Prospects for SIMPLE 2000: A large-mass, low-background Superheated Droplet Detector for WIMP searches

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Abstract

SIMPLE 2000 (Superheated Instrument for Massive Particle searches) will consist of an array of eight to sixteen large active mass (\textasciitilde 15 g) Superheated Droplet Detectors(SDDs) to be installed in the new underground laboratory of Rustrel-Pays d’Apt. Several factors make of SDDs an attractive approach for the detection of Weakly Interacting Massive Particles (WIMPs), namely their intrinsic insensitivity to minimum ionizing particles, high fluorine content, low cost and operation near ambient pressure and temperature. We comment here on the fabrication, calibration and already-competitive first limits from SIMPLE prototype SDDs, as well as on the expected immediate increase in sensitivity of the program, which aims at an exposure of \textasciitilde 25 kg-day during the year 2000. The ability of modest-mass fluorine-rich detectors to explore regions of neutralino parameter space beyond the reach of the most ambitious cryogenic projects is pointed out.

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Apfel extended the Bubble Chamber concept with the invention of Superheated Droplet Detectors (SDDs, also known as Bubble Detectors), a dispersion of small drops (radius \( \sim 10 \ \mu m \)) of superheated liquid in a gel or viscoelastic matrix. The SDD matrix isolates the fragile metastable system from vibrations and specially from convection currents (absent in gels), while the smooth liquid-liquid interfaces impede the continuous triggering on surface impurities that occurs in the walls and gaskets of even the cleanest bubble chambers. A physically-sound metaphor for the gained SDD stability over bubble chambers is the improvement that was brought on by dynamite over nitroglycerine: in SDDs, the lifetime of the superheated system is extended to the point that new practical applications such as personnel and area neutron dosimetry become possible.

In the moderately superheated industrial refrigerants used in SDDs, bubbles can be produced only by particles having elevated stopping powers \((dE/dx \gtrsim 200 \text{ keV}/\mu \text{m})\) as is the case for low-energy nuclear recoils. This behavior is described by Seitz’s classical “thermal spike” model: for the transition to occur, a vapor nucleus or “protobubble” of radius \( r_c \) must be created, while only the energy deposited along a distance comparable to this critical radius \( r_c \) is available for its formation. Hence, a double threshold is imposed: the requirement that the deposited energy \( E \) be larger than the thermodynamical work of formation of the critical nucleus, \( E_c \), and that this energy be lost by the particle over a distance \( O(r_c) \), i.e., a minimum stopping power. Protobubbles formed by energy depositions not meeting both demands simply shrink back to zero; otherwise, the transition is irreversible and the whole droplet vaporizes. Formally expressed, these two conditions become:

\[
E > E_c = \frac{4\pi r_c^2 \gamma}{3\epsilon} \\
dE/dx > E_c/\alpha r_c,
\]

where \( r_c = 2 \gamma/\Delta P, \gamma(T) \) is the surface tension, \( \Delta P = P_v - P \), \( P_v(T) \) is the vapor pressure of the liquid (generally an industrial refrigerant), \( P \) and \( T \) are the operating pressure and temperature, \( \epsilon \) varies in the range \([0.02, 0.06]\) for different liquids, and \( \alpha(T) \sim O(1) \). The parameter \( \epsilon \) is of particular importance in the calculation of the minimum recoil energy that needs to be transferred in a neutron (or WIMP) collision for a bubble to form, given that in most cases these recoils have a sufficiently high \( dE/dx \) to pass the second requirement. The physical meaning of \( \epsilon \) is often misinterpreted by modern authors as a somewhat undefined fraction of deposited energy available for protobubble formation. The reality (well-known during the bubble chamber era) is different: making \( \epsilon = 1, \) \( E_c \) as calculated in Eq. (1) becomes equal to the minimum (Gibbs) bubble expansion work, a gross but convenient underestimate of the actual work of bubble formation. Examining the process in detail, \( E_c \) can be recalculated as the much larger sum of the reversible works of bubble surface formation, evaporation of the liquid and expansion against \( P \):

\[
E'_c = \frac{4\pi r_c^2 \gamma}{3} \left( \gamma - T \frac{\partial \gamma}{\partial T} \right) + \frac{4}{3} \pi r_c^3 \rho_v h_{fg} \frac{h_{fg}}{M} + \frac{4}{3} \pi r_c^3 P,
\]

where \( \rho_v \) is the saturated vapor density, \( h_{fg} \) is the latent heat of vaporization per mole and \( M \) the molecular mass. By making

\[
\epsilon = \frac{4\pi r_c^2 \gamma}{3E'_c},
\]
Eq. (1) acquires a compact form but leads to the mentioned conceptual misunderstanding. It must be emphasized that $\epsilon$ as correctly defined in Eq. (3) is not a free parameter; it can be accurately calculated for each refrigerant and operating conditions (Fig. 1) and compared with experimental measurements (see below).

The second condition in Eq. (1) can be exploited to avoid the background from ubiquitous minimum-ionizing radiation that plagues experiments aiming to detect WIMP-induced nuclear recoils (WIMPs are one of the best candidates for the galactic dark matter [7]). SDDs of active mass $O(1)\text{kg}$ can in principle considerably extend the present experimental sensitivity [8] well into the region where new supersymmetric particles are expected. The low interaction rate expected from these particles ($<10$ recoils/kg target mass/day) and the modest active mass of commercially available SDDs ($\sim 0.03 \text{ g refrigerant/dosimeter}$), together with a desire to control and understand the fabrication process, lead us to develop in collaboration with COMEX-PRO [9] a large-volume (80 $l$) pressure reactor dedicated to SDD production. Able to withstand 60 atm, it houses a variable-speed magnetic stirrer, heating and cooling elements and micropumps for the addition of catalysts whenever chemical cross-linking of the gel is required. We have nevertheless favored thermally-reversible food gels such as agarose, gelatine, $\kappa$-carrageenan, etc., due to safety concerns in the handling of large volumes of synthetic monomers. The fabrication of 1 $l$ SDD modules containing up to 3% in superheated liquid starts with the preparation of a suitable gel matrix; the constituent materials must be carefully selected and processed in order to avoid alpha emitters, the only internal radioactive contaminants of concern [8]. A still with all contact parts made of quartz and teflon is used to produce high-purity bidistilled water. Unfortunately, a very precise density matching between the matrix and refrigerant is needed to obtain a uniform droplet dispersion, making water-based gels inadequate unless large fractions of inorganic salts are added, which can unbalance the chemistry of the composite and contribute an undesirable concentration of alpha-emitters [10]. We find that glycerol is for this and other reasons an additive of choice. The gelating agent, polymer additives and glycerol are purified using a pre-eluted ion-exchanging resin specifically targeted at actinide removal. All components are forced through 0.2 $\mu m$ filters to remove motes that might act as nucleation centers. The resulting mixture is outgassed and maintained in the reactor above its gelation temperature. The refrigerant is single-distilled prior to its incorporation to this solution, which is done at a pressure well above $P_V(T)$ to avoid boiling during the vigorous stirring that follows (Fig. 2). After a uniform dispersion of droplets is obtained, cooling, setting and step-wise adiabatic decompression produce the delicate entanglement of superheated liquid and thermally-reversible gel that makes up the SDD. Numerous practical precautions, to be described elsewhere, go into producing stable modules; for instance, the step-wise decompression procedure used is identical to that employed by scuba-divers returning to the surface, in order to minimize the cavitation of dissolved gas bubbles which in SDDs can act as inhomogeneous nucleation centers. The detectors are refrigerated and pressurized under 4 atm during storage and transportation, to inhibit their response to environmental neutrons.

While SDDs can bypass the mentioned problems associated to a former [11] bubble chamber WIMP search proposal, they are not devoid of their own idiosyncrasies. During the R&D leading to the first SIMPLE modules, we have been able to identify and solve some of the SDD particularities that can interfere with a successful WIMP search. For instance, the appearance of fractures in the gel and depletion of active mass over long exposures
via permeation processes, or the formation of clathrate-hydrates at the droplet boundaries
during fabrication or recompression (these are crystalline structures able to destroy the
metastability of the droplets). These detector improvements have been treated at some
length elsewhere [12] and are summarized here in table 1. The objective was to keep the
detector components down to a minimum for reasons of radiopurity, safety and cost, while
solving the condensed-matter issues as they appeared. Of special mention are the gains in
detector stability brought by the transition from R-12 (CCl₂F₂) to R-115 (C₂ClF₅) (see table
1). Present SIMPLE modules contain ∼ 1000 times the active mass of available commercial
SDDs (limited only by the size of the pressure reactor) and can be operated continuously
for up to ∼ 40 d. Even though a further extension of this shelf life is intended, the design
of recompression chambers that would allow for an indefinite exposure is under study. The
cost of the SDD matrix has been kept down, allowing for a much larger future design.

Prototype modules have been tested in an underground gallery 40 km south of Paris. The
27 m rock overburden and ∼30 cm paraffin shielding reduce the flux of cosmic and muon-
induced fast neutrons, the main source of nucleations above ground. Inside the shielding, a
water+glycol thermally-regulated bath maintains T constant to within 0.1°C. The character-
istic violent sound emission accompanying vaporization in superheated liquids [13,14] is
picked-up by a small piezoelectric transducer in the interior of the module, amplified and
saved in a storage oscilloscope. Special precautions are taken against acoustic and seismic
noise. Fig. 3 displays the decrease in spontaneous bubble nucleation rate brought by pro-
gressive purification of the modules, as measured in this site. The ability to rapidly modify
the fabrication process and the choice of components has been critical in achieving this.

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| component | features | goal |
|-----------|----------|------|
| water     | • immiscible with most H-free refrigerants<br>• bi-distilled (quartz and teflon still) | CHEMICAL COMPATIBILITY<br>RADIOPURITY |
|           | • density matching between sol & freon<br>• viscosity enhancer<br>• solvent behavior similar to water<br>• excellent wetting of glass surfaces<br>• low U+Th content and easy to purify<br>• does not crystallize at low T<br>• germicide<br>• strengthens gelatine gels | SDD HOMOGENEITY<br>FRACTURE CONTROL (DIFFUSION ↓)<br>CHEMICAL COMPATIBILITY<br>ABSENCE OF NUCLEATIONS ON WALLS<br>RADIOPURITY<br>LACK OF INHOMOGENEOUS NUCLEATIONS<br>NO NEED TO ADD PRESERVATIVES<br>STRUCTURAL STABILITY |
| glycerin  | • viscosity enhancer<br>• surfactant<br>• salting-out agent at low %<br>• kinetic inhibitor at low %<br>• compatible with gelatine gels<br>• chelating agent | FRACTURE CONTROL<br>SDD HOMOGENEITY<br>FRACTURE CONTROL (SOLUBILITY ↓)<br>ABSENCE OF CLATHRATE-HYDRATES<br>CHEMICAL COMPATIBILITY<br>STOPS α-EMITTER MIGRATION TO DROPLET BOUNDARIES |
| PVP       | • forms compliant gel in $T$ range<br>• non-toxic<br>• low U+Th (depends on organ origin) | STRUCTURAL STABILITY<br>SAFETY<br>RADIOPURITY |
| gelatine  | • 62% F (twice as much as R-12)<br>• non-toxic, non-flammable<br>• much lower solubility than R-12<br>• much larger molecule than R-12<br>• higher $P_V$ than R-12<br>→ allows operation at lower $T$ | HIGHER WIMP SENSITIVITY<br>SAFETY<br>CONTROL OF FRACTURES AND ACTIVE-MASS LOSSES<br>CLATHRATES IMPOSSIBLE, DIFFUSION ↓<br>FRACTURE CONTROL, DIFFUSION ↓ |
| R-115     | • operation at 2 atm | FRACTURE CONTROL<br>KEEPS RADON OUT |
| ($C_2ClF_5$) | | |


therefore delimited by vertical lines in Fig. 3: the sudden rise at \( T \sim 15^\circ C \) originates in high-\( dE/dx \) Auger electron cascades following interactions of environmental gammas with Cl atoms in the refrigerant \([4,18,19]\). The calculated \( E_c \) for R-115 at \( T = 15.5^\circ C \) and \( P = 2 \) atm is 2.9 keV, coincidental with the binding energy of K-shell electrons in Cl, 2.8 keV (i.e., the maximum \( E \) deposited via this mechanism). Thus, the onset of gamma sensitivity provides an additional check of the threshold in the few keV region.

Regrettably, alpha calibrations cannot be used for a rigorous determination of the overall sound detection efficiency because a large fraction of the added emitters drifts to gel-droplet boundaries during fabrication, an effect explained by the polarity of actinide complex ions \([20]\). We observe that this effect is seemingly dependent on matrix composition (the migration can be controlled to some extent by the addition of chelating polymers such as PVP, which can link to the actinides while becoming themselves immobilized by entanglement in the gel structure). While this migration does not alter the expected value of \( T_\alpha \) nor \( T_{\alpha r} \), it enhances the overall nucleation efficiency in a somewhat unpredictable manner \([20]\). To complete our understanding of the detector efficiency, SIMPLE modules have been exposed to a well-characterized \( ^{252}\text{Cf} \) neutron source at the TIS/RP calibration facility (CERN). The resulting spectrum of neutron-induced fluorine recoils (Fig. 5, insert) mimics a typically expected one from WIMP interactions. A complete MCNP4a \([21]\) simulation of the calibration setup takes into account the small contribution from albedo and thermal neutrons. The expected nucleation rate as a function of \( T \) is calculated as in \([8,15]\): cross sections for the elastic, inelastic, \((n,\alpha)\) and \((n,p)\) channels of the refrigerant constituents are extracted from ENDFB-VI libraries. Look-up tables of the distribution of deposited energies as a function of neutron energy are built from the SPECTER code \([22]\) and stopping powers of the recoiling species are taken from SRIM98 \([23]\). Since \( T \) was continuously ramped up during the irradiations at a relatively fast \( 1.1^\circ C/hr \), a small correction to it (<1°C) is numerically computed and applied to account for the slow thermalization of the module. Depending on \( T \), the value of \( E_{\text{thr}} \) for fluorine elastic recoils (the dominant nucleation mechanism in R-115) is set by either condition in Eq. (1), the other being always fulfilled for \( E > E_{\text{thr}} \) \([8,17]\). The handover from the second to the first condition at \( T \) above \( \sim 5.5^\circ C \) (\( \sim 2.5^\circ C \)) for \( P = 2 \) atm (\( P = 1 \) atm) is clearly observed in the data as two different regimes of nucleation rate (Fig. 5). A larger-than-expected response, already noticed in R-12 \([3]\), is evident at low \( T \): the calculated \( E_{\text{thr}} \) there is too conservative (too high). This behavior appears well below the normal regime of SDD operation (which is at \( T \) high enough to have \( E_{\text{thr}} = E_c \)) and therefore does not interfere with neutron or WIMP detection. However, it is interesting in that it points at a higher than normal bubble nucleation efficiency from heavy particles, as discussed in early bubble chamber work \([19]\). It is precisely at low \( T \) that the spontaneous nucleation rate in low-background conditions is the smallest. Therefore this effect, which could greatly improve SDD WIMP limits, merits further attention: calibrations using filtered neutron beams of energies \( 2 \pm 0.8, 24.3 \pm 2, 55 \pm 2 \) and \( 144 \pm 24 \) keV available at the research reactor of the Nuclear and Technology Institute (Sacavem, Portugal) are planned as part of the SIMPLE 2000 effort. A best-fit to the overall normalization of the Monte Carlo over the full data set (Fig. 5) enables us to determine the refrigerant mass monitored with the present sound acquisition chain as \( 34 \pm 2\% \) (74 \pm 4\%) of the total at \( P = 2 \) atm (\( P = 1 \) atm), a decisive datum to obtain dark matter limits.

The installation 500 m underground of modules identical in composition, preparation
and sound detection system to those utilized in $^{252}\text{Cf}$ calibrations started in July 1999 (Fig. 6). A decommissioned nuclear missile launching control center has been converted into an underground laboratory [24], facilitating this and other initiatives. The characteristics of this site (microphonic silence, unique electromagnetic shielding of the halls [24]) make it specially adequate for rare-event searches. Modules are placed inside a thermally-regulated water bath, surrounded by three layers of sound and thermal insulation. A 700 l water pool acting as neutron moderator, resting on a dual vibration absorber, completes the shielding. Events in the modules and in external acoustic and seismic monitors are time-tagged, allowing to filter-out the small percentage ($\sim 15\%$) of signals correlated to human activity in the immediate vicinity of the experiment. The signal waveforms are digitally stored, but no event rejection based on pulse-shape considerations [10] is performed at this stage, avoiding the criticisms [25] associated to some WIMP searches in which large cuts to the data are made. The raw counting rate from the first SIMPLE module operated in these conditions appears in Fig. 7. Accounting for sound detection efficiency and a $62\%$ fluorine mass fraction in R-115, limits can be extracted on the spin-dependent WIMP-proton cross section $\sigma_{Wp}$ (Fig. 8). The cosmological parameters and method described in [26] are used in the calculation of WIMP elastic scattering rates, which are then compared to the observed uncut nucleation rate at $10^5^\circ\text{C}$ ($14^\circ\text{C}$ for small WIMP masses). The expected nucleation rate at $T$ (i.e., integrated for recoil energies above $E_{\text{thr}}(T)$) from a candidate at the edge of the sensitivity of the leading DAMA experiment [27] ($\sim 1.5 \cdot 10^4$ kg-day of NaI) is offered as a reference in Fig. 7: evidently, with the same level of background but significantly smaller statistical error bars, this candidate could have been marginally excluded. Present SIMPLE limits are impaired by the large statistical uncertainty associated to the short exposure accumulated so far, and not yet by background rate. A considerable improvement is expected after the ongoing expansion of the bath to accommodate up to 16 modules (Fig. 8). SIMPLE 2000 aims at an exposure of $\sim 25$ kg-day in the next few months, by replacing the detectors (in batches of eight) every four to six weeks, repeating this cycle several times. A weak Am/Be neutron source will be used at the end of each run to assess the sound detection efficiency for each module in situ. In parallel to this, plastic module caps are being replaced by a sturdier design: runs using refrigerant-free modules show that a majority of the prototype events arose from pressure microleaks, correlated to the sense of $T$ ramping, able to stimulate the piezoelectric sensor (Figs. 7 and 9). In principle, if this source of background is controlled, the maximum sensitivity of SIMPLE 2000 can start to probe the spin-dependent neutralino parameter space (Fig. 8). It must also be kept in mind that a $T$–independent, flat background implies a null WIMP signal, albeit this eventual approach to data analysis can only be exploited after a sizable reduction in statistical uncertainty is achieved.

The importance of the spin-dependent WIMP interaction channel, for which fluorine-rich detectors are by far the optimal target [28], has been recently underlined by its relative insensitivity to CP-violation parameter values, which may otherwise severely reduce coherent (i.e., spin-independent) interaction rates [29]. To further stress the significance of this channel, we illustrate in Fig. 10 a not-so-obvious complementarity of spin-dependent and spin-independent searches in exploring the neutralino phase space. The top-left frame displays points generated with the help of the NEUTDRIVER code [4], each representing a possible combination of MSSM parameters. The parameter space sampled is the same as in [30] (namely, $10\text{ GeV} \leq M_2 \leq 10\text{ TeV}, 10\text{ GeV} \leq |\mu| \leq 10\text{ TeV}, 1.1 \leq \tan(\beta) \leq 50, 60$
GeV $\leq m_A \leq 1$ TeV, 100 GeV $\leq m_0 \leq 1$ TeV) and special precautions are taken to do so as homogeneously as possible, within the limitations imposed by computing time. Only a weak correlation between the values of $\sigma_{Wp}$ (i.e., the spin-dependent coupling strength, corrected for local halo density) and $\sigma_{Wn}$ (spin-independent) is observed in the plot (note the scale). As a result of this, a compact ($\sim 1$ kg active mass), low-background SDD starting to probe the neutralino $\sigma_{Wp}$ (top-right frame) generates a rather homogeneous “cleaning” of the MSSM models in a $\sigma_{Wn}$ exclusion plot (bottom-left frame, without the constrains imposed by the limits in top-right; bottom-right with them), down to values of $\sigma_{Wn}$ far beyond the reach of the most ambitious planned cryogenic WIMP searches. This can be counter-intuitive for the hardcore experimentalist, which might otherwise naively expect the SDD to take only a small bite off the top of the $\sigma_{Wn}$ cloud in the lower-left frame (in other words, might expect much more of a correlation between $\sigma_{Wp}$ and $\sigma_{Wn}$). Needless to say, the converse can be stated of the way that cutting-edge spin-independent searches will deplete the $\sigma_{Wp}$ cloud and hence the complementarity of both approaches. In conclusion, if an exhaustive test of the neutralino-as-cold-dark-matter hypothesis is ever to be achieved, the development of fluorine-rich detectors cannot be neglected: in this respect SDDs represent an ideal opportunity.

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FIG. 1. Calculated $\varepsilon$ for R-115 ($C_2ClF_5$, solid red lines) and R-12, ($CCl_2F_2$, dashed blue lines) as a function of $P,T$. 
FIG. 2. Schematic representation of the fabrication process of a R-12 SDD. The blue region denotes the liquid phase of the refrigerant, pink is for gas. Their boundary (dotted line) traces $T(PV)$. As a result of the adiabatic crossing of $T(P_V)$, the refrigerant remains in the (superheated) liquid state. The horizontal division between the sol and gel states of the matrix is only approximate, since melting and gelation temperature are not the same. The fabrication path changes radically for other refrigerants.
FIG. 3. SDD background at 90 m.w.e. and $P=2$ atm, following cumulative steps of cleansing: histogram: double distillation of water and microfiltration, $\bullet$: single distillation of refrigerant and glycerin purification, $\circ$: gelatine and PVP purification. Vertical lines separate three different regimes of background dominance (see text).
FIG. 4. High-$dE/dx$ recoiling Np daughters (emitted simultaneously to $^{241}$Am alpha decay in the gel) suffer energy losses prior to their arrival to a neighboring droplet, resulting in a moderated energy spectrum (top) that falls in the same regime where WIMP recoils are expected (few tens of keV). These recoils provide an opportunity to check the calculation of the minimum energy required for bubble formation ($E_c$, Eqs. 1-3): experimentally (bottom), the operating temperature $T_{or}$ above which they are able to produce nucleations is seen to vary with $P$ following closely the theoretical predictions (dashed lines).
FIG. 5. $^{252}$Cf neutron calibration of SIMPLE modules at the TIS/RP bench (CERN), compared with Monte Carlo expectations (dotted lines, see text). The signal-to-noise ratio was $> 30$ at all times. *Insert*: calculated energy spectrum of F recoils during the irradiations.
FIG. 6. SIMPLE at 1,500 m.w.e.  Left: DAQ system and water temperature controlling system. Middle: first 9.2 g R-115 module being immersed in the 700 l of water used as neutron moderator; sound and $T$ insulating layers of the shielding are apparent. Right: entrance to the experimental hall. The Cu-Be contacts that close the Faraday cage are visible on the rim of the door.

FIG. 7. Counting rate in the first SIMPLE module installed in Rustrel (9.2 ± 0.1 g R-115, $\Delta T = -0.75^\circ$C/day). The top axis displays the calculated threshold energy for bubble nucleation from fluorine recoils. The blue dotted line indicates the average level of spurious background observed in refrigerant-free runs (see text). The red dashed line is the expected signal (accounting for 34% sound detection efficiency and F fraction) from a WIMP of mass $m_\chi = 10$ GeV and $\sigma_{Wp} = 5$ pb, i.e., at the limit of sensitivity of the DAMA experiment: present SIMPLE limits are largely limited by low statistics.
FIG. 8. 95% C.L. limits on $\sigma_{Wp}$ extracted from only 0.19 kg-day of SDD exposure, compared with other experiments [26]. The red lines indicate the expected sensitivity of SIMPLE 2000 after an exposure of 25 kg-day, if no improvement in the background is obtained (dashed line) or at the maximum reachable level for this exposure (zero background, solid red line off the scale). “MSSM” marks the tip of the region where a lightest supersymmetric partner is expected.
FIG. 9. Signal and noise in present SIMPLE modules: the pulse shape (top-left) corresponds to a typical bubble nucleation, with a dominant frequency of $\sim 5$ kHz (top-right shows its Fourier transform) and time span of few ms. During runs with refrigerant-free “dummy” modules, similar signals (bottom-left) are observed arising from pressure microleaks in plastic SDD caps, at a rate of $\sim 1$/day. Even at atmospheric pressure, a residual rate of $\sim 0.3$/day characteristic EM noise events (bottom-right) is present. As a first measure, sturdier metallic SDD caps have been built and all non-essential equipment (PC, water chiller) is to be moved outside of the Faraday cage. The sharply-resonant piezoelectric sensors presently employed will eventually be substituted by others with a flatter spectral response, allowing for univocal identification of the nucleation sounds.
FIG. 10. A fluorine-rich SDD of modest active mass (O(1) kg), the ultimate goal of the SIMPLE program, will be sensitive to neutralino WIMP candidates beyond the reach of the most ambitious planned cryogenic experiments (see text).