Materia Oscura:
Instrumentation Development to Observe the Invisible

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GCRF Project Kick-Off Meeting,
UNAM, Mexico City, MX
October 22, 2018

Outline

1. What is GCRF?
2. Why Focus on Lead
3. Overview of the Materia Oscura Project
4. Goals for this Meeting

Outline

1. **What is GCRF? The Global Challenges Research Fund.**
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What is GCRF?

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund announced by the UK Government to support cutting-edge research that addresses the challenges faced by developing countries. The Fund forms part of the UK's Official Development Assistance (ODA) commitment which is monitored by the Organisation for Economic Cooperation and Development (OECD). ODA funded activity focuses on outcomes that promote the long-term sustainable growth of countries on the OECD Development Assistance Committee (DAC) list and is administered with the promotion of the economic development and welfare of developing countries as its main objective. The Fund is being administered by delivery partners including, the four national academies and the UK Research Councils:

- Academy of Medical Sciences
- British Academy
- Royal Academy of Engineering
- Royal Society
- Arts and Humanities Research Council
- Biotechnology and Biosciences Research Council
- Economic and Social Research Council
- Engineering and Physical Sciences Research Council
- Medical Research Council
- Natural Environment Research Council
- Science and Technology Facilities Council
- Research Councils UK

What is GCRF?

The fund can support research capacity building to address the development issues, for example, to increase the skills and knowledge base and support the development of the research capability within developing countries. Capacity building should be aimed at improving the ability to undertake and disseminate research in order to promote the welfare and economic development of the developing countries.

Key ODA compliance issues to note

Any GCRF proposal must make it clear that its primary purpose is to promote the economic development and welfare of a developing country or countries. Applicants should:

- Seek to investigate a specific problem or seek a specific outcome which will have an impact on a developing country or countries on the DAC list;
- Use the strengths of the UK to address the issue, working in collaboration with others as appropriate;
- Demonstrate that the research is of an internationally excellent standard;
- Identify appropriate pathways to impact to ensure that the developing country benefits from the research.

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Why Focus on Lead?

The motivation for growing capacity for and developing new lead measurement techniques is that lead pollution is the #1 cause of loss of life expectancy in the world, and currently 2 of the top 10 worst pollution problems in the world are associated with lead[1]. This is a problem both in LMICs and in high income countries— recent examples like the Flint, Michigan, USA, water safety breaches demonstrate that water quality in violation of WHO guidelines can happen anywhere, and information about water quality, and its variation in time, is not widespread. Even 'clean' technologies, like electric cars, employ traditional lead-based batteries; the disposal of these batteries is a leading contributor to lead pollution, particularly in LMICs.

PURE EARTH

Statistics:

- Childhood lead exposure is estimated to contribute to **600,000 new cases globally** of children with intellectual disabilities every year.
- Lead exposure is estimated to account for **143, 000 deaths per year, or 0.6% of the global burden of disease,** with the highest burden in developing regions.

Why Focus on Lead?

5,300 U.S. water systems are in violation of lead rules

By Sara Ganim, CNN

Updated 1050 GMT (1850 HKT) June 29, 2016

Water

Millions exposed to dangerous lead levels in US drinking water, report finds

New report says Flint water crisis is not an anomaly, as analysis reveals 5,363 water systems – providing drinking water to 18 million – breached federal laws

Why Focus on Lead?

http://www.worstpolluted.org/

Why Focus on Lead?

Lead exposure accounts for over 850,000 deaths each year due to long-term effects on health, with the highest burden in LMICs. The Institute for Health Metrics and Evaluation also estimates that lead exposure accounts for 9% of the global burden of idiopathic intellectual disability, 4% of the global burden of ischaemic hearth disease, and 7% of the global burden of stroke[1]. Children absorb more lead and are particularly vulnerable, with early childhood exposure known to lead to behavioral problems in adolescence, IQ decrements, cognitive impairment, and decreased visuospatial skills. Although there is no known level of lead exposure considered to be safe, lead and other heavy metals are still widely used in the production of consumer goods. In LMICs, inadequate regulation, informality of many industries, poor surveillance, and improper disposal of contaminants can result in dangerous exposures to nearby residents[2]. Mexico is the world's 5th largest producer of lead and 40% of its production is used locally in various industrial processes that cause lead contamination of the environment. Argentina similarly suffers from environmental exposure and lack of adequate or timely quantification of hazards or exposure.

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[1] Institute for Health Metrics and Evaluation (IHME). GBD Compare.

[2] https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0151-y

[3] "Low Background Gamma Spectroscopy at the Boulby Underground Laboratory", arXiv:1708.06086 (2017)

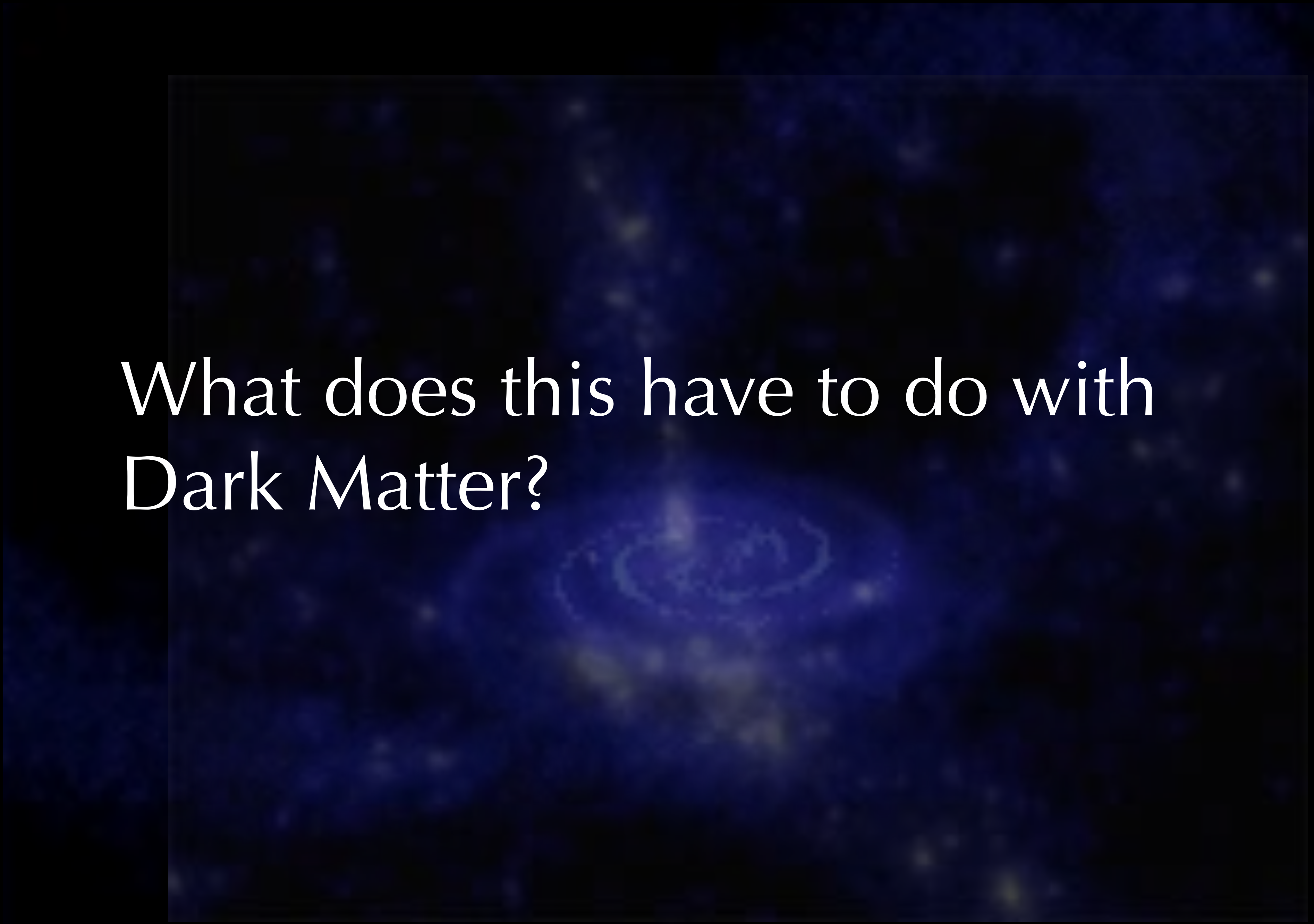
[4] "Ultra-low background background mass spectrometry for rare event searches, arXiv:1708.08860 (2017)

How Much Lead Matters to Human Health?

History of guideline development

The 1958 WHO *International Standards for Drinking-water* recommended a maximum allowable concentration of 0.1 mg/l for lead, based on health concerns. This value was lowered to 0.05 mg/l in the 1963 International Standards. The tentative upper concentration limit was increased to 0.1 mg/l in the 1971 International Standards, because this level was accepted in many countries and the water had been consumed for many years without apparent ill effects, and it was difficult to reach a lower level in countries where lead pipes were used. In the first edition of the *Guidelines for Drinking-water Quality*, published in 1984, a health-based guideline value of 0.05 mg/l was recommended. The 1993 Guidelines proposed a health-based guideline value of 0.01 mg/l, using the PTWI established by JECFA for infants and children, on the basis that lead is a cumulative poison and that there should be no accumulation of body burden of lead. As infants are considered to be the most sensitive subgroup of the population, this guideline value would also be protective for other age groups. The Guidelines also recognized that lead is exceptional, in that most lead in drinking-water arises from plumbing, and the remedy consists principally of removing plumbing and fittings containing lead. As this requires much time and money, it is recognized that not all water will meet the guideline immediately. Meanwhile, all other practical measures to reduce total exposure to lead, including corrosion control, should be implemented. JECFA reassessed lead and confirmed the previously derived PTWI. The guideline value of 0.01 mg/l was brought forward to the third edition of the Guidelines, published in 2004. In the fourth edition of the Guidelines, published in 2011, the guideline value of 0.01 mg/l was retained, but it was made provisional on the basis of treatment performance and analytical achievability. This change

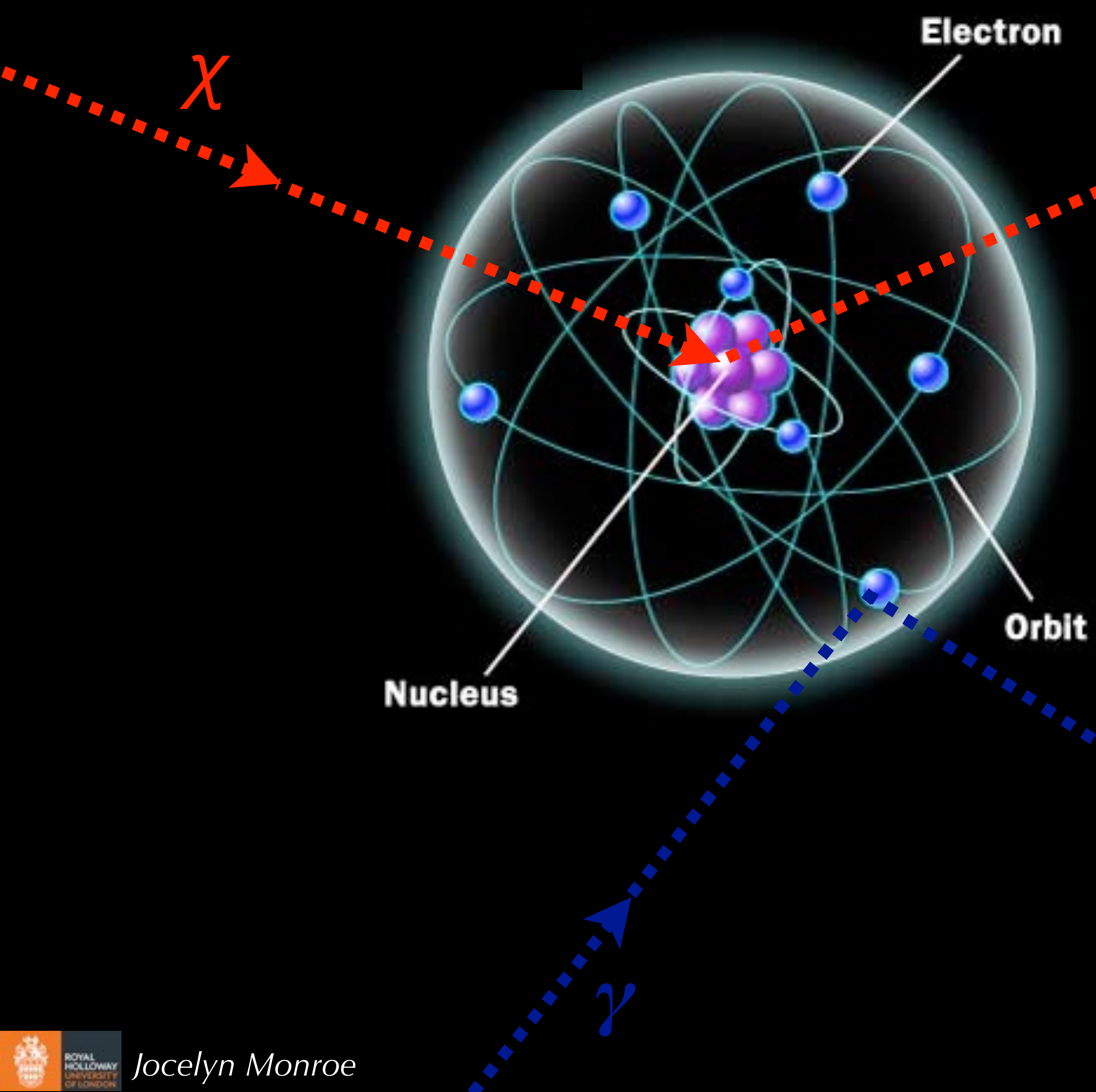
0.01 mg/l = 1E-5 g Pb/1E3 g water = 1e-8 g/gm = 0.01 ppm



What does this have to do with Dark Matter?

Direct Detection of Dark Matter

Signal: $\chi \, N \rightarrow \chi \, N$



Backgrounds:

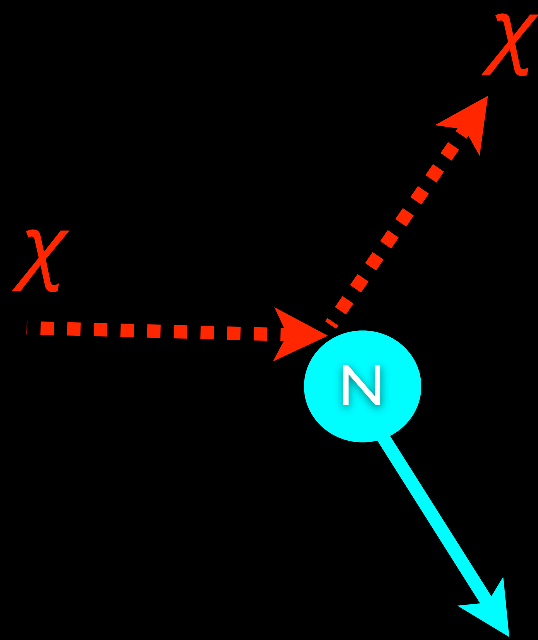
$\gamma \, e^- \rightarrow \gamma \, e^-$

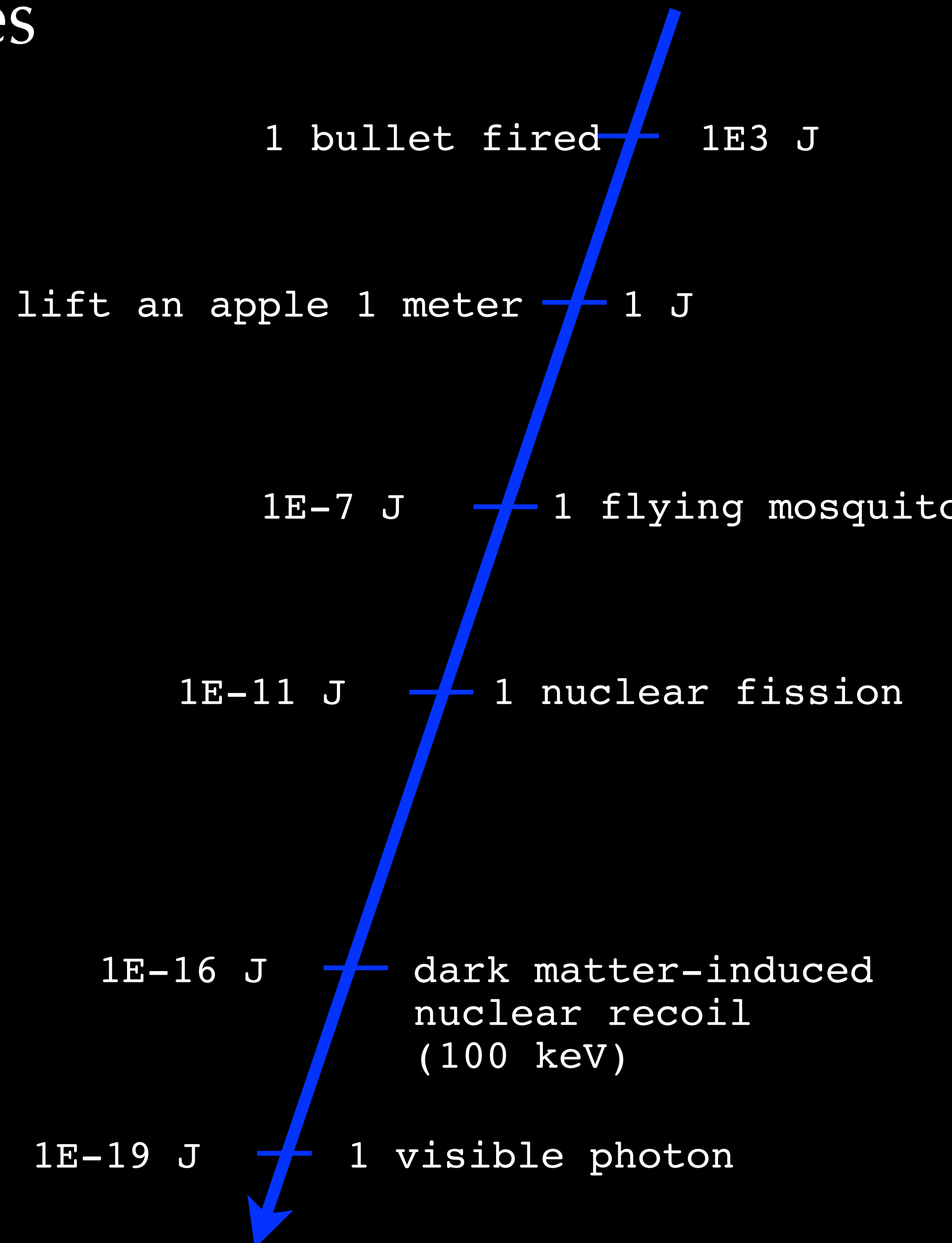
$n \, N \rightarrow n \, N$

$N \rightarrow N' + \alpha, e^-$

$\nu \, N \rightarrow \nu \, N$

Observable: Small Energies

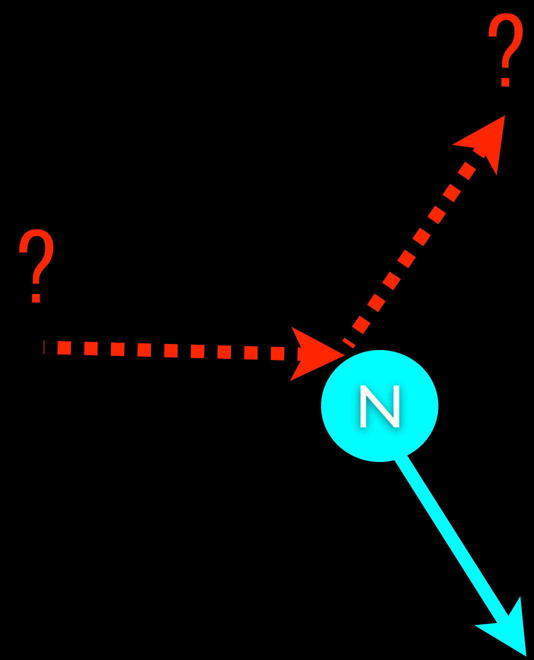




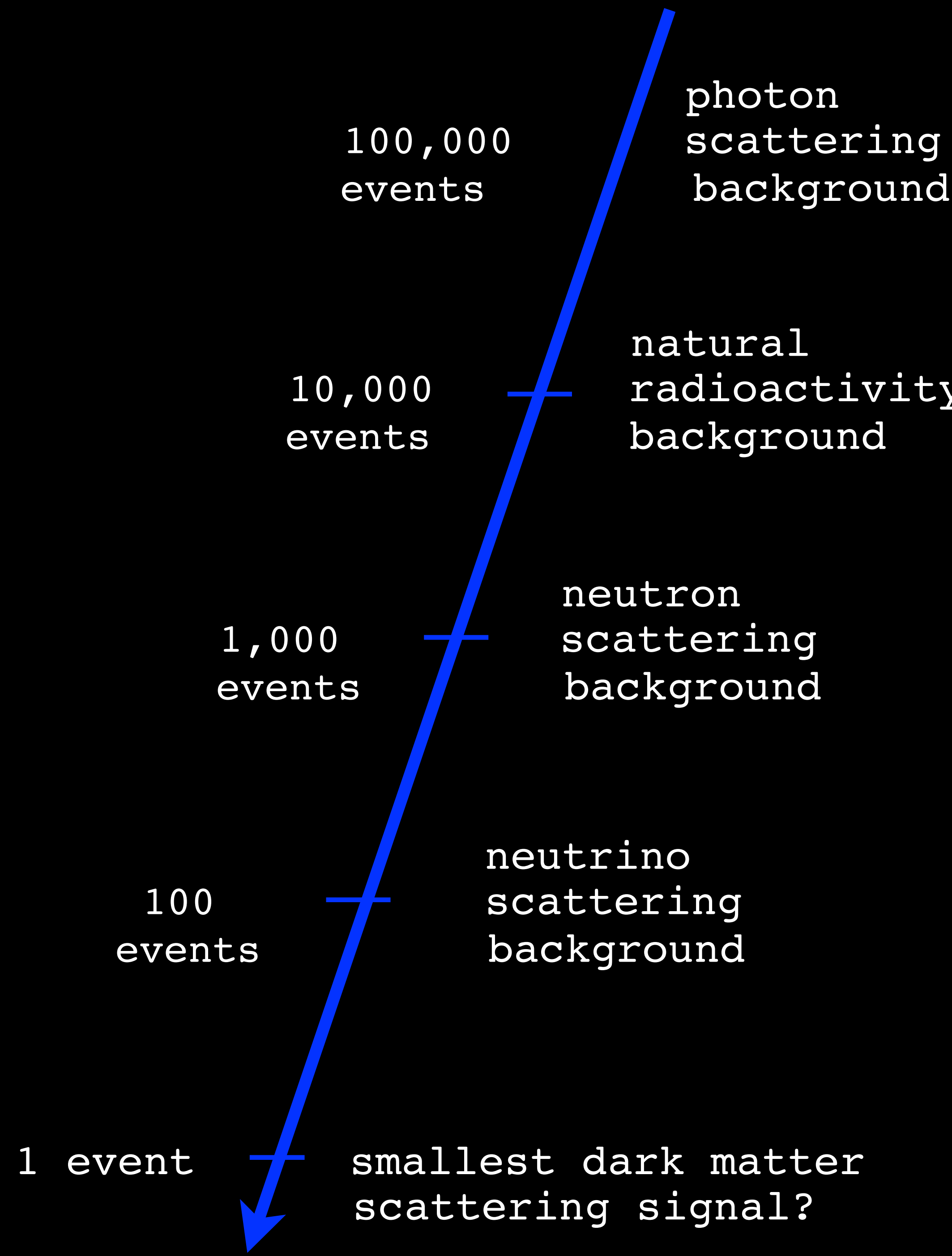
Recoil Nucleus Kinetic Energy

… and Tiny Event Rate

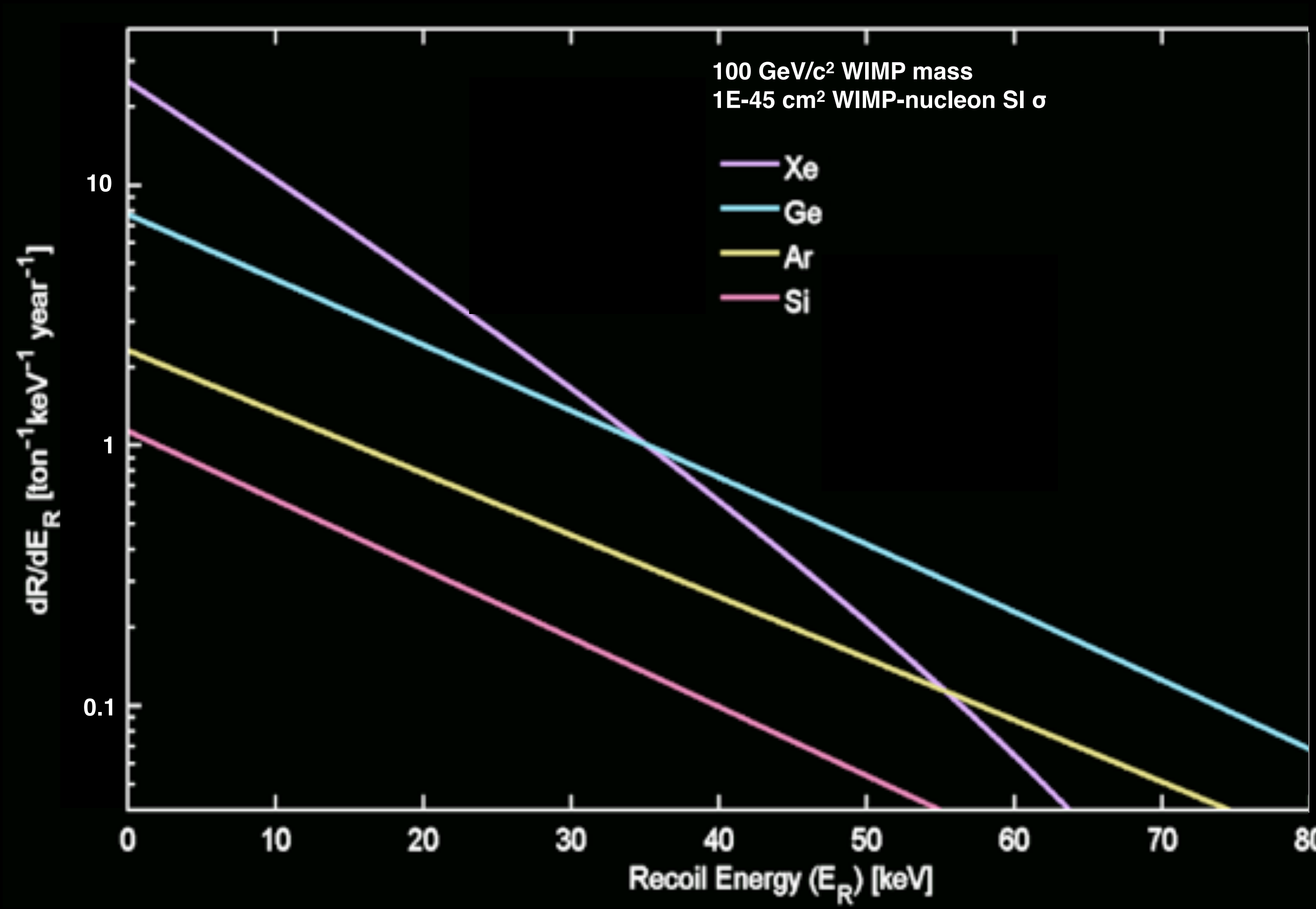
In dark matter experiments…



Anything else that does this can fake a dark matter signal!



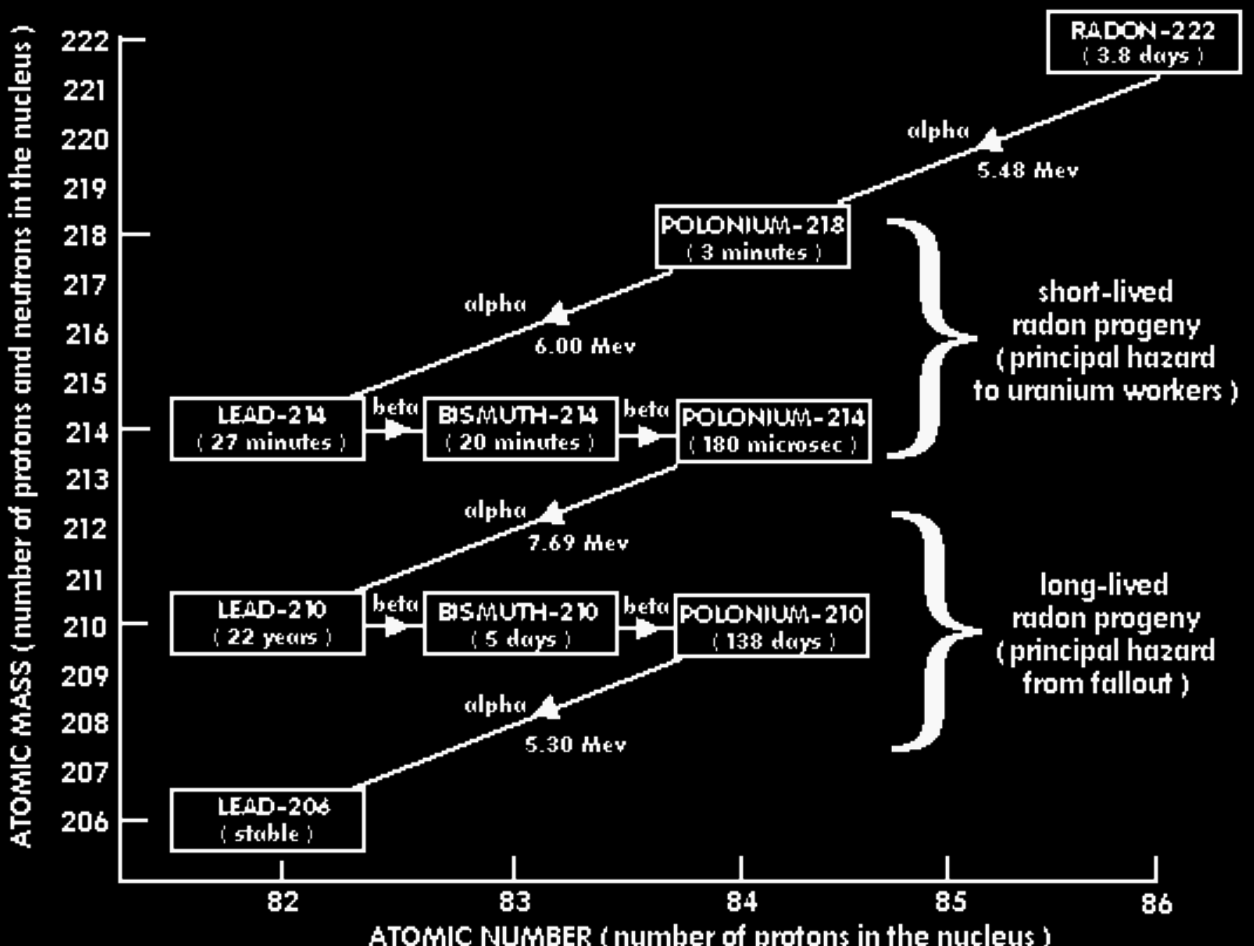
Rate vs. Energy



*Challenge: detecting **rare** events with **small** energies!*

Why Detecting Small Concentrations is Important

Can't shield a detector from uranium and thorium present in trace amounts inside detector materials, however daughters and associated decay particles can mimic dark matter signals…



so dark matter experiments "screen" to identify low-radioactivity materials.

Material Screening, Example

Table 8: ^{222}Rn emanation results for components used in the I 3600 detector contained within the stainless steel shell. A desc for many of the components can be found in Section 4. Unc ties arise from counting, sample emanation times, and detect trapping efficiency.

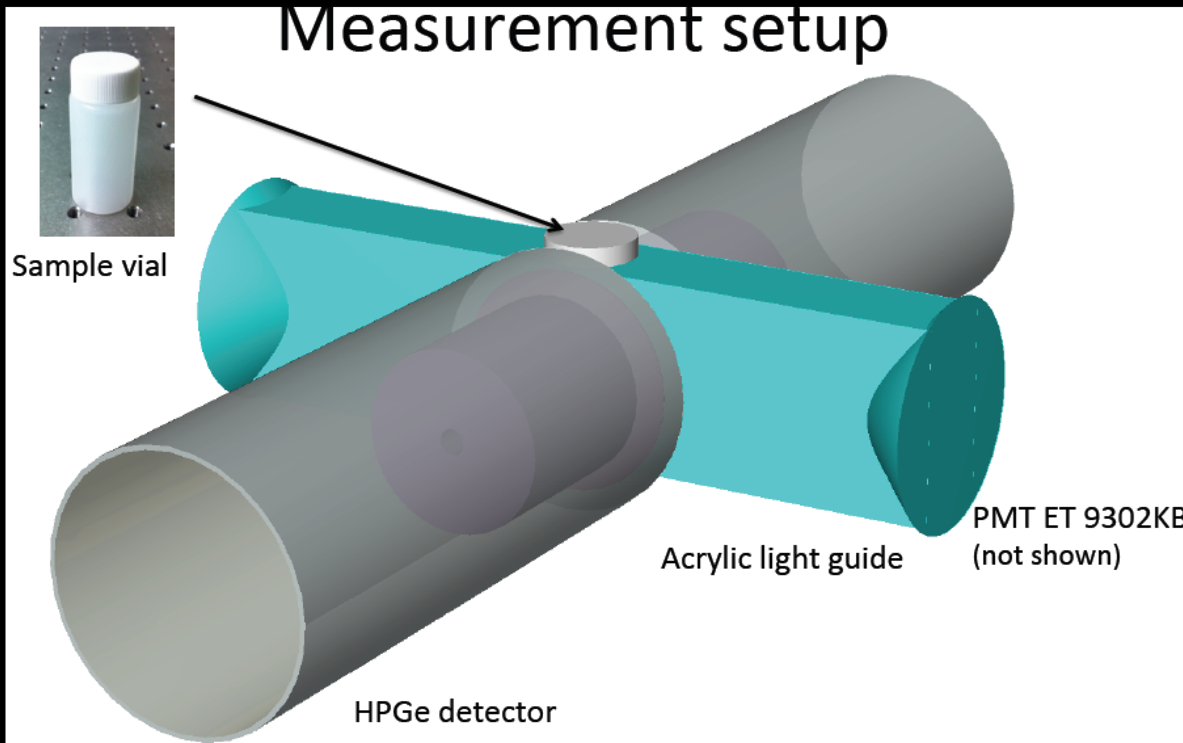
Source	Emanation
	[mBq/m^2]
Filler blocks	1.6 ± 0.5
FINEMET PMT magnetic shielding [37]	0.8 ± 0.2
ESR film reflector [2]	< 2.2
Tyvek diffuse reflector	< 0.1
Black tyvek absorber	0.4 ± 0.2
PMT mount PVC (McMaster-Carr stock)	< 0.7
PMT polyethylene foam	< 0.9
Teflon sheets (McMaster-Carr stock)	0.4 ± 0.2
High density polyethylene pipe	3.5 ± 0.8
304 Stainless Steel (McMaster-Carr stock)	< 1.6
Carbon steel (McMaster-Carr stock)	0.6 ± 0.1
White PMT mount adhesive styrofoam sheet	< 1.5
Stycast 1266 A/B (Emerson & Cuming)	< 4.2
	[mBq/m]
RG59 PMT cable (Belden E82241)	0.026 ± 0.001
Steel shell EPDM O-ring	16.1 ± 1.8
Viton O-ring	1.3 ± 0.2
Buna 451 O-ring	17 ± 2
	[mBq/unit]
Hamamatsu R5912 PMTs	< 0.3
PMT mount O-ring	0.3 ± 0.1

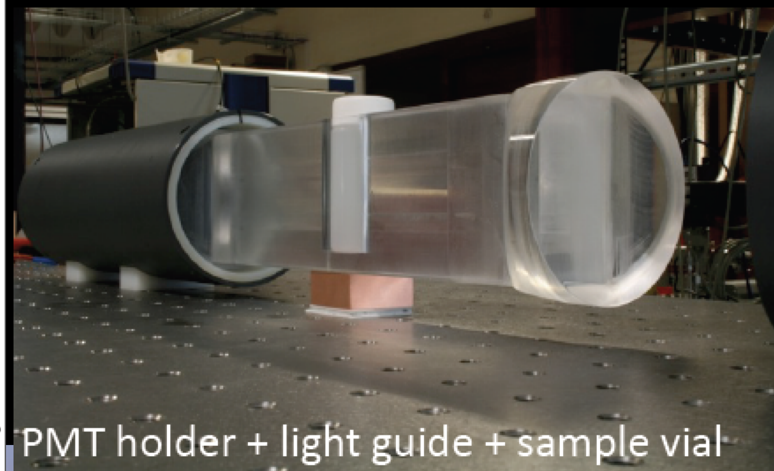
Table 7: Gamma assay results for tooling used during construction and manufacture of detector components. Activities are reported with 1-sigma uncertainties. A 90% confidence limit is placed when the measurement is below the background sensitivity of the detector. It is assumed that secular equilibrium is broken between ^{230}Th and ^{226}Ra in the ^{238}U decay chain.

Component	^{238}U$_{lower}$	^{238}U$_{upper}$	^{232}Th	^{235}U
	[mBq/kg]			
Purification System Welding				
TIG weld sample	7.7 ± 5.7	< 27	25.2 ± 7.8	< 16
SMAW weld sample	< 23	< 1255	51.9 ± 12.2	< 13
Welding electrodes A (Blue Demon TE2C-116-10T)	221 ± 65	< 493	1890 ± 184	< 56
Welding electrodes B (Blue Demon TE2C-116-10T)	66.6 ± 42.6	< 1300	710 ± 103	< 138
Welding electrodes C (Blue Demon TE2C-116-10T)	86.1 ± 21.8	< 642	911 ± 73	< 108
Weld filler rods	< 4.8	< 157	3.0 ± 2.5	< 1.8
Inner AV Sanding				
Brazed diamond sanding pad (Superabrasives)	141 ± 24	< 845	49.8 ± 17.9	31 ± 19
Plated diamond sanding pad (Superabrasives)	4680 ± 283	< 4130	6180 ± 300	218 ± 64
3M 6002J flexible diamond pads	25.1 ± 15.4	< 785	< 10.8	< 33
Diamond sandpaper (Diamante Italia)	3120 ± 136	< 2300	3370 ± 125	157 ± 22
Red sandpaper (RPT)	48.7 ± 19.7	< 335	< 10.1	< 32
LG Acrylic Polishing				
Diamond lapping film (3M 661X)	142 ± 38	< 882	93.6 ± 35.0	< 31
Diamond lapping film (3M 661X)	94.0 ± 16.5	< 276	$105. \pm 18.1$	< 33
Component	^{238}U$_{lower}$	^{238}U$_{upper}$	^{232}Th	^{235}U
	[mBq/kg]			
Methyl methacrylate monomer (LG bonding)	1.4 ± 1.0	< 15	< 0.9	< 1.8
AV acrylic	< 0.1	< 2.2	< 0.5	< 0.2
Acrylic beads (RPT)	< 3.1	16 ± 15	0.8 ± 0.3	0.6 ± 0.5
LG acrylic	< 0.1	< 9.0	< 0.3	< 0.6
304 welded stainless steel (steel shell)	1.4 ± 1.1	< 5.0	4.7 ± 1.5	< 3.3
304 stainless steel stock (steel shell)	2.1 ± 1.1	40 ± 56	1.9 ± 1.1	< 5.4
316 stainless steel bolts (steel shell)	< 6.1	< 315	94 ± 9	< 17
Carbon steel (stock)	2.0 ± 0.7	111 ± 43	10.0 ± 1.0	8.6 ± 1.9
R5912 HQE PMT glass	921 ± 34	225 ± 114	139 ± 7	25 ± 3
R5912 HQE PMT ceramic	978 ± 56	15500 ± 2800	245 ± 28	503 ± 51
R5912 HQE PMT feedthrough pieces	1140 ± 60	2350 ± 1460	430 ± 32	38 ± 9
R5912 HQE PMT metal components	< 5.5	–	< 3.3	–
RG59 PMT cable (Belden E82241)	4.5 ± 1.3	91 ± 46	1.2 ± 0.9	3.4 ± 1.4
PMT mount PVC (Harvel)	72 ± 5	232 ± 130	18.6 ± 2.5	5.6 ± 1.5
PMT mount copper	< 0.5	< 10	< 0.8	< 1.3
Filler block polyethylene	0.4 ± 0.3	< 14	< 0.1	< 0.15
Filler block Styrofoam [39]	33.5 ± 3.4	115 ± 64	< 1.5	< 1.4
White Tyvek paper (diffuse reflector)	< 0.3	50 ± 37	1.3 ± 0.8	< 2.2
Black Tyvek paper (LG wrapping)	< 1.8	< 127	5.6 ± 2.3	< 3.8
Black polyethylene tube (upper neck)	13.7 ± 1.8	< 60	3.2 ± 1.1	2.6 ± 1.4
TPB (Sigma Aldrich)	< 3.9	–	< 8.7	–

Developing New Screening Techniques, Example

Target Pb-210 concentration in DEAP-3600 experiment is 1E-21 gm of Pb-210 per gm of acrylic!
x20 below sensitivity of current techniques, so developed new method to achieve this:



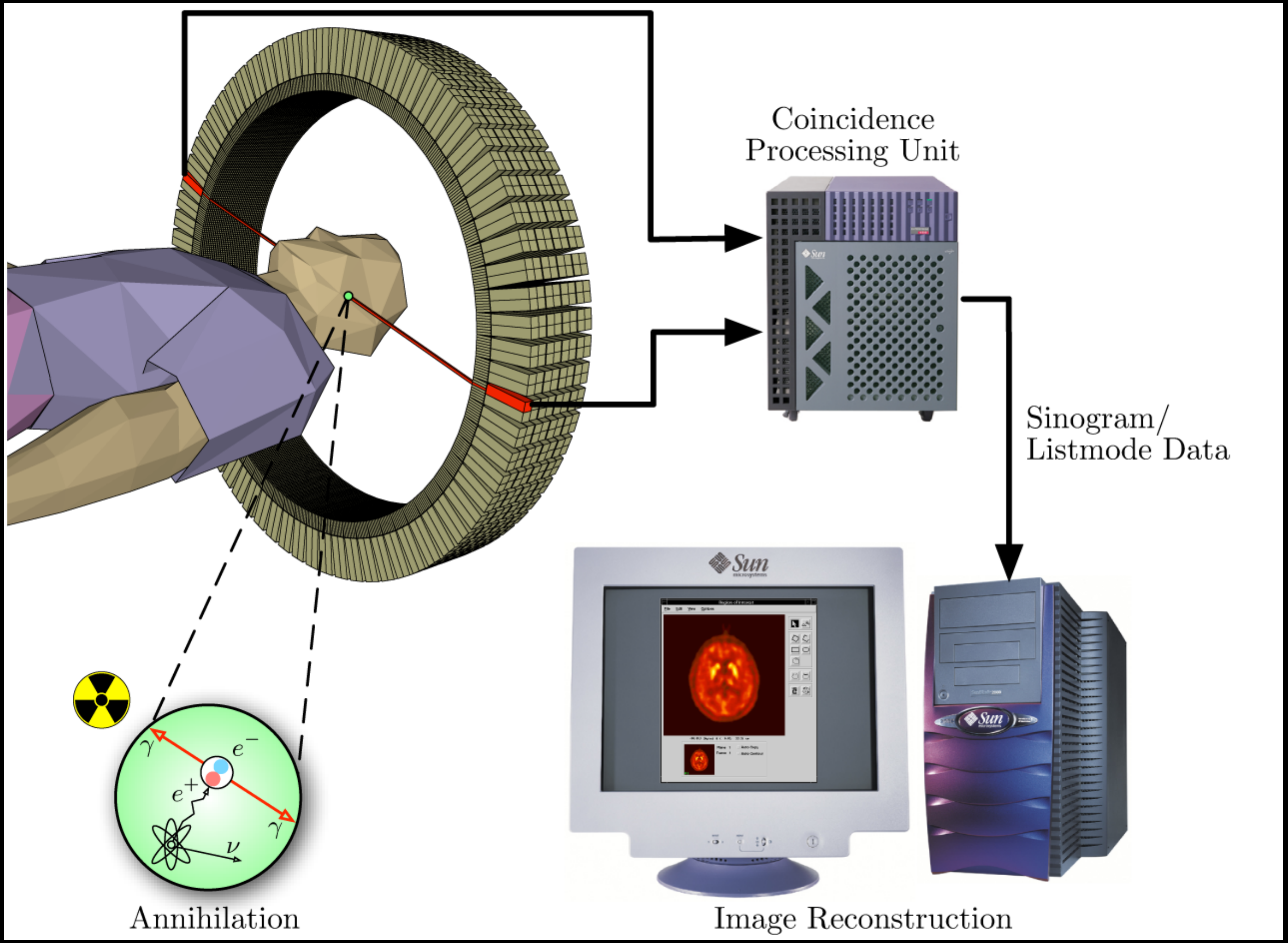


17 keV beta *and*
46.5 keV gamma,
measured in
coincidence system,
at Boulby Laboratory
M. Widorski (2015)

Is it plausible that Particle Astrophysics techniques can address global challenges?

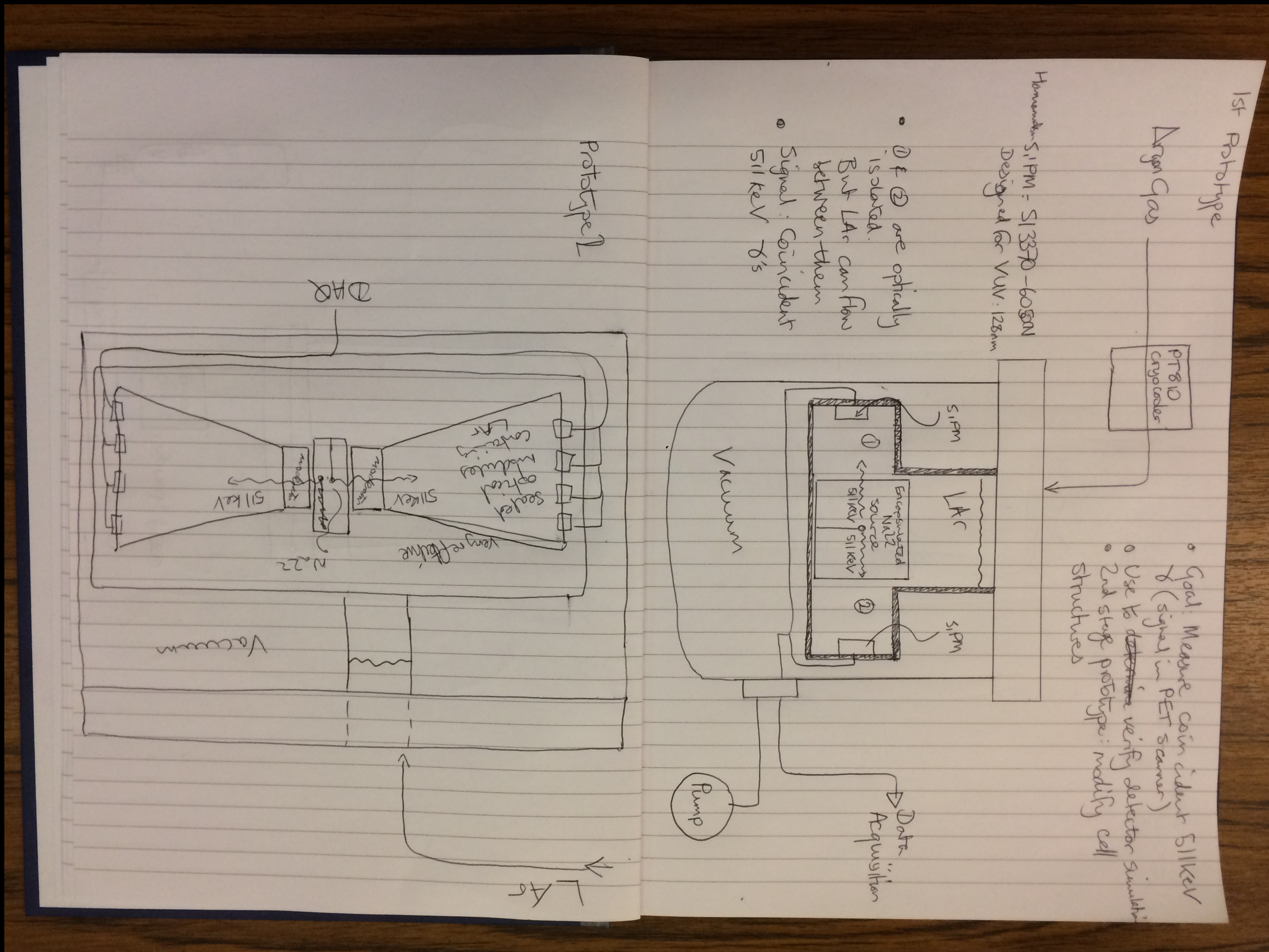
Positron Emission Tomography

nuclear medicine functional imaging technique,
observes metabolism of a tracer taken by the patient in the body



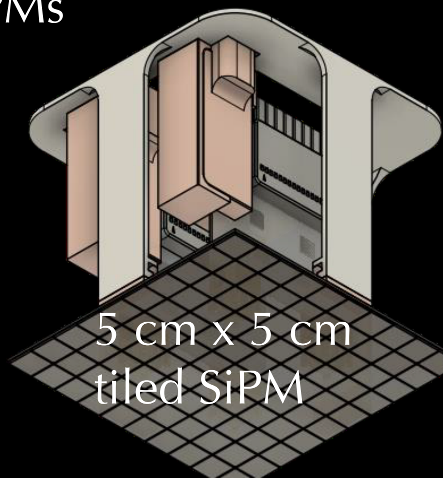
Smaller Energies = Earlier Detection

many dark matter research groups exploring liquid noble PET

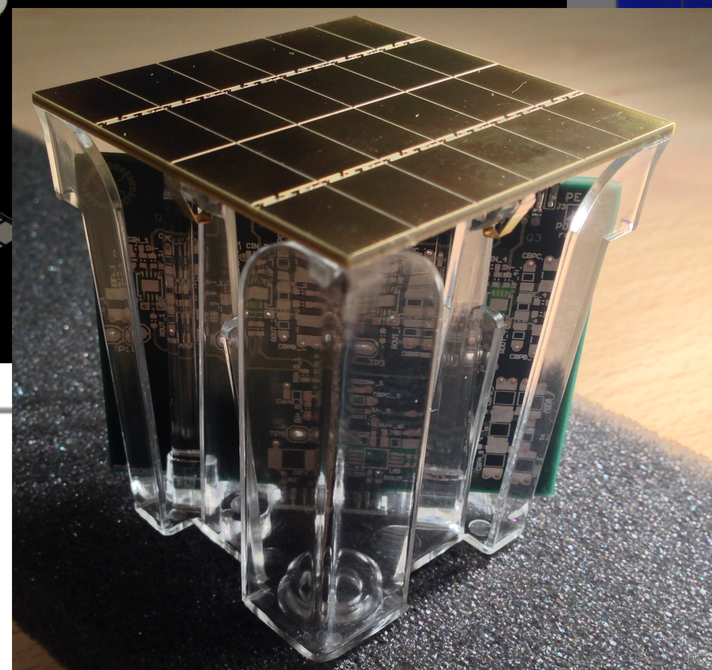


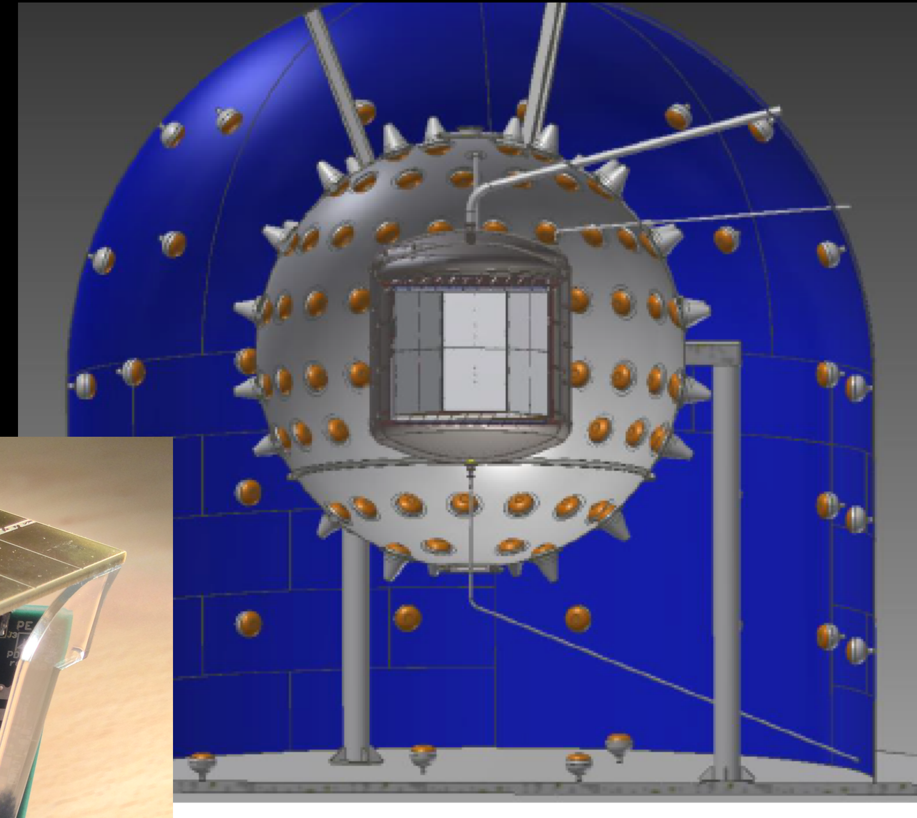
Photosensor Development

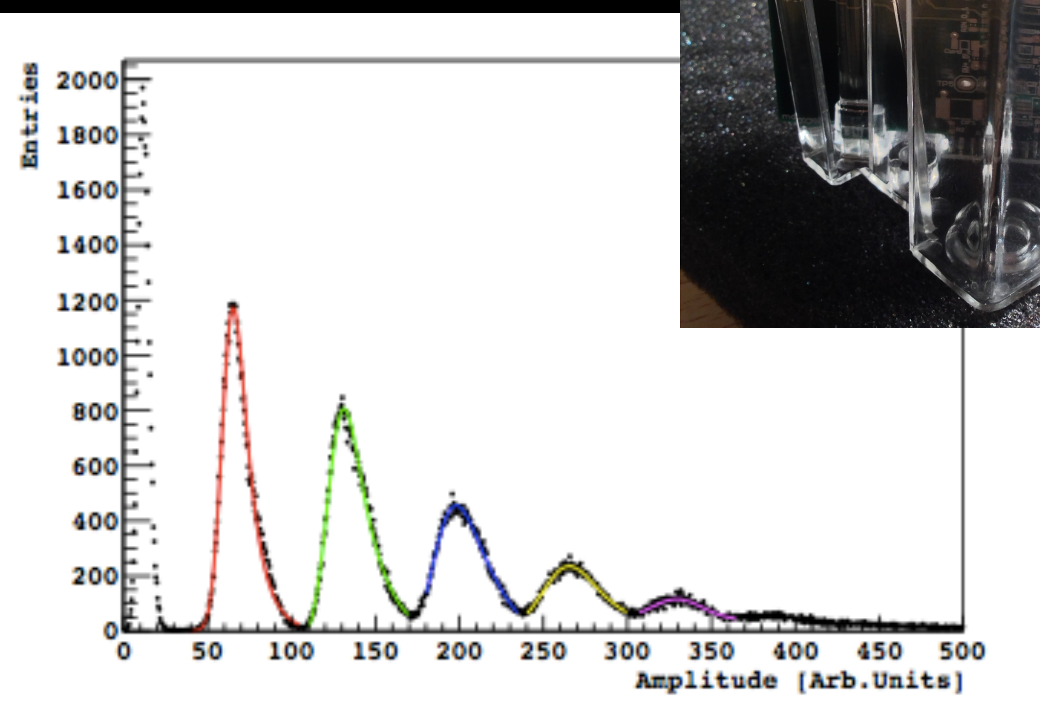
next-generation 2-phase liquid noble TPC at LNGS,
20 t liquid argon target
using SiPMs



5 cm x 5 cm
tiled SiPM



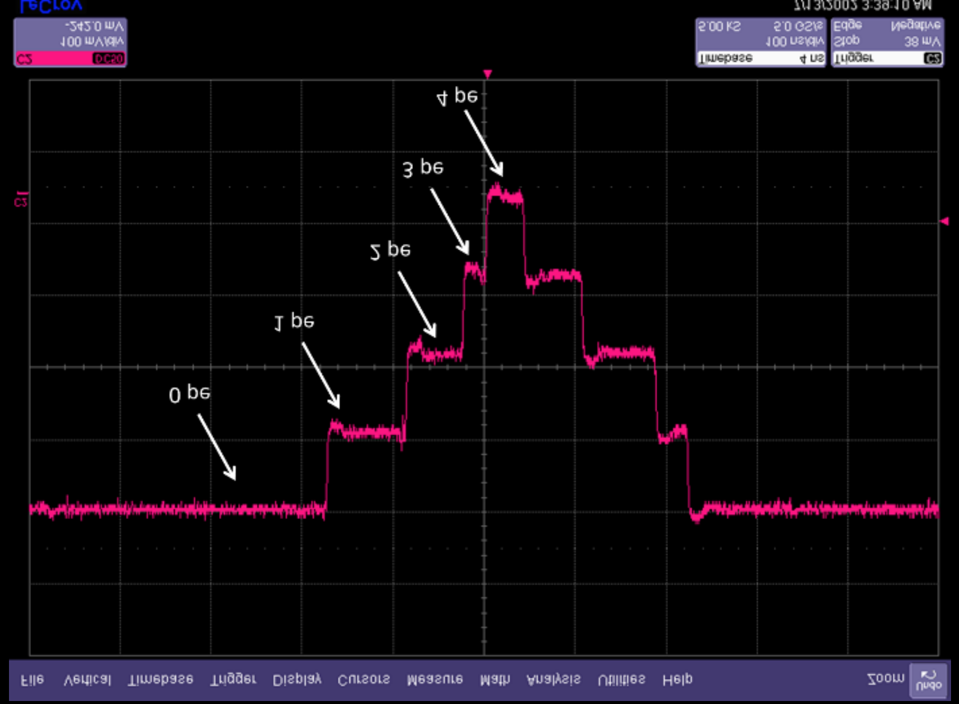




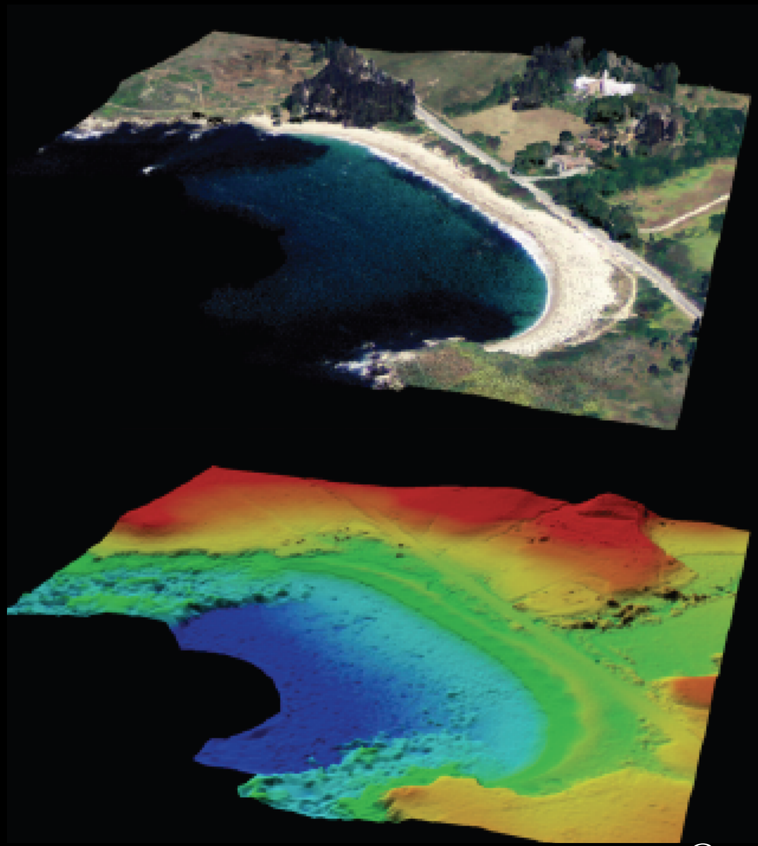
DarkSide-20k: first large-scale use of large-area cryogenic SiPMs, 45% photon efficiency

complementary with LHC: exploration of very high masses with direct search

Digital SiPMs



- TOF PET revolution
  - 10 ps ~ few mm
- Many particle physics applications
  - Plastic scintillator
  - Calorimeters with inorganic scintillators
- LiDAR
  - High precision (10ps~mm)
  - High rate
  - Possible imaging capabilities
  - Huge market: self driving cars, ...



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Materia Oscura GCRF Project

This project aims to draw on an area of expertise supported by the STFC core science programme, ultra-precise radioactivity measurement and calorimetry developed for dark matter and neutrino physics, and develop application of these techniques to the problem of measuring lead contamination in water and food.

The objectives of this proposal are:

1. to train post-doctoral researchers in México and Argentina in high precision radio-assay and calorimetry on dark matter experiments with world-leading sensitivity, in collaboration with UK scientists who are leaders in the field, and the unique UK Boulby Underground Laboratory;
2. to establish a gamma assay apparatus at the UNESCO GeoPark facility in México, and use it to train undergraduate students to perform an assay programme to measure lead contamination in coffee and water samples as well as traditional sweets produced in México, to develop a general monitoring programme of lead contamination in food samples. This leverages the renowned expertise of Prof. Espinosa, a world-expert on radiation exposure in food and the environment.
3. to develop a mobile phone application to measure the presence of lead in water samples. The app will employ the phone Si sensor (the camera) to perform radio-assay, with the goal of reaching the 10 parts per billion (ppb) sensitivity level, which is the World Health Organization limit on lead contamination in drinking water.

Materia Oscura GCRF Project

"Moon Shot" goal:

The work in this proposal aims to make lead water contamination measurements accessible to anyone with a mobile phone. Currently, such measurements require expensive, specialized equipment or 6-month measurements to reach relevant sensitivity levels for human health— even 0.1 parts per million contamination with lead produces devastating biological impacts. Developing mobile-phone assay capability makes widely-distributed metrology and real-time, crowd-sourced monitoring possible, and therefore would have transformative impact on the public health problems associated with lead pollution.

While mobile-phone based radioassay has been prototyped for higher-energy and higher-rate radioactive decays, nothing exists currently to assay lead. Reaching the sensitivity levels required for lead is an incredibly challenging problem, which we propose to address by leveraging the precision calorimetry techniques in silicon (Si) detectors developed by the DAMIC experiment, together with the lead assay coincidence methodology developed by the DEAP-3600 dark matter experiment that gives a factor of up to 10^4 in background suppression beyond conventional techniques[2].

Materia Oscura GCRF Project

"Moon Shot" goal:

[redacted] aims to deliver smart technology that can rapidly evaluate lead content in food and water using mobile instruments, eliminating the need for expensive and time consuming laboratory measurements, and minimising health risks through immediate identification and alerts of toxicity. Measurements of Pb-210 using the CMOS-based technology will be validated against existing BEGe gamma spectroscopy detectors we have developed at Boulby delivering world-leading sensitivity at <10 mBq/kg[3]. The Pb-210 to total lead content will be correlated using our word-class ICP-MS facility at UCL. Our sample preparation, calibration techniques, and analysis routines are deliberately tuned for high sensitivity to radioactive isotopes and metals, delivering the UK's most sensitive and accurate assays (<10 ppt (g/g); ~20% uncertainty)[4]. Collaborators at UCL have developed clean and rapid digestion routines with our commercial partner Analytix (UK), with whom, for example, we produced the recipe for ultra-pure Ti for LZ that also finds application in the medical and aeronautic industries. The UK BEGe and ICP-MS facilities, with the Mexico site at the Comarca Minera Geopark, Hidalgo coming online to allow local assays, will be used continuously to de-risk the technology development and perform Quality Control (QC) and Quality Assurance (QA) assessment of final procedures. Samples of, initially, water and coffee beans will be collected for assay from 50 sites identified across Mexico and Argentina where extensive quantitative peer-reviewed literature on lead-content from recent years is in place, with leading contributions from our collaborator on this proposal, Prof. Guillermo Espinosa.

Materia Oscura GCRF Project: Work Package 1

1.1 Work Package 1: Training in Radioassay Experimental Techniques

To train the PDRA cohort in the specialist calorimetry and radioassay techniques of particle astrophysics that we propose to apply to lead metrology in WPs 2 and 3, the PDRAs will receive training through DAMIC, PICO, DEAP-3600 and LZ. The work to be undertaken is:

(i) each PDRA will have a training visit to the UK Boulby Laboratory, to learn the gamma and surface activity measurement methods developed for LZ at the specialist assay facility in Boulby, relevant to observing the gamma and beta emissions from Pb-210 decay that indicate the presence of lead in an assay sample (e.g. food or water) (lead academics: Paling, Ghag);

(ii) each PDRA will have a training visit to SNOLAB, to learn DAMIC, DEAP-3600 and PICO calorimetry and coincidence assay techniques to reject radon-related alpha and beta backgrounds to the Pb-210 signal (lead academics: Bertou, Monroe, Vázquez Jáuregui); and,

(iii) the PI, Co-Is, and PDRAs will share specialist techniques and simulation tools across experiments through weekly video meetings, in order to develop a detailed simulation model to define the experimental configuration for the assay Work Packages (WPs) 2 and 3 (Walding).

For career advancement, the PDRAs working on this project must have meaningful contributions to world-leading scientific results, in addition to developing the impact programme of WPs 2 and 3. To this end, each will contribute to a world-leading scientific publication on dark matter searches within the proposal period, aligned with the research programme of the host group.

Materia Oscura GCRF Project: Work Package 2

1.2 Work Package 2: Gamma Assay Programme at GeoPark

(iv) to assess the facilities requirements (power, N2, network, cooling) required for GeoPark to host the UNAM-ICN BEGe gamma counter, and work with GeoPark to install these (lead academic: D'Olivo); funds for these consumables are requested in this proposal;

(v) deploy and operate the BEGe counter at GeoPark, cross-calibrate against calibration standards (lead academic: Aguilar-Arevalo);

(vi) train local university students to operate the gamma assay apparatus in GeoPark (lead academic: Aguilar-Arevalo), interface to local universities provided by GeoPark;

(vii) carry out first assay programme of water and coffee samples (lead academics: Espinosa, Vázquez Jáuregui), with the goal of reaching <20 mBq/kg sensitivity to Pb-210 at 68% confidence level from a 1 kg water sample with 1 week screening.

Materia Oscura GCRF Project: Work Package 3

1.3 Work Package 3: Develop Mobile Phone Radioassay for Lead in Water

(i) to measure isotopic composition of lead in water at UCL IC-PMS facility to correlate the Pb-210 to the total lead content in water, and quantify the typical variance across water samples (lead academic: Ghag);

(ii) to develop an algorithm for mobile phone calorimetry (lead: Walding). Walding will tap into the expertise of the RHUL Information Security Group, which develops software for Android phones.

(iii) to implement the DEAP-3600 background-subtraction strategy (lead academic: Monroe);

(iv) to quantify the measurement capacity with calibration standards prepared at Sussex (lead academic: Peeters) underground at Boulby; leveraging unique UK capability— the assay facility at Boulby, led by Ghag, has two BEGe detectors with <10 mBq/kg sensitivity to the 46.5 keV gamma from Pb-210;

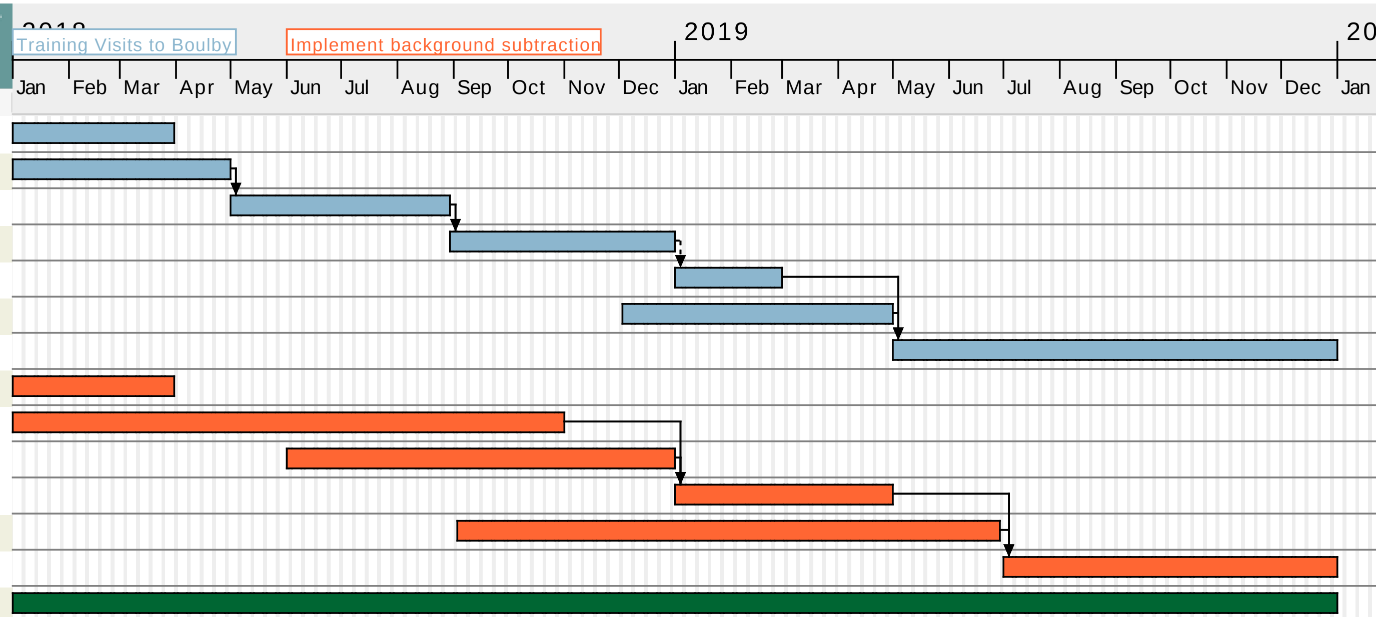
(v) simulate and measure attenuation factors to determine detection efficiency corrections (Walding);

(vi) proof of principle demonstration at Boulby (Walding, lead academics: Bertou, Paling).

Materia Oscura GCRF Project: Timeline (from Proposal)

GANTT project

Name	Begin date	End date
Training Visits to Boulby	1/1/18	3/30/18
Assess GeoPark Facilities	1/1/18	4/30/18
Installation of Geopark Ser...	5/1/18	8/29/18
Deploy BEGe counter	8/30/18	12/31/18
Calibrate BEGe counter	1/1/19	2/28/19
Train University Students	12/3/18	4/30/19
Perform Assays	5/1/19	12/31/19
Measure Pb in water	1/1/18	3/30/18
Develop mobile phone alg...	1/1/18	10/31/18
Implement background su...	6/1/18	12/31/18
Quantify measurement ca...	1/1/19	4/30/19
Simulate and measure att...	9/3/18	6/28/19
Proof of principle demons...	7/1/19	12/31/19
Dark Matter Experiment P...	1/1/18	12/31/19



*Requires revision given funding start Aug. instead of Apr.'18!

**However the funding still ends on original timescale.

Materia Oscura GCRF Project: Management Plan

5. Management plan

- Develop and keep up to date a detailed GANTT chart.
- Track the finances, progress, and deliverables.
- Ensure widespread dissemination of the results and publicity.
- Organise and chair monthly project-level video conference and provide minutes
- Compile a detailed progress report after 6, 12 and 24 months to be distributed to the collaboration.
- Organise a 6 and18 month video workshop, and a 12 month in-person workshop.

Walding will directly oversee the interaction between the WPs, which will be managed by Vázquez Jáuregui (WP1), D'Olivo Saez (WP2), and Monroe (WP3). WP manager responsibilities are:

- to organise and chair bi-weekly video conference meeting and provide minutes (for WP1, these will be monthly meetings with a specialist seminar on relevant techniques).
- To provide input to the project manager to develop and keep up to date the project GANTT chart, as well as the deliverables, finances and results.
- To organise a kick-off intensive workshop (scrum), using video conferencing and slack, followed by quarterly mini-scrums.

bi-weekly meetings Fri. 9:00 MX / 15:00 UK, slides on indico, vidyo web conference

GCRF_210Pb_survey — https://indico.cern.ch/event/764896/ — Join

Name	GCRF_210Pb_survey
Description	Video room for the 210Pb lead survey discussion
Extension	10764896
Owner	Alexander Deisting
Auto-join URL	https://client-select.web.cern.ch/?url=https%3A%2F%2Fvidyoportal.cern.ch%2Fjoin%2FyLNJN1k5jr
Useful links	Phone numbers

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https://indico.cern.ch/event/766675/timetable/#20181022

Materia Oscura GCRF Project: Awarded Funding

Salary Costs: *total estimate 286k GBP,*

Travel Costs: *total estimate 32.5k GBP,*

Consumables costs: to be purchased in the UK, total 8k
-calibration standards of Pb-210 in solution, for energy calibration and to understand the response of the HPGe once deployed in the GeoPark and test the mobile-phone assay sensitivity: 7k.
-mobile phones for lead measurement development and window efficiency correction calibration: 1k

Mechanism for disbursement of funding quarterly specified in Collaboration Agreement document, coming up on first go at this (Nov. 1, 2018).

Materia Oscura GCRF Project: Travel Funding

***Travel Costs**: total estimate 32.5k GBP, divided in 14k in Mexico/Argentina, 18.5k in the UK*

Training at SNOLAB: 1 trip to SNOLAB for each PDRA in year 1 for training in calorimetry, assay and background rejection techniques. The cost per trip is estimated at 1.5k GBP, including airfare, lodging and subsistence. *UK cost:* 2 PDRAsx1.5k = 6k. *Mexico/Argentina cost*: 2 PDRAsx1.5k = 6k.

Training at Boulby: 1 trip to Boulby for each PDRA for training in the low background counting facility, towards successfully deploying, operating and calibrating the experimental equipment at the GeoPark in México (PDRAs 2 and 3, in year 1), and for the mobile-phone lead counting experiment (PDRAs 1 and 4 in years 2 and 1 respectively). The cost is estimated to be 0.5k for travel in the UK, and 1.5k for travel from Mexico/Argentina, to include travel, lodging and subsistence. *UK cost:* 0.5k. *Mexico/Argentina cost:* 3 PDRAs x 1.5k = 4.5k.

Travel to GeoPark: for visits to deploy, install and operate HPGe, as well as for training of students and outreach activities to educate on the importance of heavy metal toxicity and radio-isotopes in health issues.

The cost is estimated to be 0.5k for travel from Mexico/Argentina, and 1.5k for travel from the UK, to include travel, lodging and subsistence. *Mexico/Argentina costs:* PDRAs 2, 3, and 4 to travel from Mexico 3 trips each for PDRAs 2 and 3, and 2 trips for PDRA 4 = 8 x 0.5k = 4k. Shipping of BEGe counter from UNAM-ICN to GeoPark and installation costs: 2k. *UK cost:* Walding, Ghag, Peeters, Paling to travel from the UK: 4 x 1.5k = 6k. Total cost is estimated to be 12k.

Collaboration workshop: 1 workshop at start of year 2 (everyone to attend, in México at UNAM). The organization of the workshop "Precision radio-assay: from dark matter to clean water" will bring experts from the UK and México, not only academics but also from health sectors and industry. This will result in a synergy, as the academics will be aware of the main issues faced by the health and industry sectors, and at the same time, discuss the potential application of experimental techniques used within astroparticle physics to develop new pathways to impact. Costs for researchers in México are estimated to be 0.5k per trip, and for researchers in UK/Argentina are estimated to be 1k per trip, for travel, lodging and subsistence.

Mexico/Argentina costs: total 3.5k. PDRAs 2, 3, and 4 to travel from Mexico: 3 x 0.5k = 1.5k + PDRA1 and Bertou to travel from Argentina = 2 x 1k = 2k. *UK costs:* Walding, Monroe, Kaboth, Paling, Ghag, Dobson to travel from UK = 6 x 1k = 6k. Total cost is estimated to be 9.5k.

Outline

1. What is GCRF? The Global Challenges Research Fund.
2. Why Focus on Lead
3. Overview of the Materia Oscura Project
4. **Goals for this Meeting**

Goals for This Meeting

1. Get to know each other
2. Learn a lot about Pb and how to measure it
3. Define realistic plans and schedules for each work package (WP)
4. Schedule training trips (WP1)
5. Prepare for WP2 deployment
6. Coordinate R&D for WP3
7. Budget plan
8. Define goals for and schedule future meetings
9. Prepare for “Grand Challenges” GCRF stage
10. Kick-off the project!
11. …

Thanks for coming / connecting!