# Data Formats BoF

## A Rough Agenda For the Next Hour

- IAU Astronomical Data Representation Working Group
- Improving FITS
- Structured Data Formats
- VO data formats as IAU Standards

# Data Formats BoF

## IAU DATA Representation Working Group

Lucio Chiappetti: I think we should try to resurrect both the [IAU] Data Representation [Working Group] and the FITS SEG (the former was never formalized, and the second never convened in its post-IAUFWG composition) before the next IAU GA

# Data Formats BoF

## IAU Data Representation Working Group

Should such a group include

- Structured Data Formats  (ASDF, HDF)
- VO Data Formats
- FITS

# Data Formats BoF

## FITS Extensions

Reconvene the FITS SEG to change the standard to allow arbitrary-length keywords:

# Data Formats BoF

## IAU Astronomical Data Formats Working Group

- Should we add VO data formats as IAU Standards

# Fits internal compression

## 3 years after the publication…

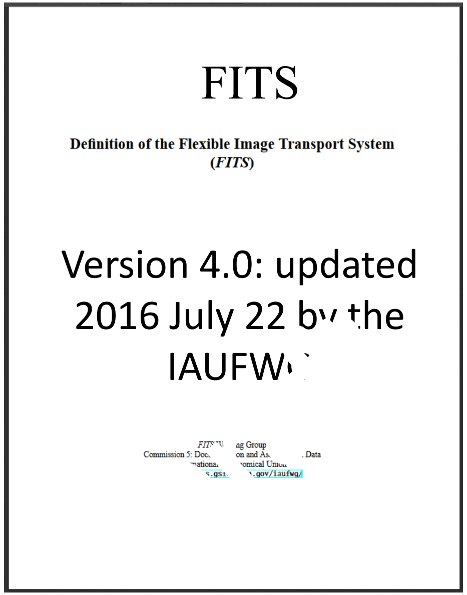
My problem
or our problem ?

Pierre Fernique
Centre de Données astronomique de Strasbourg

ADASS – Oct 2019 - Groningen

# The background

- **CDS users complain us** that **Aladin is no longer** able to **load their FITS** images => in fact internal compressed FITS images.
  => ex: Skymapper (RICE_ONE), SUBARU (GZIP_2), …
- I **tried to implement new FITS uncompress algorithms** during this summer..
- **I failed** (RICE_1 has been integrated successfully).
  *=> Too complex, too much variations:  RICE_1, RICE_ONE, GZIP1, GZIP2, HCOMPRESS and the dedicated IRAF/PLIO compressions + potentially others is not enough documented in the FITS IAU document (reference to external document, etc)*
  *=> need to look in the CFITSIO code to understand some details…*
- **Too much for me in the time and the energy that I had**.
  May be we were not enough motivated: the real interest of the FITS internal compression was not obvious for us.
  => May be **the problem was on my side**.



FITS

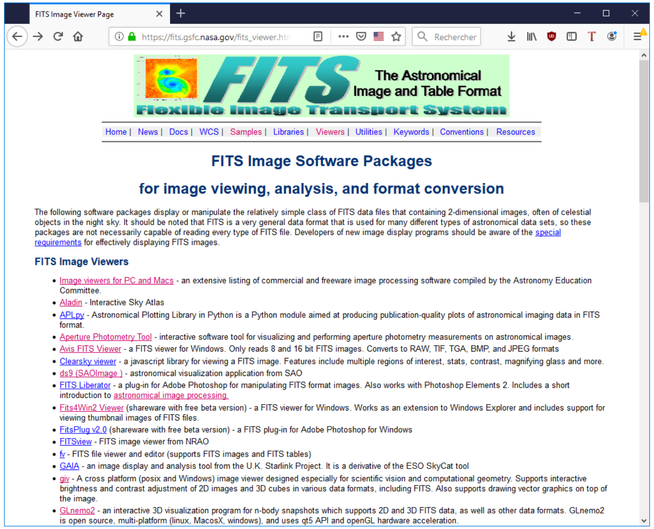
**Definition of the Flexible Image Transport System**
**(*FITS*)**

Version 4.0: updated
2016 July 22 b the
IAUFW

*FITS* W ng Group
Commission 5: Doc ion and As . Data
national omical Union
s.gs .gov/iaufwg/

- I was curious…

- I took a few hours to **install and test all recent FITS viewers** that I found, which are **not CFITSIO based**.
(for the FITS tools based and CFITSIO, the compression/uncompression integration is not a problem as it has been already coded by the promoters of this evolution)


FITS Image Viewer Page
https://fits.gsfc.nasa.gov/fits_viewer.htm
Rechercher
FITS
The Astronomical Image and Table Format
Flexible Image Transport System
Home | News | Docs | WCS | Samples | Libraries | Viewers | Utilities | Keywords | Conventions | Resources

### FITS Image Software Packages

### for image viewing, analysis, and format conversion

The following software packages display or manipulate the relatively simple class of FITS data files that containing 2-dimensional images, often of celestial objects in the night sky. It should be noted that FITS is a very general data format that is used for many different types of astronomical data sets, so these packages are not necessarily capable of reading every type of FITS file. Developers of new image display programs should be aware of the special requirements for effectively displaying FITS images.

#### FITS Image Viewers

- Image viewers for PC and Macs - an extensive listing of commercial and freeware image processing software compiled by the Astronomy Education Committee.
- Aladin - Interactive Sky Atlas
- APLpy - Astronomical Plotting Library in Python is a Python module aimed at producing publication-quality plots of astronomical imaging data in FITS format.
- Aperture Photometry Tool - interactive software tool for visualizing and performing aperture photometry measurements on astronomical images.
- Avis FITS Viewer - a FITS viewer for Windows. Only reads 8 and 16 bit FITS images. Converts to RAW, TIF, TGA, BMP, and JPEG formats
- Clearsky viewer - a javascript library for viewing a FITS image. Features include multiple regions of interest, stats, contrast, magnifying glass and more.
- ds9 (SAOImage ) - astronomical visualization application from SAO
- FITS Liberator - a plug-in for Adobe Photoshop for manipulating FITS format images. Also works with Photoshop Elements 2. Includes a short introduction to astronomical image processing.
- Fits4Win2 Viewer (shareware with free beta version) - a FITS viewer for Windows. Works as an extension to Windows Explorer and includes support for viewing thumbnail images of FITS files.
- FitsPlug v2.0 (shareware with free beta version) - a FITS plug-in for Adobe Photoshop for Windows
- FITSview - FITS image viewer from NRAO
- fv - FITS file viewer and editor (supports FITS images and FITS tables)
- GAIA - an image display and analysis tool from the U.K. Starlink Project. It is a derivative of the ESO SkyCat tool
- giv - A cross platform (posix and Windows) image viewer designed especially for scientific vision and computational geometry. Supports interactive brightness and contrast adjustment of 2D images and 3D cubes in various data formats, including FITS. Also supports drawing vector graphics on top of the image.
- GLnemo2 - an interactive 3D visualization program for n-body snapshots which supports 2D and 3D FITS data, as well as other data formats. GLnemo2 is open source, multi-platform (linux, MacosX, windows), and uses qt5 API and openGL hardware acceleration.

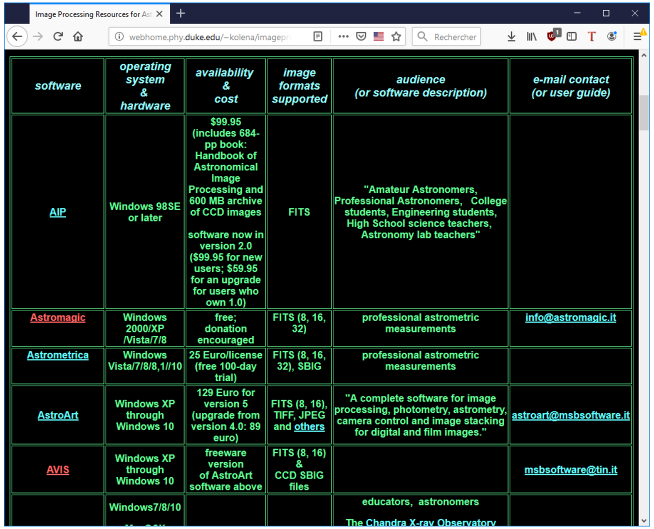
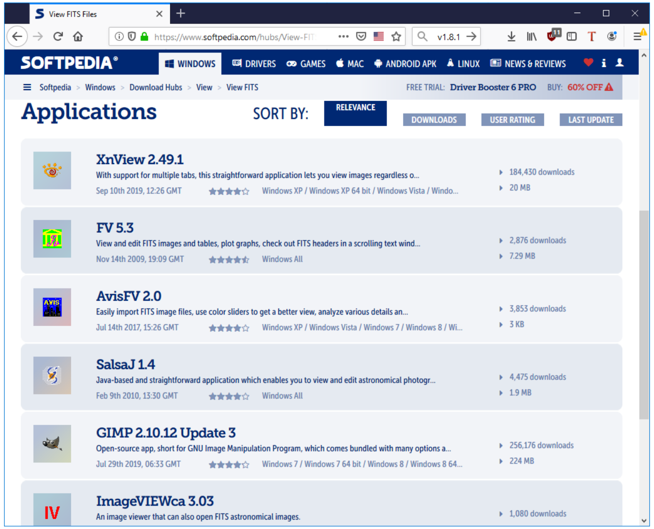


Image Processing Resources for Ast
webhome.phy.duke.edu/~kolena/imagepr
Rechercher

| *software* | *operating system & hardware* | *availability & cost* | *image formats supported* | *audience (or software description)* | *e-mail contact (or user guide)* |
|---|---|---|---|---|---|
| AIP | Windows 98SE or later | $99.95 (includes 684-pp book: Handbook of Astronomical Image Processing and 600 MB archive of CCD images<br>software now in version 2.0 ($99.95 for new users; $59.95 for an upgrade for users who own 1.0) | FITS | "Amateur Astronomers, Professional Astronomers, College students, Engineering students, High School science teachers, Astronomy lab teachers" | |
| Astromagic | Windows 2000/XP /Vista/7/8 | free; donation encouraged | FITS (8, 16, 32) | professional astrometric measurements | info@astromagic.it |
| Astrometrica | Windows Vista/7/8/8,1//10 | 25 Euro/license (free 100-day trial) | FITS (8, 16, 32), SBIG | professional astrometric measurements | |
| AstroArt | Windows XP through Windows 10 | 129 Euro for version 5 (upgrade from version 4.0: 89 euro) | FITS (8, 16), TIFF, JPEG and others | "A complete software for image processing, photometry, astrometry, camera control and image stacking for digital and film images." | astroart@msbsoftware.it |
| AVIS | Windows XP through Windows 10 | freeware version of AstroArt software above | FITS (8, 16) & CCD SBIG files | | msbsoftware@tin.it |
| | Windows7/8/10 | | | educators, astronomers<br>The Chandra X-ray Observatory | |


View FITS Files
https://www.softpedia.com/hubs/View-FIT
v1.8.1
SOFTPEDIA®
WINDOWS
DRIVERS
GAMES
MAC
ANDROID APK
LINUX
NEWS & REVIEWS
Softpedia > Windows > Download Hubs > View > View FITS
FREE TRIAL: Driver Booster 6 PRO BUY: 60% OFF
SORT BY:
RELEVANCE
DOWNLOADS
USER RATING
LAST UPDATE

## Applications

**XnView 2.49.1**
With support for multiple tabs, this straightforward application lets you view images regardless o...
Sep 10th 2019, 12:26 GMT ★★★★☆ Windows XP / Windows XP 64 bit / Windows Vista / Windo...
184,430 downloads
20 MB

**FV 5.3**
View and edit FITS images and tables, plot graphs, check out FITS headers in a scrolling text wind...
Nov 14th 2009, 19:09 GMT ★★★★☆ Windows All
2,876 downloads
7.29 MB

**AvisFV 2.0**
Easily import FITS image files, use color sliders to get a better view, analyze various details an...
Jul 14th 2017, 15:26 GMT ★★★★☆ Windows XP / Windows Vista / Windows 7 / Windows 8 / Wi...
3,853 downloads
3 KB

**SalsaJ 1.4**
Java-based and straightforward application which enables you to view and edit astronomical photogr...
Feb 9th 2010, 13:30 GMT ★★★★☆ Windows All
4,475 downloads
1.9 MB

**GIMP 2.10.12 Update 3**
Open-source app, short for GNU Image Manipulation Program, which comes bundled with many options a...
Jul 29th 2019, 06:33 GMT ★★★★☆ Windows 7 / Windows 7 64 bit / Windows 8 / Windows 8 64...
256,176 downloads
224 MB

**ImageVIEWca 3.03**
An image viewer that can also open FITS astronomical images.
1,080 downloads

1. Kstar
2. Iris
3. SubaruImageProcessor
4. SalsaJ
5. AvisFV
6. Rspec
7. ImageJ
8. GIMP
9. ImageViewca
10. Aladin
11. Ginemo

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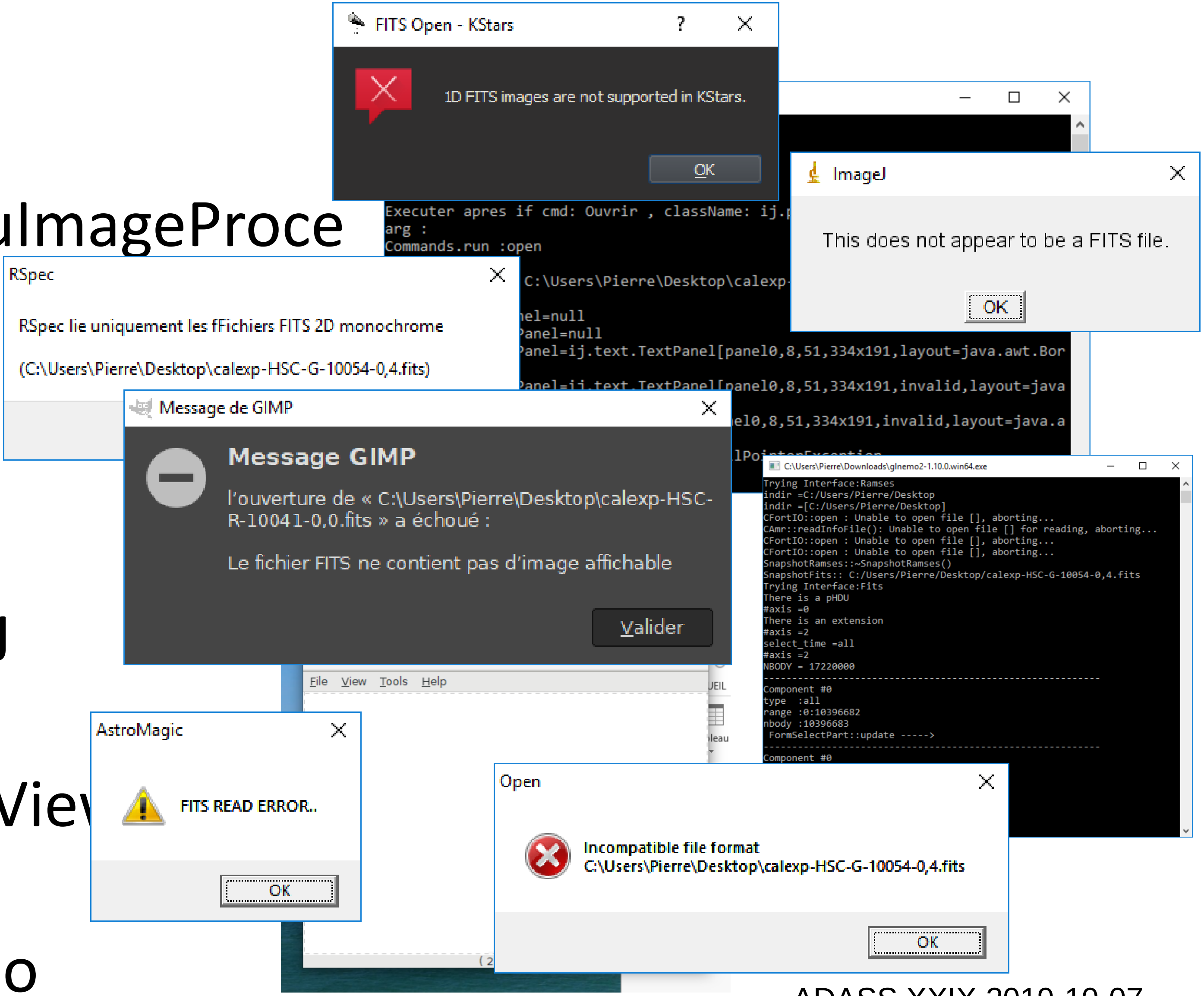
11. Ginemo



FITS Open - KStars

1D FITS images are not supported in KStars.

```
Executer apres if cmd: Ouvrir , className: ij.p
arg :
Commands.run :open

 C:\Users\Pierre\Desktop\calexp-

nel=null
Panel=null
Panel=ij.text.TextPanel[panel0,8,51,334x191,layout=java.awt.Bor

Panel=ij.text.TextPanel[panel0,8,51,334x191,invalid,layout=java

el0,8,51,334x191,invalid,layout=java.a

lPointerException
```

ImageJ

This does not appear to be a FITS file.

RSpec

RSpec lie uniquement les fFichiers FITS 2D monochrome

(C:\Users\Pierre\Desktop\calexp-HSC-G-10054-0,4.fits)

Message de GIMP

Message GIMP

l'ouverture de « C:\Users\Pierre\Desktop\calexp-HSC-R-10041-0,0.fits » a échoué :

Le fichier FITS ne contient pas d'image affichable

C:\Users\Pierre\Downloads\glnemo2-1.10.0.win64.exe

```
Trying Interface:Ramses
indir =C:/Users/Pierre/Desktop
indir =[C:/Users/Pierre/Desktop]
CFortIO::open : Unable to open file [], aborting...
CAmr::readInfoFile(): Unable to open file [] for reading, aborting...
CFortIO::open : Unable to open file [], aborting...
CFortIO::open : Unable to open file [], aborting...
SnapshotRamses::~SnapshotRamses()
SnapshotFits:: C:/Users/Pierre/Desktop/calexp-HSC-G-10054-0,4.fits
Trying Interface:Fits
There is a pHDU
#axis =0
There is an extension
#axis =2
select_time =all
#axis =2
NBODY = 17220000
-----------------------------------------------------------------
Component #0
type  :all
range :0:10396682
nbody :10396683
 FormSelectPart::update ----->
-----------------------------------------------------------------
Component #0
```

AstroMagic

FITS READ ERROR..

Open

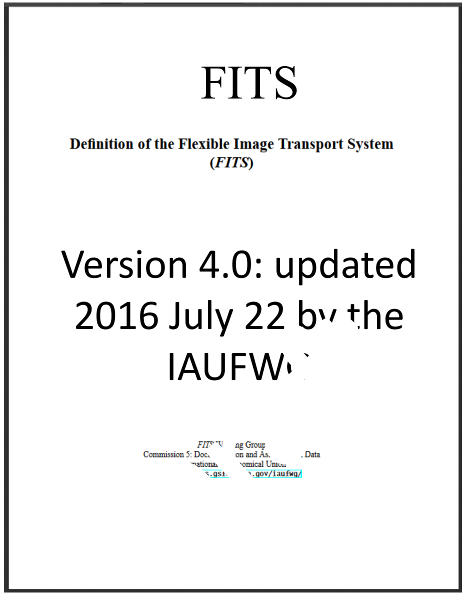
Incompatible file format
C:\Users\Pierre\Desktop\calexp-HSC-G-10054-0,4.fits

ADASS XXIX 2019-10-07

# Is it **our** problem ?

- **No one is supporting internal compression**
  ***=>*** *I'm not alone to be a little bit reluctant to integrate internal FITS compression methods.*
- My fears here – and my observation - is that the fact to **authorize a collection of compression methods in the FITS standard will probably kill - or restrict the usage of - all tools not CFITSIO based.**
- And it is certainly **not a good thing for the interoperability** but for sure an efficient way to kill the biggest interest of using FITS,
- And probably **not a good choice for the future** of the unfortunate internal compressed FITS image collections.

Is it too late?



FITS

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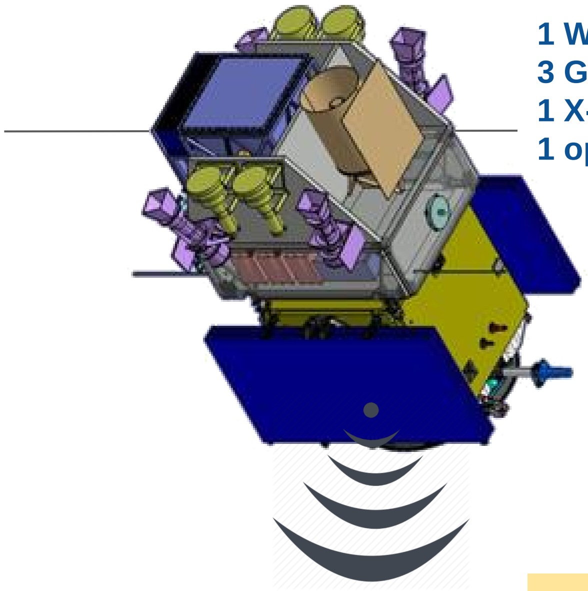
*FITS* W ng Group
Commission 5: Doc ion and As . Data
national omical Union
s.gs .gov/iaufwg/

# Annotating FITS Files with VO tags *SVOM case*

Laurent Michel - Mireille Louys
Strasbourg Observatory



1 Wide field Gamma Ray camera
1 Gamma Ray monitors
1 X-ray camera
1 optical telescope

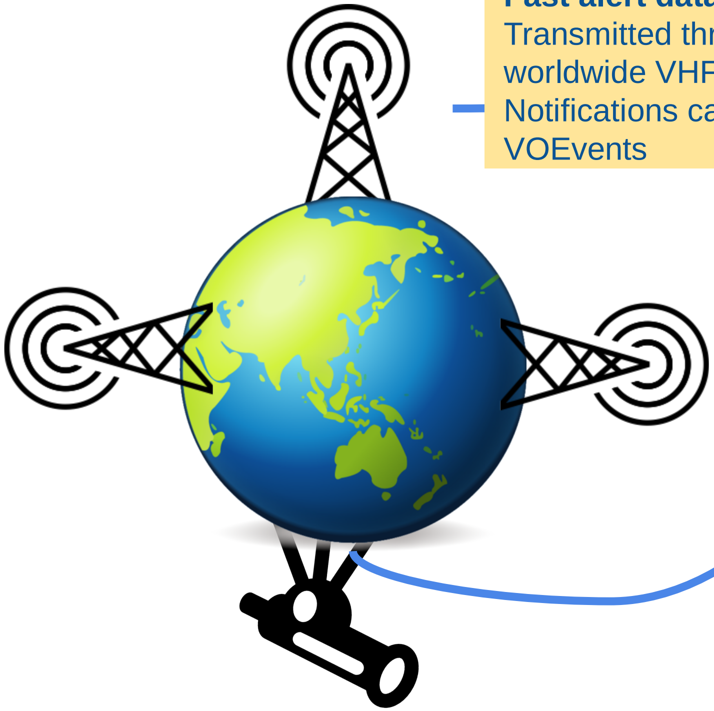
SVO
M

**X-Band data**
Downlink 6 times a day

**Fast alert data**
Transmitted through a worldwide VHF network
Notifications carried out by VOEvents

## Ground segment

China and France (FSC)



**Follow-up Data**
2 ground IR and visible telescopes
China and Mexico
Transmitted through a dedicated link

# The SVOM mission

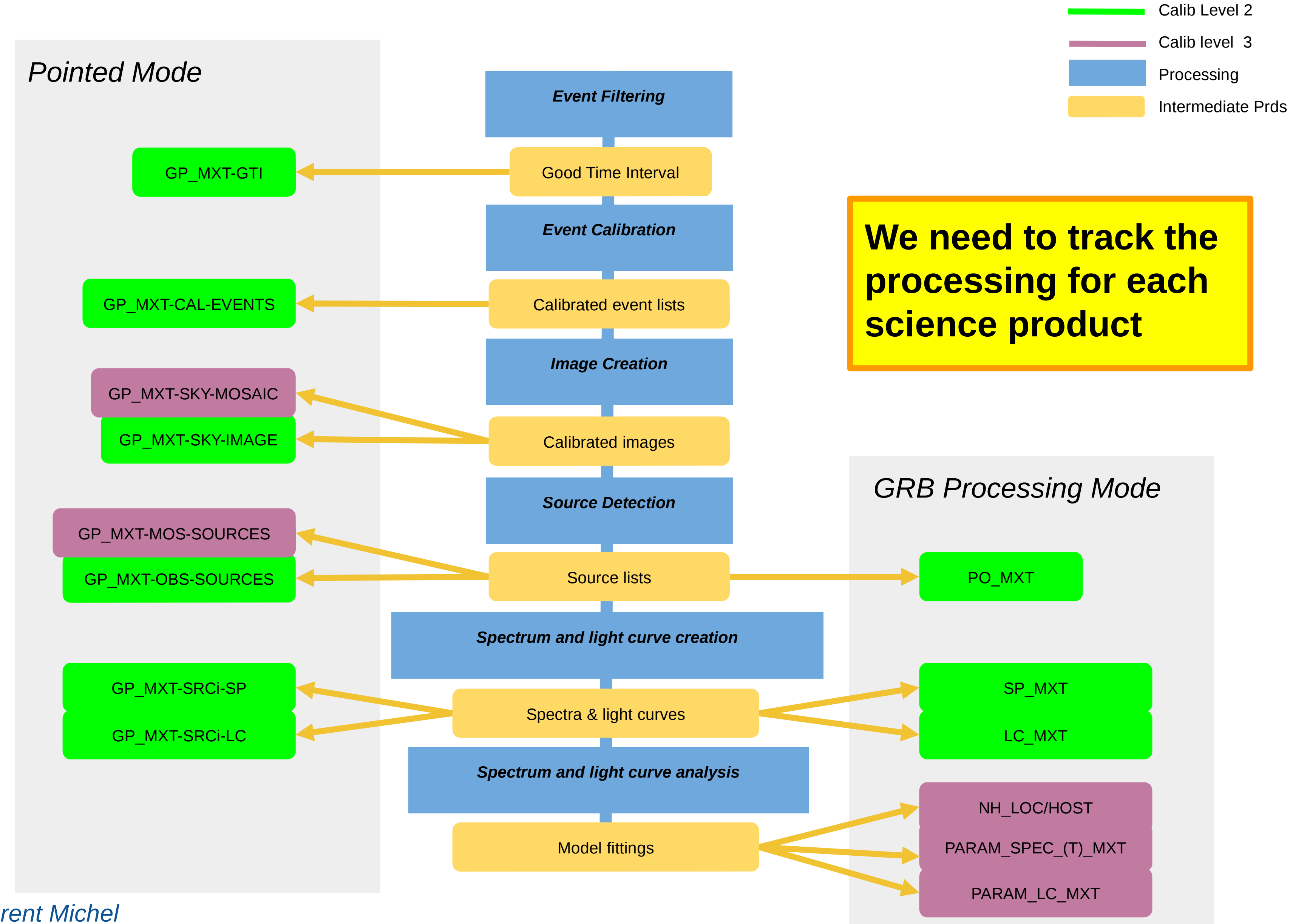
# VO in FITS at a Glance

- **All SVOM science products are in FITS format**
  - Mission requirement

- **Why VO tags in FITS files?**
  - OBSCORE: Facilitate the publishing in VO collections
  - PROVENANCE: Facilitate the reprocessing with a different setup

- **Guideline**
  - Clear separation between native data (OGIP kws, Mission data, science data) and VO stuff
    - One FITS extension for the VO: VO-TAGS
  - Obscore as a set ok keywords
  - Provenance: JSON serialization in a 1x1 ASCII table
- **Tools**
  - A python module to write and read data annotations
    - N ot public yet

# Provenance: Pipeline Workflow



Calib Level 2

Calib level 3

Processing

Intermediate Prds

*Pointed Mode*

***Event Filtering***

Good Time Interval

GP_MXT-GTI

***Event Calibration***

Calibrated event lists

GP_MXT-CAL-EVENTS

***Image Creation***

Calibrated images

GP_MXT-SKY-MOSAIC

GP_MXT-SKY-IMAGE

***Source Detection***

Source lists

GP_MXT-MOS-SOURCES

GP_MXT-OBS-SOURCES

***Spectrum and light curve creation***

Spectra & light curves

GP_MXT-SRCi-SP

GP_MXT-SRCi-LC

***Spectrum and light curve analysis***

Model fittings

*GRB Processing Mode*

PO_MXT

SP_MXT

LC_MXT

NH_LOC/HOST

PARAM_SPEC_(T)_MXT

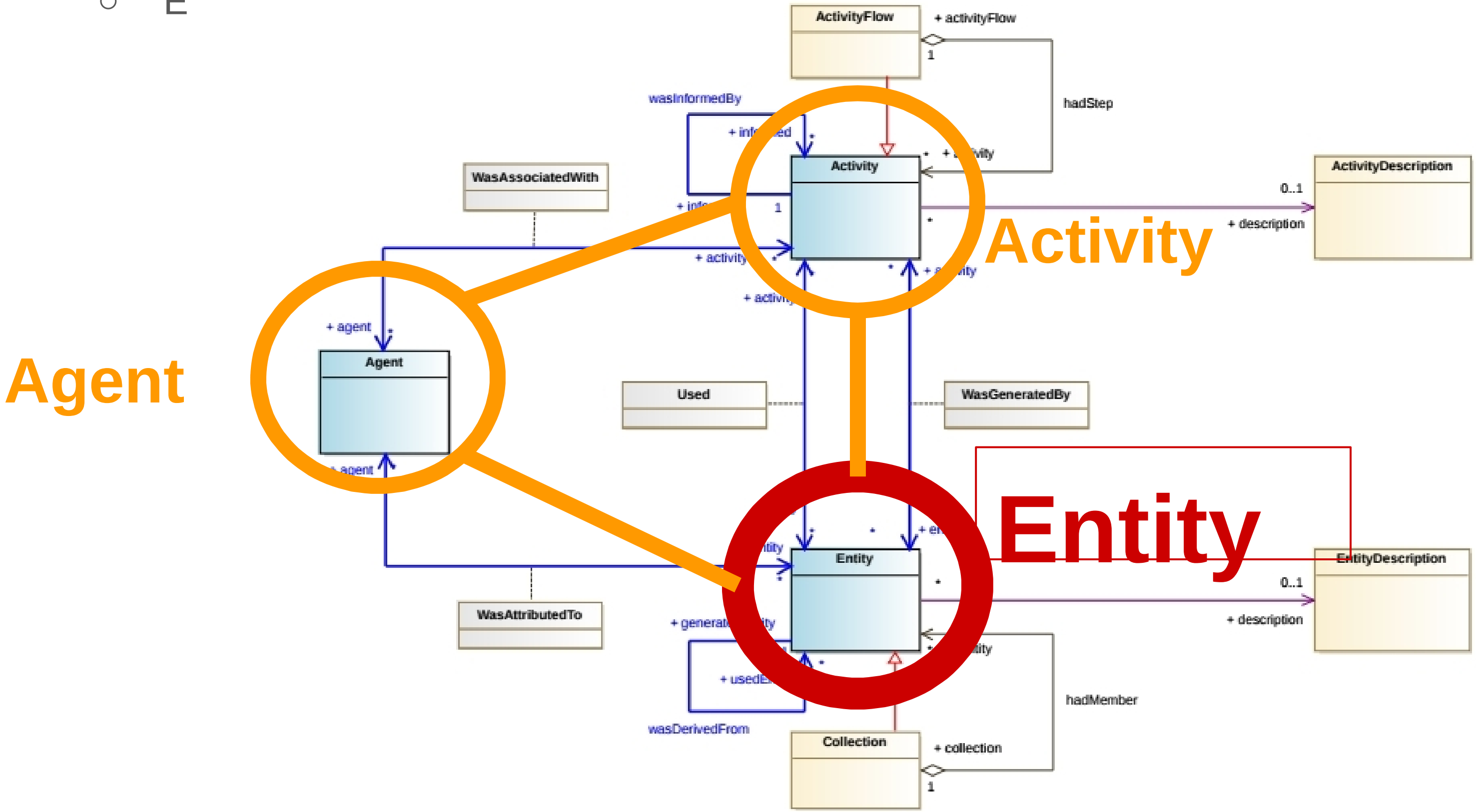
PARAM_LC_MXT

**We need to track the processing for each science product**

# Provenance DM at a Glance

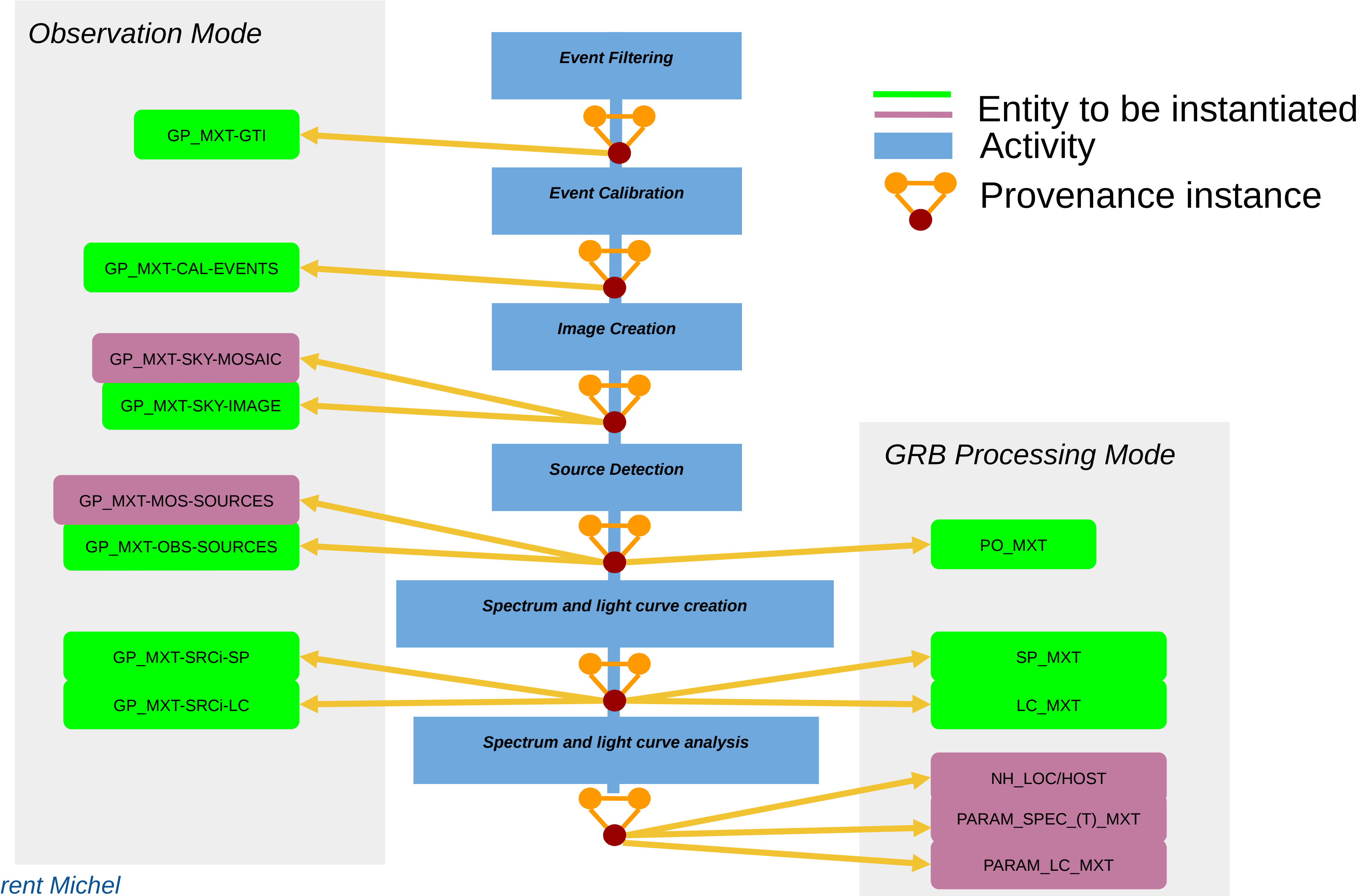
- **Designed around 3 poles** *(WARNING: the model has evolved since 2017)*
    - Activity, Agent and Entity

- ***Prov Speaking:*** **We want to describe the activities leading to our entities**
    - E

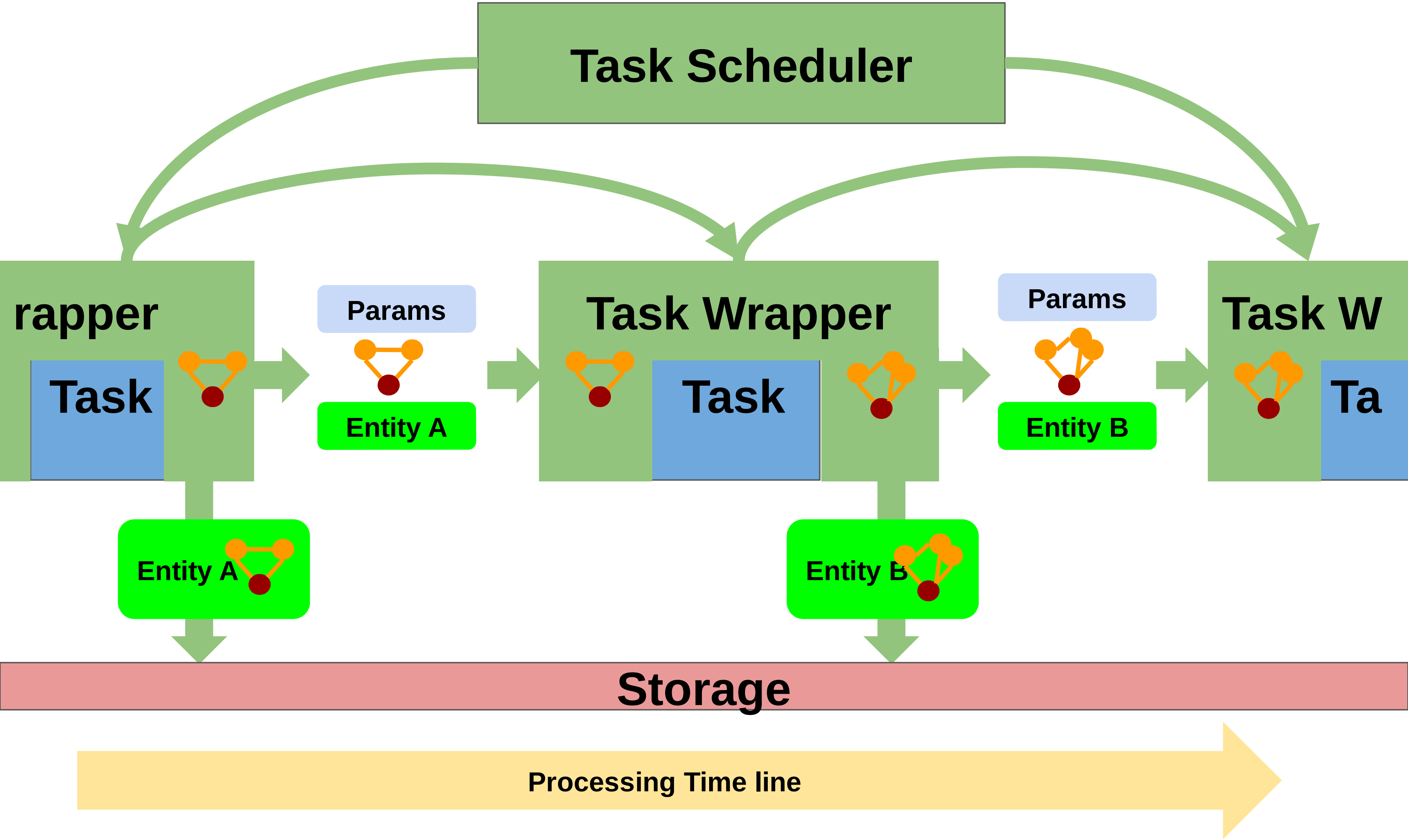


Laurent Michel

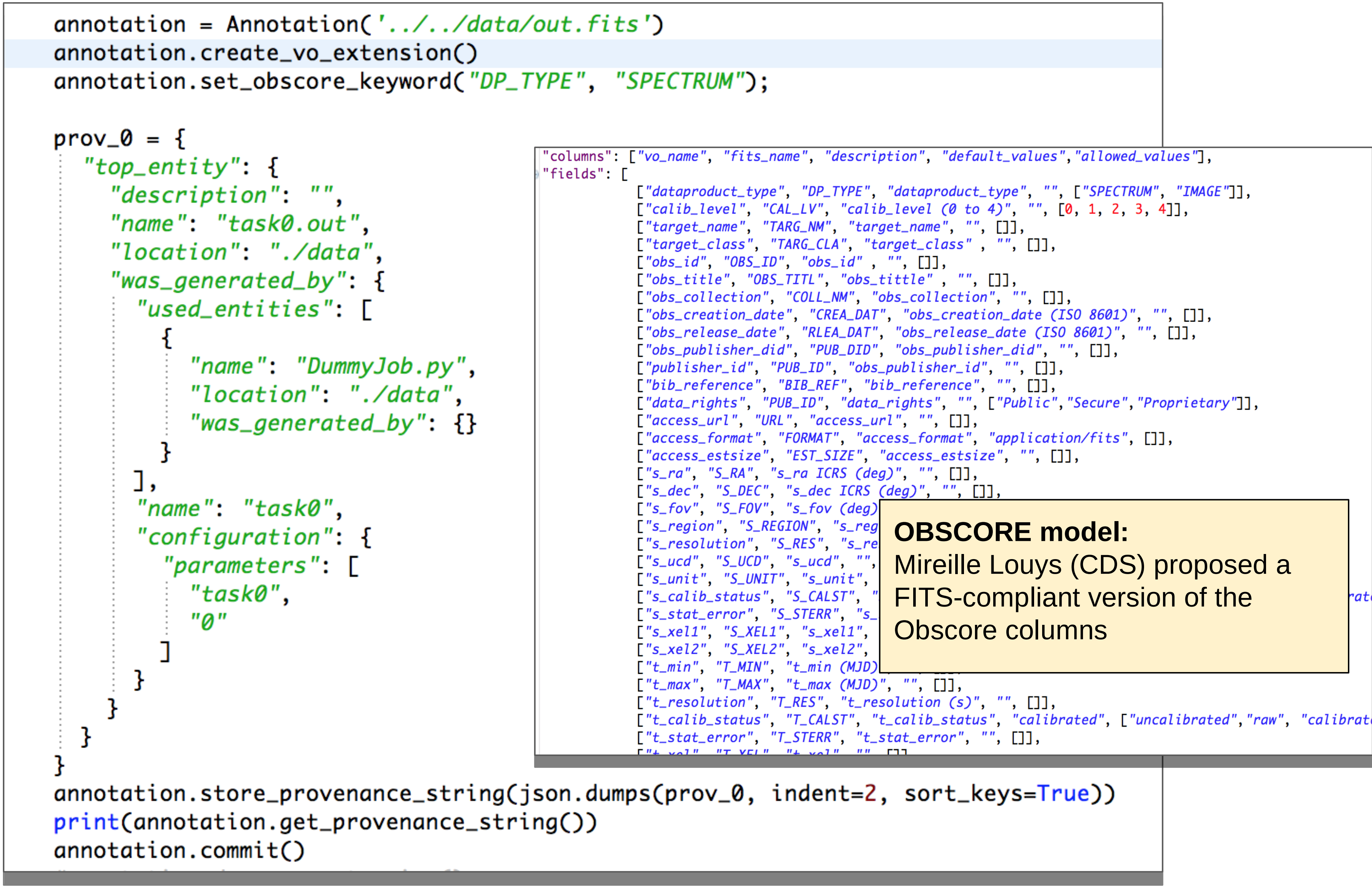
# Provenance View



# Incremental Provenance Construction



# Python Code Snippet



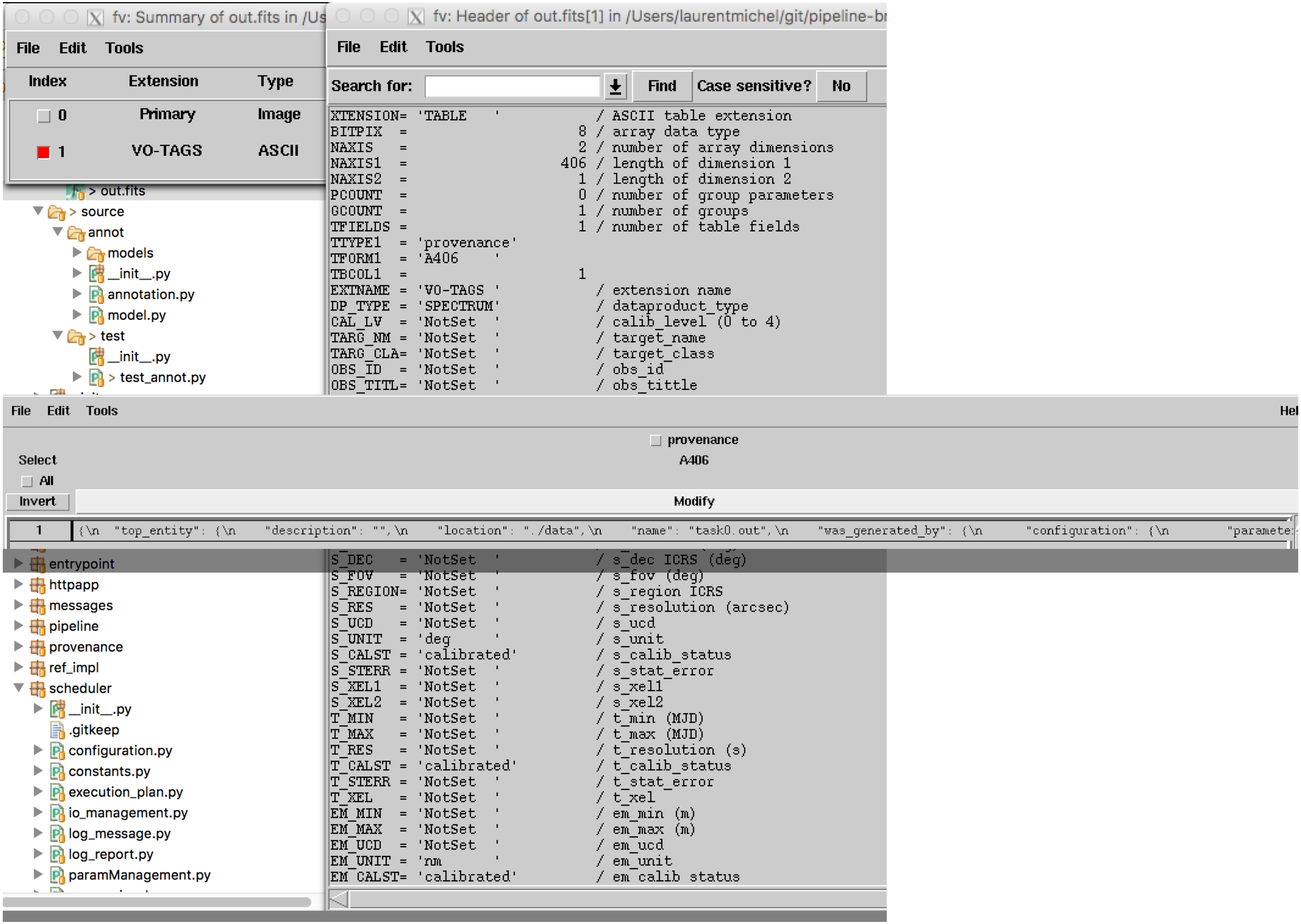
```
annotation = Annotation('../../data/out.fits')
annotation.create_vo_extension()
annotation.set_obscore_keyword("DP_TYPE", "SPECTRUM");

prov_0 = {
  "top_entity": {
    "description": "",
    "name": "task0.out",
    "location": "./data",
    "was_generated_by": {
      "used_entities": [
        {
          "name": "DummyJob.py",
          "location": "./data",
          "was_generated_by": {}
        }
      ],
      "name": "task0",
      "configuration": {
        "parameters": [
          "task0",
          "0"
        ]
      }
    }
  }
}
annotation.store_provenance_string(json.dumps(prov_0, indent=2, sort_keys=True))
print(annotation.get_provenance_string())
annotation.commit()
```

```
"columns": ["vo_name", "fits_name", "description", "default_values","allowed_values"],
"fields": [
            ["dataproduct_type", "DP_TYPE", "dataproduct_type", "", ["SPECTRUM", "IMAGE"]],
            ["calib_level", "CAL_LV", "calib_level (0 to 4)", "", [0, 1, 2, 3, 4]],
            ["target_name", "TARG_NM", "target_name", "", []],
            ["target_class", "TARG_CLA", "target_class" , "", []],
            ["obs_id", "OBS_ID", "obs_id" , "", []],
            ["obs_title", "OBS_TITL", "obs_tittle" , "", []],
            ["obs_collection", "COLL_NM", "obs_collection", "", []],
            ["obs_creation_date", "CREA_DAT", "obs_creation_date (ISO 8601)", "", []],
            ["obs_release_date", "RLEA_DAT", "obs_release_date (ISO 8601)", "", []],
            ["obs_publisher_did", "PUB_DID", "obs_publisher_did", "", []],
            ["publisher_id", "PUB_ID", "obs_publisher_id", "", []],
            ["bib_reference", "BIB_REF", "bib_reference", "", []],
            ["data_rights", "PUB_ID", "data_rights", "", ["Public","Secure","Proprietary"]],
            ["access_url", "URL", "access_url", "", []],
            ["access_format", "FORMAT", "access_format", "application/fits", []],
            ["access_estsize", "EST_SIZE", "access_estsize", "", []],
            ["s_ra", "S_RA", "s_ra ICRS (deg)", "", []],
            ["s_dec", "S_DEC", "s_dec ICRS (deg)", "", []],
            ["s_fov", "S_FOV", "s_fov (deg)
            ["s_region", "S_REGION", "s_reg
            ["s_resolution", "S_RES", "s_re
            ["s_ucd", "S_UCD", "s_ucd", "",
            ["s_unit", "S_UNIT", "s_unit",
            ["s_calib_status", "S_CALST", "                                                   rat
            ["s_stat_error", "S_STERR", "s_
            ["s_xel1", "S_XEL1", "s_xel1",
            ["s_xel2", "S_XEL2", "s_xel2",
            ["t_min", "T_MIN", "t_min (MJD)
            ["t_max", "T_MAX", "t_max (MJD)", "", []],
            ["t_resolution", "T_RES", "t_resolution (s)", "", []],
            ["t_calib_status", "T_CALST", "t_calib_status", "calibrated", ["uncalibrated","raw", "calibrat
            ["t_stat_error", "T_STERR", "t_stat_error", "", []],
            ["t_xel", "T_XEL", "t_xel", "", []]
```

**OBSCORE model:**
Mireille Louys (CDS) proposed a FITS-compliant version of the Obscore columns

# VO Stuff with FV



| Index | Extension | Type |
|---|---|---|
| □ 0 | Primary | Image |
| 🟥 1 | VO-TAGS | ASCII |

```
XTENSION= 'TABLE   '           / ASCII table extension
BITPIX  =                    8 / array data type
NAXIS   =                    2 / number of array dimensions
NAXIS1  =                  406 / length of dimension 1
NAXIS2  =                    1 / length of dimension 2
PCOUNT  =                    0 / number of group parameters
GCOUNT  =                    1 / number of groups
TFIELDS =                    1 / number of table fields
TTYPE1  = 'provenance'
TFORM1  = 'A406    '
TBCOL1  =                    1
EXTNAME = 'VO-TAGS '           / extension name
DP_TYPE = 'SPECTRUM'           / dataproduct_type
CAL_LV  = 'NotSet  '           / calib_level (0 to 4)
TARG_NM = 'NotSet  '           / target_name
TARG_CLA= 'NotSet  '           / target_class
OBS_ID  = 'NotSet  '           / obs_id
OBS_TITL= 'NotSet  '           / obs_tittle
```

□ provenance
A406

```
1  {\n  "top_entity": {\n  "description": "",\n  "location": "./data",\n  "name": "task0.out",\n  "was_generated_by": {\n  "configuration": {\n  "paramete
```

```
S_DEC   = 'NotSet  '           / s_dec ICRS (deg)
S_FOV   = 'NotSet  '           / s_fov (deg)
S_REGION= 'NotSet  '           / s_region ICRS
S_RES   = 'NotSet  '           / s_resolution (arcsec)
S_UCD   = 'NotSet  '           / s_ucd
S_UNIT  = 'deg     '           / s_unit
S_CALST = 'calibrated'         / s_calib_status
S_STERR = 'NotSet  '           / s_stat_error
S_XEL1  = 'NotSet  '           / s_xel1
S_XEL2  = 'NotSet  '           / s_xel2
T_MIN   = 'NotSet  '           / t_min (MJD)
T_MAX   = 'NotSet  '           / t_max (MJD)
T_RES   = 'NotSet  '           / t_resolution (s)
T_CALST = 'calibrated'         / t_calib_status
T_STERR = 'NotSet  '           / t_stat_error
T_XEL   = 'NotSet  '           / t_xel
EM_MIN  = 'NotSet  '           / em_min (m)
EM_MAX  = 'NotSet  '           / em_max (m)
EM_UCD  = 'NotSet  '           / em_ucd
EM_UNIT = 'nm      '           / em_unit
EM_CALST= 'calibrated'         / em_calib_status
```

# How to invite authors to better use FITS standards ? (spectra / images)

## Why ?

- Improve reusability (FITS recommendations)
  https://fits.gsfc.nasa.gov/fits_dictionary.html
- Improve discovery : **Virtual Observatory**
  DataModel ObsCore (meta-data for observation)
  example : CADC, VizieR, NED, ...

## Status

- The FITS format is generally conform (fits-verify checked)
- Authors are quite inventive / take some freedom with FITS recommendations
  - Usage of exotic keywords (e.g.: POSRA, POSDEC)
  - Uncomplete WCS .. (e.g.:CUNITx not specified)
- A large variety of serialization for spectra (WCS, multipsec..)

## To put FITS spectra/images in the Virtual Observatory

- ObsCore mapping possible with FITS recommendations

➡ are FITS recommendations well used ?

| obscore | FITS standards (ex) |
|---|---|
| target_name | OBJECT |
| s_ra | RA , WCS |
| Coord. syst. | RADESYS |
| s_dec | DEC , WCS |
| s_fov | WCS |
| s_region | WCS |
| s_resolution | WCS |
| t_min | TIME-OBS |
| t_max | TIME-END |
| t_exptime | EXPTIME |
| t_resolution | ??? |
| em_min | WCS |
| em_max | WCS |
| em_res_power | WCS |
| o_ucd | -- VO : fixed constant |
| pol_states | WCS-STOKES |
| facility_name | TELESCOP |
| instrument_name | INSTRUM |

# How to invite authors to better use FITS standards ? (spectra / images)

Authors are not lazzy but they don't know how

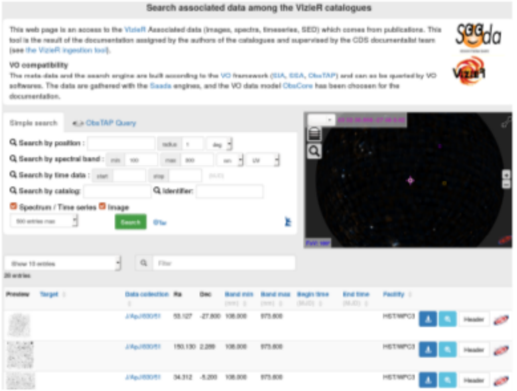
- How FITS header are reused ?
- How to create FITS header reusable for the VO ?

## Scope for improvment

- Communication with authors :
  VO schools, conferences, ...
- Guide authors to improve their data:
  - Data center documentation, good practices (NED), ...
  - Provide tools to improve FITS header:
    FITS header validators?
    ex: https://cdsarc.unistra.fr/vizier.submit/fitsvalidator.html (CDS)
- New meta-data serialisation ?
  *(e.g. SVOM serialization, Michel L.)*

**What about FITS spectra/images?**

VizieR offers a specific search for images, spectra and data-cubes in FITS format.



**Search associated data among the VizieR catalogues**

This web page is an access to the VizieR Associated data (images, spectra, timeseries, SED) which comes from publications. This tool is the result of the documentation assigned by the authors of the catalogues and supervised by the CDS documentalist team (see the VizieR ingestion tool).

**VO compatibility**

The meta-data and the search engine are built according to the VO framework (SIA, SSA, ObsTAP) and can as be queried by VO softwares. The data are gathered with the Saada engines, and the VO data model ObsCore has been choosen for the documentation.

A good FITS header is the key for reusability - the CDS encourages the usage of the FITS standards: https://fits.gsfc.nasa.gov/

**Check** that FITS file header includes:

- coordinates and wavelengths in the WCS system
- observation dates
- telescopes/instruments

If the FITS file is not in the standard WCS system, the reusability of the file is compromised.

Try this tool to check the completeness of your FITS header: http://cdsarc.u-strasbg.fr/vizier.submit/fitsvalidator.html

Part of the brochure for authors (EWASS - 2019)