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Prof. Mark Ferguson
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28th September 2012

**Re: SFI Consultation - Strategy Agenda 2020 and Operational Plan for 2013**

Dear Prof. Ferguson

The Institute of Physics in Ireland welcomes the opportunity to submit a response to the SFI Consultation - Strategy Agenda 2020 and Operational Plan for 2013.

The Institute of Physics in Ireland is a scientific membership organisation devoted to increasing the understanding and application of physics in Northern Ireland and the Republic of Ireland. It has over 2000 members, and is part of the Institute of Physics.

The Institute of Physics has a world-wide membership of over 45,000 and is a leading communicator of physics-related science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

This submission was prepared in consultation with the IOP in Ireland's governing committee, heads of third level physics departments and with input from members of the Institute in schools, third level education and industry.

The attached document highlights key issues of concern to the Institute.

If you require any further information or clarification, please do not hesitate to contact the Institute at the above address.

Yours sincerely,

Dr. Kevin McGuigan
Chairperson
Institute of Physics in Ireland

Prof. Peter Main
Director Education and Science
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**Science Foundation Ireland Consultation –**
**Strategy Agenda 2020 and Operational Plan for 2013**


## Summary

While welcoming Science Foundation Ireland's excellence driven agenda, the Institute of Physics calls attention to the apparent lack of any specific funding for excellent research for knowledge (frontiers research), which falls outside the 14 nominated priority research areas. The Institute suggests a specific fund, based on 10% of SFI's annual budget to be directed towards areas not covered elsewhere in SFI's budget.

The importance of such research is well-recognised globally as an essential part of supporting science in general and, in particular, leading to long term economic gains. Without it, Ireland runs a considerable risk of losing exceptional talent to overseas competitor nations, reputational damage to our emerging position as an innovative country, the consequent difficulty of attracting world-class researchers and industry here and the very significant demoralising effect on Irish scientists.

Even10% of SFI's total budget is probably too small to build a competitive scientific community that can win downstream EU funding. In a wider context Ireland should invest 10% of its core science research budget of €500M annually, into basic research.

This response also includes comments on SFI's public outreach programme and its aims to increase numbers taking science at second-level.

The IOP position articulated in this response has broad support from physicists working in industry, applied research and basic research.


## Support for Frontiers Research

The Institute of Physics in Ireland welcomes SFI's agenda to position Ireland as a global knowledge leader and its ambitious target indicators particularly re excellence in research and in the wider promotion of science at all levels in Ireland. There is definitely appreciation that continued funding of science research has been maintained during a time of considerable economic difficulty. It is true that over the past decade physics research has benefitted enormously from SFI funding and in turn such funding has lead to significant benefits for Ireland. Physics has a key role to play in the Irish economy with physics-based industry providing over 86,000 jobs and gross value added to the economy of €7.4 billion in 2010[1]. Certainly physicists in Ireland have proved to be adaptive to the evolving priorities of the funding agencies and will continue to be so in the future.

It is understandable in the current economic climate that SFI should seek to invest carefully in science and should be able to demonstrate the value of that investment to government and the general public. For this reason we concur with the general

proposal to target funding towards the 14 priority areas indicated in the National Research Prioritisation Exercise (NRPE). However there is also a strong case to be made to ensure room for outstanding fundamental research outside these fields. In particular, the Institute is concerned about the apparent omission of a funding instrument for such research and the suggestion that over 95% of SFI funding should be directed towards the priority areas.

The Institute, instead, suggests that there should be a specific fund, ring-fenced for frontiers research, which lies outside the priority areas. This should be at the approximate value of 10% of SFI annual funding – i.e. a budget of around €15 million. With an average spend per grant of €100,000 per year this would allow funding of 150 projects in any given year. This may equate to 30 - 50 new proposals each year - depending on size and duration of each project.. The 150 projects would translate into about 200 Ph.D. positions plus perhaps 40 post-doctoral positions.

The rational for such an approach derives from the NRPE report, which states that: *"a proportion of investment should be available to support research driven by a knowledge creation motive rather than by a direct connection to a sectoral opportunity or a specific, identified enterprise need. This type of (typically) basic research should continue to be funded in Ireland as part of a sustainable, well functioning STI system."* [2]

Such research is part of the eco-system which feeds into applied research and provides the jumping off point for discoveries which may lead to significant industrial spin-outs in areas not yet even considered. For example the discovery of graphene, for which its discoverers were awarded the Nobel Prize in 2010, was the result of the efforts of a small research group in the University of Manchester in receipt of grants, less than £500,000 and in areas classified by the UK Engineering and Physical Sciences Research Council as of '*no relevance to underpinning industrial sectors'*.[3] Graphene now has many proposed applications in electronics and computing. Its electronic properties have led some to suggest using graphene to make transistors for high-speed electrical circuits, and ultimately to replace silicon in microchips.

**Striking the research balance globally**

Many countries are facing economic difficulties and with it a concern to ensure that investment in science yields an enterprise dividend. However, it is significant that many international bodies also note the importance of frontiers research in order to achieve this very aim.

For example, an International Monetary Fund report[4] on Finland in Aug 2012, noting Finland's recovery from its deep recession in 2008-2009, commented

*"while Finland has strong fundamentals and a track record of good policies, the near-term economic outlook is highly vulnerable to external developments."*

It went on to recommend

*"Finland should refocus public R&D expenditures toward basic research.".*

This is of particular note given that in 2012, the Academy of Finland, the prime funding agency for basic research in Finland had an annual budget of €320 million while Tekes, the Finnish Funding Agency for Technology and Innovation (applied and industrial research) had a budget of €552.4 million[5].

In the UK, the 2008 report of the Research Assessment Exercise physics sub-panel cautioned strongly against over-specialisation:

*"Many of the world-leading research outputs observed in submissions originated from small responsive mode grants. The sub-panel believes that continuing availability of such grants is absolutely vital to encouraging and sustaining groundbreaking research activity....The physics and science community cannot know where future developments will come from, and attempts to focus funding too narrowly into priority research areas (or priority departments) will limit rather than enhance the prospects of breakthroughs at the highest level."* [6]

In 2007 the Austrian Science Fund (FWF) Austria's central funding organization for basic research, carried out an analysis of the competitiveness of that country's scientific research. The report emphasised:

*"With very few exceptions, all leading scientific nations, in particular smaller ones such as Switzerland, Israel, Sweden, Denmark, Finland or Holland, are world-leading not only overall but also in all individual scientific disciplines. This provides a strong indication for a wide-ranging effort to attain international quality in all areas of science and argues (also for countries with smaller economies) against too strong a focus on particular disciplines. It appears rather to be the case that excellence in individual disciplines or fields of research is hardly possible without excellence in most disciplines*." [7]

**Securing international funding for Ireland**

It is also important to note that modest investment in basic science has allowed Irish researchers to leverage access to major international facilities. However, without it, Ireland's chances of success in accessing European funding are significantly reduced. At the recent ESOF meeting in Dublin, Helga Nowotny, head of the European Research Council, warned that redirection of funds to commercially-focused research rather than basic research threatens scientific excellence in Ireland, and expressed fears that both young and experienced researchers will abandon the country as a result. Prof Nowotny highlighted that there is a direct correlation between the percentage of GDP spent on research and success at the European Research Council (ERC).

The total budget for the EU programme for science research In Horizon 2020 is €77bn with €24bn directed to Excellent Science, €18bn to Industrial Leadership and €31bn to Societal Challenges. Scientific excellence therefore represents over 30% of their investment. The ERC, which only supports excellence in research for knowledge, will receive 13.3bn (17%). We therefore need to significantly raise the amount of investment we put into research for knowledge. Even10% of SFI's total budget is probably too small to build a competitive scientific community that can win downstream EU funding. In a wider context Ireland should invest 10% of its total R&D budget which is approximately €500M annually into basic research. Consortia in the future will ignore Ireland unless they can consistently demonstrate good basic science. If the governments under-invests, Irish science will surely under-perform.

**Relevance to Industry**

It is noteworthy that there is significant understanding of the importance of fundamental research within Irish industry. Boston Scientific is currently sponsoring the CERN exhibition in Galway.

The Irish Academy of Engineering, in its 2012 report on research and the Irish economy, while agreeing that impact on the economy should be a strong criterion for research funding also noted that "*investment in high-quality, basic scientific research is important and must be maintained, while acknowledging that the associated outcomes, in terms of impact on the economy, are unpredictable and may not be realised for many years."*[8]

More specifically companies such as Valeo Vision Systems in Tuam in contributing to this submission noted:

'*Many of our employees are astrophysics, geophysics, mathematics and particle physics backgrounds (at Bachelors, Masters and PhD level) and that it is always difficult for us to find the right candidates to fill our positions. My feeling is that these areas of research will now be completely de-prioritised from a funding point of view making many of the positions within the R&D departments of our types of companies unserviceable by the education/research bodies in this country'.*
John Toner, Valeo Vision Systems

The relevancy of the funding of basic research outside the priority areas is perhaps best illustrated by a number of case studies – full details are given in Appendix I.

Projects such as Watcher at UCD, Stereo at Trinity College Dublin (see Appendix 1) and studies of the extragalactic universe at NUI Galway were funded under the SFI Research Frontiers Programme. Watcher is a study of gamma ray bursts, Stereo is a project to identify explosive events on the Sun's surface. All of these projects have led to industrial links, had significant outreach activity associated with them and the students involved are now successfully working in industry bringing both expertise there and providing on-going research-industry linkages.

**Fundamental physics – a major attractor to science**
As noted in the SFI document, Discovery to Delivery, fundamental science such as astronomy is a significant driver in encouraging young people to study science. For example in a 2012 survey of first year students in Ireland taking physics at third level, 83% cited their interest in the core questions of cosmology and particle physics as the main reason why they chose the subject.[9] If we don't have these research areas Irish students will go outside science or outside Ireland.

It is certainly essential that the teaching of fundamental physics is carried out by those also engaged in current, excellent research in those areas. Irish third-level physics departments have built up expertise in areas such as space physics with researchers mainly being funded in small grants through the Research Frontiers Programme.

There is a very real concern across physics in Ireland that many talented academic researchers in the basic sciences, especially those at the early career stage, who are paid salaries to teach and to do research, will not reach their research potential because of the lack of financial support. They will not supervise Ph.D. students, who could gain world-class research experience and advanced transferable skills (e.g. in high performance computing, Monte Carlo modelling that are the tools of the trade in astrophysics) that are attractive to companies in many sectors. Their research will not inform their teaching to the same extent as they will no longer be funded to perform at the highest level, network and present results at conferences etc. They will probably look for jobs elsewhere, which would be a disaster to our teaching

programmes in these exciting areas and in the context of the current hiring freeze. As noted in the report of the Research Prioritization Exercise[2]

*"Research for knowledge helps to develop the human capital that is required for a sustainable system including postgraduate and post-doctoral training of researchers and the recruitment and retention of world class senior researchers."*

For all of these reasons, the Institute of Physics strongly urges SFI to include a funding instrument for frontiers research within its budget.

**Outreach Programme**

In relation to SFI's public outreach programme, the Institute of Physics in Ireland will certainly continue to offer its support and partnership through Discover Science and Engineering, in areas such as teacher support, with its teacher network co-ordinators and development of materials and resources for classroom and the general public, particularly in the area of careers information. In the past year, the IOP has contributed over €100,000 towards such programmes in Ireland.

With regard to SFI's indirect target to increase the take-up of science at second level, the IOP would point to the success of its Stimulating Physics Network (SPN) programme in England. For the sixth consecutive year, the Joint Council for Qualifications (JCQ) has announced an increase in the number of students choosing to sit A-Level examinations in physics. The rise in the number of students choosing to take physics at A-level in 'SPN Partner Schools' – schools that have worked closely with physics education specialists through SPN – correlates strongly with the overall increase in the number of examination entrants at AS level.

A survey of the 276 Partner Schools (which comprise just under a tenth of all state schools in England) indicates that there has been a 30% increase in uptake of AS level physics over the past year in these schools. [10]

This is in contrast to a 1.7% increase across all schools and suggests that this year's increase of 982 students sitting AS in 2012 is largely made up of students from the Partner Schools.

The long-term impact of the project is even more striking as Partner Schools who have been working with the Network for two to three years report an average increase of 70% in the number of boys and 200% in the number of girls going on to take physics A-level.

The government-funded SPN, run by IOP in partnership with the National Network of Science Learning Centres, differentiates itself from a wide range of science education projects by being one that takes place in-school and is bespoke to meet the specific needs of non-specialist physics teachers and their school departments.

Due to a national shortage of specialist physics teachers, many of those teaching physics in schools hold degrees in other scientific disciplines and often lack the confidence to inspire their students; SPN seeks to work with these non-specialist teachers in state schools across England to ensure they are able to inspire the next generation of physicists.

Such an approach could pay significant dividends in Ireland and the Institute would be happy to share its knowledge and experience.

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**Appendix I – Case Studies from Research Frontiers Programme**
Watcher Project, Lorraine Hanlon, UCD

The main scientific goal of Watcher is the study of gamma-ray bursts. It was first funded by an RFP in 2002, the year the programme transitioned from being funded by EI to being funded by SFI, and half the grants that year were funded by IRCSET. It remains the only professional, Irish, research telescope at a dark skies site. High impact scientific results were also achieved see e.g. http://bermuda.ucd.ie/IRCSET.pdf.

Of the two students who set up Watcher, one went on to work in medical physics (and subsequently went into software) and the other works for an Irish Geophysics exploration company, who couldn't believe their luck to find a PhD in physics with field work experience in Africa, as well as all the data mining and data analysis expertise that comes from a PhD in Astrophysics. The research group also contributed to a Nature publication.

In 2007 Prof. Hanlon received another four-year RFP for development of the Watcher Robotic Telescope in Boyden Observatory in South Africa. This included the cost of upgrading the camera to a state of the art Andor EMCCD, plus site, travel and student and post-doc costs.
The initial student completed a M.Sc. and is working in a nano-science group now on his Ph.D., using the same camera which was installed on Watcher.
The next student is currently completing his PhD, with very nice new results that are in preparation for publication.

Since 2010 the team leader has been unable to pay the site costs at the observatory in South Africa due to lack of new funding. They have a big outreach programme there, and Watcher is a key part of that.

In 2011 a consortium of 13 institutes around the world successfully applied to the EU under FP7 for development of a robotic telescope network. They were awarded €2.5M for this 3 year project called GLORIA (www.gloria-project.eu). It is a major investment by Europe into a citizen science project, which will likely have a very big impact on children's learning into the future. See video clip at:
http://www.youtube.com/watch?v=HsM__Ej6VOg&feature=plcp
Watcher was basically Prof. Hanlon's buy-in to this project. Without hardware upfront, she would not have had any place at the table. Therefore, SFI's support of her research has been crucial in securing this European funding. However, there was no provision to pay site costs and without that funding prospect nationally, she does not know for how much longer she can prevail on the South Africans to host the telescope there.

In another first, the GLORIA network will be the first fully autonomous telescope network, freely open via the Web to the citizens of the world. It will be a wonderful facility. GalaxyZoo is one of the GLORIA partners and they have revolutionized Citizen Science via the Web with 100,000 citizens classifying galaxies.

In order to prepare for this, funding was obtained from Dublin City of Science to run a pilot project in schools: http://www.dublinscience2012.ie/2012/09/robotic-telescopes-in-schools/
this Autumn.

Data from Watcher is also used for undergraduate student projects in UCD's BSc Physics with Astronomy & Space Science.

There is now a new MSc student who has just started and who has wanted to work on Watcher all through his degree. He will also be part of the schools' outreach programme. " *It has taken us 10 years to get to this point and I still feel we are learning the skills of the trade in this, since my training was in high energy astrophysics from space. To do anything new, takes a long time.*

*I was lucky enough to get a 3rd RFP in 2011 to develop a new gamma-ray lens for space-based high energy astrophysics. There are potential applications to such technology in medicine. That students started last year and has worked with collaborators in Berkeley for a month and at the nuclear test reactor in Institut Laue Langevin in Grenoble for 4 weeks. Wonderful experience scientifically and also from a network building point of view. We are currently talking to engineers and materials scientists about novel ways to focus gamma-rays*."

**STEREO Project – Peter Gallagher, TCD**

I was awarded EUR 166k for 3 years under RFP2007 to work on a proposal entitled "Advanced Image Processing for the Solar Terrestrial Relations Observatory (STEREO".

Coronal Mass Ejections (CMEs) are massive explosions on the Sun's surface, which are responsible for driving "space weather". Space weather refers to the interaction of solar particles and magnetic fields accelerated on or near the Sun with the Earth's magnetosphere and upper atmosphere. We propose todevelop advanced image processing methods to identify and characterise the properties of CMEs in images from NASA's Solar TErrestrial RElations Observatory (STEREO). These methods will not only enable us to make detailed comparisons with theoretical models, but will be of great practical benefit to understanding solar activity and its effects on our Earth.

The impacts of the RFP can be summarized as follows:

International cooperation: The project connected Ireland directly to the NASA STEREO team. One of the collaborators on the project was a NASA employee who made several trips to Dublin during the research programme. A great connection for Ireland to have.

Scientific publications: We published 6 papers in highly ranked international journals, including one in Nature Communications. The latter was featured in the international media (see full list below). Great press for Ireland. We also gave something like 20 talks at international conferences.

Graduates: 2 PhD students were trained on this grant. One is now a software developer in an Irish SME (Skytek Ltd) and the other is a postdoc at the Uni of Hawaii, one of the leading centres for astro research. We now have a research project between TCD and Hawaii.

Industrial spin-out: We work with Skytek Ltd. on a project that directly resulted from our RFP and have recently secured a EUR 200k contract from ESA to further develop our techniques. We are also in the process of securing further funding from FP7 to continue this work.