Subsidie / Subsidy	:	**Vernieuwingsimpuls Vidi 2013 N**
Projectnummer / Project number	:	**016.149.331**
Hoofdaanvrager / Main applicant	:	**Dr. C. Weniger**
Projecttitel / Project title	:	**Probing the Genesis of Dark Matter**

Adviseur: 1

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. **1. Assessment of the quality of the researcher**

.a.
What is your opinion on the past performance of the researcher (as demonstrated by publications and other relevant achievements)?

The researcher has a solid publication record given his young age, including a number of very well cited papers which have established him as a known researcher in his field. His publications show that he is well connected to both experimental and theoretical results.

.b.
The Vidi scheme is intended for outstanding researchers only: the top 10-20% of his/her international peer group. Which achievements or talents of the applicant show that he/she belongs to this top?

The main achievement of the researcher is arguably his single author paper on the tentative Fermi LAT gamma line, which has attracted significant attention in both theoretical and experimental circles. This serves as evidence of the independent thinking and innovation of the applicant. Judging from his list of publications, he also has a large network of different international collaborators.

.c.
To what extent is there sufficient evidence that the applicant has the ability to lead and supervise other researchers and support staff?

The applicant has been involved in the supervision of doctoral students to a minor degree as an assistant supervisor of one completed and two ongoing PhDs. As such, there is only weak evidence of the applicant's ability in this respect and he remains relatively untested. The applicant's involvement within GAMBIT may change this, but it is not clear from the application to which degree this includes supervision of others.

. **2. Assessment of the quality of the proposal**

.a.
Please comment on the scholarly, scientific or technological relevance of the problem, as well as on the originality and challenging content of the proposal.

The search for and identification of dark matter is one of the main problems of current particle physics. As such, the proposal is at the forefront of the field and the outcomes would be very relevant on an international level and therefore has great potential to make important contributions to the advancement of science. The proposed research seems challenging but doable, given the applicant's experience in the field. However, making good decisions when recruiting PhDs and postdocs would be absolutely essential for creating a group capable of completing the task.

.b. To what extent is the proposed method suitable? Please comment.

The search for indirect signals from dark matter annihilation is one of three avenues that is being actively pursued in experimental dark matter searches. The understanding of how indirect searches relate experimental results with different dark matter models is crucial and the applicant already has significant experience in this respect. It would have been desirable to also have a clearer connection to the other two avenues, direct detection and collider searches, rather than putting the main focus on indirect detection only.

.c.
What are the innovative aspects of the proposal? Will the research break new ground by generating new concepts, a deeper understanding, new methods, etc.?

The proposal is very related to what the applicant has been doing earlier in his career. As such, it is not likely to result in generating new concepts on its own. However, it is likely to lead to a deeper understanding regardless of whether there is a signal of dark matter or not, as the absence of a signal would also be important for deducing what properties dark matter cannot have. It is possible that the proposal will result in new methods and practices

when it comes to how dark matter searches are performed, similar to those that lead the applicant to see the tentative Fermi LAT gamma line.

.d.
What is your opinion on its potential to make a major contribution to the advancement of scholarship, science or technology (academic impact)?

The results of the proposal would make a major contribution to the knowledge about what dark matter is (or is not). The impact and importance of a confirmed positive signal in this field would be astounding.

. **3. Assessment of the knowledge utilisation**
If the candidate has indicated that knowledge utilisation is possible, please address questions a and b. If the candidate has argued that knowledge utilisation is not to be expected given the nature of the research proposal, please address only question c. If you agree with the applicant's explanation why potential for uitilsation is absent you do not need to reduce the overall rating of the proposal.

.a.
What is your opinion on the described relevance of the results of the research to solving a societal/ economic/cultural/technical or policy-related challenge? Is the period in which the applicant expects possible knowledge utilisation to occur realistic?

As described in the proposal, the proposed research is on the level of fundamental research. As such there is no immediate relevance although the long-term advancement of science may be significant. The possible impact of a positive signal on other fields of science may also be ground-breaking. The societal impact of outreach programs is also discussed in the application.

.b.
Please comment on the effectiveness and feasibility of the proposed approach for knowledge utilisation. The applicant may indicate how he/she intends to contribute actively to the realisation of knowledge utilisation. In that case; what is your opinion on the researcher's intended active contribution to the realisation of knowledge utilisation?

The outreach program discussed in the application is fairly standard and part of the existing program at the host institute, which is described in some detail. It is not clear to what extend the applicant
is planning to integrate the proposed research with the outreach program and whether or not it is necessary for this.

.c.
Does the applicant provide a convincing explanation for the lack of knowledge utilisation in his research project (see also the information under criterion 3 listed above)?

N/A

. **4. Final assessment**

.a. How do you assess the entire application? Please give your final scoring (A+, A, B, UF, U).

A

.b.
Could you please <u>summarize or briefly comment</u> (point by point) on the strengths and weaknesses of the proposal?
Strengths:
+ The applicant has a strong track record in the proposed field of research, making the project viable

+ The project will lead to new insights on the topic of dark matter, one of the current forefronts of particle and astroparticle physics

+ The applicant has a strong international collaboration network within the field that will be useful to the project.

.c.
Weaknesses:
- The project is crucially dependent on recruiting the right people and having them work together as a unit. It is not clear that this is feasible or that the applicant has the experience in making this selection and supervising the group.

- The proposed research is mainly a natural continuation of the applicant's previous research and does not break new ground in this sense.

- The proposal focuses on indirect detection signals of dark matter and is thereby missing other possible forefront signals such as direct detection and production at accelerators.

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. **Should you have any questions about this form or about the review process please contact: Ed Rinia, e.rinia@nwo.nl.**
. **Thank you very much for your input and your time!**
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Adviseur: 2

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. **1. Assessment of the quality of the researcher**

.a.
What is your opinion on the past performance of the researcher (as demonstrated by publications and other relevant achievements)?

Weniger is one of the young leaders in the search for dark matter. As a theoretical physicist, Weniger has made key contributions to our understanding of how indirect detection experiments can be sensitive to the decay or annihilation of dark matter in the galaxy. His groundbreaking analysis of the public data from the FERMI satellite found tantalizing hints for a 130 GeV gamma line which might be due to annihilation of dark matter. While the evidence for this line is still under scrutiny, Weniger's careful analysis has directly influenced both theoretical and experimental research on dark matter.

.b.
The Vidi scheme is intended for outstanding researchers only: the top 10-20% of his/her international peer group. Which achievements or talents of the applicant show that he/she belongs to this top?

Weniger's analysis of the 130 GeV FERMI line is probably his most influential achievement to date, with over 200 citations in a little over a year. By itself, that would place him in the top 10-20% of researchers in his peer group on dark matter. Beyond just the original paper, though, Weniger has performed a number of critical analyses of the FERMI line, trying to find evidence both for and against the dark matter hypothesis. This attention to detail is crucial for success in the fast-moving field of dark matter research. Beyond the FERMI line, he has engaged in a number of interesting studies of dark matter in various theoretical contexts, including connections between dark matter, supersymmetry, and baryogenesis. All of these point to Weniger's ability to perform high quality dark matter research.

.c.
To what extent is there sufficient evidence that the applicant has the ability to lead and supervise other researchers and support staff?

Thus far in his scientific career, Weniger has co-advised (or is currently co-advising) 3 Ph.D. students. While that is a somewhat limited track record (understandable given Weniger's position), the research proposal does demonstrate that Weniger knows how to organize a scientific research group. The detailed timetable in the proposal is very realistic, with achievable milestones in each year with a careful accounting of the relationships between the various proposed projects. While the relationship between researchers in Figure 3 is perhaps a bit pedantic, it does show that Weniger has given careful thought to how to structure inter-related research projects.

. **2. Assessment of the quality of the proposal**

.a.
Please comment on the scholarly, scientific or technological relevance of the problem, as well as on the originality and challenging content of the proposal.

The nature of dark matter is one of the key open questions in fundamental physics. While the gravitational evidence for dark matter is overwhelming, finding corroborating evidence in non-gravitational experiments is crucial. Weniger is proposing to use indirect detection experiments to forward the search for dark matter, and will synthesize data from three different sources: gamma ray data from FERMI, antimatter data from ???AMS-02, and radio data from LOFAR. The choice of these three sources is original, well-reasoned, and takes advantage of Weniger's previous work on dark matter. In particular, his proposed FERMI research as a natural followup to his work on the 130 GeV line, his proposed AMS-02 research as a natural extension of his studies of the energy dependence of the cosmic-ray positron fraction, and his proposed LOFAR research as a natural extension of his work on charged particle propagation in galactic magnetic fields. Moreover, based on his theoretic work on dark matter and his leadership role in the GAMBIT collaboration, Weniger is well-positioned to understand the complementarity of different dark matter detection strategies, and has the background to interpret dark matter results should a positive detection be made.

.b. To what extent is the proposed method suitable? Please comment.

In general, indirect detection of dark matter is one of the best ways to test the WIMP dark matter paradigm, since the same interactions that lead to thermal freezeout of dark matter also give rise to the indirect detection annihilation signal seen today. In terms of the specifics of Weniger's proposal, the way he intends to analyze the FERMI data is a direct extension of his previous (groundbreaking) analysis, though with a more critical eye towards potential sources of backgrounds and complications from background templates. Regarding LOFAR and AMS-02, both experiments have the potential to yield an indirect detection signal, though the interpretation is more

challenging than for the FERMI analysis due to the challenge of tracking charged particles in the galactic magnetic fields. That said, Weniger's proposed methods to handle the uncertainties inherent in charged particle propagation and energy loss is reasonable. Finally, in terms of synthesizing the data, Weniger's is pursuing a reasonable plan to apply the FERMI, LOFAR, and AMS-02 results to complete models like the MSSM-25 and simplified models like dark matter with scalar/vector mediators.

.c.
What are the innovative aspects of the proposal? Will the research break new ground by generating new concepts, a deeper understanding, new methods, etc.?

Weniger's previous work had already broken new ground by showing that FERMI was more sensitive to gamma ray lines from dark matter than was previously assumed. In that vein, I suspect that the most innovative aspect of the present proposal is using the LOFAR radio data in the search for dark matter, since that is a relatively less studied experiment in the dark matter community (at least compared to FERMI and AMS-02), partly because of the difficulty in estimating the dark matter signal flux in radio. It is certain that Weniger will need to develop new analysis techniques to capitalize on the LOFAR data. I also suspect that Weniger will need to develop new methods to explore the consequences of new data on specific dark matter models. Of course, ultimately a detection of dark matter would lead to a deeper understanding of the structure of the universe, which is the primary goal of Weniger's proposal.

.d.
What is your opinion on its potential to make a major contribution to the advancement of scholarship, science or technology (academic impact)?

Regardless of whether dark matter is or is not discovered using Weniger's analyses, this work is likely to influence the search for dark matter in indirect detection experiments. Any one of the components of this research proposal (FERMi, LOFAR, AMS-02, and their synthesis) is a necessary step to unraveling the mystery of dark matter, and Weniger has the broad expertise to combine them into single research proposal. Just as Weniger's FERMI analysis influenced the way that FERMI takes data, I suspect Weniger will also have a similar influence on LOFAR data taking and analysis. It is also important to emphasize that now is a unique time in dark matter research, when the available experimental tools truly have the sensitivity to test the most well-motivated theoretical models. Weniger is well-poised to capitalize on the upcoming wealth of data relevant for dark matter indirect detection, and his work will have an international impact.

. **3. Assessment of the knowledge utilisation**
If the candidate has indicated that knowledge utilisation is possible, please address questions a and b. If the candidate has argued that knowledge utilisation is not to be expected given the nature of the research proposal, please address only question c. If you agree with the applicant's explanation why potential for uitilsation is absent you do not need to reduce the overall rating of the proposal.

.a.
What is your opinion on the described relevance of the results of the research to solving a societal/ economic/cultural/technical or policy-related challenge? Is the period in which the applicant expects possible knowledge utilisation to occur realistic?

Weniger correctly states that until an unambiguous non-gravitational signal of dark matter is found, the ultimate implications of dark matter research is not certain. Undoubtably, a positive detection of dark matter (perhaps using Weniger's proposed methods) would have enormous implications for cosmology and astronomy, since it would allow for a new way to study the properties of the cosmos. In the meantime, the immediate way that Weniger's research will have a societal impact is through outreach programs, specifically programs that emphasize the importance of fundamental research. As a people, we have a natural curiosity about our place in the universe, and the fact that dark matter is five times more abundant than ordinary matter is both puzzling and awe-inpsiring. Weniger says it best: "The quest for dark matter has all the ingredients of good fundamental research: compelling evidence for something that exceeds our knowledge, innovative theoretical ideas, challenging experiments, and a tremendous reward in case of a success. As such it is an excellent vehicle to transport the very ideas of scientific methods and the fascination that drives people who do fundamental research." In my opinion, it is a vital societal contribution to explain the importance of fundamental research through the example of dark matter.

.b.
Please comment on the effectiveness and feasibility of the proposed approach for knowledge utilisation. The applicant may indicate how he/she intends to contribute actively to the realisation of knowledge utilisation. In that case; what is your opinion on the researcher's intended active contribution to the realisation of knowledge utilisation?

Weniger intends to perform public outreach through a number of venues, including public lectures on dark matter and astroparticle physics, opportunities for high school students to do dark-matter-related projects, and contributions to the Quantum Universe website. All three activities with help achieve the goal of explaining the importance and value of fundamental physics.

.c.
Does the applicant provide a convincing explanation for the lack of knowledge utilisation in his research project (see also the information under criterion 3 listed above)?

N/A

. **4. Final assessment**

.a. How do you assess the entire application? Please give your final scoring (A+, A, B, UF, U).

A+

.b.
Could you please summarize or briefly comment (point by point) on the strengths and weaknesses of the proposal?
Strengths:
-- Coherent vision for the potential discovery of dark matter through indirect detection experiments.
-- Synthesizes data from multiple sources (FERMI, LOFAR, AMS-02, etc.) to confront a variety of dark matter scenarios.
-- Capitalizes on Weniger's previous success in analyzing FERMI data.
-- Realistic timetable with obtainable research milestones.
-- Includes a substantial focus on a project with Dutch scientific leadership (i.e. LOFAR)
-- Enhances the activities at the GRAPPA Institute, and maintains it as a center for excellence in dark matter

.c.
Weaknesses:
-- Because of space restrictions, did not have enough room to really explain the relevance/complementarity of direct detection and collider searches for dark matter.
-- As expected, proposed outreach activities are not as innovative as the proposed research itself.

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. **Thank you very much for your input and your time!**

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Adviseur: 3

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. **1. Assessment of the quality of the researcher**

.a.
What is your opinion on the past performance of the researcher (as demonstrated by publications and other relevant achievements)?

Christoph Weniger is an impressive young researcher who has quickly gained international recognition due to his high quality work during his PhD years and first postdoc. He is leading the field of dark matter indirect detection via gamma rays. C. Weniger is undoubtedly a very focussed and determined independent researcher. He has a clear vision of what he wants to achieve. He is known to have strong technical skills. He is solid and reliable. Besides his activities on indirect signals from dark matter, he has also written a couple of papers on cosmological issues arising in supersymmetric theories (graviton cosmology and leptogenesis) as well as a more formal paper on the generalized Boltzmann equation. This shows the breadth of knowledge of the applicant.

.b.
The Vidi scheme is intended for outstanding researchers only: the top 10-20% of his/her international peer group. Which achievements or talents of the applicant show that he/she belongs to this top?

C. Weniger definitely belongs to the top 10% of his international peer group. Last year, he was invited all over the places to talk about his paper "A Tentative Gamma-Ray Line from Dark Matter Annihilation at the Fermi Large Area Telescope " which has challenged both theorists and experimentalists for an entire year (starting in the spring of 2012). Although at the end of the day, the tentative signal that he brought up may end up as an instrumental effect for non-trivial reasons, his analysis boosted the field and pressed Fermi experimentalists to devote more attention to dark matter searches, which is a very timely achievement.
C. Weniger has written two highly cited papers (respectively arXiv:1204.2797 as a single author, with 224 citations and arXiv:1203.1312 , written together with Bringman, Huang, Ibarra and Vogl with 183 citations to this date). They both correspond to the gamma-line analysis of Fermi data, carried out in 2012. In these works, Weniger et al used a new optimized technique to search for gamma rays from DM annihilations towards the galactic center which consists in automatic selection of target regions with largest signal-to-noise ratio. He has also written two well-received reviews on gamma ray signals from dark matter, one before and one after the so-called 2012 "signal". C. Weniger is an expert on indirect searches for decaying dark matter. He wrote a series of papers on the subject together with A. Ibarra.
As a student, he worked as well on axion-like particles together with A. Ringwald. He is very fast in reacting to new data. For instance, earlier this year he wrote a paper shortly after the release of AMS data to set new limits on dark matter annihilation using the latest AMS positron constraints.

.c.
To what extent is there sufficient evidence that the applicant has the ability to lead and supervise other researchers and support staff?

C. Weniger is collaborating with active researchers in his field. He has developed collaborations with D. Finkbeiner in Harvard, P. Serpico in Annecy and other theorists in Stockholm, Fermilab, Mc Gill U. and Santa Cruz U. He lately gained experience in supervising students at GRAPPA. He also worked with students when he was a postdoc in Munich.
He has strong competencies in statistical techniques, and knows about modeling of galactic gamma diffuse emission, cosmic ray propagation, radio astronomy, radio emission models.
He has the competencies to train young scientists.

. **2. Assessment of the quality of the proposal**

.a.
Please comment on the scholarly, scientific or technological relevance of the problem, as well as on the originality and challenging content of the proposal.

Although there is presently an increasing number of groups in Europe conducting comparable DM research, and the multi-messenger approach to DM as well as the complementarity between direct, indirect and collider searches are already a well-established avenue of research, I think C. Weniger can still bring new relevant contributions, as he is really an expert of DM gamma ray searches and makes the bridge between experimentalists searching for indirect signatures of dark matter and theorists. Besides, this research is very timely. We have a large number of data coming now (from Fermi LAT, HESS, VERITAS, MAGIC, AMS2, Planck, Icecube, LHC and upcoming CTA)and we need theorists being able to make the most of this data and interpret it. Therefore, I strongly support this proposal which I am sure will lead to very useful results for the entire DM

community. The applicant has proven that he can have a strong impact on the community and his skills warrant that he will be able to pursue successfully his goals.

.b. To what extent is the proposed method suitable? Please comment.

The proposed method for analyzing cosmic data appears fully consistent and the interactions between the different actors of the project are realistic. The plan is to develop combined spectral analysis of multiple regions of interest, to prepare diffuse emission models, analyzing cross-correlations between several measurements, and investigate the full potential of various experiments.

.c.
What are the innovative aspects of the proposal? Will the research break new ground by generating new concepts, a deeper understanding, new methods, etc.?

The applicant has proven to be creative in generating new analysis methods. He plans to attack the dark matter hunting challenge from different fronts, using different targets, different messengers and cross correlating different sets of data. A quite unique and original aspect of the project is the investigation of the LOFAR potential. Given that this is a Dutch experiment, Weniger is in a very favorable position to lead these studies.

.d.
What is your opinion on its potential to make a major contribution to the advancement of scholarship, science or technology (academic impact)?

The academic impact of the project is very high. There is plenty of data to be analyzed and uncharted territory to be discovered.

. **3. Assessment of the knowledge utilisation**
If the candidate has indicated that knowledge utilisation is possible, please address questions a and b. If the candidate has argued that knowledge utilisation is not to be expected given the nature of the research proposal, please address only question c. If you agree with the applicant's explanation why potential for uitilsation is absent you do not need to reduce the overall rating of the proposal.

.a.
What is your opinion on the described relevance of the results of the research to solving a societal/ economic/cultural/technical or policy-related challenge? Is the period in which the applicant expects possible knowledge utilisation to occur realistic?

I agree that the applicant's field of research is particularly appropriate for outreach programs.

.b.
Please comment on the effectiveness and feasibility of the proposed approach for knowledge utilisation. The applicant may indicate how he/she intends to contribute actively to the realisation of knowledge utilisation. In that case; what is your opinion on the researcher's intended active contribution to the realisation of knowledge utilisation?

The applicant is an enthusiastic physicist with passion for fundamental science and a taste for outreach. Given his past experience in science communication to the public and the positive attitude of his host institution in this respect, his outreach proposal appears convincing.

.c.
Does the applicant provide a convincing explanation for the lack of knowledge utilisation in his research project (see also the information under criterion 3 listed above)?

Does not apply.

. **4. Final assessment**

.a. How do you assess the entire application? Please give your final scoring (A+, A, B, UF, U).

The entire application is carefully done.
The project is serious and of very high quality. My final scoring is A+.

.b.
Could you please <u>summarize or briefly comment</u> (point by point) on the strengths and weaknesses of the proposal?
Strengths:
-The applicant has an impressive background and a mature view on the broad problems he wants to tackle.
- The applicant has very clear goals and well-defined objectives.
- The project is overall very consistent and fits perfectly well the profile of the applicant.
- There is also an ideal fit between the applicant and the host institution.
-The applicant's project will benefit from the appropriate and strong GRAPPA environment.
-The plan is realistic given both the applicant's expertise and the predicted experimental situation. The timing is very good.

.c.

Weaknesses:

There is no weakness in the proposal. The only slight reservation I have regards the part III of the proposal "Consequences for DM models". The applicant presents his new "cutting edge global fitting tool" GAMBIT. The number of DM models is infinite and there is an infinite number of parameter scans one can make. A tendency of phenomenologists who have developped powerful tools is to apply them without thinking much about the relevance of the model they are studying. I am therefore tempted to encourage the applicant to think well about the models he wants to scan, and to talk not just to dark matter phenomenologists but also to real model builders with other interests (EW symmetry breaking). I am not sure 25-parameter scans of the MSSM is the most relevant thing to do. In any case, this is a minor criticism as this only reflects a small part of the project.

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. **Thank you very much for your input and your time!**

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Adviseur: 4

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. **1. Assessment of the quality of the researcher**

.a.
What is your opinion on the past performance of the researcher (as demonstrated by publications and other relevant achievements)?

The researcher has a long experience and a high expertise level in the topic of the research proposal. His academic level is excellent, as well as his career. It is remarkable and impressive the impact of his work in the community at this early stage of his career. His trajectory is also excellent, all his research positions have been at prestigious research institutes. The applicant has clearly demonstrated his ability to develop new and innovative ideas, defending them in a rigorous and precise scientific manner in seminars and international conferences/ workshops. Indeed, the applicant's original work on the Gamma ray line in Fermi LAT data is famous and highly cited in the literature.
The applicant is very well known and respected in the proposal field of research. As an assistant supervisor of two PhD students the applicant has also shown his enormous potential for leading and supervising other researchers and staff.

.b.
The Vidi scheme is intended for outstanding researchers only: the top 10-20% of his/her international peer group. Which achievements or talents of the applicant show that he/she belongs to this top?

Even if the applicant's career is still at an early stage, the applicant has largely demonstrated that his research work on the field lies in the top 10% of his international peer group. The applicant's innovative idea of the gamma ray line on the Fermi data has further corroborated that his research abilities are prodigious, showing also an incredible level of maturity and independence since the very early stages of his career.

.c.
To what extent is there sufficient evidence that the applicant has the ability to lead and supervise other researchers and support staff?

As previously stated, as an assistant supervisor of two PhD students the applicant has clearly shown his enormous potential for leading and supervising other researchers and staff.

. **2. Assessment of the quality of the proposal**

.a.
Please comment on the scholarly, scientific or technological relevance of the problem, as well as on the originality and challenging content of the proposal.

The proposal is extremely challenging since it aims to use a multi messenger approach to search for dark matter annihilation signals. Several signals are expected to be exploited and deeply analised: gamma ray measurements, cosmic ray antimatter searches, and synchrotron emission at radio frequencies. Finally, a combined search with dark matter direct detection probes is also outlined and proposed. The originality of the project is outstanding, since it is planned to analyse several data sets using new and unexplored methods (fluctuations of cosmic ray sources close to the galactic centre, cross correlation of DES shear measurements and extragalactic gamma ray background, spectral analysis of AMS-02 data) or new data (simulated CTA data, LOFAR) in terms of dark matter annihilation signals. It also aims to finally settled the existence or not of a dark matter annihilating feature in Fermi LAT data both by using new and unexplored methods and by reassessing former methods used in the literature. Therefore, there is a large number of innovative scientific elements in the current research proposal which possesses a clear potential to make important contributions to the field of dark matter direct and indirect detection signals.

.b. To what extent is the proposed method suitable? Please comment.

The proposed methodology is ideal to make the research plan outlined in the proposal a successful research project. The national and international collaborators of the applicant are prestigious world wide researchers in the dark matter field, and the researcher is already in deep contact with members of experimental collaborations, as in the case of LOFAR. The applicant is also planning to have short term visits with key international collaborators. The deep involvement of the applicant in the GAMBIT inference tool collaboration provides also an added value for the success of the proposal.

.c.
What are the innovative aspects of the proposal? Will the research break new ground by generating new concepts, a deeper understanding, new methods, etc.?

For the reasons I quoted above I believe the proposal is innovative, and it will bring to the research field new methods, ideas, unexplored data and extremely interesting results.

.d.
What is your opinion on its potential to make a major contribution to the advancement of scholarship, science or technology (academic impact)?

The academic impact of the current proposal very high, since it aims to the completion of two PhD thesis and the involvement of two postdoctoral researchers, with a good number of expected publications associated to it.

. **3. Assessment of the knowledge utilisation**

If the candidate has indicated that knowledge utilisation is possible, please address questions a and b. If the candidate has argued that knowledge utilisation is not to be expected given the nature of the research proposal, please address only question c. If you agree with the applicant's explanation why potential for uitilsation is absent you do not need to reduce the overall rating of the proposal.

.a.
What is your opinion on the described relevance of the results of the research to solving a societal/ economic/cultural/technical or policy-related challenge? Is the period in which the applicant expects possible knowledge utilisation to occur realistic?

In my opinion, the applicant is right in his description of the knowledge utilisation of the research proposal. An immediate way of knowledge utilisation is via outreach and dissemination of scientific ideas, concepts and research work among the general public.

.b.
Please comment on the effectiveness and feasibility of the proposed approach for knowledge utilisation. The applicant may indicate how he/she intends to contribute actively to the realisation of knowledge utilisation. In that case; what is your opinion on the researcher's intended active contribution to the realisation of knowledge utilisation?

Concerning the outreach activities proposed by the applicant, I believe they will be successful, since the applicant has experience in that and the applicant's institution has a very active research program, which includes public lectures for a general audience, and mentoring of high school students in scientific programs. Therefore, the knowledge of utilisation proposed in the proposal is both ideal and feasible.

.c.
Does the applicant provide a convincing explanation for the lack of knowledge utilisation in his research project (see also the information under criterion 3 listed above)?

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. **4. Final assessment**

.a. How do you assess the entire application? Please give your final scoring (A+, A, B, UF, U).

A

.b.
Could you please <u>summarize or briefly comment</u> (point by point) on the strengths and weaknesses of the proposal?

Strengths:

The applicant's capabilities, expertise and trajectory are excellent. The proposal is timely and original, and will bring a large number of new methods, ideas and tools in the field of dark matter phenomenological searches. The academic impact is also highly promising, since two PhD thesis and a large number of publications in high impact international journals are expected. Therefore in principle this proposal possesses all the ingredients to be successful.

.c.

Weaknesses:

The applicant is planning to lead a team of three/four people. Although there are no doubts in the applicant's potential concerning this task, to lead two PhD students simultaneously might be too much at this stage of his career, given the fact that until now the applicant has never fully mentored alone a PhD student.

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. **Thank you very much for your input and your time!**
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