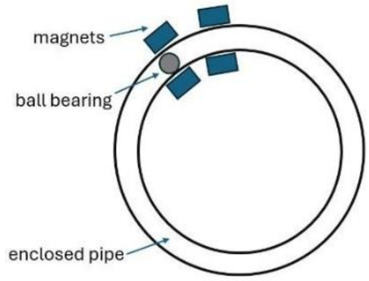
STUDENT PROPOSED?	N	
ID:	**SW24-3**	Embedded detector
SUPERVISOR:	**Simon Winberg**	
TITLE:	**Tiny Big Magnetic Particle Accelerator (TBMPA)**	

DESCRIPTION:

This project is aimed as a timing and experimental demonstrator system. It is not about building a sensing tiny particles, or indeed particle collisions of any sort, this is aimed as a super safe experiment; things are not going to be moving at extremely high speeds. However, it is intended in getting some insight into the challenges of particle accelerators, aspects of their control and their timing and sensing synchronization. This is planned as a cycling accelerator, which will accelerate a variety of objects around a closed track. Of course, enclosed track to ensure plenty of safety, nothing flying out of the pipe. Although the objects to be accelerated are unlikely to move fast. Even if the objects are only slightly accelerated that is something that can be detected, measured and logged.

The acceleration track is planned just to be plastic (or PVC) piping that will have little obstruction to magnetic fields, which will be used for accelerating the objects. See image on right. The objects to be accelerated including ball bearings, and ball bearings encased in plastic coverings and other covering (e.g. plasticine) that impact their friction on the track that they are moving around. So, the track is a particle pipe as apposed to a beam pipe. The track needs detectors that are triggered when an accelerated object (or AOb) passes the sensor. The sensor can simply comprise a laser LED and LDR. A pair of magnets can be used to accelerate – or slow down – the objects. A mechanical launch mechanism would be needed to start an AOb moving along the track. The challenge then becomes figuring out the timing of when an object is detected by one of the sensors and the right time to activate the magnets to increase the speed. Having only two magnetic accelerator points, as illustrated below, might be insufficient; it is best to plan for an additional acceleration point or two as the object may lose too much momentum as it rolls around the plastic pipe and not get back to the magnets to boost its speed back up.



Tiny Big Magnetic Particle Accelerator

It is suggested to use an STM embedded platform for controlling the particle accelerators, using GPIO and suitable designs veriboard or just breadboard circuit to control FETs to power the magnets, and also having GPIO connected to the particle detectors that tell when an object has crossed by a laser detector. The STM should connect to a PC to receive configuration parameters and other controls, together with logging data (e.g. times at which magnets are turned on/off and when Obs pass a detection sensor and their speeds, and calculated acceleration or deacceleration – the speed would simply be determined by the distance between the sensors divided by the time between the detections).

This project is classified as a 'detector' theme topic as it does involve detecting particles (although big particles or characterising the type of object that is in the pipe). The main things is to try and get the particles moving or adjusting their speed by controlling the magnets. But further to that being able to characterise the particles that have been put in the accelerator. Can you, for example, detect how heavy the

	particle is, how big it is, how much friction it has. I'm not sure if this sort of information can be gleamed just from how much energy is put in the magnets and what change that has on the speed that the particles are moving at. In terms of particle physics experiments, there is much investigations into such aspects but tends to be less control that can be done on the hadrons or whatever is being using in experiments; it is were possible to have finder grain control and sensing (which something like the TBMPA could perhaps help with modelling ideas), then perhaps there would be (for instance) move simultaneous experiments that could be carried our for investigating properties of particles, isotope formation and the like.
DELIVERABLES:	1. Requirements and user guidelines, suitably documented. 2. Functional analysis of the system, including anticipated performance. 3. Design trade-off analysis. 4. Design, build, integrate, and test system. 5. Report integrating the above steps.
SKILLS / REQUIREMENTS:	Embedded systems. Programming (Python or C is fine).
GA 1: Problem solving: *Identify, formulate, analyse and solve complex* engineering problems creatively and innovatively*	This project involves programming and some hardware/software interfacing and some PC-based programming. Part of the problem-solving and formulation that the student needs to engage in is determining performance measures, seeing if the measurements of the speed of the ball bearings are accurate (this may need to be done via separate measures or by camera and measuring how much the objects travel between frames). Determining accurate timing measures and control, for when to activate and deactivate magnets after a sensor triggers will need to be calculated and experimentally validated.
GA 4: Investigations, experiments and analysis:** *Demonstrate competence to design and conduct investigations and experiments.*	An important part of this project is assessing performance of the developed system. The investigations and experiments to be carried out to plan and assess these aspects need to be thoroughly documented in the final report. It is important that these experimental procedures are documented clearly providing a clear indication of the tools and software libraries used, and their configuration so that these experiments can be carried out by future users wanting to make adjustments and further testing of the system.
GA 5: Use of engineering tools: *Demonstrate competence to create, select and apply and recognise limitations of appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems*	For this project, competence will be demonstrated in creating, selecting, applying, and recognizing the limitations of appropriate techniques, resources. Engineering tools like the STM embedded platforms for control, GPIO for sensor interfacing, FETs for magnet control, and software development in Python or C will be employed to design, simulate, and optimize the TBMPA system. Limitations and trade-offs of these tools will also be considered in the project's development and analysis phases.
EXTRA INFORMATION:	This isn't a about cyclotron a cyclotron, yes there some done as graduate projects or built by hobbyists, you might come across this inspiring article https://www.symmetrymagazine.org/article/august-2010/do-it-yourself-cyclotron. Yes, an understanding of cyclotrons and their uses is useful and can be put in the lit review. It is more along the lines of a "Model Cyclotron" as shown by Tech Planet "Homemade Rotating Cyclotron" video on https://www.youtube.com/watch?v=FxIB5lqZUHU, but for this project it is with added sensors and controls. Possible (hopefully) using off-the-shelf electromagnets instead of winding coils… but you might need to get busy winding coils regardless, using a motor to help would save time. It would be nice having some elec magnets that can

	be used in the reverse direction to slow down the object accelerated. Safety points: In the above linked YouTube the balls are moving a couple 10s of cycles per minute. That is sufficient speed for this project. This project is not aimed to get very fast moving metal objects looping around the accelerator, you need some speed, and getting up to 50RPM would be desirable for testing purposes, slower speeds are entirely usable and most testing can be done a slow speeds. *NB:* while the video shows the acceleration channel open on the top (i.e. it is not a pipe), it is necessary to have the acceleration channel closed to ensure safety, especially (obviously so) if used in any shared area. A transparent pipe is recommended to easily see the object moving (e.g. Perspex, although that Perspex isn't flexible). Also, for this project, starting with only two magnets for accelerating would be an interesting start, there will be speed loss due to friction while the object travels a longer distance between the magnetic pushes, which contrast to above YouTube video where there are many but short distances between pushes.
BROAD Research Area:	Computer Engineering / ECE / Embedded Software
Project suitable for ME/ ECE/EE/ALL?	ME / ECE

Ethics clearance questionnaire

		Yes	No
Q1	Does this project involve data collection	X	
Q2	Does this project involve utilizing a third-party data set		X
Q3	Does this project utilize machine learning (ML) or artificial intelligence (AI)?		X
Q4	Does it exceed the minimum risk defined here: Link [Answer is No here if your project does not utilize ML and AI]		X
Q5	Does this project involve external parties, funders, etc		X

Answer the following questions if you answer "**Yes**" to any of the above questions.

If the answer is "**Yes**" to **Q1**, please answer the following questions:

		Yes	No
Q6	Are there humans or animals directly involved in the data collection process or contains any identification information		X