Carl Zeiss

Microscope Division

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Technical Information:

LSM-TIFF

The Tag Imaged File Format in the LSM

SYNOPSIS

The Carl Zeiss LSM creates images in the TIFF (Tag Image File Format) format. This format is also used to store LSM specific data with a privat tag.

WHAT IS TIFF?

Tiff is a file format that describes image data coming from scanners, frame grabbers and paint/photo retouch programs. The primary goal was to provide a rich environment within which the exchange of image data between application programs can be accomplished. This richness is required in order to take advantage of the varying capabilities of imaging devices. Though Tiff is a rich format, it can easily be used for simple applications as well.

However, most (and not only simple) Tiff applications do not support the full, rich Tiff standard and this is the reason for incompatibilities between different applications.

Tiff is capable of describing bi-level, grayscale, palette color and full color image data in several color spaces. It includes a number of compression schemes, is portable because it does not depend on particular operating systems or file systems and, allows privat tags to be defined that are specific to a particular application or organization.

FILE STRUCTURE

A Tiff file is a sequence of 8-bit bytes. Every Tiff file begins with an 8-byte Image File Header.

Image File Header

Bytes 0-1: byte order

0x4949	(=II) Intel byte order
0x4d4d	(=MM) Motorola byte order

Bytes 2-3: Tiff version
0x2a (=42) this Tiff version has never changed

Bytes 4-7: byte offset to the first Image File Directory.

Image File Directory

An IFD (= image file directory) consists of a 2-byte count of the number of entries, followed by a sequence of 12-byte field entries, followed by a 4-byte offset to the next IFD or 0 after the last IFD. So it is possible to save more than one IFD in one file. This means: more than one image can be found in one Tiff file. However, most of the Tiff applications use only the first IFD. Each 12-byte IFD entry has the following format:

Bytes 0-1: **Tag** that identifies the field
Bytes 2-3: **Type** of the field
Bytes 4-7: **Length** of the field
Bytes 8-11: **Value** Offset, file offset in bytes

The entries in an IFD are sorted in ascending order by Tag. The Value Offset is interpreted to contain the value instead of pointing to the value if the value fits into 4 bytes.

The usual field Types are:

1=BYTE 8-bit unsigned integer
2=ASCII 8-bit containing 7-bit ASCII code, null terminated
3=SHORT 16-bit unsigned integer
4=LONG 32-bit unsigned integer
5=RATIONAL Two LONGs, the first represents the numerator of a fraction, the second the denominator

There are more than 70 different Tags. Some of the most used are:
0x0100 ImageWidth
0x0101 ImageLength
0x0102 BitsPerSample
0x0103 Compression
0x0106 PhotometricInterpretation

So a valid 12-byte IFD entry look like:

0x0100 Tag=ImageWidth
0x0004 Type=LONG
0x0000.0001 Length=1
0x0000.0200 Value=0x200=512
This entry specifies an image x-size of 512 pixels.

The image data can be organized in one strip, line by line, starting at the left upper corner, or in more strips. One strip contains one or more lines of the image, so that the size of the strip is about 8kB. The start addresses of the strips can be found by the Tag StripOffsets. So it is easy to find the image data: Read the header, determine the byte order, find the first IFD, search for the Tag StripOffsets, find the first strip of image data.

For detailed information, please refer to:
TIFF, *Tag Image File Format, Revision 6.0, Draft 1, Feb 14, 1992*
by Aldus Corporation

HOW THE LSM USES TIFF?

One goal for the Tiff format was to store the LSM images in a format that makes it possible to import the data into other applications. So you can use wordprocessors or DTP programs to generate reports with images, paint and retouch programs to modify and print images, and, not at last, image processing programs to process the image data and do some image analysis. There are also image format converters on the market that accept Tiff and create other formats.

THE LSM TIFF WRITER

We use the INTEL byte order only.

The LSM program stores images in in following Tiff classes:
Grayscale Images, **Palette Color Images**, **RGB Full Color Images**.

For **all classes** we store following tags:
NewSubfileType = 0, full resolution, no multipage, no mask
ImageWidth = image x size
ImageLength = image y size
Compression = 1, no compression
Make = "Carl Zeiss, Oberkochen, Germany"
Model = "Laser Scan Microscope"
Software = "ZIF 1.81 MAR-93", software version that generated this file

This means, that we always store an uncompressed full resolution image in the first IFD. With means of the Make, Model and Software Tags you can always specify the source of the specified image.

We use these tags for **Grayscale Images**:
BitsPerSample = 8
PhotometricInterpretation = 1, black is zero
StripOffsets = offset of the first strip
SamplesPerPixel = 1
StripByteCounts = byte count of one strip

You see, that we have only 8-bit images with black represented by the value 0. All the data is stored in one strip.

Palette Color Images have following tags:
BitsPerSample = 8
PhotometricInterpretation = 3, Palette Color
StripOffsets = offset of the first strip
SamplesPerPixel = 1
StripByteCounts = byte count of one strip
ColorMap = offset of the lookup table

The only difference is the lookup table that is stored as 768 16-bit values in a red-green-blue sequence.

RGB Full Color Images are specified by following tags:
BitsPerSample = 8,8,8
PhotometricInterpretation = 2, RGB
StripOffsets = offset of chunky data or offset of the 3 planes
SamplesPerPixel = 3
StripByteCounts = byte count of chunky data or 3 byte counts of 3 planes

PlanarConfiguration = 1 (chunky format, RGB pixel sequence) or
PlanarConfiguration = 2 (planar format, R G and B in seperate planes)

There is nearly no difference in speed between storing in chunky or in planar format. Especially for data export to other applications, chunky format is more accepted (see also the test list).

We don't use following tags:
RowsPerStrip, default is 2**32-1, that is, the entire image is one strip.
ResolutionUnit
XResolution
YResolution

RowsPerStrip = 0xffff.ffff has been found to be a problem for the PhotoStyler Tiff reader, so we removed it and use the default value. The Resolution tags are normally required for all classes of Tiff images, but don't make sense for LSM images and have been left out. There is no problem for other Tiff readers with this missing tags.

Tests

This full resolution image (first IFD) has been accepted by a lot of applications:

- Microsoft WinWord 2.0 (no RGB planar format)
- MicroSoft PowerPoint 3.0 (no RGB planar format)
- Micrografx Designer 3.1
- Aldus PhotoStyler 1.1
- PaintShop Pro 1.0 (no RGB planar format)
- Carl Zeiss AxioDoc
- Shareware pv.exe (no RGB planar format)

Privat tags

Two new tags may be found in our Tiff files. One for the LSM settings and the other for an additional comment. A change was necessary, because ALDUS (the TIFF administrator) assigned us privat tags that will never be changed again.

34412=0x866c (former 0x9bc4) is made to store LSM specific information

34413=0x866d (former 0x9bc5) is made for an additional comment

The format of the LSM-information:

```
Offset  Type        Description
-------------------------------------------------------------
 0000h  WORD        Code 494Ch
 0002h  WORD        Version (0002h)
 0004h  WORD        Image type
                      Bit 0/1  Number of 8 bit planes
                      Bit 2/3  Number of channels per pixel
                      Bit 4    0: Original data,
                               1: Calculated data (animation)
```

		Bit 5 1: Time series
		Bit 6 Reserved (0 or 1)
		Bit 7 1: Image is part of sequence
		Bit 8 1: y-direction is Time
		Bit 9 1: x-direction is Time
0006h	WORD	Reserved
0008h	WORD	x size of image
000ah	WORD	y size of image
000ch	WORD	x position of ROI
000eh	WORD	x position of ROI
0010h	WORD	x size of image display mask
0012h	WORD	y size of image display mask
0014h	WORD	Reserved
0016h	WORD	Reserved
0018h	WORD	Image position number in a sequence
001ah	BYTE	Reserved
001bh	BYTE	Number of valid channel parameters (1..3)
001ch	BYTE	Number of lasers (1..4)
001dh	3 bytes	Reserved
0020h	float	x size of a pixel (µm or s)
0024h	float	y size of a pixel (µm or s)
0028h	float	z distance in a sequence (µm or s)
002ch	float	Sequence value (µm / s)
0030h	8 x WORD	List of laser lines (nm)
0040h	64 bytes	Channel parameters 1
0080h	64 bytes	Channel parameters 2 (if available)
00c0h	64 bytes	Channel parameters 3 (if available)
0100h	16 x char	User text 1
0110h	16 x char	User text 2
0120h	16 x char	Date and time text
0130h	16 x char	Beam splitter text (channel 1, should be valid for all)
0140h	time_t	The time in seconds since midnight (00:00:00), January 1, 1970, Universal Coordinated Time
0144h	WORD	Fraction of a second in milliseconds
0146h	short	Timezone difference in minutes
0148h	short	Daylight saving flag
014ah	float	Real scan time for one image (s)

014eh	2 bytes	Reserved
0150h	16 x char	Emission filter channel 1 text
0160h	16 x char	Emission filter channel 2 text (if available)
0170h	16 x char	Emission filter channel 3 text (if available)
0180h	32 x char	Reserved for lens decription text

Channel Parameters (64 bytes)

Offset	Type	Description
0000h	BYTE	Source
		1 Conv Refl
		2 Conv Trans
		3 Conv Overl
		4 Conv Fluor
		5 LSM Refl1
		6 LSM Refl2
		7 LSM Refl3
		8 LSM Trans
		9 OBIC
		10 Extern
0001h	BYTE	Pinhole
0002h	BYTE	Emission filter
0003h	BYTE	Flags
		Bit 0 TV
		Bit 1 Confocal
		Bit 2 Reserved
		Bit 3 Ratio
0004h	BYTE	Attenuation filter 1
0005h	BYTE	Attenuation filter 2
0006h	BYTE	Attenuation filter 3
0007h	BYTE	Laser (each bit represents one laser line)
0008h	BYTE	Scanning time
0009h	BYTE	Bandwidth
000ah	BYTE	Beam splitter
000bh	BYTE	Lens
000ch	BYTE	Scan function
000dh	BYTE	Averaging mode (reserved)
000eh	WORD	Number of averaging
0010h	WORD	Contrast
0012h	WORD	Brightness

0014h	long	x motor (in motor steps)
0018h	long	y motor (in motor steps)
001ch	long	z motor (in motor steps)
0020h	WORD	Zoom factor * 1000
0022h	short	Angle of rotation (0.1 degree)
0024h	WORD	Obic address 1
0026h	WORD	Obic address 2
0028h	short	Scan offset x
002ah	short	Scan offset y
002ch	BYTE	Attenuation filter 4
002dh	3 bytes	Reserved
0030h	float	Objective magnification
0034h	float	Objective apperture
0038h	float	Reserved
003ch	float	Reserved

The graphic overlay of the image can optionally be stored in the second IFD. But this data can only be read by the LSM program. There is no application known that accepts more than one IFD per file.

A subsample is prepared to be stored in a third IFD. This has the Tag NewSubfileType = 1 (reduced resolution).

The first version released was ZIF 1.30

Modifications/bug fixes of version ZIF 1.70:

The Tag StripByteCounts has been added, so we avoid some warning messages from other Tiff readers.

The Tag BitsPerSample was modified for RGB images to 8,8,8. More Tiff reader can now read our RGB format.

The Tag RowsPerStrip=0xffff.ffff made some problems with Tiff readers, so we removed it. The default is 0xffff.ffff.

Modifications/bug fixes of version ZIF 1.74:

Photometric Interpretation is set to 3 for 8 bit data with lookup table. It was 1 before and some Tiff readers don't like it and set wrong color tables.

Modifications/bug fixes of version ZIF 1.76:

The color lookup table has been improved for the AxioDoc software.

Modifications/bug fixes of version ZIF 1.81:

RGB images can be stored/loaded in the chunky format.

Most read/write operations have been tuned in speed.

The privat fields are now variable in length.

THE LSM TIFF READER

The Tiff reader of the LSM has the primary task to efficiently read the LSM Tiff files with all the options like overlay, low resolution image, privat info, privat comment. It is NOT designed to import Tiff data from other applications. Especially, the tiff reader

- do not read MOTOROLA format
- do only accept BitPerSample = 8
- do not read compressed data
- do not read data in more than 1 strip

To import Tiff images from other application, there is a Tiff import function for simple formats. This import function is automatically called in the LSM program if the Tiff reader wasn't successful.

THE LSM TIFF IMPORT

The Tiff import function accepts Motorola and Intel format. It reads uncompressed grayscale and palette color images that are 8 bits deep as well as 24 bit full color RGB images in the planar or chunky format. The image data may be in more than one strip. This function solves most of the import requirements.

Date of first version (#1) ..... Jan 12, 1993

Version ..... #3, Jun 17, 1994

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Lsm - Tiff

This is a short description of Tiff (= Tag Image File Format) and how the LSM program uses it.

What is Tiff?

Tiff is a file format that describes image data coming from scanners, frame grabbers and paint/photo retouch programs. The primary goal was to provide a rich environment within which the exchange of image data between application programs can be accomplished. This richness is required in order to take advantage of the varying capabilities of imaging devices. Though Tiff is a rich format, it can easily be used for simple applications as well.

However, most (and not only simple) Tiff applications do not support the full, rich Tiff standard and this is the reason for incompatibilities between different applications.

Tiff is capable of describing bi-level, grayscale, palette color and full color image data in several color spaces. It includes a number of compression schemes, is portable because it does not depend on particular operating systems or file systems and, allows privat tags to be defined that are specific to a particular application or organization.

File Structure

A Tiff file is a sequence of 8-bit bytes. Every Tiff file begins with an 8-byte **Image File Header**.
Bytes 0-1: byte order
0x4949 (=II) Intel byte order
0x4d4d (=MM) Motorola byte order
Bytes 2-3: Tiff version
0x2a (=42) this Tiff version has never changed
Bytes 4-7: byte offset to the first **Image File Directory**.

An IFD (= image file directory) consists of a 2-byte count of the number of entries, followed by a sequence of 12-byte field entries, followed by a 4-byte offset to the next IFD or 0 after the last IFD. So it is possible to save more than one IFD in one file. This means: more than one image can be found in one Tiff file. However, most of the Tiff applications use only the first IFD. Each 12-byte IFD entry has the following format:
Bytes 0-1: **Tag** that identifies the field
Bytes 2-3: **Type** of the field
Bytes 4-7: **Length** of the field
Bytes 8-11: **Value** Offset, file offset in bytes

The entries in an IFD are sorted in ascending order by Tag. The Value Offset is interpreted to contain the value instead of pointing to the value if the value fits into 4 bytes.

The usual field Types are:
1=BYTE 8-bit unsigned integer
2=ASCII 8-bit containing 7-bit ASCII code, null terminated
3=SHORT 16-bit unsigned integer
4=LONG 32-bit unsigned integer
5=RATIONAL Two LONGs, the first represents the numerator of a fraction, the second the denominator

There are more than 70 different Tags. Some of the most used are:
0x0100 ImageWidth
0x0101 ImageLength
0x0102 BitsPerSample
0x0103 Compression
0x0106 PhotometricInterpretation

So a valid 12-byte IFD entry look like:
0x0100 0x0004 0x0000.0001 0x0000.0200
Tag=ImageWidth
Type=LONG
Length=1
Value=0x200=512
This entry specifies an image x-size of 512 pixels.

The image data can be organized in one strip, line by line, starting at the left upper corner, or in more strips. One strip contains one or more lines of the image, so that the size of the strip is about 8kB. The start addresses of the strips can be found by the Tag StripOffsets. So it is easy to find the image data: Read the header, determine the byte order, find the first IFD, search for the Tag StripOffsets, find the first strip of image data.

For detailed information, please refer to:
Tag Image File Format, Specification, Revision 5.0, Final, 8/8/88
by Aldus Corporation and Microsoft Corporation
and:
Tag Image File Format, Revision 6.0, Draft 1, February 14, 1992
by Aldus Corporation

How the LSM uses Tiff?

One goal for the Tiff format was to store the LSM images in a format that makes it possible to import the data into other applications. So you can use wordprocessors or DTP programs to generate reports with images, paint and retouch programs to modify and print images, and, not at last, image processing programs to process the image data and do some image analysis. There are also image format converters on the market that accept Tiff and create other formats.

The LSM Tiff Writer

We use the INTEL byte order only.

The LSM program stores images in in following Tiff classes:
Grayscale Images, **Palette Color Images**, **RGB Full Color Images**.

For **all classes** we store following tags:
NewSubfileType = 0, full resolution, no multipage, no mask

ImageWidth = image x size
ImageLength = image y size
Compression = 1, no compression
Make = "Carl Zeiss, Oberkochen, Germany"
Model = "Laser Scan Microscope"
Software = "ZIF 1.81 MAR-93", software version that generated this file

This means, that we always store an uncompressed full resolution image in the first IFD. With means of the Make, Model and Software Tags you can always specify the source of the specified image.

We use these tags for **Grayscale Images**:
BitsPerSample = 8
PhotometricInterpretation = 1, black is zero
StripOffsets = offset of the first strip
SamplesPerPixel = 1
StripByteCounts = byte count of one strip

You see, that we have only 8-bit images with black represented by the value 0. All the data is stored in one strip.

Palette Color Images have following tags:
BitsPerSample = 8
PhotometricInterpretation = 3, Palette Color
StripOffsets = offset of the first strip
SamplesPerPixel = 1
StripByteCounts = byte count of one strip
ColorMap = offset of the lookup table

The only difference is the lookup table that is stored as 768 16-bit values in a red-green-blue sequence.

RGB Full Color Images are specified by following tags:
BitsPerSample = 8,8,8
PhotometricInterpretation = 2, RGB
StripOffsets = offset of chunky data or offset of the 3 planes
SamplesPerPixel = 3
StripByteCounts = byte count of chunky data or 3 byte counts of 3 planes
PlanarConfiguration = 1 (chunky format, RGB pixel sequence) or
PlanarConfiguration = 2 (planar format, R G and B in seperate planes)

There is nearly no difference in speed between storing in chunky or in planar format. Especially for data export to other applications, chunky format is more accepted (see also the test list).

We don't use following tags:
RowsPerStrip, default is 2**32-1, that is, the entire image is one strip.
ResolutionUnit
XResolution
YResolution

RowsPerStrip = 0xffff.ffff has been found to be a problem for the PhotoStyler Tiff reader, so we removed it and use the default value. The Resolution tags are normally required for all classes of Tiff images, but don't make sense for LSM images and have been left out. There is no problem for other Tiff readers with this missing tags.

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* Aldus PhotoStyler 1.1
* PaintShop Pro 1.0 (no RGB planar format)
* Carl Zeiss AxioDoc

* Shareware pv.exe (no RGB planar format)

Privat tags:
Two new tags may be found in our Tiff files. One for the LSM settings and the other for an additional comment. A change was necessary, because ALDUS (the TIFF administrator) assigned us privat tags that will never be changed again.
34412=0x866c (former 0x9bc4) is made to store LSM specific information
34413=0x866d (former 0x9bc5) is made for an additional comment
The format of the LSM-information:

Offset	Type	Description
0000h	WORD	Code 494Ch
0002h	WORD	Version (0100h)
0004h	WORD	Image type Bit 0/1 Number of planes Bit 2/3 Number of channels Bit 4 0: Original data,1: Calculated data (anim.) Bit 5 1: Time series Bit 6 Reserved (0 or 1) Bit 7 1: Image is part of sequence Bit 8 1: y-direction is Time Bit 9 1: x-direction is Time
0006h	WORD	Reserved
0008h	WORD	x size of image
000ah	WORD	y size of image
000ch	WORD	x position of ROI
000eh	WORD	x position of ROI
0010h	WORD	x size of image display mask
0012h	WORD	y size of image display mask
0014h	WORD	Reserved
0016h	WORD	Reserved
0018h	WORD	Image position number in a sequence
001ah	BYTE	Reserved
001bh	BYTE	Reserved
001ch	BYTE	Number of laser lines
001dh	3 bytes	Reserved
0020h	float	x size of a pixel (µm or s)
0024h	float	y size of a pixel (µm or s)
0028h	float	z distance in a sequence (µm or s)
002ch	float	Sequence value (µm / s)
0030h	8 x WORD	List of laser lines (nm)
0040h	64 bytes	Channel parameters 1
0080h	64 bytes	Channel parameters 2 (if available)
00c0h	64 bytes	Channel parameters 3 (if available)
0100h	16 x char	User text 1
0110h	16 x char	User text 2
0120h	16 x char	Date and time text
0130h	16 x char	Beam splitter text
0140h	time_t	The time in seconds since midnight (00:00:00), January 1, 1970, Universal Coordinated Time
0144h	WORD	Fraction of a second in milliseconds
0146h	short	Timezone difference in minutes
0148h	short	Daylight saving flag
014ah	float	Real scan time for one image (s)
014eh	2 bytes	Reserved
0150h	16 x char	Emission filter channel 1 text
0160h	16 x char	Emission filter channel 2 text (if available)
0170h	16 x char	Emission filter channel 3 text (if available)
0180h	32 x char	Reserved for lens decription text

Channel Parameters (64 bytes)

Offset	Type	Description
0000h	BYTE	Source 1 Conv Refl 2 Conv Trans 3 Conv Overl 4 Conv Fluor 5 LSM Refl1 6 LSM Refl2 7 LSM Refl3 8 LSM Trans 9 OBIC 10 Extern
0001h	BYTE	Pinhole
0002h	BYTE	Emission filter
0003h	BYTE	Flags Bit 0 TV Bit 1 Confocal Bit 2 Reserved Bit 3 Ratio
0004h	BYTE	Attenuation filter 1
0005h	BYTE	Attenuation filter 2
0006h	BYTE	Attenuation filter 3
0007h	BYTE	Laser (each bit represents one laser line)
0008h	BYTE	Scanning time
0009h	BYTE	Bandwidth
000ah	BYTE	Beam splitter
000bh	BYTE	Lens
000ch	BYTE	Scan function
000dh	BYTE	Averaging mode (reserved)
000eh	WORD	Number of averaging
0010h	WORD	Contrast
0012h	WORD	Brightness
0014h	long	x motor (in motor steps)
0018h	long	y motor (in motor steps)
001ch	long	z motor (in motor steps)
0020h	WORD	Zoom factor * 1000
0022h	short	Angle of rotation (0.1 degree)
0024h	WORD	Obic address 1
0026h	WORD	Obic address 2
0028h	short	Scan offset x
002ah	short	Scan offset y
002ch	BYTE	Attenuation filter 4
002dh	3 bytes	Reserved
0030h	float	Objective magnification
0034h	float	Objective apperture
0038h	float	Reserved
003ch	float	Reserved

The graphic overlay of the image can optionally be stored in the second IFD. But this data can only be read by the LSM program. There is no application known that accepts more than one IFD per file.

A subsample is prepared to be stored in a third IFD. This has the Tag NewSubfileType = 1 (reduced resolution).

The first version released was ZIF 1.30

Modifications/bug fixes of version ZIF 1.70:

The Tag StripByteCounts has been added, so we avoid some warning messages from other Tiff readers.
The Tag BitsPerSample was modified for RGB images to 8,8,8. More Tiff reader can now read our RGB format.
The Tag RowsPerStrip=0xffff.ffff made some problems with Tiff readers, so we removed it. The default is 0xffff.ffff.

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Photometric Interpretation is set to 3 for 8 bit data with lookup table. It was 1 before and some Tiff readers don't like it and set wrong color tables.

Modifications/bug fixes of version ZIF 1.76:
The color lookup table has been improved for the AxioDoc software.

Modifications/bug fixes of version ZIF 1.81:
RGB images can be stored/loaded in the chunky format.
Most read/write operations have been tuned in speed.
The privat fields are now variable in length.

Samples:
See the Appendix for 4 sample headers, written by our Tiff writer.
cz_gray.tif is a 512*512 grayscale image
cz_color.tif is the same as cz_gray, with neon colors
cz_rgb1.tif is a 512*480 RGB image in the planar format
cz_rgb2.tif is a 512*480 RGB image in the chunky format

The LSM Tiff Reader

The Tiff reader of the LSM has the primary task to efficiently read the LSM Tiff files with all the options like overlay, low resolution image, privat info, privat comment. It is NOT designed to import Tiff data from other applications. Especially, the tiff reader

* do not read MOTOROLA format
* do only accept BitPerSample = 8
* do not read compressed data
* do not read data in more than 1 strip

To import Tiff images from other application, there is a Tiff import function for simple formats. This import function is automatically called in the LSM program if the Tiff reader wasn't successful.

The LSM Tiff Import

The Tiff import function accepts Motorola and Intel format. It reads uncompressed grayscale and palette color images that are 8 bits deep as well as 24 bit full color RGB images in the planar or chunky format. The image data may be in more than one strip. This function solves most of the import requirements.

Appendix

---
file - cz_gray.tif

Offset	Name	Value
Header:		
00000000	Byte Order	4949

```
00000002  Version                     002A
00000004  1st IFD Pointer             00000008

IFD:
00000008  Entry Count                 000E
0000000A  NewSubfileType              00FE  0004  00000001  00000000
00000016  ImageWidth                  0100  0004  00000001  00000200
00000022  ImageLength                 0101  0004  00000001  00000200
0000002E  BitsPerSample               0102  0003  00000001  0008
0000003A  Compression                 0103  0003  00000001  0001
00000046  PhotometricInterpretation   0106  0003  00000001  0001
00000052  Make                        010F  0002  00000020  000000B6
0000005E  Model                       0110  0002  00000016  000000D6
0000006A  StripOffsets                0111  0004  00000001  00000122
00000076  SamplesPerPixel             0115  0003  00000001  0001
00000082  StripByteCounts            0117  0004  00000001  00040000
0000008E  SoftWare                    0131  0002  00000010  000000EC
0000009A  ?                           866C  0001  00000017  000000FC
000000A6  ?                           866D  0002  0000000F  00000113
000000B2  Next IFD Pointer            00000000

Fields pointed to by the tags:
000000B6  Make                        "Carl Zeiss, Oberkochen, Germany"
000000D6  Model                       "Laser Scan Microscope"
000000EC  SoftWare                    "ZIF 1.81 MAR-93"
000000FC  ?                           70  72  69  76  61  74  20  4C  53
                                      4D  20  69  6E  66  6F  72  6D  61
                                      74  69  6F  6E  00
00000113  ?                           "privat comment"

-------------------------------------------------------------------------
---
file - cz_color.tif

Offset    Name                        Value

Header:
00000000  Byte Order                  4949
00000002  Version                     002A
00000004  1st IFD Pointer             00000008

IFD:
00000008  Entry Count                 000F
0000000A  NewSubfileType              00FE  0004  00000001  00000000
00000016  ImageWidth                  0100  0004  00000001  00000200
00000022  ImageLength                 0101  0004  00000001  00000200
0000002E  BitsPerSample               0102  0003  00000001  0008
0000003A  Compression                 0103  0003  00000001  0001
00000046  PhotometricInterpretation   0106  0003  00000001  0003
00000052  Make                        010F  0002  00000020  000000C2
0000005E  Model                       0110  0002  00000016  000000E2
0000006A  StripOffsets                0111  0004  00000001  0000073C
00000076  SamplesPerPixel             0115  0003  00000001  0001
00000082  StripByteCounts            0117  0004  00000001  00040000
0000008E  SoftWare                    0131  0002  00000010  000000F8
0000009A  ColorMap                    0140  0003  00000300  00000108
000000A6  ?                           866C  0001  00000017  00000708
000000B2  ?                           866D  0002  0000001D  0000071F
000000BE  Next IFD Pointer            00000000

Fields pointed to by the tags:
000000C2  Make                        "Carl Zeiss, Oberkochen, Germany"
000000E2  Model                       "Laser Scan Microscope"
000000F8  SoftWare                    "ZIF 1.81 MAR-93"
00000108  ColorMap                    0000  0000  0000  0000  0000  0000
                                      0000  0000  0000  0000  0000  0000
```

```
                                    0000  0000  0000  0000  0000  0000
                                    0000  ...
00000708  ?                         70  72  69  76  61  74  20  4C  53
                                    4D  20  69  6E  66  6F  72  6D  61
                                    74  69  6F  6E  00
0000071F  ?                         "cz_gray.tif with neon colors"

------------------------------------------------------------------------
---
file - cz_rgb1.tif

Offset    Name                      Value

Header:
00000000  Byte Order                4949
00000002  Version                   002A
00000004  1st IFD Pointer           00000008

IFD:
00000008  Entry Count               000F
0000000A  NewSubfileType            00FE  0004  00000001  00000000
00000016  ImageWidth                0100  0004  00000001  00000200
00000022  ImageLength               0101  0004  00000001  000001E0
0000002E  BitsPerSample             0102  0003  00000003  000000C2
0000003A  Compression               0103  0003  00000001  0001
00000046  PhotometricInterpretation 0106  0003  00000001  0002
00000052  Make                      010F  0002  00000020  000000C8
0000005E  Model                     0110  0002  00000016  000000E8
0000006A  StripOffsets              0111  0004  00000003  000000FE
00000076  SamplesPerPixel           0115  0003  00000001  0003
00000082  StripByteCounts           0117  0004  00000003  0000010A
0000008E  PlanarConfiguration       011C  0003  00000001  0002
0000009A  SoftWare                  0131  0002  00000010  00000116
000000A6  ?                         866C  0001  00000017  00000126
000000B2  ?                         866D  0002  00000026  0000013D
000000BE  Next IFD Pointer          00000000

Fields pointed to by the tags:
000000C2  BitsPerSample             0008  0008  0008
000000C8  Make                      "Carl Zeiss, Oberkochen, Germany"
000000E8  Model                     "Laser Scan Microscope"
000000FE  StripOffsets              00000163  0003C163  00078163
0000010A  StripByteCounts           0003C000  0003C000  0003C000
00000116  SoftWare                  "ZIF 1.81 MAR-93"
00000126  ?                         70  72  69  76  61  74  20  6C  73
                                    6D  20  69  6E  66  6F  72  6D  61
                                    74  69  6F  6E  00
0000013D  ?                         "Clara Schumann on the 100 DM
banknote"

------------------------------------------------------------------------
---
file - cz_rgb2.tif

Offset    Name                      Value

Header:
00000000  Byte Order                4949
00000002  Version                   002A
00000004  1st IFD Pointer           00000008

IFD:
00000008  Entry Count               000F
0000000A  NewSubfileType            00FE  0004  00000001  00000000
00000016  ImageWidth                0100  0004  00000001  00000200
00000022  ImageLength               0101  0004  00000001  000001E0
```

```
0000002E  BitsPerSample              0102  0003  00000003  000000C2
0000003A  Compression                0103  0003  00000001  0001
00000046  PhotometricInterpretation  0106  0003  00000001  0002
00000052  Make                       010F  0002  00000020  000000C8
0000005E  Model                      0110  0002  00000016  000000E8
0000006A  StripOffsets               0111  0004  00000001  0000014A
00000076  SamplesPerPixel            0115  0003  00000001  0003
00000082  StripByteCounts            0117  0004  00000001  000B4000
0000008E  PlanarConfiguration        011C  0003  00000001  0001
0000009A  SoftWare                   0131  0002  00000010  000000FE
000000A6  ?                          866C  0001  00000017  0000010E
000000B2  ?                          866D  0002  00000025  00000125
000000BE  Next IFD Pointer           00000000

Fields pointed to by the tags:
000000C2  BitsPerSample              0008  0008  0008
000000C8  Make                       "Carl Zeiss, Oberkochen, Germany"
000000E8  Model                      "Laser Scan Microscope"
000000FE  SoftWare                   "ZIF 1.81 MAR-93"
0000010E  ?                          70  72  69  76  61  74  20  4C  53
                                     4D  20  69  6E  66  6F  72  6D  61
                                     74  69  6F  6E  00
00000125  ?                          "Cara Schumann on the 100 DM banknote"

------------------------------------------------------------------------
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```