Raw to Real, Green to Great

FOSDEM 2026

goeiedag, bonjour

- Partner at Ideas on Board
- Embedded Linux software developer
- 20+ years of experience with Embedded Linux
- ~10 years of experience with Cameras
- Release manager, Co-Maintainer, Support for libcamera project
- Linux kernel contributor, component maintainer

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About me

IDEAS ON BOARD

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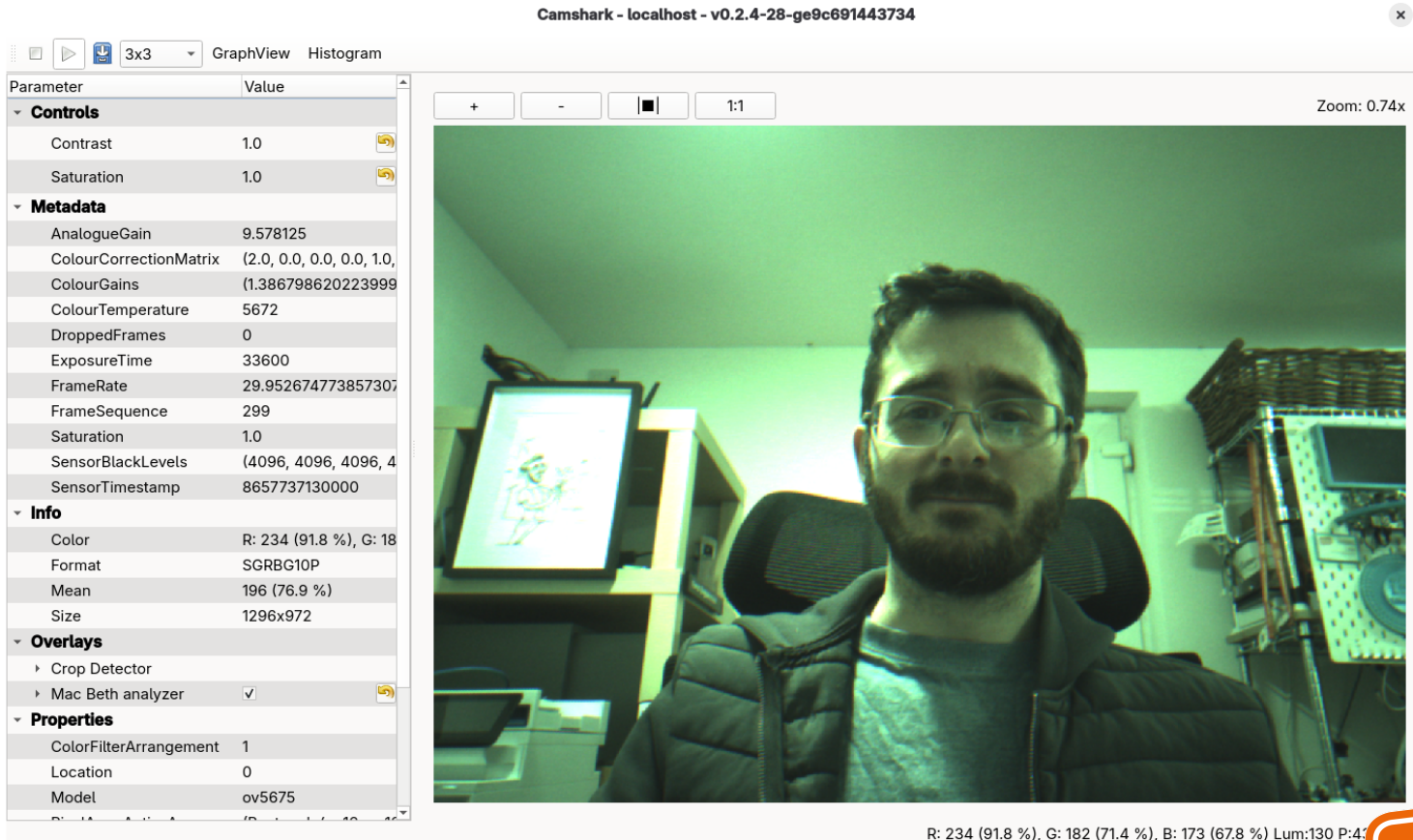
Open sourcing the tuning process

- Problem statement
- The process
- A proposal
- Help!

There's a lot which *can't* be covered in this small
slot for future discussions (De-noise, 3D-LUT, Edge enhancement, sharpness …)

Agenda



RAW Green

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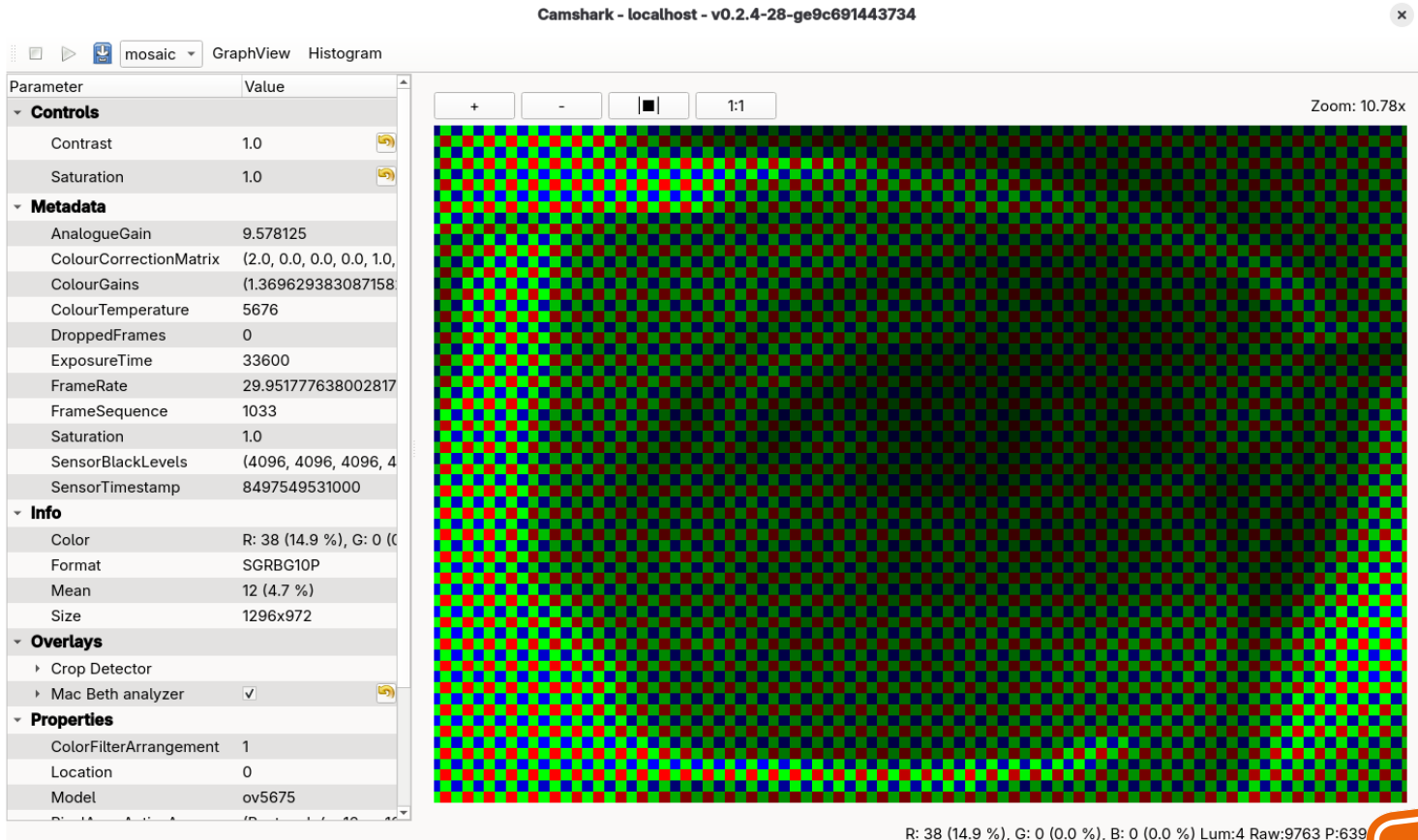

RAW Bayer / Mosaic

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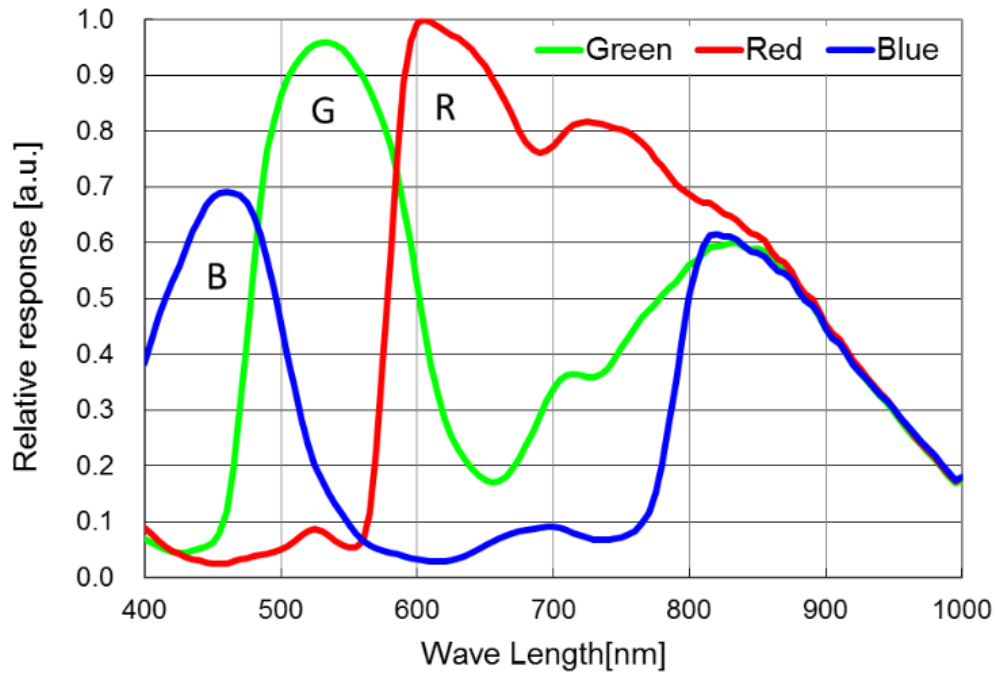
*Graph taken from a sensor datasheet

Spectral Sensitivity Characteristics

(Excludes lens characteristics and light source characteristics.)



Spectral Sensitivity

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Calibration Light Box

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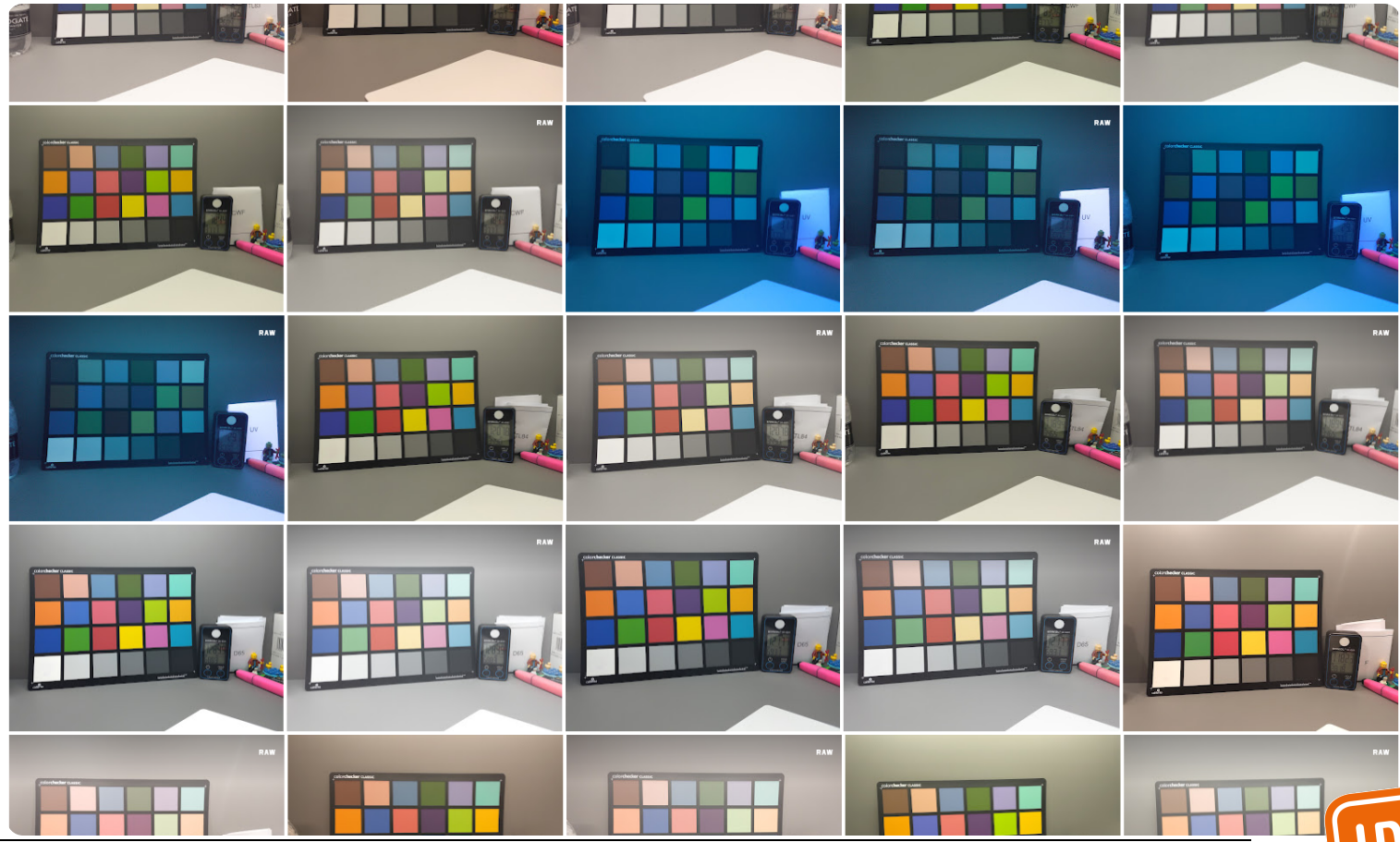

Capture

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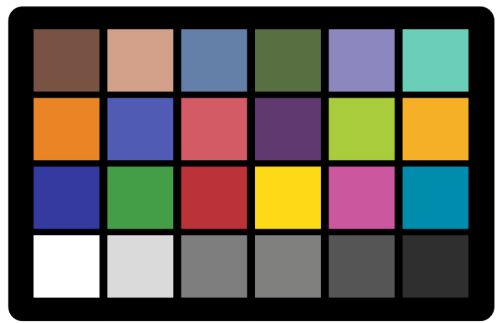
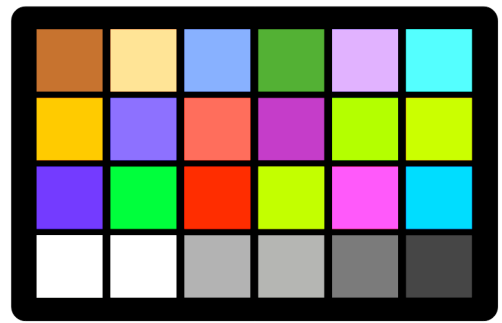
3200k



4000k



6400k

Colour Charts to Delta-E

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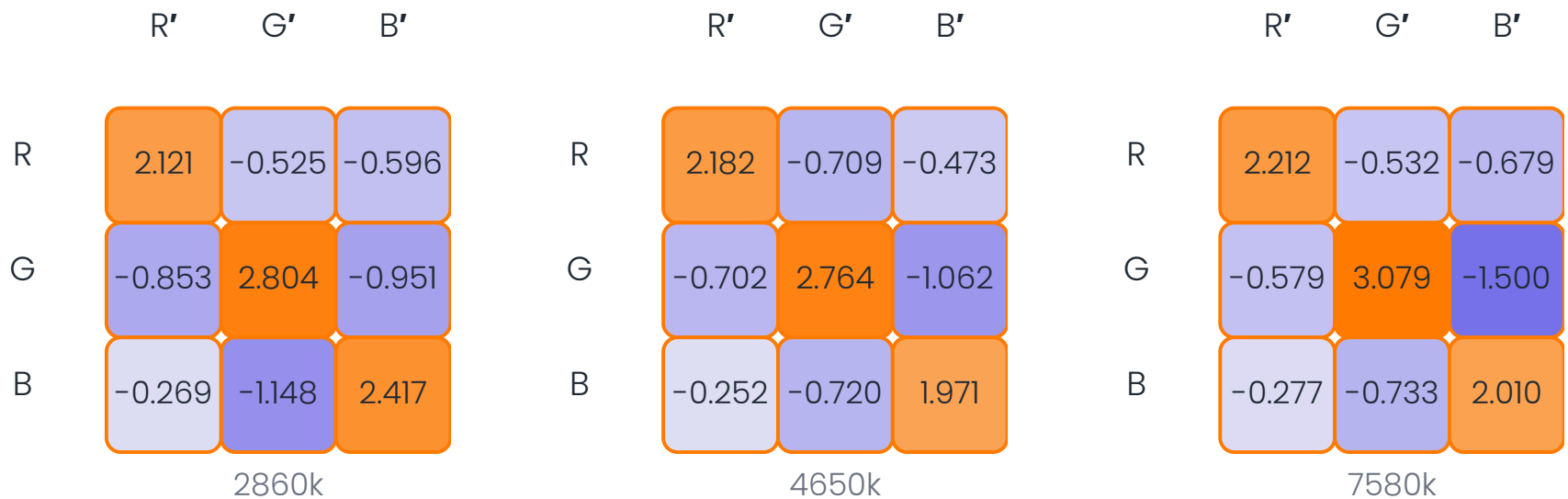

- Real CCM values from the IMX219

Colour Correction Matrix

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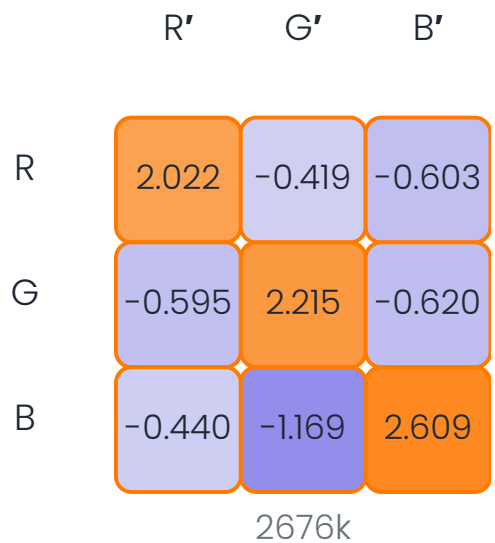

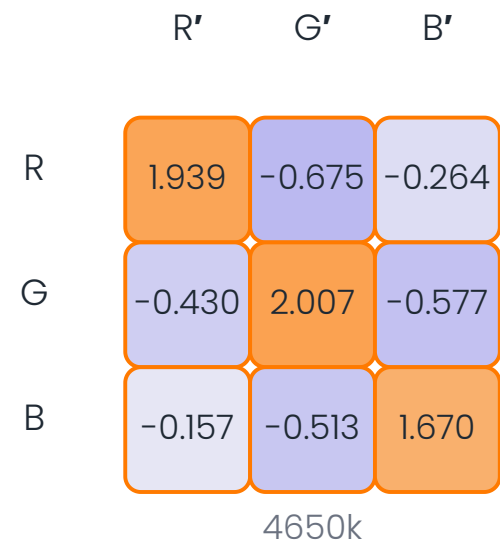

Fairphone 5 first pass camera CCM

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- Lens shading under development
- AWB should move to AwbBayes
- CCM / Cross-talk

Future:

- Autofocus
- Denoise/Sharpen
- 3D LUT
- Lens distortion correction

Simplified (GPU) ISP Pipeline

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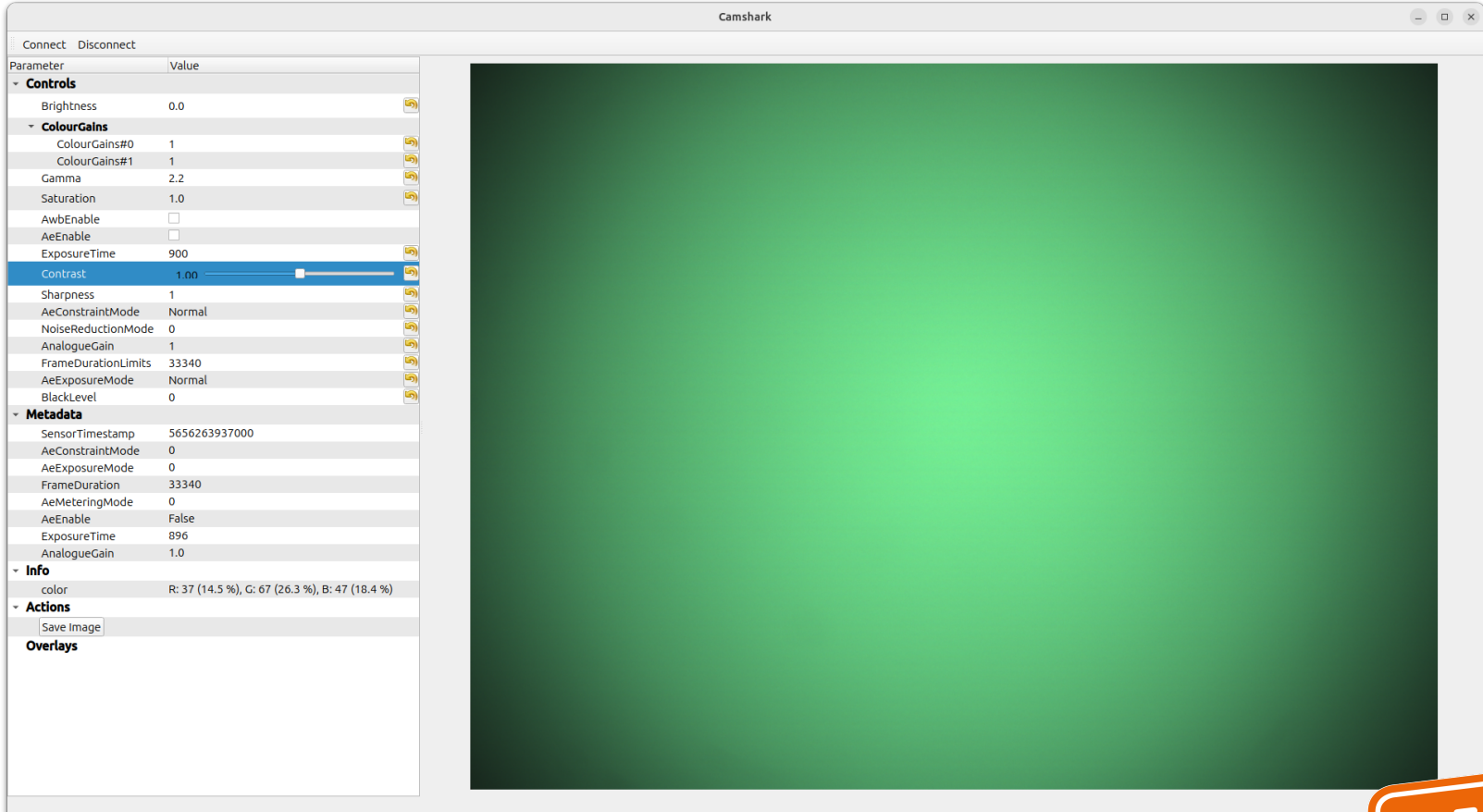

Lens Shading

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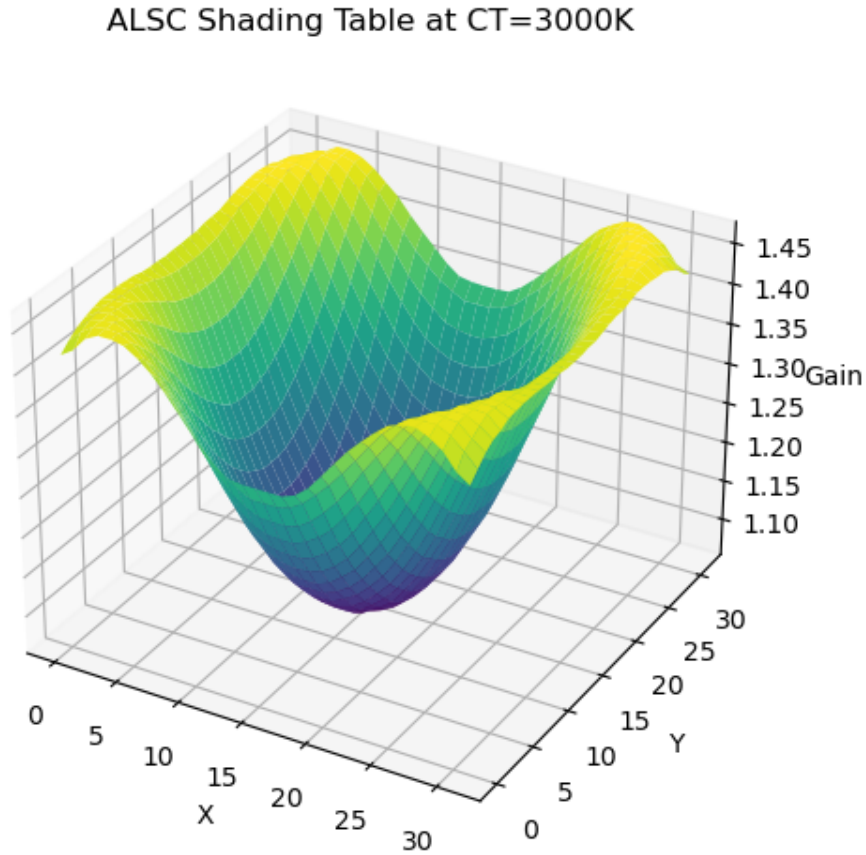
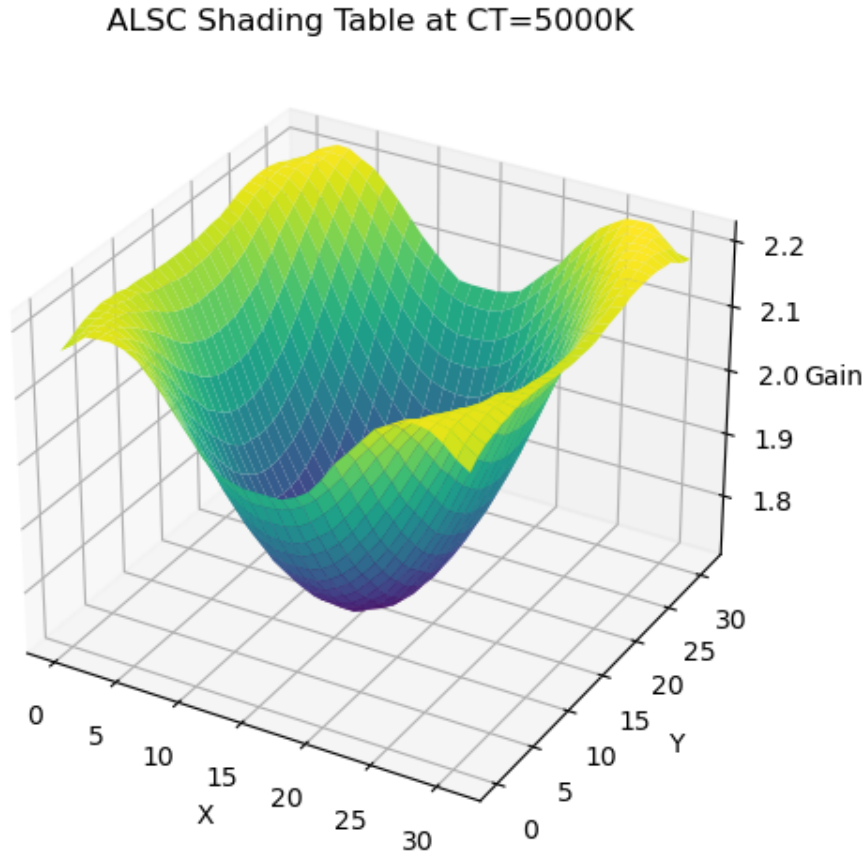


Lens Shading

IDEAS ON BOARD



Lens Shading

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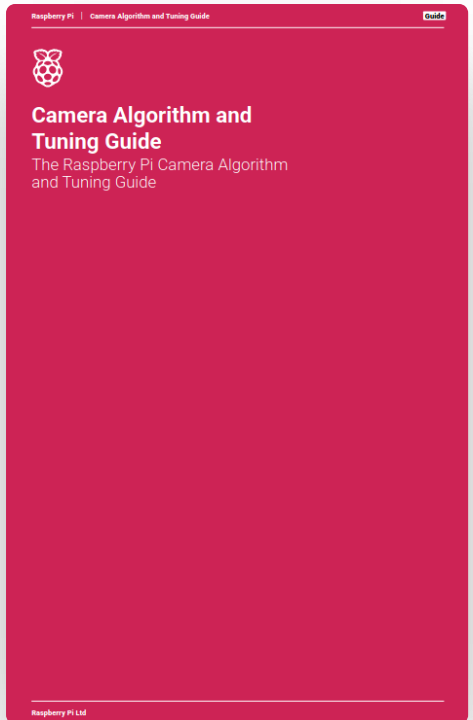
```
# install the necessary python packages
cd libcamera
python -m venv venv
source ./venv/bin/activate
pip install -r utils/tuning/requirements.txt

# run the tuning script
utils/tuning/rkisp1.py -c config.yaml -i ../tuning-data/ -o tuning-file.yaml
```

- Parses directory
- Examines filenames
- Should use metadata

Tuning Tool



Essential Reading

67 pages of gospel from David and the team

- https://datasheets.raspberrypi.com/camera/raspberry-pi-camera-guide.pdf

Stefan is working on guides for other platforms

- https://libcamera.stefanklug.com/guides/tuning/tuning.html (will be merged to libcamera.org)

Gospel

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- Bayer images - We start with RAW images
- But why is it green really
  - AWB + CCM (Plus others) need calibration
- Tuning a mobile phone camera can be hard
- Somewhat expensive / bulky equipment required

Problem statements

Tuning 100's of mobile phone cameras, and laptops, and tablets and ...

THE BIG PROBLEM

70%

Minimum Equipment needed

- Colorimeter - *£50*
- Colour checker card - *£80*

80%

Custom light box / Self builds

- Ikea box + light automation - *~£200*
- Flat panel LED - *£30*

90%

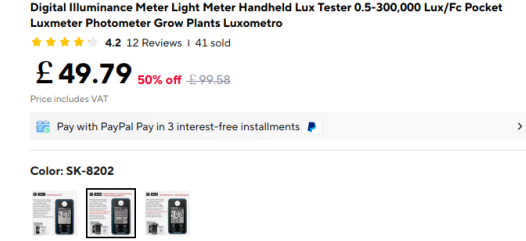
Extended equipment:

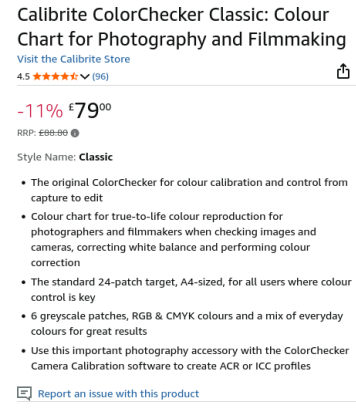
- Full light box - *£800*

100%

Commercial lab: £100,000 +++

Equipment required





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Captures vary in size but the collection will grow rapidly:

- Tunings are about 500MB to 1GB or maybe up to 2 GB per camera module.

```
libcamera@tuning:~/$ du -sh *
448M  vendors/fairphone/fp5/front
421M  vendors/raspberrypi/imx219
606M  vendors/raspberrypi/imx708
116M sensors/omnivision/ov8858
493M  sensors/sony/imx283
915M   sensors/sony/imx335
418M   sensors/sony/imx363
285M  sensors/sony/imx415
97M sensors/sony/imx462
```

Captures

Our new problem statement

- We have lots of phones.
- Lots of laptops.
- Lots of tablets.
- Varying ISPs.
- Few people with internal knowledge of the ISP pipeline.

$DEVICE_VENDOR has '100' people per phone.
We have '100' devices per person to support.

Our goal.

- Democratise, and expand tuning for everyone.
- Requirements. We have to make it easy.
- Make it open, so people build on top of existing tuning, not start from scratch.

Open source side

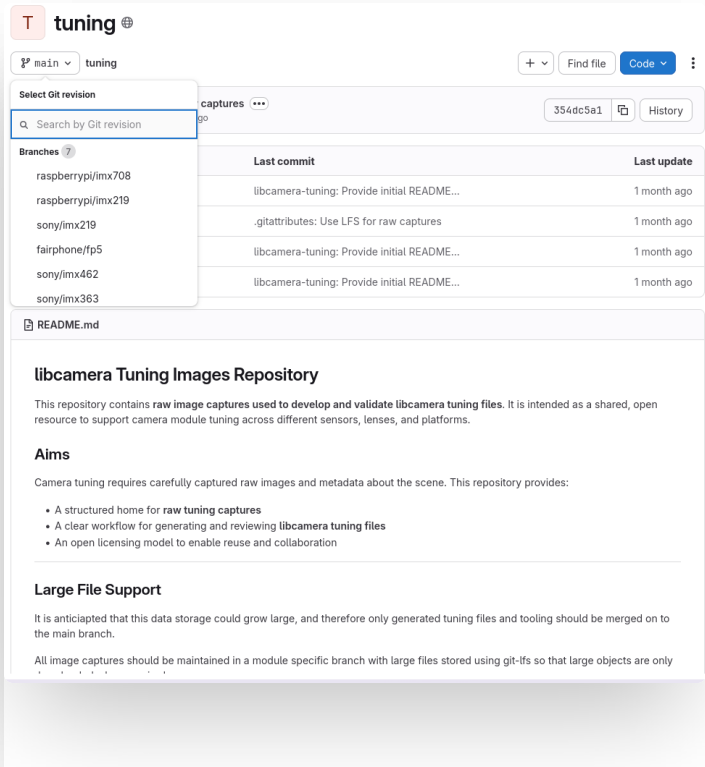
It turns out tuning is 'tricky'.

- Light box definitely provides mains flicker @ 50hz.
- 'Calibrated' lights and a cheap Snarkol SK-8201 will disagree
- It’s simply 'fiddly' to get everything in the right place
- It’s important to make sure you get a good exposure and gain
  - And make sure the colour checker card is clear and visible

Issues

- Try to include the light meter in the capture to be able to reference in pp
- Include the light 'name' in the scene
  - Printed paper worked for me
  - F, D65, TL84, UV, CWF, TL83
- Use a 'dark' room or capture at night to avoid 'light pollution'
- Make scripts to help save out the capture files
  - Or later we should make assisted capture tools
- Make sure the lights are not in shot
- Don’t face the light meter *at* the lights
- Don’t be afraid to delete captures!
  - You can always capture more

Tips



Start simple…

Can git help ?

- https://gitlab.freedesktop.org/camera/tuning

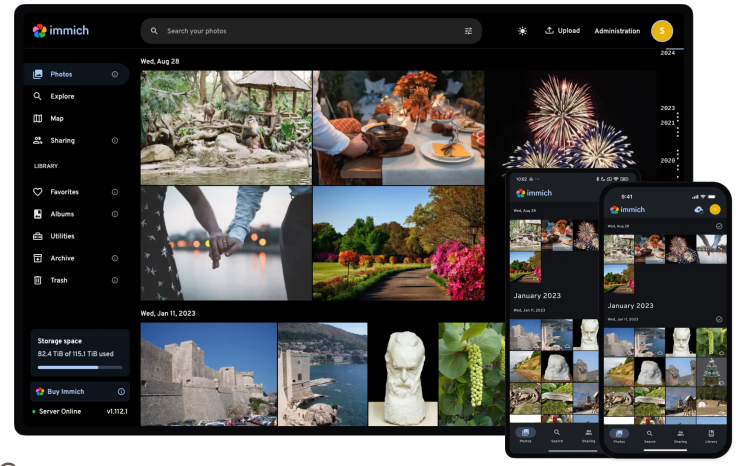
Pros and cons

- Easy …
- 'familiar'
- Requires git-lfs
- We can't fork a 500 GB repo easily

Alternatives?

- Move to S3 buckets and a web interface

Help wanted



Where do we need help...

- A web front end
  - Viewing images
  - Backend to run the tuning scripts
  - inteface to change parameters and display results
- Building on top of something existing (immich?)
  - Or do we build our own backend service entirely ?
  - What about a command line interaction directly to SoftISP

Help!

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I'd also like to propose a web interface or such on top of the Soft/GPU ISP.

- Backend using the exact same shaders
- Front end supplies 'one of the raw's
- Sliders to control parameters

- Upload the image,
- Process with the parameters
- Show the result
- Calculate delta-e directly when a colour chart is detected

Your design here ...

Web ISP

Take (RAW) pictures!

- With a colour chart
- With an estimation of colour temperature
- With an estimation of lux level
- Perhaps with ground truth / android capture too?

Build infrastructure

- Storage and sharing system
- Parameter tweaking interface

https://matrix.to/#/#libcamera:matrix.org

Contribute

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Slidev

Presentation Slides for Developers

Tools / Thanks

Your vision. Made real. Together.

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info@ideasonboard.com

#libcamera on oftc.net
https://matrix.to/#/#libcamera:matrix.org

libcamera-devel@lists.libcamera.org

Thank You!

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