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# 1 Requirements

SplitLab should run on every computer system (MS Windows, MAC, Linux, SUN) with *Matlab7.0* or higher and the *Mapping toolbox* and for full functionality the *Signal Processing toolbox*.

For information on MatLab please visit the homepage:

<http://www.mathworks.com/store/default.do>

## 1.1 License:

SplitLab is PostCard ware! If you like it, please send a Postcard of the place you live to:

**Andreas Wüstefeld  
Laboratoire Tectonophysique  
Place Eugene Bataillon  
34095 Montpellier, France**

A selection of the best Postcards will be places on the SplitLab homepage SplitLab is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

SplitLab is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the [GNU General Public License](#) for more details.

## 1.2 Bug report:

If you think you found a bug, don't hesitate and write an email to [splitlab@gmx.net](mailto:splitlab@gmx.net).

Please include the project file and the 3 SAC files in your email. This simplifies the search for the bug. Please also copy and paste the *complete* error message in the email, i.e. everything, that Matlab outputs in red...

In general, any comments are welcome, especially positive ones:-)

## 1.3 Suggestions:

Please report wishes for additional features or any changes in the source codes to [splitlab@gmx.net](mailto:splitlab@gmx.net). This helps every user and allows for the maximum functionality for every user.



## 2 Installation

After unzipping the SplitLab package, put the SplitLab directory at your favorite place

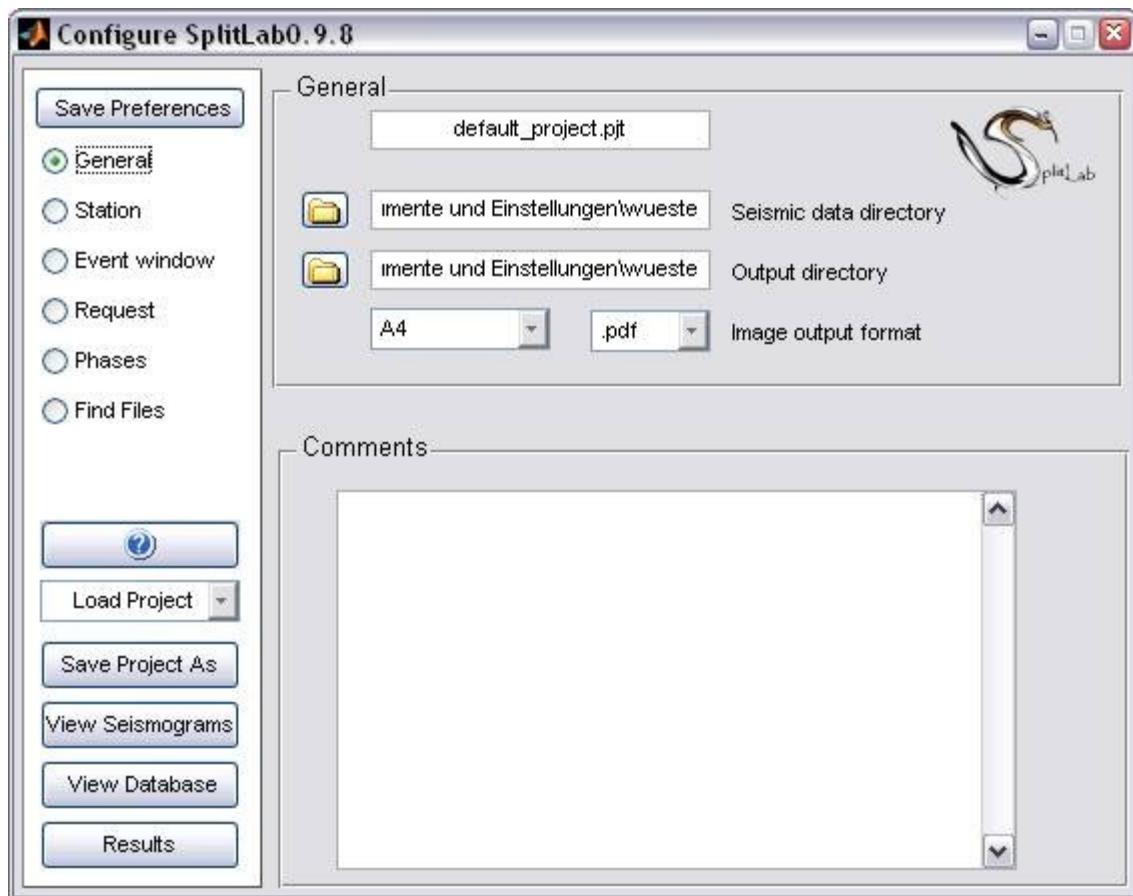
- Start Matlab
- In Matlab, go in the SplitLab directory
- The installation of SplitLab is made by running the macro named "*install\_SplitLab.m*".  
Type "**install\_SplitLab**" inside Matlab. This macro makes several things
  - i. it installs the matTaup package as a Matlab toolbox in the Matlab directories.  
matTaup is a Java program that allows the calculation of the travel times, of the hodochrons, and of the ray path through the Earth.
  - ii. it also installs in the SplitLab directory the event catalog files, such as the NEIC epicenter locations and the Harvard Centroid Moment Tensor (CMT). Either file is used in the following processes for the event selection and to create the virtual link between the seismograms and the events.
  - iii. Restart Matlab
- Perhaps [Troubleshooting](#) helps case of problems

## 3 Running SplitLab

- In the Matlab environment, type the command "**SplitLab**". It opens the "*Configure SplitLab*" window that will allow you to prepare your project, i.e. your data selection, your data request, and to build your seismic database that will allow you to manage easily data and results in the processes of shear wave splitting measurements.
- What is a *SplitLab project*? A project can be defined as a set of seismic data associated to a set of events derived from a given selection. Any given project concerns a single station since the selection of data is performed from station-events epicentral distances. A project is generally related to a directory where data are stored. A given project may concern only part of seismic data in the directory and alternatively, several projects may coexist in a given directory where data are stored: a first project may be focused on SKS splitting measurements, a second on P-wave analyses, etc.
- In order to have the project OK and operational, one has to follow the six steps presented on the left end side of the "configure" window: general -> station -> Event -> request -> phases -> find files.

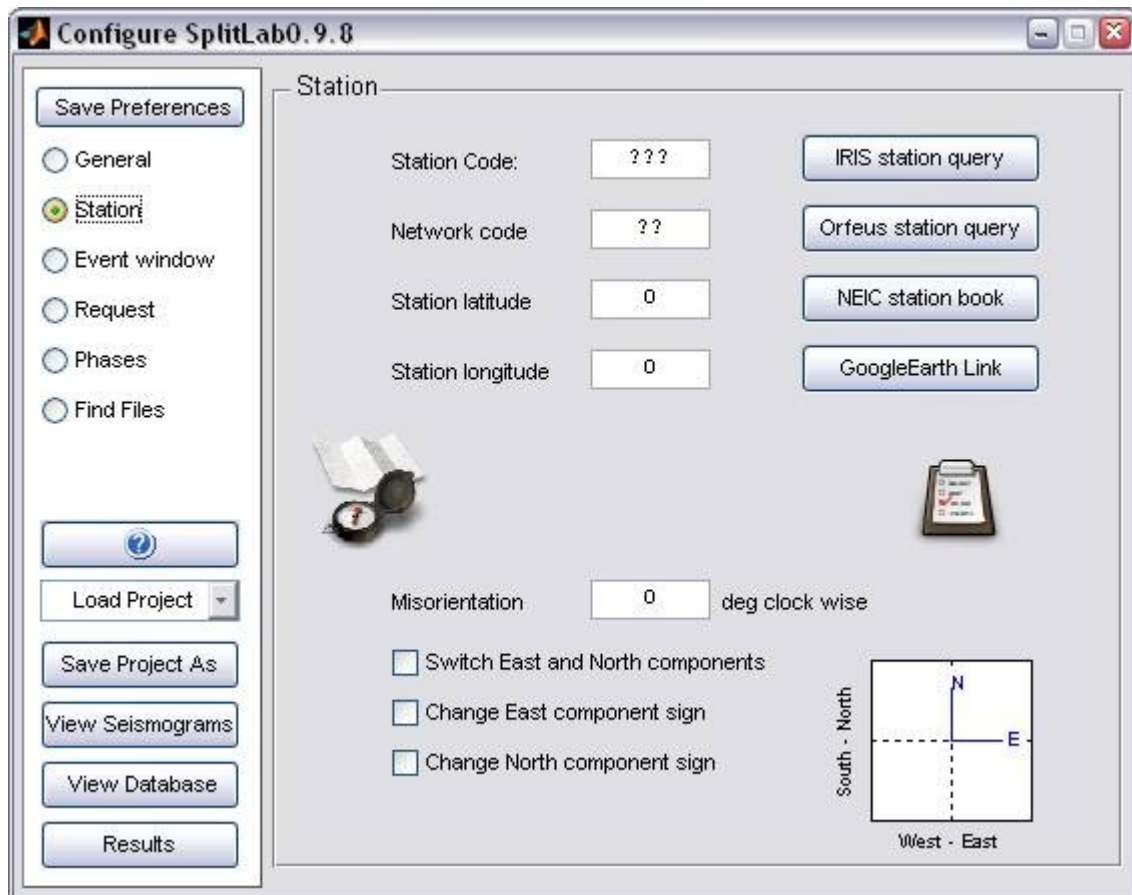
## 4 The Project Configuration Window

### 4.1 The "General" panel



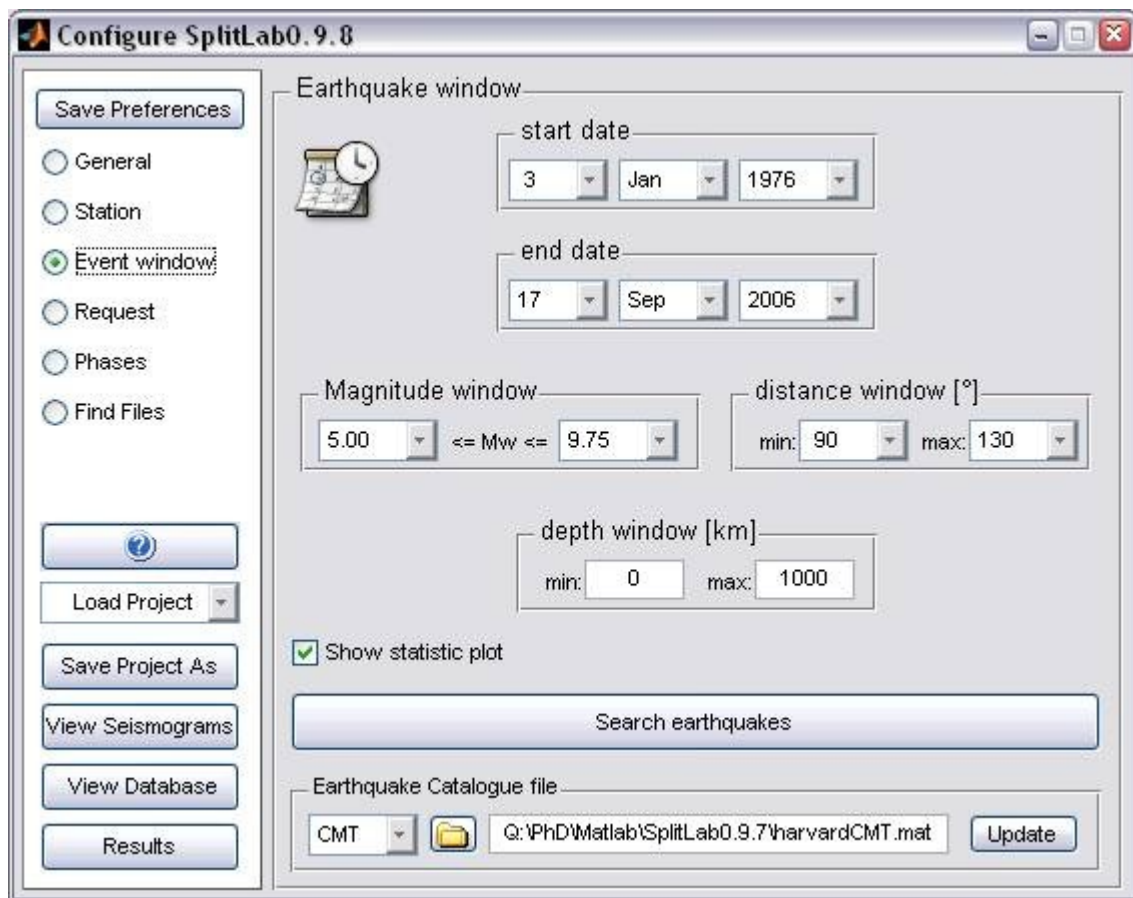
- The upper window allows you to define your project name and the directories where the data are and where the output data will be stored. This allows the user to have the data ready in a directory and to store the results in another place, without affecting the data directory.
- The lower part of the window allows you to store various comments related to this project.

## 4.2 The "Station" window:



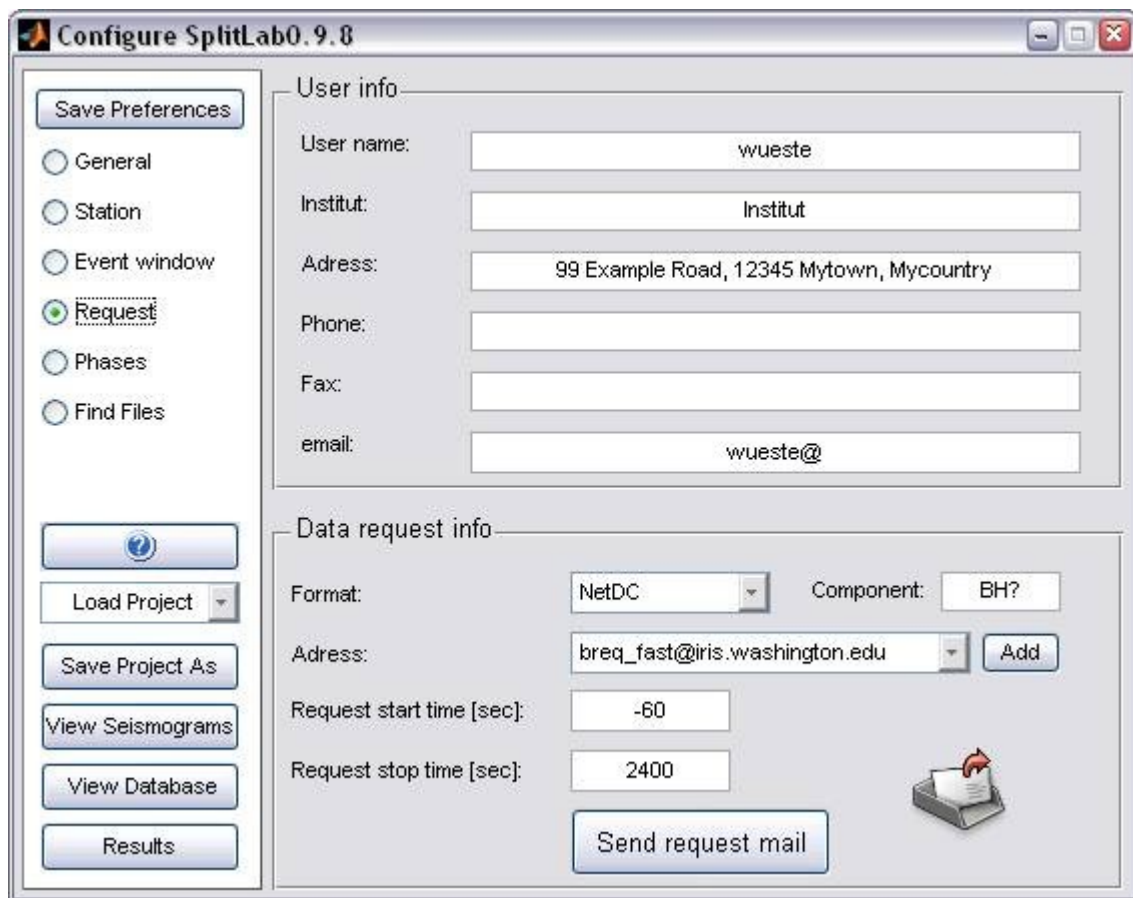
- This window summarizes the information related to the station. The station *latitude* and *longitude* are absolutely necessary since they are used to select the event from the epicentral distance and to calculate the various phases travel times.
- If the station has a known *misorientation*, the angle can be input in this window. This allow the user to work on true N, E and Z components and therefore, on the true radial and transverse components. Note that this operation is performed in Matlab and does thus not affect in any case your raw data.
- Problems of component *signs* or *polarities* may be corrected in this window and may be combined together with the component misorientation value.
- Several buttons of the right of the window provide direct Internet access to *station query tools* (such as IRIS) or to *station books* (such as NEIC). This may be useful when preparing a request, to look for instance for a stations in a given area or running during a given period.

### 4.3 The "Event" window:



- This window allows to prepare your event selection within the earthquake catalog file (NEIC or Harvard CMT) combining the *start and end dates*, the *event magnitude* ( $M_w$ ), the *epicentral distance* and the *event depth*. Click on the "Search" button when the parameters are OK. It results (if selected) in the "*statistic plot*" that displays:
  - i. the event location on a map preserving the true backazimuths,
  - ii. the histogram of the backazimuthal distribution, for  $360^\circ$  in green and for  $180^\circ$  in gray
  - iii. a rose diagram presenting the same backazimuthal distribution.
- The SplitLab package is provided with the earthquake catalog covering the period 1976 to 2006 and it may be necessary for the user to keep the local CMT or the NEIC files updated in order to search through an updated event catalog. The "*update*" button provides a way to automatically update the CMT files (in the case of the Harvard CMT format) or the information necessary to request to NEIC the data in the right format (in the case of the NEIC data format selection). Note that the NEIC catalog does not allow the calculation of the phase energy.

#### 4.4 The "Request" window:

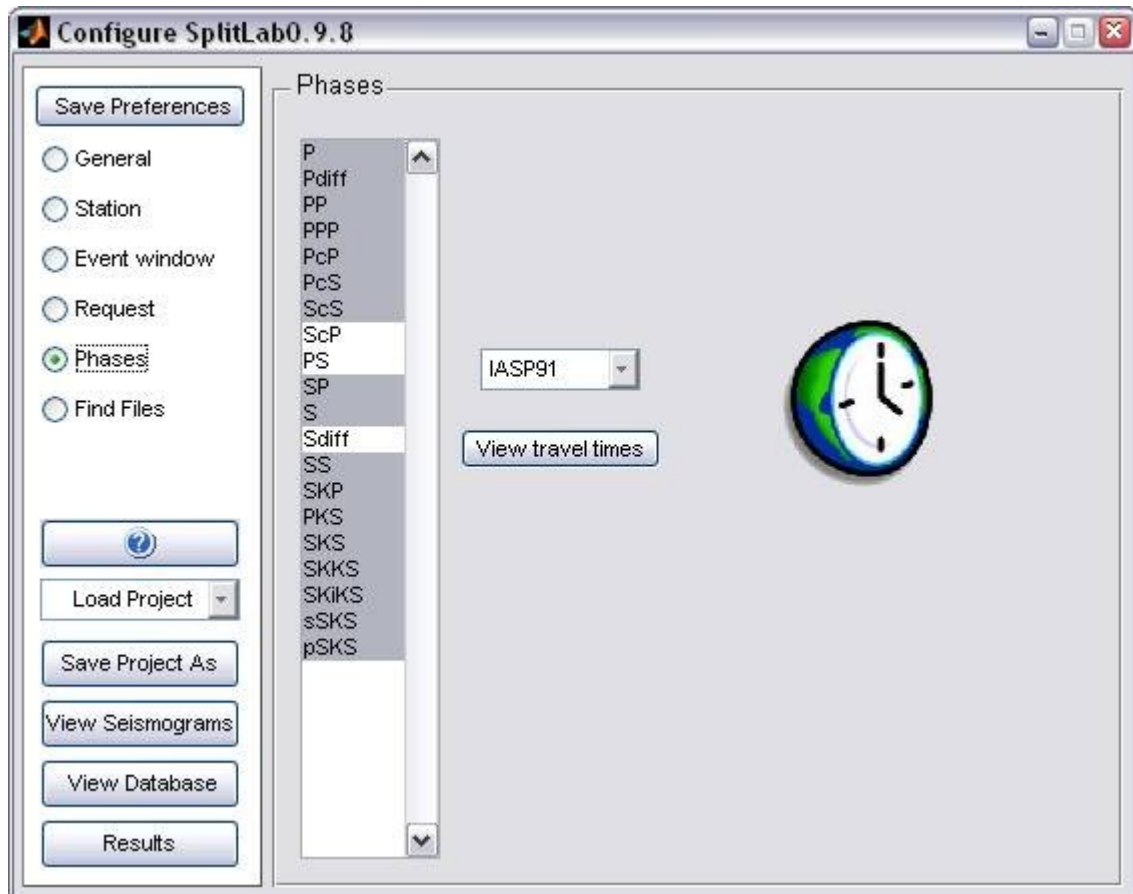


- The information that you enter here will allow to prepare, format and send the request to your selected request site. In the case where you already have the data with you (for instance after a temporary deployment or coming back on old data that you already worked on), you do not have to worry about this window. If you do not have the data with you, and if you wish to request them, you have to fill the full window:
  - i. In the upper part of the window, you have to provide the information generally requested by the automatic request systems: your *name*, your *institute*, your address. Your *email* is absolutely necessary since you will be contacted by mail on the status of your request, and on the availability of the data.
  - ii. In the lower part of the window, you have to choose between the various request types (*NetDC*, *BreqFast*, *AutoDRM* or *ASCII table*) and to the request server where the request will be sent to. You have to define the component you desire, the "*start time*" relative to the event time (0 corresponds to event time) and the *length of the seismogram* in seconds ([Figure 1a](#)). There is no way is the present version of SplitLab to prepare request relative to a phase, such as a starting time 60 seconds before a P-wave arrival... Perhaps in a future version! click "*Send*"



*request mail*" button and wait for delivery, few minutes, few hours or few days depending on the size of the request and on the activity of the servers. Multiple short requests (less than 200 events) are generally handled faster than one big.

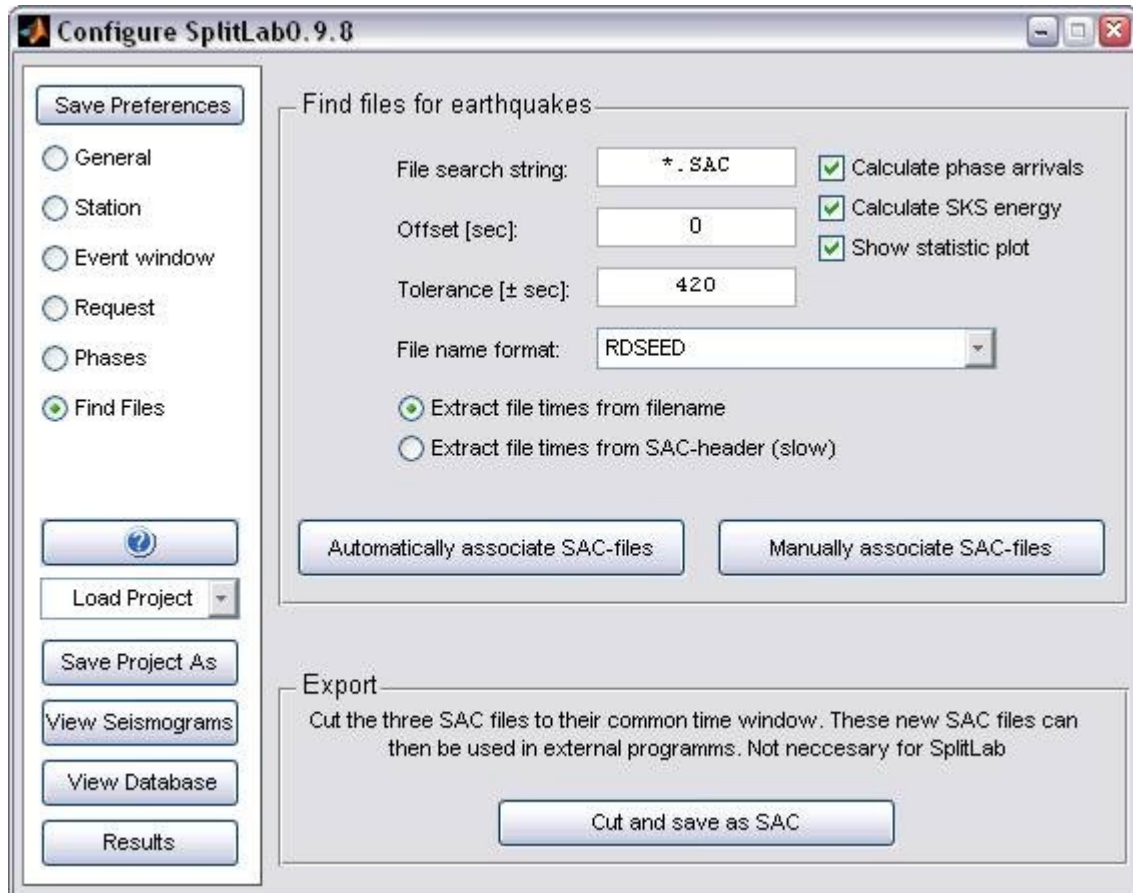
#### 4.5 The "Phases" window:



- This window allows you to select the phases for which you wish to see the arrival times on your seismograms. These theoretical arrival times are calculated by using the PREM or the IASPEI91 Earth models. The "*view travel time*" button allows you to see
  - i. the travel time of the selected phases as a function of the epicentral distance
  - ii. the travel paths through the Earth



## 4.6 The "Find Files" window



- It is the final and important step that will allow you to make the link between the event list and the seismogram list that you actually have, and therefore to build a coherent and effective seismic database. In the present state of the SplitLab package, the filename format is either

- *RDSEED* (see [homepage](#))
- *SEISAN* (see [homepage](#))
- *YYYY.MM.DD-hh.mm.ss.stn.sac.e*,
- *YYYY.JJJ.hh.mm.ss.stn.sac.e*.
- \*.e; \*.n; \*.z

See "[Create your own Format](#)" for more information

Note: A [Java version of rdseed](#) for Windows platforms is currently (Sep. 2006) under development by the IRIS consortium

- i. choose the *filename format* corresponding to your data. This is absolutely necessary to identify the seismogram components. If you selected  

$$*.e; *.n; *.z$$
the last letter of the filename is used to determine the component of each file and the file start times are extracted for the SAC header. Allowed component descriptors are **e, n, z** or **E, N, Z**
- ii. find the best file *search string* that may help the program to go through the whole set of data in the directory where your data are. As well the \* as the ? wildcard is possible. Be aware that files other than the expected seismic data may complicate the task. For instance, the presence of **\*.sac.r** or **\*.sac.t** for radial or transverse component of SAC files will not allow a right linking of events and seismograms. The safest way to make this step successful is to have the directory full of only the **sac.e, n** and **z** components.
- iii. The "*offset*" is the time duration between the event time and the starting time of your seismograms. Ideally, this offset should be identical to the "*request start time*" defined in the previous window but the data management center may have sent you data beginning later than requested. The offset value represents this difference ([Figure 1b](#)).
- iv. The "*Tolerance*" value in seconds will define the time window within which the program will try to associate a seismic file to an event file, by using either its name or the information contained in the header. It is up to the user to find the best compromise: a value too small will let orphans and a value too large will bring confusion since several files could be associated to a seismic event ([Figure 1b](#)).
- v. If the name of the sac file is (roughly) the beginning time of the seismogram, then use the "*extract time from filenames*" button else use the "*extract times from SAC headers*". This second way is slower since it has to physically open each file to read the header in order to find the begin time that will be used to connect to a given seismic event.
- vi. In the best case, the event-to-seismogram link will be created automatically by pushing the "*Automatically associate SAC files*" button. Otherwise, you can do this association manually via the "*Manually associate SAC file*" button. Anyway, at the end of the automatic association, the system may provide a list of orphan

events and of seismic files that it did not succeed to link together. This will happen when a wide event selection has been done and will be associated to a rather short existing seismic database. In that case, numerous events will not be associated to seismic files, but that is normal. Orphans may also happen when two or more events occur in a short time window, smaller than the "*tolerance window*". In that case the user may terminate manually the association. At the end of this linking process, the seismic "*Database*" is ready for use. Do not forget to save it ("*Save Project*" button). This database can then be viewed by using the "*View Database*" button that provides the list of the events together with the global map. This database will be the starting point of the following processes such as the shear wave splitting measurements.

- vii. The "*Cut and save as SAC*" can be used when the e, n and z components start and end at different times and therefore have different names. This button will cut the beginning of the triplet at the latest start time and the ending time at the earliest ending time of the triplet. The triplets are then saved under new names. This provides a way to export data with coherent lengths and names for other purposes than splitting measurements ([Figure 2](#)).

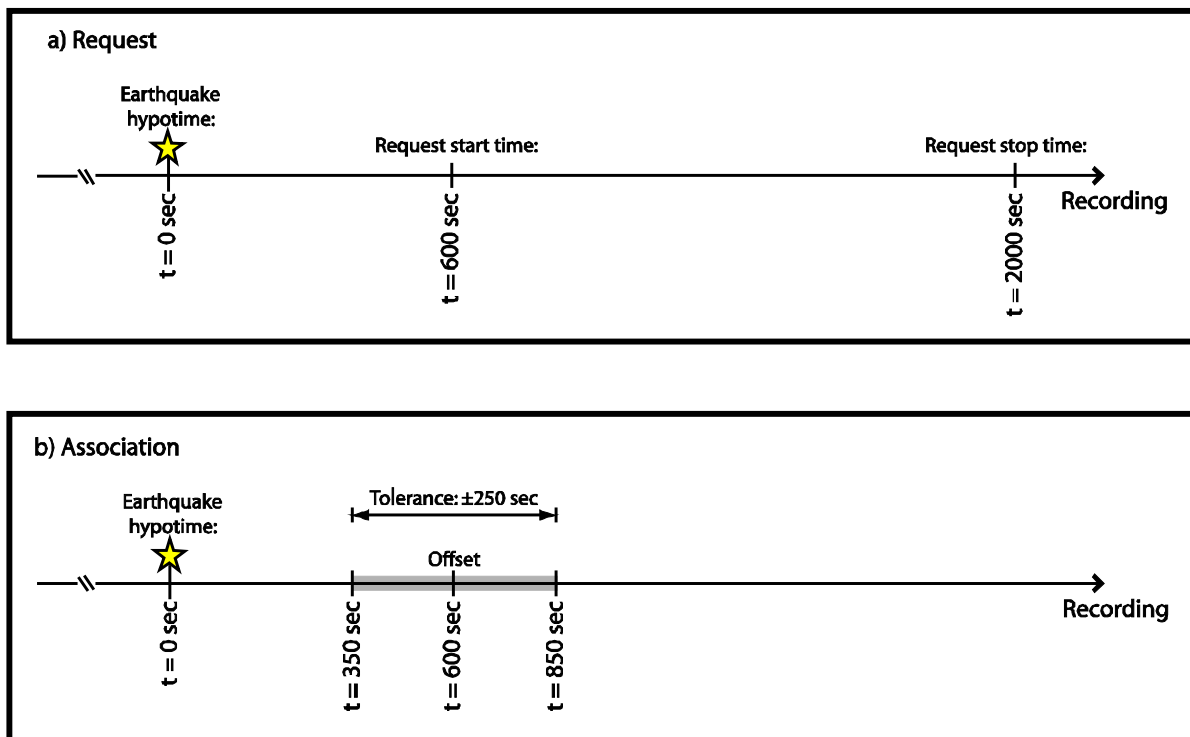


Figure 1 : (a) Definition of request start and stop time and (b) their correspondence to the file-search offset and tolerance

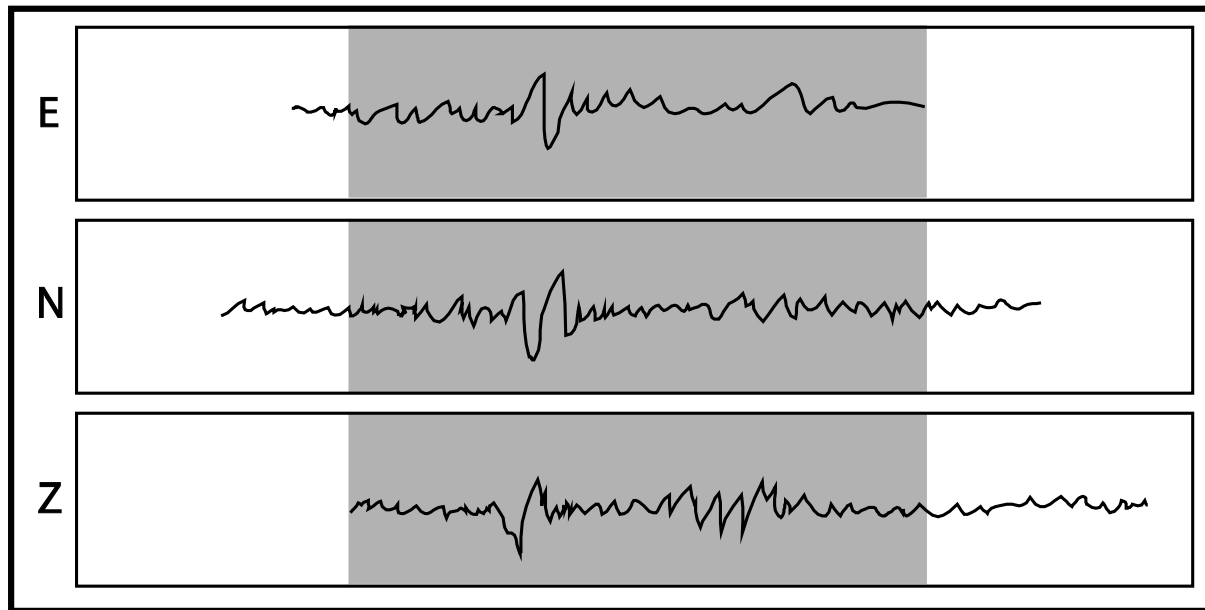


Figure 2 : The “Cut and save” button searches for the three SAC file components (East, North, Z) for their maximum common time window (here marked as gray area). Each seismogram is then cut to this time window and written to new SAC files.

#### 4.7 The “Save Preferences” button

- the current configuration is saved as default Project entries for future sessions of SplitLab

#### 4.8 The “?” button

- It provides some help and information that may be useful for the user

#### 4.9 The "Load Project" button

- Allows to load a project that has been already saved.

#### 4.10 The "Save Project As" button

- Allows to save a project. It is important to save a project after having successfully finished the association between the seismograms and the events ("*Find Files*" operation).

#### 4.11 The "View Seismograms" button

- Starts the Seismogram Viewer at the beginning of the database for a newly created database. If you loaded the project, the last used database entry will be displayed.

#### 4.12 The "View Database" button

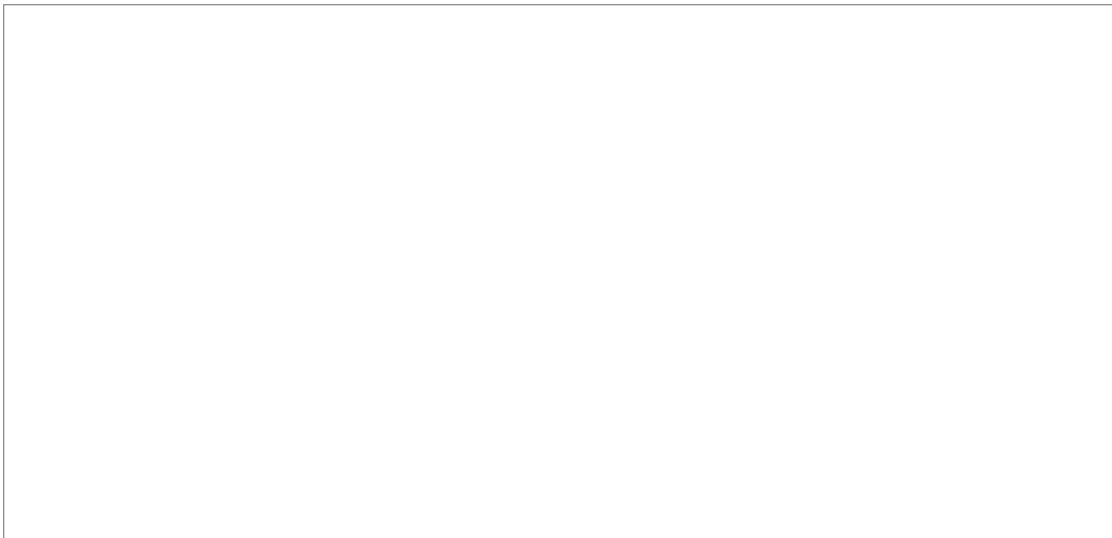
- It provides a way to select and visualize each of the seismogram from the database. The

*Database* is defined as the set of seismograms that have been successfully linked to the selected events. In other words, the database is closely related to a project and a given data selection and might not contain all the SAC files the data directory.

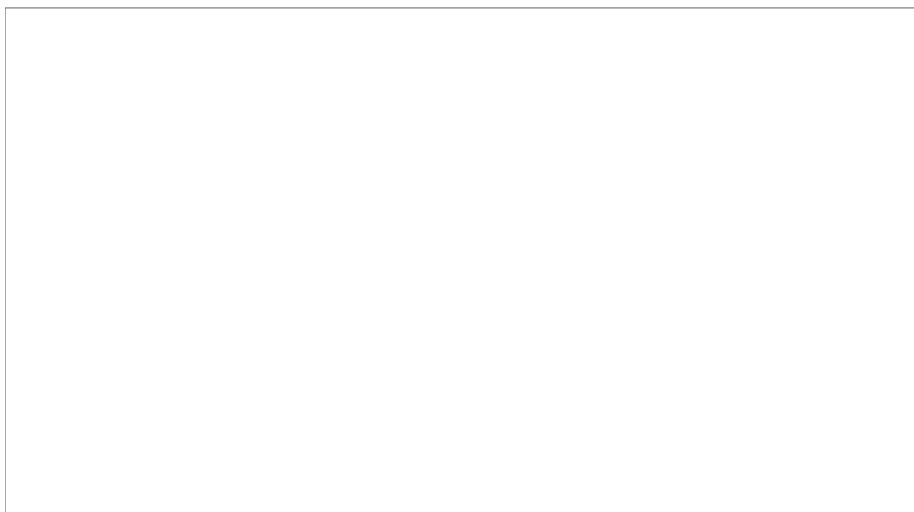
- Clicking the "*View Database*" button opens the "*Database Viewer window*".

## 5 The "Database Viewer" window

- This window lists the events present in the database and the "*World viewer*" geographically presents the events from the database.



- By clicking on one or several events from the list, you can visualize them as stars on the map. The user can zoom in and out on the map.



- The events are sorted by date as default but you can choose your sorting criteria by clicking at the top of the column, the event distance, depth or magnitude may be useful in the process of shear wave splitting measurements.

- The lower part of the window displays the shear wave splitting result(s) that have been saved for a given event. It also present some button:
  - i. The button "*view*" allows opening the "*preview*" window to see the 3 components of the selected seismogram.
  - ii. The "*Cleanup*" button allows removing from the database the events on which no splitting measurements are made. After such an operation, it may be a good idea to save the project under a new name (button "*Save Project As*"), in order to keep the possibility to come back on data that did not provide splitting measurements.
  - iii. The "*Export*" button allows to save the table as an Excel file.
  - iv. The "*statistics*" button displays:
    - the event location on a map preserving the true backazimuths,
    - the histogram of the backazimuthal distribution,
    - a rose diagram presenting the same backazimuthal distribution.
  - v. The "*Presentation*" button allows to visualize the graphical results of a splitting measurement. Indeed, when the user saves a result, a copy of the graph is also saved in the output directory.
  - vi. The "*Remove*" button allows the user to remove the result of a splitting measurement from the list.
  - vii. The "*Edit*" button allows visualizing the numerical values associated to the splitting measurements obtained on a seismic event.

## 6 The "**SeismoViewer**" window

- By clicking on the "*Preview*" button in the "*Database Viewer*", one accesses to the "*Preview*" window, which displays the 3 components of the selected event, together with the predicted arrival times (calculated at the "*Find Files*" stage). The data can be easily filtered through a set of prepared filters accessible through the keyboard. The list of the available filters are summarized together with their shortcuts appear by clicking on the "?" button at the top of the window.
- The basic operations and setups are accessible by a set of buttons aligned at the top of the window:



Figure 3 : the SeismoViewer button bar offers manifold options...

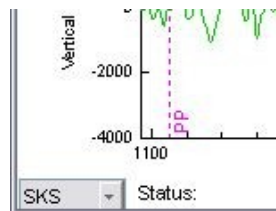
- i. The "*SAC*" button save the seismograms visible at the screen as SAC files ("SAC screenshot"). Note that only the length of the window is exported.
- ii. The "*Database*" button allows to select a seismic event through the database
- iii. The "*Print*" button allows to print the window
- iv. The "*Toggle*" button puts and removes grids on the seismogram. By default, each seismogram is vertically scaled to the maximum value of the component.
- v. The "*Lock*" button allows to present the 3 component at the same vertical scale
- vi. The "*System*" button allows to switch between the E-N-Z reference frame to the L-T-Q reference frame.
- vii. The "*Time table*" button allows to plot the arrival times and the travel paths of one of several seismic phases selected by the user for event present on the screen.
- viii. The "*Zoom In*" button allows to zoom into a time window defined by the user by dragging the mouse along the seismogram.
- ix. The "*Zoom Out*" button remove the zoom.
- x. The "*Home*" button allows to zoom directly onto a selected seismic phase, that is selected on the rolling menu at the bottom left of the window. It can be accessed also by typing on the "*home*" key (for the PC) or on the "*esc*" key for the Macintosh.
- xi. The "*Left Green Arrow*" allows to visualize the previous seismic event of the database.
- xii. The "*Particle Motion*" button presents the particle motion diagram of the 2 horizontal component (EN or QT) for the selected time window.
- xiii. The "*Options*" button allows the user to select the type of shear wave splitting measurement: either by calculating the minimum energy on the transverse component or by using one of the various methods that allows to determine the minimum eigenvalues. Furthermore, the maximum delay time for the splitting measurement can be set.
- xiv. The "*Right Green Arrow*" allows to visualize the next seismic event in the database.
- xv. The "*Trash*" button removes the current event from the database.
- xvi. The "*Speaker*" button plays the selected time window as sounds.



- xvii. The "*Camera*" button saves the actual seismogram as a graphic file.
- xviii. The "?" button provides help on shortcuts some useful things...

## 6.1 Performing shear wave splitting measurements through SplitLab

- In the "*Database Viewer*", select your seismic event and click on the "*View*" button; It is loaded in the "*preview*" window
- Visualize your event in the geographic and seismic reference frame, use different kinds of filters and zooming options to evaluate the quality of the data and to locate the core shear phase on which you wish to make your measurement.
- Select the phase-of-interest. The Phase selector can be found in the lower left corner of the SeismoViewer.



- Select the time window on which you want to make the splitting measurement. The active time window will appear in gray whereas the old selection, if any, appears in yellow.
- Press the "ENTER" key to start the measurement. When the measurement is finished, then appear the "Diagnostic Viewer" window that summarizes the results obtained by the different methods:
  - i. At the top of the window is presented the radial (in blue solid) and transverse (in red dashed) components at the same vertical scale, filtered in an extended section of the previously chosen window without any correction.
  - ii. The upper horizontal panel presents a set of diagrams obtained by using the rotation-correlation method. From left to right:
    - a) The fast (blue solid) and slow (red dashed) split components corrected from the delay time. This diagram allows checking the correlation of the waveforms.
    - b) The radial (blue) and transverse (red) components corrected from the anisotropy. This allows to see if the signal on the transverse component has been well removed after correction for the best phi and dt pair.
    - c) The particle motion diagram, before (in blue) and after (in red) the

anisotropy correction. In case of a good measurement, the elliptical particle motion is well linearized after the anisotropy ( $\phi$  and  $dt$ ) correction.

- d) The map of the correlation coefficients showing the quality of the correlation between the fast and slow split waves for  $\phi$  varying from  $-90$  to  $90^\circ$  and for  $dt$  varying from  $0$  to  $4$  s (or any other maximum delay time chosen in the SeismoViewer options Menu). Note that the program calculates the correlation for steps of  $1^\circ$  in  $\phi$  and each sample.
- ii. The lower horizontal panel presents a set of diagrams obtained by using the minimum energy (or Silver and Chan) method. From left to right:
    - a) The fast and slow split component corrected for the best delay time.
    - b) The radial and transverse component corrected from the anisotropy.
    - c) The particle motion diagram, before (in blue) and after (in red) the anisotropy correction.
    - d) The map of the Energy on Transverse components or of Eigenvalue (as chosen in the Option Menu of the SeismoViewer). Here, the grid-search parameters are  $2^\circ$  in  $\phi$  and  $2$  samples in time. For a  $20$  Hz acquisition (delta of  $0.05$  s between two samples), the time steps will be of  $2 \times 0.05 = 0.1$  s.
  - iii. The results are summarized in the upper part of the window, as numerical values and the error bars for the different methods and as a polar diagram on which the fast direction is plotted with the actual backazimuth and inclination.
- If you do not like the measurement, go in the "*Results*" menu and choose "*Discard*" to reprocess another time window, another phase or to test another filter. If you wish to keep this measurement, you have to choose a quality in the "*Quality*" menu, to indicate whether it is a null or not in the "*IsNull*" menu and to save it in the "*Save*" menu. Note that the quality and null information are just comments and have no role in the subsequent process. In that case, the figure is saved in the format selected in the "*configuration*" panel and the numerical results are also summarized in the "*Database Viewer*", linked to the right event.

## 7 The “Result Viewer” window

### 7.1 The “Options”

- The “ResultViewer Options” window allows to select which part of the result database you want to see:
  - i. In the “Phases” panel select the phases of which you want to see the results
  - ii. Select, if you want the “Manual Quality” of the “Automatic Quality”. The former uses the Quality assigned to each measurement in the “[Diagnostic plot](#)”. The latter determines the quality of each measurement based on the difference between the RC and SC results. See Wüstefeld & Bokelmann, (BSSA 2007) for details
  - iii. Select the Qualities you want to see: good, fair, poor
  - iv. Select if you want to see the Nulls or non-Nulls (or both)
  - v. Automatically determined Quality includes “Weak” splitting (both RC and SC delay times are small). Select the “Weak” option to include these events in the plots and to add the delay time thresholds to detect weak as gray area in the plot.
  - vi. Select “Show Null grid” to display grid-lines in the fast axes plots. The solid grid-lines indicate where backazimuth and fast-axes coincide. The dashed grid-lines indicate a 45° difference between backazimuth and fast axes.
- The “*Fit to Model*” panel allows to calculate the theoretical backazimuthal variation of the fast axes and delay times (Savage & Silver, 1994). Set the delay time slider of second layer to “0” to see the lines for a single layer model.

### 7.2 The “Backazimuth distribution”

- The results corresponding to the selected options are displayed for each technique (RC, SC, EV). The fast axis estimates make up the first row, the delay time estimates the second row.

### 7.3 The “Stereoplots”

- In the third row of the result plot, stereoplots of the non-Null results are displayed. The lengths of the markers scale with the delay time, the centre of the lines correspond to backazimuth and the inclination of the wave at surface.

## 8 Trouble shooting

### 8.1 Installation problems

In case of problems please check:

- The file **classpath.txt** You can view the file by typing in Matlab:  
**edit(which('classpath.txt'))**  
This file contains the path to JAVA classes in Matlab.
- At the end of the file should be the proper path to the file "**matTaup.jar**" located by default in **\$MATLABROOT/toolbox/matTaup/lib/matTaup.jar**
- After editing classpath.txt you have to restart Matlab

The Matlab search path should contain the following folders:

- SplitlabX.X.X/**
- SplitlabX.X.X/Tools**
- SplitlabX.X.X/ShearWaveSplitting**
- The path to the SacLab Utility  
**SplitlabX.X.X/SacLab**
- The path pointing to matTaup (usually at the end of the path)  
**\$MATLABROOT/toolbox/mattaup**
- For editing the path use the command: **pathtool** or edit/create your local **startup.m** file. See the [Matlab documentation for startup options](#)

### 8.2 Preferences problems

- 1) During installation, SplitLab preferences are added to the Matlab environment (See the **prefdir** documentation for further details on preferences). The SplitLab Preferences contain the fields CONFIGURATION (default SplitLab project configuration), ASSOCIATIONS (figure export file types and, on non-PCs, the system command line to open the file type) and HISTORY (recently used SplitLab Projects). These preferences are only valid for the user, who installed SplitLab. However, if a new user runs SplitLab, new default preferences are automatically created for that user. In multi-user case be sure that all users have permission to the SplitLab, SacLab and matTaup path and the paths are set correctly for each user.

### 8.3 Create your own filename format

The association of a SAC seismogram to an event in the Database is done in two steps:

- 1) The finding of appropriate file start times corresponding (within a tolerance and eventually an offset) to the hypocentral time ([Figure 1](#)). This is done in the Matlab function `/Tools/getFileAndEQseconds.m`
- 2) The ordering of three matching files by component: East, North, Vertical. This ensures that in the database variable `eq.seisfile` of your project the first entry corresponds always to the East component, the second entry to the North component and the third to the Vertical. This is done in the Matlab function `/Tools/sort_components.m`

Two variables of your project configuration determine your choices:

**config.FileNameConvention** is a string corresponding to your selection in the File-Format Menu (eg 'RDSEED')

**config.UseHeaderTimes** is a logical value: 1 means you wish to use SAC header times, and 0 means you would like to use the filename to determine the start time of the file.

Knowing all this, adding a new Filename format should now be straightforward:

- 1) edit `/Tools/getFileAndEQseconds.m`
- 2) go to the line which states  

```
switch config.FileNameConvention
```
- 3) after this line add a new *case* statement:  

```
case 'MyFormat'
```
- 4) state the position of year, julian\_day, hour, minute and second in the filename. If not all these informations are given, make sure you set the search-tolerance and search offset appropriately! Please use the existing formats as templates to your format. If your format uses day and month instead of julian\_day, you have to use the «dayofyear» function, as in the 'YYYY.MM.DD-hh.mm.ss.stn.sac.e' format.
- 5) The given values have to be transformed to seconds after Jan, 1<sup>st</sup> of the corresponding year. Add something like the following:

```
FIsec = FISS + FIMM*60 + FIHH*3600 + (FIddd)*86400;
```

Note, that this approach omits any event close to «midnight, new year».

6) Save `/Tools/getFileAndEQseconds.m`

7) edit `/Tools/sort_components.m`

8) go to the line which states

```
switch config.FileNameConvention
```

9) after this line add a new *case* statement:

```
case 'MyFormat'
```

10) Define then a variable **pos** whose value corresponds to the position of the Letter in the filename which determine the Component name. For example, if the Component corresponds to the 18<sup>th</sup> letter, use:

```
pos = 18;
```

Please use the existing formats as templates.

11) Save `/Tools/sort_components.m`

Finally add your format to the file format menu

12) edit `/private/configpanelFINDFILE.m`

13) find the line where the menu entries of the uicontrol are defined:

```
str = {'RDSEED' 'SEISAN', 'YYYY.JJJ.hh.mm.ss.stn.sac.e'  
      'YYYY.MM.DD-hh.mm.ss.stn.sac.e'};
```

14) add your format to this cell array:

```
str = {'RDSEED' 'SEISAN', 'YYYY.JJJ.hh.mm.ss.stn.sac.e'  
      'YYYY.MM.DD-hh.mm.ss.stn.sac.e' 'MyFormat'};
```

All entries should be in a single line! Furthermore, this entry name should be exactly the same as used before since it determines the value of the variable

```
config.FileNameConvention
```

15) save `/private/configpanelFINDFILE.m`

16) restart SplitLab