Science – ANSTO- Dr Michael James transcript

(Duration 40 minutes 48 seconds)

Presenters:
Dr Michael James
Chris Bormann

(slow music)

Chris: Welcome to this resource, for supporting HSC science students. In this series of interviews, we investigate the role, application and operation of particle accelerators in contemporary science research. In this interview you'll be hearing from Dr. Michael James, as he discusses the physics principles used at the Australian Synchrotron and how it is used to support research into everything from new materials, improved agriculture and COVID-19. I hope that you and your students enjoy this resource, and that it assists in adding context and depth to the scientific concepts in your Stage 6 science courses.

We have today, Dr. Michael James, who is a senior principle research scientist with ANSTO, currently leading the science team at the Australian Synchrotron. His team is responsible for operating and expanding the capabilities of the 10 existing beam lines at the Synchrotron. And he has extensive experience in designing, constructing and operating cutting edge facilities for conducting cutting edge science. He also leads team of scientists who are designing and building the nine new beam lines built as part of the BRIGHT upgrades to the Australian Synchrotron. Thank you very much Michael. We're very happy to have you with us.

Dr James-: You're welcome, thanks a lot Chris.

Chris: Are you able to describe your area of research or work, its purpose and how it might influence our lives?

Dr James: So I lead the science team at the Australian Synchrotron. We're basically one of Australia's largest scientific research facilities. We're what's called a user facility. The instrumentation that we operate at the Australian Synchrotron is for the benefit of researchers from all over Australia, from New Zealand, and indeed people travel from all around the world to come and use our instruments. In terms of the science that we do with the facility, normally I like to play a little game called "pick a subject, any subject and I'll tell you how we do it at the Australian synchrotron". But we don't have time enough for that today. But we do a lot of research into life sciences and understanding diseases. We do a lot of pharmaceutical drug development, and we've been doing some great work just recently on studying COVID and how to attack the viruses associated with COVID. We do a lot of work on environmental research, the sciences, advanced materials, new battery technologies, again, you name it and we do it. The impacts of the work we do at the Australian Synchrotron are very important they can go from creating new drugs to save people's lives, all the way through to new types of energy technologies or new ways to look after the environment. Lots of good fun to be had there.

Chris: With your team who operate the beam lines, what skills are they required to be able to accommodate such a diverse range of users?

Dr James : The people that that I lead in the science team that build and run our instruments, they all start life as something else. They either start life as a chemist the way I did, or a physicist or sometimes a molecular biologist or someone in earth sciences or environmental research, so we typically get people through their career. They come to us because they have an interest in either helping others do their research or also the instrumentation that we develop. People will come into these jobs and eventually they'll learn how to both operate this equipment and support researchers who come to our facility. Then they also learn how to maintain the equipment as well, and also design new types of synchrotron equipment. I lead the science team but the facility also has another, I don't know about 80 or 90 people in engineering and computer science and mechatronics and controls engineering, so we work with a whole range of diverse skillsets that come out of the sciences and the engineering departments of Australia.

Chris: Now, the synchrotron is a very large facility. In some ways, we might consider it to be a laboratory. What would students recognise there and what might be really quite different?

Dr James : I guess the thing that they would recognize that's common to their school laboratories is, we have what we call sample preparation laboratories, where you have all the beakers and magnetic stirrers and all those sorts of equipment as well. As I mentioned the synchrotron facility is where people come to do very specific, complicated experiments that you can't do anywhere else. So people will come to the facility, we have around our accelerator at the Australian Synchrotron a series of what's called beam lines and each beamline has a place where you will conduct a very specific measurement, using the x-rays and infrared light that we generate using our accelerator and I'll unpack all of that a little bit later. When researchers come to our facility they'll either come for, even as short as several hours, and do an experiment and then go away for a really high powered high throughput equipment. Other people will come for several days. They come from all over the world, they describe what experiments they wish to do before they apply for time. Once they secure time at the facility they'll come for just hours or days to do their experiment. They'll walk away with a huge hard drive full of data and then it's also part of our staff's job to help them with the interpretation and the analysis of that data because some of it it's very specific to synchrotron facilities.

Chris: I can imagine those hard drives stacking up fairly quickly.

Dr James-: We can generate 10 or 20 terabytes a day from some of our equipment. So sometimes we actually have to host the data on our high performance computing cluster and people will log in and process the data locally. We don't send it anywhere because it's too hard to move. It's astonishing how quickly synchrotron facilities develop both the instrumentation and the detector systems and actually the data rates they're just absolutely going through the roof in the last few years. It gives you some amazing things to be able to look at, but then people like me have the problem of working out how to cope with all the data.

Chris: How is it that you choose the direction and the capabilities of the machinery, and what role does that have on directing scientific research?

Dr James : That's a pretty big question and it's a good one, to be honest. It's interesting that some of the original plans for what some of our instruments were going to be used for, haven't really come to pass so we have a fantastic instrument called a small angle x-ray scattering beamline. It was originally designed to look at what are call colloids or polymers, because that's where the scientific research was, using that technique at the time. But since it's been developed, really the beamline, it still does get used for studying colloids and polymers but the majority of its work actually is in new types of flexible electronics and also the study of biological structures in solution. And those were areas that didn't really exist with that level of intensity, in the Australian research community at that time. All of that is a long way of saying, if you build great instrumentation and make sure it's flexible enough, in terms of how it can approach the different samples, you'll find that science changes over the lifetime of these instruments because they're not just a one or two year piece of kit, they're systems that last for a decade and during that time we'll actually upgrade them as well. We poured millions of dollars into upgrading these instruments in the last few years, because new opportunities come for what you can do with them.

Chris: Great so it's sort of like the Swiss Army Knife of particle accelerators.

Dr James : Well it is. And I guess I'm going to use that analogy, The Swiss Army Knife has all these bits that you pull off it in order to do different things, and the Australian Synchrotron is a circular accelerator, which we can talk about a bit later, and off that accelerator comes a series of beamlines that have different functions for different purposes. So yeah, that's a pretty good analogy.

Chris -: Probably value there in having multiple, the facility as a whole, probably also adds to its value.

Dr James : Again, the initial suite of beamlines that we currently operate were basically selected by the Australian Research Community telling us what it wanted and some of them are kind of no-brainers, if you don't have what's called a macro molecular crystallography beamline at the synchrotron, you're kind of kidding yourself. You've got to have one of those, we actually have two of them. Macromolecular crystallography, it's something based around a technique called x-ray diffraction, and I think most people that do physics will study Bragg's law and these sorts of things about how you solve atomic structures from diffracting x-rays off a crystal or off a powder. We want to study very complex biological molecules right down to the atomic level. In order to get crystals of these very complex biological molecules, it's incredibly difficult to do and these crystals are tiny and also they're very delicate. In the act of actually measuring the diffraction pattern of these crystals, you destroy the crystal. So there's a whole bunch of things you want to do to try and prevent that. First of all you want to be able to freeze the crystal in liquid nitrogen, well one hundred Kelvin nitrogen while you're doing the measurement to stop the damage occurring. But you also want to do that measurement incredibly quickly so that you can get the data off before you destroy the crystal. So again, we want really small, very bright x-ray beams to target these very small very delicate crystals and that's one of the types of x-ray beams we generate.

Chris: So this is a the issue of resolution being able to, I see some of the readings are talking about CT type processes, but with really really fine spatial resolution and also a time resolution, Does that all come down to that brightness of the synchrotron?

Dr James : Yeah there's probably five or six different elements to the radiation that make it really, really useful. When we typically get the x-rays out of the facility, we can also change the energy of the x-rays. That lets us either target specific elements in specific materials or do something called spectroscopy. Your example about getting very fine resolution is absolutely true. We do imaging like you would do in the hospital, like getting an x-ray, but because our x-ray beams are so powerful, we don't just take a still photo, we actually take x-ray movies and because we can generate very large beams, we have on our imaging and medical beamline, we have the largest x-ray beam in the southern hemisphere and so we can actually take not just an x-ray movie, but an x-ray movie of a really large object all at once. There's again multidimensional, there's speed in order to measure dynamic events quickly. So if you want to study a chemical reaction in real time, we can do that down to a certain level on one of our new beamlines we're building for the new program we'll be able to study changes in biological conformation down to the millisecond timing regime. We can’t actually do that at the moment, but that's the joy of building new equipment. We can study currently structures, in terms of doing some microscopy rather than imaging. If we're going to look at a very small object under one of the x-ray microscopes, we can see it down to about one micron in pixel resolution on that image. But again we're building a new beamline which is will be a hundred meters long coming out from the facility. That'll let us go down to about 65 nanometers in resolution. So we'll be looking rather than getting an image of a cell and just having a blob. We'll be able to go inside the cell and look at the organelles and structures within the cell using the nano probe, which is one of the new beamlines we're building. We always sort of run around with a bunch of clichés when we talk about the facility and that's one of them, "seeing the invisible" is one of the sort of catch phrases. Scientific instruments are changing all the time, even when I was in university, and I'm not going to tell you how long ago that was. What people were seeing with astronomy was fabulous, but you think about what people been seeing in recent times in decades, being able to detect exoplanets for example. Simply not possible when I was a kid, and even the synchrotrons I used during my PhD studies at university when I was going overseas to do this stuff, these things are a completely pale shadow of what we can do at the Australian Synchrotron and just to depress everyone, new types of synchrotrons are being built overseas at the moment that are a thousand times more powerful than ours in terms of the brightness and so in our new developments we'll be able to get to 65 nanometers and these very powerful newest facilities can go down to five nanometers or something ridiculous like that, it's all relative. Depends on how much land you've got and how big your budget is. The next synchrotron we build here in Australia, it'll be bigger and it will be even brighter. I might be retired by then we'll see.

Chris: Can you describe that importance of questioning in your work life?

Dr James : So throughout my career I've been really always driven about how to make new types of magnetic and electronic materials that people have never made before. Partly just see what you can engineer at the atomic level, but also to see what sort of applications these things are good for. I don't know if it's a piece of advice or just a comment, that one of the joys of science is that you don't have to keep doing the same thing all the time throughout your career, as new interests and new opportunities come along, you can take what you've learned and go. Ah! I could apply that to this situation over here. Do what you love. That's really important. Obviously, if you can get nice high ATAR scores along the way that's great as well but really do what you love because the study that you will need to do into the future at university, et cetera, it's hard work and it's a lot easier if you're doing something you're very passionate about or you're very interested in. By all means, at university it's a great time to get your majors all sorted out but go wild in your other subjects. You'll learn the things that you've got a great opportunity to learn while you're in university. Otherwise you'll have to try and pick them up along the way later on in your career. Which is exciting as well, but it can be a bit more challenging.

Chris: Whilst there's probably nothing typical anymore, but what would a typical day would normally look like for you?

Dr James : For me sadly it's a lot of meetings with people. Working our way through, how do we want to attract new users to the facility? How do we want to engage with them to do their experiments? How do we deal with their data? And all the other aspects around that and then looking at the inputs into the design phase and the construction and procurement of all of these advanced systems for new instrumentation. So there's never a dull moment.

Chris-: If you were to escape from a meeting and be in your happy workplace, where might we find you?

 Dr James: I'm actually working with some researchers who are studying how to improve the nutritional quality of grains and also the, how to make agricultural grain crops more productive. And so we use a whole range of techniques at the synchrotron to do that sort of work. So where I'll be really happy at the moment is studying on one of our beamlines called the x-ray fluorescence microscopy beamline. Where we're using that to study the elemental composition and the local chemistry of the different elements within biological samples.

Chris: That fluorescence technique that you're describing there, that's one of the ones which when they took us for a tour there last year, that one just absolutely jumped out. You know, the ability to go. I'd like to know where these elements are and it produces that colour map instantly, was amazing.

Dr James: There was some experiments where you get to set a data and then you've got to go away and try and interpret it. And in some cases like our imaging beamline, eventually it's pretty obvious it looks like a picture that you can sort of understand. The x-ray florescence beamline, again absolutely fantastic beamline. Partly it's a world leading beamline because of a new type of detector developed in Australia with CSIRO. But you can just, whether it's a meter square image of a painting, and looking at all the different elements within that painting all the way down to something a few millimetres in size where you're looking at micron resolution, elemental distributions. Yeah, you just see the picture and you go Aha! That's where all the potassium is because I can see it. There's a new technique that you can collect simultaneously with that where you can see structures down to 50 nanometre precision. It's a different technique and it doesn't give you an elemental map but it lets you see a black and white picture of what the structures might look like underneath that elemental map. To get that image at 50 nanometer resolution is really hard to do the analysis. And if we don't make it easy for the people coming into our facility to do the analysis, they won't use the technique. So we've actually just spent a couple of years with one of our staff members creating this data analysis pipeline. So the users don't have to touch any of the buttons or any of the analysis or anything, it's just an automated sequence of literally hundreds of thousands of images on a detector through to pressing a button and basically getting a picture at 50 nanometer resolution along with their elemental map.

Chris: What is it that makes that synchrotron really special? How is it different from other types of accelerators?

Dr James : There are a range of different accelerators in Australia and around the world. And I'll probably just describe a few of them, and then I can explain how the synchrotron is different. You can have these smaller types of what are called ion accelerators and they can be about the size of a small truck. They'll fit in a large building you basically will accelerate protons or heavier irons and smashed them into an object in order to study the chemistry or the composition of the object you're looking at. So they have some of these at different universities around the country they got them at Lucas Heights up in Sydney at ANSTO as well. Then you can go to the other scale where you're not just, the other one you can have for example, it's a linear accelerator that you would have in a hospital in order to deliver a proton beam to do radiotherapy for a patient and again they're quite compact because you need to basically move it around the patient in order to shoot the proton beam at different parts where there may be a tumour. Then you go to the big scale, then you go to the Large Hadron Collider in CERN in Geneva in Switzerland, 27 kilometres in a big loop and again this is a sort of an accelerator where you smash things into other things. You take your two beams of protons, you send them off in opposite directions to go around the loop and then of course smash into each other the other side with gargantuan energies to try and break up your proteins and look at the really subatomic particles and the Higgs Boson and all the rest of it. Quite a lot of accelerators are out there to do things like that which is particle physics to see subatomic particles and what goes on in the physics behind the physics that we can see. So our accelerator is different. Our accelerator accelerates electrons, and it really does that for the purposes of generating light. If you can indulge me I'll briefly describe how it works. So if you think about an old fashioned TV, one of the boxy types where you create an electron beam and paint a picture on a fluorescent screen with that electron beam. That's how we start life with our electrons at the Australian synchrotron. We actually have a cathode ray gun at the beginning of the whole synchrotron, it's a big one. But basically it's a hot filament that we can get electrons off. We then accelerate those electrons down a linear accelerator and that linear accelerator is only about 50 metres long but we take those electrons from their rest position and put them through an energy difference of a hundred million volts. Now we don't have a big a hundred million volt battery that we can plug this thing into, what we have is basically like a microwave generator, called, its a klystron which is a radio frequency generator. We basically pump electrical energy into this system and literally the electron surf along on these electromagnetic waves that are pushing it down this linear accelerator. So by the time it's gone 50 meters and it's increased its energy up to a hundred million electron volts. It's going at something like 99.99% of the speed of light, which is pretty fast, but it's not good enough for what we want to do. In order to generate the synchrotron light that we use, we need to raise the energy of those electrons from a hundred million volts up to three billion volts. If you come and visit a synchrotron anywhere around the world, it'll have something called a critical energy. And ours is a three GED machine, three giga electronic volt machine. So we take the electrons out of our linear accelerator, we put it into a circular accelerator called a booster ring. Sometimes physicist don't have much imagination but there you go, and it boosts the energy up from a hundred million volts up to 3 billion volts. And again this is why to think of this as a bit like sticking a kid on a roundabout in a park every time with your child or your electron bunch goes past you, you give it a whack to push it along a bit faster and you go faster and faster and faster until it hits 3 billion volts. At that point the electrons are going at 99.9999985% of the speed of light, and they're fully relativistic. So at that point they're heavy electrons, so the heavy charge particles 6,000 times the rest mass of your electrons, and then we inject them into what we call the storage ring, which is the outer ring of the facility. All the beam lines run off what we call the storage ring. So the storage ring is 216 meters in circumference, it's all under vacuum of course otherwise our electrons wouldn't be very happy going round almost at the speed of light and rather than being a circle, it's actually a 28 sided polygon. So in order to steer those electrons around the corners, because they basically want to go in a straight line, we have to put them through a magnetic field. So we have a series of what are called bending magnets, again I mentioned physicists don't have much imagination. So the bending magnets have a north pole and a south pole and as the electrons pass through the north pole and the south pole because they're charged, they'll get their trajectory changed. Because they're relativistically heavy, and because they're charged and because we're changing their trajectory, the Lorentz force pushes out light as result. As we're steering it around the corner and they lose energy, they lose energy in the form of light and the light is again because they're going at relativistic speeds, the light that they emit is in a very small direct beam in our rest coordinates compared to its relativistic coordinates. Sorry I'm a chemist so this is where all of this breaks down. But the light we generate by doing that, has got all these wonderful properties. It's over a wide range of energies from the infrared all the way up to basically hard x-rays, the very brilliant it's a very small focus. The light is polarized as well, which lets you do certain types of experiments you can't do in any other way and so we stay in the electron beams round and round the accelerator, they just keep going round and round all day. They don't actually smash into anything and that's the whole point. We want them to continue to circulate as long as they can. Every time they go through a magnet they emit a beam of light and we take that beam of light off to do our experiments in our beamlines. So the light emitted from one of these bending magnets is basically about a million times brighter than the light that's emitted from the sun. So again, when you have the synchrotrons, you'll hear people talk about brilliance. The entire light from the entire sun is a lot more than we're generating. But in terms of the lights per unit wavelength, per square millimetre or whatever it's going to be, we're a million times brighter than the light emitted from the sun. So that's good for a lot of stuff we do but if you want to do this, looking at using stuff in the nano probe and getting down to 65 nanometres, you need a different technology to generate your light.

Chris: There seems to be a preference for describing energies of particles when they're accelerated over the speed. Is it just a matter of, we get tired of writing more nines on the end of your percentage of speed of light, or is there another reason for that?

Dr James : I guess there's a few different reasons synchrotrons were born out of the particle physics infrastructure. Physicists are used to thinking in energies like electron volts for example, or other arcane units you don't really get to in high school that much. Whether you go at a three G beam machine or a six G beam machine, like some of the big ones in Europe, excuse me or America or Japan. They make a huge difference to what you can do in that synchrotron. But yeah you're just tacking a couple of an extra nines on the back end. Actually you're not getting many more nines on the back end of your speed. You're still approaching the speed of light, but not very much more in speed but you are getting a dramatic increase in the energies or the X rays and the brilliance of the X ray beams you can generate. Partly it's about also the circumference of your synchrotron. If we had much more money in Australia, we might've built a bigger one, we might have built a 500 meter circumference machine and we can go to high critical energies if you're not trying to bend electrons in such a small bending radius. So there's all these things come into it. But again the arcane units typically come from the fact that these things were designed by physicists born out of the early particle physics programs.

Chris:You were saying that you've got a three G beam machine, is that the average energy of an electron in the synchrotron?

Dr James: It's not just the average energy, I think it's pretty much all of them because we constrained to have almost all of our electrons traveling at exactly the same speed. This is one of the things that I'm constantly amazed about and it's how the Australian Synchrotronis a really fancy lightbulb. The people that come to use a facility, they don't care about the accelerator they don't care about what we need to do to generate the x-rays, and they didn't care how we get them focused at their sample, they just want to put this sample there, press go and collect data. The Australian Synchrotron itself the accelerator part of it, it's an absolute miracle it works because it's astounding, we're controlling the speed and the phase of packets of electrons, running around this thing at the speed of light and we're changing, and tuning and compressing these bunches of electrons on the fly as they go and there's about 10,000 different traffic lights that all need to be green in order for this to work and it's routine we just switch it on and our accelerator operators work it up in half an hour after we switch it on where we've got x-ray beams coming down at beamlines. It staggers me that it works at all but it's absolutely fantastic.

Chris: I imagine that the beam, the masters of beam, the beam operators might be something akin to two rock stars to your instrument scientists, but that the users the end users, they're not visible.

Dr James: Even in the facility we get very blasé about these things after a while. The Australian Synchrotron i'm going to sound like a cheerleader but it's one of the most efficient synchrotron facilities in the world in terms of we don't have much downtime, OK, we're currently switched off because we're in a maintenance program this week and even then we had Melbourne shutdown, because of COVID at the moment. When it's switched on, it's on and it's working and it's working well, we have very few times where it gets upset. Says, "I'm not going to run today", but the trick behind all that is, there's a huge degree of relatively boring stuff like maintenance and asset management plans and making sure you've got spare holdings and you're ready to switch components in and out as they fail and there's a whole range of asset management protocols sitting behind that for the engineers to deal with. But when it runs, it just runs and it's great.

Chris: And you want to have all beam lines operating at the same time and...

Dr James: We currently the facility itself can probably fit about 25 beamlines around the ring, and partly, that's the size of the building that it fits in. We currently operate 10 beamlines at the moment. Some of them are these bending magnets and others are coming out of these things that rather than having it one north pole and one south pole, imagine having an array of magnets all lined up together with alternating north poles and south poles. If you do that, sorry, I'll get my hands out of the way. If you do that, you can actually generate beams of x-rays that are a billion times brighter than the light from the sun. So the type undulators is that we're designing and purchasing to put in our new beamlines that we're building at the moment. Some of those are superconducting. Rather than using permanent magnets in an array, we're going to be using super conducting magnets cooled down to minus 250 degrees Celsius. In order to get really high powered magnetic fields compressed in space and generate, again x-ray beams that are 10 or a hundred times brighter than even the existing ones, even though we're not touching the accelerator. In order to solve complex scientific problems, you've got to collaborate with people. You've got to go and find experts who know what you don't know and again that's something I learned fairly early on in my career and it's one of the joys of being a scientist to collaborate with people. It'll be looking at advanced electronics, and a few days later we'll be looking at something to do with climate change. Our staff are working all the way through these different problems with people coming along and when people express a desire to, "I wish I knew someone that could work out how to study the molecular crystalinity of organic solar cells.", you go well, "Actually, Chris McNeill across the road of Monash is probably the guy you want to speak to on that sort of stuff.", so it's great for collaboration.

Sham Nair: So one of the things that our science extension students, kind of considering their coursework is how the modern high throughput technologies generate fast volumes of data and I'm just wondering how you and your research team actually deals with that, to identify actual data signal to noise, those kinds of things. I'm just wondering if you could just talk to that for our students.

Dr James-: We upgraded some of the detectors on our macromolecular crystallography beamlines recently. They're the ones that we bought originally when we built the instruments, we're pretty much hitting end of life, and you couldn't buy spares, you couldn't get them fixed. We decided to , we actually secured a grant through the Australian Cancer Research Foundation and that helped us to put our money in as well with some others from around the country. We bought state of the art, all singing, all dancing, single photon counting detector from a company in Switzerland and we went from having the capacity to do a measurement, it would take several minutes to do a data set on our old detector, we were then getting down to 30 seconds to do a complete diffraction data set and in the old detector we'd take 180 frames to do that in the seven minutes and then this one we were doing 1,800 frames in 30 seconds on the new detector and there's no noise in this detector either, this new one. So we were getting images off that detector where you couldn't actually even analyse it by eye even if you wanted to because the signal to noise was so extreme that tiny, tiny, tiny data points on the detector, you couldn't see with an eye if you're looking at a picture of it. Long story short, we have the capacity to go 10 times faster on our new detector than our old detector but then it meant we needed to change crystals 10 times faster. So we actually needed to upgrade the robot that switched the crystals in and out of the beam to make it cope. But then we had this huge volume of data of the new detector and we had to work out how to analyse that as well. We had to build a whole new high performance computing system just to take the data off this detector and to streamline the analysis pipeline that I sort of spoke about earlier and then we had to work out how to store this data and just to take an extreme example, which I and ask you think about the square kilometre array over in Western Australia, it just a prototype so they've got in radio astronomy. They actually take a data set, then they'll compress it and compress it again and compress it again and then shoot it to Perth and then they'll delete, once they have their instrument because they can't cope with holding onto it any anymore. They actually destroyed the data in the process of sending it to Perth, is my understanding.

Sham: wow.

Dr James: We are not quite as extreme as that, but we're starting to get close. We again have this problem of not just being able to analyse the data in a fast enough time to be useful. I mean there's no point changing a crystal every 30 seconds if it takes 10 minutes to compress and analyse the data set. So we've had to do all these things to make it work. We recognize that at the current rate of increase of data generation at our place that we physically cannot store it. Unless we're pumping millions and millions of dollars just into buying new hardware to store it. Also with some data sets you can send them to the users, but other ones as I mentioned before, you've got to leave them at the synchrotron because actually attempting to send a hundred terabytes, even if you've got a decent cable or system across the country to get to someone else just isn't going to work. Big data is a real concern for a lot of scientific research facilities around the world and we all address it in different ways. We've been at trying to address it by getting more analysis pipelines on site and more local computing power to do the analysis quickly. We can't hold onto it forever. When I joined the facility a few years ago, we were keeping every single set of data that we have generated but we just can't do it now. These data sets are so incredibly rich in some cases that your standard programs that you know are certainly used as a young researcher, when even researchers are using today, don't actually get the best value out of the data that we generate. How do we create computer systems and algorithms and analysis methods to really see what is already there in the data but we don't know how to get at the moment. Machine learning's a very exciting word in synchrotron instrumentation space and we could hire many, many more people that know how to code, to do scientific analysis and algorithms than necessarily we could hire a scientist to help people load the samples into the beamlines.

Chris: It's been amazing for us. And I hope for all of the students and teachers who get to listen and to talk about science broadly, and also the details of just how this sort of, seemingly sort of magic machine works and hopefully we can help promote them to really help build a science in Australia.

Dr James-: Yeah, for sure, I guess the closing remark is that, we do have open days from time to time, or we had one last year still we are not actually planning to have one this year and let's face it. No one's going to be able to get across the state border to come and visit us at the moment anyway. I expect that will be next year that's going to be held around October. We have a lot of Melbourne based high school students coming to visit the facility as well to take a look around. So if you're in Melbourne and you have the opportunity, connect through ASTO as our operating organisation and yeah come and have a look at the place, it's not behind razor wire with security guards and all the rest of it like the nuclear reactor is up in Sydney. You can come take a look then, you can't get into the accelerator when it's operating, it’s under all this concrete of course and you can't go and play with the x-rays when they're functioning your locked out of the experimental hutches but it's still a really great facility to come have a look. Best wished to you all and thanks for having a chat with me today.

Chris: and thank you very much, it's been great.

(slow music)

End of transcript