The Diamond-II Project

Richard P. Walker

Technical Division Director, Diamond-II Project Director

Diamond-II: challenges and novel solutions for upgrading the national synchrotron light facility

Rutherford Appleton Laboratory

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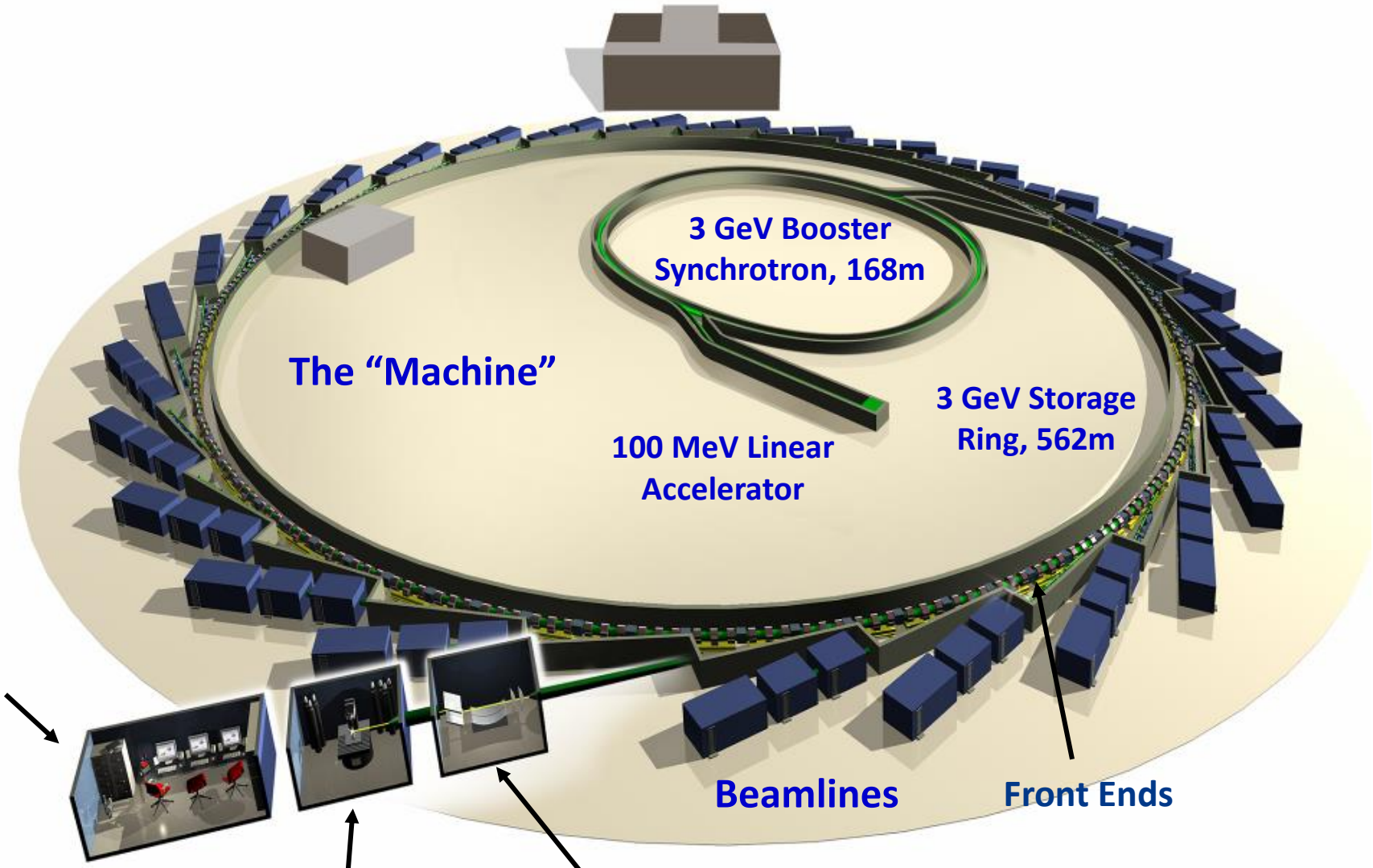
Diamond Light Source

- The UK's national synchrotron radiation facility, funded by Government (86%) and Wellcome Trust (14%).
- A major piece of UK Research Infrastructure, which started operation in 2007:
  - served over 14,000 scientists from academia and industry
  - hosted over 220 companies paying for proprietorial access, across multiple sectors
  - provided training for 8,000 PhD students
  - hosts over 6,000 visitors each year
- *"a jewel in the crown of UK research infrastructure"*: Minister of State at the Department of Science, Innovation and Technology, George Freeman MP, March 2023

Official Opening: October 2007

The Diamond Facility

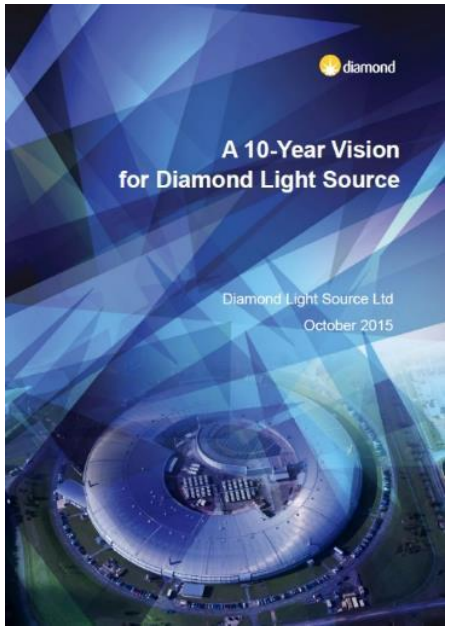


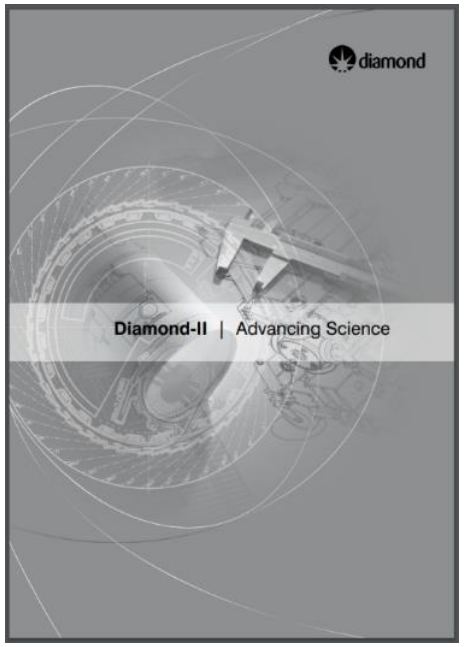
Background to Diamond-II

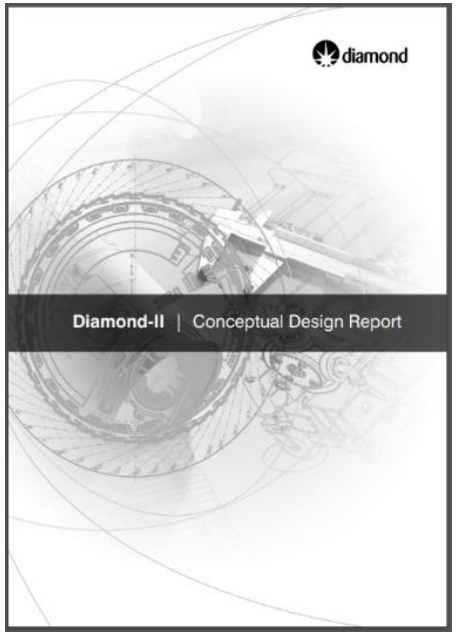
- 10-Year Vision, October 2015
  included a major upgrade: Diamond-II
- Diamond Science Advisory Committee, April 2016

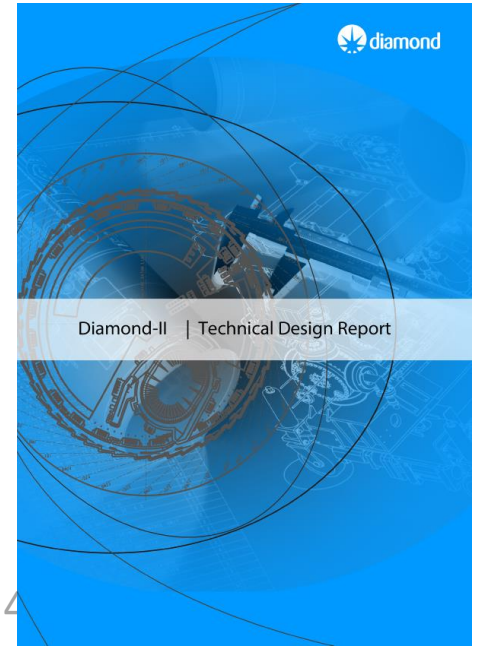
"SAC agree … that a major upgrade of DIAMOND Light Source, to achieve a source of radiation of much higher brightness, is required in order to maintain the excellence of the facility …."

- Science case endorsed by Science Advisory Committee, November 2018
- Conceptual Design Report endorsed by international review committee, April 2019
- Diamond Board approved proceeding to the Technical Design Report (TDR) phase, June 2019
- Draft Machine TDR successfully reviewed by Machine Advisory Committee, March 2022
- Machine TDR published in August 2022









Diamond-II Approval

- Wellcome Trust approval, Feb. 2021
- Gateway 2, May 2021: **AMBER**
- Outline Business Case approved Oct./Nov. 2021 by BEIS and HMT
- Gateway 3, March 2023: **AMBER**/**GREEN**

"The Review Team believes that the project is robust and that successful delivery appears probable."

- UKRI Infrastructure Advisory Working Group (IAWG), 18th April 2023
- UKRI Executive Committee, 23rd May 2023
- DSIT Projects Investment Committee, 20th June 2023
- HMT Treasury Approval Process (TAP) meeting, 6th July 2023
- Confirmation of approval, 21st July 2023
- **Official announcement, 5th September 2023, at Diamond, by the Secretary of State for Science, Innovation and Technology**

Why Upgrade Diamond ?

- When Diamond became operational in 2007 it was the brightest medium-energy light source in the world. This leading position is being steadily eroded by new facilities based on new “Multi-Bend Achromat” (MBA) technology:
  - MAX IV, Sweden - **operational**
  - SIRIUS, Brazil - **operational**

  and many facilities being upgraded:
  - ESRF, France – **operational**
  - APS-U USA – **underway**
  - ALS-U, USA – **underway**
  - SLS 2.0, Switzerland – **underway**
  - ELETTRA 2.0, Italy – **underway**
  - PETRA IV, Germany - planned
  - SOLEIL II, France - planned
  - ALBA 2.0, Spain – planned
  - BESSY III, Germany - planned

.. as well as several new facilities in China, Japan and Russia.

- **It was clear from all advice received that if not upgraded, Diamond would face becoming uncompetitive in terms of the science it enables.**

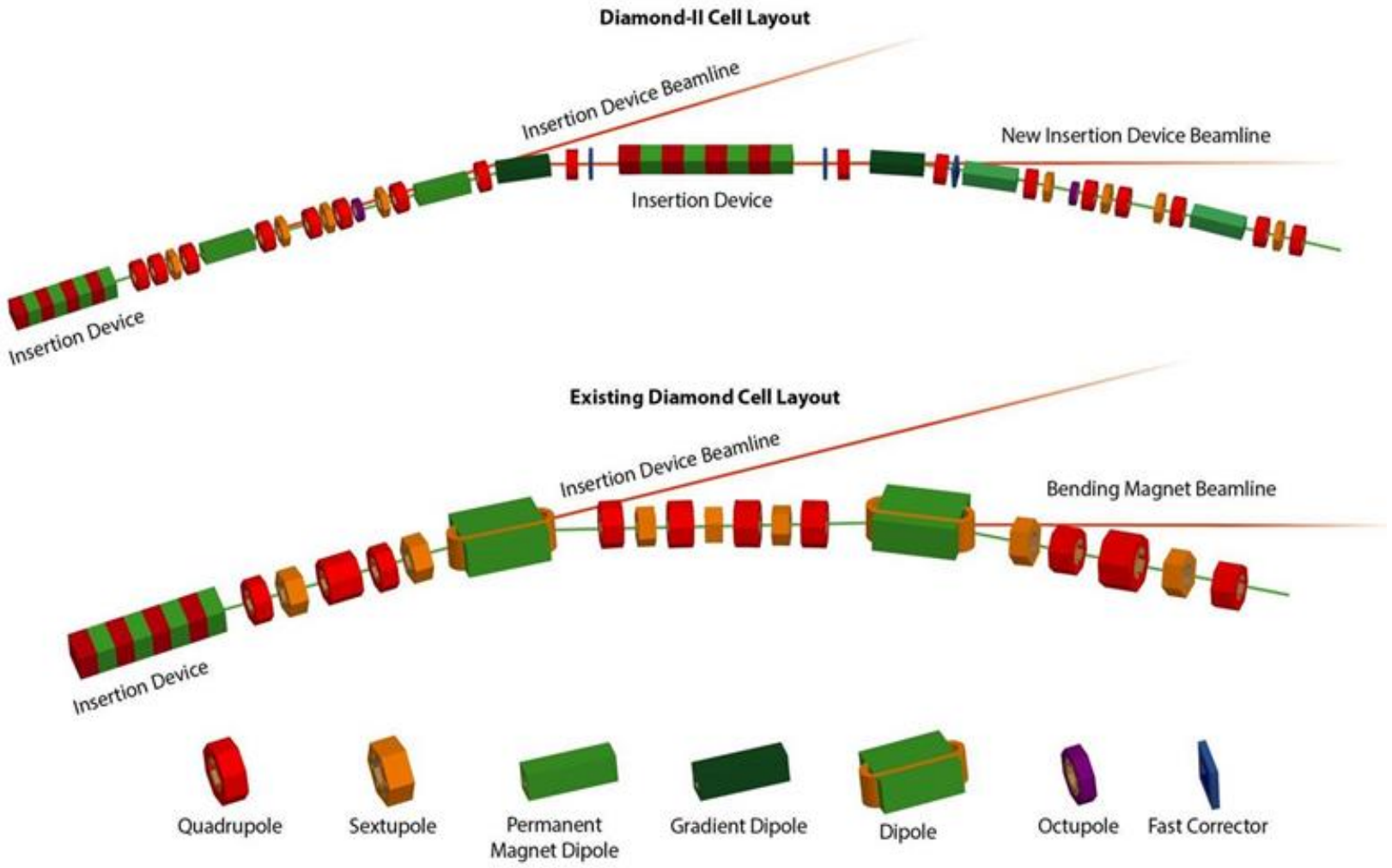
The Diamond-II Project

- A major upgrade of the machine, replacing most of the Booster synchrotron and Storage Ring.
- 3 new ‘flagship’ beamlines + significant upgrades to many existing beamlines.
- A boost in data handing and analysis hardware & software, to manage the vastly increased data rates.
- A new Diamond Extension Building for Diamond-II assembly work, as well as several other on- and off-site storage buildings.
- An enhancement of our Project Management processes.

Diamond Extension Building
- contract placed
- work started on site 15th Jan.

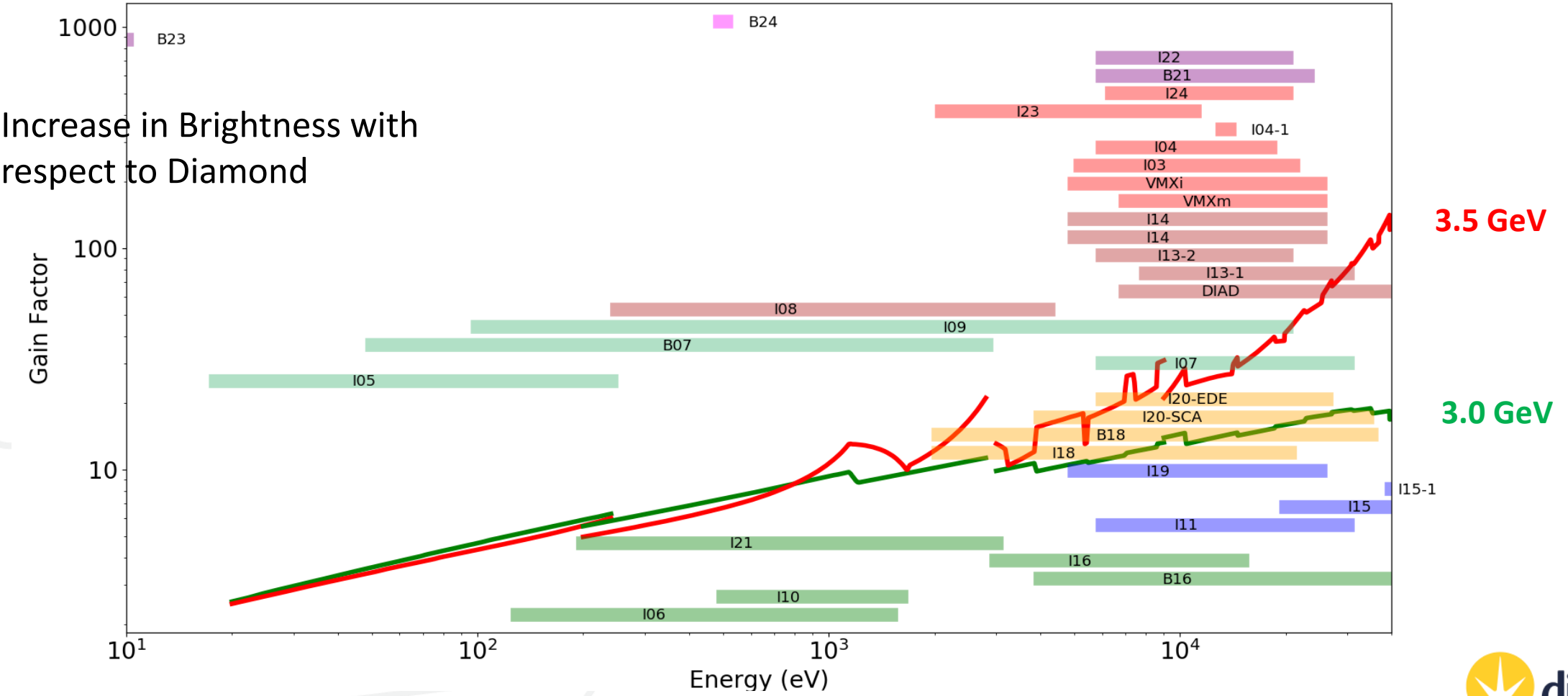
The Diamond-II Machine (i)

- Use of modern “Multi-Bend Achromat Technology” (MAX IV, ESRF EBS etc.)
- From “double bend achromat” (DBA) to 6-Bend Achromat.
- Novel inclusion of “mid-straights” provides significant increase in capacity for insertion devices and additional beamlines.



The Diamond-II Machine (ii)

- Increasing the energy from 3 GeV to 3.5 GeV enhances the brightness of Hard X-rays giving up to 70x higher brightness where the majority of our beamlines operate.



Technical Challenges (some)

- Very compact lattice with many more magnets – new "cross-talk" issues – not insignificant and requires very detailed modelling, affecting trajectory as well as magnet strengths.
- Higher strength magnets (e.g. 90 T/m vs 20 T/m) require smaller dimensions, tighter mechanical tolerances.
- Smaller magnets require smaller vacuum vessels – poor conductance – forces use of distributed NEG coating, and significant technical development to coat the complex vessels.
- Higher synchrotron radiation head loads, combined with smaller vacuum vessel dimensions, lead to significant power handling issues – and a massive amount of FEA work.
- Smaller electron beam sizes, and increasing use of higher speed detectors on beamlines, lead to tighter requirements on precision and bandwidth for orbit stability.
- Use of a combined slow/fast orbit correction needs new sophisticated control algorithms.
- New injection scheme requires development of striplines with state-of-the-art 20 kV, ~5 ns pulsers.
- A new superconducting 3rd harmonic cavity (1.5 GHz) is required.

More details in later presentations.

Diamond-II Schedule

- Project approval and first Calls For Tender – Jul. 2023
- Completion of Diamond Extension Building – Feb. 2025
- Start of the Diamond-II shutdown (the 18-month “dark period”) – Dec. 2027
- Start of machine commissioning – Dec. 2028
- Start of regular beamline X-ray commissioning – Jun. 2029
- First phase of operational beamlines – Sep. 2029
- First User on a flagship beamline – Jan. 2030
- Diamond-II Project completed – Mar. 2030

Join us on this adventure !

Recruitment:
https://www.diamond.ac.uk/Careers/Vacancies.html

Procurement:
https://tenders.diamond.ac.uk/Home.aspx

Thanks for Your Attention