Colour management

Or,

“Why don’t my prints match my screen?”

Outline

- Difficulties
- Imaging devices
  - Cameras
  - Monitors
  - The web
  - Printers
  - Ink choices
  - Paper choices
- Solutions
  - Closed system solutions
  - Choice of colour space
  - Monitor profiling
  - Printer profiling
  - Limitations
- Demo using Colormunki
  - Monitor profiling
  - Projector profiling

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Difficulties

- Every device in the chain sees/displays a different range of colours

In particular, monitors and prints are fundamentally different in how they generate colours, and do tend to have a different "look"

Colour perception

- Everyone perceives colours differently
  - Colour perception deteriorates with age
  - Women tend to have better colour perception than men
- Colour perception is influenced by the colour of the light illuminating the object
- Colour perception is influenced by the colour of the surroundings e.g. walls

Does the camera capture 'real life' colours?

- The file produced by your camera has to fit the range of colours and brightnesses it 'sees' in the 'real world' into a more limited range in its image files.
- The limited range is called a colour space, and is a subset of all possible colours that you could actually see. In fact, since digital camera sensors can 'see' colours (such as infra red) that the eye cannot, there are additional problems that arise. Normally this is managed by IR and UV filters in front of the sensor.

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How does the image get displayed on your screen?

- Your screen can only display a subset of the colours present in the file from the camera
- Different screens have different capabilities, so even matching images on two screens is not a trivial task
- If the light falling on your monitor varies e.g. through the day this can affect the apparent contrast and colours
- Poorer monitors generally approximate to the sRGB colour space and because of this sRGB is normally the safest for images on the web
- Better monitors however can display a greater range of colours than sRGB, but still generally fewer than your camera can capture!

How does the image print?

- Inkjet printers use multiple ink colours and combine inks in small dots to create a continuous spectum
- Printer manufacturers have added extra inks to increase the colour gamut e.g. the vivid magenta ink in the Ultrachrome K3 inkset, the red and blue inks for the R1800
- Additional lighter “black” (grey) inks e.g. LK, LLK provide much finer black and white prints as less colour ink is used. (Some colour ink is always used as black inks are really brown)

Inks and papers

- The best inksets can print a fairly wide range of colours
  - Normally a smaller range of colours than your camera can see
  - But normally a wider range of colours than your monitor can display (apart from expensive monitors)
- Different paper types require a different amount of ink
  - Matte papers require less ink, but create less apparent density (so have less “punch”) and tend to struggle to separate dark colours
  - Glossy papers generate a greater maximum density, but need more ink
  - Even within say the glossy paper range there is variation between the ink loading that can be handled by different papers
- Every paper has its own unique ink response curve
  - But similar paper types might be very similar
- Each paper/print setting also generates its own unique response

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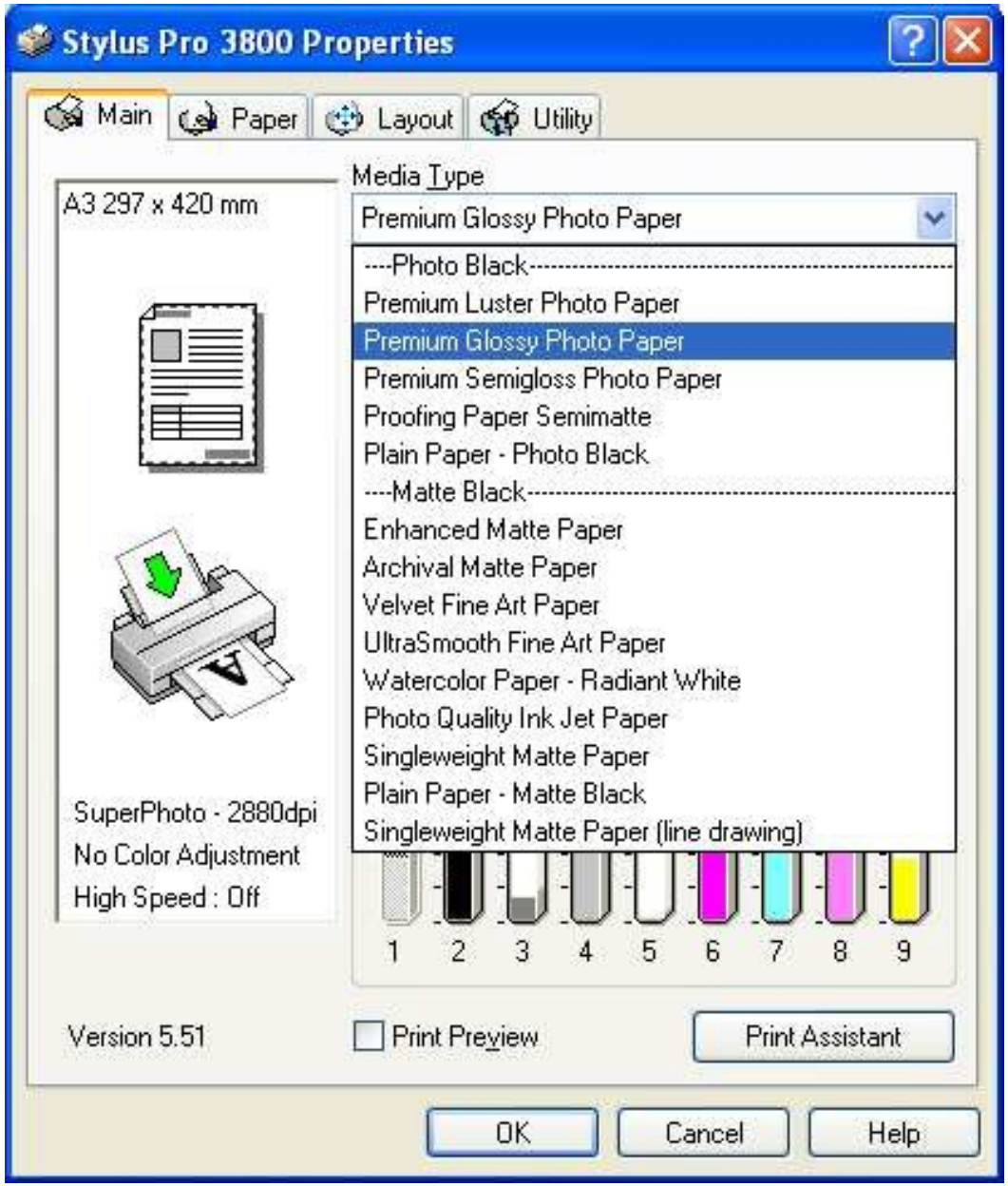

Generally increasing maximum density
Generally increasing ink requirement

Generally decreasing maximum density
Generally decreasing ink requirement

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Printing

- Higher dpi printing gives slightly smoother tones, but maybe insignificantly so
- Higher dpi printing uses more ink
- You might want to do some tests to determine good printer settings for a paper before profiling
  - Test that a good density is achieved without over inking (which tends to cause buckling, slow drying or bronzing)
  - There are more sophisticated tests available

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Closed system solutions

- Does not involve “colour management”
- It is possible to use curves to develop visually linear response and visually OK colour balance through trial and error type testing
- There are a few proprietary systems available to help with this
- Only work within a “closed system” i.e. with your monitor, printer, etc.
  - Falls down when you send an image anywhere else e.g. the club, a third party printer, etc.
- Only gives OK results anyway

Colour managed solutions

- More sophisticated
- Allows more accurate colour matching both within your home system and outside
- Allows soft proofing of colours and identification of likely problems before printing
- Actually not hard to set up!

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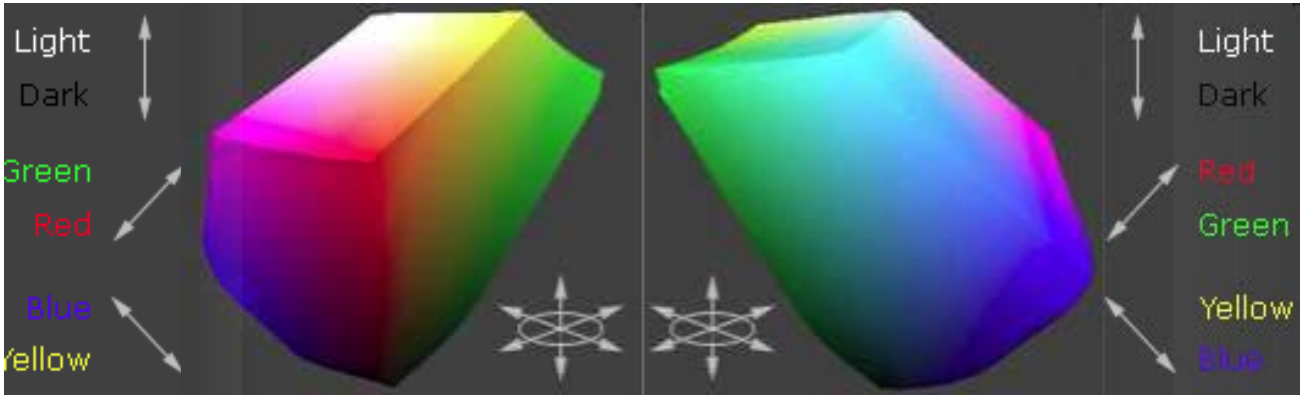
Colour management concepts

- Uses “colour space” to describe the range of colours capable of being represented e.g. by the camera, within photoshop, by monitor, etc.
- Within a colour space a RGB value represents a particular colour
  - A RGB value in an image which is not tagged with a colour profile is actually meaningless!
- Uses “profiles” to tell a device how to represent a particular colour
- Profiles are created by measuring the output (e.g. printed) response achieved to a known input value
  - Use a colorimeter or spectrophotometer to take measurements
  - Use sophisticated software to create the profile

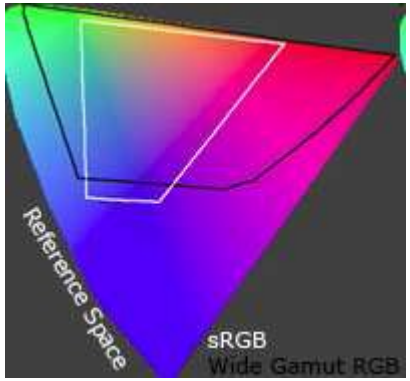
What is a colour space?

- Color spaces can be either dependent to or independent of a given device. Device-dependent spaces express color relative to some other color space, while device-independent color spaces express color in absolute terms. Device-dependent color spaces can tell you valuable information by describing the subset of colors which can be shown with a monitor or printer, or can be captured with a camera or scanner. Devices with a large color space, or "wide gamut," can realize more extreme colors, whereas the opposite is true for a device with a narrow gamut color space.
- Each dimension in "color space" represents some aspect of color, such as lightness, saturation or hue, depending on the type of space. The two diagrams below show the outer surface of a sample color space from two different viewing angles; its surface includes the most extreme colors of the space. The vertical dimension represents luminosity, whereas the two horizontal dimensions represent the red-green and yellow-blue shift. These dimensions could also be described using other color properties.



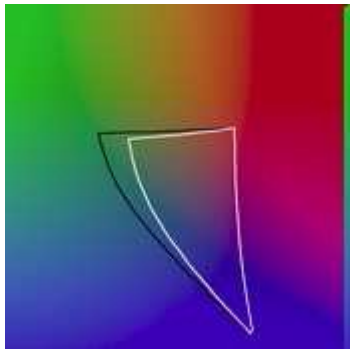
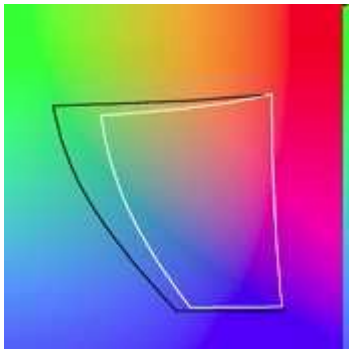
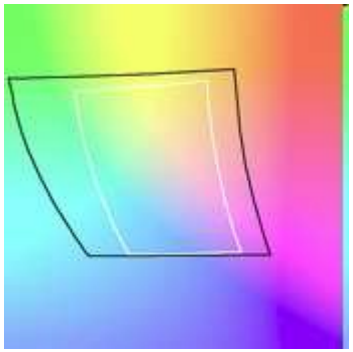
Visualisation of colour spaces

- In order to visualise, colour spaces are often represented by two-dimensional regions. These are more useful for everyday purposes since they allow you to quickly see the entire boundary of a given cross-section. Unless specified otherwise, two-dimensional diagrams usually show the cross-section containing all colors which are at 50% luminance (a horizontal slice at the vertical midpoint for the color space shown above). The following diagram shows three example color spaces: sRGB, Wide Gamut RGB, and a reference space. sRGB and Wide Gamut RGB are two working spaces sometimes used for image editing.



sRGB v Adobe RGB 1998

- The following color gamut comparison aims to give you a better qualitative understanding of where the gamut of Adobe RGB 1998 extends beyond sRGB for shadow (~25%), midtone (~50%), and highlight colors (~75%).
- Note how Adobe RGB 1998 extends into richer cyans and greens than does sRGB-- for all tonal levels. The 50% luminance diagram is often used to compare these two working spaces, however the shadow and highlight diagrams also deserve attention. Adobe RGB 1998 extends its advantage in the cyan-greens for the highlights, but now has advantages with intense magentas, oranges, and yellows--colors which can add to the drama of a bright sunset. Adobe RGB 1998 does not extend as far beyond sRGB in the shadows, however it still shows advantages in the dark greens (often encountered with dark foliage).
- (White = sRGB, Black = Adobe RGB 1998)

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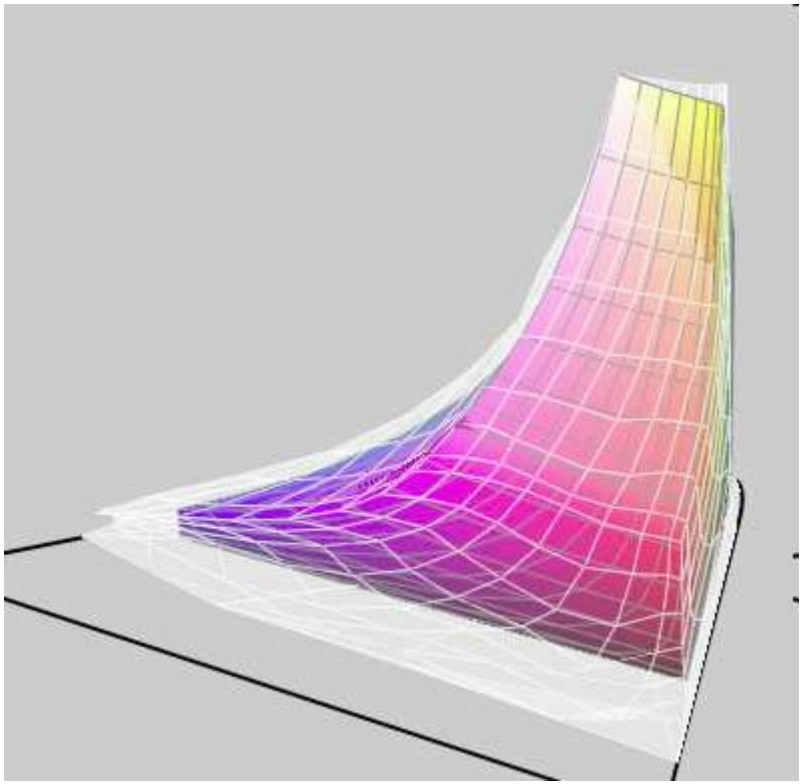
Does the camera capture 'real life' colours?



- White area is camera colour space (Canon EOS 20D, but others will be similar)
- Coloured area is Adobe RGB 1998 colour space
- sRGB is substantially smaller still than Adobe RGB 1998!
- Closest colour space to digital cameras is Prophoto RGB (used by Lightroom/ACR)

What colour space should you use in your image editor?

- Depends on your application, colour management methodology and your equipment!
- sRGB is useful for web display
  - Most monitors can display the sRGB colour space
  - But is small, limits your available colour palette
- Use for projected images
- Abobe RGB 1998 is a good compromise for printing
  - Good inkjet printers on good paper can print approximately the same volume of colours, although there will likely be a few areas that don't correspond (out of gamut printing or printing capabilities beyond the gamut of Adobe RGB 1998)
- Prophoto RGB or similar wide gamut space approximates to what your camera records
  - Most RAW converters use this e.g. Lightroom
  - Bigger space than can be printed
  - Use in Photoshop if you are happy to soft proof and resolve out of gamut issues

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Profiling

- First step: monitor profiling
  - Make sure what you see is what you have
  - Need to repeat periodically
    - Good, new-ish monitor annually is OK
    - More often for older or less good monitors
- Next step: printer and paper profiling
  - So you can print accurately
  - Allows soft proofing
  - Need to do for every paper you use
  - Could download generic profiles but not tailored to your specific printer and print settings (quality varies)
- Optional: camera profiling
  - Less necessary as profiles built into jpegs, RAW converters include known profiles for a camera (ACR offers several options for most cameras)

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Limitations

- Cannot compensate for perceptual differences between devices e.g. emitted light vs reflected light
- Profiles vary in their quality
- Cannot make a device produce colours beyond its capability
- Needs to handle out of gamut colours
- Occasional linearisation issues especially in deep shadow gradients

Using Colormunki to profile your monitor

- DEMO!

Using Colormunki to profile your printer

- Ideally you should profile each paper that you use, however **sometimes** it is possible to get good results using a profile for a similar paper e.g. two glossy papers.
- Choose a paper media type appropriate to the paper you are using (usually paper manufacturers recommend particular settings).
- For matte papers it isn't normally worth exceeding 1440 dpi. It might be worth choosing the highest resolution for high quality glossy papers.
- Turn off colour management in the printer driver.
- Turn off high speed printing in Epson printer drivers.
- Make a note of your print settings.
- Note: print a nozzle check pattern before printing targets!

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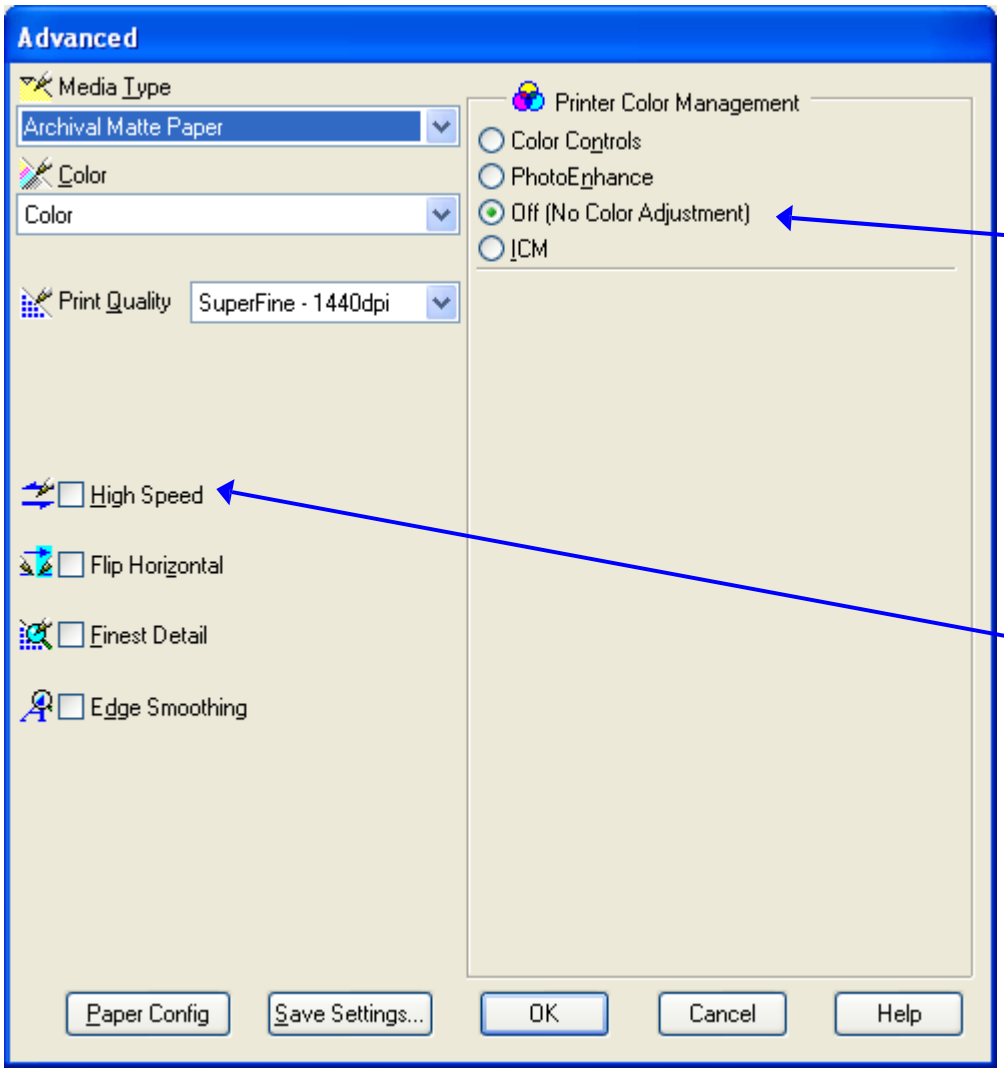
Example print settings



Turn off colour management in the printer driver

Turn off high speed printing

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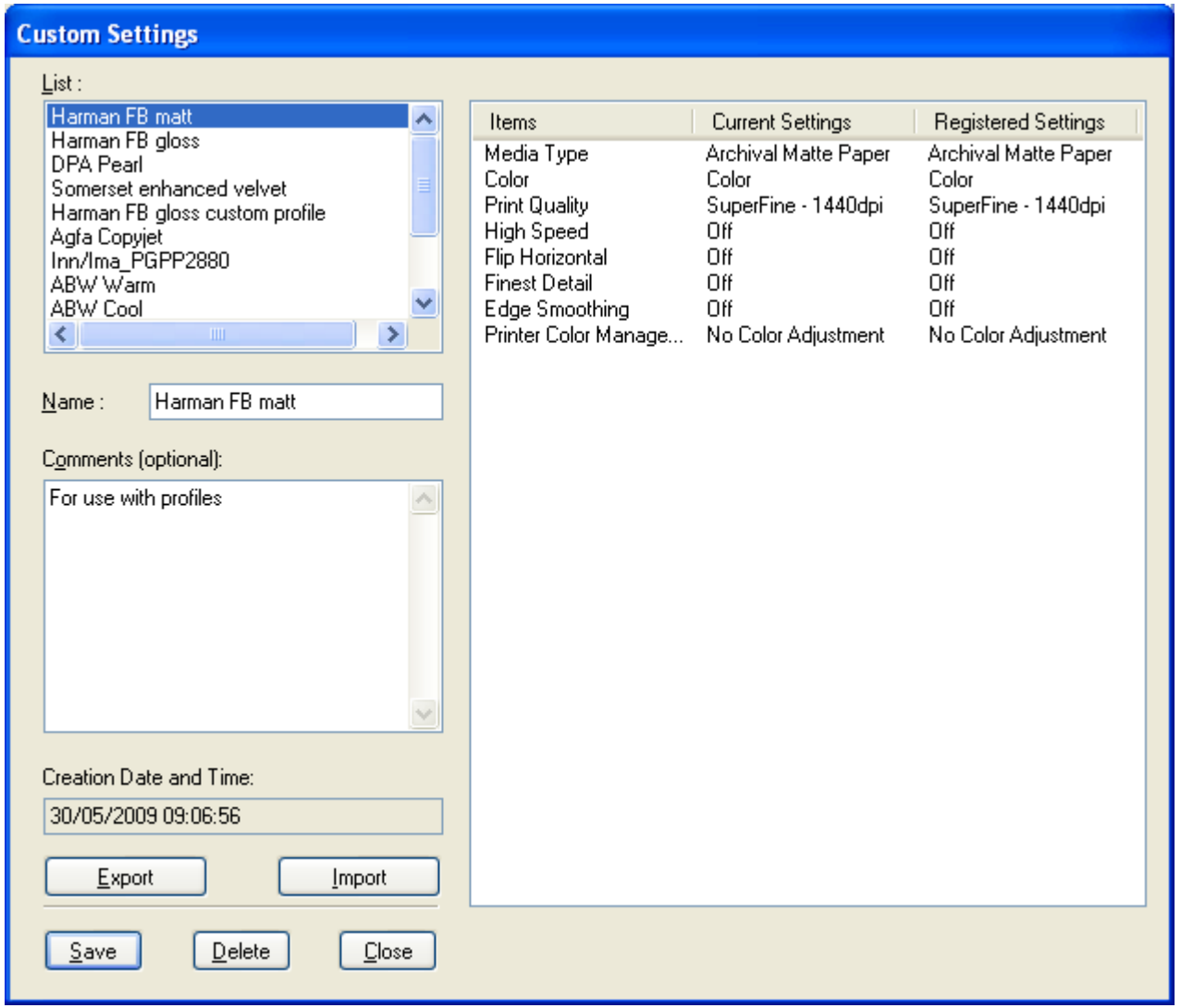
Save your print settings



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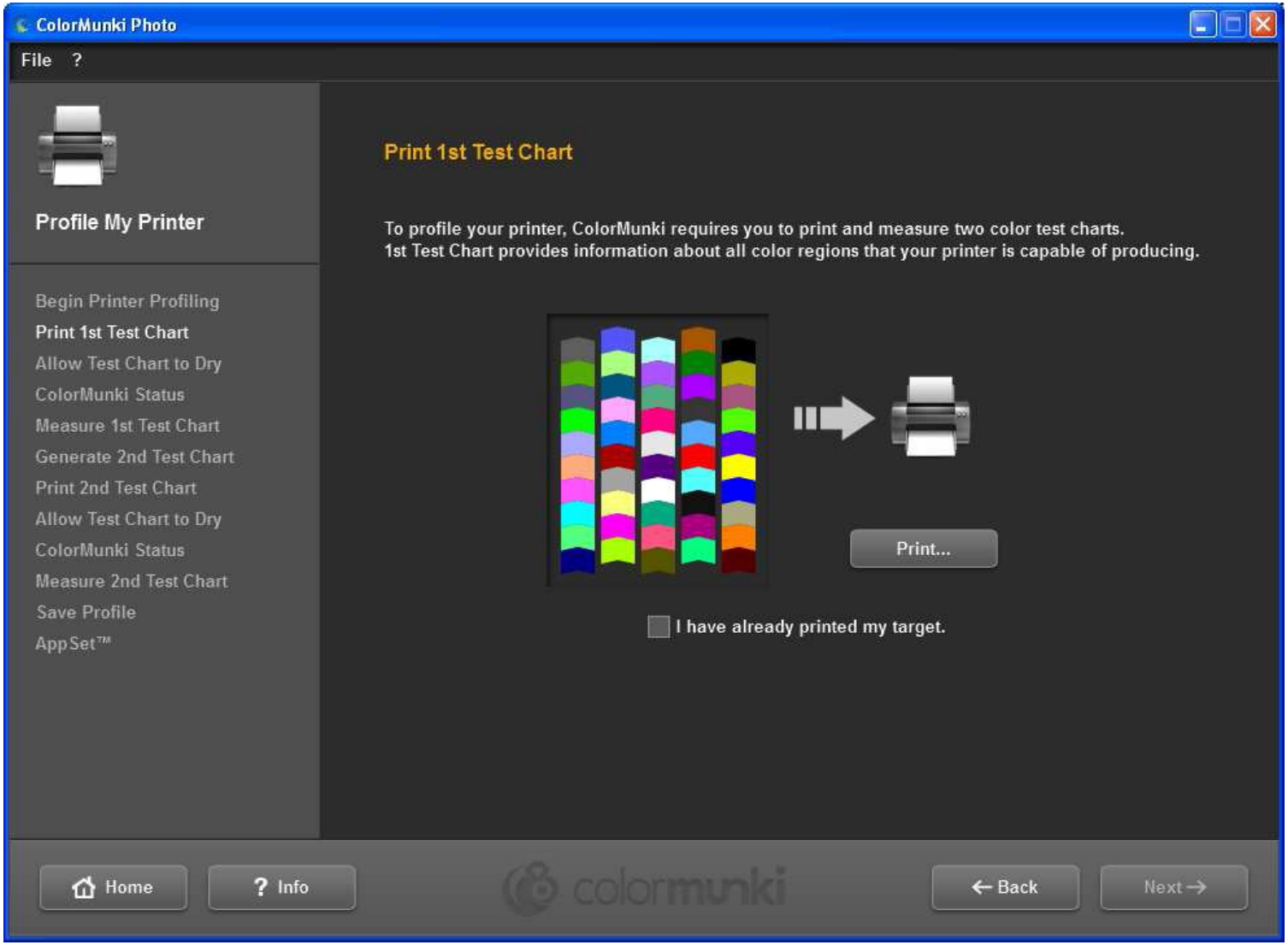
Print the first sheet



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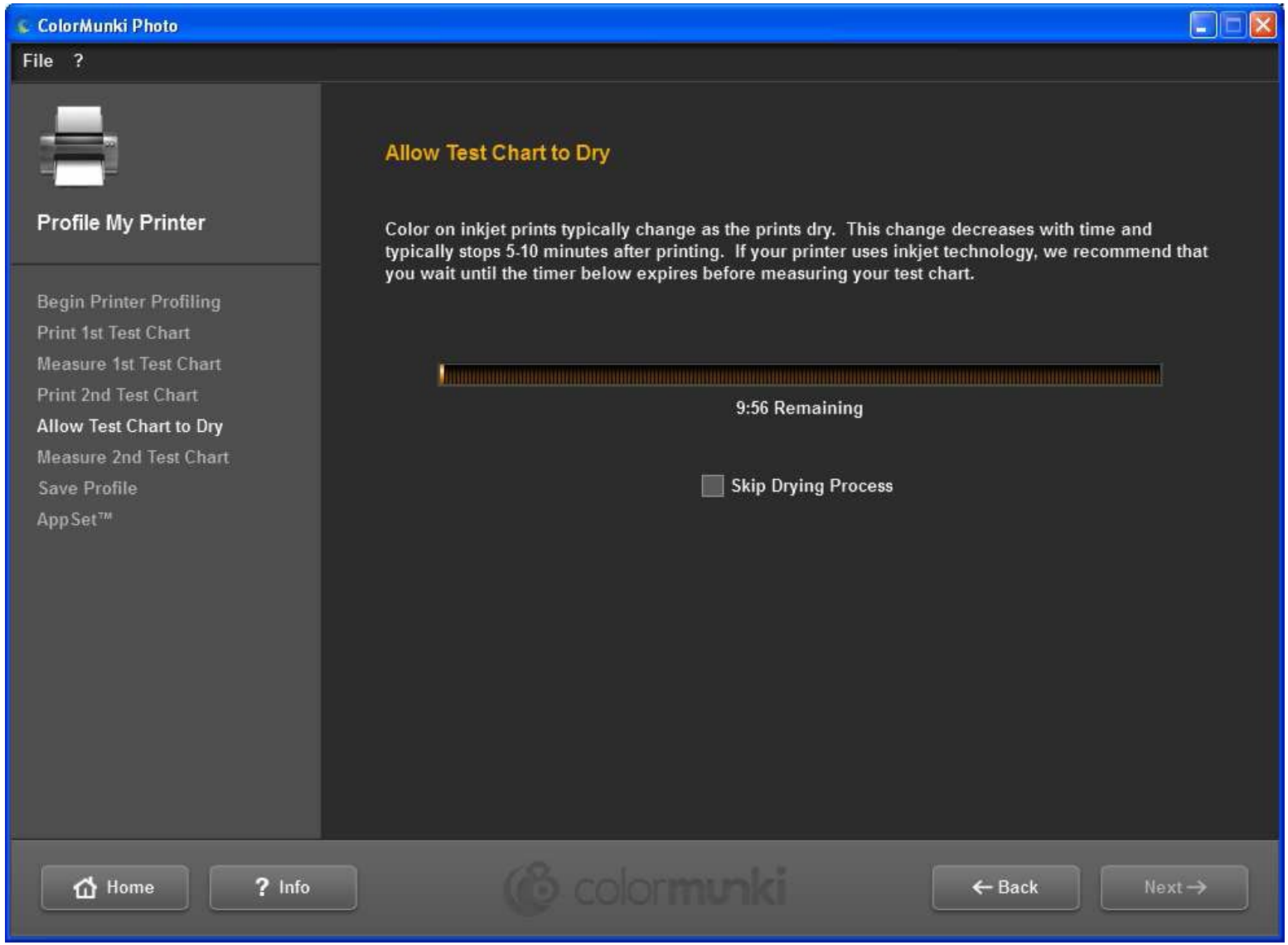
Wait 10 minutes

- Allows the ink to dry
- Colormunki provides a timer!

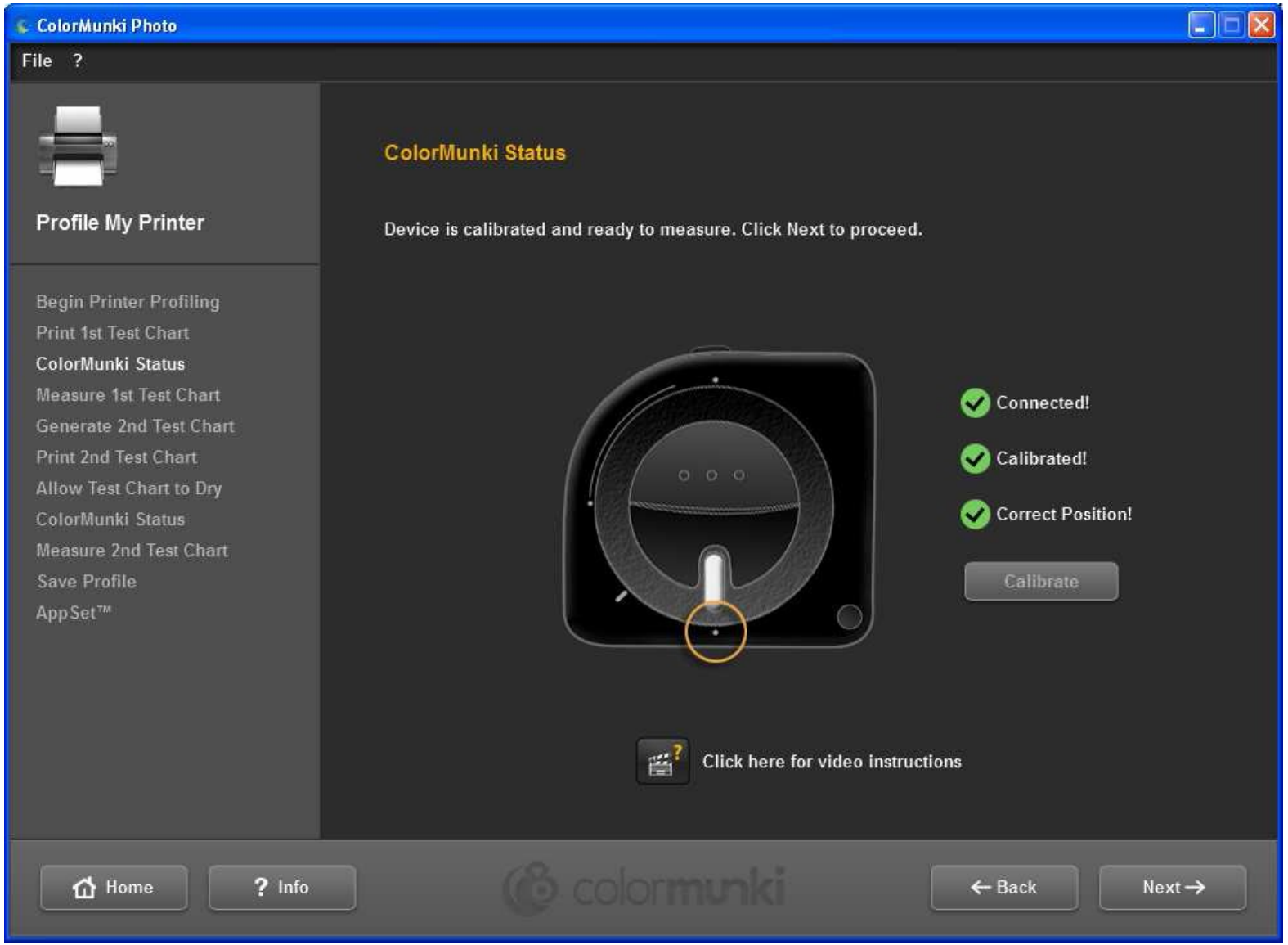
Wait 10 minutes



Calibrate

- Turn the pointer to the calibrate position
- Press the button or use the on-screen prompt

Measure first sheet



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Note

- The first sheet is always the same ie has the same patches
- It is a good idea to put a second sheet of paper underneath the paper being measured

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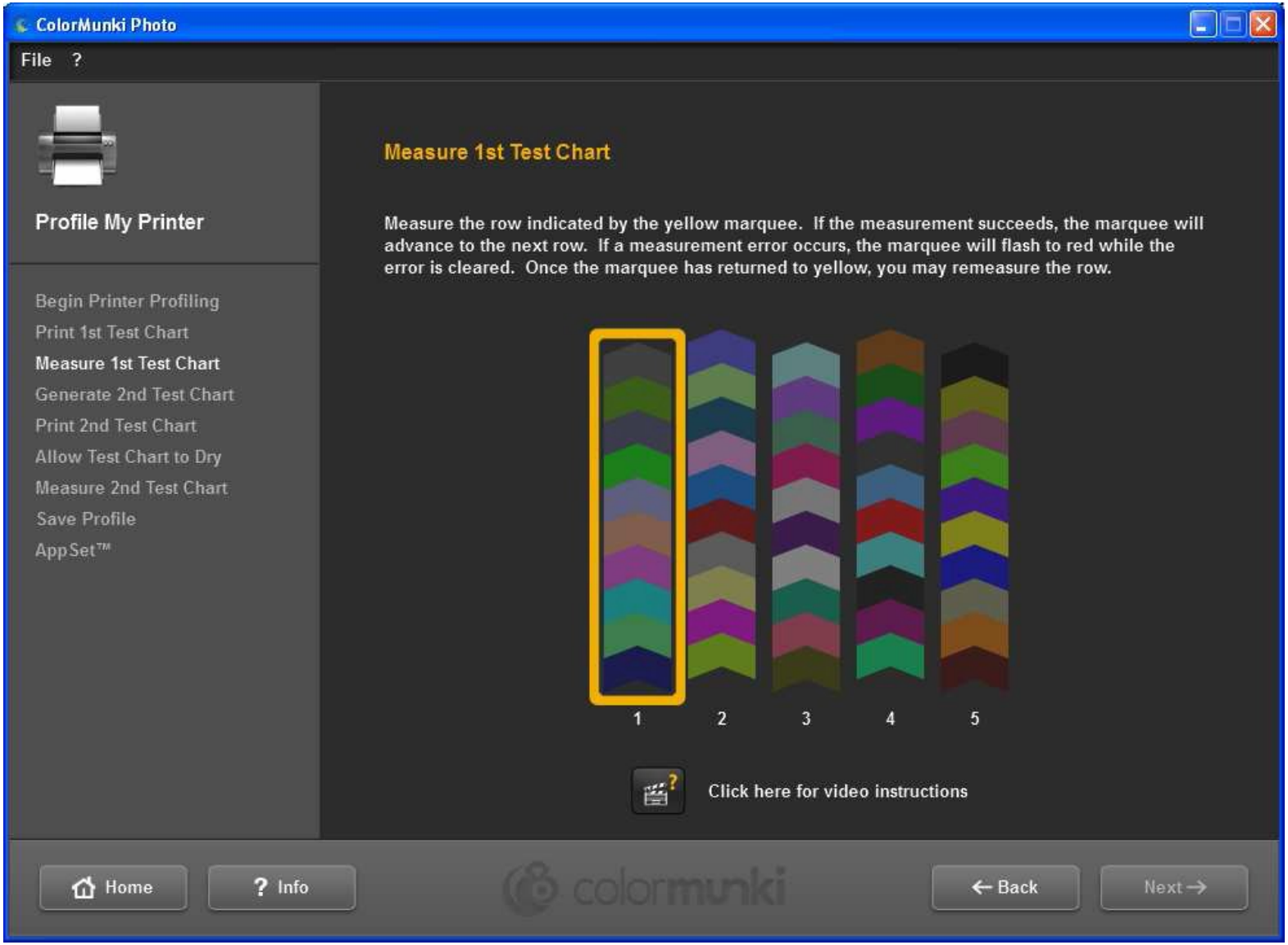
Measure first sheet



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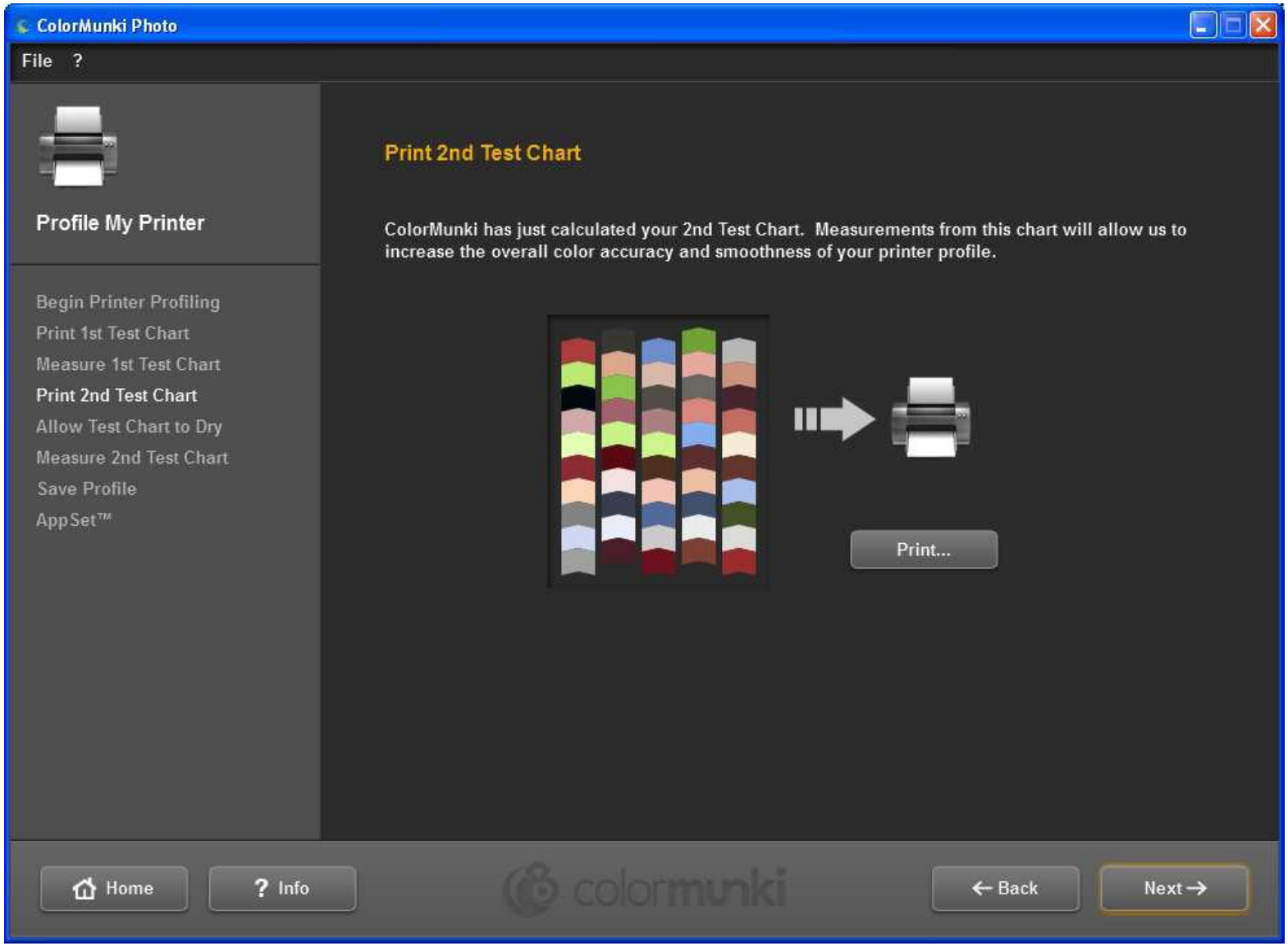
Measure first sheet

- Position the device at the end of the first row (over white paper)
- Press button and hold down
- Slide device along row (not too fast)
- When the device has finished the row and is over white paper release the button
- If you have been successful the next row will be highlighted on screen

Calculate and print second sheet

- The second sheet is slightly different for every paper and depends on the results of the first sheet
- Print the sheet using the same printer settings

Calculate and print second sheet



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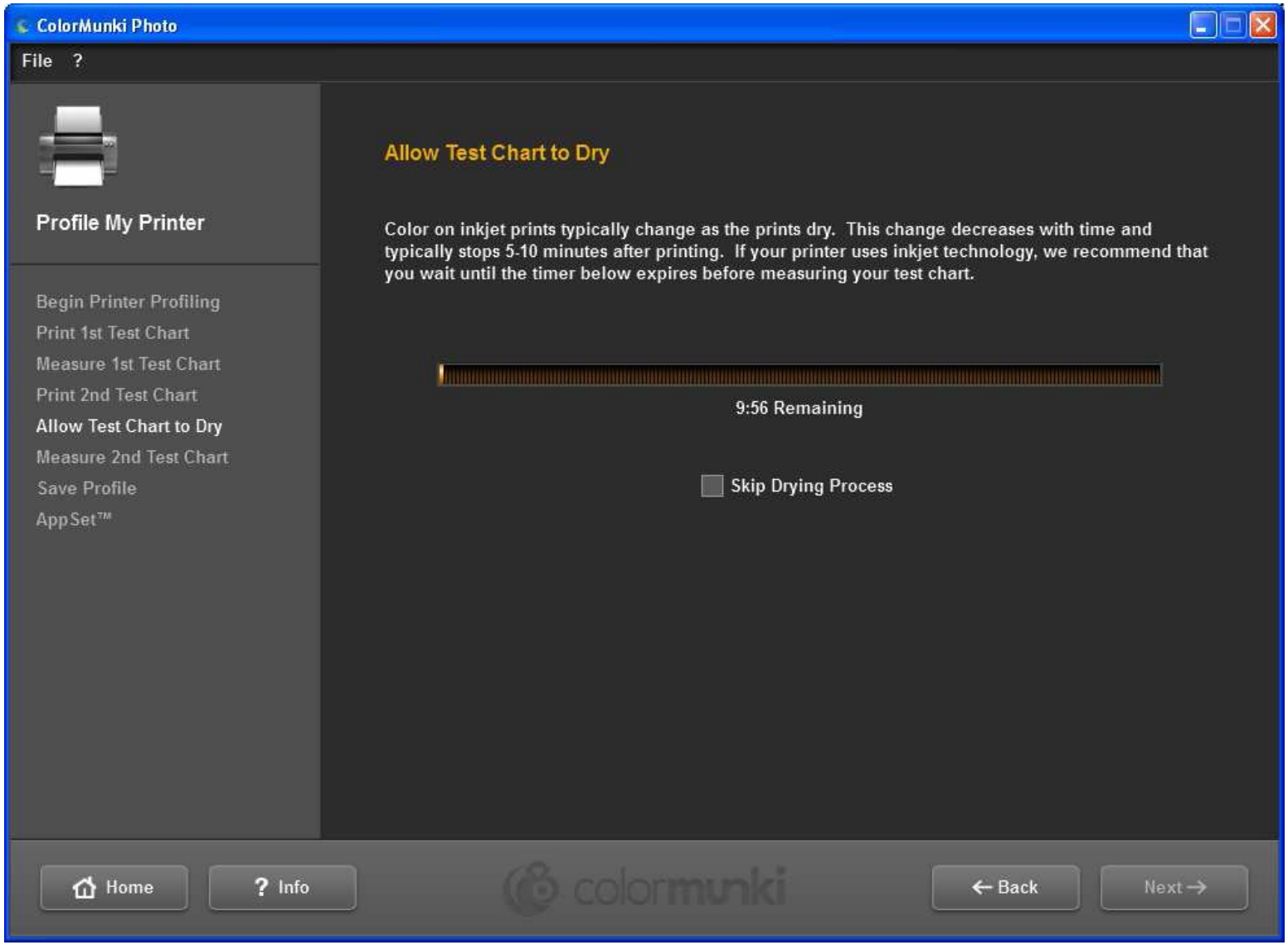
Wait 10 minutes



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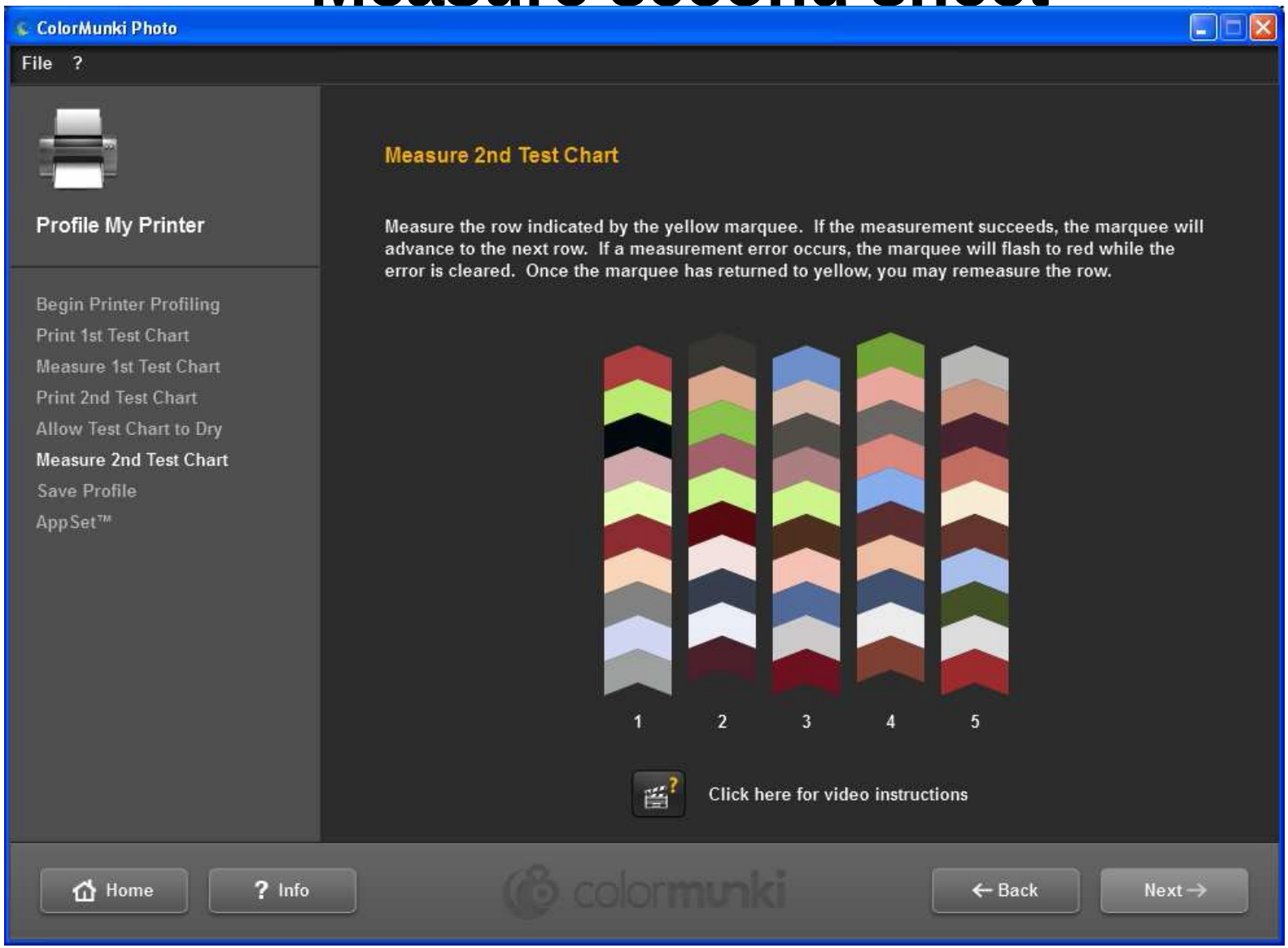
Measure second sheet



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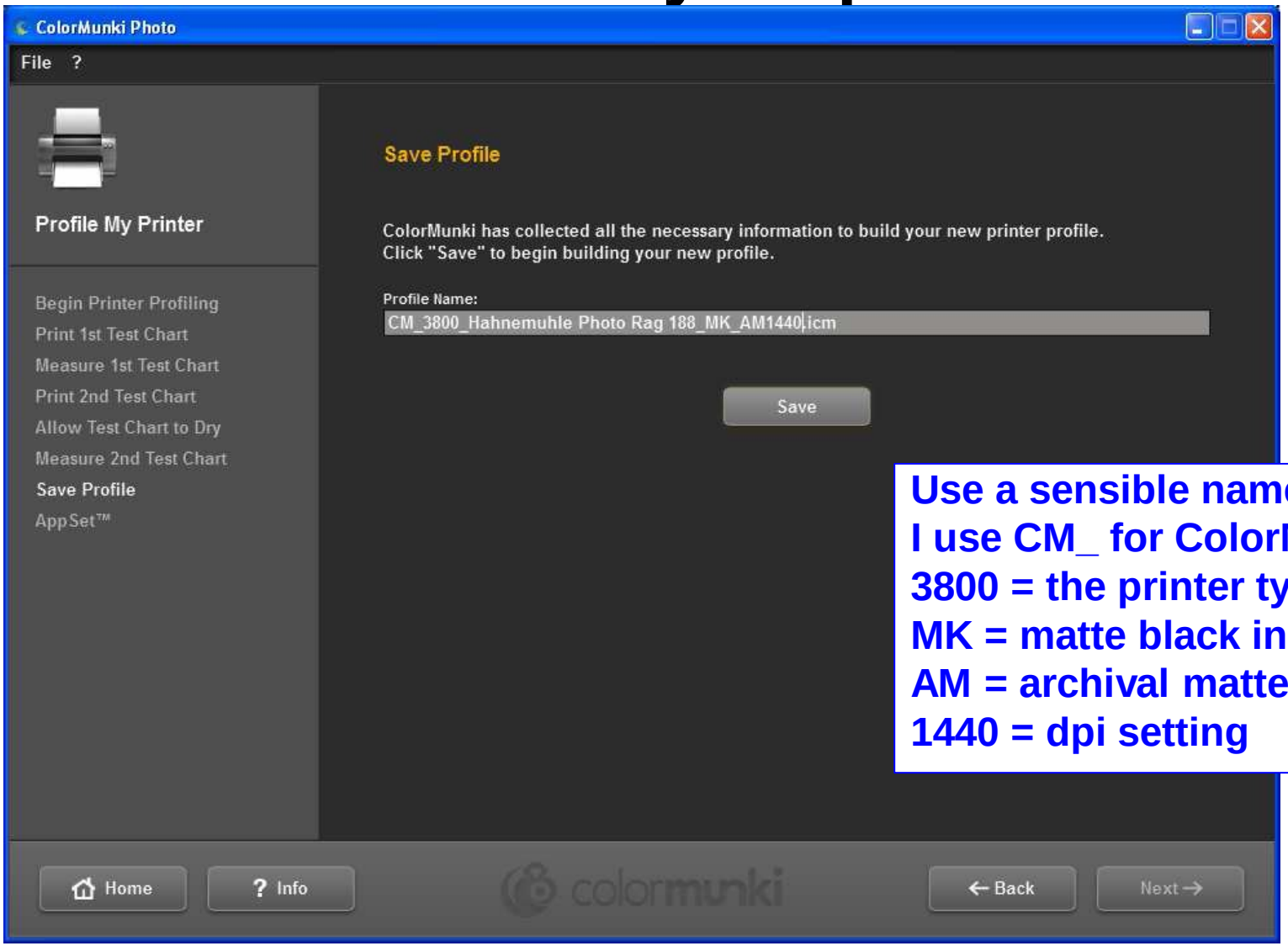
Save your profile



Use a sensible name!
I use CM_ for ColorMunki
3800 = the printer type
MK = matte black ink
AM = archival matte paper type
1440 = dpi setting

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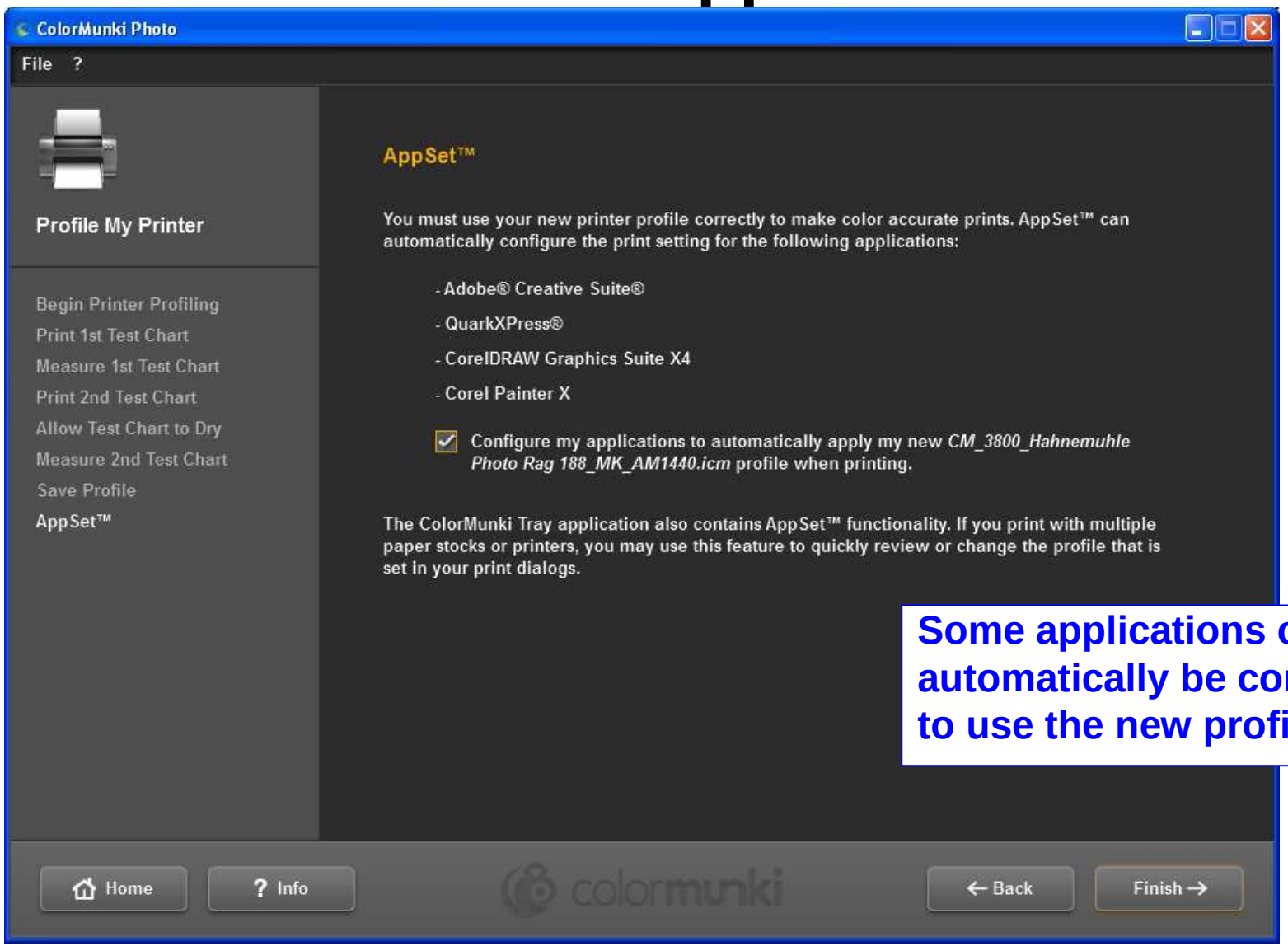
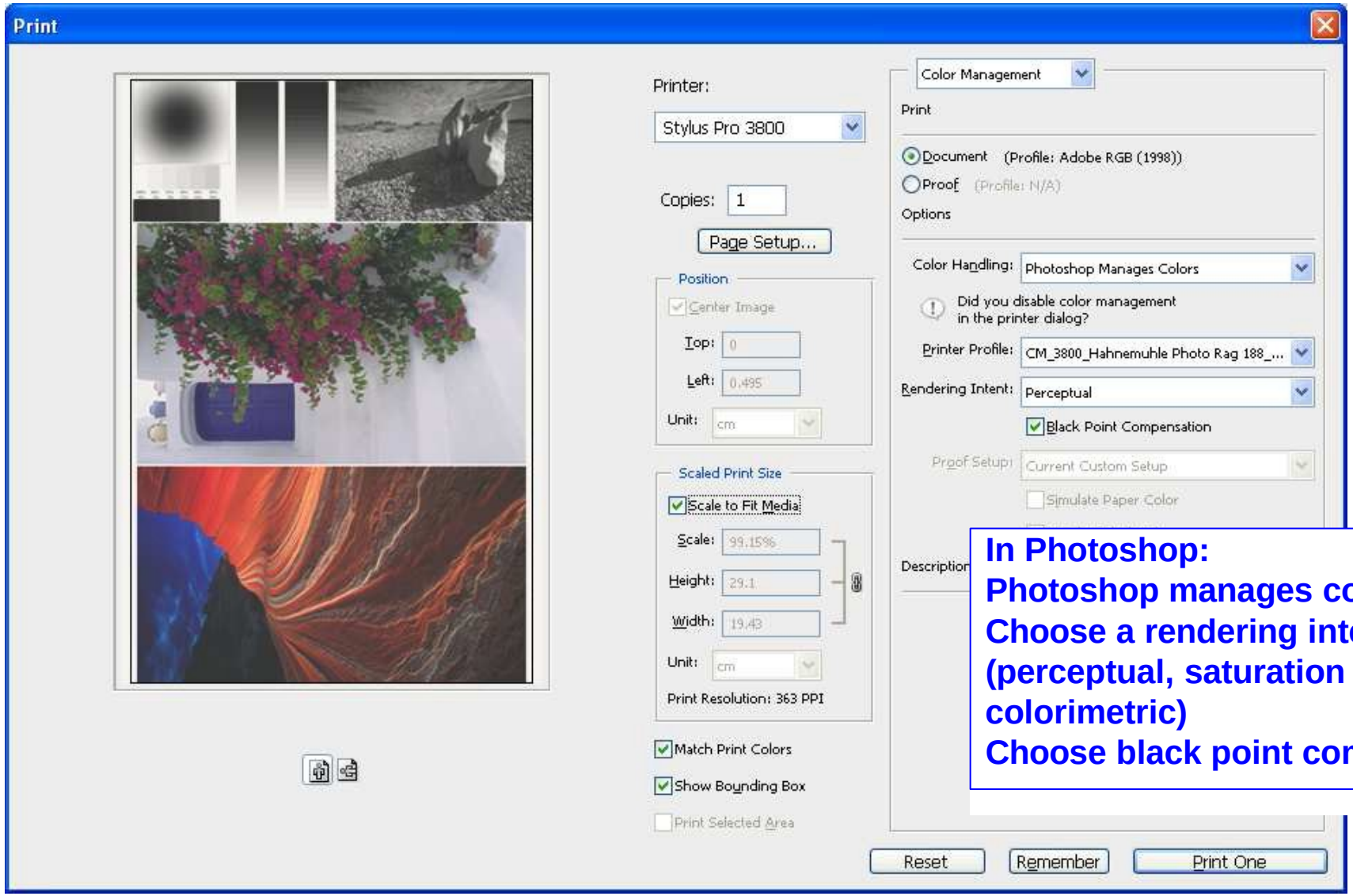
Appset



Some applications can automatically be configured to use the new profile

Print dialog



In Photoshop:
Photoshop manages colours
Choose a rendering intent (perceptual, saturation or relative colorimetric)
Choose black point compensation

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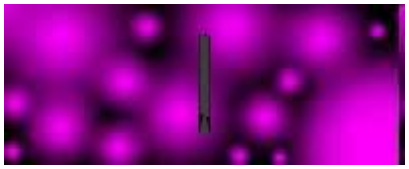
Print dialog

- Make sure your printer settings are correct before printing!

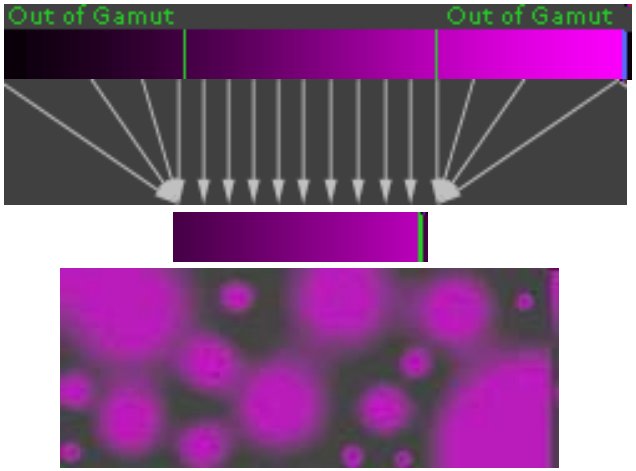
Rendering intents

Perceptual and relative colorimetric rendering are probably the most useful conversion types for digital photography. Each places a different priority on how they render colors within the gamut mismatch region. Relative colorimetric maintains a near exact relationship between in gamut colors, even if this clips out of gamut colors. In contrast, perceptual rendering tries to also preserve some relationship between out of gamut colors, even if this results in inaccuracies for in gamut colors. The following example demonstrates an extreme case for an image within a 1-D black-magenta color space:

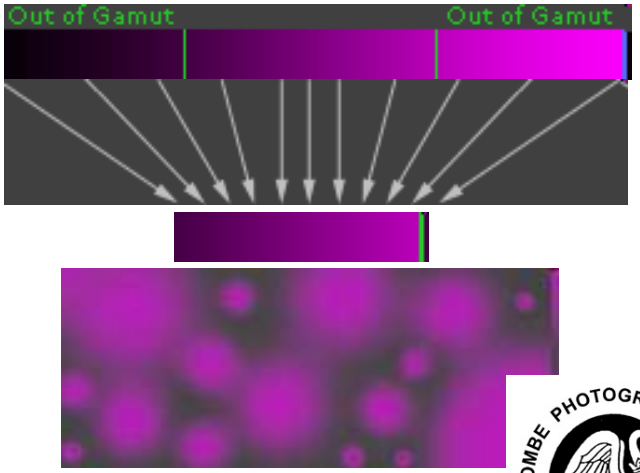
A = Wide Gamut Space
B = Narrow Gamut Space (Destination Space)



Relative Colorimetric



Perceptual



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- Note how perceptual maintains smooth color gradations throughout by compressing the entire tonal range, whereas relative colorimetric clips out of gamut colors (at center of magenta globules and in the darkness between them).
- Relative colorimetric can create jumps in gradients but most colours are reproduced more accurately
- Perceptual changes all colours, but keeps smoother gradients
- Perceptual is normally recommended for most images

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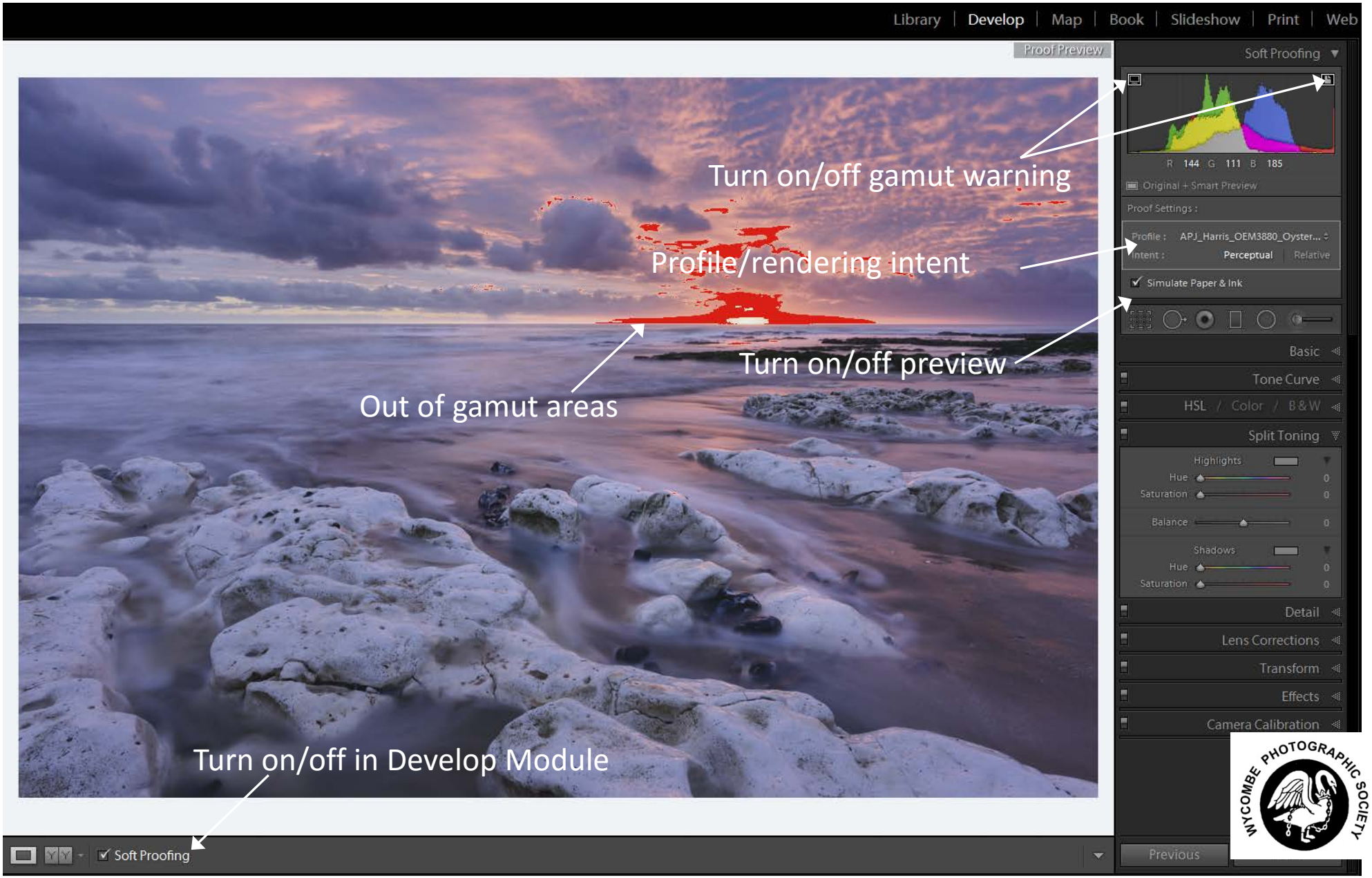
Soft proofing

- Use the soft proof capability in Photoshop to simulate how an image will print
- Load a printer profile for this
- Can also show out of gamut colours
- In PS: Access via: View\Proof setup.
- In PSE: Open Color and tone dialog box, double click Soft proof command

Soft proofing in Lightroom



Correcting Out of Gamuts

- In theory you can reduce saturation of out of gamut colours or areas to bring the image into gamut
- In practice I’ve never managed to make this work! (But gave up trying years ago)

For PDIs – Choose Profile: sRGB

- It often isn’t a pretty sight...

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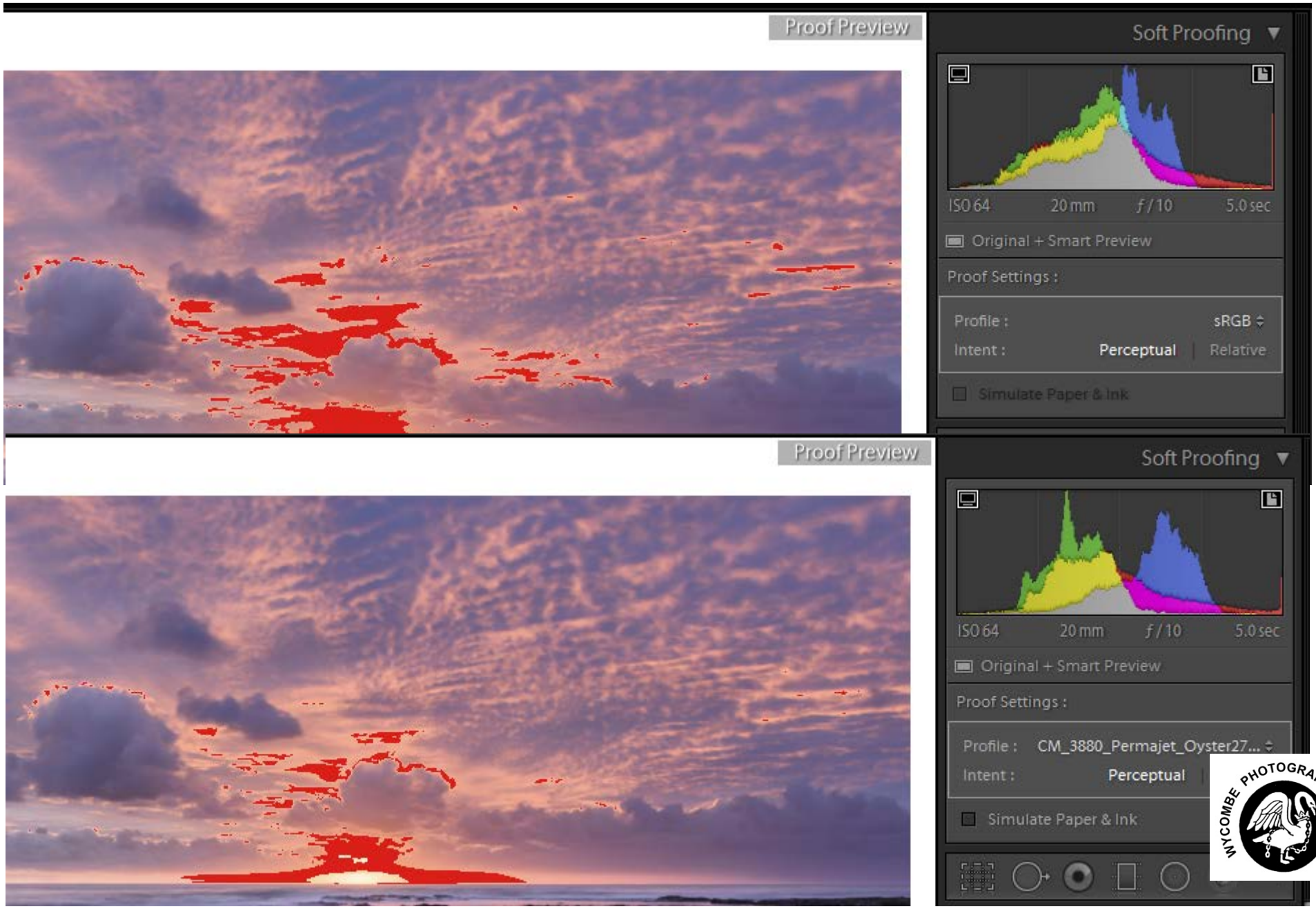
sRGB vs Printer profile



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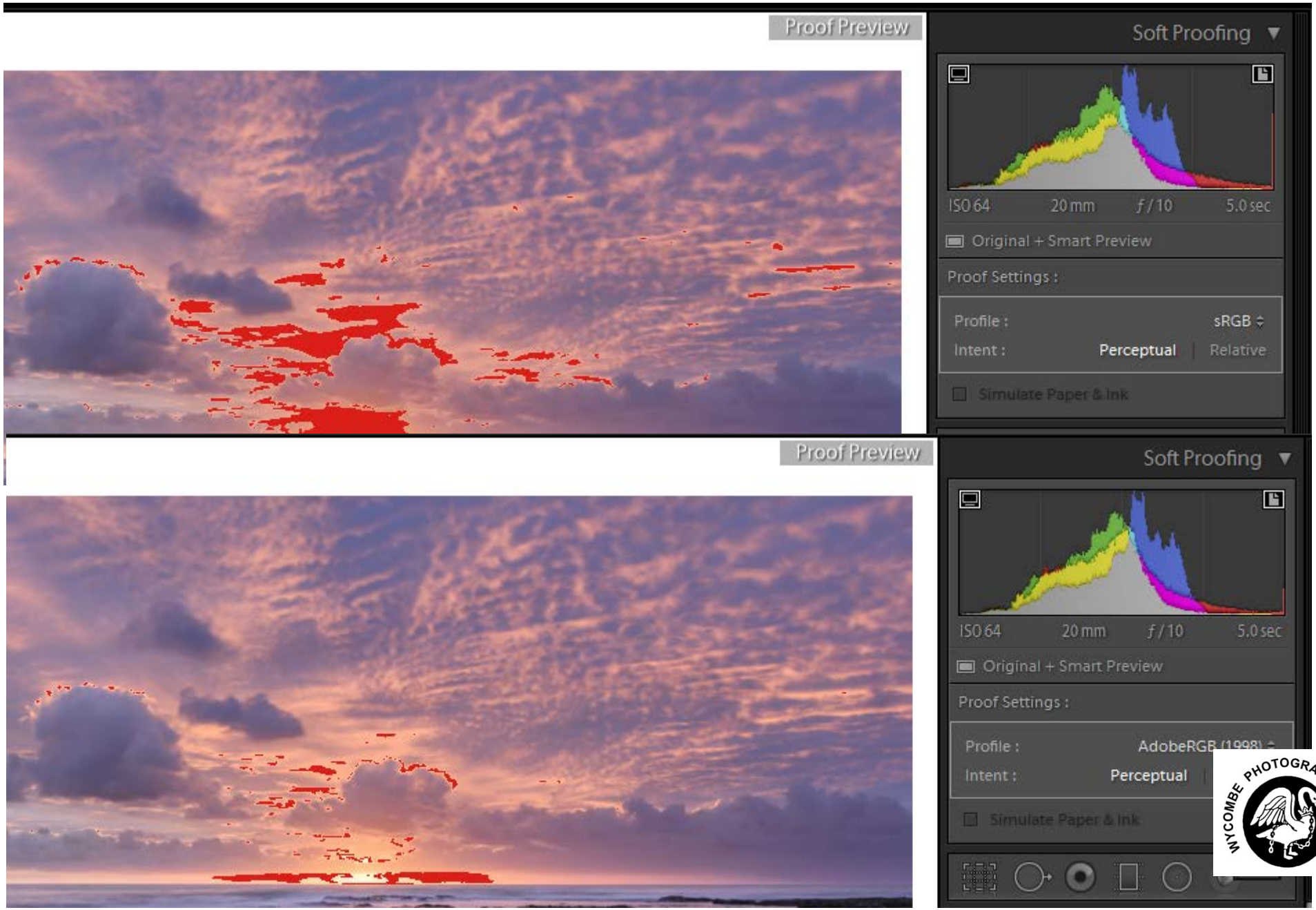
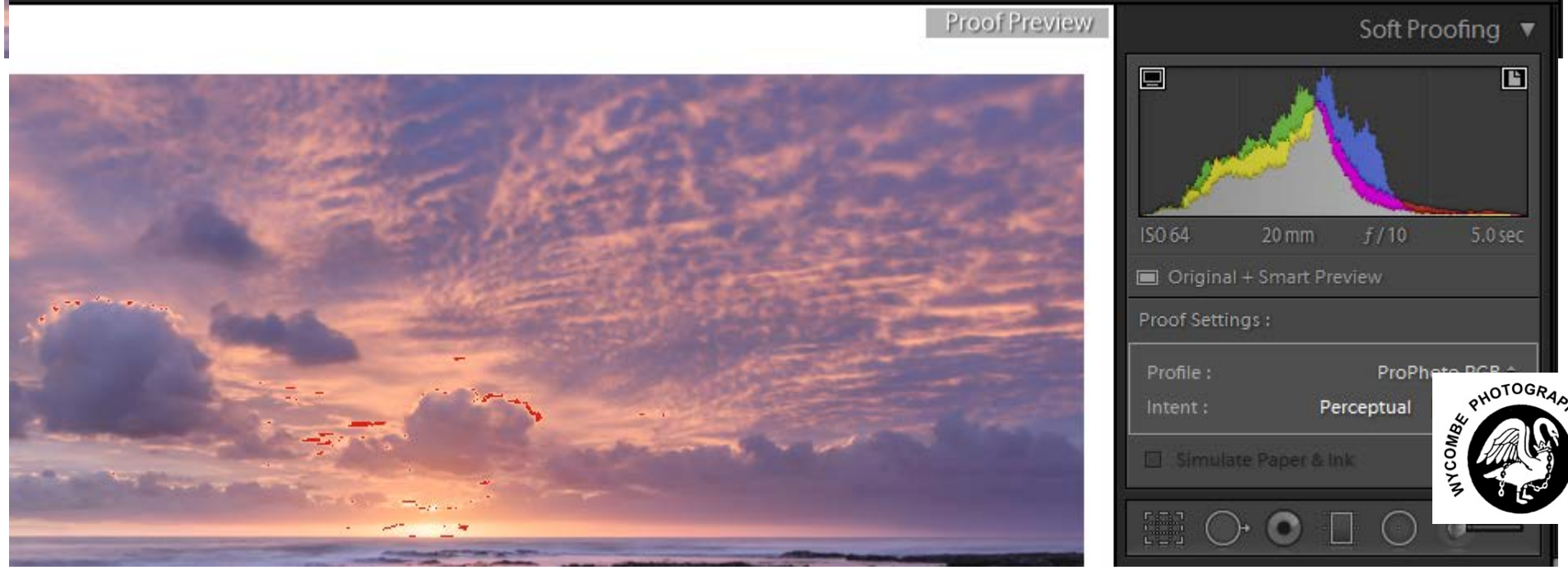
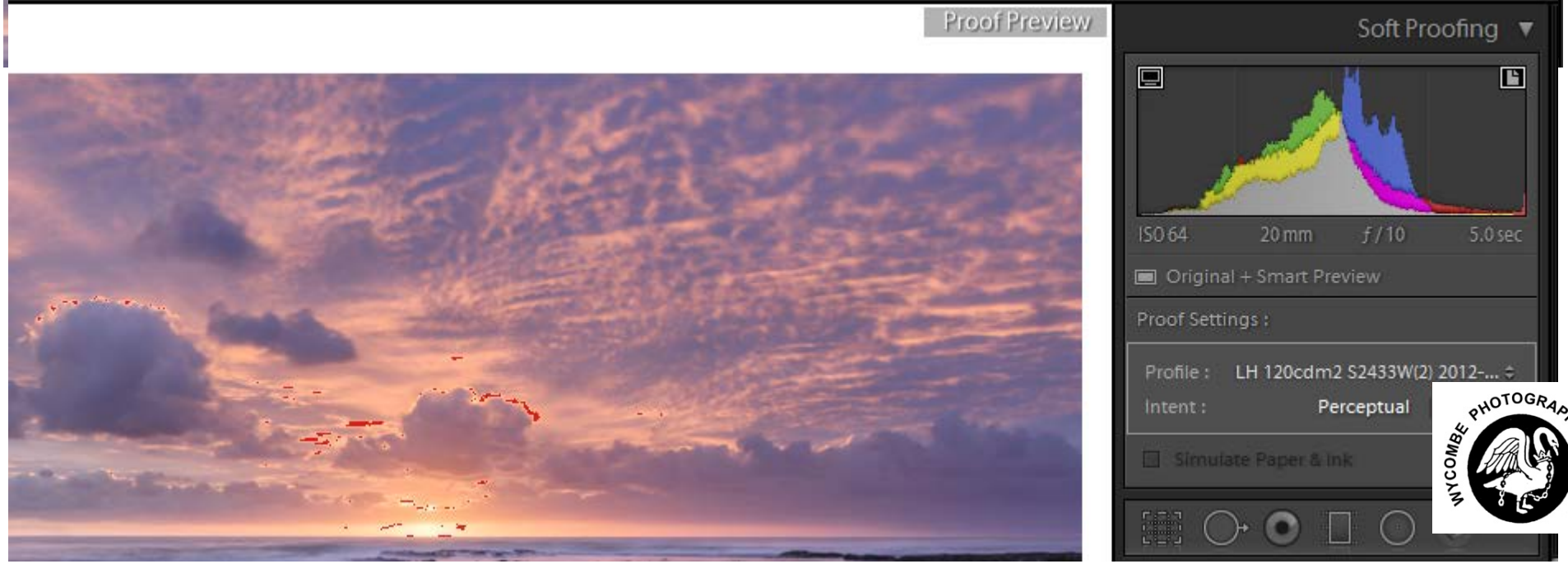
sRGB vs Adobe RGB (1998)



sRGB vs ProPhoto RGB



sRGB vs Monitor profile



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Generic and third party Bespoke custom profiles

- A Generic profile is a profile made for a particular Printer, Ink and Paper combination, however it will have been made on somebody else's printer.
- A Bespoke profile would be particular to the printer you are using. This service is offered by PermaJet (and others?) and is a more accurate way to create a profile.
- However a generic profile is a quick way to put you in the position to trial the paper and is immeasurably better than using no ICC Profile.

Where to save profiles

PC users (32Bit): Right click on the profile then left click on Install
Profile.PC users (64Bit): Please drag and drop the profile into the location listed below

Depending on which Operating System is in use the profile will now reside in one of the following folders;

PC: Windows 2000/Vista/XP/7 - C:/windows/system32/spool/driver/color
Win 9x - C:/windows/system/color

Photoshop will need to be restarted if it was open when profiles were installed.

Mac users: Drag and drop the profiles into the correct folder (see below):

Mac: OS 8-9x - System Folder > ColorSync Folder
OS X - HD > User > Library > ColorSync > Profiles
Or HD > Library > ColorSync > Profiles

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