Tutorials this week

- Linear algebra and all that jazz
  - Matrices
  - Vectors

- Can be missed if your maths is OK...
  - Might still be useful as a refresher though...

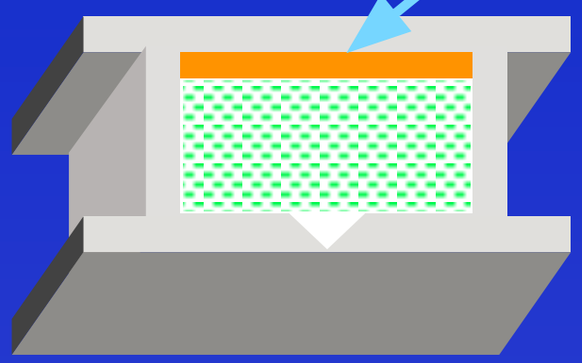
Hardware for graphics

- Printers
  - Inkjet, laser
- Screens
  - LCD, OLED, plasma, projectors (CRTs?)
- Graphics architecture
- Emerging technology
  - 3D: headsets, glasses, ...

A rather large printer

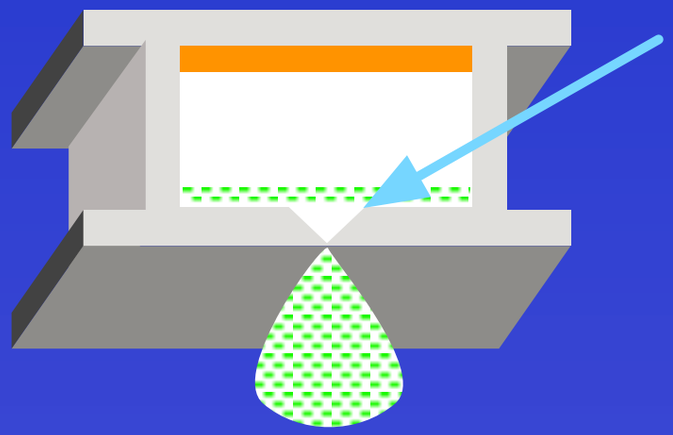
Inkjet printer operation

Heating resistor



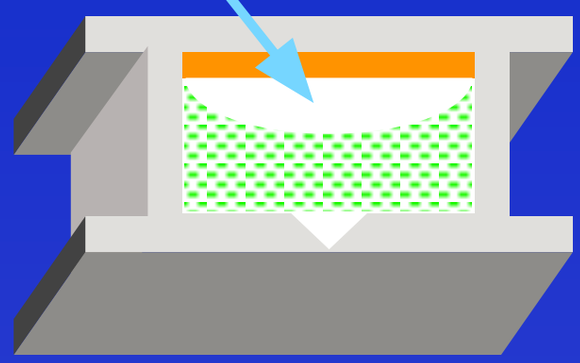
Ink is heated and starts to vapourise

Printhead nozzle

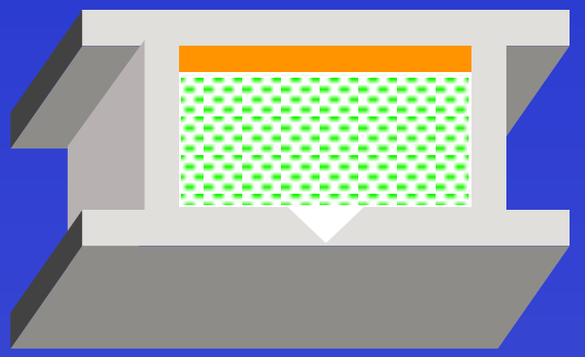


Bubble bursts and ink is forced out onto paper

Firing chamber

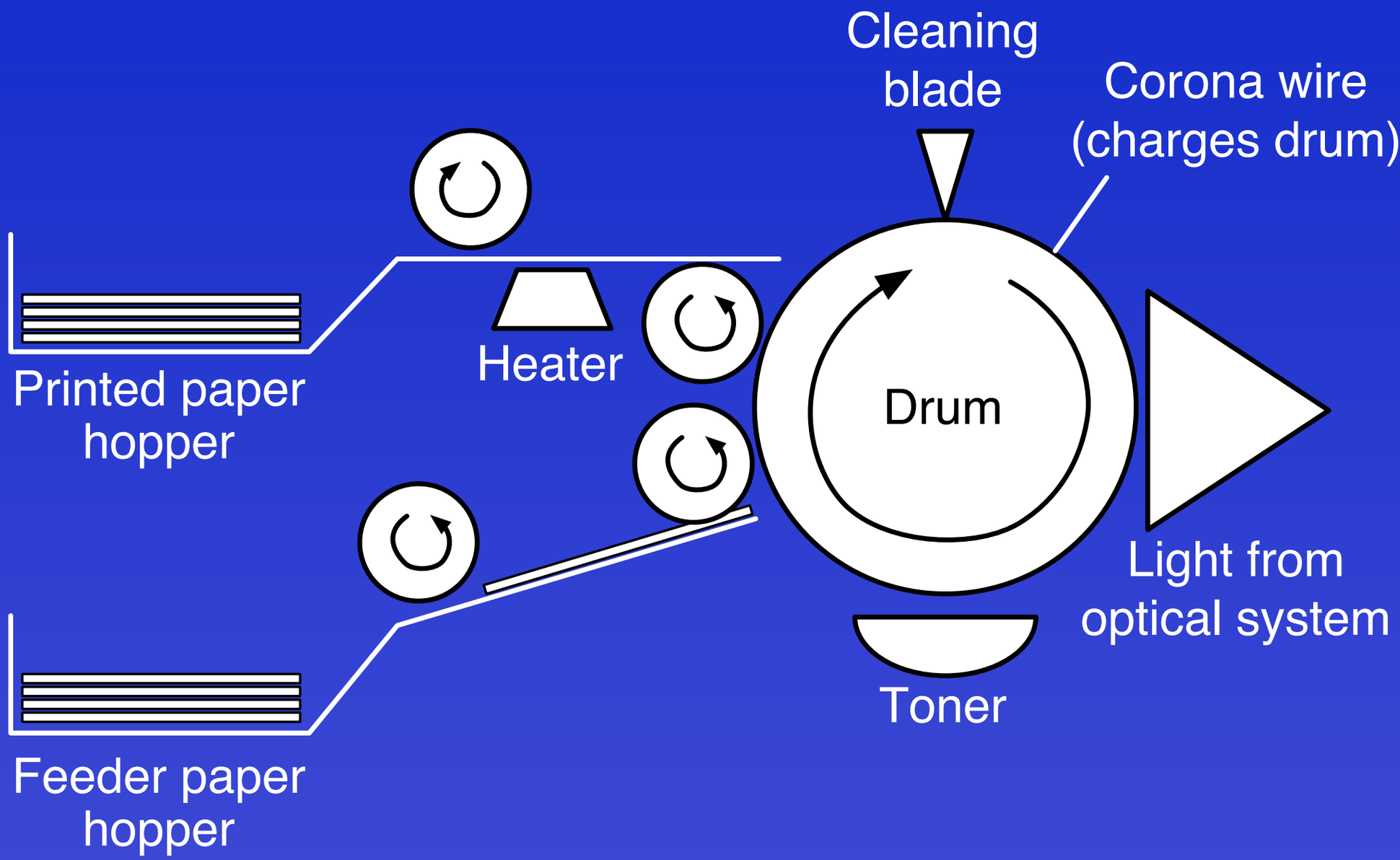


Pressure creates a bubble



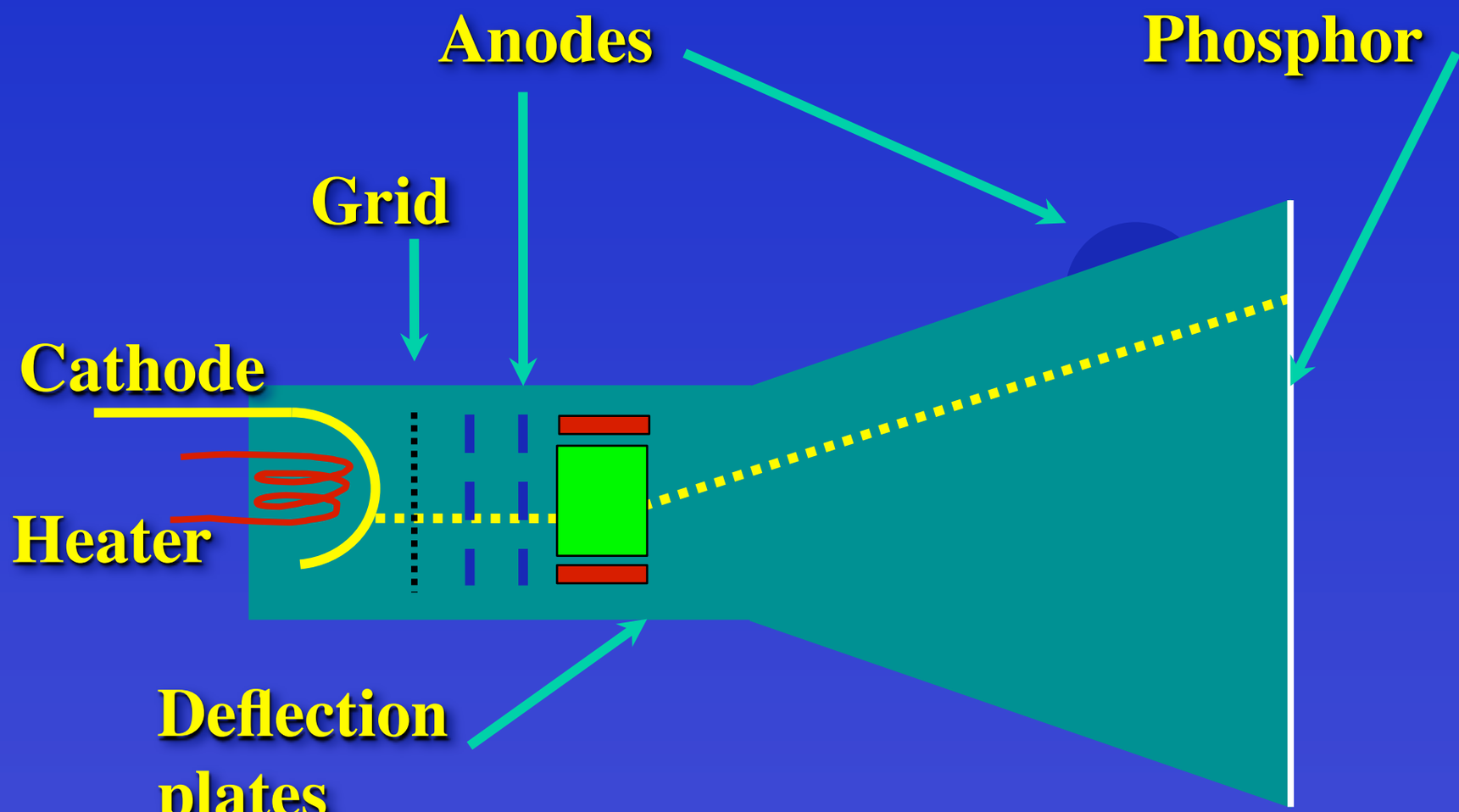
A vacuum is produced as chamber cools and ink is drawn in

Laser printer operation

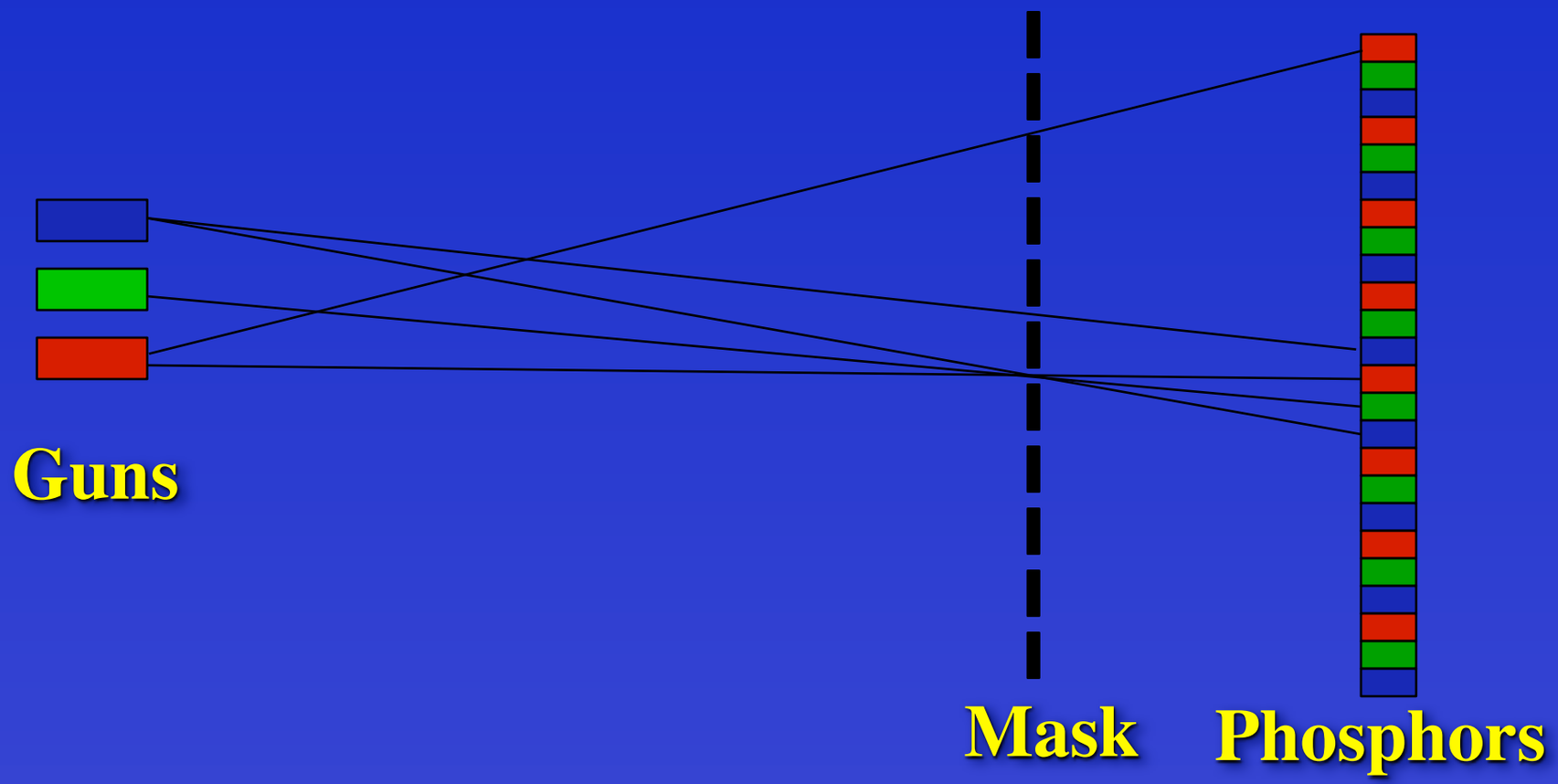


The Cathode Ray Tube

- We will no longer discuss CRTs in detail

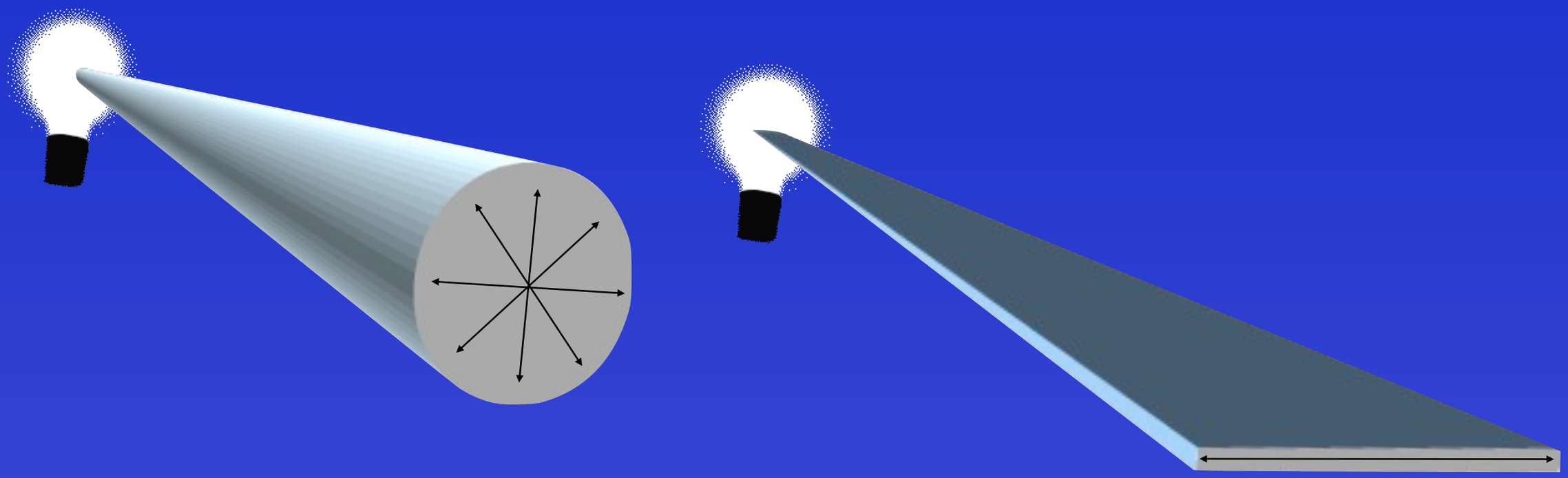


Colour CRT principle



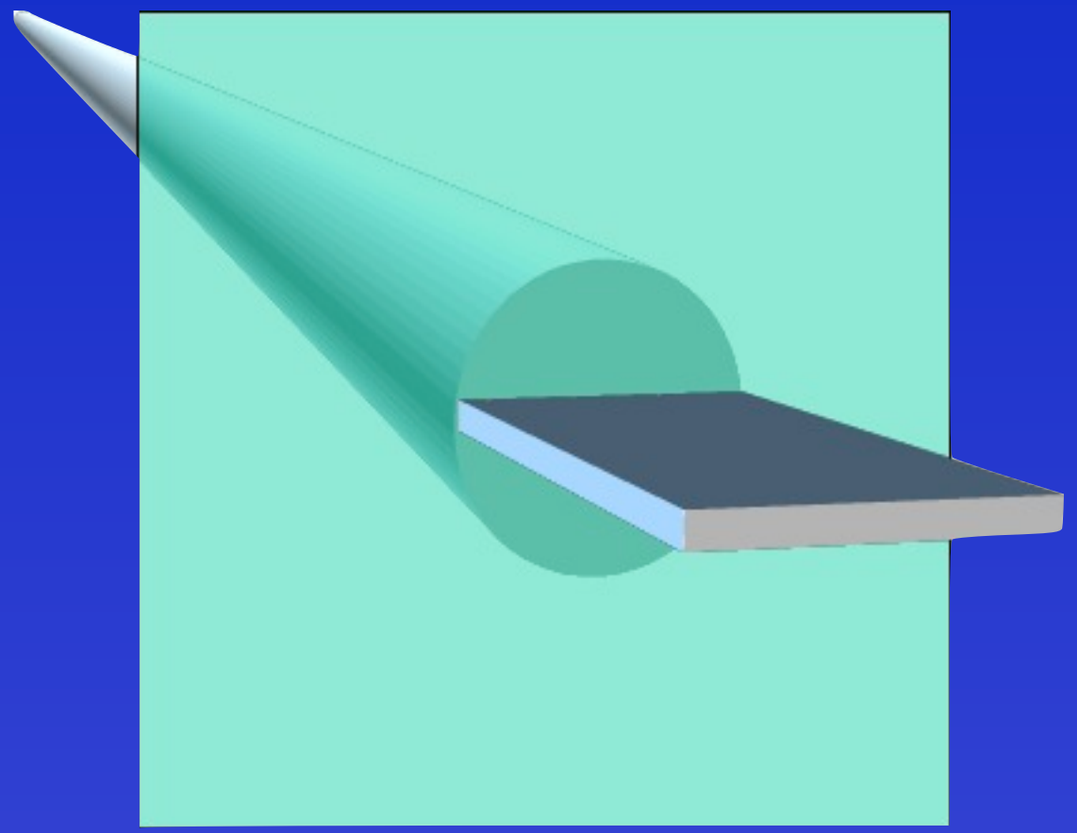
Liquid Crystal Displays

- Polarised Light



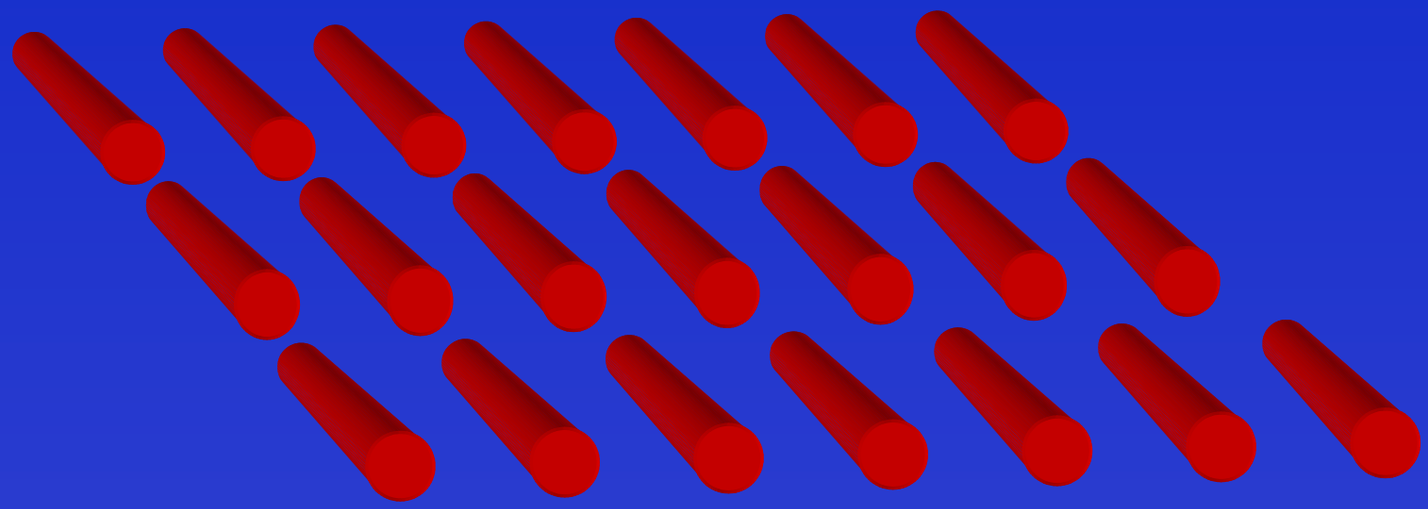
- Oscillates in only one plane

Polaroid filter



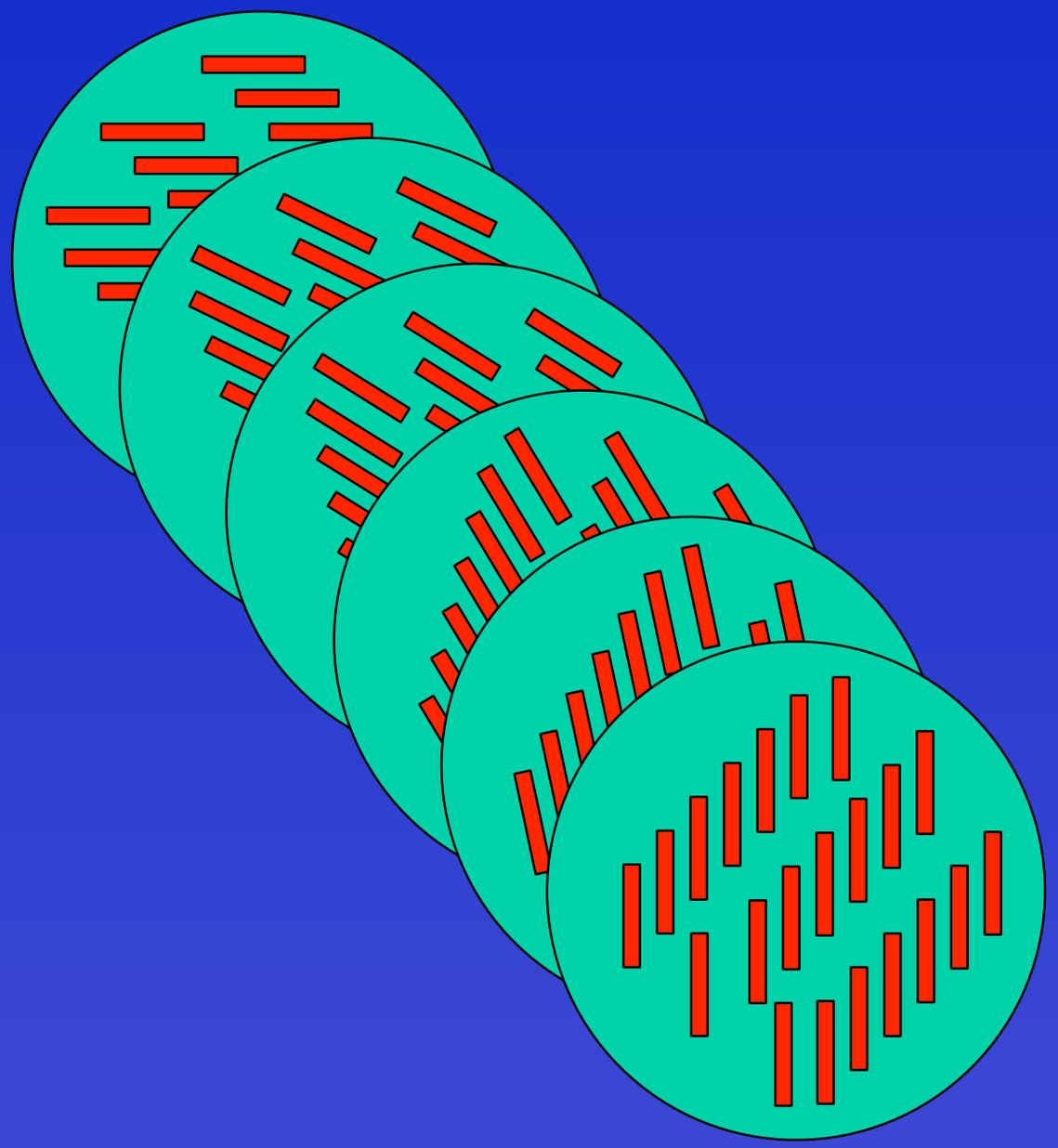
- Only lets one plane through

Liquid Crystal elements



- Lie aligned in each plane

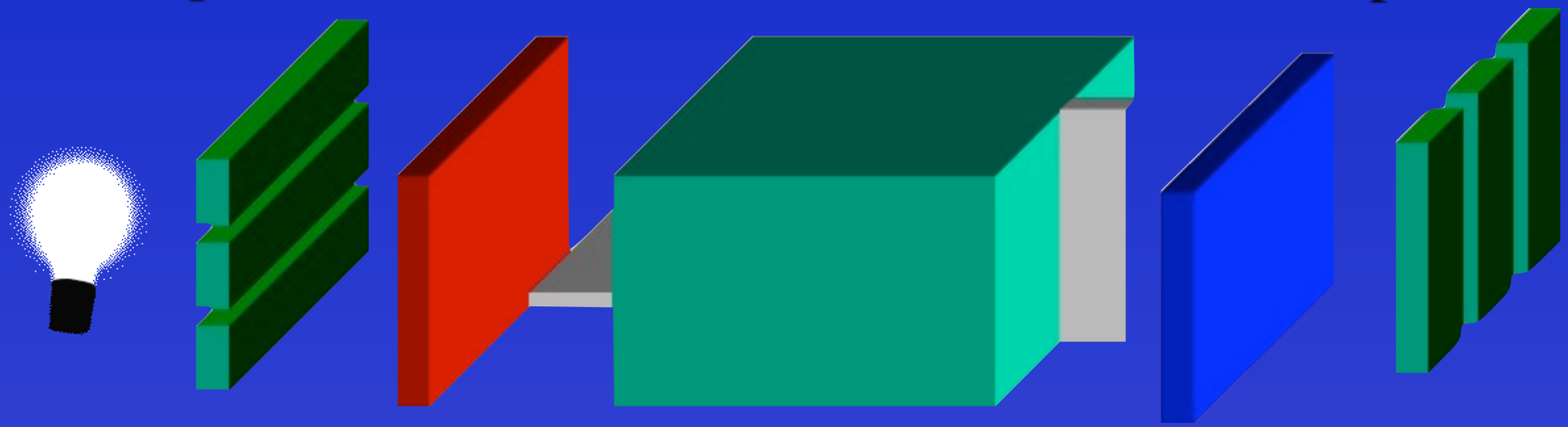
Each layer twists a bit more.



Current off: light twists

Horizontal polarizer

Vertical polarizer



Segment electrode

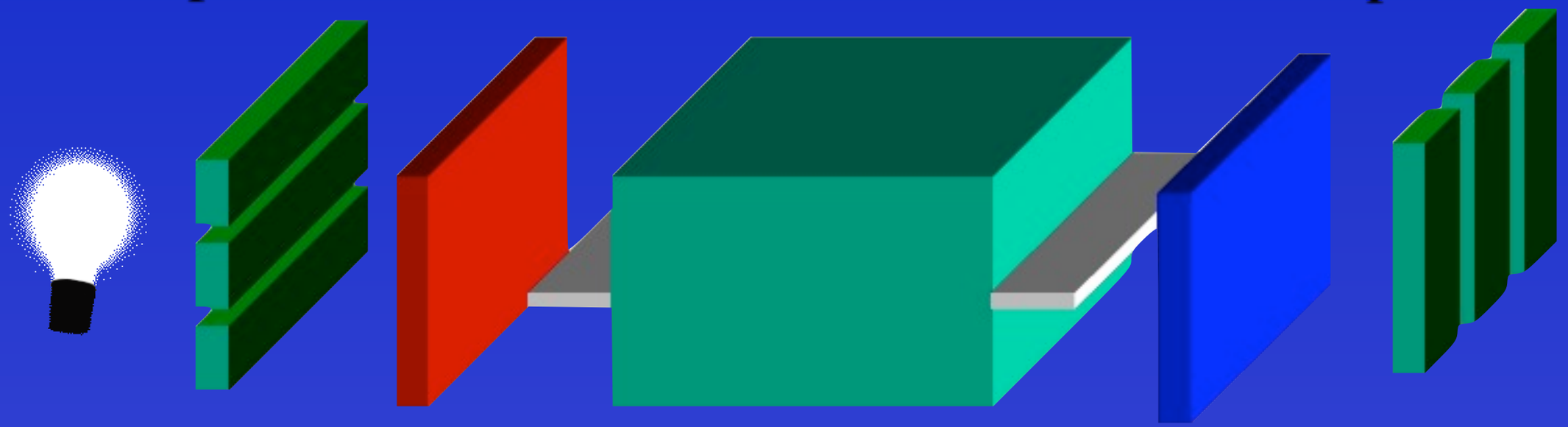
Liquid crystal

Common electrode

Current on: no twist

Horizontal polarizer

Vertical polarizer



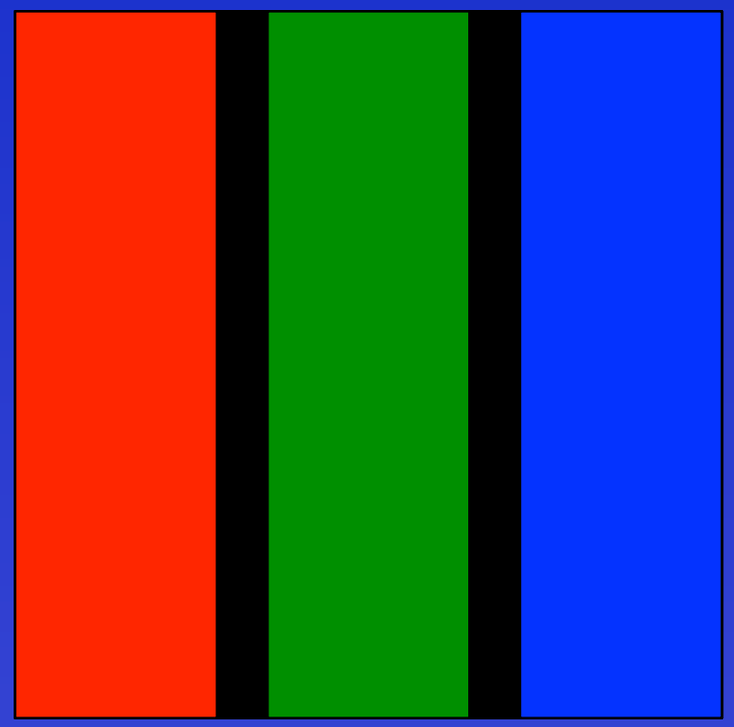
Segment electrode

Liquid crystal

Common electrode

Colour LCD

- Each pixel uses three (sub-pixel) elements
  - What is their arrangement?



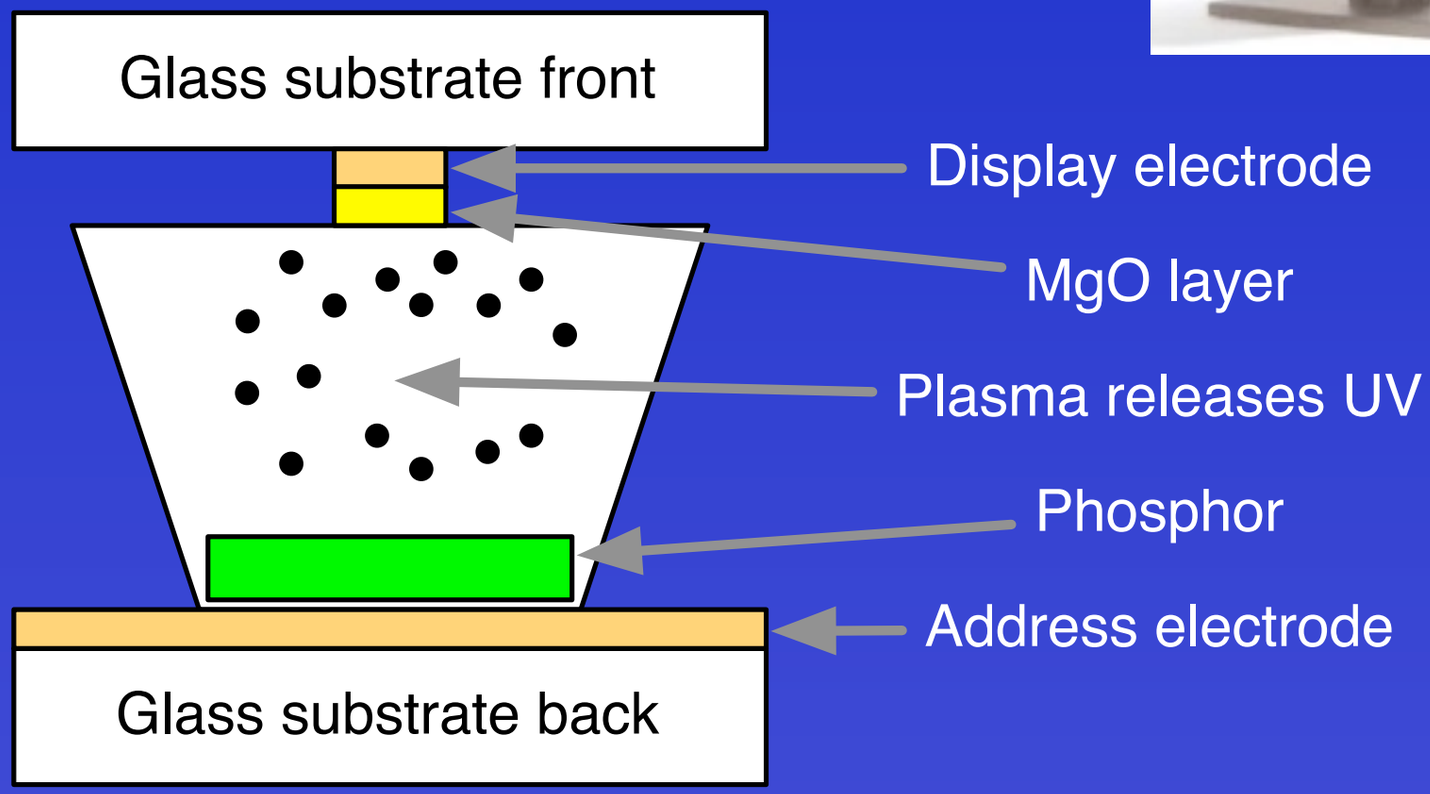
- How are they addressed?
  - Passive grid
  - Active matrix (TFT)
- Backlight: often LED

Organic Light Emitting Diode (OLED)

- LED per sub-pixel, instead of backlight
  - 'Organic' in terms of carbon chemistry
- RGB is common sub-pixel arrangement
  - but also see others used: RGBW, RGBG, etc
- Power consumption: image-dependent

Plasma displays

- Lots of mini CRTs?
  - Well... sort of...



Projectors

- "Three gun" projectors
  - Built using CRT technology
- LCD projectors
  - Often different colour path from flat-screens
- DLP projectors
  - Uses micro-mirrors (3 chips or colour wheel)

Jargon: pixels

- What is a ‘pixel’?
- Pixel = Picture Element

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- What is an alternative to using pixels?

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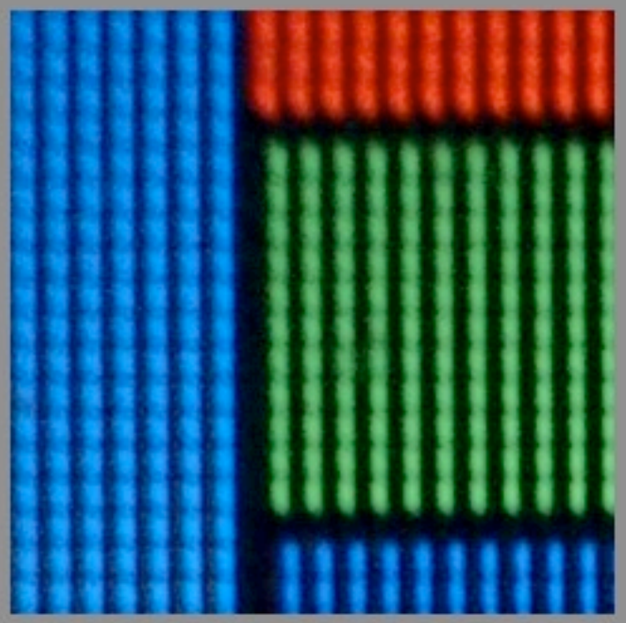
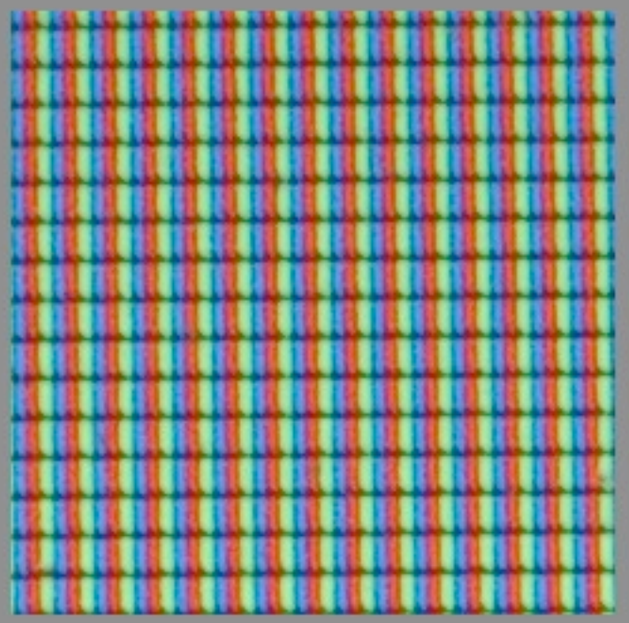
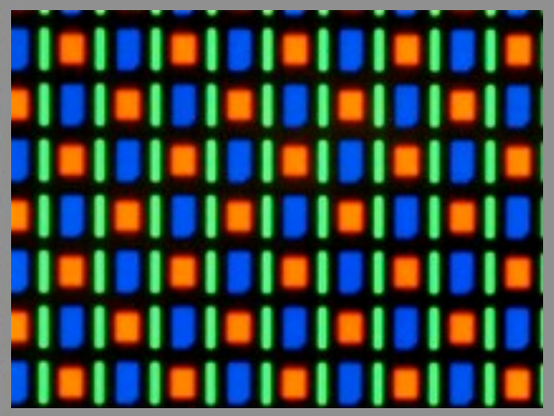
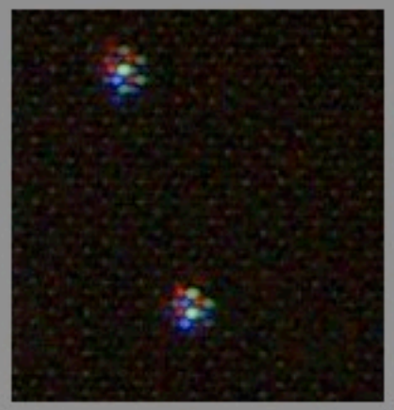
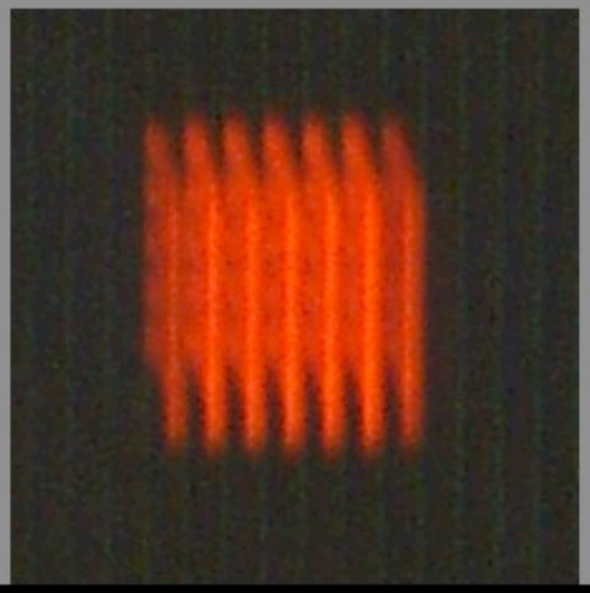
  - Displays, printers, file formats

Jargon: pixels

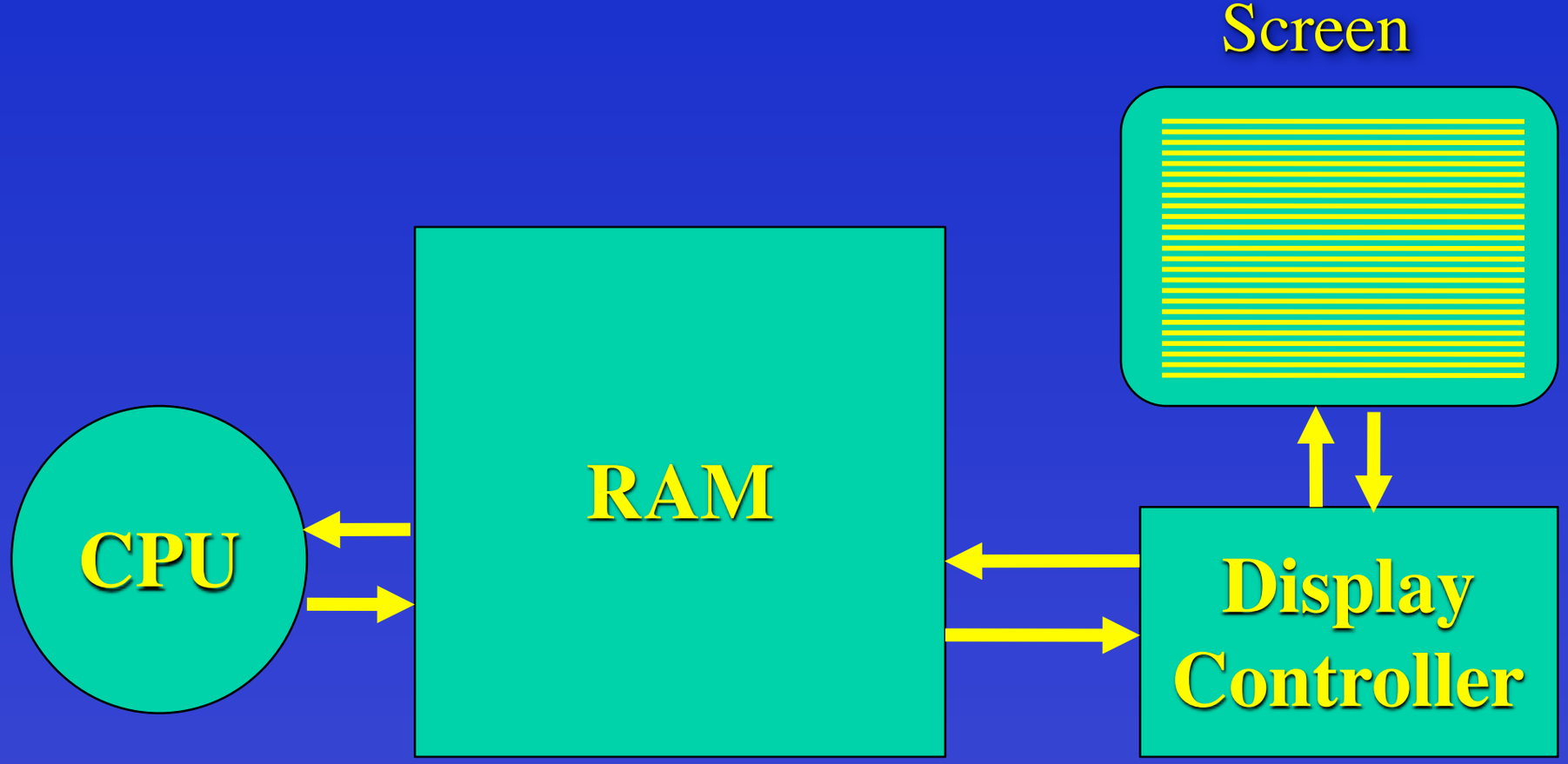
- What is a ‘pixel’?
- Pixel = Picture Element

- What is an alternative to using pixels?
- **Key distinction**! Vector versus raster
  - Displays, printers, file formats
  - e.g. PDF/SVG/EMF/PS vs TIFF/PNG/JPEG

Typical raster graphics architecture



Pixels in RAM

- Do pixels have to reside in RAM at all?
  - Character-based terminals (RAM+ROM)
  - Hardware overlays
- Today: 24-bit or 32-bit graphics (why?)
- In the past things weren't so easy!

Emerging technology: 3D

- Three dimensional displays
  - What does ‘3D’ actually mean here?
- Not a new concept
  - Chroma-based filters in cinema
  - Autostereograms
- Now: Better materials, mass production

3D: dividing up the eyes

- Colour division
  - Monochromatic channels (yuck!)
- Polarisation division
  - Cheap, passive glasses. Colour.
- Time division
  - Glasses with synchronised filters
- Space division
  - Caters for viewing position (to some degree)