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G3 Dark Matter Project

Paul Scovell – 23/02/21

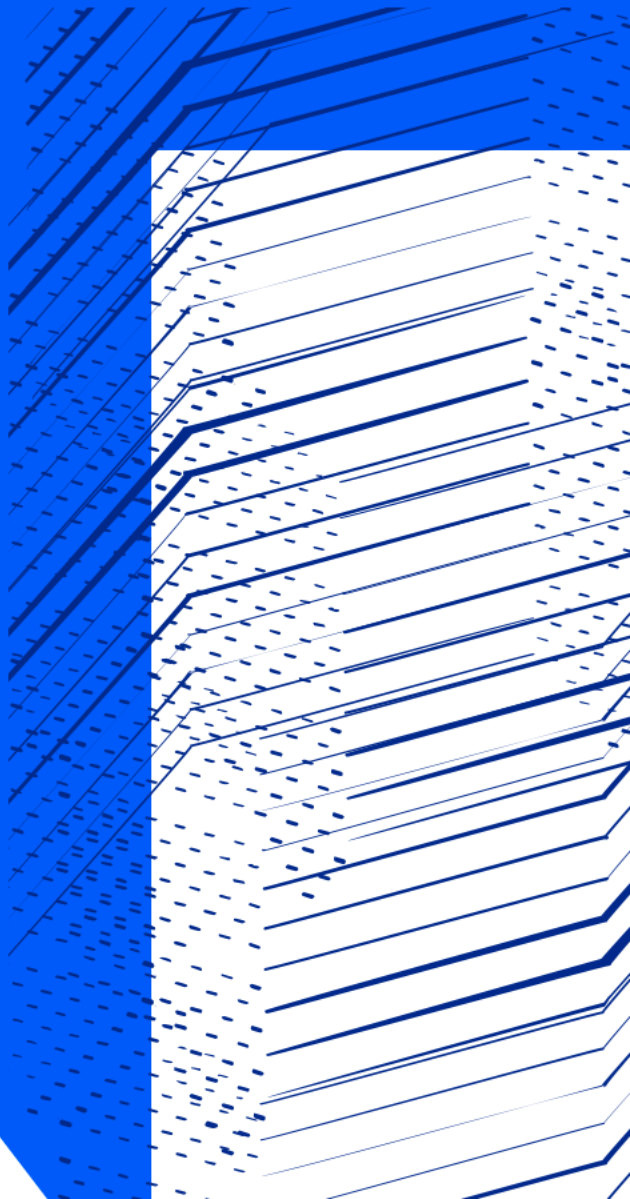

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Image © STFC Alan Ford

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PPD and Dark Matter

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A long and rich history

A Rich History in Dark Matter

- First Dark Matter work at Boulby was in the late 1980s
- This shot from 1990 shows a junior researcher from RAL PPD
- First Ge detector in use at Boulby
- Still running today!
- Junior researcher now director of SNOLAB (soon to move to TRIUMF)
- Dark Matter in PPD is a good first step in a career!

Picture: SNOLAB.ca

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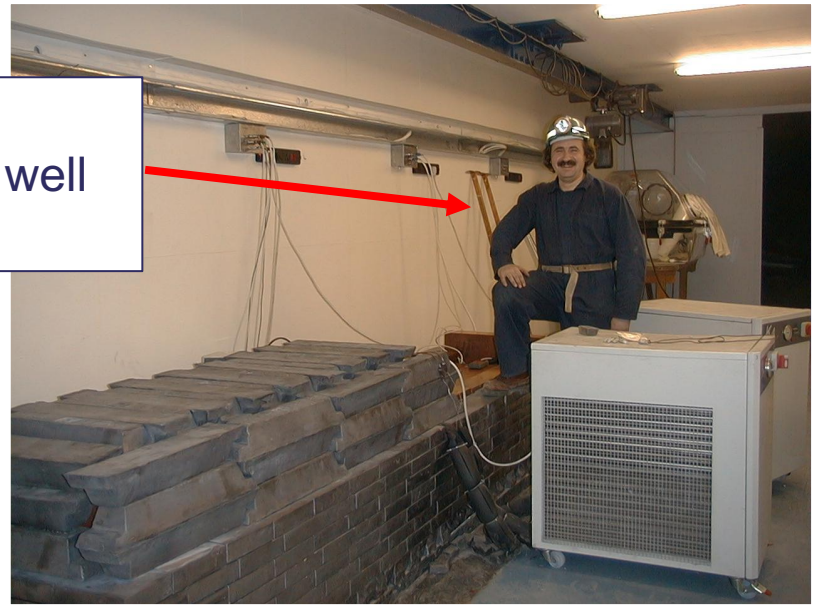
A long and rich history

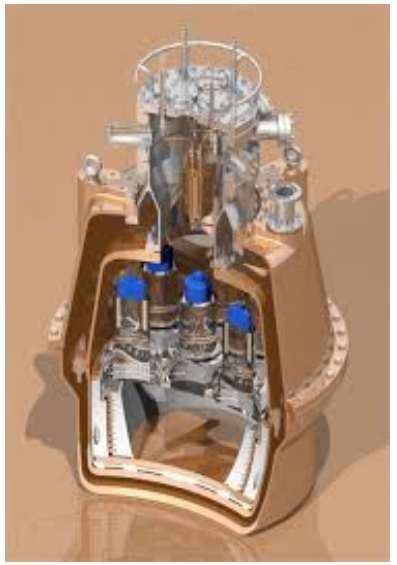
PPD have long been involved with DM at Boulby

- With liquid xenon, paved the way in the technology used today
- ZEPLIN I, II, III
- Also active in solid state (NAIAD), Directional (DRIFT) and Boulby provides radioassay for more (DAMIC, Darkside, NEWS-G)

Your potential future supervisor – probably well before you were born!

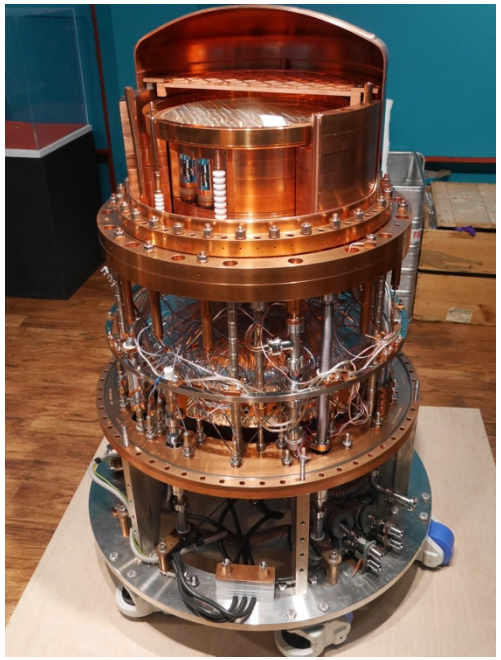


NAIAD



ZII

ZIII



Picture: Whitby Museum

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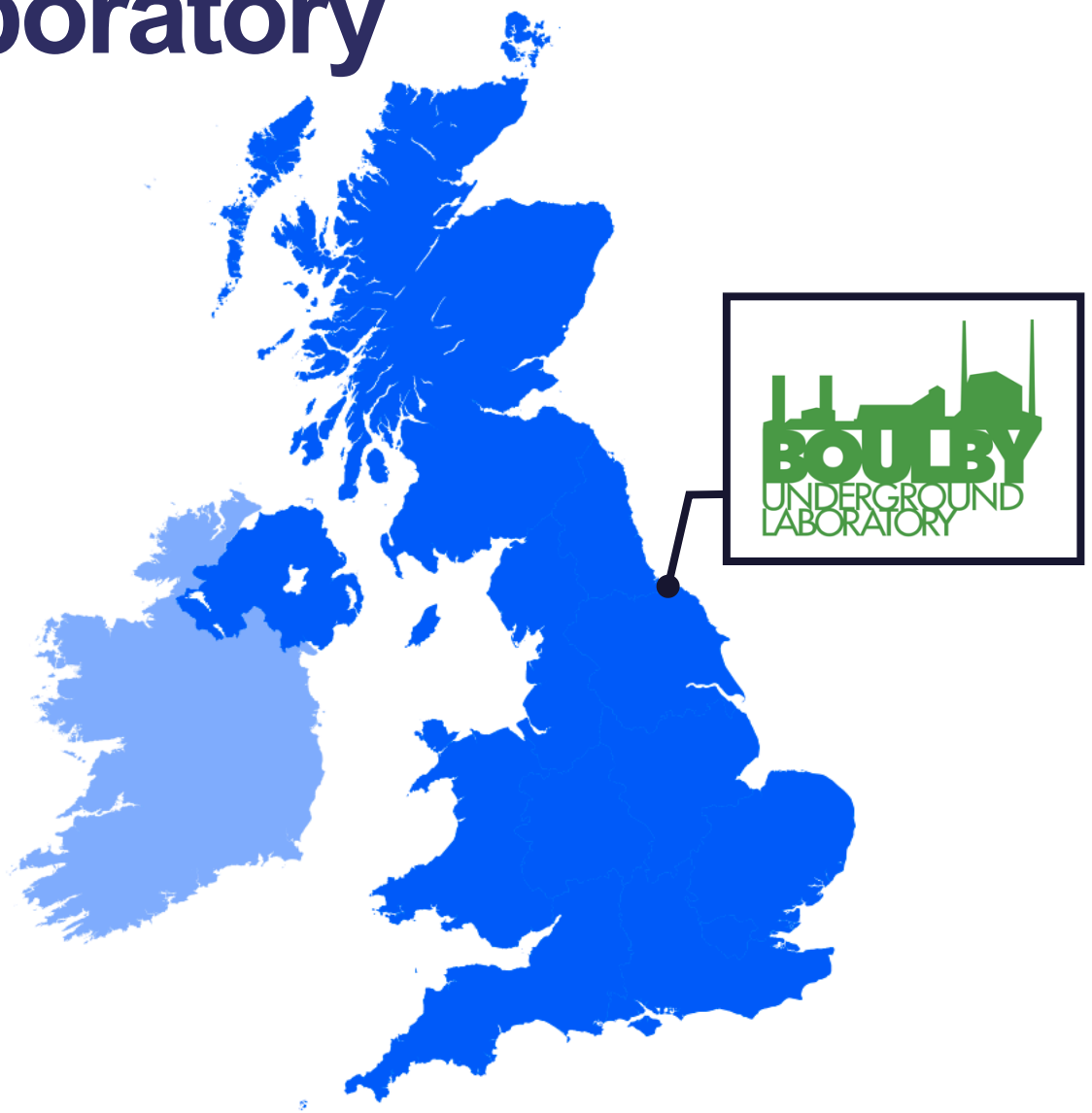
Boulby Underground Laboratory

- For those not familiar, Boulby is in the north-east of the UK.
- About half way between Middlesbrough to the north-west and Whitby to the south-east

Pictures: Wikipedia

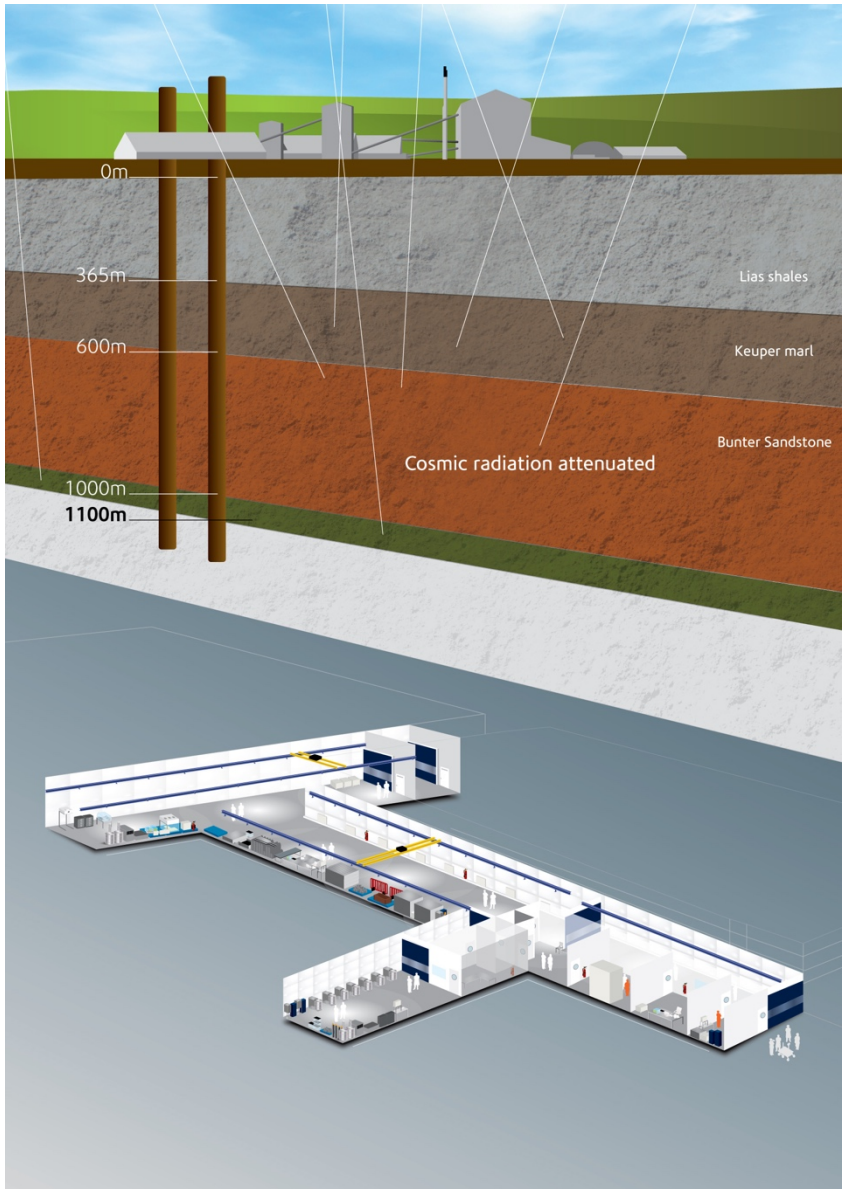


Boulby Underground Laboratory

Intro to the Lab

Virtual Tour – Ed Banks 14:00

- 1100 m underground
- Relatively small team (~10)
- Broad science programme



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BUGS at the Boulby Underground Laboratory

Building a “centre of excellence” for cleanliness

- Flagship facility for BUL, PPD & STFC
- State of the art facilities UG and (soon) on surface for material cleanliness and characterisation
- Among the broadest range of assay techniques in any UG facility worldwide

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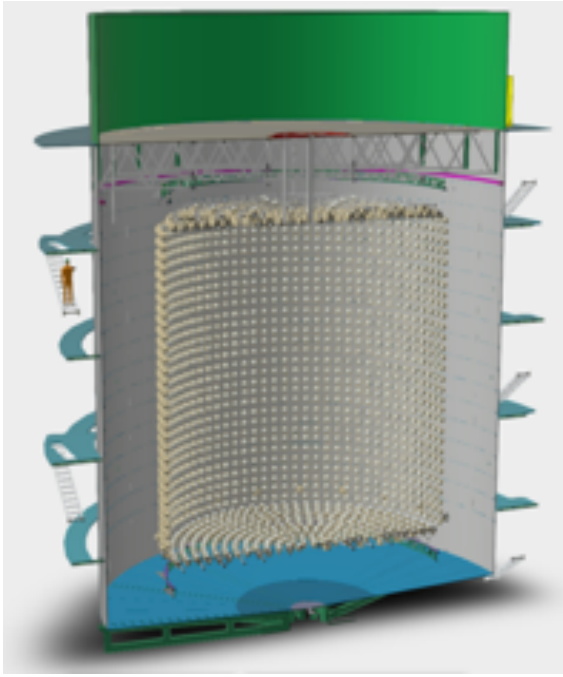
Boulby Underground Laboratory

Other Science at Boulby

- NEWS-G, DRIFT/CYGNUS
- AWE CTBT germanium
- Resource
- C14
- BISAL
- MINAR
- AIT



Pictures: Trevor Palin

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Boulby Underground Laboratory

Public Engagement

- No-one comes to Boulby just to work
- Every day underground is interacting with the public
- Many public visits per year
- Students would be encouraged to get involved
- Great opportunity to showcase work to a huge range of people
  - Politicians, Nobel prize winners, Miners, TV personalities, etc

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Current DM Activities in PPD

With thanks (and questions!) to P. Majewski

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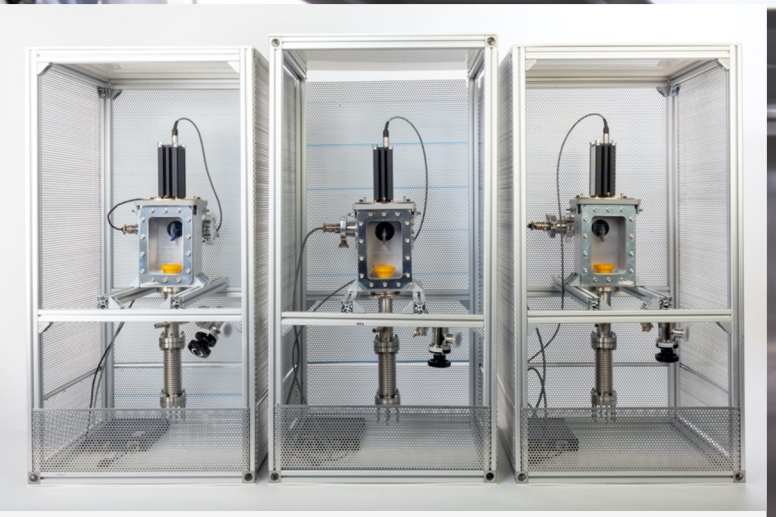
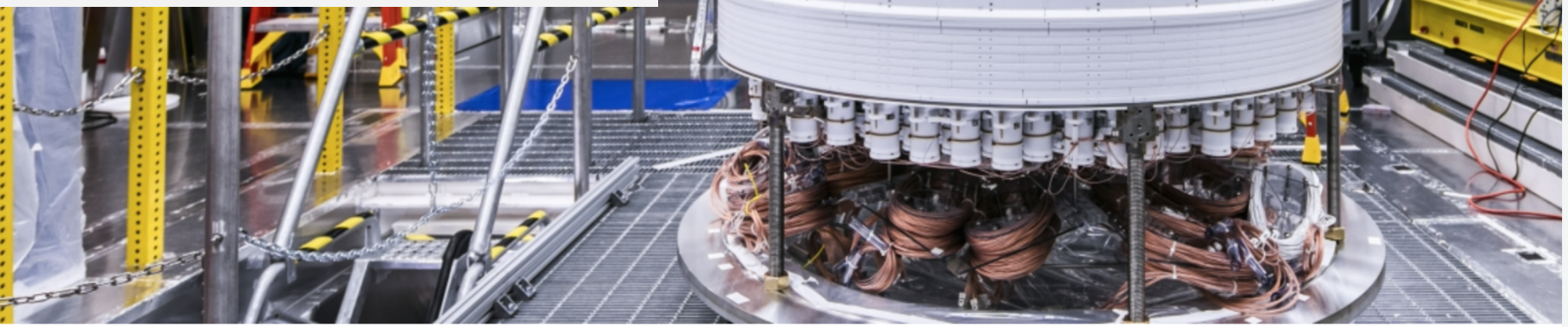
LUX-ZEPLIN



Source deployment system



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NEWS CENTER

A Supercool Component for a Next-Generation Dark Matter Experiment

UK-developed titanium cryostat arrives at the South Dakota site of LUX-ZEPLIN, a Berkeley Lab-led project

Feature Story Glenn Roberts Jr. (510) 486-5582 • JULY 17, 2018

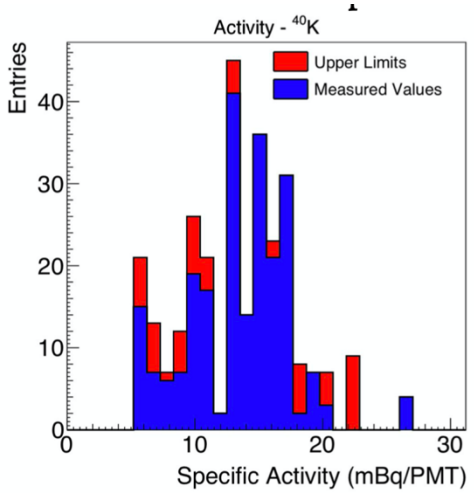
113 | 113 SHARES

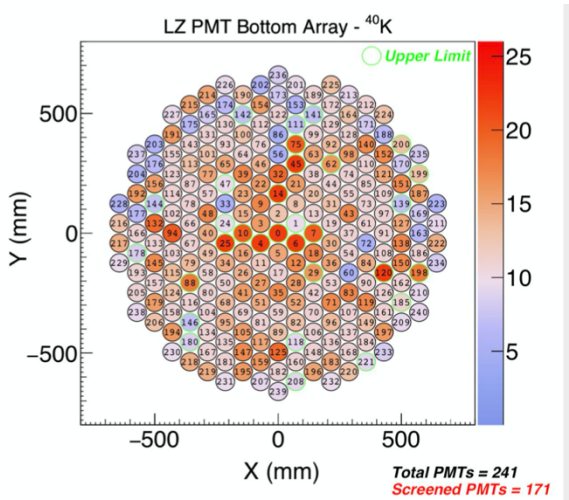
Titanium cryostat

The LUX-ZEPLIN dark matter detector is under construction on the 4850 Level of the Sanford Underground Research Facility. This photo, taken in early 2020, shows the sealed inner detector inside the water tank.

LZ Radioassay at Boulby

- Several hundred items assayed for LZ at Boulby
- Germanium assays performed in collaboration with SURF/U. Alabama/LBNL/Brown (USA) & CUP (Korea)
- Results used to determine the background radioactivity in LZ DM search





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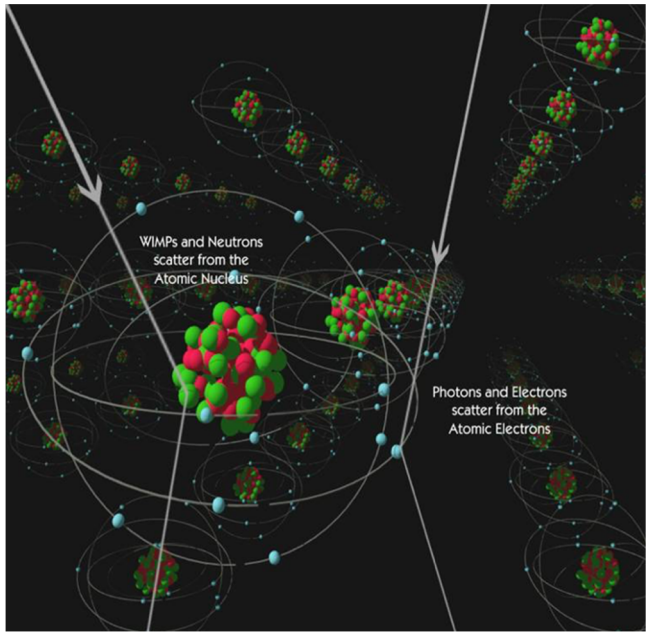
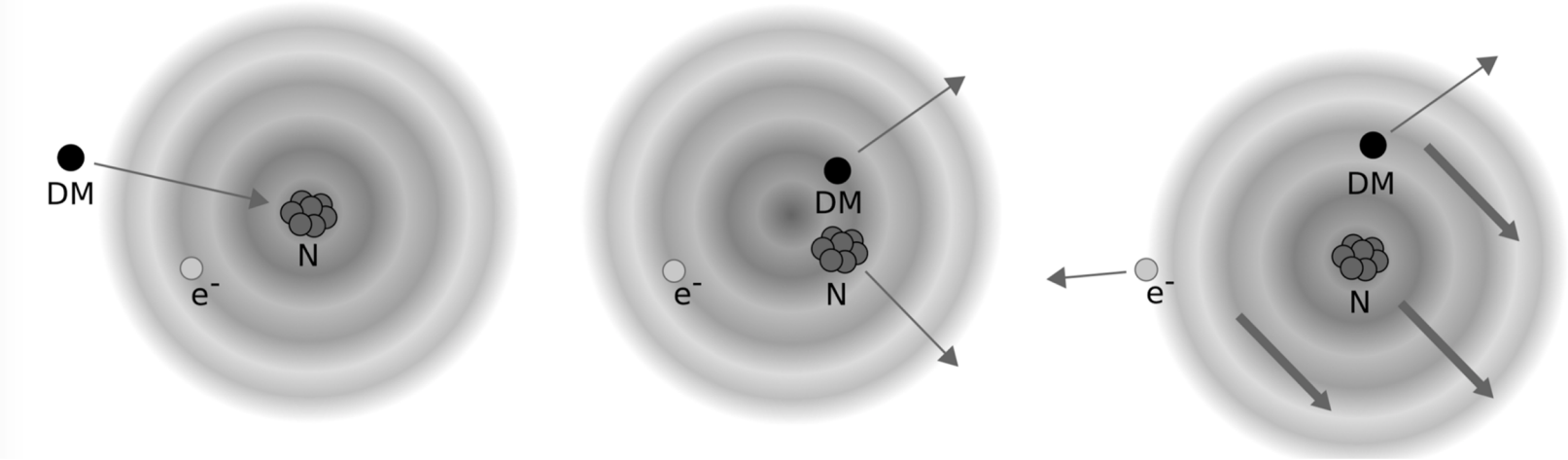
See: *The European Physical Journal,* **volume 80**, Article number: 1044 (2020)

What is the Migdal effect and why does it matter in DM searches?





Migdal Effect - nucleus moves relative to the electron cloud. An individual electron might be left behind leading to ionisation.

- DM searches use signal from nuclear recoils as a signature of the DM interaction with the detector medium.
- The Migdal effect is currently being exploited to increase sensitivity to light WIMPs in Xe & Ar, but the Migdal effect hasn't been experimentally confirmed.

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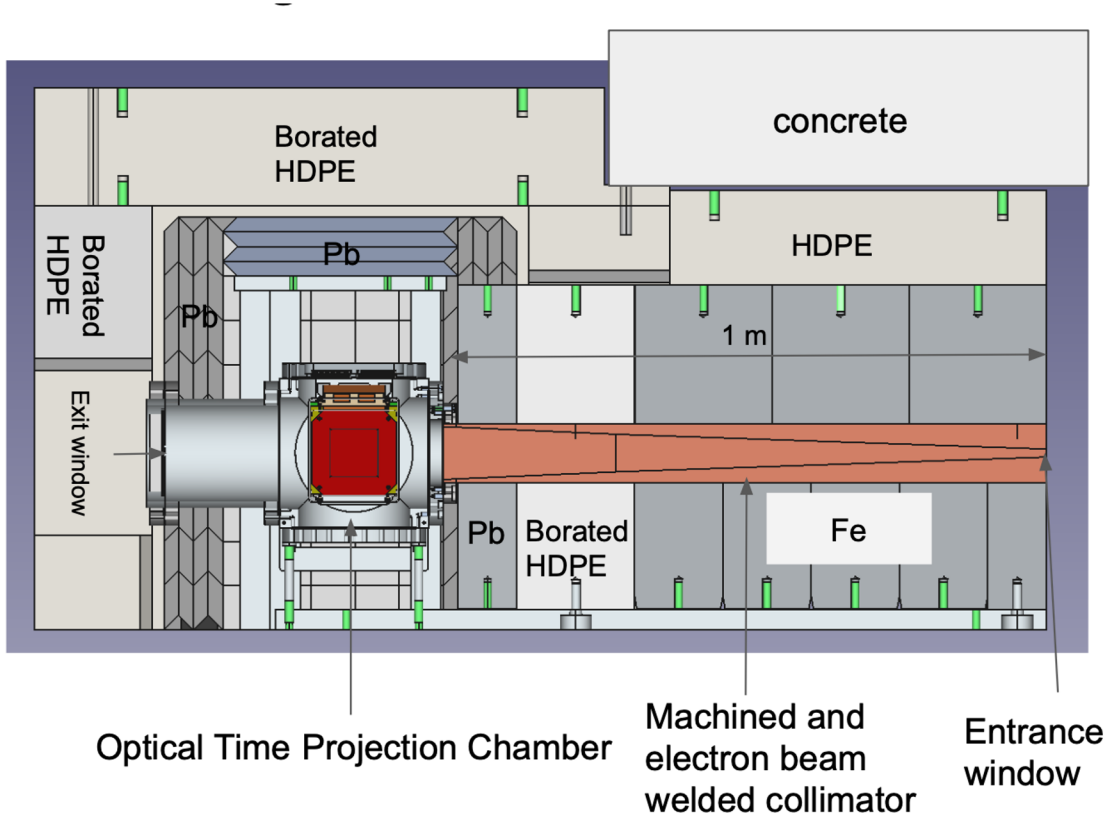
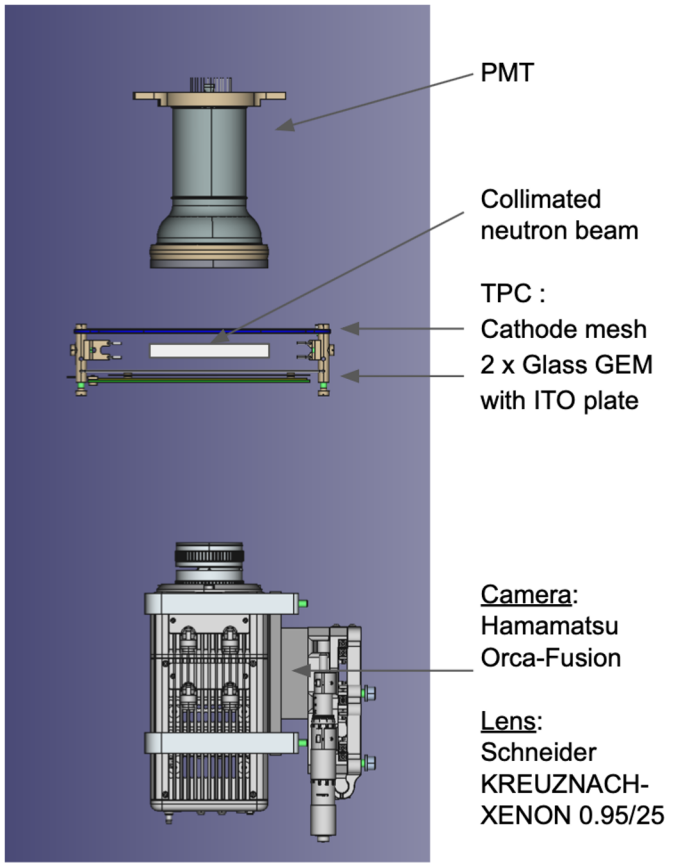
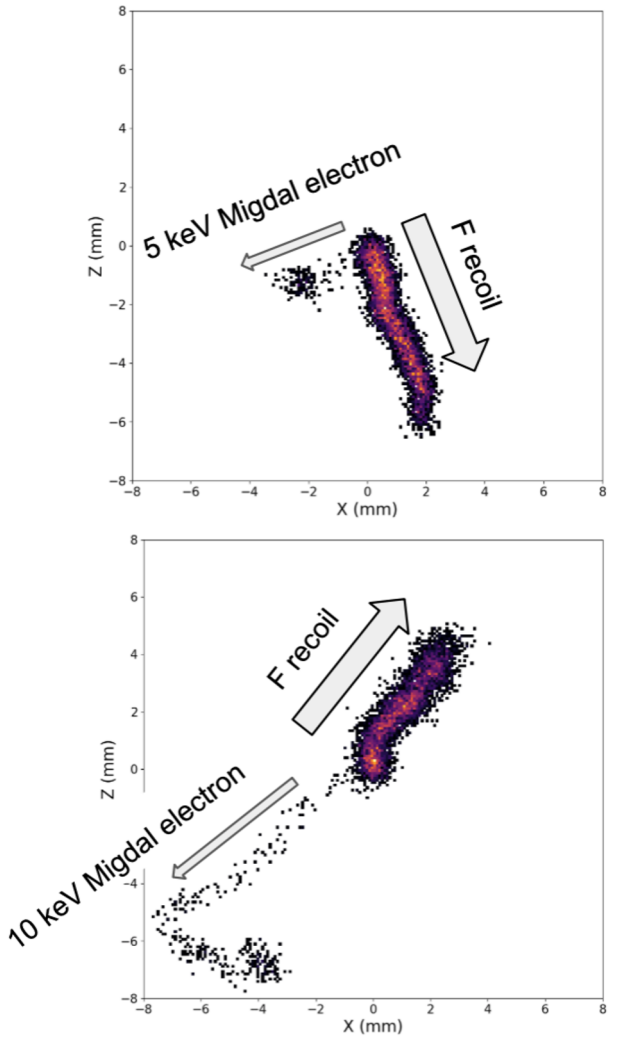
MIGDAL Experiment at RAL



Shielded detector to be installed at ISIS and work with DT generator emitting 10^{10} 14.1 MeV neutrons / s.



Optical Time Projection Chamber with Glass GEMs



Simulated Migdal effect in low pressure CF_4

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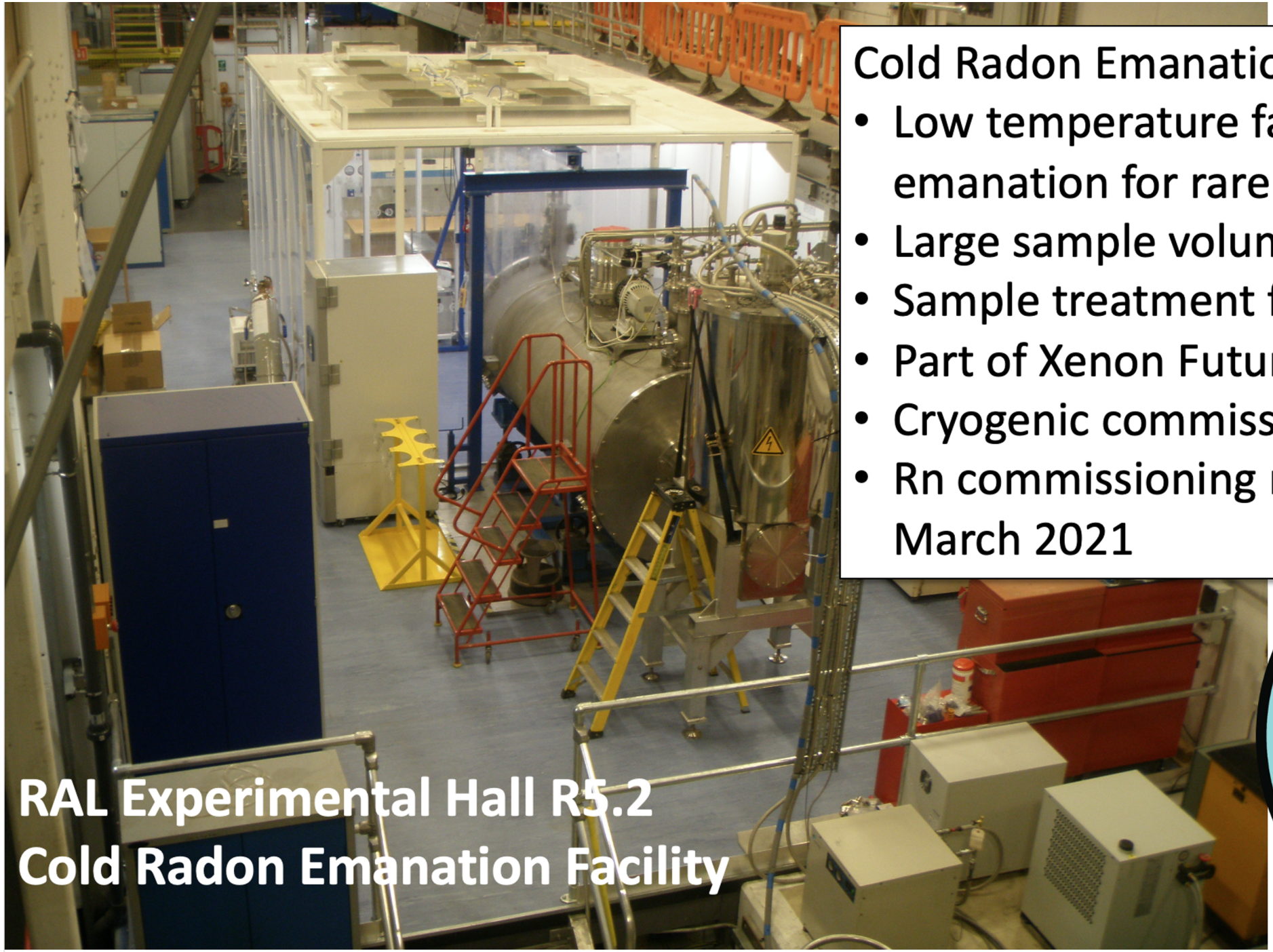

RAL Experimental Hall R5.2
Cold Radon Emanation Facility

Cold Radon Emanation Facility:

- Low temperature facility to study Rn emanation for rare event experiments
- Large sample volumes can be screened
- Sample treatment facility included
- Part of Xenon Futures program
- Cryogenic commissioning runs in 2020
- Rn commissioning measurements in March 2021

CREF

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The University Of Sheffield.

Looking to the next generation

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PhD Position – Sheffield/Boulby

G3 Dark Matter

- R&D for the next generation starting now
- If current generation experiments see a handful of events, G3 will see many
- G3 factor of 5 or more larger than current generation
- To maximise sensitivity, will need to understand and model backgrounds to unprecedented detail
- This is where you come in!
- Supervision by me (Boulby) and V. Kudryavtsev and D. Tovey (Sheffield)
- Expectation that Y1 would be in Sheffield but substantial periods of Y2 & Y3 spent at Boulby (only 2.5 hours from Sheffield)

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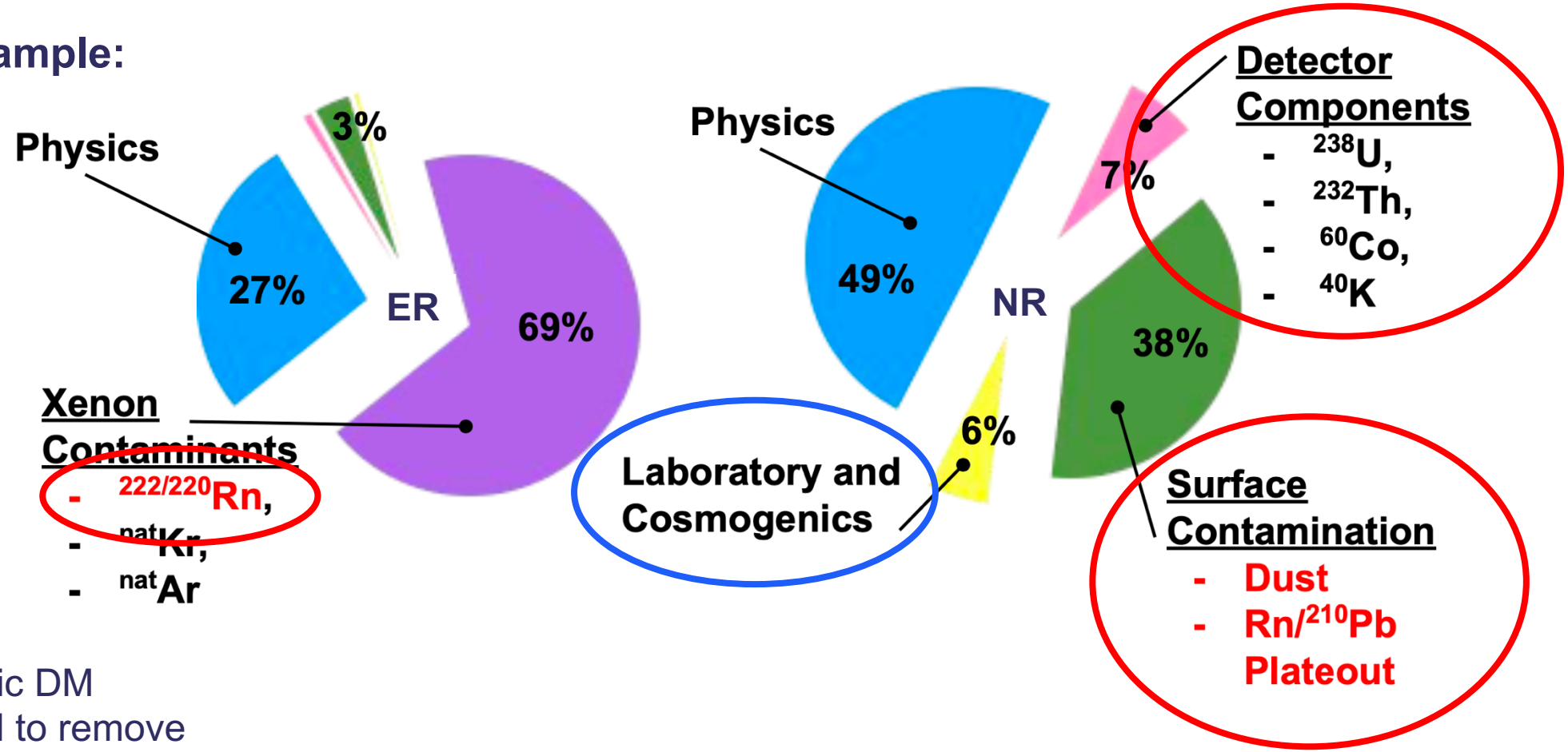
PhD Position – Boulby/Sheffield

LZ For Example:



NR = Mimic DM
ER = Hard to remove

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Boulby/Sheffield

Sheffield

Image: A. Kamaha U. Albany

PhD Position – Sheffield/Boulby

What will you look at?

- Muons and Muon induced backgrounds
  - Modelling conditions UG at Boulby
- Bulk contaminations – U/Th/K
- Airborne contaminations – Rn
- Surface contaminations – Bi-Po & ^{210}Pb

} Using BUGS (*and CREF*)

- How do measured components affect G3 detector backgrounds
  - Profile likelihood and other statistical methods
- How can we improve things
  - Assay smart, not sensitive
  - Is (100.0 ± 0.1) mBq/kg better than <10 mBq/kg ??

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PhD Position – Boulby/Sheffield

Why G3 R&D

- You will not just work on an existing experiment
- Combines modelling and data analysis with hands on experimentation
- You will be able to help shape the direction of travel in low background particle physics research for the next 10-20 years
- You will not be swallowed up by a large collaboration
- G3 will be an international effort
  - Chance to work with colleagues worldwide
  - Many opportunities for travel
  - Many opportunities following PhD
- You could be the one leading an internationally renowned laboratory in the future!

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Thank you

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