Statistics for Astroparticle Physics
Assignment

15 marks
1. Generate a plot of the Neyman constructions for the parameter which corresponds to the mean of the following distributions:
a) A poisson discrete random variable
b) A uniform discrete random variable from 0 to K
c) A normal distribution with fixed $\sigma = 1$

For each distribution, generate both the 68% central interval Neyman construction and the 90% upper limit Neyman constructions separately.

10 marks
2. Why is the ordering principle recommended in https://arxiv.org/abs/physics/9711021 required? Explain with an example.

10 marks
3. Use the ordering principle of https://arxiv.org/abs/physics/9711021 to generate a single Neyman construction which will give you a 90% C.L central interval or an upper limit, depending upon the result of your experiment, for the case of a poisson discrete random variable.

10 marks
4. In the case of 1.c) , if the σ of the distribution was unknown, how would you approach the problem of confidence intervals? Email me for a hint if you're stuck.

20 marks
5. Some of the results that have generated the most interest in the fundamental physics community in recent times are:

a) The Hubble tension
Review https://iopscience.iop.org/article/10.1088/1361-6382/ac086d
Result https://arxiv.org/abs/2112.04510

b) The recent measurement of the mass of the W boson by the CDFII collaboration
Result https://www.science.org/doi/10.1126/science.abk1781

In both cases, the interest is due to a physical quantity (the present day value of the Hubble constant and the mass of the W boson respectively) being different (in statistical tension) from expectations based on other considerations (theory, which itself is driven by other data).

Examine the papers and their background to comment on:

5.1) The size of the datasets that have been used to arrive at each of the conclusions. (i.e in the case of W boson mass, how many tagged W boson particles, in the case of H0, how many Supernovae explosions and Cepheids)

5.2) The statistical method used to arrive at the confidence intervals on the main result in both cases.

5.3) The systematic and statistical uncertainties in each measurement separately, as well as the sources of these uncertainties.