Reflection Seismic Method

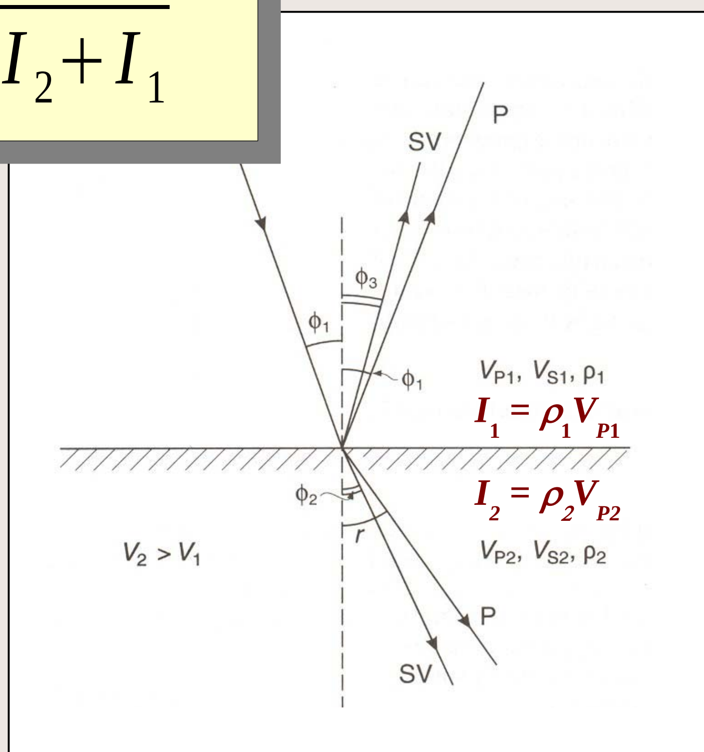
- Imaged property - Seismic Impedance;
- Acquisition and Imaging geometries;
- Refraction processing
- Reflection processing
- Interpretation

Acoustic Impedance

This is what we image in reflection sections

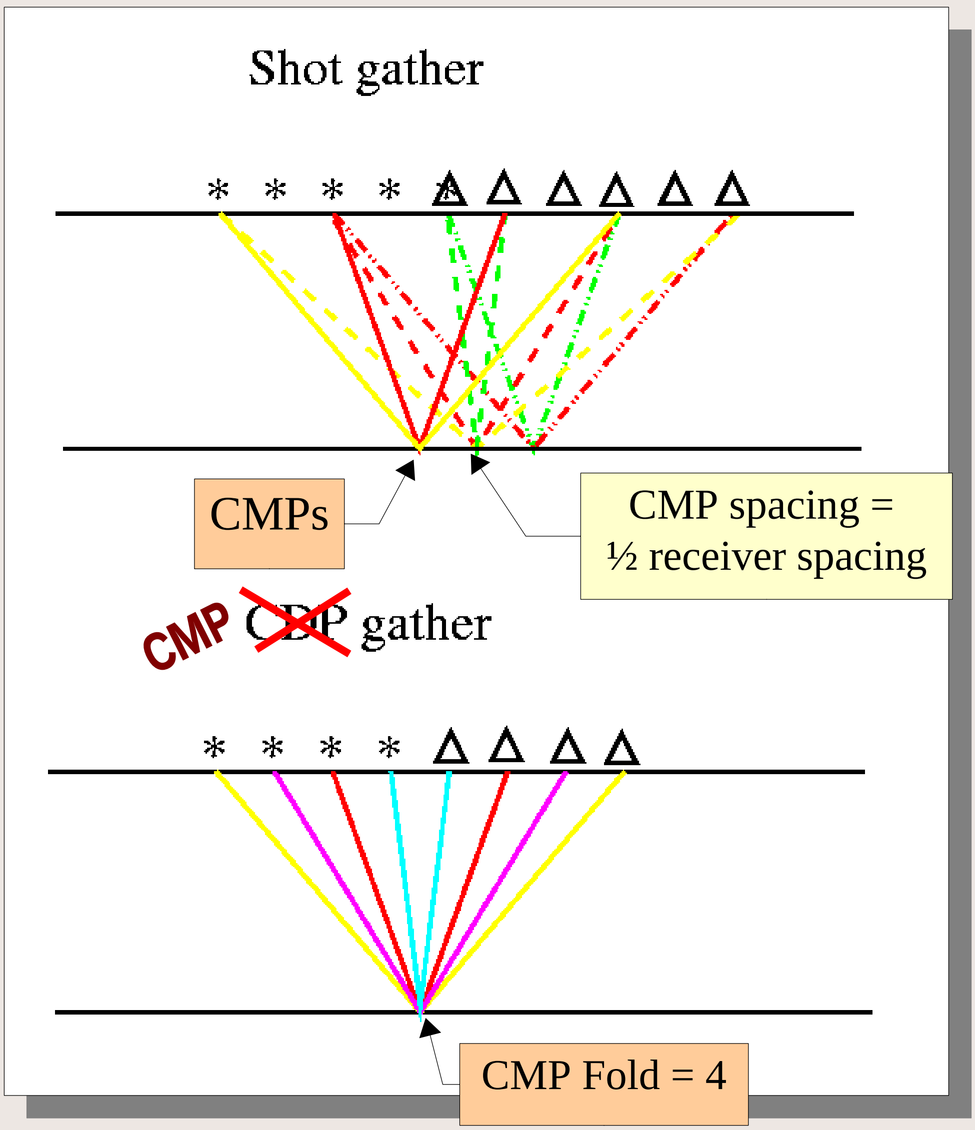
- At *near-vertical* incidence:
  - *P*-wave reflection and transmission *amplitudes* are sensitive to *acoustic impedance* ($I=\rho V$) contrasts:

$$R_{PP}=\frac{A_{P_{reflected}}}{A_{P_{incident}}}=\frac{I_2-I_1}{I_2+I_1}$$



Shot (field) and Common-Midpoint (image) sort orders

- Common-Midpoint survey:
  - Helps to reduce random noise and multiples by STACKING reflections from the same points in the subsurface;



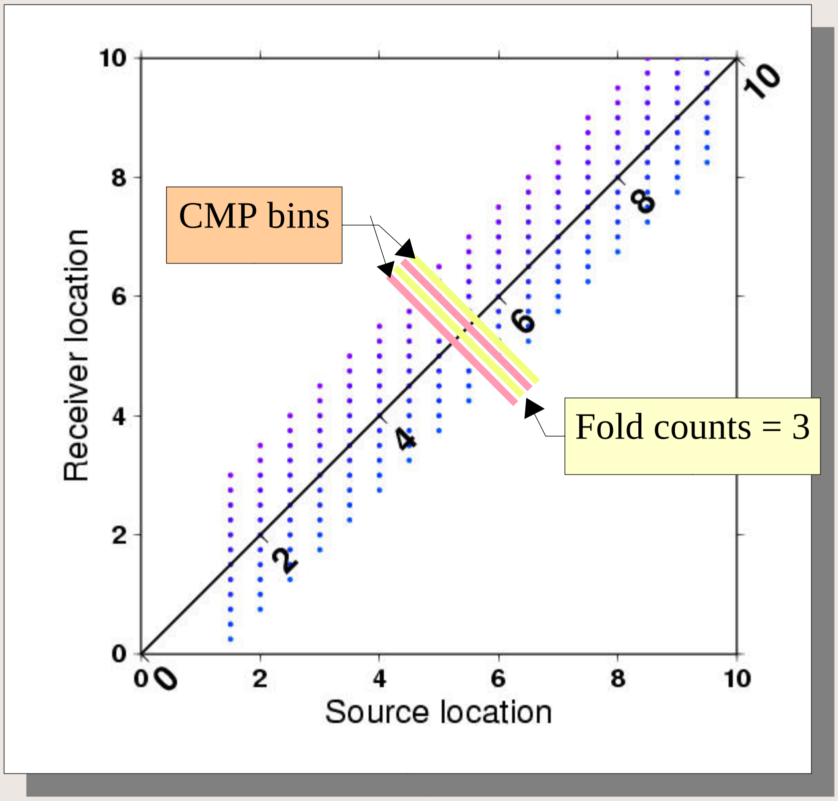
Field geometry and logs

- Survey file
  - Produced by surveyors (usually comes out of GPS unit);
- Observer's Notes
  - A record of shooting and recording sequence
    - Lists shot positions, record (“field file”) numbers (FFIDs), spread positions (“first live station”);
    - Records weather, interruptions, usual and unusual noise, state of recording system.

CMP Fold

- Fold is the Number of records per CMP
  - Should be optimal (typically, 10-40);
  - Should be uniform (this is particularly an issue with 3D).

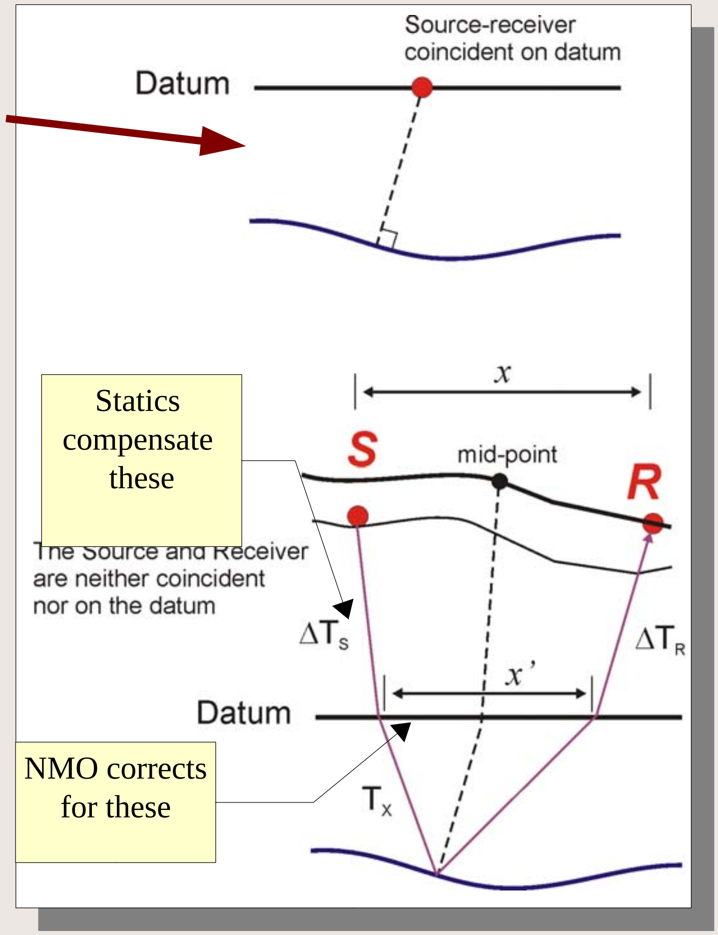
$$Fold = \frac{Number\ of\ receivers}{2\left(Num.\ of\ Shot\ point\ advances\ by\ Receiver\ spacing\right)}$$



Zero-Offset Section

(*The goal of reflection imaging*)

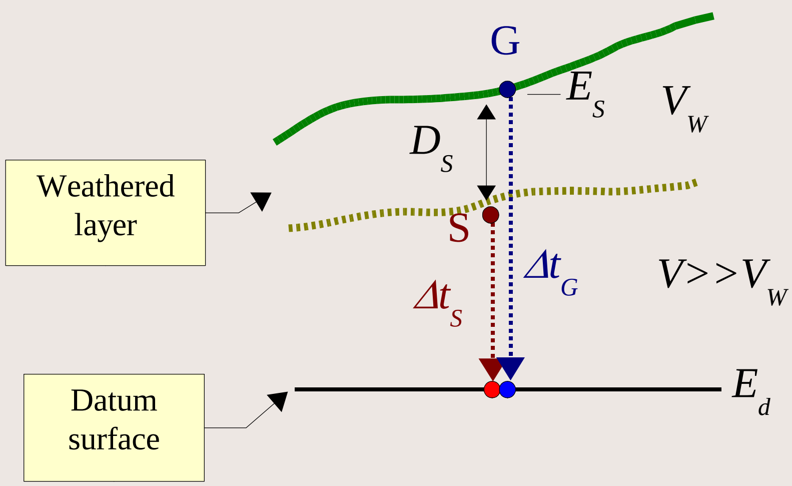
- **Ideal of reflection imaging** *is sources* and receivers *collocated* on a flat horizontal surface ("*datum*").
- In reality, however, we have to record at *source-receiver offsets*, and over complex *topography.*



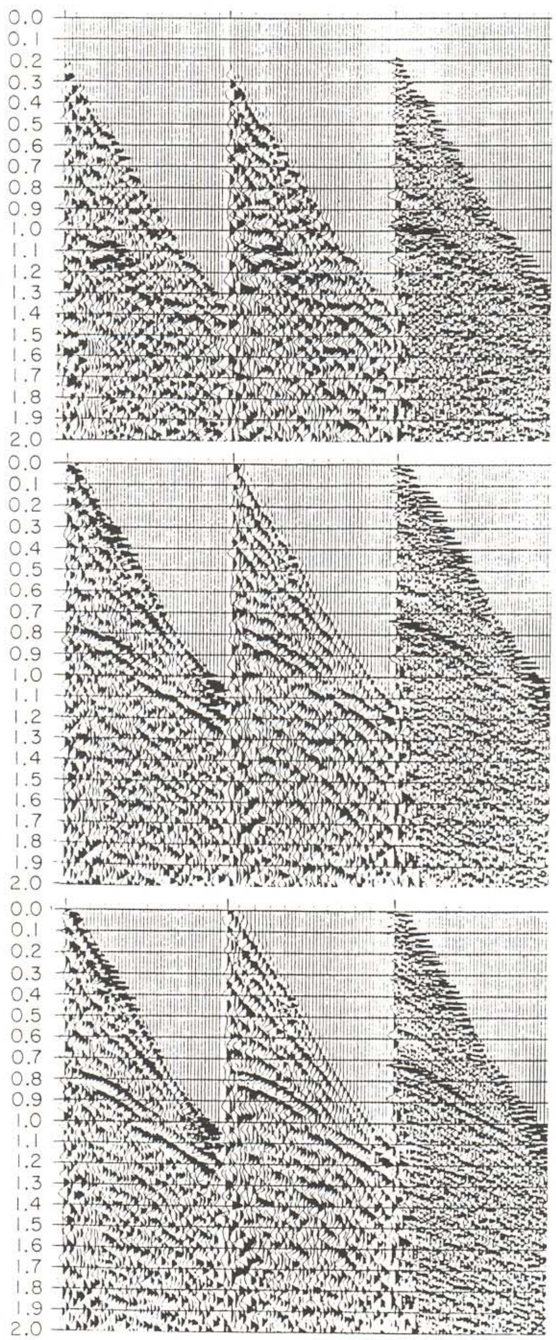
- **Two types of corrections** are applied to compensate for these factors:
  - Statics "place" sources and receivers onto the datum;
  - Normal Moveout Corrections "transforms" the records into as if they were recorded at collocated sources and receivers.
- **As a result** of these corrections (plus stacking to suppress noise), we obtain a *zero-offset section*.

Statics

- Statics are time shifts associated with source (Δt_S) and receiver (Δt_R) positions
  - When subtracted ('*applied*') from the travel-times, place the source and receiver on a common datum.
- (*Field statics*) = (*Elevation Correction*) + (*Weathering Correction*);
  - Elevation correction 'moves' the source and geophone to a common datum surface;
  - Weathering correction removes the effect of slow (~600 m/s) unconsolidated layer.
    - Obtained from *first arrivals*.



Sample shot gathers + effects of statics

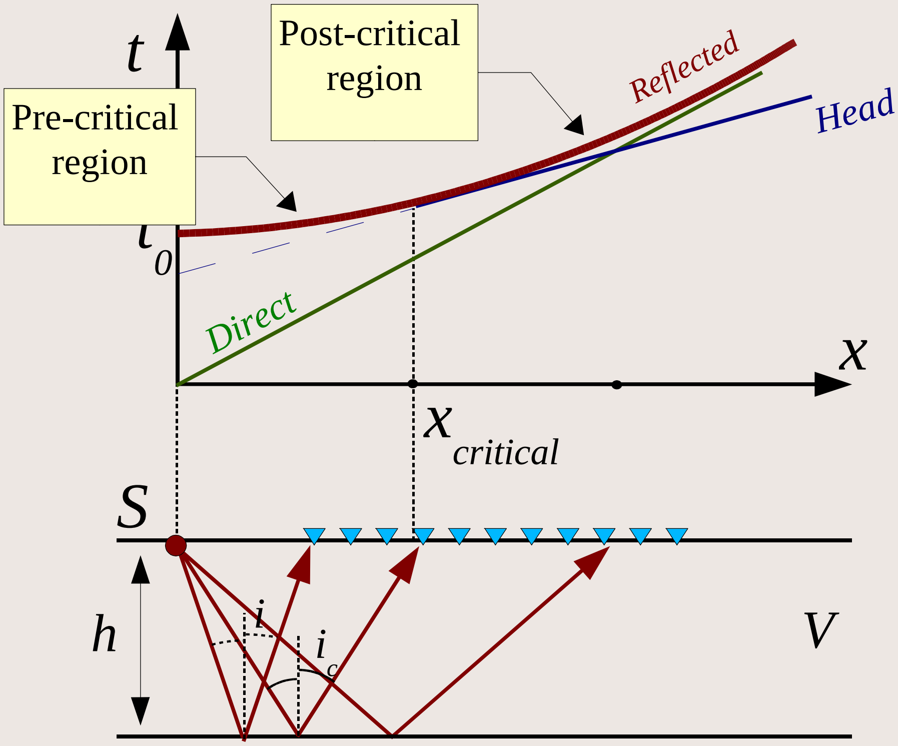


No statics

Conventional statics

GLI (tomographic) statics

Reflection travel-times
(*Single layer*)



$$t(x)=\frac{\sqrt{4h^2+x^2}}{V}=\sqrt{\left(2\frac{h}{V}\right)^2+\left(\frac{x}{V}\right)^2}=\sqrt{t_0^2+\left(\frac{x}{V}\right)^2}$$

- *t*(*x*) is called the (hyperbolic) Normal reflection Moveout (NMO)

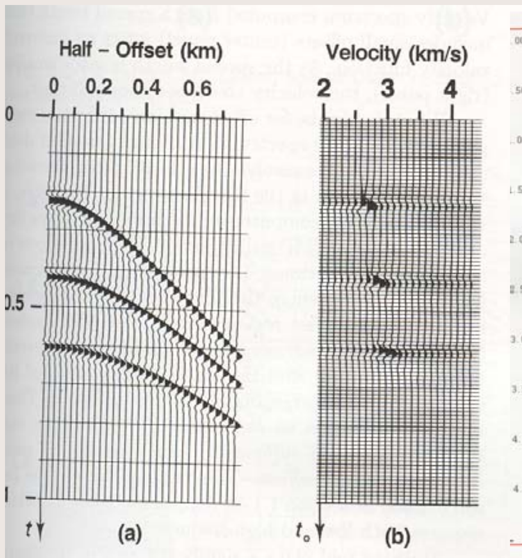
Measurement of velocities

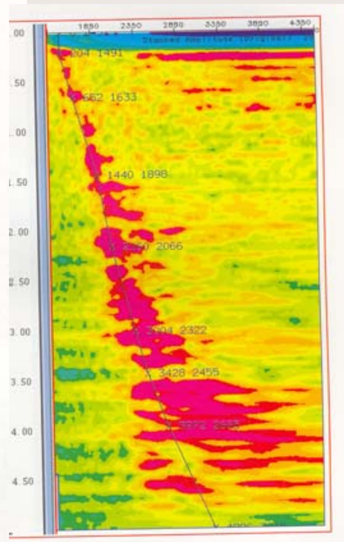
(*Velocity analysis*)

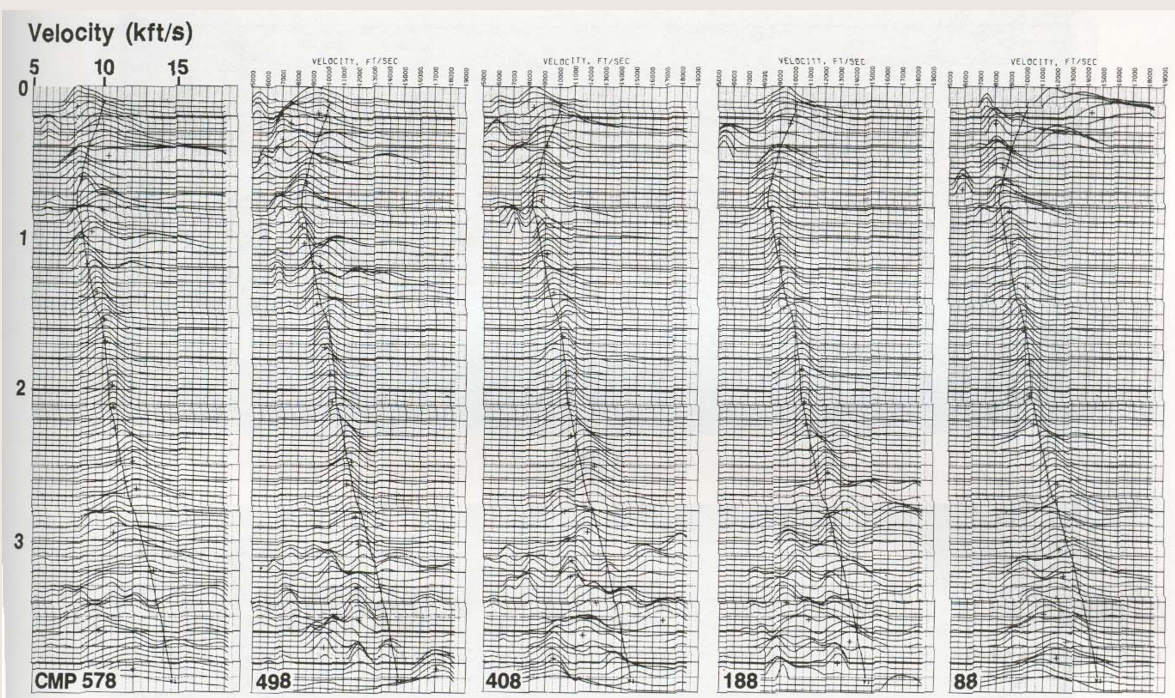
- Reflection (*stacking*) velocity analysis is usually performed in CMP gathers
  - Because they are related to specific locations within the subsurface.
- Analysis of *Velocity spectra* :
  - Stack the records along trial reflection hyperbolae;
  - Plot the resulting amplitude in a (*time*, V_{trial}) diagram;
  - Pick amplitude peaks - this results in a *V*(*time*) profile.

Velocity Spectra

CMP gathers are stacked along trial velocities and presented in time-velocity diagrams.



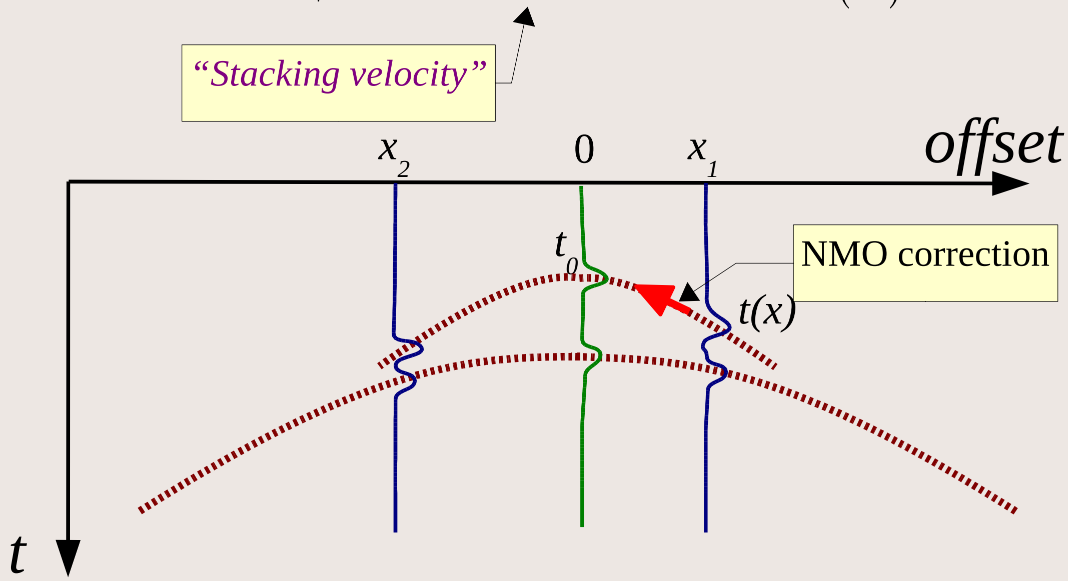




Normal Moveout (NMO) correction

- NMO correction transforms a reflection record at offset *x* into a normal-incidence (*x*=0) record:

$$t(x) \rightarrow t_0 = \sqrt{t^2(x) - \left(\frac{x}{V}\right)^2} \approx t(x) - \frac{1}{2t(x)}\left(\frac{x}{V}\right)^2$$



- *Stacking velocity* is determined from the data, as a measure of the reflection hyperbola best aligned of with the reflection.