Carl Zambuto Mirror Figuring Example – 12.5" f/5.6

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Introduction

The following details the figuring of a 12.5" f/5.6 mirror machine figured by Carl Zambuto. Additional background information may be found in the Yahoo zambutomirrorgroup group archives.

General Notes

- 12.5" diameter, f/5.6, Pyrex.
- Fixed source measurements.
- All Foucault measurements past three decimal places are the result of averaging.
- Mix of 66% Gugolz #64 and 33% #55 used for all figuring laps.
- All Foucault measurements are given in the Summary section of this document.
- All Ronchigrams were produced with a 100 lines/inch grating.
- The mirror maker's spreadsheet may be found in the Yahoo zambutomirrorgroup files section under The Mirror Maker's Spreadsheet / 3-10 Zone Spreadsheet.
- Shop temperature 68˚ F, relative humidity 65%.
- 31 oz quill weight.

Couder Mask Parameters

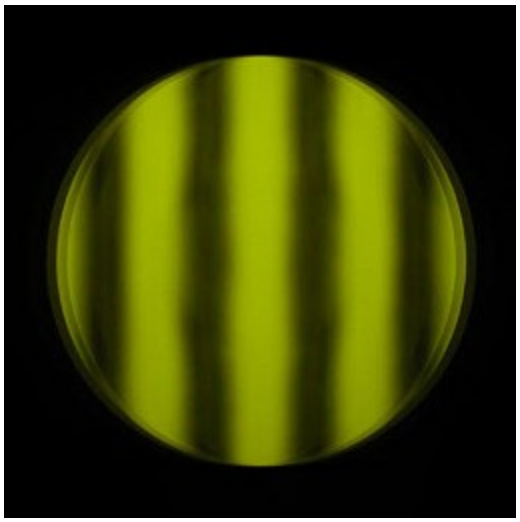
Zone	Radius (inches)
Inside Zone 1:	1.07
Outside Zone 1:	2.72
Outside Zone 2:	3.68
Outside Zone 3:	4.44
Outside Zone 4:	5.09
Outside Zone 5:	5.67
Outside Zone 6:	6.19

Polishing Details

- Gugolz #64 pitch was used for polish.

[1] A correction was added to the Couder Mask Parameters table.

Post Polishing Analysis and Strategy



Analysis

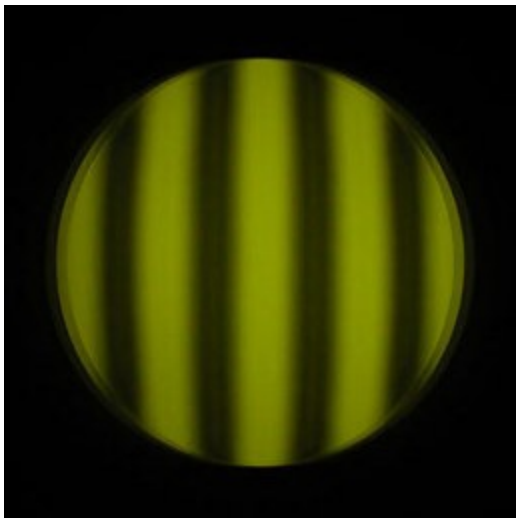
We begin by looking at the photo of the starting sphere. Overall it is spherical with a narrow slight turned edge and a ring toward the center. The condition is quite suitable to begin figuring. We begin with session one.

Overhang will be the maximum 25% for the entire session. We will do nine minutes at offset position 1/4", four minutes at offset 3/4" and two minutes at offset 1-1/4". We will repeat this four times for a total of one hour machine time.

Session 1 Figuring Steps (7.5” lap, 19 rpm eccentric, 60 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ⅞	¼	9:00	9:00
	¾	4:00	13:00
	1 ¼	2:00	15:00
1 ⅞	¼	9:00	24:00
	¾	4:00	28:00
	1 ¼	2:00	30:00
1 ⅞	¼	9:00	39:00
	¾	4:00	43:00
	1 ¼	2:00	45:00
1 ⅞	¼	9:00	54:00
	¾	4:00	58:00
	1 ¼	2:00	60:00

Post Session 1 Analysis and Strategy



Analysis

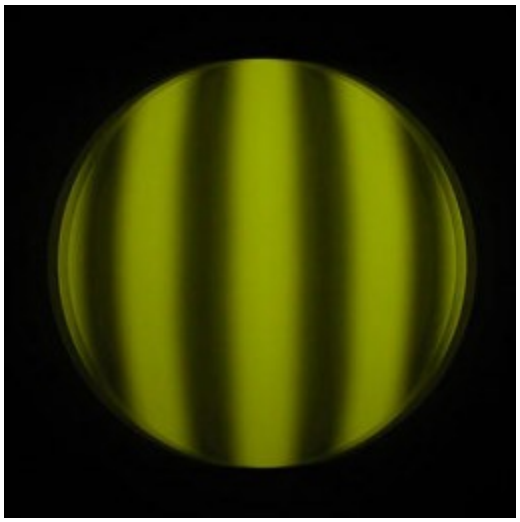
Looking at the session 1 result photo we see the mirror smoothed down well, the edge improved and a slight amount of correction was put in, although most of it went over the edge because of the stroke length. Such session do not add substantial correciton, they are for laying the foundation, or, getting the canvas ready to work on. No measurements are needed at this point, as the mirror does not have much correction in it.

We proceed with session two. We will use the same lap. We will reduce the stroke length during the session systematically, and we're going to have more than one offset pattern. We will alternate between two patterns for the most part, which are designed to push correction away from the center and begin to put it in the edge. We will be expecting a flat center, and the most correction in the outer zones.

Session 2 Figuring Steps (7.5” lap, 19 rpm eccentric, 85 minutes total)

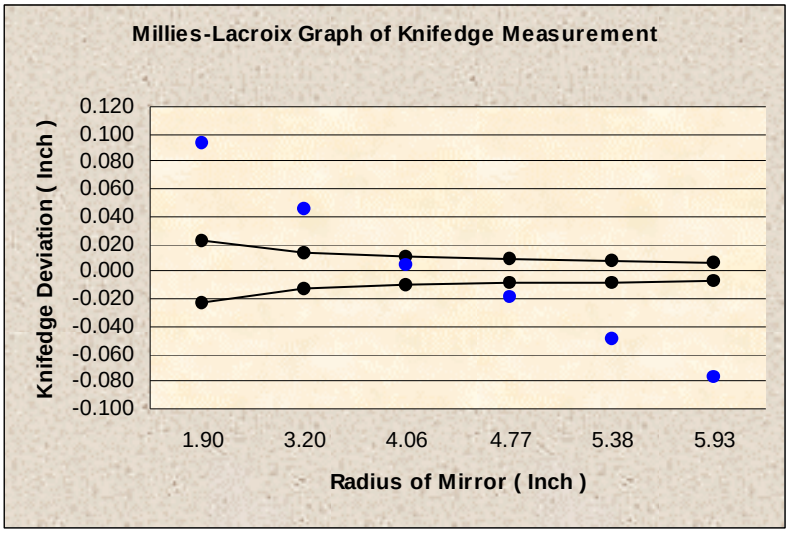
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ⅞	½	9:00	9:00
	1	4:00	13:00
	1 ½	2:00	15:00
1 ⅞	¼	5:00	20:00
	¾	3:00	23:00
	1 ¼	2:00	25:00
1 ⅝	½	5:00	30:00
	⅝	3:00	23:00
	1 ½	2:00	25:00
1 ½	¼	5:00	40:00
	¾	3:00	43:00
	1 ¼	2:00	45:00
1 ⅜	½	5:00	50:00
	⅝	3:00	53:00
	1 ½	2:00	55:00
1 ¼	¼	5:00	60:00
	¾	3:00	63:00
	1 ¼	2:00	65:00
1 ⅛	¼	5:00	70:00
	¾	3:00	73:00
	1 ¼	2:00	75:00
1	¼	5:00	80:00
	⅝	3:00	83:00
	1	2:00	65:00

Post Session 2 Analysis and Strategy



Percent Correction (%)

Zone 1-2	0
Zone 2-3	9
Zone 3-4	45
Zone 4-5	34
Zone 5-6	36
Center to 70% Zone	18
70% to Edge	35
Overall Correction	24



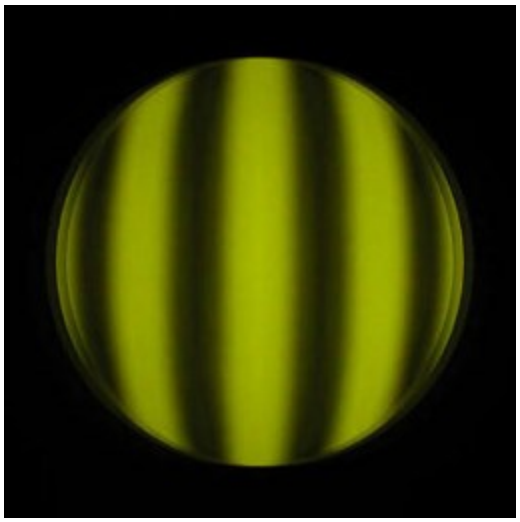
Analysis

Good progression with a zone developing where we have 45%. That is either a remnant of the beginning central zone or is caused by the edge of the lap, but in either case, I don't see it as a problem. The outer zones will catch up with it shortly. Will do another session now, cutting the time in each position down. The longer times with session #2 were more for getting things smoothed out and getting the edge where we want it. Spending that much time over the edge is not terribly efficient in correcting the mirror overall, but we do spend time like that at the beginning in most cases. Now we move inward faster to begin putting some correction into the mirror, by staying only 5 minutes in each segment.

Session 3 Figuring Steps (7.5” lap, 19 rpm eccentric, 50 minutes total)

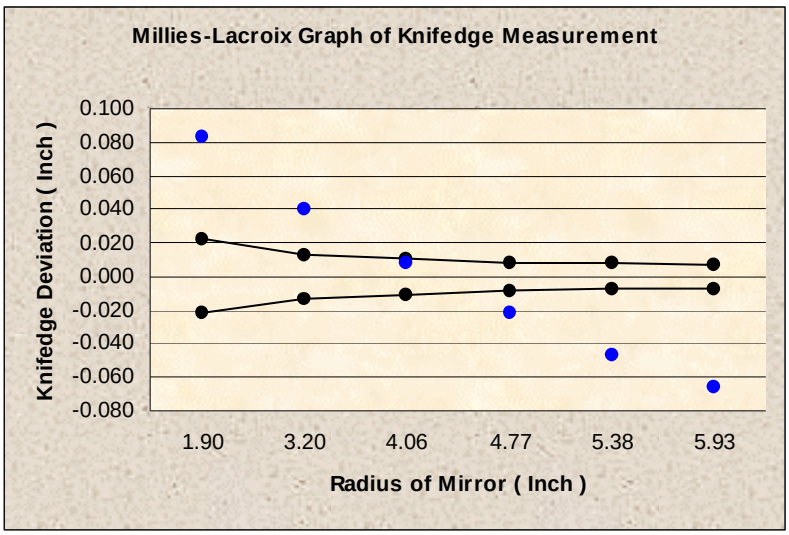
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ⅞	½	2:30	2:30
	1	1:30	4:00
	1 ½	1:00	5:00
1 ¾	¼	2:30	7:30
	¾	1:30	9:00
	1 ¼	1:00	10:00
1 ⅝	½	2:30	12:30
	1	1:30	14:00
	1 ½	1:00	15:00
1 ½	¼	2:30	17:30
	¾	1:30	19:00
	1 ¼	1:00	20:00
1 ⅜	½	2:30	22:30
	1	1:30	24:00
	1 ½	1:00	25:00
1 ¼	¼	2:30	27:30
	¾	1:30	29:00
	1 ¼	1:00	30:00
1 ⅛	¼	2:30	32:30
	¾	1:30	34:00
	1 ¼	1:00	35:00
1	¼	2:30	37:30
	¾	1:30	39:00
	1 ¼	1:00	40:00
⅞	¼	2:30	42:30
	¾	1:30	44:00
	1 ¼	1:00	45:00
¾	¼	2:30	47:30
	¾	1:30	49:00
	1 ¼	1:00	50:00

Post Session 3 Analysis and Strategy



Percent Correction (%)

Zone 1-2	8
Zone 2-3	28
Zone 3-4	34
Zone 4-5	44
Zone 5-6	57
Center to 70% Zone	23
70% to Edge	51
Overall Correction	34



Analysis

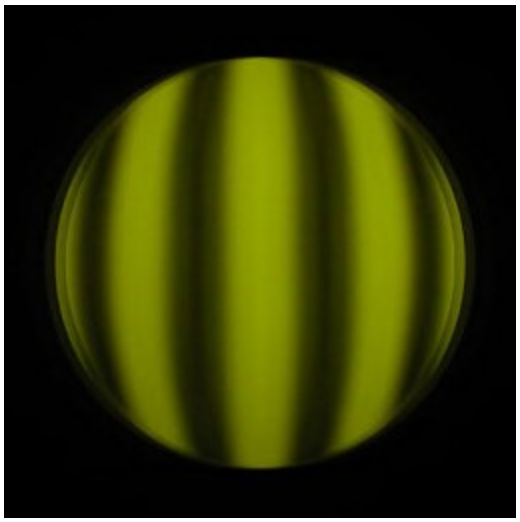
Session 3 was predictable and did essentially what we designed it to do. The ML progression is smooth and systematic. It shows no zones. We now have the option to consider using a next size smaller lap. This is a place (with 58% edge correction) where we could go either way. We could use the 7.5 one more time and keep the stroke length shorter or we could go to a smaller lap in an effort to begin to put correction further in.

We will use a 7" lap on the next session (because we have one ready and available). We will start at maximum overhang because we have a long way to do yet on the edge, but will go in further this time, in an effort to begin putting more correction further in. We will use less offset (we will eliminate the 1/2, 1, 1-1/2 offset positioning) in an effort to allow the second zone space from the edge to get closer to the edge zone in percentage of correction.

Session 4 Figuring Steps (7” lap, 19 rpm eccentric, 65 minutes total)

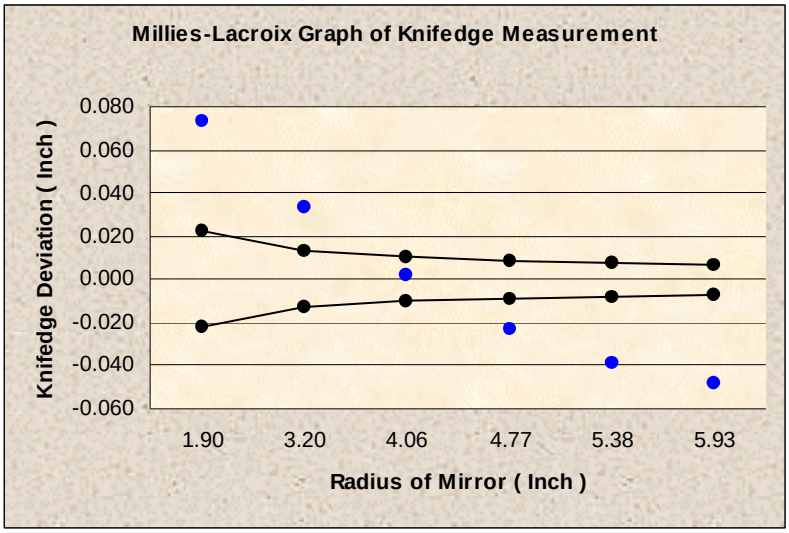
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ¾	¼	2:30	2:30
	¾	1:30	4:00
	1 ¼	1:00	5:00
1 ⅝	¼	2:30	7:30
	¾	1:30	9:00
	1 ¼	1:00	10:00
1 ½	¼	2:30	12:30
	¾	1:30	14:00
	1 ¼	1:00	15:00
1 ⅜	¼	2:30	17:30
	¾	1:30	19:00
	1 ¼	1:00	20:00
1 ¼	¼	2:30	22:30
	¾	1:30	24:00
	1 ¼	1:00	25:00
1 ⅛	¼	2:30	27:30
	¾	1:30	29:00
	1 ¼	1:00	30:00
1	¼	2:30	32:30
	¾	1:30	34:00
	1 ¼	1:00	35:00
⅞	¼	2:30	37:30
	¾	1:30	39:00
	1 ¼	1:00	40:00
¾	¼	2:30	42:30
	¾	1:30	44:00
	1 ¼	1:00	45:00
⅝	¼	2:30	47:30
	¾	1:30	49:00
	1 ¼	1:00	50:00
½	¼	2:30	52:30
	¾	1:30	54:00
	1 ¼	1:00	55:00
⅜	¼	2:30	57:30
	⅝	1:30	59:00
	1	1:00	60:00
¼	¼	2:30	62:30
	⅝	1:30	64:00
	1	1:00	65:00

Post Session 4 Analysis and Strategy



Percent Correction (%)

Zone 1-2	15
Zone 2-3	30
Zone 3-4	44
Zone 4-5	64
Zone 5-6	79
Center to 70% Zone	29
70% to Edge	71
Overall Correction	46



Analysis

The progression is not as smooth as we would like. We jump 20% from 44 to 64, which isn't a terrible thing, but I was expecting a bit smoother. Upon examination of the 7" lap on removal after the session we noted the contact in the center 2.5 inches approx was not up to par. It is possible that because of that we didn't get the correction in the inner zones that I expected. Looking at the Ronchigram it is readily apparent where the larger change in correction exists. But note the change in slope in the line is not a hard, or sharp one. It is well-rounded before it goes to "flat", and that is desirable. In any case, we move on.

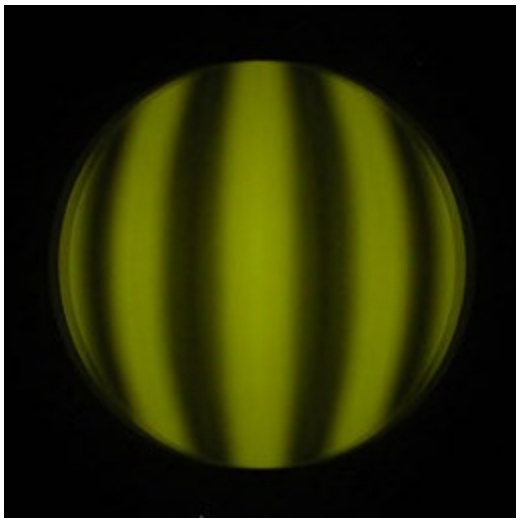
Our next session (#5) will be with the next size smaller lap. We want to address the inner zones a bit more, where indicated above. This session although a long one, will not start at maximum overhang. I want to address that 20% change in slope by targeting that area more than others outside of it. We will still get correction in the outer zone, but not as

much as if we started at full overhang. At the point where we're putting correction into the target area we will offset a bit more for a couple of sessions.

Session 5 Figuring Steps (6.5” lap, 22 rpm eccentric, 55 minutes total)

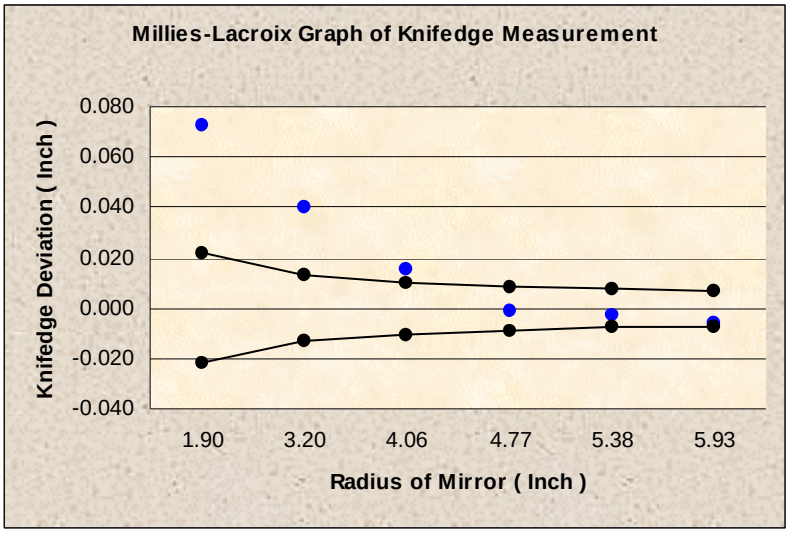
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1	¼	2:30	2:30
	¾	1:30	4:00
	1 ¼	1:00	5:00
⅞	¼	2:30	7:30
	¾	1:30	9:00
	1 ¼	1:00	10:00
¾	¼	2:30	12:30
	¾	1:30	14:00
	1 ¼	1:00	15:00
⅝	½	2:30	17:30
	1	1:30	19:00
	1 ½	1:00	20:00
½	¼	2:30	22:30
	¾	1:30	24:00
	1 ¼	1:00	25:00
⅜	½	2:30	27:30
	1	1:30	29:00
	1 ½	1:00	30:00
¼	¼	2:30	32:30
	¾	1:30	34:00
	1 ¼	1:00	35:00
⅛	¼	2:30	37:30
	¾	1:30	39:00
	1 ¼	1:00	40:00
0	¼	2:30	42:30
	¾	1:30	44:00
	1 ¼	1:00	45:00
minus ⅛	¼	2:30	47:30
	⅝	1:30	49:00
	1	1:00	50:00
minus ¼	¼	2:30	52:30
	⅝	1:30	54:00
	1	1:00	55:00

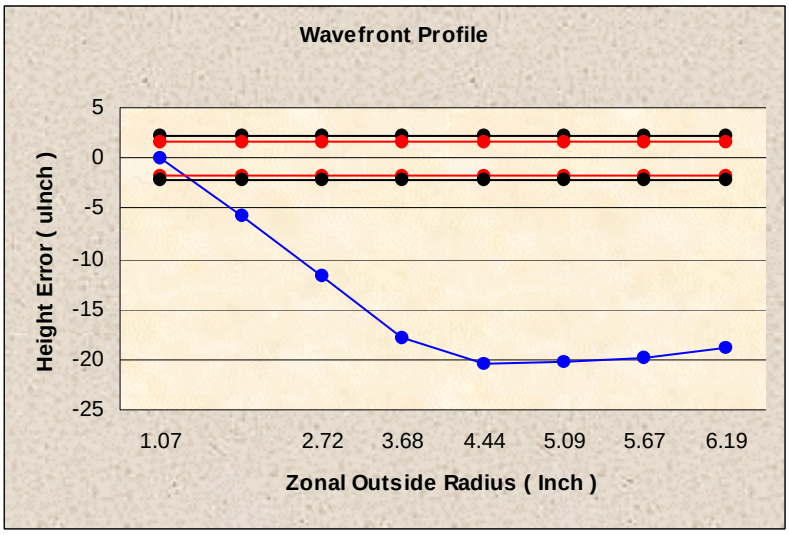
Post Session 5 Analysis and Strategy



Percent Correction (%)

Zone 1-2	32
Zone 2-3	45
Zone 3-4	63
Zone 4-5	96
Zone 5-6	92
Center to 70% Zone	46
70% to Edge	94
Overall Correction	65





Analysis

Looking at the Ronchigram we notice immediately the correction has moved further in toward the center of the mirror, and noticeably so. However, looking at the percentages, we find we have gotten ourselves into a pickle. It seems we went too long and too far with one lap, and this is what happens when we do that. When we go too far in with a particular lap (too large a lap for the reduced diameter of the area being worked) and spend too much time, it will cause a kink. The session should have been shorter, and perhaps the offsets near the end could have been narrower, as well.

This kink is troublesome because the zone outside of it is almost fully corrected. This means we can't do our typical smooth application of our "brush stroke" by moving from outside of the area inward through the area needing the major correction, because such a technique adds correction outside of the target area as well. We can't afford to do that as the next zone out (97% at present) will become overcorrected. If the difference were 15% it would not be as much of an issue, but we're looking at a 34% disparity. We have a difference of 34% correction between the two zones, and normal figuring technique as we are accustomed to will not solve this.

We have a decision to make. Either we go back to polish, or we fight through this situation by applying more advanced and exotic technique, in an attempt to smooth this mirror out. I decided in the interest of education to stay with this figure and continue, to see where we can go with this. This will give the student an opportunity to get a glimpse into some of the more exotic techniques we apply to get ourselves out of trouble (sometimes).

We type in -199 into the COC box and see that radius 4.44 is where the correction needs to begin, but not go beyond that. The ideal lap size is 5.3. We have a 6" ready and slated for use next, and because this is a longer focus mirror, I think we will use it. Positioning the sweet spot at radius 4.44 the lap position will be minus .61 inches. This technique wants to stay inside of that place, so we will begin at -5/8 inch, or -.625. The technique we're going to employ we call a "sweep". It is generally a continual offset of one minute increments with a constrained stoke length. What that means is, as we offset throughout the sweep, we adjust the stroke length as needed to keep it constrained to the indicated one. With this kind of technique we decrease the stroke length by 1/8" at some general place during the offset, often at 1" to 1-1/4". Then as we get even further out, we decrease by a full 1/4" until the outermost offset. Sometimes we end the session at the outermost offset, and sometimes we bring it back in again, depending on what we want to do with the center. In this session we're going to move out by 1/8" increments and come back by 1/4" increments.

The idea with the sweep technique is to target a very specific place (a kink) by changing offset but constraining stroke length. We can put a very large amount of correction in one place successfully by doing this. If we don't offset, much of the correction will go further in, and the zone where we want to place it will get left behind. The reason for the sweep

is to keep everything inside the target zone smooth in its progression. So we (smoothly) "sweep" outward, then back inward again

Session 6 Figuring Steps, Part 1 (6” lap, 28 rpm eccentric, 21 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
minus ⅝	0	1:00	1:00
	⅛	1:00	2:00
	¼	1:00	3:00
	⅜	1:00	4:00
	½	1:00	5:00
	⅝	1:00	6:00
	¾	1:00	7:00
minus ¾	⅞	1:00	8:00
	1	1:00	9:00
	1 ⅛	1:00	10:00
	1 ¼	1:00	11:00
minus ⅞	1 ⅜	1:00	12:00
	1 ½	1:00	13:00
	1 ⅝	1:00	14:00
	1 ½	1:00	15:00
minus ¾	1 ¼	1:00	16:00
	1	1:00	17:00
minus ⅝	¾	1:00	18:00
	½	1:00	19:00
	¼	1:00	20:00
	0	1:00	21:00

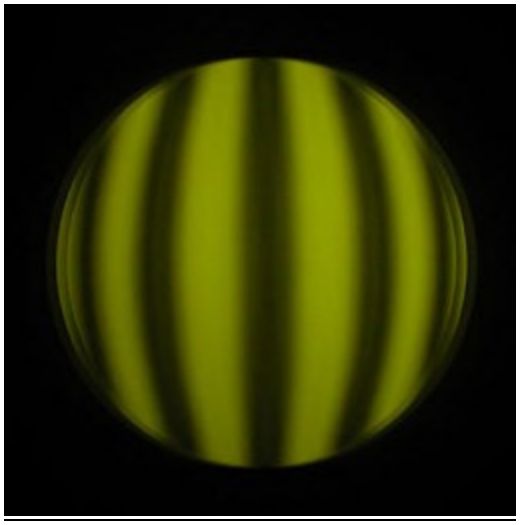
Notice the stroke length moved back out again as we moved the offset back in.

Part two is we need to address the outer zones as well. The edge zone is slightly behind the zone inside of it. We're going to employ the same technique on the edge zone. Now we put the same lap at full overhang of 1.5" and sweep from zero offset out to 2-1/2" offset. The "extreme" offset is for the purpose of shifting correction from the next-to-edge zone, out to the edge zone itself. We start at zero to keep the entire mirror smooth. We have to slow the speed down considerably to keep primary ripple low while going over the edge.

Session 6 Figuring Steps, Part 2 (6” lap, 28 rpm eccentric, 11 minutes total)

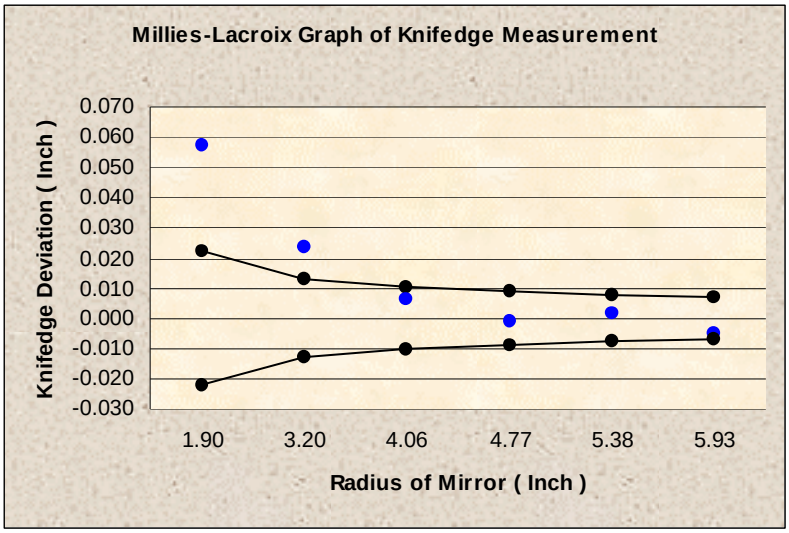
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ½	0	1:00	1:00
	¼	1:00	2:00
	½	1:00	3:00
	¾	1:00	4:00
	1	1:00	5:00
	1 ¼	1:00	6:00
	1 ½	1:00	7:00
	1 ¾	1:00	8:00
	2	1:00	9:00
	2 ¼	1:00	10:00
	2 ½	1:00	11:00

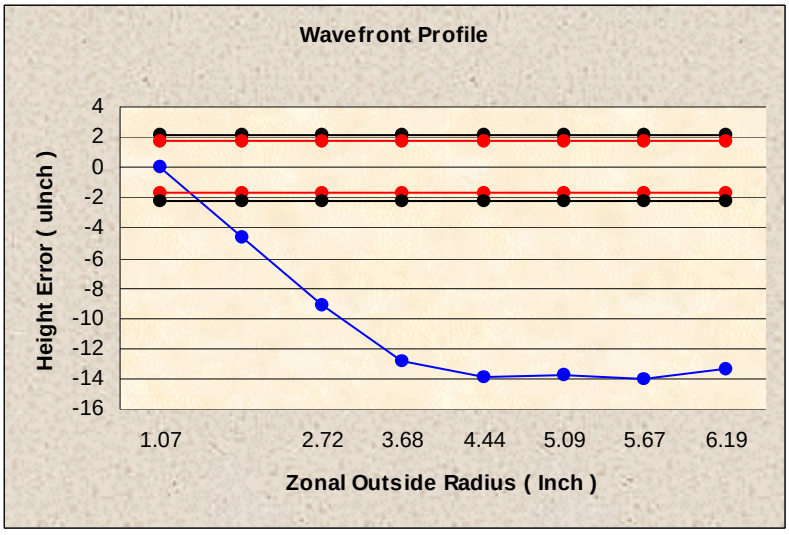
Post Session 6 Analysis and Strategy



Percent Correction (%)

Zone 1-2	29
Zone 2-3	62
Zone 3-4	83
Zone 4-5	105
Zone 5-6	86
Center to 70% Zone	57
70% to Edge	96
Overall Correction	72





Analysis

Plug in the numbers and looking at the M-L graph we see the session was largely successful, however, we added correction to the space between zone 4 and 5 after all. - Another mistake. (That's two in a row, now.) Okay, so I've been a little distracted. Looking in hindsight I would say the lap size is the culprit. It didn't care about the mirror being long-focus, we chose a 6" lap instead of 5.3" and did a sweep with it. (lesson learned. When doing an inside sweep, use a lap that is more consistent with 60% of the diameter being worked.) Using that lap apparently put correction further out overall during the session than we wanted. We could have stood to move everything in by another 1/8".

Now keeping this in perspective, that overcorrected space is not a "tragedy". It's not bad at all by general standards, but we're trying to make this mirror relatively very smooth. We have a saving grace here, and that is the edge. It is still under corrected which gives us some working room to work on zone 4-5. We're going to use the "great smoother" in the next session or two, or however many we need. That is, the full size (60% diameter) 7.5" lap to work on that area, which will be part of our next session.

On the plus side, notice the progression in the first four zones. It is smooth and very well graduated. This is the signature of the "sweep" technique we described and conducted in the last session. That part of it was very successful. It is not zoney at all.

This progression in the inner four zones will allow us to return to a standard correction technique for that area, which we will outline in our next session. So here is what we will do, it will be a two-part session. First, we will use a slightly smaller lap at 5.75 inches and do a standard correction procedure on the inner zones, reducing stroke length consistently. Then we're going to perform another sweep- this time on the entire mirror with the 60% diameter lap, targeting the edge zones. We're going to sweep from the center outward with a full length stroke, in an attempt to push the correction from zone 4-5 out to 5-6. (Doing this will also raise the center a bit, and we expect that to happen. We will counteract that with the correction we put in, in the first part of the session.) We could do this in two separate sessions, but I want to save some iteration labor and some time, so we will do both at once.

Session 7 Figuring Steps, Part 1 (5.75” lap, 27 rpm eccentric, 18 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
minus ¾	¼	2:00	2:00
	½	2:00	4:00
	¾	1:00	5:00
minus ⅞	¼	2:00	7:00
	⅝	2:00	9:00
	1	1:00	10:00
minus 1	0	2:00	12:00
	⅜	2:00	14:00
	¾	1:00	15:00
minus 1 ⅛	0	1:00	16:00
	¼	1:00	17:00
	½	1:00	18:00

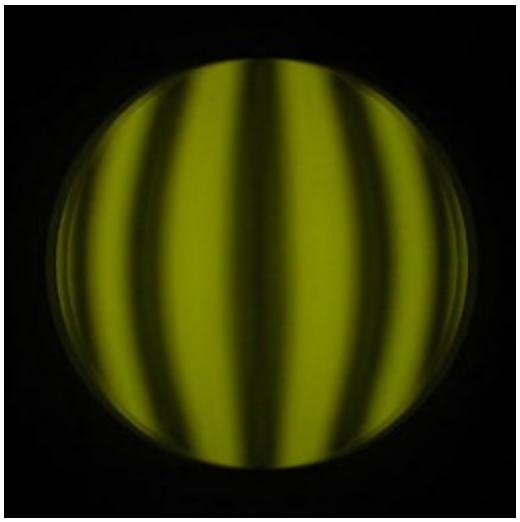
Now we change to the larger lap and do the sweep on the entire mirror. The lap will be constrained to 1-7/8" overhang throughout.

Session 7 Figuring Steps, Part 2 (7.5” lap, 17 rpm eccentric, 8 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ⅞[2]	0	1:00	1:00
	¼	1:00	2:00
	½	1:00	3:00
	¾	1:00	4:00
	1	1:00	5:00
	1 ¼	1:00	6:00
	1 ½	1:00	7:00
	1 ¾	1:00	8:00

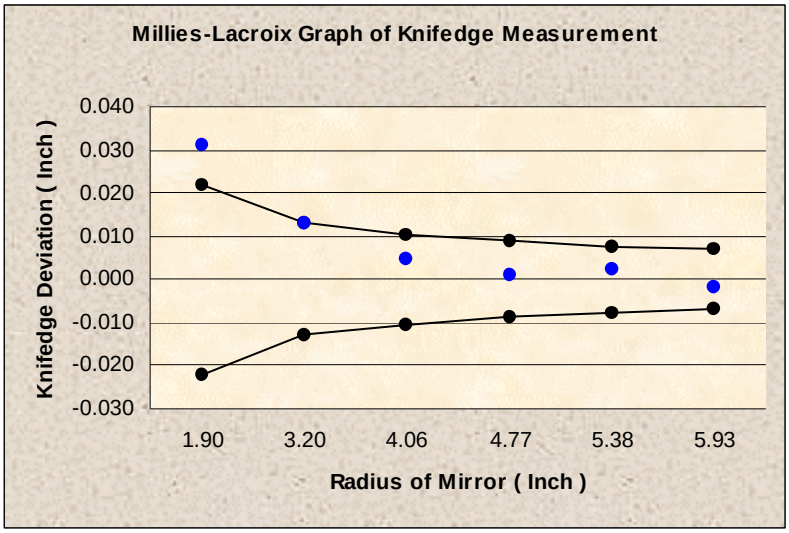
[2] Constrain overhang to 1 ⅞ inches.

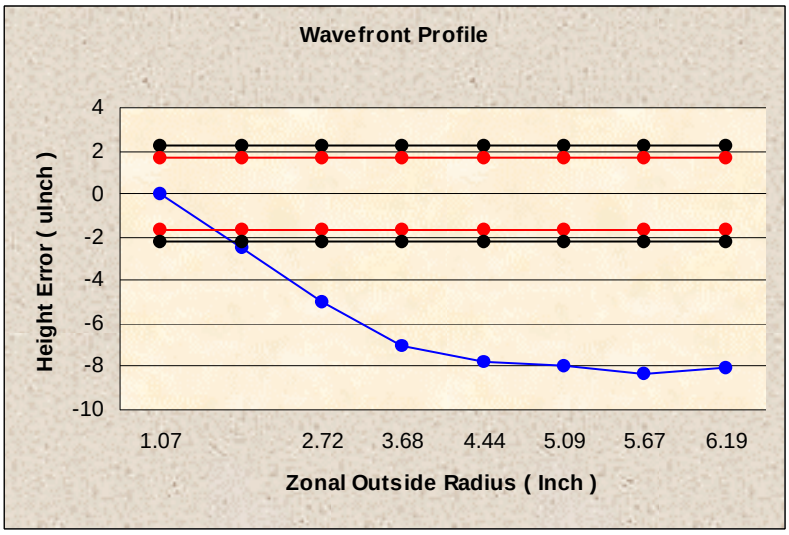
Post Session 7 Analysis and Strategy



Percent Correction (%)

Zone 1-2	62
Zone 2-3	81
Zone 3-4	92
Zone 4-5	103
Zone 5-6	90
Center to 70% Zone	78
70% to Edge	97
Overall Correction	85





Analysis

Looking at the Ronchigram this thing is starting to look like a paraboloid. Well, it should. The figure is decent.

I need to mention here that the percentages as listed will vary with the online spreadsheet mainly in the center zone, and possibly the next zone out. The reason is we're in the process of changing our reference point in the zones on our spreadsheets to the RMS instead of the mean, and, we have changed to a (slightly) more precise definition of the knife edge shift. No need to panic, in these mirrors and f/ratios any differences although detectable on paper, will be negligible in effect. (Just a note for those working along with us using the online spreadsheet.)

We see from the ML progression and percentages that smooth correction continues in the inner zones. We did well. And, we see progress in the outer zones (finally). The kink we produced earlier has smoothed a bit. Our overcorrected zone has come down 2% and the edge is coming around as well. The figure is looking more attractive on our ML graph, as the three outer plots have been smoothed by our large sweep session.

I like that session so well I'm going to do it again. We're going to work directly off the last session because everything moves in the right direction and in a good ratio. We used a rather fast eccentric speed for the inner zones, and we don't want that much correction again, so I'm going to repeat the inner section verbatim, but, with a significantly slower eccentric. We will do the outer sweep again, but this time add a bit more time to it, doing two passes, because I think based on our last session that we can do it.

Session 8 Figuring Steps, Part 1 (5.75" lap, 20 rpm eccentric, 18 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
Minus ¾	¼	2:00	2:00
	½	2:00	4:00
	¾	1:00	5:00
Minus ⅞	¼	2:00	7:00
	⅝	2:00	9:00
	1	1:00	10:00
minus 1	0	2:00	12:00
	⅜	2:00	14:00
	¾	1:00	15:00
minus 1 ⅛	0	1:00	16:00
	¼	1:00	17:00
	½	1:00	18:00

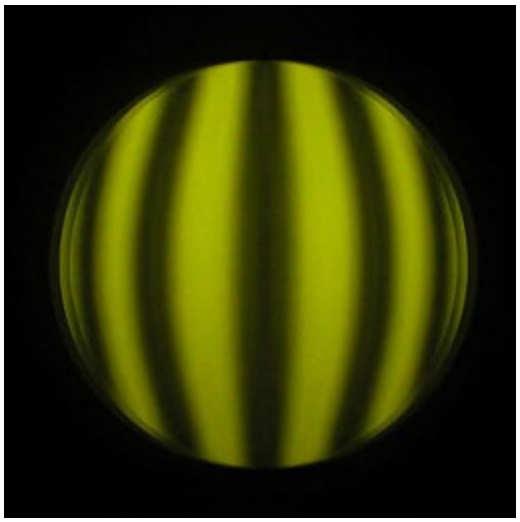
Now back out to the edge for the outer sweep.

Session 8 Figuring Steps, Part 2 (7.5” lap, 17 rpm eccentric, 14 minutes total)

Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
1 ⅞[3]	0	1:00	1:00
	¼	1:00	2:00
	½	1:00	3:00
	¾	1:00	4:00
	1	1:00	5:00
	1 ¼	1:00	6:00
	1 ½	1:00	7:00
	1 ¾	1:00	8:00
	¼	1:00	9:00
	½	1:00	10:00
	¾	1:00	11:00
	1	1:00	12:00
	1 ¼	1:00	13:00
	1 ½	1:00	14:00

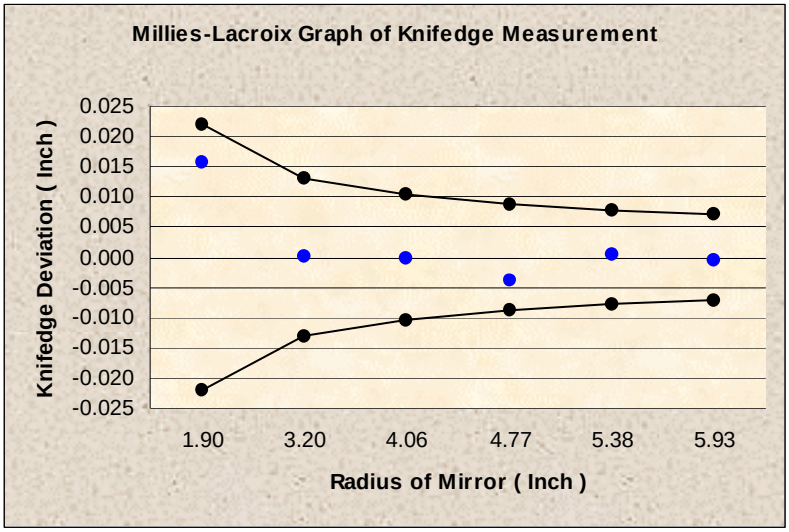
[3] Constrain overhang to 1 ⅞ inches.

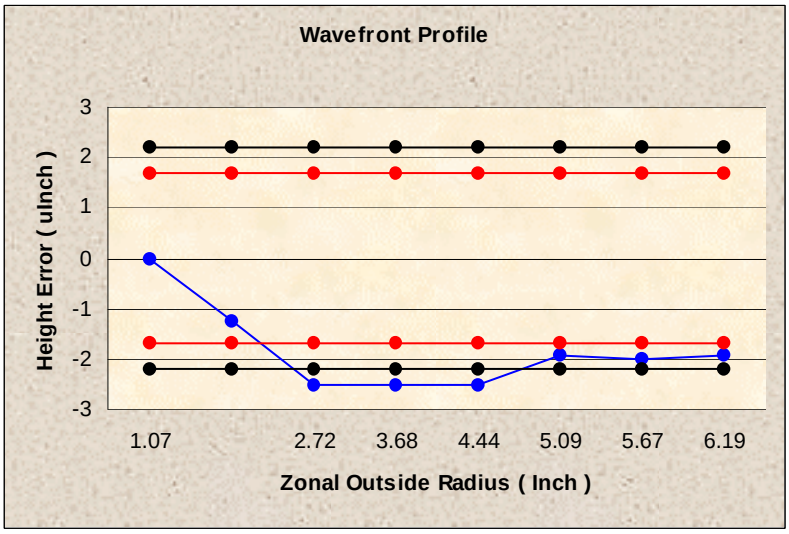
Post Session 8 Analysis and Strategy



Percent Correction (%)

Zone 1-2	67
Zone 2-3	100
Zone 3-4	91
Zone 4-5	110
Zone 5-6	98
Center to 70% Zone	86
70% to Edge	104
Overall Correction	93





Analysis

The Ronchigram shows essentially a finished mirror, and it is, save about 2 microinches on the wavefront in the center zone.

Our full mirror sweep technique finished the edge sufficiently (combined with the other zones, it is done). We did not fully eliminate the overcorrection in 4-5 but it is well within tolerance. The center zones are now all but completed.

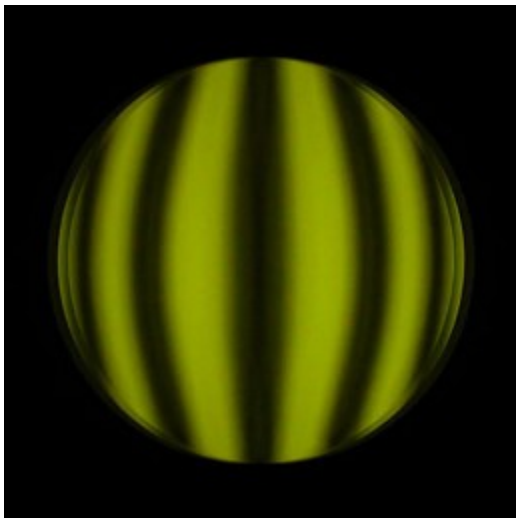
Type -20 into the COC box and see that about two microinches will finish the mirror.

We're going to use a smaller lap because of the reduced radius of the area we're working. I've chosen a 5.25" for the task. The stroke length will be relatively short, so we will spend more time than usual per microinch, in fact, 3.5 minutes each.

Session 9 Figuring Steps (5.25” lap, 27 rpm eccentric, 7 minutes total)

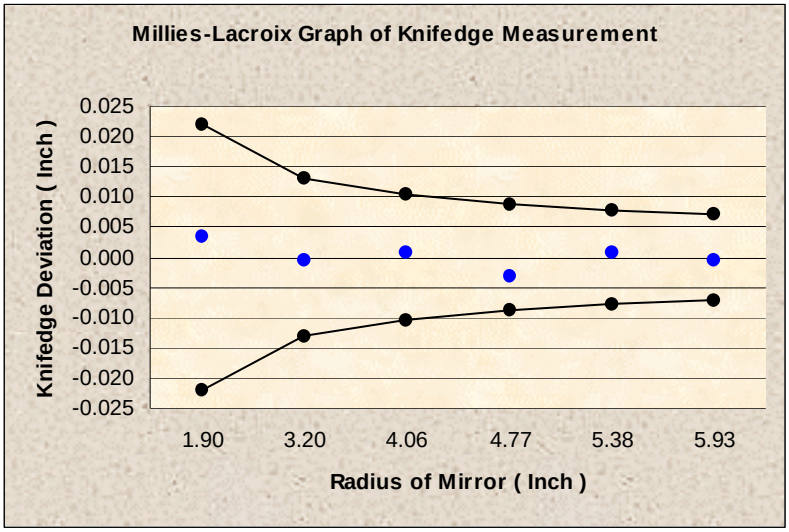
Overhang (inches)	Offset (inches)	Duration (min:sec)	Total Duration (min:sec)
Minus 1 ⅞	0	1:00	1:00
	¼	1:00	2:00
	½	1:00	3:00
Minus 2	0	1:00	4:00
	¼	2:00	6:00
	½	1:00	7:00

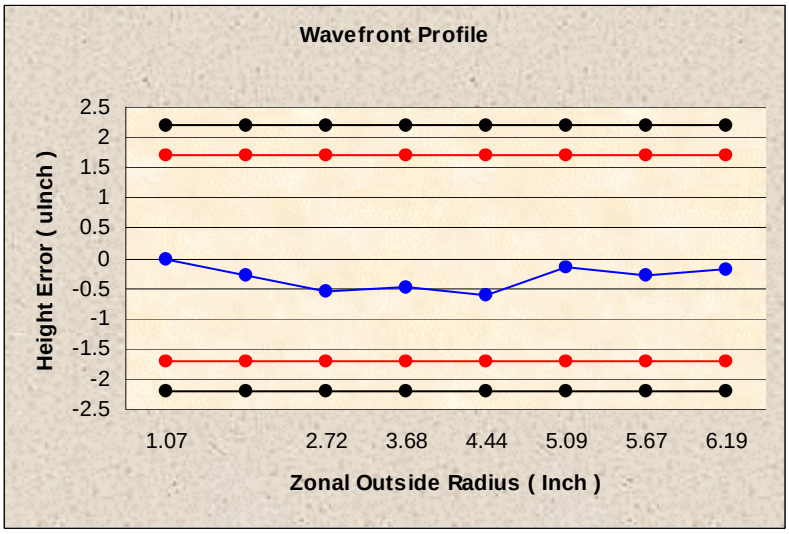
Post Session 9 Analysis and Strategy

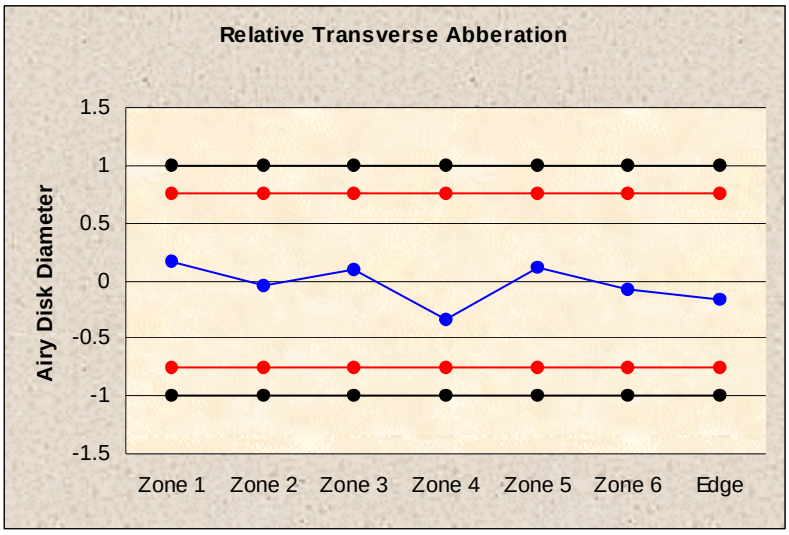


Percent Correction (%)

Zone 1-2	92
Zone 2-3	103
Zone 3-4	91
Zone 4-5	109
Zone 5-6	97
Center to 70% Zone	95
70% to Edge	103
Overall Correction	98







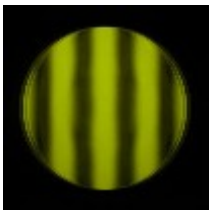
Analysis

This mirror is obviously completed. The finished relative transverse aberration is .27, or little more than 1/4 of the diffraction disk, which is superb. We were not able to totally eradicate the minor kink between zones 3, 4 and 5, however we won't complain considering the finished result. By any definition this is a superb finish. The edge is balanced, there are no visible zones on the Ronchigram, the surface is smooth and a multiple axis measurement shows no significant astigmatism.

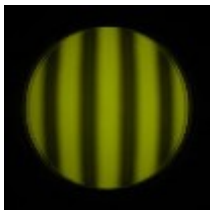
Finished radius of curvature = 140.44 inches.

Summary

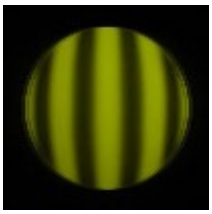
Ronchigrams (100 lines/inch grating)



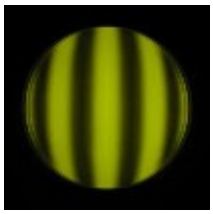
Polished Mirror



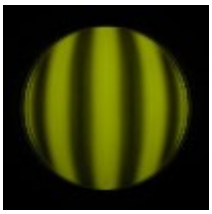
Session 1: 7.5" lap, 60 minutes



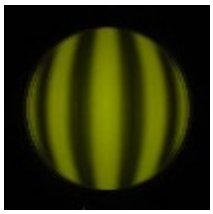
Session 2: 7.5" lap, 85 minutes



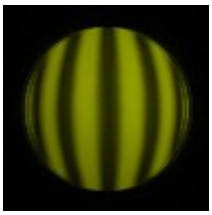
Session 3: 7.5" lap, 50 minutes



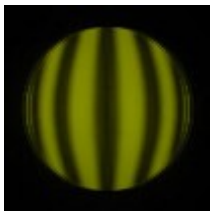
Session 4: 7" lap, 65 minutes



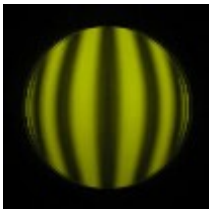
Session 5: 6.5" lap, 55 minutes



Session 6: 6" lap, 21 minutes
6" lap, 11 minutes



Session 7: 5.75" lap, 18 minutes
7.5” lap, 8 minutes



Session 8: 5.75" lap, 18 minutes
7.5” lap, 14 minutes

Session 9: 5.25" lap, 7 minutes

Foucault Measurements (inches)

	Session							
	2	3	4	5	6	7	8	9
Zone 1	0.1860	0.1445	0.2265	0.1620	0.3525	0.2705	0.1500	0.1715
Zone 2	0.1860	0.1485	0.2335	0.1770	0.3665	0.3000	0.1818	0.2150
Zone 3	0.1900	0.1610	0.2470	0.1970	0.3940	0.3360	0.2263	0.2610
Zone 4	0.2100	0.1760	0.2665	0.2250	0.4310	0.3770	0.2668	0.3015
Zone 5	0.2250	0.1955	0.2950	0.2680	0.4780	0.4230	0.3158	0.3500
Zone 6	0.2410	0.2210	0.3300	0.3090	0.5160	0.4630	0.3593	0.3930

Knifedge Deviation from Ideal (with zone 5 zeroed, inches)

	Session							
	2	3	4	5	6	7	8	9
Zone 1	0.0935	0.0839	0.0739	0.0528	0.0433	0.0227	0.0138	0.0033
Zone 2	0.0460	0.0404	0.0334	0.0203	0.0098	0.0047	-0.0019	-0.0007
Zone 3	0.0054	0.0083	0.0023	-0.0043	-0.0073	-0.0039	-0.0020	0.0007
Zone 4	-0.0191	-0.0212	-0.0227	-0.0207	-0.0147	-0.0073	-0.0059	-0.0032
Zone 5	-0.0486	-0.0462	-0.0387	-0.0223	-0.0123	-0.0059	-0.0015	0.0007
Zone 6	-0.0771	-0.0652	-0.0482	-0.0257	-0.0187	-0.0103	-0.0024	-0.0007

Percent Correction (%)

	Session							
	2	3	4	5	6	7	8	9
Zone 1-2	0%	8%	15%	32%	29%	62%	67%	92%
Zone 2-3	9%	28%	30%	45%	62%	81%	100%	103%
Zone 3-4	45%	34%	44%	63%	83%	92%	91%	91%
Zone 4-5	34%	44%	64%	96%	105%	103%	110%	109%
Zone 5-6	36%	57%	79%	92%	86%	90%	98%	97%
Center to 70% Zone	18%	23%	29%	46%	57%	78%	86%	95%
70% to Edge	35%	51%	71%	94%	96%	97%	104%	103%
Overall Correction	24%	34%	46%	65%	72%	85%	93%	98%

Final Metrics

Maximum RTA: 0.35
P-V Wavefront: 1 / 35 λ
Wavefront RMS: 1 / 93 λ
Strehl Ratio: 0.996