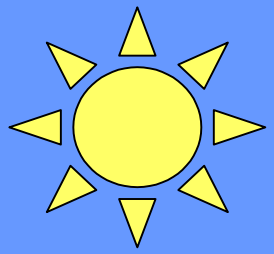


Error Analysis of Garden Variety Sundials

Roger Bailey

NASS 2003 Banff

Walking Shadow Designs

Garden Variety Sundials

- Universal designs
- Standard latitude
- Poor construction
- Poor installation
- No Longitude correction
- How bad are they?
- How can you correct the errors?

Error Analysis

- Error due to Latitude difference
  - Determine design latitude
  - Error magnitude
  - Tilt Correction
  - Gnomon only correction
- Orientation: Twist for Longitude Correction
- Artistic dials with arbitrary gnomon and experimental hour points

Sundial of Hope, Riley Park

- Historic ~ 1930 sundial
- Sundial disappeared long ago
- Child Find Alberta provided a new "*Sundial of Hope*" in 1993 to mark 10th anniversary
- Repeatedly vandalized
- Gnomon disappeared
- Replacement proposed to mark NASS 10th anniversary

Errors in "Sundial of Hope"

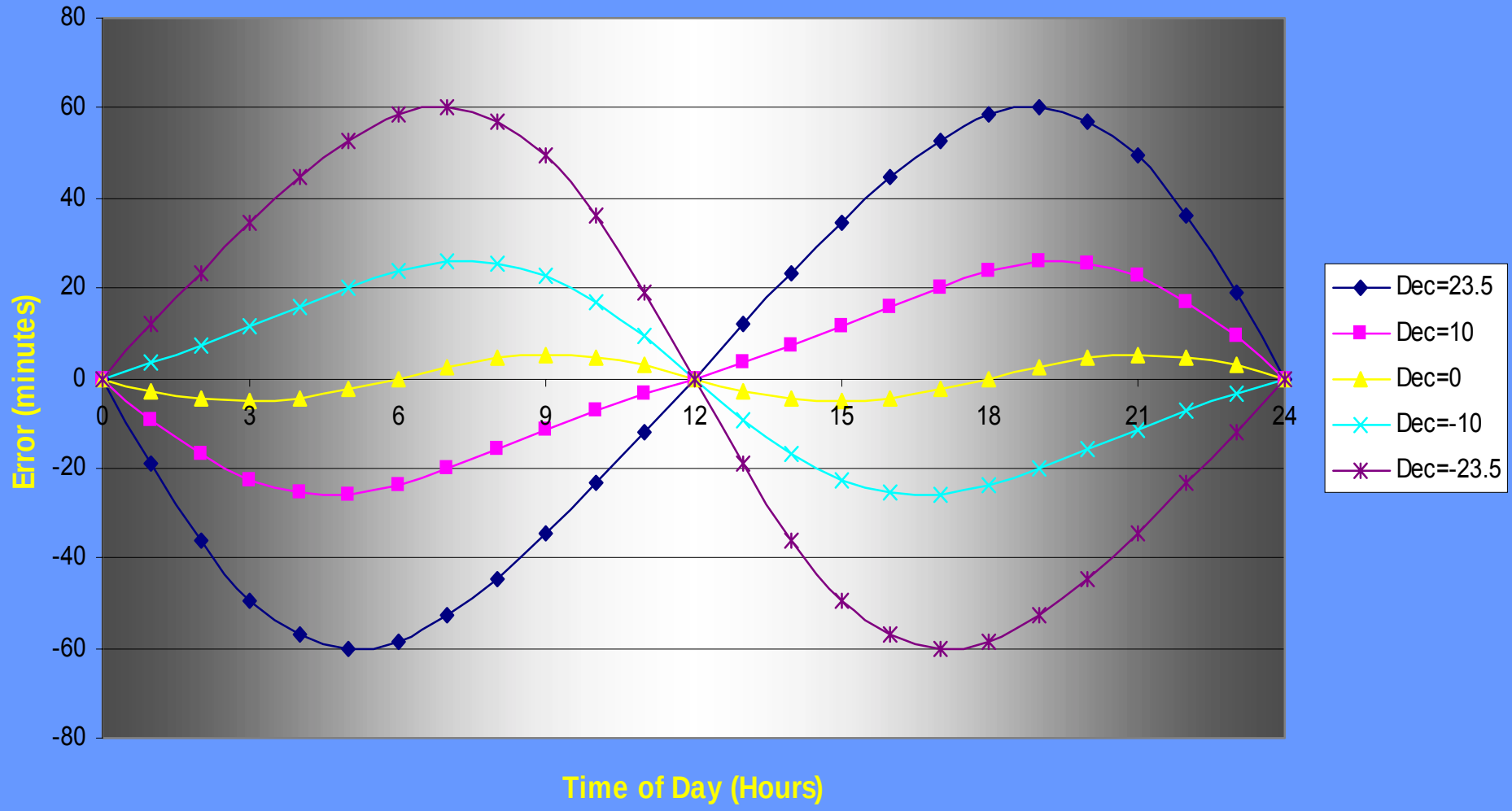
- Designed for Latitude 42° vs 51°
- Aligned wrong to correct for longitude of 114° vs 105° (36 minutes)
- Fragile gnomon

	Design 42
Time	Hour Angle
0	0.0
1	10.2
2	21.1
3	33.8
4	49.2
5	68.2
6	90.0

"Error in a Misplaced Dial"

- Derivation by F. W. Sawyer NASS 1-4 Dec 94
- Error varies with difference in latitude, time and solar declination
- Tan T_2=Sin T/(Cos T Cos M+Tan D SinM) where M = L-L_2 the difference in Latitudes
- Spreadsheet used to calculate and plot the results for M = 51-42 or 9°
- Errors are large, over an hour, mid morning and afternoon on the solstices

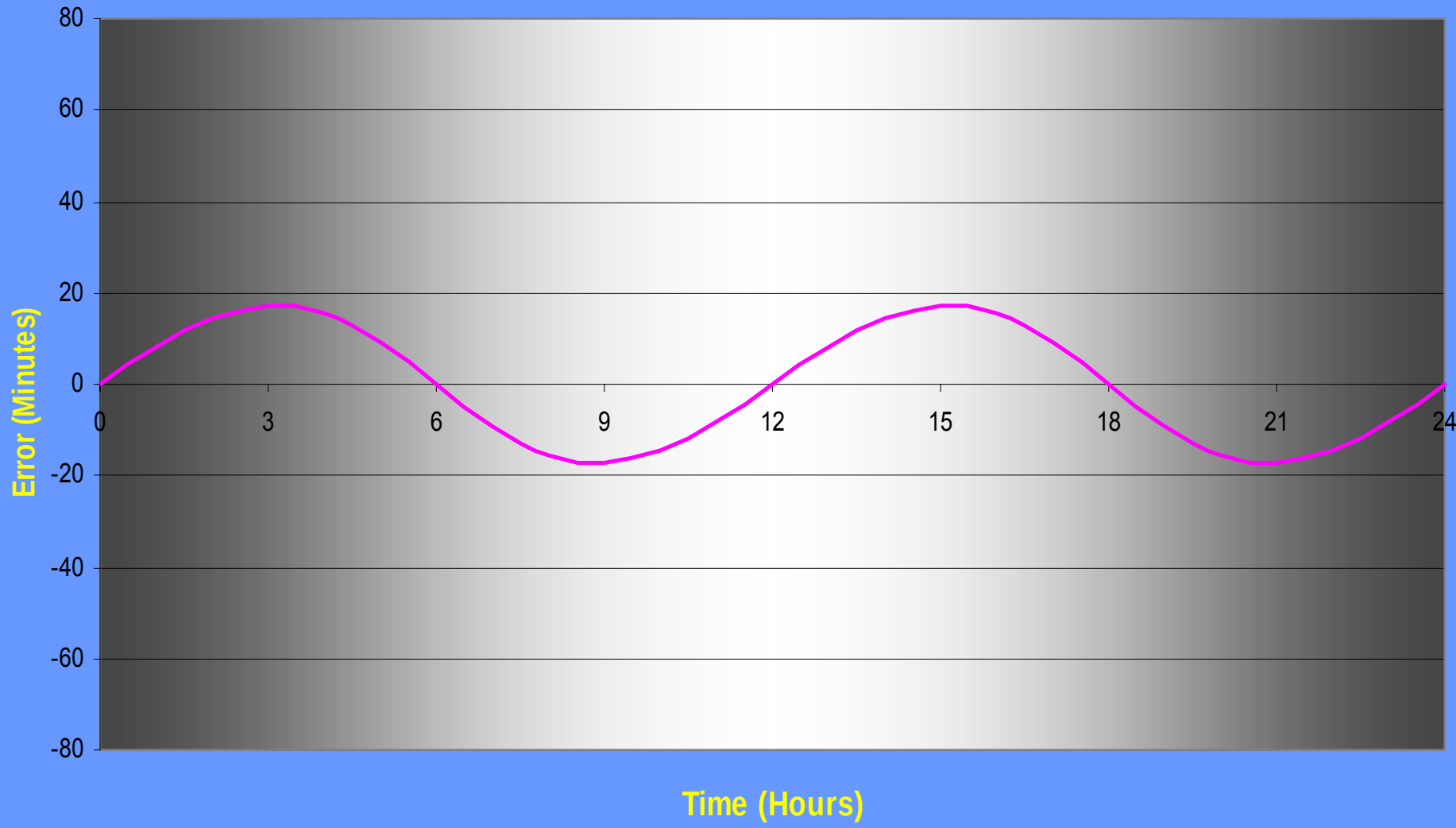
Error Due to Latitude Difference



Replace the Gnomon?

- Tilting the dial corrects for the latitude difference but it looks strange
- How much is the error reduced by just correcting the angle of the gnomon
- Hour angles on the base uncorrected
- Again the results for M = 9° are calculated and plotted with a spreadsheet
- Error is reduced by factor of 3 to ~ 20 minutes for the worst case

Gnomon Angle Correction

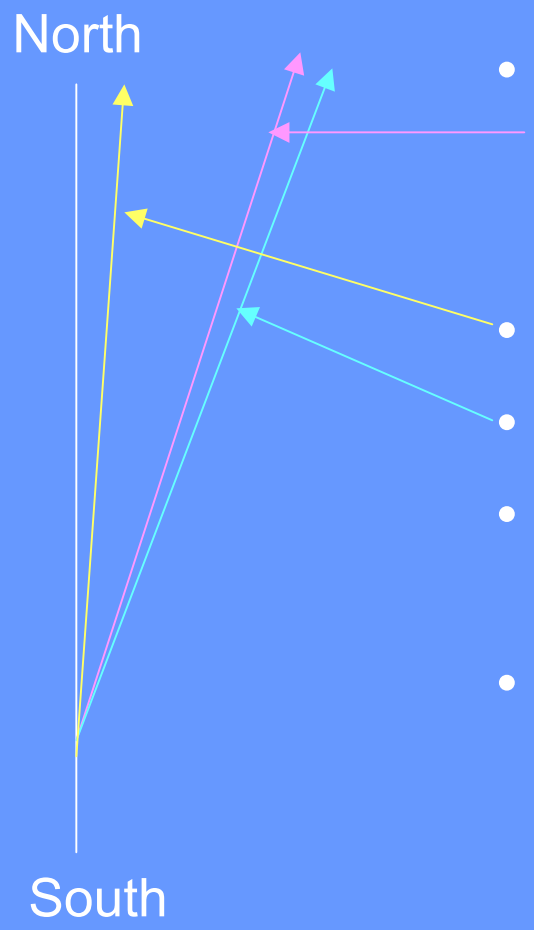


Alignment Errors

Az @ 1:25 MST 18 Feb = 10°
Az indicated @ 1:15= 17°

- Sundials are often twisted from the North south axis to correct for longitude
- Correction typically applied at noon
- Riley Park dial misaligned ~7° for 9 ° or 36 minute longitude correction
- How great is the error?

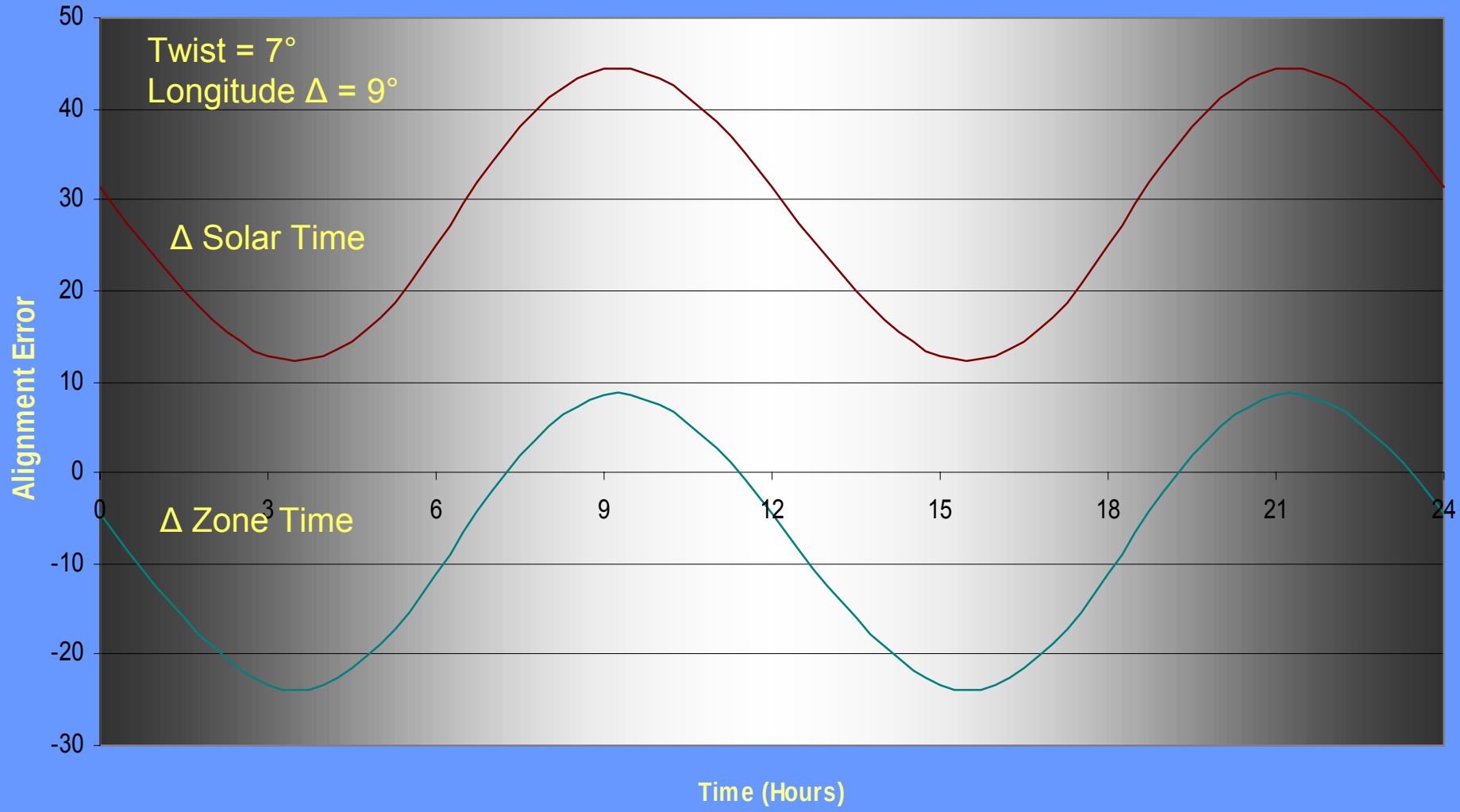
Analysis of Longitude Twist



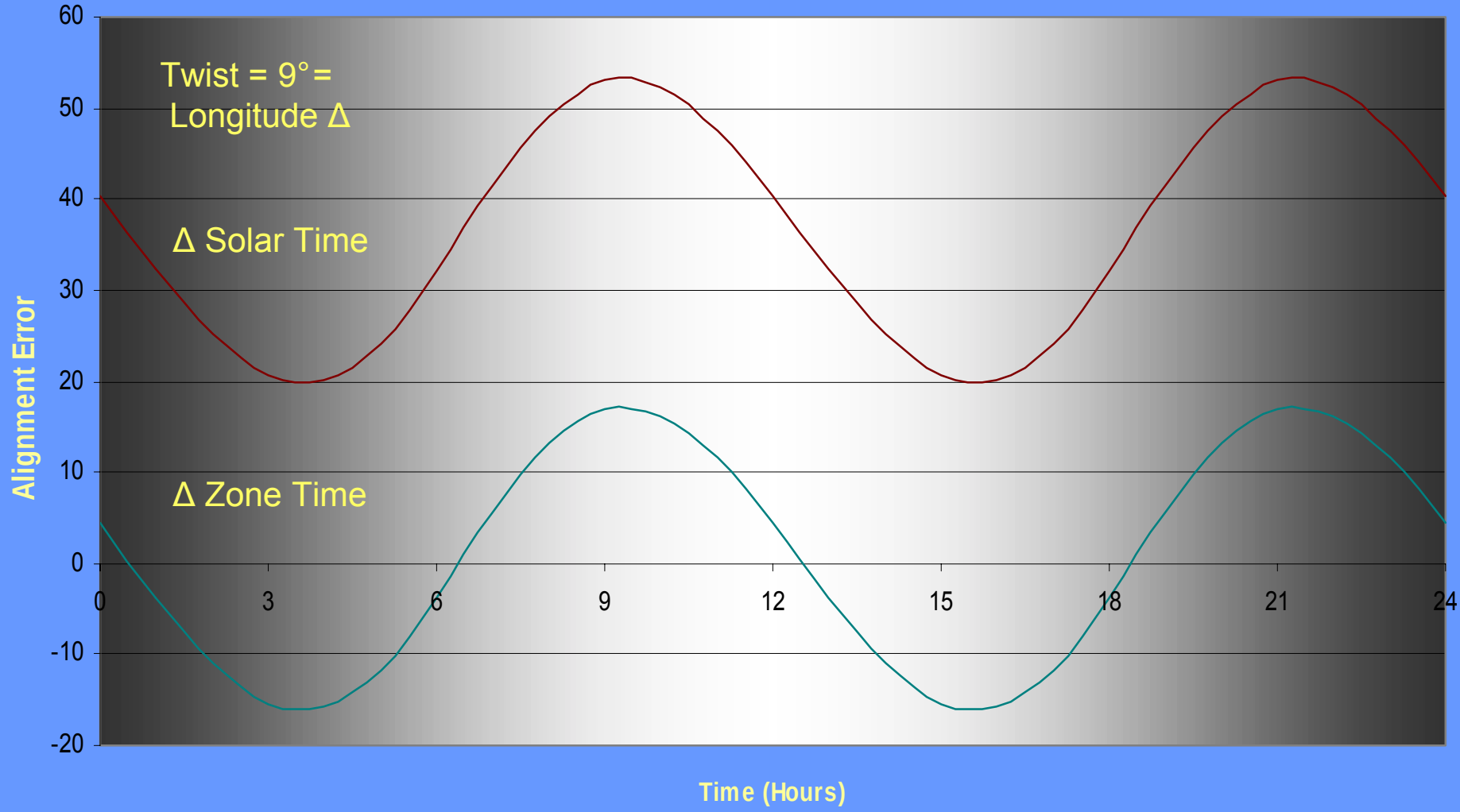
- Calculate Hour Angles for time angles

  Tan HA = Sin Lat x Tan t
- Add Twist to Hour Angles
- Recalculate "corrected" time angle
- Plot difference from solar zone and local solar time
- Ref: "Error Analysis of the Horizontal Sundial VI" Lauroesch & Edinger NASS 3-4 1996

Rotation to Correct for Longitude



Rotation to Correct for Longitude



Conclusions on Longitude Twist

- Time angle is linear, hour angle is not
- Error is introduced by twisting hour angle vs time angle
- For Riley Park dial, maximum error is ~ 18 minutes, dial fast, at mid morning and dial slow, mid afternoon
- Analysis ignores gnomon twist which is a function of declination
- Do errors interact?
- Gnomon correction gives 20 minute dial slow mid morning and dial fast, mid afternoon!

Options for "Sundial of Hope"

- Do nothing? No! Errors are over an hour
- Tilt the dial? No! Aesthetics bad.
- Change the gnomon? Perhaps. Must be replaced. Errors are reasonable.
- Change the dial? Yes. Base needed to be aligned
- Replacement was the best option for the Riley Park dial

Local Artistic Sundials

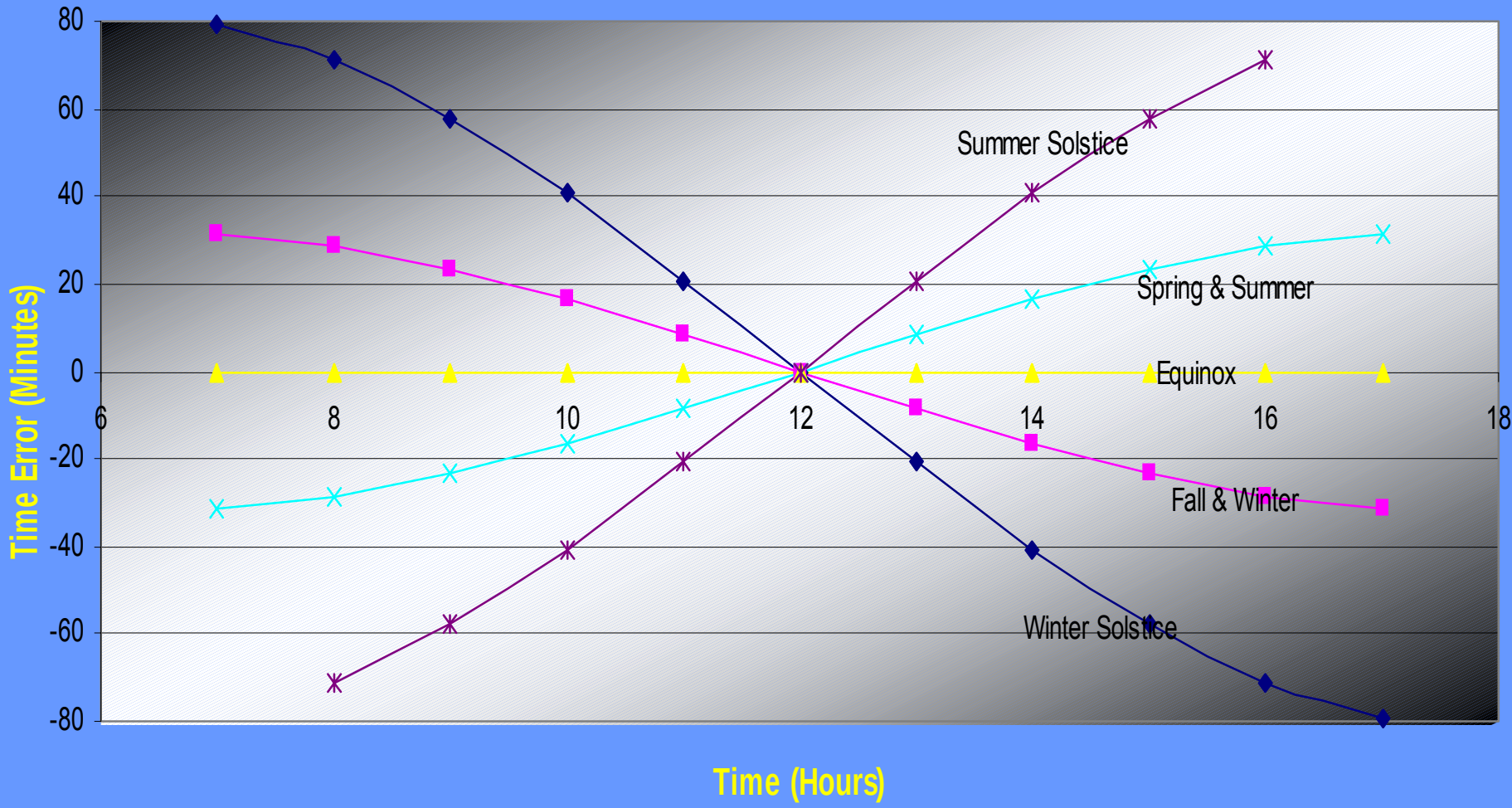
Furhman Dial by G.Gaber

- Local sundials are commonly painted on site with hours determined experimentally
- Time is correct for the day when the dial was set
- Gnomon placement is arbitrary, based on aesthetics, often vertical
- What are the typical errors for such dials?

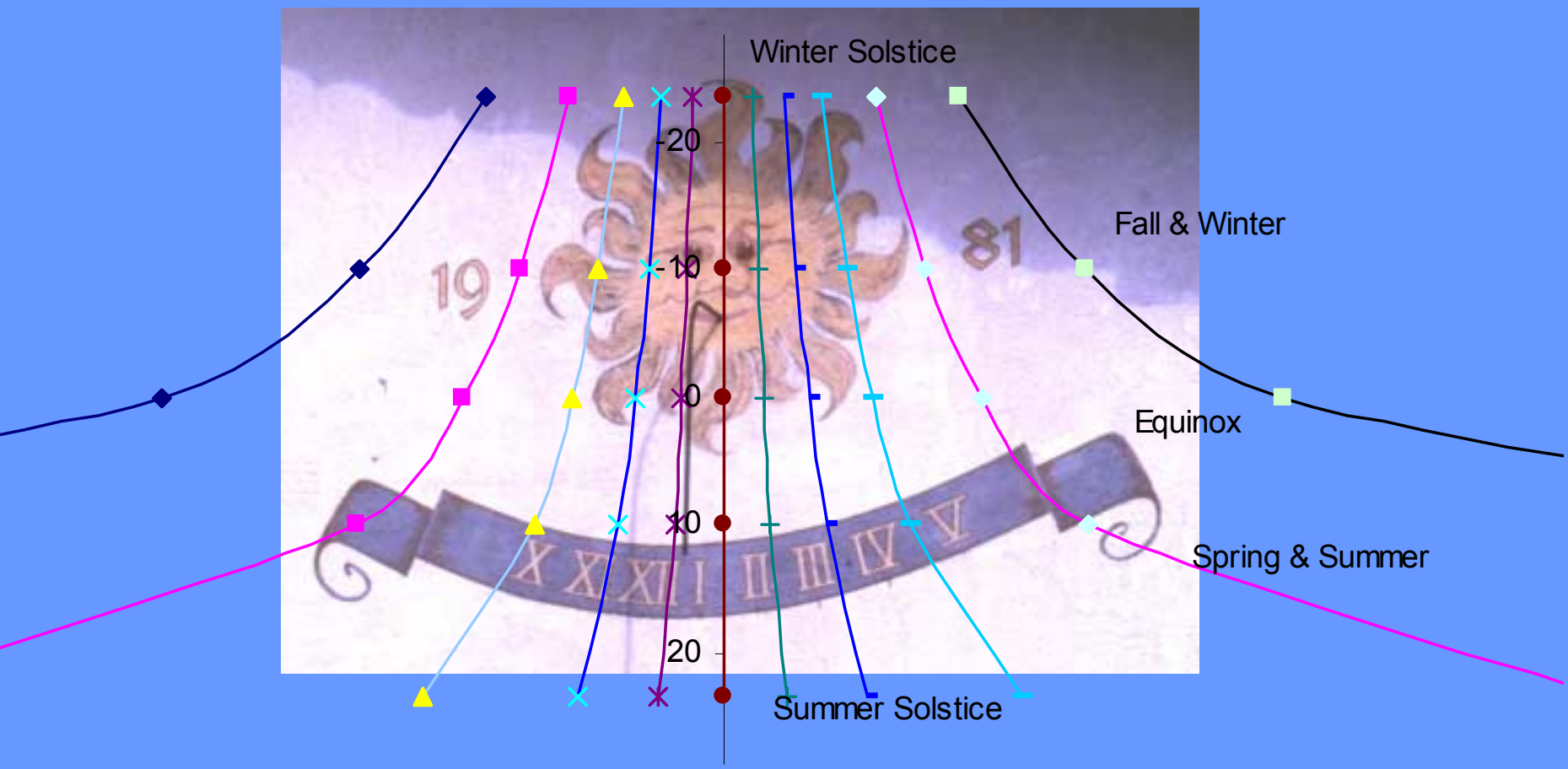
Azimuthal Sundial

- Wapiti House B&B Canmore
- European Alpine style
- Dial painted by Gustov Garber in 1981
- Gnomon is vertical
- Hours scale experimental
- How much error with declination changes?
- Change to a polar gnomon?

Azimuthal Dial Errors



Azimuth Changes With Seasons



Local Artistic Dials

- Gustov Gaber of Banff painted attractive sundials
- Experimental hour points are OK for spring and summer
- Artistic style fits with regional architecture
- Technical corrections inappropriate