CHARA/SPICA: AG du JMMC

4 décembre 2020

Plan:

- rappel rapide sur l'instrument et les objectifs astrophysiques, dernières nouvelles
- présentation de la base de données dynamique SPICA-DB et articulation avec le JMMC

CHARA/SPICA

- **SPICA-VIS** is a combination of new CHARA AO systems, single mode fibres for spatial filetering and modern EMCCD detectors
- It will operate in LR (R=140), MR (R=3000), and HR (R=10000) dispersed fringes of 6T (15 baselines). It is assisted by a H band fringe tracking system (**SPICA-FT**). It has an angular resolution of ~0.2mas (mR~8-10).

Mesure directe: *survey* interférométrique plusieurs milliers d'étoiles sur l'ensemble du diag. HR

JMMC

Images: étude de « l'activité stellaire » de plusieurs centaines d'étoiles (binarité, rotation, vent et environnement)

gaia

VizieR

Catalogue moderne de **paramètres fondamentaux stellaires et planétaires** sur l'ensemble du diagramme HR

&

Etalonnage de **relation brillance de surface couleur (SBCR)** robustes sur l'ensemble du diag. HR prenant en compte les diagnostiques d'activité stellaire.

Paramètres fondamentaux stellaire

- independent **radius** of stars at the 1-2% precision level
- **Effective temperature** of stars with a good precision (σT_{eff} ~25-30K)
- **Masses and Ages** of the stars (asterosismology)

PLATO Mission Consortium — PLanetary Transits and Oscillations of stars

Fundamental parameter of **transiting planets** (Rp, Mp, age)

CHARA/SPICA: Commissioning end of 2021; First science operation mid 2022.

Main activities related to PLATO (WP122300 WG3&4)

1) Production of a **pipeline** to produce, on the basis of the new CHARA/SPICA interferometric measurements, R*inter* & T*eff,inter* for ~2000 stars, with a large majority in the P2 field (F5-K7 IV/V)of PLATO (survey 2022-2024 + extension 2024-2026). This will be part of the PLATO (SAPP) pipeline
2) Production of new accurate SBCR for radius estimation (R*sbcr*) in the SAPP pipeline
3) For a few hundreds of stars, direct measurement of the limb darkening

1% angular diameter determination CHARA/SPICA domain of validity

Dwarfs	Challouf			Salsi-1			Salsi-2		
SpTy	O	B0	A0	F5	G7	K4	M0	M3	M4
V // V-K	-2	-1	0	1	2	3	4	5	6
0	0,10	1,00	3,35	6,28	11,82	22,25	39,94	70,70	125,14
1	0,06	0,63	2,11	3,96	7,46	14,04	25,20	44,61	78,96
2	0,04	0,40	1,33	2,50	4,71	8,86	15,90	28,14	49,82
3	0,02	0,25	0,84	1,58	2,97	5,59	10,03	17,76	31,43
4	0,02	0,16	0,53	0,99	1,87	3,53	6,33	11,20	19,83
5	0,01	0,10	0,33	0,63	1,18	2,23	3,99	7,07	12,51
6	0,01	0,06	0,21	0,40	0,75	1,40	2,52	4,46	7,90
7	0,00	0,04	0,13	0,25	0,47	0,89	1,59	2,81	4,98
8	0,00	0,03	0,08	0,16	0,30	0,56	1,00	1,78	3,14
9	0,00	0,02	0,05	0,10	0,19	0,35	0,63	1,12	1,98
10	0,00	0,01	0,03	0,06	0,12	0,22	0,40	0,71	1,25

Giants	Challouf			Salsi-1			Salsi-2		
SpTy	O	B0	A0	F5	G7	K4	M0	M3	M4
V // V-K	-2	-1	0	1	2	3	4	5	6
0	0,24	1,09	3,16	6,72	11,79	20,68	36,41	62,26	106,46
1	0,15	0,69	1,99	4,24	7,44	13,05	22,97	39,28	67,17
2	0,10	0,44	1,26	2,68	4,69	8,23	14,49	24,79	42,38
3	0,06	0,27	0,79	1,69	2,96	5,20	9,15	15,64	26,74
4	0,04	0,17	0,50	1,07	1,87	3,28	5,77	9,87	16,87
5	0,02	0,11	0,32	0,67	1,18	2,07	3,64	6,23	10,65
6	0,02	0,07	0,20	0,42	0,74	1,30	2,30	3,93	6,72
7	0,01	0,04	0,13	0,27	0,47	0,82	1,45	2,48	4,24
8	0,01	0,03	0,08	0,17	0,30	0,52	0,91	1,56	2,67
9	0,00	0,02	0,05	0,11	0,19	0,33	0,58	0,99	1,69
10	0,00	0,01	0,03	0,07	0,12	0,21	0,36	0,62	1,06

1% angular diameter determination CHARA/SPICA domain of validity + LD measurement

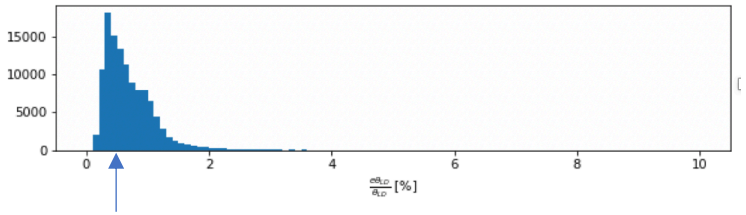
Dwarfs	Challouf			Salsi-1			Salsi-2		
SpTy	O	B0	A0	F5	G7	K4	M0	M3	M4
V // V-K	-2	-1	0	1	2	3	4	5	6
0	0,10	1,00	3,35	6,28	11,82	22,25	39,94	70,70	125,14
1	0,06	0,63	2,11	3,96	7,46	14,04	25,20	44,61	78,96
2	0,04	0,40	1,33	2,50	4,71	8,86	15,90	28,14	49,82
3	0,02	0,25	0,84	1,58	2,97	5,59	10,03	17,76	31,43
4	0,02	0,16	0,53	0,99	1,87	3,53	6,33	11,20	19,83
5	0,01	0,10	0,33	0,63	1,18	2,23	3,99	7,07	12,51
6	0,01	0,06	0,21	0,40	0,75	1,40	2,52	4,46	7,90
7	0,00	0,04	0,13	0,25	0,47	0,89	1,59	2,81	4,98
8	0,00	0,03	0,08	0,16	0,30	0,56	1,00	1,78	3,14
9	0,00	0,02	0,05	0,10	0,19	0,35	0,63	1,12	1,98
10	0,00	0,01	0,03	0,06	0,12	0,22	0,40	0,71	1,25

Giants	Challouf			Salsi-1			Salsi-2		
SpTy	O	B0	A0	F5	G7	K4	M0	M3	M4
V // V-K	-2	-1	0	1	2	3	4	5	6
0	0,24	1,09	3,16	6,72	11,79	20,68	36,41	62,26	106,46
1	0,15	0,69	1,99	4,24	7,44	13,05	22,97	39,28	67,17
2	0,10	0,44	1,26	2,68	4,69	8,23	14,49	24,79	42,38
3	0,06	0,27	0,79	1,69	2,96	5,20	9,15	15,64	26,74
4	0,04	0,17	0,50	1,07	1,87	3,28	5,77	9,87	16,87
5	0,02	0,11	0,32	0,67	1,18	2,07	3,64	6,23	10,65
6	0,02	0,07	0,20	0,42	0,74	1,30	2,30	3,93	6,72
7	0,01	0,04	0,13	0,27	0,47	0,82	1,45	2,48	4,24
8	0,01	0,03	0,08	0,17	0,30	0,52	0,91	1,56	2,67
9	0,00	0,02	0,05	0,11	0,19	0,33	0,58	0,99	1,69
10	0,002	0,011	0,032	0,067	0,118	0,207	0,364	0,623	1,065

What is a surface brigthness color relations (SBCR) **?**
A relation between V, V-K and the angular diameter

Based on JMDC/JMMC ....

- .... with a careful methodology and selection of stars based on stellar activity diagnostics
- Current precision for late-type (1-2.5%, **see figure**).
- Interesting result: the SBCR depends on the class. Theoretical study on-going.
- Test on PLATO Input catalogue:

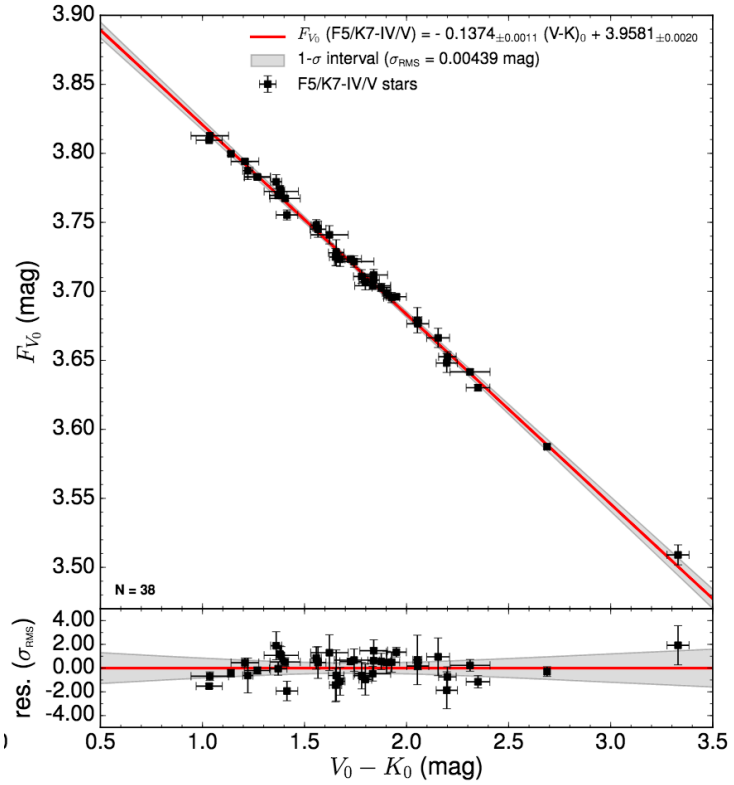


0.5% of precision on the angular diameter using SBCR based on *Gaia*, *Gaia* photometry, *2MASS*, with the assumption of a robust SBCR calibrated by CHARA/SPICA (rms of 1%, with stellar activity taken into account).

Precise calibration of the dependence of surface brightness–colour relations on colour and class for late-type stars★

A. Salsi[1], N. Nardetto[1], D. Mourard[1], O. Creevey[1], D. Huber[2], T. R. White[3,4,5], V. Hocdé[1], F. Morand[1], I. Tallon-Bosc[6], C. D. Farrington[7], A. Chelli[1], G. Duvert[8]

A&A, 2020, 640, 2



Pour une description plus détaillée:

- Voir talk de à l'AG du JMMC l'année dernière:

http://www.jmmc.fr/twiki/pub/Jmmc/JmmcJournee2019/SPICA__JMMC.pdf

- Site web de l'instrument:

https://lagrange.oca.eu/fr/spica-project-overview

- Papiers:

Mourard+17, JOSAA, 34, 37
Mourard+18, SPIE, 1070, 20
Pannetier+20, SPIE, *in prep*

Progress of the CHARA/SPICA project

Pannetier C.[a,b], Mourard D.[a], Berio P.[a], Cassaing F.[b], Allouche F.[a], Anugu N.[c,d,e], Bailet C.[a], ten Brummelaar T.[f], Dejonghe J.[a], Gies D.[f], Jocou L.[g], Kraus S.[e], Lacour S.[h], Lagarde S.[a], Le Bouquin J.B.[g], Lecron D.[a], Monnier J.[d], Nardetto N.[a], Patru F.[a], Perraut K.[g], Petrov R.[a], Rousseau S.[a], Stee P.[a], Sturmann J.[f], and Sturmann L.[f]

- Contact us if you want to join the Science Group: 75 people at the moment, 13 working groups (exo, astero, early-type stars, M stars, A4F4 stars, SBCR, pulsations stars, binaries, rotators, winds and environment).

Développement d'une base de données SPICA (SPICA-DB)

Objectifs:

- une base de données **opérationnelle**: optimisation de la stratégie d'observation des étoiles sur le ciel, optimisation des priorités en lien avec les objectifs astrophysiques (flag d'activitité stellaire, ...)

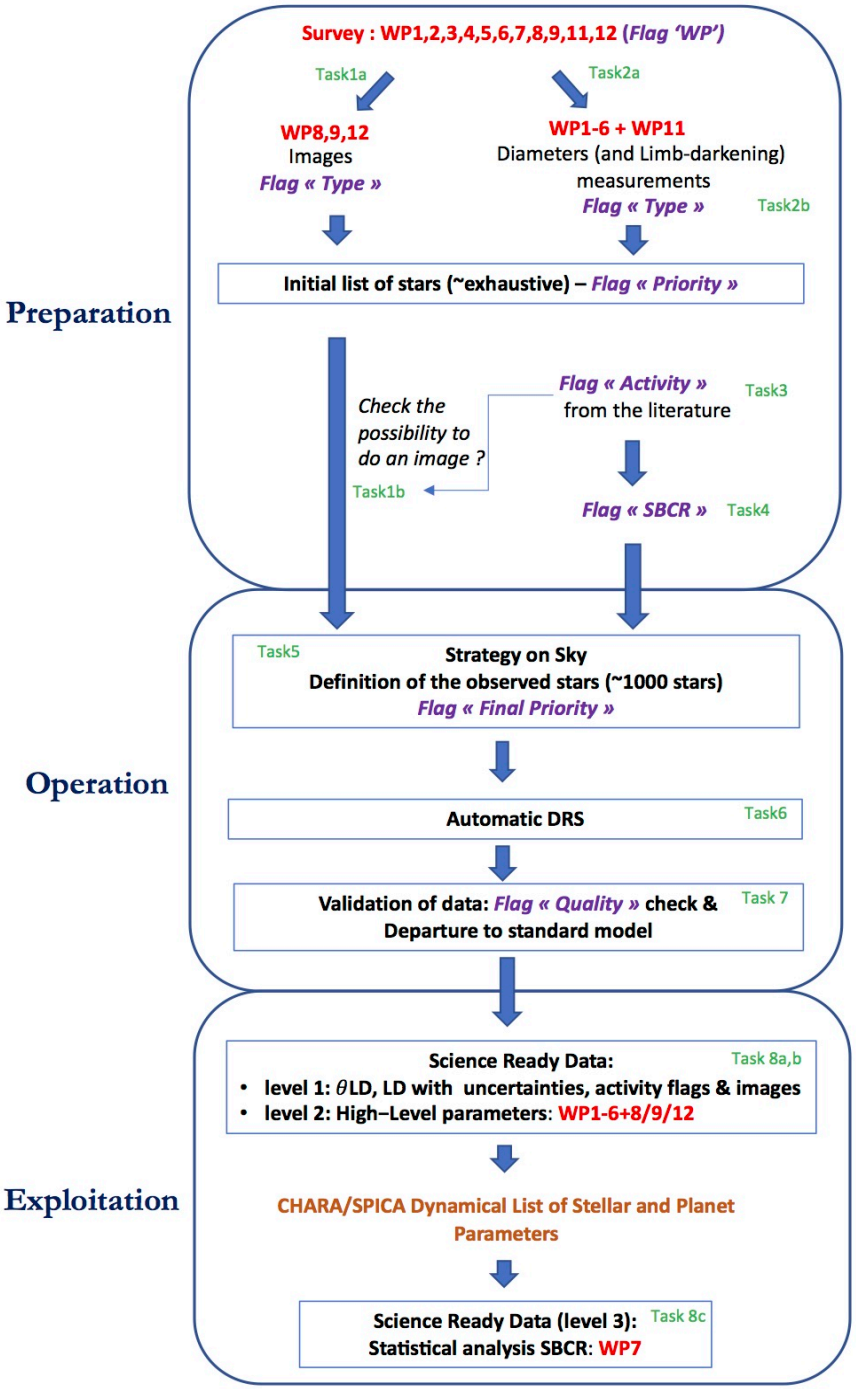
- autant que possible « **automatique** » pour une meilleur gestion du survey

- utilisation de la base pour **une analyse homogène** (autant que possible) des paramètres fondamentaux (R, Teff, M, age) sur la diagramme HR

- **dynamique**: possibilité de mettre la jour la base facilement (exemple: utiliser les parallaxes de la DR3 plutôt que la DR2)

The Science Survey Management: *a linear description of the data flow of CHARA/SPICA*

A complex procedure based on working group astrophysical objectives, taking into account diameter and images determination respectively, with three steps: preparation, operation and exploitation steps.



The SPICA database: a dynamical description

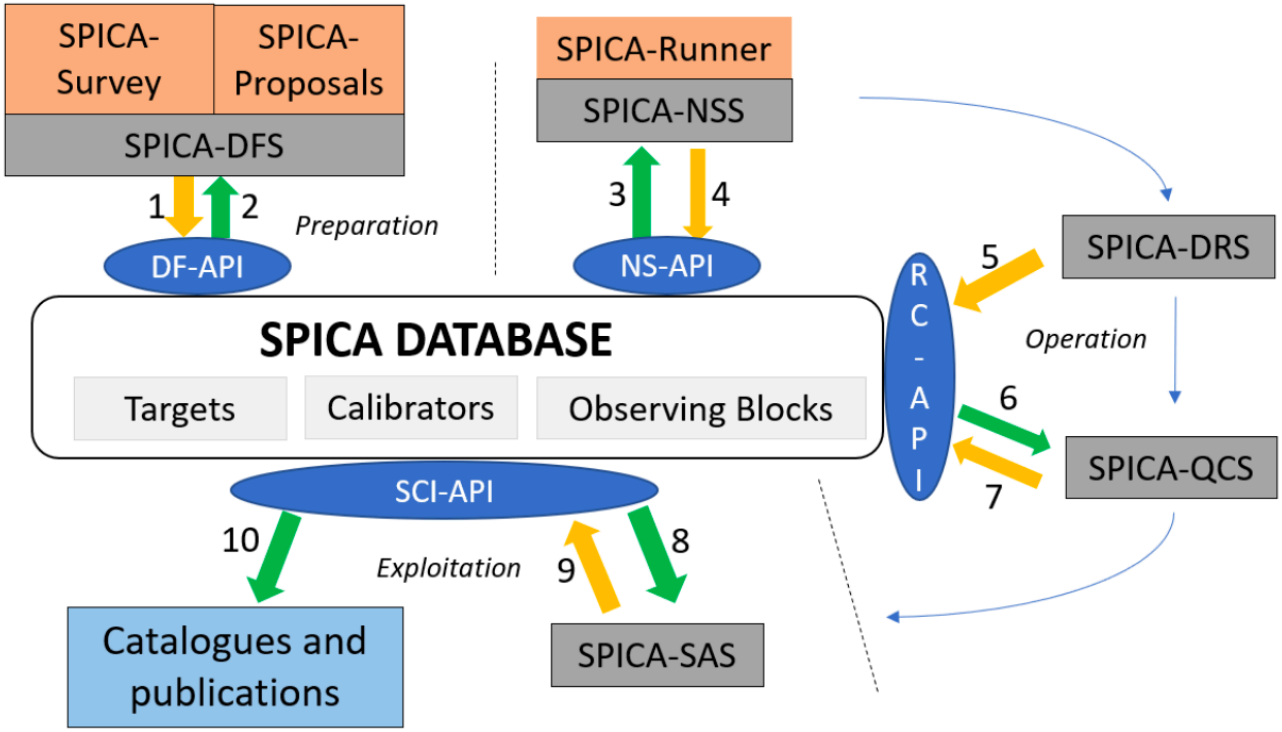


Figure 1: Schematic representation of the database. The yellow (resp. green) arrows correspond to feeding (resp. querying) actions. The grey boxes represent different user's applications linked to the DB. The blue box represents the final product in term of the public catalogue for the survey program

SPICA-DFS: SPICA Database Feeding Software
SPICA-NSS: SPICA Night Scheduling process
SPICA-DRS: SPICA Data Reduction Software
SPICA-QCS: SPICA Quality Control Software
SPICA-SAS: SPICA Science Analysing Software + extraction of catalogues

Definition of the SPICA-DB:

Currently, 90 keywords corresponding to different modules (RA, DEC, Photometry, parallax, CHARA, SPICA configuration, stellar activity flags, priorities...)

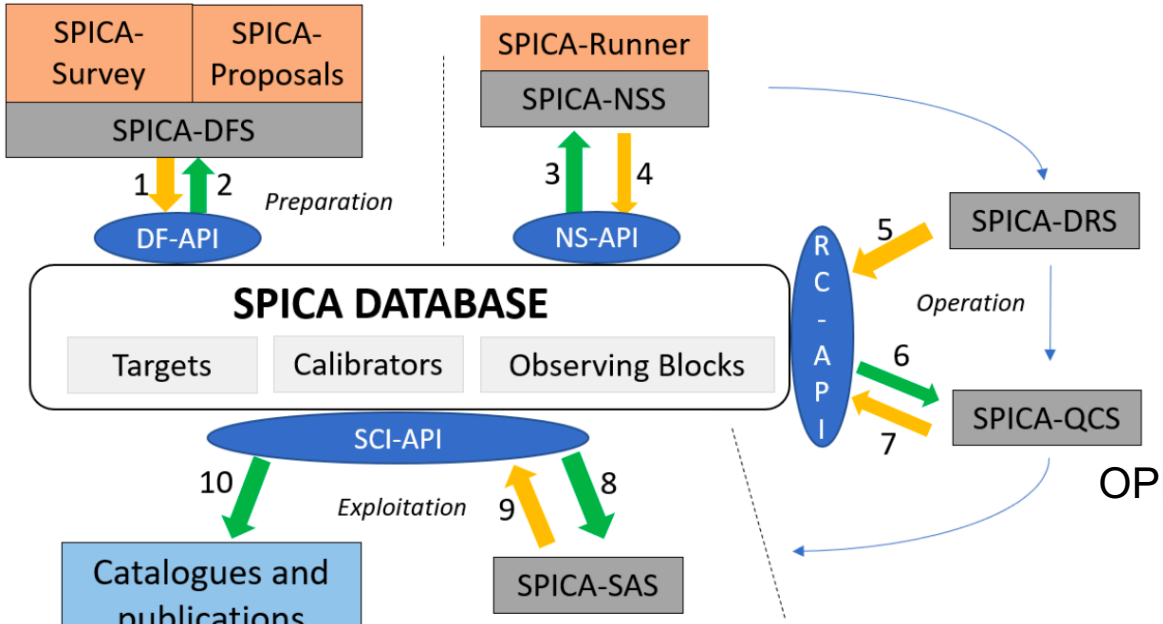
PREPARATION_OP (« Observing Parameters »)

PREPARATION_ACTIVITY

PREPARATION_SBCR

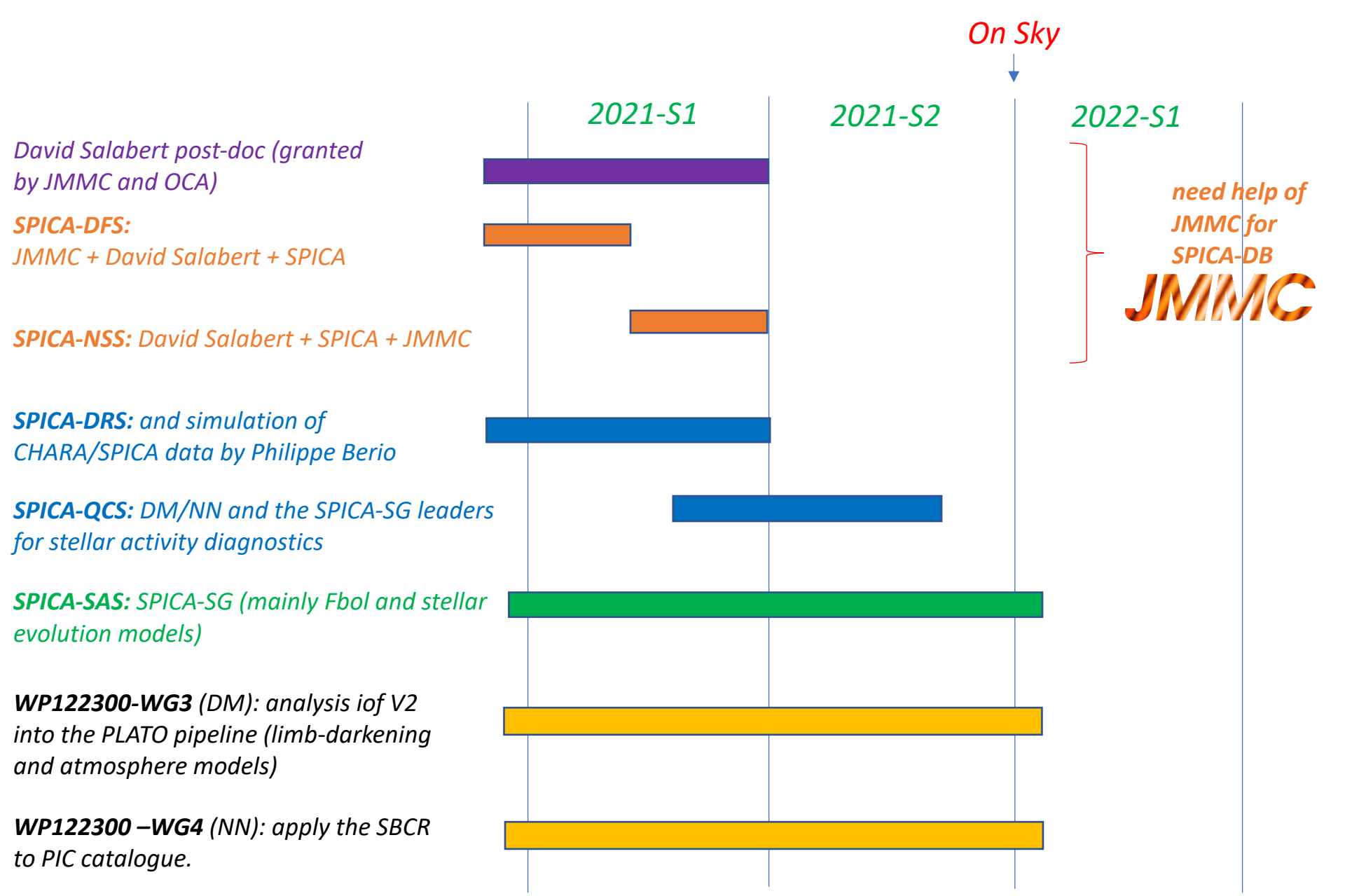
PREPARATION_PRIORITY

PREPARATION_PI



OPERATION_QCS

EXPLOITATION_SAS


On Sky
2021-S1
2021-S2
2022-S1
David Salabert post-doc (granted by JMMC and OCA)
SPICA-DFS: JMMC + David Salabert + SPICA
SPICA-NSS: David Salabert + SPICA + JMMC
SPICA-DRS: and simulation of CHARA/SPICA data by Philippe Berio
SPICA-QCS: DM/NN and the SPICA-SG leaders for stellar activity diagnostics
SPICA-SAS: SPICA-SG (mainly Fbol and stellar evolution models)
WP122300-WG3 (DM): analysis iof V2 into the PLATO pipeline (limb-darkening and atmosphere models)
WP122300 –WG4 (NN): apply the SBCR to PIC catalogue.
need help of JMMC for SPICA-DB
JMMC

Conclusion et prochaines étapes

- **SPICA-VIS & SPICA-FT** avancent bien. Intégration fin 2021, début de l'exploitation scientifique en 2022
- **SPICA-SG**: objectifs astrophysiques clairs, liste d'étoiles bien avancée. En ce moment, préparation d'un prototype (première version) de la base de données SPICA-DB avec les paramètres différents clefs liés aux objectives astrophysiques.
- Importance des **outils du JMMC** à tous les niveaux: ASPRO2, SearchCal, OIDB, Obsportal, Image reconstruction, AMRHRA, LITpro
- **Besoin d'un groupe de travail CHARA/SPICA/JMMC**. Déjà démarré à l'Automne avec également le financement JMMC de 4 mois de post-doc à David Salabert (+ 2 mois OCA)
- **2021, une année cruciale pour CHARA/SPICA:**
  - intégration de SPICA-VIS
  - besoin cruciale de mettre en place la base de données ainsi que les différents modules: injection des listes d'étoiles et paramètres, stratégie d'observation, DRS, contrôle qualité, exploitation astrophysique, et lien entre ces différents modules

- **Merci aux différents soutiens:** INSU, CSA, PNPS (priorité P0 de la prospective INSU), PNP, ASHRA, JMMC, UCA, OCA, Lagrange, Région SUD, et Université d'Aarhus

Annex 1: Detailed description of modules

Description of Arrows 1, 2 (PREPARATION SPICA-DFS)

SPICA-SG: List of calibrators, RA, DEC, Gaia_ID, HD

MODULE « PREPARATION-PI » (Proposal or Survey)
List of **targets** : RA, DEC, Gaia_ID, HD, PI, Prog Number, Type=« DIA, LDL, IB, IR, IW », Flag Priority_PI_SPICA and CHARA setups, Quality Needed, Nobs and Strategy
List of **mandatory calibrators**: RA, DEC, Gaia_ID, HD, … Type=« S-CAL»

Module Type:
« diameter type »:
. flag **Type=** **«** DIA or LDL »

MODULE « PREPARATION Observing Parameters »
. Photometry V, R, J, H, K
. UD_R, UD_H (JSDC2 with uncertainties from JSDC1)
. Only for Targets : flag « priority_LD »
. Specific constraints for observation (HA, Time constraint, UV coverage, …)

MODULE « PREPARATION STELLAR ACTIVITY »
Activity flags: BIN, ROT, WIND, DISK

MODULE « PREPARATION SBCR »
. Parallax
. Photometry Ks, G, BP, RP, E(B-V), Av, Ag
. Spectral Type, Teff, logg, Fe/H
. Priority SBCR
. NB: SBCR preparation is done for targets (survey) but also for calibrator in case we want to use internal SBCR calibration (from SPICA or others)

MODULE « PREPARATION PRIORITY »
Weighting of priority_PI, LD, SBCR
Then SPICA-NSS can use this priority to build Strategy of observations

DF-API

Description of Arrows 3,4 (EXPLOITATION SPICA-NSS)

MODULE "EXTRACTION"
List of targets following specific criteria (observability at a certain date, declination range, TYPE of obs) with their observing parameters
List of suitable calibrators for the corresponding targets

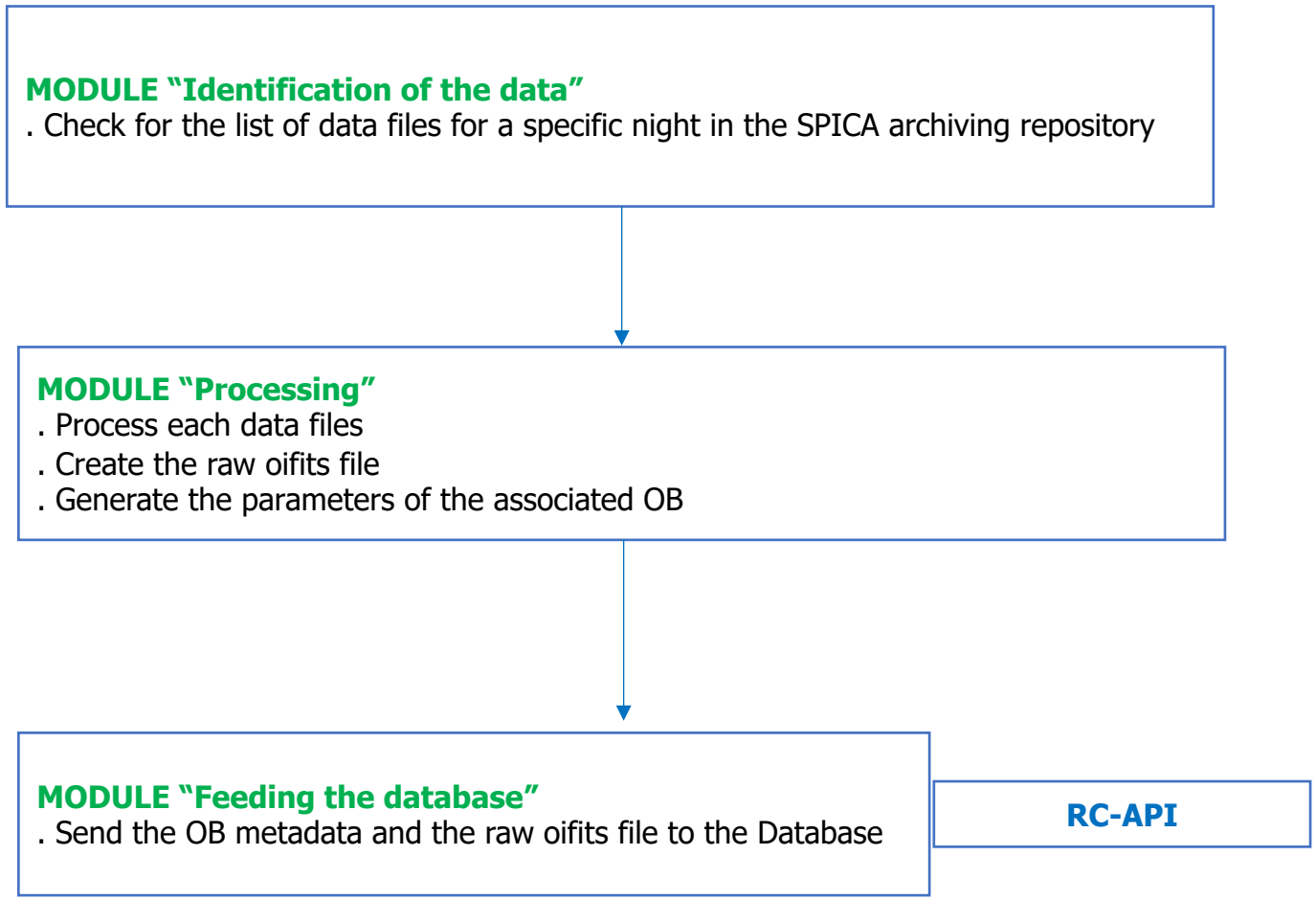
NS-API

MODULE "SORTING and ASPRO2 INJECTION"
. Validation of targets depending on priorities, completion rates
. Addition of the mandatory calibrators if any
. Sorting of targets and calibrators according to the night strategy
. Transfer of the list of objects to ASPRO2 with the associate parameters

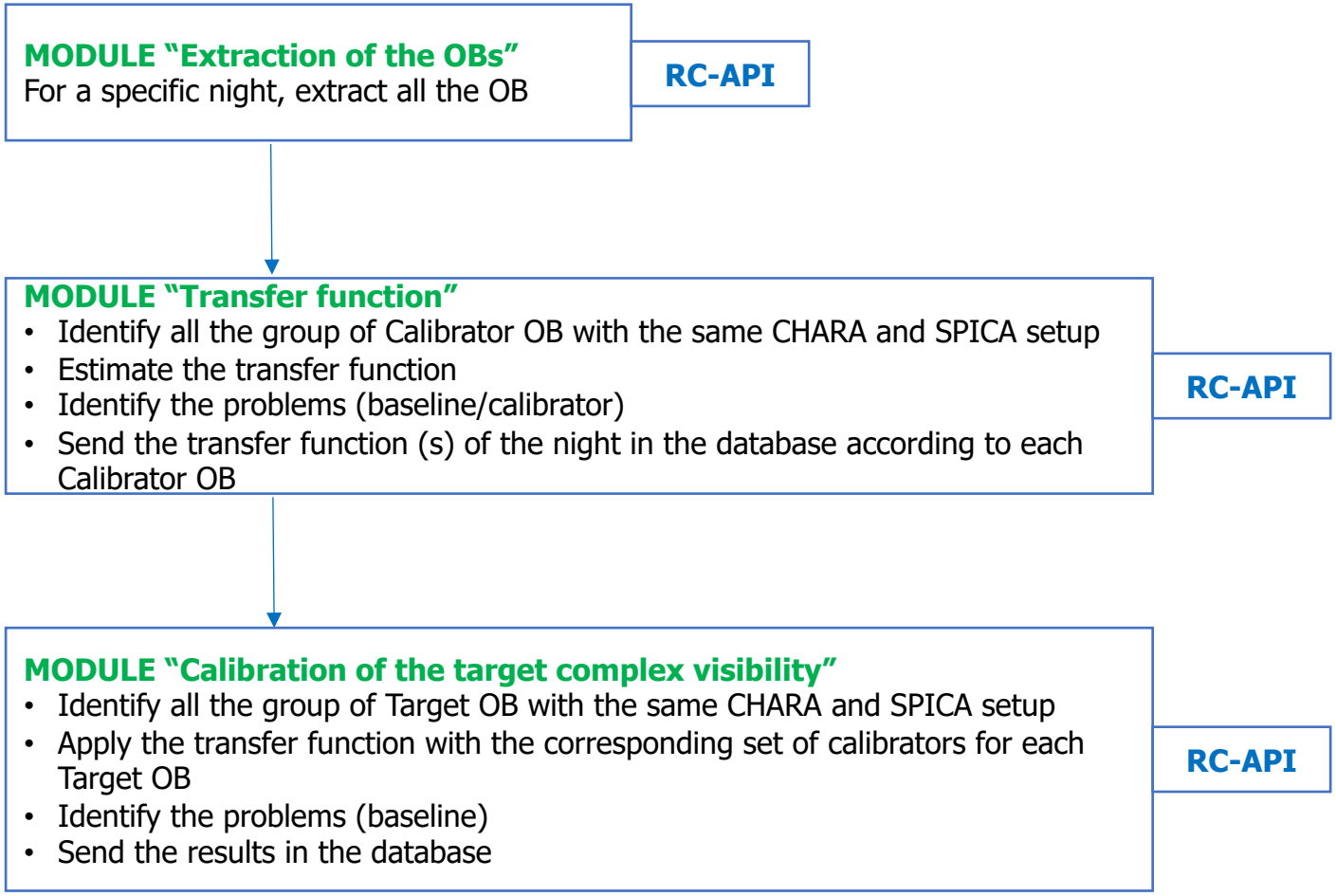
MODULE ASPRO2 Night Preparation
. Use of ASPRO2 for finalizing the night preparation (POPs, Setup, #blocks…)
. Identification of additional calibrators if necessary, with SearchCal, then SPICA-DB feeding

NS-API

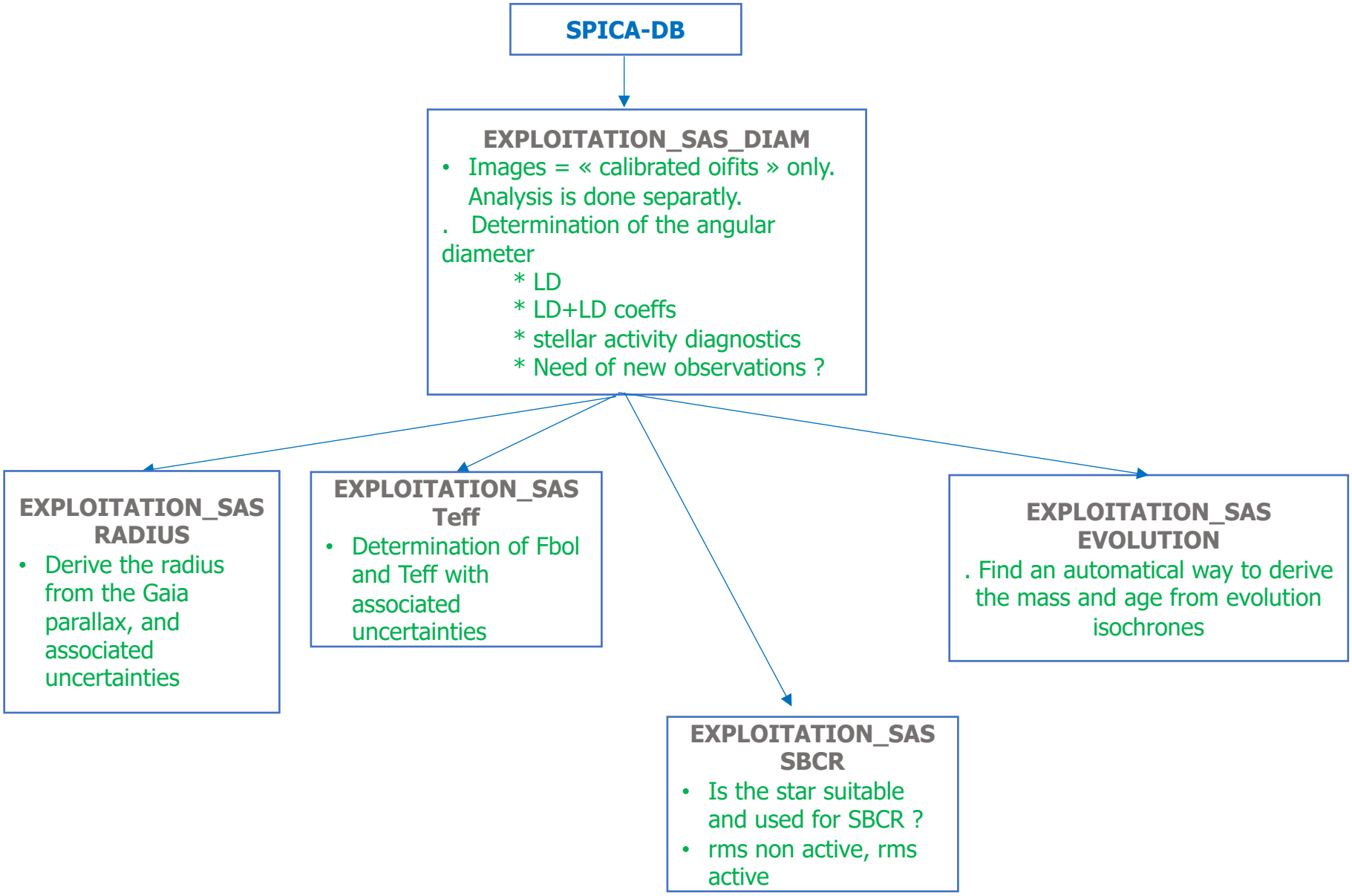
Description of Arrows 5 (EXPLOITATION SPICA-DRS)



Description of Arrows 6,7 (EXPLOITATION SPICA_QCS)



Description of Arrows 8/9/10 (EXPLOITATION SPICA-SAS)



NB: A MODULE with a crosscheck with Interferometric, spectroscopic and asteroseismic BENCHMARKS might be necessary as a check. Perhaps in prep also to give priority on such stars ?

Annex 2: Description of columns in SPICA-DB

PREPARATION_PI

SPICA-DB identifier	SPICA-DB itself	TARGET_ID
RA: Right Ascension	`Simbad.list_votable_fields()`	TARGET_RA
DEC: Declination	`Simbad.list_votable_fields()`	TARGET_DEC
GAIA_ID: Gaia identifier	Gaia (I/345/gaia2)	TARGET_Gaia_ID
HD number	`Simbad.list_votable_fields()`	TARGET_HD
CHARA number	SPICA-NSS	TARGET_CHARA_ID
PI Name	PI	TARGET_PINAME
Program Name	PI	TARGET_PROGNAME
flag_type asked by PI = [IB, IR, IW, DIA, DLD]	PI	TARGET_Flag_Type
flag_priority_PI = [0, 1, 2] (0 = highest priority)	PI	TARGET_Flag_Priority_PI
SPICA-Setup	TO BE DONE: PI	TARGET_SPICA_SETUP
CHARA-Setup	TO BE DONE: PI	TARGET_CHARA_SETUP
Calibrators Specifications	TO BE DONE: PI	TARGET_CAL_IDS
Flag Quality Criteria = [0, 1, 2] (0 = highest priority)	SPICA-QCS	TARGET_QualityRequired
Number of Observations requested / strategy (TBD)	SPICA-QCS	TARGET_Nobs

Clear, no difficulty (already done)

To be precised at some point

Should be provided by the SPICA-PI soon to go further

PREPARATION_OP (« Observing Parameters »)

Vmag	Simbad.list_votable_fields()	TARGET_Vmag
e_Vmag	Simbad.list_votable_fields()	TARGET_eVmag
Rmag	Simbad.list_votable_fields()	TARGET_Rmag
eRmag (II/237)	Simbad.list_votable_fields()	TARGET_eRmag
Jmag (II/246)	JSDC2 (II/346/jsdc_v2)	TARGET_Jmag
e_Jmag (II/246)	JSDC2 (II/346/jsdc_v2)	TARGET_eJmag
Hmag (II/246)	Simbad.list_votable_fields()	TARGET_Hmag
e_Hmag (II/246)	Simbad.list_votable_fields()	TARGET_eHmag
Kmag (II/246)	Simbad.list_votable_fields()	TARGET_Kmag
e_Kmag (II/246)	Simbad.list_votable_fields()	TARGET_eKmag
LD (JSDC2)	JSDC2 (II/346/jsdc_v2)	TARGET_LD_JSDC2
eLD (JSDC2)	JSDC2 (II/346/jsdc_v2)	TARGET_eLD_JSDC2
LD (JSDC)	JSDC (II/300/jsdc)	TARGET_LD_JSDC
eLD (JSDC)	JSDC (II/300/jsdc)	TARGET_eLD_JSDC
UD_R (JSDC2)	JSDC2 (II/346/jsdc_v2)	TARGET_UD_R _JSDC2
UD_H (JSDC2)	JSDC2 (II/346/jsdc_v2)	TARGET_UD_H_JSDC2

Clear, no difficulty (already done)

To be precised at some point

Should be provided by the SPICA-PI soon to go further

PREPARATION_ACTIVITY

flag_activity_ROT = YES/NO	TBD: various databases/references	TARGET_Flag_Activity_ROT
flag_activity_BIN = YES/NO	TBD: various databases/references	TARGET_Flag_Activity_BIN
flag_activity_WIND = YES/NO	TBD: various databases/references	TARGET_Flag_Activity_WIND
flag_activity_DISK= YES/NO	TBD: various databases/references	TARGET_Flag_Activity_DISK

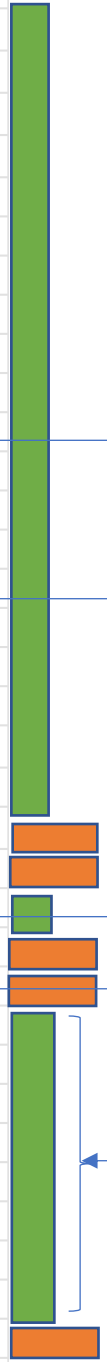
Clear, no difficulty (already done)

To be precised at some point

Should be provided by the SPICA-PI soon to go further

PREPARATION_SBCR

SpT : Spectral Type from Simbad	Simbad.list_votable_fields()	TARGET_SpT
Plx (I/345/gaia2)	TBI: Simbad.list_votable_field	TARGET_Plx
e_Plx (I/345/gaia2)	TBI: Simbad.list_votable_field	TARGET_ePlx
	2MASS (II/246/out)	TARGET_Ksmag
e_Ksmag (II/246)	2MASS (II/246/out)	TARGET_eKsmag
Gmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_Gmag
e_Gmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_eGmag
BPmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_BPmag
e_BPmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_eBPmag
RPmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_RPmag
e_RPmag (I/345/gaia2)	Gaia (I/345/gaia2)	TARGET_eRPmag
E(B-V)	Stilism website	TARGET_E(B-V)
eE(B-V)	Stilism website	TARGET_eE(B-V)
Av : absorption in V band (PLATO methodology)	Formulae	TARGET_Av
eAv	Formulae	TARGET_eAv
Ag : absorption in G band (PLATO methodology)	Formulae (Danielski+18, A&A, 614, 19)	TARGET_Ag
e_Ag	TBI = e_Av	TARGET_eAg
teff	Gaia (I/345/gaia2)	TARGET_Teff_litterature
e_teff	Gaia (I/345/gaia2)	TARGET_eTeff_litterature
log g	TBI: Simbad.list_votable_field	TARGET_logg
e_log g	TO BE DONE	TARGET_elogg
Fe_H	TBI: Simbad.list_votable_field	TARGET_FeH
e_Fe_H	TO BE DONE	TARGET_eFeH
flag_type verification from SBCR (LD/DLD)	function	TARGET_Flag_Type_VERIF
flag_priority_LD = [0, 1, 2] (0 = highest priority)	TO BE DONE: function	TARGET_Flag_Priority_LD
flag_SBCR_Box = [0, i], where i is the number of Boxes (spT)	TBI: function	TARGET_Flag_Box
SBCR_VK_LD_SALSI	Salsi+20, A&A, 640, 2	TARGET_LD_SBCR_VK
SBCR_VK_eLD_RMS	Salsi+20, A&A, 640, 2	TARGET_eLD_SBCR_VK_RMS
SBCR_VK_eLD_Coeffs	Salsi+20, A&A, 640, 2	TARGET_eLD_SBCR_VK_Coeffs
SBCR_VK_eLD_PHOTO	Salsi+20, A&A, 640, 2	TARGET_eLD_SBCR_VK_PHOTO
SBCR_GK_LD_SALSI	Salsi+20, A&A, 640, 2 (corrected)	TARGET_LD_SBCR_GK
SBCR_GK_eLD_RMS	Salsi+20, A&A, 640, 2 (corrected)	TARGET_eLD_SBCR_GK_RMS
SBCR_GK_eLD_Coeffs	Salsi+20, A&A, 640, 2 (corrected)	TARGET_eLD_SBCR_GK_Coeffs
SBCR_GK_eLD_PHOTO	Salsi+20, A&A, 640, 2 (corrected)	TARGET_eLD_SBCR_GK_PHOTO
flag_priority_sbcr=[0,1,2] (0 = highest priority)	TO BE DONE: function	TARGET_Flag_Priority_SBCR



Done using STILISM

Done using Danielski+

Done using CHARA/SPICA performance

Done using a complex strategy with different steps

Done using SBCR by Salsi+ & Challouf