MIGDAL

Migdal In Galactic Dark mAtter expLoration

RD-51 COLLABORATION MEETING

# Current status of the preparations for the MIGDAL experiment

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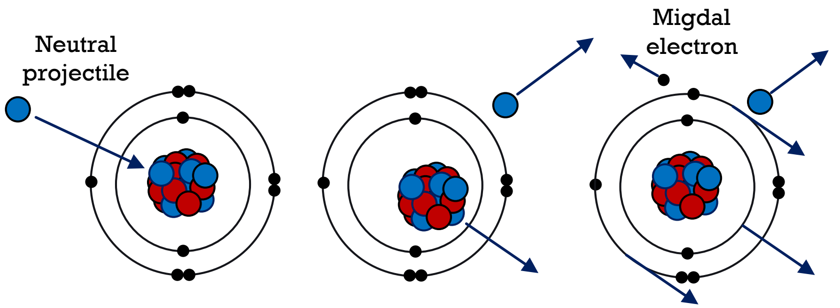
For the MIGDAL collaboration

# Update overview

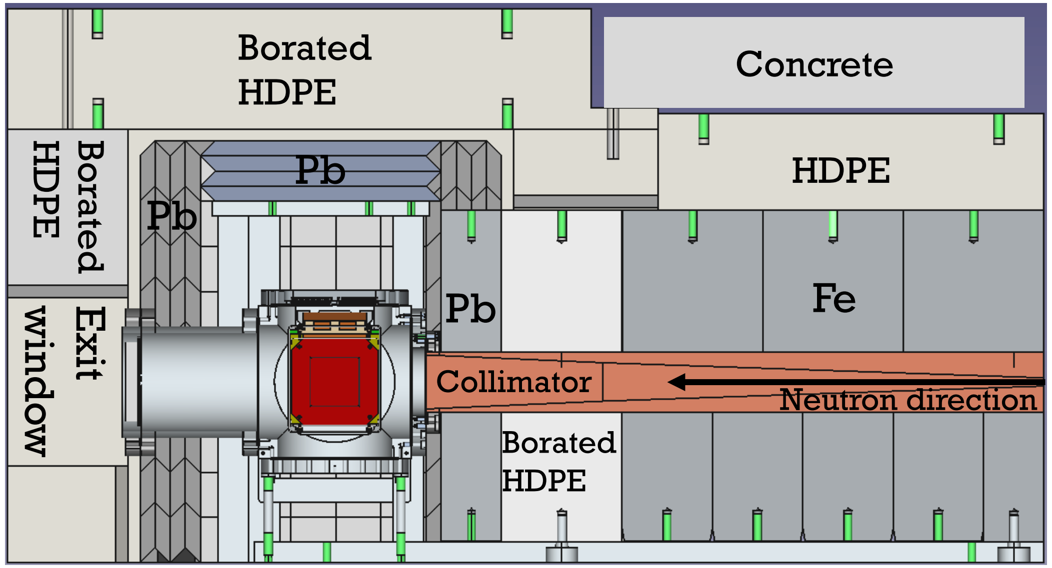
- Design completion and procurement
- MIGDAL at the NILE facility, RAL
- Signal rates and major backgrounds
- End-to-end simulations

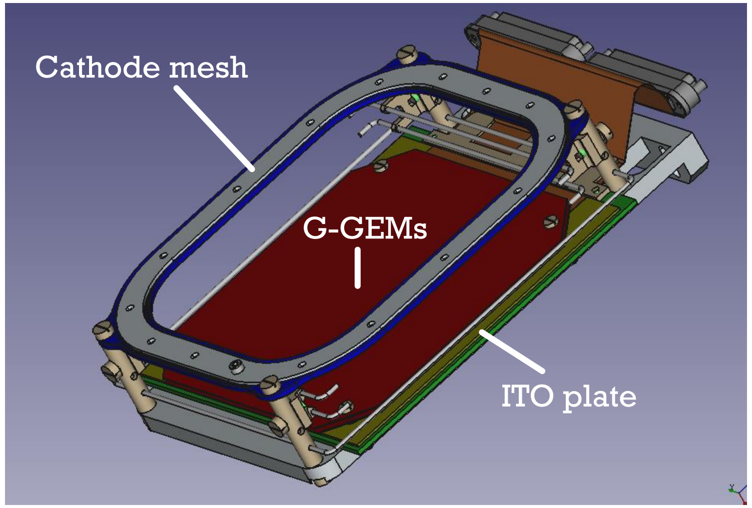
# Overview of the MIGDAL experiment



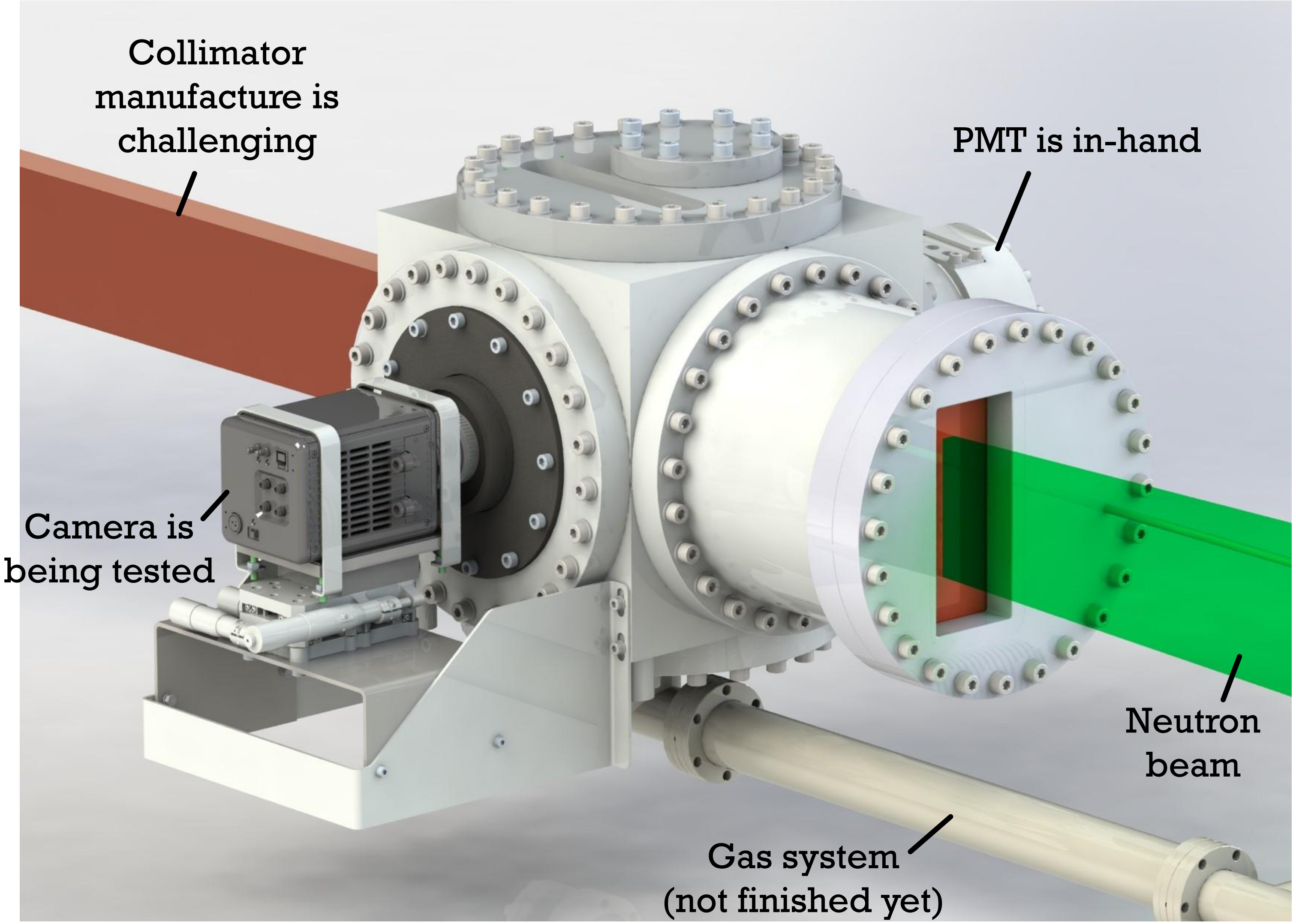

Migdal event topology involves a nuclear recoil and electron recoil originating from the same vertex.

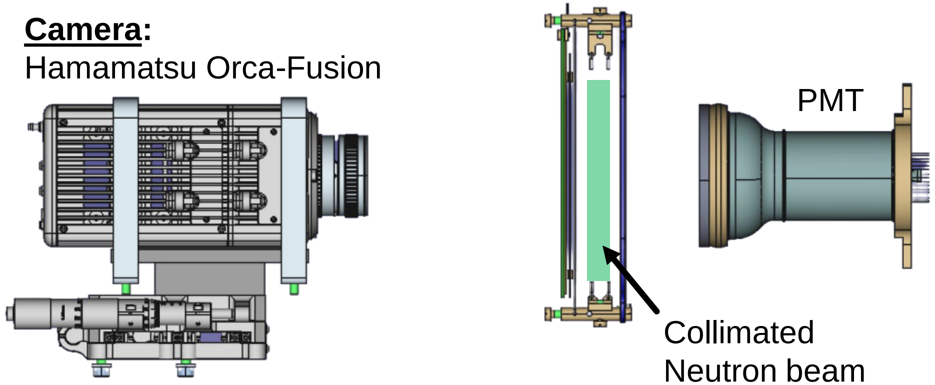
- The Migdal effect is currently being exploited to increase sensitivity to light WIMPs, but it has not been experimentally confirmed.
- We will utilise the increased Migdal probability of high energy neutron scattering to directly observe the Migdal Effect with a GEM-based OTPC in low pressure $CF_4$.
- We will use a low-pressure chamber where recoil tracks are long enough to be resolved by our camera.



# Our design is complete

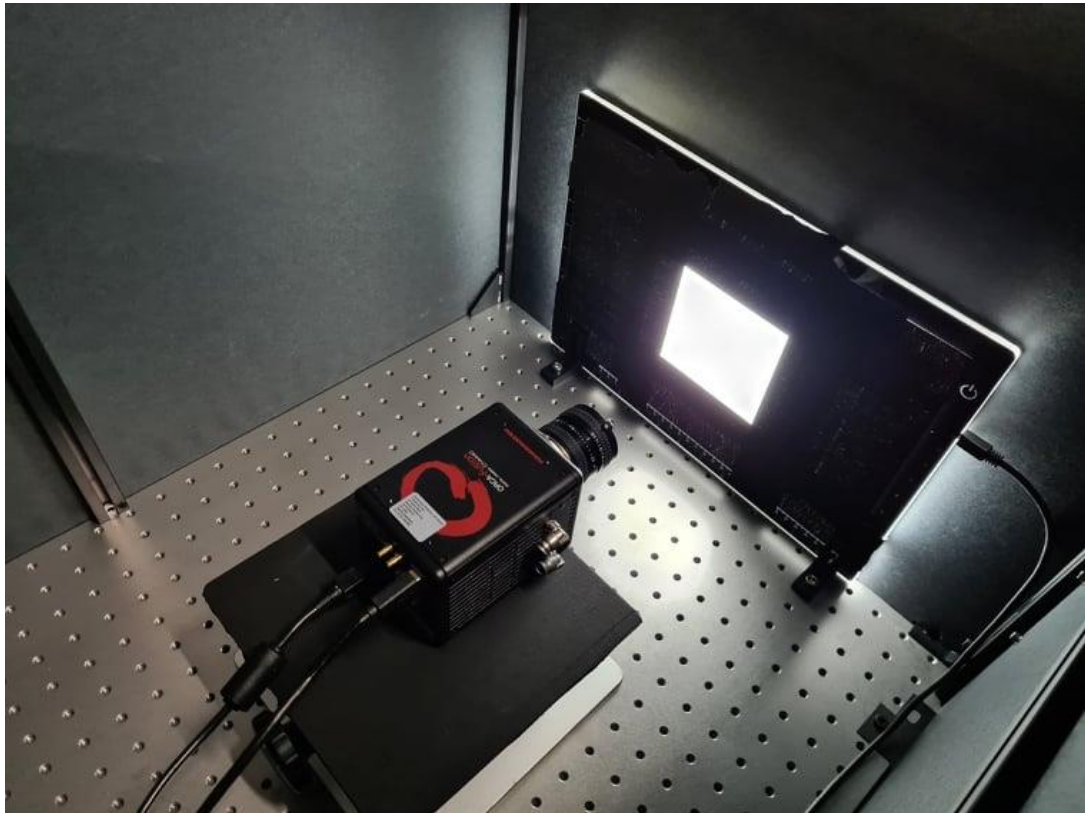


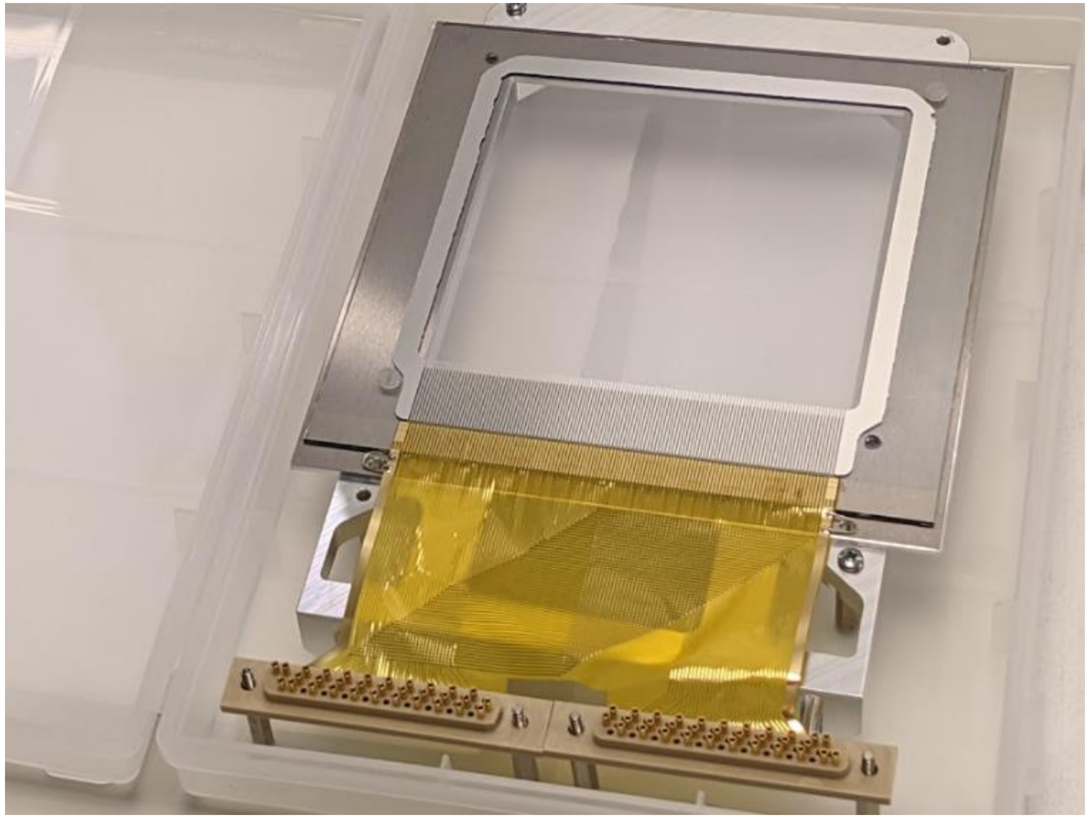




- Most of the design is aluminium, with some stainless steel flanges.
- Almost all major parts are in-hand or have been ordered.
- Most of the shielding is already at RAL. Lead is waiting at Boulby.

# The readout components are coming together

- Camera and PMT readout have been delivered and are awaiting assembly.
- The ITO plate (120 strips) has been assembled and wire bonded.





# NILE facility at RAL



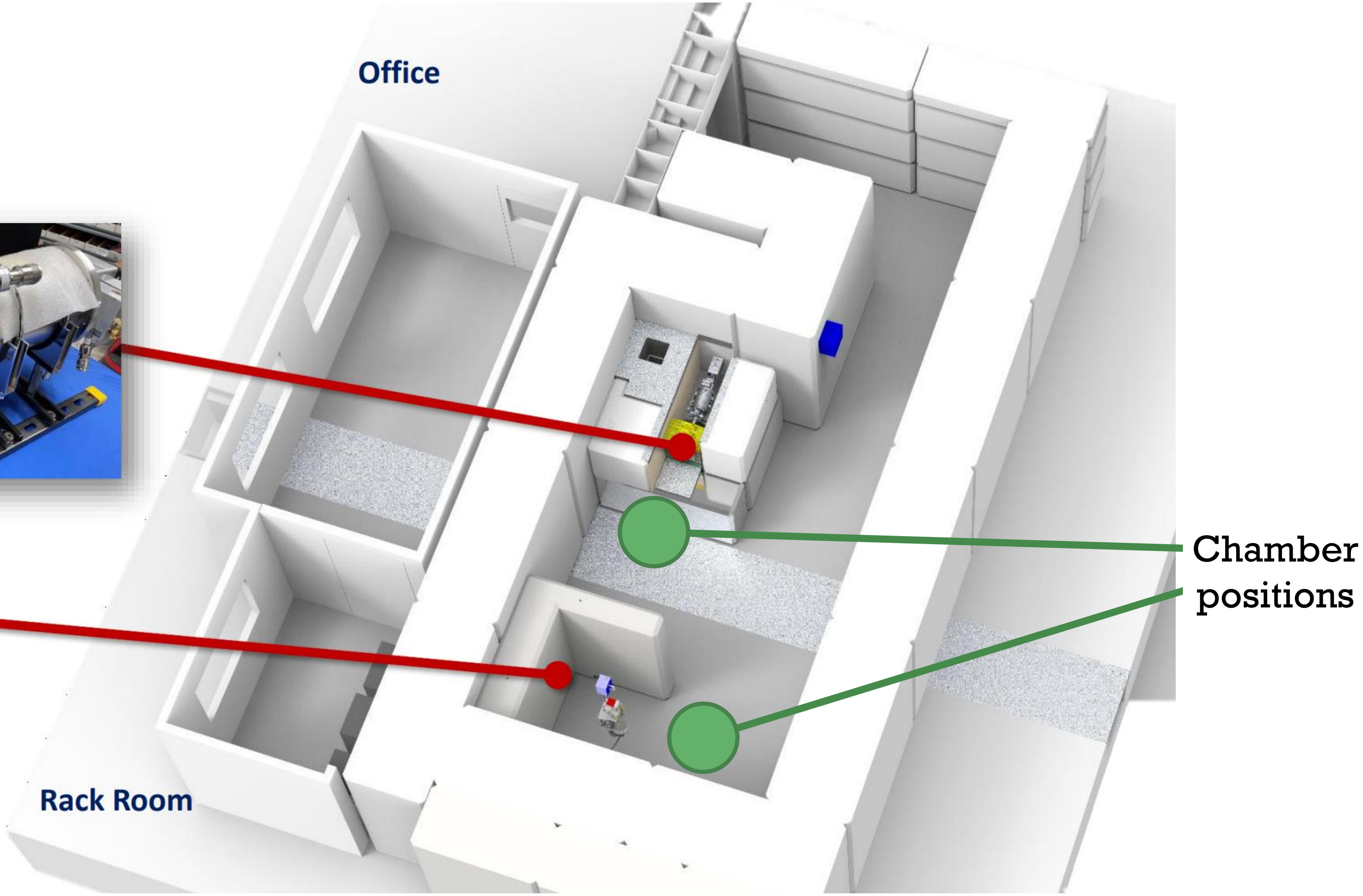
Our sources have been delivered!

14.1 MeV DT neutron source

Flux: $10^{10}$ n / sec

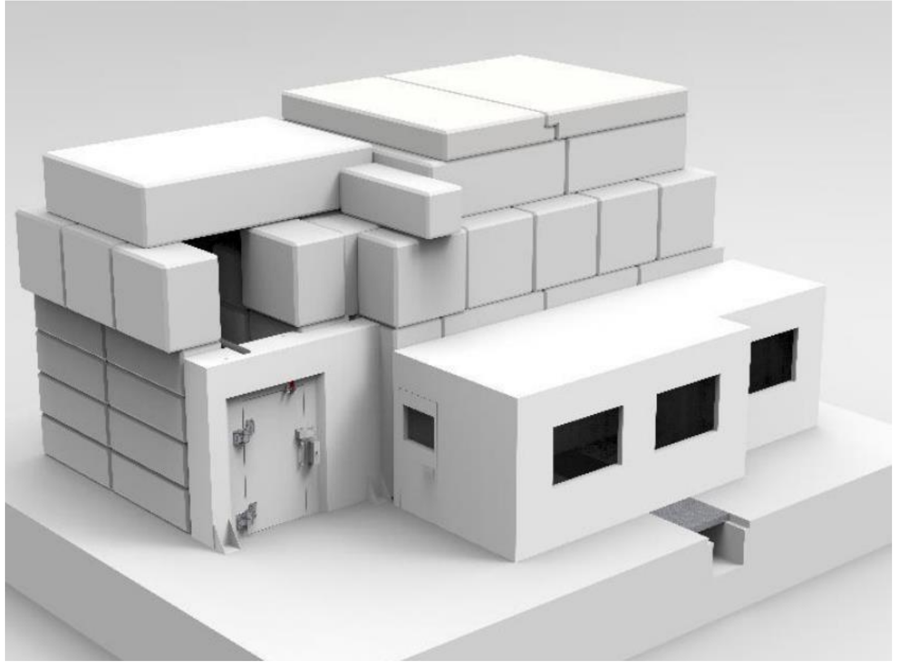
2.45 MeV DD neutron source

Flux: $10^{9}$ n / sec



# Door and shielding blocks

- We have our door!
- Here's a 3D model of the room with the roof on.
- You can see the trench for cable / pipe access.

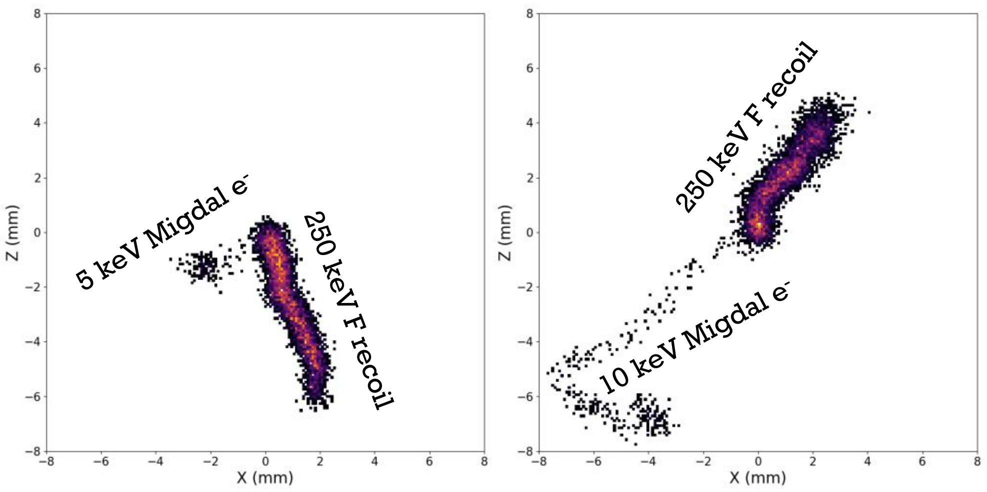


# It’s all coming together

- The lid is off at the moment, so the crane can be operated safely.
- The next steps will be to populate the office furniture and set up the rack room.
- NILE is located at ISIS/RAL.


# Signal and background

# Migdal rates




- Above is an example Migdal signal topology after 10 mm drift in pure $CF_4$ at 50 Torr.
- To the right are calculated Migdal rates in **events/day** for nuclear recoils with $E_r$ > 150 keV, and Migdal electrons with $E_e$ > 5 keV.
- Our background comes from the production of electron recoils near nuclear recoil vertices.
- Most potential sources of background are avoided by operating at low pressure, some turn out to produce electrons far below our threshold.

| | DT source ($10^{10}$ n/s) | DD source ($10^9$ n/s) |
|---|---|---|
| Fluorine | 190 | 23 |
| Carbon | 20 | 3 |

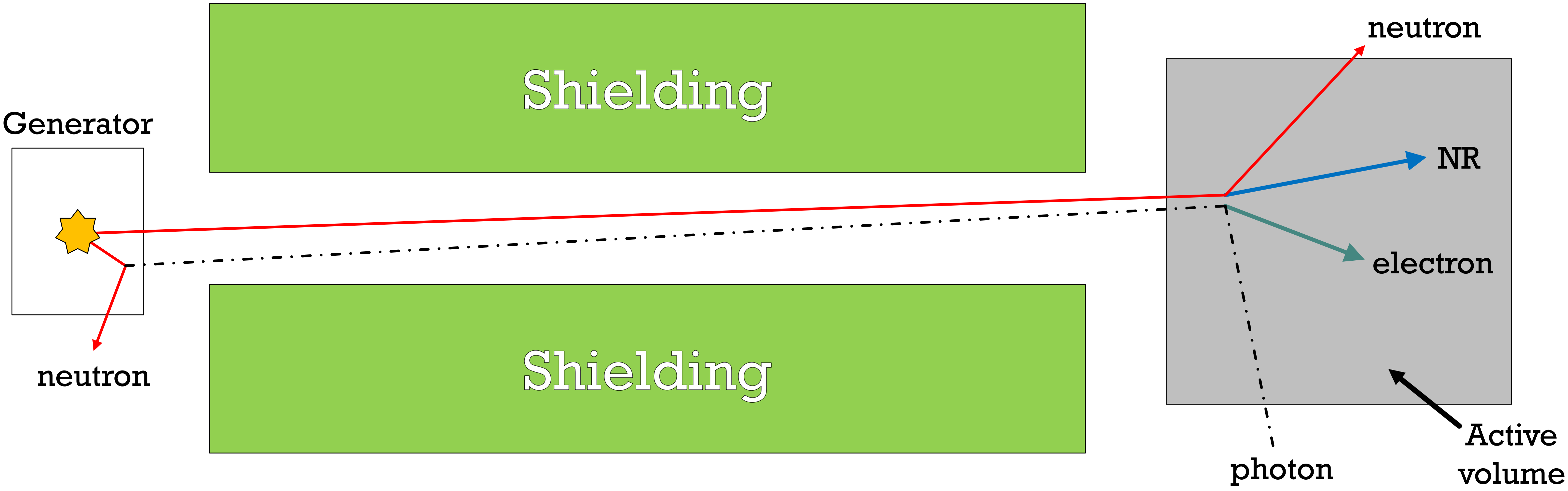
Fluorine rate is very high because each $CF_4$ has 4 fluorines.

**Assumptions:**

- Detection volume: 5x5x5 $cm^3$
- Pure $CF_4$
- Pressure: 50 Torr
- Temperature: 293.15 K.
- DT & DD sources are 1.4 m & 1 m away from the detection volume respectively.

# Photons from DT generator

- Photons are produced from inelastic neutron scattering inside the detector itself. These photons are the dominant source of background for Migdal search as they can produce Compton electrons near existing NR vertices (looks like Migdal).
- Predicted background rate: 21 ± 2 events/day (more of an obstruction with timing information from PMT).



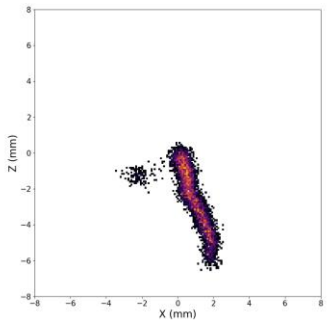
# Shielding optimisation

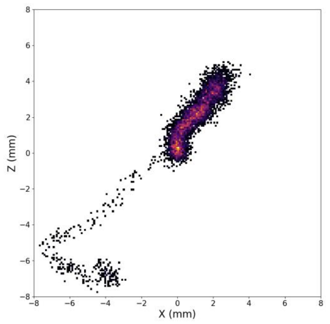
- The optimisation of the shielding is non-trivial.
- Adding additional shielding can increase the probability of gammas and charged particles reaching our active region.
- Our generators emit over the full solid angle, so we need to collimate the beam. The shape of the collimator requires optimisation to maximise exposure in the active region.
- The detector operates at low-pressure, which means the neutron beams must pass through window material which can degrade the quality of the beam and produce gammas / charged particles which enter our active region.
- If we want to reduce the background from the generators, we require extra intervening material which will also degrade the quality of the beam.

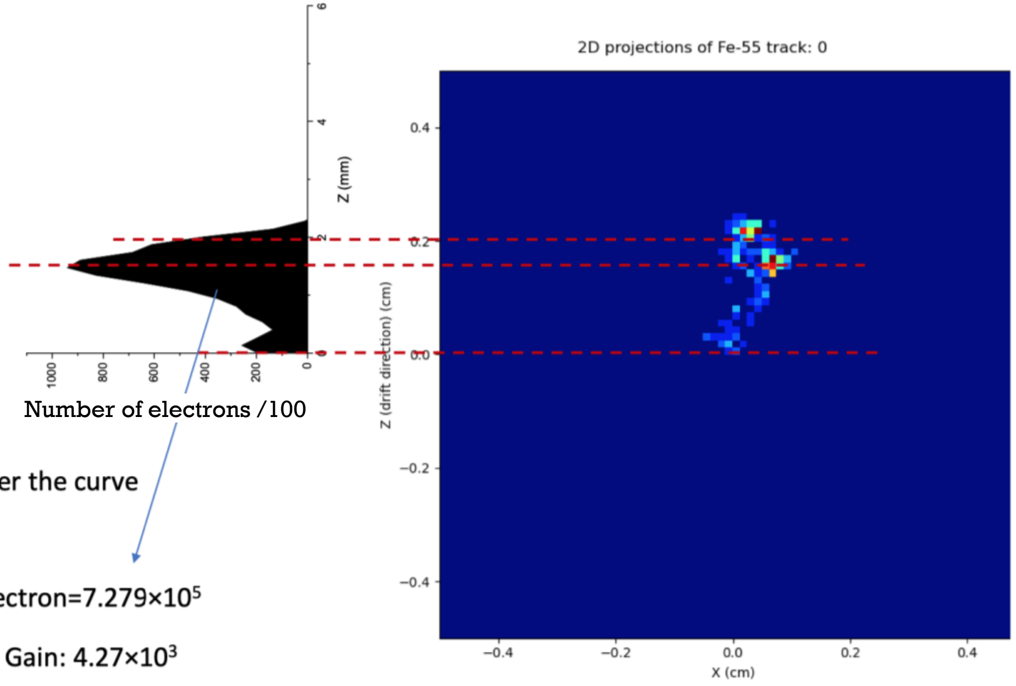
# End-to-end simulations

# The pipeline

- Electron track production with DEGRAD.
- NR track production with SRIM (Garfield++ interface).
- Diffusion is applied using parameters from Magboltz.
- Field map of Two-GEM system is simulated using ANSYS.
- Electron amplification is simulated using AvalancheMicroscopic model in Garfield++.
- Electrons are drifted from the edge of the GEM onto the ITO strips.
- Electrons induce current onto the ITO strips.
- Current is convolved with electronics response functions to obtain the voltage pulses.
- Using deconvolution on voltage pulses, dE/dx can be recovered in the drift direction.




Area under the curve

Number of electron=$7.279\times10^5$

Gas/Amplifier Gain: $4.27\times10^3$

**dE/dx can be determined with a good accuracy !**

# Summary

- Most of the primary components of our detector have been delivered, some are being tested.
- The facility is almost ready, we aim to begin full assembly within a few months.
- Signal and background calculations are promising.
- Full-chain simulation for high confidence in discovery is going well. Full track reconstruction has begun.

# Thank you