

WCSTools 4.0: Building Astrometry and Catalogs into Pipelines

Catalogs

Images

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Supported Catalogs

- Originally, only the HST Guide Star Catalog was supported
- Then extractions from the Digitized Sky Survey were added
- Deep all-sky catalogs have been supported since USNO-A1.0
- Catalogs are supported in their native format through a single API
- `scat`, `imcat`, `imwcs`, and `immatch` use a standard catalog interface

Deep All-Sky Catalogs (for recent epoch CCD images)
USNO-B1.0 Catalog: 1,0366,366,767 stars, 83 Megabytes, send a hard drive to USNO
GSC 2.2, 2.3 Catalog: 998,402,801 stars, >80 Megabytes, accessible over web from STScI
2MASS Point Source Catalog: 470,992,970 stars, 32 Megabytes, ingest from 5 DVDs
USNO-A2.0 Catalog: 526,280,881 stars, 6 Gigabytes, once available on 11 CDs

Astrometric Catalogs (with accurate proper motions)
UCAC2 Catalog 48,366,996 stars, 2 Gigabytes, install over web from CDS
Tycho-2 Catalog: 2,539,913 stars, 529 Megabytes, available on CDROM or from CDS

Photometric Catalogs (with accurate photometry across catalog)
SDSS Photometry Catalog: 53,000,000 sources, accessible over web from SDSS
+ 2MASS PSC + Tycho-2

Wide Field Catalogs (for multi-degree fields with big pixels)
HST Guide Star Catalog: 25,541,952 sources, 1.2 Gigabytes, from 2 CDROMs
PPM Catalog: 378,910 stars with proper motions, 22 Megabytes, available from SAO-TDC
SAO Catalog: 258,996 stars with proper motions, 16 Megabytes, available from SAO-TDC

The WCSTools package was originally developed to create and access world coordinate systems in FITS image headers. In order to do that, programs and subroutines which access, modify, and extract information from FITS image headers and data, extract information from catalogs of sources, and manipulate sky, image, and time coordinates have been developed. Package functionality has always been available at both the subroutine level for developers of other packages, such as `ds9`, and at the scripting level for use in data processing pipelines. On the occasion of a major upgrade to the latest level of Mark Calabretta's WCSLIB library, lesser-known features, such as data and time format conversions and command line name to coordinate resolution will be presented along with demonstrations of the use of WCSTools programs in several different data pipelines.

Image World Coordinate System Utilities

imwcs Match image stars to catalog stars and fit a WCS
immatch Match catalog and image stars using image WCS
imstar Find and list stars in an IRAF or FITS image
sky2xy Print image pixel coordinates for given sky coordinates
xy2sky Print sky coordinates for given image pixel coordinates
wcshead Print basic WCS information for images
imsize Print center and size of image from image WCS
delwcs Delete the WCS keywords from an image

Image Extraction Utilities

getfits Extract portion of a FITS file into a new FITS file, preserving WCS
getpix Return value(s) of specified pixel(s)
imextract Extract 1D file from 2D file or 2D file from 3D file
imstar Find and list stars in an IRAF or FITS image
sumpix Total pixel values in row, column, or specified area

Image Header Utilities

cphead Copy keyword values between images
delhead Delete specified keywords from image file headers
edhead Edit the header of a FITS or IRAF file
gethead Return values for keyword(s) specified after filename
imhead Print FITS or IRAF header
keyhead Change keyword names in image headers
sethead Set header keyword values in FITS or IRAF images

Image Modification Utilities

addpix Add a constant value(s) to specified pixel(s)
conpix Operate on all of the pixels of an image
i2f Read two-dimensional IRAF image file, write FITS image file
imrot Rotate and/or reflect FITS or IRAF image files
imstack Stack 1-dimensional images into a 2-dimensional image
newfits Create blank FITS files (dataless by default with BITPIX=0)
remap Rebin an image from its current WCS to a new one
setpix Set specified pixel(s) to specified value(s)
fixpix Replace regions of bad pixels with interpolated values
subpix Subtract a constant value(s) from specified pixel(s)

Catalog Utilities

imcat List catalog sources in area of the sky covered by an image.
immatch Match catalog and image stars using WCS in image header
scat Search a source catalog given a region on the sky

Miscellaneous Useful Utilities

char2sp Replace this character with spaces in output (default=_)
crlf Change CR's to newlines in text file (for logs)
filename Drop directory from pathname, if present
fileroot Drop file name extension, if present
getdate Convert between two date formats
gettab Extract values from tab table data base files
httpget Send contents returned from URL to standard output
isnum Return 1 if argument is an integer, 2 if floating point, else 0
isrange Return 1 if argument is a range of the format n1[-n2[xs]],...
nedpos Return position of named object from NED
simpos Return position of named object from SIMBAD
skycoor Convert between sky coordinate systems
sp2char Replace space in string with specified character

Image Extraction

A portion of a large FITS image can be extracted with an intact world coordinate system and a second WCS pointing to the original pixels.

```
> getfits mc00380r270w.fits `nedpos m44` 1000 1000
mc00380r270wa.fits
```

```
SIMPLE = T
BITPIX = 16
NAXIS = 2
NAXIS1 = 1000
NAXIS2 = 1000
WCSNAME = 'PLATE'
CRPIX1 = 'PIXEL'
CRPIX2 = 'PIXEL'
CRVAL1 = -3798
CRVAL2 = 1
CDELT1 = 1
CDELT2 = 1
CTYPE1 = 'PIXEL'
CTYPE2 = 'PIXEL'
CUNIT1 = 'pixels'
CUNIT2 = 'pixels'
HISTORY 'TZP 3.3.0 2004-06-24T17:18'
HISTORY 'Copy of image mc00380.fits'
DATE-OBS = '1910-06-23T00:00'
CRVAL1 = 129.136370755
CRVAL2 = 19.72793105
NSA = '08:35:52.457'
MJD = '+19:49:134.80'
NPOX = 2000
NQUAD = 2000
RADECSYS = 'FK4'
CRPIX1 = 910.54
CRPIX2 = 362.78
CTYPE1 = 'RA---TAN'
CTYPE2 = 'DEC--TAN'
CD1_1 = -0.000548642906
CD1_2 = -0.000004732716
CD2_1 = -0.00000340255
CD2_2 = 0.000548290586
WCSNAME = 'ppm'
WCSNAME = 'mc00380r270_wcs'
WCSNAME = 'ppm'
WCSNAME = 'mc00380r270_wcs'
WCSNAME = 'ppm'
WCSNAME = 'mc00380r270_wcs'
RA = '08:36:32.729'
DEC = '+19:46:22.06'
EQUINOX = 1950
SOLAR_ANG = 1.9752
SRCTYPE = 1.9739
WCSNAME = '1.945'
EPOCH = 1950
HISTORY 'GETFITS WCSTools 3.6.3 2005-09-30T17:24'
```

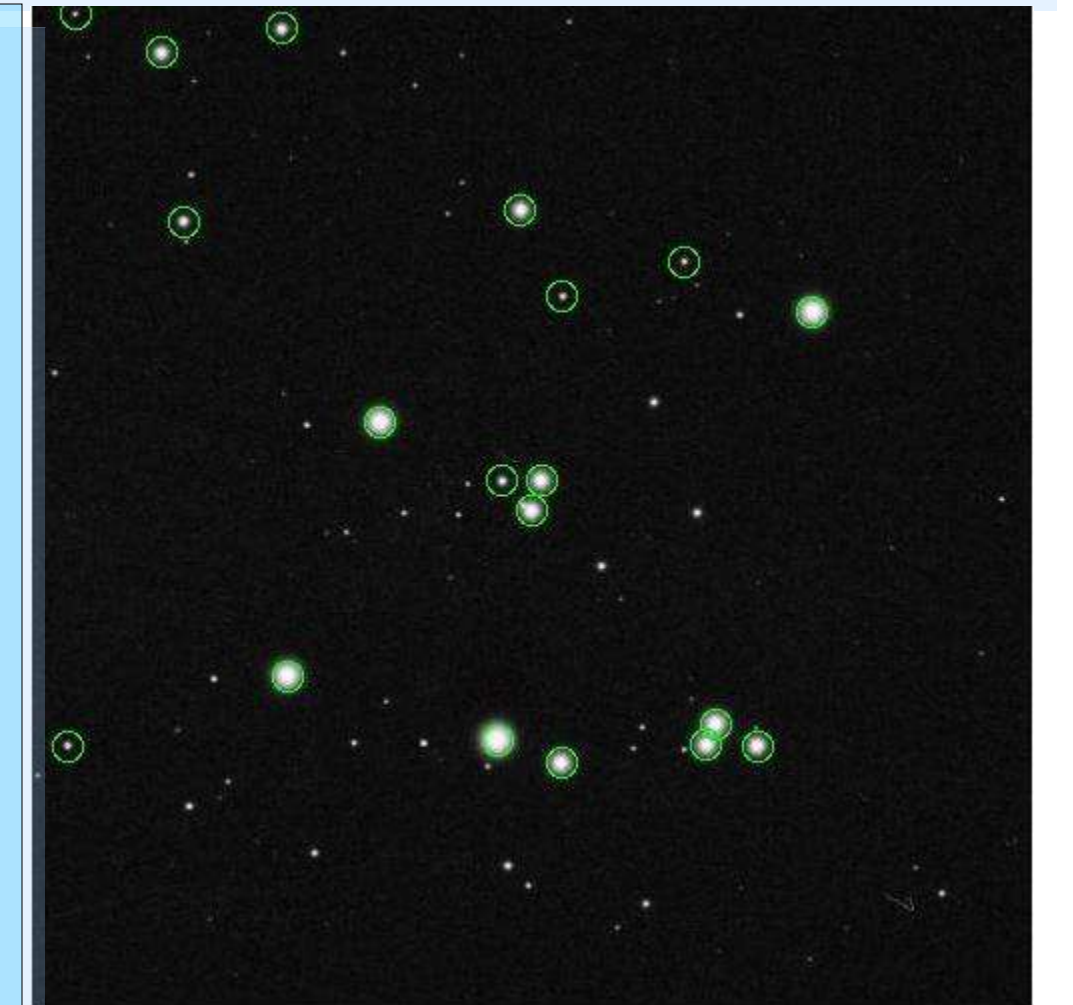
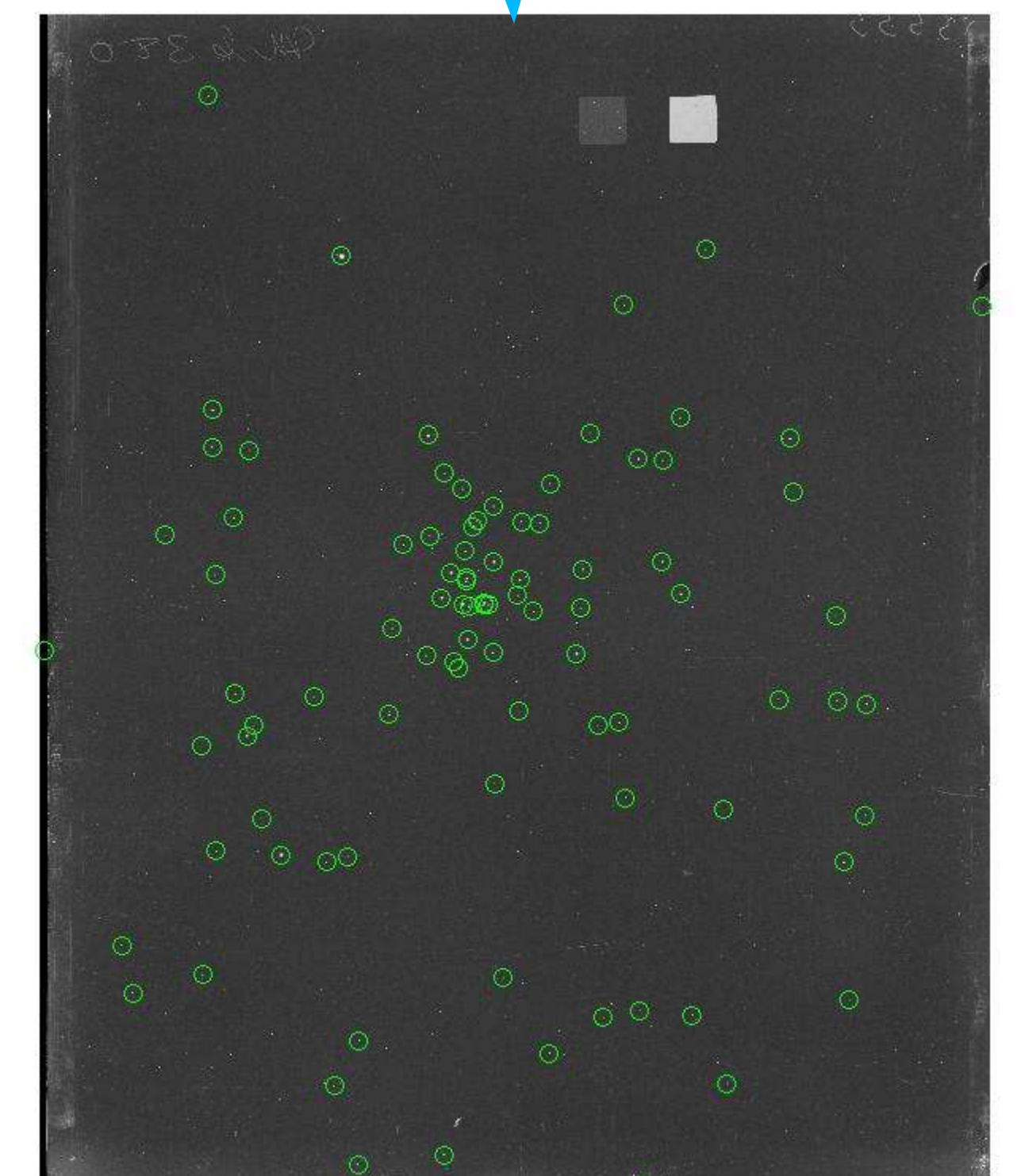


Image Rotation

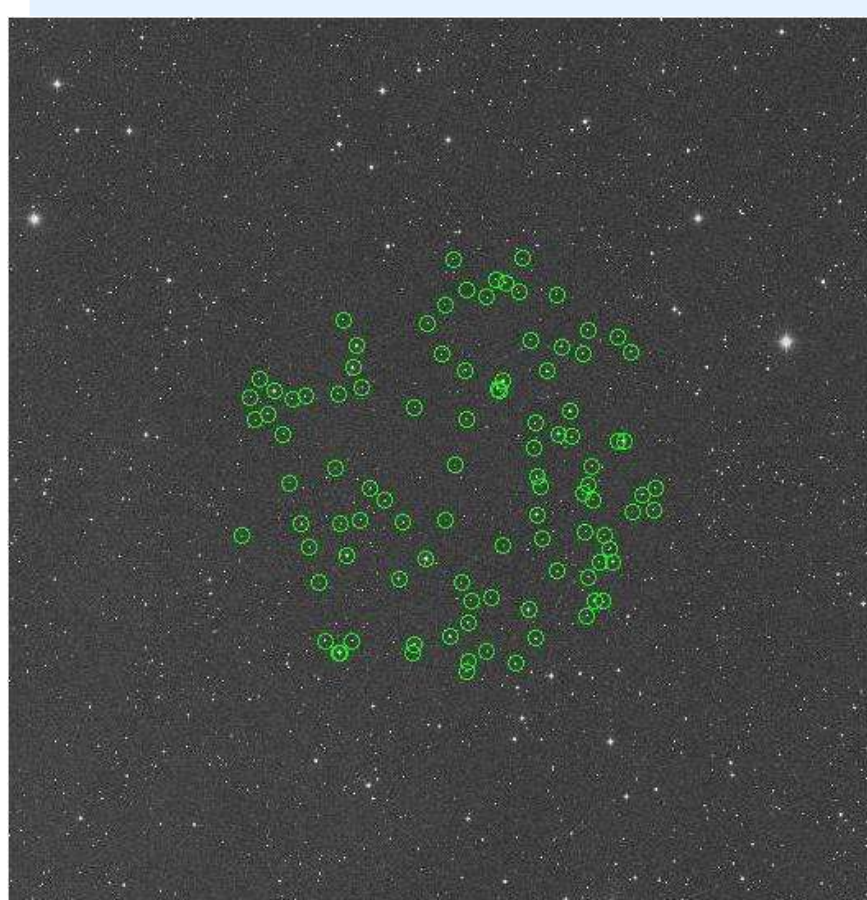
Image can be rotated any multiple of 90 degrees and/or reflected about either axis.

```
> imrot -r 270 mc00380.fits
```

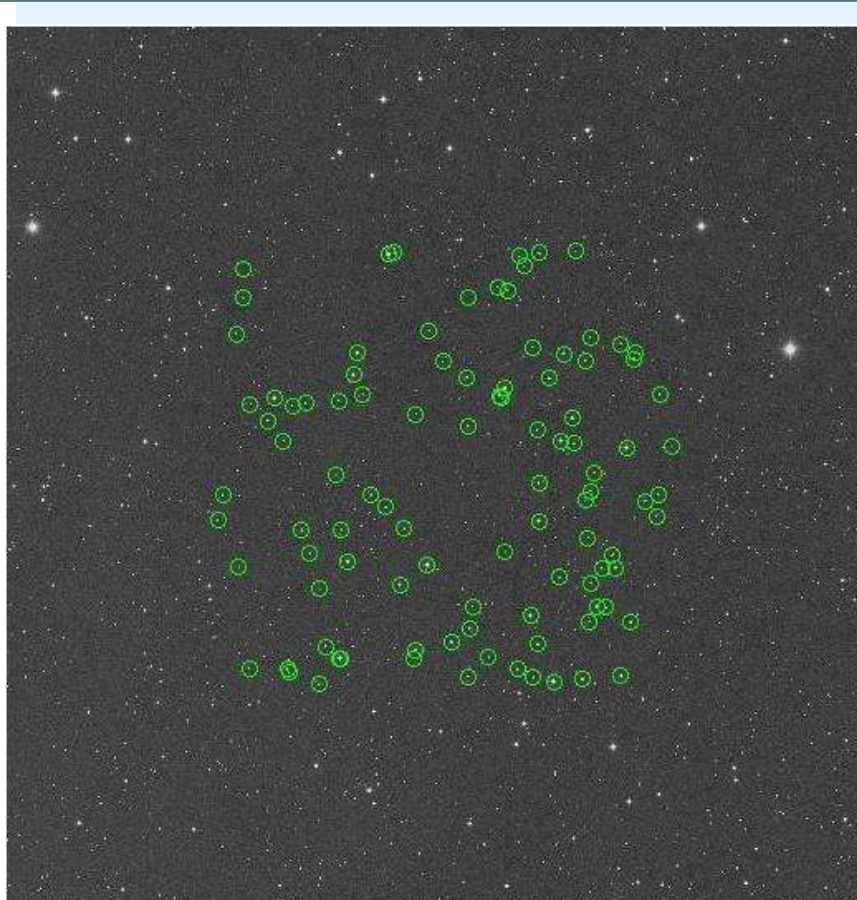


Catalog Search Options

Circle on the sky
center and radius specified
> subl -tn 10000 -r 900 10:00 85:00 J2000



Square on the sky
center and half-side specified
> subl -tn 10000 -r -900 10:00 85:00 J2000



Rectangle in coordinates
center and half-sides specified
subl -tn 10000 -rz 900,900 10:00 85:00 J2000

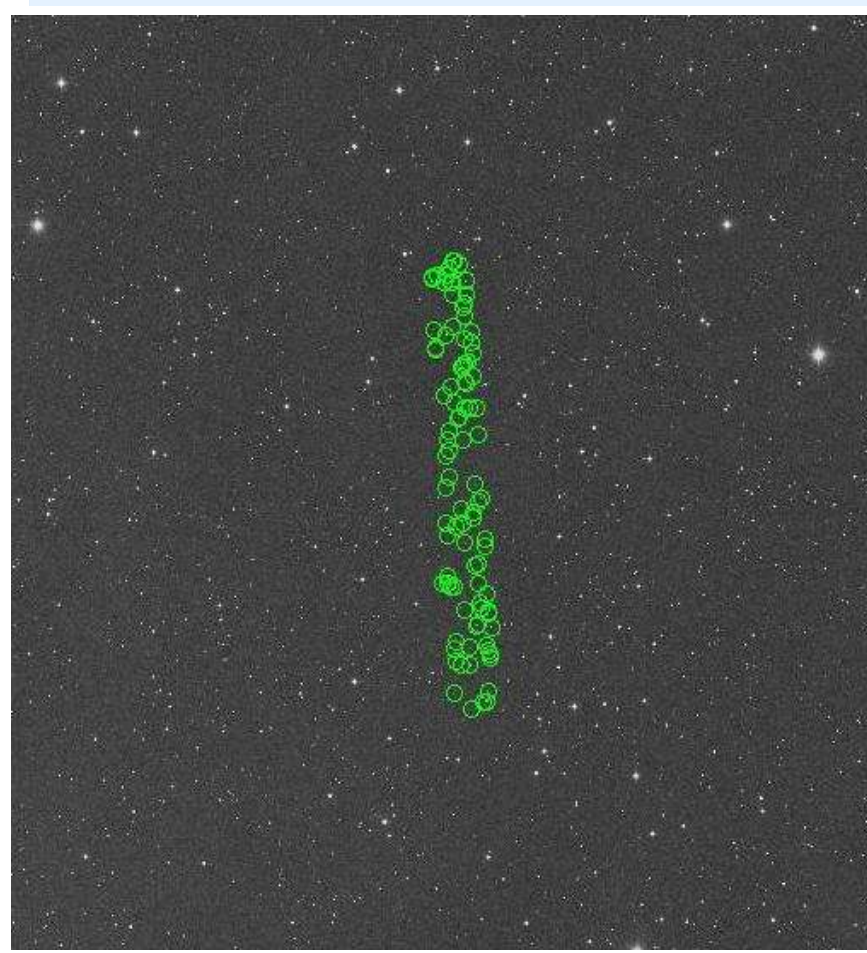
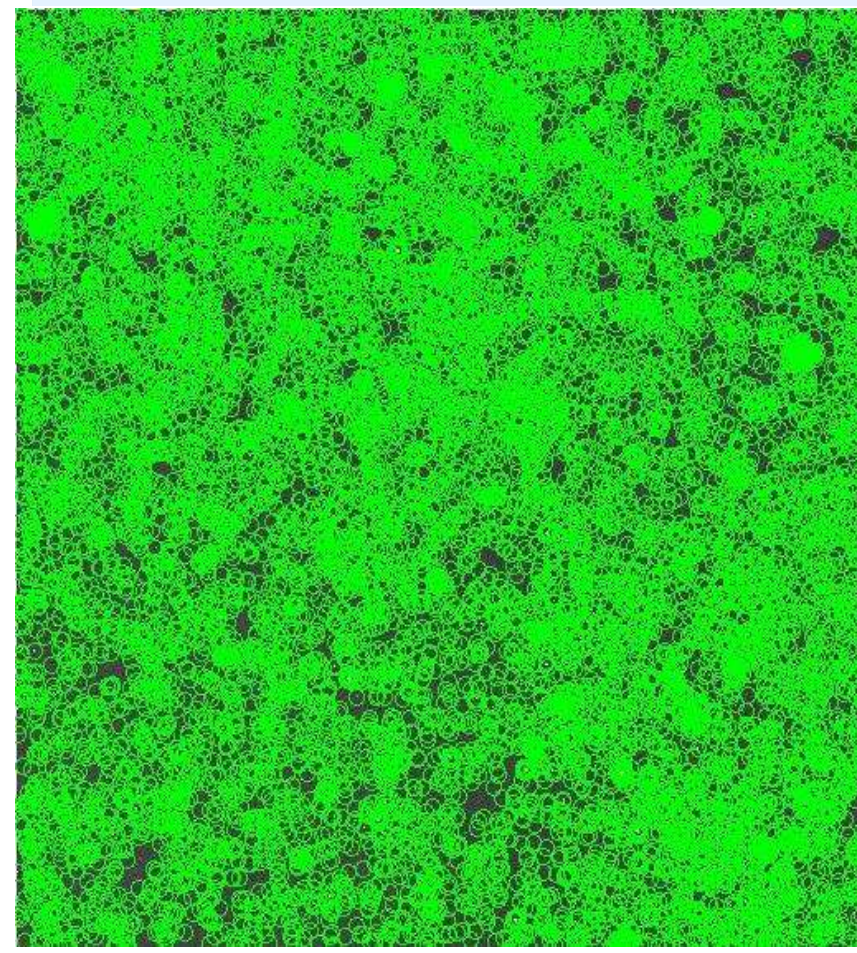


Image on sky using FITS WCS
to specify region of coverage
> imubl -n 30000 -q o -r 30 ds85.fits
makes a region file for ds9



Command Line Object Coordinates

- Query either NED or SIMBAD

```
> nedpos m44
08:40:22.198 +19:40:19.43
> simpos m44
08:40:24.000 +19:41:00.00 J2000
```

- WCSTools coordinate conversion and formatting

```
> nedpos -g m44
205.910635 +32.479519 Galactic
> simpos -e m44
127.346995 +1.291450 Ecliptic
```

WCSTools Email Lists

WCSTools 4.0 is still being debugged. To keep users informed as to the status of the package, two email lists have been created:

wcstools-announce will be used only for software update announcements

wcstools will allow users to help each other and let me know what features need more work or more documentation.

To subscribe, email majordomo@cfa.harvard.edu with

subscribe wcstools and/or subscribe wcstools-announce
in the body of the message.

Time Manipulation

- Current time to FITS ISO time

```
> getdate now2fd
2005-09-30T17:49:53.000
```
- Current time to Julian Date

```
> getdate now2jd
2453644.24304
```
- FITS ISO time to Julian Date

```
> getdate fd2jd 2005-09-30T17:49:53.000
2453644.24297
```
- FITS ISO time to Modified Julian Date

```
> getdate fd2mjd 2005-09-30T17:49:53
53643.74297
```



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