

Optical Espionage

(and other fun ways
to exploit physics)

@samykamkar
samy.pl

ground
truth

energy

energy/time

====

power

1 horsepower lifts
550 lbs 1 ft in 1 sec

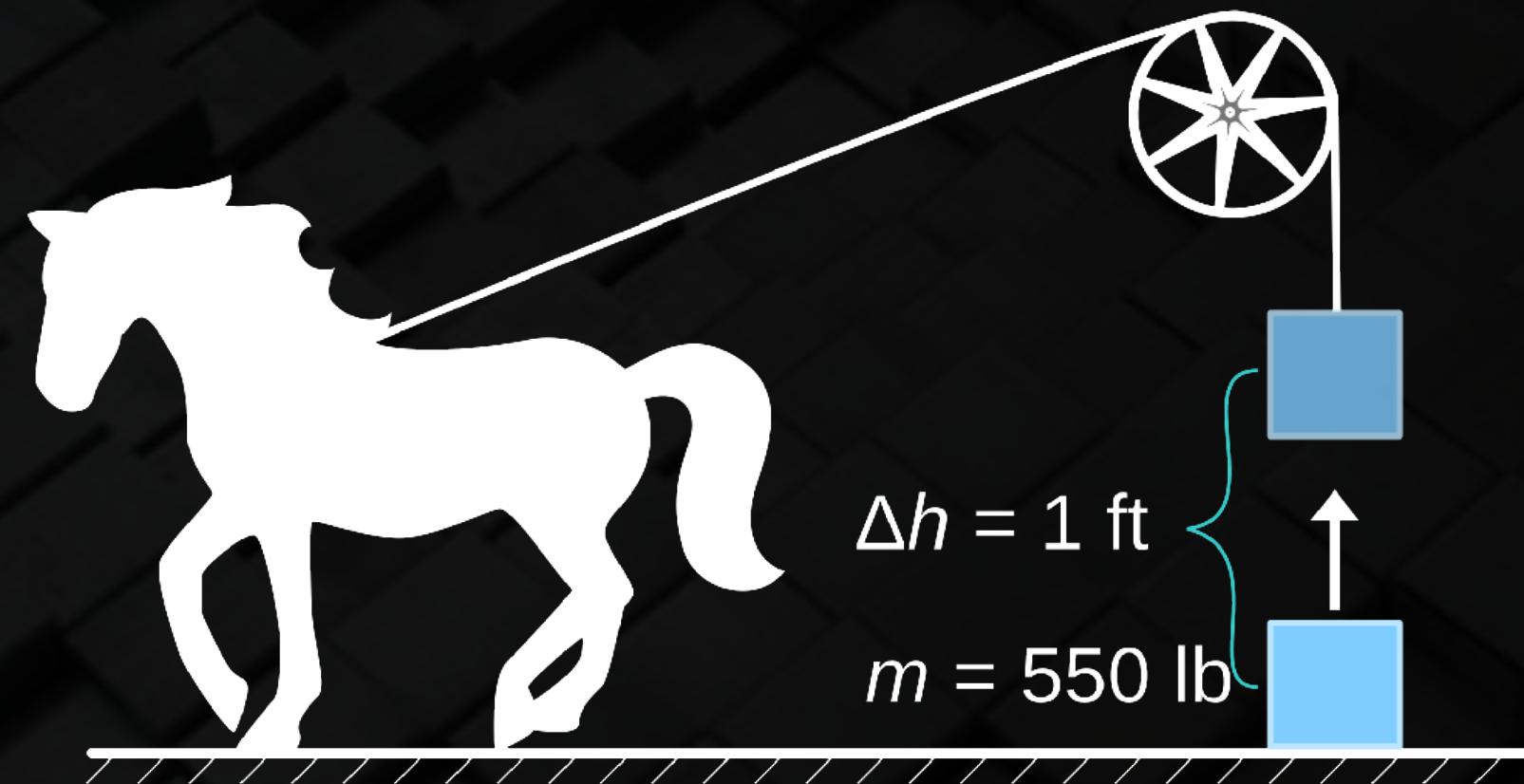


1 imperial horsepower
lifts 550lbs 1ft in 1sec



1 imperial horsepower

lifts 550lbs 1ft in 1sec



1 metric horsepower

lifts 542lbs 1ft in 1sec



energy/time

====

power

energy



information



light

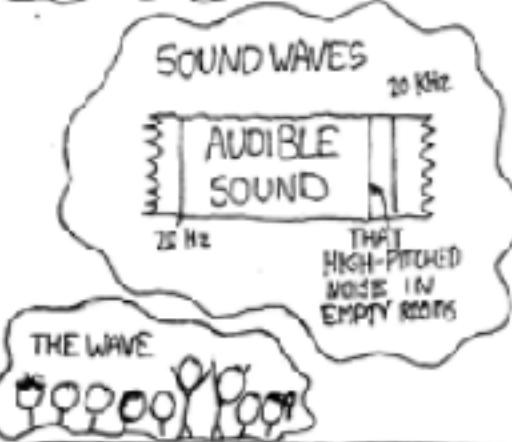




THE ELECTROMAGNETIC SPECTRUM

THESE WAVES TRAVEL THROUGH THE ELECTROMAGNETIC FIELD. THEY WERE FORMERLY CARRIED BY THE AETHER, WHICH WAS DECOMMISSIONED IN 1897 DUE TO BUDGET CUTS.

OTHER WAVES:



SHOUTING CAR DEALERSHIP COMMERCIALS



CELL PHONE
CANCER RAYS

SPACE RAYS
CONTROLLING
STEVE BALMER

99.3
"THE FOX"
101.5
"THE BADGER"
106.3
"THE FRIGHTENED
SQUIRREL"

2½
NPR
Pledge
DRIVES

AM (AM)
VHF UHF
FHF

VISIBLE
LIGHT

ALIENS
SETI

GRAVITY

SUPERMAN'S
HEAT VISION

JACK BLACK'S
HEAT VISION

SULAWESI

WIFI BRAIN
WAVES

SUNLIGHT
MAIN
DEATH
STAR
LASER

MAIL-
ORDER
X-RAY
GLASSES

POTATO
BLOGORAYS

SINISTER
GOOGLE
PROJECTS

X-RAYS
VISIBLE
DARK
UV
RINGER
LIGHT

IR
TOASTERS

MICROWAVES

RADIO & TV

POWER &
TELEPHONE

λ (m) 10^3 10^2 10^1 10^0 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12} 10^{-13}

100km 10km 1km 100m 10m 1m 10cm 10mm 1mm 100nm 10µm 1µm 100nm 10nm 1nm

100fm 10fm 1fm 100pm 10pm 1pm 100nm 10nm 1nm

100fm 10fm 1fm 100pm 10pm 1pm 100nm 10nm 1nm

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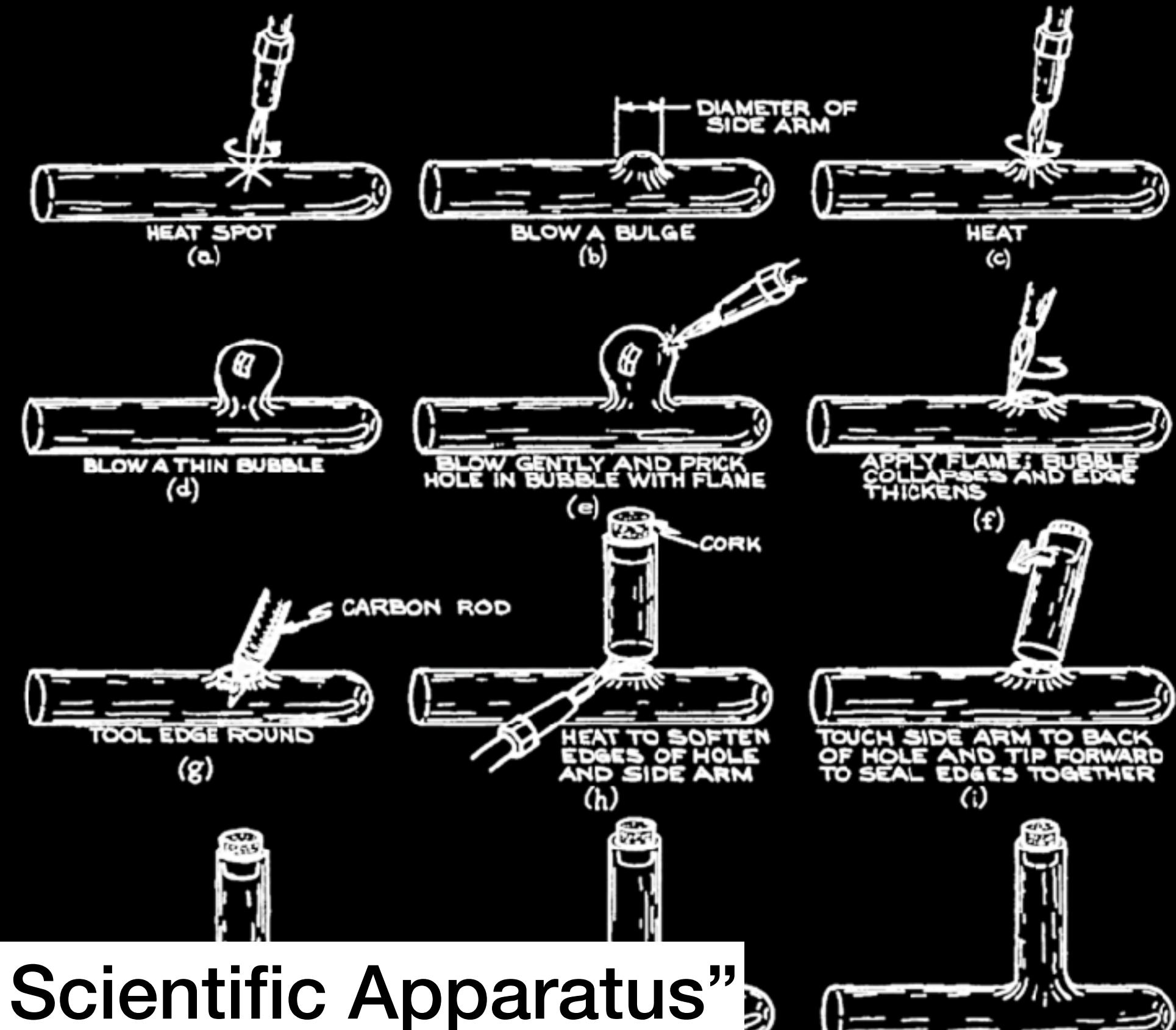
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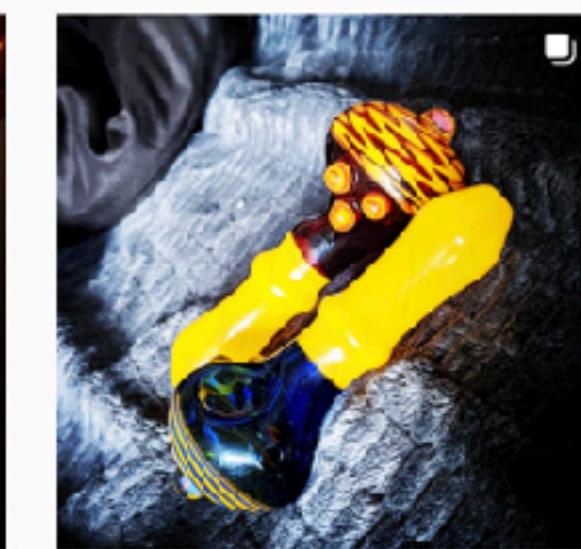
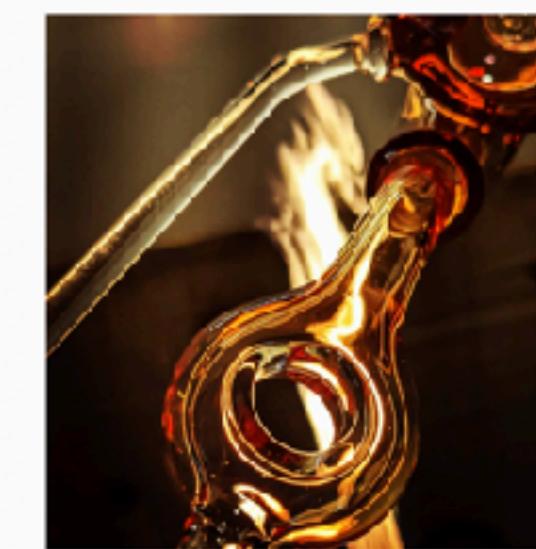
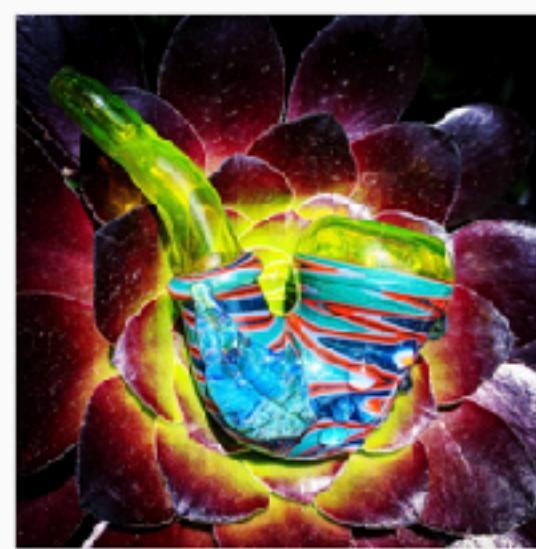
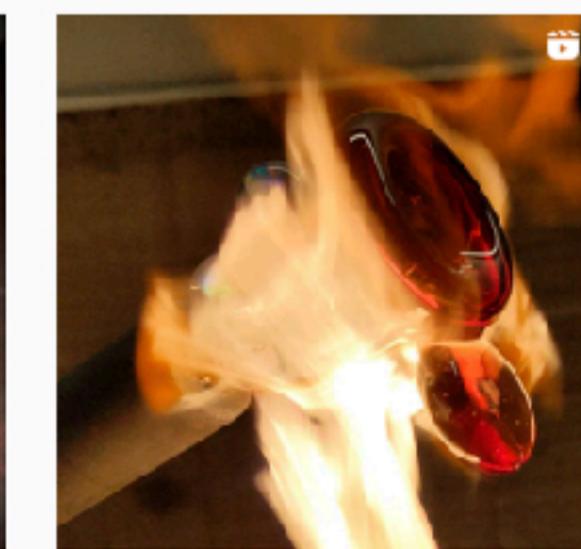
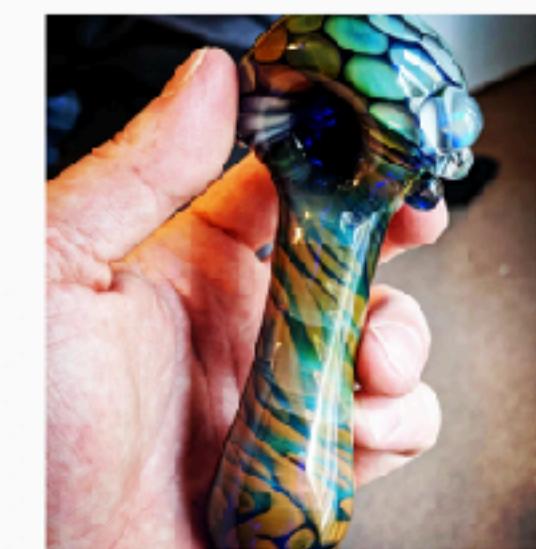
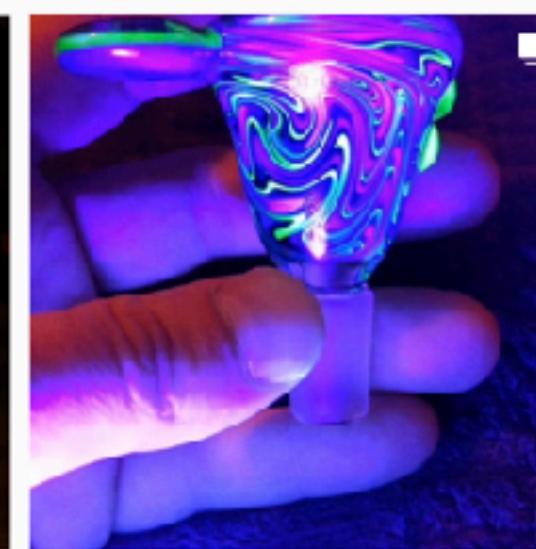
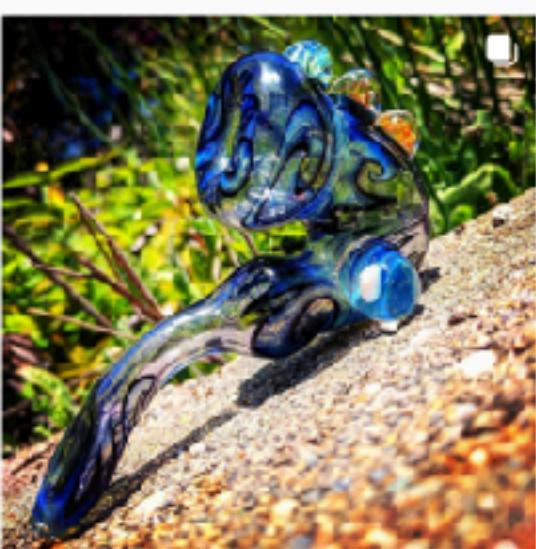
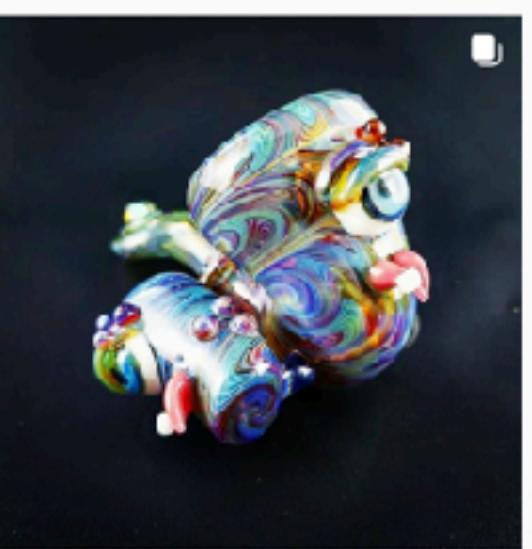
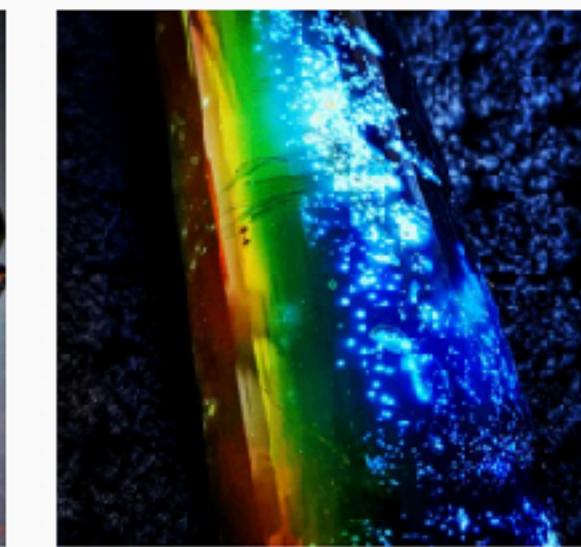
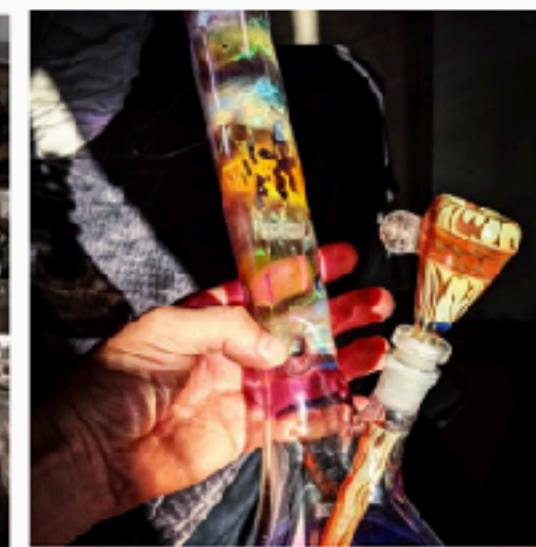
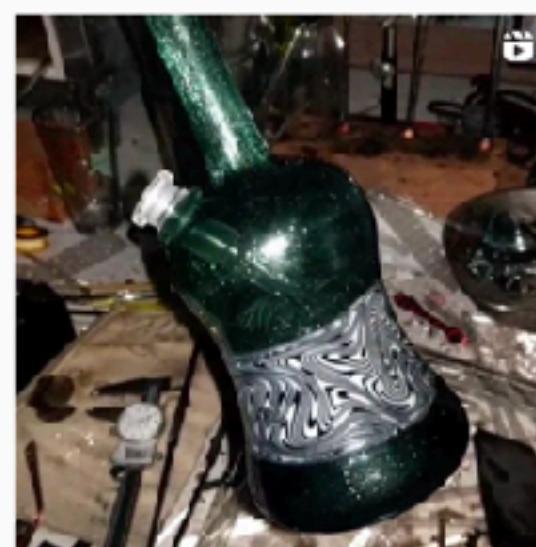
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instagram.com/thereal_snorlaxglass/



scientific glassblower

People ▾

Connections ▾

Locations ▾

Curre

About 152,000 results



samy, see the 1.5K+ decision makers from your s

Try Sales Navigator for free

Experience



Scientific Glass Blower

Sigma-Aldrich

...



Catie • 11:29 AM

Well, that makes a bit more sense! I see that you are in LA, we are located in Milwaukee, WI. Is this something that you are thinking you would travel here for?

It's Time To Check In [External](#) ⏪

Los Angeles to Minneapolis – DL 1065

Feb 1, 11:15 AM–4:48 PM

✈ Take-off
Feb 1, 11:15 AM

🛬 Landing
Feb 1, 4:48 PM

⌚ Flight duration
3 hr, 33 min

👤 Passenger name
Samy

✉️ Confirmation number
H54RYB

Seat
-

Minneapolis to Madison – DL 2922

Feb 1, 8:45 PM–9:55 PM

Delta Air Lines <DeltaAirLines@t.delta.com>
to DELTA ▾

Mon, Jan 31, 11:16 AM

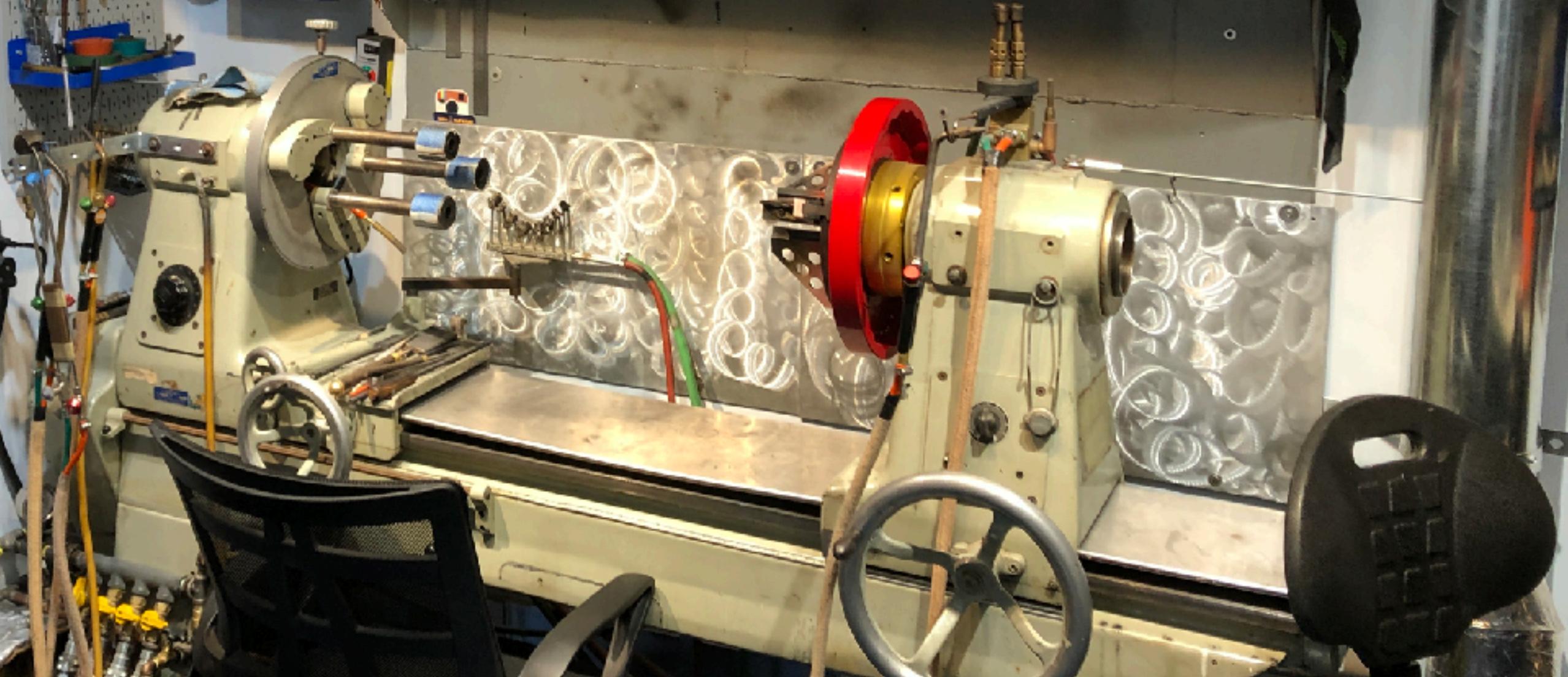


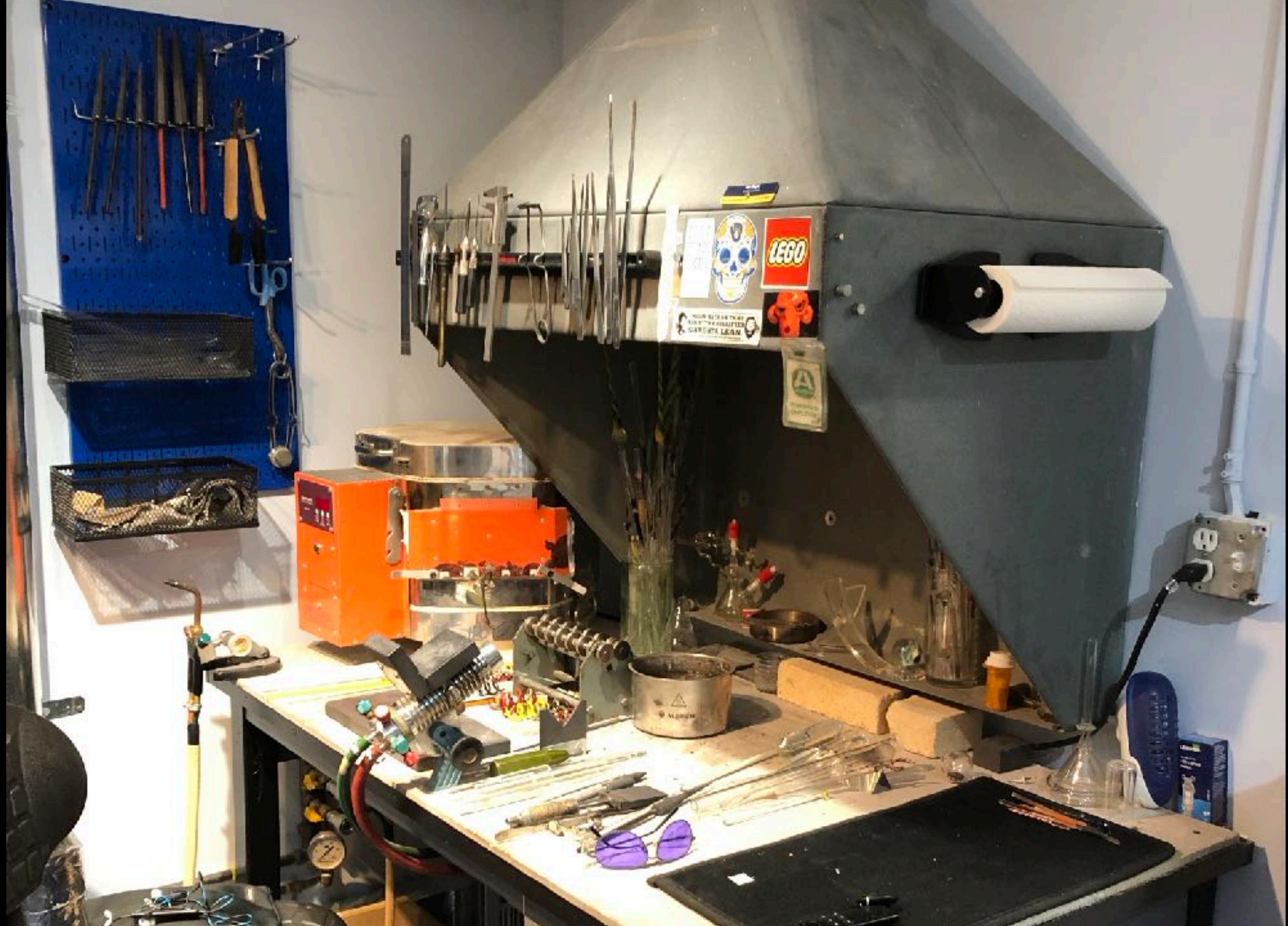
Hello, Samy



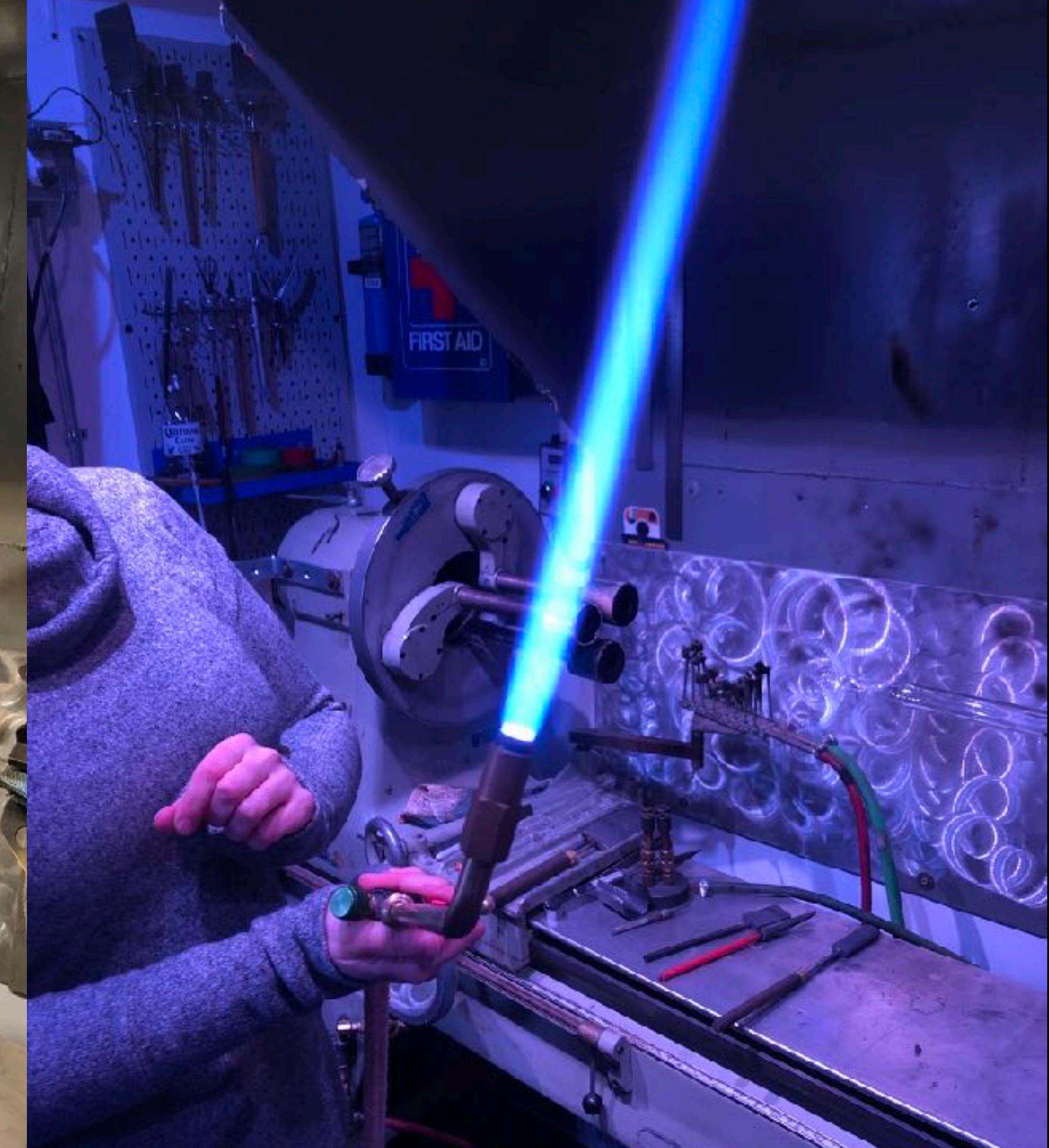
Welcome Samy!

To your private tutorial...



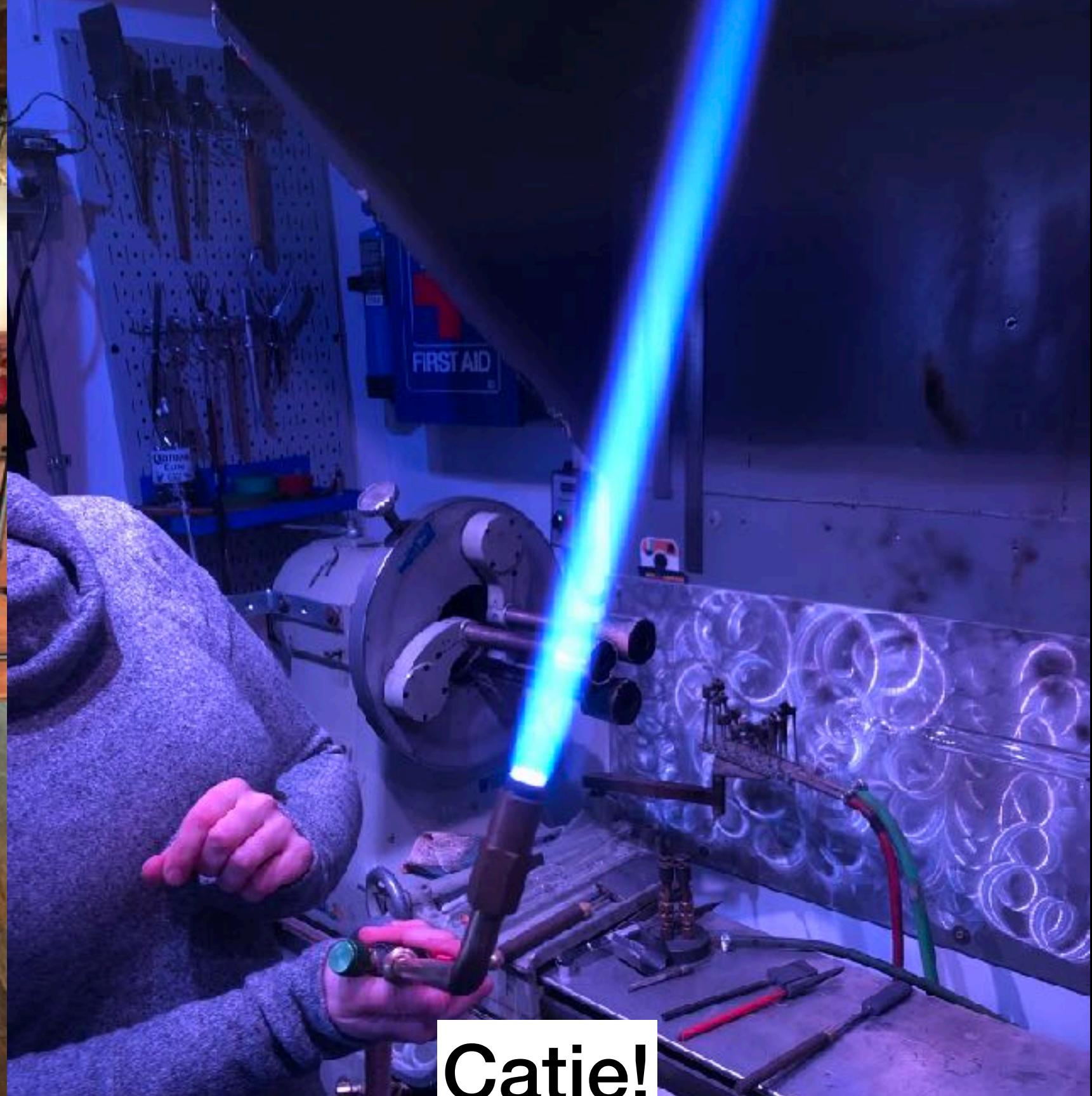






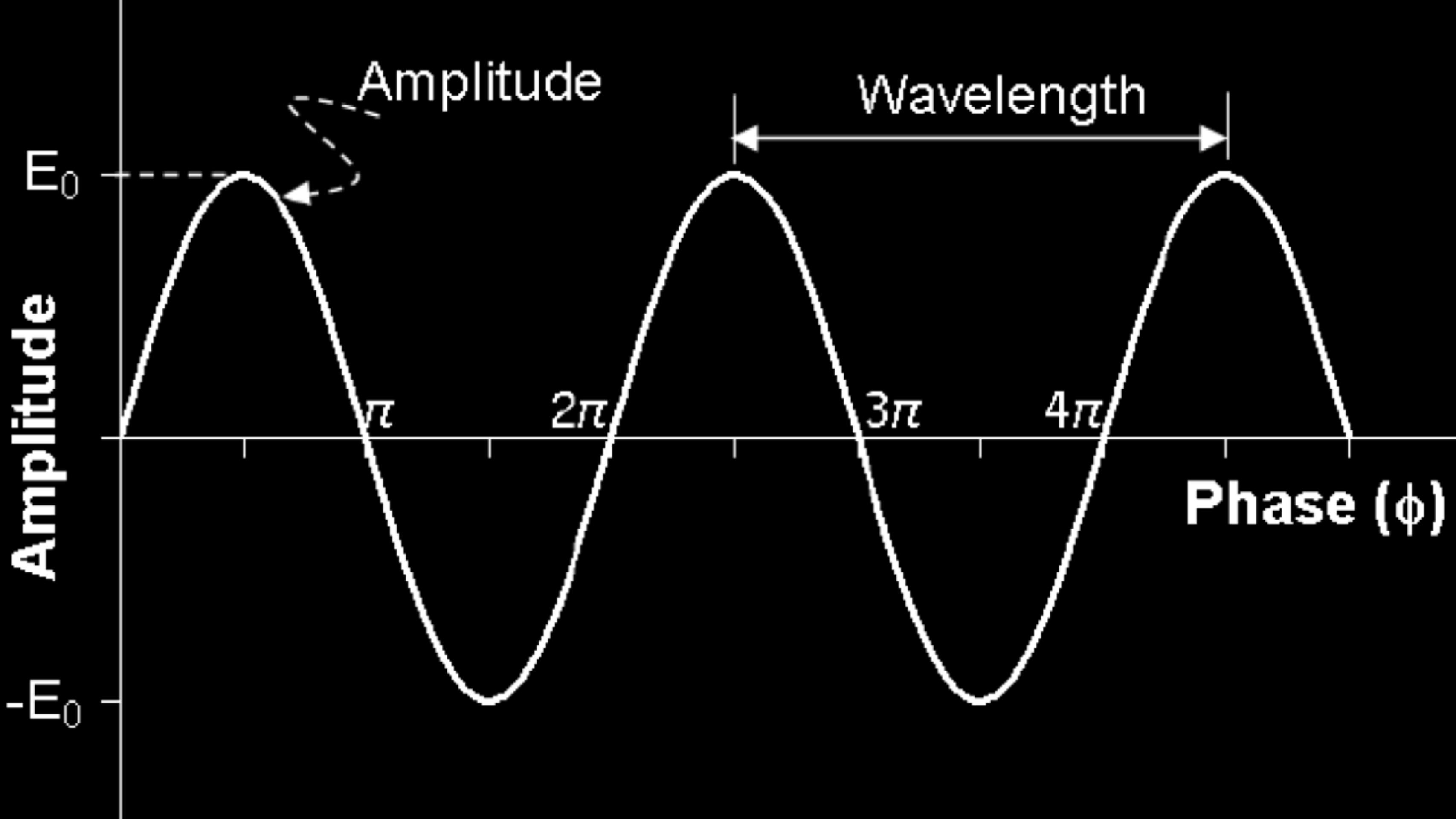


ian!
mkelabware.com



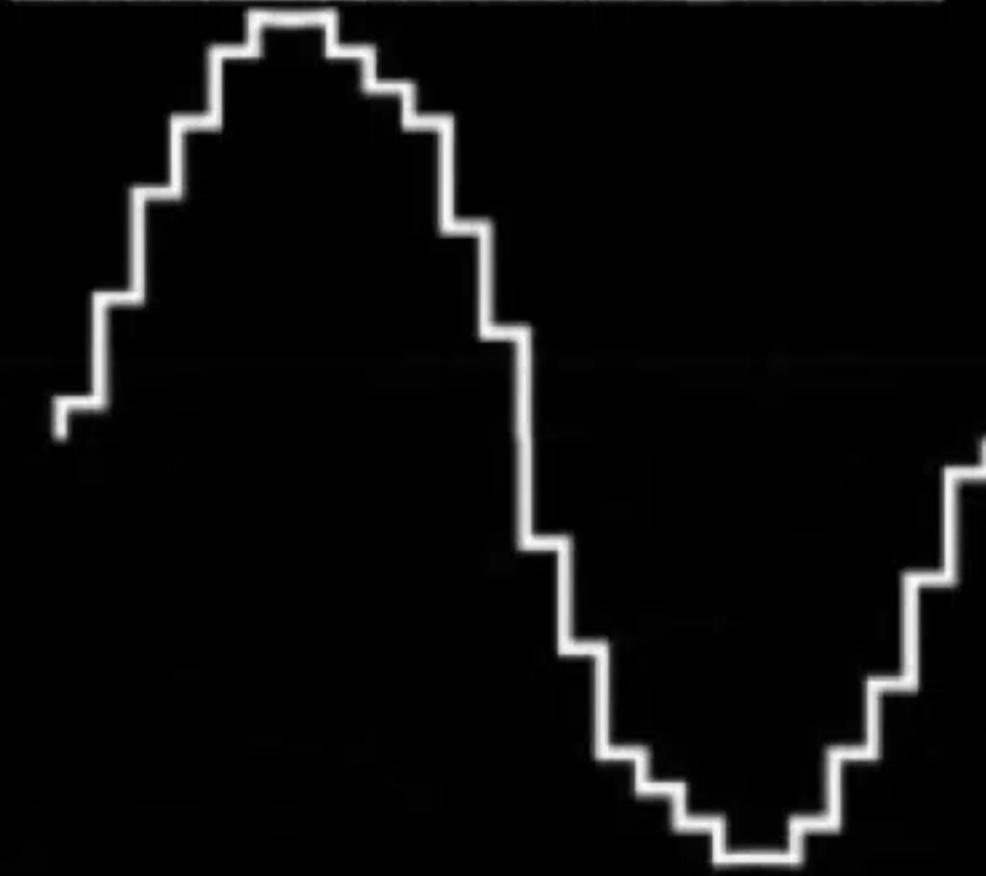
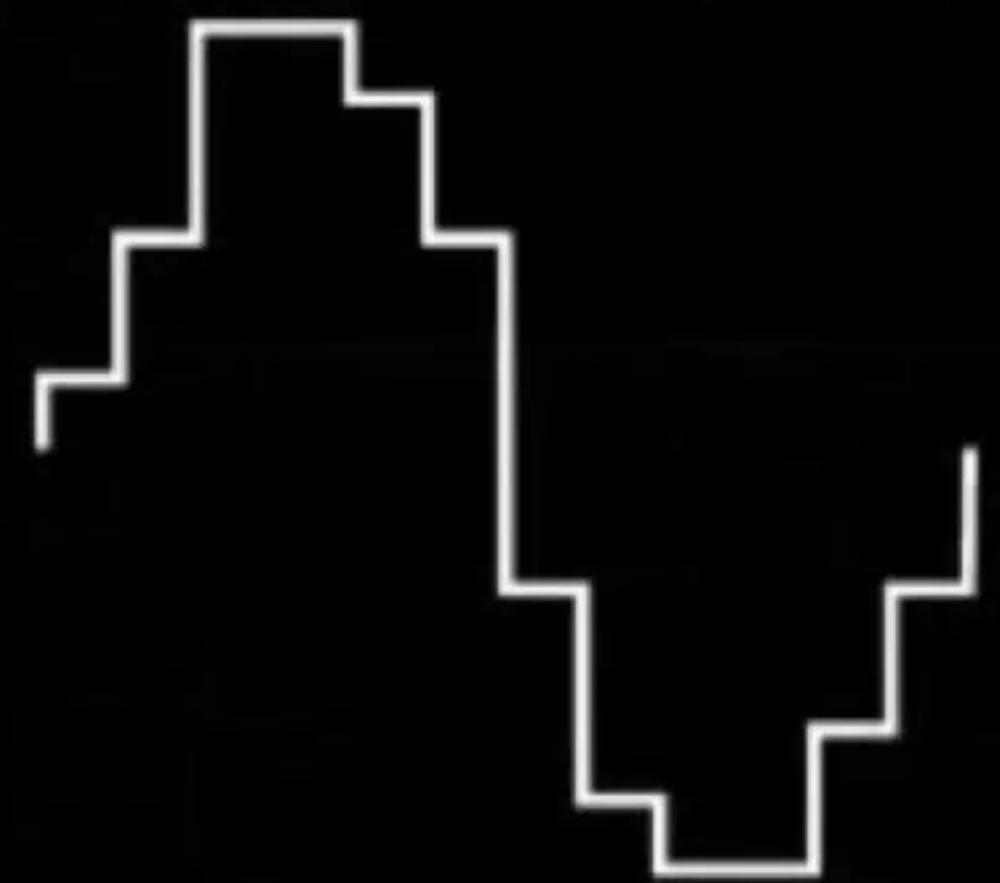
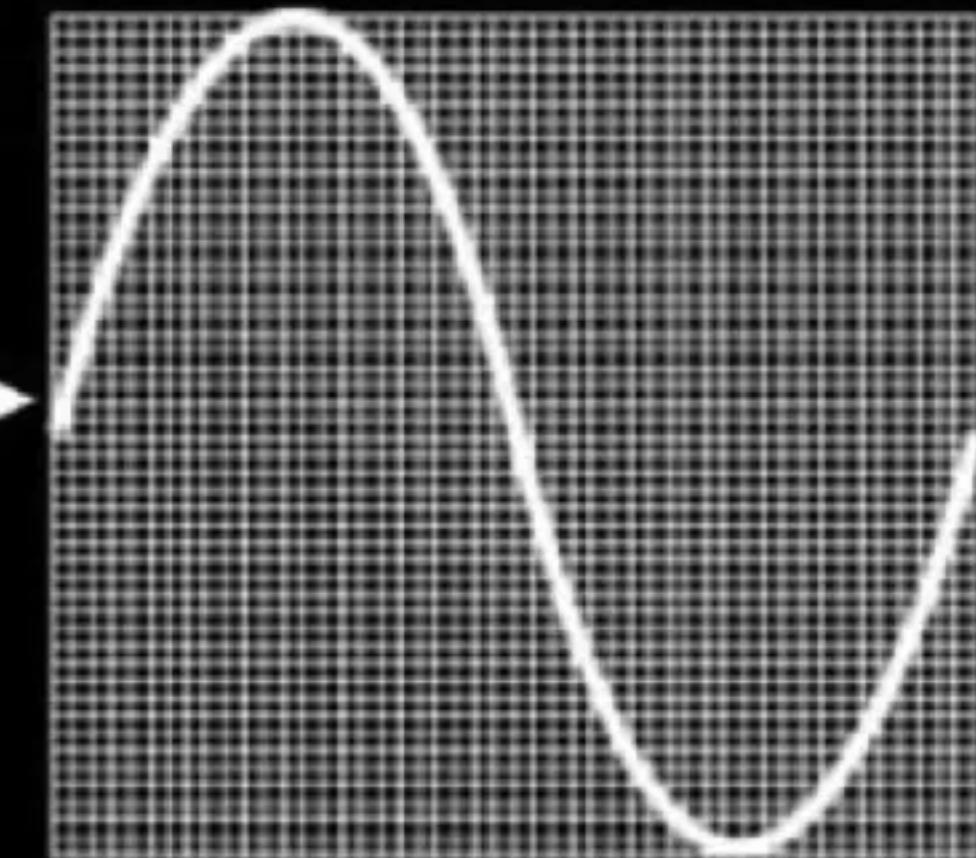
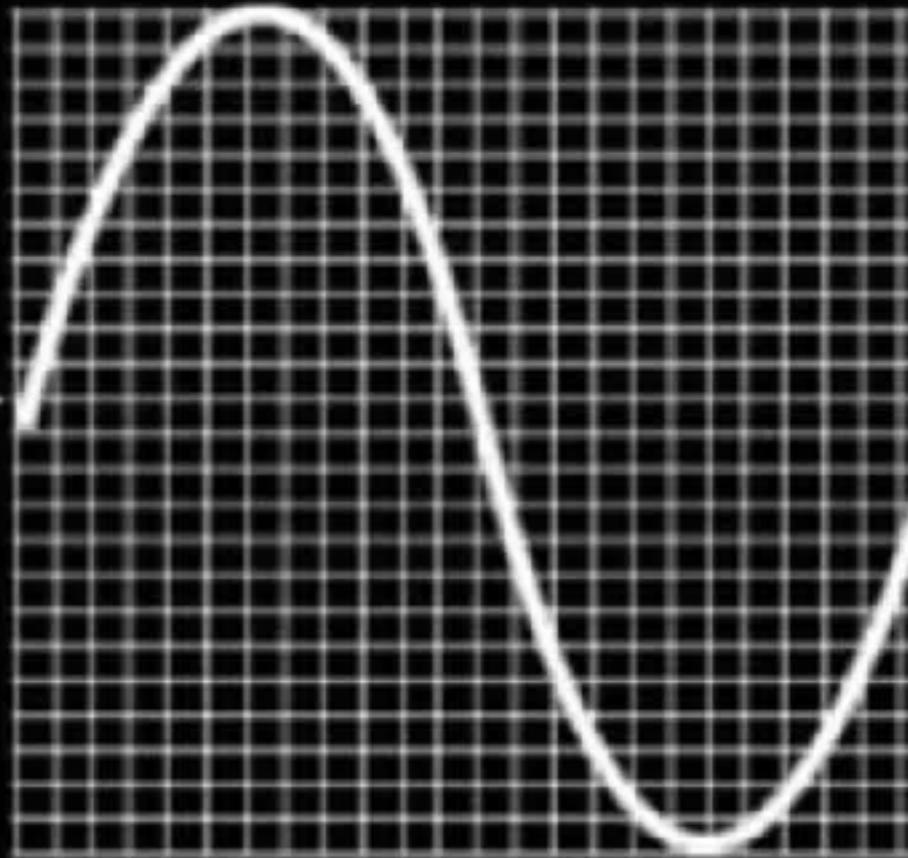
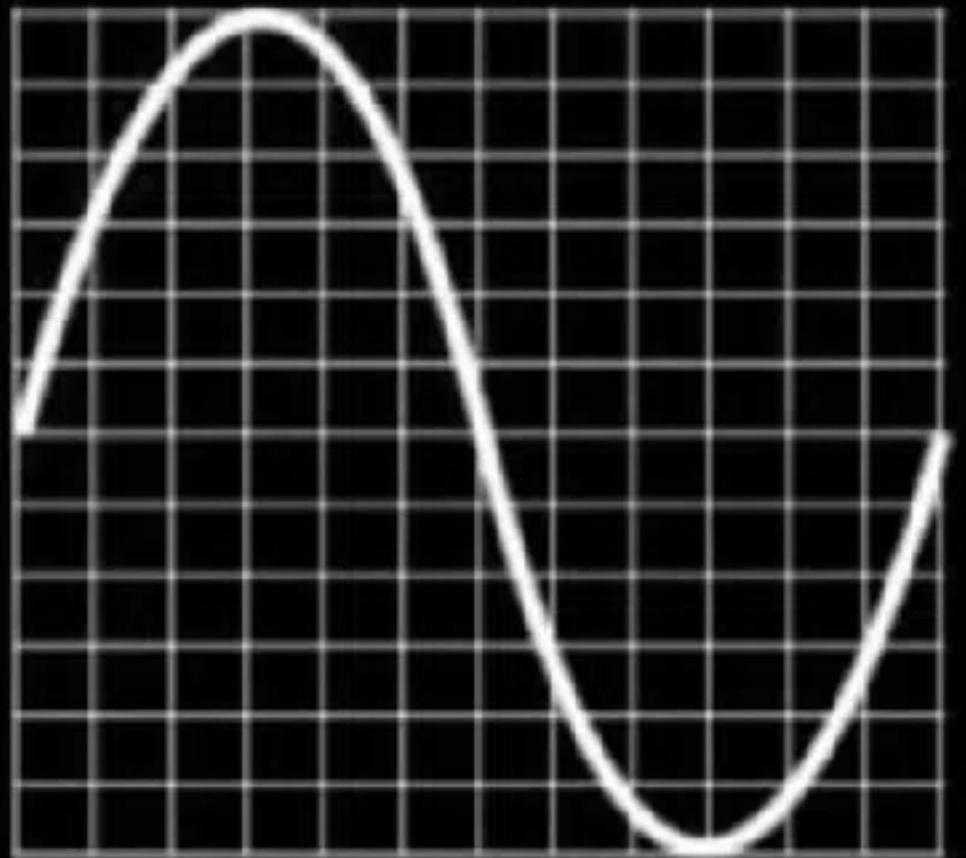
Catie!
catybyrd@gmail.com

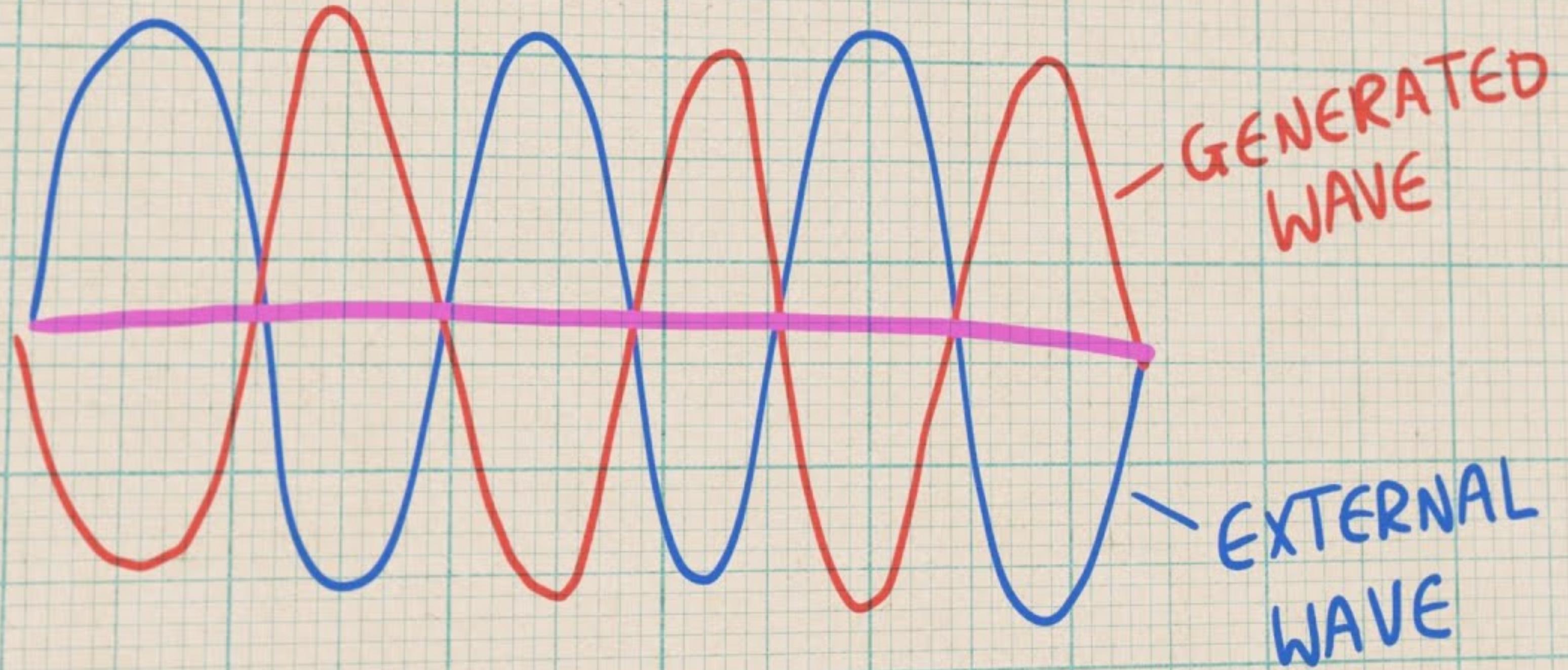
waves



Sample Rate

Bit Depth





S
C
I
T
H
U
B



youtube.com/watch?v=luv6hY6zsdo (/Veritasium)

light

—

visible



STEM
@stem_feed

...

Isaac Newton designing the cover for Pink Floyd's album.



twitter.com/stem_feed/status/1533465304654700544

The Dark Side of the Moon



Studio album by Pink Floyd

Released 1 March 1973

Recorded 31 May 1972 – 9 February 1973^[1]

← Increasing Frequency (ν)

$10^{24} \quad 10^{22} \quad 10^{20} \quad 10^{18} \quad 10^{16} \quad 10^{14} \quad 10^{12} \quad 10^{10} \quad 10^8 \quad 10^6 \quad 10^4 \quad 10^2 \quad 10^0$ ν (Hz)

γ rays

X rays

UV

IR

Microwave

FM

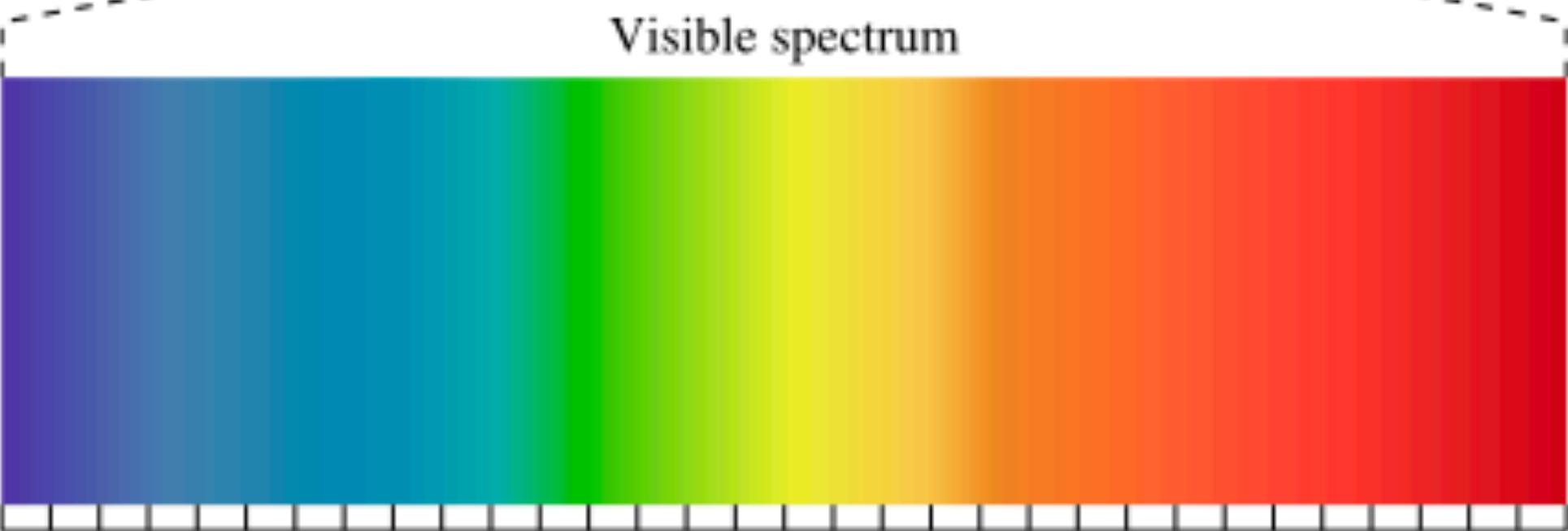
Radio waves

Long radio waves

$10^{-16} \quad 10^{-14} \quad 10^{-12} \quad 10^{-10} \quad 10^{-8} \quad 10^{-6} \quad 10^{-4} \quad 10^{-2} \quad 10^0 \quad 10^2 \quad 10^4 \quad 10^6 \quad 10^8$ λ (m)

Increasing Wavelength (λ) →

Visible spectrum



400

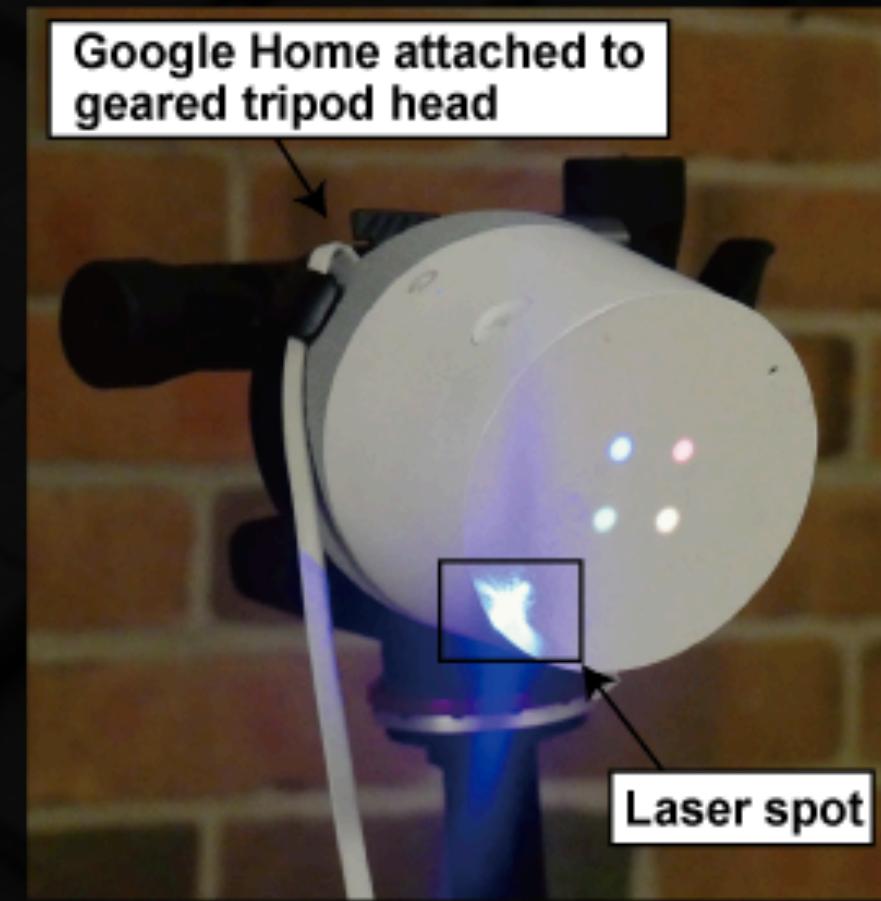
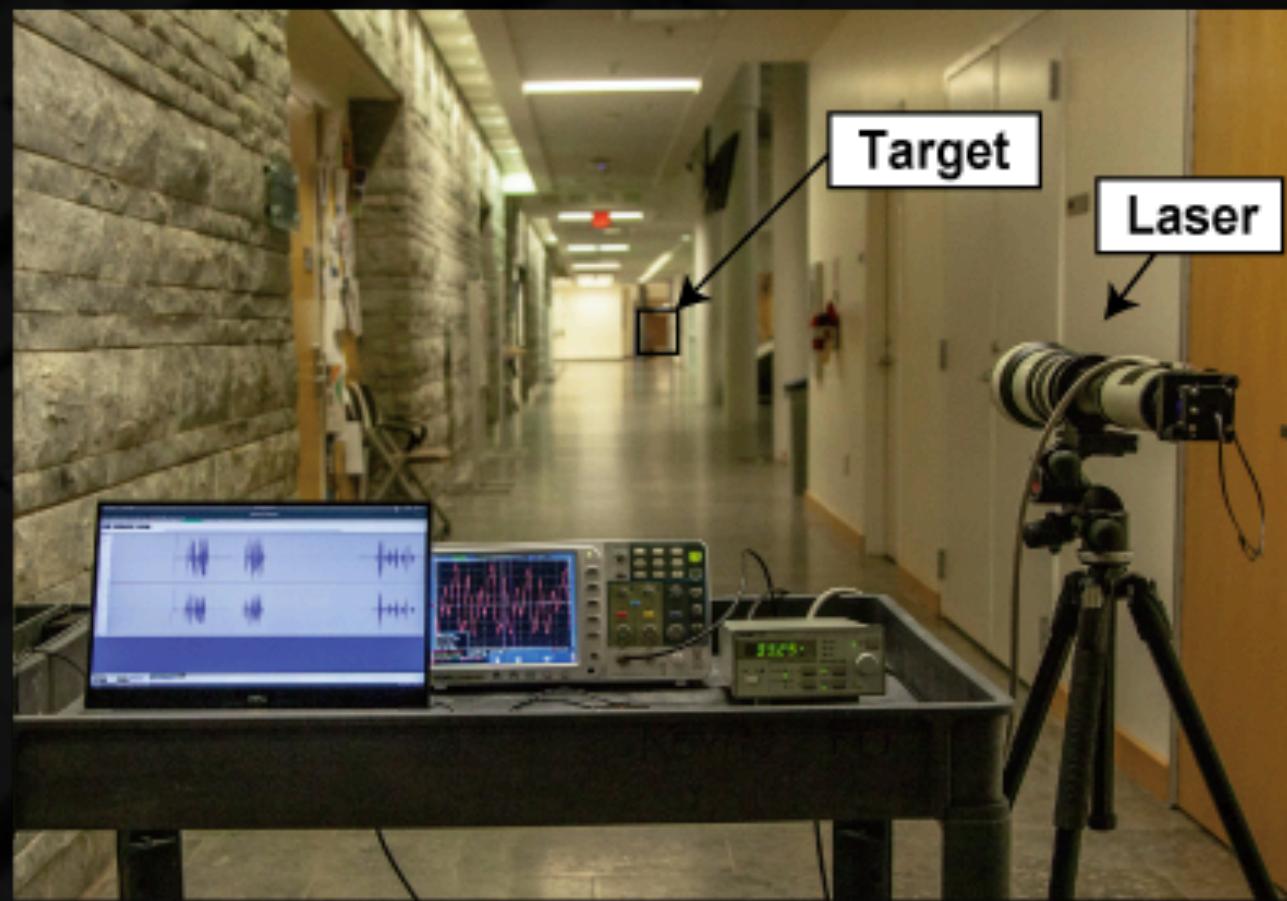
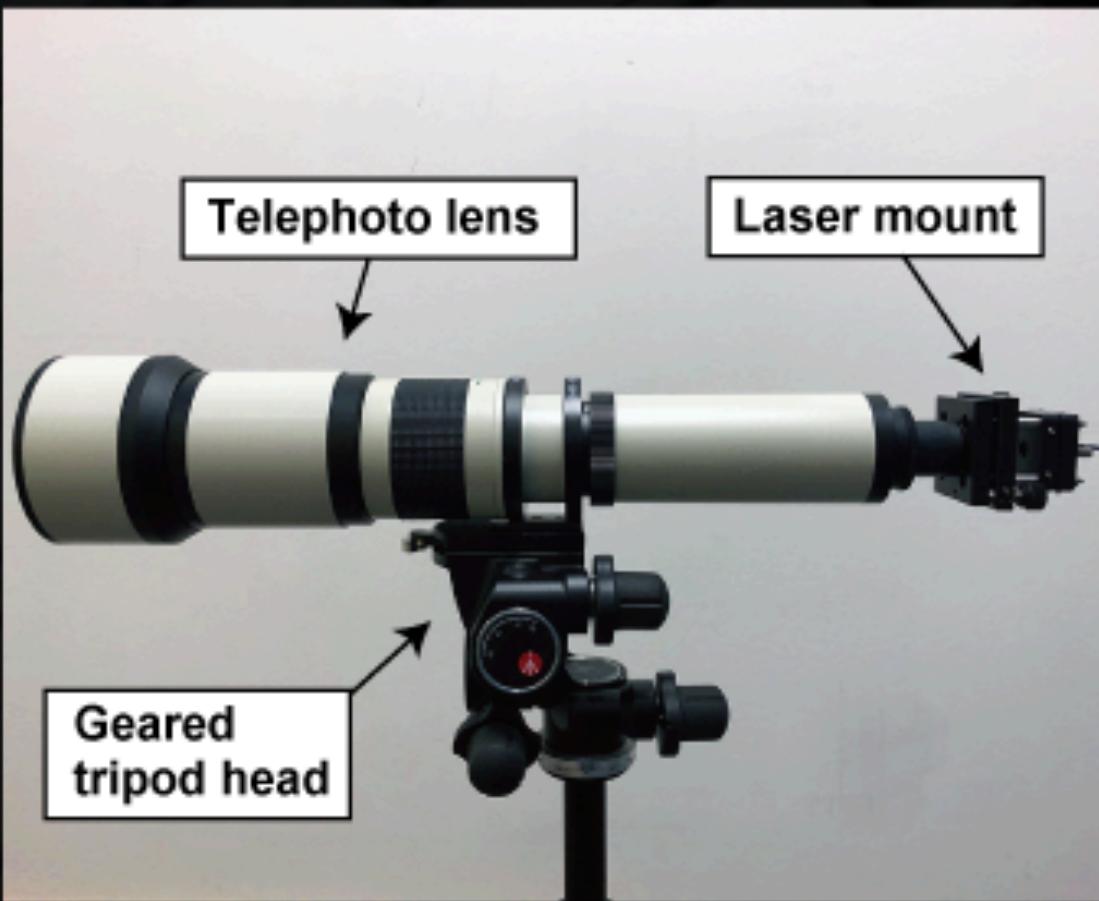
500

600

700

Increasing Wavelength (λ) in nm →

visible light fault injection

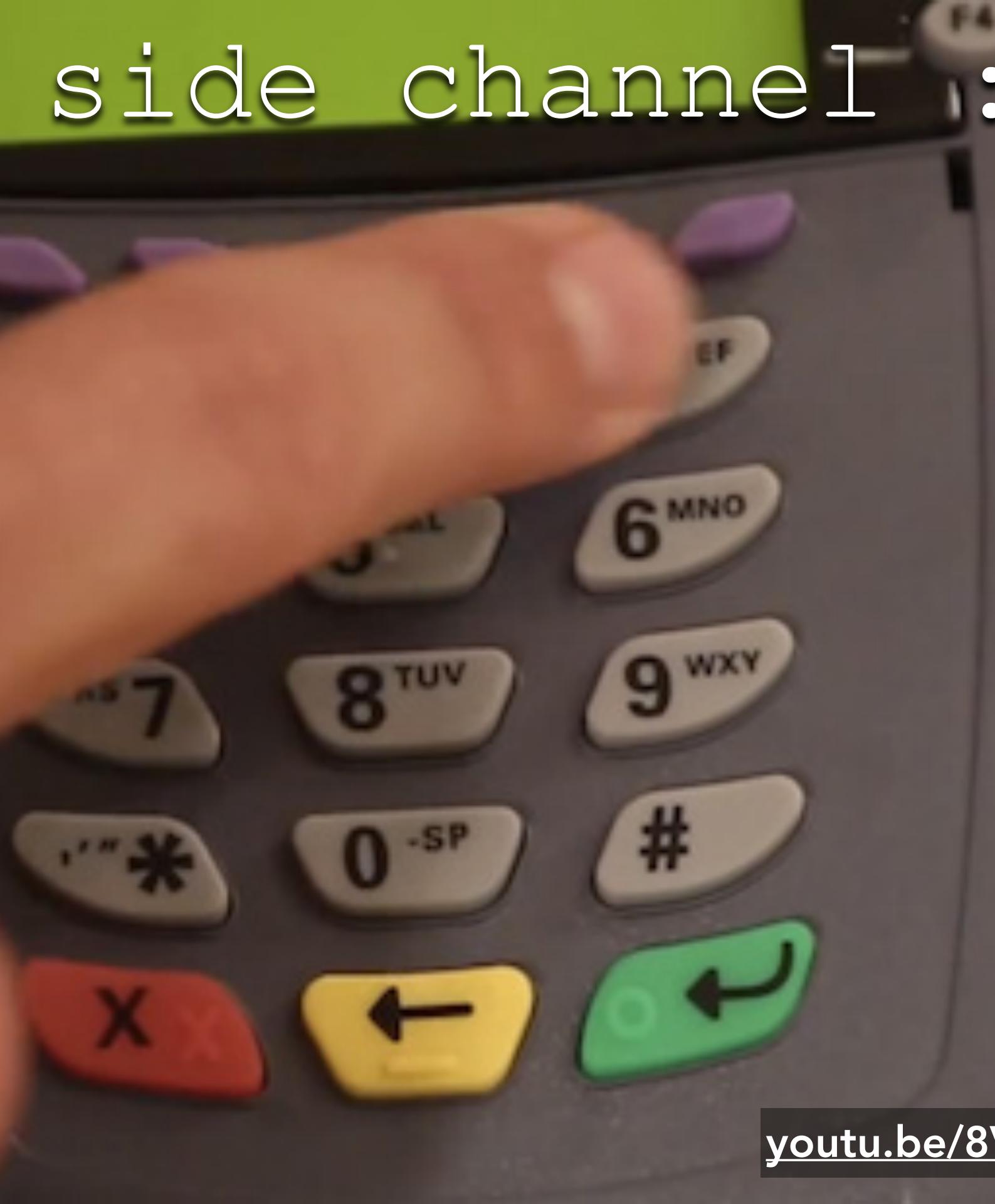


light

infrared

infra- from Latin, “below”

side channel :: infrared (IR)



light

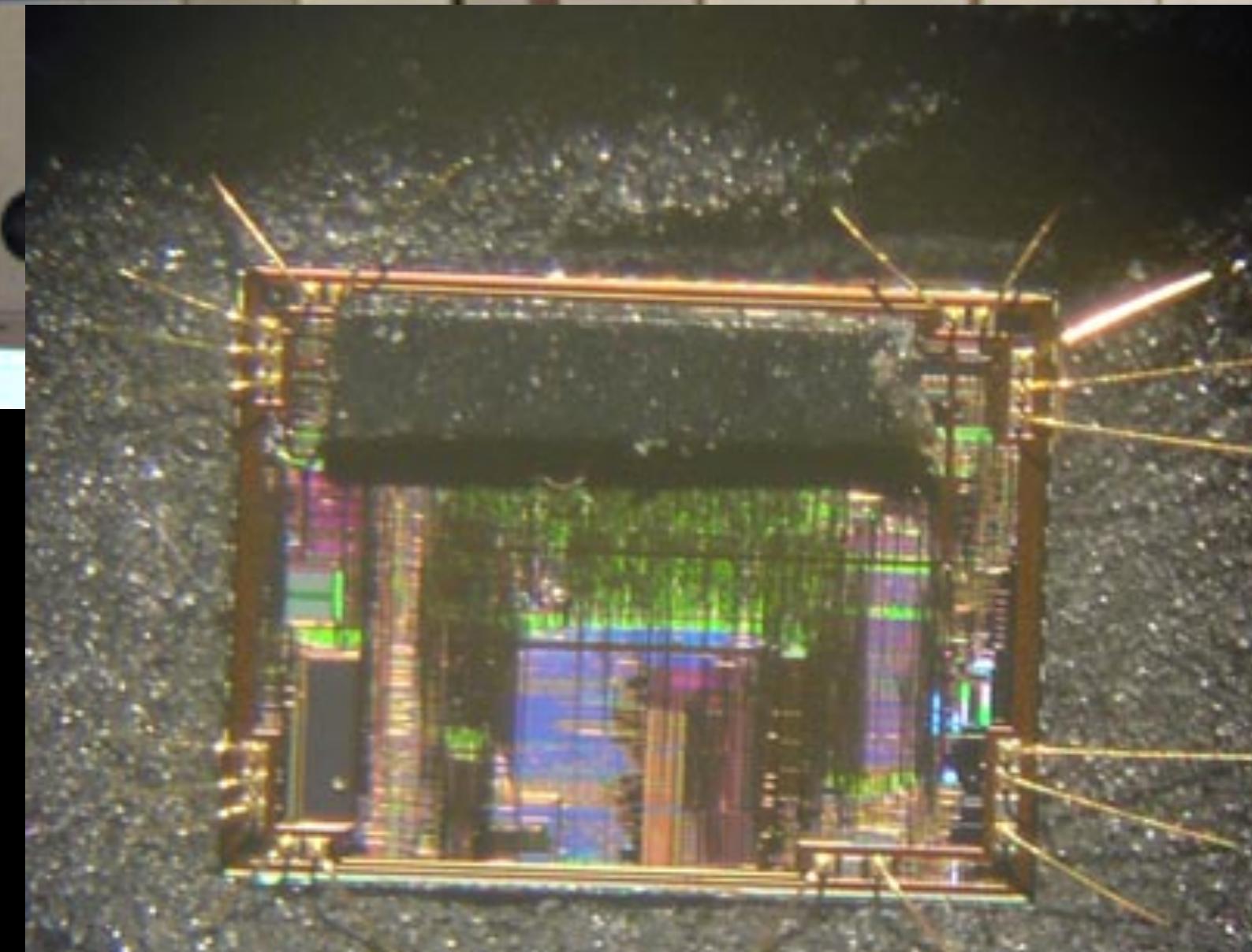
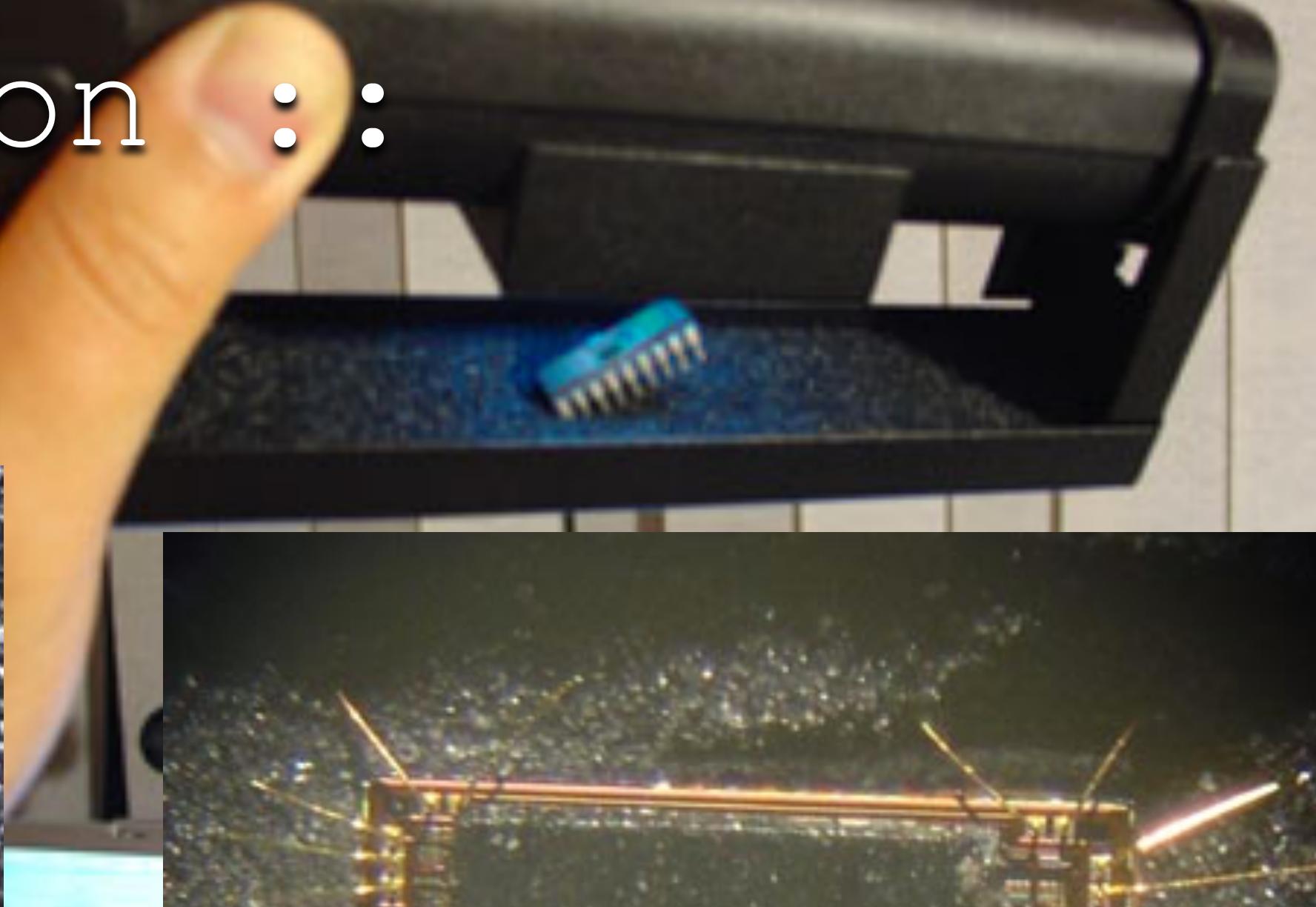
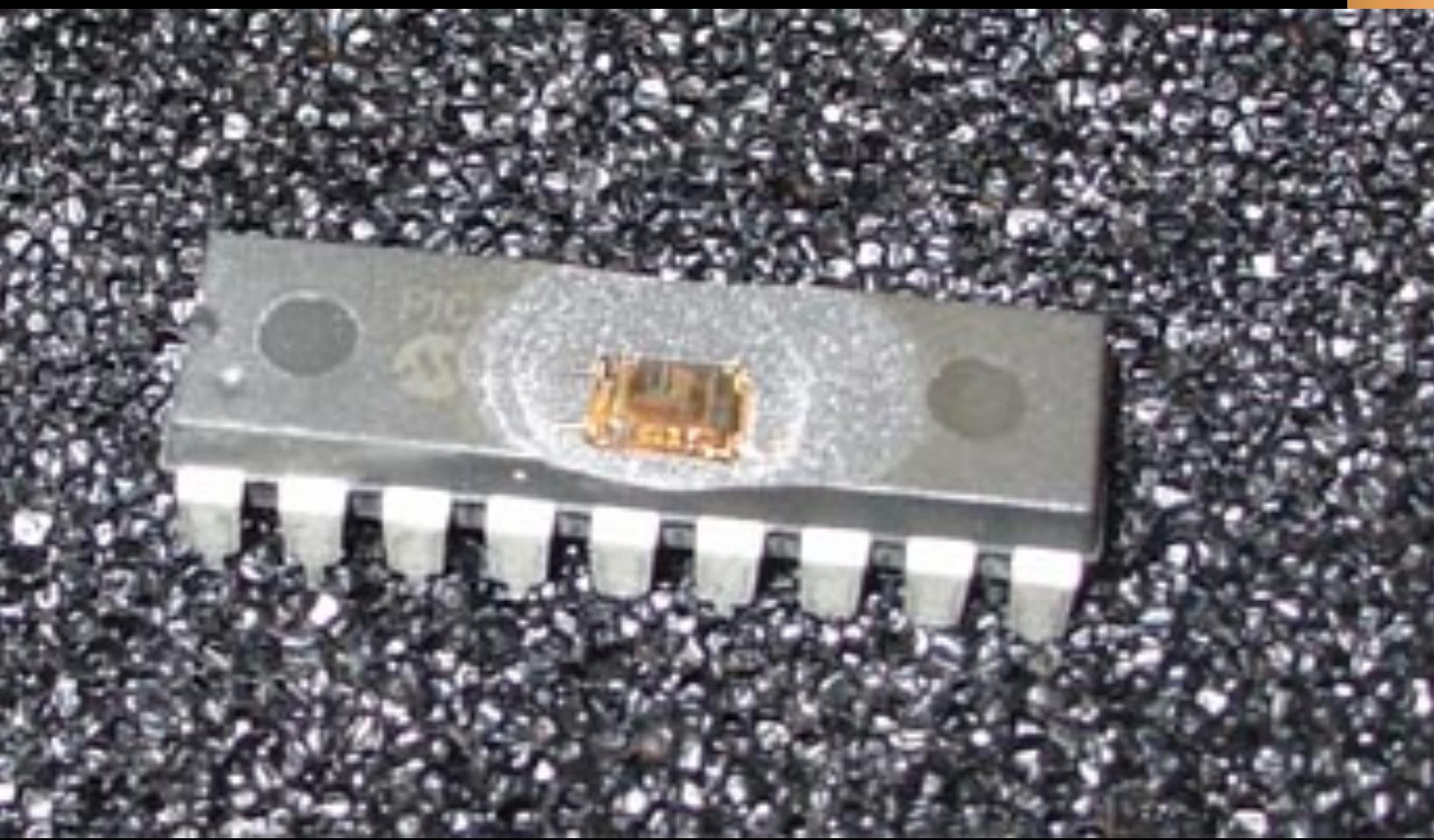
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ultraviolet

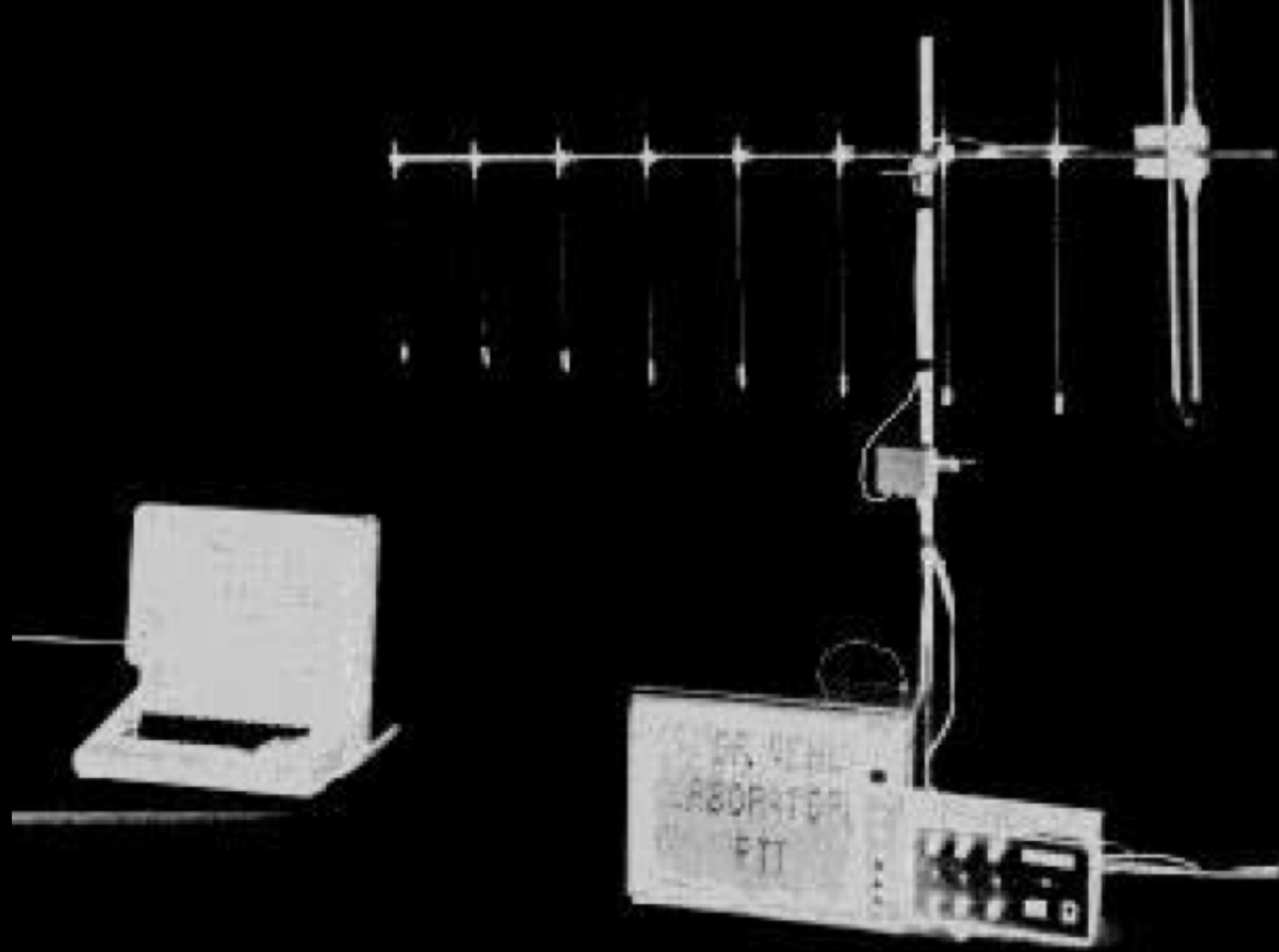
ultra- from Latin

“beyond” or “on the far side of”

fault injection ::
ultraviolet



radio



nsa.gov/

REDACTED

frequency/

REDACTED

pdf

← Increasing Frequency (ν)

$10^{24} \quad 10^{22} \quad 10^{20} \quad 10^{18} \quad 10^{16} \quad 10^{14} \quad 10^{12} \quad 10^{10} \quad 10^8 \quad 10^6 \quad 10^4 \quad 10^2 \quad 10^0$ ν (Hz)

γ rays

X rays

UV

IR

Microwave

FM

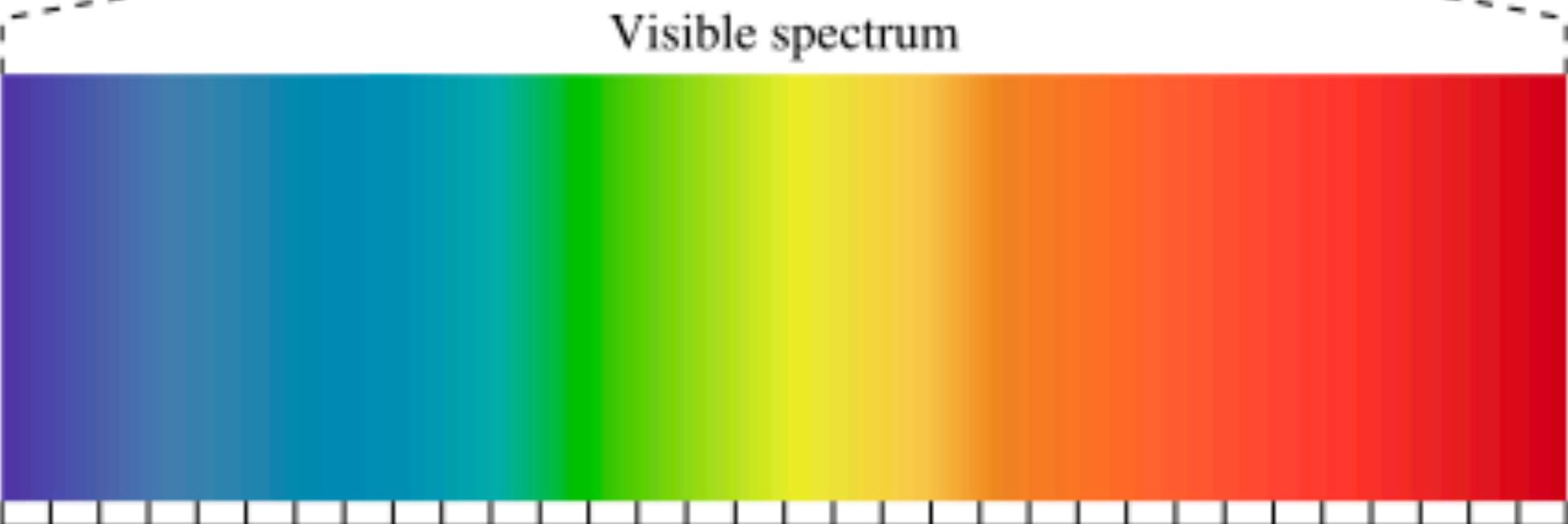
Radio waves

Long radio waves

$10^{-16} \quad 10^{-14} \quad 10^{-12} \quad 10^{-10} \quad 10^{-8} \quad 10^{-6} \quad 10^{-4} \quad 10^{-2} \quad 10^0 \quad 10^2 \quad 10^4 \quad 10^6 \quad 10^8$ λ (m)

Increasing Wavelength (λ) →

Visible spectrum



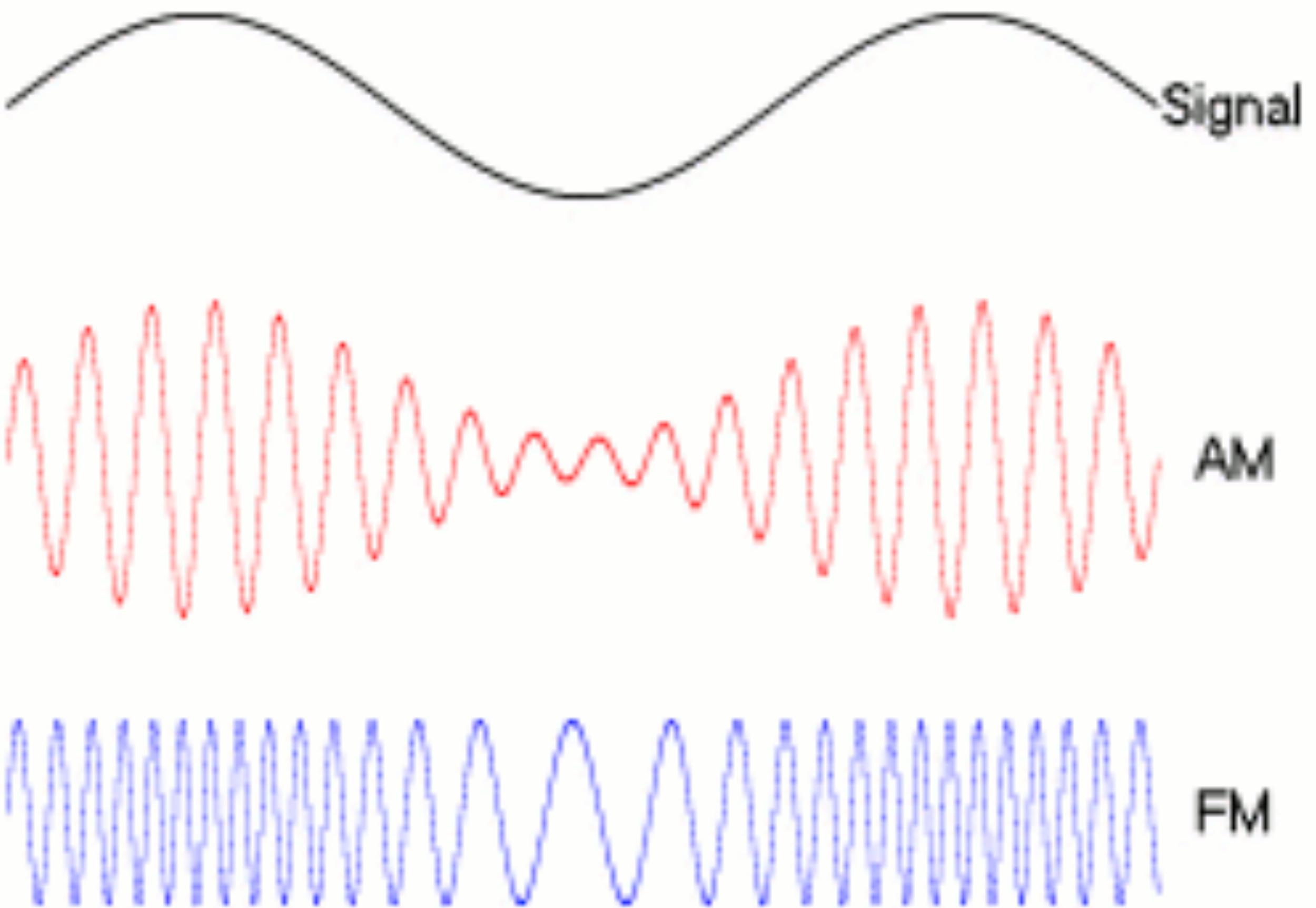
400

500

600

700

Increasing Wavelength (λ) in nm →



electro-
magnetism

electro- magnetism

electro- from Greek ‘ēlektron’, “amber”

electro- magnetism

electro- from Greek ‘ēlektron’, “amber”

magnetism from ‘magnētis lithos’, "Magnesian stone"

Alpha
Chemicals.com

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Fe₃O₄

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Rate Per Hour: \$ 1.50
Coin or Credit Card
Max. Stay 2 hours

MORE TIME LESS CANCEL OK



Insert coin or credit card to start



COINS

sound

sound

audible

(meaning, to most humans)

side channel ::
audible sound



sound

ultra sound

ultra- from Latin

“beyond” or “on the far side of”



energy
conversion

light + sound

laser
microphone

Leon Theremin



Lev Termen demonstrating the theremin,
December 1927

Born	Lev Sergeyevich Termen 27 August [O.S. 15 August] 1896 Saint Petersburg, Russian Empire
Died	3 November 1993 (aged 97) Moscow, Russia
Occupation(s)	Engineer, physicist
Known for	Theremin, The Thing

The Theremin



Leon Theremin



Lev Termen demonstrating the theremin,
December 1927

Born

Lev Sergeyevich
Termen
27 August [O.S. 15
August] 1896
Saint Petersburg,
Russian Empire

Died

3 November 1993
(aged 97)
Moscow, Russia

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Engineer, physicist

Known for

Theremin, The Thing

The Thing



Leon Theremin



Lev Termen demonstrating the theremin,
December 1927

Born Lev Sergeyevich
 Termen

27 August [O.S. 15
August] 1896
Saint Petersburg,
Russian Empire

Died 3 November 1993
 (aged 97)
 Moscow, Russia

Occupation(s) Engineer, physicist

Known for Theremin, The Thing

k g b

light + sound

~~Laser~~ optical
microphone

Sniffing Keystrokes With Lasers/Voltmeters



Side Channel Attacks Using Optical Sampling Of Mechanical Energy And Power Line Leakage

Andrea Barisani

Chief Security Engineer

<andrea@inversopath.com>

Daniele Bianco

Hardware Hacker

<daniele@inversopath.com>

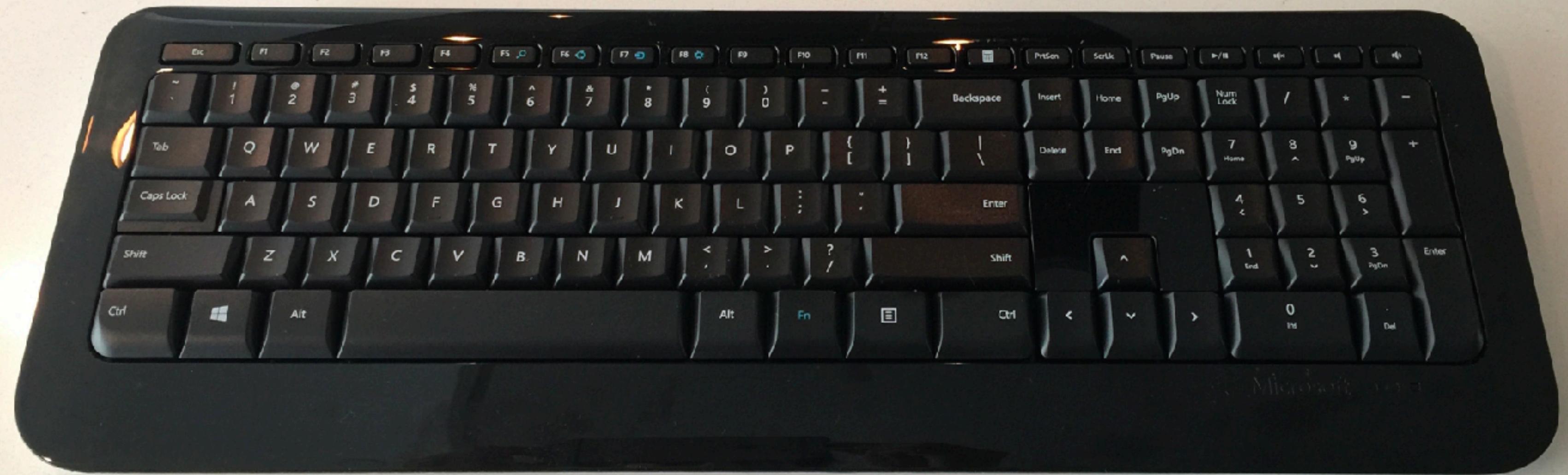
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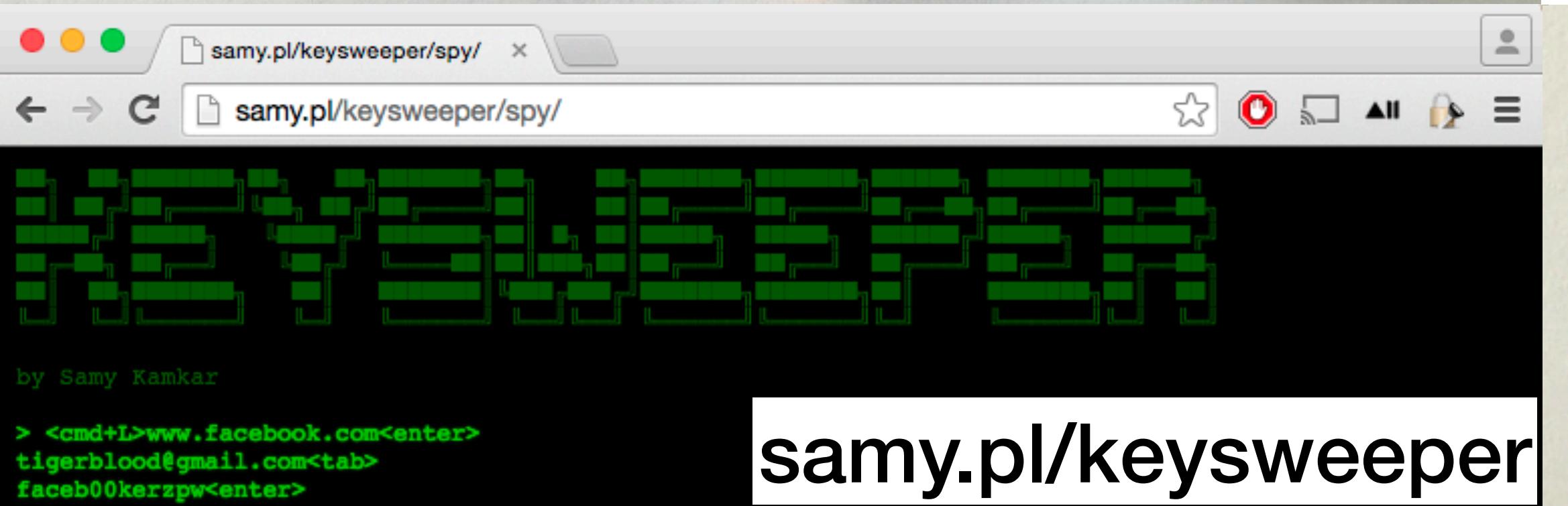
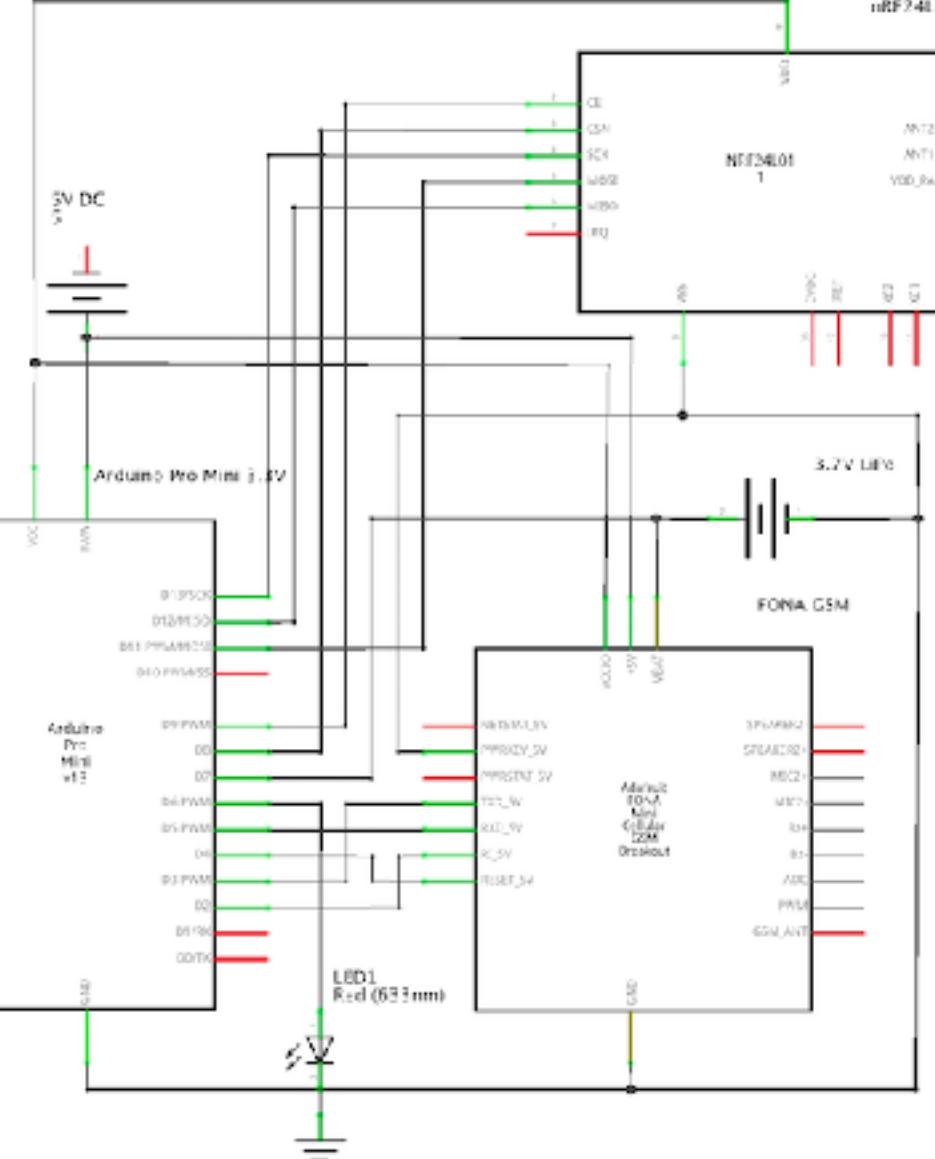
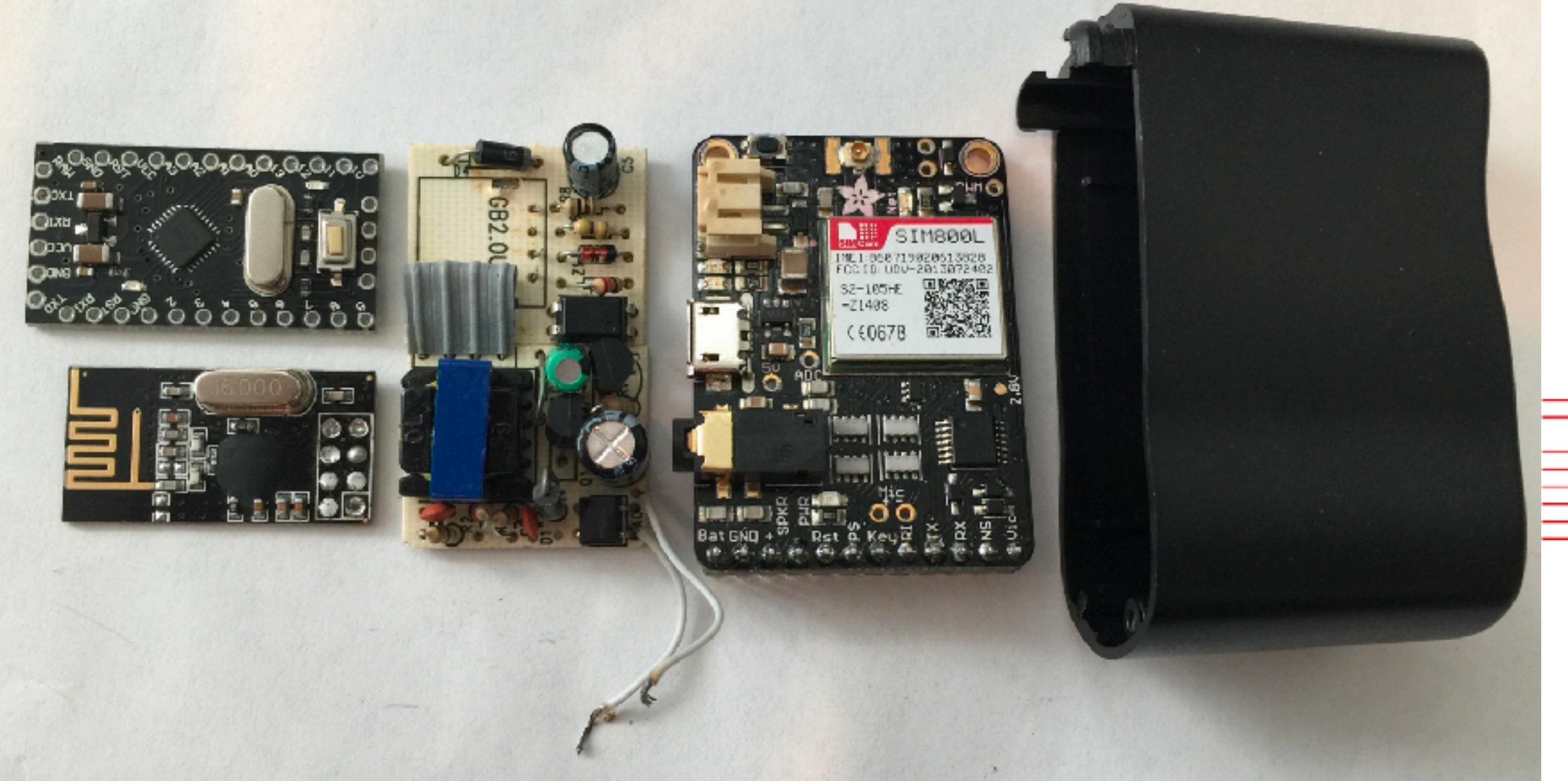
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Sniffing Keystrokes With Lasers/Voltmeters

DC17: Andrea Barisani & Daniele Bianco: Sniffing Keystrokes With Lasers/Voltmeters







Private Industry Notification

FEDERAL BUREAU OF INVESTIGATION, CYBER DIVISION



The KeySweeper device in use.

Wireless Keystroke Logger Disguised as USB Device Charger Targets Wireless Keyboards

Summary

KeySweeper is a covert device that resembles a functional Universal Serial Bus (USB) enabled device charger which conceals hardware capable of harvesting keystrokes from certain wireless keyboards. If placed strategically in an office or other location where individuals



Private Industry Notification

FEDERAL BUREAU OF INVESTIGATION, CYBER DIVISION

Additional best practices to prevent a compromise could include but are not limited to office policies that address mobile device chargers:

- Limiting which outlets are available for device charging
- Knowing whose chargers are currently being used
- Immediate removal of an unknown charger from the office facility (although the optional backup battery can allow data theft even when unplugged)

The KeySweeper device in use.

placed strategically in an office or other location where individuals

info.publicintelligence.net/FBI-KeySweeper.pdf



Private Industry Notification

FEDERAL BUREAU OF INVESTIGATION, CYBER DIVISION

Additional best practices to prevent a compromise could include but are not limited to office policies that address mobile device chargers:

- Limiting which chargers are available for device charging
- Knowing whose chargers are currently being used
- Immediate removal of an unknown device from the office facility (although the optional backup battery can allow data theft even when unplugged)

The KeySweeper device in use.

placed strategically in an office or other location where individuals

Sniffing Keystrokes With Lasers/Voltmeters



Side Channel Attacks Using Optical Sampling Of Mechanical Energy And Power Line Leakage

Andrea Barisani

Chief Security Engineer

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Daniele Bianco

Hardware Hacker

<daniele@inversopath.com>

INVERSE  PATH

<http://www.inversopath.com>

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Sniffing Keystrokes With Lasers/Voltmeters

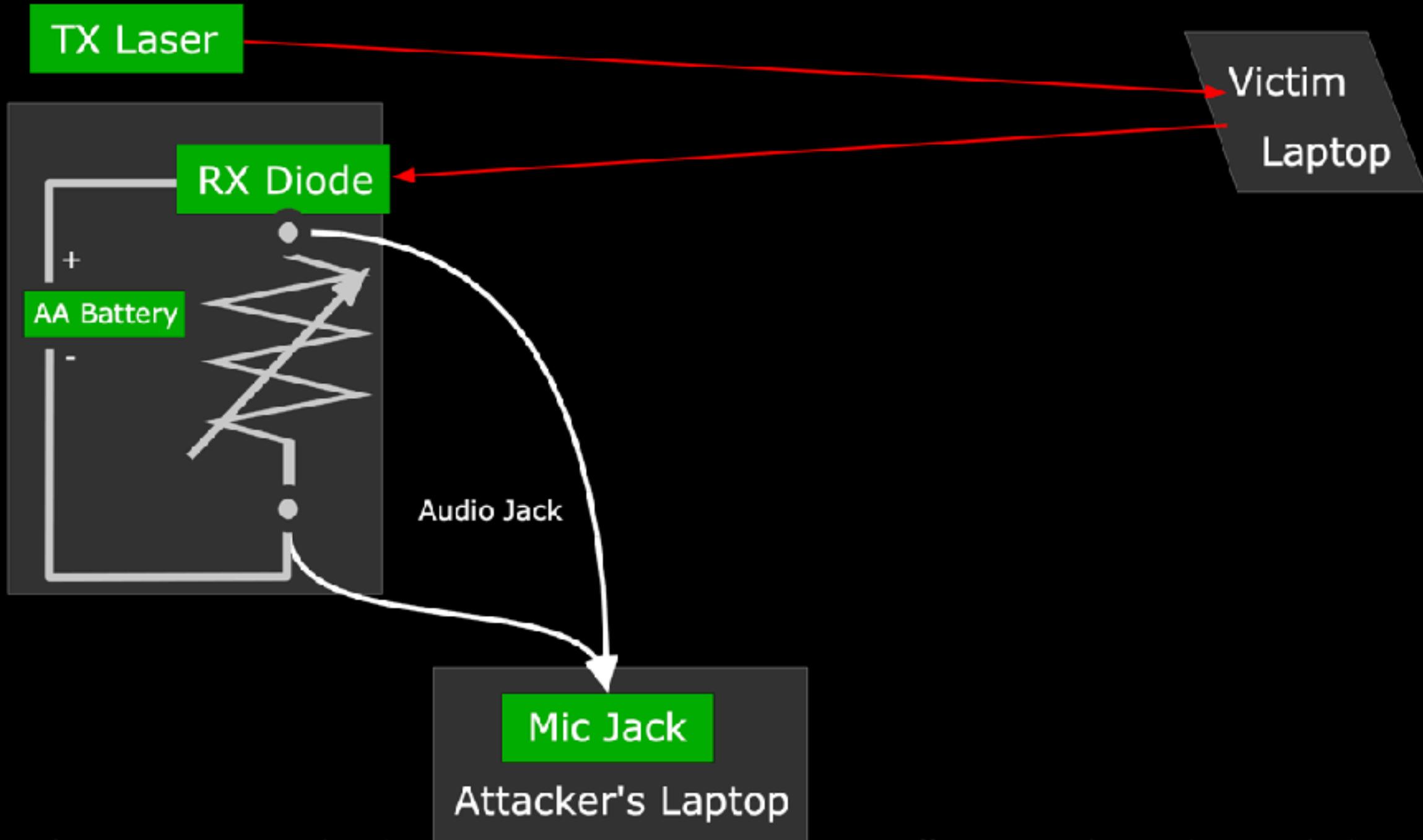
Laser Microphone Assembly



- 1 x Laser (more expensive lasers means more range)
- 1 x Photoresistor or Photodiode
- 1 x Resistor
- 1 x AA Battery
- 1 x Universal Power Adapter
- 1 x Jack Cable
- 1 x Laptop with sound card
- 2 x Tripod
- 1 x Focusing lens (for long distances)

\$ 79.99

Diagram



Copyright 2009 Inverse Path Ltd.

Sniffing Keystrokes With Lasers/Voltmeters

more amazing research

- Ben Nassi
Lamphone, Glowworm, ...
- Andrea Barisani & Daniele Bianco
Sniffing Keystrokes With Lasers
- Abe Davis, Michael Rubinstein, Neal Wadhwa, Gautham Mysore,
Frédo Durand, William T. Freeman
The Visual Microphone
- Joshua Harrison, Ehsan Toreini, and Maryam Mehrnezhad:
Keyboard Acoustic Side Channels
- Daniel Genkin, Adi Shamir, Eran Tromer:
Acoustic Cryptanalysis
- Li Zhuang, Feng Zhou, J. D. Tygar:
Keyboard Acoustic Emanations Revisited
- NSA: ANT catalog, XKeyscore, ...
- KGB: The Thing, ...

laser
microphone
improvements

laser
safety





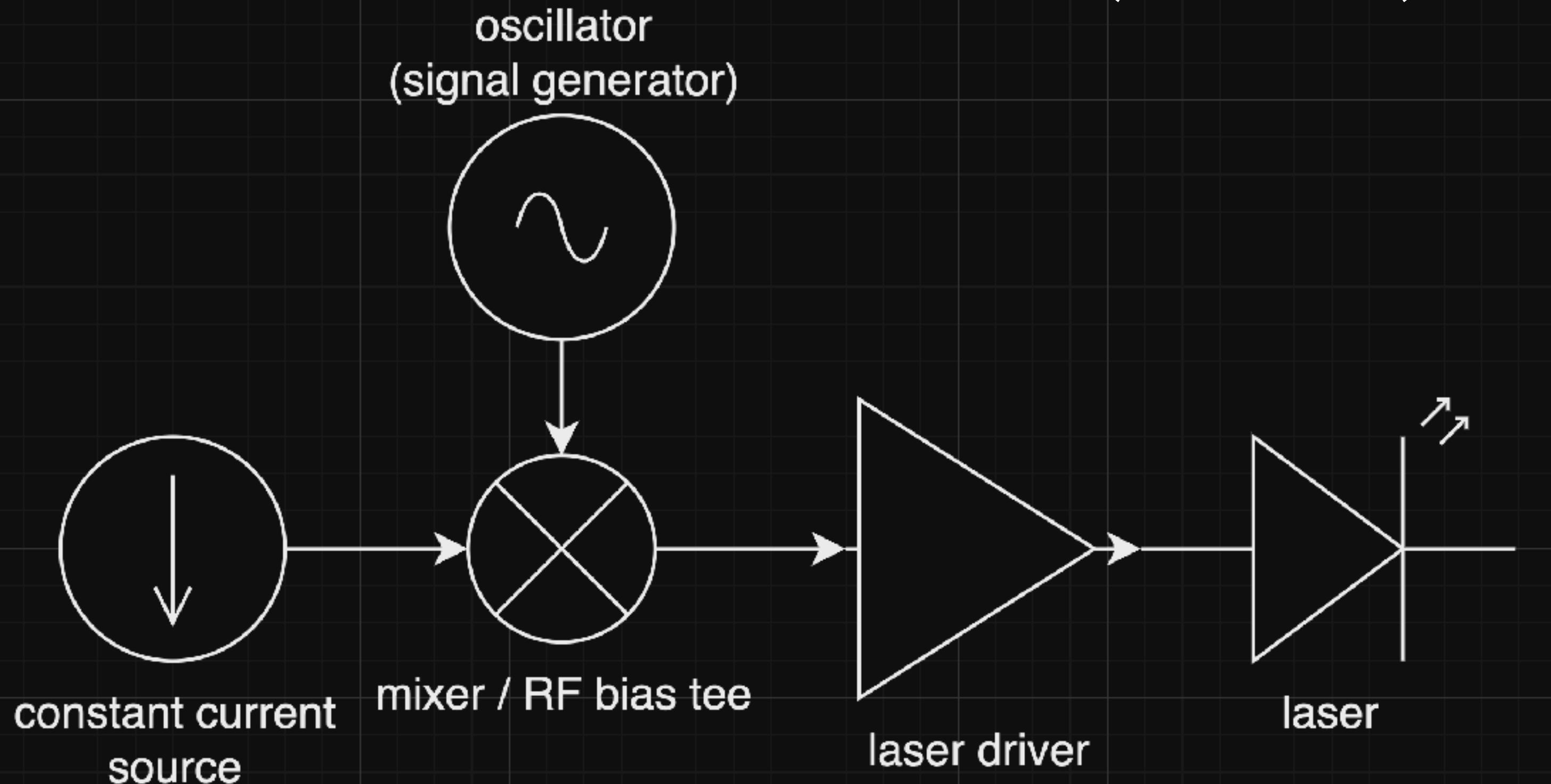
laser safety
ANSI Z136.1
/ EN 207

hardware

hardware tx side

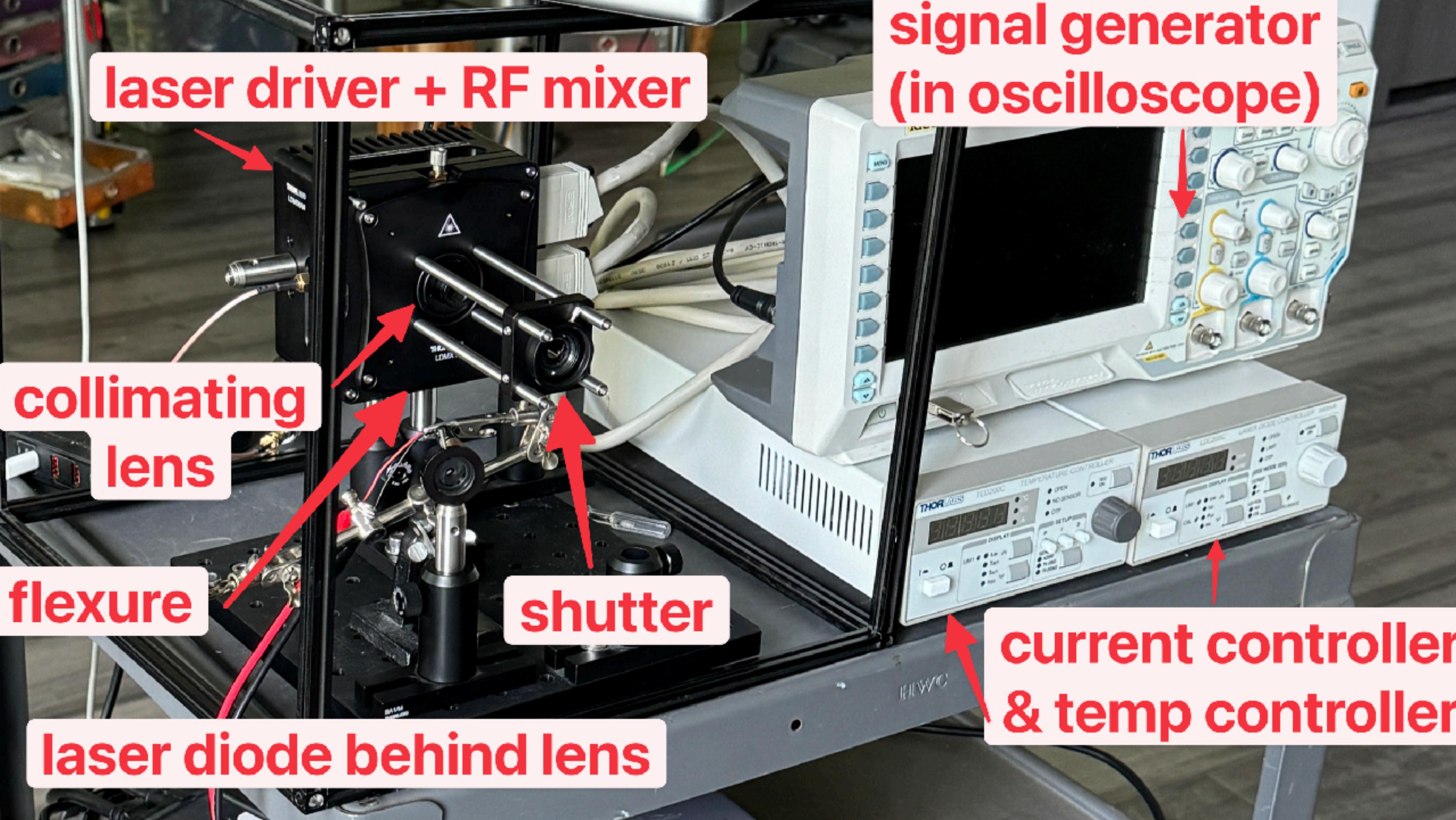


hardware (tx)

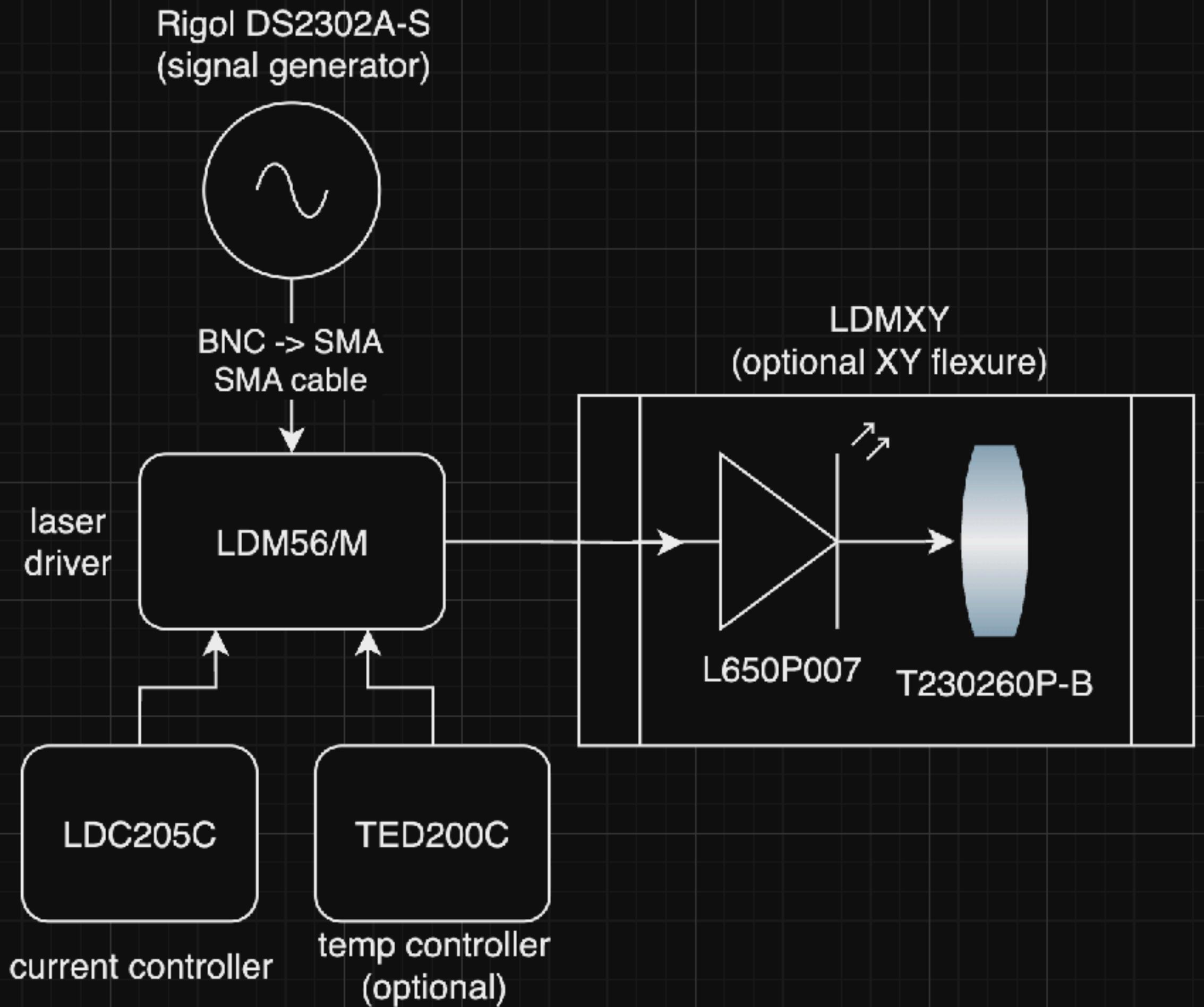


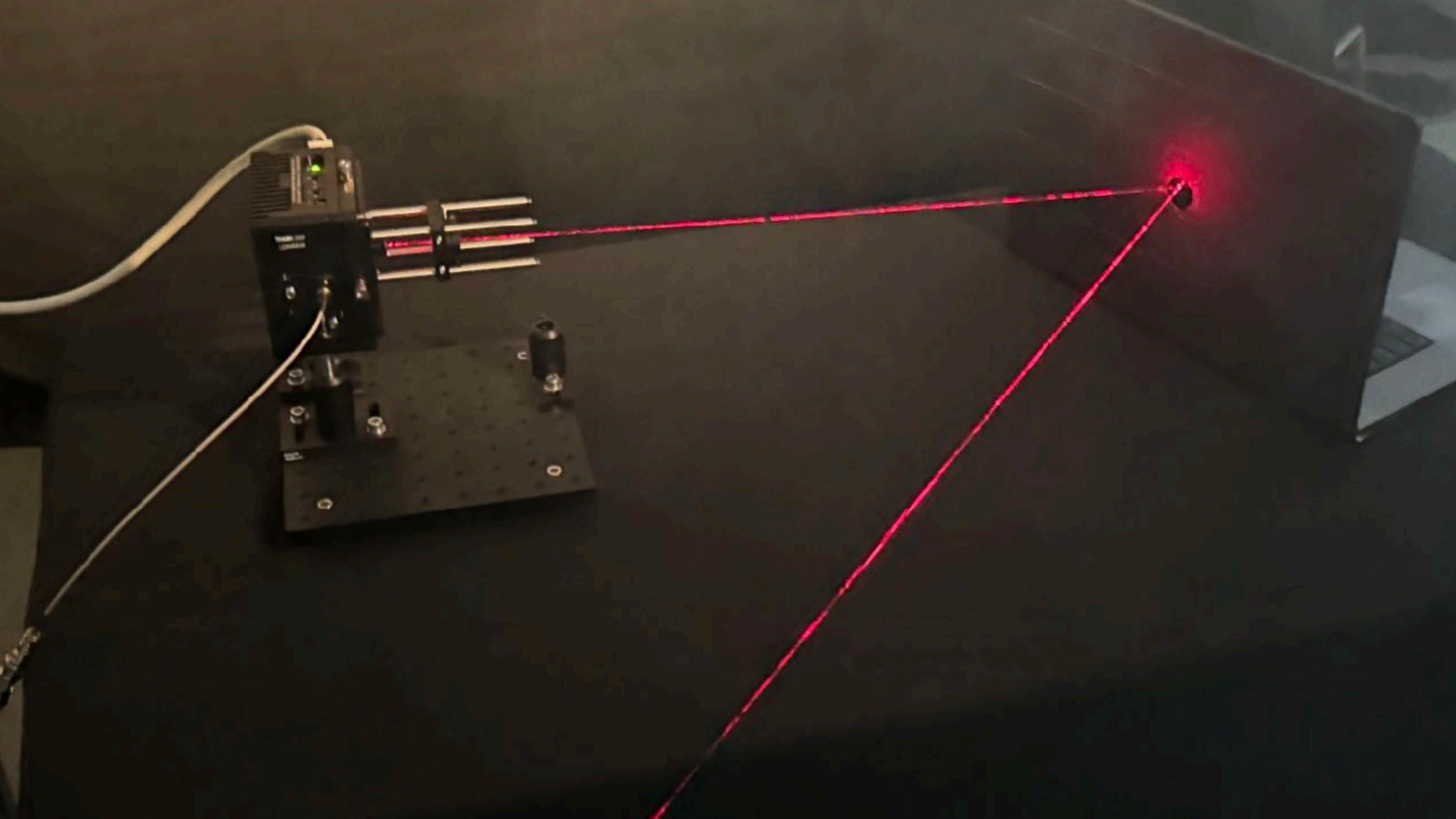
signal generator
(in oscilloscope)

laser driver + RF mixer



our
tx
side



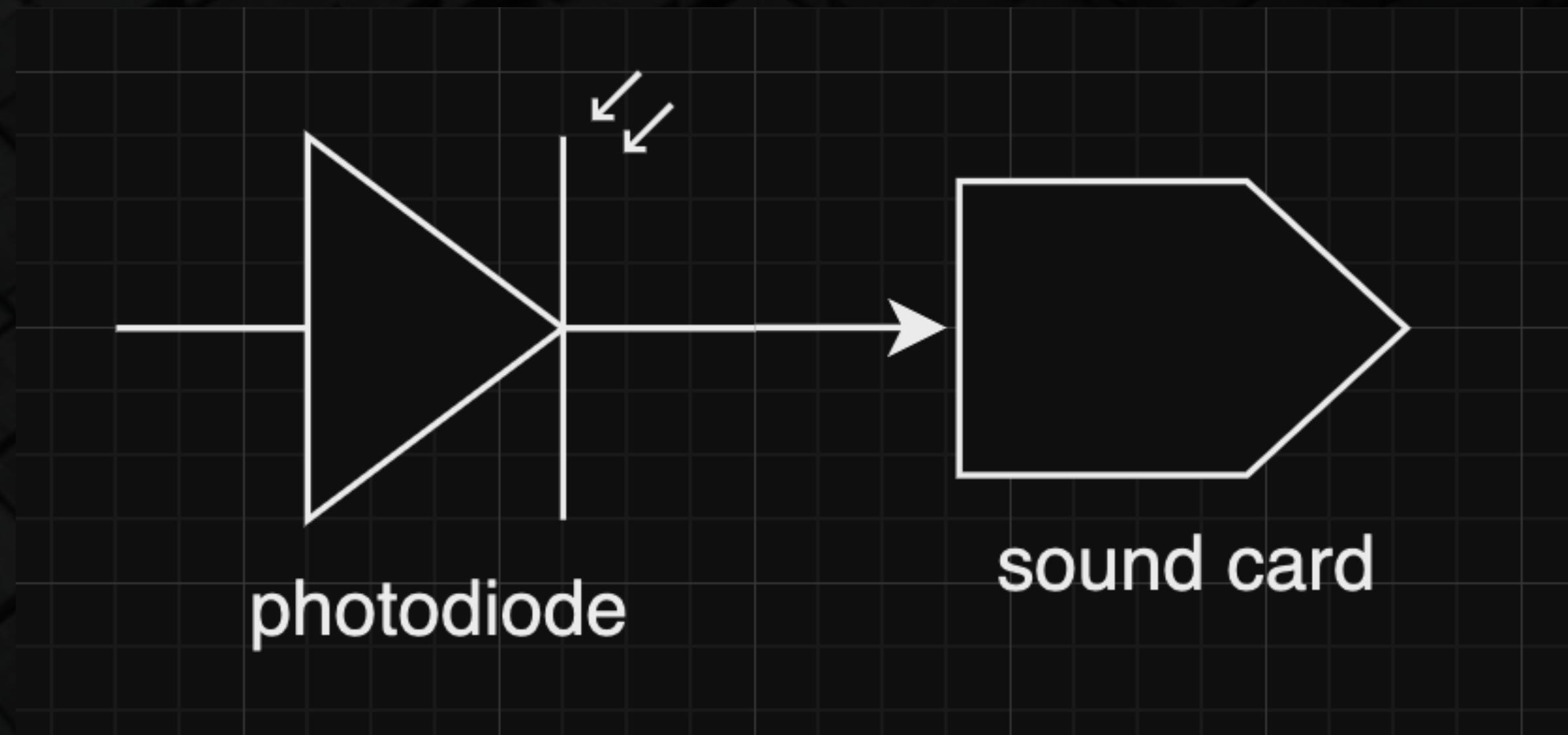


hardware
rx side

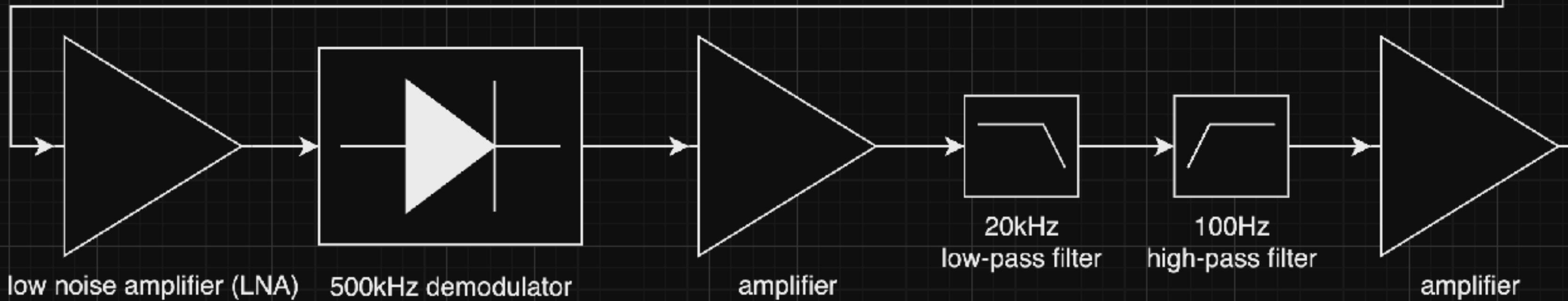
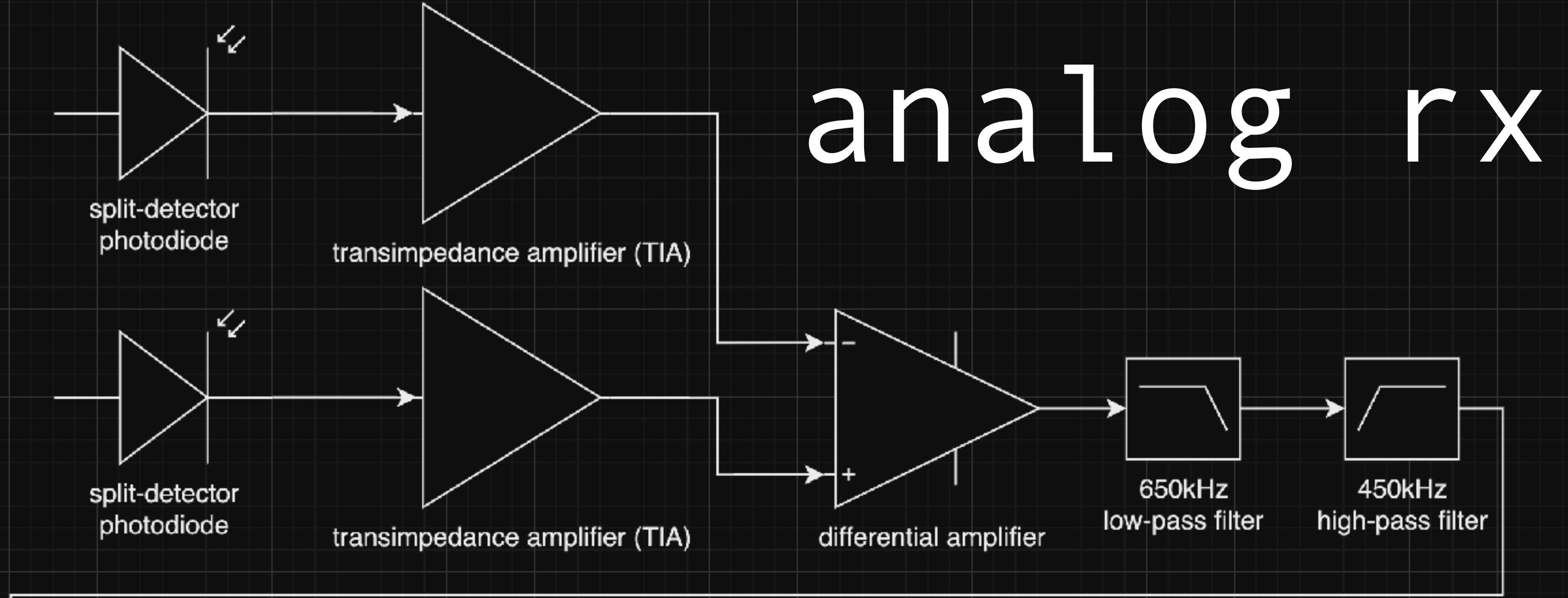


hardware (rx)

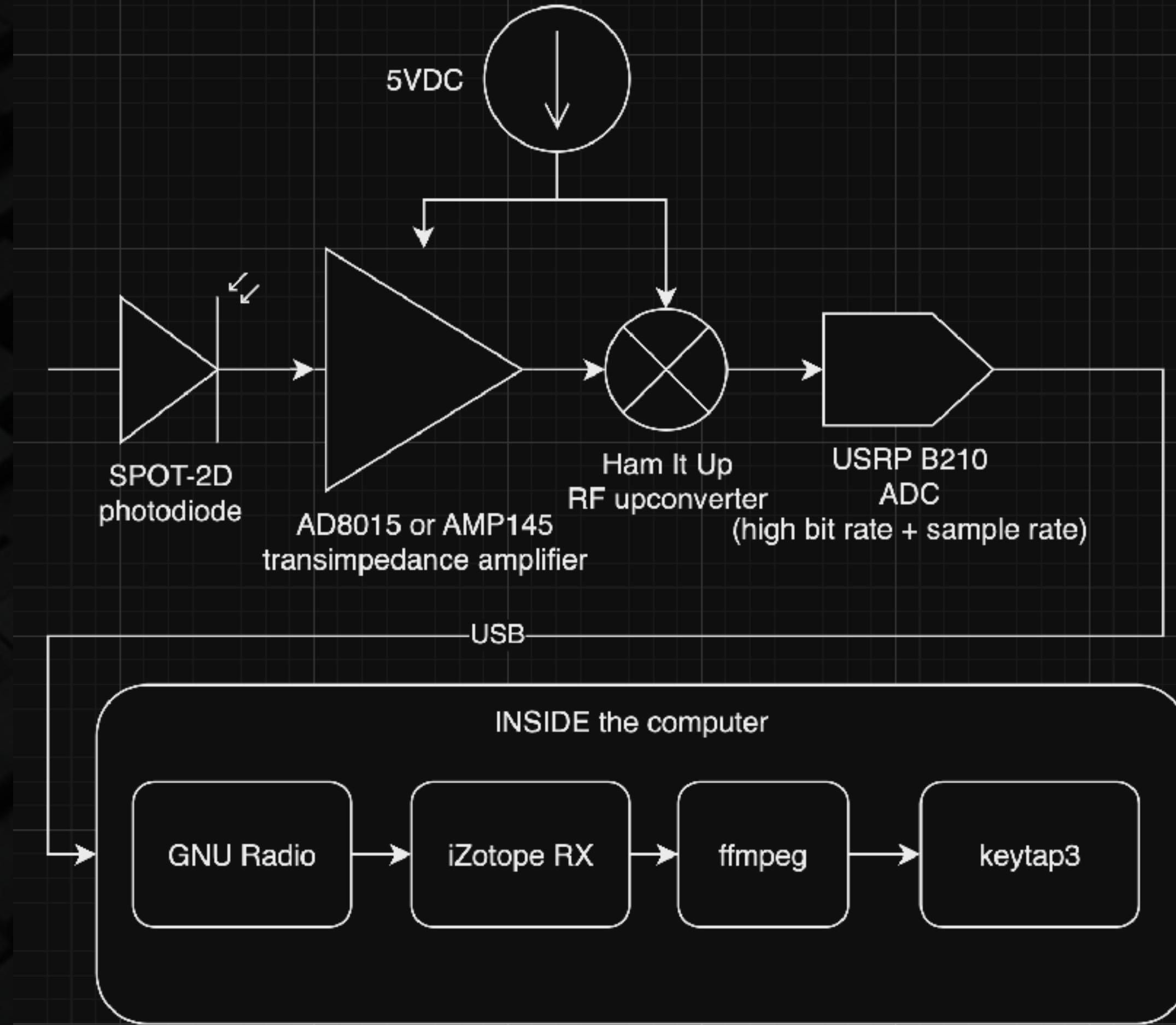
typical setup



analog rx



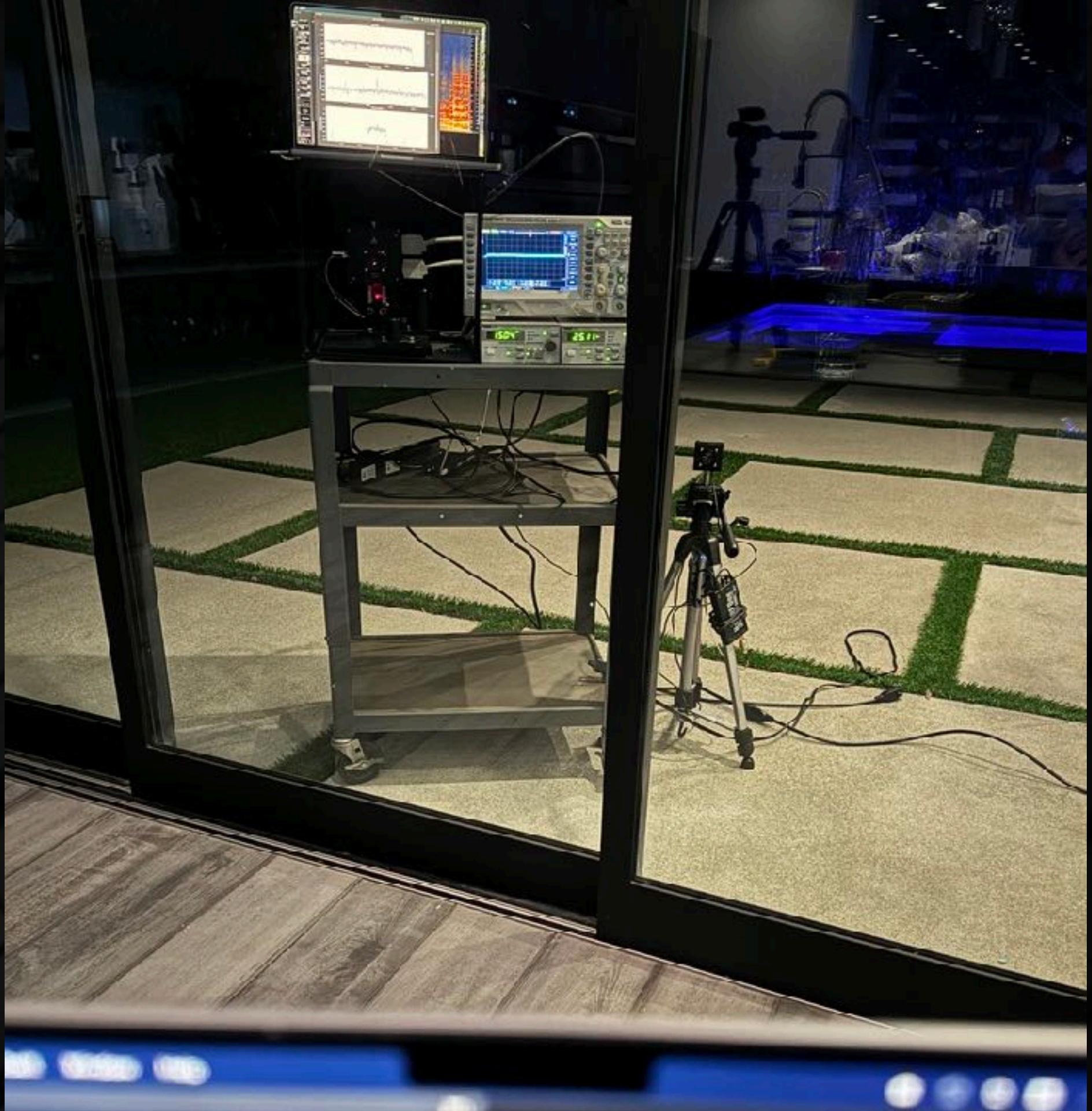
our
rx
side



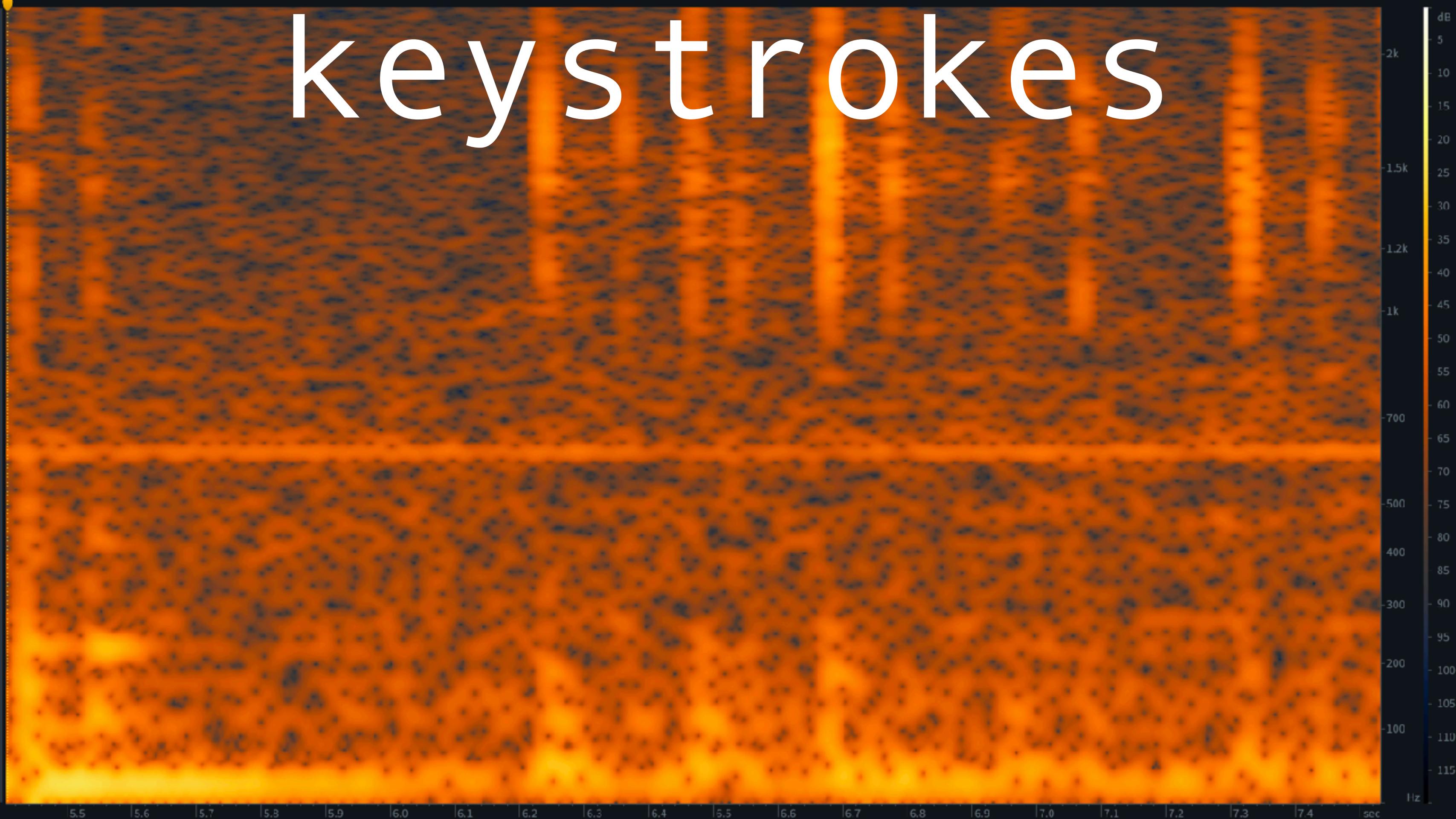
photodiode
lens

amplifier





key strokes



hardware (tx)

- red laser diode: L650P007 (7mW! **DANGER!**)
- IR laser diode: HL8338MG (50mW! **DANGER!**)
- Collimating lens: LT230260P-B
- Laser driver (w/bias tee+TEC): LDM56/M
- Current controller: LDC205C
- Signal generator/oscope: Rigol DS2302A-S
- Flexure adapter (optional): LDMXY
- Temp controller (optional): TED200C

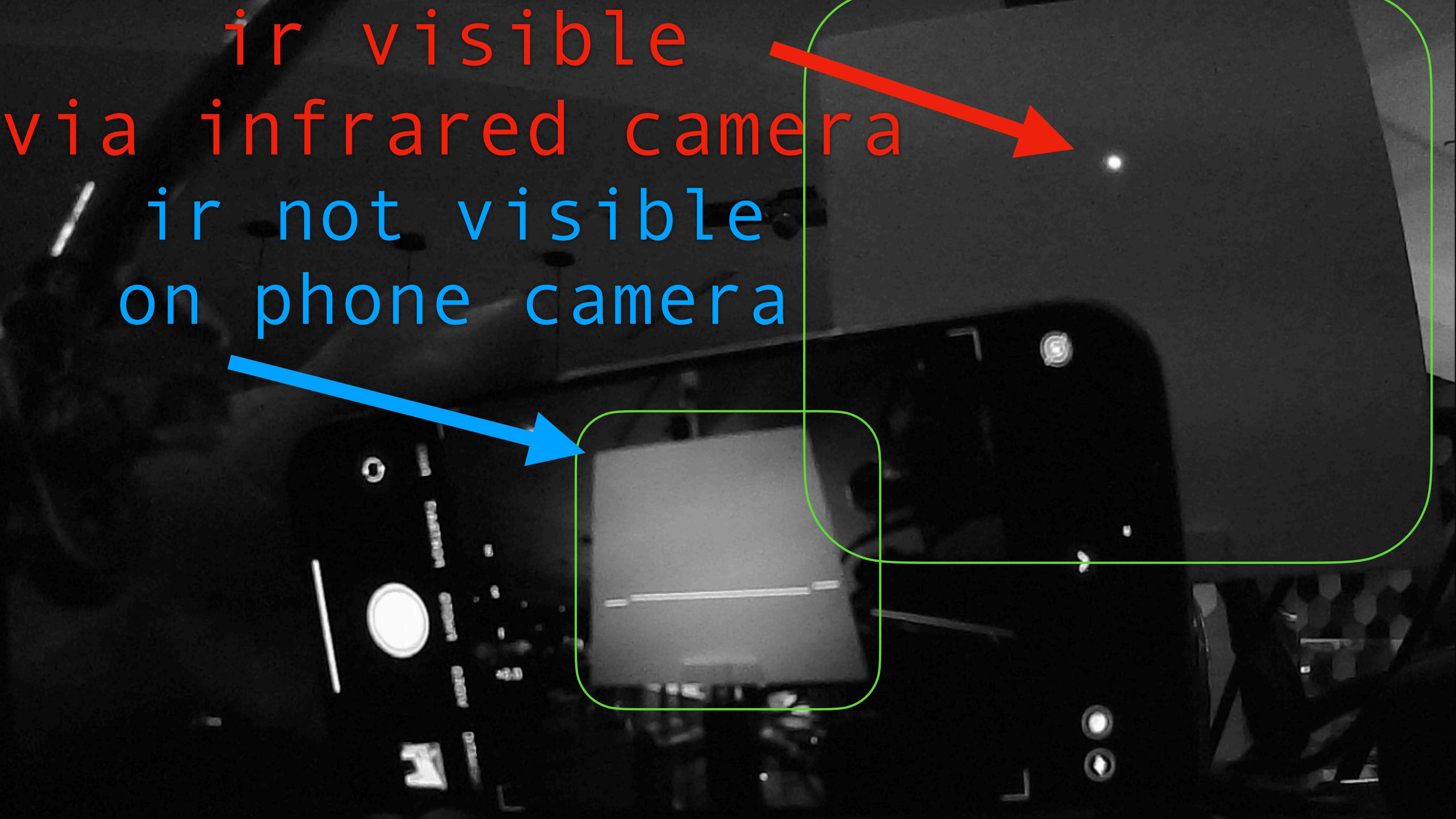
hardware (SDR rx)

- UV+Vis+IR camera (for locating+aligning IR laser): XNiteUSB2S-M
- Focusing Lens: LB1471
- Split-cell photodiode: SPOT-2D
- Transimpedance amp (TIA): AD8015 or AMP145
- MF (350-450kHz) band pass filter: ZFBP-400K-S+
- HF upconverter: Ham It Up Plus v2
- SDR: USRP B210
- Software: GNU Radio + iZotope RX + ffmpeg + keytap
- USB battery

tx
infrared

ir visible
via infrared camera

ir not visible
on phone camera

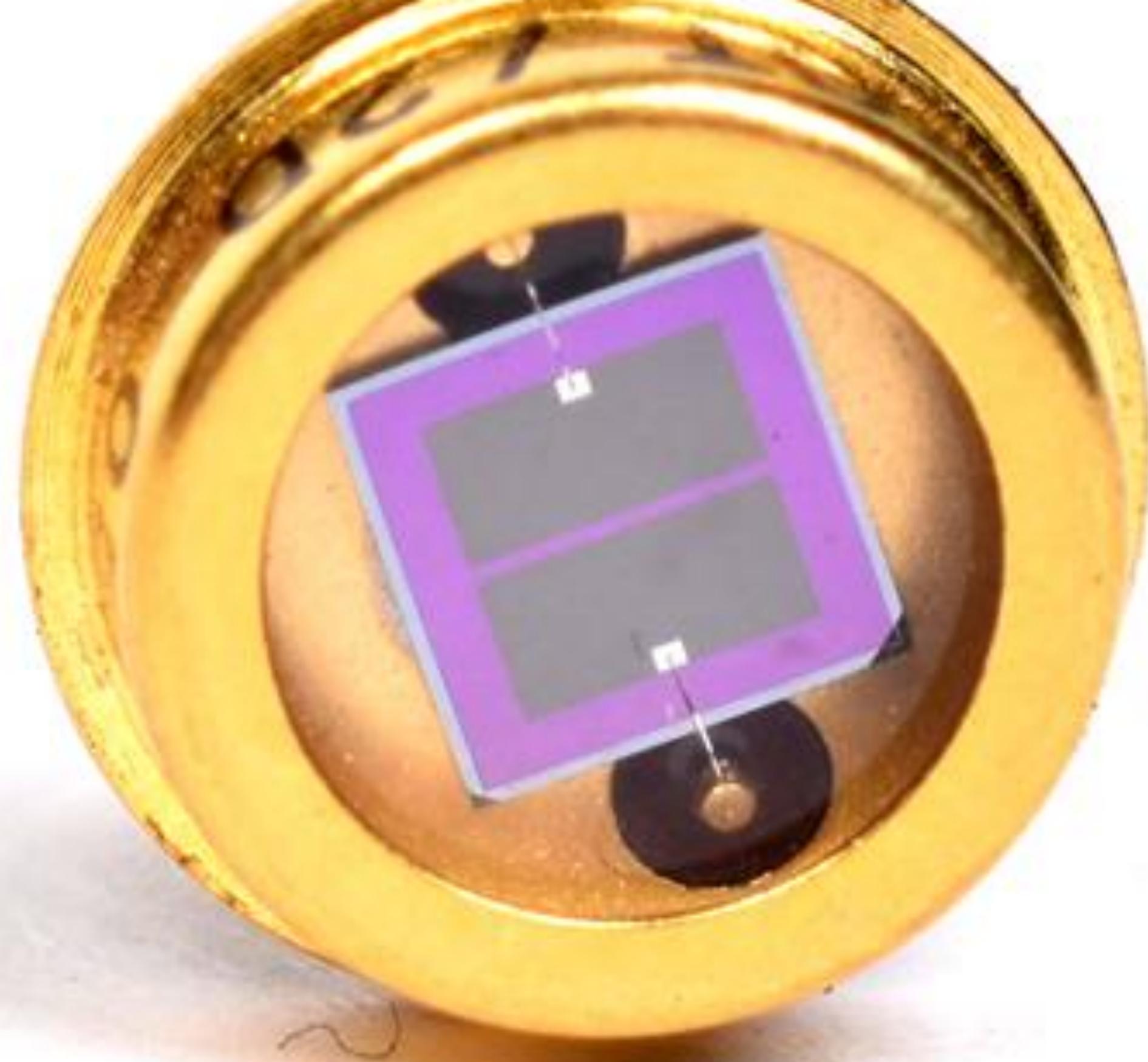




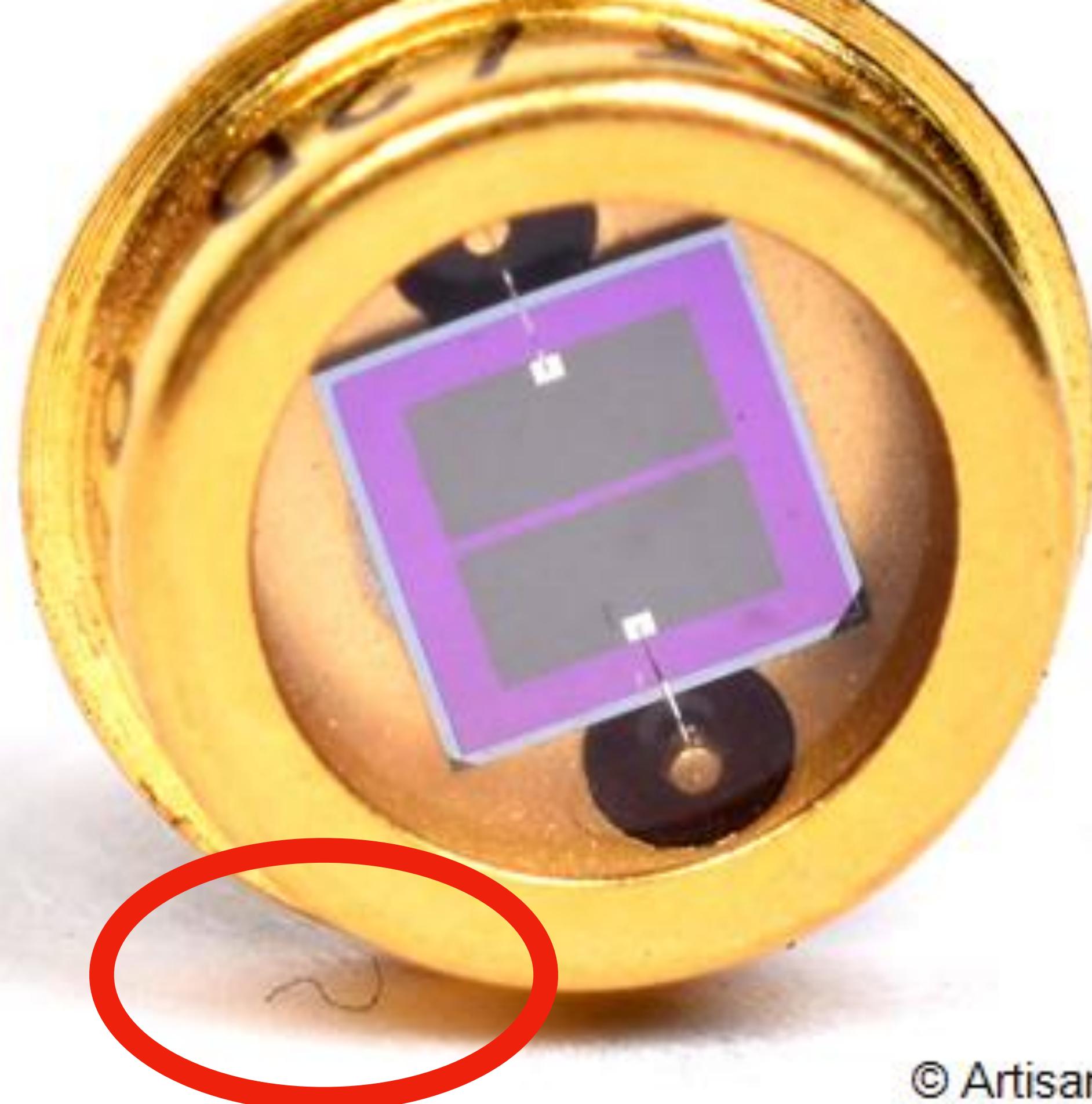


tx RF
modulation

rx split cell
photodiode



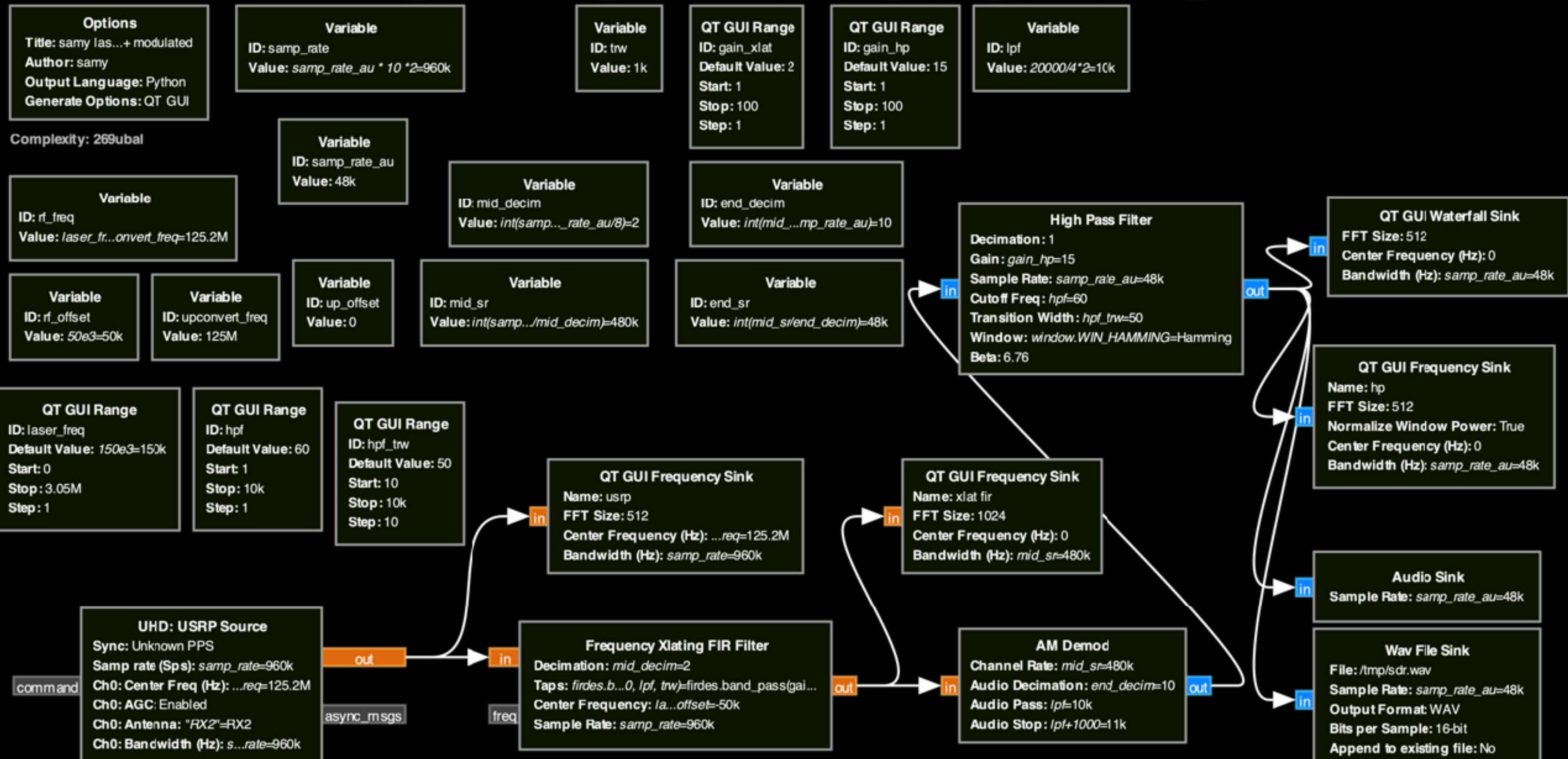
© Artisan Technology Group



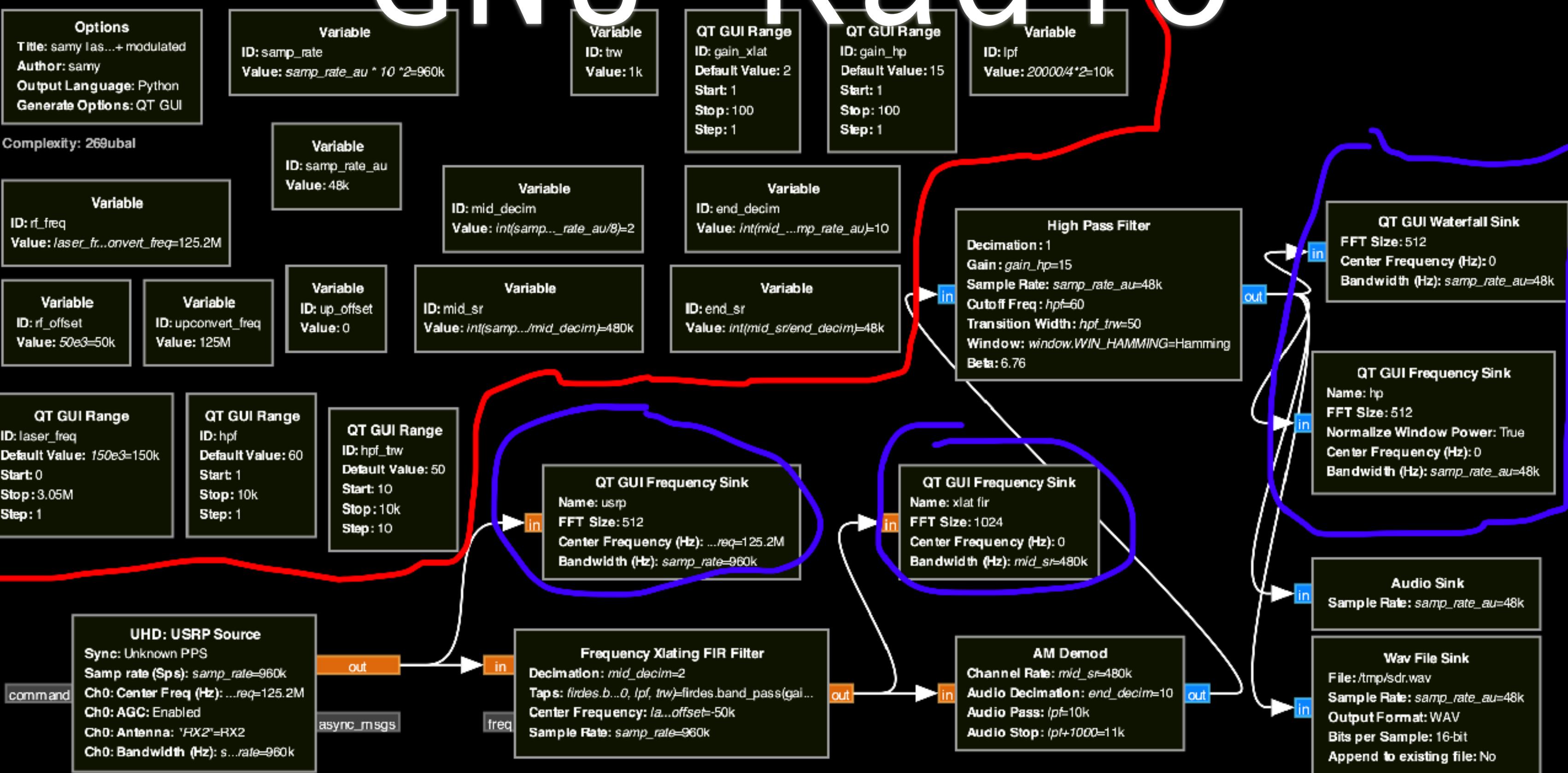
© Artisan Technology Group

software

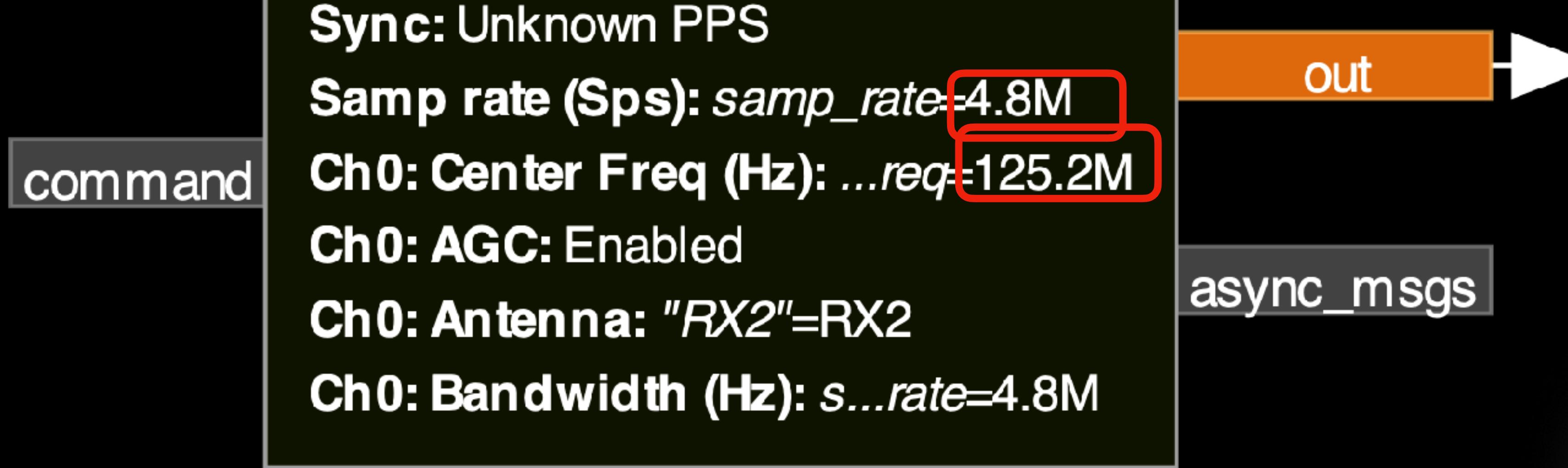
GNURadio



GNURadio



GNU Radio

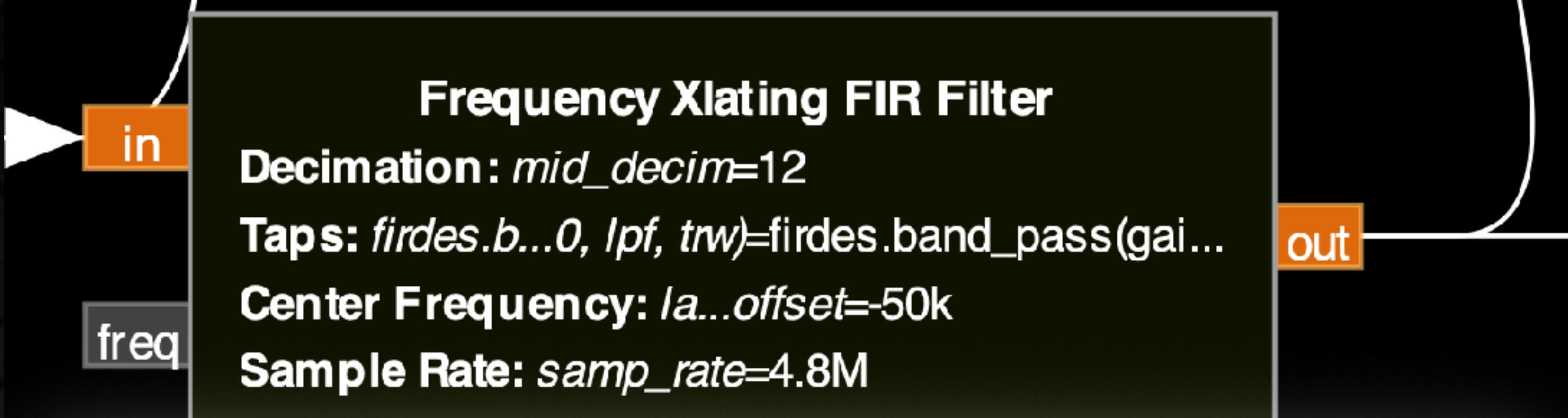


Model	Frequency Range	Bandwidth	ADC Resolution	Sample Rate	Transmit Capability	RX Channels	TX Channels	Bias Tee	RF Input
comm sgs	Generic RTL-SDR Dongles	25 MHz – 1.7 GHz	2.4 MHz	8 bits	3.2 MSPS	No	1	0	Yes MCX
	HackRF	1 MHz – 6 GHz	20 MHz	8 bits	20 MSPS	Yes (Half-Duplex)	1	1	Yes SMA
	ADALM-Pluto	70 MHz – 6 GHz	56 MHz	12 bits	61.44 MSPS	Yes (Full Duplex)	1	1	No SMA
	LimeSDR Mini v2	10 MHz – 3.5 GHz	40 MHz	12 bits	30.72 MSPS	Yes (Full Duplex)	1	1	No SMA
	BladeRF x40	300 MHz – 3.8 GHz	40 MHz	12 bits	40 MSPS	Yes (Full Duplex)	2	2	No SMA
	LimeSDR	100 kHz – 3.8 GHz	61.44 MHz	12 bits	61.44 MSPS	Yes (Full Duplex)	6	4	No U.FL
	Ettus B210	70 MHz – 6 GHz	61.44 MHz	12 bits	61.44 MSPS	Yes (Full Duplex)	2	2	No SMA

Logic 2 [Logic Pro 16 - Disconnected] [Session 0]



BladeRF x40	300 MHz – 3.8 GHz	40 MHz	12 bits	40 MSPS	Yes (Full Duplex)	2	2	No	SMA	sgs
LimeSDR	100 kHz – 3.8 GHz	61.44 MHz	12 bits	61.44 MSPS	Yes (Full Duplex)	6	4	No	U.FL	
Ettus B210	70 MHz – 6 GHz	61.44 MHz	12 bits	61.44 MSPS	Yes (Full Duplex)	2	2	No	SMA	



Properties: Frequency Xlating FIR Filter

General Advanced Documentation Generated Code

Type: Complex->Complex (Complex Taps) ▾

Decimation	mid_decim	[int]
Taps	<code>firdes.band_pass(gain_xlat, samp_rate, 30, lpf, trw)</code>	[complex_vector]
Center Frequency	<code>laser_freq-laser_freq-rf_offset+up_offset</code>	[real]
Sample Rate	<code>samp_rate</code>	[real]

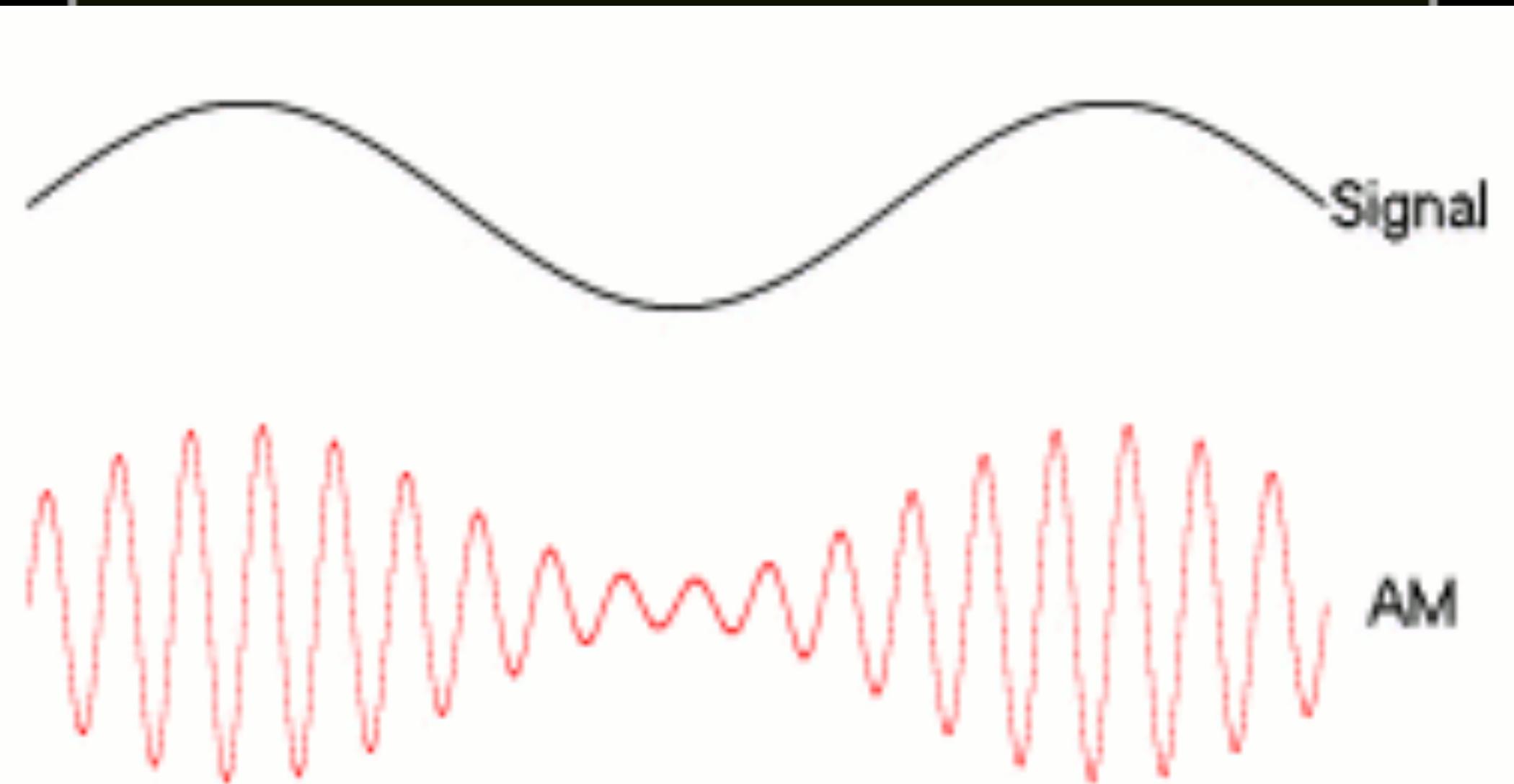
AM Demod

Channel Rate: $mid_sr=400k$

Audio Decimation: $end_decim=8$

Audio Pass: $lpf=10k$

Audio Stop: $lpf+1000=11k$



Audio Sink

Sample Rate: *samp_rate_au=48k*

Wav File Sink

File: */tmp/sdr.wav*

Sample Rate: *samp_rate_au=48k*

Output Format: WAV

Bits per Sample: 16-bit

Append to existing file: No



a5.wav

keys2.wav

keys3.wav

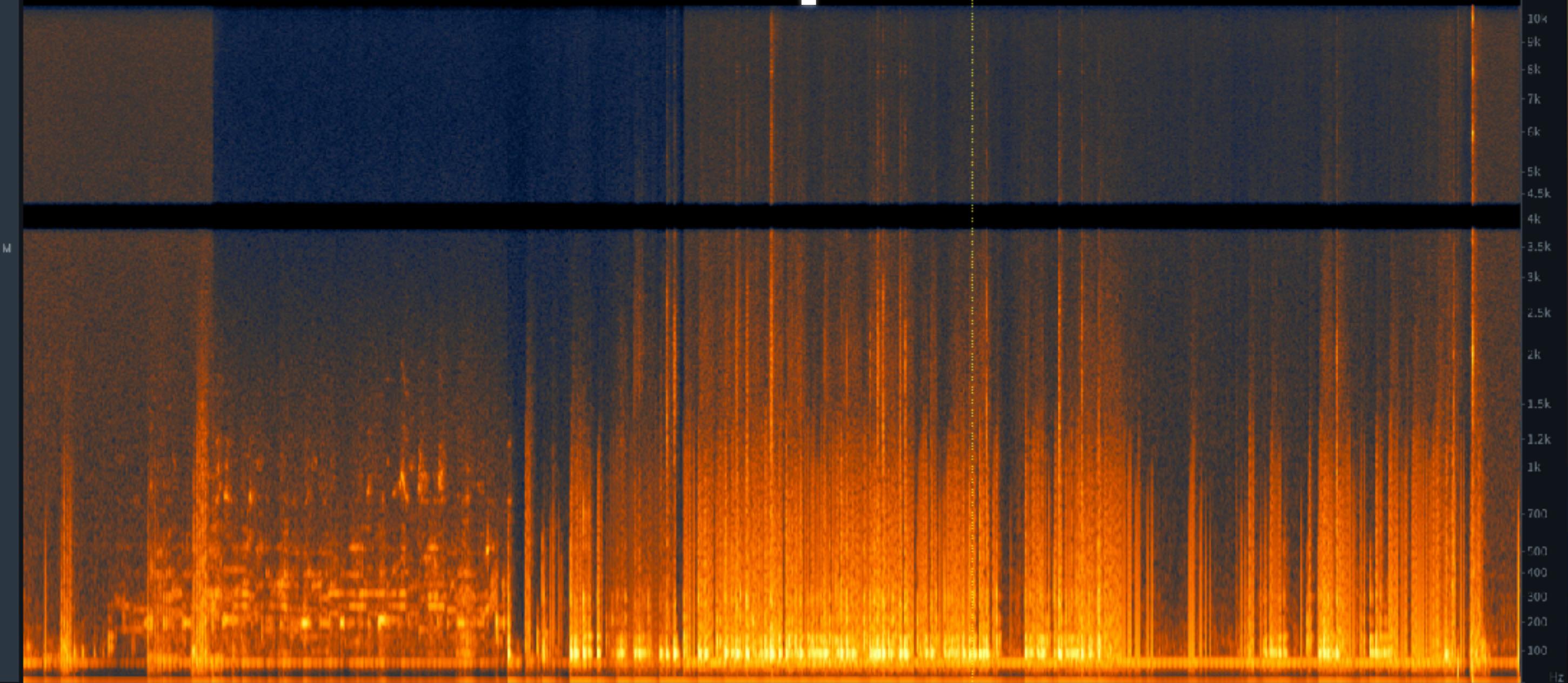
window2.wav

keys4.wav

keys5.wav

Repair Assistant

iZotope RX



- All
- De-bleed
- De-click
- De-clip
- De-crackle
- De-ess
- De-hum
- De-plosive
- De-reverb
- De-rustle
- De-wind
- Deconstruct
- Dialogue Contour
- Dialogue Isolate
- Guitar De-noise
- Interpolate
- Mouth De-click
- Music Rebalance
- Spectral De-noise
- Spectral Recovery
- Spectral Repair
- Voice De-noise
- Wow & Flutter
- Utility
- Azimuth
- Dither
- EQ
- EQ Match
- Fade
- Gain
- Leveler
- Loudness Control

ffmpeg

NAME

ffmpeg - ffmpeg video converter

SYNOPSIS

```
ffmpeg [global_options] {[input_file_options]} -i input_url ... {[output_file_options]} output_url ...
```

DESCRIPTION

ffmpeg is a very fast video and audio converter that can also grab from a live audio/video source. It can also convert between arbitrary sample rates and resize video on the fly with a high quality polyphase filter.

ffmpeg reads from an arbitrary number of input "files" (which can be regular files, pipes, network streams, grabbing devices, etc.), specified by the "-i" option, and writes to an arbitrary number of output "files", which are specified by a plain output url. Anything found on the command line which cannot be interpreted as an option is considered to be an output url.

Each input or output url can, in principle, contain any number of streams of different types (video/audio/subtitle/attachment/data). The allowed number and/or types of streams may be limited by the container format. Selecting which streams from which inputs will go into which output is either done automatically or with the "-map" option (see the Stream selection chapter).

To refer to input files in options, you must use their indices (0-based). E.g. the first input file is 0, the second is 1, etc. Similarly, streams within a file are referred to by their indices. E.g. "2:3" refers to the fourth stream in the third input file. Also see the Stream specifiers chapter.

As a general rule, options are applied to the next specified file. Therefore, order is important, and you can have the same option on the command line multiple times. Each occurrence is then applied to the next input or output file. Exceptions from this rule are the global options (e.g. verbosity level), which should be specified first.

Do not mix input and output files -- first specify all input files, then all output files. Also do not mix options which belong to different files. All options apply ONLY to the next input or output file and are reset between files.



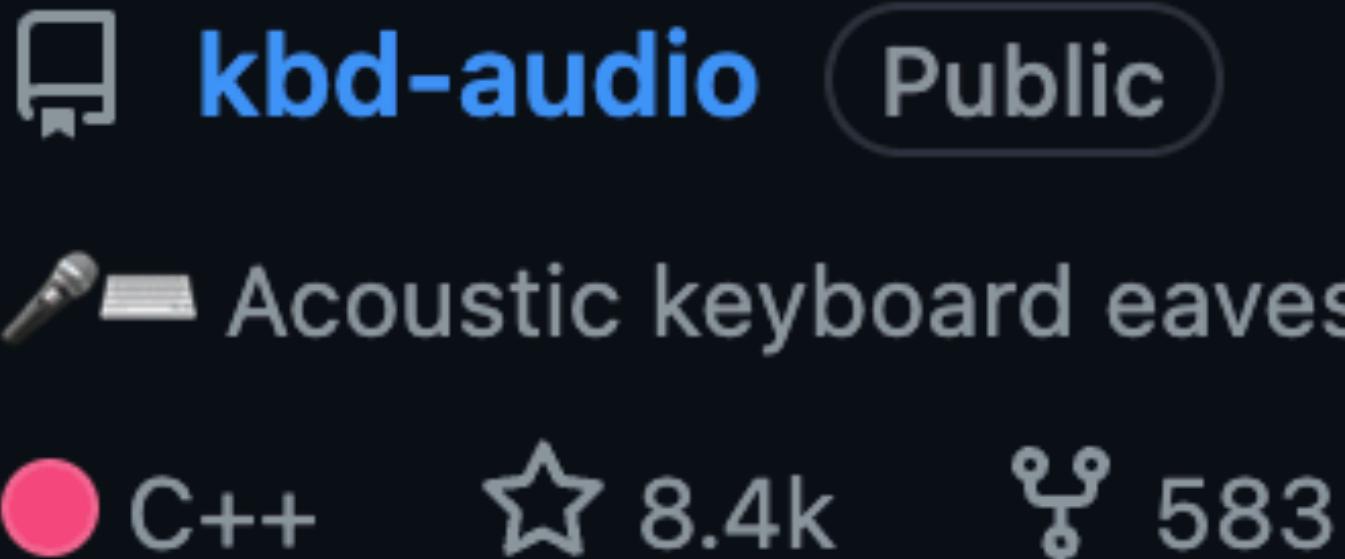
Georgi Gerganov
ggerganov

Unfollow

Heart Sponsor

I like big .vimrc and I cannot lie

github.com/ggerganov/kbd-audio



keytap3



Georgi Gerganov
ggerganov

Unfollow

Sponsor

I like big .vimrc and I cannot lie

github.com/ggerganov/kbd-audio

kbd-audio Public

Acoustic keyboard eavesdropping

C++ 8.4k 583

keytap3

H E R > 9 L A V P K I O L T G O G
N 9 + B φ □ O □ D W Y . < □ K 3 Θ
B X J C M + u z G W φ - L □ H J |
S 9 9 Δ L J A □ v o 9 O + + R K O |
□ Δ M + - □ T D I φ F P + P O K /
9 A R A F J O - □ O C x F > O D φ
□ e + K φ □ I O N C X G V . □ L I
φ G e J 7 □ O + □ N Y φ + □ L A
O < M + 8 + Z R O F B C X A O O K
- φ J u v + A J + O 9 A < F B X -
U + R / e L E I D Y B 9 8 T M K O
e < J R J I □ e T e M . + P B F
φ O A S X □ + N I e F B C φ J A R
J G F N A 7 e O O B . C V e L + +
Y B X e □ e O A C E > V U Z - +
I C . O φ B K φ O 9 L . e M φ G O
R C T + L O O C < + F J W B I φ L
+ + φ W C φ W C P O S H T / φ φ 9.
I F K D W < A T B D Y O B B - C C |
> M D H N 9 K S φ Z O A I K E +



CASE: 69014
ARMSTRONG + TOSINI







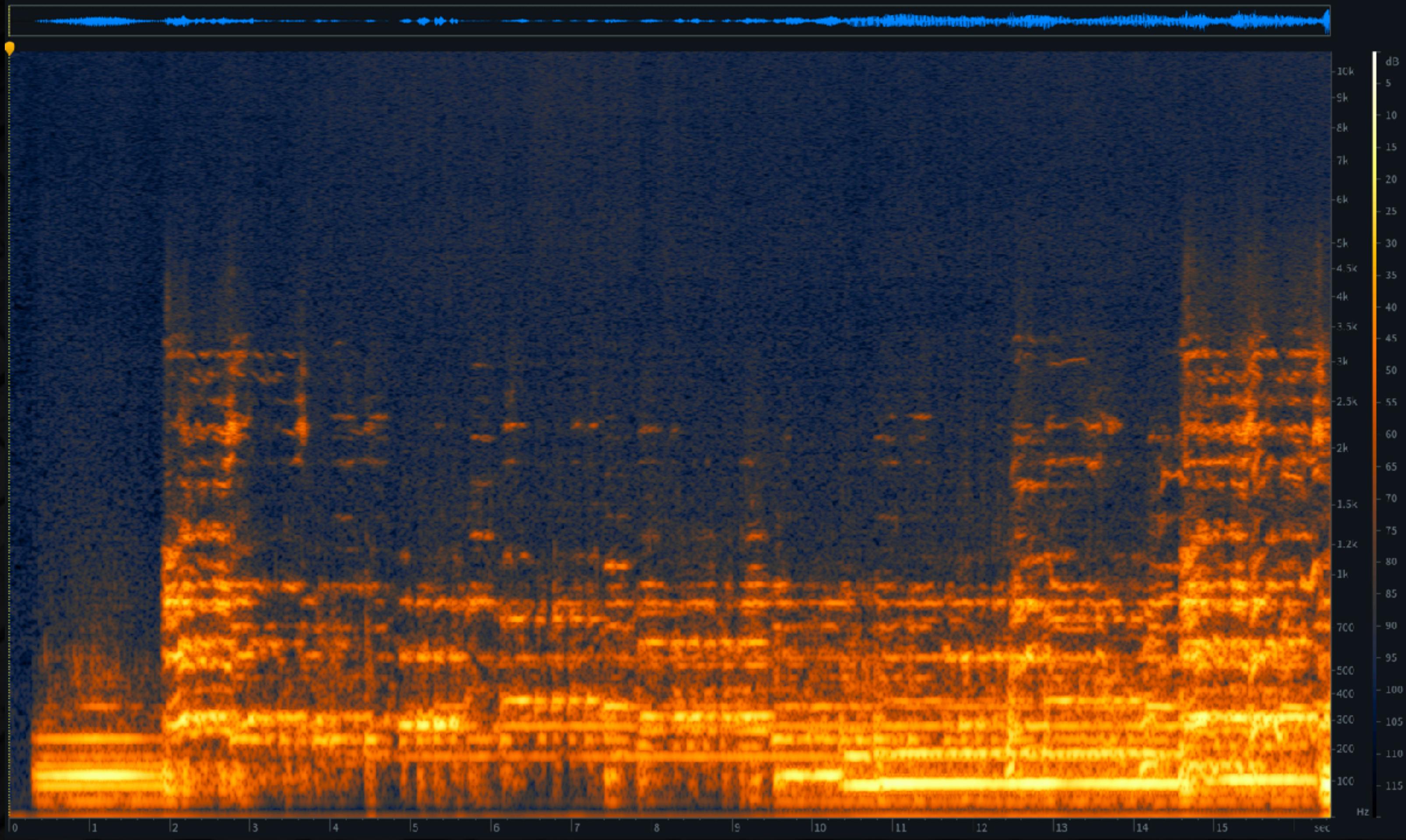
↪ keytap git:(master) []

typed:

hello and welcome to the laser microphone test where we are now converting light to sounds well actually signal as we never technically hear the signal as sound since it does not get directly recorded or played back

key tap3:

hhello and welcome to thheplaser microohone test where we are now converting lightto sounds a welll acituallylsignasl aos we netheir technicallytreast the sigaal as sound isince int ddoes not get aged intly recolrded or llayedf



challenges

improvements

latest @ samy.pl/dc32

Optical Espionage

thank you!

@samykamkar

samy.pl