Lab 6

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Physics 434

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```
clear all; close all;

%NOTE the difference in the pt size is the pt range
```

Problem 1

To begin with, a background is created with a poisson distribtion. From this distribution, the first aim is to determine where the 5σ sensitivity threshold is.

```
%OLD CODE :(
% figure(1);
% title("Comparison of QCD and Higgs, Data Rows 1 and 4")
%
% h_H1=histogram(H1);
% set(h_H1,'FaceColor',"[0 0.392 0]");
% title("1: Higgs Pseudorapidity");

sig5=1/(3.5 * 10.^6);

%Sensitivity threshold:
S5=icdf('poisson',1-sig5,100)
```

```
S5 = 154
```

```
S5_lower=icdf('poisson',sig5,100)
```

```
S5_lower = 54
```

Here, we take the inverse cdf to the upper and lower bounds of 5σ to find the corresponding sensitivity threshold for our generated poisson distribution.

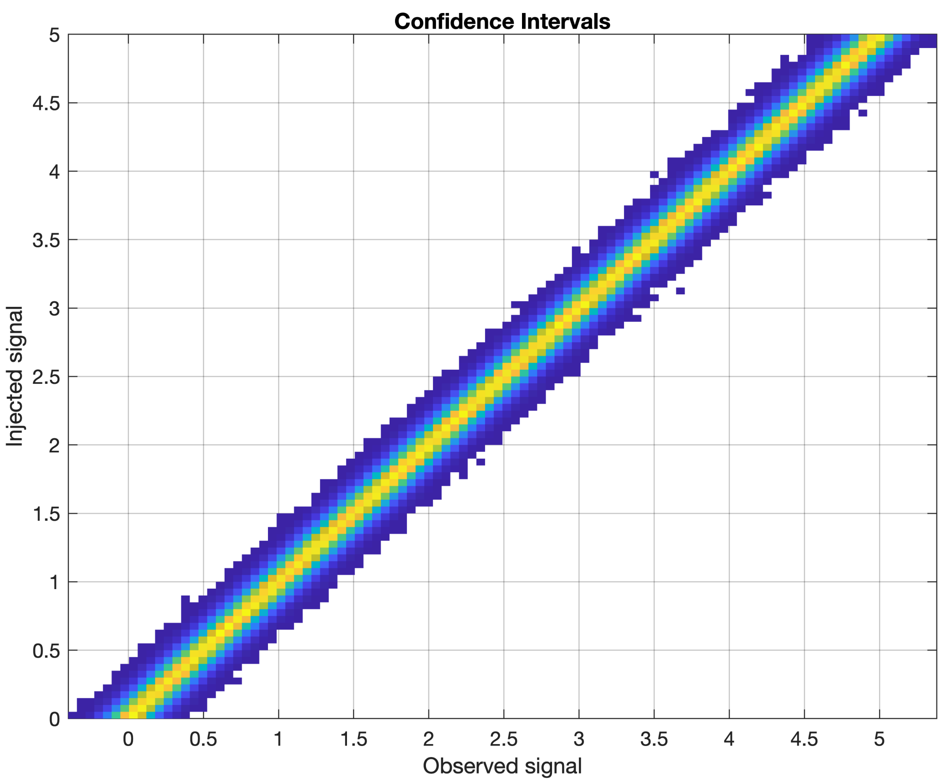
Problem 2

Now create a set of injected (simulated) signals of a single strength. You will want to make your signal moderately strong, say somewhere in the 8-30 σ range. Inject this signal into your background data many times.

Background has lambda=100

Background is extremely unlikely to ever fluctuate to say 14 sigma, so choose something greater than 190 because the signal chosen should be greater than such as 8 sigma, and 8 sigma of the signal is 190

```
%********
sig15=3*(10^(-17));

%Sensitivity threshold:
S15=icdf('poisson',1-sig15,100);

size = 1000;
N = randn(size,size)*0.1;
%SigStrength = [1:1000];

SigStrength = linspace(0,5,1000);
[input1, signal] = meshgrid(SigStrength);

Observed = N + signal;

figure()
h = histogram2(Observed,signal,100,'DisplayStyle','tile','ShowEmptyBins','off');
ylabel("Injected signal")
xlabel("Observed signal")
title("Confidence Intervals")
```



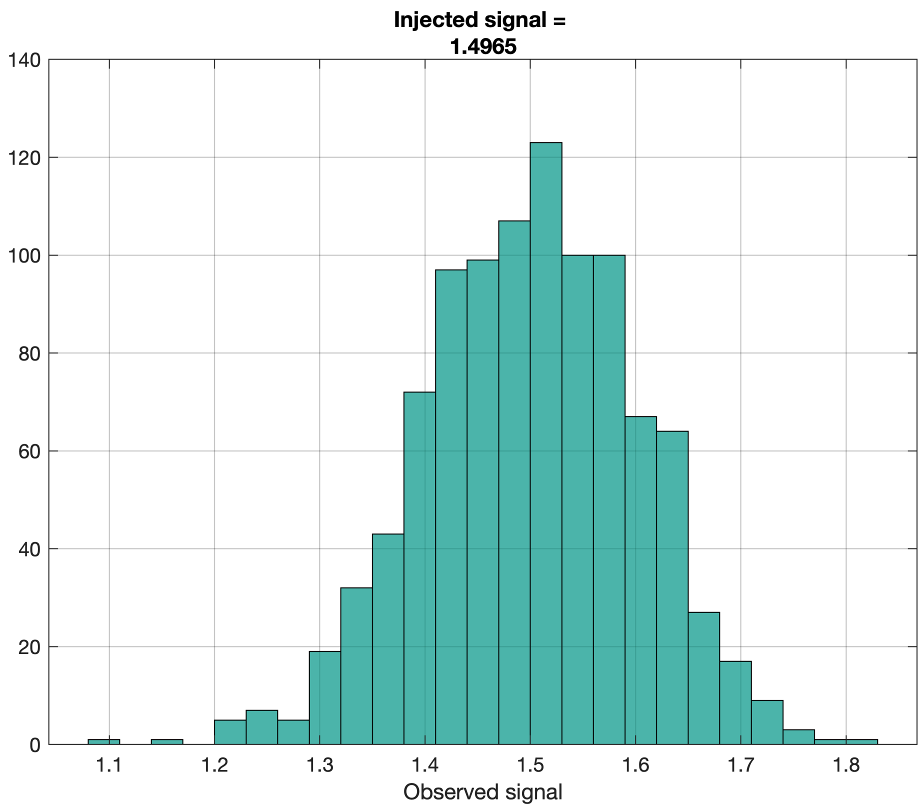

```
figure()
index = 300;
s=signal(index)
```

```
s = 1.4965
```

Part 2.A

Histogram how **bright** *(number of events)* the observed signal appears to be, and discuss it's shape. Say in words what this histogram is telling you.

```
h1=histogram(Observed(index,:),25);
%xlim([-0.2 5.1]);
set(h1,'FaceColor',"[0 0.9 0.8]");
grid on
title(["Injected signal = ", num2str(signal(index))]);
xlabel("Observed signal");
```



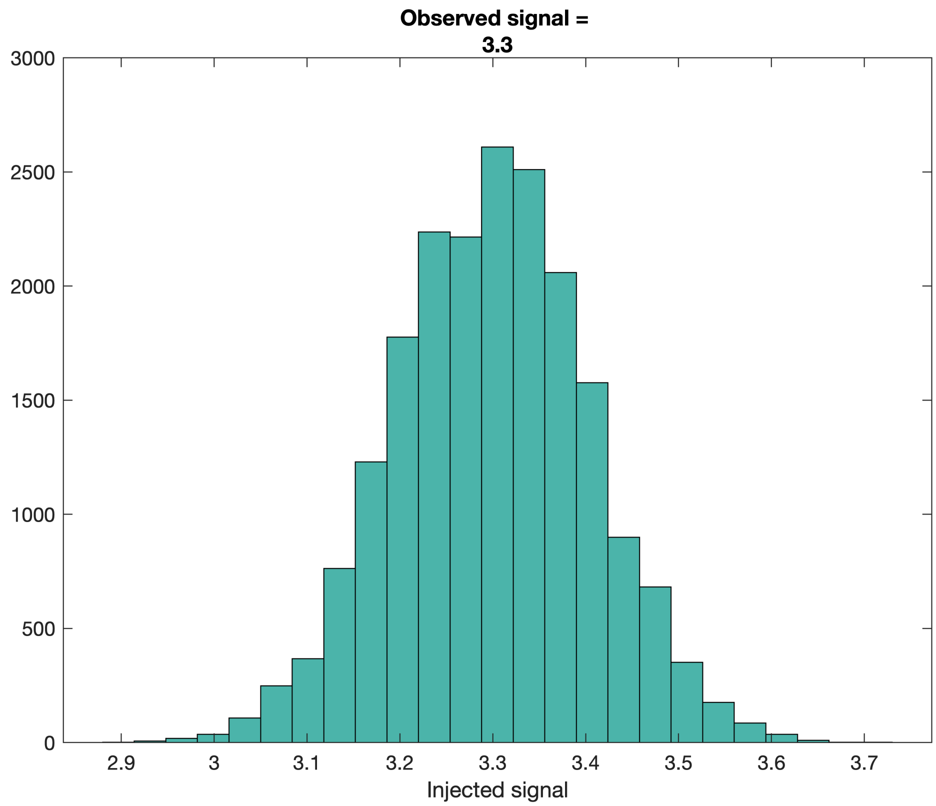
Part 2.B

b) Is your observed signal biased? (e.g. is the observed value equally likely to be stronger or weaker than the true injected signal?) Is it symmetric?

If 1=1 not biased, or if 1=3 biased

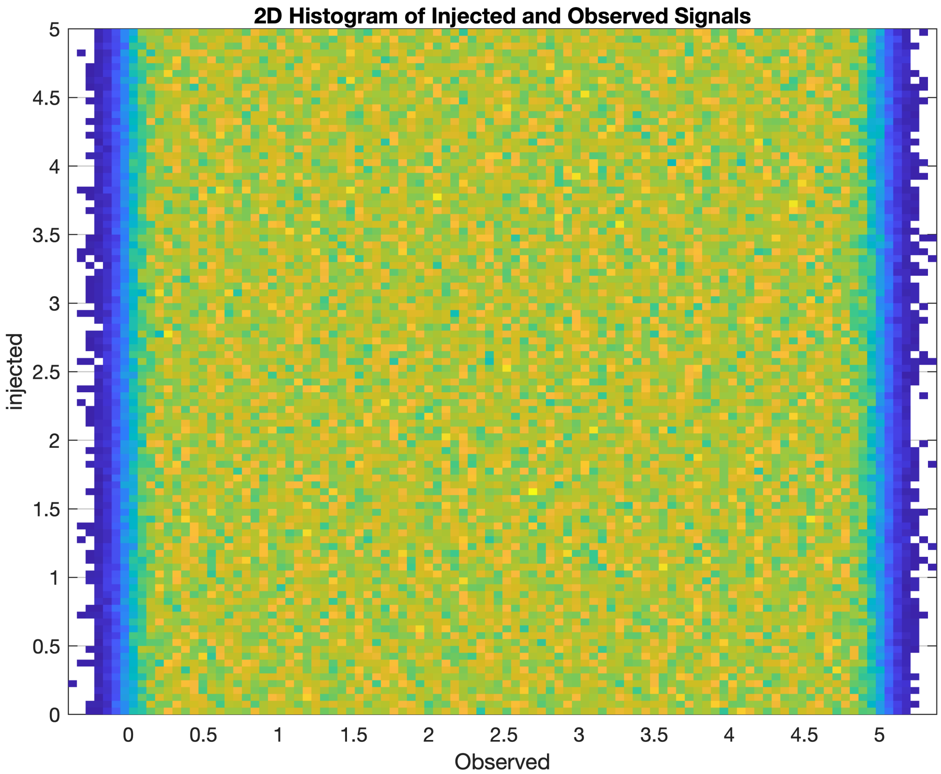
```
observation=3.3;

injected = signal(abs(Observed - observation)<0.05);
h2=histogram(injected,25);
%xlim([-0.2 5.1]);
```

```
title(["Observed signal = ", num2str(observation)]);
xlabel("Injected signal");
set(h2,'FaceColor',"[0 0.9 0.8]");
```

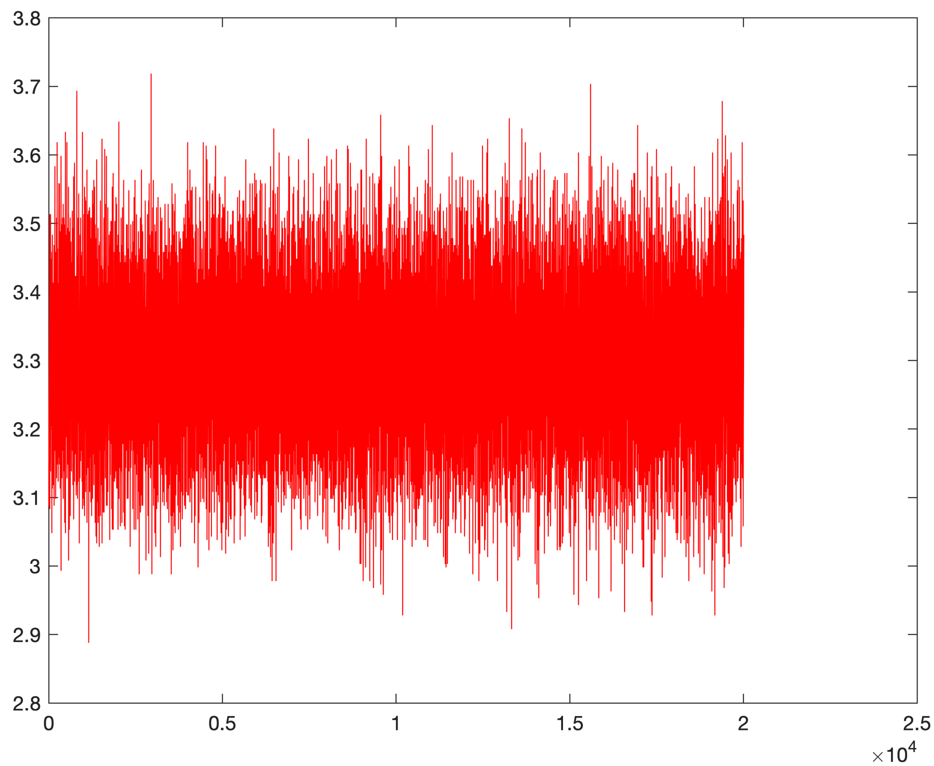


Because the line for the data does not follow a model of y=x, instead shifted so that y=mx, where m is some multiplier on x, it indicates that the data is biased.

```
injected1=[injected(1:1:1000)];
histogram2(Observed, input1,100,'DisplayStyle','tile','ShowEmptyBins','off')
title('2D Histogram of Injected and Observed Signals')
xlabel('Observed')
ylabel('injected')
```




```
plot(injected,"red");
```



The data is also interpreted to be symmetric because the dispersion of the count intensity, as seen on the 2D histogram, is not symmetrical around the y=mx line, with more activity seen on the upper side of the line.

Problem 3

Continuing from Problems 1 and 2, we will make a "suite" of injected signals with various strengths, ranging from zero to more than 10σ.

Now make a suite of injected signals. You will want to have a range of injected signal strengths, starting at zero and extending well above 5σ

(30σ or more).

Part 3.A

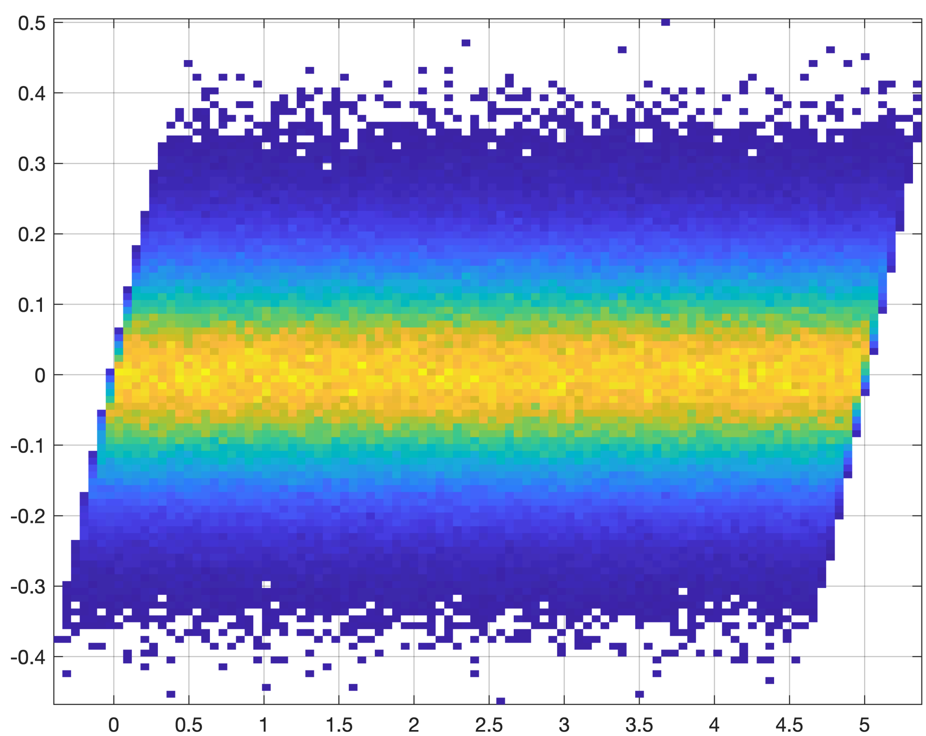
The statement of what we intend to simulate is as follows:

Clearly state what you are simulating, and make a 2D histogram of injected signal vs. observed signal

We have our determined true signal, but what is the range of signals we could see?

Below is the 2D plot of the observed signal vs. the normal data.

```
histogram2(Observed,N,100,'DisplayStyle','tile','ShowEmptyBins','off')
```



Part 3.B

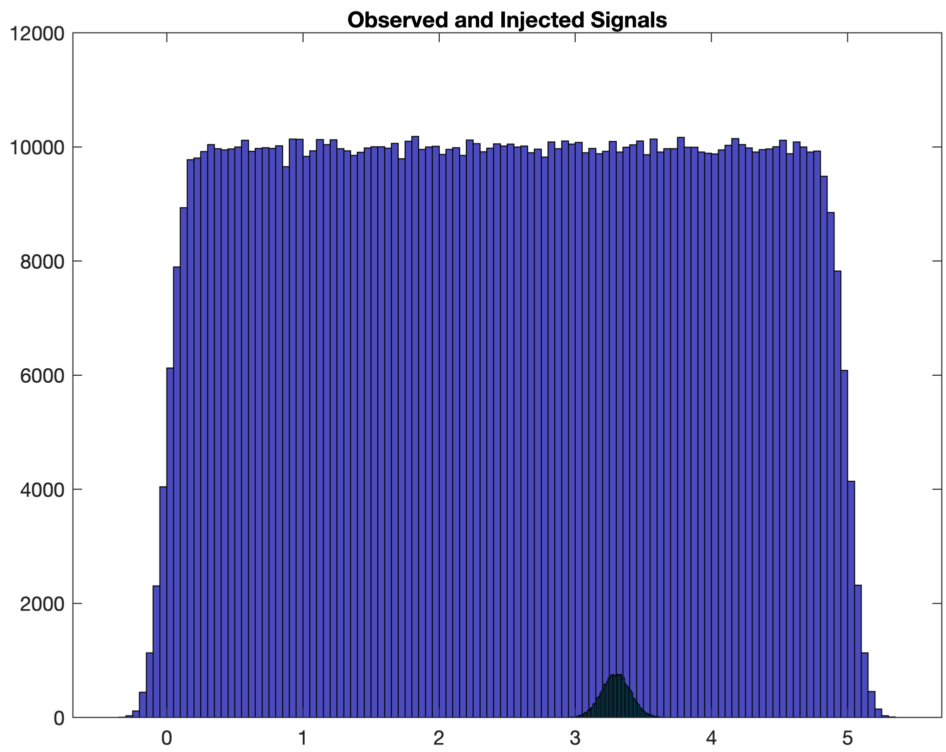
To show that the same injected signal power was achieved for both Problem 2's injected signal and this problem's injected signal, we use the following method:

If you choose the same injected signal power as in problem 2, show that you get the same answer.

Part 3.C

Below is a histogram of a chosen observed signal () and the injected signal pdf.

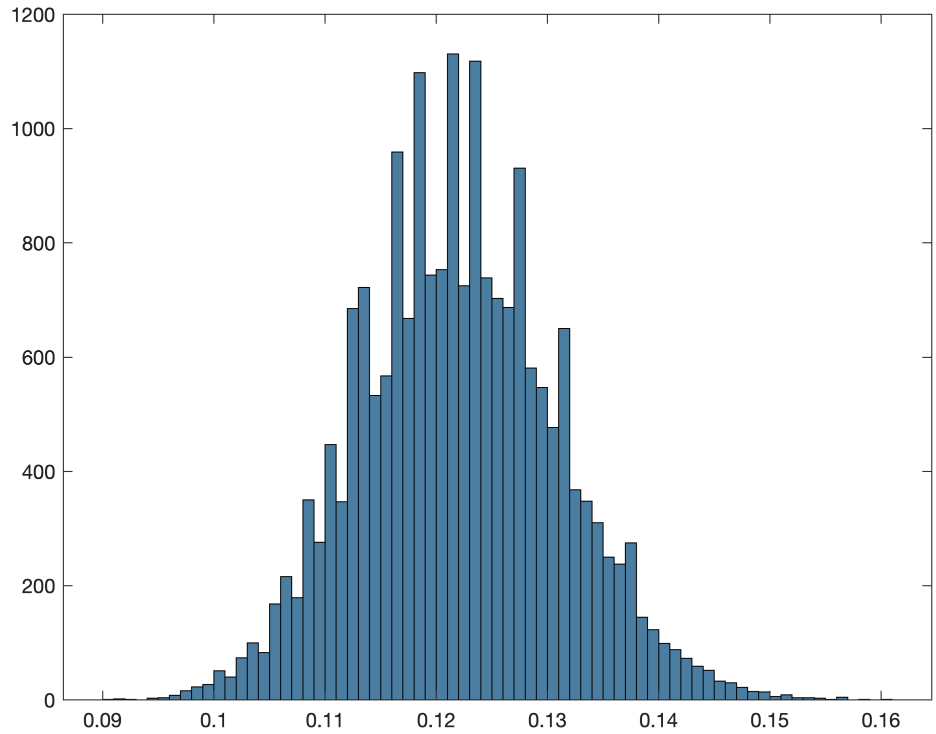
```
histogram(Observed,'FaceColor',"blue")
title("Observed and Injected Signals")
hold on
histogram(injected,'FaceColor',"cyan")
hold off
```



The histogram shows that the injected signal has a much more decreased range than the observed signal, and that it is also much lower in magnitude.

Now reverse the problem, select an observed signal (pick something quite a bit stronger than 5σ) and create a 1D histogram of the injected signal pdf(). Describe the meaning of this histogram.

```
new=pdf('poiss',1,injected);
histogram(new)
```



This histogram shows the pdf of the injected signal fit to a Poisson distribution. Most of the injected signal fits well, but some of the points are outliers.

Part 3.D

For the observed signal, the 1σ uncertainty on the true signal strength is:

For your observed signal, what is the 1σ uncertainty on the true signal strength?

Part 3.E

Discuss the answer to part d in some depth. Is it symmetric? Is it biased? Does this make sense?

A poisson distribution is not symmetric , therefore our answer is not symmetirc. The distribution is close to being symmetric, since for any large n a distribution approaches the gaussian which is symmetric, but currently this distribution is still not symmetric.

Is it biased? Does this make sense?

This distribution is biased.

Problem 4

With the same setup as Problem 3, a weak signal is now used:

Using the same setup as in problem 3, now pick a relatively weak signal (say in the 1σ range, exact strength not important).

Part 4.A

Repeating the procedure in Part 3.C, the injected signal pdf is calculated.

It is shown that the pdf extends to zero.

Repeat problem 3c, calculating the injected signal pdf(). One of the differences you should immediately see is that the pdf() extends to zero.

Part 4.B

The pdf of the inject signal extends to zero because...

Describe what it means to have the true signal pdf() extend to zero.

Part 4.C

c) Calculate a 95% confidence upper bound. [Hints: make sure your pdf() is normalized. The statistical question is: if I observe this candidate signal (and it is too weak to claim a detection), then the true signal would be less than X 95% of the time.]