



<b>Publication Year</b>	2020
<b>Acceptance in OA</b>	2023-03-07T13:32:59Z
<b>Title</b>	SED Builder Tutorial (v4.0)
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<b>Handle</b>	<a href="http://hdl.handle.net/20.500.12386/33993">http://hdl.handle.net/20.500.12386/33993</a>

# SED<sup>(t)</sup> Builder Tutorial (v4.0 – 12/2020)

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# 1 Introduction

**SED Builder** is a tool designed to produce and display the Spectral Energy Distribution (SED) of astrophysical sources, developed at the Space Science Data Center (SSDC) of the Italian Space Agency (ASI).

It mainly relies on data from a large number of catalogs and several missions and experiments, both ground and space-based, but also allows users to add their own datasets.

Based on a Java/Javascript code and a MySQL database system, **SED Builder** provides transparent access to SSDC-resident catalogs as well as to external archives covering the whole electromagnetic spectrum, from radio to TeV energies; in particular, several astronomical catalogs from past and current high-energy missions (*e.g.* *Swift*, *AGILE*, *Fermi*) are available.

The tool also provides several features to analyze SED's properties and plotting options to accomplish user's requirements: SEDs can be expressed in several flux units *versus* frequency, energy or wavelength; providing a cosmological redshift, these units include rest-frame luminosities (eventually, a photometric redshift calculator is available); a variety of profiles, resulting from numerical models, can be fitted to data to compare SEDs with theoretical expectations; sensitivity curves of selected instruments can be overlapped to the plot, a particularly useful option for weak sources.

The growing number of telescopes operating at a very wide range of frequencies, both ground-based and on orbit, increases the probability for many astrophysical sources of being repeatedly observed over time: to exploit the ever increasing amount of data, **SED Builder** has been refined to allow time filtering of data in order to build time-resolved SEDs, thus making variability studies far easier. The possibility of saving data in the form of VO tables and querying the VO registry is being implemented.

Since August 2020, a new interface that allows to upload a list of sources, opportunely arranged in a CSV file, has been implemented. On the one hand, this allows to build the SEDs of each source in the list and retrieve them in output, in form of ASCII files collected in a tarball; on the other hand, it continues to provide a quick access to all the features described above in order to perform a refined analysis on selected sources in the list, if desired.

Since October 2020, the collection of input catalogs has been expanded to include the contribution of multi-messenger events, such as neutrinos and cosmic rays, that will play an increasingly large role in the forthcoming years, enabling to build a so-called "hybrid SED".

The aim of this document is to describe in some details the SSDC **SED Builder** functions to help the user quickly get hold of its capabilities and make the most of its potential.


## 1.1 Registration

A large number of **SED Builder** features is accessible to most users, who can search for already existing SEDs previously built by themselves, customize a new one by filtering out data from public catalogs, compare a SED with theoretical expectations, download collected data in the form of an ASCII file or the plot as a PNG file, just to mention some of the most common.

However, registered users can take advantage of improved capabilities, mostly related to handling not only public, but also proprietary data; furthermore, they can also save and potentially share each session with other people with the correct data rights.

Registering is an easy and quick step: link to the **User Manager** web page (<https://tools.ssdsc.asi.it/UserManager/requestUser.jsp>), fill in the user account request form, and click Submit (➡). At your email address you will quickly receive an email with further instructions to complete your registration: change your temporary password and you will finally obtain your definitive login credentials, to be used for being authenticated at any access in the future.

**User Account Request Form**

Username	<input type="text"/>
First Name	<input type="text"/>
Last Name	<input type="text"/>
E-Mail	<input type="text"/>
Alternative E-Mail	<input type="text"/>
Phone	<input type="text"/>
Home Phone	<input type="text"/>
Mobile Phone	<input type="text"/>
Info	<input type="text"/>
IM	<input type="text"/>
<input type="checkbox"/> I'm not a robot  reCAPTCHA Privacy · Terms	
<input type="submit" value="Submit"/>	

Any time you want to authenticate, search for a **Login** link that is generally found at the top right of the **SED Builder** web page, as well as for other SSDC tools. In the **Login Details** box that will show up, like the one here at right, insert your login credentials, and finally confirm (➡).

**Login Details**

User Name	<input type="text"/>
Password	<input type="password"/>
<input type="button" value="Login"/>	
<a href="#">New User Registration</a>	<a href="#">Forgot password</a>

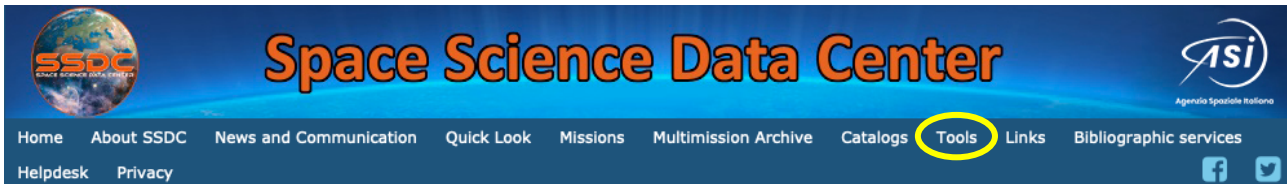
As a result, in place of the **Login** link, you will find another one with your username: if you click it, you will be directed to a webpage in which you will find a form summarizing the information you provided, that can be updated when needed.

On the top right, **User Browser** will show you the whole list of registered users. These can be included in one or several groups of users, listed under the **Group Browser** link. To create a group, a registered user needs to send a request to the SSDC helpdesk listing the name of registered users that have to be included in.

A summary of the groups of registered users in which you are included, and those in which you are not, is shown underneath the form with your information.

## 2 How to access SED Builder

**SED Builder** can be accessed in a few equivalent ways: you can find it scrolling the **Tools** menu, at the top of the main SSDC web page (<https://www.ssdc.asi.it/>).

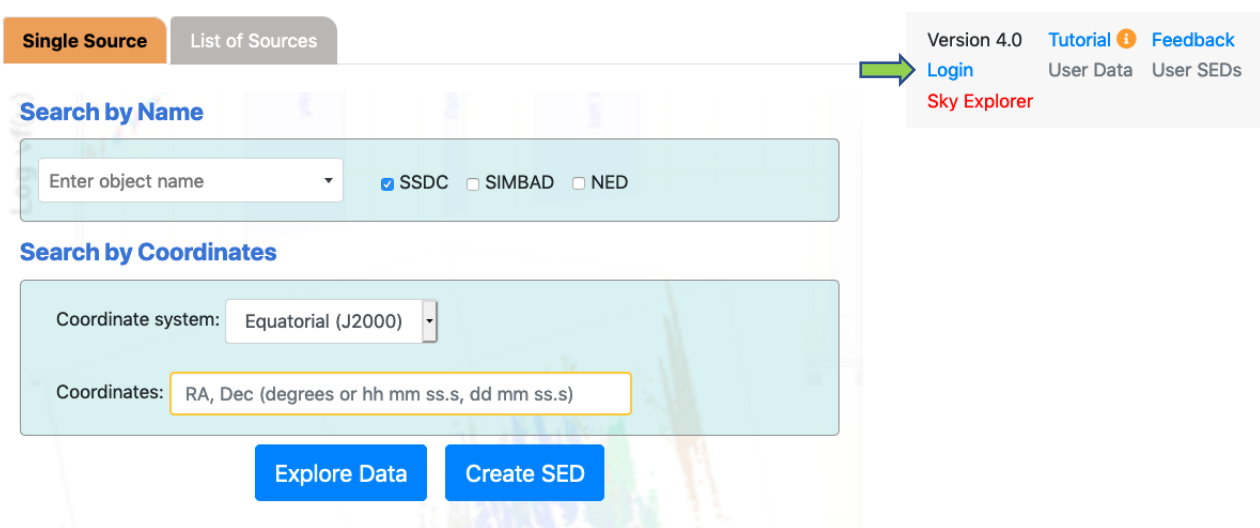


In alternative, click the corresponding quick access button, at the center of the same web page.



Finally, you can find it at the following URL: <https://tools.ssdc.asi.it/SED/>.

As a result, a page with the main query interface shown here below will appear:



You may be interested in building the SED for a single source or for a larger number of objects. Thus, you have to select the corresponding tab: as you can see, **Single Source** is the default and is accessible to all users, while **List of Sources** is an option allowed only to registered ones; click the link at the top right of the page (→) to login.

Among the few other links at the top right of the page, some of them (initially in grey when not logged in) are allowed only to registered users (see Section 3.4). In addition to these, we emphasize the link to the **Sky Explorer**, the SSDC tool conceived as main starting point for any general search on astrophysical sources.

## 2.1 Single Source

If you are interested in building the SED of one source in particular (in this tutorial a well known blazar, OJ 287, has been adopted as template source), most probably you know its name or, in alternative, its coordinates.

In the former case, fill the name in the query interface and select some name resolver service, among those available, to associate a set of coordinates to the input name. Then, select your favourite entry from the list of matching entries that will be displayed: as a result, the coordinates field will be appropriately filled up.

In the latter case, appropriately insert the coordinates, adopting your favourite coordinate system; once coordinates are acquired, switching among different coordinate systems will automatically convert them.

Finally, click **Explore Data** to use the **Data Explorer** tool, in case you want to investigate multifrequency properties of your source before building its SED; otherwise, click **create SED** to go the main **SED Builder** page, described in Section 3.

## 2.2 List of Sources

In order to exploit the new functionality of building the SED for a group of sources, you need to register and log in; then, you will see the query interface shown here. The maximum number of sources that can be put in a list is currently fixed to 10.

Single Source | **List of Sources**

**Input File**

List of sources: ⓘ Choose File no file selected

CSV format: Source Names (using SSDC name resolver) ▾

**Output Parameters**

X: Frequency (Hz) ▾ Y:  $\nu F_{\nu}$  (erg/cm<sup>2</sup>/s) ▾

Logarithmic values  Include upper/lower limits  Print comment  Comment char: #

→ Load CSV

The list of sources must be preliminarily arranged in a comma separated values (CSV) file, each row corresponding to a different source.

Source Names (using SSDC name resolver)  
RA, Dec (J2000, degrees)  
l, b (degrees)  
✓ Mixed List (Source Names or RA, Dec)

You can choose among four different formats for the CSV file: values can be names or coordinates, both equatorial and Galactic, in degrees; it is also possible to combine names and equatorial coordinates for different sources in the list.

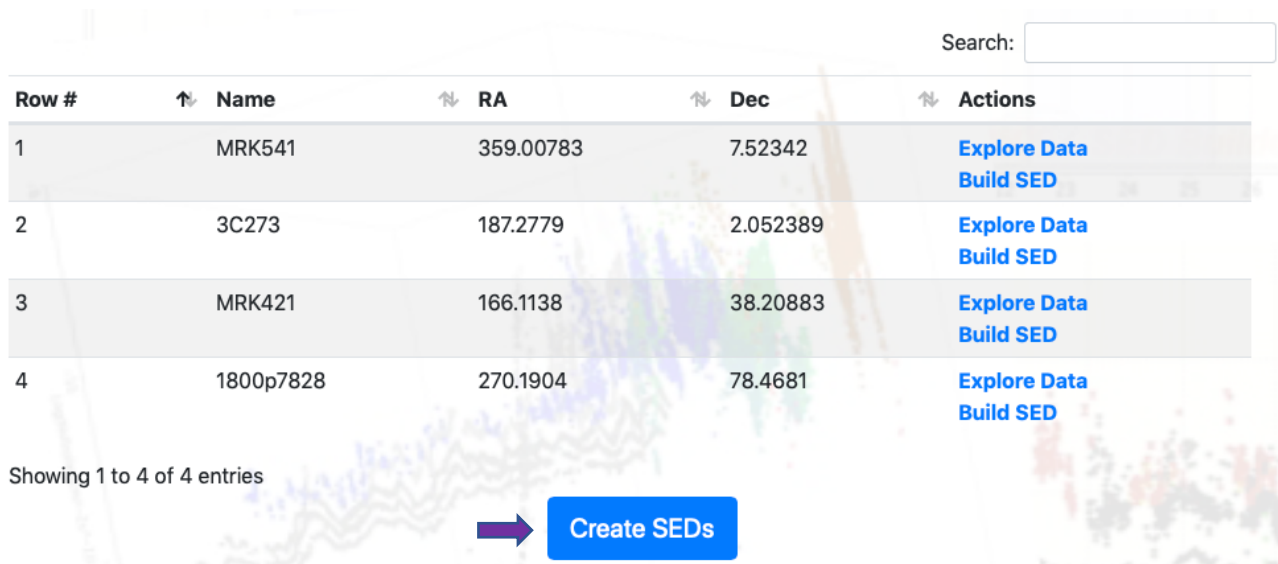
For example, use your favourite editor to prepare a CSV file with this content:

```
MRK541
3C273
MRK421
270.1904,78.4681
```

Once the file is ready, there are three steps to upload it in the **SED Builder**:

1. click **Choose File** (➡) to pick it from the storage directory;
2. select the appropriate format (names, coordinates, or mixed list);
3. click **Load CSV** (➡).

A warning message appears if your CSV file does not match the format shown in the corresponding menu, or if something else is wrong; otherwise, a new table like the one shown here below will appear at the bottom of the page.



The screenshot shows a web interface with a search bar at the top right. Below it is a table with the following data:

Row #	Name	RA	Dec	Actions
1	MRK541	359.00783	7.52342	Explore Data Build SED
2	3C273	187.2779	2.052389	Explore Data Build SED
3	MRK421	166.1138	38.20883	Explore Data Build SED
4	1800p7828	270.1904	78.4681	Explore Data Build SED

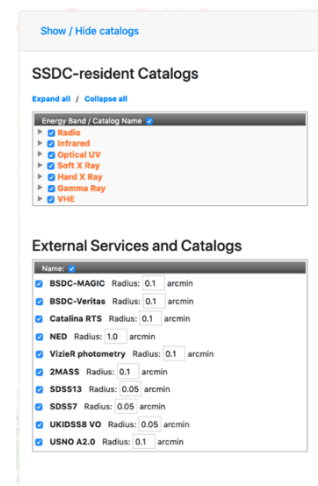
Below the table, it says "Showing 1 to 4 of 4 entries". At the bottom center, there is a blue button labeled "Create SEDs" with a right-pointing arrow.

This table, summarizing the essential details of your list of sources, is convenient as a starting point for further investigation on each of them, that can be carried out independently from the building of the SEDs as a group: in fact, in the last column, a click on **Explore Data** or **Build SED** will open the SSDC **Data Explorer** or **SED Builder** tools, respectively, in a new browser tab.

Before obtaining the SEDs as a group, in the **Output Parameters** field you may also specify the physical quantities that will be given in the results; on the right side of the page, you may also select the catalogs (both SSDC-resident and external ones) that will be used. In both cases, there are default values that can be changed at your convenience.

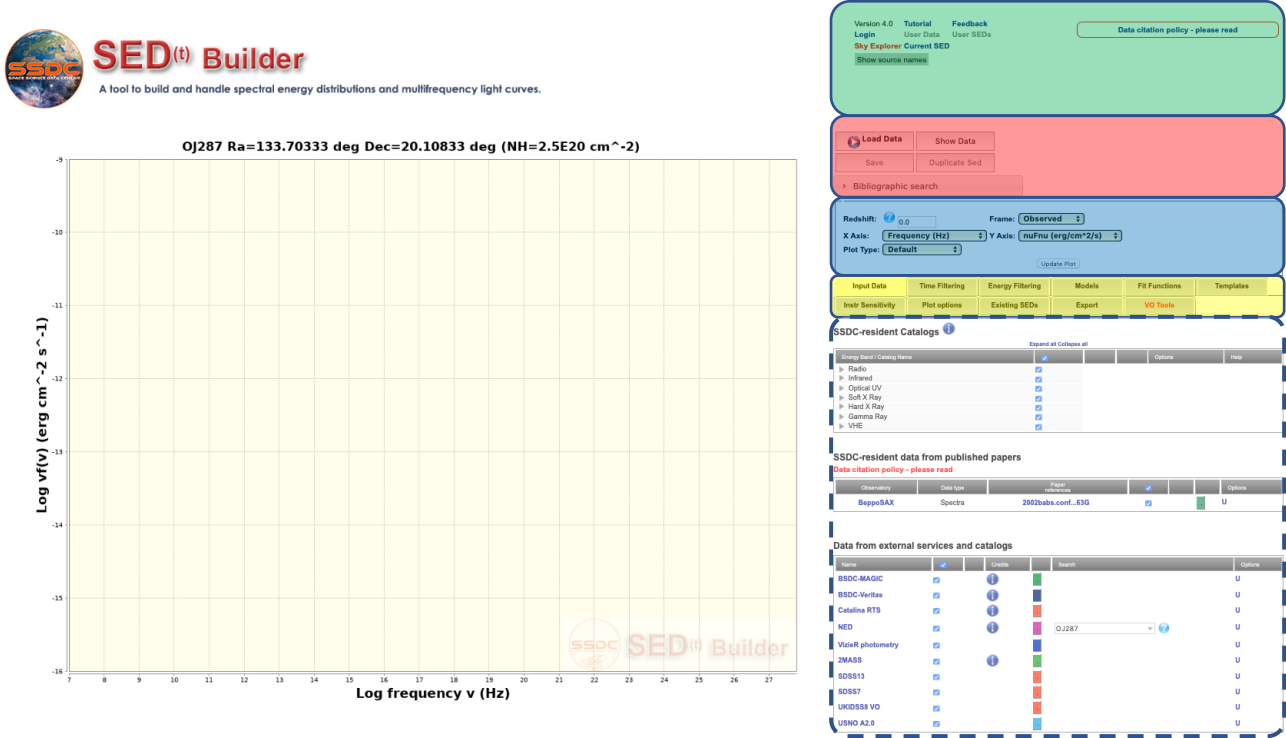
Once ready, click **Create SEDs** (➡) and a window will pop up, notifying that you are going to receive an email. Then, click the link in this email to download a zipped archive file including the results in form of distinct text files, one for each source.

At the top of each file, a few details about the source are reported to help identifying it, followed by data retrieved from the selected catalogues in the format previously specified in the **Output Parameters** field.



# 3 The main **SED Builder** web page

At first glance you can distinguish two main areas in the **SED Builder** page: on the left, an initially empty graph; on the right, a control panel with four primary areas.



These areas can be distinguished in the above figure by light-colored boxes. From top to bottom:

- 1) a **GREEN** area, with a miscellany of links (such as **Tutorial** and **Feedback**) including those to access the restricted area for registered users (**Login**, **User Data**, **User SEDs**);
- 2) a **RED** area, with five grey buttons (**Load Data**, ..., **Bibliographic Search**) for handling data used to build the SED;
- 3) a **BLUE** area, a rectangular box (**Redshift**, ..., **Plot Type**) to customize the plot properties;
- 4) a **YELLOW** area, with eleven tabs (**Input Data**, ..., **VO Tools**) to manage several tool's features.

These four areas remain always visible and substantially unchanged during any selection and operation you will carry out in the process of building the SED of your source.

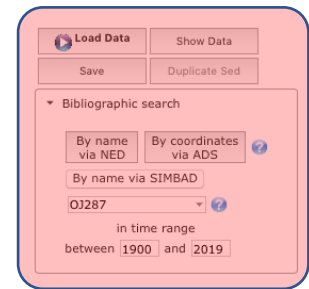
Conversely, the content of what is shown underneath the yellow area, marked by a thick dashed line in the above figure, will change according to which of the eleven tabs in the yellow area is active: here above, several catalogs used to build the SED and grouped in different lists are shown, since the **Input Data** tab is the active one.

Further details to help the reader take over the **SED Builder** tool are given in the following Sections. The description will start in Section 3.1 from the **RED** area, guiding you through the preliminary steps to build a SED; the **BLUE** and the **YELLOW** areas will follow in Sections 3.2 and 3.3, respectively; the **GREEN** area, despite on top of the right panel, will be described at last, in Section 3.4.

## 3.1 RED area: data used to build the SED

The **RED** area collects a few functions related to data used to build the SED that is plotted in the main graph.

Some of these functions are very preliminary and hence among the most frequently used; they are complemented by others, described in Section 3.3.1, related to selecting and managing catalogs from which input data are extracted.



At your first access to the **SED Builder** web page you will see that, by default:

- the main graph is blank;
- **Input data** is the active tab in the yellow area;
- all the small boxes next to the names of each catalog listed underneath are ticked and colored in blue, meaning that all these catalogs are ready to be queried.

To make this query start, just click **Load Data** and the main graph will be populated with all data retrieved adopting default settings; different colors correspond to different catalogs.

Note that such settings may not be the optimal choice in your specific case: as example, the default search radius of some given catalog may include data from spurious sources at close angular separation from your input coordinates.

To avoid including unwanted data in your SED you have to tune opportunely these default settings before starting the query: all the details can be found in Section 3.3.1. In alternative, erase data from the plot once you are certain that they have no relation with your source.

One way to perform this task goes through the second main function, **Show Data**, described below; another way to achieve the same goal is described in Section 3.3.8.

Click **Show Data** to see all the details about data used to build the SED. A list of entries corresponding to each selected catalog is reported; sky coordinates and fluxes at a given frequency are quoted for each entry, possibly with other useful information.

Source Data : **FIRST** (3 entries)

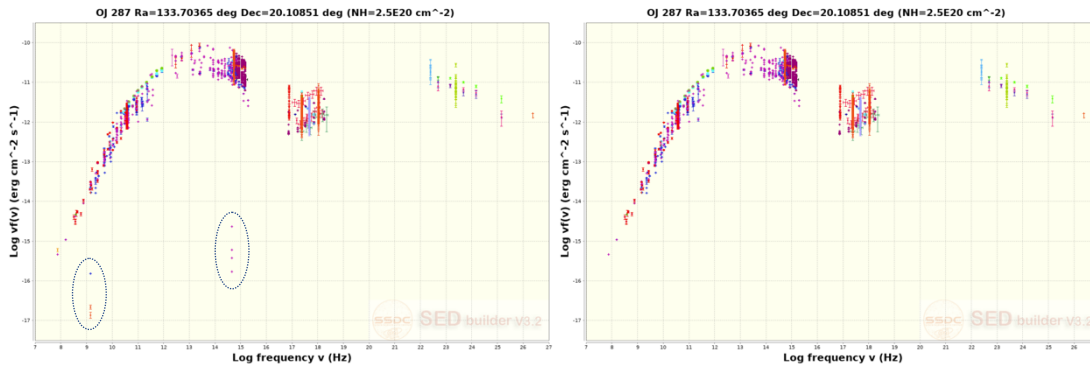
<input type="checkbox"/>	Name	RA(hh mm ss.s)	Dec(dd mm ss.s)	RA(deg)	Dec(deg)	Nufnu (erg cm <sup>-2</sup> s <sup>-1</sup> )	Frequency (Hz)	Source Data	Start Time (MJD)	Stop Time (MJD)	Start Time (YYYY-MM-DD hh:mm:ss UT)	Stop Time (YYYY-MM-DD hh:mm:ss UT)	Warning/Info
<input type="checkbox"/>	4H	08 54 47.68	+20 06 29.09	133.69868	20.10808	1.3720E-17+2.4640E-18/-2.4640E-18	1.400E09	DB	49078.5	49443.5	1993-04-01 12:00:00	1994-04-01 12:00:00	
<input checked="" type="checkbox"/>	4H	08 54 48.88	+20 06 30.53	133.70367	20.10848	1.6550E-14+2.4500E-18/-2.4500E-18	1.400E09	DB	49078.5	49443.5	1993-04-01 12:00:00	1994-04-01 12:00:00	
<input type="checkbox"/>	4H	08 54 47.18	+20 06 44.28	133.69659	20.11230	2.1700E-17+2.4640E-18/-2.4640E-18	1.400E09	DB	49078.5	49443.5	1993-04-01 12:00:00	1994-04-01 12:00:00	

Export: [csv](#) | [xls](#)

[Update](#) | [Back to SED](#)



As already pointed out, spurious entries unrelated to your source of interest may appear included in these lists: to exclude them, simply untick their box and click **Update** (→). When you are happy with your selections, click **Back to SED** (→) to go back to the main **SED Builder** page.



In the example shown above, you can see the comparison of the SED of OJ 287 as it appears soon after clicking [Load Data](#) (left panel) and once you remove a few spurious data points (right panel) within the ovals, including those emphasized in the previous table.

Registered users can click the [Save](#) button to store the built SED in a personal area (<https://tools.ssdsc.asi.it/SED/manageowned.jsp>) under the **Your SED** list (see also Section 3.4).

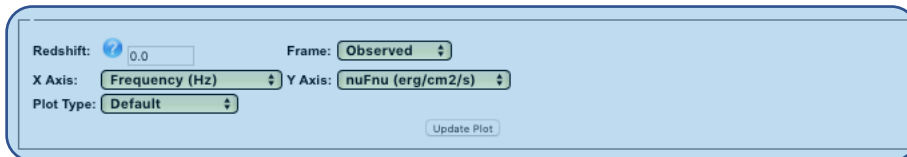
Consider the possibility that, after storing a SED plot in your personal area, you want to make some changes on it (for example removing data corresponding to a specific observation) but you want to keep the original plot as backup.

To do this, click [User SEDs](#) (see Section 3.4), select the SED you want to modify from the **Your SED** or the **Shared SED** lists, and click **View SED** to display it within the main **SED Builder** page. Thus, click [Duplicate SED](#) and operate your changes; once you are done, you are ready to save it in your SED storage area with a new name to distinguish it from the original plot.

Click [Bibliographic search](#) if you need a quick access to literature as listed in the NASA Extragalactic Database (NED), the NASA Astrophysics Data System (ADS), or the SIMBAD Astronomical Database at CDS; the same information, and also many additional features, can be retrieved using the **Data Explorer** tool (see Section 3.4).

## 3.2 BLUE area: SED graph appearance

Assume you have created a preliminary SED, as described in the previous section: a few general properties of the output graph, in which the SED is displayed, can be managed and adjusted tuning the corresponding values included in the rectangular box shown below.



The image shows a control panel for the SED Builder tool. It contains the following elements:

- Redshift:** A text input field with the value "0.0" and a blue circular icon to its left.
- Frame:** A dropdown menu with "Observed" selected.
- X Axis:** A dropdown menu with "Frequency (Hz)" selected.
- Y Axis:** A dropdown menu with "nuFnu (erg/cm2/s)" selected.
- Plot Type:** A dropdown menu with "Default" selected.
- Update Plot:** A button located at the bottom right of the panel.

If known, the **Redshift** of your source can be set here. Furthermore, you can specify the reference **Frame** (observer rather than rest-frame) in which you want to express the SED and choose the quantities to be reported in the **X axis / Y axis** selecting among those listed in two drop-down menus.

The SED in the main graph is given by default in a log-log scale as  $\nu F(\nu)$  versus  $\nu$ , with frequency given in Hz and  $\nu F(\nu)$  given in  $\text{erg cm}^{-2} \text{s}^{-1}$ .

On the X axis you can replace frequency with photon energy (in your favourite multiple of eV), wavelength (in micron or Angstrom), but you can also adopt time (Modified Julian Date or years).

On the Y axis you can adopt your favourite choice among flux density  $F(\nu)$  or luminosity  $L(\nu)$ , eventually multiplied by frequency, and use corresponding favourite units.

If you fix a redshift value, rest-frame quantities can be also visualized, but consider that no K-correction will be applied.

A valuable opportunity is given by the selection of Time (year or MJD) in the **X axis** menu: in this way, in presence of rich datasets collected on sources over extended time intervals, eventually in different energy ranges, it is possible to display corresponding light curves in the main graph. A specific thread (see Section 4.3) is devoted to this topic.

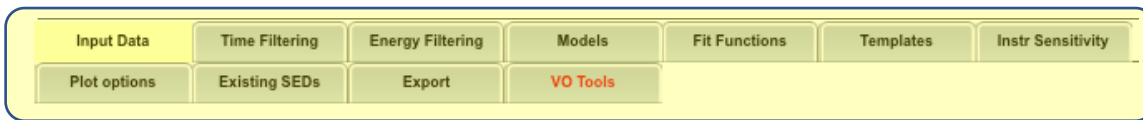
In the **Plot type** menu you can choose among three ways of displaying data (**Default**, **Sequence** or **Stacked**). The former is adopted at your first access to the **SED Builder** tool.

The **Sequence** option is a dynamic way of displaying time-resolved SEDs, created by specifying more than a single time interval (see Section 3.3.2), in a series of frames with a final result similar to a short movie.

Finally, the **Stacked** option permits to display variables (flux density,  $\nu F(\nu)$ , etc.) corresponding to several frequencies in separate Y-axes, sharing a common X-axis (frequency, or any equivalent quantity); see an example in Section 3.3.3.

Once you are done, click **Update Plot** to make your changes effective.

### 3.3 YELLOW area: control panel tabs



A collection of eleven grey tabs, indicated in Section 3 as the yellow area, is displayed in the center of the right control panel.

The selection of one of these tabs (which turns yellow itself, when active) displays, from time to time, several additional fields underneath, that let you control a variety of properties according to your needs, such as the possibility to manage input data, to compare data with theoretical expectations and with the sensitivity curves of several popular instruments, to perform fit with simple analytical functions and to tailor the plot settings.

Details about the functions corresponding to each of these tabs are described in the following subsections.

#### 3.3.1 Input Data

The **Input data** tab is the default one and displays the variety of resources from which you can take data to build the SED for your source of interest. According to proprietary rights that regulate them, these resources are organized in a few groups distinguishing **SSDC-resident**, **external** and **User** ones.

##### SSDC-resident Catalogs

[Expand all](#) [Collapse all](#)

Energy Band / Catalog Name	<input checked="" type="checkbox"/>			Options	Help
▶ Radio	<input checked="" type="checkbox"/>				
▶ Infrared	<input checked="" type="checkbox"/>				
▶ Optical UV	<input checked="" type="checkbox"/>				
▶ Soft X Ray	<input checked="" type="checkbox"/>				
▶ Hard X Ray	<input checked="" type="checkbox"/>				
▶ Gamma Ray	<input checked="" type="checkbox"/>				
▶ VHE	<input checked="" type="checkbox"/>				

##### SSDC-resident data from published papers

[Data citation policy - please read](#)



Observatory	Data type	Paper references	<input checked="" type="checkbox"/>		Options
BeppoSAX	Spectra	2002babs.conf...63G	<input checked="" type="checkbox"/>	<input type="checkbox"/>	U

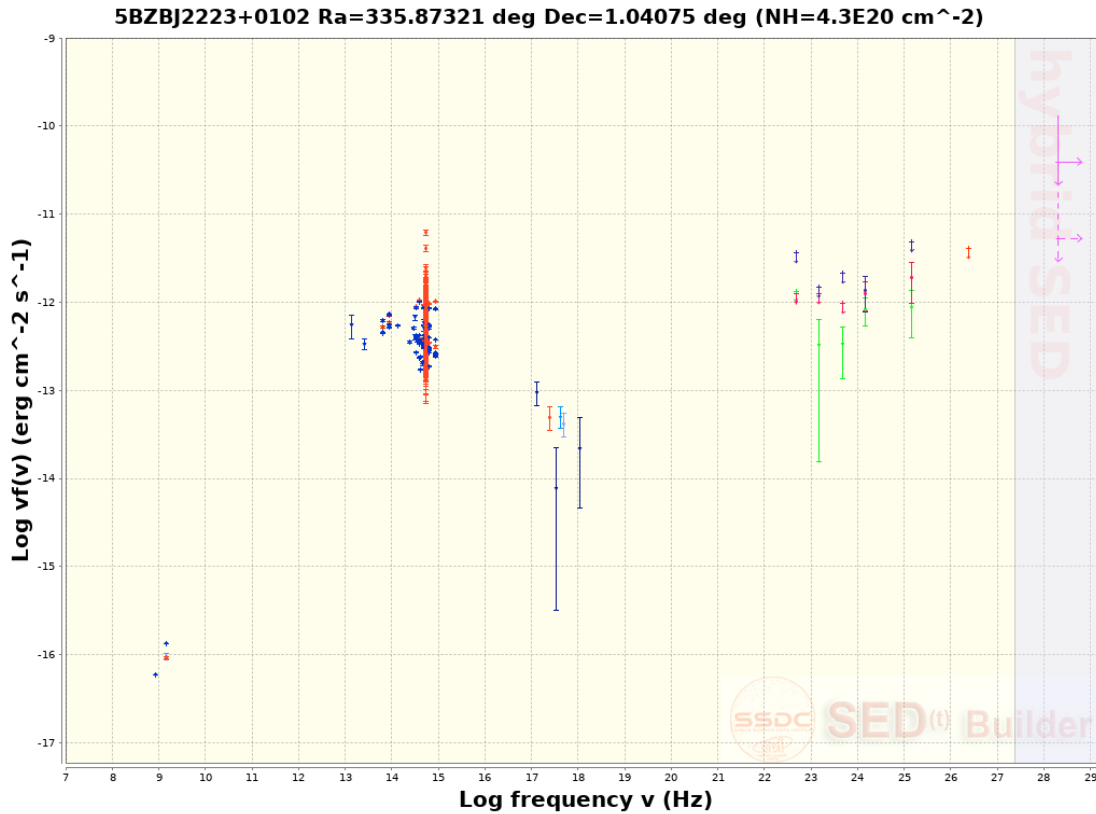
SSDC-resident resources include **SSDC-resident Catalogs** and **SSDC-resident data from published papers**, locally stored and distributed by SSDC; the former group is further organized by range of frequencies.

##### SSDC-resident multi-messenger Catalogs

Catalog Name	<input type="checkbox"/>			Options	Help
▼ Neutrinos	<input checked="" type="checkbox"/>				
▼ IceCube	<input checked="" type="checkbox"/>				
IceCube HESE (4 years)	<input checked="" type="checkbox"/>			 v u 	

Since October 2020, the new section of **SSDC-resident multi-messenger Catalogs** (shown in the above figure) has been created to accommodate catalogs of events such as neutrinos detected by IceCube and UHE cosmic rays detected by AUGER: at present, it includes the catalog of candidate astrophysical neutrinos based on single-track neutrino events, among all High-Energy Starting Events (HESE), observed by the IceCube detector during the first four years of observations (2010-2014), hence called IC4HESE.

This section will not show up among SSCD-resident resources at any time, but only if the input coordinates lay within two degrees from the neutrino track uncertainty region. Furthermore, to display data on the main plot, you need to manually check the box (  ) before loading data (see Section 3.1) and click U (  ).



- FIRST • NVSS • Catalina RTS • VizieR photometry • SDSS13 • SDSS7 • allwise w1 • allwise w2 • WISE W1 PointPsf • WISE W2 PointPsf
- 1SWXRT (0.1-10 keV) • 1SWXRT (0.1-2.4 keV) • 1SXPS(0.3-1keV) • 1SXPS(0.3-10 keV) • 1SXPS(1-2keV) • 1SXPS(2-10 keV) • Fermi1FGL (6Gev)
- Fermi2FGL (60Gev) • Fermi2FGL (6Gev) • Fermi3FGL (2Gev) • Fermi3FGL (600 Mev) • Fermi3FGL (60Gev) • Fermi3FGL (6Gev) ↓ Fermi1FGL (200 Mev)
- ↓ Fermi1FGL (2Gev) ↓ Fermi1FGL (600 Mev) ↓ Fermi1FGL (60Gev) ↓ Fermi2FGL (200 Mev) ↓ Fermi2FGL (2Gev) ↓ Fermi2FGL (600 Mev) ↓ Fermi3FGL (200 Mev)
- ↓ ARGOS2LAC — ICTJ2227+0000 ↓ ICTJ2227+0000 ↓ ICTJ2227+0000

For each neutrino event in this catalog two upper limits on the neutrino flux were derived, corresponding to an emission time of 0.5 years (which is the overall duration of the gamma-ray flare detected from TXS 0506+056 at the epoch when this BL Lac object was established as the first identified source of high-energy astrophysical neutrinos) and the 4-years whole IceCube livetime.<sup>1</sup>

In the above figure it is shown the hybrid SED of the blazar 5BZBJ2223+0102, that is found within two degrees from the IC140114A neutrino reconstructed arrival position (named as ICTJ2227+0000 in the IC4HESE catalog): in addition to data marking the electromagnetic emission from the radio to the gamma-ray band, the purple strip in the TeV-PeV band marks the primary neutrino energy domain, with the two flux upper limits corresponding to an assumed emission time of 0.5 years (solid arrow) and 4 years (dashed arrow), respectively.

<sup>1</sup> Further details on the assumptions needed to perform such a computation can be found in <https://schedule.adass2020.es/adass2020/talk/NM7YBC>

**Data from external services and catalogs**

Name	<input checked="" type="checkbox"/>	Credits		Search	Options
BSDC-MAGIC	<input checked="" type="checkbox"/>				U
BSDC-Veritas	<input checked="" type="checkbox"/>				U
Catalina RTS	<input checked="" type="checkbox"/>				U
NED	<input checked="" type="checkbox"/>				U
VizieR photometry	<input checked="" type="checkbox"/>				U
2MASS	<input checked="" type="checkbox"/>				U
SDSS13	<input checked="" type="checkbox"/>				U
SDSS7	<input checked="" type="checkbox"/>				U
UKIDSS8 VO	<input checked="" type="checkbox"/>				U
USNO A2.0	<input checked="" type="checkbox"/>				U

Search results for NED:  
 OJ287  
 OJ287  
 PKS0851+202  
 PKS0851+202  
 BZBJ0854+2006  
 WMAP5J0019+2020  
 1Jy0851+202  
 2FGLJ0854.8+2005  
 PLCKERC353G206.1  
 PLCKERC857G206.1

The opportunity of retrieving **data from external services** such as NED, 2MASS, USNO A2.0 and SDSS is also given.

Among these services, a query to NED goes through an intermediate step. Such a query is in fact performed by specifying a name for the object, that can be selected from a list built by means of a local tool and displayed in a drop-down menu ( ); if you prefer to insert a different name, just type it in.

This local tool retrieves all names corresponding to objects whose coordinates are found within 0.5 arcminutes from *a*) those that you directly inserted in the main interface (see Section 2) or *b*) those associated to the name that you typed.

#### User Catalogs

Name	<input checked="" type="checkbox"/>			Options
OJ287_sw00030901006xpcw2po_cl.evt.gz	<input checked="" type="checkbox"/>			V S U
sw00030901053xpcw3po_cl.evt.gz	<input checked="" type="checkbox"/>			V S U
OJ 287 optical photometry	<input checked="" type="checkbox"/>			V S U

Reload Catalog

Finally, an additional group (**User catalogs**) is shown at the bottom of all other tables to registered users only and lists private datasets, previously uploaded by themselves (see Section 3.4).

Note that, only if you are registered, a **Reload Catalog** option appears at the bottom of all lists. This can be useful to include personal datasets, eventually at a later time with respect to the public ones that are uploaded by clicking the **Load Data** button, before operating some further procedures such as, for example, fitting a polynomial function to data, as described in Section 3.3.5.

It is worth to remark here that, at variance with other tools and resources, data in the infrared, optical, and ultraviolet bands from all catalogs just described, when present, are corrected for Galactic dust extinction using the extinction law derived by Cardelli et al. 1989 (ApJ, 345, 245).

Furthermore, as far as concerns catalogs corresponding to high-energy missions, data are generally provided in the form of count rates detected by corresponding instruments: in these cases their conversion to fluxes is performed taking into account the instrument response and assuming a power law spectral model (when not given, spectral index is fixed to the Crab value).

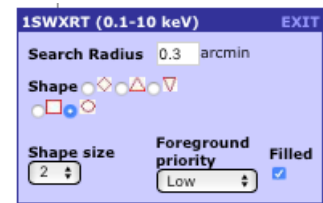
Also note that data in the soft X-ray energy range are corrected for Galactic absorption, assuming hydrogen column density values derived by Kalberla et al. 2005 (A&A, 440, 775).

As already reported in Section 3.1, when you first access to the **SED Builder** web page all the small boxes next to the names of each listed catalog are automatically ticked and colored in blue, meaning that all the listed catalogs are ready to be queried.

To start the query, click **Load Data**: as a result, a new symbol will be displayed aside the box, with a green or a red tick marking a positive or negative request outcome, respectively. However, a positive outcome of the request to the selected catalog does not imply that any data has been found in it, within the corresponding default search radius: in case of no data the small box will turn blank.

As a result, after clicking **Load Data** some boxes are colored in blue while the remaining are empty. A filled box implies that some of the points in the plotted SED belong to that catalog; if the box is empty, there are no data for that catalog in the plot.

Each catalog comes with default settings for its search radius as well as for some other features such as shape, size, and look of the marker used for corresponding data on the main plot. If you prefer to change these default values click the catalog name itself and a small window, like the one shown here as example, will pop up. To confirm your choice, you need to click U (→).



1SWXRT (0.1-10 keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SWXRT (0.1-2.4 keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SWXRT (2-10 keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SXPS(0.3-1keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SXPS(0.3-10 keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SXPS(1-2keV)	<input checked="" type="checkbox"/>	✓	■	V S U
1SXPS(2-10 keV)	<input checked="" type="checkbox"/>	✓	■	V S U
XRTGRBDEEP	<input type="checkbox"/>	✓	■	U

As far as concerns the color choice, it can be modified by clicking on the boxes next to their names (→): in this case the change will be instantaneous, with no need to update.

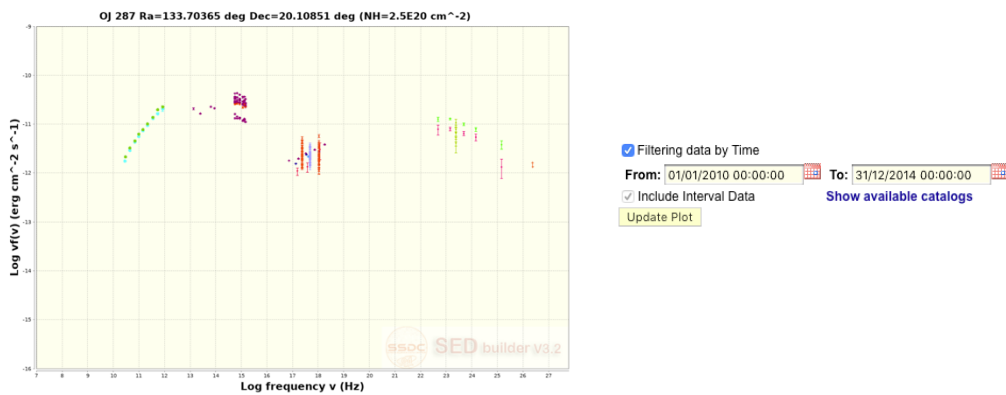
Data from each catalog can be specifically viewed (click **V**) and eventually excluded from the main plot. Consider also that, every time you make some changes on any catalog, you have to confirm them with a plot update (click **U**).

Registered users can also save data (click **S**) from specific catalogs.

### 3.3.2 Time filtering

Most catalogs include data corresponding to observations taken at different epochs. The **Time Filtering** option enables to define one, or several, time intervals so that only data matching them will appear in your SED; in this way, it is feasible to create a collection of nearly-simultaneous SEDs taken at different epochs, eventually distinguished by different colors. This capability can be very useful for variability studies.


Suppose to start from a SED built with all available data of your source and you want to display only data obtained in a certain time interval. Click the **Time Filtering** tab and three panels will appear under the **YELLOW** area; tick the **Filtering data by Time** option in the center panel, the one shown here above, then set start and stop time of your interval (5 years in the example), and finally click **Update Plot**.



In addition, suppose you want to split an interval in shorter periods of equal duration: for example five one-year intervals in place of a single five-year interval. You just need to establish this duration (➡) in addition to start and stop of the whole time range, filling the corresponding fields in the **Sequential Display of Time Resolved SEDs** panel.

When you are ready, first click **Create Intervals** (➡) in this panel and these will be listed in the **Time Resolved Plot** panel (you need to click the **Time filtering** tab again to see it).

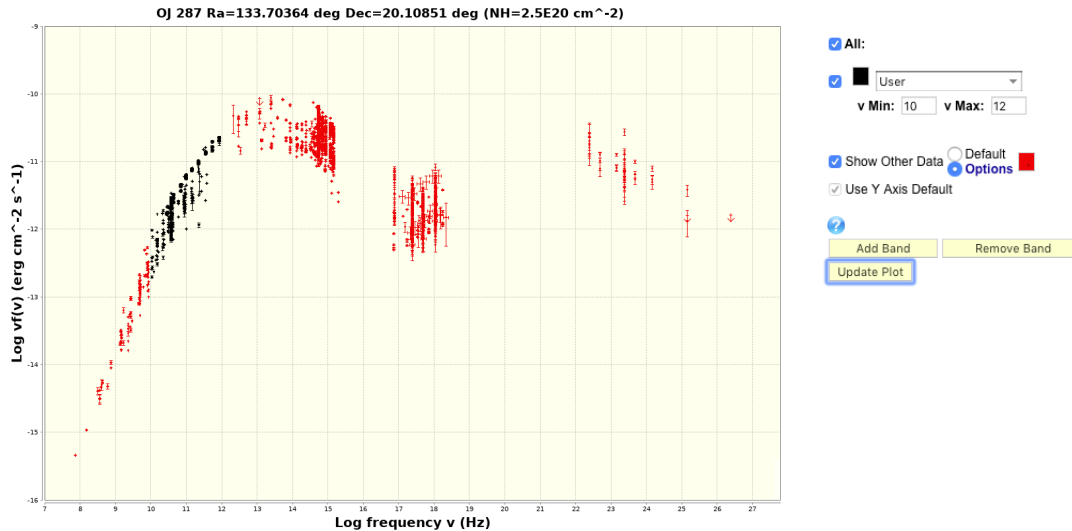
Then, click **Create images and run Sequence** (➡) to display the image gallery with the time-resolved SEDs corresponding to the intervals you just set up, on the left side of the main **SED Builder** page. Details about the current frame can be highlighted clicking on the **i** symbol, in the bottom-left corner of the plot.

A list of small thumbnails, one for each time interval, will appear on the right edge of the Sequence plot. You can use buttons underneath these thumbnails, on the bottom-right corner, to switch among different frames, just like any similar gallery of pictures you are familiar with for other devices; the short movie can be stopped also by the **Stop Sequence** () button.

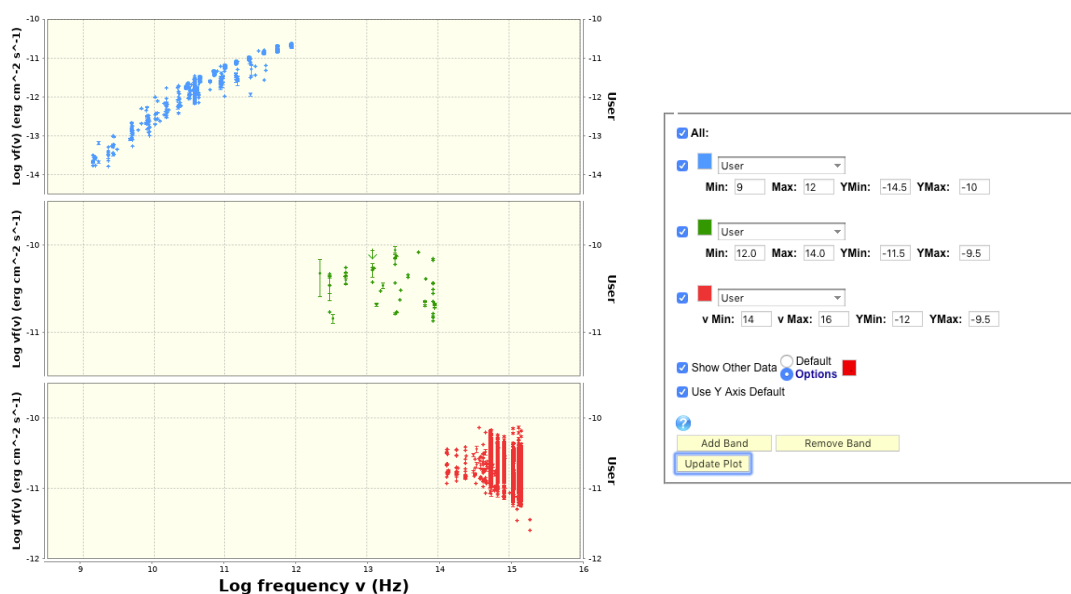
In alternative to a regular split of a longer time interval, you can obviously create ad hoc intervals with different durations according to your needs. In any case, consider that the creation of intervals by clicking the corresponding button is needed in order to create the images and running the sequence.

### 3.3.3 Energy Filtering

Once a preliminary SED is ready, you can set filters on available data according to one or more frequency bands adopting default values or specifying the ranges opportunely; other features (symbol, size, color, etc.) can be customized as usual.



Suppose that, in the SED of OJ 287 that you have built, you want to emphasize data in the  $10 < \text{Log } \nu < 12$  frequency range. Click the **Energy filtering** tab to display the dedicated control panel, with a number of fields controlling data as a whole and a couple of buttons to add and remove frequency bands. Select **Options** instead of **Default** to uniform the color of the marker for all data, choosing your favourite one (red in the example). Click **Add band** and fix the logarithmic values of lower (10) and upper (12) bound of the frequency range and choose the color for corresponding data (black in the example). You can repeat this step adding further bands at your convenience. Once you are ready, click **Update plot** to obtain the final result as shown in the above figure.



Suppose instead you want to display data corresponding to three energy bands (say, for example,  $9 < \text{Log } \nu < 12$ ,  $12 < \text{Log } \nu < 14$ , and  $14 < \text{Log } \nu < 16$ ) in stacked plots sharing a common X-axis. Repeat the steps described above to add two further bands, each of them with a different color. Then, select **Stacked Plot** in the **Plot Type** menu (see Section 3.2) and click **Update Plot**. You can tailor the final result adjusting also the range of both X and Y axes of the plot as a whole, as explained in Section 3.3.8.

### 3.3.4 Models

You may be interested in comparing the SED that you have built with some emission models: the **SED Builder** tool provides a Synchrotron Self Compton (SSC) emission model, based on a numerical approach to the problem.

This model allows to choose among different electron's distributions (power law, power law+cut off, etc.), tuning the values of several physical parameters (radius of the emitting region, magnetic field intensity, etc.) and possibly taking into account Synchrotron self-absorption; it requires a non-zero redshift to be specified in the given field of the **BLUE** area (see Section 3.2).

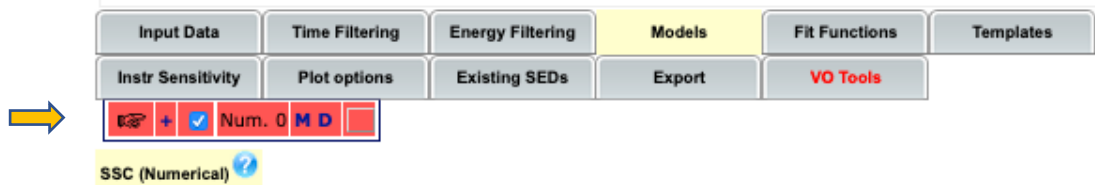
Authors taking advantage of this code in their publications are kindly requested to cite the paper by Tramacere et al. 2009 (A&A, 501, 879).

Log R(cm)	17	B (Gauss)	0.1
$\delta$	10	N	10
Log (y min)	1	Log (y max)	6
redshift	0		
<input checked="" type="radio"/> Power Law $\alpha$ 2			
<input type="radio"/> Power Law + Cut Off			
<input type="radio"/> Broken Power Law			
<input type="radio"/> Log Parabola			
<input type="radio"/> Power Law + Log Parabola			
Synchrotron self-absorption <input checked="" type="radio"/> YES <input type="radio"/> NO <input checked="" type="radio"/> fast <input type="radio"/> accurate			

Update Create New Save FIT Params Save Plot



After selecting the **Models** tab in the yellow area (Section 3.3), choose the electron's distribution accepting default values for the physical parameters or modifying them, then click **Create new** (red arrow) at the bottom to draw the colored profile of this model on the main SED plot. Opportunely tune the values and click **Update** (blue arrow) until you find a reasonable agreement between model and data.

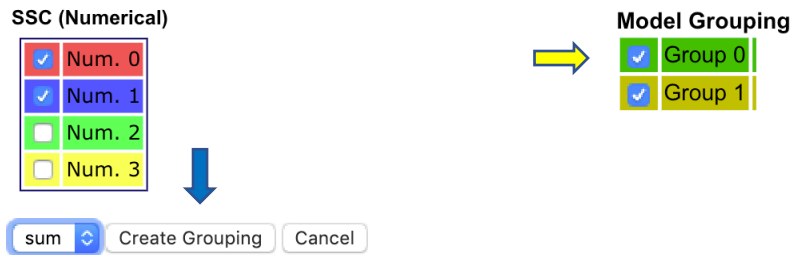


A new row (yellow arrow) with the same color of the line on the plot, summarizing model's properties, will appear under the eleven grey tabs.

	+	<input checked="" type="checkbox"/>	Num. 0	<b>M D</b>	
	+	<input checked="" type="checkbox"/>	Num. 1	<b>M D</b>	
	+	<input checked="" type="checkbox"/>	Num. 2	<b>M D</b>	
	+	<input checked="" type="checkbox"/>	Num. 3	<b>M D</b>	

Create Model Grouping

If you want to compare the model just created with new ones, repeat the same procedure described above. Then, every time you click **Create new** ( ) at the bottom, a colored row corresponding to the new model will be added to the list and its profile will be drawn in the main plot using the same color.



You may also want to assemble contributions from various SSC components in a single comprehensive model: click **Create Model Grouping** ( ) under the list of created models and a further box will show up; from the list of models that you previously created, pick those that you want to assemble (for example, #0 and #1), then **Create Grouping** ( ) and this will be drawn in the plot using a thicker marker; furthermore, a new **Model Grouping** field will appear ( ) with a corresponding **Group 0** entry.

You may eventually group different selections of components (for example, #2 and #3), that will be listed as new entries (**Group 1**, etc.) in the **Model Grouping** list.

### 3.3.5 Fit Functions

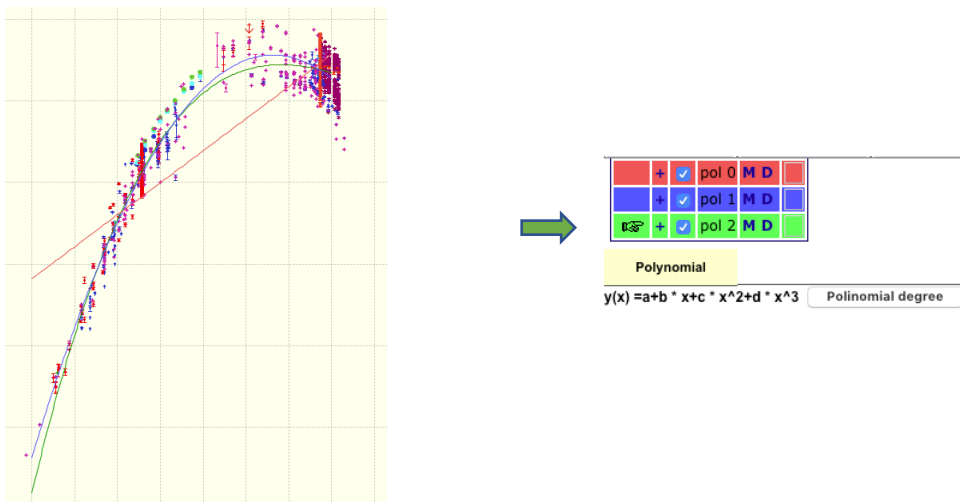
If you want to fit your SED data with a polynomial function, select the **Fit Functions** option. This opportunity is useful if you want to estimate relevant quantities related to the peak of emission components that can be distinguished in your SED, such as the peak energy, or the peak flux density, of the synchrotron component in the BL Lac object OJ 287.

$y(x) = a + b \cdot x + c \cdot x^2 + d \cdot x^3$  Polynomial degree

<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
<input type="text" value="0"/>	Max value of Log $\nu f(\nu)$	<input type="text" value="0"/>	Interval for X-Axis limits for FIT		
<input type="text" value="0"/>	$\nu_{max} = \nu(\text{Log } \nu f(\nu)_{max})$	<input type="text" value="0"/>	Log X min	<input type="text" value="8"/>	Log X max
<input type="text" value="0"/>	StdError	<input type="text" value="0"/>	<input type="text" value="8"/>	<input type="text" value="15"/>	<input type="text" value="15"/>
<input type="text" value="0"/>	Correlation Coefficient	<input type="text" value="0"/>	<input type="button" value="FIT"/> <input type="button" value="Update"/> <input type="button" value="Draw new line"/> <input type="button" value="Save FIT Params"/> <input type="button" value="Save Plot"/>		
<input type="text" value="0"/>	Num Terms	<input type="text" value="0"/>	<span style="color: yellow;">↑</span> <span style="color: orange;">↑</span> <span style="color: red;">↑</span> <span style="color: purple;">↑</span>		

Click **Polynomial degree** to select the degree, up to the third, of the polynomial function; set the boundaries of the frequency range in which the fit is being carried out and eventually some starting values for parameters, then click **FIT** ( ➡ ) at the bottom of the frame in which fit results (peak frequency  $\nu_{max}$ , etc.) will be shown.


If you want to change any parameter value, do not forget to click **Update** ( ➡ ) to see how these changes affect the profile of the polynomial function on the main plot.



In a similar way to what described in the case of the **Models** option (see Section 3.3.4), you can fit the same component with a different function, or another component in the SED, keeping track of previous fits.

Click **Draw new line** ( ➡ ) and a new colored row ( ➡ ) will be added to the list of model fits; as usual, a symbol in the first column indicates the active row. Repeat the procedure described above for the new fit that you want to carry out.

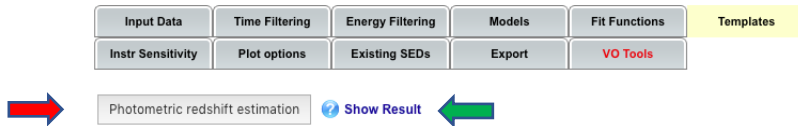
At any time, you can select any row by clicking **M**, make changes and finally confirm them by clicking **Update** to compare. Click **D** to remove a model that is not suited from the list, or simply uncheck the corresponding box to hide it in the plot.

When you are happy with the obtained results, you can save the parameters of your fits or save the plot clicking on the corresponding button (  ) at the bottom.

### 3.3.6 Templates

Once you express the SED of your source in luminosity, you can compare it with **Templates** of various astrophysical sources taken from literature. At this purpose the **SED Builder** tool provides the following templates for comparison:


1. a composite QSO optical spectrum from SDSS (Vanden Berk et al. 2001, ApJ, 122, 549) plus Standard X-ray emission, which requires a *radio-to-optical flux ratio parameter* to be defined;
2. a giant elliptical galaxy template (Mannucci et al. 2001, MNRAS, 326, 745);
3. other templates for spiral galaxies derived from Coleman, Wu & Weedman (1980, ApJS, 43, 393).



The **SED Builder** also enables to estimate a photometric redshift for extragalactic objects, using the public software **HYPERZ** (v.11) originally written by Bolzonella, Miralles and Pellò (2000, A&A, 363, 476) and later adapted by F. Lucarelli (SSDC/INAF-OAR).

To achieve this goal, **HYPERZ** compares the SED you built with a set of templates (both observed and synthetic SEDs) more suited to the object in analysis, choosing among three alternatives: power law templates, quasar templates, and Giant Elliptical Galaxy templates.


- Power law templates collect 40 power law template SEDs having the form  $F(\lambda) \propto \lambda^{-b}$ , with  $b$  ranging from 0.05 to 2; these are particularly suited to photometric redshift estimation of active galaxies such as blazars (BL Lacs/FSRQs) (see Rau et al. 2012, A&A, 538, 26).
- Quasar templates contain a composite QSO optical spectrum from the Sloan Digital Sky Survey (SDSS) (Vanden Berk et al. 2001, ApJ, 122, 549) and other quasar templates (Hatziminaoglou, Mathez and Pellò 2000, A&A, 359, 9).
- The Giant Elliptical Galaxy templates include the mean observed spectra of local elliptical galaxies from Coleman, Wu and Weedman (1980, ApJS, 43, 393) and three synthetic templates from the SWIRE library (Polletta et al. 2007, ApJ, 663, 81; Silva et al. 1998, ApJ, 509, 103).

Click **Photometric Redshift Estimation** (  ) and choose your favourite template in the yellow window that will pop up. In order to run the tool, please do not change the default  $vF(v)$  values [ $\text{erg cm}^{-2} \text{s}^{-1}$ ].

The capability of this tool is enhanced when strong spectral features, such as the Ca H&K break (3934 Å and 3969 Å) or the Lyman limit (912 Å), are identified in the SED. For this reason, the procedure automatically selects only near IR-to-UV data, *i.e.* with frequencies in the  $1 \cdot 10^{14} - 5 \cdot 10^{15}$  Hz range. Public data from the SDSS survey (Albaret et al. 2017, ApJS, 233, 25 for the DR13), from the Optical/UV SSDC Catalogs such as *Swift*-UVOT data from the UVOTPLKSED catalog (Giommi et al. 2011, A&A, 541, 160) and the GALEX Survey catalogs (Martin et al. 2005, ApJL, 619, L1), are

allowed in the fitting procedure; further optical/UV data may become available in the near future. Finally, as desirable, there are no restrictions on registered user's own data sets.

Although this is not the most common case, there are sources with a large amount of data at single frequencies, possibly extending to a rather wide range of fluxes. In such cases, **HYPERZ** will preventively compute a mean value at each frequency; however, if data exceed an established threshold of 50 elements, the procedure fails and returns an error message. In any case, the fitting results are expected to improve if you manually restrict this range selecting a few representative values, possibly obtained within the same observation epoch.

Once some filtering of data for the current SED has been applied, according to the caveats just described, click **Run** in the yellow pop-up window to start the **HYPERZ** fitting procedure. At the end of the execution, click **Show Result** (  ) to display the best estimate  $z_{\text{phot}}$  for the photometric redshift, and some related statistics such as the integrated probability within  $z_{\text{phot}} \pm 0.1$ .

High values of the integrated probability (together, of course, with a low reduced  $\chi^2$  fitting value) are a hint for the reliability of this fitting procedure. Furthermore, for active galaxies lacking strong spectral features (such as, for example, BL Lacs), the procedure is expected to be reliable for redshift values higher than 0.8, when the Lyman limit starts to affect the UV part of the spectrum.

### 3.3.7 Instrumental Sensitivity

You may want to compare SED data collected for your source with the sensitivity of several instruments. **SED Builder** enables this opportunity, providing sensitivity expected for corresponding instruments.



Click the **Instr Sensitivity** tab and a number of instruments, sorted by increasing frequency, will be listed underneath. With your mouse, hover the question mark symbols to show further details about the corresponding sensitivity curves. Consider that an updating work of some instrument sensitivity curves is in progress.

To give some examples, Planck sensitivity curves refer to a  $5\sigma$  sensitivity threshold for point source's detection, estimated from the [Planck Bluebook \(Planck Collaboration 2005\)](#) where background confusion is not included.

For NuSTAR, an exposure of  $10^6$  s has been assumed; INTEGRAL ISGRI and PICsIT curves refer to an exposure of  $10^6$  s ( $3\sigma$ ).

In  $\gamma$ -ray ( $E > 100$  MeV) detectors (AGILE, Fermi, EGRET) the limiting sensitivity corresponds to high galactic latitude and one year of observations; in Cherenkov telescopes, sensitivities are computed for 50 hours of observations.

Tick the boxes of instruments you are interested in and the corresponding sensitivity curves will show up in the main plot for comparison with your SED data.

### 3.3.8 Plot Options

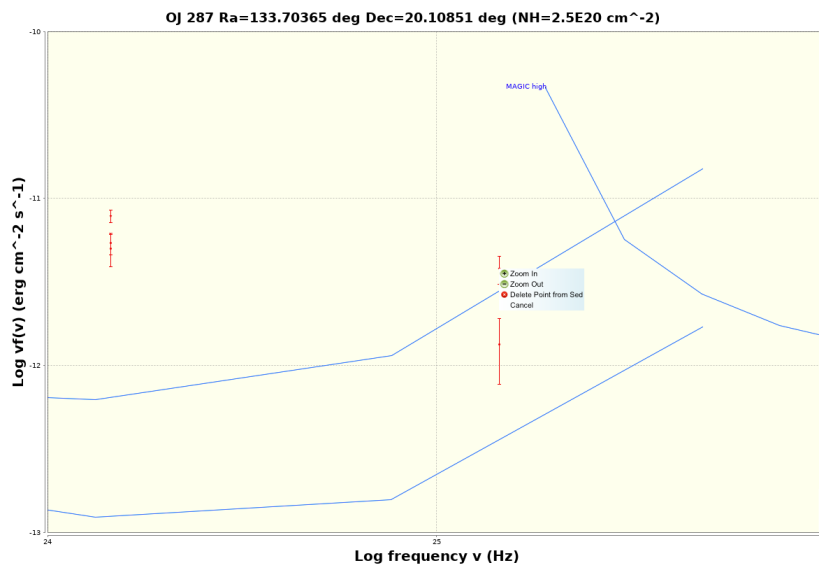
The **Plot Options** tab collects a few operations to customize the SED plot that help you improve its legibility and meet your requirements.



Adjust the ranges of both X and Y axes in the **Plot Axis Interval** field, using red arrows for their fine tuning; hide lower/upper limits in the SED; erase the SSDC logo and the date of creation of your SED from the plot background; uniform the color (red in the example above) of all data points from multiple catalogs, or change the background color.

The **Show Plot Legend** option displays the names of all catalogs used to build the SED, in a legend appearing at the bottom of the main SED plot; this can be particularly useful in cases of a reasonable (not too high) number of data points.

The **Show Tooltip** option allows the quick removal of a few specific data points from the plot, for example to test variations of fit results (see Section 3.3.5).



Tick the **Show Tooltip** box, then use the mouse to hover the data point and click as soon as the cursor changes shape to display the tooltip (if you experience any difficulty with this operation, the use of an alternative browser may help). This enables you to zoom in and out, erase the selected data point, or cancel to get back to some other action.

Consider that, even if you erase a data point from the plot, you can easily retrieve it back from the catalog at any time.

Show / Hide bands

<input type="checkbox"/> All		
<input type="checkbox"/> Radio	<input type="checkbox"/> Micro Wave	<input type="checkbox"/> Infrared
<input type="checkbox"/> Optical	<input type="checkbox"/> UV	<input type="checkbox"/> Soft X Ray
<input type="checkbox"/> Hard X Ray	<input type="checkbox"/> MeV Gamma Ray	<input type="checkbox"/> GeV Gamma Ray
<input type="checkbox"/> TeV Gamma Ray	<input type="checkbox"/> PeV Energy	

In the **Show/Hide bands** field a list of main energy bands is reported: tick the box of one of them to overlap a light-shaded area to the plot extending over the corresponding boundaries.

### 3.3.9 Existing SEDs

You can quickly manage the set of SEDs built for the source you are investigating by selecting the **Existing SEDs** tab; this is similar to the homonymous button in the **GREEN** area, but in that case the SEDs built for all the sources you worked on are shown.

### 3.3.10 Export a SED

There are several available formats to save both data of your SED and the plot itself.

Data can be saved as an ASCII or VO table, as well as in a format ready for the use with QDP or Supermongo (SM), opportunely selecting the entry in the **Export Type** menu; the plot that you have produced can be saved in any of the PNG, PS and EPS formats.

Export Type: **ASCII**

Downloads: **PNG** **PS** **EPS**

Export ASCII Option

- Logarithmic value
- Print Comment
- # Comment Char



Export ASCII SED


Consider also that, in addition to data, you can include in your ASCII file the values corresponding to a source's template (see Section 3.3.6), if you are interested in a more direct comparison with the SED of your favourite source.

### 3.3.11 VO Tools

The integration (currently **under development**) of **SED Builder** with other VO-compliant tools increases the capability of handling data of the SED you have built.


For example, you can currently send data to TOPCAT in the form of multi-frequency light curves: at this purpose you simply need to select a few ranges of frequencies, customizing some of them already set as default and eventually adding others.

Once ready, click **Launch** (  ) to open the Java applet if TOPCAT is not already installed on your laptop; otherwise, click **Register** (  ) and after giving your agreement, a list of registered clients will appear.


Click **Send** (  ) and your data will appear within TOPCAT, formatted in a table analogous to the one shown below, ready for further processing.

VO Tools like TOPCAT can be used to handle SED data in the time domain.

Warning: Data points for which an observation date is not available are artificially associated to  $t_{year}=2000.0$  equivalent to  $t_{MJD}=51544.0$

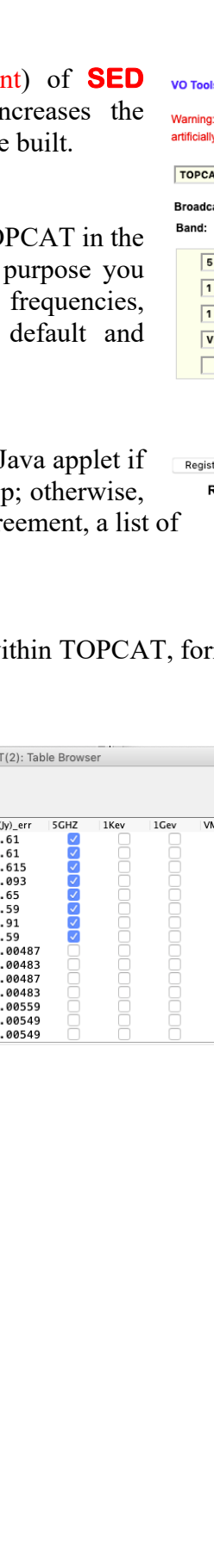


Band:	Logv <sub>min</sub>	Logv <sub>max</sub>	Label
5 GHZ	9.6	9.7	5 GHZ
1 Kev	17.13	17.39	1 Kev
1 Gev	23.38	23.39	1 Gev
VMAG	14.7	14.8	VMAG



Registered Clients

- Hub (meta+) (subs+)
- topcat (meta+) (subs+) **Send**
- Monitor ASDC SED (meta+) (subs+)



	Time(MJD)	Nufnu(ergcm <sup>-2</sup> s <sup>-1</sup> )	Fnu(y)	Time(Years)	Nufnu(ergcm <sup>-2</sup> s <sup>-1</sup> )_err	Fnu(y)_err	5GHZ	1Kev	1Gev	VMAG	5GHZ_...	1Kev_U...	1Gev_U...	VMAG_...	Upper
1	51544.	1.305000E-13	2.61	2000.	1.305000E-13	2.61	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	51544.	1.305000E-13	2.61	2000.	1.305000E-13	2.61	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	51544.	1.895000E-13	3.908	2000.	1.753000E-13	3.615	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	51544.	1.504000E-13	3.1	2000.	1.500000E-13	3.093	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	51544.	7.978000E-14	1.74	2000.	7.565000E-14	1.65	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	51544.	1.347000E-13	2.69	2000.	1.297000E-13	2.59	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	51544.	1.495000E-13	3.06	2000.	1.422000E-13	2.91	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	51544.	1.305000E-13	2.61	2000.	1.295000E-13	2.59	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	53469.18946	2.815000E-11	0.00517	2005.27198	2.655000E-11	0.00487	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	53469.19759	2.789000E-11	0.00512	2005.272	2.631000E-11	0.00483	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	53469.20575	2.815000E-11	0.00517	2005.27202	2.655000E-11	0.00487	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	53469.21386	2.789000E-11	0.00512	2005.27205	2.631000E-11	0.00483	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	53481.23159	3.232000E-11	0.00593	2005.30497	3.049000E-11	0.00559	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14	53481.23975	3.173000E-11	0.00582	2005.30499	2.993000E-11	0.00549	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15	53481.24789	3.173000E-11	0.00582	2005.30502	2.993000E-11	0.00549	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 3.4 GREEN area: links to SSDC resources

Version 4.0
[Tutorial](#)
[Feedback](#)
[Login](#)
[User Data](#)
[User SEDs](#)
[Sky Explorer](#)
[Current SED](#)
[Show source names](#)

[Data citation policy - please read](#)

In this area you can find a collection of general information and useful links, such as the current **SED Builder** version, or the data citation policy that you are kindly invited to comply with; furthermore, there is a link to retrieve the most updated version of the tutorial, and also another one to send a message in case you need assistance, or to give us any feedback on the tool.

Next to the link to the SSDC **Sky Explorer** tool, always useful for quick reference, the [Current SED](#) link has been designed in case that, after a series of unsaved changes, you want to get back to the latest updated SED. Furthermore, the list under [Show source names](#) is created as a result of a local search to SSDC-resident catalogs within 0.5 arcmin from the used input coordinates (see Section 2).

All the links described above are accessible to all users. Conversely, [User Data](#) and [User SEDs](#) are allowed to registered users only: to enable them, click [Login](#).

Click [User Data](#) to enter a private area for managing your own datasets and catalogs. Whether for a single source or multiple sources, new data have to be formatted in a single ASCII file following the templates shown below.

### Upload New Data

**Example for a single source**

```

! Use ! to comment row - Delimiter used '|'
! frequency frequency error flux flux error tstart tstop flux_limit_flag(optional)
! Hz Hz erg/cm2/s erg/cm2/s MJD or YYYY-MM-DDThh:mm:ss MJD or YYYY-MM-DDThh:mm:ss (LL = Lower Limit, UL= UpperLimit)
Single source 133.70333 |
| 6.9343E14 | 0.531E14 | 1.5101E-11 | 2.4341E-13 | 51125.2 | 51125.3 | UL | <- Tstop equal to Tstart
| 1.4791E15 | 0.14E15 | 1.1534E-11 | 3.1875E-13 | 51125.2 | 51125.3 | | <- No time information
| 1.1402E15 | | 1.1803E-11 | | | | | LL | <- Flux error no specified
| 20:10833 | 1.3459E15 | | 1.2474E-11 | 4.0218E-13 | 50043.1 | | | <- Frequency error with no value (0)
| 5.5590E14 | | 1.5066E-11 | 2.7754E-13 | 54251 | 54252 | |
| 8.5704E14 | | 1.4322E-11 | 2.9682E-13 | | | |

```

**Example for multiple sources**

```

! Use ! to comment row - Delimiter used '|'
! ra dec frequency frequency error flux flux error tstart tstop flux_limit_flag(optional)
! deg deg Hz Hz erg/cm2/s erg/cm2/s MJD or YYYY-MM-DDThh:mm:ss MJD or YYYY-MM-DDThh:mm:ss (LL = Lower Limit, UL= UpperLimit)
Multiple sources 149.588 | 32.401 | 6.9343E14 | 0.69E14 | 1.5101E-11 | 2.4341E-13 | 51125.2 | 51125.3 | UL
| 149.588 | 32.401 | 1.4791E15 | 0.4E15 | 1.1534E-11 | 3.1875E-13 | 51125.2 | 51125.3 |
| 299.5875 | 35.20083 | 1.1402E15 | | 1.1803E-11 | | | | | <- Frequency error with no value (0)
| 149.5876 | 32.40053 | 1.3459E15 | | 1.2474E-11 | 4.0218E-13 | 50043.1 | | LL | <- Flux error no specified
| 299.5875 | 35.20083 | 5.5590E14 | | 1.5066E-11 | 2.7754E-13 | 54251 | 54252 |
| 182.635 | 39.406 | 8.5704E14 | | 1.4322E-11 | 2.9682E-13 | | |


```


In case of a single source, coordinates are automatically associated; you need to specify at least six columns corresponding to frequency and its error (in Hz), flux and its error (in  $\text{erg cm}^{-2} \text{s}^{-1}$ ), start and stop times of observation (in Modified Julian Date, MJD).


For multiple sources two additional columns are required, with the former two reporting Right Ascension and Declination of each source in degrees units.

In both cases, upper and lower limits can be optionally provided for fluxes: if so, no flux errors are due and a latter column must be added to the file quoting UL or LL tags at the right place, respectively.

Logarithmic Value (Frequency and Flux)

 Name/Description

 Comment

 Default Search Radius

Delimiter


Time format





Time Start

Time Stop








Default Color

File to upload  no file selected



When your file is ready, tick the opportune circle (single/multiple sources), browse to the folder where it is saved () , choose a name for this dataset () to distinguish it from others in the **User Data Available** table, eventually including comments () , then **Upload Data** () : as a consequence, your new dataset will be listed in the **User Data Available** table, at the bottom of the page. Any entry in this list can be edited or deleted at any time by clicking the **E** or **D** letters, respectively, in the **Options** column.

### User Data Available

Catalog Name	Comment	Search Radius	Default Color	Creation Date	Options	Option
sw00053675002xpcw2po_cl.evt.gz		1.00			<b>E D</b>	
nustar_FPMA_powerlaw_194.0462_-5.7887		1.00			<b>E D</b>	
sw00088811001xpcw3po_cl.evt.gz		1.00			<b>E D</b>	
sw00083368051xpcw3po_cl.evt.gz		1.00			<b>E D</b>	
OJ287_sw00030901006xpcw2po_cl.evt.gz		1.00			<b>E D</b>	
sw00030901053xpcw3po_cl.evt.gz	2009/10/25 Swift XRT	1.00			<b>E D</b>	
OJ 287 optical photometry	2019/11/08 Observation	1.00			<b>E D</b>	


Export: [csv](#) | [xls](#)

Groups not Allowed	Groups Allowed
<input type="button" value="Join"/>	<input type="button" value="Leave"/>
agile AgileLV3 AgileLV3Admin AgileTeam ams_private ams_public ams_test anonymous asdc BackupManagerAdmin Beijing BeijingAdmin brera BZG CBPF CBPFAdmin CHANGE:ALL CosmicRaysAdmin DAWN.VIRVMT devcatalog	

The **Edit** option not only allows the user to set preferences on marker color and dataset name, but also enables it to be shared with other working groups: click **E** to display a control panel distinguishing not allowed/allowed groups, like the one shown here.

The status of a group can be easily changed highlighting its name and clicking the **Join** and **Leave** buttons on top of this panel. In this case, you don't need to do anything else to make your changes effective.

Let's assume that you have previously built a SED for your source using data from other popular catalogs: thus, click **Current SED** and then **Update Plot** (see Section 3.2) to include also data from the new dataset/catalog.

As a result, if *any* data included in your new dataset is found within a circle from the input coordinates, **SED Builder** will include this dataset in the **User Catalogs** list, which appears when the **Input Data** tab (see Section 3.3.1) is active; the default radius of this circle, 1 arcmin () , can be changed. Furthermore, all data of sources whose coordinates are within the default search radius of this dataset (see how to change its value in Section 3.3.1) will be plotted in the SED graph.

After building SEDs for any astrophysical source, registered users have the possibility to store them in their reserved area: once logged in, click **User SEDs** to access this area, in which SEDs are splitted in two lists: **Your SEDs** and **Shared SEDs**.

### Your SEDs

Projects	SED List					
	Name	R.A.	Dec	nH	Creation Date	Options
- 200911	3C273	187.2779	2.05239	1.67E20	2019-07-10 15:17:27.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>
	3C279	194.04667	-5.78944	2.05E20	2019-07-26 10:39:28.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>
	OJ 287	133.70365	20.10851	2.49E20	2019-11-08 11:25:31.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>
- My SEDs	Name	R.A.	Dec	nH	Creation Date	Options
	OJ287	133.70333	20.10833	2.49E20	2019-11-04 12:36:39.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>
	3C279	194.04625	-5.78917	2.05E20	2020-07-31 15:35:26.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>
	3C273	187.2779	2.05239	1.67E20	2020-08-03 15:59:37.0	<a href="#">Edit</a> <a href="#">Delete</a> <a href="#">View SED</a>

The former list, **Your SEDs**, includes all the SEDs previously built by yourself (see Section 3.1), organized in different projects; each of them can be viewed, edited, or deleted at your convenience.


### SED


Name	Project name	R.A.	Dec	nH	Created By	Creation Date	Option
3C279	200911	194.04667	-5.78944	2.05E20	maselli	2019-07-26 10:39:28.0	<a href="#">Update SED</a>

Groups not Allowed	Groups Allowed
<a href="#">Join</a>	<a href="#">Leave</a>
Fermi FermiAdmin FodaFull GaiaCatalogs GaiaCatalogsAdmin GRBaseAdmin GROND icneutrino ImgLoader Limadou LiteBIRD MatisseAdmin MatisseViewer mmcAdmin mmcanonymous mmcgroup MoU Planck nustar openUniverse pamela_private	

In addition to changing its name or its project, editing a SED also allows to share it with other working groups. However, in order to do this, you need to verify that user catalogs, eventually including data for your source of interest, have been previously shared with the same working groups as well.

In a similar way to what described above for user's data, click **Edit** in the **Options** column of the panel listing **Your SED** to display allowed/not allowed groups, highlight the group of your interest, then change its status using the **Join/Leave** buttons.

However, at variance with the previous case, this time remember to click **Update SED** (  ) to make your changes effective. Consider that access rights to shared personal data and SEDs can be modified only by the creator and not by users, even though they benefit from sharing, being included in allowed groups.

The latter list, **Shared SEDs**, includes all the SEDs created by other users, that you have been enabled to access. Conversely to those included in the former list, you cannot modify SEDs created by other users, but only view them. However, you can create a duplicate of a SED (  ) and modify at your convenience.

### Shared SEDs

Groups	SED List						
+ SEDs							
+ MoU Planck							
+ variable							
+ 3LAC							
+ 2LAC							
- anonymous	Name	R.A.	Dec	nH	Created By	Creation Date	Options
	NGC 1275	49.95067	41.5117	1.36E21		2015-02-19 12:23:45.0	<a href="#">View SED</a> <a href="#">Clone SED</a>

When you're done, click [Current SED](#) on the top right to get back to the main **SED Builder** page.

# 4 Threads

In this section a few threads, dealing with scientific cases that are frequently encountered, are described in detail; in any of them, the user is expected to be registered and logged in.

## 4.1 Quick comparison of new data with archival ones

Suppose you have new, fresh optical data collected at your telescope on a source of interest and you are curious to see how they match archival, multifrequency data.

1. Create an ASCII file with data you want to upload, formatted in the proper number of columns as described in Section 3.4;
2. go to the **Sky Explorer** web page (<https://tools.ssdc.asi.it>) and provide the source's name (or, in alternative, its coordinates);
3. click **Search by name** (or **Search by coordinates**) and an output table will appear at the bottom of the page;

Name	RA (J2000) degrees	Dec (J2000) degrees	RA (B1950) degrees	Dec (B1950) degrees	Galactic L	Galactic B	Ecliptical Lon	Ecliptical Lat	Distance (arcmin)	Quality Flag	Reference Catalog	Resolver	Tools
OJ287	133.70333	20.10833	132.98824	20.29941	206.812206	35.820556	130.502264	2.601650		1	VERON10	LOCAL	Data Explorer Create SED
OJ 287	133.70364	20.10851	132.98855	20.29959	206.812120	35.820892	130.502497	2.601901				NED	Data Explorer Create SED
OJ 287	133.70365	20.10851	132.98855	20.29959	206.812119	35.820893	130.502498	2.601903				SIMBAD	Data Explorer Create SED

4. click **Create SED** in the last column of this table (**Tools**) and a new tab with the **SED Builder** tool will open up in your browser;
5. click **Load Data** and the SED, built with data from all the catalogs containing the coordinates of your favourite source within their search radius area, will appear in the main graph on the left side;
6. at your convenience, deselect some catalogs and manage properties (such as the search radius) of the remaining ones, then click **Update plot**;

**User Data Available**

Catalog Name	Comment	Search Radius	Default Color	Creation Date	Options	Option
sw00053675002xpcw2po_cl.evt.gz		1.00	■		E D	
nustar_FPMA_powerlaw_194.0462_-5.7887		1.00	■		E D	
sw00088811001xpcw3po_cl.evt.gz		1.00	■		E D	
sw00083368051xpcw3po_cl.evt.gz		1.00	■		E D	
OJ287_sw00030901006xpcw2po_cl.evt.gz		1.00	■		E D	
sw00030901053xpcw3po_cl.evt.gz	2009/10/25 Swift XRT	1.00	■		E D	
OJ 287 optical photometry	2019/11/08 Observation	1.00	■		E D	

Export: [csv](#) | [xls](#)


7. click **User Data** to access your personal area, then select the **Single Source** option and upload your ASCII file: consequently, an output table will appear at the bottom of the page with newly uploaded data (→);

8. click **Current SED** to get back to the main **SED Builder** page;

**User Catalogs**

Name	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Options
OJ287_sw00030901006xpcw2po_cl.evt.gz	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	V S U
sw00030901053xpcw3po_cl.evt.gz	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	V S U
OJ 287 optical photometry	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	V S U

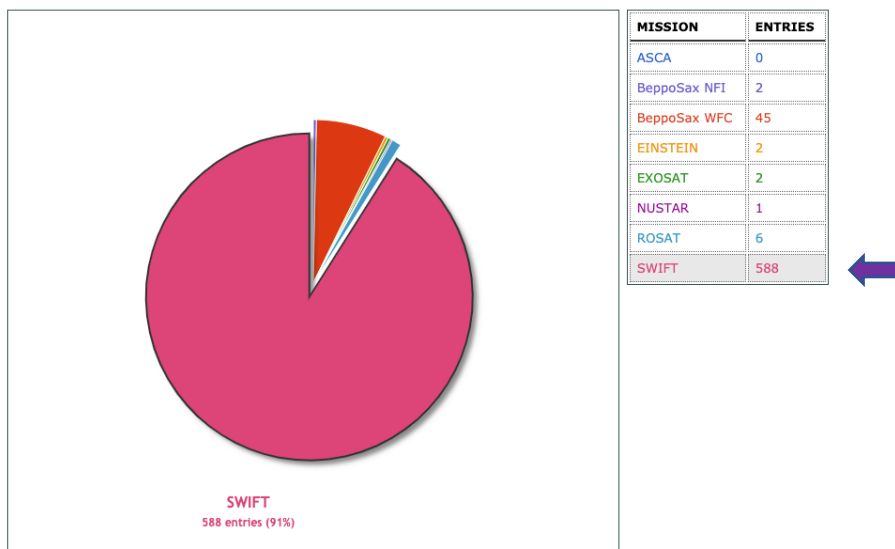
 

9. click **Reload Catalog** at the bottom of the **User Catalogs** table to finally display the data you just uploaded (  ) and see how they match all other data in the main plot.

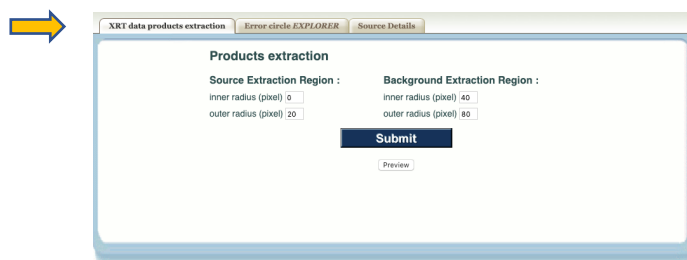
## 4.2 Energy spectrum from SSDC “Interactive Analysis”

Suppose that your source of interest has been observed by some high-energy mission (*Swift*, NuSTAR, AGILE) for which SSDC provides the possibility to perform interactive analysis, and you want to compare the results from any observation in the mission archive with an archival SED. In this thread, we will focus on the soft X-ray spectrum resulting from a *Swift* XRT observation.

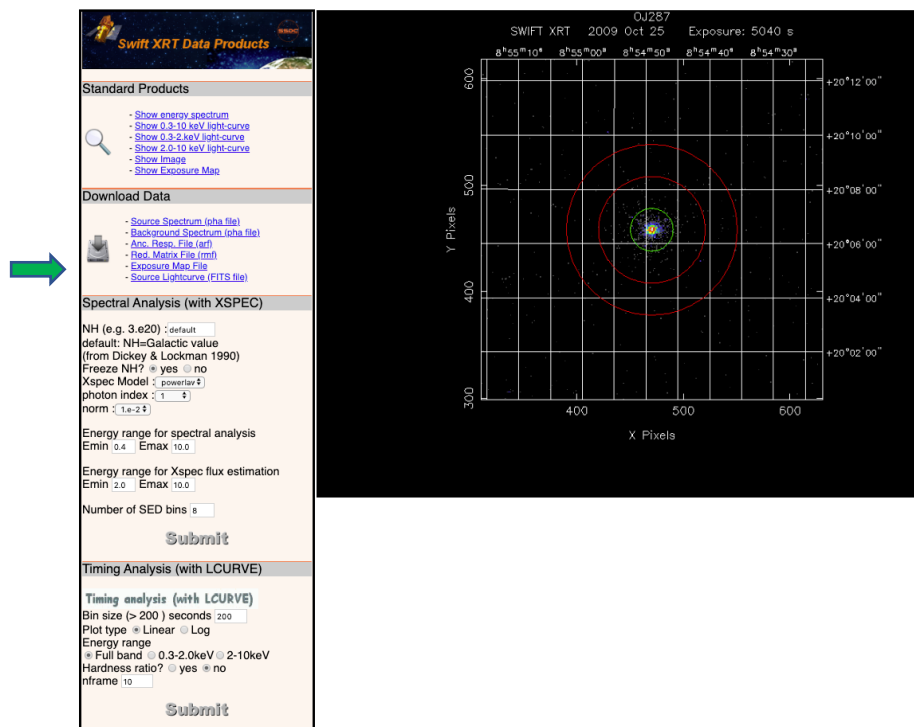
1. Open the main SSDC **Multi-Mission Interactive Archive** web page (<https://www.ssdc.asi.it/mma.html>) and provide the name of your target (or, in alternative, its coordinates) to search for all X-ray observations in the SSDC archives;



- filter only *Swift* observations, clicking on the corresponding slice of the pie chart or the name in the list (➡), and pick from the resulting query table the single one you are interested in. We took, for example, the one with the longest XRT exposure (obsID 00030901053) performed on 2009 October 25, easily picked among a few hundreds of entries after sorting all observations by exposure time;
- click the corresponding **XRT Interactive Analysis** button and a new tab will open up: select the appropriate Photon Counting (PC) or Windowed Timing (WT) data mode for the analysis, click **Submit**, and wait for a few seconds while processing data;
- move the cursor over your X-ray source in the map, then double-click on it: a new **SSDC Data Explorer** panel with all the information at the corresponding coordinates will open up;



- click the **XRT Data Products Extraction** tab (➡) on the left side of the panel: then, select proper shape (circle or annulus, depending on possible pile-up issues affecting the observation) and dimensions for both source and background regions; click **Preview** to verify your selection, then click **Submit** to confirm your choice;



6. in the left control panel you will find, among others, the **Spectral Analysis (with XSPEC)** field (→): modify the parameters (Galactic absorbing column density, spectral model, etc.) at your convenience, then click **Submit** to perform the spectral fitting of the adopted model to XRT data;

**Spectral Energy Distribution (SED):**

```
1.25817133E+17 2.42611364E+16 3.0732708E-12 2.47333133E-13
1.85931093E+17 3.58528236E+16 2.90796402E-12 1.99781625E-13
2.74766788E+17 5.29828841E+16 3.39657013E-12 1.89505204E-13
4.06047136E+17 7.82974857E+16 4.5329851E-12 2.52266009E-13
6.00051736E+17 1.15707106E+17 5.10955774E-12 3.79319433E-13
8.86749462E+17 1.7099062E+17 5.83575766E-12 4.81020822E-13
1.31042792E+18 2.52687924E+17 6.15640048E-12 6.31516161E-13
```

**SSDC SED Builder:**  
(click below to include SED data points)

Add data to SED

7. Fitting session results will be displayed in a new tab. At the bottom of this page, in the SSDC **SED Builder** section, click **Add data to SED** and then (in an intermediate tab) the **Confirm Upload** button to transfer these results also to your personal **User data** area;

**User Catalogs**

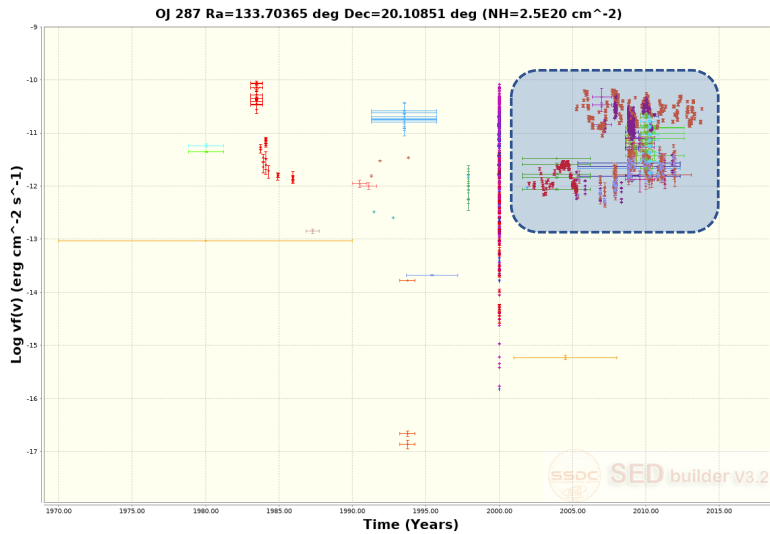
Name	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Options
OJ287_sw00030901006xpcw2po_cl.evt.gz	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	V S U
sw00030901053xpcw3po_cl.evt.gz	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	V S U
OJ 287 optical photometry	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	V S U

8. Click **Current SED** to get back to SSDC **SED Builder** and you will find the same results (→) in the **User Catalogs** table, visible at the bottom of the right control panel when the **Input Data** tab is selected, ready to be included in your SED.

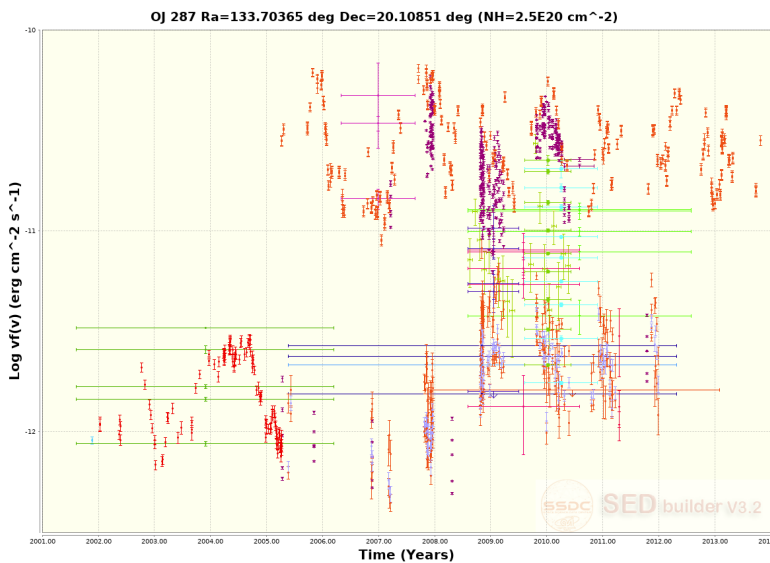
### 4.3 Light curves in different energy bands

Suppose your source has been frequently observed in distinct energy bands for quite extended time intervals, plausibly due to some flaring activity, and you want to compare the corresponding light curves.

1. Click **Load Data** from the main **SED Builder** web page;
2. select **Time (Years or MJD)** from the **X axis** menu, then click **Update Plot** in the **BLUE** area;

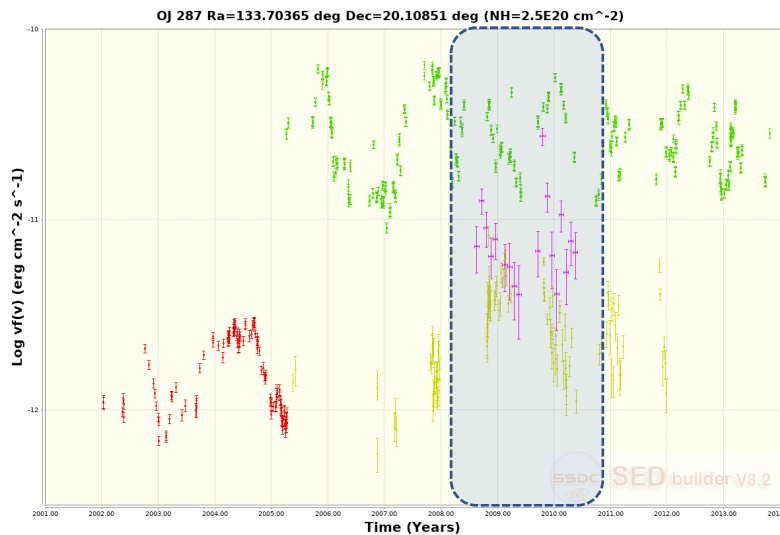


3. click the **Plot Options** tab and adjust the axes intervals to focus on the plot region that is crowded with data points, possibly in different energy bands: after selecting values opportunely, click **Update Image**.



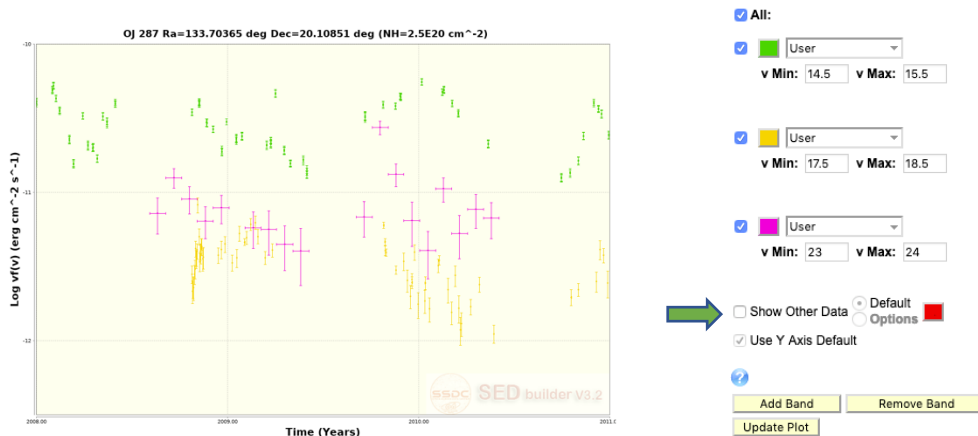
At this point you may want to filter some data out of the plot, particularly those single measurements with large error bars and/or with a limited time coverage compared to other datasets:

4. click the **Input Data** tab and select your data opportunely. In our example we focused on the following catalogs (further details can be found in the description's web page at [https://tools.ssdsc.asi.it/SED/docs/SED\\_catalogs\\_reference.html](https://tools.ssdsc.asi.it/SED/docs/SED_catalogs_reference.html)): NIEPPOCAT in the radio band, Catalina RTS (V filter) in the optical band, *Swift* 1SWXRT (2-10 keV) in the X-ray band, and *Fermi* 2FglLC in the  $\gamma$ -ray band. Adjust colors to better distinguish datasets.

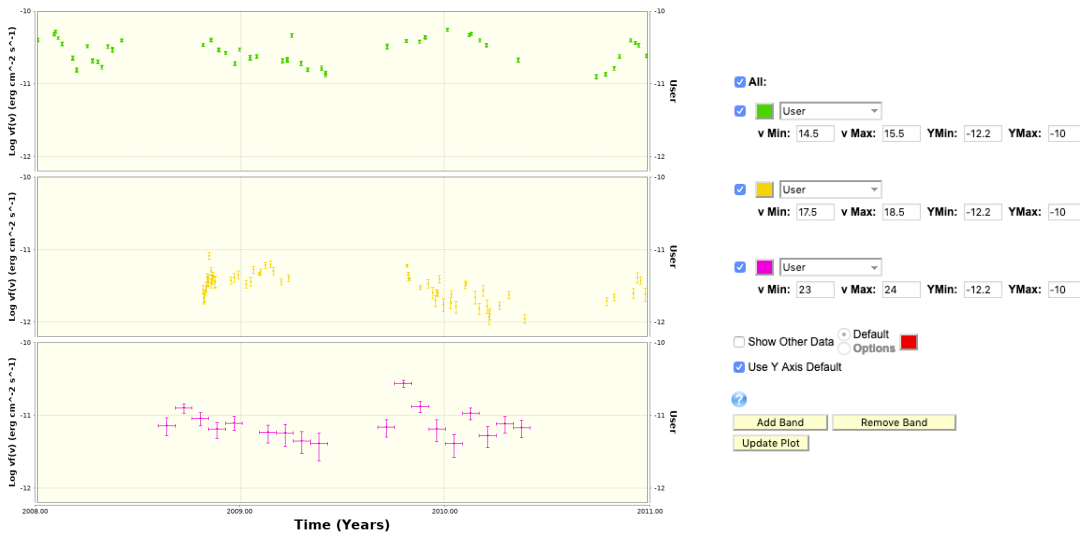


You can further focus your attention on a shorter time interval in which there are a few, almost simultaneous, light curves to be compared: in our example there is a very limited overlap of radio data with other datasets, so that we focus on the 2008-2011 period to compare optical, X-ray and  $\gamma$ -ray light curves, each in a separate frame.

5. Click the **Plot Options** tab to further adjust the range of the X-axis interval, then **Update Image**;



6. Click the **Energy Filtering** tab to arrange three different bands including the desired datasets, expunging the **Show Other Data** option (➡), then click **Update Plot** ;



7. select **Stacked Plot** from the **Plot Type** menu, then **Update plot** ; you may also want to adjust the Y axis range, eventually common to each frame, to obtain the result displayed above.

Edited by *Alessandro Pselli*