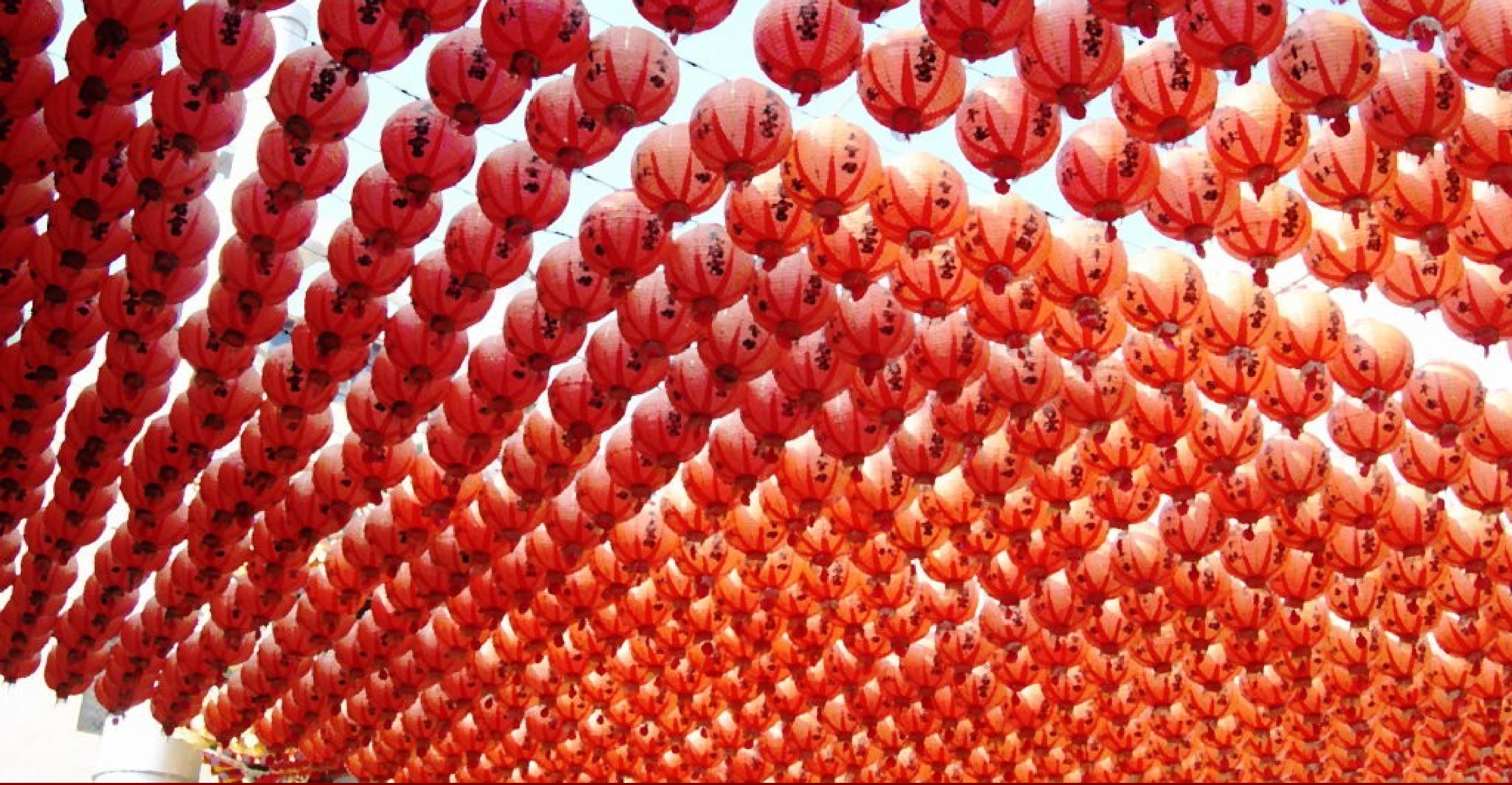

Passive Infrared Motion Sensing

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TriEmbed November 11, 2019

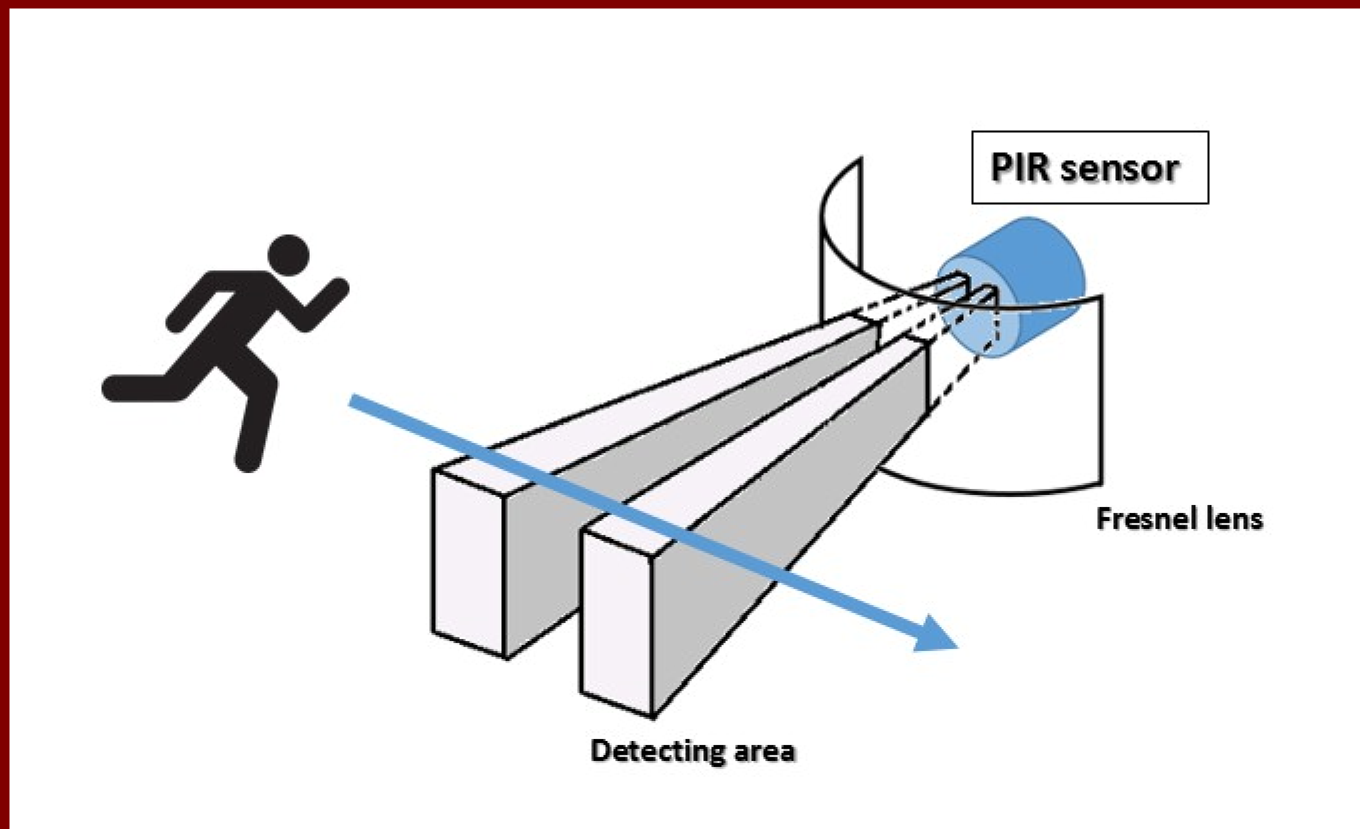
Pyroelectricity

- Pyro (heat), ferro (reversible polarity), and piezo(pressure) are all crystal property cousins
- Example: the mineral tourmaline
  - 2333 years ago, give or take, Theophrastus mentioned seeing sawdust and bits of straw sticking to this mineral when it was heated
  - Over 2000 years later, Johann Georg Schmidt noticed hot ashes but not cold ashes attracted
  - We get it now (see text in “extra” slide in archive)

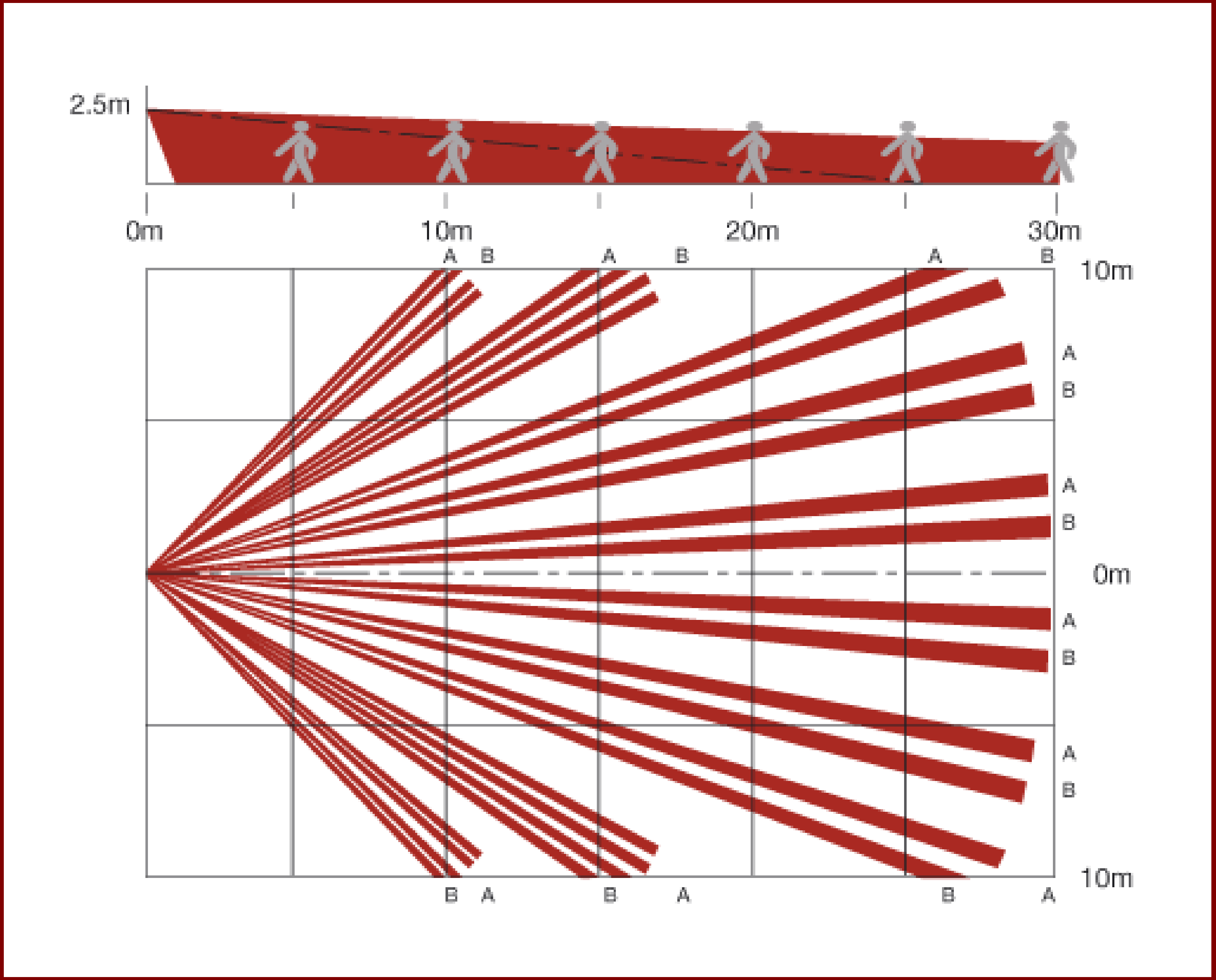
Modern PIR: differential heat

- Pairs of small elements of pyroelectric materials in the path of infrared light
- Differential current detected between pairs
- IR arranged to hit elements equally: background temp is common mode
- A differential signal means an object warmer/colder than its surroundings in view of the elements is in motion
- Orientation of element pairs and details of lens and/or mirror directing IR light determine performance

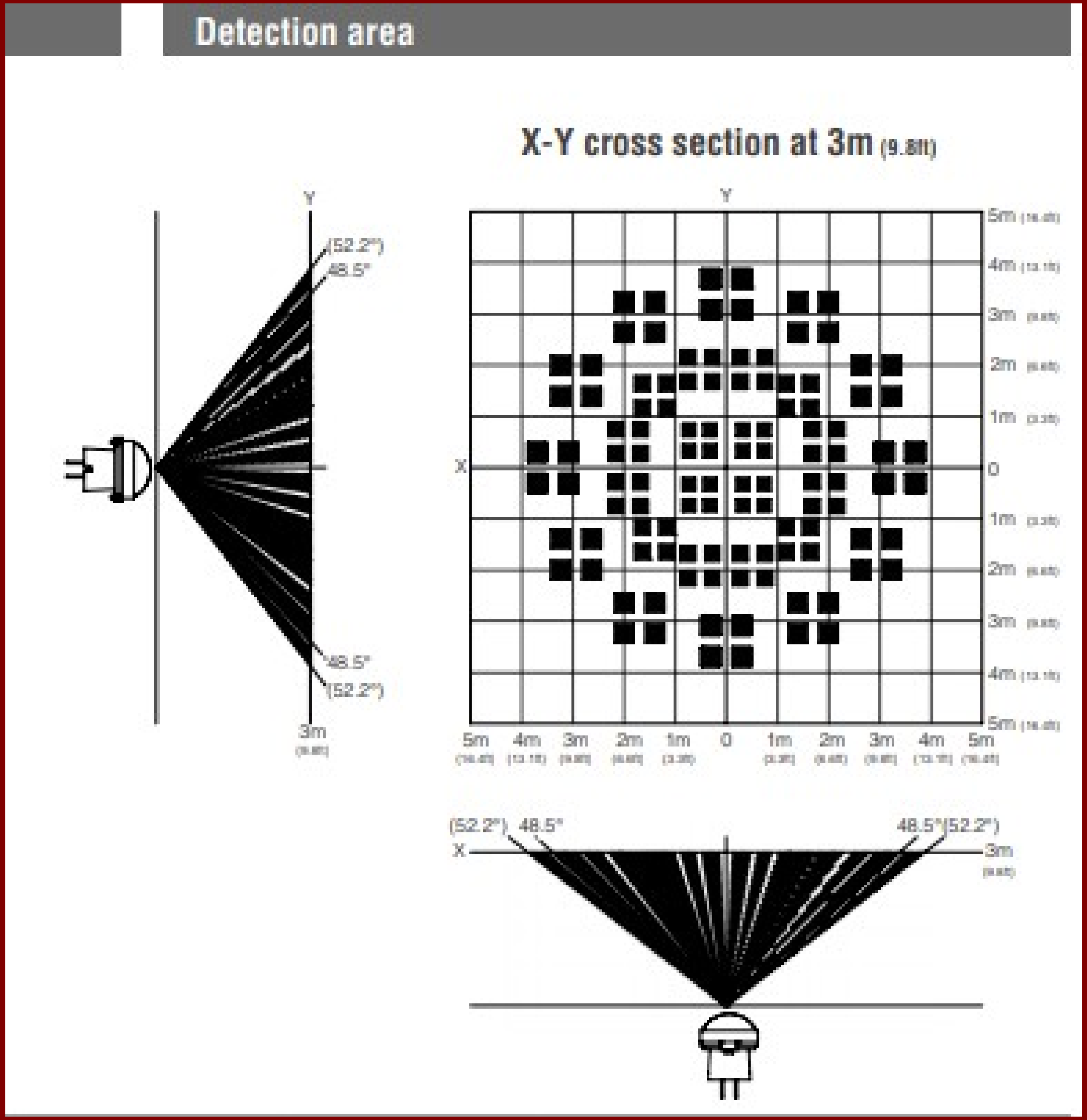
Side by side elements: mostly horizontal sensitivity



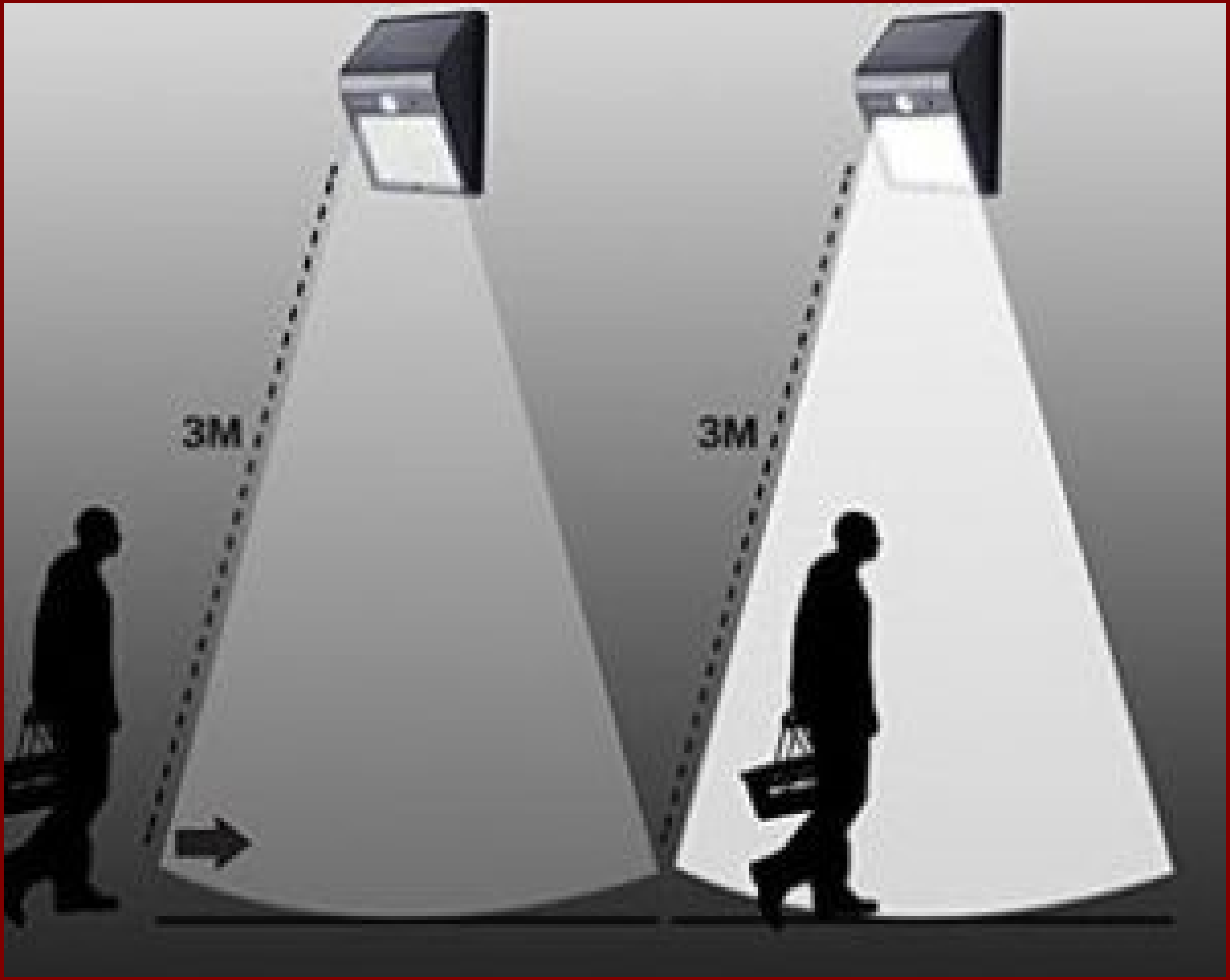
Forward/backward motion tricky



Two pairs of elements: two planes of motion detection



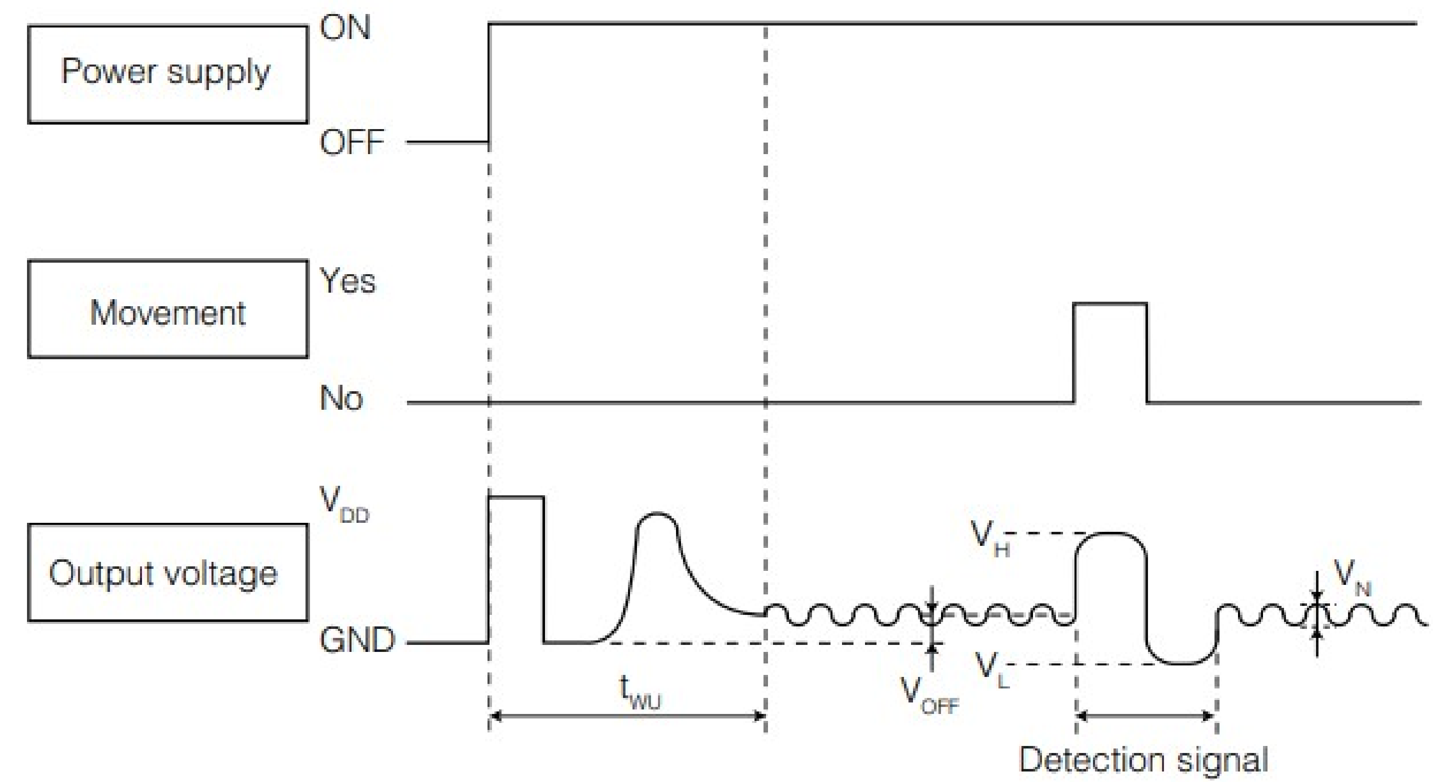
Arbitrary horizontal motion detection requires down-looking



PIR Interface Flavor: Digital

- After motion for a “mask time” period, the sensor output changes state
- When motion stops, after some “hold time”, the state changes back
- Both mask and hold times are adjustable with minimums that can sometimes be eliminated, but the nature of the sensor makes it slow to respond (a third of a second).
- Many systems are hybrid, with sensitivity setting between analog front end and digital output

PIR Interface Flavors: Analog (no mask/hold times)



Explanation of the timing

t_{WU} Circuit stability time: max. 30 seconds

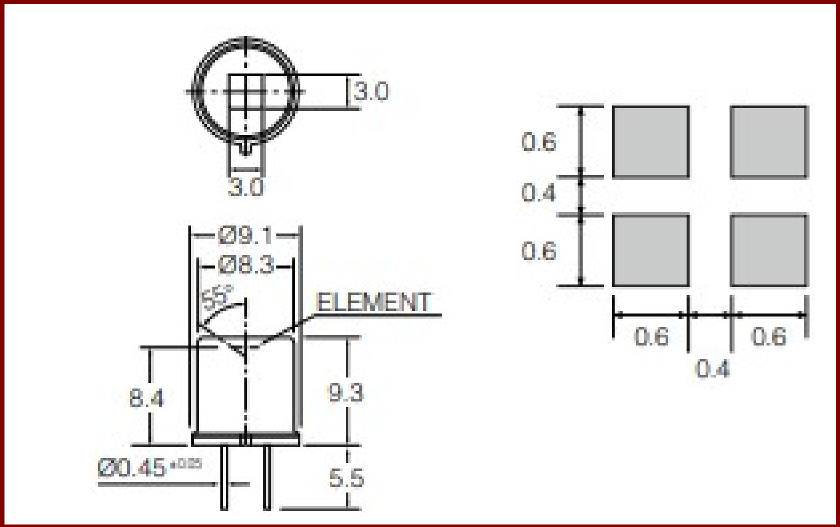
While the circuitry is stabilizing after the power is turned on, the sensor output is not fixed. This is true regardless of whether or not the sensor has detected anything.

Easy choices

- If you can tolerate mask and hold times: ubiquitous boards like Adafruit https://www.adafruit.com/product/189
- Easier to use, all in one small package: Panasonic PaPIR series digital and analog sensors
  - Only sensor, no drive capability
  - Good noise immunity, excellent signal conditioning
  - Bare TO5 can and with lens

Roll Your Own

- Panasonic PaPIR series data here: https://tinyurl.com/yhm74hb7
- Custom lenses: https://3dlens.com



Questions?

Slides here:

http://triembed.org/blog/meetings/triembed-presentation-archive/

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Extra Slide: from https://en.wikipedia.org/wiki/Pyroelectricity#Crystal_classes

All crystal structures belong to one of thirty-two crystal classes based on the number of rotational axes and reflection planes they possess that leave the crystal structure unchanged (point groups). Of the thirty-two crystal classes, twenty-one are non-centrosymmetric (not having a centre of symmetry). Of these twenty-one, twenty exhibit direct piezoelectricity, the remaining one being the cubic class 432. Ten of these twenty piezoelectric classes are polar, i.e., they possess a spontaneous polarization, having a dipole in their unit cell, and exhibit pyroelectricity. If this dipole can be reversed by the application of an electric field, the material is said to be ferroelectric. Any dielectric material develops a dielectric polarization (electrostatics) when an electric field is applied, but a substance which has such a natural charge separation even in the absence of a field is called a polar material. Whether or not a material is polar is determined solely by its crystal structure. Only 10 of the 32 point groups are polar. All polar crystals are pyroelectric, so the ten polar crystal classes are sometimes referred to as the pyroelectric classes.

Piezoelectric crystal classes: 1, 2, m, 222, mm2, 4, -4, 422, 4mm, -42m, 3, 32, 3m, 6, -6, 622, 6mm, -62m, 23, -43m
Pyroelectric: 1, 2, m, mm2, 3, 3m, 4, 4mm, 6, 6mm