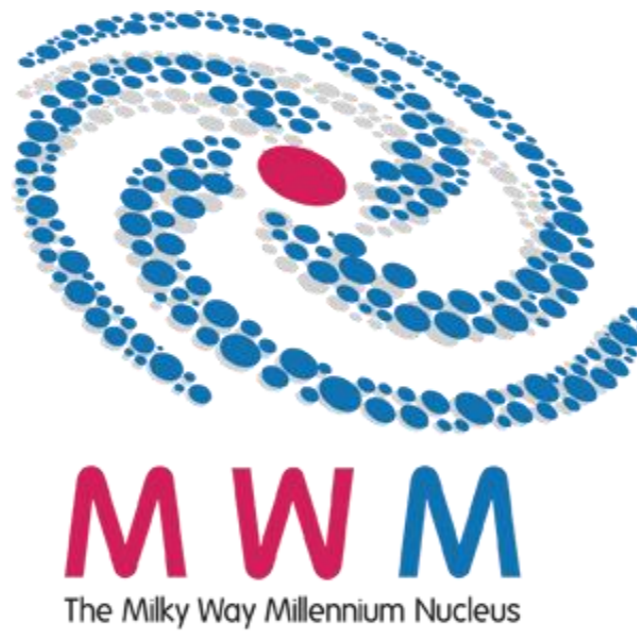


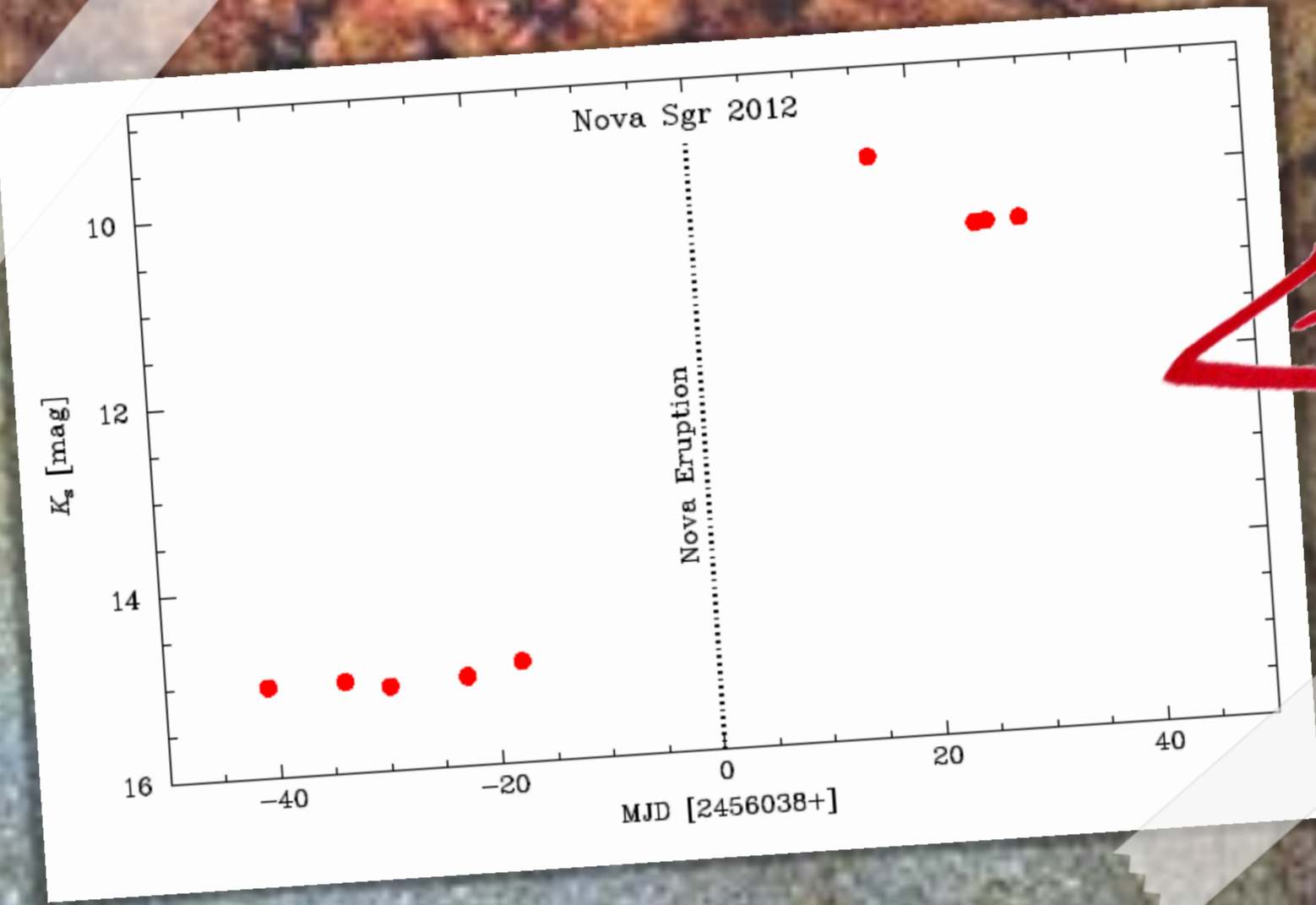
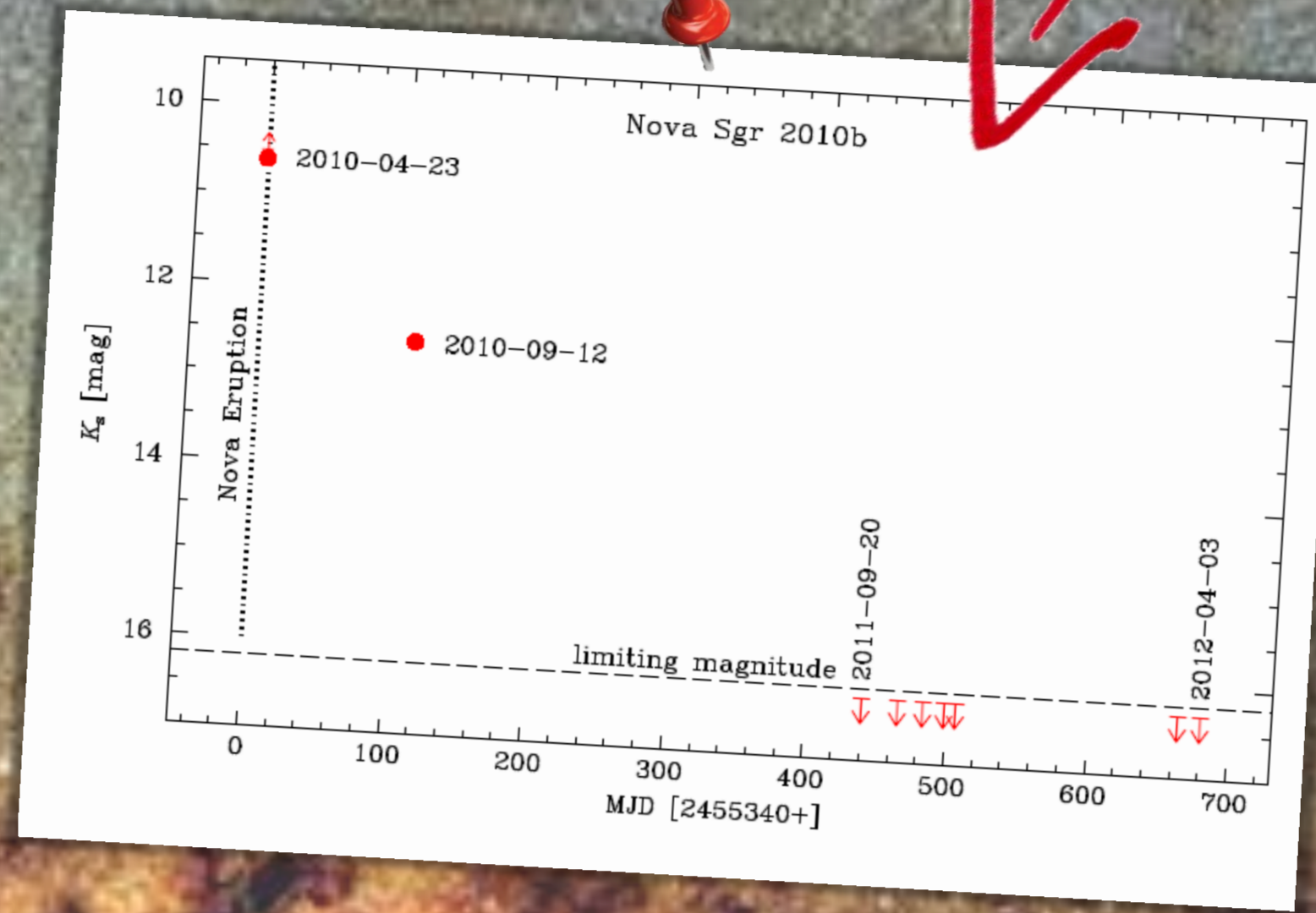
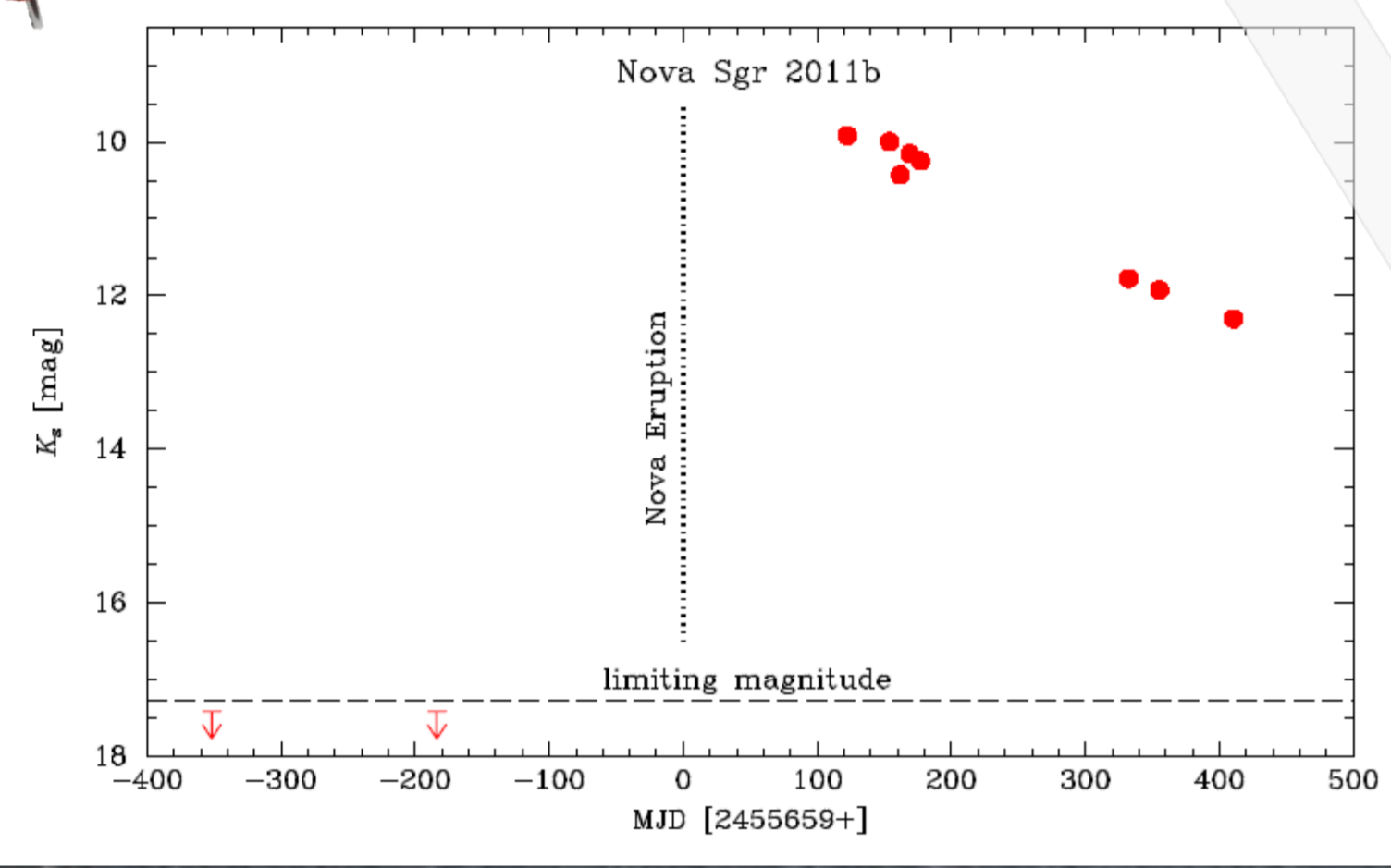
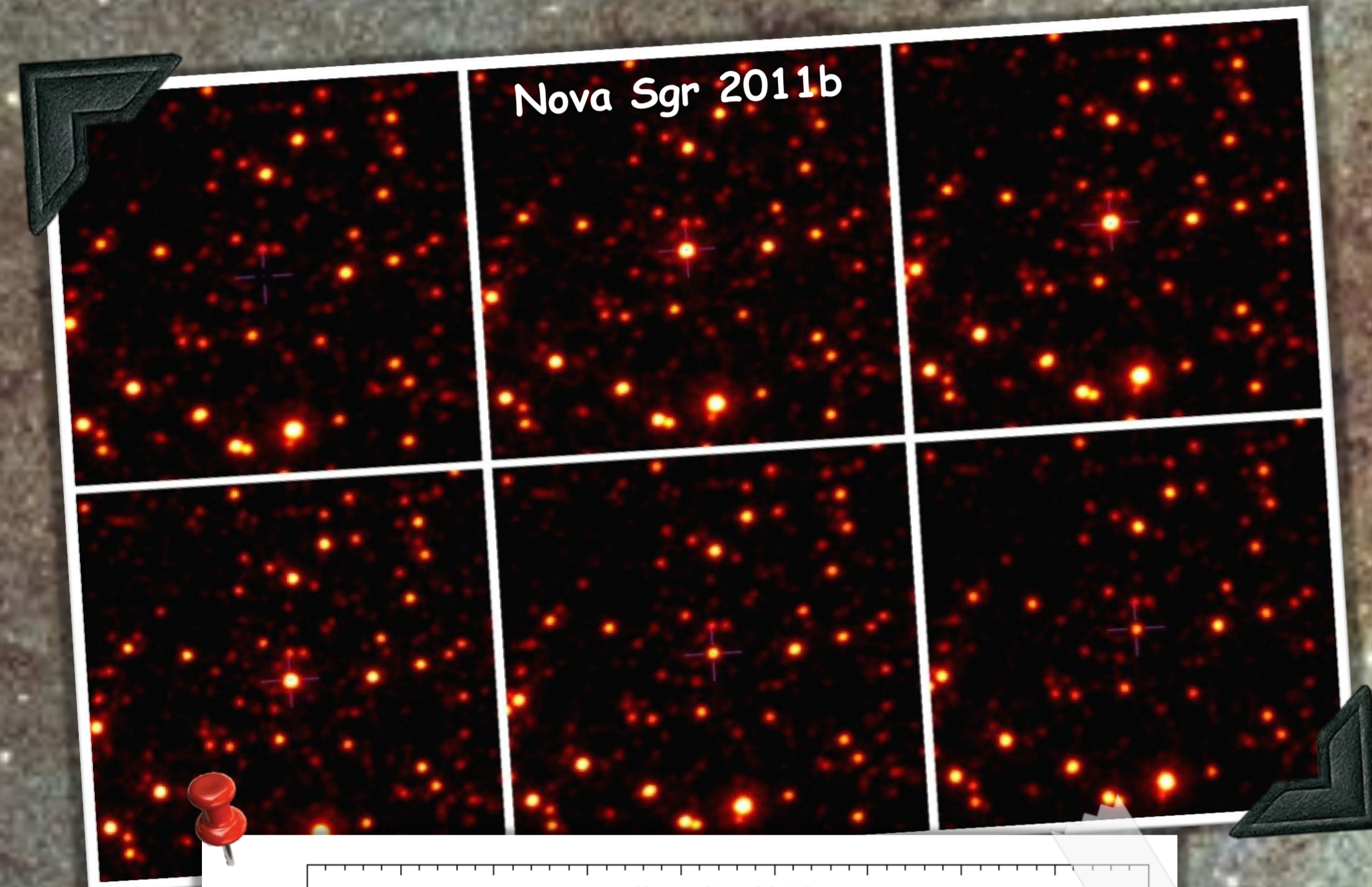
A first glimpse on novae studies with the VVV Survey



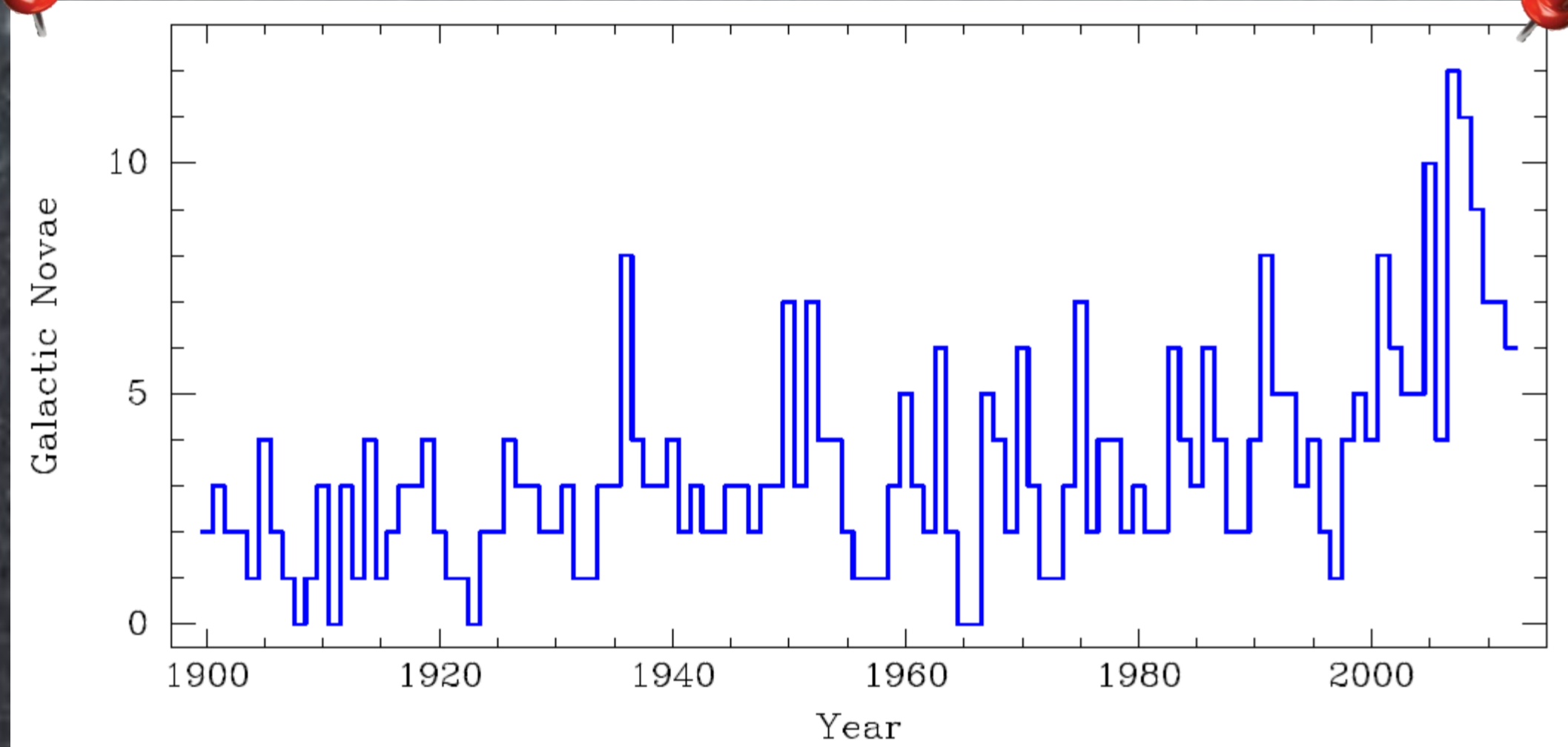
Roberto K. Saito^{1,2,3}, Dante Minniti^{1,3,4}
 Márcio Catelan^{1,3} and Rodolfo Angeloni^{1,3}

1 - Pontificia Universidad Católica de Chile, 2 - Universidad de Valparaíso
 3 - The Milky Way Millennium Nucleus, 4 - Vatican Observatory

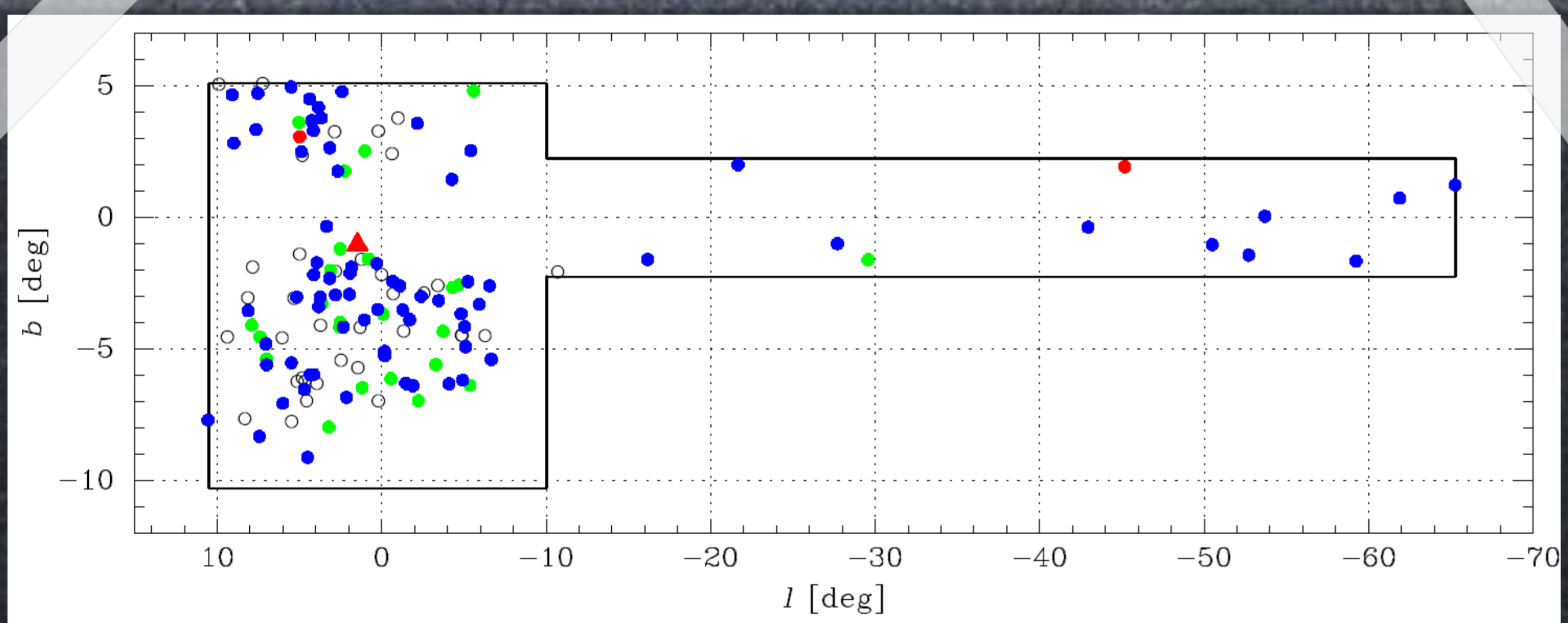
The VISTA Variables in the Vía Láctea is an ESO Public survey scanning the Milky Way bulge and southern plane, in five near-IR bands (ZYJHKs), plus a variability campaign of ~80 epochs in Ks-band spanning over many years [1]. VVV is about 4 mag deeper than previous IR surveys, and thanks to its higher spatial resolution, it allows one to go deep into the most crowding and high extinction regions of the Milky Way.



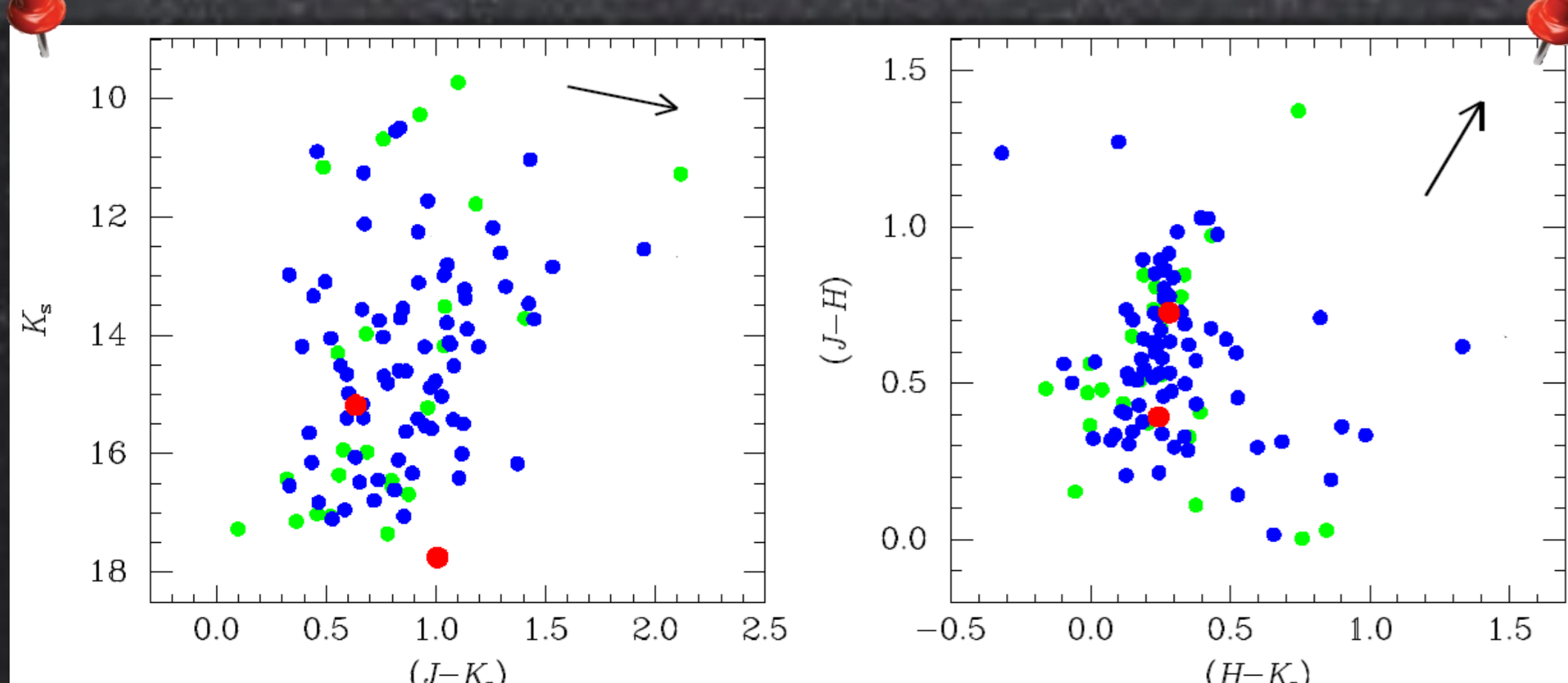
The number of novae discovered in the Milky Way in comparison with novae in nearby Galaxies suggests that there are many novae in the Galaxy that are still undetected. Even with an increment in the last two decades, the historical records shows a rate below than a dozen novae discovered per year in the MW, while several results pointed out to a nova rate spanning from about 20 novae per year [2] to ~ 37 yr⁻¹ in the Galaxy [3], or even higher values, reaching up to 100 yr⁻¹ (e.g., [4]).



The spatial distribution of Galactic novae in the VVV area. A total of 138 objects are shown. We note the presence of a "zone of avoidance" on the Galactic plane, with just a few objects belonging the most obscured regions of the Milky Way. VVV can be a major contributor for the discovery of novae in the high extinction regions of the Galaxy.



We produced a JHKs catalogue of known Galactic novae in the VVV Survey Area [5]. Filled symbols in the figure above mark all novae detected in the VVV data. Red circles are nova progenitors while blue circles mark novae with the coordinates matching a single source within 2" from the position given by the catalogue [6]. Green circles mark novae with multiple sources within the error circle or saturated objects. Figure below shows the Ks*(J-Ks) and the (J-H)*(H-Ks) diagrams for novae in the VVV area. The colour pattern and symbols are the same used above.



Nova Sgr 2010b (V5586 Sgr) caught during eruption by VVV observations

ATel #4353; R. K. Saito (Pontificia Universidad Católica de Chile, Universidad de Valparaíso, The Milky Way Millennium Nucleus) and D. Minniti (Pontificia Universidad Católica de Chile) on 5 Sep 2012; 14:22 UT
 Credential Certification: Roberto Saito (rsaito@astro.puc.cl)

Subjects: Infra-Red, Nova
 Nova Sgr 2010b (V5586 Sgr) was discovered in eruption by K. Nishiyama and F. Kabashima (CBET 2261; IAUC 9140), with 11.2 mag in unfiltered light on Apr 23.782 2010 UT. The nova was reported with coordinates RA 17:53:02.99 DEC -28:12:19.4 (J2000). The VISTA Variables in the Vía Láctea Survey (VVV) is mapping the Galactic Bulge and Southern plane in the near-infrared with the VISTA telescope at ESO's Cerro Paranal Observatory since March 2010 (vvsurvey.org; Minniti et al. 2010, New Astronomy, 15, 433). VVV observations taken on April 23 2010 caught Nova Sgr 2010b during eruption, about half day before the first observation reported by Nishiyama and Kabashima. A Ks-band observation taken on Apr 23.2479 2010 UT shows Nova Sgr 2010b as a stellar source with Ks=10.609+/-0.010, while in a J-band observation on Apr 23.2501 2010 UT the object appeared as a saturated source with J=7.764+/-0.010. Taking into consideration novae usually have (J-Ks)=0, one can conclude that the VVV observations caught Nova Sgr 2010b rising during eruption. A complementary observation taken on Sep 12 2010 shows the object with Ks=12.581+/-0.015. Nova Sgr 2010b faded beyond detection in several Ks-band observations taken from Sep 2011 to Apr 2012, allowing us to infer that the object dropped to Ks>16.3, the VVV limiting magnitude in this field. Nova Sgr 2010b is the innermost nova in the Galaxy. The VVV coordinates for the target are RA 17:53:02.98 DEC -28:12:18.84 (J2000), corresponding to (l,b) = (1.466, -1.023).

VVV observations of the Nova Sagittarii 2012 Progenitor

ATel #4372; R. K. Saito (Pontificia Universidad Católica de Chile, Universidad de Valparaíso, The Milky Way Millennium Nucleus) and D. Minniti (Pontificia Universidad Católica de Chile) on 12 Sep 2012; 18:19 UT
 Credential Certification: Roberto Saito (rsaito@astro.puc.cl)

Subjects: Infra-Red, Nova, Transient
 Nova Sagittarii 2012 (PNV J17452791-2305213) was discovered in eruption by S. Korotkiy and K. Sokolovsky (CBET 3089), with 9.6 mag in unfiltered light on April 21 2012. The nova was reported with coordinates RA 17:45:28.03 DEC -23:05:22.8 (J2000). Follow-up observations taken in different wavelengths registered the evolution of the system during and after outburst (radio, near-IR, optical, ultraviolet and X-ray; ATel 4088, 4093, 4094, 4110, 4142).

VVV survey observations taken during 2010 and 2012 detected the possible progenitor of Nova Sgr 2012. A single stellar source is seen in the VVV images before the eruption at the position reported in CBET 3089, with coordinates RA 17:45:28.02 DEC -23:05:22.72 (J2000). Quasi simultaneous JHKs observations were acquired on March 18 2010, while additional 5 epochs were taken in the Ks-band from March 11 to April 03, 2012. The VVV data are in the natural VISTA Vegamag system (vvsurvey.org; Minniti et al. 2010, New Astronomy, 15, 433).

Table of observations:

Date (UT)	filter	mag
2010 03 18.3326	H	15.421+/-0.047
2010 03 18.3349	Ks	15.178+/-0.056
2010 03 18.3382	J	15.813+/-0.035
Date (UT)	filter	mag
2012 03 11.3691	Ks	15.028+/-0.050
2012 03 18.3269	Ks	15.016+/-0.050
2012 03 22.3023	Ks	15.093+/-0.054
2012 03 29.3373	Ks	15.041+/-0.057
2012 04 03.3046	Ks	14.914+/-0.043

Acknowledgements: We gratefully acknowledge use of data from the ESO Public Survey programme ID 179.B-2002 taken with the VISTA telescope, and data products from the Cambridge Astronomical Survey Unit.

VVV-NOV-001: the first Galactic nova candidate discovered by the VVV Survey in the Milky Way bulge

ATel #4426; R. K. Saito (Pontificia Universidad Católica de Chile, Universidad de Valparaíso, The Milky Way Millennium Nucleus), D. Minniti (Pontificia Universidad Católica de Chile, Vatican Observatory, The Milky Way Millennium Nucleus), R. Angeloni (Pontificia Universidad Católica de Chile, The Milky Way Millennium Nucleus) and M. Catelan (Pontificia Universidad Católica de Chile, The Milky Way Millennium Nucleus) on 26 Sep 2012; 16:37 UT
 Distributed as an Instant Email Notice Nova
 Credential Certification: Roberto Saito (rsaito@astro.puc.cl)

Subjects: Infra-Red, Nova, Transient

We report the discovery of a likely Galactic nova in the VVV Survey data (vvsurvey.org; Minniti et al. 2010, New Astronomy, 15, 433). VVV observations taken during 2010 and 2011 show the presence of a red stellar source fading in brightness from July 1st 2010 to May 29 2012. The fading of the light curve follows the expected behavior of the late stages of a nova outburst, with VVV-NOV-001 fading by Delta_Ks>2.5 over 698 days, with a roughly constant fading rate.

The coordinates of VVV-NOV-001 are RA, DEC= 18:06:03.18, -21:19:47.31 (J2000), corresponding to (l,b)=8.897,-0.158 deg. Quasi simultaneous VVV JHKs observations taken on July 1st 2010 show VVV-NOV-001 with (J-Ks)=8.06 mag. According to the VVV reddening maps (Gonzalez et al. 2012, A&A, 543, 13) assuming the Nishiyama et al. (2009, ApJ, 696, 1407) extinction law, the extinction for a 2 arcmin region around the target position is E(J-Ks)=2.45 mag, which corresponds to AV=10.97 mag.

2MASS data show a stellar source in the same position of VVV-NOV-001 that can be the candidate nova progenitor. The source is detected in the K-band only, with K=12.08 mag. In the other two 2MASS bands the object is flagged as "U" (upper limit on magnitude, see table below).

We recommend further observations in order to discard the hypothesis of a rare Long Period Variable or OH/IR star with P>700 days and Delta_Ks>2.5mag.

VVV-NOV-001 Observations:

Date (UT)	filter	mag
2010-07-01.2564	H	13.057+/-0.010
2010-07-01.2594	Ks	9.951+/-0.010
2010-07-01.2624	J	18.008+/-0.140

2MASS data (possible VVV-NOV-001 progenitor)

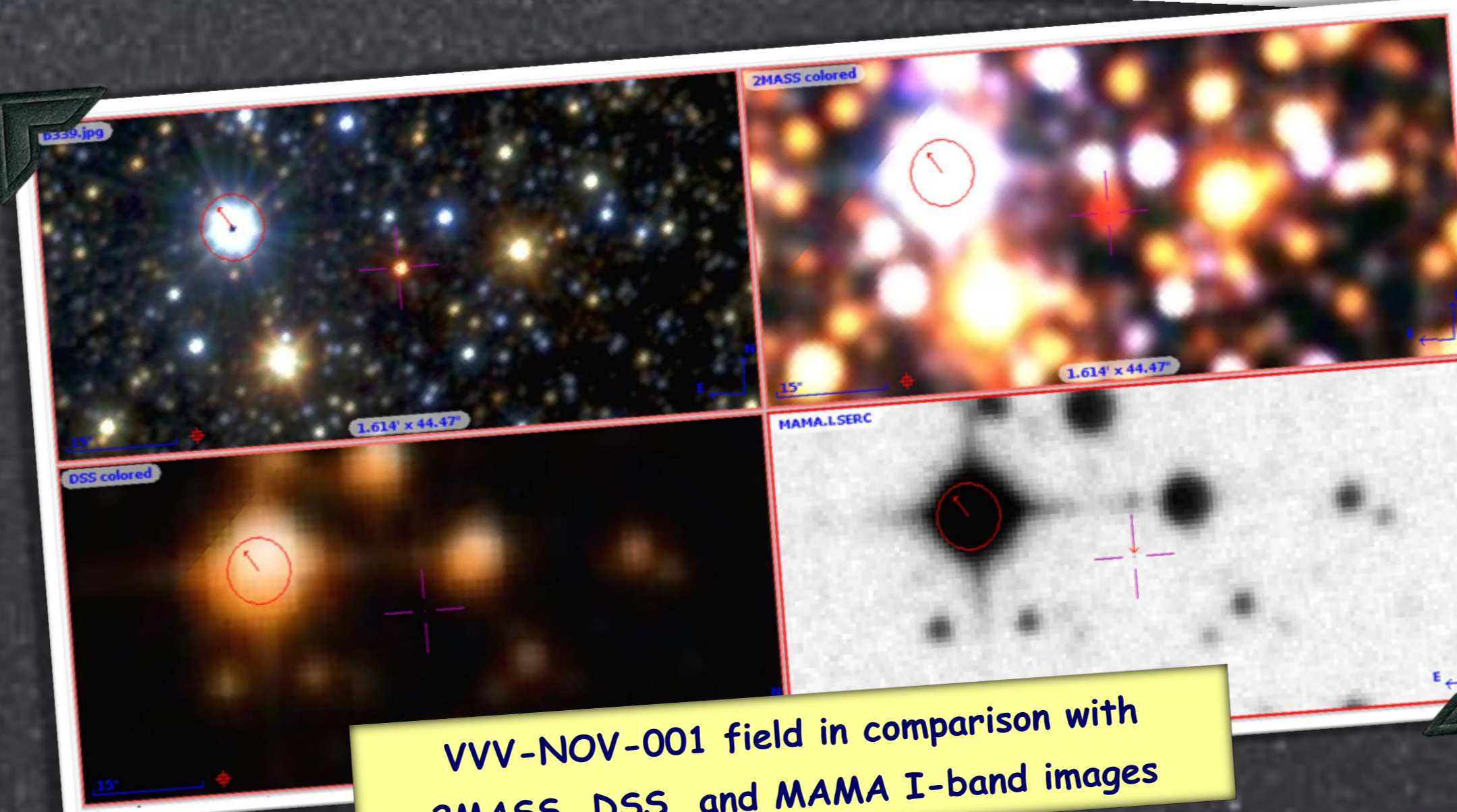
filter	mag	Qflag
J	16.030	U*
H	14.593	U*
K	12.078+/-0.019	A

*U = upper limit on magnitude

Acknowledgements: We gratefully acknowledge use of data from the ESO Public Survey programme ID 179.B-2002 taken with the VISTA telescope, and data products from the Cambridge Astronomical Survey Unit.

References:

- [1] Minniti, D., Lucas, P. W., Emerson, J. P., et al. 2010, New Astronomy, 15, 433
- [2] della Valle, M., & Livio, M. 1994, A&A, 286, 786
- [3] Shafter, A. W., & Irby, B. K. 2001, ApJ, 563, 749
- [4] Liller, W. 1993, Rev. Mexicana Astron. Astrofis., 26, 41
- [5] Saito, R. K., Minniti, D., Angeloni, R., et al. 2012, in preparation
- [6] The International Variable Star Index (VSX), provided by the AAVSO, aavso.org/vsx/



We gratefully acknowledge use of data from the ESO Public Survey programme ID 179.B-2002 taken with the VISTA telescope, data products from the Cambridge Astronomical Survey Unit, and funding from the FONDAPE Center for Astrophysics 15010003, the BASAL CATA Center for Astrophysics and Associated Technologies PFB-06, the FONDECYT from CONICYT, and the Ministry for the Economy, Development, and Tourism's Programa Iniciativa Científica Milenio through grant P07-021-F, awarded to The Milky Way Millennium Nucleus.