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Very Large Telescope Paranal Science Operations PIONIER Template Manual

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List of Abbreviations

AT	Auxiliary Telescope
CS	Constraint Set
ESO	European Southern Observatory
GPAO	Gravity+ Adaptive Optics
LST	Local Sidereal Time
NAOMI	New Adaptive Optics Module for Interferometry
OB	Observation Block
OD	Observation Description
OPC	Observation Program Committee
OT	Observation Toolkit
PIONIER	Precision Integrated-Optics Near-infrared Imaging ExpeRiment
SM	Service Mode
TSF	Template Signature File
USD	User Support Department
UT	Unit Telescope
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer

1 INTRODUCTION

1.1 Scope

This document describes the **templates** for the PIONIER interferometric instrument.

Like for all VLTI instruments, observations with PIONIER are carried out with **observation blocks** (OBs) grouped into **concatenations**. The OBs and concatenations must be prepared and submitted by the user during Phase-2 preparation. An OB consists of a set of information and several templates that describe the target acquisition and the observation sequence. For these templates, the user has to indicate the values of **keywords** (parameters). The OBs for science and calibrator stars are grouped into concatenations, i.e. sequences of OBs to be carried out one after the other.

This manual requires the user to already have an insight of PIONIER operation, as described in the “PIONIER User Manual”, that can be downloaded from:

<http://www.eso.org/sci/facilities/paranal/instruments/pionier/manuals>

For instructions about phase 2, see:

<http://www.eso.org/sci/observing/phase2/>

For service mode observations, it is important to read the PIONIER-specific service mode instructions given on the webpage:

<http://www.eso.org/sci/observing/phase2/SMGuidelines.PIONIER.html>

This page gives suggestions for OB edition (name, constraint set), as well as the requirements for the “readme” file and for the finding charts.

1.2 Contact information

In case of questions or suggestions related to Phase-2 preparation, please contact the ESO User Support Department (usd-help@eso.org).

1.3 Period of validity of this manual

This manual only applies for observations with PIONIER in ESO Period 116, starting 1 October 2025 and ending 30 April 2026.

1.4 Glossary

- **Constraint Set (CS)**

List of requirements for the conditions of the observation that is given inside an OB. OBs are only executed under this set of minimum conditions.

- **Observation Block (OB)**

An Observation Block is the smallest schedulable entity for the VLT. It consists in a sequence of Templates. Usually, one Observation Block include one target acquisition and one or several templates for exposures.

- **Observation Description (OD)**

A sequence of templates used to specify the observing sequences within one or more

OBs.

- **Observation Toolkit (OT)**

Tool used to create queues of OBs for later scheduling and possible execution (service mode).

- **Proposal Preparation and Submission (Phase-I)**

The Phase-I begins right after the Call-for-Proposal (CfP) and ends at the deadline for CfP. During this period the potential users are invited to prepare and submit scientific proposals. For more information, see:

<http://www.eso.org/sci/observing/phase1.html>

- **Phase-2 Proposal Preparation**

Once proposals have been approved by the ESO Observation Program Committee (OPC), users are notified and the Phase-2 begins. In this phase, users are requested to prepare their accepted proposals in the form of OBs, and to submit them by Internet. For details and instructions see:

<http://www.eso.org/sci/observing/phase2.html>.

- **Service Mode (SM)**

In service mode (opposite of the “Visitor-Mode”), the observations are carried out by the ESO Paranal Science-Operation staff (PSO) alone. Observations can be done at any time during the period, depending on the CS given by the user. OBs are put into a queue schedule in OT which later send OBs to the instrument.

- **Template**

A template is a sequence of operations to be executed by the instrument. The observation software of an instrument dispatches commands written in templates not only to instrument modules that control its motors and the detector, but also to the telescopes and VLTI sub-systems.

- **Template signature file (TSF)**

File which contains template input parameters.

- **Visitor Mode (VM)**

The classic observation mode. The user is on-site to supervise his/her program execution.

2 PIONIER TEMPLATES

2.1 Observing modes

As indicated in the “PIONIER User Manual” and webpages, the following instrumental setup will be offered for P116:

- The fringes can either be dispersed (GRISM) or undispersed (FREE)

Hence, the number of templates for P116 is small:

1. Preset, acquisition and fringe search
2. Fringe track observation, either as a science or calibrator target
3. Beam combiner kappa-matrix exposures
4. Detector dark exposure

Each OB must have all four of these templates, in exactly this order, but the kappa-matrix should actually be executed *only* on the brightest target of a concatenation.

The OBs have to be combined into concatenations. Two options exist for concatenations to be observed with PIONIER: Either three OBs of the structure calibrator-science-calibrator or five OBs of the structure calibrator-science-calibrator-science-calibrator. For the execution time policy adopted by ESO for observations with PIONIER see the Table on the PIONIER webpages at <http://www.eso.org/sci/facilities/paranal/instruments/pionier/overview.html>. The further instrumental parameters, which cover basically the detector setup, depend on the sky conditions and will be adapted by the operator at the time of observations. Except for targets brighter than $m_H = 1$ mag we guarantee that these parameters are not changed during the execution of a concatenation. *However, in order to be able to do so, calibrators and science targets have to be of similar brightness, with the difference optimally not exceeding about 1 magnitude.*

Since for brighter targets suitable calibrators are often not available, cross-calibration with different detector gains may be required. This introduces systematic effects to the visibility transfer function of up to 5% and may not be suitable if the highest absolute precision is needed. For bright targets, it is desirable to select calibrators of $H=2.5$ and brighter, to ensure they can be done at least with MEDIUM gain.

Thus, the number of keywords to be set by the user is very limited.

2.2 The acquisition template

According to the observing block rules, the first template in an OB must be an acquisition template. In the case of PIONIER, the name of this template is: *PIONIER_acq*.

The sequence of this template starts by a “preset”: the target coordinates (α, δ) are sent to the telescopes and the delay lines, so they can slew to the position corresponding to the target coordinate at preset time. Once the telescopes are tracking and coudé-guiding, the target should be seen in IRIS. To ensure beam interference, the images from both beams must be overlapped. This is done by centering them on the beam reference pixels on IRIS that are determined at the beginning of every night.

For properties and limitations of the telescopes and the VLTI see the VLTI user manual. The template parameters for the guide star must be set by the user (see Sect. 2.6.1).

2.3 The observation template

This template is the second in any PIONIER OB description for P116. The observation template records interferograms by scanning. Depending on whether the target is a science or calibrator object, the template *PIONIER_obs_science* or *PIONIER_obs_calibrator* must be used. In terms of observational procedure, both templates are identical, but the recorded data is handled differently in the archive and for data reduction.

2.4 The dark template

This template, *PIONIER_gen_cal_dark*, is the third in any PIONIER OB description for P116. It closes all shutters and records a number of dark exposures. The only keyword, SEQ.DOIT, must be set to “T” in all cases, i.e. a dark exposure must not be skipped.

2.5 The kappa matrix template

This template, *PIONIER_gen_cal_kappa*, is the fourth in any PIONIER OB description for P116. It sequentially opens the shutters for each beam and records a number of exposures to determine the light splitting ratios between each of the four input beams into the 24 output beams.

Note that in service mode, the only keyword, SEQ.DOIT, must be set to “T” in only one OB of a concatenation, and “F” in all others. The purpose to nevertheless have a template in all OBs is to enable the operator to take an additional kappa matrix if desirable.

2.6 User keywords

In the following tables, we give for each template the keywords that have to be set by the user.

2.6.1 PIONIER_acq

Keyword name	Description	Unit, format, possible values	Default value
TEL.TARG.PARALLAX	Parallax of the target	−1 to 1 in arcsec	0
TEL.TARG.MAG.H	Magnitude in H-band (1.6 μm) of the target	m_H	0
INS.DISP.NAME	Dispersive element	FREE or GRISM	FREE
COU.AO.TYPE	Coudé guiding mode, only natural guide star in the visible for PIONIER	NGS_VIS for automatic acquisition (point sources, no crowded field), NGS_VIS_TCCD for manual acquisition	NGS_VIS
COU.NGS.SOURCE	Type of coudé guiding	SCIENCE: no off-target guiding, other COU.. keywords except magnitude are ignored SETUPFILE: off-target guiding, guide star used	SCIENCE
COU.NGS.NAME	Guide star name	Catalog identifier	Name
COU.NGS.ALPHA	Right ascension of coudé guide star	HH:MM:SS.SS (e.g.: 22:54:30.53 for 22 h 54 m 30.53 s)	0
COU.NGS.DELTA	Declination of coudé guide star	DD:MM:SS.SS (e.g.: -16:22:45.91 for -16° 22' 45.91")	0
COU.NGS.PARALLAX	Parallax of the guide star	−1 to 1 in arcsec	0
COU.NGS.PMA	Right ascension proper motion of coudé guide star	arcsec/year	0
COU.NGS.PMD	Declination proper motion of coudé guide star	arcsec/year	0
COU.NGS.EPOCH	Epoch of coordinates and proper motion of coudé guide star	year	2000
COU.NGS.MAG	Natural guide star magnitude as seen by sensor	m_R	0
ISS.BASELINE		see VLTi manual	None
ISS.VLTITYPE		see VLTi manual	None

Notes:

- If you are not using an off-axis coudé target, you **MUST** enter as value of `COU.NGS.MAG` the *R*-band magnitude of your target. The minimum allowed magnitude (i.e. maximum flux) -1.7 with the ATs.
- If the target or the off-axis guide star is a variable star, the magnitude of the star when it is at its maximum of brightness (i.e., the minimum magnitude) should be given for `COU.NGS.MAG`, this to prevent the coudé detectors from being overilluminated for having set up an underestimated neutral density. Also, a comment should be added in the OB, specifying the magnitude interval of the star.
- If no off-axis guiding is used (`COU.NGS.SOURCE=SCIENCE`) values for `COU.NGS.ALPHA` and `COU.NGS.DELTA` can be left at zero.
- Possible values for `ISS.BASELINE` and `ISS.VLTITYPE` are given in the VLTi manual for the respective period.

2.6.2 PIONIER_obs_science and PIONIER_obs_calibrator

Keyword name	Description	Unit, format, possible values	Default value
<code>SEQ.NEXPO</code>	Number of fringe track exposures	integer value, 1 to 100	5

Notes:

- The choice of template implicitly sets the `DPR.CATG` keyword to either `SCIENCE` or `CALIB`.
- 5 fringe tracks are the mandatory value for `SEQ.NEXPO` for service mode observations. The value can be modified only in visitor mode.

2.6.3 PIONIER_gen_cal_dark

Keyword name	Description	Unit, format, possible values	Default value
<code>SEQ.DOIT</code>	Determines whether the dark is taken	T/F	T

- The dark expoure is mandatory for all observations, i.e. the value must always be set to "T".

2.6.4 PIONIER_gen_cal_kappa

Keyword name	Description	Unit, format, possible values	Default value
<code>SEQ.DOIT</code>	Determines whether the kappa matrix is taken	T/F	T

Notes:

- Only one kappa matrix per concatenation must be set to "T", all others must be "F".

2.6.5 Observation description

As mentioned in Sect. 2, possible ODs are limited to two options, depending on whether the target is a science or calibrator object. Any OD begins with the acquisition template *PIONIER_acq*, then one execution of either *PIONIER_obs_science* or *PIONIER_obs_calibrator*, which is followed by *PIONIER_gen_cal_dark* and *PIONIER_gen_cal_kappa*.

2.7 Constraints on the concatenation level

- A concatenation for PIONIER can have three or five OBs. The first OB in a concatenation must have the *PIONIER_obs_calibrator* template, the following must alternate between *PIONIER_obs_science* and *PIONIER_obs_calibrator* templates, i.e. concatenations are either CAL-SCI-CAL or CAL-SCI-CAL-SCI-CAL.
- The CAL targets can be different objects, e.g. to encircle the SCI target, but the SCI targets in the CAL-SCI-CAL-SCI-CAL concatenation must be identical.
- The LST windows of the calibrator OBs must extend to 15 minutes before and after the LST windows of the science OB(s).
- Only one kappa matrix template per concatenation can have the SEQ.DOIT keyword set to “T” (for “TRUE”). This should usually be done on the brightest target of the concatenation.

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