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DETECTION OF SMALL IMPACTING ASTEROIDS WITH ATLAS

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Asteroid Terrestrial-impact Last-alert System

- Concept described in Tonry et al. 2011, funded by NEOO in 2013
- 0.5 m f/2 Schmidt covering 30 deg² (7.5° FOV illuminating 5.4° × 5.4°)
- Optimized for maximum AΩ per unit cost and fast cadence. 2 years, $1M to replicate
- Currently two operating in Hawaii
- Open every clear night, 10⁸ obs/night, 0.5 TB/night
- Tonry et al. 2018 PASP for full details
Asteroid Terrestrial-impact Last-alert System

• 110 Mpixel STA1600 detector, 4” PSF, 2” pix scale
• Broadband “c” and “o” filters (moon-dependent)
• 10,000 deg² × 4 visits / night, \( m = 19.5 \)
• Gaia astrometry, Pan-STARRS photometry
• Simple scheduling — declination bands observed in “quads” (4 exposures separated by ~15 min)
• Observed impactor 2018 LA in routine ops
• Robotic, automated
  • must handle interruptions for self-followup, external requests
  • real-time weather/failure corrections

• Carefully designed for characterization
  • well-calibrated, 1% photometry, 0.1" routine
  • “righteous” 5σ limiting magnitude for every exposure
  • wide-field cloud correction
  • MBAs for moving object detection efficiency (with caveats)
What are we missing?

\[ P_{\text{obs}} = P_{\text{real}} \times \text{eff} \]

ATLAS: focus on near-impacting asteroids 
\((d < 0.05 \text{ AU})\) instead of general population census
• 452 days of ATLAS observing (2 sites)
• Granvik 730,000 asteroids H<25
• 42 billion Granvik clones 25<H<30
• Simulated at pixel level, including trails/streaks, re-subtraction of 500,000 exposures (20 CPU years)
• Fully reprocessed through MOPS pipeline
SIMULATION DESIGN

57904 – 58356 (452 days)
01 JUN 2017 – 26 AUG 2018

Nights visited
Deficit: unmodeled system losses (lightcurves, followup)
ENCOUNT VELOCITIES

Asteroids approaching within 0.05 AU of Earth

$H = 20-23$
$140 \text{ m}$

$H = 23-25$
$75 \text{ m}$

$H = 25-28$
$20 \text{ m}$

Large bias against large encounter velocities, especially for small objects!
TAKEAWAYS

• 0.05 AU imminent impactor view is useful (vs population)

• $N(H<27) = 10^7$ (Trilling et al. 2017 $N=10^6$, Valdes 2019 $N=10^8$)

• Tunguska-like impact rates of 1 per 766 yr (preliminary)

• Additional ATLAS telescopes in South Africa and Chile will address short visibility windows, fill entire night sky (coming late 2020)

• Followup efficiency still hard to model

Learn more at fallingstar.com