Gaia and brown dwarfs from Spain

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Gaia e nane brune dalla Spagna

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How many brown dwarfs will Gaia see? (Google)

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Gaia and the Unseen The **Brown Dwarf** Question
gaiabds.oato.inaf.it/
Gaia will revolutionise Astronomy and the study of **brown dwarfs** is no exception. We are organizing this meeting to mix the **brown dwarf** and **Gaia** communities ...

Programme - **Gaia** and the Unseen The **Brown Dwarf** Question
gaiabds.oato.inaf.it/programme.php
Programme. Unito. Days 09:00-17:30, Coffee @ ~10:30 and ~15:30, Lunch ...

Gaia and the Unseen - The **Brown Dwarf** Question, a GREA...
https://lists.cam.ac.uk/pipermail/ast-great-announce/.../msg00000.html
Oct 7, 2013 - The majority of **brown dwarfs** will be too faint for **Gaia**; however a subset of the closest, youngest, and most massive will be detectable along ...

GaiaScienceMeetings - Great Wiki - University of Cambridge
great.ast.cam.ac.uk/Greatwiki/**GaiaS**cienceMeetings
See also the Calendar of Meetings on the ESA **Gaia** pages. ... GREAT-ESF Workshop **Gaia** and the Unseen: The **Brown Dwarf** Question, 24-26 March 2014, ...

[PDF] Isolated **Brown Dwarfs** - RSSD - ESA
https://www.rssd.esa.int/SA/**GAIA**/docs/.../IN_isolated_**brown_dwarfs**.pd...
Gaia - Taking the Galactic Census. Isolated **Brown Dwarfs**. Left: the evolution of the

Gaia

Stereoscopic Census of our Galaxy

http://www.rssd.esa.int/Gaia

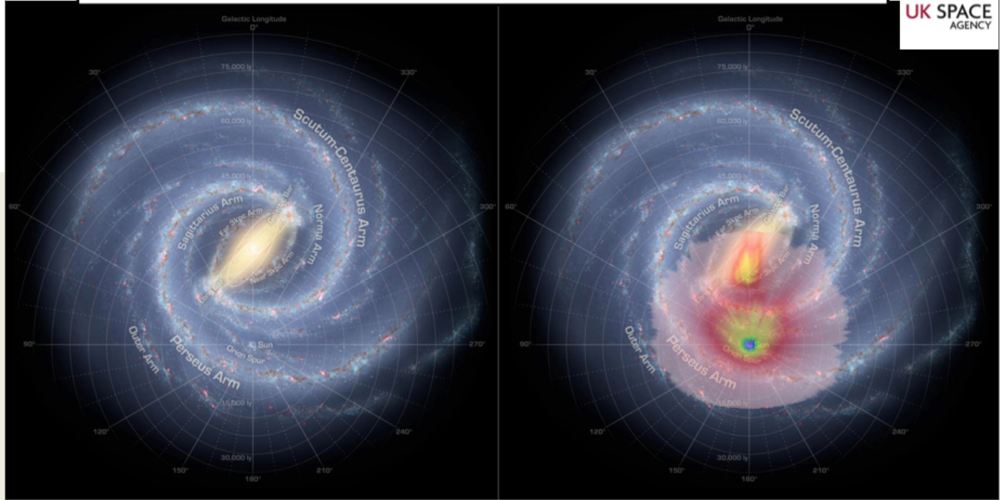
one billion pixels for one billion stars

Prof Gerry Gilmore

UK Gaia Data Processing PI

Institute of Astronomy, Cambridge

Gaia will deliver precise data for 1 billion stars – 1% of our Milky way Galaxy
The first Galactic census – 3D positions, plus motions



PLUS: 1million galaxies; 500,000 QSOs; 10,000 Supernovae – in real-time; 250,000 asteroids; 15,000 extra-solar planets; 200,000 white dwarfs; 50,000 brown dwarfs, GRB, ...

PLUS: real-time discoveries of transients, supernovae, new NEOs, ...

Ds; 10,000 Supernovae – in real-time; 250,000
white dwarfs; 50,000 brown dwarfs, GRB, ...

of transients, supernovae, new NEOs, ...

Airbus Military, Astrium and Cassidian are now Airbus Defence and Space

From Hipparcos to Gaia

8 November 2013

In Kourou, Astrium is putting the finishing touches to the Gaia satellite, ESA's second global astrometry mission after Hipparcos.
Gaia will take off from French Guiana in a few weeks, headed for one of the five Lagrange points orbiting the sun at 1.5 million kilometres from Earth. It will then assume its role as the keenest 'eye' to have ever contemplated the Milky Way.

"In astrometric terms, Gaia will have a precision 100 to 1,000 times greater than its predecessor Hipparcos," explains Vincent Poinsignon, head of Gaia's design and manufacture at Astrium.

When ESA launched Hipparcos – also primed by Astrium – in August 1989, it was the first satellite devoted to astrometry, a branch of astronomy involving measurement of the position and movement of celestial bodies as well as their distance from Earth. Up until its retirement in 1993, it amassed a catalogue of 120,000 stars with a precision 200 times greater than any previous measurements.

Now, Gaia's high-end technology will make Hipparcos seem as primitive as a pair of binoculars. Once in orbit around the sun, Gaia will begin to measure with extreme precision the characteristics of a billion stars, and this data will then be used to generate a 3D chart of our galaxy. Its telescopes will have each star in their sights around 70 times over a five-year period, making a total of 40 million observations per day. The data recorded on each of these stars will include their speed, magnitude, position and distance from Earth.

While Hipparcos could measure the diameter of a human hair at a distance of 20 kilometres, Gaia will be capable of the s[illegible]00 kilometres. This sensitivity will enable it to detect more than 250,000 objects in our solar system (mostly asteroids), 15,000 extrasolar planets, 50,000 brown dwarfs and approximately 20,000 supernovae.

Gaia | *Science* | *Space Exploration* | *Universe*

The Little Books of Gaia

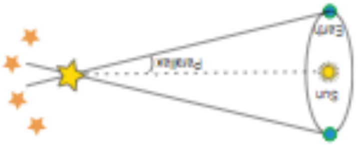
EVERYTHING YOU EVER WANTED TO KNOW ABOUT GAIA!

June 2009

What is Gaia?
Gaia is a satellite that the European Space Agency will launch in spring 2012. It will measure distances, positions, and velocities of stars in our Galaxy, the Milky Way, to create the most accurate 3-D picture of our Galaxy that we've ever had.

Why bother measuring distances and velocities?
Because knowing the distance to a star allows us to determine many of the essential properties (age, mass, true luminosity, etc) of the star. Velocities give us information about where the star was millions of years ago and where it will be in the future. By measuring these quantities Gaia will determine the nature, formation history and evolution of the Milky Way.

How do we measure the distance to a star?
Astronomers use a quantity called the stellar parallax. It is the apparent angular displacement of a star in the sky when viewed from opposite points of the Earth's orbit around the Sun. Stellar parallax can be converted into distance by using simple geometry.



Why go to space to measure parallaxes?
Stellar parallax is very difficult to measure because it is a very small quantity and it decreases the further a star is from the Earth. Very precise measurements are needed to determine a stellar parallax and this is why we need to get out of the Earth's atmosphere, to get away from the distortions that it creates.

How accurate will these measurements be?
Gaia will have an accuracy of about 20 microarcseconds (approximately 6 billionths of a degree). This accuracy corresponds to the angle subtended by a five-story building at the distance of Mars, when Mars is the furthest away from us.

How many people work in the Gaia project?
Gaia is in the implementation phase during which the elements of the craft and instruments are manufactured, assembled, tested and integrated and plans for Gaia's operations are worked out in detail. Currently about 2500 people are working on Gaia, including ESA staff and members of the space industry, scientific community and academic world.

How long does it take to build a satellite like Gaia?
A mission like Gaia may be studied and discussed for several years before ESA's advisors approve it. Detailed designing and advanced technology studies then take 3 to 4 years, and a further 3 to 4 years are needed to build and test the satellite, and prepare it for launch.

Who builds the satellite?
Many individuals, scientific institutes, and industrial companies contribute to a mission like Gaia. As many as about 400 scientists, 2000 engineers and managers, and 20 to 30 companies might be involved.

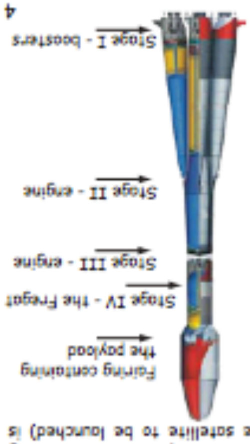
Who will have access to the data gathered by Gaia?
The data acquired by Gaia will be converted into useful information (distances, velocities...) by experts in Europe. Results will be available to the general public once the data have been reduced. Scientists from any institute, amateur astronomers, or students will have free access to Gaia's data. The general public will also be informed of any interesting discoveries through the internet and other media.

How will Gaia be transported into space?
The Gaia satellite has been designed to be placed in space by the Soyuz/ST rocket. First the rocket is sent to a low altitude parking orbit. Then the Fregat upper stage of the rocket is fired to send the satellite to its final operational location, L2.

How do rockets work?
Liquid or solid propellants (a mixture of fuel and oxidizer) are burnt inside the rocket producing pressurized gas that escapes through a nozzle. This gas provides a thrust that propels the rocket in the upward direction (just like a balloon starts moving if we release its nozzle).

What is a Soyuz-Fregat rocket?
Soyuz launch vehicles have a special place in the history of space flight. They launched the first satellite and the first man into space. Soyuz rockets have launched ESA's Cluster and Mars Express satellites and will launch more ESA satellites in the future, including Gaia.

The main componets of the Soyuz are: the fairing where the payload (the satellite to be launched) is located, and four different engine 'stages'. Each stage performs a different function. Stage I - the boosters - propel the rocket from Earth. Stage II and III are used to put the rocket into orbit above Earth. Stage IV - the Fregat - is a complex stage which is able to start and stop several times. This allows it to perform complex manoeuvres and to place the satellite into many different orbits.



Where will Gaia be in space?
Gaia will be operated in a Lissajous-type orbit, around the L2 Lagrangian point of the Sun-Earth system, at about 1.5 million kilometres from the Earth. This L2 point represents a location where gravitational and repulsive forces are balanced. This orbit is eclipse-free, which allows a very stable thermal environment and a high observing efficiency, and lies in a low radiation region.

How long will it take Gaia to reach this orbit?
Gaia will have to travel for about 1 month to arrive at its chosen orbit.

How much time will Gaia be in space?
Immediately after insertion in its final orbit, Gaia will start taking measurements which will continue for a period of 5 years.

How big is the computation needed to reduce all of Gaia's data?
Gaia's data reduction using an average PC would take about 300 years! The Gaia team will complete this in only 3 years using advanced technology.

How is a satellite controlled from the Earth?
Radio signals are sent to the satellite using large radio dishes which are pointed to the satellite's location in space. The large quantity of information sent from the satellite to the ground is also transmitted by high frequency radio waves.

What will happen to Gaia after it stops functioning?
After Gaia comes to the end of its 'lifetime', it will be left to orbit freely. As its orbit is far from Earth and from other more crowded areas of space, it won't affect other satellites. Only an impact by a meteorite or a comet will destroy the 'dead' satellite.

How many stars will Gaia measure?
Gaia will measure about one billion stars. This constitutes about 1 per cent of the total star content in the Milky Way.

What other objects will Gaia observe?
Gaia will also observe more than 350000 objects in our solar system (mostly asteroids), around 15000 new extrasolar planets, more than 50000 brown dwarfs (stars of very low mass that do not emit much light because no nucleosynthesis takes place in their interior), about 20000 supernovae (stars exploding at the end of their lives), and a large number of galaxies.

How far is the closest star to us?
The closest star to us apart from the Sun is Proxima Centauri, in the Alpha Centauri star system. It lies at a distance of 4.3 light years from the Earth.

How big is our Galaxy?
If we could travel at the speed of light, it would take around 100000 years to reach the other end of our Galaxy.

What is the predicted size and weight of Gaia?
Based on the current design, Gaia will be 3 metres high, about 10 metres across, and will weigh around 2000 kg.

What does Gaia mean?
For ancient Greeks, Gaia was the goddess of Earth, the Universal Mother. More recently, this name was adopted for a theory which states that the Earth (including all living organisms, the biosphere, the rocks, the air, and the oceans) behaves like a living system in its own right. Now it is the name given to this ambitious project to discover the structure, origin and evolution of our Galaxy.

esa

More detailed information can be found on the Gaia web site: http://sci.esa.int/Gaia

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June 2009

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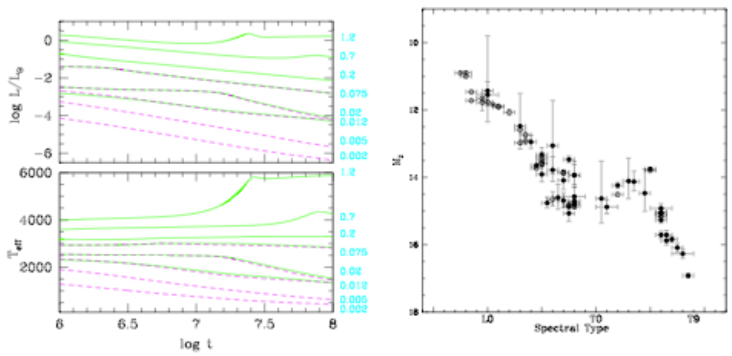

Left: the evolution of the luminosity (top) and effective temperature (bottom) as function of time (in yr) of brown dwarfs for different masses (shown on the right of this figure, in blue, in units of the solar mass). The solid green lines assume no dust formation; the dashed pink lines permit dust formation and retain it in the atmosphere. Gaia will measure accurate properties for young brown dwarfs in numerous clusters and star-forming regions (Baraffe et al. 2002, A&A, 382, 563). Right: absolute J-band magnitudes of field brown dwarfs obtained from ground-based astrometry and photometry. Late-L and T dwarfs are very faint in the optical, so Gaia will only be able to detect a limited sample of old field brown dwarfs out to several parsec. Yet even for these, Gaia will measure distances to better than 1% (Vrba et al. 2004, AJ, 127, 2948).

Gaia: Isolated Brown Dwarfs

In observing the entire sky down to 20-th magnitude, Gaia will observe large numbers of isolated brown dwarfs in the solar neighbourhood. Structural models show that brown dwarfs cool and fade rapidly after formation, so that the distance out to which Gaia can detect them is a function of their mass and age. Gaia should see Pleiades-age (~100 Myr) brown dwarfs out to around 400 pc and younger brown dwarfs, such as those in the Orion Nebula Cluster (1–3 Myr), out to about 1 kpc. This volume encompasses numerous young clusters and star-forming regions such as Chamaeleon, where brown dwarfs are known to exist. For an $I = 20$ mag brown dwarf at 200 pc, Gaia will obtain a distance accuracy of about 4% and transverse velocities to around 0.2 km s^{-1}.

One of the main contributions of Gaia to substellar astrophysics will be a detailed spatial and kinematic map of brown dwarfs in clusters of known age and metallicity (determined from Gaia parallaxes of higher-mass stars), permitting a comprehensive study of mass segregation and ejection of brown dwarfs. These are key ingredients to understanding the formation mechanism of substellar mass objects, whether it be via cloud fragmentation and gravitational collapse, premature ejection from an accreting envelope, or some other mechanism.

Brown dwarfs will be identified primarily from their absolute luminosities obtained from the precise Gaia parallaxes as well as from the on-board multi-band photometry. The latter will provide physical parameters of brown dwarfs, in particular the effective temperature, but perhaps also metallicity and the nature of cloud coverage. As brown dwarfs will be found in clusters of a range of ages, a significant contribution of Gaia will be an accurate observational determination of their cooling curves. The photometry and absolute magnitudes will furthermore help in the detection of spatially and astrometrically unresolved brown-dwarf binaries. From this information, we will be able to determine the substellar mass function and the three-dimensional spatial and age distribution of brown dwarfs, thus establishing their formation history in the context of the Galaxy.

Predictions of the number of brown dwarfs which Gaia will detect depend sensitively on their cooling function and their distribution. Rough estimates based on current knowledge are of the order of 50,000 over a wide range of masses and ages. The absolute luminosities, colours, and kinematics obtained from Gaia will provide us with detailed insight into the physical properties, formation, and evolution of this substellar population.

ESA SER portal ***Gaia science homepage*** – The Mission – Science – Science topics / Information sheets – Isolated brown dwarfs (created 2004-03-18)

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This slide was added after the presentation (thanks to R. L. Smart)

How many brown dwarfs will *Gaia* see? (ADS)

A&A 369, 339–363 (2001)
DOI: 10.1051/0004-6361:20010085

Astronomy & Astrophysics

GAIA: Composition, formation and evolution of the Galaxy

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Received 1 November 2000 / Accepted 5 January 2001

Abstract. The GAIA astrometric mission has recently been approved as one of the next two "cornerstones" of ESA's science programme, with a launch date target of not later than mid-2012. GAIA will provide positional and radial velocity measurements with the accuracies needed to produce a stereoscopic and kinematic census of about one billion stars throughout our Galaxy (and into the Local Group), amounting to about 1 percent of the Galactic stellar population. GAIA's main scientific goal is to clarify the origin and history of our Galaxy, from a quantitative census of the stellar populations. It will advance questions such as when the stars in our Galaxy formed, when and how it was assembled, and its distribution of dark matter. The survey aims for completeness to $V = 20$ mag, with accuracies of about 10 μas at 15 mag. Combined with astrophysical information for each star, provided by on-board multi-colour photometry and (limited) spectroscopy, these data will have the precision necessary to quantify the early formation, and subsequent dynamical, chemical and star formation evolution of our Galaxy. Additional products include detection and orbital classification of tens of thousands of extra-Solar planetary systems, and a comprehensive survey of some 10^5–10^6 minor bodies in our Solar System, through galaxies in the nearby Universe, to some 500 000 distant quasars. It will provide a number of stringent new tests of general relativity and cosmology. The complete satellite system was evaluated as part of a detailed technology study, including a detailed payload design, corresponding accuracy assesments, and results from a prototype data reduction development.

Key words. instrumentation: miscellaneous – space vehicles: instruments – astrometry – galaxy: general – techniques: photometric – techniques: radial velocities

2.6. Brown dwarfs and planetary systems

Sub-stellar companions can be divided in two classes: brown dwarfs and planets. There exist three major genesis indicators that can help classify sub-stellar objects as either brown dwarfs or planets: mass, shape and alignment of the orbit, and composition and thermal structure of the atmosphere. Mass alone is not decisive. The ability to simultaneously and systematically determine planetary frequency and distribution of orbital parameters for the stellar mix in the Solar neighbourhood is a fundamental contribution that GAIA will uniquely provide. Any changes in planetary frequency with age or metallicity will come from observations of stars of all ages.

An isolated brown dwarf is typically visible only at ages <1 Gyr because of their rapidly fading luminosity with time. However, in a binary system, the mass is conserved, and the gravitational effects on a

Examples of specific objects: 10^6–10^7 resolved galax-

10^5–10^6 (new) Solar System objects; $\gtrsim$50 000 brown dwarfs; 30 000 extra-Solar planets; 200 000 disk white

within 250 pc.

How many brown dwarfs will *Gaia* see? (ADS)

SAO/NASA Astrophysics Data System (ADS)

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2	2002MNRAS.331..649B Belokurov, V. A.; Evans, N. W.	39.000 Astrometric microlensing with the GAIA satellite	04/2002	A F G X R C U H
3	2009ApJ...706.1114B Bowler, Brendan P.; Liu, Michael C.; Cushing, Michael C.	32.000 The Benchmark Ultracool Subdwarf HD 114762B: A Test of Low-metallicity Atmospheric and Evolutionary Models	12/2009	A E F X R C S U
4	2010AJ....139.1844B Benedict, G. Fritz; McArthur, Barbara E.; Bean, Jacob L.; Barnes, Rory; Harrison, Thomas E.; Hatzes, Artie; Martioli, Eder;	20.000 The Mass of HD 38529c from Hubble Space Telescope Astrometry and High-precision Radial Velocities	05/2010	A E F X D R C S U

How many **brown dwarfs** will ***Gaia*** see? (ADS)

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How many brown dwarfs will *Gaia* see? (ADS)

10	1995ESASP.379...55B	8.000	00/1995	F G T C	
	Berstein, H.-H.; Bastian, U.	Finding Planets and Brown Dwarfs with Gaia			
11	2005A&A...442.1003S	7.000	11/2005	A E F X R C S N U	
	Söderhjelm, S.; Dischler, J.	Eclipsing binary statistics Theory and observation			
12	2007A&A...475..667J	5.000	11/2007	A E F D R C S	
	Johnas, C. M. S.; Guenther, E. W.; Joergens, V.; Schweitzer, A.; Hauschildt, P. H.	Lithium abundances of very low mass members of Chamaeleon I			
13	2008IAUS..248...23B	4.000	07/2008	A F G T R C U	
	Benedict, G. F.; McArthur, B. E.; Bean, J. L.	HST FGS astrometry the value of fractional millisecond of arc precision			
14	2007A&A...466..323J	4.000	04/2007	A E F R C S O	
	Johnas, C. M. S.; Hauschildt, P. H.; Schweitzer, A.; Mullamphy, D. F. T.; Peach, G.; Whittingham, I. B.	The effects of new Na I D line profiles in cool atmospheres			
15	2008A&A...484..413S	3.000	06/2008	A E F X D R C S U	
	Schmidt, T. O. B.; Neuhäuser, R.; Vogt, N.; Seifahrt, A.; Roell, T.; Bedalov, A.	Confirmation of the binary status of Chamaeleon Hα 2 - a very young low-mass binary in Chamaeleon			
16	2013A&A...550A..44S	2.000	02/2013	A E F X R C S U	
	Sarro, L. M.; Berihuete, A.;	Properties of ultra-cool dwarfs with Gaia. An assessment of the accuracy for the			

FINDING PLANETS AND BROWN DWARFS WITH GAIA

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ABSTRACT

The astrometric interferometer satellite GAIA, proposed for ESA's Horizon 2000+ programme, will be able to investigate about half a million stars for Jupiter-sized planetary companions and many more for brown-dwarf companions. Such companions cause non-linear motion of their parent stars on the sky, i.e., they show up as astrometric binaries. GAIA will perform one-dimensional astrometric measurements, much as Hipparcos did, but with a tremendously increased accuracy. It will be a non-trivial problem to derive three-dimensional binary orbits from such data.

We demonstrate, using actual Hipparcos measurements, that this problem can indeed be solved. We sketch the numerical method being used for the discovery of hitherto unsuspected astrometric binaries from the Hipparcos data, and present a few illustrative examples showing that the expected sensitivity is actually reached.

Key words: astrometry; space astrometry; Hipparcos; GAIA; interferometry; extrasolar planets; brown dwarfs

(1995) under the (implicit) assumption of a simple detection method: one-year two-dimensional normal points on the sky are formed from the individual one-dimensional GAIA (or Hipparcos) measurements. Then the deviations of these normal points from an assumed constant proper motion is tested for statistical significance. In their analysis, Casertano et al. considered a companion to be detectable if the semimajor axis of the parent star's reflex ellipse is larger than 3 times the mean error σ_1 of a one-year normal point. This is a very reasonable and conservative estimate.

However, the method of normal points does not fully utilize the information content of the individual satellite measurements. Furthermore, it cannot work properly for periods of less than two years. In the present paper we sketch a more powerful method. Its sensitivity limit is given not by the mean error of one-year normal points, but by the mean errors of the astrometric parameters derived from the entire mission. Furthermore, the method not only *detects* the binarity signature, it also attacks the more difficult problem of deriving orbital parameters.

How many...?

Title:	Field Brown Dwarfs & GAIA
Authors:	Haywood, M.; Jordi, C.
Affiliation:	AA(GEPI, Observatoire de Paris, 92195 Meudon, France), AB(Departament d'Astronomia i Meteorologia, Universitat de Barcelona, Avda. Diagonal 647, 08028 Barcelona, Spain)
Publication:	"EAS Publications Series, Volume 2, Proceedings of "GAIA: A European Space Project", held 14-18 May, 2001 Les Houches, France. Edited by O. Bienaymé and C. Turon. EDP Sciences, 2002, pp.199-205"
Publication Date:	00/2002
Origin:	AUTHOR
DOI:	10.1051/eas:2002018
Bibliographic Code:	2002EAS.....2..199H

Abstract

Because of their very red colours and intrinsic faintness, field brown dwarfs will represent a small but valuable subset of the GAIA catalogue. The return of the astrometric satellite is expected to be important because of the inherent difficulty of obtaining good parallaxes in general and for this class of objects in particular. Our first estimates show that, due to the photometric sensitivity of the astrometric CCD (ASM1) towards relatively blue objects, GAIA is unlikely to detect field brown dwarfs that have not been already seen is previous near-IR surveys, to the notable exception of the galactic plane region. The real advantage of GAIA over ground-based surveys will be the very accurate (to within a few percents) astrometric data for a few thousands brown dwarfs. These data should permit a detailed mapping of the transition region between stellar and substellar regimes, together with the kinematical and density patterns of the youngest brown dwarfs in our neighbourhood.

How many...?

A Giant Step: from Milli- to Micro-arcsecond Astrometry
Proceedings IAU Symposium No. 248, 2007
W. J. Jin, I. Platais & M. A. C. Perryman, eds.

doi:10.1017/S1743921308019753

L and T dwarfs in Gaia/SIM

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Abstract. We discuss the role of distances for understanding brown dwarfs and estimate the contribution expected by Gaia. We show that Gaia will only observe 25% of L and T dwarfs within 50pc which, at a conservative estimate, amounts to less than 400 objects. We discuss how Gaia results will nevertheless aid the ground-based programs providing reliable, bias free constraints for the calculation of parallaxes in an absolute system. We list the current ground-based programs underway and the possibilities for future all sky survey programs.

Keywords. stars: low-mass, brown dwarfs, stars: distances

How many…?

Properties of ultra-cool dwarfs with *Gaia*

An assessment of the accuracy for the temperature determination

L. M. Sarro[1], A. Berihuete[2], C. Carrión[1], D. Barrado[3,4], P. Cruz[3], and Y. Isasi[5]

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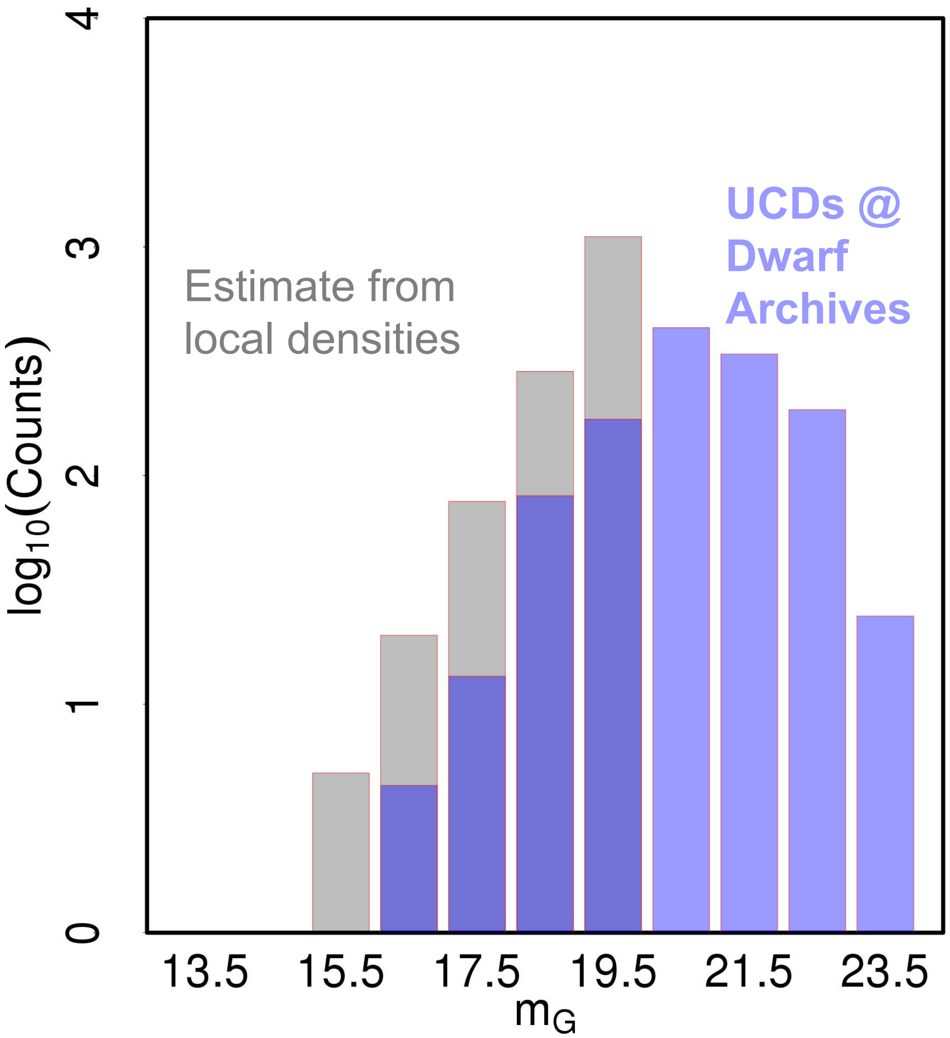
ABSTRACT

Context. The *Gaia* catalogue will contain observations and physical parameters of a vast number of objects, including ultra-cool dwarf stars, which we define here as stars with a temperature below 2500 K.
Aims. We aimed to assess the accuracy of the *Gaia* $T_{\rm eff}$ and log (g) estimates as derived with current models and observations.
Methods. We assessed the validity of several inference techniques for deriving the physical parameters of ultra-cool dwarf stars: Gaussian processes, support vector machines, k-nearest neighbours, kernel partial least squares and Bayesian estimation. In addition, we tested the potential benefits of data compression for improving robustness and speed. We used synthetic spectra derived from ultra-cool dwarf models to construct (train) the regression models. We derived the intrinsic uncertainties of the best inference models and assessed their validity by comparing the estimated parameters with the values derived in the bibliography for a sample of ultra-cool dwarf stars observed from the ground.
Results. We estimated the total number of ultra-cool dwarfs per spectral subtype, and obtained values that can be summarised (in orders of magnitude) as 400 000 objects in the M5–L0 range, 600 objects between L0 and L5, 30 objects between L5 and T0, and 10 objects between T0 and T8. A bright ultra-cool dwarf (with $T_{\rm eff} = 2500$ K and log (g) = 3.5) will be detected by *Gaia* out to approximately 220 pc, while for $T_{\rm eff} = 1500$ K (spectral type L5) and the same surface gravity, this maximum distance reduces to 10–20 pc. We found the cross-validation RMSE prediction error to be 10 K for regression models based on the k-nearest neighbours

How many…?



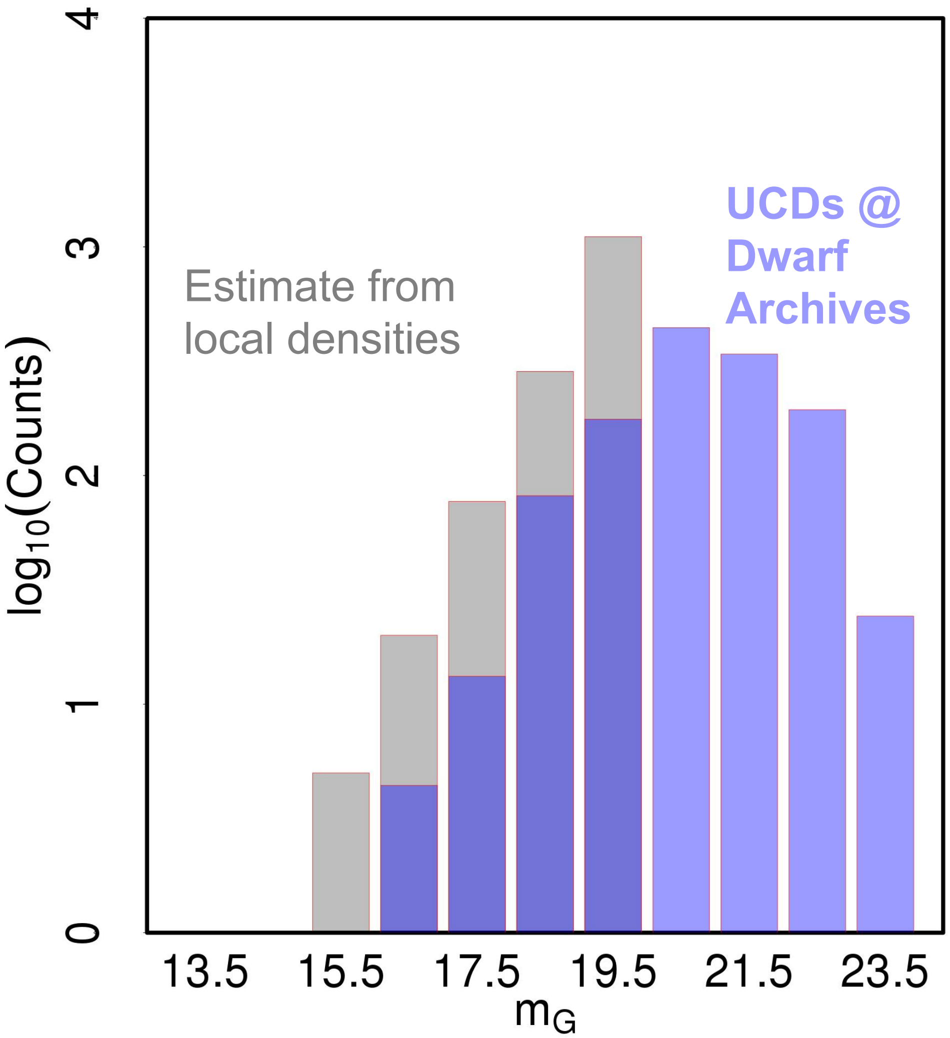
[Luisma **Sarro**'s, on Monday]

- Dwarfarchive.org ∧ SDSS

- A few hundred M9-L1V (very low-mass stars, not BDs), but a few dozens >L2V

- Some T dwarfs (e.g., J0758+32, J1254-01 – ε Ind Bab, Luhman 16 B)

How many…?



[Luisma **Sarro**'s, on Monday]

- Caballero, Burgasser & Klement (2008)'s spatial densities could be overestimated

- Avoid using theoretical *r*-band magnitudes

Isolated brown dwarfs: *Gaia* science

- Focus on the **200-500** *Gaia* ultracool dwarfs (Haywood & Jordi, Smart et al., Sarro et al.)

- Identify them in advance (plus any new *Gaia* ultracool dwarf discovery? E.g., low Galactic latitude)

- *In advance*, collect **homogeneous** low- and high-resolution spectroscopy & multi-band photometry + *Gaia* parallaxes & proper motions → Accurate L, T_{eff}, $\log g$, R, spatial densities, Galactocentric velocities

Isolated brown dwarfs: *Gaia* science

- Homogeneous, VO-compliant, public catalogue (mini-"ESO-Gaia"?) [Marocco's]

- → Atmosphere models, field mass luminosity/function, multiplicity, moving groups, ages, metallicity (in multiple systems)…

- Remark (or why that title?): European observatories with 2-4+ m-class telescopes in Northern Hemisphere are in **Spain** (La Palma, Calar Alto)

Non-isolated brown dwarfs: follow-up

- [~isolated] Faint brown dwarf *companions* to brighter *Gaia* stars: appendix to ‘LT-Gaia’ catalogue?

- Transiting: photometric and radial-velocity monitoring [Bouchy’s, Dzigan’s – tens]. Also: microlensing

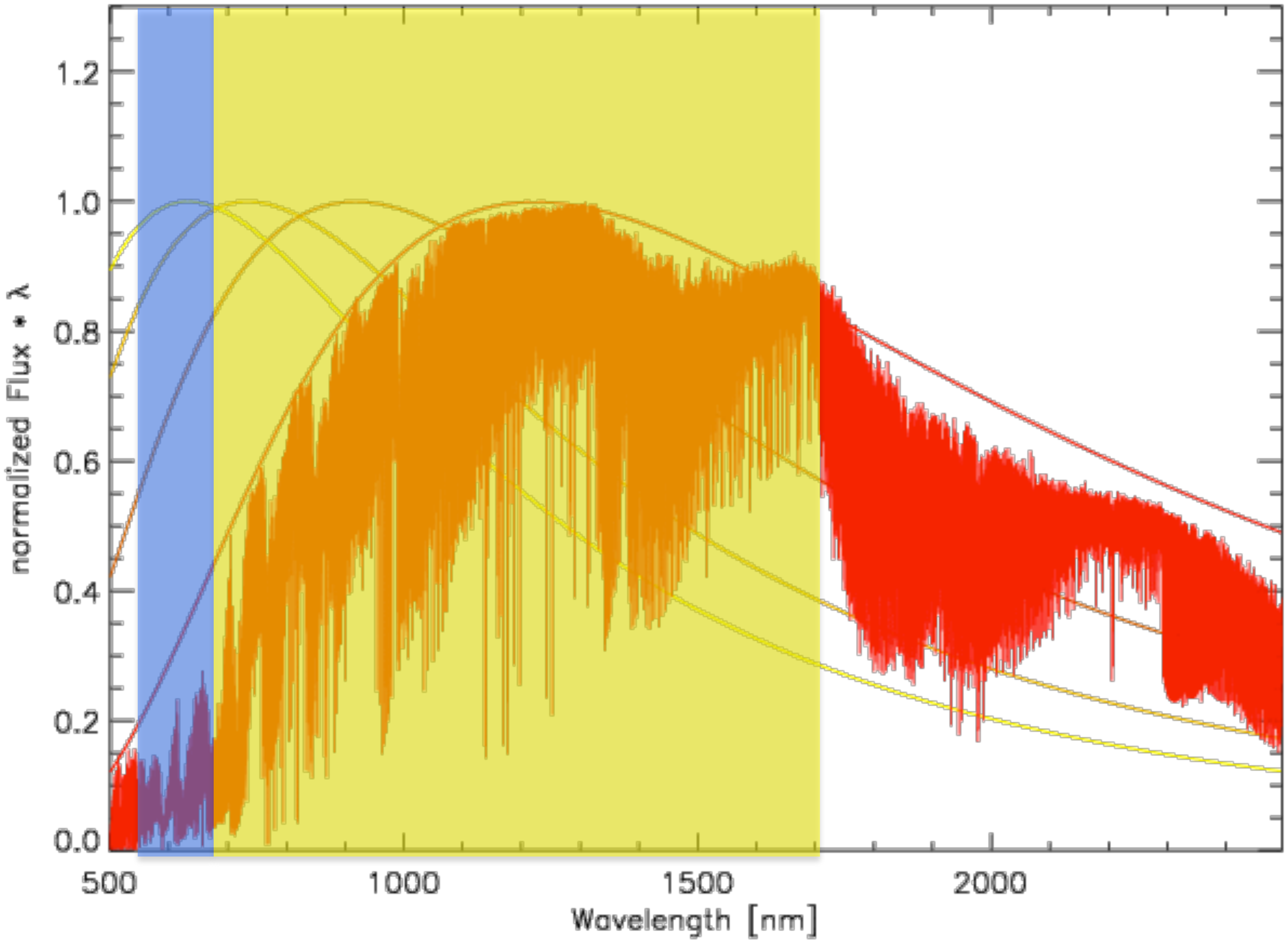
- Astrometric (and RVS?) BD candidates:
  - to solar-like stars: **FIES** (NOT), SOPHIE, CORALIE, HARPS & ESPRESSO, **HARPS-N** (TNG)
  - to M dwarfs: **CARMENES** (Calar Alto), SPIRou…

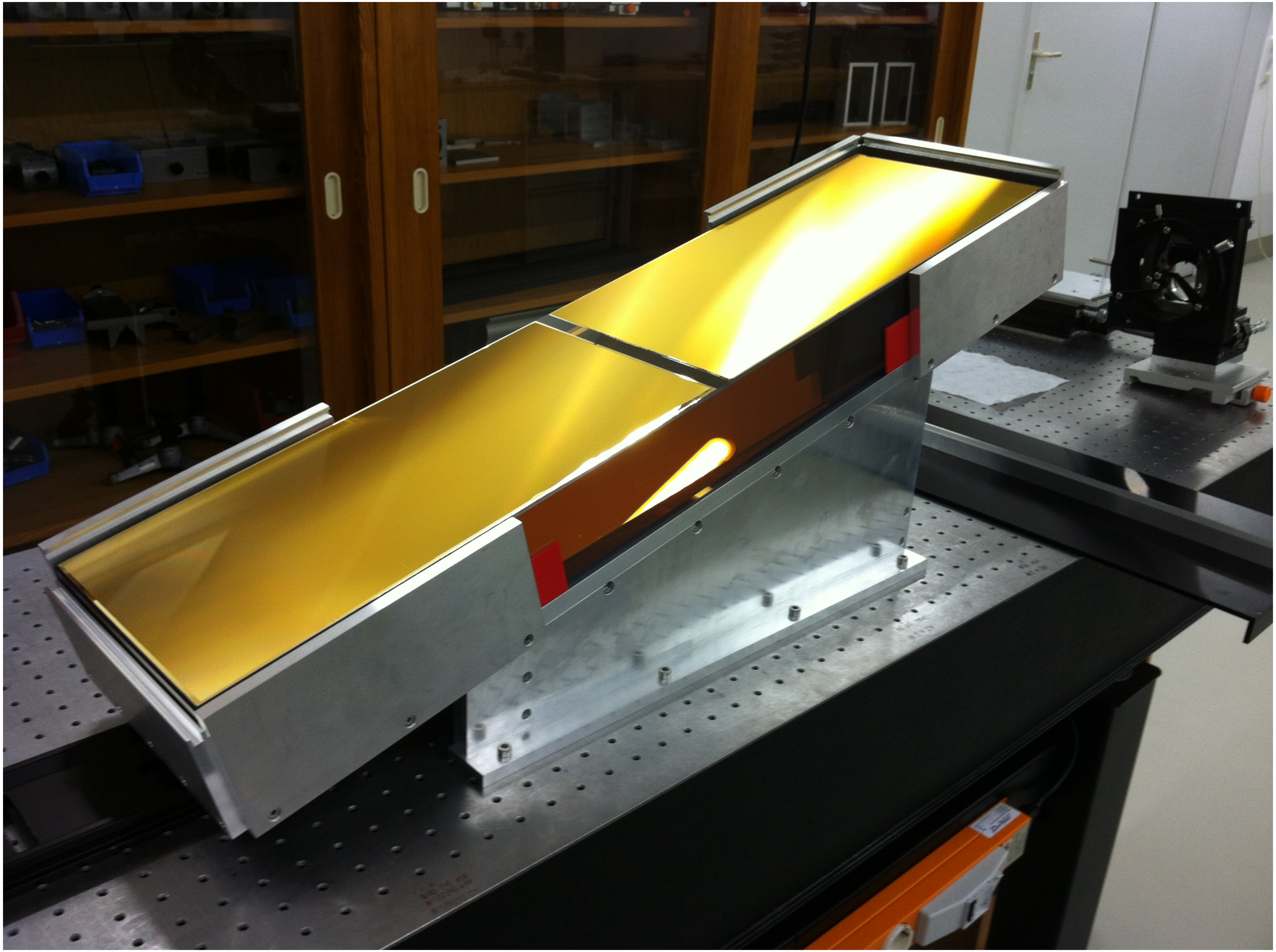
Radial-velocity follow-up

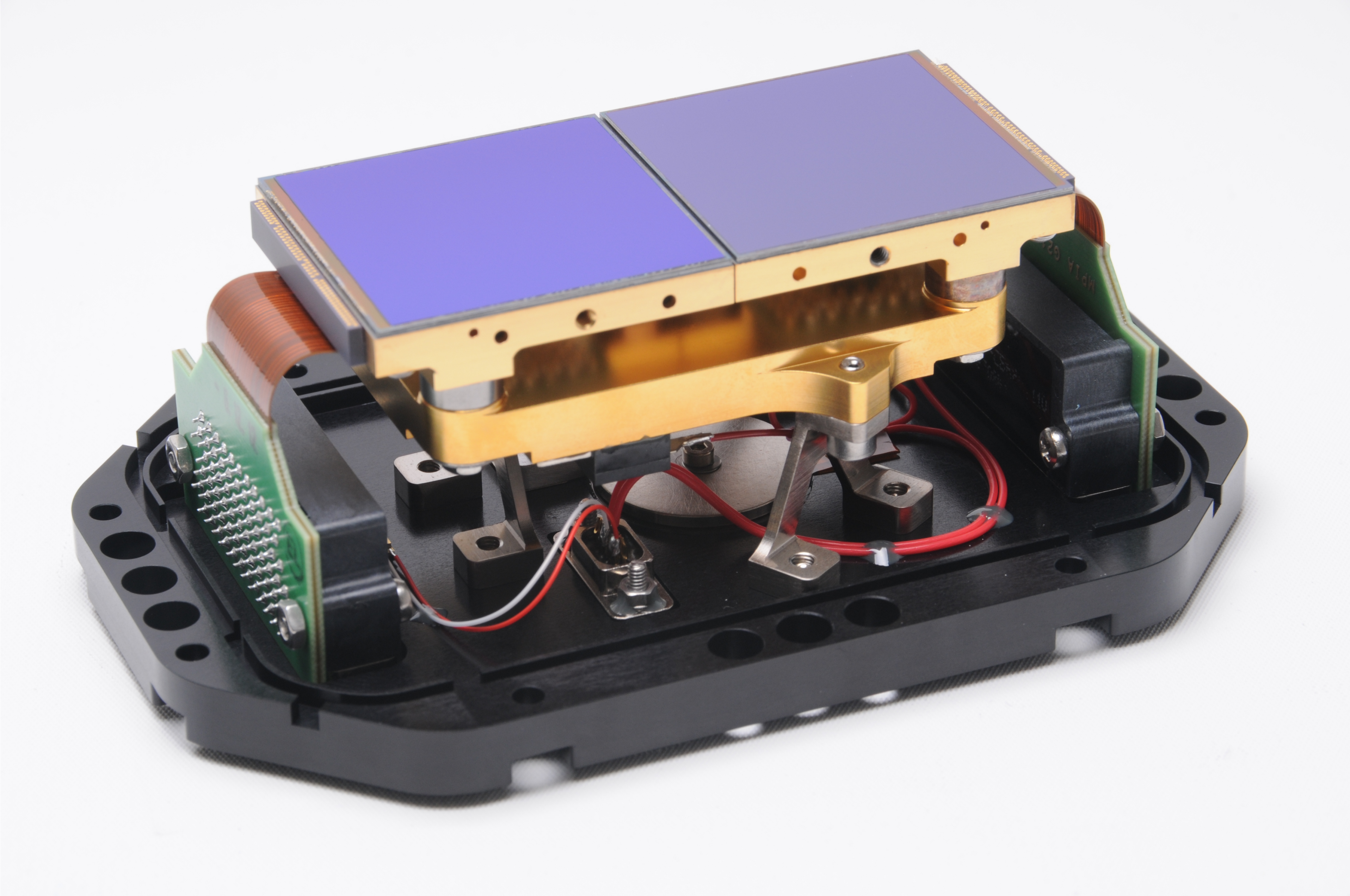
- Isolated ultracool dwarfs:
  - for accurate kinematics [Bochanski, *Marocco*, BDs and moving groups]:, X-shooter, CRIRES(+), ESPaDOnS, PHOENIX, **GIANO** (TNG), **'Y-shooter'** (NTT), **CARMENES**, SPIRou…
  - for (planetary?) astrometric companions [Sahlman's]: **CARMENES**, SPIRou, NIRspec@NTT… HiReS (E-ELT)

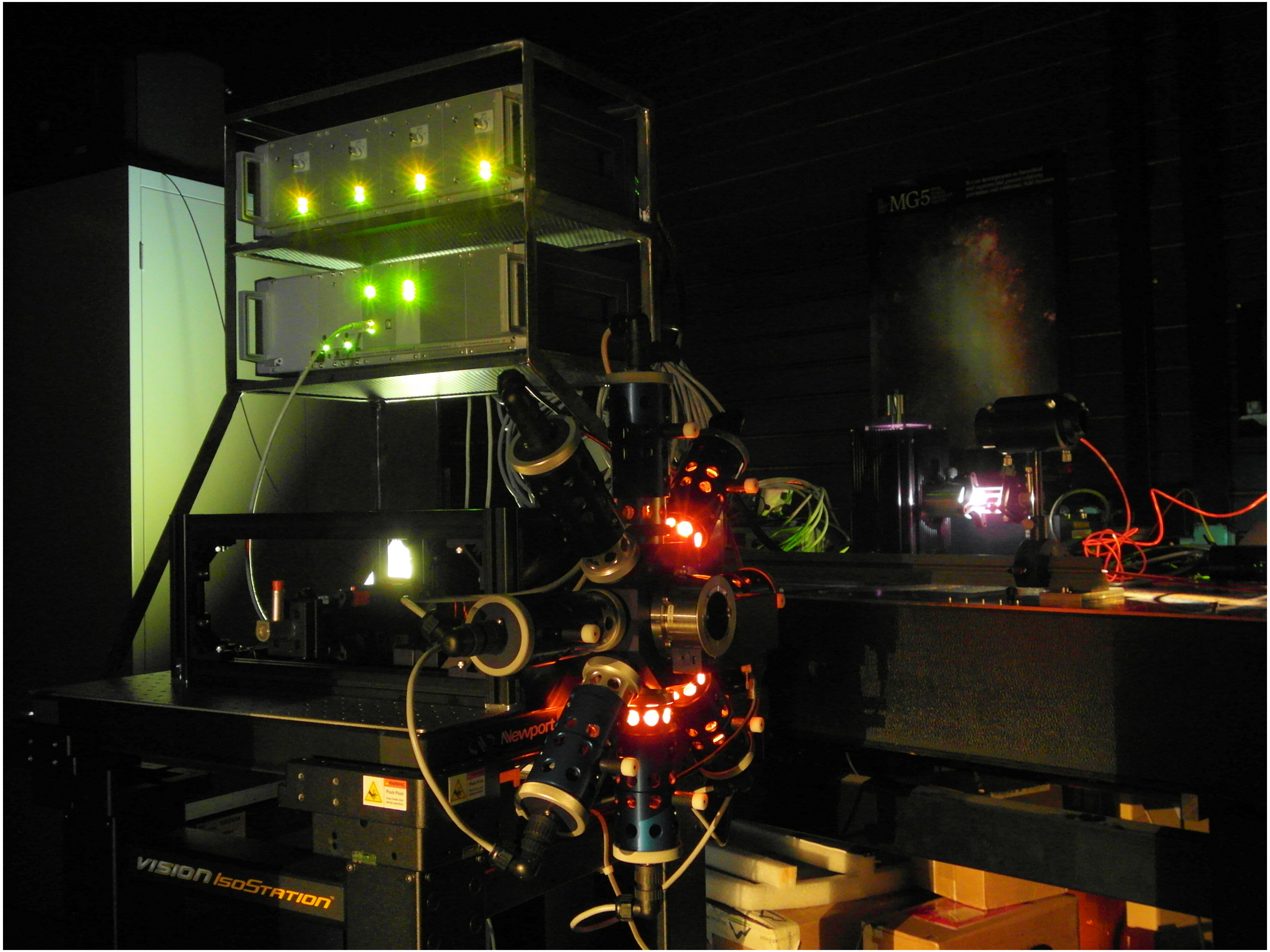
CARMENES @ 3.5m CA

Calar **A**lto high **R**esolution search for **M** dwarfs with **E**xoearths with **N**ear-infrared and optical **E**chelle **S**pectrographs








MG5
Newport
VISION IsoSTATION

carmenes

Young brown dwarfs

- Field 'isolated' brown dwarfs in young moving groups (e.g., LP 944-20 in ??? M9V, a few in TW Hydrae, Tucana-Horologium…) [Faherty et al.'s] → In the '(M)LT-*Gaia* catalogue'

Young brown dwarfs

- Brown dwarfs in clusters [**Sarro**'s]
  - (Re-)do estimations
  - Assume field M dwarf SEDs
  - Probably only M5-7 young BDs (70-50 M_{Jup})
    - In σ/λ Orionis: M7, 42/49 M_{Jup}
    - In Upper Scorpius: M8, 21 M_{Jup}
    - In Pleiades: M7, 58 M_{Jup}
  - Account for extinction (e.g., ρ Oph), background (e.g., ONC)…
  - Compile exhaustive lists of substellar members
  - A dozen BDs per cluster?
  - "Good" clusters: σ and λ Orionis, Upper Scorpius, Pleiades… [Caballero, Barrado, Bouy]

Young brown dwarfs

The real *Gaia* input for brown dwarfs:

Determine precise heliocentric **distances** to clusters → (+accurate photometry) luminosity function → (+theoretical models) **mass function**

(the largest uncertainty of mass function determination in young open clusters is distance)

Gaia and brown dwarfs from Spain

- *Red española de Explotación de Gaia* (RecGaia)

- Network coordinated from Barcelona; researchers from virtually all astronomy centres in Spain

- Several research lines, including **'very low-mass stars, brown dwarfs and exoplanets'** (*BajaMasa*, low mass), with 20+ investigators

BajaMasa RecGaia research lines

- **EXOS:** exoplanetary systems
  - EXOS-1: astrometry of known systems
  - EXOS-2: radial velocity of new systems
  - EXOS-3: detailed characterisation
- **MLT:** ultracool dwarfs
  - MLT-1: late M (H-R diagrams, kinematics…)
  - MLT-2: L and T (isolated or companions)
- **YBD:** young brown dwarfs
  - Bottom of the (I)MF in young open clusters and stellar associations

https://gaia.am.ub.es/Twiki/bin/view/RecGaia/BajaMasa/

http://carmenes.caha.es/

Parlami dell' esistenza di mondi lontanissimi, di civilità sepolte, di continenti alla deriva.

Tell me of the existence of worlds and planets far away, of past civilizations, of continents gone adrift.

Háblame de la existencia de mundos lejanísimos, de culturas sepultas, de continentes perdidos.

Synergies I

- CARMENES → *Gaia*:
  - Accurate radial velocities of M dwarfs (*Vr*: G > 13 mag)
  - Rotational velocities (*vsini*: G > 17 mag)
  - Spectral types (science preparation)
  - Reliable abundances (G > 12 mag)
  - Activity indicators (and Ca IRT at much higher resolution)

Synergies II

- ***Gaia* → CARMENES:**
  - Accurate parallactic distances to *all* targets (→ absolute magnitudes, luminosities, radii…)
  - Very accurate proper motions (→ galactocentric space velocities, stellar kinematic groups, wide multiplicity…)
  - Unresolved multiplicity ($\rho < 0.2$ arcsec)
  - Astrometric upper limits to radial-velocity companion mass (or even *determination of real masses!*)