Laser Cyclops

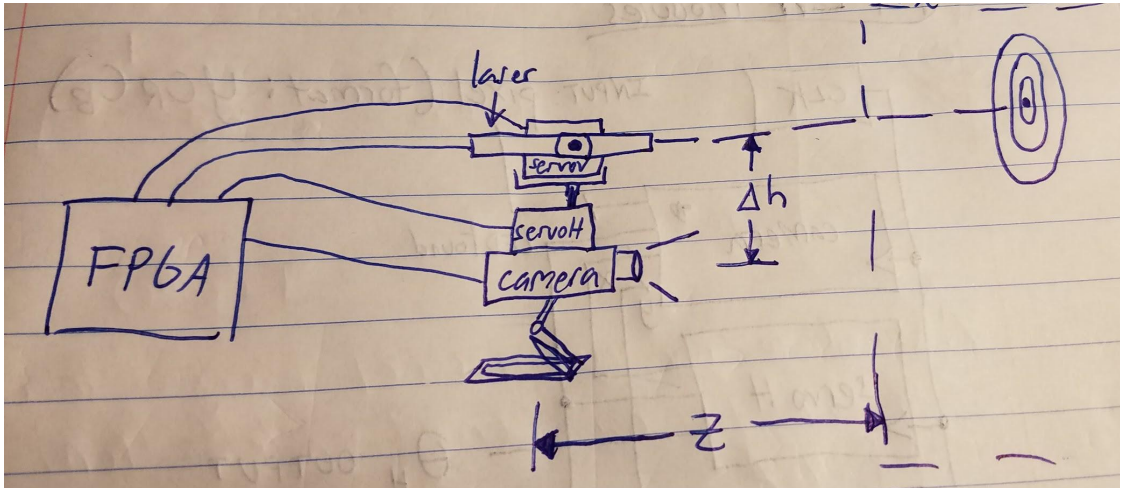
13 November 2018

Carlos Cuevas & Cody Winkleblack

Overview

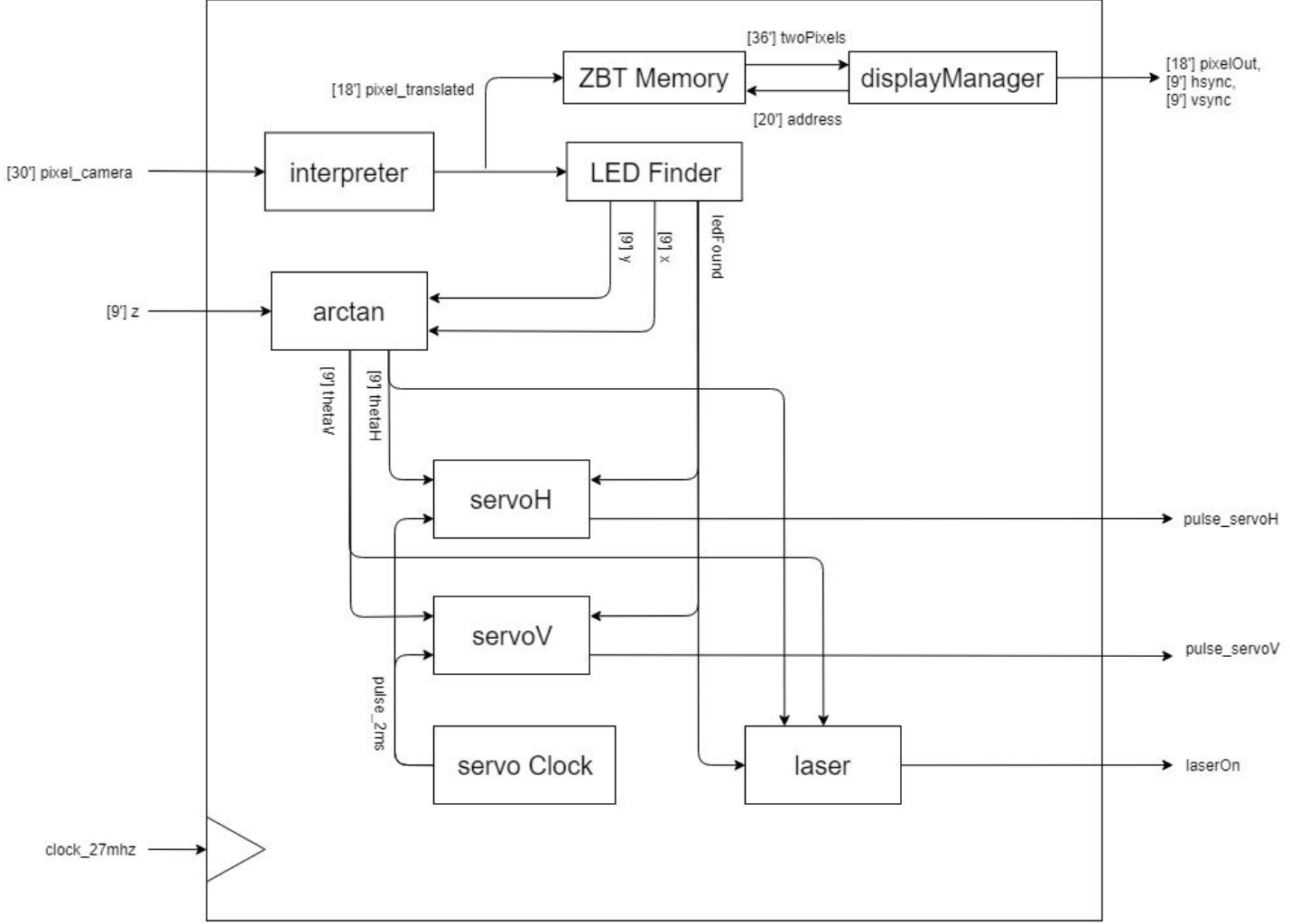
- **Use a NTSC camera to detect a target and, given the depth, fire a laser at it.**
- Infrared LED is used on the target; filter allows only infrared rays through.
- Two servos are used to aim the laser.
- Laser should only be firing when over the LED.
- VGA display will also be used to see where the FPGA thinks the target is at, as well as for later extension goals.

Hardware



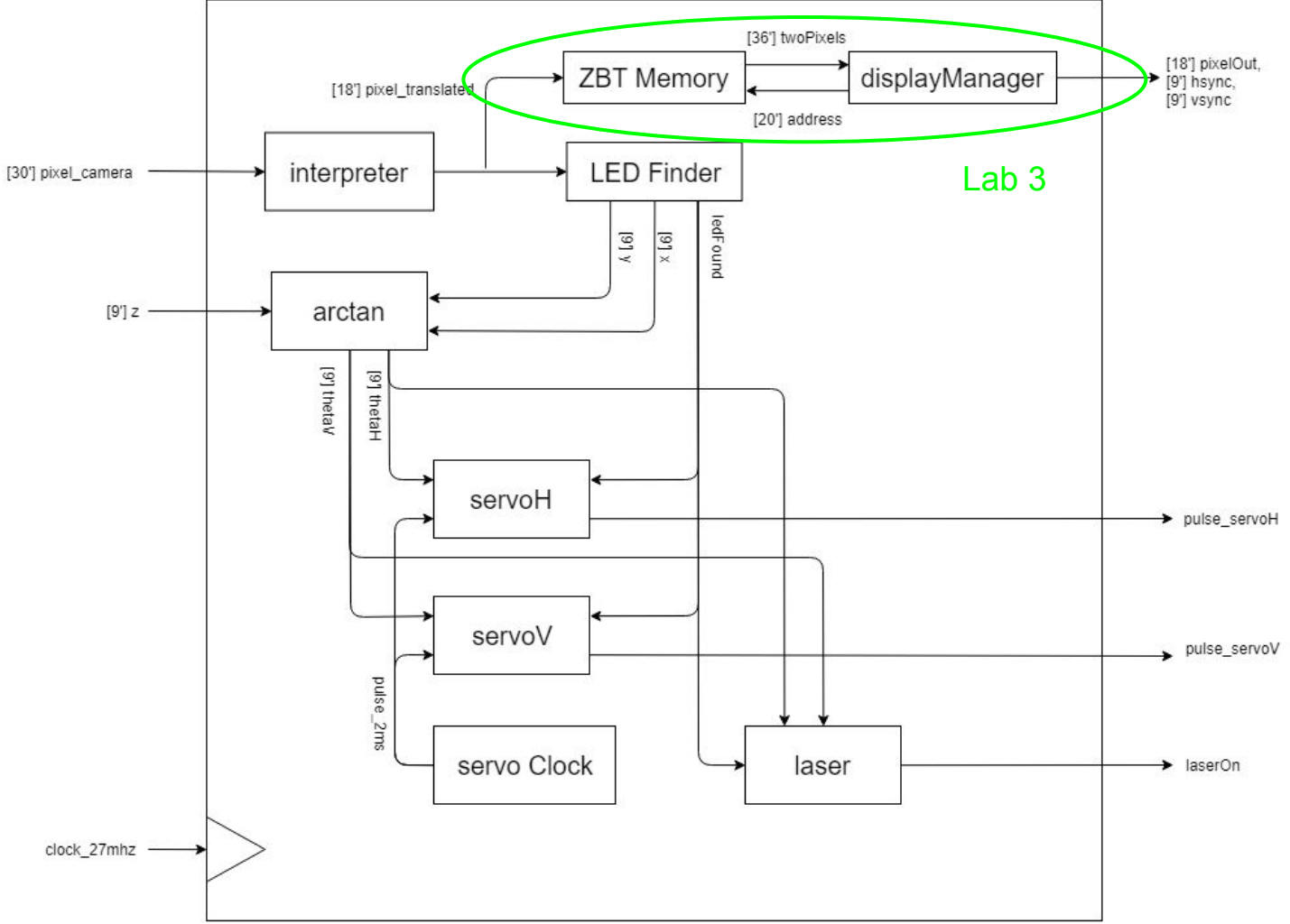
- [2] Servos
- [1] 523nm Laser
- [1] NTSC Camera
- [1] Infrared filter
- [1] Circular Target
- [1] Infrared LED (at center of target)
- 3D Printed Components connecting the camera, laser, and servos

FPGA Major Modules



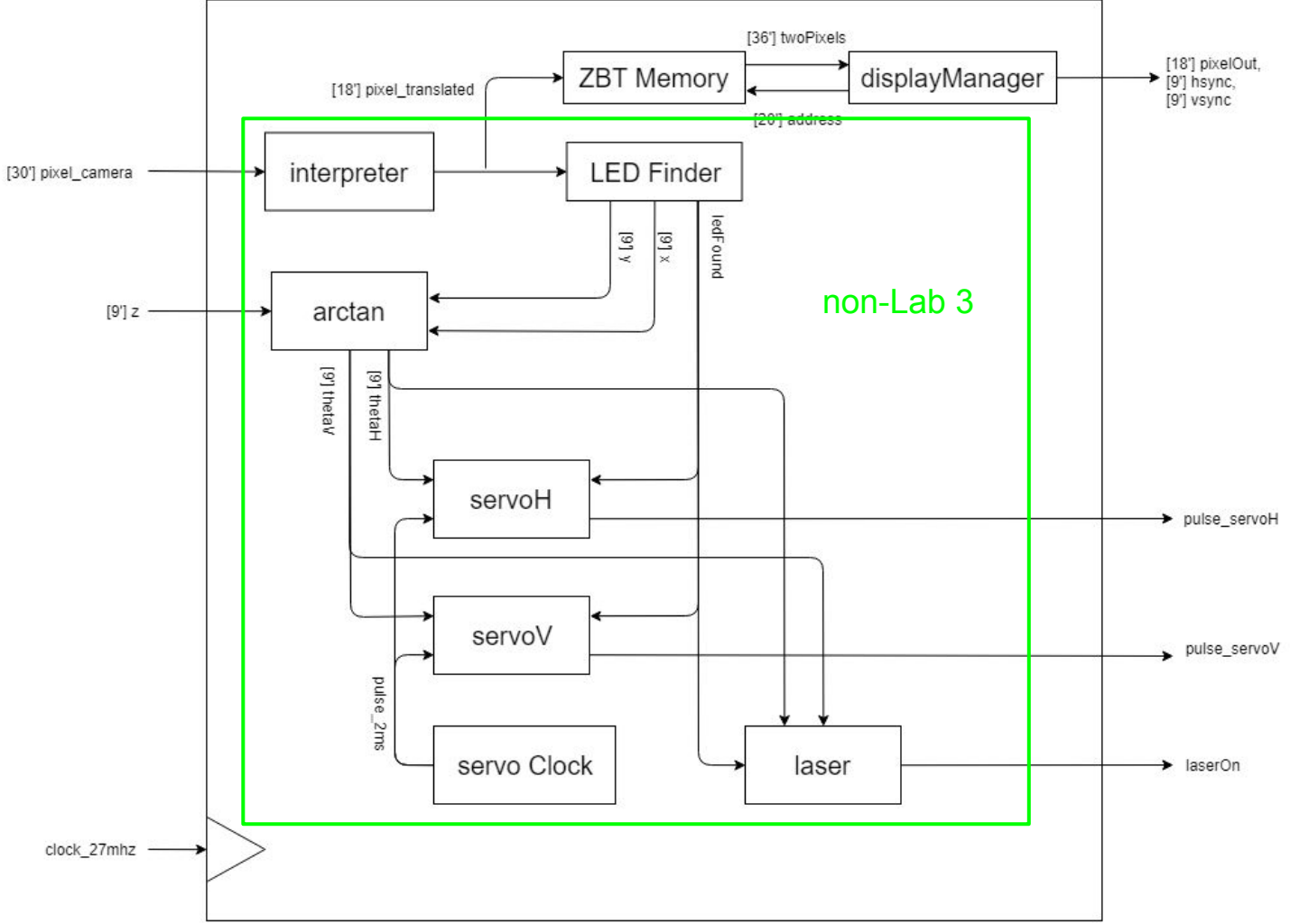
Laser Cyclops FPGA

FPGA Major Modules



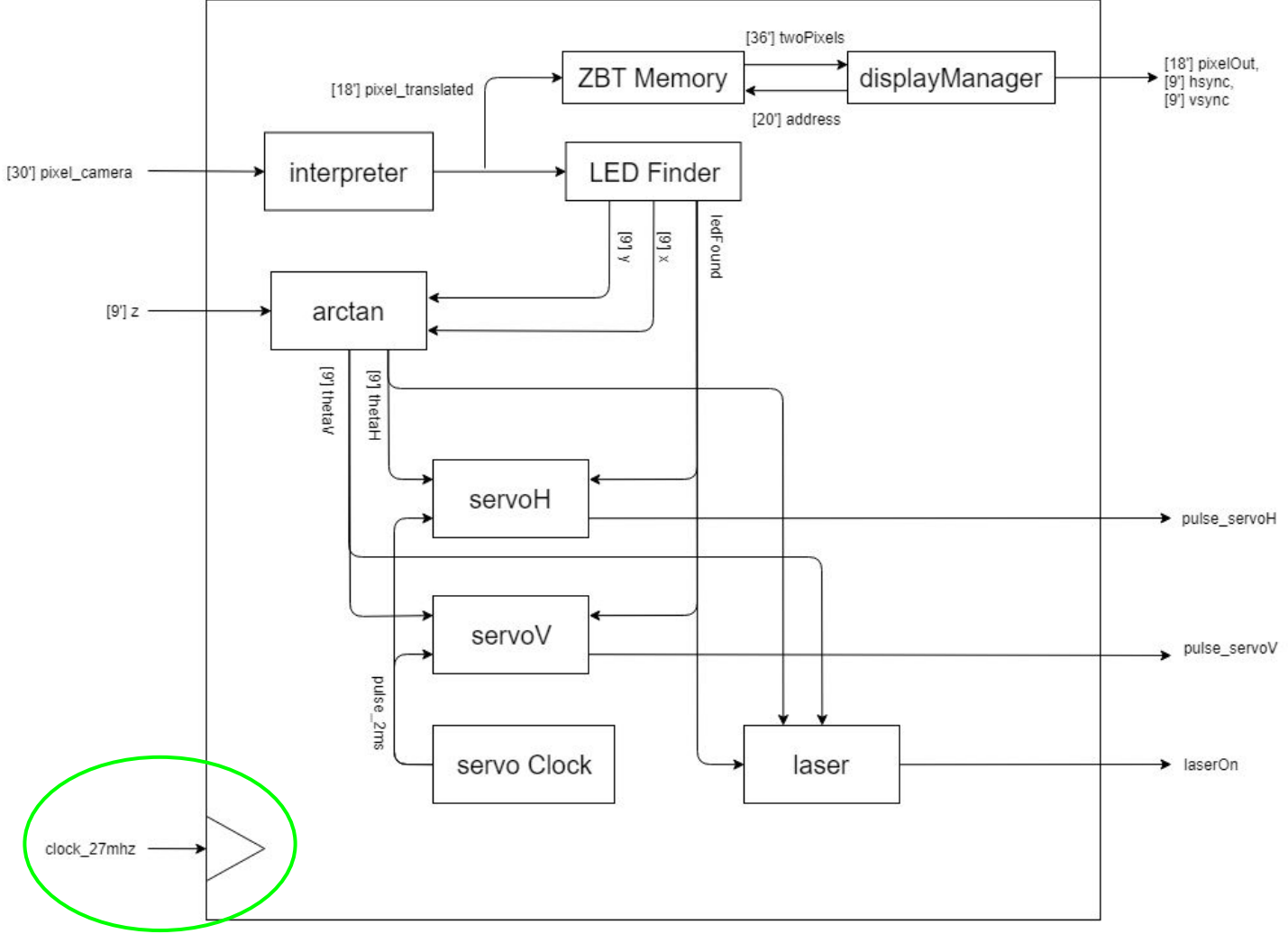
Laser Cyclops FPGA

FPGA Major Modules



Laser Cyclops FPGA

FPGA Major Modules



Laser Cyclops FPGA

Module (interpreter)

Input = [29:0] YCrCb

Output = [17:0] {R[9:4], G[9:4], B[9:4]}

Equations:

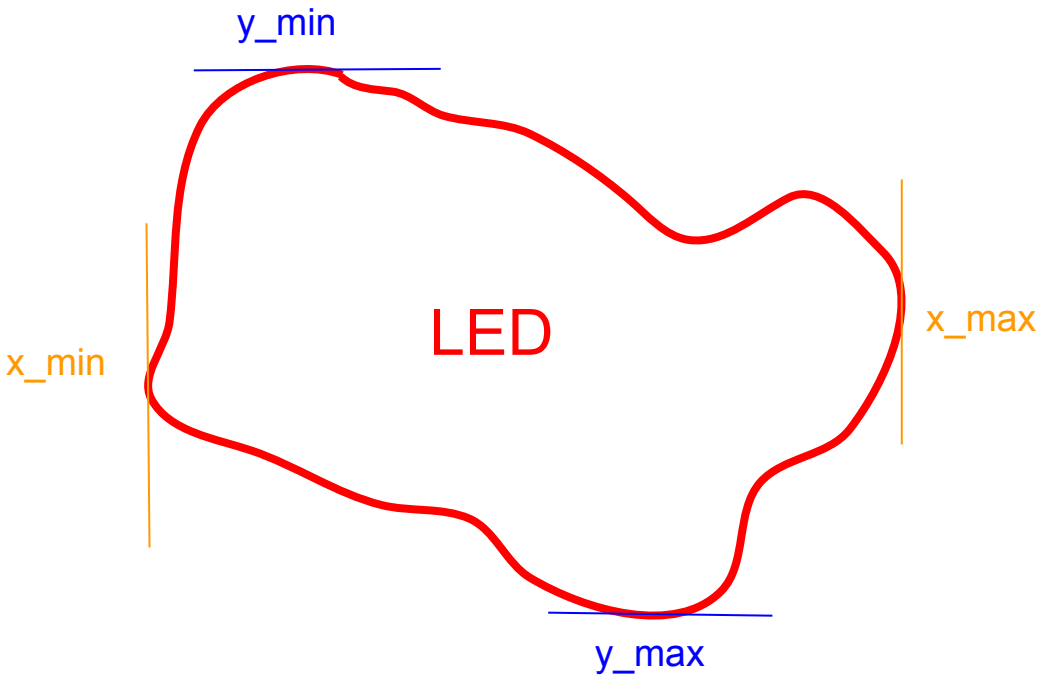
$$r = 1.164*(y-16) + 1.596*(Cr-128)$$

$$g = 1.164*(y-16) - 0.813*(Cr-128) - 0.391*(Cb-128)$$

$$b = 1.164*(y-16) + 2.018*(Cb-128)$$

Module (LED Finder)

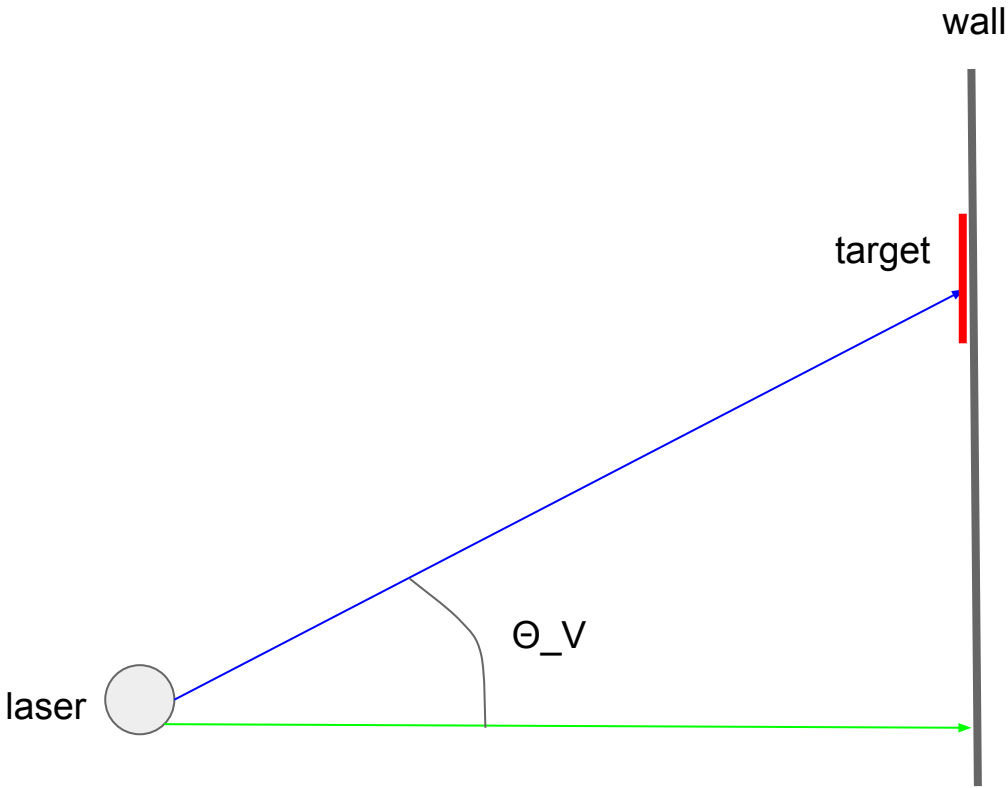
```
x = (x_min + x_max) >> 1

y = (y_min + y_max) >> 1
```



Module (arctan)

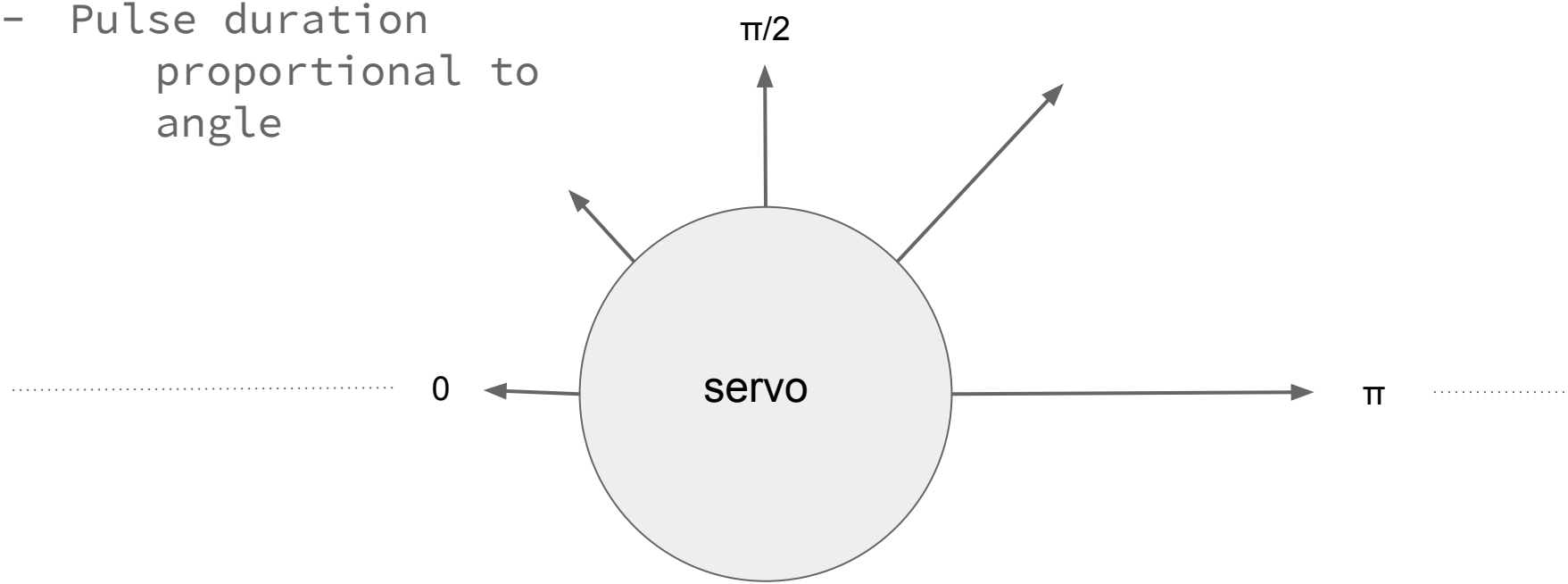
$\Theta H = \arctan(x/z)$

$\Theta V = \arctan(y/z)$



Module (servo)

- Pulse every 2ms
- Pulse duration proportional to angle



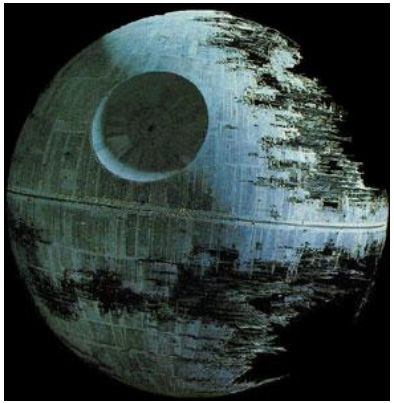
Module (Laser)

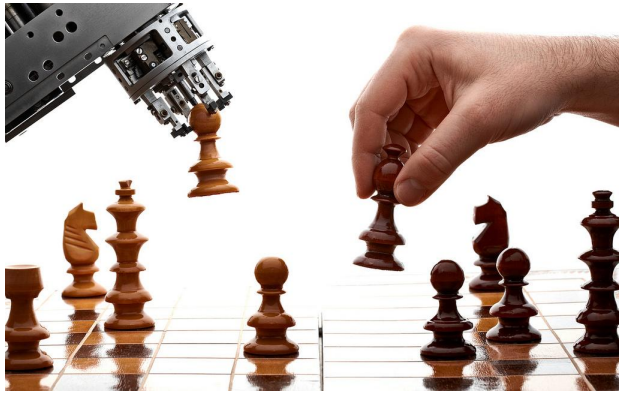
```
if(ledFound &&
       abs(ΘH[n-1] - ΘH[n]) <=E &&
       abs(ΘV[n-1] - ΘV[n]) <=E)
    laserOn <= 1;
else laserOn <= 0;
```

Parameter **E = π/180 radians**

Reach Goals

- Chroma Keying
- Cross Hairs
- Image Overlay on the target
- Landscape/backdrop
- Cyclops versus Human





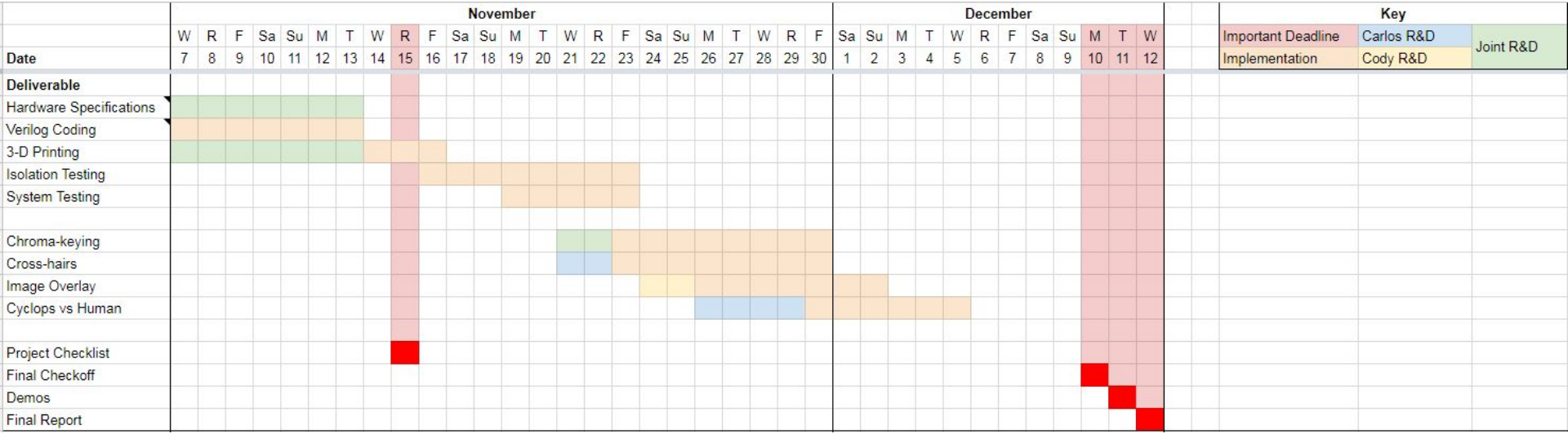
Implementation Complexities

- Math Module-Arctan
  - Taylor Series

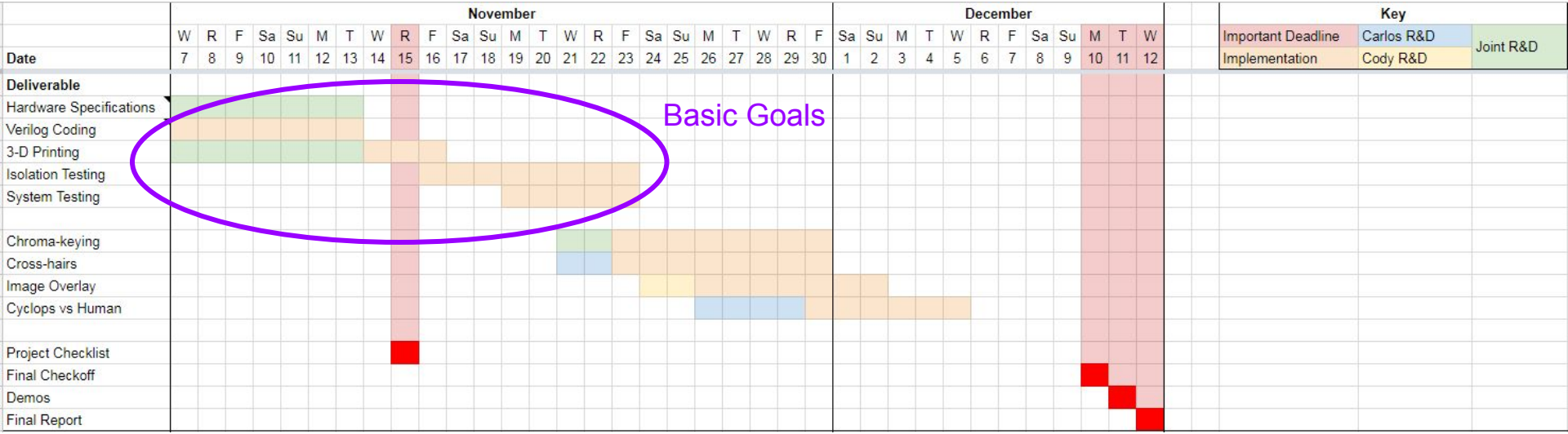
$$\arctan z = z - \frac{z^3}{3} + \frac{z^5}{5} - \frac{z^7}{7} + \cdots$$
$$= \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n+1}}{2n+1}; \qquad |z| \leq 1 \qquad z \neq i, -i$$

- Noise from the camera -IE picking up multiple targets
  - Filter before the camera
  - FPGA: Take the largest feature found
- Accuracy issues (offset of laser relative to camera)
  - Tweaking in Verilog, but no continuous feedback system

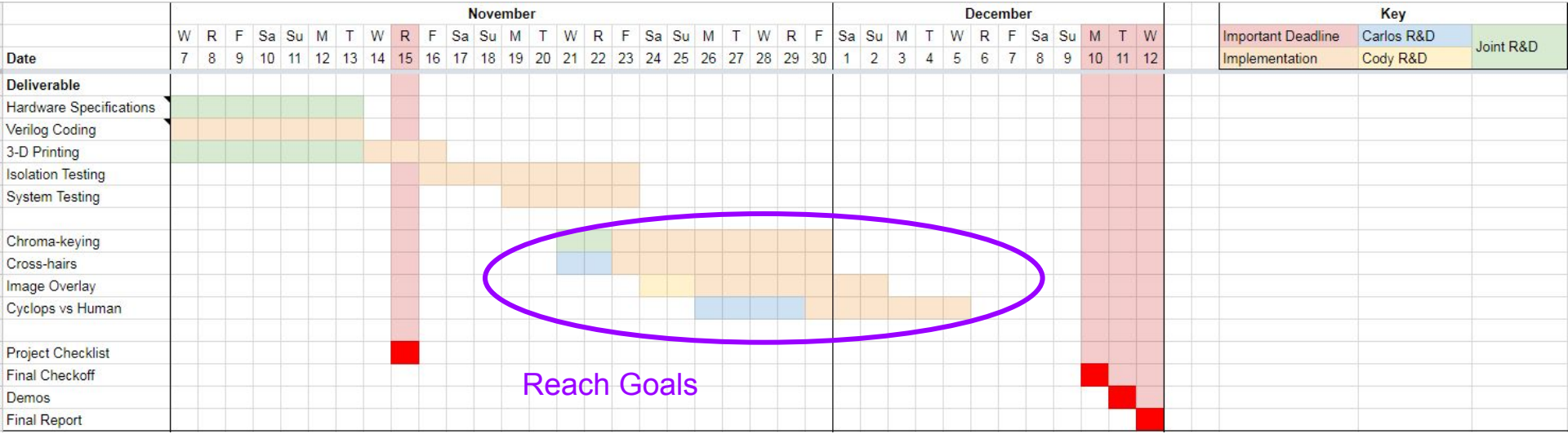
Project Timeline



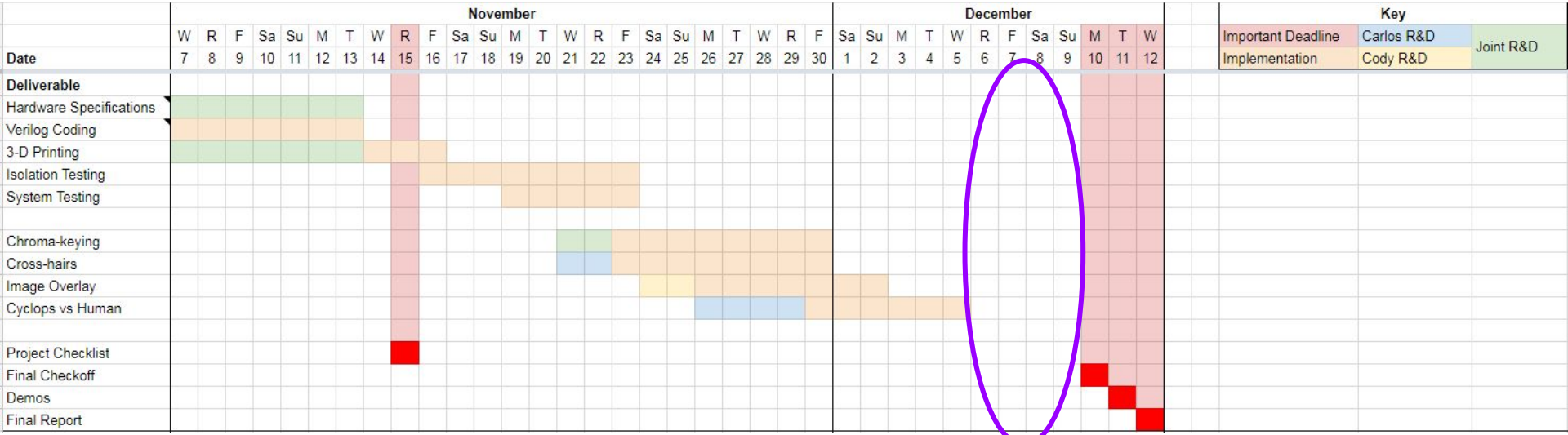
Project Timeline



Project Timeline



Project Timeline



Bug Gap

Thank you

Questions?