ADASS XV in Spain: The Old Systems Are Dying. Will They Be Reborn in the Virtual Observatory?

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San Lorenzo de El Escorial

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Rafael Leon for ADASS XV

San Lorenzo de El Escorial

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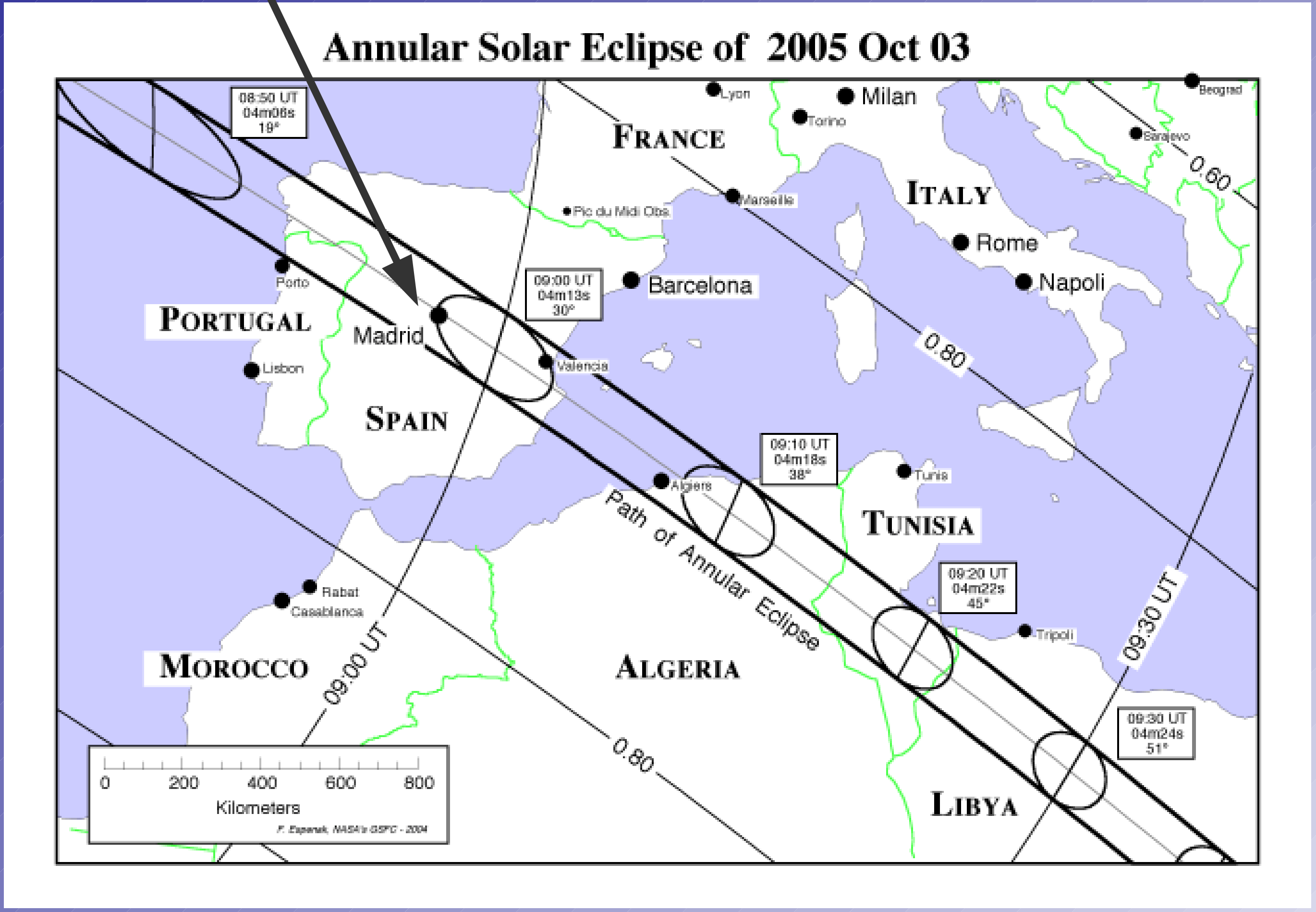
Astronomical Data Analysis Software and Systems

- Annular Solar Eclipse!
- Old Software systems are losing support
- Scripting and API's are being talked about
- FITS standards moving ahead faster
- Virtual Observatory Update
- Components for scripting
  -> My WCSTools paper
- My To Do List

Annular Eclipse

San Lorenzo de El Escorial was 8 km from center line



Annular Eclipse

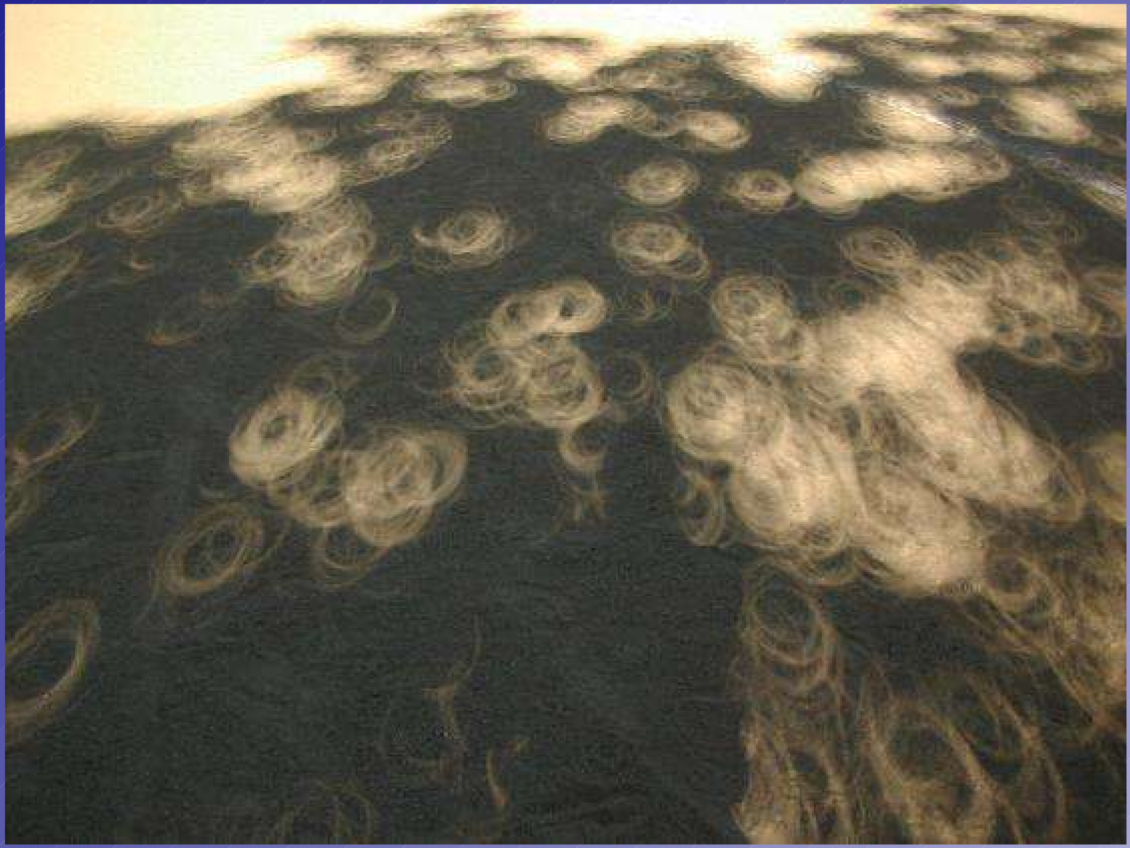
After a welcome and the first invited talk on eclipse chasing by Glenn Williams of the University of Arizona, we all went out to a nearby soccer field to watch the event

Annular Eclipse

You don't need much equipment to observe the sun

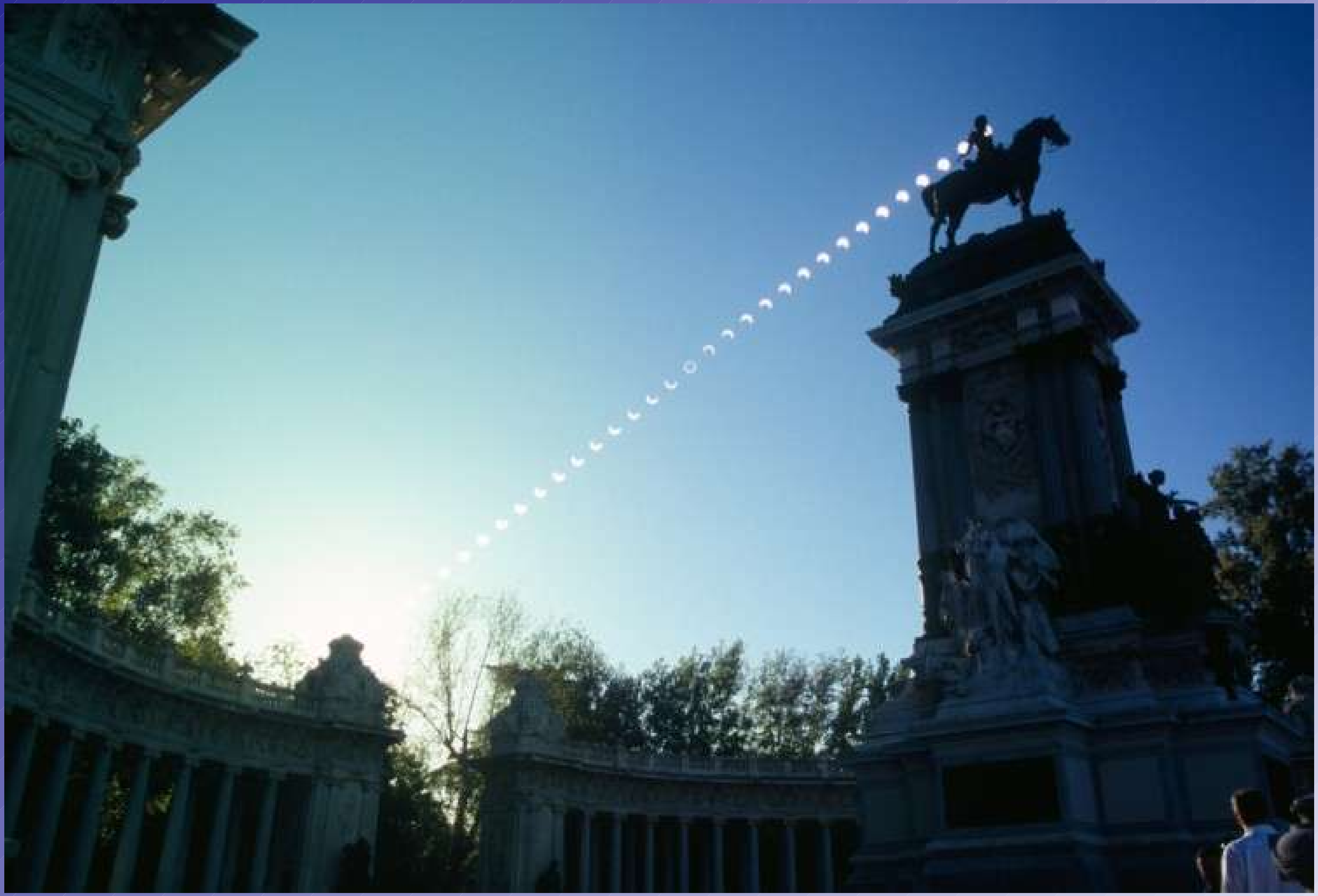
Annular Eclipse

Nature projects the event for you



Annular Eclipse

Eclipse sequence above Alfonso XII monument in Madrid



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The Setting

In the past few years, support for the major data analysis systems has declined

- Starlink in England is no longer supported
- MIDAS in continental Europe is no longer supported
- IRAF development is pretty much on hold
- NRAO development has moved from AIPS to ALMA
- Will each project develop only for themselves?

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A Proposal

Since 1995, there has been a Birds of a Feather meeting at ADASS entitled Future Astronomical Data Systems.
It started as sort of an outsider event, but this year the convenors were Doug Tody (NRAO and NVO) and Preben Grosbol (ESO and Opticon)

The European Opticon Network is working with the US NVO to define requirements, general architecture, and interface specifications for a new system which

- Runs on a desktop
- Can run pipeline scripts
- Works with the Virtual Observatory
- Has an open architecture
- Works at all wavelengths
- Is user-programmable
- Is scalable

An Earlier Proposal

From Joe Harrington in 1996:

Ideally, we should all be able to make use of the same analysis, display, and plotting routines. I'll take it a step further and say we should even be able to call routines written by each other in different scripting languages. The idea would be that the system core ... would take care of managing the objects and connecting to dynamically linked modules, including those that handle interpreting the different languages, plotting, etc.

Reality

More than ever, the astronomical community is converging on Python as its scripting language (despite this year's new, improved IRAF ECL and the suggestion from the audience of IDL)

To avoid reinventing the wheel, interfaces to the legacy data analysis systems are being developed

- Pyraf for IRAF at STScI (and PyFITS, too)
- PyMidas at ESO (as Finnish contribution
- ParselTongue for AIPS by RadioNet
  (part of the ALBUS project)
- PyWCS at the CfA?

This Year's Cool Software

- **R** statistical computing package
  tutorial before meeting, widely-used, extensible

- **SkyBot** web service to find asteroids
  returns all asteroids in field of view from1949

- **SCAMP** automatic photometric and astrometric calibration from Emmanuel Bertin (Sextractor)

- Others?

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FITS

- FITS MIME types have been approved by IESG
- 64-bit integers have almost been added to standard
- Spectral coordinates paper III has been approved
- Mark Calabretta promises to get back to Paper IV on distortion
- Arnold Rots has promised a draft outline of Paper V on time coordinates by the end of 2005. He is doing similar work for the IVOA
- Mark Calabretta is starting to think about Paper VI on color

Virtual Observatory

- 1/3 of ADASS papers mention VO explicitly; ½ – 2/3 have connection - Bob Hanisch
- In the US, there will be a central NVO facility to manage ongoing US VO operations, curate registries, and serve as the equivalent to an observatory staff
- In Europe, AVO is becoming Euro-VO with its own center, Euro-VO Technolgy Centre
- ESO, which has one of the largest pipeline-reduced archives, has dedicated staff to putting it into the VO

IVOA Interop

- Protocols are evolving and becoming more useful
- There are new applications and old ones support protocols
- Theoretical data is being incorporated into the VO
- VOEvent uses protocols for near-real-time observation coordination
- Most, but not all, applications are still catalog matching

IVOA Interop

Protocols are evolving

- Simple Spectral Access Protocol (SSAP)
  Moving beyond SEDs: non-photometric spectra are mentioned

- Spectral Line Access Protocol (SLAP)
  New protocol to store catalogs of line positions (to match observation and theory)

- Simple Image Access Protocol (SIAP)
  a new version is being prepared

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IVOA Interop

The application session was interesting:

Isa Barbarisi	New functionalities in VOSpec : Spectral Line Access & Theoretical Models
Raúl Gutiérrez	VOSed: a tool for building spectral energy distributions Comparison with theoretical models
Claudio Gheller	VisIVO interoperability with VO enabled tools
Pierre Fernique	Experience gained by enabling Interoperability in Aladin
Francesco Pierfederici	**Python** Tools for the VO Generation
Noel Winstanley	ACR - a VO Client Implementation
John Taylor	VO- enabled xmdv- lite and Plastic

WCSTools 4.0: Building Astrometry and Catalogs into Pipelines

by Douglas Mink

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http://tdc-www.harvard.edu/software/wcstools/

Abstract

While the WCSTools package was developed to deal with world coordinate systems in FITS image headers, it does a lot more.

- Source catalog extraction and manipulation
- Command line name resolution
- Time and space coordinate conversion
- FITS and IRAF image manipulation

Documentation is at http://tdc-www.harvard.edu/software/wcstools/

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Supported Catalogs

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

Supported Catalogs

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, 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

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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

Supported Catalogs

Photmetric Catalogs (accurate photometry across catalog)

- **SDSS Photometry Catalog:** 53,000,000 sources, accessible over web from SDSS
- **2MASS Point Source Catalog:** 470,992,970 stars, 32 Megabytes, ingest from 5 DVDs
- **Tycho-2 Catalog:** 2,539,913 stars, 529 Megabytes, available on CDROM or from CDS

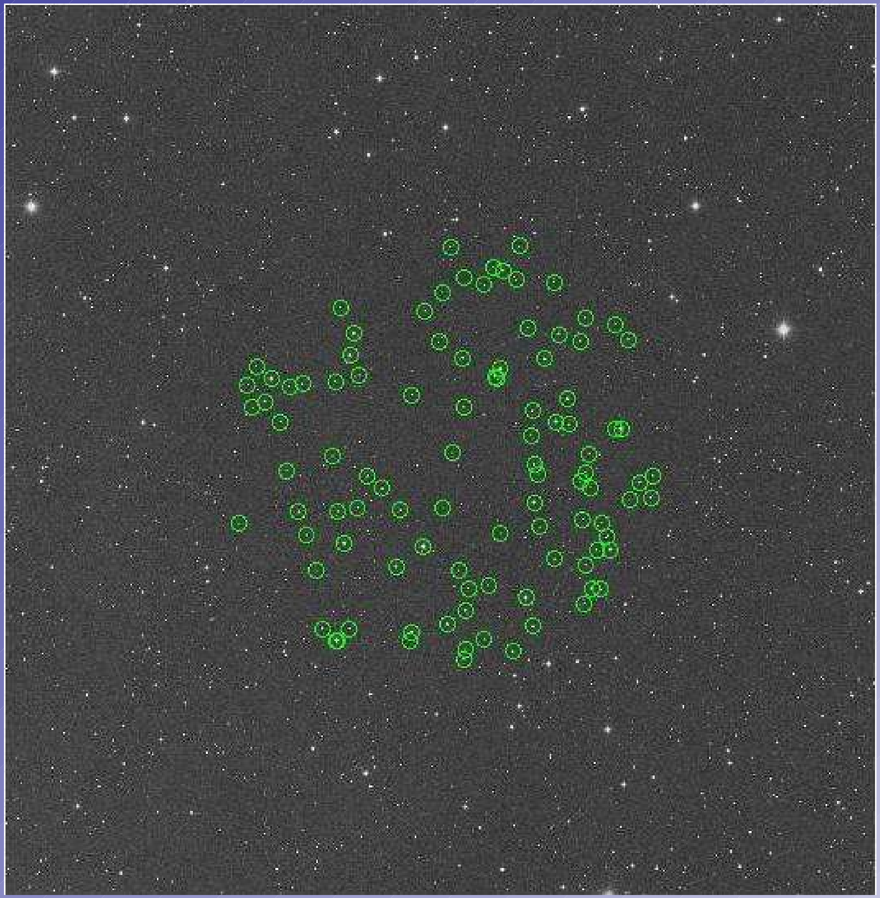
Wide Field Catalogs (reasonably complete at bright end)

- **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

Catalog Search Options

Circle on the sky, center and radius specified

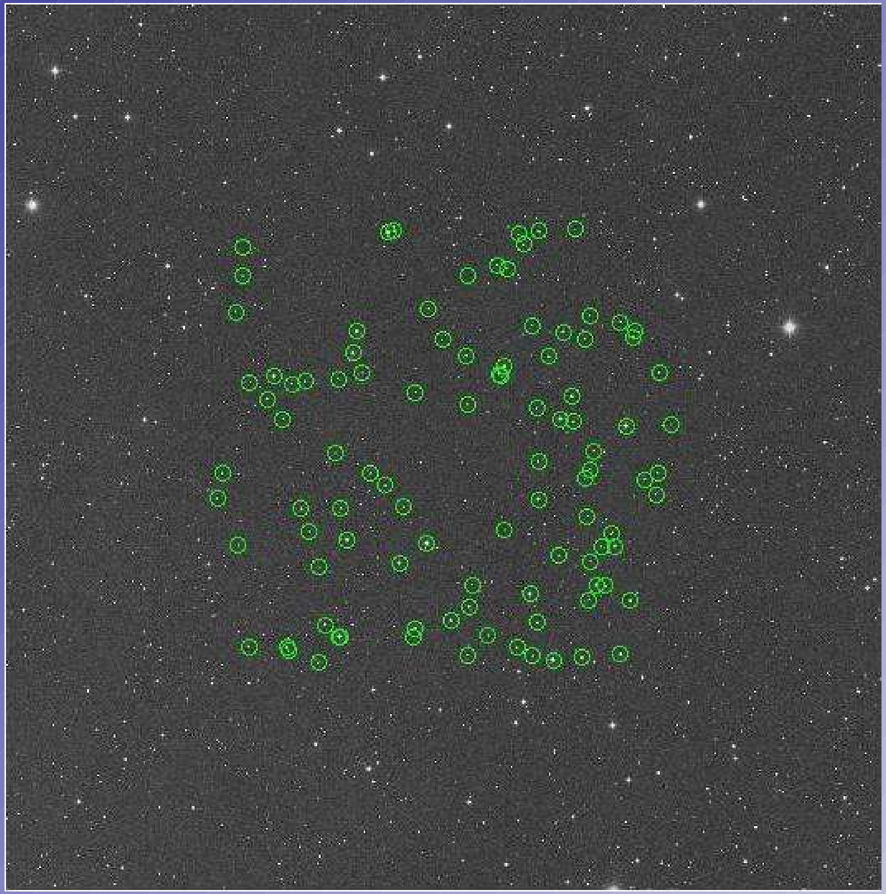
```
> scat -c ub1 -tn 10000 -r 900 10:00 85:00 J2000
```



Catalog Search Options

Square on the sky, center and half-side specified

```
> sub1 -tn 10000 -r -900 10:00 85:00 J2000
```



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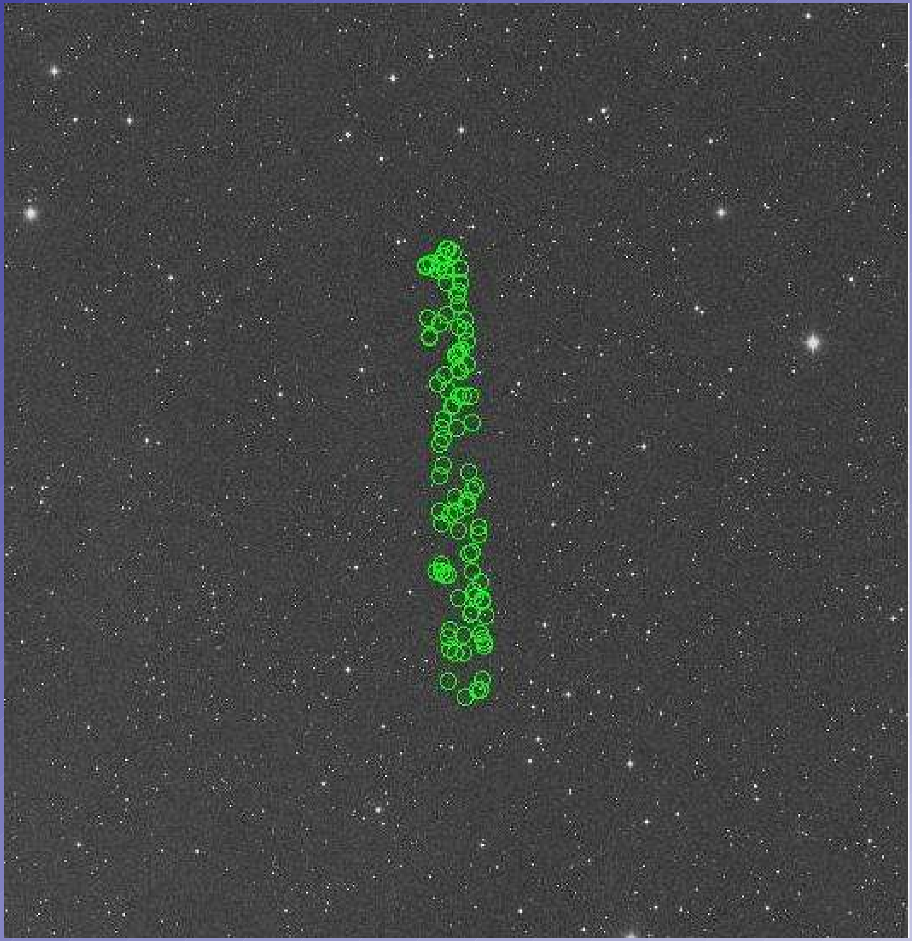
Catalog Search Options

Rectangle in coordinates, center and half-sides specified

```
> sub1 -tn 10000 -rr 900,900 10:00 85:00 J2000
```

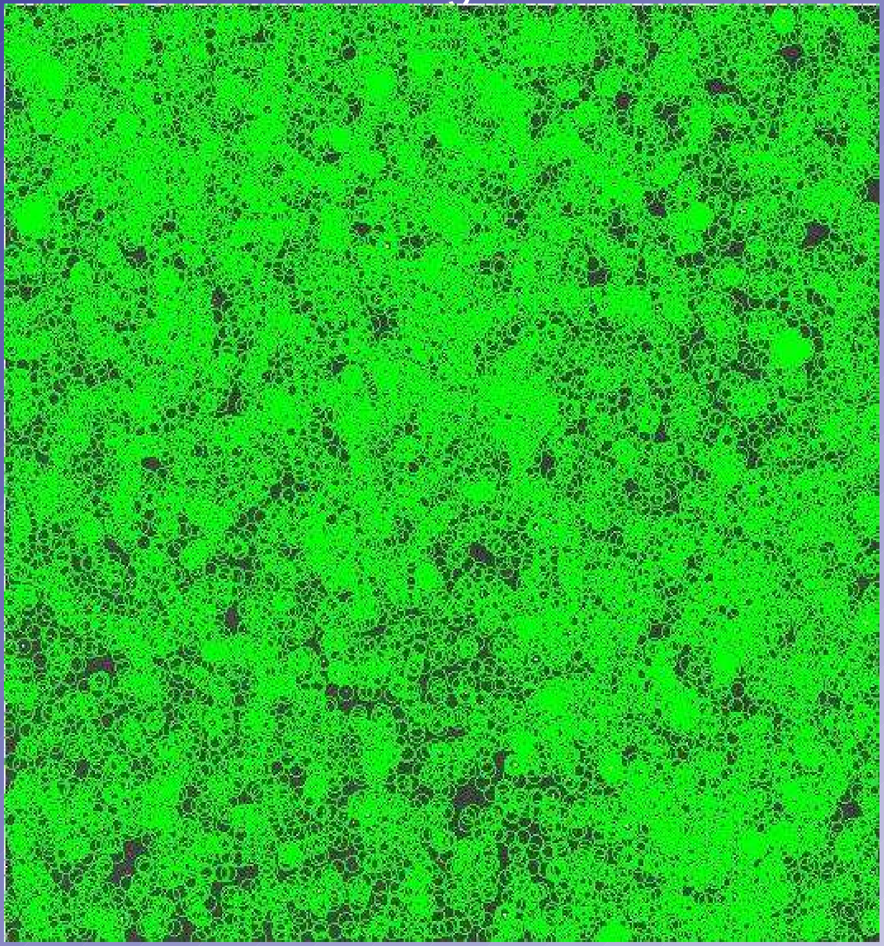


Catalog Search Options

Image on sky using FITS WCS to specify region of coverage

```
> imub1 -n 30000 -q o -r 30 dss85.fits
```

makes a region file for ds9



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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
```

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Coordinate Manipulation

- **J2000 to Galactic**

```
> skycoor -g 10:00 10:00 J2000
227.54286  46.19107 galactic
```

- **J2000 to Ecliptic**

```
> skycoor -e 10:00 10:00 J2000
148.58768  -2.09451 ecliptic
```

- **J2000 to B1950**

```
> skycoor -b 10:00 10:00 J2000
09:57:20.232 +10:14:24.99 B1950
```

- **J2000 degrees to hours, minutes, seconds**

```
> skycoor -j 150.0 10.0 J2000
10:00:00.000 +10:00:00.00 J2000
```

- **Angular separation (in arcseconds)**

```
> skycoor -r 10:00 10:00 09:57 10:14
2787.590
```

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
```

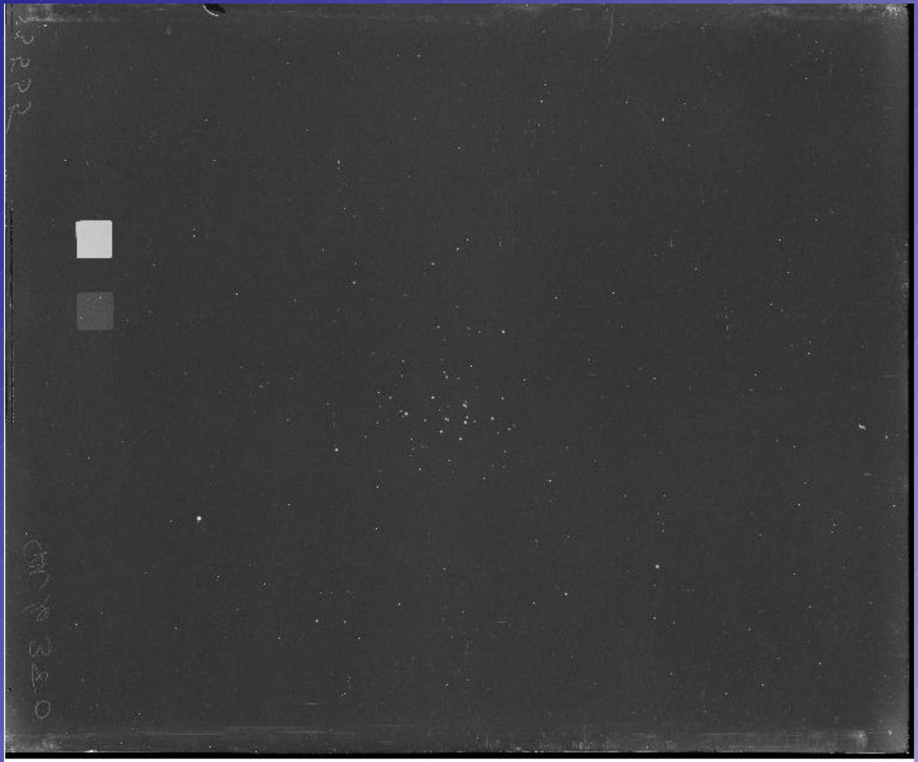
- **FITS ISO time to Modified Julian Date**

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

Image Rotation

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

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



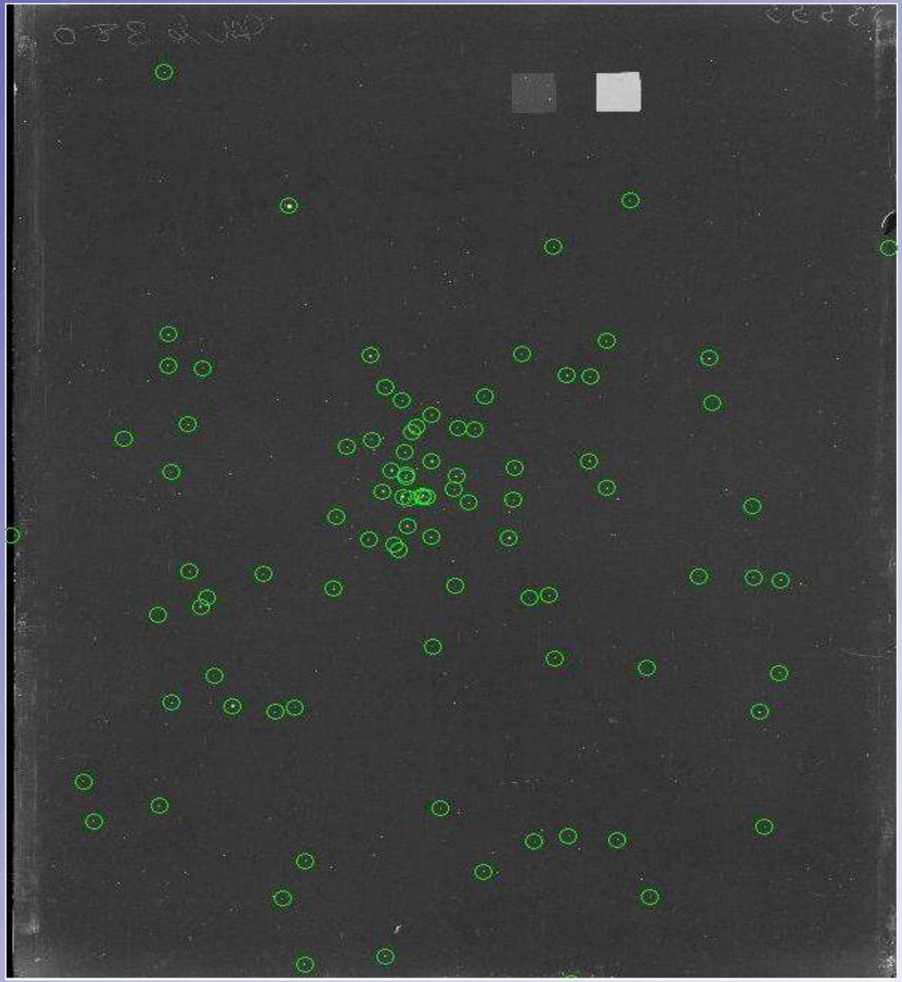


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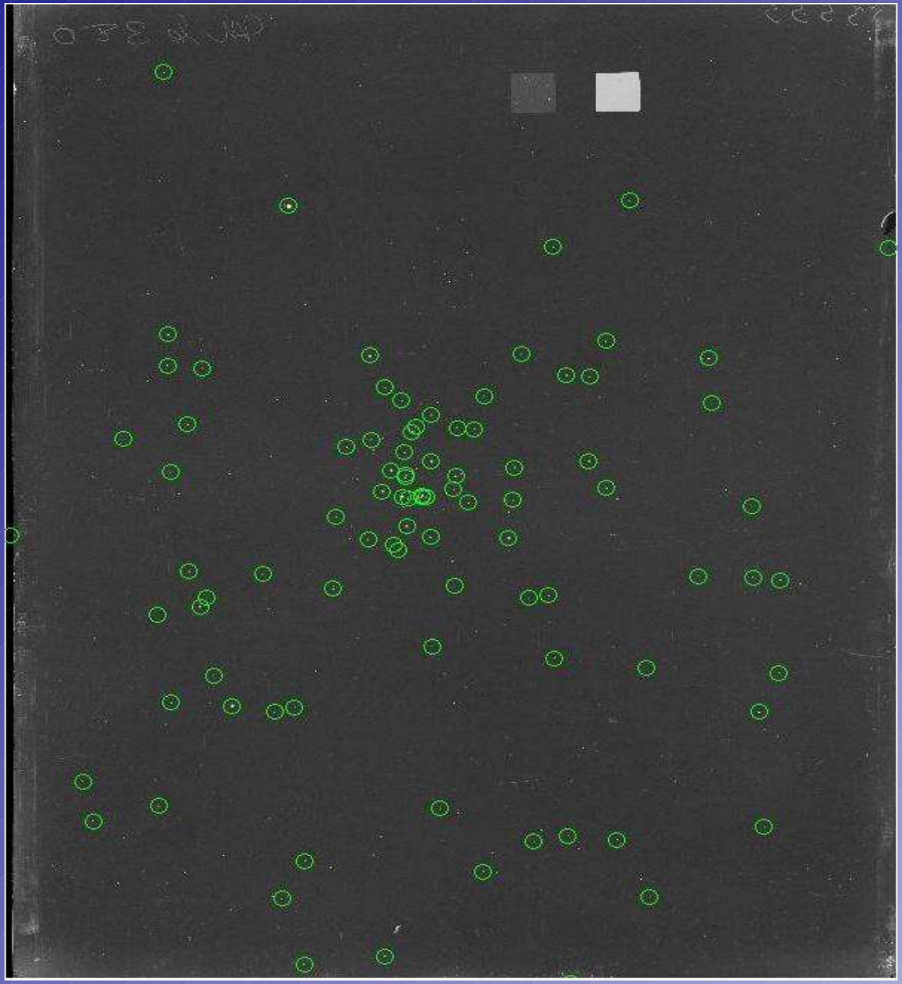
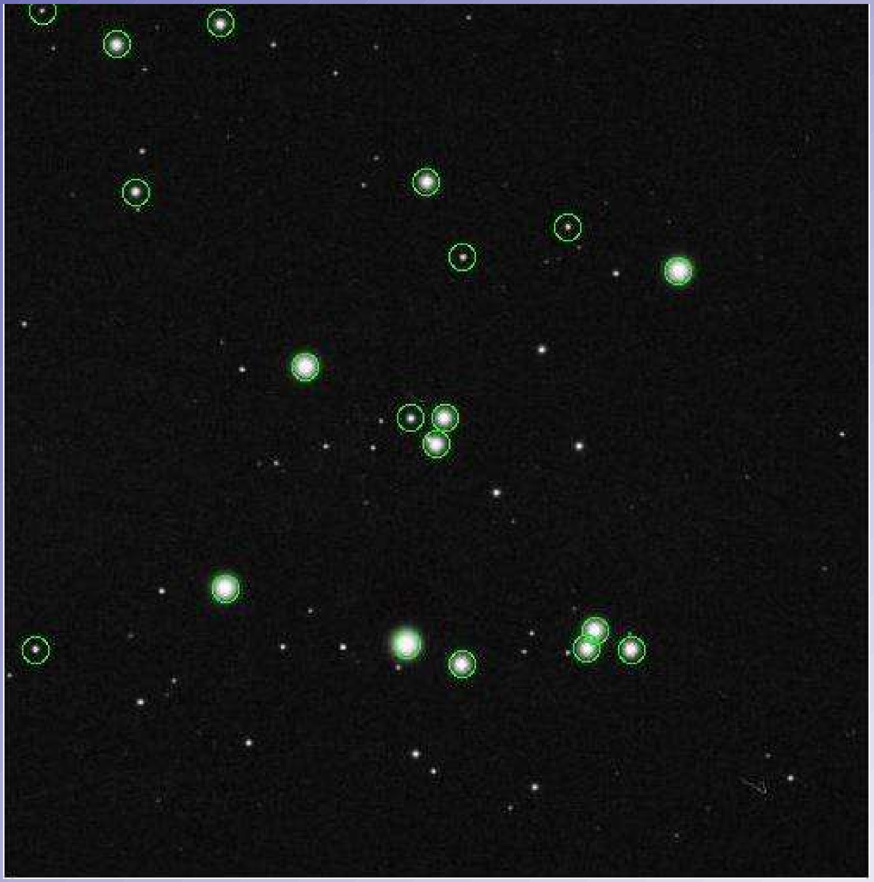
Image Extraction

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
```





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ADASS 2005-10-20

Image Extraction

The header of the extracted FITS file contains a world coordinate system which references any pixel to the corresponding pixel in the original image

```
SIMPLE  =                    T
BITPIX  =                   16
NAXIS   =                    2
NAXIS1  =                 1000
NAXIS2  =                 1000
WCSNAMEP= 'PLATE   '
CTYPE1P = 'PIXEL   '
CRPIX1P =                -3798
CRVAL1P =                    1
CDELT1P =                    1
CTYPE2P = 'PIXEL   '
CRPIX2P =                -5651
CRVAL2P =                    1
CDELT2P =                    1
HISTORY  T2F 3.3.0 2004-06-24T17:18
HISTORY  Copy of image mc00380.fits
DATE-OBS= '1910-04-28T0:00'
CRVAL1  =        129.136370755
CRVAL2  =         19.772793105
WRA     = '08:35:52.657'
WDEC    = '+19:49:34.80'
WEPOCH  =                 2000
WEQUINOX=                 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   =       -0.000005340255
CD2_2   =        0.000548290586
WCSRFCAT= 'ppm     '
WCSIMCAT= 'mc00380r270.sex'
WCSMATCH=                   90
WCSNREF =                  100
WCSTOL  =              10.0000
RA      = '08:36:32.729'
DEC     = '+19:46:22.06'
EQUINOX =                 1950
SECPIX1 =               1.9752
SECPIX2 =               1.9739
WCSSEP  =                3.945
EPOCH   =                 1950
HISTORY  GETFITS WCSTools 3.6.3 2005-09-30T17:24
```

Image Distortion

A FITS-WCS standard for distortion is on its way, but in the mean time, the Spitzer Space Telescope needed to put distortion coefficients in image headers, so they used a snapshot of the developing standard.

```
CTYPE1  = 'RA---TAN-SIP'        / RA---TAN with distortion in pixel space
CTYPE2  = 'DEC--TAN-SIP'        / DEC--TAN with distortion in pixel space
CRPIX1  =             128.5000  / Reference pixel along axis 1
CRPIX2  =             128.5000  / Reference pixel along axis 2
CRVAL1  =        324.025314317  / [deg] RA at CRPIX1,CRPIX2 averaged over DCE
CRVAL2  =         56.870353364  / [deg] DEC at CRPIX1,CRPIX2 averaged over DCE
CD1_1   =       0.000182402127
CD1_2   =       0.000286039417
CD2_1   =       0.000286039417
CD2_2   =      -0.000182402127
A_ORDER =                    2 / polynomial order, axis 1, detector to sky
A_0_2   =         -1.263000E-5 / distortion coefficient
A_1_1   =         -2.603000E-5 / distortion coefficient
A_2_0   =          2.771000E-5 / distortion coefficient
A_DMAX  =                0.684 / [pixel] maximum correction
B_ORDER =                    2 / polynomial order, axis 2, detector to sky
B_0_2   =          4.940000E-8 / distortion coefficient
B_1_1   =          2.015000E-5 / distortion coefficient
B_2_0   =         -4.806000E-6 / distortion coefficient
B_DMAX  =                0.415 / [pixel] maximum correction
AP_ORDER=                    2 / polynomial order, axis 1, sky to detector
AP_0_1  =         -1.100000E-6 / distortion coefficient
AP_0_2  =          1.263000E-5 / distortion coefficient
AP_1_0  =          1.374000E-5 / distortion coefficient
AP_1_1  =          2.603000E-5 / distortion coefficient
AP_2_0  =         -2.771000E-5 / distortion coefficient
BP_ORDER=                    2 / polynomial order, axis 2, sky to detector
BP_0_1  =          4.199000E-6 / distortion coefficient
BP_0_2  =         -4.947000E-8 / distortion coefficient
BP_1_0  =         -5.882000E-6 / distortion coefficient
BP_1_1  =         -2.015000E-5 / distortion coefficient
BP_2_0  =          4.806000E-6 / distortion coefficient
```

Remapping an Image

Pixels can be remapped from any projection WCSTools supports, including distortion, into a more standard projection such as plane tangent .

WCSTools Email Lists

WCSTools 4.0 is still being debugged.

To keep users informed about the status of the package, two email lists have been created:

- ***wcstools-announce*** will only announce software updates
- ***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 one of the following in the body of the message:

- subscribe wcstools
- subscribe wcstools-announce

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Doug's To Do Lists

Last year:

- WCSTools: **Set up user mailing list**
  Upgrade to WCSLIB 3.6
  Add XML/VOTable parser to catalog search
- Archives: Add last two years of FAST calibration data
  Start setting up access to data by program
- VO: Set up registry in a box for TDC archives

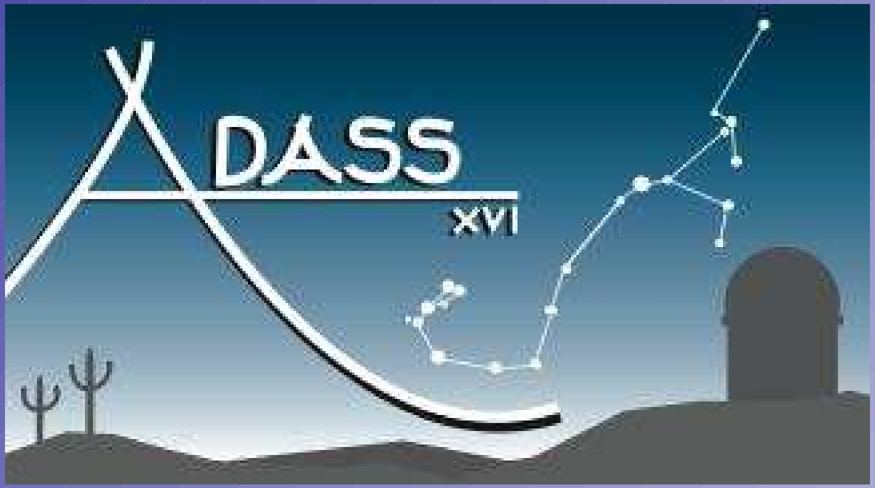
This year:

- WCSTools: Finish debugging version 4.0
  Sign up users for mailing list
- Archives: Write code to translate DEEP spectra format
  Put first 10 years of FAST spectra online
- Scripting: Learn Python and R
  Write WCSTools Python package

Astronomical Data Analysis Software & Systems XVI

October 15-18, 2006

Tucson, Arizona, USA



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