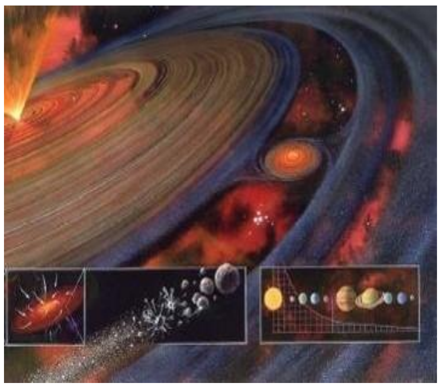
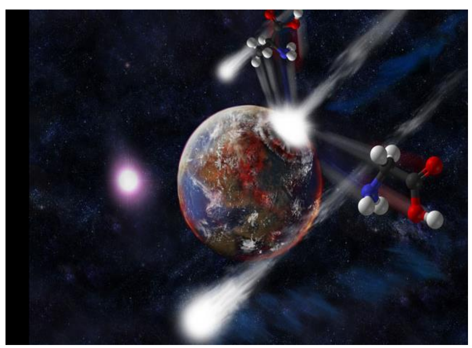
The “small” NEA population: results of a spectroscopic survey in the framework of the NEOShield-2 project



Davide Perna

INAF OAR l'Observatoire de Paris LESIA

European Planetary Science Congress 2017
Riga, 21 September 2017

European Commission
Horizon 2020
European Union funding
for Research & Innovation

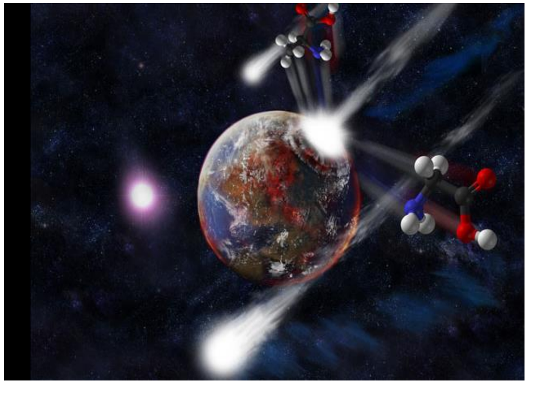
Why near-Earth asteroids do matter

- The closest building blocks of the solar system
  - ✓ Relevant for the origin of prebiotic material on the early Earth
  - ✓ Study of small-sized asteroids

- Accessible targets for space missions
  - ✓ Science
  - ✓ Water/mineral resources

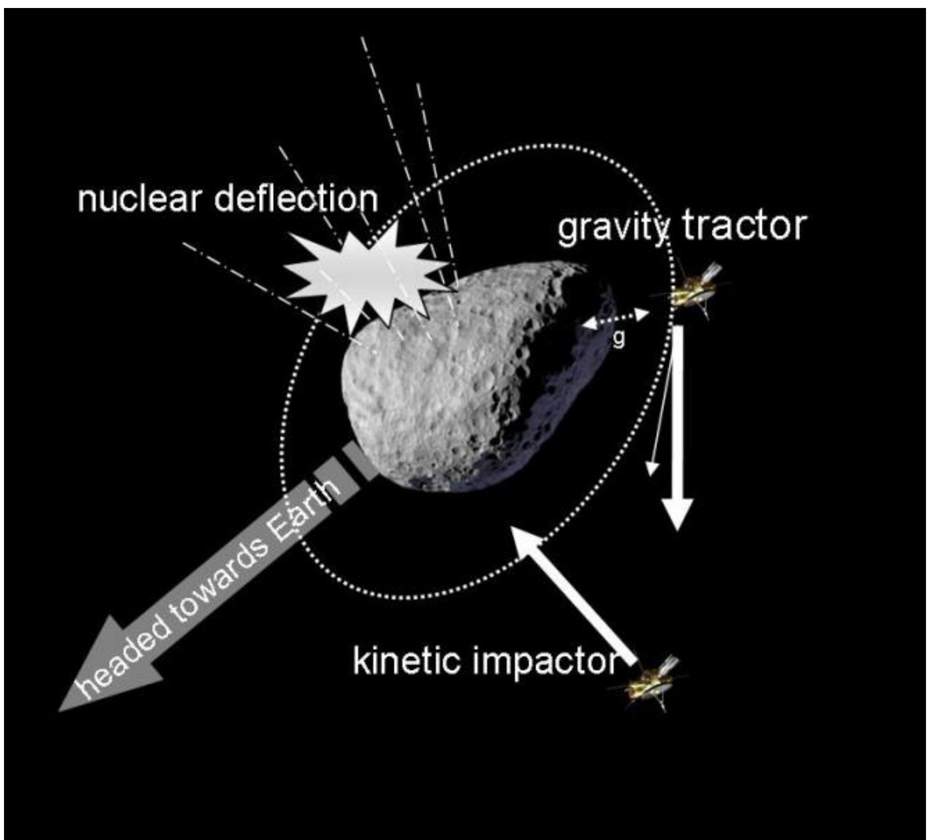
- Planetary defense



The first NEOShield project (Jan 2012 – May 2015)

- Consortium of 13 partners from 6 countries
- Response to the European Commission's FP7 call "Prevention of impacts from near-Earth objects (NEOs) on our planet"
- Funding by the European Commission: 4.0 Meuro
- Science, technology development, response planning
- Detailed study of 3 deflection techniques:



Participant organisation	Country
DLR, Berlin *Coordinating partner*	Germany
Observatoire de Paris (LESIA and IMCCE)	France
CNRS (Obs. Côte d'Azur)	France
Open University	UK
Fraunhofer – EMI	Germany
Queen's Univ. Belfast	UK
Airbus D&S	Germany France UK
Deimos Space	Spain
Carl Sagan Center, SETI Inst.	USA
TsNIIMash (Roscosmos)	Russia
Univ. of Surrey	UK

The NEOShield-2 project (Mar 2015 – Sep 2017)

Horizon 2020
European Union funding
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- Consortium of 11 partners from 5 countries
- Response to the European Commission's H2020 call "Access technologies and characterisation for Near Earth Objects (NEOs)"
- Funding by the European Commission: 4.2 Meuro
- Two specific challenges:
  - ✓ Technology development for GNC and material sampling
  - ✓ Physical characterization of NEOs (in particular, 50-300 m size range)

l'Observatoire de Paris — LESIA

- ○ Leader of WP10 (LESIA, IMCCE, CNRS, INAF, QUB, DMS) [NEO Observations and data reduction/analysis]
- ○ Responsible of Task 10.3: Spectroscopic observations

Participant organisation	Country
Airbus D&S *Coordinating partner (D)*	Germany France UK
DLR, Berlin	Germany
Observatoire de Paris (LESIA and IMCCE)	France
CNRS (Obs. Côte d'Azur)	France
INAF	Italy
Fraunhofer – EMI	Germany
Queen's Univ. Belfast	UK
Deimos Space	Spain
GMV A&D	Spain

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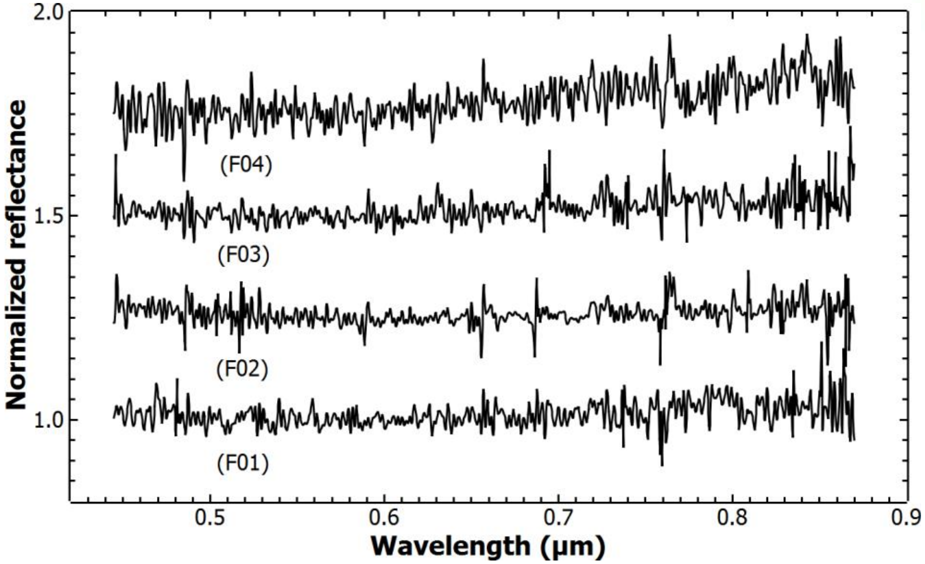
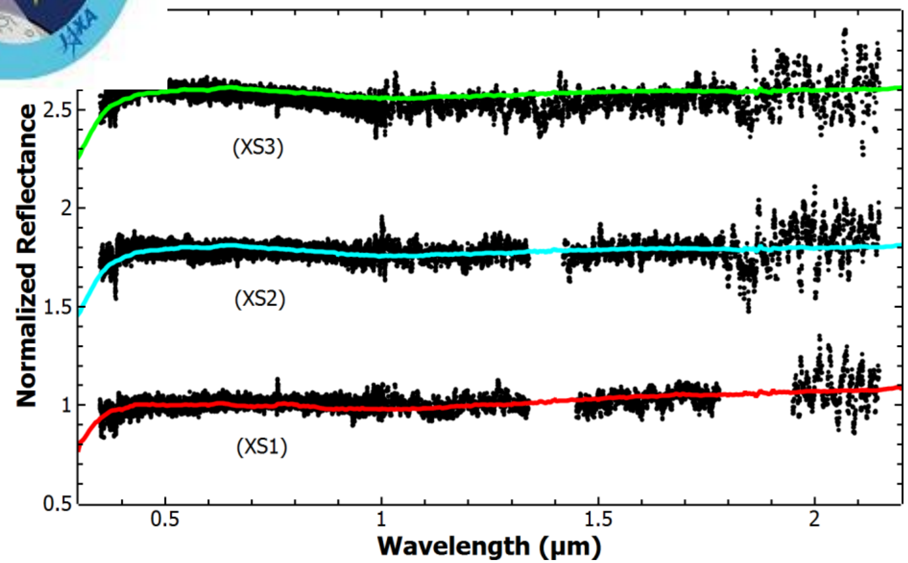
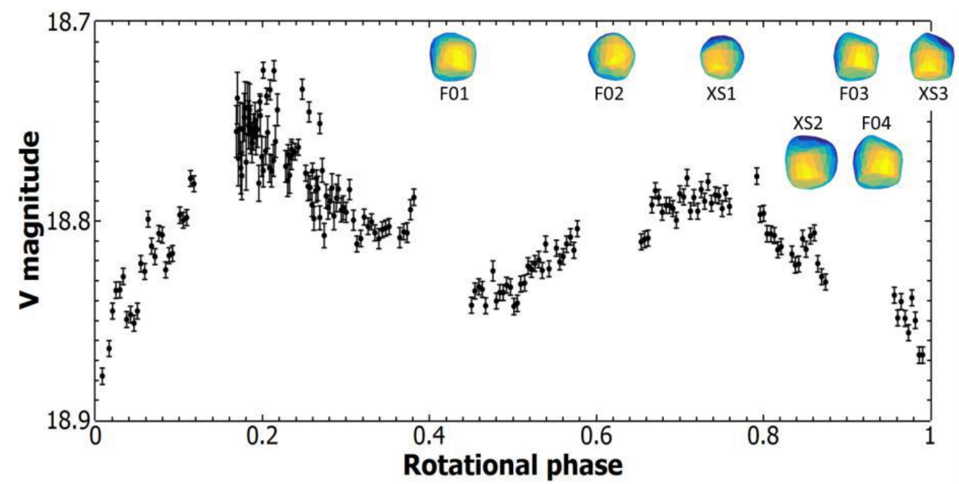
- Responsible of Task 10.3: Spectroscopic observations
  - ❑ Ryugu
  - ❑ PHAs
  - ❑ Small NEAs

ESO-VLT observations of Ryugu





- Double-peaked lightcurve: P ~ 7.63 h
- Only slight spectral variations (surface coverage ~ 60%)
- C-type spectrum
  - ✓ No 0.7-µm absorption
  - ✓ No blue drop-off (< 0.55 µm)
  - ✓ Possible UV drop-off (< 0.4 µm)
  - ✓ Possible association with (thermally altered) CM meteorites



Perna et al. 2017. A&A 599, L1

The PHA population

- ✓ New data + literature (EARN) = 261 objects
- ✓ Distribution of PHAs ≈ as for NEOs in general

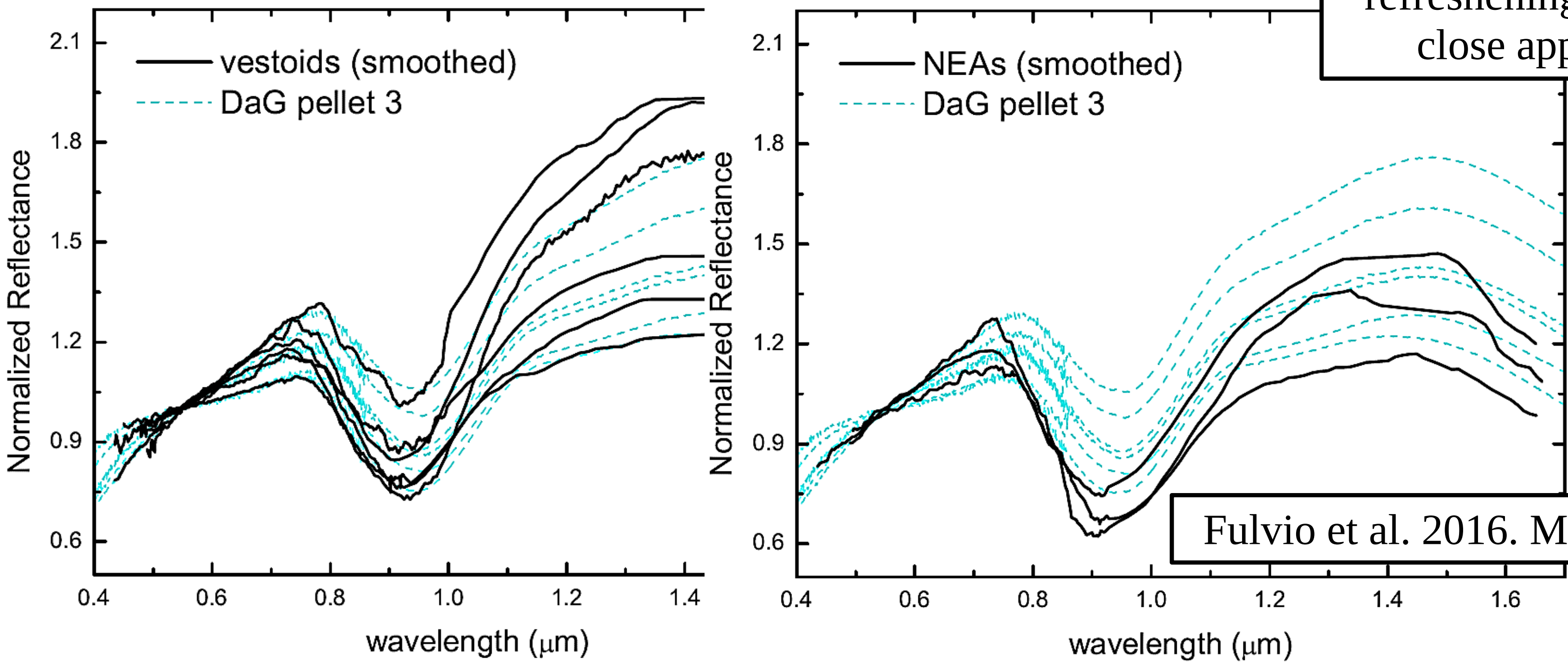
- ✓ We define 4 major groupings:
  - **Silicaceous** (S-complex, Q, A, O)
  - **Basaltic** (V)
  - **Carbonaceous** (B, C, D, P, T, Xc)
  - **Miscellaneous** (X, Xe, Xk, K, L)

Grouping (sample)	a (au)	e	i (°)	q (au)	Q (au)	T_J	Earth MOID (au)
Silicaceous (184)	1.56 (0.42)	0.49 (0.13)	8.7 (4.8)	0.84 (0.12)	2.38 (0.78)	4.20 (0.79)	0.021 (0.010)
Basaltic (12)	1.55 (0.33)	0.53 (0.12)	16.0 (10.3)	0.69 (0.18)	2.43 (0.75)	4.13 (0.63)	0.016 (0.008)
Carbonaceous (40)	1.85 (0.69)	0.51 (0.17)	6.4 (3.6)	0.88 (0.11)	2.75 (1.25)	3.85 (0.90)	0.015 (0.010)
Miscellaneous (25)	1.45 (0.38)	0.47 (0.12)	9.1 (4.8)	0.84 (0.18)	2.28 (0.83)	4.44 (1.03)	0.026 (0.013)

Perna et al. 2016. AJ 151, 11

The PHA population

Lack of reddening: surface refreshening induced by close approaches?



Fulvio et al. 2016. MNRAS 455, 584

Grouping (sample)	a (au)	e	i (°)	q (au)	Q (au)	T_J	Earth MOID (au)
Silicaceous (184)	1.56 (0.42)	0.49 (0.13)	8.7 (4.8)	0.84 (0.12)	2.38 (0.78)	4.20 (0.79)	0.021 (0.010)
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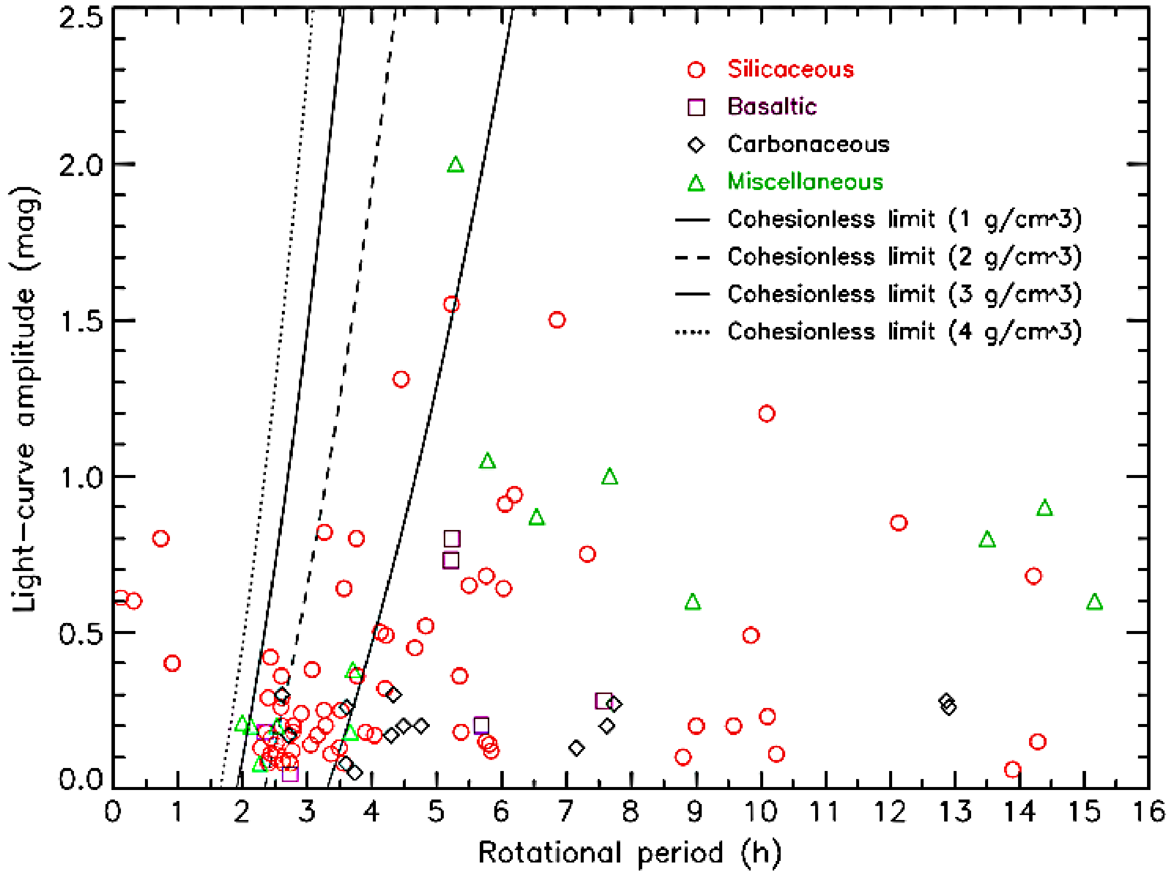
Perna et al. 2016. AJ 151, 11

The PHA population

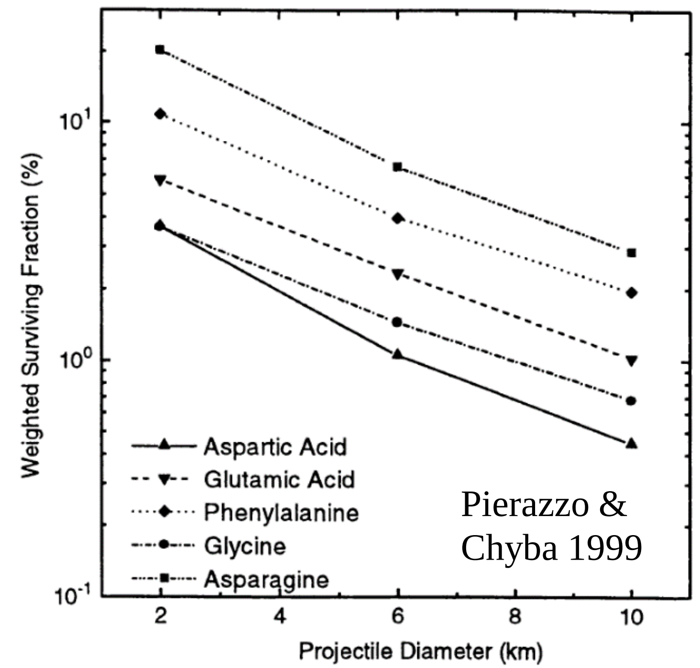
Grouping (sample)	H (mag)	Albedo (%)	Rot. period (h)	Δm (mag)
Silicaceous (184;62;98;98)	18.6 (1.5)	23.1 (8.1)	4.20 (1.77)	0.30 (0.20)
Basaltic (12;5;6;6)	17.8 (1.4)	30.6 (8.9)	5.22 (1.40)	0.24 (0.13)
Carbonaceous (40;22;19;19)	18.7 (0.9)	4.6 (2.2)	7.15 (3.56)	0.20 (0.07)
Miscellaneous (25;14;14;14)	18.8 (0.9)	14.5 (4.9)	5.53 (3.14)	0.60 (0.40)

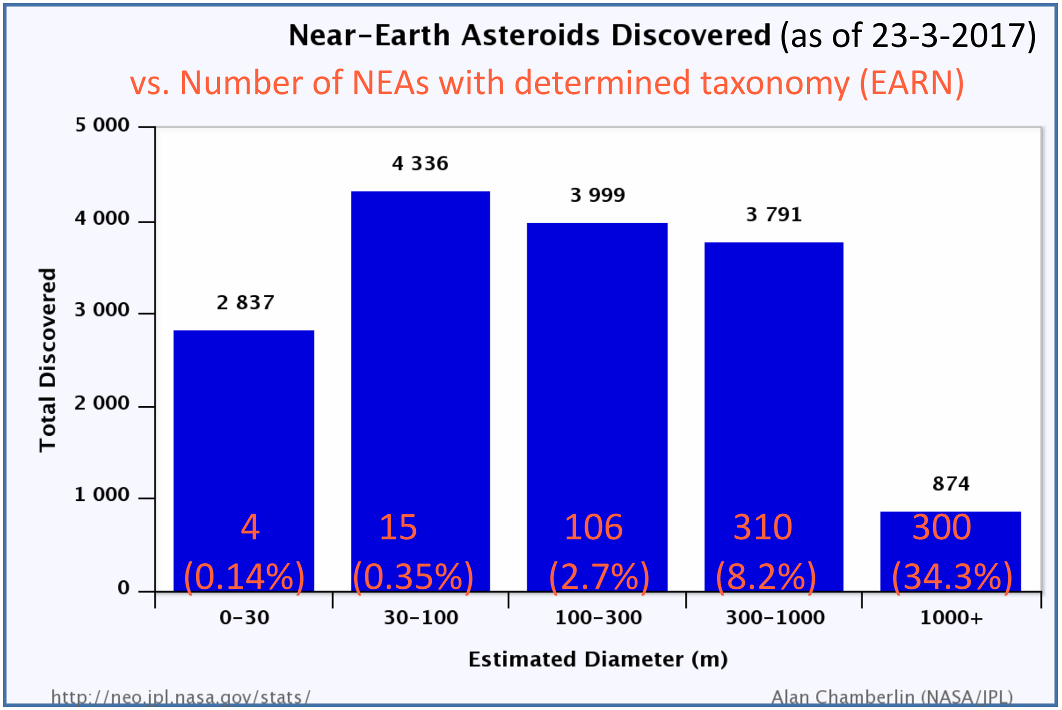


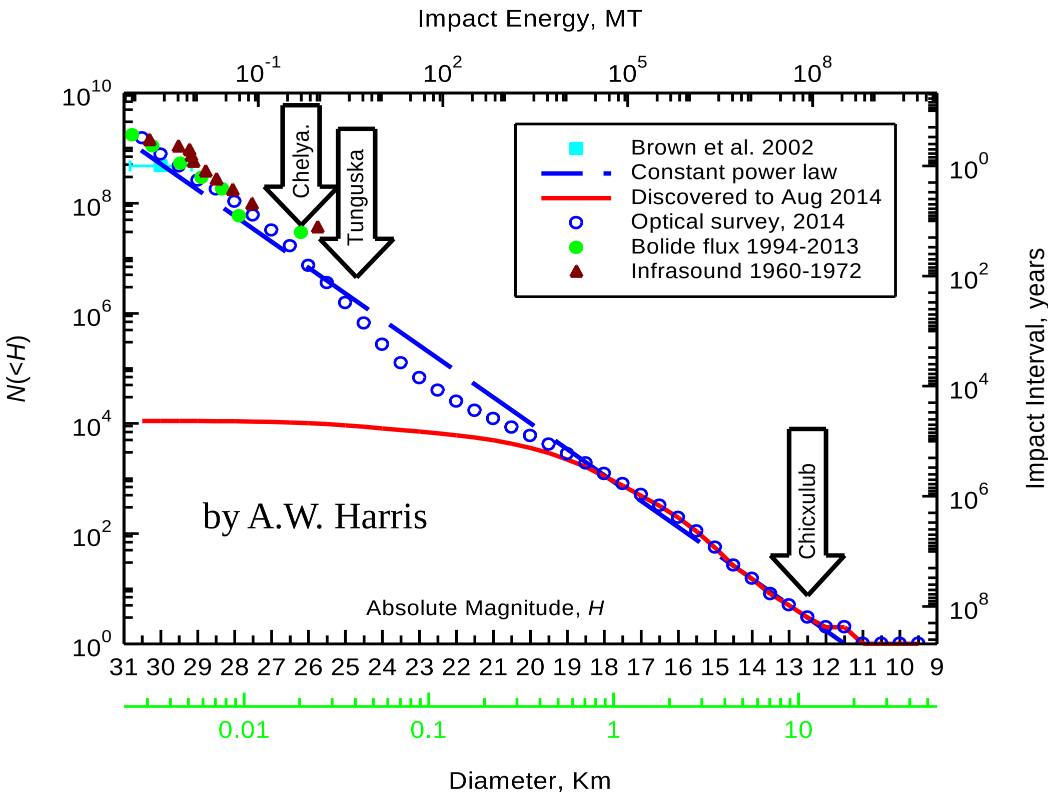
Perna et al. 2016. AJ 151, 11

Why to study the small NEA population?

- Most probable hazard in the near future
- Water and organics better preserved in “small” impacts
- Opportunity to study size-dependent physical properties
- Extremely poorly known
  (characterized << discovered << estimated)

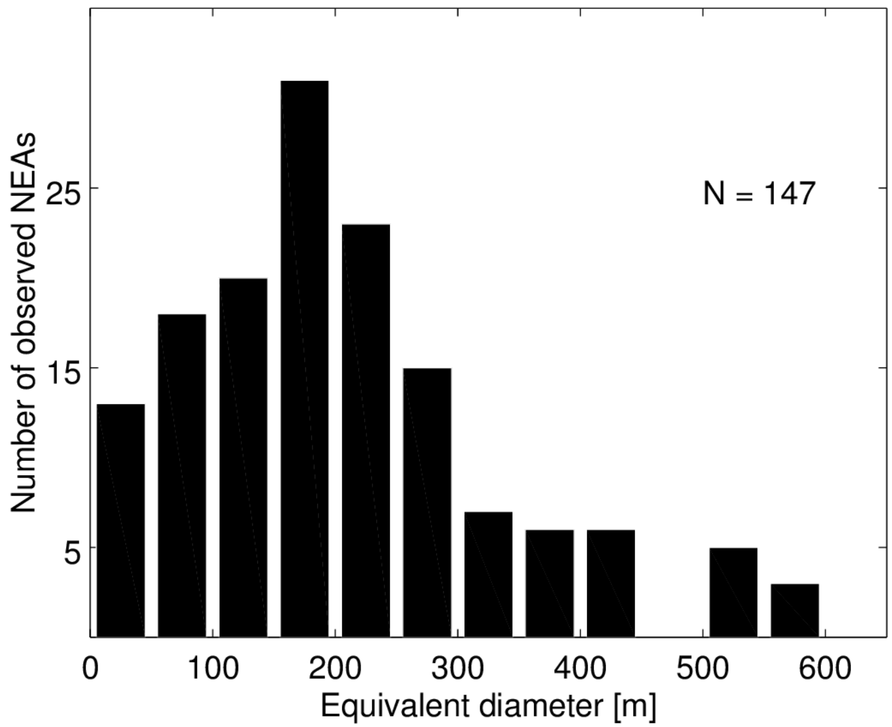




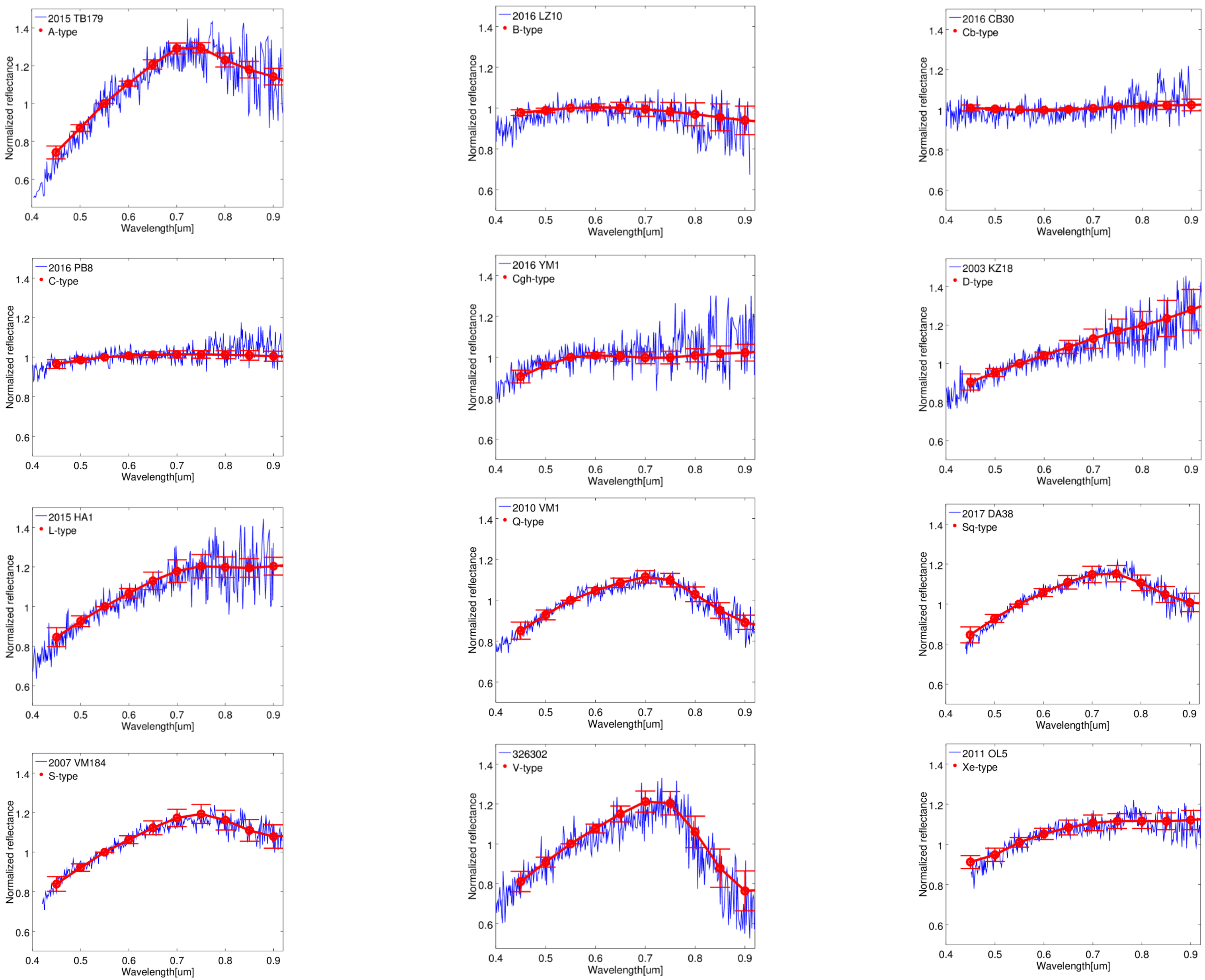


Guaranteed Time Observations of small NEAs @ ESO-NTT

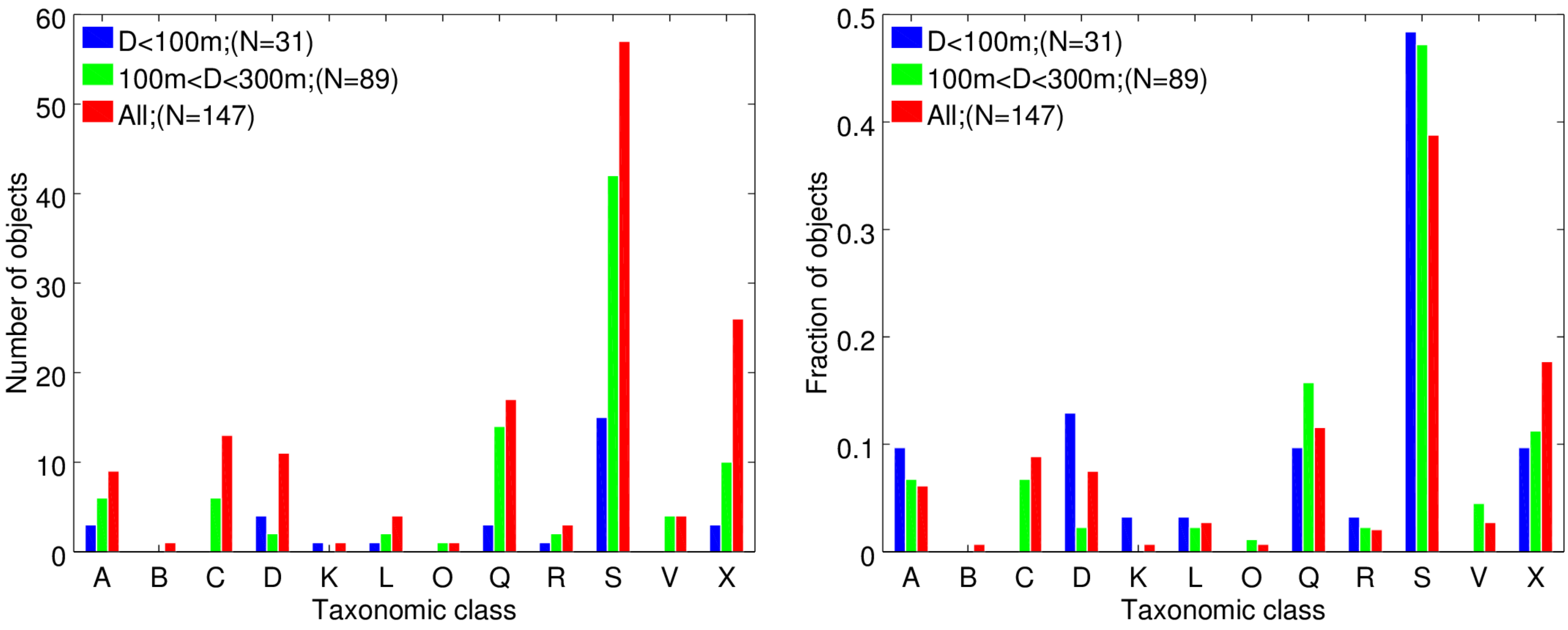
- 30 observing nights over 4 semesters (4/2015 – 3/2017)
- Most of our targets were observed soon after their discovery
- 147 small NEAs characterized by visible spectroscopy (homogeneous sample!)



Small NEAs @ ESO-NTT: taxonomic classification

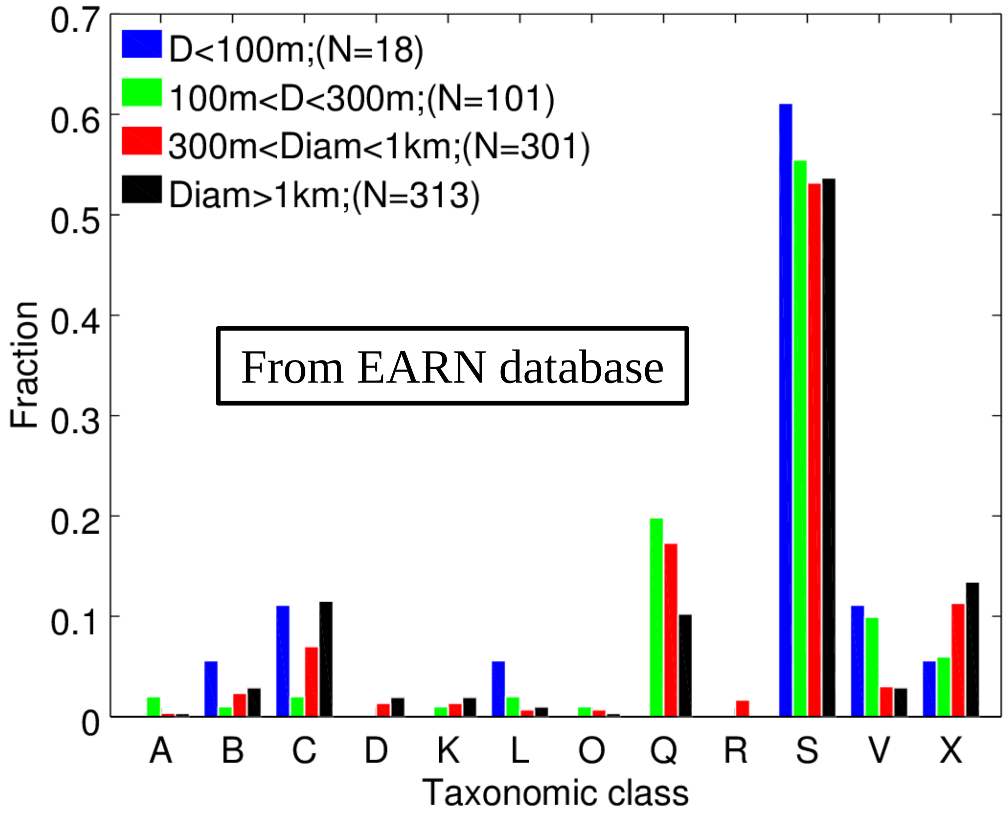


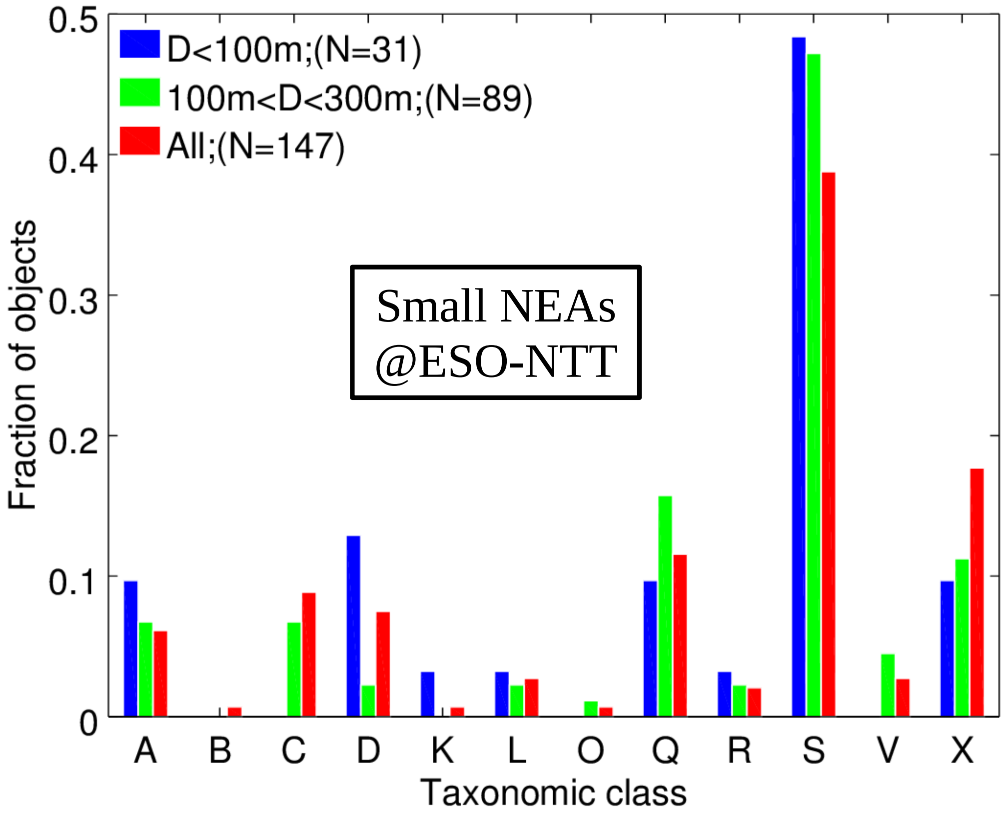
Small NEAs @ ESO-NTT: taxa distribution



- Targets selected by H ≥ 20 → Larger objects are low albedo ones
- Bias against very small low albedo objects

Small NEAs @ ESO-NTT: taxa distribution (vs. literature)





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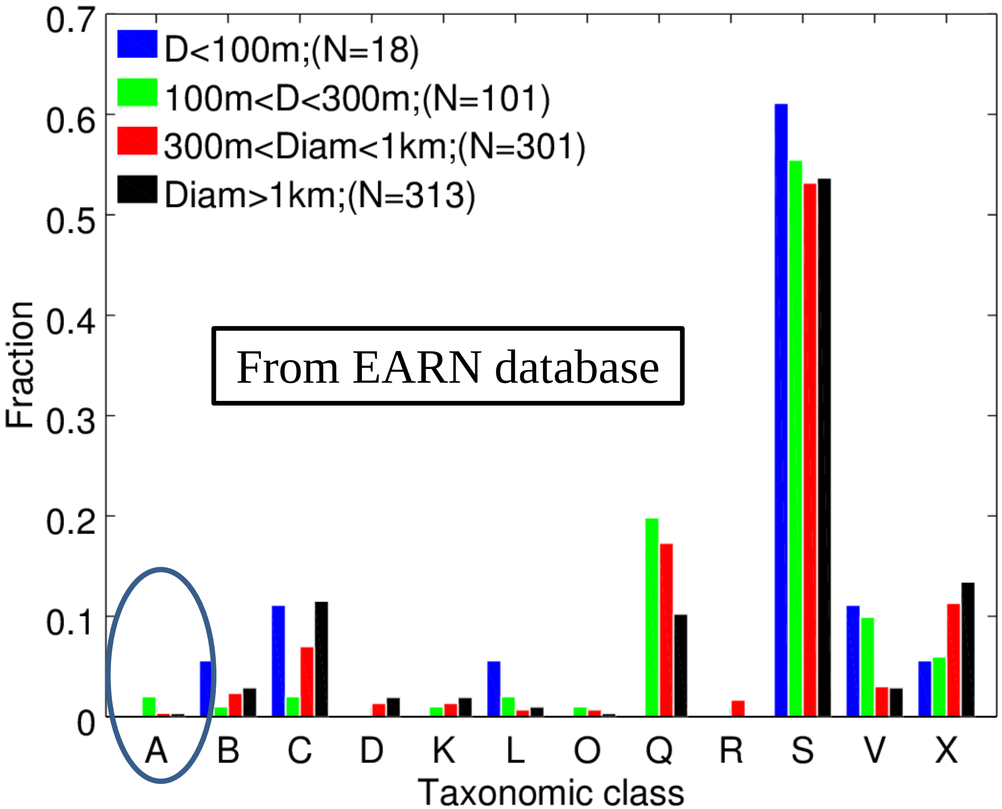

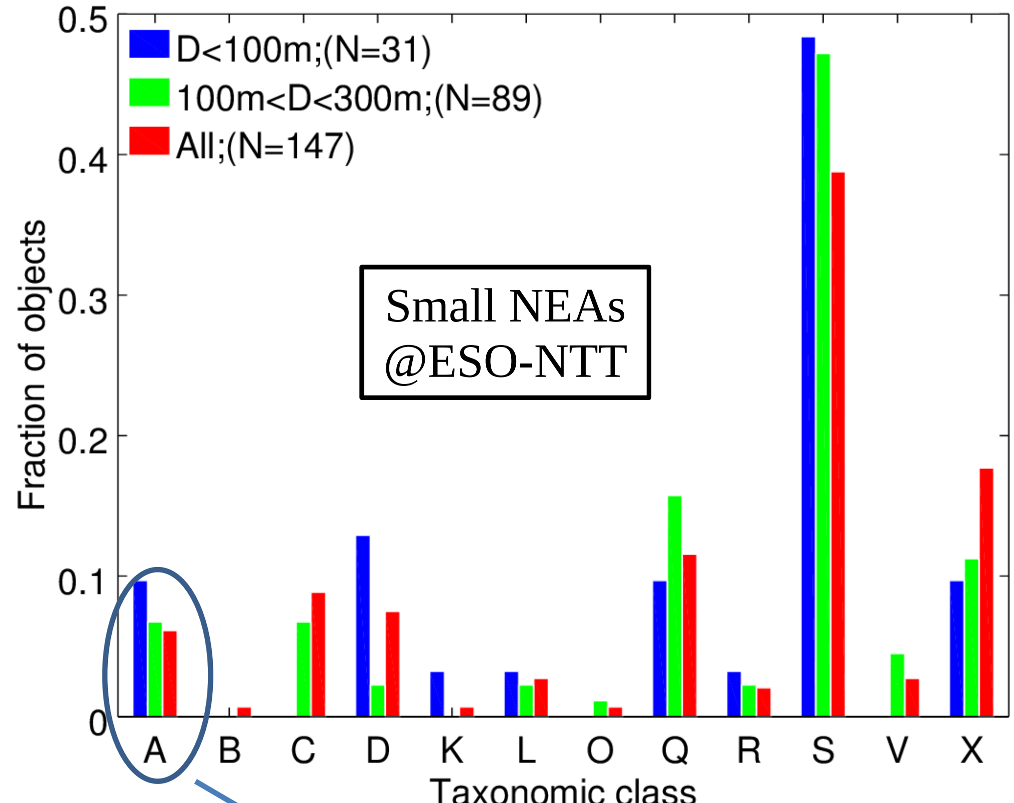

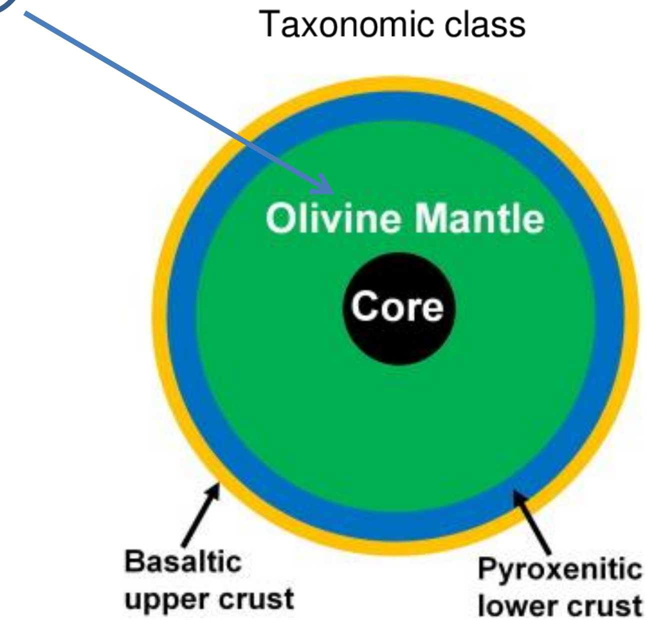

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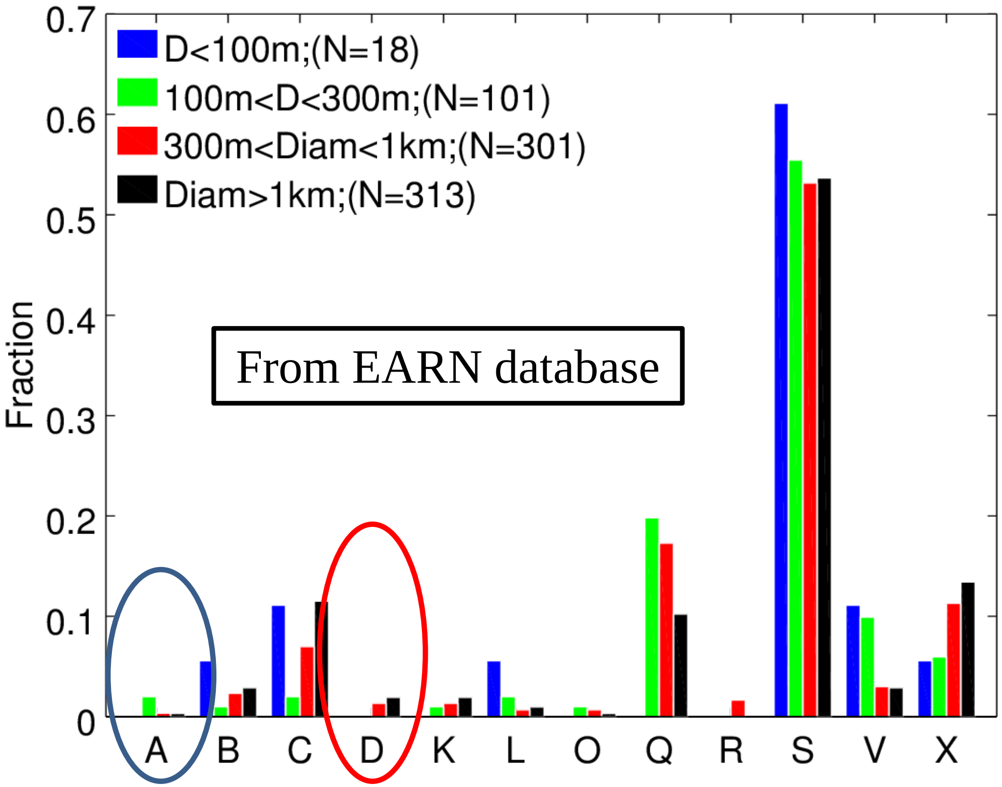
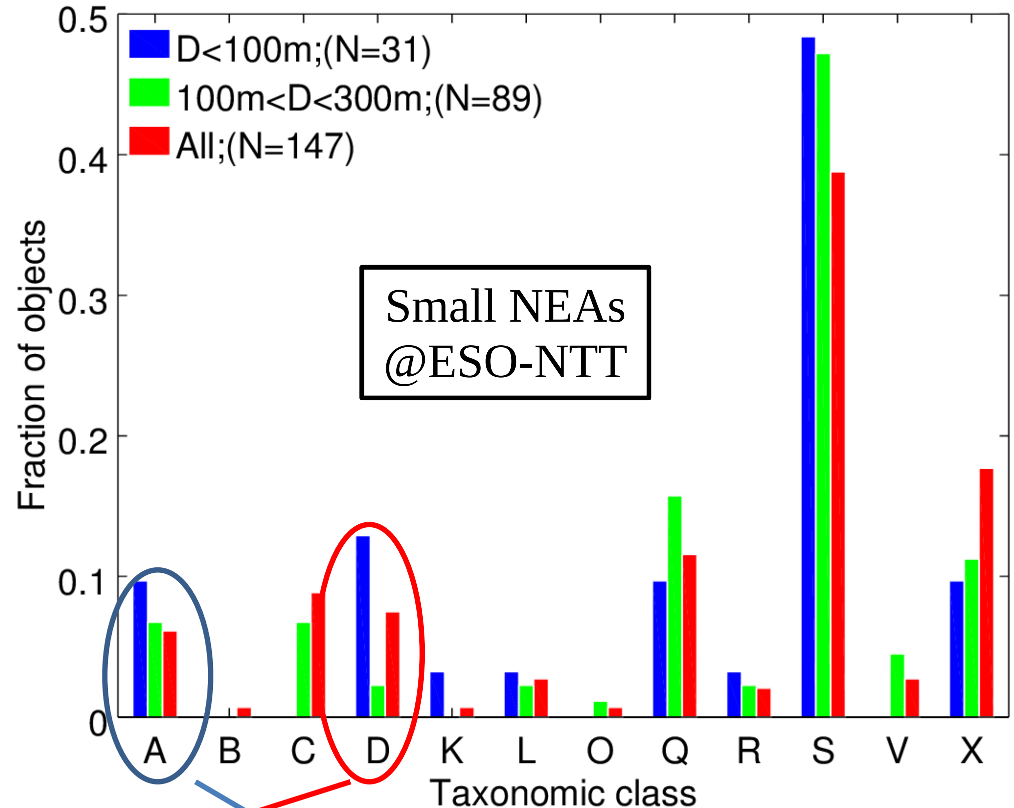
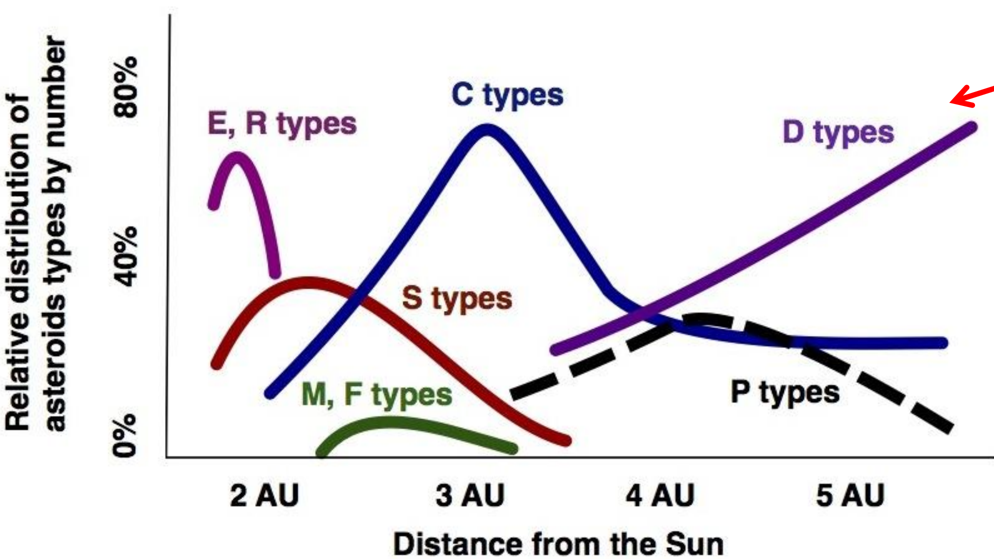
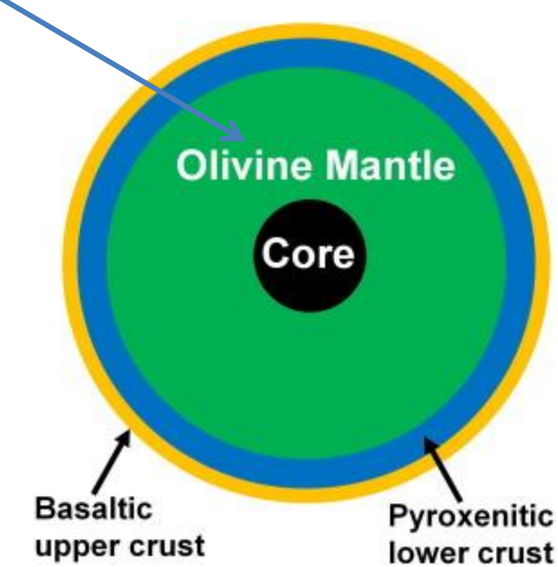


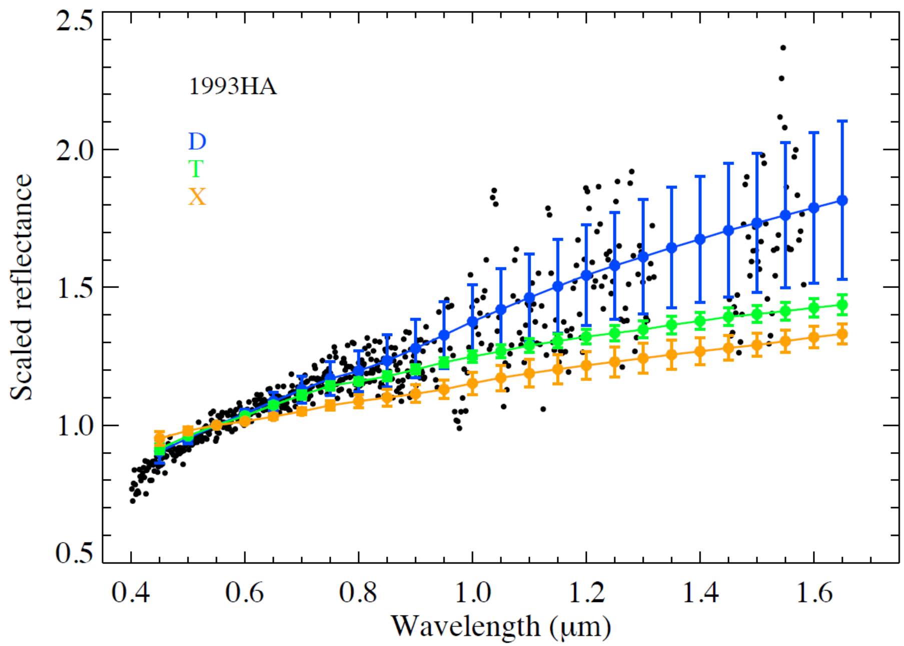


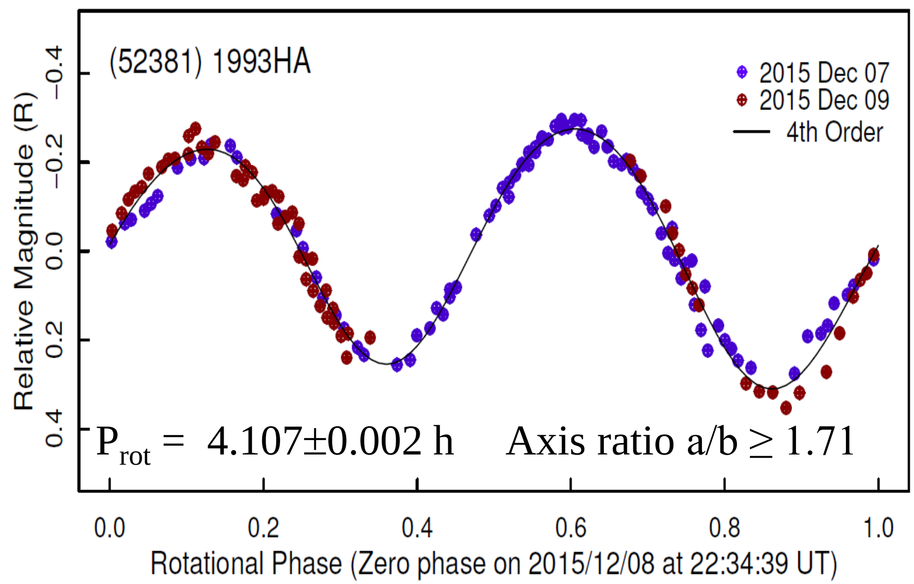




Small NEAs @ ESO-NTT: low-ΔV D-types

- We found 8 new low-ΔV (<7 km/s) D-types (vs. 5 in the literature)
- (52381) 1993 HA (ΔV= 5.3 km/s ; H=20.0 ; a=1.28 AU ; e=0.14 ; i=7.7)

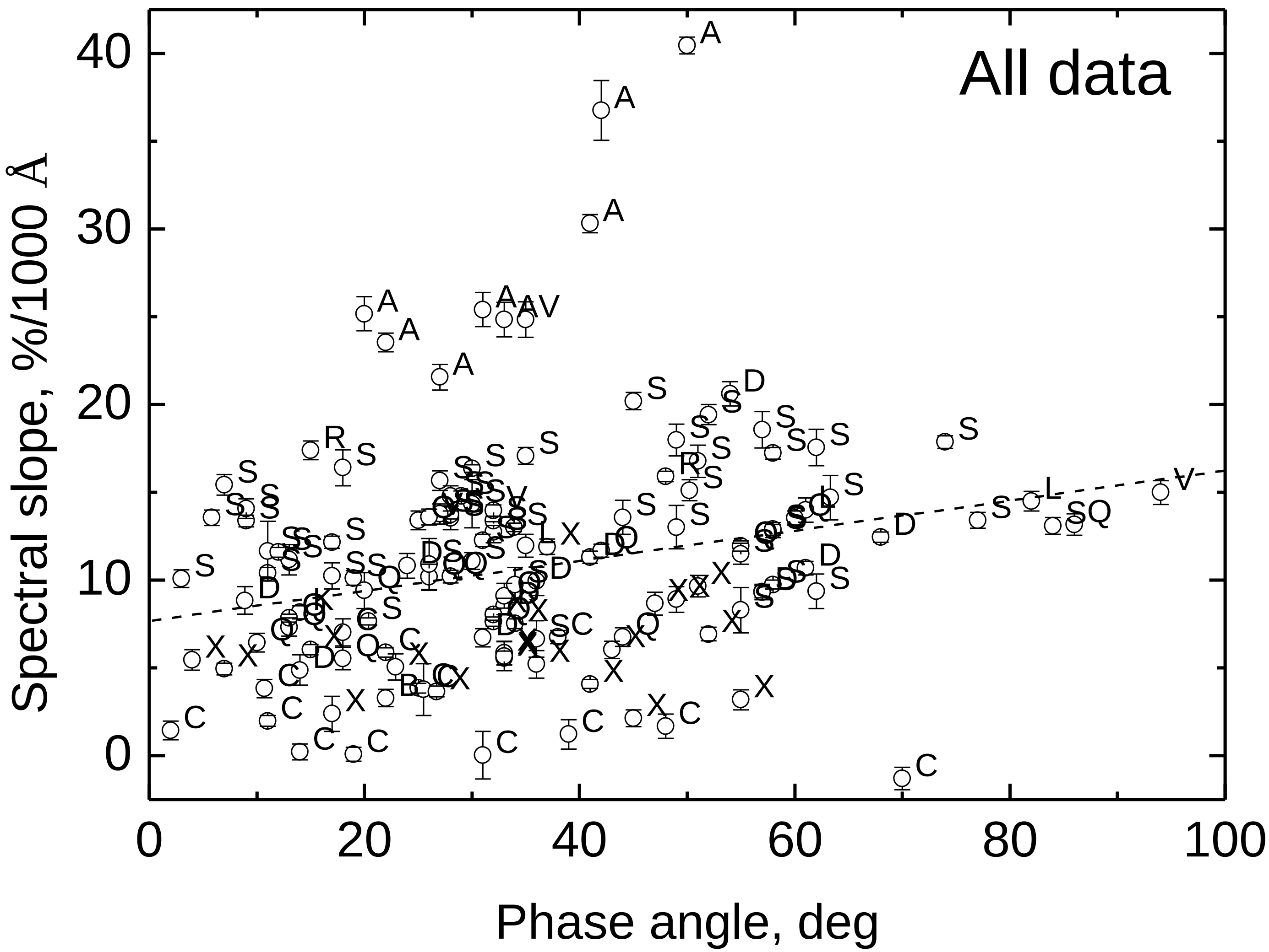




Perna et al. 2017. A&A 597, A57

- See next talk for more information…

Small NEAs @ ESO-NTT: phase reddening



- See next talk for more information…

Summary

<u>Ryugu</u>

- Short period solution clearly excluded by double-peaked lightcurve (P~7.63 h)
- Limited dishomogeneity, possible link with (thermally altered) CM meteorites

<u>The PHA population</u>

- Distribution of taxonomic classes as for NEAs in general
- Carbonaceous PHAs: the most PH among PHAs?
- V-types: low-MOID & lack of spectral reddening
- A few (silicaceous) monolithic fast rotators exist in the PHA population

<u>The "small" NEA population</u>

- Many A-types (towards a solution of the "missing olivine problem"?)
- Many D-types (potential source of prebiotic material)
- Several D-types are favourable targets for space missions
- Distinctive phase reddening for different taxonomic types

I acknowledge financial support from the European Commission's Horizon 2020 programme (NEOShield-2 contract No. PROTEC-2-2014-640351 and Marie Sklodowska-Curie grant agreement n. 664931)