Experimental and theoretical measurements - Ben Criger

I'd like to this opportunity to clarify something that confuses a lot of students when they first learn about quantum mechanics, which is the difference between measurements that occur in a laboratory and measurements that we describe in theory. And also, I'd like to point out hopefully the ways in which these things are similar

So, you may have already seen a picture like this one. My apologies to my experimental friends if it's not exactly the same. But, in the laboratories you can measure some currents in nanoamperes, and if there's a spin in the down state pointing parallel to the field, there will be no bump in the current. And if it's in the up state, there will be a bump. And this is a large macroscopic classical signal that they can detect. And this relates to a measurement operator.

You can imagine that we take the total area under this curve; the total amount of current, in the case that there's no bump, and that corresponds to the spin down state. And the total current in the case that there is a bump will be slightly higher, and that corresponds to the spin up state.

So, that real number: the amount of current times the projector on to the down state plus the total amount of current in the case that there is bump times the projector on to the up state gives us our measurement operator.

Now, the important thing about these two signals being distinguishable, but there being a large difference between them, is that if they're equal, we end up with some number times down-down plus some number which is identical, times up-up. So, the measurement operator becomes the identity, which doesn't discern between the up and down states. So as useless is the measurement.

But if these numbers are discernably different, then down-down and up-up receive different measurement outcomes, and out measurement operator is more like a Z, which is one we could use to actually distinguish between the computational basis states in quantum computing.