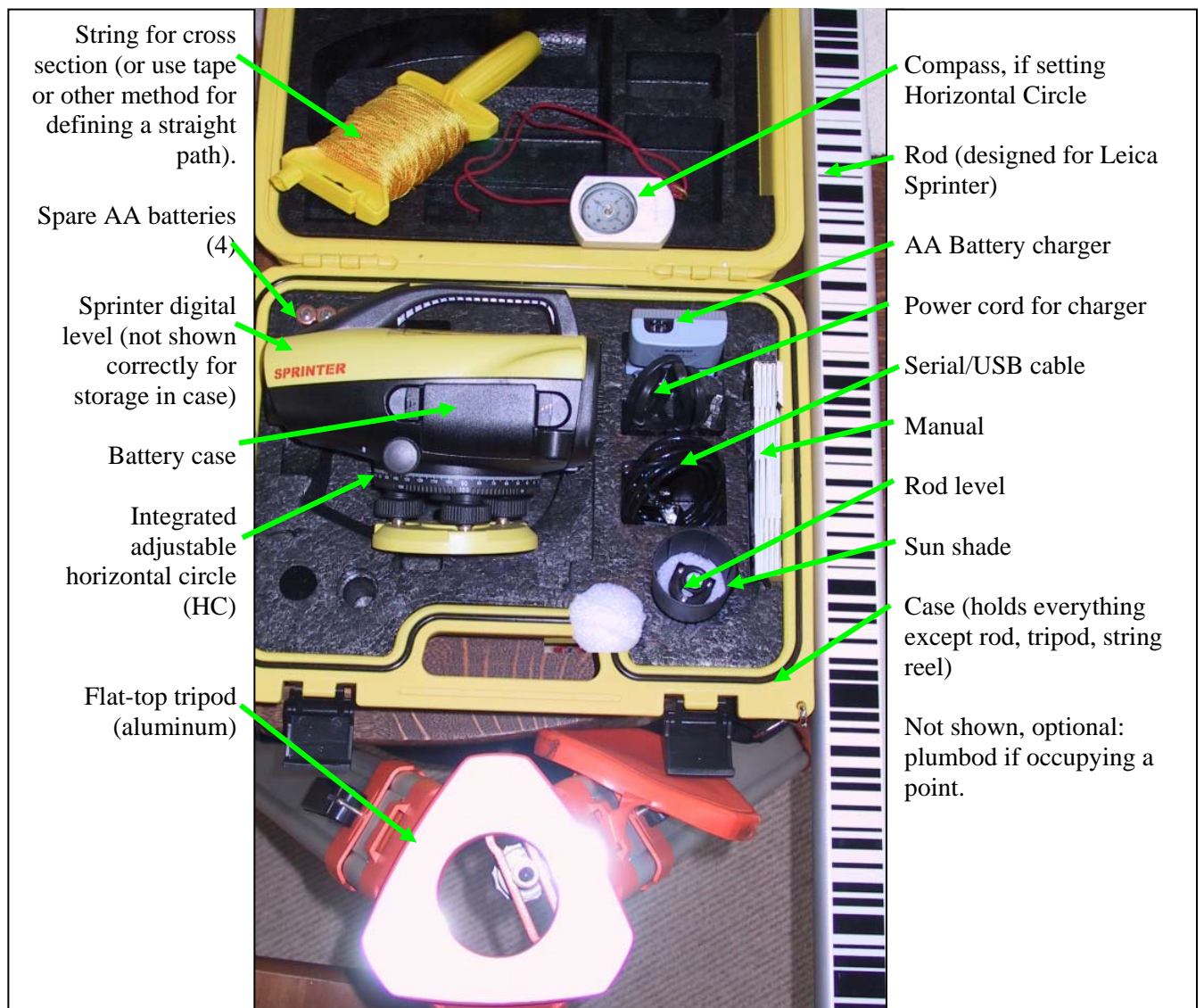


Using the Leica Sprinter Digital Level

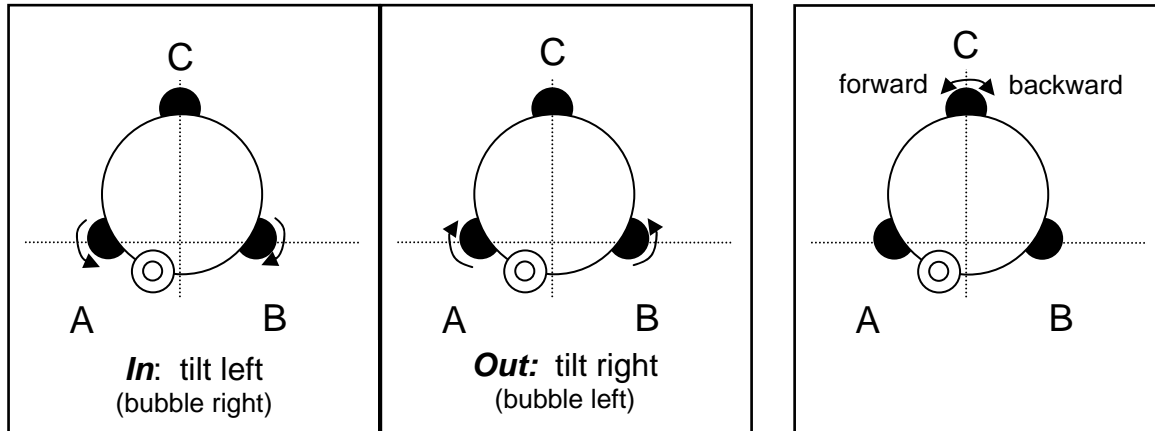
These instructions describe the basic use of the Leica Sprinter digital level, then demonstrate how to use it to complete a fairly quick stream or valley cross section with (a few) mm-accuracy vertically and dm-accuracy horizontally.

Accuracy tests in 44-m line survey test using the Sprinter 100M at SFSU:

- Vertical: mm accuracy (better than total station).
- Horizontal distance: RMSE 0.02 m
- Horizontal angle: RMSE 0.3° -- results in to ~ 0.5 m horizontal error at 100m



1. Set up the tripod with the top close to horizontal, and mount the level with the tripod screw.
2. Aligning yourself behind two of the foot knobs, level the level with the bubble level, looking down through the mirror, first getting the left-right tilt centered by turning the two lateral knob simultaneously in or out, then front-to-back by turning the opposite knob. *If you prefer you can also do this in reverse, with C towards you and A & B away from you.*



3. Power the unit on. While the level can be used optically with a stadia rod, its distance laser, data storage, and computations are only available with power. Before you make any readings you'll see two icons in the upper right: an upright rod (staff) indicating conventional (not inverted) use, and a horizontal battery indicator. You'll also see a line for vertical readings, with no current values, and a line for horizontal distance readings, also with no current values.

Method 1 (Simplest): Read Vertical and Horizontal Distances Without Recording

This works just like a standard optical level, except we'll also see distances from the instrument to the staff. At the main screen, with the unit focused on the staff (barcode side), press the red measure button and wait for the values to display. You should eventually see the vertical and horizontal distance values, with vertical from the base of the staff, and horizontal distance to the staff. You can simply write these numbers down. You would use the vertical measurements in a similar way as with an optical level – record benchmark or turning points as backsights (+), and observations as foresights (-). Distances can be recorded for other computations, and you may want to also record the horizontal circle.

Method 2: Using Memory to Record Values

Recommended

With this method, we can record values and download them later to a computer using the serial cable. The data will need to be processed later with a spreadsheet, but the format is simple.

1. Start by going to the menu, and turn on Recording (6) – select Memory. This is also where you turn it off.
2. Now at the main screen, you'll see a new field: PtID, which will initially be set to 1. You can use the menu to change this value, and it can include alphabetics as well as numerics. The id will be automatically incremented numerically:
 - 5 increments to 6, etc.
 - C1 increments to C2, etc.
 - C increments to C1, etc.
3. At the main screen, with the unit focused on the staff (barcode side), press the red measure button and wait for the values to display. You should eventually see the PtID, vertical and horizontal distance values, with vertical from the base of the staff, and horizontal distance to the staff. If you're starting at a benchmark, you might want to give it a special ptID, so you can process this later (the next method will allow you to enter a reference.)
4. Repeat for other measurements.

Method 3: Using built-in Line Leveling

This method lets you use built-in computations so you don't have to do it later in a spreadsheet, but the data exported may take some work to understand. For now, I don't recommend it.

The advantage is the removal of data entry errors when moving the instrument and re-establishing the backsight. Most of the methods are the same as Method 2, so we won't repeat those here. The differences are:

1. Menu: go to Line Leveling, and select the BIF method (Backsight, Intermediate, Foresight). Another method is the BF, apparently for simple line leveling where the instrument is moved between each staff location – we won't cover that here.
2. The first reading is the backsight to a benchmark (known elevation). You can go to the menu to change the PtID and RL (reduced level: known elevation of the benchmark). When the reading is complete, press Enter (MENU) button to Accept.
3. In BIF mode, the next reading is shown as F, but we want to use this to enter intermediate points. Go to the menu to turn Intermediate Sight On. Then back at the measurement screen, you'll see the 'I' highlighted. You can now collect a sequence of intermediate points. For each you are asked to Accept the reading. The intermediate points setting will remain until you go to the menu to turn it off.
4. When you're finished with intermediate sightings and wish to survey a foresight to a turning point (to later backsight to), use the menu to turn Intermediate Sight Off and then shoot the foresight. Note that the RL will change to this new value. *Note that this RL will be retained by the instrument even after you turn it off – when you start the BIF mode survey again, you'll be prompted to backsight to this RL.*
5. When you download these data, you'll find a lot more fields stored. The distance is stored in two fields – BS_DIST and IS_DIST, and the elevation is stored in RL.

Note: to get OUT of this program and back to normal use (method 2), press the Esc button.

Download Methods:

Leica Geo Office (Sprinter 100m)

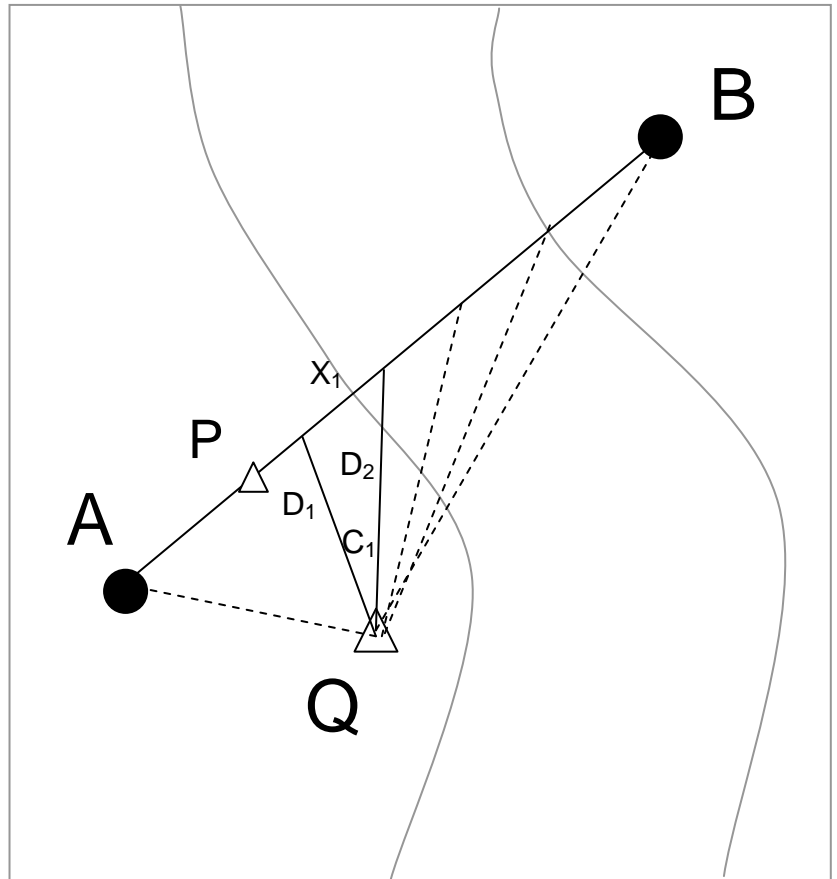
1. The computer must have Leica Geo Office Tools installed, or use other software to communicate via the RS232 interface. The USB/serial transfer cable must be installed, and the Sprinter turned on.
2. In Leica Geo Office Tools, go to Tools/Data Exchange Manager, and to Serial Ports and to whichever com port is being used by the cable -- probably COM1 for the standard serial cable, and COM3 or higher (you may have to try multiple ones to find it) for the USB/serial cable. If "COM_ : Sprinter100" is not displayed, you may have to right-click the COM and go to its **Settings** then the **COM Settings** tab to select **SPRINTER** as the instrument, Baud rate **38400**, Parity **None**, 1 Stop Bit, 8 Data Bits. *If this works*, you should be able to expand the COM_ serial port and see **Internal Memory**, then **Jobs**, then **Job 1: DEFAULT**, where you'll see a file called "Measurements data: ___ Blocks"
3. Drag the measurement data file to the right area of contents on your computer, using a folder you can find – start in the Files area. Change the file name to something you want, ending in '.txt', and change the format to ASCII (the default GSI format uses some kind of hexadecimal codes.) You'll see a downloading message and then a Download Complete! Message displayed on the Sprinter.
4. You should be able to open the file from Windows with Notepad, and open it from Excel by searching for text files, then going with its **Fixed width** data format.
5. Back at the Sprinter, you can use the Sprinter Data Manager in the Sprinter menu to view or delete all data – that's about all you can do – there's apparently only one file. This menu also lets you download data, and you may need to do this if you use something other than Leica Geo Office to download.

Sprinter DataLoader (for Sprinter 250M)

1. The cable with the 250M goes into a telephone-tab port inside the battery compartment. Plug it in and turn it on – it gets power from your computer.
2. Start Sprinter DataLoader, and press the USB Connect button. Wait a few seconds. If all goes well, you'll see the serial number and other stuff displayed on the left part of the screen.
3. In the Data Export area, select EXCEL Data Listing to request data to be exported to Excel format. If all goes well, the output will start Excel, and appear nicely formatted.

Cross Section

A stream or valley cross section is a fairly simple process involving a series of readings on a straight line, starting at one margin and crossing the stream approximately perpendicularly (in the figure, from A to B). As with most stream measurements, vertical accuracy is much more critical, so we can take advantage of these very characteristics of a level. One challenge of measuring a cross section is measuring the cross-sectional distance, so we'll make use of the distance-measuring capabilities of the Sprinter. *If we can set up the instrument in line with the section at P, the measurements can be used directly (with distances either positive or negative before or after the level), and this can produce much more accurate results.* Make sure to record which readings are before and after the instrument position.



With the simple distance method (set up at P), you can expect cm accuracy horizontally. If vegetative obstructions exist, and you're willing to degrade horizontal accuracy to a decimeter or so, you can use a solution using instrument position Q. Using the horizontal circle (HC) of the Sprinter, initially turned to zero, we have what we need to derive cross-section distances. A cross-sectional distance segment X_1 can be derived with the law of cosines as $X_1^2 = D_0^2 + D_1^2 - 2D_0D_1\cos C_1$. We need to record the HC manually and include it with the data we downloaded (using method 2 above). It might be a good idea to record all of the data in a notebook, but also use the downloaded memory to avoid errors.

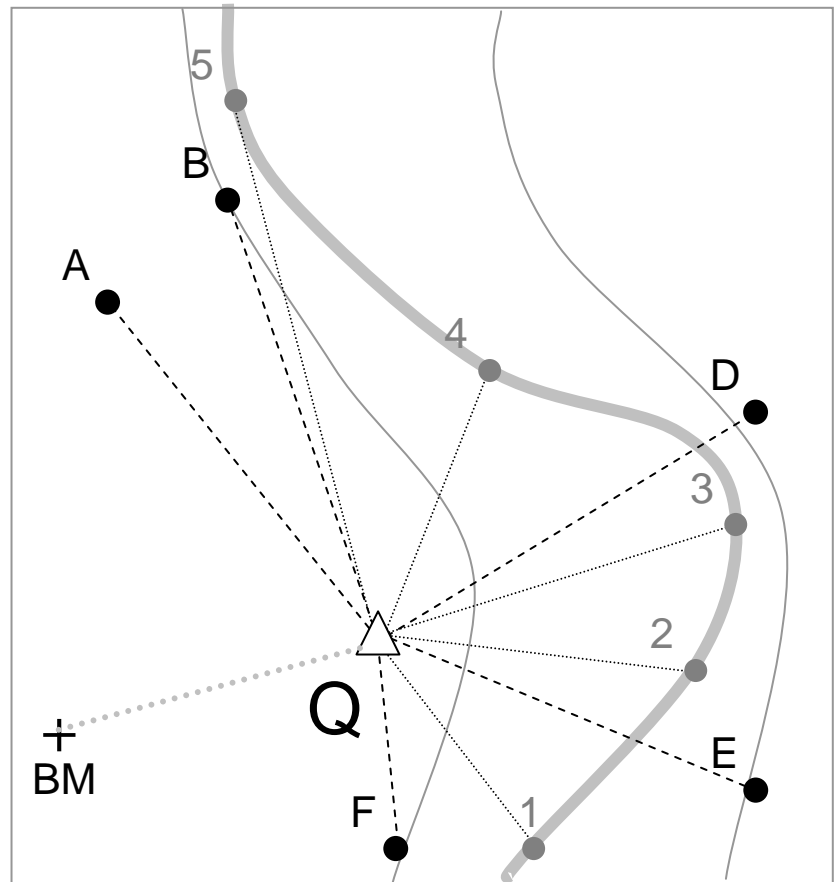
With a bit of care, this makes a quick cross section. The field method doesn't require a tape mounted across the stream, but we need to use some method to ensure we are going in a straight line – such as a string tied from bank to bank. A check on accuracy is to derive XY for each point, and both plot these to observe its linearity and derive a Pearson correlation between X and Y of > 0.999 .

=SQRT(C2*2+C3*2-2*C2*C3*COS(RADIANS(E3)))								
	A	B	C	D	E	F	G	H
1	PtID	HEIGHT	DISTANCE	HC	Ang	XSdist(i)	XSdist	ELEV
2	1	1.169	9.36	0		0	0	100
3	2	1.188	8.45	358	358	0.961489	0.961489	99.981
4	3	1.191	7.52	354.9	-3.1	1.02512	1.986609	99.978
5	4	1.412	6.61	351.1	-3.8	1.023067	3.009676	99.757
6	5	1.427	5.78	346.8	-4.3	0.950783	3.960459	99.742
7	6	1.376	4.96	339.1	-7.7	1.090597	5.051056	99.793
8	7	1.341	4.27	330.5	-8.6	0.97589	6.026947	99.828
9	8	1.285	3.68	320.2	-10.2	0.924418	6.951264	99.894

Spreadsheet built from Sprinter-downloaded data (PtID, HEIGHT, DISTANCE), with added data (HC=horizontal circle), derived angles, XS distance segments and accumulated XS distance $G3 = F3+G2$ etc. ELEV is derived by using the first reading (PtID=1) as a backsight to a known elevation of 100 and using the formula copied from H3 $=H\$2+B\$2-B3$.

General Survey

The Sprinter's high vertical accuracy and reasonable horizontal accuracy also makes it a decent tool for doing a general survey – not as accurate horizontally as a Total Station, but good enough for many purposes, including a longitudinal profile. For this purpose we'll add a bit to the Cross Section survey method: (1) setting up the instrument at a known point; and (2) setting the horizontal circle to read azimuth. Then we'll record data as before, adding the HC readings to our notebook as before.



1. Setting up the instrument at a known control point, or preferably in a location (Q) to backsight to a benchmark (BM). *If not backsighting to BM, measure the instrument height HI above the control point to get Z_Q , which you may want to note is HI above any established Z for the control point on the ground.*

2. Set HC to true azimuths: Stand back from the instrument, then use a compass to sight through the instrument position to an easily identifiable feature in the distance, preferably near level. Better yet, have the rod held at a distance, and sight on that. Convert that compass azimuth to a true azimuth by adding the magnetic declination (currently 15.5 near SNFC). Move the HC to the true (not magnetic) azimuth setting.

3. Backsight to benchmark BM (at a known XYZ) by reversing the HC reading from Q to BM.

$$\begin{aligned} X_Q &= X_{BM} + D_{QtoBM} * \sin(\text{radians}(\text{HC}_{QtoBM} + 180)) \\ Y_Q &= Y_{BM} + D_{QtoBM} * \cos(\text{radians}(\text{HC}_{QtoBM} + 180)) \\ Z_Q &= Z_{BM} + V \end{aligned}$$

All readings will be offsets from the instrument position, which you should have at this point. After you download your data and enter the HC readings, the computations in the spreadsheet for a given position should be as follows, with HC, D (distance), V (height) as inputs, and X_Q , Y_Q and Z_Q being the position of the instrument at Q:

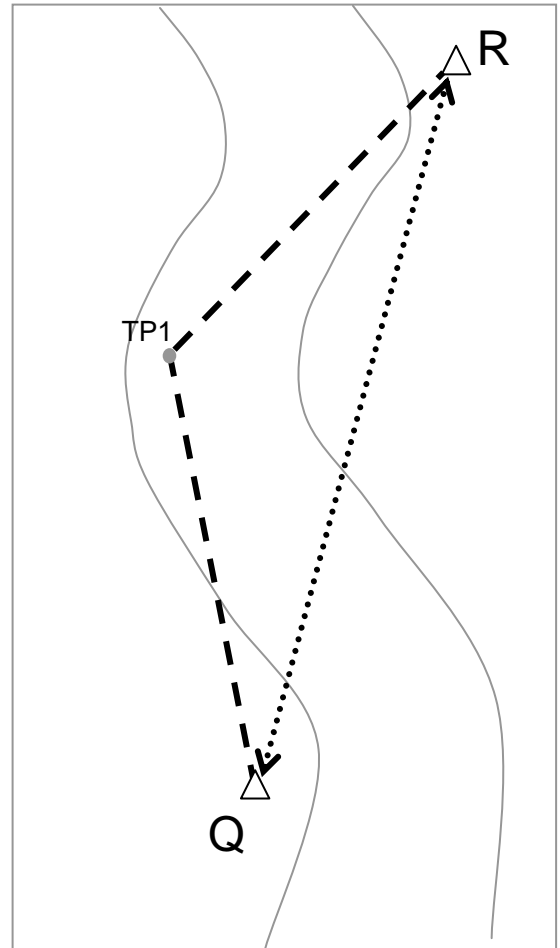
$$\begin{aligned} X &= X_Q + D * \sin(\text{radians}(\text{HC})) \\ Y &= Y_Q + D * \cos(\text{radians}(\text{HC})) \\ Z &= Z_Q - V \end{aligned}$$

Moving the Level using a Turning Point

In many surveys, including most longitudinal profiles, you won't be able to get all measurements from one instrument position. You'll need to move the instrument, but we will want to maintain vertical and horizontal control.

To maintain **vertical control**, which is critical in any leveling survey, we'll use a *turning point*, which we'll establish on a stable surface: boulders work well, or the best available surface – the key is that it's not going to move while you move the instrument, and preferably it's an easily identifiable feature so if we accidentally move the rod, we can put it back reliably. Vertical control is passed from the instrument (for which we know its elevation as HI) at Q to the rod at TP1. Think of TP1 as a new benchmark. Then when we backsight from the new instrument location at Q to TP1, we can derive a new HI for measurements from R.

For **horizontal control**, which is not as critical and only used if we are going to make a plan map at the same time as our leveling profile, we need to determine (1) where R is, and (2) have horizontal circle readings that work like true azimuths, at R as we did at Q. Ideally we can establish this by adding a foresight from Q to R (to get an XY for R and an azimuth from Q to R we'll call AZ_{QR}), then a backsight from R to Q to set the horizontal circle to a reversed azimuth ($AZ_{QR}+180$). If QR visibility is blocked, we'll need to (1) establish the horizontal circle at R with a compass, and (2) establish XY at R by reversing a reading from R to TP1.



So the process to get both vertical and horizontal control goes like this:

1. First, we survey to the turning point (from Q to TP1 in the diagram), just like any other reading, as a foresight. *Note that the rod holder needs to stay in place while the instrument is moved.* Think of TP1 as a new benchmark. We'll be deriving XYZ for TP1, just like for other foresight readings.
2. If possible, and it doesn't compromise your surveying efficiency, also survey Q to R to get XY for R, and AZ_{QR} from the HC.
3. Leaving the rod holder at TP1, reposition the instrument at R.
4. If backsighting to Q, do that first to establish the HC as $AZ_{QR}+180$ (or minus 180). Otherwise use a compass as before to make the HC read true azimuths.
5. Backsight to TP1 to establish the HI at R. If you didn't backsight to Q, you can establish XY at R by reversing the HC reading from R to TP1.

$$X = X_{TP1} + D_{RtoTP1} * \sin(\text{radians}(HC_{RtoTP1}+180))$$

$$Y = Y_{TP1} + D_{RtoTP1} * \cos(\text{radians}(HC_{RtoTP1}+180))$$