NEWFIRM

SYSTEM DESIGN NOTE

Title: SDN9006 NEWFIRM Observational Recipe Book					
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National Optical Astronomy Observatories
Kitt Peak National Observatory Mayall 4m Telescope
NOAO Extremely Wide Field Infra-Red Mosaic Project
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NEWFIRM Observation Recipe Book

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Abstract. This documents the observation recipes and scripts used by NEWFIRM as well as the expected output(s) to the data handling system.

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1. Introduction

This document attempts to bring together several threads of thought on the day-to-day operation of the NEWFIRM camera. It is an attempt, then, to codify the recognized use cases [1] in the context of the observation control system (NOCS) and the data handling system (DHS) [2, 3, 4]. Note that the commands described may, at first, appear cumbersome but they can (and will) be hidden behind user-friendly graphical user interfaces.

1.1. Definition of an Observation

The fundamental element is the *observation* which may consist of a set of coadded exposures using high-order Fowler sampling and/or per-pixel digital averaging. The details of coaddition, Fowler sampling and digital averaging are internal to the MONSOON image acquisition system and, although they are free parameters to the astronomer, the end result is *always* the same: 1 full array readout—*the observation*—is sent to the DHS. Although there is a facility in MONSOON for sending the separate coaddition images, this is not expected to be used in science observing.

Setting up MONSOON to take data in an appropriate way is also straightforward involving setting it into a known mode and then adjusting the free parameters. We could do this by hand:

```
gpxSetMode    nfDark
gpxSetAVP     intTime=1.5
gpxSetAVP     coadds=1
gpxSetAVP     fSamples=1
gpxSetAVP     acq0DigAvg=1
gpxSetAVP     acq1DigAvg=1
gpxSetAVP     acq2DigAvg=1
gpxSetAVP     acq3DigAvg=1
gpxSetAVP     seqDigAvgCntr=1
```

These global modes will have been determined beforehand by instrument scientists and detector engineers for optimum performance for the required observation. In the rest of this document, we assume that these modes already exist.

The simplest observation involves flushing meta-data to the DHS first, exposing the chip to light and then updating the meta-data to the DHS. The known meta-data items, at the time of writing, are given in ‘attribute-value-comment’ format in Tables 5, 6, 7 and 8 in Appendix 16. on page 22. Thus we can write a canonical Observe.EXEC as follows:

```
!! Observe.EXEC   Canonical data capture sequence
nohs_newobs       !! Pre-observation meta data
gpxStartExp       !! Start the observation
nohs_endobs       !! Post-observation meta data
```

Although the pre- and post-observation meta-data delivered to the DHS are documented, there are some items that would assist the data handling pipeline in configuring itself to take appropriate action when data floods the pike. These items are shown in Table 1. Note that NFOBSTYP may be one of: BIAS, DARK, DFLATON, DFLATOFF, TFLAT, SFLAT, ARC, CALIB, OBJECT or SKY and that at the start of every minimum schedulable block, the NFOBSNO counter resets to 1.

1.2. Definition of a Dither, Double Dither, Map or Offset

To allow full sampling and area coverage, three techniques are used—dithering, offsetting and mapping—with the discriminating factor being the size of the shift between observations. In *dithering*, this offset is typically $<10\%$ of the field size ($\sim$arcseconds) whereas in *mapping* it is, typically, of the order of the field of view ($\sim$25arcminutes). However, be aware that there is no strict

Table 1.: Per-Observation Volatile Meta-Data

Name	Description
NFOBSMSB	minimum schedulable block identifier
NFOBSRSD	recipe star date
NFOBSTIM	observation time requested
NFOBSNUM	number of observations requested
NFOBSID	observation identifier
NFOBSNO	observation number (in this sequence)
NFOBSTOT	total number of observations (in this sequence)
NFOBSFIL	filter
NFOBSDPAT	dither pattern
NFOBSDITER	dither iterations requested
NFOBSDROF	dither offset in RA
NFOBSDDOF	dither offset in Dec
NFOBSDUNIT	dither units
NFOBSDREP	dither sequence number
NFOBSDPOS	dither position number
NFOBSMPAT	map pattern
NFOBSMITER	map iterations requested
NFOBSMROF	map offset in RA
NFOBSMDOF	map offset in Dec
NFOBSMUNIT	map units
NFOBSMREP	map sequence number
NFOBSMPOS	map position number
NFOBSORA	offset in RA
NFOBSODEC	offset in Dec
NFOBSOUNIT	offset units
NFOBSTYP	observation type
NFOBSDHS	recipe for data handling

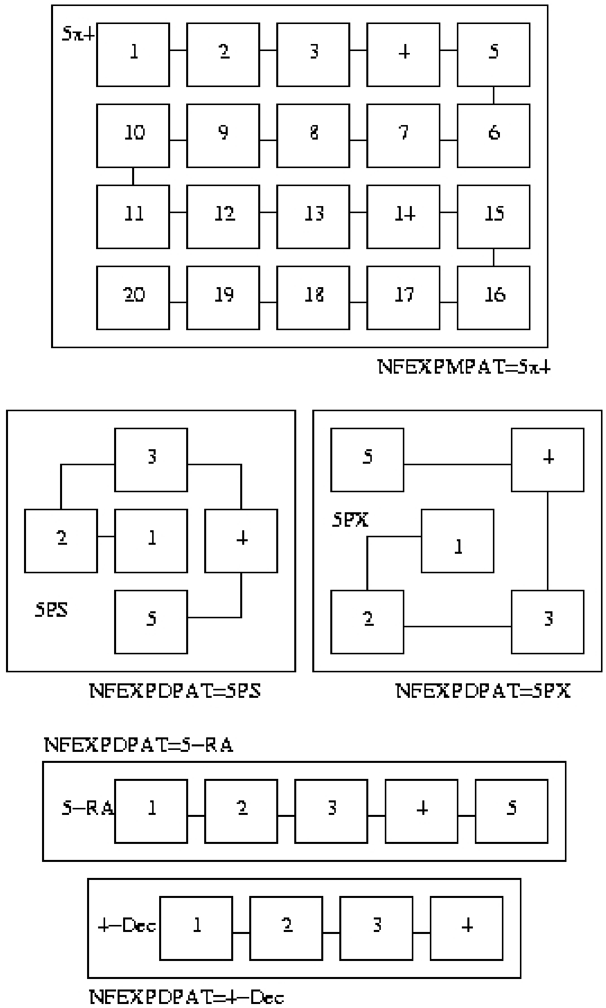

Figure 1.: NEWFIRM Dither/Mapping Patterns

demarcation for these offset sizes and in some recipes a dither can (and is) executed over a tightly-constrained map with offsets of the same order as the dither pattern. Such a technique can also be referred to as 'double dithering'. Offsetting, alone, is a move to blank sky and may be a considerable distance from the target object (∼degrees). In order to give the astronomer the most flexibility, the following generic dither/offset/map patterns are recognized:

***n*–RA** The observation position is adjusted in RA only.

***n*–Dec** The observation position is adjusted in Declination only.

n*×*m the observation position is adjusted as shown for a 5×4 pattern in figure 1.2.

5PS the observation position spirals out from the centre as shown in figure 1.2.

5PX the observation position forms a cross as shown in figure 1.2.

The DHS *must* recognize that these are *generic* names for documentation only. The observation meta-data items NFOBSDPAT and NFOBSMPAT will contain specific values for the patterns as seen, by example, in the figure.

1.3. Observing Pseudo-Code

The acceptance of multiple observations, multiple filters, multiple dithers and multiple map options complicates the data taking process so recipes are required so that the NOCS/DHS interface remains scientifically useful. These recipes are described below with the idea of describing the data taking sequences in pseudo-code as defined in Table 2.

Table 2.: NEWFIRM Observing Recipes Pseudo-Code

Item	Description
gpxSetMode *mode*	Set MONSOON into *mode*
gpxSetAVP P_1 P_2 ... P_n	Adjust $P1_1$, $P2_2$, ... P_n
nics_filter *name*	Move filter wheel to *name*
ndgi_moveto DomeFlatScreen	Move telescope to dome flat screen
ndgi_moveto Zenith	Move telescope to zenith
ndgi_moveto Osunset	Move telescope to sky opposite Sunset
ndgi_moveto *RA Dec Epoch*	Move telescope to *(RA,Dec)* co-ordinates for *Epoch*
ndgi_offset δRA δDec	Offset telescope from *current* position by given amounts
set D_{pat} D_{ra} D_{dec} D_{iter}	Select dither pattern, RA,Dec offsets and repeats
set M_{pat} M_{ra} M_{dec} M_{iter}	Select map pattern, RA,Dec offsets and repeats
do *n* { *seq* }	Execute {*seq*} *n*-times

1.4. Command Line Interface Parameters

For every observing recipe identified, there is a command line interface that allows the astronomer to execute some simple tests or a whole program without using databases, observing tools and the like. Common to *all* these commands are a set of parameters shown in Table 3. Note that there is *no* space between the parameter and any required data value! If a parameter is *not* specified, a default value is used as shown in the last column of Table 3. Optional parameters are shown in Table 4.

Table 3.: Common Command Line Interface Parameters

Syntax	Data Type	Description	Default
–C*i*	int	number of coadds per observation	1
–D*i*	int	number of digital averages	1
–F*i*	int	number of Fowler samples	1
–H	none	print help text and exit	n/a
–I*f*	float	integration time per observation	1.0 second
–R	none	execute script immediately	TRUE if present
–X	none	do nothing but shown configuration	TRUE if present
–x	none	dump EXEC to local disk	TRUE if present

Three forms of telescope position are recognized:

Table 4.: Optional Command Line Interface Parameters

Syntax	Data Type	Description	Default
–fs	string	filter	J
–h f	float	integration time for H filter	1.0 second
–j f	float	integration time for J filter	1.0 second
–k f	float	integration time for K filter	1.0 second
–ni	int	number of observations	1
–si	int	number of sky frames	1
–ts	string	telescope position	zenith
–dd$\pm f$	float	dither Dec offset	30.0 units
–di$i$	int	dither iterations	1
–dp$s$	string	dither pattern	None
–dr$\pm f$	float	dither RA offset	30.0 units
–du$s$	string	dither units	arcseconds
–od$\pm f$	float	Dec offset	0.0 units
–or$\pm f$	float	RA offset	0.0 units
–ou$s$	string	offset units	RA,Dec co-ordinates
–md$\pm f$	float	map Dec offset	30.0 units
–mi$i$	int	map iterations	1
–mp$s$	string	map pattern	None
–mr$\pm f$	float	map RA offset	30.0 units
–mu$s$	string	map units	arcminutes

–tz — zenith

–to — opposite Sunset

–thh:mm:ss.ss,±dd.dddd,epoch — RA=hh:mm:ss.ss, Dec=±dd.dddd, Epoch=epoch

2. DARK: Dark Observation

2.1. Description

This is the simplest type of obervation recipe in which a sequence of observations is taken of the *cold dark* (CD) filter with no light falling on the detector. Integration times are the same as those used during typical, night-time science observing although this recipe can be executed during daylight hours.

2.2. Recipe

title DARK	!! DARK
gpxSetMode nfDark	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
nics_filter CD	!! Move to CD filter
do *n* Observe.EXEC	!! Take data

2.3. nfd [–n*i*]

Alias(es): nfDark

2.4. Worked Example(s)

nfDark –H

```
nfDark, v1.0.0, P. N. Daly, 15-Sep-2004.
(C) AURA Inc.  All rights reserved.

Use:  nfDark -Cint -Dint -Fint -H -Iflt -R -nint

Parameters(s):
  -Cint - number of coadds per observation [default:  1]
  -Dint - number of digital averages [default:  1]
  -Fint - number of Fowler samples [default:  1]
  -H - print help text and exit [default:  n/a]
  -Iflt - integration time per observation [default:  1.0]
  -R - execute script immediately [default:  T if present]
  -nint - number of observations [default:  1]

Example:
% nfDark -I60.0 -R -n10
  This example will produce 10 DARK observations (-n10)
  of 60.0 seconds each (-I60.0) and the script will be
  sent for immediate execution (-R).
```

nfd –I15.0 –R –n4

This command will produce 4 DARK observations (–n4), each of 15.0 seconds (–I15.0) and the script will be sent for immediate execution (–R). In Table 9, on page 27, the NFOBSRSD is 2453243.6281214454211295.

3. DFLAT: Dome Flat Observation

3.1. Description

This calibration recipe requires the telescope be moved the the dome flat screen and the dome flat lamp turned off or on as required. A sequence of observations is then taken. Typically, this is repeated in the other filters. This recipe can be executed during daylight hours.

3.2. Recipe

title DFLAT	!! DOME FLAT
gpxSetMode nfDflat	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
ndgi_moveto DomeFlatScreen	!! Move telescope
nics_filter { J || H || K }	!! Move to desired filter
break	!! BREAK: turn lamp on or off
do *n* Observe.EXEC	!! Take data

3.3. nfdfon [–f*s* –n*i*]

Alias(es): nfDomeFlatOn

3.4. nfdfoff [–f*s* –n*i*]

Alias(es): nfDomeFlatOff

3.5. Worked Example

nfdfon –I30.0 –fJ –n3

This command will produce 3 DFLATON observations (–n3) in the J filter (–fJ) of 30.0 seconds duration (–I30.0). The script, 2453243.6281274640932679.EXEC, is stored for later execution. Note that is is *assumed* that the dome flat lamp is *on* during the data capture!

4. DFLATS: Dome Flat Sequence

4.1. Description

This calibration recipe is a specific sequence of dome flat observations that can be executed as a single block. As such, it requires two 'breaks' so that the observer can interact with the lamp. This recipe can be executed during daylight hours.

4.2. Recipe

title DFLATS	!! DOME FLAT SEQUENCE
gpxSetMode nfDflat	!! Set up MONSOON
ndgi_moveto DomeFlatScreen	!! Move telescope
break	!! BREAK: turn lamp ON
nics_filter J	!! Move to J filter
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
do *n* Observe.EXEC	!! Take data
nics_filter H	!! Move to H filter
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
do *n* Observe.EXEC	!! Take data
nics_filter K	!! Move to K filter

```
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
do n Observe.EXEC                                !! Take data
nics_filter H                                    !! Move to H filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
nics_filter J                                    !! Move to J filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
break                                            !! BREAK: turn lamp OFF
do n Observe.EXEC                                !! Take data
nics_filter H                                    !! Move to H filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
nics_filter K                                    !! Move to K filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
do n Observe.EXEC                                !! Take data
nics_filter H                                    !! Move to H filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
nics_filter J                                    !! Move to J filter
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
do n Observe.EXEC                                !! Take data
```

4.3. nfdfseq [–n*i* –j *f* –h *f* –k *f*]

Alias(es): nfDomeFlatSequence

4.4. Worked Example

nfdfseq –R –n2 –j35.0 -h25.0 –k15.0

This command requests dome flats to be taken in the filter sequence J–H–K–K–H–J with the flat lamp on, followed by the same sequence with the flat lamp off. To facilitate the interaction with the dome flat lamp, the command produces two *breakpoints* which pause the data capture. At each filter position, 2 observations are made (–n2). Different integration times are specified for each filter (–j35.0, –h25.0 and –k15.0). Therefore, the total number of observations expected is 24. The command is executed immediately (–R) with NFOBSRSD 2453243.6281312829814851 in Table 9 on page 27.

5. TFLAT: Twilight Flat Observation

5.1. Description

This calibration recipe is the first of the on-sky recipes and is, in effect, similar to the DFLAT recipe but with the telescope pointing to sky rather than the dome flat screen. This recipe is, typically, used at the start or at the end of night time observing.

5.2. Recipe

```
title TFLAT                                      !! TWILIGHT FLAT
gpxSetMode nfTflat                               !! Set up MONSOON
```

gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
ndgi_moveto { Zenith || Osunset || RA Dec Epoch }	!! Move telescope
nics_filter { J || H || K }	!! Move to desired filter
do *n* Observe.EXEC	!! Take data

5.3. nftf [–fs –ni –ts]

Alias(es): nfTwilightFlat

5.4. Worked Example

nftf –I35.0 –fK –n2 –tz

This example produces 2 (–n2) K-band (–fK) twilight flat fields of 35 seconds each (–I35.0) with the telescope pointed at zenith (–tz). The NFOBSRSD is 2453244.4222729508765042 in Table 9 and the script is stored for later execution.

6. SFLAT: Sky Flat Observation

6.1. Description

This calibration recipe, if required, is taken during the night when the astronomer desires to have images of realtively empty fields specifically to construct flat fields. This occurs when the science field is very rich in sources or contains extended objects and the subsequent science frames will, typically, use these flats rather than dome or twilight flats. Since they are 'populated' fields (albeit sparsely), a dither pattern must be executed.

6.2. Recipe

title SFLAT	!! SKY FLAT
gpxSetMode nfSflat	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
nics_filter { J || H || K }	!! Move to desired filter
do D_{iter} {	!! Repeat
ndgi_moveto RA Dec Epoch	!! Move telescope
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC }	!! Take data
ndgi_moveto RA Dec Epoch	!! Move back to home
}	!! End

6.3. nfsf [–dd±f –dii –dps –dr±f –dus –fs –ni –ts]

Alias(es): nfSkyFlat

6.4. Worked Example

nfsf –I30.0 –R –fH –to –dr+30.0 –dp2-RA

This example produces 1 (–n=1 by default) H-band (–fH) sky flat of 30 seconds duration (–I30.0) at each dither position of 2-RA (–dp2-RA) offset by 30 seconds of arc in RA only (–dr30.0). The Dec offset defaults to zero, the units default to seconds of arc and the number of iterations defaults to 1. The total number of frames is 2 (one at each position). The telescope points opposite Sunset (–to) and the script is executed immediately (–R). The NFOBSRSD is 2453243.6345678901234567 in Table 10.

7. SFLATO: Sky Flat Offset Observation

7.1. Description

This calibration recipe has a similar use to the previous, related, case but includes offsets and a 'double dither' mapping technique. That is to say a tightly constrained mapping pattern is used with a dither at two different sky positions.

7.2. Recipe

title SFLATO	!! SKY FLAT OFFSET
gpxSetMode nfSflato	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
foreach M_{pos} in M_{pat} {	!! StartMap
ndgi_moveto RA$_i$ Dec$_i$ Epoch	!! Move telescope to i-th position
foreach D_{pos} in D_{pat} { do n Observe.EXEC }	!! Take data
ndgi_moveto RA$_i$ Dec$_i$ Epoch	!! Move to i-th position home
ndgi_offset δRA δDec	!! Offset telescope
foreach D_{pos} in D_{pat} { do n Observe.EXEC }	!! Take data
}	!! EndMap

7.3. nfsfo [–dd$\pm f$ –di$i$ –dp$s$ –dr$\pm f$ –du$s$ –fs –md$\pm f$ –mi$i$ –mp$s$ –mr$\pm f$ –mu$s$ –ni –od$\pm f$ –or$\pm f$ –ou$s$ –ts]

Alias(es): nfSkyFlatOffset

7.4. Worked Example

nfsfo –I45.0 –fK –t12:12:12,-30.75,2000 –dp5PS –dd+15 –dr+15 –od+45 –or+45 -oum

This command requests 45 second observations (–I45.0) with the K-filter (–fK). The telescope will point at RA=12:12:12 Dec=-30.75 using the J2000 epoch (–t12:12:12,-30.75,2000). A 5-point dither (–dp5PS) has been selected with 15″ offsets in RA,Dec (–dd15 –dr15) and 1 observation (–n1) at each dither position. After completing the first dither pattern, the telescope is offset by 45 arcminutes in each direction (–od45 –or45 –ouamin). Thus we expect 10 observations in total as shown in Table 10 for NFOBSRSD 2453243.5896140378899872.

8. STANDARD: Standard Star Observation

8.1. Description

This calibration recipe is taken during night-time oberving for flux calibration and such stars are, typically, at the bright end of the system dynamic range and so use short integration times. Although a dither map is used, the dither offsets can be very large to cover wide areas.

8.2. Recipe

title STANDARD	!! STANDARD STAR
gpxSetMode nfStandard	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters

```
nics_filter { J || H || K }                                  !! Move to desired filter
do D_iter {                                                  !! Repeat
  ndgi_moveto RA Dec Epoch                                   !!   Move telescope
  foreach D_pos in D_pat { do n Observe.EXEC }               !!   Take data
  ndgi_moveto RA Dec Epoch                                   !!   Move back to home
}                                                            !! End
```

8.3. nfs [–dd$\pm f$ –di$i$ –dp$s$ –dr$\pm f$ –du$s$ –fs –ni –ts]

Alias(es): nfStandard

8.4. Worked Example

nfs –I60.0 –tz –dp5PX –dd+30 –dr+30 –dus –di2

This command takes 60 second (–I60.0) exposures at zenith (–tz) of a 5-point X-pattern dither (–dp5PX) with RA,Dec offsets of 30″,30″ respectively (–dd+30 –dr+30). The default J-filter is used and the dither pattern is repeated twice (–di2) giving a total of 10 observations as seen for NFOBSRSD 2453244.9876543210987654 in Table 10.

9. QUICKLOOK: Quick Look Given Pointing

9.1. Description

This science recipe is performed to verify the positioning of the telescope. Usually, only 1 filter is used and sky subtraction corrects or supresses most first-order system signature effects and allows identification of fainter sources.

9.2. Recipe

```
title QUICKLOOK                                  !! QUICK LOOK GIVEN POINTING
gpxSetMode nfQuickLook                           !! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg     !! Adjust parameters
nics_filter { J || H || K }                      !! Move to desired filter
ndgi_moveto RA Dec Epoch                         !! Move telescope
do 1 Observe.EXEC                                !! Take data
ndgi_offset δRA δDec                             !! Offset telescope
do 1 Observe.EXEC                                !! Take data
ndgi_moveto RA Dec Epoch                         !! Move telescope
```

9.3. nfql [–fs –ni –od$\pm f$ –or$\pm f$ –ou$s$ –ts]

Alias(es): nfQuickLook

9.4. Worked Example

nfql –I15.0 –fK –od+1 –or+1 –oud –tz

This command takes 2×15 second (–I15.0) exposures: one at zenith (–tz) and the other offset by 1 degree in each direction (–od+1 –or+1 –oud). The K-filter is used. The NFOBSRSD is 2453244.9989765431234566 in Table 10.

10. DEEPSPARSE: Deep Look Single Sparse Field

10.1. Description

This science recipe provides its own mean sky frame for sky subtraction. Dithers and other offsets are kept small and centred on the home position to maximize the field of view bounding the stacked image data. Note that this, also, uses a double dither technique to 'randomize' the area around the home position.

10.2. Recipe

title DEEPSPARSE	!! DEEP LOOK SINGLE SPARSE FIELD
gpxSetMode nfDeepSparse	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
foreach M_{pos} in M_{pat} {	!! StartMap
ndgi_moveto RA_{home} Dec_{home} Epoch	!! Move telescope to home position
ndgi_moveto RA_i Dec_i	!! Move to i-th map position
foreach D_{pos} in D_{pat} { do n Observe.EXEC }	!! Take data
}	!! EndMap

10.3. nfds [–dd$\pm f$ –dii –dps –dr$\pm f$ –dus –fs –md$\pm f$ –mii –mps –mr$\pm f$ –mus –ni –ts]

Alias(es): nfDeepSparse

10.4. Worked Example

nfds –I15.0 –dp5PS –mp5PX

This command takes 15 second (–I15.0) exposures in a 5-point spiral pattern superposed on a 5-point cross grid. Since so few command line parameters are used, there are many defaults. The end result is 25 science frames centred around the home position. The NFOBSRSD is 2453246.0912348729029722 in Table 11.

11. DEEPRICH: Deep Look Single Rich Field

11.1. Description

In this case, the telescope must be offset at intervals to a 'empty' sky field to obtain data for sky subtraction. These intervals will be on the order of a few minutes of time whilst the offset position may be several degrees away from the science target. Equal amounts of time must be spent on the science and sky fields and it is important to re-acquire the scientific home position accurately.

11.2. Recipe

title DEEPRICH	!! DEEP LOOK SINGLE RICH FIELD
gpxSetMode nfDeepRich	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
foreach M_{pos} in M_{pat} {	!! StartMap

ndgi_moveto RA^{obj}_{home} Dec^{obj}_{home} Epoch !! Move telescope object home
ndgi_moveto RA^{obj}_{i} Dec^{obj}_{i} Epoch !! Move telescope to i-th object
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC } !! Take data
ndgi_moveto RA^{sky}_{home} Dec^{sky}_{home} Epoch !! Move telescope to sky home
ndgi_moveto RA^{sky}_{i} Dec^{sky}_{i} Epoch !! Move telescope to i-th sky
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC } !! Take data
} !! EndMap

11.3. nfdr [–dd$\pm f$ –di$i$ –dp$s$ –dr$\pm f$ –du$s$ –fs –md$\pm f$ –mi$i$ –mp$s$ –mr$\pm f$ –mu$s$ –ni –ts]

Alias(es): nfDeepRich

11.4. Worked Example

nfdr –I22.5 –fK –dp2-RA –mp2x2 –od10.0 –or10.0 –oud

This command takes 22.5 second (–I22.5) exposures in a 2-RA pattern superposed on a 2×2 grid. The large offset is 10 degrees in both directions (–od10.0 –or10.0 –oud). The K filter is specified (–fK). The NFOBSRSD is 2453246.1246902765389543 in Table 12.

12. QUICKMAP: Quick Map Large Area Point Sources

12.1. Description

Previous seuqences have involved lots of dithering around a single home position plus, possibly, an offset to a spatially disjoint position to define blank sky. In contrast, a quick large area map involves lots of offsetting to adjacent fields with only a few dither positions around each offset pointing. Typical time spent at a given offset pointing is ∼5 minutes.

12.2. Recipe

title QUICKMAP !! QUICK MAP LARGE AREA POINT SOURCES
gpxSetMode nfQuickMap !! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg !! Adjust parameters
set D_{pat} D_{ra} D_{dec} !! Set dither parameters
set M_{pat} M_{ra} M_{dec} !! Set map parameters
nics_filter { J || H || K } !! Move to desired filter
ndgi_moveto RA Dec Epoch !! Move telescope
foreach M_{pos} in M_{pat} { !! StartMap
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC } !! Take data
} !! EndMap

12.3. nfqm [–dd$\pm f$ –di$i$ –dp$s$ –dr$\pm f$ –du$s$ –fs –md$\pm f$ –mi$i$ –mp$s$ –mr$\pm f$ –mu$s$ –ni –ts]

Alias(es): nfQuickMap

12.4. Worked Example

nfqm –I10.0 –fK –dp2-Dec –mp4x4

This command takes 10.0 second (–I10.0) exposures in a 2-Dec pattern superposed on a 4×4 grid. The number of frames is, therefore, 32. The NFOBSRSD is 2453246.34567890098765432 in Table 13.

13. QUICKMAPWITHSKY: Quick Map Large Area Extended Sources

13.1. Description

This is distinguished from the previous example by the need to offset to blank sky at regular intervals. The same blank sky may be used for sky subtraction from different offset positions. Therefore, the frequency of switching between science map and blank sky is driven by the variablility of the sky level and significantly more time may be executed on the map than on acquiring blank sky frames.

13.2. Recipe

title QUICKMAPWITHSKY	!! QUICK MAP LARGE AREA EXTENDED SOURCES
gpxSetMode nfQuickMapWithSky	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
ndgi_moveto RA$_{sky}$ Dec$_{sky}$ Epoch	!! Move telescope to sky
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC }	!! Take data
foreach M_{pos} in M_{pat} {	!! StartMap
ndgi_moveto RA$_i$ Dec$_i$ Epoch	!! Move telescope to i-th position
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC }	!! Take data
ndgi_moveto RA$_i$ Dec$_i$ Epoch	!! Move to i-th position home
if (!i%N) {	!! StartSky (after N frames)
ndgi_moveto RA$_{sky}$ Dec$_{sky}$ Epoch	!! Move telescope to sky
ndgi_offset δRA δDec	!! Offset telescope
do D_{iter} { do *n* Dither.EXEC }	!! Take data
}	!! EndSky
i++	!! Increment counter
}	!! EndMap
ndgi_moveto RA$_{sky}$ Dec$_{sky}$ Epoch	!! Move telescope to sky
ndgi_offset δRA δDec	!! Offset telescope
foreach D_{pos} in D_{pat} { do *n* Observe.EXEC }	!! Take data

13.3. nfqmws [–dd$\pm f$ –di$i$ –dp$s$ –dr$\pm f$ –du$s$ –fs –md$\pm f$ –mi$i$ –mp$s$ –mr$\pm f$ –mu$s$ –ni –si –ts]

Alias(es): nfQuickMapWithSky

13.4. Worked Example

nfqmws –I10.0 –dp2-RA –m3x3 –s12

This command takes 10.0 second (–I10.0) exposures, J filter, in a 2-RA pattern superposed on a 3×3 grid. First, 2 sky frames are taken and then the mapping pattern is begun. After 12 observations, a move back to sky is made. This occurs just after the 6-th map position. The mapping sequence is then resumed but no further excusions to sky are made until the end. A final sky pair is then taken resulting in 24 observations total. The NFOBSRSD is 2453246.9876509876543897 in Table 14.

14. MODMAPSPARSE: Moderate Map Moderate Area Point Sources

14.1. Description

This is similar to § 12. but with fewer offsets and more dithered positions at each offset pointing. To smooth out the effects of sky variations, changing extinction and other slowly varying secular effects in the system signature, we iterate a number of times over the whole map rather than repeating individual map positions to build up the total integration time.

14.2. Recipe

title MODMAPSPARSE	!! MODERATE MAP MODERATE AREA POINT SOURCES
gpxSetMode nfModMapSparse	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
do M_{iter} {	!! Repeat
ndgi_moveto RA Dec Epoch	!! Move telescope
foreach M_{pos} in M_{pat} {	!! StartMap
foreach D_{pos} in D_{pat} { do n Observe.EXEC }	!! Take data
}	!! EndMap
}	!! End

14.3. nfModMapSparse [–f*str* –n*int* –t*str*]

Alias(es): nfmms

14.4. Worked Example

nfmms –I10.0 –fK –dp2-Dec –mp4x4 –mi4

This command is, in effect, a multiple iteration of that given in § 12.4. and produces an output similar to that at NFOBSRSD is 2453246.34567890098765432 in Table 13. The main difference is 4× as much data so a total of 128 observations with the MITER parameter incrementing after every 32 observations. No output is, therefore, shown.

15. MODMAPRICH: Moderate Map Moderate Area Extended Sources

15.1. Description

This is similar to § 13. but with the need to offset to blank sky at regular intervals and the increase in iterations in the mapping.

15.2. Recipe

title MODMAPRICH	!! MODERATE MAP MODERATE AREA EXTENDED SOURCES
gpxSetMode nfModMapRich	!! Set up MONSOON
gpxSetModeAVP intTime coadds fSamples digAvg	!! Adjust parameters
set D_{pat} D_{ra} D_{dec}	!! Set dither parameters
set M_{pat} M_{ra} M_{dec}	!! Set map parameters
nics_filter { J || H || K }	!! Move to desired filter
ndgi_moveto RA_{sky} Dec_{sky} Epoch	!! Move telescope to sky
foreach D_{pos} in D_{pat} { do n Observe.EXEC }	!! Take data

```
do M_iter {                                                !! Repeat
  foreach M_pos in M_pat {                                 !!   StartMap
    ndgi_moveto RA_i Dec_i Epoch                           !!     Move telescope to i-th position
    foreach D_pos in D_pat { do n Observe.EXEC }           !!     Take data
    ndgi_moveto RA_i Dec_i Epoch                           !!     Move to i-th position home
    if ( !i%M ) {                                          !!     StartSky (after M frames)
      ndgi_moveto RA_sky Dec_sky Epoch                     !!       Move telescope to sky
      ndgi_offset δRA δDec                                 !!       Offset telescope
      do D_iter { do n Dither.EXEC }                       !!       Take data
    }                                                      !!     EndSky
    i++                                                    !!     Increment counter
  }                                                        !!   EndMap
  ndgi_moveto RA_sky Dec_sky Epoch                         !!   Move telescope to sky
  ndgi_offset δRA δDec                                     !!   Offset telescope
  foreach D_pos in D_pat { do n Observe.EXEC }             !!   Take data
}                                                          !! End
```

15.3. nfModMapRich [–f*str* –n*int* –t*str*]

Alias(es): nfmmr

15.4. Worked Example

nfmmr –I10.0 –dp2-RA –m3x3 –s12 -mi4

This command is, in effect, a multiple iteration of that given in § 13.4. and produces an output similar to that at NFOBSRSD is 2453246.9876509876543897 in Table 14. The main difference is $4\times$ as much data with the MITER parameter incrementing after every 32 observations. No output is, therefore, shown.

16. Document Revision History

23 August 2004, PND: Original version.
17 September 2004, PND: Adjusted recipes after input from scientist. Added more worked examples.
31 October 2004, PND: Final version?

Acknowledgments.

References

1. Probst, R. G. 2004, 'NEWFIRM Scientific Use Cases for OCS Definition', NFM-AD-02-9502, NEWFIRM Project, 950 N Cherry Avenue, Tucson AZ 85719, USA.

2. Daly, P. N. *et al.*, 2004, 'On An Observation Control System for NEWFIRM', NFM-AD-04-9000, NEWFIRM Project, 950 N Cherry Avenue, Tucson AZ 85719, USA.

3. http://www.noao.edu/ets/newfirm/nohs-md-1.0.1.txt

4. http://www.noao.edu/ets/newfirm/dhs-api-1.0.1.txt

A NEWFIRM Observation Header System Meta-Data

Table 5.: NEWFIRM Meta-Data (Part I)

Name (32-char)	Value (32-char)	Comment (64-char)
BITPIX	32	number of bits per data pixel
NAXIS	2	number of data axes
NAXIS1	4096	length of data axis 1
NAXIS2	4096	length of data axis 2
EXTEND	T	FITS dataset may contain extensions
TELESCOP	kpno_4m	Kitt Peak National Observatory Mayall 4m
UTC	20040421	UTC
SEMESTER	2004A	semester
PROPOSAL	2004A-1234	proposal identifier
ASTRONOM	Phil Daly	astronomer
NFOBSMSB	2453244.4222993385046721	minimum schedulable block identifier
NFOBSRSD	2453244.4222993385012345	recipe star date
NFOBSTIM	1.0	observation time requested
NFOBSNUM	5	number of observations requested
NFOBSID	2453244.4222881234354656	observation identifier
NFOBSNO	1	observation number (in this sequence)
NFOBSTOT	5	total number of observations (in this sequence)
NFOBSFIL	CD	filter
NFOBSDPAT	None	dither pattern
NFOBSDITER	0	dither iterations requested
NFOBSDROF	0.0	dither offset in RA
NFOBSDDOF	0.0	dither offset in Dec
NFOBSDUNIT	None	dither units
NFOBSDREP	0	dither sequence number
NFOBSDPOS	0	dither position number
NFOBSMPAT	None	map pattern
NFOBSMITER	0	map iterations requested
NFOBSMROF	0.0	map offset in RA
NFOBSMDOF	0.0	map offset in Dec
NFOBSMUNIT	None	map units
NFOBSMREP	0	map sequence number
NFOBSMPOS	0	map position number
NFOBSORA	0.0	offset in RA
NFOBSODEC	0.0	offset in Dec
NFOBSOUNIT	None	offset units
NFOBSTYP	DARK	observation type
NFOBSDHS	nfDark	recipe for data handling
F8IDENT	unknown	f8.main.ident: control program id and version
F8PID	1234	f8.main.pid: process id of ”f8mid”
F8IDENT	cinammon	f8.main.host: host for ”f8mid”
F8LINK	up	f8.main.link: serial link status
F8FOCUS	12000.00	f8.focus.position: focus microns
F8FOCT	12000.00	f8.focus.target: desired focus microns
F8TIP	0.50	f8.tip.angle: mirror tip angle degrees
F8TIPT	0.50	f8.tip.target: desired tip angle degrees
F8TILT	0.50	f8.tilt.angle: mirror tilt angle degrees
F8TILTT	0.50	f8.tilt.target: desired tilt angle degrees
TCSLINK	up	tcs.main.link: TCP link status
TCSHOST	cinammon	tcs.main.host: host for tcs4m
TCSPID	5678	tcs.main.pid: process id of tcs4m
TCSCOMPU	cinammon	tcs.main.computer: name of TCS computer
TCSUPDAT	on	tcs.main.updates: tcs4m polling enable

Table 6.: NEWFIRM Meta-Data (Part II)

Name (32-char)	Value (32-char)	Comment (64-char)
UT	12:12:12	tcs.time.ut: universal time
UTDATE	04/21/2004	tcs.time.utdate: universal date
ST	12:12:12	tcs.time.st: sidereal time
RA	12:12:12	tcs.target.ra: right ascension
DEC	30:30:00.0	tcs.target.dec: declination
EPOCH	J2000	tcs.target.epoch: epoch
RAPRE	12:12:12	tcs.target.ra: right ascension preset
DECPRE	30:30:SS.S	tcs.target.dec: declination preset
EPOCHPRE	J2000	tcs.target.epoch: epoch preset
ALT	12:12:12	tcs.telescope.alt: telesscope altitude
AZ	30:30:00.0	tcs.telescope.az: telesscope azimuth
EQUINOX	2000	tcs.telescope.equinox: year
ZD	28.4	tcs.telescope.zenithdist: zenith distance degrees
AIRMASS	1.29	tcs.telescope.airmass: airmass
PARALL	0.0	tcs.telescope.parallactic: parallactic
RAOFF	0.0	tcs.telescope.ra_offset: RA offset arcsec
DECOFF	0.0	tcs.telescope.dec_offset: Dec offset arcsec
RAINST	0.0	tcs.telescope.ra_inst_center: RA instrument center arcsec
DECINST	0.0	tcs.telescope.dec_inst_center: Dec instrument center arcsec
RAZERO	0.0	tcs.telescope.ra_zero: RA zero arcsec
DECZERO	0.0	tcs.telescope.dec_zero: Dec zero arcsec
RAINDEX	0.0	tcs.telescope.ra_index: RA index arcsec
DECINDEX	0.0	tcs.telescope.dec_index: Dec index arcsec
RADIFF	0.0	tcs.telescope.ra_diff: RA diff arcsec
DECDIFF	0.0	tcs.telescope.dec_diff: Dec diff arcsec
TCPMODE	dunno	tcs.telescope.mode: telescope mode
TCPTRACK	tracking	tcs.telescope.tracking: telescope tracking status
TCPSLEW	dunno	tcs.telescope.slew: telescope slew status
CASSADC	dunno	tcs.telescope.adc: cass ADC mode
CASSADCT	0.0	tcs.telescope.adctop: cass ADC top angle degrees
CASSADCB	0.0	tcs.telescope.adcbot: cass ADC bottom angle degrees
FOCUS	0.06	tcs.telescope.focus: focus mm
FOCI	dunno	tcs.telescope.fratio: Telescope foci
FIELD	dunno	tcs.telescope.field: telescope field
TCPHA	12.45	tcs.telescope.ha: telescope HA
HASERVO	39.55	tcs.telescope.haservo: Ha servo position degrees
DECSERVO	39.55	tcs.telescope.devservo: Dec servo position degrees
ACTPRI	on	tcs.telescope.active_primary: Primary mirror mode
ALRTSERV	none	tcs.servo.servo: servo alert
ALRTHA	none	tcs.servo.ha: Ha alert
ALRTDEC	none	tcs.servo.dec: Dec alert
ALRTSTOW	none	tcs.servo.stowed: stow alert
DOMEAZ	0.0	tcs.dome.az: dome position degrees
DOMEERR	0.0	tcs.dome.error: dome error distance from target degrees
DOMEMODE	vignetted	tcs.dome.mode: dome mode
DOMESTAT	ok	tcs.dome.status: dome status
INSTR	NEWFIRM	tcs.instrument.name: name of current instrument
NODPOS	object	tcs.nod.position: nod position (object—sky)
NODOFF	0	tcs.nod.offsets: X and Y offset for nod arcsec
TCPGDR	on	tcs.guider.mode: guider status (on—off)
TCPGDRMO	enabled	tcs.guider.motion: guider motion enable
GDRPROBE	north	tcs.guider.probe: current guider probe
TCPGDRNX	10.00	tcs.guider.northx: north guider probe X position mm
TCPGDRNY	10.00	tcs.guider.northy: north guider probe Y position mm
TCPGDRSX	10.00	tcs.guider.southx: south guider probe X position mm
TCPGDRSY	10.00	tcs.guider.southy: south guider probe Y position mm
GDCLEAKY	dunno	tcs.guider.leaky: guider leaky switch
GDRUPDAT	20	tcs.guider.update: guider update rate seconds
GDRCAL	dunno	tcs.guider.calibration: guider calibration

Table 7.: NEWFIRM Meta-Data (Part III)

Name (32-char)	Value (32-char)	Comment (64-char)
NFIDENT	x.y.z	newfirm.main.ident: control program id and version
NFAUTH	Shelby Gott	newfirm.main.auth: author(s) of the NICC code
NFDATE	04/21/2004	newfirm.main.date: date of last modification
NFECPOS	open	newfirm.ecover.position: detected position
NFECCMD	open	newfirm.ecover.cmd: demand position
NFFW1POS	7	newfirm.filter.fw1pos: wheel 1 actual pos
NFFW1CMD	7	newfirm.filter.fw1: wheel 1 demand pos
NFFW2POS	5	newfirm.filter.fw2pos: wheel 2 actual pos
NFFW2CMD	5	newfirm.filter.fw2: wheel 1 demand pos
NFFILTER	J	newfirm.filter.name: actual name
NFFILCMD	J	newfirm.filter.pos: demand name
NFVS1	1000	newfirm.vacuum.vs1: sensor 1 utorr
NFVS2	2000	newfirm.vacuum.vs2: sensor 2 utorr
NFVS3	3000	newfirm.vacuum.vs3: sensor 3 utorr
NFPS	11000	newfirm.pressure.ps1: sensor 1 mbar
NFPS2	2000	newfirm.pressure.ps2: sensor 2 mbar
NFPS3	3000	newfirm.pressure.ps3: sensor 3 mbar
NFDELAY1	10	newfirm.thermal.delay1: thermal cycle 1 delay, measured seconds
NRDELAY1	10	newfirm.thermal.rdelay1: thermal cycle 1 delay, demand seconds
NFDELAY2	10	newfirm.thermal.delay2: thermal cycle 2 delay, measured seconds
NRDELAY2	10	newfirm.thermal.rdelay2: thermal cycle 2 delay, demand seconds
NFDELAY3	10	newfirm.thermal.delay3: thermal cycle 3 delay, measured seconds
NRDELAY3	10	newfirm.thermal.rdelay3: thermal cycle 3 delay, demand seconds
NFLN1FS	273.0	newfirm.thermal.lens1fs: lens 1 front surface kelvin
NFLN1RS	273.0	newfirm.thermal.lens1rs: lens 1 rear surface kelvin
NFLN2ES	273.0	newfirm.thermal.lens2es: lens 2 edge surface kelvin
NFLN2CF	273.0	newfirm.thermal.lens2cf: lens 2 cell finger kelvin
NFLN3ES	273.0	newfirm.thermal.lens3es: lens 3 edge surface kelvin
NFLN3CF	273.0	newfirm.thermal.lens3cf: lens 3 cell finger kelvin
NFLN4ES	273.0	newfirm.thermal.lens4es: lens 4 edge surface kelvin
NFLN4CF	273.0	newfirm.thermal.lens4cf: lens 4 cell finger kelvin
NFLN5ES	273.0	newfirm.thermal.lens5es: lens 5 edge surface kelvin
NFLN5CF	273.0	newfirm.thermal.lens5cf: lens 5 cell finger kelvin
NFLN6ES	273.0	newfirm.thermal.lens6es: lens 6 edge surface kelvin
NFLN6CF	273.0	newfirm.thermal.lens6cf: lens 6 cell finger kelvin
NFLN7ES	273.0	newfirm.thermal.lens7es: lens 7 edge surface kelvin
NFLN7CF	273.0	newfirm.thermal.lens7cf: lens 7 cell finger kelvin
NFLN8ES	273.0	newfirm.thermal.lens8es: lens 8 edge surface kelvin
NFLN8CF	273.0	newfirm.thermal.lens8cf: lens 8 cell finger kelvin
NFFMRS	273.0	newfirm.thermal.fmrs: fold mirror rear surface kelvin
NFFMSS1	273.0	newfirm.thermal.fmss1: fold mirror side surface 1 kelvin
NFFMSS2	273.0	newfirm.thermal.fmss2: fold mirror side surface 2 kelvin
NFFWM1	273.0	newfirm.thermal.fwm1: filter wheel motor 1 kelvin
NFFWM2	273.0	newfirm.thermal.fwm2: filter wheel motor 2 kelvin
NFFWFH	273.0	newfirm.thermal.fwfh: filter wheel front of housing kelvin
NFFWRS	273.0	newfirm.thermal.fwrs: filter wheel radiation shield kelvin
NFFBTT	273.0	newfirm.thermal.fbtt: front baffle tube top kelvin
NFFBTM	273.0	newfirm.thermal.fbtm: front baffle tube middle kelvin
NFFBTB	273.0	newfirm.thermal.fbtb: front baffle tube bottom kelvin
NFTB1DW	273.0	newfirm.thermal.tb1dw: tangent bar 1 dewar wall kelvin
NFTB1OSS	273.0	newfirm.thermal.tb1oss: tangent bar 1 optical support kelvin
NFTB1MID	273.0	newfirm.thermal.tb1mid: tangent bar 1 mid point kelvin
NFTB2MID	273.0	newfirm.thermal.tb2mid: tangent bar 2 mid point kelvin
NFTB3MID	273.0	newfirm.thermal.tb3mid: tangent bar 3 mid point kelvin
NFUOSS1	273.0	newfirm.thermal.uoss1: upper optical support 1 kelvin
NFUOSS2	273.0	newfirm.thermal.uoss2: upper optical support 2 kelvin
NFUOSS3	273.0	newfirm.thermal.uoss3: upper optical support 3 kelvin
NFMOSS1	273.0	newfirm.thermal.moss1: middle optical support 1 kelvin
NFMOSS2	273.0	newfirm.thermal.moss2: middle optical support 2 kelvin
NFMOSS3	273.0	newfirm.thermal.moss3: middle optical support 3 kelvin

Table 8.: NEWFIRM Meta-Data (Part IV)

Name (32-char)	Value (32-char)	Comment (64-char)
NFLOSS1	273.0	newfirm.thermal.loss1: lower optical support 1 kelvin
NFLOSS2	273.0	newfirm.thermal.loss2: lower optical support 2 kelvin
NFLOSS3	273.0	newfirm.thermal.loss3: lower optical support 3 kelvin
NFARS1	273.0	newfirm.thermal.ars1: active radiation shield 1 kelvin
NFARS2	273.0	newfirm.thermal.ars2: active radiation shield 2 kelvin
NFARS3	273.0	newfirm.thermal.ars3: active radiation shield 3 kelvin
NFPRS1	273.0	newfirm.thermal.prs1: passive radiation shield 1 kelvin
NFPRS2	273.0	newfirm.thermal.prs2: passive radiation shield 2 kelvin
NFDMRS	273.0	newfirm.thermal.dmrs: detector mount radiation shield kelvin
NFCH1S2	273.0	newfirm.thermal.ch1s1: cold head 1, stage 1, measured kelvin
NFRCH1S2	273.0	newfirm.thermal.rch1s1: cold head 1, stage 1, demand kelvin
NFCH1S2	273.0	newfirm.thermal.ch1s2: cold head 1, stage 2, measured kelvin
NFRCH1S2	273.0	newfirm.thermal.rch1s2: cold head 1, stage 2, demand kelvin
NFCH2S1	273.0	newfirm.thermal.ch2s1: cold head 2, stage 1, measured kelvin
NFRCH2S1	273.0	newfirm.thermal.rch2s1: cold head 2, stage 1, demand kelvin
NFCH2S2	273.0	newfirm.thermal.ch2s2: cold head 2, stage 2, measured kelvin
NFRCH2S2	273.0	newfirm.thermal.rch2s2: cold head 2, stage 2, demand kelvin
NFCH3S1	273.0	newfirm.thermal.ch3s1: cold head 3, stage 1, measured kelvin
NFRCH3S1	273.0	newfirm.thermal.rch3s1: cold head 3, stage 1, demand kelvin
NFCH3S2	273.0	newfirm.thermal.ch3s2: cold head 3, stage 2, measured kelvin
NFRCH3S2	273.0	newfirm.thermal.rch3s2: cold head 3, stage 2, demand kelvin
NFCS1E	273.0	newfirm.thermal.cs1e: cold strap 1, end kelvin
NFCS2E	273.0	newfirm.thermal.cs2e: cold strap 2, end kelvin
NFCS3E	273.0	newfirm.thermal.cs3e: cold strap 3, end kelvin
NFCS4E	273.0	newfirm.thermal.cs4e: cold strap 4, end kelvin
NFCS5E	273.0	newfirm.thermal.cs5e: cold strap 5, end kelvin
NFCS6E	273.0	newfirm.thermal.cs6e: cold strap 6, end kelvin
NFCS7E	273.0	newfirm.thermal.cs7e: cold strap 7, end kelvin
NFCS8E	273.0	newfirm.thermal.cs8e: cold strap 8, end kelvin
NFABCM	273.0	newfirm.thermal.abcm: array baseplate cold mass kelvin
NFABE	273.0	newfirm.thermal.abe: array baseplate elsewhere kelvin
NFAM	273.0	newfirm.thermal.am: array mount kelvin
NFNRDA1	273.0	newfirm.thermal.nrda1: narrow range detector array 1 kelvin
NFNRDA2	273.0	newfirm.thermal.nrda2: narrow range detector array 2 kelvin
NFNRDA3	273.0	newfirm.thermal.nrda3: narrow range detector array 3 kelvin
NFNRDA4	273.0	newfirm.thermal.nrda4: narrow range detector array 4 kelvin
NFECTEMP	273.0	newfirm.thermal.ecover ecover inside surface kelvin
NFGC1EXP	1.0	newfirm.camera1.exposure: exposure time seconds
NFGC1CCD	273.0	newfirm.camera1.temperature: CCD temperature Celsius
NFGC1AMB	277.0	newfirm.camera1.ambient: ambient temperature Celsius
NFGC1MOD	Enabled	newfirm.camera1.guider: guider mode
NFGC1BIN	1.0	newfirm.camera1.bin: binning factor
NFGC1POW	On	newfirm.camera1.power: power state
NFGC1REG	On	newfirm.camera1.regulator: regulator state
NFGC1FIL	V	newfirm.camera1.filter: current filter
NFGC2EXP	1.0	newfirm.camera2.exposure: exposure time seconds
NFGC2CCD	273.0	newfirm.camera2.temperature: CCD temperature Celsius
NFGC2AMB	277.0	newfirm.camera2.ambient: ambient temperature Celsius
NFGC2MOD	Enabled	newfirm.camera2.guider: guider mode
NFGC2BIN	1.0	newfirm.camera2.bin: binning factor
NFGC2POW	On	newfirm.camera2.power: power state
NFGC2REG	On	newfirm.camera2.regulator: regulator state
NFGC2FIL	V	newfirm.camera2.filter: current filter

A DHS Output(s) For Worked Examples

Table 9.: Observation Parameters for Worked Examples *nfDark*, *nfDomeFlatOn*, *nfDomeFlatSequence*, *nfTwilightFlat*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfDark –I15.0 –R –n4 — Refer to section § 2.							
2453243.6281214454211295	15.0	4 / 1 / 4	CD	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DARK	DARK
2453243.6281214454211295	15.0	4 / 2 / 4	CD	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DARK	DARK
2453243.6281214454211295	15.0	4 / 3 / 4	CD	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DARK	DARK
2453243.6281214454211295	15.0	4 / 4 / 4	CD	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DARK	DARK
nfDomeFlatOn –I30.0 –fJ –n3 — Refer to section § 3.							
2453243.6281274640932679	30.0	3 / 1 / 3	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLAT
2453243.6281274640932679	30.0	3 / 2 / 3	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLAT
2453243.6281274640932679	30.0	3 / 3 / 3	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLAT
nfDomeFlatSequence –R –n2 –j35.0 –h25.0 –k15.0 — Refer to section § 4.							
2453243.6281312829814851	35.0	2 / 1 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	35.0	2 / 2 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	25.0	2 / 3 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	25.0	2 / 4 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	15.0	2 / 5 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	15.0	2 / 6 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	15.0	2 / 7 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	15.0	2 / 8 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	25.0	2 / 9 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	25.0	2 / 10 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	35.0	2 / 11 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	35.0	2 / 12 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATON	DFLATS
2453243.6281312829814851	35.0	2 / 13 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	35.0	2 / 14 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	25.0	2 / 15 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	25.0	2 / 16 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	15.0	2 / 17 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	15.0	2 / 18 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	15.0	2 / 19 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	15.0	2 / 20 / 24	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	25.0	2 / 21 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	25.0	2 / 22 / 24	H	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	35.0	2 / 23 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
2453243.6281312829814851	35.0	2 / 24 / 24	J	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	DFLATOFF	DFLATS
nfTwilightFlat –I35.0 –fK –n2 –tz — Refer to section § 5.							
2453244.4222729508765042	35.0	2 / 1 / 2	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	TFLAT	TFLAT
2453244.4222729508765042	35.0	2 / 2 / 2	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	TFLAT	TFLAT

Table 10.: Observation Parameters for Worked Examples *nfSkyFlat*, *nfSkyFlatOffset*, *nfStandard*, *nfQuickLook*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfSkyFlat –I30.0 –R –fH –to –dr30.0 –dp2-RA — Refer to section § 6.							
2453243.6345678901234567	30.0	1 / 1 / 2	H	2-RA / 1 / 1 / 30.0 / 0.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.6345678901234567	30.0	1 / 2 / 2	H	2-RA / 1 / 2 / 30.0 / 0.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
nfSkyFlatOffset –I45.0 –fK –t12:12:12,-30.75,2000 –dp5PS –dd15 –dr15 –n1 –od45 –or45 -ouamin — Refer to section § 7.							
2453243.5896140378899872	45.0	1 / 1 / 1	K	5PS / 1 / 1 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 2 / 2	K	5PS / 1 / 2 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 3 / 3	K	5PS / 1 / 3 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 4 / 4	K	5PS / 1 / 4 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 5 / 5	K	5PS / 1 / 5 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 6 / 6	K	5PS / 1 / 1 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 7 / 7	K	5PS / 1 / 2 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 8 / 8	K	5PS / 1 / 3 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 9 / 9	K	5PS / 1 / 4 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
2453243.5896140378899872	45.0	1 / 10 / 10	K	5PS / 1 / 5 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	SFLAT	SFLAT
nfStandard –I60.0 –tz –dp5PX –dd+30 –dr+30 –dus –di2 — Refer to section § 8.							
2453244.9876543210987654	60.0	1 / 1 / 10	J	5PX / 2 / 1 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 2 / 10	J	5PX / 2 / 2 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 3 / 10	J	5PX / 2 / 3 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 4 / 10	J	5PX / 2 / 4 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 5 / 10	J	5PX / 2 / 5 / 30.0 / 30.0 / 1	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 6 / 10	J	5PX / 2 / 1 / 30.0 / 30.0 / 2	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 7 / 10	J	5PX / 2 / 2 / 30.0 / 30.0 / 2	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 8 / 10	J	5PX / 2 / 3 / 30.0 / 30.0 / 2	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 9 / 10	J	5PX / 2 / 4 / 30.0 / 30.0 / 2	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
2453244.9876543210987654	60.0	1 / 10 / 10	J	5PX / 2 / 5 / 30.0 / 30.0 / 2	None / 0 / 0 / 0.0 / 0.0 / 0	STANDARD	STANDARD
nfQuickLook –I15.0 –fK –od+1 –or+1 –oud –tz — Refer to section § 9.							
2453244.9989765431234566	15.0	1 / 1 / 2	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	OBJECT	QUICKLOOK
2453244.9989765431234566	15.0	1 / 2 / 2	K	None / 0 / 0 / 0.0 / 0.0 / 0	None / 0 / 0 / 0.0 / 0.0 / 0	SKY	QUICKLOOK

Table 11.: Observation Parameters for Worked Example *nfDeepSparse*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfDeepSparse –I15.0 –dp5PS –mp5PX — Refer to section § 10.							
2453246.0912348729029722	15.0	1 / 1 / 25	J	5PS / 1 / 1 / 30.0 / 30.0 / 0	5PX / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 2 / 25	J	5PS / 1 / 2 / 30.0 / 30.0 / 0	5PX / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 3 / 25	J	5PS / 1 / 3 / 30.0 / 30.0 / 0	5PX / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 4 / 25	J	5PS / 1 / 4 / 30.0 / 30.0 / 0	5PX / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 5 / 25	J	5PS / 1 / 5 / 30.0 / 30.0 / 0	5PX / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 6 / 25	J	5PS / 1 / 1 / 30.0 / 30.0 / 0	5PX / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 7 / 25	J	5PS / 1 / 2 / 30.0 / 30.0 / 0	5PX / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 8 / 25	J	5PS / 1 / 3 / 30.0 / 30.0 / 0	5PX / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 9 / 25	J	5PS / 1 / 4 / 30.0 / 30.0 / 0	5PX / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 10 / 25	J	5PS / 1 / 5 / 30.0 / 30.0 / 0	5PX / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 11 / 25	J	5PS / 1 / 1 / 30.0 / 30.0 / 0	5PX / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 12 / 25	J	5PS / 1 / 2 / 30.0 / 30.0 / 0	5PX / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 13 / 25	J	5PS / 1 / 3 / 30.0 / 30.0 / 0	5PX / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 14 / 25	J	5PS / 1 / 4 / 30.0 / 30.0 / 0	5PX / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 15 / 25	J	5PS / 1 / 5 / 30.0 / 30.0 / 0	5PX / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 16 / 25	J	5PS / 1 / 1 / 30.0 / 30.0 / 0	5PX / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 17 / 25	J	5PS / 1 / 2 / 30.0 / 30.0 / 0	5PX / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 18 / 25	J	5PS / 1 / 3 / 30.0 / 30.0 / 0	5PX / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 19 / 25	J	5PS / 1 / 4 / 30.0 / 30.0 / 0	5PX / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 20 / 25	J	5PS / 1 / 5 / 30.0 / 30.0 / 0	5PX / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 21 / 25	J	5PS / 1 / 1 / 30.0 / 30.0 / 0	5PX / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 22 / 25	J	5PS / 1 / 2 / 30.0 / 30.0 / 0	5PX / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 23 / 25	J	5PS / 1 / 3 / 30.0 / 30.0 / 0	5PX / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 24 / 25	J	5PS / 1 / 4 / 30.0 / 30.0 / 0	5PX / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE
2453246.0912348729029722	15.0	1 / 25 / 25	J	5PS / 1 / 5 / 30.0 / 30.0 / 0	5PX / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	DEEPSPARSE

Table 12.: Observation Parameters for Worked Example *nfDeepRich*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfDeepRich –I22.5 –fK –dp2-RA –mp2x2 –od10.0 –or10.0 –oud — Refer to section § 6.							
2453246.1246902765389543	22.5	1 / 1 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 2 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 3 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 1 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 4 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 1 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 5 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 6 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 7 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 2 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 8 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 2 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 9 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 10 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 11 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 3 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 12 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 3 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 13 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 14 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	DEEPRICH
2453246.1246902765389543	22.5	1 / 15 / 16	K	2-RA / 1 / 1 / 30.0 / 30.0 / 0	2x2 / 1 / 4 / 30.0 / 30.0 / 0	SKY	DEEPRICH
2453246.1246902765389543	22.5	1 / 16 / 16	K	2-RA / 1 / 2 / 30.0 / 30.0 / 0	2x2 / 1 / 4 / 30.0 / 30.0 / 0	SKY	DEEPRICH

Table 13.: Observation Parameters for Worked Example *nfQuickMap*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfQuickMap –I10.0 –fK –dp2-Dec –mp4x4 — Refer to section § 12.							
2453246.34567890098765432	10.0	1 / 1 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 2 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 3 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 4 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 5 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 6 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 7 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 8 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 9 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 10 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 11 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 12 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 13 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 14 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 15 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 16 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 17 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 18 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 19 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 20 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 21 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 22 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 23 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 24 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 25 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 26 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 27 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 28 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 29 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 30 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 31 / 32	K	2-Dec / 1 / 1 / 30.0 / 30.0 / 0	4x4 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP
2453246.34567890098765432	10.0	1 / 32 / 32	K	2-Dec / 1 / 2 / 30.0 / 30.0 / 0	4x4 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAP

Table 14.: Observation Parameters for Worked Example *nfQuickMapWithSky*

RSD	TIM	NUM/NO/TOT	FIL	DPAT/DITER/DPOS/DROF/DDOF/DREP	MPAT/MITER/MPOS/MROF/MDOF/MREP	TYP	DHS
nfQuickMapWithSky –I10.0 –dp2-RA –mp3x3 –s12 — Refer to section § 12.							
2453246.9876509876543897	10.0	1 / 1 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 2 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 3 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 4 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 1 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 5 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 6 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 2 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 7 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 8 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 3 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 9 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 10 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 4 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 11 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 12 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 5 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 13 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 14 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 6 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 15 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 16 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 17 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 18 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 7 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 19 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 20 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 8 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 21 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 9 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 22 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 9 / 30.0 / 30.0 / 0	OBJECT	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 23 / 32	J	2-RA / 1 / 1 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY
2453246.9876509876543897	10.0	1 / 24 / 32	J	2-RA / 1 / 2 / 30.0 / 30.0 / 0	3x3 / 1 / 0 / 30.0 / 30.0 / 0	SKY	QUICKMAPWITHSKY