The EURONEAR project and its successful collaboration with students and amateurs

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IAC & IMCCE associated

ING Seminar
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Brief introduction to asteroids

Johann Daniel Titius

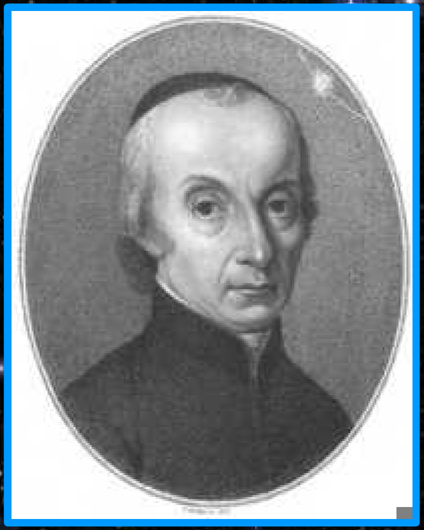
Johann Elert Bode

1750-1800: "The missing planet"

Titius-Bode Law (1766):

$a = 0.4 + 0.3 \cdot 2^n$
$n = -\infty, 0, 1, 2, \ldots$

n	calc	obs	planet
-oo	0.4	0.39	Mercury
0	0.7	0.72	Venus
1	1.0	1.00	Earth
2	1.6	1.52	Mars
3	2.8	??	??
4	5.2	5.20	Jupiter
5	10.0	9.54	Saturn
6	19.6	19.2	Uranus (1781)



Giuseppe Piazzi

1800/1801 (31 Dec/1 Jan)!

The priest Giuseppe Piazzi discovered a new “star”. The following nights he observed this star was moving, so he announced it as a new “comet”, after which this object was lost, due to few observed nights and bad weather which prevent him to predict future movement.

Carl Friedrich Gauss

Dec 1801:

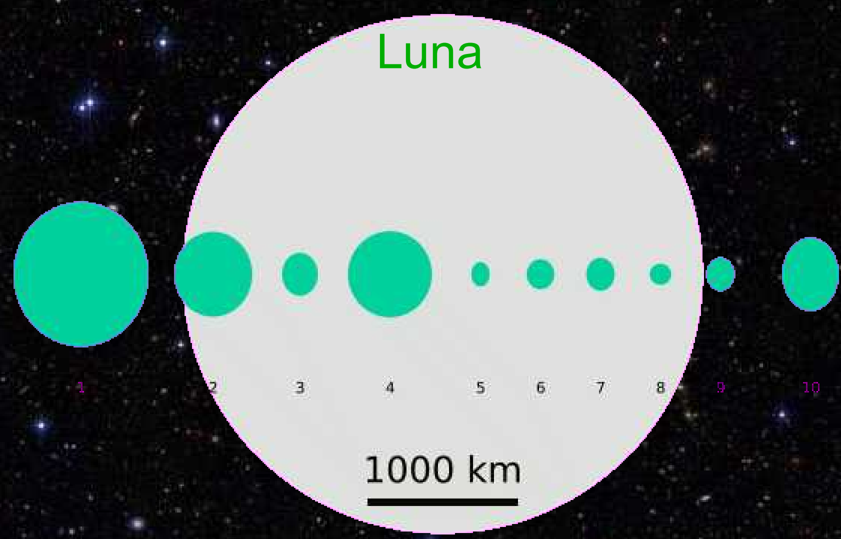
Following months of hard work, the German mathematician Carl Gauss (only 23 years old!) developed a method to predict the position of the new object which was found immediately only 0.5 degrees away from its prediction!

The object was named "Ceres", being identified with the lost “comet” between Mars and Jupiter.

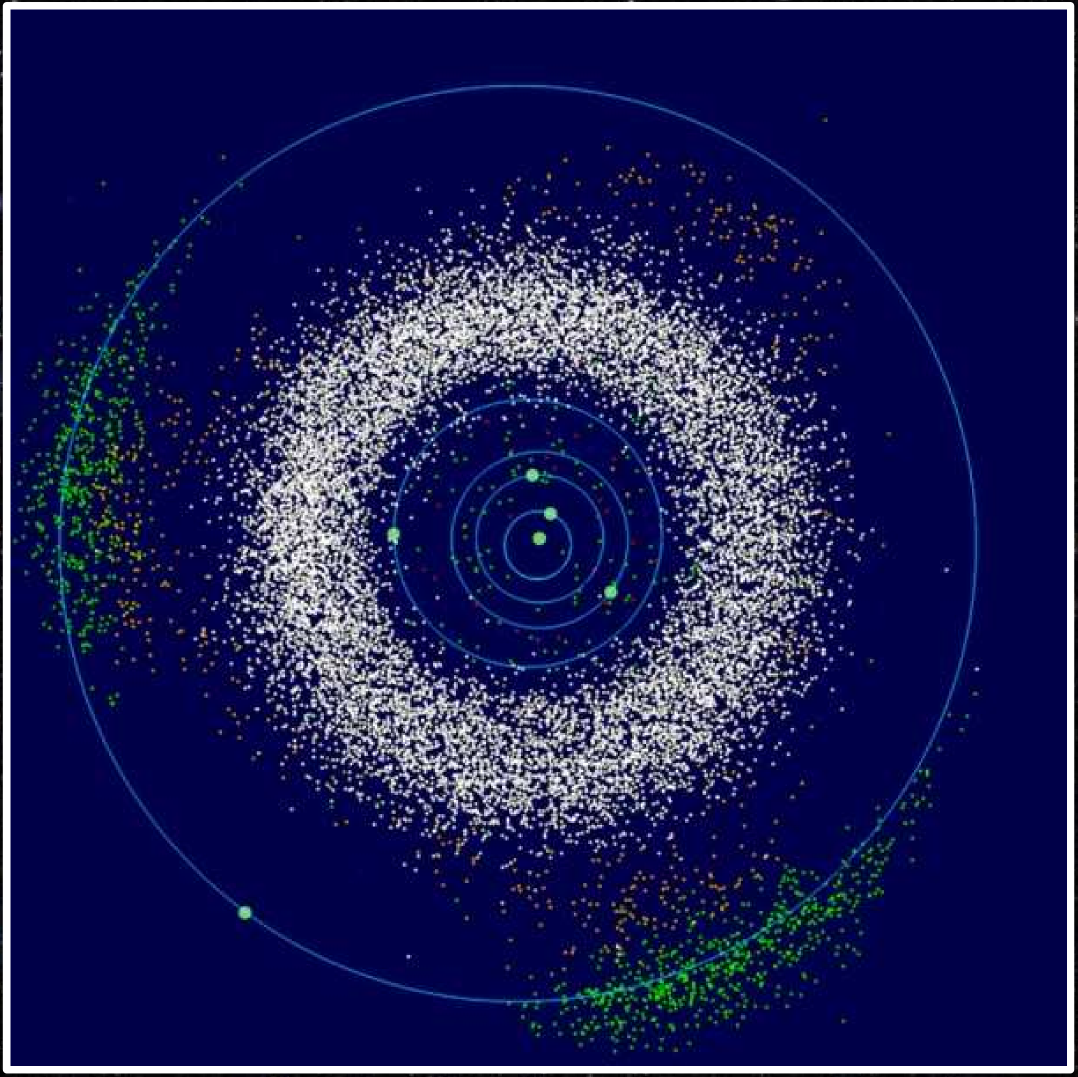
The first 10 asteroids discovered in 50 years

1801: (1) Ceres (Piazzi)
1802: (2) Pallas (Olbers)
1704: (3) Juno (Harding)
1807: (4) Vesta (Olbers)
a long 38 years pause....

1845: (5) Astraea (Hencke)
1847: (6) Hebe (Hencke)
1847: (7) Iris (Hind)
1847: (8) Flora (Hind)
1848: (9) Metis (Graham)
1849: (10) Hygea (de Gasparis)



Inner Solar System view and the Main Belt



Dec 2012:

More than **610.000** known asteroids !

More than ...

- 570,000 MBAs
- 9,200 NEAs
- 1,350 PHAs
- 300-500 VIs

... known objects!

Data from Minor Planet Center (MPC)

Few definitions

MBA = Main Belt Asteroids:
asteroides with 2.0 < a < 3.5 AU and small e (quasi-circular orbits)

NEA = Near Earth Asteroids: asteroids with perihelion distance q<1.3 AU;

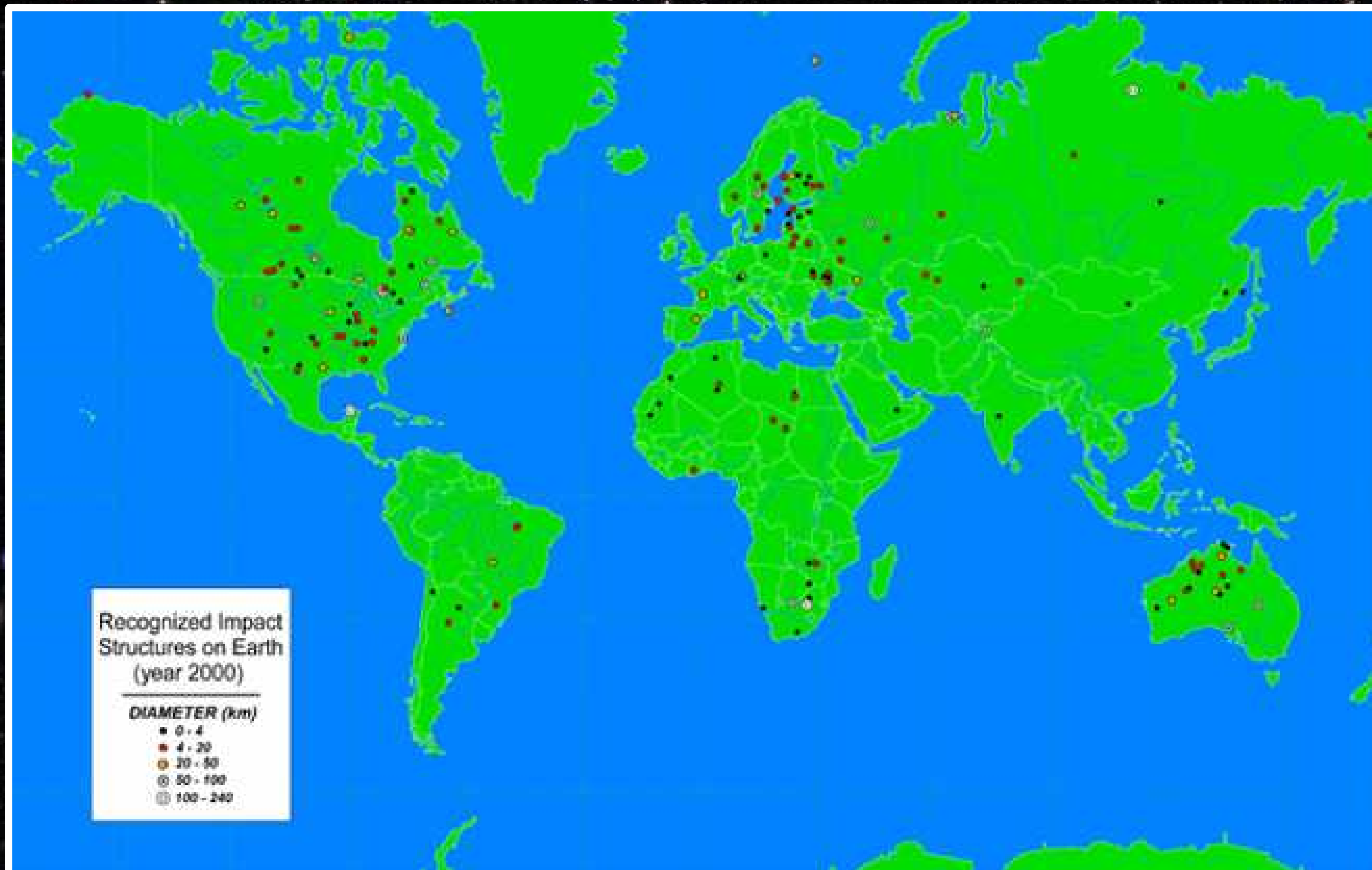
PHA = Potentially Hazardous Asteroids:
NEAs with MOID < 0.05 AU and H < 22 mag.
MOID = minimum orbital intersection distance (between two orbits);
H = absolute magnitude: magnitude of an asteroid hypothetically
placed at 1 AU from Sun & Earth having a phase angle 0 deg;
AU = Astronomical Unit = average distance Earth – Sun (150.000.000 km)

VI = Virtual Impactors:
PHAs or NEAs with impact probabilities given the current orbit uncertainty.

3 main groups NEAs:

Atens = Earth-crossing NEAs with a < 1 AU
Apollos = Earth-crossing NEAs with a > 1 & q < 1.017 AU
Amors = Earth-approaching NEAs with a > 1 AU & 1.017 < q < 1.3 AU

Why Near Earth Asteroids?



Earth Impact Database: 160 known craters!

(University of New Brunswick, Canada, http://www.passc.net/EarthImpactDatabase)

Effects of a possible impact of Earth with an asteroid...

Table I.1 Impact Effects

SIZE	IMPACT FREQUENCY	EFFECT AND REFERENCES
1 mm–1 cm (sand grain/pebble)	1 per second (thousands per day)	Bright "shooting star," destroyed in the atmosphere. Chapters 1, 3, and 4.
1 cm–0.5 m (rock)	1 per hour (more than 10 per day)	Fireball, most destroyed in the atmosphere. Chapters 4 and 5.
0.5–1 m (microwave oven)	1 per day	Bolide (brilliant fireball), most destroyed in the atmosphere. Chapter 5.
1–10 m (automobile)	1 per 10 years	Stony or icy boulders can be destroyed in the atmosphere; iron boulders and some others reach the surface and can crash through a roof or damage a car. Chapters 5 and 7.
10–50 m (house)	1 per 100 years	Local disaster, equivalent to several Hiroshima-sized bombs. Chapter 5.
50–100 m (football field)	1–2 per 1000 years	Regional disaster, equivalent to the Meteor Crater or Tunguska event (about 15 megatons of TNT). Chapters 2, 3, and 9.
100 m–1 km (small village)	1 per 50,000–500,000 years	Continent-size disaster, equivalent to thousands of megatons of TNT. Chapters 2, 3, and 5.
1–10 km (small city)	1 per 10–100 million years	Mass extinction, threat to all life (millions of megatons of TNT). Chapter 9.
>10 km	<1 per billion years	Threat to the continued habitability of the planet. Chapter 9.

(Sumners 1999, "The Cosmic Pinball Risk")

Fortunately, only some artist concept of a hypotethical catastrophic impact of an asteroid with the Earth (Don Davis, NASA)

Barringer Meteor Crater
Arizona US
about 50,000 yrs ago

Carangas, Peru
(close to lake Titicaca)
15 Sep 2007

1.2 Km diameter crater, 170m deep
Asteroid ~ 50m diam
Energy 2.5 MT TNT ~ 150x Hyroshima

10m crater provoked by
3m meteorite energy 10T TNT

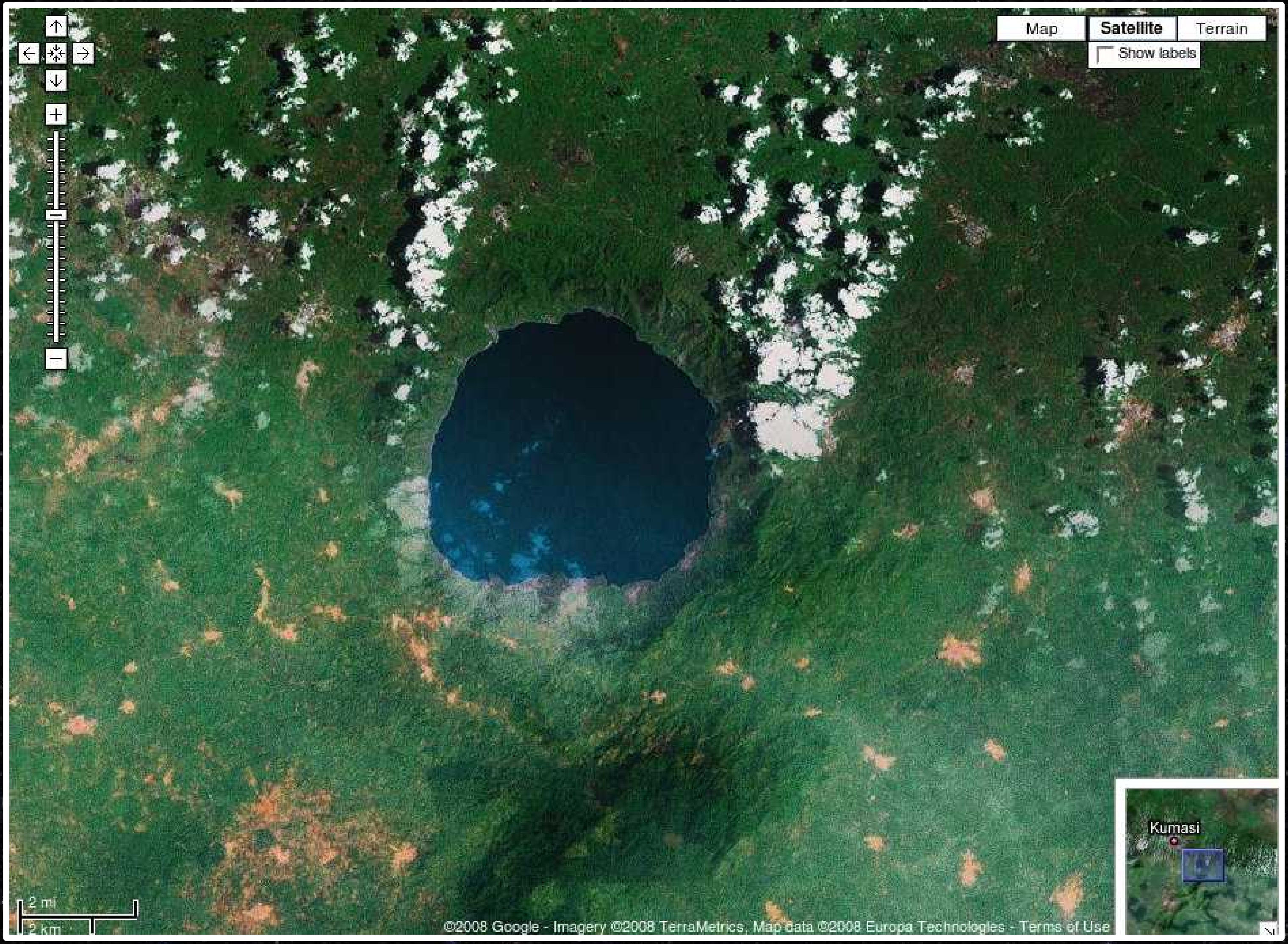
Crater Gosses Bluff, Australia

142 millon years, 10 km diam

Crater Manicouagan, Canada

212 millon years, 72 km diam

Crater and lake Bosomtwe, Ghana



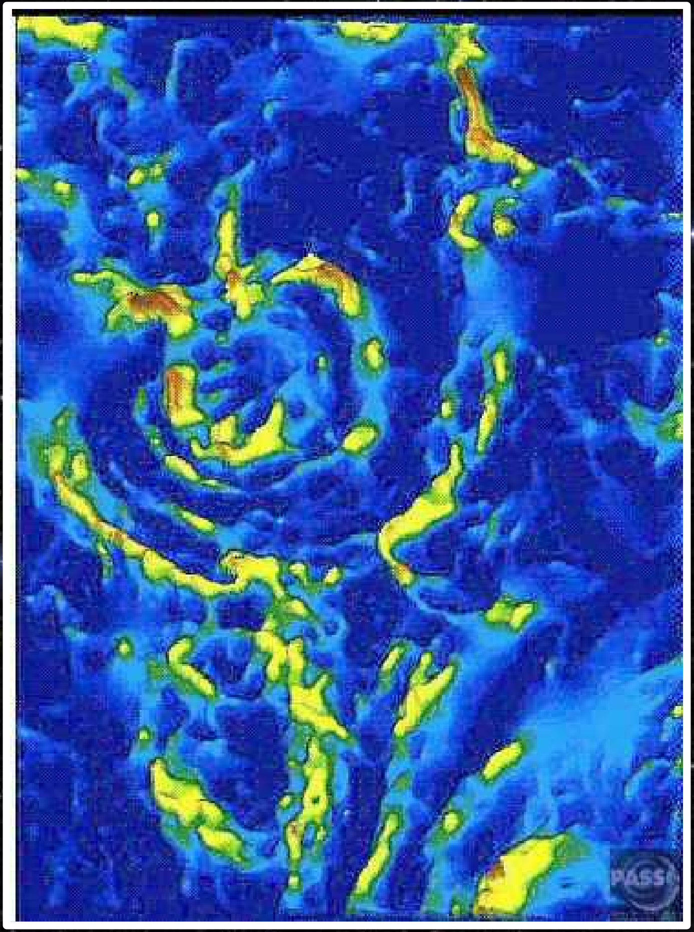
1.2 million years, 10 km diam

30 Jun 1908
Tunguska Siberia, Russia

A huge atmospheric explosion
(5-30 MT TNT ~ 1000 Hiroshima bombs)
completely burned trees over an area of
2.150 km², broking windows and
blowing people up to 400 km away!

There are many theories about this
Event, with the most accepted being
Caused by a small comet or a meteorite
80m diam which exploded few km
above the Earth surface.

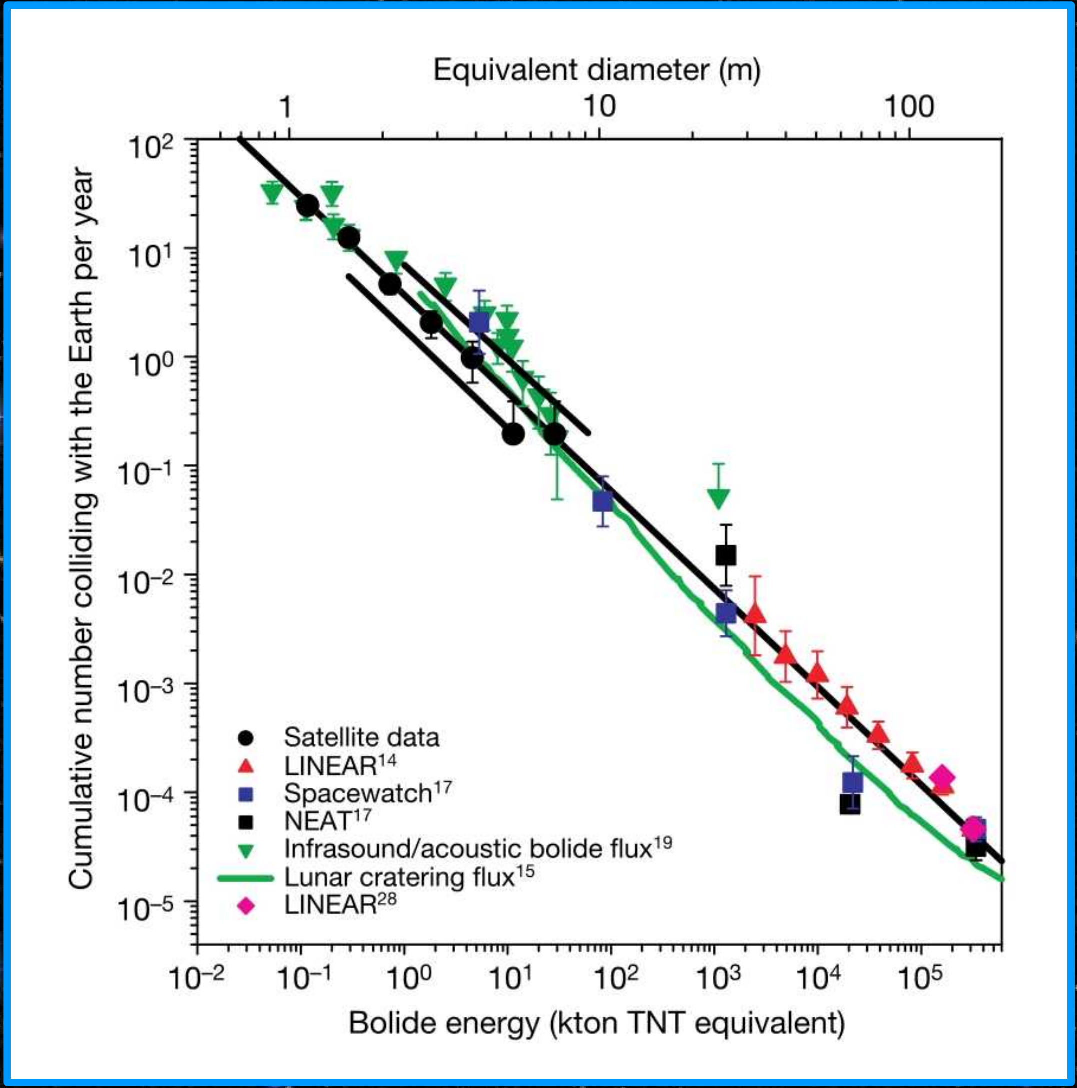
65 million years ago Chicxulub, Peninsula Yukatan, Mexico



Map of gravity anomaly
of the Chicxulub impact structure
(USGS 2003)

The researchers found a big 180km diam submarine structure associated with a cosmic impact. The size of the asteroid was estimated at ~10km. 65 million years coincides with the famous mass extinction of the dinosaurs!

The impact frequency



Earth impact probabilities
With meteorites and NEOs
as big as 200m diam

(Brown et al, 2002)

Tunguska event:
each ~1000 years

Chicxulub event:
each 100 milliones years

The initial SPACEGUARD project

> Stated in 1994 as an international project but funded mainly by NASA since 1997;

> The original goal: to discover 90% of the entire NEA population > 1km within one decade;

The first 5 U.S. surveys dedicated to discovery of NEAs:

> Catalina (Catalina 0.7m, Mt. Lemmon 1.5m & Siding Spring 0.5m & 1m)
http://www.lpl.arizona.edu/css
> LINEAR (Lincoln Lab, MIT – NASA & US Air Force) 2x1m + 0.5m in Socorro, NM
http://www.ll.mit.edu/LINEAR
> NEAT (NASA/JPL) 1.2m in Maui Hawaii & 1.2m Palomar http://neat.jpl.nasa.gov

> Spacewatch (LPL Univ. of Arizona) 0.9m & 1.8m at Steward Observatory
http://spacewatch.lpl.arizona.edu
> LONEOS (Lowell Observatory) - 0.6m in Flagstaff, Arizona
http://asteroid.lowell.edu/asteroid/loneos/loneos.html

> The European contribution: quasi zero – less than 1% in discovery, few local initiatives, no telescope dedicated to permanent observations of NEAs (discovery or followup)!

Other NEO surveys and follow-up work

> La Sagra, Spain (Observatorio Astronomico de Mallorca, OAM - public outreach site)
currently the most prolific European NEA survey (49 discovered NEAs)
Three 0.45m telescopes; http://www.minorplanets.org/OLS

> PIKA, Slovenia (Crni Vrh Observatory) http://www.observatorij.org
0.6m remotely controlled telescope (20 discovered NEAs)

> CINEOS Italy (Campo Imperatore Rome Observatory & IASF)
0.6m, 0.9m & 1.8m http://sirio.rm.astro.it./cimperatore/en/cineos.html

> Ondrejov Observatory (Czech Republic)
0.65m telescope http://sunkl.asu.cas.cz/~ppravec

> KLENOT, Czech Republic (Klet Observatory) - 1m telescope http://klenot.klet.org

> Bisei Astronomical Observatory, Japan
0.35m & 1m http://www.spaceguard.or.jp/BSGC/eng

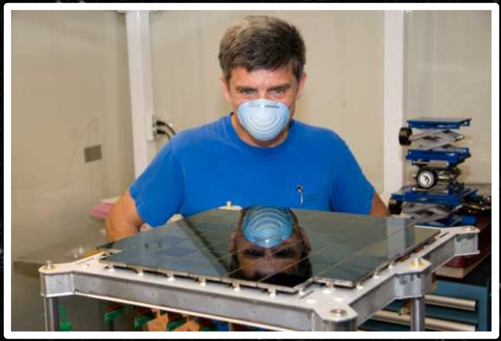
> Sormano Observatory, Italy - 0.5m http://www.brera.mi.astro.it/sormano

> OTESS, USA (Goodricke-Pigott Observatory – Roy Tucker)
3x35cm automated http://gpobs.home.mindspring.com/gpobs.htm

Present y future surveys (NEAs & others) lead by the U.S.

> Pan-STARRS – Panoramic Survey Telescope & Rapid Response System:
Pan-STARRS 1 - Large field of view 3 deg 1.8m diam telescope;
Huge mosaic camera 64 x 64 CCDs each of 600x600 pixels (1400 Mpix)
(OTA – new orthogonal transfer array technology to read very fast);
University of Hawaii's Institute for Astronomy, Haleakala, Maui, Hawaii Islands;
PS1 Science Consortium – 11 institutions from US, UK, Germany and Taiwan;
Pan-STARRS 4 – to include four Pan-STARRS 1 telescopes by ~2017.

Pan-STARRS 1 camera

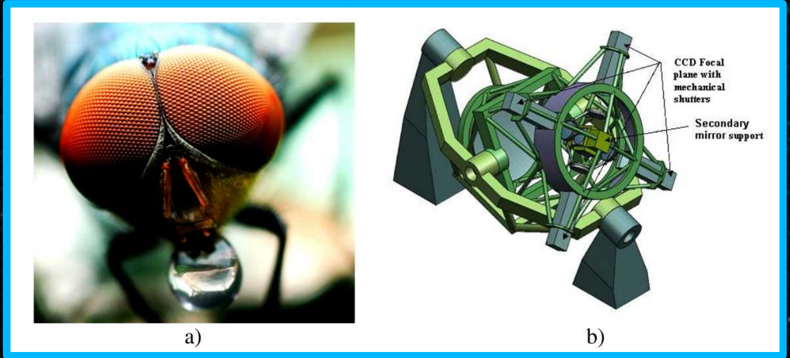


> LSST – Large Synoptic Survey Telescope:
Large field 3.5 deg 8.4m diam telescope able
to image the whole sky every 3 nights in 5 filters!
Huge mosaic camera (3200 Mega pixels)
producing 30 TB of data (about 60 laptop HDDs)
every clear night!
LSST Consortium includes presently 36 US institutions;
To be installed in Cerro Pachon, Chile ~2017.

LSST rending

Plans for ESA 1m survey

> ESA NEO-SSA –
a project of the European Space Agency

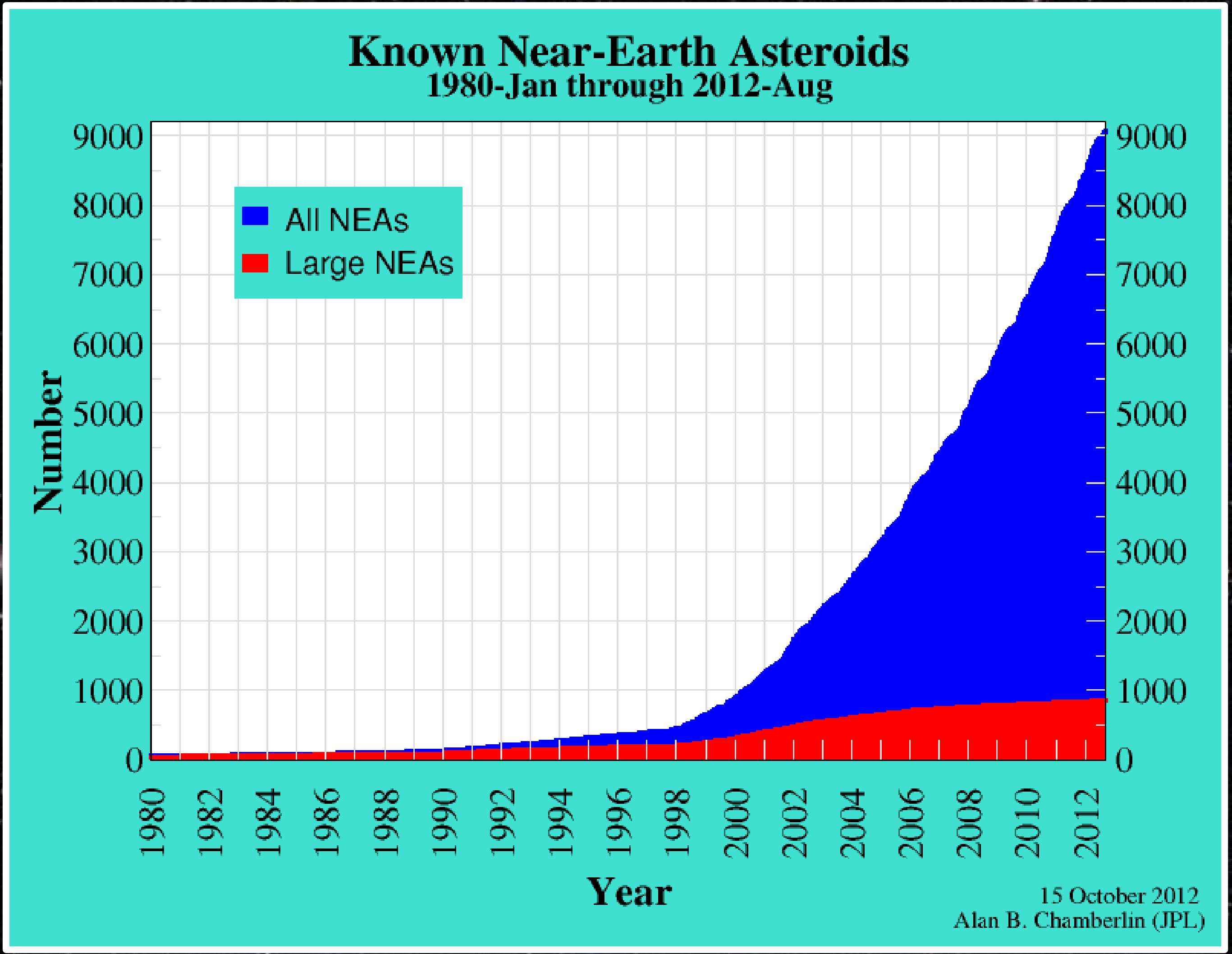


TELAD “fly-eye” concept (Cibin et al 2012)

Near Earth Object - Space Situational Awarness program:
Designed mainly for discovery and tracking space debris, it also covers NEOs;
TELAD – very large field of view 6.5 deg 1m diam telescope
Introducing a new design “fly-eye” telescope concept which splits the beam in 16 sub-fields, thus one can use for each small field correctors and normal cameras.
Introducing a new “dynamical fence of optical sensors” concept alowing for one telescope to scan 49x14 sq. deg. from 14 pointings in 42s time using 1s exposures necessary to fence against fastest (1000"/s) low Earth orbit objects.
For NEOs, the aim is to reach V=21.5 which allow detection of Tunguska-size objects at 0.2 AU (~3 weeks warning time)

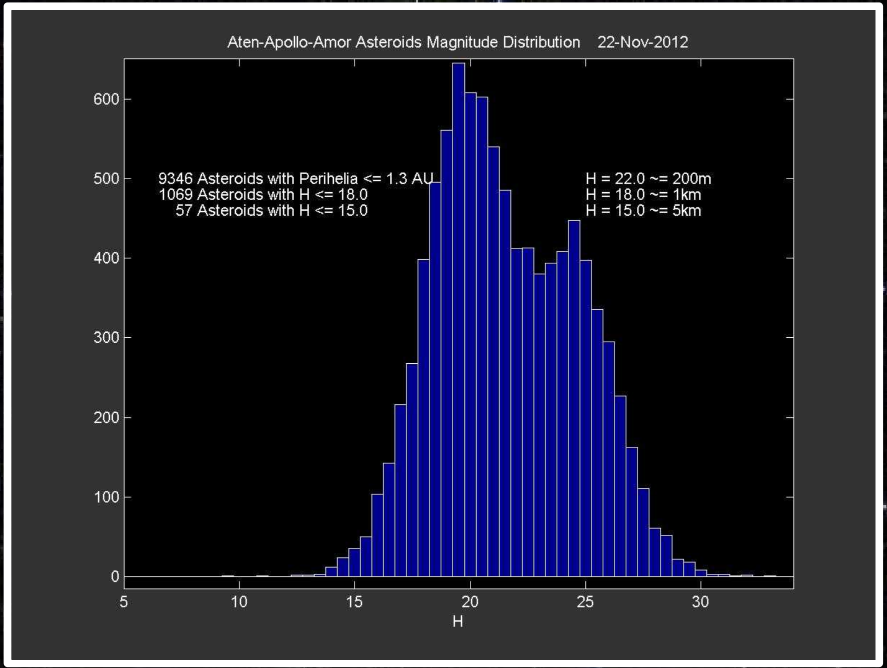
Mosaic camera (256 Mpix) pixel scale 1.5"
Italian consortium: CGS SpA (private space company), INAF, DM Pisa, INAF-CNR.
Probable to receive European funding to build one TELAD prototype telescope;
If successful, the aim will be to build a 1m TELAD network including 10 telescopes!

NEA discovery statistics



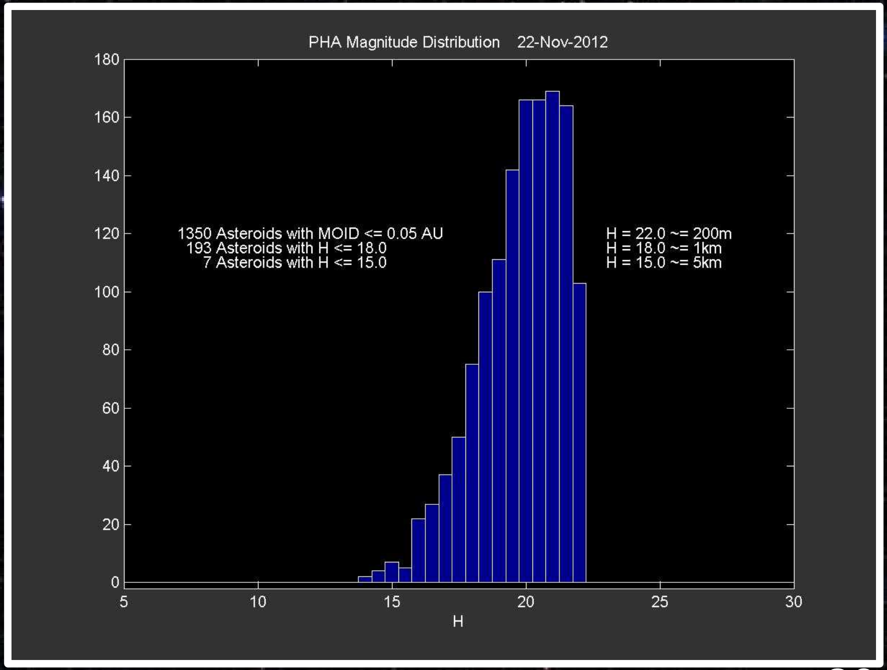
More than 9000 known NEAs (NASA/JPL http://neo.jpl.nasa.gov)

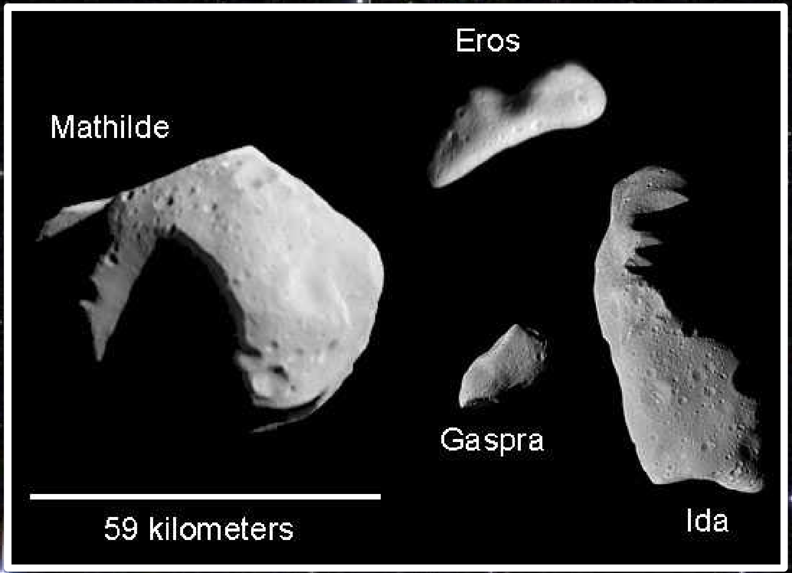
NEA discovery statistics



NEA and PHA distribution
in absolute magnitude

(EARN http://earn.dlr.de/nea)

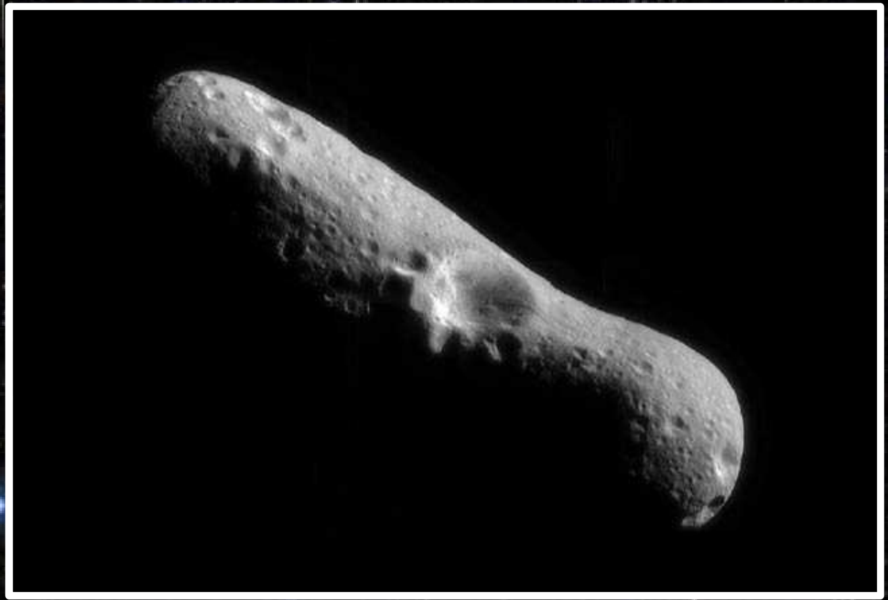


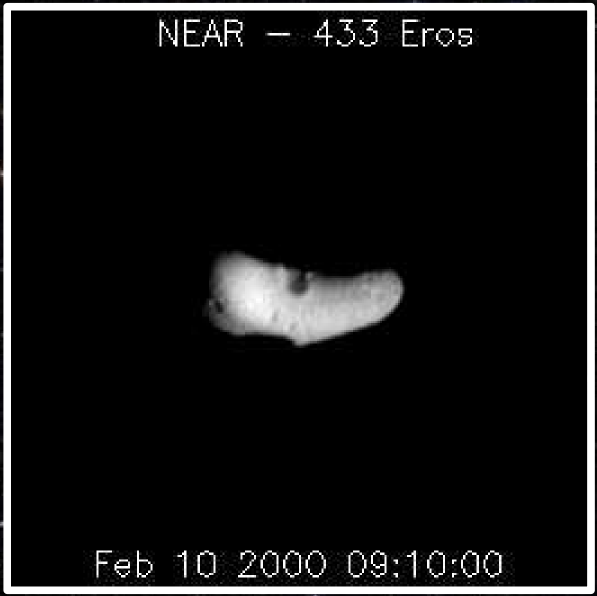


Asteroids & NEAs visited by space missions:

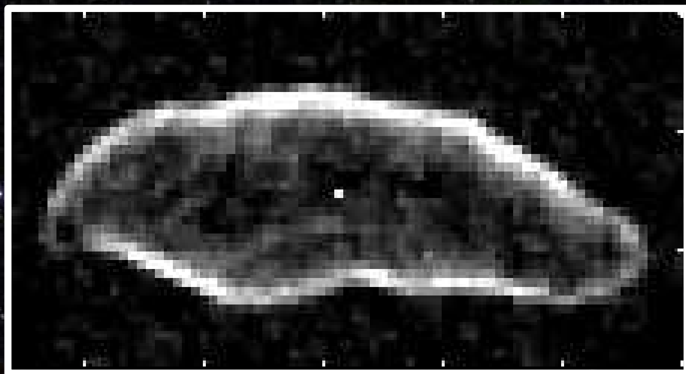
(951) Gaspra – Galileo 1991
(243) Ida – Galileo 1993
(253) Mathilde – NEAR 1997

NEA (433) Eros – NEAR 2000

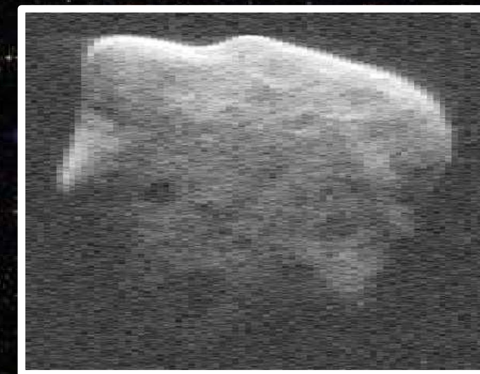




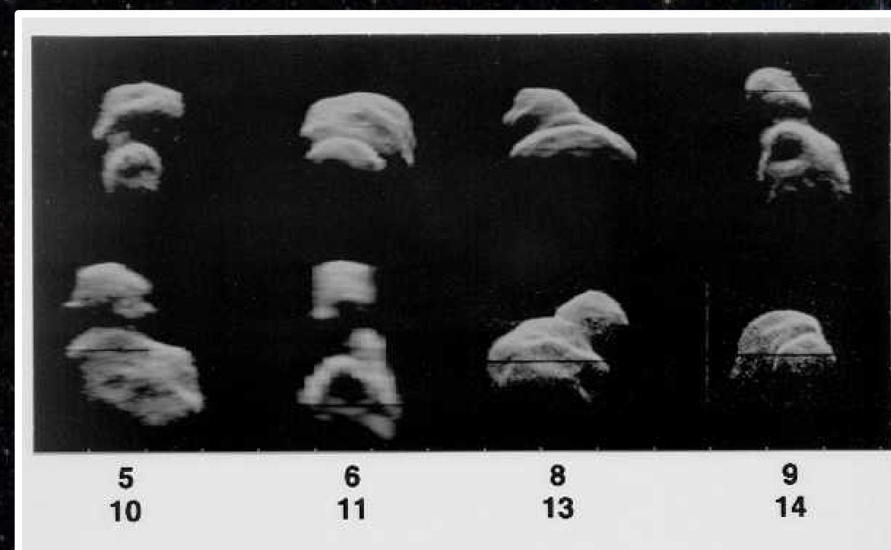
NEAs observed with radar by NASA



NEA (1620) Geographos – Goldstone 1994



PHA (53319) 1999 JM8 – Goldstone 1999



PHA (4179) Toutatis – Goldstone 1992 (~5km size, one of the most dangerous)

What is EURONEAR?

The **EURO**pean **N**ear **E**arth **A**steroid **R**esearch

> A project to establish an European coordinated network
to contribute in NEAs research (astronomers, students, amateurs, governments, society, etc);

> Proposed to study orbital and physical properties of NEAs;

> The “dream”: 2 automated telescopes in both hemispheres;

> A project aimed also to education and public outreach;

> Born in May 2006 at IMCCE/Obs de Paris (initiated by
O. Vaduvescu and M. Birlan).

EURONEAR – Scientific Goals

A: Orbital properties: amelioration and secular evolution:

1) Securing the orbits of newly discovered objects;
2) Follow-up and recovery of NEAs and PHAs in most need of data;
3) Data mining existing imaging archives (available online);
4) Additional discovery of many MBAs and some NEAs.

B: Physical properties via photometry, spectroscopy
and polarimetry: rotation, size, mass, binarity, albedo,
taxonomy, etc.

EURONEAR – Results

> Observations: need telescopes (NEA-friendly TACs or big funding for new dedicated facilities):

> Data mining of existing archives (needs only internet :-)

> Education and public outreach: need only dedicated students and amateurs;

> Publications and science: 15 papers, 50 MP(E)Cs, 15 international conferences during the last 6 years;

> Glory and fame for saving the world :-)

Observing runs within the EURONEAR network

Observing NEAs from 5 countries with 15 telescopes:

> Cerro Tololo, Chile - Blanco 4m (June 2011);
> Isaac Newton Group, La Palma - WHT 4.2m (2011,2012);
> Isaac Newton Group, La Palma - INT 2.5m (2009-present);
> La Silla, Chile - ESO/MPG 2.2m with WFI camera (Mar 2008);
> TLS Tautenburg, Germany - Schmidt 2m with CCD (2012);
> Las Campanas Observatory, Chile - Swope 1m (3 runs 2008);
> Cerro Tololo, Chile - Yale 1m telescope (May 2008);
> La Silla Observatory, Chile - ESO 1m (Aug 2007);
> Cerro Armazones Observatory, Chile - 0.84m (Nov 2007);
> Haute Provence Observatory, France - 1.2m (2007-2012);
> Pic du Midi Observatory, France - T1m 1m (2006-2012);
> Argelander Institute for Astronomy, Bonn, Germany - 0.5m (2011-2012);
> Galati Public Outreach Observatory, Romania - 0.40m (2011 - present);
> Bucharest Urseanu public outreach Observatory, Romania – 0.25m and 0.30m telescopes (started 2006).

Observing runs and network (2)

Six papers including 20+ EURONEAR observing runs:

1-2. Observing NEAs with a small telescope

> Big surveys overview, planning observations, data reduction, catalogs, etc

> Application with York University 0.6m telescope (Toronto)

> Romanian Astronomical Journal, Vaduvescu 2004 and 2005;

3. EURONEAR First Results

> Two runs 1m telescopes, (Pic T1m and OHP 1.2m)

> 17 observed NEAs, planning tools, reduction pipeline,

> astrometry, O-C calculator, etc

> Planetary and Space Science, Vaduvescu et al. 2008

Observing runs and network (3)

4. Paper presenting 162 NEAs observed during regular runs
   > 55 nights total (1500 reported positions)
   > Using eight 1-2m telescopes (INT 2.5m, ESO 2.2m, OHP 1.2m, Swope 1m, CTIO 1m, Pic 1m, ESO 1m, OCA 0.85m)
   > Astronomy & Astrophysics, Birlan et al. 2010, including 9 students and amateurs

5. Recovery, follow-up and discovery of NEAs and MBAs using 3 large field 1-2m telescopes (Swope 1m, ESO 2.2m & INT 2.5m)
   > 100 NEAs, 558 known MBAs, 628 unknown objects (including 58/500 MBA discoveries and 4-16 NEA candidates)
   > Some MBA and NEA observability statistics using 1-2m scopes
   > Planetary and Space Science, Vaduvescu et al. 2011, including 13 students and amateurs

More observing runs and network (4)

6. Total of 741 NEAs observed presently (Sep 2012) by the EURONEAR network (Nov 2012)

> To include 10 new runs taken with 9 telescopes: Blanco 4m MOSAIC-2, WHT 4.2m, INT 2.5m WFC, TLS Tautenburg 2m and OHP 1.2m, Pic T1m, plus 3 educational/amateur scopes in Bonn 0.5m, Galati 0.4m and Urseanu Bucharest 0.3m.

> To be submitted soon and include 24 co-authors students and amateurs from Romania, Chile, Germany, France, UK, Iran;

> More than 50 MPC and MPEC publications including our NEA and MBA reports;

> About 15 communications in conferences including students/amateurs.

Data mining of imaging archives

Four NEA data-mining projects and papers in collaboration mostly with students and amateurs:

1. EURONEAR: Data mining of asteroids and NEAs:

> Introducing PRECOVERY server.
> Application on the Astronomical Observatory Bucharest Plate Archive - 13,000 plates 0.4m refractor, 1930-2005
> Astronomische Nachrichten, Vaduvescu et al. 2009, 2 students/amateurs

2. CFHT Legacy Survey Archive (CFTHLS) MegaCam survey:

> 25,000 MegaCam mosaic CCD images 3.6m, 2003-2009
> 143 NEAs and PHAs found and reported from 508 images
> Astronomische Nachrichten, Vaduvescu et al. 2011, 6 students/amateurs

Data mining of imaging archives (2)

3. Mining the ESO WFI and INT WFC archives. Mega-Precovery.

> 330,000 mosaic CCD images taken with ESO/MPG 2.2m WFI and the ING/INT 2.5m WFC 1998-2009
> 152 NEAs and PHAs found in 761 images reported to MPC
> prolonged orbits for 18 precovered objects and 10 new opposition recoveries

> Introducing Mega-Precovery server and Mega-Archive: 28 instrument archives (ESO, NOAO, etc) including 2.5 million images to query for known NEAs and other asteroids via Mega-Precovery

> Astronomische Nachrichten (accepted), Vaduvescu et al. 2012, Includes 13 students and amateurs

More data mining of imaging archives (3)

4. Data Mining the SuprimeCam Archive for NEAs

> 50,000 SuprimeCam mosaic CCD images taken with Subaru 8.3m telescope (1999-2010)
> 500 known NEAs to be searched for on 2100 candidate images

> Additionally, scanning some 1000 selected SuprimeCam fields for new NEAs to improve the NEA statistics at the faint end

> Poster presented at ACM2012 meeting in Japan
> To become a paper 2013, collaboration with 14 students/amateurs.

Other topics and papers related to EURONEAR

Four papers related to asteroids and comets lead by some EURONEAR collaborators:

1. Asteroid pairs: Formation of pairs by rotational fission (Pravec, et al. 2010, Nature)

2. Binary asteroids: Distribution of orbit poles of small, inner main-belt binaries (Pravec et al. 2011, Icarus)

3. Main Belt Comets: (596) Scheila in outburst: A probable collision event in the Main Asteroid Belt (Moreno et al. 2011, Astrophysical Journal)

4. Comets and evolution: Spectroscopic observations of new Oort cloud comet 2006 VZ13 and four other comets (Gilbert et al, 2011, Monthly Notices RAS)

Asteroid discoveries and IAU naming

1. About 500 new MBAs from which 58 official based on the ESO/MPG 2.2m 3-night run in 2008 reduced by students and amateurs;

2. First Romanian discoverers of asteroids (2008) lead by two Romanian astronomers from Diaspora in a team of 9 mostly students and amateurs;

3. About 1000 new MBAs from which ~100 to become official based on the INT opposition 3-night mini-survey run in 2012 reduced by 5 students and amateurs;

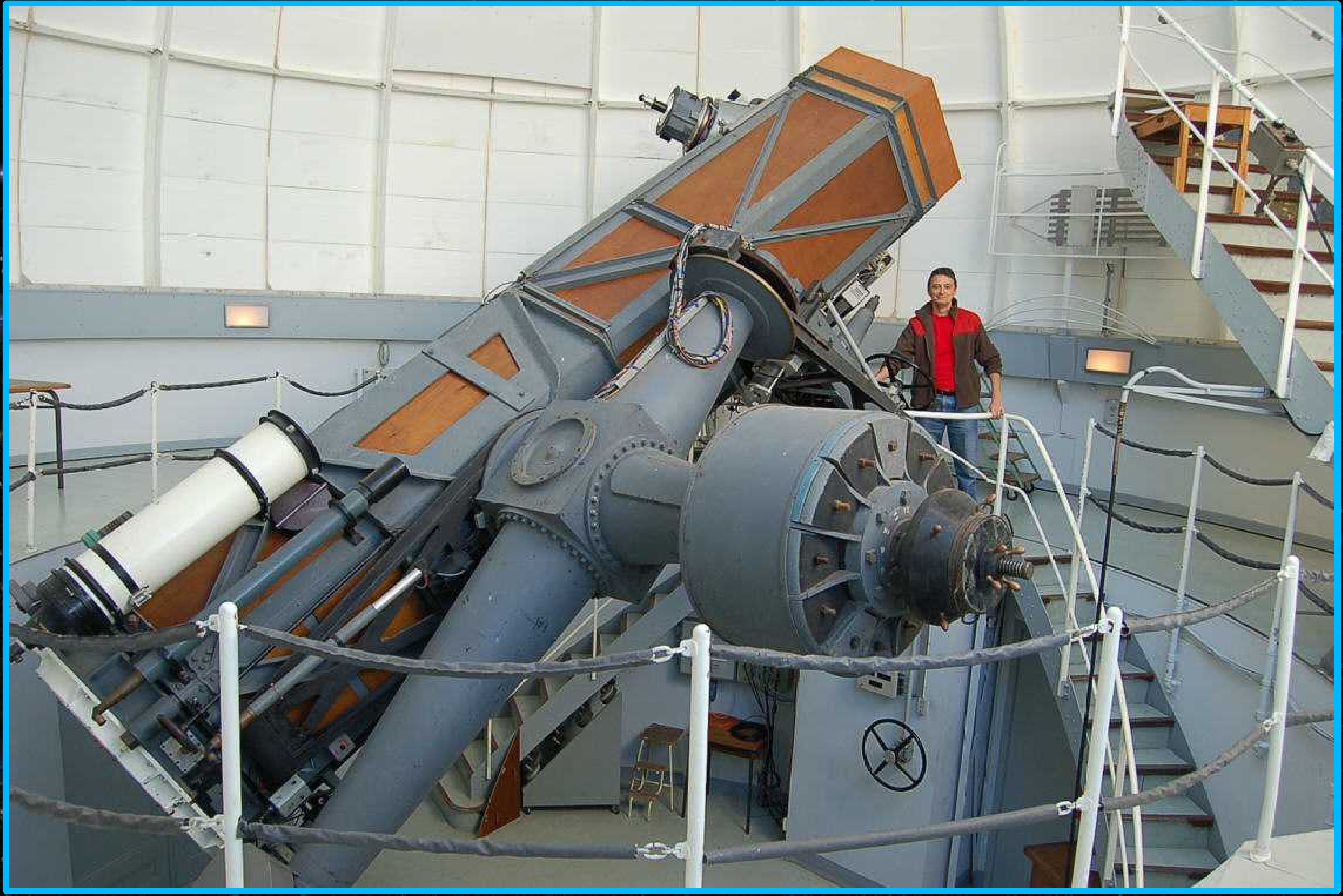
4. First 4 asteroids discovered by Romanians recently named after passed away Romanian astronomers and famous amateurs: (263516) Alexescu, (257005) ArpadPal, (320790) Anestin and (330634) Boico;

Few memories… Pic du Midi 2006

First EURONEAR run

Haute de Provence 2007

EURONEAR run using the old Newtonian 1.2m telescope



Cerro Tololo, Chile 2006

La Silla 2006

Las Campanas 2008

Alex Tudorica, the first Romanian student observing in Chile

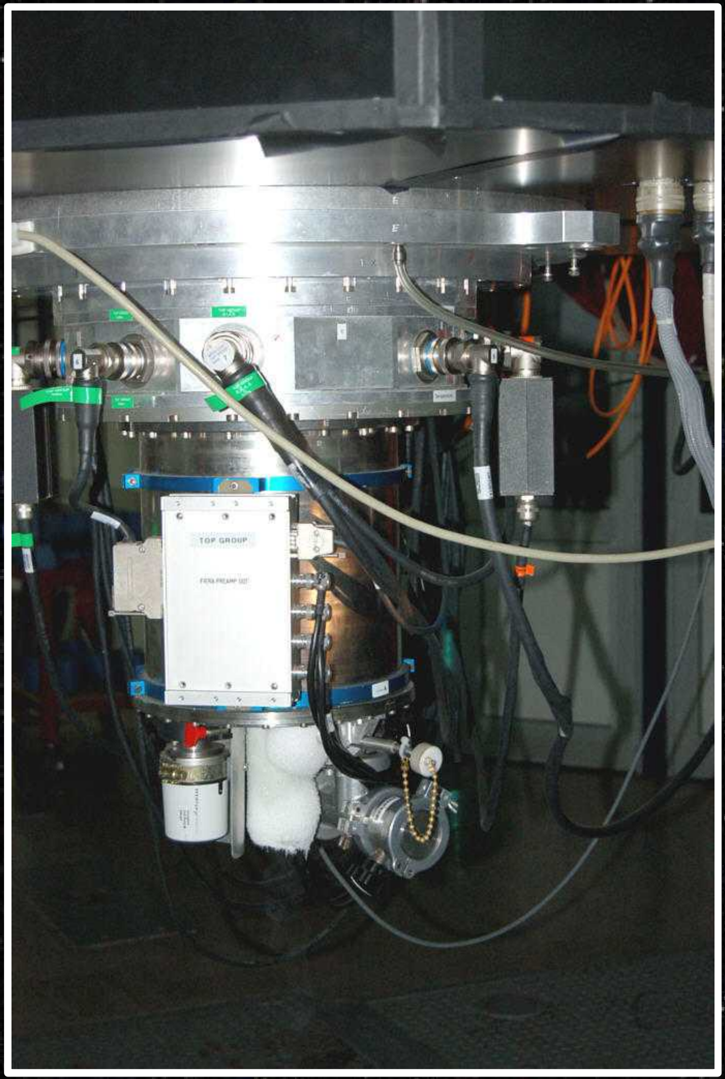
Cerro Tololo 2008

Observers under the Yale 1m telescope

Atacama Dessert, Chile 2008

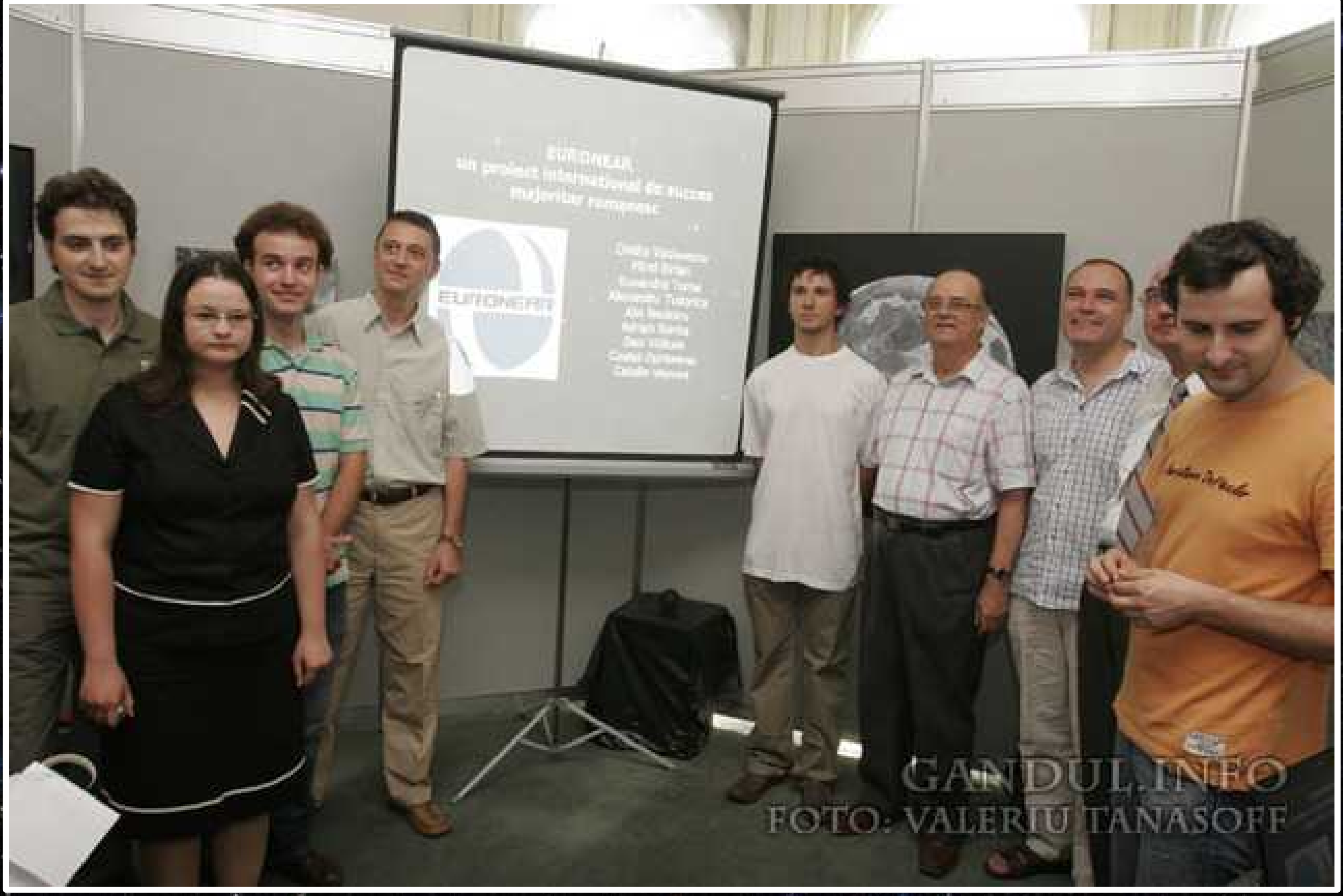
Cerro Armazones 2008
The 40cm and 85cm domes of IA-UCN bellow the E-ELT peak

La Silla 2008
Observers besides the ESO/MPG 2.2m and the WFI camera



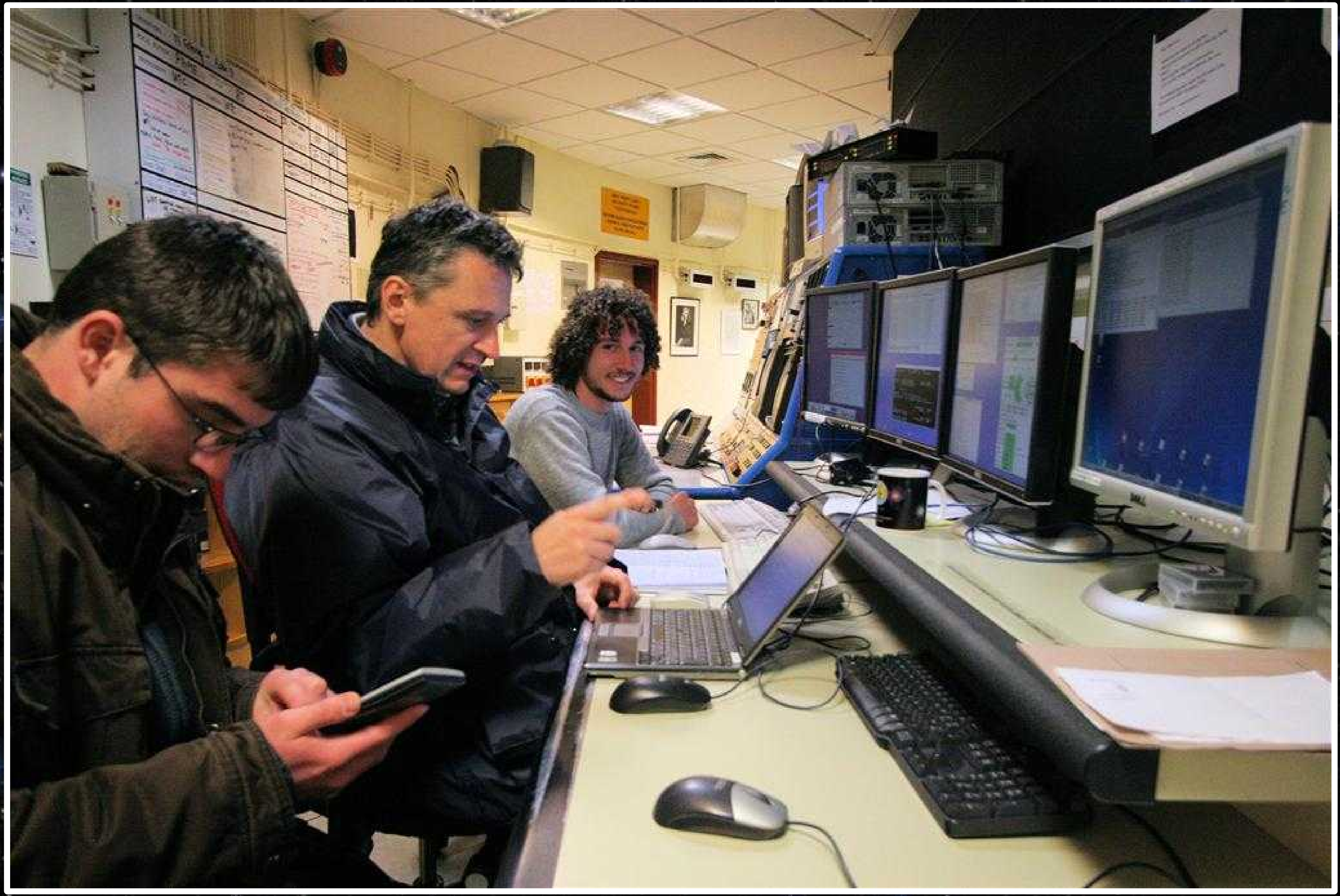
Few memories… Bucharest 2008

First Romanians to discover asteroids using ESO/MPG



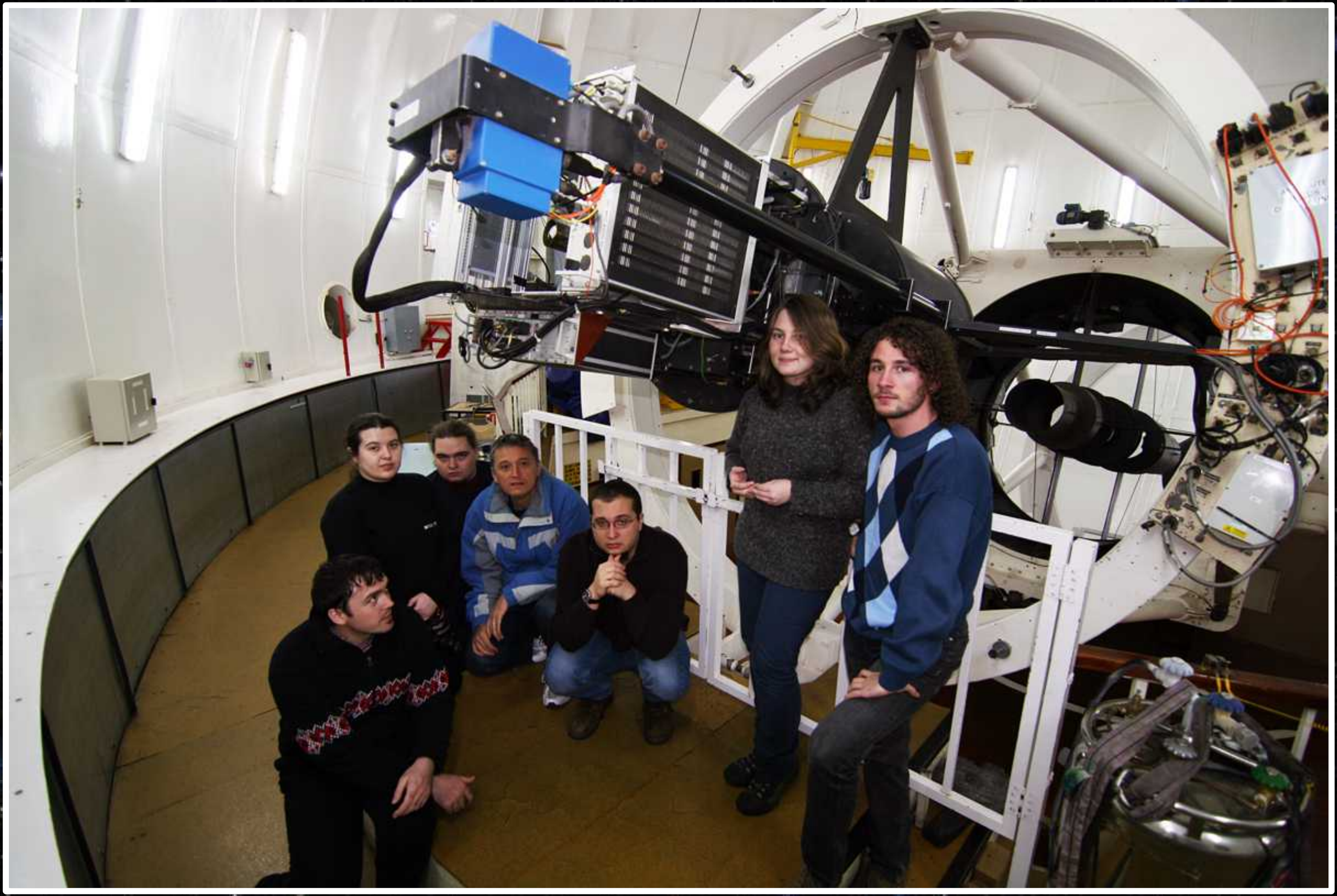
La Palma 2009

First Romanian students observing with the INT!



La Palma 2012

6 Romanian and German students under the WFC



La Palma 2012
Observing visiting students under the INT

La Palma 2012

Milky Way and a meteor above Roque de Los Muchachos

Analysis and measurements

Dedicated software for image processing and field correction:

> THELI (Erben, Schrimer, Dietrich et al, 2005):

- Applied if needed to correct the field and improve very much the astrometry;
- Needed especially for large field and/pr PF cameras (INT WFC, OCA 0.85m, etc);

> SDFRED for Subaru SuprimeCam (Ouchi, Yagi, 2002, 2004);
> Our own IRAF pipeline for image reduction some tasks;

> FIND_ORB (Gray, 2012) and ORBFIT (Millani et al, 2012) for orbits

Analysis and measurements

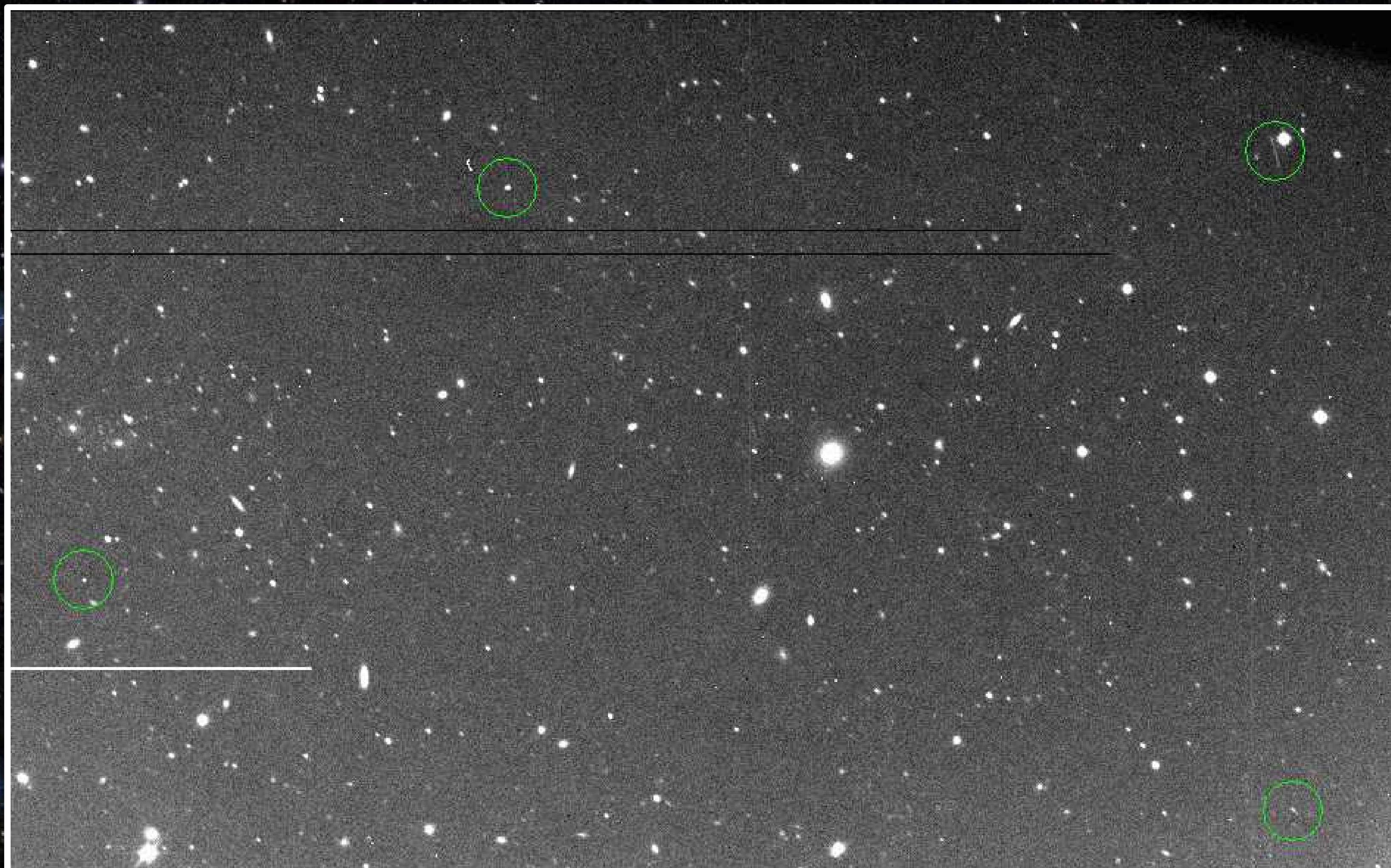
Astrometrica (Raab, 2012):

> To identify fields and resolve astrometry and photometry;
> Easy to learn and use for students and amateurs;
> Detect and measure known objects – MPC database;

> Blink all fields, measure and report:
- the target NEA;
- all known objects identified by software;
- all unknown moving objects, give acronyms;

> All known and unknown objects reported to MPC (astrometry and photometry).

Data reduction
Visual blink with Astrometrica to search for moving objects



Improved astrometry

(Birlan et al, 2010)

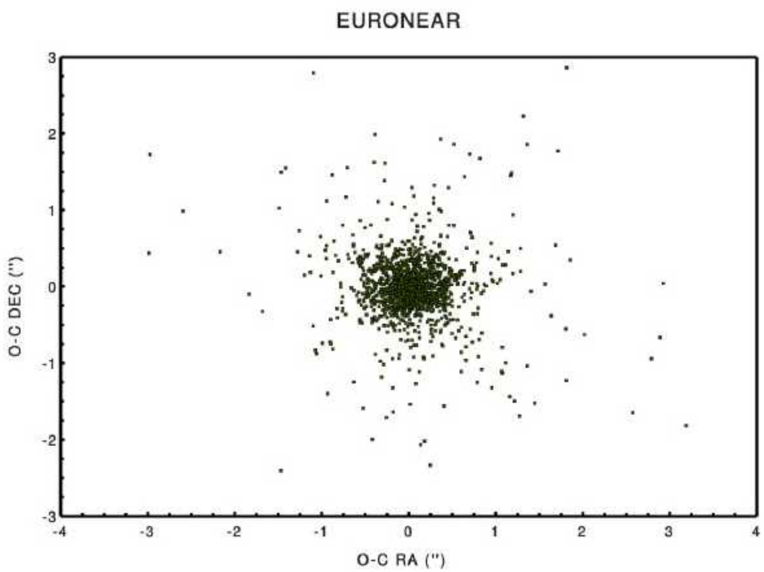


Fig. 2. (o-c) residuals for 1538 positions of 162 NEAs observed in the EURONEAR network. Most of the points are confined within 1″, probing the observational capabilities for all facilities and the accurate data reduction.

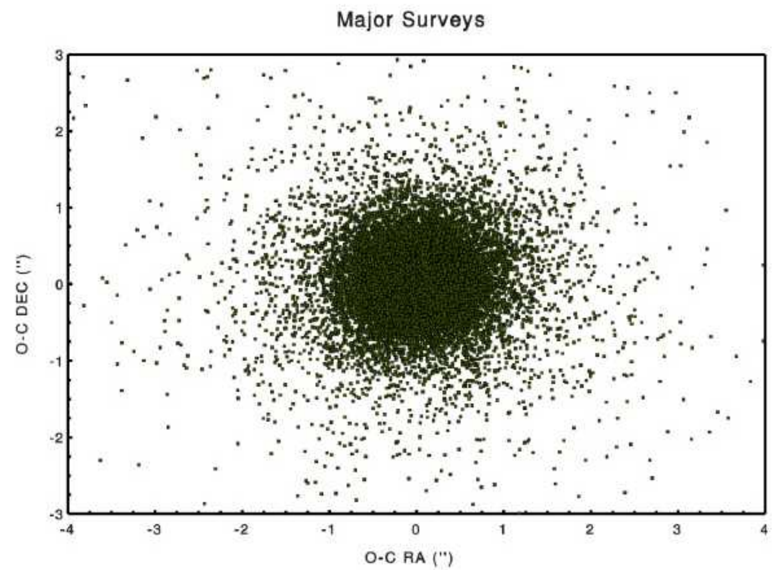
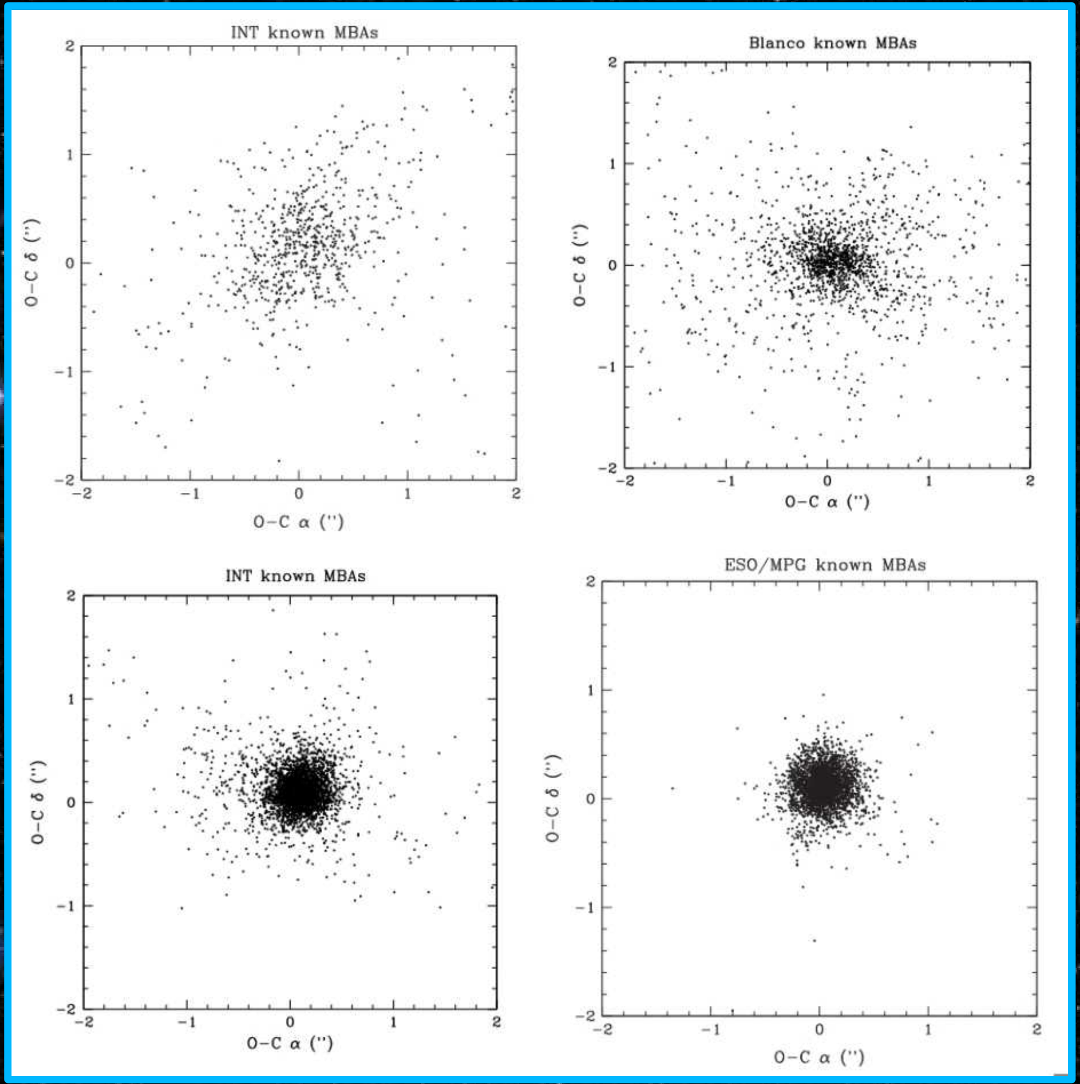


Fig. 3. Over 23 000 (o-c) residuals related with observations performed by all other surveys which observed in the past the same asteroids with EURONEAR. Comparing this plot with the one of Fig. 2, one can observe that EURONEAR observations appear better confined around zero, and this fact is also supported by statistics.

Residuals = O-C (Observed minus Calculated)
Smaller O-Cs => Improved orbits
EURONEAR FWHM 0.4″ versus 0.6″ major surveys

Comparing large field 2-4m facilities



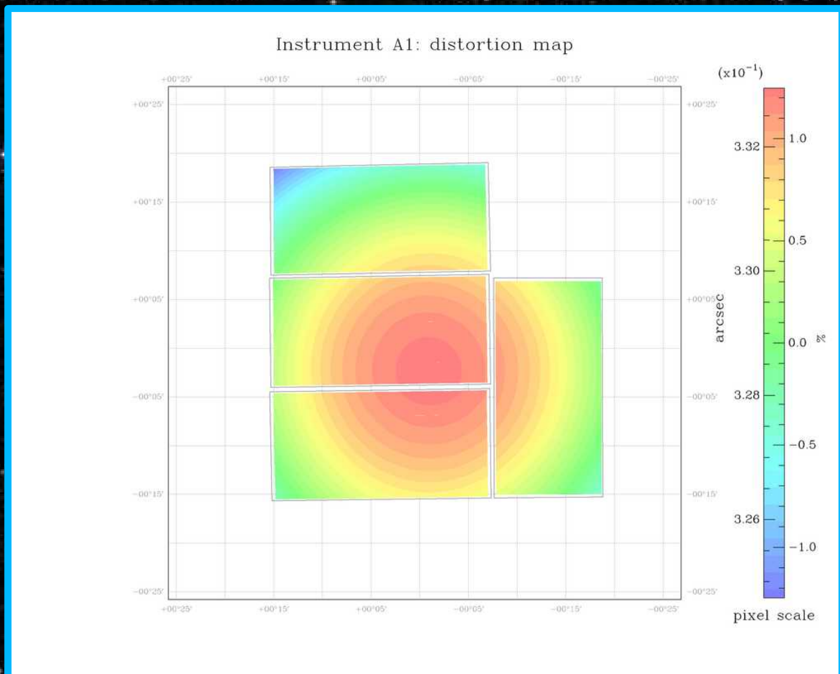
Upper-left: PF WFC field not corrected (2010): RMS = 0.97″

Upper-right: Blanco PF Mosaic-II not corrected (2011): RMS = 0.90″

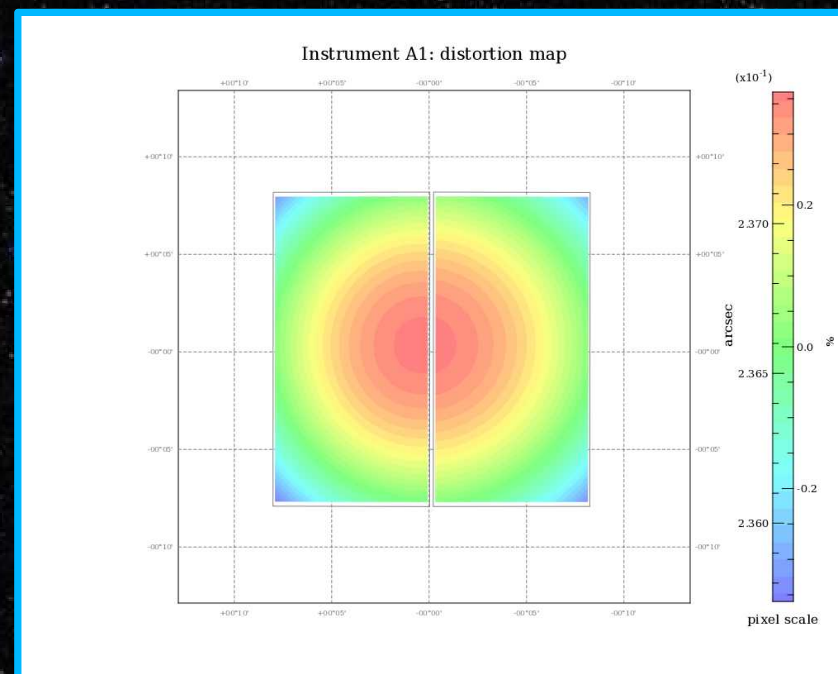
Bottom-left: INT PF WFC field corrected (2012): RMS = 0.41″

Bottom-right: WFI Cass field not corrected (2008): RMS = 0.28″

Solving the WFC and PFIP field distortion

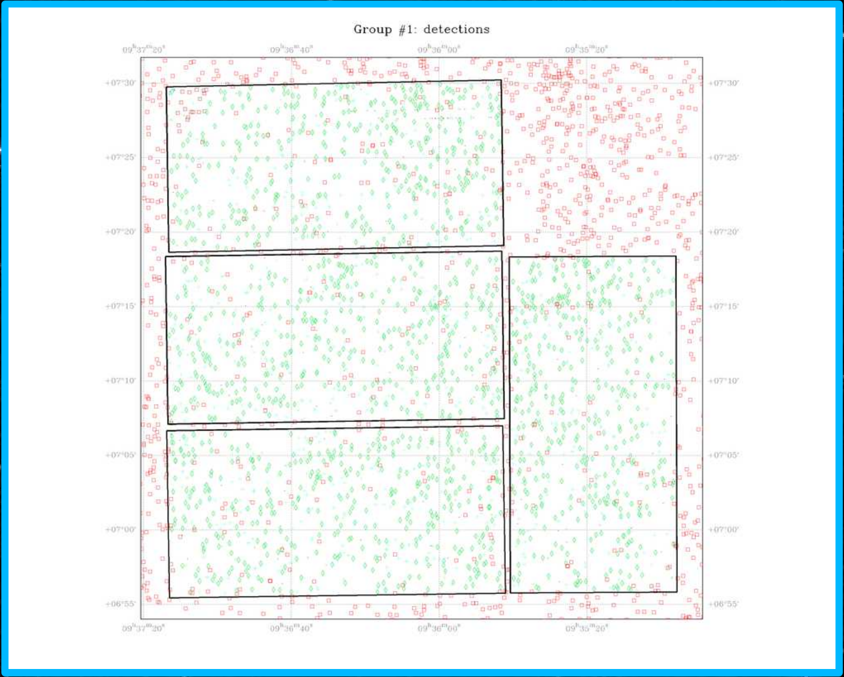


Left: INT WFC distortion map shows pixel scale changes from 0.325 to 0.333"/pix from center to margins equivalent to ~10" astrometric errors should a simple linear model be applied.

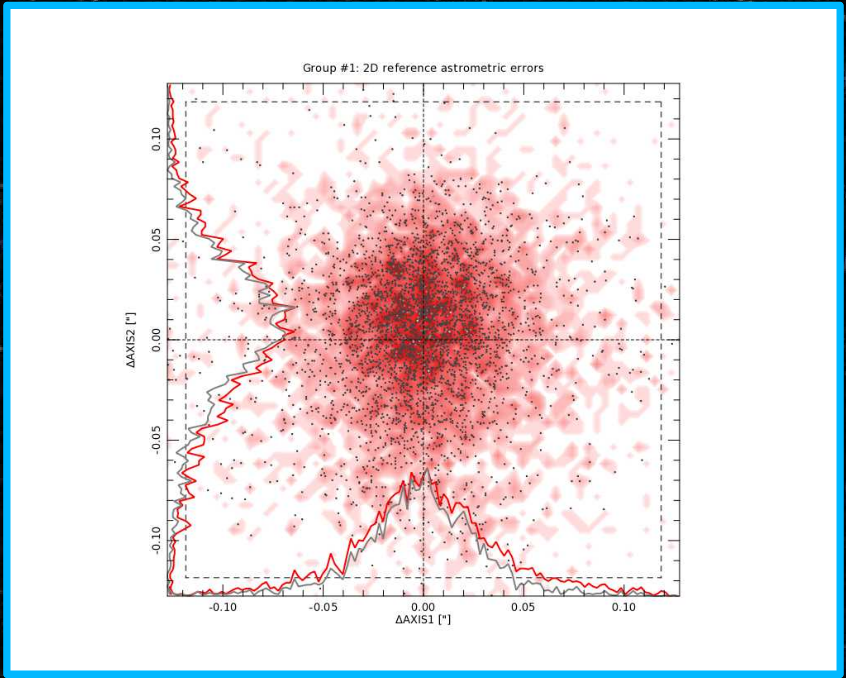


Right: WHT PFIP map shows optical distortions from 0.2358 to 0.2374"/pix from center to margins, resulting in ~2" errors without field correction (THELI/SCAMP plots)

Solving the WFC and PFIP field distortion (2)



Left: INT WFC matched stars (green symbols) used for field correction and not matched red catalog stars (outside the field or surpassing the used astrometric tolerance accuracy)



Right: WHT PFIP map showing O-C astrometric residuals following field correction (THELI/SCAMP plots)

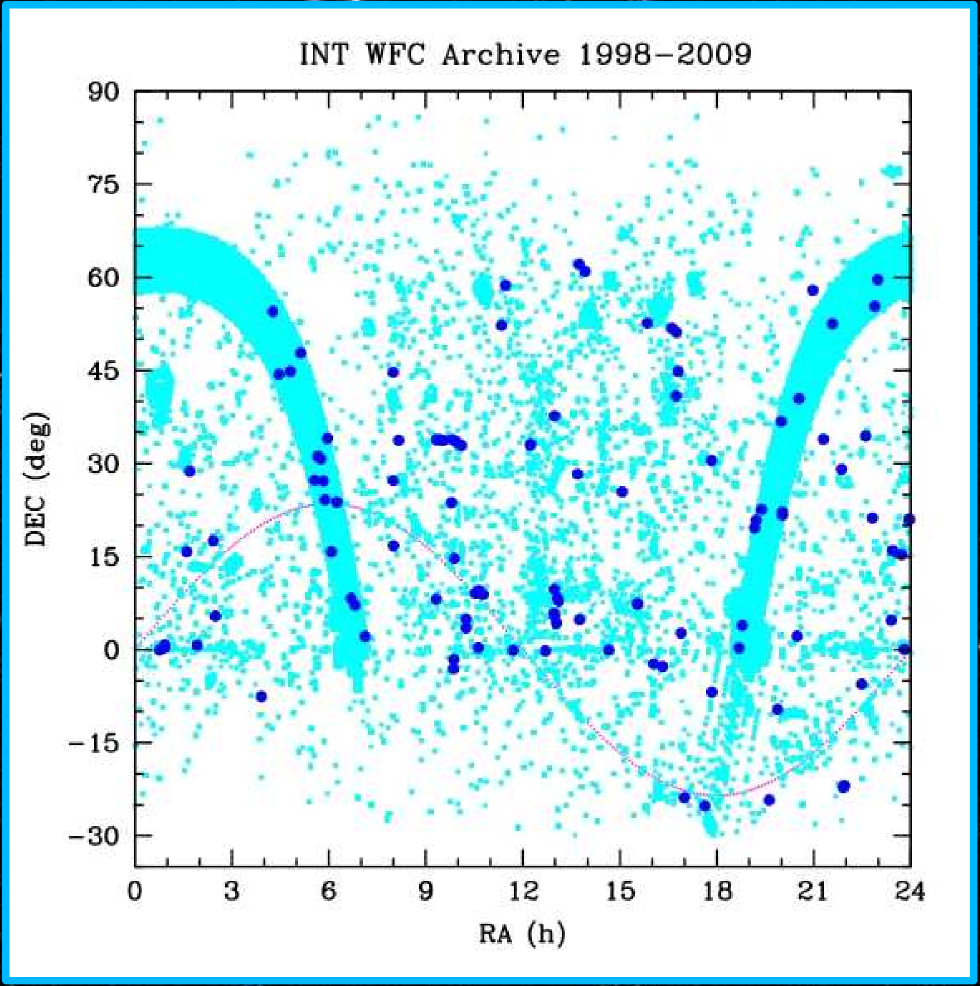
Extending orbital arcs at either ends

(Vaduvescu et al, 2011a)

Table A1 Five special classes including 58 NEA and PHA asteroids data mined in the CFHTLS. Besides the asteroid name we give its MPC classification, the number of CFHTLS observations, the orbital arc and the number of covered oppositions before and after adding our data, and some comments showing how our work improved the orbits.

Asteroid	Classification	Obs.	Arc	Opp.	Comments
		Extended Arcs at First Opposition (Precoveries):			
2008 ED69	NEA very desirable	6	9m/4y	2/3	Arc prolonged by 3 yrs
2005 CJ	PHA very desirable	3	5/8m	2	Arc prolonged by 3 mths
2006 PA1	PHA very desirable	1	4y	3	Arc prolonged by one mth
2008 OX2	PHA	4	2y	2	Arc prolonged by 1.5 mths
2003 WO151	NEA very desirable	3	2y	2	Arc prolonged by 1.5 mths
2005 LW	NEA very desirable	2	4/5y	3/4	Arc prolonged by 8 mths
2005 OW	NEA extremely desirable	3	4/5m	1	Short arc prolonged by 1 mth
2005 QN11	NEA extremely desirable	3	4/5m	1	Short arc prolonged by 1 mth
2005 QS10	NEA very desirable	3	4y	2	Arc prolonged by 1.5 mths
2005 SS4	NEA very desirable	4	3y	3	Arc prolonged by 2 weeks
2004 BE86	NEA very desirable	4	5y	2	Arc prolonged by one mth
2007 RM133	NEA	8	3y	2	Arc prolonged by one week
2008 SQ1	NEA	5	5y	2	Arc prolonged by one mth
2008 AF4	PHA very desirable	1	4m/6y	2/3	We only at 2nd opp, Goldstone radar target
2007 FS35	NEA very desirable	4	3m/8y	2/3	We only at 2nd opp
2008 CR118	PHA	1	8m/5y	2/3	We only at 2nd opp
2006 SV19	NEA	3	6y	3/4	We only at 2nd opp, numbered (212546)
2006 SU49	PHA very desirable	3	7y	3/4	We only at 2nd opp
2005 RN33	NEA very desirable	6	4y	2	We first at 2nd opp
2008 XE3	NEA	4	4y	2	We 2nd set at 1st opp
2005 UU3	NEA very desirable	4	2y	2	We 2nd set, only just 4 hrs after discovery
		Extended Arcs at Last Opposition (Recoveries):			
1998 VD35	PHA desirable	1	2/7y	3/4	Arc prolonged by 5 yrs, numbered (20425)
1993 BX3	PHA desirable	6	11/13y	3/4	Arc prolonged by 5 yrs, numbered (65717)
1999 GS6	PHA desirable	3	7/8y	4/5	Arc prolonged by 1 yr, numbered (152754)
2005 RR6	PHA very desirable	4	2y	2	Arc prolonged by 2 weeks
2005 WA1	PHA extremely desirable	3	1/7m	1	Initial 3 week arc prolonged by 6 mths
2003 TG2	NEA for survey recovery	3	18/24d	1	Very small arc prolonged by one week, old object
2004 XG29	NEA extremely desirable	1	25/35d	1	Very small arc prolonged by 10 days
1998 XA5	NEA very desirable	3	4/8y	3/4	Arc prolonged by 4 yrs

Serendipitous apparition of NEAs in archives



Cyan fine dots: 230,000 WFC pointings 1998-2009

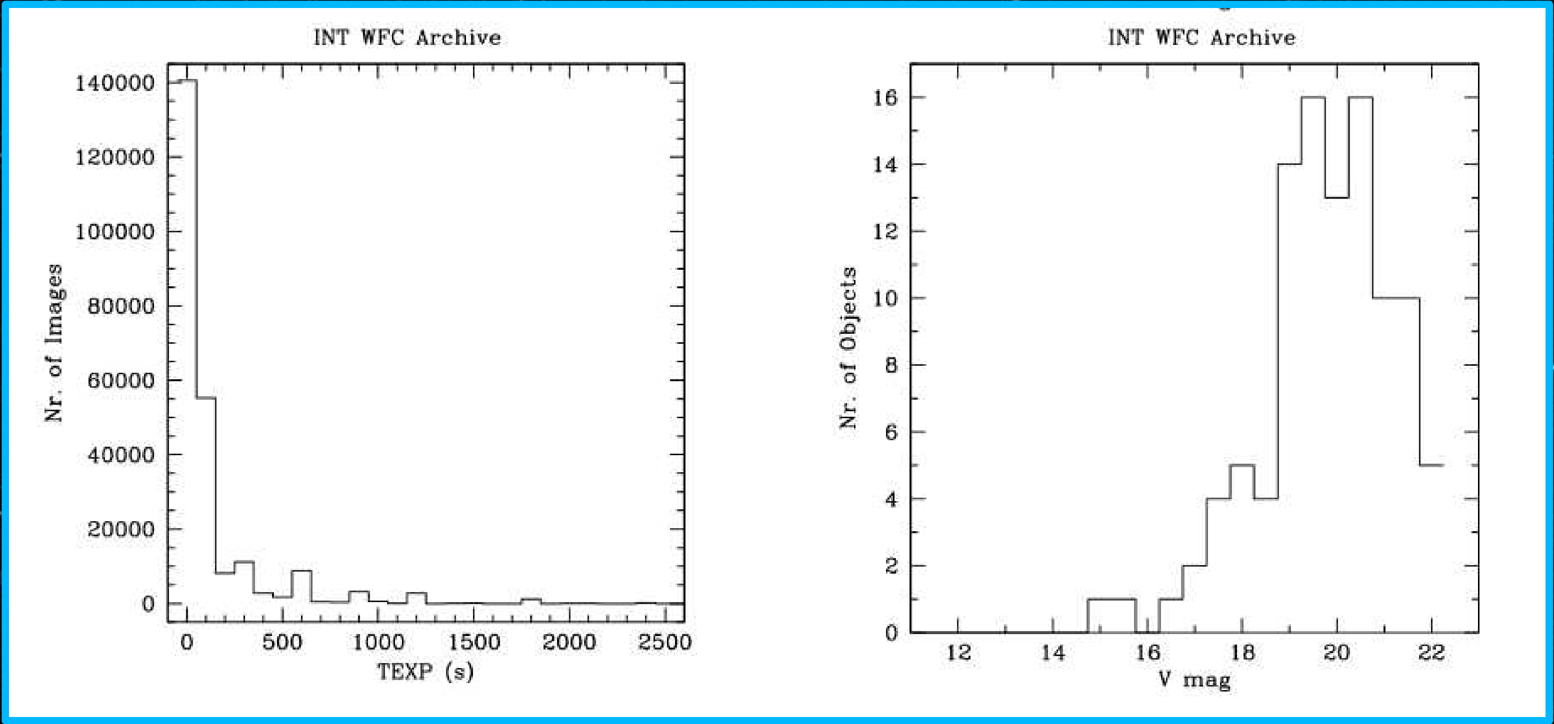
Blue larger dots:
97 NEA findings measured and reported (445 positions)

worth like 5 (very spread) observing nights or ~15,000 EUR!

(Vaduvescu et al, 2011a)

WFC archive statistics and NEAs

(Vaduvescu et al, 2011a)



Left: Most WFC images were taken with short (<2 min) exposure times, making them suitable for mining for fast moving NEAs
Right: V (apparent magnitude) of encountered NEAs shows the INT efficient up to V=22, surpassing the existing 1-2m surveys

Other results

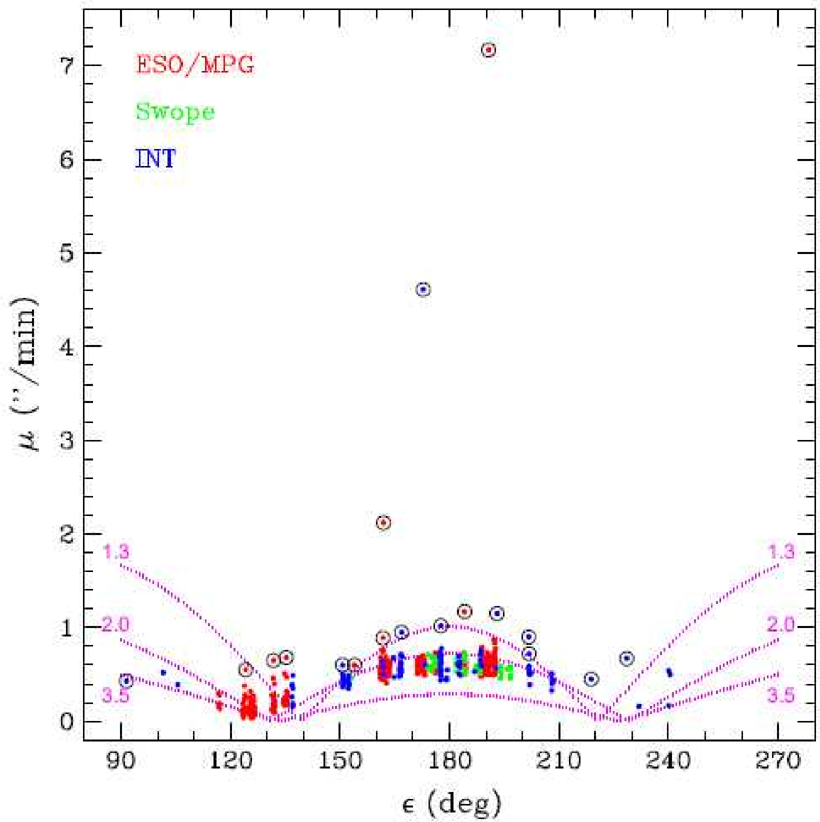


Fig. 5. Basic orbital model using the asteroid observed proper motion μ and the solar elongation ε. We plot all unknown objects observed at ESO/MPG (red), Swope (green) and INT (blue). The three overlaid dotted magenta curves correspond to asteroids orbiting between a=2.0 and a=3.5 AU (Main Belt) and a=1.3 (Near Earth Objects limit). The model allows us to easily flag NEO candidates in a survey. We mark with circles our NEO candidates and we include their properties in Table 4. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Simple orbital model to distinguish between MBAs and NEA candidates based on proper motion and Solar elongation

(Vaduvescu et al, 2011b)

1-2m survey statistics in magnitude distribution

(Vaduvescu et al, 2011b)

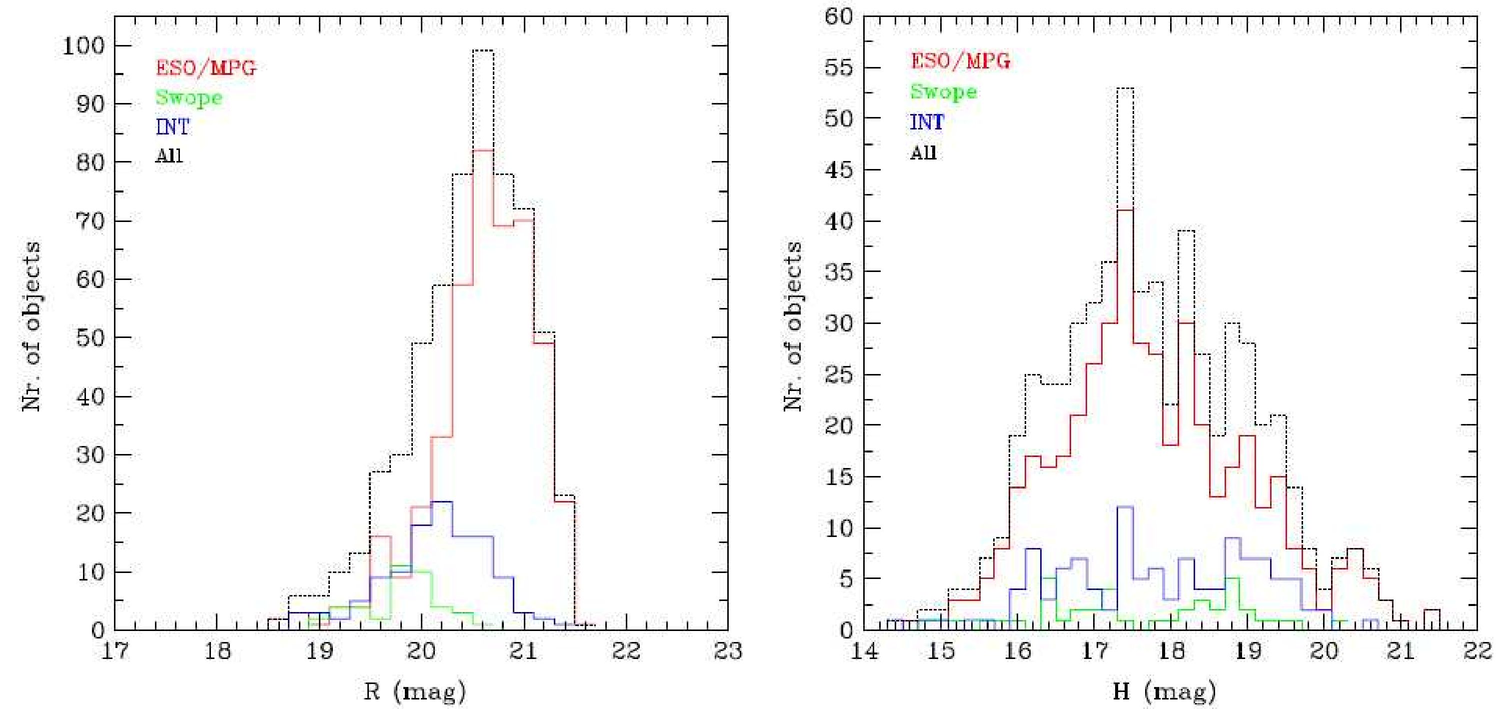


Fig. 9. Histograms showing number of unknown objects as function of observed apparent *R* magnitude (left) and calculated absolute magnitude *H* (right) for the ESO/MPG dataset (red), Swope (green), INT (blue) and the total number of objects (black dots). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

1-2m survey statistics in orbital distribution of discovered MBAs

(Vaduvescu et al, 2011b)

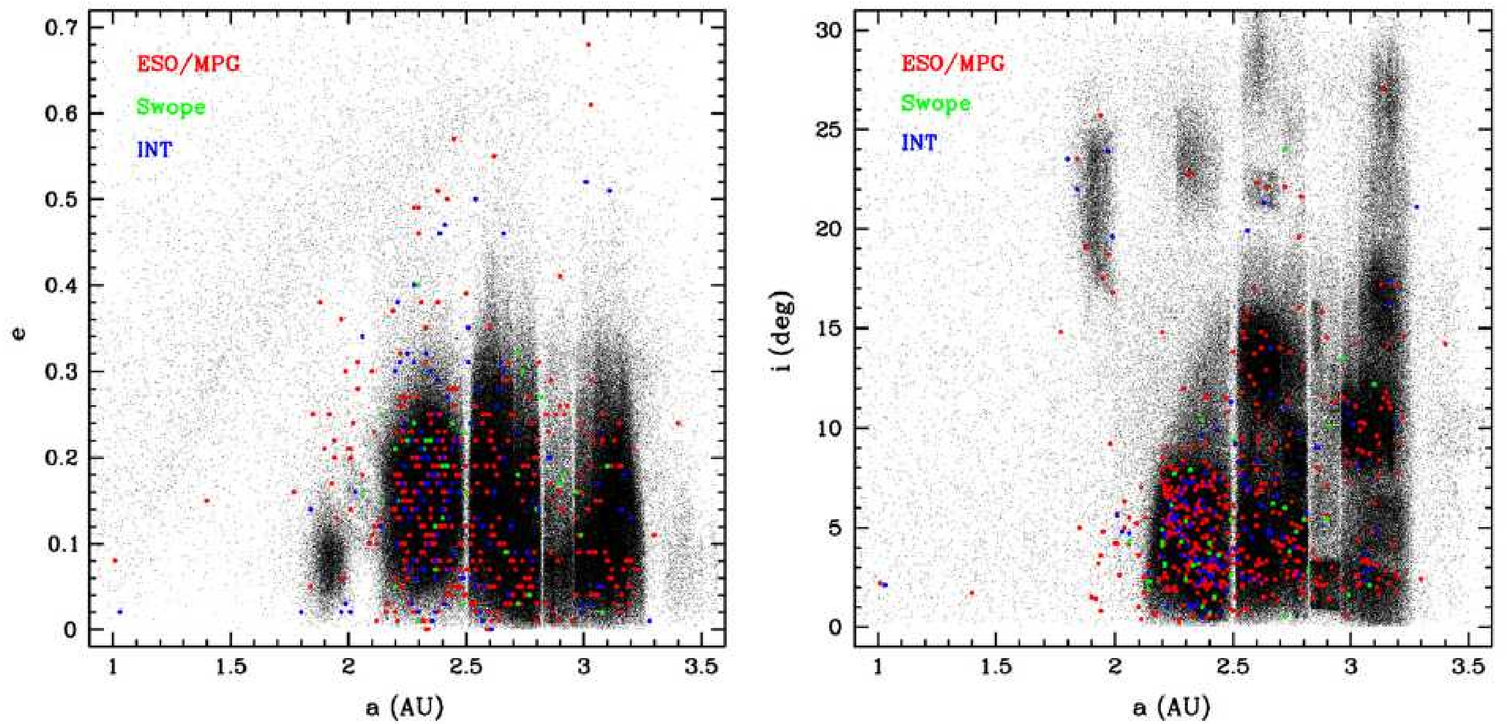


Fig. 7. Orbital distributions of 628 unknown objects observed at ESO/MPG (red points), Swope (green) and INT (blue) compared with the entire known asteroid population (ASTORB - 541,260 fine black points). Although our preliminary orbits were derived using mostly short arcs, the distributions are consistent with the known MBA population, showing the usefulness of the FIND_ORB orbital fit in *a*, *e* and *i*. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Collaboration with Spanish Virtual Observatory

(Enrique Solano et al, 2011)

Identificación de asteroides cercanos a la Tierra

Inicio Registro Ayuda Asteroides Hall of fame Créditos Email: Pass: Login

Bienvenidos al programa de recuperación de Asteroides Cercanos a la Tierra. Este es un programa educativo coordinado por el Observatorio Virtual Español, cuyo principal objetivo es ofrecer a estudiantes, astrónomos aficionados y al público en general la posibilidad de identificar en archivos astronómicos asteroides que pueden impactar contra la Tierra.

Si quieres saber más sobre la identificación de asteroides, haz click en "Ayuda". Si quieres participar en este programa, haz click en "Registro". Si ya te has registrado, introduce tu correo y tu contraseña y haz click en "login". Una vez esto, haz click en "Asteroides" para empezar a utilizar el sistema.

Novedades

04/08/2012

2012 AE1 es, en realidad, 2007 HX3

2012 AE1 es un asteroide de tipo Apolo descubierto el 1 de enero de 2012. Gracias al programa de identificación de asteroides cercanos a la Tierra fue posible descubrir que dicho asteroide ya aparecía en las imágenes SDSS del 31 de marzo de 2003. Las medidas fueron realizadas por los siguientes colaboradores:

F. Arias Arias,
E. Arredondo Pi, V. Bibe, F. Cabello, J. C. Cabrera Garcia,
C. De Diego Garcia, J. M. De La Osa Lopez, A. Del Castillo,
A. Deza Portero, M. Fernandez Hergueta, M. A. Fernandez Muros,
E. Galvez Ranera, F. Garcia De La Cuesta, E. Garcia Del Moral,
F. Garcia Marin, A. Garijo Martinez, C. A. Garrido Lopez,
C. Godina Minana, E. Gomez Fernandez, M. Gomez Florez,
M. A. Gomez Sanchez-Tirado, P. L. Gonzalez, F. Gutierrez Munoz,
Y. Guzman Reche, V. Hernandez Rodriguez, F. Ledesma Vinas,

“Mega-Archive” includes 2.5 million images

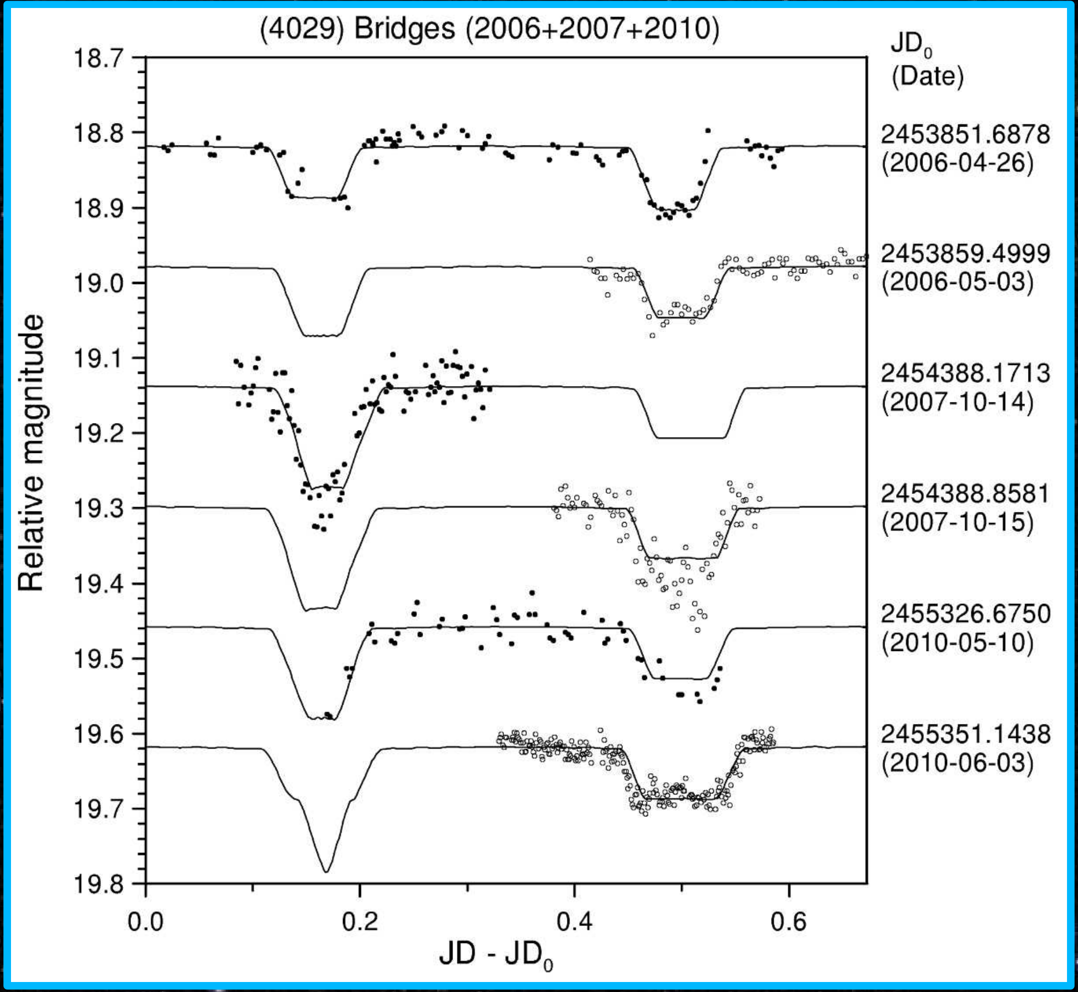
(Vaduvescu et al, 2012)

Table A3 28 instrument archives available in August 2012 in the *Mega-Archive* used by *Mega-Precovery* adding together about 2.5 million images. We list the telescope, instrument, number of images (thousands rounded), archive start and end date, field of view (in arcmin), number of CCDs (for mosaics) and estimated V limiting magnitude suitable to detect NEAs.

Telescope	Instrument	Nr. images	Start Date	End Date	FOV ′	CCDs	V
			ESO Instruments:				
VLT 8.2m	FORS1	36,000	23-01-1999	26-03-2009	6.8 × 6.8	2	26
VLT 8.2m	FORS2	111,000	30-10-1999	25-02-2012	6.8 × 6.8	2	26
VLT 8.2m	HAWKI	69,000	01-08-2007	24-02-2012	7.5 × 7.5	4	26
VLT 8.2m	ISAAC	199,000	01-03-1999	25-02-2012	2.5 × 2.5	1	26
VLT 8.2m	NACO	275,000	02-12-2001	29-02-2012	1.0 × 1.0	1	26
VLT 8.2m	VIMOS	66,000	30-10-2002	28-02-2012	12.8 × 16.0	4	26
VLT 8.2m	VISIR	67,000	11-05-2004	26-02-2012	0.5 × 0.5	1	26
VISTA 4.1m	VIRCAM	230,000	16-10-2009	22-06-2011	46.3 × 46.3	16	25
VST 2.6m	OmegaCam	19,000	01-04-2011	15-03-2012	58.4 × 58.4	32	24
NTT 3.5m	EMMI	18,000	17-03-2004	01-04-2008	9.1 × 9.1	2	25
NTT 3.5m	SOFI	126,000	30-03-2006	15-02-2012	4.9 × 4.9	1	25
NTT 3.5m	SUSI2	17,000	02-04-2004	29-12-2008	5.5 × 5.5	2	25
ESO 3.6m	EFOSC2	47,000	03-07-2004	16-03-2012	4.1 × 4.1	1	25
ESO 3.6m	TIMMI2	64,000	08-05-2004	28-06-2006	1.6 × 1.2	1	25
ESO/MPG 2.2m	WFC	124,000	20-06-1998	25-02-2012	33.6 × 32.7	8	23
			AURA NVO Instruments:				
KPNO 4m	MOSAIC	33,000	01-09-2004	27-06-2012	36 × 36	8	25
KPNO 4m	NEWFIRM	130,000	30-06-2007	10-07-2012	28 × 28	4	25
WIYN 3.5m	Mini Mosaic	6,000	17-03-2009	19-07-2012	10 × 10	2	25
WIYN 3.5m	WHIRC	89,000	04-04-2009	11-04-2012	3.3 × 3.3	1	25
WIYN 0.9m	MOSAIC	9,000	27-05-2009	03-05-2012	59 × 59	8	21
CTIO 4m	MOSAIC-2	67,000	11-08-2004	20-02-2012	37.0 × 37.5	8	25
CTIO 4m	NEWFIRM	74,000	18-05-2010	17-10-2011	28 × 28	4	25
CTIO 0.9m	Cass Img	228,000	27-03-2009	24-07-2012	13.5 × 13.5	1	21
SOAR 4m	OSIRIS	60,000	17-03-2009	20-07-2012	3.3 × 3.3	2	25
			Other Instruments:				
CFHT 3.6m	CFHTLS	25,000	22-03-2003	02-02-2009	57.6 × 56.4	36	25
INT 2.5m	WFC	230,000	20-06-1998	10-07-2009	34.1 × 34.5	4	23
Subaru 8.3m	SuprimeCam	60,000	05-01-1999	31-12-2010	35.1 × 27.6	10	26
AAT 3.9m	WFC	5,000	21-08-2000	05-02-2006	31.4 × 31.4	8	25

Photometric surveys and classification of asteroids

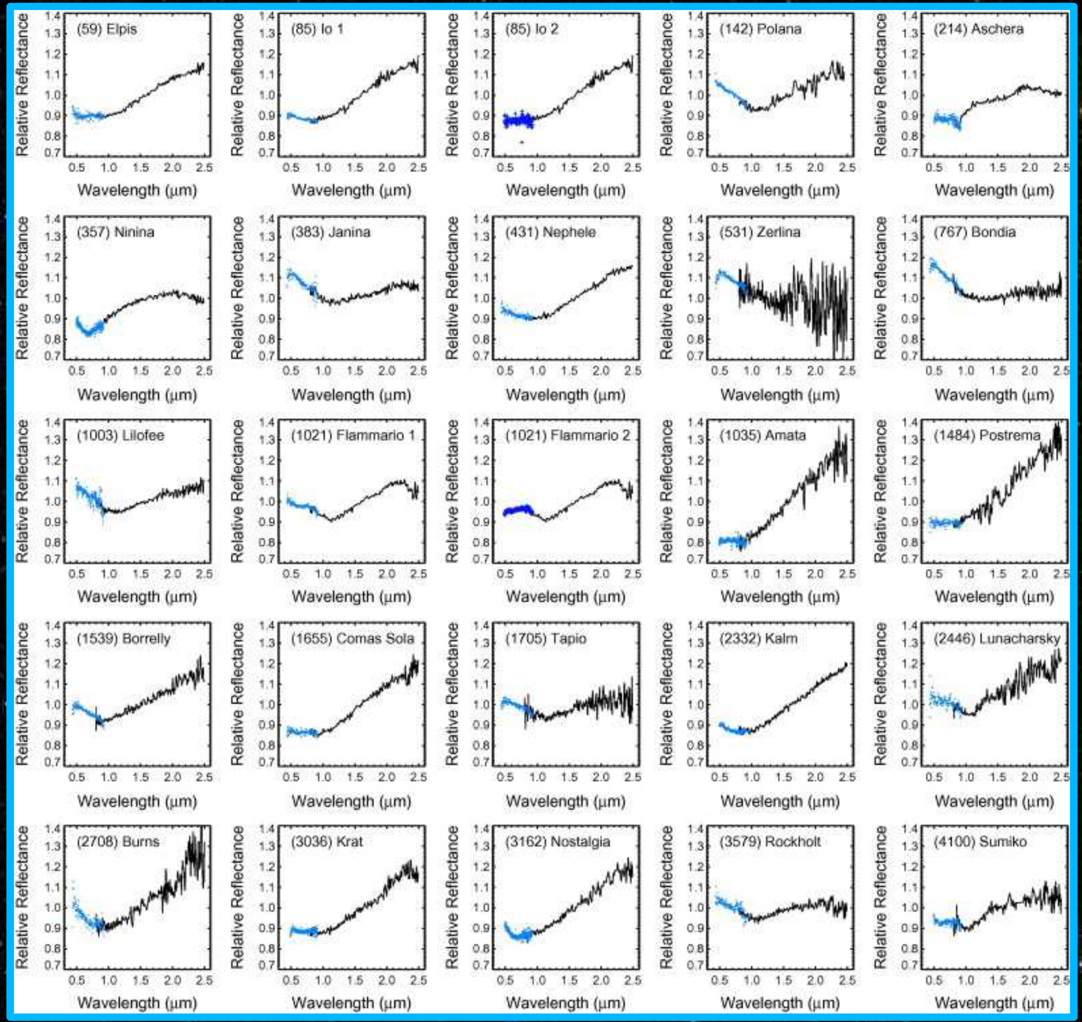
(Pravec et al, 2012)



Much time is necessary for photometry to derive important physical properties of asteroids

Spectroscopic surveys and classification of asteroids

(De Leon, Licandro et al, 2012)



Much time is necessary for NIR and visible spectroscopy to classify taxonomy of asteroids

EURONEAR Collaborators

> IMCCE, France (6p): Mirel Birlan et al;

> Armagh Observatory, UK (4p): David Asher et al;

> Tuorla Observatory, Finland (5p): Rami Rekola et al;

> Ondrejov Observatory, Czech Republic (7p): Petr Pravec et al;

> Instituto de Astronomia, UCN, Chile (6p): E. Unda-Sanzana and Students;

> ING La Palma, UK+NL+SP (6p): Ovidiu Vaduvescu, Jure Skvarc and Students;

> IAC Tenerife, Spain (2p): Javier Licandro et al;

> IAA Granada, Spain (2p): Jose Luis Ortiz, Rene Duffard;

> Padova Observatory, Italy (5p): Monica Lazzarin et al;

> CSIC-IEEC, Institute of Space Sciences, Spain (2p): Josep Maria Trigo and Student;

> Univ of Alicante, Spain (2p): Adriano Campo Bagatin and Student;

> PSSRI - Open University, UK (3p): Simon Green et al;

> Torino Observatory, Italy (2p): Alberto Cellino et al;

> Cote d'Azur Observatory, France (3p): Paolo Tanga et al;

> TLS Observatory, Tautenburg, Germany (2p): Bringfried Stecklum et al;

> Spanish Virtual Observatory, Barcelona, Spain (2p): Enrique Solano Marquez et al;

> Unidad de Astronomia, UA, Chile (3p): E. Unda-Sanzana and Students;

Conclusions and future work?

My dreams which were not fulfilled...

> To upgrade two retired 1m telescope (ESO 1m in the South and JKT 1m in the North) did not succeed (FP7 application 2007);

> To use the INT or apply for also did not succeed (FP7 2010 & 2011);

> To unite Europe in a common NEO survey, so that Americans continue to be the major contributors leaders in NEO discovery followed by two European <u>amateur and public outreach</u> projects (La Sagra Spain and Crni Vrh Slovenia);

> I might give up EURONEAR in case we could not get funding or partnership for a 2m class telescope (needed today) dedicated to NEAs.

> One possible project could be applying for a long term INT WFC program or apply for funding for a new wider WFC for the INT;

> Another could be some association with ESA-SSA program (which could buy INT nights (and/or ToO time) necessary to secure their 1m survey discoveries;

> Another could be to apply for FP8 funding for a dedicated 2m telescope (~10 ME..).

Conclusions and future work?

But I had many successful collaboration with the amateurs:

> Involving in EURONEAR about 25 amateurs and students, mostly from my natal Romania and also from other countries (Chile, France, Germany, UK, Spain, etc), which included some past ING students (H. Ledo, A. Tyndall, L. Patrick, D. Fohring, M. Karami);

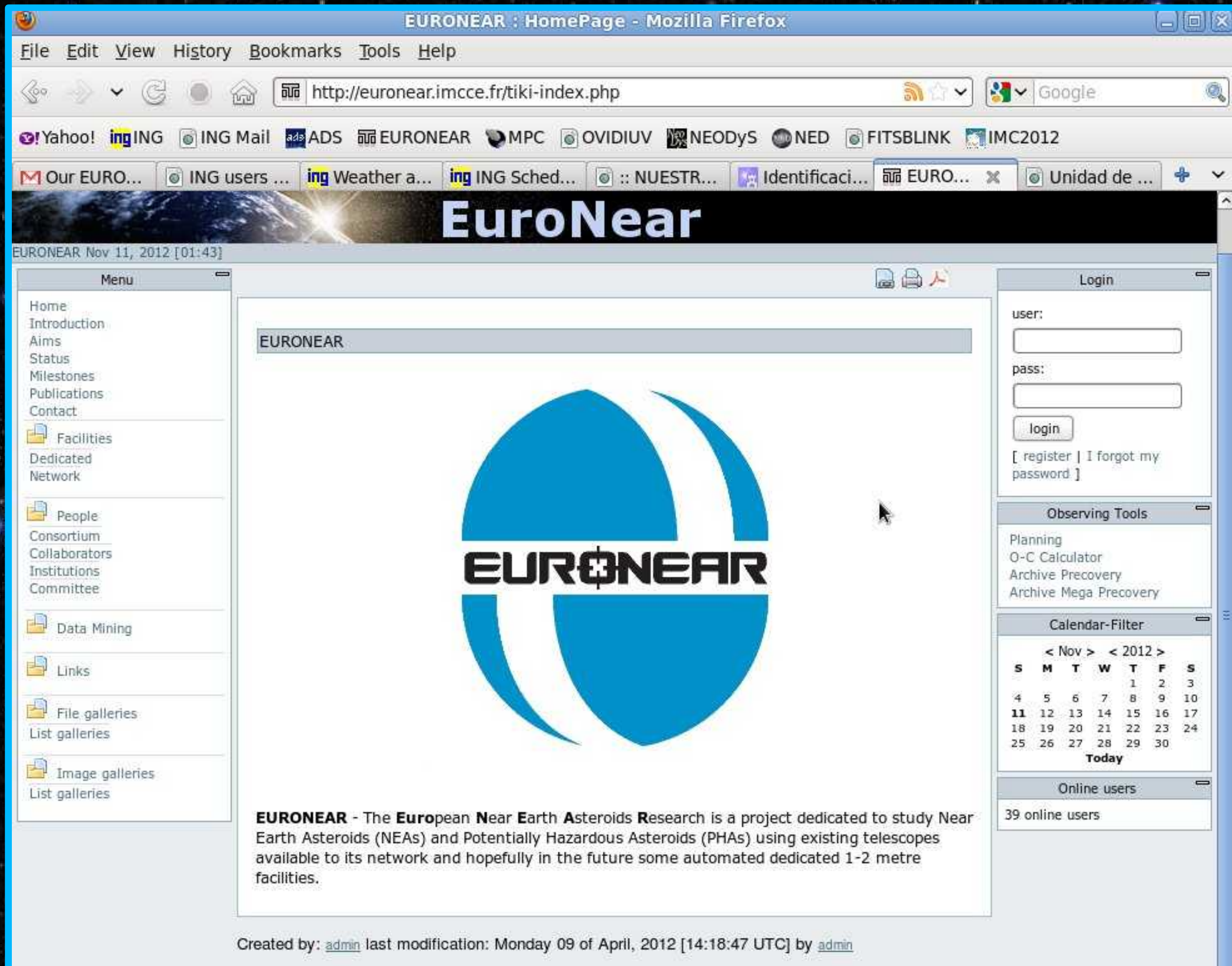
> During the last 5 years we published 10 papers about EURONEAR work and other 4 papers related to it;

> Through EURONEAR we did lots of education and public outreach.

Few numbers about the INT WFC:

> In about 10 nights total INT discovered 100 objects and 1000 unknown 1n MBAs;
> In any ecliptic field, 1.7 unknown for each known MBAs could be discovered to R~22;
> About one NEA could be discovered in any 2 sq. deg. (8 pointings) with the INT WFC;
> In 2-4 years the INT could double the MBA population to over one million bodies;

References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EURONEAR
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