Roxanne Guenette – Lecture 3 Questions

Questions marked in green were answered during the Q&A session. I haven't tried to correct grammar/spelling. Where a slide number was given it is shown.

Q1 (slide 4). Sorry didn't understand how high power protons will help for experiment, can you please explain again

Ans: We want future beams to be as powerful as possible in order to send as high intensity neutrino beam as possible. In order to do that, we need more protons on target (to produce more mesons that will decay into neutrinos). To achieve this, we want to have more protons in each accelerated bunch, have more bunches and make them go around quicker. The exact energy of the accelerated protons was chosen to use technical improvements that are feasible and the energy of the neutrinos that are produced to have an optimal beam.

Q2 (slide 6). Why are we concerned about reducing systematic uncertainty when statistical uncertainties are much larger? Shouldn't we focus on reducing statistical uncertainties somehow first?

Ans:It is true that the first thing we want to do is get good statistics. In DUNE, the statistical errors will remain dominant for the first ~ 5 years of running (depending on how quickly we can ramp up the other detector modules). Note that if we had the full 40kt, statistics stops being dominant after ~2 years of running. But quickly after that systematics are dominant and we are aiming at very low systematics of the order of few percents. See arXiV:2006.16043

Q3 (slide 7). Why are there four different graphs? Are they all different experiments?

Ans: These graphs are from the NoVA experiments where they show the error budget for 4 different analyses. Top Left: numu, Top Right: anti-numu, Bottom-Left: nue, Bottom-right: anti-nue. The band widths show the errors in %. The point I wanted to make here is that cross sections uncertainties (or interaction underatintines) are major in all analyses.

Q4 (slide 14). Is this for one neutrino energy, or for the spectrum of energies from an on or off-axis beam?

Ans: Here we get around picking a certain energy by plotting the probability in function of E/L (where E is energy and L is baseline). If you want to think of a particular energy, you can think that this plot is in function of distance, if you want to pick a constant baseline, then you can think of this in function of E. I prefer the latter, as then you can see how the spectrum varies in function of energy, which relates directly to a beam energy spectrum.

Q5 (slide 18). Is DUNE going to have a hard time measuring delta_CP if it's -pi/2?

Ans: I assume here you are asking because the difference between the red and black curve for DUNE is smaller at -pi/2 than at +pi/2. This indeed makes measuring delat_CP a bit harder at -pi/2 (if you look at the sensitivity on slide 24, the sensitivity is slightly worst at -pi/2), but we still have enough sensitivity to make a good measurement if it's there...

Q6. Can you comment on the new MINOS /Daya Bay / Bugey-3 results that exclude much of the sterile neutrino mixing phase space allowed by the LSND and MiniBooNE experiments?

Ans: Their new results put a strong constraint, which indeed exclude a large space of LSND/MiniBooNE. But this big tension between disappearance results (like MINOS) and appearance results (like LSND and MiniBooNE) has been around for a while, it's just getting more obvious with more precise measurements. This is why on slide 51 of my talk (taken from Michele Maltoni) summarises these tensions as not being reconcilable by the "simple" sterile neutrino hypothesis.

Q7 (slide 17). For great presentation (really enjoyed it), I would like to ask why we don't have 3000 km baseline neutrino experiment (we can't align the neutrino beam for so long distances)?

Ans: Thanks! In theory we could opt for a 3000km baseline. The main issue here would be the very low flux at 3000km! 1/r^2 from 1300km to 3000kn is big. Secondly after many different studies of the interplay of all the effects (matter effect, delta-cp sensitivity), it was shown that 1300km is more ideal to make the different measurements.

Q8 (slide 22). Why are there fewer anti-neutrino events?

Ans: It is harder to produce anti-neutrinos with our beams mostly because you smash positive protons to a target, leading to more positively charged mesons, decaying to mostly neutrinos.

Q9. Sorry, very basic/general question. When is it currently estimated that DUNE will be able to start operating?

Ans: The current goal is to have the 1st detector module around 2024 (and further modules come every ~2 years after that). The beam was originally planned to come around 2026, but this may be delayed.

Q10 (slide 25). How should I understand the vertical shift of the curves?

Ans: This only comes from the amount of data acquired. The top curve is for 7 years of data and the bottom one if for 15 years. The more data you get, the more precise the measurement (resolution) gets.

Q11. Can you explain the LSND anomaly and how was it related to GALLEX?

Ans: LSND was looking for oscillation between anti-numu to anti-nue at a L/E ~1 (which would come from a delta_m2 ~1 eV2). They did observe an excess of events that could be explained by oscillations. In this case, an anti-numu would convert to a sterile neutrino and then reconvert to an anti-nue (creating the excess observed). In the case of GALLEX, they were using a radioactive source producing nue (to calibrate their solar neutrino experiment). When calculating the flux of the radioactive source and comparing to the observed flux, it was noticed that the observation show a deficit of events compared to the prediction. In this case the nue would convert to sterile neutrino, creating the deficit. When looking at the parameters needed with the energy of each sources (LSND beam and radioactive source) and the baseline of each (LSND ~30m, Gallex ~< 1m), the oscillation parameters all point out to a delta_m^2 ~ 1 eV^2.