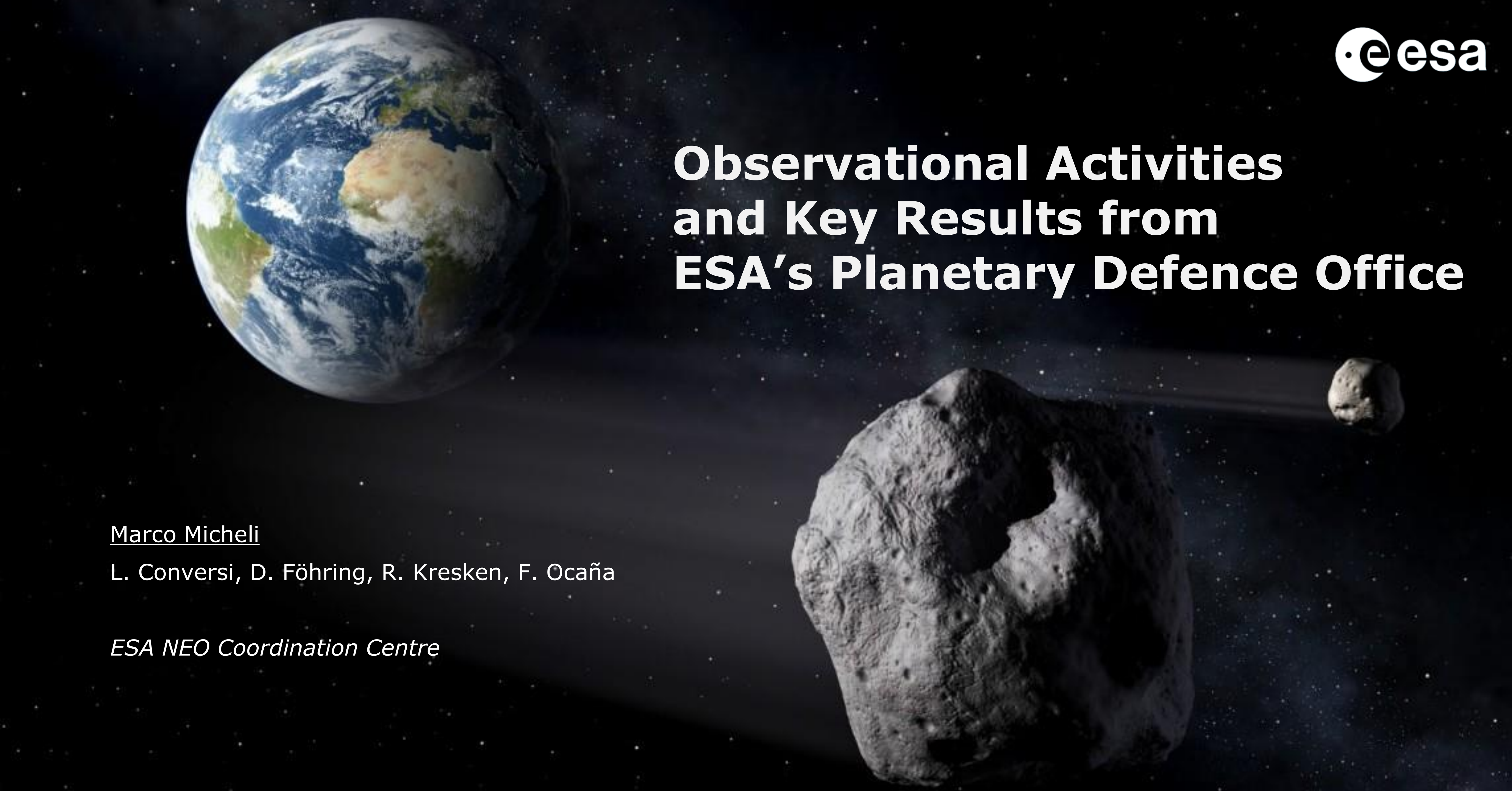


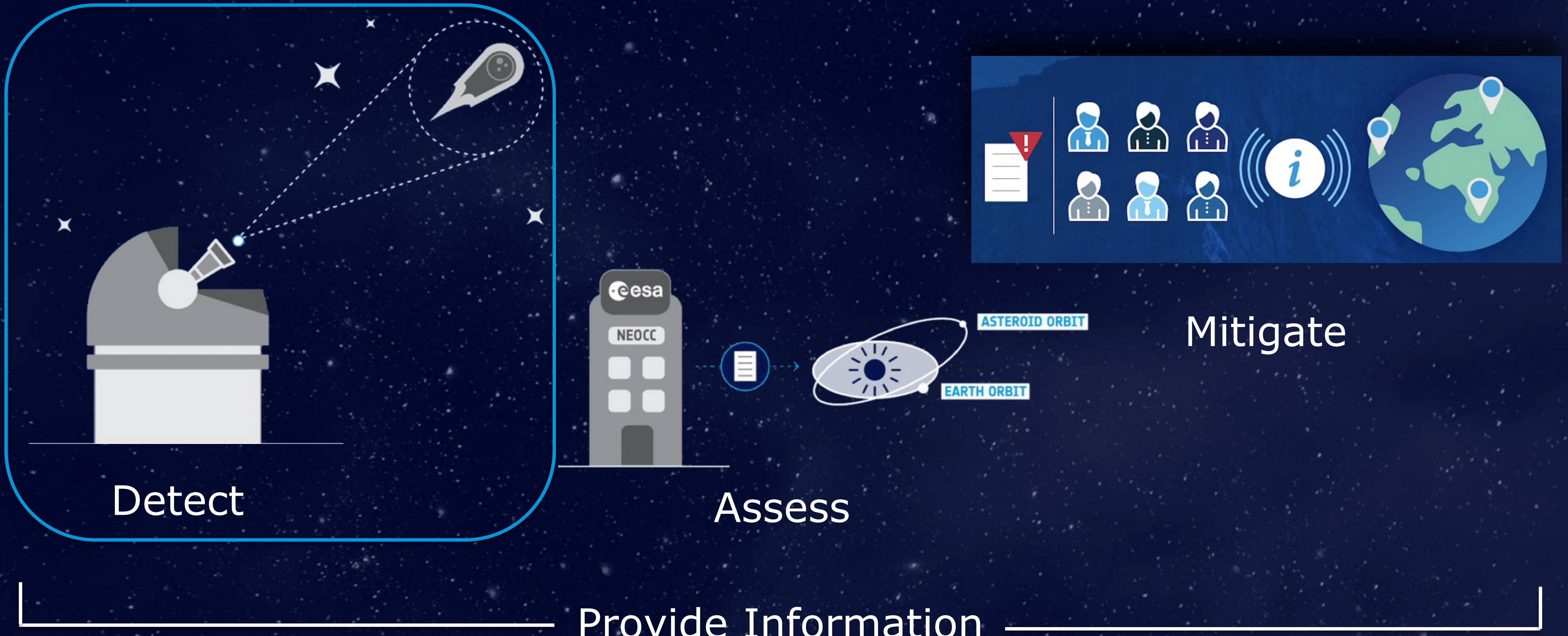
Observational Activities and Key Results from ESA's Planetary Defence Office

Marco Micheli

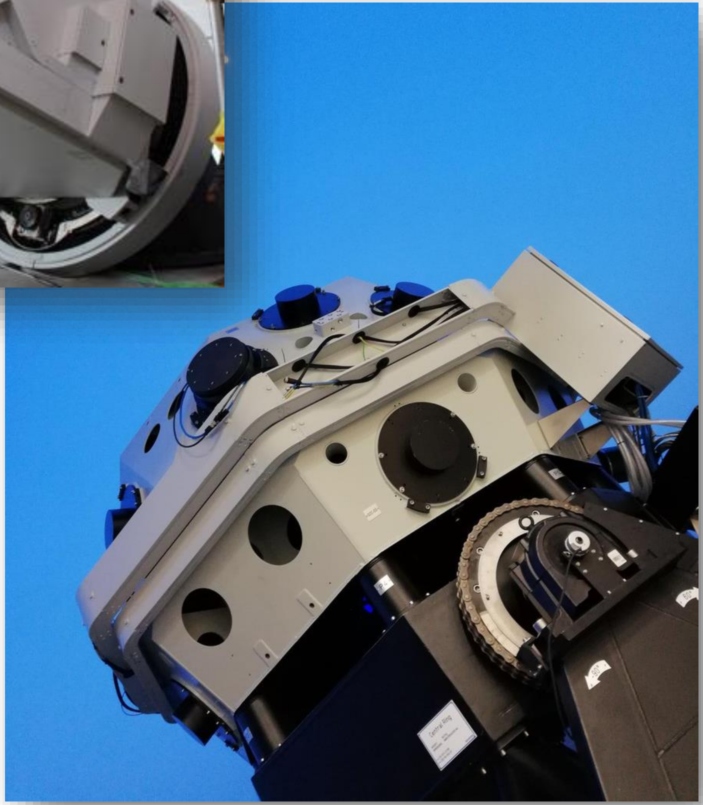
L. Conversi, D. Föhring, R. Kresken, F. Ocaña

ESA NEO Coordination Centre

The Three Pillars Of ESA Planetary Defence



Flyeye Survey Telescope



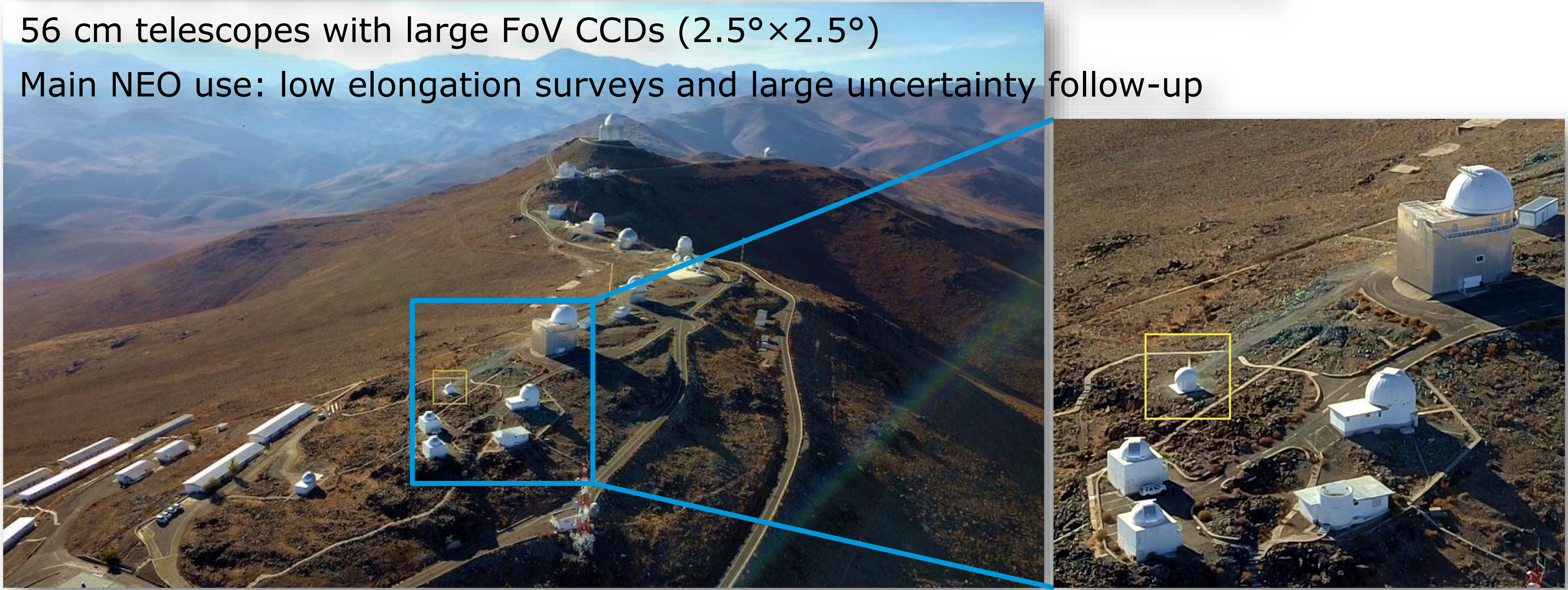
See Dora Föhring's talk later today for more details on the telescope status.

Test-Bed-Telescopes (TBTs)

2 TBTs now deployed: Cebreros Tracking Station (Spain) & La Silla (Chile)

56 cm telescopes with large FoV CCDs (2.5°×2.5°)

Main NEO use: low elongation surveys and large uncertainty follow-up



A wide telescope network

Legend

- Scientific Agreement
- ESA owned/funded
- 6ROADS Southern Hemisphere
- 6ROADS Asia
- LCO
- Flyeye #1

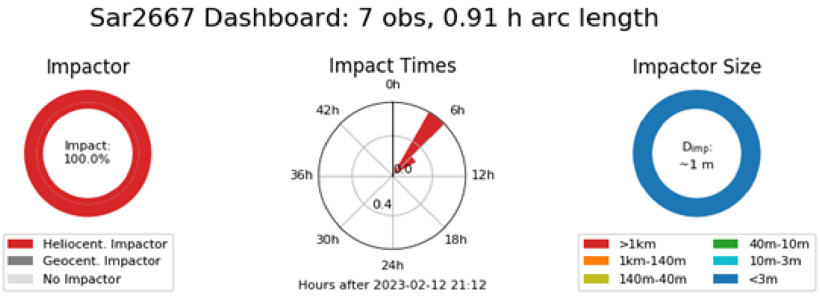
Fast, global and accurate response

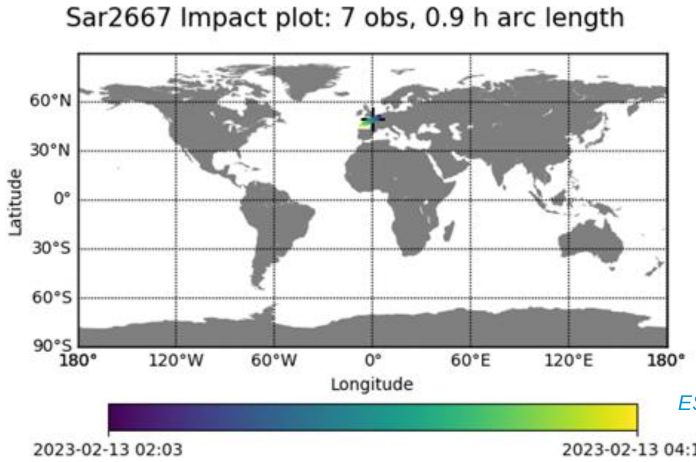
Some observations, such as the rapid follow-up of imminent impactors, require the availability of telescopic resources with little advance warning.

These telescopes need to be well understood to extract valuable data.

An example: the impact of 2023 CX1

- The time between alert and impact is often very short: it is essential to plan the observing strategy, possibly even in advance!
- Multiple observations from the same location are not helpful: it is useful to get parallax from various continents
- At least some observations need to have excellent timing, to “calibrate” the time dimension of the trajectory determination.





ESA / PDO

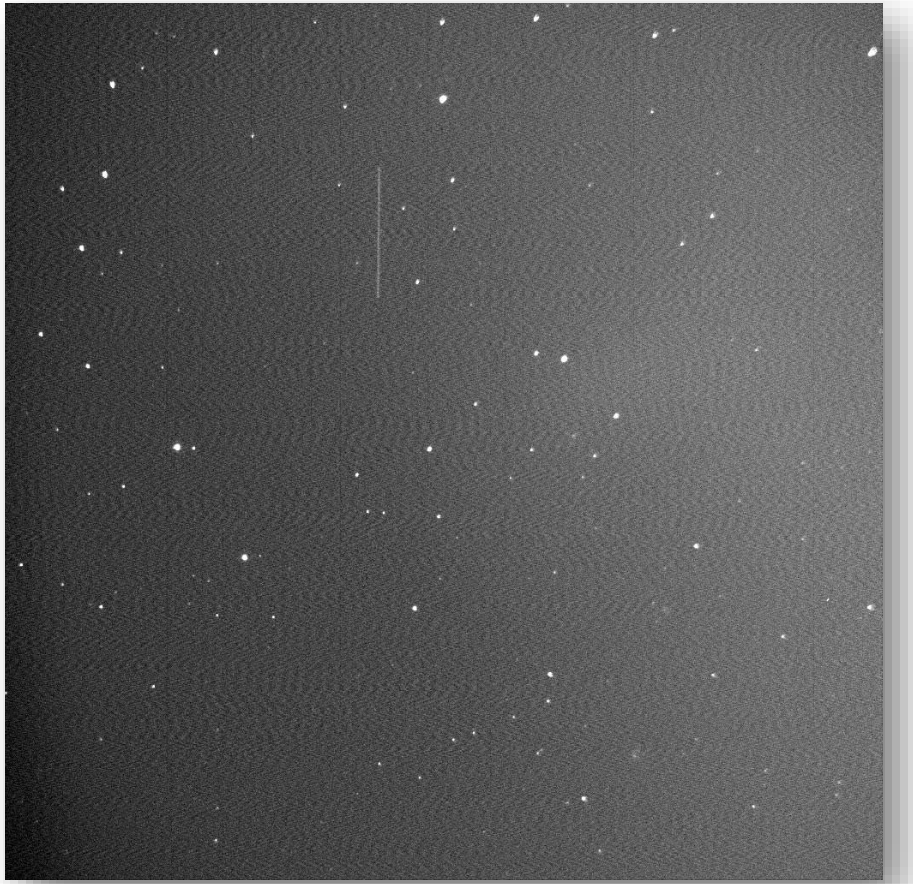
High-precision astrometry

Observing imminent impactors and close approachers often requires tracking very fast moving objects, and results in trailed detections.

Extra care must be placed while extracting astrometry.

An example: the impact of 2022 EB5

- A proper ephemeris needs to be used, and the exposures need to be carefully timed.
- Astrometry of the obtained detections is often not trivial, requiring trail-fitting.
- Astrometric uncertainties need to be derived properly, in both directions.
- Timing biases need to be understood and taken into account.



P. Bacci, M. Maestripieri, A. Carbognani

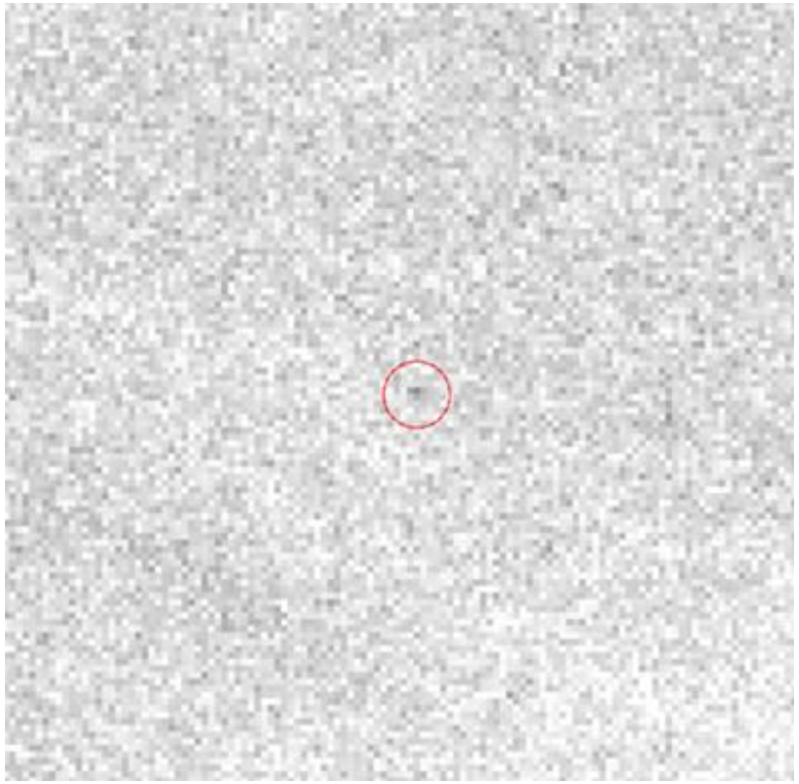
Faintest targets

We routinely use ESO's Very Large Telescope to observe faint (V~27) high-rated objects from our Risk List, and extract high-precision astrometry from the detections.

This requires pushing current ground-based telescopes to their limits.

An example: follow-up of 2021 QM1

- A high-rated impactor discovered one year earlier.
- Recoverable at magnitude 27, but in challenging conditions.
- Requires an 8-10 meter class telescope like VLT.
- Object detected ⇒ Impact excluded.
- At V~27.0, this is a good example of the faintest NEOs that can be observed.
- (We reached V~27.2 on another target in October)



ESO, O. Hainaut / ESA NEOCC

And when they cannot be observed…

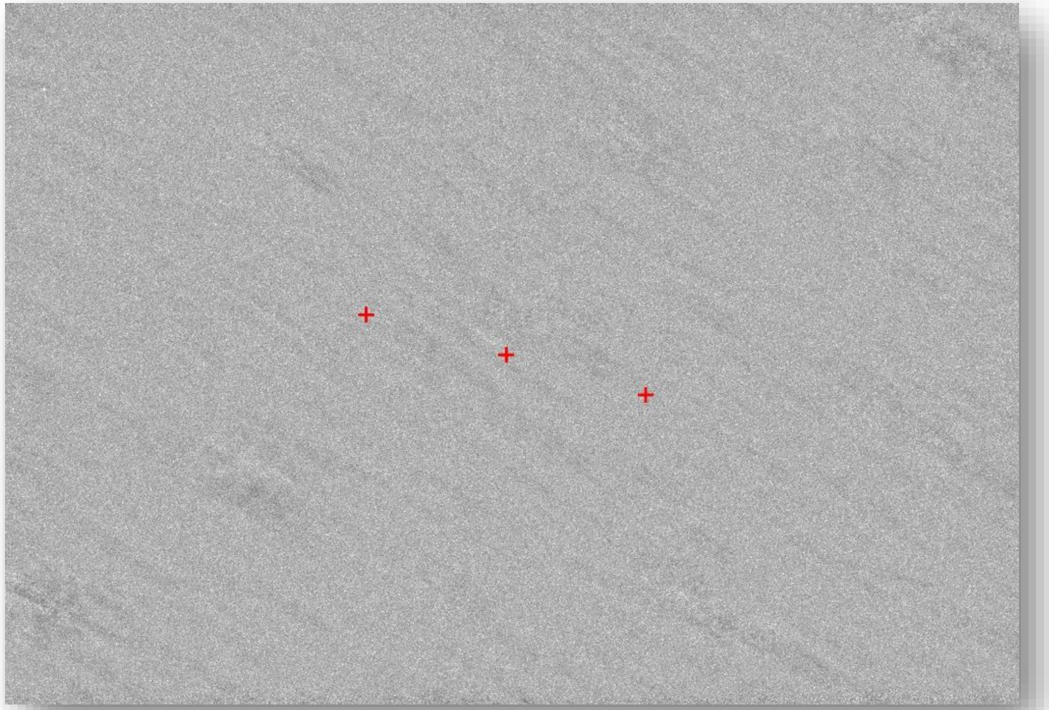
Not all objects we may want to observe are actually observable.

Moving objects can be lost, when we don't know their orbit and ephemeris well enough.

In some cases when the objects are not recoverable, we need to use alternative methods:

An example: negative recovery of 2006 QV89

- An upcoming high-rated impactor.
- Difficult recovery with sufficient warning time.
- We observed the location in the sky where impacting location would have appeared (marked by the red crosses + in the figure).
- Object not detected ⇒ Impact excluded.
- A proper protocol to ensure extended use of the same technique is being developed.



See *Hainaut et al.; A&A, 653:A124 (2021)*

Two major hardware improvements

Two new technologies are changing the way we obtain astrometry observations today:

CMOS sensors

These new sensors ensure extremely fast readout speeds.

↓

Very little time is lost downloading frames.

↓

It is now competitive to observe an object with many individual short frames (hundreds to thousands), instead of using longer individual exposures.

GPUs

It is now not uncommon to obtain many GBs of imaging data on a single target.

↓

These images need to be combined, tracked on the motion of the asteroid.

↙ ↘

If we know the motion, we can stack images in seconds.

If we don't, we can test all motion vectors (synthetic tracking).

A summary of our main observational goals

- Collecting quick-reaction observations for urgent objects (e.g. imminent impactors or fly-bys). Typically, we need to be “on the sky” within minutes to hours.
- Obtaining extended follow-up of faint high-importance objects (e.g. risk list objects, Atiras or Trojans, ISOs).
- Organizing and/or participating in international campaigns (e.g. IAWN, DART).
- Observing objects in challenging conditions (e.g. low elevation, twilight).
- Experimenting with new observing techniques (e.g. synthetic tracking, non-linear stacking, timing calibration, CMOS sensors).
- Observing artificial objects that might be a source of confusion for NEO follow-up (high Earth orbiting satellites or debris, interplanetary launches or fly-bys).

THANKS!