JRA4-TRE-0000-0001

Revision : 0.1

Date : 17/09/2004

JRA4

Progress Report (17/09/2004)

Alain Chelli (Coordinator)

1 What has been done so far?

- Kick-off Meeting: the JRA4 kick-off meeting was held on 7 and 8 of January in Nice with 40 participants. Tasks and persons contributing to the Archictectural design were identified
- Web page: a dynamical WEB page at the address, http://eii-jra4.ujf-grenoble.fr, was settled for the JRA4. It contains the description of WP, lists of contributors, Working Groups and to date more than 40 documents
- Follow-up: 3 teleconferences with coordinator & Work Project Leaders
- Deliverables: contributors to each WP have been identified (WP1.1/D1 & WP1.2/D1: done)
- Progress of work: see the attached report

2 How the delay in getting the EU money has affected progress ?

In the absence of EU Funds, people hiring was delayed for 8 month in most of the groups, Substantial work was however performed, almost totally imparting on institutes “matching funds”, keeping the Project roughly in pace with schedule.

3 Some idea of spending so far and project spended for the rest of 2004 and the early part of 2005

No changes: according to schedule.

4 Next events and deliverables

- Next event: Joint EII/ESO Workshop, April 2005, Garching, Germany
- Next deliverables:
  - ✓ WP1.1/D2: Final report on concept studies (April 2005)
  - ✓ WP1.1/D3: List of contributors to feasibility studies (April 2005)
  - ✓ WP2/D1: Software functional specifications (Jan. to Jun. 2005)

JRA4

Work Package 1.1

ADVANCED INSTRUMENTS

CONCEPT STUDIES

PROGRESS REPORT

Denis Mourard (Denis.Mourard@obs-azur.fr)
JMMC/OCA
Frank Pryzgoda
MPIA/OCA
Fabien Malbet
LAOG
Olivier Lardière
Arcetri
David Busher
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TABLE OF CONTENTS

1 Introduction

This is a report about WorkPackage 1.1 “Advanced Instruments: feasibility and design studies. This WorkPackage has been described into details in the following documents: *JRA4-MEM-1100-0001 and JRA4-MIN-1100-0001*. This document is a progress report. Eight feasibility studies have been selected during the kick-off meeting of the JRA4. This reports concerns the progress of the four main projects.

2 Project B2 “APRESMIDI” report (F. Pryzgoda)

2.1 Introduction

2.1.1 APreS-MIDI overview

APreS-MIDI is an extension for the existing two-beam interferometric instrument MIDI for up to four beams. Next to the availability of a better UV-coverage this will allow to measure closure phases and to produce aperture synthesis images for the first time in the mid-infrared spectral regime.

2.1.2 Milestones and deliverables

Presently the work on a proposal for financial support by INSU is in progress. It will be submitted until end of September. The next main milestone is the presentation of the APreS-MIDI project at the ESO-EII workshop for next generation VLTI instrumentation in April 2005.

2.2 Organisation of the project

2.2.1 Personnel and responsibilities

PI	Bruno Lopez	lopez@obs-nice.fr
Co Project Manager	Uwe Graser	graser@mpia.de
Project Engineer	Michel Dugue	dugue@obs-nice.fr
Project Scientist	Sebastian Wolf	swolf@mpia.de
Interface with ESO	Phillipe Gitton	pgitton@eso.org
Interface MPIA-OCA	Frank Przygodda	przygodda@mpia.de

2.2.2 Work breakdown

For details of the personel recources see the section about the project’s status below where the activities of individual participants are described.

2.3 Progress report

The progress of the phase A studies concerns the optical layout and the mechanical setup of the extension as well as theoretical analysis of the expected performance in terms of sensitivity and quality of the reconstructed images. The results from the latter points were taken into account for the definition of science cases. In the following the points are explained in more detail.

2.3.1 Status of the project

The feasibility of the combination of up to four beams by using a new principle called "densified image recombination" was studied. This was done in two attempts an analytical (Bruno Lopez, Jean Luc Menut) and also by simulations using the Zemax software package (Yves Bresson). The conclusion was, that this principle is well adapted for the extension of the existing MIDI instrument in terms of performance and expenses.

The close cooperation of engineers from OCA Nice (M. Dugue, P. Antonelli, S. Lagarde, Y. Bresson, Y. Huges, A. Roussel, S. Flament) and people of MPIA Heidelberg (Frank Przygodda who spend three month at OCA, Ch. Leinert, U. Graser, R.-R. Rohloff) resulted in an internal document discussing all critical points o connecting the four-beam extension APreS-MIDI to the already existing MIDI instrument. This "Mechanical Interface Document" is the basis for further discussions with people from ESO (e.g. Phillipe Gitton) before it will become part of the official proposal for next generation VLTI instruments.

Parallel to the described opto-mechanic studies, the expected performance of APre MIDI was investigated in detail. An important point, the sensitivity or rather the limiting magnitude, was calculated on basis of real MIDI data. For this, special datasets were taken during MIDI commissioning runs in February and August 2004 which allows a signal-to-noise estimation under realistic conditions for APreS-MIDI.

Another part of the studies was testing the imaging capabilities of APreS-MID together with the VLTI infrastructure (UTs, different AT stations etc.). This has been done under coordination of Frank Przygodda (MPIA) on basis of realistic test images produced by radiative transport simulations (Sebastian Wolf) in collaboration with people from MPIfR Bonn (Karl-Heinz Hofmann, Stefan Krauss). First results were very promising, further test to investigate the importance of parameters like number of baselines, accuracy of visibilities and closure phases etc. with respect to the quality of the reconstructed images will be done in a next step.

The results of the sensitivity estimation and the image reconstruction tests were taken into account for preparing the most important part of the studies: the definition of th science cases. This work was done by people from all the contributed institutes (B Lopez, O. Chesneau, A. Dutrey, K. Meisenheimer, F. Przygodda and many others) coordinated by Sebastian Wolf. It resulted in a preliminary "Science Case Document", which includes lists of different types of objects like Young Stellar Objects, AGN and Evolved Stars and points out the astrophysical potential of high resolution imaging in context of specific questions concerning the nature of those objects.

At this point we also want to mention that the Ph.D. of Jean-Luc Menut is connected to the project.

2.3.2 Ressources

Lab/name	Month-FTE	Task performed
MPIA ressources (Total: 15 MonthFTE – 30/9/2004)		
Frank Przygodda	6	Post-Doc
Uwe Graser	1	Management
Ralph-Rainer Rohloff	1	Mechanics
Udo Neumann	0.75	Software
Olivier Chesneau	2.5	Software + Science cases

Christoph Leinert	0.5	Consultant (design + interfaces)
Sebastian Wolf	3	Science cases
Secretary	0.25	Travels, ...
OCA ressources (Total: 30.25 MonthFTE – 30/9/2004)		
Bruno Lopez	8	Management (PI)
Michel Dugue	6	Project manager
Stephane Lagarde	2	Optical design & Interfaces
Pierre Antonelli	1	Implementation & Interfaces
Yves Besson	4	Electronic design
Alain Roussel	1	Mechanics/construction
Yves Hugues	4	Mechanical interfaces
Sebastien Flament	1	Data reduction software
Michel Dugue	1	Software
Nicole Berruyer	0.5	Science case document
Philippe Mathias	0.75	Science case document
Jena-Luc Menut	0.5	Science case document
Secretary	0.5	Tavels, ...
Other collaborations (Total: 2.25 MonthFTE – 30/9/2004)		
Annelie Grazenborg	0.25	Consulting in Optics (ASTRON)
Anne Dutrey	0.5	Science cases (Obs Bordeaux)
Eric Thiebaut	0.5	Image reconstruction (Obs Lyon)
Jean-Charles augereau	0.25	Science cases (Leiden)
Karl-Heinz Hofmann	0.5	Image reconstruction
Gerd Weigelt	0.25	Image reconstruction

2.4 Reference documents

Proceedings of SPIE conference 'Astronomical Telescopes and Instrumentation' Glasgow, 21 - 25 June 2004
Proceedings of 37th Liège International Astrophysical Colloquium 'Science Case for Next Generation Optical/Infrared Interferometric Facilities' 23 - 25 August 2004

3 Project C1 "VITRUV" report (F. Malbet)

3.1 Introduction

3.1.1 VITRUV overview

The science objectives of VITRUV is to investigate the morphology of compact astrophysical objects in optical wavelengths like the environment of AGN, star forming regions, stellar surfaces. This instrument will take full advantage of the VLTI site with 4 very large telescopes and 4 auxiliary telescopes. The instrument concept is to built aperture synthesis images like the millimeter-wave radiointerferometer of the IRAM Plateau de Bures. VITRUV coupled to the VLTI will have similar and even better resolution than ALMA. The astrophysical specifications although not yet finalized will be a temporal resolution of the order of 1 day, spectral resolution from 100 to 30,000, image dynamic from 100 to 1,000, a field of view of 1 arcsec for an initial wavlength coverage from 1 to 2.5 microns that could be extended from 0.5 to 5 microns. The technology that is favored at this stage is integrated optics.

3.1.2 Milestones and deliverables

As described in the JRA funding document

3.2 Organisation of the project

The goal of the project under the JRA4 activity is to prepare the science cases and complete the R&D study before the JRA4/ESO workshop in April 2005 on *Second generation instrumentation for the VLTI*.

3.2.1 Personnel and responsibilities

- F. Malbet (LAOG), *principal investigator*
- J.-P. Berger (LAOG), *responsible for R&D and system studies*
- P. Kern (LAOG), *project manager*
- P. Petrucci, K. Perraut, F. Ménard, (LAOG) *Science Group*
- J.-B. Lebouquin, L. Jocou, L. Lagny (LAOG/JMMC), *Combiner studies*
- P. Labeye, CEA/LETI, I. Schanen, IMEP/INPG, *Integrated Optics components*
- E. Tatulli (LAOG, PhD student), E. Thiébaut (CRAL/JMMC), *Image reconstruction*
- P. Garcia, I. Carvalho, (CAUP), Portugal, *System studies*

3.2.2 Work breakdown

3.3 Progress report

At the date of 10 September 2004, the VITRUV pre-study project has progressed in the following direction:

- science justification. The science cases, although not yet complete, have been studies and focuses mainly on compact objects. A paper has been presented at the SPIE'2004 conference (Malbet et al., 2004)
- R&D workbench. The 8T simulator is almost in the construction stage.
- R&D. Several configurations for the beam combiner have been studied and evaluated in order to fid the best concept (see Le Bouquin et al., SPIE 2004)
- A 4T multiaxial beam combiner has been simulated (Lagny)
- Image reconstruction has been initiated and comparisons of what can be obtained with current existing instrument (3T AMBER instrument) and with the VITRUV project have been investigated. Simulations have been presented and analyzed in a SPIE'2004 paper (Tatulli et al. 2004)
- A simulation of the effects of diferential birefringence on interferometric observables was done and the results are presented in the VIT-SYS-004 memo. The financing delay affected manpower (student/postdoc) and therefore the project. We should already have completed the chromatic effects and started the laboratory tests of the model.

3.3.1 Status of the project

The study projet is progressing well and the objective to be ready in April 2005 should be met with various presentations at the JRA4 workshop.

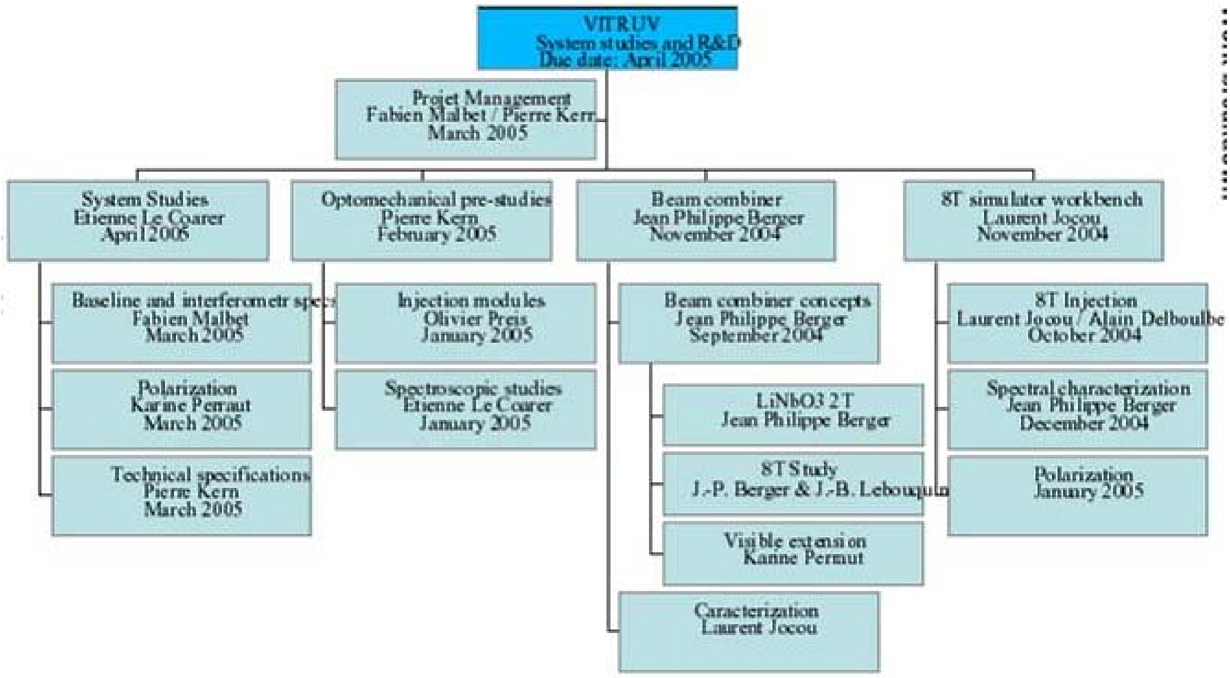
The financing delay affected manpower (student/postdoc) and therefore the project on the Porto site. We should already have completed the chromatic effects and started the laboratory tests of the model.

3.3.2 Ressources

Manpower: 14 men.month

- Science group: 1 man.month (Petrucci, Perraut, Ménard, Malbet)
- Project management: 1 man.month (Kern, Berger, Malbet)
- System studies:
  - Birefringence (Carvalho / Garcia): 3 men.months (to be confirmed)
  - Combiner design (Berger/Lebouquin/Lagny): 6 men.month
  - Workbench/simulator (Jocou): 2 men.month
- Image reconstruction (Tatulli/Thiébaut): 1 men.month

Fig. 1 Work Breakdown Structure



All manpower are out of EU funds.

3.4 Reference documents

[1] Fabien Malbet, Jean-Philippe Berger, Pierre Kern, Karine Rousselet-Perraut, Pierre-Olivier Petrucci, Francois Menard, Alain Chelli, Gilles Duvert, Jean-Baptiste Lebouquin, Eric Tatulli, Pierre Labeye, Isabelle Schanen-Duport, Eric Thiebaut, Paulo Garcia, Ines Carvalho, 2004, *VITRUV, a second generation VLTI instrument for aperture synthesis imaging with eight telescope,*SPIE conference on "New Frontiers in Stellar Interferometry", eds. W. Traub, J. Monnier, M. Schoeller, in press

[2] J-B LeBouquin, J-P Berger, P. Labeye, E. Tatulli, F. Malbet, K. Perraut, P. Kern 2004, *Comparison of Integrated Optics concepts for a near infrared*

multitelescope beam combiner, SPIE conference on "New Frontiers in Stellar Interferometry", eds. W. Traub, J. Monnier, M. Schoeller, in press

[3] E. Tatulli, E. Thiébaut, F. Malbet, G. Duvert, 2004, *Imaging Young Stellar Objects with AMBER and VITRUV on the VLTI,* SPIE conference on "New Frontiers in Stellar Interferometry", eds. W. Traub, J. Monnier, M. Schoeller, in press

4 Project C2 “VIDA” report (O. Lardière)

4.1 Introduction

4.1.1 Project VIDA overview

According to the "hypertelescope" imaging mode, stellar interferometers could provide direct snapshot images. Whereas the Fizeau imaging mode is useless when the aperture is highly diluted, a "densified-pupil" or "hypertelescope" imaging mode can concentrate most light into the high-resolution central interference peak, allowing direct imaging of compact sources and stellar coronagraphy for exoplanets finding. The current VLTI is able to combine light from 3 telescopes coherently (AMBER), but the combination of 4 to 8 telescopes (UTs and ATs), equipped with adaptive optics or tip-tilt corrector, is foreseen in subsequent phases. In order to exploit this unique forthcoming infrastructure, a second generation VLTI instrument, referred as VIDA (Vlti Imaging with a Densified Array) is proposed for very high-resolution snapshot imaging in the near-infrared and in the visible.

The two main scientific objectives of VIDA are the direct imaging of compact objects in the visible (stellar surfaces and atmospheres, close binary systems, AGNs…) and the coronagraphic search and characterization of close-in exoplanets (Pegasides) in the near-IR. The project VIDA is then the extension of AMBER toward the visible, as well as the extension of the project VLT-Planet Finder toward the very high angular resolution.

4.1.2 Milestones and deliverables

2003-2005: Concept study:

- Science cases
- Performances and requirements (AO, tip-tilt and cophasing).
- Multi-beam FSU design (*phase diversity* or *dispersed speckles* approaches)
- Multi-beam-combiner optical schemes (bulky optics or optical fibers + integrated optics)
- Coronagraphic device
- Field extension methods and data reduction.
- Focal instrumentation (spectral resolution, bandwidth, polarimetry…?)

2005-2006: Feasibility study

- Detailed study of the selected optical scheme,
- Global system analysis and interface with the VLTI infrastructure (PRIMA STS and FSUs…)
- Realisation of a FSU prototype

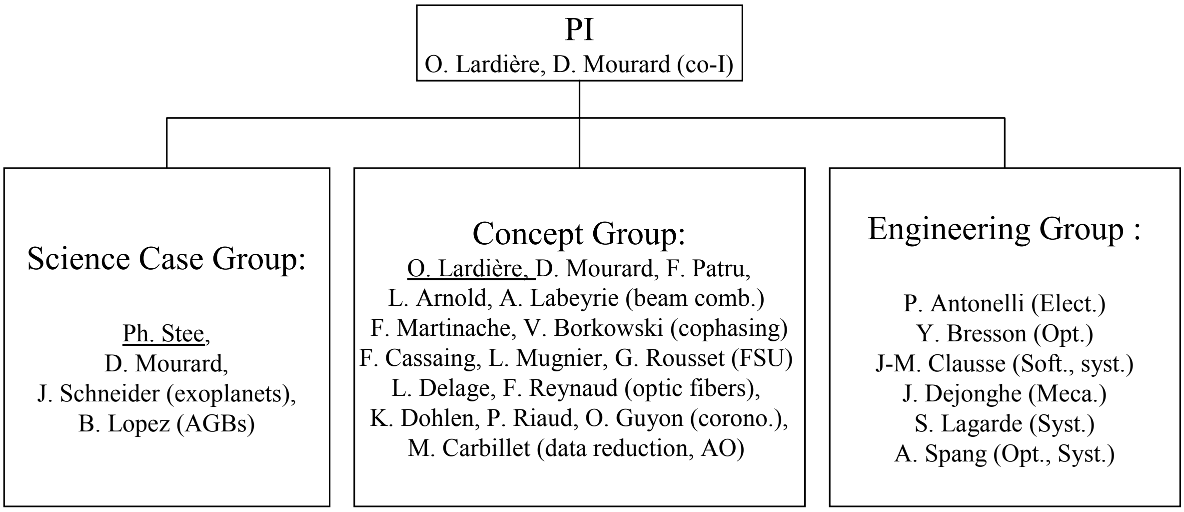
- Realisation of a sky testbench at OCA (SIRIUS) for checking the FSU prototype, the beam combiner and the wavefront requirements (AO, tip-tilt and cophasing).

2006-2009 : Realisation of elements, integration and tests of VIDA
2009-2010 : Commissioning and first science observations at Paranal

4.2 Organisation of the project

A working group has been created in 2003 for the concept study.

4.2.1 Personnel and responsibilities



Involved Laboratories:

- Observatoire de la Côte d'Azur (OCA)
- Laboratoire d'Interférométrie Stellaire et Exoplanétaire (LISE)
- Observatoire de Haute-Provence (OHP),
- Observatoire de Paris-Meudon,
- IRCOM,ONERALaboratoire Astrophysique de Marseille

4.2.2 Work breakdown

The science group is examining the new science cases interesting for direct imaging and coronagraphy (stellar surfaces and exoplanets). The direct imaging of Pegasides seems possible with VIDA and MACAO.

Concerning the concept study, O. Lardière et al. have calculated the theoretical imaging performance and the high-level requirements (AO, tip-tilt, piston) for stellar coronagraphy.

F. Patru, D. Mourard, A. Spang et al. have build a multi-beam combiner prototype (SIRIUS) at OCA to check in laboratory the performances and the requirements of VIDA.

ONERA (G. Rousset, F. Cassaing, L. Mugnier) is studying a multi-beam FSU using the phase-diversity approach. A test-bench (BRISE) built for DARWIN can serve also for VIDA.

The LISE/OHP group (A. Labeyrie, F. Martinache, V. Borkowski) is studying a new multi-beam cophaser using “dispersed speckles”, also interesting for VIDA.

The IRCOM group (F. Reynaud, L. Delage) is studying solutions for combining and densifying the beams with single-mode optics fibers.

4.3 Progress report

4.3.1 Status of the project VIDA

The VIDA instrument will combine the advantages of the very high angular resolution provided by long baseline interferometry with ones of direct imaging and coronagraphy. In 2004, we have calculated the expected performances with a coronagraph, computed from numerical simulations including cophasing and adaptive optics residual errors.We have also shown that a Roddier-Roddier phase mask associated with a pupil apodization is well-suited for the unconventional VLTI exit pupil and provides a total star extinction when there are no wavefront corrugations. A planet/star contrast of 10^{-5}-10^{-6} is reachable at 1 resel from the star with the MACAO adaptive optics and differential piston errors lower than λ/120rms, in 10h in J band. Then, direct imaging and spectral analysis of most of known hot-jupiters will be possible with VIDA.

A detailed concept study of VIDA is under process in order to define more exactly the science cases and to choose an optical scheme for the beam combination and densification (bulky optics or fibers) and for the focal instrument (certainly a fiber-feeded spectro-imager). Some studies are also planned to try to extend the usable field of view (multi-field, narrow-bandwidth observation, or image processing...)

In the same time, a test-bench referred to as SIRIUS is under development at the OCA to validate the hypertelescope imaging mode with a VLTI-like array configurations (UTs+ATs) in laboratory and on sky behind a 1.5-m telescope equipped with AO. This test-bench will serve as a prototype for the VIDA instrument by checking concretely the imaging properties (Fizeau/densified, field, SNR...) and the wavefront requirements (AO and cophasing). First laboratory tests with SIRIUS have been made in the Fizeau case (4UTs+4ATs). The densified pupil mode will be tested in lab at the end of 2004. Sky test are also planned in 2005

Lastly, a new attractive design for the beam-combiner is under study using single mode optical fibers and allowing a multi-field imaging mode.

4.3.2 Ressources

Manpower involved in 2004 (in month-FTE):

Lab/name	Time fraction (%)	Month-FTE	Task performed
Arcetri			
M. Carbillet	10	1.2	Data processing
O. Lardière	70	8.4	Concept design, coronagraphy, management
OCA			
P. Antonelli	10	1.2	Electronics
Y. Bresson	10	1.2	Optical design
J.M. Clausse	10	1.2	Software, system
S. Largarde	10	1.2	System
B. Lopez	5	0.6	Science case (AGBs)
D. Mourard	20	2.4	Concept design, science case
F. Patru	70	8.4	Concept design, prototyping
A. Spang	20	2.4	Optical design, system
Ph. Stee	10	1.2	Science case
LISE			
V. Borkowski	10	1.2	Beam cophasing
J. Dejonghe	10	1.2	Mecanics
A. Labeyrie	10	1.2	Concept design
F. Martinache	10	1.2	Cophasing
LAM			
K. Dolhen	5	0.6	Optical design, coronagraphy
OHP			
L. Arnold	5	0.6	Concept design
Meudon			
J. Schneider	10	1.2	Science case (exoplanets)
IRCOM			
L. Delage	5	0.6	Concept design, optical fibers
F. Reynaud	10	1.2	Concept design, optical fibers
ONERA			
F. Cassaing	10	1.2	Multi-beam cophasing
L. Mugnier	10	1.2	Cophasing, data processing
G. Rousset	10	1.2	Cophasing
Liege			
P. Riaud	10	1.2	Coronagraphy
Subaru			
O. Guyon	5	0.6	Coronagraphy
Total :		**43.8**	

The total in around 44 month-FTE for 2004.

4.4 Reference documents

[1] "VIDA (Vlti Imaging with a Densified Array): a densified pupil combiner proposed for snapshot imaging with the VLTI.", O. Lardière, A. Labeyrie, D. Mourard, P. Riaud, L. Arnold, J. Dejonghe, S. Gillet, in Proc. SPIE vol. 4838, Hawaii, 2002.

[2] "Coronagraphic imaging on the VLTI with VIDA", O. Lardière, in High Contrast Imaging in Astronomy, EAS, 2004, in press.

[3] "VIDA: A hypertelescope on the VLTI: Last instrument design studies and performance analysis", O. Lardière, D. Mourard, F. Patru, A. Labeyrie, J. Dejonghe, F. Martinache, M. Carbillet, in Proc. SPIE 5491, in press, 2004.

[4] "An interferometric test bench for imaging : The densified pupil concept applied to the VLTI", F. Patru, D. Mourard, O. Lardière, A. Spang, J.-M.Clausse, Y. Bresson, S. Lagarde, in SF2A-2004: Semaine de l'Astrophysique Francaise, EdP-Sciences, Conference Series, p.60, 2004.

[5] BRISE testbench, ONERA 2004.

[6] "Global wavefront sensing for interferometers and mosaic telescopes: the dispersed speckles principle", F. Martinache, *J. Opt. A: Pure Appl. Opt.* **6**, 216-220

5 Project C3 "Bulk Optic" report (D. Buscher)

5.1 Introduction

This is a report about progress on Work Package 1.1, Project C3 "A 4-8 way beam combiner for the VLTI".

5.1.1 Project C3 overview

This project concerns the development of a concept for a bulk-optics 4-8 way near-IR combiner for the VLTI. We expect to investigate possible optical and mechanical designs and to study performance metrics such as throughput, tolerances, stability, wavefront quality and cost. We also intend to assess optimization with respect to available detectors and to investigate the performance of such a combiner in the presence of smaller numbers of beams being available and/or optical operation.

5.1.2 Milestones and deliverables

Milestone D2: Instrument Concept Report (April 2005)

5.2 Organisation of the project

The project will have a flat structure, with Dr Chris Haniff acting a project manager and a design team which meets at weekly intervals.

5.2.1 Personnel and responsibilities

Dr Chris Haniff is the project manager. Dr David Buscher and Dr John Young are acting as the design team leaders. The design team will include a graduate student and an OPTICON-supported postdoc (these last two are not in place yet).

5.2.2 Work breakdown

There are three sub-packages to the concept-development project, as follows:

C3-001: Requirements definition
C3-002: Concept generation and evaluation
C3-003: Report writing

5.3 Progress report

5.3.1 Status of the project

The delay in getting EU funds has meant that we have not been able to hire the post-doc supporting this effort (7.5 months of activity are allocated to this person). We were only permitted to advertise for the post as of 1 September 2004, and so are currently awaiting applications.

The activity on this project has therefore been less than anticipated at the WP1.1 kick-off meeting. Tasks which have been initiated are as follows:

C3-001-01 Assessment of volume and footprint envelopes
C3-002-01 Enumeration of possible concepts
C3-002-02 Identification of manufacturers for required opto-mechanical components
C3-002-03 Tolerancing of optics and input beam trajectories

No tasks have been taken to completion, but some memoranda exist in draft form.

5.3.2 Ressources

This far, effort on this project has been provided by the time of two staff supported by the Higher Education Funding Council of England (Haniff/Buscher) and one PPARC-supported postdoc (Young). A total of roughly 2 staff-months of time has been utilised.

We have this far not spent any of our EU funds. We expect further spends of EU funds to be solely associated with the salary costs of the post-doc we hire (7.5 staff-months at an annual rate in the range 19k-29k UK pounds).

5.4 Reference documents

[7] JRA4-MEM-1100-0001, Revision 4.0, Description of WP1.1

JRA4

Work Package 1.2

ADVANCED INSTRUMENTS

COPHASING AND FRINGE TRACKING

PROGRESS REPORT

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INAF - OATo

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1 WP1.2

1.1 Overview

Current CFT (Cophasing & Fringe Tracking) concepts are reasonably well established, and their extrapolation to a number of new implementation cases is reasonably straightforward. Adoption of new technologies, as integrated optics, may provide significant benefits on performance for future instruments; their characteristics can be included in detailed CFT simulations as soon as the specific device parameters and instrument concepts are defined.

The WP is focused on analysis and optimisation in three areas:

1. Current cophasing instrumentation performance;
2. Measurement operations;
3. Cophasing schemes for future instruments.

The first two items concern the consolidation of current interferometric instrumentation (e.g. VLTI, LBT / VLTI FINITO, PRIMA FSUs),), with the aim of improving their performance and ease their accessibility to the astronomical community at large. The third is related to the future development perspective, in particular with reference to the concept studies developed within WP1.1. The fundamental pre-requisite to all of them is the detailed modelling of current CFT devices.

1.2 Milestones and deliverables

Report on CFT referred to advanced concept studies
Report on CFT performance analysis at VLTI

Due date: First quarter 2005

2 Organisation of the project

An initial version of the WP1.2 task list, with a call for interest, was circulated among the EII participants on January, 2004. The list of participants below (Working Group) is composed from the answers to the initial call. The current list of study areas is:

- T1. Analysis of performance of current fringe tracking systems
- T2. Fringe sensors hardware improvements
- T3. High sensitivity operation
- T4. Fringe sensors detection schemes
- T5. OPD measurement filtering
- T6. High precision astrometric calibration
- T7. Baseline and wavelength bootstrap
- T8. Multi-beam fringe sensor concepts
- T9. Identification of technology development requirements
- T10. Analysis of applicability of advanced detector (e.g. NIR STJ)
- T11. Analysis of applicability of integrated optics (in bands J, K, ...)

The task list, in the form of a management plan, will be updated and circulated once a year, based on the inputs generated within the working group, and from the EII. The changes will be based on the results of ongoing research activity within the WP1.2 and the inputs / requests from other EII groups (e.g. need for specific analyses concerning specific instrument concept studies). Decisions will be managed within the working group, by the WP leader, after discussion with the interested parties.

2.1 Personnel and responsibilities

Table of groups and tasks

Institute	Contact point	Tasks	# members
INAF-OATo	M. Gai	T1, T3, T5; T2, T4, T6	7
Obs. Haute-Provence	V. Borkowski	T4, T5, T6, T7, T8	4
Cologne (Köln, D)	C. Straubmeier	T1, T4, T5	4
Technion	E. Ribak	T4, T7, T8, T9, T11	2
ONERA	F. Cassaing	T8; T4	(1)
Obs. Bordeaux	G. Daigne	T1, T3, T6, T8, T9	(1)
MRAO (Cambridge, GB)	J. Young	All	(3)

2.2 Work breakdown

- The INAF-OATo group is working on the VLTI fringe sensors FINITO and PRIMA FSU, and plans tests in the lab and at Paranal.
- The LISE team (Obs. Haute-Provence) is working on a lab prototype to test the “dispersed speckle” method (Borkowski et al. 2002).
- The Köln group is working on the LINC-NIRVANA Fringe-And-Flexure-Tracker for LBT.
- The ONERA group proposes to work in strict collaboration with some of the WP1.1 groups, on future simulations and lab tests.
- The Technion group aims at in-depth practice on interferometric techniques, and multiple beam combination concepts in particular.
- The Obs. Bordeaux group is interested in Group Delay Tracking, astrometric measurements, and in phase-coherencing.
- The Cambridge group proposes to provide comments on the activity reports and documents generated within WP1.2.

3 Progress report

The work in progress in OATo (I) was focused mainly on the design and analysis activity for the PRIMA FSU (PM9, 25-26 March 2004, and ongoing algorithm / performance implementation), and in setup optimisation for FINITO (alignment refinement in July 2004 (first two commissioning nights on Uts: 3-4 August 2004). The status was described in contributions to the SPIE conference (Glasgow, UK, June 2004). Support to definition of two VLTI SDT proposals and on the proposal to ESO on the PRIMA reference mission is coordinated by Guy Perrin.

In the framework of the Exchange Visitor Program, E. Ribak was in Torino between July, 31st and August, 21st, for analysis of implementation issues of current instruments and evaluation of future multi-beam instrument concepts.

A preliminary evaluation on feasibility and performance of an interferometer in Antarctica was started, upon request from INAF, and is currently in progress; a report on the results will be circulated within the working group in October 2004.

The LISE team (OHP, F) is carrying on the analysis and laboratory activity aimed at the “dispersed speckles” experiment.

The Köln group presented the current results on the LBT Fringe and Flexure Tracker at the SPIE conference (Glasgow, UK, June 2004).

Recent publications:
D. Bonino, M. Gai, L. Corcione, G. Massone
Models for VLTI fringe sensor units: FINITO and PRIMA FSUs
Proc. SPIE 5491-168, 2004, in press

M. Gai, S. Menardi, S. Cesare, B. Bauvir, D. Bonino, L. Corcione, M. Dimmler, G. Massone, F. Reynaud, A. Wallander
The VLTI Fringe Sensors: FINITO and PRIMA FSU
Proc. SPIE 5491-61, 2004, in press

Virginie Borkowski
La methode "speckles disperses": mise en phase pour faire de l'imagerie directe avec des interferometres et des hypertelescopes.
PhD Thesis, Obs. Haute-Provence

T. Bertram, D.R. Andersen, C. Arcidiacono, C. Straubmeier, A. Eckart, U. Beckmann, T. Herbst
The LINC-NIRVANA Fringe and Flexure Tracking System: differential piston simulation and detection
Proc. SPIE 5491-167, 2004, in press

C. Straubmeier, T. Bertram, A. Eckart, Y. Wang, L. Zealouk, T. Herbst, D. Andersen, R. Ragazzoni, G. Weigelt
The Fringe and Flexure Tracking System for LINC-NIRVANA: Basic Design and Principle of Operation
Proc. SPIE 5491-171, 2004, in press

3.1 Status of the project

Activity on several of the tasks enlisted for WP1.2 has started; the definition of the mechanisms for progress reporting and internal circulation of documents is in progress. Implementation of some critical activities (e.g. interaction with the instrument concept studies) lags behind, also due to the need for several groups to wait for EU funds for “switching on” the main programs.

3.2 Resources

All current activities, at the moment, have been supported by internal resources of the participating groups, since EU funds have not yet been received.

Institute	Person	Task	EU financed Time [months]	Non-EU financed Time [months]
INAF-OATo	M. Gai	T1		1
INAF-OATo	G. Massone	T2		1
INAF-OATo	D. Bonino	T1, T4		2
INAF-OATo	D. Gardiol	T8		0.5
INAF-OATo	D. Loreggia	T3, T8		1.5
INAF-OATo	M. Lattanzi	T1, T6		1
INAF-OATo	L. Corcione	T2, T5		1
OHP	V. Borkowski	T4, T8		(to be completed)
Köln	C. Straubmeier	T1, T2		(to be completed)
Technion	E. Ribak	T8		(to be completed)
ONERA	F. Cassaing	...		(to be completed)
Obs. Bordeaux	G. Daigne	...		(to be completed)
MRAO – Cambridge	J. Young	...		(to be completed)

4 Reference documents

[1] JRA4-MEM-1100-0001, Revision 4.0, Description of WP1.1
[2] JRA4-MEM-1200-0001, Revision 2.0, Description of WP1.2

JRA4

Work Package 2

SOFTWARE

PROGRESS REPORT

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TABLE OF CONTENTS

1 Introduction

This document summarizes the intermediate Progress Reports received from all European groups involved in the OPTICON JRA4-WP2 "Software" activity for period Jan 1, 2004 to Sep 1, 2004.

1.1 Project overview

The workpackage is aimed at delivering two successive versions of a software of general use in a 5 -years span, starting from 'scratch'. This software aims at facilitating the use of large modern interferometric facilities such as ESO's VLTI to an end-user non specialist of Optical interferometry. We will develop our software by integrating in an easy to use manner the basic tools used by optical interferometry specialists: comparison of observables with models (achromatic, then chromatic models, support of classical geometrical models then support of more physical or ad hoc models), blind image reconstruction from observables, astrometry-related measurements from phase-referenced interferometry. The tool should be oblivious of the origin of the data (we expect to work on reduced, calibrated, interferometric observables, such as provided by the VLTI pipeline), and should manage comparision and merging with other data issued from other interferometers and even other observational techniques. Due to the complex task in view, we split the work into 5 Tasks that will develop quite independently an aspect of the whole. All the Tasks are scheduled to arrive at the same time at each software acceptance release.

1.2 Milestones and deliverables

The milestones and deliverables have been defined in the Statement OF Work [JRA4-SOW-0000-0001] document.

2 Organisation of the project

Due to the complexity of the task, the work is distributed into 5 Tasks that develop quite independently a functionality of the whole software. See [1].

2.1 Personnel and responsibilities

See Software Management Plans Documents [11], [12], [13], [14], [15] and [16].

2.2 Work breakdown

As above.

3 Progress report

3.1 WP2.1 General Management and User Support

- A *web site* has been set up, with all services needed for communication between JRA4 (WP1 and WP2) groups, documentation, reporting, software repositories, software configuration, etc...

  Web site: http://eii-jra4.ujf-grenoble.fr .

  We have also provided setup and continue to provide maintaining of the server and abovementioned services.
- *User Support* has been started:

2 persons have been scheduled part time for User Support: G. Duchène (JMMC/LAOG) and P. Kervella(JMMC/LESIA).

- Template documents have been written for all scheduled kinds of reporting and deliverables.

3.2 WP2.2 Common Software

JMMC/LAOG has worked full time on the following subjects:

- Early concepts documentation
- Studies of Base libraries for interprocess communication
- Error handling
- Log and reporting
- Programming rules

And has nearly completed writing of a preliminary version of the corresponding libraries.

3.3 WP2.3 Model Fitting

The main parts of the model fitting program have been defined and a preliminary test version has been coded in JMMC/CRAL

- Reading of OI Exchange Format files and the storage of data,
- A few basic model functions to evaluate complex visibilities,
- Evaluation of residuals and weights for the Chi-square method
- Use of a modified Levenberg-Marquardt algorithm (modified with the trust regions method for the fit of the parameters).

All these parts must be linked together in order to achieve a complete model fitting procedure.
For testing the fit, examples of OI DATA files are written. To enlarge the existing library of models is also necessary.
Furthermore, a first version of the Applications Programing Intefaces (API) has been released in July. It will evolve through the remarks of the whole group and the progress of the operational prototype.
In parallel, are written by the JMMC/OCA group parametric models of astrophysical objects that will be implemented in WP2.3 during its second phase.

3.4 WP2.4 Astrometry

No work was performed on this task in the reporting period due to lack of EU funds.

3.5 WP2.5 Image reconstruction

3.5.1 JMMC/CRAL/ONERA group

The group has begun exploring the three aspects of the problem described in the project overview, using and adapting existing prototype reconstruction codes at CRAL and at ONERA called MIRA and WISARD respectively.
We have explored two ways of dealing with the unknown turbulence: the MIRA code deals with it by formulating the reconstruction problem using only the closure phases and not the unknown pistons, while the WISARD code introduces aberrations due to the turbulence and explicitly searches for them simultaneously with the object. Both codes use a common minimization engine called VMLM-B developed by CRAL for large-scale constrained minimization problems.

We have so far tried two regularization metrics: the regularization used by MIRA is an entropic term while the one used by WISARD is a quadratic one that uses the knowledge of the Power Spectral Density of the object, which could be estimated from the data.
Lastly, WISARD now has the possibility to use a data-fidelity metric that accurately models the noise statistics while remaining convex for given aberrations.

3.5.2 CAMBRIDGE group

The result of funding delays is that the software engineer has not yet been hired and progress is therefore behind schedule. The efforts of a graduate student were applied to the project, but he has now had to stop so as to prepare his thesis. As a result, work on the systematic testing of the algorithm and its improvement has been halted.

The following tasks have been completed

- WP02-03-01 Initial implementation of MEM based algorithm
- WP02-03-02 Initial testing of first implementation for SPIE beauty contest. The Cambridge algorithm won the contest.
- WP02-03-03 Publication of SPIE paper with initial results and also comparison of results from other teams (beauty contest)

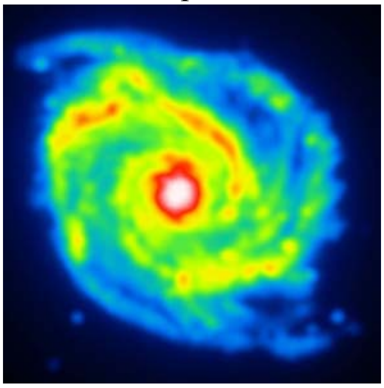
3.5.3 MPIFR/MPIA group

Following the schedule described in JRA4-PLA-2530-0001, the MPIA and MPIfR group are currently working on the Software User Requirements, the Software Validation Plan, and the Software Prototypes. Furthermore, there were efforts at MPIA and MPIfR to hire astronomers (e.g., job advertisement and interviews).

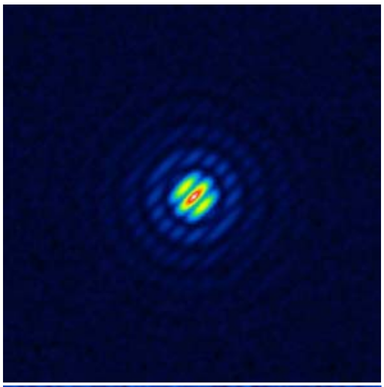
In the text below we show first results of our image reconstruction experiments. LINC-NIRVANA is a near-infrared beam combiner instrument for the Large Binocular Telescope (LBT), which is currently under construction. Aperture-synthesis images with a resolution corresponding to the diffraction limit of a single-dish 23 m telescope can be reconstructed from typically three or four images recorded at different hour angles.

Within our JRA4 activity we carried out computer simulations of image reconstruction from LBT data. We studied, for example, the dependence of the image quality on photon and detector noise. For image reconstruction, we used the Lucy-Richardson algorithm. We present one example of the simulations performed:

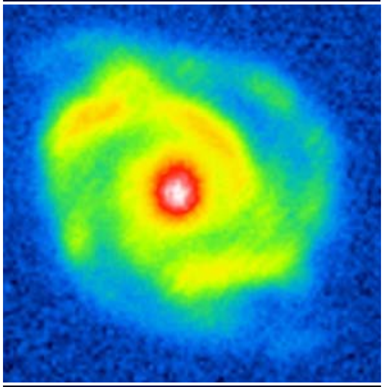
This object brightness distribution was used for some of our simulations.



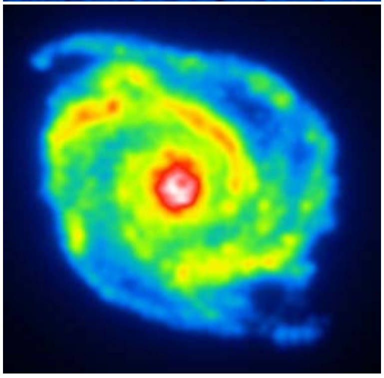
One of the four point spread functions (PSF) used for image reconstruction. The four PSFs were simulated for complementary position angles of 0°, 45°, 90°, and 135°.



With an assumed K magnitude of 16^m, a total efficiency of 20%, and an integration time of 1000 seconds, LBT should provide interferograms of the quality shown here. Observation at four different position angles are assumed for our simulation.



Using the Richardson-Lucy algorithm (Richardson 1972, J. Opt. Soc. Am. 52, 55, Lucy 1974, AJ 79, 745), we reconstructed the image shown on the right from the four interferograms described above.



3.5.4 UGR/IAA-CISC/UAM group

Work started effectively in March 2004 with the production of the Software Management Plan of the UGR/IAA-CSIC/UAM team (Document JRA4-PLA-2540-0001), released on April 2004.
After a period of inactivity, in July 2004 efforts have been aimed towards understanding the internal structure of the standard optical (visible/IR) interferometry data format (OI-Exchange Format) and the FITS interferometry Data Interchange Format (FITS-IDI) which is the standard for radio interferometry. The objective is to produce an interface between these two data formats.
The construction of this interface software, internally referred as OI2IDI, is in progress. It is based on the CFITSIO library and is being written in Fortran 77. With this interface, optical interferometry data will be directly read into the AIPS software package, as a first step for reducing these data with radio software packages.

- <u>All Groups:</u>

The JMMC/CRAL, JMMC/ONERA, and CAMBRIDGE groups have participated to an international image reconstruction contest organized by Peter Lawson (JPL, USA) within the framework of the International Astronomical Union, in which their

respective sofware were used and compared. The results have been presented at the SPIE conference in Glasgow, UK, 2004 and are published in the following proceedings:
P. R. Lawson, W. D. Cotton, C. A. Hummel, J. D. Monnier, M. Zhao, J. S. Young, H. Thorsteinsson, S. C. Meimon, L. Mugnier, G. Le Besnerais, E. Thiébaut, and P. G. Tuthill. *An interferometric imaging beauty contest*. In “New frontiers in stellar Interferometry”, volume 5491. Proc. Soc. Photo-Opt. Instrum. Eng., 2004.

3.6 Ressources

3.6.1 WP2.1

People	*Month FTE*
Gilles Duvert	1.0
Gérard Zins	2.0
Alain Chelli	1.0
Sylvain Lafrasse	3.0
Guillaume Mella	1.0
Gaspard Duchêne	0.25

3.6.2 WP2.2

People	*Month FTE*
Gilles Duvert	0.5
Gérard Zins	3.0
Laurence Gluck	6.0
Sylvain Lafrasse	1.0
Guillaume Mella	4.0

3.6.3 WP2.3

People	*Month FTE*
Isabelle Tallon-Bosc Michel Tallon Eric Thiébaut Clémentine Béchet Lyon (CRAL)	8.5
Merieme Chadid Romain Petrov Denis Mourard Philippe Stee Jean-Michel Clausse Nice (UNSA-OCA)	1.75
Gérard Zins Gilles Duvert Alain Chelli Grenoble (LAOG) Guy Perrin Paris	0.25

3.6.4 WP2.5

- JMMC/CRAL-JMMC/ONERA

People	*Month FTE*
Eric Thiébaut Laurent Mugnier	2.0 2.0

- CAMBRIDGE

People	*Month FTE*
Hrobjartur Thorteinsson Dave Busher John Young	3.0 0.5 0.5

- MPIFR/MPIA
  Up to now, no work performed was financed by the EU. As described above, there were efforts at MPIA and MPIfR to hire astronomers (e.g., job advertisement and interviews).

  Since the start of the JRA4 project (15/03/04), the following persons have been involved in the project and financed by MPIfR/MPIA funds:

People	*Month FTE*
General Management: Gerd Weigelt, Thomas Driebe, Tom Herbst	1/4
Simulations on Image Reconstruction: Thomas Driebe, Karl-Heinz Hofmann, Stefan Kraus, Dieter Schertl, Matthias Heininger, Patrick Kaster	2
Observation Preparation Software: Wolfgang Gässler, Martin Kürster, Florian Briegel	1

The MPIfR and MPIA infrastructure (working space, secretary time, and computers) was used.

4 Conclusions

In the absence of EU Funds, people hiring was delayed for 8 month in all groups, adding the risk of losing valuable people who could have been hired retroactively starting January, 1st, if EU financing and country regulations would have permitted. Substantial work was however performed, almost totally imparting on institutes "matching funds", keeping the Project roughly in pace with schedule. No work was performed at all for WP 2.4.

5 Reference documents

[1] JRA4-SOW-0000-0001, Revision 0.1, JRA4 Contract: Statement of Work
[2] JRA4-PLA-0000-0001, Revision 4.0, JRA4 Documentation Management Plan

[3] JRA4-MOD-0000-0001, Revision 1.0, Word Document Template
[4] JRA4-MOD-0000-0002, Revision 1.0, Word Minutes Template
[5] JRA4-MOD-0000-0003, Revision 1.0, PowerPoint Presentation Template
[6] JRA4-MOD-0000-0004, Revision 1.0, Latex Document Style
[7] JRA4-MEM-2000-0001, Revision 2.0, JRA4 Description of WP2
[8] JRA4-TRE-2000-0001, Revision 2.0, JRA4 Software Preliminary Concept Description
[9] JRA4-MOD-2000-0002, Revision 1.0, JRA4 Software User Requirement Template
[10] JRA4-MOD-2000-0001, Revision 1.0, JRA4 Software Functional Specifications Template
[11] JRA4-PLA-2000-0001, Revision 1.0, JRA4 Software Management Plan
[12] JRA4-PLA-2200-0001, Revision 1.0, JRA4 Common Software - Software Management Plan
[13] JRA4-PLA-2300-0001, Revision 1.0, JRA4 Model Fitting - Software Management Plan
[14] JRA4-PLA-2520-0001, Revision 1.0, JRA4 Image Reconstruction - Cambridge University team - Software Management Plan
[15] JRA4-PLA-2530-0001, Revision 1.0, JRA4 Image Reconstruction - MPIfR/MPIA team - Software Management Plan
[16] JRA4-PLA-2540-0001, Revision 1.0, JRA4 Image Reconstruction - UGR/IAA-CSIC/UAM team - Software Management Plan
[17] JRA4-TRE-2300-0001, Revision 1.0, JRA4 Model Fitting - Software Progress Report
[18] JRA4-TRE-2510-0001, Revision 1.0, JRA4 Image Reconstruction – CRAL/ONERA team - Software Progress Report
[19] JRA4-TRE-2520-0001, Revision 1.0, JRA4 Image Reconstruction - Cambridge University team - Software Progress Report
[20] JRA4-TRE-2530-0001, Revision 1.0, JRA4 Image Reconstruction - MPIfR/MPIA team - Software Progress Report
[21] JRA4-TRE-2540-0001, Revision 1.0, JRA4 Image Reconstruction - UGR/IAA-CSIC/UAM team - Software Progress Report