EERO AF HEURLIN

RGB EFFECTS ON LONG LED STRIPS WITH NUMPY AND RASPBERRYPI

YOURS TRULY

Electronics hobbyist since childhood

Active in Finlands hackerspace scene

Currently working at http://anders.fi

Believer: Open Source & Open Hardware

https://github.com/rambo

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SOME SPECS

- 50m x 30LEDs/m = 1500LEDs RGB
- in 5m strips using APA102 superLEDs with integrated controller
- SPI-like control protocol
- 5V working voltage (a problem with long strips)
- 10 point-of-load regulators with custom milled cases

PROJECT BACKGROUND

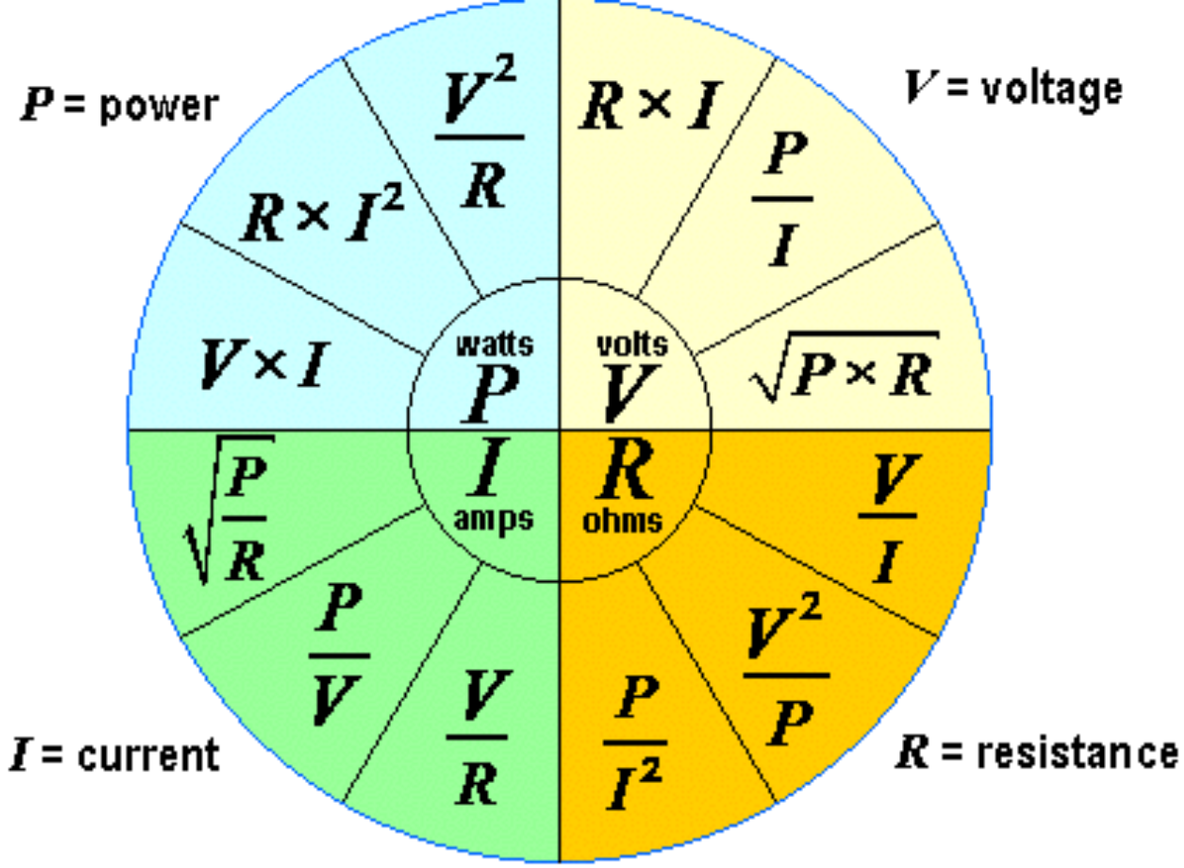
ARTISTS' RENDITION OF THE WALK TO HACKLAB DOOR DURING AUTUMN

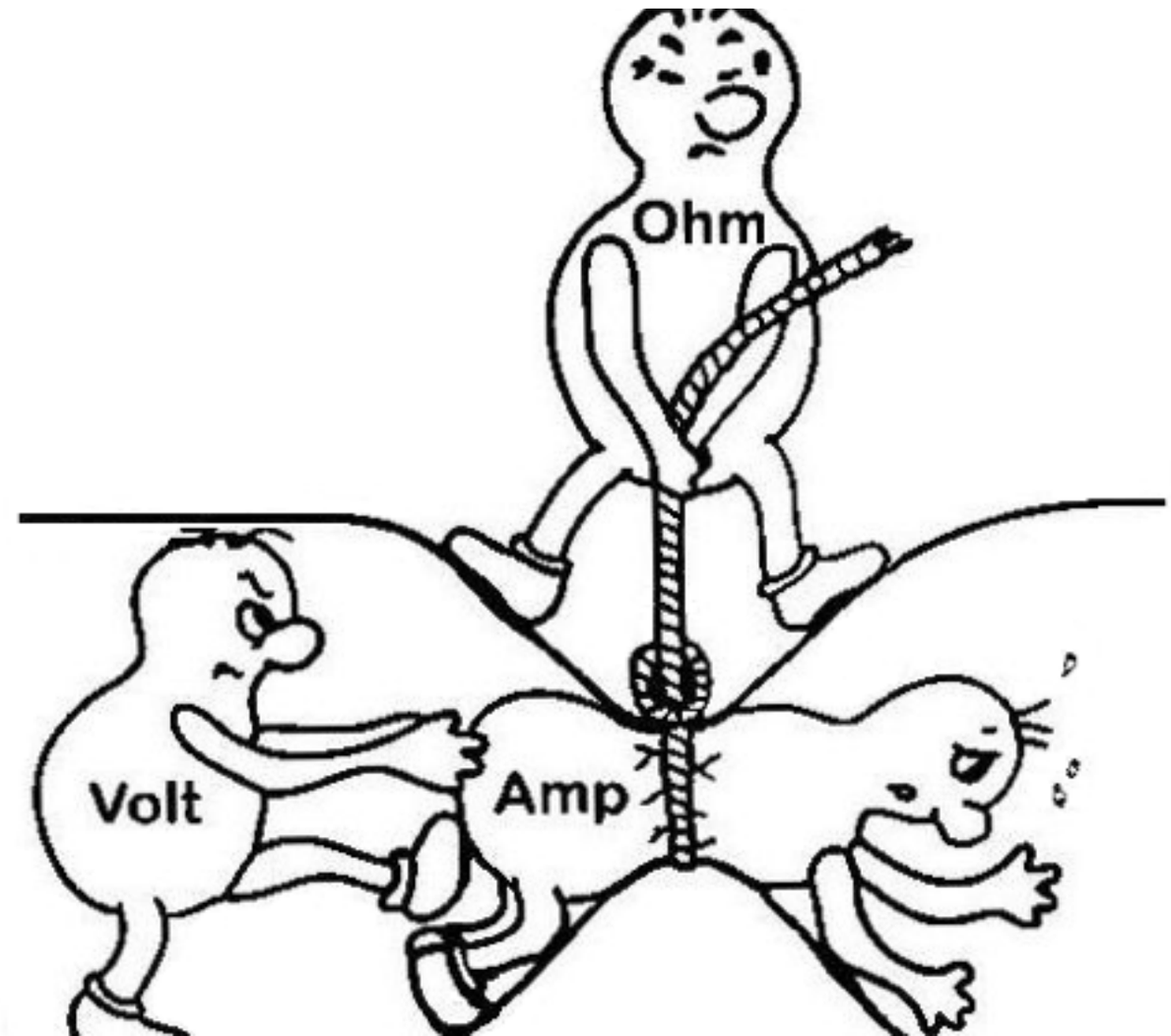
FINDING THE LED STRIPS

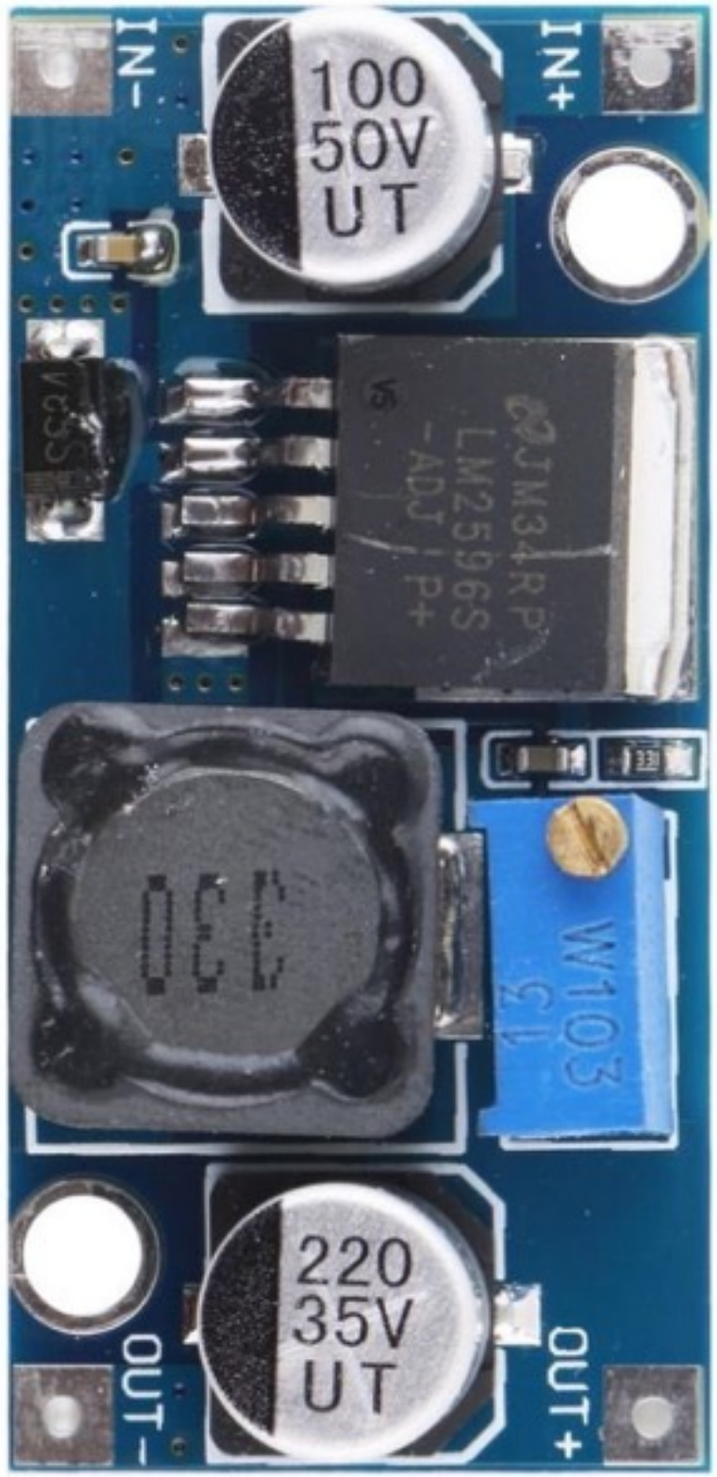
- WS2812 is no-go, the one-wire control protocol is really fiddly with timing and very sensitive to electrical noise
- APA102 is the new hotness, a bit expensive though.
- Alibaba to the rescue.
- After shipping and taxes ~400EUR for 10 * 5m reels.

ELECTRONICS INTERLUDE

- P = U * I and I = U / R
- 5V is not a good voltage to deliver significant power
- At full brightness each led takes about 30-40mA -> 45A for 1500 LEDs
- Still “only” 225W of power
- Add point-of-load regulators every 5m fed with 24V -> ~10A for 225W





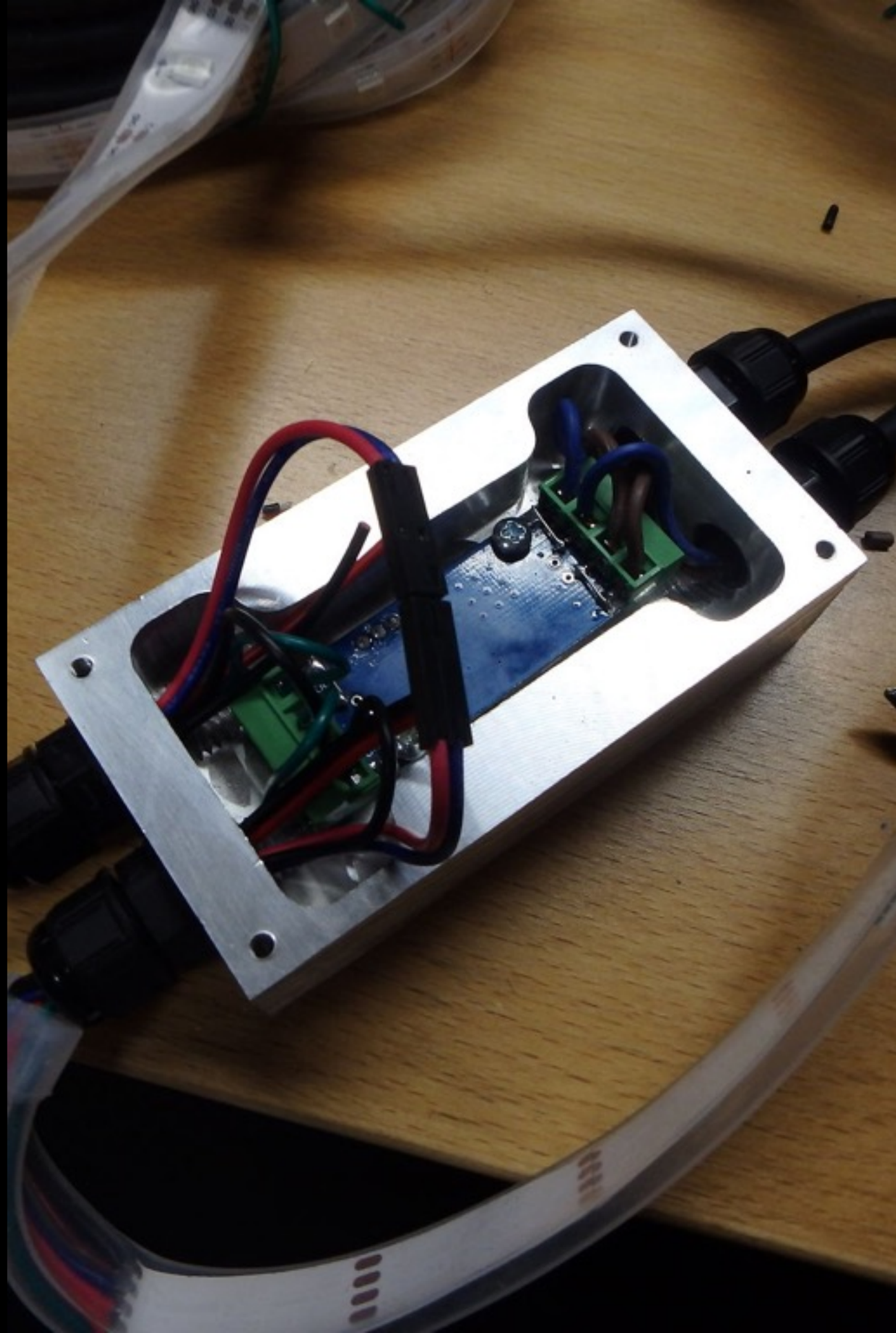


THE REGULATORS

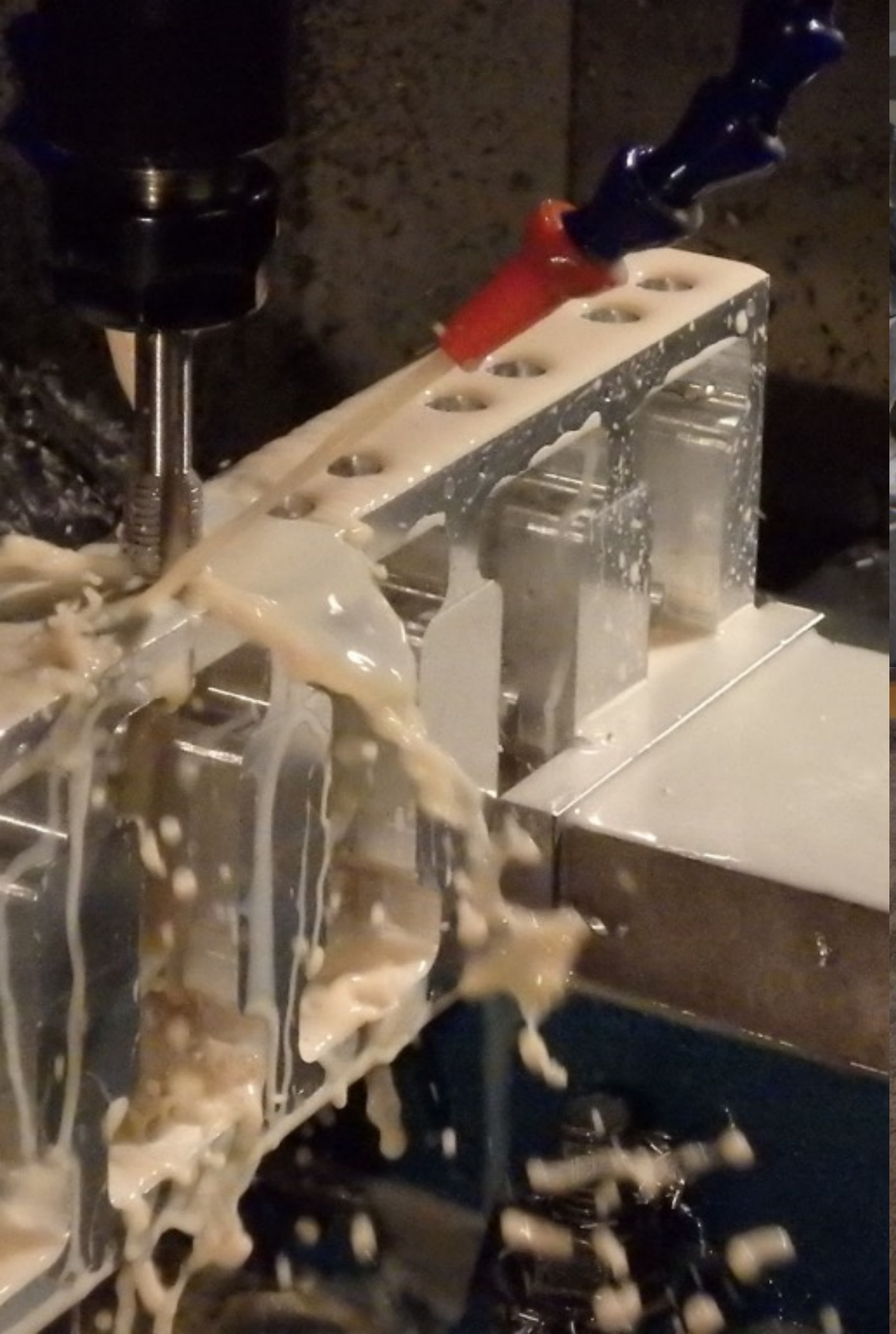
- This design (and a tens of small variations) is small, ubiquitous and cheap
- Had some in my own stock, got a lot more from Aliexpress
- Rated for 2A, some do not reach even that
- Total price maybe 10EUR
- Calibrated output on all to 5.0xxV under load with my HP6632Bs

CASES

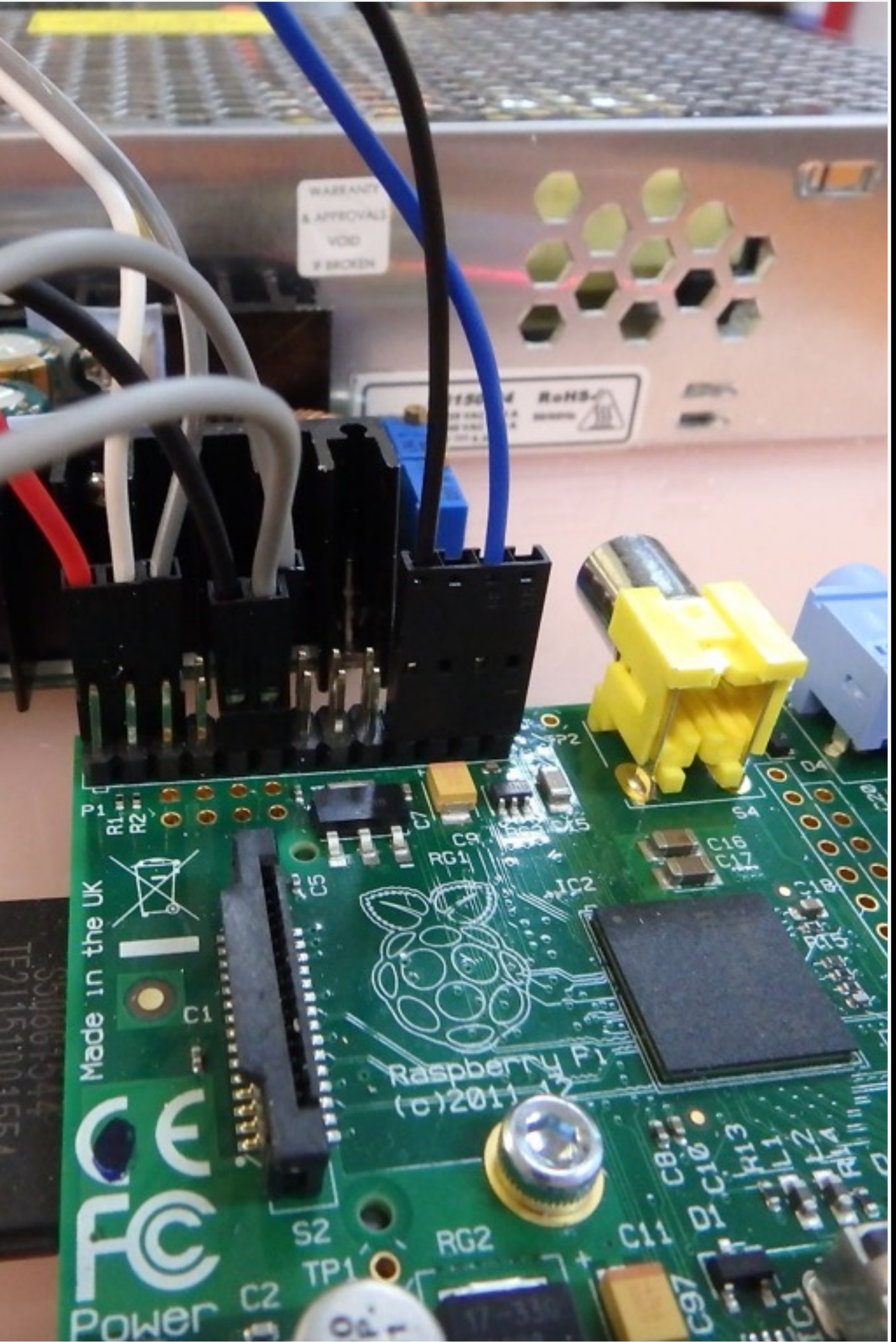
- Waterproof
- Acts as heatsink
- Designed in Fusion360
- Used 3D printed versions to test for parts fit
- Using cheap cable glands, proper connectors would have cost a fortune.



Heatsink-case v78*



OH YEAH, PYTHON...



GETTING SPI OUT

- RPi has usable SPI hardware
- Libraries “problematic”
- Wrote a ZMQ<->SPI bridge in C (a while back)
- But default kernel settings do not allow over 4k SPI buffer, we send over 6k…

FIRST IMPLEMENTATION

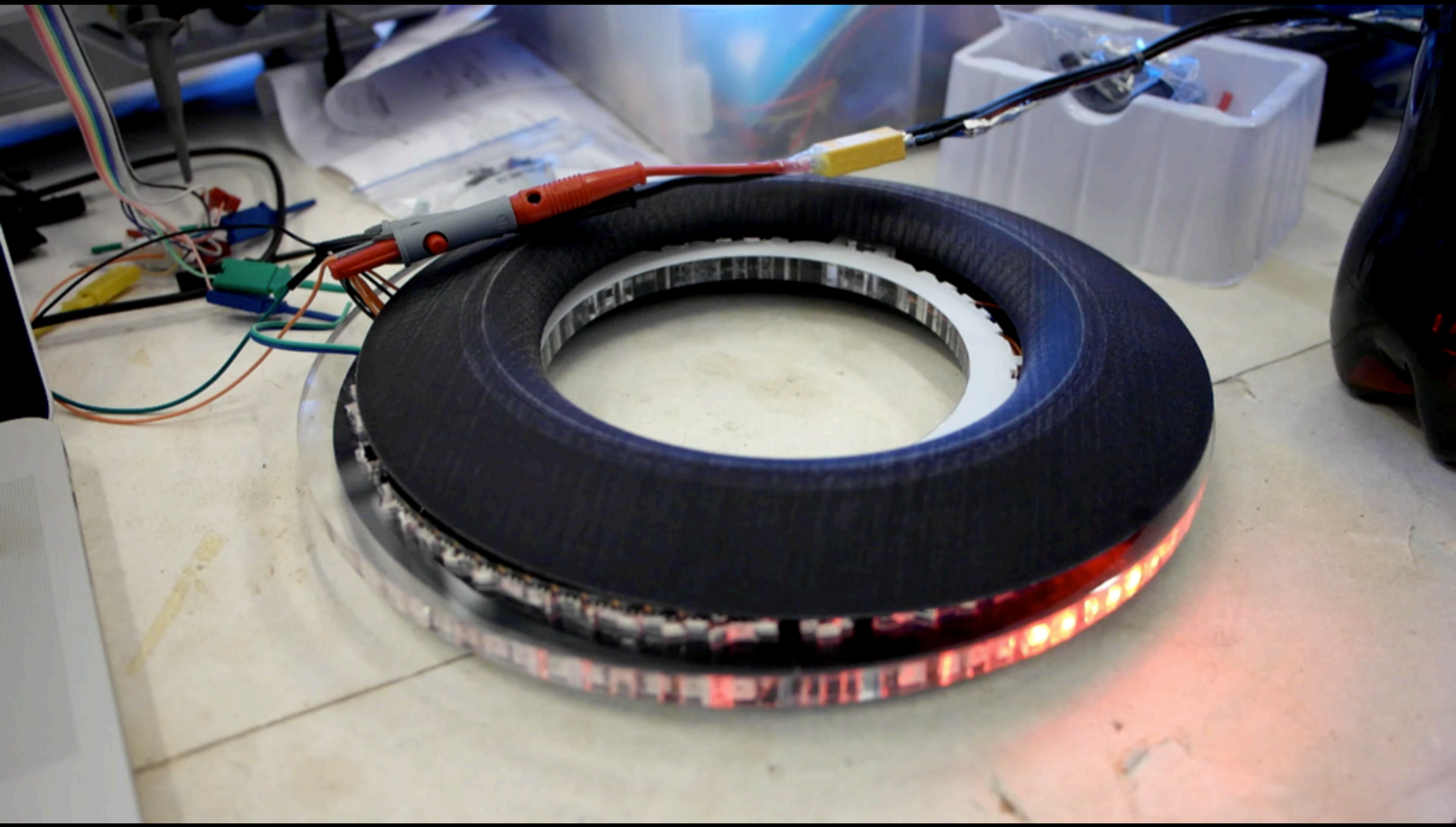
- Very simple effect
- Naive
- Pure Python
- Way too slow on the RPi

```
# -*- coding: utf-8 -*-
from __future__ import print_functio
import math
from utils import rgb_floats2bytes

def colors2frame(colors):
    """The colors param is array chr
    # start frame
    frame = bytearray([0x0, 0x0, 0x0,
    # Leds
    for color in colors:
        frame.append(0xff)  # we do
        rgbbytes = color.rgb256
        frame.append(rgbbytes[2])
        frame.append(rgbbytes[1])
        frame.append(rgbbytes[0])
    # End frame
    eofbits = len(colors) / 2.0
    eof = bytearray([0xff] * int(mat
    return frame + eof
```

```
def recalculate_chase_mix(self):
    self.chasepattern = np.zeros([1 + self._tailsize, 4], np.uint8)
    # TODO: Gamma-correct ??
    rgbbytes = self._chasecolor.rgb256
    self.chasepattern[-1] = [0xff, rgbbytes[2], rgbbytes[1], rgbbytes[0]]
    for x in range(self._tailsize):
        tailcolor = chroma.Color(self._chasecolor)
        tailcolor.alpha = 1.0 / self._tailsize * x
        blended = self._basecolor + tailcolor
        rgbbytes = blended.rgb256
        self.chasepattern[x] = [0xff, rgbbytes[2], rgbbytes[1], rgbbytes[0]]

@property
def numleds(self):
    return self._numleds

@numleds.setter
def numleds(self, value):
    self._numleds = value
    self.pattern = np.zeros([value, 4], np.uint8)
    self.initialize_frame()

def initialize_frame(self):
    eofbits = self._numleds / 2.0
    eofbytes = int(math.ceil(eofbits / 8.0))
    self.frame = np.zeros(self.pattern.size + APA102_FRAME_START_SIZE + eofbytes, np.u
    self.frame[-eofbytes:] = 0xff

def next(self):
    return self.__next__()

def _position_single_tail(self, chasepos):
    # TODO make this case work too.
    if chasepos < 0:
        return
    tailend = chasepos - len(self.chasepattern)
    # TODO: Gamma-correct ??
    rgbbytes = self._basecolor.rgb256
    self.pattern[tailend - 1] = [0xff, rgbbytes[2], rgbbytes[1], rgbbytes[0]]
    if tailend < 0:
        self.pattern[tailend:] = self.chasepattern[0:abs(tailend)]
        self.pattern[0:chasepos] = self.chasepattern[abs(tailend):]
    else:
        self.pattern[tailend:chasepos] = self.chasepattern

def __next__(self):
    chasepos = self.i % (self._numleds - 1)
    for x in range(self._numtails):
        self._position_single_tail((chasepos + x*self._tailinterval) % (self._numleds
```

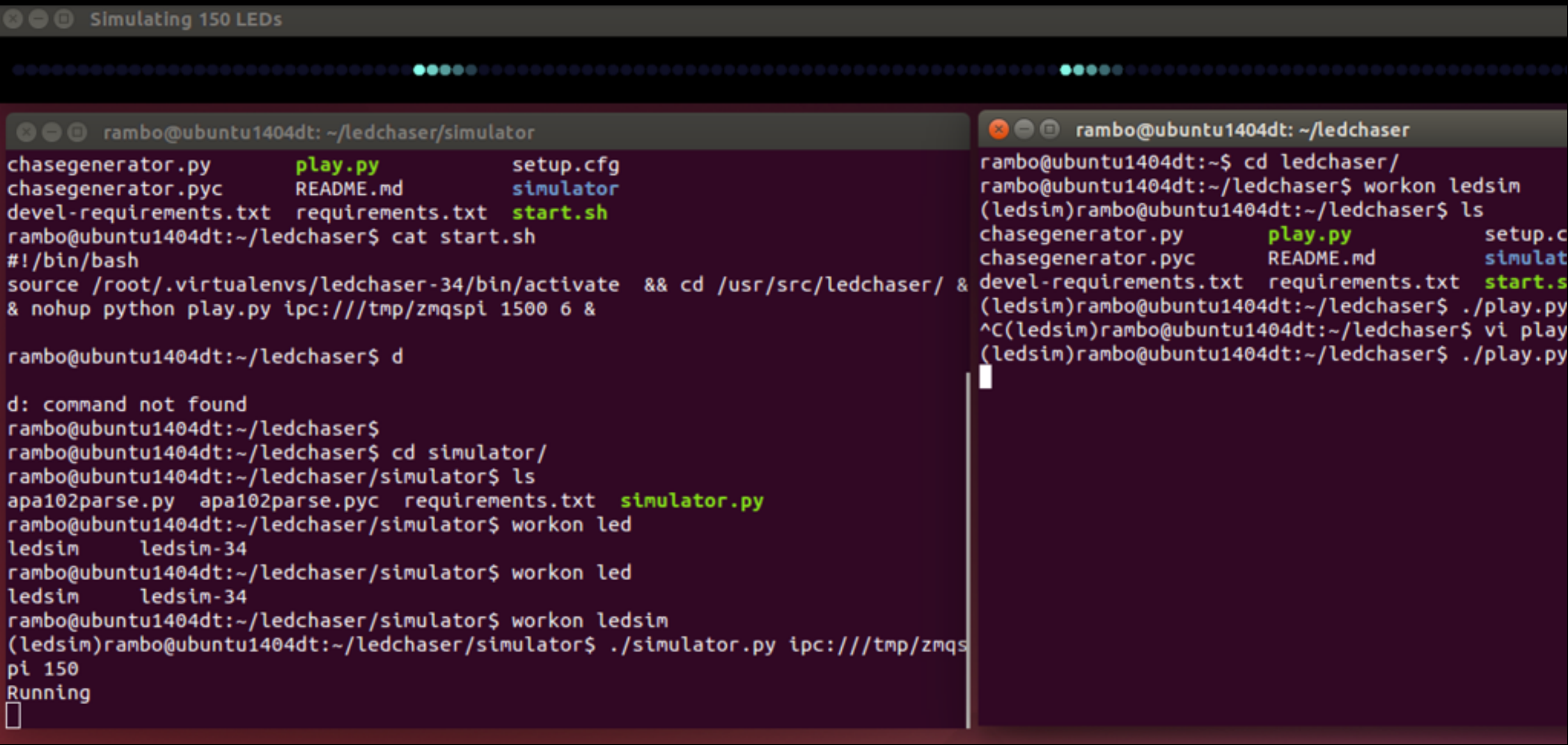
GO NUMPY

- Use NumPy arrays instead of list
- Use partial array updates
- Use NumPy vector operations
- Pre-calculate color mixing



"You mentioned a simulator"

–MEMBER OF THE AUDIENCE



SIMULATOR

- Accepts exact same frame data as is sent to SPI over ZMQ
- My first VPython application
- Doesn't really scale to hundreds of LEDs as-is.

```
lass ledscene(object):

  def __init__(self, numleds, zmqstream, spacing=33, ledradius=15):
      self.numleds = numleds
      self.stream = zmqstream
      self.stream.on_recv_stream(self.frame_recv)

      visual.scene.width = 1500
      visual.scene.height = 80
      visual.scene.autoscale = True
      visual.scene.title = "Simulating %d LEDs" % self.numleds
      self.strip = visual.frame(pos=(self.numleds / 2 * spacing * -1, 0, 0
      self.leds = []
      for x in xrange(self.numleds):
          self.leds.append(
              led(ledradius, frame=self.strip, pos=(x * spacing, 0, 0))
          )

  def frame_recv(self, stream, msg):
      ledquads = apa102parse(np.fromstring(msg[0], dtype=np.uint8))
      i = 0
      for quad in ledquads:
          self.leds[i].color = (quad[1] / 255.0, quad[2] / 255.0, quad[3]
          i += 1
          if i >= self.numleds:
              break
      stream.send("")

def run(self):
      print("Running")
      try:
          visual.scene.visible = True
          visual.scene.autoscale = False
          ioloop.IOLoop.instance().start()
      except KeyboardInterrupt:
          self.quit()

def quit(self):
      print("Quitting")
      ioloop.IOLoop.instance().stop()
```

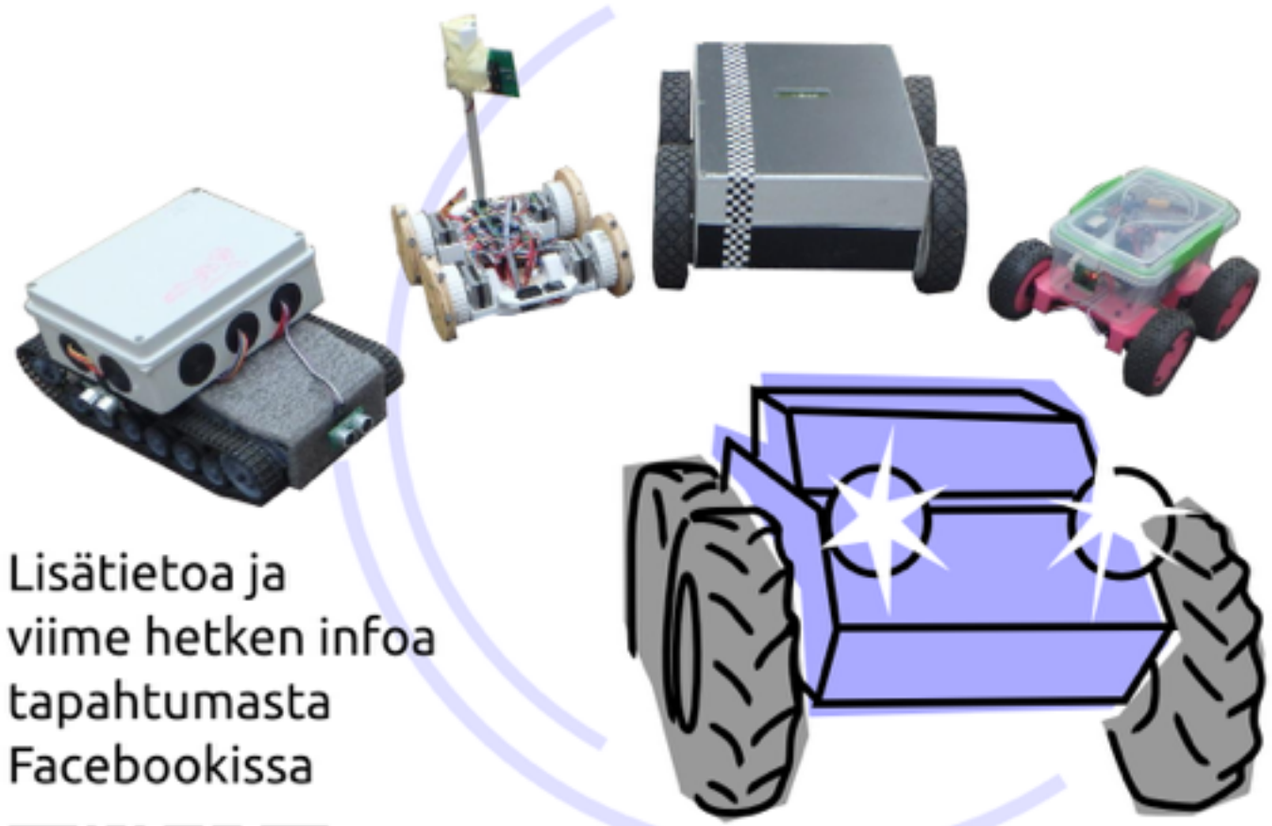
SHAMELESS PLUG

Robotit Strömbergin puistossa

la 11.6. klo 16

Pienoisrobotit kohtaavat sokkeloradalla
Strömbergin puistossa

Avoin ja maksuton tapahtuma kaikenikäisille!

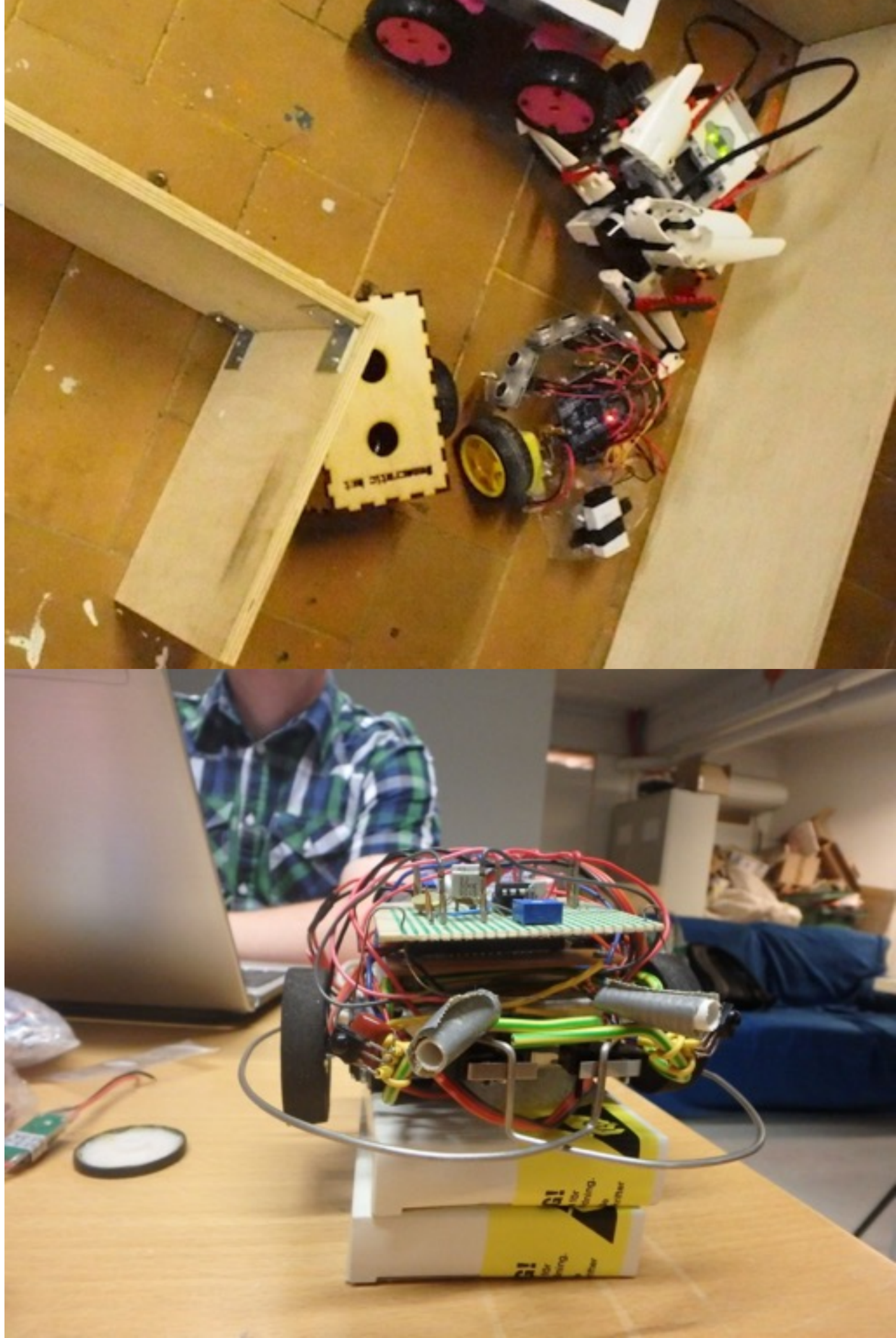


Lisätietoa ja
viime hetken infoa
tapahtumasta
Facebookissa

Tapahtuman järjestäjä

hacklab.fi

Tapahtuma Facebookissa: Robotit Strömbergin puistossa!
http://tiny.cc/robotit_puistossa



QUESTIONS ?

COMMENTS?

AND WE'RE DONE

THANK YOU