## FWO DMP Template - Flemish Standard Data Management Plan

Project supervisors (from application round 2018 onwards) and fellows (from application round 2020 onwards) will, upon being awarded their project or fellowship, be invited to develop their answers to the data management related questions into a DMP. The FWO expects a **completed DMP no later than 6 months after the official start date** of the project or fellowship. The DMP should not be submitted to FWO but to the research co-ordination office of the host institute; FWO may request the DMP in a random check.

At the end of the project, the **final version of the DMP** has to be added to the final report of the project; this should be submitted to FWO by the supervisor-spokesperson through FWO's e-portal. This DMP may of course have been updated since its first version. The DMP is an element in the final evaluation of the project by the relevant expert panel. Both the DMP submitted within the first 6 months after the start date and the final DMP may use this template.

The DMP template used by the Research Foundation Flanders (FWO) corresponds with the Flemish Standard Data Management Plan. This Flemish Standard DMP was developed by the Flemish Research Data Network (FRDN) Task Force DMP which comprises representatives of all Flemish funders and research institutions. This is a standardized DMP template based on the previous FWO template that contains the core requirements for data management planning. To increase understanding and facilitate completion of the DMP, a standardized **glossary** of definitions and abbreviations is available via the following link.

	1. General Project Information
Name Grant Holder & ORCID	Lukas Nulens - https://orcid.org/0000-0001-7480-4317
Contributor name(s) (+ ORCID) & roles	Joris Van de Vondel - Promotor - https://orcid.org/0000-0001-6894-7258
	Margriet Van Bael - Copromotor - https://orcid.org/0000-0002-7687-4498
Project number <sup>1</sup> & title	Quantum phase-slip centers as building blocks for circuit quantum electrodynamics.
Funder(s) GrantID <sup>2</sup>	11K6523N
Affiliation(s)	⊠ KU Leuven
	☐ Universiteit Antwerpen
	☐ Universiteit Gent
	☐ Universiteit Hasselt
	☐ Vrije Universiteit Brussel
	□ Other:
	Provide ROR <sup>3</sup> identifier when possible:
Please provide a short project description	Superconducting circuits are among the most suitable and successful candidates for the realization of a qubit. These circuits include one specific nonlinear superconducting element, the Josephson tunnel junction. While the Josephson junction has been meticulously researched leading to several breakthroughs and realizations, its dual counterpart the 'quantum-phase slip (QPS) center' remains poorly understood. In this superconducting center, the superconducting phase fluctuates (it 'slips') and gives rise to different energy states. Moreover, by tuning the QPS-rate different energy states can be coupled, creating a two-level system or qubit. Mooij and Harmans suggested in 2005 that a small nanowire embedded in a superconducting loop could be used as a phase-slip qubit. However, a quantitative description of how different macroscopic variables determine the QPS-rate, and therefore the behavior of the qubit, is lacking. In this proposal, I aim to realize a Molybdenum Germanium phase-slip qubit and determine the QPS-rate from the qubit energy splitting. This I will achieve using nondestructive high frequency measurements at cryogenic temperatures. As such I will be able to gain new insights on the effect of macroscopic parameters on the QPS-rate. Moreover, the quality of the qubit (e.g. lifetimes) will be determined. These combined experiments will pave the road for QPS-based devices.

<sup>&</sup>lt;sup>1</sup> "Project number" refers to the institutional project number. This question is optional since not every institution has an internal project number different from the GrantID. Applicants can only provide one project number.

<sup>&</sup>lt;sup>2</sup> Funder(s) GrantID refers to the number of the DMP at the funder(s), here one can specify multiple GrantIDs if multiple funding sources were used.

<sup>&</sup>lt;sup>3</sup> Research Organization Registry Community. https://ror.org/

2.	Researc	ch Data	<b>Summary</b>
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List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data4.

				ONLY FOR DIGITAL	ONLY FOR DIGITAL	ONLY FOR DIGITAL	ONLY FOR PHYSICAL
				DATA	DATA	DATA	DATA
Dataset	Description	New or Reused	Digital or	Digital Data Type	Digital Data	Digital Data	Physical Volume
Name			Physical		Format	Volume (MB, GB,	
						TB)	
Experimental	Resulting	☑ Generate new	☑ Digital	☐ Observational	□ .por	□ < 100 MB	
data -	cryogenic	data	☐ Physical		□ .xml	□<1 GB	
measurement	transport	☐ Reuse existing		☐ Compiled/	□ .tab	□ < 100 GB	
S	measurements	data		aggregated data	⊠ .csv	⊠ < 1 TB	
	(AC-DC)			☐ Simulation	□ .pdf	□ < 5 TB	
				data	⊠ .txt	□ < 10 TB	
				☐ Software	□ .rtf	□ < 50 TB	
				☐ Other	□ .dwg	□ > 50 TB	
				□NA	□ .tab	□NA	
					☐ .gml		
					□ other:		
					□NA		

 $<sup>^{\</sup>rm 4}$  Add rows for each dataset you want to describe.

Measuremen	Developed	□ Generate new	□ Digital	☐ Observational	☐ .por	□ < 100 MB	
t software	measurement	data	☐ Physical	☐ Experimental		□ < 1 GB	
	software (both	☐ Reuse existing		☐ Compiled/	☐ .tab	⊠ < 100 GB	
	Python and	data		aggregated data	□ .csv	□ < 1 TB	
	LabVIEW)			☐ Simulation	☐ .pdf	□ < 5 TB	
				data	□ .txt	□ < 10 TB	
					☐ .rtf	□ < 50 TB	
				☐ Other	☐ .dwg	□ > 50 TB	
				□ NA	☐ .tab	□ NA	
					☐ .gml		
					oxtimes other: .py ;		
					labview		
					□ NA		
Measuremen	Developed	⊠ Generate new	□ Digital	☐ Observational	☐ .por	□ < 100 MB	
t analysis	scripts for the	data	☐ Physical	☐ Experimental	☐ .xml	□ < 1 GB	
script	analysis of	☐ Reuse existing		☐ Compiled/	☐ .tab	⊠ < 100 GB	
	experimental	data		aggregated data	☐ .csv	□ < 1 TB	
	data			☐ Simulation	☐ .pdf	□ < 5 TB	
				data	☐ .txt	□ < 10 TB	
				⊠ Software	☐ .rtf	□ < 50 TB	
				☐ Other	☐ .dwg	□ > 50 TB	
				□ NA	☐ .tab	□ NA	
					☐ .gml		
					⊠ other: .py		
					□ NA		
Samples	Fabricated and	⊠ Generate new	☐ Digital	☐ Observational	☐ .por	□ < 100 MB	In order to fit our
	measured	data	□ Physical	☐ Experimental	☐ .xml	□ < 1 GB	system the size will
	samples				☐ .tab	□ < 100 GB	be around (7 x 4)

		☐ Reuse existing		☐ Compiled/	☐ .csv	□ < 1 TB	mm for every
		data		aggregated data	☐ .pdf	□ < 5 TB	sample.
				☐ Simulation	☐ .txt	□ < 10 TB	
				data	☐ .rtf	□ < 50 TB	
				☐ Software	☐ .dwg	□ > 50 TB	
				☐ Other	☐ .tab	□ NA	
				□NA	☐ .gml		
					$\square$ other:		
					□ NA		
Samples	Code to	⊠ Generate new	⊠ Digital	☐ Observational	☐ .por	□ < 100 MB	
design	generate	data	$\square$ Physical	☐ Experimental	☐ .xml	□ < 1 GB	
	designs for	☐ Reuse existing		☐ Compiled/	☐ .tab	⊠ < 100 GB	
	lithography	data		aggregated data	□ .csv	□ < 1 TB	
				☐ Simulation	☐ .pdf	□ < 5 TB	
				data	☐ .txt	□ < 10 TB	
				⊠ Software	☐ .rtf	□ < 50 TB	
				☐ Other	☐ .dwg	□ > 50 TB	
				□NA	☐ .tab	□ NA	
					☐ .gml		
					⊠ other: .py, .gds		
					□ NA		

GUIDANCE:	
DATA CAN BE DIGITAL OR PHYSICAL (FOR EXAMPLE BIOBANK, BIOLOGICAL METHOD.	SAMPLES,). DATA TYPE: DATA ARE OFTEN GROUPED BY TYPE (OBSERVATIONAL, EXPERIMENTAL ETC.), FORMAT AND/OR COLLECTION/GENERATION
	SOR READINGS, SENSORY OBSERVATIONS); EXPERIMENTAL (E.G. MICROSCOPY, SPECTROSCOPY, CHROMATOGRAMS, GENE SEQUENCES); ARIABLES, 3D MODELLING); SIMULATION DATA (E.G. CLIMATE MODELS); SOFTWARE, ETC.
EXAMPLES OF DATA FORMATS: TABULAR DATA (.POR,. SPSS, STRUCTURED DATA, DOCUMENTATION & COMPUTATIONAL SCRIPT.	D TEXT OR MARK-UP FILE XML, .TAB, .CSV), TEXTUAL DATA (.RTF, .XML, .TXT), GEOSPATIAL DATA (.DWG,. GML,), IMAGE DATA, AUDIO DATA, VIDEO
DIGITAL DATA VOLUME: PLEASE ESTIMATE THE UPPER LIMIT OF THE VOLU	IME OF THE DATA PER DATASET OR DATA TYPE.
PHYSICAL VOLUME: PLEASE ESTIMATE THE PHYSICAL VOLUME OF THE RES AFTER).	EARCH MATERIALS (FOR EXAMPLE THE NUMBER OF RELEVANT BIOLOGICAL SAMPLES THAT NEED TO BE STORED AND PRESERVED DURING THE PROJECT AND/OR
If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type.	Not applicable
Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? If so, please describe these issues further and refer to specific datasets or data types when appropriate.	<ul> <li>Yes, human subject data</li> <li>Yes, animal data</li> <li>Yes, dual use</li> <li>No</li> <li>If yes, please describe:</li> </ul>

<sup>&</sup>lt;sup>5</sup> These data are generated by combining multiple existing datasets.

Will you process personal data <sup>6</sup> ? If so, briefly	☐ Yes
describe the kind of personal data you will use.	⊠ No
Please refer to specific datasets or data types	If yes:
when appropriate. If available, add the reference	
to your file in your host institution's privacy	- Short description of the kind of personal data that will be used:
register.	- Privacy Registry Reference:
Does your work have potential for commercial	□ Yes
valorization (e.g. tech transfer, for example spin-	⊠ No
offs, commercial exploitation,)?	If yes, please comment:
If so, please comment per dataset or data type	
where appropriate.	
Do existing 3rd party agreements restrict	☐ Yes
exploitation or dissemination of the data you	⊠ No
(re)use (e.g. Material/Data transfer agreements,	If yes, please explain:
research collaboration agreements)?	
If so, please explain to what data they relate and	
what restrictions are in place.	
Are there any other legal issues, such as	☐ Yes
intellectual property rights and ownership, to be	⊠ No
managed related to the data you (re)use?	If yes, please explain:
If so, please explain to what data they relate and	
which restrictions will be asserted.	

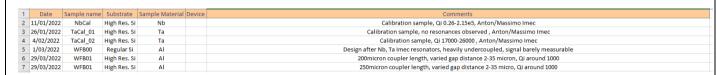
<sup>&</sup>lt;sup>6</sup> See Glossary Flemish Standard Data Management Plan

## 3. Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep **data understandable and usable**, for yourself and others, now and in the future (e.g. in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, Codebook.tsv etc. where this information is recorded).

The following structure will be followed (all this data is saved on the shared folder, see point 4.):

 One Excel .csv labeled Sample\_log\_Lukas, this document is the overview of all data (and can be used to track everything), it includes the measurement date, sample label, material properties, and most important findings.



- For every sample the measurement data and interpretation/comments/thoughts are combined in a PowerPoint (pptx), the full path location of the data shown in the PowerPoint is included. The PowerPoint is labeled Data\_overview\_SampleName\_date.pptx
- Similarly the fabrication step are combined in presentation, including picture, recipes and followed protocols. The PowerPoint are labeled Fabrication\_SampleName\_date.pptx
- The sample designs (.gds) and code to generate this design are stored in folder labeled Sampled\_name\_ready\_for\_ebeam. Each folder contain three separate folders Top, Middle, and Bottom indicating the design used at the specific position.
- All experimental fabrication steps, e.g. MBE, PLD, ebeam are additionally logged in a physical logbook present at the tool, which will remain present at the tool at all time.

Will a metadata standard be used to make it	□ Yes
easier to <b>find and reuse the data</b> ?	⊠ No
If so, please specify which metadata standard will be used. If not, please specify which	If yes, please specify (where appropriate per dataset or data type) which metadata standard will be used:
metadata will be created to make the data easier to find and reuse.	If no, please specify (where appropriate per dataset or data type) which metadata will be created:
REPOSITORIES COULD ASK TO DELIVER METADATA IN A CERTAIN FORMAT, WITH SPECIFIED ONTOLOGIES AND VOCABULARIES, I.E.	As mentioned in the previous point
STANDARD LISTS WITH UNIQUE IDENTIFIERS.	

## 4. Data Storage & Back-up during the Research Project

Where will the data be stored?	
where will the data be stored:	All experimental data will be stored on the Network drives provided on site at the department (smb or nfs protocol), the system consists of two backup systems. The drive is backed up daily, and deleted folders/files can be recovered up to 64 snapshots. Secondly, this is with a 30-day retention policy, which means we can restore deleted or previous versions of our files up to 30 days in the past. This backup is physically on another server to prevent data loss in case of hardware failures of the main fileserver.  The documentation mentioned in point 3 is also stored on our Network drive, moreover locally on my department laptop and personal hard drive (weekly).  Physical samples are placed in sample boxes and labeled as described in the overview dataset. The volatile samples will be kept secure in our available vacuum pots (capacity of around 800 samples, present in our
	lab), while the robust samples are stored under ambient conditions in my personal office space. However, the storage of fabricated samples is not always as useful as conceived. Some samples degrade over time or are destroyed purely by the removal process inherent to our cryostats.
How will the data be backed up?	
Market and the state of the sta	Combined in the previous point.
What storage and backup procedures will be in place to prevent data loss? Describe the locations, storage media and procedures that will be used for storing and backing up digital and non-digital data during research. <sup>7</sup>	
REFER TO INSTITUTION-SPECIFIC POLICIES REGARDING BACKUP	
PROCEDURES WHEN APPROPRIATE.	

<sup>&</sup>lt;sup>7</sup> Source: Ghent University Generic DMP Evaluation Rubric: <a href="https://osf.io/2z5g3/">https://osf.io/2z5g3/</a>

Is there currently sufficient storage & backup capacity during the project? If yes, specify concisely. If no or insufficient storage or backup capacities are available, then explain how this will be taken care of.	<ul> <li>✓ Yes</li> <li>☐ No</li> <li>If yes, please specify concisely:</li> <li>If no, please specify:</li> </ul>
How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?  CLEARLY DESCRIBE THE MEASURES (IN TERMS OF PHYSICAL SECURITY, NETWORK SECURITY, AND SECURITY OF COMPUTER SYSTEMS AND FILES) THAT WILL BE TAKEN TO ENSURE THAT STORED AND TRANSFERRED DATA ARE SAFE. 7	To gain access to the network drives, one need to go through a process initiated by our ICT responsible and be KULeuven/physics associated. The only way to access is through our personal department laptop or lab desktop.
What are the expected costs for data storage and backup during the research project? How will these costs be covered?	No additional resources are needed, covered by our department/KULeuven.

## 5. Data Preservation after the end of the Research Project

Which data will be retained for at least five years (or longer, in agreement with other retention policies that are applicable) after the end of the project? In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies).	For data leading to a publication, we combine the following data in one folder which will never be removed:  • Tex file to generate manuscript  • Raw experimental data  • Scripts to analyze, plot, visualize data  • Correspondence journal e.g. referee response  • Analyzed data  • Detailed fabrication process
Where will these data be archived (stored and curated for the long-term)?	Departmental Network drives
What are the expected costs for data preservation during the expected retention period? How will these costs be covered?	No additional resources are needed, covered by our department/KULeuven, personal.

	6. Data Sharing and Reuse
Will the data (or part of the data) be made available for reuse after/during the project? Please explain per dataset or data type which data will be made available.	<ul> <li>☐ Yes, in an Open Access repository</li> <li>☐ Yes, in a restricted access repository (after approval, institutional access only,)</li> <li>☐ No (closed access)</li> <li>☒ Other, please specify:</li> </ul>
NOTE THAT 'AVAILABLE' DOES NOT NECESSARILY MEAN THAT THE DATA SET BECOMES OPENLY AVAILABLE, CONDITIONS FOR ACCESS AND USE MAY APPLY. AVAILABILITY IN THIS QUESTION THUS ENTAILS BOTH OPEN & RESTRICTED ACCESS. FOR MORE INFORMATION:  HTTPS://WIKI.SURFNET.NL/DISPLAY/STANDARDS/INFO-EU-REPO/#INFOEUREPO-ACCESSRIGHTS	Data used in a publication will not be placed online in a repository, but is stored on our network drives accessible by all our team members. The data that support the plots of our papers and other findings within our studies are available upon reasonable request.
If access is restricted, please specify who will be able to access the data and under what conditions.	Not applicable, data is accessible upon reasonable request.
Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)? Please explain per dataset or data type where appropriate.	<ul> <li>Yes, privacy aspects</li> <li>Yes, intellectual property rights</li> <li>Yes, ethical aspects</li> <li>Yes, aspects of dual use</li> <li>Yes, other</li> <li>No</li> <li>If yes, please specify:</li> </ul>
Where will the data be made available? If already known, please provide a repository per dataset or data type.	Not applicable

When will the data be made available?	Not applicable
THIS COULD BE A SPECIFIC DATE (DD/MM/YYYY) OR AN INDICATION SUCH AS 'UPON PUBLICATION OF RESEARCH RESULTS'.	
Which data usage licenses are you going to provide? If none, please explain why.	Not applicable
A DATA USAGE LICENSE INDICATES WHETHER THE DATA CAN BE REUSED OR NOT AND UNDER WHAT CONDITIONS. IF NO LICENCE IS GRANTED, THE DATA ARE IN A GREY ZONE AND CANNOT BE LEGALLY REUSED. DO NOTE THAT YOU MAY ONLY RELEASE DATA UNDER A LICENCE CHOSEN BY YOURSELF IF IT DOES NOT ALREADY FALL UNDER ANOTHER LICENCE THAT MIGHT PROHIBIT THAT.  EXAMPLE ANSWER: E.G. "DATA FROM THE PROJECT THAT CAN BE SHARED WILL BE MADE AVAILABLE UNDER A CREATIVE COMMONS ATTRIBUTION LICENSE (CC-BY 4.0), SO THAT USERS HAVE TO GIVE CREDIT TO THE ORIGINAL DATA CREATORS." 8	
Do you intend to add a PID/DOI/accession number to your dataset(s)? If already available, please provide it here.	☐ Yes ☑ No If yes:
INDICATE WHETHER YOU INTEND TO ADD A PERSISTENT AND UNIQUE IDENTIFIER IN ORDER TO IDENTIFY AND RETRIEVE THE DATA.	ii yes.
What are the expected costs for data sharing? How will these costs be covered?	Not applicable

<sup>&</sup>lt;sup>8</sup> Source: Ghent University Generic DMP Evaluation Rubric: <a href="https://osf.io/2z5g3/">https://osf.io/2z5g3/</a>

7. Responsibilities		
Who will manage data documentation and metadata during the research project?	Lukas Nulens	
Who will manage data storage and backup	Lukas Nulens	
during the research project? Who will manage data preservation and	Lukas Nulens	
sharing? Who will update and implement this DMP?	Lukas Nulens	