NEO Search Programs


MATRIX
RELOADED

Outline

- Background
- The Five Major Surveys
  - LINEAR
  - NEAT
  - Spacewatch
  - LONEOS
  - CSS (Catalina)

Background

- NEO – Near-Earth Object
  - Perihelion distance < 1.3 AU
  - Aphelion distance > 0.983 AU
- NEA – Near-Earth Asteroid
  - As opposed to a comet

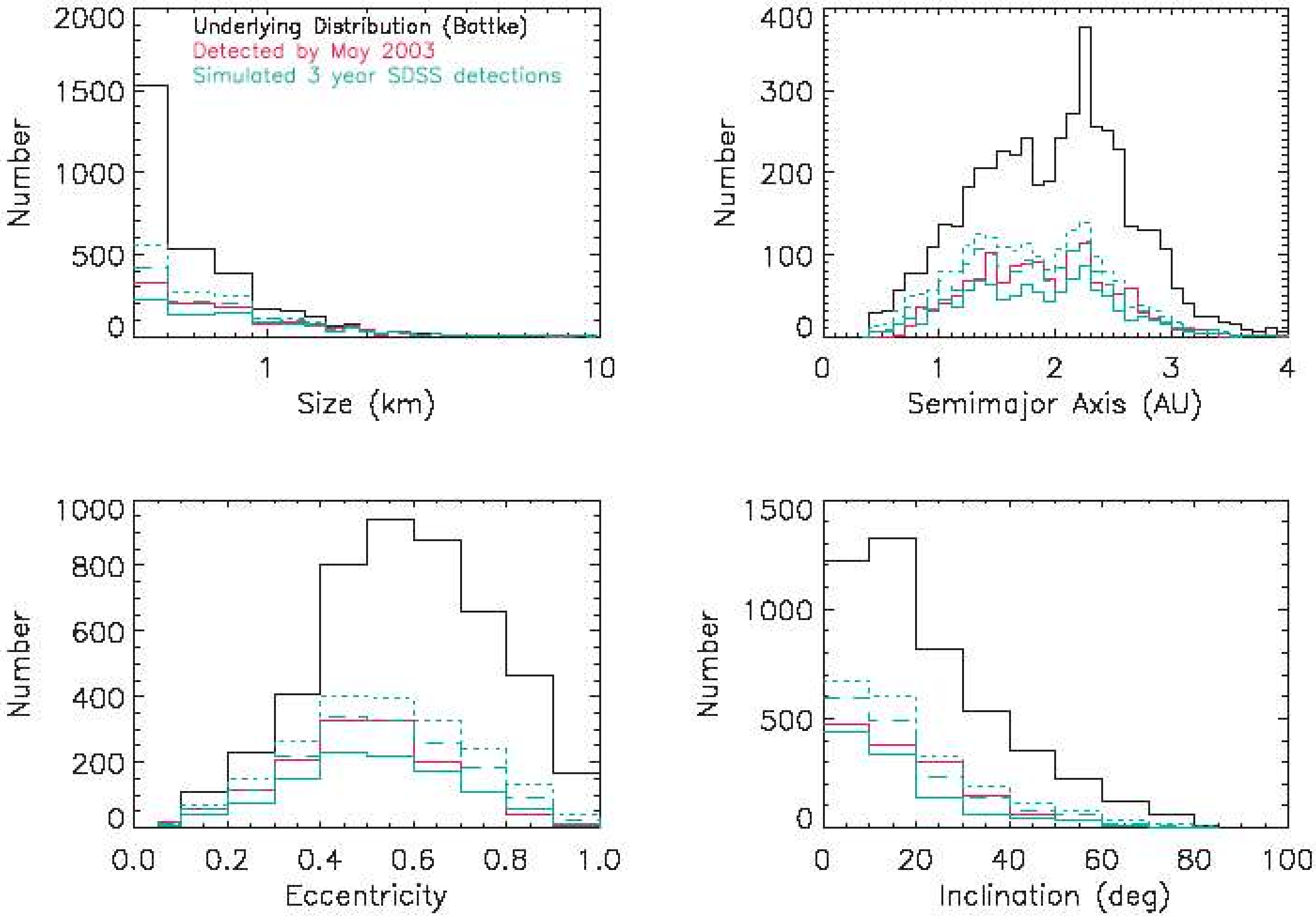


FIG. 1.—Orbital parameter and size distributions of NEOs with $H \leq 20$. The red line indicates known NEOs as of 2003 May. The black line is the Bottke et a (2002) model, which we take as the underlying distribution. The number of currently known NEOs in this absolute magnitude range is 1405, where the Bottke mode predicts 4668, including 961 larger than 1 km. The green lines are the NEOs detected by a 3 yr simulation using our NEO strategy with the SDSS system. The dotte green line indicates NEOs detected once in our simulation (1933 objects), the dashed line indicates NEOs with multiple detections (1533 objects), and the soli green line indicates NEOs for which accurate orbits may be determined (three detections in 10 days; 1023 objects) using only the 2.5 m data. A follow-up progran using the 3.5 m and/or one of the smaller APO telescopes could provide orbits for the remaining NEOs that were detected only once or twice. Note that our mode includes objects as small as 400 m, but the top left panel begins at 600 m to avoid overshadowing ≥1 km NEOs.

Background - Types of NEA's

- Amors
  - approach the Earth's orbit from the outside
- Apollos
  - cross the Earth's orbit
- Atens
  - approach the Earth's orbit from the inside

Background - Motivation

- Relation to meteorites
- Relation to devolatilized comets
- Source of metals
- And…

Background - Motivation

"The risk you face of dying as a result of an asteroid impact is about 1 in 20,000, the same risk you face of dying in a plane crash."

- *Spaceguard Survey*

66 NEAs: Last Updated Feb 28, 2005

Sort by Palermo Scale (cum.) or by Object Designation

Object Designation	Year Range	Potential Impacts	Impact Prob. (cum.)	$V_{infinity}$ (km/s)	H (mag)	Est. Diam. (km)	Palermo Scale (cum.)	Palermo Scale (max.)	Torino Scale (max.)
2004 VD17	2091-2104	9	1.3e-04	18.22	18.8	0.580	-0.97	-1.16	1
2004 MN4	2034-2055	8	1.5e-04	5.86	19.2	0.320	-1.44	-1.72	1
1997 XR2	2101-2101	2	9.7e-05	7.17	20.8	0.230	-2.44	-2.71	1
2004 XP14	2082-2102	8	6.1e-06	17.40	19.5	0.420	-2.69	-2.84	0
1994 WR12	2054-2102	134	1.0e-04	9.84	22.4	0.110	-2.96	-3.75	0
1979 XB	2056-2101	3	3.3e-07	24.54	18.5	0.685	-3.07	-3.14	0
2000 SG344	2068-2101	68	1.8e-03	1.37	24.8	0.040	-3.08	-3.43	0
2000 QS7	2053-2053	2	1.3e-06	12.32	19.6	0.420	-3.27	-3.46	0
1998 HJ3	2100-2104	3	2.1e-07	24.09	18.4	0.694	-3.49	-3.69	0
2004 XK3	2029-2104	66	1.7e-04	6.55	24.5	0.040	-3.81	-4.06	0
1994 GK	2051-2071	7	6.1e-05	14.87	24.2	0.050	-3.83	-3.84	0
2000 SB45	2074-2101	83	1.5e-04	7.54	24.3	0.050	-3.86	-4.28	0
2001 CA21	2020-2073	4	1.7e-08	30.66	18.5	0.678	-3.89	-4.10	0

http://neo.jpl.nasa.gov/cgi-bin/db?name=2004+MN4

THE TORINO SCALE

Assessing Asteroid/Comet Impact Predictions

No Hazard	**0**	The likelihood of collision is zero, or is so low as to be effectively zero. Also applies to small objects such as meteors and bolides that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.
Normal	**1**	A routine discovery in which a pass near the Earth is predicted that poses no unusual level of danger. Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern. New telescopic observations very likely will lead to re-assignment to Level 0.
Meriting Attention by Astronomers	**2**	A discovery, which may become routine with expanded searches, of an object making a somewhat close but not highly unusual pass near the Earth. While meriting attention by astronomers, there is no cause for public attention or public concern as an actual collision is very unlikely. New telescopic observations very likely will lead to re-assignment to Level 0.
	3	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of localized destruction. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
	4	A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of regional devastation. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by the public and by public officials is merited if the encounter is less than a decade away.
Threatening	**5**	A close encounter posing a serious, but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.
	6	A close encounter by a large object posing a serious, but still uncertain threat of a global catastrophe. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than three decades away, governmental contingency planning may be warranted.
	7	A very close encounter by a large object, which if occurring this century, poses an unprecedented but still uncertain threat of a global catastrophe. For such a threat in this century, international contingency planning is warranted, especially to determine urgently and conclusively whether or not a collision will occur.
Certain Collisions	**8**	A collision is certain, capable of causing localized destruction for an impact over land or possibly a tsunami if close offshore. Such events occur on average between once per 50 years and once per several 1000 years.
	9	A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.
	10	A collision is certain, capable of causing a global climatic catastrophe that may threaten the future of civilization as we know it, whether impacting land or ocean. Such events occur on average once per 100,000 years, or less often.

Fig. 2. Public description for the Torino Scale, revised from Binzel (2000) to better describe the attention or response that is merited for each category.

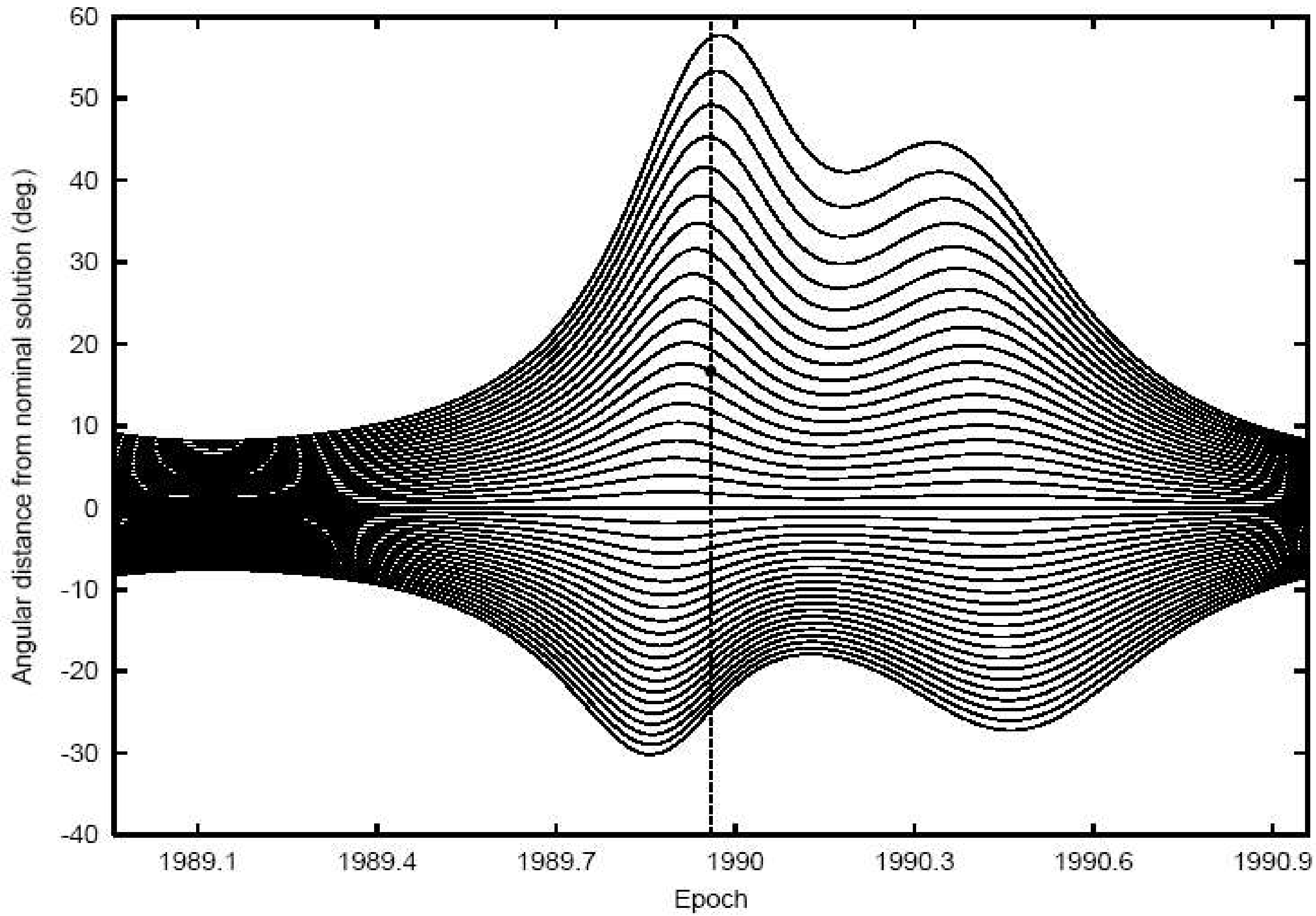
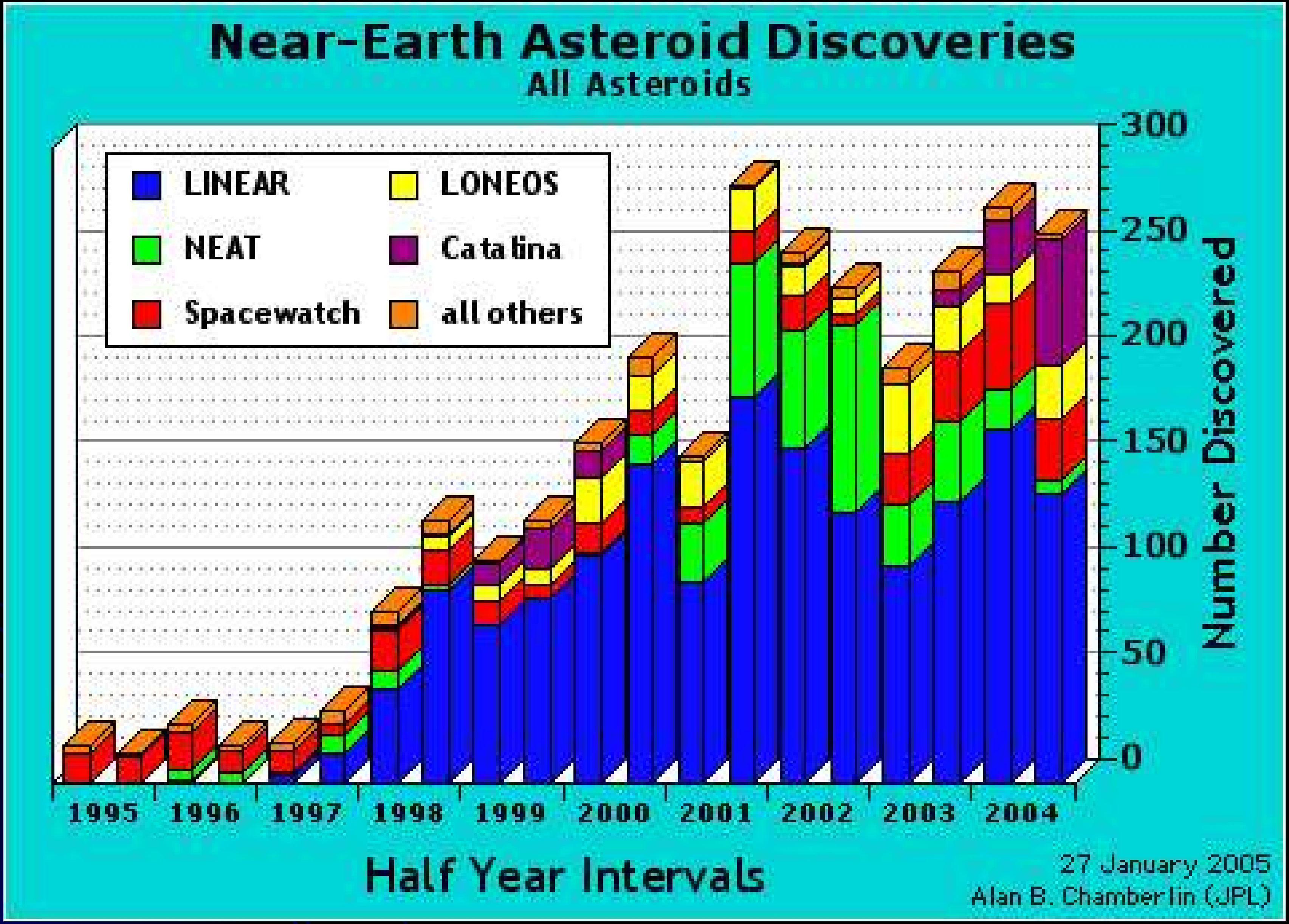
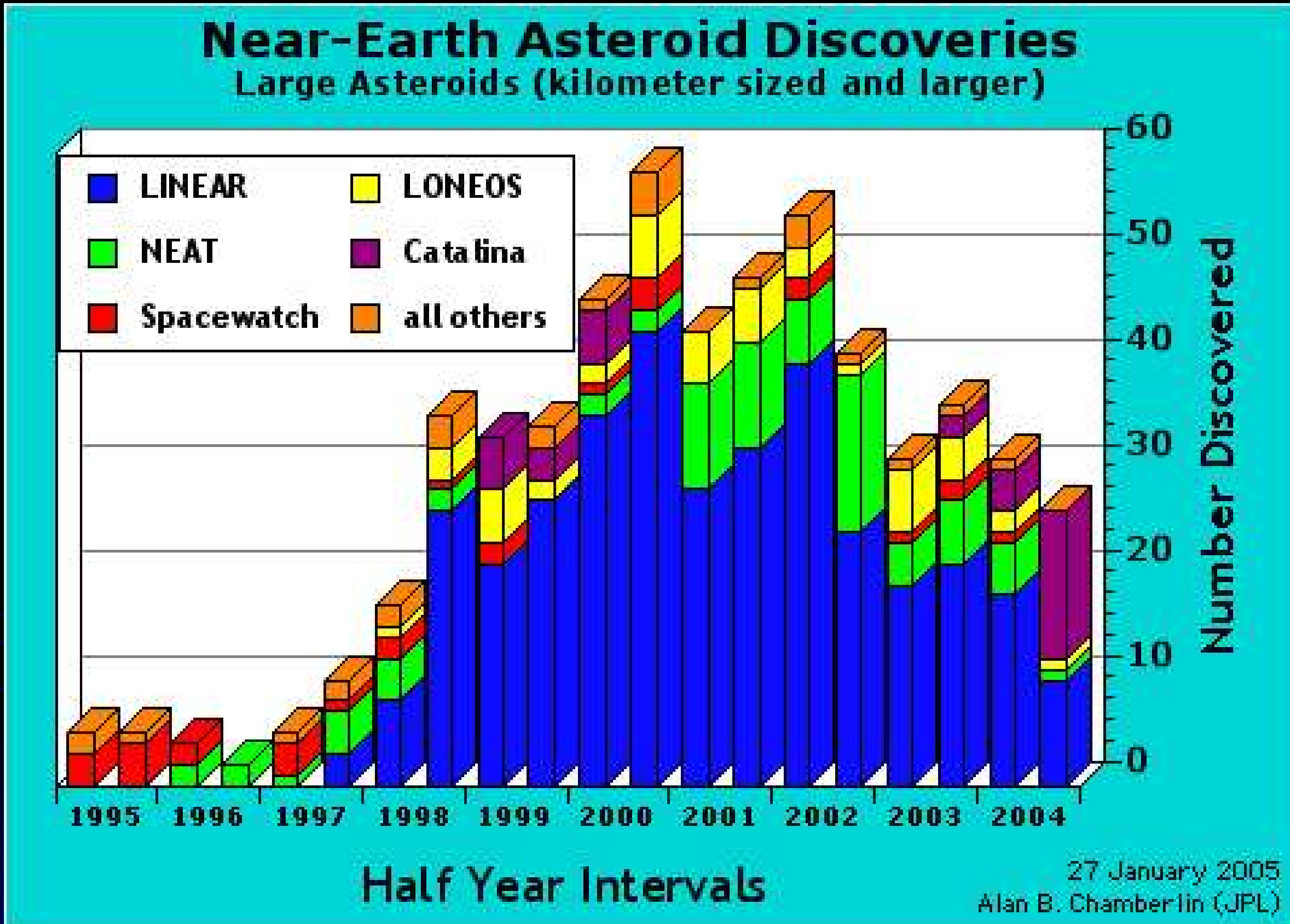


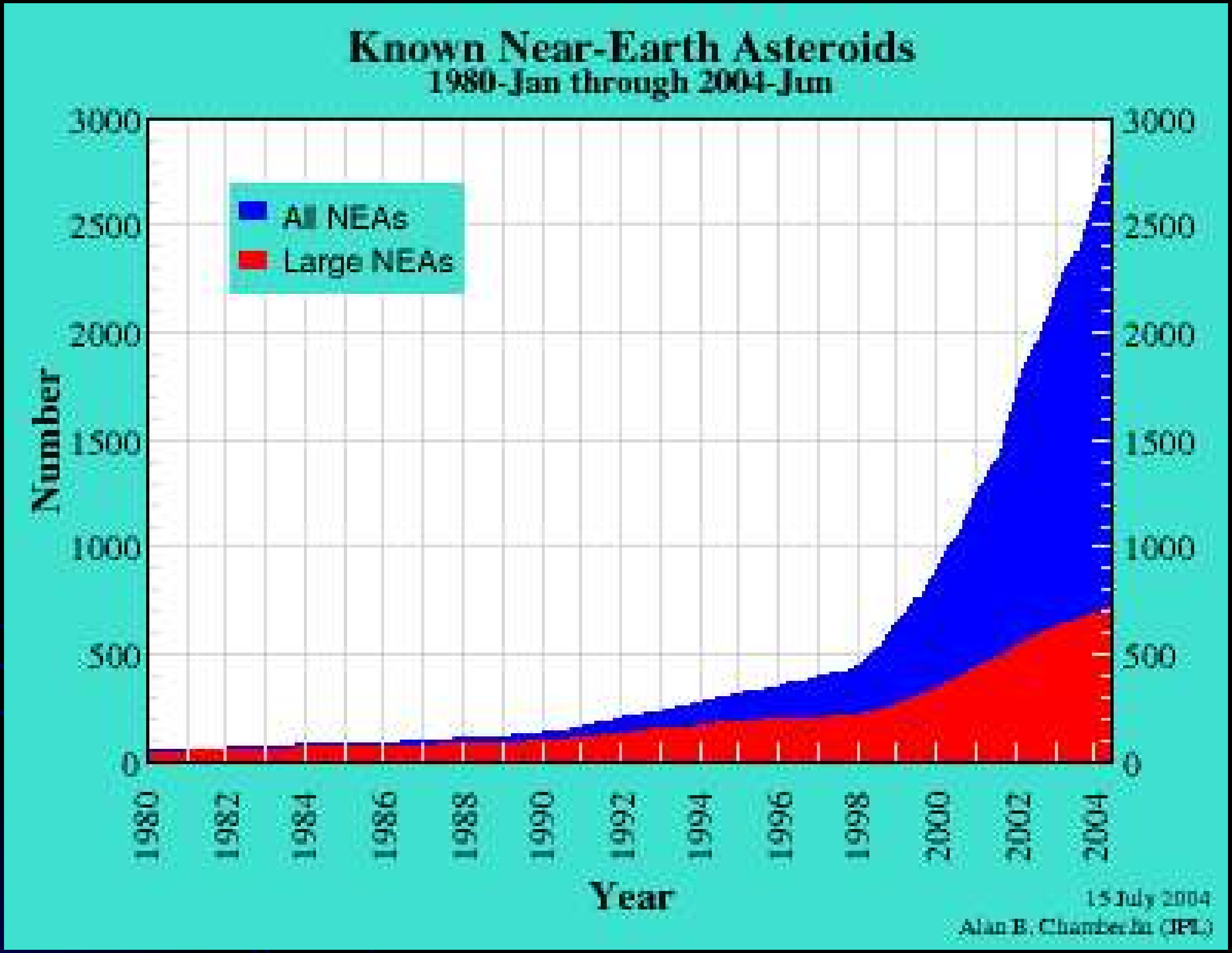
Fig. 3. Precovery circumstances of 1998 NU. In this plot we can see 41 continuous curves, each one corresponding to one of 41 orbits produced with the *MS* method at the 3σ level. For all of them the plot shows the angular distance from the nominal solution, which is represented by the only curve perfectly parallel to the X-axis. In this scheme the nominal solution is the orbit No. 21, while the confidence region is filled with 20 orbits on each side of the nominal solution. The position of 1998 NU is indicated by the small dot in the middle of the plot: it is located very close to solution No. 29. The *MS* figure covers two years, from 1989 to 1991. It is important to notice its asymmetric shape, an evident manifestation of nonlinearity.

The 5 Major Surveys

- LINEAR
- NEAT
- Spacewatch
- LONEOS
- CSS (Catalina)


Near-Earth Asteroid Discoveries
All Asteroids
LINEAR
LONEOS
NEAT
Catalina
Spacewatch
all others
300
250
200
150
100
50
0
Number Discovered
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Half Year Intervals
27 January 2005
Alan B. Chamberlin (JPL)


Near-Earth Asteroid Discoveries
Large Asteroids (kilometer sized and larger)
LINEAR
LONEOS
NEAT
Catalina
Spacewatch
all others
0
10
20
30
40
50
60
Number Discovered
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Half Year Intervals
27 January 2005
Alan B. Chamberlin (JPL)


Known Near-Earth Asteroids
1980-Jan through 2004-Jun
All NEAs
Large NEAs
Number
0
500
1000
1500
2000
2500
3000
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year
15 July 2004
Alan B. Chamberlin (JPL)

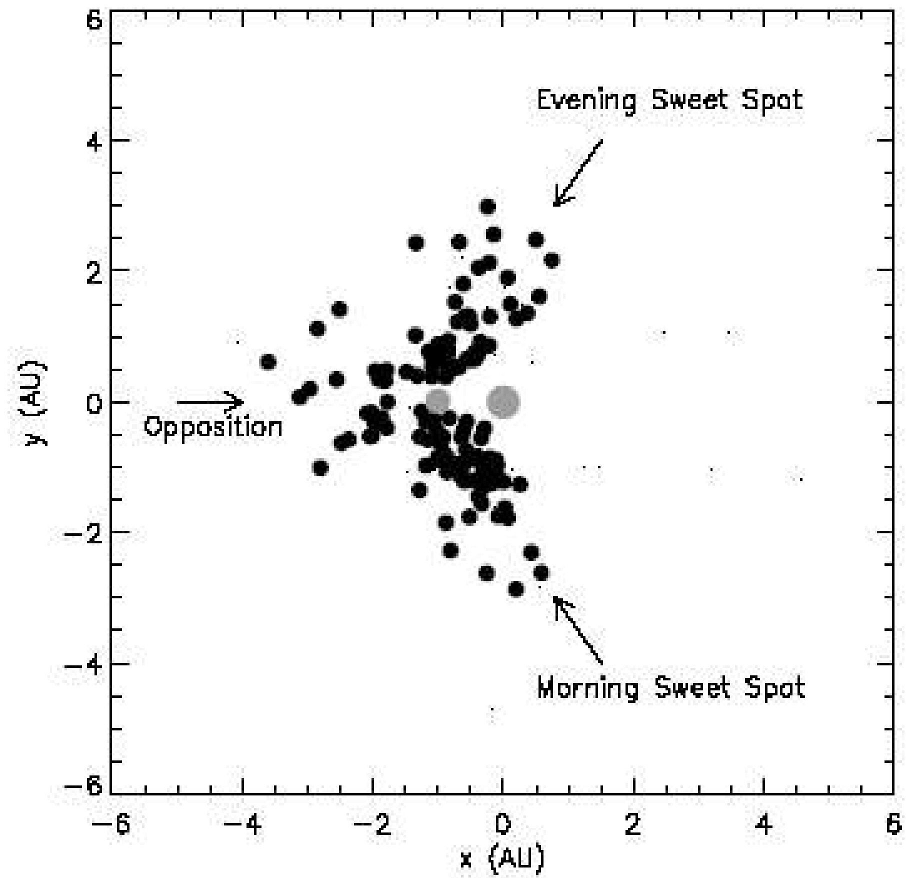


FIG. 6.—Detections in the 1 month simulation from Fig. 5, in *x-y* coordinates. The Sun is depicted in gray at the origin, and Earth is in gray at the appropriate location in its orbit and a distance of 1 AU. The large circles represent NEO detections, and the dots represent the total instantaneous distribution of NEOs. The sweet spots and opposition are labeled, with the "evening sweet spot" being observed first after sunset.

LINEAR

- Lincoln Near-Earth Asteroid Research
- Headed by MIT’s Lincoln Laboratory in cooperation with the USAF and NASA
- Responsible for the majority of NEO discoveries

LINEAR - Instrumentation

- Two 1-meter GEODSS telescopes
  - 1960x2560 pixel CCD
  - 2 square degree FOV
- One 0.5-meter telescope for follow-up observations

LINEAR - Site

NEAT

- Near-Earth Asteroid Tracking
- Autonomous observatory associated with JPL and NASA

NEAT - Instrumentation

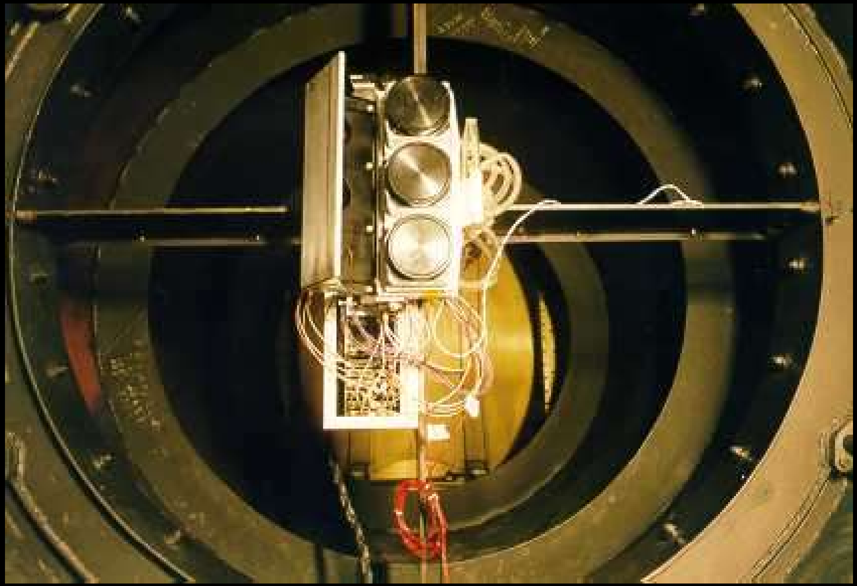
- 1-meter GEODSS telescope owned by the USAF
  - 4096 x 4096 pixel CCD
  - 1.2x1.6 sq. degree FOV

NEAT - Instrumentation

- 1.2-meter MSSS telescope
  - Same CCD
  - Same FOV

NEAT - Instrumentation

- 1.2-meter Schmidt telescope
  - Three cameras, each with its own 4096x4096 pixel CCD



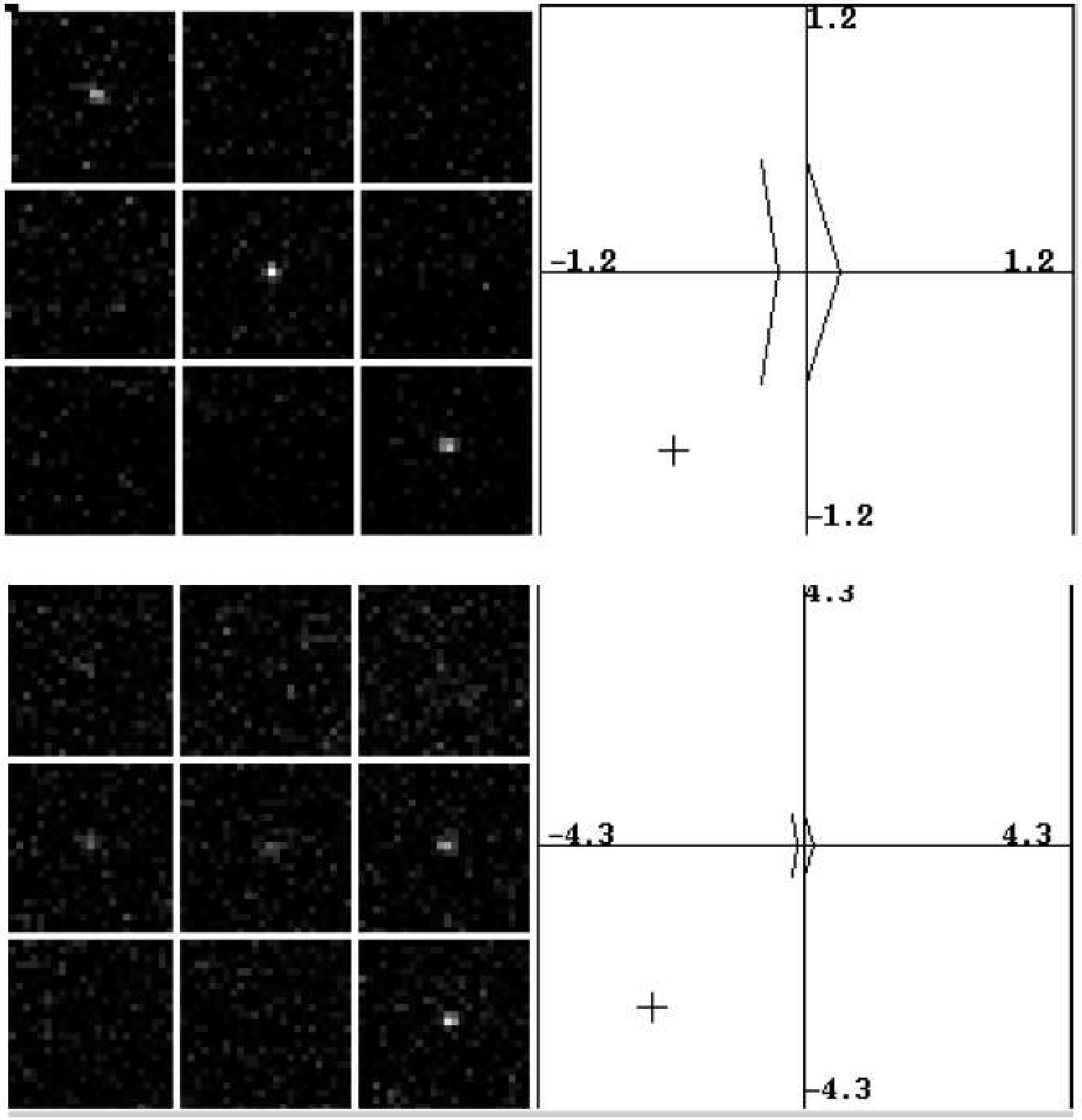
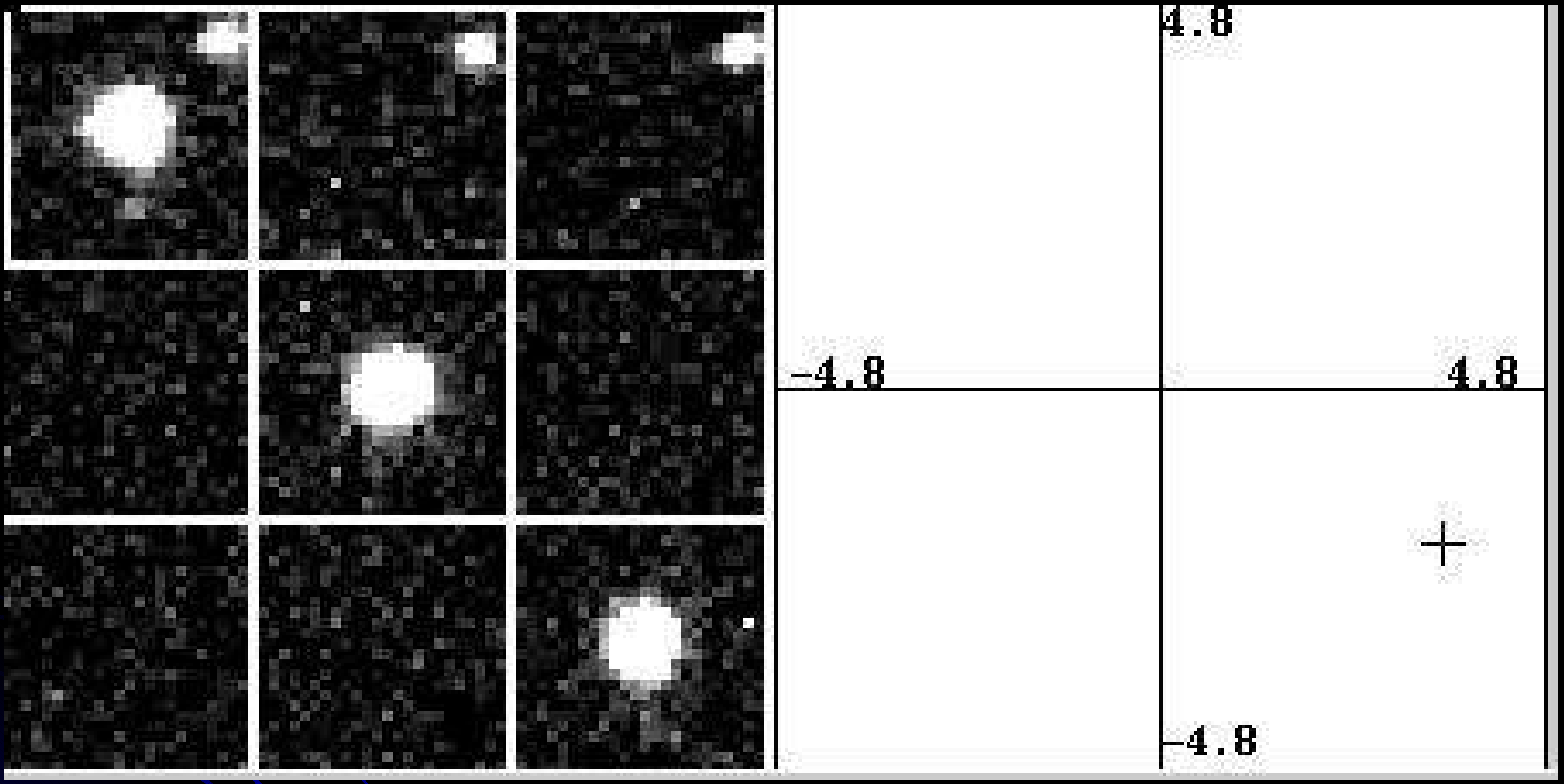


FIG. 4.—PATCHVIEW displays of the discovery image of 1998 DG_{16}, an Aten Earth-crossing asteroid (*top*). PATCHVIEW display of a false posit
(*bottom*).


4.8
-4.8
4.8
-4.8

NEAT

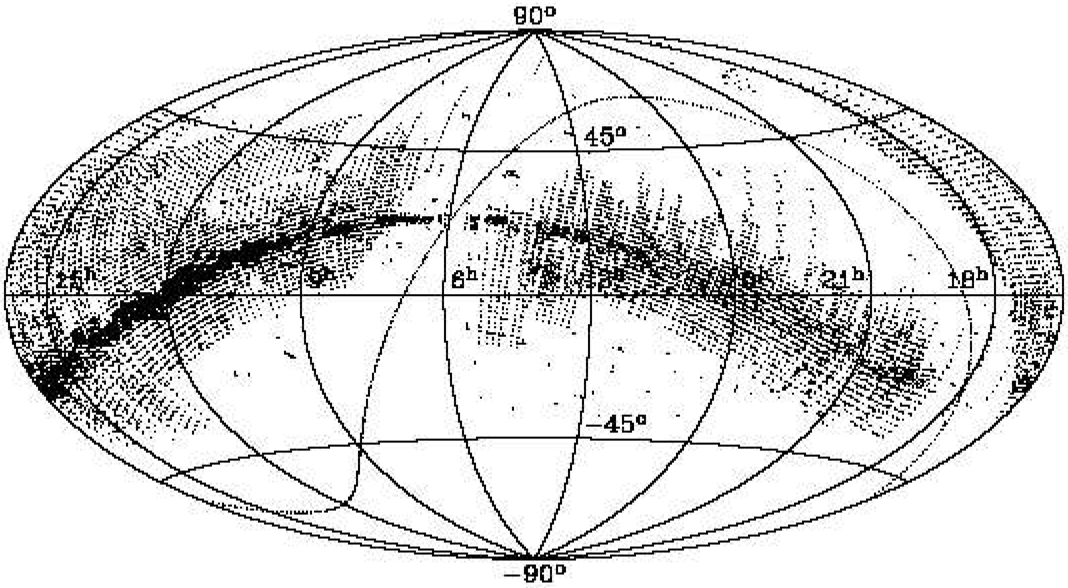


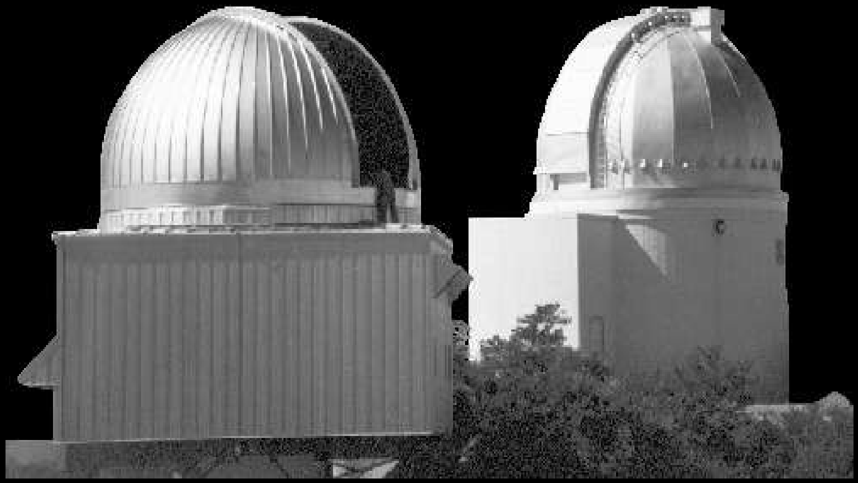
FIG. 9.—Celestial coordinates of areas searched by NEAT 1995 December to 1998 July. The Galactic plane, an area of avoidance for NEAT observations, is shown as a dotted line.

Spacewatch

- The oldest NEO search program
- Operated by the University of Arizona

Spacewatch - Instrumentaion

- 0.9 – meter telescope
  - Four 4608x2048 CCD's
  - Scans 200 sq. degrees of sky each night
- 1.8-meter telescope
  - Outfitted for more rapid searches (follow-ups)



LONEOS

- Lowell Observatory Near-Earth Object Search
- Run by the Lowell Observatory

LONEOS - Instrumentation

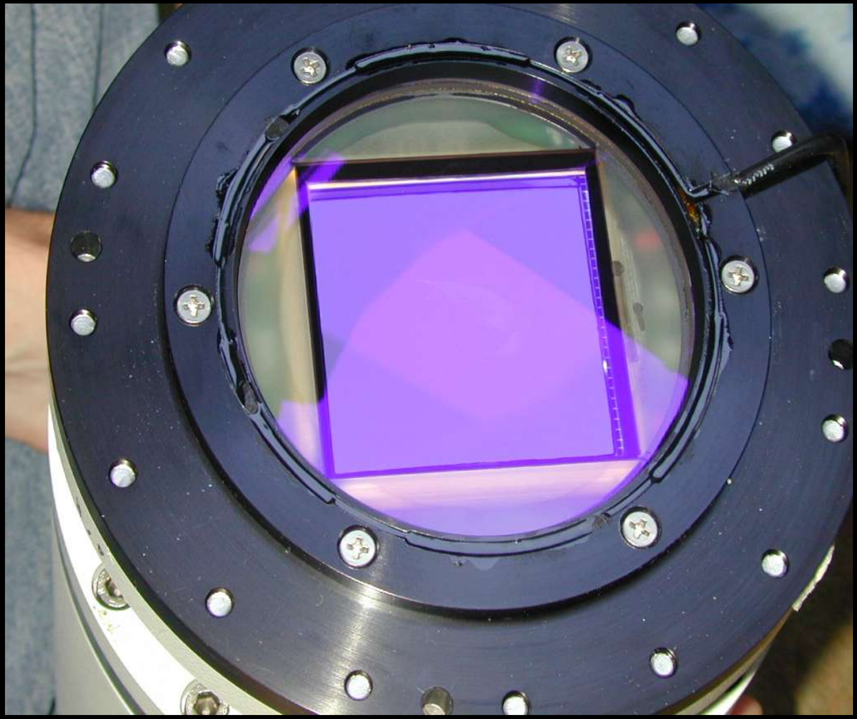
- 0.6-meter Schmidt Telescope
  - 2048x4096 pixel CCD
  - 8.1 sq. degree FOV

CSS

- Catalina Sky Survey
- Actually a consortium of 3 cooperating surveys:
  - The original Catalina Sky Survey (CSS)
  - Siding Springs Survey (SSS)
  - Mt. Lemmon Survey (MLSS)

The original Catalina Sky Survey

- 0.6-meter Schmidt Telescope
  - 4096x4096 pixel CCD



Siding Springs Survey

- 0.5-meter Schmidt telescope
  - CCD identical to CSS's
- 1-meter telescope used for follow-up observations

Mt. Lemmon Survey

- 1.5-meter reflector
  - Dedicated to rapid follow-up observations

Can't forget the spectra…

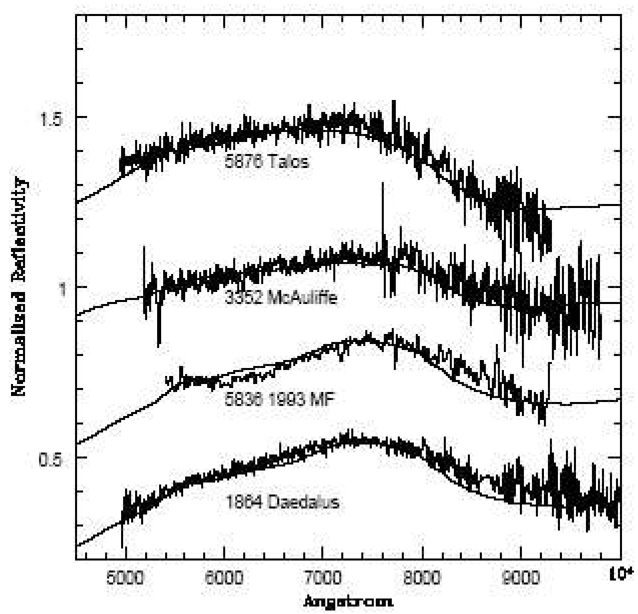


Fig. 3. Spectra of near-Earth asteroids compared with laboratory spectra of ordinary chondrites assemblages. Averaged L4-subtype OC spectrum is superimposed to 1864 *Daedalus* and 5836 *1993 MF*; averaged H4-subtype OC spectrum is compared with 3352 *McAuliffe* and averaged H6-subtype OC spectrum is superimposed to the spectrum of 5876 *Talos*.

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