



GPS in Archaeoastronomy

Examples of GPS in Archaeoastronomy

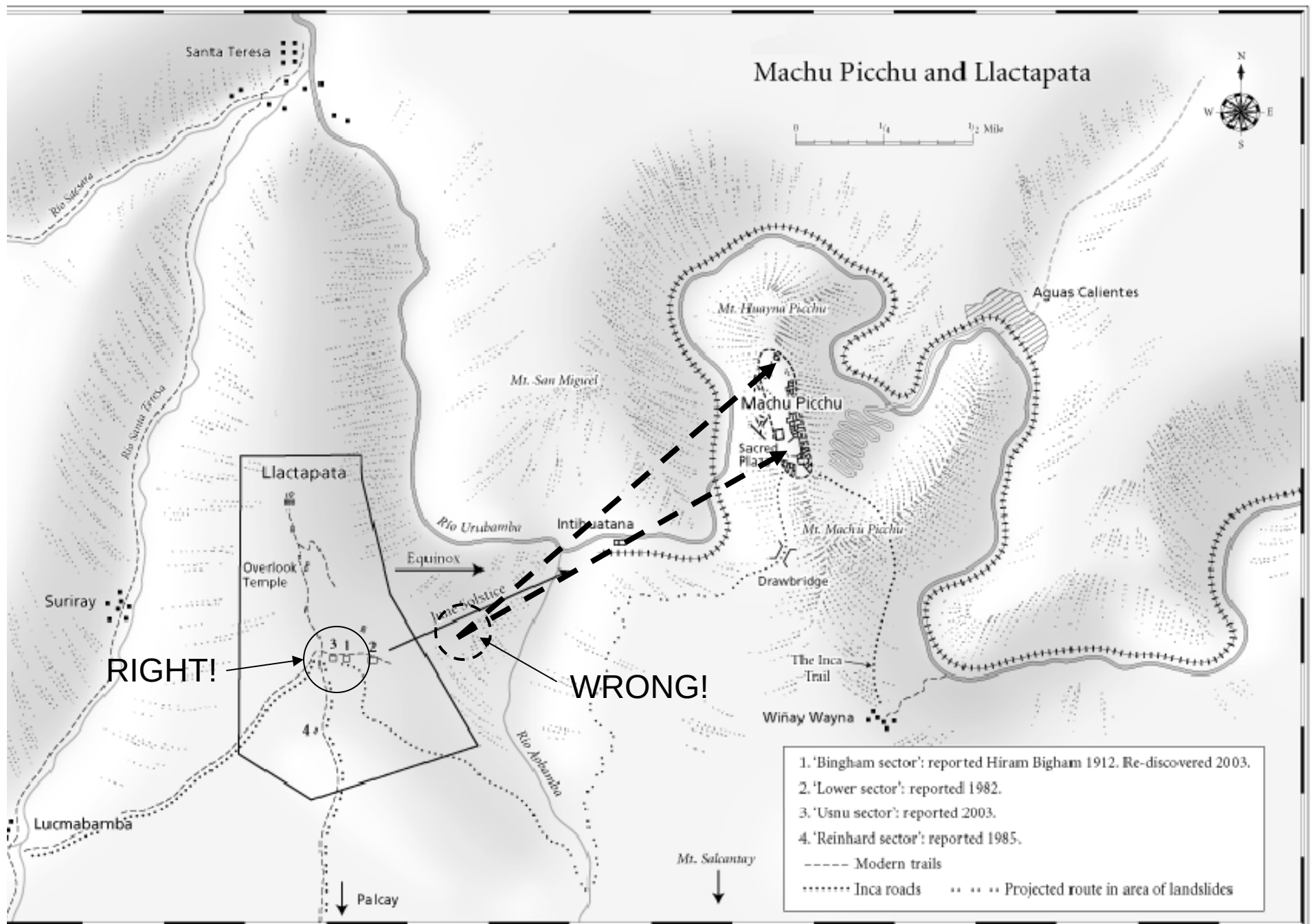
Machu Picchu as viewed from
Llactapata



In 2003 we thought we could easily find Llactapata because of compass bearings made by Hiram Bingham in 1910.

We triangulated using his old bearings, but we couldn't find it.

Magnetic declination had changed from 8° 5' E to 3°14' W during those 93 years, and we had not taken that change into account.



After two days of cutting through
the cloud forest we found it.



After clearing

View from
double-jamb
doorway to
Machu Picchu



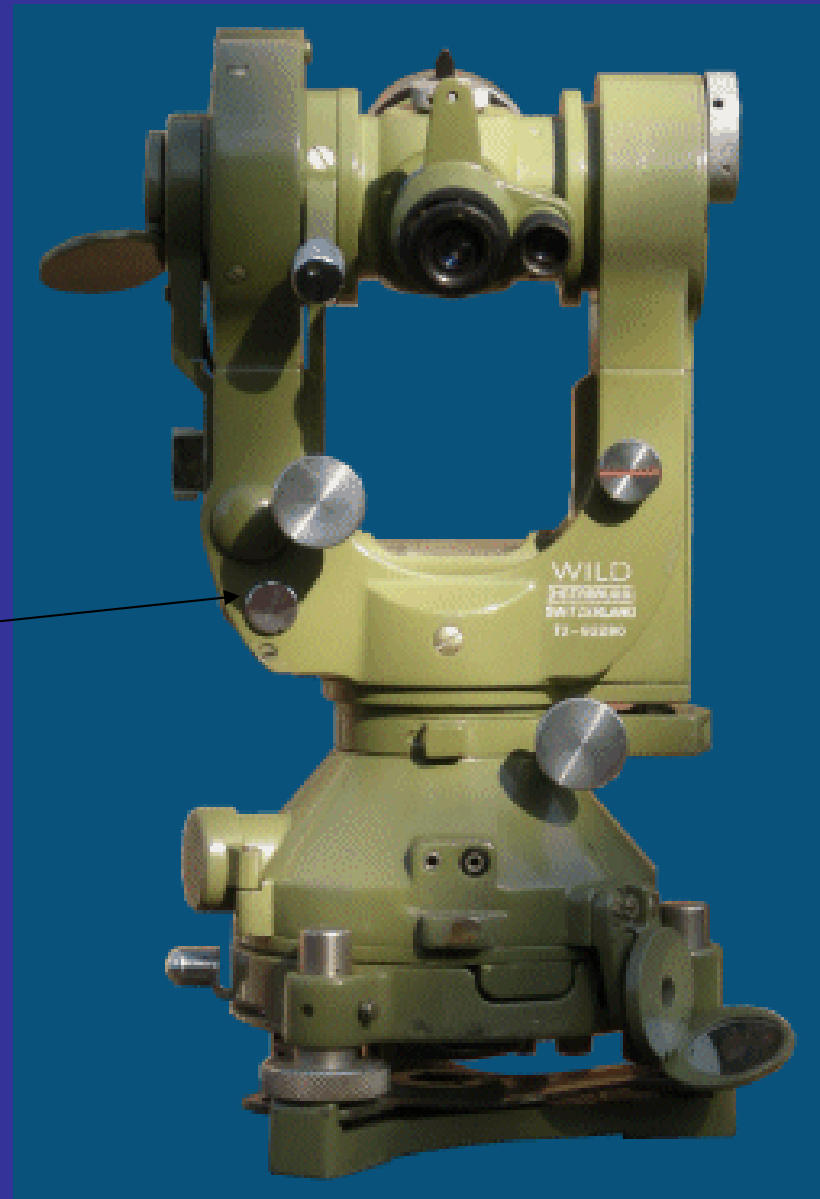
Long sightlines



- GPS errors of 5-10 meters can be compensated by measurements of end points of sightlines
- 1 km baseline with an error of 10 meters gives a precision of $\frac{1}{2}$ degree

Machu Picchu Llactapata

- 5300 meters separation
- Orientation measured by theodolite
- 3' difference between theodolite and GPS

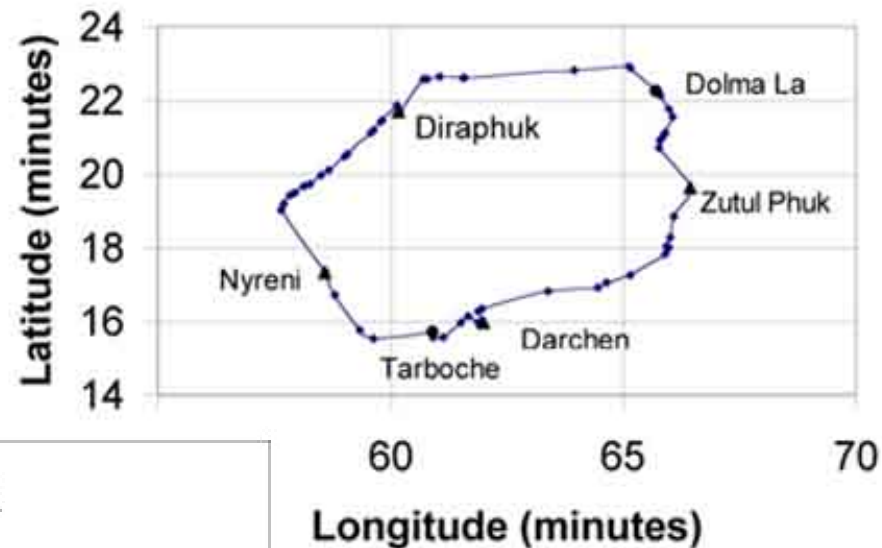


Mt Kailash, Tibet

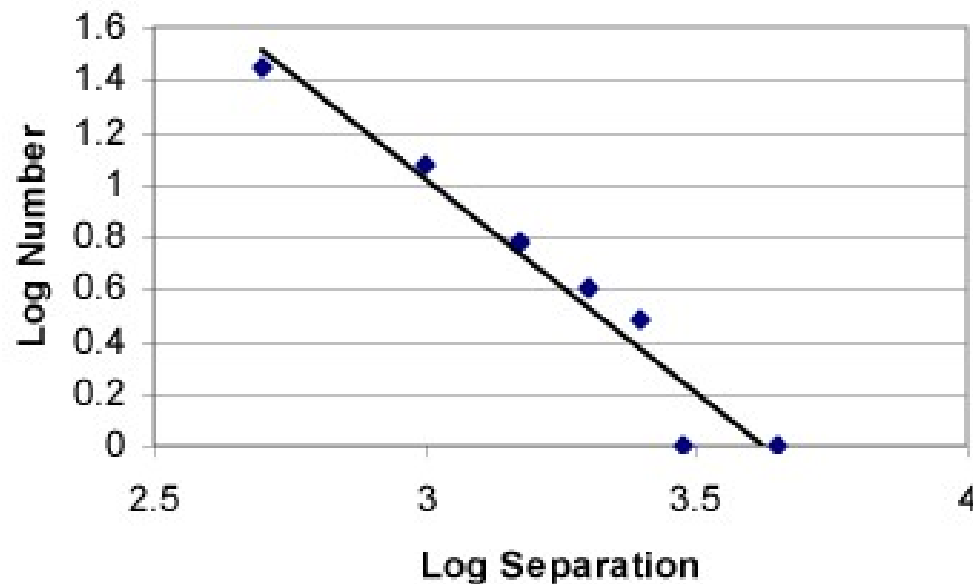


We talked
around the
mountain
measuring every
Buddhist shrine

Shrines and Gompas of the Kailash Kora

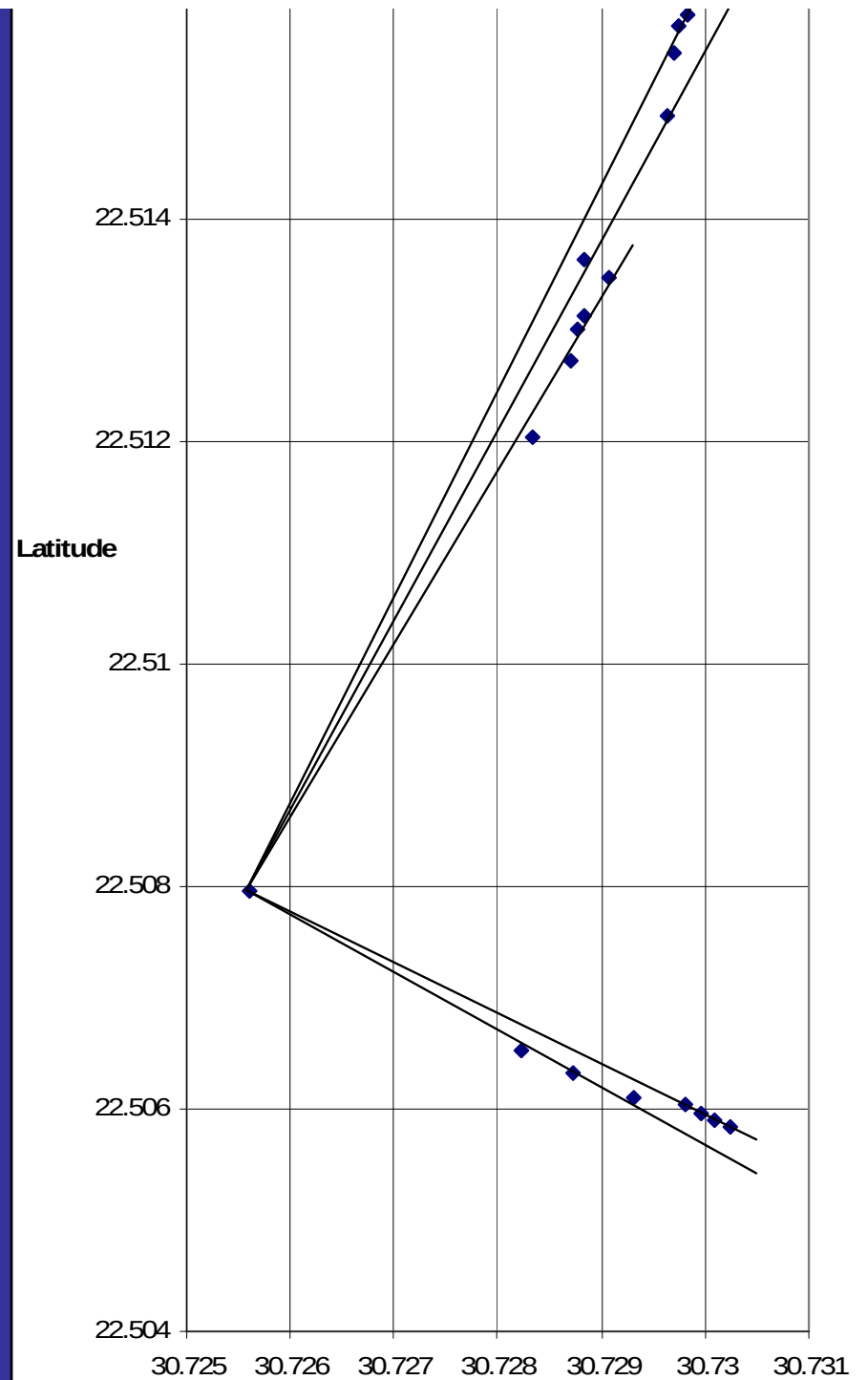


Shrines of Kailash Kora

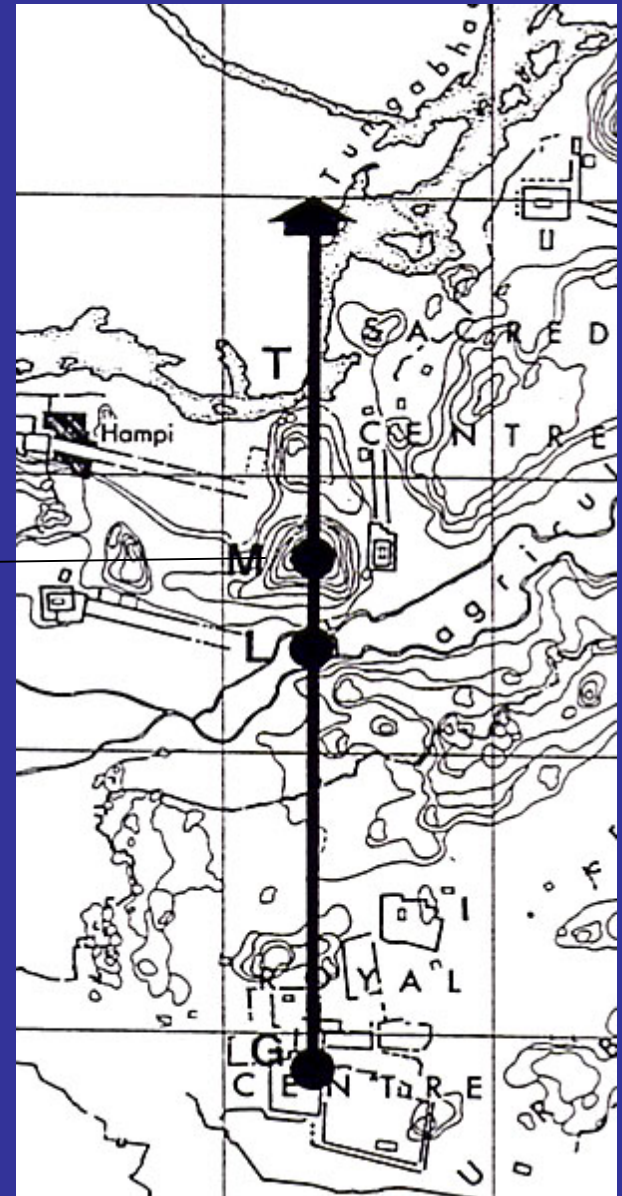
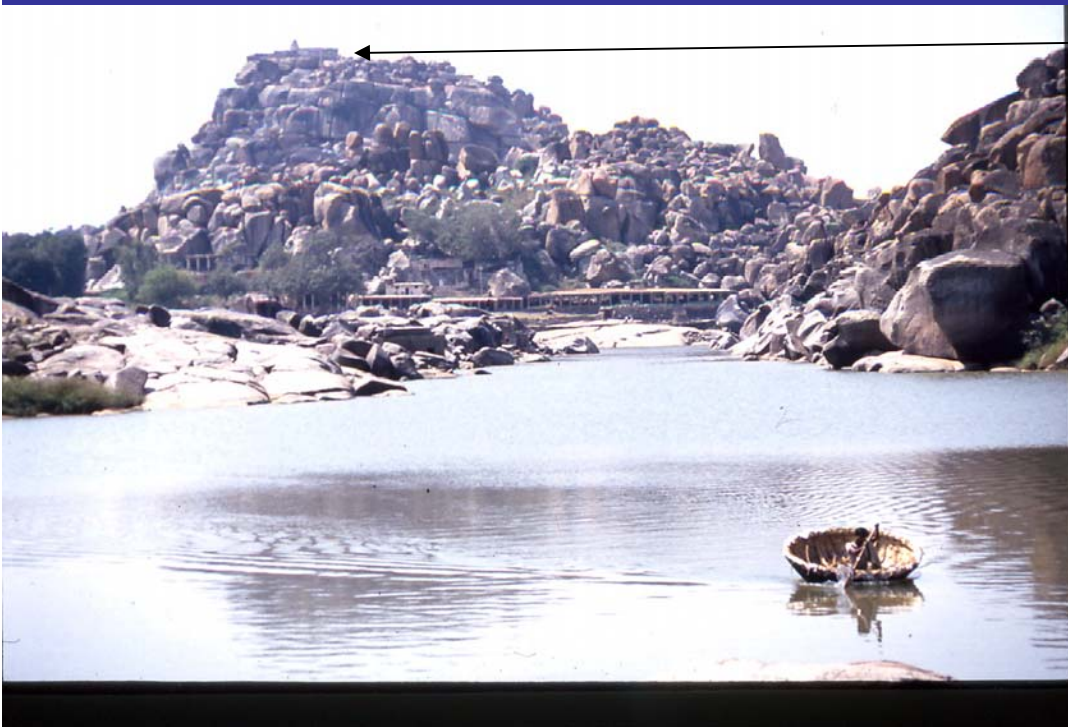


Their regularity is
evidence of self-
organized
complexity

Nabta Playa



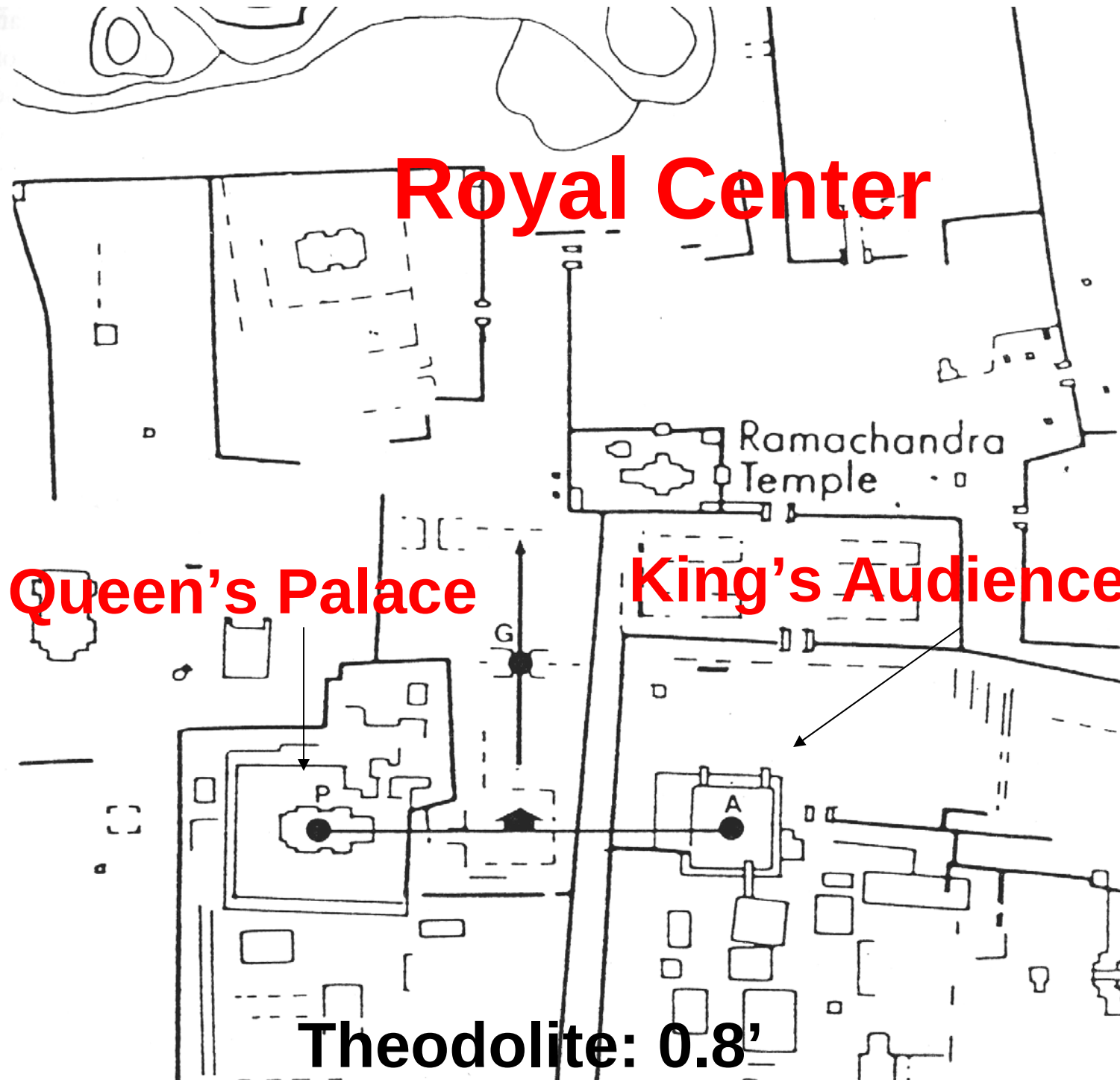
Vijayanagara, South India. Dominant North-South Axis



Royal Center

Queen's Palace

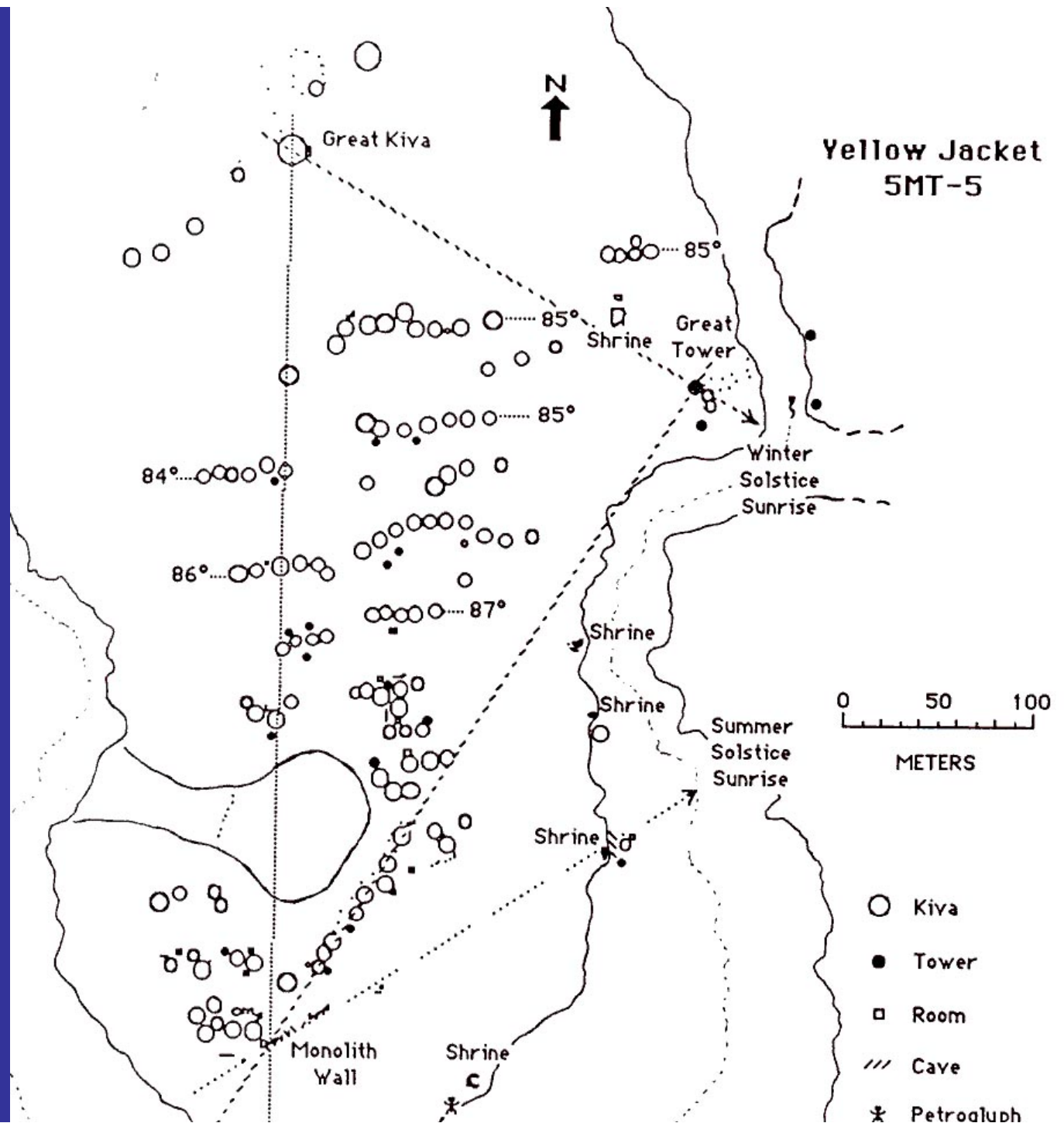
King's Audience Hall



Theodolite: 0.8'

Yellow Jacket Colorado

Largest
Ancestral
Pueblo
community
AD 900-
1300



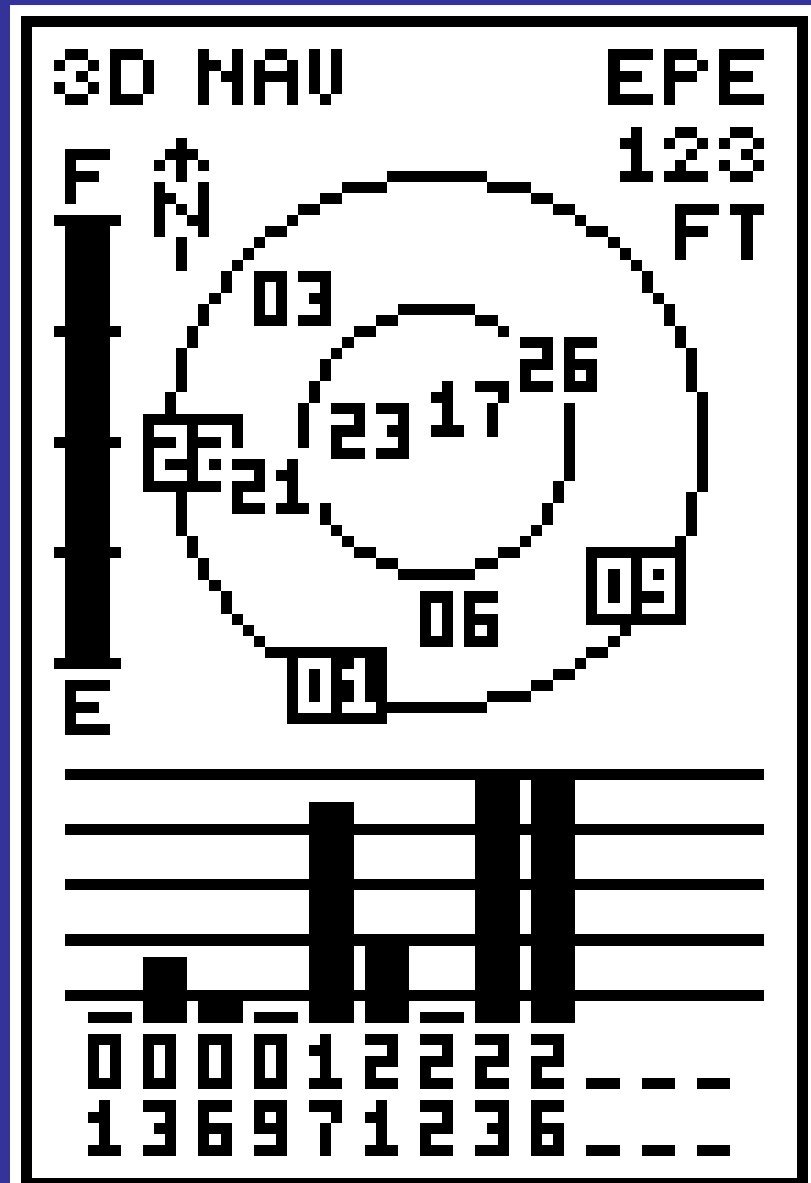
- **The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use.**

- **GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth.**
- **GPS receivers take this information and use triangulation to calculate the user's exact location.**
- **The GPS receiver compares the time a signal was transmitted by a satellite with the time it was received.**
- **The time difference tells the GPS receiver how far away the satellite is.**
- **More satellites, the better the determination of the position.**

Garmin 12XL

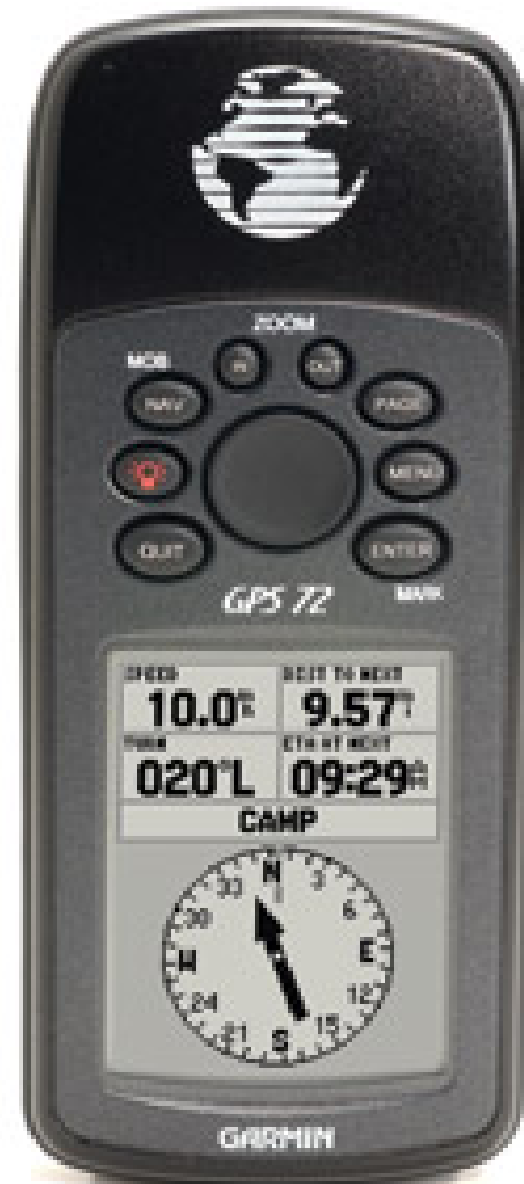
- \$50 or less on eBay
- Discontinued
- 9 meters 95% of the time
- 3-4 meters when averaging





Garmin 72

- \$130-\$99
- WAAS enabled in US giving 3 meters 95% of the time
- Floats!



Sources of Error

- **Start up uncertainty**
- **Ionospheric delays** - The signal slows as it passes through the atmosphere. The GPS system uses a built-in model that calculates an average amount of delay in an attempt to correct for this type of error.
- **Signal multipath** - This occurs when the GPS signal is reflected off objects such as tall buildings or large rock surfaces before it reaches the receiver. This increases the travel time of the signal, thereby causing errors.

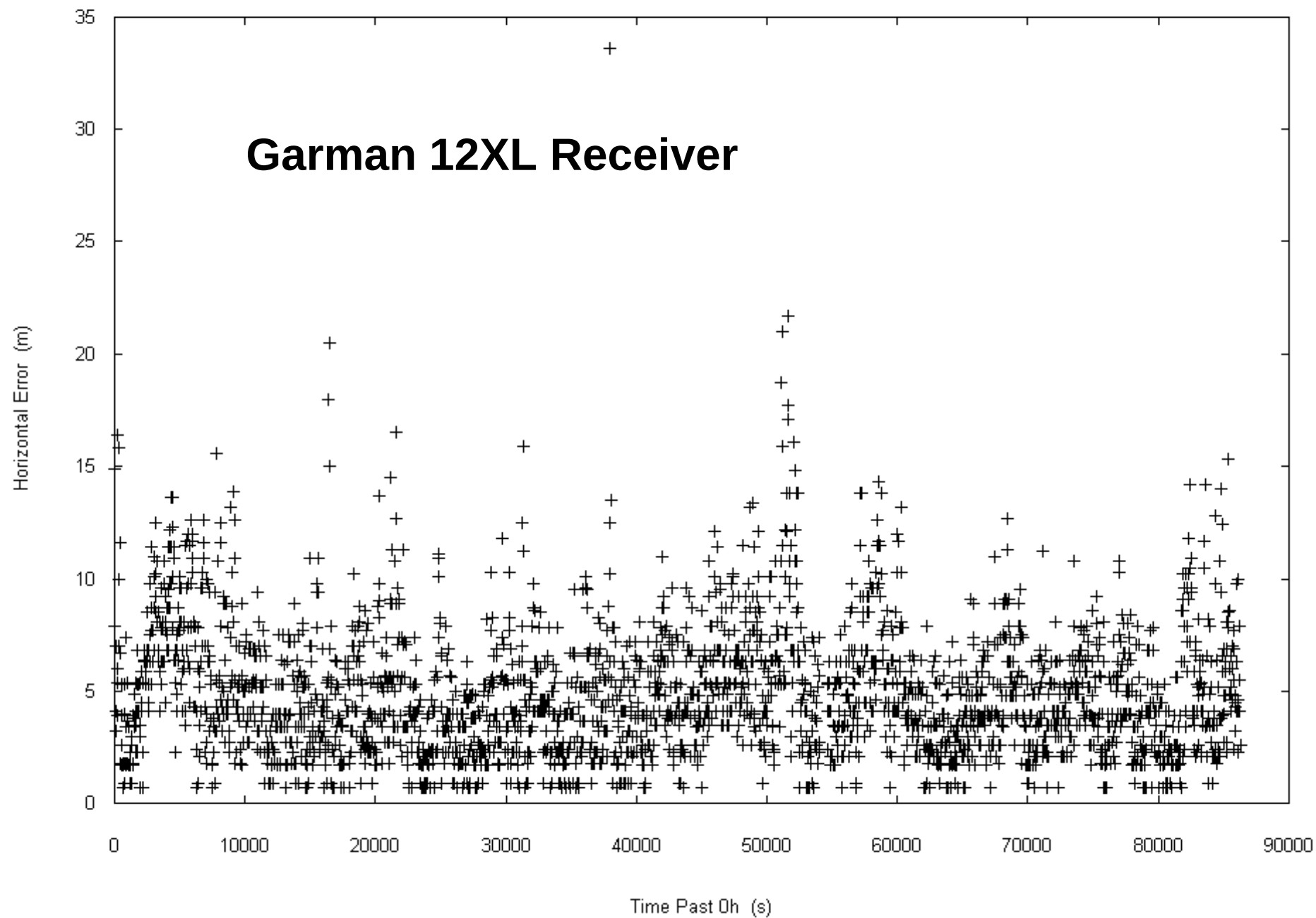
Sources of Error

- **Receiver clock errors** - A receiver's built-in clock is not as accurate as the atomic clocks onboard the GPS satellites. Therefore, it may have very slight timing errors.
- **Orbital errors** - Also known as ephemeris errors, these are inaccuracies of the satellite's reported location.

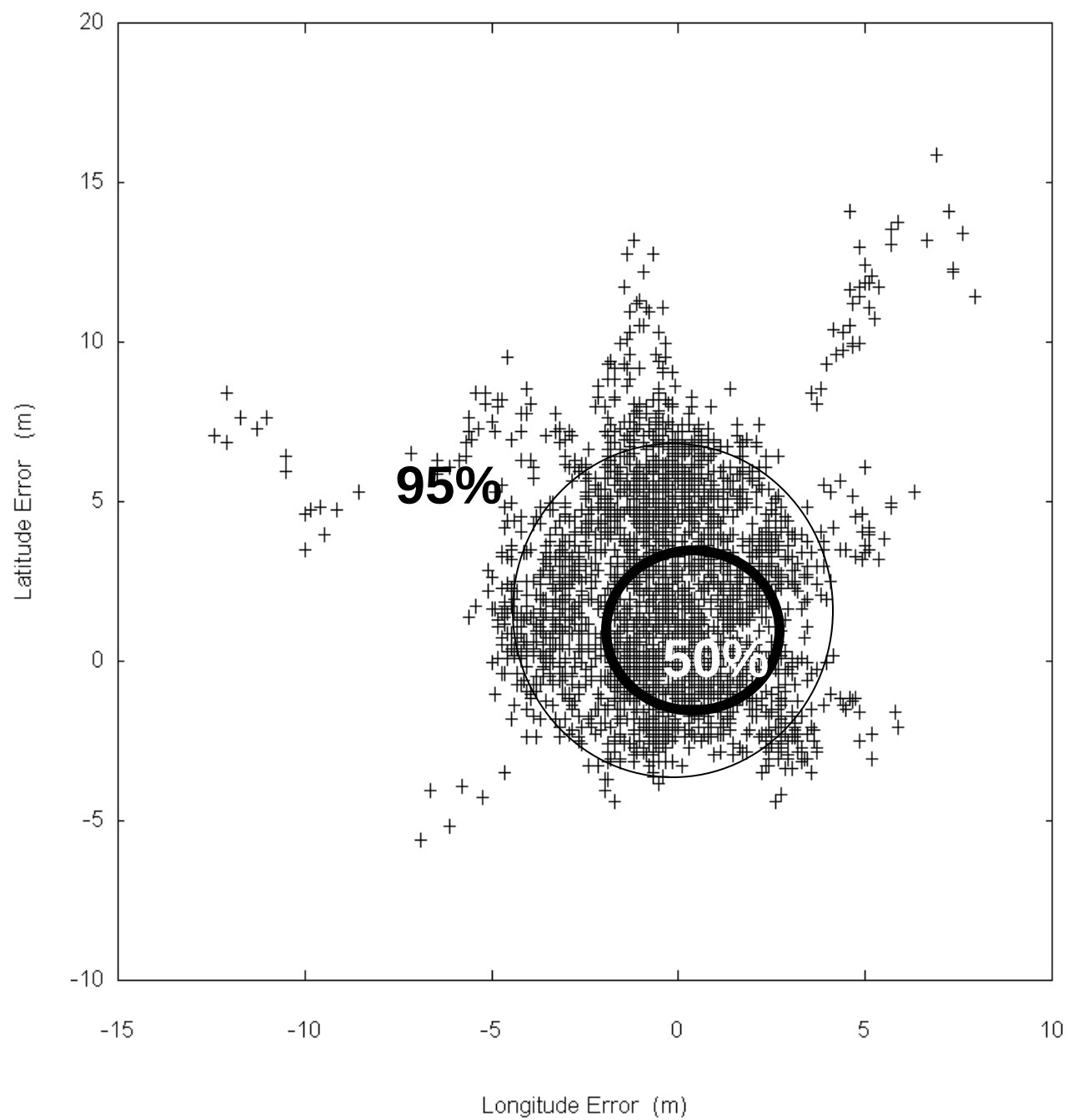
Sources of Error

- **Number of satellites visible** - The more satellites a GPS receiver can "see," the better the accuracy. Buildings, terrain, electronic interference, or sometimes even dense foliage can block signal reception, causing position errors or possibly no position reading at all. GPS units typically will not work indoors, underwater or underground.
- **Satellite geometry.** Ideal satellite geometry exists when the satellites are located at wide angles relative to each other. Poor geometry results when the satellites are located in a line or in a tight grouping.

Attic #2 -- May xx, 2001, Garmin 12XL



ERLA -- May 3, 2000, Single Freq., No Model



Averaging reduces error

