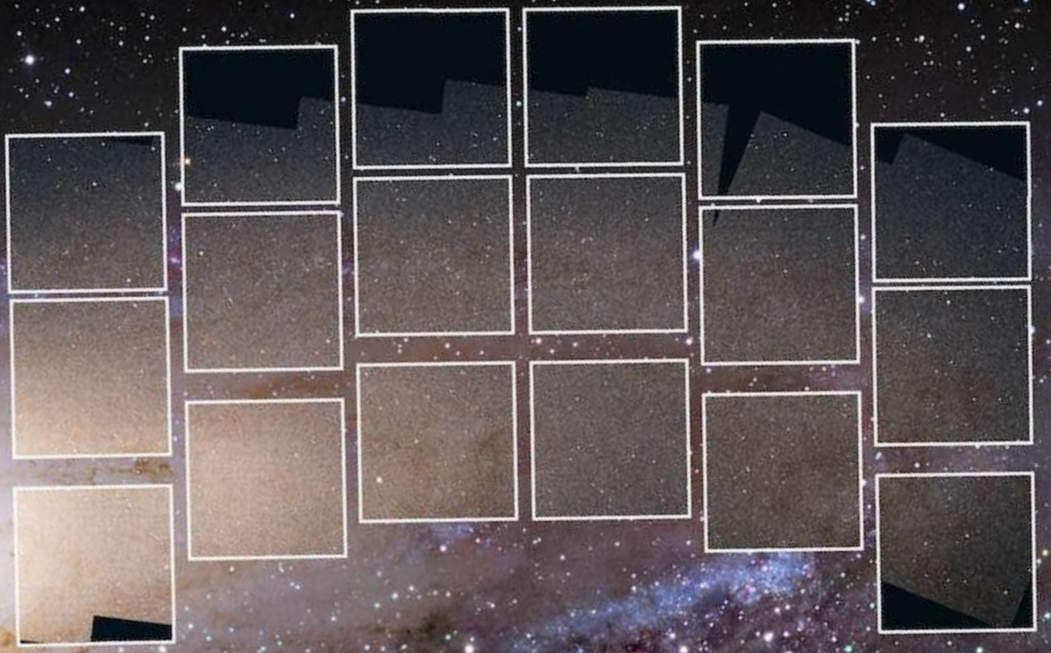
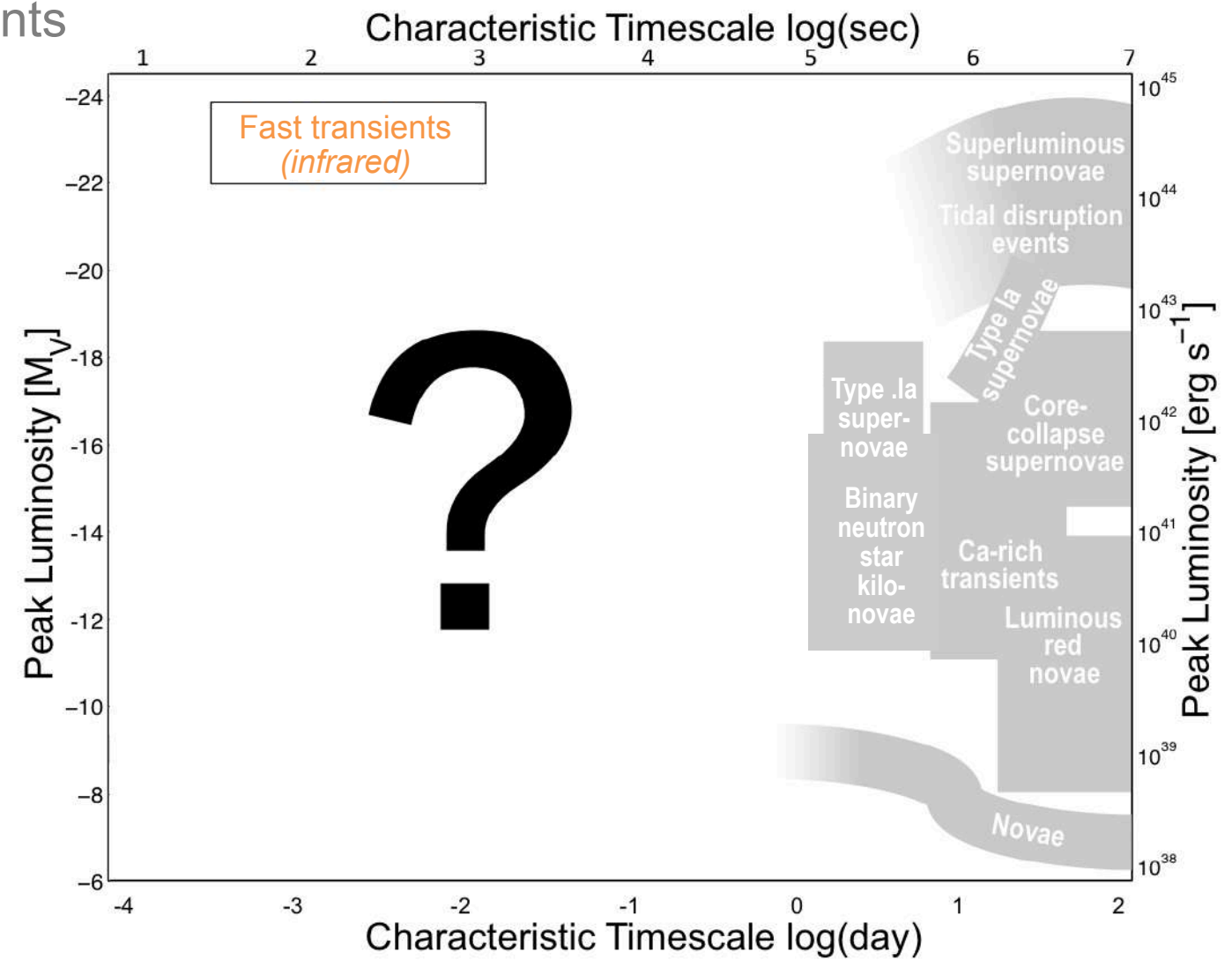
A Roman program for very fast transients



Jeff Cooke, Jielai Zhang, Simon Driver, Umaa Rebbapragada, Jason Rhodes, Eric Huff,

fast transients



Fast *(millisecond-to-day duration)* **IR transients is an essentially unexplored field**

If history has taught us anything, its that nature has surprises when we develop a new instrument capability

- Fast transients are relatively rare → Need to probe large volumes, need wide field instruments
- Fast exposures equate to shallow depths → Need sensitive telescopes/wide-field instruments
- Atmospheric transmission hinders some of this work from the ground, deep imaging needed to detect extragalactic fast transients and very early detections of slower-evolving transients
- Space-based imaging and depth of Roman enables accurate localisation in host galaxies, locations in tidal tails, and/or outside galaxies
- Observations of IR contribution to many known fast transient classes fragmented or non-existent
- Early detection or pre-burst detections of transients lacking in the IR
- True fast transient rates and overall transient rates require IR

science *(non-exhaustive list)*

Fast transients, early detection of slower transients, rates

- **New** unexplored regime – New, unknown classes
- **Theorized** events – Ultrafast novae, FRB counterparts, blitzars, NS-BH kilonovae, accretion-induced collapse, etc.
- **Known, high-impact** transients – Kilonovae
  Search for non-GW-detected kilonovae and beyond LIGO/Virgo horizons (rates, populations)
- **Dust-obscured** known classes – Novae, SNe, FBOTs, etc. *(for true rates, behaviors, etc.)*
- **Early detection and fast time-scale monitoring** of slower-evolving events
  - Tidal Disruption Events, AGN activity
  - All supernova types (explosion physics, CSM, environment, etc)
  - Stellar collisions/mergers, SPRITES, Intermediate Luminosity Red Transients, etc.

Deep IR information for fast transients previously detected in other regimes

- Particle origins *(neutrino, cosmic rays)*
- Gamma-ray bursts *(on- and off-axis, 'dark' GRBs, long, short, third?)*
- Soft gamma-ray repeaters, magnetars
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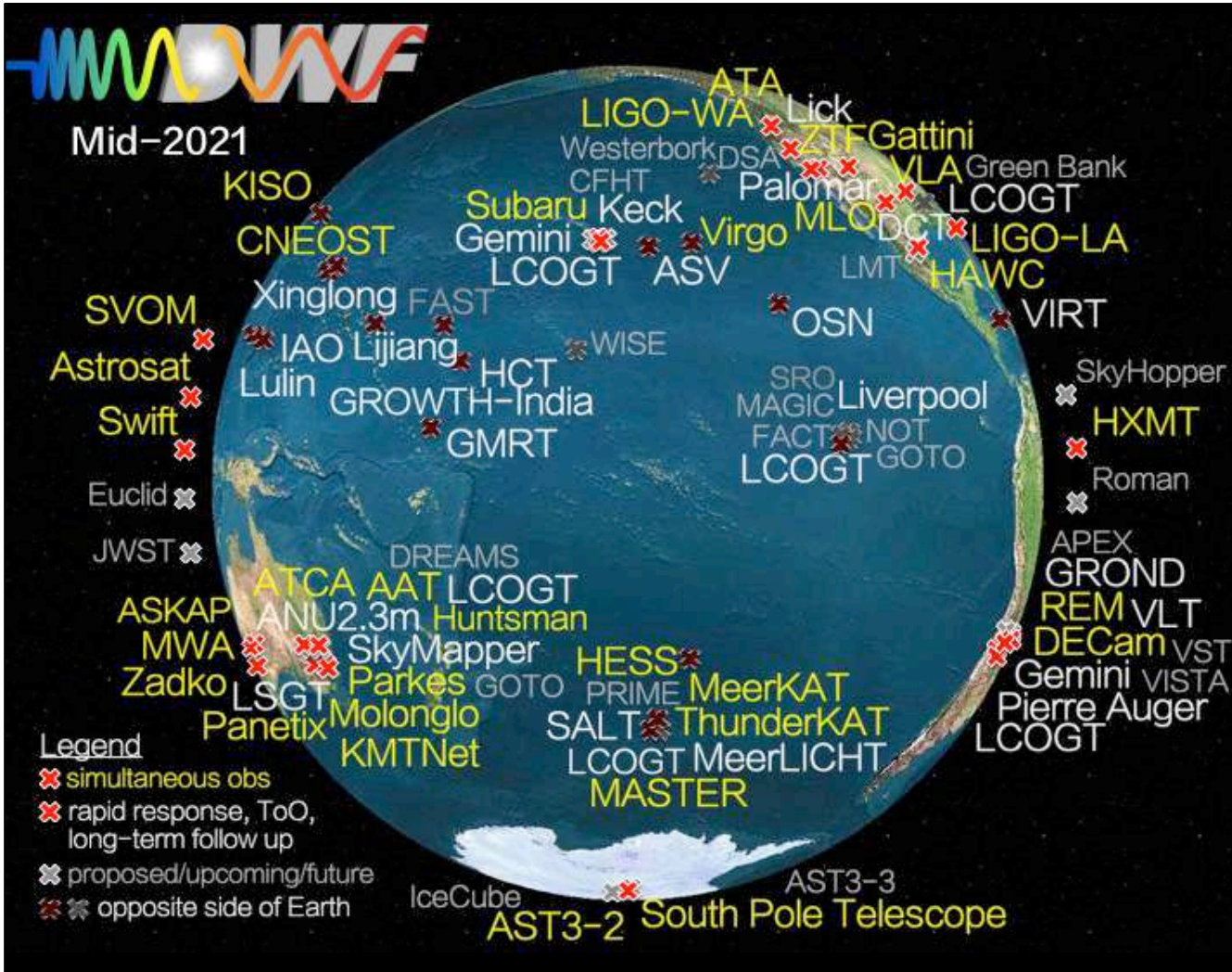
- SN Type Ia ejecta collisions with companion stars *(progenitor models)*
- Flare stars *(test theory whether IR energy loss equals gain in all others)*
- Supernova shock breakouts *(core-collapse, Type Ia)*
- Sub-mm/mm transients *(new regime)*
- Fast radio burst counterparts, radio fast transients, intra-day variables, etc.

New Norcia Observatory – Western Australia

DWF program

Existing infrastructure



Overall concept:

- Coordinated simultaneous wide-field all-wavelength and particle deep, fast-cadenced observations on the same field at the same time
- Real-time (minutes) data processing, analysis, transient identification
- Rapid-response (minutes) multi-wavelength triggers and conventional (hours later) ToOs
- Field monitoring and late-time observations

Strategy

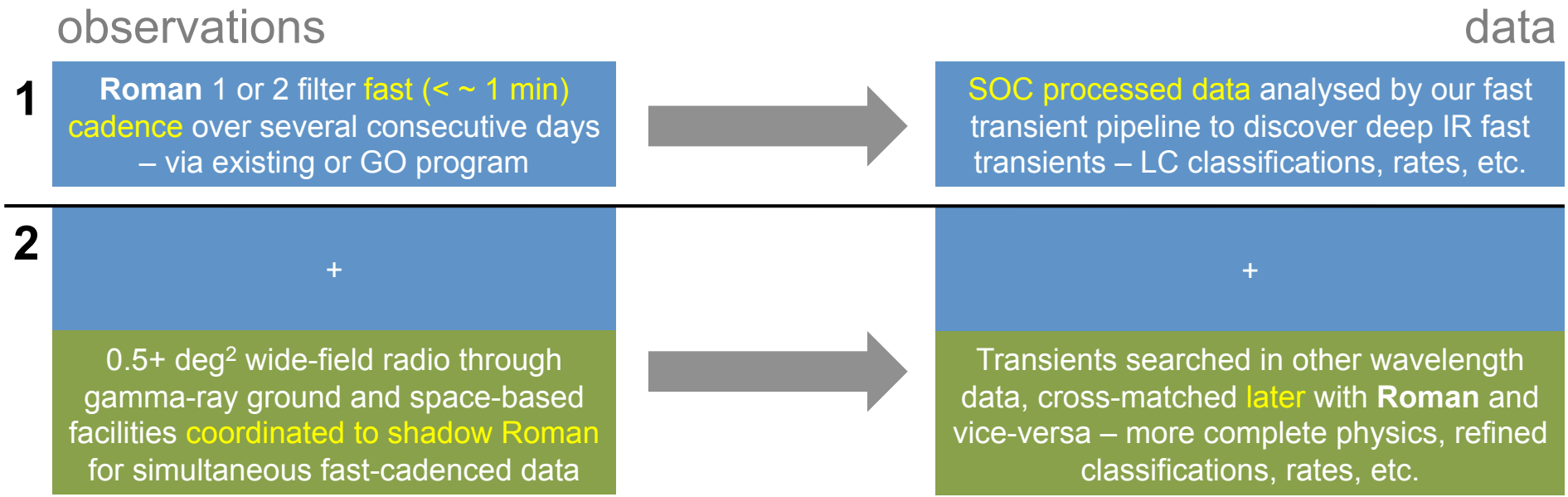
	observations	data
1	**Roman** 1 or 2 filter fast (< ~ 1 min) cadence over several consecutive days – via existing or GO program	SOC processed data analysed by our fast transient pipeline to discover deep IR fast transients – LC classifications, rates, etc.

observational mode and data flow

1

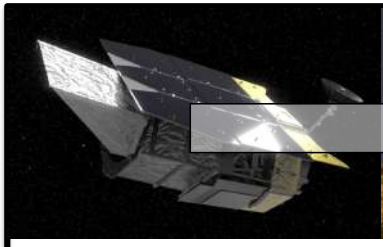
Strategy

Strategy


observations
data
1
Roman 1 or 2 filter fast (< ~ 1 min) cadence over several consecutive days – via existing or GO program
SOC processed data analysed by our fast transient pipeline to discover deep IR fast transients – LC classifications, rates, etc.
2
+
+
0.5+ deg² wide-field radio through gamma-ray ground and space-based facilities coordinated to shadow Roman for simultaneous fast-cadenced data
Transients searched in other wavelength data, cross-matched later with Roman and vice-versa – more complete physics, refined classifications, rates, etc.

observational mode and data flow

2



infrared
light curves

Roman

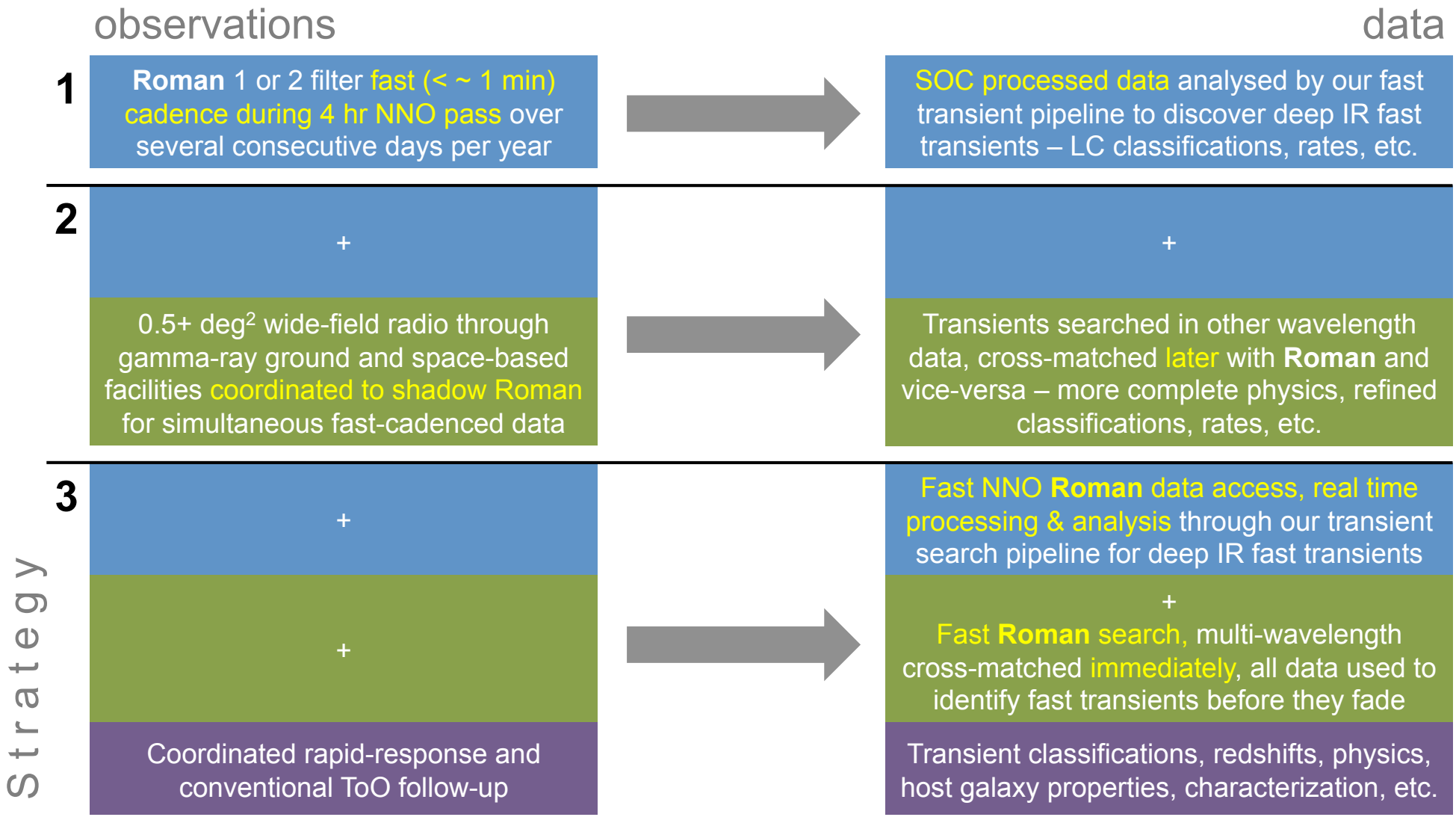
New Norcia

STScI

FT team

Real-time analysis
Pierre Auger, HAWC, IceCube, Swift, HESS, CTA, HXMT, NICER, Astrosat, DECam, HSC, **Keck Wide-Field Imager**, South Pole Telescope, LMT, Parkes, MeerKAT, ATA, ASKAP, MWA, etc.

Simultaneous high-energy particles, **gamma-ray**, **X-ray, UV, optical**, **mm/sub-mm, radio**


observations
data
1
Roman 1 or 2 filter fast (< ~ 1 min) cadence during 4 hr NNO pass over several consecutive days per year
SOC processed data analysed by our fast transient pipeline to discover deep IR fast transients – LC classifications, rates, etc.
2
+
+
0.5+ deg² wide-field radio through gamma-ray ground and space-based facilities coordinated to shadow Roman for simultaneous fast-cadenced data
Transients searched in other wavelength data, cross-matched later with Roman and vice-versa – more complete physics, refined classifications, rates, etc.
3
+
Fast NNO Roman data access, real time processing & analysis through our transient search pipeline for deep IR fast transients
+
+
Fast Roman search, multi-wavelength cross-matched immediately, all data used to identify fast transients before they fade
Coordinated rapid-response and conventional ToO follow-up
Transient classifications, redshifts, physics, host galaxy properties, characterization, etc.
Strategy

observational mode and data flow

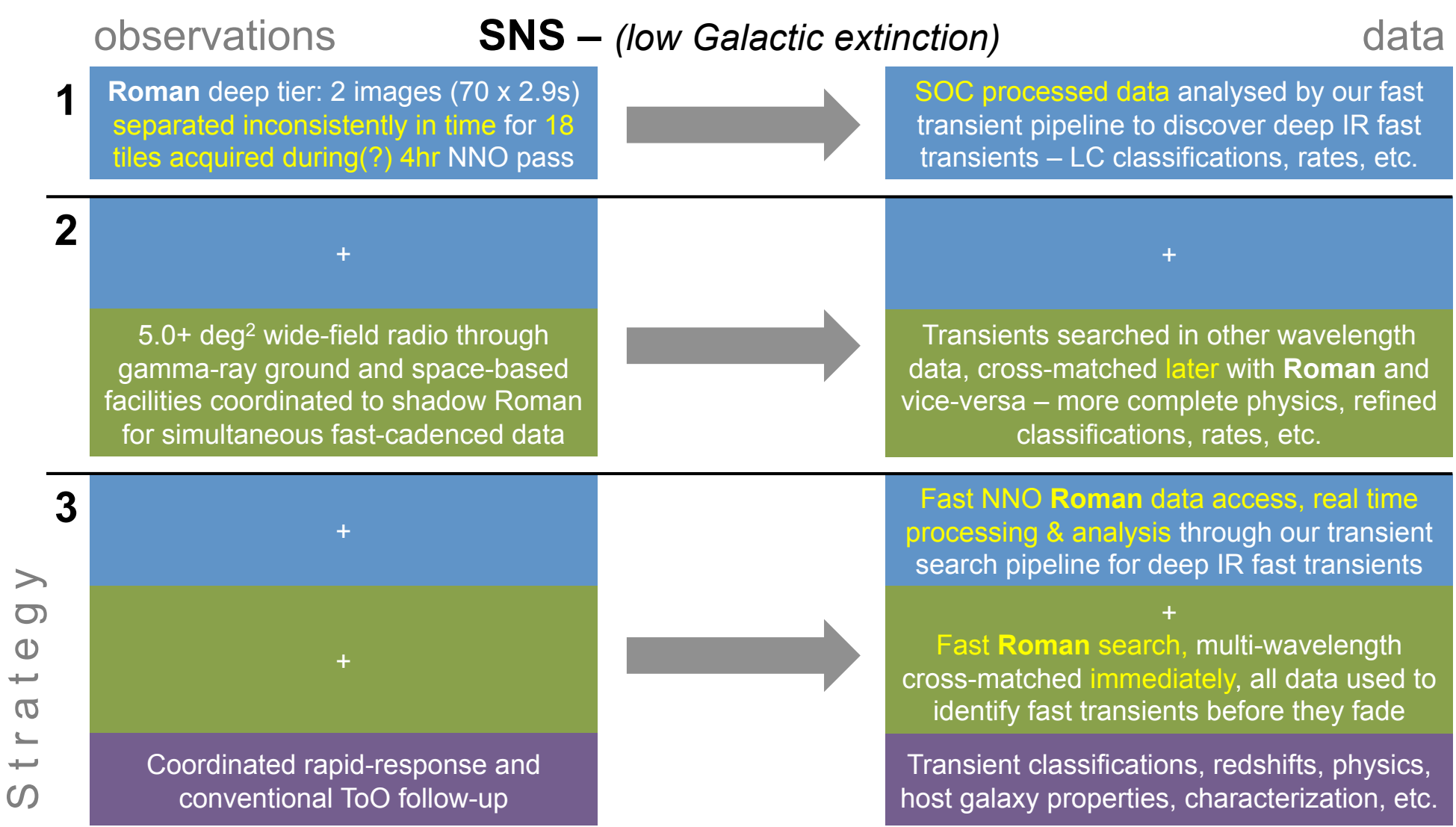
Roman **New Norcia** **Pawsey** **OzSTAR**

3

Simultaneous high-energy particles, gamma-ray, X-ray, UV, optical, mm/sub-mm, radio

Multi-wavelength rapid-response *(seconds to minutes)* triggers, conventional (hours later) ToOs

Strategy


observations
SNS – (low Galactic extinction)
data
1
Roman deep tier: 2 images (70 x 2.9s) separated inconsistently in time for 18 tiles acquired during(?) 4hr NNO pass
SOC processed data analysed by our fast transient pipeline to discover deep IR fast transients – LC classifications, rates, etc.
2
+
5.0+ deg2 wide-field radio through gamma-ray ground and space-based facilities coordinated to shadow Roman for simultaneous fast-cadenced data
+
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3
+
+
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Fast NNO Roman data access, real time processing & analysis through our transient search pipeline for deep IR fast transients
+
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Strategy

SNS – *(low Galactic extinction) poor cadence/sampling*

missed science in pink

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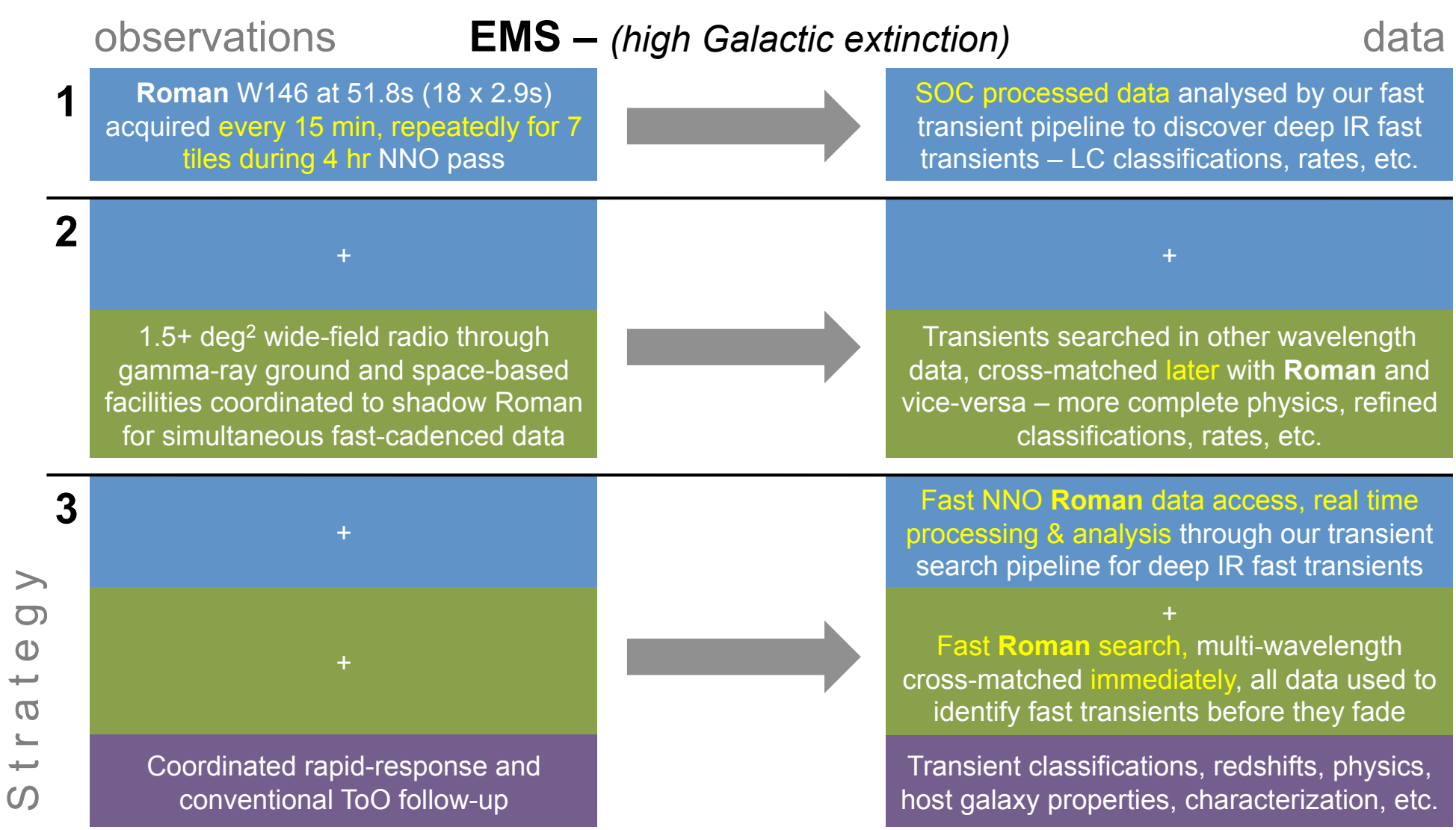
observations
EMS – (high Galactic extinction)
data
1
Roman W146 at 51.8s (18 x 2.9s) acquired every 15 min, repeatedly for 7 tiles during 4 hr NNO pass
SOC processed data analysed by our fast transient pipeline to discover deep IR fast transients – LC classifications, rates, etc.
2
+
1.5+ deg² wide-field radio through gamma-ray ground and space-based facilities coordinated to shadow Roman for simultaneous fast-cadenced data
+
Transients searched in other wavelength data, cross-matched later with Roman and vice-versa – more complete physics, refined classifications, rates, etc.
3
+
+
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+
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Strategy

EMS – *(high Galactic extinction) shallow to no optical or UV*

missed science in pink

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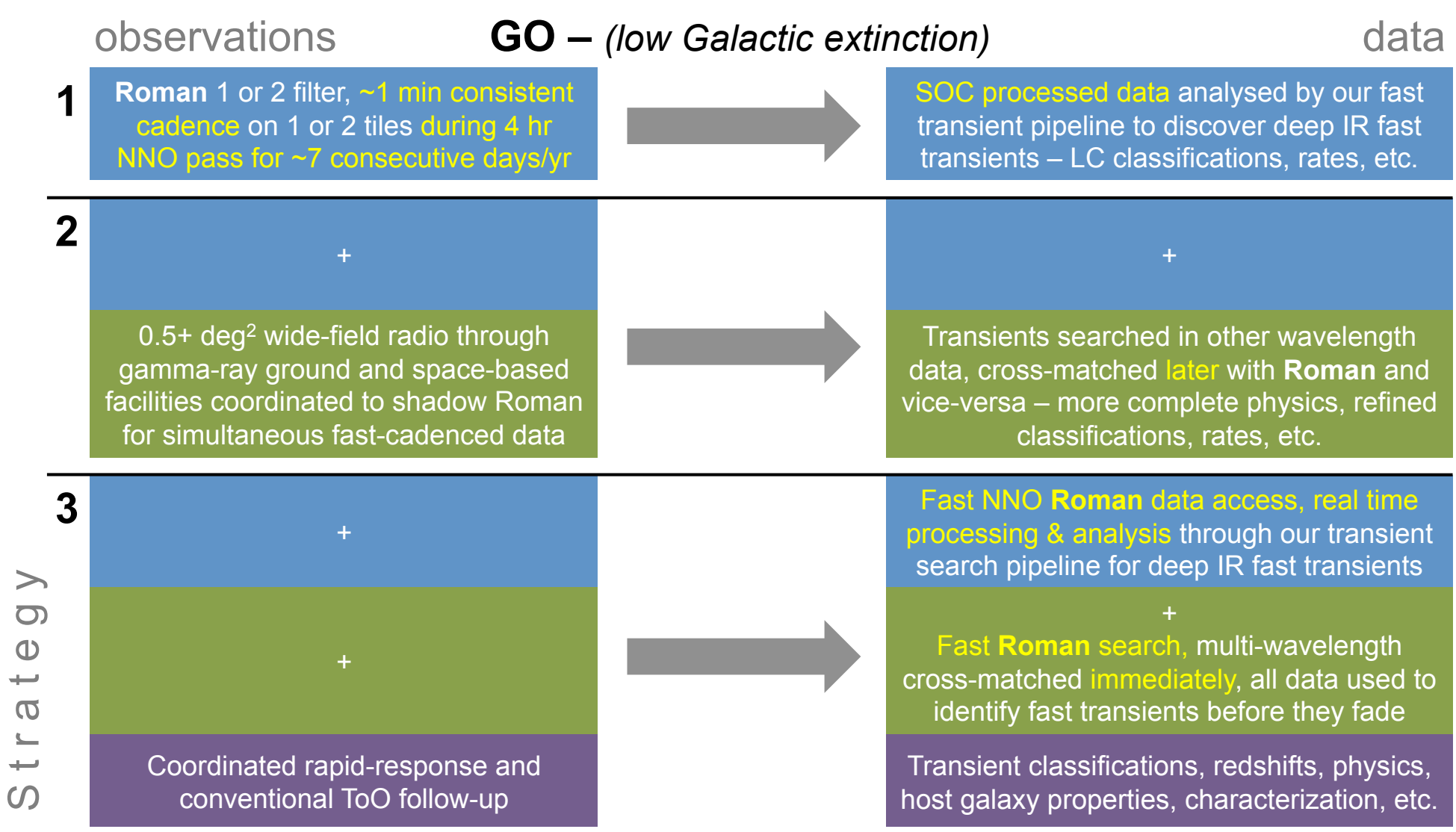
observations
GO – (low Galactic extinction)
data
1
Roman 1 or 2 filter, ~1 min consistent cadence on 1 or 2 tiles during 4 hr NNO pass for ~7 consecutive days/yr
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2
+
0.5+ deg² wide-field radio through gamma-ray ground and space-based facilities coordinated to shadow Roman for simultaneous fast-cadenced data
+
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+
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Strategy

GO – *(low Galactic extinction) best chance to get all science*

Roman fast transients

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summary

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- True fast transient rates and overall transient rates require IR

Fast transient program with Roman

Capitalizes on fast access to New Norcia Observatory data, builds on existing DWF program

Observational approach #1

Detects fast IR transients, cannot confirm or classify many, no redshift, spectral, or physics info

Observational approach #2

Detects fast IR transients, confirms and classifies some, physics insight, no redshift or spectral info

Observational approach #3

Detects fast IR transients, confirms and classifies many, provides redshift, spectral, and physics info