Hi Ben,

As promised, here are some details that cropped up during our meeting today.

First, just to confirm the basic sizes. The disc/face of the equatorium and the epicycle have the same outer circumference. For the purposes of the author, that was 72π" (i.e. they both have diameter 72"). The band of metal on the epicycle ring is 2" wide (or 2/72 of the total diameter, since your model is obviously smaller) and the bar across the epicycle and label are both 1" wide (though the shape of the label means that it is 2" wide at the midpoint). The internal diameter of the epicycle ring is 68" (72-2-2). Matching this is a 68" circle on the face, which is called the "encloser of the signs" (EOTS). The 2" ring between the EOTS and the edge of the face is the limb; this is covered with parchment or brass, and the zodiac signs and degree scale are marked on it.

The EOTS and internal circumference of the epicycle are the reference circles of the whole instrument – that radius from the centre to the "top" of the face (90° anticlockwise from the head of Aries on the right) is called "line alhudda", and is 34" long. Any measurements (e.g. eccentricities of planets) are given in manuscripts relative to that length. So Evans' value of 0.10284 for the eccentricity of Mars (the distance from the centre to Mars' deferent) would be multiplied by 34" to make a model of the ideal 72" size – so the deferent of Mars would be 3.5" from the centre, and the equant double that. In Price and some other texts these values are given in degrees – those are sixtieths of the total. Note that Price's eccentricities (p. 115 of his edition) are defined as earth-equant distance, not earth-deferent. So in the case of Mars Price gives values ranging from 11,13 (i.e. 11° 13', which is 11+(13/60), or 11.2167°) to 13,00. As that's in sixtieths of the total, to find that as a proportion of 34" it's something like (13/60)*34, which is 7.37" – that's roughly double 3.5", as you'd expect.

The line alhudda is divided into 5 sections (so the centre of the face is 0 and the EOTS is 5) – this is used for the moon's latitude.

Note also that there is something called the "common centre deferent" (CCD) marked as a reference point on the internal circumference of the epicycle, 90° round from the bar that crosses the epicycle. This is the bit that you're supposed to fix to the deferent of the planet you want. It's not exactly clear what the author wants but I interpret it as a hole. You can see what I did in my physical model: http://2.bp.blogspot.com/-4UZ5VVIWf78/UcL0YQscnCI/AAAAAAAAAVM/tyB8cM7EYi4/s1600/Equatorium.jpg - the CCD is the obvious lumpy hole on the left of the epicycle. The hole is (supposed to be) exactly on the internal circumference of the epicycle, so it is 34" from the centre, just like the EOTS.

Right, now all that's clear, here are the values I think you should be using. I will give them as decimals like Evans, so that 1 would be the full distance from the centre to the encloser of the signs.
Eccentricities (centre-deferent):
Venus: 0.018056
Mars: 0.095
Jupiter: 0.049583
Saturn: 0.0543056
For all those, the equant is double that distance from the centre.
For Mercury, the equant should be at 0.05056 from the centre. As we discussed, the deferent moves on a circle whose centre is the same distance again from the equant – so 0.10111 from the

centre. So the deferent might be as far as 0.15167 from the centre, if it is sitting right on its line of apsides. But as we discussed, it moves round clockwise by the same amount as the mean motus moves anticlockwise.

The Sun just has an equant, no deferent. Now we discussed the sun's eccentric circle, which has its centre 1/32 from the centre along line alhudda, and a radius of 30/32 of line alhudda. So at the far end of line alhudda it is just 1/32 from EOTS, and 180° round the face (remember the radius that goes down there is called the "midnight line" and is divided in ninths) the sun's eccentric circle comes 3/32ths from the EOTS (i.e. a radius of 30/32, offset by 1/32).

The result of all this is that the Sun is operating on a different scale from all the planets. Their eccentricities are calculated as a fraction of EOTS, but the Sun has its own eccentric circle that we've just drawn. The centre of that eccentric circle is the equant, and that's what's used to hold the white string in the method we discussed.

The only one remaining is the Moon. That has a complex method I'll describe below, but for the purpose of marking the face, what you need to know is that it has a circle of holes, centred on the earth/centre, with radius 0.20778 of the EOTS. So it should just about fit on the brass plate (I didn't mention that before, but as I think you know it's 16" in diameter. So its 8" radius is 0.235 of the EOTS (of course it's a quarter of the whole face)).

How many holes for the circles of Mercury/the Moon? As many as you can, while still making it look good!

Next we have the radii of the epicycles – these are marked on the label and are obviously used to locate the black string in the final stage of the method. I think you should use the following values:
Mercury: 0.36722
Venus: 0.76639
Mars: 0.68611
Jupiter: 0.184167
Saturn: 0.10361
Moon: 0.08694

As you'll see, those are pretty close to Evans' Table 7.4 (those that appear there), but are slightly different. The values I've given you are my best guess at those that would have been used by our author.

Now you want the daily mean motion in longitude (a.k.a. mean motus) and epicyclic anomaly (a.k.a. mean argument). And you want the "radix" or epoch values, i.e. the value of each at our start date, which is 31 December 1392. They are as follows (I've presented them in the same units as Evans Table 7.4, for clarity – you'll see that the daily motions are very close to those presented by Evans, if not absolutely identical):

	Mean motus on 31/12/1392	Daily mean motus (°/day)	Mean argument on 31/12/1392	Daily mean argument (°/day)
Moon	130°28’	13.1763947	84°38’	13.0649885
Mercury	288°33’	0.9856464	259° 47’	3.10670237
Venus	288°33’	0.9856464	23°13’	0.61651574
Sun	288°33’	0.9856464	N/A	N/A
Mars	92° 12	0.52406791	196° 20’	0.46157849
Jupiter	324° 45’	0.08312709	323° 47’	0.90251931
Saturn	184°45’	0.3349673	103° 47’	0.95214966

The tables also contain epoch values for the “era of Christ” i.e. year 0, but I’m not sure we need to use these.

That just leaves the longitudes of the apogees (aka auges/auxes)... (Incidentally, this is basically the same as the line of apsides, except that of course the line of apsides is a full diameter – it goes to the apogee and perigee – whereas the aux line is just a radius. What we want on the face is just a radius for each.) Our manuscript lists them for 31 December 1392 (as well as the era of Christ), as follows:
Sun/Venus: 90°09’ (which is why the Sun’s equant can be set neatly on line alhudda)
Mercury: 209°23’
Mars: 133°56’
Jupiter: 172°20’
Saturn: 252° 07’
The Moon, of course, doesn’t have an apogee.

Now for the Moon’s method. The equatorium will give you the longitude and latitude. Longitude first:

The moon has a moving deferent centre: To locate this, find the difference between the Moon’s mean motus and the Sun’s mean motus. Subtract the result from the Sun’s mean motus (i.e. count back clockwise) to find the location of the deferent centre on the circle of holes.
The equant will be precisely 180° round the circle from the deferent centre.

The epicycle is placed with its CCD on the moon’s deferent centre. Then you put the epicycle centre/pole under the BLACK string (laid out for the mean motus) instead of the white one – there’s no use of parallel strings here.

Now you use the white string; as I say, the equant is 180° round the Moon’s circle of holes from the deferent. Run the white string over the centre of the epicycle, similar to the method for the planets – but of course it’s not parallel to the mean motus. (The angle between the white and black strings at this point is the equation of centre, which you need for the Moon’s latitude – see below.)

Now the rest of the method is similar to the planets – you turn the label to mark the mean argument/anomaly, starting from where the white string crosses the far side of the epicycle, but this time you turn it CLOCKWISE. Then you move the black string to the Moon’s mark on the label and read off the true longitude on the limb.

For the Moon's latitude, we need some new information.

1. The Moon's true motus. I mentioned the Moon's equation of centre above – you add this to the Moon's mean motus to get its true Motus.
2. The true motus of Caput Draconis – this is a value found in tables, as follows:

Radix/epoch value of true motus of Caput Draconis, 31 December 1392: 15°21'
Daily CLOCKWISE motion of true motus of Caput Draconis (°/day): 0.05295426

Use these values to calculate the true motus of Caput Draconis for the desired day. Then subtract the true motus of Caput Draconis from the true motus of the Moon. (If the result is negative, add 360°).
If the result is more than 180°, subtract 180° and remember that your final answer will be negative.
So you now have a number of degrees between 1 and 180°. Now you use a thread on the top half of the face, on the scale of fifths I mentioned earlier. It must be laid parallel with the 0-180° diameter (i.e. perpendicular to line alhudda), and laid so that one end of the string sits on the number of degrees you've just found.
Now, where the string crosses line alhudda, you read off the number of degrees between 0° and 5°, and that is the latitude of the Moon. So when the difference between the true motuses of the Moon and Caput Draconis is 0 or 180, the latitude will be 0. When the difference is 90, the latitude will be 5°. When the difference is 270, the latitude will be -5°.

I realise this may be extraordinarily difficult to reproduce with your model – we can discuss later if you like.