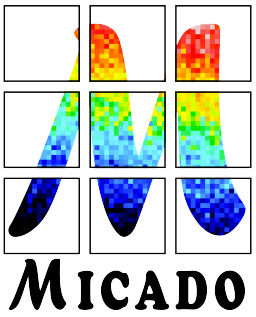


ELT – MICADO

Phase B

ScopeSim instrument packages for MICADO

ELT-TRE-MCD-56306-0059

Issue: 1.0

Date: 04. December 2020

Prepared:	K. Leschinski, O. Czoske, M. Verdugo	2020-12-04	
	Name	Date	Signature
Approved:			
	Name	Date	Signature
Released:			
	Name	Date	Signature

Change record

Issue/Rev.	Date	Section/Parag. affected	Reason/Initiation/Documents/Remarks
0.0.1	2020-10-15	All	(KL) Layout initialised
0.0.2	2020-12-04	All	(KL) Added new data, tables, plots to all sections

Relevant Documents

Ref. No.	Title
ELT-TRE-MCD-56306-0058	SimCADO v2 User Manual
ELT-TRE-MCD-56306-0060	ScopeSim: A flexible astronomical instrument data simulation environment

Contents

Chapter 1

Introduction

1.1 Document Scope

This document aims to serve as a reference for the contents of the instrument packages relevant to the implementation of the MICADO instrument simulator using the ScopeSim package. The information provided here is a snapshot of the FDR release (Dec. 2020) of the these packages. It is possible that changes will made to files contained in the packages. For more up-to-date information, the reader is referred to the online GitHub repository.

This document does not provide an overview of how to use the MICADO packages with ScopeSim. For this the reader should consult the online documentation for ScopeSim.

1.2 Overview of the Instrument Packages relevant to MICADO

The MICADO instrument simulator has moved from using the stand alone SimCADO package to using the generic astronomical instrument simulator ScopeSim. As the ScopeSim code is instrument agnostic, all data related to creating instrument models are contained inside instrument packages, which are hosted on the instrument reference database (IRDB).

1.2.1 Primary MICADO packages

This document is primarily concerned with describing the contents of the two major MICADO instrument descriptions: `MICADO` and `MICADO_Sci`. These two packages serve two different audiences:

1. The `MICADO` package contains all information available pertaining to the optical effects expected for the MICADO optical system. The primary user of this package will be the data flow system. The primary use case for this package is the creation of raw data frames for testing the algorithms of the reduction pipelines for the different modes of MICADO. This package is large and therefore computationally expensive and slow.
2. The `MICADO_Sci` package contains a subset of the effects in the `MICADO` package. The primary users of this package will be the science team and outside astronomers interested in simulating observations with the future MICADO instrument. The goal of this package is enable observations to be simulated quickly, so that the user can quickly iterate on observation strategies and/or target choices. As such this package contains only the effects which cause the major optical aberrations. It is by nature not complete, but aims to provide a level of detail sufficient for the majority of observation feasibility studies for MICADO

1.2.2 Support packages

The MICADO packages, as the names suggest, only describe the contents of the MICADO instrument. Observations with MICADO will however rely on the ELT infrastructure, which can be decomposed into several parts: Location, Telescope, Relay optics. Each of these additional parts can be considered as closed optical elements in the full observational optical system. Indeed the relay optics element is a replacable element in the optical path (with MAORY vs stand-alone mode) Hence each of these optical elements have been given their own instrument package, and are referred to as support packages.

The support packages needed to simulate MICADO observations are also described in this document. Specifically these are:

- Armazones
- ELT
- MAORY
- Stand-alone relay optics

For each observation the Armazones and ELT packages are required. However only one of MAORY or the stand-alone relay optics packages are required.

1.2.3 Adding content to the packages

The contents of the packages are currently in the public domain. The raw data is hosted on Github.

Periodically this data is compiled into an instrument package and uploaded to the ScopeSim server. It is these packages which are downloaded by ScopeSim when setting up an observation simulation.

New data or Effect objects can be added by submitting a pull request to the Github repository.

1.3 Contents of packages

Each package contains three types of files:

1. configuration,
2. effect descriptions, and
3. raw data

The configuration files are responsible for controlling which effects and which parameters and values are used when generating the optical model for an observation simulation The effect files describe which classes and which values should be used when applying an effect to the photon flux of the target object, e.g. which PSF kernel should be applied at which wavelength The raw dta files provide the raw data needed by the Effect objects, e.g. the bitmaps of the PSF kernels

In the following sections each optical element is described. Each optical elements contains a description of all the optical Effects associated with it, as well as a list of the configuration keywords and values required by the effect. If an Effect required data from an external file (e.g. PSF kernels, linearity curves, etc), these data are presented as part of each Effect object - either in the `Table` or `Data` sections.

> **Note**
> The raw data will not always be displayed directly.
> A representation of the data will be presented where available. For further details the reader is directed to the view the data directly on the IRDB

Chapter 2

MICADO Pipeline package

2.1 Summary of Effects in Optical Elements:

element	name	class	included	z_orders
armazones	armazones_atmo_default_ter_curve	AtmosphericTERCurve	True	[111, 511]
armazones	armazones_atmo_dispersion	AtmosphericDispersion	False	[231]
armazones	armazones_atmo_skycalc_ter_curve	SkycalcTERCurve	False	[112, 512]
ELT	scope_surface_list	SurfaceList	True	[20, 120, 520]
ELT	scope_vibration	Vibration	True	[244, 744]
ELT	eso_combined_reflection	TERCurve	False	[10, 110, 510]
MICADO	micado_static_surfaces	SurfaceList	True	[20, 120, 520]
MICADO	micado_ncpas_psf	NonCommonPathAberration	True	[241, 641]
MICADO	filter_wheel_1	FilterWheel	True	[124, 224, 524]
MICADO	filter_wheel_2	FilterWheel	True	[124, 224, 524]
MICADO	pupil_wheel	FilterWheel	True	[124, 224, 524]
micado_detector_array	full_detector_array	DetectorList	False	[90, 290, 390, 490]
micado_detector_array	detector_window	DetectorList	True	[90, 290, 390, 490]
micado_detector_array	qe_curve	QuantumEfficiencyCurve	True	[113, 513]
micado_detector_array	exposure_action	SummedExposure	True	[860]
micado_detector_array	dark_current	DarkCurrent	True	[830]
micado_detector_array	detector_linearity	LinearityCurve	True	[840]
micado_detector_array	shot_noise	ShotNoise	True	[820]
micado_detector_array	readout_noise	PoorMansHxRGReadoutNoise	True	[811]
default_ro	relay_psf	FieldConstantPSF	True	[262, 662]
default_ro	relay_surface_list	SurfaceList	True	[20, 120, 520]
MAORY	maory_surface_list	SurfaceList	True	[20, 120, 520]
MAORY	maory_generic_psf	FieldConstantPSF	True	[262, 662]
MICADO_IMG_LR	micado_wide_field_mirror_list	SurfaceList	True	[20, 120, 520]
MICADO_IMG_LR	micado_adc_3D_shift	AtmosphericDispersionCorrection	False	[632, 232]
MICADO_IMG_HR	zoom_mirror_list	SurfaceList	True	[20, 120, 520]
MICADO_IMG_HR	micado_adc_3D_shift	AtmosphericDispersionCorrection	False	[632, 232]
MICADO_SPEC	spec_mode_optics	SurfaceList	True	[20, 120, 520]
MICADO_SPEC	spectroscopic_slit_aperture	ApertureMask	True	[80, 280, 380]
MICADO_SPEC	micado_spectral_traces	SpectralTraceList	True	[70, 270]

2.2 OpticalElement: "MICADO"

Element: instrument

Alias: INST

Description: Effects from the MICADO common optics

2.2.1 Global properties

```
     temperature : -190
filter_file_format : filters/TC_filter_\{\}.dat
    element_name : MICADO
```

2.2.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO	micado_static_surfaces	SurfaceList	True	[20, 120, 520]
MICADO	micado_ncpas_psf	NonCommonPathAberration	True	[241, 641]
MICADO	filter_wheel_1	FilterWheel	True	[124, 224, 524]
MICADO	filter_wheel_2	FilterWheel	True	[124, 224, 524]
MICADO	pupil_wheel	FilterWheel	True	[124, 224, 524]

2.2.2.1 SurfaceList: "micado_static_surfaces"

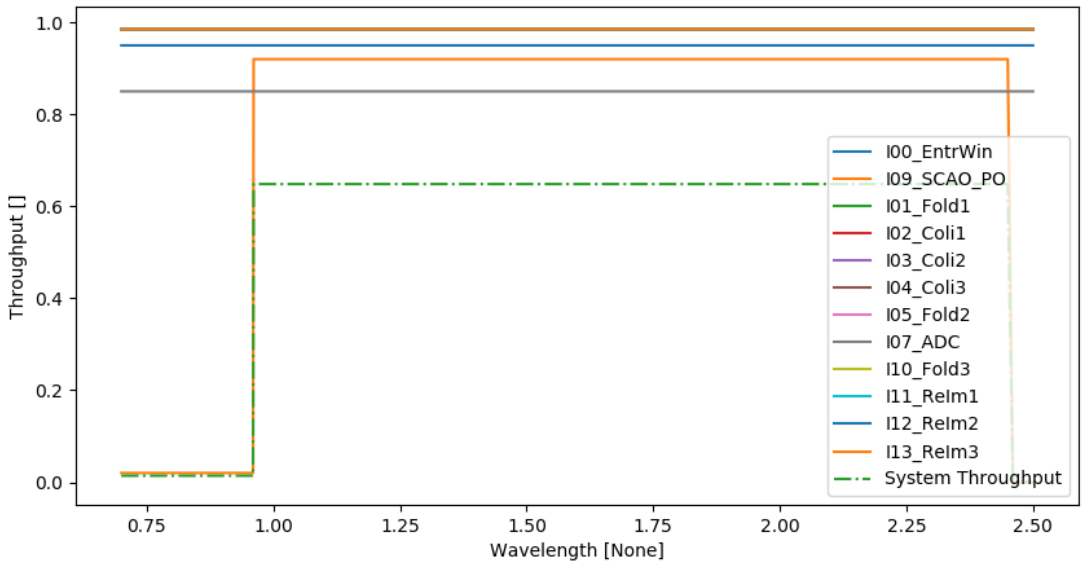
Included by default: `True`

File Description: surfaces list for wide field optics

Class Description: <no docstring>

Changes:

- 2019-01-28 (KL) Changed column names and added units to header
- 2019-07-10 (KL) Shortened the list to only the swappable mirrors
- 2020-08-25 (KL) Updated angle_unit to degree from degrees (why has astropy not complained until now?)
- 2020-10-10 (KL) Added SCAO pick-off dichroic after CM17 conversation



name	outer	inner	angle	temperature	action	filename
I00_EntrWin	0.5	0.0	0	0	transmission	TER_entrance_window.dat
I09_SCAO_PO	0.5	0.0	45	-190	reflection	TER_SCAO_dichroic.dat
I01_Fold1	0.5	0.0	45	-190	reflection	TER_mirror_gold.dat
I02_Coli1	0.4	0.0	10	-190	reflection	TER_mirror_gold.dat
I03_Coli2	0.2	0.0	10	-190	reflection	TER_mirror_gold.dat
I04_Coli3	0.2	0.0	10	-190	reflection	TER_mirror_gold.dat
I05_Fold2	0.2	0.0	45	-190	reflection	TER_mirror_gold.dat
I07_ADC	0.2	0.0	0	-190	transmission	TER_full_adc.dat
I10_Fold3	0.2	0.0	45	-190	reflection	TER_mirror_gold.dat
I11_ReIm1	0.2	0.0	10	-190	reflection	TER_mirror_gold.dat
I12_ReIm2	0.2	0.0	10	-190	reflection	TER_mirror_gold.dat
I13_ReIm3	0.2	0.0	10	-190	reflection	TER_mirror_gold.dat

Data

Meta-data

```
        filename : LIST_MICADO_mirrors_static.dat
           name : micado_static_surfaces
    temperature : -190
filter_file_format : filters/TC_filter_\{\}.dat
```

```
      element_name : MICADO
           author : Kieran Leschinski
           source : Ric's SPIE 2018 PPT presentation
      date_created : 2018-11-19
     date_modified : 2019-07-10
           status : Design, pre PDR list of all static MICADO surfaces
             type : mirror:list
       outer_unit : m
       inner_unit : m
       angle_unit : degree
   temperature_unit : deg_C
          z_order : [20, 120, 520]
          include : True
     ignore_wings : False
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
        wave_unit : !SIM.spectral.wave_unit
         wave_bin : !SIM.spectral.spectral_resolution
 report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
          etendue : !TEL.etendue
```

2.2.2.2 NonCommonPathAberration: "micado_ncpas_psf"

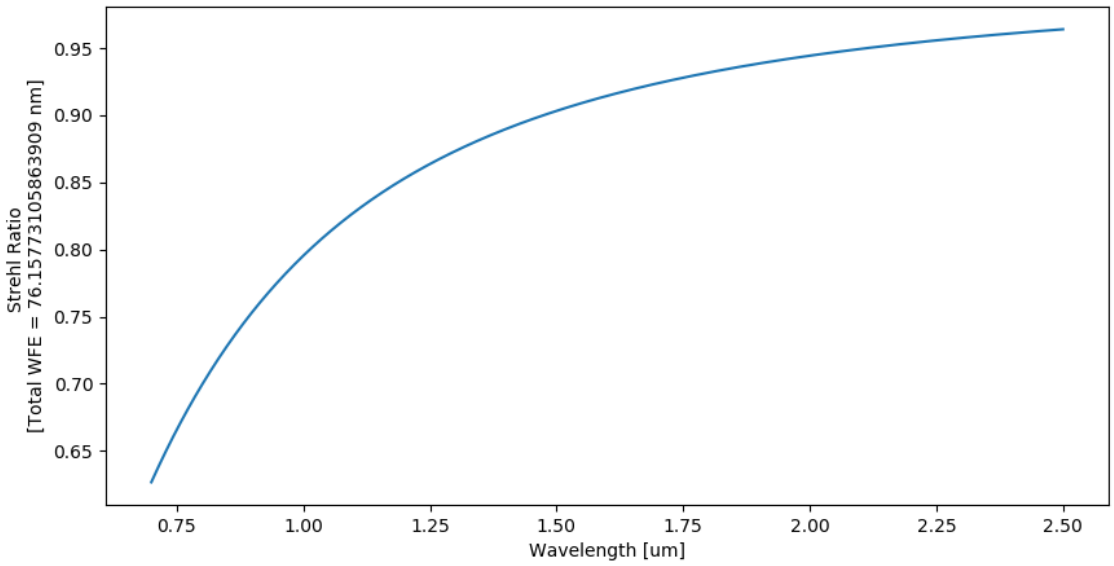
Included by default: `True`

File Description: Effective NCPA induced PSF kernel

Class Description: Needed: pixel_scale

Changes:

- 2018-11-19 (KL) updated meta data to new format



Data

Meta-data

```
         filename : INST_MICADO_wavefront_error_budget.dat
             name : micado_ncpas_psf
      temperature : -190
 filter_file_format : filters/TC_filter_\{\}.dat
     element_name : MICADO
      pixel_scale : 0.004
           author : Kieran Leschinski
          sources : Ric Davies email
     date_created : 2016-11-21
    date_modified : 2018-11-19
             type : instrument:wavefront_errors_list
           status : Idea - based on the WFE budget and emails with Ric
     wfe_rms_unit : nm
          z_order : [241, 641]
          include : True
    flux_accuracy : 0.001
   sub_pixel_flag : False
    convolve_mode : full
        wave_key : WAVE0
  normalise_kernel : True
report_plot_include : True
```

```
report_table_include : False
      kernel_width : None
      strehl_drift : 0.02
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
```

2.2.2.3 FilterWheel: "filter_wheel_1"

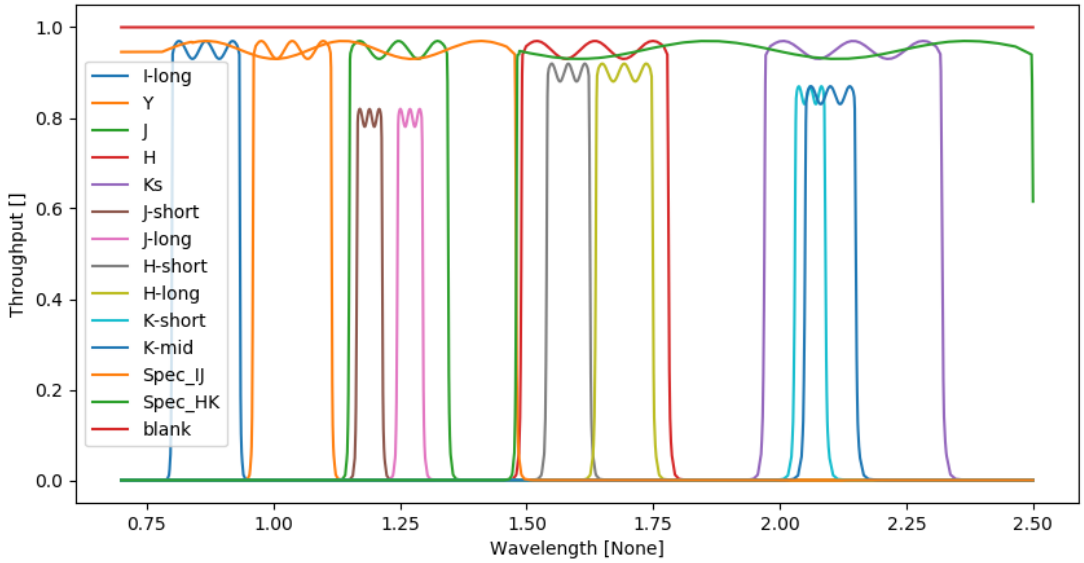
Included by default: `True`

File Description:

Class Description: Examples

Changes:

-



name	centre	width	blue cutoff	red cutoff
I-long	0.8689	0.1340	0.8019	0.9359
Y	1.0396	0.1550	0.9621	1.1171
J	1.2502	0.1950	1.1527	1.3477
H	1.6395	0.2900	1.4945	1.7845
Ks	2.1500	0.3500	1.9750	2.3250

... continued on next page

name	centre	width	blue cutoff	red cutoff
J-short	1.1902	0.0490	1.1657	1.2147
J-long	1.2702	0.0490	1.2457	1.2947
H-short	1.5830	0.0850	1.5405	1.6255
H-long	1.6937	0.1120	1.6377	1.7497
K-short	2.0602	0.0600	2.0302	2.0902
K-mid	2.1005	0.1000	2.0505	2.1505
Spec_IJ	1.1663	0.6990	0.8168	1.5158
Spec_HK	2.0345	1.0200	1.5245	2.5445
blank	2.7545	2.7000	1.4045	4.1045

Data

Meta-data

```
          filename : None
             name : filter_wheel_1
       temperature : -190
  filter_file_format : filters/TC_filter_\{\}.dat
      element_name : MICADO
      filter_names : ['I-long', 'Y', 'J', 'H', 'Ks', 'J-short', 'J-long', 'H-
    filename_format : !INST.filter_file_format
     current_filter : !OBS.filter_name_fw1
  minimum_throughput : 0.000101
           outer : 0.2
        outer_unit : m
          z_order : [124, 224, 524]
          include : True
             path :
 report_plot_include : True
report_table_include : True
report_table_rounding : 4
```

2.2.2.4 FilterWheel: "filter_wheel_2"

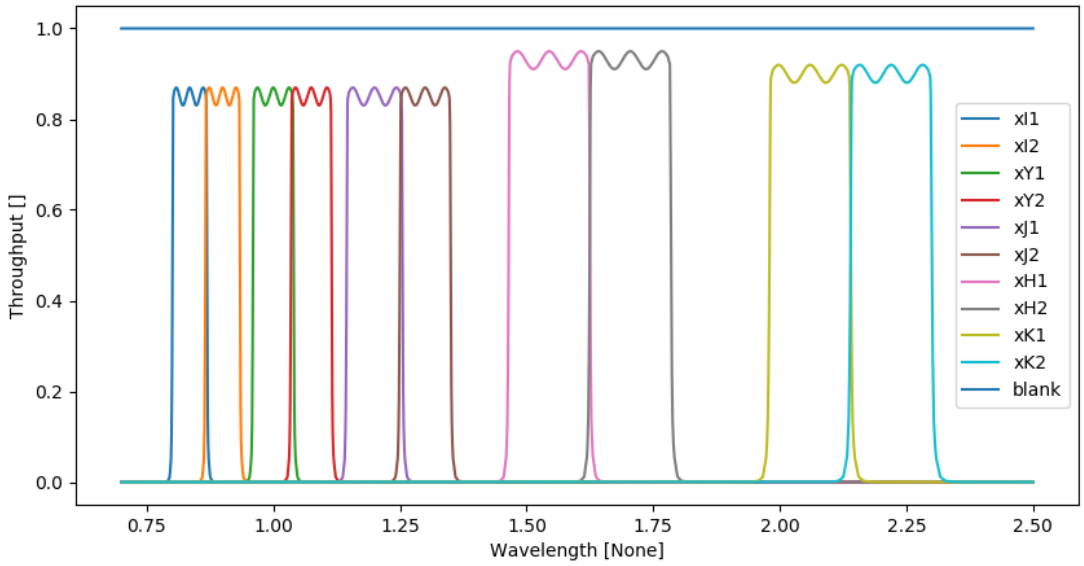
Included by default: `True`

File Description:

Class Description: Examples

Changes:

-



name	centre	width	blue cutoff	red cutoff
xI1	0.8355	0.0680	0.8015	0.8695
xI2	0.9005	0.0680	0.8665	0.9345
xY1	1.0006	0.0800	0.9606	1.0406
xY2	1.0756	0.0800	1.0356	1.1156
xJ1	1.2009	0.1100	1.1459	1.2559
xJ2	1.3007	0.1000	1.2507	1.3507
xH1	1.5465	0.1600	1.4665	1.6265
xH2	1.7064	0.1600	1.6264	1.7864
xK1	2.0612	0.1600	1.9812	2.1412
xK2	2.2211	0.1600	2.1411	2.3011
blank	2.7545	2.7000	1.4045	4.1045

Data

Meta-data

```
          filename : None
             name : filter_wheel_2
```

```
        temperature : -190
  filter_file_format : filters/TC_filter_\{\}.dat
       element_name : MICADO
       filter_names : ['xI1', 'xI2', 'xY1', 'xY2', 'xJ1', 'xJ2', 'xH1', 'xH2',
     filename_format : !INST.filter_file_format
      current_filter : !OBS.filter_name_fw2
  minimum_throughput : 0.000101
             outer : 0.2
        outer_unit : m
           z_order : [124, 224, 524]
           include : True
              path :
 report_plot_include : True
report_table_include : True
report_table_rounding : 4
```

2.2.2.5 FilterWheel: "pupil_wheel"

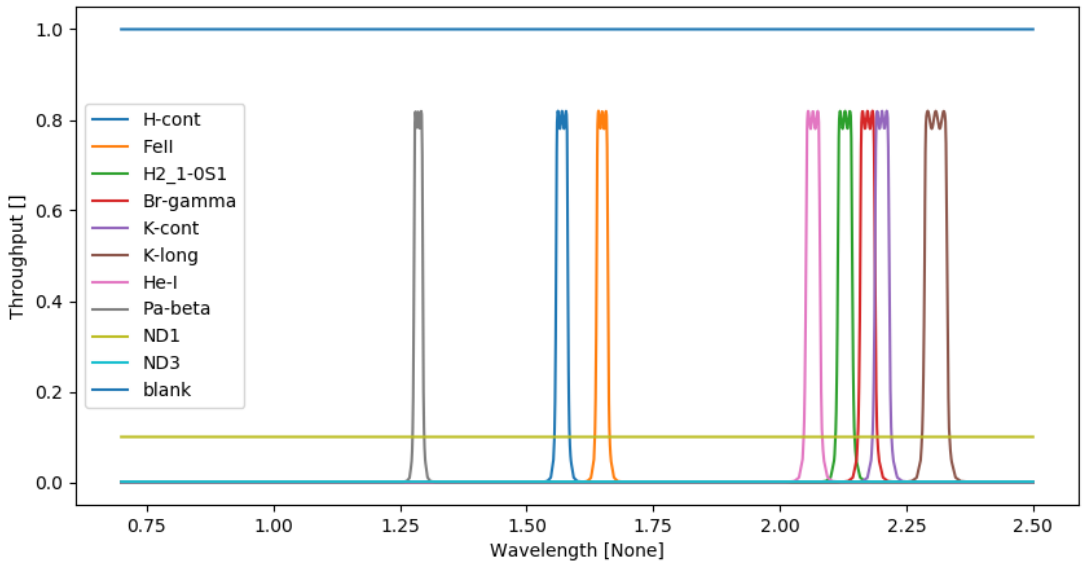
Included by default: `True`

File Description:

Class Description: Examples

Changes:

-



name	centre	width	blue cutoff	red cutoff
H-cont	1.5701	0.0220	1.5591	1.5811
FeII	1.6495	0.0210	1.6390	1.6600
H2_1-0S1	2.1289	0.0280	2.1149	2.1429
Br-gamma	2.1734	0.0280	2.1594	2.1874
K-cont	2.2019	0.0270	2.1884	2.2154
K-long	2.3081	0.0440	2.2861	2.3301
He-I	2.0656	0.0270	2.0521	2.0791
Pa-beta	1.2865	0.0170	1.2780	1.2950
ND1	2.7529	0.0000	2.7529	2.7529
ND3	2.7529	0.0000	2.7529	2.7529
blank	2.7545	2.7000	1.4045	4.1045

Data

Meta-data

```
          filename : None
             name : pupil_wheel
      temperature : -190
  filter_file_format : filters/TC_filter_\{\}.dat
     element_name : MICADO
     filter_names : ['H-cont', 'FeII', 'H2_1-0S1', 'Br-gamma', 'K-cont', 'K-
    filename_format : !INST.filter_file_format
    current_filter : !OBS.filter_name_pupil
  minimum_throughput : 0.000101
           outer : 0.2
       outer_unit : m
          z_order : [124, 224, 524]
          include : True
            path :
 report_plot_include : True
report_table_include : True
report_table_rounding : 4
```

2.3 OpticalElement: "MICADO_IMG_LR"

Element: instrument

Alias: INST

Description: additional effects for the wide-field imaging mode

2.3.1 Global properties

```
 pixel_scale : 0.004
 plate_scale : 0.26666666666
element_name : MICADO_IMG_LR
```

2.3.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_IMG_LR	micado_wide_field_mirror_list	SurfaceList	True	[20, 120, 520]
MICADO_IMG_LR	micado_adc_3D_shift	AtmosphericDispersionCorrection	False	[632, 232]

2.3.2.1 SurfaceList: "micado_wide_field_mirror_list"

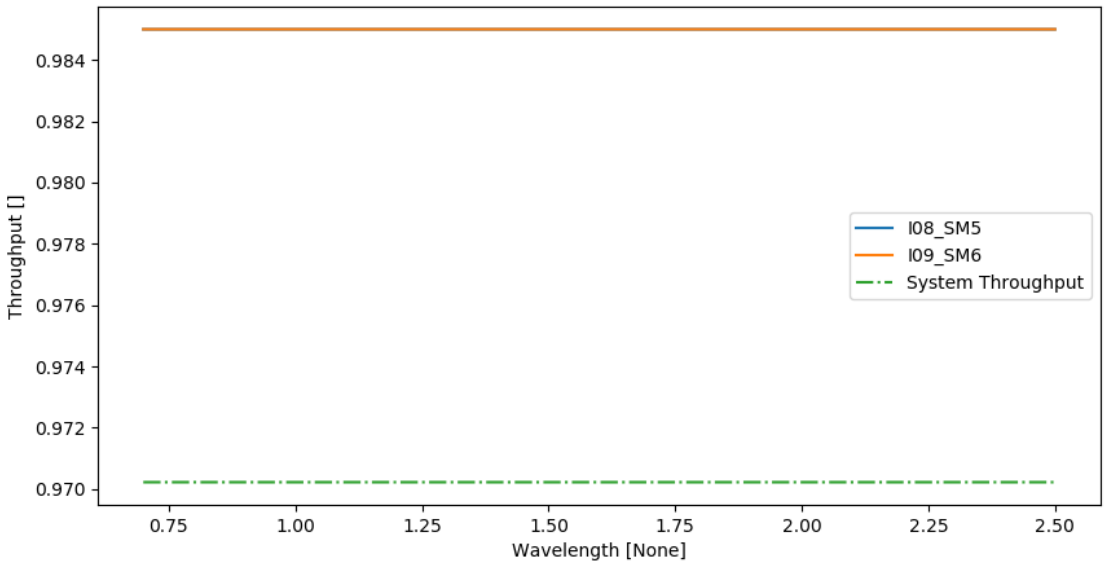
Included by default: `True`

File Description: list of extra mirrors needed for the wide field mode

Class Description: <no docstring>

Changes:

- 2019-01-28 (KL) Changed column names and added units to header
- 2019-07-10 (KL) Shortened the list to only the swappable mirrors



name	outer	inner	angle	temperature	action	filename
I08_SM5	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat
I09_SM6	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat

Data The list of surfaces from the rotating optics wheel that are added to the optical train when observing in the wide field mode

Meta-data

```
        filename : LIST_MICADO_mirrors_wide.dat
            name : micado_wide_field_mirror_list
     pixel_scale : 0.004
     plate_scale : 0.26666666666
    element_name : MICADO_IMG_LR
          author : Kieran Leschinski
          source : Ric's SPIE 2018 PPT presentation
    date_created : 2018-11-19
   date_modified : 2019-07-10
          status : Design, pre PDR list of MICADO mirrors for wide-field mode
            type : mirror:list
      outer_unit : m
      inner_unit : m
      angle_unit : degree
```

```
   temperature_unit : deg_C
          z_order : [20, 120, 520]
          include : True
      ignore_wings : False
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
        wave_unit : !SIM.spectral.wave_unit
         wave_bin : !SIM.spectral.spectral_resolution
 report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
          etendue : !TEL.etendue
```

2.3.2.2 AtmosphericDispersionCorrection: "micado_adc_3D_shift"

Included by default: `False`

File Description: atmospheric disperson corrector

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
         filename : None
            name : micado_adc_3D_shift
         include : False
      pixel_scale : 0.004
      plate_scale : 0.26666666666
     element_name : MICADO_IMG_LR
        altitude : !ATMO.altitude
       longitude : !ATMO.longitude
        latitude : !ATMO.latitude
         airmass : !OBS.airmass
      temperature : !ATMO.temperature
        humidity : !ATMO.humidity
        pressure : !ATMO.pressure
      pupil_angle : !OBS.pupil_angle
       efficiency : 1
        wave_mid : !SIM.spectral.wave_mid
```

```
        quick_adc : True
          z_order : [632, 232]
 report_plot_include : True
report_table_include : False
```

2.4 OpticalElement: "MICADO_IMG_HR"

Element: instrument

Alias: INST

Description: additional effects for the zoom imaging mode

2.4.1 Global properties

```
 pixel_scale : 0.0015
 plate_scale : 0.1
element_name : MICADO_IMG_HR
```

2.4.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_IMG_HR	zoom_mirror_list	SurfaceList	True	[20, 120, 520]
MICADO_IMG_HR	micado_adc_3D_shift	AtmosphericDispersionCorrection	False	[632, 232]

2.4.2.1 SurfaceList: "zoom_mirror_list"

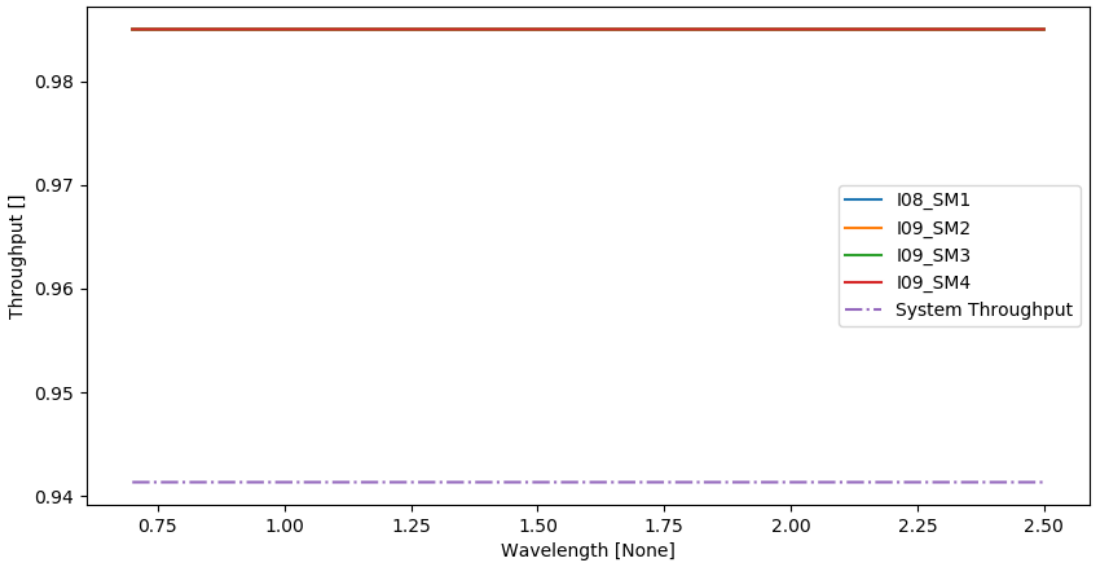
Included by default: `True`

File Description: list of extra mirror needed for the zoom imaging mode

Class Description: <no docstring>

Changes:

- 2019-01-28 (KL) Changed column names and added units to header
- 2019-07-10 (KL) Shortened the list to only the swappable mirrors



name	outer	inner	angle	temperature	action	filename
I08_SM1	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat
I09_SM2	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat
I09_SM3	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat
I09_SM4	0.2	0.0	0	-190	reflection	TER_mirror_gold.dat

Data

Meta-data

```
        filename : LIST_MICADO_mirrors_zoom.dat
           name : zoom_mirror_list
     pixel_scale : 0.0015
     plate_scale : 0.1
    element_name : MICADO_IMG_HR
         author : Kieran Leschinski
         source : Ric's SPIE 2018 PPT presentation
   date_created : 2018-11-19
  date_modified : 2019-07-10
         status : Design, pre PDR list of swappable mirrors for zoom mode
           type : mirror:list
          ETYPE : SURFLIST
           EDIM : 1
```

```
       outer_unit : m
       inner_unit : m
       angle_unit : degree
  temperature_unit : deg_C
         z_order : [20, 120, 520]
         include : True
     ignore_wings : False
        wave_min : !SIM.spectral.wave_min
        wave_max : !SIM.spectral.wave_max
       wave_unit : !SIM.spectral.wave_unit
        wave_bin : !SIM.spectral.spectral_resolution
report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
         etendue : !TEL.etendue
```

2.4.2.2 AtmosphericDispersionCorrection: "micado_adc_3D_shift"

Included by default: `False`

File Description: atmospheric disperson corrector

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
         filename : None
            name : micado_adc_3D_shift
         include : False
     pixel_scale : 0.0015
     plate_scale : 0.1
    element_name : MICADO_IMG_HR
       altitude : !ATMO.altitude
      longitude : !ATMO.longitude
       latitude : !ATMO.latitude
        airmass : !OBS.airmass
     temperature : !ATMO.temperature
       humidity : !ATMO.humidity
       pressure : !ATMO.pressure
```

```
       pupil_angle : !OBS.pupil_angle
          wave_mid : !SIM.spectral.wave_mid
        efficiency : 1
         quick_adc : True
           z_order : [632, 232]
 report_plot_include : True
report_table_include : False
```

2.5 OpticalElement: "MICADO_SPEC"

Element: instrument

Alias: INST

Description: additional effects for the spectroscopy mode

2.5.1 Global properties

```
 pixel_scale : 0.004
 plate_scale : 0.2666666667
element_name : MICADO_SPEC
```

2.5.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_SPEC	spec_mode_optics	SurfaceList	True	[20, 120, 520]
MICADO_SPEC	spectroscopic_slit_aperture	ApertureMask	True	[80, 280, 380]
MICADO_SPEC	micado_spectral_traces	SpectralTraceList	True	[70, 270]

2.5.2.1 SurfaceList: "spec_mode_optics"

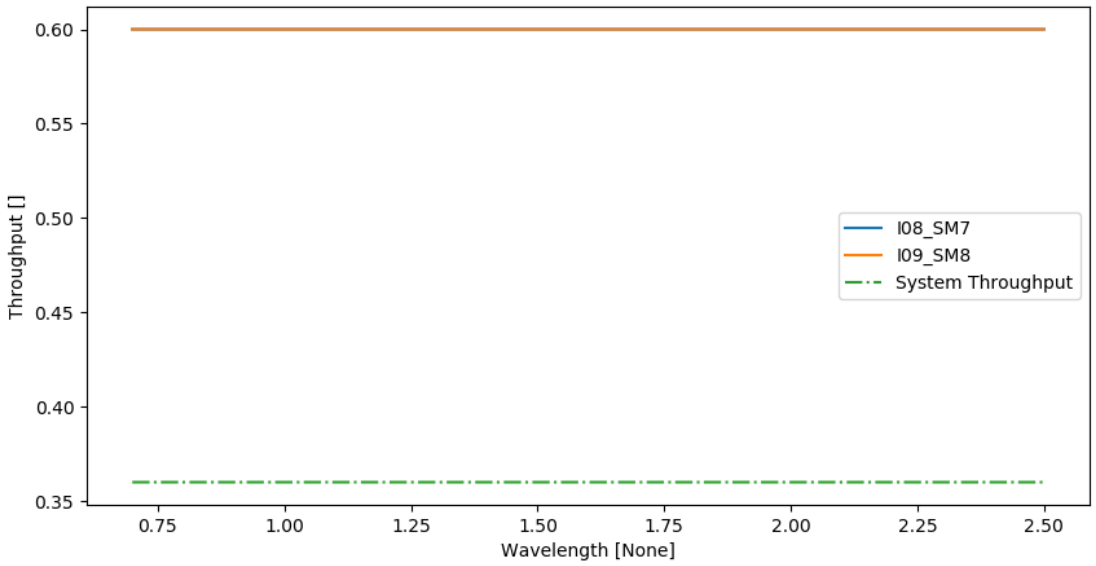
Included by default: `True`

File Description: list of extra mirrors needed for the spectroscopy mode

Class Description: <no docstring>

Changes:

- 2019-01-28 (KL) Changed column names and added units to header
- 2019-07-10 (KL) Shortened the list to only the swappable gratings



name	outer	inner	angle	temperature	action	filename
I08_SM7	0.2	0.0	0	-190	reflection	TER_grating.dat
I09_SM8	0.2	0.0	0	-190	reflection	TER_grating.dat

Data

Meta-data

```
        filename : LIST_MICADO_mirrors_spec.dat
            name : spec_mode_optics
     pixel_scale : 0.004
     plate_scale : 0.2666666667
    element_name : MICADO_SPEC
          author : Kieran Leschinski
          source : Ric's SPIE 2018 PPT presentation
    date_created : 2018-11-19
   date_modified : 2019-07-10
          status : Design, pre PDR list of swappable optics for spectroscopy
            type : mirror:list
           ETYPE : SURFLIST
            EDIM : 1
     outer_unit : m
     inner_unit : m
```

```
        angle_unit : degree
   temperature_unit : deg_C
          z_order : [20, 120, 520]
          include : True
      ignore_wings : False
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
        wave_unit : !SIM.spectral.wave_unit
         wave_bin : !SIM.spectral.spectral_resolution
 report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
          etendue : !TEL.etendue
```

2.5.2.2 ApertureMask: "spectroscopic_slit_aperture"

Included by default: `True`

File Description: Slit mask for the short, wide slit (3 arcsec x 50 mas)

Class Description: Only provides the on-sky window coords of the Aperture

Changes:

- 2019-07-10 (KL) Created the file
- 2020-03-24 (KL) Changed geometry to 3000x50mas

Data

x	y
-1.5000	-0.0250
1.5000	-0.0250
1.5000	0.0250
-1.5000	0.0250

Meta-data

```
          filename : !OBS.slit_file
             name : spectroscopic_slit_aperture
       pixel_scale : 0.004
       plate_scale : 0.2666666667
      element_name : MICADO_SPEC
```

```
            author : Kieran Leschinski
            source : My imagination
      date_created : 2019-07-10
     date_modified : 2019-07-10
            status : Guess - in the train on the way home from CM13
              type : aperture:slit_geometry
            x_unit : arcsec
            y_unit : arcsec
           z_order : [80, 280, 380]
           include : True
           no_mask : True
             angle : 0
             shape : rect
    conserve_image : True
                id : 0
 report_plot_include : False
report_table_include : True
report_table_rounding : 4
```

2.5.2.3 SpectralTraceList: "micado_spectral_traces" : 17 traces

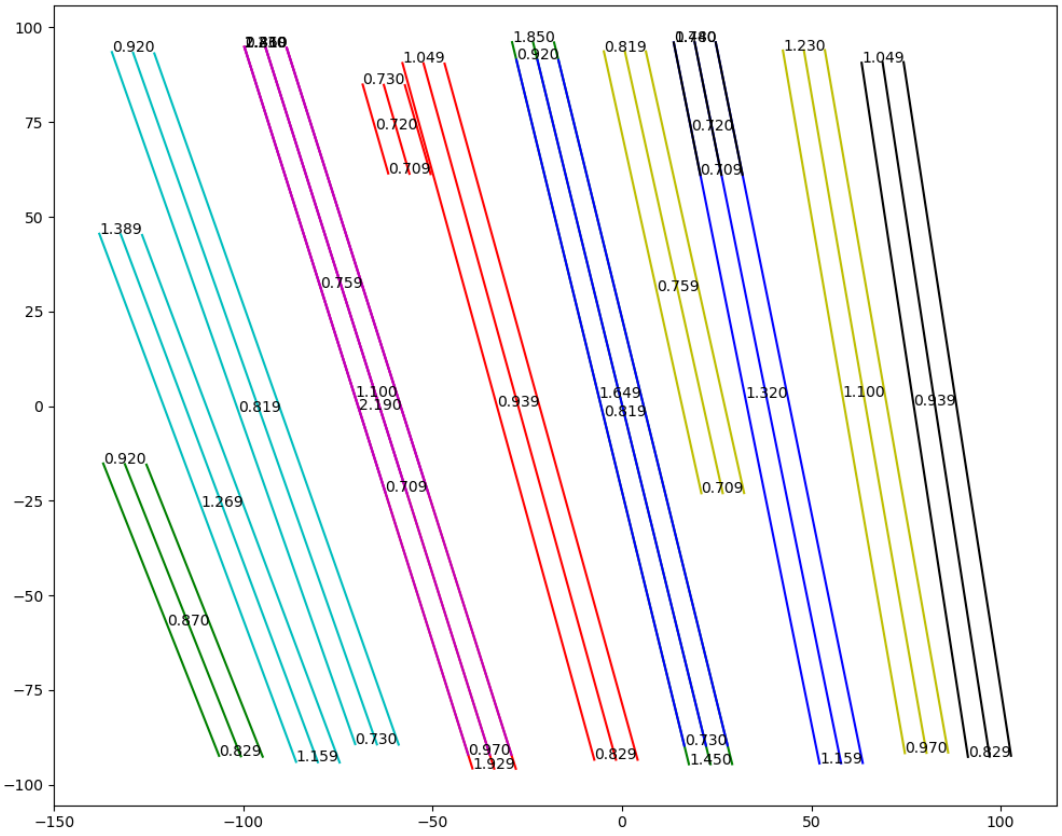
Included by default: `True`

File Description: list of spectral order trace geometry on the focal plane

Class Description: List of spectral trace geometries for the detector plane

Changes:

-



Data

Meta-data

```
        filename : !OBS.trace_file
            name : micado_spectral_traces
    pixel_scale : 0.004
```

```
       plate_scale : 0.2666666667
      element_name : MICADO_SPEC
      wave_colname : lam
        s_colname : xi
   col_number_start : 1
     invalid_value : 0
           SIMPLE : True
           BITPIX : 8
            NAXIS : 0
           EXTEND : True
         FILETYPE : Spectral Layout Definition
           AUTHOR : Oliver Czoske
             DATE : 2018-09-16
           SOURCE : Frank Grupp
         ORIGDATE : 2018-06-29
           STATUS : Design PDR
             ECAT : 1
            EDATA : 2
         DESCRIPT : Maps spectral traces from long slit aperture to detector
         DATE_CRE : 2018-06-29
         DATE_MOD : 2019-09-16
          HISTORY : 2019-09-16 : (KL) Added aperture-imagePlane table to EXT 1
          z_order : [70, 270]
          include : True
         wave_min : !SIM.spectral.wave_min
         wave_mid : !SIM.spectral.wave_mid
         wave_max : !SIM.spectral.wave_max
        x_colname : x
        y_colname : y
 center_on_wave_mid : False
            dwave : 0.002
 report_plot_include : True
report_table_include : False
```

2.6 OpticalElement: "micado_detector_array"

Element: detector

Alias: DET

Description: A set of 9 H4RG detectors

2.6.1 Global properties

```
image_plane_id : 0
  temperature : -230
        dit : !OBS.dit
       ndit : !OBS.ndit
 element_name : micado_detector_array
```

2.6.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
micado_detector_array	full_detector_array	DetectorList	False	[90, 290, 390, 490]
micado_detector_array	detector_window	DetectorList	True	[90, 290, 390, 490]
micado_detector_array	qe_curve	QuantumEfficiencyCurve	True	[113, 513]
micado_detector_array	exposure_action	SummedExposure	True	[860]
micado_detector_array	dark_current	DarkCurrent	True	[830]
micado_detector_array	detector_linearity	LinearityCurve	True	[840]
micado_detector_array	shot_noise	ShotNoise	True	[820]
micado_detector_array	readout_noise	PoorMansHxRGReadoutNoise	True	[811]

2.6.2.1 DetectorList: "full_detector_array"

Included by default: `False`

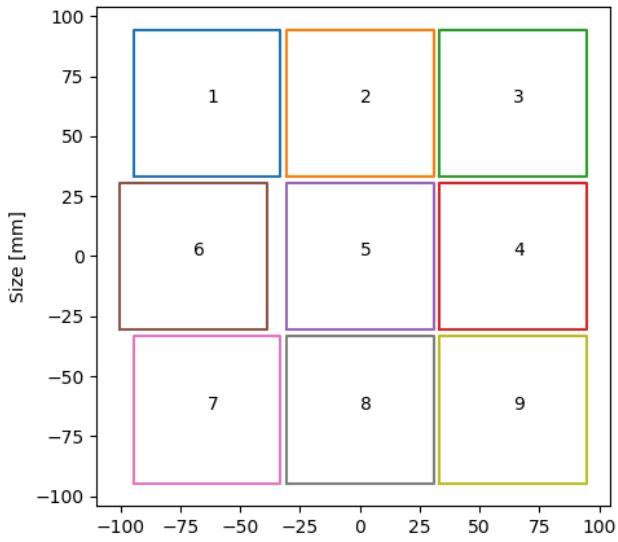
File Description: MICADO detector array list

Class Description: A description of detector positions and properties

Changes:

- 2017-08-12 (OC) id changed to conform with spectroscopy report
- 2018-07-26 (OC) large gap (chips 5 and 6) reduced to 8 mm
- 2018-11-19 (KL) updated meta data to new format

- 2019-01-28 (KL) moved units into header



id	x_cen	y_cen	x_size	y_size	x_len	y_len	pixel_size	angle	gain
1	-63.84	63.84	61.44	61.44	4096	4096	0.015	0.0	1.0
2	0.0	63.84	61.44	61.44	4096	4096	0.015	0.0	1.0
3	63.84	63.84	61.44	61.44	4096	4096	0.015	0.0	1.0
4	63.84	0.0	61.44	61.44	4096	4096	0.015	0.0	1.0
5	0.0	0.0	61.44	61.44	4096	4096	0.015	0.0	1.0
6	-69.44	0.0	61.44	61.44	4096	4096	0.015	0.0	1.0
7	-63.84	-63.84	61.44	61.44	4096	4096	0.015	0.0	1.0
8	0.0	-63.84	61.44	61.44	4096	4096	0.015	0.0	1.0
9	63.84	-63.84	61.44	61.44	4096	4096	0.015	0.0	1.0

Data

Meta-data

```
        filename : FPA_array_layout.dat
           name : full_detector_array
        include : False
  image_plane_id : 0
     temperature : -230
```

```
             dit : !OBS.dit
            ndit : !OBS.ndit
    element_name : micado_detector_array
active_detectors : all
          author : Oliver Czoske
         sources : E-MCD-FPA-572089EB.uda, ELT-TRE-MCD-56300-0011
    date_created : 2017-06-28
   date_modified : 2018-07-26
            type : detector:chip_list
     x_cen_unit : mm
     y_cen_unit : mm
      xhw_unit : mm
      yhw_unit : mm
     x_len_unit : pix
     y_len_unit : pix
   pixsize_unit : mm
     angle_unit : deg
      gain_unit : electron/adu
        z_order : [90, 290, 390, 490]
    pixel_scale : !INST.pixel_scale
report_plot_include : True
report_table_include : True
     x_size_unit : mm
     y_size_unit : mm
```

2.6.2.2 DetectorList: "detector_window"

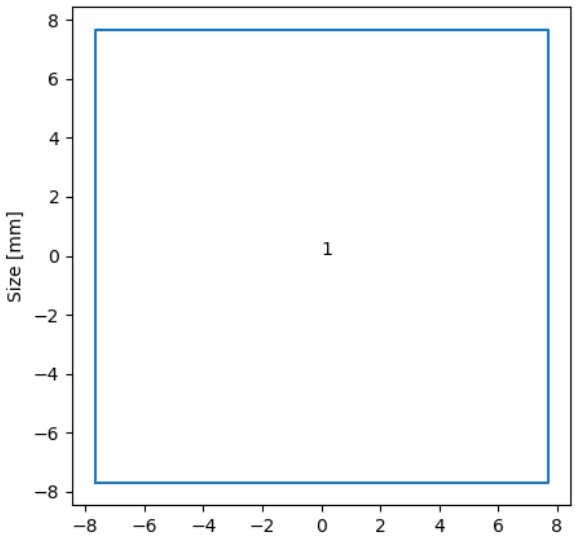
Included by default: `True`

File Description:

Class Description: A description of detector positions and properties

Changes:

-



id	pixel_size	angle	gain	x_cen	y_cen	x_size	y_size
1	0.015	0.0	1.0	0.0	0.0	15.36	15.36

Data

Meta-data

```
         filename : None
            name : detector_window
         include : True
    image_plane_id : 0
      temperature : -230
            dit : !OBS.dit
           ndit : !OBS.ndit
     element_name : micado_detector_array
       x_cen_unit : mm
       y_cen_unit : mm
      x_size_unit : mm
      y_size_unit : mm
   pixel_size_unit : mm
       angle_unit : deg
        gain_unit : electron/adu
          z_order : [90, 290, 390, 490]
       array_dict : \{'id': [1], 'pixel_size': [0.015], 'angle': [0.0], 'gain
```

```
       pixel_scale : !INST.pixel_scale
   active_detectors : all
 report_plot_include : True
report_table_include : True
```

2.6.2.3 QuantumEfficiencyCurve: "qe_curve"

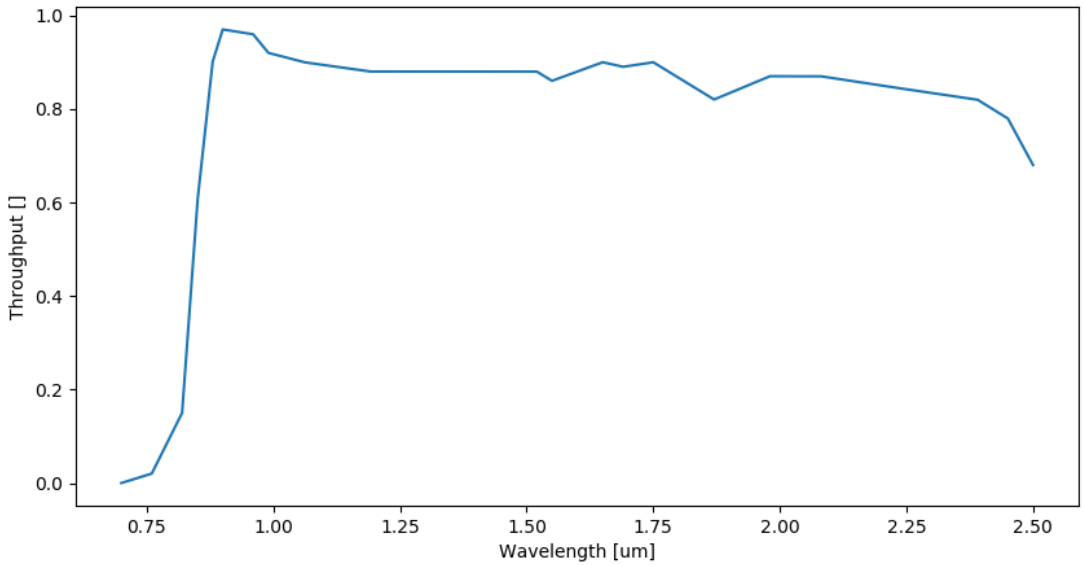
Included by default: `True`

File Description: Quantum efficiency curves for each detector

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) updated meta data to new format
- 2019-08-09 (KL) Added action keyword to meta data



Data

Meta-data

```
         filename : QE_detector_H2RG.dat
             name : qe_curve
```

```
    image_plane_id : 0
      temperature : -230
             dit : 60
            ndit : 1
     element_name : micado_detector_array
           author : Kieran Leschinski
          sources : Finger+ 2008 SPIE
     date_created : 2016-01-01
    date_modified : 2019-08-09
             type : detector:quantum_efficiency
           status : Design, guestimated by reading off the graph in Finger+ 20
   wavelength_unit : um
           action : transmission
          z_order : [113, 513]
          include : True
     ignore_wings : False
        wave_min : 0.7
        wave_max : 2.5
       wave_unit : um
        wave_bin : 0.0001
report_plot_include : True
report_table_include : False
          position : -1
```

2.6.2.4 SummedExposure: "exposure_action"

Included by default: `True`

File Description: Summing up sky signal for all DITs and NDITs

Class Description: Simulates a summed stack of `ndit` exposures

Changes:

-

Data

Meta-data

```
    filename : None
       name : exposure_action
image_plane_id : 0
  temperature : -230
         dit : !OBS.dit
```

```
       ndit : !OBS.ndit
 element_name : micado_detector_array
     z_order : [860]
     include : True
```

2.6.2.5 DarkCurrent: "dark_current"

Included by default: `True`

File Description: MICADO dark current

Class Description: required: dit, ndit, value

Changes:

-

Data

Meta-data

```
    filename : None
       name : dark_current
image_plane_id : 0
  temperature : -230
        dit : !OBS.dit
       ndit : !OBS.ndit
 element_name : micado_detector_array
      value : 0.1
     z_order : [830]
     include : True
```

2.6.2.6 LinearityCurve: "detector_linearity"

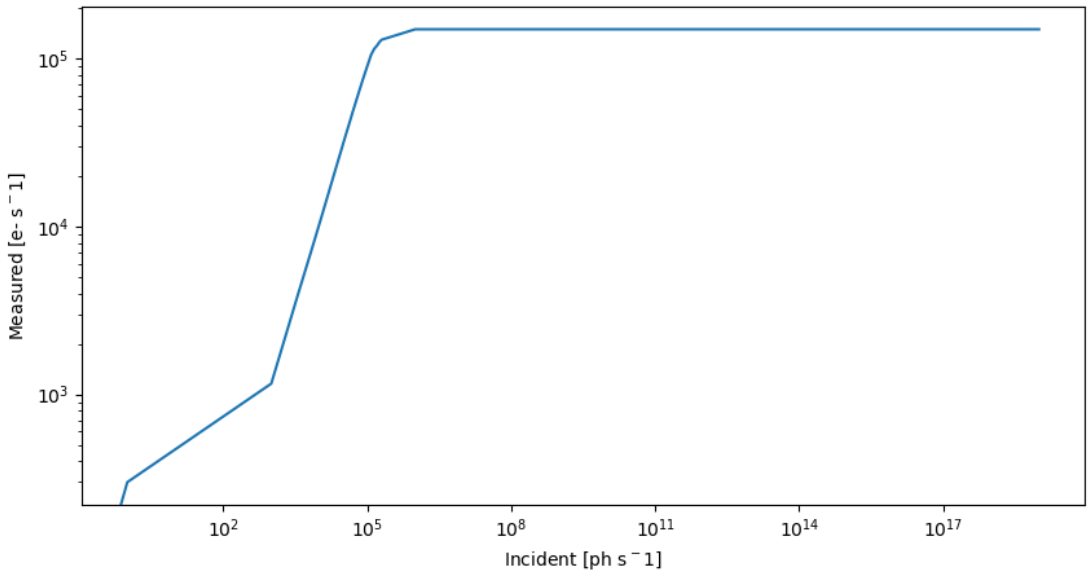
Included by default: `True`

File Description: Linearity characteristics of H4RG chips

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) updated meta data to new format
- 2019-08-14 (KL) replaced long 1000000000 with 1e99



Data

Meta-data

```
         filename : FPA_linearity.dat
             name : detector_linearity
    image_plane_id : 0
      temperature : -230
             dit : !OBS.dit
            ndit : !OBS.ndit
     element_name : micado_detector_array
           author : Kieran Leschinski
          sources : Ingraham+ 2014 - Gemini Calibrations II for H2RG
     date_created : 2016-01-01
    date_modified : 2018-11-19
             type : detector:linearity
           status : Design, approximated from the H2RG
    incident_unit : ph
    measured_unit : ph
          z_order : [840]
          include : True
 report_plot_include : True
report_table_include : False
```

2.6.2.7 ShotNoise: "shot_noise"

Included by default: `True`

File Description: apply poisson shot noise to images

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
    filename : None
       name : shot_noise
image_plane_id : 0
  temperature : -230
        dit : !OBS.dit
       ndit : !OBS.ndit
 element_name : micado_detector_array
     z_order : [820]
     include : True
  random_seed : !SIM.random.seed
```

2.6.2.8 PoorMansHxRGReadoutNoise: "readout_noise"

Included by default: `True`

File Description: Readout noise frames

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
        filename : None
           name : readout_noise
    image_plane_id : 0
```

```
      temperature : -230
            dit : !OBS.dit
           ndit : !OBS.ndit
     element_name : micado_detector_array
       noise_std : 12
      n_channels : 64
        z_order : [811]
        include : True
  pedestal_fraction : 0.3
     read_fraction : 0.4
     line_fraction : 0.25
   channel_fraction : 0.05
      random_seed : !SIM.random.seed
 report_plot_include : False
report_table_include : False
```

2.7 OpticalElement: "MICADO_simulation_paramters"

Element: simulation

Alias: SIM

Description: RC simulation paramters which need to change for a MICADO run

2.7.1 Global properties

```
    random : \{'seed': 9001\}
  spectral : \{'wave_min': 0.7, 'wave_mid': 1.6, 'wave_max': 2.5\}
 computing : \{'preload_field_of_view': True\}
   reports : \{'preamble_file': '../docs/preamble.rst'\}
element_name : MICADO_simulation_paramters
```

Chapter 3

MICADO Science package

3.1 Summary of Effects in Optical Elements:

element	name	class	included	z_orders
MICADO_Sci	micado_common_optics	TERCurve	True	[10, 110, 510]
MICADO_Sci	filter_wheel	FilterWheel	True	[124, 224, 524]
micado_sci_detector	micado_detector_window	DetectorWindow	True	[90, 290, 390, 490]
micado_sci_detector	h4rg_qe_curve	QuantumEfficiencyCurve	True	[113, 513]
micado_sci_detector	exposure_action	SummedExposure	True	[860]
micado_sci_detector	dark_current	DarkCurrent	True	[830]
micado_sci_detector	shot_noise	ShotNoise	True	[820]
micado_sci_detector	h4rg_detector_linearity	LinearityCurve	False	[840]
micado_sci_detector	readout_noise	PoorMansHxRGReadoutNoise	True	[811]
MICADO_SPEC	micado_adjustable_slit	RectangularApertureMask	True	[80, 280, 380]
MICADO_SPEC	spectral_trace_3000x50mas	SpectralTraceList	True	[70, 270]
MICADO_SCAO	scao_relay_optics_ter	TERCurve	True	[10, 110, 510]
MICADO_SCAO	scao_const_psf	AnisocadoConstPSF	True	[42, 652]
MICADO_MCAO	maory_mms_ter	TERCurve	True	[10, 110, 510]
MICADO_MCAO	maory_const_psf	AnisocadoConstPSF	True	[42, 652]

3.2 OpticalElement: "MICADO_Sci"

Element: instrument

Alias: INST

Description: base configuration for MICADO

3.2.1 Global properties

```
     temperature : -190
filter_file_format : filters/TC_filter_\{\}.dat
    element_name : MICADO_Sci
```

3.2.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders [3]
MICADO_Sci	micado_common_optics	TERCurve	True	10 .. 510
MICADO_Sci	filter_wheel	FilterWheel	True	124 .. 524

3.2.2.1 TERCurve: "micado_common_optics"

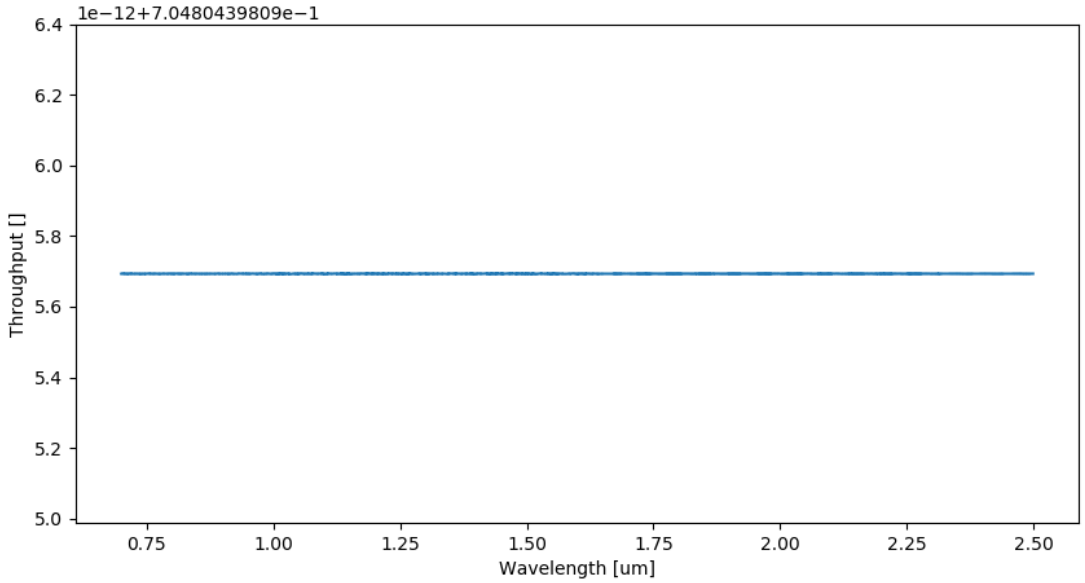
Included by default: `True`

File Description: combined transmission for MICADO common optics

Class Description: Transmission, Emissivity, Reflection Curve

Changes:

-



Data

Meta-data

```
         filename : TER_MICADO_IMG_common.dat
             name : micado_common_optics
      temperature : -190
 filter_file_format : filters/TC_filter_\{\}.dat
     element_name : MICADO_Sci
           author : Auto-compiled from source
           source : LIST_MICADO_mirrors_static.dat
     date_created : 2020-08-25
    date_modified : 2020-08-25
             area : 0.19634954084936207
        area_unit : m2
   wavelength_unit : um
    emission_unit : photlam
         z_order : [10, 110, 510]
         include : True
     ignore_wings : False
         wave_min : 0.7
         wave_max : 2.5
        wave_unit : um
         wave_bin : 0.001
report_plot_include : True
```

```
report_table_include : False
```

3.2.2.2 FilterWheel: "filter_wheel"

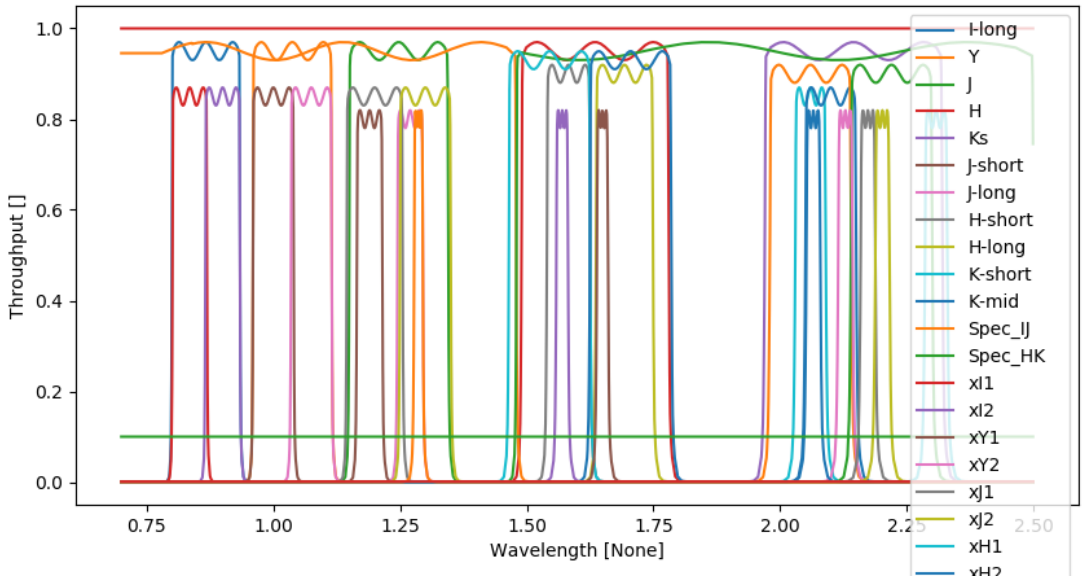
Included by default: `True`

File Description:

Class Description: Examples

Changes:

-



name	centre	width	blue cutoff	red cutoff
I-long	0.8689	0.1340	0.8019	0.9359
Y	1.0396	0.1550	0.9621	1.1171
J	1.2502	0.1950	1.1527	1.3477
H	1.6395	0.2900	1.4945	1.7845
Ks	2.1500	0.3500	1.9750	2.3250
J-short	1.1902	0.0490	1.1657	1.2147
J-long	1.2702	0.0490	1.2457	1.2947
H-short	1.5830	0.0850	1.5405	1.6255

... continued on next page

name	centre	width	blue cutoff	red cutoff
H-long	1.6937	0.1120	1.6377	1.7497
K-short	2.0602	0.0600	2.0302	2.0902
K-mid	2.1005	0.1000	2.0505	2.1505
Spec_IJ	1.1663	0.6990	0.8168	1.5158
Spec_HK	2.0345	1.0200	1.5245	2.5445
xI1	0.8355	0.0680	0.8015	0.8695
xI2	0.9005	0.0680	0.8665	0.9345
xY1	1.0006	0.0800	0.9606	1.0406
xY2	1.0756	0.0800	1.0356	1.1156
xJ1	1.2009	0.1100	1.1459	1.2559
xJ2	1.3007	0.1000	1.2507	1.3507
xH1	1.5465	0.1600	1.4665	1.6265
xH2	1.7064	0.1600	1.6264	1.7864
xK1	2.0612	0.1600	1.9812	2.1412
xK2	2.2211	0.1600	2.1411	2.3011
blank	2.7545	2.7000	1.4045	4.1045
H-cont	1.5701	0.0220	1.5591	1.5811
FeII	1.6495	0.0210	1.6390	1.6600
H2_1-0S1	2.1289	0.0280	2.1149	2.1429
Br-gamma	2.1734	0.0280	2.1594	2.1874
K-cont	2.2019	0.0270	2.1884	2.2154
K-long	2.3081	0.0440	2.2861	2.3301
He-I	2.0656	0.0270	2.0521	2.0791
Pa-beta	1.2865	0.0170	1.2780	1.2950
ND1	2.7529	0.0000	2.7529	2.7529
ND3	2.7529	0.0000	2.7529	2.7529

Data

Meta-data

```
          filename : None
             name : filter_wheel
      temperature : -190
filter_file_format : filters/TC_filter_\{\}.dat
     element_name : MICADO_Sci
     filter_names : ['I-long', 'Y', 'J', 'H', 'Ks', 'J-short', 'J-long', 'H-
   filename_format : !INST.filter_file_format
```

```
     current_filter : !INST.filter_name
  minimum_throughput : 0.000101
               outer : 0.2
          outer_unit : m
             z_order : [124, 224, 524]
             include : True
               path :
 report_plot_include : True
report_table_include : True
report_table_rounding : 4
```

3.3 OpticalElement: "SCAO"

Element: instrument

Alias: INST

Description: SCAO optical system

3.3.1 Global properties

```
element_name : SCAO
```

3.4 OpticalElement: "MICADO_SCAO"

Element: instrument

Alias: INST

Description: MICADO SCAO mode effects

3.4.1 Global properties

```
      psf : \{'strehl': 0.8, 'wavelength': 'Ks'\}
element_name : MICADO_SCAO
```

3.4.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_SCAO	scao_relay_optics_ter	TERCurve	True	[10, 110, 510]
MICADO_SCAO	scao_const_psf	AnisocadoConstPSF	True	[42, 652]

3.4.2.1 TERCurve: "scao_relay_optics_ter"

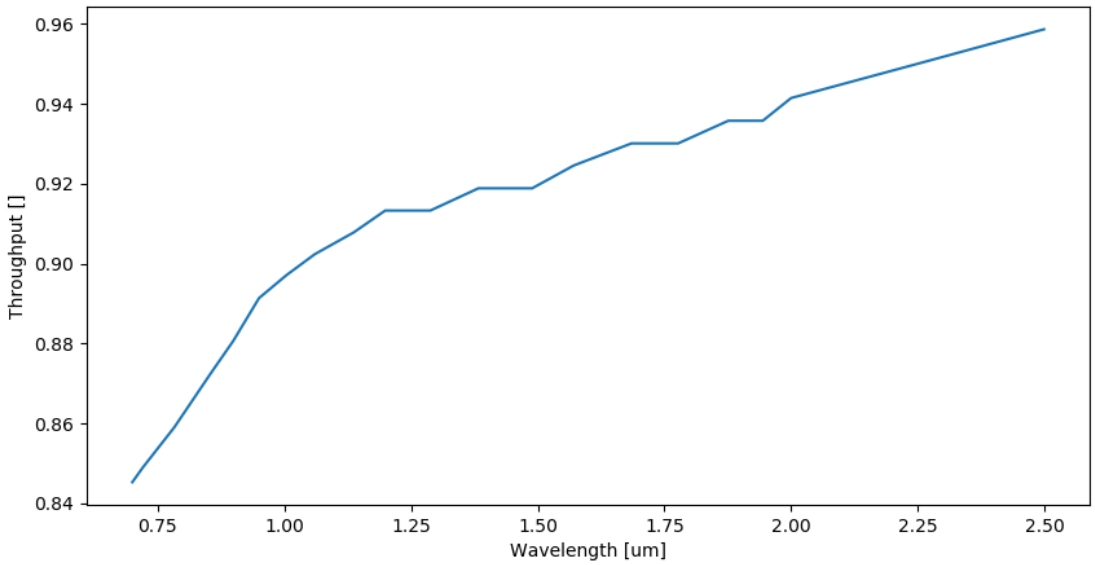
Included by default: `True`

File Description: Combined TER curve for stand-alone relay optics module

Class Description: Transmission, Emissivity, Reflection Curve

Changes:

-



Data

Meta-data

```
          filename : TER_MICADO_RO.dat
             name : scao_relay_optics_ter
              psf : \{'strehl': 0.8, 'wavelength': 'Ks'\}
      element_name : MICADO_SCAO
            author : Auto-compiled from source
            source : LIST_RO_SCAO_mirrors.dat
      date_created : 2020-08-25
     date_modified : 2020-08-25
              area : 0.22061834409834324
         area_unit : m2
    wavelength_unit : um
     emission_unit : photlam
          z_order : [10, 110, 510]
          include : True
      ignore_wings : False
         wave_min : 0.7
         wave_max : 2.5
        wave_unit : um
         wave_bin : 0.001
 report_plot_include : True
report_table_include : False
```

3.4.2.2 AnisocadoConstPSF: "scao_const_psf"

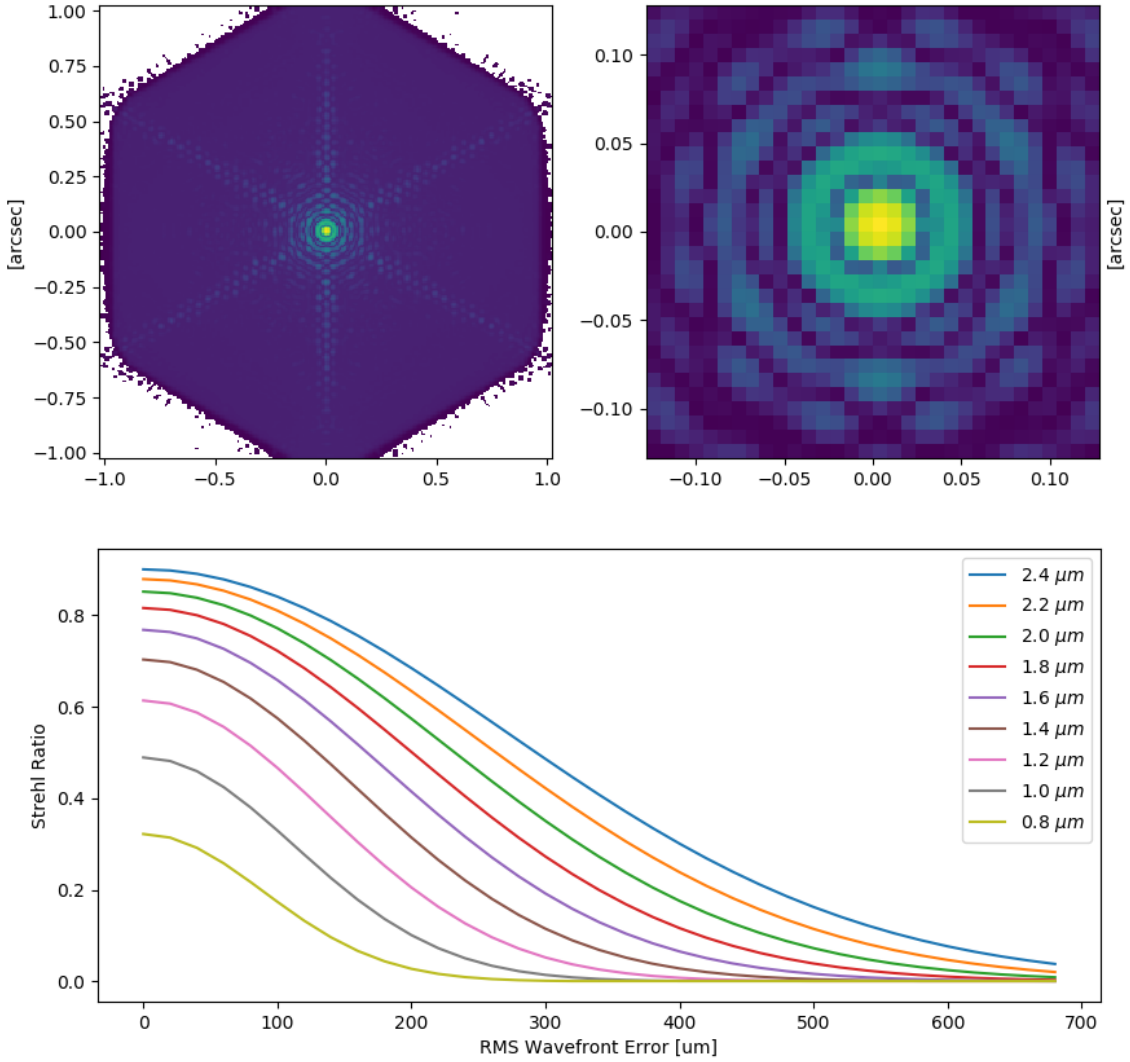
Included by default: `True`

File Description: field constant PSF as produced by stand-alone SCAO

Class Description: Makes a SCAO on-axis PSF with a desired Strehl ratio at a given wavelength

Changes:

-



Data

Meta-data

```
filename : MICADO_AnisoCADO_rms_map.fits
   name : scao_const_psf
    psf : \{'strehl': 0.8, 'wavelength': 'Ks'\}
```

```
      element_name : MICADO_SCAO
           strehl : !INST.psf.strehl
       wavelength : !INST.psf.wavelength
   psf_side_length : 256
           offset : [0, 0]
     rounded_edges : True
     convolve_mode : full
           SIMPLE : True
           BITPIX : -64
            NAXIS : 2
           NAXIS1 : 35
           NAXIS2 : 9
           EXTEND : True
           CRVAL1 : 0
           CRVAL2 : 0.8
           CRPIX1 : 1.0
           CRPIX2 : 1.0
           CDELT1 : 20
           CDELT2 : 0.2
           CUNIT1 : nm
           CUNIT2 : um
           CTYPE1 : LINEAR
           CTYPE2 : LINEAR
           LABEL1 : nmRMS
           LABEL2 : wavelength
           AUTHOR : Kieran Leschinski
        DATE_CRE : 2019-07-30
        DATE_MOD : 2019-07-30
           SOURCE : AnisoCADO
           STATUS : Strehl as a function of wavelength and wavefront error (nm
            ETYPE : SRMAP
             ECAT : -1
            EDATA : 0
         XOFFSET : 0
         YOFFSET : 0
         z_order : [42, 652]
         include : True
    flux_accuracy : 0.001
    sub_pixel_flag : False
        wave_key : WAVE0
  normalise_kernel : True
report_plot_include : True
report_table_include : False
```

3.5 OpticalElement: "MICADO_Sci_SCAO_detector_override"

Element: detector

Alias: DET

Description: A settable window on the detector plane

3.5.1 Global properties

```
     width : 1024
    height : 1024
element_name : MICADO_Sci_SCAO_detector_override
```

3.6 OpticalElement: "MCAO"

Element: instrument

Alias: INST

Description: MCAO optical system

3.6.1 Global properties

```
element_name : MCAO
```

3.7 OpticalElement: "MICADO_MCAO"

Element: instrument

Alias: INST

Description: MICADO MCAO mode effects

3.7.1 Global properties

```
      psf : \{'strehl': 0.4, 'wavelength': 'Ks'\}
element_name : MICADO_MCAO
```

3.7.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_MCAO	maory_mms_ter	TERCurve	True	[10, 110, 510]
MICADO_MCAO	maory_const_psf	AnisocadoConstPSF	True	[42, 652]

3.7.2.1 TERCurve: "maory_mms_ter"

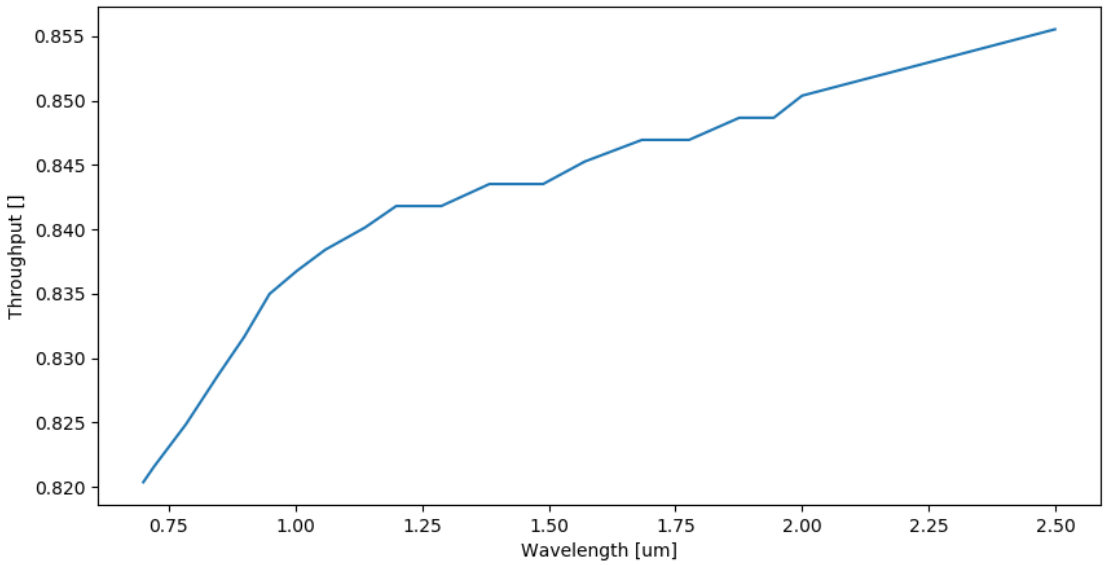
Included by default: `True`

File Description: Combined TER curve for MAORY MMS relay optics module

Class Description: Transmission, Emissivity, Reflection Curve

Changes:

-



Data

Meta-data

```
          filename : TER_MAORY_MMS.dat
             name : maory_mms_ter
              psf : \{'strehl': 0.4, 'wavelength': 'Ks'\}
      element_name : MICADO_MCAO
            author : Auto-compiled from source
            source : LIST_mirrors_maory_mms.tbl
      date_created : 2020-08-25
     date_modified : 2020-08-25
              area : 0.9503317777109126
         area_unit : m2
    wavelength_unit : um
     emission_unit : photlam
          z_order : [10, 110, 510]
          include : True
      ignore_wings : False
         wave_min : 0.7
         wave_max : 2.5
        wave_unit : um
         wave_bin : 0.001
 report_plot_include : True
report_table_include : False
```

3.7.2.2 AnisocadoConstPSF: "maory_const_psf"

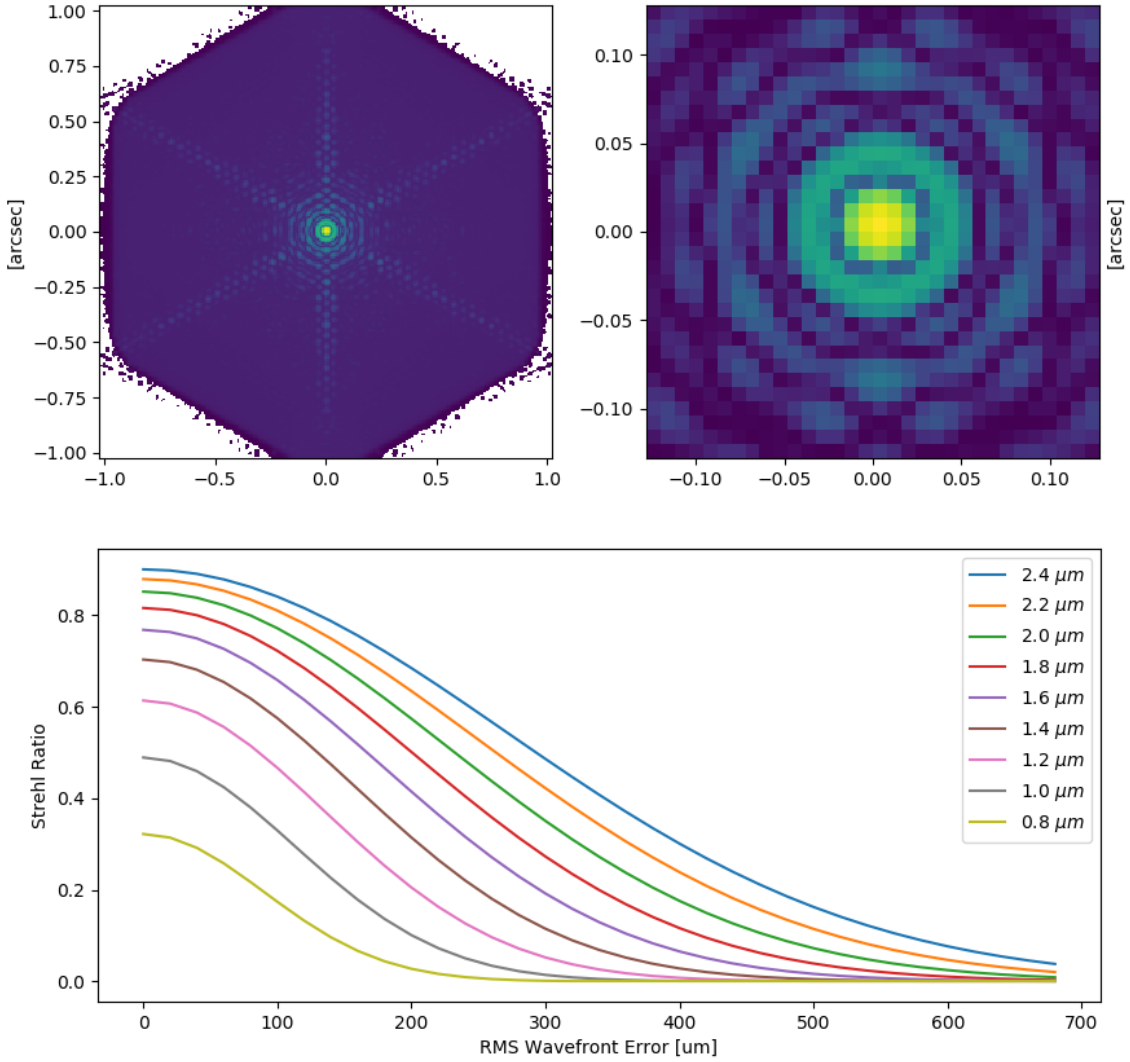
Included by default: `True`

File Description: field constant PSF as produced by MAORY

Class Description: Makes a SCAO on-axis PSF with a desired Strehl ratio at a given wavelength

Changes:

-



Data

Meta-data

```
filename : MICADO_AnisoCADO_rms_map.fits
   name : maory_const_psf
    psf : \{'strehl': 0.4, 'wavelength': 'Ks'\}
```

```
      element_name : MICADO_MCAO
           strehl : !INST.psf.strehl
       wavelength : !INST.psf.wavelength
   psf_side_length : 256
           offset : [0, 0]
     rounded_edges : True
     convolve_mode : full
           SIMPLE : True
           BITPIX : -64
            NAXIS : 2
           NAXIS1 : 35
           NAXIS2 : 9
           EXTEND : True
           CRVAL1 : 0
           CRVAL2 : 0.8
           CRPIX1 : 1.0
           CRPIX2 : 1.0
           CDELT1 : 20
           CDELT2 : 0.2
           CUNIT1 : nm
           CUNIT2 : um
           CTYPE1 : LINEAR
           CTYPE2 : LINEAR
           LABEL1 : nmRMS
           LABEL2 : wavelength
           AUTHOR : Kieran Leschinski
        DATE_CRE : 2019-07-30
        DATE_MOD : 2019-07-30
           SOURCE : AnisoCADO
           STATUS : Strehl as a function of wavelength and wavefront error (nm
            ETYPE : SRMAP
             ECAT : -1
            EDATA : 0
         XOFFSET : 0
         YOFFSET : 0
         z_order : [42, 652]
         include : True
    flux_accuracy : 0.001
    sub_pixel_flag : False
        wave_key : WAVE0
  normalise_kernel : True
report_plot_include : True
report_table_include : False
```

3.8 OpticalElement: "MICADO_Sci_MCAO_detector_override"

Element: detector

Alias: DET

Description: A settable window on the detector plane

3.8.1 Global properties

```
     width : 4096
    height : 4096
element_name : MICADO_Sci_MCAO_detector_override
```

3.9 OpticalElement: "SPEC"

Element: instrument

Alias: INST

Description: Spectroscopy

3.9.1 Global properties

```
 filter_name : Spec_HK
 pixel_scale : 0.004
 plate_scale : 0.26666666666
element_name : SPEC
```

3.10 OpticalElement: "MICADO_SPEC"

Element: instrument

Alias: INST

Description: MICADO SPEC mode effects

3.10.1 Global properties

```
      psf : \{'wavelength': '!INST.filter_name', 'strehl': 0.4\}
   aperture : \{'x': 0, 'y': 0, 'width': 3, 'height': 0.05\}
element_name : MICADO_SPEC
```

3.10.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MICADO_SPEC	micado_adjustable_slit	RectangularApertureMask	True	[80, 280, 380]
MICADO_SPEC	spectral_trace_3000x50mas	SpectralTraceList	True	[70, 270]

3.10.2.1 RectangularApertureMask: "micado_adjustable_slit"

Included by default: `True`

File Description:

Class Description: <no docstring>

Changes:

-

Data

x	y
-1.5000	-0.0250
1.5000	-0.0250
1.5000	0.0250
-1.5000	0.0250

Meta-data

```
          filename : None
             name : micado_adjustable_slit
              psf : \{'wavelength': 'Ks', 'strehl': 0.4\}
         aperture : \{'x': 0, 'y': 0, 'width': 3, 'height': 0.05\}
      element_name : MICADO_SPEC
            width : !INST.aperture.width
           height : !INST.aperture.height
                x : !INST.aperture.x
                y : !INST.aperture.y
          z_order : [80, 280, 380]
          include : True
       pixel_scale : !INST.pixel_scale
          no_mask : True
            angle : 0
            shape : rect
    conserve_image : True
               id : 0
 report_plot_include : False
report_table_include : True
report_table_rounding : 4
           x_unit : arcsec
           y_unit : arcsec
```

3.10.2.2 SpectralTraceList: "spectral_trace_3000x50mas" : 1 traces

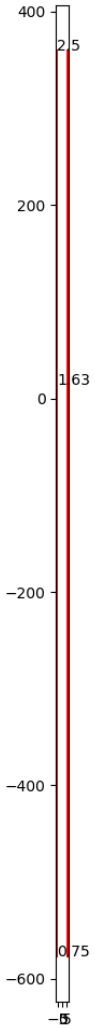
Included by default: `True`

File Description:

Class Description: List of spectral trace geometries for the detector plane

Changes:

-



Data

Meta-data

```
        filename : TRACE_SCI_3arcsec.fits
           name : spectral_trace_3000x50mas
            psf : \{'wavelength': 'Ks', 'strehl': 0.4\}
```

```
         aperture : \{'x': 0, 'y': 0, 'width': 3, 'height': 0.05\}
     element_name : MICADO_SPEC
 center_on_wave_mid : True
          SIMPLE : True
          BITPIX : 8
           NAXIS : 0
          EXTEND : True
            ECAT : 1
           EDATA : 2
         z_order : [70, 270]
         include : True
      pixel_scale : !INST.pixel_scale
      plate_scale : !INST.plate_scale
        wave_min : !SIM.spectral.wave_min
        wave_mid : !SIM.spectral.wave_mid
        wave_max : !SIM.spectral.wave_max
       x_colname : x
       y_colname : y
       s_colname : s
     wave_colname : wavelength
   col_number_start : 0
          dwave : 0.002
     invalid_value : None
report_plot_include : True
report_table_include : False
```

3.11 OpticalElement: "MICADO_Sci_SPEC_detector_override"

Element: detector

Alias: DET

Description: A settable window on the detector plane

3.11.1 Global properties

```
     width : 800
    height : 1024
element_name : MICADO_Sci_SPEC_detector_override
```

3.12 OpticalElement: "4mas"

Element: instrument

Alias: INST

Description: wide-field imager : 4mas/pix

3.12.1 Global properties

```
 filter_name : Ks
 pixel_scale : 0.004
 plate_scale : 0.26666666666
element_name : 4mas
```

3.13 OpticalElement: "1.5mas"

Element: instrument

Alias: INST

Description: zoom imager : 1.5mas/pix

3.13.1 Global properties

```
 filter_name : Ks
 pixel_scale : 0.0015
 plate_scale : 0.1
element_name : 1.5mas
```

3.14 OpticalElement: "micado_sci_detector"

Element: detector

Alias: DET

Description: List of MICADO detector effects relevant for astronomers

3.14.1 Global properties

```
image_plane_id : 0
  temperature : -230
        dit : !OBS.dit
       ndit : !OBS.ndit
      width : 4096
     height : 4096
          x : 0
          y : 0
 element_name : micado_sci_detector
```

3.14.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
micado_sci_detector	micado_detector_window	DetectorWindow	True	[90, 290, 390, 490]
micado_sci_detector	h4rg_qe_curve	QuantumEfficiencyCurve	True	[113, 513]
micado_sci_detector	exposure_action	SummedExposure	True	[860]
micado_sci_detector	dark_current	DarkCurrent	True	[830]
micado_sci_detector	shot_noise	ShotNoise	True	[820]
micado_sci_detector	h4rg_detector_linearity	LinearityCurve	False	[840]
micado_sci_detector	readout_noise	PoorMansHxRGReadoutNoise	True	[811]

3.14.2.1 DetectorWindow: "micado_detector_window"

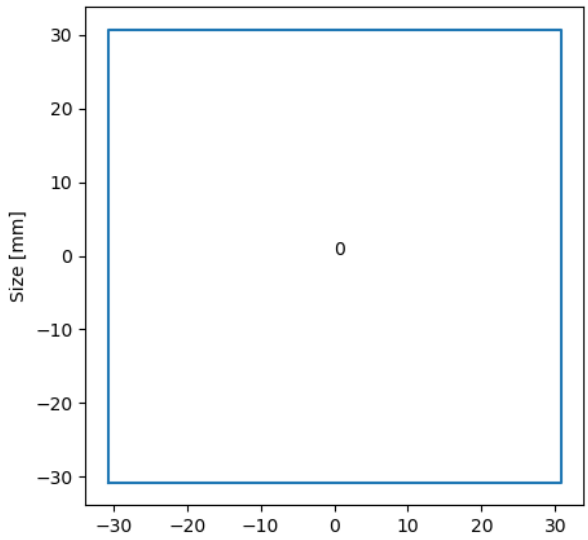
Included by default: `True`

File Description:

Class Description: For when a full DetectorList if too cumbersome

Changes:

-



id	x_cen	y_cen	x_size	y_size	angle	gain	pixel_size
0	!DET.x	!DET.y	!DET.width	!DET.height	0	1	0.015

Data

Meta-data

```
         filename : None
             name : micado_detector_window
       orig_units : pixel
       x_cen_unit : pixel
       y_cen_unit : pixel
      x_size_unit : pixel
      y_size_unit : pixel
  pixel_size_unit : mm
       angle_unit : deg
        gain_unit : electron/adu
   image_plane_id : 0
      temperature : -230
              dit : !OBS.dit
             ndit : !OBS.ndit
    element_name : micado_sci_detector
        z_order : [90, 290, 390, 490]
        include : True
```

```
       pixel_scale : !INST.pixel_scale
   active_detectors : all
 report_plot_include : True
report_table_include : True
```

3.14.2.2 QuantumEfficiencyCurve: "h4rg_qe_curve"

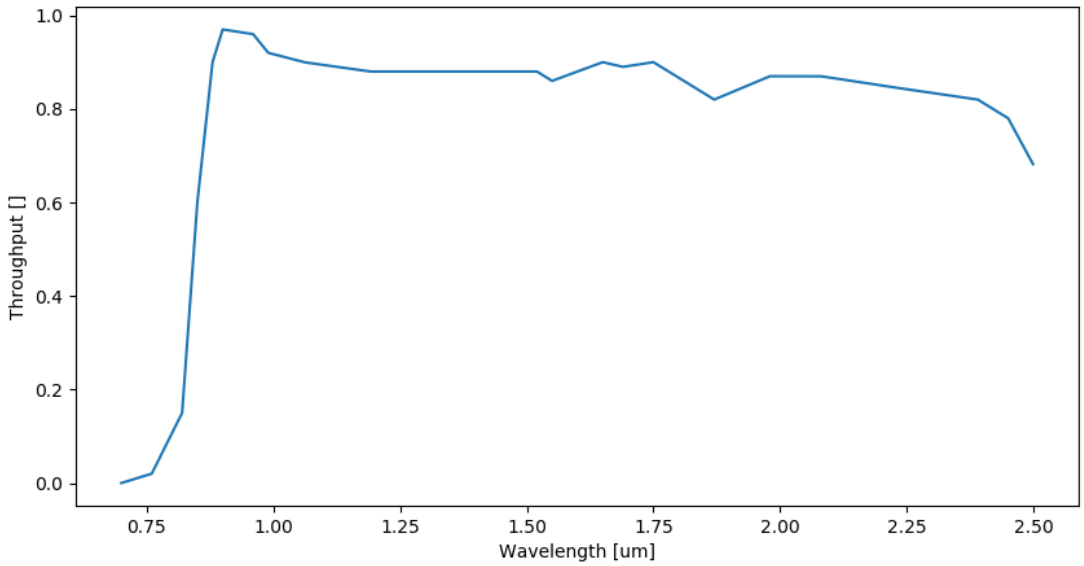
Included by default: `True`

File Description: Quantum efficiency curves for each detector

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) updated meta data to new format
- 2019-08-09 (KL) Added action keyword to meta data



Data

Meta-data

```
         filename : QE_detector_H2RG.dat
             name : h4rg_qe_curve
```

```
    image_plane_id : 0
      temperature : -230
            dit : 60
           ndit : 1
          width : 4096
         height : 4096
             x : 0
             y : 0
     element_name : micado_sci_detector
         author : Kieran Leschinski
        sources : Finger+ 2008 SPIE
     date_created : 2016-01-01
    date_modified : 2019-08-09
          type : detector:quantum_efficiency
         status : Design, guestimated by reading off the graph in Finger+ 20
   wavelength_unit : um
         action : transmission
        z_order : [113, 513]
        include : True
     ignore_wings : False
        wave_min : 0.7
        wave_max : 2.5
       wave_unit : um
        wave_bin : 0.001
report_plot_include : True
report_table_include : False
        position : -1
```

3.14.2.3 SummedExposure: "exposure_action"

Included by default: `True`

File Description: Summing up sky signal for all DITs and NDITs

Class Description: Simulates a summed stack of `ndit` exposures

Changes:

-

Data

Meta-data

```
    filename : None
```

```
        name : exposure_action
image_plane_id : 0
  temperature : -230
         dit : !OBS.dit
        ndit : !OBS.ndit
       width : 4096
      height : 4096
           x : 0
           y : 0
 element_name : micado_sci_detector
     z_order : [860]
     include : True
```

3.14.2.4 DarkCurrent: "dark_current"

Included by default: `True`

File Description: MICADO dark current

Class Description: required: dit, ndit, value

Changes:

-

Data

Meta-data

```
     filename : None
        name : dark_current
image_plane_id : 0
  temperature : -230
         dit : !OBS.dit
        ndit : !OBS.ndit
       width : 4096
      height : 4096
           x : 0
           y : 0
 element_name : micado_sci_detector
       value : 0.1
     z_order : [830]
     include : True
```

3.14.2.5 ShotNoise: "shot_noise"

Included by default: `True`

File Description: apply poisson shot noise to images

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
     filename : None
        name : shot_noise
image_plane_id : 0
  temperature : -230
         dit : !OBS.dit
        ndit : !OBS.ndit
       width : 4096
      height : 4096
           x : 0
           y : 0
  element_name : micado_sci_detector
      z_order : [820]
      include : True
   random_seed : !SIM.random.seed
```

3.14.2.6 LinearityCurve: "h4rg_detector_linearity"

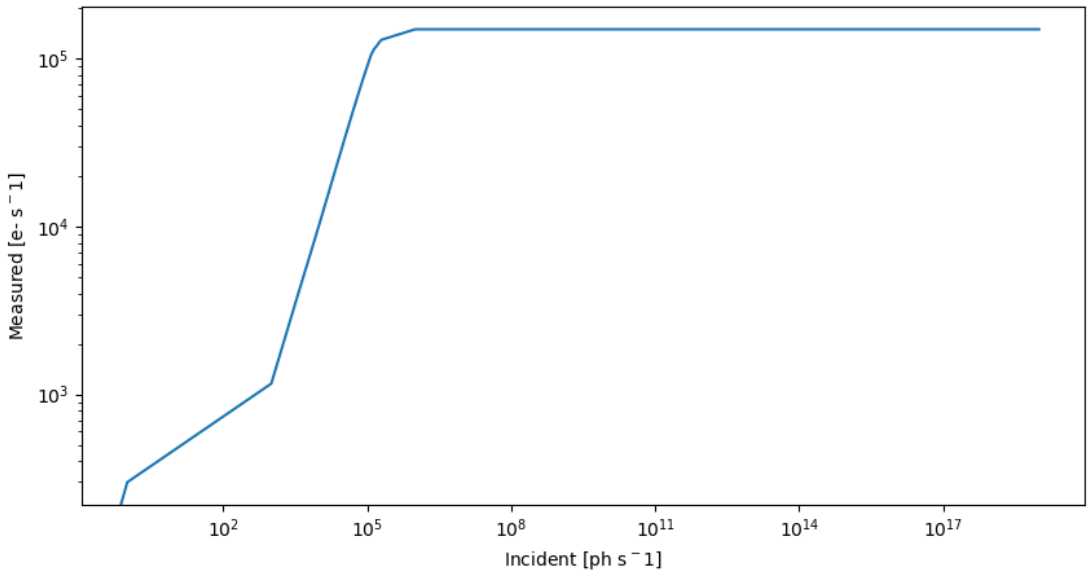
Included by default: `False`

File Description: Linearity characteristics of H4RG chips

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) updated meta data to new format
- 2019-08-14 (KL) replaced long 1000000000 with 1e99



Data

Meta-data

```
        filename : FPA_linearity.dat
            name : h4rg_detector_linearity
         include : False
    image_plane_id : 0
      temperature : -230
             dit : !OBS.dit
            ndit : !OBS.ndit
           width : 4096
          height : 4096
               x : 0
               y : 0
     element_name : micado_sci_detector
          author : Kieran Leschinski
         sources : Ingraham+ 2014 - Gemini Calibrations II for H2RG
     date_created : 2016-01-01
    date_modified : 2018-11-19
            type : detector:linearity
          status : Design, approximated from the H2RG
    incident_unit : ph
    measured_unit : ph
         z_order : [840]
```

```
 report_plot_include : True
report_table_include : False
```

3.14.2.7 PoorMansHxRGReadoutNoise: "readout_noise"

Included by default: `True`

File Description: Readout noise frames

Class Description: <no docstring>

Changes:

-

Data

Meta-data

```
         filename : None
             name : readout_noise
    image_plane_id : 0
      temperature : -230
             dit : !OBS.dit
            ndit : !OBS.ndit
           width : 4096
          height : 4096
               x : 0
               y : 0
     element_name : micado_sci_detector
       noise_std : 12
      n_channels : 64
         z_order : [811]
         include : True
  pedestal_fraction : 0.3
     read_fraction : 0.4
     line_fraction : 0.25
   channel_fraction : 0.05
      random_seed : !SIM.random.seed
 report_plot_include : False
report_table_include : False
```

Chapter 4

Supoort packages

4.1 OpticalElement: "armazones"

Element: atmosphere

Alias: ATMO

Description: Atmosphere and location details for Cerro Armazones

4.1.1 Global properties

```
   altitude : 3060
  longitude : -70.1918
   latitude : -24.5899
temperature : 7
   humidity : 0.1
   pressure : 0.755
        pwv : 2.5
    airmass : !OBS.airmass
pupil_angle : !OBS.pupil_angle
pixel_scale : !INST.pixel_scale
 background : \{'filter_name': 'Ks', 'value': 13.6, 'unit': 'mag'\}
   spectrum : \{'filename': 'TER_armazones_default_FULL_IMG.dat'\}
element_name : armazones
```

4.1.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
armazones	armazones_atmo_default_ter_curve	AtmosphericTERCurve	True	[111, 511]
armazones	armazones_atmo_dispersion	AtmosphericDispersion	False	[231]
armazones	armazones_atmo_skycalc_ter_curve	SkycalcTERCurve	False	[112, 512]

4.1.2.1 AtmosphericTERCurve: "armazones_atmo_default_ter_curve"

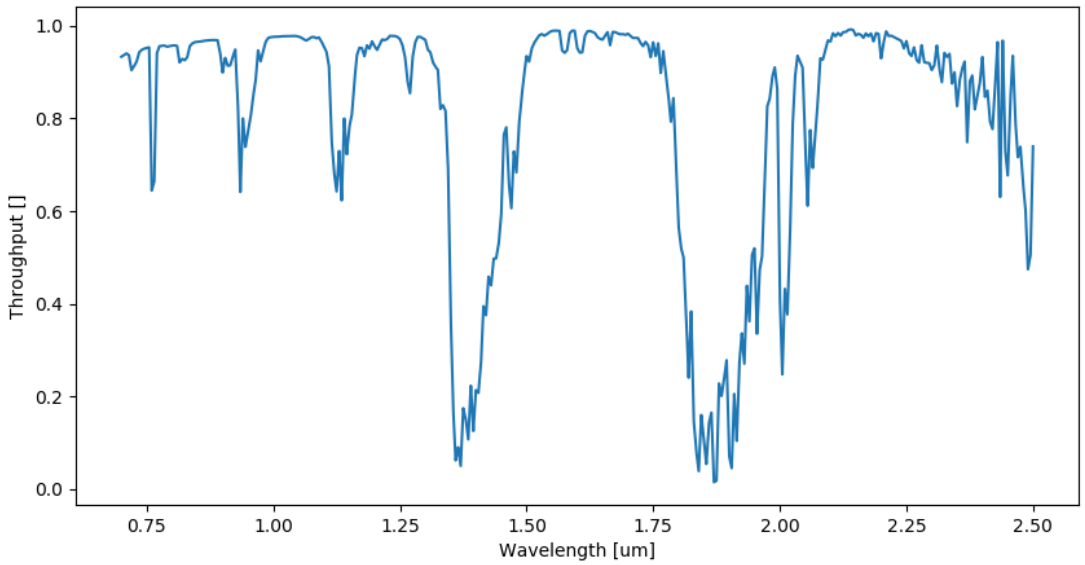
Included by default: `True`

File Description: atmospheric emission and transmission

Class Description: <no docstring>

Changes:

- 2020-10-29 (MV) Created file



Data

Meta-data

```
        filename : TER_armazones_default_FULL_IMG.dat
           name : armazones_atmo_default_ter_curve
         include : True
        altitude : 3060
       longitude : -70.1918
        latitude : -24.5899
     temperature : 7
        humidity : 0.1
        pressure : 0.755
            pwv : 2.5
         airmass : 1.2
     pupil_angle : 0
     pixel_scale : 0.004
      background : \{'filter_name': 'Ks', 'value': 13.6, 'unit': 'mag'\}
        spectrum : \{'filename': 'TER_armazones_default_FULL_IMG.dat'\}
    element_name : armazones
            area : 0
rescale_emission : \{'filter_name': 'Ks', 'filename_format': 'filters/TC_f
          author : Miguel Verdugo
          source : skycalc_ipy tool for standard Armazones conditions
    date_created : 2020-10-29
```

```
     date_modified : 2020-10-29
          status : Design
            type : atmosphere:ter_curve
          wdelta : 10
            wmin : 300
            wmax : 15000
          season : entire year
            time : entire night
          action : transmission
   wavelength_unit : um
    emission_unit : ph s-1 m-2 um-1 arcsec-2
         z_order : [111, 511]
     ignore_wings : False
        wave_min : 0.7
        wave_max : 2.5
       wave_unit : um
        wave_bin : 0.0001
report_plot_include : True
report_table_include : False
        position : 0
```

4.1.2.2 AtmosphericDispersion: "armazones_atmo_dispersion"

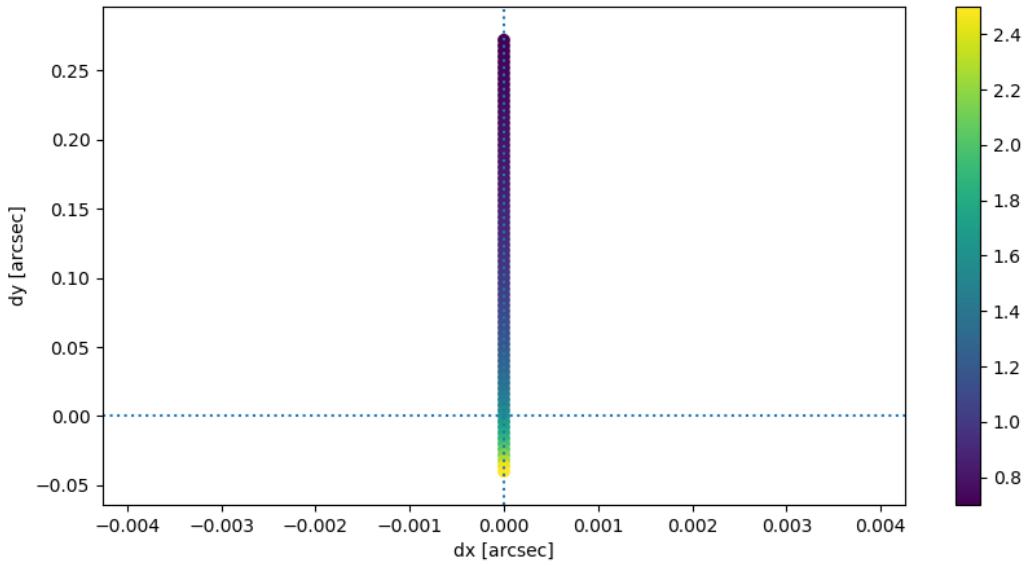
Included by default: `False`

File Description: atmospheric dispersion

Class Description: Used to generate the wavelength bins based on shifts due to the atmosphere

Changes:

-



Data

Meta-data

```
          filename : None
             name : armazones_atmo_dispersion
           include : False
          altitude : 3060
         longitude : -70.1918
          latitude : -24.5899
       temperature : 7
          humidity : 0.1
          pressure : 0.755
              pwv : 2.5
           airmass : 1.2
       pupil_angle : 0
       pixel_scale : 0.004
        background : \{'filter_name': 'Ks', 'value': 13.6, 'unit': 'mag'\}
          spectrum : \{'filename': 'TER_armazones_default_FULL_IMG.dat'\}
      element_name : armazones
           z_order : [231]
 report_plot_include : True
report_table_include : False
          wave_min : 0.7
          wave_mid : 1.6
```

```
        wave_max : 2.5
sub_pixel_fraction : 1
       num_steps : 1000
              z0 : 33.55730976192071
            temp : 7
         rel_hum : 10.0
            pres : 755.0
             lat : -24.5899
               h : 3060
```

4.1.2.3 SkycalcTERCurve: "armazones_atmo_skycalc_ter_curve"

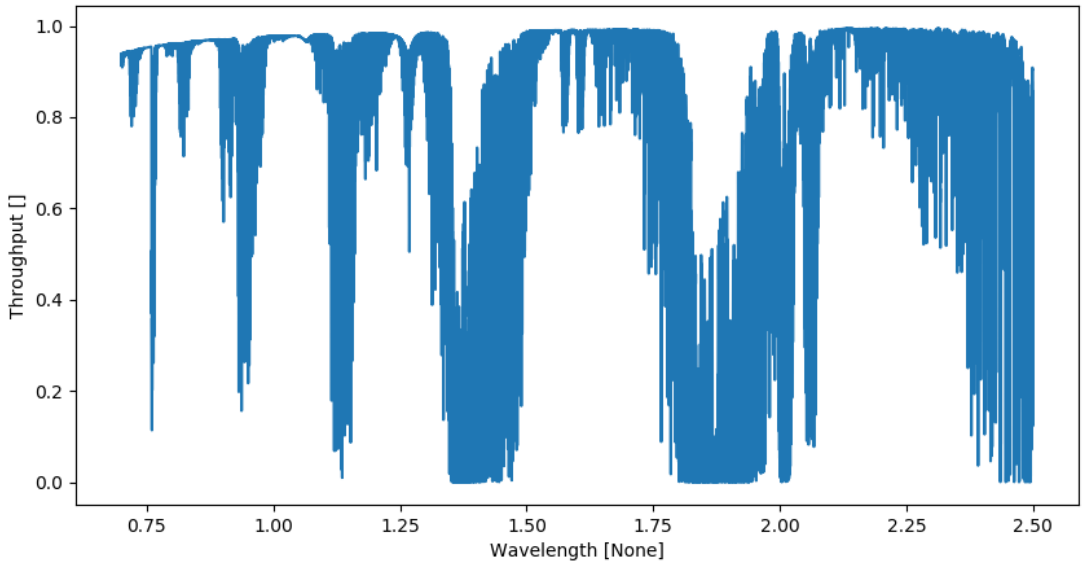
Included by default: `False`

File Description: atmospheric spectra pulled from the skycalc server

Class Description: <no docstring>

Changes:

-



Data

Meta-data

```
         filename : None
            name : armazones_atmo_skycalc_ter_curve
         include : False
        altitude : 3060
       longitude : -70.1918
        latitude : -24.5899
     temperature : 7
        humidity : 0.1
        pressure : 0.755
            pwv : 2.5
         airmass : 1.2
     pupil_angle : 0
     pixel_scale : 0.004
      background : \{'filter_name': 'Ks', 'value': 13.6, 'unit': 'mag'\}
        spectrum : \{'filename': 'TER_armazones_default_FULL_IMG.dat'\}
    element_name : armazones
     observatory : armazones
            wmin : 699.9999999999999
            wmax : 2499.9999999999995
           wunit : um
          wdelta : 0.09999999999999999
         z_order : [112, 512]
    ignore_wings : False
        wave_min : 0.7
        wave_max : 2.5
       wave_unit : um
        wave_bin : 0.0001
report_plot_include : True
report_table_include : False
          action : transmission
        position : 0
```

4.2 OpticalElement: "ELT"

Element: telescope

Alias: TEL

Description: The extremely large telescope

4.2.1 Global properties

```
 temperature : !ATMO.temperature
element_name : ELT
```

4.2.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
ELT	scope_surface_list	SurfaceList	True	[20, 120, 520]
ELT	scope_vibration	Vibration	True	[244, 744]
ELT	eso_combined_reflection	TERCurve	False	[10, 110, 510]

4.2.2.1 SurfaceList: "scope_surface_list"

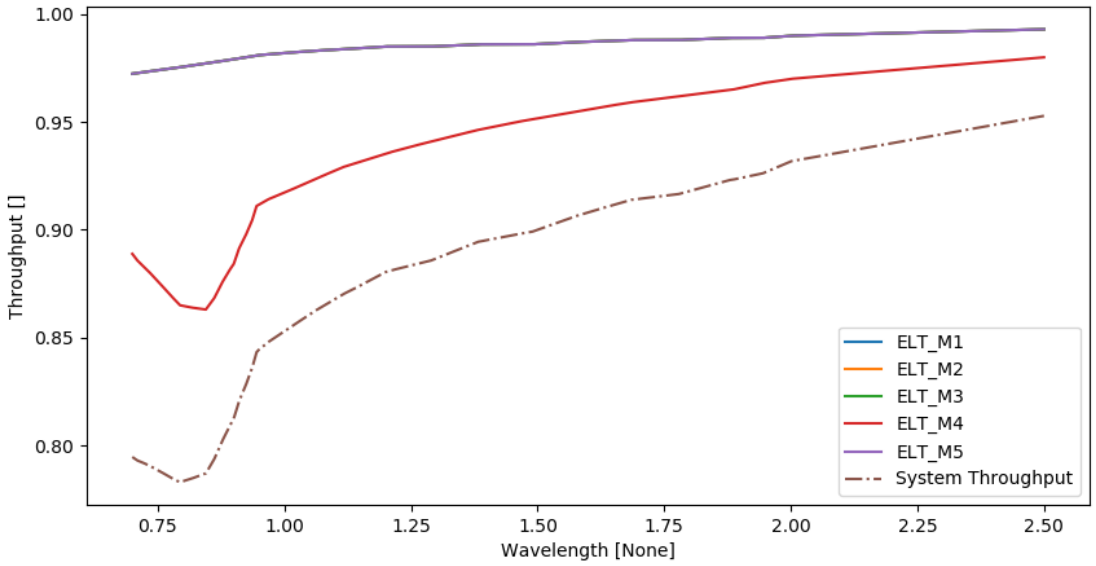
Included by default: `True`

File Description: list of ELT surfaces

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) Added meta data, added Action column
- 2019-01-28 (KL) Fixed YAML format in meta data
- 2020-08-17 (KL) Updated M1 and M4 dimensions according to ESO-253082_4 sect 4.7 "all-glass" diameter
- 2020-08-17 (KL) Pegged temperature to the atmosphere



name	outer	inner	angle	temperature	action	filename
ELT_M1	36.9	10.95	0.0	!ATMO.temperature	reflection	TER_ELT_mirror_mgf2agal.dat
ELT_M2	4.2	0.545	0.0	!ATMO.temperature	reflection	TER_ELT_mirror_mgf2agal.dat
ELT_M3	3.8	0.14	0.0	!ATMO.temperature	reflection	TER_ELT_mirror_mgf2agal.dat
ELT_M4	2.54	0.536	7.75	!ATMO.temperature	reflection	TER_ELT_mirror_aluminium.da
ELT_M5	2.66	0.0	37.25	!ATMO.temperature	reflection	TER_ELT_mirror_mgf2agal.dat

Data

Meta-data

```
      filename : LIST_mirrors_ELT.tbl
          name : scope_surface_list
   temperature : !ATMO.temperature
  element_name : ELT
        author : Oliver Czoske, Kieran Leschinski
        source : ESO ELT DRM, ESO-253082_4
  date_created : 2018-11-19
 date_modified : 2020-08-17
        status : Design, pre MICADO-FDR mirror list
    outer_unit : m
    inner_unit : m
    angle_unit : degree
```

```
   temperature_unit : deg_C
            notes : ['2020-08-17 (KL) Coatings match those described in ESO-25
          z_order : [20, 120, 520]
          include : True
      ignore_wings : False
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
        wave_unit : !SIM.spectral.wave_unit
         wave_bin : !SIM.spectral.spectral_resolution
 report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
          etendue : !TEL.etendue
```

4.2.2.2 Vibration: "scope_vibration"

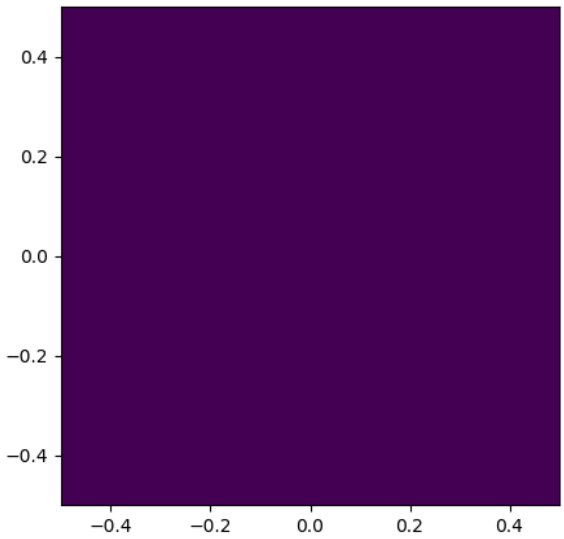
Included by default: `True`

File Description: residual vibration of telescope

Class Description: Creates a wavelength independent kernel image

Changes:

-



Data

Meta-data

```
         filename : None
            name : scope_vibration
      temperature : 7
     element_name : ELT
            fwhm : 0.001
      pixel_scale : 0.004
         z_order : [244, 744]
         include : True
    flux_accuracy : 0.001
    sub_pixel_flag : False
     convolve_mode : full
         wave_key : WAVE0
   normalise_kernel : True
 report_plot_include : True
report_table_include : False
     width_n_fwhms : 4
```

4.2.2.3 TERCurve: "eso_combined_reflection"

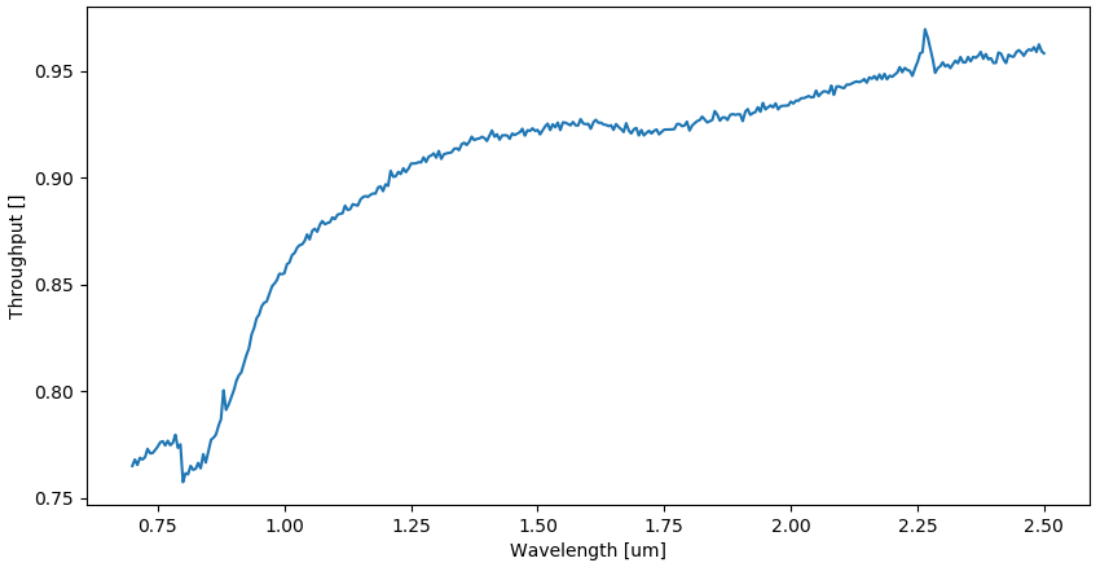
Included by default: `False`

File Description: single combined reflection curve for clean ELT 5 mirror combination

Class Description: Transmission, Emissivity, Reflection Curve

Changes:

- 2019-11-06 (KL) Converted from .xlsx to .dat file, added ScopeSim meta data
- 2020-07-09 (KL) Added inner and outer dimensions to meta, for use with MICADO-Sci
- 2020-08-17 (KL) Added emissivity column according to ESO-253082_4, sect 4.12.2



Data

Meta-data

```
        filename : TER_ELT_system_20190611.dat
           name : eso_combined_reflection
         include : False
     temperature : 7
    element_name : ELT
      temperture : 7
          author : R. Holzloehner
          source : See ESO-306070 and ESO-293390 for background.
    date_created : 2018-09-18
   date_modified : 2019-06-11
            type : TERCurve
          status : design
          action : reflection
           outer : 37.3
     outer_unit : m
           inner : 11.1
     inner_unit : m
wavelength_unit : um
           notes : ['Baseline coatings.', 'Fresh coatings without contaminati
         z_order : [10, 110, 510]
   ignore_wings : False
```

```
         wave_min : 0.7
         wave_max : 2.5
        wave_unit : um
         wave_bin : 0.0001
 report_plot_include : True
report_table_include : False
```

4.3 OpticalElement: "MAORY"

Element: relay_optics

Alias: RO

Description: MAORY AO relay module

4.3.1 Global properties

```
 temperature : !ATMO.temperature
psf_filename : None
element_name : MAORY
```

4.3.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
MAORY	maory_surface_list	SurfaceList	True	[20, 120, 520]
MAORY	maory_generic_psf	FieldConstantPSF	True	[262, 662]

4.3.2.1 SurfaceList: "maory_surface_list"

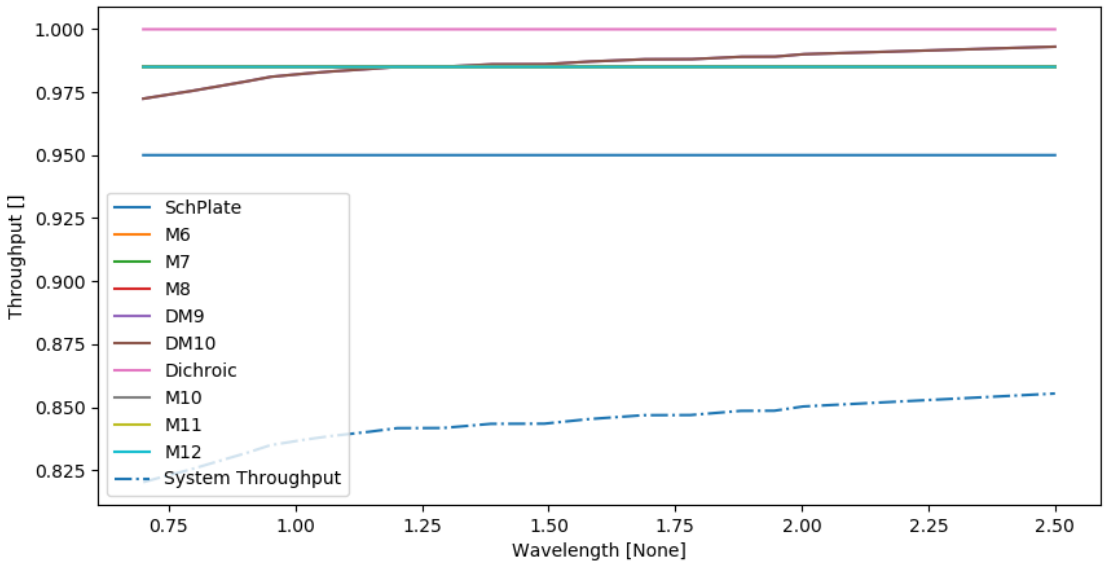
Included by default: `True`

File Description: list of surfaces in MAORY

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) Added meta data, changed Dichr. filename
- 2019-01-28 (KL) Fixed YAML format in meta data
- 2020-06-22 (KL) Updated file to match the MMS configuration from Carmelo
- 2020-08-17 (KL) Pegged temperature to atmosphere
- 2020-12-03 (KL)



name	outer	inner	angle	temperature	action	filename
SchPlate	1.1	0.0	0.0	!ATMO.temperature	transmission	TER_entrance_window.dat
M6	1.1	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da
M7	0.7	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da
M8	0.85	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da
DM9	0.75	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_mgf2aga
DM10	0.75	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_mgf2aga
Dichroic	0.6	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_lgs_dichroic.dat
M10	0.6	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da
M11	0.8	0.0	45.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da
M12	0.8	0.0	0.0	!ATMO.temperature	reflection	TER_MAORY_mirror_silver.da

Data

Meta-data

```
      filename : LIST_mirrors_maory_mms.tbl
          name : maory_surface_list
   temperature : !ATMO.temperature
  psf_filename : None
  element_name : MAORY
        author : Kieran Leschinski
```

```
           source : Carmelo Archidiacono private email
      date_created : 2018-11-19
     date_modified : 2020-06-22
           status : Design, new MAORY MMS design
       outer_unit : m
       inner_unit : m
       angle_unit : degree
   temperature_unit : deg_C
          z_order : [20, 120, 520]
          include : True
      ignore_wings : False
         wave_min : !SIM.spectral.wave_min
         wave_max : !SIM.spectral.wave_max
        wave_unit : !SIM.spectral.wave_unit
         wave_bin : !SIM.spectral.spectral_resolution
 report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
          etendue : !TEL.etendue
```

4.3.2.2 FieldConstantPSF: "maory_generic_psf"

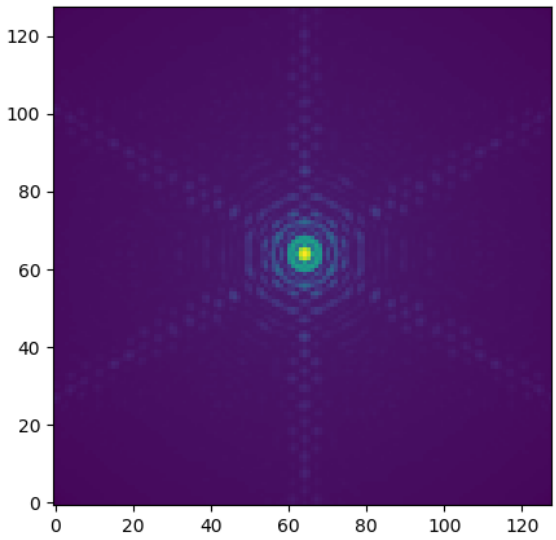
Included by default: `True`

File Description: MAORY field varying MCAO PSF

Class Description: <no docstring>

Changes:

-



Data

Meta-data

```
         filename : PSF_MCAO_ConstPSF_40_18_6.fits
             name : maory_generic_psf
      temperature : 7
     psf_filename : None
     element_name : MAORY
          warning : Default PSF is not Field Varying. See Documentation
           SIMPLE : True
           BITPIX : 8
            NAXIS : 0
           EXTEND : True
           AUTHOR : Kieran Leschinski
         DATE_CRE : 2019-07-30
         DATE_MOD : 2019-07-30
           SOURCE : AnisoCADO
           STATUS : Best guess for a MAORY ConstantPSF with AnisoCADO
            ETYPE : CONSTPSF
             ECAT : -1
            EDATA : 1
          XOFFSET : 0
          YOFFSET : 0
          z_order : [262, 662]
```

```
          include : True
     flux_accuracy : 0.001
    sub_pixel_flag : False
     convolve_mode : full
         wave_key : WAVE0
   normalise_kernel : True
 report_plot_include : True
report_table_include : False
```

4.4 OpticalElement: "default_ro"

Element: relay_optics

Alias: RO

Description: Simple stand-alone relay optics module

4.4.1 Global properties

```
 temperature : !ATMO.temperature
psf_filename : None
element_name : default_ro
```

4.4.2 Effects

Summary of Effects included in this optical element:

element	name	class	included	z_orders
default_ro	relay_psf	FieldConstantPSF	True	[262, 662]
default_ro	relay_surface_list	SurfaceList	True	[20, 120, 520]

4.4.2.1 FieldConstantPSF: "relay_psf"

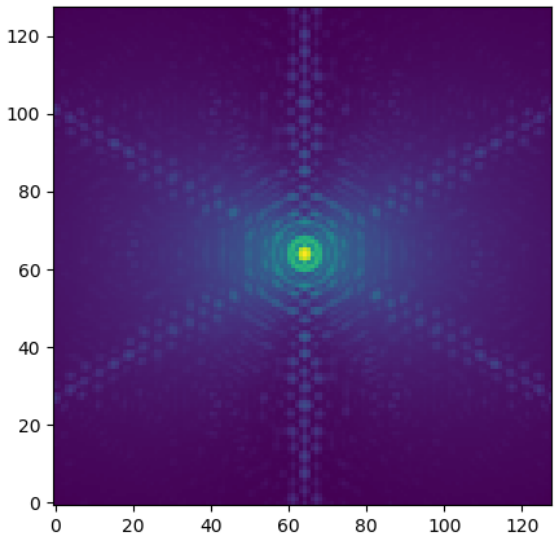
Included by default: `True`

File Description: SCAO PSF

Class Description: <no docstring>

Changes:

-



Data

Meta-data

```
         filename : PSF_SCAO_ConstPSF_0_5off.fits
             name : relay_psf
      temperature : 7
     psf_filename : None
     element_name : default_ro
          warning : Default PSF is NOT field varying. See documentation.
           SIMPLE : True
           BITPIX : 8
            NAXIS : 0
           EXTEND : True
           AUTHOR : Kieran Leschinski
         DATE_CRE : 2019-07-30
         DATE_MOD : 2019-07-30
           SOURCE : AnisoCADO
           STATUS : Best guess for a standard observations
            ETYPE : CONSTPSF
             ECAT : -1
            EDATA : 1
          XOFFSET : 0
          YOFFSET : 5
          z_order : [262, 662]
```

```
          include : True
     flux_accuracy : 0.001
    sub_pixel_flag : False
     convolve_mode : full
         wave_key : WAVE0
   normalise_kernel : True
 report_plot_include : True
report_table_include : False
```

4.4.2.2 SurfaceList: "relay_surface_list"

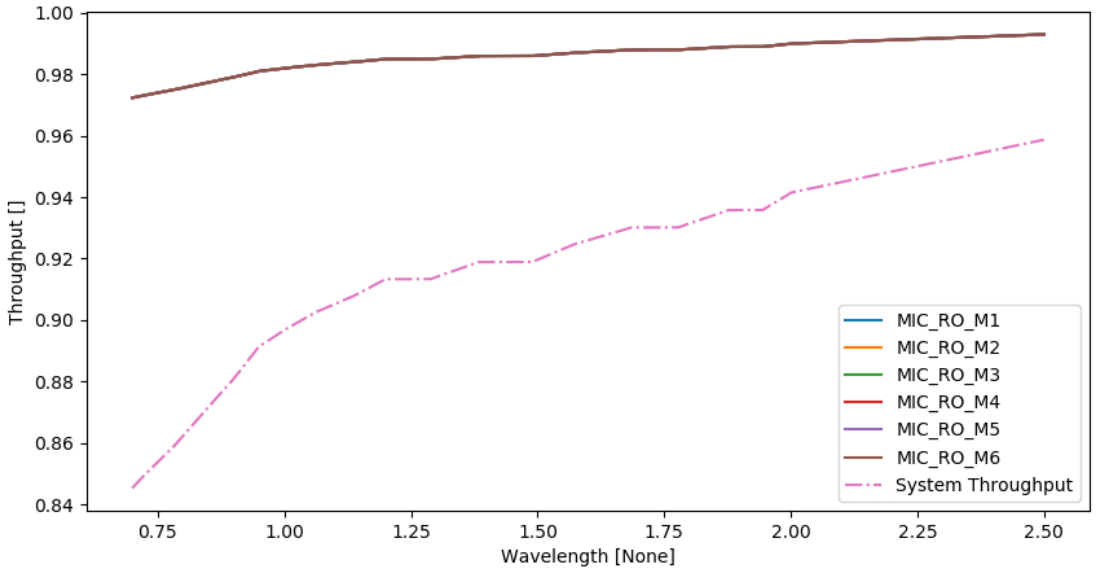
Included by default: `True`

File Description: list of surfaces in the relay optics

Class Description: <no docstring>

Changes:

- 2018-11-19 (KL) Added meta data
- 2019-01-28 (KL) Fixed YAML format in meta data
- 2020-07-18 (KL) Added all 6 mirrors from the CM16 update pdf
- 2020-07-18 (KL) Pegged temperature to atmosphere



name	outer	inner	angle	temperature	action	filename
MIC_RO_M1	0.505	0.0	45.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga
MIC_RO_M2	0.51	0.0	10.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga
MIC_RO_M3	0.184	0.0	10.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga
MIC_RO_M4	0.53	0.0	10.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga
MIC_RO_M5	0.406	0.0	20.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga
MIC_RO_M6	0.406	0.0	35.0	!ATMO.temperature	reflection	TER_MICADO_mirror_mgf2aga

Data

Meta-data

```
         filename : LIST_RO_SCAO_mirrors.dat
            name : relay_surface_list
     temperature : !ATMO.temperature
     psf_filename : None
     element_name : default_ro
          author : Oliver Czoske, Kieran Leschinski
          source : P12_RelayOptics_Status_2020-06-23-MICADO-CM16-RO-v2.pdf
     date_created : 2018-11-19
    date_modified : 2020-08-17
          status : Design, pre FDR list of stand-alone SCAO relay optics mirr
            type : mirror:list
      outer_unit : m
      inner_unit : m
      angle_unit : degree
  temperature_unit : deg_C
         z_order : [20, 120, 520]
         include : True
     ignore_wings : False
        wave_min : !SIM.spectral.wave_min
        wave_max : !SIM.spectral.wave_max
       wave_unit : !SIM.spectral.wave_unit
        wave_bin : !SIM.spectral.spectral_resolution
report_plot_include : True
report_table_include : True
 minimum_throughput : !SIM.spectral.minimum_throughput
         etendue : !TEL.etendue
```