Time Allocation Committee for
MPG time at the ESO 2.2m-telescope
c/o MPI für Astronomie
Königstuhl 17
D-69117 Heidelberg / Germany

| Application No. | |
|---|---|
| Observing period | **Autumn 2020** |
| Received | |

APPLICATION FOR OBSERVING TIME

from [X] MPIA [ ] MPG institute [ ] other

1. Telescope: 2.2-m [X] **L**


2.1 Applicant

| | |
|---|---|
| Dr. Olga **Zakhozhay** | MPIA / MAO NASU (Kiev, Ukraine) |
| Name | Institute |
| Königstuhl 17 | 69117 Heidelberg |
| street | ZIP code - city |
| zkholga | zakhozhay@mpia.de |
| ESO User Portal username | e-mail |

2.2 Collaborators

| | |
|---|---|
| R. Launhardt[1], Th. Henning[1], A. Müller[1] | [1]MPIA |
| name(s) | institute(s) |
| S. Brems[2],S. Reffert[2], M. Kürster[1], T. Trifonov[1] | [1]MPIA, [2]LSW |
| name(s) | institute(s) |

2.3 Observers

| | |
|---|---|
| Olga Zakhozhay | André Müller |
| name | name |


By specifying the names under item 2.3 it is obligatory to also send out these observers to La Silla, if required. Correspondence on the rating of this application will be sent to the applicant (P.I.) as quoted under 2.1 above.

3. Observing programme: Category: E

Title : **Radial Velocity Survey for Planets around Young stars (*RVSPY*)**


Abstract : We propose to continue our radial velocity search for planets around young stars with debris disks. By the end of the 4th observing semester, we have obtained at least one sufficient series of high-cadence observations for 103 of all 111 survey targets. During the following semesters, we plan to complete the initial cadence survey for 8 remaining stars and to obtain the follow-up spectra for 52 targets, that are down selected from the main sample with adapted cadence. The large target overlap between our RV survey and the NaCo–*ISPY* ESO–GTO direct imaging survey will enable us to infer the up-to-date most robust constraints on the occurrence and properties of giant planets in debris disks.


4. Instrument: [ ] WFI [X] FEROS [ ] GROND

5. Brightness range of objects to be observed: from 4.5 to 10.6 V-mag

6. Number of hours:

| applied for | | | already awarded | still needed |
|---|---|---|---|---|
| 92 | | | 725 | 400 |
| no restriction | grey | dark | | |

7. Optimum date range for the observations: .................................. 10.2020 – 03.2021
Usable range in local sideral time LST: .......................................... 20h – 17h

## Astrophysical context

Planets and some brown dwarfs (BD) are born in gaseous protoplanetary disks that surround young stars during the first few million years. While we are now nearly every day gaining new insights into the structure and composition of protoplanetary disks, detections of forming protoplanets in such disks are still extremely challenging and therefore very rare [21, 1, 18, 9]. Within only a few million years, protoplantary disks lose their gas due to accretion onto the star and newly formed planets, but also via disk winds. By this time, the primordial dust has coagulated to pebbles and planetesimals or has been accreted onto planets. Collisional cascades within the disk then lead to the formation of debris dust. Relatively massive debris disks characterize the phase after initial planet formation, when the planetary systems still evolve due to dynamical interactions and migration. By this time, the stars experience already much less chromospheric activity than at younger ages during the protoplanetary phase such that planet searches become possible, albeit still challenging [19]. Several properties of debris disks like, e.g., outer dust belts that are larger than predicted by collisional cascade models, or the co-existence of hot inner dust belts, can be explained by the action of newly formed planets [14]. Thus, the observable properties of debris disks could be indicative of embedded and still evolving planetary systems. Yet, the relation between debris disk properties and the existence and properties of planets has never been investigated systematically by observations. There is, however, growing evidence that the frequency of giant planets (GP) in young debris disks is significantly higher than around main-sequence (MS) stars [13]. In order to systematically investigate the relation between debris disk properties and GPs, we have initiated the large NaCo–$ISPY$ ESO–GTO direct Imaging Survey for Planets around Young stars. Since this imaging survey is only sensitive to companions at large separations (>5-10 au), we have launched in 2017 the first and complementary radial velocity (RV) survey for planets in shorter orbits around these debris disk stars ($RVSPY$).

## Immediate aim

We propose to continue our systematic RV survey for GPs and BDs around debris disk stars in orbits shorter than seen by direct imaging. In particular, we want to complete the initial screening of all 111 selected targets for both activity-related rotational modulation and the presence of hot companions (HC), which both have typical periods of a few days and thus require high-cadence observations (see Box 10 for justification of sample size and data points). Although we know that HC are not frequent around MS stars [24], this may not necessarily apply to the debris disk phase. Since HCs induce much larger RV signals than longer-period planets, they are also the 'easiest' targets. Longer-period planets induce smaller RV amplitudes and are difficult to identify if the activity-related RV jitter is too large. Therefore, this proposal mainly aims at searching for HC and characterizing stellar activity. Target selection criteria are described in Box 8e. Target list parameter distributions are shown in Fig. 1. Characterizing the stellar activity jitter is also a prerequisite for identifying those stars for which we have a chance of detecting longer-period planets. Figure 5 shows the achievable companion mass detection limits for 1-year orbital periods (as a proxy), here assumed to be $3\,\sigma$ above the activity jitter derived from the high-cadence observations for all stars observed during p101-102 within our program. Based on this evaluation, we have already selected a promising sub-sample of stars suitable for longer-term RV monitoring with the aim to search for planets on longer-period orbits and thus further decrease the gap in orbital separations probed by imaging ($ISPY$) and the RV search. Fig. 2 illustrates the detection spaces of the two related surveys including a long-term extension (3 − 5 yrs) of $RVSPY$. This evident synergy is thus far unique and makes the proposed RV survey scientifically extremely valuable.

## Previous work

During the first four semesters, we have observed 110 stars in high cadence (including 7 stars with insufficient/interrupted time series). Preliminary analysis of the *RVs* shows that we can sub-divide our sample into 5 categories: *(1)* stars with companion candidates (Fig. 4), *(2)* stars with evidence for rotational modulation, *(3)* binary stars, *(4)* stars with indication of a long-term $RV$ trend, and *(5)* stars with inconclusive RV modulation. 18 stars from category *(1)* have a highest priority for follow-up observations (priority 1 in Box 9), among which 9 stars have indications for short period (<14 d) and 9 for long period (>14 d) signals.

## Layout of observations

We request 92 hrs distributed in 2 blocks of 14–17 consecutive nights to complete the initial high-cadence survey (8 stars) and to follow up some of the most promising targets with individually adapted cadence. The high-cadence observations (each star observed once per night during 14 consecutive nights) will be interlaced with follow-up observations (in cadence defined for each case individually) of targets selected based on $RVSPY$ initial survey data. Spectra will be taken in the object–calibration mode of FEROS. Selected RV standards will be observed during each run.

## Strategic importance for MPIA

The search for and characterization of exoplanets is one of the key research topics at MPIA. Exploiting the synergy of this survey with the NaCo-$ISPY$ survey is a strategic key project of the PSF department.

## 8b. Figures and tables

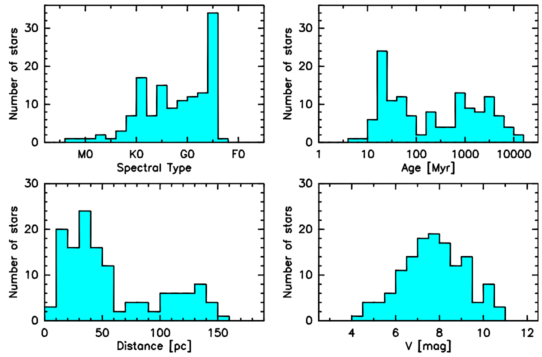


Figure 1: Distribution of spectral types, ages, distances, and $V$ magnitudes of our survey targets.

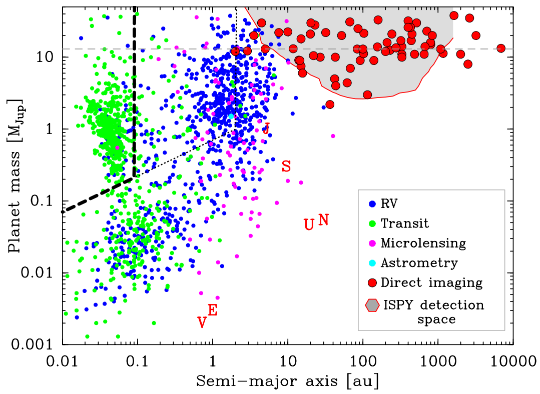


Figure 2: Distribution of planet mass vs. orbital separation of known exoplanets and candidates as listed on exoplanet.eu (Nov. 2019). Detection methods are marked by different symbols and colors. The lines show the parameter space probed by the related NaCo-*ISPY* (red dashed line), initial *RV SPY* (thick black dashed line) and *RV SPY* follow-up observations extending out to periods of 3 yrs (black dotted line).

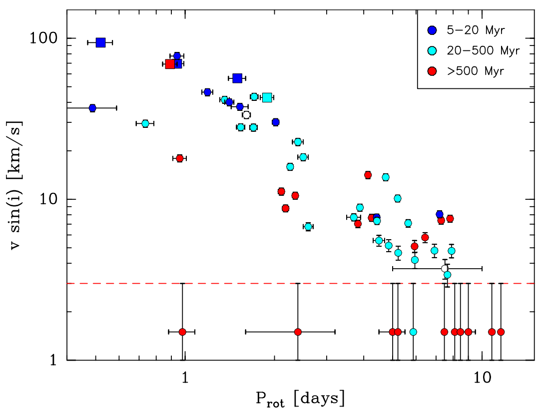


Figure 3: *RV SPY* FEROS derived $v\,sin\,i$, vs. stellar rotation periods derived from TESS light curves. Ages are color-coded. Squares mark targets with a strong positive $BS(RV)$ correlation ($r_P > 0.7$). The horizontal dashed red line marks the lower sensitivity limit of our $v\,sin\,i$ measurements).

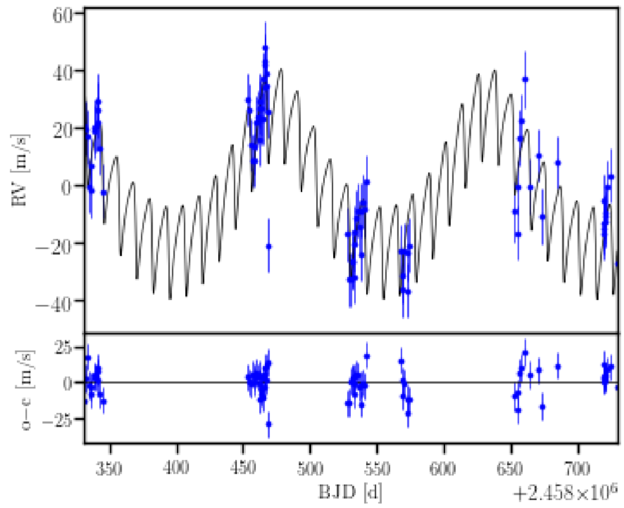


Figure 4: FEROS *RVs* of HD 23484 (blue circles) and best fit model ($\chi^2_\nu$=1.18) with two companions with $m$ sin($i$)∼0.6 and ∼0.2 $M_{jup}$ and periods of 159 and 12 days, respectively (black curve). The lower panel shows the *RV* residuals.

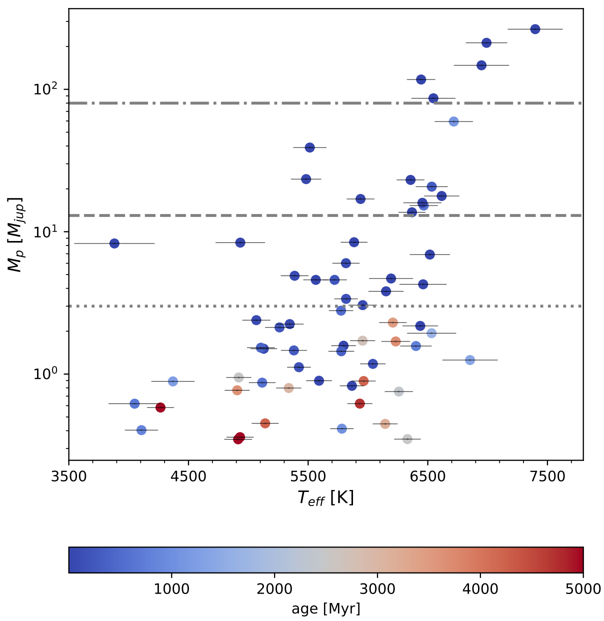


Figure 5: Masses of $P = 1$ year hypotetical companions that induce an *RV* amplitude three times larger than the activity jitter RMS derived from the high-cadence observations in P101-102, plotted vs. host star temperature. The dot-dashed line marks the approximate boundary between the low mass stellar and substellar regimes and dashed line marks the approximate boundary between the planetary and brown dwarf regime. The dotted line marks the 3 $M_{\rm Jup}$ of the planetary mass that will be used to set the targets priority.

*General:* The present proposal is mostly a follow-up monitoring of promising targets identified from the high-cadence observations during the first two observing years of *RVSPY* program. The follow-up monitoring for individual targets may extend up to 3–5 yrs, with the observing load decreasing over time. Continuity in the project is guaranteed by the PI (OZ) having a permanent position (in Ukraine) and an agreement with MPIA (TH) for long-term guest status with an initial 1-year stay at MPIA and later frequent short-term visits. Other members of the team also have permanent or longer-term positions. Extensive expertive in observing, data reduction, and analysis is available in the team. Computing and data storage capacities at MPIA are available and arranged (e.g., access to the astro-node cluster).

*Target selection:* Our target list contains only stars with confirmed debris disk signature and with ages $\geq$ 10 Myrs (to avoid the most active early phases). Spectral types are restricted to the range F5–M3 because earlier types have too broad and too few spectral lines and later spectral types are known to have less massive debris disks and fewer giant planets. We also set a brightness limit at V$\leq$10.5 mag to limit individual exposure times. About 50% of our targets are also being imaged with NaCo in the framework of the *ISPY* GTO program (due to various method-related constraints, complete overlap is not possible). We have queried the ESO archive for useful RV data (FEROS, HAPRS, HIRES) for all $\approx$200 target candidates from our master list complied with the above selection criteria. We keep stars with less than 10 archive spectra in our final survey list. Stars with $\geq$120 spectra are excluded, but we will analyse their archive data in the same way as our own FEROS spectra and include the results in our survey analysis. For stars with an intermediate number of archive spectra, we verified case by case whether sequences of spectra with sufficiently high cadence are available and included or rejected them from our survey list. The final survey target list consists of 111 stars which are evenly distributed over the sky.

*Complementary data:* We will complement our spectra by all available archival spectra which qualify for our purposes and can be calibrated to be combined with our FEROS data. Furthermore, the majority of our targets (88%) are in the TESS observing list. The analysis of the TESS data that are already publicly available already allowed us to derive the rotational periods for the majority of our stars (see Fig.3 and [26] for more details). For stars that are not covered by the TESS observing program, but have interesting RV time series, we have an agreement with Andres Jordan to obtain dedicated photometric data with the CHAT telescope at the Las Campanas observatory in Chile. We are also prepared to exploit the *Gaia* individual measurement data when they will be released to bridge the remaining gap at orbital separations of a few au in detection space.

*Analysis tools and strategy:* The unofficial sub-title of our initial high-cadence survey, *"Hot planets and rubble - lets face the trouble"*, already suggests that planet signals won't come out easy for these still relatively young stars and we have to deal a lot with the effects of stellar activity. Rotational modulation of spectral line shapes can both induce large RV jitter that may mask a planetary RV signal or even mimic a planetary signal when the spots are very stable. Therefore, we need to analyse and cross-correlate with the RV variations several activity indicators (well-established ones, but also new ones recently developed by us), like, e.g., Ca II line emission, $H_\alpha$ line parameters, the V I and Fe I line depth ratio, the bisector velocity span, displacement, and curvature, or the chromatic RV index, which is now routinely used in the *Carmenes* M-star survey [25]. While the reduction of the spectra and extraction of RVs will be done in a semi-automatic fashion with the *CERES* pipeline [2], the spectral type classification and extraction of most activity indicators will be done with the *ZASPE* [3] and *ATHOS* [8] pipelines. For the analysis, we have all necessary tools available (many developed by AM): individual line measurement (e.g. for equivalent width), circumstellar disk component analysis, bisector analysis, synthetic spectrum calculation and fitting, multicomponent Gauss fitting for wind/accretion analysis, spot modelling, periodograms (GLS, LS, BGLS, and others), 2D line velocity maps including 2D periodograms, Kepler orbit fitting (for single and multiple planets), etc. Based on our results together with the information about spectral type, $v \sin i$, stellar inclination and age of each individual target we will be able to identify quiet stars and stars for which the activity can be modelled well enough. These stars will become the targets for our future observations aiming to detect and characterise planetary companions with longer periods.

*Publication plan:* We are currently preparing for submission the first paper that will introduce the survey after the first year of observations (the latest version of the draft is attached to this proposal). Additional publications on individual targets with interesting results (activity, multiplicity or HCs) are in the stage of discussions and preliminary analysis - more observational data are needed for solid conclusions. As soon as the initial high-cadence survey is fully completed, we also plan to publish a survey overview paper which will also include a statistical analysis of stellar activity and possible companion discoveries.

9. Objects to be observed

(Objects to be observed with high priority should be marked in last column)

| Designation | $\alpha$ (2000) | $\delta$ (2000) | magnitude in spectral range to be observed | priority |
|---|---|---|---|---|
| HD 870[a] | $00^h\,12^m\,50\overset{s}{.}249$ | $-57^\circ\,54'\,45.390''$ | 7.226 | 2[b] |
| HD 3296 | $00^h\,36^m\,01\overset{s}{.}854$ | $-05^\circ\,34'\,14.590''$ | 6.71 | 2 |
| HD 3670 | $00^h\,38^m\,56\overset{s}{.}704$ | $-52^\circ\,32'\,03.420''$ | 8.21 | 2 |
| HD 5133 | $00^h\,53^m\,01\overset{s}{.}135$ | $-30^\circ\,21'\,24.900''$ | 7.171 | 2 |
| HD 13246 | $02^h\,07^m\,26\overset{s}{.}020$ | $-59^\circ\,40'\,45.780''$ | 7.5 | 2 |
| HD 14082B | $02^h\,17^m\,24\overset{s}{.}734$ | $28^\circ\,44'\,30.330''$ | 7.74 | 2 |
| HD 15060 | $02^h\,23^m\,35\overset{s}{.}538$ | $-55^\circ\,37'\,00.480''$ | 7.02 | 1 |
| HD 23484 | $03^h\,44^m\,09\overset{s}{.}173$ | $-38^\circ\,16'\,54.380''$ | 6.996 | 1 |
| BD +23 551 | $03^h\,48^m\,16\overset{s}{.}910$ | $23^\circ\,38'\,12.500''$ | 10.11 | 2 |
| HD 24649 | $03^h\,53^m\,27\overset{s}{.}22$ | $-41^\circ\,13'\;\;21''74$ | 7.3 | 2 |
| HD 28069 | $04^h\,25^m\,57\overset{s}{.}34$ | $05^\circ\,09'\;\;00''52$ | 7.4 | 2 |
| HD 28447 | $04^h\,30^m\,20\overset{s}{.}057$ | $28^\circ\,07'\;\;54''800$ | 6.515 | 2 |
| HD 33081 | $05^h\,07^m\,08\overset{s}{.}669$ | $-17^\circ\,17'\;\;59''710$ | 7.04 | 2 |
| HD 38397 | $05^h\,43^m\,35\overset{s}{.}790$ | $-39^\circ\,55'\;\;24''840$ | 8.14 | 2 |
| HD 48370 | $06^h\,43^m\,01\overset{s}{.}023$ | $-02^\circ\,53'\,19.340''$ | 7.91 | 2 |
| HD 50571 | $06^h\,50^m\,01\overset{s}{.}015$ | $-60^\circ\,14'\,56.920''$ | 6.098 | 2 |
| HD 57703 | $07^h\,23^m\,04\overset{s}{.}61$ | $18^\circ\,16'\;\;24''28$ | 6.8 | 2 |
| HD 59659 | $07^h\,28^m\,30\overset{s}{.}06$ | $-49^\circ\,08'\;\;58''89$ | 8.9 | 2 |
| HD 59967 | $07^h\,30^m\,42\overset{s}{.}512$ | $-37^\circ\,20'\;\;21''700$ | 6.64 | 2 |
| HD 72687 | $08^h\,33^m\,15\overset{s}{.}410$ | $-29^\circ\,57'\;\;23''880$ | 8.26 | 1 |
| HD 76151 | $08^h\,54^m\,17\overset{s}{.}948$ | $-05^\circ\,26'\;\;04''060$ | 6.0 | 2 |
| HD 76748 | $08^h\,54^m\,51\overset{s}{.}204$ | $-63^\circ\,42'\;\;06''990$ | 9.44 | 2 |
| CD -49 3972 | $08^h\,56^m\,10\overset{s}{.}78$ | $-49^\circ\,29'\;\;26''64$ | 10.4 | 2 |
| HD 93932 | $10^h\,50^m\,25\overset{s}{.}512$ | $-15^\circ\,06'\;\;15''080$ | 7.53 | 2 |
| HD 104231 | $12^h\,00^m\,09\overset{s}{.}405$ | $-57^\circ\,07'\;\;02''000$ | 8.54 | 2 |
| HD 105912 | $12^h\,11^m\,21\overset{s}{.}799$ | $-03^\circ\,46'\;\;43''940$ | 6.94 | 1 |
| MML 8 | $12^h\,12^m\,35\overset{s}{.}772$ | $-55^\circ\,20'\;\;27''310$ | 10.48 | 2 |
| HD 109832 | $12^h\,38^m\,42\overset{s}{.}78$ | $-68^\circ\,45'\;\;49''12$ | 8.09 | 1 |
| HD 111520 | $12^h\,50^m\,19\overset{s}{.}717$ | $-49^\circ\,51'\;\;48''960$ | 8.87 | 1 |
| HD 117214 | $13^h\,30^m\,08\overset{s}{.}976$ | $-58^\circ\,29'\;\;04''340$ | 8.06 | 1 |
| HD 117524 | $13^h\,31^m\,53\overset{s}{.}615$ | $-51^\circ\,13'\;\;33''200$ | 9.892 | 2 |
| MML 36 | $13^h\,37^m\,57\overset{s}{.}302$ | $-41^\circ\,34'\;\;41''960$ | 10.084 | 2 |
| HD 118972 | $13^h\,41^m\,04\overset{s}{.}171$ | $-34^\circ\,27'\;\;50''970$ | 6.92 | 2 |
| CD-29 10609 | $13^h\,48^m\,57\overset{s}{.}84$ | $-30^\circ\,22'\;\;04''74$ | 10.4 | 1 |
| HD 122948 | $14^h\,04^m\,43\overset{s}{.}206$ | $04^\circ\,46'\;\;45''800$ | 8.51 | 2 |
| HD 125451 | $14^h\,19^m\,16\overset{s}{.}220$ | $13^\circ\,00'\;\;15''760$ | 5.41 | 2 |
| HD 131156 | $14^h\,51^m\,23\overset{s}{.}28$ | $19^\circ\,06'\;\;02''28$ | 4.54 | 2 |
| HD 132950 | $15^h\,01^m\,29\overset{s}{.}974$ | $15^\circ\,52'\;\;07''990$ | 9.354 | 1 |
| HD 134910 | $15^h\,13^m\,50\overset{s}{.}39$ | $-40^\circ\,25'\;\;01''91$ | 9.6 | 2 |
| HD 135953 | $15^h\,19^m\,05\overset{s}{.}420$ | $-36^\circ\,21'\;\;44''210$ | 9.36 | 2 |
| HD 138398 | $15^h\,33^m\,51\overset{s}{.}925$ | $-50^\circ\,05'\;\;23''890$ | 8.29 | 2 |
| HD 141011 | $15^h\,48^m\,24\overset{s}{.}783$ | $-42^\circ\,37'\;\;05''010$ | 8.97 | 2 |
| HD 145229 | $16^h\,09^m\,26\overset{s}{.}628$ | $11^\circ\,34'\;\;28''050$ | 7.44 | 1 |
| HD 145560 | $16^h\,13^m\,34\overset{s}{.}333$ | $-45^\circ\,49'\;\;03''660$ | 8.9 | 2 |
| HD 145972 | $16^h\,16^m\,03\overset{s}{.}84$ | $-49^\circ\,04'\;\;29''39$ | 8.4 | 1 |

[a]We list here only 45 (sorted by RA) of 60 follow-up survey targets due to the space limitations.

[b]Priority 1 is given to the most promising targets based on the initial high cadence survey (for more details see "Previous work" in Box 8a). Priority 2 is given to the stars for which the existence of long period can not be excluded according to figure 5 and currently available data.

10. Justification of the amount of observing time requested:

For statistical reasons, in order to put robust constraints on the frequency of GPs in debris disks and their relation to debris disk properties, we would ideally have a sample size of ≥200 stars. Taking into account the time that is realistically available with FEROS, the minimum number and sampling of data points per star for the proposed initial high-cadence screening, the target selection criteria set by the observing method and instrument (see Box 8e), and the number of suitable stars matching our selection criteria for which we found a sufficient number of qualified spectra in the ESO archives (these stars will not be re-observed, but re-reduced and included in our statistical analysis), we down-selected the list of targets for this survey to 111 stars. Including archival data, which will be included in our statistical survey analysis, we will then have a total sample size of ≈200 stars.

To characterize the stars for activity-related rotational modulation and identify HC candidates, we need about 15 high-SNR spectra for every star, distributed such that the relevant periods (distribution mean ≈3–4 days) are sampled. Since the more quiet stars in our sample have an RV jitter of order 10–20 m/s, we aim for an intrinsic RV precision of the same order, which we are typically achieving with an $SNR \approx 100$. Based on experience (more accurate than the ETC), we need integration times between 3 min for stars with V≤ 6 mag and 20 min for stars with $V = 10 - 11$ mag to achieve this. With integration times adapted to each individual star, we need a total of 12.6 hrs integration time (or 17.6 hrs of telescope time, accounting 5 min overhead per pointing) to obtain one high-SNR spectrum for each of the 60 target stars that we intent to observe in the next semesters.

In P101-104, we have already used 585 hrs and observed 110 out of the 111 survey stars in high cadence. However, for 7 of these stars, we could not obtain sufficiently sampled time series due to weather and technical losses. Therefore, in p106 and p107, we anticipate to observe eight stars with high-cadence and to follow-up those 52 stars with individually adapted cadence (mostly 3-7 observations per run), which are the most promising candidates for longer-term RV monitoring. To continue our program at the same pace and be able to complete the initial high-cadence screening of all 111 survey targets with at least 15 spectra per star, we therefore request a total of 92 hrs of telescope time in the autumn 2020 semester (p106), subdivided into two observing blocks with $12 - 14$ consecutive nights each.

If the observations in p106 will be successful and we manage to complete the high-cadence survey, including the follow-up of all stars with short-period companion candidates, by the end of p107, we will decrease the time requests to ∼70 hrs per semester to follow up only the stars with the long-period candidates.

11. Constraints for scheduling observations for this application:

The requested two observing blocks can be scheduled with at least 3 month separation across the semester in service or visitor mode. The best and most complete scheduling of the requested 92 hrs can be achieved when the observations are scheduled during October 2020 (37 hrs) and March 2021 (55 hrs). Each observing block ideally consists of the even fractions of $12 - 14$ consecutive nights (i.e. ∼3 hrs per night in October and ∼4.5 hrs per night in March). This will allow us to observe all stars which require high-cadence follow-up observations during 14 consecutive nights. The targets we follow-up for longer-period companions will be observed about 3–4 times within one week of the run to account for the stellar rotational modulations.

12. Observational experience of observer(s) named under 2.3:
(at least one observer must have sufficient experience)

OZ, RL, AM, SR, MK, TT all have a large observing experience with FEROS and other high resolution spectrographs.

13. Observing runs at the ESO 2.2m-telescope (preferably during the last 3 years)
and publications resulting from these

| Telescope | instrument | date | hours | success rate | publications |
|---|---|---|---|---|---|
| 2.2m | FEROS | many runs | many hours | 80% | [20, 21, 15, 16, 17, 10, 7] |
| 3.5m | HARPS | P97 | 120 | 70% | [22, 23] |
| 2.2m | FEROS | P99 | 20 | 80% | [23] |
| 2.2m | FEROS | P101 | 165 | 87% | [26] [a] |
| 2.2m | FEROS | P102 | 130 | 92% | [26] [a] |
| 2.2m | FEROS | P103 | 140 | 79% | -- |
| 2.2m | FEROS | P104 | 150 | 50% | -- |
| 2.2m | FEROS | P105 | 140 | observations ongoing | observations ongoing |

[a] We are currently preparing for submission the first paper that will introduce our survey after the first completed year of observations (the latest version of the draft is attached to this proposal).

14. References for items 8 and 13:


[1] Biller et al. (2012): *A likely close-in low-mass stellar companion to the transitional disk star HD 142527*, ApJL, **753**, L38

[2] Brahm et al.(2017a): *CERES: A Set of Automated Routines for Echelle Spectra*, PASP bf 129, 034002

[3] Brahm et al.(2017b): *ZASPE: A Code to Measure Stellar Atmospheric Parameters and their Covariance from Spectra*, MNRAS **467**, 971

[4] Chen et al. (2014): *The Spitzer Infrared Spectrograph Debris Disk Catalog. I. Continuum Analysis of Unresolved Targets*, ApJS **211**, 25

[5] ESO Science Archive: http://archive.eso.org

[6] Extrasolar Planets Encyclopaedia: http://exoplanet.eu

[7] Fang et al. (2014): *GW Orionis: Inner disk readjustments in a triple system*, A&A **570**, 118

[8] Hanke et al. (2018): *ATHOS: On-the-fly stellar parameter determination of FGK stars based on flux ratios from optical spectra*, A&A **619**, 134

[9] Keppler et al.(2018): *Discovery of a planetary-mass companion within the gap of the transition disk around PDS 70*, A&A **617**, A44

[10] Kóspál et al. (2014): *Radial velocity variations in the young eruptive star EX Lup*, A&A **561**, 61

[11] Marshall et al.(2014): *Interpreting the extended emission around three nearby debris disc host stars*, A&A **570**, A114

[12] MASCARA survey: http://mascara.strw.leidenuniv.nl

[13] Meshkat et al.(2017):*A Direct Imaging Survey of Spitzer detected debris disks: Occurrence of giant planets in dusty systems*, AJ **154**, 245

[14] Moór et al.(2015): *Stirring in massive, young debris discs from spatially resolved Herschel images*, MNRAS **447**, 577

[15] Müller et al. (2011): *A young star has reached its rotational limit*, A&A **530**, A85

[16] Müller et al. (2011): *HD 144432: A young triple system*, A&A **535**, 3

[17] Müller et al. (2013): *Reanalysis of the FEROS observations of HIP 11952*, A&A **556**, 3

[18] Rameau et al. (2013): *Confirmation of the Planet around HD 95086 by Direct Imaging*, ApJL, **779**, L26

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**Tolerance limits for planned observations:**

| | | | | | |
|---|---|---|---|---|---|
| **maximum seeing:** | 2″ | **minimum transparency:** | 60% | **maximum airmass:** | 1.8 |
| **photometric conditions:** | no | **moon: max. phase / ∠ :** | 1/10° | **min. / max. lag:** | 0/0 nights |