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ERL17 WORKSHOP, WG5 SUMMARY: APPLICATIONS

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Abstract

For the ERL17 Applications Working Group (WG5), a focus was identified for Photon science and Particle and Nuclear Physics application areas. For the Photon applications; THz, FEL and Compton drivers were most relevant and for the Particle and Nuclear Physics field, Compton, Polarised and Cooled beams were most prominent. The following then highlights the key performance needs, challenges and anticipated future demands for each of these application areas as reviewed and discussed at the workshop.

PHOTON APPLICATIONS

THz

For optimum THz user delivery, there is a fundamental need for high power and broad spectral range (ideally upto 3THz). It was noted that broadband, short-pulse, high repetition rate THz is inconsistent with competing demands for highly monochromatic and coherent THz delivery, which ideally should be accomplished using the same ERL platform. Good pulse-pulse THz stability is also a key operational requirement. The challenges to achieve such requirements are driven by the stability of the energy recovered beam in terms of bunch charge, beam energy, bunch length and RF stability. Careful and repeatable machine optimisation is therefore required, however it was noted that the use of a THz cavity could provide a more consistent THz beam for user exploitation. In addition, the transport of THz radiation across long distances is difficult and it was reported that Jlab have a precision HeNe laser alignment system which includes source-point tracking for their THz distribution line in order to minimise transmission losses from the ERL to their exploitation area. THz utilisation is most definitely a growing field of scientific research and with advent of diffraction-limited performance from synchrotrons, the scope for THz research is expected to expand even further.

FEL

For effective ERL delivery for FEL applications, the stability of the entire machine was cited as the fundamental requirement, in particular the beam energy and pulse-pulse stability in order to achieve the required FEL wavelength and output power. Utilisation of complex, fast feedback across the ERL laser, RF and FEL systems are identified as the most effective direct mitigation mechanism, however achieving higher repetition rates with equivalent stability performance is a fundamental target for ERLs in comparison with single pass linac topologies.

EUV

Industrial demands for achieving high power EUV radiation at <13.5nm wavelengths for X-ray lithography applications drive the FEL output performance to way beyond current state-of-the-art. Such an ERL platform requires >10kW EUV power at >98% machine availability with an extremely high degree of beam stability throughout the entire accelerator chain. In order to achieve such demanding requirements, necessitates a considerable level of inherent system redundancy and relaxation (wherever possible) of the sub-system complexity and operational demands, to the extent whereby even complete system replication can be incorporated, which will facilitate rapid change-over should a system failure occur. Such consumer demand is driving technologies to shorter and shorter wavelength regimes and whilst commercial commitment is not yet at the stage to formally launch a complete ERL platform delivery, this is likely to change in the near future as competing demand continues to strive towards higher integrated circuit transistor densities.

Compton

Laser Compton Scattering (LCS) techniques for both X-ray and γ-ray beam generation, with X-rays being used for medical imaging and γ-rays being used for nuclear material security interrogation. The demand for such capabilities requires high energy beams to enable reduced exposure times for imaging/interrogation; for X-rays, typically need 50MeV, 10mA and >100kW laser power to achieve ~40keV X-ray energy and for γ-rays utilising various Nuclear Resonance Fluorescence (NRF) techniques. For both, the key challenge is the provision of a suitable high power laser source which can be accommodated in a small footprint. A laser enhancement cavity which can store dual-beams with a fast polarisation switch appears to be a suitable solution for providing both X and γ-ray beam generation. Compact ERL platform demands for implementation into a hospital environment is an overriding challenge for medical imaging.

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PARTICLE AND NUCLEAR PHYSICS APPLICATIONS

Polarisation and Cooling

Provision of a high performance polarised electron beam injector is a key technology requirement for cooling and spin polarised experiments. The challenge is in achieving the required peak current and operational Quantum Efficiency. Precise control is needed for the transported beam current, particularly for spin polarisation measurement of exotic particles, requiring optimised diagnostics to effectively characterise beam emittance, energy spread and fundamental photocathode performance.

CONCLUSIONS

For each of the application areas identified, an operational performance spreadsheet has been formulated, which attempts to collate the necessary beam parameters for each of the beam delivery programmes presented. Whilst this spreadsheet is not yet complete, it identifies some of the operational variability an ERL platform may hope to provide for Photon, Particle and Nuclear Physics programmes.