GANIL Scientific Council (17-18 January 2023)
The New JEDI Project

Beyhan BASTIN (GANIL), on the behalf of the New JEDI collaboration

New JEDI core collaboration:
GANIL (France): Beyhan Bastin, François de Oliveira, Marek Lewitowicz, Jean-Eric Ducret, Olivier Sorlin, Dieter Ackermann, Christelle Stodel, Abdelouahad Chbihi, Jean-Charles Thomas, Gilles De France, Marek Ploszajczak ; **IJCLab (France): Isabelle Deloncle, Jürgen Kiener**, **Alain Coc**, Charles-Olivier Bacri, Clarisse Hamadache, Adrien Laviron, Jérôme Bourçois, Vincent Tatischeff, Fairouz Hammache, Nicolas de Séréville and Brigitte Roussière ; **IAP (France): Cyril Pitrou** ; **IP2I (France):** Bernadette Rebeiro and Yasmine Demane ; **Minnesota University (USA): Maxim Pospelov ; NPI (Czech Republic): Jaromir Mrazek,** Anastasia Cassisa, Eva Simeckova and Vaclav Burjan **; ULB (Belgium): Pierre Descouvemont** ; **INFN LNS (Italy): Livio Lamia**, Marco La Cognata, Gianluca Pizzone, Guiseppe D'Agata, Alessia Di Pietro, Aurora Tumino, Maria Letizia Sergi, Dominico Santonocito, Giovanni Luca Guardo and Guiseppe Rapisarda; **iThemba LABS (South Africa) : Lindsay Donaldson**, Philip Adsley, Pete Jones, Kgashane Malatji, Ignasio Wakudyanaye, Elena Lawrie and Johann Wiggert Brummer.

Project synthesis and status:
Our universe is mainly composed of dark energy and dark matter, at estimated percentages of 69 % and 26%, respectively. The Standard Model of particle physics fails to describe these hidden sectors of our universe. To date, the real composition of the classical Dark Sectors of our Universe remains a mystery. We still do not have a clear answer to the question "of what is Dark Matter composed?". In recent decades, an alternative approach to our current understanding of the Universe has been considered through a new theory: The Dark Sectors theory. It is based on the idea that we may also consider an indirect interaction between Ordinary Matter (including stars, planets, interstellar gases…) and Dark Sectors of the Universe. In this theoretical framework, Dark Sectors are defined as hypothetical sets of light particles that interact with ordinary matter with an amplitude a few orders of magnitude less that the electromagnetic interaction, via portals (bosons). Thus, the idea is to verify the existence of a new particle (named Dark Boson) that will act as the messenger of a new fifth force of nature. Our investigation is further motivated by the recent claim of an anomaly observed in the electron-positron pair decays of an excited state in ^{8}Be, during an experiment of the Hungarian ATOMKI group, which may be interpreted as the signature of a hypothetical dark boson (named X17). However, uncertainties linked to the structure of ^{8}Be and new hypotheses to explain the experimental results are currently debated. The ATOMKI group confirmed latter on the existence of this anomaly on other nuclei such as ^{4}He and ^{12}C. The quantum nature of this hypothetical boson is also unclear at the moment. Independent measurements are needed. The New JEDI (New Judicious Experiments for Dark sector Investigations) project has been initiated in 2017. It aims to develop a collaboration between the GANIL, IJCLab, University of Minnesota, INFN-LN, NPI, iThemba LABS, IAP, TRIUMP, IP2I and ULB research teams concerning the study of a Dark Boson in the MeV range, on a wider scale. For that purpose, a prototype was defined and built up based on test experiments carried out at the ARAMIS-SCALP facility (Orsay, France) from 2018 to 2020, as well as some GEANT 3 simulations. We commissioned this prototype in June 2021 at the tandetron facility located at Rez (2 weeks of experimental run in Czech Republic). We realized afterwards some mechanical and

detection modifications to complete the first New JEDI setup. The first common scientific objective is to check the existence of the ^{8}Be anomaly (as requested by the GANIL PAC in 2020). The first experiment on ^{8}Be was realized successfully from June to July 2022 at the ANDROMEDE facility located at Orsay (7 weeks of experimental run). A PhD student from GANIL will be in charge of the fine analysis of these data starting from December 2022. Then, we will investigate the impact of additional nuclear physics effects in the ^{8}Be quantum system to see to what extent it impacts the result concerning the X17 boson. This experiment is expected to take place in 2023 at iThemba LABS (South Africa) and will be led by the iThemba LABS, IJCLab and INFN-LNS New JEDI partners. Later, if adequate resources are allocated to ensure the sustainability of the project, the existence of a Dark Boson in the MeV range will be investigated in other light quantum systems where nuclear structure uncertainties are much reduced. This wider study will be carried out mainly at the GANIL-SPIRAL2 facility. If this boson exists, it would open up an entire new field in Particle Physics Beyond the Standard Model.

1) Scientific scope of the project

1.1) The Dark Sectors theory as a new alternative scenario to the standard direct Dark Matter detection approach

Understanding the composition and functioning of our Universe are among the most fundamental and challenging questions in Physics. Despite its apparent complexity, ordinary matter (OM) is in reality composed of just a few elementary particles (quarks and leptons). These particles, together with the force carrying and the Higgs Bosons constitute the main components of the Standard Model of Particle Physics [1].
This theory is able to describe 5% of the Universe (made of OM). 26% of the Universe is made of Dark Matter that does not emit light and whose existence has been inferred as necessary to explain, e.g., the star's rotational velocity within galaxies or the gravitational lensing effects observed in space. The remaining 69% of the Universe is made of Dark Energy, distributed uniformly, acting as a repulsive force counterbalancing gravity. The existence of Dark Energy could explain the accelerated expansion of the Universe. The relative composition of the Universe was deduced from the Cosmic Microwave Background anisotropy [2], in accordance with the prediction of Jim Peebles, awarded the 2019 Nobel Prize in Physics [3]. This is our current and conventionally accepted description of the structure of the Universe. To date, the real composition of the classical Dark Sectors remains a mystery. We still do not have a clear answer to the question "of what is Dark Matter composed?". There are some indications, several candidates, but, despite all the efforts over the last three decades all around the world [4], none of the dedicated experiments has proved the existence of dark particles. To date, the intrinsic nature of dark matter remains a mystery.
To address this issue, several models have been developed and in recent years particular attention is paid to studies of so-called Dark / Hidden Sectors, introduced in refs. [5][6][7][8] but poorly tested [9]. It is based on the idea that we may also consider an indirect interaction between Ordinary Matter and Dark Sectors of the Universe. In this framework, Dark Sectors can be defined as hypothetical sets of relatively light particles with interaction orders of magnitude lower than the electromagnetic interactions. These Dark Sectors may or not include Dark Matter particles. We will keep this definition of Dark Sectors in the following text. From a theoretical point of view, Dark Sectors are composed of one or more particles, that

couple to the Visible Sector - Ordinary Matter well described by the Standard Model - through portals, as described in Fig. 1. A Dark Boson will act as the messenger of this interaction. It is the Dark Force carrier. This leads to the fundamental question of the existence of a fifth force of nature (in addition to the gravitational, electromagnetic, strong and weak forces). Different portals could be possible, depending on the quantum nature of the Dark Boson (spin and parity). Nuclear Physics experiments allow the study of scalar, pseudo-scalar, vector and pseudo-vector hypothesis.

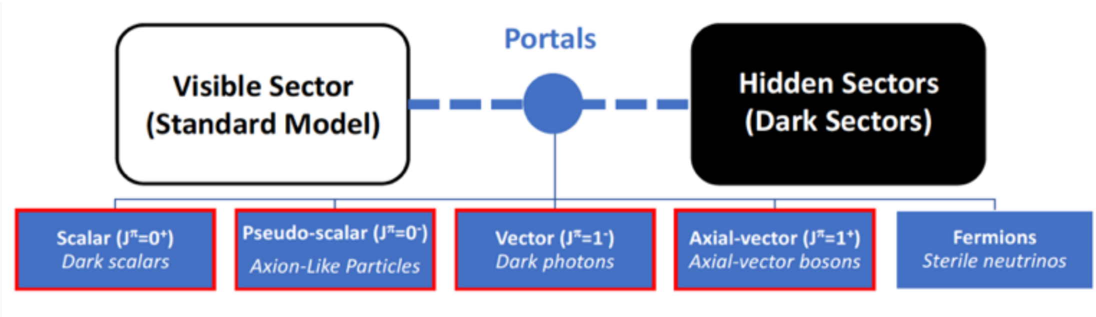

Fig. 1: Illustration of the Standard Model coupling to Dark Sectors through given portals. Portals that might be studied though nuclear physics experiments are indicated with a red frame.

Non-trivial dynamics in the hidden sectors model can lead to novel phenomenology, whose thorough characterization has only begun.

1.2) Dark Sectors experimental studies: state-of-art and ^{8}Be anomaly

Currently, there is much activity in both North America and Europe, evaluating various proposals attempting to see how different experiments can better probe Dark Sectors [9][10]. In the US, experiments at Jefferson lab, SLAC and Fermilab facilities have been discussed. In 2016, CERN launched the “Physics Beyond Colliders” study group to assess the possibility of using the CERN facility for physics not necessarily related to the LHC. One of the physics goals of these exercises is to look at the sensitivity of various proposals for the study of Dark Sectors. From this prospective works, one may see that, up to now, many experiments using different techniques have just provided exclusion zones, ruling out certain masses and interaction strengths of the possible Dark Boson. An example is given in Fig. 2 of [11] concerning the Dark Photon (vector) portal hypothesis (see Fig. 1). Until now, the scientific community that conducts experimental studies on Dark Sectors is mainly the High Energy Physics one. However, during the last years, there is a Nuclear Physics experiment that has caught the scientific community’s attention, performed by a Hungarian research team [12]. Our investigation is further motivated by the recent claim that the anomaly they observed in the electron-positron pair decays of excited states in ^{8}Be can be interpreted as the signature of a hypothetical Dark Boson. The bump observed at 140 degrees has been interpreted as the possible signature of a Dark Boson decay, which was named X17. This experiment provides the main constraint on the Dark Boson mass : mX =16.70 ± 0.35(stat) ± 0.5(syst) MeV/c2. From this experiment, the following branching ratios were also extracted: proton decay, γ-decay, internal pair creation and ejection of a new (X17) particle. Has a Dark Boson finally been observed? It is not very clear yet. First, the given result is not compatible with the conclusions from the NA48 complementary experiment performed at CERN [13]. Compatibility might be enforced if some

extreme hypothesis are considered, such as a protophobic dark photon [11]. But, the ATOMKI group has also later studied the signature of a Dark Boson in ^{4}He and ^{12}C, claiming the existence of a similar anomaly [14][15][16]. However, the synthesis made by J.L. Feng et al. [17] underlines (see Tab. III of the article) very well that it is difficult to build up a coherent conclusion concerning the quantum nature of the X17 particle based on all the ATOMKI experimental results. A possible explanation could be a X17 production mechanism rather proceeding through a direct capture process than through any nuclear resonance, as suggested by ref. [18]. Therefore, an independent measurement is needed.
There are lots of experimental programs that started recently to study the X17 anomaly. Even if they look like providing very promising sensitive probes, one may see that experiments conventionally used for high energy physics such as LHCb needs major updates and could provide a first experimental run very later on (final detector expected 2025) [19]. NA64 managed to realize an additional experimental run in 2018. The results obtained did not allowed to conclude about the X17 anomaly but allow to improve the sensitivities of their previous measurement [20] and will need an upgrade of the setup to go further on this topic [21]. PADME, as for it, could search for this dark photon with a few proper experimental set-up changes [22]. In parallel, new emerging Nuclear Physics experimental programs, including New JEDI, are under development or reached the commissioning phase, even some have carried out already a first experiment [23][24][25][26][27]. These experiments are well suited to investigate the MeV terra incognita area. In section 3, we will provide details concerning the New JEDI project, which has realized recently its first long experimental run on ^{8}Be at the ANDROMEDE facility [28] (from June to July 2022). It was a great and symbolic achievement for the collaboration.

1.3) Aims and objectives of the New JEDI project

a) The first goal of the New JEDI collaboration is to **confirm the X boson experimental signature observed in ^{8}Be through an independent measurement**.

For that purpose, a new, specific, efficient and high-resolution detection system, coupled to a new generation digital data acquisition system, has been built mainly at GANIL. A first experiment has been carried out successfully at the ANDROMEDE facility from June to July 2022 to study the existence of the X17 boson in ^{8}Be in an independent way. The fine data analysis will be carried out by Ignasio Wakudynaye, a PhD student from GANIL.

b) The second aim is **to check the existence and the impact of additional nuclear physics effects in the ^{8}Be quantum system and to see to what extent it impacts the result concerning the X boson**.

In practice, we will verify the electromagnetic nature of the transitions and compare with theory (collaboration with Petr Navratil, Guillaume Hupin and Pierre Descouvemont). These experiments will be the focus of the work at the iThemba LABS tandetron laboratory, where we will be able to perform high-efficiency measurements with high beam intensities, a necessity if these experiments are to succeed. A letter of intent has been submitted by Jurgen Kiener in December 2020. A proposal has been submitted by Lyndsay Donaldson in August 2022 and will be defended by Philip Adsley in January 2023. Colleagues from INFN-LNS (Marco La Cognata) will also be strongly involved in these experiments. The electromagnetic nature of the transitions is vital for two reasons. The first is that these EM transitions provide an alternative explanation for the anomaly observed by the ATOMKI group. Ruling out competing

nuclear-physics explanations for the anomaly ranks, alongside independent confirmation of the anomaly, is a necessary first step in investigating the possible observation of a Dark-Sector Boson. The second aspect, looking for two-gamma decays of the possible X boson, provides two magnificent opportunities. The first is in confirming the existence of the X boson with an independent signal - not based on lepton pairs but on gamma rays. The second is in providing information on the nature of the X boson since only a pseudo-scalar boson is able to decay by two-gamma emission; observation of the two-gamma decay channel would be direct evidence for the X boson being pseudo-scalar and not axial vector. These gamma-gamma coincidence measurements will also allow us to test whether the X boson signal observed by the ATOMKI group could result from an experimental artefact such as a two-gamma cascade decaying from ^{8}Be states or more exotic explanations such as a hard gamma-gamma process.
The commissioning of the astrophysics beamline of the new tandetron facility and the detection setup are ongoing. The results from the first tests realized in November 2022 at iThemba LABS are very promising.

c) The third objective is **to check the existence of a light gauge boson in much simpler quantum systems, for which uncertainties linked to nuclear structure are greatly reduced**. In addition, these new measurements will **bring additional constraints on the boson characteristics (mass, coupling strength with ordinary matter)** and it will help to **clarify its nature, if it exists**.

To start with, interesting nuclei for which the nuclear structure uncertainty is diminished are deuterium (d) and ^{3}He for example. Indeed, deuterium does not have excited states since it is a weakly bound system. No excited states in ^{3}He have yet been established. We plan to investigate the existence of a light gauge boson (MeV) on a wider scale in these simpler quantum systems through experiments that will be carried out at the GANIL SPIRAL2 facility. A letter of intent has been submitted in 2020 at the GANIL PAC and a proposal will be submitted in 2023 if the conditions allow it.

Up to now, the collaboration managed to run a successful scientific program with little means at their disposal and the use of laboratories' common goods. We are facing at the moment financial and human resources issues, that could put at risk the achievement of the New JEDI's targets in the long term. The aim of the document is to study also the way to make this scientific program more sustainable.

2) New JEDI collaboration and implication of their members in the project

The New JEDI core collaboration members are listed at the top of the current document. The main French participating institutes are: GANIL (Caen), IJCLab (Orsay) and IAP (Paris). The other main international partners are: University of Minnesota (USA), NPI (Czech Rep.), the University of Catania / INFN-LNS (Italy) and iThemba LABS (South Africa). They have already collaborated in the past on other projects. The consortium of partner labs gathers worldwide-recognized experts in the different fields of experimental and theoretical Nuclear Physics (GANIL, IJCLab, iThemba Labs, University of Catania and NPI), Dark Sectors theories (University of Minnesota) and Big-Bang Nucleosynthesis modelling (IAP and IJCLab) that should ensure the success of New JEDI project and the quality of the incoming associated scientific results.
The New JEDI project general organization is given in fig. 2. The project scientific coordinator and co-spokespersons have very good expertise in all the experimental and theoretical aspects

required by the New JEDI project. The experimentalists among them have led or co-led several experiments (all completed successfully) at radioactive ion-beam facilities worldwide including GANIL, CERN-ISOLDE, JYFL and TRIUMF, and contributed in many other experiments in the same or other international facilities. The project scientific coordinator (SC) has also a long-standing experience in the coordination of national and international projects. She devotes 70% of the working time to the New JEDI project (including management, supervision, reporting, etc.).
The SC was in charge of the mechanical assembly, the tests of detectors, the electronics development and characterization of the New JEDI prototype, as well as the online and the offline data analysis programs (see Fig. 2 and Fig. 3), in close collaboration with the GANIL DELTA group and other GANIL technical staffs. She focused her expertise on the Double-Sided Silicon Strips Detectors (DSSSDs) later on. The optimization and the new design of the Plastic detectors has been led by Isabelle Deloncle and Jürgen Kiener, in collaboration with the IJCLab mechanical design department. Jurgen is also realizing the GEANT 3 simulations needed for the project.

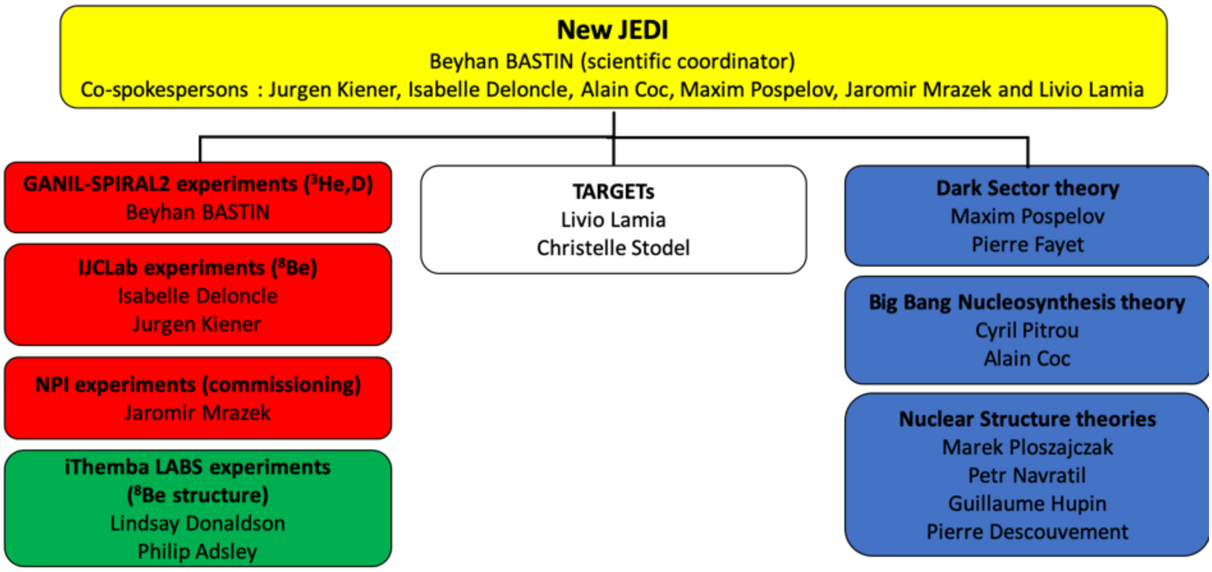

Fig.2: New JEDI project general organization

The New JEDI experimental program is distributed in several facilities. For all these experiments the targets manufacturing and characterization are perfectly taken in charge by the INFN-LNS partner of the project. They also provide a strong contribution to the experiments: about two persons are present during all the experimental process, including the preparation, the realization, the calibration and the setup dismounting.
- The New JEDI setup commissioning was realized at the tandetron facility located at Rez, in Czech Republic. The New JEDI co-spokesperson and NPI local coordinator, Jaromir Mrazek, together with his team (Guiseppe D'Agata and Anasatia Cassisa) and the Czech technical staff were strongly involved in the integration, the assembling and the realization of this first online experiment. In a general way, NPI is providing for any New JEDI experiment a material support concerning the beam current monitoring (FC and associated electronics) as well as on the New JEDI network system (e.g. cameras and rate monitoring of the experimental parameters via raspberries…). They also provide a precious help for any New JEDI experiment.

- The first experiment on ^{8}Be was led by Jürgen Kiener, Beyhan Bastin and Isabelle Deloncle. It required a strong involvement on site from their side. The IJCLab Nuclear Physics researchers' community provided an active contribution during this experiment, ensuring to a large extend its success. In addition to the recurring contribution of the INFN-LNS and NPI partners, some colleagues of GANIL could join also this experiment. We have also needed to extend the collaboration to researchers from other fields. We faced strong difficulties to fill the shift schedule. The length of such an experiment (7 weeks), looking for rare events signature, requires an organization similar to a High-Energy Physics project. This should be mandatorily improved for the next experiment.

Since September 2022, we have started to involve students to the project:

- Sabiha Tasneem, a Master 2 Erasmus-Mundus student (from September 2022 to January 2023), is studying the reaction parameters the New JEDI first experiment such as the beam energy characterization.
- Damiani Stramaccioni, another Master 2 Erasmus-Mundus student (from September 2022 to January 2023), is in charge to realize « realistic » GEANT 4 simulations of the New JEDI setup to study multi-scattering effects observed experimentally (contributions of electron/positron-electron and electron/positron nucleus effects, differences between electron and positron interaction with the detection system…) and comparison with data (e.g. ^{207}Bi calibration run)
- Ignasio Wakudyanaye, a Phd Student from the University of Caen affiliated at GANIL (from December 2022 to November 2023), will be in charge of the fine analysis of the data recored during the first New JEDI experiment on ^{8}Be.

In parallel to this, there is an active and recurrent interaction between the experimentalists and theoreticians of the new JEDI collaboration all along. The New JEDI annual collaboration meeting allows having a detailed synthesis of activities on both components of the project.

We also have an almost weekly online collaboration meeting between experimentalists, where a synthesis of activities is given, results from data analysis or simulations are presented and decisions concerning the next steps to follow are defined together. A total of 57 meetings have taken place up to now.

3) Description of the New JEDI scientific project

The New JEDI project aims to provide, in a general manner, quick and reliable tests of the existence of a light Dark Boson (MeV range) that couples the Standard Model to Dark Sectors. Fig. 3 shows the mechanical scheme (at the center) of the New JEDI setup first version and pictures of its components (chamber, detectors, target holder and units). This version has been used during the commissioning that took place in June 2020 at the tandetron facility located at Rez, in Czech Republic [29]. It was developed based on test experiments conducted at the ARAMIS facility (Orsay, France) [30] and Geant 3 simulations, carried out since 2017.

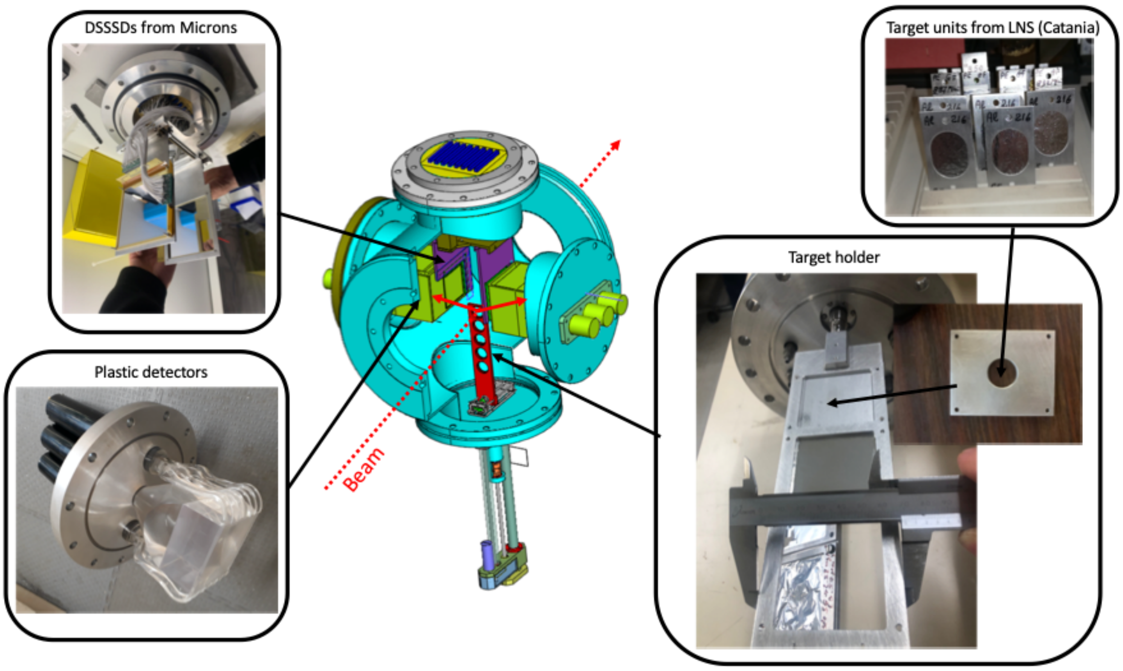

Fig.3: Mechanical scheme (at the center) of the New JEDI setup (first version) and pictures of its components (chamber, detectors, target holder and units).

The set of Double-Sided Silicon Strips Detectors (DSSSDs) of the New JEDI setup provides information concerning the electrons and positrons emission angles. In addition, the sets of plastic detectors is used to measure the energies of electrons and positrons. They are also used to veto external background events. The detection system is coupled to the new generation NUMEXO2 digitizers [31]. A specific charge integration firmware and a coincidence cross-check mode have been developed for the project. The conclusions from the commissioning are the following: there is a major contribution of the $^{19}F(p,\alpha)^{15}O$ reaction in the DSSSDs that needs to be stopped using a thick foil in front of the detector. The Lithium target emits also a lot of electrons that can be stopped in this front foil providing it is a conductive one, to avoid charge and discharge effects. Surprisingly there is also a need to protect the back of the DSSSDs as well which see also electrons. We observed multi-scattering processes that needs to be investigated more in details in the next experiment. The methods developed to measure and to check the proper coincidences between the different detectors seems to work properly. The CaF and PTFE targets developed by the INFN-LNS laboratory, part of the New JEDI collaboration, in order to disentangle the contribution of reaction from F in the spectra, showed online very promising characteristics. We needed to refine the optimal target thicknesses to get benefit of the full beam intensity expected from the simulations. In this configuration, a reasonable efficiency of 10% is estimated for the X boson electron-positron pair decay, if it exists. We also observed interesting geometrical effects.
All this was investigated and optimized for the first experimental run that took place at the ANDROMEDE facility from June to July 2022. The sketch of the experimental setup is given in Fig. 4. Proton beams of 1.1 MeV with about 300 nA, delivered by the Van de Graff accelerator, impinged on a 300 ugr/cm^2 LiF target, on a 30 ugr/cm^2 C backing. The target was rotated at 50°. This first experiment aims to study the existence of a Dark Boson in the MeV range in ^{8}Be (search for the X17 anomaly). New plastic detectors and target holder were used. The detection efficiency for X boson e-e+ pair decay is much better: ε_{coinc}=18.0%. Examples of

some spectra recorded online are also given in this figure. As expected, we observe the population of excited states of ^{8}Be around 18 MeV. The energy loss distribution in the DSSSDs is consistent with the predictions. We estimate a production of about 500 bosons/week in this configuration, if it exists. About 3.5 weeks of proper data were collected on disks. The fine analysis of the data will start in December 2022 by the Ignasio Wakudyanaye (New JEDI PhD student at GANIL).

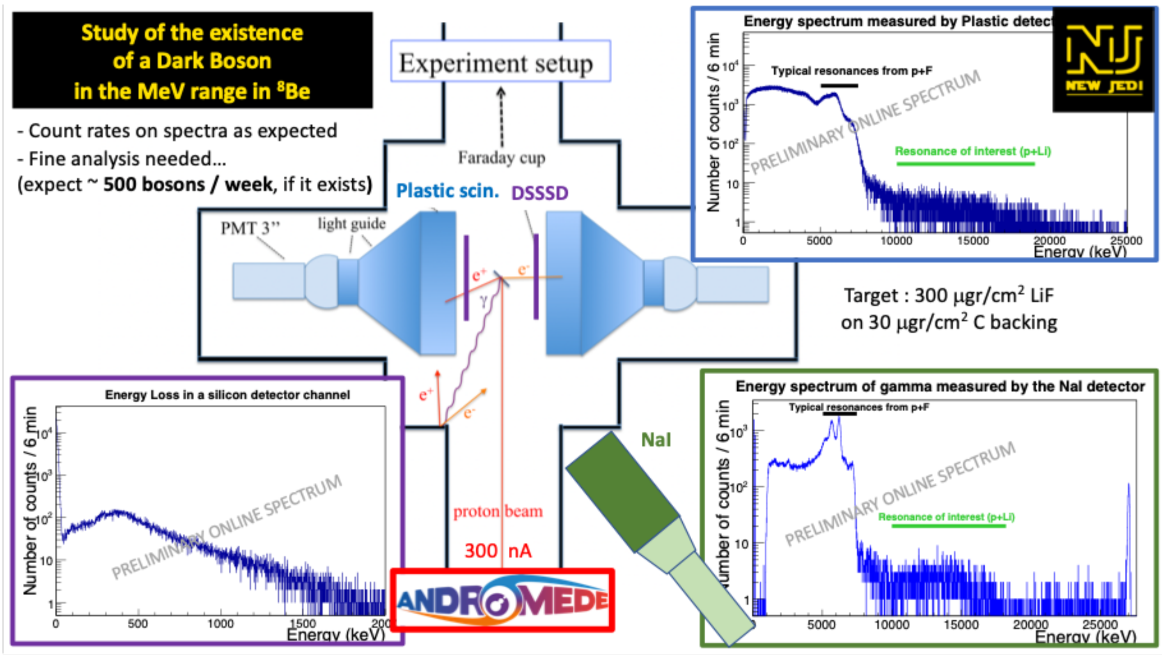

Fig.4: New JEDI setup new configuration designed for its first experiment at the ANDROMEDE facility. Examples of some online spectra recorded from the reaction of a 1.1 MeV proton beam impinging on a LiF target, populating excited states of ^{8}Be around 18 MeV.

We now plan to develop a long-term research program in the MeV terra incognita energy range at the new SPIRAL2 facility (Caen, France) [32], that will deliver unique high-intensity beams of light, heavy-ions and neutrons in Europe.

4) Timeline, human and financial resources and calls for funding

4.1) Methodology and proposed research plan

The project is organized into 6 phases:

- **Phase 1** concerns (i) simulations in order to design an optimal detection system, studies of experimental effects, including electrons multiple scatterings, the design and construction of the reaction chamber and (ii) reaction targets construction and characterization.
- **Phase 2** is about the equipment – more particular detectors and associated electronics and DAQ system- assembling, characterization and use.
- **Phase 3** is allocated to the tests and commissioning of the final setup for the first experiment (the study of the ^{8}Be anomaly) that will take place at the NPI tandetron facility.
- **Phase 4** is about the preparation, the realization and the analysis of the first experiment on the X boson signature in ^{8}Be at the ANDROMEDE facility. Depending on the experimental results, a complementary experiment could be realized later on.

- **Phase 5** is foreseen in 2023 a few months after the tandetron beamline at the iThemba LABS will be operational, after getting the scientific committee approval (expected January 2023). It will be devoted to the study of the nuclear structure of ^{8}Be, in particular gamma-ray decay spectroscopy studies of ^{8}Be.
- **Phase 6** is envisaged from 2024. It will be devoted to the preparation, the realization and the analysis of the other crucial experiments (e.g. search for a X boson emission in ^{3}He or ^{2}H) that should take place at the SPIRAL2 facility.

The project has now reached Phase 5. The schedule may shift depending on external conditions (pandemic, electricity sobriety, inflation…) that may impact travelling as well as beam scheduling.

4.2) Timeline of the New JEDI project

The timeline of the New JEDI project including the working program is described in Fig. 5.

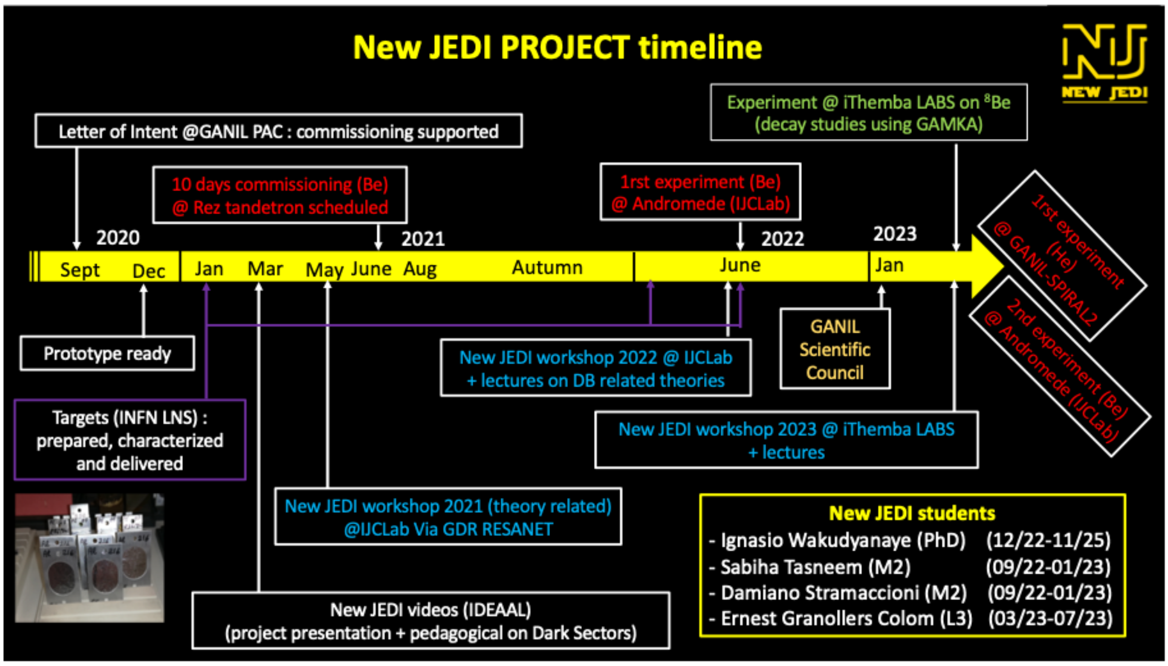

Fig.5: Timeline for the New JEDI project

In practice, two to three experiments using the New JEDI setup concerning the existence or not of the X17 Dark Boson are envisaged between 2022 and 2025: one to two at the ANDROMEDE facility and one at SPIRAL2 looking for the signature in ^{8}Be and ^{3}He quantum systems, respectively. In addition, one crucial experiment (not using the New JEDI detector) focused on ^{8}Be spectroscopic decay study is foreseen at iThemba LABS using the unique coupling of low-energy beam from the tandetron accelerator and the half-AFRODITE multi-detectors array. It corresponds to the French South African Experimental REsearch on Dark bosons (FASERED) project, for which the New JEDI collaboration received a 2-years mobility grant. The aim is to investigate deeply if the X17 signal can be an artefact linked to an experimental error or a subtle nuclear physics effect in ^{8}Be, which has a complex nuclear structure.

In addition, every year a collaboration workshop takes place, following the first edition in 2021 [34]. Since 2022, these workshops are now coupled with some academic lectures on modern theories and experimental approaches. In 2022, Pierre Fayet accepted to provide online lectures on “The U boson as a generalized dark photon, possibly behaving as an axionlike particle” at IJCLab. Such way, these events will allow the dissemination of results to better define the next experimental setups and incoming programs and provide a high-level educational program.

4.3) Critical analysis of the situation and identification of required resources

Fig. 6 provides a SWOT analysis applied to the New JEDI project. To synthetize, this analysis underlines the fact that all the expertise for the project success is already in place. It already enjoys a great international recognition. The first experiment carried out at the ANDROMEDE facility was a real success. However, several critical issues have been identified. The main issue relies on the fact that each experiment requires about 4 weeks of optimal data taking. Some critical expertise is concentrated in only few hands. This is a serious problem. There should be a core-team of experts, having a good academic background on nuclear physics and astrophysics, on site all along the experiment, that can provide support 24/24 and 7/7. The collaboration can provide contribution to shifts but a better organization is needed well before. Most of the New JEDI collaboration members are senior scientists. One need to increase the number of students who can do more easily night shifts. The need of an experienced post-doc who can be of great help and support to the scientific coordinator is identified. There is also a strong need to develop an accurate GEANT4 simulation package of the New JEDI setup to be able (1) to apply proper efficiency corrections and (2) to define the final and optimal new JEDI setup (including BGO detectors, an identification of positron and electrons….) needed for a long-term scientific program. We need to realize systematic studies (mask, thresholds, G&D efficiency vs count rate, dead time estimations…) and understand effects that put trouble during the experiment (charging effects, tripping…) and solve them…

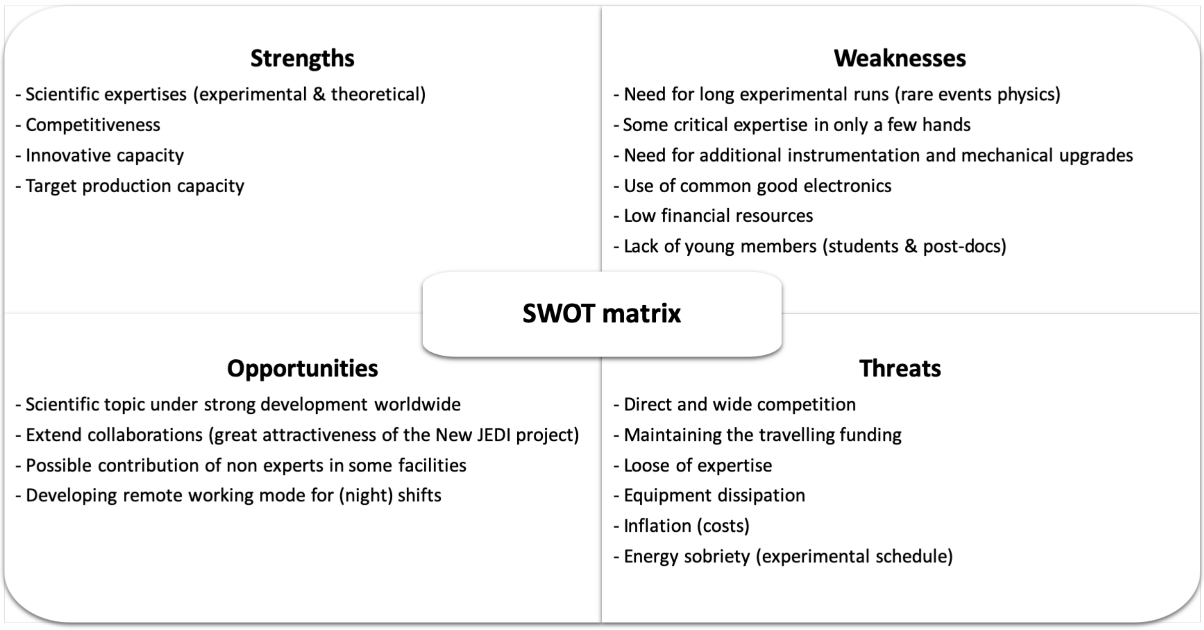

Fig.6: SWOT analysis applied to the New JEDI project

The New JEDI setup was built up using common use electronics and DAQ modules. The fact that this equipment becomes immobilized for the need of the project is also an issue. On need maybe to buy progressively dedicated units. However, it is mandatory at the moment to keep on using the same NUMEXO 2 digitizers to avoid additional systematic effects on results.

Based on the given timeline and scientific program, we defined the need of the following equipment by order of priority (a fine budget estimation will be given later on):

- A set of 4 DSSSDs for each experiment (4 x 8 keuros).
- A set of 2 photomultipliers for each experiment (2 x 3 keuros).
- A mesytech MSCF-16 amplifier and shaper.
- Linear Gate Stretchers (5 units).
- Data storage servers (3 keuros).

In the future, considering the implementation of additional BGO detectors and the possibility to have an electron positron identification system, another adapted reaction chamber will be needed. We will need to have also a dedicated New JEDI DAQ system.

Considering the funding applications, the SC have submitted in February 2019 an ERC consolidator grant application. We received a good evaluation concerning the project but not enough to get the funding. We received almost the same comments from the ANR application submitted in November 2019. There is a clear difficulty for the referees to understand the possible contributions from nuclear physics experiments to the Dark Sectors research field, being conventionally studied by the High-Energy Physics community. We decided thus to try to build up, with local means, a prototype and just afterwards a first setup good enough to realize the ^{8}Be and ^{3}He experiments at the ANDROMEDE and SPIRAL2 facilities, respectively.
Later on, in August 2022, the SC applied to an ERC advanced grant. The level requested for such a grant is much higher. The application was rejected. However, the evaluation remained the same. Therefore, results from the first experiment are mandatory and a regional financial support to sustain the collaboration activity meanwhile could be a good solution.
End of 2021, we were rewarded a mobility grant for 2 years by the French Ministry of Foreign Affairs and the Ministry of Higher Education and Research from the French side (grant No. PROTEA - FASERED - 47796WF), and the Department of Science and Innovation and the National Research Foundation in South Africa (grant No. 138131). It corresponds to the French South African Experimental REsearch on Dark bosons (FASERED) project which aims to test conventional explanations for the X17 anomaly.
Each New JEDI experiment requires one-year upstream work (tests and characterization of detectors, delivery delays…). Therefore, to be able to run an experiment in 2024, the material should be bought in 2023. The last new JEDI experiment took place in July 2022. In order to keep the expertise and also the collaboration unified, it is also important to maintain a given experimental activity.

To summarize, if adequate resources are allocated to ensure the sustainability of the project, the New JEDI collaboration plans to investigate the existence of a Dark Boson in the MeV range in other light quantum systems where nuclear structure uncertainties are much reduced. This wider study will be carried out mainly at the GANIL-SPIRAL2 facility. If this boson exists, it would open up an entire new field in Particle Physics Beyond the Standard Model.

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