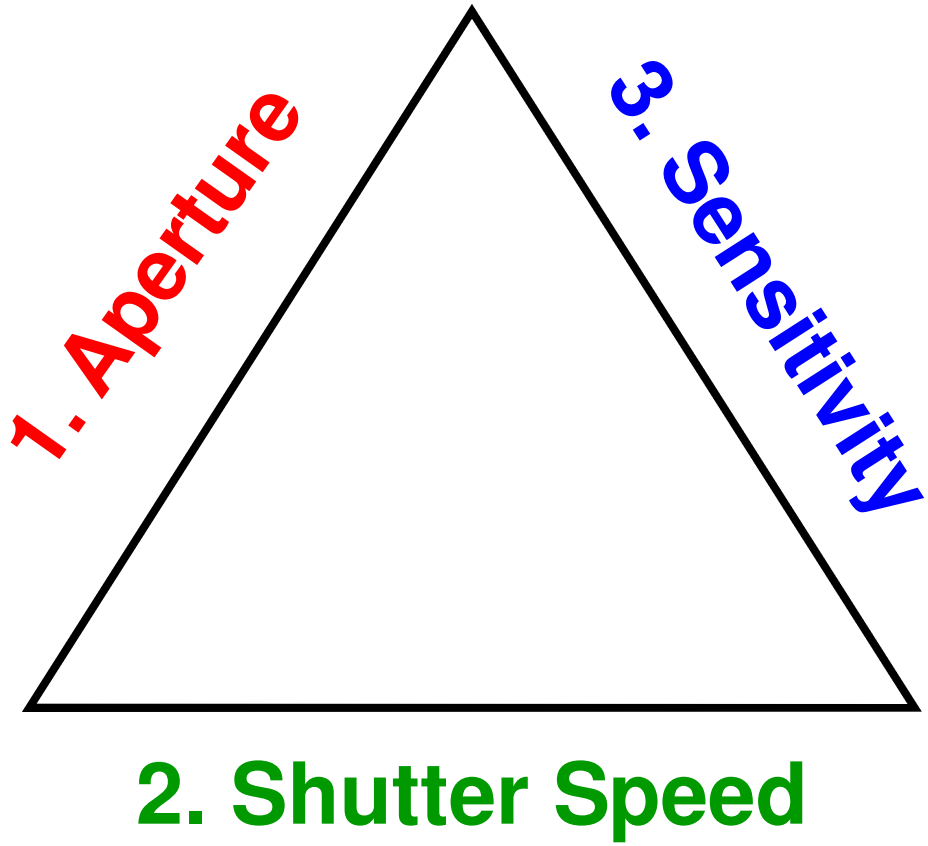
Exposure Triangle

By George Themelis

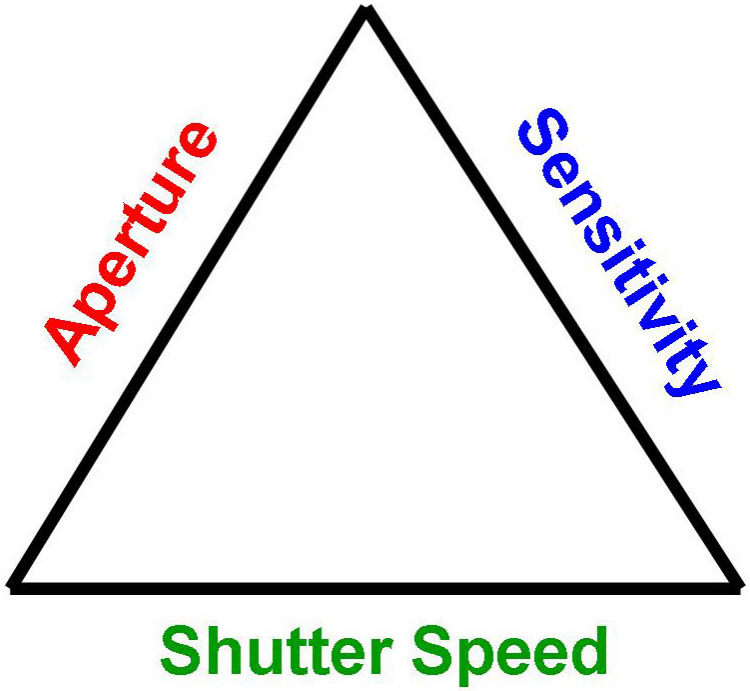
April 2023

Three Variables that Determine Exposure



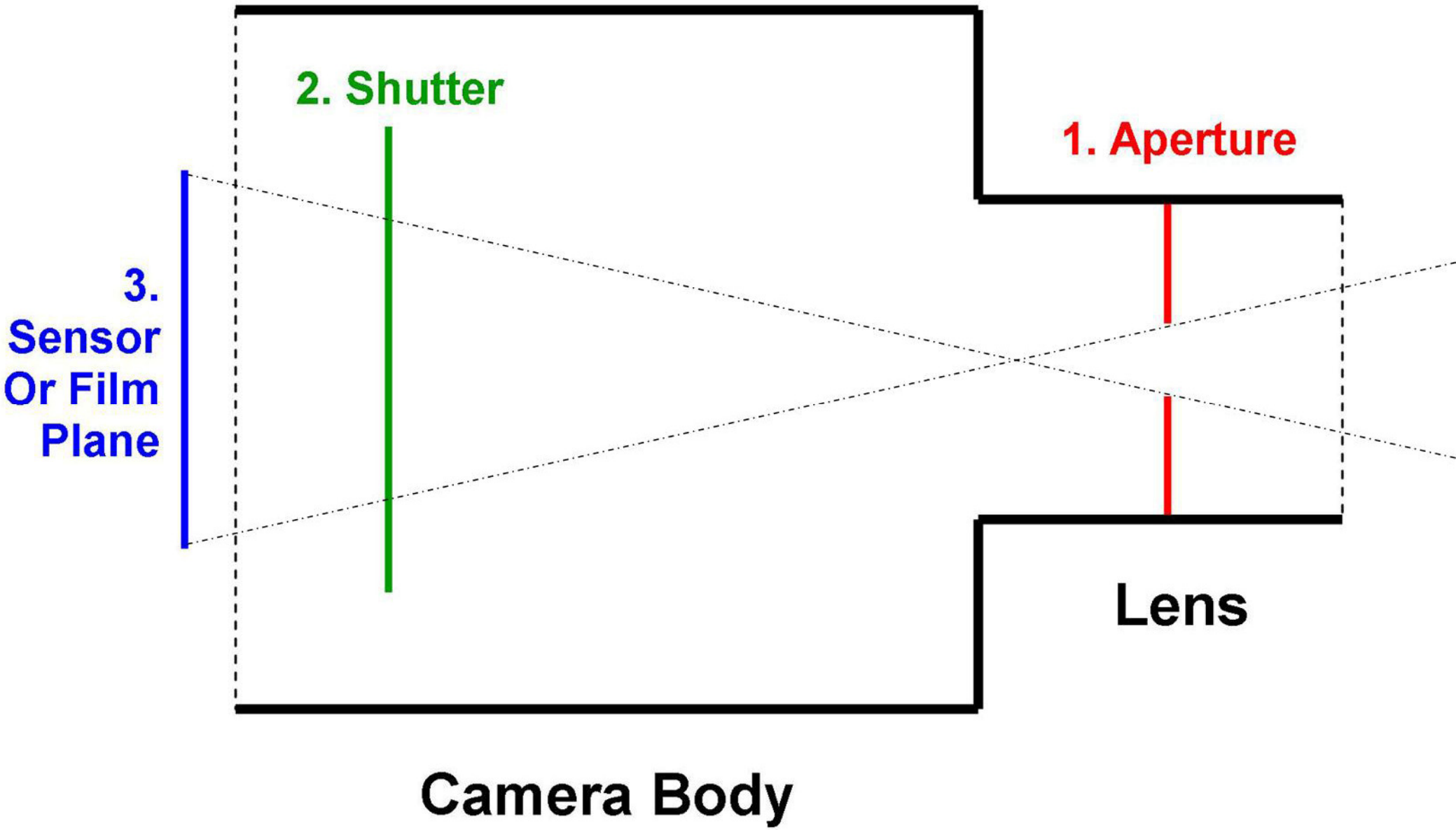
Topics to be discussed:

- **What is each setting and how does it affect exposure?**
- **What else is affected and how?** (DOF, sharpness, noise)
- **How are these set in a modern camera?**



- **Which setting is more important (if any) and why?**

What is the best mode to use? (Is there a reason to use anything else other than Automatic Mode?)


2. Shutter
1. Aperture
3.
Sensor
Or Film
Plane
Lens
Camera Body

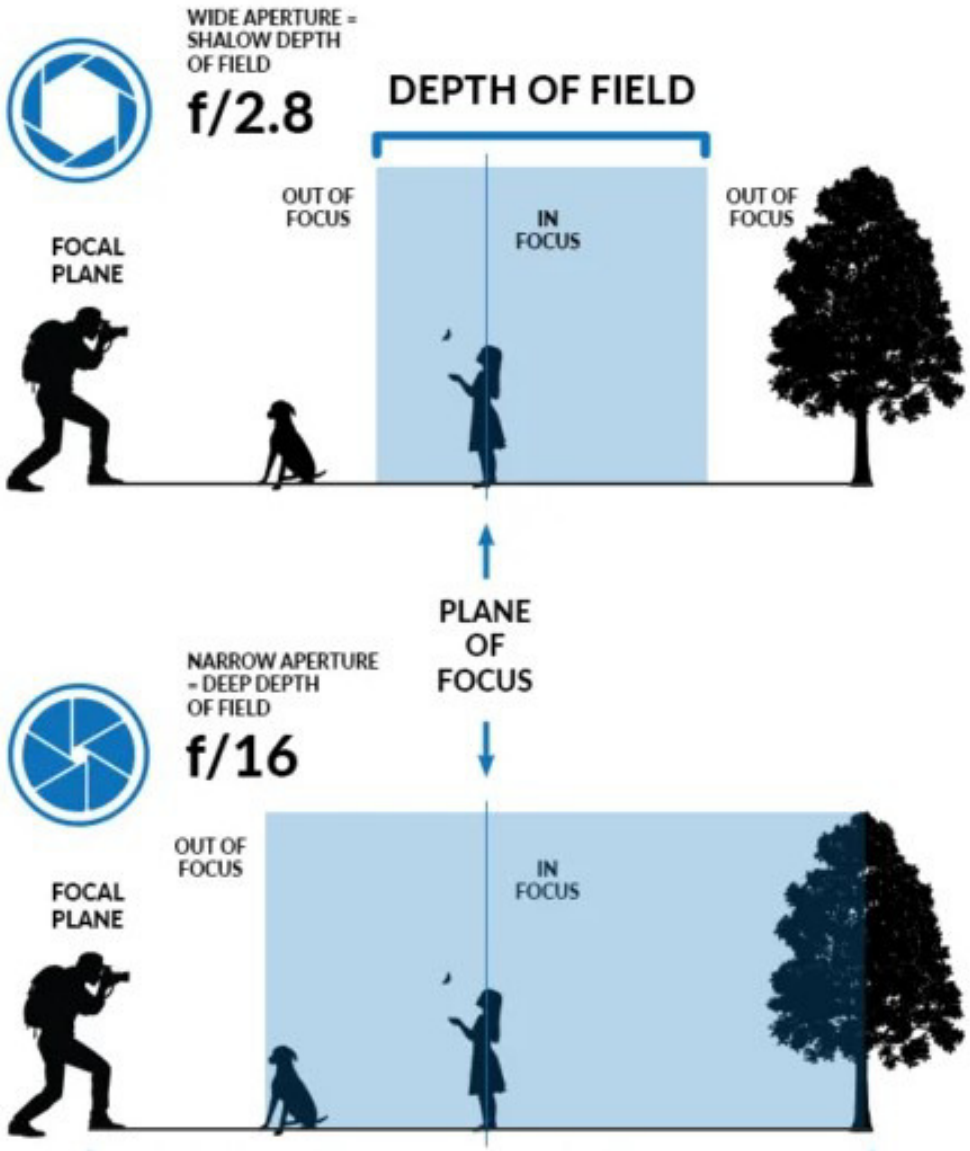
Lens Aperture

- Related to size of the lens opening
- Measured by the **f-stop** (focal length / lens opening)
- Ratio values: 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22
- Scale is not linear, but goes by the $\sqrt{2}$ (1.41)
- Affects amount of light and depth of field (DOF)
- Large (wide) aperture → small f-stop number = more light, less Depth of Field (DOF)
- Aperture ring is missing from many modern lenses
- Maximum aperture is an important characteristic of a lens

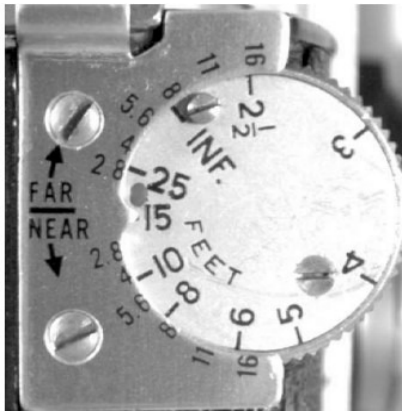
Aperture Ring for Stereo Realist f2.8

More modern 35mm f1.4 lens

Depth of Field (DOF)



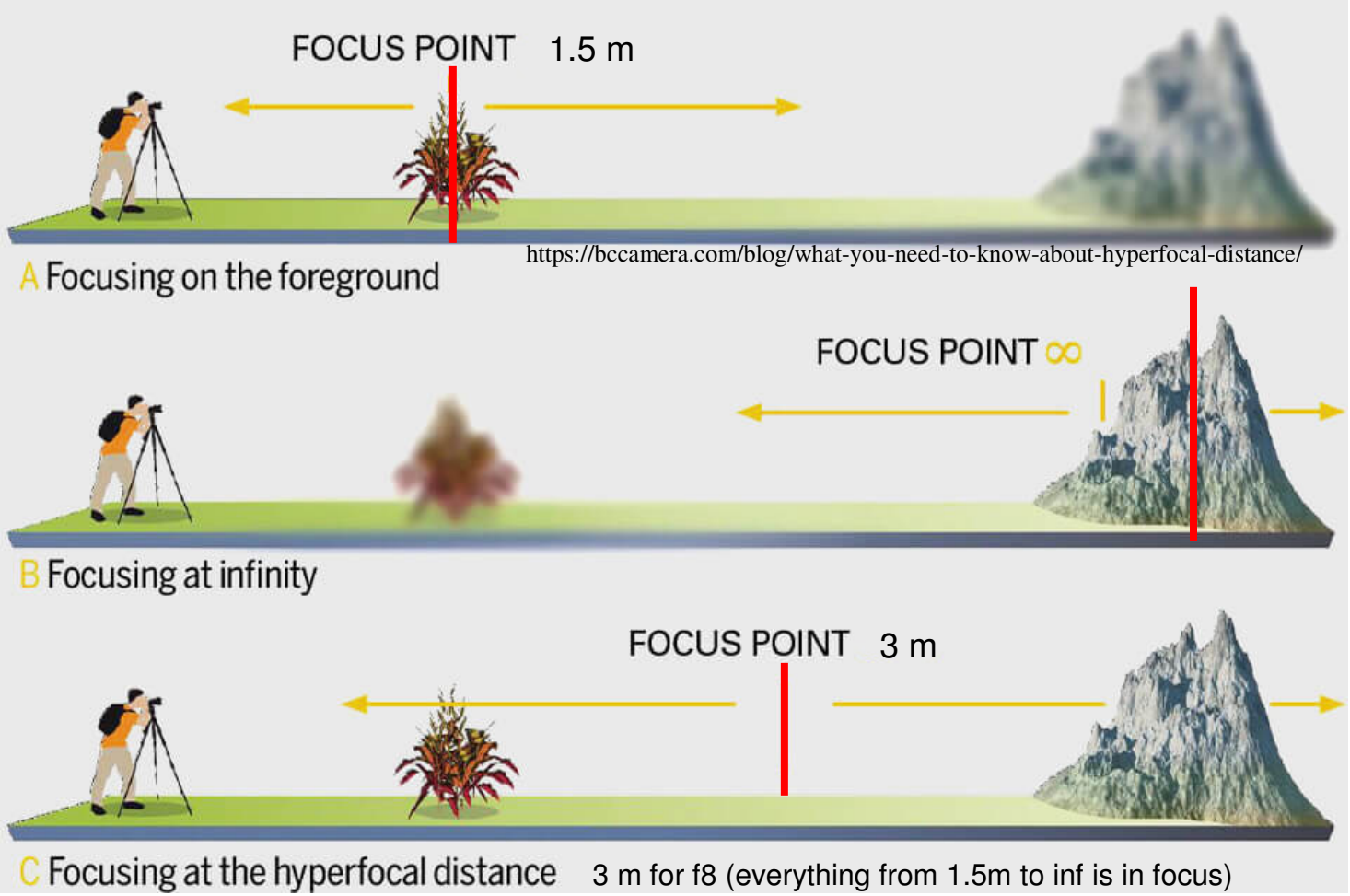
- **<u>Depth of Field</u> (DOF): is the distance range (near to far) that objects appear to be "acceptably sharp"**
- **<u>DOF depends on</u>:**
  1) **Focus distance**
  2) **Focal length**
  3) **Aperture**

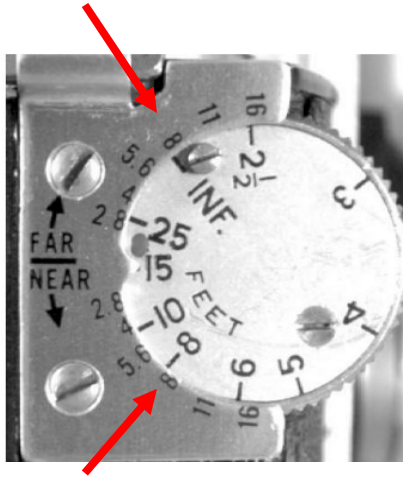


Many lenses have DOF marking that show the DOF for a given aperture

https://expertphotography.com/understanding-depth-of-field-photography/

Hyperfocal Distance





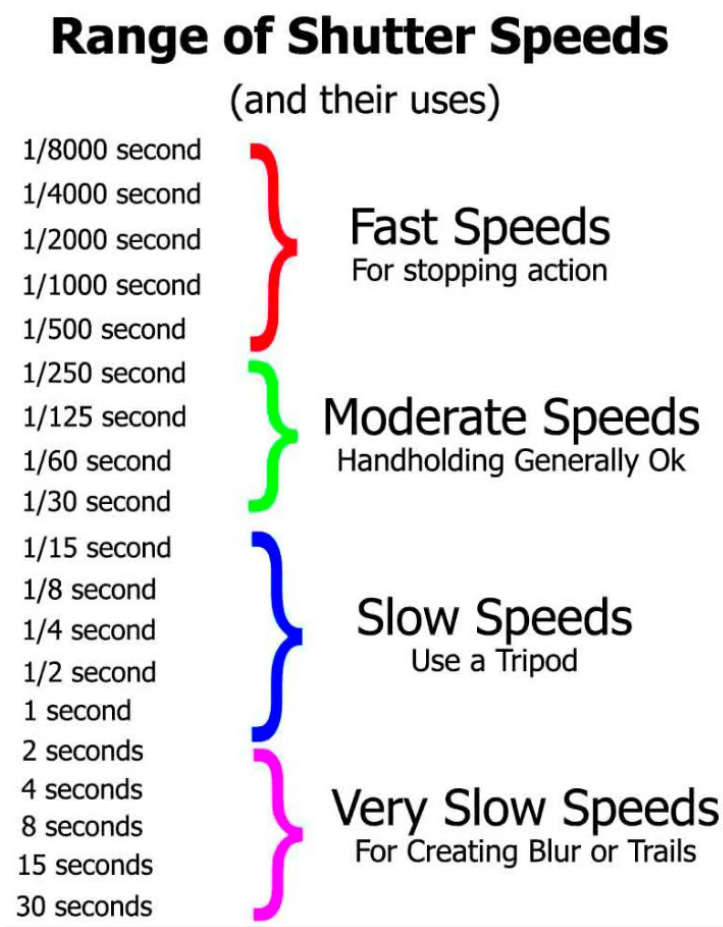
Both lenses are focused at the hyperfocal distance for f8.

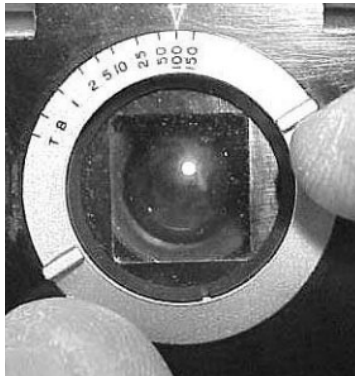
<u>Hyperfocal distance</u>:
The nearest focus distance for which infinity is in focus
(Everything from 1/2 x hyperfocal distance to infinity is in focus)

3D Photography favors manual focus & hyperfocal focusing

Shutter Speed

- **Measurement of how fast the shutter moves**
- **Expressed as exposure time, which is measured in seconds** (usually a fraction, often omitted: 1, 2, 4, 8, 15, 30, 60, 125, 250, 500, 1000, 2000, etc.)
- **Affects the amount of light and motion blur**
- **Two types of motion: 1) Subject, 2) Camera**
- **Longer exposure times (slow speeds) = more light + more motion blur**





Stereo Realist & Modern camera shutter dials. Many cameras today do not have a dial

B (Bulb): Shutter remains open as long as the shutter button is pressed

T (Time): Pressing the shutter button opens the shutter, pressing it again, closes the shutter

Minimum Handholding Speed

Rule of Thumb: **Safe (min) Handholding speed = 1/FL**

Examples: 50mm lens, Min HHS = 1/50 or 1/60s, 500mm → 1/500s

Image stabilization has changed this

IS is measured in additional stops of exposure. For example if the 50mm lens has 3 stops image stabilization, then it is safe to use: 1/60 → 1/30 → 1/15 → 1/8

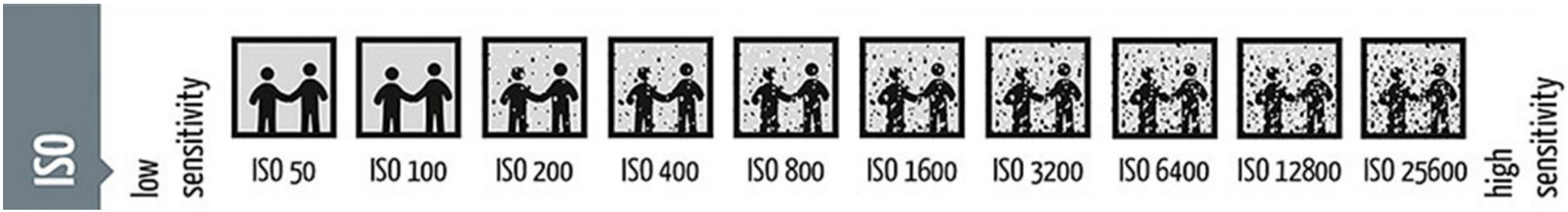
- ✗ Fuji W3
- ✓ Panasonic 3D1
- ✓ Most modern digital Cameras
- ✗ My Sony RX1

Be mindful of **Effective FL**

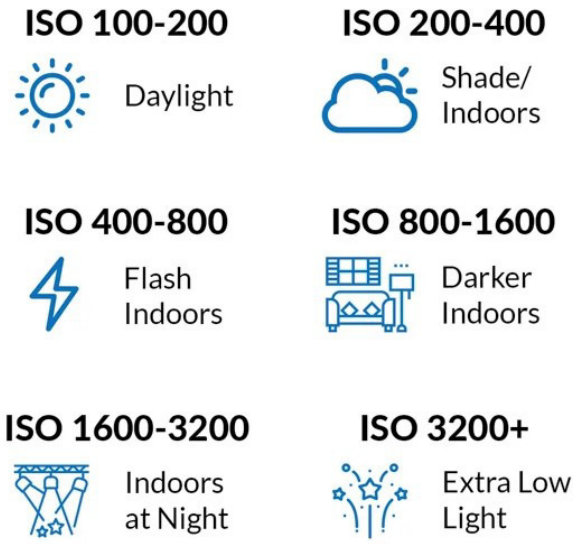
If you crop & enlarge an image, you can see the blur more, as if you were using a longer FL lens (**Effective FL**).

PS. My Sony RX1 has a 35mm focal length lens, but I routinely use 1/125 shutter speed when I use this camera, just for this reason.

Film/Sensor Sensitivity

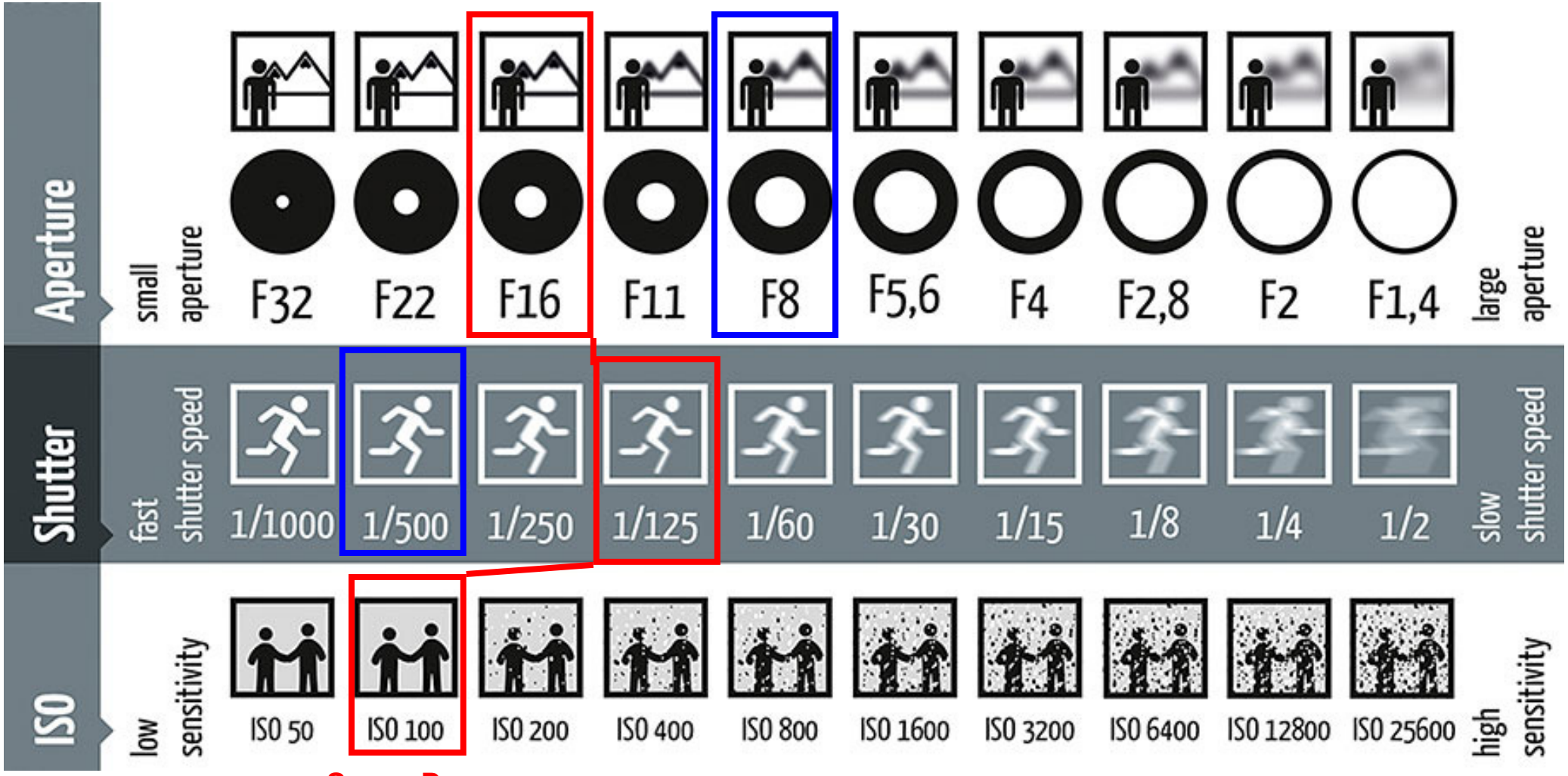


- **Measurement of the sensor's sensitivity to light**
- **Measured on a linear scale (ISO)**
- **Affects the exposure + noise/grain**
- **Low sensitivity = less exposure + low noise**
- **High sensitivity = more exposure + more noise**
- **For nice clean pictures you want low ISO (100)**



Balancing Exposure

https://www.picturecorrect.com/the-only-exposure-triangle-cheat-sheet-youll-ever-need/



Sunny Day

More light
(less exposure)

Less light
(more exposure)

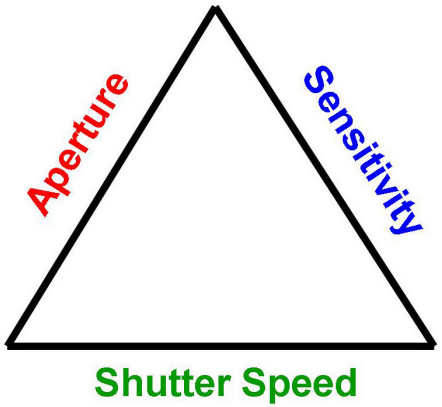
Which setting is more important for 3D?

All 3 settings are important:

Aperture: You need good DOF (especially true for 3D)

Shutter Speed: You need to freeze motion

Sensitivity: You want low noise (especially true for 3D)



Strategy for setting these:

1. **Use aperture small enough for the DOF you need**
2. **Use shutter speed high enough to freeze motion**
3. **Use lowest ISO that satisfies 1 & 2**

A lesson I learned in 1988 after my first rolls from the Stereo Realist. I was using, say **f11 & 1/50**. The pictures were not very sharp. I thought that this was caused by the aperture and that I did not have good DOF. So, I switched to **f16 @ 1/25**. The pictures got worse! I realized that the problem was not the aperture but the shutter speed. It was not high enough so I was getting camera shake. I switched to **f8 @ 1/100**. Problem solved. Moral of the story: Shutter speed is more important than aperture. You have plenty of DOF at f8 or f5.6, while you are risking camera shake at 1/50 or 1/25

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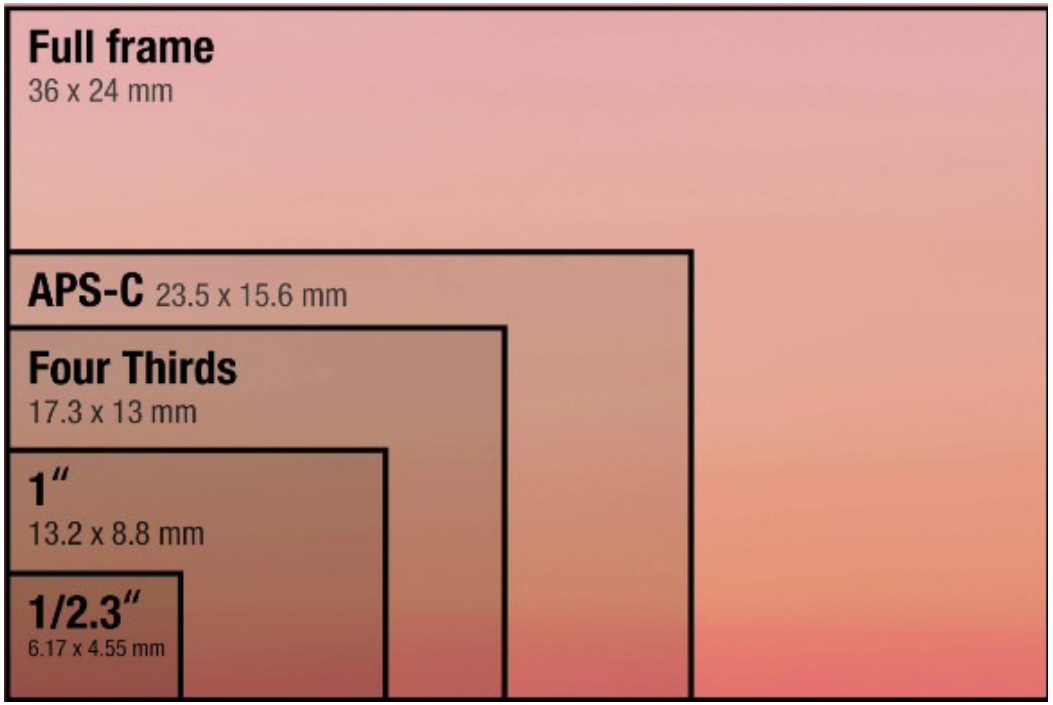
I tend to Favor faster shutter speeds over smaller apertures

Effect of Sensor Size



Source: www.bhphotovideo.com

Fuji W3 Lumix 3D1 Qoocam EGO Phones | **Sony RX0 RX10, RX100** | **Panasonic & Olympus M4/3** | **Sony A6000** | **Sony RX1**

Sensor Size affects choice of:

- **Aperture** (indirectly via DOF)
- ~~**Shutter Speed**~~
- **Sensitivity** (indirectly via enlargement)

A **small sensor** normally uses a lens with a **short focal length**

Example: The focal length of the Fuji W3 is 6.5mm at the wide end

A **short FL lens** has **large DOF** for the same aperture

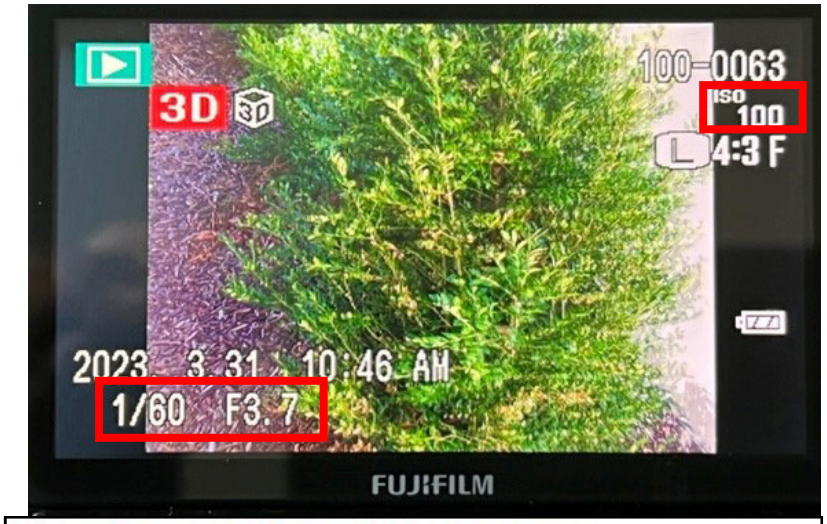
Cannot see out of focus under normal conditions. Phones use tricks to blur the background.

The importance of Aperture is minimized in today's compact digital cameras

Check Settings

In today's modern digital cameras, **exposure is rarely a problem**

- But the other effects of our three exposure variables (**DOF, motion blur, noise**) can be a problem
- You can check the settings that the camera is using
- Either **in camera**
- Or later check **image properties** (in windows Explorer, right click at picture, select "Properties", then "Details", scroll down)



WATER-ACROBATICS.jpg Properties

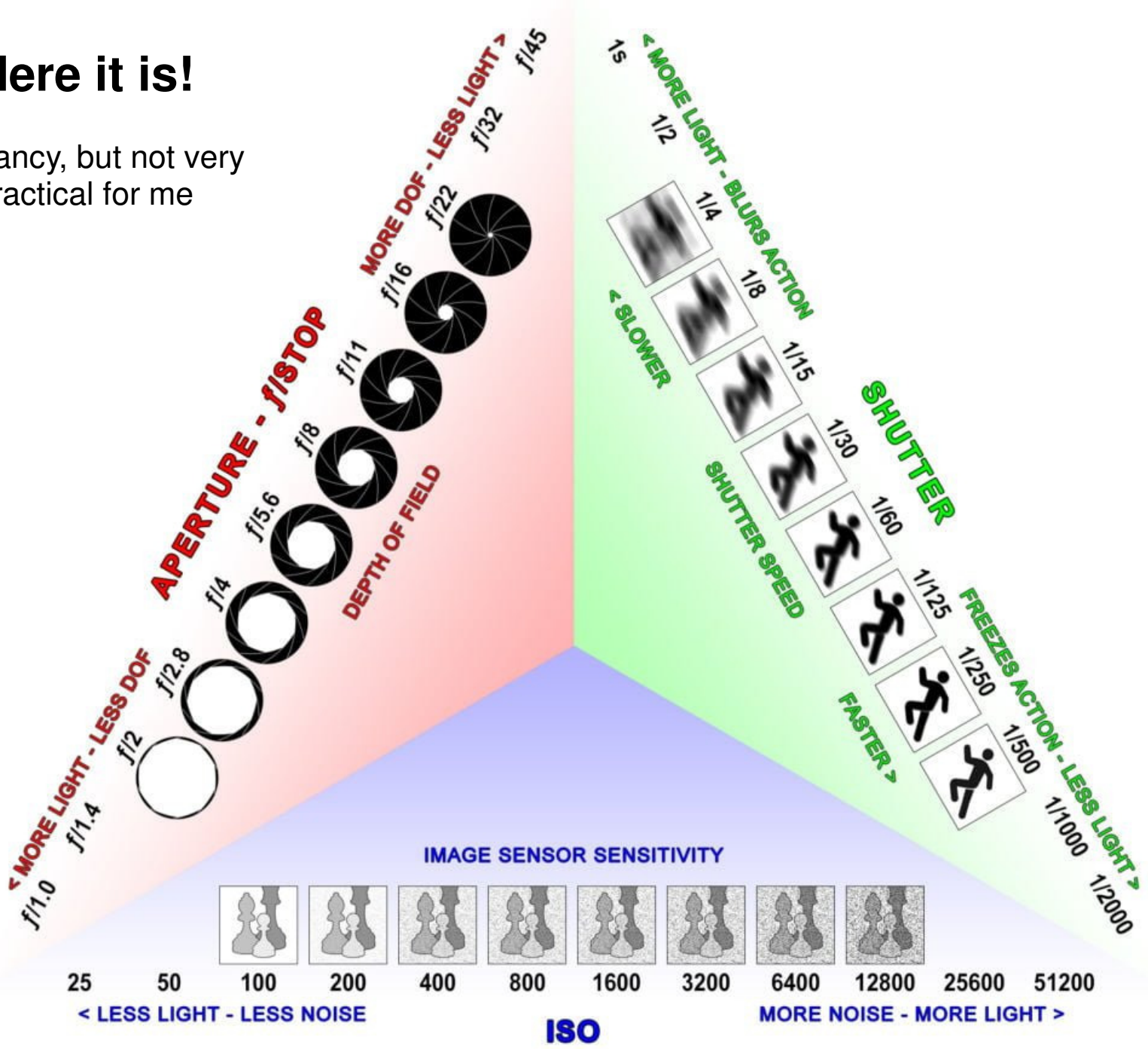
General | Details | Previous Versions

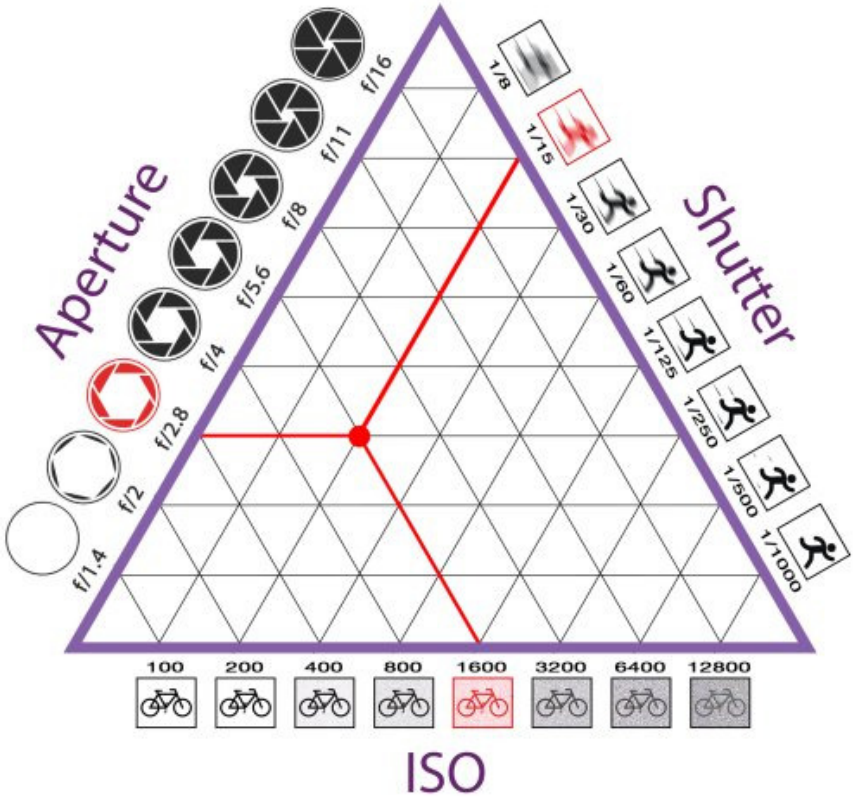
Property	Value
Camera maker	SONY
Camera model	DSC-RX10M4
F-stop	f/7.1
Exposure time	1/500 sec.
ISO speed	ISO-100
Exposure bias	-0.3 step
Focal length	73 mm
Max aperture	4
Metering mode	Center Weighted Average
Subject distance	
Flash mode	No flash, compulsory
Flash energy	
35mm focal length	200

What happened to the Triangle?

Here it is!

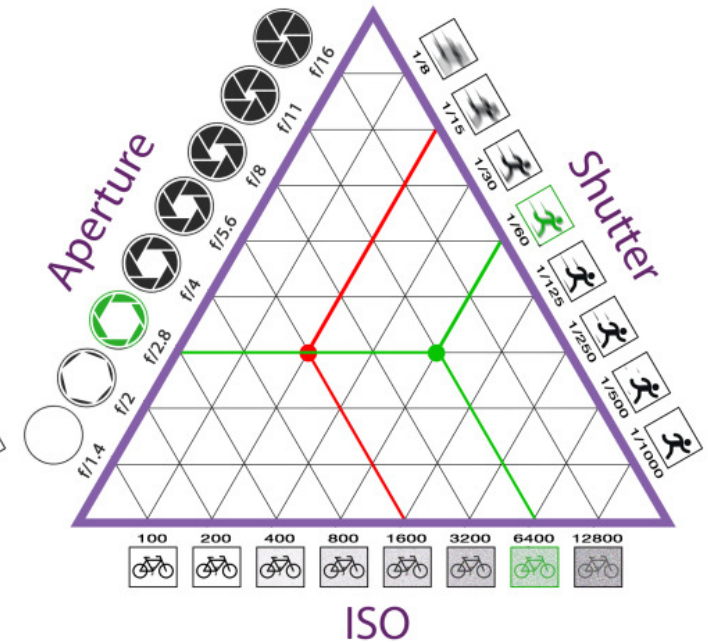
Fancy, but not very practical for me



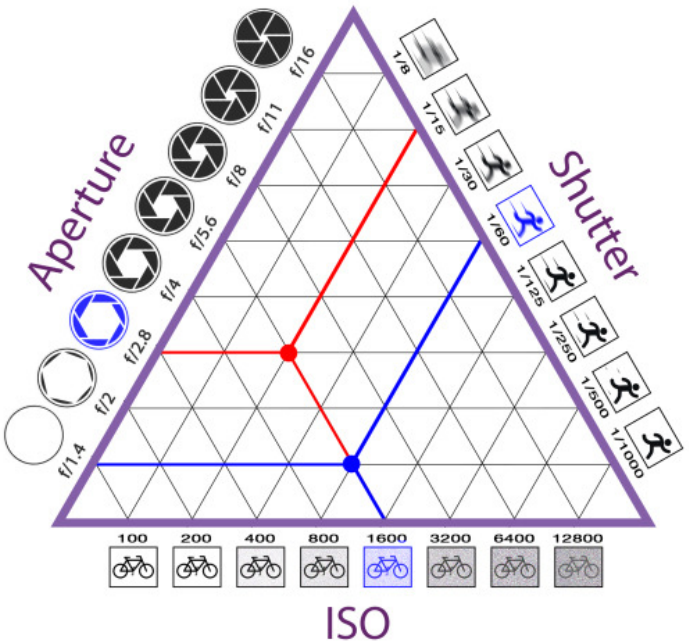


Every point in this triangle is one exposure

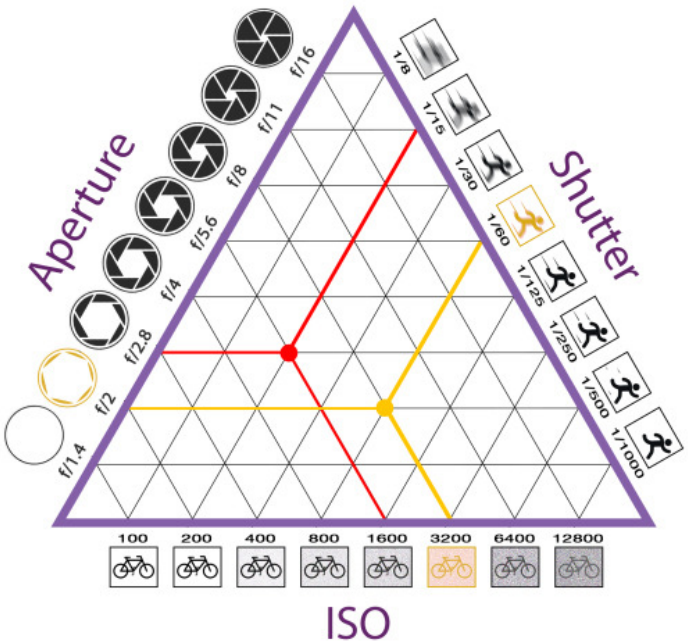
(and it's pretty slow - f2.8 1/15, ISO 1600, that's 12 steps less than sunny day)



Keeping f2.8 constant increase shutter speed and ISO



Keeping ISO constant increase shutter speed and open aperture



All three variables have changed, exposure remains the same

History of Exposure Automation

Film Cameras

- In film cameras **ISO was fixed** by the film used

- This left two variables: **Aperture** & **Shutter Speed**
- Without any automation, the photographer had to decide what aperture & shutter speed to use
- **Sunny Day Rule**: f16 @ 1/ISO (1/100)
- Exposure Tables

Exposure table for ASA (ISO) 100 film

Shutter	*f-stop*	*Rating*	*Light Conditions*
1/100	f22	+1	Extremely bright w/sand or snow
1/100	**f16**	**0**	**Sunny** and bright, distinct shadows
1/100	f11	-1	Weak sun, soft shadows, side light
1/100	f8	-2	Cloudy bright, no shadows
1/50	f8	-3	Heavy overcast, bright shade
1/50	f5.6	-4	Dark shade
1/25	f3.5	-7	Bright interiors; Max exp. handheld

- Hand-held exposure meters
- Built-in exposure meters (not coupled)

- Coupled exposure meters → Automatic exposure:
  - **Aperture Priority**: User sets Aperture, camera sets shutter speed
  - **Shutter Priority**: User sets shutter speed, camera sets aperture
  - **Manual Mode**: User sets both, guided by cameras exposure indication
  - **Automatic (Program) Mode**: Camera sets both aperture + shutter speed, following a certain program

Another important camera automation: **Auto Focus**

Digital

- Digital cameras: **retain Aperture & Shutter Speed.** Instead of Film we now have a sensor **but use the same scale (ISO)**
- Big difference **ISO can vary from picture to picture**, so now we have **three variables** to control from picture to picture. We also have a lot of Automatic Control.

MODE Dial

Source: Wikepedia

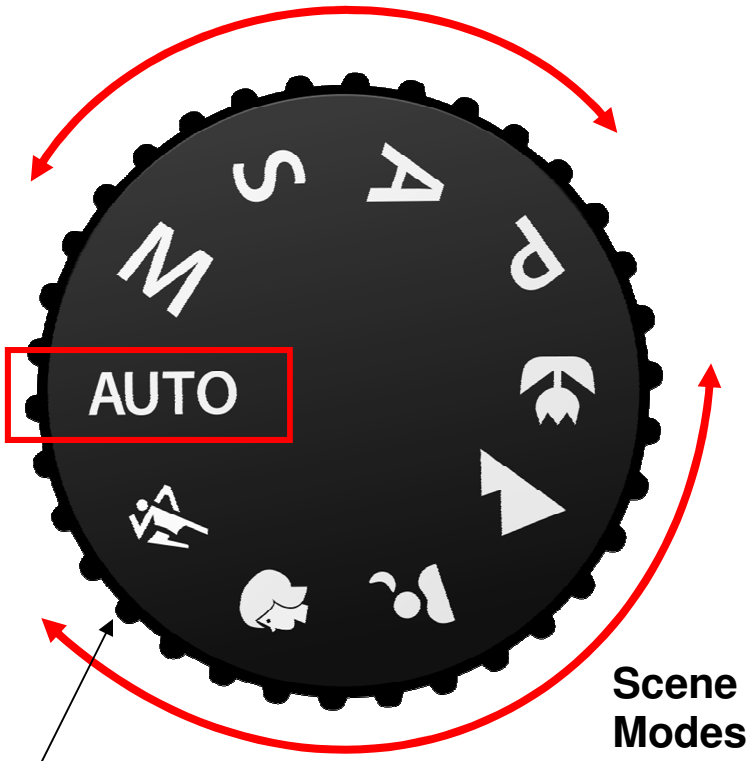
The **Shutter Dial** of Film Cameras

evolved into

the **Mode Dial** of Digital Cameras

MODE Dial Explained

Basic Modes (P, A, S, M)



Mode		User Controls
AUTO	**Automatic**	Nothing
P	**Program**	ISO, Exposure Compensation, White Balance
A	**Aperture Priority**	Aperture
S	**Shutter Priority**	Shutter
M	**Manual**	Aperture and Shutter
Scene Modes		Nothing but the scene

Scene modes are preset exposure modes that use the proper settings, depending on the type of scene to be photographed.

For example, in action/sports mode, the camera will favor faster shutter speeds, to freeze motion. An experienced photographer can use S (shutter priority).

In most cameras **ISO has its own control**, either Auto or fixed

If it is Auto, even in Manual mode the ISO can change to satisfy the exposure. Only if fixed the user has full control over the exposure.

More MODE Dials

Sony RX100

Scene choices appear in a menu at this setting

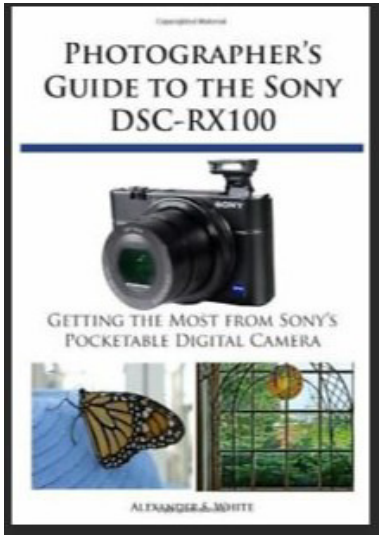
Sony RX1

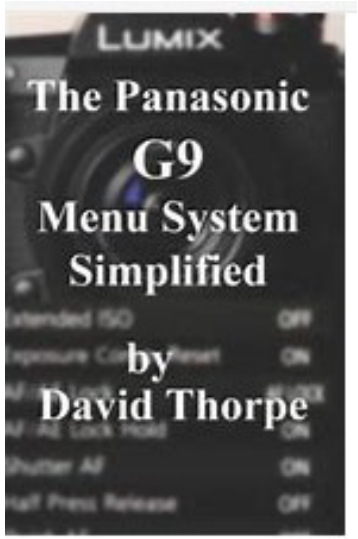
Recalls frequently used settings

Sony RX0

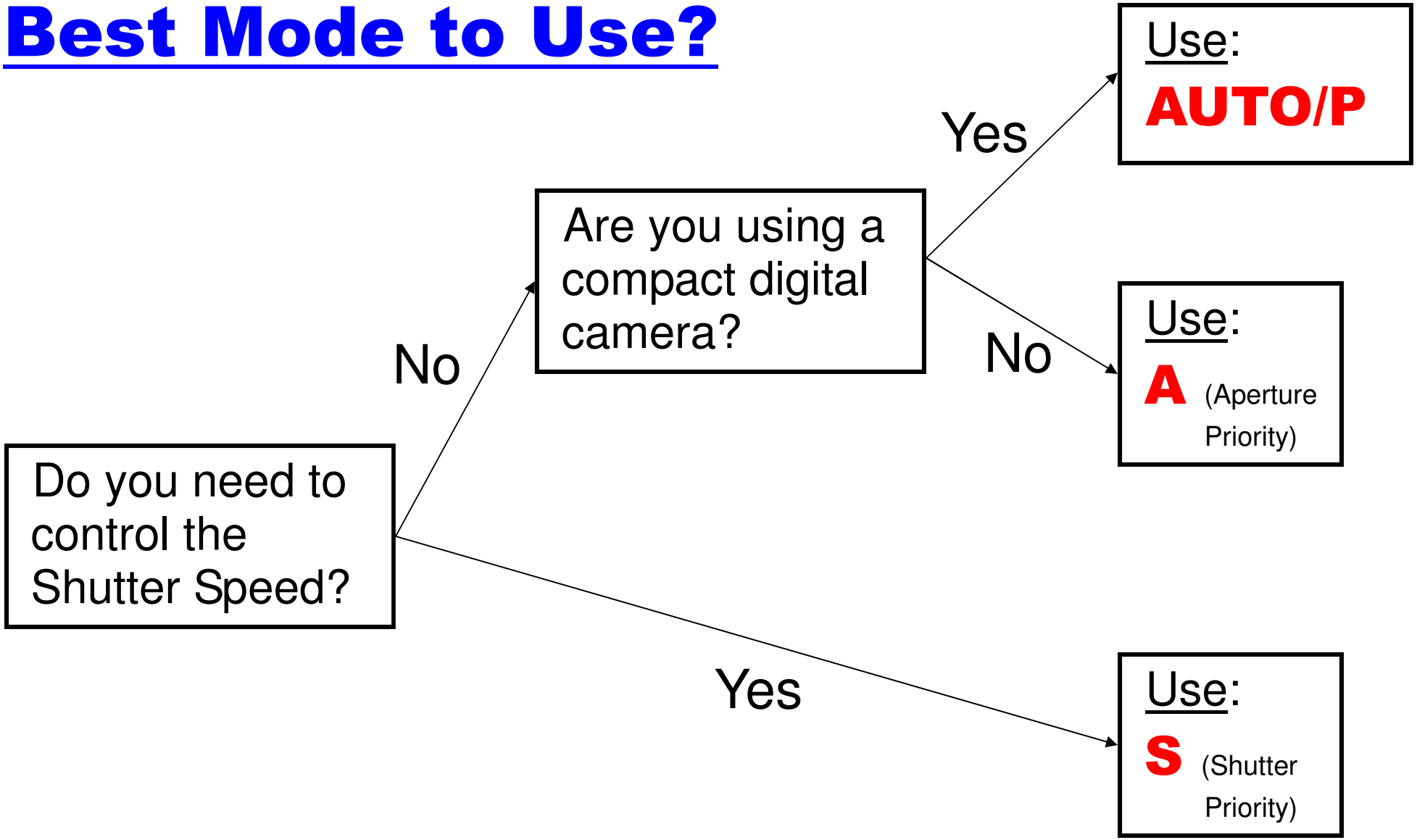
Very compact / Sports cameras **do not have a mode dial** (as a way to make the camera waterproof). You can change mode through menus.

Cameras / menus have gotten so **complicated** that people now need to read a book to figure out what these options do and how to use their cameras!





Best Mode to Use?



Fuji W3 Mode Dial - AUTO

AUTO mode logic:

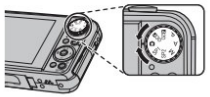
- **Moderate shutter** speed for hand-holding the camera
- **Favors lower ISO over f-stop.** It will use lens wide open to achieve a lower ISO. As the light decreases, it will raise the ISO. After the ISO reaches the max value, it will lower the shutter speed, while warning the user for potentially shaking camera.
- This is what I would have done too :)

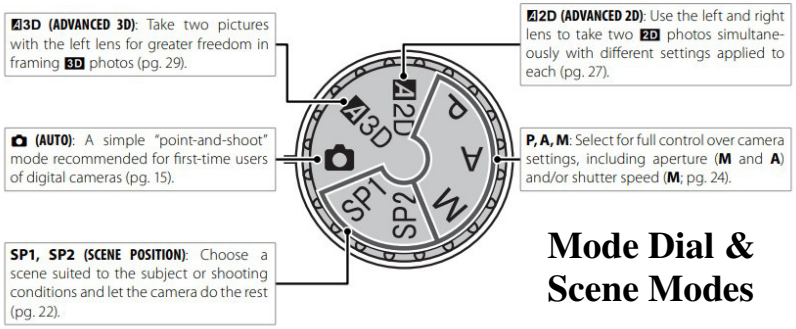
AUTO →

Interesting that there is A but no S mode!

The Mode Dial

To select a shooting mode, align the mode icon with the mark next to the mode dial.

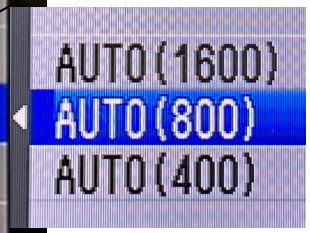




Mode Dial & Scene Modes

Shooting Menu in AUTO Mode

Control of Shutter Speed and Aperture is only available in Manual (M) Mode



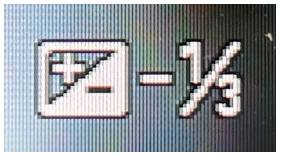
User can adjust the maximum AUTO ISU used

Scene	Description
ANTI-BLUR	Choose ANTI-BLUR (picture stabilization) mode for fast shutter speeds that reduce blur caused by camera shake or subject movement. Recommended for photographs of children and pets.
NATURAL &	Get good results with backlit subjects and other difficult lighting. The camera takes two shots: one without the flash and one with.
NATURAL LIGHT	Capture natural light indoors, under low light, or where the flash can not be used. The flash turns off and sensitivity is raised to reduce blur.
PORTRAIT	Choose for soft-toned portraits with natural skin tones.
LANDSCAPE	Choose for crisp, clear daylight shots of buildings and landscapes.
SPORT	Choose when photographing moving subjects. QUICK AF is automatically selected for POWER MANAGEMENT and priority is given to faster shutter speeds.
NIGHT	Choose this mode for poorly lit twilight or night scenes. Sensitivity is automatically raised to reduce blur caused by camera shake.
NIGHT (TRIPOD)	Choose this mode for slow shutter speeds when shooting at night. Use a tripod to prevent blur.
SUNSET	Record the vivid colors in sunrises and sunsets.
SNOW	Choose for crisp, clear shots that capture the brightness of scenes dominated by shining white snow.
BEACH	Choose for crisp, clear shots that capture the brightness of sunlit beaches.
UNDERWATER	Choose for vivid blues when taking photographs of subjects in an aquarium.
PARTY	Capture indoor background lighting under low-light conditions.

Use P instead of AUTO

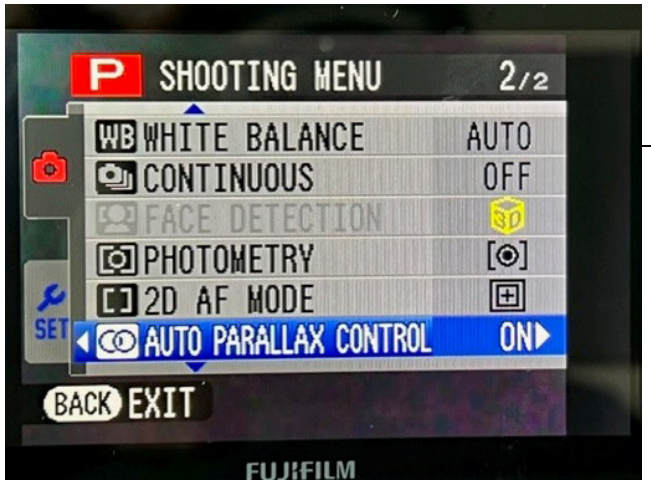
I use AUTO occasionally (when exposure or light is tricky, like indoors) but often **prefer P** because it gives me extra control of:

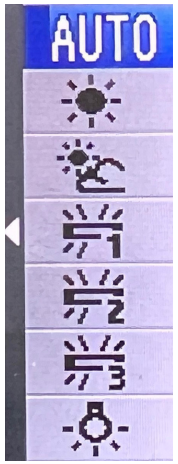
- **Exposure compensation**
- **ISO**
- **White Balance**



I routinely use –1/3 exposure compensation because the camera tends to overexpose

In addition to setting the max ISO value (top 3 options) you can also fix the





Option	Description
AUTO	White balance adjusted automatically.
☀	For subjects in direct sunlight.
	For subjects in the shade.
	Use under "daylight" fluorescent lights.
	Use under "warm white" fluorescent lights.
	Use under "cool white" fluorescent lights.
	Use under incandescent lighting.
	For underwater subjects in an aquarium.

I use AUTO indoors

Daylight or Shade outdoors

Fuji W3 in Manual Mode

Manual Mode allows you to set all three variables:

- **Aperture**: **f3.7- f8**
- **Shutter Speed**: **1/2s - 1/500s**
- **ISO**: **100 - 1600** (**fixed**)

This has a few implications:

- The Fuji is **not a good choice** if you want to use **slow shutter speeds** (but see also note below)
- It is OK for higher shutter speeds but there **is no automatic exposure** because the ISO is fixed. Perhaps the Sports/Action Scene mode works well (I have not tried it)

From the instruction Manual

This seem to say that scene modes give wider adjustments than Manual (for example, the exposure time for night/tripod goes to 3s)

Shutter speed • : 1/8 S–1/500 S • : 3 S–1/500 S • **M**: 1/2 S–1/1,000 S • **Other modes**: 1/4 S–1/1,000 S

Shutter Speed Control

For certain pictures you might need faster or slower shutter speeds. In this case, consider:

- **S (Shutter Priority)**
- **M (Manual Mode)**
- Might also need to **fix the ISO**

https://www.phototraces.com/photography-tips/shutter-speed-chart/

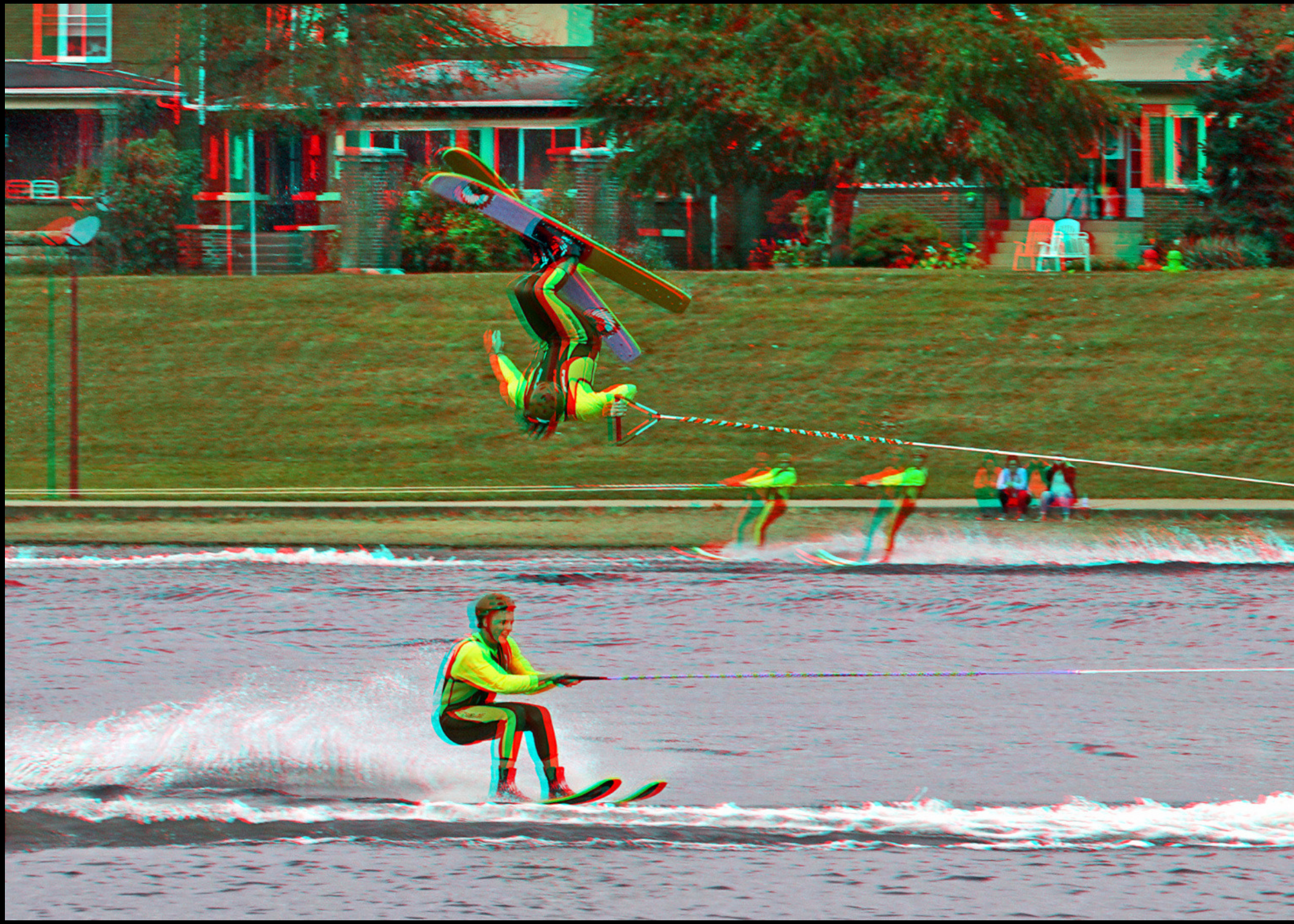
A note about Landscape Photography:

I always wondered why landscape photographers use a tripod even though there is enough available light to hand-hold the camera. Answer:

- They use large sensor cameras
- Fix ISO to lowest value (100)
- Close the aperture for better DOF
- Use a tripod to completely eliminate the possibility of shaking the camera

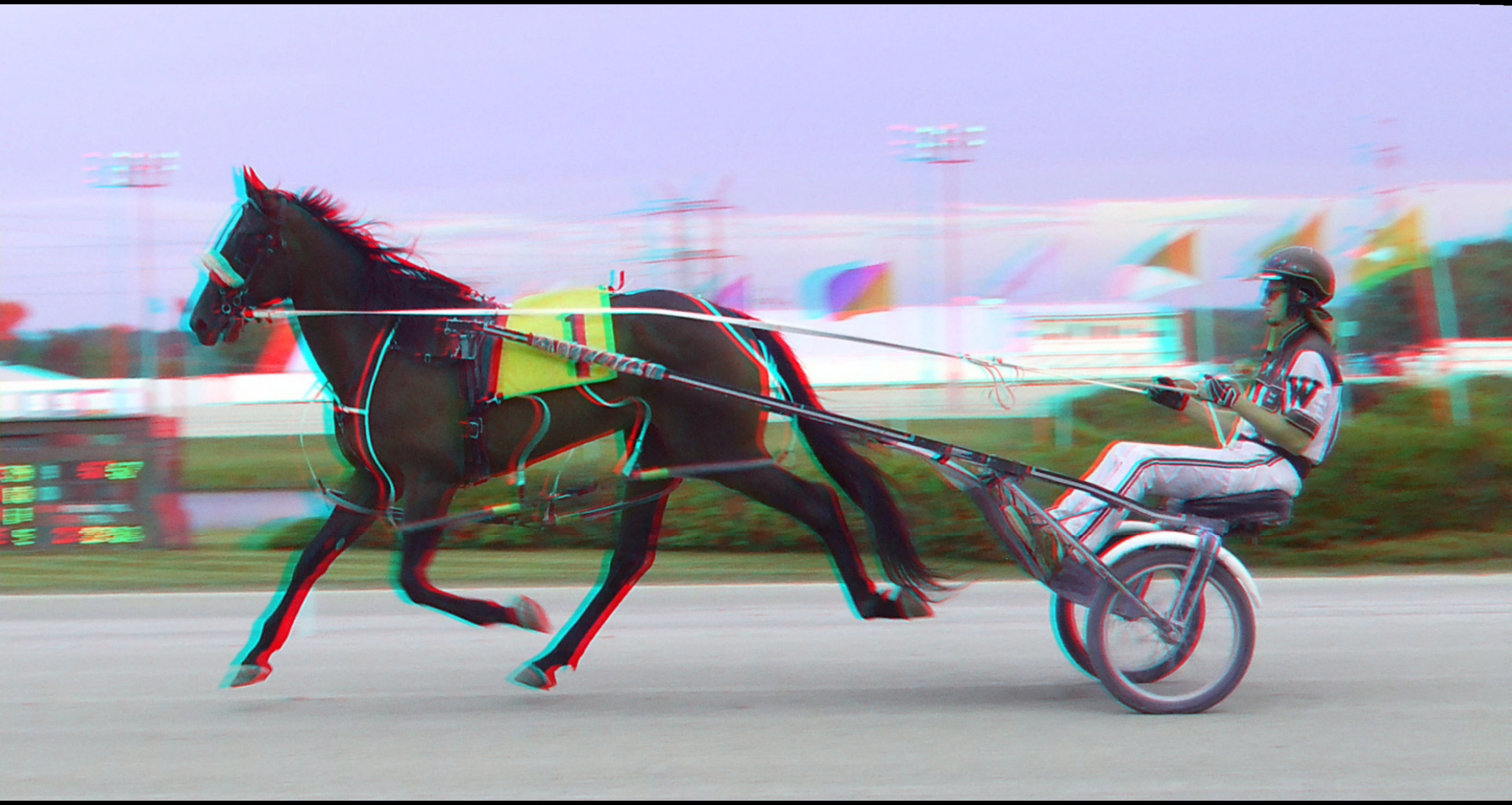
“Vinny Jumping” Sony RX100 [50mm, f4, 1/1000, ISO 1600]

“Water Acrobatics” Sony RX10 [200mm, f7.1, 1/500, ISO 100]

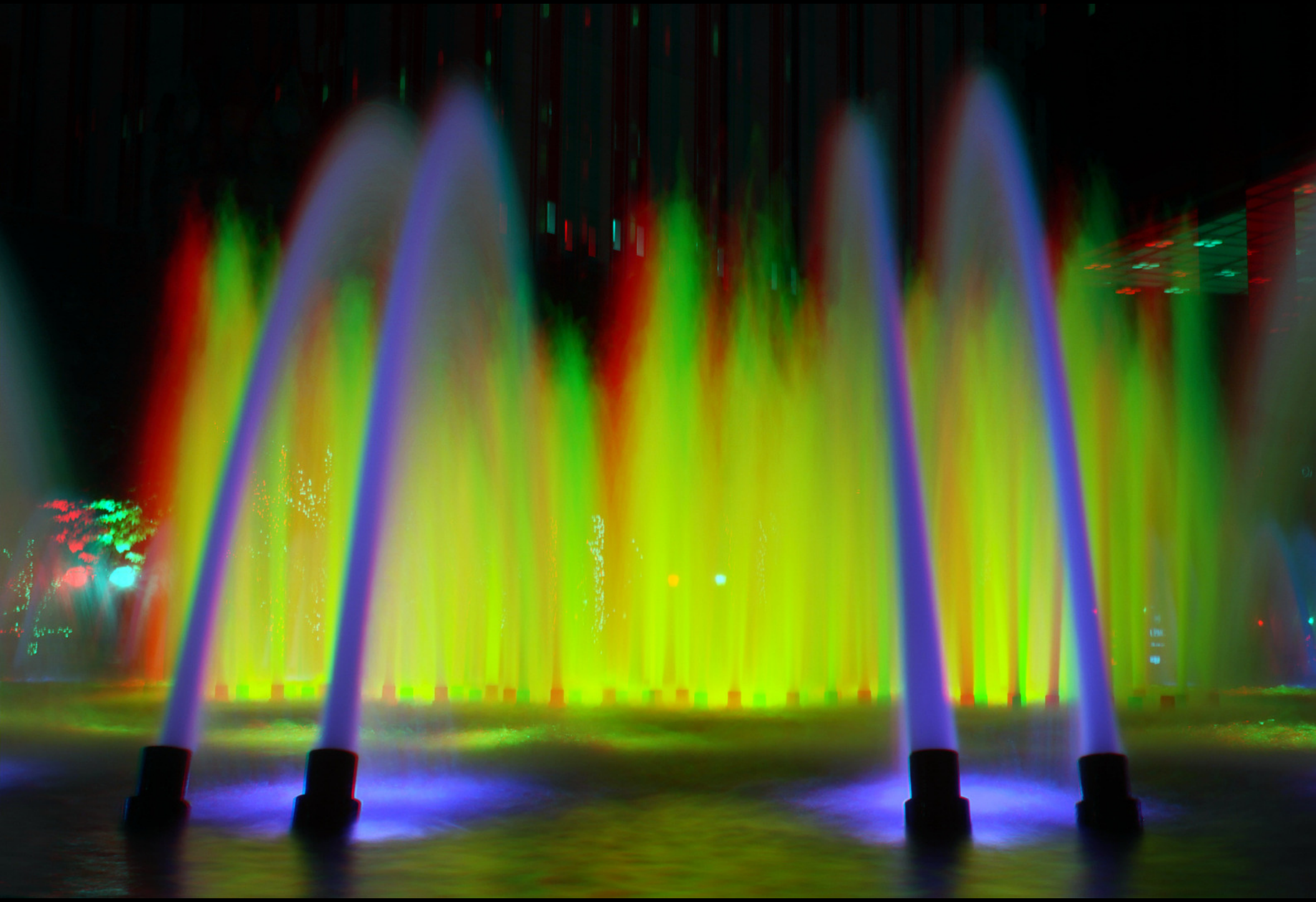


“Bee on Flower” Panasonic GX7 & 3D Lens [60mm, f12, 1/640 + FLASH, ISO 125]

“At The Races” Fuji W3 [135mm, f4.2, 1/25, ISO 100]



“Water Fountain at Night” Samsung NX1000 rig [30mm, f16, 3s, ISO 100]



“Fireworks” Twin rig [~50mm, f11-16, ~5s, ISO 100]

Flowing Water

This exposure is impossible to achieve under bright light

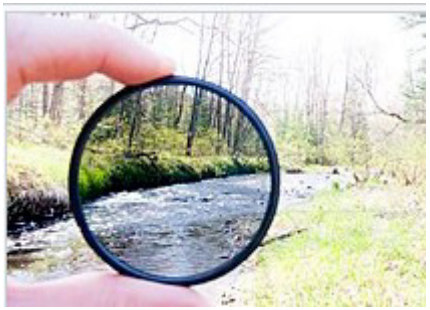
Example: Sunny Day Exposure

f22 min @ **1/60** (**100 ISO** min)

To use a slow shutter speed (say 1/2s) we need 5 stops less light (60, 30, 15, 8, 4, 2)

The camera cannot give this exposure. This is only possible using **Neutral Density Filters**. These reduce the exposure without affecting anything else.

https://digital-photography-

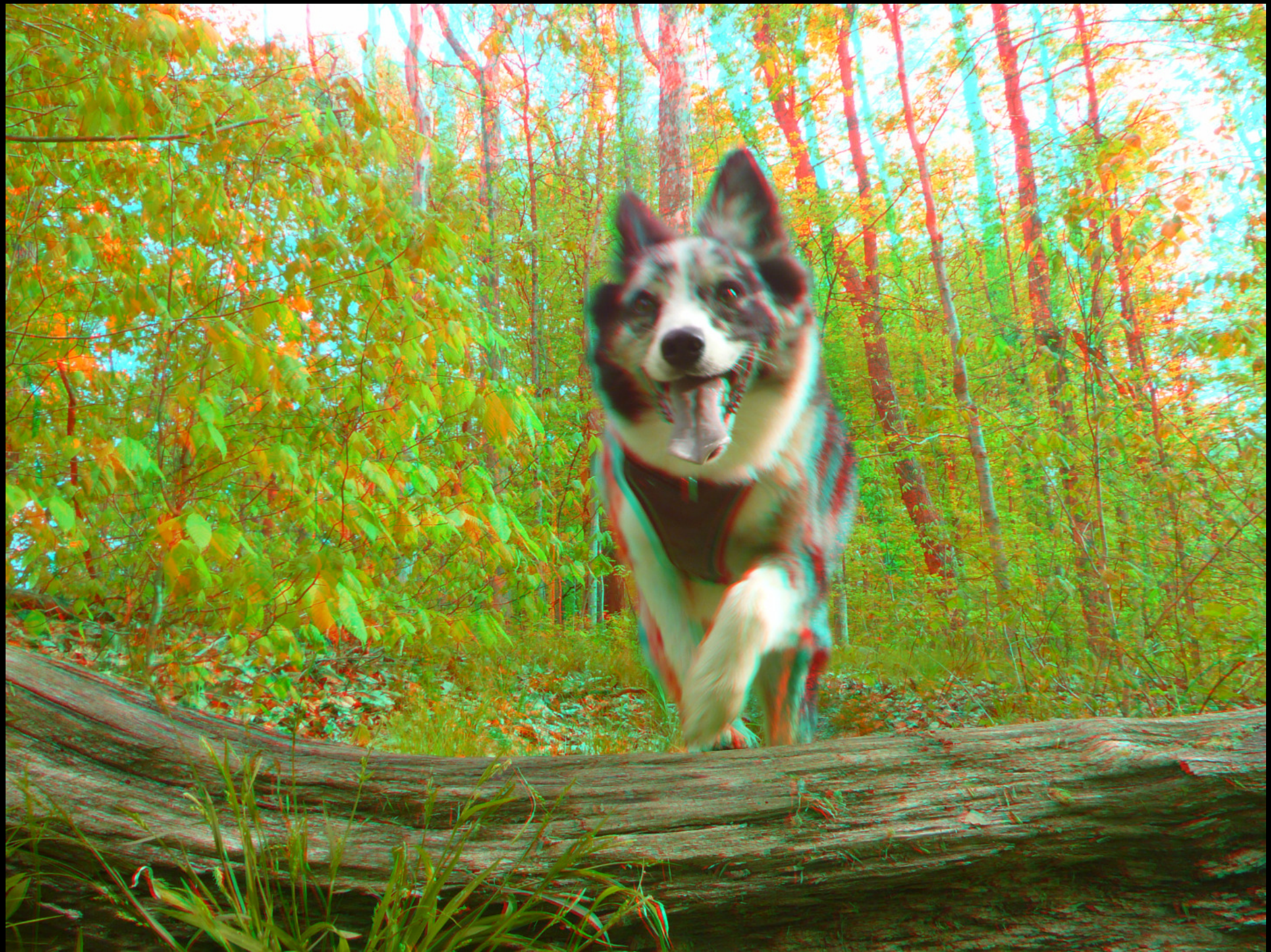


Can I use my camera in AUTO only?

Panasonic 3D1: Can only be used in AUTO mode when in 3D
The camera works well for most pictures, except for three situations:

- **No shutter speed control**: In low light pictures can come out blurred. I wish there was an option to control shutter speed.
- **No White Balance options**: When photographing a scene with warm colors (Fall, sunset, etc.) the auto white balance creates unpleasant pictures
- **No Possibility of External Flash (slaved)**: This requires manual mode to set the correct aperture & shutter speed (and ISO)

“Vinny in Action” [30mm, f3.9, 1/100, ISO 100]

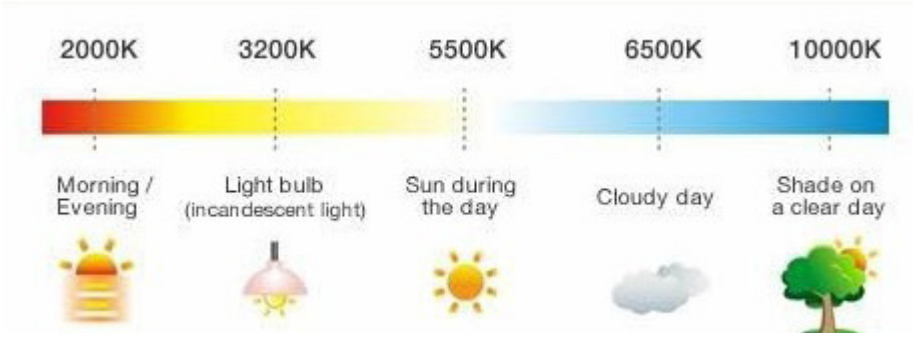


AUTO White Balance - Or Not?

AUTO White Balance

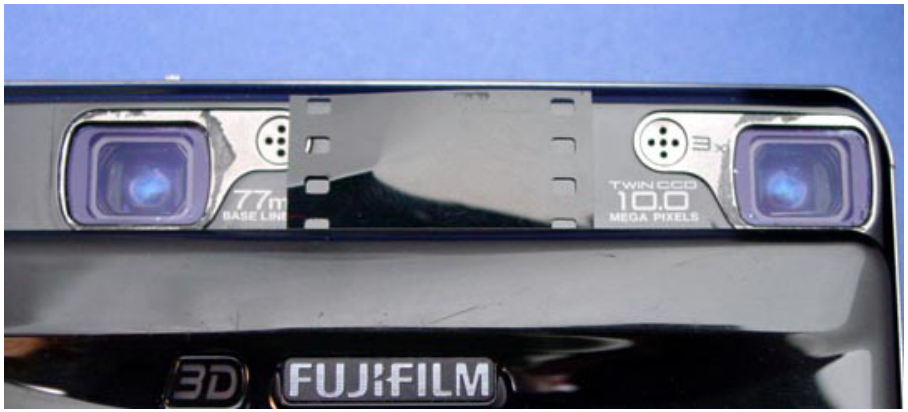
CLOUDY White Balance

- **AUTO White Balance fails** when the picture has a **natural warmth**
- The color balance can be changed in post-processing but…
- I personally **prefer warmer pictures**, so I tend to set the White Balance to "**cloudy**" instead of "Auto"



- I use **AUTO Balance indoors** or in trick light color situations
- **Outdoors** you can use "**Daylight**" or "**Cloudy**" (slight warmth) or "**Shade**" (more warmth)

FUJI w/External Flash



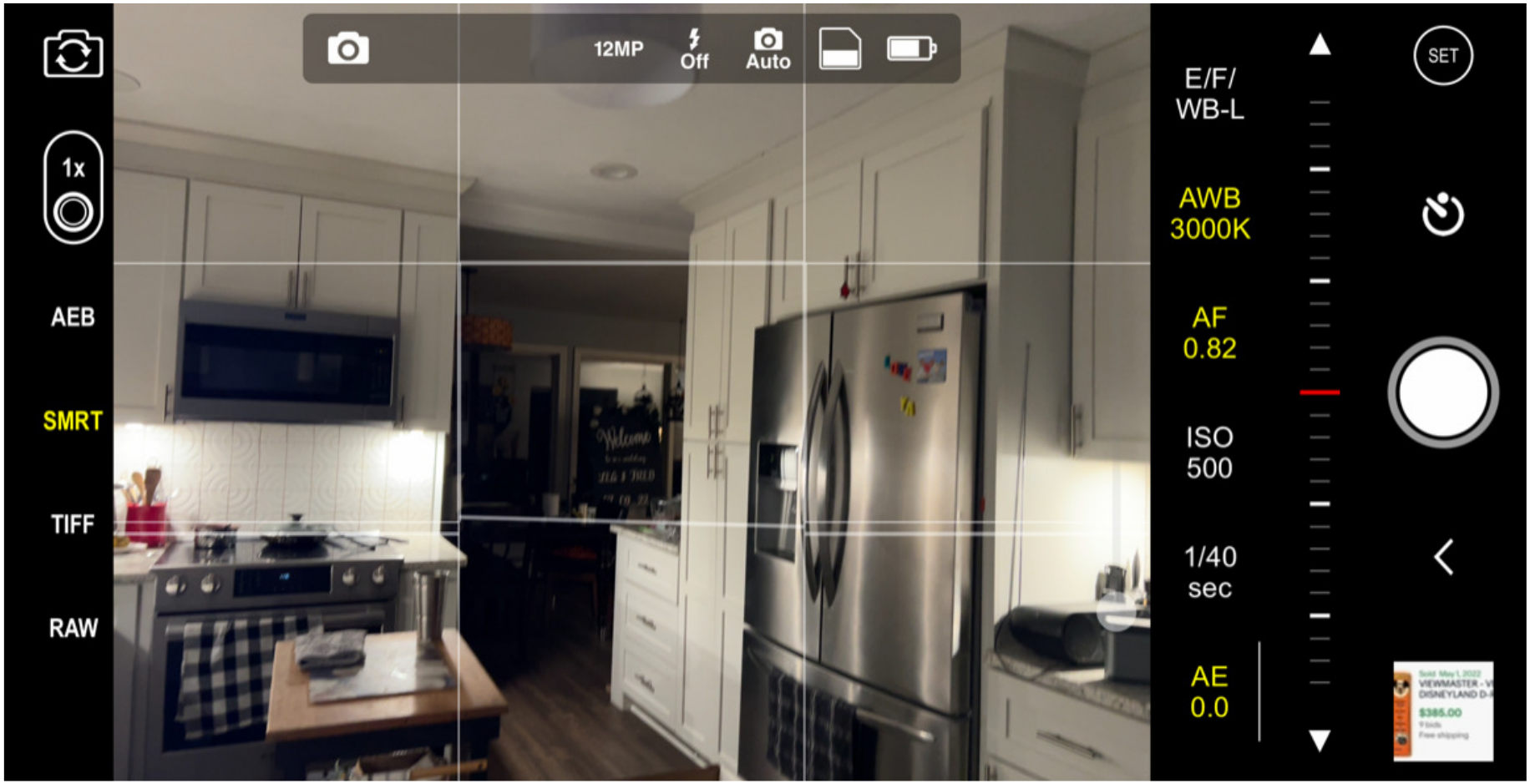
- It is possible to use the Fuji with external flash. The first step is to **block Fuji's Flash** to stop light from the flash affecting the exposure, but still pass IR, which will **trigger a slave flash**

- You need **manual control (aperture & ISO mainly** the shutter speed affects the ambient light only**)** to get the correct exposure → NOT possible with the Lumix 3D1 :(

Camera Phones

- Most people use them in fully automatic mode and would never even think of doing anything differently

- There are apps that allow you to take control of the camera's settings



Full Frame Camera in AUTO/P

When I first started using my twin Sony RX1 (full frame sensor) in P, **the camera was using the widest aperture** (f2.0) and the backgrounds were **out of focus**.

Here is how I use the camera for ordinary 3D shooting:

- **Aperture Priority f8** (for good DOF)
- **Minimum Shutter Speed: 1/125** (makes sure there is no motion blur). I adjust this as needed, for example raise it if I photograph action.
- **Variable ISO** (adjusts to achieve correct exposure)

The camera will use f8 @ 1/125 and adjust the ISO. If there is a lot of light and the ISO reaches the lowest value (100), it will increase the shutter speed

- For Vertical orientation I set the **aspect ratio** to **1:1**
- I set the **White Balance to "Cloudy"**
- I have saved all these settings at **Memory #1**
- I switch to other modes as needed, especially **S**
- I occasionally use **AUTO**

Summary

- **Exposure Triangle:** Three variables (Aperture, Shutter Speed, Sensor Sensitivity that affect exposure, but also **DOF, motion blur, noise**

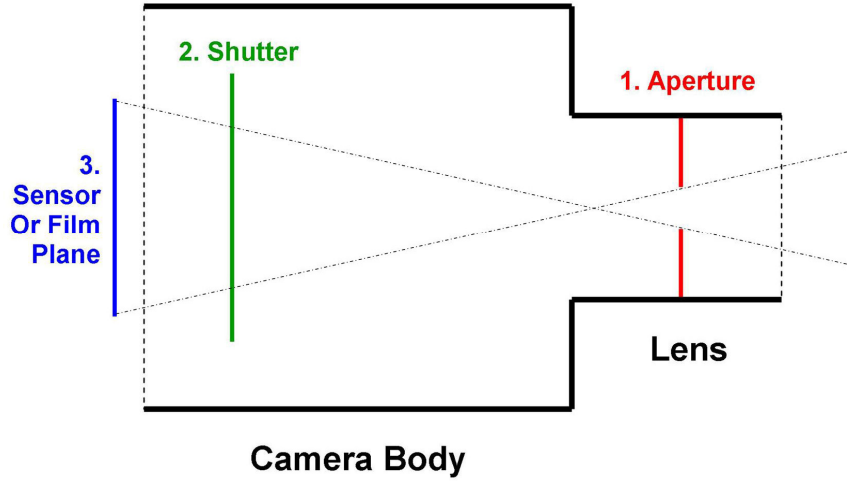
- **Exposure Challenge**: Find the best values for these three variables to get a good exposure. (Exposure is not an issue in today's automated digital cameras & post processing, but the effects of these variables are important)

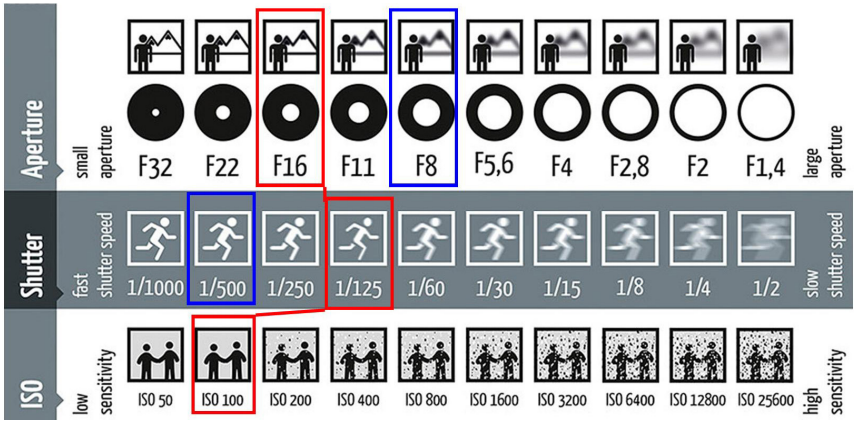
- In 3D all variables are important but in **compact digital cameras** (small sensor), **aperture (DOF) is not an issue**.

- Digital cameras have a **MODE dial** with different choices. What is the best mode to use?

- If shutter control is not important the **AUTO/P** mode works well for **compact cameras**. In **full frame cameras**, the Aperture continues to be important.

- Consider controlling the **Shutter Speed** for many interesting effects/pictures





Best Mode to Use?