

**Florian Merges**

**Grado de Ingeniería de Informática  
Ingeniería del Software**

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June, 2019

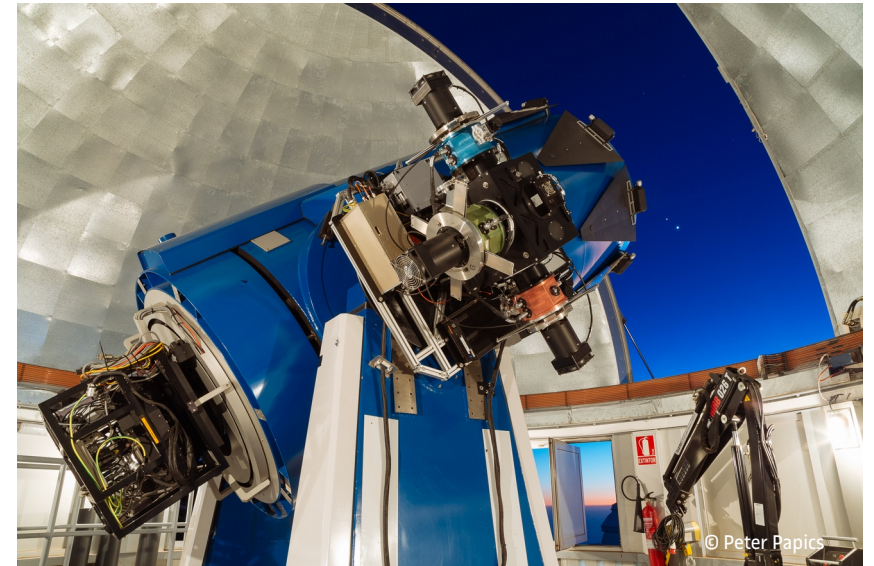


Universitat  
Oberta  
de Catalunya

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# Telescopes and instruments

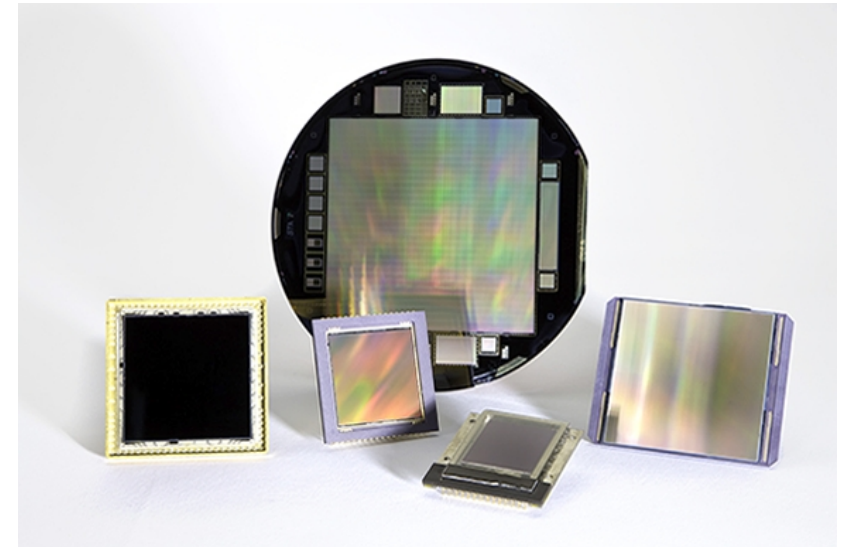
- Explore the universe
- Understand how it works, and the origin of life



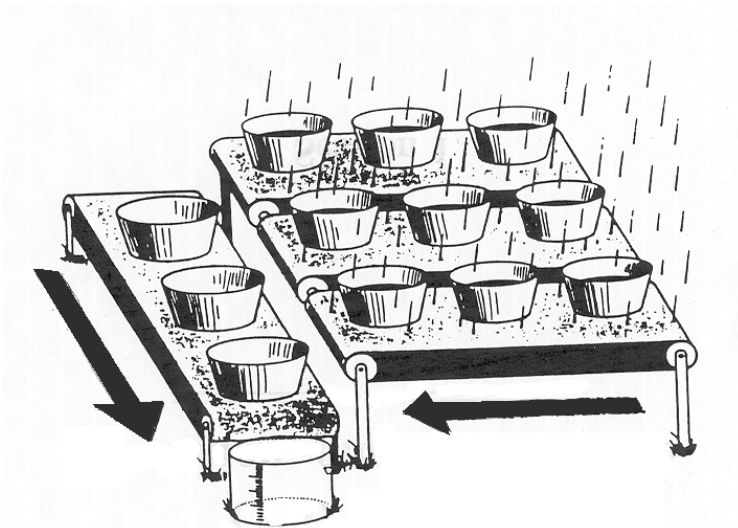
- Instruments are the main data producers.
- Spectroscopy, imaging, ...

# Charge Coupled Devices

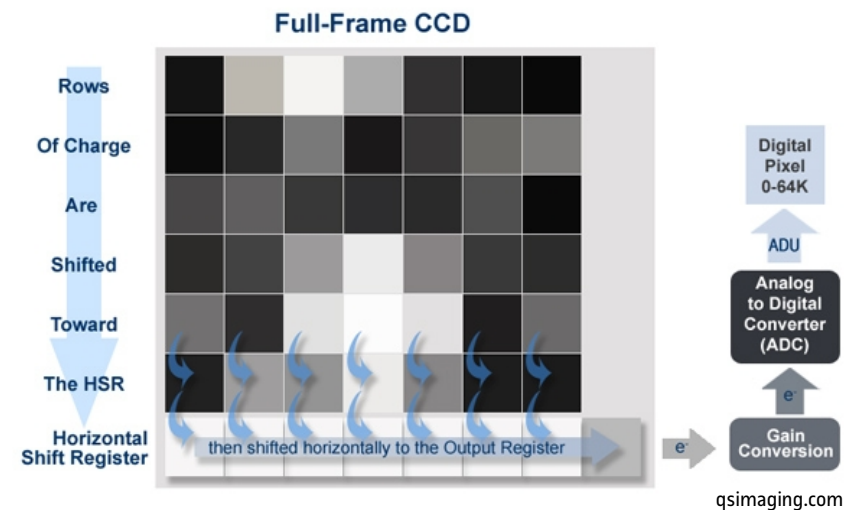
- Light sensitive
- “Buckets of light”
- wave or particle?



Spectral Instruments

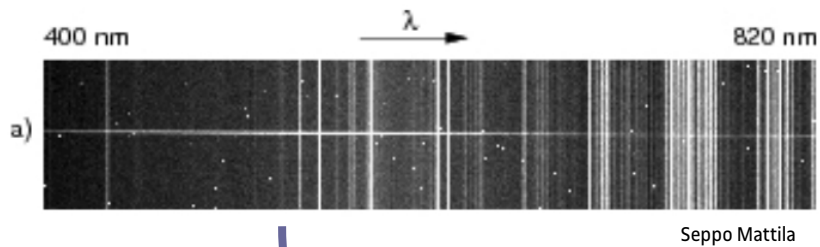


Howell 2006



# Raw data vs. reduced data

Raw target frame  
(narrow slit)



from...

- Raw data

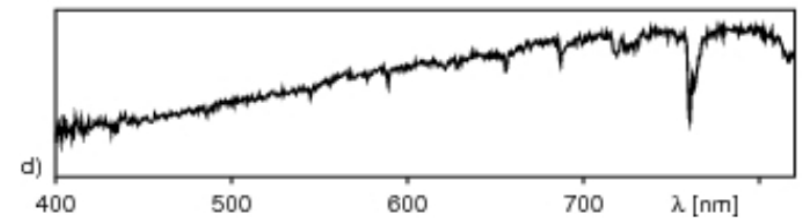
The images show a raw spectra and the reduced wavelength calibrated

Software pipelines use raw data with calibration data to create reduced data.

...to

- Reduced data

Wavelength calibrated



Seppo Mattila

# Introducing the FITS format

- Flexible Image Transport System
- Header and pixel data
- Header date units or extensions
- > 35 years old
- Mandatory fields:
  - SIMPLE
  - BITPIX
  - NAXIS
  - NAXIS1
  - NAXISn
  - GROUPS
  - PCOUNT
  - GCOUNT
  - END

```
PRIMARY SCI SCI SCI
SIMPLE = T / conforms to FITS standard
BITPIX = 8 / array data type
NAXIS = 0 / number of array dimensions
EXTEND = T
ORIGIN = 'Instituut voor Sterrenkunde, KU Leuven' / Institution
OBSERVAT= 'LaPalma ' / Observatory name
TELESCOP= 'Mercator' / Telescope name
OBSGEO-X= 5327306.5552 / Cartesian X [meters] GRS80
OBSGEO-Y= -1718448.6952 / Cartesian Y [meters] GRS80
OBSGEO-Z= 3051947.7715 / Cartesian Z [meters] GRS80
OBSERVER= 'Foo Bar ' / Observer
PROG_ID = 3 / Programme ID
INSTRUME= 'MAIA ' / Instrument
CREATOR = 'revision_20170521' / Version of data acquisition system
HDRVERS = '20151026' / Version of FITS header
FILENAME= '/disk/50/data/maia/20180531/raw/00880392_OBJ.fits' / Original
filenamUNSEQ = 880392 / Unique sequence number
OBSMODE = 'OBJ ' / Observing mode
IMAGETYP= 'OBJECT ' / Image type
EXPTYPE = 'OBJ ' / Exposure type
COMMENTS= '' / Free comments by the observer
DATE-OBS= '2019-05-31T22:12:41.998509' / Start of observation
DATE-END= '2019-05-31T22:13:18.000414' / End of observation
DATE-AVG= '2019-05-31T22:12:59.999461' / Midpoint of observation
DATE = '2019-05-31T22:14:07.645376' / Time of file creation
BJD = 2458270.4028625 / Barycentric Julian Date of midpoint
BVCOR = 2.53061 / [km/s] Barycentric rv correction at midpoint
EXPTIME = 120 / Exposure time
OBJECT = 'HD 128165' / Object name
OBJ_RA = 218.3704166666667 / [deg] Object RA
OBJ_DEC = 52.90877777777778 / [deg] Object DEC
EQUINOX = 2000.0 / Equinox of coordinates
RADECSYS= 'FK5 ' / Coordinate system
```

# Objectives

- Design and develop a general purpose astronomical data archive
- User can search, inspect, and download data
- Manage data access

## What for?

- Small to medium sized telescopes, astronomers and amateurs
- Replaces shared folders, FTP, CSV files, and others
- Can be used for public and private data

# How? ... with software!

- Knowing the target audience and their needs
- Using an agile development methodology
- Gantt charts }:-)

## ...by means of

- Research, talk, observe
- SCRUM



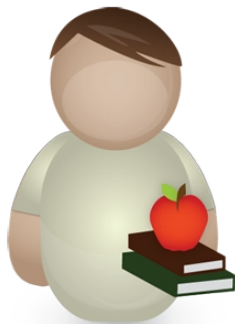


# Users@want.stories



**Admin**

- Import new data
- Manage users



**User**

- Sign up
- Search data
- Inspect data
- Access to the end of night report
- Finding charts and catalog information
- Raw header access
- Analyze the reduced data
- Select data to download
- Download data as tarball (zipped)
- Receive notifications: when new data is available, when a tarball is ready to download

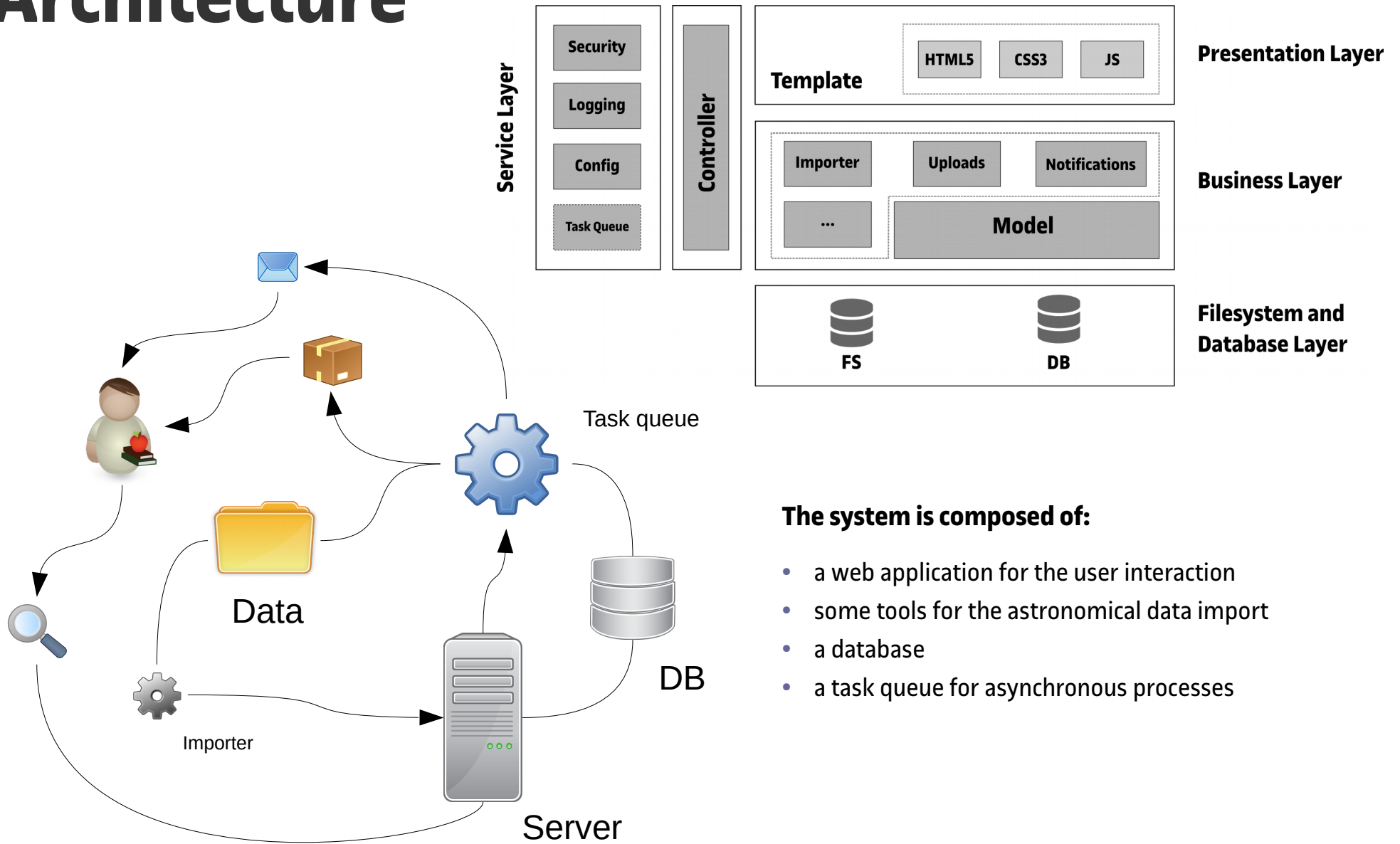
- Define details of my programs
- Manage users access to them
- Upload proposals to them
- Follow the progress of it



**Principal  
Investigator  
(PI)**



# Architecture



## The system is composed of:

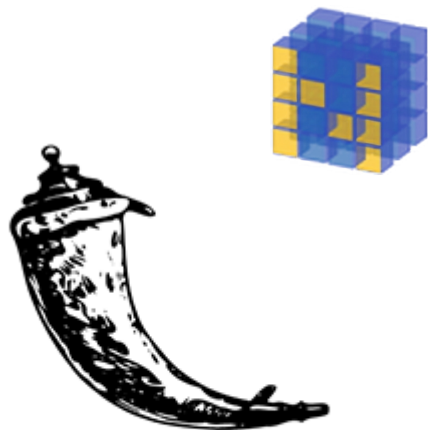
- a web application for the user interaction
- some tools for the astronomical data import
- a database
- a task queue for asynchronous processes

# Technology



PostgreSQL

SQLAlchemy



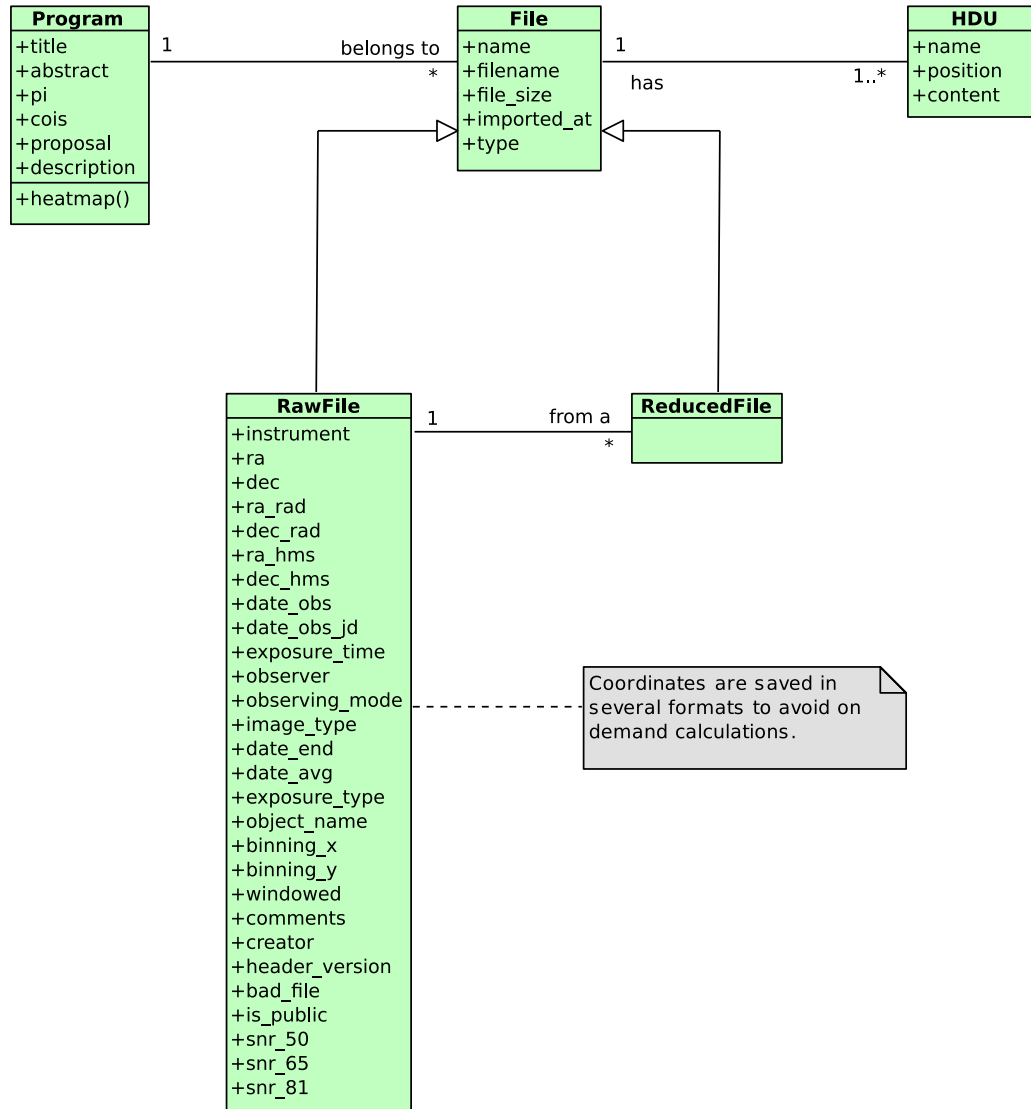
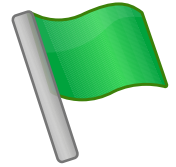
Flask



NGINX



# Ready, set, go...



- File class is the parent class of RawFile and ReducedFile, they represent raw and reduced data respectively
- Program class represents an observing program
- HDU class, an acronym that stands for Header Data Units, models the FITS file headers

# Head(er)ache...



```
DATE = '31/10/97' / Date file was written (dd/mm/yy) 19yy
ORIGIN = 'CEA/SSL UC Berkeley' / EUVE Science Archive
CREATOR = 'STWFITS ' / Fitsio version 11-May-1995
TELESCOP= 'EUVE ' / Extreme Ultraviolet Explorer
INSTTYPE= 'DS/S ' / Instrument type (DS/S, SCANNER)
OBJECT = 'NGC 4151' / Name of observed object
RA_OBJ = 182.635454000001 / R.A. of the object (degrees)
DEC_OBJ = 39.4057280000001 / Declination of the object (degrees)
RA_PNT = 182.988000000001 / R.A. of the pointing direction (degrees)
DEC_PNT = 39.5477 / Declination of the pointing direction (degrees)
RA_PROC = 182.637910000001 / R.A. used to process data (degrees)
DEC_PROC= 39.41343 / Declination used to process data (degrees)
```

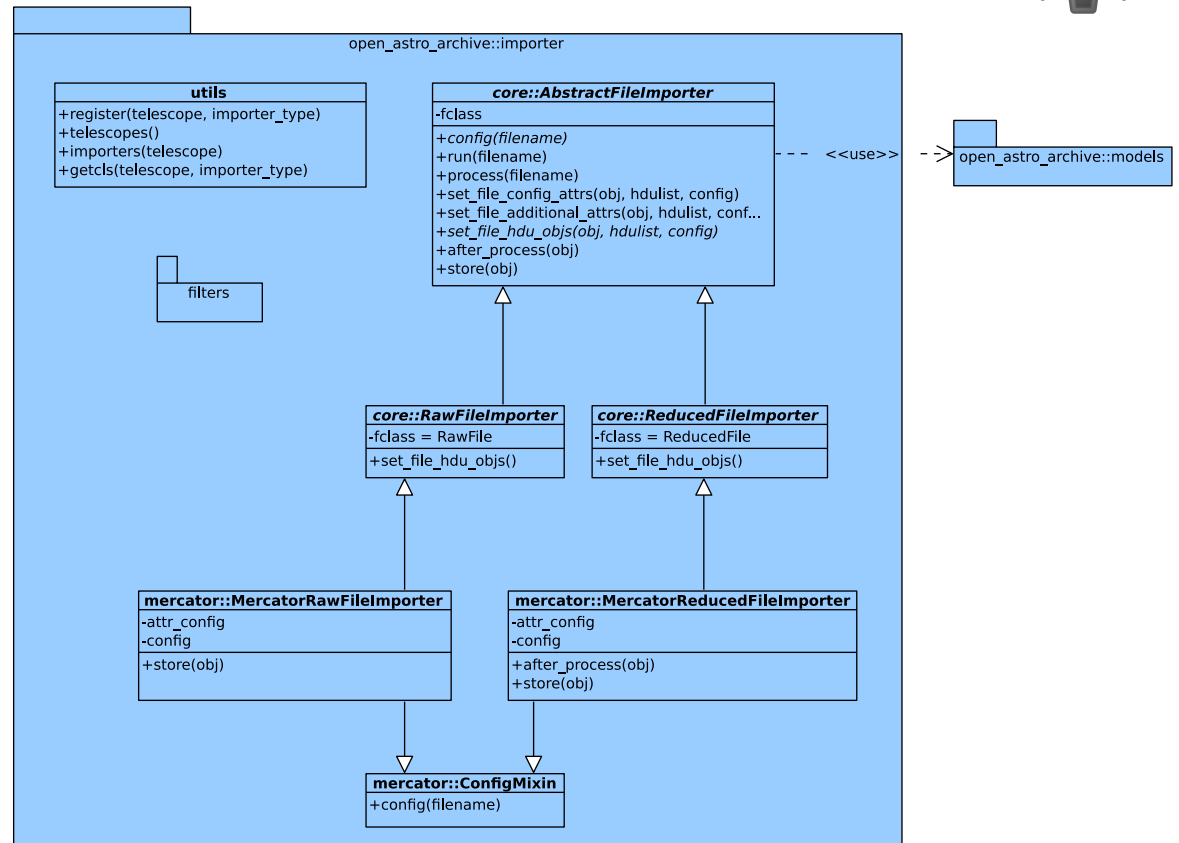
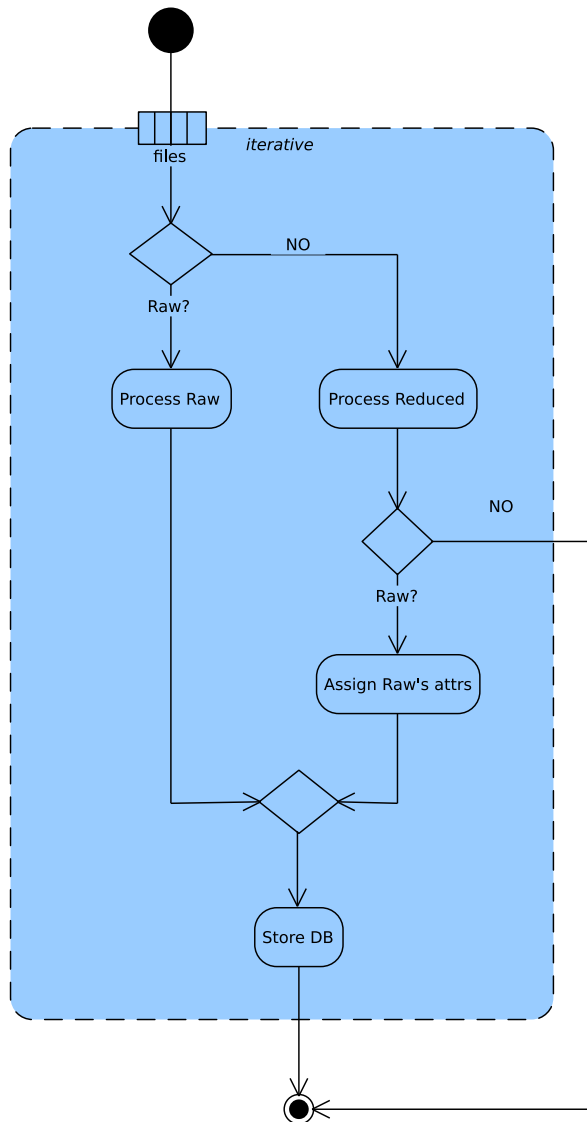
```
DATE-OBS= ' 2/07/96 ' / UT date of start of observation (dd/mm/yy)
TIME-OBS= '14:03:54 ' / UT time of start of observation (hh:mm:ss)
EXPSTART= 50266.58605108 / exposure start time (Modified Julian Date)
EXPEND = 50266.58949003 / exposure end time (Modified Julian Date)
EXPTIME = 297.1250000000 / exposure duration (seconds)--calculated
EXPFLAG = 'NORMAL ' / Exposure interruption indicator

/ TARGET & PROPOSAL ID
TARGNAME= 'NGC4151 ' / proposer's target name
RA_TARG = 0.1826357541667E+03 / right ascension of the target (deg) (J2000)
DEC_TARG= 0.3940567500000E+02 / declination of the target (deg) (J2000)
```

```
TELESCOP= 'Gemini-North' / Telescope
PARALLAX= 0. / Parallax of Target
RADVEL = 0. / Heliocentric Radial Velocity
EPOCH = 2000. / Epoch for Target coordinates
EQUINOX = 2000. / Equinox for Target coordinates
TRKEQUIN= 2000. / Tracking equinox
SSA = 'Walls ' / SSA
RA = 105.915125 / RA of Target
DEC = 10.77030556 / Declination of Target
ELEVATIO= 55.9472013888889 / Current Elevation
AZIMUTH = 259.745640277778 / Current Azimuth
CRPA = 19.8191902202926 / Current Cass Rotator Position Angle
HA = '+02:16:26.42' / Telescope hour angle
LT = '03:34:28.3' / Local time at start of observation
```

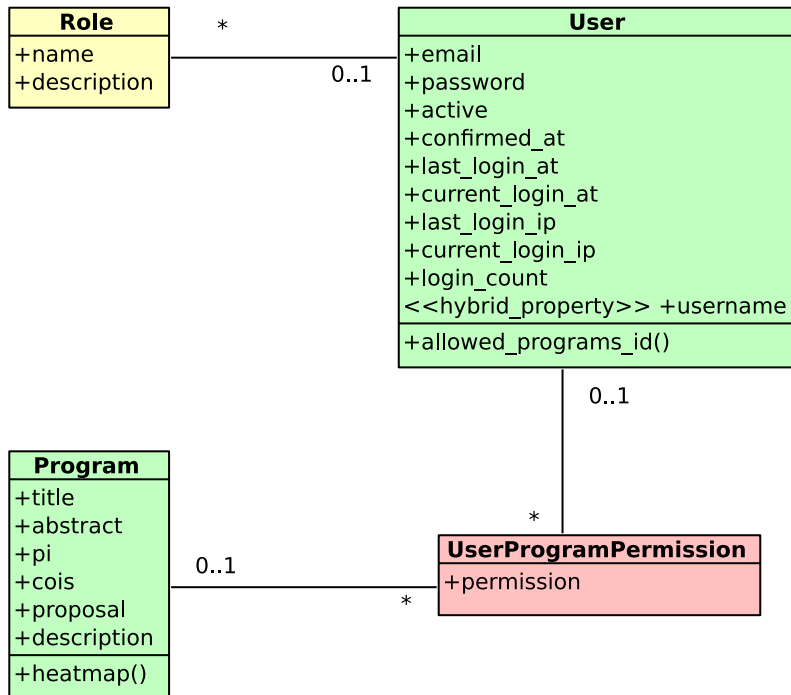
```
ORIGIN = 'UIT/GSFC' / WHERE TAPE WRITTEN
ASTRO = 2 / ASTRO MISSION NUMBER
FRAMENO = 'b0582 ' / ANNOTATED FRAME NUMBER
CATHODE = 'CSI ' / IMAGE TUBE PHOTOCATHODE
FILTER = 'B1 ' / CAMERA/FILTER IDENTIFIER
PDSDATIM= '06-JUL-1995 07:20' / MICRODENSITOMETRY DATE & TIME
PDSID = 21 / MICRODENSITOMETER IDENT
PDSAPERT= 20 / MICRოდ. APERTURE, MICRONS
PDSSTEP = 10 / MICRოდ. STEP SIZE, MICRONS
PIXELSIz= 8.0000000E+01 / CURRENT PIXEL SIZE, MICRONS
EQUINOX = 2.0000000E+03 / EQUINOX OF BEST COORDINATES
NOMRA = 182.0044 / 1950 I.P.S. R.A., DEGREES
NOMDEC = 39.6839 / 1950 I.P.S. DEC., DEGREES
NOMROLL = 323.9500 / I.P.S. ROLL ANGLE
NOMSCALE= 5.6832500E+01 / NOMINAL PLATE SCL (ARCSEC/MM)
CALIBCON= 5.00000E-16 / PREFLIGHT LAB CALIB FOR CAMERA
FEXPTIME= '8355 ' / EXPOSURE TIME, APPLICABLE FRM
DATE-OBS= '13/03/95' / DATE OF OBSERVATION (GMT)
```

# Data import 2.0

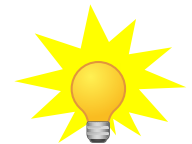


Strategy + Template + Decorator = Framework 

# Users, roles, and permissions



- A user may have many roles, although only 'admin' is defined at the time being.
- A user may have access to a program, either as a program-user, meaning he can access a given program, or as a program-admin.



Party – Role

# Data search

- Coordinate search
- Date interval
- Instrument
- Program
  
- Object lookup
  
- Cone search

Open Astro Archive Search Programmes Help f merges

## Search

Name

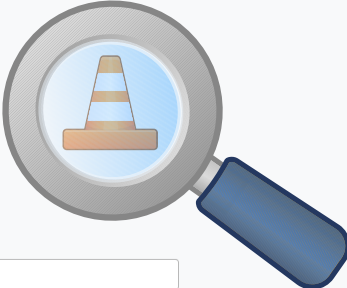
Queries SIMBAD for object name

RA  DEC  Radius   
In degrees

From Date  Thru Date

Instrument  Program

[Search](#)



Copy Excel CSV PDF Print

Object	RA	DEC	Instrument	Program	Date Obs	JD	Name	Time (s)	SNR 50	SNR 65	SNR 81
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-31 22:12:41	2458635.43	00923104_HRF_OBJ	36	50.79	41.09	17.63
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	MAIA	3	2019-05-31 22:12:41	2458635.43	00880392_OBJ	120			
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	MAIA	3	2019-05-30 21:15:26	2458634.39	00876924_OBJ	120			
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-30 21:15:26	2458634.39	00922920_HRF_OBJ	36	43.22	36.49	14.47
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	MAIA	3	2019-05-29 21:12:59	2458633.38	00880544_OBJ	90			
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-29 21:12:59	2458633.38	00922810_HRF_OBJ	36	47.09	38.72	15.94
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-28 21:23:01	2458632.39	00922708_HRF_OBJ	36	50.64	42.60	19.30
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-21 20:54:34	2458625.37	00921988_HRF_OBJ	36			
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	MAIA	3	2019-05-19 20:44:47	2458623.36	00880413_OBJ	120			
<a href="#">Q</a> HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-19 20:44:47	2458623.36	00921782_HRF_OBJ	36	43.89	39.25	16.46

Showing 1 to 10 of 41 entries

Previous [1](#) [2](#) [3](#) [4](#) [5](#) Next

Show  entries

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# Inspect data



- See the extracted metadata of a raw file.
- See the finding chart with a link to Simbad.
- Access to the observing program.
- Inspect the reduced spectrum.
- See the raw FITS header.
- See the list of reduced files.
- Access the end of night report.

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File: 00923104\_HRF\_OBJ

### General Info

Object Name	HD 128165	DEC	+52:54:31.6
RA	14:33:28.9	Julian Date	2458635.43
Date Obs	2019-05-31 22:12:41	Observing Mode	HRF_OBJ
Exposure Time	36.0s	Exposure Type	OBJ
Image Type	OBJECT	Date Avg	2019-05-31 22:13:18
Date End	2019-05-31 22:13:18		
Binning XY	1 x 1		
Observer	Foo Bar		
Program	<a href="#">Radial Velocity Standards</a>		
Comments	11.392		

SNR 50.8 41.1 17.6

### Plot

Cosmics removed wavelength merged

Flux

Wavelength  $\lambda$  (Å)

You can click and drag to zoom. Double-clicking will zoom you back out. Shift-drag will pan.

### Header Info

FoV: 5.98" [Link to Simbad](#)

# PI for a program can:



- Change the details of the program
- Manage its attachments
- Set the program permissions.

Open Astro Archive Search Programmes Help

Program: Radial Velocity Standards

Title  
Radial Velocity Standards

Abstract  
"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum."

PI  
Foo

Col(s)

Description

File Attachments:  
Browse... No file selected.  
Upload

File	Action
<a href="#">memoria.pdf</a>	

Save

Permissions:

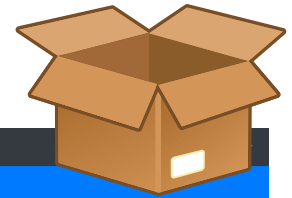
User  
Permission  
User of this program

Add

Username	Permission	Action
omartig	User of this program	Revoke

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# Download data aka Shopping time



Tarball File Mode:

Select	F	R	F+R	RA	DEC	Instr	
<input type="checkbox"/>	F	Raw only			DEC		
<input type="checkbox"/>	F	R	Reduced files only	9	+52:54:31.6	HERM	
<input type="checkbox"/>	R	F+R	Raw and reduced files	9	+52:54:31.6	HERM	
<input type="checkbox"/>	F+R			HD 128165	14:33:28.9	+52:54:31.6	HERM

Select all Deselect all Add Print CSV PDF

Object	RA	DEC	Instrument	Program	Date Obs	
<input type="checkbox"/> F	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-31 22:
<input type="checkbox"/> R	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-30 21:
<input type="checkbox"/> F+R	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-29 21:
<input type="checkbox"/>	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-28 21:

- User puts data-sets in the cart
- Checkout, or tarball generation
- And download

Open Astro Archive Search Programmes Help

Tarball: c7f3a9f4d9fb49c18ae8ec49ac30fe38

OPEN 6 6.3 MB Create

Contents:

Select	Deselect	Remove	Print	CSV	PDF								
	Object	RA	DEC	Instrument	Program	Date Obs	JD	Name	Time (s)	SNR 50	SNR 65	SNR 81	
<input type="checkbox"/>	F+R	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-29 21:12:59	2458633.38	00922810_HRF_OBJ	36	47.09	38.72	15.94
<input type="checkbox"/>	R	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-30 21:15:26	2458634.39	00922920_HRF_OBJ	36	43.22	36.49	14.47
<input type="checkbox"/>	F	HD 128165	14:33:28.9	+52:54:31.6	HERMES	1	2019-05-31 22:12:41	2458635.43	00923104_HRF_OBJ	36	50.79	41.09	17.63

Showing 1 to 3 of 3 entries

Previous 1 Next

Show 25 entries

Previous Tarballs:

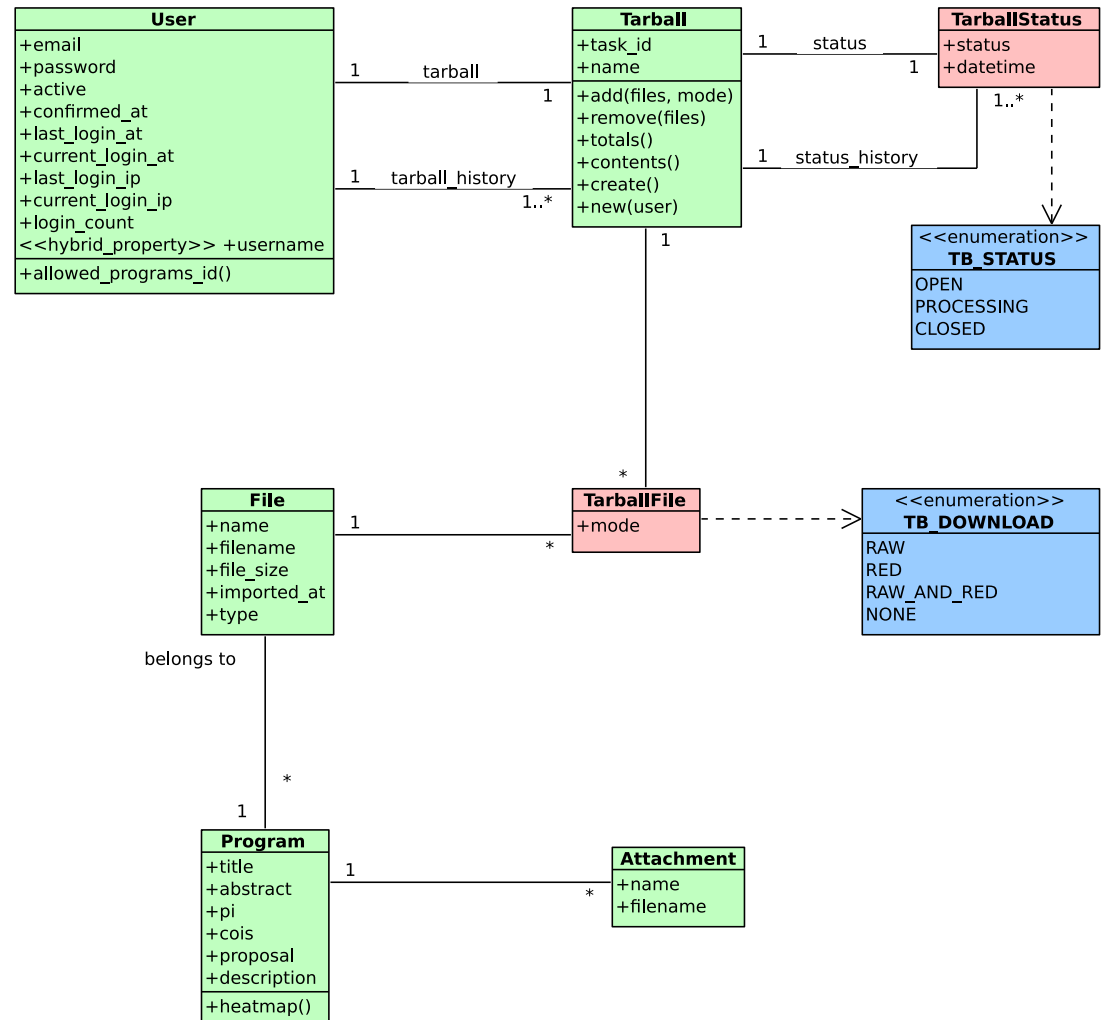
Status	Name	Date
<span style="background-color: black; color: white; padding: 2px;">CLOSED</span>	cdef3066fe0043e2a95240df21caaf89	2019-06-04 22:18:12

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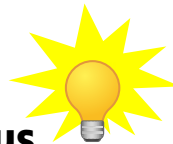
# ...under the hood



- One active tarball at a time
- Sets of file added
- Tarball has state and history
- User got tarballs!



Order – OrderLine – OrderStatus



# Notifications



- User can subscribe to events
- For each event a user can choose both:
  - Internal notification
  - E-mail notification

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## Notifications ⚙️ Settings

Select all Deselect all Mark Read Mark Unread

<input type="checkbox"/>		Date	Type	Description
<input type="checkbox"/>		Tue, 04 Jun 2019 22:35:20 GMT	Program Data	<a href="#">New data for program 2</a>
<input type="checkbox"/>		Tue, 04 Jun 2019 22:35:20 GMT	Program Data	<a href="#">New data for program 1</a>
<input type="checkbox"/>		Tue, 04 Jun 2019 22:34:04 GMT	Program Permission	<a href="#">Permission change for program 1</a>
<input type="checkbox"/>		Tue, 04 Jun 2019 22:45:19 GMT	Program Permission	<a href="#">Permission change for program 1</a>
<input type="checkbox"/>		Wed, 05 Jun 2019 10:17:36 GMT	Tarball Created	<a href="#">Tarball c7f3a9f4d9fb49c18ae8ec49ac30fe38 created</a>
<input type="checkbox"/>		Wed, 05 Jun 2019 14:46:32 GMT	Tarball Created	<a href="#">Tarball fc1ac6be085f470b87e503e15816ad45 created</a>

Showing 1 to 6 of 6 entries

Show  entries

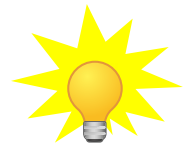
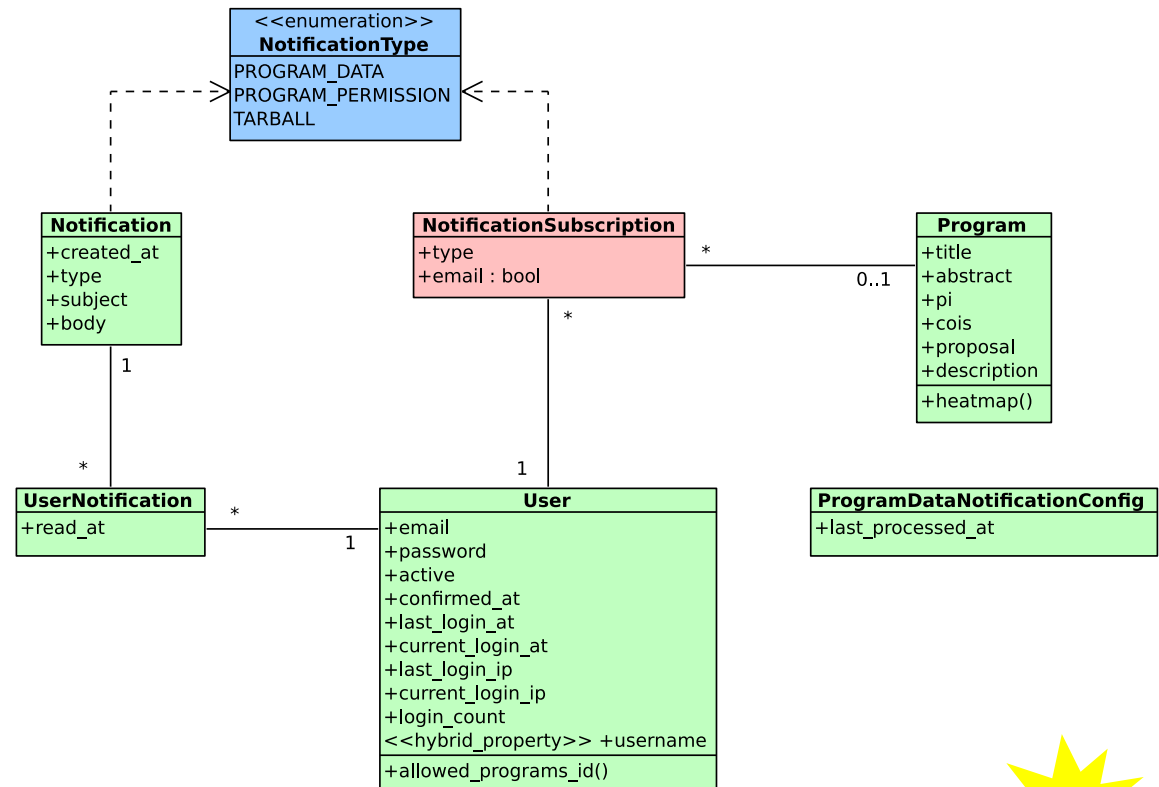
Previous **1** Next

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# ...running out of time!



- Only one notification per event
- UserNotification is an association class
- User can subscribe to different events
- Program data and program permission subscription are only available based on the user permissions for the program
- ProgramDataNotificationConfig is to keep track when was the last time they were processed



**Singleton – Service – Subscription**

# Time is up:



# Thank you!

For further questions, check out my thesis or drop me a mail: [fmerges@uoc.edu](mailto:fmerges@uoc.edu)

## ... part II after Summer

<http://www.open-astro-archive.org>

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