

ANNUAL IMPACT REPORT

2022

Technical and Natural Sciences
Villum Fonden

*Villum Experiment grantee Morten Meldal
received the Nobel Prize 2022 in chemistry for
Click Chemistry*

Executive summary

Through its support for technical and natural science Villum Fonden contributes extensively to the Danish science ecosystem – from supporting young scientists receiving their first funding to participation in major national initiatives such as the creation of Pioneer Centres aimed at transformative solutions to major societal challenges.

This is the annual report from the Technical and Natural Sciences (TNF) funding area to the Villum Fonden Board on the impact of funding scientific projects at Danish universities. The activities described are primarily performed by the grantees, additional activities are conducted by the foundation secretariat and by the committees appointed by the board.

By way of introduction, the report presents five cases of technical and natural research funded by Villum Fonden so as to supplement the quantitative data with inspiring real-life examples of how Villum Fellows conduct their research. They range from the major interdisciplinary initiative of the Algorithms, Data and Democracy (ADD) project to the Villum Young Investigator establishing herself as a research leader in Denmark.

After two years impacted by the COVID-19 pandemic activities are almost back to pre-2020 levels. The pandemic did not entirely close down activities at the universities, but outreach activities, conferences, lab work and international collaboration were challenged in particular. For some, creative virtual solutions were found, while others were challenged mentally, and we have received accounts of scientists suffering with mental disease as a result of the COVID-19 pandemic.

The green transition was an important theme for Villum Fonden in 2022. The foundation initiated a major green transition project with DTU by establishing a P2X (power-to-X) accelerator to prototype green technology developed at Danish universities. Villum Fonden co-funded a Danish Pioneer Centre on P2X in collaboration with a number of public and private foundations. This is the third pioneer center and a fourth center is being planned.

Community building was also on the agenda in 2022, and the first Villum Fellow meeting was held for Villum grantees. The idea is to create a community through which grantees from different research institutions and research fields can meet, make use of each other's experience and form new collaborations. One example of this was the formation of the Young Academy of Technology, Science, and Innovation (YATSI) – a platform for young scientists and entrepreneurs who are trying to transfer basic science into technology and vice versa.

As in the previous years, TNF has worked towards achieving the four strategic targets set by the working group/TNF. Progress has been made on all targets. The gender balance among active grantees is comparable to that of the eligible researchers in Denmark. Funding of interdisciplinary science is on target. International recruitment at the Danish universities is supported by a well-run Mobility Fund, and the share of funding for technical sciences has increased.

Key results of the year 2022:

- A new record of 121 grants were awarded in 2022
- Villum Fonden funding accounts for 15% of the competitive funding for the technical and natural sciences in Denmark
- A portfolio of 562 active grants in 2022, representing a total grant amount of DKK 3.9 billion
- Grantees in 2022: 32% are female scientists; 63% are foreign nationals

- The success rate for applicants in 2022 was 21% – a major increase from 15% in 2021
- 1045 reviews were performed by committee members and external reviewers
- Villum grantees published more than 2300 publications in 2022
- Villum grantees conducted 950 outreach activities – communicating their science to a non-scientific audience – comparable to pre-pandemic levels
- More than 900 PhD students and postdocs were funded through a Villum grant in the 2012-2021 period
- International PhD students and postdocs who join Villum-funded projects tend to stay in Denmark at a Danish university after leaving the projects
- The Villum Young Investigator programme has succeeded attracting and retaining international research talents to Denmark

Strategic initiatives of change

- Gender: The share of female active grantees increased from 19% in 2019 to 25% in 2022
- International recruitment: 13 family packages were granted in 2022 from Villum Fonden to the Mobility Fund
- Interdisciplinary science: Villum Synergy Programme grants were made for the third time
- Technical sciences: 45% of TNF grantees are affiliated to a technical university in Denmark

Remarkable events

- The Nobel Prize in Chemistry 2022 was awarded to Professor Morten Meldal – a Villum Experiment grantee from University of Copenhagen
- A “service check” investigation of the TNF grant area in Villum Fonden performed by Aarhus University in 2022 revealed that the foundation has an exceptional bibliometric impact; the relations with grantees, rejected grantees and university managements were highly praised by stakeholders, making Villum Fonden a preferred partner for the best researchers in Denmark in the technical and natural sciences

Impact stories – highlights of TNF grantees’ contributions to science and society

In the following, we present five examples of funded scientific projects within the Technical and Natural Sciences. They illustrate the broad span of funding: from large to smaller grants, from single disciplines to interdisciplinary science, from basic science to applied science and technology, from science to public outreach.

Sine Nørholm Just

On interdisciplinary research and outreach

Grant: Algorithms, Data & Democracy (ADD) from 2021. The ADD project combines research and outreach in a project funded jointly by Villum Fonden and Velux Fonden with a total grant of DKK 100 million over ten years. The research component is headed by Professor Sine Nørholm Just.



Nationality: Danish

Education: MA in Rhetoric from University of Copenhagen; PhD in communication from Copenhagen Business School

Now: Professor at Department of Communication and Arts, Roskilde University

Research: The ADD project brings together researchers from computer science and from the social sciences/humanities to address the ways Danish democracy is impacted by an ever-increasing use of algorithms

and data. In her own work, Sine researches processes of meaning formation, with a particular emphasis on the digital transformation of public debate.

Outreach

In addition, an outreach component is headed by Strategy Director Lisbeth Knudsen, and Professor David Budtz Pedersen heads the project's knowledge broker unit.



Sine Nørholm Just on the ADD project:

ADD is a "seismograph" capturing the current tremors of our new digital reality. We explore how digitalisation challenges democracy and suggest how those challenges may become opportunities for advancing democratic legitimacy and social trust. More specifically, we investigate specific cases where digital technologies shape individual and collective opinion formation and decision making.

ADD is an interdisciplinary consortium engaged in ambitious collaboration across very diverse fields: communication, computer science, sociology, economics, technology and innovation.

Astrid Eichhorn

On establishing a career in science and becoming a research leader



Grant: Villum Young Investigator 2019

Nationality: German

Education: Physicist from University of Jena, Germany

Now: Professor at University of Southern Denmark.

Associate Professor at the time of granting; became professor in 2023.

Research: As a theoretical physicist Astrid is exploring the basic structure of our Universe, both the nature of space

and time itself and of the matter contained in the Universe. Her main goal is to develop a fundamental theory for this structure and to devise ways in which such a fundamental theory, which concerns unimaginably tiny length and time scales, can be connected to astronomical observations and to experiments at, e.g., CERN.



Astrid on her career and leadership:

After completing my PhD, my research took me to Canada, the UK, Germany and then finally Denmark, where I became an associate professor and could build my group with the Villum Young Investigator Grant.

My international stays have helped me to grow while being exposed to different research cultures and different ways of communicating research. Learning from these different cultures has helped me to decide how I prefer to run my research group and communicate my research.

Academia in Denmark is dynamic and offers a research environment with a flat hierarchy as well as open communication between junior and senior researchers. I have hugely enjoyed not just the research itself, but also leading my group, mentoring my group members and attempting to build an environment in which diverse people with different goals, strengths and challenges thrive and are enabled to develop to the best of their abilities.

Kim Guldstrand Larsen

On how curiosity-driven research can lead to sustainable solutions



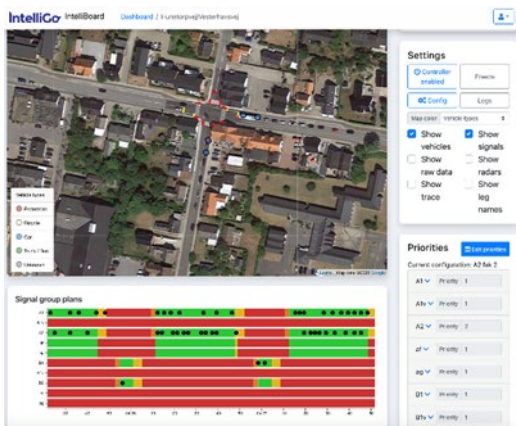
Grant: Villum Investigator 2021

Nationality: Danish

Education: PhD in Computer Science, University of Edinburgh

Now: Professor at Aalborg University

Research: Kim has specialised in ensuring that software does what it is meant to do: Kim works with the specification and verification of systems. Recently his focus has been on cyber-physical systems (CPS), i.e. systems where physical components are controlled by algorithms. Examples include intelligent cars, smart buildings and smart energy grids.



Kim on his research:

We often meet cyber-physical systems (CPS) in our daily life (without noticing). They play a vital role in building a sustainable society and enabling the safe and efficient functioning of systems. My research is focused on the reliability of these systems, and I have been the lead on developing an award-winning tool UPAAL (downloaded more than 13,000 times per year) for efficient performance analysis. This has made an impact on a number of application areas, including traffic control and water management.

While creating reliable systems is my main aim, CPS offers several benefits in the context of sustainability: optimised energy consumption, reduced waste generation and improved resource allocation. In the future, this will presumably get more attention and be a pivotal element in new infrastructure.

Tejs Vegge

On how to make a vital mark on the green transition



Grant: Pioneer Center for Accelerating P2X Materials Discovery (CAPeX). Villum Fonden has supported the centre with DKK 48.5 million out of a total of DKK 300 million. Additional funding comes from Novo Nordisk Foundation, Carlsberg Foundation, Lundbeckfonden, the Danish Ministry of Higher Education and Science, and the Danish National Research Foundation.

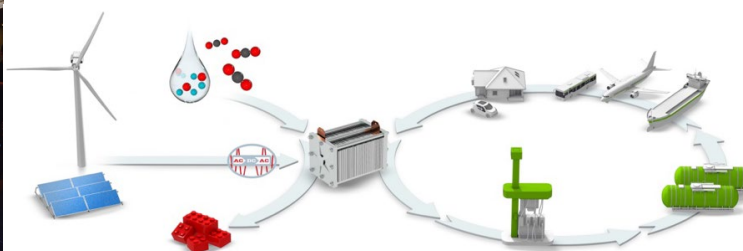
Tejs Vegge heads the centre in collaboration with Professor Frede Blaabjerg from Aalborg University (Villum Investigator 2017).

Nationality: Danish

Education: PhD in Materials Physics, Technical University of Denmark

Now: Professor and Head of Section at Technical University of Denmark

Research: Tejs Vegge is working within the area of sustainable materials for the green transition. His main focus is catalysts, batteries and other technologies for energy conversion and storage, in particular computational and AI-accelerated design and discovery of scalable clean energy materials.



Tejs Vegge on the grant:

The Pioneer Center will accelerate the discovery and development of materials and technologies for Power2X to fast-track the green transition. We all sense that it is a race against time to achieve results in creating a sustainable society. With the pioneer grant, we will address the global challenges through an integrated cross-border approach, where Danish and international experts from Canada, the USA and the

Netherlands can collaborate closely using self-driving laboratories. It is exciting as well as challenging to establish such transdisciplinary and decentralised approaches, but necessary since this is a global challenge that goes beyond the individual researcher, laboratory and country.

One thing is to create great scientific results, another is to build research capacity. Hence, we have committed to educating the next generation of “Power2xperts” – at least 100 PhD students and postdocs will over the next 13 years – who will obtain new knowledge, transdisciplinary competencies and digital skills. Hopefully, this will contribute to a brighter and greener future ahead.

YATSI – The Young Academy of Technology, Science, and Innovation

On how to join forces as Villum Fellows

Grants: Villum Young Investigators (2018, 2016, 2020) and a DKK 5 million grant from Villum Fonden to build up and launch YATSI.

Andreas Laustsen-Kiel (DK) Professor at Technical University of Denmark

Kirsten Jensen (DK) Associate Professor at the University of Copenhagen

Janus Eriksen (DK) Associate Professor at Technical University of Denmark



During a Villum network meeting in 2022, three Villum Young Investigators – Kirsten Jensen, Andreas Laustsen-Kiel and Janus Eriksen – together with Sandra Thrane from biotech company Bactolife came up with the idea of establishing a young academy focusing not only on basic science but on the interface between science, technology and innovation – called YATSI – as a counterpart to the Danish Young Academy under the Royal Danish Academy of Sciences and Letters. The idea is to strengthen applied science and build bridges between academia and industry, while also fostering a joint meeting place for talented young scientists and entrepreneurs. The academy launched in 2023. The Danish Academy of Technical Sciences (ATV) will host YATSI. ATV is a not-for-profit organisation and think-tank, which works to improve the framework for science and applied technology in Denmark.

Kirsten Jensen – On the need to build YATSI:

Janus, Andreas and I had met on many occasions – through the network of Villum Young Investigator grantees. Together we found a common interest in sharing our knowledge and challenges in the technical sciences. In my field of materials chemistry and nanoscience, there is a short distance between curiosity-driven science and applied science, and I find it rewarding to know that I can contribute to the development of more effective energy materials and a sustainable future. Hopefully, by joining forces YATSI can play a part in getting even more out of the efforts made in the technical sciences in Denmark and build close relations with to industry partners when creating solutions for great challenges.



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Introduction

Villum Fonden supports the technical and natural sciences with the aim of strengthening excellence such that Danish research is enabled to reach an international top level for the benefit of the Danish science ecosystem, its affiliated researchers, science environments, education as well as for Danish society at large.

The purpose of the present report is to provide the Villum Fonden Board with an overview of how the Technical and Natural sciences (TNF) funding area ultimately benefits Danish society in the broadest sense. The report covers information on the talents funded, classic scientific impact and new indicators such as grantee innovation activities as well as the impact of education of PhD students and postdocs.

The report is structured according to our “Theory of Change”. It presents a flow of activities that transform an initial donation to basic science at a Danish university into a broader societal impact, mainly through the education of highly skilled young researchers. The report has been prepared by the Villum Fonden secretariat assisted by consultants from Iris Group (Metrics F and G) and researchers at the Danish Centre for Studies in Research and Research Policy at Aarhus University (Metric D).

The approach underlying the report is to develop a method and metrics which can be used year after year with few modifications. We make use of the foundation’s own datasets: data reported by grantees in annual reports and in Researchfish, and data from the foundation’s administrative platform. We supplement these with data from relevant national registers produced by Statistics Denmark and international acknowledged citation datasets in Clarivate Analytics “Web of Science”.

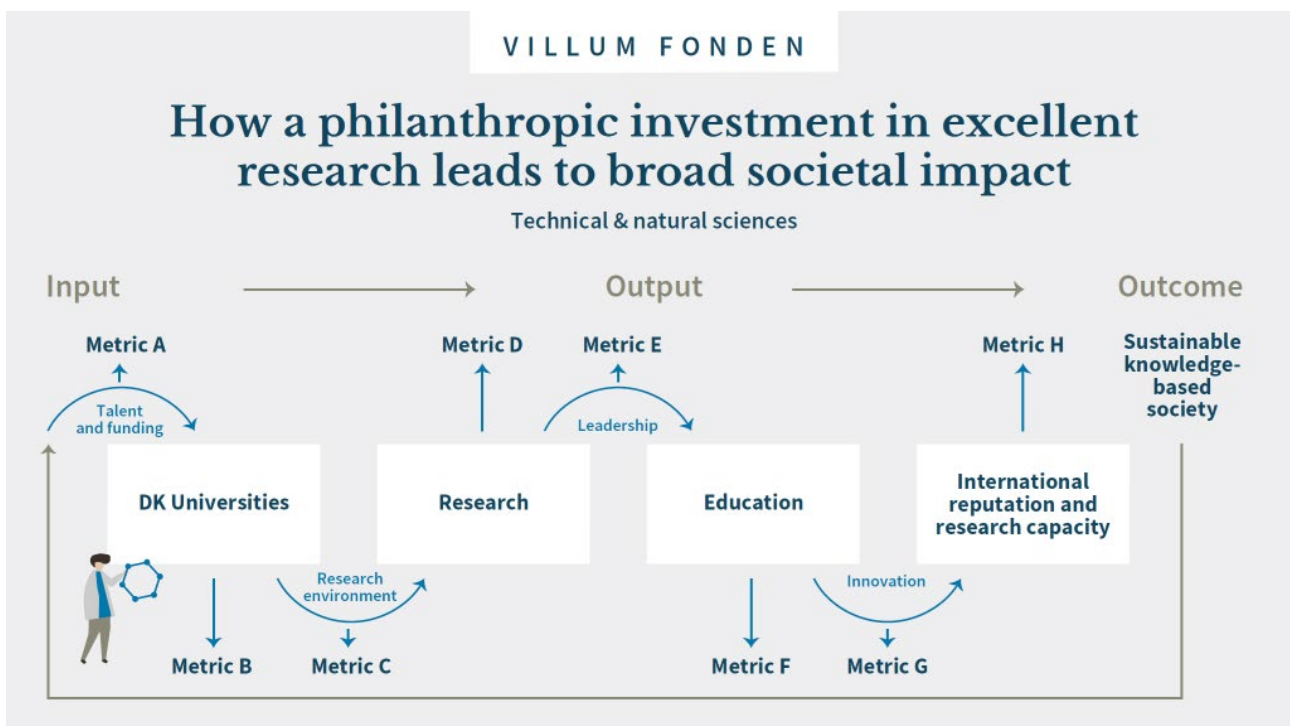
Structure of the report

We follow the steps of the Theory of Change (illustrated below) systematically when reporting impact – from Metric A to Metric H. Finally, we highlight TNF performance in 2022 within the four strategic initiatives: gender balance, interdisciplinary science, international recruitment, and technical sciences.

Theory of Change

The hypothesis that funding of curiosity-driven excellent research results in broad societal impact is rooted in two main assumptions:

1. Denmark will benefit from being at the front of the global knowledge economy, and our funds are particularly well-suited to support this goal. In turn, this requires excellent scientists and excellent universities in Denmark. The best scientists are attracted from all over the world by great opportunities to pursue their own ideas (i.e. curiosity-driven bottom-up research) via the programmes offered by Villum Fonden.
2. Top scientists attract top PhD students and postdocs who get – or create – jobs (in Denmark and elsewhere) at the front of the global knowledge economy. Research environments that support and include innovation and entrepreneurship as part of their excellent research create new jobs in both start-ups and in existing companies.



1. Metric A – Talents and funding

Villum Fonden provides funding for scientific top talents affiliated with Danish universities, who participate in building and maintaining excellent science capacity in Denmark.

The talents are selected primarily in open competition by the internationally highly acknowledged scientists serving on Villum Fonden's scientific committees.

Metric A highlights the volume of funding from Villum Fonden to the technical and natural sciences, the quality of the applicants, and the quality of the committee processes.

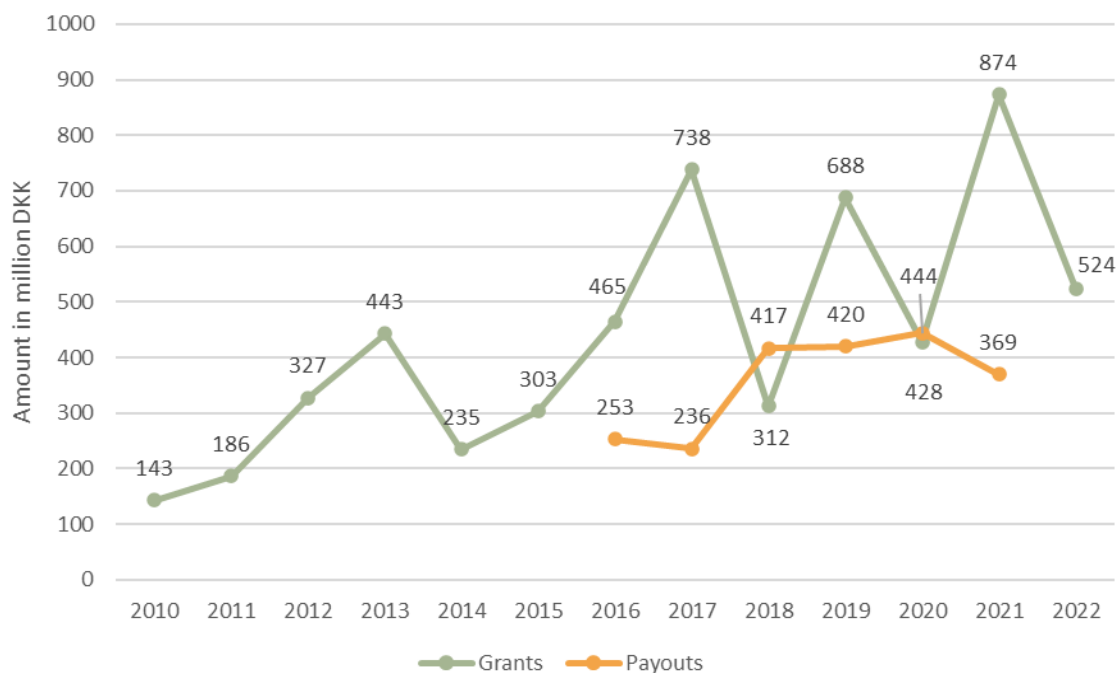
Key points:

- 121 grants were awarded in 2022, amounting to a total of DKK 524 million
- Villum Fonden funding accounts for 15 % of the competitive funding for the technical and natural sciences in Denmark
- TNF received and evaluated 542 applications
- New grantees in 2022: 32% are female scientists; and 63% are foreign nationals
- 1045 reviews were performed by committee members and external reviewers
- 562 grants were active in 2022, representing a total grant amount of DKK 3.9 billion

Funding

In 2022, Villum Fonden awarded grants for a total of DKK 524 million (figure 1.1). The total grant budget was considerably lower than the 2021 budget, which totalled DKK 874 million. This is mainly due to the fact that Villum Investigator Programme grants totalling about DKK 400 million were made in 2021, but not in 2022. Villum Investigator grants are made every other year.

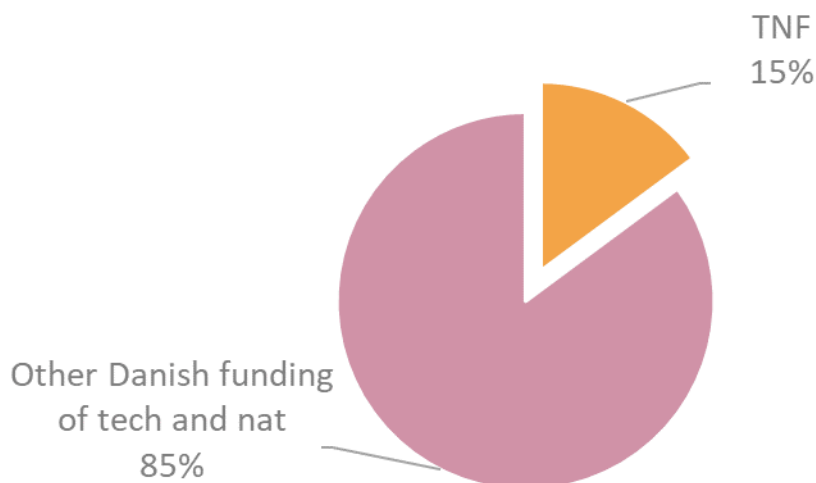
Figure 1.1 Grants 2010-2022 and payouts 2016-2021



Source: Villum Fonden – July 2023

Villum Fonden awards 15% of Danish competitive project funding for Danish science within the natural and technical sciences, as shown below in Figure 1.2. This figure is based on two-year averages to avoid fluctuations across the years.

Figure 1.2 Villum Fonden share of Danish competitive funding of technical and natural sciences



Source: Statistics Denmark and Villum Fonden – July 2023

Grants in 2022

Grants that have not been part of open calls are categorised as “Missions” in figure 1.3 below. Since they are not identified through an open call, they have involved extensive dialogue with either a university or a foundation with the aim of achieving a certain future goal. Two significant grants were made:

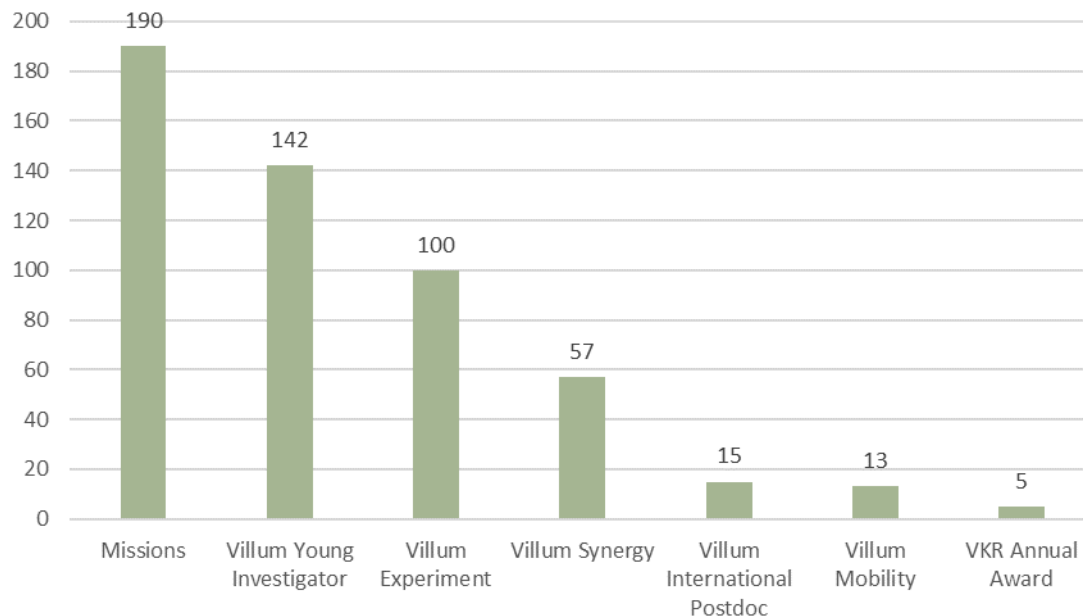
1. Funding for the third Danish Pioneer Center “The Danish Pioneer Center for Accelerating P2X Materials Discovery”. Along with the grant from Villum Fonden (DKK 48.5 million), funding is provided by a number of Danish public and private foundations, including the Danish National Research Foundation.
2. Funding for “The VILLUM P2X Accelerator” at Technical University of Denmark, which received a grant of DKK 80 million. DTU will establish and run a national hub to propel research ideas within the P2X area into industrial application. Many P2X technologies are still in their infancy and need to be brought closer to the market in order to support the future energy infrastructure.

In 2016, Villum Fonden supported the establishment of the VILLUM Center for the Science of Sustainable Fuels and Chemicals. The project will end in 2024, and it was decided to extend some of the activities by granting a total of DKK 40 million to two follow-up projects headed by PI Professor Ib Chorkendorff and Co-PI Professor Jens Nørskov.

Villum Experiment grantee Morten Meldal received the Nobel Prize 2022 in Chemistry for Click Chemistry. The Villum Board decided to follow up on Morten Meldal’s exceptional achievement by awarding him a research grant.

Finally, three Villum Young Investigators decided to join forces and establish a new young academy with the aim of building a bridge between basic science and industry. This is a great example of Villum grantees collaborating on a joint project after having met at a Villum Fellow meeting.

Figure 1.3 Grant amount by programme 2022



Note:

Missions include grant for the VILLUM P2X Accelerator, a pioneer centre, and grants related to the green transition at DTU, YATSI Young Academy, a grant for ATV, and for the Nobel Prize winner Morten Meldal.

Villum Young Investigator include YIP+ grants

Source: VILLUM FONDEN – July 2023

Talents

All grants within this category are based on external evaluations of scientific excellence as the main criterion. The evaluation is described further below (“Quality assurance in technical and natural sciences”, p. X).

Villum Fonden awarded 121 grants within the TNF grant area in 2022. Generally speaking, the increase in the grant volume can be attributed to the introduction of the Villum Experiment Programme in 2017, under which about 50 new grants are awarded annually, as well as the introduction in 2020 of the Villum Synergy and Villum International Postdoc programmes, under which a total of about 20 grants are awarded annually.

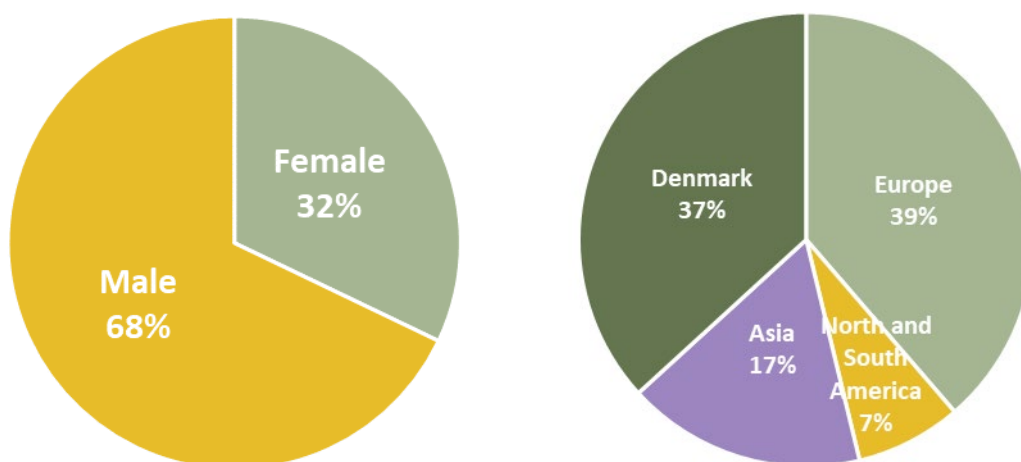
Figure 1.4 Number of awarded grants by year 2010-2022



Source: Villum Fonden – July 2023

Of the talents selected to receive a grant from Villum Fonden in 2022, 32% were female and 68% were male. The grantees are of diverse geographical origin with 63% being non-Danish nationals (figure 1.5).

Figure 1.5 Gender and nationality of new grantees from 2022

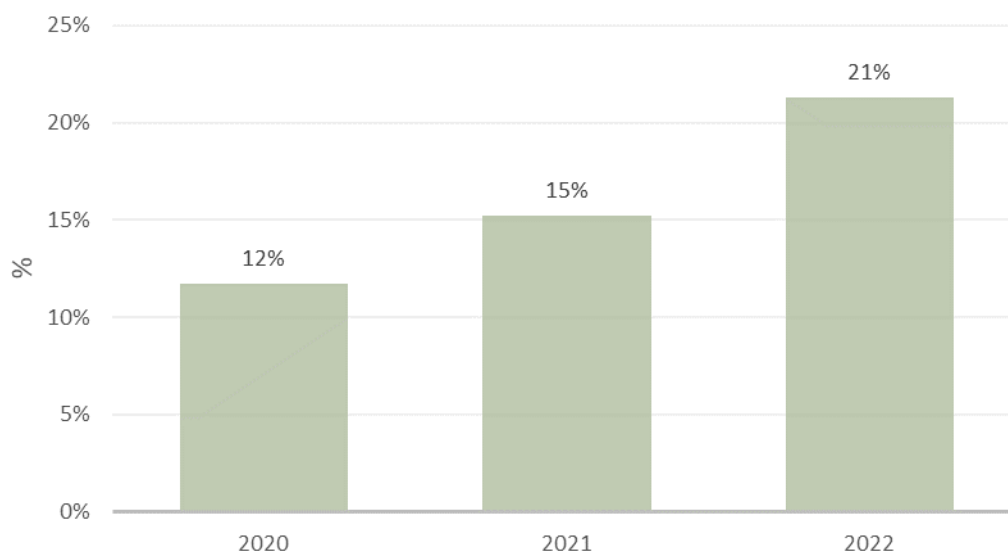


Source: Villum Fonden – July 2023

Success rates

In 2022, 21% of all grant applications were successful. This represents an increase compared to 2020 and 2021 levels (figure 1.6) and reflects Villum Fonden’s deliberate attempt to receive fewer applications by making it clear to potential applicants what the conditions of the programmes are in close collaboration with the universities. This should generally lower the burden of researchers, who prepare numerous research proposals, and enhance the quality of the proposals received by the foundation.

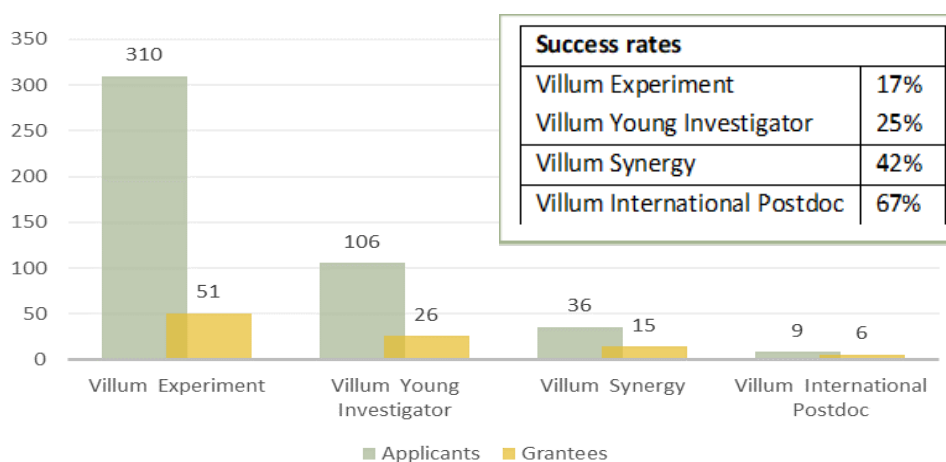
Figure 1.6 Success rates by year



Source: Villum Fonden – July 2023

Success rates increased from 2021 to 2022 for almost all programmes, especially for the Villum Synergy Programme where application numbers were down. The reason for the decline in Synergy applications is currently being looked into. The Villum International Postdoc Programme has a considerably higher success rate due to the fact that the call is limited to one or two applications from each university (figure 1.7).

Figure 1.7 Applications, grants and success rates 2022 by programme

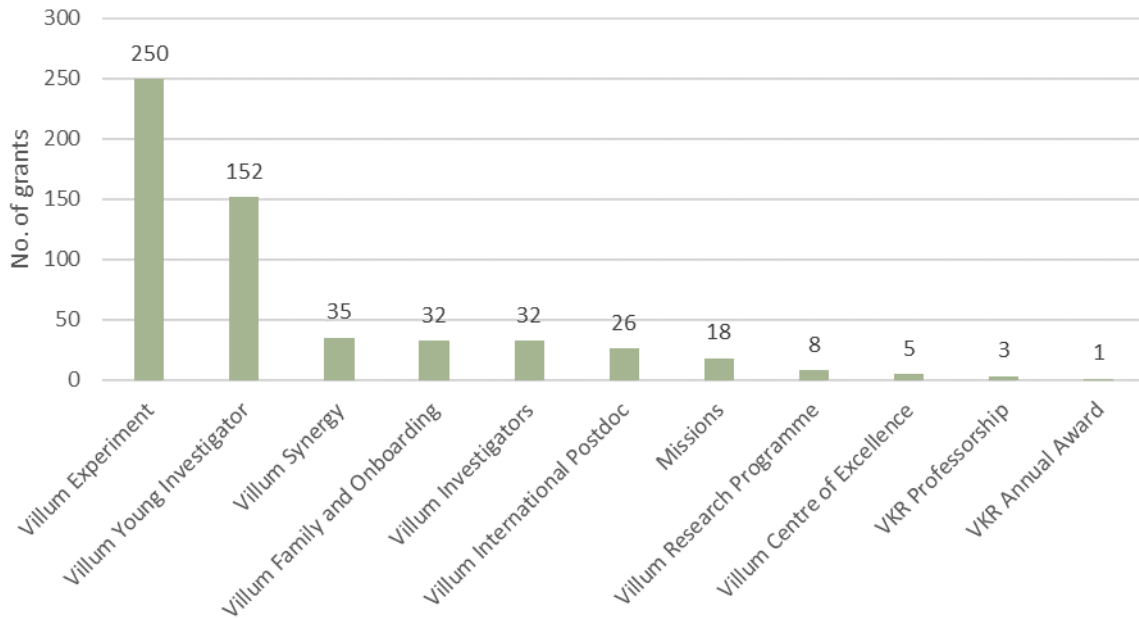


Source: Villum Fonden – July 2023

Active grantees

A total of 562 grants were active in 2022, accounting for a total grant amount of DKK 3.9 billion. Almost half of the grants pertain to the Villum Experiment Programme (figure 1.8). The number of active grants is slowly increasing, due to the increase in number of awarded grants per year.

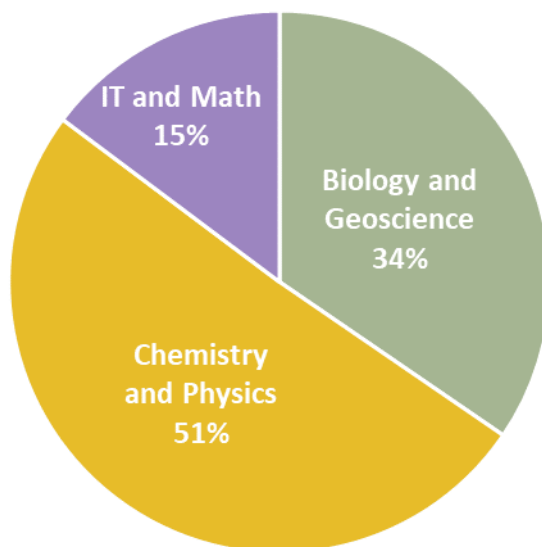
Figure 1.8 Active grants by programme



Source: Villum Fonden – July 2023

Villum grantees have strong ties to chemistry/physics and biology/geoscience: 85% of grantees are affiliated with a department within these research areas, while 15% work within the disciplines of IT/mathematics (figure 1.9). IT/mathematics has increased its relative volume from 9% in 2020, which is primarily due to the Villum Synergy Programme. Please note that the disciplines as defined here cut across the natural science/technical science divide.

Figure 1.9 Disciplines, active grantees 2022



Source: Villum Fonden – July 2023

Quality assurance in technical and natural sciences, Villum Fonden

To ensure a high level of scientific quality in the evaluation processes, VILLUM FONDEN has appointed five committees: The working group within technical and natural sciences (TNF), the Villum Synergy Committee, the Young Investigator Committee, the Villum Experiment Panel and the Annual Award Committee. In addition, external reviewers, identified by the secretariat, write peer reviews for applications within the Villum Investigator Programme and the Villum Synergy Programme, as well as for the selection of the annual award.



Most of the 1045 reviews are performed by the Villum Experiment Panel. The 21 panel members evaluate proposals virtually using a digital review tool developed by Villum Fonden.

Table 1.1 – Committee and panel activities

Committee or panel	Activities	Programmes
TNF	Evaluate applications, conduct Interviews, advise on strategy and calls, attend follow-up meetings	Villum Investigator Villum Synergy (+ 3 external members) Villum International Postdoc
Villum Young Investigator Committee	Evaluate applications, conduct interviews	Villum Young Investigator
Villum Experiment Panel	Evaluate applications (anonymous)	Villum Experiment
Annual Award Committee	Assess nominated candidates	Villum Kann Rasmussen Annual Award

Source: VILLUM FONDEN – 2023

All members are internationally highly regarded scientists at major research institutions. They are affiliated with the following research institutions (table 1.2).

Table 1.2 International affiliations of committee members 2022

Universities and research institutions	
Aalto University (FI)	University of California, Berkeley (US)
Alfred Wegener Institute (AWI), Potsdam (DE)	University of Cambridge (UK)
Chalmers University of Technology (SE)	University of Durham (UK)
Delft University of Technology (NL)	University of Geneva (CH)
ENS (Ecole Normale Supérieure) PSL, Paris (FR)	University of Lausanne (CH)
EPFL (CH)	University of Luxembourg (LU)
FAU (Friedrich Alexander University) (DE)	University of Manchester (UK)
Ghent University (BE)	University of Munich (DE)
Harvard University (US)	University of Oxford (UK)
Imperial College London (UK)	University of Sheffield (UK)
KTH Royal Institute of Technology (SE)	University of Stockholm (SE)
Linköping University (SE)	University of Ulm (DE)
Lund University (SE)	University of York (UK)
Sapienza (Università di Roma) (IT)	University of Zürich (CH)
Stanford University (US)	Uppsala University (SE)
Trinity College Dublin (IE)	Utrecht University (NL)
Umeå University (SE)	

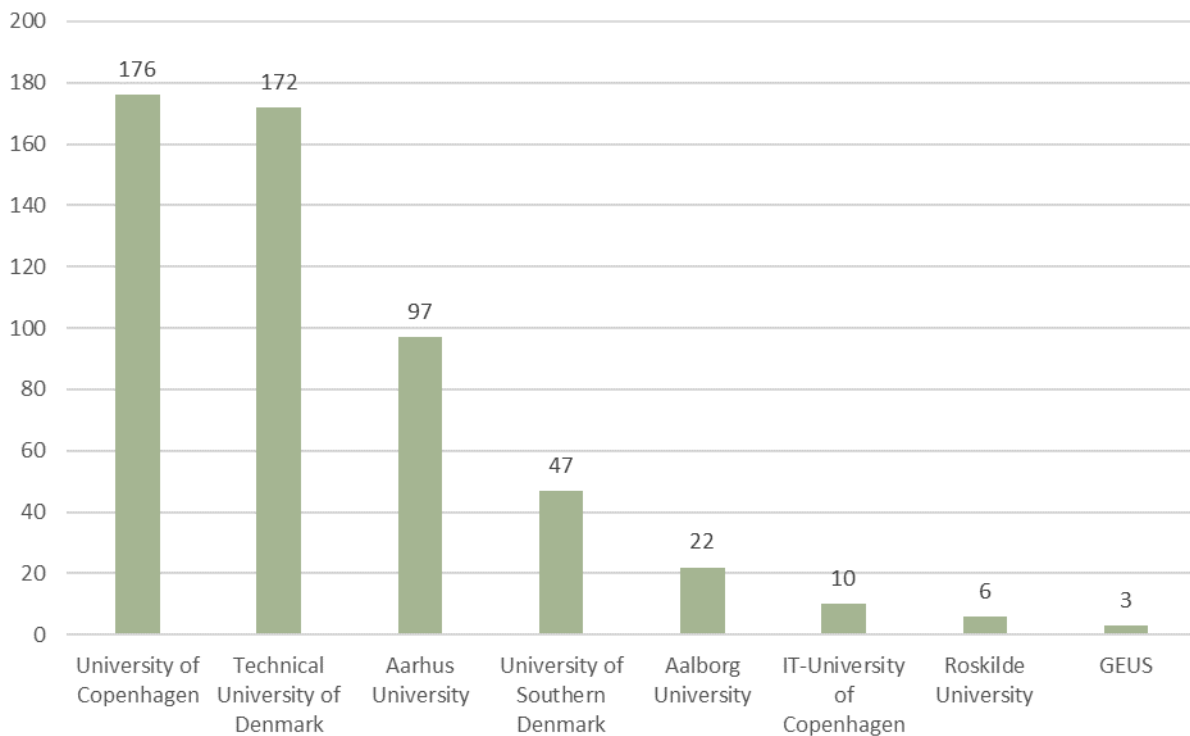
Source: Villum Fonden – 2023

2. Metric B – Universities

Metric B highlights the distribution of Villum Fonden science funding across the Danish universities. Seven Danish universities and the Geological Survey of Denmark and Greenland (GEUS) host Villum grantees (figure 2.1).

The majority of grants are based at the three largest universities: University of Copenhagen, Technical University of Denmark and Aarhus University. They account for 80% of the active grants.

Figure 2.1. Active grants by institution 2022



Source: Villum Fonden – July 2023

3. Metric C – Research environment

The universities host the grantees supported by Villum Fonden, and Metric C highlights Villum Fonden's relations and contact with the institutions to ensure high-quality research institutes for the Villum grantees.

Key points:

- TNF attended 4 follow-up meetings with grantees (large grants)
- The TNF secretariat attended 18 meetings with university managements or research support offices

It is important that grantees have a good relationship with the institutions and that they are offered conditions in terms of lab space, administrative support etc. that support their scientific projects and goals. To ensure optimal research environments, the TNF secretariat holds a wide variety of dialogue meetings with grantees and the universities. In 2022 18 such meetings were held.

TNF meets with grantees to follow up on the progress of large grants with a long timeframe. The grantees present their research results and talk about how they manage the project, coordinate work and educate PhD students and postdocs. At these meetings, the head of department is invited as the administrative representative from the institution. Due to the increase in grant numbers in 2021, it was decided to supplement these meetings with shorter so-called “coffee meetings” with fewer attendees.

The TNF secretariat holds an annual seminar for the heads of department within the technical and natural sciences as well as individual meetings with all rectors in order to get the opportunity to discuss strategy or provide information on new initiatives. The secretariat also holds meetings or workshops on open calls – these meetings are usually planned by the research support departments.

Table 3.1 Meetings with grantees and universities conducted in 2022

Grantee – follow-up meetings 2022		
Grantee	Programme	Research institution
Eugene Polzik	Villum Investigator	UCPH
Staffan Persson	Villum Investigator	UCPH
Per Christian Hansen	Villum Investigator	DTU
V-Sustain/Ib Chorkendorff	Jubilee Centre	DTU

University meetings 2022	
Event	Interval
Meeting with the heads of departments and deans within the technical and natural sciences at Danish universities	1 meeting
Rector meetings	7 meetings
Meetings with research support at universities	10 meetings a year

Source: *Villum Fonden – 2023*

4. Metric D – Research

Metric D highlights the outcome and impact of the research activities performed by Villum grantees after having received a grant from the foundation. This includes the number of publications and the scientific impact of the publications as measured by peer citations. The impact is benchmarked against national and international figures. Finally, we look at activities related to dissemination of science to non-scientific audiences.

Key points:

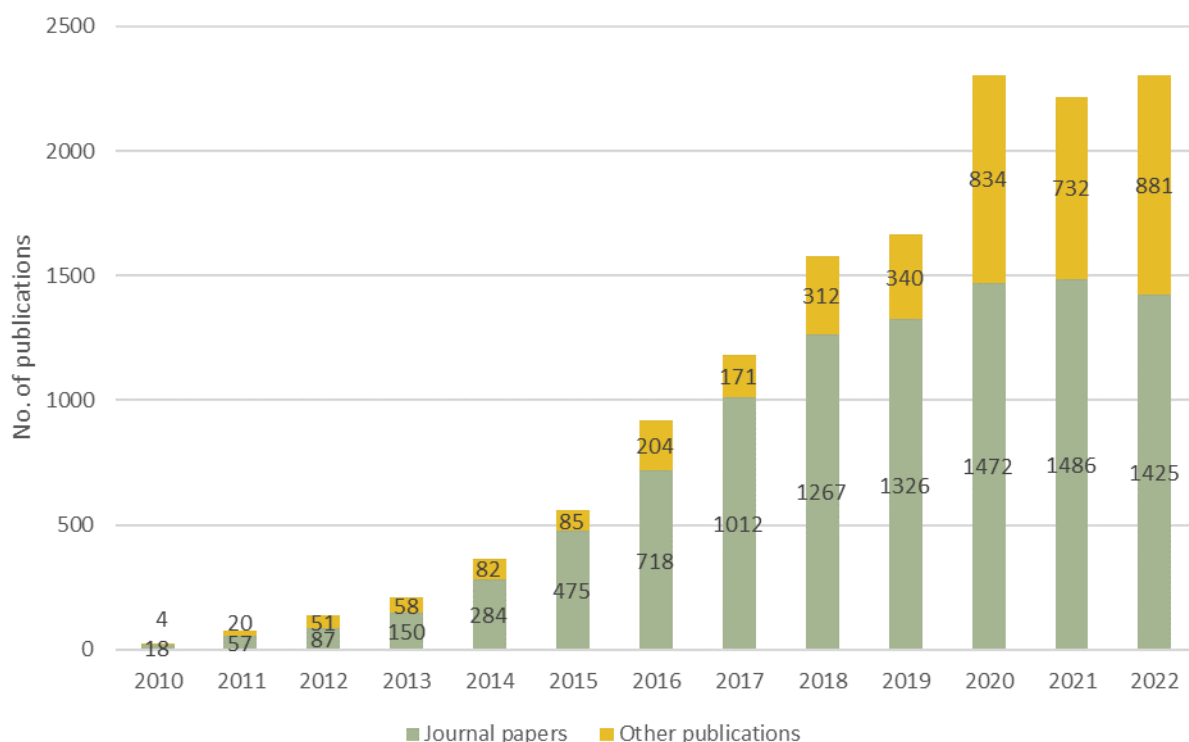
- Villum grantees published more than 2300 publications in 2022
- Scientific articles published by Villum grantees have a scientific impact on a par with the best in Denmark
- The level of scientific impact is above the three largest universities in Denmark
- Villum grantees conducted more than 950 outreach activities

Publications

Figure 4.1 shows the number of publications published in the 2010-2022 period as reported by Villum grantees themselves in Researchfish, an online platform for impact reporting. Villum Fonden asks all grantees to report their publications in Researchfish annually. The publications are divided into two categories: scientific journal papers and other publications (working papers, conference proceeding abstracts, book chapters etc.). In 2022, scientific journal papers made up 62% of all publications.

In 2021, we saw a drop in number of publications, presumably due to the COVID-19 pandemic. In 2022, the number of publications returned to pre-pandemic levels.

Figure 4.1 Publications reported in Researchfish by Villum grantees, 2010-2022

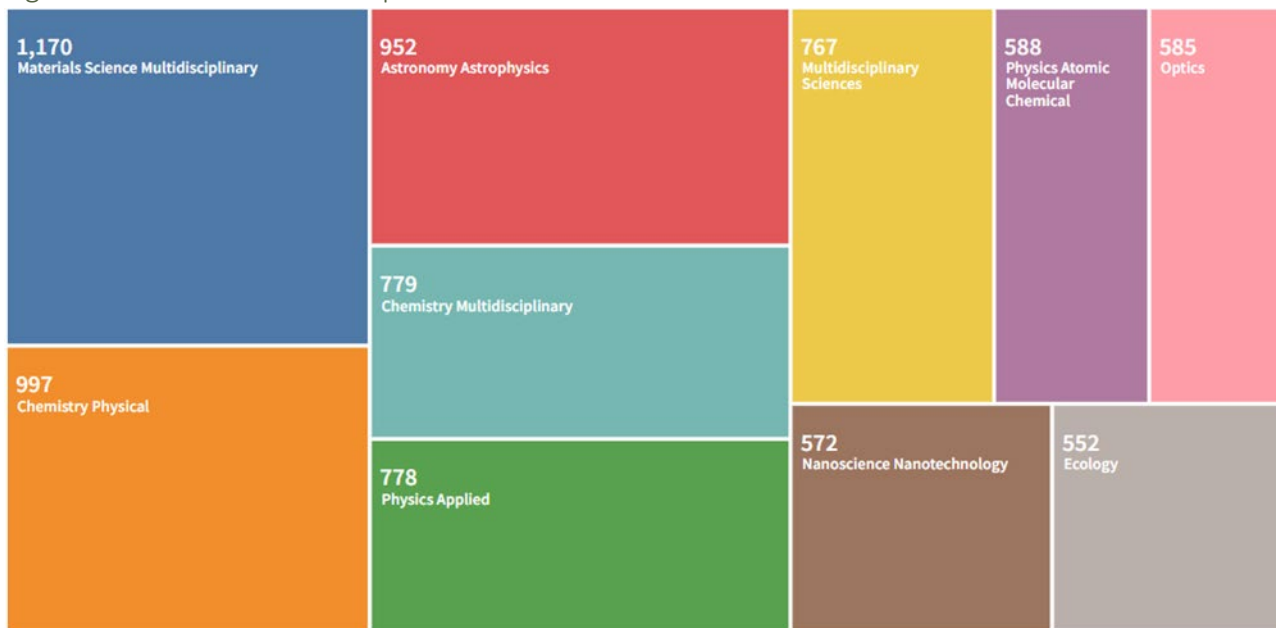


Source: Researchfish – July 2023

Web of Science (WoS) is one of the most highly acclaimed sources for scientific citations. In WoS the scientific field categories most commonly attached to papers by Villum grantees are 'Multidisciplinary materials science', 'physical chemistry' and 'astronomy & astrophysics' (figure 4.2).

It should be noted that a journal paper can be indexed under more than one category. The category is dependent on the journal it has been published in; categories are not identified according to the specific paper.

Figure 4.2 Research fields for publications in Web of Science 2006-2022



Source: Clarivate Analytics' Web of Science – July 2023

Research – Scientific Impact

We consider the scientific impact of TNF grantee publications by looking at how often researchers are cited by their peers.

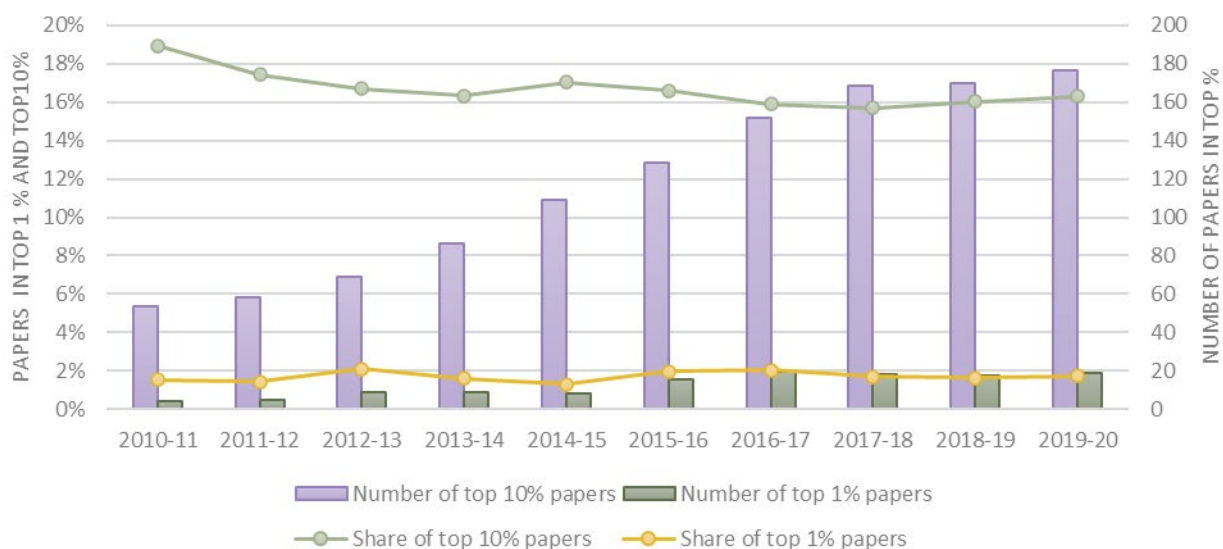
The report focuses on two indicators: the share of articles among the top 10% most cited and the top 1% most cited, respectively. A group of researchers performing as well as the world average will have a “top 10% most cited” indicator of 10% (and correspondingly a “top 1% most cited” indicator equal to 1%).

Figure 4.3 below shows the scientific performance of Villum Fonden grantees with the curves indicating the world share of scientific performance, and the columns indicating the volume of publications.

Both indicators show that Villum Fonden grantees perform above the world average. The top 10% indicator (yellow) was at 16% in 2019-2020, and the top 1% indicator (pink) was at 1.7% in 2019-2020.

These are excellent results and show that Villum grantees perform significantly above the world average and have maintained a relatively stable level of scientific quality, despite the significant increase in the number of publications funded by Villum Fonden over the past ten years.

Figure 4.3. Share and number of highly cited journal papers by Villum Fonden grantees, 2010-2020



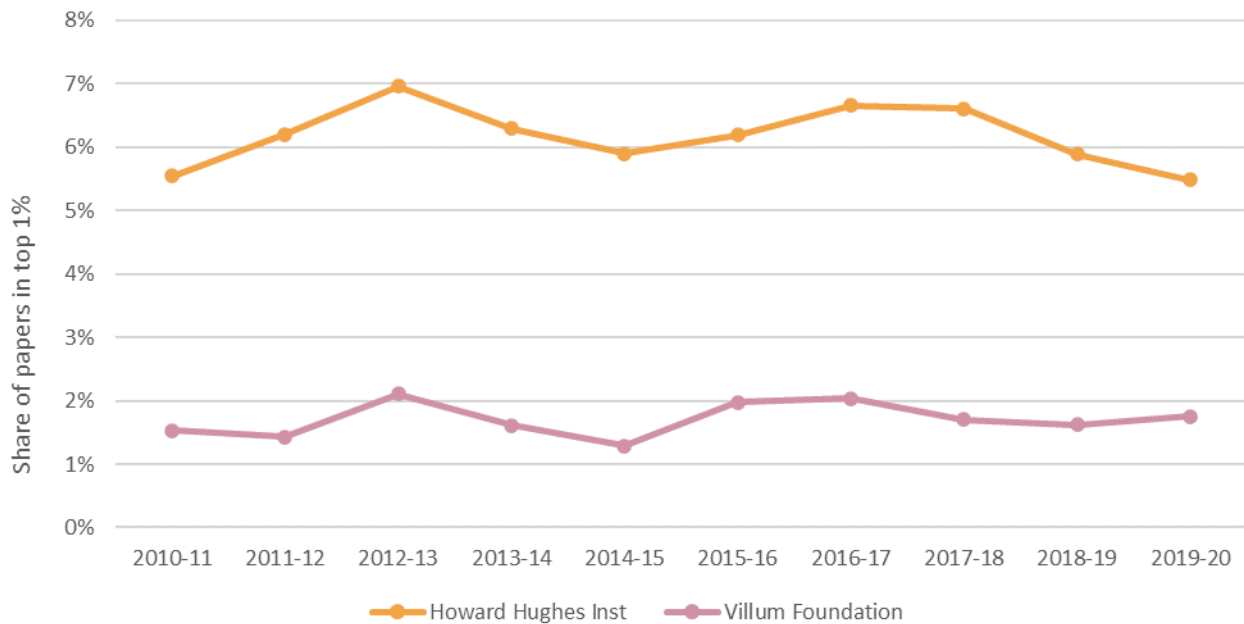
Source: Danish Centre for Studies in Research and Research Policy – May 2023

Figure 4.4 provides an insight into the performance of Villum grantees compared to the highest scientific level internationally (indicator: top 1% most cited), here illustrated in comparison to Howard Hughes Medical Institute grantees. Howard Hughes Medical Institute is regarded as one of the most prestigious funders in the world with a budget of about USD 660 million, roughly eight times the average TNF budget.

In the figure, the most recent data point from 2019-2020 shows that VILLUM grantees are at 1.7% whereas Howard Hughes grantees are at 5.5%.

Howard Hughes grantees publish primarily within medicine and biomedicine, whereas Villum Fonden grantees publish primarily in the technical and natural sciences. Researchers within the two research fields perform differently in how they publish: frequency, choice of sources, number of co-authors. Thus, data have been field-normalised to make the two funders comparable across fields. It should be noted though that it is not always possible to normalise these differences completely.

Figure 4.4: Share of journal articles among the top 1% most cited journal articles in the world – comparison of Howard Hughes Medical Institute and Villum Foundation grant recipients, 2010/11-2019/20

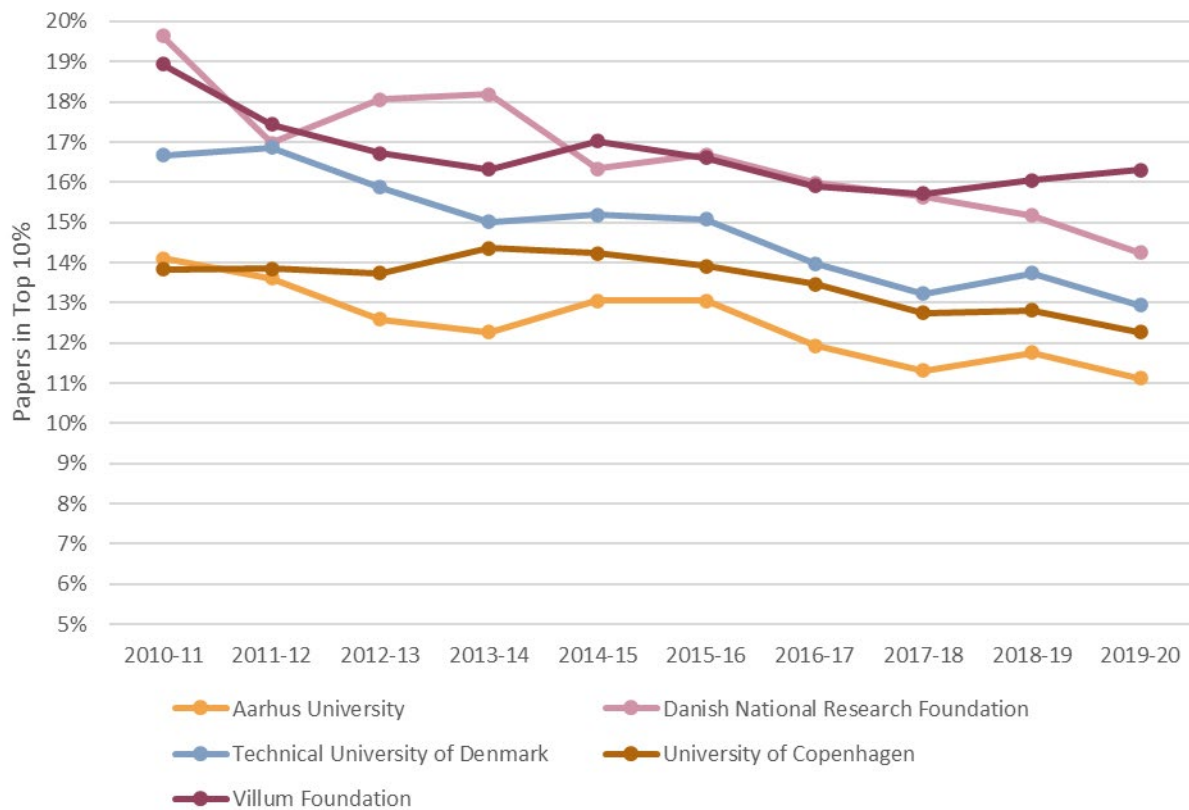


Source: Danish Centre for Studies in Research and Research Policy – May 2023

Figure 4.5 presents a comparison of Villum Fonden’s performance among Danish funders and Danish research institutions, by looking at the share of the top 10% most highly cited journal articles.

In 2017-2018, Villum Fonden and the Danish National Research Foundation (DNRF/Danmarks Grundforskningsfond) grantees perform at around the same level of 16%, which is well above the world average. In 2019-2020 the performance of VILLUM grantees rose slightly whereas the performance of DNRF grantees went down. DNRF is considered the gold standard of successful funding of research centres of curiosity-driven research in Denmark. The three universities perform slightly lower. Villum Fonden has maintained the same level of performance over the past few years, whereas the universities have dropped slightly in performance.

Figure 4.5 Top 10 % highly cited journal articles Villum Fonden and benchmarks



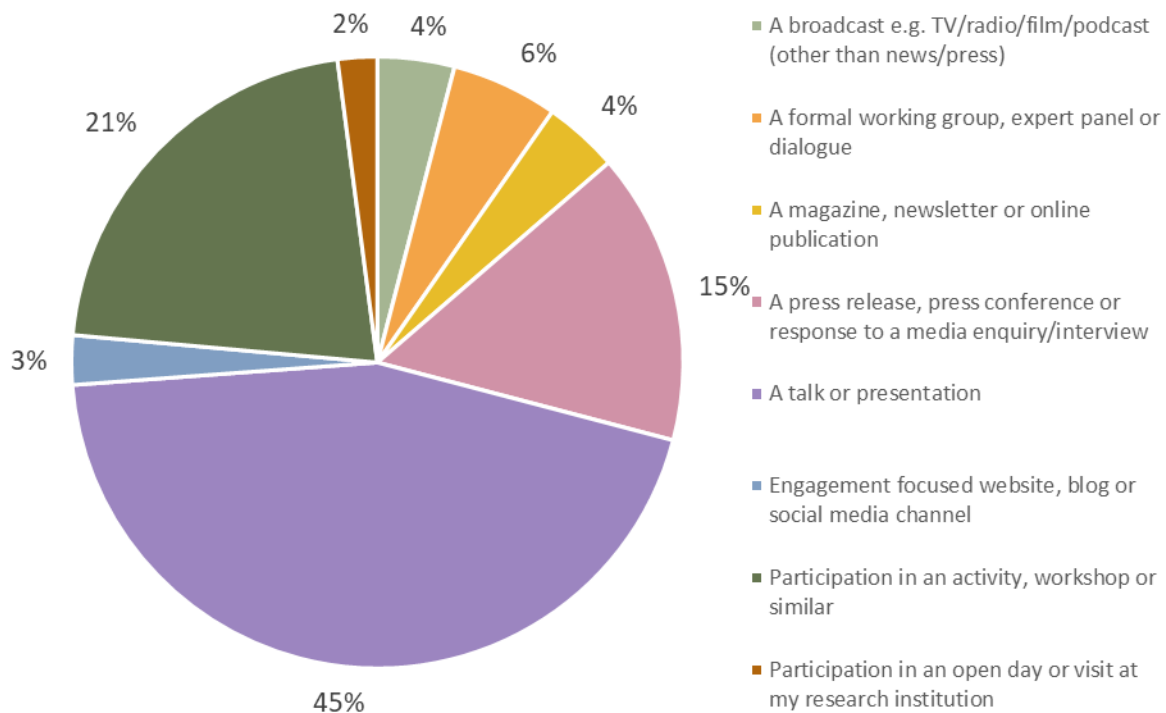
Source: Danish Centre for Studies in Research and Research Policy – May 2023

Outreach

Outreach activities cover a wide range of activities from presentations for non-academic audiences, to media appearances and social media. In 2022, grant recipients reported more than 950 activities. As for the level of publications, we see an increase in activities from 720 activities in 2021.

The main types of outreach activities conducted by grantees are talks and presentations (figure 4.6).

Figure 4.6 Outreach in 2022



Source: Researchfish – July 2023

5. Metric E – Leadership

Metric E highlights activities related to grant management by the grantees. It is a fairly new indicator that emphasises the important coupling between research and the broader university culture. Leadership is in this regard an important component, also in relation to students and teaching.

Key points:

- TNF conducted a leadership course “Footprint” for Villum Investigator grantees from 2021
- For Villum Young Investigators a pre-meeting and an annual seminar were conducted

Leadership activities

TNF organises a specific leadership course “Footprint” for Villum Investigators (VIPs). Villum Fonden has run the course for the three cohorts granted in 2017, 2019 and 2021, and will now initiate it for a fourth time for the grantees from 2023. VIPs are included in setting up the course, which has been facilitated by the strategy consultants “Mobilize” the first three times and now with a new consultancy firm “Think about it”, who are experienced in giving courses on leadership training.

For some years now, an annual seminar has been arranged for the Villum Young Investigators (YIPs) who are young researchers building their own group for the first time. On the agenda are a research management tools and networking. All active grantees are invited each year, which makes it possible for more experienced YIPs to give advice to new YIP grantees. The seminar was cancelled in 2020 and 2021 due to the COVID-19 restrictions, but was taken up again in 2022. The seminar is to provide new research leaders with leadership tools and to complement the short meeting for the new YIPs set up to introduce Villum Fonden just prior to them officially receiving their grant at the annual award ceremony.

Table 5.1. Leadership activities for grantees initiated by Villum Fonden, 2022

Programme	Event	Participants – no.
VIP	Footprint leadership study trip (2021)	11
VIP	Footprint leadership seminar (2021)	10
YIP	Pre-meeting (virtual) prior to award ceremony	16
YIP	Annual seminar	60

Source: Villum Fonden – 2023

6. Metric F – Education

Metric F highlights the impact of educating PhD students and postdocs funded through a Villum grant.

The idea is to monitor the career path of the PhD students and postdocs, who transfer knowledge into society.

Key points:

- More than 900 PhD students and postdocs are or have been funded through a Villum grant in the 2012-2021 period
- 29% of the PhD students and postdocs are female
- 64% are foreign nationals
- After leaving their Villum-funded project, the PhD students and postdocs tend to stay in Denmark at a Danish university (short timeframe)

Some characteristics of the group:

Of the group of PhD students and postdocs funded through a Villum grant, 53% are postdocs and 47% are PhD students, while 29% are female and 71% are male, as shown in figures 6.1 and 6.2 below.

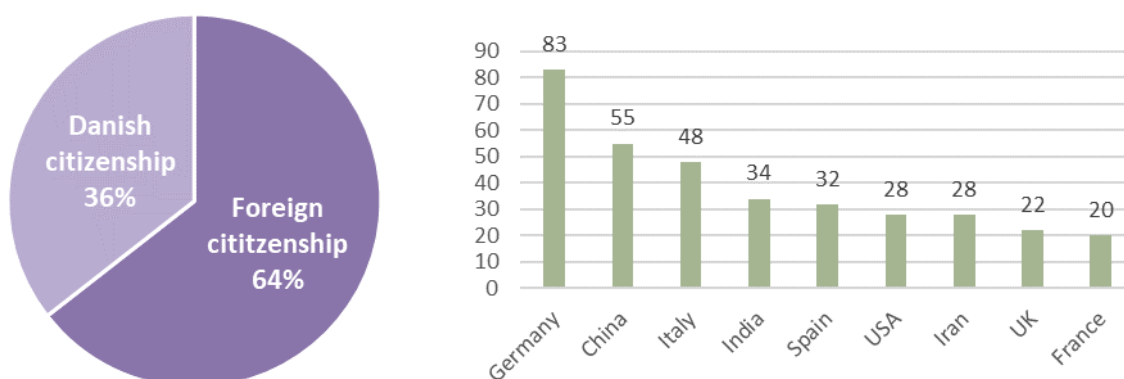
Figures 6.1 and 6.2. Share of PhD students and postdocs and their gender, funded 2012-2021



Source: Iris Group and Villum Fonden – July 2023

64% of PhD students and postdocs are foreign nationals, representing 61 different countries, primarily European. Figure 6.3 below ranks the most frequent nationalities of PhDs and postdocs, with Germany being the most frequent nationality.

Figure 6.3. Citizenship of PhD students and postdocs, funded 2012-2021

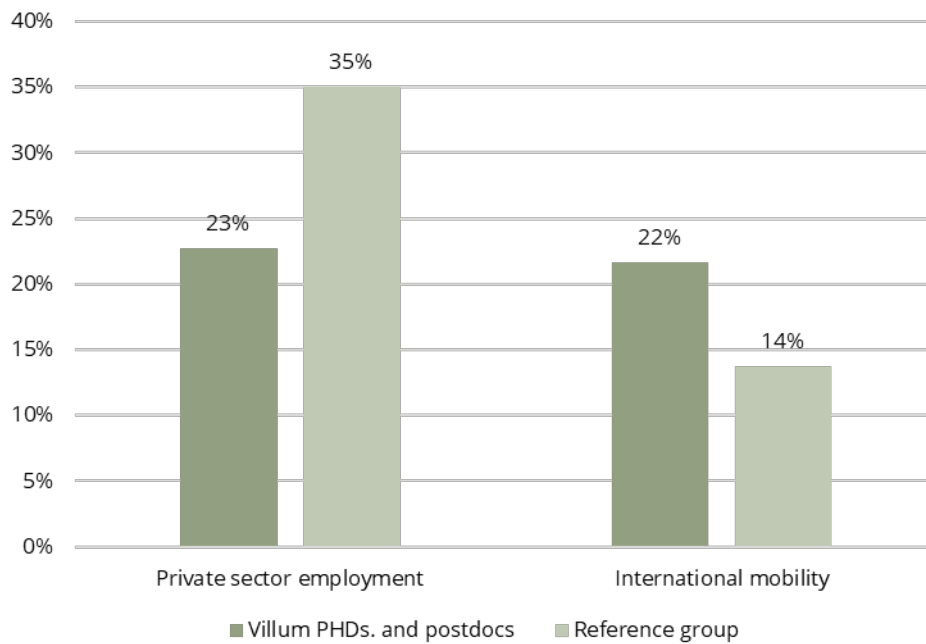


Source: Iris Group – June 2023

Career after leaving project

In this section, we follow the further career of the PhD students and postdocs. Only PhD students and postdocs who have finished their employment with a Villum-funded project and who can be identified in national registers are followed. Thus, this is a subgroup of the group described above. In 2022, the subgroup consisted of 185 PhD students and postdocs. The investigation is focused on the proportion who choose a career either in the private sector or who pursue a career internationally.

Figure 6.4 PhD students and postdocs' occupation in the private sector and international mobility compared to a reference group



Source: Iris Group and Statistics Denmark – June 2023 N=185

Data show (figure 6.4) that 23% of the PhD students and postdocs trained in a Villum-funded project are employed in the private sector, while 22% are pursuing an international career. The remaining 55% are employed in the Danish public sector, primarily at Danish universities.

Comparing these results with the pre-pandemic figures shows a drop in international mobility both for the group of Villum-funded PhD students and postdocs, and for the reference group. We believe it has been caused by travel restrictions during the COVID-19 pandemic. We have already seen a slight increase in international mobility from 2021 figures. We will be monitoring developments in the coming years.

7. Metric G – Innovation

In Metric G, we identify to what extent and how grantees contribute to the practical application of their scientific results through innovation activities.

We investigate 411 Villum grantees whose activities are included in the analysis.

Key points:

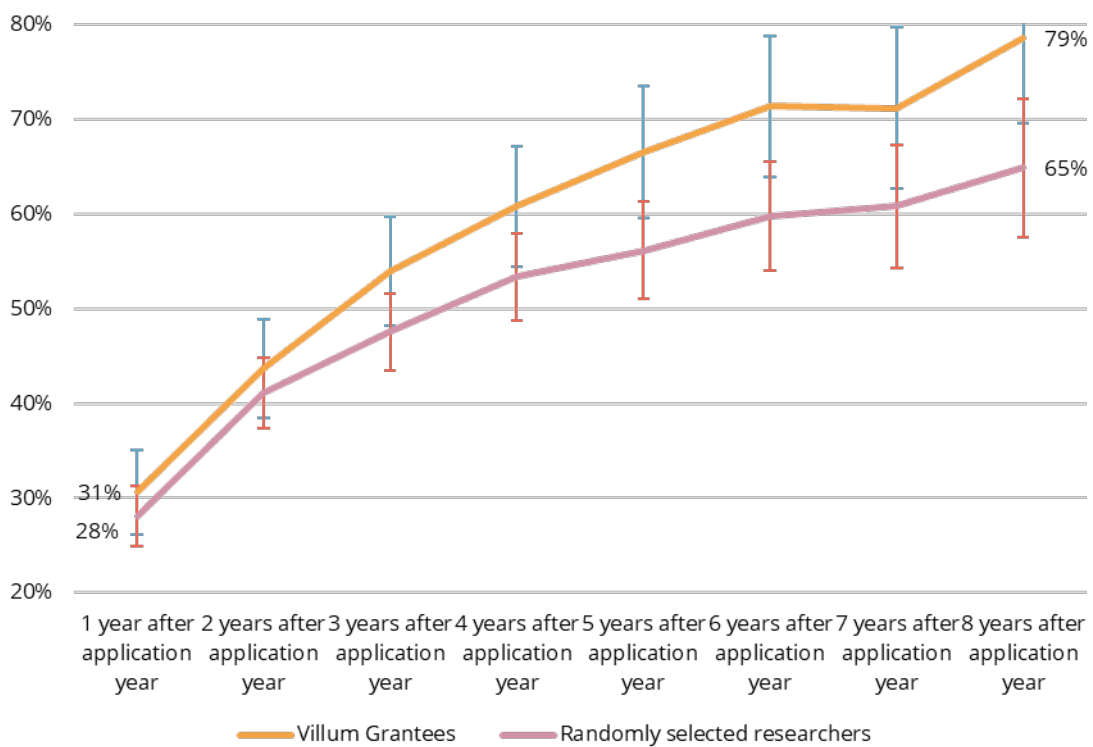
- Villum grantees have a slightly higher rate of participation in innovation activities than a reference group of randomly selected researchers with the same scientific profile
- Seven years after the year of application, 74% of Villum grantees have participated in at least one innovation activity

When looking at the data for the whole group of Villum grantees, we define innovation activities as:

- Scientific journal papers cited in patent applications
- Patent applications
- Scientific journal articles co-authored with industrial partners
- Formation of new companies

Figure 7.1 shows the share of Villum grantees who have participated in at least one innovation activity within 1-8 years of the application year. The error bars show the uncertainty. Compared to the reference group of randomly selected researchers, Villum grantees have a slightly higher rate of participation in innovation activities.

Figure 7.1 Participation in innovation activities by Villum grantees and reference group, 8 years after application



Source: Iris Group and Statistics Denmark – June 2023

8. Metric H – International reputation and research capacity

If successful, the sum of the processes reported above (Metrics A to G) will increase the visibility of Danish research internationally, attracting even better talents and international collaborations that in turn will strengthen the sustainable knowledge-based Danish society of the future.

In this section, the degree of international visibility of Villum grantees is highlighted by identifying their appearance as keynote speakers at international conferences, and by looking at the recruitment and

retainment of international talents to the Villum Young Investigator Programme and by following these talents as they contribute to the research capacity by staying in Denmark or moving abroad.

Key points:

- 171 keynotes were delivered at international conferences by Villum grantees in 2021
- The majority of Villum Young Investigators whose funding have run out continue to pursue a career in research at a Danish university – and thus contribute to build research capacity in Denmark

International visibility

High international visibility, e.g. through keynote presentations at conferences, is important to build up the capacity at the Danish universities. Villum grantees report when they attend conferences as invited keynote speakers (figure 8.1). In 2020, the number of keynotes was 107, which is less than half the number of keynotes in 2019. Numbers were up in 2021 and 2022, but remain low as they are probably still challenged by the implications of the COVID-19 pandemic while virtual events have become more popular.

Figure 8.1. Keynotes delivered by Villum grantees 2016-2022



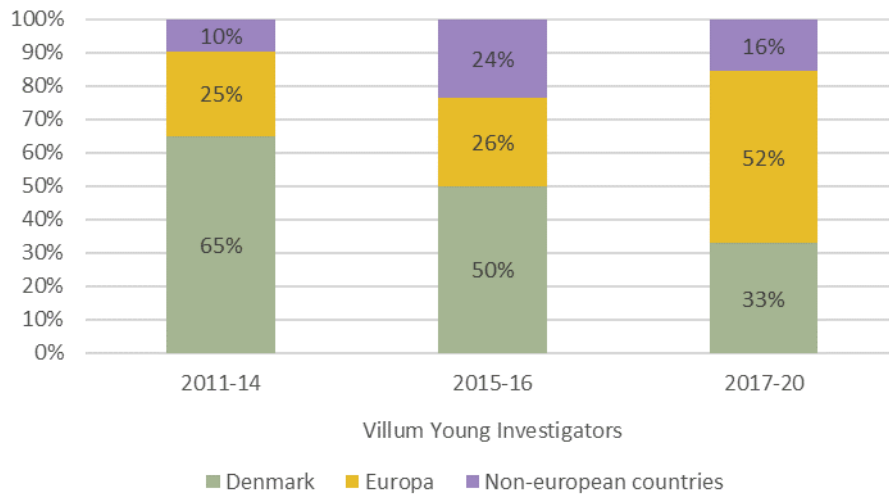
Source: Researchfish – July 2023

Tracking Villum Young Investigators

The Villum Young Investigator Programme (YIP) has awarded grants for young researchers since 2011. An important aspect of the programme is to attract young top research talents to Denmark.

A significant share of grantees with foreign citizenship has been present from the beginning of the YIP programme, and the number keeps increasing (figure 8.2).

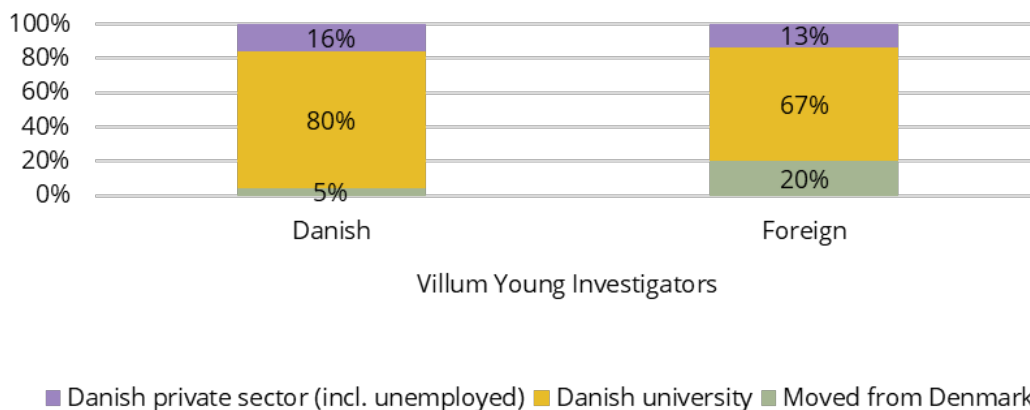
Figure 8.2 Citizenship Villum Young Investigators 2011-2020



Source: Iris Group and Statistics Denmark – June 2023 N= 161

At the moment 74 YIP grantees have finished their grant, and since the programme attracts foreign research talents, we are interested in tracking their career moves: do they stay in Denmark and build up research capacity, or do they return to their home country. Figure 8.3 below shows the occupation of Danish and foreign YIP grantees more than one year after their funding has ended. Danish-citizen Grantees primarily stay in Denmark, and around two thirds of the grantees with foreign citizenship continued to stay at a Danish university, whereas 20% left Denmark.

Figure 8.3 Occupation of Villum Young Investigators by nationality, 2011-2020



Source: Iris Group and Statistics Denmark – June 2023 N= 74

9. Strategic initiatives of change

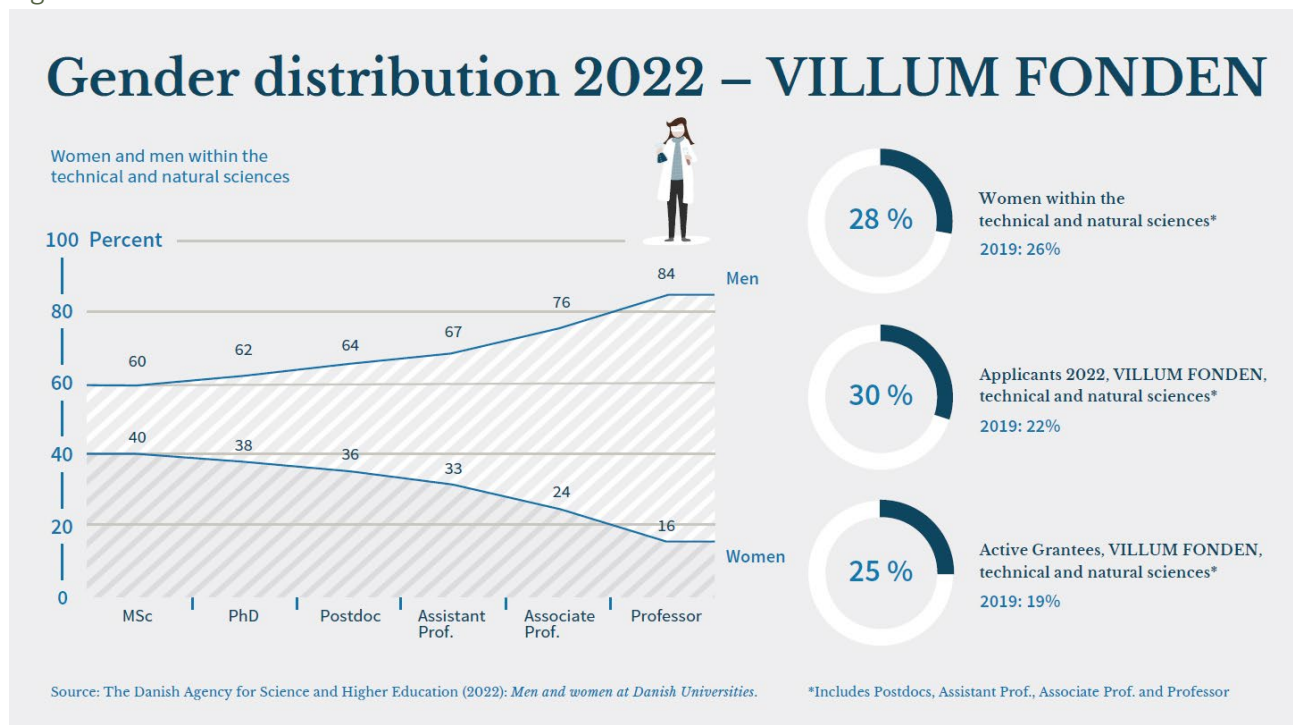
TNF has chosen to further highlight progress within the four strategic focus areas, where change is particularly important. Progress on the achievement of targets is presented in the following.

Gender balance

Target: Female representation among applicants and grantees should align with the national level of female representation.

Villum Fonden 2022: The target is almost met (figure 9.1). Among active grantees, the share of female grantees increased from 19% in 2019 to 25% in 2022. The national level is 28%.

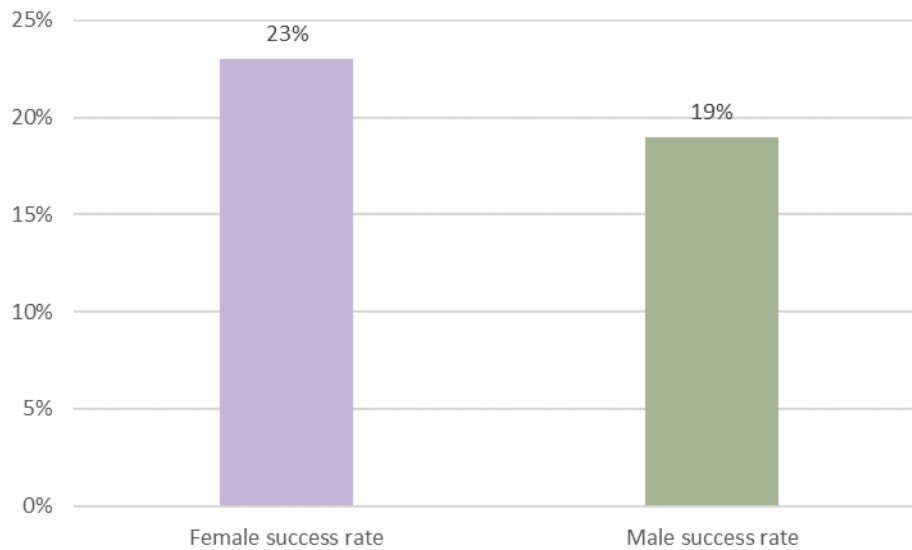
Figure 9.1



Source: Villum Fonden – 2023

The gender success rates for 2022 across all programmes are presented in figure 9.2 below. In 2022, the female success rate was 23%, which is a little higher than the male success rate of 19%. In 2021, the success rates were 13% for women and 15% for men.

Figure 9.2. Gender success rates 2022 – all scientific programmes (excl. Villum International Postdoc Programme)

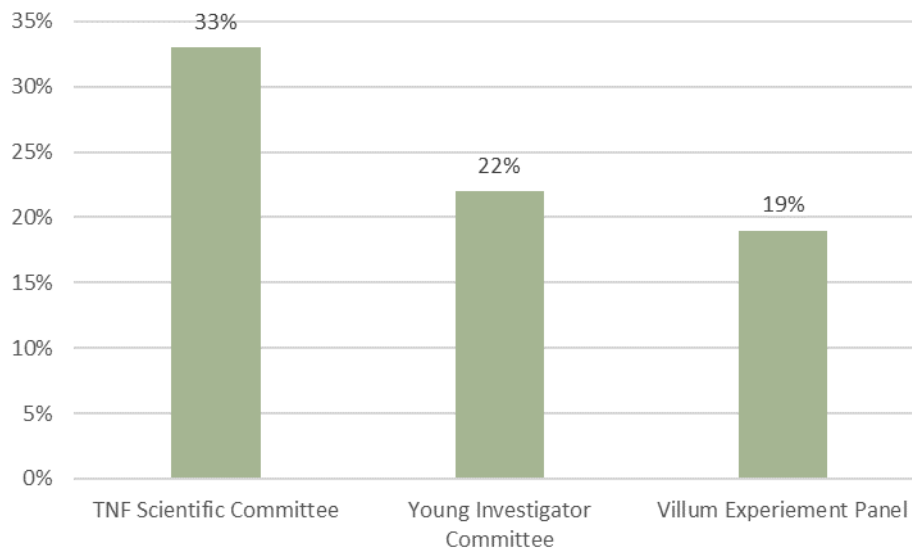


Source: Villum Fonden – 2023 N=452 applicants and 92=grantees

For committees, the gender balance target is a minimum of 33-40% of the least represented gender.

Villum Fonden 2021: For TNF, the target is met (figure 9.3), but across all committees the level is 22%. Efforts are going into addressing the gender imbalance, and the secretariat has a continuous focus on this when recruiting new members.

Figure 9.3 Female share on committees 2022



Source: Villum Fonden – 2023

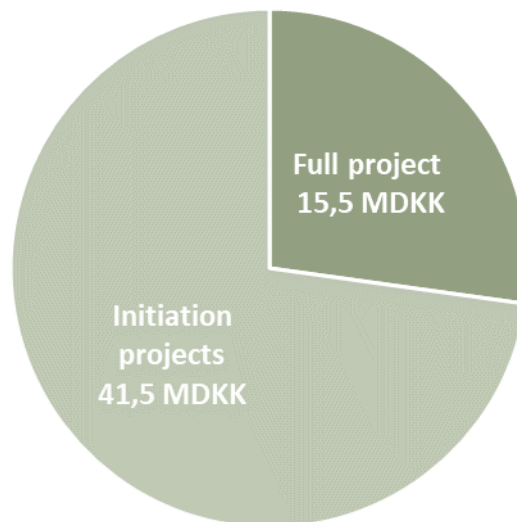
Interdisciplinary science

Target: Support excellent interdisciplinary science with DKK 50 million a year through the Villum Synergy Programme.

Villum Fonden 2022: The target is met through the implementation of the Villum Synergy Programme. This is the third time Villum Synergy grants were made. Villum Synergy grants have two principal investigators (PIs) – one a methodological expert from computer science, statistics or applied mathematics, and the other a domain expert from a field of application. Figure 9.4 below shows the distribution of funds between the two project types. In 2022, one large project and 14 initiation projects were funded.

A total of 20 Villum Synergy grants have been made with a total grant sum of almost DKK 154 million.

Figure 9.4. Villum Synergy programme distribution 2022



Source: Villum Fonden – 2023

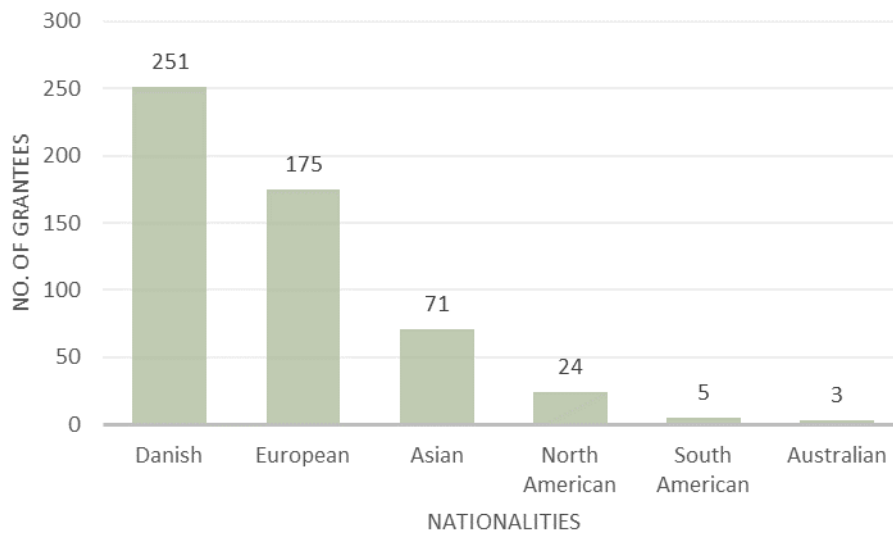
International recruitment

Villum Fonden wants to support the universities in their recruitment of top international research talents and in creating good onboarding terms for researchers. Hence, Villum Fonden has launched the Villum Family and Onboarding Support Programme, under which universities can apply for funding in support of their affiliated researchers.

In 2020, the Mobility Fund was created by Villum Fonden. The Mobility Fund acts as the main point of contact to the universities, and the universities must apply to the Mobility Fund, when wanting to make use of their mobility package grants.

The share of active Villum grantees with an international background is 53%. They are primarily from Europe (figure 9.6), and a total of 42 different nationalities are represented among the grantees.

Figure 9.5. Nationality of active grantees 2022

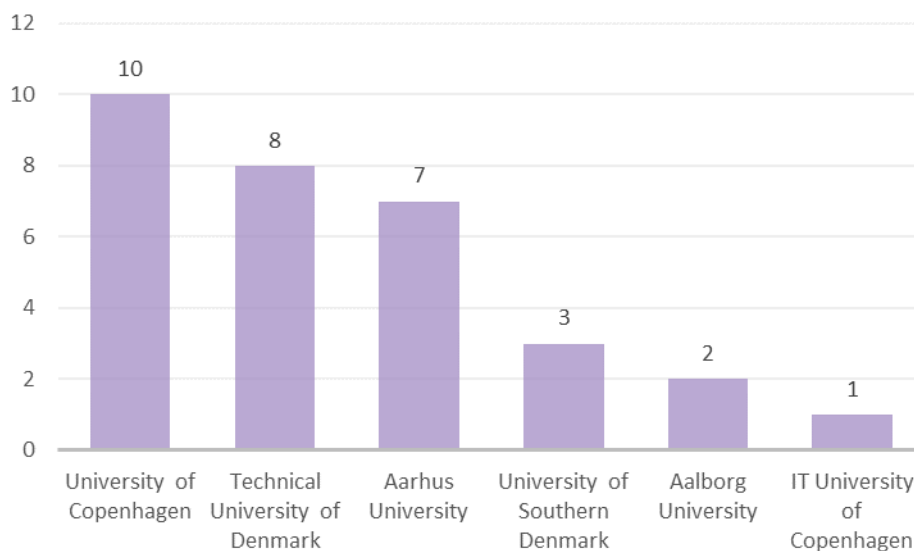


Source: Villum Fonden – July 2023 N=529

Target: Funding for mobility packages (16 per year)

Villum Fonden 2022: 13 grants from Villum Fonden were awarded to the universities in 2022. This means that the target was almost met. Figure 9.6 shows the distribution of grants to the universities, and grant numbers keep increasing as the universities learn about the opportunity they have to apply for family packages. The three largest universities have applied for the majority of the funding.

Figure 9.6 Awarded Mobility Package grants 2020-2022



Source: Villum Fonden – 2023

Technical sciences

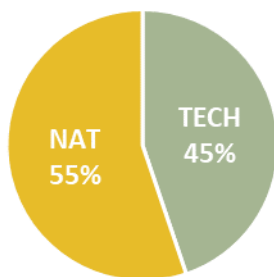
Target: To support excellent technical sciences with a target in 2020 at 20% of the total grant distribution, rising to 30% in 2030.

Villum Fonden 2020: The target has been met as the number of tech-related active grants in 2022 was 45%, and 47% of grantees from 2022.

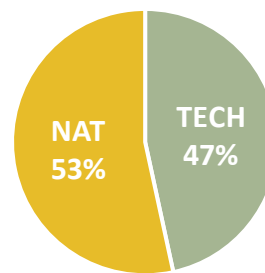
The definition of technical and natural sciences is based on the department affiliation of the grantees.

Figure 9.7. Technical sciences share among grantees

Active grantees 2022



Grant recipients 2022



Source: Villum Fonden – 2023

Appendix A: Sources and data used in the report

Sources:

Villum Fonden: Funding administrative platform of Villum Fonden

Researchfish: Web-based platform for grantees reporting research results to Villum Fonden

Clarivate Analytics – Web of Science: Citation index covering scientific publications worldwide

Statistics Denmark (*Danmarks Statistik*): Data collected through various registers administered by Statistics Denmark

Danish Patent and Trademark Office (*Patent- og Varemærkestyrelsen*): Data on patents.

Data

Figures in this report are primarily based on the above-mentioned sources, and figures from the suppliers of data mentioned below.

Suppliers of data

Villum Fonden has two suppliers of data for the report:

Danish Centre for Studies in Research and Research Policy (CFA) at Aarhus University

CFA contributed to the analysis of the metrics on scientific impact. They use data from Web of Science Clarivate Analytics / CWTS Leiden edition.

Villum Fonden has asked the Danish Centre for Studies in Research and Research Policy (CFA) at Aarhus University to identify data and develop indicators for measuring scientific impact. The publications have been identified by their acknowledgements to Villum Fonden in a citation index: Web of Science produced by Clarivate Analytics. Web of Science is one of the leading providers of citation data internationally.

Only publications up until 2020 are included in the analysis of scientific impact. This is to ensure that a stable level of citations is reached before citations are harvested.

Iris Group

Iris Group has contributed to the analysis of the metrics on education, innovation activities and tracking of Villum Young Investigators.

Education analysis

Villum Fonden has engaged with Iris Group (Danish consultancy firm) to investigate the impact of funding PhD students and postdocs through Villum grants. Iris Group has contributed metrics on education (PhD students and Postdocs) and innovation. They use data from Villum Fonden (annual reports and data from applications) and from Statistics Denmark.

Since Villum Fonden does not collect data on where the PhD students and postdocs go after leaving the Villum-funded projects, Iris Group has used data from Statistics Denmark to identify their location (national/international) and employment (e.g. private sector). This is a challenging exercise, since central registry numbers (CPR numbers) are not yet collected by Villum Fonden. Only PhD students and postdocs up until 2021 could be included due to a time lag in the statistics from Statistics Denmark.

Innovation analysis

Villum Fonden has asked Iris Group to collect data from relevant sources and develop indicators for Villum-funded grantees to identify the extent to which and how grantees contribute to the application of their scientific results through “innovation”.

YIP (Villum Young Investigator) – tracking

To gauge the extent to which international recruitment is retained in Denmark, Iris Group is asked to identify the YIP grantees with a terminated grant in registers at Statistics Denmark to identify if they have moved abroad or taken up a job in the private sector.