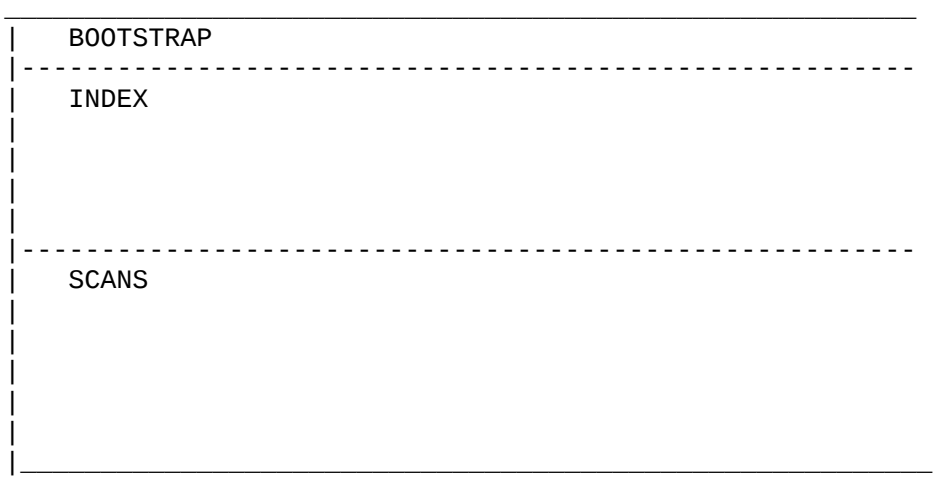
The SDD File Format

The native format of UniPOPS for storing and retrieving data is called SDD. The file consists of three parts: bootstrap, index, and scans, and is a direct-access file. The file has the following layout,

SDD File Format



The binary representation used in an SDD file is that of the IEEE standard. The checkfile.exe utility will list the contents of the bootstrap and index section of the file while makeindex.exe will reconstruct the index and some of the items in the bootstrap part of the file by looking at the scan section of the file. The makefile.exe utility will create an empty SDD file with a specified size.

As of the fall of 1993, a new bootstrap and index format are in use. All of the primary UniPOPS programs are able to read both the old and the new forms transparently to the user. The new format primarily involves switching from 16-bit integers to 32-bit integers. The makeindex.exe utility can be used to generate a new bootstrap and index for an old-format SDD file. The makeoldindex.exe utility can be used to generate an old-format bootstrap and index.

SDD: Bootstrap

The bootstrap occupies one record. The structure and contents of the bootstrap record is:

SDD Bootstrap Structure

Word Size	Description
Integer*4:	Number of records in index including the bootstrap record.
Integer*4:	Number of data records which follow index records.
Integer*4:	Bytes per record.
Integer*4:	Number of bytes per index entry.
Integer*4:	Number of index entries already used.
Integer*4:	Counter which indicates whether the file has been updated.
Integer*4	Type of SDD file (0 if data, 1 if individual records)
Integer*4	SDD version number (this is version 1)
Integer*4:	Zeros to pad out the record to its full size.

Old SDD Bootstrap Structure

Word Size	Description
Integer*2:	Number of records in index including the bootstrap record.
Integer*2:	Number of data records which follow index records.
Integer*2:	Bytes per record.
Integer*2:	Number of bytes per index entry.
Integer*2:	Number of index entries already used.
Integer*2:	Counter which indicates whether the file has been updated.
Integer*4:	Zeros to pad out the record to its full size.

The actual number of bytes in each record of the file can be different for each file. Typically, it is 512 bytes per record and all records in the file have the same size.

Each scan in the scan section of the file is summarized by an entry in the index part of the file. The bootstrap gives the number of bytes occupied by each index entry and has a minimum value of 64 bytes. The number of bytes in each record of the file must be evenly divisible by the number of bytes in each index entry.

As scans are stored in the file, the number of index items already used will give the number of the highest index entry that describes a scan. It need not be the entry describing the last scan written to the file and not all index entries lower than that one need be filled (i.e., index entries need not be filled sequentially). This number is zero for an empty SDD file. Also, as scans are stored in the file, the number of records in the data section of the file is stored in the bootstrap as well. This entry in the bootstrap is zero for an empty SDD file.

If there are N-1 index records (so that there are N records in the bootstrap plus index), and if each index entry takes up M bytes, and if the file has L byte records, the number of scans which can be stored in the file will be: (N-1)*L / M. Typically, N is 129 or 513, so the number of scans which can be stored in an SDD format is 1024 or 4096. The number of records in the index thus dictates the maximum number of scans which the index can describe and the limit on how many scans can be stored in a file. When an SDD file is created (with the makefile.exe utility), the user can specify the maximum number of scans which the file will contain. The expandsdd utility can be used to expand the index size of an existing SDD file. The mergesdd utility can be used to merge two SDD files into one SDD file.

The new bootstrap can be differentiated from the old format by assuming the new format and looking for a 1 at the eighth 32-bit integer. If that value is 0, then it must be the old 16-bit integer format. If that value is neither 1 or 0 then there must be a problem with the file. Individual records data (indicated by a 1 in the seventh 32-bit integer location) is currently only available for Green Bank data.

SDD: Index

One index entry describes one scan in the scan section of the file. Each index entry occupies the number of bytes given in the bootstrap. The number of index entries depends upon the number of records in the index, the number of bytes per record, and the number of bytes per index entry. In most cases, there will be something like 1024 or 4096 index entries.

Each index entry must contain at least 64 bytes of the following information:

SDD Index Entry Structure

```
Word Size   Description
-------------------------------------------------------------
Integer*4:    Starting record number for the scan about to be
                described in the index.
Integer*4:    Last record number for that scan.
Real*4:       Horizontal Coordinate in degrees.
Real*4:       Vertical Coordinate in degrees.
Character*16: Source name.
Real*4:       Scan number.
Real*4:       For spectral-line scans, the frequency resolution
                in MHz.
              For continuum scans, the slew rate of the
                telescope in degrees/sec.
Real*8:       For spectral-line scans, the rest frequency of
                the observation in MHz.
              For continuum scans, the integration time per
                point.
Real*4:       LST in hours.
Real*4:       UT date in YYYY.MMDD format.
Integer*2:    Observing mode (Coded).
Integer*2:    (Record_number*64 + Phase_number)
Integer*2:    Position Code.
Integer*2:    Zeros for padding out index item to the number
                of bytes in each index entry.
-------------------------------------------------------------

                Old SDD Index Entry Structure
-------------------------------------------------------------
Word Size   Description
-------------------------------------------------------------
Integer*2:    Starting record number for the scan about to be
                described in the index.
Integer*2:    Last record number for that scan.
Integer*2:    Magic number indicating format of the data.
Integer*2:    Position Code.
Real*4:       Horizontal Coordinate in degrees.
Real*4:       Vertical Coordinate in degrees.
Character*16: Source name.
Real*4:       Scan number.
Real*4:       For spectral-line scans, the frequency resolution
                in MHz.
              For continuum scans, the slew rate of the
                telescope in degrees/sec.
Real*8:       For spectral-line scans, the rest frequency of
                the observation in MHz.
              For continuum scans, the integration time per
                point.
Real*4:       LST in hours.
Real*4:       UT date in YYYY.MMDD format.
Integer*2:    Observing mode (Coded).
Integer*2:    (Record_number*64 + Phase_number)
Integer*2:    Zeros for padding out index item to the number
                of bytes in each index entry.
-------------------------------------------------------------
```

Notes for the current SDD format and the old SDD format:

- (1) Scans need not be written in sequential order in the index, nor do they need to be written sequentially in the data section. The index entry used depends upon how the scan is stored in the

file. For example, the KEEP verb in UniPOPS will try to store scans into the file sequentially. SAVE, on the other hand, tries to write scans sequentially to the data section of the file but will use an index entry whose location in the file is determined by the value of the adverb NSAVE.

- (2) The scan described by the index entry is stored starting in the given record number of the file; the last record in that scan is also given. For example, if index plus bootstrap occupies 129 records and the scan you are about to write to the file occupies 4 records, then the starting and stopping record numbers could be 130 and 133 respectively.
- (3) Magic number describes the format of the data in the data section of the file. 1=IEEE KEEP, 2=SDD(version 1) This exists only in the old SDD format index.
- (4) Position code indicates what coordinate system is used to give positions in the index entry. 1=Galactic (LII,BII); 2= 1950 RA,DEC; 3=EPOCH RA,DEC; 4=Mean RA,DEC at start of scan; 5=Apparent RA,DEC; 6=Apparent HA,DEC; 7=1950 Ecliptic; 8=EPOCH Ecliptic; 9 Mean Ecliptic at start of scan; 10=Apparent Ecliptic; 11=Az,El; 12=User defined; 13=2000 RA,DEC; 14=Indicated RA,DEC
- (5) For individual records SDD file (see the information on the bootstrap, currently only Green Bank data can be in an individual records file), the record number and phase number are combined in the index as shown above. For normal data files, this field is ignored but should be set to -1.
- (6) Observing mode indicates the type of observation which took the scan. The mode is coded as follows:

```
Continuum = type_code + 256
Spectral-Line = type_code + 512
```

The possible type_codes, and what they represent (as of the data this document was prepared), are:

SDD Observational Type Code

Type_Code	Short Form	Description
0		No mode present
1	PS	Position Switched
2	APS	Absolute Position Switched
3	FS	Frequency Switched
4	BSP	Beam_Switch + Position_Switch
5	TPON	Total Power On
6	TPOF	Total Power Off
7	ATP	Absolute Total Power
8	PSM	Position Switched Map
9	APM	Absolute Position Switched Map
10	FSM	Frequency Switched Map
11	TPMO	Total Power Map On
12	TPMF	Total Power Map Off
13	DRF	Drift Map
14	PCAL	Position Calibrate
15	BCAL	Beam Calibrate
16	BLNK	Blanking
17	SEQ	Sequence
18	FIVE	Five Point
19	MAP	Continuum Map
20	FOC	Focalize
21	NSFC	North-South Focalize

```
22          TTIP            Total Power Tip
23          STIP            Switched Power Tip
24          DON             Continuum On
25          CAL             Calibration
26          FSPS            Freq Switch + Position Switch
27          BSPS            Beam Switch + Position Switch
28          ZERO            Zero Check
29          TLPW            Total Power
30          FQSW            Frequency Switched
31          NOCL            No Calibration
32          PLCL            Pulse Cal
33          ONOF            Continuum On-Off Scan
34          BMSW            Nutation
35          PSSW            Position Switched, Tucson, old
36          DRFT            Continuum Drift Scans, Tucson
37          OTF             On-the-fly, Tucson
38          SON             See Tucson for an explanation
39          SOF             See Tucson for an explanation
40          QK5             See Tucson for an explanation
41          QK5A            See Tucson for an explanation
42          PSS1            PS flip or PS-1 mode, Tucson
43          VLBI            VLBI, Tucson
44          PZC             See Tucson for an explanation
45          CPZM            See Tucson for an explanation
46          PSPZ            PS - polarization, Tucson
47          CPZ1            See Tucson for an explanation
48          CPZ2            See Tucson for an explanation
-------------------------------------------------------------
```

Note: The short form of the modes is that which makes up part of the OBSMODE header word stored within the header of the SDD scan.

SDD: Scan Format

The scans section of the file usually has zero length when it is created. In principle, the scans section of the file can be of various formats (as described by the index entry of each scan). Usually, however, the format of the data will be SDD version 1. This section is the same for both the old and new SDD bootstrap and index formats.

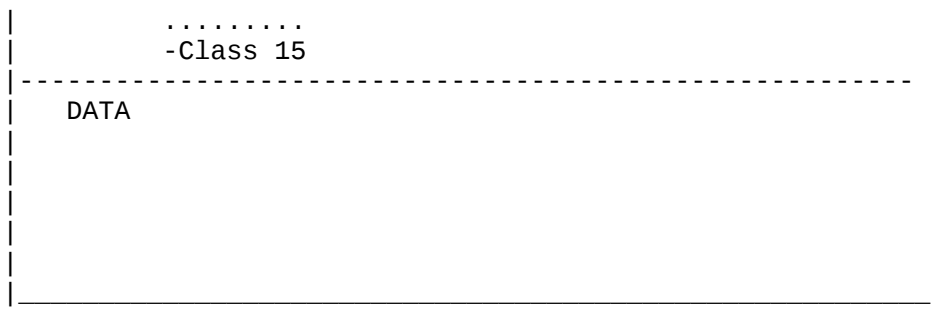
Each scan in the data section can occupy more than one record. If the scan doesn't fill a record, the record is padded with zeros.

Records may be empty within the data section. Empty records are created when UniPOPS tries to overwrite a scan in the file with one that takes up less space. Also, if the scan to be written occupies more records than the scan to be overwritten, the new scan is usually tacked onto the end of the file and the old scan is overwritten with zeros. Thus, SDD files can have holes in them.

If the stored scan is in SDD (version 1) format, the scan has the following graphical format,

SDD Scan Format

```
|   PREAMBLE
|-----------------------------------------------------
|   HEADER-Class 1
|         -Class 2
|         -Class 3
|         .........
```



The preamble describes the locations in the header where the various classes begin and end, as well as the number of classes present. Its structure is,

SDD Preamble Structure

Word Size	Description
Integer*2	Number of classes
Integer*2	Starting Real*8 word for classes (15)

Up to 15 classes of header words can exist in the header. A minimum of 13 are needed. Each class describes a particular aspect of the scan (pointing, mapping, etc). Each class must contain a minimum amount of information. This minimum amount must be in a certain format and must follow prescribed conventions. Extra information may exist in each class after the minimum information is provided. Each entry in each class occupies a multiple of 8 bytes. The memo, dated October 21, 1986 and entitled "Single Dish FITS tape", by Betty Stobie and Lorrie Morgan contains a lengthier, though sometimes out-of-date discussion of the uses of the various classes.

The data section contains the data values. The format, and information on what the data structure is like, is stored in the header. UniPOPS dictates an upper limit of 10240 data points but the SDD file format has no real limits.

Class 1 : Basic Information

Description	Keyword	Size	Units
Length of Header	HEADLEN	R*8	Bytes
Length of Data	DATALEN	R*8	Bytes
Scan Number	SCAN	R*8	
Observer Initials	OBSID	C*8	
Observer Name	OBSERVER	C*16	
Telescope Descriptor	TELESCOP	C*8	
Project Identification	PROJID	C*8	
Source Name	OBJECT	C*16	
Type of Data and Observing Mode	OBSMODE	C*8	
Frontend Descriptor	FRONTEND	C*8	
Backend Descriptor	BACKEND	C*8	
Data Precision of Spectrum	PRECIS	C*8	
Save number from which scan was retrieved	SAVENUM	R*8	
Number of records for indiv. records scan Or the tot. # of OTF spectra in this row	NORECORD	R*8	
The record number for this indiv. record Or the # of this OTF spectra	RECORDID	R*8	

Class 2 : Pointing Parameters

Description	Keyword	Size	Units
Total Az/RA Pointing Correction	XPOINT	R*8	arcsec
Total El/Dec Pointing Correction	YPOINT	R*8	arcsec
User Az/RA Pointing Correction	UXPNT	R*8	arcsec
User El/Dec Pointing Correction	UYPNT	R*8	arcsec
Pointing Constants(1)	PTCON	R*8	arcmin
Pointing Constants(2)	PTCON+1	R*8	arcmin
Pointing Constants(3)	PTCON+2	R*8	arcmin
Pointing Constants(4)	PTCON+3	R*8	arcmin
Receiver Box or Secondary Orientation	ORIENT	R*8	Degrees
Radial Focus	FOCUSR	R*8	mm
North-South Focus	FOCUSV	R*8	mm
East-West Focus	FOCUSH	R*8	mm
Pointing Model	PT_MODEL	C*8	

Class 3 : Observing Parameters

Description	Keyword	Size	Units
Universal Time Date	UTDATE	R*8	YYYY.MMDD
Universal Time	UT	R*8	Hours
LST	LST	R*8	Hours
Number of Receiver Channels	NORCHAN	R*8	
Number of Switching Variables	NOSWVAR	R*8	
Number of Phases per Cycle	NOPHASE	R*8	
Length of Cycle	CYCLLEN	R*8	Seconds
Length of Sample	SAMPRAT	R*8	Seconds
Class 11 type	CL11TYPE	C*8	
The phase number of this indiv. scan	PHASEID	R*8	

Class 4 : Positions

Description	Keyword	Size	Units
Epoch	EPOCH	R*8	Years
Commanded Source X	XSOURCE	R*8	Degrees
Commanded Source Y	YSOURCE	R*8	Degrees
Commanded Reference X	XREF	R*8	Degrees
Commanded Reference Y	YREF	R*8	Degrees
Commanded Epoch Right Ascension	EPOCRA	R*8	Degrees
Commanded Epoch Declination	EPOCDEC	R*8	Degrees
Commanded Galactic Longitude	GALLONG	R*8	Degrees
Commanded Galactic Latitude	GALLAT	R*8	Degrees
Commanded Azimuth	AZ	R*8	Degrees
Commanded Elevation	EL	R*8	Degrees
Indicated X Position	INDX	R*8	Degrees
Indicated Y Position	INDY	R*8	Degrees
Descriptive Origin(1)	DESORG	R*8	Degrees
Descriptive Origin(2)	DESORG+1	R*8	Degrees
Descriptive Origin(3)	DESORG+2	R*8	Degrees
Coordinate System Code	COORDCD	C*8	

Class 5 : Environment

Description	Keyword	Size	Units
Ambient Temperature	TAMB	R*8	C
Ambient Pressure	PRESSURE	R*8	cm-Hg
Ambient relative humidity	HUMIDITY	R*8	%
Index of Refraction	REFRAC	R*8	
Dew Point	DEWPT	R*8	C
Mm of Water	MMH2O	R*8	mm

Class 6 : Map Parameters

Description	Keyword	Size	Units
Map Scanning Angle	SCANANG	R*8	Degrees
X Position at Map Reference Position Zero	XZERO	R*8	Degrees
Y Position at Map Reference Position Zero	YZERO	R*8	Degrees
Delta X or X Rate	DELTAXR	R*8	(arcsec or
Delta Y or Y Rate	DELTAYR	R*8	arcsec/sec)
Number of Grid Points	NOPTS	R*8	
Number of X Grid Points	NOXPTS	R*8	
Number of Y Grid Points	NOYPTS	R*8	
Starting X Grid Cell Number	XCELL0	R*8	
Starting Y Grid Cell Number	YCELL0	R*8	
XY Reference Frame Code	FRAME	C*8	

Class 7 : Data Parameters

Description	Keyword	Size	Units
Beam Halfwidth at Half Maximum	BFWHM	R*8	arcsec
Off Scan Number	OFFSCAN	R*8	
Bad Channel Value	BADCHV	R*8	K
Velocity Correction	RVSYS	R*8	km/sec
Velocity with respect to Reference	VELOCITY	R*8	km/sec
Velocity Definition and Reference	VELDEF	C*8	
Type of Calibration	TYPECAL	C*8	

Class 8 : Engineering Parameters

Description	Keyword	Size	Units
Antenna Aperture Efficiency	APPEFF	R*8	
Antenna Beam Efficiency	BEAMEFF	R*8	
Antenna Gain	ANTGAIN	R*8	
Rear Spill & Scat Efficiency	ETAL	R*8	
Forward Spill & Scat Efficiency	ETAFSS	R*8	

Class 9 : Telescope Dependent Parameters- Green Bank

Description	Keyword	Size	Units
L1	L1	R*8	MHz
L1F1	L1F1	R*8	MHz
L1F2	L1F2	R*8	MHz

L2	L2	R*8	MHz
L2F1	L2F1	R*8	MHz
L2F2	L2F2	R*8	MHz
LA	LA	R*8	MHz
LB	LB	R*8	MHz
LC	LC	R*8	MHz
LD	LD	R*8	MHz
Level Correction	LEVCORR	R*8	Volts
Pointing Fudge(1)	PTFUDGE	R*8	arcmin
Pointing Fudge(2)	PTFUDGE+1	R*8	arcmin
RHO	RHO	R*8	Degree
THETA	THETA	R*8	Degree
Center Frequency Formula	CFFORM	C*24	

Class 9 : Telescope Dependent Parameters- Tucson 12 M

Description	Keyword	Size	Units
Synthesizer Frequency	SYNFREQ	R*8	MHz
LO Factor	LOFACT	R*8	
Harmonic	HARMONIC	R*8	
LOIF	LOIF	R*8	MHz
First IF	FIRSTIF	R*8	MHz
Reference Azimuth Offset	RAZOFF	R*8	arcsec
Reference Elevation Offset	RELOFF	R*8	arcsec
Beam Throw	BMTHROW	R*8	arcsec
Beam Orientation	BMORENT	R*8	Degree
Baseline Offset	BASEOFF	R*8	K
Observing Tolerance	OBSTOL	R*8	arcsec
Sideband	SIDEBAND	R*8	
Wavelength	WL	R*8	mm
GAIN Scan Number	GAINS	R*8	
+ Beam (1)	PBEAM	R*8	arcsec
+ Beam (2)	PBEAM+1	R*8	arcsec
- Beam (1)	MBEAM	R*8	arcsec
- Beam (2)	MBEAM+1	R*8	arcsec
RA/Dec Offsets (1)	SROFF	R*8	arcsec
RA/Dec Offsets (2)	SROFF+1	R*8	arcsec
RA/Dec Offsets (3)	SROFF+2	R*8	arcsec
RA/Dec Offsets (4)	SROFF+3	R*8	arcsec
Frequency switching signal offset	FOFFSIG	R*8	MHz
Frequency switching reference offset 1	FOFFREF1	R*8	MHz
Frequency switching reference offset 2	FOFFREF2	R*8	MHz

Class 10 : Open Parameters (Data Reduction)

Description	Keyword	Size	Units
Open Parameter Values(1)	OPENPAR	C*8	
Open Parameter Values(2)	OPENPAR+1	C*8	
Open Parameter Values(3)	OPENPAR+2	C*8	
Open Parameter Values(4)	OPENPAR+3	C*8	
Open Parameter Values(5)	OPENPAR+4	C*8	
Open Parameter Values(6)	OPENPAR+5	C*8	
Open Parameter Values(7)	OPENPAR+6	C*8	
Open Parameter Values(8)	OPENPAR+7	C*8	
Open Parameter Values(9)	OPENPAR+8	C*8	

Description	Keyword	Size	Units
Open Parameter Values(10)	OPENPAR+9	C*8	

Class 11: Phase Block -- CL11TYPE = "ORIG " or unset -- Original

Description	Keyword	Size	Units
Variable Value	VARVAL	R*8	
Variable Descriptor	VARDES	C*8	
Phase Table	PHASTB	C*8	

Class 11: Phase Block -- CL11TYPE = "PROTO12M" -- 12-m Prototype

Description	Keyword	Size	Units
Number of Fast Switching Variables	NOSWVARF	R*8	
Number of Slow Cycles per Scan	NUMCYC	R*8	
Number of Fast Cycles per Scan	NUMCYCF	R*8	
Number of Fast Phases per Cycle	NOPHASEF	R*8	
Length of Fast Cycle	CYCLENF	R*8	Seconds
Length of Fast Phase Sample	SAMPTIMF	R*8	Seconds
Variable Value nn	VARVALnn	R*8	
Variable Descriptor nn	VARDESnn	C*8	
Phase Table nn	PHASTBnn	C*32	

(last 3 repeat (NOSWVAR+NOSWVARF) times)
(nn is currently limited to 01 through 10)

Class 12 : Descriptor Block for Each Receiver Channel

Description	Keyword	Size	Units
Observed Frequency	OBSFREQ	R*8	MHz
Rest Frequency	RESTFREQ	R*8	MHz
Frequency Resolution or Scale Fcator	FREQRES	R*8	MHz or K/Count
Bandwidth	BW	R*8	MHz
Receiver Temperature	TRX	R*8	K
Calibration Temperature	TCAL	R*8	K
Source System Temperature	STSYS	R*8	K
Reference System Temperature	RTSYS	R*8	K
Source Temperature	TSOURCE	R*8	K
RMS of Mean	TRMS	R*8	K
Reference Point Number	REFPT	R*8	
X Value at the Reference Point	X0	R*8	km/sec or degrees
Delta X	DELTAX	R*8	km/sec degrees
Total Integration Time	INTTIME	R*8	seconds
Number of Integrations	NOINT	R*8	
Starting Point Number	SPN	R*8	
H2O Opacity	TAUH2O	R*8	
H2O Temperature	TH2O	R*8	K
O2 Opacity	TAUO2	R*8	
O2 Temperature	TO2	R*8	K
Polarization	POLARIZ	C*8	
Effective Integration Time	EFFINT	R*8	
Receiver Information	RX_INFO	C*16	

Class 13: Reduction Parameters

Description	Keyword	Size	Units
Number of scans stacked	NOSTAC	R*8	
First Scan in stack	FSCAN	R*8	
Last Scan in stack	LSCAN	R*8	
Line Amplitude	LAMP	R*8	K
Line Width	LWID	R*8	km/sec
Integrated Line Intensity	ILI	R*8	K km/sec
RMS Noise	RMS	R*8	K