Slit Mask Design Tool – Design Notes

Version History

|  |  |  |
| --- | --- | --- |
| Date | Author | Notes |
| 2018-03-13 | Shui Hung Kwok | Initial draft (mostly for DEIMOS) |
|  |  |  |

# Introduction

Keck’s instruments LRIS and DEIMOS are multi-object spectrographs, which require slitmasks that must be fabricated for the desired target field. These slitmasks contain a number of small slits, each of them producing a spectrum of a source in the target field. The slit mask design tool facilitates the placement of the slitlets on the mask and provides a graphical user interface to interactively control the selection of the objects and the position and orientation of the slitlets.

The output of the slitmask design tool is a list of X/Y coordinates describing the slitlets. This information is fed to another software program that generates the necessary CNC machine code to produce the physical mask.

Target List

Slitmask Design   
Tool

Slitlet List

Instrument   
Information

Slitmask Submission

Slitmask

Not in scope

-Slitmask database

-Fabrication

Figure 1: High level overview of slitmask design process

Additional information about LRIS and DEIMOS can be found at:

* LRIS  
  <https://www2.keck.hawaii.edu/inst/lris/lrishome.html>
* DEIMOS  
  <https://www2.keck.hawaii.edu/realpublic/inst/deimos/pre_observing.html>

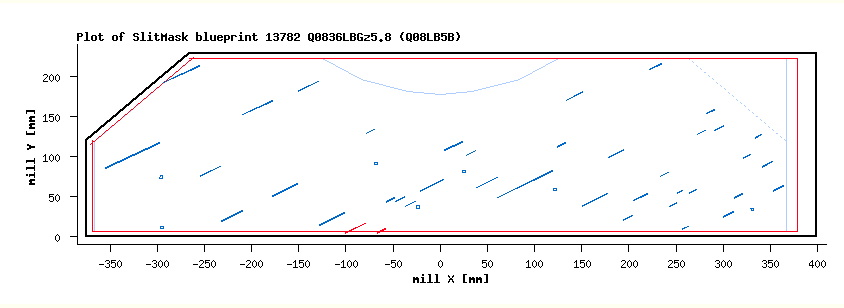


Figure 2: Example of a blueprint of a DEIMOS slitmask

# Slitmask Design

The purpose of the slitmask design tool is to assist the user in the process of creating slitmasks for a number of targets in an efficient way by providing means to manage the targets, to place the slitmask in the desired target field and to verify the geometry of the slitlets.

Before starting the design process, the user must prepare a list of targets, which must include the RA and DEC of the targets amongst other information (more details later). The list can contain more targets than the maximum possible number of slitlets in the mask. The footprint of the targets can cover an area larger than a slitmask. In this case, the design tool can create multiple masks according to the assigned priority of the targets and other constraints given by the user. The user can interactively change the priority of the targets, adding and removing targets in the mask.

The design tool allows the user to overlay the target field and the slitmask showing the positions of the targets and the slitlets. The user can position and rotate the slitmask such that the number of targets covered is optimized. This step can be automated based on some criteria to be defined by the user. The user has to option to modify the result of the automated placement and the target selection.

Once the slitmask is placed and saved, the selected targets are flagged as covered. Another slitmask can be created with the remaining targets. Depending on the density of the targets, multiple masks can overlap each other covering the same region but different targets. However, targets can be selected for multiple masks depending on the options.

In addition to the targets provided by the user, the design tool can select and overlay alignment stars, provided by standard guide star catalogs. The tool can place these alignment stars automatically and the user can modify their placement and add or remove alignment stars.

For DEIMOS, the output of the mask design is a FITS file that contains all the necessary information to fabricate the mask.

For LRIS, the output is a text file. The format is to be described later.

# High Level System Requirements

## User Target List

The slitmask design tool must be able to:

* Read a target list in for format specified in appendix A
* Modify target’s selection, priority, slitmask assignment, lengths and widths
* Save a target list in the same format
* Display targets graphically distinguishing the different properties

## Slitmask Management

Multiple slitmasks can be associated with a target list. The design tool must provide:

* naming convention to designate the masks
* clear text descriptions of the masks, including position, rotation, length and width of slits
* bookkeeping of observing information, such as observer names, observing dates, name of field
* functions to duplicate and remove masks, with corresponding selection and release of targets
* graphical display of slitmask, individually and overlaid
* reading and saving functions for slitmasks files and associated FITS files

## Slitmask Design

The design tool must provide the following functions:

* selection of alignment stars, at least two alignment stars on each end recommended
* detection and elimination of double stars for alignment
* guide star selection on guider field of view, between 15 and 17 in R
* selection of sky PA and preferred slit angle relative to sky PA
* selection of global slit width and individual slit width

## Graphical User Interface

The design tool must provide a graphical user interface to allow an interactive design process. This includes the display of the input and output parameters in clear text and in graphical form, such as sky projection of the targets, slitmask overlay and slitmask physical layout.

## Software Delivery

The design tool’s functionality must be available via the web. With exception of a web browser, no other software should be required. A server component is implemented and hosted at Keck. Users access the slitmask design tool via the Keck’s public home page.

# Prototyping

To ensure that underlying algorithms and methods are understood, various prototypes shall be implemented to verify their correctness. These prototypes are:

* Read and write target lists with optional parameters, see format in appendix A
* Display targets in sky coordinates (RA/DEC)
* Display targets and slits overlaid in sky coordinates
* Display slit physical layout
* Sky coordinates to slitmask physical coordinates transformation
* Instrument detector geometry calibration

# Testing

At least five complete sets of input target list and output files must be made available for verification and regression tests.

# Appendix A – File Formats

## DSIMULATOR Target List format

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column** | **Field** | **Description** | **Datatype** | **Units** | **Example** |
| 1 | Object Name | Currently limited to 16 characters. No whitespace allowed. | string |  | Cl0016+16\_gal276 |
| 2 | RA | Right Ascension | real | sexagesimal hours | 00:16:00.000 |
| 3 | Dec | Declination | real | sexagesimal degrees | +16:00:00.00 |
| 4 | Equinox | Equinox of RA/Dec coordinates | real | year | 2000.0 |
| 5 | Magnitude | Brightness of target | real | mag | 21.50 |
| 6 | Passband | Filter in which the brightness was measured | string |  | V |
| 7 | Pcode | Priority code: indicates target type and relative weighting of science targets as indicated [below](https://www2.keck.hawaii.edu/inst/deimos/dsim.html#pcode). | integer |  | 1000 |
| *Optional Fields* | | | | | |
| 8 | Sample | Sample to which the object belongs. When auto-selecting, objects in Sample 1 are selected first; remaining space is then filled with Sample 2, then Sample 3, etc. Default=1. | integer |  | 1 |
| 9 | Select | Flag indicating whether to pre-select the target. If non-zero, object is pre-selected. This is useful for objects that you definitely want to appear on the mask, eg, extremely high-priority objects, or e.g., a set of useful alignment stars. Default=0. | integer |  | 0 |
| 10 | SlitPA | Position angle of the slit | real | degrees | 180.00 |
| 11 | Len1 | Requested length above object (in direction of PA) | real | arcsec | 4.0 |
| 12 | Len1 | Requested length below object (opposite to PA) | real | arcsec | 4.0 |
| 13 | SlitWidth | Desired slit width. Not implemented, so this value is ignored. Slit width is set globally by the input parameters. | real | arcsec | 1.5 |

Example:

# OBJNAME RA DEC EQX MAG band PCODE LIST SEL? PA L1 L2

11013349 14:15:49.332 25:02:22.34 2000.0 19.19 R -2 0 1

11007300 14:15:35.215 25:00:26.93 2000.0 19.26 R -2 0 1

11028008 14:14:35.936 25:09:20.73 2000.0 20.44 R -2 0 1

11027556 14:15:04.153 25:09:00.97 2000.0 18.00 R -1 0 1

11013025 14:15:49.852 25:01:12.76 2000.0 23.38 R 100

11500307 14:15:39.858 24:59:56.40 2000.0 0.00 R 100

11006783 14:15:42.861 25:00:32.86 2000.0 21.07 R 100

11006484 14:15:42.924 25:01:01.99 2000.0 23.94 R 100

11013368 14:15:44.835 25:01:27.84 2000.0 22.47 R 100

11013366 14:15:44.425 25:01:39.15 2000.0 21.65 R 100

11006782 14:15:36.929 25:00:36.21 2000.0 19.18 R 100

11013370 14:15:39.591 25:01:21.24 2000.0 20.89 R 100

11007192 14:15:35.834 25:00:50.10 2000.0 23.38 R 100

11013013 14:15:39.166 25:01:43.75 2000.0 23.81 R 100

11013288 14:15:41.960 25:02:23.95 2000.0 23.53 R 100

11013128 14:15:41.506 25:02:30.50 2000.0 23.68 R 100

11013360 14:15:37.097 25:01:49.75 2000.0 22.84 R 100

11013352 14:15:36.943 25:02:08.59 2000.0 22.82 R 100 2

……

## Deimos DSimulator Output FITS Table Formats

### Table ObjectCat

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit/Type** |
| ObjectId | A number identifying the object in this list | integer |
| OBJECT | Name of object | string |
| RA\_OBJ | Object’s right ascension in hour | hour, float |
| DEC\_OBJ | Object’s declination in degree | degree, float |
| RADESYS | Coordinate Frame, blank | ? |
| EQUINOX | Equinox in year, eg 2000.0 | year, float |
| MJD-OBS | Modified Julian-date of observation, eg. 0 | 0.0 |
| mag | Object’s magnitude, what wavelength? | float |
| pBand | Photometric band, eg. B | char |
| RadVel | Radial velocity, eg 0 | ? |
| MajAxis | 0 | ? |
| MajAxPA | Major axis position angle, in deg | degree, float |
| MinAxis | 0 | ? |
| PM\_RA | Proper motion in RA | ? |
| PM\_Dec | Proper motion in DEC | ? |
| Parallax | 0, ? | degree, float |
| ObjClass | Object’s class, eg. Alignment Star, Program\_Target | string |
| CatFilePK | 1, ? | ? |

Example:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **ObjectId** | **OBJECT** | **RA\_OBJ** | **DEC\_OBJ** | **RADESYS** | **EQUINOX** | **MJD-OBS** | **mag** | **pBand** | **RadVel** | **MajAxis** | **MajAxPA** | **MinAxis** | **PM\_RA** | **PM\_Dec** | **Parallax** | **ObjClass** | **CatFilePK** |
| **0** | 0 | N2419-D17 ... | 114.605900 | 38.941200 |  | 2000.0 | 0.0 | 17.52 | I | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | Alignment\_Star | 1 |
| **1** | 1 | N2419-D6 ... | 114.584450 | 38.953953 |  | 2000.0 | 0.0 | 17.27 | I | 0.0 | 0.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | Program\_Target | 1 |
| **2** | 2 | N2419-S1000 ... | 114.543467 | 38.910525 |  | 2000.0 | 0.0 | 20.86 | I | 0.0 | 0.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | Program\_Target | 1 |
| **3** | 3 | N2419-S1004 ... | 114.543871 | 38.870425 |  | 2000.0 | 0.0 | 16.59 | I | 0.0 | 0.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | Program\_Target | 1 |
| **4** | 4 | N2419-S1007 ... | 114.544088 | 38.854778 |  | 2000.0 | 0.0 | 18.78 | I | 0.0 | 0.0 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | Program\_Target | 1 |
|  | … | … | … | … |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

### Table CatFiles

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit** |
| CatFilePK | ? | ? |
| CatFileName | ? | ? |

Example:

|  |  |  |
| --- | --- | --- |
|  | **CatFilePK** | **CatFileName** |
| 0 | 1 | INDEF ... |

### Table MaskDesign

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit/Type** |
| DesId | A number identifying this mask | integer |
| DesName | Name of this mask | string |
| DesAuth | Namer of email of author | string |
| DesCreat | Software used | string |
| DesDate | Creation date | ISO date format |
| DesNslit | Number of slits | integer |
| DesNobj | Number of objects | integer |
| ProjName | Project’s name | string |
| INSTRUME | Instrument | string |
| MaskType | ??? |  |
| RA\_PNT | Pointing RA in hour | hour, float |
| DEC\_PNT | Pointing DEC in degree | degree, float |
| RADEPNT | ?? |  |
| EQUINPNT | Pointing equinox in year | year, float |
| PA\_PNT | Position angle in degree | degree, float |
| DATE\_PNT | Observation date, eg. 2018-03-02 | date |
| LST\_PNT | Local sidereal time, in degree | degree, float |

Example:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **DesId** | **DesName** | **DesAuth** | **DesCreat** | **DesDate** | **DesNslit** | **DesNobj** | **ProjName** | **INSTRUME** | **MaskType** | **RA\_PNT** | **DEC\_PNT** | **RADEPNT** | **EQUINPNT** | **PA\_PNT** | **DATE\_PNT** | **LST\_PNT** |
| **0** | 1 | n2419c ... | Evan Kirby <enk@astro.caltech.edu> ... | Dsimulator: Ver 0.0b ... | 2017-09-22T10:36:40 | 100 | 107 | M31 ... | DEIMOS ... | ??? ... | 114.593027 | 38.792944 |  | 2000.0 | 50.0 | 2017-10-21 | -30.0 |

### Table DesiSlits

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit/Type** |
| dSlitId | Slit Id, a number | integer |
| DesId | Mask ID | integer |
| SlitName | Name of slit, eg. 000 | 3 digits |
| slitRA | Slit’s RA, in hour | hour, float |
| slitDec | Slit’s DEC in degree | degree, float |
| slitTyp | Type, A=Alignment, P=Program target | char |
| slitLen | Length of slit, in arcsec | arcsec, float |
| slitLPA | Slit’s position angle in degree | degree, float |
| slitWid | Slit’s width, in arcsec | arcsec, float |
| slitWPA | Slit’s width PA, in degree ?? | degree, float |

Example:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **dSlitId** | **DesId** | **SlitName** | **slitRA** | **slitDec** | **slitTyp** | **slitLen** | **slitLPA** | **slitWid** | **slitWPA** |
| **0** | 0 | 1 | 000 | 114.605902 | 38.941200 | A | 4.000 | 50.0 | 4.0 | 140.0 |
| **1** | 1 | 1 | 001 | 114.584492 | 38.953970 | P | 5.851 | 60.0 | 0.7 | 140.0 |
| **2** | 2 | 1 | 002 | 114.543678 | 38.910619 | P | 6.669 | 60.0 | 0.7 | 140.0 |
| **3** | 3 | 1 | 003 | 114.543766 | 38.870376 | P | 6.508 | 60.0 | 0.7 | 140.0 |
| **4** | 4 | 1 | 004 | 114.544311 | 38.854877 | P | 5.946 | 60.0 | 0.7 | 140.0 |
|  | … | … | … |  |  |  |  |  |  |  |

### Table SlitObjMap

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit/Type** |
| DesId | Mask Id | integer |
| ObjectId | Object’s Id | integer |
| dSlitId | Slit’s Id | integer |
| TopDist | Distance to top end of slit arcsec | arcsec, float |
| BotDist | Distance to bottom end of slit arcsec | arcsec, float |

Example:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **DesId** | **ObjectId** | **dSlitId** | **TopDist** | **BotDist** |
| **0** | 1 | 0 | 0 | 2.000 | 2.000 |
| **1** | 1 | 1 | 1 | 2.796 | 3.055 |
| **2** | 1 | 2 | 2 | 2.657 | 4.013 |
| **3** | 1 | 3 | 3 | 3.601 | 2.907 |
| **4** | 1 | 4 | 4 | 2.256 | 3.690 |
|  | … | … | … |  |  |

### Table MaskBlu

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Unit/Type** |
| BluId | Blue mask Id | integer |
| DesId | Mask Id | integer |
| BluName | Mask name | string |
| guiname | GUI name | string |
| BluObsvr | Observer’s name and email | string |
| BluCreat | Software used | string |
| BluDate | Creation date | ISO date |
| LST\_Use | Local sidereal time ? degree | degree, float |
| Date\_Use | Date, yyyy-mm-dd | date |
| TELESCOP | Telescope, Keck I, Keck II | string |
| RefrAlg | Refraction algorithm, eg slalib | string |
| AtmTempC | Atmospheric temperature, degree | degC, float |
| AtmPres | Atmospheric pressure, mbar? | float |
| AtmHumid | Relative humidity, fraction 0-1 | float |
| AtmTTLap | Tropospheric lapse rate, degC/Km ?? | ?? |
| RefWave | Reference wavelength, in micron | um, float |
| DistMeth | ?? |  |

Example:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **BluId** | **DesId** | **BluName** | **guiname** | **BluObsvr** | **BluCreat** | **BluDate** | **LST\_Use** | **Date\_Use** | **TELESCOP** | **RefrAlg** | **AtmTempC** | **AtmPres** | **AtmHumid** | **AtmTTLap** | **RefWave** | **DistMeth** |
| **0** | 1 | 1 | n2419c ... | n2419c | Evan Kirby <enk@astro.caltech.edu> ... | DSIMULATOR -- 02Jul25 ... | 2017-09-22T10:36:40 | 5.636 | 2017-10-21 | Keck II ... | SLALIB ... | 0.0 | 615.0 | 0.4 | 0.0065 | 656.3 | INDEF ... |

### Table BluSlits

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Type** |
| bSlitId | Blue Slit Id | integer |
| BluId | Mask Id | integer |
| dSlitId | Slit Id | integer |
| slitX1 | Slit X1, arcsec | float |
| slitY1 | Slit Y1, arcsec | float |
| slitX2 | Slit X2, arcsec | float |
| slitY2 | Slit Y2, arcsec | float |
| slitX3 | Slit X3, arcsec | float |
| slitY3 | Slit Y3, arcsec | float |
| slitX4 | Slit X4, arcsec | float |
| slitY4 | Slit Y4, arcsec | float |

Example:

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **bSlitId** | **BluId** | **dSlitId** | **slitX1** | **slitY1** | **slitX2** | **slitY2** | **slitX3** | **slitY3** | **slitX4** | **slitY4** |
| **0** | 0 | 1 | 0 | 255.496 | 156.367 | 252.569 | 156.335 | 252.565 | 159.257 | 255.492 | 159.289 |
| **1** | 1 | 1 | 1 | 244.103 | 210.942 | 239.888 | 211.641 | 239.888 | 212.152 | 244.102 | 211.453 |
| **2** | 2 | 1 | 2 | 107.327 | 176.250 | 102.541 | 177.075 | 102.541 | 177.587 | 107.327 | 176.762 |
| **3** | 3 | 1 | 3 | 39.562 | 94.827 | 34.893 | 95.645 | 34.893 | 96.158 | 39.562 | 95.339 |
| **4** | 4 | 1 | 4 | 14.079 | 62.857 | 9.813 | 63.611 | 9.813 | 64.123 | 14.079 | 63.370 |
|  | … | … | … | … |  |  |  |  |  |  |  |

### Table RDBmap

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Type** |
| MEMBER\_NAME | Fits table name | string |
| KwdOrCol | ??, eg C? | char |
| Element | Column name in fits table | string |
| RDBtable | Table name in database | string |
| RDBfield | Field name in database | string |

Example:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **MEMBER\_NAME** | **KwdOrCol** | **Element** | **RDBtable** | **RDBfield** |
| **0** | BluSlits | C | bSlitId | BluSlits | bSlitId |
| **1** | BluSlits | C | BluId | BluSlits | BluId |
| **2** | BluSlits | C | dSlitId | BluSlits | dSlitId |
| **3** | BluSlits | C | slitX1 | BluSlits | slitX1 |
| **4** | BluSlits | C | slitY1 | BluSlits | slitY1 |
|  | … |  |  |  |  |