SPICA & JMMC

Journée JMMC Mardi 9 avril 2019

CHARA/SPICA in very brief

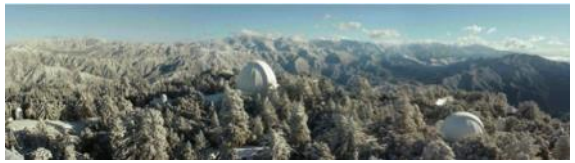
The goal is to provide a renewed vision of fundamental stellar parameters on a large sample of stars. It will serve as strong constraints for stellar models, will bring unique and direct data, and will at the end permit to build new statistical relations.

SPICA is build on the combination of the new AO systems, single mode fibres for spatial filtering, and modern EMCCD detectors.
It will operated in LR (R=300) and MR (R=3000) dispersed fringes of 6T (15 baselines).
It is assisted by a H-band fringe tracking system.

SPICA activities are divided in three main groups:

1. Science group
2. SPICA-FT
3. SPICA-VIS

As such, SPICA has many science goals but the top level requirements are given by the idea of a large survey of stellar fundamental parameters.



Atmosphere models
(T_{eff}, log(g), Z, v_t)

θ cal

V^2(cal) V^2 (sci, brut)

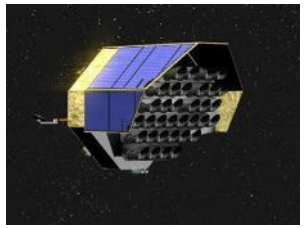
Transfert function (strategy)

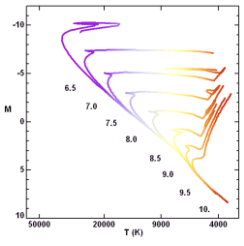
LD Law

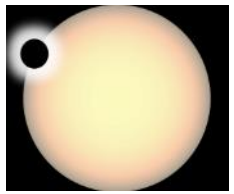
θ_{UD} (sci)

θ_{LD} (sci)

Phase 1: 1000 bright stars (mv<8)
Phase 2: PLATO follow-up







Evolution Atmosphere Models Binarity

π Gaia

Stellar activity

$age_\star$ $R_\star$ $M_\star$ $T_{eff,\star}$

Transits $\rho_\star$

RV

R_p M_p

ρ_p

Objective 1 : Life Habitable Zone

Model of Planets

Evolution Atmosphere Models Binarity

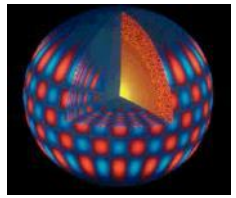
Scaling relations

π Gaia

Stellar activity

$age_\star$ $R_\star$ $M_\star$ $T_{eff,\star}$

Objective 2: Fundamental parameters



Evolution Atmosphere Models Binarity

SED Analysis Diagnostic of activity

Homogeneous Photometry

$age_\star$ $R_\star$ $M_\star$ $T_{eff,\star}$

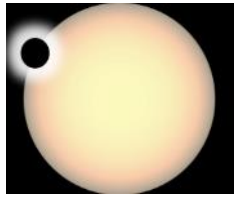
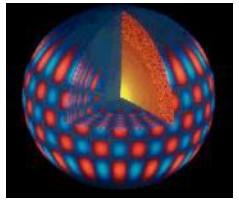
Objective 3a: Surface-Brightness Color Relations (SBCR) for all types and classes corrected from stellar activity

Tool for faint stars observed by PLATO (phase 2)

Objective 3b: Distance scale Ho

Three objectives:

1. Exoplanet Host Stars
2. Asteroseismology
3. SBCR for distances of EB and PLATO

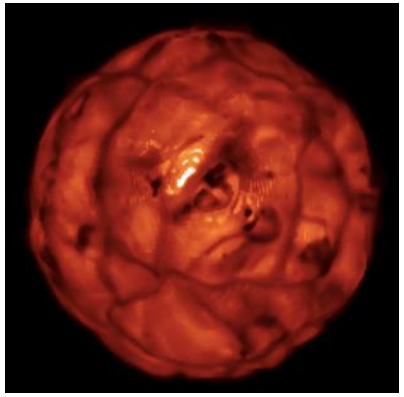

For these three objectives, stellar activity has to be taken into account:

1 – Spots

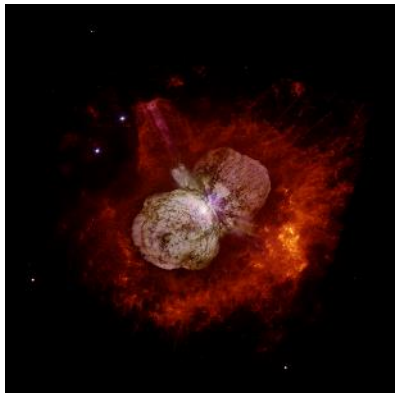
Stellar Activity

5 – Binarity

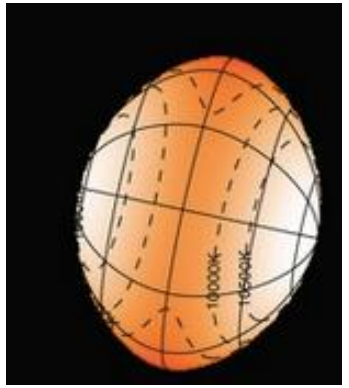
2 – Convection

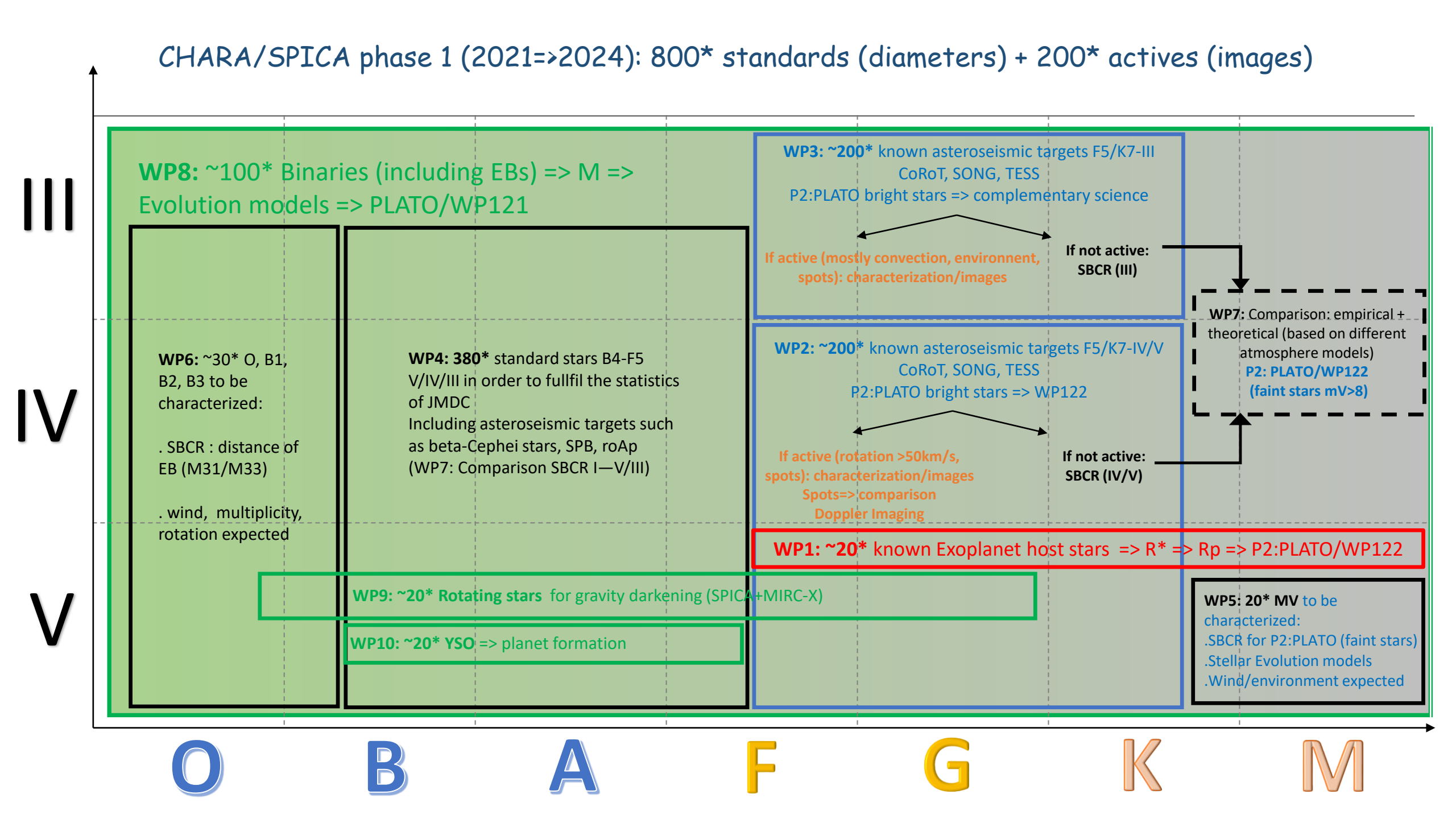


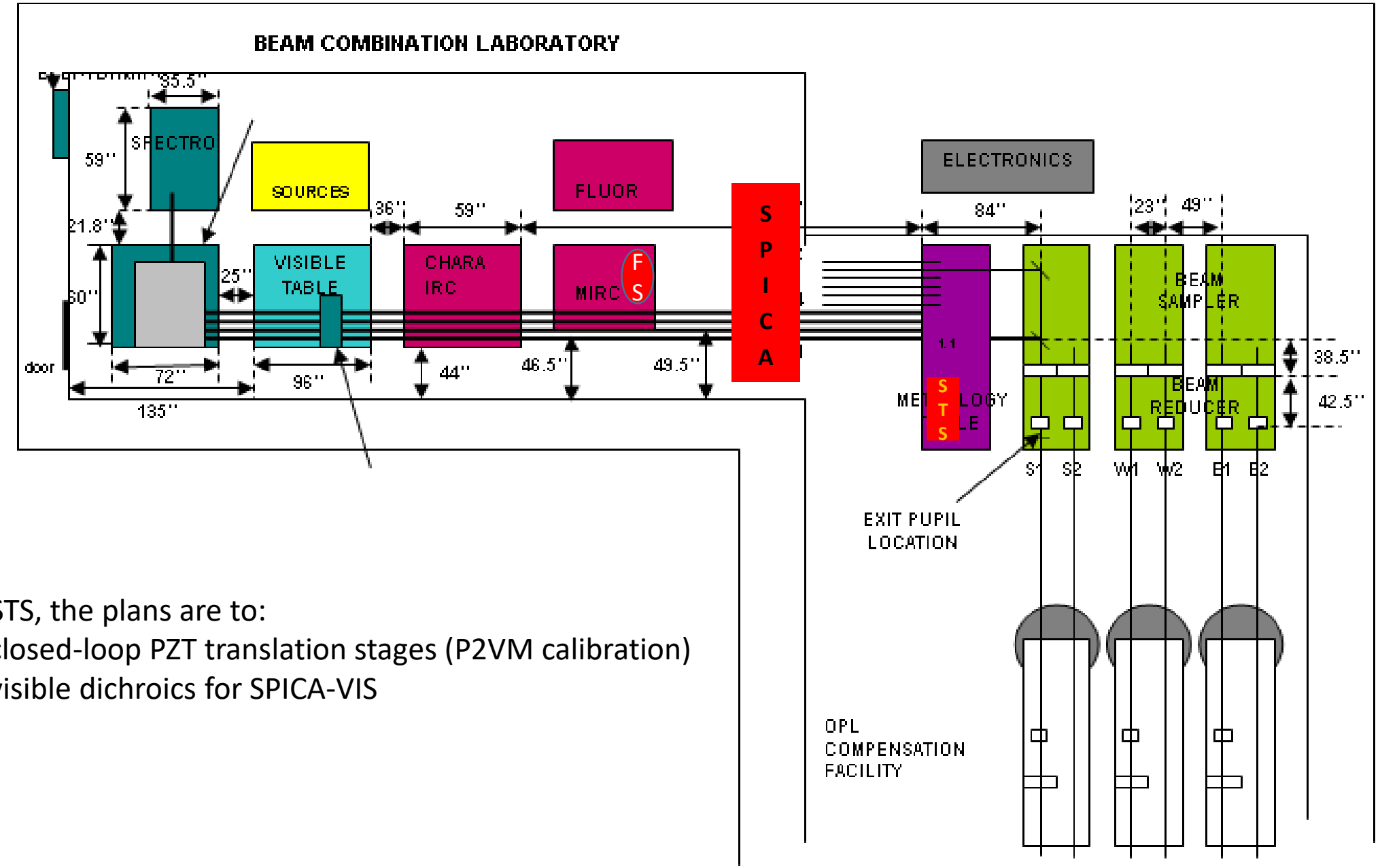
3 – Wind & environment



4 – Rotation




CHARA/SPICA phase 1 (2021=>2024): 800* standards (diameters) + 200* actives (images)
III
IV
V
WP8: ~100* Binaries (including EBs) => M => Evolution models => PLATO/WP121
WP6: ~30* O, B1, B2, B3 to be characterized:
. SBCR : distance of EB (M31/M33)
. wind, multiplicity, rotation expected
WP4: 380* standard stars B4-F5 V/IV/III in order to fullfil the statistics of JMDC
Including asteroseismic targets such as beta-Cephei stars, SPB, roAp
(WP7: Comparison SBCR I—V/III)
WP3: ~200* known asteroseismic targets F5/K7-III
CoRoT, SONG, TESS
P2:PLATO bright stars => complementary science
If active (mostly convection, environnent, spots): characterization/images
If not active: SBCR (III)
WP2: ~200* known asteroseismic targets F5/K7-IV/V
CoRoT, SONG, TESS
P2:PLATO bright stars => WP122
If active (rotation >50km/s, spots): characterization/images
Spots=> comparison Doppler Imaging
If not active: SBCR (IV/V)
WP7: Comparison: empirical + theoretical (based on different atmosphere models)
P2: PLATO/WP122
(faint stars mV>8)
WP1: ~20* known Exoplanet host stars => R* => Rp => P2:PLATO/WP122
WP9: ~20* Rotating stars for gravity darkening (SPICA+MIRC-X)
WP10: ~20* YSO => planet formation
WP5: 20* MV to be characterized:
.SBCR for P2:PLATO (faint stars)
.Stellar Evolution models
.Wind/environment expected
O
B
A
F
G
K
M

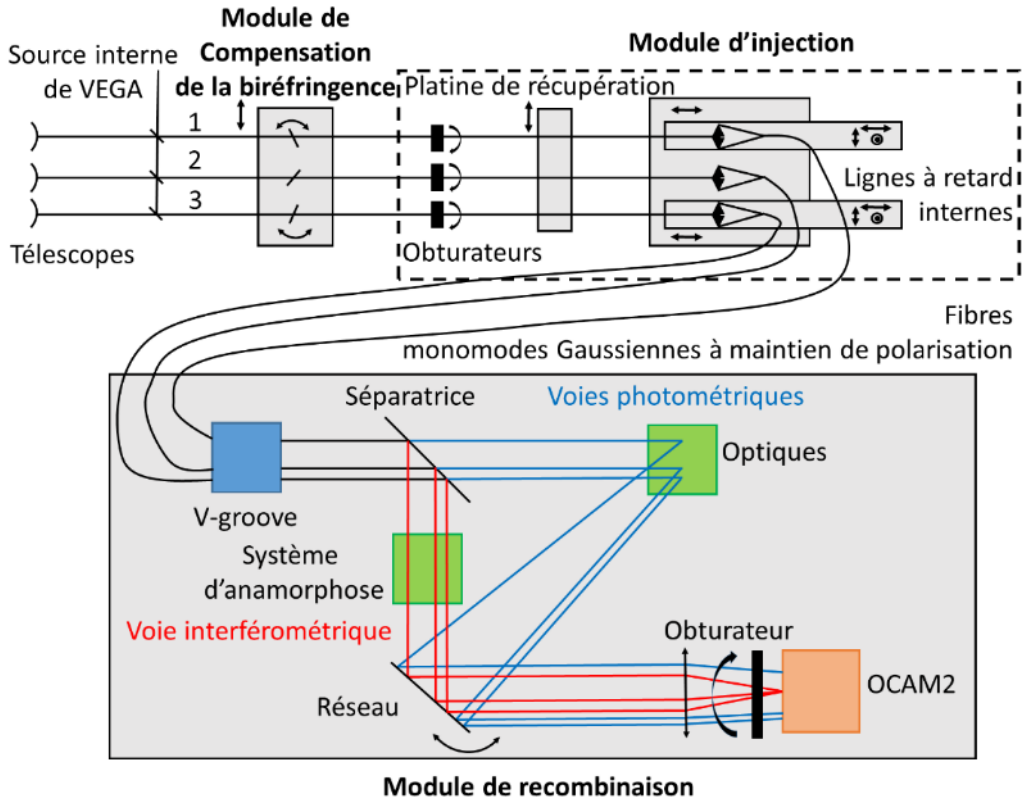


For the STS, the plans are to:

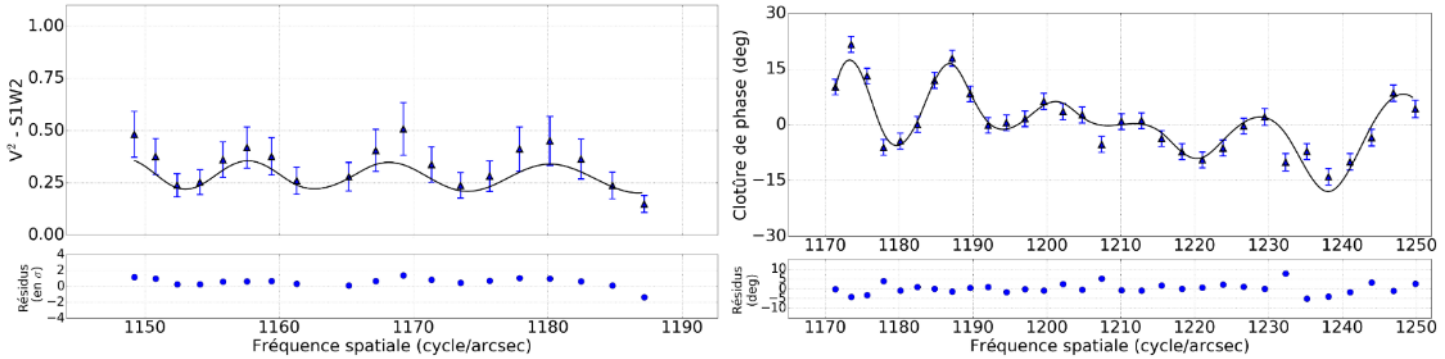
- Add closed-loop PZT translation stages (P2VM calibration)
- Add visible dichroics for SPICA-VIS

SPICA-VIS: The FRIEND prototype

Limitations of VEGA + AO on CHARA
➔ opportunity for fibered interferometry in the visible
➔ Prototype for know-how and expertise in Nice



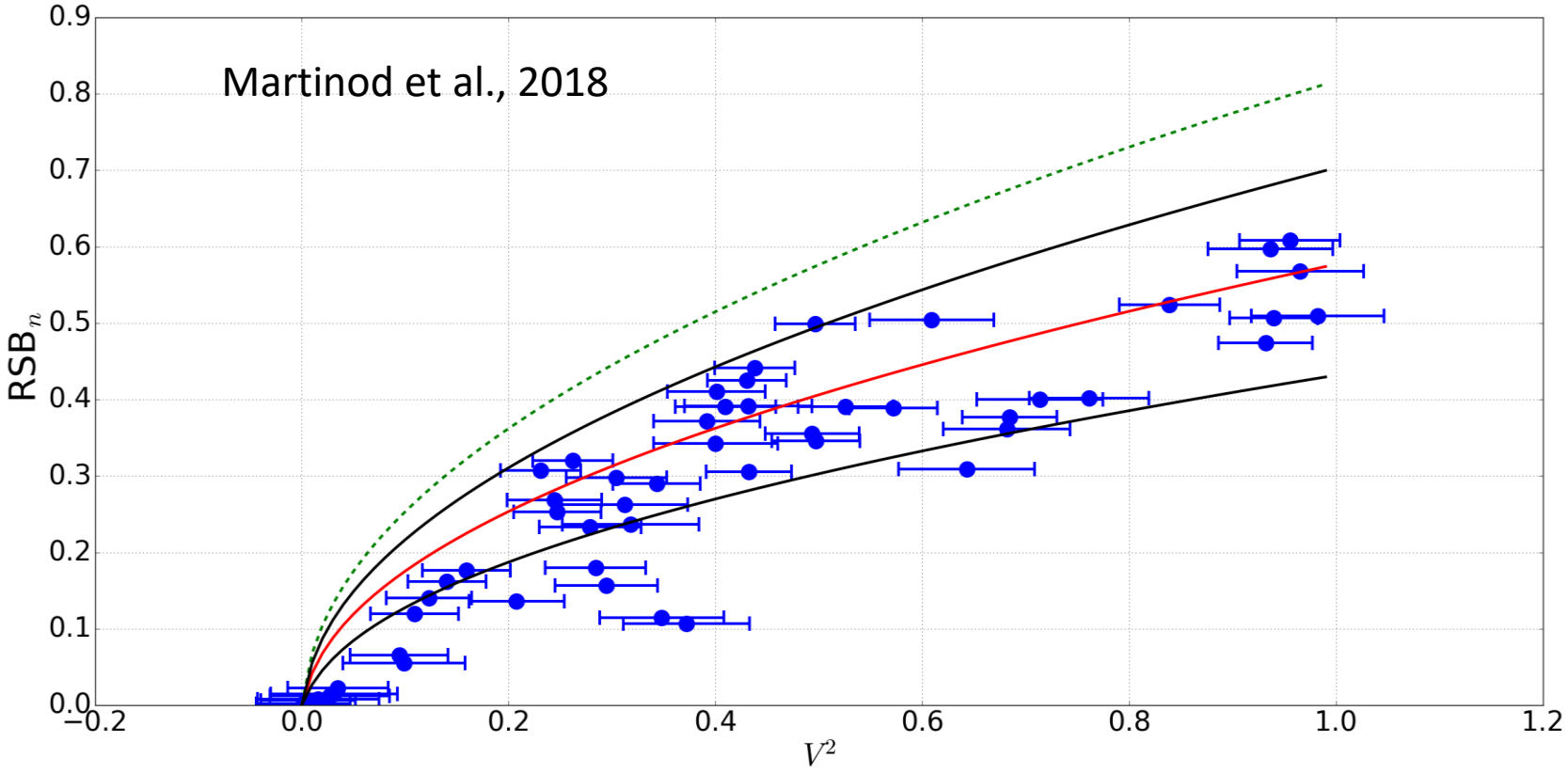
Lessons learned on:
- Visible fibres and injection with partial AO
- Birefringence correction
- EMCCD detector
- Data processing with fibered combiner: V^2 and $C\phi$



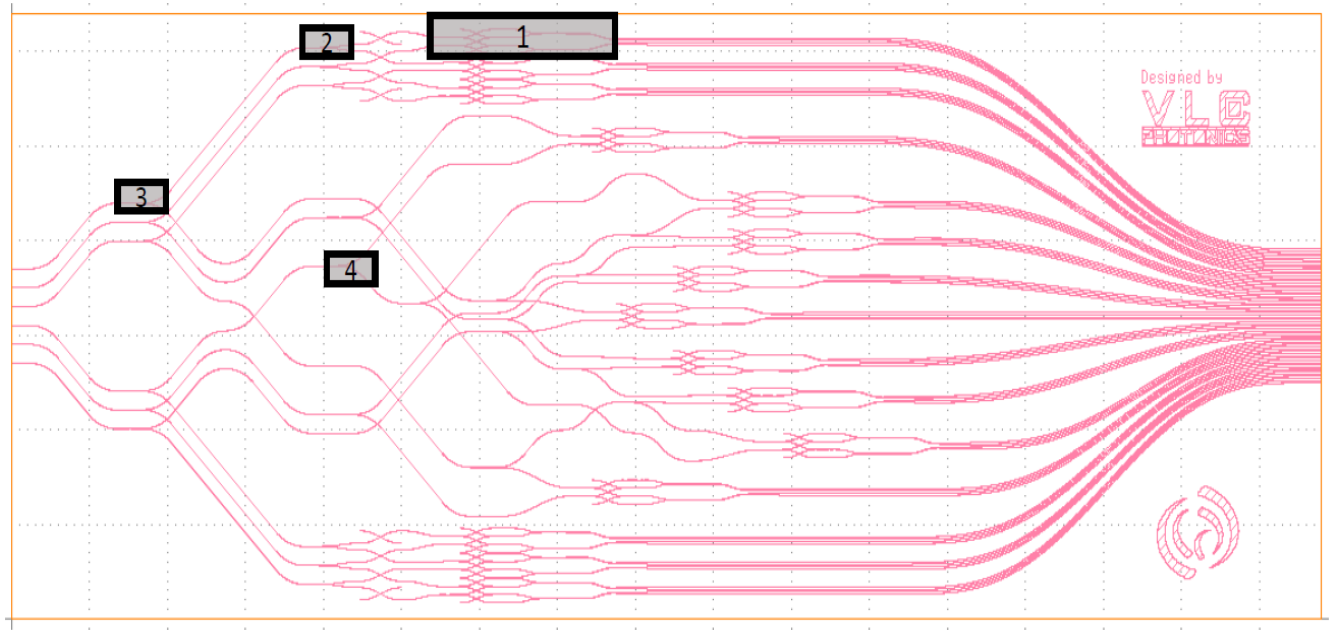
Martinod et al., 2018

SNR model and sky calibration: Excess Noise Factor

$$RSB_{E_{HF},FRIEND} = \frac{\left(\frac{N_{ph}\, V_{instr}\, V_{obj}{}^{2}}{N_{tel}}\right)^{2} \widetilde{Gab_{ij}}\, \sqrt{N_{img}}}{\sqrt{\text{PhotonNoise} + \text{ReadNoise} + \text{CoupledTerms}}\, \sqrt{N_{\text{pic-frange}}}}$$

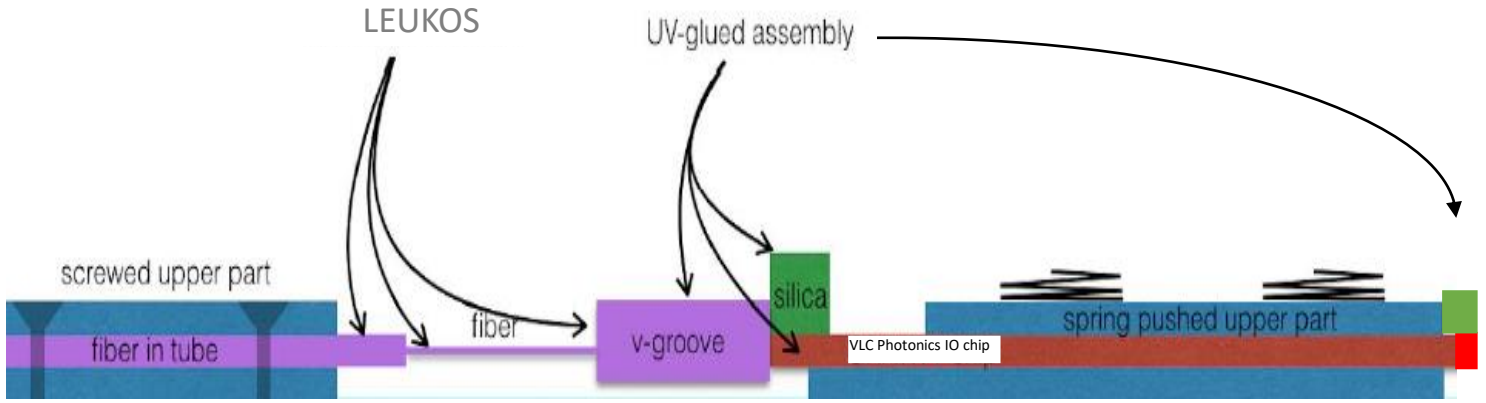


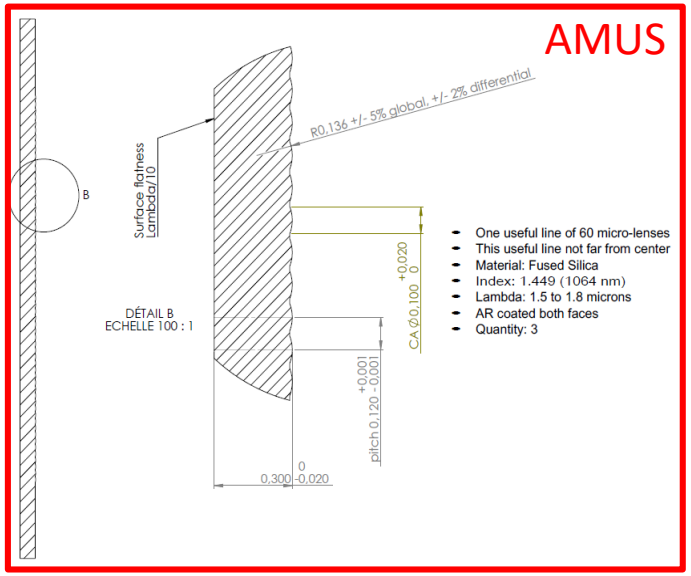
IO component for 6T-ABCD fringe sensor



Adapted from a design by Labeye PhD 2008
Similar to GRAVITY (but 6T and H band)

- Single-mode waveguides over the H band
- Number of telescopes to be combined: 6
- Number of baselines to be coded: 15
- Type of fringe coding: ABCD coding





Summary SPICA-VIS & SPICA-FT

- SPICA-VIS
  - With VEGA: test of survey mode, observing strategy…
  - With FRIEND: testbed for fibres, birefringence, EMCCD (OCAM² ➔ ANDOR Ixon), pipeline. Sky demonstration, precision of measurements, model of SNR.
  - With CESAR: study and optimisation of the injection into the SM fibres
  - Preliminary design ok, some high level choices to be done
  - Funding for FRIEND, CESAR, ANDOR. No funding for SPICA-VIS for the moment
  - SPICA-VIS: hardware ~200k€ + SG activities + operation cost
  - Schedule not guaranteed but end of 2021 is considered now.
  - PLATO & ARAUCARIA projects consider contributing to support for the operation.

- SPICA-FT
  - Funding CNRS/INSU and UCA (~200 k€). H2020 Opticon 2yr postdoc (Vis. Interferometry: CHARA/SPICA + iVis/VLTI) + Lagrange & OCA.
  - Integration in progress in Nice, lab and software activities.
  - First light inside CHARA and MIRCx considered for Nov-Dec/2019

- Soutien PNPS, PNP, ASHRA

SPICA & JMMC-MOIO

- ASPRO2 for SPICA
  - Simulation amont
  - Outil de gestion du survey et de gestion de stratégies de nuit
  - Outil d'observation (A2P2 vers Cosmic Debris)
- Searchcal for SPICA
  - Très probablement prêt. Stratégies d'observation en cours d'analyse
- LITpro for SPICA
  - Probablement prêt mais version intégrée dans pipeline pour validation et données haut-niveau à voir
- Image reconstruction
  - Aspects chromatiques à voir.
- OIDB for SPICA
  - Probablement prêt aussi. Remplissage automatique en fin de nuit en cours de réalisation avec l'aide d'Atlanta (Jeremy Jones)

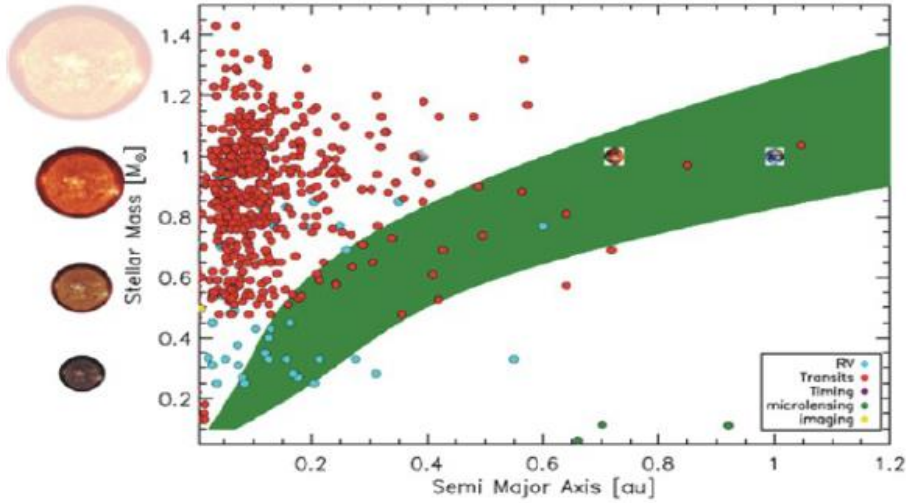
SPICA & JMMC ➔ PLATO

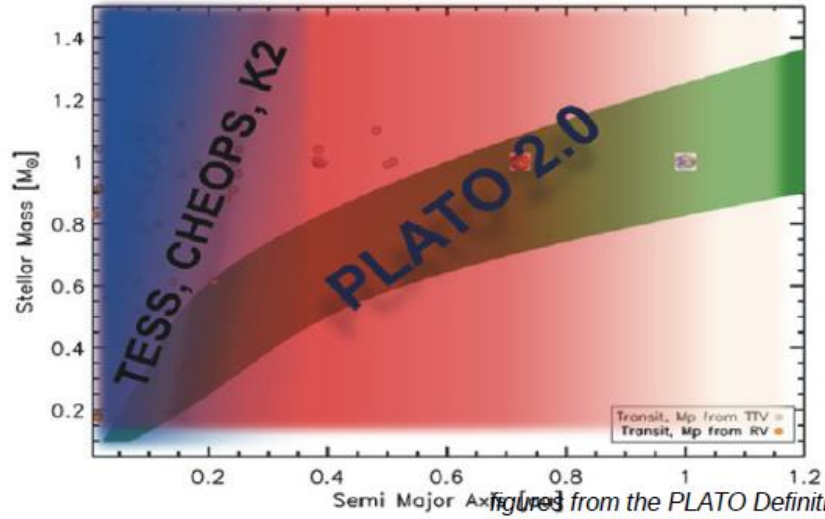
- Lien scientifique évident.
- Demande forte de la communauté PLATO sur l'apport des données interférométriques
- Opportunité forte à saisir… pour SPICA et pour le JMMC

PLATO main objectives

Characterize planets to:

- explore planet diversity
- detect and characterize terrestrial planets in the habitable zone
- constrain planet formation and evolution processes



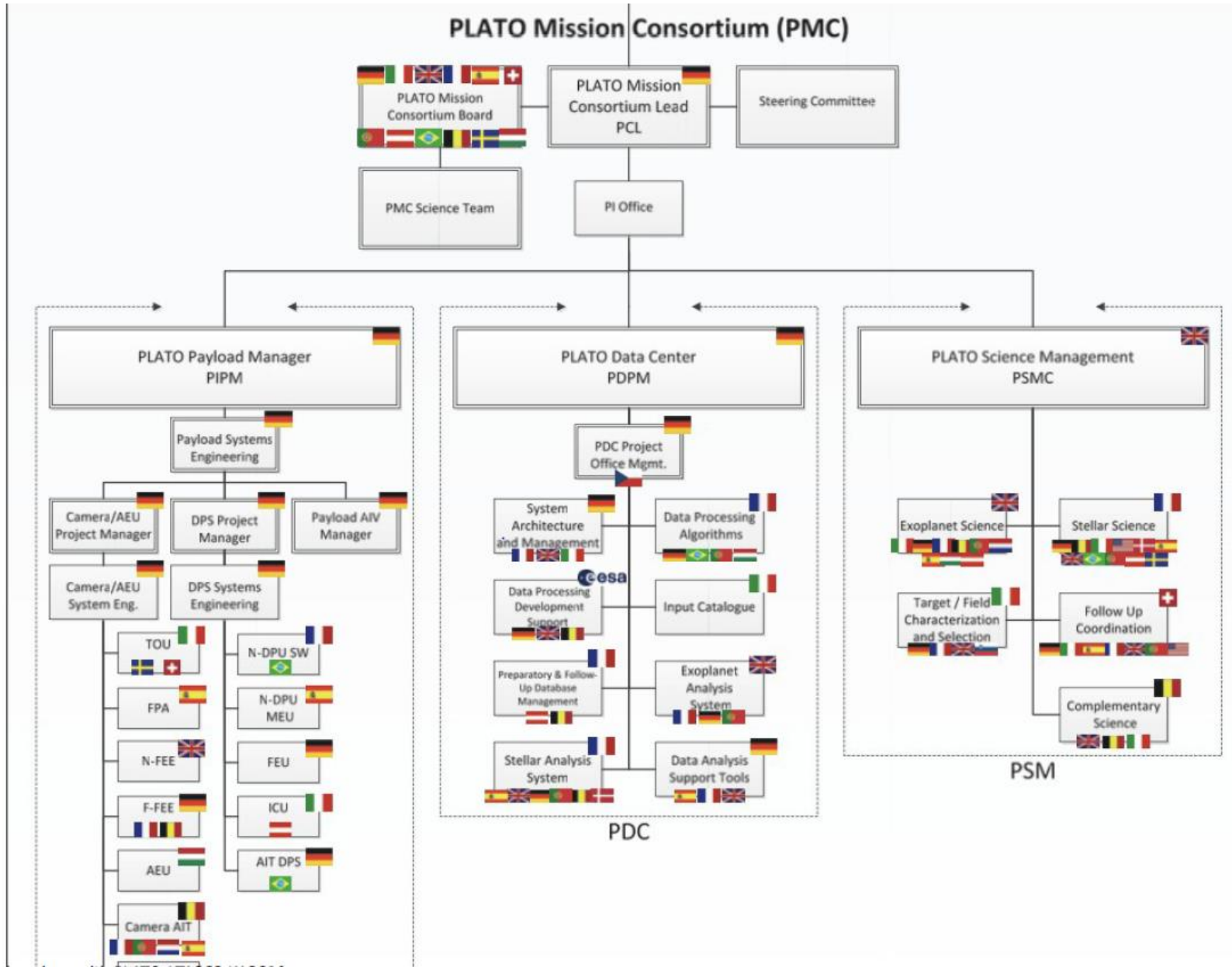


figures from the PLATO Definition Study Report

*Determine the bulk properties (mass, **radius**, mean density) of planets in a wide range of systems, including terrestrial planets in the habitable zone of solar-like stars.*

Specificité of PLATO : to derive accurate planetary system age

PLATO Mission Consortium



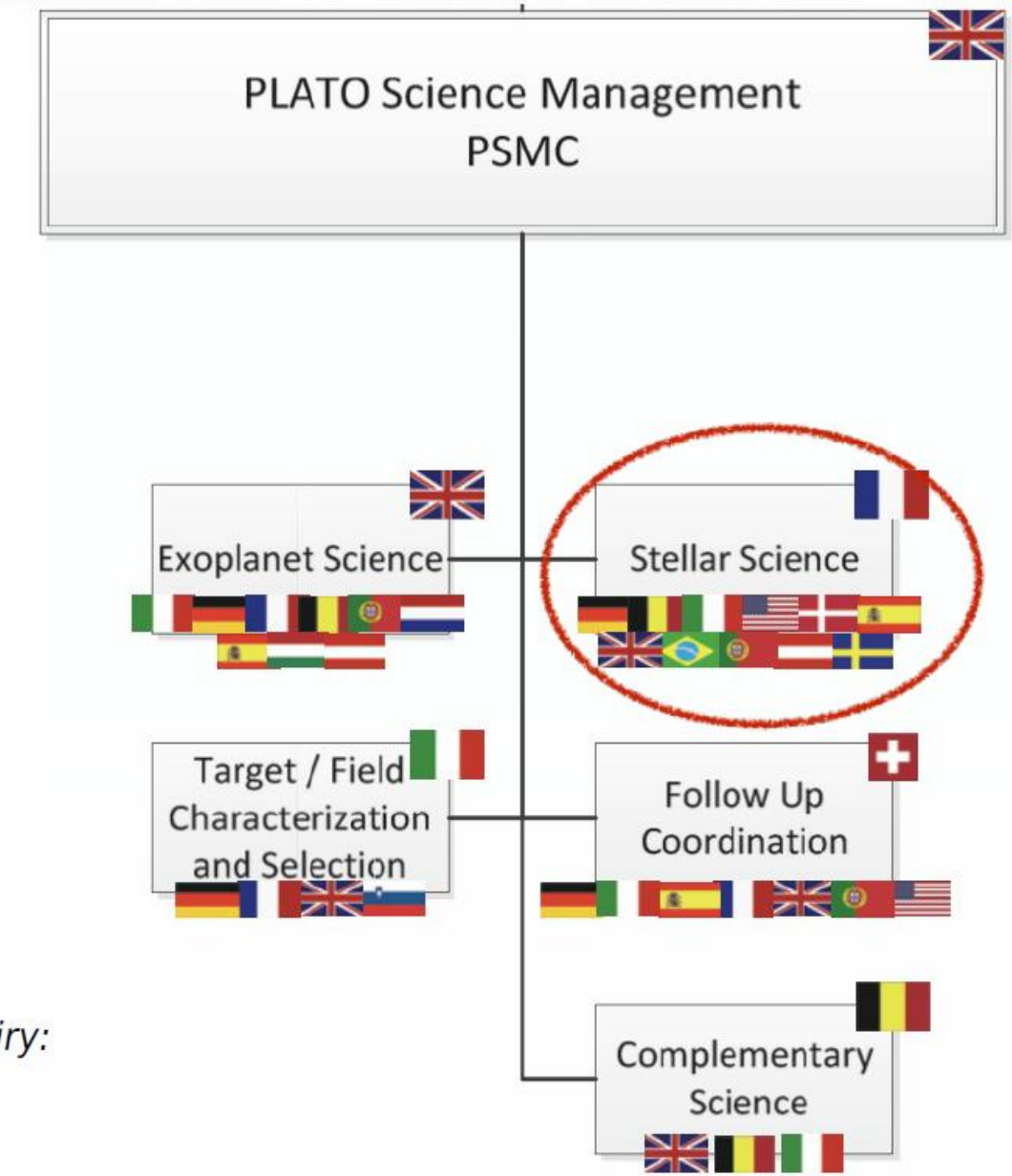
PLATO Science Management (PSM): Stellar Science

- PSM stellar science must provide the specifications and algorithms to the PDC for deriving DP3 to DP5 with associated error-bars

↓

Still a lot of preparatory work to do before launch !

Especially to assess both the precision and accuracy of the data products



If you want to join or for any other inquiry:
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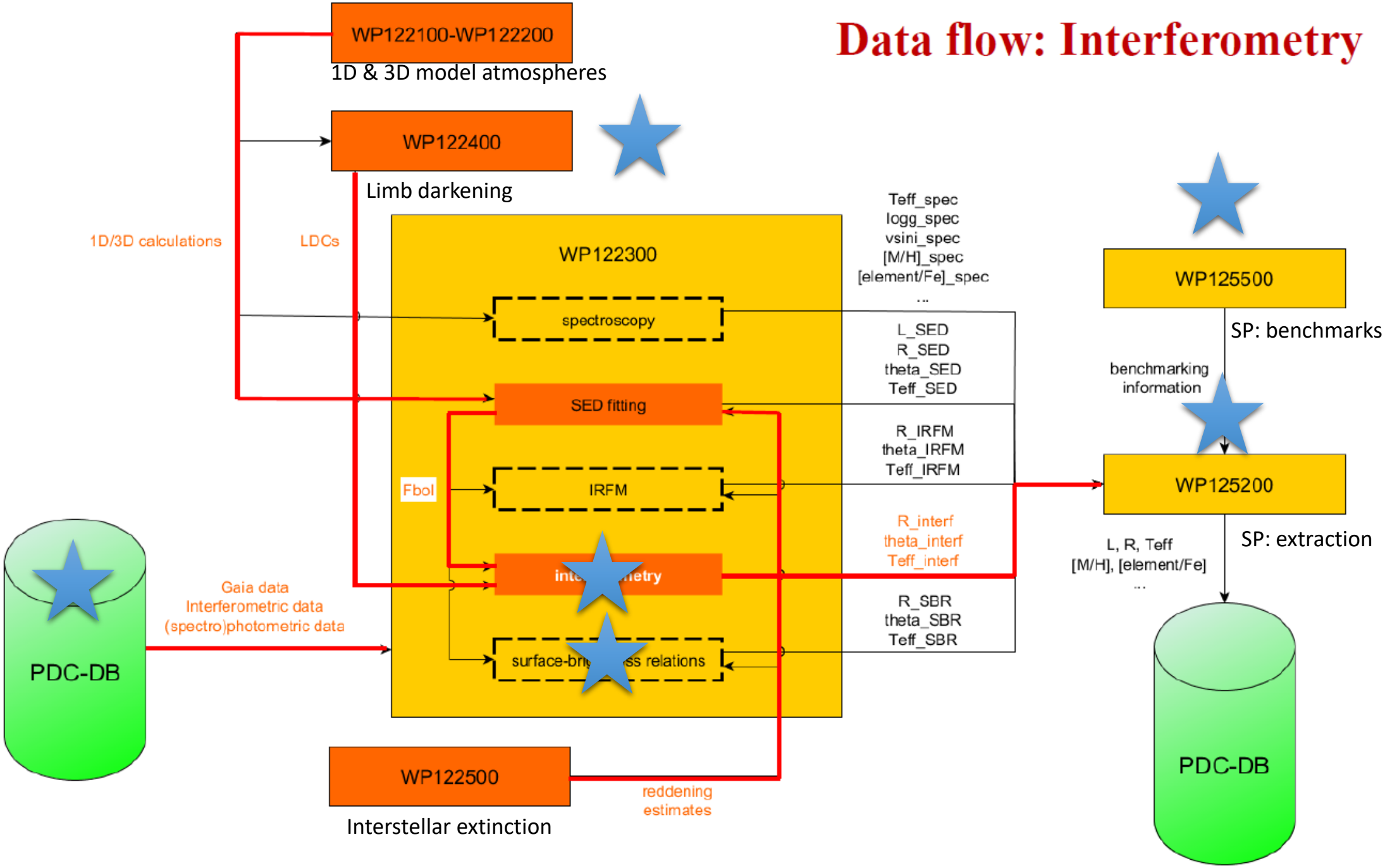
plato

PLATO WP122
Non-seismic parameters and model atmospheres

Data flow: Interferometry



Take-away messages

Thierry Morel, Kevin Belkacem, Jan-Feb 2019

The interferometric and CHARA/SPICA communities can greatly contribute to PLATO core programme in several ways, including:

- ✓ Determining the radius of the targets: direct interferometric measurements for P2 sample + SBR for fainter samples
- ✓ Develop the module for the treatment of interferometric data in WP122 pipeline, which must be validated and operational as soon as the fields/targets are defined (about 2 years prior to launch)!
- ✓ Benchmarking within WP125

BUT: need to plan/coordinate work within WP122300 ASAP + define what input data are exactly needed and must be made available in the PDC-DB (e.g. what photometric bandpasses for SBR?) .

Proposed action for WP122300 members: issue a document about SBR in PLATO (state of the field, input data needed, expected performance for the various samples, …).

JMMC-SPICA ➔ PLATO: quelles actions?

- Prochaine étape: meeting du WP122 22&23 Mai 2019 à Liège (NN, DM)
- Description d'un squelette du pipeline interferometry
  - Lien PDC-DB OIDB
  - Extraction theta; ajout Gaia pour Rayon; ajout photométrie pour Teff
  - Démontrer les performances en diamètre, assombrissement centre-bord et Teff.
  - Contribuer aux études via les 'benchmark' stars
- Description de la production et de l'utilisation des relations brillance de surface
  - Précision et biais selon activité
  - Domaines de validité
  - Etalonnage galactique
- In fine: intégration opérationnelle dans PLATO de OIDB+LITPRO+JSDC++
  - SPICA alimentera OIDB, comme tout autre instrument (dans la phase initiale avant lancement puis focus sur les champs PLATO puis follow-up des cibles intéressantes).
  - JMMC devrait donc porter la contribution interférométrique dans PLATO
- Monter un groupe JMMC/PLATO?
  - Apparaitre officiellement dans le consortium français
  - Rechercher la reconnaissance française et CNES de cette nouvelle action. ➔ supports possibles à terme à analyser