NOTES 7: On-Source Analysis, R.O.C. Curves, and G.R.B's

R.O.C. - Curve : detection prob., vs. false alarm prob   stands for R.eceiver O.peration C.haracteristics
On-Source analysis, Proper: We create a single noise file with multiple injections.

On-Source analysis, Our Version:

A. First, choose some statistic, $\rho(m, \chi)$. Also, keep a constant interval length

1. generate a set of random noise, as well as random wave form to inject as follows
for A*, sample [1, 50] for f*, sample [90, 110] for γ*, sample [0, 2] for $t_0 = t*$, sample [0, $t_f - (Len)$]
We've then construct a signal $h(A*, f*, \gamma*)$, and then $d_i(t) = n(t) + h(A*, f*, \gamma*)$

B. Next, we loop through the (A, f, γ) / (f, γ) template parameter space, and test the generated $h_j^T(t)$ against $d_i(t)$:

2. with your $d_i(t)$ and some separate $h_j^T(t)$, generate an $m^T(t)$, $\chi^T(t)$; also generate the 'foreground' values: $\max_{[t_0-\Delta, t_0+\Delta]}(m^T(t))$, $\max_{[t_0-\Delta, t_0+\Delta]}(\chi^T(t_0))$; where t_0 is the point of injection of the randomly generated signal

3. 'background' values: we repeat step 2, but maximize over each time intervals that's not the 'foreground values' window

4. along with all this, save the two time series m(t) and $\chi(t)$ used for your data, as well as the generated-data. E.G. output=[[[d1 off source], ...,[dn off source]] , [d1 on source, .. dn on source]]

5. Make sure then that you also save the the generated $d_i(t)$ file

C. The above can be done within the constructor, with multiple generated-datas; the following is separate:

6. 'false alarm probability': Now you go and calculate how many background values have a rho that are greater than the on-source rho from the 'foreground' values. With this, we calculate $\frac{N_{BG}(\rho > \rho_{on-source})}{N_{BG}}$

N_{BG} = # of background subdivisions
$N_{BG}(\rho > \rho_{on-source})$=# of intervals with a ho max greater than the on-source rho max

7. now, choose some threshold value T; you will compare your on-source interval rho and all your $N_{BG}(\rho > \rho_{on-source})$ rhos and see if any go over rho.

D. Now, the above is all for a single set of generated data checked against multiple possible templates. What we want now is to check if this single test was successful. To do so, use the chosen threshold value T, and look at the set of on/off-source's which go over this threshold for each individual template-check. If any of the template-checks on this data has an on-source value which corresponds to the largest rho value over T (within the template-checks set of on/off sources), we count the data-test as successful.

E. After doing this test for one set of generated-data, we repeat it for multiple sets of generated data; we sum the number of generated-data's which had successful tests at a given threshold, and label this sum $\#N(T)$. we then plot T vs. $\#N(T)$.

F. Lastly, we can create a heat map over an f $vs.$ γ plane by counting the 'height' at a given (f, γ) pair as the number of successful generated-data tests which has (f, γ) as their randomly generated-data f and gamma

Code construction outline:

```
class OnSource:
    def __init__(self, template variables):
        #initialize tempalte variables
        #make random noise+signal time series, d_i(t)
        #make waveform
        #construct your m(t) and χ(t) for for the various d_i(t)
    ...
    ...
    other methods to perform:
        thresholding
        false alarm probability calculations
        Curve generation
        heat-map generation
```

GRB's:

Long-duration G.R.B's: could be minutes of lengths, but really anything longer than 2. These come from hyper-novas, which result from ancient stars that used to be much more massive. These stars were made primarily of hydrogen, since it was the only thing around. Now these atoms had only 1 electron; moreover, those electrons could absorb photons/radiation and go to an excited state. So, these electrons would take away some of the stars outgoing radiation; as the electrons went up in energy, they had an increase in motion, which increased the temperature of the gas. If they went fast enough, they'd escape in large bursts! Today, these 'escapes' are known as corona mass bursts

At some point these stars would become so massive they'd collapse in. There would be no solid core like some stars today, so when they collapsed inward they would make black holes and massive explosions. These explosions gave off large gamma ray bursts.

In todays universe, elements have higher atomic numbers. So when they get carried off, the star loses mass; so we can no longer get stars as massive as those ancient stars, and as such no longer have hyper-novas.

But hyper-novas from the ancient universe can still be seen today, since some are just reaching us.

Short-Duration G.R.B's: 2 seconds or shorter; people are trying to find the significance of the 2 seconds, but it was originally just from histograms. They come from binary neutron star coalescence; which are also gravity way emitters. So you looked at archived data in LIGO to see if theres a gravity-wave trigger around time and location space where the short G.R.B occurred. We have a window around this registration time though, and we call it the 'On-Source analysis'

these are difficult to see though since the beam is likely to not be in your direction. Additionally, there's guaranteed to be more farther away than close because of how volume shells grow. These two factors tell us that its almost guaranteed that when we see these Long/Short G.R.B's they are very far away.