

ATLAS

Doing More with More

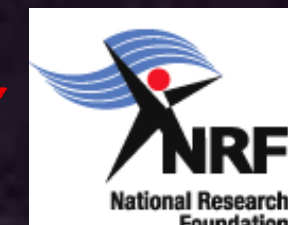
Asteroid Terrestrial-impact Last Alert System

*Comet C/2024 G3 (ATLAS)
El Sauce Observatory, Chile
Credit: Obstech SA*

2025 Planetary Defense Conference
Larry Denneau, John Tonry and the ATLAS Team
May 7, 2025



**QUEEN'S
UNIVERSITY
BELFAST**



SAAO
South African
Astronomical Observatory



ATLAS System

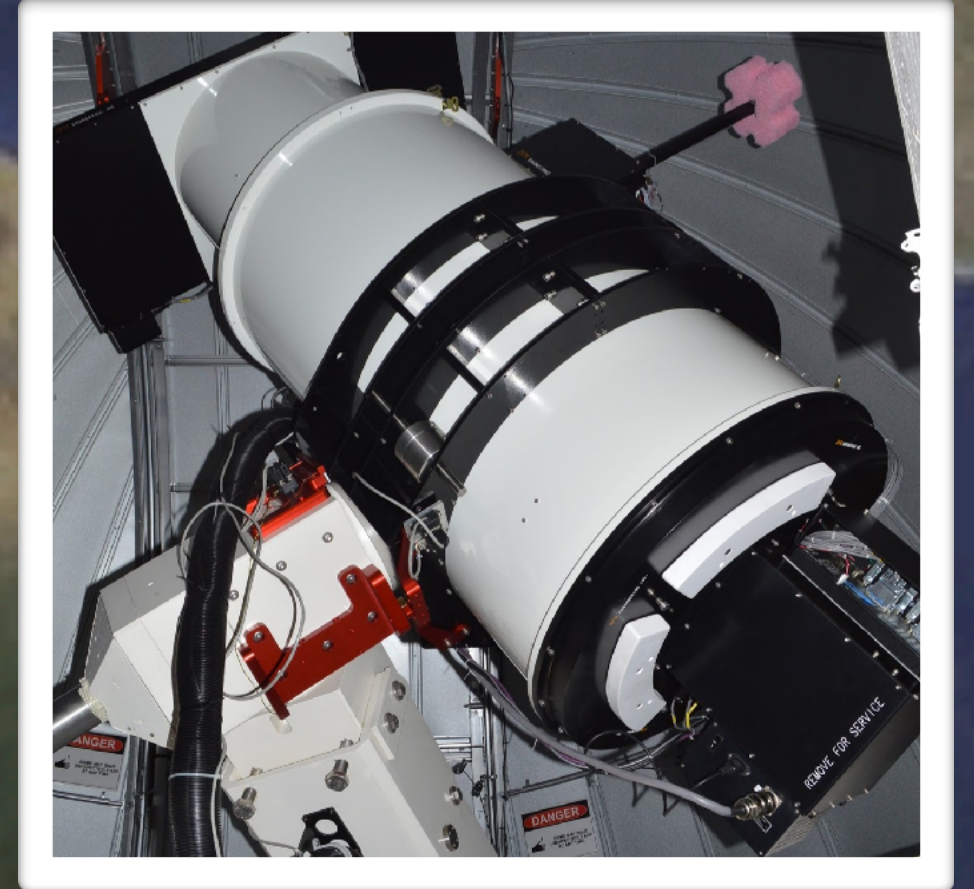
Haleakalā
(T05)

2
1

Mauna Loa
(T08)

- PDCO-funded NEO survey (through 2026)
- Tonry+ 2018 PASP (arXiv:1802.00879)
- All-sky $V < 19.7$
- Quad observing (4X each footprint), single-night discovery
- Cadence ~1.3 nights (4 telescopes, good weather)
- Robotic operation 24/7/365, automatic data processing
- 3.5 FTEs

5
Teide
(R17)



Sutherland
(M22) 3

El Sauce
(W68) 4

2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

ATLAS
1 & 2
funded

ATLAS HKO
constructed

ATLAS MLO
constructed

Start of
Survey

PME funded
(ATLAS 3 & 4)

COVID

ATLAS 3 & 4
commissioned

2024 PT5

ATLAS 5

2018 LA

2019 MO

2020 VT4

DART | 2022 WJ1

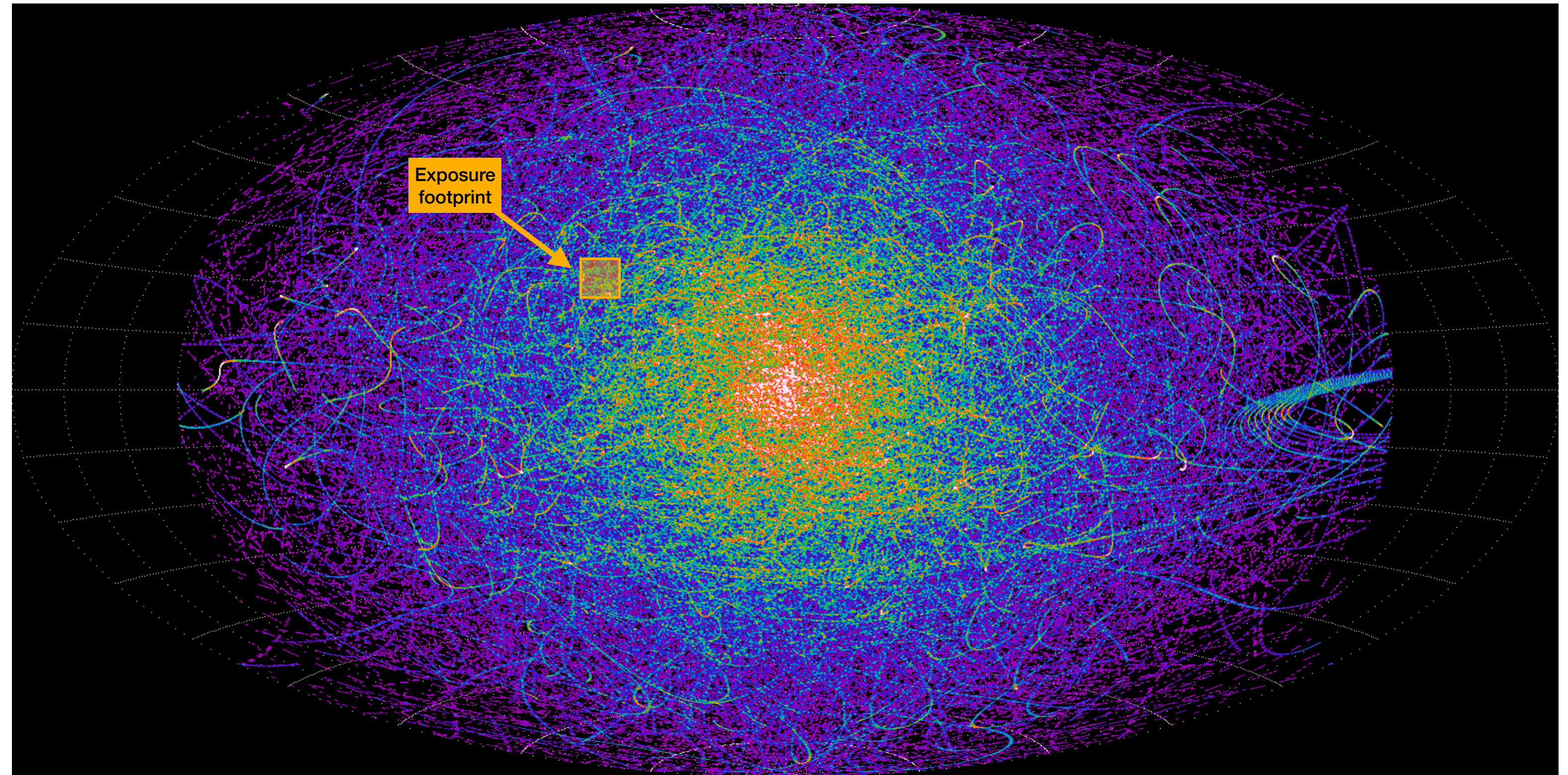
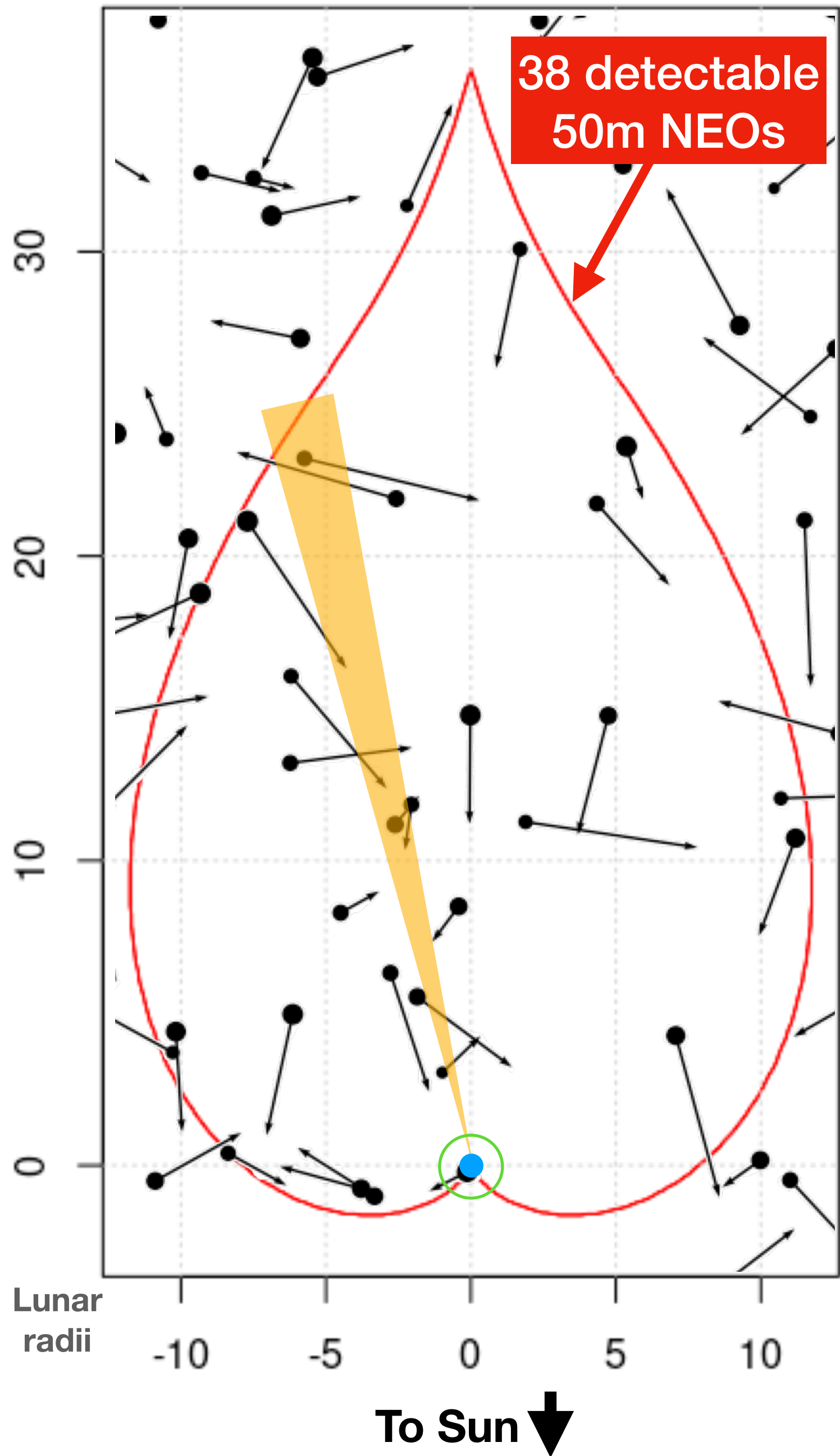
2024 UQ

2024 YR4

Idealized Detection Scenario

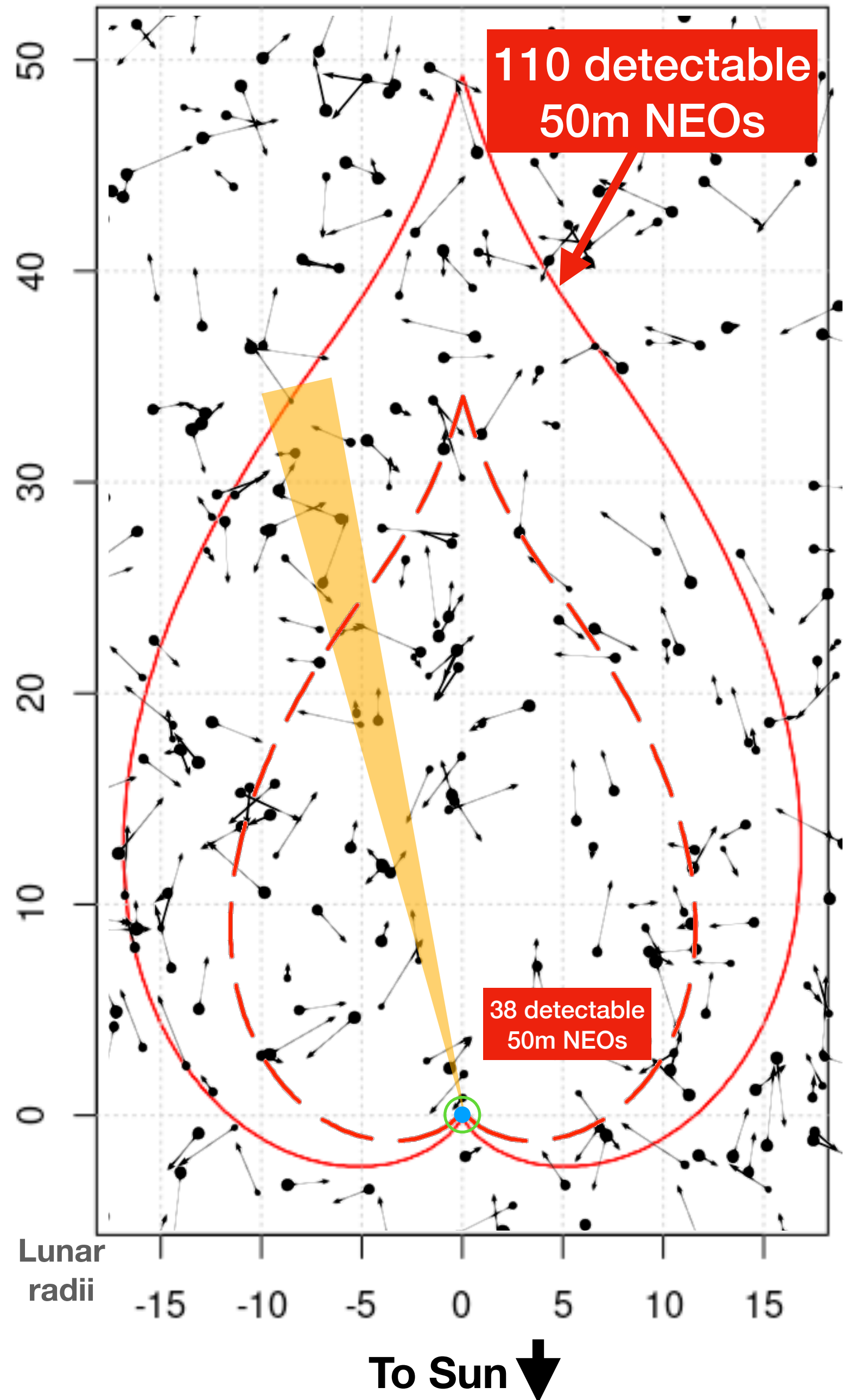
ATLAS “candle flame”
V=19.5, d=50m

Opposition



Opposition-centric sky-plane distribution of NEOs (from Granvik 2018)

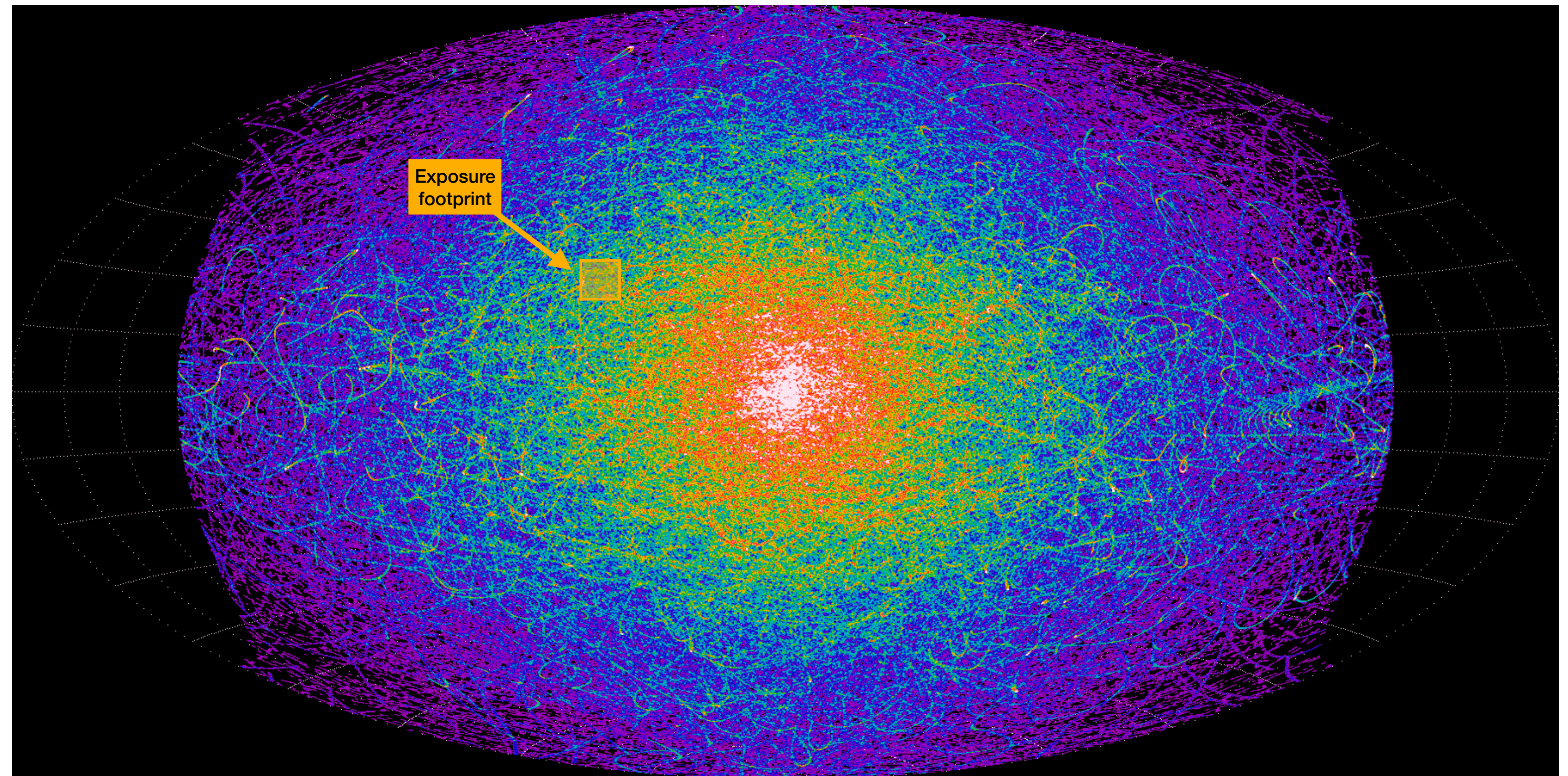
Opposition



Idealized Detection Scenario

ATLAS “candle flame”
V=20.2, d=50m

- Candle flame is not fixed in size — shrinks/grows on lunation cycle because of bright Moon
- Moon avoidance carves out “holes” in the candle flame volume
- Edges are “ragged” due to weather and observing variability



Opposition-centric sky-plane distribution of NEOs (from Granvik 2018)

Maximizing the Discovery Volume

Design Considerations

- 4 (now 5) ATLAS telescopes
- 1 day cadence
- Need 4 exposures to discover most NEOs
- Want 3+ days warning for 50m object (cadence)

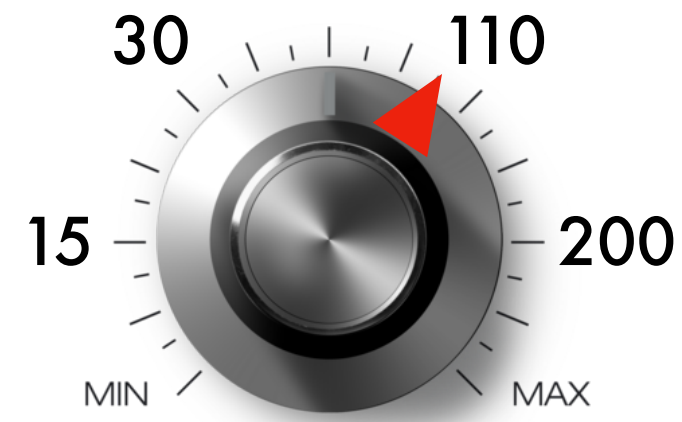
Strawman “Solution”

- 110 sec, $V=20.2$
- 3-night cadence
- No other changes

Still subject to weather and observation losses, much less sensitive to smaller objects

Can we improve on this?

Maximizing the Discovery Volume



110 sec, $V=20.2$

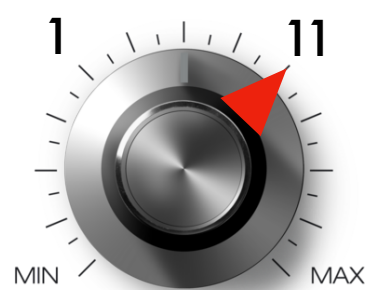
EXPOSURE TIME



TRACKLET SIZE



CROSS-NIGHT LINKING



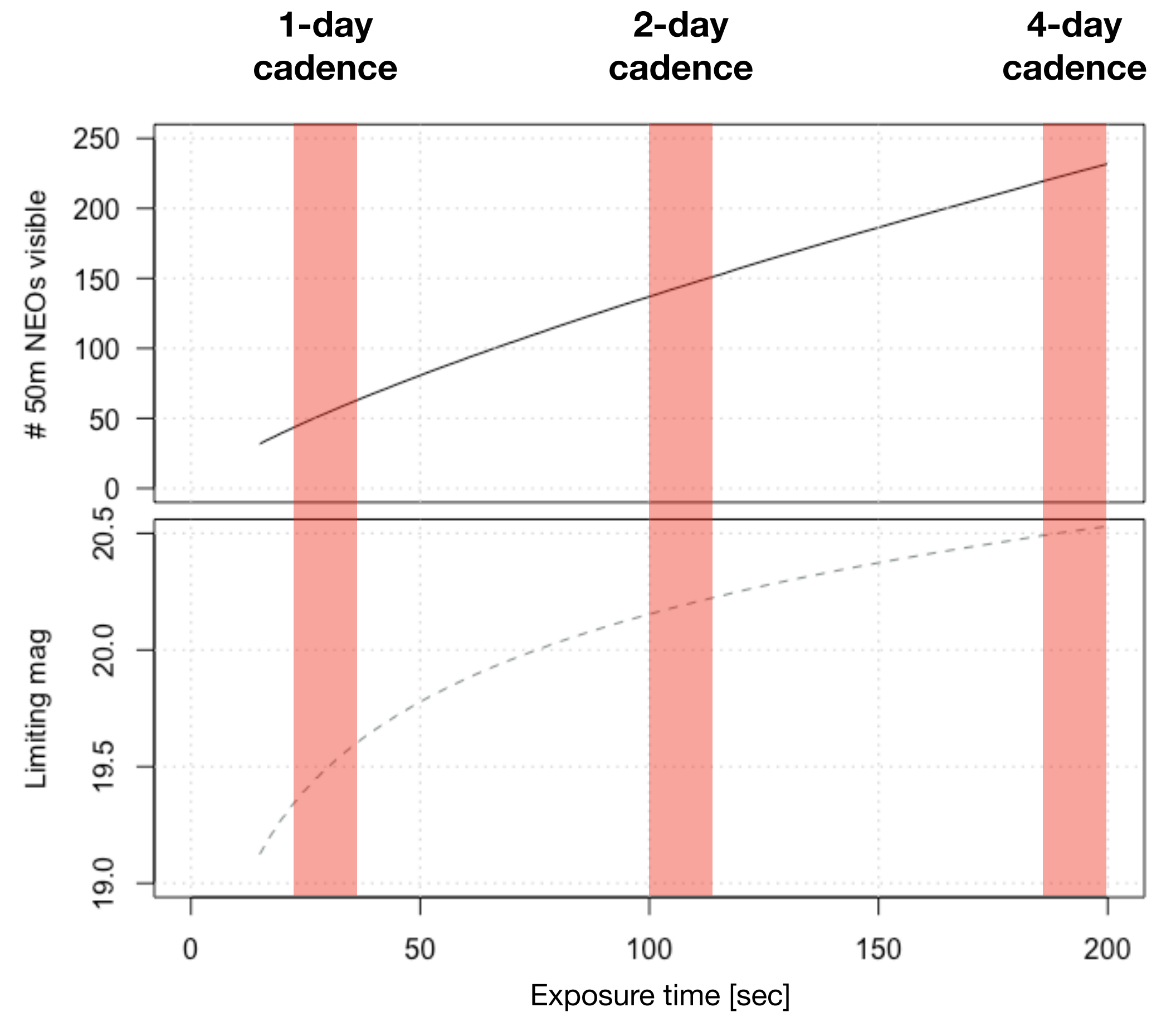
SKY COVERAGE

3 exposures per footprint (only 2.25X slower), but many more false tracklets at SNR=5

Link multiple *pairs or triples* of low-SNR detections between nearby nights to obtain four detections

Backfill “holes” in schedule lost due to weather or other failures; awareness of refresh rates and diffusion of NEOs on sky

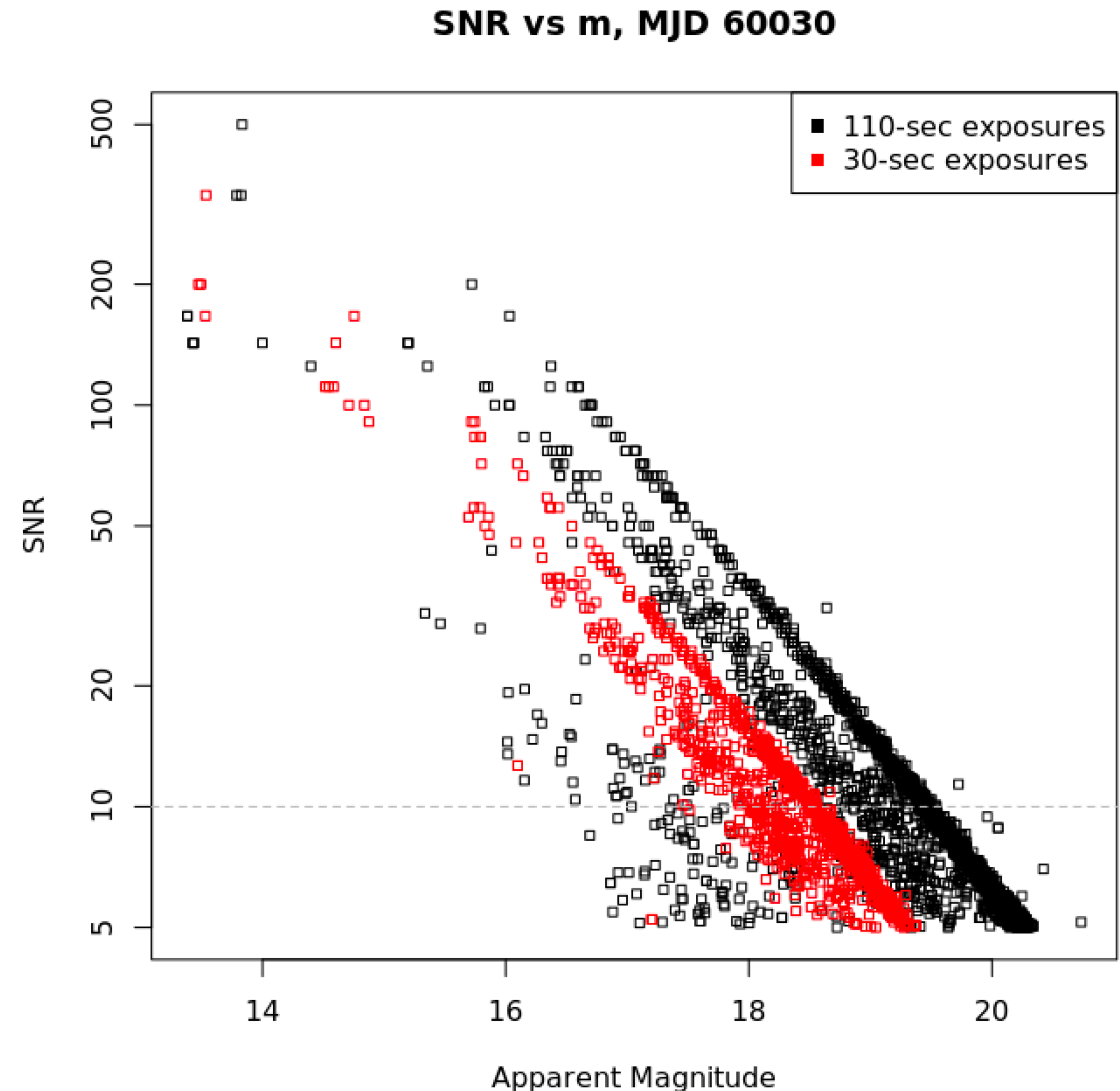
maximize detection probability!



Implementation

“PUMALINK” Linker and orbit fitter

- SNR=10 tracklets from single-night triples (inner candle flame)
- SNR=5 linked pairs across nights
- Trailed objects are “easy”
- Described in Tonry 2023 paper



Implementation

“ADIOS” Observation Scheduler

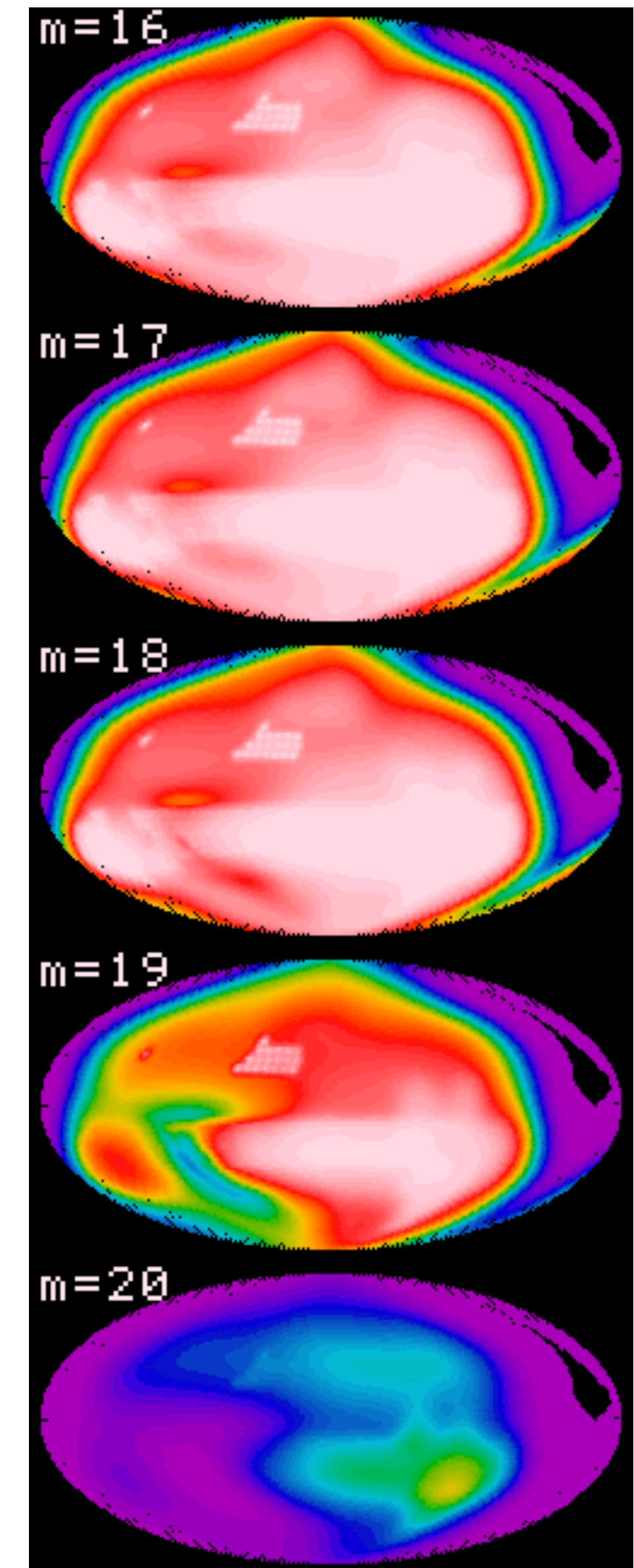
Inputs

- NEO model (Granvik 2018)
- Recent sky coverage/completion across entire system; multi-night linking awareness
- Instantaneous local weather

Outputs

- **Where to observe RIGHT NOW to produce the most NEO discoveries (à la NEOFIXER “benefit”)**
- Real-time observation commands across all telescopes

Where should ATLAS observe to detect NEOs?



Future

- **PUMALINK 90% complete**
- **ADIOS scheduler 75% complete**
- **5 ATLAS sites! 2-day cadence achievable**
- **CSS 703 to be incorporated**
- **Adaptable as an advisory service to global NEO surveys — for a survey with a limiting magnitude m , where (statistically) is the best place to survey?**