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Review of International 4th Generation Synchrotron Light Sources

Professor Michael James

Science. Ingenuity. Sustainability.

Future Australian Light Source Workshop

Purpose:

- To inform the community as to planning for a new 4th Generation Synchrotron Light Source

- To seek input from the community about requirements and capabilities of a new synchrotron facility

- Kick-start the process to develop the Business and Science Cases for a new Australian Synchrotron Light Source

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A Synchrotron Upgrade for Australia

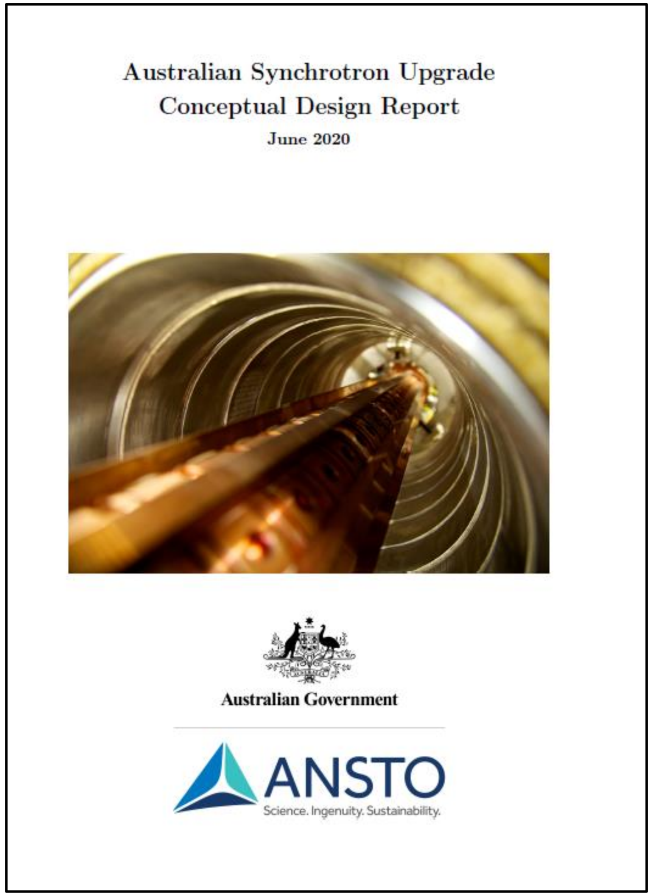
- Long term strategy of Synchrotron Science to look at the options in ~15 years time when the current facility is nearing end of life.

- "What facility and capabilities should replace the current "Australian Synchrotron"?

- The Accelerator Physics Team has explored the feasibility of a lattice upgrade using the existing infrastructure of the Australian Synchrotron as much as possible.

  This option will not lead to world-class light source.

- They have modelled what would be possible if a 600m ring could be constructed.



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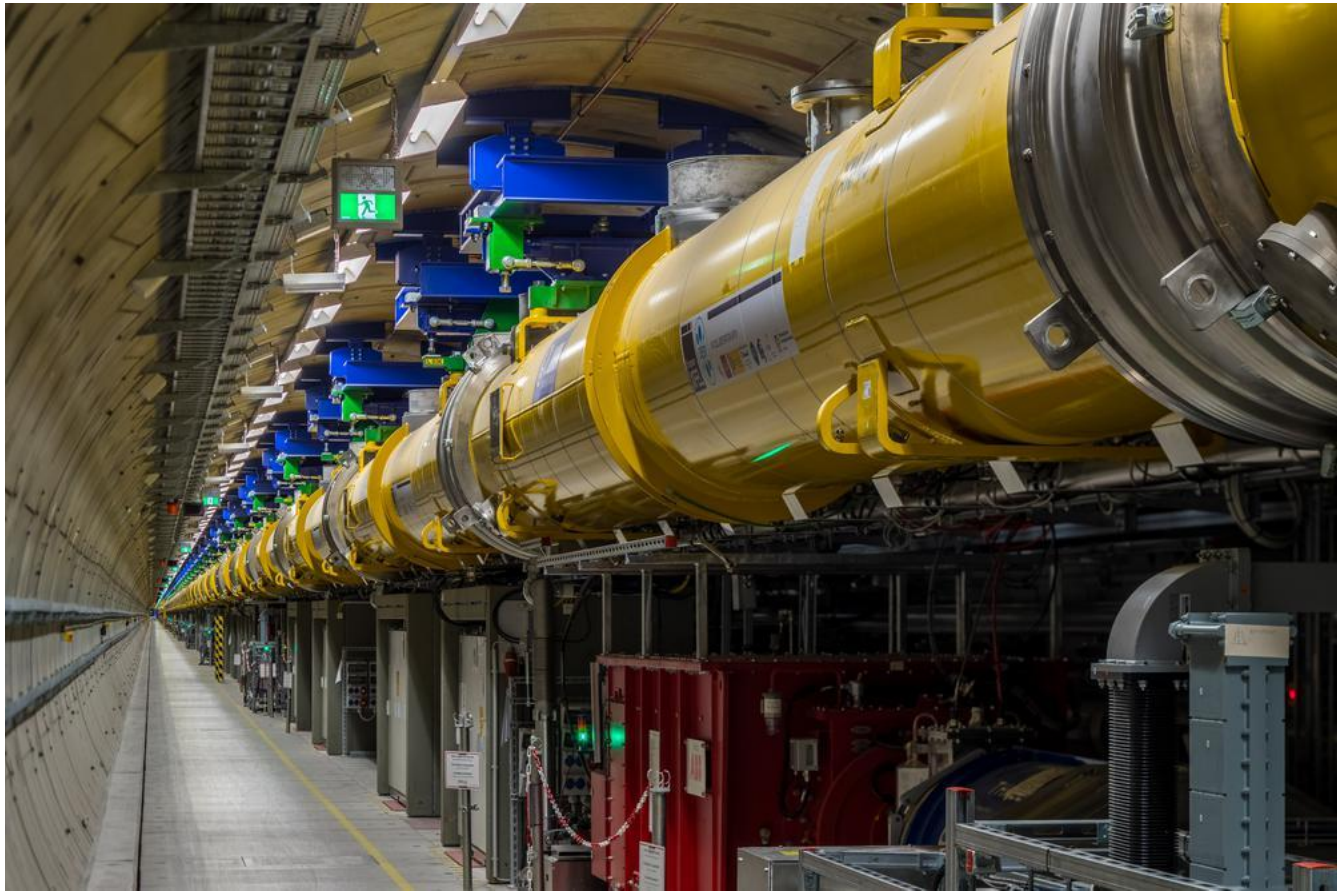
What is a 4th Generation Synchrotron Light Source?

It is *not* a X-ray Free Electron Laser… (Sorry for those who would like one)



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What is a 4th Generation Synchrotron Light Source?

It is *not* a 3rd Generation machine based upon Dipole Bending Magnets and Insertion Devices (in-vacuum undulators and wigglers)

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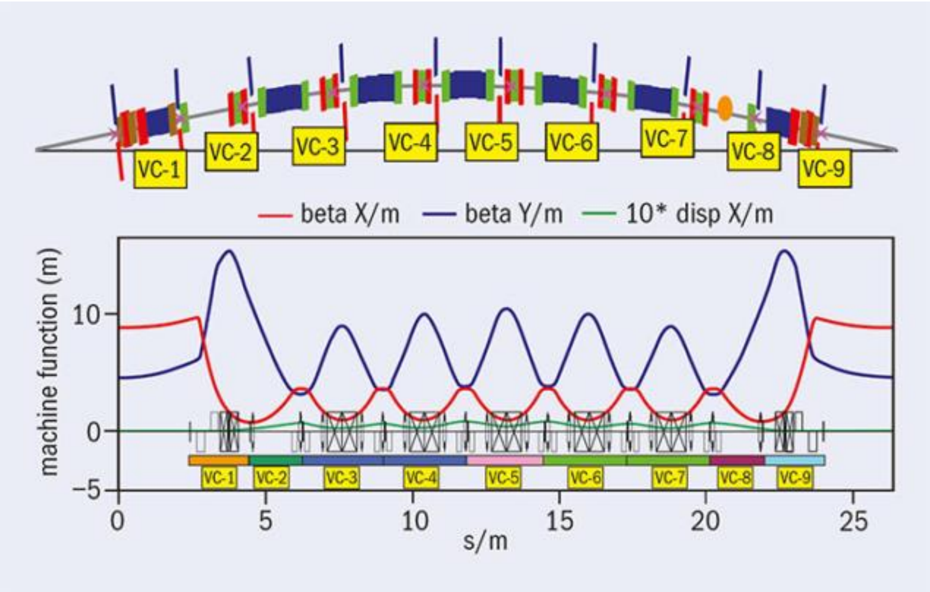
What is a 4th Generation Synchrotron Light Source?

Are based upon Multi-Bend Acromat accelerating structures in concert with Insertion Device sources (in-vacuum undulators and wigglers)

SIRIUS MBA Storage Ring, Brazil



MAX IV MBA Lattice

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New and Upgraded Synchrotron Facilities

4th generation synchrotrons have/are been built or are being planned at facilities around the world

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New 4th Generation Synchrotron Projects

MAX IV – Lund, Sweden

Circumference: 528 m
Critical Energy: 3 GeV
Beam Current: 300 mA
Horizontal Emittance: 0.3 nm rad

Operational Since: 2016

Number of Beamlines:

(1.5 GeV ring) 5 Operational

(3 GeV ring) 7 Operational

4 Under construction

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New 4th Generation Synchrotron Projects

SIRIUS – Campinas, Brazil

Circumference: 518 m
Critical Energy: 3 GeV
Beam Current: 350 mA*
Horizontal Emittance: 0.26 nm rad

Operational Since: 2020
Number of Beamlines:
- 4 Operational
- 10 Under construction
- (38 Beamlines possible)

*Currently undergoing Machine & Beamline commissioning

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New 4th Generation Synchrotron Projects

High Energy Photon Source (HEPS) – Beijing, China

Circumference: 1360 m
Critical Energy: 6 GeV
Beam Current: 200 mA
Horizontal Emittance: 0.06 nm rad

Currently Under Construction
14 Phase I Beamlines
(90 Beamlines possible)

First Light: mid 2024
Project Completion: late 2025

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New 4th Generation Synchrotron Projects

Synchrotron Light in Tohoku, Japan (SLiT-J)

Circumference: 349 m
Critical Energy: 3 GeV
Beam Current: 200 mA
Horizontal Emittance: 1.14 nm rad

7-10 Phase I Beamlines
(26 Beamlines possible)

Site preparation work started March 2019
First beam is scheduled in 2023

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Upgraded 4th Generation Synchrotron

ESRF – Extremely BRIGHT Source (EBS), Grenoble, France

Circumference: 844 m
Critical Energy: 6 GeV
Beam Current: 200 mA
Horizontal Emittance: 0.13 nm rad

Brightness: 2 orders greater than ESRF

Restarted operations – August 2020

50 Beamlines

10 New or Upgraded Beamlines

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Planned 4th Generation Synchrotron Upgrade

Advanced Photon Source (APS-U), Chicago, USA

Circumference: 1100 m
Critical Energy: 6 GeV
Beam Current: 100 mA
Horizontal Emittance: 0.07 nm rad

Brightness: 2 orders greater than APS

Upgrade: 1 year starting April 2023
Commence operations 2024
~60 Beamlines

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Planned 4th Generation Synchrotron Upgrade

Advanced Light Source (ALS-U), San Francisco, USA

Circumference: 197 m
Critical Energy: 2 GeV
Beam Current: 500 mA
Horizontal Emittance: ~0.05 nm rad
Diffraction limited Soft X-rays

Brightness: 2-3 orders greater than ALS

Detailed design completed by 2022
~40 Beamlines planned

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Planned 4th Generation Synchrotron Upgrade

Swiss Light Source (SLS 2.0), Villigen, Switzerland

Circumference: 290 m
Critical Energy: 2.4 GeV
Beam Current: 400 mA
Horizontal Emittance: ~0.05 nm rad

Brightness: 1-2 orders greater than SLS

Detailed design completed by 2022
Commencement of Operations 2025
~40 Beamlines planned

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Planned 4th Generation Synchrotron Upgrade

Diamond Light Source (Diamond-II), Didcot, UK

Circumference: 561 m
Critical Energy: 3.5 GeV
Beam Current: 300 mA
Horizontal Emittance: ~0.15 nm rad

Brightness: 1-2 orders greater than Diamond

Funding Announcement 2022
First User dates 2027-2030
~40 Beamlines planned

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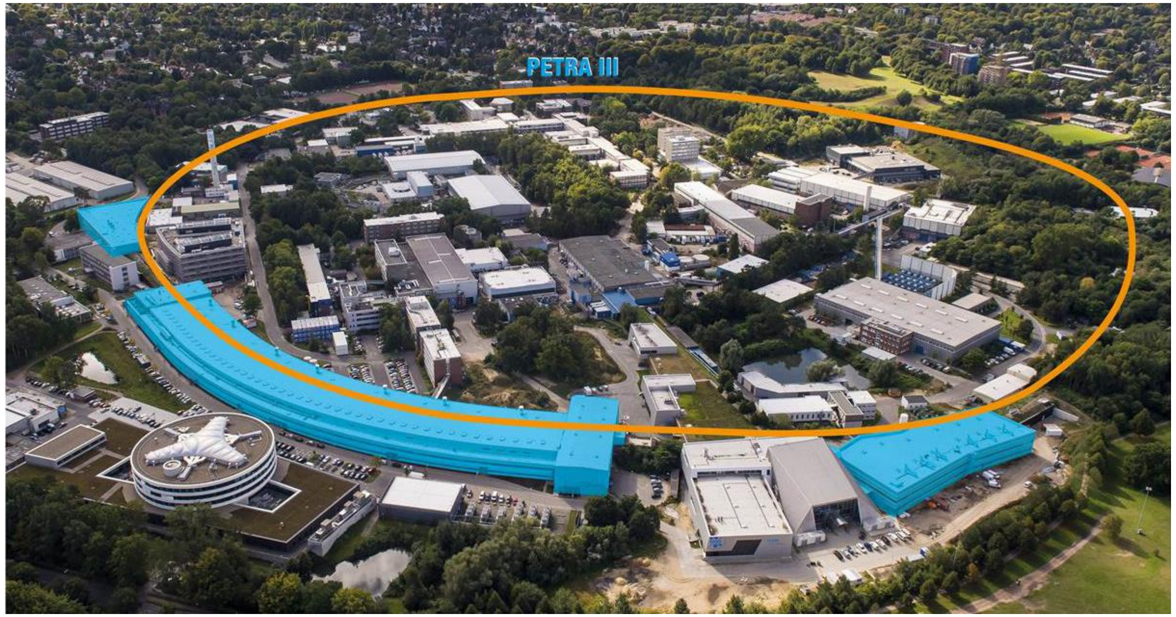
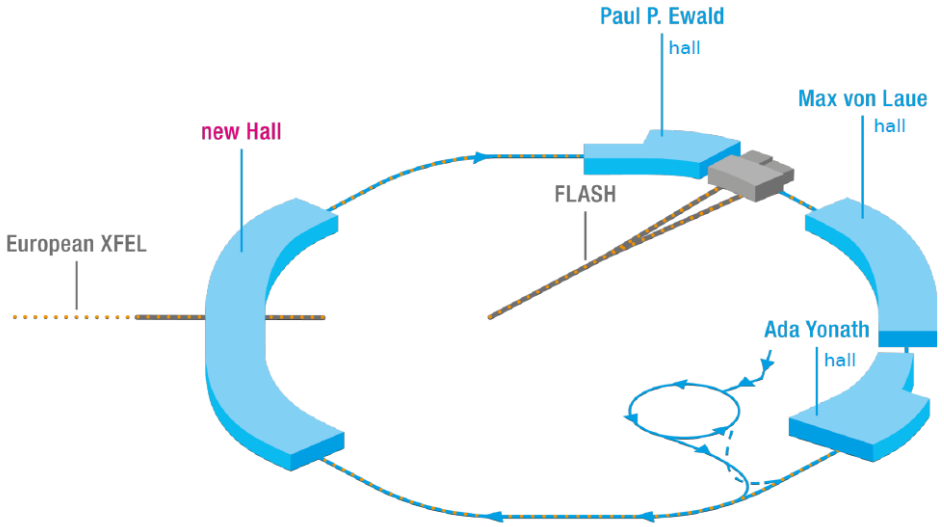
Planned 4th Generation Synchrotron Upgrade

PETRA IV, Hamburg, Germany



Circumference: 2300 m
Critical Energy: 6 GeV
Beam Current: 200 mA
Horizontal Emittance: 0.01-0.03 nm rad

Brightness: 1-2 orders greater than PETRA III



Expected start of operation 2027
~30 Beamlines planned

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Planned 4th Generation Synchrotron Upgrade

Elettra Sincrotrone II (Elettra-II), Trieste, Italy

Circumference: 259 m
Critical Energy: 2.0 / 2.4 GeV
Beam Current: 310 / 160 mA
Horizontal Emittance: 0.15 / 0.21 nm rad

Brightness: 1-2 orders greater than Elettra

~30 Beamlines planned

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Planned 4th Generation Synchrotron Projects

Canadian Light Source (CLS 2.0), Saskatoon (?), Canada

Circumference: 578 m
Critical Energy: 3.0 GeV
Beam Current: 300 mA
Horizontal Emittance: ~0.05 nm rad

Brightness: 2-3 orders greater than CLS

New green field site
Location ???...
> 40 Beamlines possible

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Planned 4th Generation Synchrotron Upgrade

Soleil-II, Paris, France

Circumference: 354 m
Critical Energy: 2.75 GeV
Beam Current: 500 mA
Horizontal Emittance: ~0.08 nm rad

Brightness: 1-2 orders greater than Soleil

~30 Beamlines planned

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Planned 4th Generation Synchrotron Upgrade

SPring-8-II, Hyogo, Japan

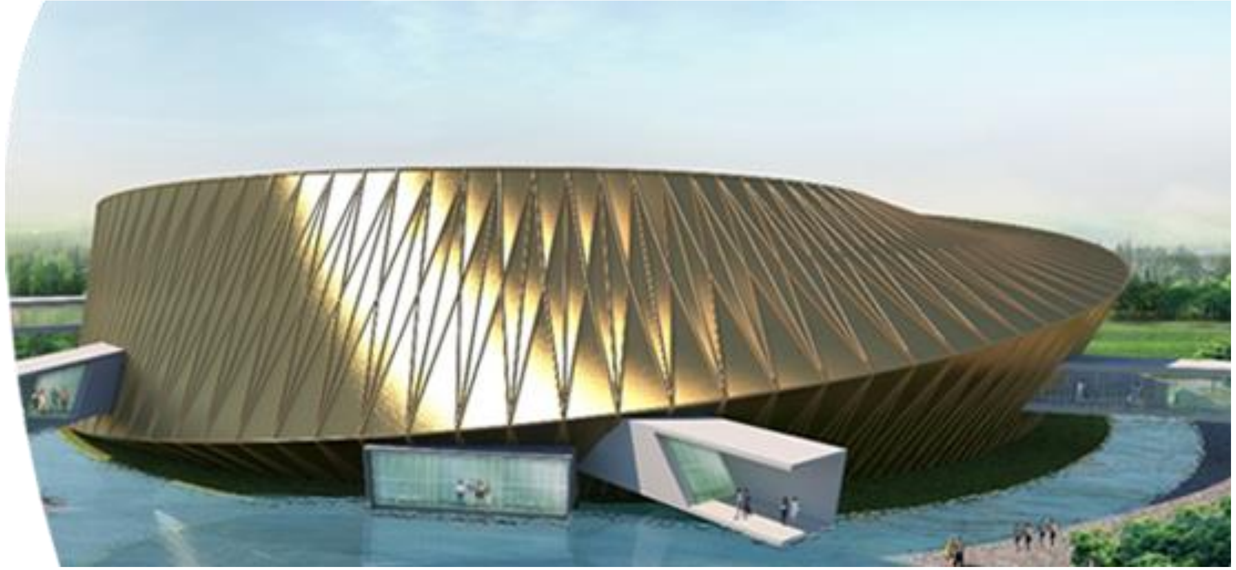
Circumference: 1436 m
Critical Energy: 6.0 GeV
Beam Current: 100 mA
Horizontal Emittance: ~0.15 nm rad

Brightness: 1-2 orders greater than Spring-8

~55 Beamlines

Planned 4th Generation Synchrotron Projects

Siam Photon Source II (SPS-II) – Rayong Province, Thailand



Circumference: 321 m
Critical Energy: 3 GeV
Beam Current: 300 mA
Horizontal Emittance: 0.96 nm rad

Brightness: ~4 orders greater than SPS
(81m, 1.2 GeV)

New green field site
7 Phase I Beamlines
(22 Beamlines possible)

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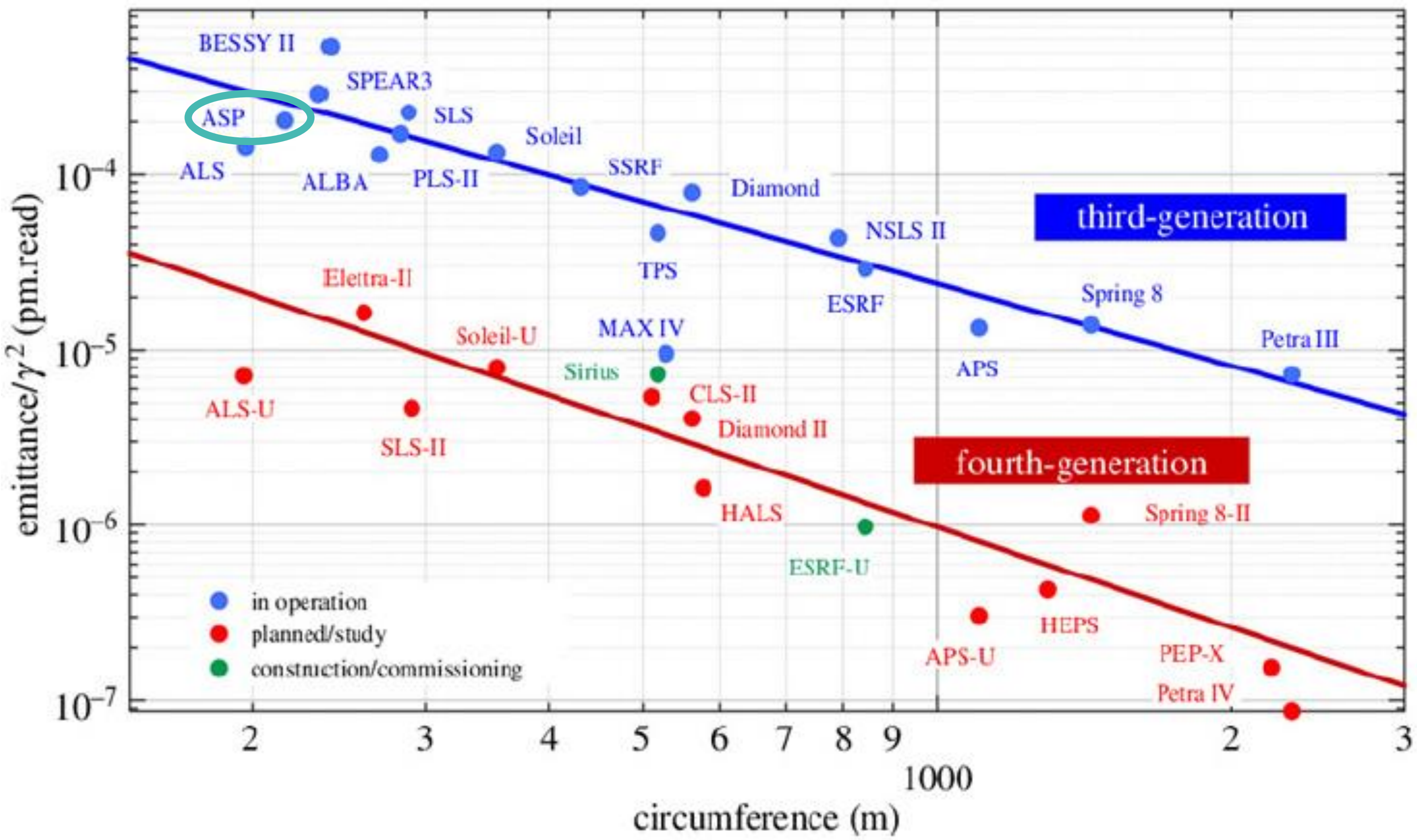
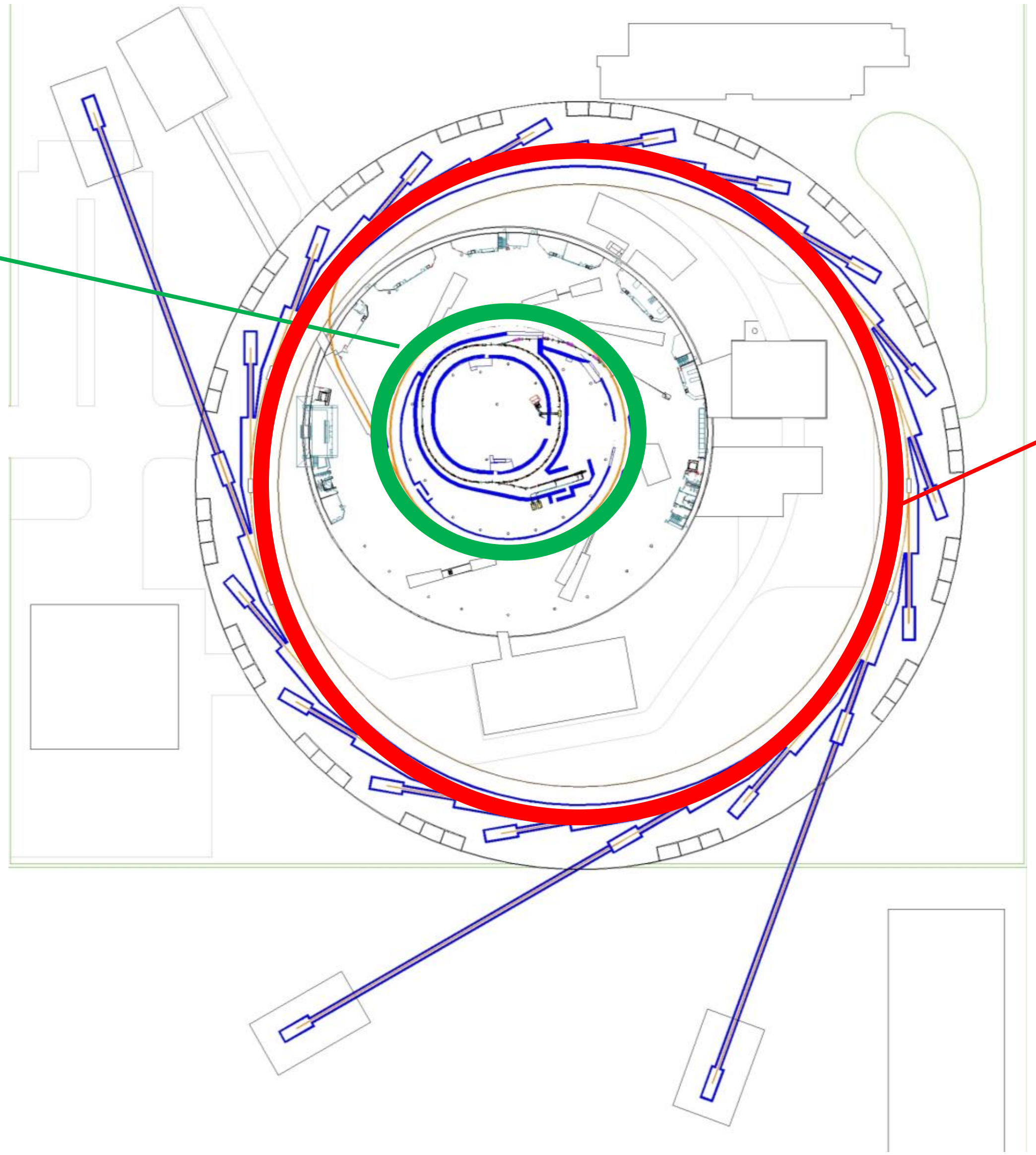
Current state of play for Light Sources

- 4^{th} generation LS implies an order of magnitude emittance decrease.
- Multi Bend Achromat lattices.
- Ring Circumference dictates minimum achievable emittance



A 600m Ring Compared to the Australian Synchrotron

Australian Synchrotron: 216 m



Australian Synchrotron-II: 600 m

Thank you.

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