DarkSide

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1) Scientific Context

Dual-phase noble liquid Time Projection Chambers (TPCs) are the present leading technology in the field of direct dark matter search. The "dual phase" technique has the main advantage to provide simultaneous access to the scintillation (S1) and to the ionization (S2) signals, allowing for the event topology reconstruction and for the discrimination between electron and WIMP-like (or nuclear) recoils.

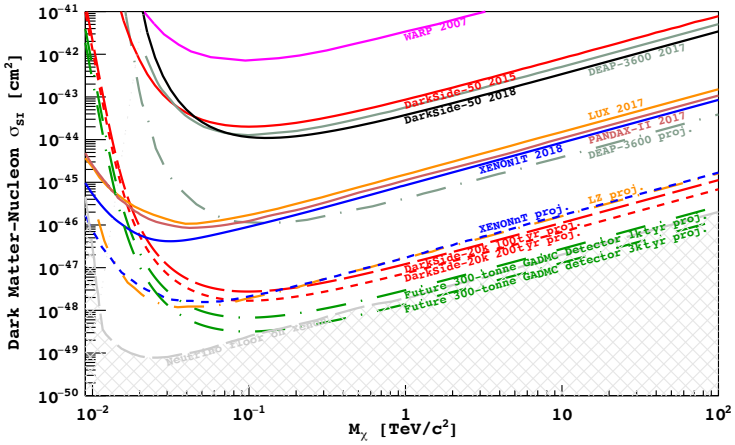
A number of TPC's, such as Xenon1T, PandaX, and LUX, successfully profit from liquid xenon (LXe) target masses, which guarantee an excellent radio-purity and a high stopping power for penetrating radiation. Dual-phase LXe TPCs are currently the detectors providing the most stringent limits on the WIMP-nucleus cross section, at WIMP masses larger than 6 GeV/c^2. Liquid argon (LAr) has similar properties but suffers of the intrinsic contamination of cosmogenic ^{39}Ar, though recently mitigated by a factor ~1,400 by the DarkSide-50 (DS-50) collaboration using 150 kg (50 kg fiducial mass) of argon extracted from deep underground (UAr). On the other hand, LAr is intrinsically characterized by an **extraordinary discrimination power** (>10^8) between nuclear and electron recoils, exploiting the scintillation pulse shape. The potential of LAr has been recently demonstrated by DS-50, operating with UAr: the outcome of the dark matter search is a null result with a ~20 ton-days exposure. The discrimination between events induced by natural radioactivity and nuclear recoils – the potential candidate dark matter events – confirms once more that a future generation of liquid argon detectors will also be able to operate **completely free of background** and in a real discovery mode. Such generation will also benefit from the technological overlap with DUNE, which will build four 10 kton LAr TPCs for neutrino physics. In addition, the analysis of very-low energy events in DS-50, characterized by the presence of the sole ionization events, has led to the **world-best limits for masses below 6 GeV/c^2**. The improvement with respect to competing experiments is of one order of magnitude, thus bringing DarkSide into the lead.

In the next decade, multi-ton scale noble liquid detectors like LZ and XENONnT (LXe) and DarkSide-20k (LAr) will reach similar sensitivities and will dominate the WIMP search above the GeV/c^2 mass scale and should be able to close the gap with the neutrino floor. Their **complementarity**, *id est* the simultaneous observation of event excesses in LXe and LAr, represents the smoking gun for WIMP discovery, together with directionality (promising R&D started in LAr) and annual modulation.

2) The project

DarkSide is a multi-stage program, which began in 2010 with the construction of DS-10, a 10 kg LAr prototype detector. Afterwards, DS-50 with 50 kg fiducial mass, was installed underground at LNGS in 2013, inside an active neutron veto based on a boron-loaded organic scintillator, which is in turn installed inside a 1000 ton water Cherenkov muon veto. The acquisition started in Nov 2013, with the detector filled with atmospheric argon (AAr). This run demonstrated the extraordinary power of the pulse shape discrimination, by rejecting 1.5x10^7 events of ^{39}Ar in the WIMP search region. In April 2015, DS-50 was filled with low-radioactivity argon from underground sources and has been running in a stable manner since then. The 3 years exposure has allowed to reach the two milestones previously mentioned: the most stringent exclusion limits on WIMP-nucleon interactions in the [1.8, 6] GeV/c^2 mass range, and the capability to operate in complete background-free mode above 20 GeV/c^2.

Building on the successful experience of DS-50, the four world-leading argon dark matter projects (ArDM at LSC, DS-50 at LNGS, DEAP-3600 and MiniCLEAN at SNOLab) agreed on joining forces to carry out a **unified program forming the Global Argon Dark Matter Collaboration** (GADMC), for the next DarkSide phase, DS-20k [DS18b], a dual-phase LAr TPC with an active (fiducial) mass of 23 ton (20 ton), and the ultimate detector with 400 ton fiducial mass. The collaboration counts ~350 scientists from ~80 institutes, spread over 13 countries. DS-20k was approved by INFN, LNGS and NSF in 2017 and is officially supported by LNGS, LSC (Canfranc) and SNOLab (Canada). It is also a Recognized Experiment at CERN as RE37.



1) DS-50 limit and projected sensitivity of GADMC in the high-mass WIMP region

The LAr TPC will be deployed within an 8.5x8.5x8 m^3 cryostat, using the **same technology of DUNE**, based on a French patent by GTT. The cryostat will house 700 ton of LAr and 20 ton of Gd-loaded plastic scintillators, acting as active veto against muons and neutrons, respectively. This solution allows to host the entire TPC in an ultra-pure acrylic vessel, suppressing, *ab initio*, one of the dominant sources of radiogenic neutrons identified with DS-50: the steel cryostat. The other main source, the PMTs, will be substituted by 15 m^2 of silicon photomultipliers (SiPMs). The photosensing unit, developed by FBK in collaboration with DarkSide, will be a "photodetector module" (PDM), consisting of a large tile of SiPMs covering an area of 5x5 cm^2 and operating as a single detector. This solution offers several advantages: higher radiopurity and lower material mass than PMTs, very high quantum efficiency and fill factor (~40% photodetection efficiency), low noise (0.1-1 Hz/mm^2), and high single electron resolution.

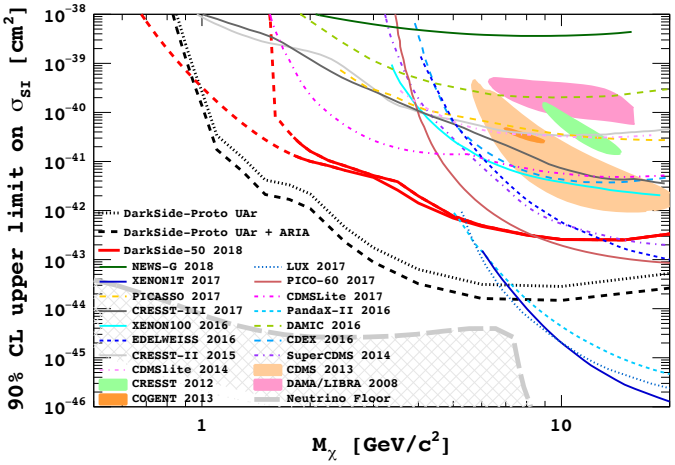
Such innovative design, along with the use of UAr, the LAr scintillation pulse shape discrimination, and the veto system, is the **key to unlocking the path to large LAr TPC detector masses, while maintaining an "instrumental background-free" experiment**, an experiment in which less than 0.1 events (other than ν-induced nuclear recoils) is expected to occur within the WIMP search region during the planned exposure. This will give sensitivity to WIMP-nucleon cross sections of 1.2×10^{-47} cm^2 for WIMPs of 1 TeV/c^2 mass, to be achieved during a 5 yr run producing an exposure of 100 t yr.

DS-20k will be more than two orders of magnitude larger than DS-50 in size and will use new technologies. Therefore the collaboration plans to build a **~1 ton mass prototype detector**, **DS-Proto**, incorporating the new technologies for their full validation. This effort will be completed in 2019 at CERN, with the support of the CERN Neutrino Platform. The recent DS-50 result has pushed the collaboration to reconsider DS-Proto as an experiment dedicated to the low-mass WIMP search, using the ionization channel only. For this reason, we are evaluating the possibility to install it at LNGS, after the commissioning at CERN, operating it in UAr mode. Sensitivity studies (see figure 2) have demonstrated that DS-Proto can extend current limits by more than one order of magnitude below 6 GeV/c^2.

In the high mass regime, the discovery potential of DS-20k could be boosted by a **directional signature**. This is under investigation within the collaboration with a dedicated R&D program, looking for a dependence of S1 and S2 on the recoil track direction with respect to the electric field.

For the procurement of UAr, the collaboration has defined a two-fold strategy: the **URANIA** project will extract and purify the UAr from the CO_2 wells at the Kinder Morgan Doe Canyon Facility located

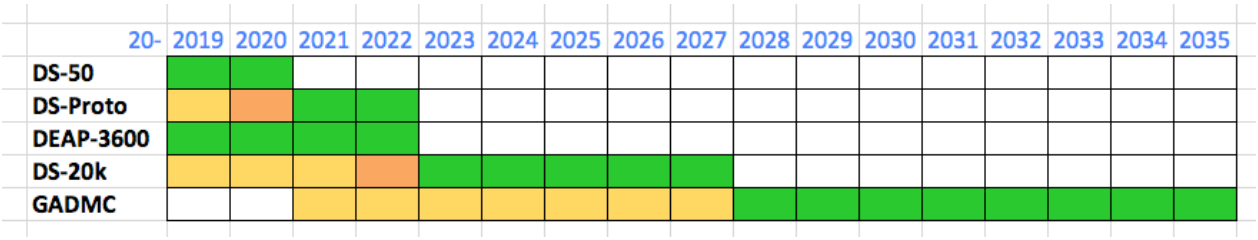
in Cortez, CO, at a production rate of 100 kg/day; the **ARIA** project will isotopically separate ^{39}Ar from ^{40}Ar thanks to a ~350 m tall distillation column, installed in the Seruci mine in Sardinia, able to process about 150 kg/day of argon. Performances of URANIA and ARIA in terms of ^{39}Ar depletion will be tested at CANFRANC with the **DART** project (conceived and designed by French groups), a small-scale chamber, immersed in the ArDM detector, which will be exploited as an active shielding against external background.



2) DS-50 limit and projected sensitivity of DS-Proto in the low-mass WIMP region

Finally, **DEAP-3600**, mostly thanks to the initiative of Art McDonald, has become part of the DarkSide program, as a consequence of the merging of the DarkSide and DEAP collaborations. After the end of the current data campaign with AAr, whose data are now accessible to the entire global collaboration, DEAP-3600, which operates in single-phase mode, will perform the first physics run with UAr at SNOLAB. SNOLAB is also the proposed lab for hosting GADMC, the ultimate dual-phase LAr detector, with 400 ton fiducial mass.

The following plot shows the DarkSide timeline. Yellow, orange, and green cells correspond to construction, calibration phases, and physics run, respectively. In particular, DS-Proto will run at CERN until 2020, and will be moved the year after to LNGS for the physics run. DS-20k will run in AAr mode in 2022.



3) DarkSide in France

In 2012, Pierre Binetruy, the former APC director, encouraged activities in the field of direct dark matter search, at that time a missing topic at the laboratory. A. Tonazzo and D. Franco (APC) have enthusiastically adhered to Pierre's initiative, because of their personal interest for such an intriguing subject, and to the proximity with underground neutrino physics, the field of origin of both researchers.

The perspectives of a LAr detector were welcomed at APC, and found a positive consensus also at IPHC with A. Meregaglia and C. Jollet, who contributed to the experiment until 2014. In the same year, C. Giganti and S. De Cecco from LPNHE joined the experiment. Recently, also P. Pralavorio and F. Hubaut from CPPM have expressed an interest toward DarkSide: discussion with the DarkSide management is ongoing, and the decision process, internal to CPPM, will end in a few months.

In 2012, we reported to this Conseil Scientifique the objectives we intended to pursue within DarkSide. In that presentation, we highlighted two items: photodetection with SiPM and simulations. It is worth to mention that **we have been the first, within DarkSide, to propose the use of SiPMs**. The idea arose from a discussion with A. Savoy-Navarro, an expert in the field, with whom we've tried to set up measurements to characterize SiPM behavior in cryogenic environment,

thanks to a BQR funding of ~12 kEuro. This effort is documented in reference [Pr13]. Although we've abandoned this line of research for lack of additional funding, the SiPM technology has been repurposed by other groups in DarkSide a couple of years later, becoming the baseline for the photo-detection in DS-20k.

The second item proposed to the Conseil Scientifique in 2012, the development of the DarkSide Monte Carlo, was aimed to mitigate the poor knowledge of the physical processes at the basis of scintillation and ionization processes in LAr. LAr primary scintillation, the main particle energy estimator, depends on a double mechanism: the direct excitation of argon molecules, and the recombination between electrons and ions. Both the processes lead to an excited state of the argon dimer. The WIMP signal is expected at very low energies, from zero to a few tens of keV, in a region where models are unable to predict the scintillation response, and where calibrations with radioactive sources are extremely challenging. In 2012, we had the insight that a high accuracy LAr response model would have boosted the DarkSide sensitivity. We have then produced a new Monte Carlo package, G4DS, embedding a custom made **LAr response model (PARIS)**. As described in detail in the next section, the expertise acquired investigating the LAr response brought us to acquire leading position in physics analyses. In addition, we have established collaboration with IPNO and performed **a beam test experiment (ARIS) at the ALTO facility**, confirming and extending the PARIS model, and providing the most accurate measurement of the nuclear recoil quenching factor in LAr.

This effort has been supported at APC by the France-Chicago FACCTS grant (15 kDollar) in 2014, and the France-Berkeley Fund (12 kDollar) and the LabEx UnivEarthS Jeune Equipe (JE2) project (150 kEuro) in 2015. The JE2 grant was further extended up to 2018 with additional ~10 kEuro. In addition, Prof. C. Galbiati, the spokesperson of DarkSide and full professor at Princeton University, participated to the activities at APC thanks to a 1-year invited professorship chair from Sorbonne Paris Cité in 2016 (112 kEuro). The LPNHE group has been supported with a local contribution from the lab of 16 kEuro, and with 0.2 FTE of a mechanical engineer in 2016, and 0.4 FTE of a software engineer between 2017 and 2018.

French responsibilities in DarkSide

D. Franco	Since 2016	WBS Level-1 Manager of the "Science, Simulations, and Computing" Work Package
	2015-2016	WBS Level-2 Manager of the "Simulation" Work Package
	2012-2015	Coordinator of the Monte Carlo group
	2014-2015	Member of the Steering Committee
	Since 2015	Member of the Technical Board
	Since 2014	Member of the Executive Board
C. Giganti	Since 2016	WBS Level-2 Manager of the "Science" Work Package
	Since 2016	Member of the Speakers' Bureau
P. Agnes	Since 2016	Member of the Editorial Board
	Since 2016	WBS Level-2 Manager of the "Simulation" Work Package
A. Tonazzo	2014-2015	Member of the Analysis Review Committee
A. Meregaglia	2013-2014	Member of the Speakers' Bureau

Three students have/are performed/performing their PhD in DarkSide at the STEP'UP doctoral school: P. Agnes (2013-2016), A. Navrer-Agasson (2016-2019), and M. Lai (2017-2020, in cotutelle with University of Cagliari). Q. Riffard was hired for a two-years post-doc at APC (2015-2017), P. Agnes spent two years (2016-2018) at APC as invited scientist, with a Houston U. fellowship, and L. Agostino at LPNHE with 1 year ATER in 2014. Finally, several NPAC master stages are organized every year. For the future, beyond a possible contribution from IN2P3, we will apply for a project within the renewal of LabEx UnivEarthS, if approved. In addition, a new partnership has been

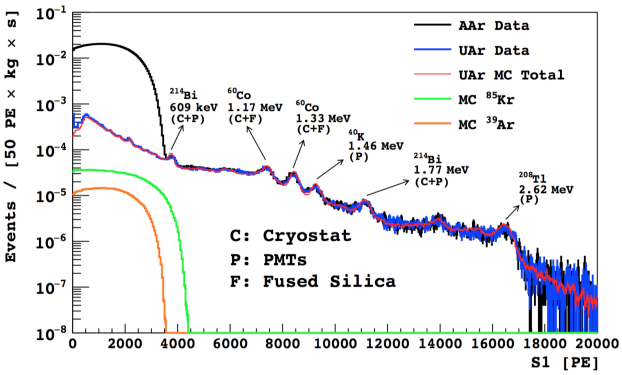
formalized between APC and ASTROCENT, a new Polish institute in Warsaw, ready to fund PhD fellowships within DarkSide in *cotutelle* with the STEP'UP doctoral school.

4) Main achievements

The French contribution to DarkSide, fundamental for the approval of DS-20k by NSF and INFN, spans over a wide range of experimental aspects from simulation development, reconstruction algorithms, and data analyses, to calibration, sensitivity studies, and dedicated measurements of LAr response. For reasons of space, we have selected a few of them, which better characterize our profile.

Monte Carlo and background model

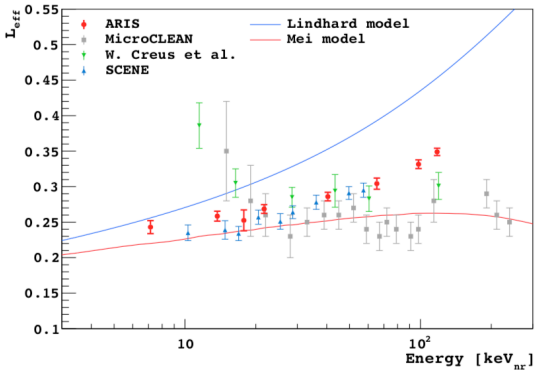
The core of G4DS [DS15], the DarkSide Monte Carlo entirely developed by the French teams, is the new LAr response model, named PARIS (Precision Argon Response Ionization and Scintillation). The essence of the PARIS approach is an empirical parametrization of the ion-electron recombination probability, which depends on the kinetic energy of the ionizing particle. The model is able to reproduce data at a few percent accuracy, demonstrated with internal and external calibration sources. It is worth to remark that G4DS/PARIS is able to reproduce also the detector resolution, without any additional artificial smearing, confirming that we are mastering the correct statistics governing the LAr photon emission. The effort in modeling the detector response represented the key for the successful evaluations of the ^{39}Ar depletion factor, quantified in ~1400, in underground argon, and the identification of the unexpected ^{85}Kr contamination [DS16]. The French teams, in fact, developed a custom-made multivariate fitter, with a binned likelihood estimator, based on full simulations of each background expected in DarkSide. The good agreement between contaminant concentrations in the different detector materials resulting from the fit and from material screening measurements, demonstrated the robustness of our approach. Furthermore, we have developed a TALYS–based extension of G4DS, to embed a radiogenic neutron generator, through which we evaluated the nuclear recoil background expected in DarkSide-50. Neutron predictions from G4DS have been recently confirmed by the flux measured in the veto [DS18c].



3) Result form the multivariate fit of UAr energy spectrum, and compared with the AAr one

ARIS: Argon Response Ionization and Scintillation

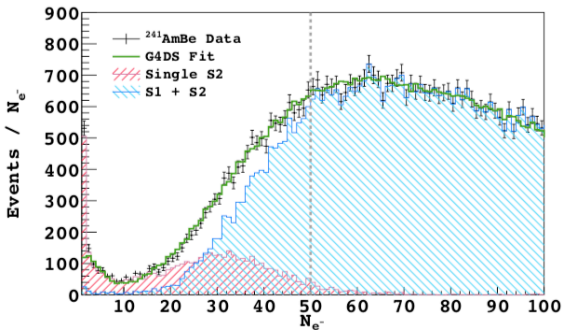
ARIS is a small-scale dual-phase TPC, exposed to a collimated neutron beam. The project was conceived to validate and extend PARIS, the LAr response model. To achieve this result, D. Franco led a collaboration of 11 institutes, from France, Italy, and US, counting 28 physicists, with the support of 5 engineers. ARIS was exposed to the LICORNE neutron source at the ALTO facility (IPNO) for 12 days in October 2016. LICORNE, unique in the world, produces a highly collimated, pulsed, and quasi-monoenergetic beam (~1.5 MeV) thanks to 14.6 MeV ^{7}Li ion interactions on a pure target of Hydrogen, through the p(^{7}Li,n)^{7}Be reaction. At the same time, 478 keV gammas are emitted by the ^{7}Li de-excitation, occasionally excited when interacting with the source materials. The beam thus



4) ARIS measurement of nuclear recoil quenching factor in LAr

guarantees a double signature: nuclear and electronic recoils from neutrons and Compton electrons perfectly disentangled thanks to the time-of-flight (TOF) technique. Eight neutron detectors, opportunely placed around the TPC, detect scattered neutrons and gammas, allowing for the kinematical reconstruction of the recoil energy in the LAr target.
This work [Ar18] has led to the most precise measurement and lowest energy probe of the quenching of the nuclear recoil scintillation efficiency in LAr (figure 4). In addition, Compton scattered electrons induced by gammas from $^{7}Li^{*}$ de-excitation allowed to constrain the light yield linearity for electron recoils at null field in the [40, 511] keV range within 1.6%, the most stringent constraint of the linearity of LAr scintillation response. The success of ARIS has allowed establishing and consolidating a fruitful collaboration with IPNO, which is now officially a technical partner of DarkSide, available to provide beam time and support for future ARIS-like measurements.

Low-mass dark matter search in DS-50



5) DS-50 calibration with AmBe source

The low-mass analysis, previously mentioned, is the byproduct of a close collaboration between APC, LPNHE, Princeton, and Sao Paolo University (USP). The USP group showed that DS-50 has high sensitivity to low mass WIMPs, by analyzing the ionization signal only with an analysis threshold of 100 eV_{ee} (100% trigger efficiency), and using the background model developed by APC and LPNHE. At that time, there was no candle able to calibrate the detector at such low energies. To overcome this issue, French teams have re-analyzed calibration data taken with AmBe (figure 5) and AmC neutron sources, deployed in the scintillator veto, outside the DS-50 cryostat. We have then developed a fitter based on Monte Carlo spectra, which allowed to measure the ionization yield down to 4 ionization electrons or ~100 eV_{ee} (23.4 eV per ionization electron). This calibration paved the way to the strongest exclusion limit of WIMP masses below 6 GeV/c^2 [DS18]. It is worth to stress that such result has broken the generally recognized direct dark matter search paradigm, for which noble liquid experiments were competitive only above 10 GeV/c^2, and solid state ones at the GeV/c^2 scale.

DS-20k veto

The first design of DS-20k foresaw the suppression of the neutron veto, assuming high rejection efficiency by fiducializing the LAr active mass. The French teams have demonstrated, with simulations, that a veto is unavoidable in order to guarantee the instrumental "background-free" condition and to maximize the UAr fiducial mass. As a consequence, we have driven the design of the new veto, to be integrated in the DUNE-like cryostat. Our conceptual design of the veto is based on a thick Gd-doped acrylic vessel, surrounding the TPC. The two LAr buffer regions, between the TPC and the acrylic and external to the acrylic, will be instrumented with photosensors to observe gammas from neutron capture on Gd. This design has been recently accepted as baseline for the veto by the collaboration.

Solar neutrino physics with GADM

The ultimate phase of DarkSide will see a giant detector, GADMC, with hundreds of tons of fiducial mass, which has the potential to explore solar neutrinos with high precision. In the current state of the art, solar CNO and low energy (<3 MeV) ^{8}B neutrinos have not been yet observed in real–time mode. We have explored [Fr16] the sensitivity of GADMC to solar neutrinos, assuming it is located at LNGS, and considering all cosmogenic and radiogenic backgrounds. Such an experiment can reach precisions at the level of ~2%, ~10%, and ~15% for the ^{7}Be, pep and CNO neutrino rates, respectively, with one-year exposure. These expectations can be compared to the best present

measurements of the first two components (4.6% and 21.6%), and the best upper limit for the CNO neutrinos (1.7-2.3 times the expected values, depending on the metallicity model) from Borexino. The recent proposal by our Canadian colleagues of locating GADMC at SNOLAB, which is deeper than LNGS, would further suppress the cosmogenic component of the background.

3Dπ: Positron Emission Tomography

At 40,000 photons/MeV, LAr light yield is much larger than that of the scintillating crystals commonly used for standard PETs. We have adapted G4DS to simulate 3Dπ, a total-body TOF-PET based on LAr and SiPM technology developed for DarkSide. Preliminary results indicate a resolution of 2 mm orthogonal to the LOR (line of response), and potentially a similar resolution also along the LOR, following filtered back projection analysis [Re18]. With these improvements, a better than tenfold reduction of the dose required for a PET scan would be possible. A significant reduction of the high dose currently required for PET scans would open up new possibilities for the screening of cancer patients. It would enable more frequent PET scans in adult patients and the adoption of PET scans for pediatric cancer patients.

5) Prospective in France and SWOT

The well recognized expertise acquired in France thanks to simulations, sensitivity studies, data analyses, and test beam measurements, places APC and LPNHE in a leading role in the recently formed Global Argon Dark Matter Collaboration, the largest collaboration in the direct dark matter search. Furthermore, the already mentioned exchange of technology between DUNE and DarkSide, supported by the CERN Neutrino Platform, places French teams in the ideal position to reinforce the cooperation between the two communities: from one side, our LAr model and expertise in photodetection in LAr detectors are of interest for DUNE; on the other, the DUNE-like cryostat adopted by DS-20k has been developed in France, and is in phase of commissioning for the two Proto-DUNE technologies.

In the following, we summarize the activities foreseen for the next years.

(a) **DS-50 and DS-20k design**

We are currently involved in the following activities that will be finalized in the next months:

- Improvement of DS-50 background model at low energies and, consequently, of the low-mass WIMP limit. In addition, we have already implemented models for extracting limits on axions and ALPs (A. Navrer-Agasson, PhD).
- DS-20k sensitivity to Supernova neutrinos looking at coherent scattering, charge current, and elastic scattering (M. Lai, PhD).
- Characterization of the LAr time response with ARIS.
- DS-20k veto design and background budget.

In view of DS-20k, we are strongly interested in collaborating with the CERN Neutrino Platform in the commissioning and calibration of DS-Proto and R&Ds to enhance LAr light collection in the DS-20k TPC and veto.

(b) **DS-Proto**

DS-Proto, once installed at LNGS, will have a large potential in low-mass WIMPs, being 20 times larger than DS-50 and equipped with SiPMs. DS-Proto operations at CERN will be devoted to validating the technology. This will be particularly challenging, because of the high cosmic ray flux expected aboveground. We intend to contribute to the calibration strategy mainly based on the detection of cosmic muons detected in coincidence with a scintillator-based telescope, and on the injection of gaseous ^{83m}Kr. In order to optimize the S2 signal, in terms of amplification and

uniformity of the response, essential for future low-mass measurements, we are investigating a single electron source, extracted from a metal target, via photoelectric effect using LED photons.

(c) **R&Ds on LAr light collection**

The presence of TPB, the wavelength shifter, deposited on the detector inner surfaces, induces non-uniformity in the light collection in large LAr target like DS-20k and its veto. Simulations of such effect are complicate because of the required large CPU-time. This problem is of priority also for DUNE. Thanks to our expertise in optical simulations and modeling LAr response, we intend to collaborate with DUNE colleagues (we are already in contact with Universities of Manchester and of Campinas) to define a strategy to optimize such kind of simulations. In addition, in collaboration with the CERN Neutrino Platform, we intend to investigate the possibility to directly dope LAr with TPB, as it has been done with TMG molecule in ICARUS. This solution, which can be of interest for both DS-20k and DUNE, would increase the probability to convert UV in the visible range, and consequently improve uniformity in the light collection.

The close collaboration with the newly Polish institute, ASTROCENT, funded by EU, member of DarkSide, and partner of APC, will provide us next year a PhD student *in cotutelle*. We are also defining an agreement with University of Sao Paolo for another PhD *in coutelle*. For the future, we will apply for an extension of JE2 within the renewal of the LabEx UnivEarthS. Approval from IN2P3 with a contribution on a regular basis, mainly covering mission costs, would allow to secure proposed activities.

Strengths	**Opportunities**
- Well recognized expertise in LAr modeling, data analysis, simulations with leadership roles - Experience with LICORNE neutron beam and support by IPNO - Attraction of PhD students and post-doc funded by other institutions	- Discovery potential in low and high mass WIMPs - Access to the DEAP-3600 data - Cooperation with DUNE - Medical imaging (3Dπ PET) - Dark matter directionality
Weakness	**Threats**
- Difficulty in having access to technical support - Limited manpower	- Budgetary constraints

[Ar18] *Measurement of the liquid argon energy response to nuclear and electronic recoils,* P. Agnes et al. (ARIS Collaboration), Phys. Rev. D97 (2018) 11 112005

[DS15] *Simulation of argon response and light detection in the DarkSide-50 dual phase TPC*, DarkSide Collaboration, JINST 12 (2017) P10015

[DS16] *Results from the first use of low radioactivity argon in a dark matter search*, DarkSide Collaboration, Phys. Rev. D 93, 081101 (2016)

[DS18] *Low-mass Dark Matter Search with the DarkSide-50 Experiment*, DarkSide Collaboration, Phys. Rev. Lett. 121 (2018) 081307

[DS18b] *DarkSide-20k: A 20 Tonne Two-Phase LAr TPC for Direct Dark Matter Detection at LNGS*, DarkSide Collaboration, Eur. Phys. J. Plus 133 (2018) 131.

[DS18c] *DarkSide-50 532-day Dark Matter Search with Low-Radioactivity Argon*, DarkSide Collaboration, arXiv:1802.07198 (2018).

[Fr16] *Solar neutrino detection in a large volume double-phase liquid argon experiment*, D. Franco *et al.*, JCAP 1608 (2016) 8, 017

[Pr13] D. Prêle, D. Franco *et al.*, *SiPM cryogenic operation down to 77 K*, 10th International Workshop On Low Temperatures Electronics, 30-34 (2013), https://hal.archives-ouvertes.fr/hal-00932628

[Re18] A. Renshaw, *Simulations of 3Dπ performance and presentation of white paper*, talk at 3Dπ Meeting, June 2018 at GSSI, https://indico.gssi.it/event/7/