A SOFTWARE CODE FOR DESIGN AND SIMULATION OF SUN DIALS

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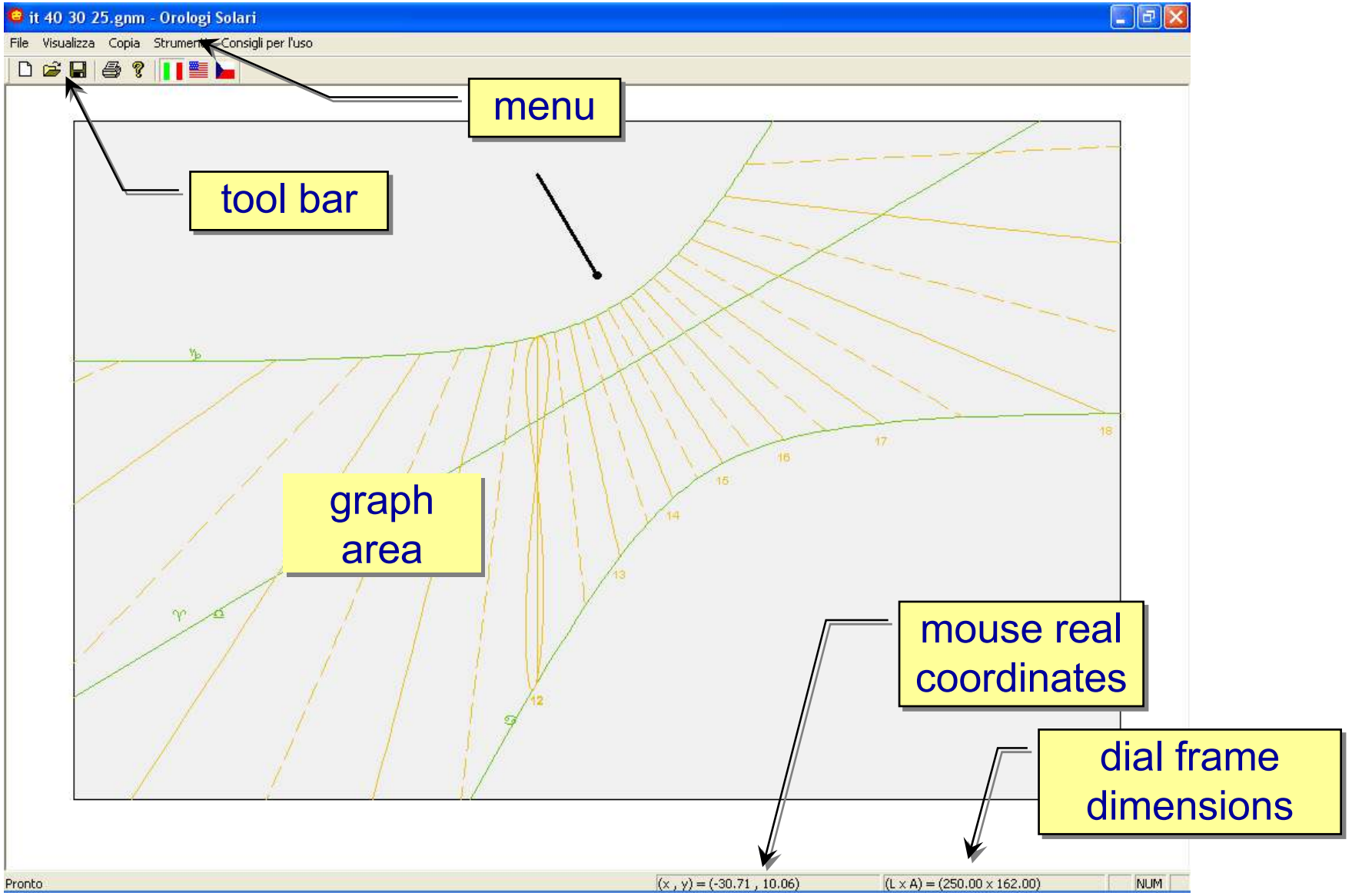
anni di Seminari

Program features

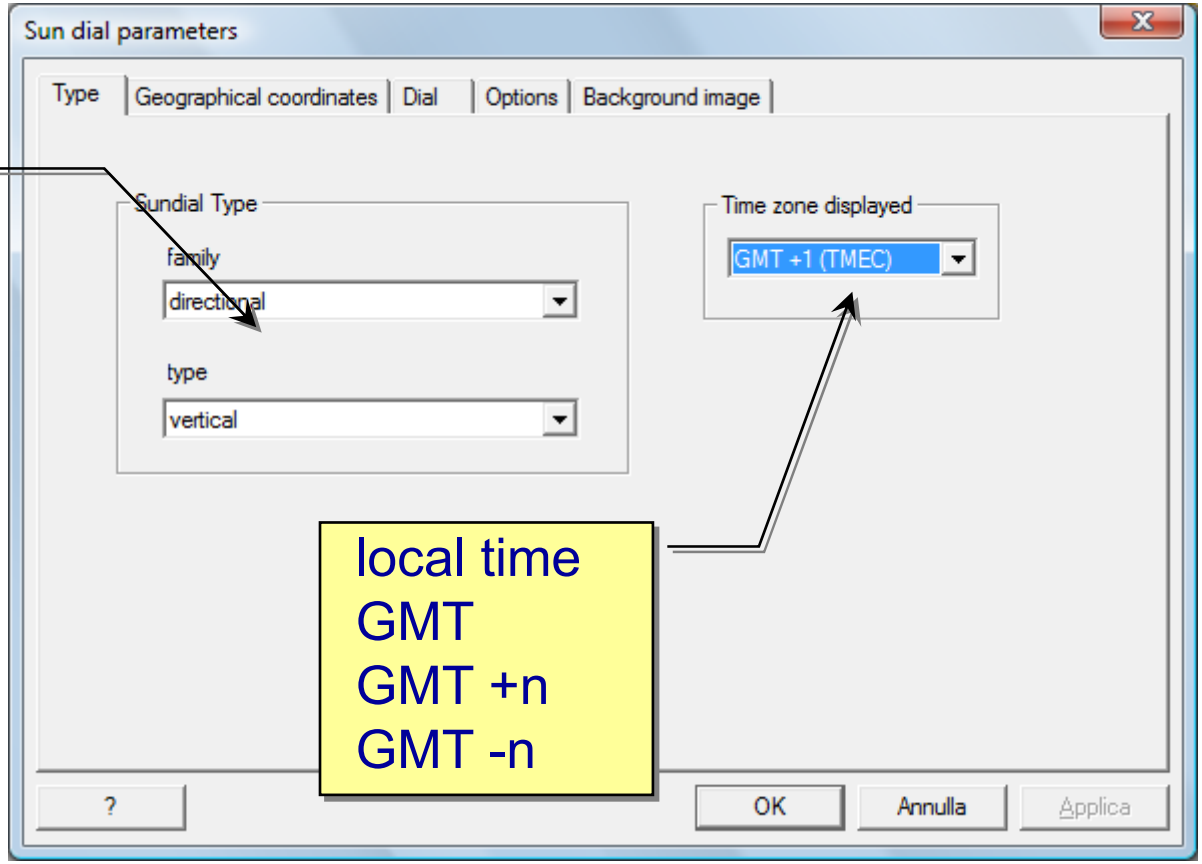
- Operating System : XP / 2000 / Vista (WINE compatible)
- directional and azimuth dials
- hour lines and day lines design
- graph export to vector / raster file
- shadow simulation
- reverse engineering of existing dials
- freeware

User interface

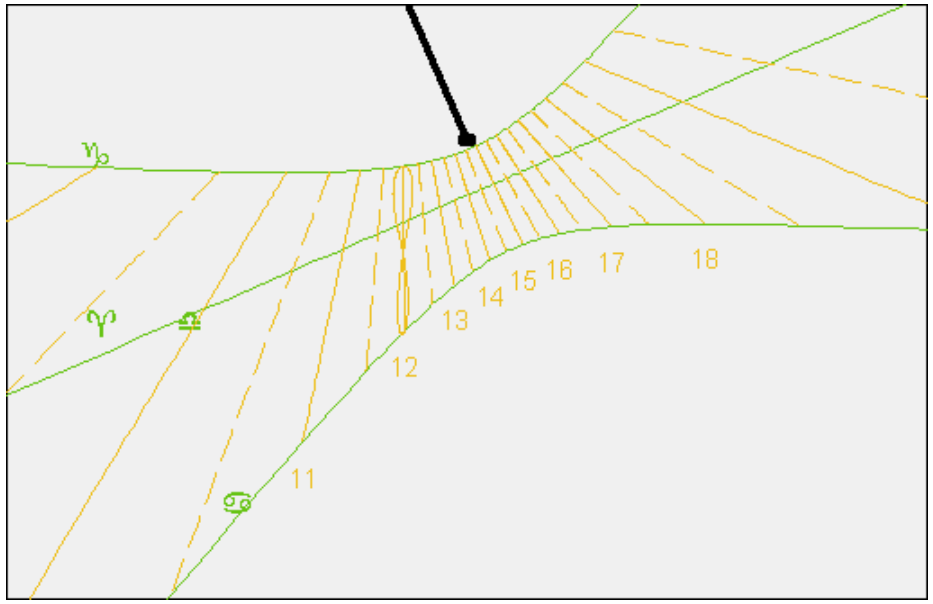


Definition of a new dial : type

family :
- directional
- azimuth



Dial types



directional :

- **inclined declining**
- vertical declining
- horizontal
- polar
- equatorial

azimuth :

- horizontal analemmatic
- verticale declining analemmatic
- horizontal ortographic projective
- vertical declining ortographic projective
- horizontal stereographic projective
- vertical declining stereographic projective

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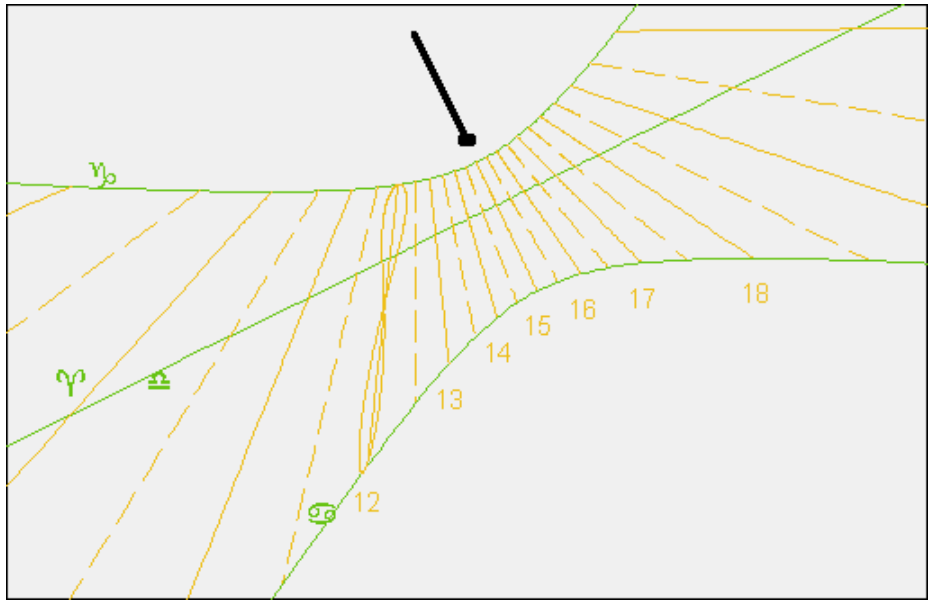

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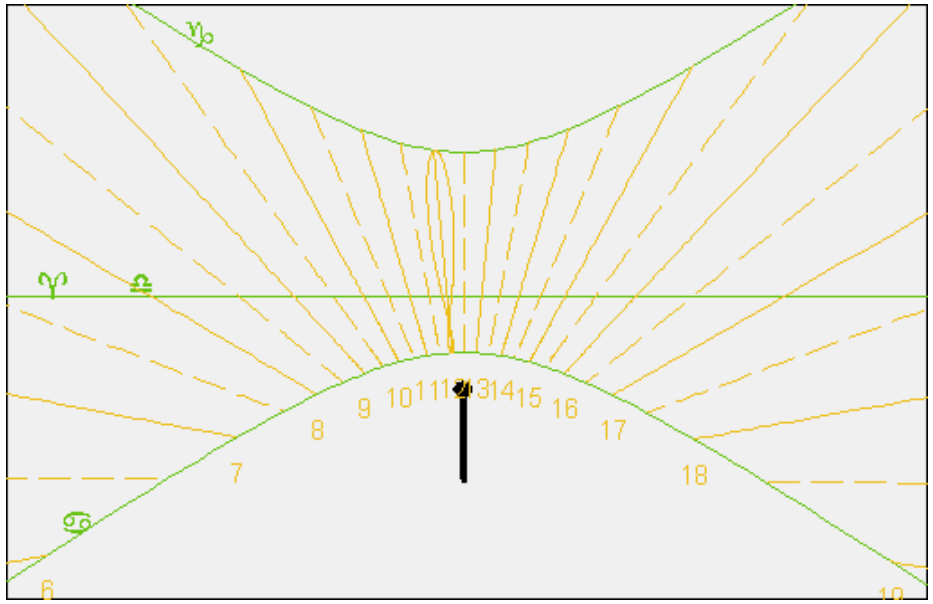

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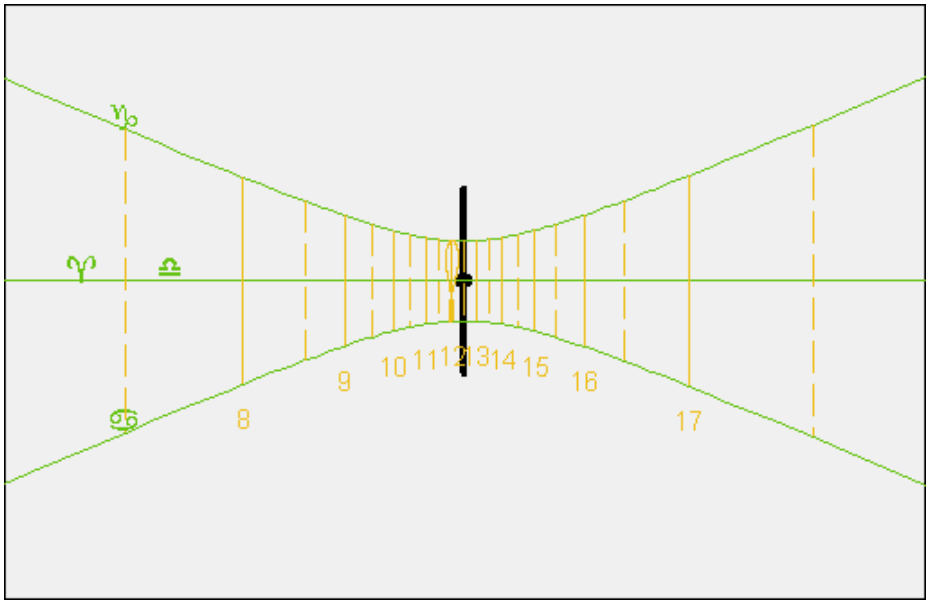

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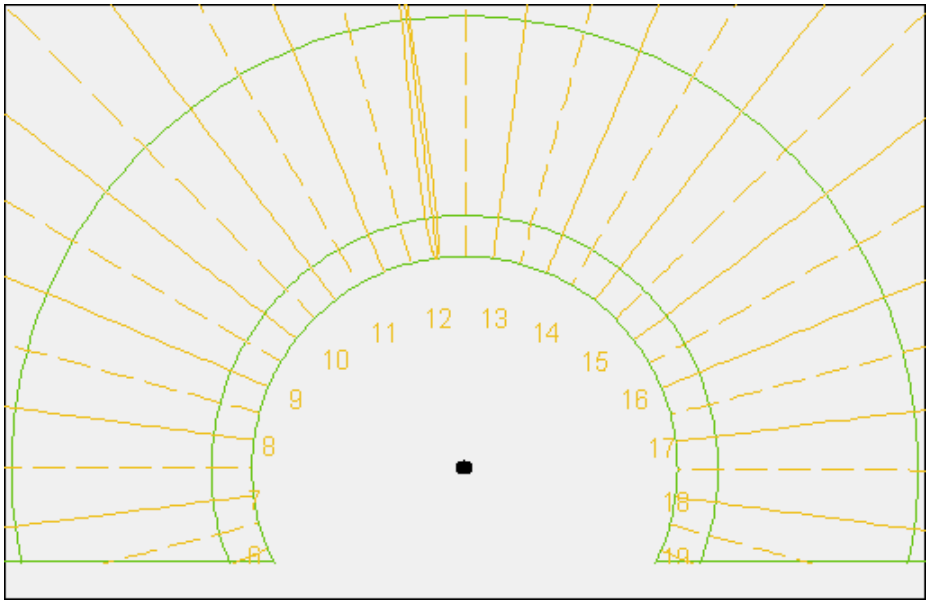

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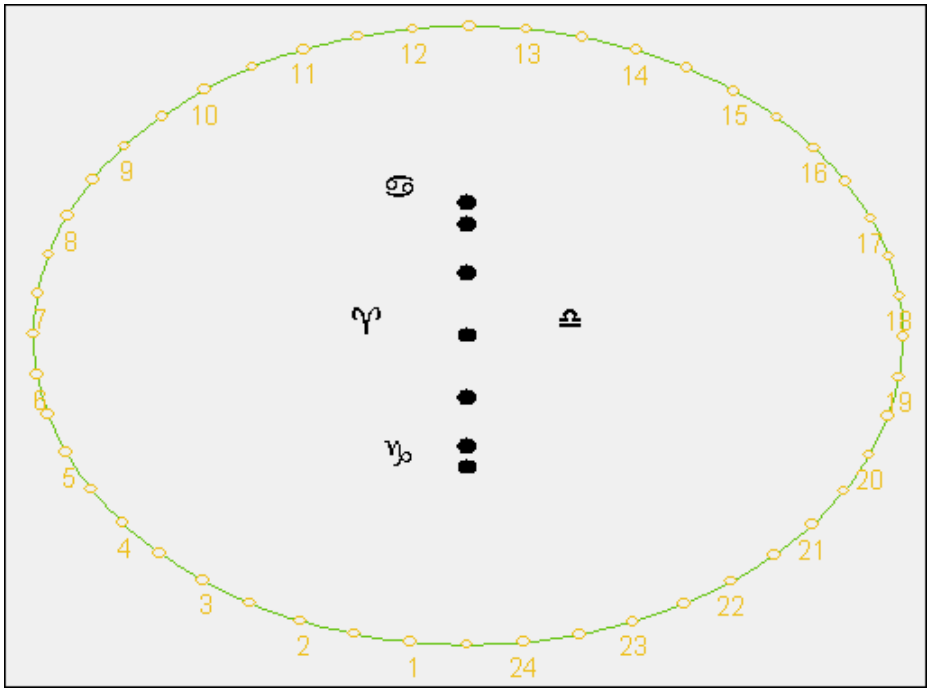

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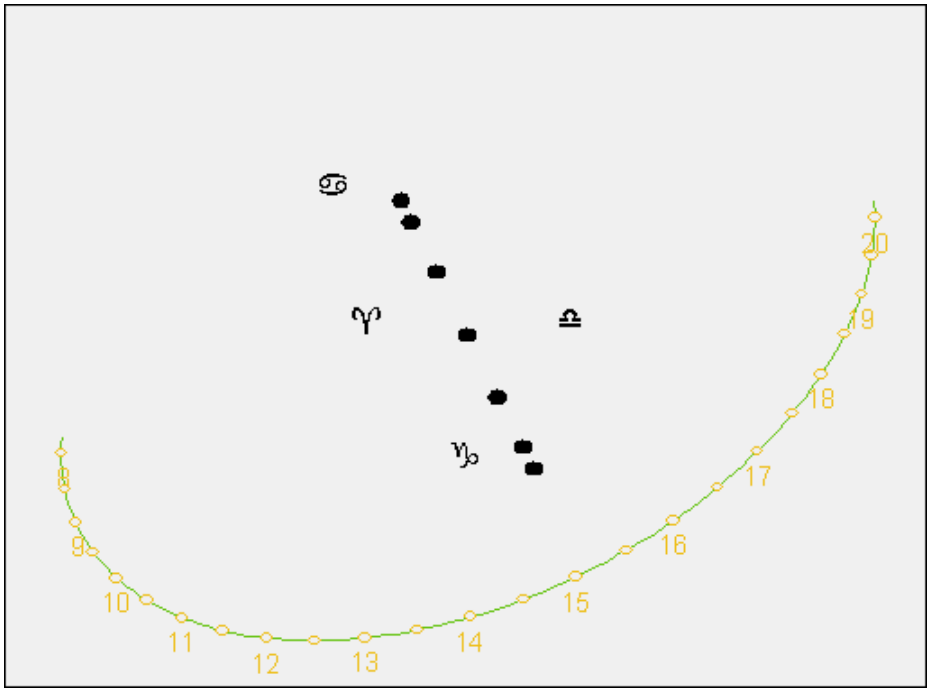

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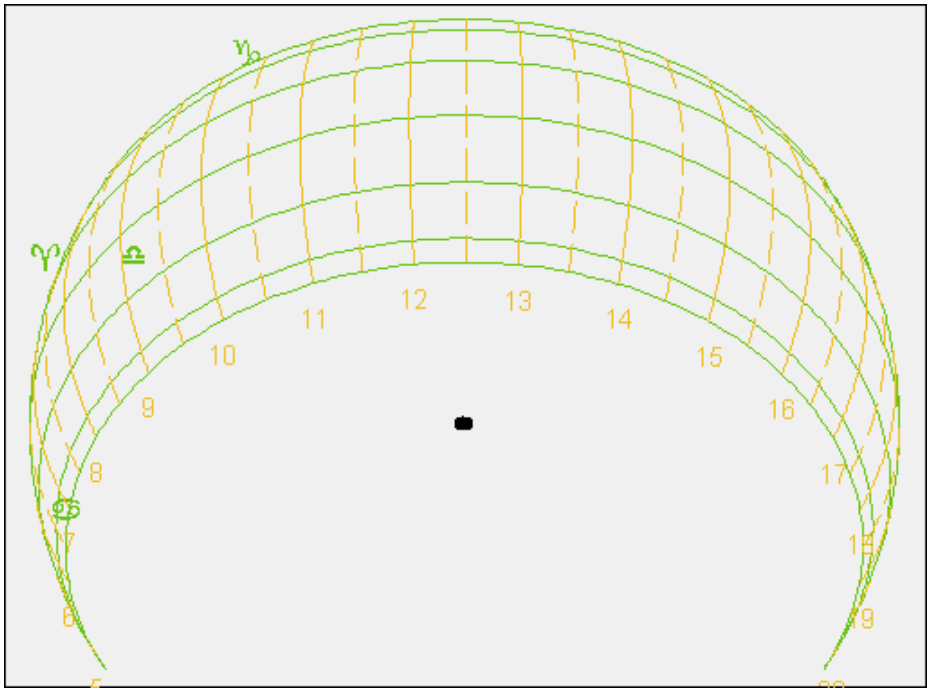

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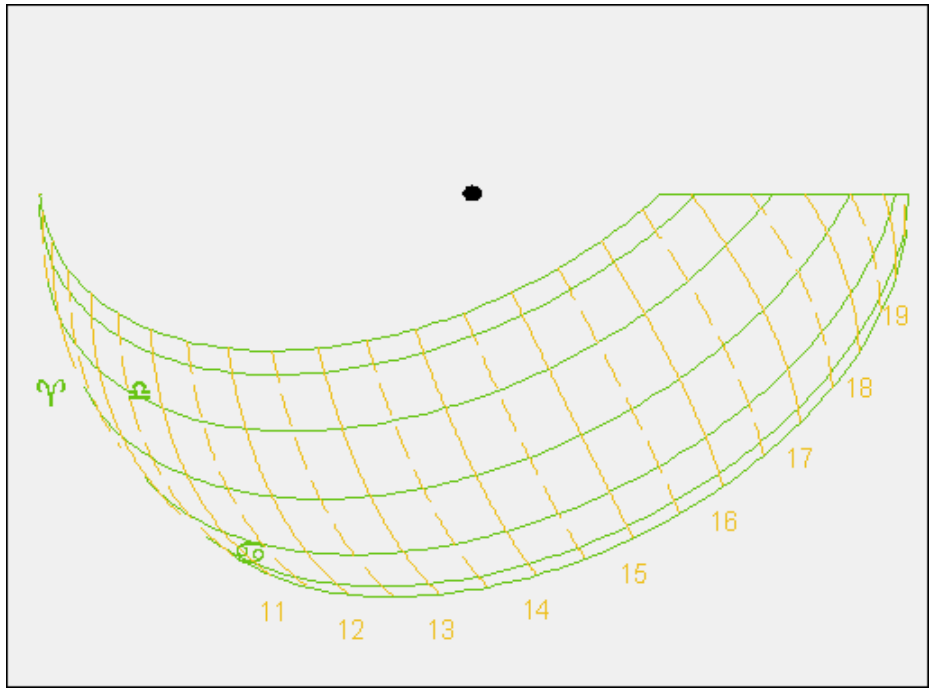

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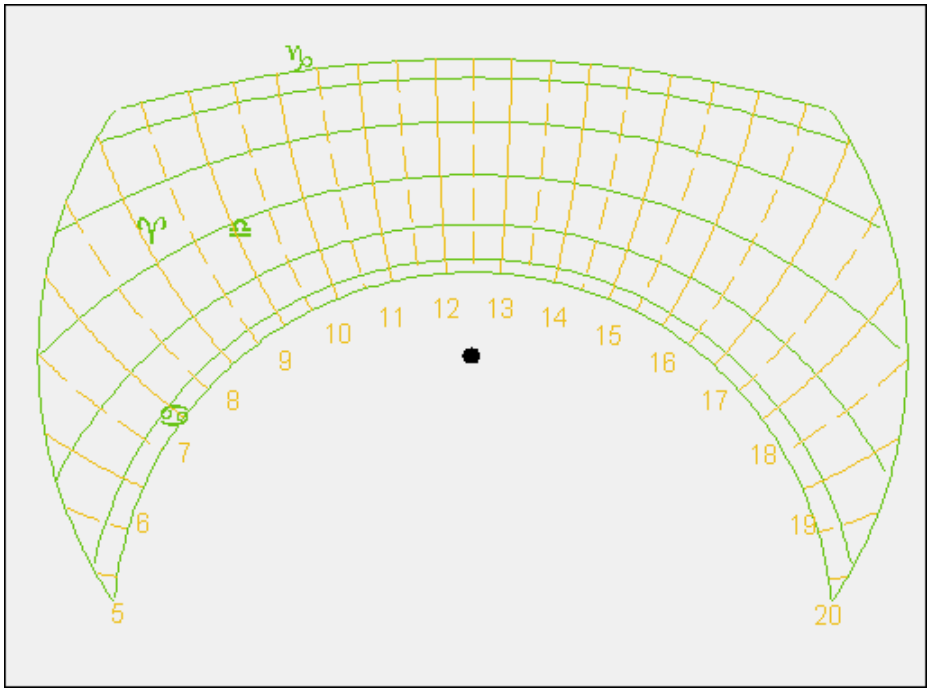

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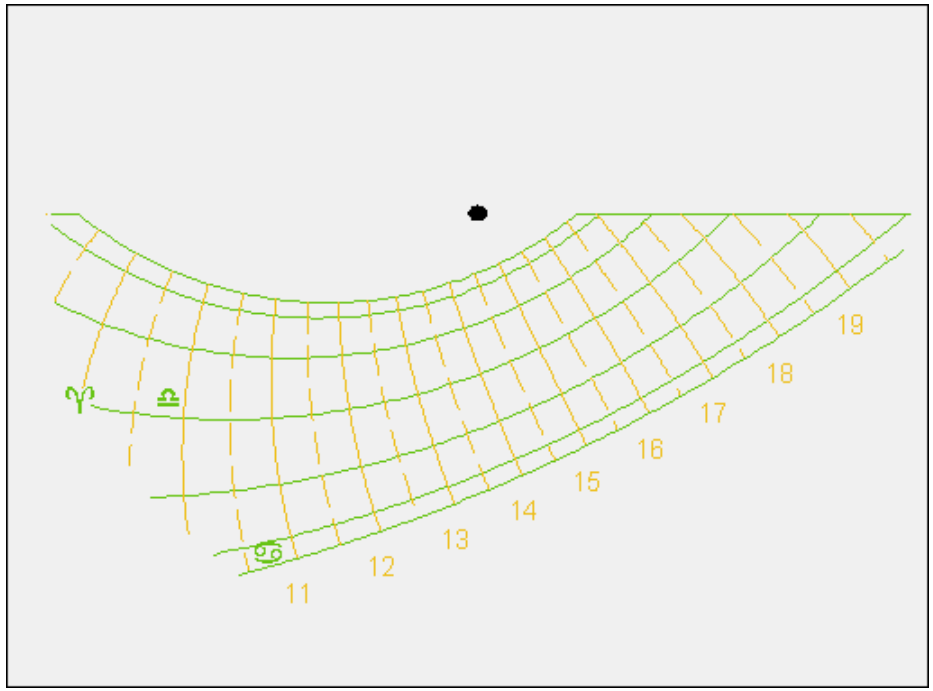

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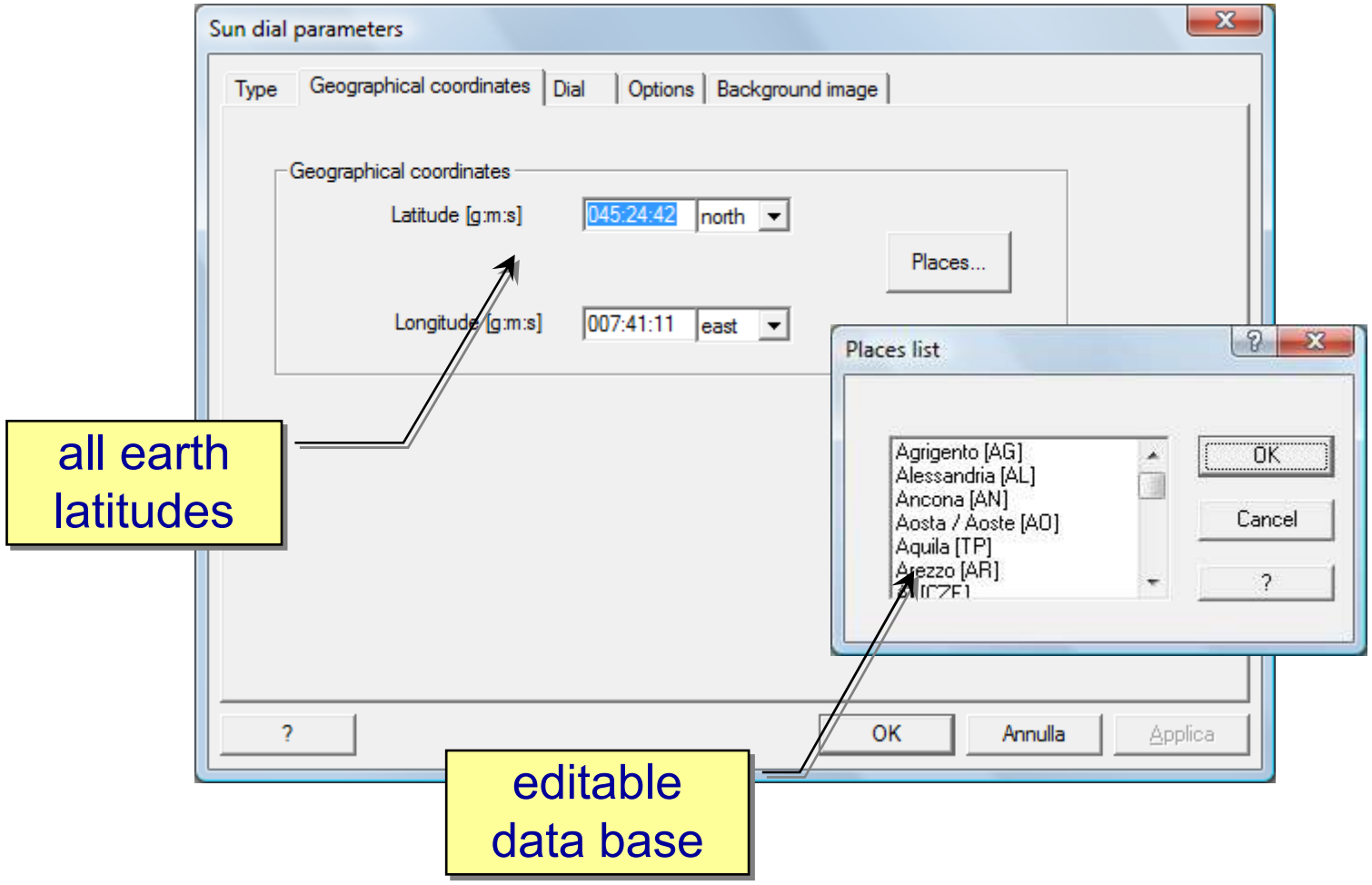
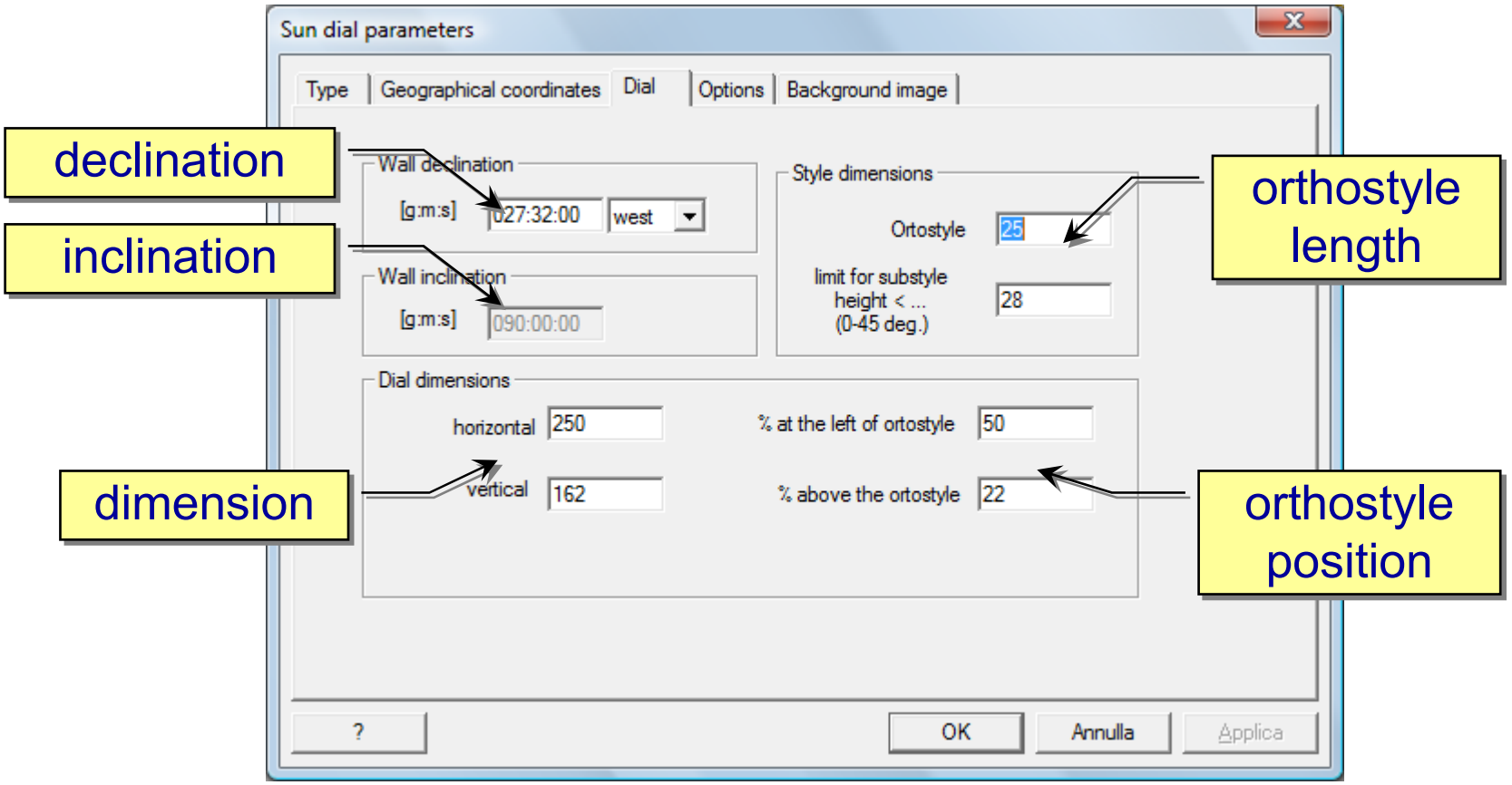
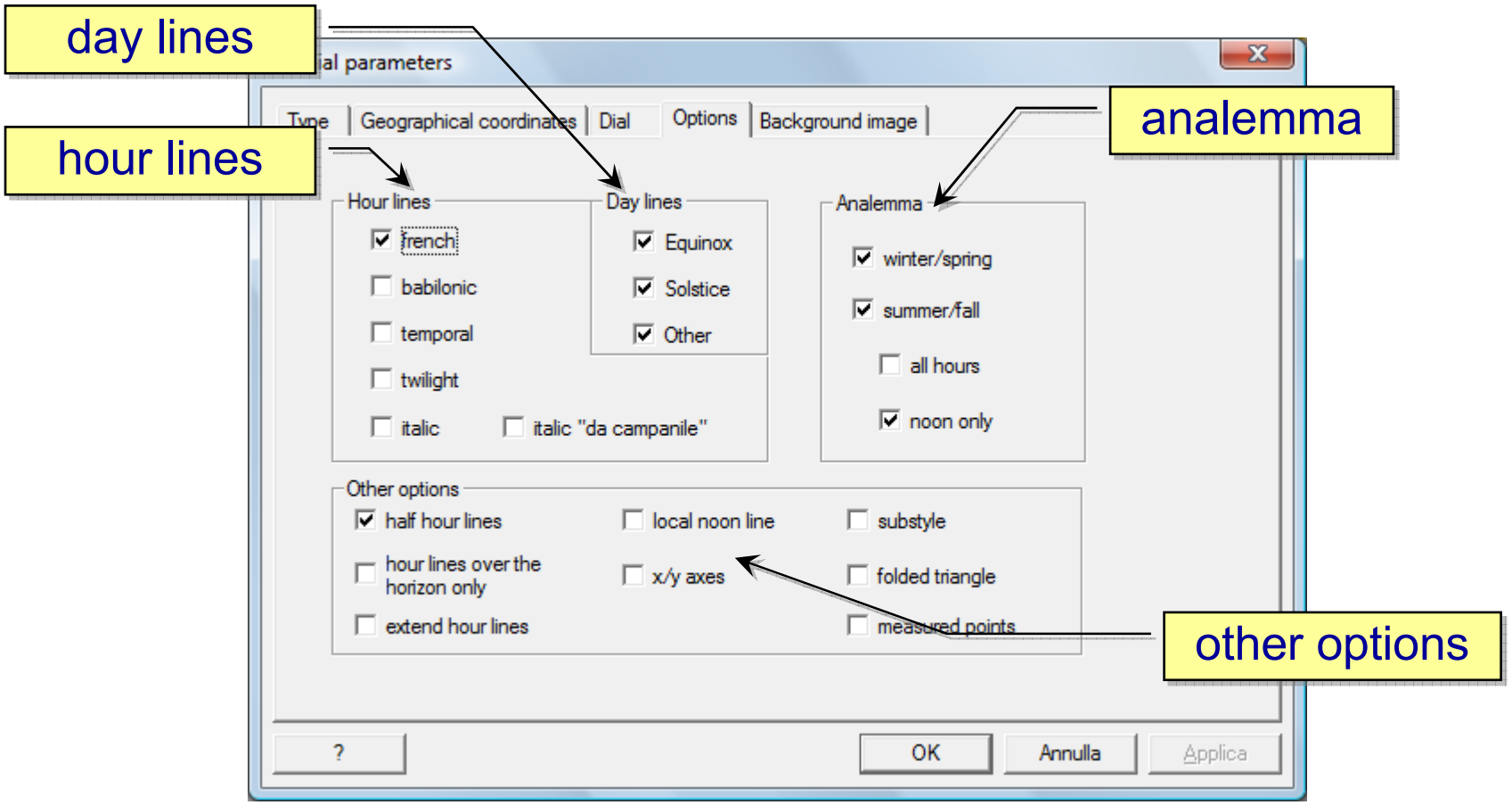
New dial definition : coordinates



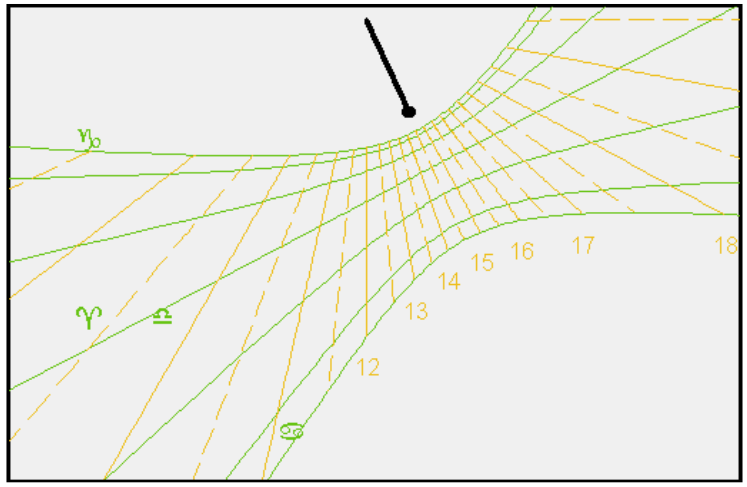
New dial definition : dial frame



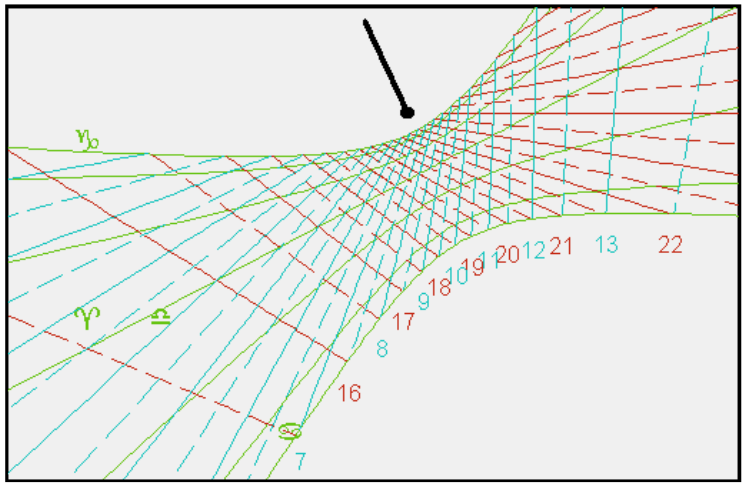
New dial definition : options



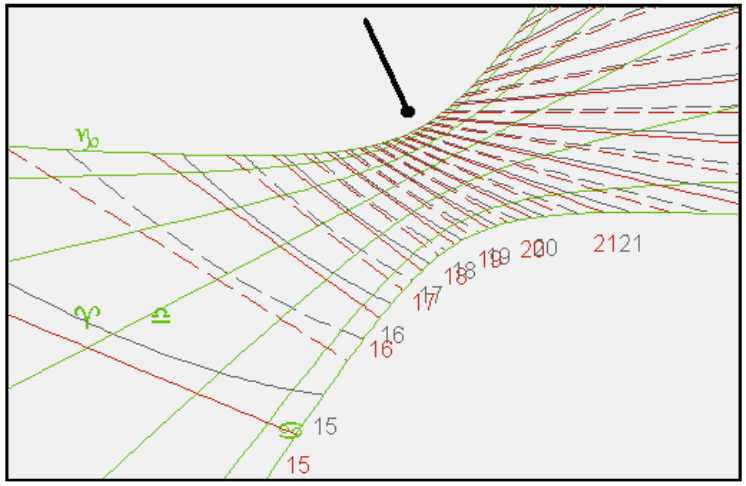
Hour line types



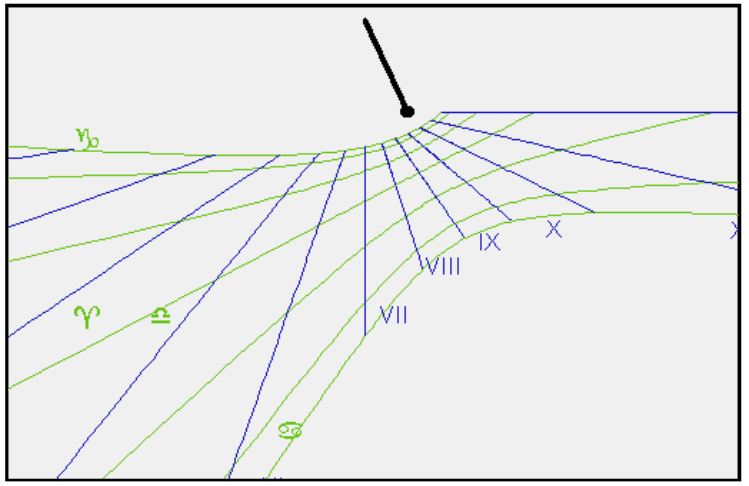
astronomical (french)



italic and babilonic

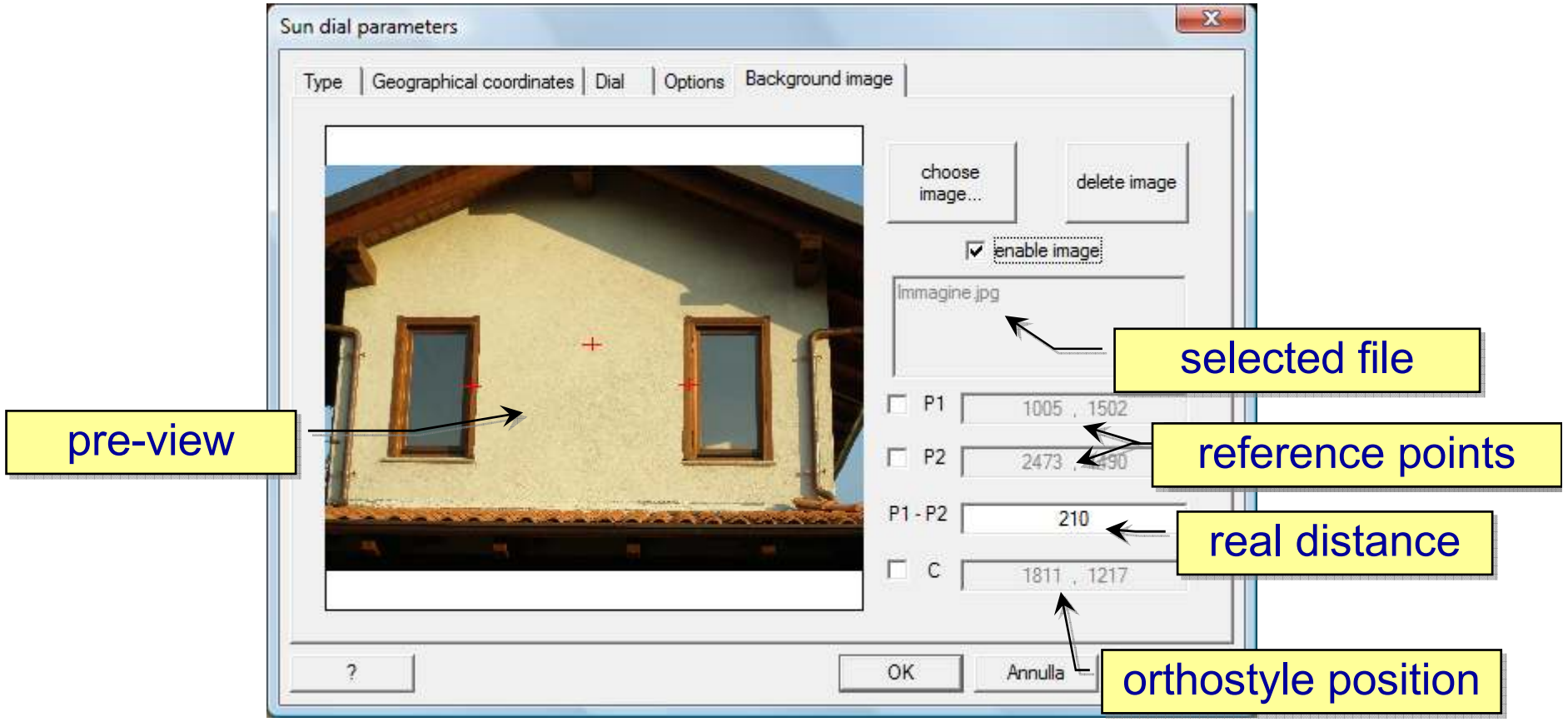


"*da campanile*" and twilight

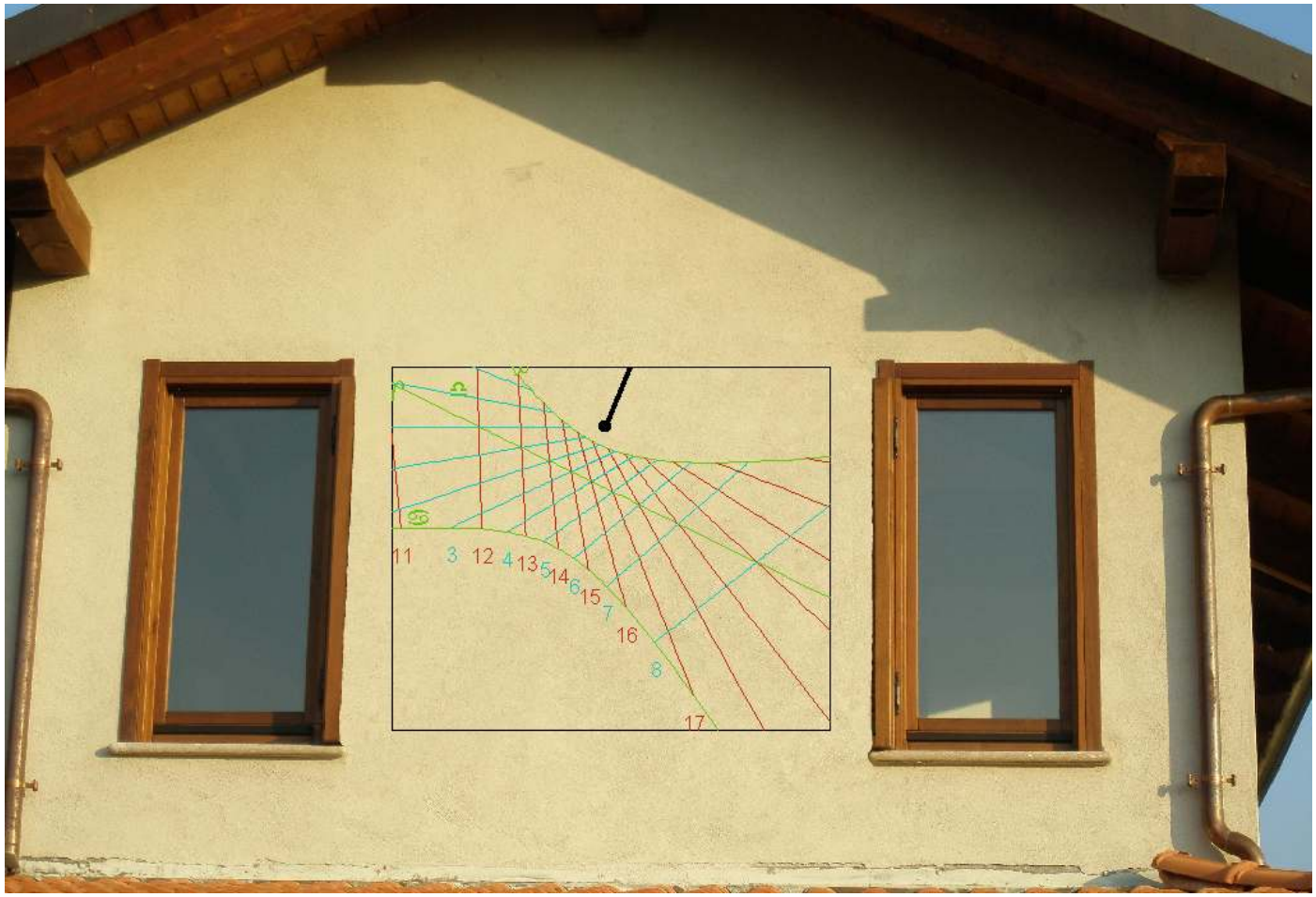


temporal

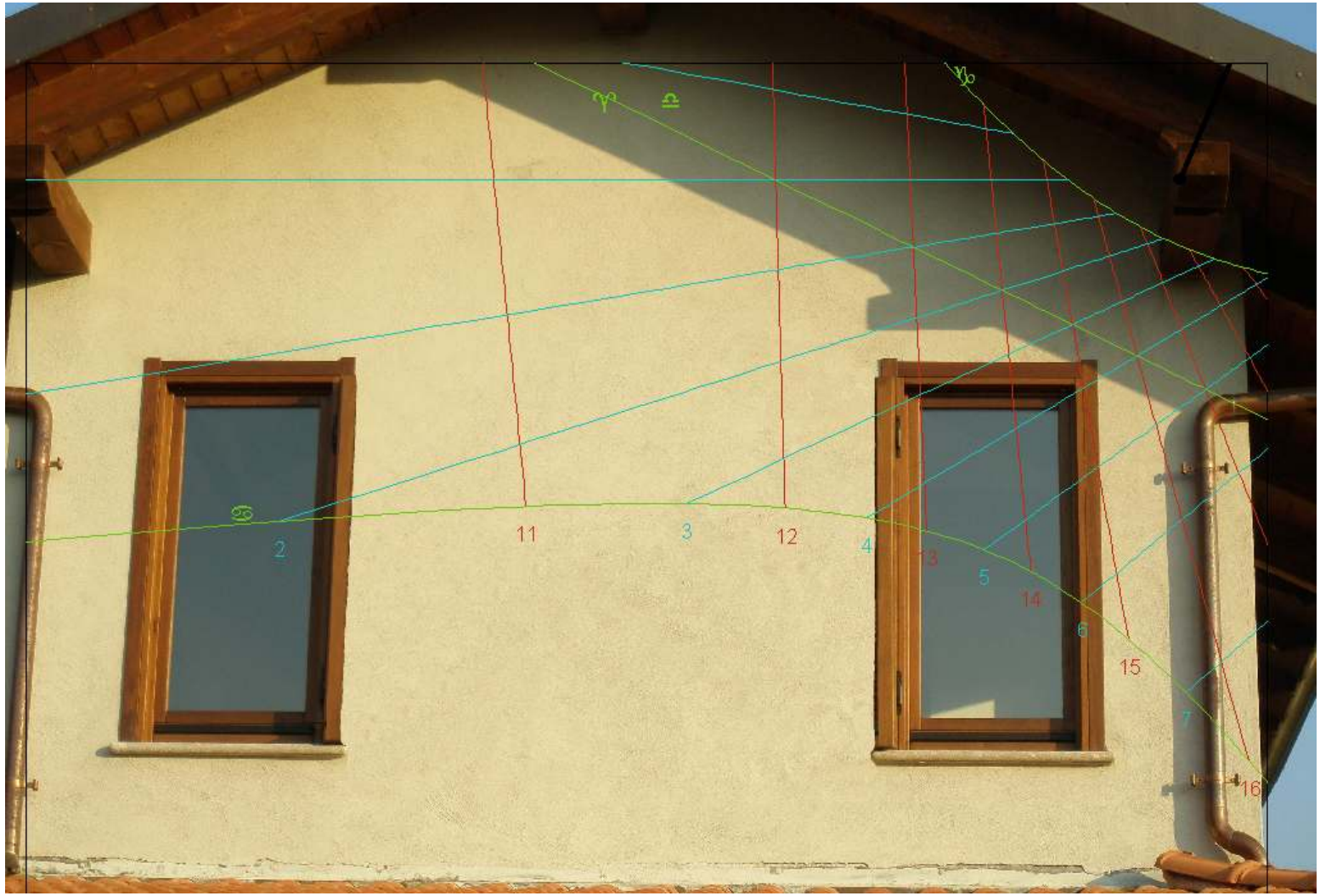
New dial definition : background image



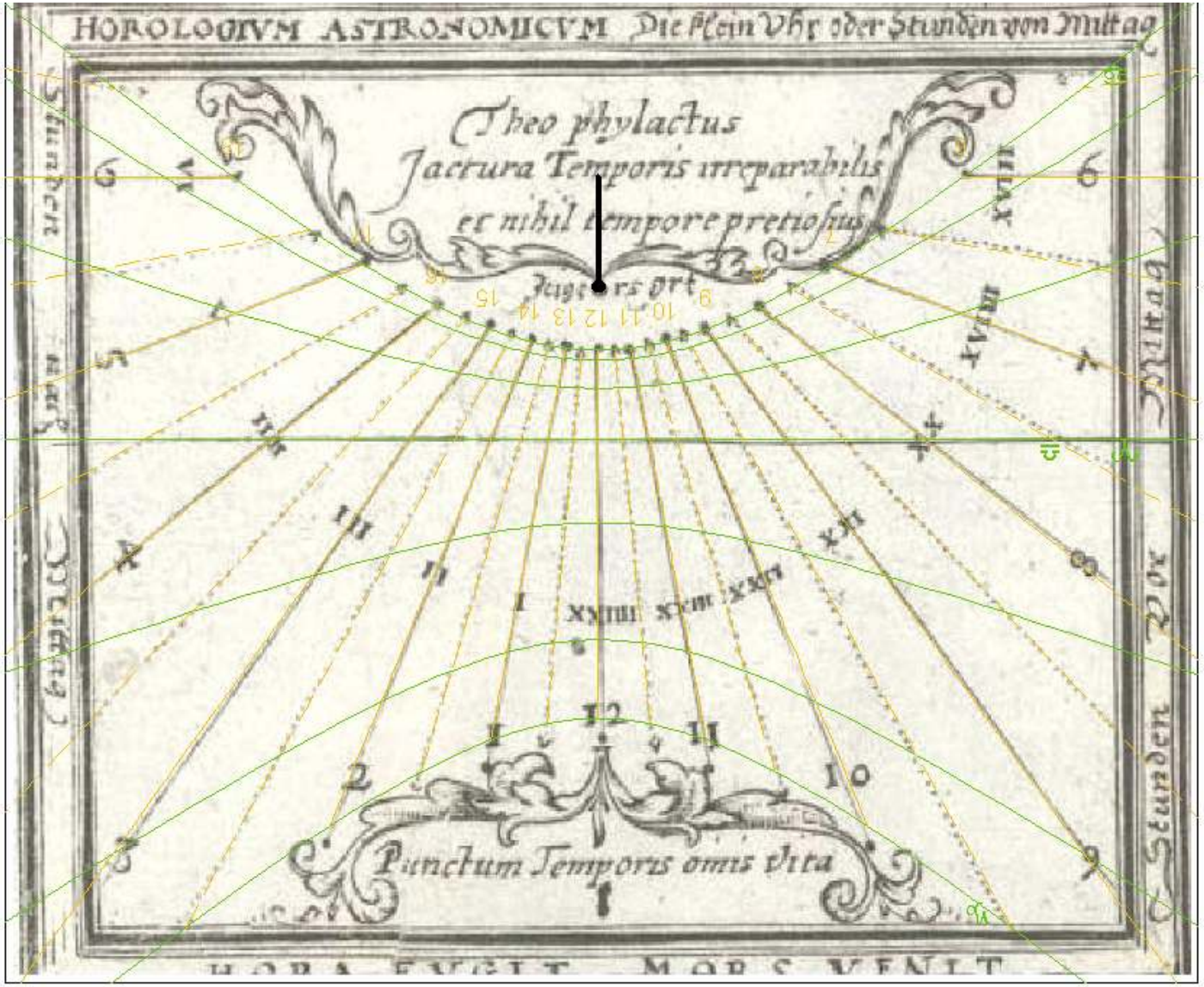
Positioning and dimensioning



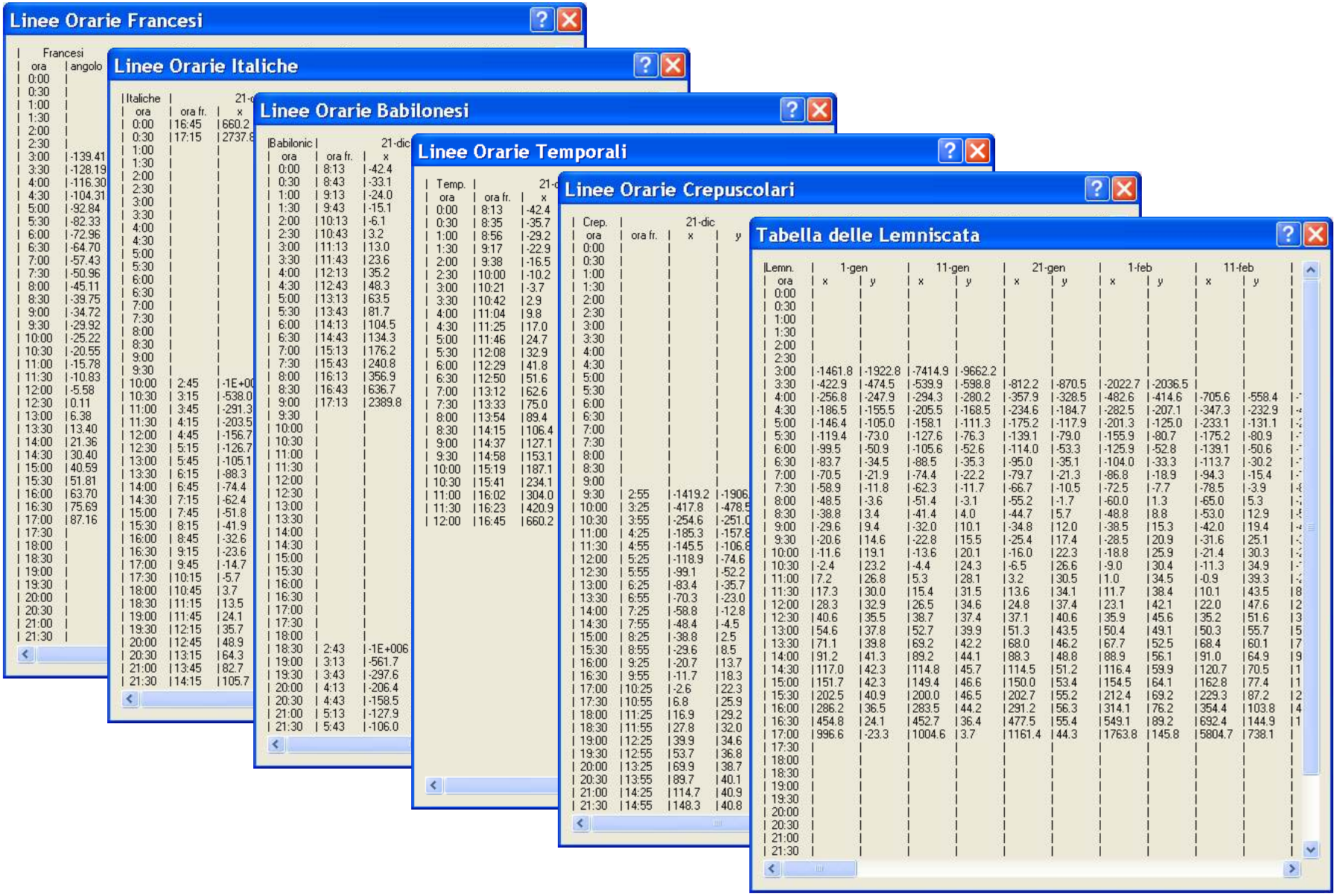
Compute shadow of obstacles



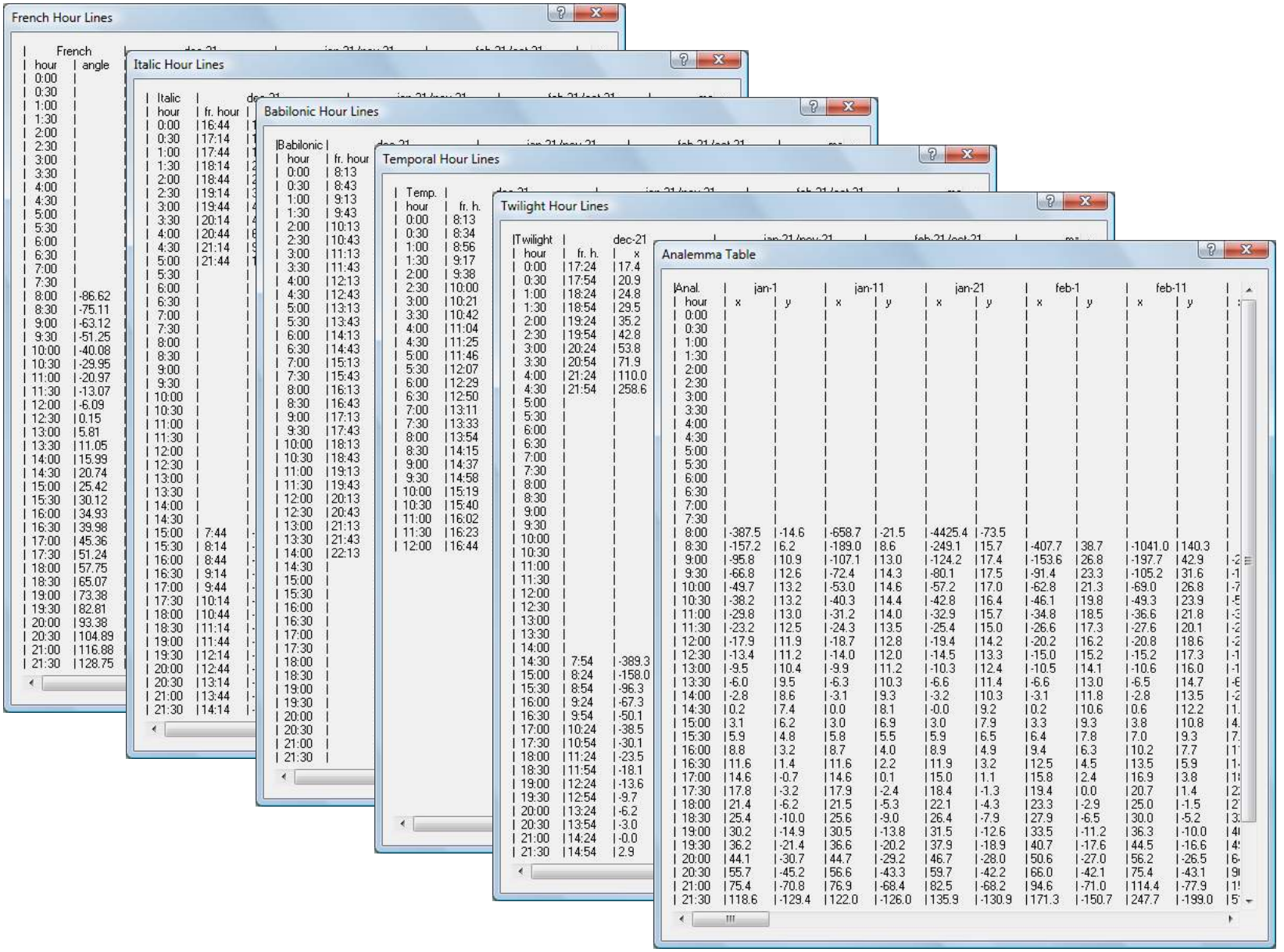
Existing dials simulation



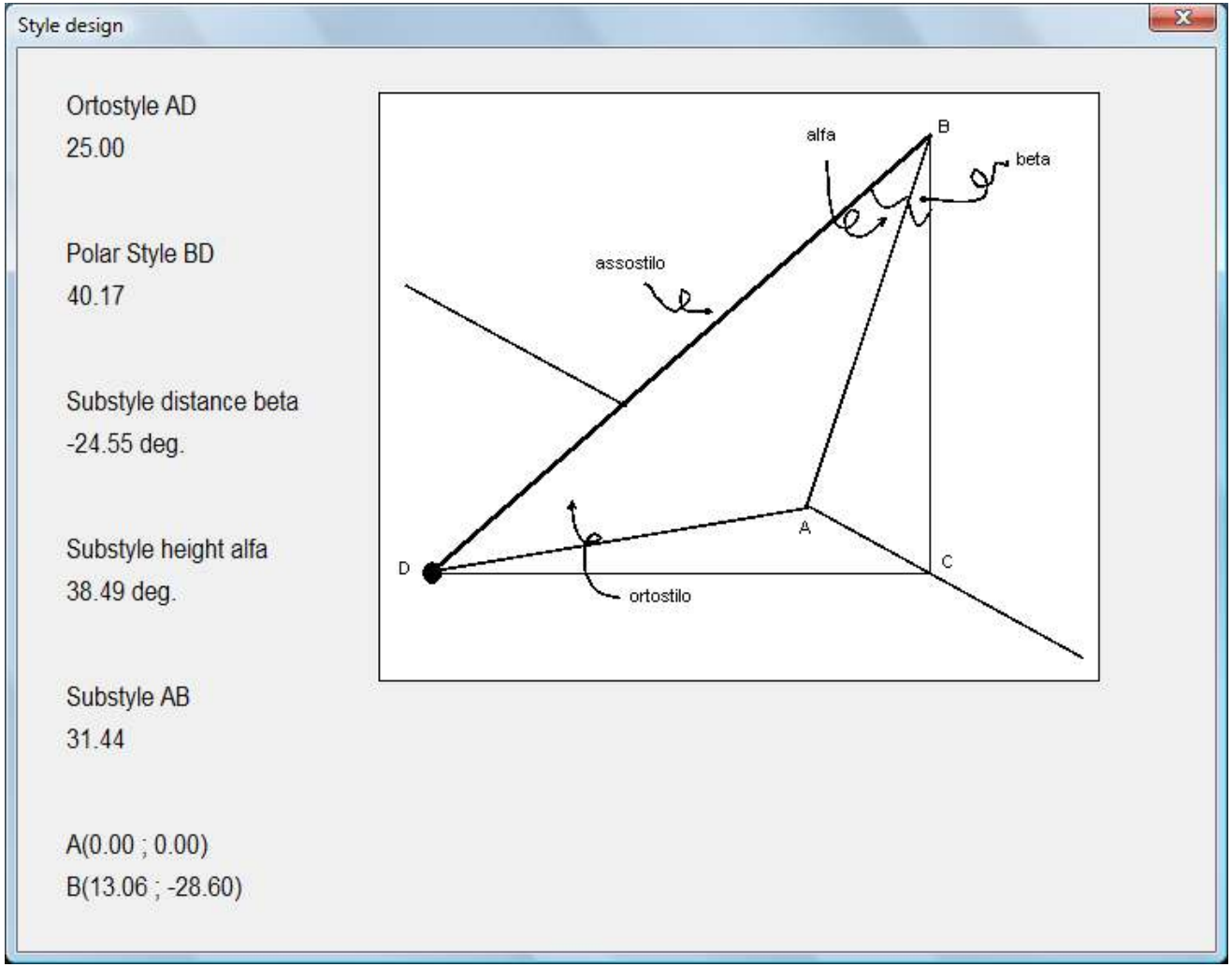
View : tables


Linee Orarie Francesi
Linee Orarie Italiche
Linee Orarie Babilonesi
Linee Orarie Temporali
Linee Orarie Crepuscolari
Tabella delle Lemniscata

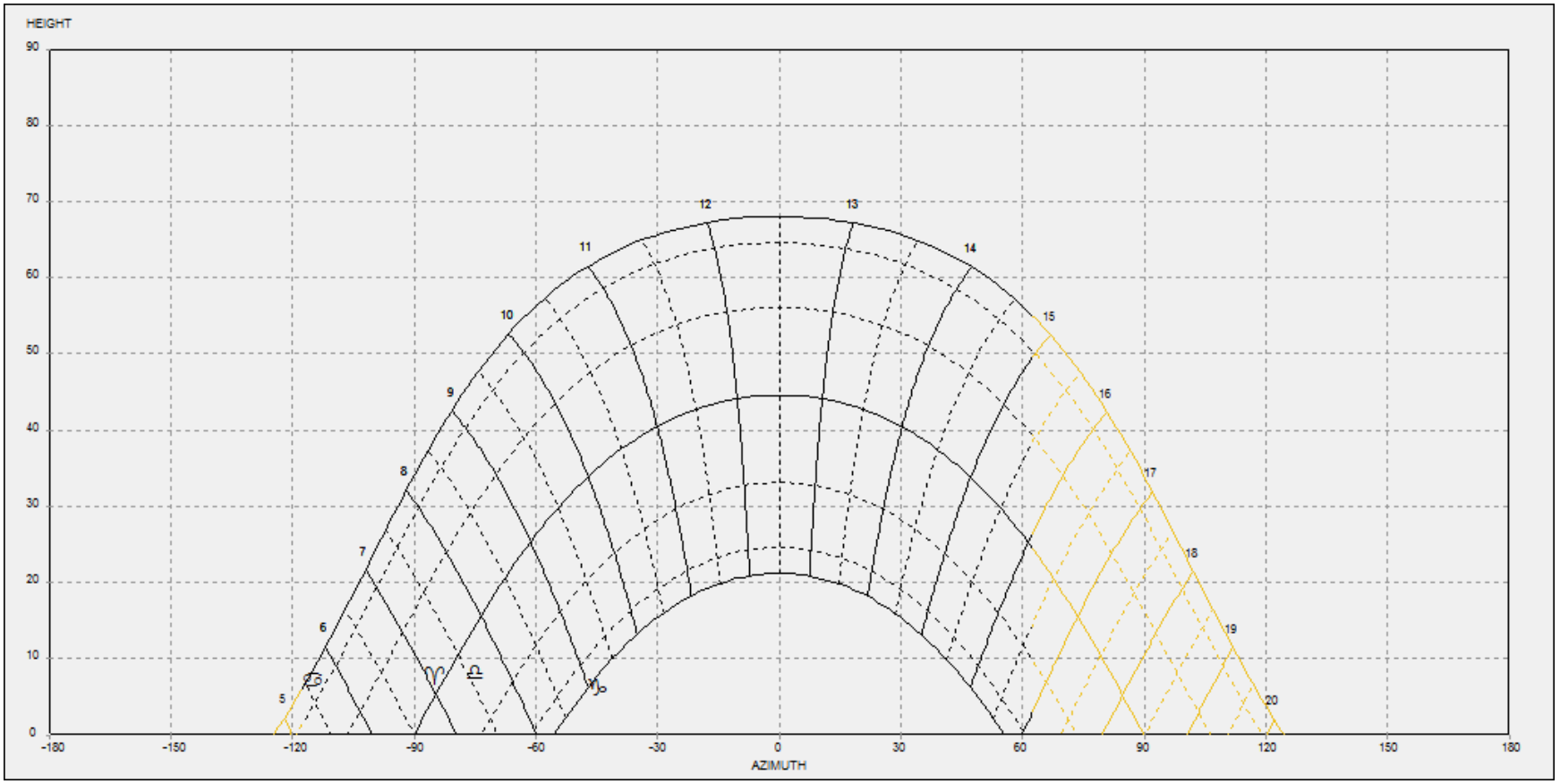
View : tables


French Hour Lines
Italic Hour Lines
Babilonic Hour Lines
Temporal Hour Lines
Twilight Hour Lines
Analemma Table

View : style parameters



View : lighting conditions



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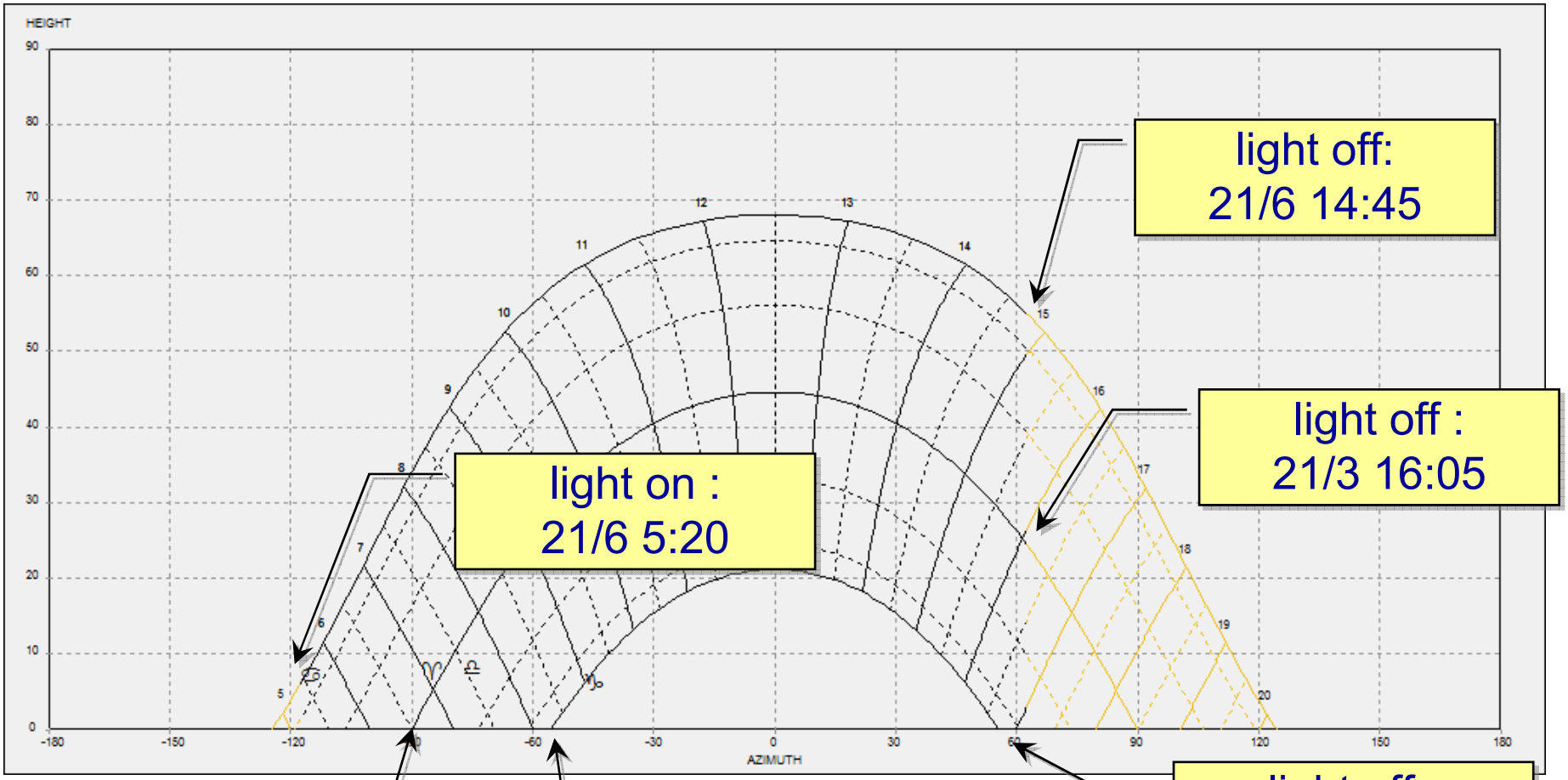

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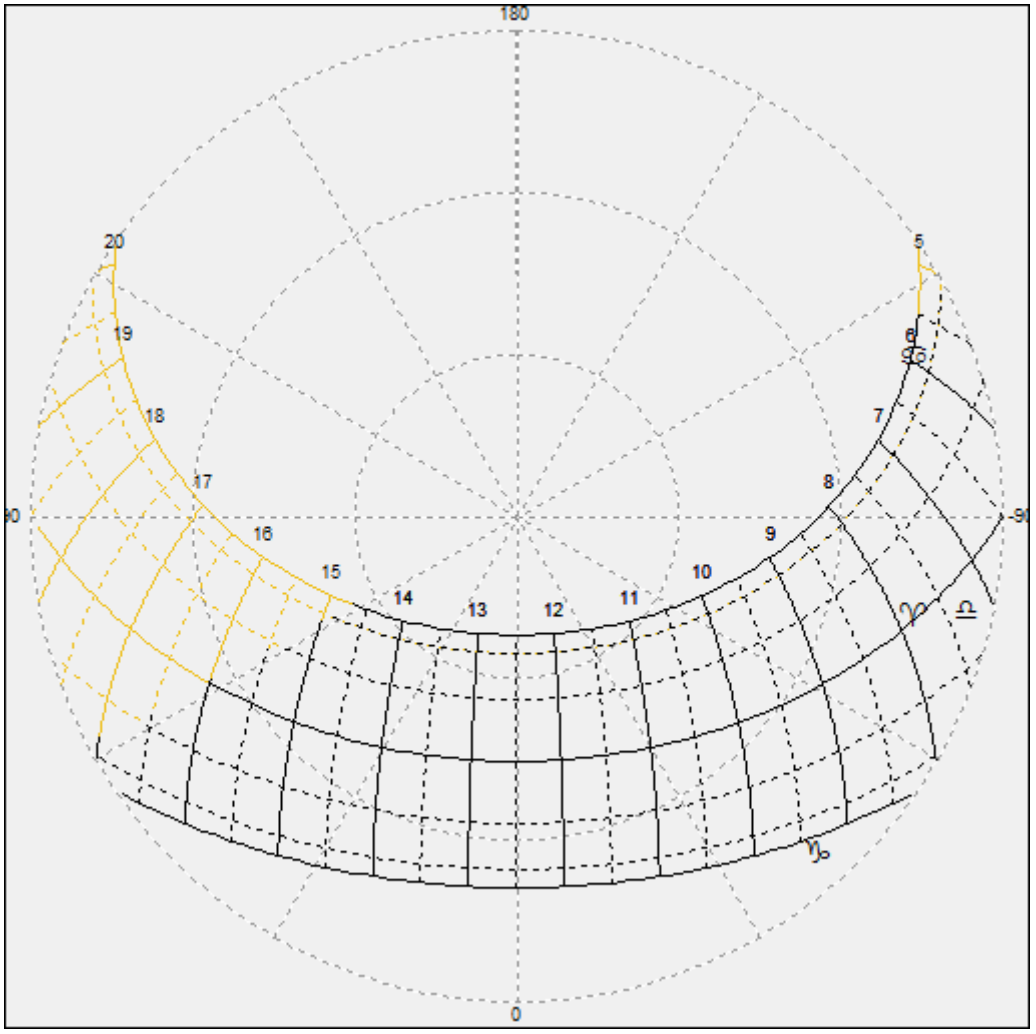
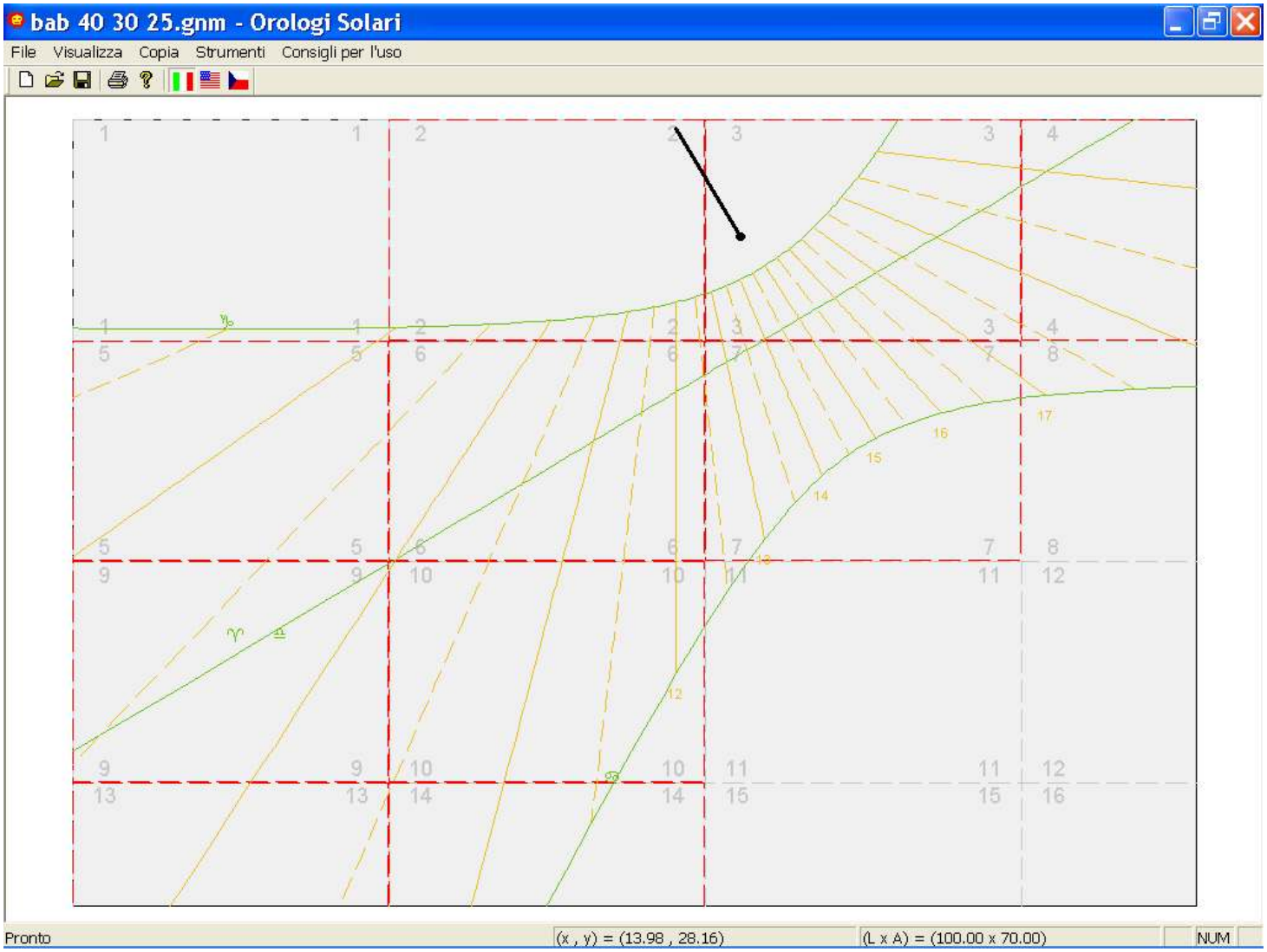


Print, save, export

- copy graphs and tables to the clipboard
- print report with selected graphs and tables
- export to DXF vector file
- export to JPG, TIF, GIF, PCX, BMP raster file
- 1:1 multipages print

1:1 multipages print



Help

Orologi Solari Help

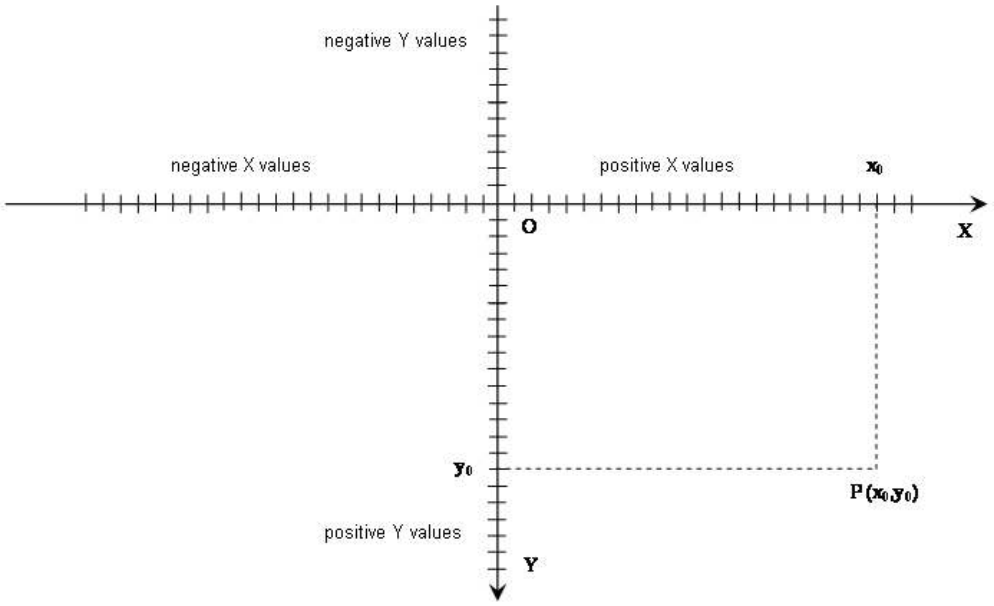
Nascondi | Precedente | Stampa | Opzioni

Contenuto | Indice | Cerca

- Introduction
- Basic concepts on sun dials
- User interface
  - Main window
  - Mouse and keyboard
  - Coordinate system
  - Menu
- How to design a new dial
- Glossary
- Version
- Screen Saver
- Acknowledgements

Coordinates

The following cartesian reference system is used in the program when referring to the coordinates of a point:



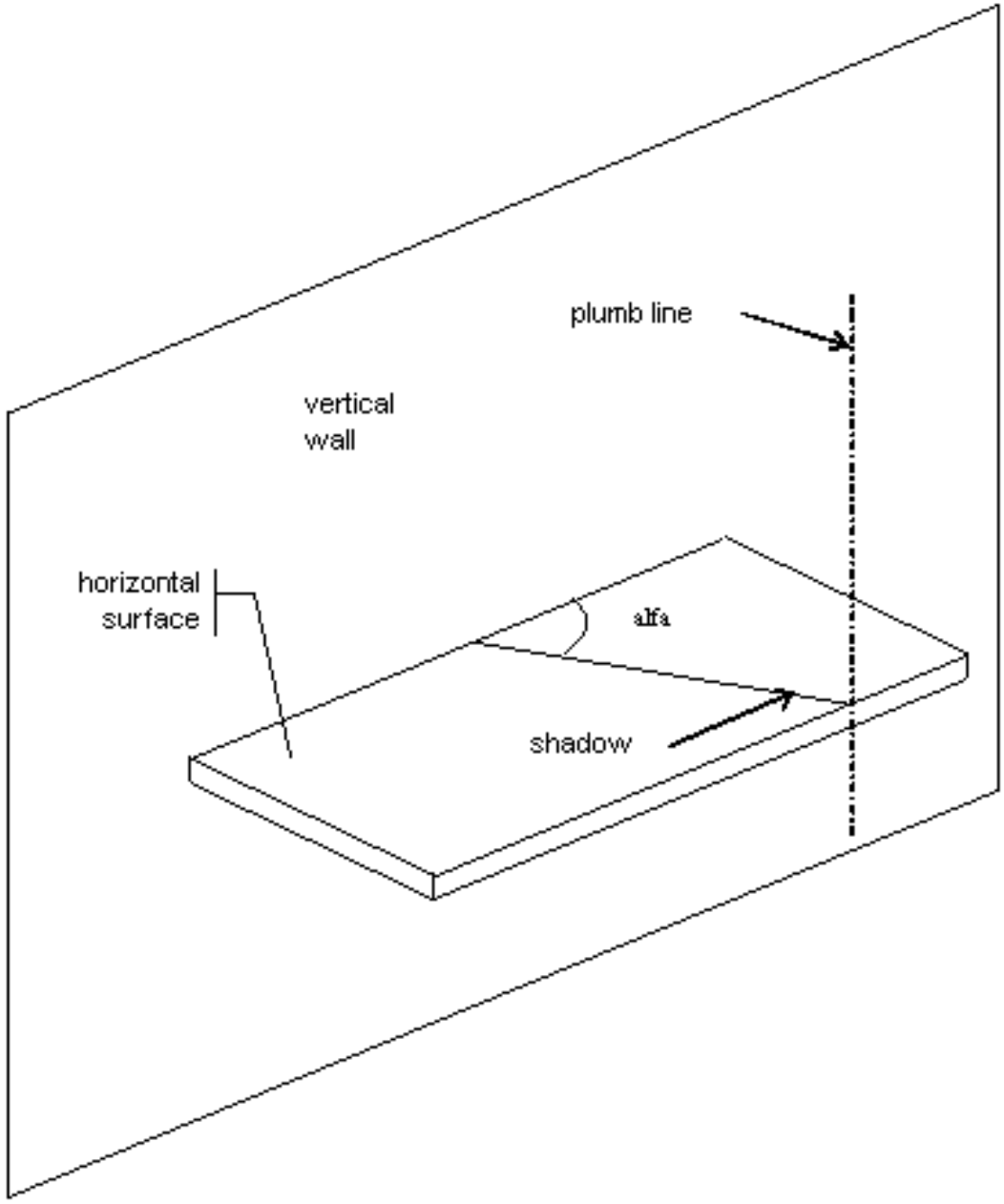
The center O corresponds to the base of the orthogonal style (for the analemmatic dials it corresponds to the style position at the equinox).

Each point in the plan is identified by the two values X_0 and Y_0 as shown in the picture. Note that x has negative values at the left of O and positive values at the right of O, and y has negative values above O and positive values below O.

When moving the mouse pointer over a dial, you can see the current mouse position in real world coordinates in the bottom righ part of the display as (X_0, Y_0).

Wall declination

- Based on the shadow/wall angle
- compute sun parameters and wall declination
- put the result into the actual project



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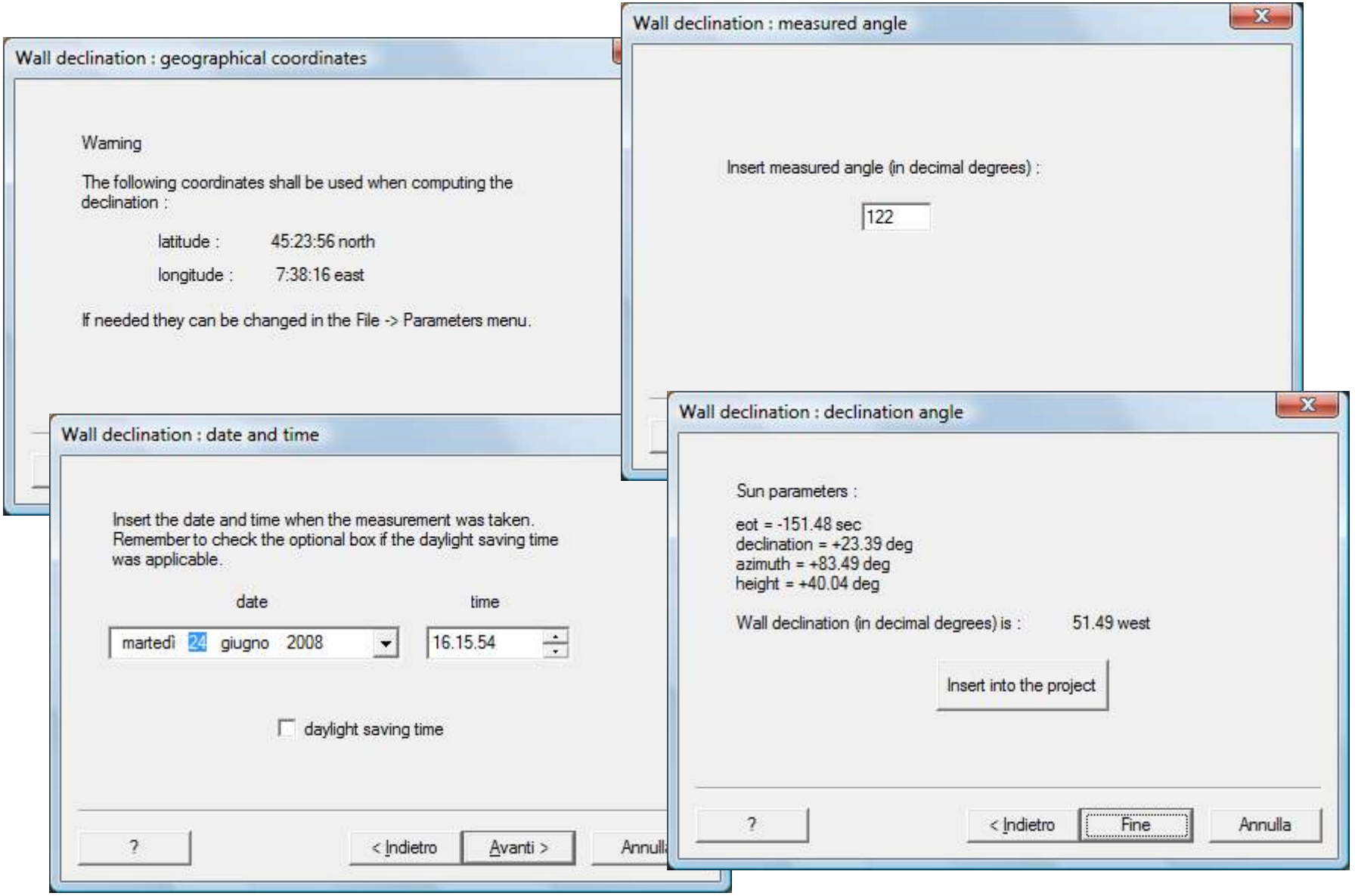
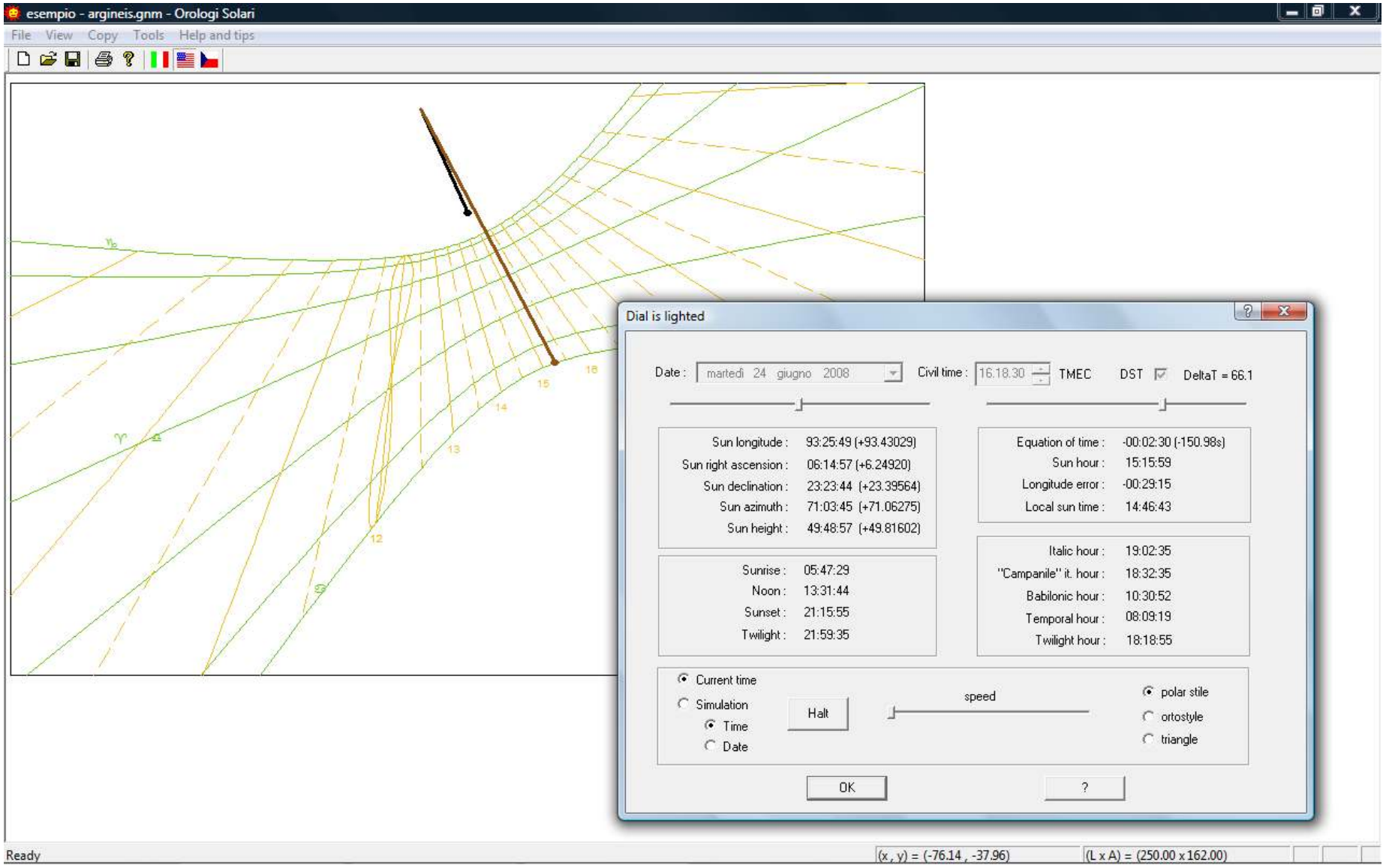


Shadow simulation and sun parameters computation

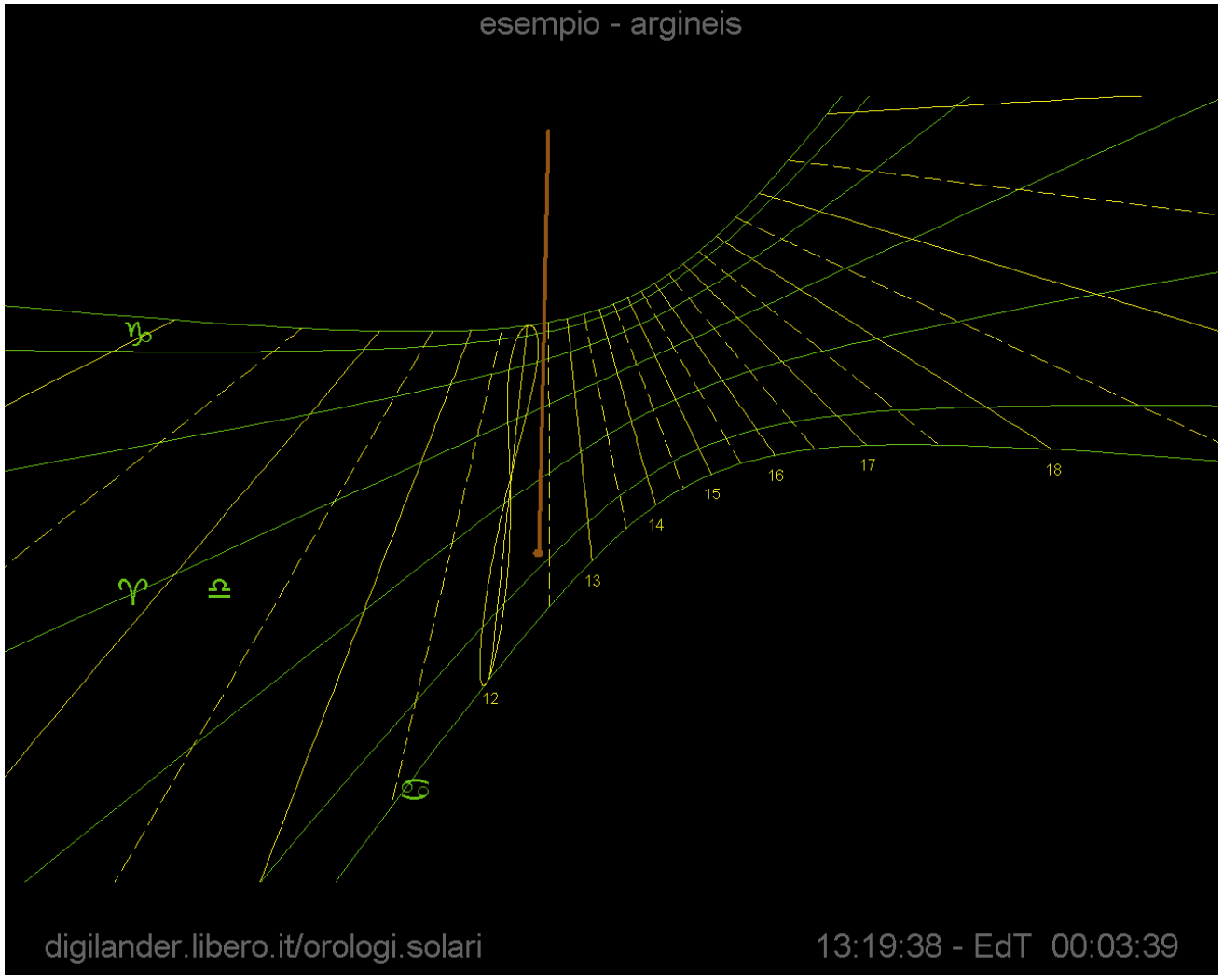
- simulation of any sun dial type (directional, azimuth)
- simulation time : current, manually set or dinamically changed (date / time)
- main sun parameters computation (declination, azimuth, height …)
- current time shown for any time measurement system
- show sunrise, sunset, local noon, twilight

Shadow simulation and sun parameters computation



"Screen Saver"

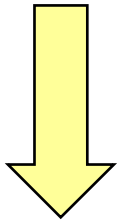
- based on any sundial you designed with the program



Reverse engineering

Problem

given an old dial with only some elements left
(lines, points, style …)



compute the original design parameters
(latitude, declination, style …)

Reverse engineering

Classical approach

For any particular situation : measure an element and then find the unknowns by means of trigonometric relationships.
ex. equinox line is available => measure angle, find declination

Disadvantages:

- huge number of possible situations, a program can not cover them all
- program would be a long list of commands, one for each situation / unknown

Reverse engineering

Innovative approach

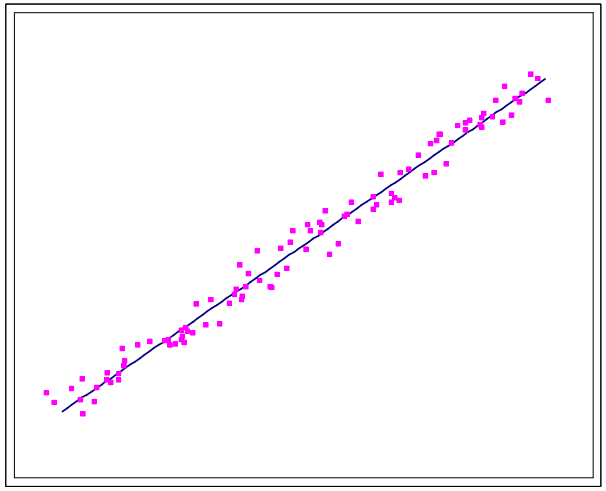
Consider the problem as a “data fitting” situation :

“*given a list of measured values, find the parameters of the given model that best match measurements*”

ex. linear regression

$$Y = a * X + b$$

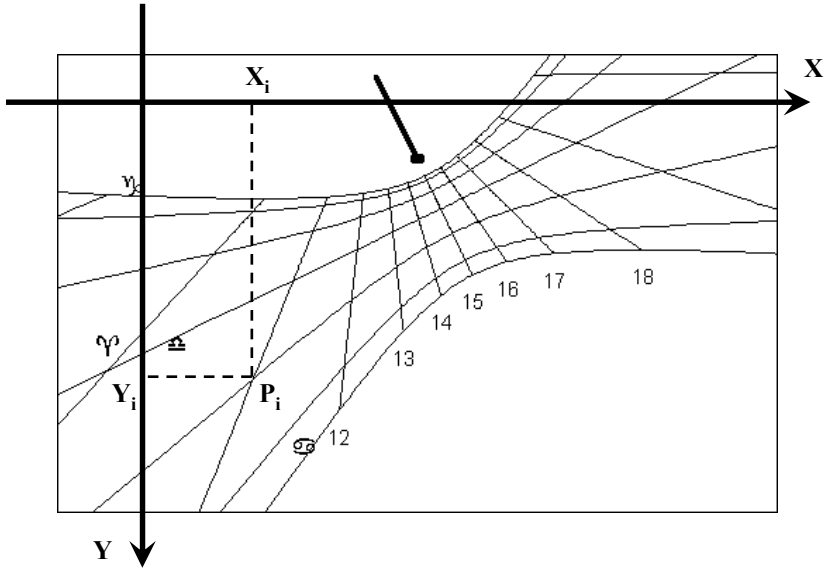
Given measurements (X_i, Y_i) find parameters a and b that best approximate the results.



Reverse engineering

ex. declining vertical dial showing local time

$$\begin{cases} X_i = X(\omega, \delta, \varphi, d, \lambda, x, y) \\ Y_i = Y(\omega, \delta, \varphi, d, \lambda, x, y) \end{cases}$$



ω = known hour angle
δ = known sun declination

φ = latitude
d = wall declination
λ = orthostyle length
x,y = orthostyle base coordinates

Reverse engineering

1. measure the position of N points (with known ω e δ)
2. make a system of 2*N non-linear equations with 5 unknowns

$$f_i (\varphi , d , \lambda , x, y) = k_i \qquad i = 1 \div 2N$$

where k_i are the measured coordinates of N points.

3. solve the system and find the 5 unknown parameters

Reverse engineering

Levenberg-Marquardt algorithm

Consider the cost function

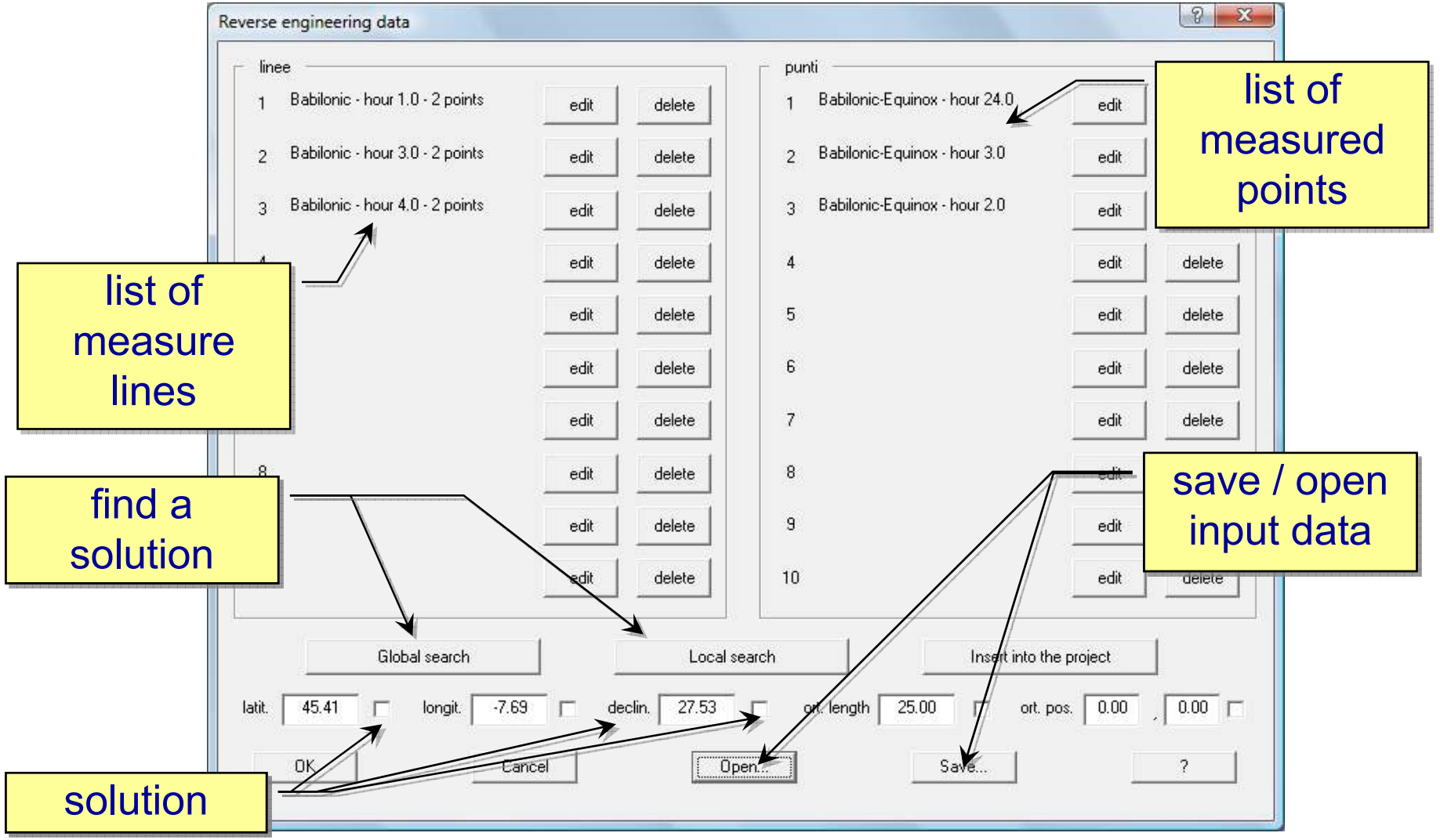
$$F(\varphi, d, \lambda, x, y) =$$

$$= \sum_{i=1}^{N} \left(f_i(\varphi, d, \lambda, x, y) - k_i \right)^2 = \sum_{i=1}^{N} \varepsilon_i{}^2$$

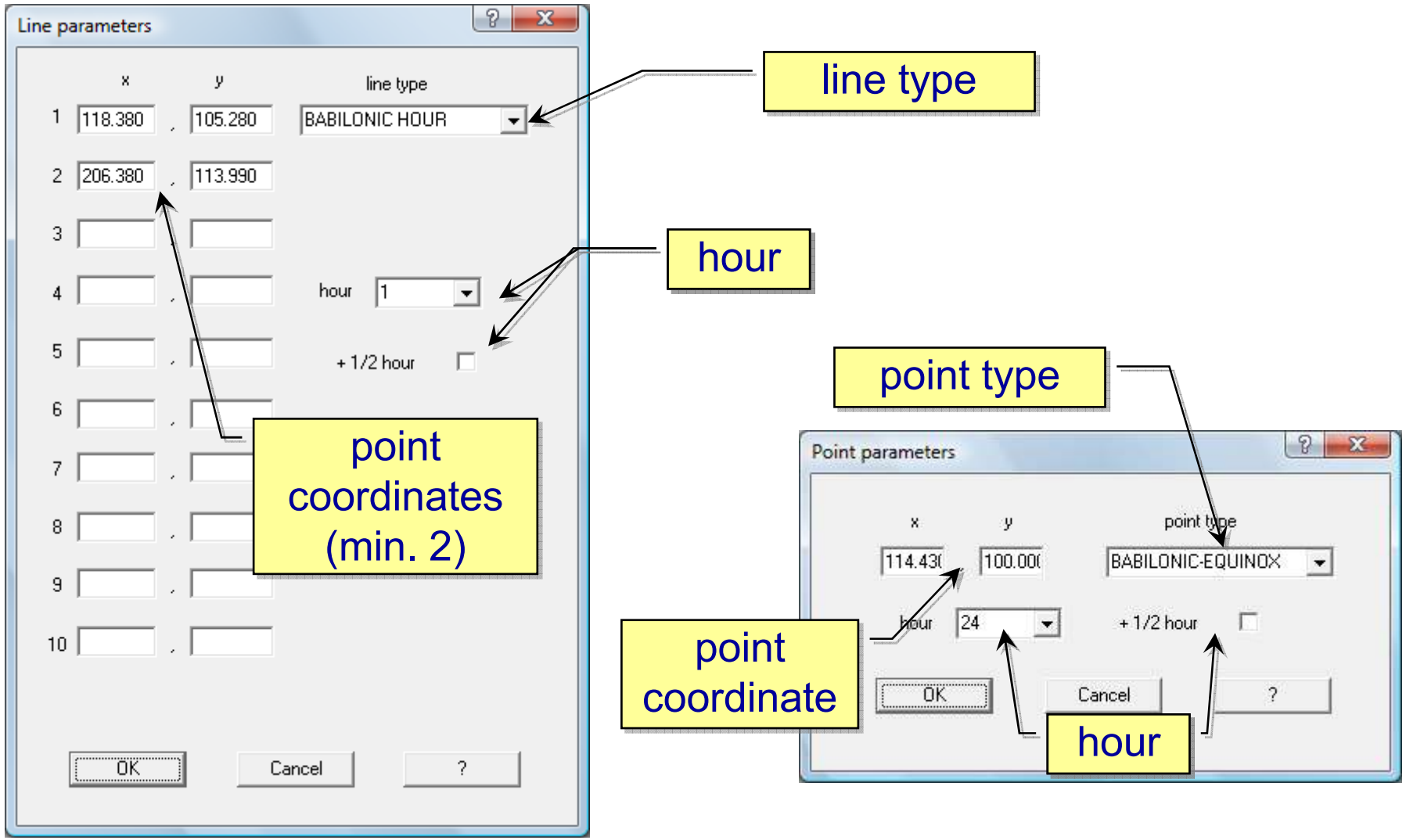
equal to the sum of squares of residual errors between model and measurements.

The algorithm will look for a minimum of F through an iterative process that should converge to the local minimum nearest to the initial starting hypothesis.

Reverse engineering



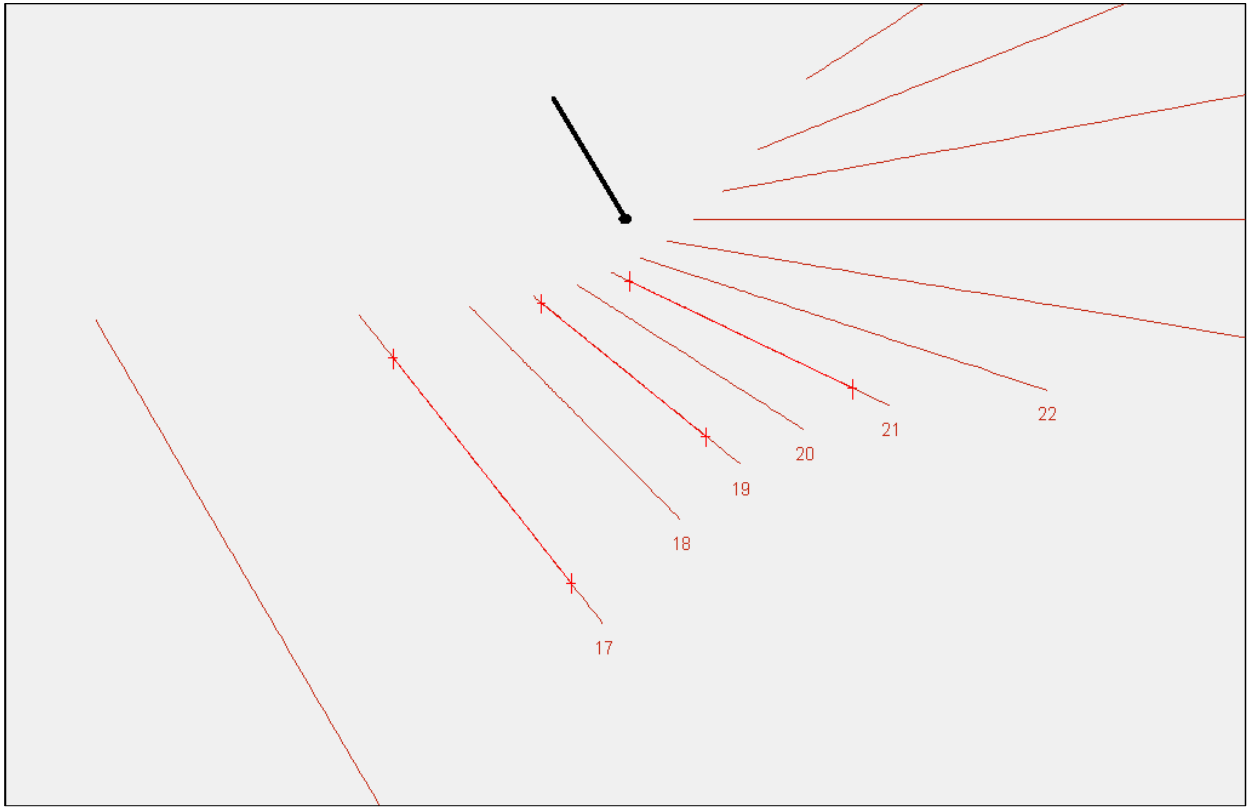
Reverse engineering : input of measured lines and points



Reverse engineering

ex. italic hour dial, three hour lines known

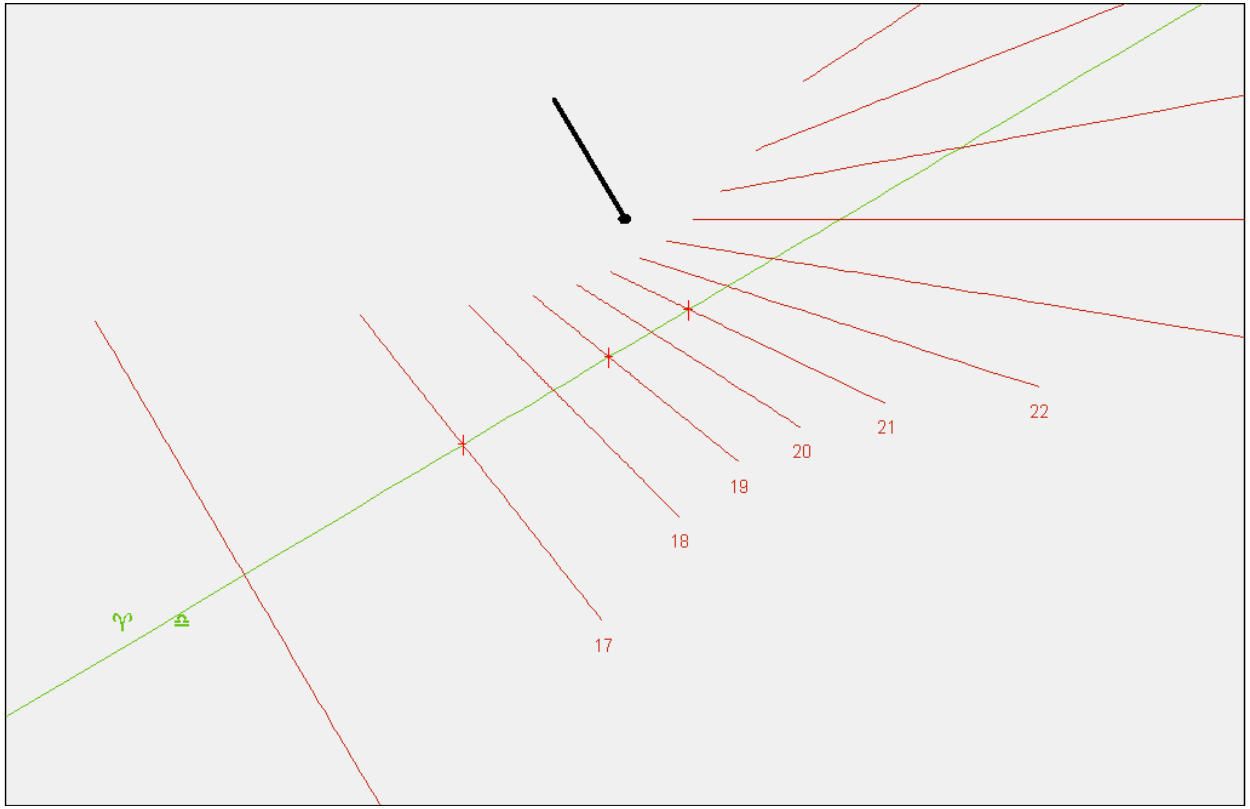
recovered dial :



Reverse engineering

ex. italic hour dial, three points known (intersection between hour lines and equinox line)

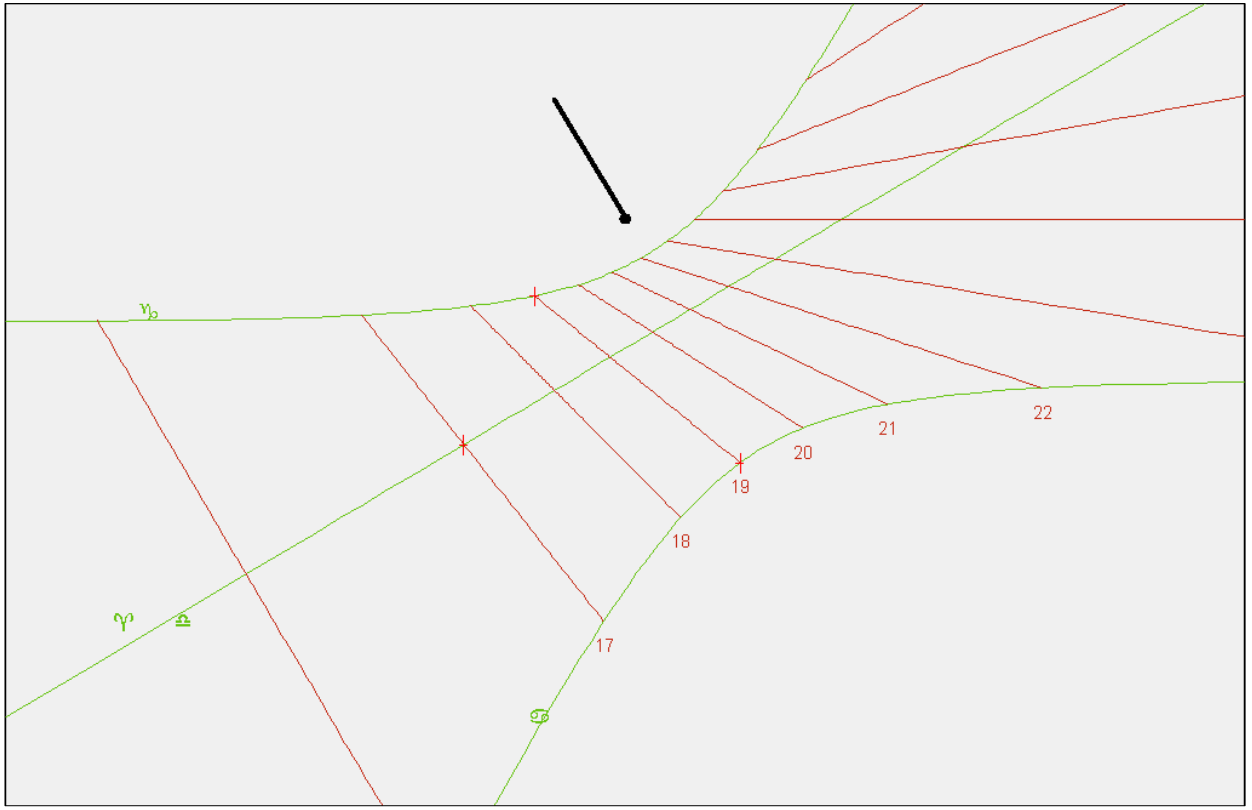
recovered dial :



Reverse engineering

ex. italic hour dial, three points known (intersection between hour lines and day lines)

recovered dial :



Reverse engineering

ex. italic hour dial

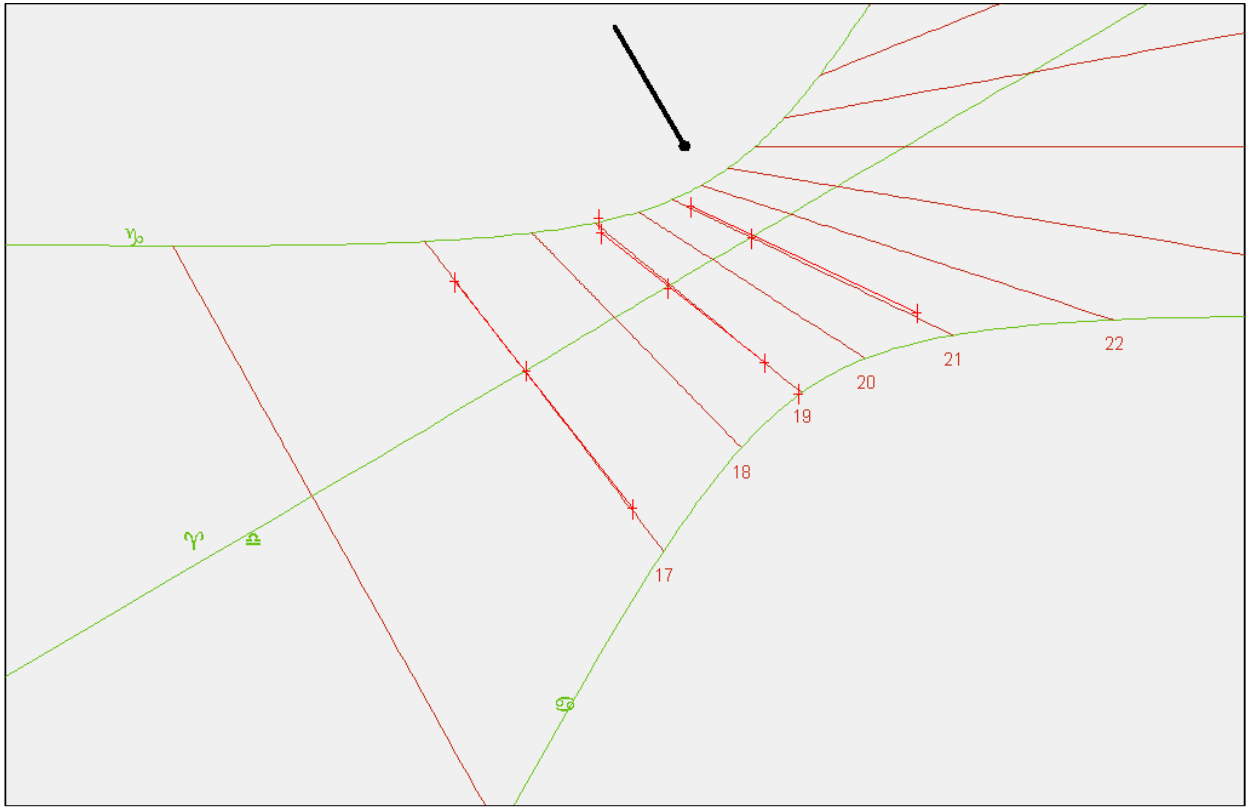
results :

unknown	true value	case 1	case 2	case 3
φ	40.00	40.03	40.01	40.02
d	30.00	29.92	30.05	30.00
λ	25.00	25.19	24.98	25.02
x	125.00	125.36	125.06	125.03
y	37.00	37.11	37.01	36.99

Reverse engineering

ex. italic dial ±1 cm error : in the presence of errors use as many data as possible

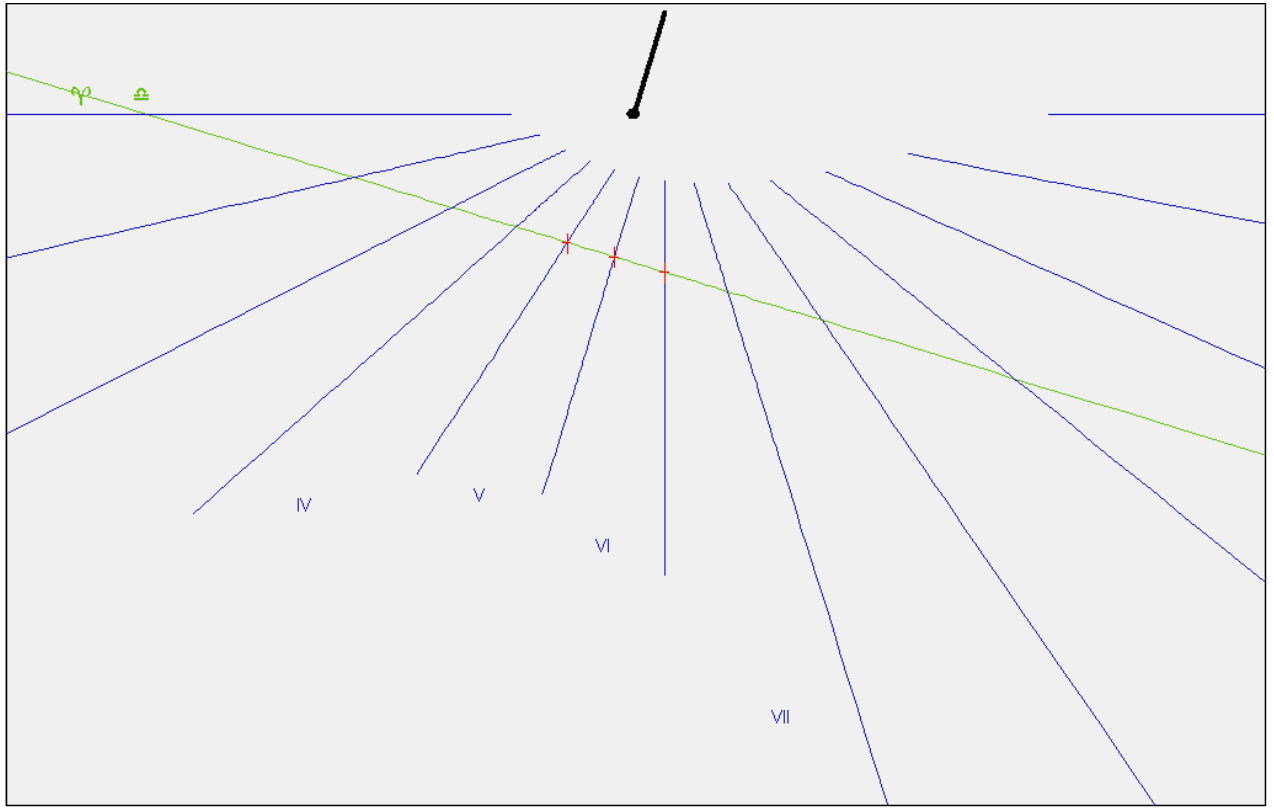
recovered dial :



Reverse engineering

ex. temporal hour dial, three points known (intersection between hour lines and equinox line)

recovered dial :



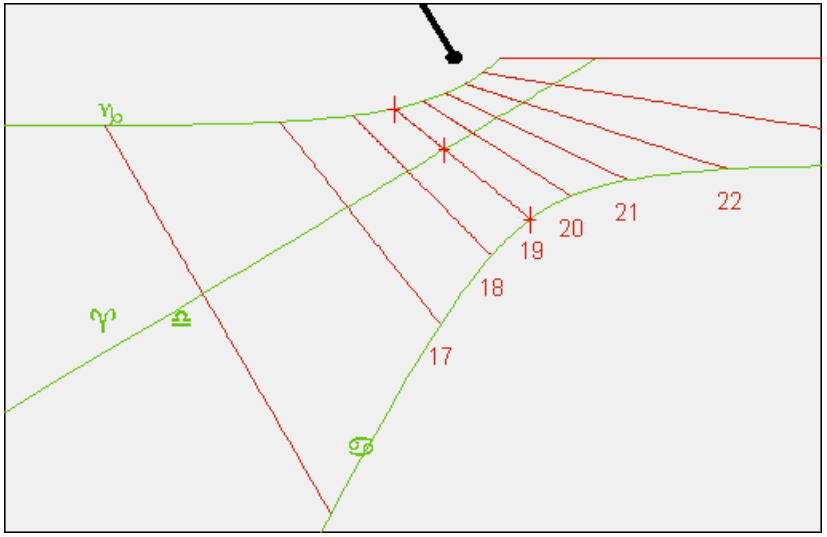
Reverse engineering

Measured elements must allow the identification of one and only one dial.

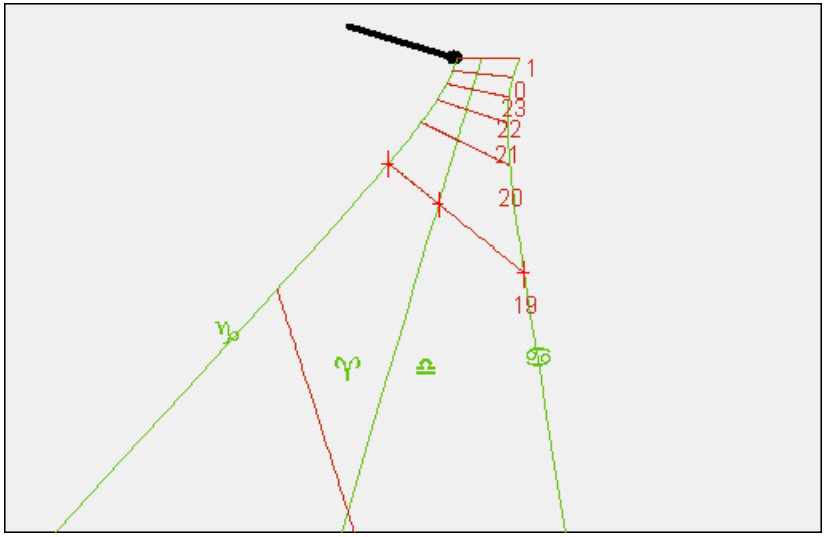
ex. left: italic dial with three hour lines / day lines intersections known, right : recovered dial

=> more than one solution exist

starting dial



recovered dial



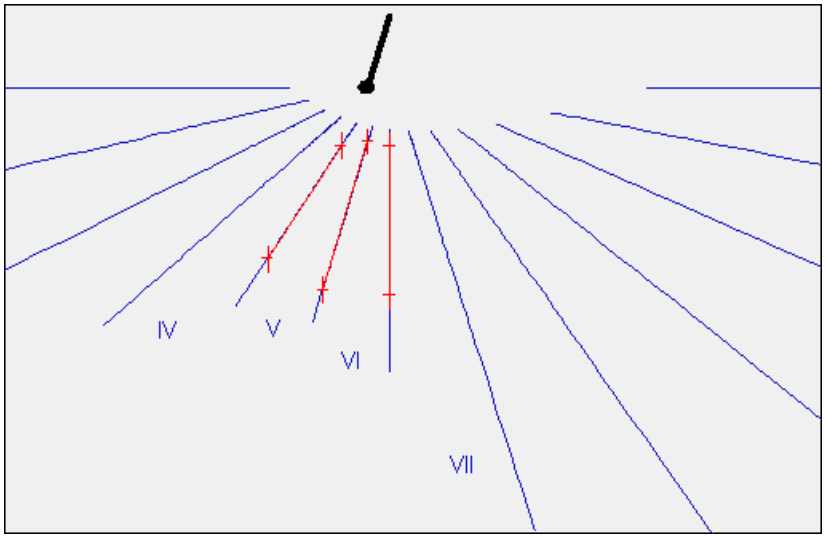
Reverse engineering

Measured elements must allow the identification of one and only one dial.

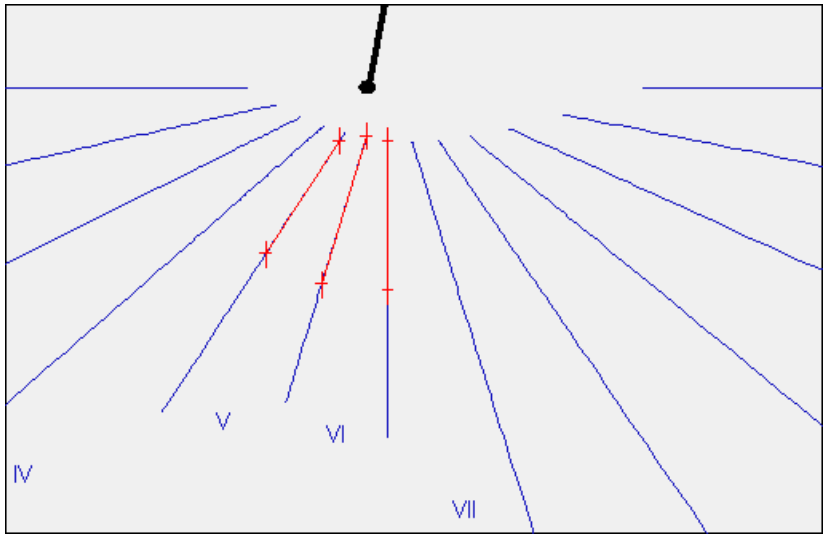
ex. left : temporal dial with three hour lines known, right : recovered dial

=> more than one solution exist

starting dial



recovered dial



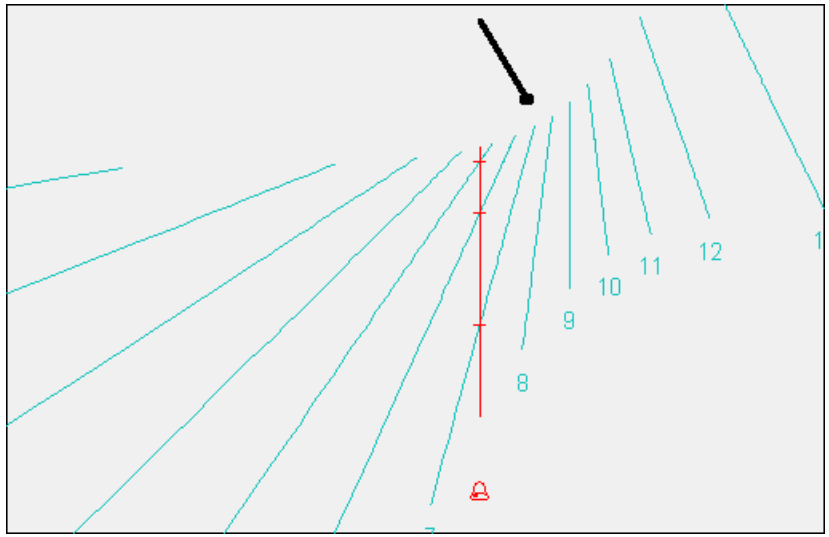
Reverse engineering

Measured elements must allow the identification of one and only one dial.

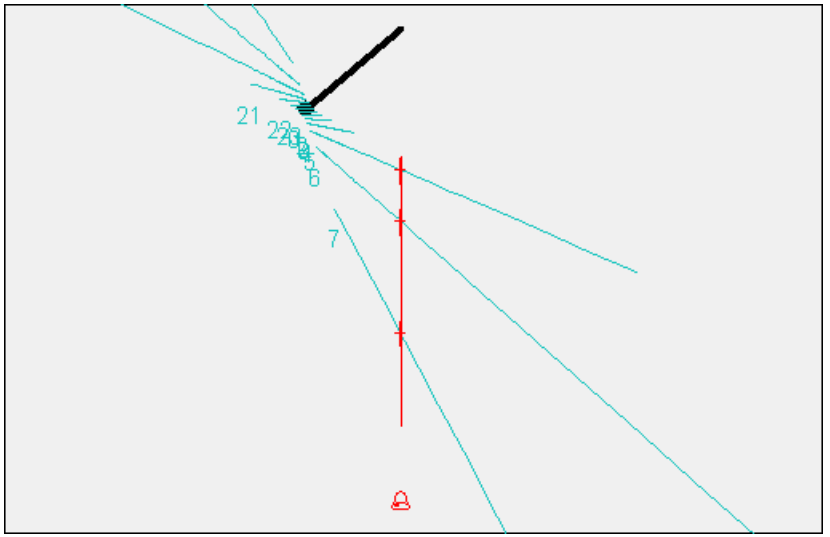
ex. left : babilonic dial with three meridian / hour lines intersections, right : recovered dial

=> more than one solution exist

starting dial



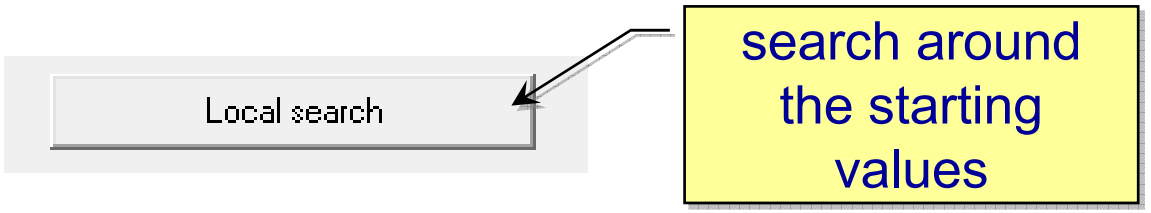
recovered dial



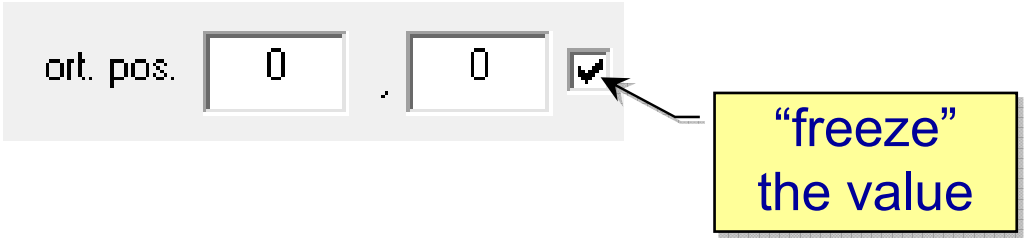
Reverse engineering

For good solutions it is advisable to :

- intrduce the larger possible number of input data
- use points instead of lines (as long as possible)
- try a local search starting from “good”starting values



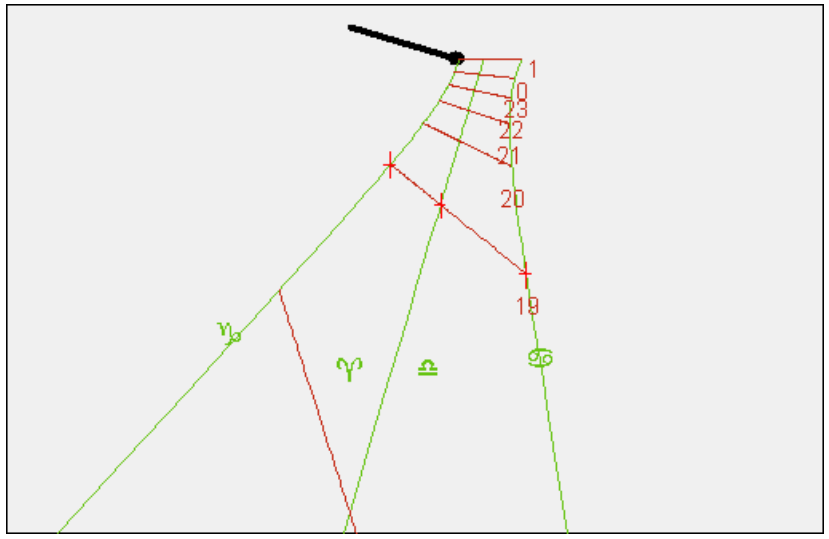
- “freeze” known values



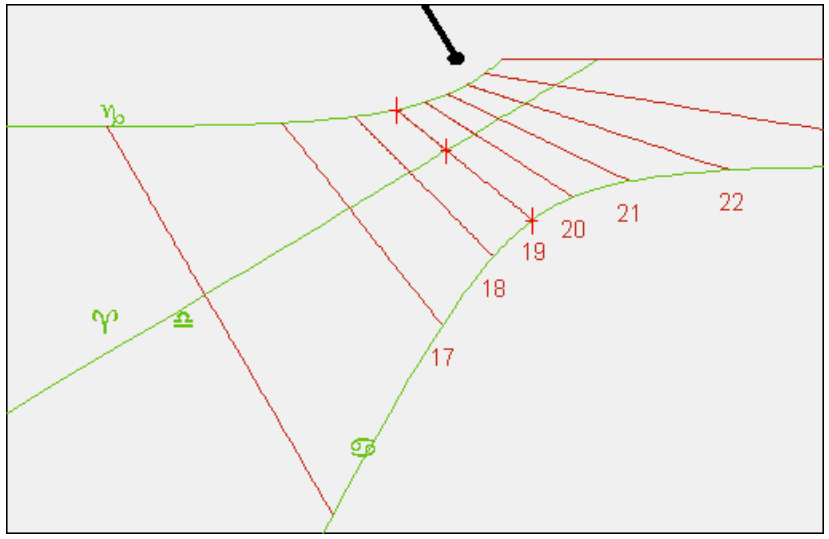
Reverse engineering

previous ex. (italic dial with three hour lines / day lines intersections known) : when the style position is known and introduced (“frozen”) we obtain the correct result

wrong



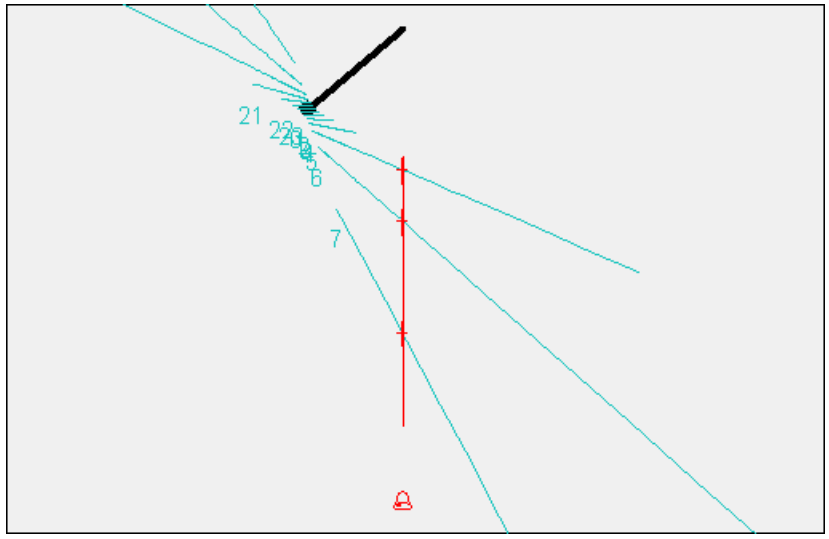
good



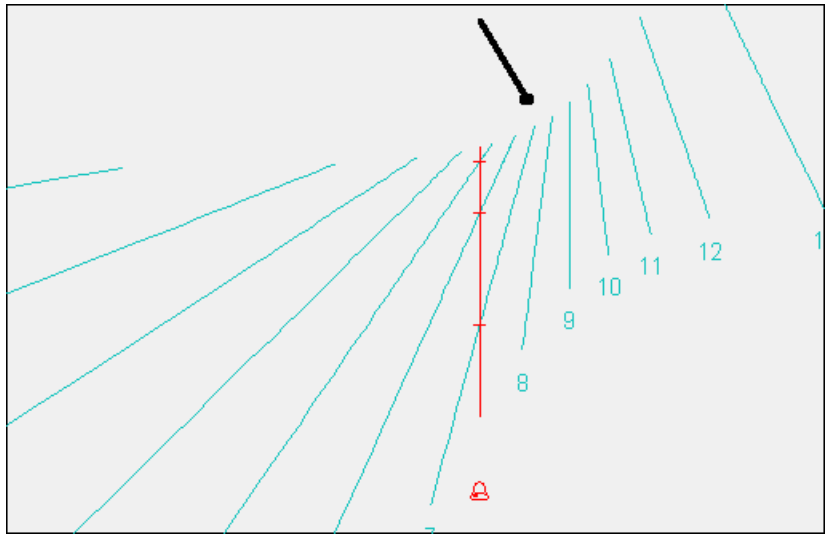
Reverse engineering

previous ex. (babilonic dial with three meridian / hour lines intersections known) : when the style position is known and introduced (“frozen”) we obtain the correct result

wrong



good



Future enhancements

New types of dials :

- sheppard cylindrical dial
- Joël Robic's cylindrical dial
- height dials
- reflection (mirror) dials
- bifilar dials

Future enhancements

Various :

- day lines for 12 months (azimuth dials)
- style position for 12 months (analemmatic dials)
- quarter of hour lines
- user preferences (line thickness, colour etc.)
- user interface and help files translated to new languages

Download, comments, suggestions, bugs …

http://digilander.libero.it/orologi.solari

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