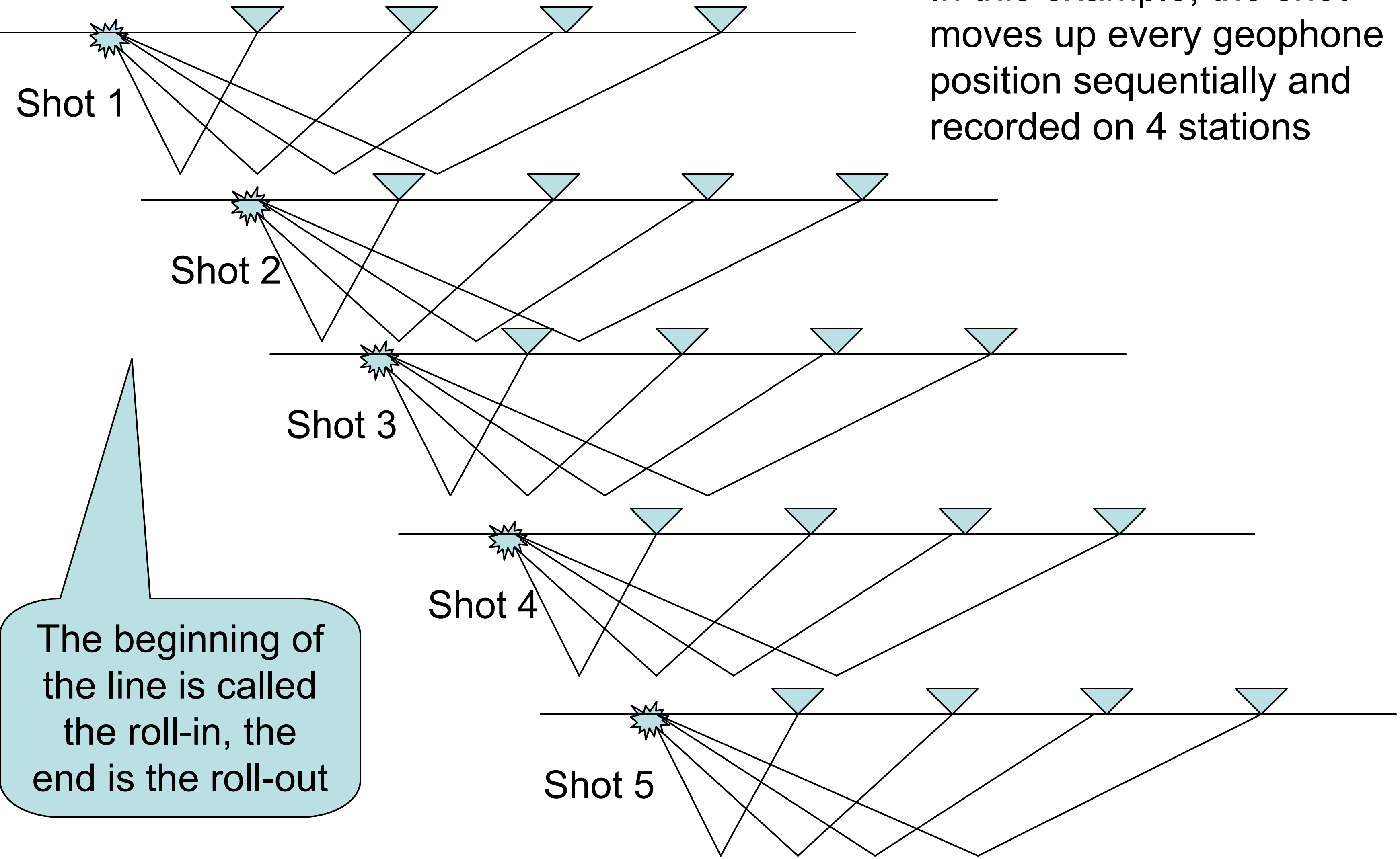
Prestack migration

- Up to now, we have considered only migration of cmp stacked sections.
- The cmp stack is an approximation only good for flat layers
- We can do better!

Shot gathers

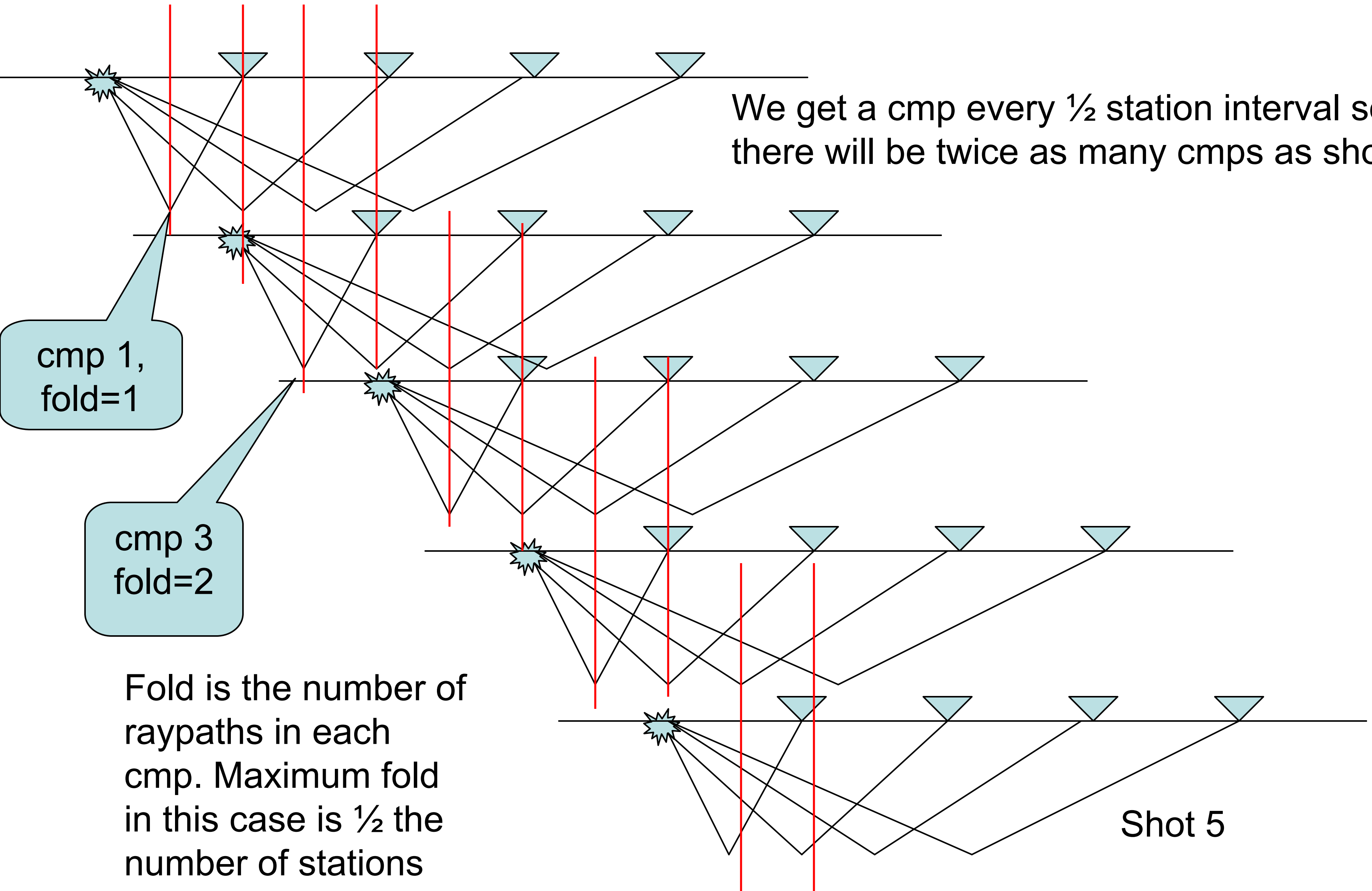
In this example, the shot moves up every geophone position sequentially and recorded on 4 stations



The Common Midpoint Sort

- The common midpoint sort coverts shot gathers to common midpoint gathers
  - Shot gathers have all stations recording a single shot; this is the way the data is recorded.
  - Common midpoint gathers have all the shot-receiver paths with the same midpoint; this is the processing geometry.

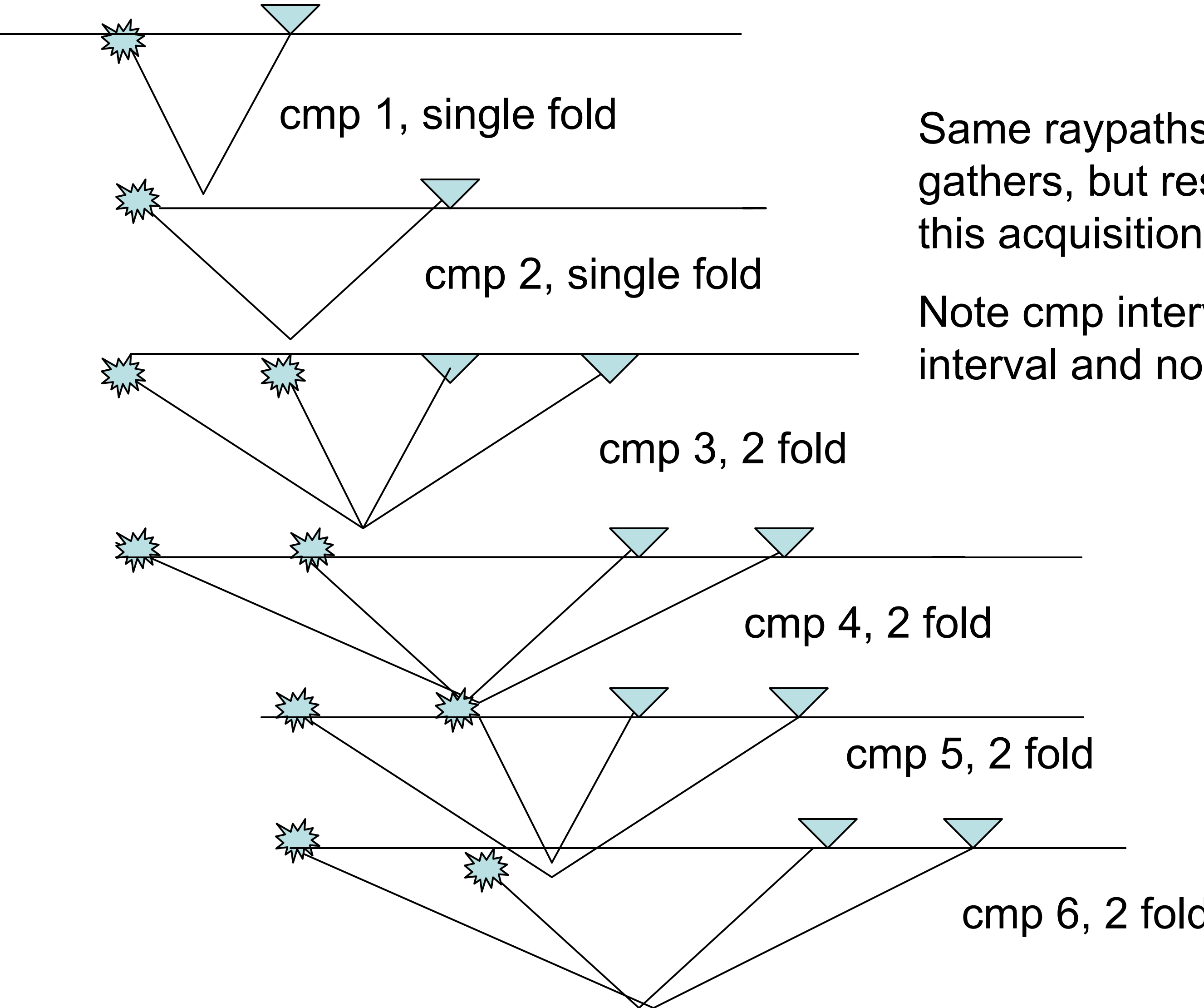
Shot gathers and midpoints



We get a cmp every ½ station interval so there will be twice as many cmps as shots

Fold is the number of raypaths in each cmp. Maximum fold in this case is ½ the number of stations

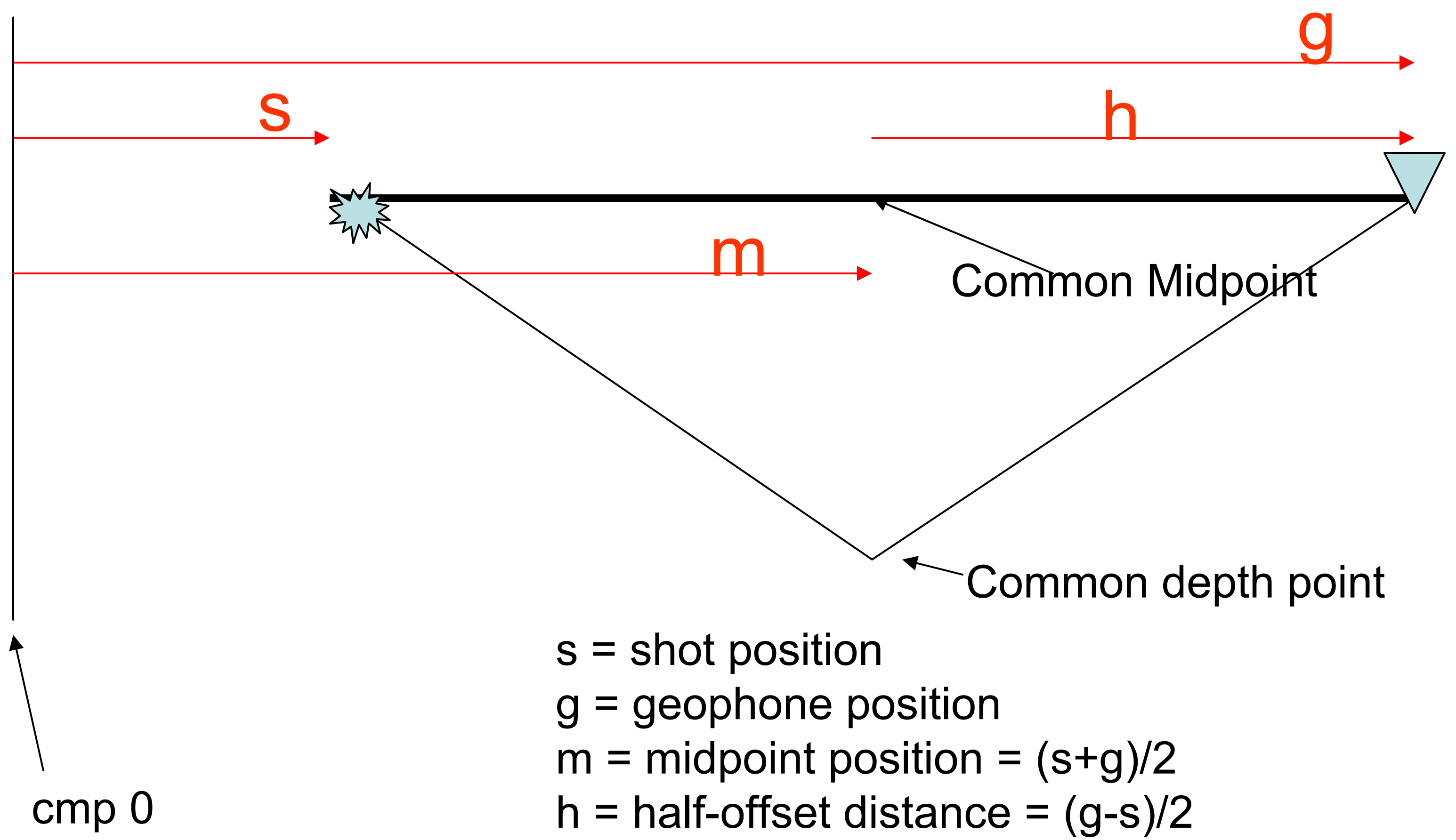
CMP gathers now



Same raypaths as with shot gathers, but resorted to simulate this acquisition geometry.

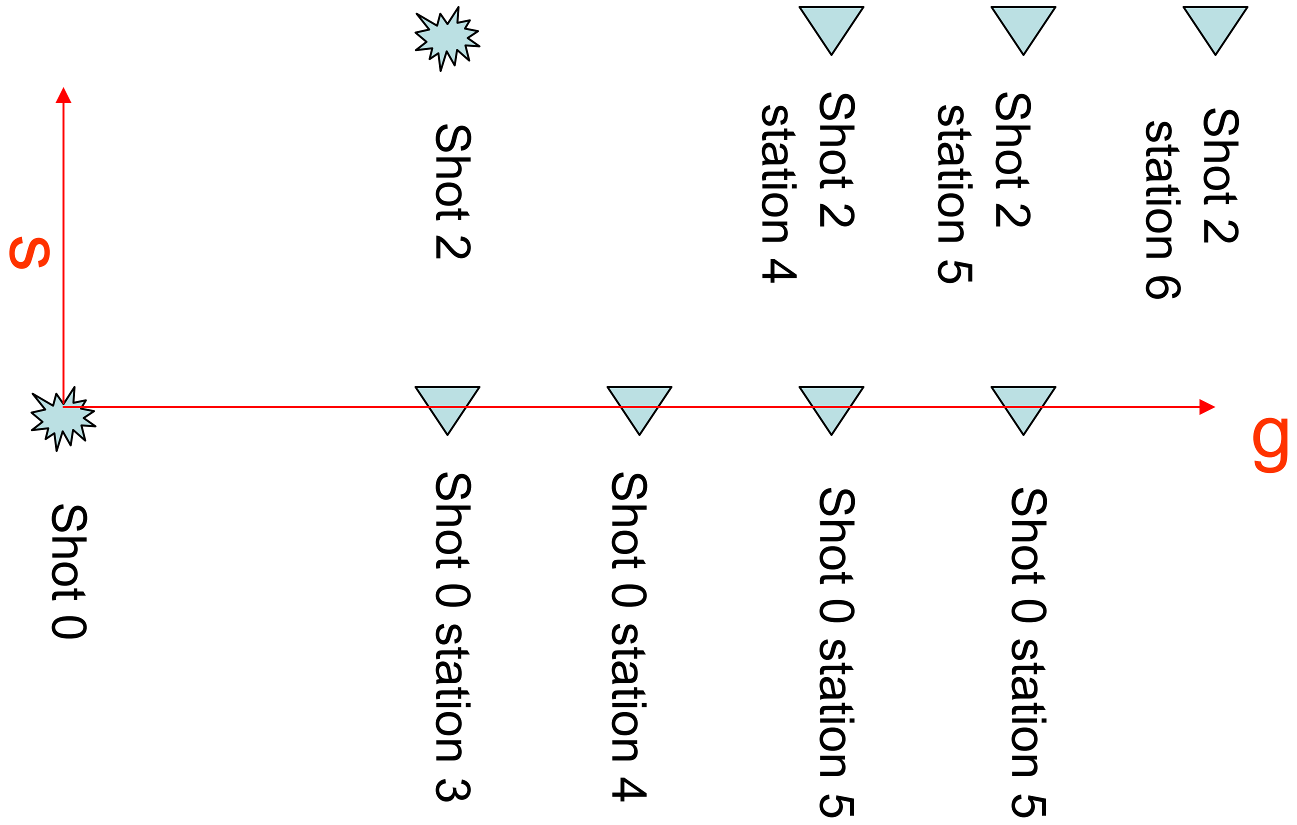
Note cmp interval is ½ the station interval and nominal fold is 2.

Shot geometry variables



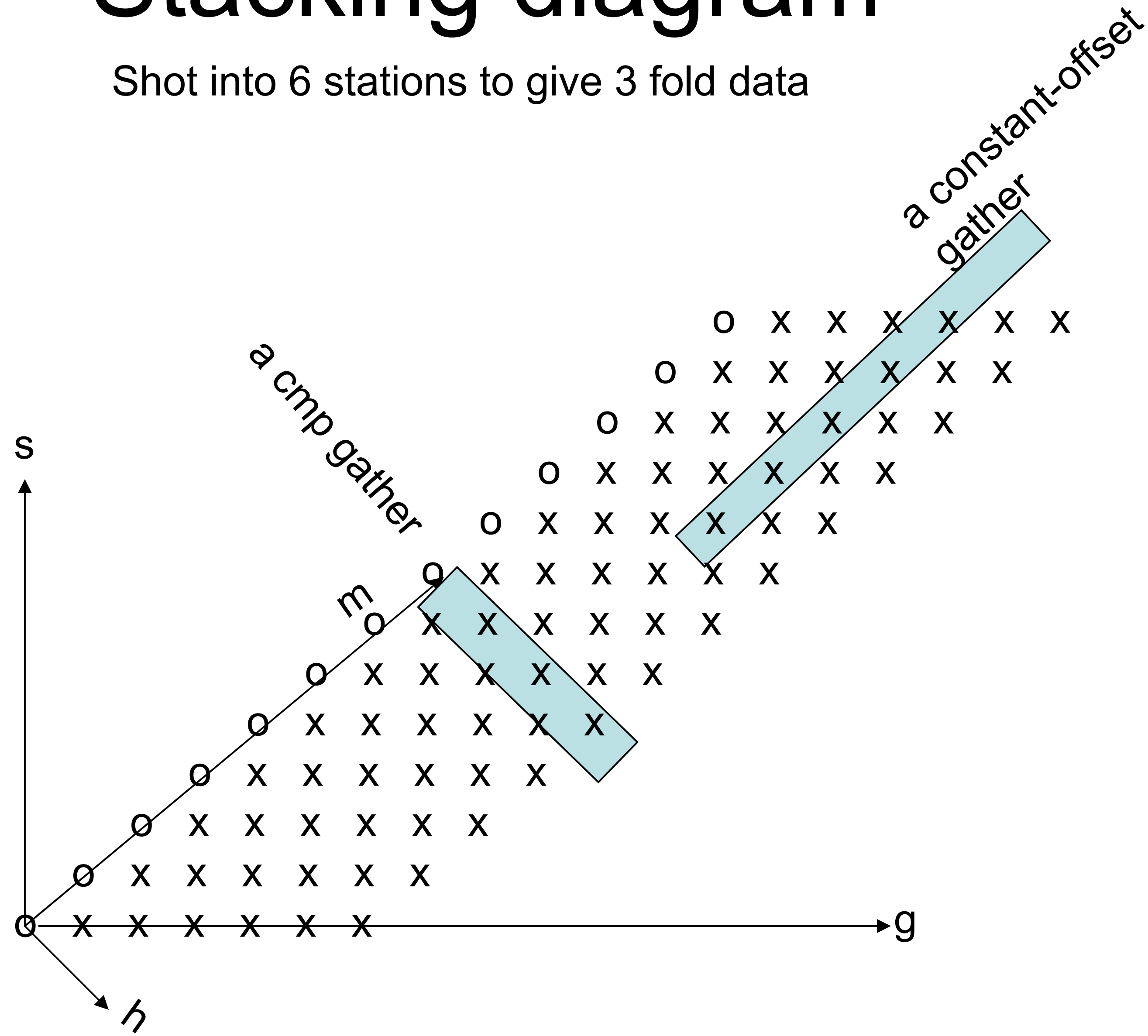
s = shot position
g = geophone position
m = midpoint position = (s+g)/2
h = half-offset distance = (g-s)/2

Shot geometry



Stacking diagram

Shot into 6 stations to give 3 fold data



Crooked line geometry

- What if the line takes a bend?
  - Needs to follow roads, canyons, …
  - Need to avoid lakes, mountains, cliffs, …
  - Permitting and permission issues

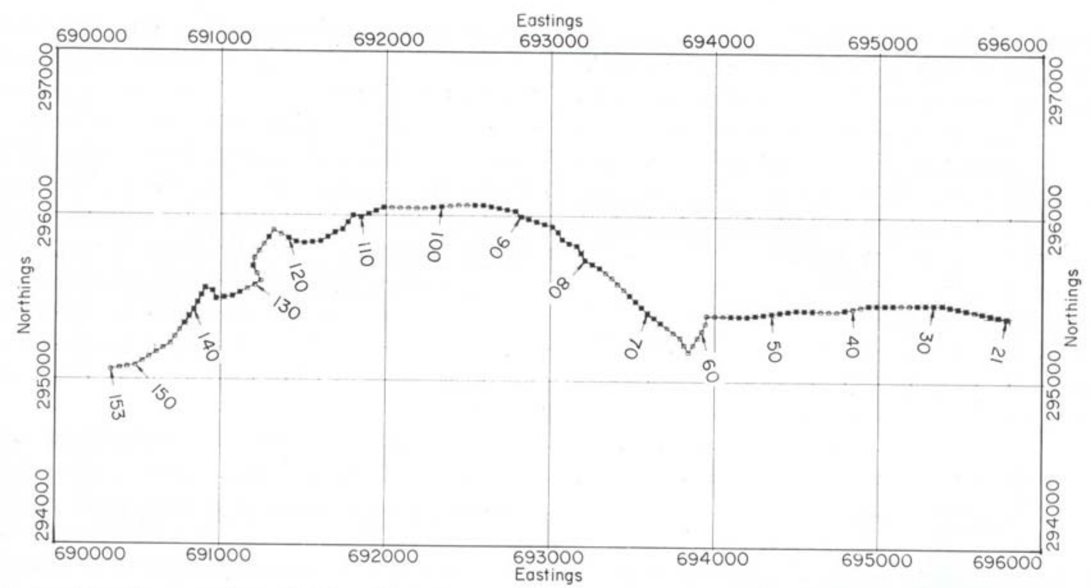


Fig. 3.90. A plan view of a typical crooked land line. Shot positions are indicated by dark squares and receiver positions by light squares.

Crooked line midpoints

- Midpoints are unequally spaced and spread out

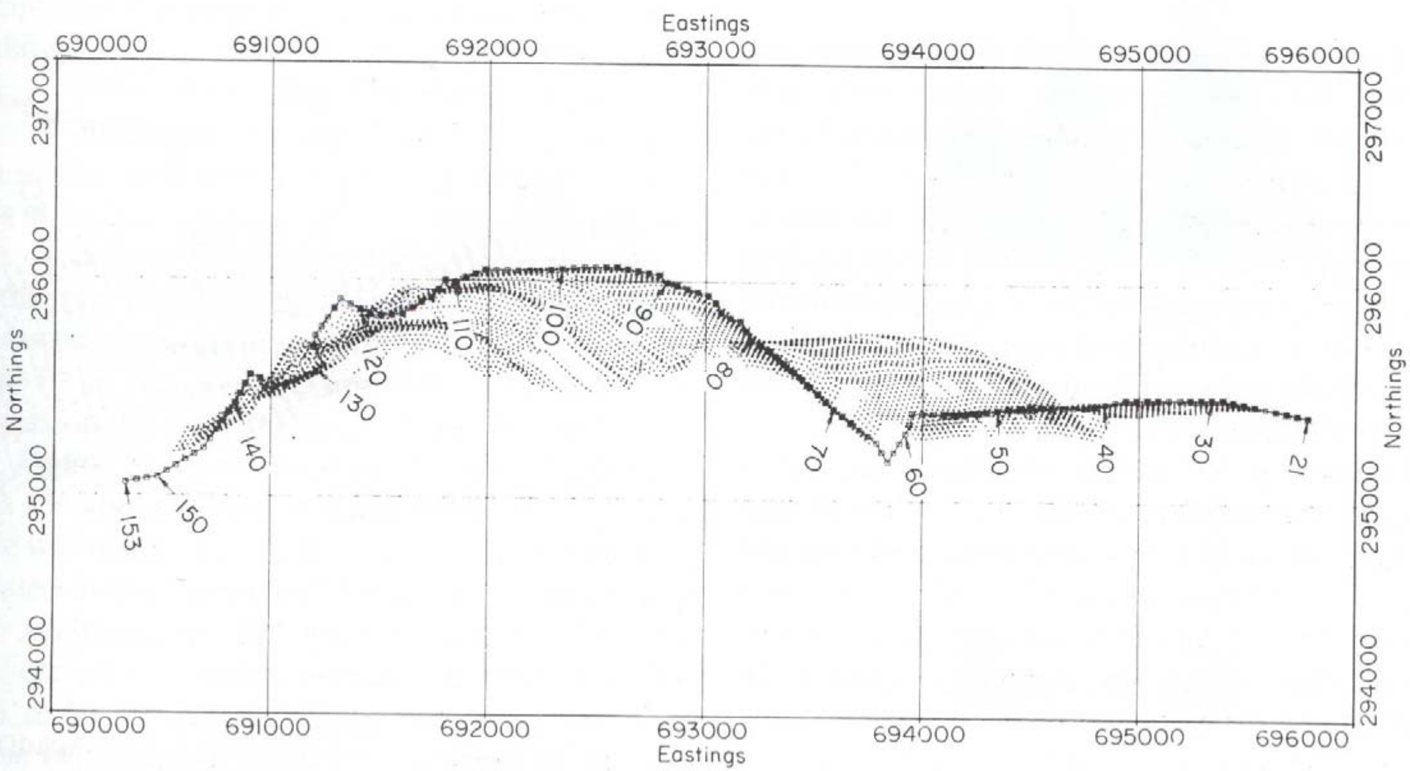


Fig. 3.91. As in Fig. 3.90 but with the mid-point positions between the sources and receivers indicated.

Crooked line cmp binning

- To make the cmp sort, we divide the line into cmp “bins” and sort the midpoints by which bin the lie in

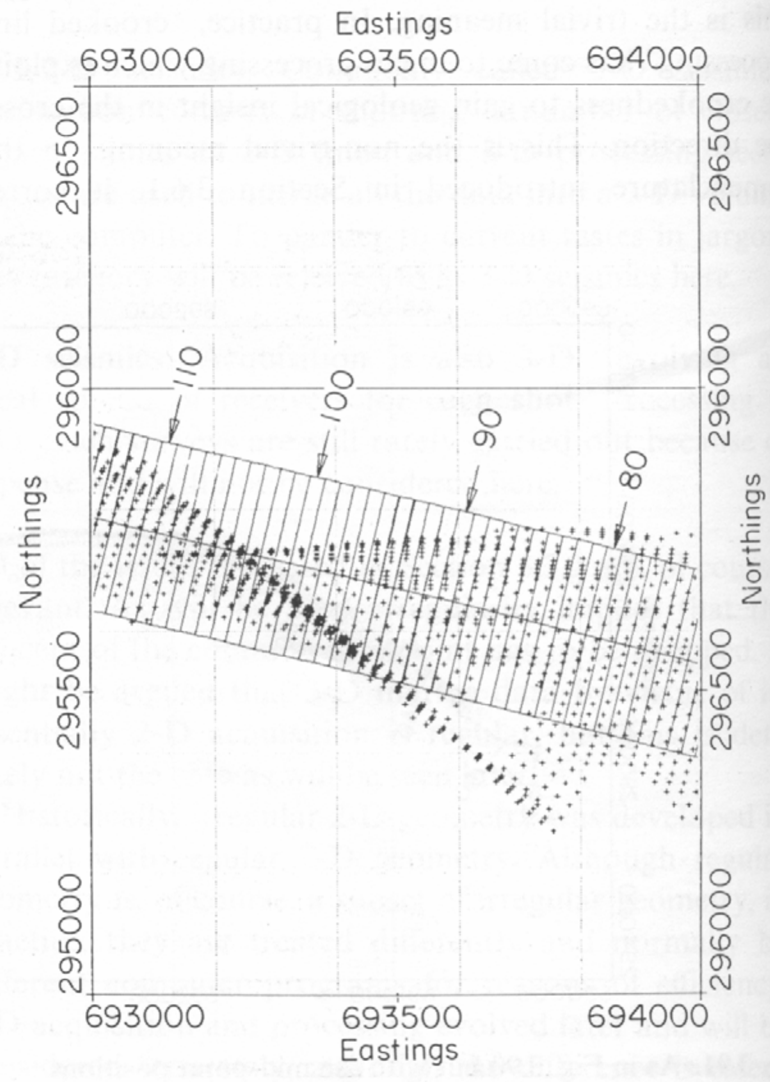


Fig. 3.93. An enlargement of part of Fig. 3.92.

A binned crooked cmp line

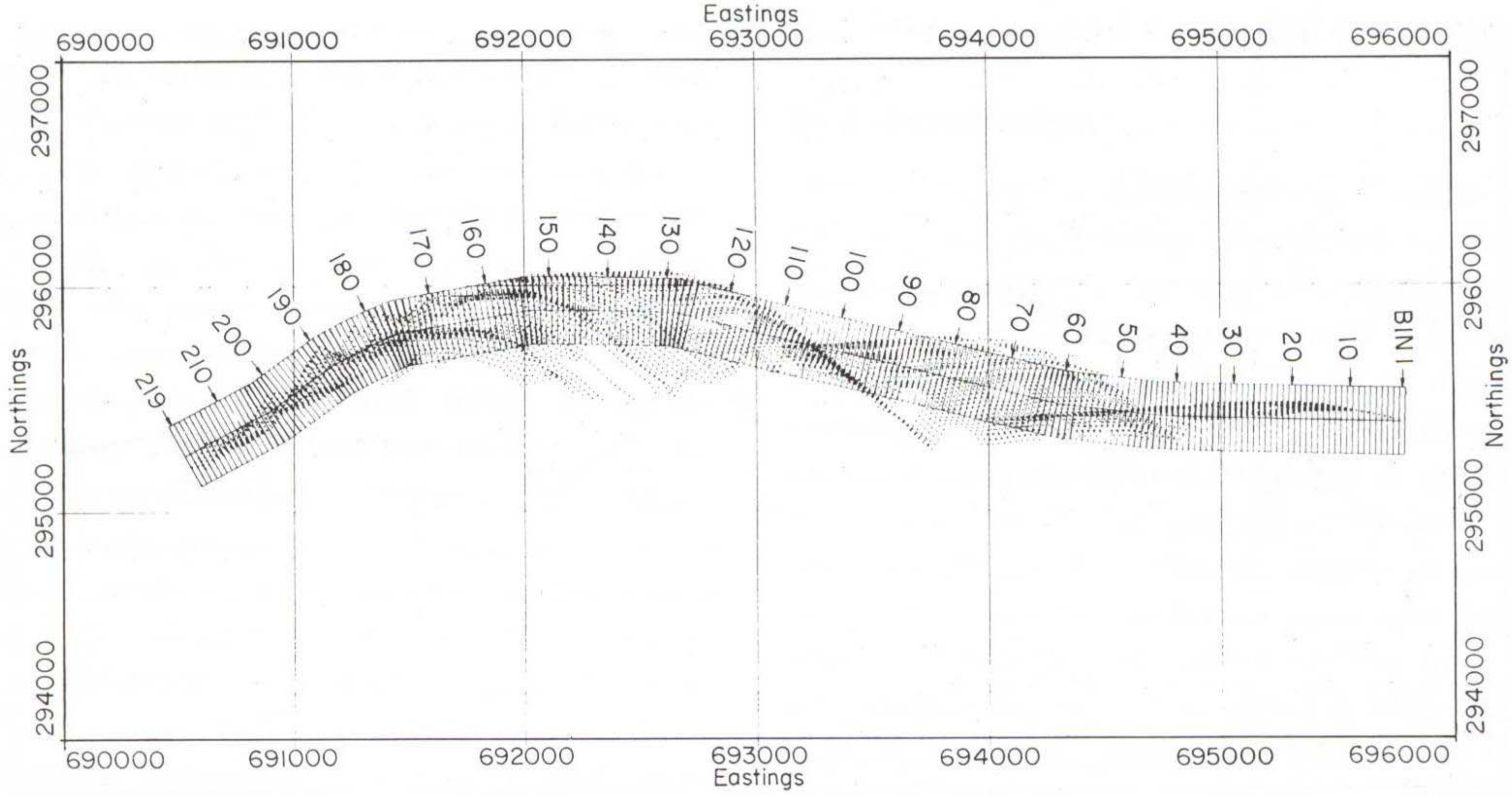
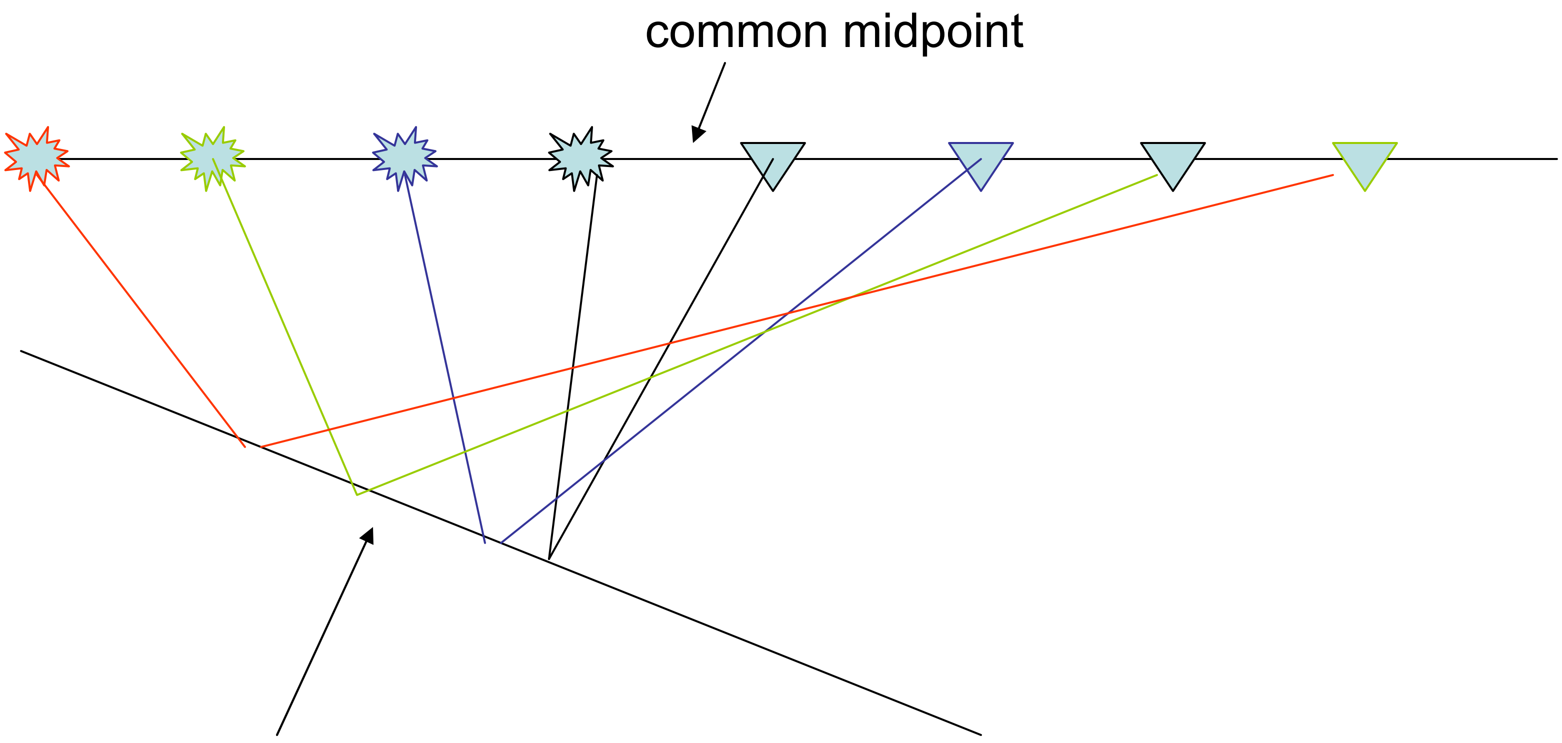


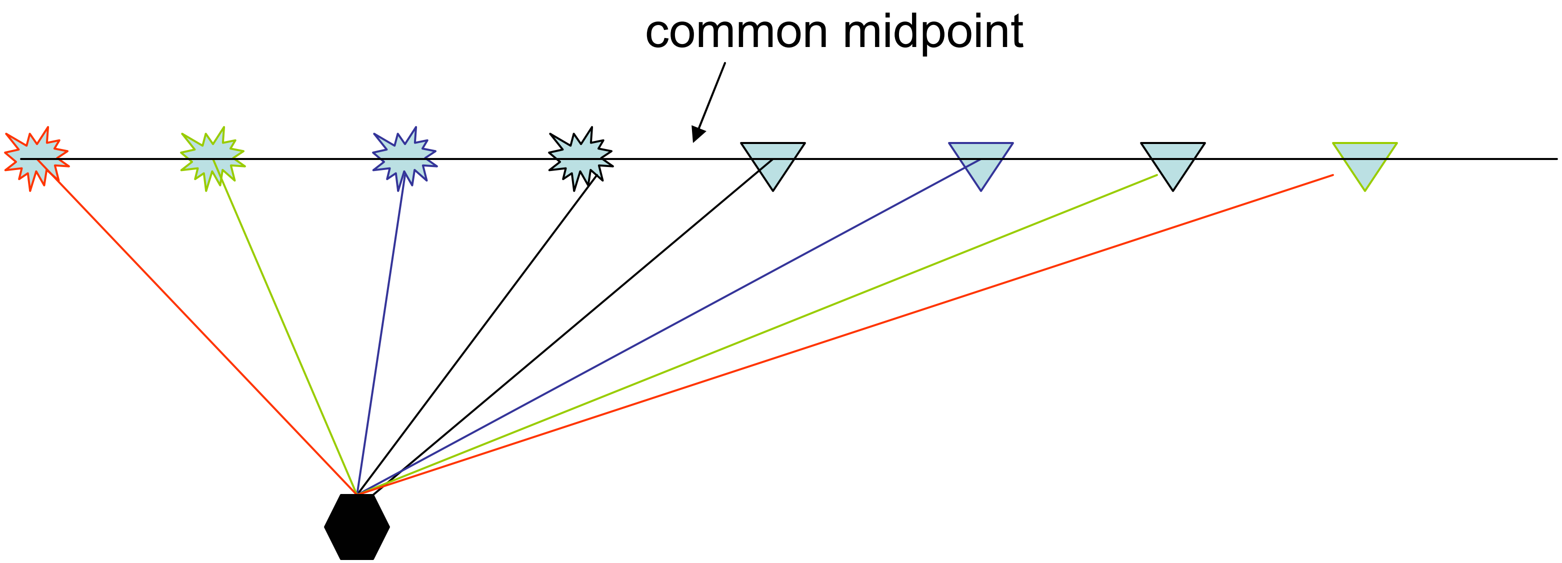
Fig. 3.92. A 'binning strategy' for the mid-point distribution of Fig. 3.91.

So whats wrong with the cmp stack?



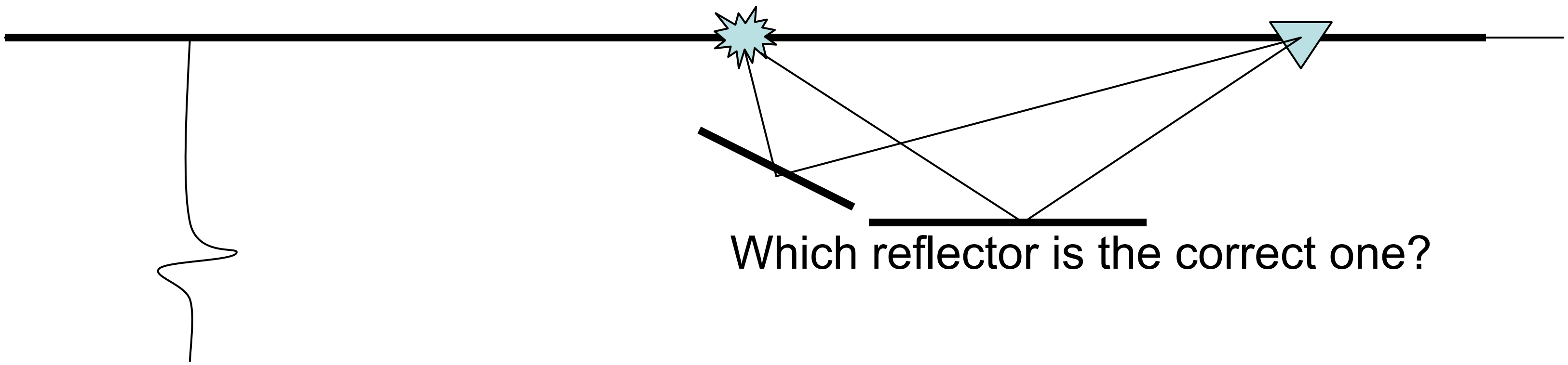
No common depth points! The bounce point marches up dip with increasing offset

Point scatterer



This won't stack right either!

How to migrate with nonzero offset

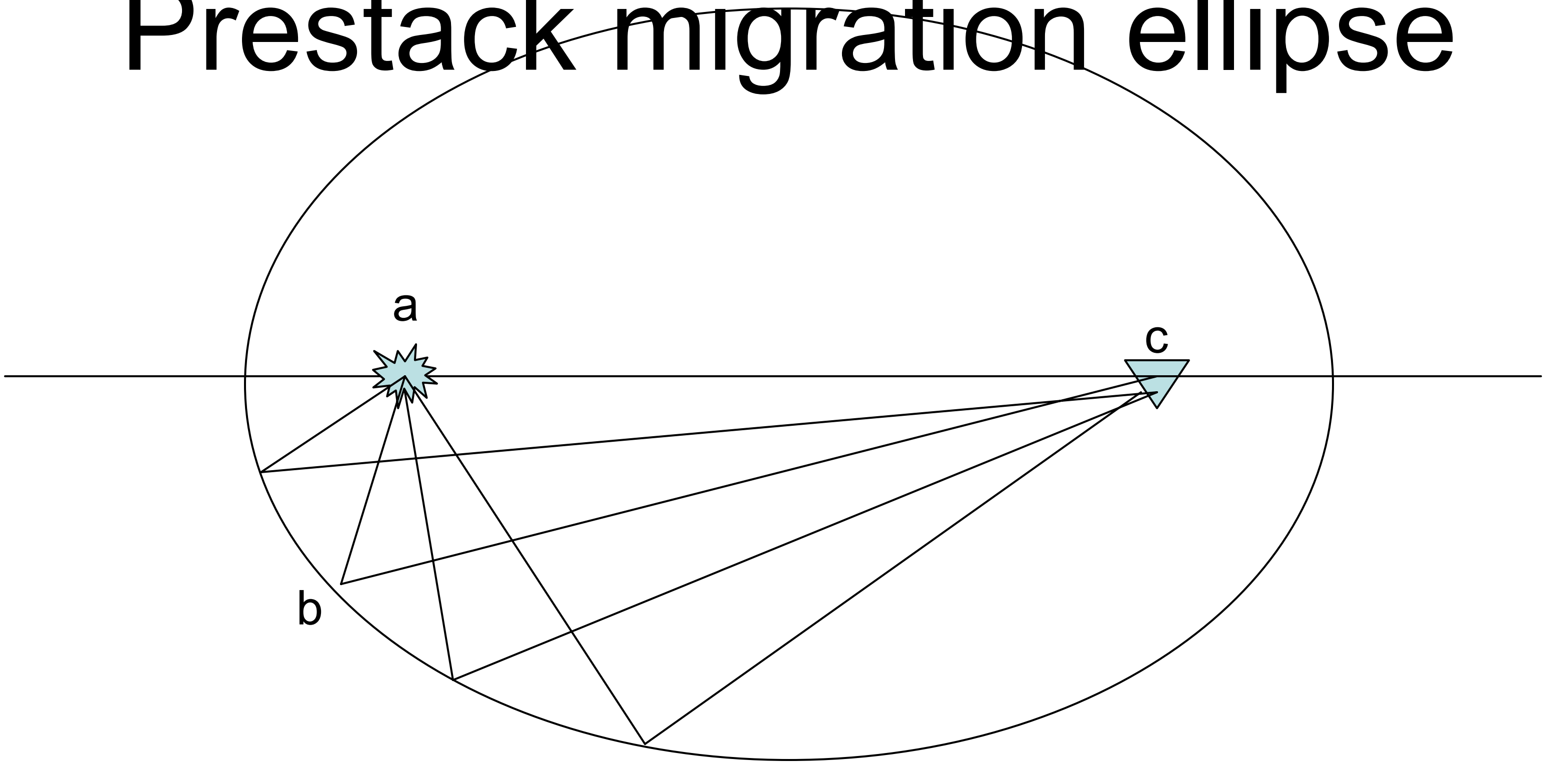


Which reflector is the correct one?

If we record a single trace at time t for a nonzero offset, where did it come from?

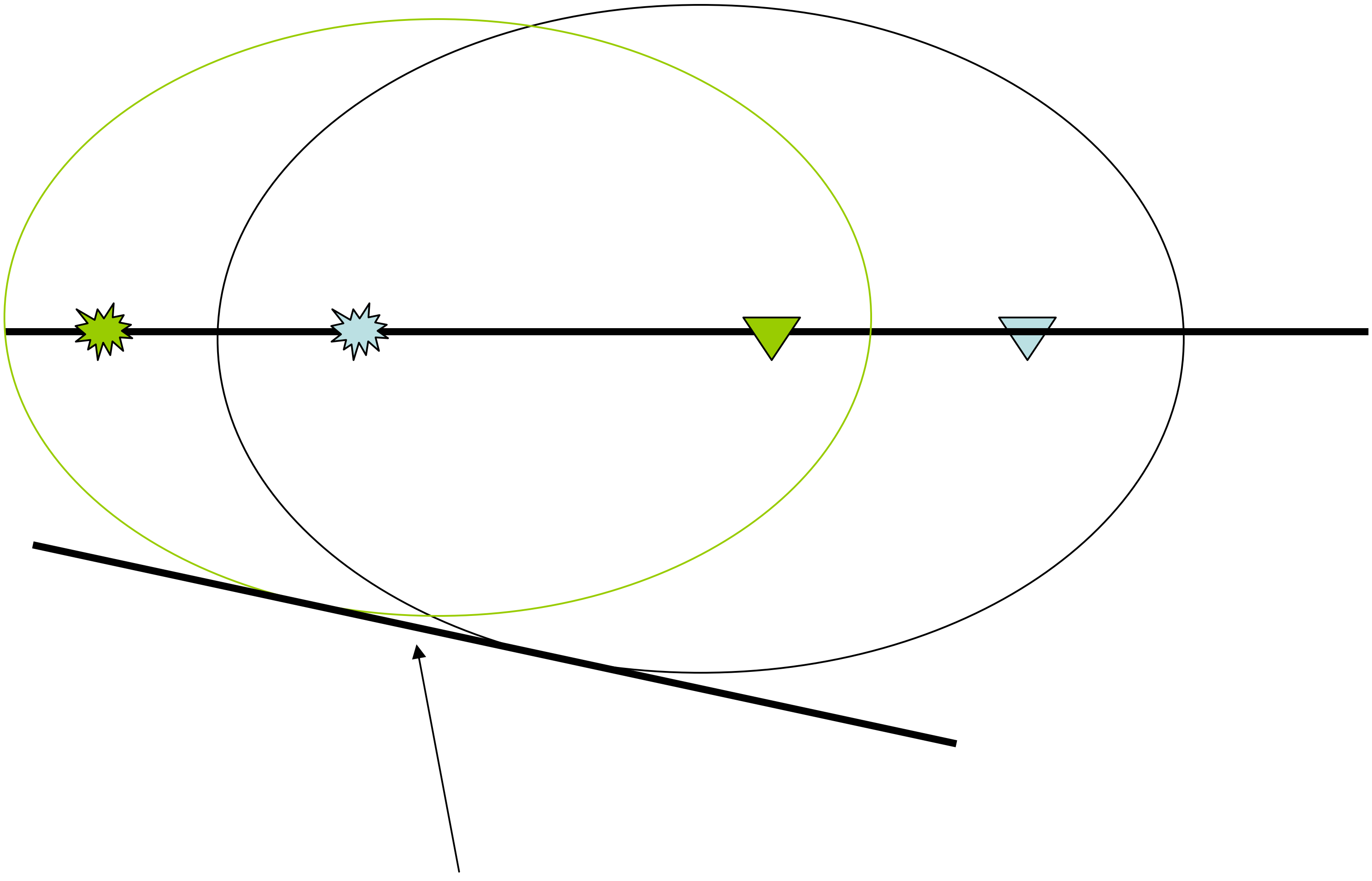
The total path length is d=vt

Prestack migration ellipse



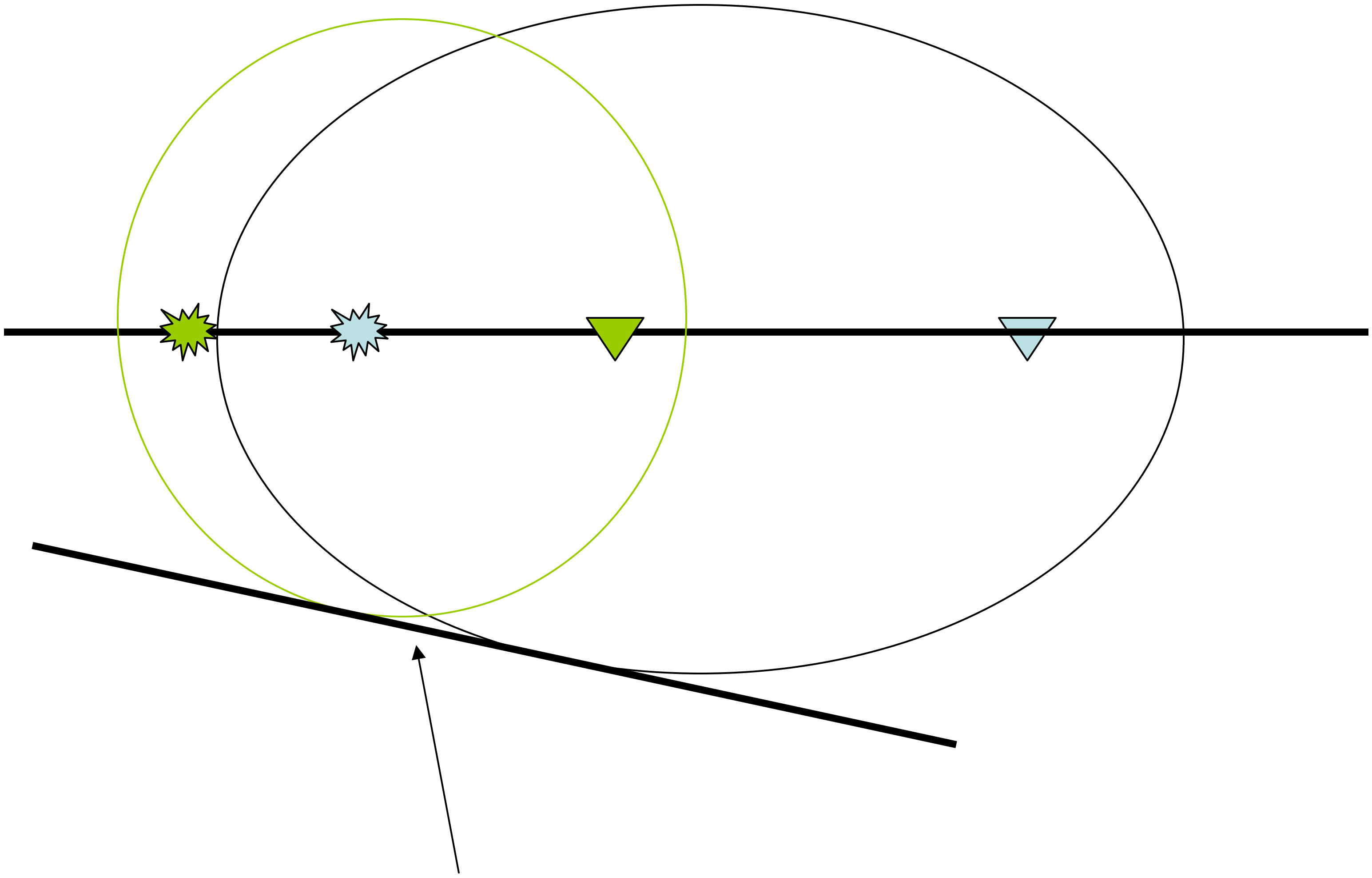
An ellipse is the geometrical shape for which all points have the same total distance from two foci! So distance *abc* is always the same!

So for prestack migration we smear reflectors out in ellipses instead of the semicircles we used for poststack migration.



Reflector is where outer edges of ellipses meet!

In this example I used two shots with the <u>same</u> source-receiver distances.

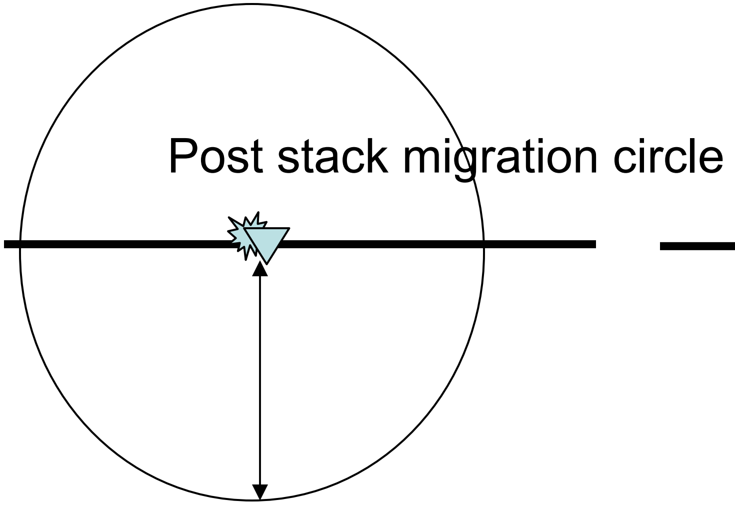


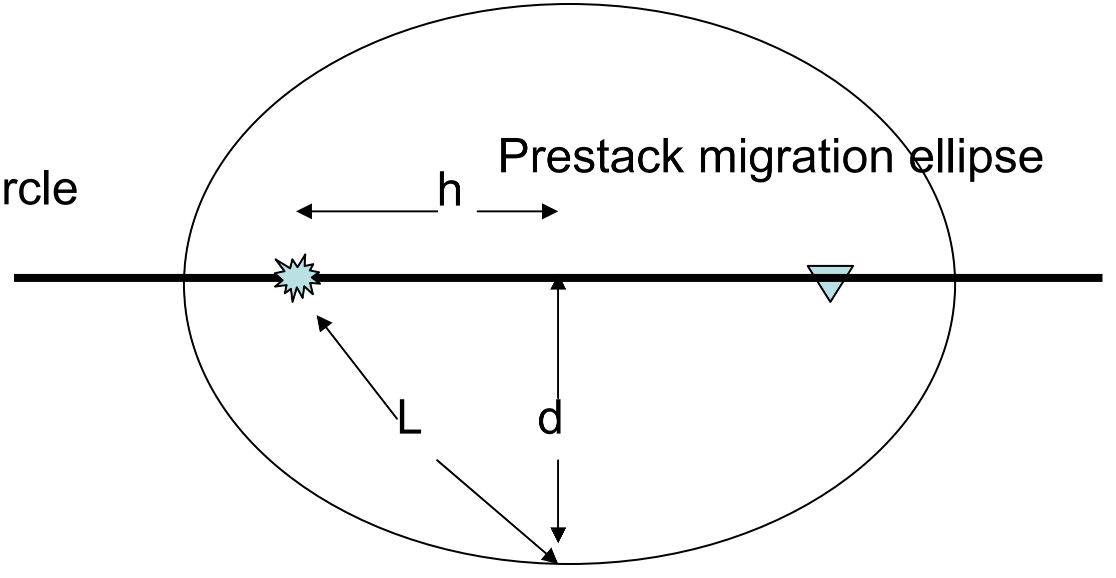
Reflector is where outer edges of ellipses meet!

In this example I used two shots with the <u>different</u> source-receiver distances.

How to implement

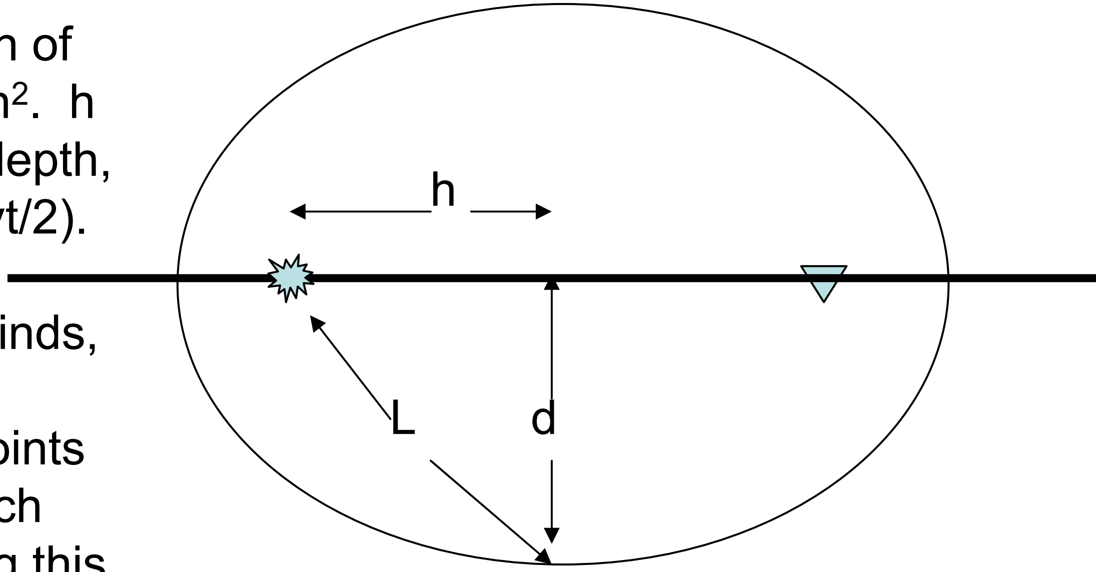
- Normal processing
  - NMO correction
  - Stack
  - Migrate
- Prestack processing
  - NMO correction
  - Pre-stack migration
  - Stack





Prestack migration implementation

The NMO correction finds the depth of the ellipse midpoint from $d^2 = L^2 - h^2$. h is the half-offset, d is the reflector depth, and L is half the total path length (vt/2).



The prestack migration correction finds, for each reflection, the ellipse that represents all possible reflection points with an equivalent path length. Each reflection is then smeared out along this ellipse. Each point gets mapped to a zero-offset trace directly above the reflector.

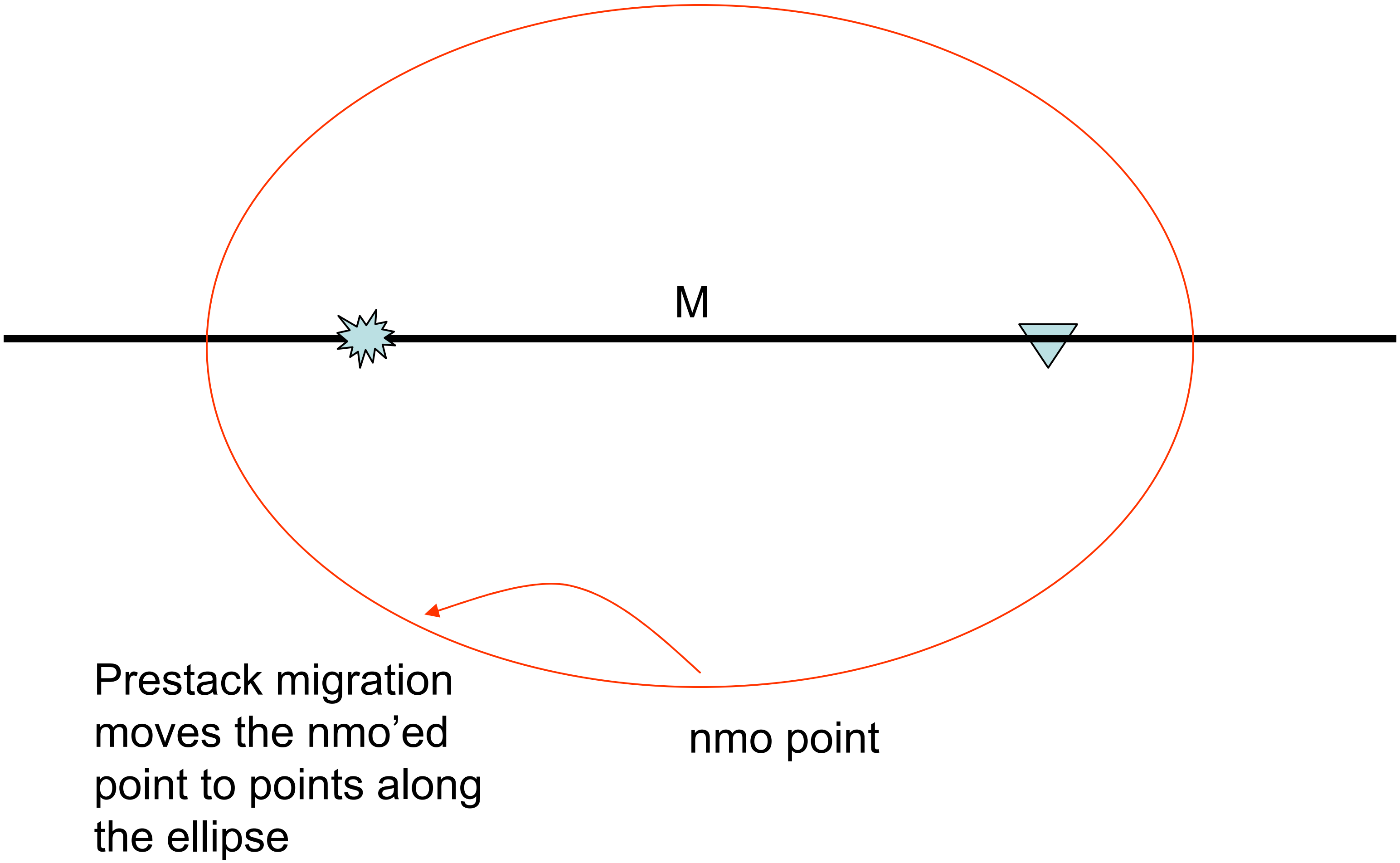
The stacking process then adds up zero-offset traces at each common-mid-point (cmp).

But what if we want to correct for dip pre-stack, but prefer an unmigrated section?

- Unmigrated sections can be useful
  - Diffractions can be used to identify fault and reflector edges or irregular surfaces
  - They don’t have migration artifacts such as the “migration smile”

Partial prestack migration or Dip Moveout (DMO)

- Consider the following sequence
  - NMO data
  - Prestack migrate (with ellipses)
  - Stack
  - Reverse poststack migrate (with semicircles)


M
nmo point
Prestack migration moves the nmo'ed point to points along the ellipse

Now we “reverse migrate” this elliptical reflector by the zero-offset cmp method. This is just the reverse of the semicircle migrations done in the earlier lecture.