Assignment A2b: Photon Detection

John Mays (jkm100)

1. Simulating a dim flash of light

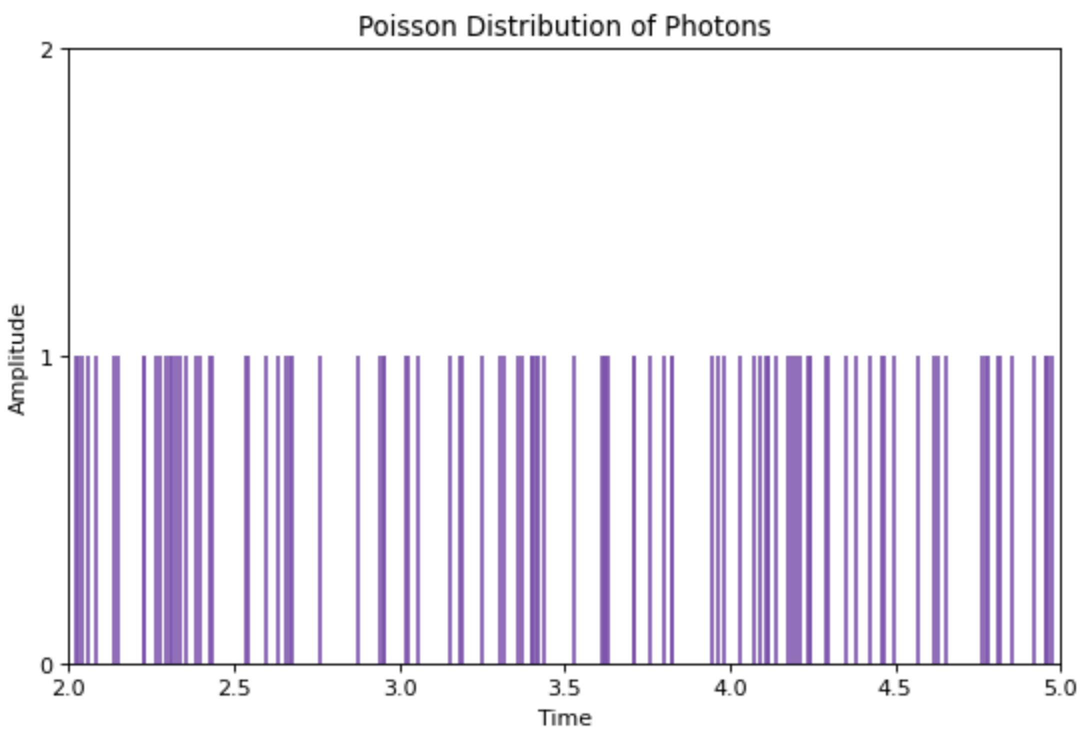
In [ ]:

```
# Appropriate Libraries
from A2b_code import *
```

1a. Random times

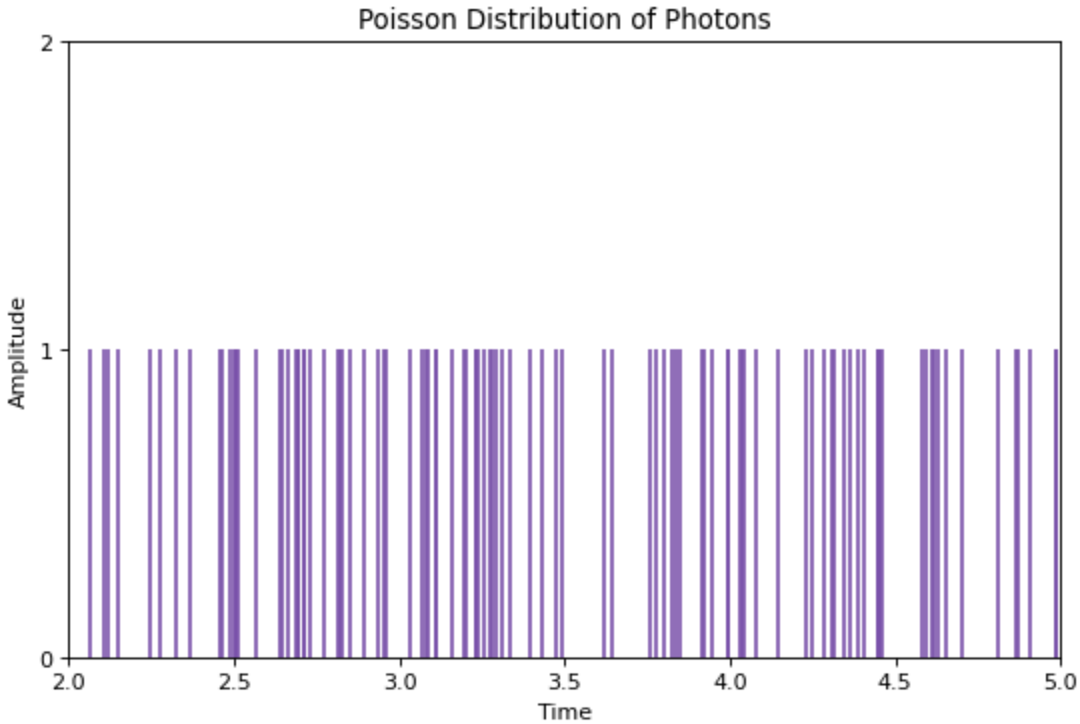
In [ ]:

```
t = randtimes(100, 2, 5)
plotflash(t, 2, 5)
```



In [ ]:

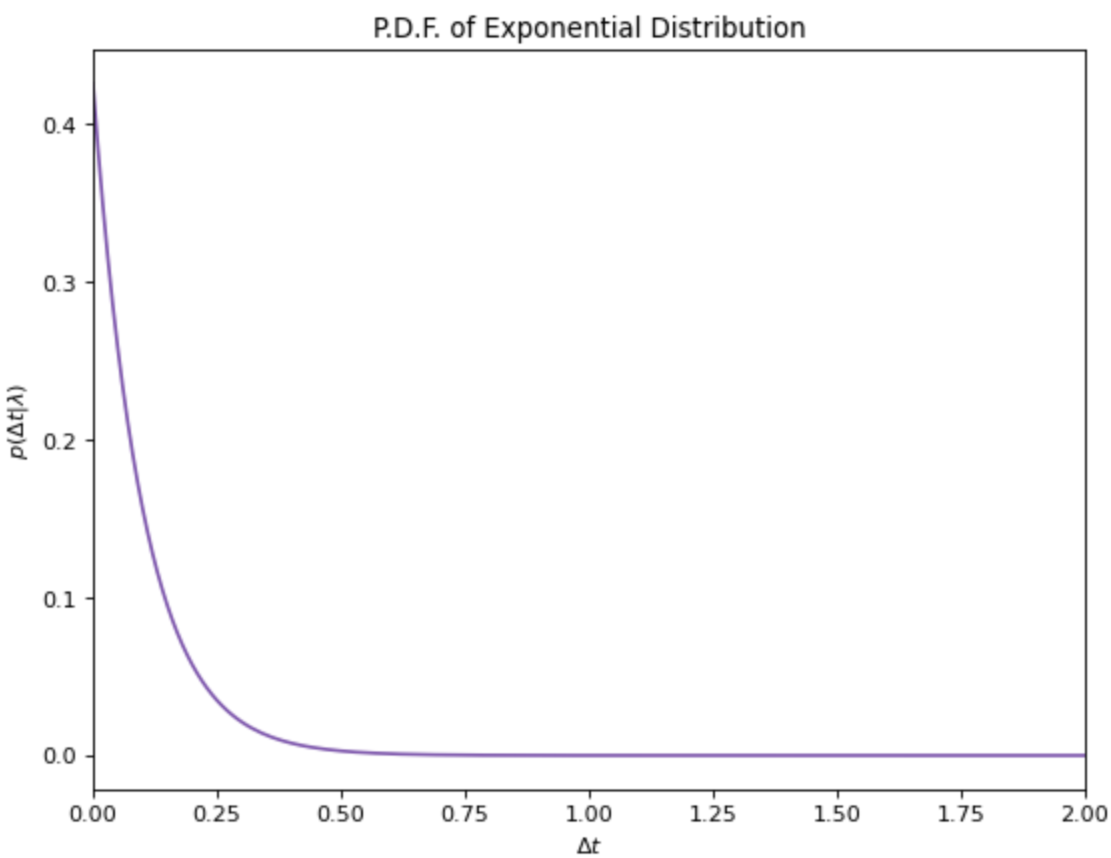
```
t = randtimes(100, 2, 5)
plotflash(t, 2, 5)
```



1b. Random intervals

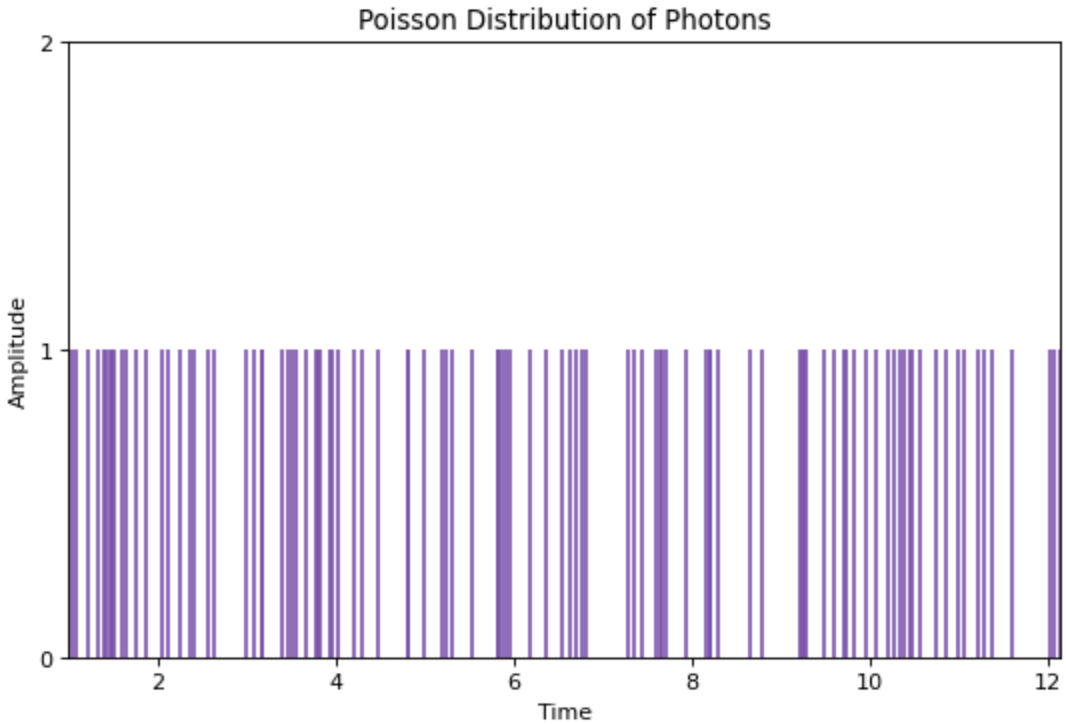
In [ ]:

```
plotpdfexp(lam=10)
```



In [ ]:

```
t = randintervals(100, 10, 1)
plotflash(t, 1)
```



1c. Seeing the flash

They have the same output, but different approaches. The first describes the likelihood of a flash occurring at a given time, independent of the flashes around it, and the second describes the likelihood of a flash occurring w/r/t the amount of time that passed since the flash that came right before it.

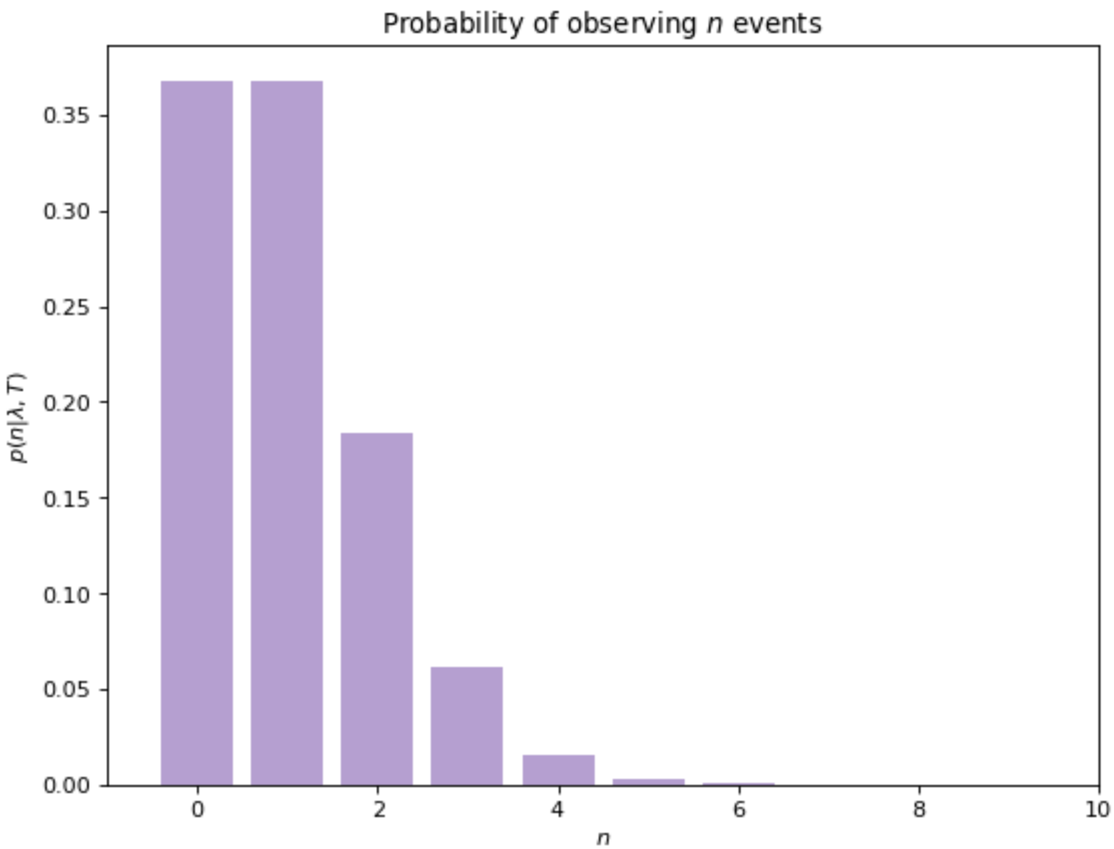
This is inherently probabilistic because the stream of photons entering the eyeball is a random stream with plenty of noise and variation over time, therefore how many are actually going to be detected is a non-deterministic process.

2. Calculating the probability detection

2a. The probability of K photons

In [ ]:

```
K = np.arange(0, 10)
plotbarpdfphotons(K, lam=10)
```

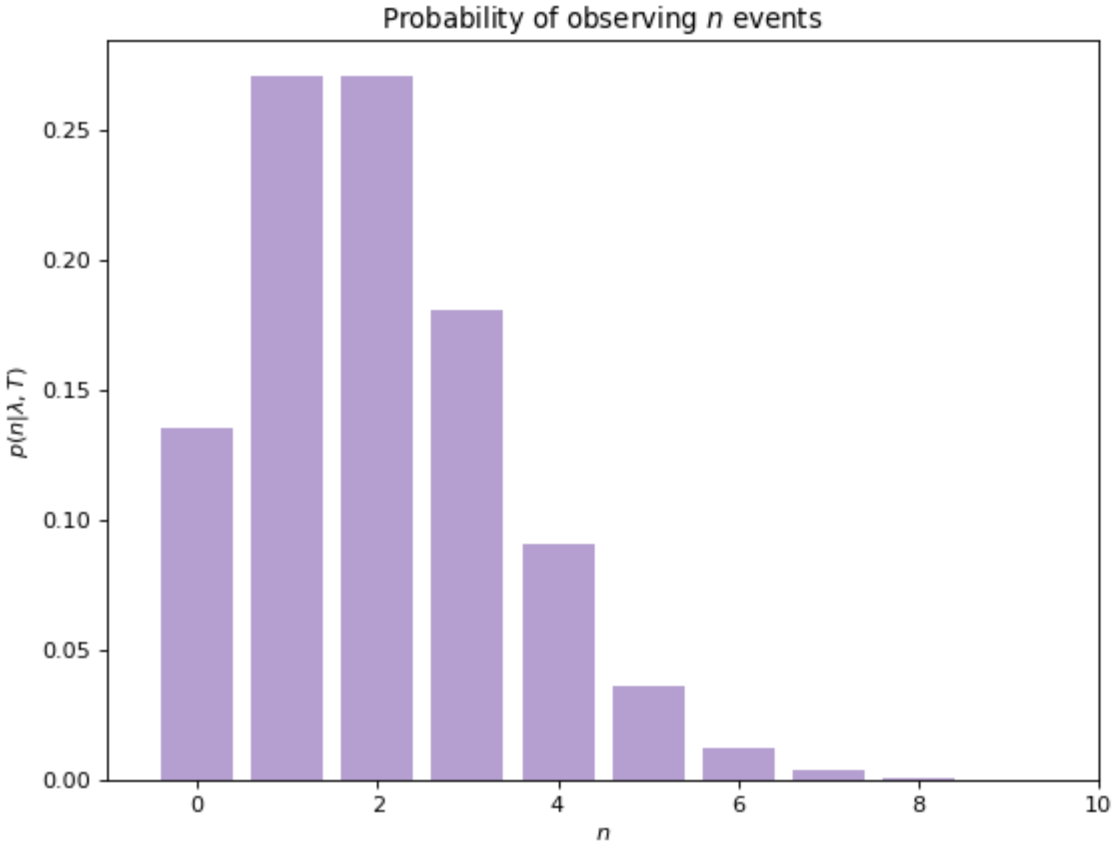


At this rate, the subject would most likely not see the flash, as the probabilities of seeing 6, 7, 8, ... photons are close to 0.

Doubling the rate:

In [ ]:

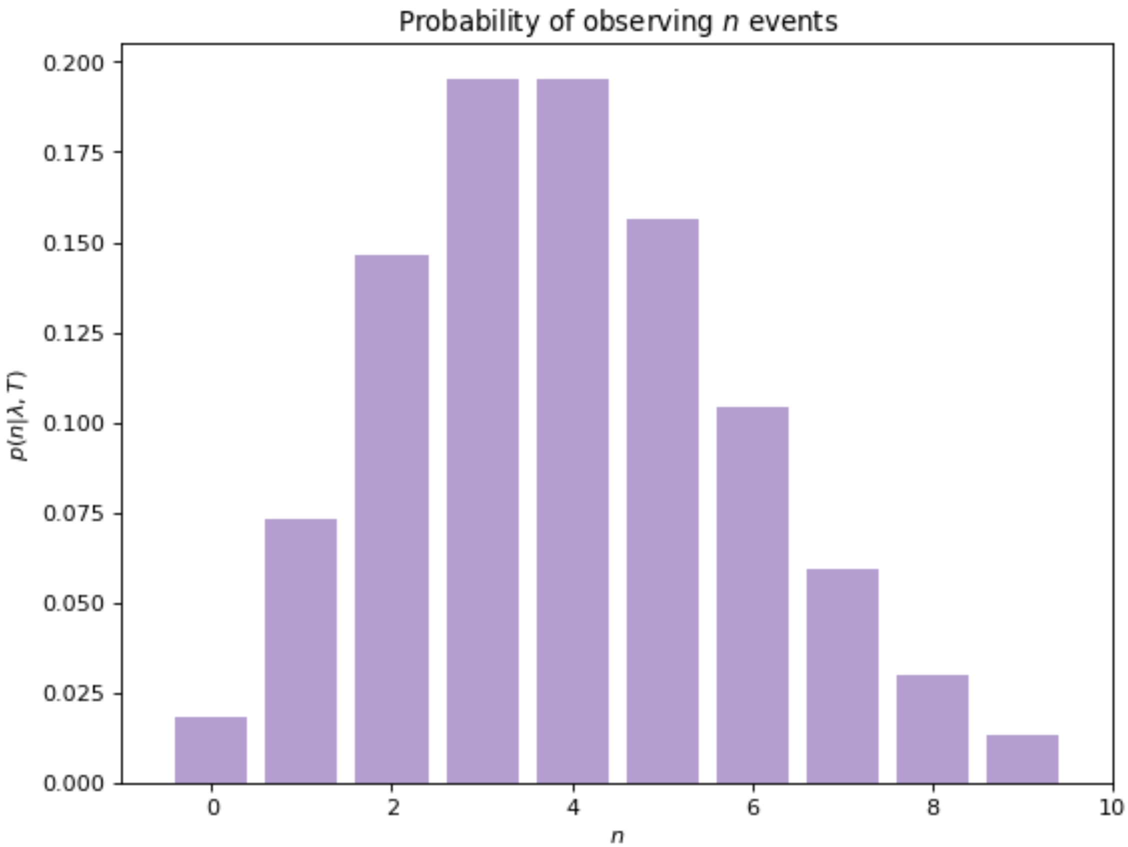
```
plotbarpdfphotons(K, lam=20)
```



Doubling the rate again:

In [ ]:

```
plotbarpdfphotons(K, lam=40)
```



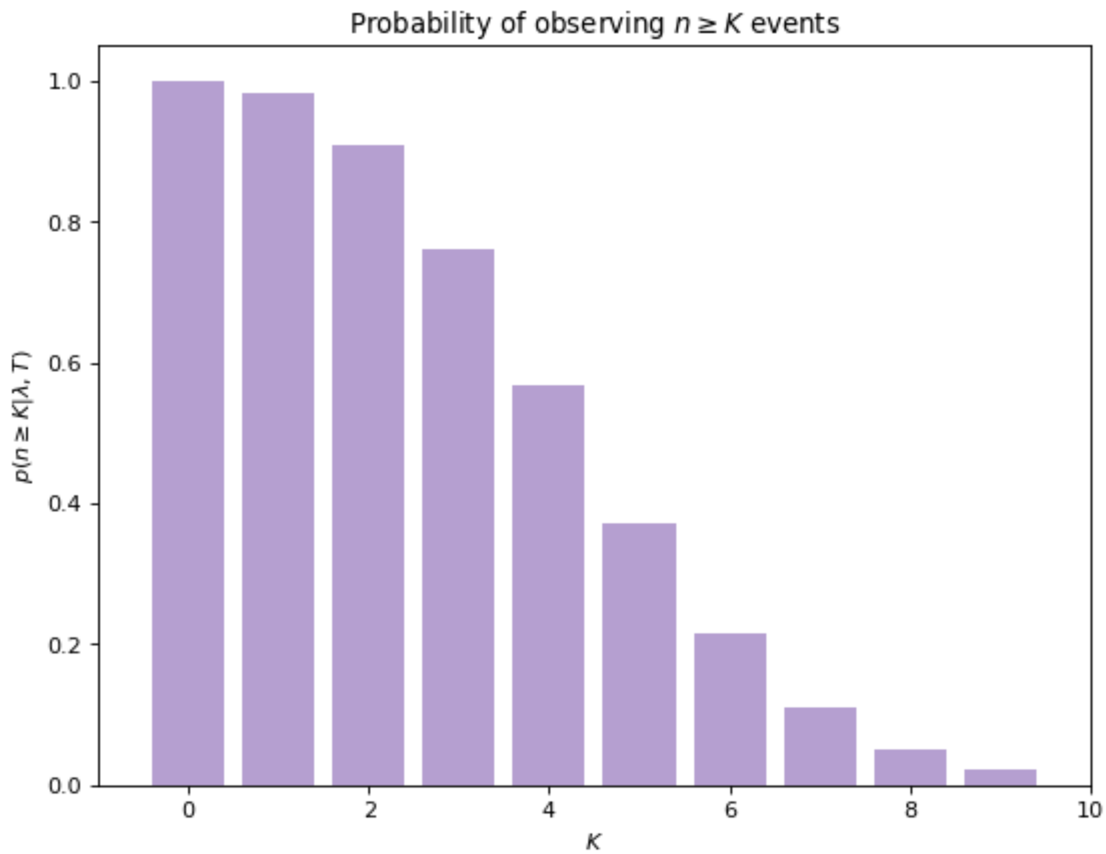
As the rate goes up, the mean of the distribuition increases, and becomes closer to 6.

2b. The probability of K or more photons

In [ ]:
```
detectionprob(6)
```

Out[ ]: 0.21486961296959484

In [ ]:
```
K = np.arange(0, 10)
plotbarcdfphotons(K)
```

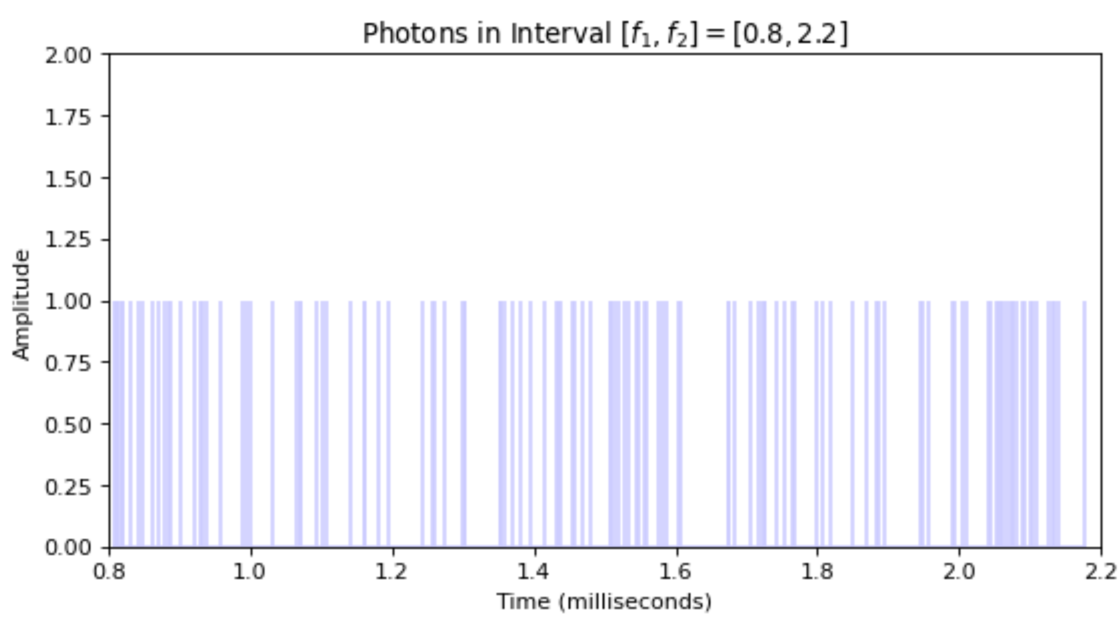


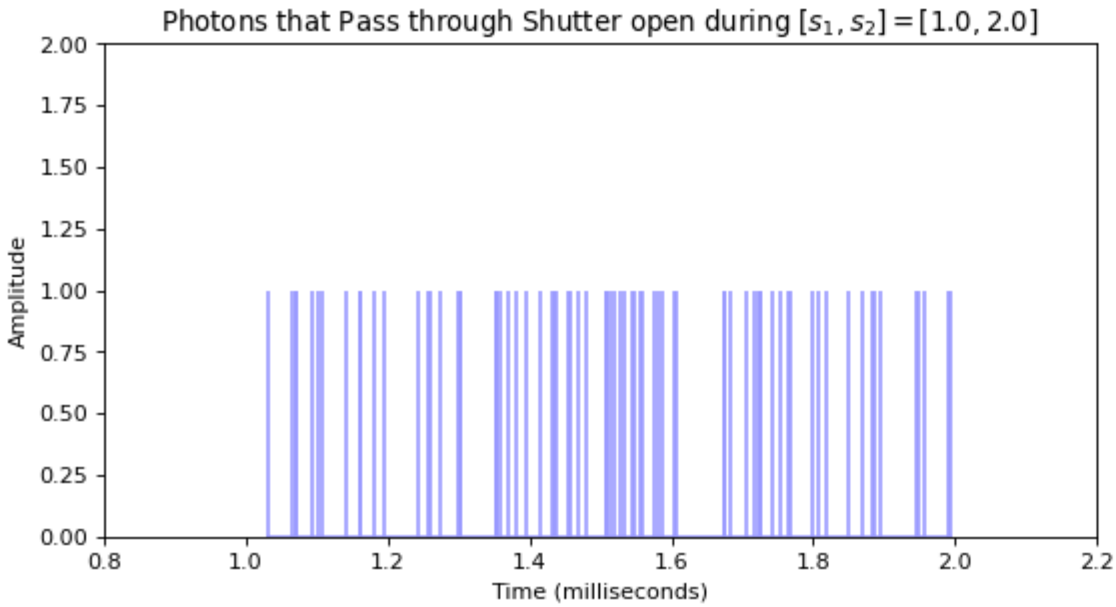
3. Estimating the threshold from experimental data

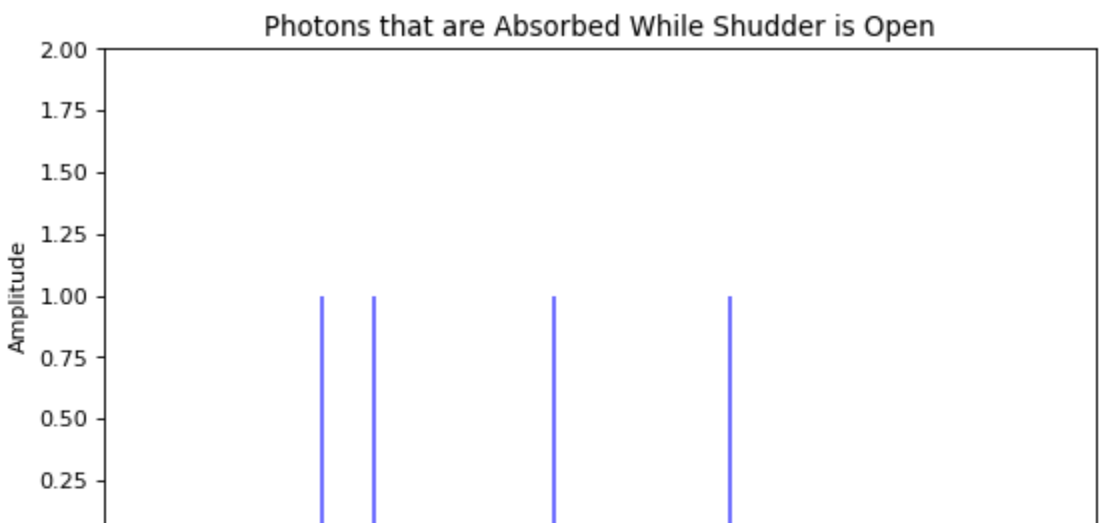
3a. Simulating the photon stream

In [ ]:

```
plotHSPsimulation()
```







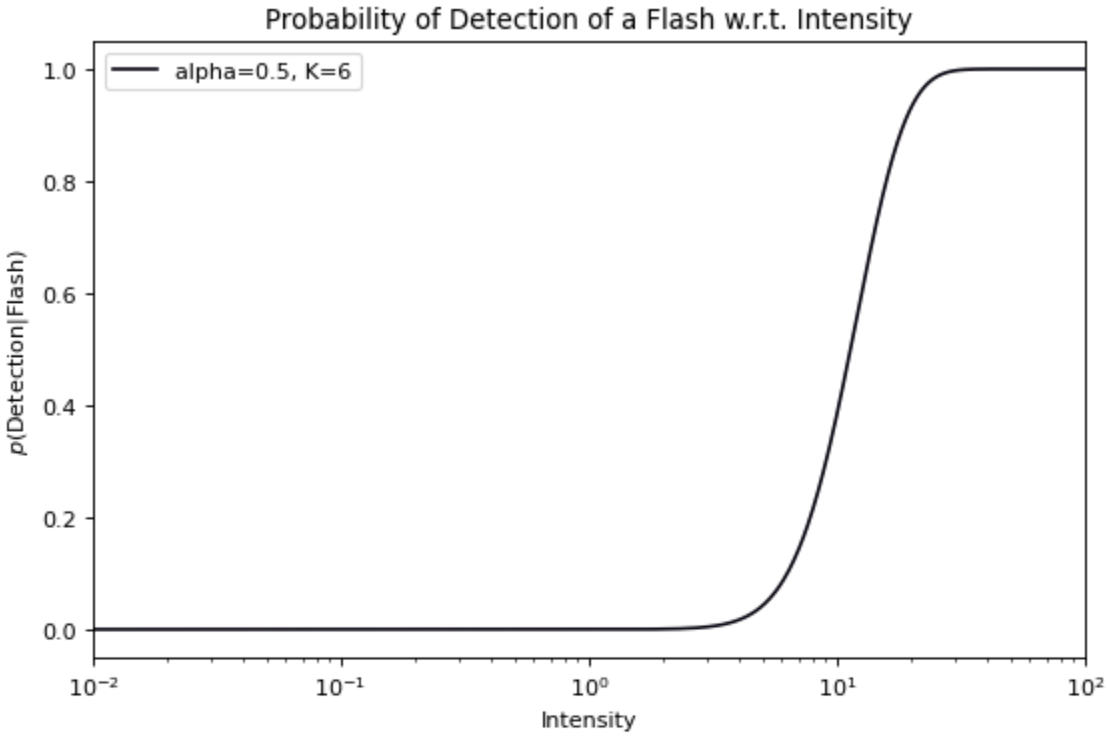
3b. Probability of seeing

In [ ]:
```
probseeing(I=100)
```

Out[ ]: 0.5543203586353891

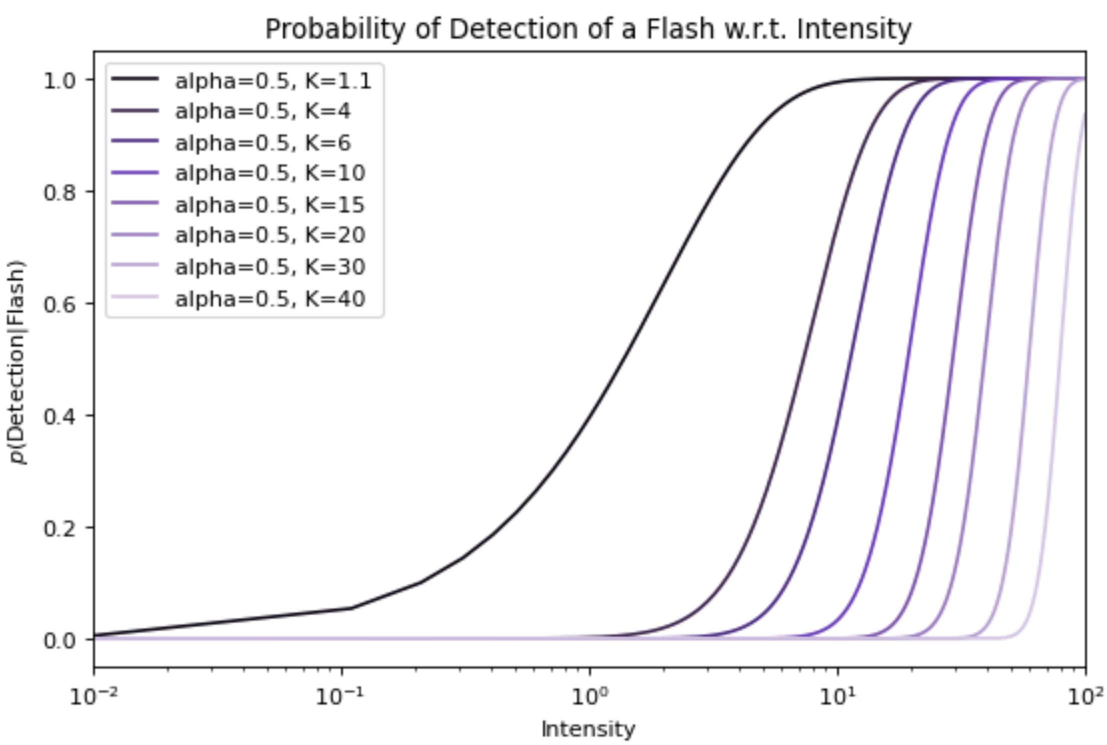
3c. Plotting % detected vs light intensity for different parameters

In [ ]:
```
plotdetectioncurve(alpha = 0.5, K=6, seperatecurves=True)
```



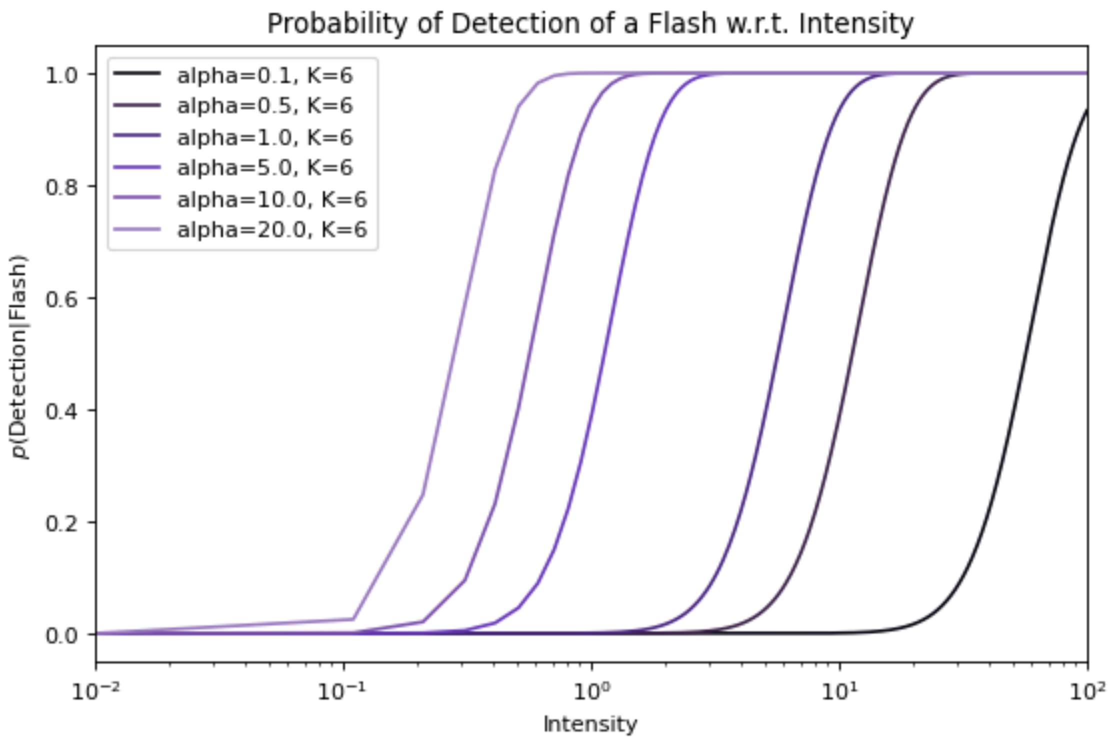
Changing only K

```
alpha = [0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5, 0.5]
K=[1.1, 4, 6, 10, 15, 20, 30, 40]
plotdetectioncurve(alpha, K, seperatecurves=True)
```



Changing only α

In [ ]:
```
alpha = [0.1, 0.5, 1.0, 5.0, 10.0, 20.0]
K=[6, 6, 6, 6, 6, 6]
plotdetectioncurve(alpha, K, seperatecurves=True)
```

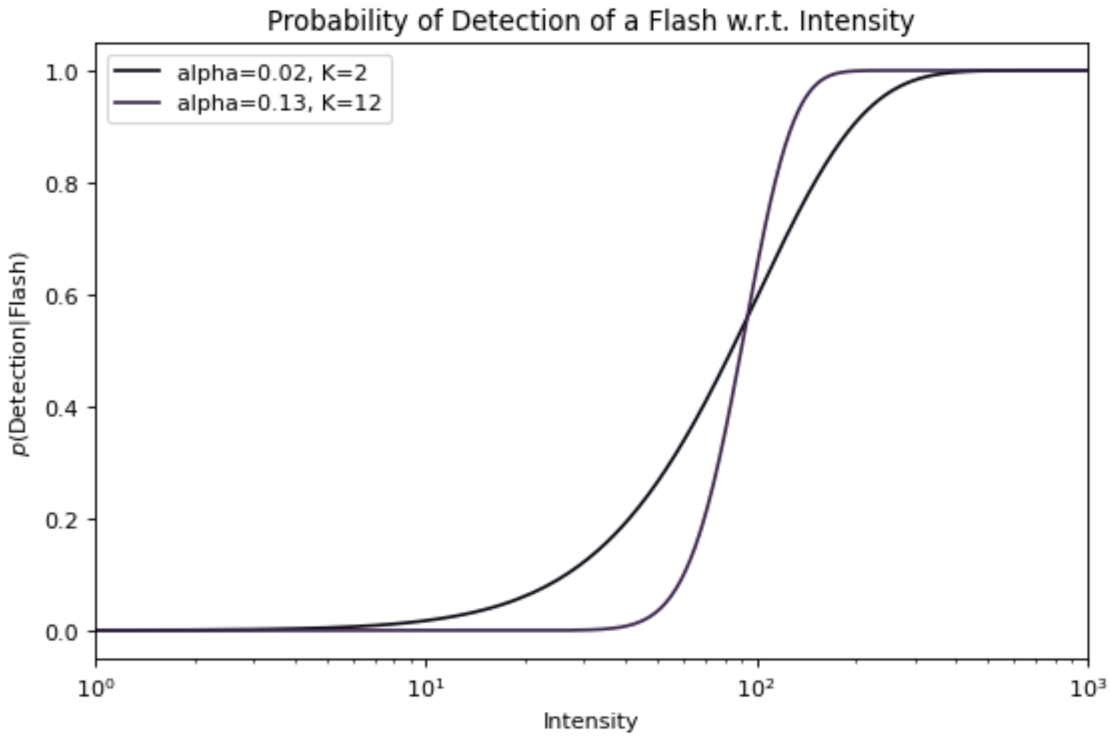


It seems as if α increasing shifts the graph to the left and K increasing shifts the graph to the right and makes it steeper.

3d. Fitting parameters to experimental data

Just the two pairs of data:

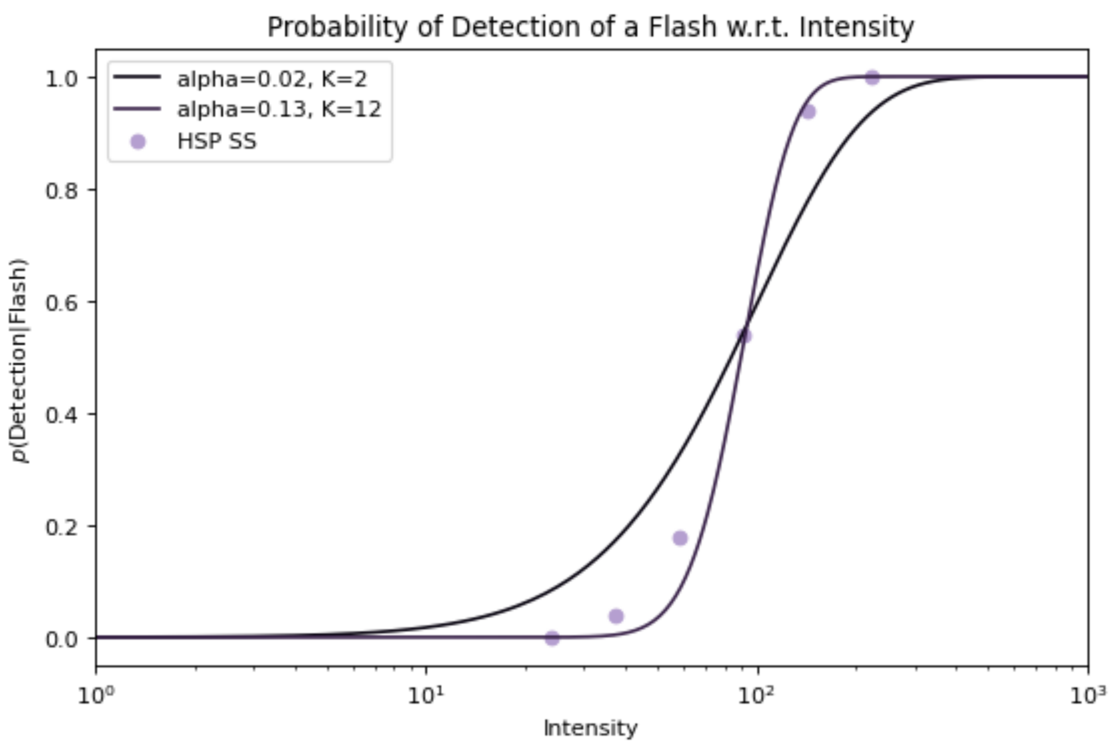
In [ ]:
```
alpha = [0.02, 0.13]
K = [2, 12]
plotdetectioncurve(alpha, K, seperatecurves=True, xlimit=(1,1000))
```



Original two pairs overlaid on the HSP subject SS's pairs:

In [ ]:

```
plotdetectioncurve(alpha, K, seperatecurves=True, xlimit=(1,1000), show_ss=Tr
```



Approximately Optimal Results: $\alpha = 0.0793$ and $K = 7.417$

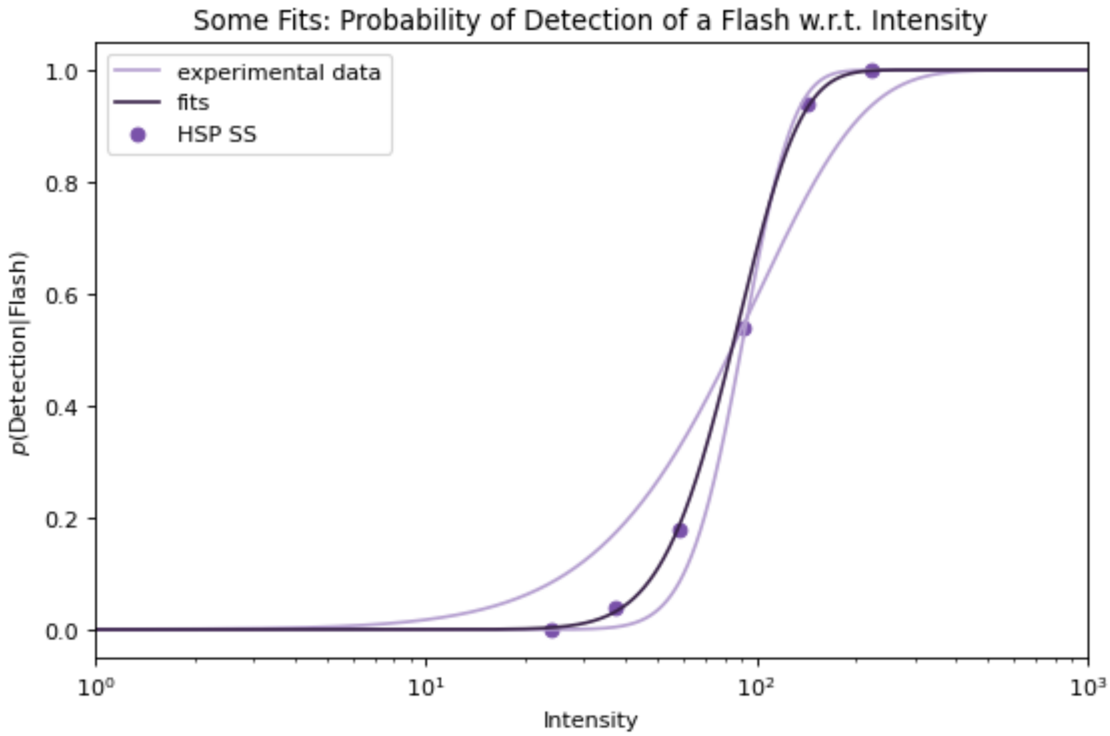
In [ ]:

```
findfit()
```

Out[ ]: (0.0793, 7.416666666666666)

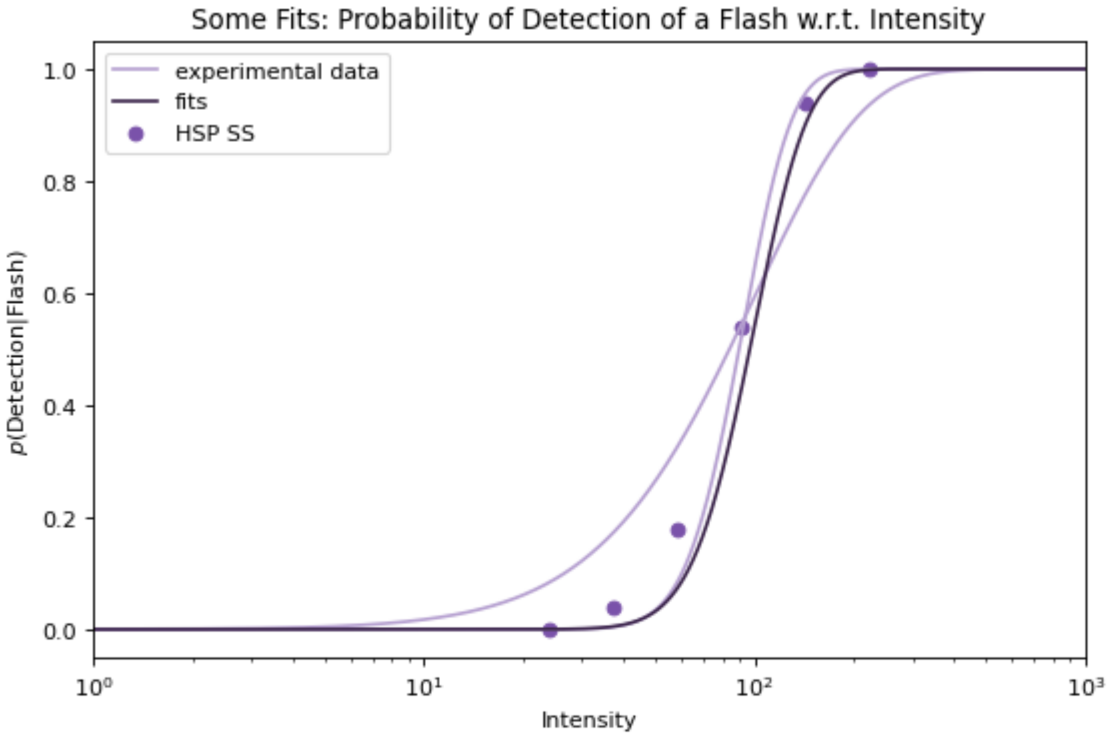
The good fit:

In [ ]:
```
plotfit(alpha=0.0793, K=7.416666666666666, xlimit=(1, 1000), show_fit = True,
```

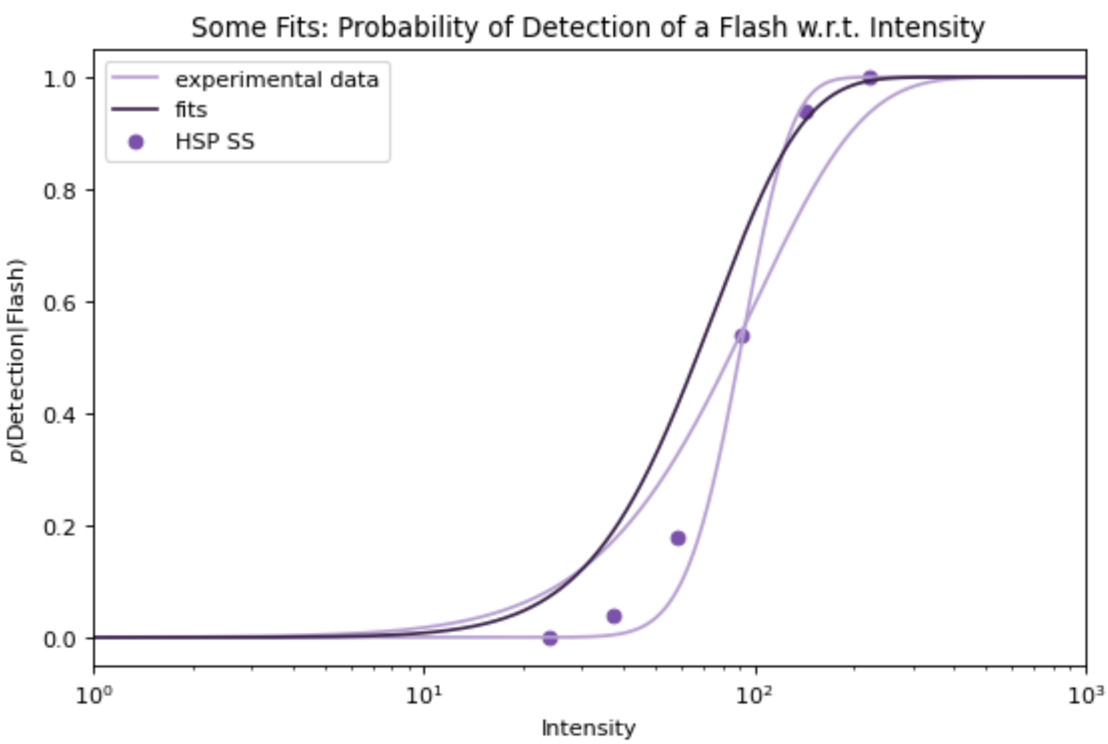


Some not-so optimal fits:

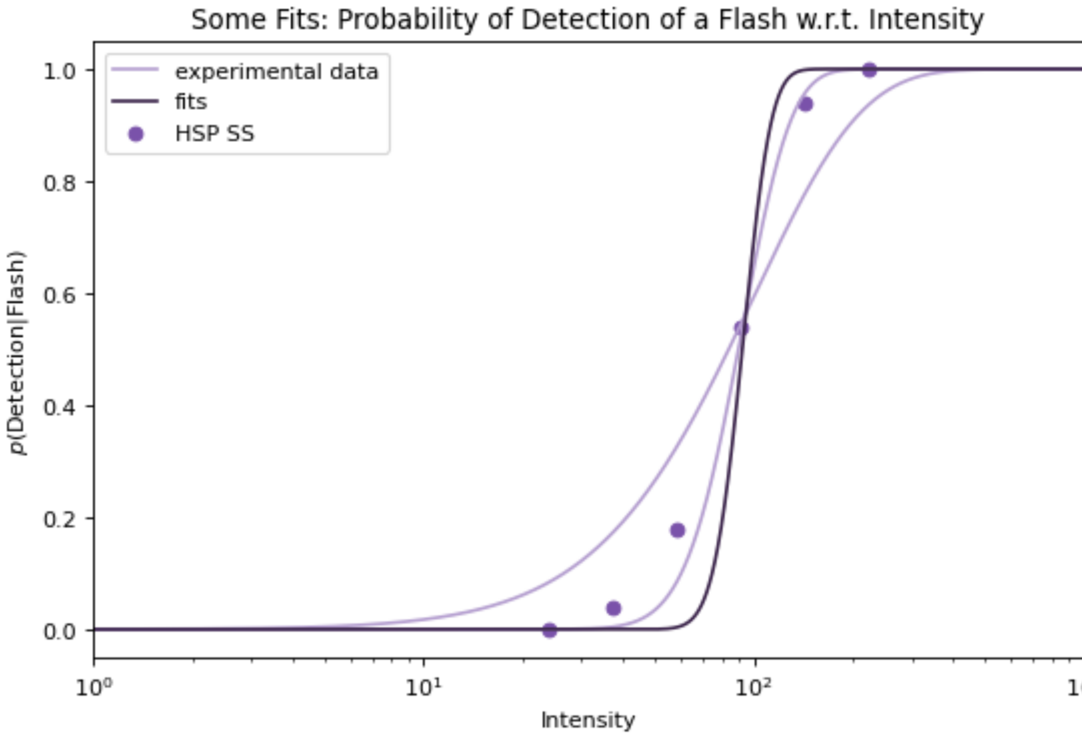
In [ ]:
```
plotfit(alpha=0.10, K=10, xlimit=(1, 1000), show_fit = True, show_ss=True)
```



In [ ]:
```
plotfit(alpha=0.04, K=3.5, xlimit=(1, 1000), show_fit = True, show_ss=True)
```



In [ ]:
```
plotfit(alpha=0.43, K=40, xlimit=(1, 1000), show_fit = True, show_ss=True)
```



I would explain that, in order to see a dim flash of light, assuming there is a tight mean that can describe the α probability of a photon being absorbed by the human retina $\approx 7\%$, it takes around 7 photons arriving within a given timespan, usually with a maximum of 100 ms, in order to be detectable.