STFC Early-Stage research and development scheme: Intention to submit (ItS)

To apply for the STFC Early-stage research and development scheme, all applicants are required to complete the below pro forma and submit it to **KEGroup@stfc.ac.uk**

Please title the email **Early-Stage research and development scheme ItS**

Any applications received which have not submitted this this version of the form will not be accepted.

These ItS will be assessed internally by a sift panel who will determine if the project is eligible for the scheme. They will determine if

- the applicant and lead institution meets the STFC criteria for holding a grant.
- the project TRL is suitable for the scheme
- the project has been developed from STFC science and fits within the STFC remit
- the project is of potential benefit to the PPAN community and/or the wider UK community

Applicant details

Lead applicant name:	J S Lapington
Lead applicant e-mail:	jsl12@le.ac.uk
Lead institution:	University of Leicester

If the project is planned as part of a larger collaboration, please state the names and affiliations of all partner organisations	DRD4 WP4.2.1 – 13 international collaborators – see “Proposal for a Collaboration on the Research and Development for Photon Detectors and Particle identification Techniques (DRD4)”, https://indi.to/rsrhm . The full collaboration comprises the following groups: **UK Universities**: Bristol, Birmingham, Edinburgh, Leicester, Warwick **International collaborators**: CERN LHCb – Switzerland, Erlangen – Germany, Ferrara – Italy, Iowa – US, Ljubljana - Slovenia, Lyon - France, Nagoya - Japan, Padova - Italy, USTC - China
Project details	TRL: 3 Cost: 600,000 Start date: 01/4/2025 Duration: 36 months Institutes: Leicester (lead), Bristol, Warwick, and Birmingham.
Please state the proposed title of the project:	Developing novel gain structures for future vacuum photon detectors

Please mark with an X the relevant box, stating the remit area you work in

Quantum Science	Particle physics	Astronomy	Particle astrophysics	Solar and planetary science	Nuclear Physics	Accelerator science	Supporting Computing science	Other (please state)
	X							

Please mark with an X the relevant box, stating the remit area the project is looking to target

Quantum Science	Particle physics	Astronomy	Particle astrophysics	Solar and planetary science	Nuclear Physics	Accelerator science	Supporting Computing science	Other (please state)
X	X	X			X			

Please provide a brief (less than 300 words) overview of the project, including high level aims and objectives
We propose to develop a new, very fast, low-noise, radiation hard photo detector technology. Vacuum photodetectors have unique performance characteristics and are still the primary technology of choice for many applications. Their large area, radiation hardness, single photon sensitivity, and excellent timing resolution are unmatched by solid state detectors. However, their high-rate capability and lifetime are challenging. In particle physics this makes them the most suitable detectors to equip Cherenkov-based and Time-of-Flight detectors used in particle identification. We propose the development and use of transmissive diamond dynodes to substantially improve this technology. Diamond is one material that has great potential as a dynode, with a high secondary emission yield due to its high bandgap and negative electron affinity when suitably terminated. Our first objective will be to investigate a hybrid detector comprising a diamond membrane as a transmission dynode acting as protection for the photocathode as well as a first gain stage with tighter gain distribution and enhanced photoelectron detection efficiency. Such a device would have a substantially enhanced lifetimes compared to existing vacuum photo detector. Proof of the transmission dynode concept in conjunction with our extensive detector simulation expertise will naturally lead on to more novel devices, for example, the prospect of a multi-stage transmission diamond dynode, with highly controlled electron trajectories compared to conventional MCPs or PMTs. This offers the potential for unprecedented timing resolution of a few picoseconds, and the discrete dynode layout will allow much faster recharge and rate capability than the continuous dynode MCP. The project team comprises Leicester, Bristol, Warwick, and Birmingham, and includes material science groups with expertise in diamond technologies, and detector groups with device characterisation expertise. The team has a strong history and working relationship with our industrial partner, Photek, who are a world leading manufacturer of custom vacuum phototubes.

Please provide a brief (less than 300 words) overview of • who the project will benefit • how the project has been developed from STFC science and technology
The project will benefit future particle physics detectors. Fast timing photodetectors with high spatial resolution, high rate capabilities will be critical in many areas of particle physics – be it in the next generation of Cherenkov-based based Time Of Flight detectors (widely used for particle ID in flavour physics, and in the future potentially to aid tracking in high-pileup situation), "4-D" Ring Imaging Cherenkov detectors, or optical 3-D reconstruction in Liquid Noble Gas detectors. It will also have benefits to other areas of science and instrumentation that require large area, single photon, picosecond photodetectors. For example, imaging florescence lifetime measurements in the life sciences. Our industrial partner Photek are keen to exploit the commercial opportunities arising from the disruptive potential of this project. This project arose from the TORCH project, which developed a highly pixellated large area MCP based PMT for the TORCH TOF detector.