



## Acknowledgments

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## At A Glance

A magnetic camera designed to monitor Tokamak toroidal B fields, designed to address the specific requirements of the upcoming SOUTH Tokamak:

- 20 kHz Bandwidth achieved through an FPGA and multiple ADCs
- Entirely off-the-shelf construction
- Measures in excess of  $\pm 150$  mT, with an effective sensitivity of  $\approx 0.32$  mT
- Robust operation in harsh conditions
- Pedagogical potential

# 2D Hall Arrays for High Resolution Tokamak Magnetic Field Imaging

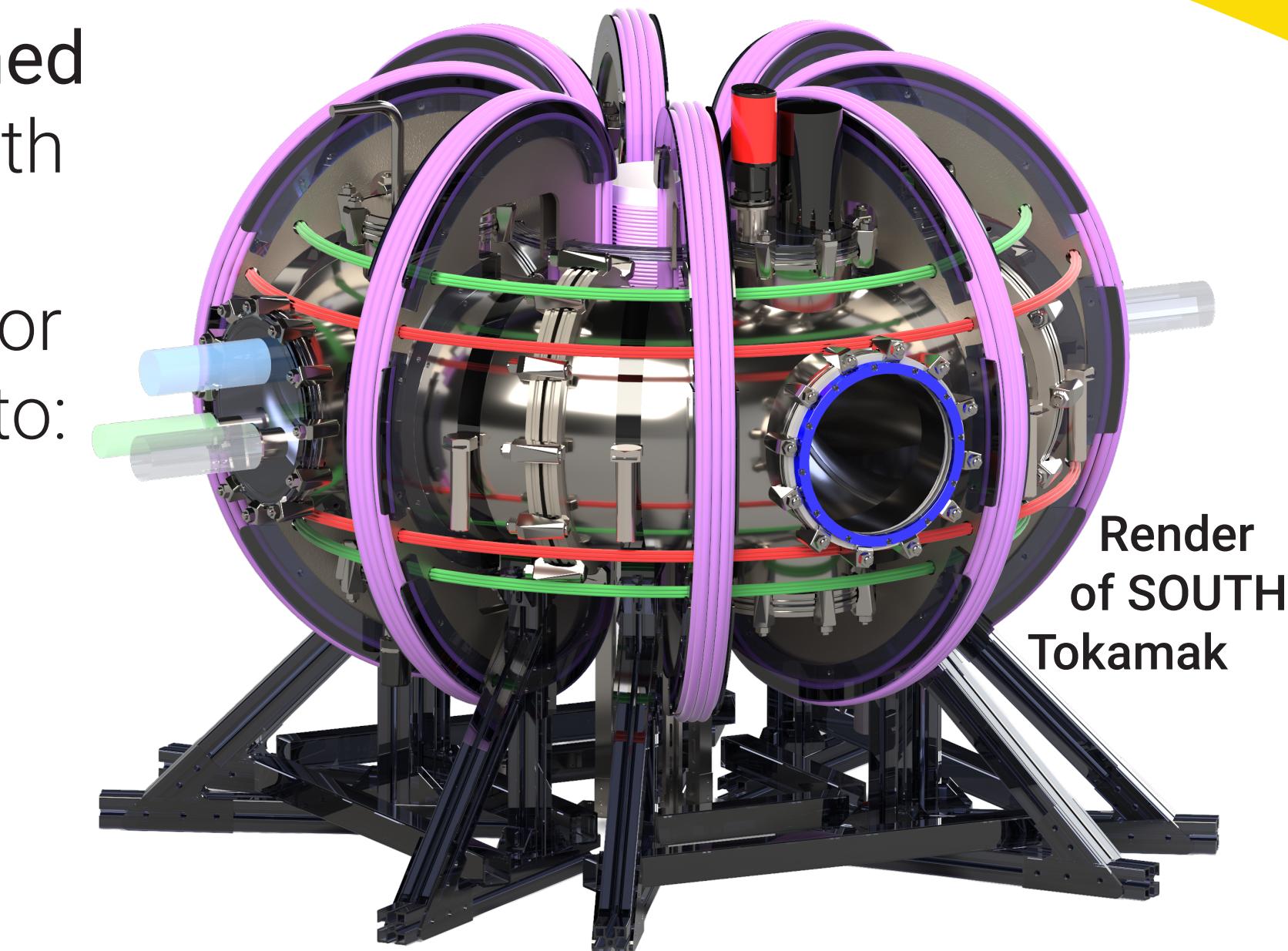
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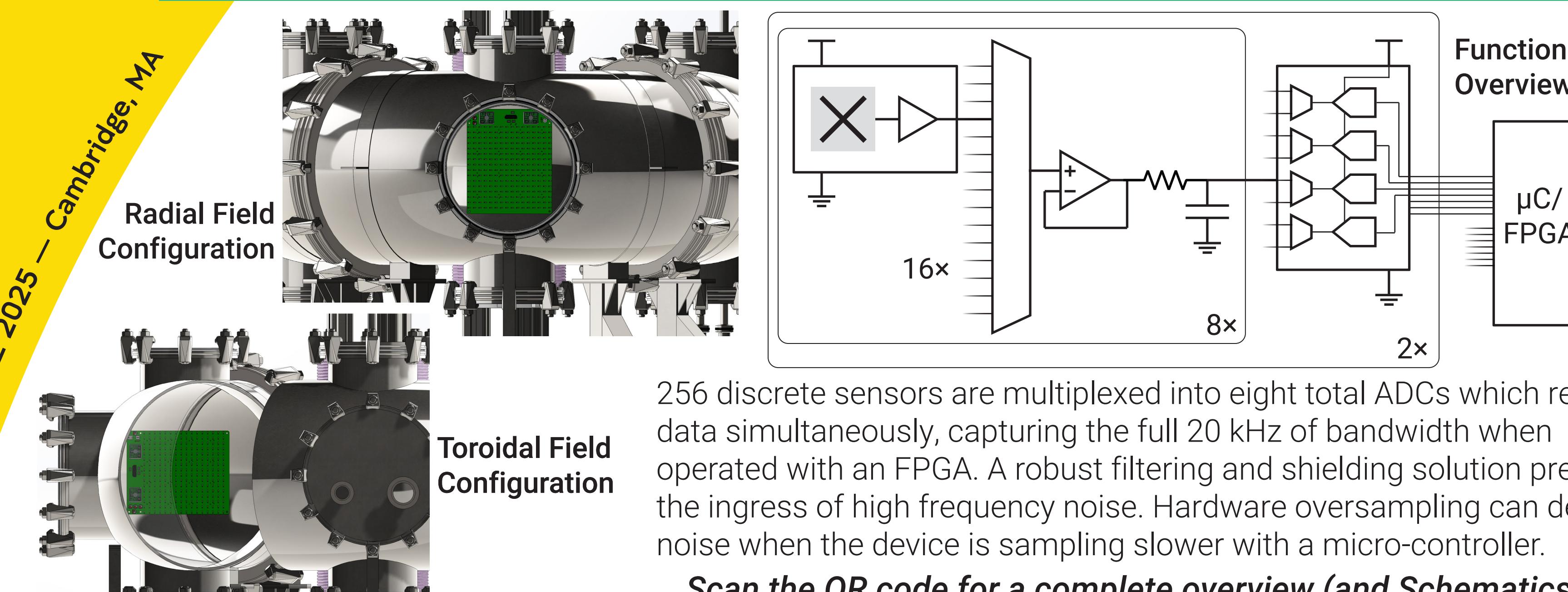
## Motivations: The SOUTH Tokamak

The SOUTH Tokamak is an upcoming undergraduate designed and built Tokamak constructed at the University of New South Wales in Sydney, Australia. The project has many unique requirements, stemming from a very tight budget. This sensor is engineering focused – plant, not plasma – and designed to:

- Verify that the correct  $B$  field is being produced
- Validate our multiphysics simulations
- Catch manufacturing defects or deficiencies
- Avoid the requirement for more comprehensive and expensive field mapping solutions



## Device Description



256 discrete sensors are multiplexed into eight total ADCs which record data simultaneously, capturing the full 20 kHz of bandwidth when operated with an FPGA. A robust filtering and shielding solution prevents the ingress of high frequency noise. Hardware oversampling can decrease noise when the device is sampling slower with a micro-controller.

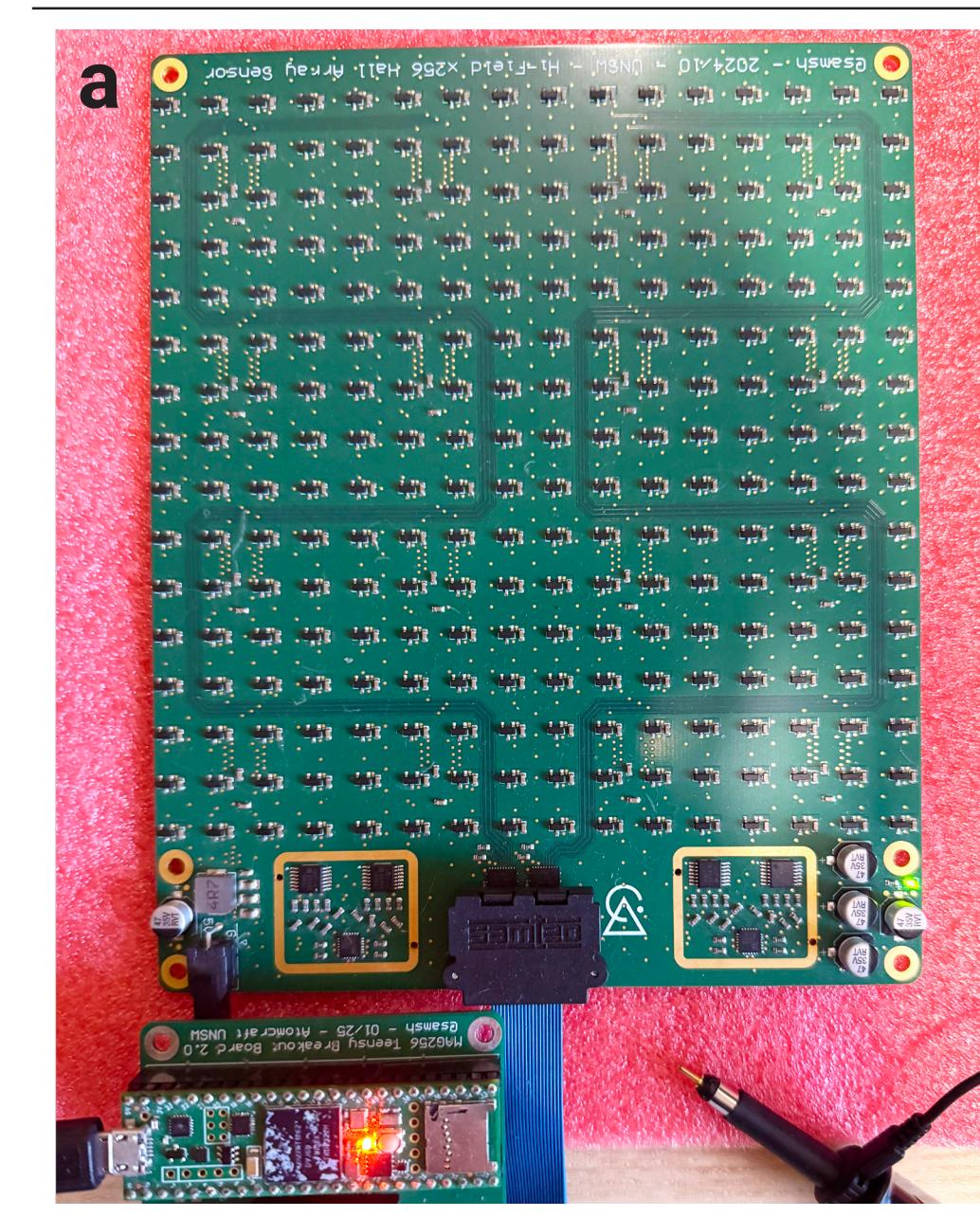
Scan the QR code for a complete overview (and Schematics)!

## Specifications

Sensor Layout	16x16, 9 mm Pitch
Overall Dimensions	175x142 mm
B Field Range	$>\pm 150$ mT
Analogue Bandwidth	20 kHz
Sampling Rate	>40 kSPS / Sensor
Mechanical Structure	6 Layer FR4 with ENIG
Number of Components	>600
ADC Bits	12, ~10.4 ENOB
Effective Sensitivity	$\sim 0.32$ mT
Data Production Rate	>122.88 mbps
Power Consumption	~7.5 W

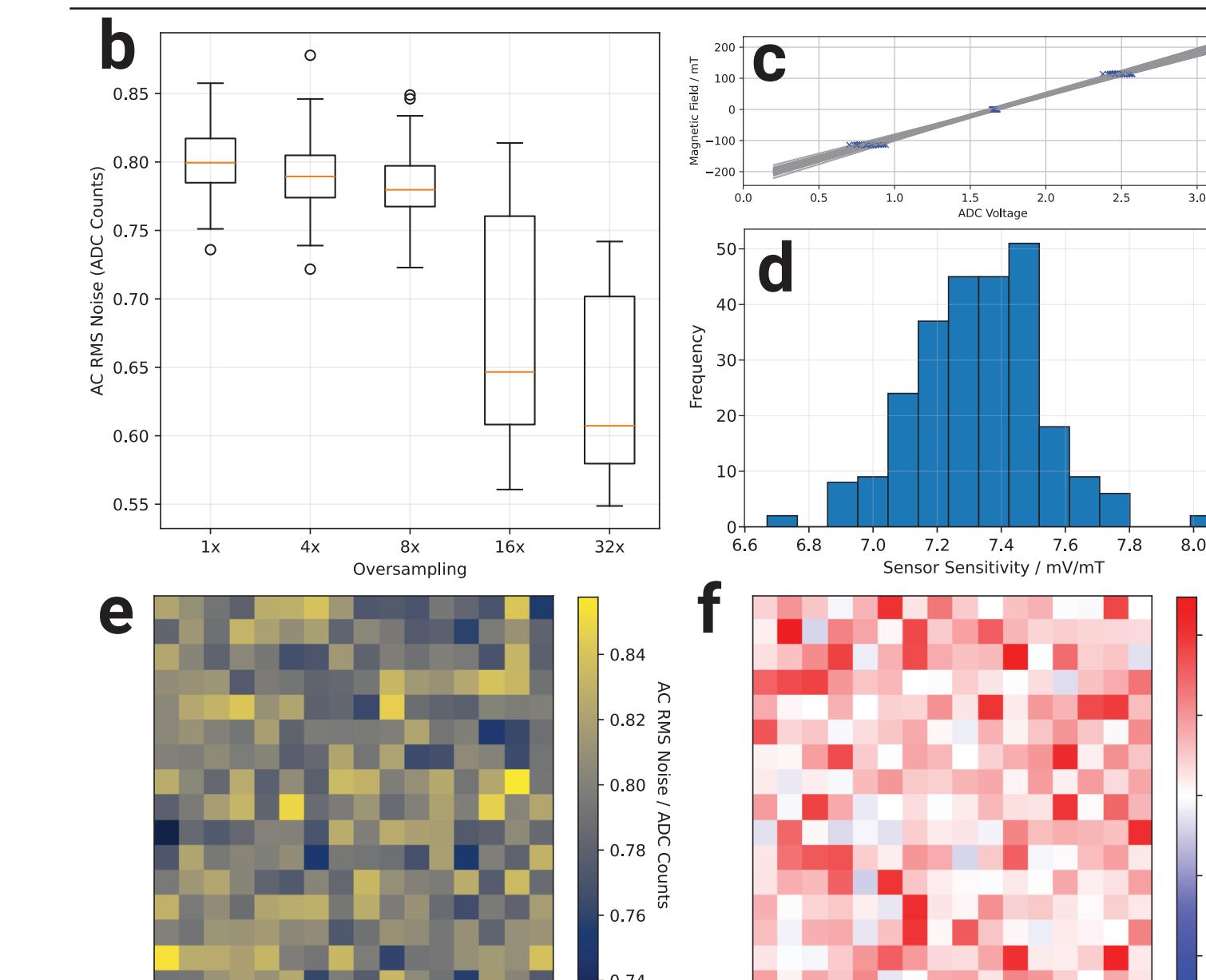
## Preliminary Results

### Completed Device



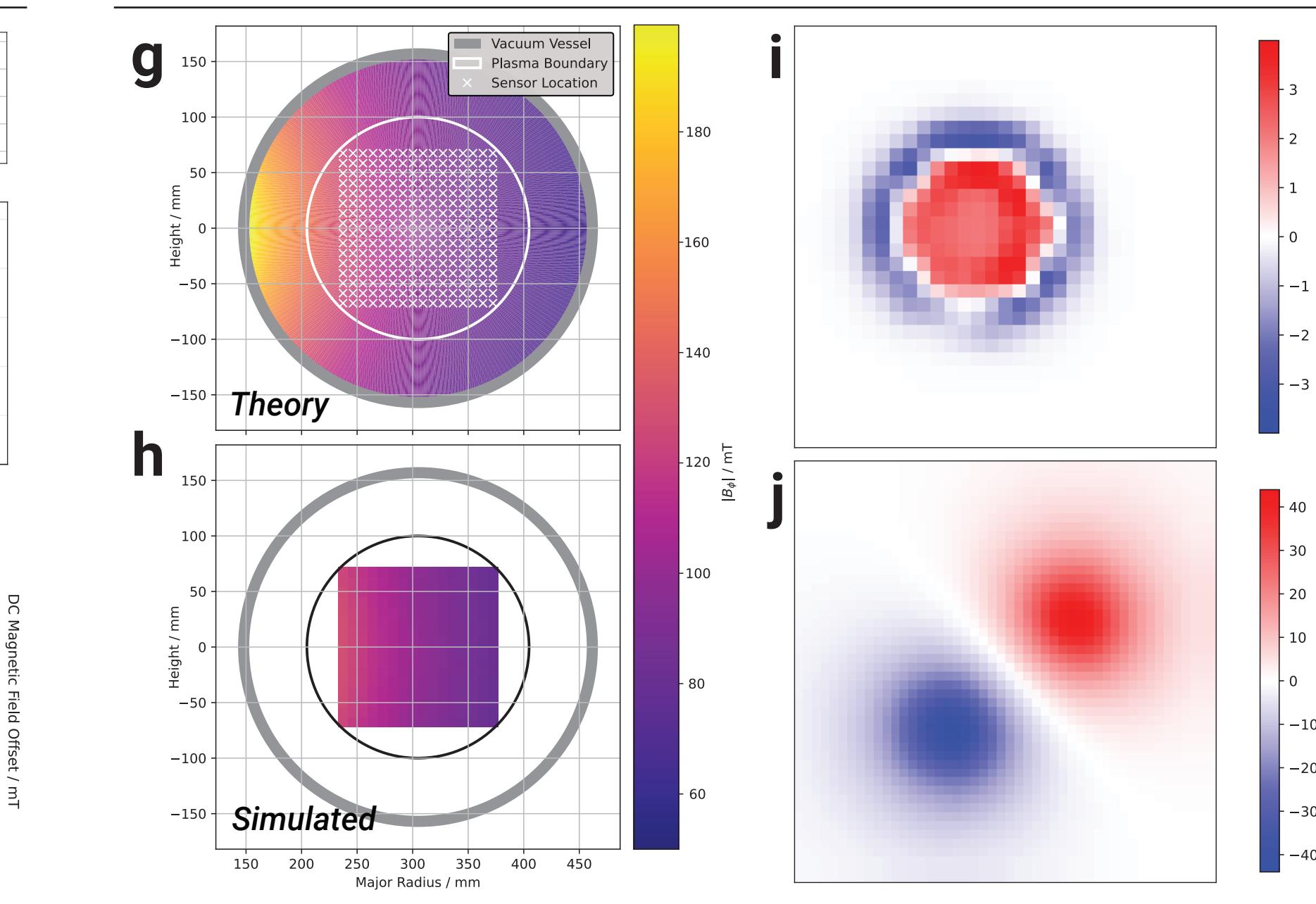
a) Assembled device connected to Teensy 4.1 Micro-controller via a SYZYGY connector + breakout.

### Noise & Calibration



b) AC RMS noise statistics; c) Sensor predicted range; d) Sensor sensitivity histogram e) DC bias distribution; f) AC RMS Noise Distribution

### Imagery



g) Theory toroidal field with sensor geometry; h) Simulated reconstruction; i) Magnetic field of Apple MagSafe Charger; j) Magnetic field of Bar Magnet – Scan QR code for Videos!

This device will be used to aid in SOUTH's R&D, manufacturing and commissioning over the next 18-24 months, with toroidal field measurements coming soon.

## Learn More?

