Many (all) the questions have been answered during the Q&A period. Nevertheless, we ask that you provide written answers below so students can come back to read them again. Thanks!

1. Doesn't the cross-section for neutrinos on chlorine depend on the standard model? However Bahcall's 1964 paper predated Weinberg's 1967 paper on SU(2) x U(1). So how was a model-independent estimate of cross-section done without even having a standard model of particle physics in place? As I understand it took a while before people believed Weinberg's model was correct. So despite that how were Bahcall and others confident that the particle physics needed for calculating event rates was right?

Before the Standard Model, there were ways to calculate cross sections and decay rates, although these calculations break down at higher energies. For example, Fermi calculated beta decay using the "four Fermi" vertex where there were four legs coming out of a single point (n,p,e, and neutrino). We now know that the e and the neutrino are the decay products of off-shell W bosons. That doesn't matter much at low energies, and for interactions like the one the Bahcall was calculating on Chlorine, the physics is calculations of the matrix element, which can be gotten in part from beta-decay measurements. Today, a "complete" Standard Model calculation would be pretty hard to do because the Chlorine nucleus is so complex, so a new calculation might not in the end be so different.

2. Only a comment. Two more counterarguments (in nuclear/particle physics) on publishing in a refereed journal. Salam's 1964 paper which got a nobel prize was published in a conference proceedings. Aage Bohr's (Neil Bohr's son) work which got him the nobel Prize was published in a book (AFAIK)

   Ah, very good! Certainly some people are able to get away with such things, but I expect that it is "easier" for theorists than experimentalists, as the "results" are entirely open—they are not subject to the kind of skepticism that experimental results are.

3. You referred to the Kamland experiment a few times. Can you tell us more about it?

KamLAND is a liquid scintillator detector, roughly about 1 ktonne of scintillator, that is underground in the Kamioka mine (the same place as Kamiokande II and Super-Kamiokande). KamLAND measured the rate of antineutrino interactions produced by Japan's many nuclear reactors, and showed very clearly that those neutrinos were "disappearing" with a mass difference and mixing angle that was consistent with the solar experiments, and very explicitly showed the mixing angle was large.

4. Yesterday's talks and also yours mentioned neutrino oscillations as BSM physics. However the first papers on neutrino oscillations were written long before Weinberg's paper on SU(2) x U(1) and before the standard model was established. So why is it then considered as BSM physics.

Well, perhaps "outside the Standard Model" rather than "beyond" is a better term. Before the Standard Model, there were plenty of ideas that today we would say are "beyond" the Standard Model, meaning, I suppose, that they are not included in the Standard Model. The Standard Model only included the things that were known at the time to be in agreement with experiment, so those ideas were not included.

5. How does the charge current and neutral current interaction affect the measurements?

For SNO, the charged-current measurement looked at the Cherenkov light created directly by the outgoing electron. The neutral-current events were much trickier: they split the deuteron into its constituent nucleons. The proton was not visible (it is too slow to make Cherenkov light in water), but the neutron bounced around inside the heavy water until it was captured. In “pure” heavy water, that neutron eventually is captured by a deuteron, creating a 6.1 MeV gamma-ray. That gamma-ray Compton scattered an electron which in turn created Cherenov light. In Phase II of SNO, we added NaCl to the detector, so that the neutron would capture on Cl and created about 8 MeV of gamma-ray energies, in a cascaded that looked very isotropic compared to the Cherenkov light of the single electron from the charged-current events, which helped us separate the signals. In Phase III, we actually inserted 3He-filled proportional counters and the neutrons captured on those, creating a triton and a proton, which created exclusive signals we could see independent from the CC events.

6. Where does neutrinos astronomy stand today?

   Solar neutrinos have been dominated in recent years by the Borexino experiment, which recently saw with high significance, the CNO solar neutrinos, which was a big deal by itself. That also will help us understand whether the Sun is really “metal poor” as its surface seems to indicate, or “metal rich” which is what we’d expect from the rest of the solar system. We are still waiting for (another) detectable supernova burst, but people are actively trying to see the “background” supernova neutrinos, which are those left over from all the supernovae that have happened in the past. The Super-Kamiokande experiment has added gadolinium to its water, to capture the neutrons created in coincidence with the positrons from anti-neutrino interactions. The Theia experiment, which is a proposed hybrid Cherenkov/scintillation experiment, should also have good sensitivity to these. At the high-energy end of things, the ICECUBE experiment has observed neutrinos that likely come from active galactic nuclei, and even in at least one case in coincidence with an astronomical jet observation. I expect that ICECUBE, and related radio-detection techniques will continue to push astrophysical neutrino detection to higher energies.