



Science and  
Technology  
Facilities Council

# Assembly of hybrid detector modules for advanced medical imaging

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# Agenda

## 1 STFC and MH3D an overview

Brief description of both organizations and what they do

## 2 Motivation – Targeted Alpha Therapy and Theranostics

Real-life impact of the project and commercial application of the assembled modules

## 3 Module assembly technique

Overview of how HEXITEC modules are assembled from wafer to a full working module

## 4 Future plans

# Who are we?

- Science and Technology Facilities Council (STFC) is a multi-disciplinary science organization. We support fundamental research in astronomy, physics, computational science, space science and operates world-leading, large-scale facilities across a range of physical and life sciences.
- STFC-RAL long-standing experience with building and integration of **pixel radiation detectors** used for experiments at synchrotrons and with other high-energy X-ray radiation sources



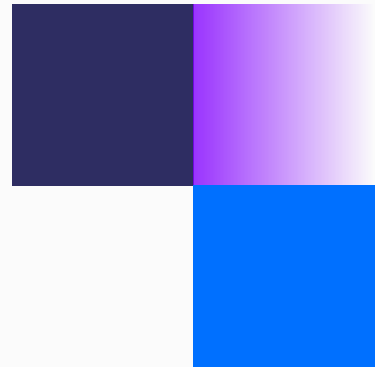
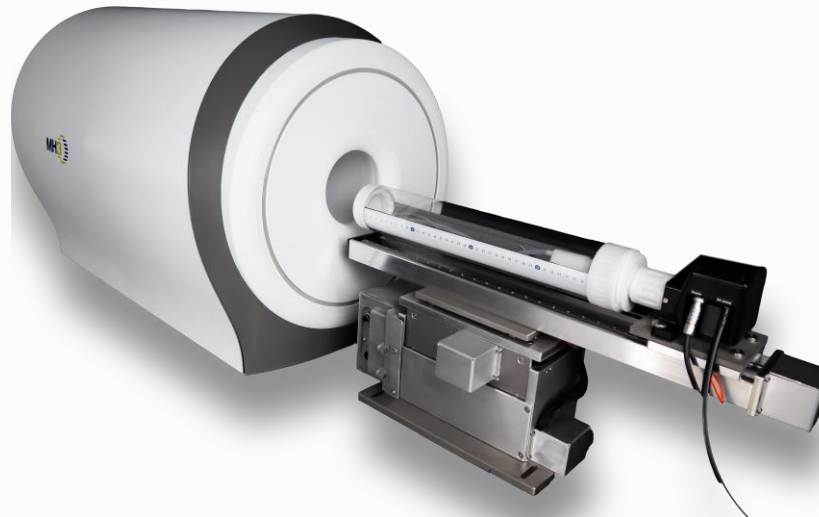
# STFC Interconnect capabilities

- We are involved in different impactful projects including **ATLAS ITk** upgrade, **Kirana** (high speed camera, 7M frames per second), **LPD** for European XFEL etc
- Building large pitch ( $\sim 500\mu\text{m}$ ) and small pitch ( $\sim 55\mu\text{m}$ ) radiation detectors
- Indium bump bonding for fine pitched devices for quantum computing applications in collaboration with NQCC.
- Solder reflow in formic acid environment for applications like ATLAS ITk pixel modules

# MH3D an Overview

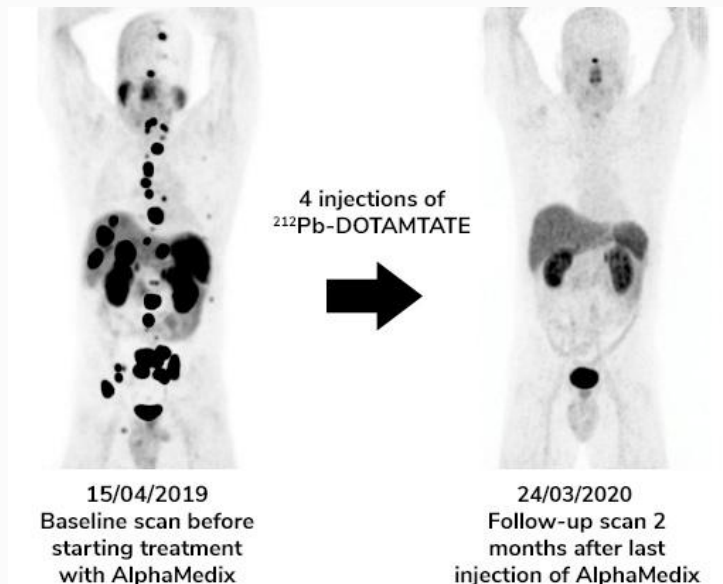
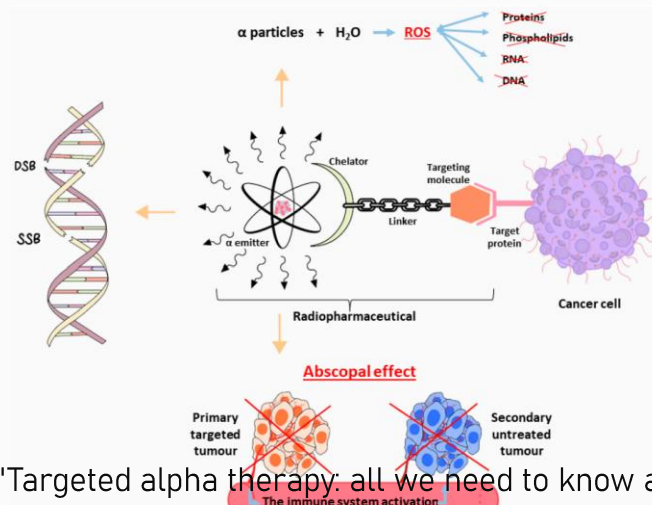


- Start-up founded in 2023, spin-off of university of Michigan and university of Illinois
- Currently developing next generation SPECT (Single Photon Emission Computed Tomography) imaging systems for early detection and monitoring of cancer, cardiovascular, and neurodegenerative diseases.
  - Aims to deliver sub - 1 mm resolution Alpha-SPECT™ Mini
  - Scanners for preclinical research (mice and rats)



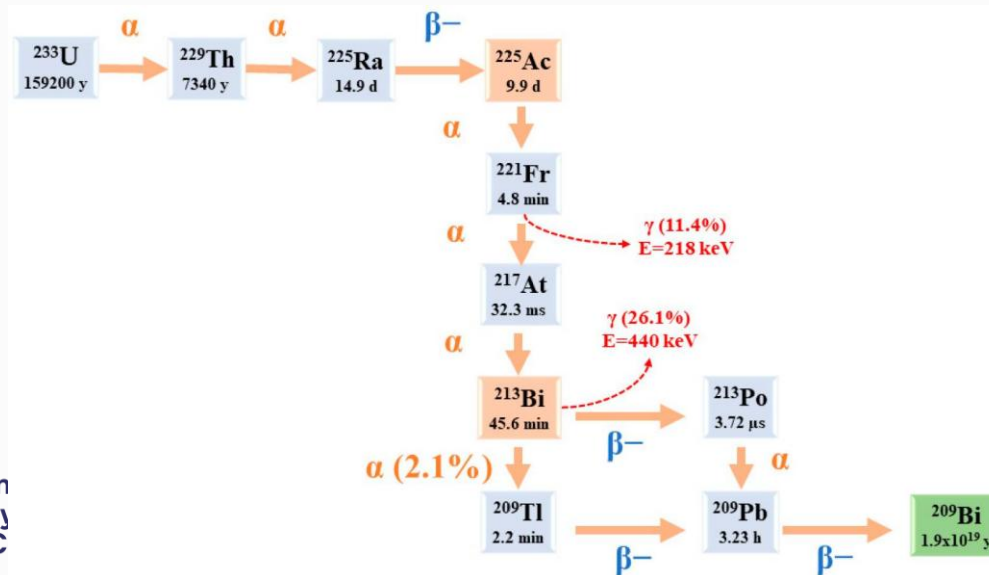
# Targeted Alpha Therapy

- Targeted Alpha Therapy uses  $\alpha$  particles to selectively destroy tumour cells while preserving adjacent healthy tissues
- $\alpha$  particles travel short distances less than 0.1mm.
- Radionuclides like  $^{225}\text{Ac}$  and  $^{212}\text{Pb}$  are used
- TAT can target primary targeted tumour as well as the secondary untreated tumour due to abscopal effect.



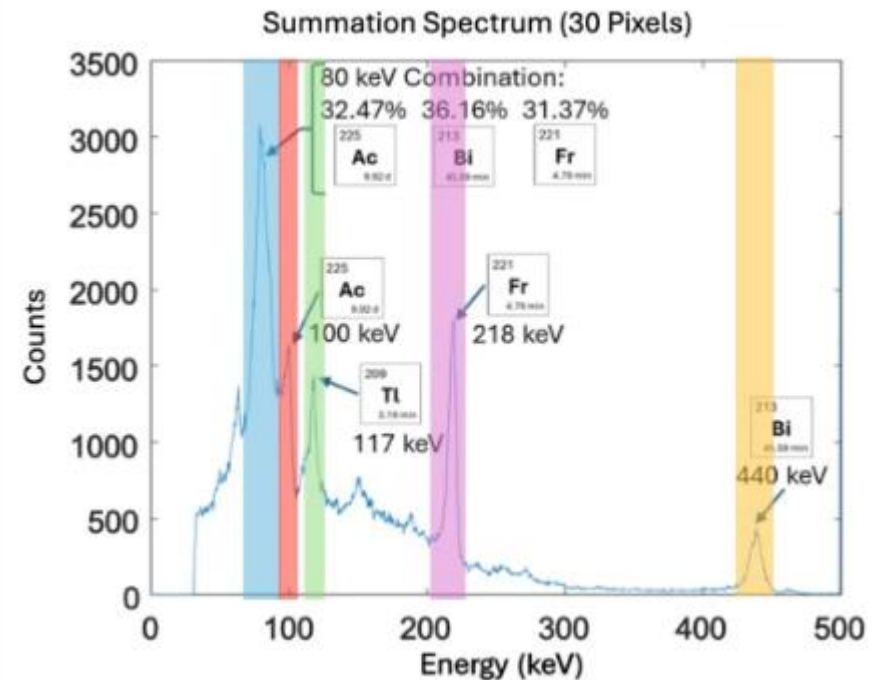
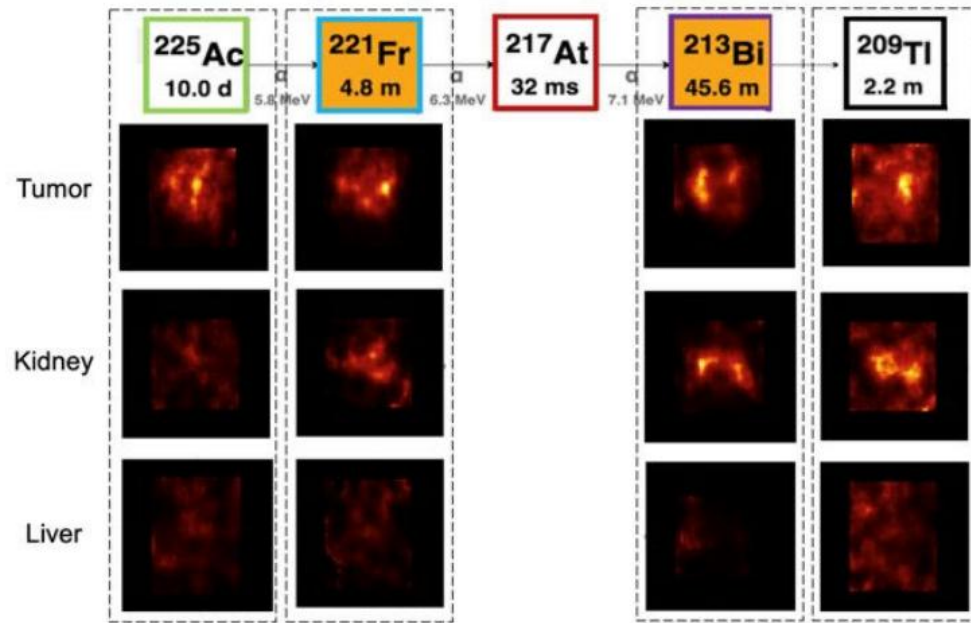
# Theranostics

- Combination of targeted diagnostic imaging with radioactive therapy
- The radioactive tracers emit gamma rays then captured by the gamma camera to construct a 3D image.
- Radionuclides used for SPECT have longer half lives and the  $\alpha$  emitters have complex decay schemes producing daughter isotopes.



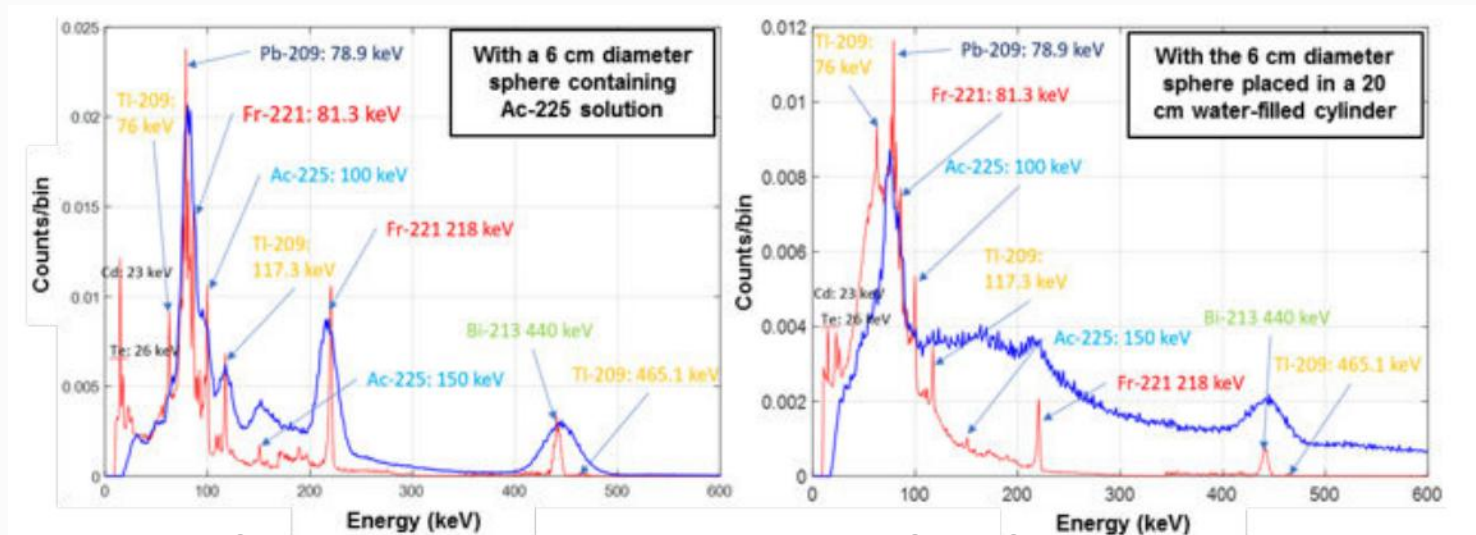
- The clinicians need to know not just "where," but "which" isotope in the decay chain to accurately calculate the dose delivered to the cancer and healthy tissues, like the kidney and liver.

### Distribution of Ac-225-Labeled Antibody in Mouse



# HEXITEC

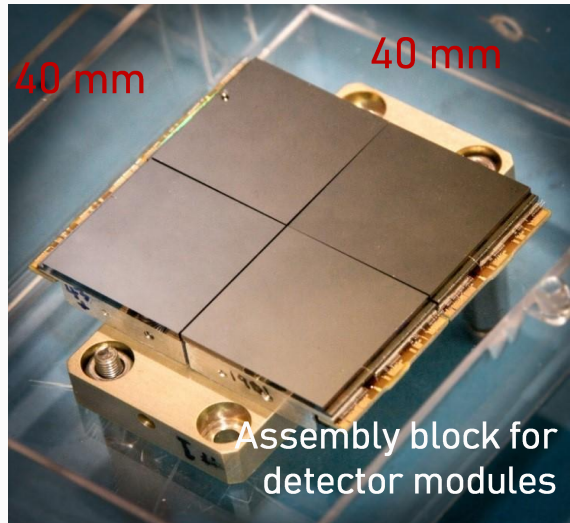
- HEXITEC ASIC developed by STFC in 2007–2009. It's an 80x80 pixel array, on a 250  $\mu\text{m}$  pitch. Pitch of 500  $\mu\text{m}$  MH3D i.e, 40x40 array.
- Delivers excellent energy and spatial resolution capabilities
- HEXITEC can distinguish closely-spaced emission peaks from different radioisotopes. Ideal for SPECT imaging.



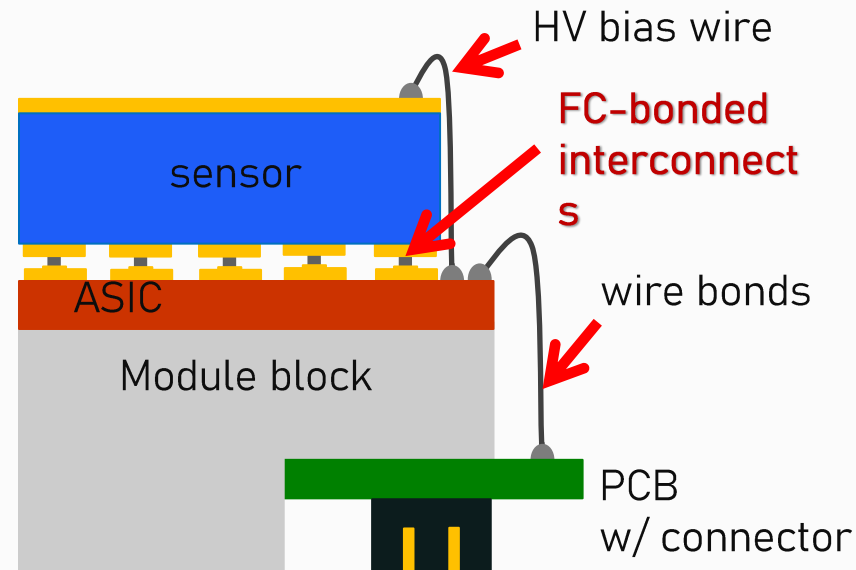
*Comparison between the alpha SPECT Mini and a conventional Siemens SPECT system*

# Assembly of a full module

- A full module consists of an HEXITEC ASIC (Application Specific Integrated Chip) flip-chip bonded to a compound high-Z semiconductor. In this case CZT (Cadmium Zinc Telluride) sensor.
- CZT can stop high energy photons and operates at room temperature.
- Depending on the application, the full modules are arrayed to a panel

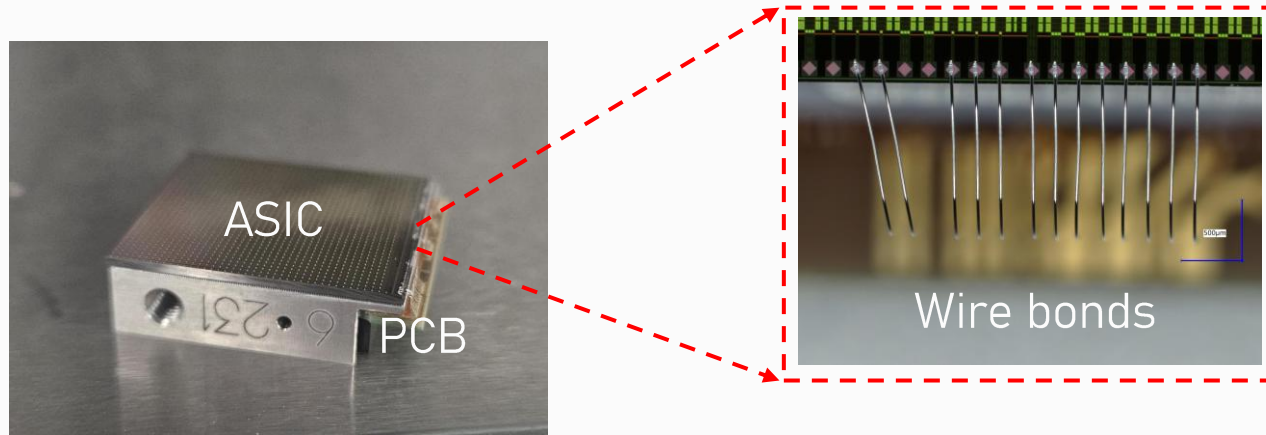


Panel assembly

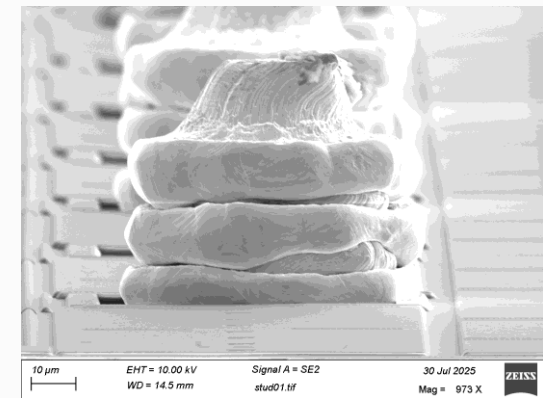


# Key Assembly steps for HEXITEC

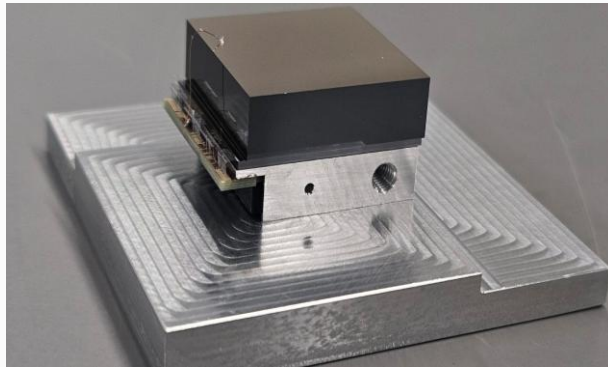
1. ASIC studding – Starts with ASICS on a wafer. Gold studs formed on ASIC pads to provide electrical contact point & mechanical standoff
  - Average triple studs of height  $\sim 40\mu\text{m}$
2. A door-step PCB is attached to an Al block. The studded ASIC is mounted onto the block
3. The ASIC is wire bonded to the PCB. Before putting the CZT on the ASIC, they are Vcal (Voltage calibration) test. This will determine if the ASIC is dead or alive.



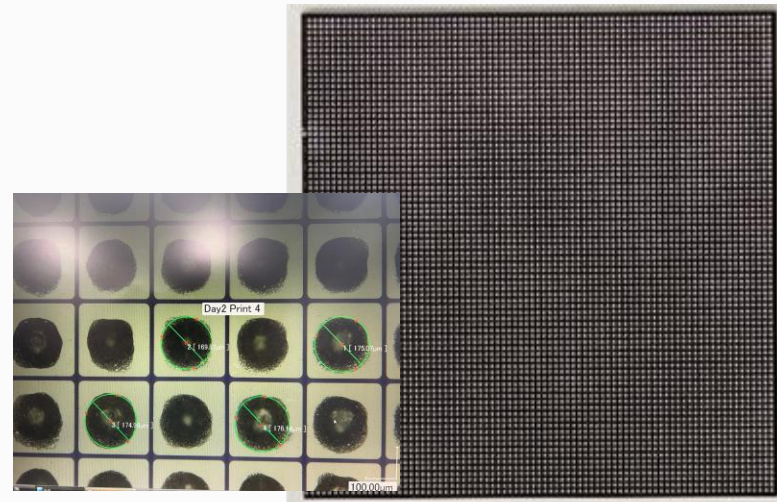
SEM image of gold studs



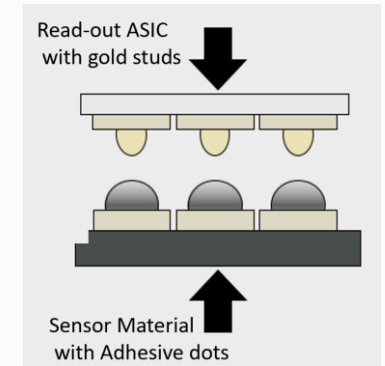
3. Stencil Printing – Thixotropic conductive epoxy is deposited on the CZT sensor pads using a precision stencil print
4. Flip chip bonding – The studs on the ASIC are aligned and bonded to the epoxy dots on the sensor, through controlled pressure and temperature.
5. A CZT is connected with a bias wire



Fully assembled module

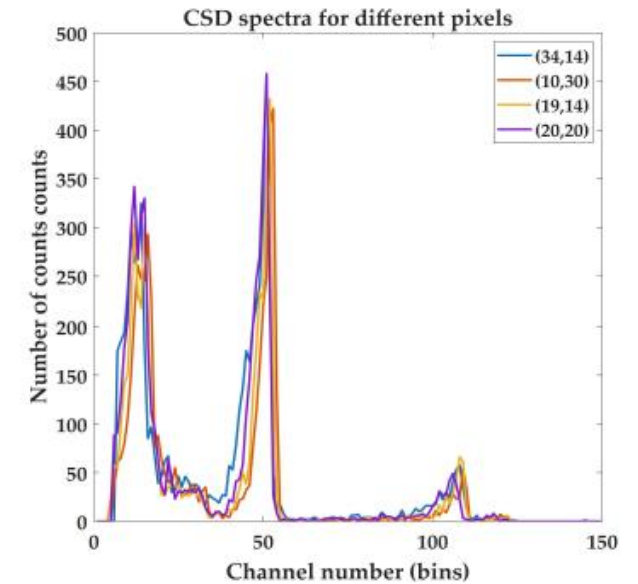
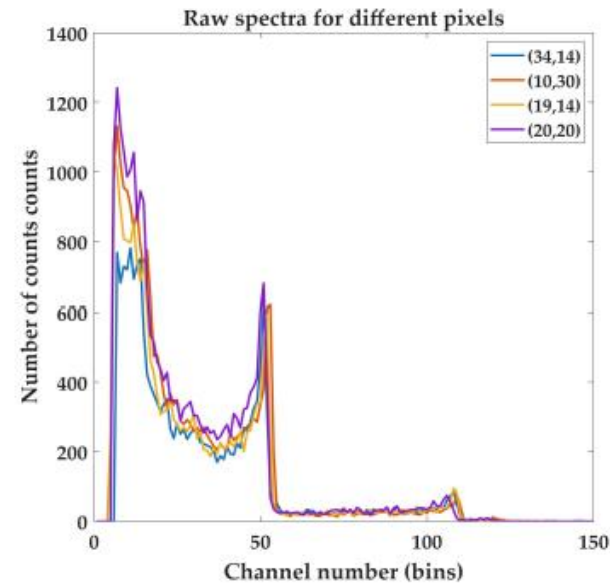
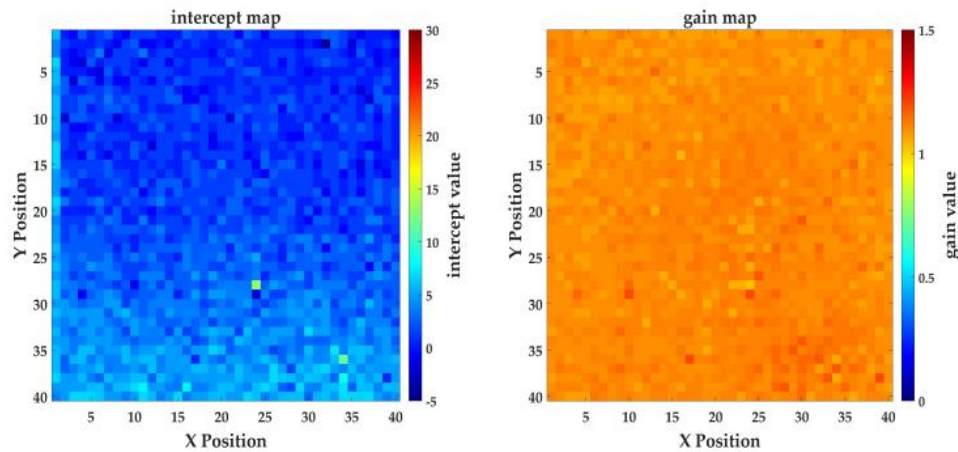


CZT with epoxy dots. On average  
~160µm in diameter and ~40µm in height

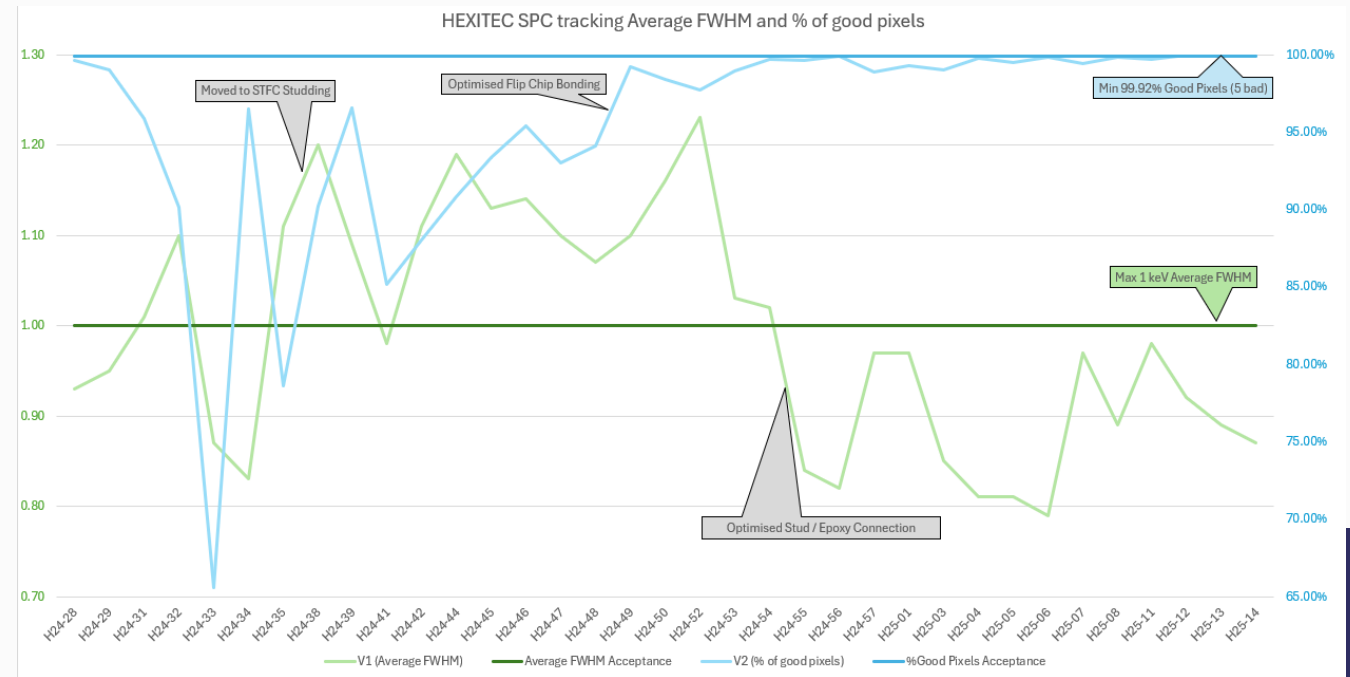
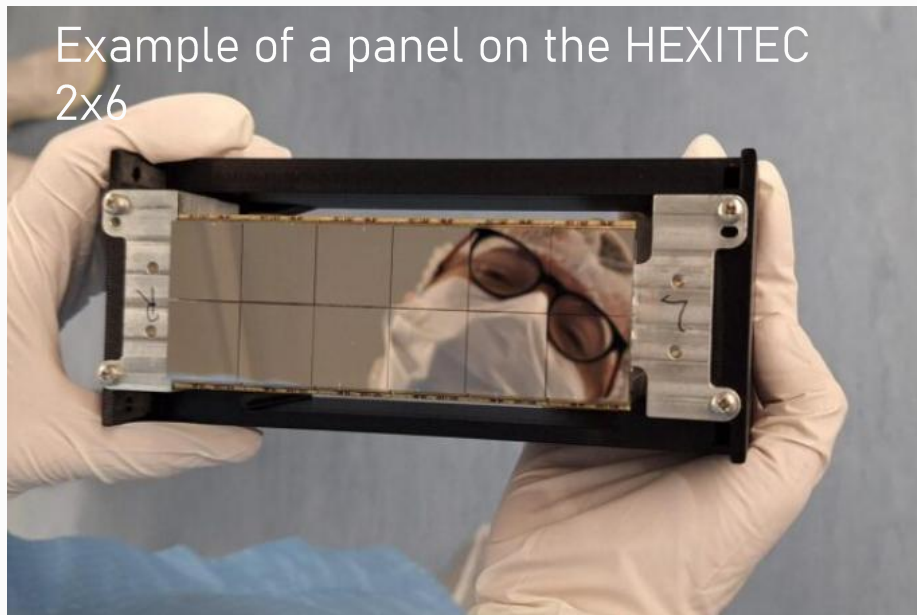


- The assembled modules are tested with Americium-241 and Cobalt-57 radiation sources

The tested full modules have a spectroscopic energy resolution of ~3–4 keV full width half maximum(FWHM) measured at 60keV in low gain and a bond yield of 99%.



- After testing, the full modules are assembled on to a panel
- Currently STFC is able to produce 100+ full modules every month with a yield of 95%.



# Outcomes

 MH3D · Nov 24, 2025 · 2 min read



## MH3D Announces First Commercial Installation of Alpha-SPECT™ Mini at Johns Hopkins University School of Medicine

Updated: Nov 25, 2025

BALTIMORE, MD – November, 2025 – MH3D is proud to officially announce the first commercial installation of its flagship preclinical SPECT/CT imaging system, the Alpha-SPECT™ Mini. The state-of-the-art system has been installed at the prestigious Johns Hopkins University School of Medicine.

 MH3D · Apr 20 · 2 min read



## MH3D, Inc. Announces Purchase of Alpha-SPECT Mini Unit by Minerva Imaging

Ann Arbor, MI —April 20th, 2026— MH3D, Inc., a leader in next-generation quantitative SPECT imaging technology, today announced that Minerva Imaging, a globally recognized contract research organization (CRO), has purchased an **Alpha-SPECT™ Mini** unit, marking the first adoption of MH3D's technology in Europe. This commercial milestone represents growing demand for high-precision, quantitative imaging solutions in pre-clinical theranostics research.

Further read [News | MH3D Inc.](#)



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# MH3D – forecast and future plans

- Alpha SPECT MINI for small animals (mice) are mainly targeting radionuclide development companies
  - Requires hundreds of HEXITEC modules per mini scanner
- **Next step is to Move on to brain scanner – 200+ HEXITEC modules**
- **Full SPECT scanner (Humans)**

For STFC, the production will move to a high throughput line by the end of 2026



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Questions?