



# BB84 Implementation on Custom QKD Setup

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Thesis Advisors:

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# Motivation

- Educational outreach



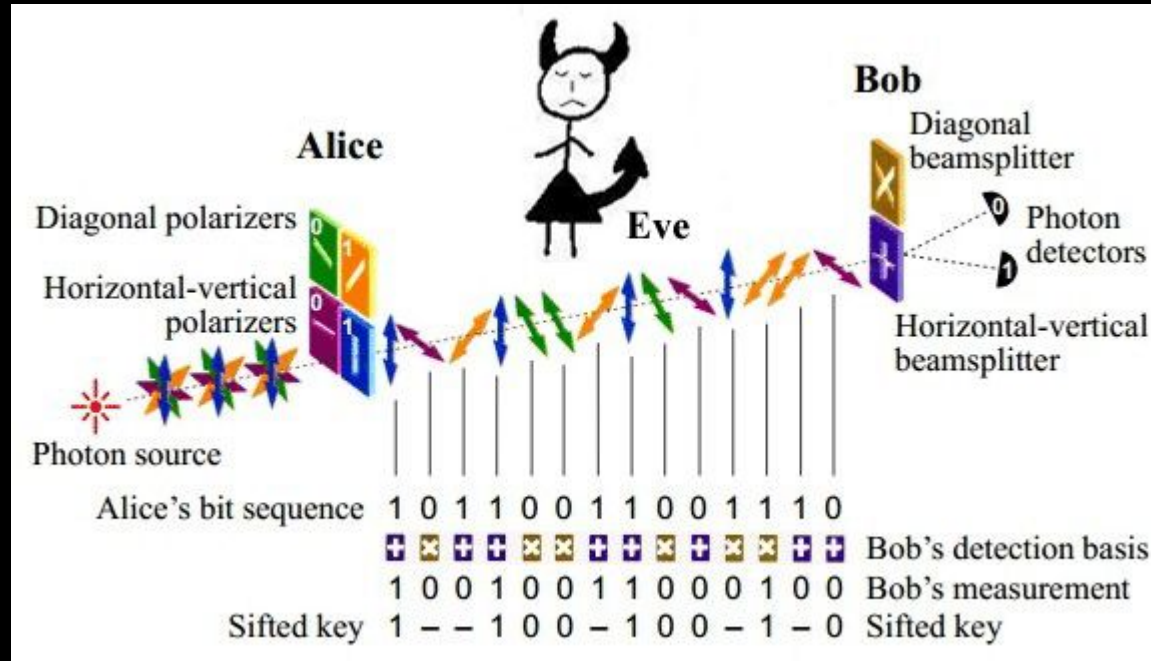
- Hardware experimentation



- Cost constraints

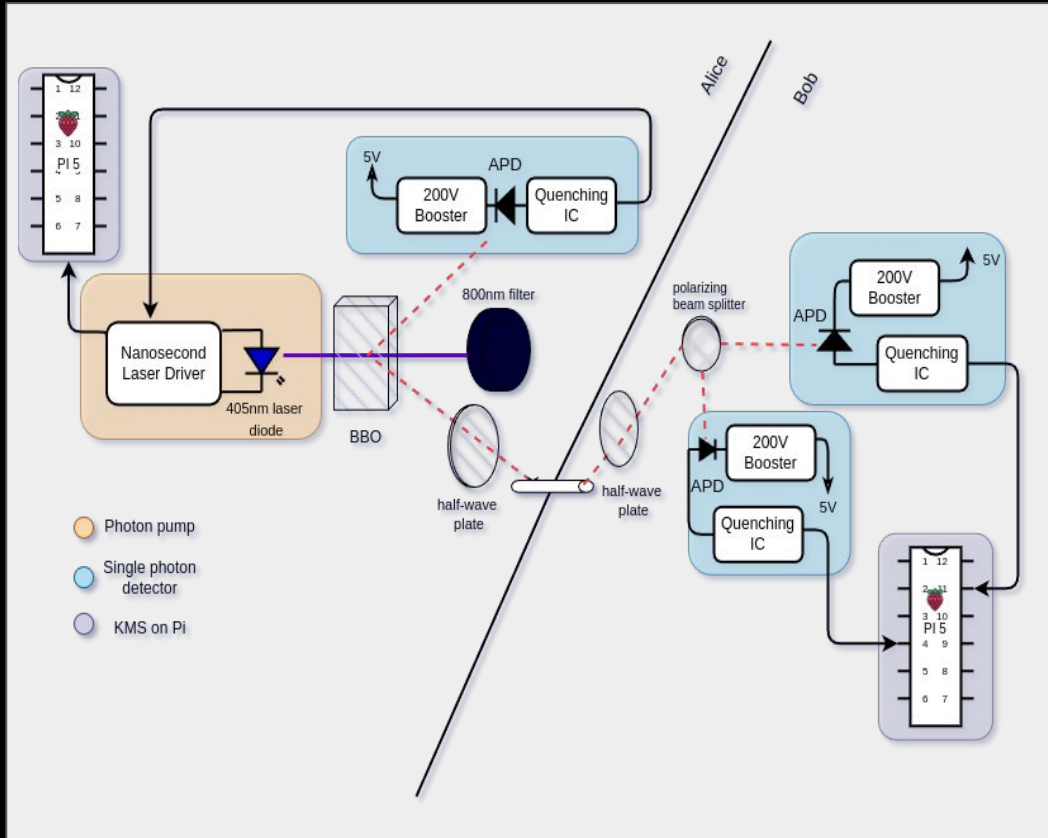


# BB84 recap



Credit : Weerasinghe, WAA Maheshya. "Quantum Cryptography." (2012).

# Overview of the setup



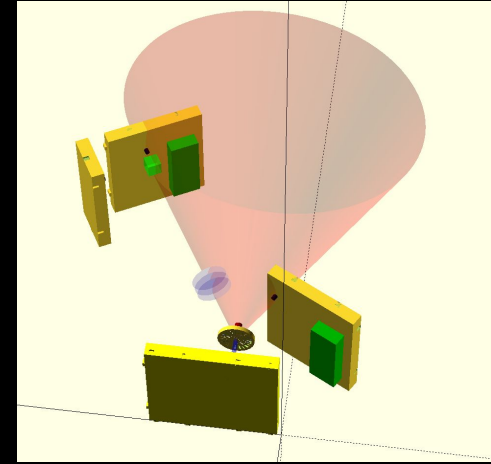
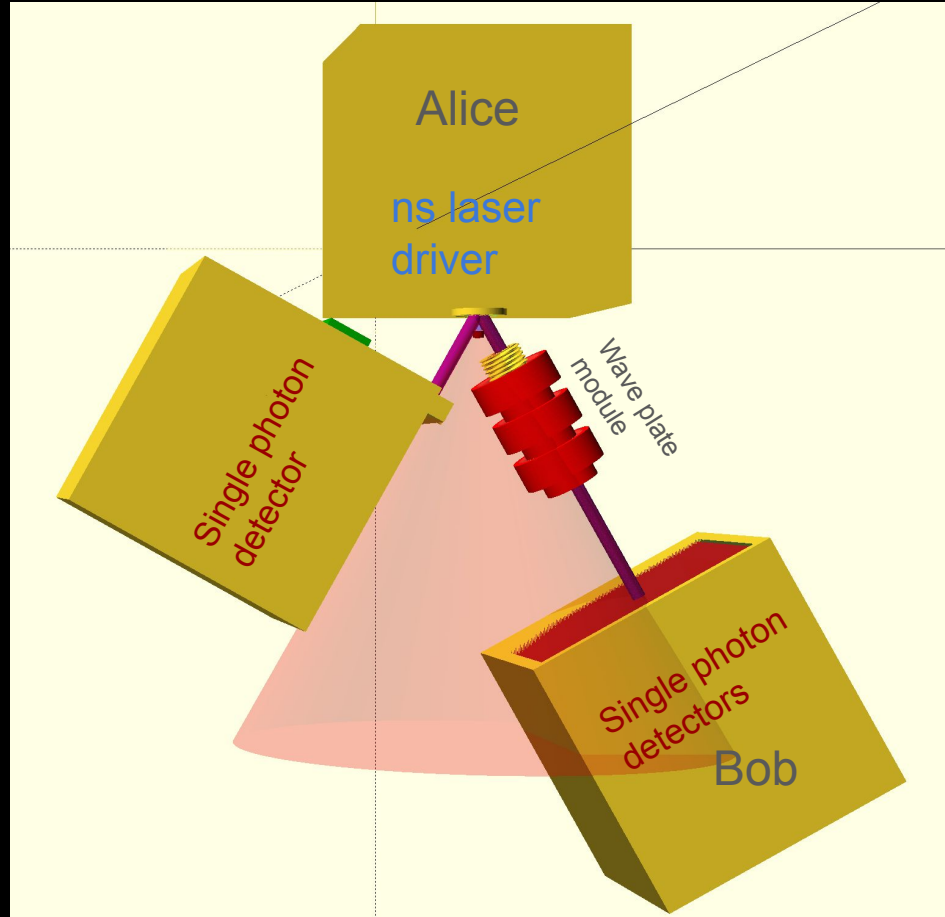
Round	Alice Bit	Alice Basis	Bob Basis	Bob Result	Same Basis?
1	1	B	A	0	No
2	1	A	A	1	Yes
3	0	A	B	1	No
4	0	B	B	0	Yes
5	1	A	B	1	No
6	0	B	A	1	No
7	1	B	B	1	Yes
8	0	A	A	0	Yes

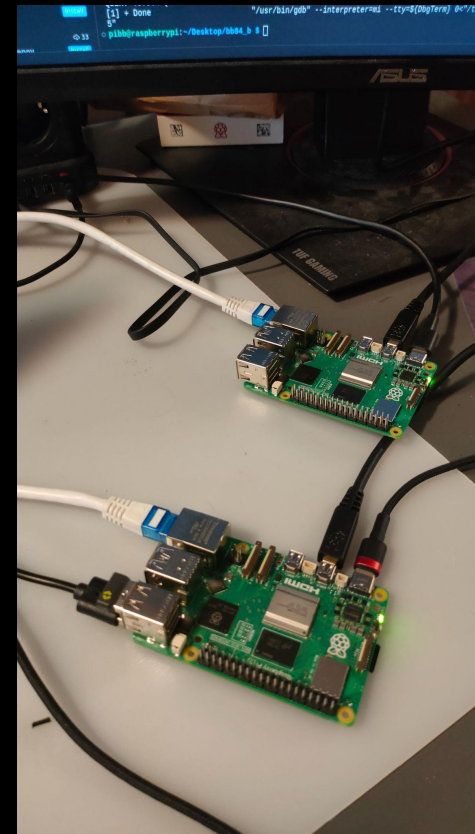
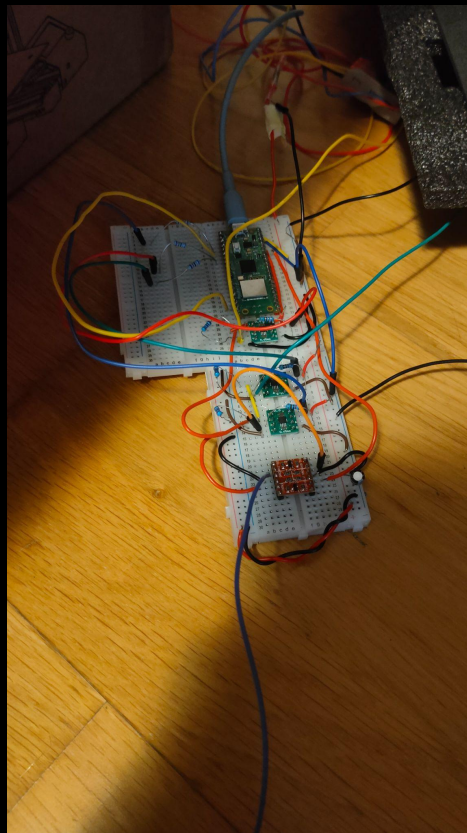
Target Base	Target State	Desired Polarization	HWP Angle (from H)
Z	H	0°	0°
Z	V	90°	45°
X	D	45°	22.5°
X	A	135°	67.5°

# 3D design

Modular design

Compatible with  
breadboards and PCBs



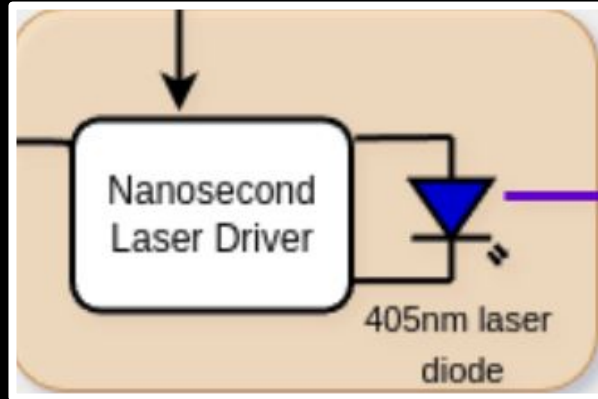


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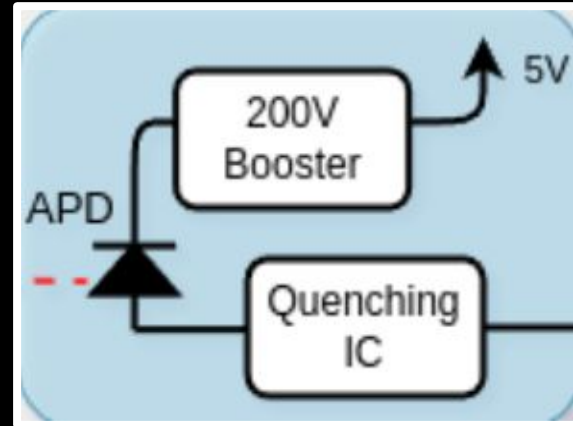


# Hardware Design

1

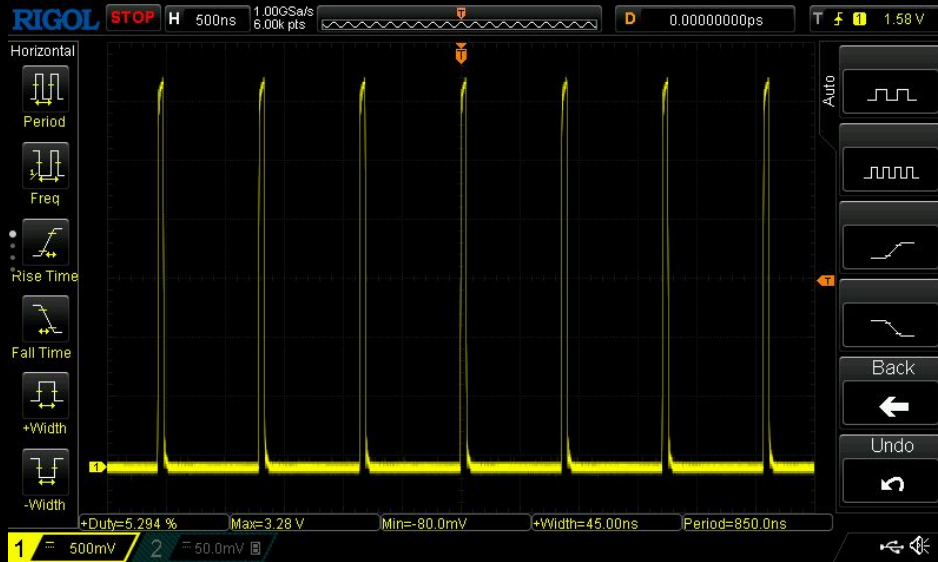


2

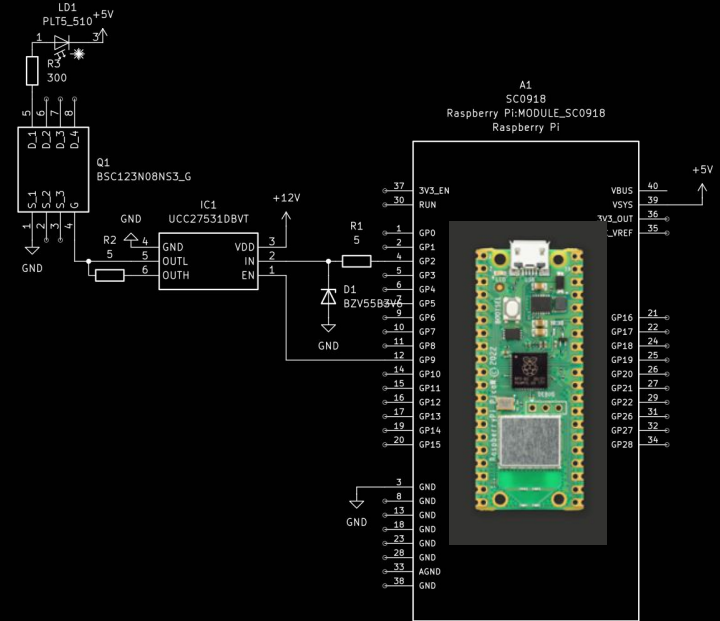


3

# Hardware Design of the LASER driver



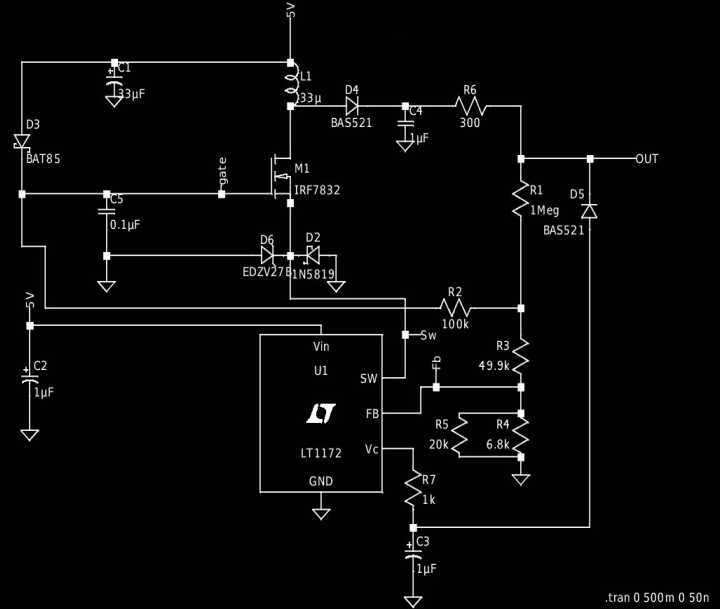
pio - 10ns per instruction



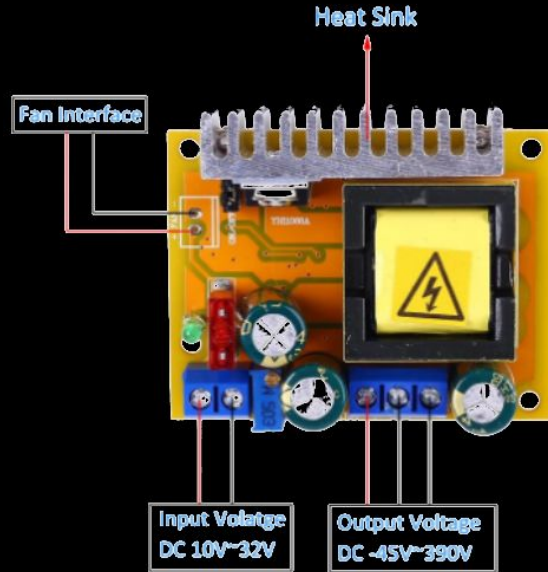


# Hardware Design of the 5V to 200V Boost Converter

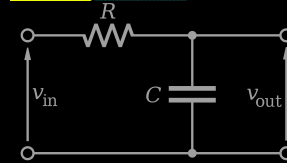
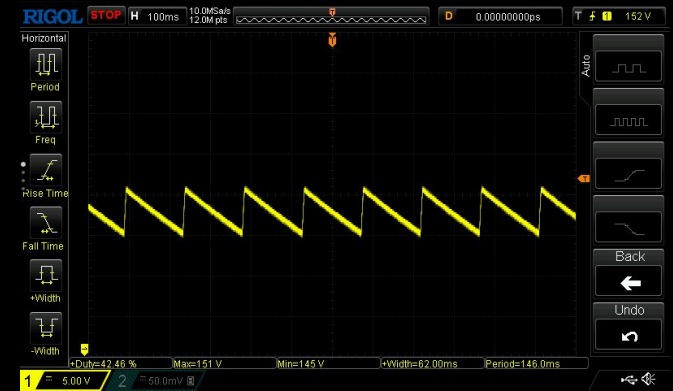
Jim Williams, AN98



# Hardware Design of the Adjustable Boost Converter

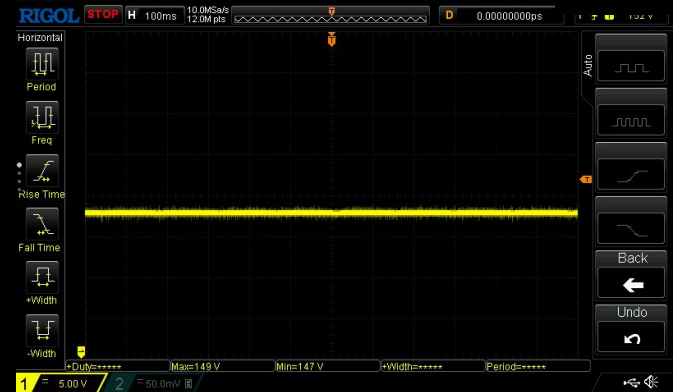


YH11068A

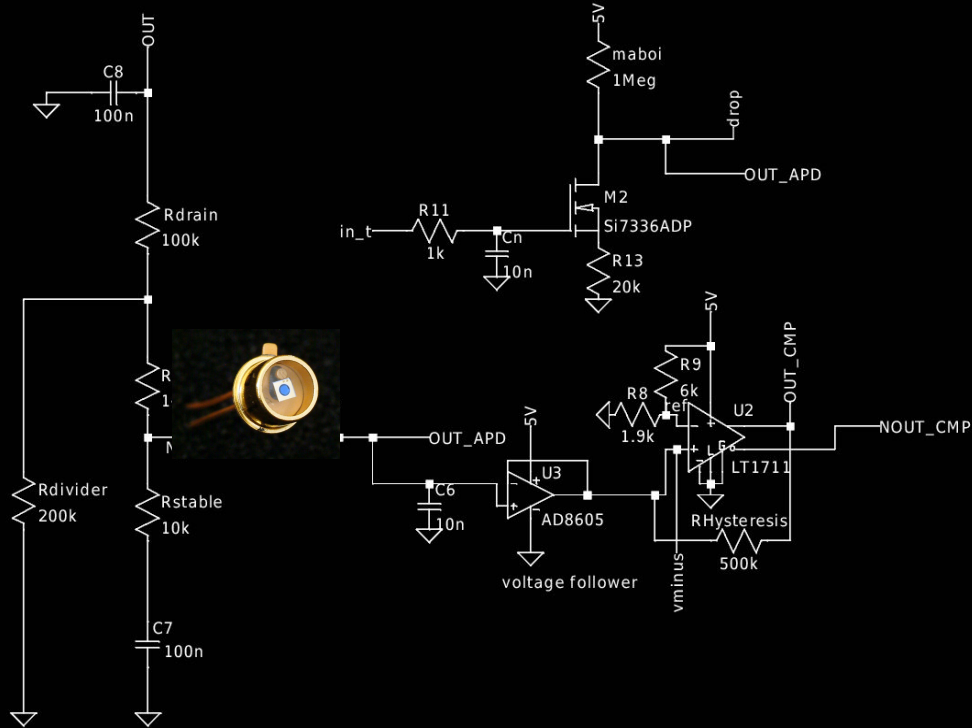


Low pass filter

Cut-off  $\approx 0.16$  Hz

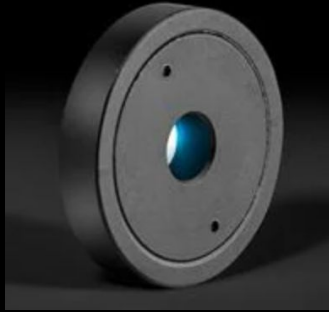


# Hardware Design of the Single Photon Detector with Active Quenching



# Optics and alignment considerations

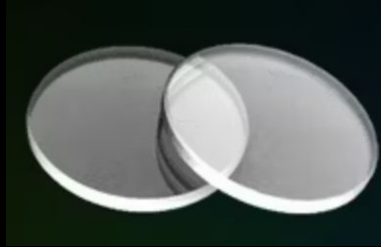
Creating single photons



BBO crystal -  
Type 1 SPDC

P/P@400-800  
nm

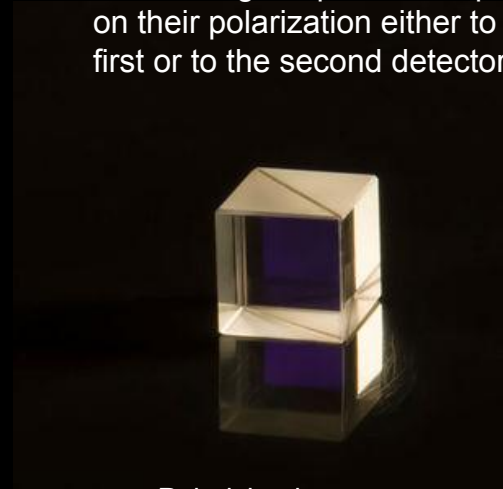
Changing photon state  
and measurement basis



Half-wave plates

25mm Dia.,  $\lambda/2$   
Retarder Film

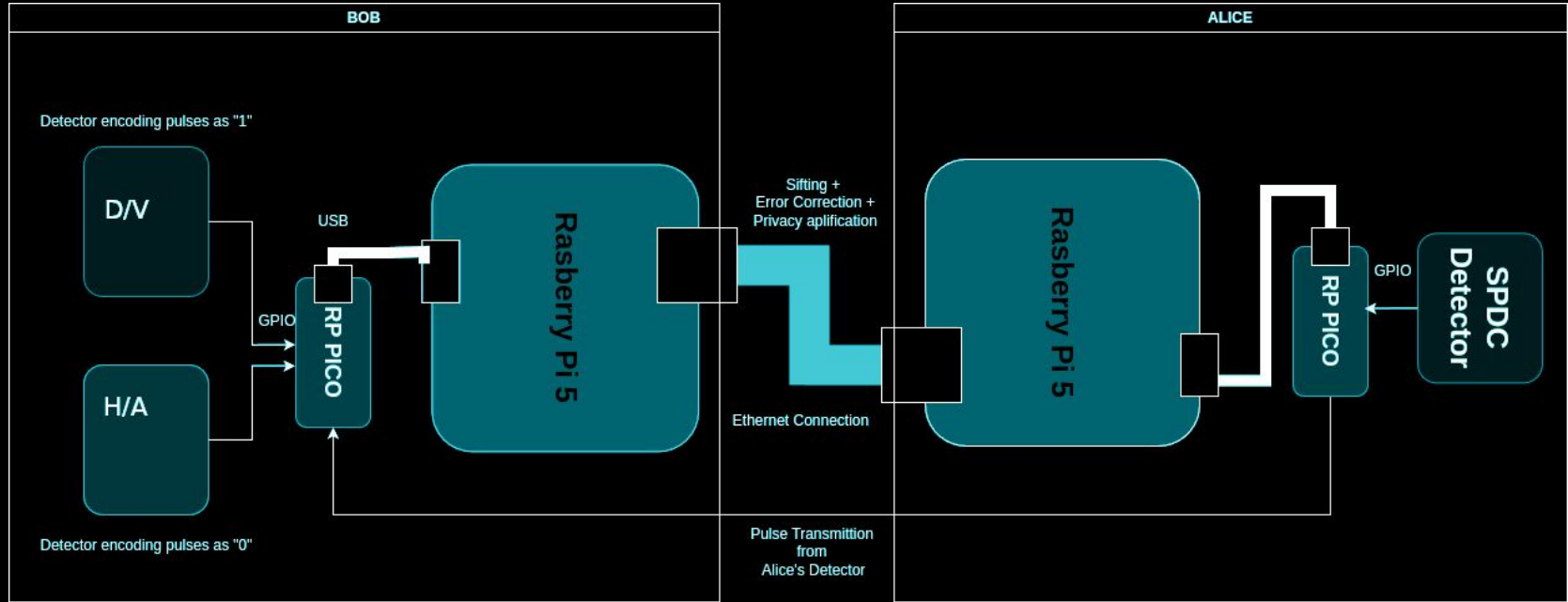
Redirecting the photons depending  
on their polarization either to the  
first or to the second detector.



Polarizing beam  
splitter

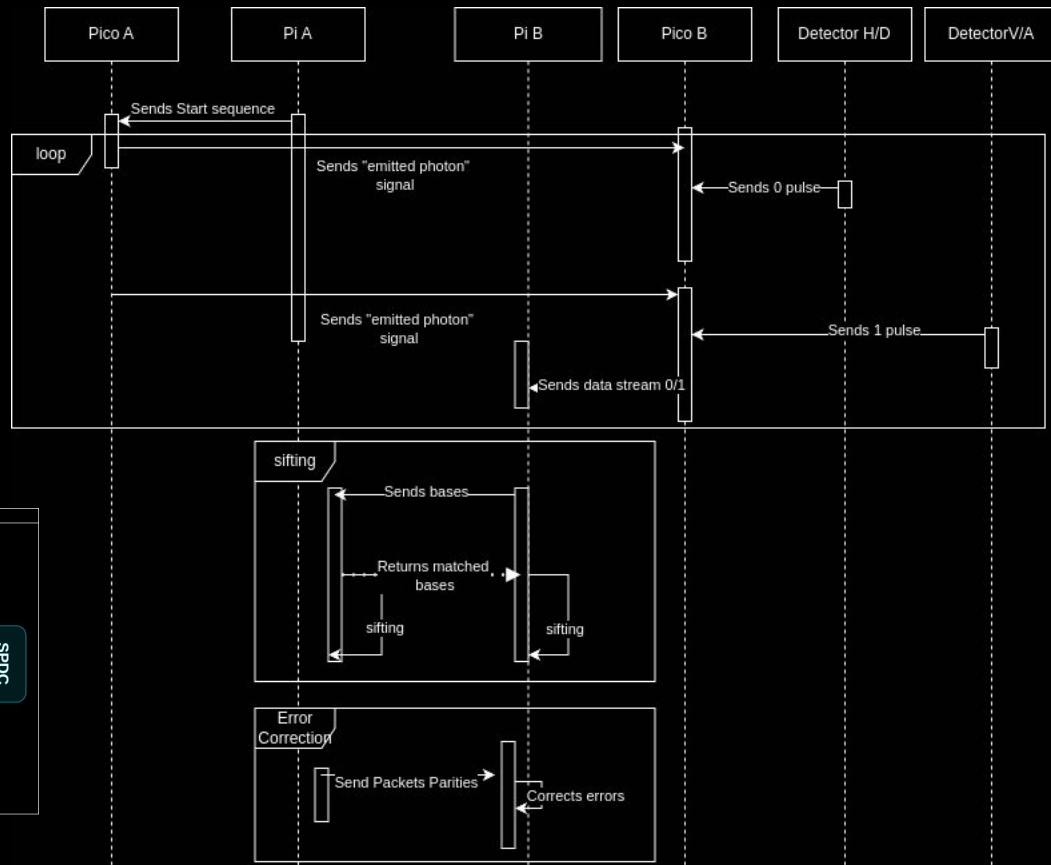
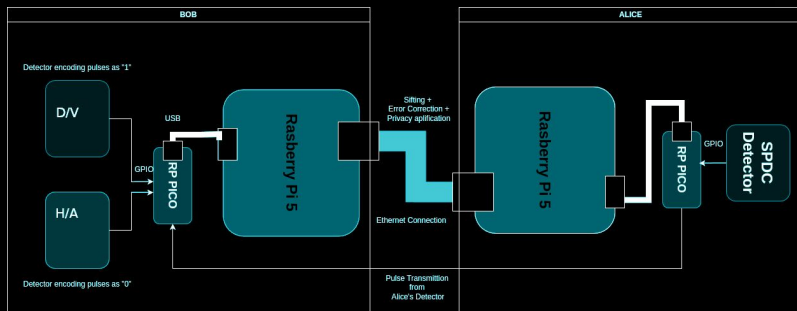
780nm  $R_s > 99.5\%$   
 $T_p > 95\%$  10 x 10 mm

# The software



# The software

- Raw key storage
- Key Sifting
- Error Correction
- Calculating Qubit Error Rate

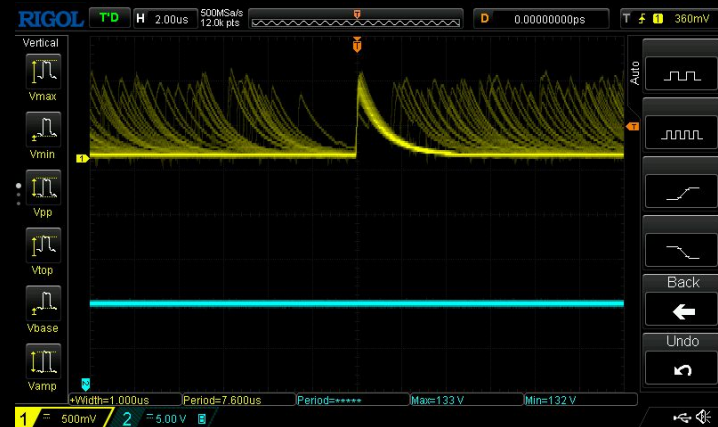




# Results



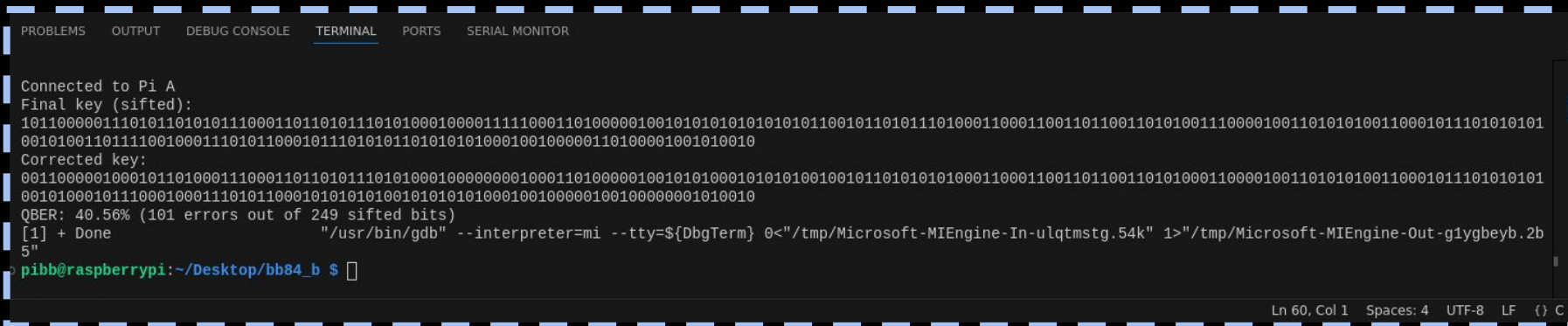
Pulses into clean 3V3 TTL signal



# Results

average of 40% qubit error rate

$$\text{QBER} = \frac{\text{Number of mismatched bits}}{\text{Total number of sifted bits}}$$

A screenshot of a terminal window with a dark background and light blue text. The terminal shows the results of a quantum key distribution (QKD) experiment. It displays the 'Final key (sifted)' and 'Corrected key' as long strings of 0s and 1s. The QBER is calculated as 40.56% (101 errors out of 249 sifted bits). The terminal also shows a command to run a debugger (gdb) on a file named '5n'. The prompt is 'pibb@raspberrypi:~/Desktop/bb84\_b \$'. The terminal window has tabs for 'PROBLEMS', 'OUTPUT', 'DEBUG CONSOLE', 'TERMINAL', 'PORTS', and 'SERIAL MONITOR'. The status bar at the bottom indicates 'Ln 60, Col 1', 'Spaces: 4', 'UTF-8', 'LF', and '{ } C'.

Not usable unless we use super aggressive error correction which is not safe!



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# Future work

- Noise reduction -> Cooling
- Better single photon generation -> Refining optical alignment
- Higher photon detection rate -> Use SiPM (silicon photomultiplier)



<https://github.com/irina-b-dev/custom-qkd-source>