

Helmholtz Young Investigator Groups – Annual Report

Disclaimer: The questionnaire is provided in English and can also be filled out in German.

**All form fields with a red frame are mandatory and need to be filled out.
(If you cannot make an entry, please enter “-” or “n/a”.)**

Core data		
Funding program	Helmholtz Young Investigator Groups	
Project ID number	VH-NG- 1303	
Project title	Searches for Dark Matter and Axion-Like Particles at Belle II	
Name of reporting person	Torben Ferber	
Helmholtz Center	DESY Hamburg	
Partner university	Universität Hamburg	
Helmholtz research field	Matter	
Reporting period [dd.mm.yyyy – dd.mm.yyyy]	01.01.2019-31.12.2019	
Number and length of cost-neutral extensions of the project (if applicable)	not applicable	
Annual installment (reporting year)	Reference value (in EUR)	Actual value (in EUR)
Share of the Initiative and Networking Fund	150.000	131.789,47
Share of the Helmholtz Center	160.500	141.743,95

1 How do you assess the utilization of the current allocated annual installment until the end of the year? (forecast)	
Code	Item
V1.1	<p>I am planning to use 320.500 EUR of this year's allocated planned installment.</p> <p>(The planned annual installments are listed in the contract, which was concluded between the Helmholtz Association and the Helmholtz Center.)</p>

2 Please explain last year's expenses with regard to the following categories:	
Code	Item
V2.1	<p>Investment costs:</p> <p>2739 €</p> <p>Personal computing equipment (PCs, monitors) for my group.</p>
V2.2	<p>Personnel costs:</p> <p>241.304,43 €</p> <p>Torben Ferber Sam Cunliffe (Post Doc) Michael DeNuccio (PhD) Abtin Narimani (PhD), started April 2019 Sascha Dreyer (PhD), started Nov 2019</p> <p>Financial support (travel and per-diem) for Mr. Sebastian Stengel (University Mainz) who graduated in my group as masterstudent (until Dec 1 2019). Financial support (travel) for Ms. Katharina Dort (University of Giessen) who worked on a Machine Learning project for the Belle II Dark Sector group under my supervision (February 2019).</p>
V2.3	<p>General expenses/material costs:</p> <p>29489,99 €</p> <p>All expenses are related to travel costs: Most of the travel costs come from trips to collaboration meetings and detector shifts in Japan as well as national and international conferences.</p>

3 How do you rate the following aspects?						
Code	Item	I fully agree	I agree	I partially agree	I agree less	I do not agree
V3.1	My research group has reached full development.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.2	I am well connected with my university partner.	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.3	The status of my career development corresponds to my vision.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.4	I am satisfied with my overall situation.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.4C	Please list positive or critical aspects, if applicable: Universität Hamburg has no interest to include YIGs in their faculty body. I could not get access to the online student management (despite leading tutorials) since i am not a member of the "Fachbereich".					
V3.5	The working progress of my research group is according to my schedule.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.6	The promises of the Helmholtz Center, e. g. regarding access to technology and infrastructure, financial independence, personnel responsibility are being kept.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V3.6C	Please list positive or critical aspects, if applicable: DESY gives me complete freedom for my research.					

4 How do you assess the independence of your research group?			
Code	Item	Yes	No
V4.1	I can freely decide on the budget allocated to me as per the application.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V4.2	I continue to develop my research agenda autonomously.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V4.3	I make my own personnel decisions.	<input checked="" type="checkbox"/>	<input type="checkbox"/>

5 How do you assess the progress of the project?			
Code	Item	Yes	No
V5.1	Compliance with the timeline as described in the proposal	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V5.1C	In case you deviated from the timeline, please give a brief explanation: Data taking at Belle II is much slower than expected. This effects the single photon analysis and forces me to move resources away from all high-statistics analyses (see V6.1).		
V5.2	Achievement of important milestones in line with the proposal	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V5.2C	In case milestones have not been reached, please give a brief explanation:		
V5.3	Compliance with the financial plan as described in the proposal	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V5.3C	If changes to the financial plan have occurred, please give a brief explanation:		

6 Please describe the scientific progress of the project in the reporting year along the individual work packages.	
Code	Item
V6.1	Max. one page
	<p>The activities of the YIG are originally divided into four work packages: Search for invisible Dark Photons decays into Dark Matter (WP1), Search for visible Dark Photons decays (WP2), Search for Axion-Like Particles (WP3), and Photon Reconstruction, Efficiency Measurement, and Energy Calibration (WP4).</p> <p>Belle II data-taking in 2018 and 2019 provided a much smaller dataset than expected, yielding a total calibrated dataset of less than 10fb⁻¹ (end of 2019). In addition, the overall schedule of the experiment has been adjusted so that the full dataset is expected only in 2029. As a consequence, activities that require large datasets will likely not be possible during the YIG funding period: WP1 will be delayed by about one year, and WP2 is not longer feasible as it requires at least 500 fb⁻¹. As a consequence the YIG has shifted attention towards a two new activities in-line with the YIG physics goal that are grouped in two new WPs: WP5 “Search for long-lived particles” and WP6 “Real-time data selection”. In the following, the progress of the different working packages is summarised, and the two new working packages are introduced.</p> <p>Search for invisible Dark Photons decays into Dark Matter (WP1): This search requires a dataset of at least 20 fb⁻¹ with good quality data including the inner layers of the barrel KLM system. This dataset will be available by the end of 2020. The group has finished large scale MC production of all relevant backgrounds, has finalised trigger (L1 and HLT) studies, and is currently working on data/MC tuning. A milestone is to show background estimations at the summer conferences 2020 with a subset of the data.</p> <p>Search for visible Dark Photons decays (WP2): Not possible since datasets are too small (see above).</p> <p>Search for Axion-Like Particles (WP3): The group is leading the analysis of the search for Axion-Like Particles (ALPs) decaying into two photons. The analysis is in its final stage and is expected to reach publication readiness before summer 2020.</p> <p>Photon Reconstruction, Efficiency Measurement, and Energy Calibration (WP4): I am leading the Physics Performance working group of Belle II since July 2019. This is a high-level management position, coordinating an international team of more than 50 scientists. S. Longo (DESY fellow in my group) is leading the Physics Performance subgroup “Neutrals”. The photon efficiency measurement is documented and under internal review. However, the main analyst will be on parental leave in 2020. A publication on pulse-shape discrimination is in preparation and planned for early 2020. A master thesis on π⁰ selection has been instrumental for first neutral meson studies in the experiment.</p> <p>NEW: Search for long-lived particles (WP5) Several dark sector models predict the existence of long-lived particles that decay with visible displacement in collider experiments. The YIG has been pushing phenomenological work on inelastic Dark Matter (publication in 2020), and a PhD student has started to work on heavy, long-lived scalars in B-decays in the YIG. The group works to further establish this lifetime frontier searches within the Belle II experiment. These searches partially require new trigger algorithms and additional phenomenological work that has been initiated already. I have received additional funding for a joint experiment/theory project “Dark QCD at colliders and in gravitational waves” under Germany’s Excellence Strategy (EXC 2121 “Quantum Universe” – 390833306).</p> <p>NEW: Real-time data analysis (WP6) Physics under WP1 and WP5 features final states that are difficult to select and can result in huge amount of offline data. Real-time data selections will be a critical component to make these searches feasible at highest collisions rates. The YIG is working towards Machine Learning applications to classify calorimeter clusters using fast inference on specialised hardware. The Belle II experiment, with significant contribution of YIG members, only recently added a new feature to their CsI(Tl) crystal calorimeter: Offline pulse shape discrimination as a new technique to identify strongly interacting particles. Made possible by the recent advances in machine learning and the availability of powerful FPGAs, the YIG plans to push this technique one step further and apply pulse shape discrimination not just offline but in real-time. I have received additional funding for a joint DESY/ University project 2020-2022 “Real-time data selection for Dark Matter searches” under Germany’s Excellence Strategy (EXC 2121 “Quantum Universe” – 390833306).</p>

7 How do you assess your career development and networking with the university?			
Code	Item	Yes	No
V7.1	I work closely together with the university and its structures (e.g. integration into the faculty council, doctoral procedures).	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V7.2	I am gaining teaching experience.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V7.2C	If yes, please indicate the number of semester hours per week: 2 hours/week during WS 2019/2020		
V7.3	I am appointed to a joint junior professorship.	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V7.4	I am appointed to a joint W2/W3 professorship.	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V7.5	I have an option for permanent employment ("tenure").	<input checked="" type="checkbox"/>	<input type="checkbox"/>
V7.6	Please describe your foreseeable or planned future career prospects: I am expecting a formal tenure offer from DESY. I am gaining teaching experience to qualify for professorship positions. The development of real-time analysis (see V6.1, WP 6) will ideally lead to possible applications in the industry which may open up additional options.		
V7.7	I have taken advantage of the employer's support for family phases.	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V7.8	Please describe your current function within the Helmholtz Center (position description): Staff scientist (tenure track) leading a Young Investigator Group		
V7.9	Please describe your current function within the university (e. g. also as a committee member): Steering Board member of the Excellence Cluster "Quantum Universe" Supervision of master and PhD student Co-supervision of masterstudents (with Prof. Kasieczka) Speaker and founder of "Young Investigator Network" at the Bahrenfeld Campus		
V7.10	Please indicate the current status of networking with other actors (multiple answers possible): <input checked="" type="checkbox"/> Cooperations at the partner university <input checked="" type="checkbox"/> Cooperations with other universities in Germany <input checked="" type="checkbox"/> Cooperations with universities abroad <input type="checkbox"/> Cooperations with other non-academic research institutions in Germany <input type="checkbox"/> Cooperations with non-academic research institutions abroad <input type="checkbox"/> Cooperations with companies <input type="checkbox"/> Cooperations with other organisations, namely		

8 Please describe the current output of your group.			
Code	Item	Amount / total sum	N/a
V8.1	Peer-reviewed publications in the reporting year	1 (significant contribution) 13 (collaboration)	<input type="checkbox"/>
V8.2	Registered patents in the reporting year		<input checked="" type="checkbox"/>
V8.3	Spin-offs in the reporting year		<input checked="" type="checkbox"/>
V8.4	Acquisition of third-party funding in the reporting year (please mention the type and amount of funding as well as the involved persons): a) 2020-2022 "Real-time data selection for Dark Matter searches" under Germany's Excellence Strategy (EXC 2121 "Quantum Universe" – 390833306) b) 2021-2023 "Dark QCD at colliders and in gravitational waves" under Germany's Excellence Strategy (EXC 2121 "Quantum Universe" – 390833306)	99.000 € 75.000 € Σ = 174.000 €	<input type="checkbox"/>
V8.5	Awards and recognitions (please include the names of the respective persons):		<input checked="" type="checkbox"/>
V8.6	Please describe which activities you have carried out in the area of knowledge and technology transfer:		<input checked="" type="checkbox"/>

9 How do you assess the personnel development measures and qualification? (Helmholtz Academy)				
Code	Item	Yes	No	N/a
V9.1	Have you fully attended the course "Leading Your Group"?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V9.2	Have you implemented the acquired personnel development measures and the qualification plan?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
V9.3	Have you been assigned a permanent contact person?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
V9.4	Did you have opportunities for discussions with the institute management to reflect on your own development and career planning?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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