Flat Calibration and Integration in WBPP

Calibration and stacking workflow for removing vignetting, using PixInsight's Weighted Batch Preprocessing (WBPP 3.2.0) with flats captured in NINA.

Updated 2026-11-08 (v1.0.1) · Worked example: NGC 1333, session of 2026-11-06 (ZWO ASI2600MM Pro on a Celestron EdgeHD 14, dithered lights)

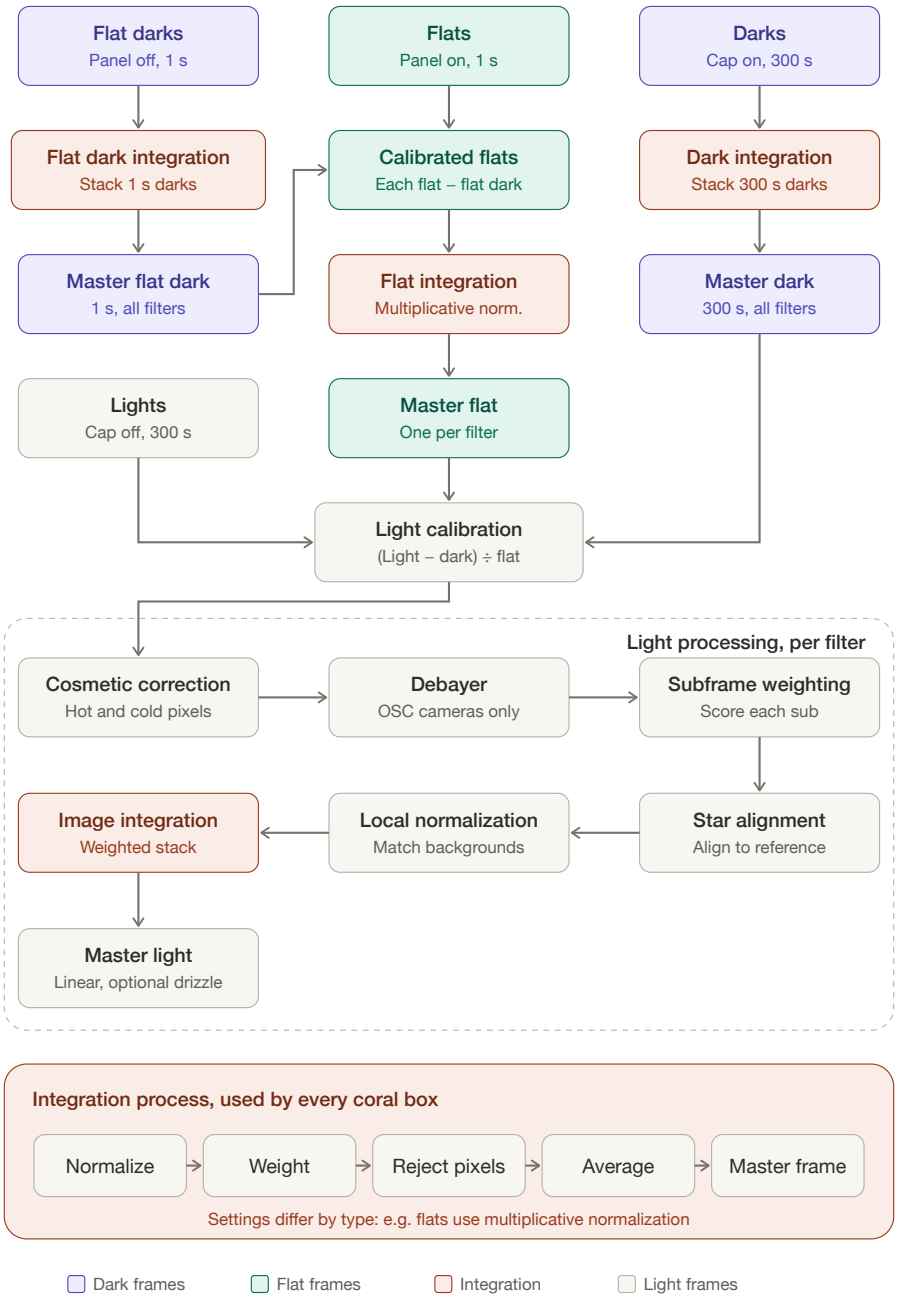

Figure 1. WBPP calibration and integration flow. Coral boxes are integration steps that all use the shared process shown at the bottom. The 300 s light and 1 s flat exposures are examples; see the note in Section 2.

PART 1 · CALIBRATION

1. Purpose

Flat frames record the optical system's uneven illumination: vignetting, dust donuts and sensor non-uniformity. Dividing each light frame by a normalized master flat removes these patterns. For that division to work, every frame must first have its offset (pedestal) signal removed with a matching dark.

For example, if a corner receives 70% of the light the center receives, the master flat records 0.70 in that corner. Dividing the light by the flat scales the corner back to match the center. If the flat's offset is not removed, the flat might record 0.80 instead of 0.70, and the corners come out over- or under-corrected.

2. Frame types

Frame	How it is captured	Purpose
☐ Flat darks	Panel off, scope covered, same exposure, gain, offset and temperature as the flats (e.g. 1 s)	Remove offset and dark signal from the flats
☐ Flats	Evenly lit panel, same optical setup (focus, rotation, filter) as the lights	Record vignetting and dust shadows
☐ Darks	Cap on, same exposure, gain, offset and temperature as the lights (e.g. 300 s)	Remove offset, thermal signal and amp glow from the lights
☐ Lights	The target exposures	The image data

> **Exposure times in this tutorial are examples.** 300 s lights (with 300 s darks) are used throughout only to keep the numbers concrete. Light exposures can be 30 s, 60 s, 90 s, 120 s, 180 s, 240 s, 300 s or longer, depending on the target, filter, sky and mount. Whatever you choose, the rule is the same: **each light exposure needs a master dark of the same exposure** (plus the same gain, offset and temperature). If a night mixes exposures, for example 120 s broadband and 300 s narrowband, build one master dark for each. The worked example in Part 2 uses 120 s lights.

3. Why bias frames are not needed

A bias frame is a zero-length exposure. It records only the camera's offset (pedestal) and readout pattern. Every other frame already carries that same bias signal underneath its own:

Frame	What it contains
Dark (e.g. 300 s)	Bias + thermal signal + amp glow
Flat dark (e.g. 2 s)	Bias + a small thermal signal
Flat	Bias + thermal signal + the panel's light pattern (vignetting, dust)
Light	Bias + thermal signal + sky and target

Subtracting a dark taken at the **same exposure, gain, offset and temperature** removes the bias and the thermal signal in one step, because the dark contains both:

```
Light − Master dark = (bias + thermal + sky) − (bias + thermal) = sky
```

```
Flat − Master flat dark = (bias + thermal + panel) − (bias + thermal) = panel
```

Subtracting a master bias as well would remove the offset twice. A bias is only needed when a dark must be **scaled** to a different exposure (WBPP's *Optimize master dark*, or flats with no matching flat dark): only the thermal part grows with exposure time, so the bias has to be separated out before the dark can be scaled. With a matched dark for the lights and a matched flat dark for the flats, nothing is scaled and the bias has no job left.

> **Matched darks are also more accurate than bias on CMOS.** Many CMOS sensors do not hold a stable offset at the very shortest exposures, so a master bias can differ from the real offset in a 2 s flat or a 300 s light. A matched dark or flat dark measures the offset at the exposure actually used. **In WBPP: leave the Bias tab empty and keep *Optimize master dark* off.**

4. The process, step by step

The full flow is shown in Figure 1 at the top of this tutorial.

A. Build the dark masters

1. **Flat dark integration:** stack the flat darks (1 s in this example) into the **master flat dark**.
2. **Dark integration:** stack the darks taken at the lights' exposure (300 s in this example) into the **master dark**. Build one master dark for every light exposure used.

B. Build the master flat (one per filter)

3. **Calibrate each flat:** subtract the master flat dark from every individual flat.

   ```
   Calibrated flat = Flat − Master flat dark
   ```

4. **Flat integration:** stack the calibrated flats using multiplicative normalization to produce the **master flat**.

> **Order matters.** Each flat is calibrated *before* integration. Integrating first and subtracting afterward fails, because multiplicative normalization scales the offset along with the flat signal, so it can no longer be removed cleanly.

C. Calibrate the lights

5. Calibrate each light with the master dark and the master flat of its filter:

```
Calibrated light = (Light − Master dark) ÷ Master flat
```

D. Process and integrate the lights (per filter)

6. **Cosmetic correction:** fix hot and cold pixels the dark missed.
7. **Debayer:** convert color-camera (OSC) data to RGB. Mono cameras skip this step.
8. **Subframe weighting:** score each sub (star sharpness, noise), so better subs count more.
9. **Star alignment:** register all subs to the best reference frame.
10. **Local normalization:** match each sub's background and gradients to the reference.
11. **Image integration:** weighted stack with outlier rejection, producing the **master light**, which is still linear. Drizzle is optional.

5. The shared integration process

Every integration step (flat dark, dark, flat and light) runs the same sequence: **Normalize → Weight → Reject pixels → Average → Master frame**. The settings differ by frame type:

Step	Darks / flat darks	Flats	Lights
Normalize	None (absolute levels must be kept)	Multiplicative (each flat scaled to the same brightness)	Additive with scaling, or local normalization
Weight	Equal	Equal	By quality score (subframe weighting)
Reject pixels	Cosmic rays, hot-pixel outliers	Dust specks, outliers (stars in sky flats)	Satellites, planes, cosmic rays
Average	Mean	Mean	Weighted mean

6. Flats in NINA: Dynamic Brightness with one exposure

Recommendation: in NINA's Flat Wizard, use **Dynamic Brightness** mode with **one flat exposure shared by every filter**. The exposure stays fixed, and NINA adjusts the panel brightness for each filter until its flats reach the target level.

	Dynamic exposure	Dynamic brightness (recommended)
Flat exposure	Different for each filter (e.g. 0.72 s, 0.75 s, 2.5 s, 16 s, 20 s)	One exposure for all filters (e.g. 2 s)
Flat darks	One set for every exposure	**One set for all filters**
WBPP matching	Exposures 0.03 s apart; tolerance must be 0 or flats get the wrong dark	One flat dark exposure; nothing to confuse
Short exposures	Bright filters can drop below 1 s (panel flicker, unstable offset)	Exposure chosen to stay at 1–3 s or longer
Flat dark library	Many masters to keep and refresh	One master flat dark, reused across sessions

Setting it up

- **Choose one exposure of at least 1–3 s** (e.g. 2 s). Shorter exposures risk panel PWM flicker and an unstable CMOS offset.
- **Size it for the dimmest filter.** Narrowband filters (Ha, O3, S2) must reach the target level (roughly 30–50% of full scale) before the panel is at full brightness. The bright filters (L, R, G, B) then simply run the panel dimmer.
- **If no single exposure fits** (narrowband still too dim, or L too bright at the panel's lowest setting), use two exposures: one for LRGB and one for narrowband, each with its own flat darks. That is still far fewer than one per filter.
- **Take one set of 30–50 flat darks** at that exposure, with the same gain, offset, temperature, binning and readout mode. NINA's Flat Wizard takes flat darks after every filter by default; with one shared exposure those sets are duplicates, so skip them or stack them together into one cleaner master.
- **Reuse the master flat dark** across sessions while those settings stay the same. Refresh it every few months or after a driver or firmware update.
- Check that every filter's flats actually reach the target level.

7. How WBPP matches calibration frames

- WBPP has no separate "flat dark" category. It reads the `IMAGETYP` header (NINA writes `DARKFLAT`) and treats flat darks as darks.
- Darks are grouped by **exposure time**, binning, image size and any grouping keywords.
- Each flat group gets the master dark with the **closest matching exposure**, so 1 s flats get the 1 s master. Lights get their own matching long dark.
- The filter is not used for dark matching, so one set of flat darks works for every filter.

> **Check the Calibration tab.** Each flat group should show `Master Dark 1.00s`. If it shows a long dark (e.g. 300 s, often marked "optimized"), WBPP found no matching flat dark and is scaling the long dark instead. Scaling is inaccurate on CMOS and causes over-corrected corners. The fix is a matching flat dark (not a bias); override the assignment manually if needed.

8. Troubleshooting vignetting that remains

Symptom	Likely cause
Over-corrected (corners brighter than center)	Missing or mismatched flat darks; offset mismatch; WBPP using an optimized long dark for the flats
Under-corrected (corners still dark)	Flats too bright (non-linear or clipped); light leak or stray light during the flats
Dust donuts remain or are shifted	Focus, camera rotation or filter changed between lights and flats
Uneven gradients	Uneven panel or sky flat; panel flicker at short exposures
Correction varies between filters	Narrowband flats too dim (panel at maximum); flat darks taken at a different gain or offset

> **Integration cannot fix bad flats.** Leftover vignetting sits in the same place on the sensor in every sub. Alignment, normalization and stacking all keep it, and dithering only shifts the image a few pixels. If one calibrated light shows dark or bright corners, the fix belongs in the flat steps.

9. WBPP settings that can cause problems

WBPP sorts files into darks, flats and lights by the `IMAGETYP` header NINA writes, so everything can be added from one folder. These settings are the most common sources of trouble, roughly in order of impact on flats.

Setting	What to check	If it is wrong
File recognition	After adding the folder, check the file count and filter names in the Darks, Flats and Lights tabs, and that the Bias tab is empty.	Frames land in the wrong tab or are skipped; lights get no flat.
Flat dark assignment	Calibration tab: every flat group uses the 1 s master dark.	A scaled long dark is used; corners over-correct.
Optimize master dark	Turn off for CMOS cameras when matching darks exist.	Dark scaling is inaccurate; over-correction or residual amp glow.
Bias frames	Not used. Leave the Bias tab empty; flats are calibrated with matched flat darks (Section 3).	Flats calibrated with a bias alone keep an offset error; corners over- or under-correct.
Filter names	Names must match exactly between flats and lights (e.g. "Ha" vs. "H-alpha").	Separate groups; lights calibrated without a flat.
Grouping keywords (multi-night)	If the camera is rotated or refocused between nights, add a keyword such as `NIGHT` or a session folder so flats match their own night.	One night's flats applied to all nights; dust donuts and vignetting mismatch.
Gain / offset	WBPP does not match on these by default. Add `GAIN` and `OFFSET` as grouping keywords if files use different settings.	Darks from another gain or offset are used.
Temperature	WBPP does not match darks by temperature; keep the dark library at the lights' temperature.	Thermal signal and amp glow not removed.
Dark exposure tolerance	Keep it small so a 1 s flat cannot pick up a 2–3 s dark.	Mismatched flat darks.
Output pedestal	Keep on Automatic in light calibration.	Weak narrowband pixels go negative and clip to black.
CFA images	Mono: off. OSC: on, Bayer pattern Auto, separate CFA flat scaling factors enabled.	Mono data debayered into a checkerboard; color-channel flat errors on OSC.
Cosmetic correction	Enable with automatic hot/cold detection or a template.	Hot pixels cause walking noise after stacking.
Cache	If a setting change does not change the output, use **Purge cache** and re-run.	Old intermediate results are reused.

Quick check before a full run. Open one calibrated light (files with `_c` in the name in the `calibrated` folder) and apply a strong screen stretch. Even corners mean the flats work. Bright or dark corners mean the Calibration tab assignments need fixing.

10. Checklist

- Flats taken in NINA **Dynamic Brightness** mode, with one exposure shared by every filter.
- Flat darks match the flats exactly: exposure, gain, offset, temperature, binning, readout mode.
- No bias frames: the Bias tab is empty.
- Flats are taken without changing focus, rotation or the filter setup from the lights.
- Flat exposure is at least 1–3 s; flat level is about 30–50% of full scale for every filter.
- The Darks, Flats and Lights tabs show the expected file counts, and filter names match between flats and lights.
- WBPP's Calibration tab shows the 1 s master dark assigned to every flat group, with dark optimization off.
- Grouping keywords separate nights when the camera was rotated or refocused.
- CFA setting matches the camera (off for mono, on for OSC); output pedestal is Automatic.
- A single calibrated light shows flat corners before the full integration.

PART 2 · WBPP STEP BY STEP

11. Overview

Weighted Batch Preprocessing 3.2.0 with a mono camera (ZWO ASI2600MM Pro on an EdgeHD 14) and dithered lights. The screens are from the NGC 1333 session of 2026-11-06.

WBPP runs the whole flow in Figure 1 from a single window. The work is done in seven tabs, left to right, plus three settings dialogs on the Lights tab:

Step	Screen	What you do there
1	Bias tab	Load files (no bias); set the global options and output folder
2	Darks tab	Check the dark and flat dark exposures; set exposure tolerance
3	Flats tab	Check one flat group per filter; set flat integration
4	Lights tab	Check light groups; turn on the processing steps
5	Calibration tab	Confirm which dark and flat each group uses
6	Post-Calibration tab	Drizzle and integration grouping
7–9	Lights tab ⚙ dialogs	Image Registration, Local Normalization, Image Integration
10	Pipeline tab	Review the full run before pressing Run
11	—	Run, then check the results

Why dithering matters in WBPP

Dithering moves the telescope a few pixels between subs. After registration, the stars line up but the sensor's hot pixels, cold pixels and fixed pattern noise land in a different place in every sub. That has three effects on the settings:

- **Pixel rejection works much better.** A defect is an outlier in only one sub at each sky position, so the rejection step removes it cleanly. Use a strong method (Generalized ESD) rather than relying on Auto.
- **Drizzle becomes possible.** Drizzle needs sub-pixel offsets between frames, which dithering provides.
- **The edges of the stack are ragged.** Each sub covers a slightly different area, so turn on **Autocrop** to trim the edges of the master light.

> **Dithering does not fix flats.** Vignetting and dust shadows stay fixed on the sensor, not the sky, so they move with every dither and stay in the stack. Only correct flats remove them (Section 8).

Problems found in the worked example

#	Problem	Fix	Step
1	L group holds an old master flat *and* 51 new raw flats; WBPP uses the master and ignores the new flats	Remove the L master flat so WBPP builds a new one from the 51 raw flats	3
2	Flats taken in dynamic exposure mode: five flat exposures (0.72 s to 20 s), each needing its own flat dark	Next session: NINA Dynamic Brightness with one exposure for every filter, and one flat dark set (Section 6)	2
3	No 1.00 s flat dark for the new L flats	Shoot 30–50 flat darks at 1.00 s, same gain, offset and –10 °C; add them on the Darks tab	2, 3
4	Calibration exposure tolerance 600 s merges 60 s and 120 s B lights; the 60 s subs get the 120 s dark	Set tolerance to 2 s; shoot 60 s darks or remove the 60 s subs	4
5	Autocrop off	Turn on Autocrop	4
6	Rejection on Auto; Large-scale High off	Generalized ESD; tick Large-scale pixel rejection High	9
7	A master bias was loaded from the library	Remove it; it is not used (Section 3)	1

Problem 1 is the most likely cause of the leftover vignetting: if the L master flat was made before the camera was rotated to 25°, it no longer matches the lights.

Step 1 — Load the files (Bias tab)

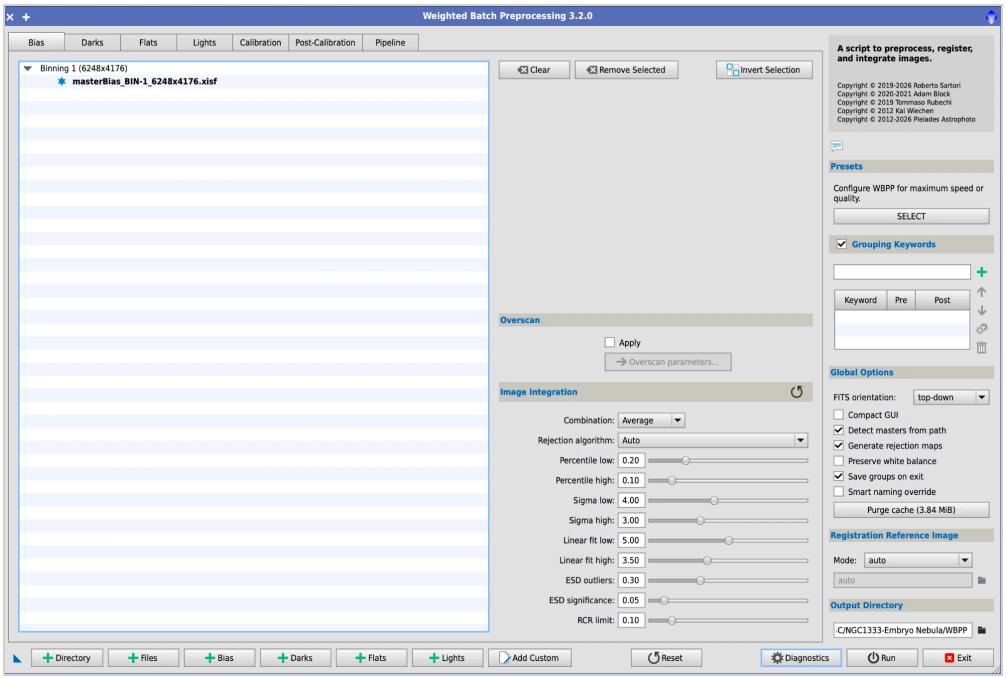

Figure 2. Bias tab with the global options panel on the right. The master bias it shows came from the library and should be removed.

Load everything

1. Click **+ Directory** (bottom left) and select the folder with the lights, and the calibration library folder. WBPP reads the `IMAGETYP` header of each file and sorts it into Bias, Darks, Flats or Lights. **+ Files** adds individual files.
2. Files already stacked into masters show a blue star (✱) and the name `master…`. WBPP recognizes them because **Detect masters from path** is on.
3. **Keep the Bias tab empty.** If a master bias was picked up from the library (as in Figure 2), select it and click **Remove Selected**. It is not needed (Section 3).

Global options (right-hand panel, same on every tab)

Option	Setting	Why
Grouping Keywords	Empty for one night; add `NIGHT` (or a session keyword) for multi-night projects with re-rotation or refocus	Keeps each night's flats with that night's lights
Detect masters from path	**On**	Uses master darks and flats from the library
Generate rejection maps	**On**	Lets you check what rejection removed
Save groups on exit	**On**	Reopens WBPP with the same files
Registration reference	auto	WBPP picks the best-weighted frame
Output Directory	A drive with room (this run needs ~25 GiB)	All calibrated, registered and master files go here

No bias in this workflow. The darks match the lights' exposure and the flat darks match the flats, so neither needs a bias; the Bias column shows ✕ in Step 5. That is correct for a CMOS camera.

Step 2 — Check the darks (Darks tab)

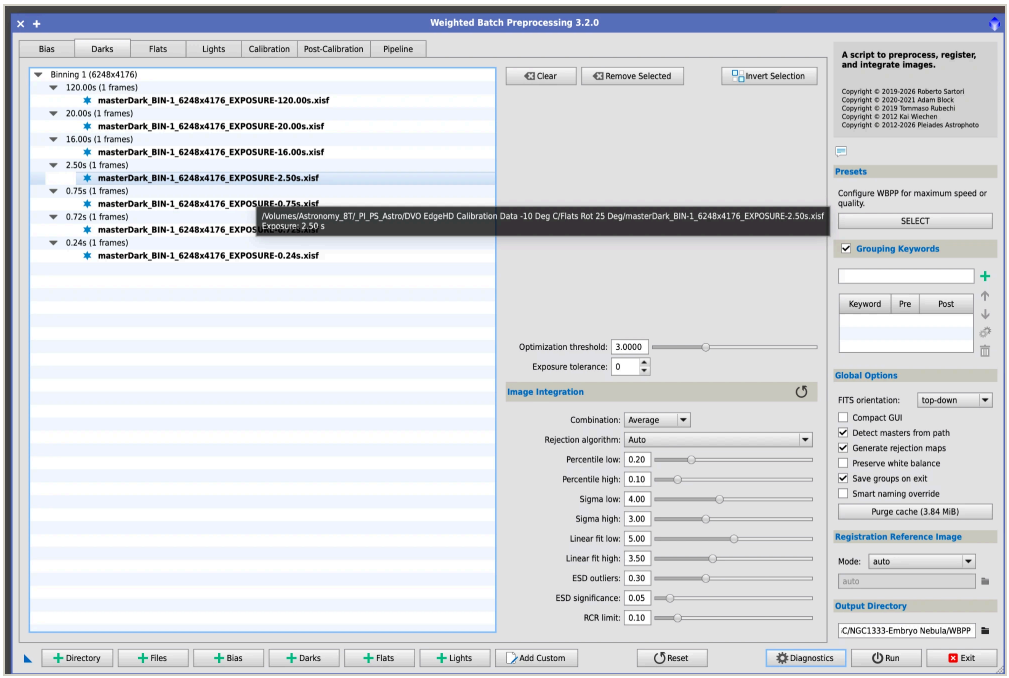

Figure 3. Darks tab. Each exposure time is its own group.

Darks and flat darks both appear here, grouped by exposure. In this session:

Exposure	Used by
120 s	Lights (B, G, L, R)
20 s, 16 s	Narrowband flats (S2 20 s; Ha and O3 16 s)
2.5 s, 0.75 s, 0.72 s	Flats R, B and G
0.24 s	No matching flat; unused
1.00 s — missing	**Needed for the new L flats**

Settings

- **Exposure tolerance: 0.** **Correct.** The 0.72 s and 0.75 s darks are only 0.03 s apart; any tolerance risks giving a flat the wrong dark. With one shared flat exposure (Section 6) this risk disappears.
- **Optimization threshold** only applies when dark optimization is turned on in the Calibration tab. It is off (Step 5), so this value is ignored.
- **Image Integration** (master dark settings): Average with Auto rejection is fine. These only apply when raw darks are loaded; here all darks are already masters.

Flat darks and exposure. This session's flats were taken in dynamic *exposure* mode, so each filter has its own flat exposure (0.72 s to 20 s) and each needs its own flat dark. With the recommended Dynamic Brightness and one shared exposure (Section 6), this tab would hold just two groups: the 120 s dark for the lights and one flat dark for every filter.

Step 3 — Check the flats (Flats tab)

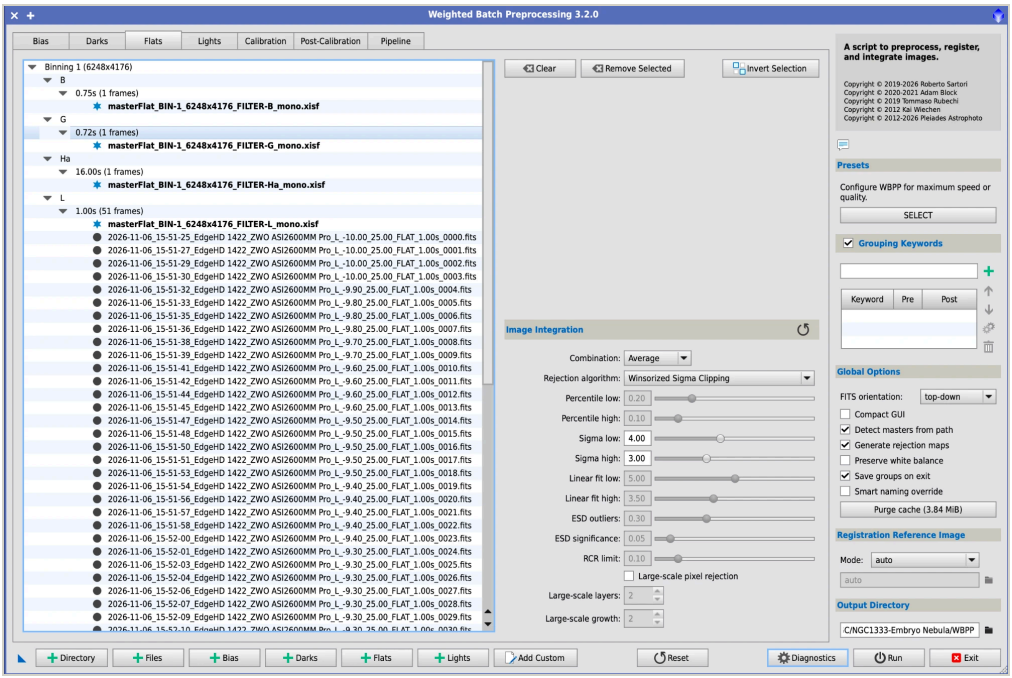

Figure 4. Flats tab, grouped by filter, then exposure. The L group has a master flat and 51 raw flats.

What to check

- **One group per filter, with names matching the lights exactly.** Here: B, G, Ha, L, O3, R, S2 (scroll down to see them all).
- **Each group holds either one master flat or raw flats, never both.** The L group has both. WBPP uses the master and ignores the 51 new raw flats.
- **Every flat exposure has a matching dark** on the Darks tab.

Fix for this session

1. Click `masterFlat_BIN-1_6248x4176_FILTER-L_mono.xisf`, then **Remove Selected**.
2. Add a 1.00 s master flat dark (or 30–50 raw 1.00 s flat darks) on the Darks tab.
3. WBPP will now calibrate the 51 flats and build a new L master flat. A *Flat calibration* and *Flat integration* step will appear in the Pipeline (Step 10).

Flat integration settings (right panel)

- **Rejection: Winsorized Sigma Clipping, sigma 4.0 / 3.0.** Good for 20–60 flats.
- **Large-scale pixel rejection: off.** Fine for panel flats.

The flat filenames show the sensor drifting from −10.0 to −9.3 °C during the flat run. It is minor, but let the cooler settle for a few minutes before starting flats.

Step 4 — Lights and processing steps (Lights tab)

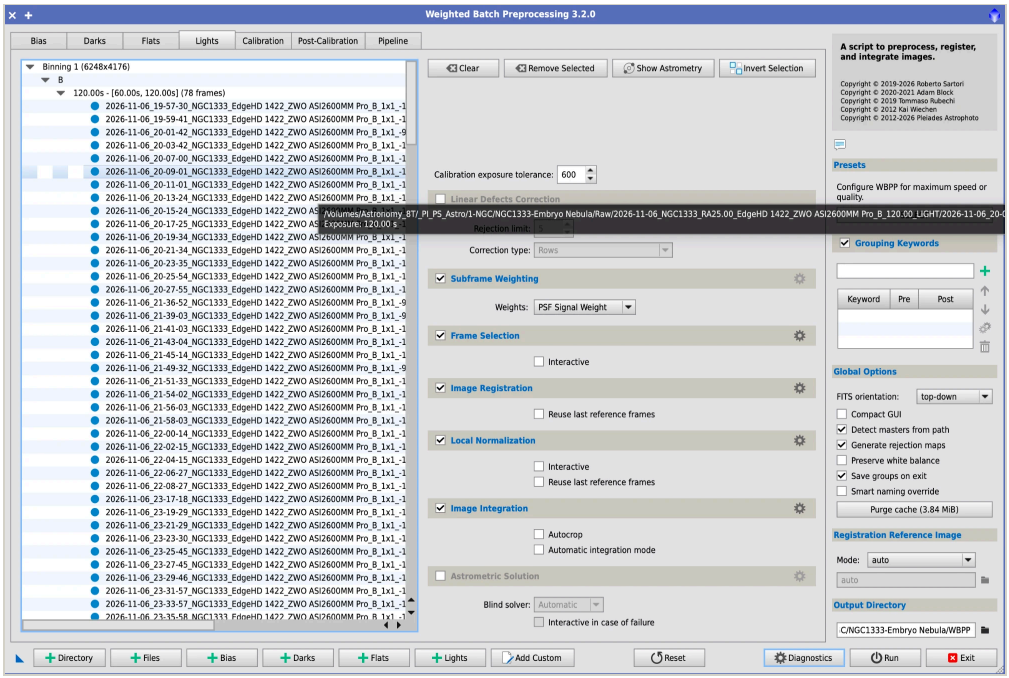

Figure 5. Lights tab. The B group header reads 120.00s – [60.00s, 120.00s] (78 frames).

Setting	Value shown	Use
Calibration exposure tolerance	600	2. 600 s merges the 60 s and 120 s B lights, so the 60 s subs get the 120 s dark.
Linear Defects Correction	Off	Off (only for sensors with bad columns)
Subframe Weighting	On, PSF Signal Weight	Keep
Frame Selection	On, not interactive	Keep. Removes clouded or trailed subs.
Image Registration ⚙	On	Keep. See Step 7.
Local Normalization ⚙	On	Keep. See Step 8.
Image Integration ⚙	On	Keep. See Step 9.
Autocrop	Off	On. Trims the ragged dither edges.
Automatic integration mode	Off	Off, so the Step 9 settings are used
Astrometric Solution	Off	Optional; turn on for plate-solved masters for SPCC

> **After setting the tolerance to 2:** the 60 s B subs become their own group and need a 60 s master dark. If there are only a few, removing them is simpler than shooting new darks.

Step 5 — Confirm the calibration matches (Calibration tab)

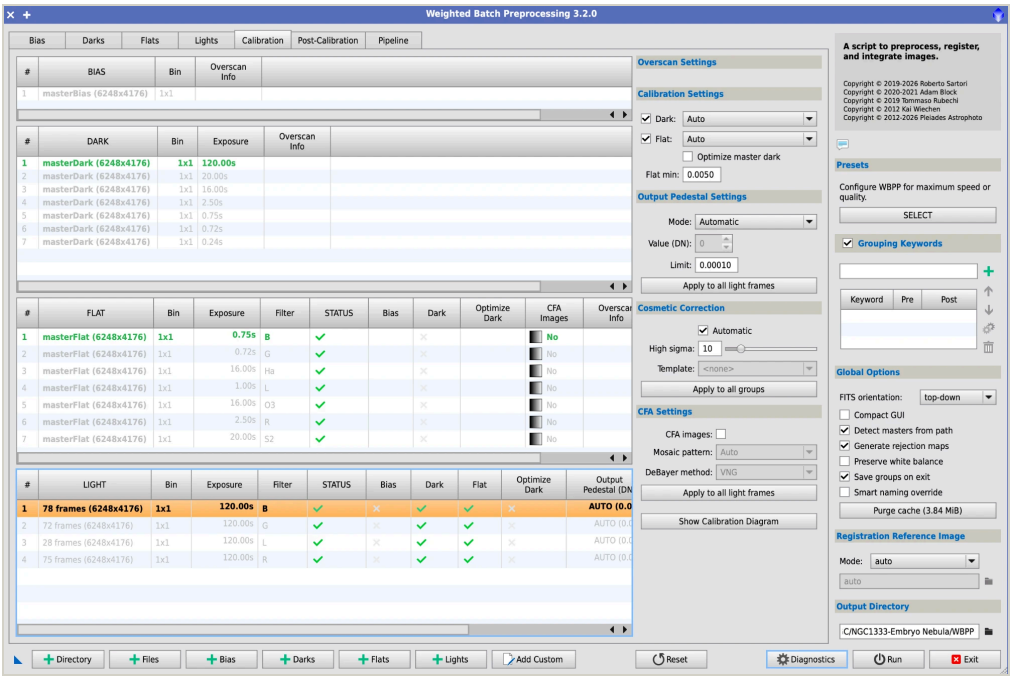

Figure 6. Calibration tab with the B light group selected. The dark and flat it uses are highlighted in green.

This is the most important check before running. **Click each light group** in the bottom table; WBPP highlights in green the master dark and master flat that group will use.

- **B lights → 120 s master dark and 0.75 s B master flat.** Correct, except that the 60 s subs in this group also get the 120 s dark (Step 4).
- **Every light group needs Dark ✓ and Flat ✓.** All four (B 78, G 72, L 28, R 75 frames) pass.
- **Flat groups:** masters already calibrated show no dark (✕); raw flat groups must show their matching flat dark.

Setting	Value	Note
Dark / Flat	Auto	**Keep**. Override per group only if the match is wrong.
Optimize master dark	Off	**Keep off** for CMOS.
Flat min	0.0050	Default
Output pedestal	Automatic	**Keep**. Stops faint pixels clipping to zero.
Cosmetic Correction	Automatic, high sigma 10	**Keep**. A light first pass; rejection handles the rest with dithering.
CFA images	Off	**Correct** for mono.

Show Calibration Diagram draws the same matching as a flow chart, which is useful for a final check.

Step 6 — Drizzle and integration groups (Post-Calibration tab)

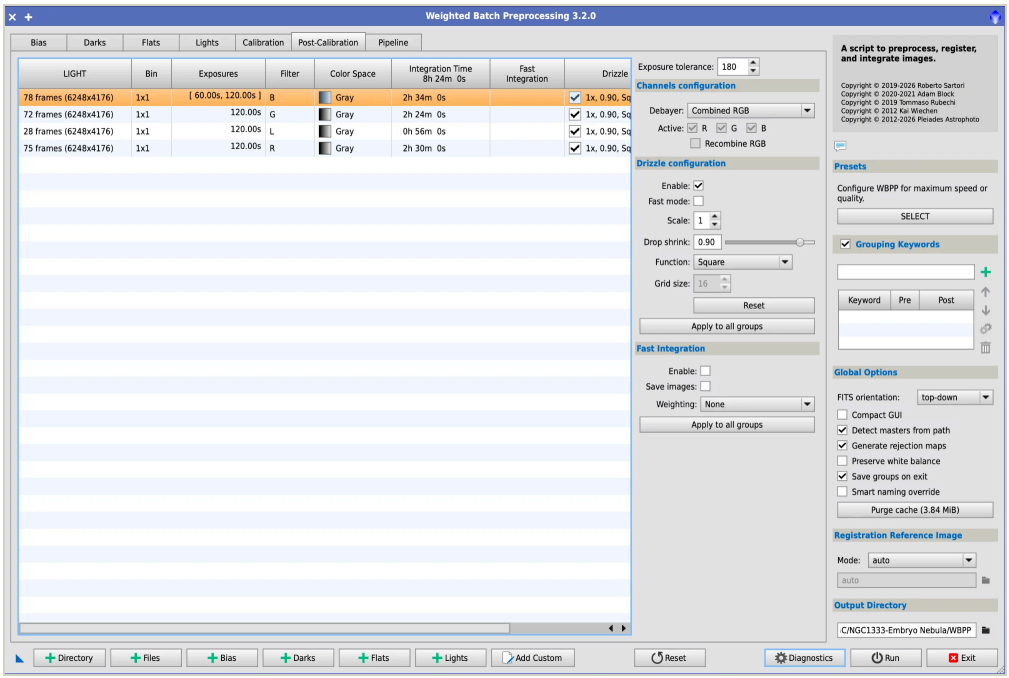

Figure 7. Post-Calibration tab. One integration per filter; drizzle on for every group.

Setting	Value	Note
Exposure tolerance	180	Fine. Here it only groups subs for stacking, so the 60 s and 120 s B subs can be stacked together; weighting handles the difference.
Channels / Debayer	Combined RGB	Ignored for mono
Drizzle: Enable	**On**	Uses the dither offsets
Drizzle: Scale	1	**Keep 1×.** At about 0.2–0.3″/pixel the data is already oversampled; 2× only makes files 4× larger and noisier.
Drop shrink / Function	0.90 / Square	**Keep**
Fast Integration	Off	**Keep off** for a quality run

Click **Apply to all groups** after changing drizzle settings. Total integration for this session: **8 h 24 m** (B 2 h 34 m, G 2 h 24 m, R 2 h 30 m, L 0 h 56 m).

Step 7 — Image Registration ⚙ (Lights tab)

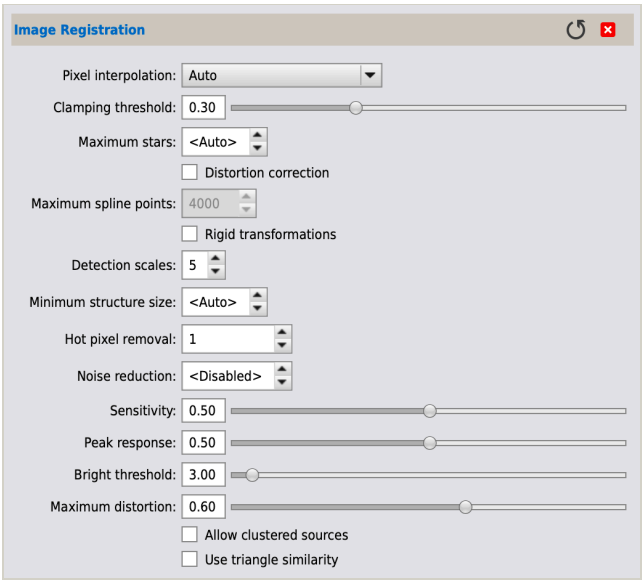

Figure 8. Image Registration settings (defaults).

- **All defaults are right for this setup.** Pixel interpolation Auto, clamping 0.30, detection scales 5, hot pixel removal 1.
- **Distortion correction: off.** The EdgeHD has a flat, well-corrected field. Turn it on only for wide-field refractors, camera lenses or mosaics.
- **Drizzle data** is generated automatically when drizzle is on in the Post-Calibration tab. WBPP 3.x has no separate checkbox here.

Step 8 — Local Normalization ⚙ (Lights tab)

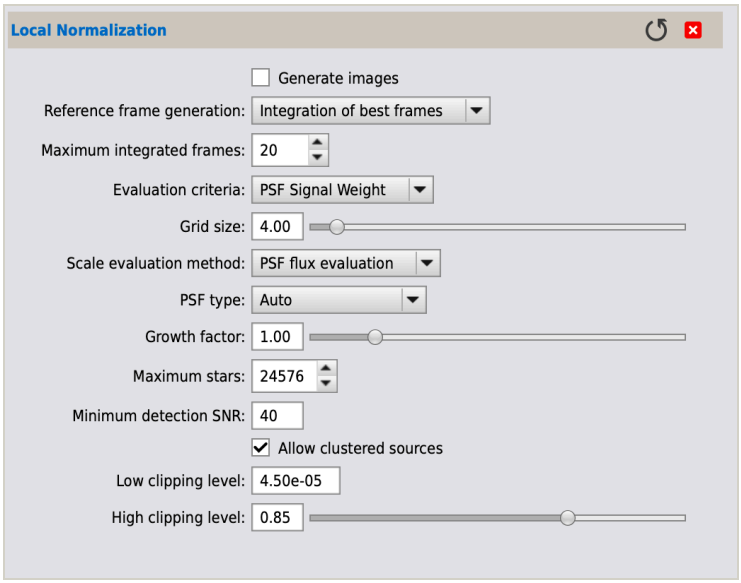

Figure 9. Local Normalization settings (defaults).

- **Reference: Integration of best frames, 20 frames, PSF Signal Weight.** Builds a clean reference from the best subs; every sub's background and gradients are matched to it.
- **Grid size 4.00:** right for an extended nebula like NGC 1333. Smaller values follow gradients more closely but can erase faint dust.
- **Scale evaluation: PSF flux; PSF type Auto.** Keep.
- **Generate images: off.** Saves several GB; only the normalization data is kept.

Step 9 — Image Integration ⚙ (Lights tab)

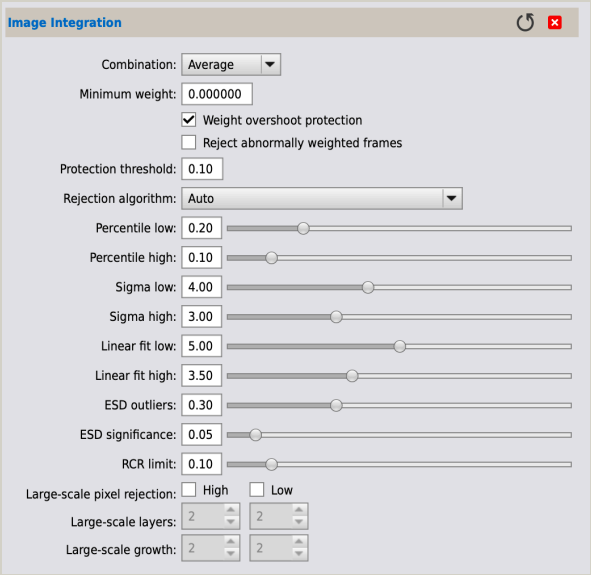

Figure 10. Image Integration settings for the lights.

Setting	Value shown	Use with dithering
Combination	Average	**Keep**
Weight overshoot protection	On, 0.10	**Keep**. Stops one sub from dominating.
Reject abnormally weighted frames	Off	Keep off; Frame Selection already does this.
Rejection algorithm	**Auto**	**Generalized Extreme Studentized Deviate (ESD)**. Same method for every filter, whatever the frame count; ideal for 20+ dithered subs.
ESD outliers / significance	0.30 / 0.05	**Keep**
Large-scale rejection: High	**Off**	**On**, layers 2, growth 2. Removes satellite and aircraft trails.
Large-scale rejection: Low	Off	Keep off; it can eat faint dark dust lanes.

Step 10 — Review the run (Pipeline tab)

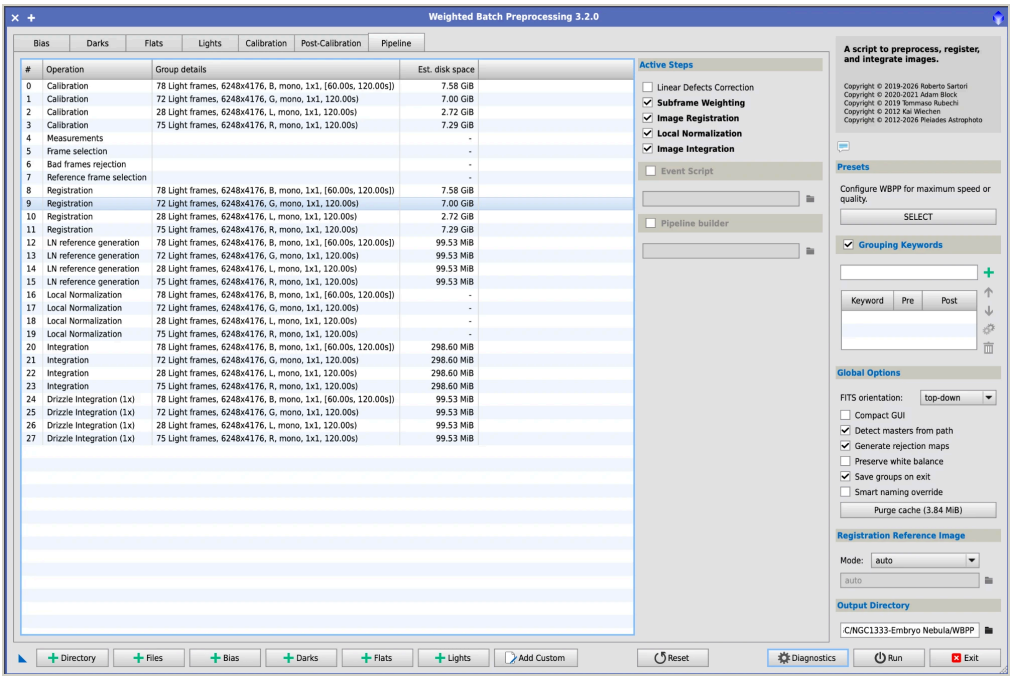

Figure 11. Pipeline tab: every operation WBPP will run, in order, with estimated disk space.

Read the list top to bottom before pressing Run:

1. **Flat calibration and flat integration** appear first when raw flats are loaded. They are missing here, which confirms the 51 raw L flats will not be used (Step 3).
2. **Calibration** of each light group. The B row still shows `[60.00s, 120.00s]` until the tolerance is fixed (Step 4).
3. **Measurements, Frame selection, Bad frames rejection, Reference frame selection.**
4. **Registration** per filter.
5. **LN reference generation** and **Local Normalization** per filter.
6. **Integration** and **Drizzle Integration (1×)** per filter.

Total estimated disk space is about **25 GiB**. Make sure the output drive has room before starting.

Step 11 — Run and check the results

1. **Purge cache** if calibration files changed since the last run, so old results are not reused.
2. Click **Run**. WBPP shows progress for each pipeline step; a run of this size takes a while.
3. **Check one calibrated light first.** Open a file from the `calibrated` folder in the output directory and apply a strong STF auto-stretch.
   - Even corners: the flats work.
   - Dark corners: under-corrected; flat or flat dark mismatch.
   - Bright corners: over-corrected; wrong flat dark or offset.
   - Dust donuts as rings: flat from a different focus or rotation.
4. **Open the master lights** in the `master` folder. Use the drizzled versions for processing.
5. **Open the rejection maps** (high and low) for one filter. With dithering, the high map should show hot pixels scattered evenly and any satellite trails as lines. A star pattern in the low map means rejection is too strong.
6. **Read the log** in the `logs` folder for warnings, such as groups without a dark or flat, and frames rejected by Frame Selection.

13. WBPP checklist for dithered data

- No bias frames: the Bias tab is empty.
- Flats taken with NINA Dynamic Brightness at one exposure for every filter; one flat dark set covers them all.
- Every flat group holds either one master flat or raw flats, not both.
- Every flat exposure has a flat dark of the same exposure; dark exposure tolerance is 0.
- Light calibration exposure tolerance is small (2 s); each light exposure has its own master dark.
- Calibration tab: every light group shows Dark ✓ and Flat ✓; optimize master dark off; pedestal Automatic.
- Subframe weighting, Frame selection, Registration, Local normalization and Integration on; Autocrop on.
- Integration rejection Generalized ESD; large-scale High on.
- Drizzle on at 1× (2× only for undersampled data, above about 2″/pixel).
- Pipeline tab shows flat integration steps when new raw flats were added.
- One calibrated light shows even corners before the full results are trusted.