elecnor deimos

The European NEO Coordination Centre and the Gaia opportunity

ettore perozzi

and the

SSA NEO Team

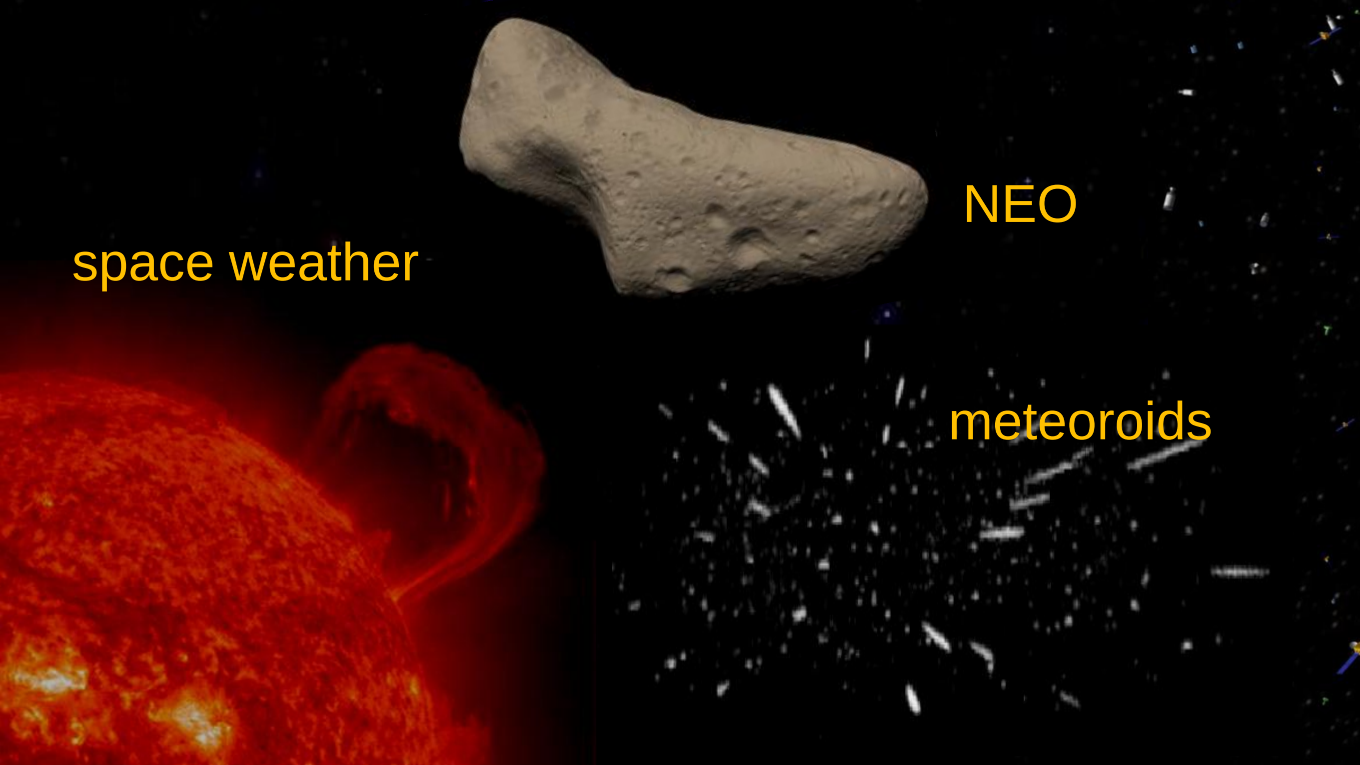
Third Gaia-FUN-SSO workshop
Paris, 24-26 November 2014

esa SpaceDyS Astos Solutions serco


SPACE SITUATIONAL AWARENESS
OPPORTUNITIES
THE NEO SYSTEM
OBSERVATIONS

SSA PROGRAMME

The aim of the ESA Space Situational Awareness Programme is to support the European independent utilisation of and access to space for research or services, through providing timely and quality data, information, services and knowledge regarding the environment, the threats and the sustainable exploitation of the outer space surrounding our planet



SSA SEGMENTS

SST: Space Surveillance and Tracking of man-made space objects

SWE: Space Weather monitoring and forecast

NEO: Near-Earth Objects hazard monitoring

NEO SEGMENT

a little history

- 2009-10: Enabling Technologies
  design the NEO Segment
  SBDC, Collaborating Observatories, Wide Survey
  ↳ **NEOCC** ↵

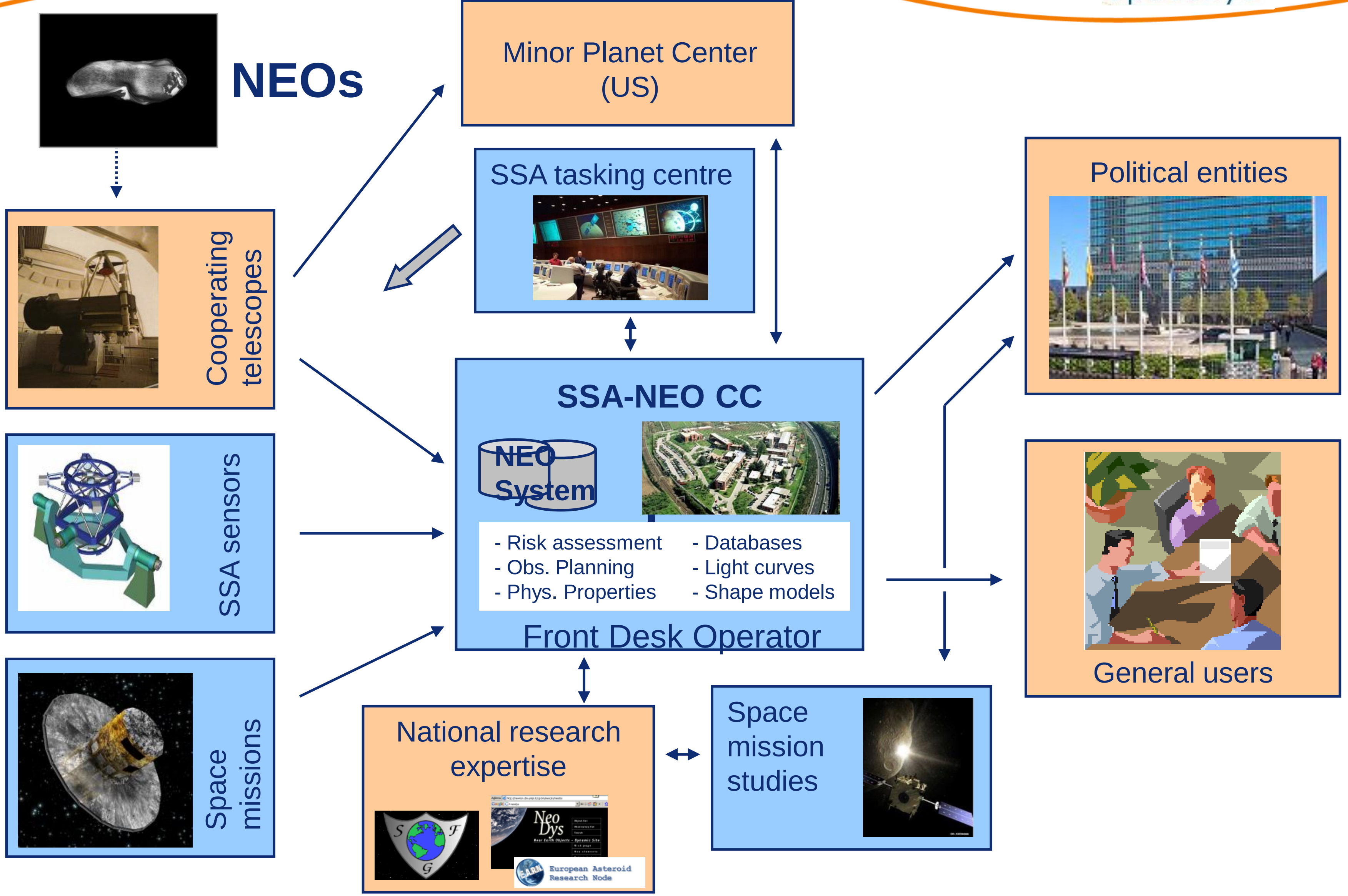
- 2011-12: SN-III Precursor Services
  establish the NEO System
  Web Portal, Database, ESRIN Office

- 2013-14: SN-V Precursor Services Operations
  operate the NEOCC
  System Maintenance & Improvement, Astronomical Observations, NEO Ops

- 2015: P2-NEO-I Operations
  nominal NEOCC operations
  System Maintenance & Improvement, Astronomical Observations, NEO Ops

NEO Coordination Centre inauguration
22 May 2013

OVERVIEW
NEOCC Context Diagram



elecnor deimos

The NEO SYSTEM

esa

Detlef Koschny

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deimos SPACE

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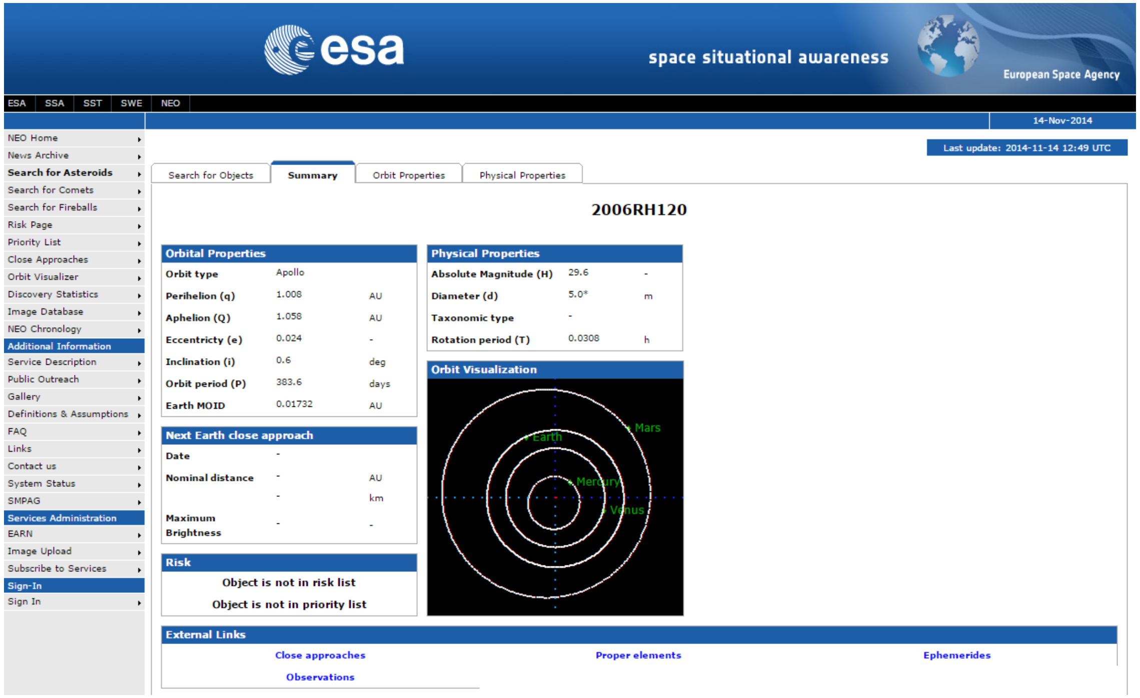
Andrea Tesseri

Fiammetta Cerreti



WEB PORTAL

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ESA | SSA | SST | SWE | NEO

12-Nov-2014

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NEO Coordination Centre

Precursor services

Please note that all SSA-NEO Services are under development

Current number of known NEAs: **11609**

Current number of NEAs in risk list: **460**

Last update: 2014-11-12 08:12:00 UTC

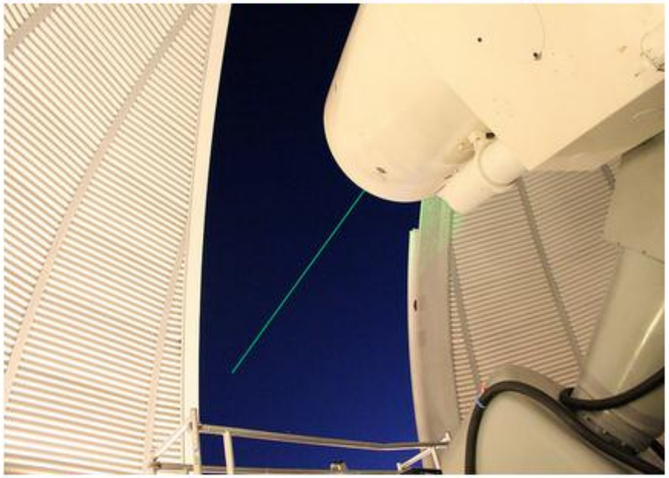
News

Print

Focus on: ESA OGS

30 October 2014

The ESA Optical Ground Station has quickly become a major asset for the NEO Coordination Centre, thanks to the many nights devoted to observing asteroids. It is located at an altitude of 2400 m on the slope of a volcano, in Tenerife, hosted at the Observatorio del Teide - Instituto the Astrofisica de Canarias. The telescope has been originally committed to advanced optical communication experiments on board the ESA geostationary satellite Artemis, and it is therefore equipped with a state-of -the-art laser equipment, still operational. During the SSA social media event on 7 October a spectacular transit of the International Space Station had been organised: a laser link with the ISS was established while the telescope provided incredibly clear images of the Space Station as shown in the *image below* (http://www.iac.es/divulgacion.php?op1=16&id=891, https://www.flickr.com/photos/esa_events/sets/72157648061826537/).



Once the Artemis mission was over, OGS became available for supporting other programs. The Space Debris office of ESA installed a focal reducer and a wide-field CCD camera for observing space debris and satellites. In the meantime, the telescope has turned out extremely useful for fulfilling the ESA Space Situational Awareness observing needs. Over the past few years the SSA-NEO programme has been allocated approximately four nights per month, around new moon, entirely dedicated to asteroid observations. These observations are managed by the NEOCC. As can be seen from the image, laser communication is still part of the activities at the OGS.

The main focus of these activities is to collect follow-up observations of NEOs. A significant fraction of the targets are the so-called "NEOCP objects", recently discovered asteroids whose preliminary ephemerides are posted by the IAU Minor Planet Center on the NEO Confirmation Page (http://www.minorplanetcenter.net/iau/NEO/toconfirm_tabular.html). In most cases these recent discoveries have been observed only for a very short amount of time and it is therefore impossible to determine their orbits and carefully assess if they are indeed dangerous NEOs. In most cases, this same lack of knowledge results in very large positional uncertainties in the sky, thus requiring a telescope with a large field of view to be certain that the object is going to be visible in the image. The OGS, with its 47 arcminutes square field, is ideal for these searches; over the last year, about a dozen candidates per night were successfully targeted and approximately half of them were confirmed to be NEOs thanks to our observations.

The second main focus of follow-up activities is guided by the Priority List published on the NEOCC website. At any given time, the list highlights about a dozen objects in urgent need of observations, plus many lower priority ones. We therefore try to observe as many of them as possible down to at least a visual magnitude of 22, which is the practical limit of the instrument. This activity is essential in order to prevent most of these targets from being lost because of a

RISK PAGE

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ESA | SSA | SST | SWE | NEO

05-Oct-2014

Last update: 2014-10-05 13:30 UTC

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Current number of NEOs in risk list:
454

In the table below for each impact the encounter with the highest impact risk is listed. When better measurements are not available, the size of the objects is estimated [illegible] the absolute magnitude. Data are initially sorted by Palermo Scale value but the order can be changed using the table headers.

Ris

Object Name	Size [m]	Date/Time	IP	PS	TS	Vel. [km/s]	In list since [days]	IT	PP	OV
2009FD	472.0	2185-03-29 18:06	1/383	-0.44	n/a	19.41	1397			
101955 Bennu	484.0	2196-09-24 07:55	1/10638	-2.32	n/a	12.68	2018			
2010RF12	9.0*	2095-09-05 23:50	1/11	-3.11	0	12.29	1431			
1979XB	830.0*	2056-12-12 21:39	1/3.7E6	-3.23	0	27.54	12649			
2008UB7	71.0*	2060-10-31 19:06	1/10482	-3.29	0	21.57	2137			
2010MZ112	808.0	2041-02-17 04:52	1/729927	-3.39	0	11.31	1518			
2010DG77	315.0	2047-01-12 04:39	1/97087	-3.44	0	11.49	1606			
2009JF1	16.0*	2022-05-06 08:12	1/2906	-3.57	0	26.41	1947			
2000SG344	46.0*	2071-09-16 00:55	1/2057	-3.62	0	11.27	5100			
99942 Apophis	375.0	2068-04-12 15:13	1/531914	-3.67	0	12.62	3509			

Download as CSV file | Download as Excel file

Full Risk List

http://neo.ssa.esa.int

Close Approaches

space situational awareness

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List of forthcoming and recent close approaches to Earth. Data are initially sorted by date but the order can be changed using the table headers.

The Maximum Brightness value allows to estimate the observability of an object at encounter. For a detailed description see the "Definitions and Assumptions" page. Note that when the encounter occurs is in daylight the maximum brightness value is augmented by one hundred to warn that the geometry is unfavorable for observations.

Last update: 2014-11-14 12:37 UTC

Upcoming close approaches to Earth

1 AU = ~150 million kilometers
1 LD = Lunar Distance = ~384000 kilometers

Object Name	Close Approach Date	Miss Distance [AU]	Miss Distance [LD]	Estimated Diameter [m]	H [mag]	Maximum Brightness [mag]	Relative Velocity [km/s]
2014UW57	2014-Nov-16	0.031	12.1	20.0*	26.6	20.4	4
2006WZ184	2014-Nov-19	0.0238	9.3	26.0*	26	121.7	6.6
2014UY	2014-Dec-01	0.0355	13.8	35.0*	25.4	20.3	3.2
2012YK	2014-Dec-23	0.0434	16.9	110.0*	23	16.8	9.3
2013AH53	2015-Jan-03	0.0309	12	30.0*	25.7	21.3	11.1
2013BY2	2015-Jan-14	0.0266	10.3	15.0*	27.3	21.5	12.1
2007ED125	2015-Mar-03	0.0313	12.2	250.0*	21.1	16.5	13
2010LN14	2015-Jun-21	0.0483	18.8	250.0*	21.1	17.4	15.9
2010NY65	2015-Jun-25	0.044	17.1	228.0	21.5	118	13.5
2005VN5	2015-Jul-07	0.0326	12.7	17.0*	27	22.7	6.9
2013BQ18	2015-Jul-20	0.0222	8.6	37.0*	25.3	120.9	14.1
2004ME6	2015-Jul-29	0.0464	18.1	130.0*	22.6	18.8	9.6
2012JA	2015-Aug-08	0.0423	16.5	44.0*	24.9	121.2	10.6
2009DB1	2015-Aug-10	0.0471	18.3	110.0*	22.9	19.2	12.4
281375 2008JV19	2015-Sep-01	0.0447	17.4	310.0*	20.7	15.8	7.2
2008HD2	2015-Sep-29	0.0417	16.2	41.0*	25.1	20.5	13
2010SX11	2015-Oct-09	0.0415	16.2	45.0*	24.8	20.2	7.8
2011SE97	2015-Oct-18	0.0308	12	49.0*	24.7	20.4	12.9

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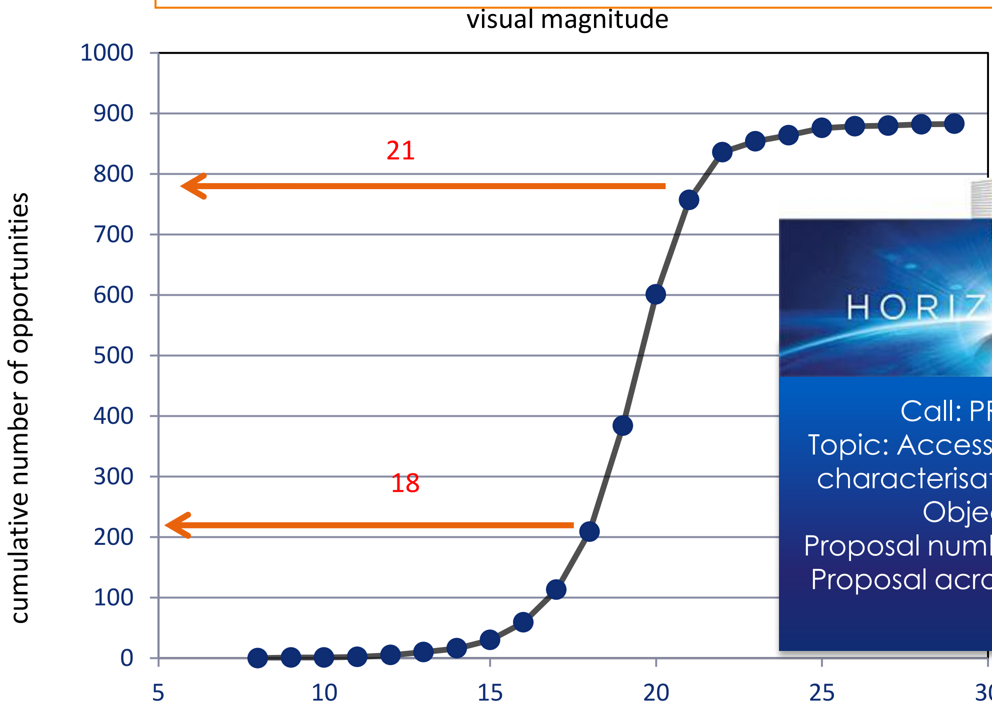
HORIZON 2020 NEOShield-2 project
NEO Physical Characterization

cumulative distribution of 2012 close approachers observation opportunities as a function of their visual magnitude

present discovery rate dominated by small Earth approachers

V=21 is the typical magnitude limit for physical characterization from a 4m class telescope

V=18 is the typical magnitude limit for physical characterization from a 1m class telescope



Call: PROTEC-2014
Topic: Access technologies and characterisation for Near Earth Objects (NEOs)
Proposal number: SEP-210130790
Proposal acronym: NEOShield-2

the possibility of pushing the limiting magnitude to 21 allows to encompass the vast majority of the 2012 Earth approachers population

need of a rapid response network for physical characterization

Priority List

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European Space Agency

Last update: 2014-10-05 13:13 UTC

The Priority List addresses the problem of efficiently planning and executing NEO follow-up observations. It classifies the need to observe especially newly discovered objects into four categories: urgent, necessary, useful and low priority. The aim is to ensure that the highest possible percentage of these bodies can be recovered at other apparitions. Sorting order can be changed using the table headers.

Visibility chart for Observation code

Faintest Mag.

Brightest Mag.

Min. Declination

Max. Declination

Priority List

Priority	Object	Inserted	R.A.	Decl.	Elong.	Magn.	Sky uncert.	End of Visibility
UR	2012CO46	2014-10-05	04h14m	34.1	124	**20.7**	1937	2015-02-19
UR	2012KY3	2014-10-05	05h09m	-72.6	92	**15.6**	1	2014-10-11
UR	2014KT86	2014-10-05	07h21m	-21.4	80	**21.1**	92	2015-02-23
UR	2014ML68	2014-10-05	22h00m	-12.9	135	**21.5**	600	2015-02-21
UR	2014MQ67	2014-10-05	18h53m	50.4	95	**19.7**	2495	2015-01-24
UR	2014NU64	2014-10-05	21h03m	-24.2	119	**20.7**	63287	2014-12-01
UR	2014PC68	2014-10-05	04h42m	-53.7	104	**21.5**	8	2014-10-14
NE	2014TS16	2014-10-05	22h02m	-12.3	136	**20.6**	2	2014-11-12
NE	2014TF17	2014-10-05	01h42m	13.7	164	**21.3**	2	2014-11-20
NE	2014TJ17	2014-10-05	23h11m	26.0	149	**19.8**	3	2014-10-30
NE	2014TM17	2014-10-05	02h36m	-1.5	152	**21.1**	1	2014-10-26
NE	2014TN17	2014-10-05	00h39m	27.4	157	**19.2**	1	2014-10-27
US	2014EB49	2014-10-05	00h42m	20.9	164	**21.6**	0	2014-10-18
US	2014EH45	2014-10-05	01h33m	41.2	142	**21.5**	0	2014-10-20
US	2014FL33	2014-10-05	05h13m	-2.0	113	**21.8**	3	2014-11-26
UR	2014SB145	2014-10-05	04h45m	31.0	118	**18.8**	7	2014-10-09

SFG

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PRIORITY LIST

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Faintest Mag.

Min. Declination

Max. Declination

NEOCC Priority List can be used as a real-case Gaia alert simulator

Priority List

Priority	Object	Inserted	R.A.	Decl.	Elong.	Magn.	Sky uncert.	End of Visibility
UR	2012CO46	2014-10-05	04h14m	34.1	124	**20.7**	1937	2015-02-19
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UR	2014MQ67	2014-10-05	18h53m	50.4	95	**19.7**	2495	2015-01-24
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UR	2014PC68	2014-10-05	04h42m	-53.7	104	**21.5**	8	2014-10-14
NE	2014TS16	2014-10-05	22h02m	-12.3	136	**20.6**	2	2014-11-12
NE	2014TF17	2014-10-05	01h42m	13.7	164	**21.3**	2	2014-11-20
NE	2014TJ17	2014-10-05	23h11m	26.0	149	**19.8**	3	2014-10-30
NE	2014TM17	2014-10-05	02h36m	-1.5	152	**21.1**	1	2014-10-26
NE	2014TN17	2014-10-05	00h39m	27.4	157	**19.2**	1	2014-10-27
US	2014EB49	2014-10-05	00h42m	20.9	164	**21.6**	0	2014-10-18
US	2014EH45	2014-10-05	01h33m	41.2	142	**21.5**	0	2014-10-20
US	2014FL33	2014-10-05	05h13m	-2.0	113	**21.8**	3	2014-11-26
UR	2014SB145	2014-10-05	04h45m	31.0	118	**18.8**	7	2014-10-09

INAF

Summary Page

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Last update: 2014-11-14 12:49 UTC

Search for Objects | **Summary** | Orbit Properties | Physical Properties

2006RH120

Orbital Properties

Orbit type	Apollo	
Perihelion (q)	1.008	AU
Aphelion (Q)	1.058	AU
Eccentricity (e)	0.024	-
Inclination (i)	0.6	deg
Orbit period (P)	383.6	days
Earth MOID	0.01732	AU

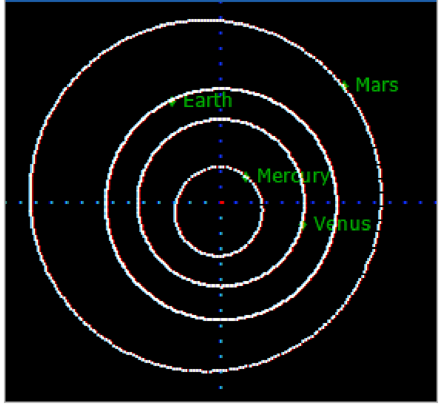
Physical Properties

Absolute Magnitude (H)	29.6	-
Diameter (d)	5.0*	m
Taxonomic type	-	
Rotation period (T)	0.0308	h

Next Earth close approach

Date	-	
Nominal distance	-	AU
	-	km
Maximum Brightness	-	-

Orbit Visualization



Risk

Object is not in risk list

Object is not in priority list

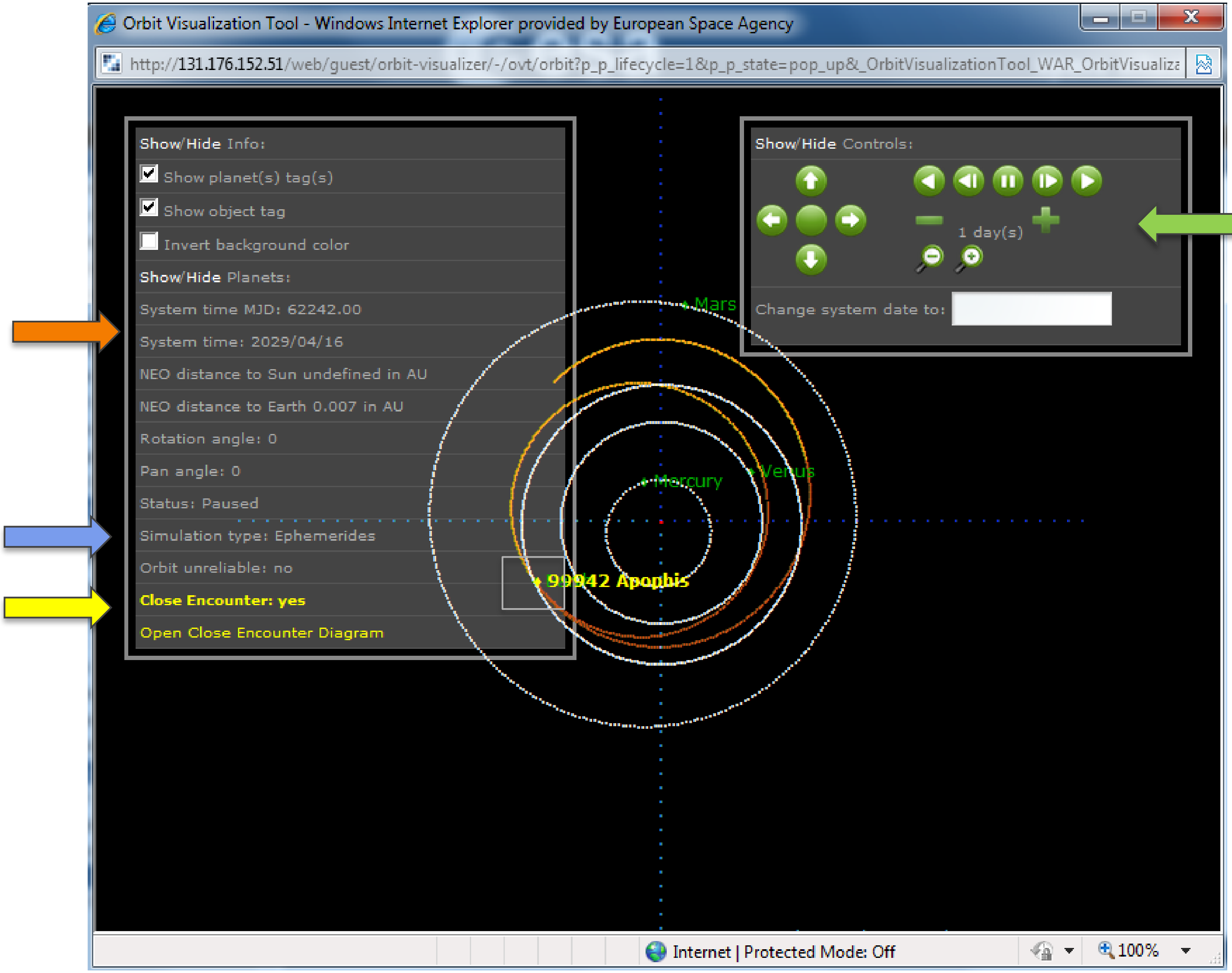
External Links

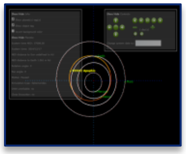
Close approaches | Proper elements | Ephemerides

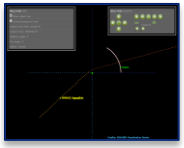
Observations

ORBIT VISUALIZATION TOOL
Apophis perturbed trajectory

2029 Earth encounter

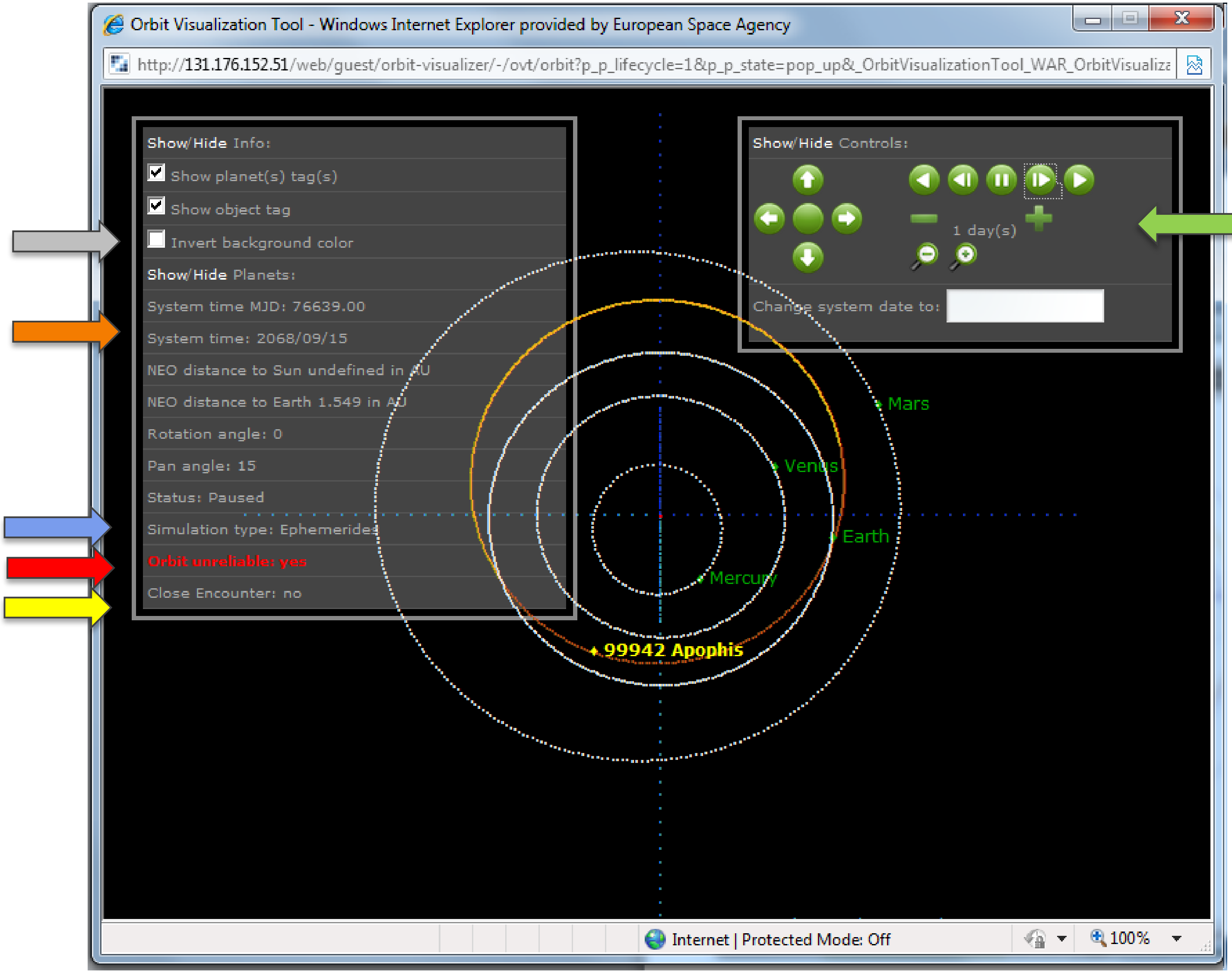






ORBIT VISUALIZATION TOOL
Apophis perturbed trajectory

2068



NEO SYSTEM

An evolving environment

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serco
SpaceDyS

SN-III

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debiased NEO population model

openAM authentication

NEOCC OBSERVATIONS

COLLABORATING OBSERVATORIES

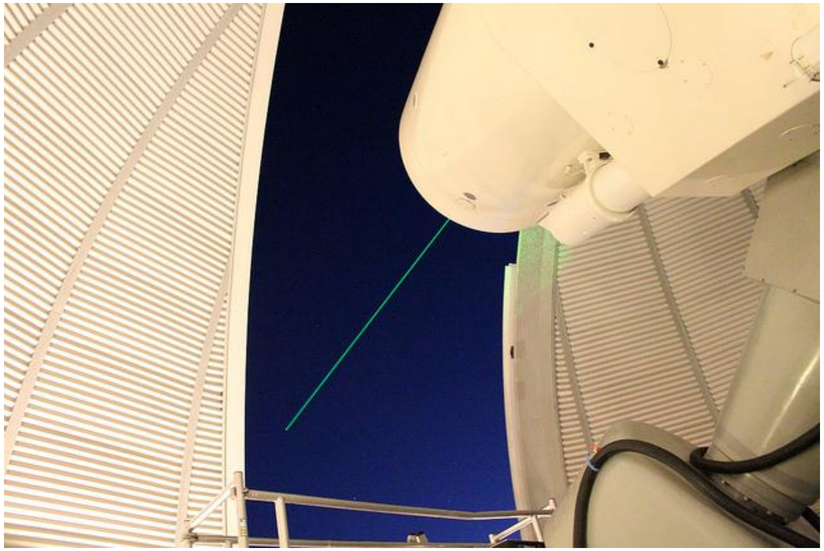
OBSERVING CAMPAIGNS

Marco Micheli

Detlef Koschny

Fabrizio Bernardi

ESA Optical Ground Station (OGS)



A 1.0 meter ESA telescope in Tenerife, Canary Islands.

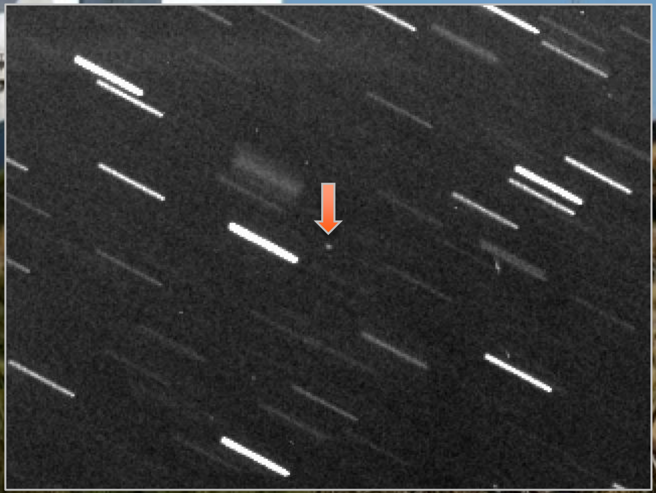
Originally designed for satellite optical communication experiments

The OGS is one of the few follow-up facilities that can reach magnitude 22

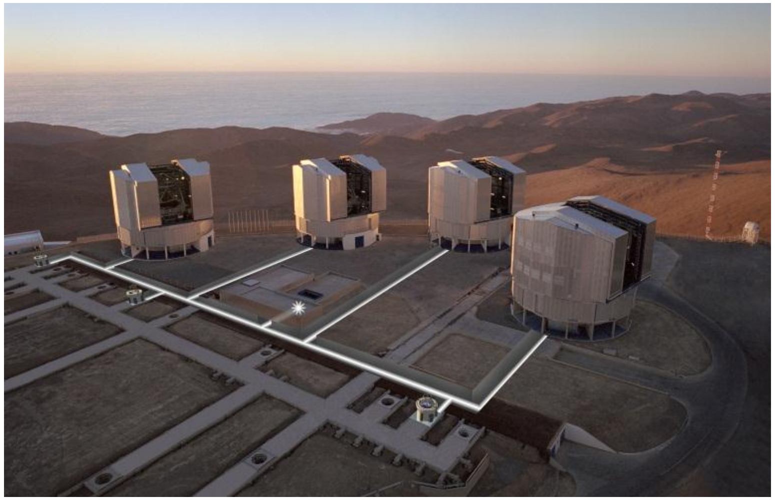
We have 4 to 8 nights per month, around new Moon

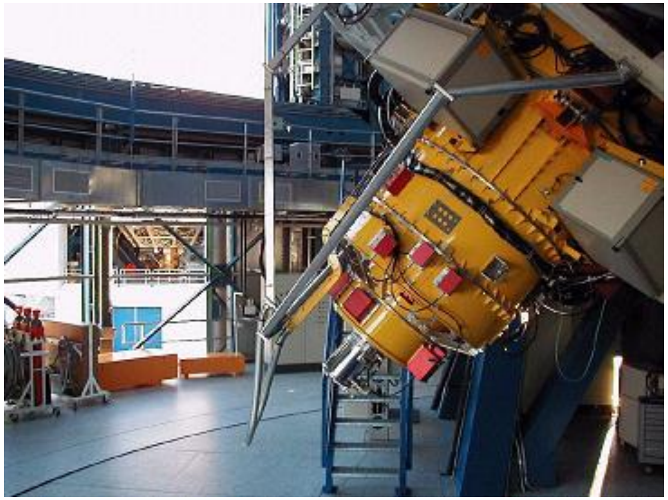
ESA OGS (Tenerife)

- ~4 nights per month
- ~180 NEO observed in 2014
- ~10-15 NEO candidates every night (~50 % actual NEOs)
- 85% success rate (= target located)
- 5 NEOs discovered (10th most successful discovery station in 2014)
- 1 Virtual Impactor discovered: 2014 QN266
- Hundreds of new Main Belt asteroids discovered
- 1 comet discovered in 2014: C/2014 C1 (TOTAS)
- 1-2 NEO or Comet recoveries per month



ESO Very Large Telescope (VLT)



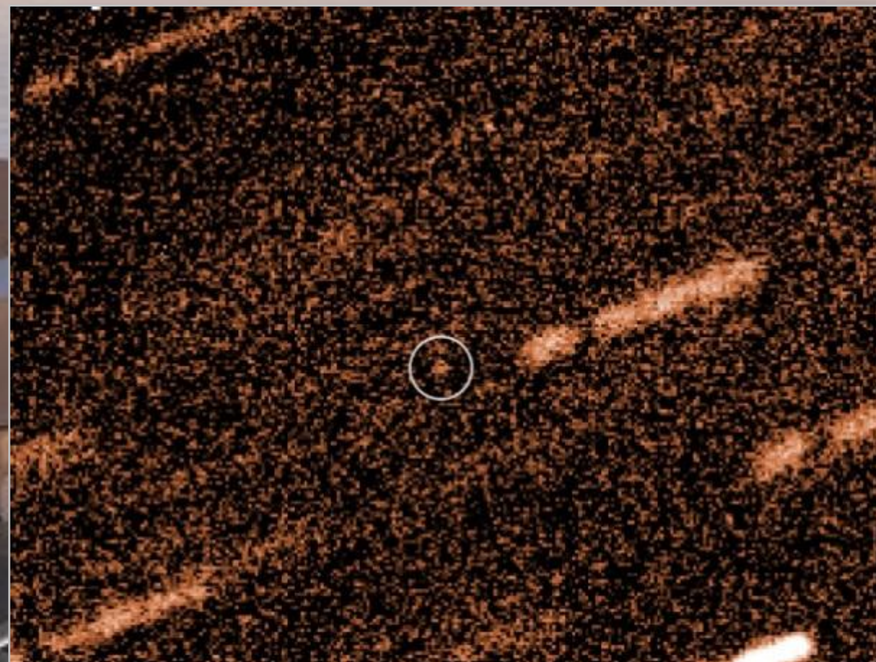


Four large 8.2 meter telescopes at Cerro Paranal, Chile

We use the FORS2 camera on the first telescope, 7 arcminutes field

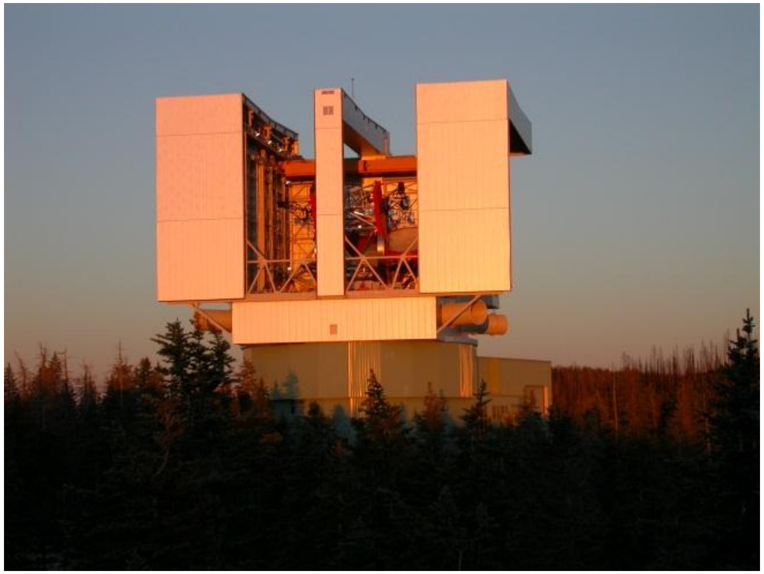
We have ~11 hours per semester to observe Virtual Impactors, thanks to an agreement with ESO

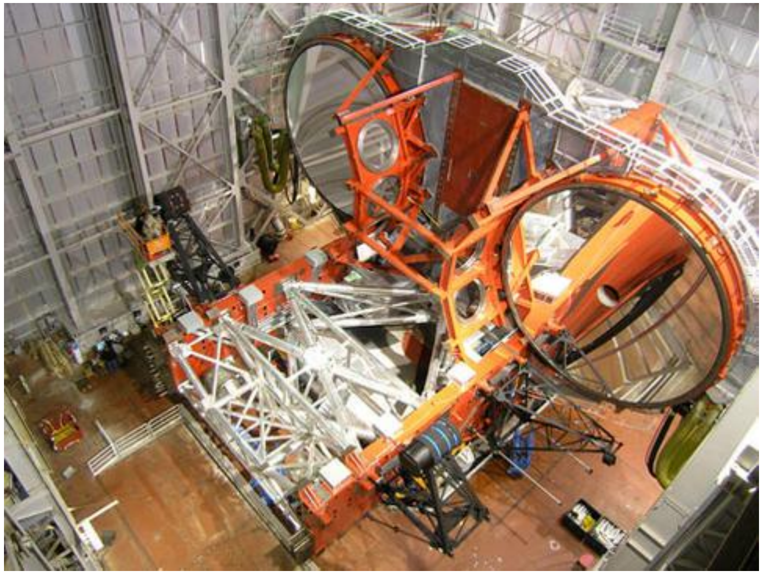
ESO VERY LARGE TELESCOPE (CHILE)



- ~20 NEO observed in 2014 (all VIs), including a few recoveries
- ~50 % removed from the risk list
- > 90 % success rate (= target located):
- Targets as faint as V=26 successfully observed

COLLABORATING OBSERVATORIES
INAF Large Binocular Telescope (LBT)





Two twin comounted 8.4 meter telescopes

Two wide field cameras, 27 arcminutes field, different sensitivities

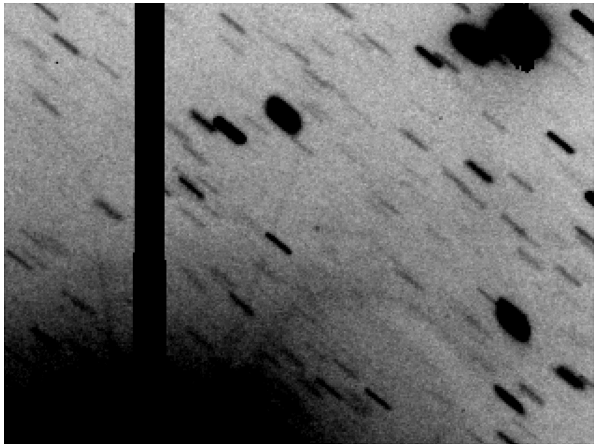
We have reached an agreement with the Italian partnership (INAF) for rapid response DDT time

Faint large-uncertainty NEOs

We can use LBT for wide field faint recoveries

2014 KC46, one of the faintest NEOs ever seen!

- We recovered it in October 2014
- V=26, uncertainty spanning the whole field
- First-ever NEO observation with LBT!
- Published on MPEC 2014-V35
- All impact solutions were removed



Future improvements: the two sides allow for simultaneous color observations

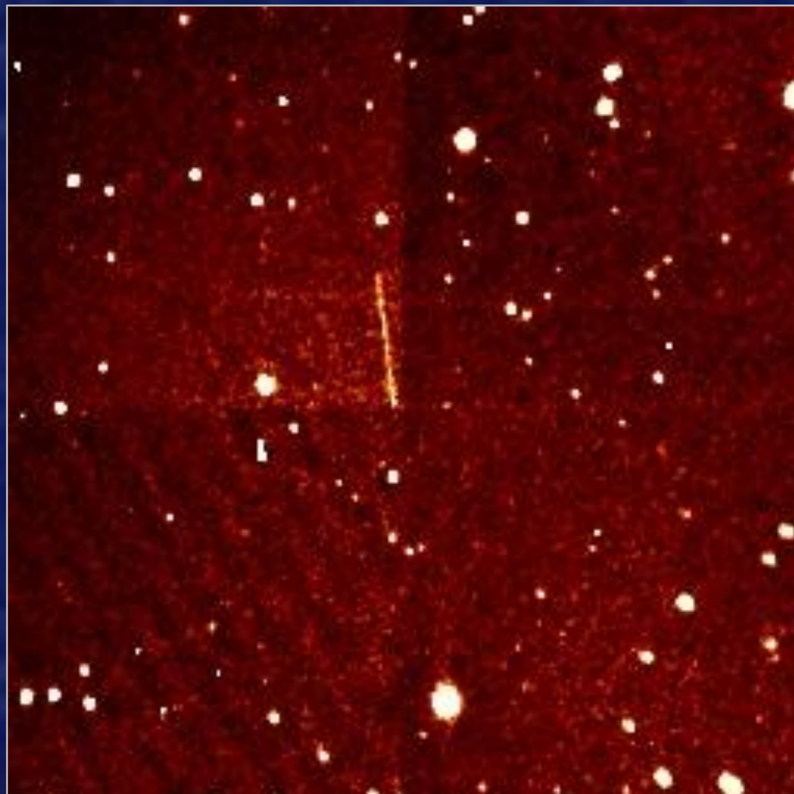
Asteroid 2002 GT, a relatively large object a few hundred metres across, made a distant flyby of Earth on 26 June, passing us at almost 50 times the distance of the Moon.

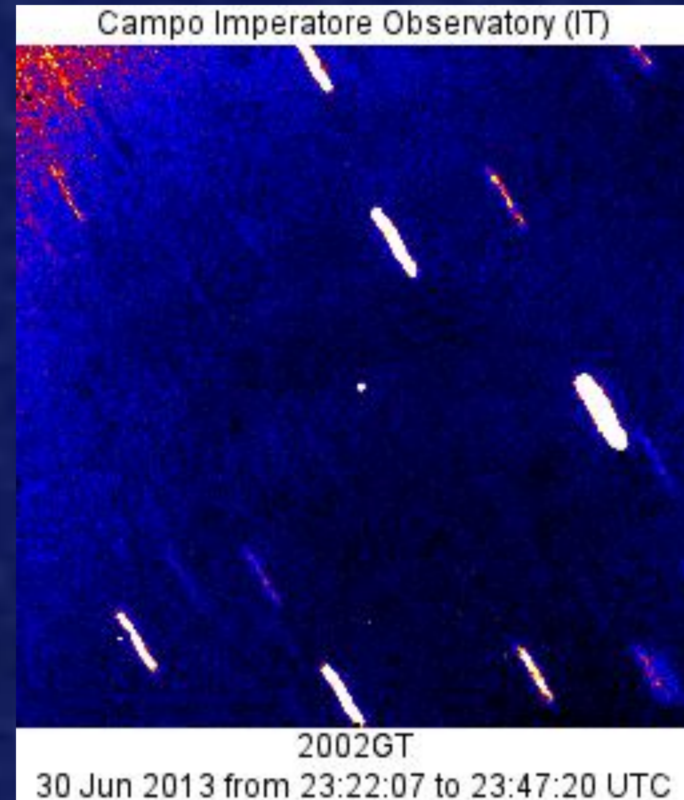
Yet the encounter sparked intensive worldwide observations because the asteroid is the target of NASA's Epoxi mission in January 2020.

By alerting and then collating observations from diverse European teams, ESA's NEO Coordination Centre was able to provide a comprehensive set of results back to the scientific and space exploration communities

OBSERVATION CAMPAIGNS

2002 GT



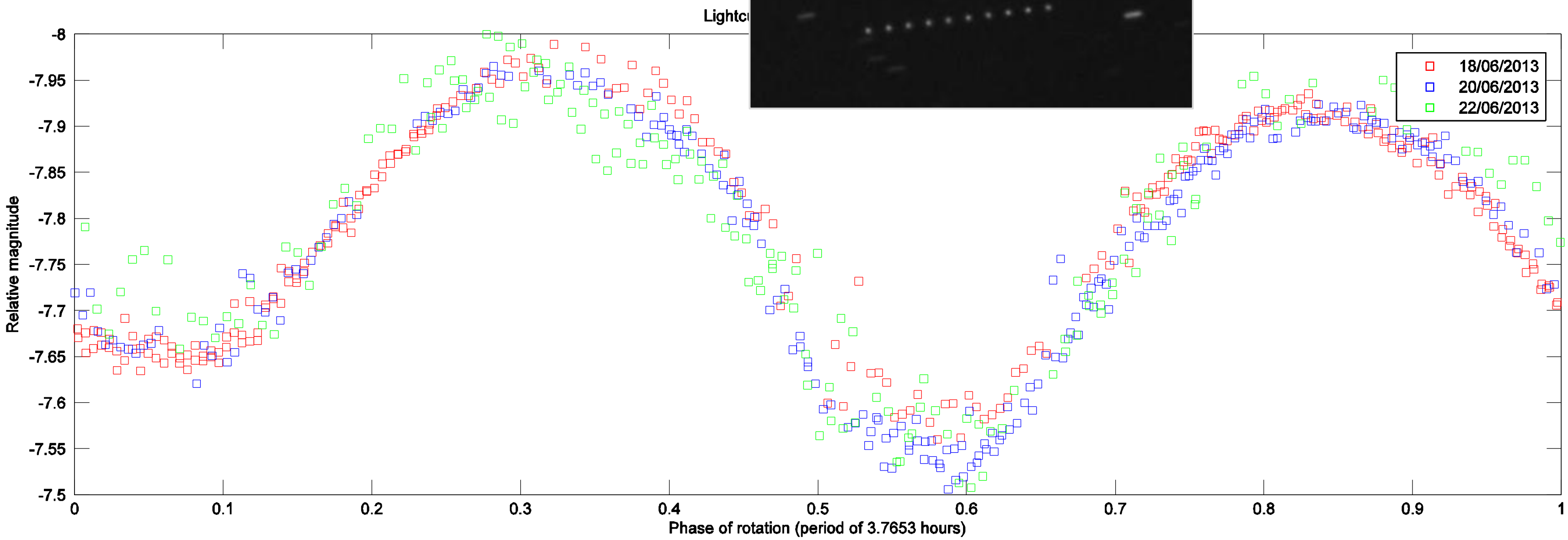


Infrared observations from the Campo Imperatore Station of the INAF Rome Astronomical Observatory.

Even under bad weather conditions, it was possible to spot the asteroid 20 days before Earth flyby.

OBSERVATION CAMPAIGNS

2002 GT

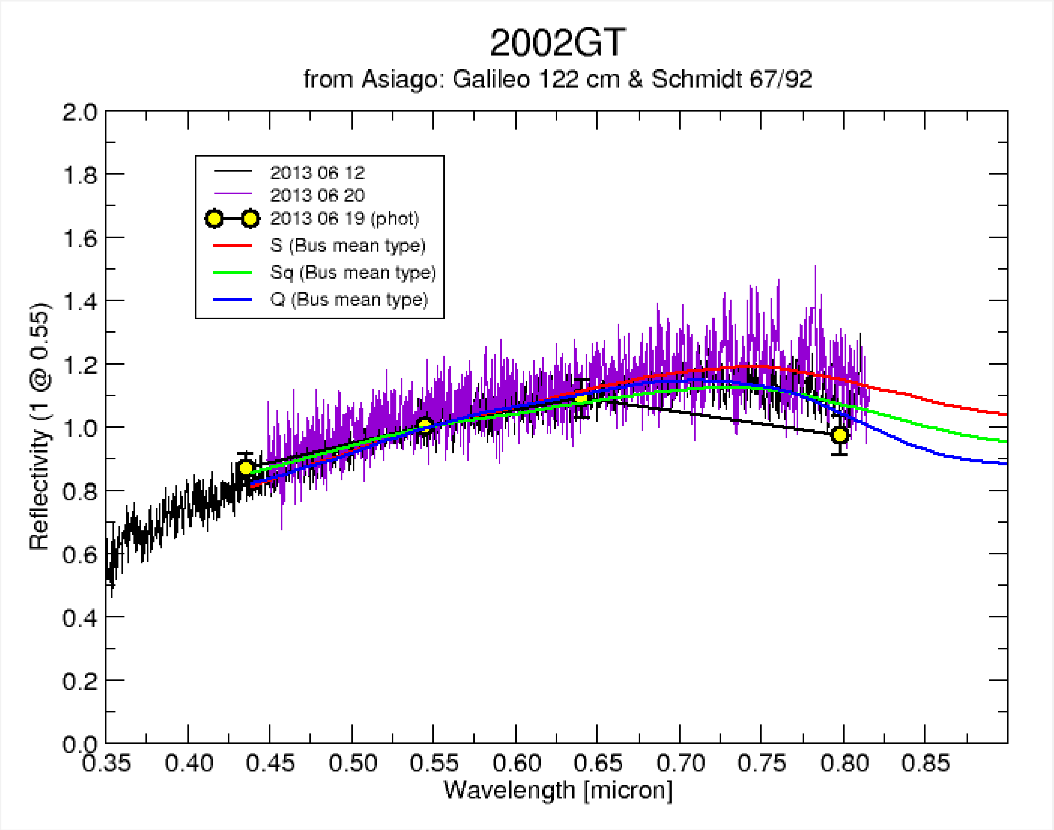


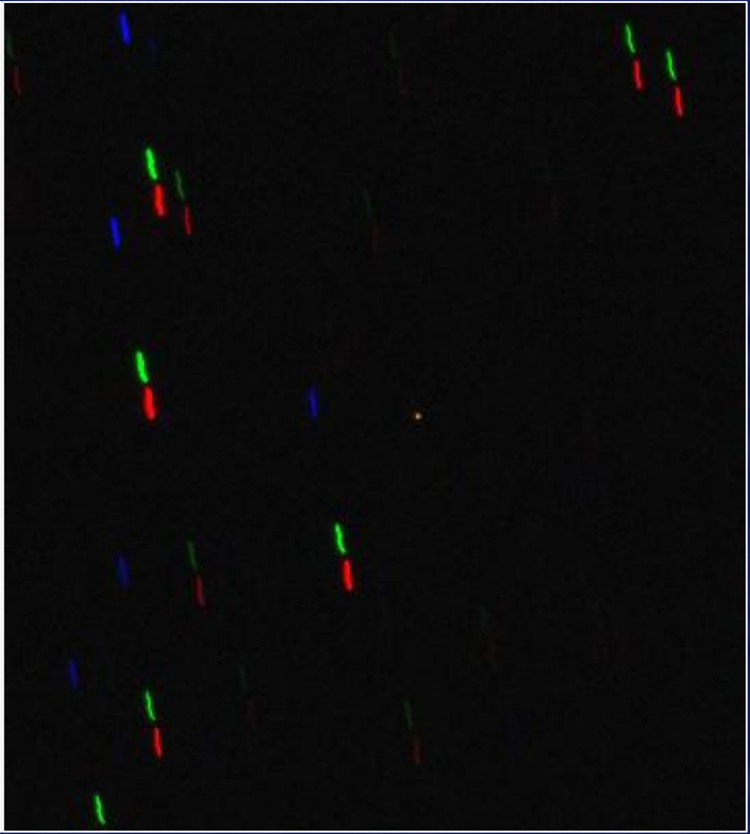
Photometry and light-curve data from the 1 m-diameter C2PU telescope at the Observatoire de la Cote d'Azur allowed calculation of the rotation period (3.77 hours).

The shape of the light curve is compatible with the presence of a satellite.

OBSERVATION CAMPAIGNS

2002 GT





Spectra and photometric data from Asiago Observatory *(University of Padova and Observatory of Padova*) allowed determination of the asteroid type (Sq), in agreement with other observations.

OBSERVATION CAMPAIGNS
2002 GT

elecnor deimos

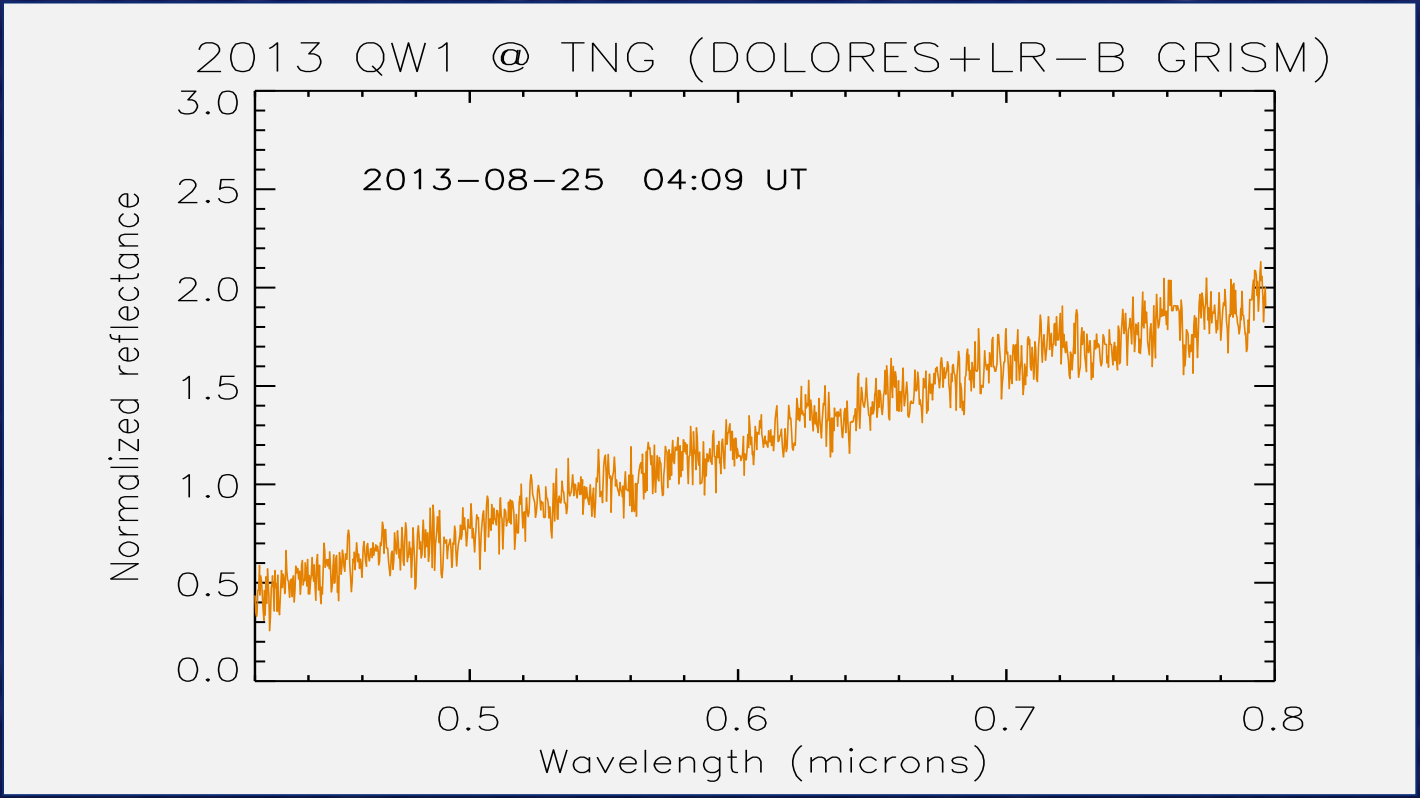
Astrometry from Gaia-FUN-SSO: Six telescopes observed 2002 GT providing astrometric measurements. *These were sent to the Minor Planet Centre and processed at IMCCE for computing orbital elements.*

On August 23rd an unusual object was spotted in the sky: provisionally named 2013QW1 it was moving on a faraway geocentric orbit, thus puzzling astronomers on its own nature: natural or artificial?

The ESA NEO Coordination Centre has promptly sent an alert to collaborating observatories to contribute to the worldwide efforts to solve the ridde.

The challenge was taken over by a joint team from INAF - Osservatorio di Roma and the Observatoire de Paris Meudon who succeeded to obtain Director's Discretionary Time at the Italian Telescopio Nazionale Galileo, to obtain a visible spectrum

The outcome does not resemble at all an asteroid spectrum, being similar to that of "space junks" found in the literature



This provided evidence of the artificial nature of 2013 QW1 - possibly a booster of a lunar mission - now removed from the NEO catalogue and included as 2010-050B in the Minor Planet Centre DASO (Distant Artificial Satellite Observations) list.

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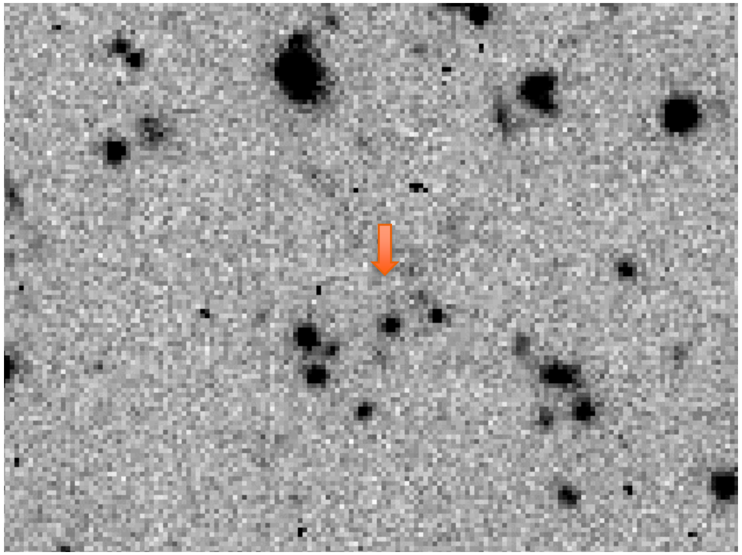
If the object is already gone, and lost we can search for precoveries in existing data



2008 CK70, top-10 in the list of VI

- 5-day arc, would have been lost
- We found precovery images in CFHT
- One month before (arc extension)
- The impactor was removed

Main sources:

- Archives from large telescopes (e.g. CFHT, DECam)
- Archives from asteroid surveys (e.g. Pan-STARRS)
- Internal archive from cooperating observatories

One year of objects removed from the Risk List

Object	Date	PS_0	Telescope	Instrument	Archive
2007 UW1	2013-11-28	-3.4	CFHT	MegaCam	-
2013 XE2	2013-12-10	-4.0	PS1	GPC	PS1
2008 CK70	2013-12-18	-3.1	CFHT	MegaCam	CADC
2013 BP73	2013-12-20	-3.8	SDSS	SDSS	CADC
2013 YC	2014-01-22	-2.9	VLT (UT1)	FORS2	-
2014 BD33	2014-01-29	-4.2	PS1	GPC	PS1
2004 BX159	2014-02-18	-4.5	CFHT	MegaCam	CADC
2014 AF16	2014-03-11	-2.4	VLT (UT1)	FORS2	-
2012 HP13	2014-04-09	-6.6	VLT (UT1)	FORS2	-
2014 DN112	2014-05-01	-3.6	VLT (UT1)	FORS2	-
2014 HM129	2014-05-22	-4.2	VLT (UT1)	FORS2	-
2014 HM187	2014-05-28	-4.5	VLT (UT1)	FORS2	-
2012 VU76	2014-06-09	-6.1	VLT (UT1)	FORS2	-
2013 YD48	2014-06-30	-4.8	VLT (UT1)	FORS2	-
2014 LU27	2014-07-17	-2.4	PS1	GPC	PS1
2014 PB58	2014-08-12	-4.5	PS1	GPC	PS1
2014 QF392	2014-08-14	-8.0	PS1	GPC	PS1
2014 QJ392	2014-08-14	-6.1	PS1	GPC	PS1
2014 RC	2014-09-04	-7.0	PS1	GPC	PS1
2014 KC46	2014-10-30	-4.1	LBT	LBC	-

20 objects
in less than one year

and counting…

OPPORTUNITIES

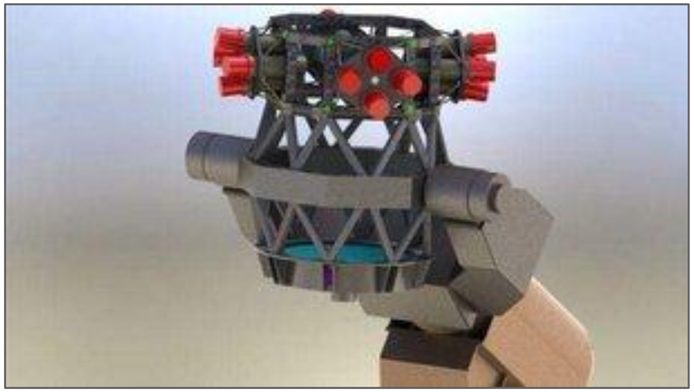
- NEO System as an evolving environment: *(e.g precoveries, short-arc orbit determination algorithms, imminent impactors)*

- NEOCC Priority List as a Gaia simulator

- Collaborating observatories and observing campaigns for follow-up observations *(e.g. faint large-uncertainty objects, rapid response systems)*

- Physical Characterization: Synergies with other projects *(e.g. Horizon 2020 NEOShield-2)*

- SSA Fly-eye prototype
  - automated telescope for all sky survey
  - splits image in 16 subfields
  - equivalent to a 1 m-diameter telescope,
  - very large field of view: 45 square deg
  - 21.5 limiting magnitude
  - detect objects >40m at least 3 weeks before impact
  - detailed design on-oing



KEEP ON ROCKING !

thank you