Centro de Estudios de Física del Cosmos de Aragón

TECHNICAL REQUIREMENTS SPECIFICATION FOR THE J-PAS FILTERS SUPPLY CONTRACT

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1. REFERENCE DOCUMENTS

	Doc title	Doc Number
RD1	Centro De Estudios De Física Del Cosmos De Aragón, The Project. M. Moles, 2008.	
RD2	Memoria Descriptiva	
RD4	OAJ T250 Optical Analysts	OAJ-TRE-AMO-1000-009-is5.pdf
RD3	Wide field 14-CCD mosaic camera for the 250cm telescope of the OAJ.	OAJ-JPCAM

2. LIST OF ACRONYMS AND ABBREVIATIONS

CEFCA	Centro de Estudios de Física del Cosmos de Aragón
JPCAM	Wide Field Mosaic Camera for the T250.
FoV	Field of View
OAJ	Observatorio Astrofisico de Javalambre
JPAS	Javalambre PAU Astrophysical Survey
JST/T250	OAJ 250cm aperture telescope
FWHM	Full Width Half Maximum

TBC: "To Be Confirmed" by the CEFCA during Contract negotiations or at an agreed date during Contract duration.

TBD: "To Be Defined" and agreed between the CEFCA and the Contractor at the time of Contract signature or at an agreed date during Contract duration.

3. DEFINITIONS

<u>JST/T250</u>	The 250cm aperture OAJ telescope
<u>JAST/T80</u>	The 80cm aperture OAJ telescope
<u>Contractor</u>	Refers to the Company entrusted with the design and build of the Telescope and the EB
<u>Temperature of Reference</u>	The temperature of reference for all the dimensions and tolerances, unless otherwise specified, shall be 21° C.

4. INTRODUCTION

The Observatorio Astrofísico de Javalambre (OAJ, [*RD1, RD2*]) is a new astronomical facility located at the Sierra de Javalambre (Teruel, Spain) whose primary role will be to conduct all-sky astronomical surveys. The OAJ facility will have two wide-field telescopes: the JST/T250; a 2.55-m telescope with a 3º diameter field of view (FoV), and the JAST/T80; an 0.83-m telescope with a 2º diameter FoV. The definition, construction, operation and scientific exploitation of the OAJ will be the responsibility of the CEFCA.

The JST/T250 will be installed, accepted and therefore ready for scientific operation by the end of 2013. The telescope has a plate scale of 22.67"/mm and a f/# = 3.6. The 3º diameter FoV corresponds to 476.4mm [*RD3*].

The main scientific instrument for JST/T250 is JPCam [*RD4* and figures 1 and 2], a 14-CCD mosaic camera using the new large format e2v 9k-by-9k 10µm pixel detectors. JPCam will be installed at the Cassegrain focus of the JST/T250 and will cover a large fraction of the telescope's FoV with a pixel scale of 0.2267 "/pixel. The Camera Filter Unit will be designed to admit 5 filter trays. Each one of the filter trays shall contain 14 square filters corresponding to the 14 CCDs of the mosaic. Each CCD will view only its corresponding filter without any cross-talk between them. Figure 3 shows a preliminary design of a JPCam filter tray.

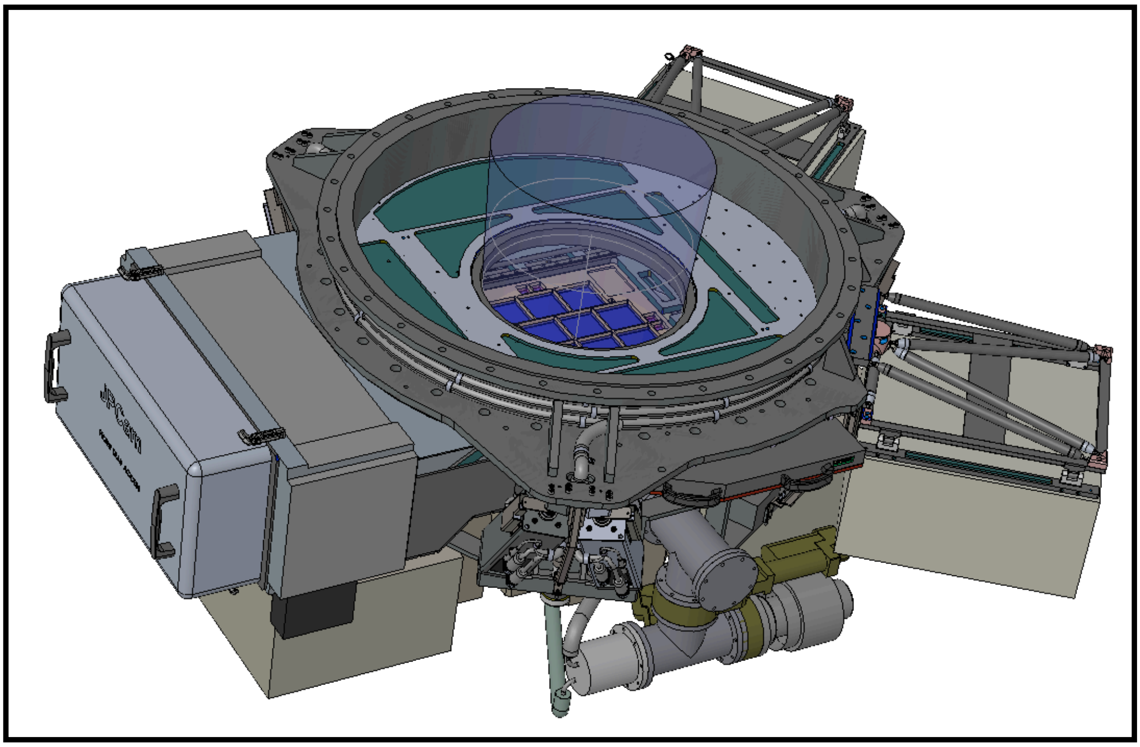

Figure 1: JPCam mechanical design. The incident cone angle is shown in blue. The location of the filter tray can be also seen.

JPCam has been designed to perform the Javalambre-PAU Astrophysical Survey (J-PAS), an innovative photometric survey of more than 8000 square degrees of northern sky using the following system of 59 filters:

- 56 main filters, 54 narrow-band (FWHM=14.5 nm) filters continuously populating the spectrum between 370 to 920 nm with 10.0 nm steps, plus 2 broad-band filters.
- A custom $u_{J\text{-}PAS}$ broad band filter.
- Two Sloan filters (g_{SDSS} and r_{SDSS}).

The filters will operate close to, but up-stream from the dewar window in a fast converging optical beam. This optical configuration imposes challenging requirements for the J-PAS filters, some of them requiring the development of new filter design solutions. These filters, specified bellow, will allow a redshift determination of thousands of galaxies with a precision of $\sigma_z \sim 0.003(1 + z)$, sufficient to obtain a much better precision in the Dark Energy parameters than J-PAS predecessors. This survey will be completed in about 4-5 years and will reach m_{AB}~22 at the 5σ level.

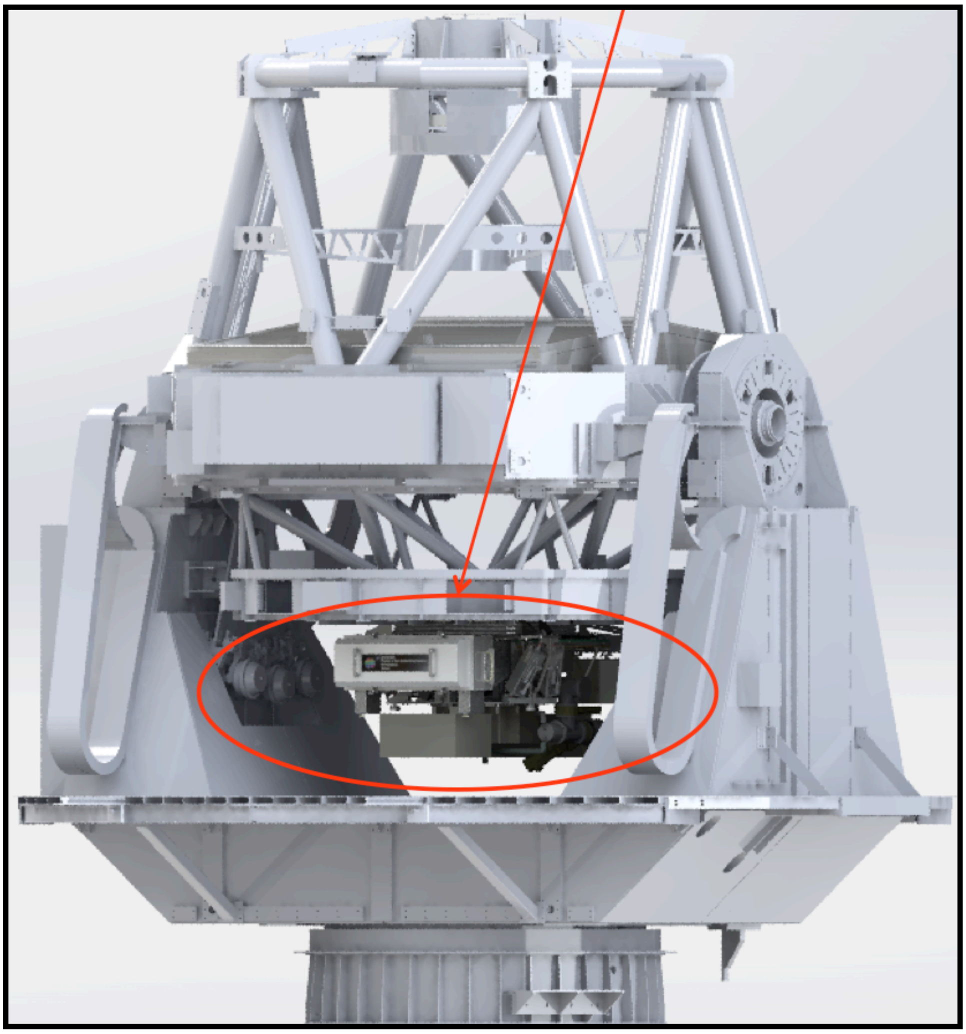

Figure 2: JPCam installed on the Cassegrain focus of the JST/T250.

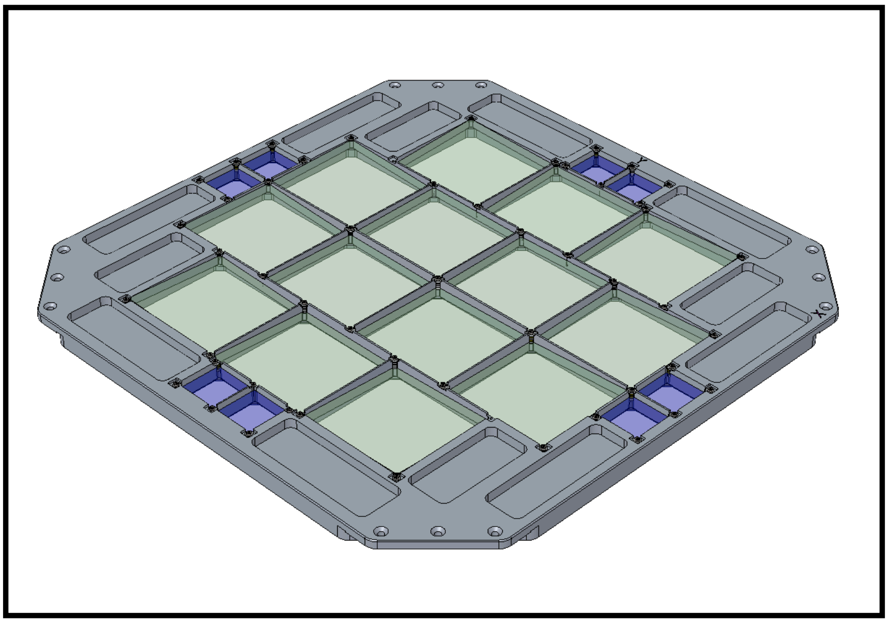

Figure 3: Tilter tray preliminary design. The 14 filters are shown in light green. JPCam has 5 filter trays

5. SCOPE OF THE DOCUMENT AND SCOPE OF WORK

This document gives the requirements for the J-PAS filter set. The contractor's scope of work and the project's maximum cost and timescale are also presented. A J-PAS filter set is composed by 70 filters, the 56 main filters plus several copies of the custom $u_{J\text{-}PAS}$ and the Sloan g_{SDSS} and r_{SDSS} filters to fully populate the five JPCam filter trays. The definition of a J-PAS filter set is shown in table 1. The contractor shall design, manufacture, test and deliver **two** sets of J-PAS filters. These filters shall be delivered in the appropriate delivery boxes and together with the long-term storing boxes/supports.

Filter name	Number of filters per Set	Number of Requested Sets	Total
$u_{J\text{-}PAS}$	4	2	8
g_{sdss}	3	2	6
r_{sdss}	7	2	14
#1	1	2	2
#2	1	2	2
...	...	...	...
#56	1	2	2
Total number of requested filters			**140**

Table 1: Number of required J-PAS filters.

6. OVERALL REQUIREMENTS

6.1. Functional Requirements

The temperature of reference for all dimensions and tolerances during manufacturing of components shall be 21 ºC.

Figures 4 and 5 show the generic filter transmission function for the broad- and narrow-band filters, respectively. The detailed filter transmission functions are specified bellow. Once mounted on JPCam, the filters will operate close to the detector, in a fast converging beam. The specified filter transmission curves correspond to the filter working conditions, so the **filters shall be designed to fulfill the following requirements when placed on a f/#=3.64 converging beam with the chief ray being perpendicular to the filter**.

The interference layer technology shall be optimized in order to reduce the sensitivity of the central wavelength versus the incidence angle.

Filter's mechanical design shall be optimized to minimize stress induced by temperature changes and gradients.

The filter tray (filter support) is progressing in its mechanical design. This implies that some filter physical requirements (size) are preliminary and shall be decided at the beginning of this project. The filter tray design will be finished before contract signature.

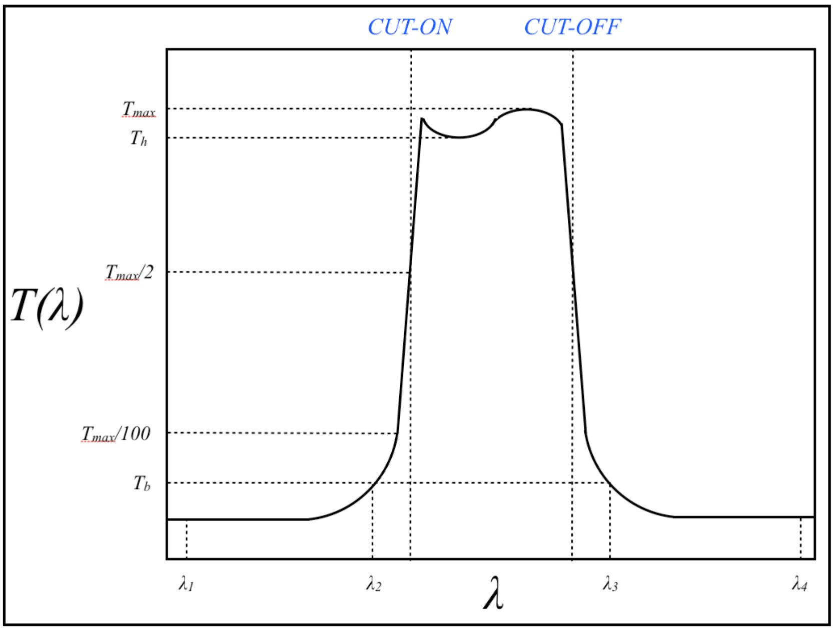

Figure 4: Generic broad-band filter transmission curve.

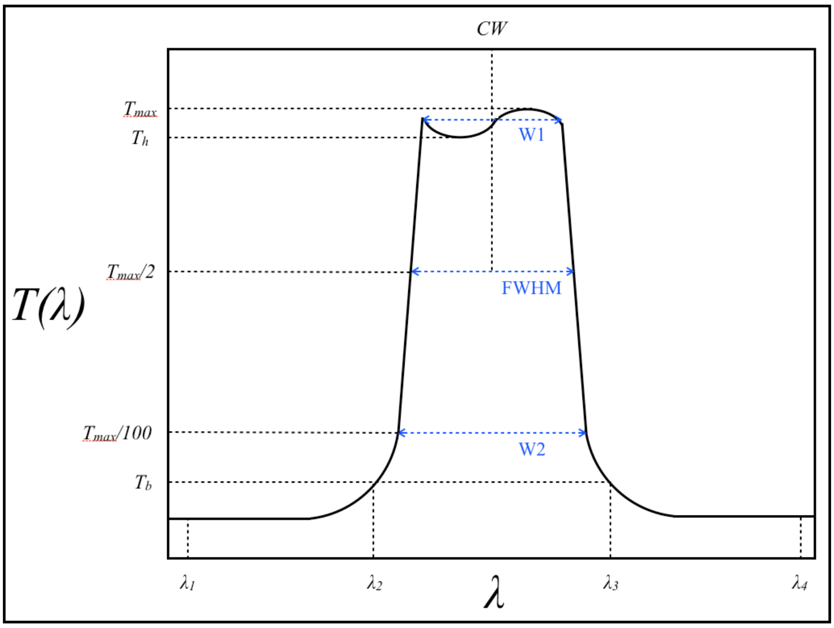

Figure 5: Generic narrow-band filter transmission curve.

6.1.1. Functional requirements for $u_{J\text{-}PAS}$ and Sloan filters

6.1.1.1. Cut-on wavelength

Table 2 lists the required cut-on wavelength for the broad-band filters.

Filter name	CUT-ON (nm)	CUT-OFF (nm)
$u_{J\text{-}PAS}$	324	400
g_{sdss}	400	550
r_{sdss}	550	700

Table 2: $u_{J\text{-}PAS}$ and Sloan filters[1].

6.1.1.2. Cut-on wavelength tolerance

Cut-on wavelength tolerance for the broad-band filters shall be ±3nm.

6.1.1.3. Cut-on Slope

Cut-on slope, defined as *ABS[lamda80%(peak)-lambda5%(peak)/lambda5%(peak)]*100*, shall be around 1%. This slope shall agreed during the design phase

[1] *Definition and design notes for the SDSS filters can be found at Fukugita et al (1996), AJ, 111, 1748*

6.1.1.4. Cut-off wavelength

Table 1 lists the required cut-off wavelength for the broad-band filters.

6.1.1.5. Cut-off wavelength tolerance

Cut-off wavelength tolerance for the broad-band filters shall be ±3nm.

6.1.1.6. Cut-off Slope

Cut-off slope, defined as *ABS[lamda80%(peak)-lambda5%(peak)/lambda5%(peak)]*100*, shall be around 1%. This slope shall agreed during the design phase

6.1.2. Functional requirements for J-PAS main filters

6.1.2.1. Central Wavelength

Table 3 lists the required central wavelength (CW) for the 56 main filters (54 narrow- plus 2 broad-band). Figure 6 illustrates the specified transmission curves for the J-PAS filter set. The 56 main filters are shown in the top panel while the custom $u_{J\text{-}PAS}$ filter and the 2 Sloan filters are shown in the lower panel.

# Filter	CW (nm)	FWHM (nm)	W1 (*) (nm)	W2 (*) (nm)
1	348,5	49.5	47	57
2	378,5	15.5	13	20
3	390,0	14.5	12	19
4	400,0	14.5	12	19
5	410,0	14.5	12	19
...	...	...	...	...
54	900,0	14.5	12	19
55	910,0	14.5	12	19
56	1007,5	188.8	185	197

Table 3: J-PAS main filters.

(*) Goal W1 and W2 values are listed. Final values shall be agreed during the design phase.

6.1.2.2. Central Wavelength Tolerance

CW listed in Table 3 are considered as a goal, but some flexibility can be accepted in CW in order to fulfill the "Statement of Continuity" requirement (6.1.3.7). The tolerance in CW shall be ±0.2% of the CW. Final CW shall be agreed during the design phase.

6.1.2.3. Central Wavelength Uniformity

The central wavelength shall be uniform across the filter's usable area within ±0.25% of the CW (goal ±0.20%).

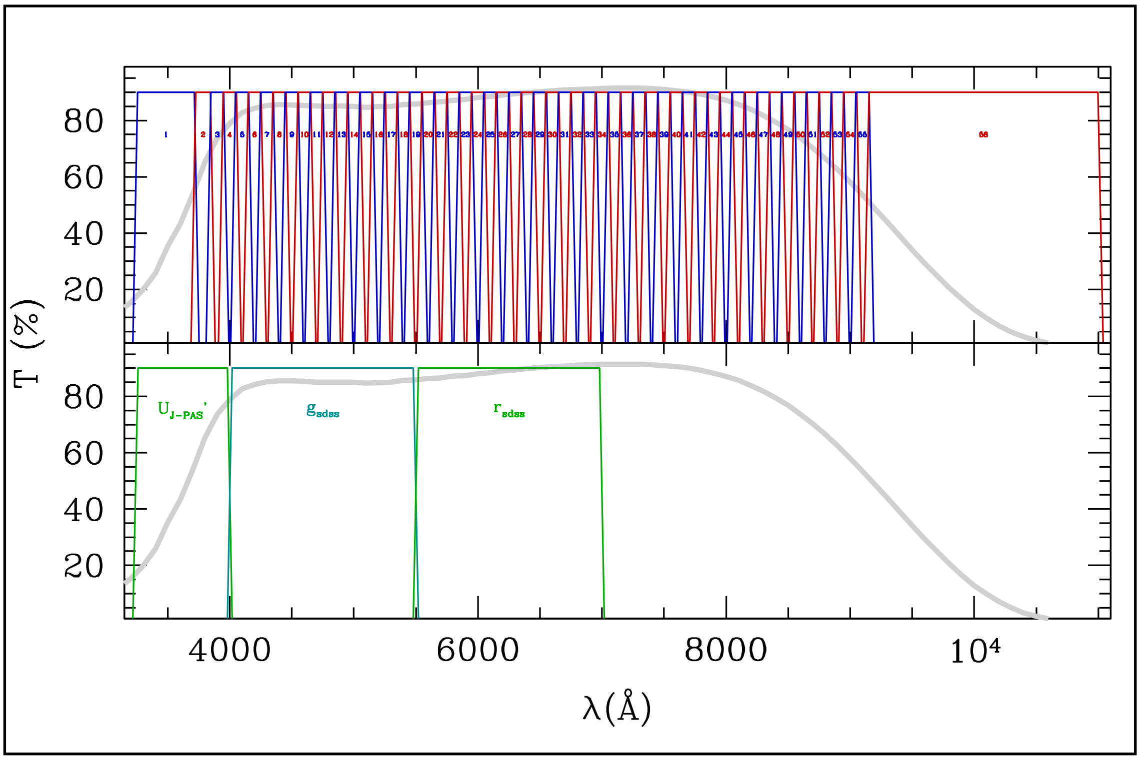

Figure 6: J-PAS set of filters. J-PAS filters are shown in red and blue (upper panel) while the $u_{J\text{-}PAS}$ and Sloan filters are shown in green (lower panel).

6.1.2.4. FWHM

Table 3 lists the required FWHM for the set of 56 filters. Some flexibility in FWHM is allowed if required to fulfill the "Statement of Continuity" requirement (6.1.3.7). If the proposed FWHM differs form the specified one, this change shall be agreed by CEFCA during the design phase.

6.1.2.5. FWHM Tolerance

The tolerance in FWHM shall be ±0.5nm.

*6.1.2.6. Full Width at 0.95*T_{max} (W1)*

Table 3 lists goal values for W1. Final W1 shall be agreed by CEFCA during the design phase.

6.1.2.7. W1 Tolerance

The tolerance in W1 shall be ±1nm.

6.1.2.8. Full Width at T_{max}/100 (W2)

Table 3 lists goal values for W2 for the narrow-band filters. Final W2 shall be agreed by CEFCA during the design phase.

6.1.2.9. W2 Tolerance

The tolerance in W2 shall be ±1nm.

6.1.3. Functional requirements for all filters

6.1.3.1. Peak Transmittance (T_{max})

The peak transmittance within passband shall be higher than 85% (with a goal of >90%) except for filters #1, #2 and #3. For these three filters, the peak transmittance within passband shall be higher than 70% (with a goal of >80%).

6.1.3.2. Peak Transmittance Uniformity

The peak transmittance T_{max} shall vary less than ±4% (goal ±2.5%) across the filter's usable area.

6.1.3.3. Transmittance Flatness

The filters transmission function within W1 shall vary (peak-to-valley) less than 7% (goal 5%) of T_{max}, that is, $T_{max} - T_h < 0.07*T_{max}$, except for filters #1, #2 and #3. For these filters, the transmission function within W1 shall vary (peak-to-valley) less than 10% of T_{max}, with a goal of 5%.

6.1.3.4. Short-Wave Blocking Range

The filters shall block light with wavelength in the interval [λ_1, λ_2], where λ_1 = 250 nm and $\lambda_2 = \lambda_{100}$ - 0.5 nm, being λ_{100} the wavelength at with the filter transmission is T_{max}/100, with λ_{100} < CW.

6.1.3.5. Long-Wave Blocking Range

The filters shall block light with wavelength in the interval [λ_3, λ_4], where λ_4 = 1050 nm (goal 1100 nm) and $\lambda_3 = \lambda'_{100}$ + 0.5 nm, being λ'_{100} the wavelength at with the filter transmission is T_{max}/100, with λ'_{100} > CW.

6.1.3.6. Upper Transmittance Limit Within Blocking Ranges (T_b)

The upper transmittance limit within the short- and long-wave blocking ranges (T_b) shall be, on average, lower that $10^{-5}*T_{max}$.

6.1.3.7. Statement of Continuity

Transmission curves of two adjacent J-PAS filters shall overlap at transmissions higher than $0.70*T_{max}$ at any filter position of the filter's usable area (goal $0.75*T_{max}$ or higher).

Figure 7 illustrates the adjacent filters overlapping requirement. The overlapping points of two adjacent filters are marked with black circles. Upper panel shows the ideal case while the lower one shows a more realistic situation in which the overlapping occurs at wavelengths where the filter transmittance is higher than $0.75*T_{max}$.

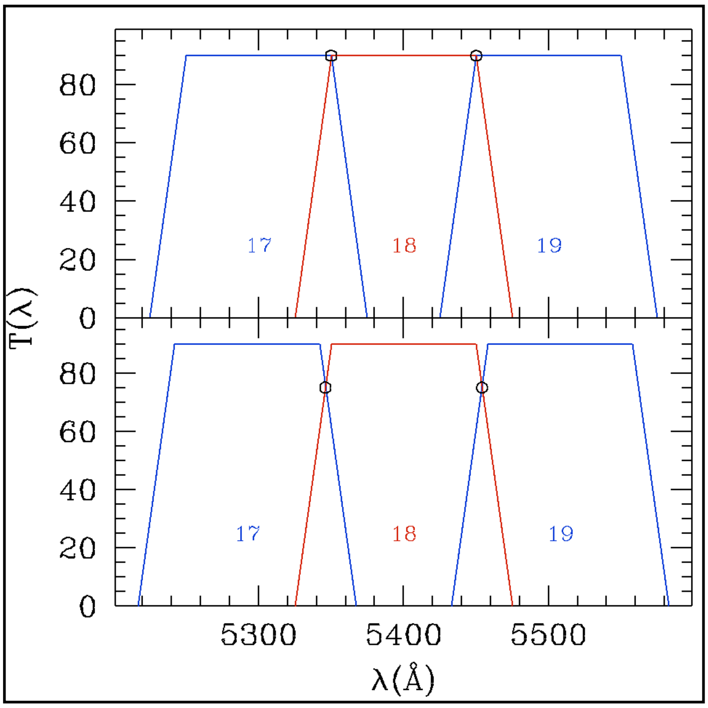

Figure 7: Adjacent filters overlapping.

If required to fulfil this statement of continuity, some flexibility in requirements 6.1.2.2 and 6.1.2.4 is allowed. In that case, any change in these requirements shall be agreed by CEFCA.

6.2. Physical Requirements

6.2.1. Filters Substrate Material

The reference filters substrate material shall be suprasil or B270, with the exceptions described in requirement 6.2.3.

6.2.2. Filters Effective Refractive Index

The filters effective refractive index shall be in the range [1.45, 1.56], the goal being a refractive index as close as possible to that of suprasil.

6.2.3. Filters Total Reflectivity

In order to reduce undesired ghosts in the final images, the filters shall be designed to minimise reflectivity. Figure 8 shows the location of each filter within the five available JPCam filter trays. From now on, "internal filters" refers to filters located in filter tray positions 1 to 4, while "external filters" refers to filters located in filter tray positions 5 to 14.

6.2.3.1. Internal Filters

For internal filters, total reflectivity shall be lower than 1% (average) within the filter's bandpass. When possible, the filters shall minimise total reflectivity within the bandpasses of the four internal filters mounted on the same filter tray.

6.2.3.2. External Filters

For external filters, total reflectivity shall be lower than 1% (average) within the filter's bandpass and within the bandpasses of the four internal filters mounted on the same filter tray.

<u>Suggested option:</u>
In order to reduce the filter's total reflectivity a long-pass, absorbent colorglass substrate could be included in the filter's design. In this design suggestion, the filters substrate material would be be a stack of suprasil or B270 plus an absorbent colorglass whose cut-off wavelength will be filter dependent. The absorption glass cut-off wavelengths shall be defined during the detailed design phase.

6.2.4. Filters Internal Reflections

Filters shall be designed to avoid internal reflections susceptible of creating perceptible ghosts on the final images. The intensity of the parasitic light shall at least six orders of magnitude smaller than the incident light.

6.2.5. Filters Physical Dimension

The filters shall be rectangular, with a dimension of 101.7mm x 96.5mm (TBC) (see figure 9).

6.2.6. Filters Physical Dimension Tolerance

The tolerance in the filters side dimension is ±0.1 mm.

6.2.7. Bevels

Filters shall have 0.1 mm bevels on all edges, 45º.

Figure 8: Alternative filter distribution along the five different filter trays.

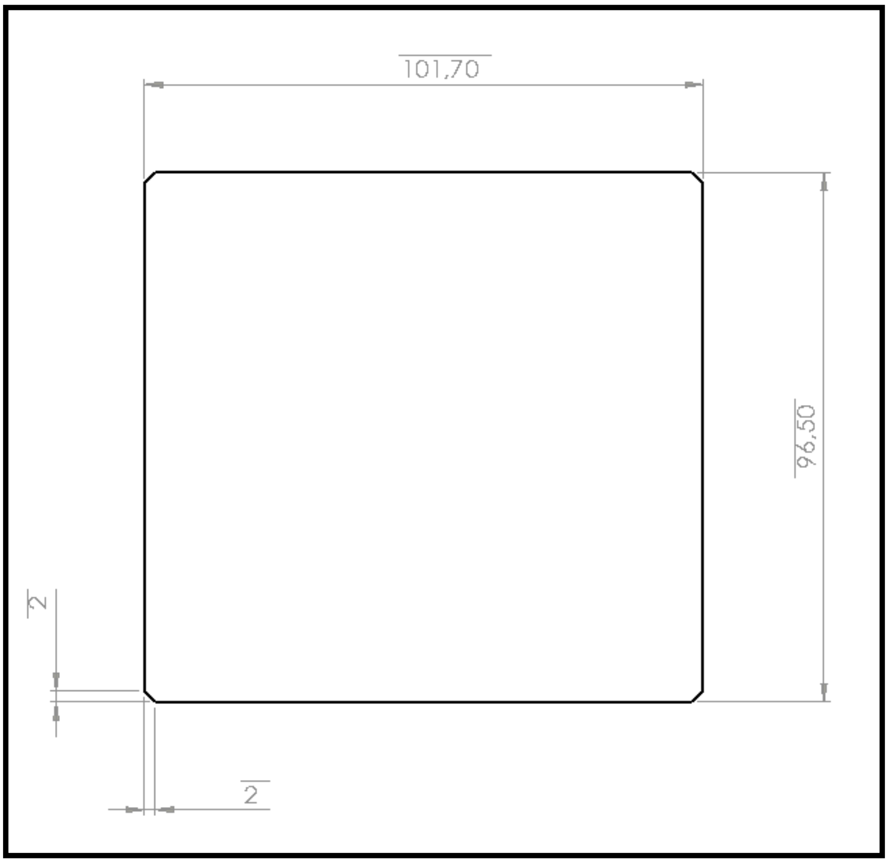

Figure 9: Filters physical dimensions. Units are in mm.

6.2.8. Bevels tolerance

The tolerance in the bevels +0/-0.05 mm.

6.2.9. Corner Chamfer

Filters shall have corner chamfers of 2 mm, 45º (see figure 9).

6.2.10. Clear aperture

The clear aperture shall be equal to the filter's physical size minus the size of the bevel described in requirement 6.2.7.

Note: Filters shall operate in a fast converging beam so the clear aperture in operating conditions is driven by the filter's upper surface (incident light cone). Lower surfaces have less impact in the effective clear aperture.

6.2.11. Substrate Thickness

The substrate thickness shall be 8 mm if the filter's effective refractive index (RI) is equal to that of suprasil. As the observations will be performed with 14 filters at the same time, if the filter's effective RI (including coatings) differs from suprasil then the filter thickness shall be computed for each filter to warrantee image quality on final science images.

In this case, the contractor shall provide the detailed filters' design (including number of coating layers, their thickness and RI, the substrate RI...). Based on each filter's design, CEFCA will perform the system optical analysis and will provide the contractor with the required substrate's thickness.

6.2.12. Substrate Thickness Tolerance

The substrate thickness tolerance shall be ±40 µm, with a goal of ±20 µm.

6.2.13. Filter Thickness

The thickness of the whole filter, including substrates, coatings and any additional component shall be less than 8.5mm.

6.2.14. Surface Roughness

The filter substrate shall be polished to a residual surface roughness of 2 nm R.M.S. or better over its whole clear aperture. Coating blemishes shall be included in the allowable surface roughness.

6.2.15. Surface Imperfections

Surface quality shall meet the 60/40 scratches/digs MIL-C-13830A specifications. Coating blemishes shall be included in the allowable surface imperfections.

6.2.16. Pinhole restriction

No pinhole shall be visible to the unaided eye in viewing chamber defined by Mil-O-13830A. Coating blemishes shall be included in the allowable pinhole restrictions.

6.2.17. Bubbles restriction

The total cross-section of all bubbles/inclusion ≥ 0.03 mm shall be less than 0.5 mm^2 per 100 cm^3 of glass volume.

6.2.18. Maximum Wedge

The wedge shall be lower than 30 arcsec.

6.2.19. Total Transmitted Wavefront Error

Transmitted wavefront RMS error shall be $\lambda/2$ at 632.8 nm over its whole clear aperture (goal $\lambda/4$).

6.2.20. Local Transmitted Wavefront Error

Transmitted wavefront RMS error shall be λ/8 at 632.8 nm in each sub-aperture of 25mm x 25mm (goal λ/16).

6.3. Operational Requirements

6.3.1. Environmental Requirements

The filter set shall be designed to operate and survive in the general conditions of the OAJ. In particular, it shall operate in the conditions given in the table below.

The filter requirements shall be fulfilled under the Nominal conditions. The filters shall be able to operate up to the Limit of operation conditions but the filters specifications do not need to be fulfilled to this level. Under Survival conditions the filters are assumed not to be in operation.

	Nominal conditions	Limit of operation	Survival limit
Temperature	-15°C to +10°C	-20°C to +20°C	-25°C to +25°C
Thermal variation (at night) in 15 minutes	0°C to 0.9°C	N/A	N/A
Thermal variation (at night) in 1 hour	0°C to 1.8°C	N/A	N/A
Thermal variation (at night) in 2 hours	0°C to 2.4°C	N/A	N/A
Relative humidity	2% to 90%	95% (or condensation)	0% to 100% with condensation

6.3.2. Autofluorescence

If the filters show a level of autofluorescence, it shall occur in a wavelength out of the CCD sensitivity range [250nm, 1050nm] (goal [200nm, 1100nm]). The CCD sensitivity curve is shown in figure 10. If the autofluorescence occurs at a wavelength within the CCD sensitivity range, the filter design shall block this autofluorescence avoiding its impact on the CCD.

6.3.3. Edge Marking

The filters edge shall be marked with the customer's name, filter's description, filter's orientation and the manufacturing trace code.

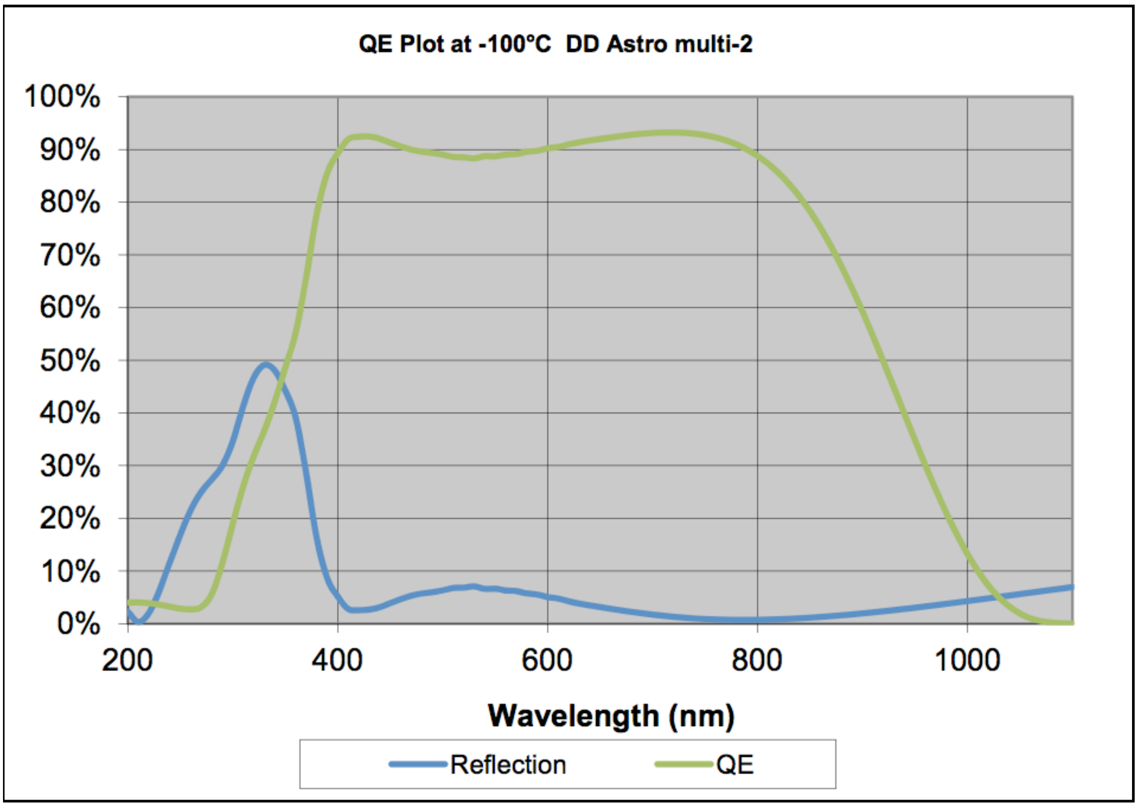

Figure 9: Quantum efficiency curve of the CCD.

6.3.4. Packaging, Handling, Storage and Transportation Requirements

The equipment supplied under the resulting contract shall be cleaned and prepared in the workshop prior to shipping. The shipping package shall be designed to support normal air and sea transport conditions. The package shall be also designed to be used for preventive and maintenance tasks and in case of reparation. It shall be designed to support at least 10 packing and 10 unpacking operations keeping all its performances.

The filters shall be also delivered with the appropriate long term storing boxes or filter supports. The design of these items shall prevent the filters from being damaged under the conditions at the OAJ clean room environment during a period of time larger than 5 years.

6.3.5. Delivery

The contractor shall deliver the **two** sets of J-PAS filters to the CEFCA headquarters: in Plaza San Juan 1, planta 2, E44001, Teruel.

6.4. Reliability Requirements

6.4.1. Filters Lifetime

The filters shall be designed for a minimum lifetime of 10 years of operation.

6.4.1. AR coating durability

The minimum AR coating durability shall meet the MIL-C-48497A specifications.

6.5. Documentation

For each filter, the following documentation shall be provided:
- ASCII file with the spectrophotometric trace of filter's transmission band under working conditions (f/#=3.64) in %T. Transmission data shall be measured at several locations over the filter's usable area (see verification plan).
- ASCII file with the spectrophotometric trace of filter's reflectivity under working conditions (f/#=3.64) in %R. Reflectivity data shall be measured at several locations over the filter's usable area (see verification plan).
- Certificate of acceptance.
- Procedure for cleaning the filters.

7. WORKING PLAN

There are 3 phases identified during the process of manufacturing the filters:

- ***Phase 1. Design***. During this phase the contractor shall produce a detailed design of the filters to fulfill the requirements. The detailed design shall be agreed and approved by CEFCA.

- ***Phase 2: Manufacturing and Verification.*** In this phase, the contractor shall manufacture the filters. The filters will be tested for functionality and verification at the contractor's premises. People from CEFCA will be invited to participate in the testing in order for CEFCA to certify the fulfillment of the requirements. This will constitute the Preliminary Acceptance of the filters.

- ***Phase 3*: *Packing, shipping to CEFCA and verification***. After the Preliminary Acceptance, the filters will be packed and shipped to CEFCA, in Teruel. Filters shall be delivered clean. The contractor shall be responsible, in cost and risk, to transport the equipment manufactured from its facilities to the CEFCA facilities. The filters should arrive at CEFCA in no more than 2 weeks after the Preliminary Acceptance. CEFCA shall make all tests to verify the integrity and functionality of the filters. The whole process shall not take more than 5 weeks. The process will be terminated with the Final Acceptance certificate.

8. VERIFICATION PLAN

The filter requirements shall be measured and validated at the contractor premises. The contractor shall provide a verification matrix designed to demonstrate fulfillment of requirements. This verification matrix shall be agreed by CEFCA. Verification tests shall be accomplished following the agreed verification methods. Appendix A shows a verification matrix that can be used as a guideline for the final verification matrix definition.

9. COST

The maximum cost of the present contract shall be **1.100.000,00** EUR, taxes excluded.

10. DELIVERY TIME

The maximum delivery time of the J-PAS filters shall be **120 weeks**.

11. APPENDIX A: VERIFICATION PLAN GUIDELINE

The following requirements shall be measured and validated under operating conditions. Verification shall be accomplished by one or more of the following verification methods:

Test (T): When requirements have to be verified by measuring product performance and functionality. The analysis of data derived from test shall be considered an integral part of the test.

Demonstration (D): Can be considered as test where qualitative operational performance and requirements are demonstrated.

Analysis (A): When verification is achieved by performing theoretical o empirical evaluation by accepted techniques, the method shall be referred to as “Analysis”. An example is the modeling and computational simulation.

Inspection (I): When verification is achieved by visual determination of physical characteristics (such as construction features, hardware conformance to document drawings, etc) the method shall be referred to as “Inspection”.

The following Verification Matrix (**VM**) shows the methods that shall be used to accept each one of the critical requirements.

NV means No Verification is needed.

Requirement	Tolerance	Verification Method	Comments
6.1. Functional Requirements			
6.1.1. Functional requirements for $u_{J\text{-}PAS}$’ and Sloan filters			
6.1.1.1. Cut-on wavelength		**T:** Spectrophotometer	
6.1.1.2. Cut-on wavelength tolerance	±3nm	**T:** Spectrophotometer	
6.1.1.3. Cut-on Slope	1%	**T:** Spectrophotometer	
6.1.1.4. Cut-off wavelength		**T:** Spectrophotometer	

6.1.1.5. Cut-off wavelength tolerance	±3nm	**T:** Spectrophotometer	
6.1.1.6. Cut-off Slope	1%	**T:** Spectrophotometer	
6.1.2. Functional requirements for J-PAS filters			
6.1.2.1. Central Wavelength		**T:** Spectrophotometer	
6.1.2.2. Central Wavelength Tolerance	±0.2% of the CW	**T:** Spectrophotometer	
6.1.2.3. Central Wavelength Uniformity	±0.25% of the CW	**T:** Spectrophotometer	
6.1.2.4. FWHM		**T:** Spectrophotometer	
6.1.2.5. FWHM Tolerance	±0.5nm	**T:** Spectrophotometer	
6.1.2.6. Full Width at 0.95*Tmax (W1)		**T:** Spectrophotometer	
6.1.2.7. W1 Tolerance	±1nm	**T:** Spectrophotometer	
6.1.2.8. Full Width at Tmax /100 (W2)		**T:** Spectrophotometer	
6.1.2.9. W2 Tolerance	±1nm	**T:** Spectrophotometer	
6.1.3. Functional requirements for all filters			
6.1.3.1. Peak Transmittance (Tmax)	>85% or >70%	**T:** Spectrophotometer	
6.1.3.2. Peak Transmittance Uniformity	±4%	**T:** Spectrophotometer	
6.1.3.3. Transmittance Flatness	7% p-t-v	**T:** Spectrophotometer	
6.1.3.4. Short-Wave Blocking Range		**T:** Spectrophotometer	
6.1.3.5. Long-Wave Blocking Range		**T:** Spectrophotometer	
6.1.3.6. Upper Transmittance Limit Within Blocking Ranges (Tb)	$Tmax*10^{-5}$ average	**T:** Spectrophotometer	
6.1.3.7. Statement of Continuity	Overlap at >0.70*Tmax	**T:** Spectrophotometer	
6.2. Physical Requirements			
6.2.1. Filters Substrate Material		**A**	
6.2.2. Filters Effective Refractive Index	[1.45, 1.56]	**A**	
6.2.3. Filters Total Reflectivity		**T:** Spectrophotometer	

6.2.3.1. Internal Filters	0.5% within bandpass		
6.2.3.2. External Filters	0.5% within bandpass and within internal filters of the same tray		
6.2.4. Filters Internal Reflections	10^{-6}	**T**	
6.2.5. Filters Physical Dimension	(TBC)	**T**: Mechanical probe	
6.2.6. Filters Physical Dimension Tolerance	±0.1mm	**T**: Mechanical probe	
6.2.7. Bevels	0.1 mm, 45º	**I**: Magnifying lens	
6.2.8. Bevels tolerance	±0.05mm	**I**: Magnifying lens	
6.2.9. Corner Chamfer	2 mm, 45º	**I**: Magnifying lens	
6.2.10. Clear aperture	(TBC)	**T**: Micrometer	
6.2.11. Thickness		**T**: Micrometer	
6.2.12. Thickness Tolerance	±40µm	**T**: Micrometer	
6.2.13. Filter Thickness		**T**: Micrometer	
6.2.14. Surface Roughness	2 nm R.M.S.	**T**: White light interferometer	
6.2.15. Surface Imperfections	60/40 scratches/ digs MIL-C-13830A	**I**: Visual	
6.2.16. Pinhole restriction	Mil-O-13830A	**I**: Visual	
6.2.17. Bubbles restriction		**I**: Visual	
6.2.18. Maximum Wedge	30 arcsec	**T**: Micrometer	
6.2.19. Total Transmitted Wavefront Error	λ/2 at 632.8 nm	**T**: Interferometer	
6.2.20. Local Transmitted Wavefront Error	λ/8 at 632.8 nm in each sub-aperture of 25mm x 25mm	**T**: Interferometer	
6.3. Operational Requirements			

6.3.1. Environmental Requirements	Temp. of operation: -15ºC to +10ºC	**T:** Spectrophotometer	A minimum of one filter shall be measured at -15ºC, -5ºC and +10ºC (performances and thermal cycle). Measurements shall include filter's transmission curve and TWFE.
6.3.2. Autofluorescence		**A**	
6.3.3. Edge Marking		**I**: Visual	
6.3.4. Packaging, Handling, Storage and Transportation Requirements		**A**	
6.4. Reliability Requirements			
6.4.1. Filters Lifetime	10 Years		
6.4.1. AR coating durability	MIL-C-48497A		
6.5. Documentation			

Zaragoza, a 13 de Diciembre de 2013

El VICEPRESIDENTE DEL PATRONATO

Fdo: Miguel Ángel García Muro