Caratterizzazione della variabilita' in Gaia

Vincenzo Ripepi

INAF-Osservatorio Astronomico di Capodimonte - Italy

on behalf of the Italian-based CU7 members:
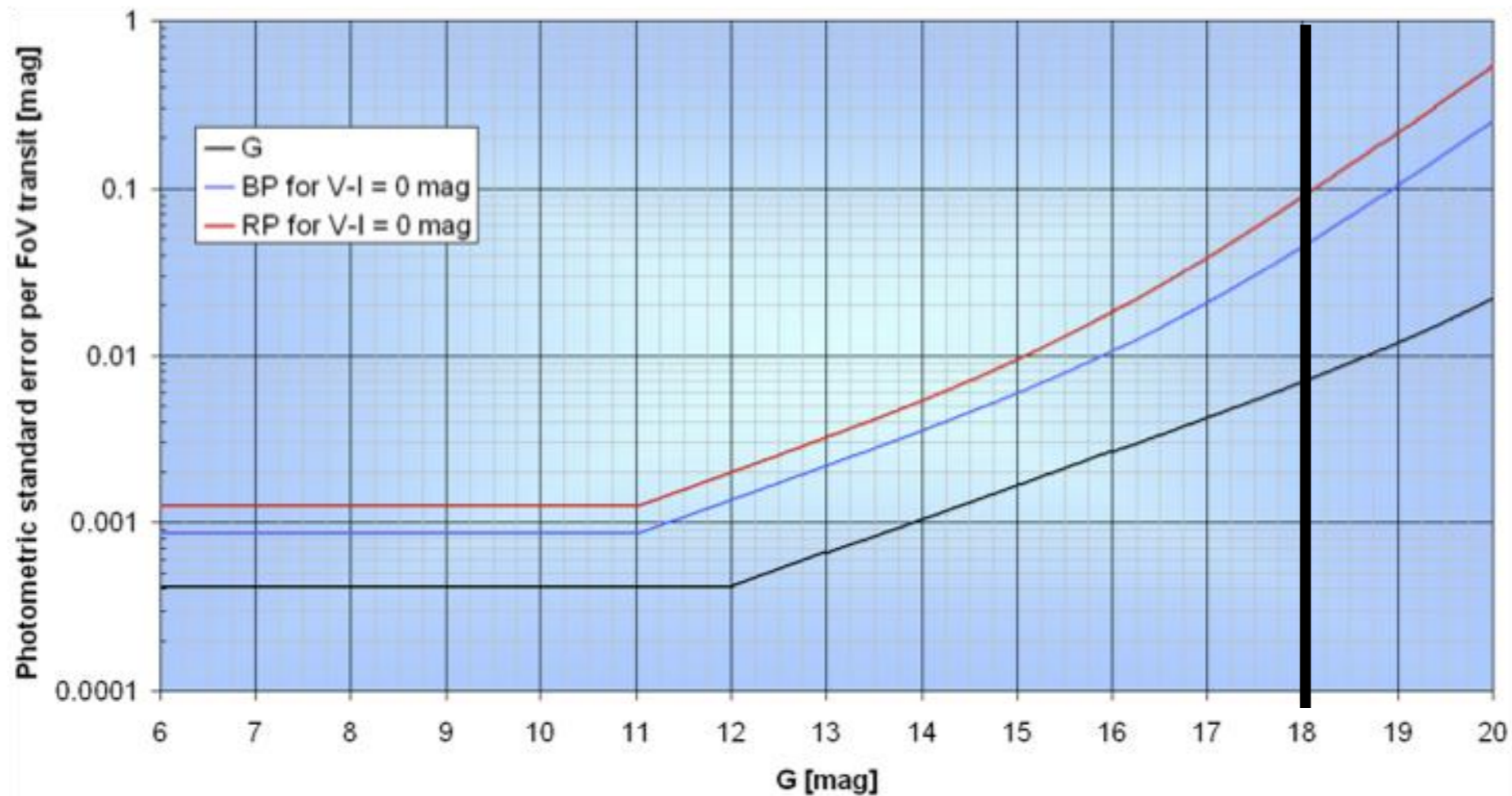
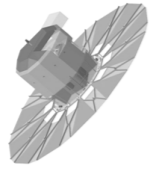|				
G. Clementini	INAF-OABO		A. Lanzafame	UnivCT; INAF-OACT
V. Ripepi	INAF-OACN		E. Di Stefano	INAF-OACT
S. Leccia	INAF-OACN		A. Lanza	INAF-OACT
M. Marconi	INAF-OACN		S. Messina	INAF-OACT
I. Musella	INAF-OACN		I. Pagano	INAF-OACT
G. Bono	Univ. Roma Tor Vergata		G. Cutispoto	INAF-OACT
A. Piersimoni	INAF-OACTe			

DPAC - Coordination Unit 7

‣ The Gaia Coordination Unit for Variability Processing (CU7) is in charge of characterising the photometric and spectral variability.

‣ The purpose of the CU7 variability data processing is to populate the Gaia catalogue with information on the variable objects present in the Gaia database.

  ✓ Classification of the variability type (e.g. RR Lyrae, Cepheid, Mira, spotted star, PMS, etc.)

  ✓ Derivation of parameters characteristic for the specific variability type, e.g. period(s), amplitudes, Fourier decomposition etc.

‣ This is done through automatic pipelines for the catalogue production and through some interactive tools for validation and quality assessment of the data.

Gaia Epoch photometry

- Mean number of transits: 80   (range ~50-150)

- Epoch photometry to G=20 mag

- Epoch low resolution spectra to 16-17 mag from BP and RP

- Epoch medium resolution spectra to 12-13 mag from RVS

- Teff to ~200 K, log(g) to 0.2 dex, [Fe/H] to 0.2 dex, extinction....
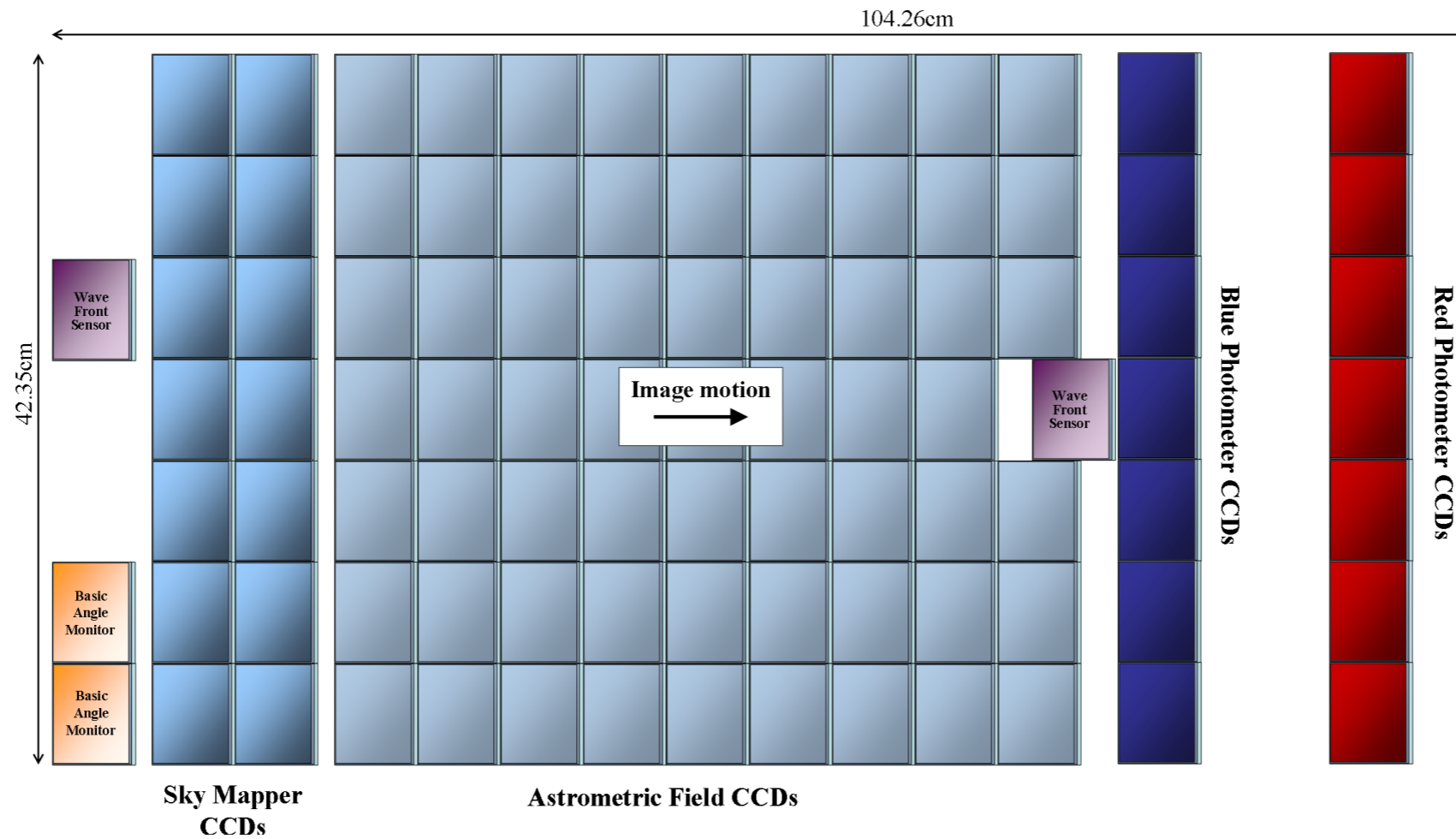
Gaia per-CCD photometry

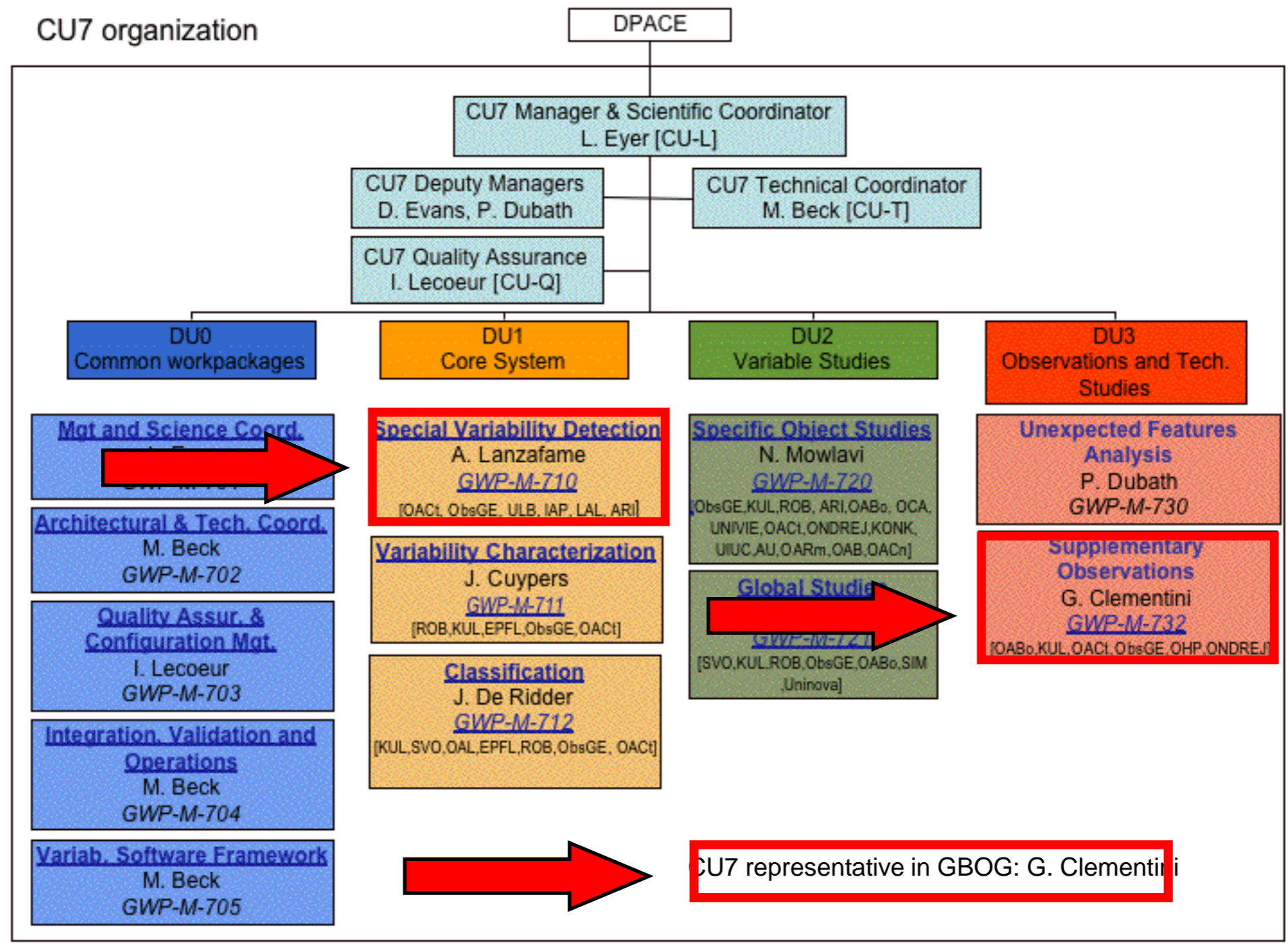**Gaia Focal Plane**

106 CCDs ≈ 938 million pixels ≈ 2800 cm²

One G measurement per AF column during transit

CCD exp time= 4.72 sec

Total = 42.49 sec

CU7 Organization

CU7 organization

DPACE

CU7 Manager & Scientific Coordinator
L. Eyer [CU-L]

CU7 Deputy Managers
D. Evans, P. Dubath

CU7 Technical Coordinator
M. Beck [CU-T]

CU7 Quality Assurance
I. Lecoeur [CU-Q]

DU0 Common workpackages	DU1 Core System	DU2 Variable Studies	DU3 Observations and Tech. Studies

Mgt and Science Coord.

Architectural & Tech. Coord.
M. Beck
GWP-M-702

Quality Assur. & Configuration Mgt.
I. Lecoeur
GWP-M-703

Integration, Validation and Operations
M. Beck
GWP-M-704

Variab. Software Framework
M. Beck
GWP-M-705

Special Variability Detection
A. Lanzafame
GWP-M-710
[OACt, ObsGE, ULB, IAP, LAL, ARI]

Variability Characterization
J. Cuypers
GWP-M-711
[ROB,KUL,EPFL,ObsGE,OACt]

Classification
J. De Ridder
GWP-M-712
[KUL,SVO,OAL,EPFL,ROB,ObsGE, OACt]

Specific Object Studies
N. Mowlavi
GWP-M-720
[ObsGE,KUL,ROB, ARI,OABo, OCA, UNIVIE,OACt,ONDREJ,KONK, UIUC,AU,OARm,OAB,OACn]

Global Studies
GWP-M-721
[SVO,KUL,ROB,ObsGE,OABo,SIM ,Uninova]

Unexpected Features Analysis
P. Dubath
GWP-M-730

Supplementary Observations
G. Clementini
GWP-M-732
[OABo,KUL,OACt,ObsGE,OHP,ONDREJ]

CU7 representative in GBOG: G. Clementini

Special Variability Detection

Manager: Alessandro Lanzafame (UniCt & INAF-OACt)

Team: E. Distefano, L. Eyer, L. Guy, I. Lecoeur,
                       S. Messina, B. Tingley, M. Varadi, S. Zucker

Aim: Identification and parametrization of short time-scale and
                       small amplitude variability not identified with other
                       methods (including the use of per-CCD photometry)

Context: Planetary transits
                       Solar-like variability
                       Short time-scale variability (e.g. β Cep, δ Scuti, roAp, ZZ
Ceti)

                       Small amplitude variability

Supplementary Observations

Manager: Gisella Clementini (INAF-OABo)

Team: V. Ripepi, S. Leccia, L. Szabados, P. Klagyivik, G. Marschalko,
L. Eyer, N. Mowlavi, M. Varadi, P. Dubath, S. Sasen,
R. Anderson, L. Palaversa, P. Koubsky, T. Lebzelter, I. Kolka

Aims:
- Observations of groups of variable objects, either from ground-based observatories or from other satellites, to prepare and complement our knowledge of the Gaia sources.
- Observations for quality control of the algorithms developed by CU7 for the characterization of the variable source observed by Gaia.
- Contribution to the development and validation of the Gaia Science Alerts (GSA) system and tracking of the satellite (GBOT)

Context: Photometry of selected Cepheids (period changes, binarity)
Spectra of LPVs (Miras, Ir variables)
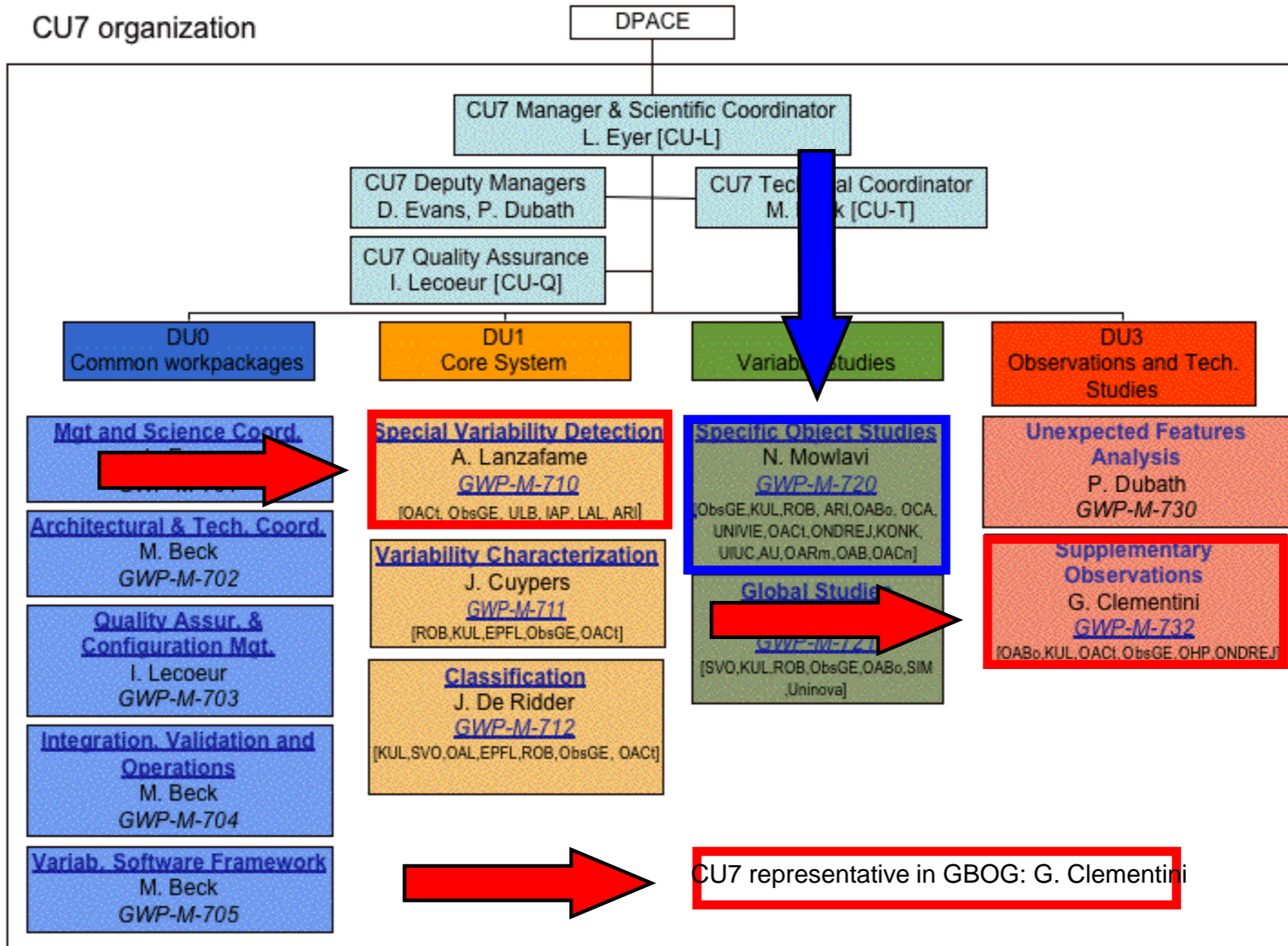Photometry of short period variables (δ Scuti & SX Phoenicis)
Time series photometry of the NEP
Time series photometry of the SEP
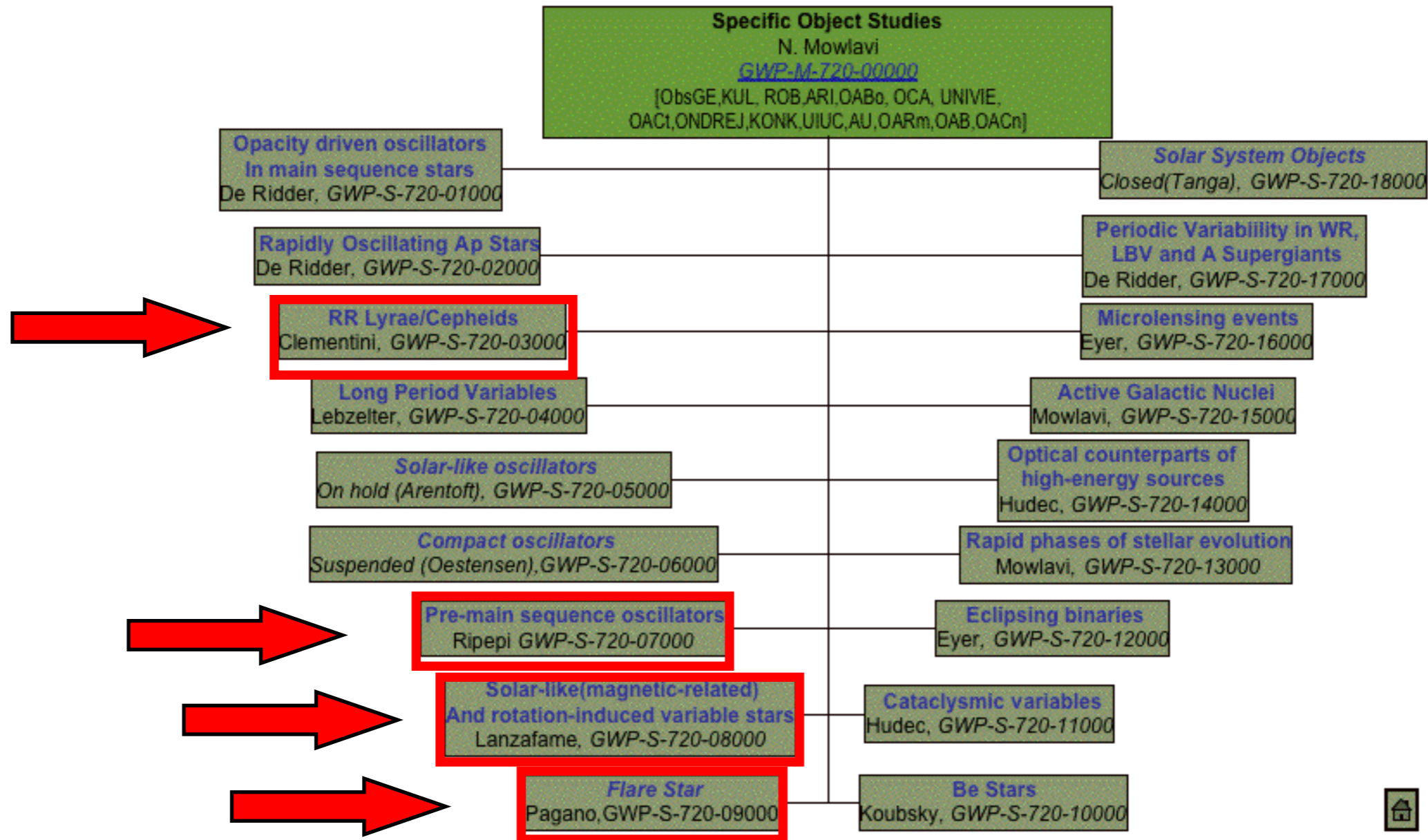Tests of the GSA & GBOT

CU7 Organization

CU7 organization

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                                    ┌─────────────┐
                                    │    DPACE    │
                                    └─────────────┘
                                           │
                    ┌──────────────────────────────────────────┐
                    │  CU7 Manager & Scientific Coordinator     │
                    │          L. Eyer [CU-L]                   │
                    └──────────────────────────────────────────┘
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CU7 Deputy Managers D. Evans, P. Dubath	CU7 Technical Coordinator M. Beck [CU-T]

CU7 Quality Assurance
I. Lecoeur [CU-Q]

DU0 Common workpackages	DU1 Core System	Variability studies	DU3 Observations and Tech. Studies

Mgt and Science Coord.
L. Eyer
GWP-M-701

Special Variability Detection
A. Lanzafame
GWP-M-710
[OACt, ObsGE, ULB, IAP, LAL, ARI]

Specific Object Studies
N. Mowlavi
GWP-M-720
[ObsGE,KUL,ROB, ARI,OABo, OCA, UNIVIE, OACt,ONDREJ,KONK, UIUC,AU,OARm,OAB,OACn]

Unexpected Features Analysis
P. Dubath
GWP-M-730

Architectural & Tech. Coord.
M. Beck
GWP-M-702

Variability Characterization
J. Cuypers
GWP-M-711
[ROB,KUL,EPFL,ObsGE,OACt]

Global Studies
GWP-M-721
[SVO,KUL,ROB,ObsGE,OABo,SIM ,Uninova]

Supplementary Observations
G. Clementini
GWP-M-732
[OABo,KUL,OACt,ObsGE,OHP,ONDREJ]

Quality Assur. & Configuration Mgt.
I. Lecoeur
GWP-M-703

Classification
J. De Ridder
GWP-M-712
[KUL,SVO,OAL,EPFL,ROB,ObsGE, OACt]

Integration, Validation and Operations
M. Beck
GWP-M-704

Variab. Software Framework
M. Beck
GWP-M-705

CU7 representative in GBOG: G. Clementini

Specific Object Studies (SOS)

CU7 : Specific Object Studies

Specific Object Studies
N. Mowlavi
GWP-M-720-00000
[ObsGE,KUL, ROB,ARI,OABo, OCA, UNIVIE,
OACt,ONDREJ,KONK,UIUC,AU,OARm,OAB,OACn]

**Opacity driven oscillators
In main sequence stars**
De Ridder, *GWP-S-720-01000*

Rapidly Oscillating Ap Stars
De Ridder, *GWP-S-720-02000*

RR Lyrae/Cepheids
Clementini, *GWP-S-720-03000*

Long Period Variables
Lebzelter, *GWP-S-720-04000*

Solar-like oscillators
On hold (Arentoft), *GWP-S-720-05000*

Compact oscillators
Suspended (Oestensen),*GWP-S-720-06000*

Pre-main sequence oscillators
Ripepi *GWP-S-720-07000*

**Solar-like(magnetic-related)
And rotation-induced variable stars**
Lanzafame, *GWP-S-720-08000*

Flare Star
Pagano,*GWP-S-720-09000*

Solar System Objects
Closed(Tanga), *GWP-S-720-18000*

**Periodic Variabiility in WR,
LBV and A Supergiants**
De Ridder, *GWP-S-720-17000*

Microlensing events
Eyer, *GWP-S-720-16000*

Active Galactic Nuclei
Mowlavi, *GWP-S-720-15000*

**Optical counterparts of
high-energy sources**
Hudec, *GWP-S-720-14000*

Rapid phases of stellar evolution
Mowlavi, *GWP-S-720-13000*

Eclipsing binaries
Eyer, *GWP-S-720-12000*

Cataclysmic variables
Hudec, *GWP-S-720-11000*

Be Stars
Koubsky, *GWP-S-720-10000*

Specific Object Studies: Cepheids and RR Lyrae

Manager: G. Clementini   INAF-OABologna

Active members:

V. Ripepi	INAF-OACapodimonte
S. Leccia	INAF-OACapodimonte
M. Marconi	INAF-OACapodimonte
I. Musella	INAF-OACapodimonte
L. Szabados	Konkoly Obs. (Hungary)
P. Klagyivik	Konkoly Obs. (Hungary)
G. Marschalko	Konkoly Obs. (Hungary)
N. Mowlavi	ISDC-Geneve (Switzerland) - SOS Leader
I. Lecoeur	ISDC-Geneve (Switzerland) - SW, Doc support

Associate members (≤ 0.1 FTE):

G. Bono	Univ. Roma Tor Vergata
A.Piersimoni	INAF-OATeramo
B.M. Groenewegen	Royal Obs. Bruxelles (Belgium)
C.K. Kolenberg	Harvard-Smithsonian Center for Astrophysics, USAM.
D.Chadid	Observatoire de la Côte d'Azur, FranceC.C.
E.Ngeow	Graduate Inst. of Astronomy, National Central Univ., Taiwan

Specific Object Studies, Cepheids and RR Lyrae

Aims:

1) Verify the classification provided by the Classification WP

2) Characterize in detail the targets and calculate the parameters to be added to the Gaia catalogue.

	Hipparcos	Gaia
Classical Galactic Cepheids	273 observed (2 new) P: 2 to 36 days ~ 100 with $\sigma_\pi < 1$ mas	Census of galactic Cepheids with $G \leqslant 20$: ~ 9000 Cepheids All periods, colours and metallicities Up to 1-2 kpc with $\sigma_\pi/\pi < 1\%$ All galactic Cepheids with $\sigma_\pi/\pi < 10\%$ Cluster membership
Population II Cepheids	~ 30	~ 2000
LMC Cepheids	None	1000-2000 Cepheids with $\sigma_\pi/\pi \sim 50 - 100\%$ Mean distance of groups of Cepheids expected to 10% Mean distance of LMC expected to 0.5% Depth of LMC expected to 1%
RR Lyrae	186 observed (9 new) Only RR Lyr with accurate π 126 with $\sigma_\pi/\pi \sim 30\%$	All galactic RR Lyrae: $\sim 70\,000$ All metallicities Up to 1 kpc with $\sigma_\pi/\pi < 1\%$ In globular clusters: mean $\sigma_\pi/\pi < 1\%$
All pulsating variables		Extensive surveys of all types of variables Astrometry, photometry and spectroscopy Extensive sampling versus period, colour, metallicity Determination of the zero-points and slopes the P-L(-C) relations Determination of the intrinsic dispersion of the P-L(-C) relations Cluster membership

Specific Object Studies, Cepheids and RR Lyrae

- Engine: G,Bp,Rp/RV curves analysis: Lomb-Scargle/linear + non-linear least square fit

- Gaia stellar parameters if available (Teff, logg, [Fe/H], reddening, parallax)
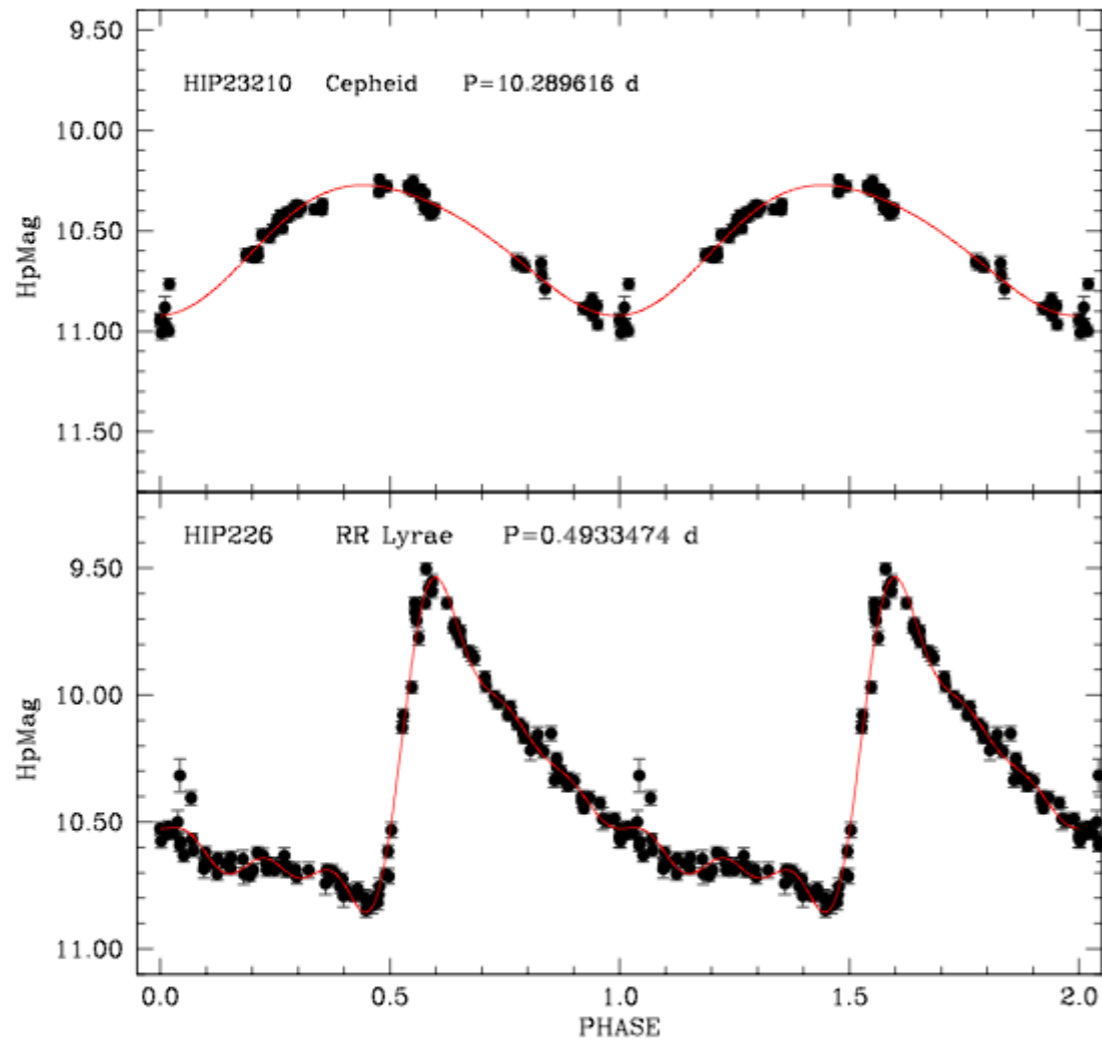
Main deliverables:

RR Lyrae	Cepheids
‣ Period(s), Epochs, average quantities (G, Rp, Bp, RV etc.), Peak-Peak Amplitude	‣ Period(s), Epochs, average quantities (G, Rp, Bp, RV etc.), Peak-Peak Amplitude
‣ Fourier parameters (R21,φ21 etc.)	‣ Fourier parameters (R21,φ21 etc.)
‣ Reject false positives	‣ Reject false positives
‣ Mode identification (RRab,RRc,RRd)	‣ Idenfitication of Binary/Multiple Cepheids
‣ RRd period ratios	‣ Type identification (DCEP, T2CEP, AC)
‣ Blazkho flag (Blazkho period?)	‣ Mode identification (F, FO,....F/FO,......)

Tests on Hipparcos/M3 observations

Leccia, Ripepi, Clementini et al. 2011, GAIA-C7-TN-OACN-SL-001-01

Specific Object Studies: PMS Oscillators

P.I. V. Ripepi   INAF-OACapodimonte
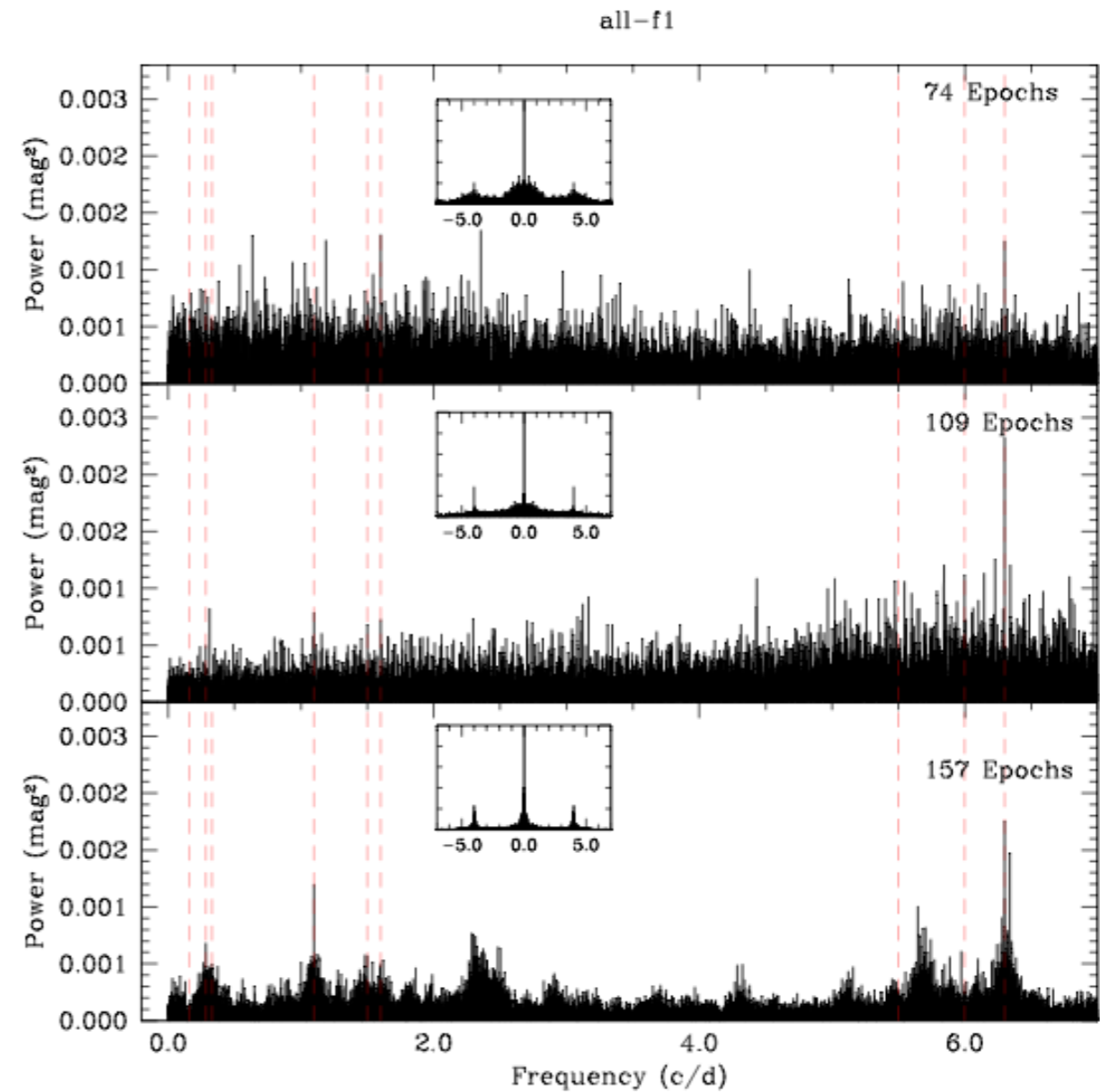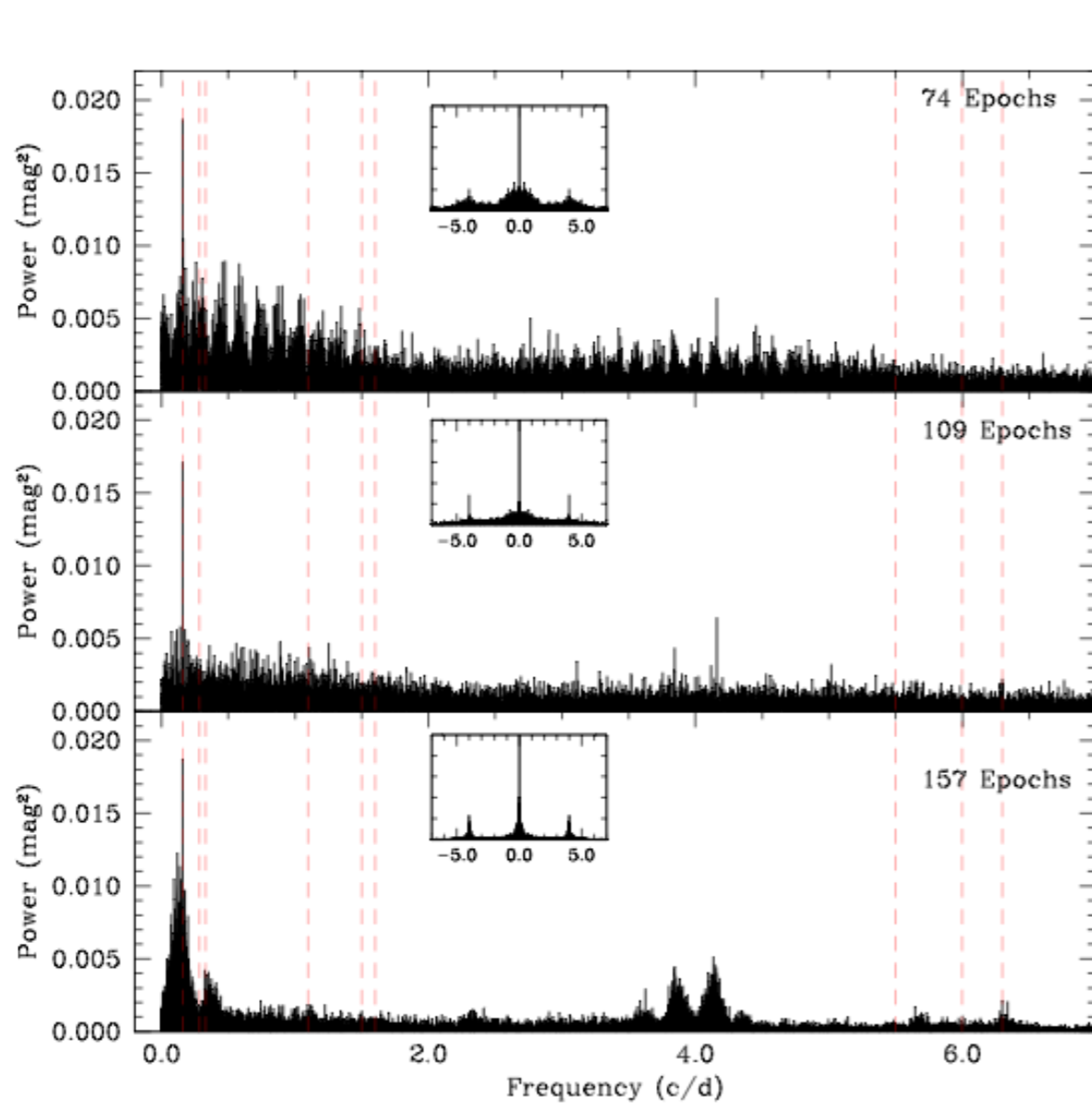
Active members:

V. Ripepi	INAF-OACapodimonte
S. Leccia	INAF-OACapodimonte
M. Marconi	INAF-OACapodimonte
D. Lorenz	Inst. of Astronomy, Vienna, Austria
N. Mowlavi	ISDC-Geneve (Switzerland) - SOS Leader
I. Lecoeur	ISDC-Geneve (Switzerland) - SW, Doc support

Aims:

1) Extract the PMS Oscillators among all the stars classified as δ Sct/γ Dor (Classification WP)

2) characterize in detail the targets and calculate the parameters to be added to the Gaia catalogue

(variable type classification, pulsation frequencies, amplitudes, phases).

Simulations with the Gaia scanning law

f1	0.157 c/d	100 mmag	f4	1.1 c/d	20 mmag	f7	5.5 c/d	10 mmag
f2	0.283 c/d	15 mmag	f5	1.5 c/d	15 mmag	f8	6.0 c/d	20 mmag
f3	0.331 c/d	10 mmag	f6	1.6 c/d	20 mmag	f9	6.3 c/d	30 mmag

Specific Object Studies: Solar-like and flare variability

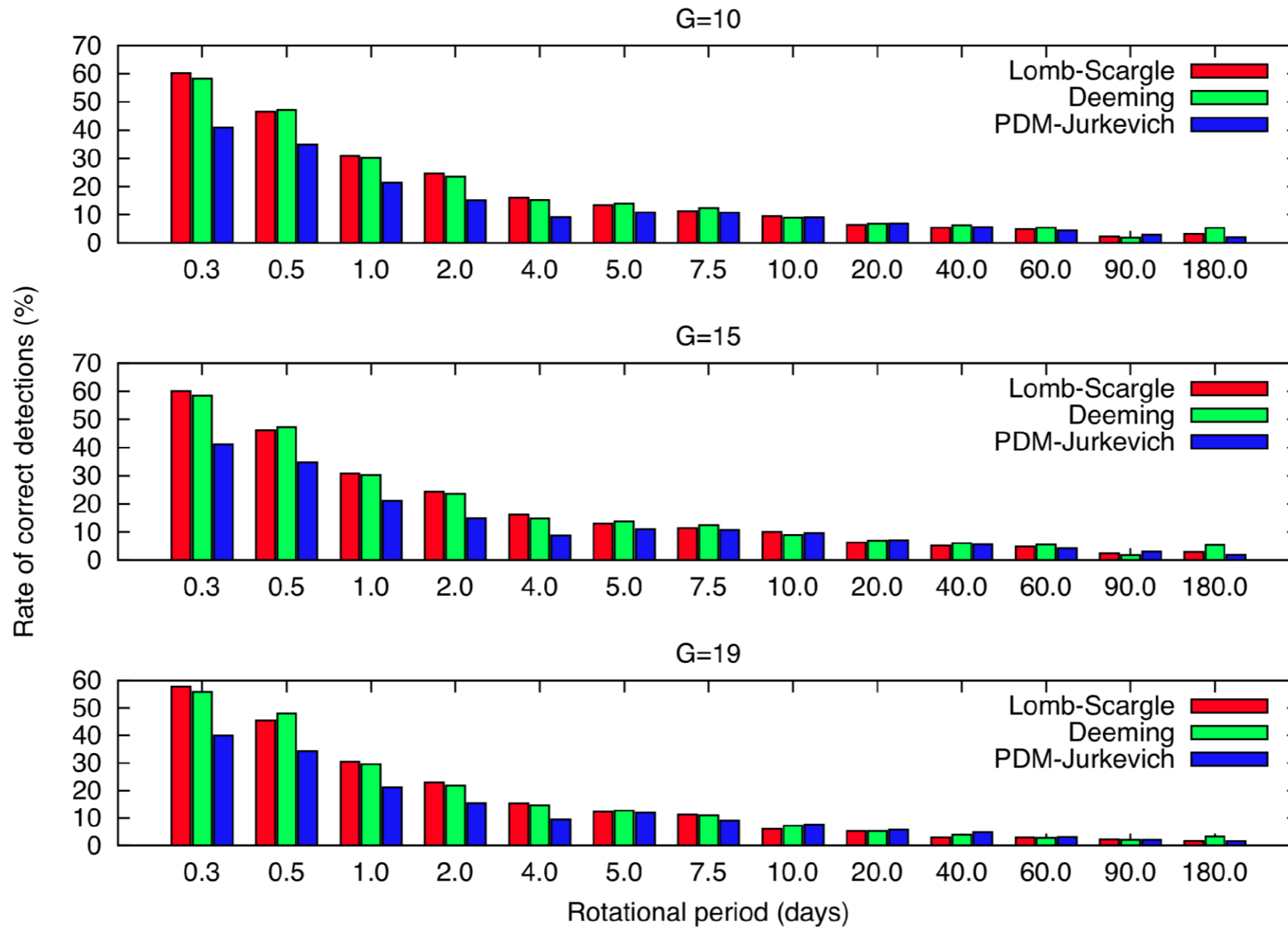UniCt & INAF-OACt team:

Alessandro Lanzafame
Elisa Distefano
Antonino Lanza
Sergio Messina
Isabella Pagano
Giuseppe Cutispoto

Main deliverables:

➢ Solar-like stars identification

➢ Rotation period

➢ Photospheres' activity level

➢ Flare parameters identification (including per-CCD photometry)

Rotational period recovery with Gaia

Science objectives with partial data: example for SOS-CepheidsAndRRLyrae WP

South Ecliptic Pole (SEP) commissioning field

‣ test and validation of the algorithms

‣ construction of relevant relations (P-A, P-L) in the Gaia bands

‣ transformation equations, e.g.: Johnson $\Rightarrow$ Gaia

ELSEWHERE

‣ identification and characterization of new RR Lyrae stars and Cepheids and preparation of the related catalogues

‣ analysis of the spatial distributions, search for overdensities of RR Lyrae stars and Cepheids that may trace streams, new faint galaxies, etc.

Regions/objects of interest

RA	DEC	YEAR					Target
		1	2*	3*	4*	5*	
80.893	-69.75	14	28	47	63	81	LMC
39.997	-34.44	27	51	77	103	132	Fornax
38.416	20.175	9	17	26	43	53	Segue II
344.62	5.9525	10	18	26	38	72	Pisces II
283.83	-30.54	11	20	32	44	58	Sagittarius dSph
266.41	-29.0	10	18	34	47	54	The MW
260.05	57.915	18	36	50	66	84	Draco
247.75	12.791	19	33	52	58	75	Hercules
227.28	67.222	18	33	46	64	78	Ursa Minor UGC 9749
210.02	14.5	8	23	49	68	77	Bootes (I)
209.5	12.85	10	30	56	77	84	Bootes II
209.3	26.8	15	34	85	107	114	Bootes III
202.01	33.555	22	48	57	88	98	Canes Venatici (I)
194.29	34.32	24	36	45	63	94	Canes Venatici II
186.74	23.403	15	33	42	49	61	Coma Berenices
173.23	-0.533	23	31	40	47	82	Leo IV
172.78	2.22	39	48	57	65	90	Leo V

* cumulative numbers

Conclusions

- Key WPs are leaded by Italian researchers.

- Overall significant Italian contribution to CU7 operations:

  4.3 FTEs including staff and non-staff researchers.

- Huge contribution by two TD members: Elisa Distefano

  (INAF-OACT) and Silvio Leccia (INAF-OACN)