Astronomy Visualisation Metadata Tagging Methods

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1 Executive summary

Below are some (very) detailed descriptions of most aspects of the WCS AVM metadata tagging. Possibly most of this can be ignored, but may serve as background information. In simple terms the process is as follows:

1. The final PR image tiff file (original size) to be tagged is identified (via a dynamic query in Djangoplicity: https://www.eso.org/public/djangoplicity/admin/customsearch/customsearch/136/search/ (click edit)
2. The corresponding FITS file (containing the WCS information) is located typically via a link: https://www.eso.org/public/outreach/internal/pressreleases/2014/ (replace the year)
3. Match up the stars in the PR image and the FITS file in PinPoint (or use Astrometry.net)
4. Extract WCS coordinates
5. Transform coordinates to the needed AVM standard
6. Add coordinates in Djangoplicity
7. Check the result (for instance in WWT on the online page for the PR image (example: https://www.eso.org/public/images/eso1250a/)

Do the easiest ones first. Let's discuss the harder cases (contact: Olivier Hainaut, ohainaut@eso.org).

2 Astronomy Visualisation Metadata

2.1 Overview

The astronomical education and public outreach (EPO) community plays a vital role in conveying the results of scientific research to the general public. A key product of EPO development is a variety of non-scientific public image resources; both derived from scientific observations and created as artistic visualisations of scientific results. This refers to general image formats such as JPEG, TIFF, PNG, GIF, not scientific FITS datasets. Such resources are currently scattered across the internet in a variety of galleries and archives, but are not searchable in any coherent or unified way.

The primary focus of this document is on print-ready and screen ready astronomical imagery that has been rendered from telescopic observations (also known as “pretty pictures”). Such images can combine data acquired at different wavebands and from different observatories. While the primary intent is to cover data-derived astronomical images, there are broader uses as well. Specifically, the most general subset of this schema is also appropriate for describing artwork and illustrations of astronomical subject matter.

The intended users of astronomical imagery cover a broad variety of fields: educators, students, journalists, enthusiasts, and scientists. The core set of required tags defines the key elements needed in a practical database for the identification of desired resources. For example, one might choose to search for images of the Crab Nebula that include both infrared and visible light elements, or for any images within two degrees of a specified location on the sky that include at least some data from the Chandra X-ray Observatory.

The metadata used to characterize an image are only useful if they remain easily associated with the image for all users. Once an image is separated from its source web page, any contextual information is generally lost, including, most importantly, the original source of the image.

The AVM standard therefore encompasses not only the span of metadata tags, but an implementation for embedding these tags directly within the image file itself. This keeps the metadata available even for “loose” images.

The advantages of embedded image identity metadata are numerous. Including metadata effectively makes the images self-documenting, which is particularly useful when the source URL for an image is lost. This information can now be accessed by multimedia management packages, or indexed by databases designed to read the embedded information. For instance, an online or desktop planetarium program could load an image from the web and extract the appropriate metadata to place it in the proper position in the sky.

Many observatories have adopted the AVM standard for outreach images, including the Spitzer Science Center (SSC) and the Chandra X-ray Center (CXC). In 2009 the SSC launched an AVM-driven website[1]. The CXC is tagging all images with AVM, and migrating to an AVM-driven website. ESO and ESA/Hubble is in the process of tagging the images and their web system is AVM driven, and will soon be able to dynamically update the AVM info in the tiff files from a web interface. Third party software such as Microsoft’s Worldwide Telescope and Google Sky have adopted the standard, lending a new perspective to outreach products through a digital sky. The AVM standard is widely adopted among EPO teams.

[1] http://spitzer.caltech.edu

2.2 Definition of AVM

The Adobe Extensible Metadata Platform (XMP) specification describes a widely used method for embedding descriptive metadata within images. XMP tags are stored within the image header of all common image formats (JPEG, TIFF, PNG, GIF, PSD) and can be read by popular image processing and cataloging packages. The XMP standard is also widely used by photographers and the publication industry. Users of consumer and professional digital cameras may already be familiar with Exchangeable Image File Format (EXIF) metadata tags that include camera and exposure information within the digital photo file as a set of XMP tags. In practice an XMP header is a block of XML text included in the header block of the image file and is only supported in image types with header/comment blocks.

Refer to the Astronomy Visualization Metadata (AVM) Standard for the Virtual Astronomy Multimedia Project (VAMP) and other Virtual Observatories[2] documentation for a detailed description of the AVM standard.

2.3 Software Tools

There exist various methods to tag EPO images, each of which are discussed in this document. They include:

1. FITS Liberator
2. Adobe XMP Panels (accessible through Adobe Photoshop and Adobe Bridge)
3. AVM Toolkit (web application by VAMP)
4. Djangoplicity (via the Python-XMP-Toolkit and Python-AVM-Library)

To retrofit the EPO images with World Coordinate System information (the standard for writing astronomical coordinates), there exist three commonly used tools:

5. Astrometry.net
6. PinpointWCS
7. WorldWide Telescope

This guide will first discuss the installation process of the most user-friendly tools listed above, followed by instructions for tagging and retrofitting EPO images with WCS.

[2] http://virtualastronomy.org/avm_metadata.php#2

3 Installation

3.1 FITS Liberator

FITS Liberator is a stand-alone software developed by the European Space Agency, European Southern Observatory, and National Aeronautics and Space Administration. Its main purpose is to convert the FITS file format to a tiff format (after dynamic range compression) that can be opened in Photoshop for image processing, but it also allows users to edit the metadata of the processed image.

The ESA/ESO/NASA FITS Liberator is available from,

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http://spacetelescope.org/projects/fits_liberator/

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as a free download for Mac and Windows platforms.

There are two methods to install FITS Liberator, using the automatic installer or by a manual installation. Since FITS Liberator is a Photoshop plug-in, Photoshop must already be installed to use this software. Using the automatic installer is advised, unless a problem arises that may be resolved via the manual installation process.

Refer to the download page of FITS Liberator for a detailed description of the installation process[3].

3.1.1 Automatic Installation

3.1.1.1 Mac Installation

Installing FITS Liberator on a Mac consists of the following steps:

8. Open the disk image.
9. Double-click on the FITS Liberator Installer (FITS Liberator.mpkg) and follow the steps in the installer. **Note:** Make sure to select the correct destination.
10. Double-click the Extras.mpkg file to install the File Info … panels and FITS Concatenator script. You may have to select your preferred Photoshop installation folder depending on the version you are running.
11. Eject and discard the disk image.

3.1.1.2 Windows Installation

The recommended way of installing the FITS Liberator on Windows is to use the setup program. This will install all the necessary files and optionally register FITS files with Photoshop.

3.2 Adobe XMP Panels

The AVM standard is an extension of Adobe's XMP standard. As a result there are tools that work within Adobe products to add and modify AVM. These tools depend on the version of the user's Adobe product, each having a unique installation method.

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[3] http://spacetelescope.org/projects/fits_liberator/download_v23/

There is an automatic installer contained within FITS Liberator, which installs the necessary files in the correct directories.

For users that have not installed the extra package contained with FITS Liberator, using Adobe CS6 and CC, or do not want to install FITS Liberator, follow the manual instructions below, adhering to the correct version of Adobe Creative Suite.

The necessary files may be downloaded from

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http://spacetelescope.org/projects/fits_liberator/download_v23/.

This page contains links to download the panels for CS3 and CS4, the panels for CS5 to CC are the same as CS4.

3.2.1 Adobe Creative Suite 3

When the user has downloaded the CS3 panels, there will be six text files, each representing a different category of astronomy visualization metadata. For Windows, the files need to be copied to the directory,

```
C:\Program Files\Common Files\Adobe\XMP\Custom File Info Panels,
```

For Mac the files need to be copied to,

```
/Library/Application Support/Adobe/XMP/Custom File Info Panels.
```

3.2.2 Adobe Creative Suite 4

Installing the CS4 panels requires slightly more effort than the CS3 panels. Upon extracting the files from the download, the user will have a directory containing:

```
manifest.xml
bin/AstronomyVisualization.swf
loc/AstronomyVisualization_de_DE.dat
loc/AstronomyVisualization_en_US.dat
loc/AstronomyVisualization_fr_FR.dat
loc/AstronomyVisualization_jp_JP.dat
```

For a Windows machine all these files and directories need to be moved to,

```
{Program Files}\Common Files\Adobe\XMP\Custom File Info.
```

Additionally, the user should create a file named AstronomyVisualization.cfg in

```
{System}\Macromed\Flash\FlashPlayerTrust.
```

For 32-bit Windows {System} is usually

```
C:\Windows\System32
```

whereas for 64-bit Windows {System} is usually

```
C:\Windows\SysWOW64.
```

The file must contain the path to the location of the CS4 XMP panels, for example

```
C:\Program Files\Common Files\Adobe\XMP\Custom File Info
Panels\2.0\panels\AstronomyVisualization.
```

For a Mac machine the files and directories need to be moved to,

```
/Library/Application Support/Adobe/XMP/Custom File Info Panels/2.0/panels/.
```

Additionally the user should place the trust file AstronomyVisualization.cfg in the directory,

```
/Library/Application Support/Macromedia/FlashPlayerTrust.
```

3.2.3 Adobe Creative Suite 5

The installation process for CS5 panels is similar to that of CS4. The only difference is the location in which the files are copied.

Follow the instructions for CS4, but change the directory "2.0" to "3.0" in each path.

3.2.4 Adobe Creative Suite 6 & Creative Cloud

To install the CS6 or CC panels on Windows Vista and 7, all of the extracted files and directories need to be copied to,

```
C:\users\<Username>\Appdata\Roaming\Adobe\XMP\Custom File Info Panels\4.0\Panels\
```

Additionally, the user should create a simple text file named AstronomyVisualization.cfg as a trust file which contains the path and file name of the panels, for example

```
C:\Documents and Settings\<Username>\Application Data\Adobe\XMP\Custom File Info
Panels\4.0\Panels\AstronomyVisualization\bin\AstronomyVisualization.swf
```

The trust file needs to be saved in the User Flash Player trust folder which is located in,

```
C:\Documents and Settings\<Username>\Application
Data\Macromedia\FlashPlayer\#Security\FlashPlayerTrust
```

For Macs, the extracted files and directories need to be copied to,

```
/User/<Username>/Library/Application Support/Adobe/XMP/Custom File Info Panels/
4.0/Panels/
```

and user should place the trust file AstronomyVisualization.cfg in,

```
/User/<Username>/Library/Preferences/Macromedia/FlashPlayer/#Security/FlashPlayerTrust
```

Note that creating one or more of mentioned directories in the paths might be necessary.

3.3 PinpointWCS

PinpointWCS is an easy-to-use application for retrofitting EPO images with World Coordinate System (WCS) info. Currently it is only available for **Intel-based Macs**. To obtain the software visit the webpage at:

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https://github.com/kapadia/PinpointWCS/releases/download/v0.9.2/PinpointWCS.zip

---

Here the user can download a disk image. After the file has downloaded, double-click the disk image and drag the application to the "Applications" folder.

3.4 WorldWide Telescope

WorldWide Telescope (WWT) is a desktop planetarium package that is currently being developed by Microsoft Research. It is aimed at both the general public and professional astronomers. There are hidden tools available to outreach astronomers that assist in retrofitting EPO images with WCS info.

To install the software a **Windows machine** is necessary. Visit

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http://www.worldwidetelescope.org

To download the installer. Depending on the user's computer, WWT may need additional packages installed, namely Microsoft's .NET 2.0 framework and the Windows Imaging Component. If these are needed, the WWT installer will notify the user, and offer a link to the location of these packages.

4 Tagging Tools

This section guides the user through the steps involved in using some of the aforementioned tools to tag and retrofit EPO images with WCS information. The most user-friendly tools are discussed.

4.1 Adobe XMP Panels

The Adobe XMP Panels provide a user-friendly way to tag EPO images with AVM. Many of the tags are self explanatory, but some sections require information that is difficult to obtain for archived images.

To begin tagging a single EPO image, open Adobe Bridge. The screen should appear as below.

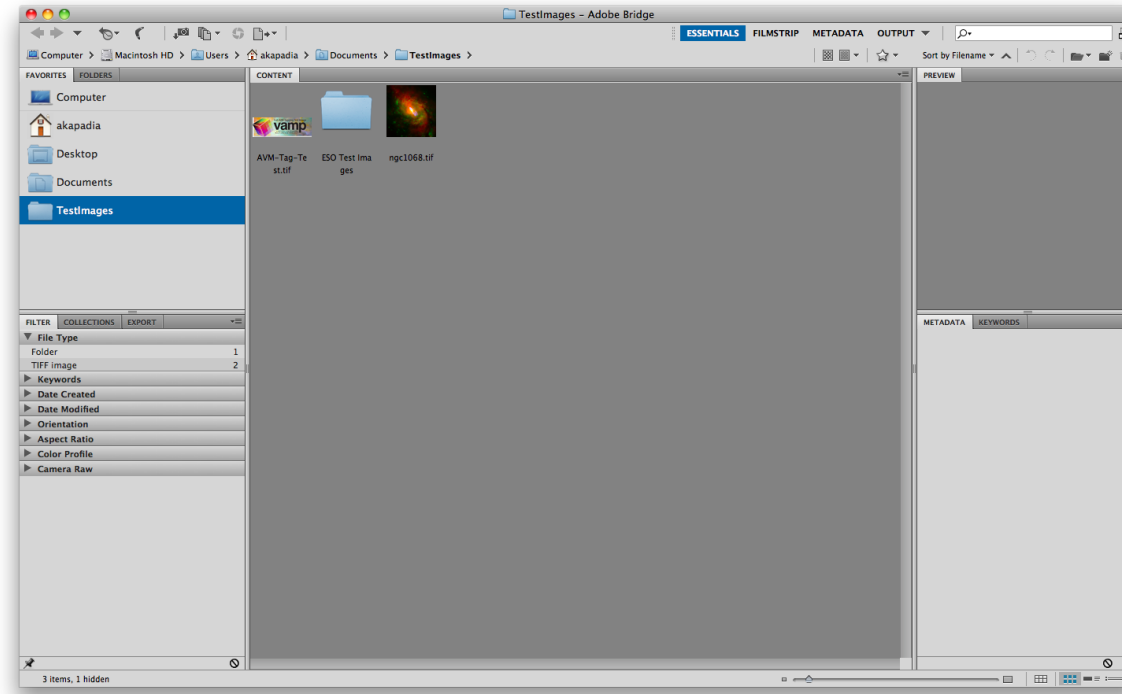

Figure 4-1 The Adobe Bridge Interface

Select an EPO image by single-clicking it. Open the “File Info…” dialog by selecting the File -> File Info... menu item. This will open a dialog allowing the user to edit XMP. With the AVM panels installed, the user will also be able to edit AVM.

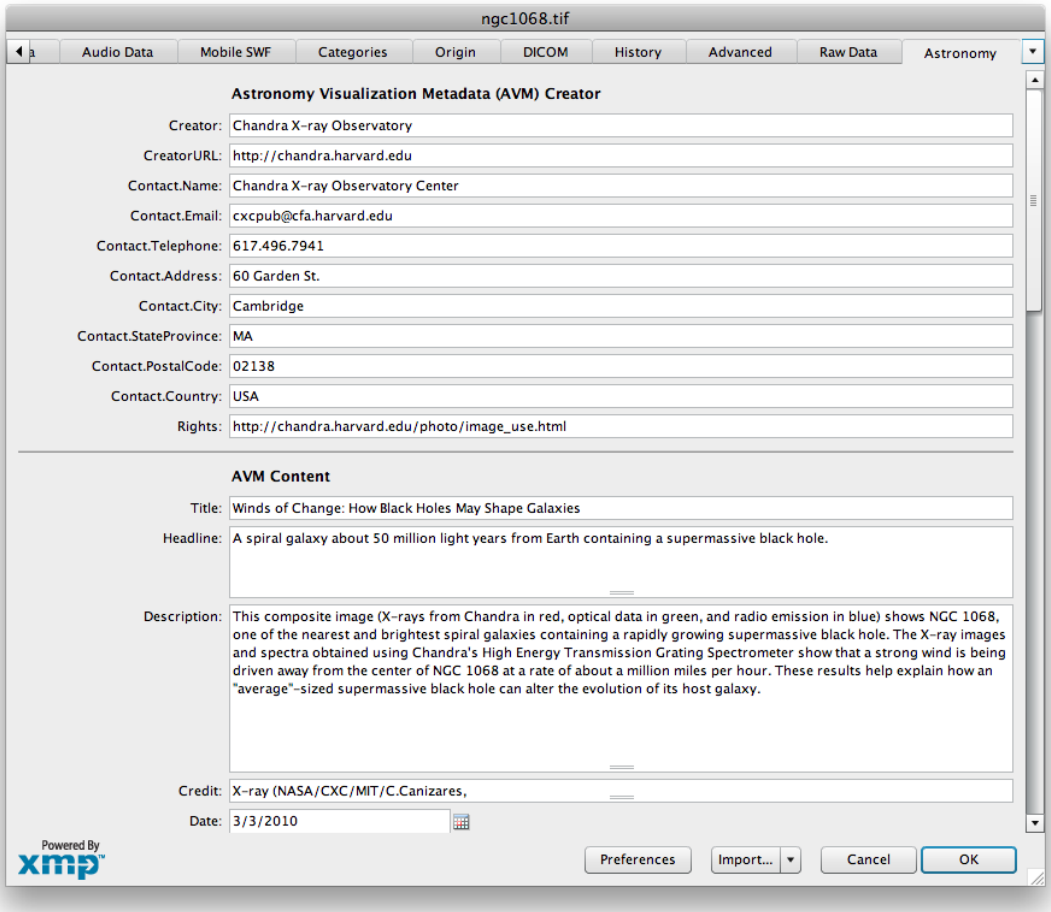

Figure 4-2 The XMP panel for editing AVM

Selecting the “Astronomy” tab reveals all of the AVM fields. The user should complete this form with as much information as possible. AVM is split into six distinct categories.

12. Creator metadata includes contact information to the observatory releasing the EPO image. This information is general to all EPO images produced by the observatory.
13. Content metadata includes specific information about the context of the EPO image release. Much of this information is generally available on the web page associated with the image release.
14. Observation metadata include more technical information about the various observations that were used to create the EPO image. This category includes information such as the telescope and instrument that was used, as well as the colour mapping that was applied to the generate the image.
15. Coordinate metadata refers to the World Coordinate System information that can correctly locate the image on the sky. This information describes the location, dimensions, scale, and rotation of the image when projected on to the sky.
16. Publisher metadata is a category reserved for a future central repository of EPO images. Many of the fields in this section are not currently relevant.
17. FITS Liberator metadata contains the function and numerical values used to stretch and scale the raw science data for EPO processing. The user should not worry to complete these fields.

4.2 AVM Toolkit

AVM Toolkit is a web-based solution for AVM management for EPO images. The web application is a product of The Virtual Astronomy Multimedia Project (VAMP). Allowing registered users to edit or create AVM for EPO images online, AVM toolkit provides the user all editable AVM fields. To use the AVM Toolkit the user needs to create an account linked to an email address. The account also includes a Publisher ID though that is not being used currently (and can be changed under your account settings).

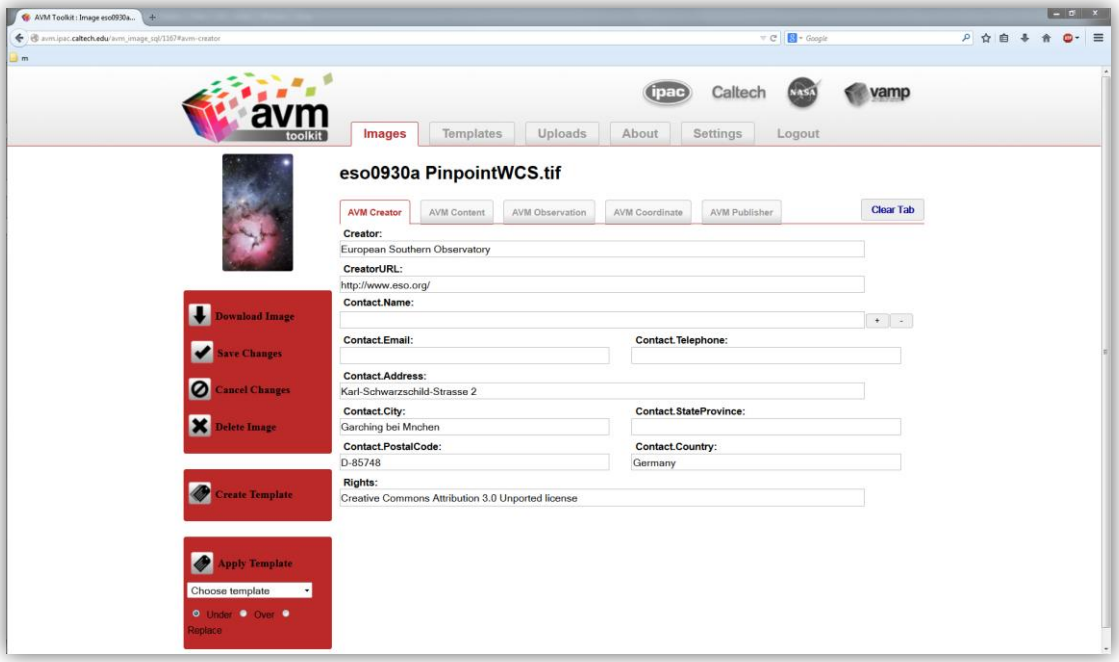

Figure 4-3 Image panel in AVM Toolkit

The user may upload one or more files in the Upload panel and edit their AVM in Images panel, as it would be done using Adobe XMP panels. By choosing Edit option next to the thumbnail picture of the uploaded file the web application opens all AVM fields of the file.

Currently, the known issue with AVM Toolkit is its 20 GB of storage. If user end up uploading lots of large images the storage could fill up. It is necessary to clean up and delete images that are no longer needed.

The web-based application is accessible at

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http://avm.ipac.caltech.edu/

4.3 Djangoplicity

An alternate method to tag EPO images is through the Djangoplicity web interface deployed for websites run at the European Southern Observatory. This content management system (CMS) is used for the ESO and ESA/Hubble websites and uses the Python-XMP-Toolkit and Python-AVM-Library to manipulate metadata. It allows the user to keep track of every webpage and all media products. For EPO images, the CMS contains a form with all editable AVM fields.

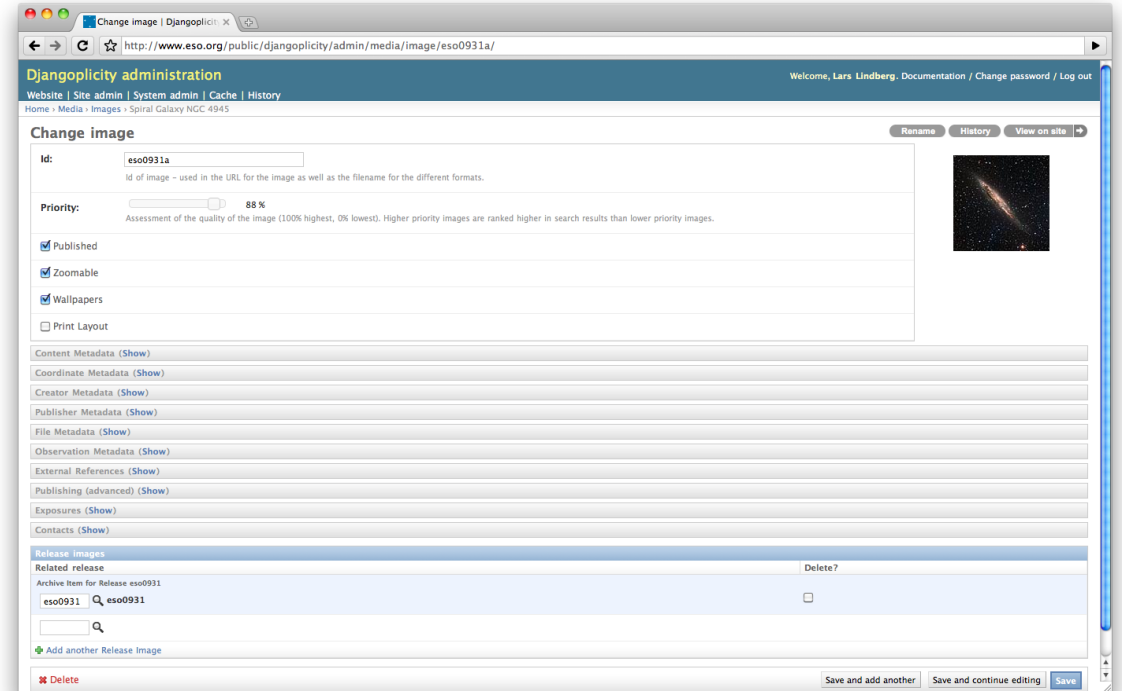

Figure 4-4 Djangoplicity CMS Interface

The user may edit each field, the as would be done using Adobe XMP panels. Once the information is saved, the metadata is simultaneously updated in the website's database and the EPO image header.

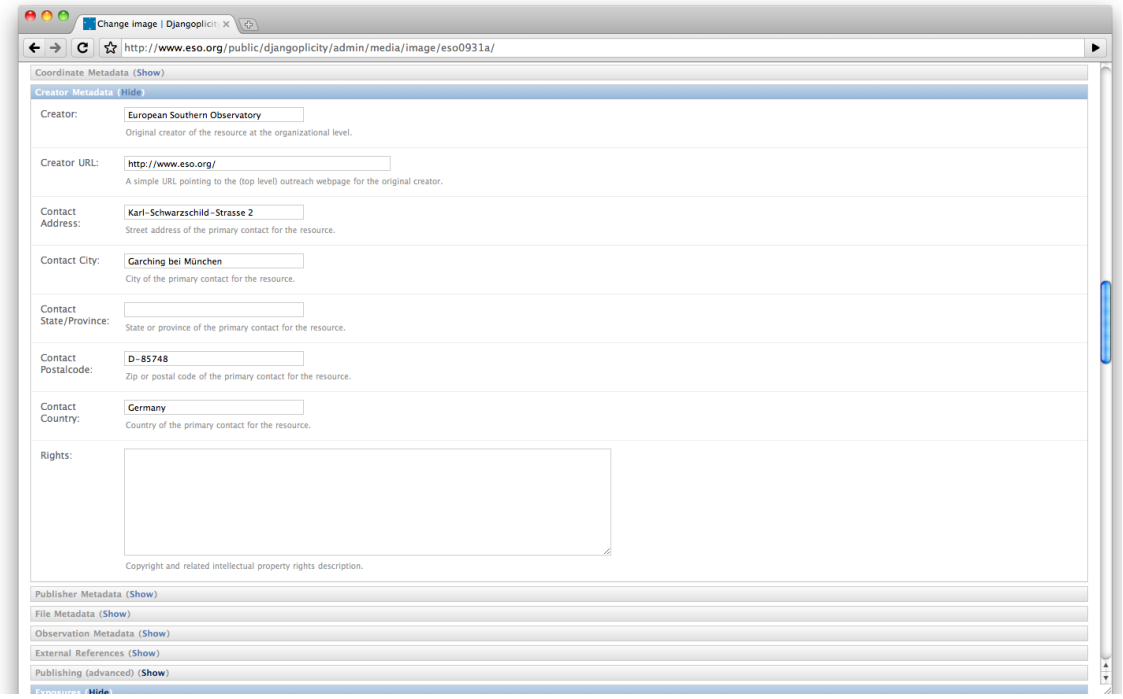

Figure 4-5 Creator metadata form in Djangoplicity

5 World Coordinate System Recovery Tools

Education and public outreach images undergo various linear transformations during image processing. These transformations, such as scaling, cropping, and rotating, invalidate the world coordinate system information that is embedded with the FITS images. Since these transformations are never recorded, it is necessary to re-compute the celestial coordinates for the EPO image. This section describes three commonly used tools for this purpose. These tools may be used independently, or in conjunction with each other.

5.1 Astrometry.net

Astrometry.net is software that computes WCS for astronomical images in TIFF, JPEG or FITS format blindly. The use of the word “blind” means that this software is able to compute coordinates without any reference input. The system is robust, allowing a wide variety of images to be correctly matched against a database of stars. The result is accurate astrometry solved in an automated manner. The Astrometry.net system uses the USNO-B star catalog, considered to contain accurate astrometry to within 0.2 arc-second accuracy.

The web-based service is in beta testing, and may be accessed at

---

http://nova.astrometry.net/.

No user account is required, however it is encouraged to create one to keep track of all images submitted to the service.

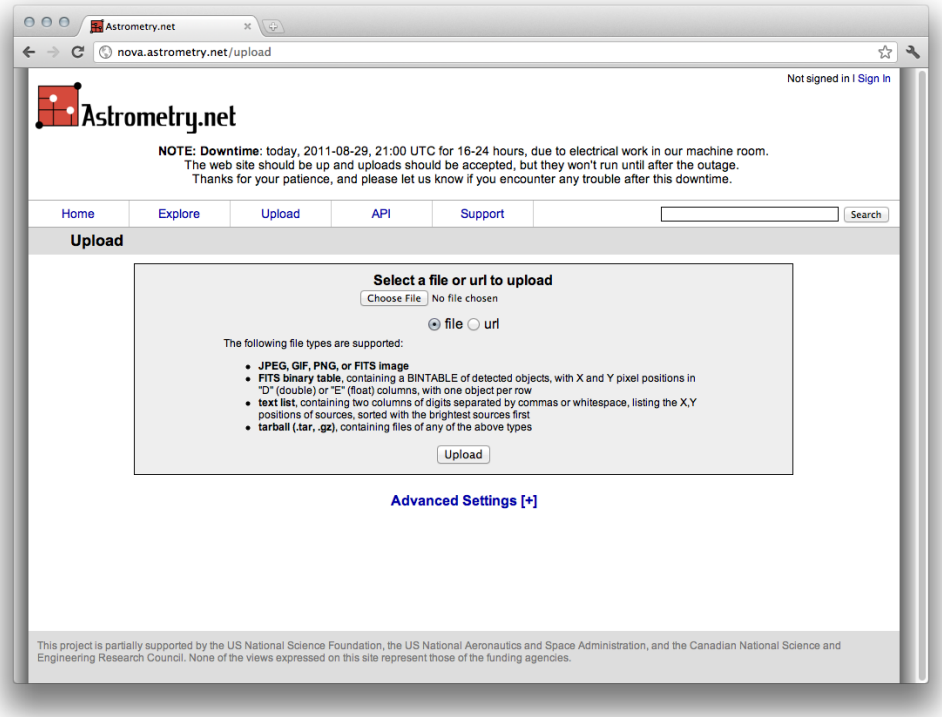

Figure 5-1 Astrometry.net web-based form

Applies to Astrometry.net Alpha version: The top two fields are specific to the user, email and name. When resolving EPO images, the user may choose to upload the image, or supply a URL to the image. At this point, the user may submit the image, but it is beneficial to supply additional information to speed the search process. In the section titled “Scale of the image”, the user should enter an approximate scale. The scale of an image refers to the length of sky that is represented by the image (i.e. the number of degrees that span the image). Many telescopes have instruments that span only a tiny portion of the sky, so the scale will be small. The webpage includes a tip stating, “Most digital-camera images are at least 10 degrees wide; most professional-grade telescopes are narrower than 2 degrees”. For many EPO images, it is sufficient to approximate the scale of the image to be 2 degrees or less, depending on the instrument used.

The service will usually take a few minutes when attempting to resolve an image, be patient. Notifications are sent via email when the system begins and finishes the job.

NOTE: This method is the preferred tool when the EPO image has a large field of view (> 7-8 arcminutes). When the field of view is too small, the image will not be able to resolve, and Astrometry.net will fail to compute coordinates. This is a limitation of the star catalogs, rather than the methodology used. There may be ways to improve the efficiency of the resolver but this cannot be confirmed. Downsampling the images, noise-reduce them (to remove the faintest stars) or other ideas could be tested.

For small fields of view the following tools may be more successful.

5.2 PinpointWCS

One alternative to Astrometry.net is *PinpointWCS*. It is being developed at the Chandra X-ray Center specifically for education and public outreach purposes. This software requires the user to have a FITS image containing WCS in equatorial coordinates of the same region of sky as the EPO image. It is preferred that the FITS image is of similar or higher resolution (note: this means that also similar archival observations can be useful). The user matches corresponding features between the FITS image and EPO image. With a minimum of three features matched, WCS is computed for the EPO image. For a more accurate fit, it is beneficial to match more features; approximately 10 will offer a good fit.

Upon opening PinpointWCS the user will see the following window.

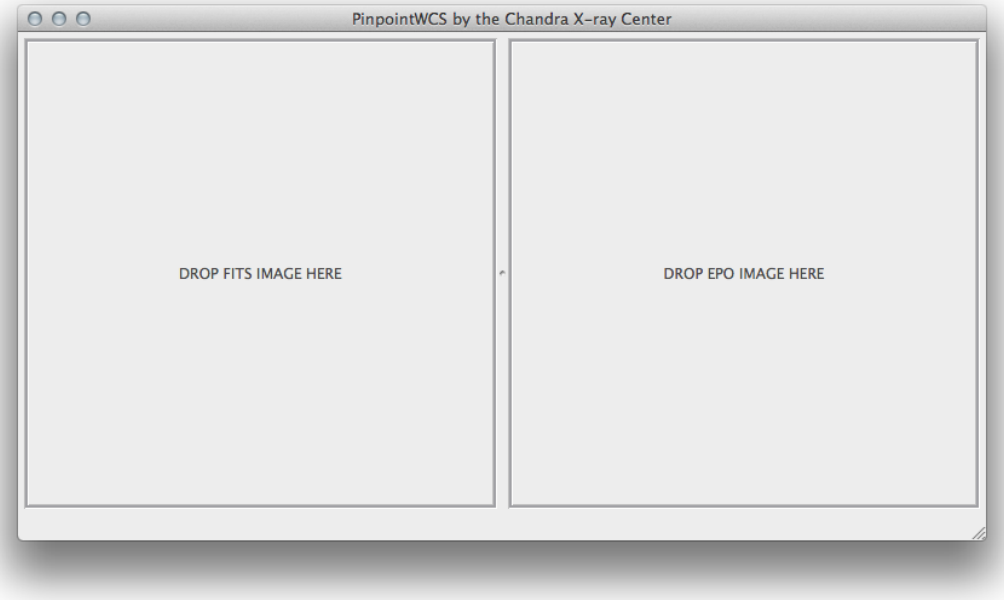

Figure 5-2 The PinpointWCS interface

To import data into the program, drag-and-drop the FITS file on the left panel, and the EPO image on the right panel. Once both files have been dropped into the application, PinpointWCS will first verify that the FITS image has appropriate WCS; it will then display a recommended scale of the image.

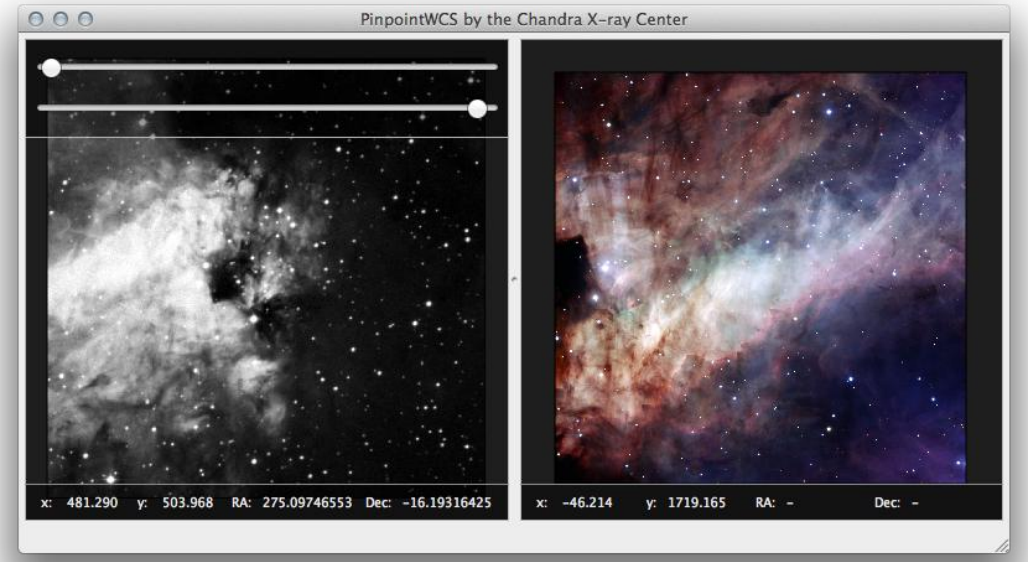

Figure 5-3 PinpointWCS with data imported. In the left panel is a FITS image from DSS, in the right panel is the EPO image.

In the upper left of the software are two scrollbars used to adjust the stretch of the FITS image for optimal viewing. To view the WCS contained in the FITS, choose "WCS Info" from the "View" menu (not shown). Various shortcut commands have been implemented offering the user an easy way to manipulate the view of the image.

Point Manager	Cmd + P
Panning Image	Click + Mouse Drag
Rotate Image CW	Cmd + R
Rotate Image CCW	Shift + Cmd + R
Zooming Image	Scroll Wheel via Mouse

Next the user must match features between both images. A minimum of three corresponding features is needed to retrofit EPO images with WCS. More corresponding features will result in a more precise pixel mapping from the FITS image to the EPO image. After each additional correspondence, PinpointWCS will update its calculations.

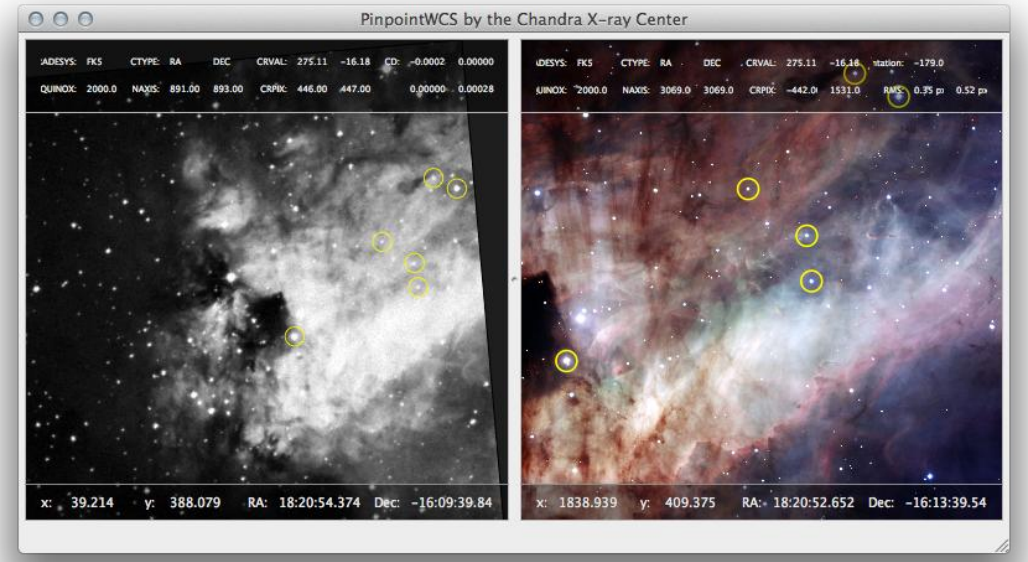

Figure 5-4 PinpointWCS highlighting corresponding features detected by the user

Notice in Figure 5-4 that new coordinates have been computed for the EPO image. In the "WCS Info" panel for the EPO image there is a field titled RMS (Root Mean Square), which gives an average offset in the equations that transform the FITS WCS to EPO WCS. The user should minimize these values for optimal fitting. After the user is finished matching features, the new data must be exported. There are currently three export options: (1) embedding the WCS directly into the EPO image via the AVM standard (2) exporting the data as an XMP file in the AVM standard, (3) exporting the data as a FITS image.

In order to quality check the WCS solution, it is encouraged that the user exports in both options. The output FITS image can be compared to the original FITS image using the FITS viewing program, DS9.

This program may be obtained from,

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http://hea-www.harvard.edu/RD/ds9/.

To compare the original FITS image with the output from PinpointWCS, open both images in DS9. DS9 displays each image in the same window, each within its own frame. Next choose the menu item "Frame -> Match Frames -> WCS".

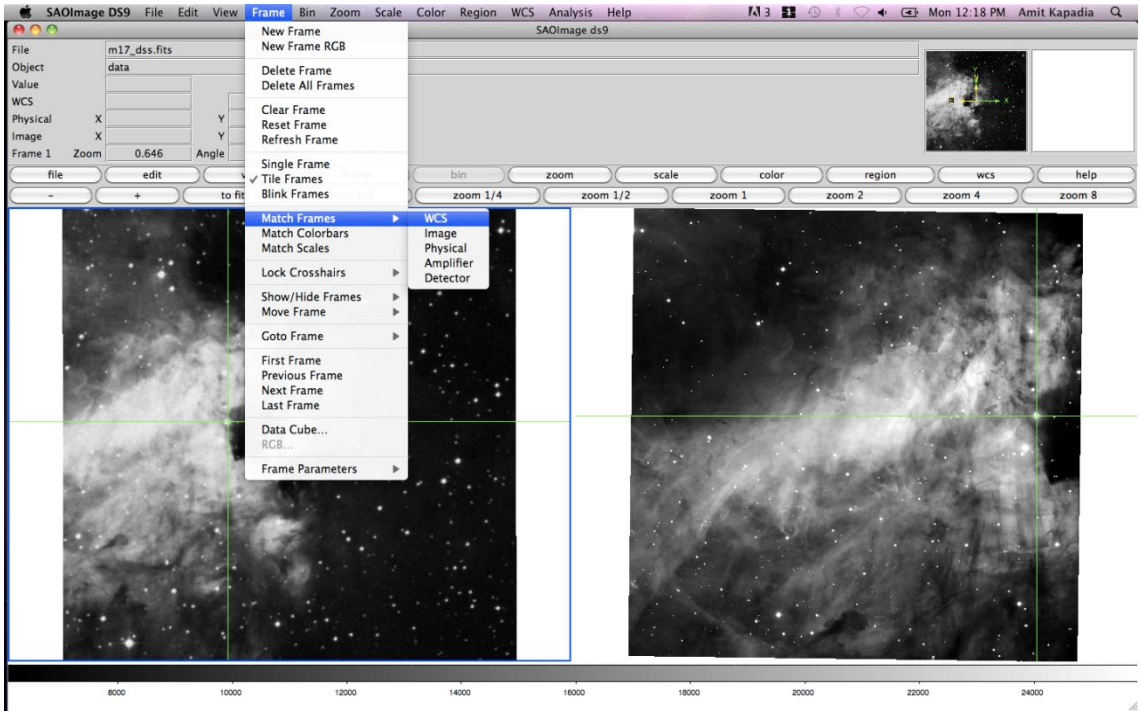

Figure 5-5 Matching frames using WCS

This function will align both images using the WCS in the FITS header. Next choose the menu item “Frame -> Lock Crosshairs -> WCS”. Then change the cursor to the crosshairs by choosing “Edit -> Crosshair”.

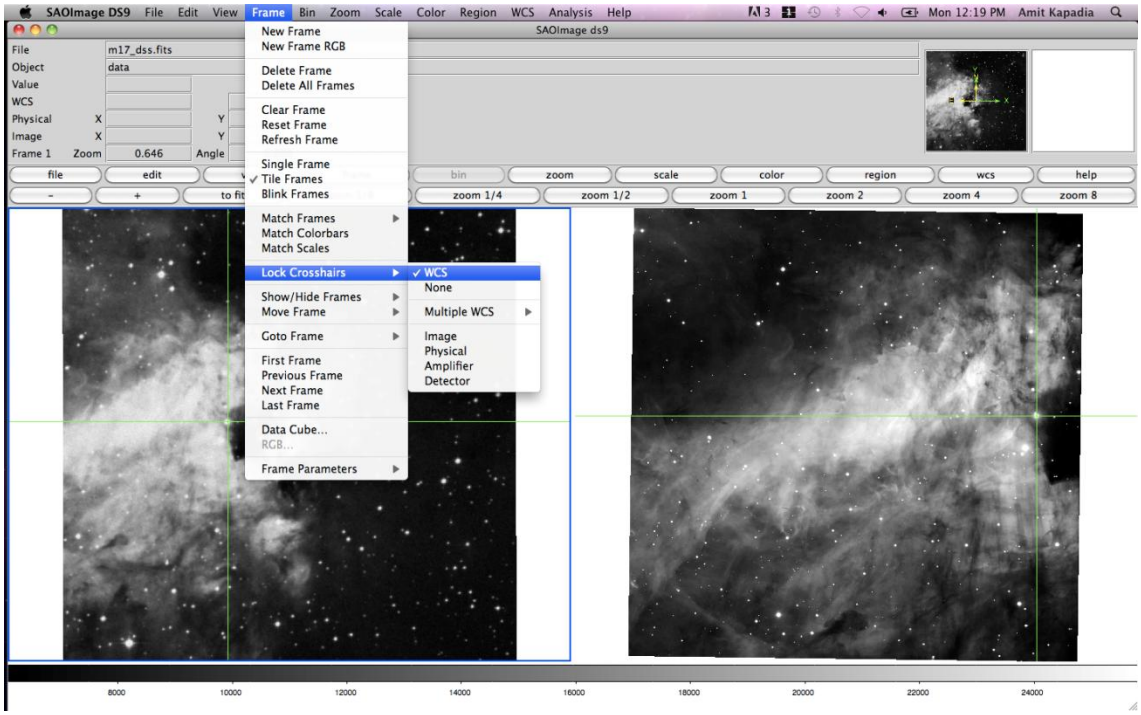

Figure 5-6 Locking crosshairs using WCS

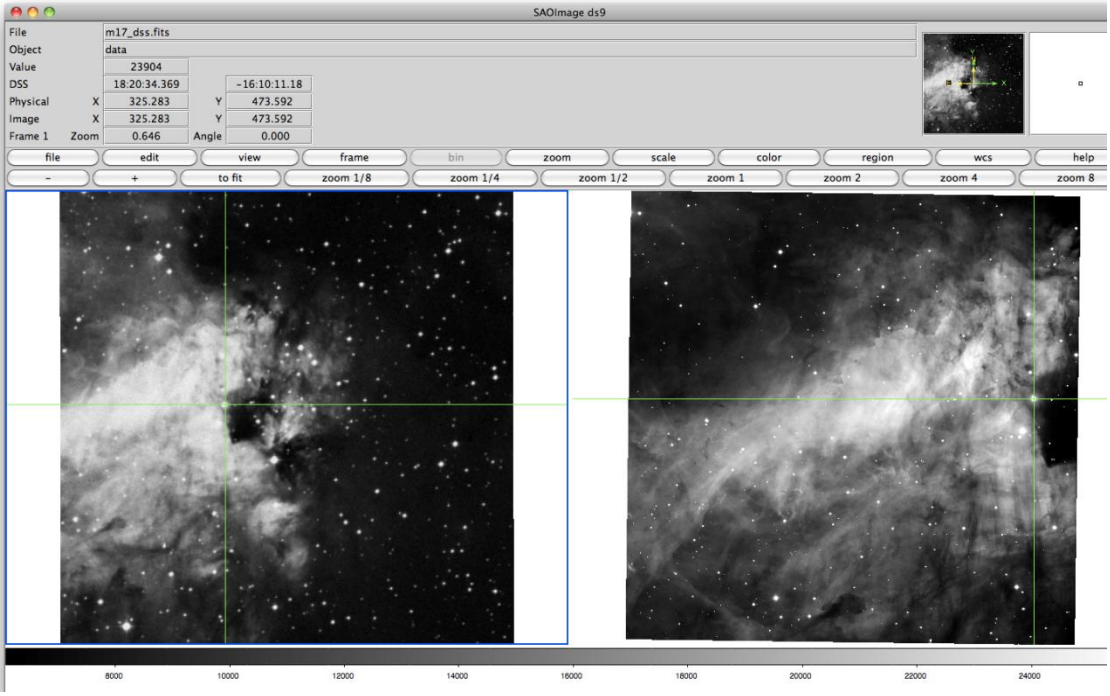

Figure 5-7 Checking the new WCS against the original FITS image

The user may now check that corresponding features are aligned. Though PinpointWCS is helpful for retrofitting EPO images with WCS information, it should be noted that the WCS is only as accurate as the FITS image used. If the FITS image contains mis-aligned WCS, then the computed WCS will also be mis-aligned. Additionally, due to inherent limitations, the computed WCS will be projected in the gnomonic (tangent) projection; hence for images with a large field of view, distortion will become largely apparent for pixels far from the reference pixel.

5.3 WorldWide Telescope

WorldWide Telescope (WWT) may be used to align EPO images. The developers of WWT have introduced tools to facilitate retrofitting EPO images with WCS information.

Documentation may be found at:

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http://www.worldwidetelescope.org/docs/WorldWideTelescopeDataToolsGuide.html#ImageAlignmentwithinWorldWideTelescope

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To begin retrofitting, launch WWT. Ensure that the software is in "Sky" mode. This may be changed using the drop-down menu located in the bottom left.

Figure 5-8 WorldWide Telescope in Sky mode

Locate approximate coordinates for the object in the EPO image. Enter approximate right ascension and declination, as shown in Figure 5-9.

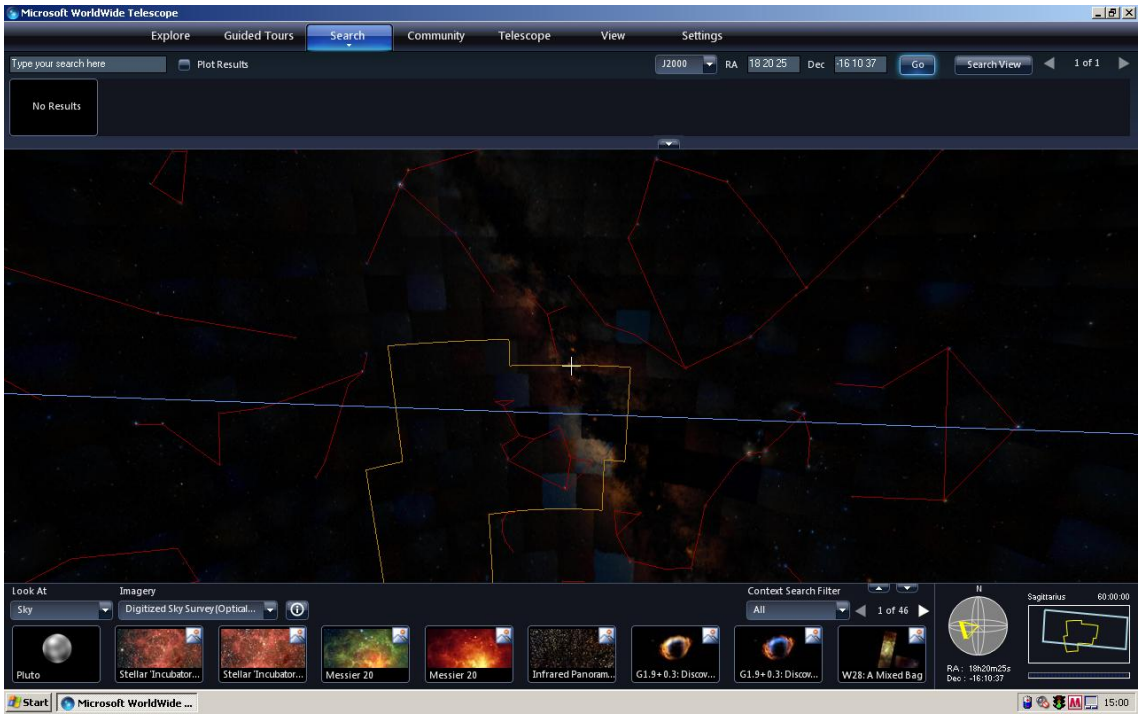


Figure 5-9 Enter approximate coordinates of the object in the upper right

With the sky position on the correct object, open the EPO image by using the menu item “Explore -> Open -> Image…”

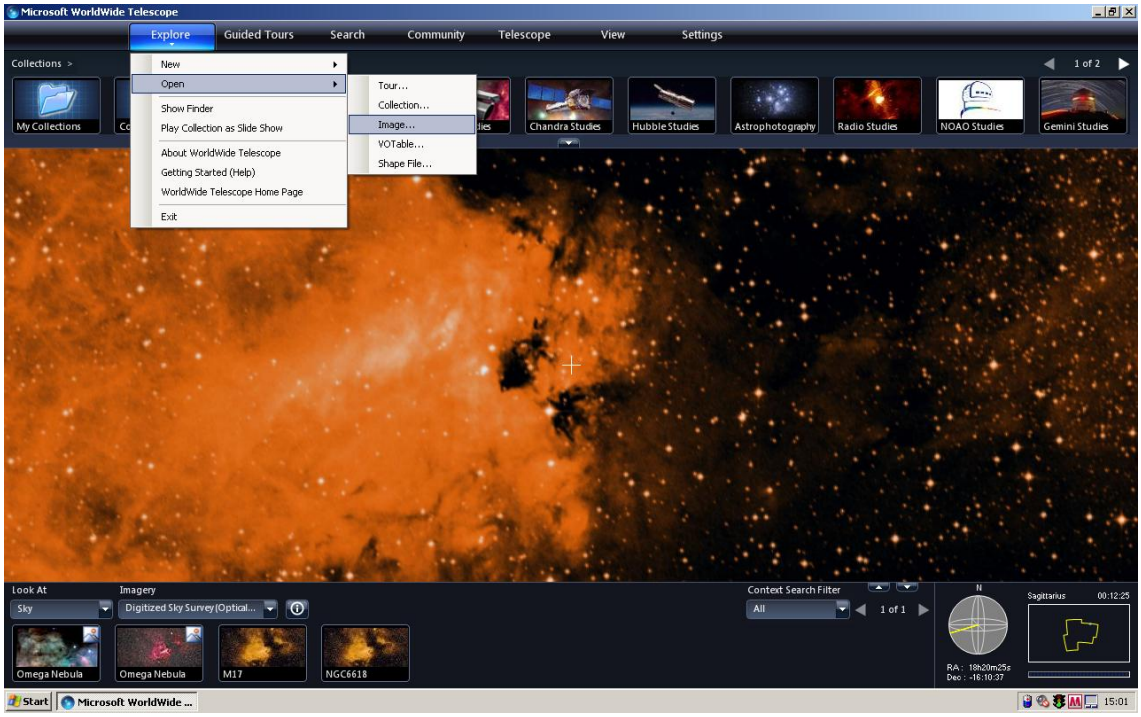


Figure 5-10 Opening an EPO image in WWT

Upon selecting an image to import, the user may be prompted with a message stating that no coordinates were found in the image. Once the image has loaded, the user may adjust the position by entering “Image Alignment” mode, activated by pressing Ctrl + E.

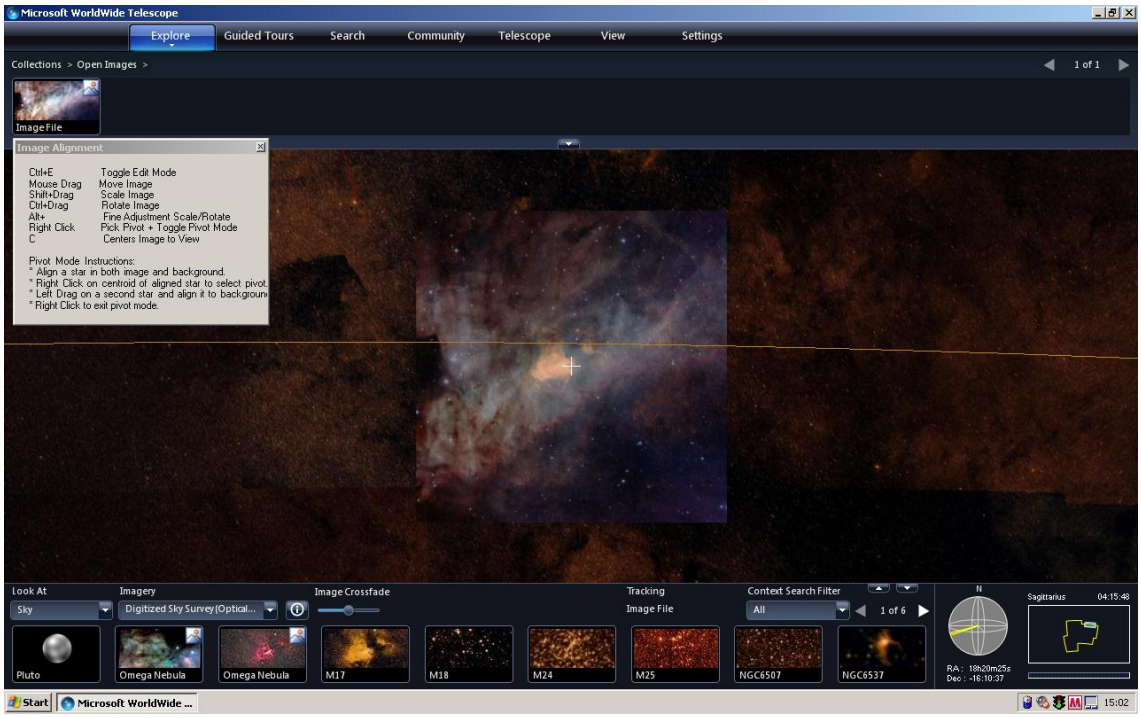


Figure 5-11 Image Alignment mode in WWT

Using a combination of panning, rotating, and scaling, the user can adjust the position of the EPO image against the background images in WWT. To compute exact WCS coordinates, the user can find the central point of the image using crop or selection tool in Photoshop and match estimated central point of the image with the central sign (+) in the middle of WWT window. Right-click on the image thumbnail and choose “Edit” then click on “From View” option in the Edit panel. With the image aligned, the coordinates must be saved to the WTML format. Right-click on the image thumbnail and choose “Add to Collection”. The user may add it to an existing collection, or to a new collection. If a new collection is created, the coordinates will be easier to locate in the WTML file. If the coordinates are added to an existing collection, the user must take care not to confuse the new coordinates with coordinates from another image in the collection.

With the coordinates computed, the metadata must be transferred from the WTML file to AVM; this is done in Adobe Bridge. WWT does not use the AVM field names in the WTML format, so the user must use the mapping below when transferring the information to AVM.

AVM Fields	WTML Fields
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	2000.0
Spatial.ReferenceValue	CenterX; CenterY
Spatial.ReferenceDimension	Must be filled from image information
Spatial.ReferencePixel	OffsetX; OffsetY
Spatial.Scale	-BaseDegreesPerTile; BaseDegreesPerTile
Spatial.Rotation	-Rotation
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full

After the metadata is transferred, the process is complete. The EPO image has been retrofitted with WCS information, with the new coordinates stored in the AVM format.

5.4 WCS Recalibration Decision Tree

With three options to recalibrate EPO images, it is not immediately clear which method is the most effective. Each EPO image will have its own optimal tool. The best workflow to adopt will be determined by the user, but this section offers guidance.

If the image has a sufficiently large field of view (FOV), then begin with Astrometry.net. This tool has an extremely high success rate when solving images with a FOV of at least 8 arcminutes. Images of a smaller scale will take longer to process, and may not resolve.

The FOV of the image depends on the instrument that was used to collect the data.

Table 1 Range of FOV for ESO and Hubble Instruments

Instrument	Range of FOV	Preferred WCS Resolver
AMBER[4]	60 mas to 250 mas	PinpointWCS/WWT
EMMI		PinpointWCS/WWT
FORS1 & FORS2[5]	4.25 arcmin x 4.25 arcmin to 6.8 arcmin x 6.8 arcmin	Astrometry.net/PinpointWCS/WWT
HAWK-I[6]	7.5 arcmin x 7.5 arcmin	Astrometry.net
ISAAC[7]	1.2 arcmin to 2.5 arcmin	PinpointWCS/WWT
NACO[8]	0.23 arcmin to 0.93 arcmin	PinpointWCS/WWT
PC2		PinpointWCS/WWT
SOFI[9]	< 4.92 arcmin	PinpointWCS/WWT
VISTA[10]	Up to 99 arcmin	Astrometry.net
Hubble/all instruments	Up to 2 arcmin	PinpointWCS/WWT

It is near certain that Hubble observations will not resolve through Astrometry.net, unless it is a large mosaic. For these images, it is best to begin with PinpointWCS or WWT.

Below is a decision tree that assists the user in choosing the most optimal tool.

[4] http://www.eso.org/sci/facilities/paranal/instruments/amber/inst/
[5] http://www.eso.org/sci/facilities/paranal/instruments/fors/overview.html
[6] http://www.eso.org/sci/facilities/paranal/instruments/hawki/index.html
[7] http://www.eso.org/sci/facilities/paranal/instruments/isaac/inst/isaac_img.html
[8] http://www.eso.org/sci/facilities/paranal/instruments/naco/overview.html
[9] http://www.eso.org/sci/facilities/lasilla/instruments/sofi/
[10] http://www.eso.org/public/teles-instr/surveytelescopes/vista/index.html

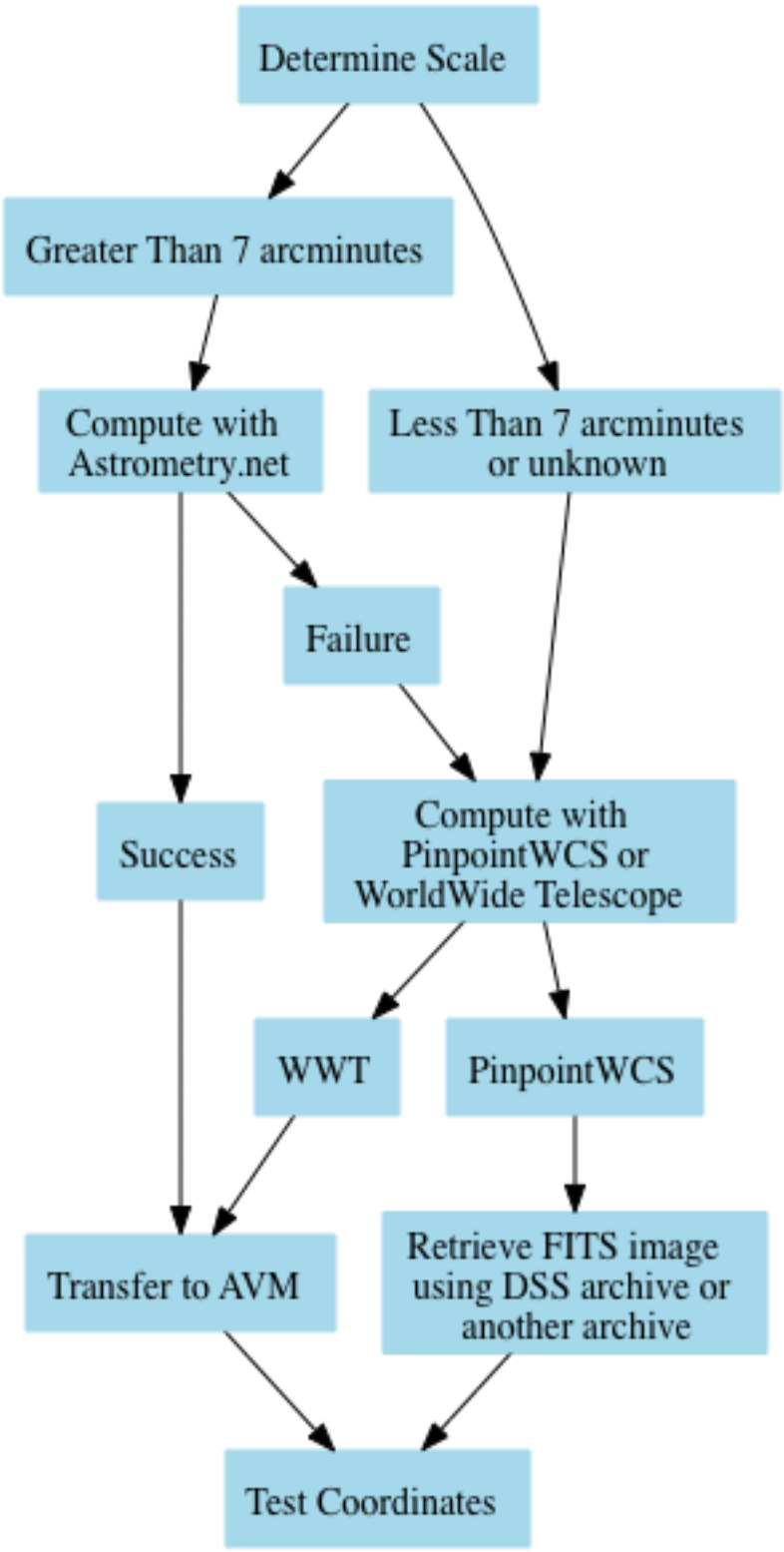


Figure 5-12 WCS Retrofitting Decision Tree

6 Detailed Instructions for Tagging ESO Images with PinpointWCS

ESO is collecting coordinate data for various astronomical images. To obtain these data, an image must be processed through the workflow outlined in this section. The contractor will be provided with a list of education and public outreach (EPO) images. Many of these images require astronomical coordinates to be calculated, but some images do not. This section outlines the process of obtaining necessary data, checking the image type, collecting coordinates for the EPO images, and delivering them to ESO databases. Prior to reading this section, it is encouraged to read sections 17 and 5.2 to understand the Djangoplicity interface, and PinpointWCS, each important tools in this workflow.

The list of all ESO images that need AVM coordinate tagging is at:
Published:
https://www.eso.org/public/djangoplicity/admin/customsearch/customsearch/136/search/

Unpublished:
https://www.eso.org/public/djangoplicity/admin/customsearch/customsearch/137/search/
(often empty).

Check Image Type

Only a subset of images require astronomical coordinates. Many images do not require coordinates; it is important to ensure that the EPO image qualifies as one needing coordinates. Double-check that the image is not

- An image of a comet or planet
- Has any graphics on it

Below are examples of images that are to be excluded from this process.

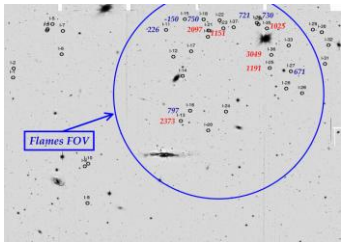


Figure 6-1 Image contains too many labels

Figure 6-2 Image is of a comet

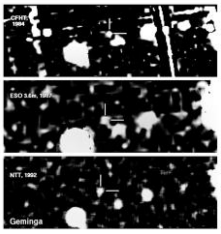


Figure 6-3 Image of a collage of many images

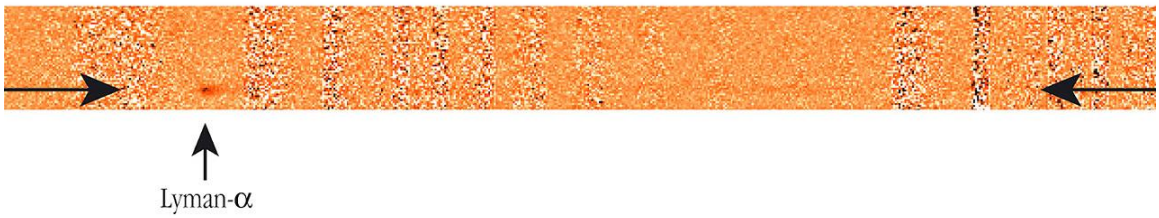


Figure 6-4 Image contains labels

Visit the URL in the column *image url* to see the webpage for the image. Inspect the image on this page to determine whether coordinates must be calculated. If the image qualifies as needing coordinates, mark the field *needs wcs?* with "yes", and proceed with the steps that follow; otherwise mark the field "no", and repeat the process for the next image.

Get EPO Image

Images that require coordinates will be processed through a software specially designed for EPO images. This software required two files, the EPO image, and an image in the FITS format. Each of these images must be downloaded from ESO.

To retrieve the EPO image, locate the column labeled *full resolution jpeg url*. Using a web browser, download the image from the URL.

For example for the image ID eso1129a, navigate to

http://www.eso.org/public/archives/images/large/eso1129a.jpg

to download the image.

Get FITS Image

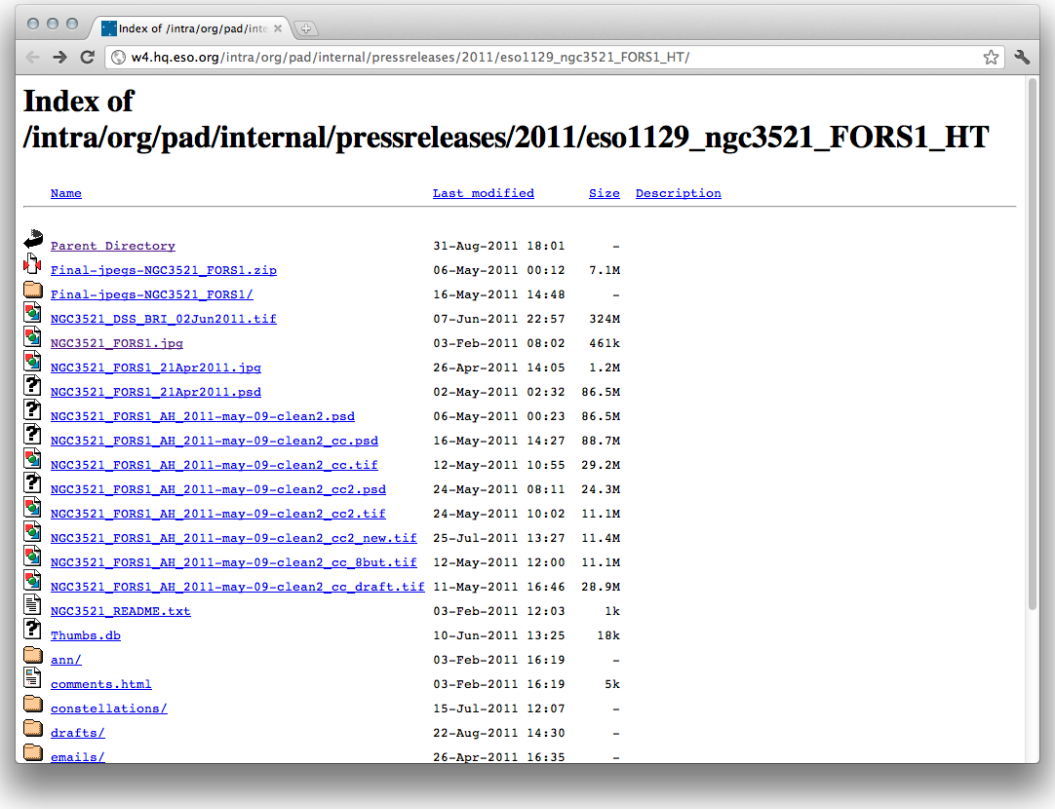
To obtain the FITS image, navigate to the URL listed in the column *internal url directory*. Search through this directory for files of the FITS format; these files have the extensions *.fits* or *.fit*. There may be many FITS files in the directory, or there may be none.

In the example for eso1129a the internal URL is:

https://www.eso.org/public/outreach/internal/pressreleases/2011/eso1129_ngc3521_FORS1_HT/

This in an internal page that requires login information (request login from lars@eso.org).

Navigating to the URL will show various files corresponding to the image ID. This directory needs to be searched for FITS files. In some cases the files are stored in a directory labeled fits.



If a FITS file is stored in the directory download it and proceed to the next step. If the FITS image is not in the directory, you can obtain one by searching the *STScI Digital Sky Survey* website.

http://archive.stsci.edu/cgi-bin/dss_form

An example of using this website is outlined in Test Case 3: eso0925a of this document.

Load Images in *PinpointWCS*

The software you will be using is titled *PinpointWCS*. It is being developed at the Chandra X-ray Center specifically for education and public outreach purposes. Documentation on obtaining and using the software is available in section 5.2 World Coordinate System Recovery Tools above or at the following website.

https://www.cfa.harvard.edu/~akapadia/pinpointwcs/

Export Results

After processing the images through PinpointWCS, the coordinates must be exported. The results should be saved using the *XMP Packet* option in *PinpointWCS*. This is a text file in the XML format.

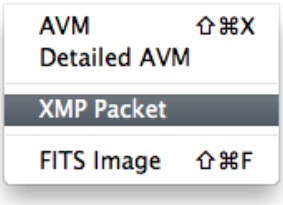


Figure 6-5 Export menu in PinpointWCS

The file is viewed using a text editor. Transfer these data to Djangoplicity by reading the fields in the text file, and finding the corresponding field in Djangoplicity. Search only for the fields relevant to the WCS:

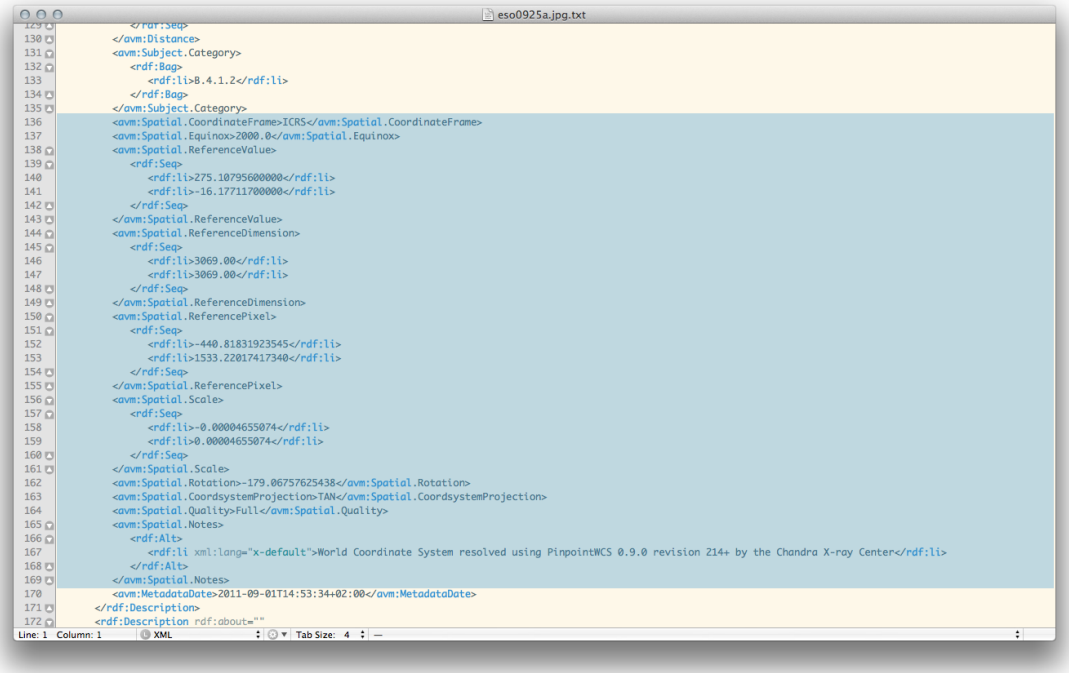


Figure 6-6 The relevant data is highlighted in blue. These fields must be transferred to Djangoplicity.

These fields are listed in the *Metadata Tags Overview* documents found at:

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http://virtualastronomy.org/avm_1.1_ref_table_final_draft.pdf

---

and include:

- Spatial.CoordinateFrame
- Spatial.Equinox
- Spatial.ReferenceValue
- Spatial.ReferenceDimension
- Spatial.ReferencePixel
- Spatial.Scale
- Spatial.Rotation
- Spatial.CoordsystemProjection
- Spatial.Quality
- Spatial.Notes.

Login in to Djangoplicity at (request login from lars@eso.org),

---

http://www.eso.org/public/djangoplicity/admin/

---

and navigate to the image from the URL in the column labeled “djangoplicity url”.

The form necessary to transfer coordinates from the XML file to the ESO database will be shown when selecting the tab titled “Coordinate Metadata” as shown in the Figure 6-7.

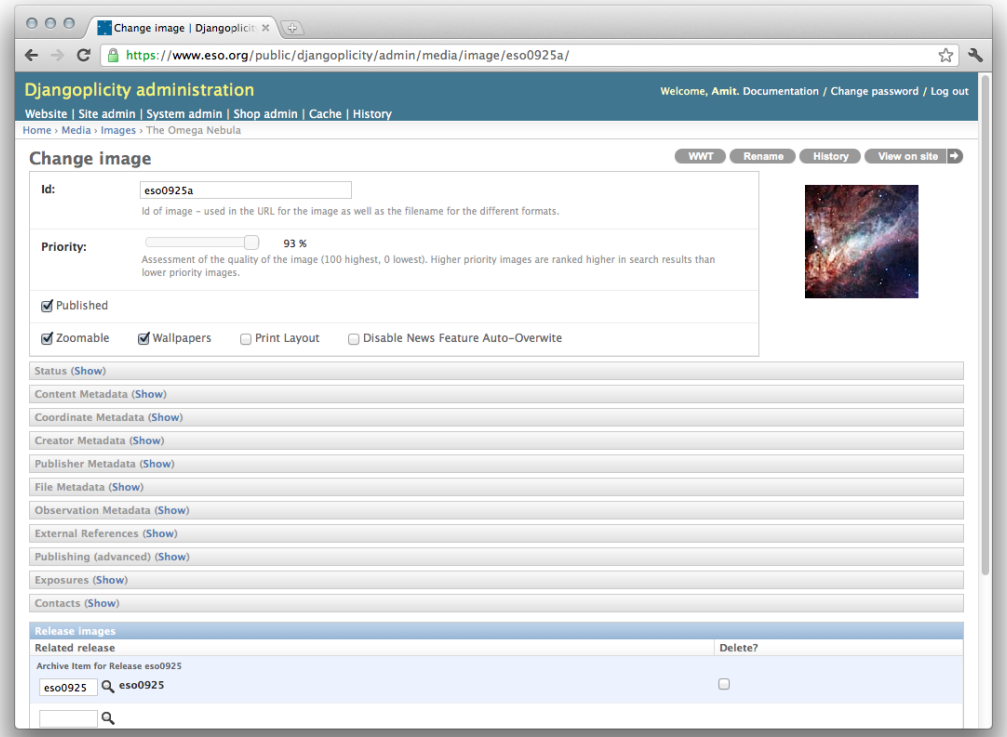

Figure 6-7 Form for manipulating metadata of an ESO image.

Copy and paste each value into the appropriate field of Djangoplicity.

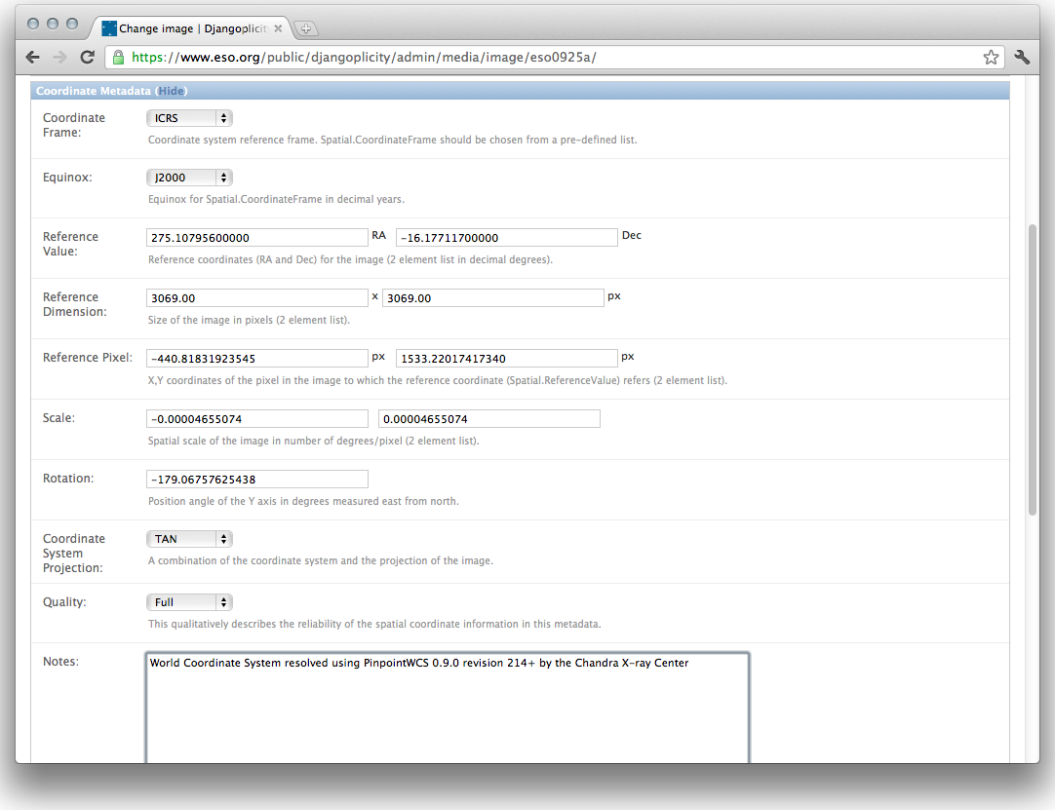

Figure 6-8 Completed form containing coordinate metadata.

In a near future an upload option in Djangoplicity for the XMP file will be provided.

Verify Coordinates

The quality of coordinates for every image on the spreadsheet must be checked. Once the coordinates have been transferred via Djangoplicity, a link will appear in the top right of the image page. Pressing this link will load the image in an online version of WorldWide Telescope (WWT) only if latest Internet Explorer (IE) browser on a Windows 7 machine is being used. Verify that the EPO image aligns correctly with the background image of WWT; an example of this process is outlined in Test Case 7: m17_ISAAC_jhk.

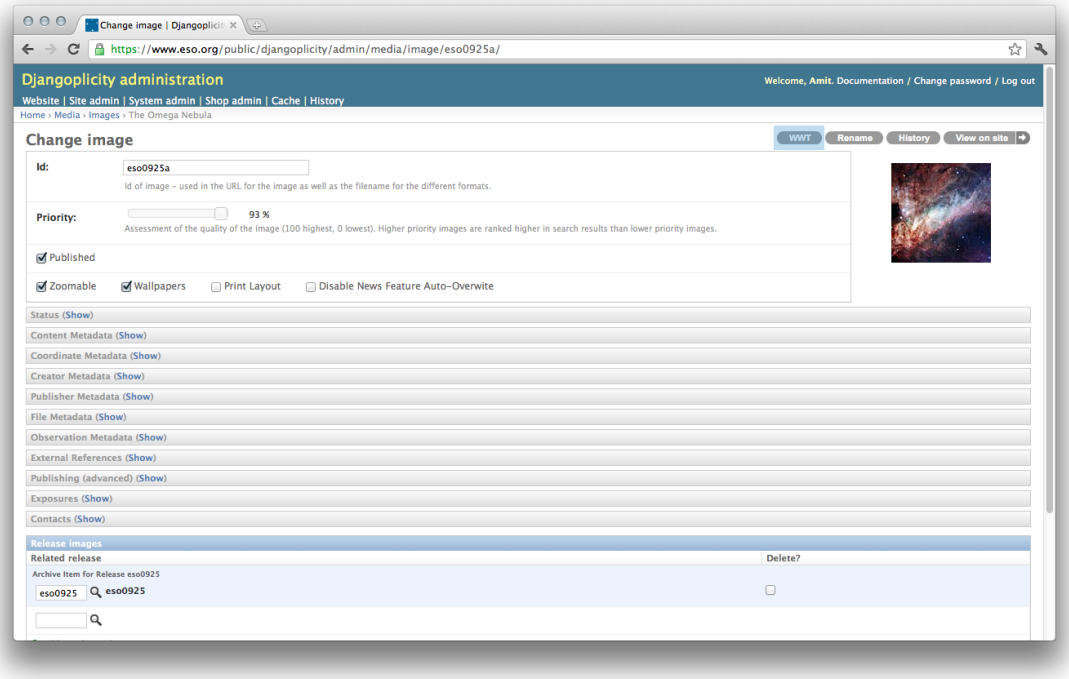

Figure 6-9 Highlighted WWT link in the top right

Update Spreadsheet

For each step in the process the spreadsheet contains fields that must be marked as completed. Be sure to mark each one as they are completed. The fields are titled:

- epo image obtained
- fits image obtained
- pinpointwcs done
- coordinates transfered to djangoplicity
- coordinates verified in WWT

Flowchart

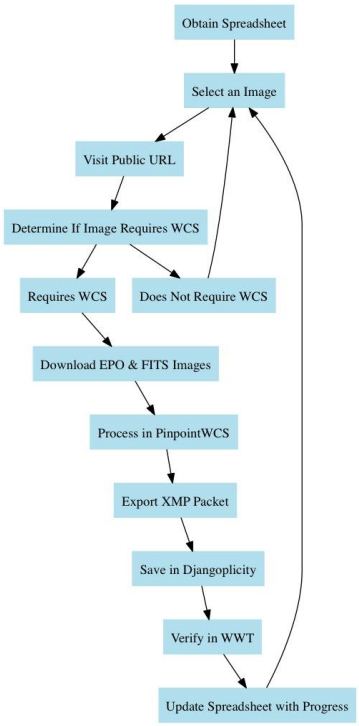

Figure 6-10 Flowchart of the WCS Process

7 Test Cases

The rest of this guide will follow a test case of tagging multiple EPO images derived from various observatories and instruments. The instruction provides a realistic perspective of the caveats that are inherent to the tagging process. The images in this test case were derived from ESO observatories and Hubble Space Telescope observations. Each image is tagged as complete as possible, and re-calibrated with WCS information.

The following example images are described:

Image name	Telescope	Instrument	Approx. Field of View	URL to tag image in Djangoplicity	WCS resolved?	WCS Resolver	Other problems
potw1007a	HST	ACS/HRC	0.48 arcminutes	https://www.spacetelescope.org/admin/media/image/potw1007a/	Yes	Pinpoint WCS	WCS is not very accurate due to the lack of features in the image.
eso0928c	VLTI	AMBER	-	http://www.eso.org/public/djangoplicity/admin/media/image/eso0928c/	No	-	Only one filter available. No coordinates calculated.
eso0925a	NTT	EMMI	8.6 arcminutes	http://www.eso.org/public/djangoplicity/admin/media/image/eso0925a/	Yes	Pinpoint WCS	
potw1009a	VLT	FORS1	6.74 arcminutes	https://www.spacetelescope.org/admin/media/image/potw1009a/	Yes	Pinpoint WCS	
eso0911a	VLT	FORS2	5.63 arcminutes	http://www.eso.org/public/djangoplicity/admin/media/image/eso0911a/	Yes	Pinpoint WCS	
ngc0157_HAWKI	VLT	HAWK-I	7.2 arcminutes	-	Yes	Astrometry.net	Unreleased image, no content metadata
m17_ISAAC_jhk	VLT	ISSAC	8.8 arcminutes	-	Yes	Pinpoint WCS	Did not resolve using Astrometry.net.

7.1 Metadata Templates

Using Adobe Bridge, navigate to the directory containing the test case images.

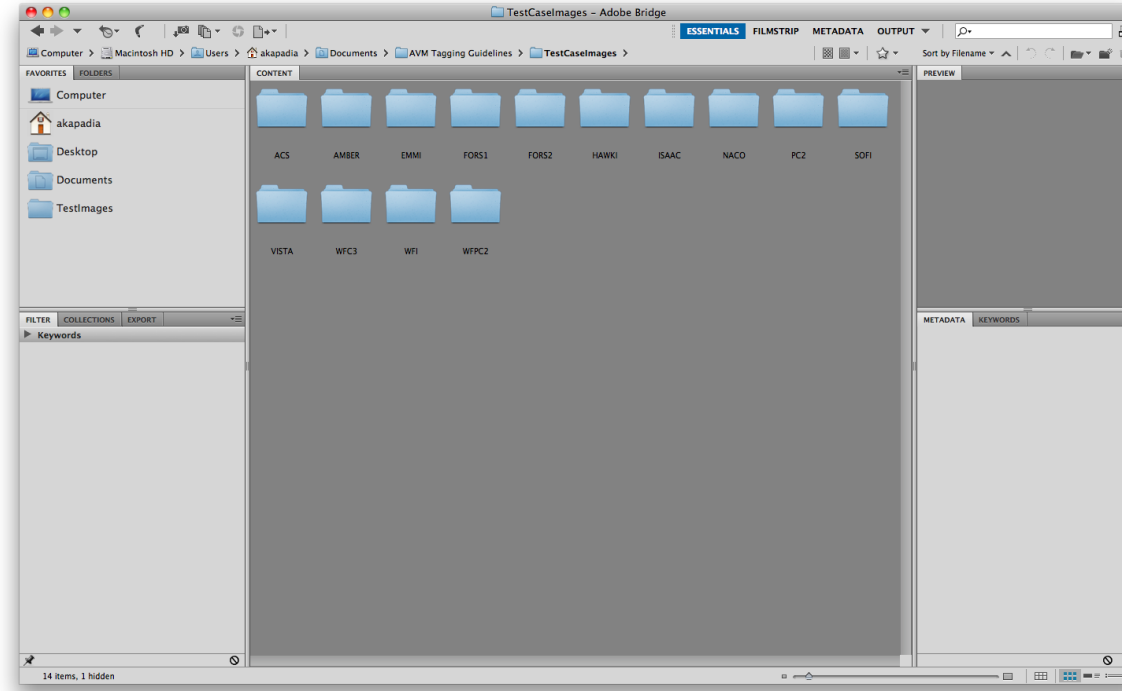

Figure 7-1 Adobe Bridge interface

This directory contains original FITS files and derived EPO images from several instruments equipped on ESO observatories and the Hubble Space Telescope. Each set of images is contained in its own directory.

The first objective is to tag all EPO images with “Creator” metadata. In this case, the ESO derived images will use the following information,

Creator	European Southern Observatory
Creator URL	http://www.eso.org
Contact Address	Karl-Schwarzschild-Strasse 2
Contact City	Garching bei München
Contact State/Province	Bavaria
Contact Postalcode	D-85748
Contact Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html

while the HST images will use,

Creator	ESA/Hubble
Creator URL	http://www.spacetelescope.org
Contact Address	Karl-Schwarzschild-Strasse 2
Contact City	Garching bei München
Contact State/Province	Bavaria
Contact Postalcode	D-85748
Contact Country	Germany
Rights	http://www.spacetelescope.org/copyright/

The quickest way to apply general metadata to a large number of images is to use a metadata template. Two templates will be created, one containing the contact information for ESO images, the other containing the contact information for ESA/Hubble images.

In Adobe Bridge, select “Tools->Create Metadata Template…” from the menu bar.

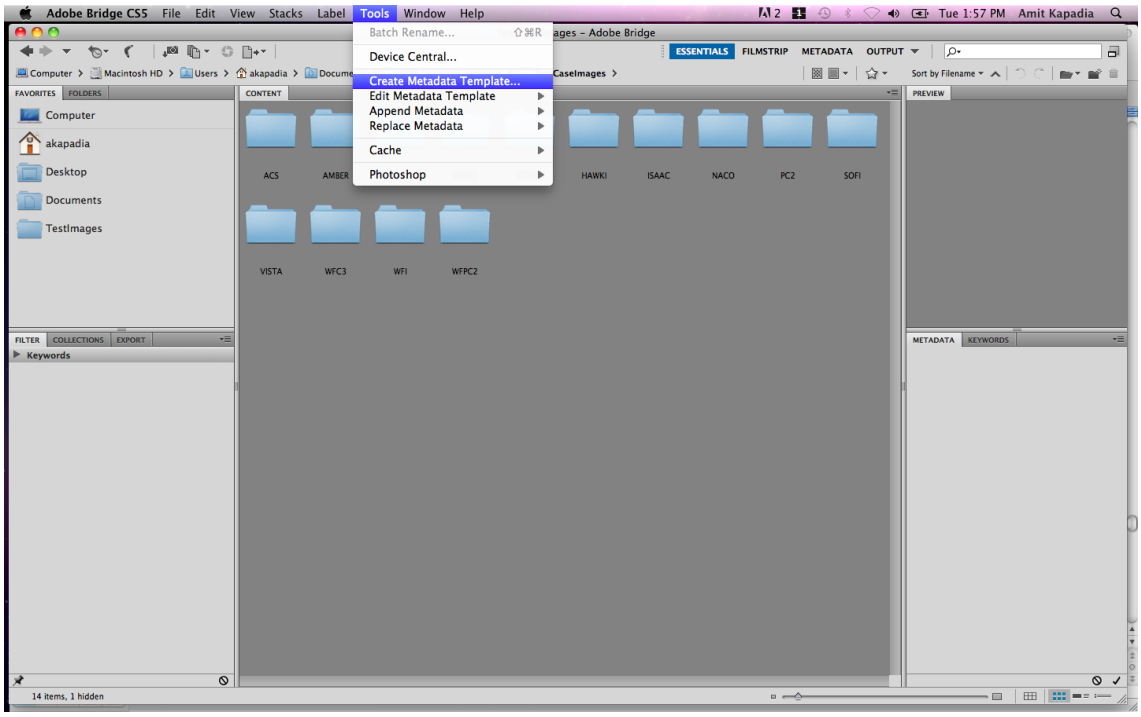

Figure 7-2 Creating a metadata template

This will open a dialog allowing users to create metadata templates. To create the template for ESO images, set the Template Name to an appropriate title, for instance, “ESO Contact Info”. The contact information that AVM uses is borrowed from the IPTC Core contact information. This means that to create an AVM template with contact information, the user must use the IPTC Core contact information.

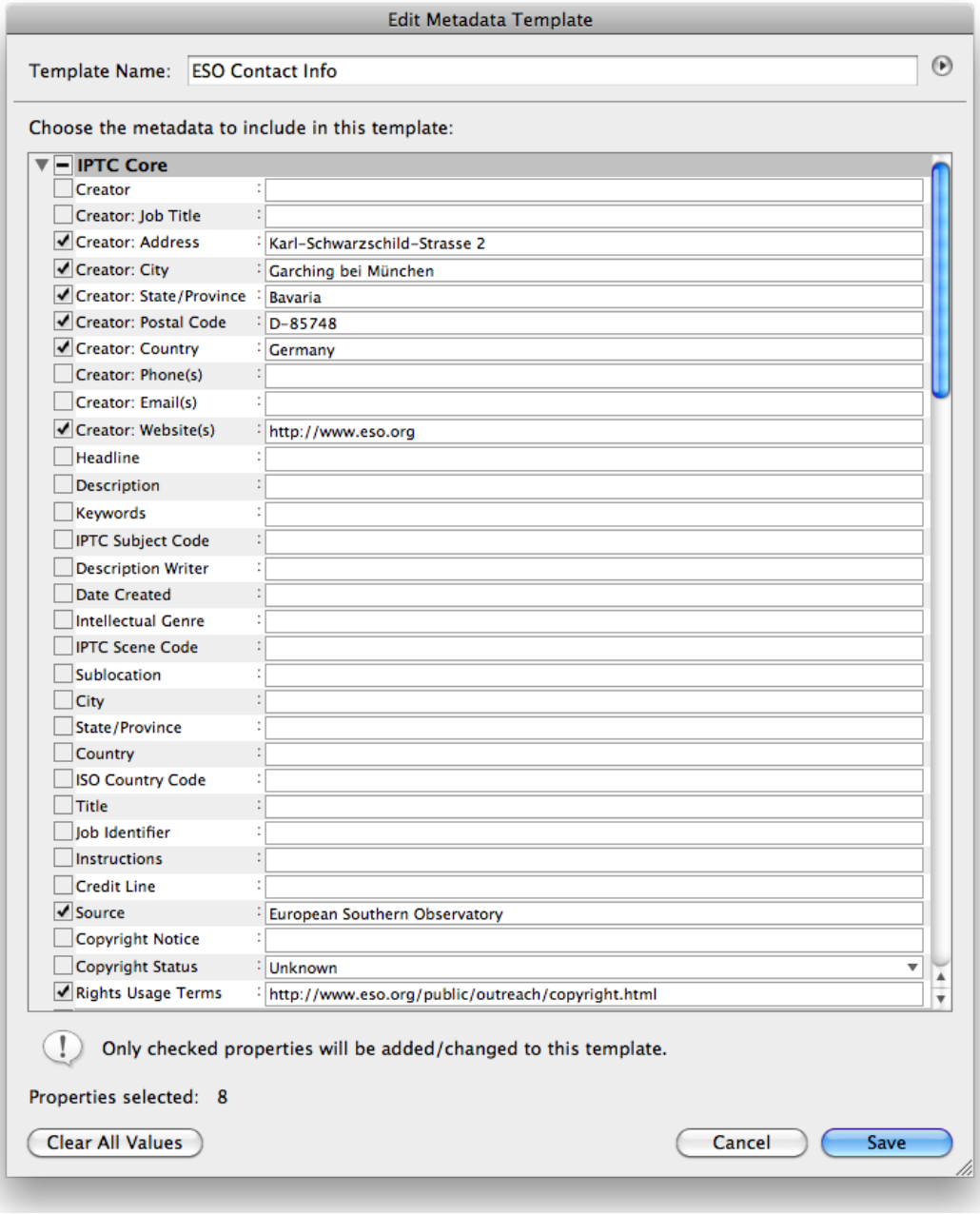

Figure 7-3 ESO contact metadata template

Notice that only the fields checked will be included in the template. Once the contact information has been included, click “Save”. This template is now available to quickly tag images with contact information.

The same is done for the ESA/Hubble images, with slightly different contact information.

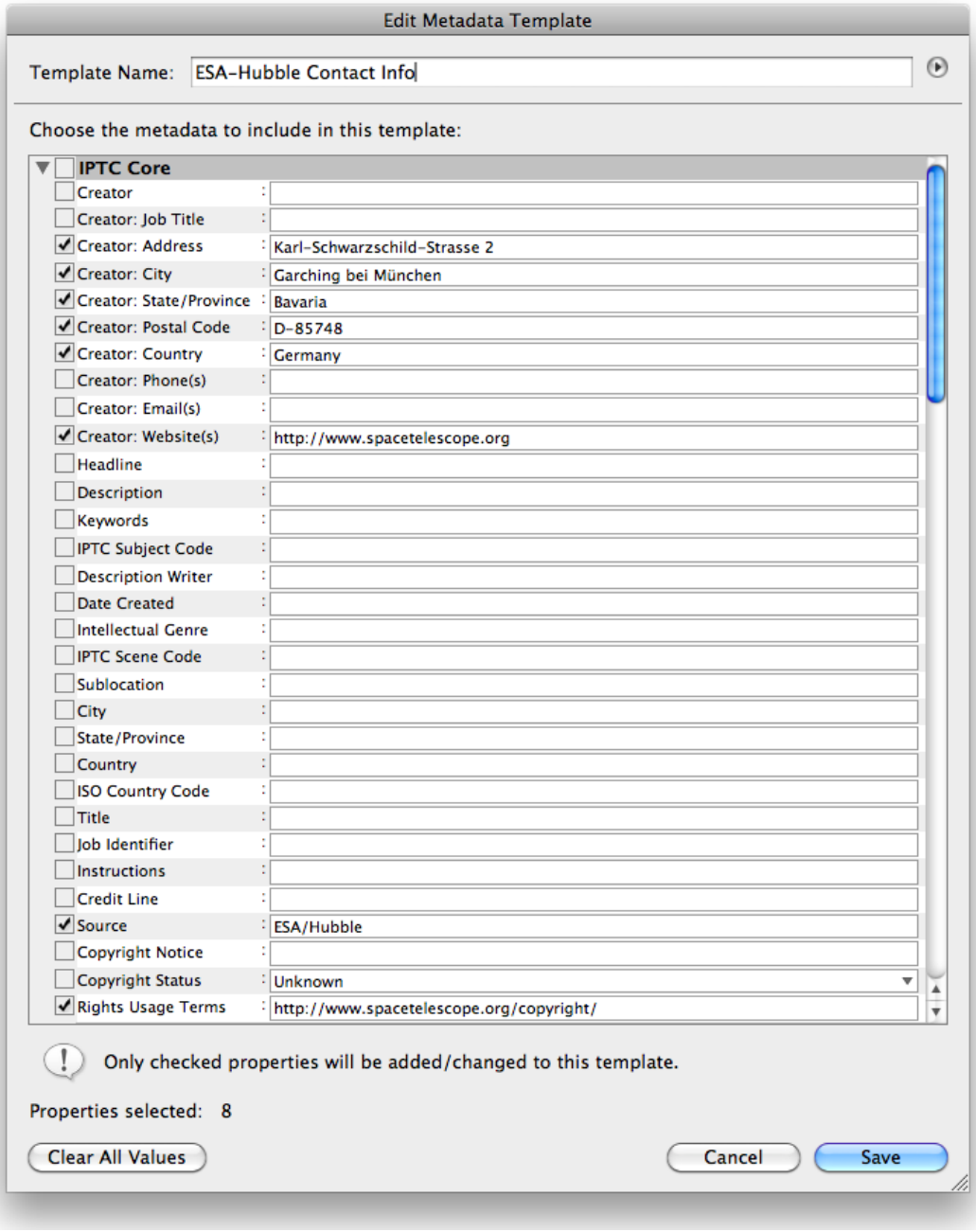

Figure 7-4 ESA/Hubble contact metadata template

With the metadata templates created, the test case images can be more easily tagged.

7.2 Test Case 1: Potw1007a

The first test case image is potw1007a. This is an EPO image derived from HST using the Advanced Camera for Surveys (ACS) instrument's High Resolution Channel (some of the highest resolution and smallest images from HST). To begin tagging the image, select it, then open the "File Info…" dialog in Adobe Bridge, and select the "Astronomy" tab.

On the bottom right of the dialog appears a drop-down menu that lists the metadata templates created in the previous section. Since this is an ESA/Hubble image, the image requires the ESA/Hubble contact information.

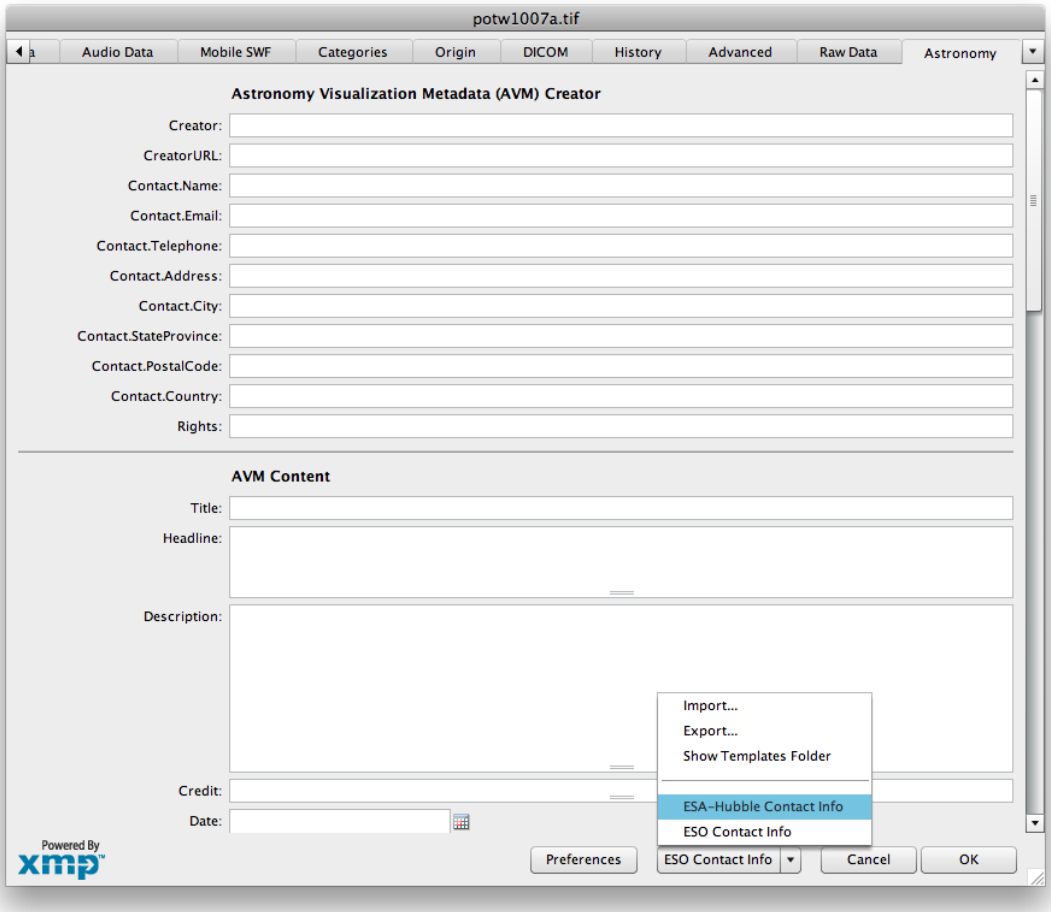

Figure 7-5 Applying a metadata template

Just before applying the template, Bridge prompts the user to select the method in which to apply the metadata. Choose the second method, “Keep original metadata, but replace matching properties from template”. This choice ensures that any existing metadata is preserved, while overwriting the contact information with metadata contained in the template.

Once the contact metadata has been completed, the user needs to complete the other AVM fields, which are specific to the image. Much of the information in the “Content” category can be obtained from the web page associated with the image release.

Searching on www.spacetelescope.org , the image release page is found to be: http://www.spacetelescope.org/images/potw1007a/.

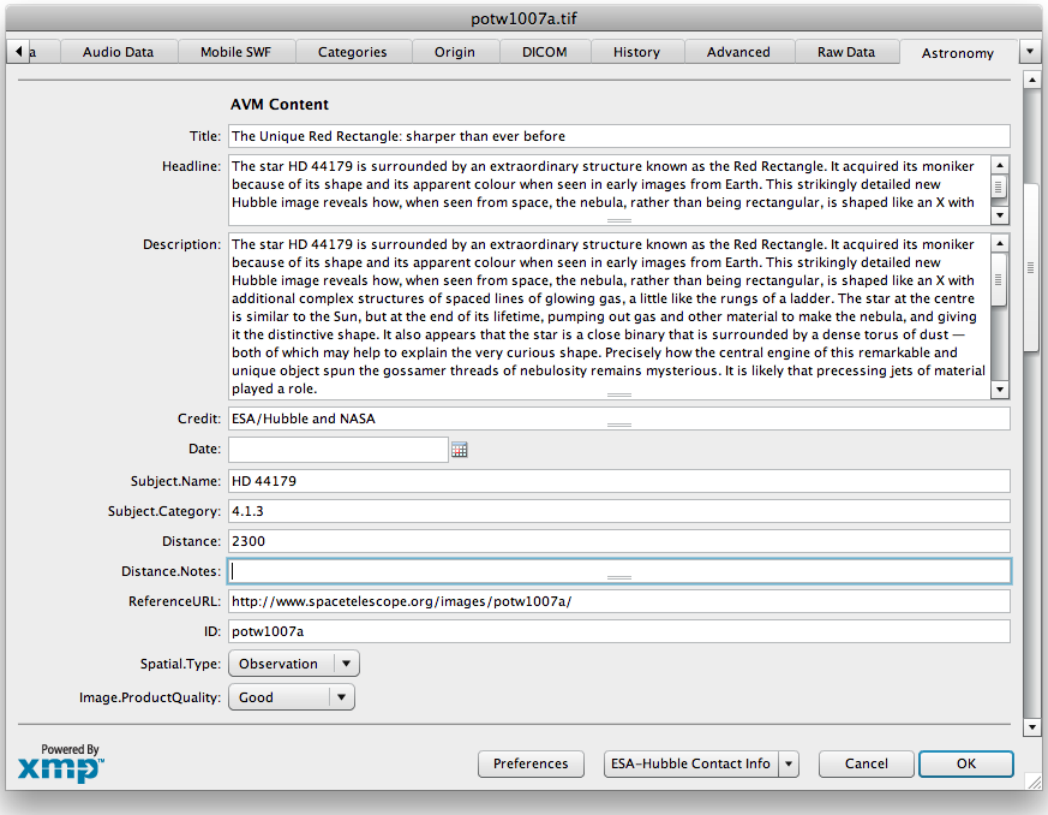

Figure 7-6 AVM Content fields

- The **Title** field is taken from the release title on the webpage.
- The **Headline** field is meant to summarize the description in a few sentences; it is generally okay to select the first few sentences from the description, while also ensuring the headline is self-contained and coherent.
- The **Description** field may be copied directly from the article on the webpage.
- The **Credit** field is also copied directly from the webpage.
- The **Date** field refers to the date in which the image was released. This information is not readily available from the webpage.
- The **Subject.Name** may be copied from the webpage; it is located in the section titled “About the Object”.
- The **Subject.Category** field is a numeric code specifying the type of astronomical object. These codes are available in the appendix of this document.
- The **Distance** field can store up to two values, the first is a value with units of light years, and the second has units of red shift. In this case, only the light years unit is available in the description of the image. Often Simbad (http://simbad.u-strasbg.fr/Simbad) have reliable distance values.
- The **Distance.Notes** is an optional field reserved for a more detailed description of the Distance field. In this case, no additional information is necessary.
- The **ReferenceURL** field refers to the URL of the webpage containing this information.
- The **ID** field refers to the specifier used by ESA/Hubble to identify the image.

- The Spatial.Type refers to the type of image; in this case, the image was derived from observations.
- The Image.ProductQuality is a subjective field that measures the quality of the image. Since the image has high-resolution, this field may be marked as "Good".

The next category is "Observation". This category requires the user to hunt for more detail. Often with archived images, the information needed to complete these fields may not be available. Attempt to complete as many fields as possible.

In this case, much of the "Observation" information is found in the description of the object. The image is composed of two observations from the HST using the ACS instrument. The two filters are F658N and F625W, which are colored red and blue, respectively.

- The Facility field composes of two facilities: "HST; HST". Keep in mind that many of these fields are multi-valued, with each value separated by a semi-colon.
- The Instrument field is "ACS; ACS", since both observations come from the ACS instrument.
- The Spectral.ColorAssignment is "Red; Blue". The first layer is colored red, the second, blue.
- The Spectral.Band is "Optical; Optical" since both observations are samples from the optical wavelengths.
- The Spectral.Bandpass is "H-alpha; R". These are more specific abbreviations associated with the wavelength captured by each observation. In this case, these observations may be found from the ACS documentation found at: http://www.stsci.edu/hst/acs/documents/handbooks/cycle18/toc.html.
- The Spectral.CentralWavelength are "658; 625", and refer to the wavelength that is in the middle of the observed spectral band. These values are measured in nano-meters.
- The Temporal.StartTime refers to the date or date-time in which the observation was taken. This information can only be found in the FITS header of the original data. Since this image is composed of two observations, both FITS files are required to obtain the complete information. Currently only one of the FITS files is available, the one associated with the F625W image; only this portion of the data will be filled. Using DS9, select "File->Display FITS Header…" and search for the FITS keyword "DATE-OBS". This field is filled with the following: "-; 2006-10-24", where the dash represents missing data.
- The Temporal.IntegrationTime refers to the duration in which the observation was conducted. This information is also located in the FITS header of each observation. As in the case above, only one FITS file is available, so the data will be partially completed. The associated FITS keyword is "EXPTIME", in this case, the field is filled with "-; 264.0", measured in seconds.
- The DatasetID field is completed using a unique identifier to each observation. As in the above cases, only one observation is available. In this case, the FITS keyword "ASN_ID" yields "J9QO01020" as the identifier.
- The Spectral.Notes field is reserved for any additional notes that the user wants to provide.

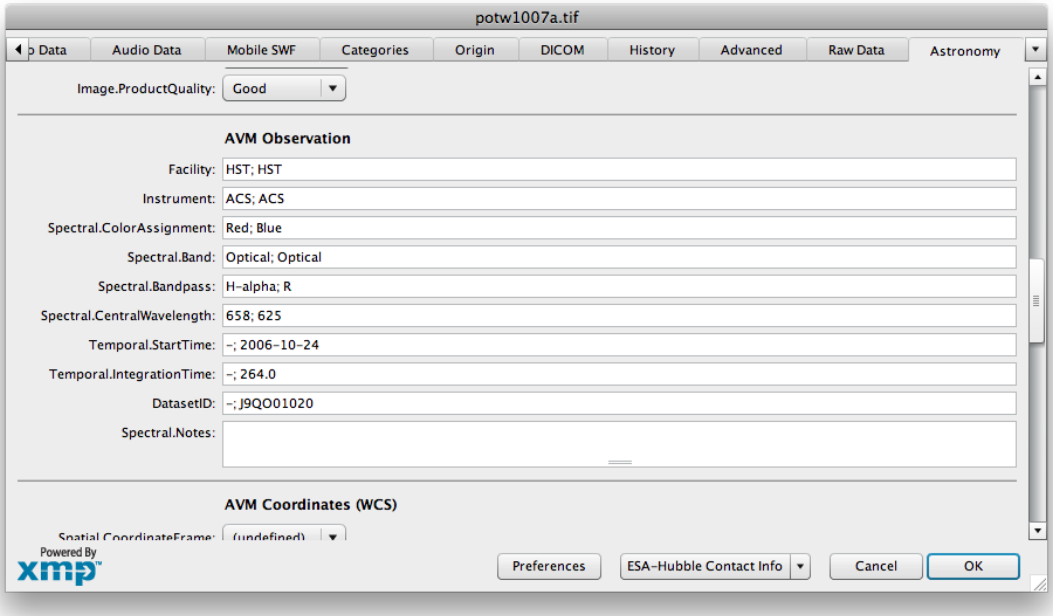

Figure 7-7 AVM Observation fields

It is important to note the majority of these fields are multi-valued. In this case, there are two elements for each field. If the image were composed of more layers, then there would be one element for each layer, for each field.

To properly complete the next category, the image needs to be retrofitted with World Coordinate System (WCS) information. These data are astronomical coordinates that describe the location, scale, and rotation of the object in the celestial coordinate system. Since this is an HST image, the preferred method is to use PinpointWCS.

To use PinpointWCS, the user must have access to a FITS image with WCS of the same field of view as the EPO image. It is best to use a FITS image that was used to derive the EPO image, but this is not strictly necessary.

Open PinpointWCS, and drag the FITS image on to the left panel, and the EPO image on to the right panel.

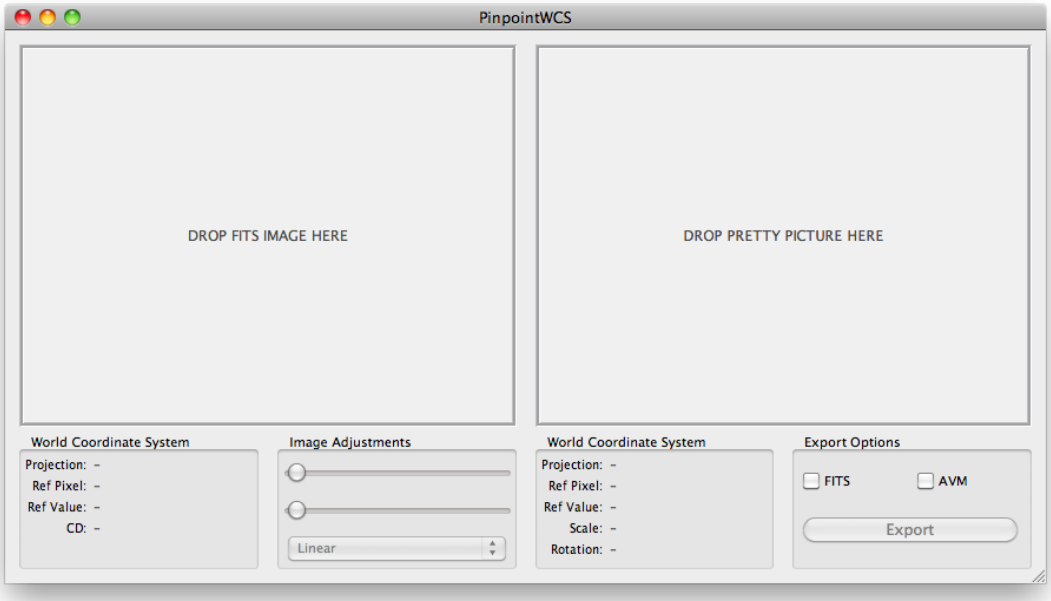

Figure 7-8 PinpointWCS interface

Once both images have been loaded, search both images for common features. When common features are found, start by double-clicking on the feature in the FITS image, followed by double-clicking the corresponding feature in the EPO image. This is place a marker over each image. This must be done a minimum of 3 times in order for the new coordinates to be calculated.

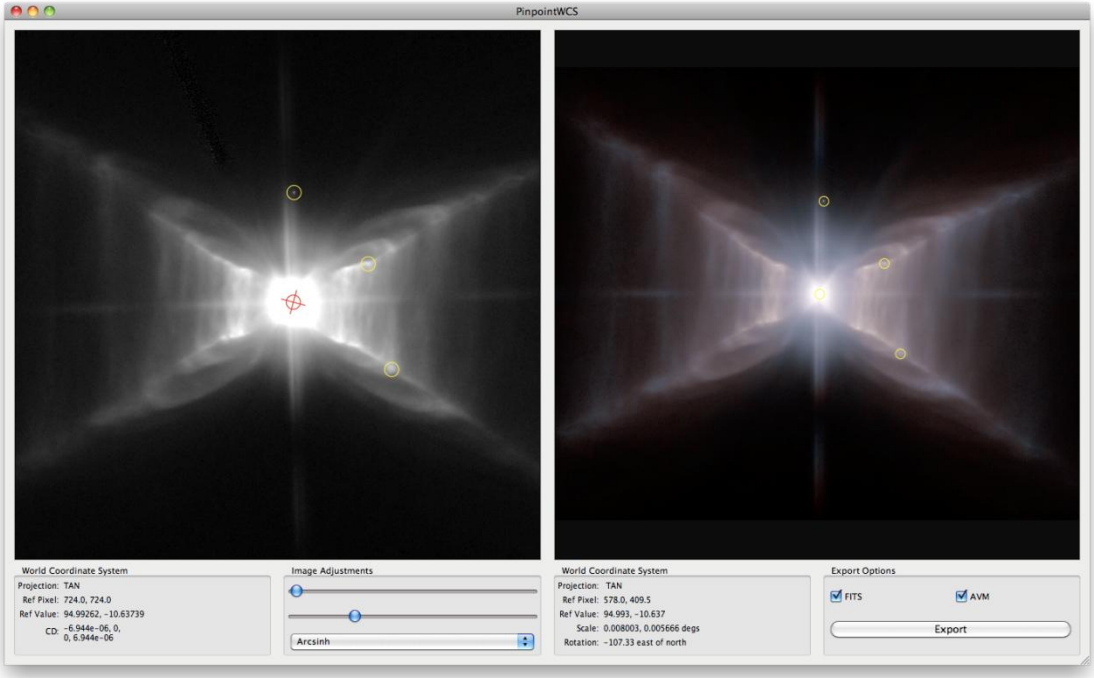

Figure 7-9 PinpointWCS with images loaded

Once the WCS for the EPO image is calculated, it must be exported. There are currently two options for export: as a FITS image, or via AVM. The FITS image option will export a FITS file that may be opened in any FITS viewer, the AVM option will write the coordinates directly to the image.

Export as AVM, and view the addition in Adobe Bridge.

The last section to complete is the Publisher category. Many of these fields are reserved for a future service, thus, they cannot be completed at the present. The only fields that can be completed are, MetadataDate and MetadataVersion. Mark the current date for the first, and version 1.1 for the latter.

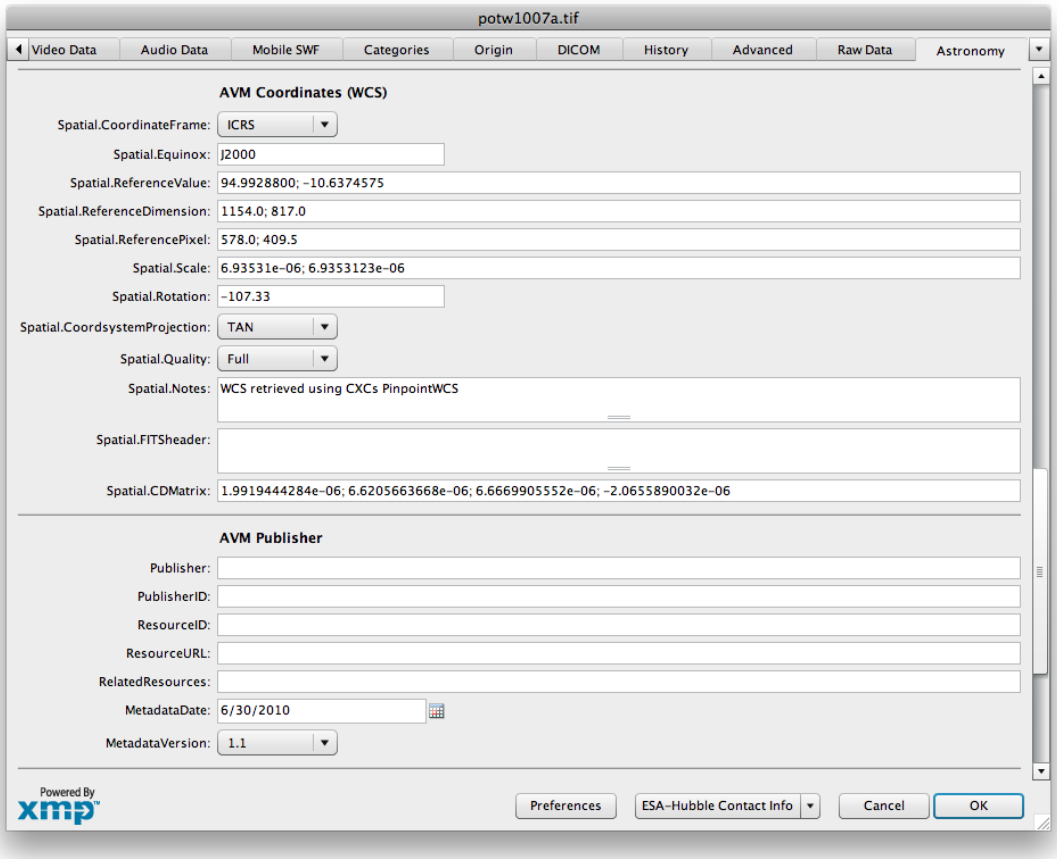

Figure 7-10 AVM Coordinates and Publisher fields

This completes the tagging of the first test case. Below is a table summarizing the metadata for this case.

Creator	ESA/Hubble
CreatorURL	http://www.spacetelescope.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.spacetelescope.org/copyright/
Title	The Unique Red Rectangle: sharper than ever

	before
Headline	The star HD 44179 is surrounded by an extraordinary structure known as the Red Rectangle. It acquired its moniker because of its shape and its apparent colour when seen in early images from Earth. This strikingly detailed new Hubble image reveals how, when seen from space, the nebula, rather than being rectangular, is shaped like an X with additional complex structures of spaced lines of glowing gas, a little like the rungs of a ladder.
Description	The star HD 44179 is surrounded by an extraordinary structure known as the Red Rectangle. It acquired its moniker because of its shape and its apparent colour when seen in early images from Earth. This strikingly detailed new Hubble image reveals how, when seen from space, the nebula, rather than being rectangular, is shaped like an X with additional complex structures of spaced lines of glowing gas, a little like the rungs of a ladder. The star at the centre is similar to the Sun, but at the end of its lifetime, pumping out gas and other material to make the nebula, and giving it the distinctive shape. It also appears that the star is a close binary that is surrounded by a dense torus of dust — both of which may help to explain the very curious shape. Precisely how the central engine of this remarkable and unique object spun the gossamer threads of nebulosity remains mysterious. It is likely that precessing jets of material played a role. The Red Rectangle is an unusual example of what is known as a proto-planetary nebula. These are old stars, on their way to becoming planetary nebulae. Once the expulsion of mass is complete a very hot white dwarf star will remain and its brilliant ultraviolet radiation will cause the surrounding gas to glow. The Red Rectangle is found about 2 300 light-years away in the constellation Monoceros (the Unicorn). The High Resolution Channel of the NASA/ESA Hubble Space Telescope's Advanced Camera for Surveys captured this view of HD 44179 and the surrounding Red Rectangle nebula — the sharpest view so far. Red light from glowing Hydrogen was captured through the F658N filter and coloured red. Orange-red light over a wider range of wavelengths through a F625W filter was coloured blue. The field of view is about 25 by 20 arcseconds.

Credit	ESA/Hubble and NASA
Subject.Name	HD 44179
Subject.Category	4.1.3
Distance	2300
ReferenceURL	http://www.spacetelescope.org/images/potw1007a/
ID	potw1007a
Type	Observation
Image.ProductQuality	Good
Facility	HST; HST
Instrument	ACS; ACS
Spectral.ColorAssignment	Red; Blue
Spectral.Band	Optical; Optical
Spectral.Bandpass	H-alpha; R
Spectral.CentralWavelength	658; 625
Temporal.StartTime	-; 2006-10-24
Temporal.IntegrationTime	-; 264.0
DatasetID	-; J9QO01020
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	J2000
Spatial.ReferenceValue	94.9928800; -10.6374575
Spatial.ReferenceDimension	1154.0; 817.0
Spatial.ReferencePixel	578.0; 409.5
Spatial.Scale	6.93531e-06; 6.9353123e-06
Spatial.Rotation	-107.33
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full
Spatial.Notes	WCS retrieved using CXCs PinpointWCS
Spatial.CDMatrix	1.9919444284e-06; 6.6205663668e-06; 6.6669905552e-06; -2.0655890032e-06
MetadataDate	6/30/2010

MetadataVersion	1.1

7.3 Test Case 2: eso0928c

The next test case is an ESO image with ID eso0928c. Many of the steps for tagging this image are identical to the first test case; however, there are some differences.

First the image needs to be tagged with contact information. Just as in the first test case, locate the file in Adobe Bridge, open the metadata panels, and apply the “ESO Contact Info” template.

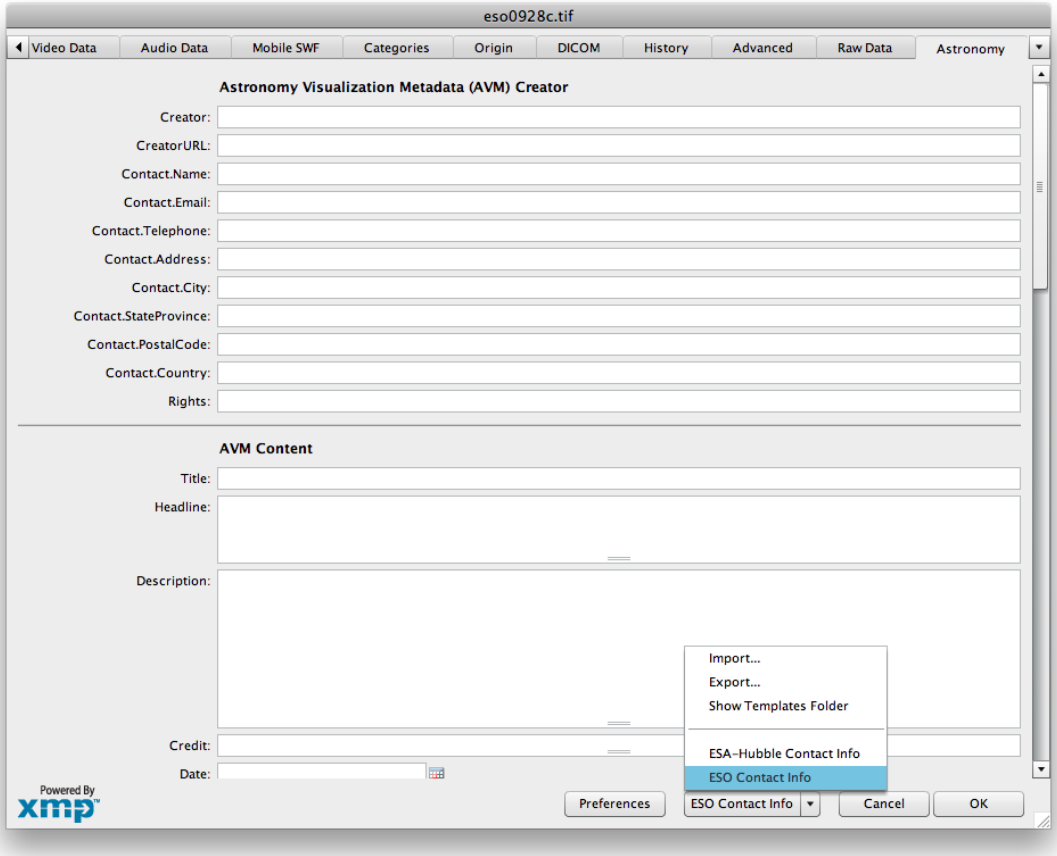

Figure 7-11 Applying contact template

Next, search www.eso.org to locate the webpage corresponding to the image. In this case the webpage is located at: http://www.eso.org/public/images/eso0928c/. Much of the information needed for the Content category is located on this webpage; however, additional information can be found in the paper written by the principle investigator of these observations. That papers can be found at: http://www.eso.org/public/archives/oldpdfs/HD87643_v4_1.pdf.

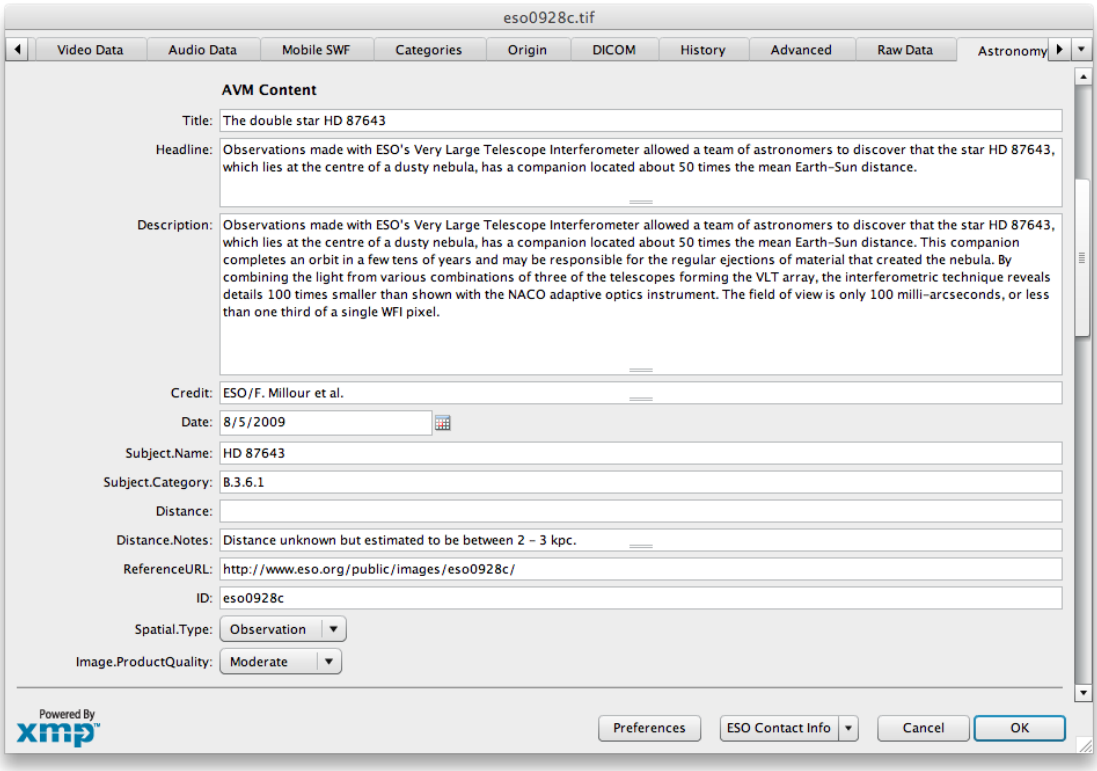

Figure 7-12 AVM Content fields

Notice the Distance field is left blank. In the scientist's paper it is stated that there are no precise measurements for the object's distance, only a rough estimate between 2–3 kpc.

The Observation category is filled using data from a single FITS files. Even though the EPO image is derived from more than one observation, these other FITS images are not readily accessible. The Observation category will be filled, though incomplete.

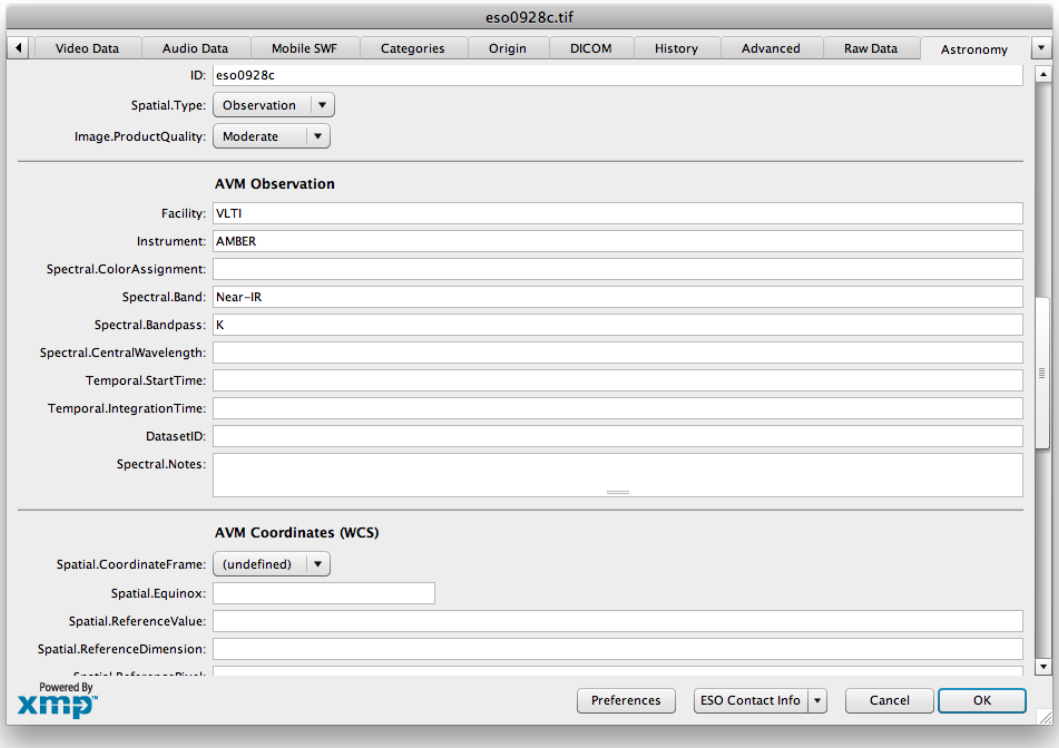

Figure 7-13 AVM Observation fields

Since the FITS image does not contain much information, the image may only be tagged with the information show in the image above.

Additionally, WCS retrofitting of this image is not possible since the FITS image does not contain WCS information. One alternative is to use Astrometry.net, however the image does not resolve with so few point sources. This is an example of an image that cannot be resolved using the currently available EPO tools.

To complete the tagging of this image, the MetadataData and MetadataVersion need to be filled, using the current date, and version “1.1”, respectively.

Below is a table summarizing the metadata.

Creator	European Southern Observatory
CreatorURL	http://www.eso.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html

Title	The double star HD 87643
Headline	Observations made with ESO's Very Large Telescope Interferometer allowed a team of astronomers to discover that the star HD 87643, which lies at the centre of a dusty nebula, has a companion located about 50 times the mean Earth-Sun distance.
Description	Observations made with ESO's Very Large Telescope Interferometer allowed a team of astronomers to discover that the star HD 87643, which lies at the centre of a dusty nebula, has a companion located about 50 times the mean Earth-Sun distance. This companion completes an orbit in a few tens of years and may be responsible for the regular ejections of material that created the nebula. By combining the light from various combinations of three of the telescopes forming the VLT array, the interferometric technique reveals details 100 times smaller than shown with the NACO adaptive optics instrument. The field of view is only 100 milli-arcseconds, or less than one third of a single WFI pixel.
Credit	ESO/F. Millour et al.
Date	8/5/2009
Subject.Name	HD 87643
Subject.Category	B.3.6.1
Distance.Notes	Distance unknown but estimated to be between 2 - 3 kpc.
ReferenceURL	http://www.eso.org/public/images/eso0928c/
ID	eso0928c
Type	Observation
Image.ProductQuality	Moderate
Facility	VLTI
Instrument	AMBER
Spectral.Band	Near-IR
Spectral.Bandpass	K
MetadataDate	6/30/2010
MetadataVersion	1.1

7.4 Test Case 3: eso0925a

This test case differs from the previous two, in that the user has access to two FITS images. Much like the process for the previous two cases, the user must apply the ESO contact information using the metadata template, locate the webpage associated with eso0925a, and complete the Content and Observation categories. The associated webpage is: http://www.eso.org/public/news/eso0925/.

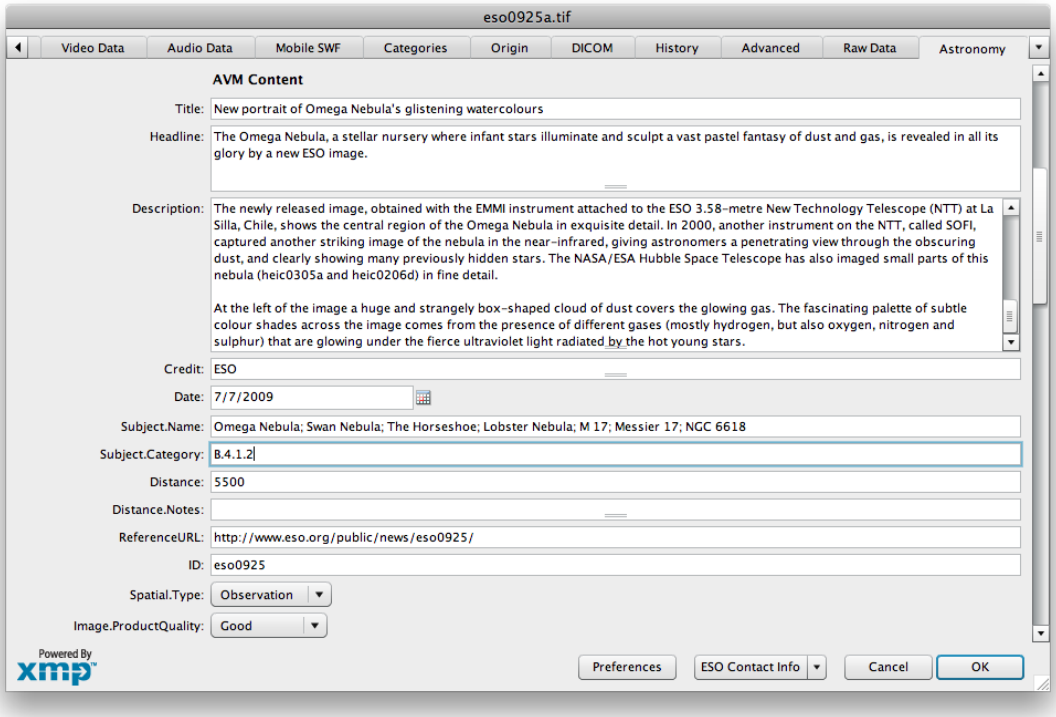

Figure 7-14 AVM Content fields

In this case, there is no explicit credit listed, so it is offered to ESO. If this were an ESA/Hubble image the credit would be attributed to ESA/Hubble. The Subject.Name field contains a variety of names that refer to the object. Many of these names are stated in the description, while some are taken from the HEIC webpage: http://www.spacetelescope.org/images/heic0305a/. It is important to use other references to get a complete description of the object(s) in the image.

The Observation category is difficult for this case. Because of the richness in color, it is clear that the image is derived from at least 3 observations (probably more), but the description does not offer any information about the composition. Based on one of the FITS files, the Observation metadata may be filled out as shown in the figure.

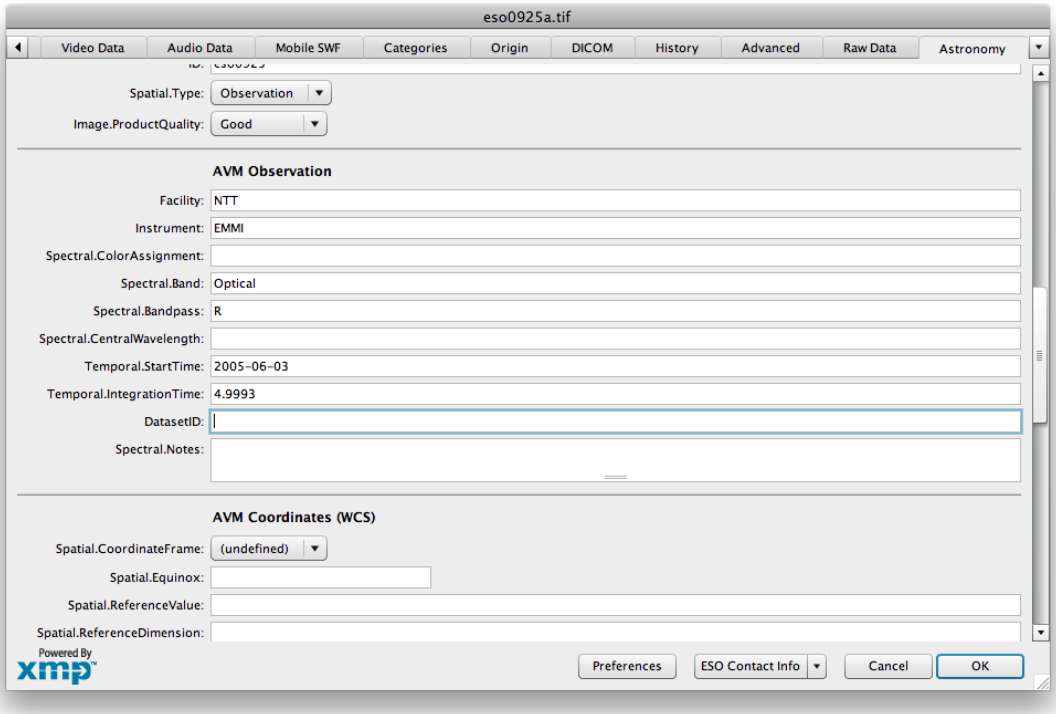

Figure 7-15 AVM Observation fields

For the last category, Coordinates, the user is limited. The FITS images that are supplied do not contain equatorial coordinates, so PinpointWCS will not able to compute a tangential mapping. Submitting the image through Astrometry.net does not work either; the image fails to resolve. Another alternative is to obtain another FITS image containing the same object, and which has an equatorial projection. The DSS archive is the easiest database to search[11].

[11] http://archive.stsci.edu/cgi-bin/dss_form

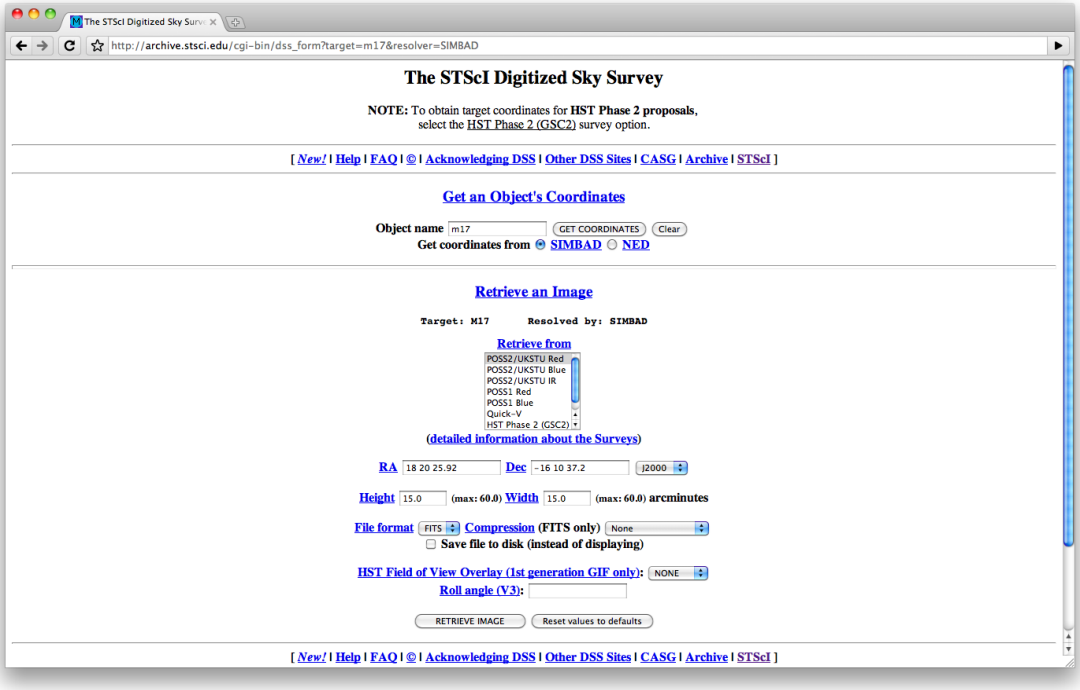

Figure 7-16 DSS Archive

Type the name of the object in the field titled “Object name”, and press “GET COORDINATES”; SIMBAD is usually able to resolve the right ascension and declination. Next click “Retrieve Image”, and a DSS image of the field of view will be downloaded. Be sure to rename the file, adding the extension “.fits”, otherwise FITS viewers, such as PinpointWCS, may not be able to recognize the file.

Using PinpointWCS, import the DSS and EPO images, and begin matching corresponding features.

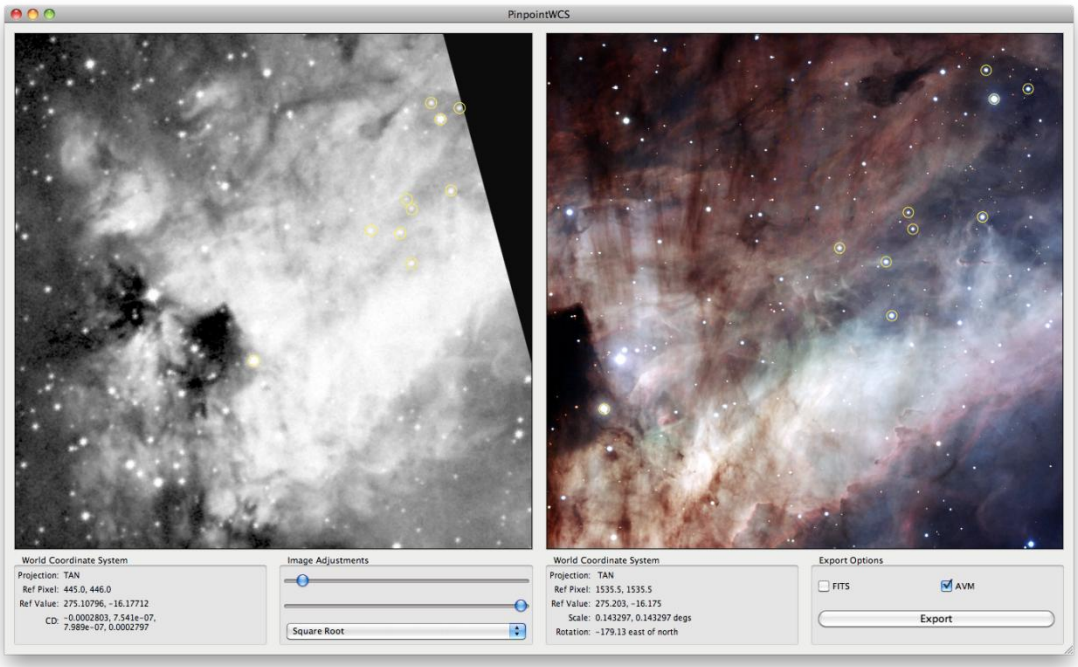

Figure 7-17 PinpointWCS with DSS data

When a sufficient number of features have been matched, export via AVM. Upon checking in Adobe Bridge, the new coordinates appear.

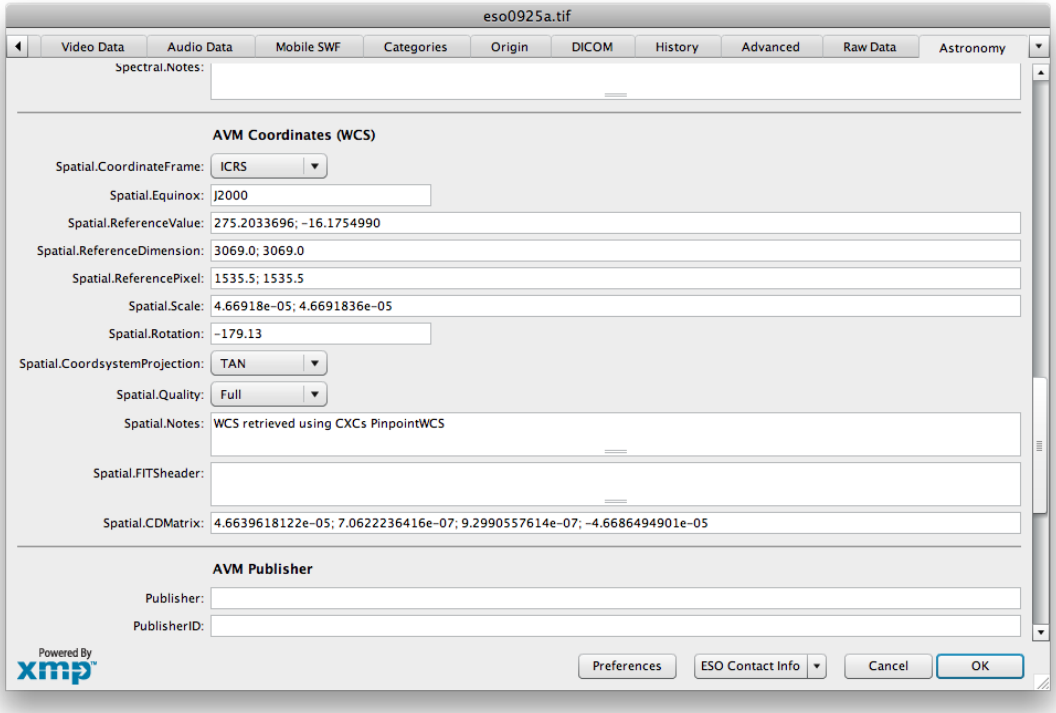

Figure 7-18 Coordinates for M17 retrieved using PinpointWCS

This case highlights the absence of observation data, and requires the user to search for an appropriate FITS image to compute coordinates. These are standard procedures needed to effectively tag an EPO image, and will be used frequently in practice.

Just as done for the previous test cases, the MetadataDate and MetadataVersion fields need to be completed.

Creator	European Southern Observatory
CreatorURL	http://www.eso.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html
Title	New portrait of Omega Nebula's glistening watercolours
Headline	The Omega Nebula, a stellar nursery where infant stars illuminate and sculpt a vast pastel fantasy of dust and gas, is revealed in all its glory by a new ESO image.
Description	The Omega Nebula, sometimes called the Swan Nebula, is a dazzling stellar nursery located about 5500 light-years away towards the constellation of Sagittarius (the Archer). An active star-forming region of gas and dust about 15 light-years across, the nebula has recently spawned a cluster of massive, hot stars. The intense light and strong winds from these hulking infants have carved remarkable filigree structures in the gas and dust. When seen through a small telescope the nebula has a shape that reminds some observers of the final letter of the Greek alphabet, omega, while others see a swan with its distinctive long, curved neck. Yet other nicknames for this evocative cosmic landmark include the Horseshoe and the Lobster Nebula. Swiss astronomer Jean-Philippe Loys de Chéseaux discovered the nebula around 1745. The French comet hunter Charles Messier independently rediscovered it about twenty years later and included it as number 17 in his famous catalogue. In a small telescope, the Omega Nebula appears as an enigmatic ghostly bar of light set against the star fields of the Milky Way. Early observers were unsure whether this curiosity was really a cloud of gas or a remote cluster of

	stars too faint to be resolved. In 1866, William Huggins settled the debate when he confirmed the Omega Nebula to be a cloud of glowing gas, through the use of a new instrument, the astronomical spectrograph. In recent years, astronomers have discovered that the Omega Nebula is one of the youngest and most massive star-forming regions in the Milky Way. Active star-birth started a few million years ago and continues through today. The brightly shining gas shown in this picture is just a blister erupting from the side of a much larger dark cloud of molecular gas. The dust that is so prominent in this picture comes from the remains of massive hot stars that have ended their brief lives and ejected material back into space, as well as the cosmic detritus from which future suns form. The newly released image, obtained with the EMMI instrument attached to the ESO 3.58-metre New Technology Telescope (NTT) at La Silla, Chile, shows the central region of the Omega Nebula in exquisite detail. In 2000, another instrument on the NTT, called SOFI, captured another striking image of the nebula in the near-infrared, giving astronomers a penetrating view through the obscuring dust, and clearly showing many previously hidden stars. The NASA/ESA Hubble Space Telescope has also imaged small parts of this nebula (heic0305a and heic0206d) in fine detail. At the left of the image a huge and strangely box-shaped cloud of dust covers the glowing gas. The fascinating palette of subtle colour shades across the image comes from the presence of different gases (mostly hydrogen, but also oxygen, nitrogen and sulphur) that are glowing under the fierce ultraviolet light radiated by the hot young stars.
Credit	ESO
Date	7/7/2009
Subject.Name	Omega Nebula; Swan Nebula; The Horseshoe; Lobster Nebula; M 17; Messier 17; NGC 6618
Subject.Category	B.4.1.2
Distance	5500
ReferenceURL	http://www.eso.org/public/news/eso0925/

ID	eso0925
Type	Observation
Image.ProductQuality	Good
Facility	NTT
Instrument	EMMI
Spectral.Band	Optical
Spectral.Bandpass	R
Temporal.StartTime	2005-06-03
Temporal.IntegrationTime	4.9993
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	J2000
Spatial.ReferenceValue	275.2033696; -16.1754990
Spatial.ReferenceDimension	3069.0; 3069.0
Spatial.ReferencePixel	1535.5; 1535.5
Spatial.Scale	4.66918e-05; 4.6691836e-05
Spatial.Rotation	-179.13
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full
Spatial.Notes	WCS retrieved using CXCs PinpointWCS
Spatial.CDMatrix	4.6639618122e-05; 7.0622236416e-07; 9.2990557614e-07; -4.6686494901e-05
MetadataDate	6/30/2010
MetadataVersion	1.1

7.5 Test Case 4: potw1009a

This test case is an image from ESO's VLT observatory using the FORS1 instrument. Two FITS files are supplied. As is usual, search for the EPO image via the ESO website. The webpage is found to be: http://www.eso.org/public/images/potw1009a/.

Using the information found on this page, the user may fill out the AVM fields.

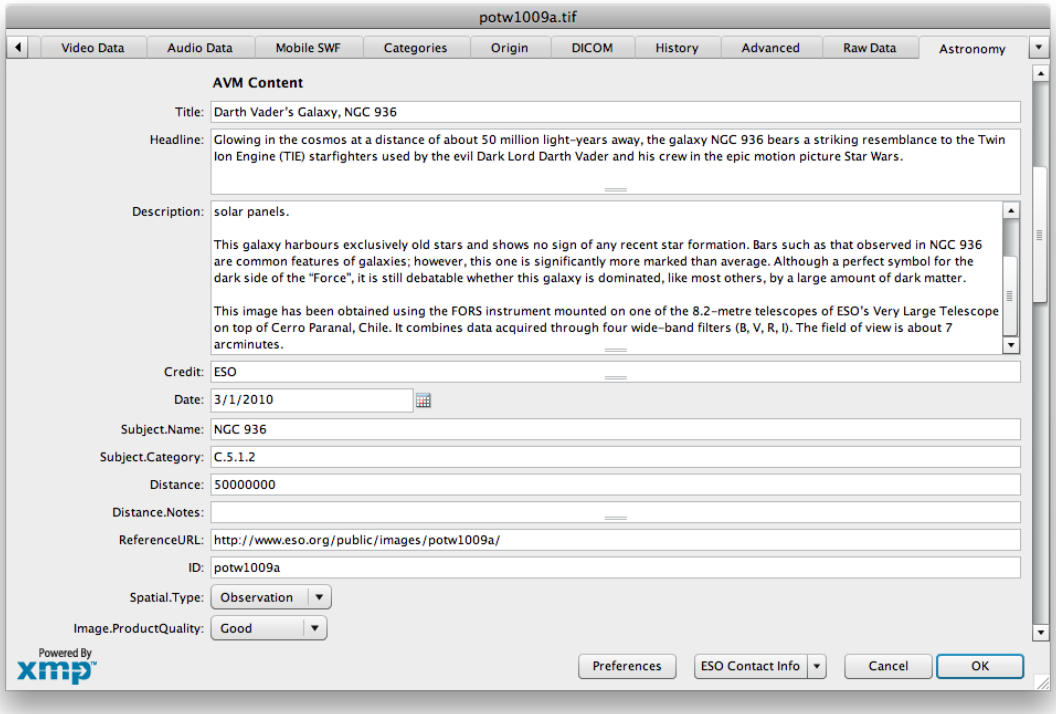

Figure 7-19 Content metadata for Potw1009a

Each of these fields is directly pulled from information on the webpage. The Subject.Category field represents a barred galaxy.

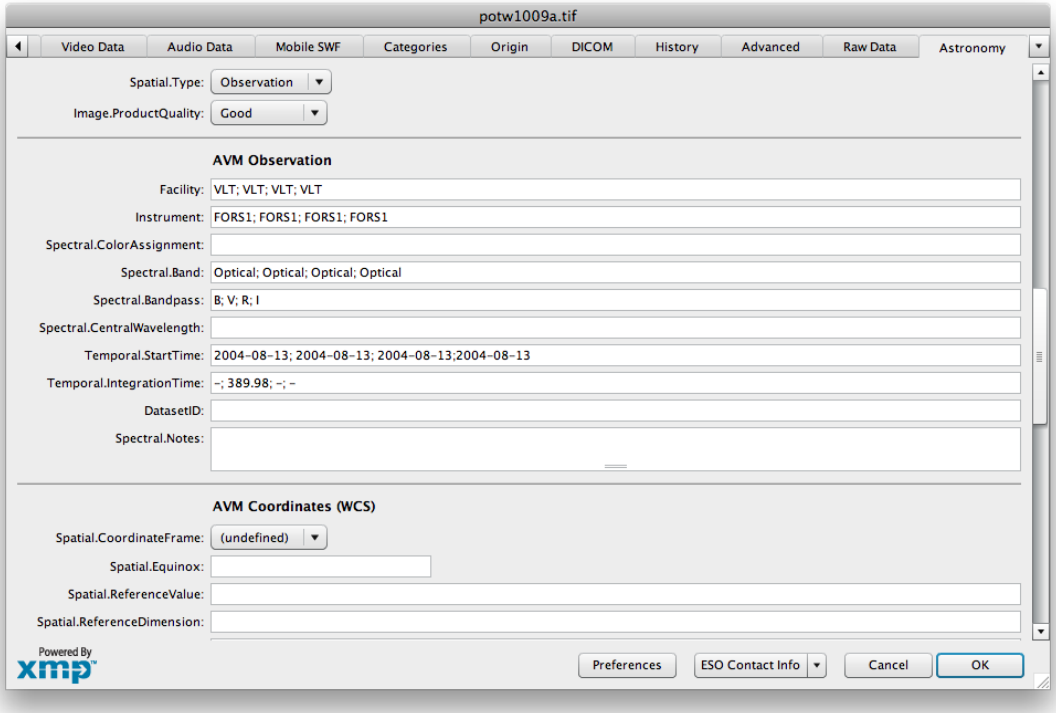

Figure 7-20 Observation metadata for Potw1009a

Based on the information on the webpage, the user may complete some fields from the observation category. The Temporal.StartTime and Temporal.IntegrationTime are obtained for only one image from one of the FITS files, using the FITS keywords “DATE-OBS” and “EXPTIME”, respectively.

PinpointWCS is used to obtain the Coordinate metadata. This process is completed exactly as done previously.

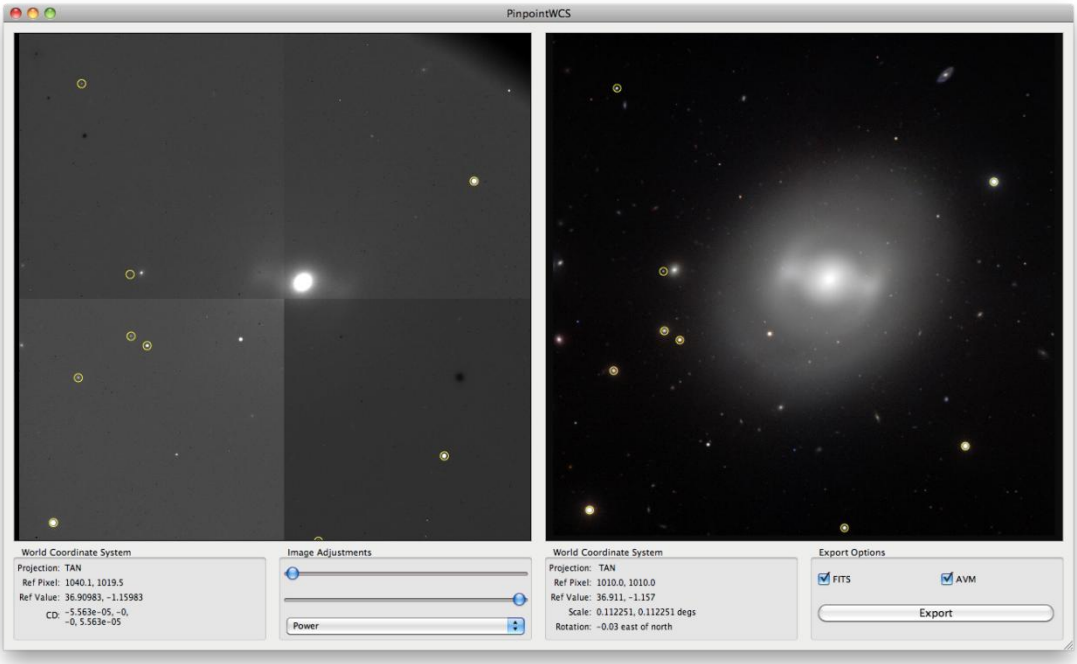

Figure 7-21 WCS retrofitting of the EPO image using PinpointWCS

Lastly, the MetadataDate and MetadataVersion need to be filled. This completes test case 4.

Creator	European Southern Observatory
CreatorURL	http://www.eso.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html
Title	Darth Vader’s Galaxy, NGC 936
Headline	Glowing in the cosmos at a distance of about 50 million light-years away, the galaxy NGC 936 bears a striking resemblance to the Twin Ion Engine (TIE) starfighters used by the evil Dark Lord Darth Vader

	and his crew in the epic motion picture Star Wars.
Description	Glowing in the cosmos at a distance of about 50 million light-years away, the galaxy NGC 936 bears a striking resemblance to the Twin Ion Engine (TIE) starfighters used by the evil Dark Lord Darth Vader and his crew in the epic motion picture Star Wars. The galaxy's shiny bulge and a bar-like structure crossing it bring to mind the central engine and cockpit of the spacecraft; while a ring of stars surrounding the galactic core completes the parallel, corresponding to the wings of the TIE fighters that are equipped with solar panels. This galaxy harbours exclusively old stars and shows no sign of any recent star formation. Bars such as that observed in NGC 936 are common features of galaxies; however, this one is significantly more marked than average. Although a perfect symbol for the dark side of the "Force", it is still debatable whether this galaxy is dominated, like most others, by a large amount of dark matter. This image has been obtained using the FORS instrument mounted on one of the 8.2-metre telescopes of ESO's Very Large Telescope on top of Cerro Paranal, Chile. It combines data acquired through four wide-band filters (B, V, R, I). The field of view is about 7 arcminutes.
Credit	ESO
Date	3/1/2010
Subject.Name	NGC 936
Subject.Category	C.5.1.2
Distance	50000000
ReferenceURL	http://www.eso.org/public/images/potw1009a/
ID	potw1009a
Type	Observation
Image.ProductQuality	Good
Facility	VLT; VLT; VLT; VLT
Instrument	FORS1; FORS1; FORS1; FORS1
Spectral.Band	Optical; Optical; Optical; Optical
Spectral.Bandpass	B; V; R; I

Temporal.StartTime	2004-08-13; 2004-08-13; 2004-08-13; 2004-08-13
Temporal.IntegrationTime	-; 389.98; -; -
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	J2000
Spatial.ReferenceValue	36.9114872; -1.1573008
Spatial.ReferenceDimension	2018.0; 2018.0
Spatial.ReferencePixel	1010.0; 1010.0
Spatial.Scale	5.5625e-05; 5.5625026e-05
Spatial.Rotation	-0.03
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full
Spatial.Notes	WCS retrieved using CXCs PinpointWCS
Spatial.CDMatrix	-5.5649232101e-05; 2.473281687e-08; 7.9653824471e-09; 5.5625020063e-05
MetadataDate	7/7/2010
MetadataVersion	1.1

7.6 Test Case 5: eso0911a

Just as the previous test cases, the process for eso0911a does not differ too much. One caveat to point out refers to the Content metadata.

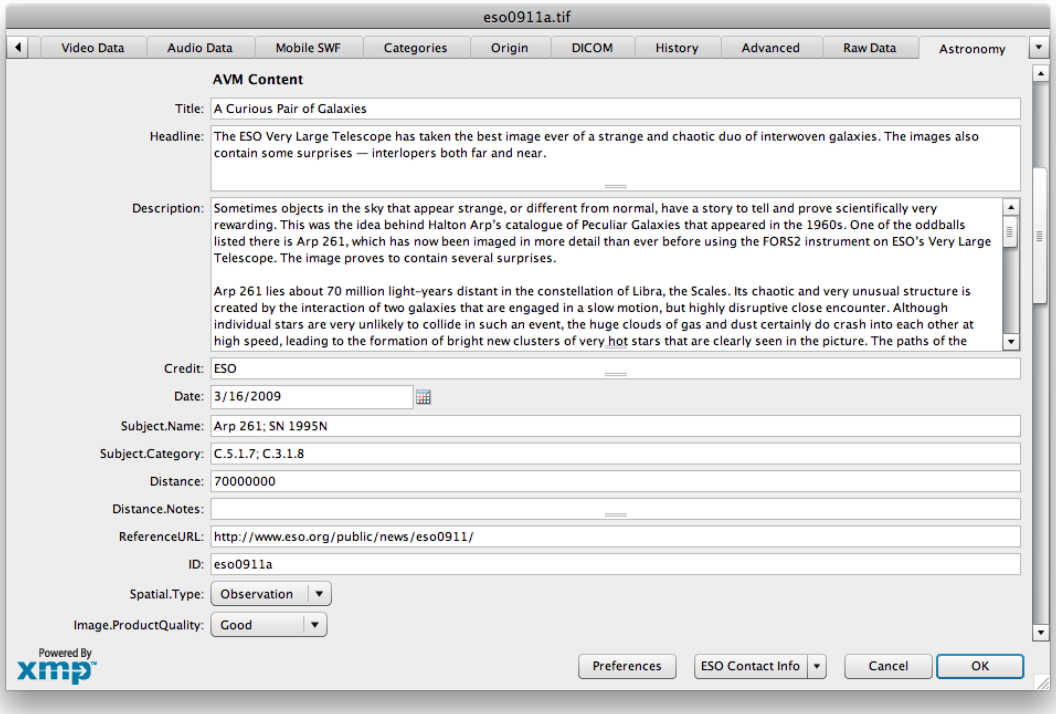

Figure 7-22 Content metadata for eso0911a

Carefully reading the description on the webpage http://www.eso.org/public/news/eso0911/, the user will notice that the image refers to two distinct objects. The most prominent object is Arp 261, two colliding galaxies; the second object of interest is the supernova SN 1995N. To properly tag this image, both objects need to be acknowledged in the metadata. This is apparent in the fields Subject.Name and Subject.Category.

For the Observation metadata the user needs to use information located on the webpage: http://www.eso.org/public/images/eso0911a/. This page contains information about the composition of the image. It describes the telescope, instrument, wavelengths, and colors used to create the EPO image.

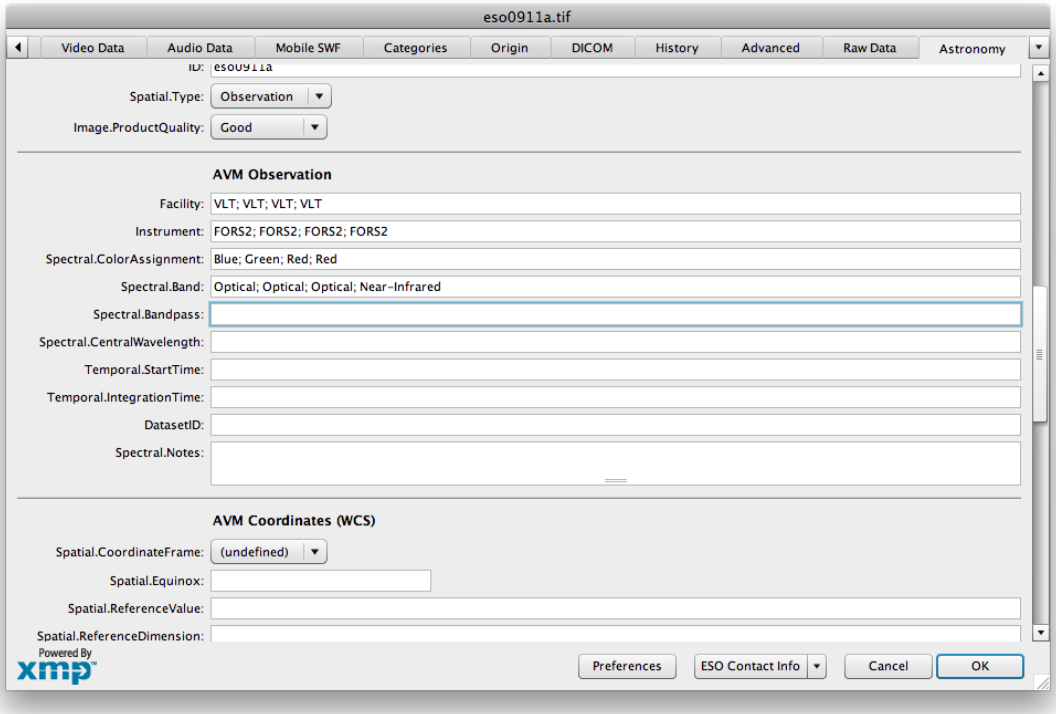

Figure 7-23 Observation metadata for eso0911a

To retrofit the EPO image with WCS info, the user may try Astrometry.net; however, the image fails to resolve. Another option is PinpointWCS, but the FITS files supplied do not contain equatorial coordinates, and cannot be used by the program. A third option is to retrieve another FITS image from a service such as DSS.

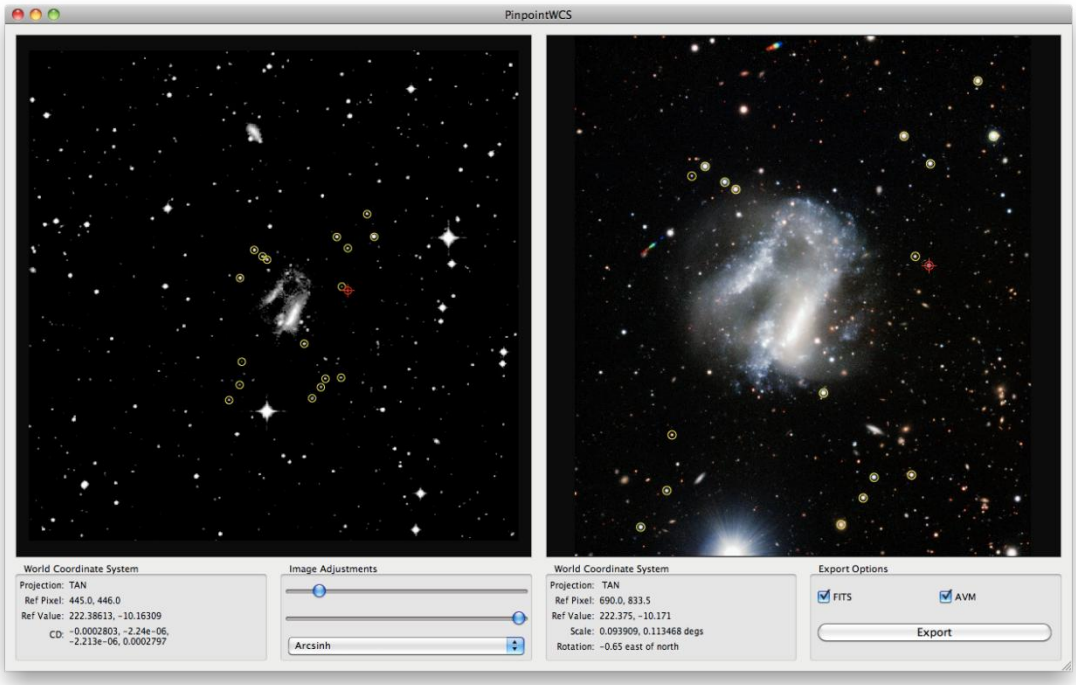

Figure 7-24 WCS retrofitting using DSS data

Using the DSS image, the user is able to re-calibrate the EPO image. This is a delicate process when the EPO image is of a narrower field of view than the FITS image. The user should make sure that each star is correctly aligned; otherwise, the coordinates will be calculated incorrectly.

Creator	European Southern Observatory
CreatorURL	http://www.eso.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html
Title	A Curious Pair of Galaxies
Headline	The ESO Very Large Telescope has taken the best image ever of a strange and chaotic duo of interwoven galaxies. The images also contain some surprises — interlopers both far and near.
Description	Sometimes objects in the sky that appear strange, or different from normal, have a story to tell and prove scientifically very rewarding. This was the idea behind Halton Arp's catalogue of Peculiar Galaxies that appeared in the 1960s. One of the oddballs listed there is Arp 261, which has now been imaged in more detail than ever before using the FORS2 instrument on ESO's Very Large Telescope. The image proves to contain several surprises. Arp 261 lies about 70 million light-years distant in the constellation of Libra, the Scales. Its chaotic and very unusual structure is created by the interaction of two galaxies that are engaged in a slow motion, but highly disruptive close encounter. Although individual stars are very unlikely to collide in such an event, the huge clouds of gas and dust certainly do crash into each other at high speed, leading to the formation of bright new clusters of very hot stars that are clearly seen in the picture. The paths of the existing stars in the galaxies are also dramatically disrupted, creating the faint swirls extending to the upper left and lower right of the image. Both interacting galaxies were probably dwarfs not unlike the Magellanic Clouds orbiting our own galaxy.

	The images used to create this picture were not actually taken to study the interacting galaxies at all, but to investigate the properties of the inconspicuous object just to the right of the brightest part of Arp 261 and close to the centre of the image. This is an unusual exploding star, called SN 1995N, that is thought to be the result of the final collapse of a massive star at the end of its life, a so-called core collapse supernova. SN 1995N is unusual because it has faded very slowly — and still shows clearly on this image more than seven years after the explosion took place! It is also one of the few supernovae to have been observed to emit X-rays. It is thought that these unusual characteristics are a result of the exploding star being in a dense region of space so that the material blasted out from the supernova ploughs into it and creates X-rays. Apart from the interacting galaxy and its supernova the image also contains several other objects at wildly different distances from us. Starting very close to home, two small asteroids, in our Solar System between the orbits of Mars and Jupiter, happened to cross the images as they were being taken and show up as the red-green-blue trails at the left and top of the picture. The trails arise as the objects are moving during the exposures and also between the exposures through different coloured filters. The asteroid at the top is number 14670 and the one to the left number 9735. They are probably less than 5 km across. The reflected sunlight from these small bodies takes about fifteen minutes to get to the Earth. The next closest object is probably the apparently bright star at the bottom. It may look bright, but it is still about one hundred times too faint to be seen with the unaided eye. It is most likely a star rather like the Sun and about 500 light-years from us — 20 million times further away than the asteroids. Arp 261 itself, and the supernova, are about 140 000 times further away again than this star, but still in what astronomers would regard as our cosmic neighbourhood. Much more distant still, perhaps some fifty to one hundred times further away than Arp 261, lies the cluster of galaxies visible on the right of the picture. There is no doubt, however, that a much more remote object lies, unrecognised, amongst the faint background objects seen in this marvellous image.
Credit	ESO

Date	3/16/2009
Subject.Name	Arp 261; SN 1995N
Subject.Category	C.5.1.7; C.3.1.8
Distance	70000000
ReferenceURL	http://www.eso.org/public/news/eso0911/
ID	eso0911a
Type	Observation
Image.ProductQuality	Good
Facility	VLT; VLT; VLT; VLT
Instrument	FORS2; FORS2; FORS2; FORS2
Spectral.ColorAssignment	Blue; Green; Red; Red
Spectral.Band	Optical; Optical; Optical; Optical
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	J2000
Spatial.ReferenceValue	222.3750575; -10.1712461
Spatial.ReferenceDimension	1378.0; 1665.0
Spatial.ReferencePixel	690.0; 833.5
Spatial.Scale	6.81491e-05; 6.8149076e-05
Spatial.Rotation	-0.65
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full
Spatial.Notes	WCS retrieved using CXCs PinpointWCS
Spatial.CDMatrix	-7.1307903502e-05; 7.7339197881e-07; 3.0295752549e-06; 6.8144687593e-05
MetadataDate	7/7/2010
MetadataVersion	1.1

As of this writing, this image has yet to be released. In this test case, the image will only be re-calibrated with WCS. The image is composed of observations from ESO's HAWK-I instrument on the VLT. Referring to Table 1 the HAWK-I instrument has a field of view of approximately 7.5 x 7.5 arcminutes. This may be a sufficient size for Astrometry.net.

Navigate to the online service at: http://live.astrometry.net/. Fill in the form with an email address, name, and choose the image for upload. In the section titled “Scale of the image” set an between upper bound 8 – 10 arcminutes. Submit the job, and wait patiently for Astrometry.net to recalibrate the image.

If successful, Astrometry.net will supply a link to the job with the WCS information.

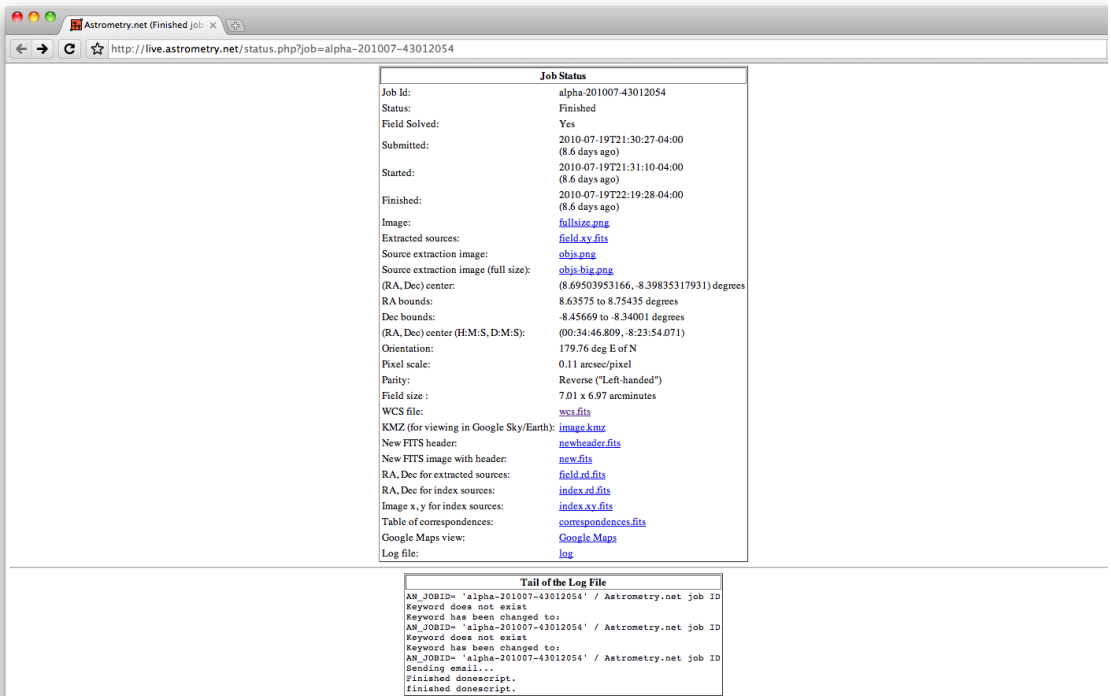

Figure 7-25 Webpage of a successful Astrometry.net job

These data need to be transferred over to AVM. This may be done by copying and pasting certain values in the appropriate fields via Adobe Bridge. Below is a table showing the Astrometry.net fields that correspond to AVM fields.

Table 2 Astrometry.net fields to AVM fields

Astrometry.net Fields	AVM Fields
(RA, Dec) center	Spatial.ReferenceValue
Pixel scale	Spatial.Scale
Orientation	Spatial.Rotation

The other AVM fields need to be completed by the user.

Table 3 Additional WCS information to complete

AVM Fields	Data
Spatial.CoordinateFrame	ICRS
Spatial.Equinox	2000.0
Spatial.ReferenceDimension	{pixel dimensions of the image}

Spatial.ReferencePixel	{location of the center pixel}
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full

Note: When applying Spatial.Scale, two values are necessary. It is important to add a negative sign to the second value. This will solve a well-known reflection difference that exists between FITS and other image formats.

The image below shows the values that have been entered to re-calibrate the EPO image.

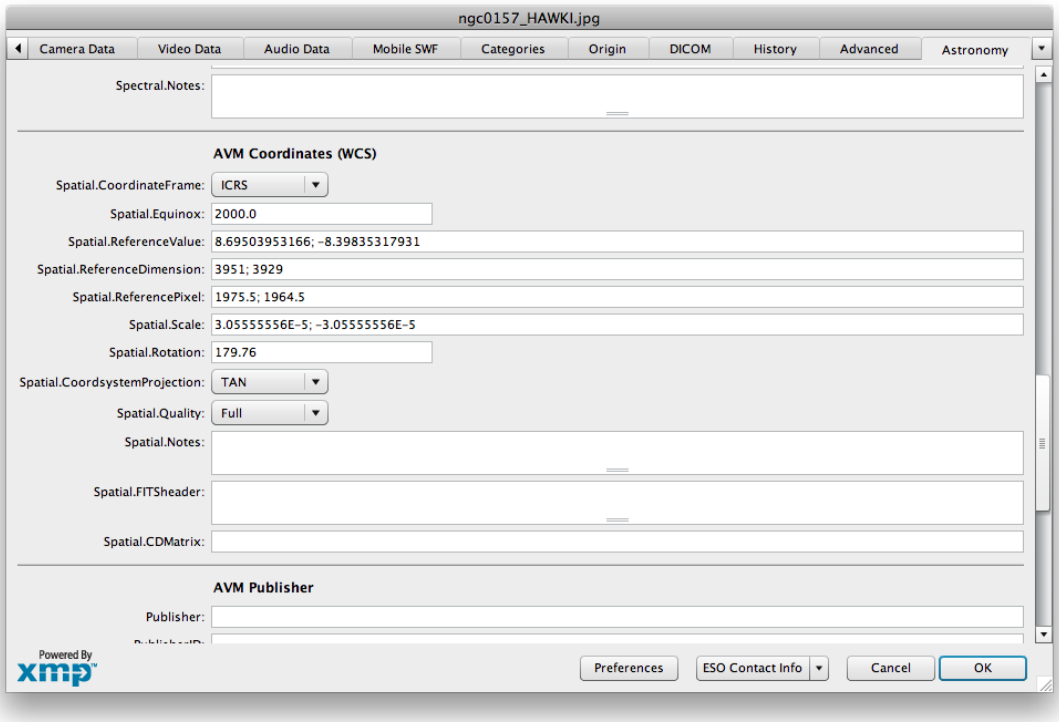

Figure 7-26 AVM coordinates from Astrometry.net

Creator	European Southern Observatory
CreatorURL	http://www.eso.org
Contact.Address	Karl-Schwarzschild-Strasse 2
Contact.City	Garching bei München
Contact.StateProvince	Bavaria
Contact.PostalCode	D-85748
Contact.Country	Germany
Rights	http://www.eso.org/public/outreach/copyright.html
Spatial.CoordinateFrame	ICRS

Spatial.Equinox	J2000
Spatial.ReferenceValue	8.69503953166; -8.39835317931
Spatial.ReferenceDimension	3951; 3929
Spatial.ReferencePixel	1975.5; 1964.5
Spatial.Scale	3.05555556E-5; -3.05555556E-5
Spatial.Rotation	179.76
Spatial.CoordsystemProjection	TAN
Spatial.Quality	Full
MetadataDate	7/28/2010
MetadataVersion	1.1

7.7 Test Case 7: m17_ISAAC_jhk

Beginning with this test case, only WCS retrieval will be discussed. ISAAC on the VLT has a very narrow field of view as shown in Table 1. Astrometry.net will most likely not resolve this image, so it is best to turn to PinpointWCS or WWT. Since a FITS file is readily available, WCS is computed using PinpointWCS. These steps are just as previously explained. It is best to match corresponding point sources in all areas of the image.

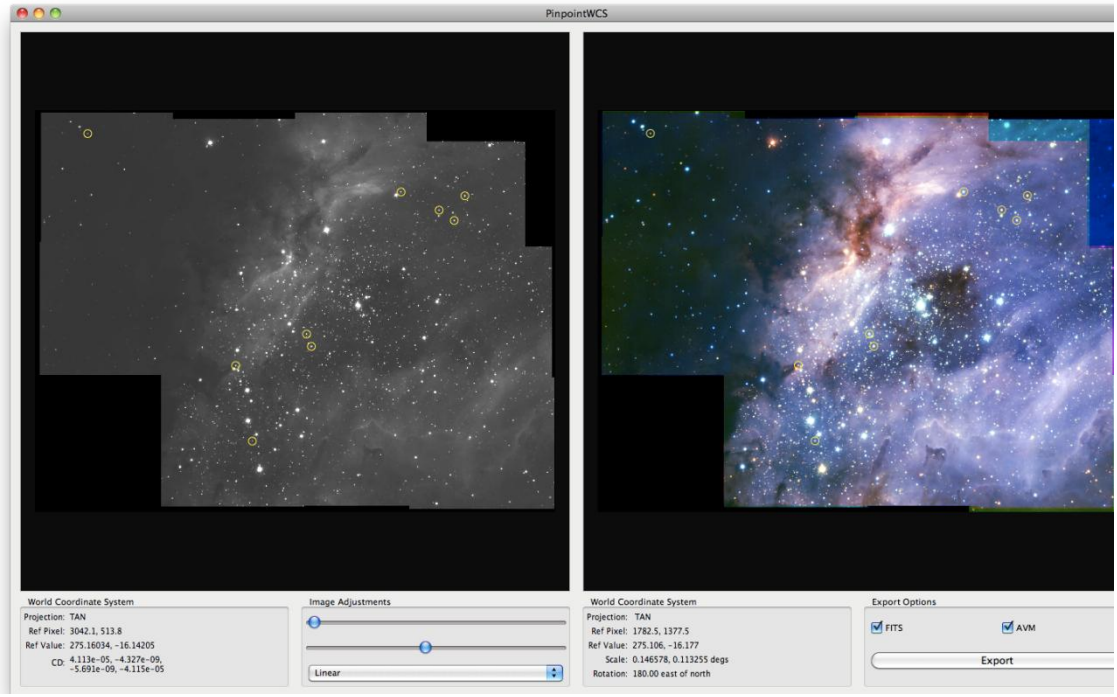

Figure 7-27 PinpointWCS for M17

When there are many point sources to choose from, it is best to use smaller features where the center is not as ambiguous. Figure 7-28 shows a smaller feature being used despite the presence of a larger star nearby.

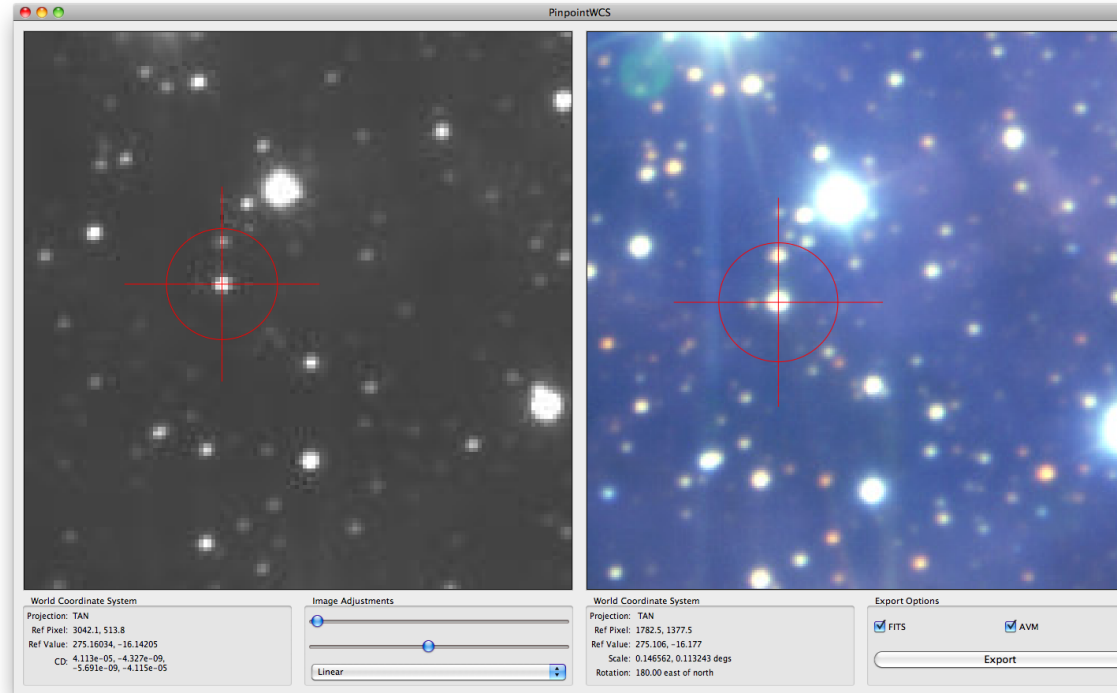

Figure 7-28 Matching point sources in PinpointWCS

When the WCS has been exported it may be tested in DS9. Just as explained previously, the frames need to be aligned via WCS, as well as the cursor.

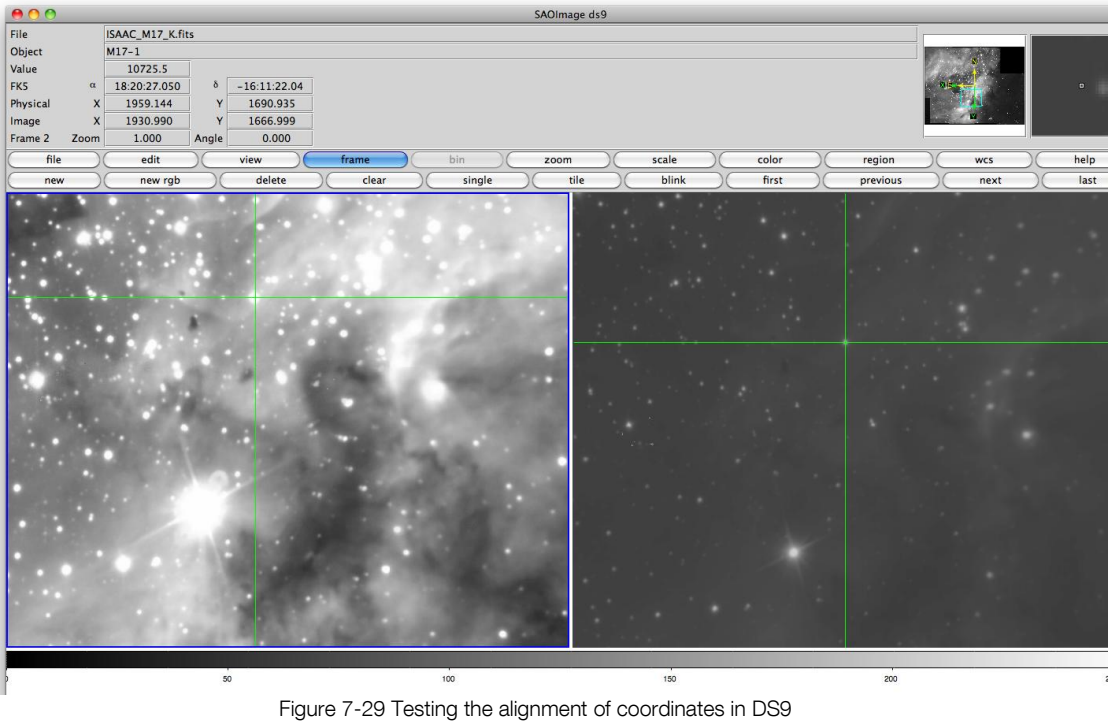

Figure 7-29 Testing the alignment of coordinates in DS9

The image may also be tested in a desktop planetarium program such as WWT.

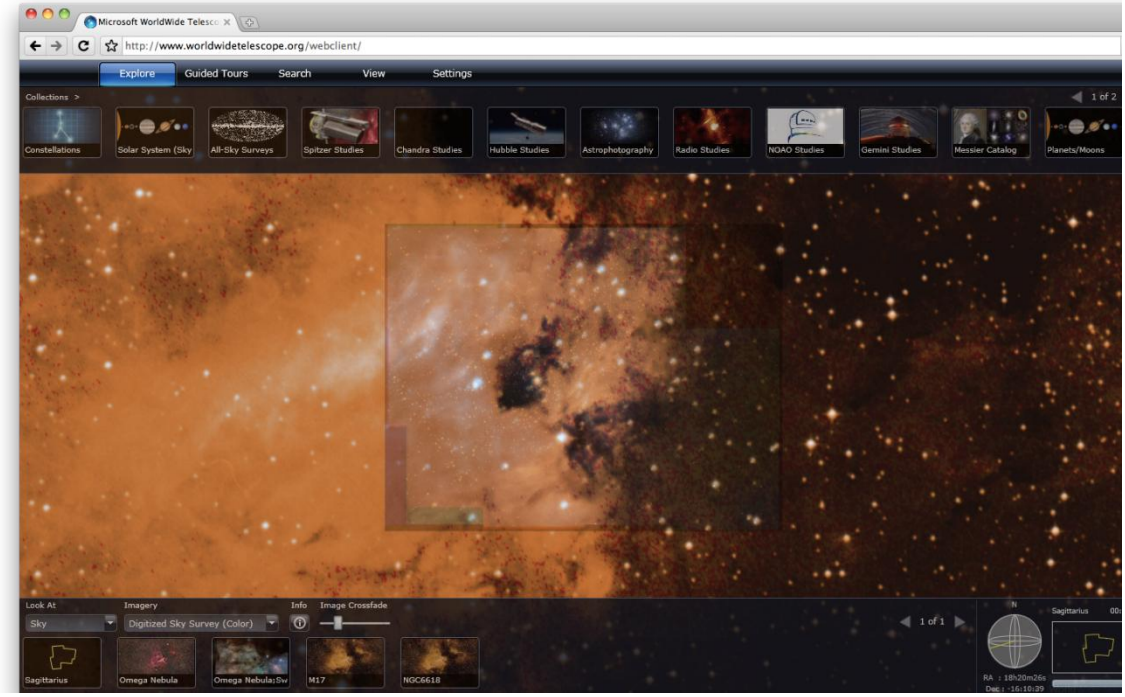

Figure 7-30 Transparent EPO image over WWT background sky.

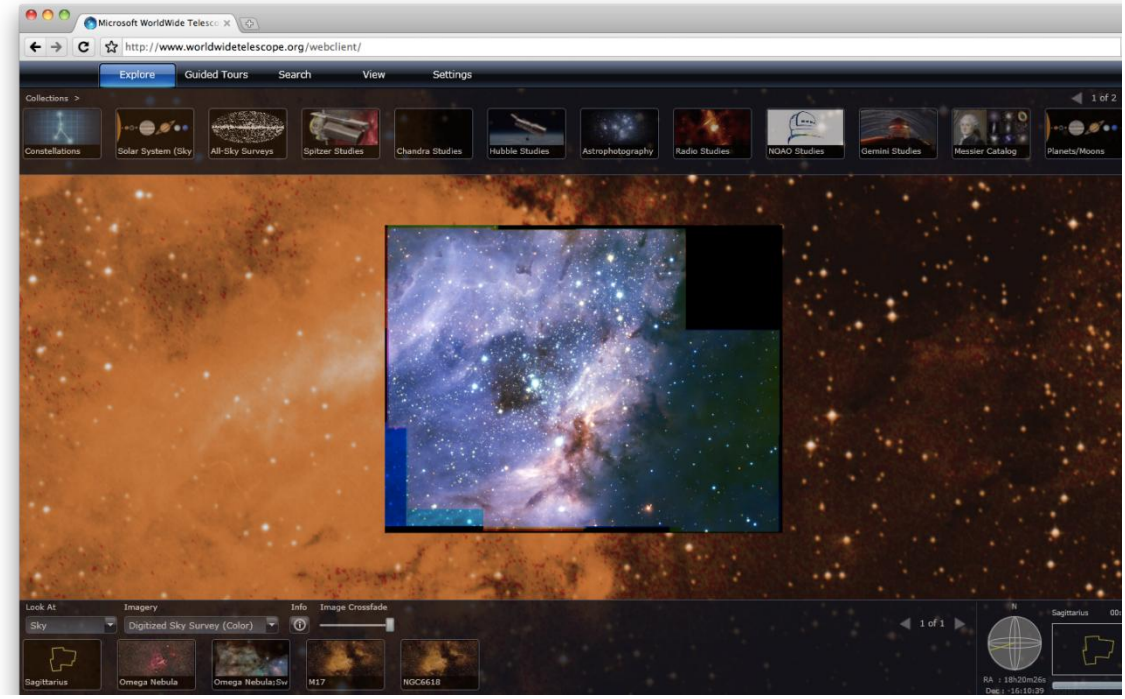

Figure 7-31 Opaque EPO image over WWT background sky