Backfocus, demystified

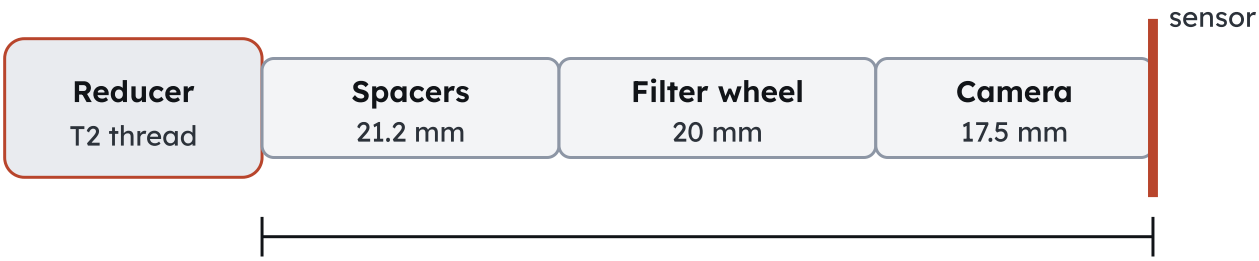
Whether it even applies to you, how many millimeters your reducer asks for, how to get there and how to know you've nailed it.

A guide by Fran López, with his own gear

Backfocus gave me a hard time. Odd stars in the corners, spacers coming and going, and always the same number in the forums: **"55 mm"**. Until I realized that my reducer didn't ask for 55 mm but for 58, and that **the same reducer asks for a different number depending on the scope you put it on**.

My case isn't everybody's: some reducers are made for one specific scope, some generic ones give a single number, and others, like mine, come with a table. So the first thing to do is **read up on your reducer and on your scope**.

This guide isn't about diagrams of stars with little lines pointing in or out. It's about what you actually need: knowing whether it applies to you, **finding your number**, adding up what each part contributes, **measuring it with calipers** and checking with a photo that you've nailed it.



58.67 mm: from the reducer's thread to the sensor (58 + the filter)

The guide's example: the Photoline on a 600 mm scope asks for 58 mm, and the 2 mm filter raises that by a third of its thickness, to 58.67. The camera uses 17.5 mm and the wheel 20; what's left, 21.2 mm, is spacers.

What you need

- [ ] Your reducer, flattener or corrector, and the manufacturer's spec sheet or manual.

- [ ] Your telescope's focal length, in millimeters.
- [ ] Your camera's spec sheet (or its T-ring, if it's a DSLR or mirrorless camera).
- [ ] Calipers: a cheap digital pair will do.
- [ ] Spacers in several sizes, ideally including a thin one (0.5 or 1 mm).
- [ ] One clear night for the test shot.

The 5 steps

1. **Does backfocus apply to you?** Only if you have a reducer, a field flattener or a corrector. Without one, there's no distance to hit: you just find focus and you're done.
2. **Your reducer's number (and why it isn't always 55).** Read up on your reducer and your scope: the manufacturer's own reducer gives a fixed number; a generic one gives a starting point or a table by focal length.
3. **What each part adds.** The camera already uses up part of it; the filter wheel, the off-axis guider and the spacers make up the rest. And the filter, if you have one, raises the number you have to hit.
4. **Measure it with calipers.** What's printed on the rings isn't always what you've got: with everything assembled and tightened, measure, add the camera and compare.
5. **Check it with a photo.** One test frame and a program that measures the stars in each corner will tell you whether it's backfocus, tilt or focus.

And at the end, a sheet to write your backfocus down. The web version, always up to date, with the spacer calculator: astrolarius.com/en/learn/backfocus

Step 1 of 5

Does backfocus apply to you?

Only if you have a reducer, a field flattener or a corrector. Without one, there's no distance to hit: you just find focus and you're done.

No reducer, no backfocus

If you put the camera straight into the telescope's focuser, with nothing in between correcting the light, **there is no distance to hit**. You move the focuser until the stars are points, and that's it. Right now my 600 mm scope is set up that way, with no reducer, and backfocus simply doesn't exist.

What can still happen is that the stars in the corners don't come out perfect: that's the field curvature of the scope itself, and moving the camera won't fix it. That's exactly what flatteners are for.

What creates the problem

Backfocus shows up when you add a part that **corrects the light and is designed for the sensor to sit at one specific distance** from it:

- **A reducer**: it shortens the focal length (0.79x turns 600 mm into 474) and flattens the field.
- **A field flattener**: it doesn't change the focal length, it only flattens the field.
- **A coma corrector**, on Newtonians: it makes the stars at the edge round again.
- **A scope with the flattener built in**: many small refractors made for astrophotography (the Petzval designs) have nothing added, but the manufacturer still gives you a distance. If your scope has one, it applies to you.

> **Heads-up**
>
> Without a reducer something else can happen: the camera can't reach focus because the focuser runs out of travel. That's fixed with an extension tube, and there's nothing to measure to the millimeter.

> **Fran’s advice**
>
> Before you buy spacers or fight with your corners, look at what you’re actually using. If there’s no reducer, flattener or corrector, forget about backfocus: focus well and move on.

☐ **Step 1 done**

Step 2 of 5

Your reducer's number (and why it isn't always 55)

Read up on your reducer and your scope: the manufacturer's own reducer gives a fixed number; a generic one gives a starting point or a table by focal length.

Where it's measured from

The manufacturer gives the distance **from one specific thread on the reducer to the sensor**: almost always the T2 (M42) or the M48, whichever faces the camera. That's the only measurement that counts, and you'll find it on the product page or in the manual.

If all you read is "backfocus 55 mm", check which thread it's measured from, and whether it's a single figure or a table.

Three kinds of reducer

Before you go looking for the number, work out which kind of reducer you have (or are about to buy):

What to expect from each kind

Kind	What number it gives	What to expect
Made by your scope's manufacturer, for that scope	A fixed one, almost always 55 mm	The easy case: they were designed together. Set the distance and it works
Generic, with a single number	One number for every scope, often 55 mm	A starting point: the result depends on how well two optical designs that weren't made together happen to match. You may have to experiment

Kind	What number it gives	What to expect
Generic, with a table by focal length	One number for each focal-length range	The manufacturer has done the work for you: look up your focal length in the table (mine is below)

> **Tip**
>
> If you haven't bought it yet: **if you can, buy the reducer from the same manufacturer as your telescope**, made for that scope. With a generic one, finding the sweet spot can give you headaches.

My case: same reducer, different number

My reducer is the 2″ **TS-Optics Photoline 0.79x**, a generic one with a table: **the distance depends on the focal length of the telescope** you put it on. With my 600 mm scope, 58 mm. On a short scope it would ask for as much as 70.

TS-Optics Photoline 0.79x (2″ and 3″): distance from the thread to the sensor	
Telescope focal length	Backfocus
Up to 350 mm	70 mm
Up to 420 mm	65 mm
450–500 mm	61 mm
510–600 mm	58 mm (my case: 600 mm)
610–700 mm	57 mm
710–790 mm	56 mm
800 mm and up	55 mm

Manufacturer's figures. On the 2″ version it's measured from the T2 thread; on the 3″, from the M48. It's designed for sensors up to APS-C.

> ⚠ **Heads-up**
>
> The longer the focal length, the fewer millimeters. If you copy the “55 mm” from a forum and your scope is 400 mm, you’ll be 10 mm short, and you won’t understand why your corners look bad.

Sensor size counts too

Every reducer corrects an image circle of a certain size. The Photoline is meant for sensors up to APS-C: with a full-frame sensor, **the corners will look bad even if you nail the distance**, because they fall outside what it corrects. Check which sensor size yours was made for before you blame backfocus.

> **Fran’s advice**
>
> Start by reading up on the reducer and on the scope: which kind it is, which thread it’s measured from, and whether your telescope’s manufacturer makes one for it. If you fall in a gap in the table or your reducer is generic, treat the number as a starting point and check it with a photo (step 5).

☐ **Step 2 done**

Step 3 of 5

What each part adds

The camera already uses up part of it; the filter wheel, the off-axis guider and the spacers make up the rest. And the filter, if you have one, raises the number you have to hit.

The camera already uses up part of it

The sensor isn't at the camera's front face: it sits a few millimeters inside. That depth is the camera's backfocus, and it's the first thing to subtract.

How much each part adds

Part	What it adds	Where to look it up
DSLR or mirrorless, with its T-ring	Exactly 55 mm	T-rings are made for exactly that, whatever the mount
Cooled ZWO camera ("Pro"), with its adapter	17.5 mm	ZWO's spec sheet
Any other astronomy camera	Whatever its spec sheet says	Look for "back focus" or "sensor distance"
Filter wheel, off-axis guider (OAG), tilt adjuster	Its thickness	Each part's spec sheet
Spacers	What's printed on the ring	And measure it (step 4)
Filter between the reducer and the camera	Takes up no room: it raises the target by a third of its thickness	A 2 mm filter raises the target by 0.67 mm

On a mirrorless camera, the T-ring for its mount is already longer, to get you to 55 mm. If you use a DSLR-to-mirrorless adapter (EF to RF, say), the whole stack also adds up to 55.

With a mirrorless camera

My Canon EOS R has its mount very close to the sensor (20 mm). With the EF-to-RF adapter and a DSLR T-ring, the stack adds up to 55 mm again, just like a DSLR: **what counts is the total, not each piece**.

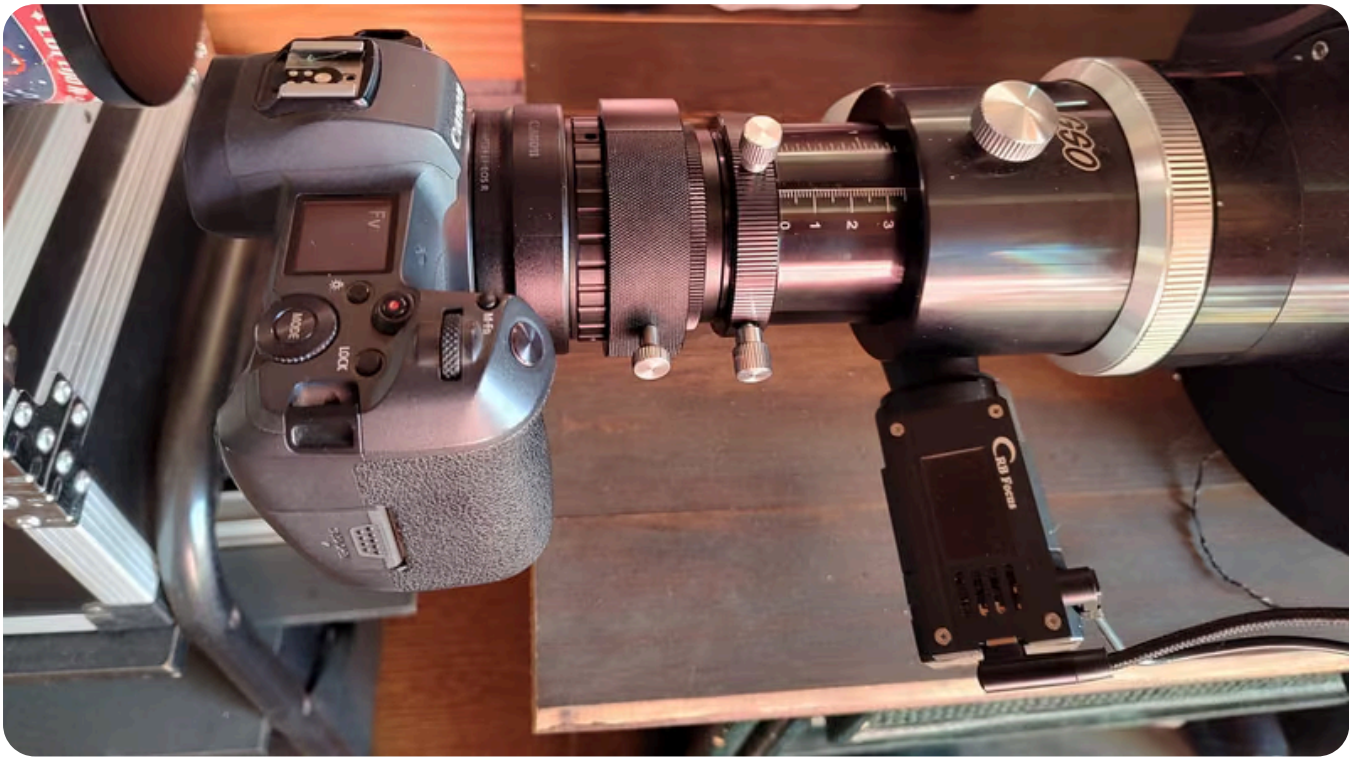


Photo: Fran López

The filter counts too

A glass filter in the light path **pushes focus back by about a third of its thickness**: 1 mm gives you 0.33 mm; 2 mm, 0.67; 3 mm, 1 mm. It only counts if it sits between the reducer and the sensor (in a wheel, or in a filter drawer behind the reducer). A filter threaded in front of the reducer changes nothing.

Watch the sign: because focus moves back, the sensor has to sit **farther away**, so the filter **raises the number you have to hit** and you need **more** spacers, not fewer. Switch to a thicker filter and you may have to add half a millimeter.

Two examples with my reducer

On my 600 mm scope the reducer asks for 58 mm:

- **With a DSLR**: the T-ring gives 55. You're **3 mm** short: one 3 mm spacer and you're done.
- **With a cooled ZWO and a 20 mm filter wheel** with 2 mm filters: the filter raises the target to 58 + 0.67 = 58.67 mm, so 58.67 − 17.5 − 20 = **21.2 mm** of spacers. For example, 20 + 1 + 0.3.

> **Tip**
>
> You don't have to do the math by hand: the calculator at the end of the guide does it and tells you which spacers to use.

> **Fran's advice**
>
> Write the sum out, part by part, before you thread anything together. Half of all backfocus problems are one part that got left out of the math.

☐ **Step 3 done**

Step 4 of 5

Measure it with calipers

What's printed on the rings isn't always what you've got: with everything assembled and tightened, measure, add the camera and compare.

Why measure

The math in the previous step is the theory. In practice, a part from another brand, an adapter that doesn't thread on all the way or a ring that isn't properly tightened will change the real distance. **A pair of calipers that costs a few dollars tells you in a minute.**

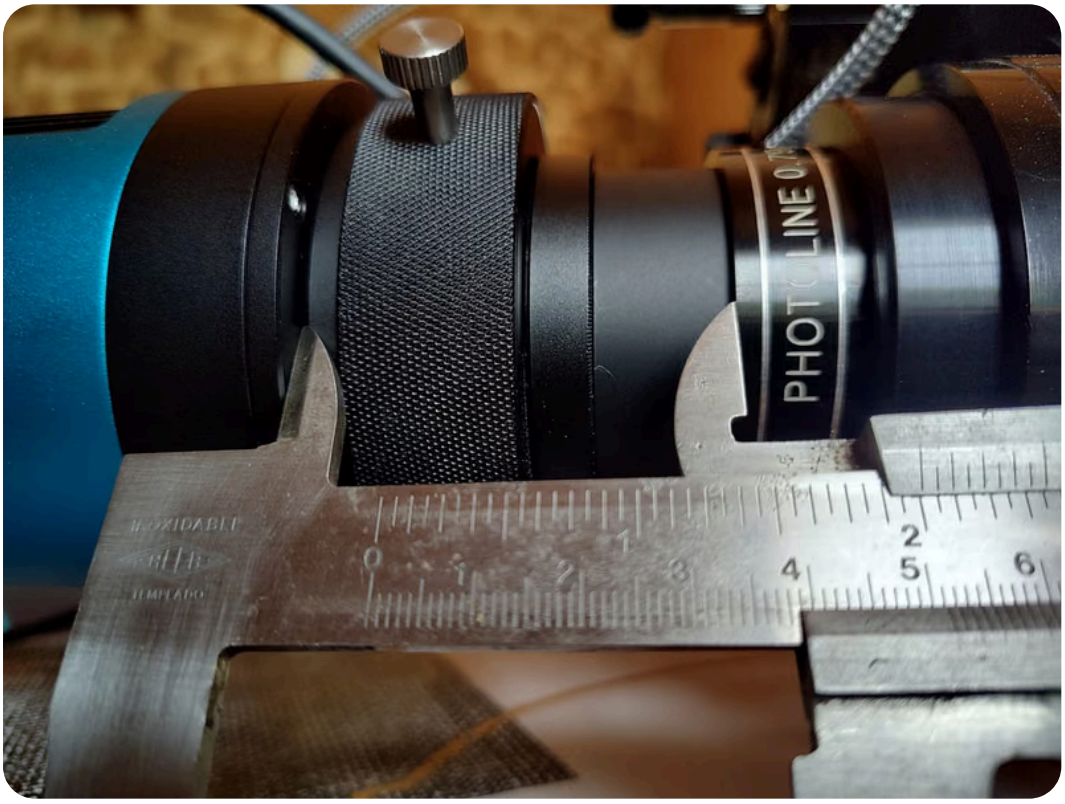


Photo: Fran López

How to measure it

1. **Assemble the whole train**, from the reducer to the camera, with every thread properly tightened. Exactly as you'll use it at night.

2. Rest one jaw of the calipers on **the face of the reducer thread** the manufacturer measures from, and the other on **the front face of the camera**, where its backfocus starts.
3. **Add the camera's backfocus** (17.5 mm on a cooled ZWO, measured from the front of its 11 mm adapter; 6.5 mm if you measure to the camera body itself) to whatever the calipers read.
4. **Compare** with your reducer's number. If you're short or long, add or remove spacers and measure again.
5. **Measure at two or three points** around the train. If you get different readings, something is loose or crooked: fix it before going on.

> **Tip**
>
> Once you've got it, mark the position of each part with a paint pen or a sticker. That way you can take it apart and put it back together without measuring again.

> **Fran's advice**
>
> Always measure with the train assembled and tightened, never part by part on the table: threads and adapters are where that millimeter gets lost (or gained).

☐ **Step 4 done**

Step 5 of 5

Check it with a photo

One test frame and a program that measures the stars in each corner will tell you whether it's backfocus, tilt or focus.

The test frame

Point at a field full of stars, high in the sky, and **focus in the center**. Take a single 30- to 60-second exposure and don't process it. That's all you need.

Let the computer look at it

Your eye will fool you. Better to use a program that measures star size in each part of the frame: **ASTAP** (free) has an image inspector that plots it, and **N.I.N.A.**, with the Hocus Focus plugin, does a similar analysis while you're capturing.

Backfocus, tilt or focus?

What the photo is telling you		
What you see	What it is	What to do
All four corners alike, worse than the center	Backfocus	Change the distance (below)
One side or one corner worse than the rest	Tilt, or something loose	Tighten and check the train; if it persists, a tilt adjuster. Changing the distance won't fix it
Everything soft, the center too	Focus (or seeing)	Refocus before you touch anything else

> **Heads-up**
>
> Tilt and backfocus get mixed up all the time. If only one corner is bad, don't spend the night swapping spacers.

Adjust and compare

You don’t need to know which way the stars are “pulling”. Do the practical thing:

1. Change the distance by **1 mm** (add or remove a spacer).
2. Refocus in the center and take another frame, the same as before.
3. If the corners **get better**, keep going that way; if they **get worse**, go back and try the other direction.
4. When you’re close, fine-tune in **half-millimeter** steps.

> **Tip**
> The faster the system (the lower the f-number), the more a millimeter either way shows.

Write down where you focus

Once you’ve got it, note which mark on the focuser scale you reach focus at. If on another night you focus a long way from that mark, **something has moved in the train**: a loose thread, an extra spacer or a different filter. It’s the quickest way to notice without redoing the tests.



Photo: Fran López

> **Fran's advice**
>
> When you nail it, write it down: the number, the parts and the filter. And don't take the train apart unless you have to: every time you do, you have to check it again.

☐ **Step 5 done**

Your backfocus sheet

When you nail it, write it down: the number, the parts and the filter. That way, if you take the train apart, you can put it back together the same.

Date	
Telescope and its focal length (mm)	
Reducer, flattener or corrector	
Thread it's measured from (T2, M48…)	
Your number: manufacturer's backfocus (mm)	
Camera and what it uses (mm)	
Filter wheel or drawer (mm)	
Filter and its thickness (mm) → adds a third to the target	
Spacers used (each one and the total)	
Measured with calipers (at 2 or 3 points)	
Focuser position at focus	

The test frame

- ☐ All four corners good, and like the center.
- ☐ All four corners bad, and equally so: backfocus. Add or remove spacers and try again.
- ☐ One or two corners worse than the others: it isn't backfocus, it's tilt.

Changes I’ve tried:

How many spacers are you missing? The calculator works it out with the ones you have: astrolarius.com/en/tools/backfocus-calculator