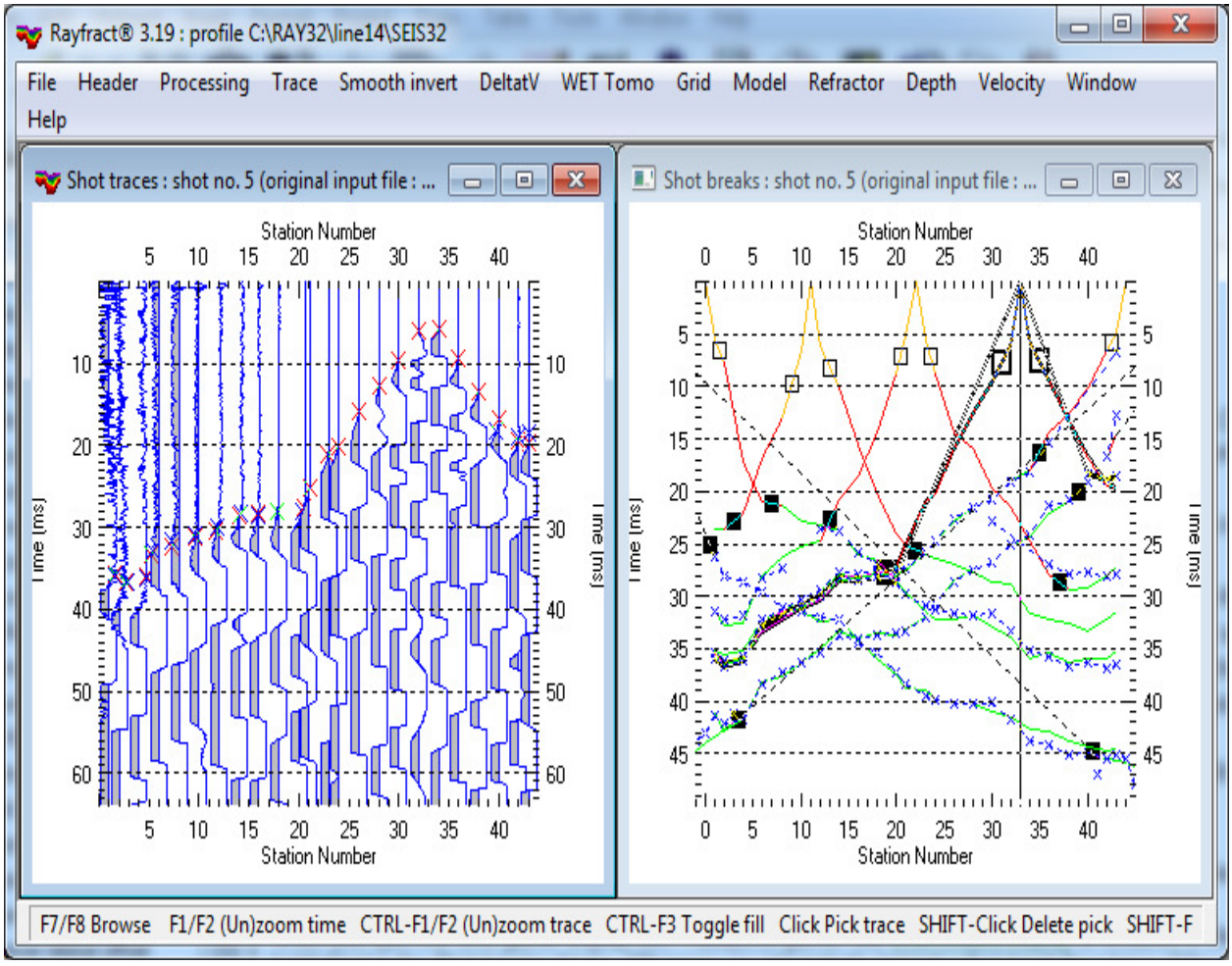
Picking first breaks

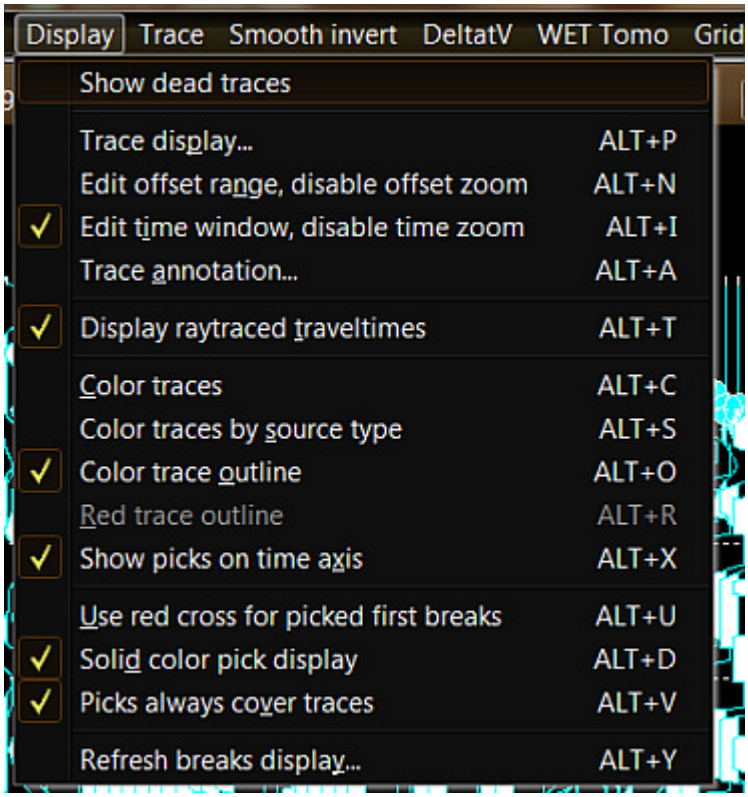
Next select ***Trace*/*Shot gather*** :



- browse shot records with function keys F8 (forward) and F7 (reverse)
- zoom/unzoom traces in the amplitude coordinate with function keys CTRL+F1/CTRL+F2
- toggle trace display modes with CTRL+F3
- zoom/unzoom the vertical time scale with F1/F2
- page down the zoomed time axis by one section with PgDn
- page up the zoomed time axis by one section with PgUp
- zoom/unzoom the horizontal station number axis with SHIFT+F1 and SHIFT+F2
- page left one zoomed gather section with SHIFT+PgUp
- page right one zoomed gather section with SHIFT+PgDn

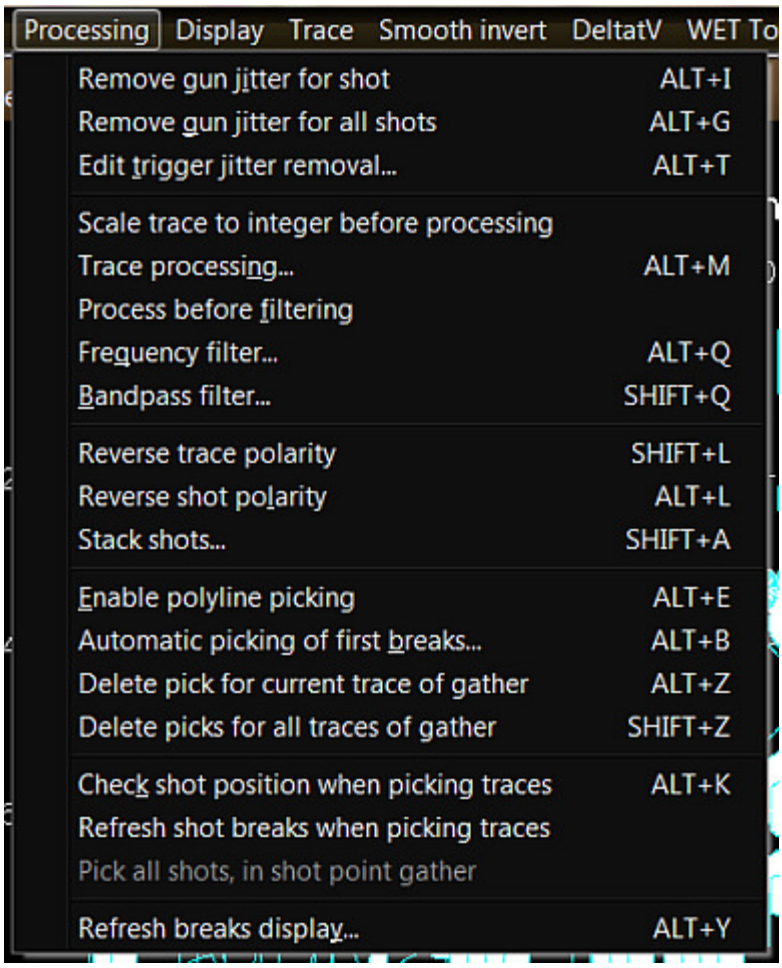
See Dialog box control and function keys, for a complete listing of function keys and their functionality.

Color traces in *Trace menu gather displays*, with options in menu *Display* :



- Color the variable trace area filling with *Display|Color traces*
- Color the trace outline with *Display|Color trace outline*.
- *Display|Color traces by source type* colors shot traces by *source type*, as selected in *Header|Shot*.

Edit trace processing options and select processing commands in menu *Processing* :



Since version 3.20, above *trace display* settings and following *trace filtering* and *trace processing* settings are stored separately in your profile database, for each gather type (shot-sorted, midpoint-sorted, offset-sorted, shotpoint-sorted, receiver-sorted). Also, these settings are restored whenever you reopen this profile database via *File menu*, and when you reopen these gather type displays with *Trace menu*.

Pick and delete first breaks & navigate traces and samples with keyboard or mouse

- move the *picking cursor* ("plus" symbol) along the currently selected trace outline with up-arrow and down-arrow keys. Move the cursor to next left/right trace with left-arrow and right-arrow keys.
- hit the *space bar key* to pick the first break for the current trace, at the current sample (as indicated at bottom of display)
- pick with the *left mouse key* to first select current trace and sample and then pick the first break at that position, in one operation
- delete the first break pick for the current trace, with ALT+DEL or ALT+Z. Use *SHIFT+left mouse key* to first select the trace and then delete the pick for that trace, in one operation
- use SHIFT+Z keyboard shortcut, to delete first break picks for all traces of the current shot

Trace cursor attributes are shown at bottom of trace gather display, when moving the pick cursor with left/right/up/down arrow keys. We show station number, gather specific trace number, shot number,

channel number, sample number, time and amplitude attributes .

SHIFT+L keyboard shortcut lets you *reverse polarity of current trace* in *Trace menu gather displays*. Select the current trace with arrow-left and arrow-right keys.

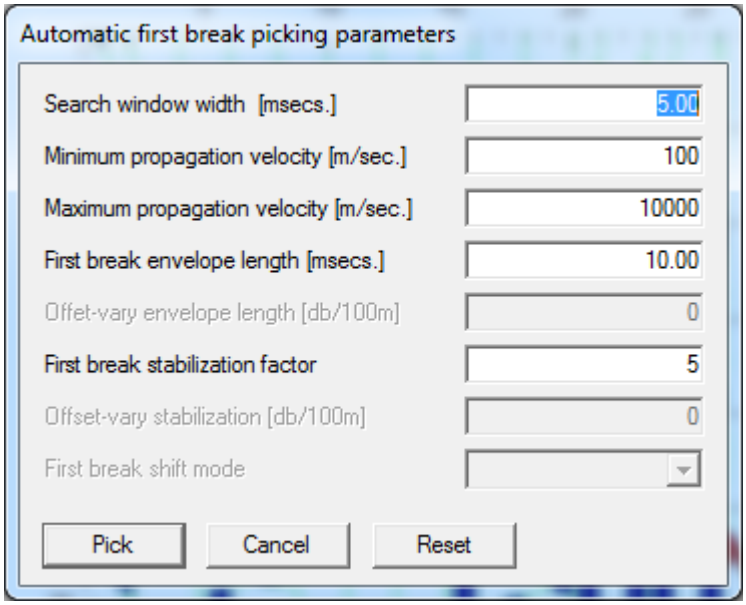
When you open the *Shot gather display* with *Trace|Shot gather*, the *Shot breaks display* is rendered in the lower half of your display. Select *Window|Tile* for above side-by-side window display. The traveltime curve corresponding to the currently selected shot gather is highlighted in the *Shot breaks display*. Whenever you interactively (re)pick a first break for a trace of the current shot gather, that traveltime curve is redisplayed automatically. If you selected branch points for that traveltime curve before repicking first breaks, automatic branch point validation is carried out while redisplaying the traveltime curve. To redisplay the whole *Shot breaks display*, press keys ALT+Y (*Processing|Refresh breaks display*). You may zoom up the *Shot gather display* to fill the whole screen by double-clicking on its title bar with your left mouse key. Double-click on the main Rayfract® title bar as well to maximize its size.

Make sure that **picked traveltime curves for adjacent shots are at least somewhat similar to each other**, when reviewing them in our *Refractor|Shot breaks display*. See our tutorials at https://rayfract.com/tutorials/TUTORIAL.ZIP and https://rayfract.com/SAGEEP10.pdf for typical traveltime curve sections. Refraction tomography is based on the assumption that subsurface physical properties (related to propagation speed of seismic waves) have a quasi-continuous nature and do not vary randomly on a small scale. Since first break energy incited at adjacent shot points propagates through the subsurface along similar wave paths and rays, the measured and picked traveltime curves for these shots should be similar.

Traces in *Trace menu displays* are shifted by *delay time* and *trigger delay*, as specified in *Header|Shot* . This lets you interactively correct shots for reciprocal errors caused by trigger delays, visible in our *Trace|Offset gather display*. For tutorials showing how to identify reciprocal picking errors see https://rayfract.com/tutorials/riveral8.pdf and https://rayfract.com/samples/GEOXMERC.pdf. **Use Trace menu item Export reciprocal errors...** to compute and export reciprocal traveltime picking errors to ASCII .ERR file. Import the .ERR file into Microsoft Excel and sort by any column. Use our Trigger jitter removal dialog to automatically update the *trigger delay* assuming a constant-velocity overburden.

Automatic picking

Do semi-automatic first break picking with *Processing|Automatic picking* (ALT+B) :



Edit these parameters :

- *Search window width* This parameter is used for Semi-automatic first break picking. Decrease this parameter in situations of a high degree of pre-first break noise, or with weak first break signals. The smaller the parameter value, the closer the automatic pick will be to the linearized time defined by your picked polyline.
- *Minimum propagation velocity* Minimum velocity (in meters per second) regarded when carrying out automatic first break picking. Trace signal peaks/troughs detected later than the time window resulting from mapping this minimum velocity gradient to the current shot gather are excluded from the picking process.
- *Maximum propagation velocity* Maximum velocity (in meters per second) regarded when carrying out automatic first break picking. Trace signal peaks/troughs detected earlier than the time window resulting from mapping this velocity gradient to the current shot gather are not regarded during the picking process.
- *First break envelope length* Determine the trace signal time window regarded when automatically picking the first break. Increase this parameter in case of weak first break amplitudes and if the automatically picked first breaks are too late. Once all first breaks are picked about correctly or too early, increase parameter *First break stabilization factor* to prevent too early picks due to pre-first break noise.
- *First break stabilization factor* Helps in situations of strong pre-first break noise, caused by surface sources, such as circulation / trees moved by wind / footsteps. Increase parameter value to filter out increasingly larger amplitude noise / if first breaks picked automatically are too early.

For context-sensitive help on these parameters, tab to the dialog control of interest and then press F1.

Once you have specified appropriate parameter values, hit enter key to carry out the semi-automatic picking. In situations of strong pre-first break noise or weak first break signals, adjust parameters *First break envelope length* and *First break stabilization factor*.

Polyline-guided picking

With noisy traces you can force first breaks picked automatically to be located in the vicinity of a polyline consisting of multiple straight line segments connected to each other, picked interactively with the right mouse button. Move the mouse cursor to the trace located closest to the shot point position, positioning it at a vertical time offset approximating the visually estimated first break time. Then click the right mouse button once. Now move the mouse away from the shot point, i.e. to the left for reverse shots and to the right for normal (forward) shots. Try to follow the visually estimated positions of first breaks, for the traces being crossed with the mouse. Once you detect a systematic change of slope of that direction, click the right mouse button a second time, to define the first line segment of the polyline. Once you have done so, automatic picking will be carried out for all traces located in the offset range covered by that line segment. For each such trace, the pick search window will be centered at the linearized time just picked. The window's width will be limited to parameter *Search window width*, as specified above.

Once these traces have been picked for the first line segment, you may define further line segments of the same polyline by moving the mouse still further away from the shot position, and clicking the right mouse button at appropriate offsets. Whenever a new line segment has been picked by you in such a way, the traces recorded at offsets covered by that segment will be picked automatically, as just described for the first segment. Terminate the polyline picking process by clicking the left mouse button. Please note that parameters *First break envelope length* and *First break stabilization factor* are regarded during this picking process, while parameters *Minimum propagation velocity* and *Maximum propagation velocity* have a meaning if no linearized time has been defined for a trace by picking such a polyline only. In case of low signal to noise ratio or bad traces, we advise to set parameter *Search window width* to its minimum value of 0.1 msec.

Recompute depth and velocity sections after repicking traces or remapping refractors

Whenever you repick a first break or remap traces to refractors, all depth and velocity sections computed previously are invalidated. If such sections are currently displayed, these windows are shut down automatically. To recompute and redisplay these depth and velocity sections, remap all traces to refractors by selecting Mapping|Remap all traces in your Shot breaks display or Midpoint breaks display. Then optionally update the weathering velocity specification in Header|Station. Now reselect the appropriate items in the Depth menu and Velocity menu.

Select Mapping|Undo trace mapping and corrections in your *Shot breaks display* or *Midpoint breaks display* to internally reset the trace to refractor mapping for all traces and to reset first break corrections for shot position offsets and shot hole depths as computed and applied previously. This gives you the option to restart the weathering velocity estimation and subsequent correction of traveltimes for shot position offsets and hole depths from a clean slate.

Select Mapping|Display regressed traveltimes in your *Shot breaks display* to show synthetic traveltimes for the basement (deepest refractor) as computed from the traveltime field characteristic functions resulting from the traveltime field regression (as described by Brueckl, E. 1987). This regression is carried out automatically whenever you redo the Wavefront or Plus-Minus time-to-depth conversion after selecting Mapping|Remap all traces as described above.

Instead of picking first breaks in the *Trace|Shot gather display*, you may pick in *Trace|Offset gather display*. Use arrow keys as described above, for trace and sample navigation. Color traces with menu items in *Processing menu*. Do frequency filtering, bandpass filtering and trace processing as in *Trace|Shot gather display*. For identification and correction of reciprocal traveltime errors, see https://rayfract.com/tutorials/riveral8.pdf and https://rayfract.com/samples/GEOXMERC.pdf . You may repick individual traces, or correct the *trigger delay* for whole shots, in ***Header|Shot*** . **Use Trace menu item Export reciprocal errors...** to compute and export reciprocal traveltime picking errors to ASCII

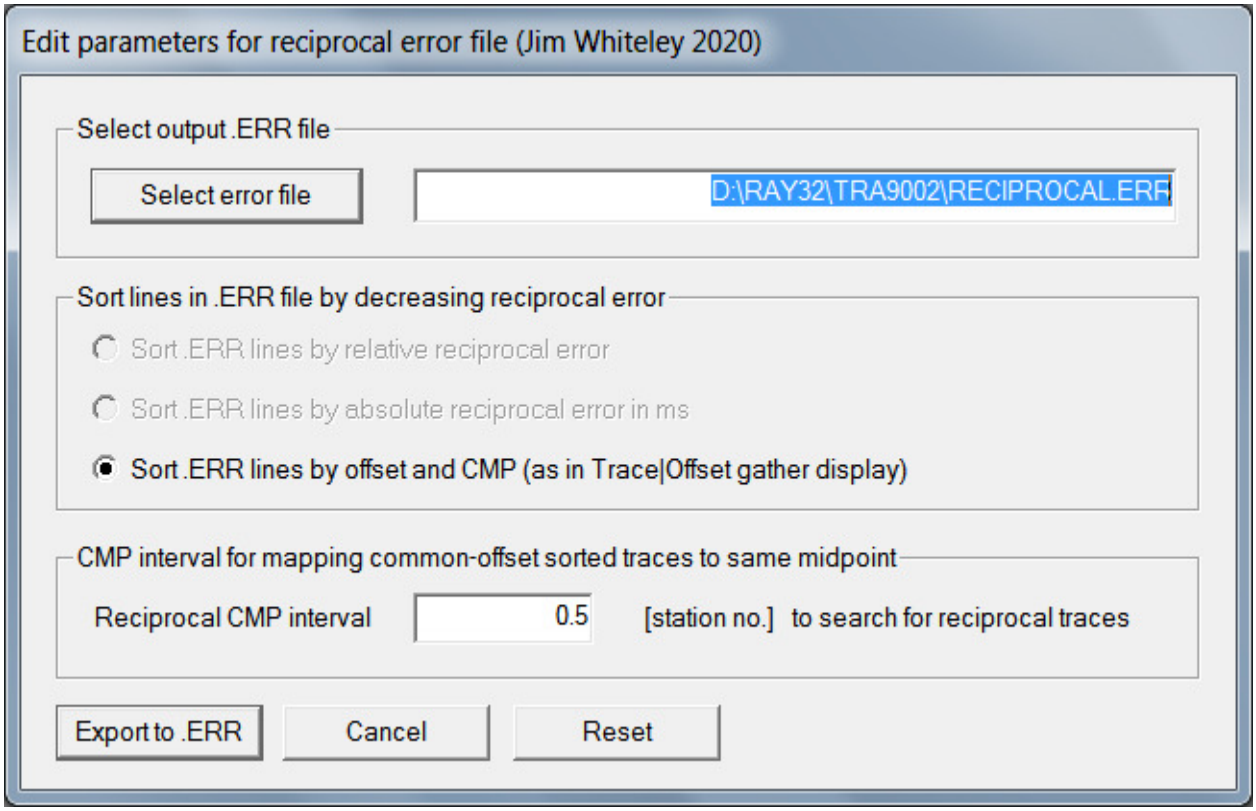
.ERR file. Import the .ERR file into Microsoft Excel and sort by any column.

Picking of shear-wave records, with sign-inverted traces recorded for the same shot point, is easy with our *Trace|Shot point gather display* and appropriate trace coloring with our *Processing menu*.

Use SHIFT+S keyboard shortcut to export first breaks to .LST, in *Trace menu* and *Refractor menu displays*. The current trace gather display or refractor display will stay open. This allows you to quickly save different picking versions to .LST .

Reciprocal traveltime picking error export

Since version 4.01 released in May 2021 we support export of reciprocal traveltime picking errors to ASCII .ERR file with space character separated columns listing absolute reciprocal error in ms and relative reciprocal error in percent. See **Whiteley J. et al. 2020**. Landslide monitoring using seismic refraction tomography - The importance of incorporating topographic variations. Engineering Geology 2020. https://www.researchgate.net/publication/339280163



Edit these parameters in Trace|Export reciprocal errors dialog :

- *Error file name* Specify the filename of the ASCII formatted .ERR file written to
- *Select error file* Click to select folder and to specify filename for .ERR file written to
- *Sort .ERR lines by offset and CMP* Sort ASCII text lines in the .ERR file by offset in meters (first column) and CMP station (second column).

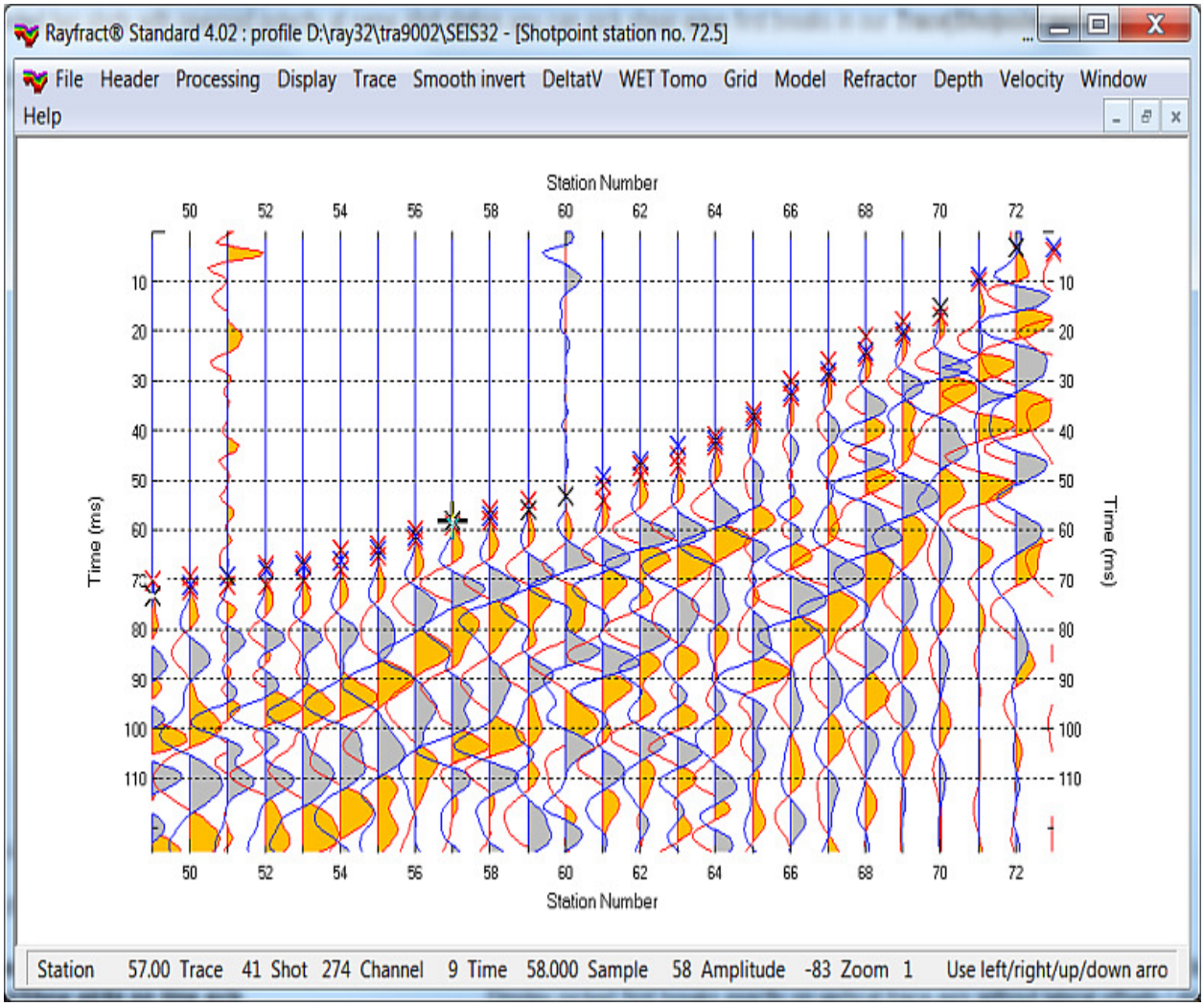
- *Reciprocal CMP interval* Specify the CMP interval [in station numbers] to search for pairs of reciprocal traces mapping to the same CMP

We also list forward shot&channel and reverse shot&channel plus shot station and receiver station of trace pairs used to computer these reciprocal errors. Sort this .ERR file in Microsoft Excel by any column to identify bad shots or receivers.

.ERR lines are sorted by offset (m) and CMP station as in our Trace|Offset gather display. Any trace pair with relative reciprocal picking error above 5 percent or absolute error exceeding 5ms or 10ms needs to be repicked.

Shear wave picking

If you recorded two shots with reversed polarity at same shot station you can pick shear-wave first breaks in our ***Trace|Shotpoint gather*** display :



Optionally check these options :

- ***Processing*|*Pick all shots, in shotpoint gather*** Pick traces from all shots at same station number and in same shotpoint gather display with one mouse click
- ***Display*|*Show picks on time axis*** Display picked first breaks exactly on vertical trace axis without lateral offsets / disregarding the trace signal amplitude at the picked sample

Browse between shotpoint gathers with F7/8 function keys as described for ***Trace*|*Shot gather*** display; see top of this chapter.

Doug Crice describes cross-hole and down-hole shear wave recording geometry in his paper http://geostuff.com/Downhole_Shearwaves.pdf .

For Smooth inversion and WET inversion we assume that you record shots with a hydrophone streamer in one borehole as shown at https://geotomographie.de/equipment/borehole-receivers/

e.g. hydrophone string BHC5 with e.g. 24 channels.

Next import the SEG-2 shots, pick first breaks and run our Smooth inversion and WET inversion with constant-velocity CONSTVEL.GRD starting model as in chapter Crosshole survey interpretation and as in our tutorial https://rayfract.com/tutorials/mdw2011.pdf .