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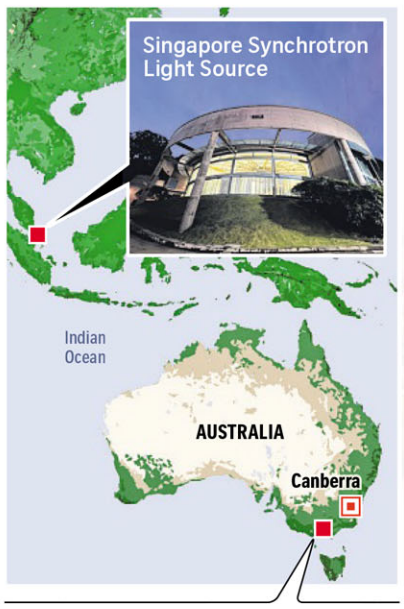
A 'lightbulb' to illuminate science secrets

From 2023, more Singapore scientists will get to use a high-tech research facility in Australia called the Australian Synchrotron. **Shabana Begum** and **Lim Yong** break down the nuts and bolts of the Australian Synchrotron, the range of scientific discoveries it can open doors to, and how it compares with the Singapore Synchrotron Light Source.



THE AUSTRALIAN SYNCHROTRON

What is it

- The stadium-like building (right) in Clayton, Melbourne, houses a network of tunnels inside that are connected to numerous experiment stations.
- Energised electrons whizz through the tunnels to create intense light across the electromagnetic spectrum that reveals the innermost secrets of objects – from a fossil to human tissue.

What it does

1. **An electron gun shoots out electrons,** which travel down the linear accelerator.

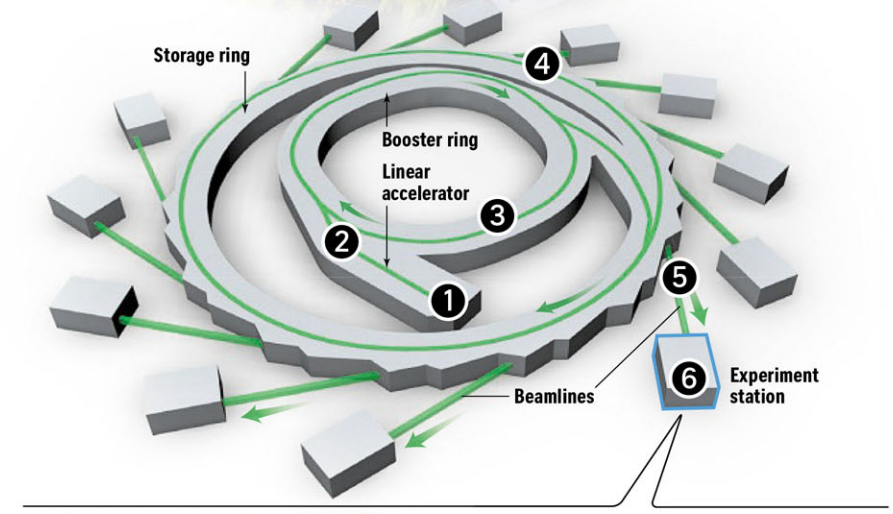
2. **Microwave radiation is also pushed into the accelerator,** to enable the electrons to reach 99.9997% of the speed of light.

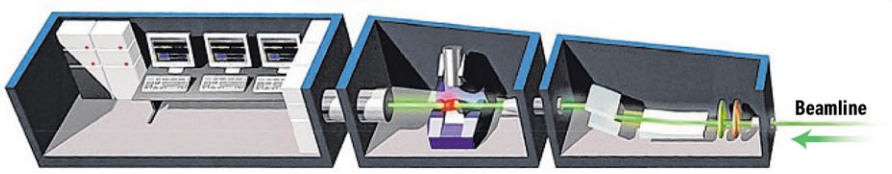
3. **Pockets of electrons are injected into the booster ring,** and their energy is raised from 100 million volts to 3 billion volts. The electrons reach 99.9999985% of the speed of light.

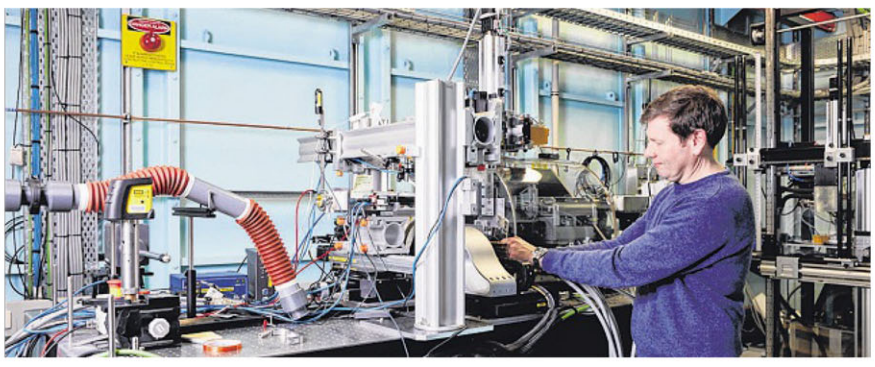
4. **The heavily charged electrons are pushed into the outer storage ring.** When magnets in the ring cause electrons to bend, the electrons release energy in the form of light – which can be up more than a million times brighter than the sun.

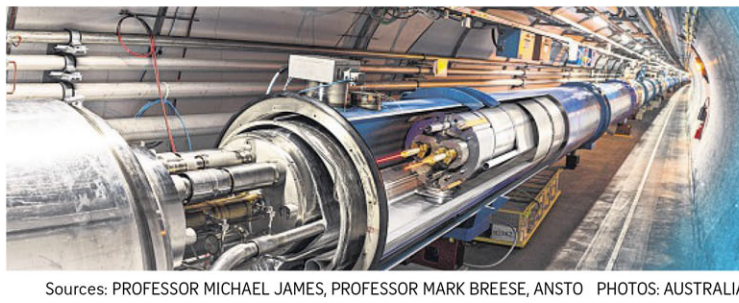
5. The light energy – which ranges from infrared to visible light to X-rays – is **filtered to travel through separate beamlines into individual experiment stations.**

6. **Scientists carry out experiments here.** To study proteins and viruses, for instance, a station with an X-ray beam would be suitable (right).









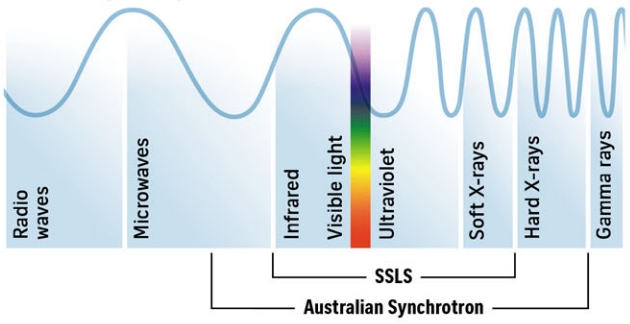
SYNCHROTRON V LARGE HADRON COLLIDER

- The Large Hadron Collider (left) near Geneva, Switzerland, is the world's largest science experiment.
- While both mega-structures accelerate charged particles, their objectives are different.
- The Large Hadron Collider makes subatomic particles such as protons smash together millions of times per second, **to study the fundamental forces of the universe.**

SINGAPORE V AUSTRALIA

Singapore Synchrotron Light Source (SSLS)		Australian Synchrotron
12m, one of the smallest in the world	Size (circumference of synchrotron)	216m (Australian Synchrotron; SSLS)
700 million electron volts	Electron energy	3 billion electron volts
From the whole infrared spectrum to soft X-rays, which are lower-energy X-rays	Range of light	From far infrared to some gamma rays

Electromagnetic spectrum



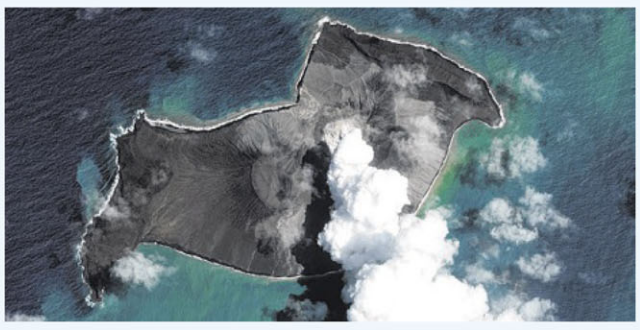
HOW HIGH-TECH SYNCHROTRONS BOOST SCIENCE

Developing Covid-19 drugs

- When a hard X-ray beam is aimed at molecules, such as copies of the Sars-CoV-2 spike protein, the protein's structure is amplified.
- When scientists inject a potential antiviral into a solution containing the spike protein, they can observe if the drug is effective in stopping the virus from replicating.
- Pfizer's antiviral drug Paxlovid was developed with the help of a synchrotron.

Deep dive into volcanic eruptions

- Like a human CT (computerised tomography) scan, X-ray beams can penetrate volcanic rock to reveal its components and hidden gas molecules.
- Scrutinising volcanic rocks allows scientists to look back in time and map out how a volcano erupted the way it did.
- The undersea Hunga Tonga-Hunga Ha'apai volcano (below) erupted in January, becoming the largest eruption of the 21st century so far. A volcanologist from New Zealand collected volcanic samples and fragments to find out how the unexpected eruption happened, with the Australian Synchrotron's help.
- He hopes the micro clues gained from the research on Hunga could then be applied to better monitor volcanoes in the Pacific. Hunga is located in the South Pacific Ocean.



Hidden painting

- Art experts at Australia's National Gallery of Victoria had a hunch that French artist Edgar Degas' Portrait Of A Woman (below left) was painted over another artwork. Hints of the concealed painting appear as dark smudges on the woman's left cheek.
- To uncover the mystery, powerful X-ray beams were fired across the canvas at the Australian Synchrotron.

- The researchers detected different metallic elements in the pigments that Degas used, which included copper, zinc and cobalt.
- They digitally reconstructed the hidden painting – a fair woman with auburn hair (left).

Sources: PROFESSOR MICHAEL JAMES, PROFESSOR MARK BREESE, ANSTO PHOTOS: AUSTRALIAN SYNCHROTRON, KRZYSZTOF BANAS, NATIONAL GALLERY OF VICTORIA, SCIENTIFIC REPORTS, EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH, SYNCHROTRON SOLEIL, AFP, REUTERS