Slitmasks from Observer to Telescope

astrometric slitmask manufacturing and control for Keck spectrographs

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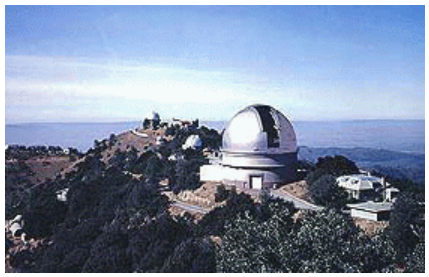

Lick Observatory

Keck Observatory

This poster/paper describes the design, fabrication and use of astrometric slitmasks for two Keck spectrographs: DEIMOS and LRIS. We explain how our system for managing slitmasks was developed, and what features it offers to observers, summit staff, and instrument scientists. We discuss the costs and implications of generalising the system to support multiple instruments.

Overview:

Mask designs are submitted by observers for storage in a master database residing at Lick Observatory in California, via a multi-featured Web interface. Various levels of error checking are performed during and after design submission. A second copy of the mask data resides in a shadow database server at Keck Observatory, updated daily. Masks may be milled either in California or Hawai'i, from design data extracted from the local copy of the database. A mill operator's GUI simplifies and guides the process of mask production and labelling. Mask status (progress through the milling process) is also stored in the databases. If milling takes place in Hawai'i, the mainland (master) database is automatically updated as well as the local copy. The DEIMOS spectrograph is equipped with an internal scanner for positive automated identification of loaded slitmasks. Mask design data are appended to every DEIMOS image for which a slitmask was used.

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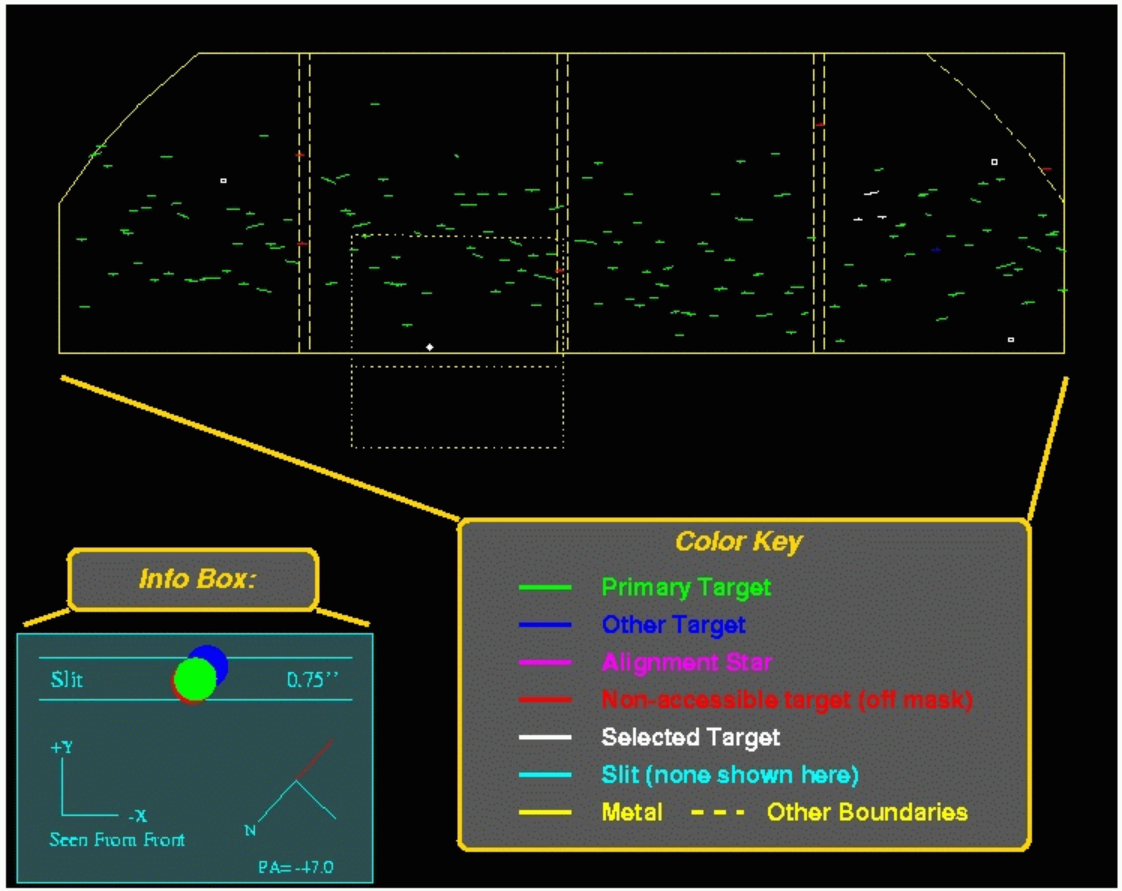
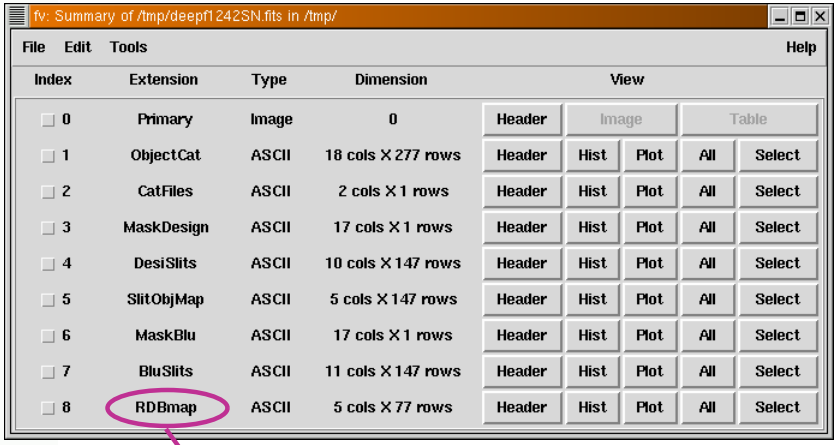
designing the mask



The observer uses a copy of DSIMULATOR at his/her home institution to design a DEIMOS slitmask.

The output from this process is a Mask Design File (a FITS file containing multiple table extensions).



The RDBmap table contains the mapping from FITS table extensions to RDBMS tables and thus provides built-in 'unpacking instructions' for ingesting the design file into the authoritative database.

LRIS users may use a variety of older tools to produce an ASCII mask design file which will later be converted into a standard FITS Mask Design File.

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submitting the mask design

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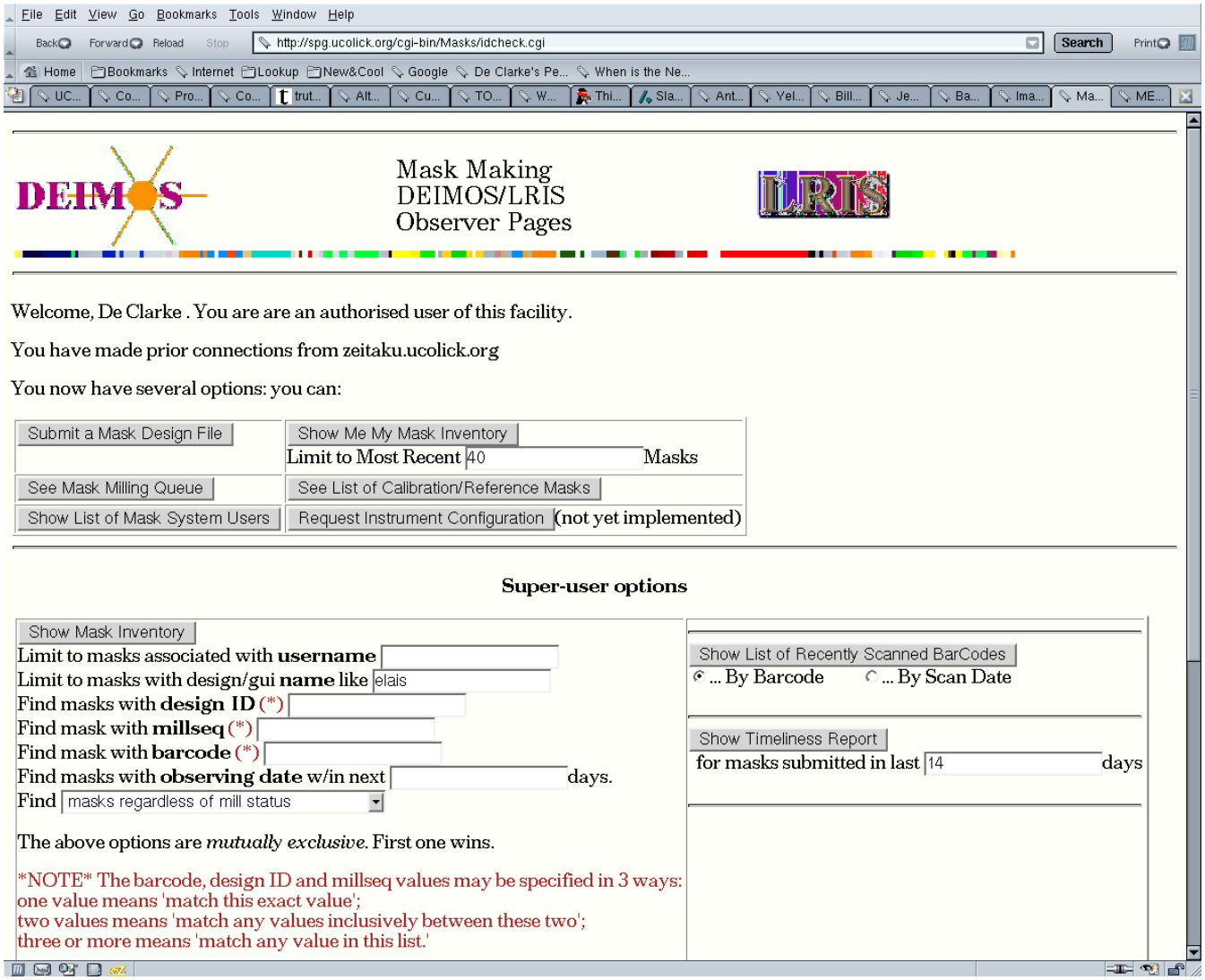

Authenticated users access a 'master' page offering a variety of mask services. Note the important distinction between ordinary users and 'super-users'. The ordinary user cannot see other people's mask data.

A user who chooses the 'submit mask design file' option will be led through the process by a series of subsequent pages. The mask design file will not be accepted until it has passed a basic 'sanity check.'

Once the design file has been accepted and ingested into the authoritative database, the user will be able to view the mask design as raw data or as a plot.

The user can also view the queue of designs waiting to be milled, to see what place their masks are in and whether they are done yet.

Super-users can retrieve designs from the archive regardless of authorship, using fairly sophisticated search parameters. Super-users have access to standard reports, like the 'Timeliness Report' which shows the number of days between mask submission and observing date.

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milling the mask

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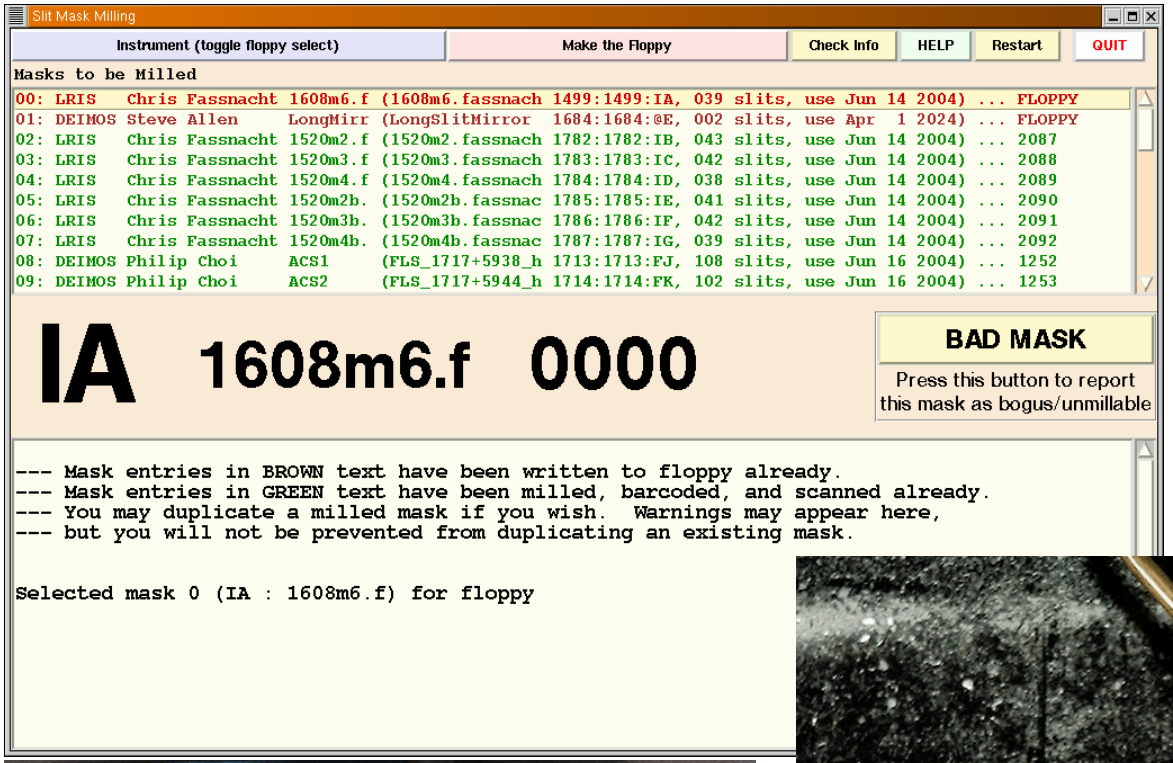
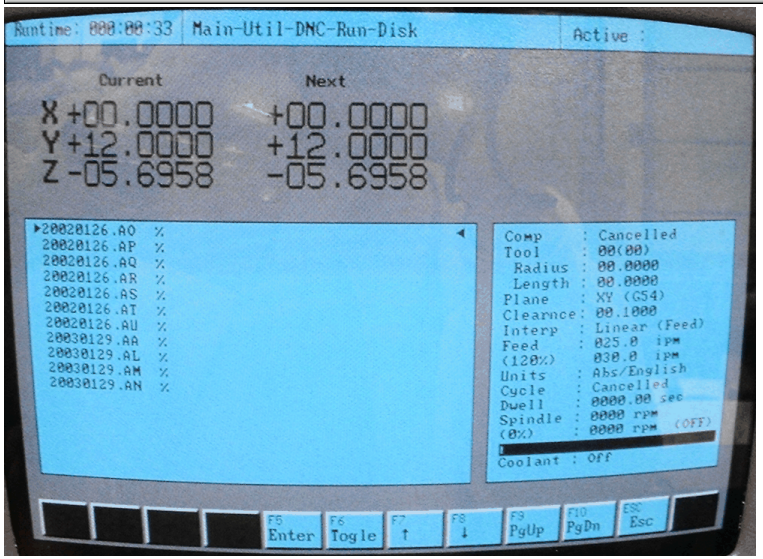


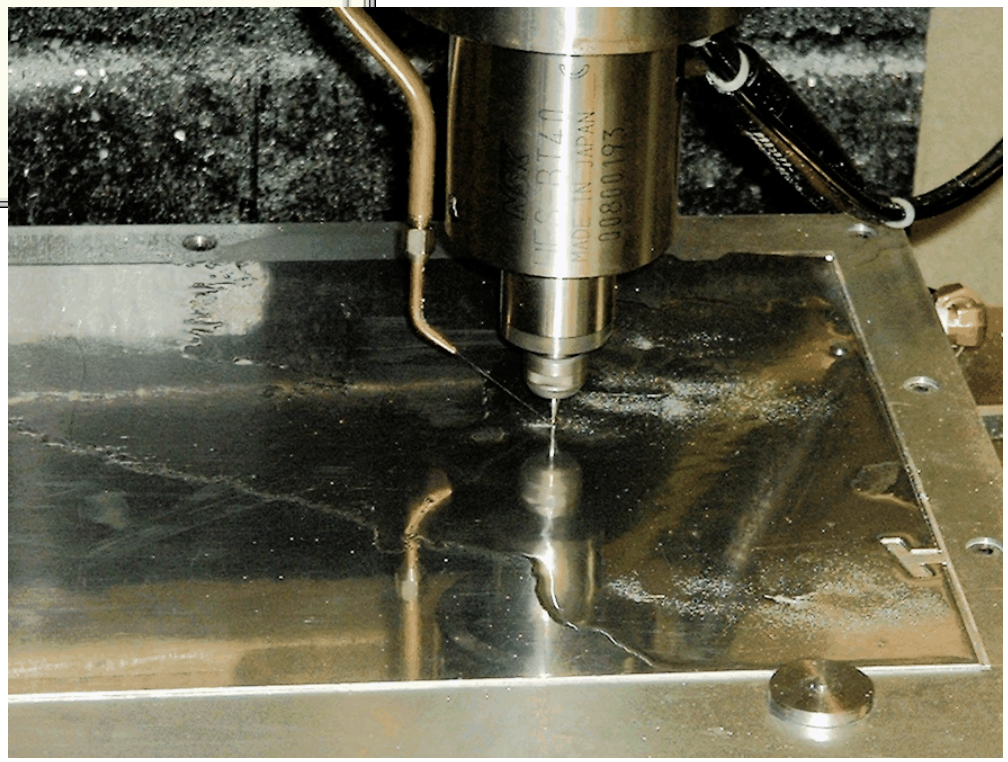
Near the mill sits a networked PC which extracts mask status and design data from the local database and presents them in menu format as part of a dedicated Mill Operator's GUI.

The mill operator selects the highest-priority masks in the current queue to be written to a floppy, which is hand-carried to the CNC mill. At the mill, the operator positions a slit mask blank on the vacuum chuck and selects a mill code file from the floppy, then starts the milling process.

The mill will operate unattended until this mask is finished. The time needed to mill a mask varies with the number of slitlets, from 20 minutes to over an hour.

When the milled mask is removed from the vacuum chuck it will require thorough cleaning with solvent and compressed air prior to inspection and barcoding.





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identifying the mask

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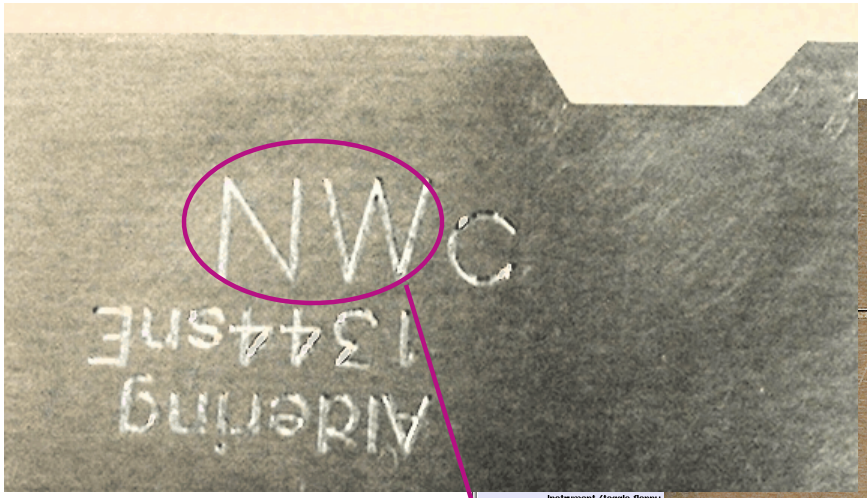
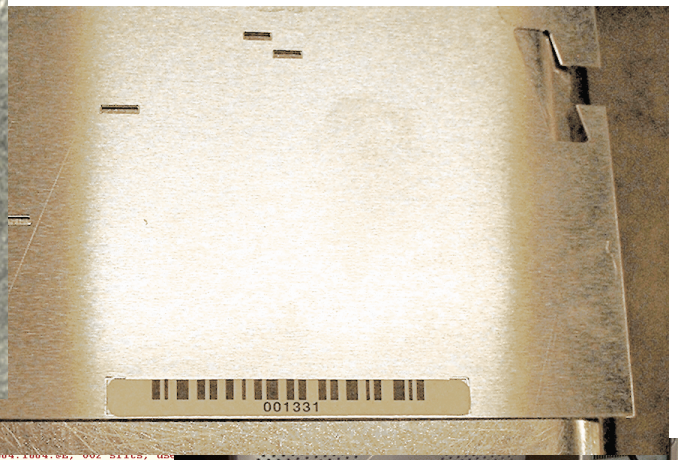


Among the last features milled into the mask is an engraved label area including its 'gui name', the observer's name, and the 2-letter mill-sequence code.

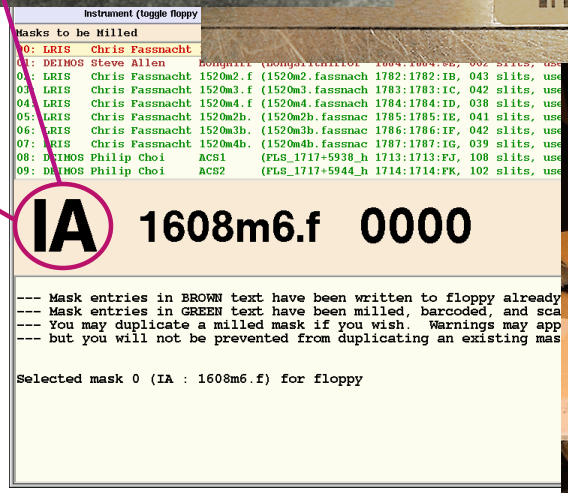


If this engraving or the edge cutouts for automated mask handling are faulty or missing, then the miller knows the milling process failed. Even a cursory inspection will tell us if the mill bit broke during milling, for example.

After the mask is cleaned, inspected, and found acceptable, the miller applies an unique preprinted barcode label to one corner.

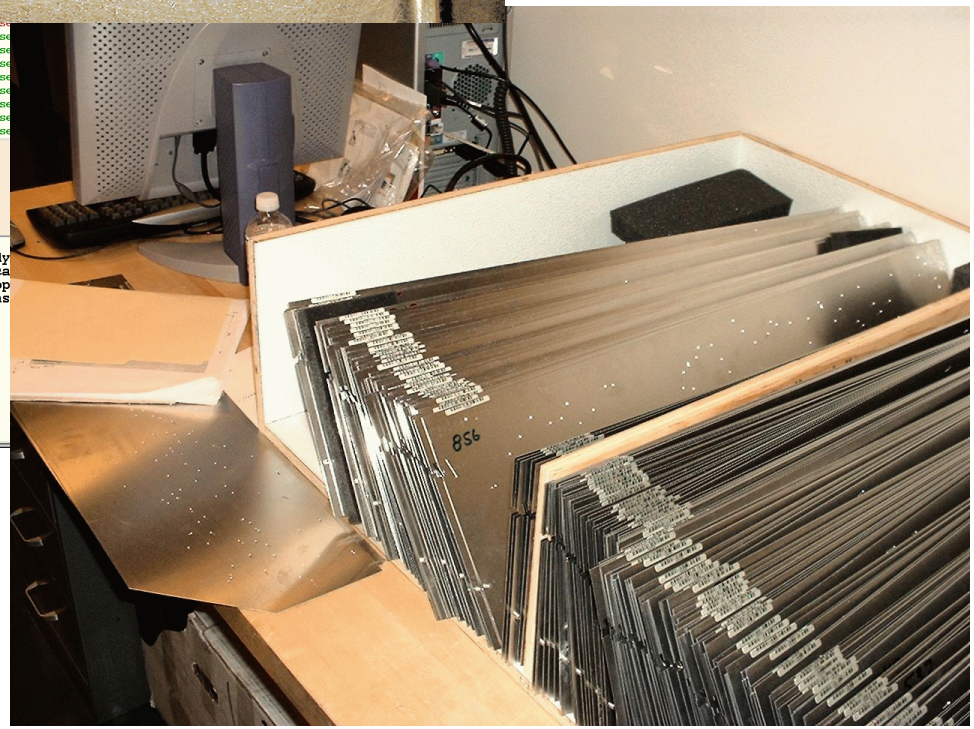
When the barcode label has been successfully applied, the miller finds the mask again in the milling queue, verifying its large, easily-read mill sequence code. In this case IA, the selected mask, does not match the engraved NW; so this mask cannot be correctly scanned until NW is selected.

After selecting the mask from the list shown in the GUI, the miller scans its barcode with a scanner gun attached to the PC at the milling station.



This scan event causes inserts and updates to occur in the database. The software allows the user to recover from errors during scanning (wrong mask scanned), rewriting the database contents as necessary.

Once scanned, the barcode is now associated in the mask database with the selected mask design and all related information. The cleaned, inspected, coded and identified mask is placed in storage awaiting the observing run during which it will be used.



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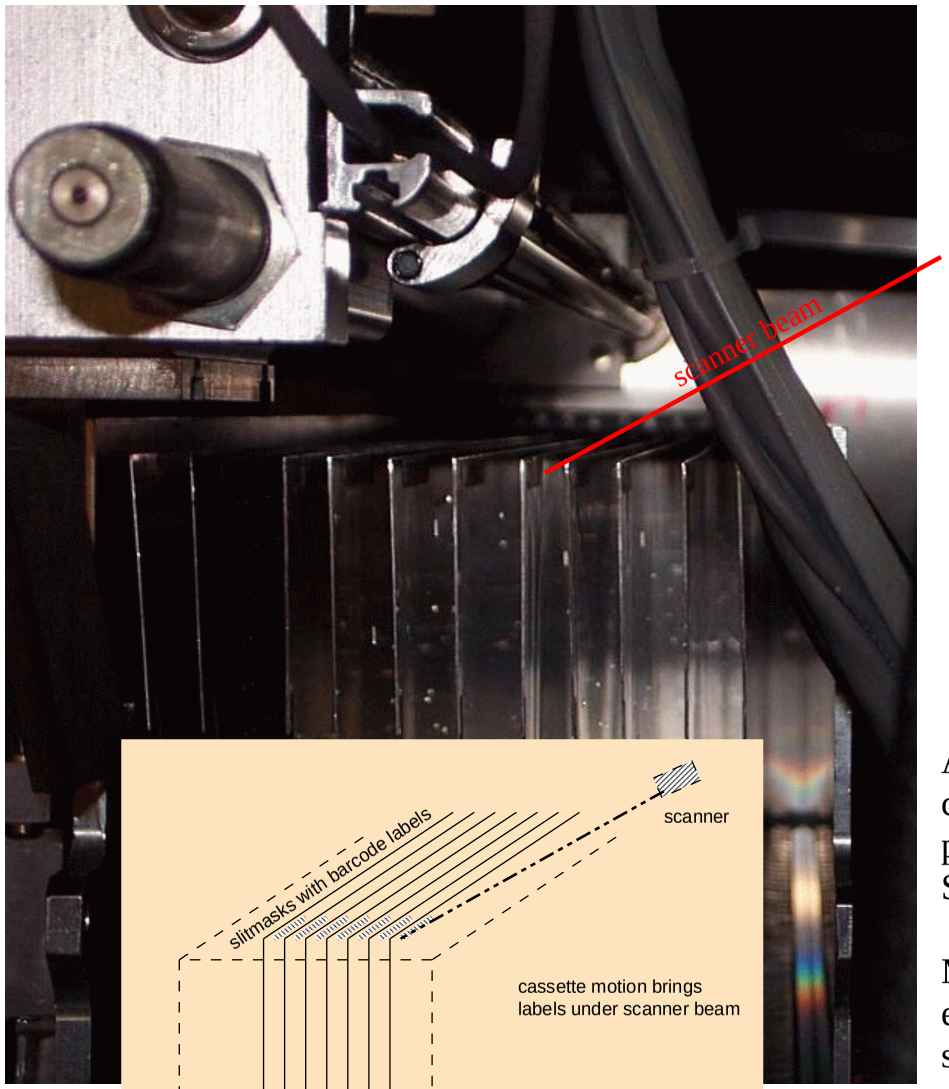
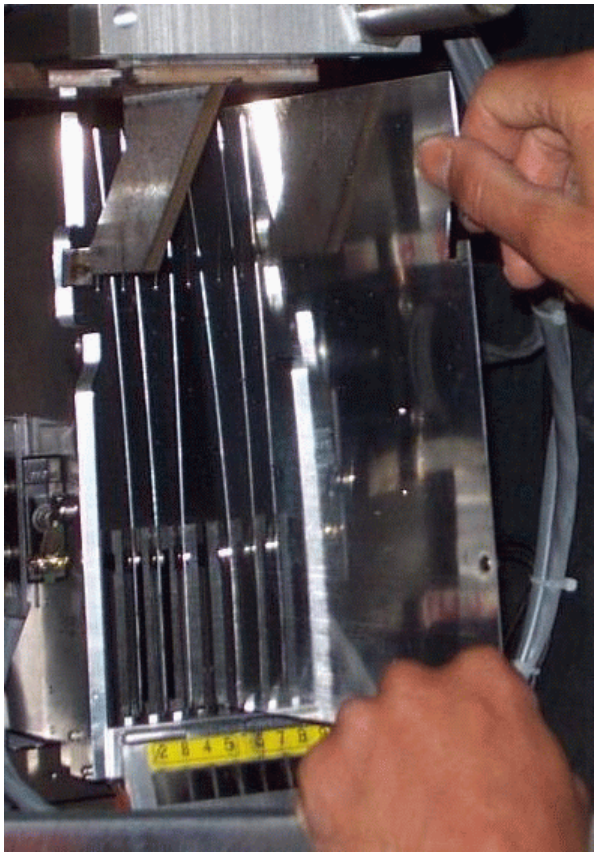
configuring the instrument

Requested masks are identified by their bar code labels, names, and mill sequence codes, and loaded into the mask cassette by an instrument technician (top right).





After masks are loaded into DEIMOS, their barcode labels can be scanned automatically within the instrument for positive identification of the mask in each cassette slot. See inset drawing and photo at left.

Mask design information is extracted (in FITS format) for each loaded mask and made available to the image capture software.

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observing with slitmasks

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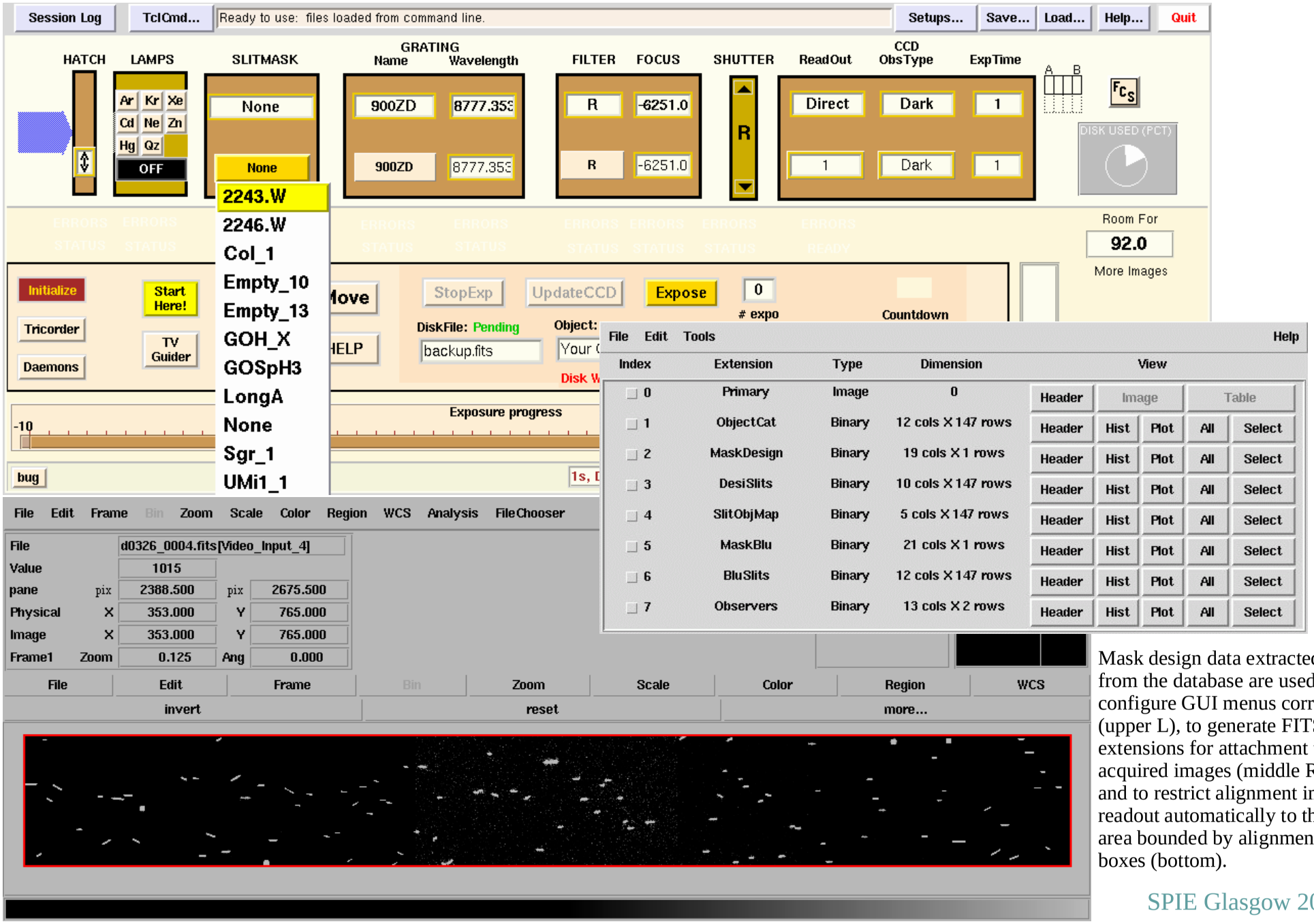

Mask design data extracted from the database are used to configure GUI menus correctly (upper L), to generate FITS extensions for attachment to acquired images (middle R), and to restrict alignment image readout automatically to the area bounded by alignment boxes (bottom).

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archival data preserved with images

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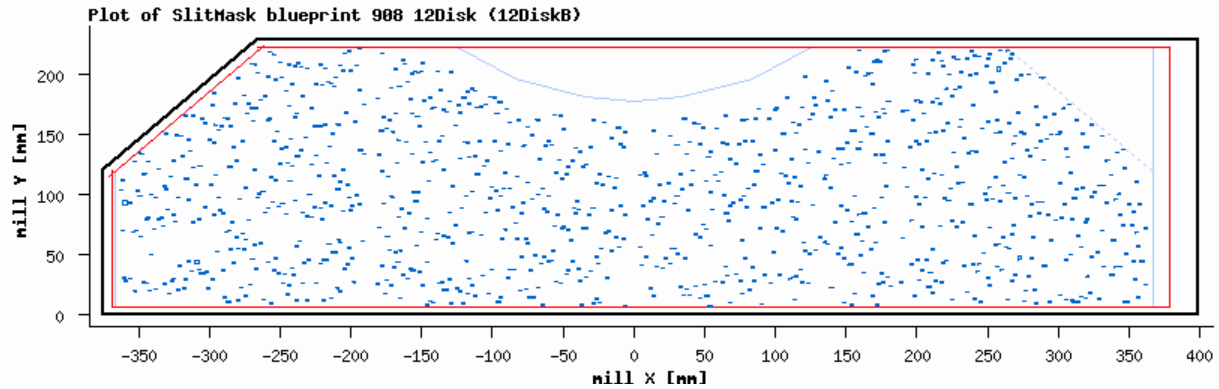
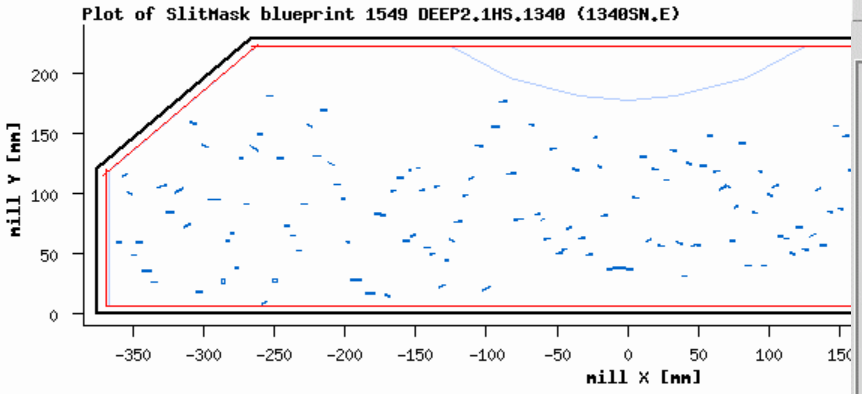


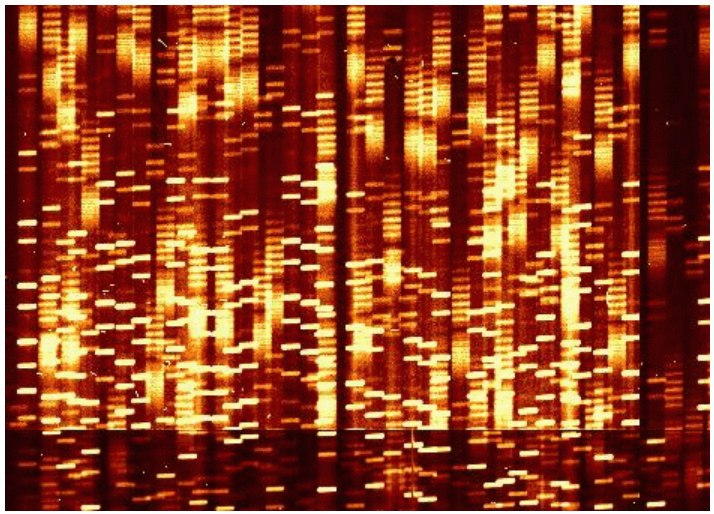
At top left appears a 'Megamask', a mask with an unusually large number of slitlets designed for use with a narrow-band-pass filter. Below is a more normal mask, for comparison: note the marked difference in slitlet count.

Every one of the 1031 slitlets in the megamask design is fully documented in each image taken through that mask. When we consider a small area of the spectral image, the importance of keeping these archival data attached to the image becomes clear.



File Edit Tools Help

Index	Extension	Type	Dimension	View				
0	Primary	Image	0	Header	Image	Table		
1	Video_Input_2	Image	2140 X 4096	Header	Image	Table		
2	Video_Input_4	Image	2140 X 4096	Header	Image	Table		
3	Video_Input_6	Image	2140 X 4096	Header	Image	Table		
4	Video_Input_8	Image	2140 X 4096	Header	Image	Table		
5	Video_Input_10	Image	2140 X 4096	Header	Image	Table		
6	Video_Input_12	Image	2140 X 4096	Header	Image	Table		
7	Video_Input_14	Image	2140 X 4096	Header	Image	Table		
8	Video_Input_16	Image	2140 X 4096	Header	Image	Table		
9	ObjectCat	Binary	12 cols X 1031 rows	Header	Hist	Plot	All	Select
10	MaskDesign	Binary	19 cols X 1 rows	Header	Hist	Plot	All	Select
11	DesiSlits	Binary	10 cols X 1031 rows	Header	Hist	Plot	All	Select
12	SlitObjMap	Binary	5 cols X 1031 rows	Header	Hist	Plot	All	Select
13	MaskBlu	Binary	21 cols X 1 rows	Header	Hist	Plot	All	Select
14	BluSlits	Binary	11 cols X 1031 rows	Header	Hist	Plot	All	Select
15	Observers	Binary	12 cols X 2 rows	Header	Hist	Plot	All	Select



Enough design information is captured in FITS table extensions appended to the image file (as shown above) to permit the correct identification of slitlets and objects in the intimidating spectral region shown at left, *without additional external documentation.*

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slitmask information flow diagram

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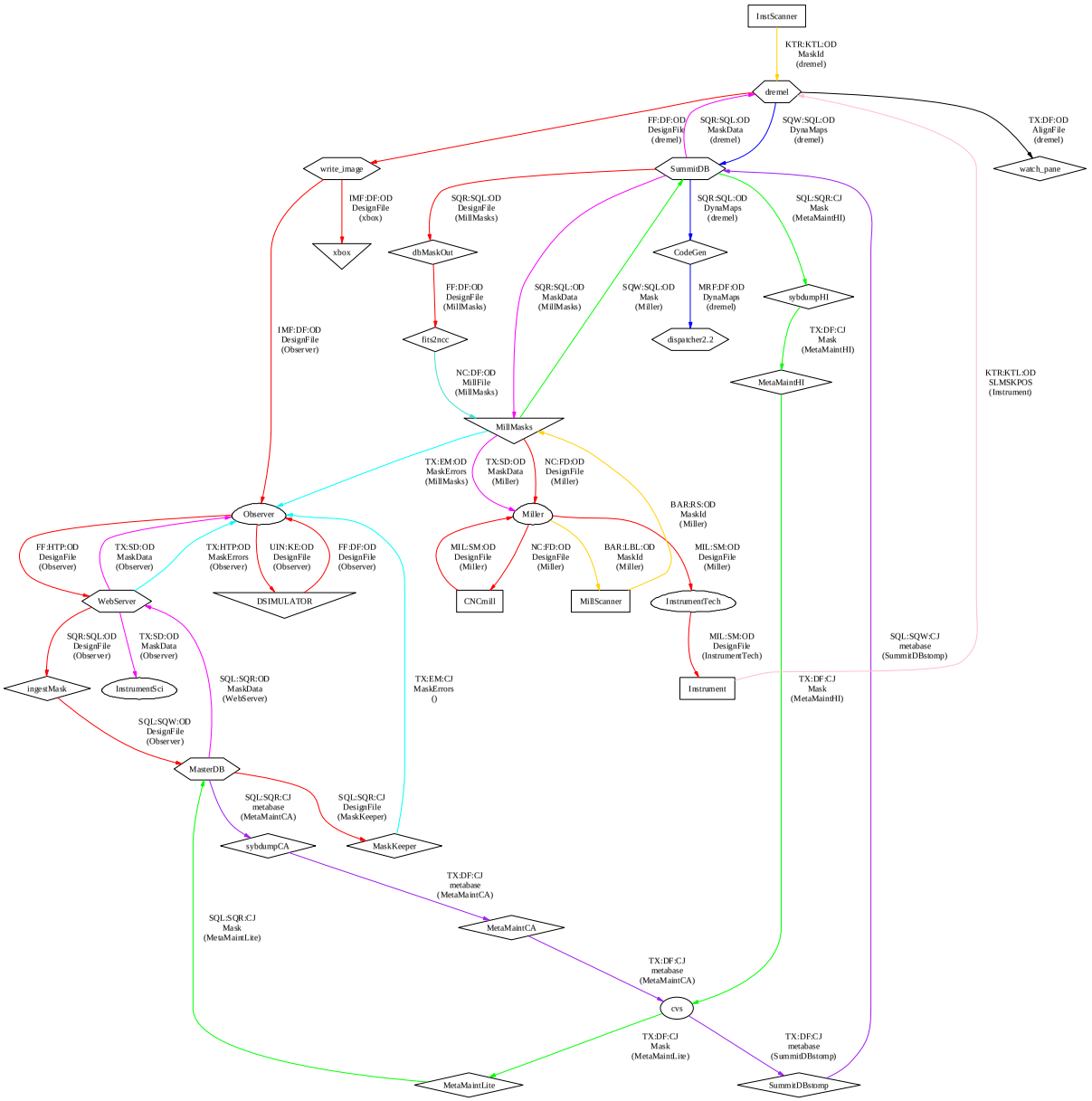

This diagram documents the flow of data through the slit mask management system. Each discrete type of information is colour-coded; mask design errors, for example. are cyan in this version; the original design file data provided by the observer are red.

This reduced version is nearly unreadable and serves only to suggest the complexity of the system and the number of participants (human and software) in the mask-making game. The original eps file is available at our web site (see URLs on end page).

For those who wish to peer closely at the diagram in hope of getting some understanding of the information flow: deformed ovals are human players; squashed hexagons are servers (web or database); triangles are GUI applications, diamonds are command-line applications; rectangles are hardware devices.

No information about real-world timing of events is included in this diagram. While some transactions are noted as "On Demand" and others as "Cron Job" there is no attempt to show actual times of day or how transactions are queued or scheduled. Timing, transaction dependency, and interaction with external constraints like workday hours and the rituals of instrument checkout and prep at the summit, present another layer of complexity for which we lack a visual metaphor.

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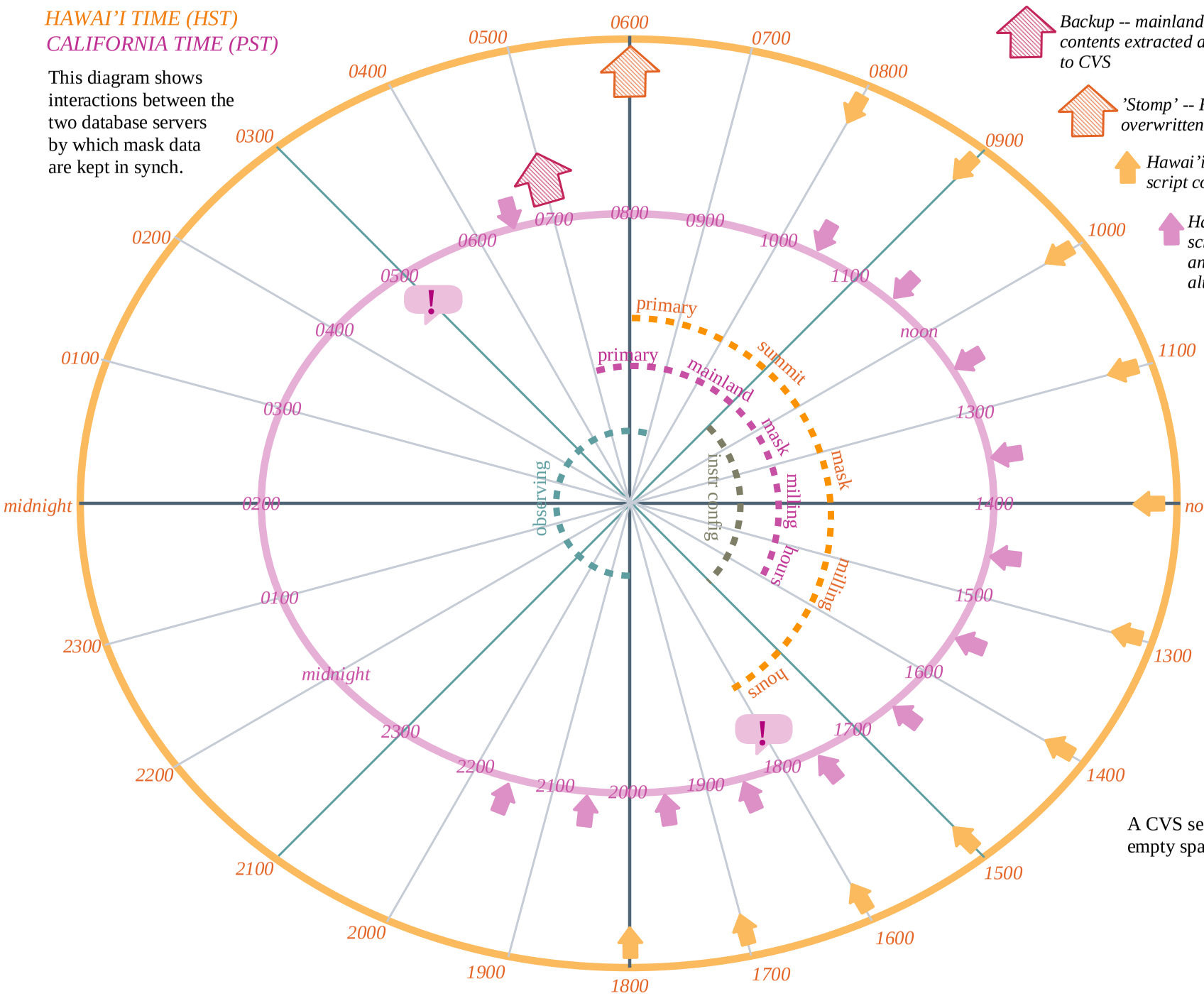
synchronising database contents

HAWAI'I TIME (HST)
CALIFORNIA TIME (PST)

This diagram shows interactions between the two database servers by which mask data are kept in synch.



Backup -- mainland database contents extracted and committed to CVS

'Stomp' -- Hawai'i database overwritten with CVS contents

Hawai'i milling activity update script committed to CVS

Hawai'i milling activity update script checked out from CVS and run; mainland DB altered, alterations committed to CVS

!

MaskKeeper checks mask data and sends mail to all and sundry

Mask submission events via Web interface to mainland DB occur round the clock, at any time.

From Spring through Fall, PDT, CA is three rather than two hours ahead. Winter time (PST) is shown here. For summer time, rotate the inner wheel 1 hour CCW.

A CVS server implicitly occupies the empty space between the two wheels.

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acknowledgments and URLs for further reading

The authors would like to thank

The UCO/Lick Observatory mask millers: Jeff Lewis and Matt Thompson
The summit staff of Keck Observatory, in particular Hector Rodriguez, Chris Hunt and Bill Mason
Drs. Judith Cohen and Patrick Shopbell of Caltech, authors of LRIS mask design tools
The brave DEIMOS and LRIS users who were the first to try the new mask making system
The computing support staff at both Keck and Lick Observatories
William Joye of Harvard/CFA for his efforts to enhance ds9 for our specific needs
Don Libes of NIST for the CGItcl package

The following URLs provide more information about astrometric mask design and use

http://spg.ucolick.org/Docs/SPIE/2004
http://www.ucolick.org/~de/Masks/Doco/
http://www.ucolick.org/~phillips/deimos_ref/masks.html
http://alamoana.keck.hawaii.edu/inst/deimos/
http://alamoana.keck.hawaii.edu/inst/lris/