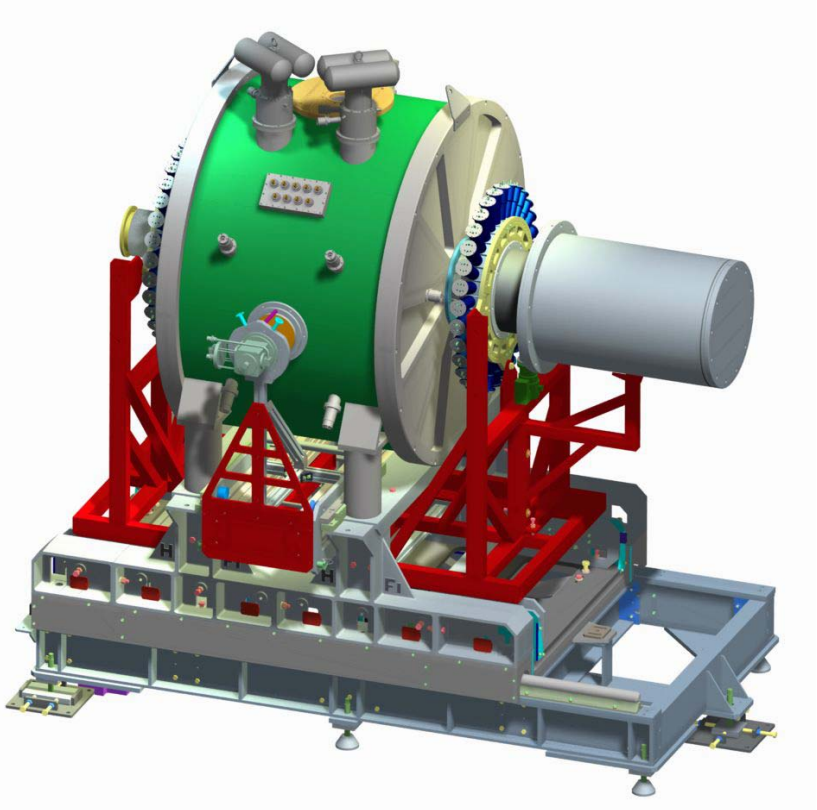
The New High Field Muon Spectrometer at ISIS

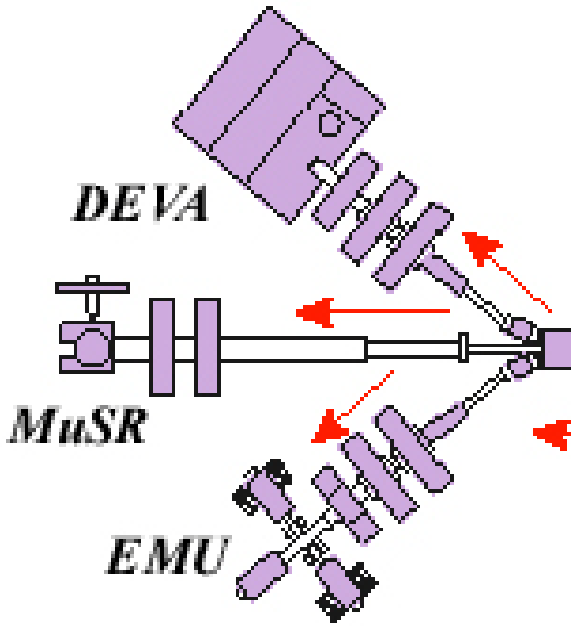
Philip King, ISIS

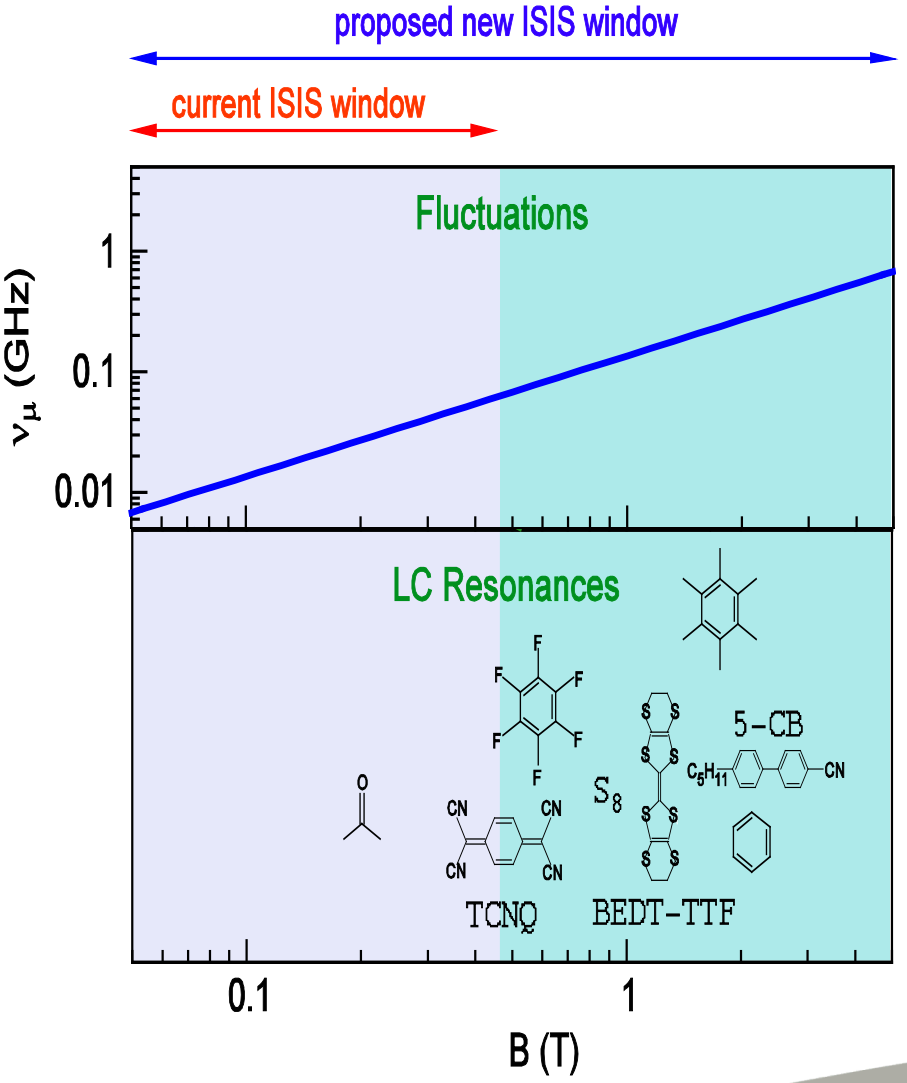


1. *Why higher fields?*
2. *Specification*
3. *Construction*
4. *Science examples*

1. Why higher fields?

- MuSR – 0.25T (LF), 0.06T (TF)
- EMU – 0.5T (LF), 0.01T (TF)
- DEVA – 0.2T (LF)
- *ARGUS – 0.4T (LF), 0.02T (TF)*
- *CHRONUS – 0.4T (LF), 0.02T (TF)*





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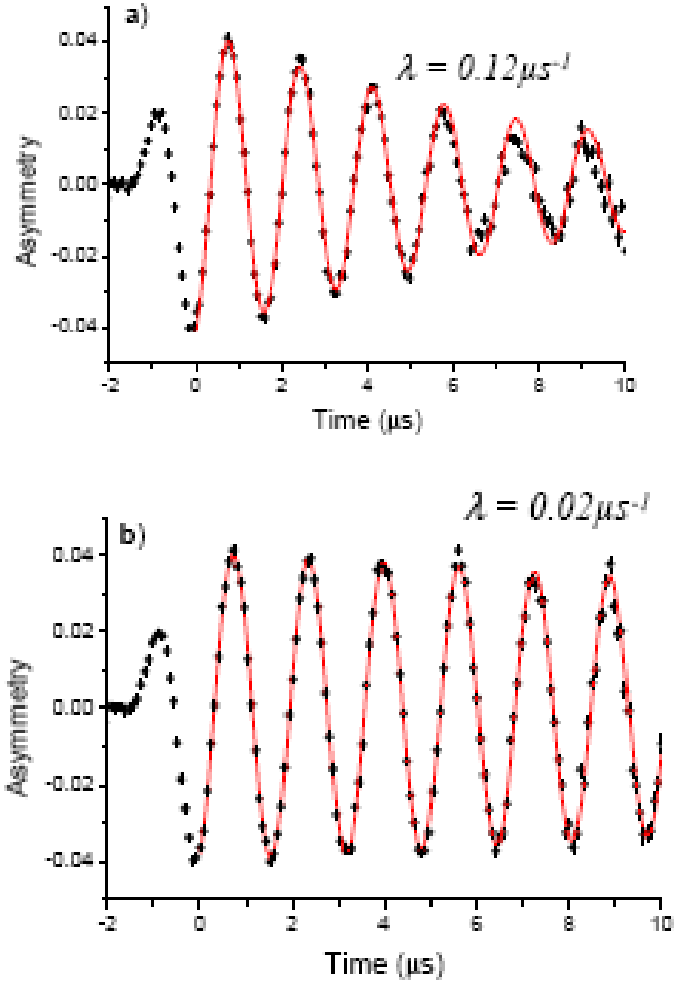
1. Why higher fields?

Four broad areas benefit:

- Fluctuations, diffusion, dynamics
- Spectroscopy (level crossing)
- State preparation
- Pulsed techniques

- **Optimised for a pulsed muon source: high time-differential data rates for high-field studies**

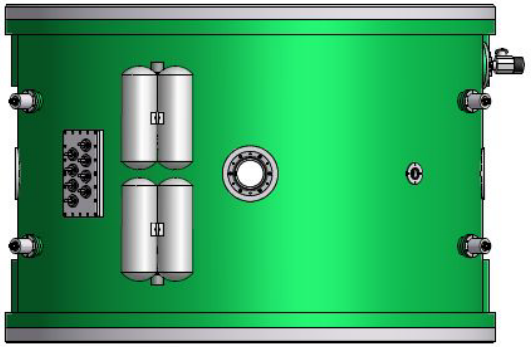


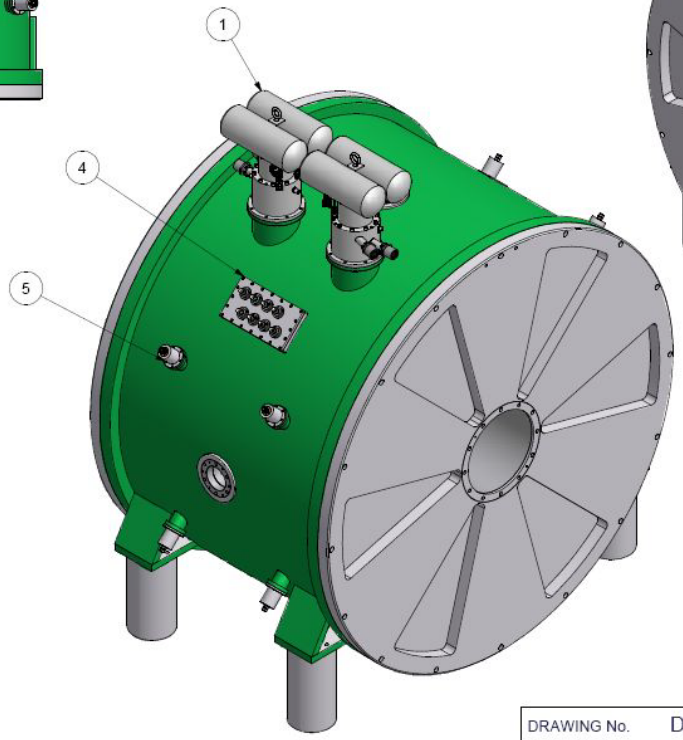
2. Specification

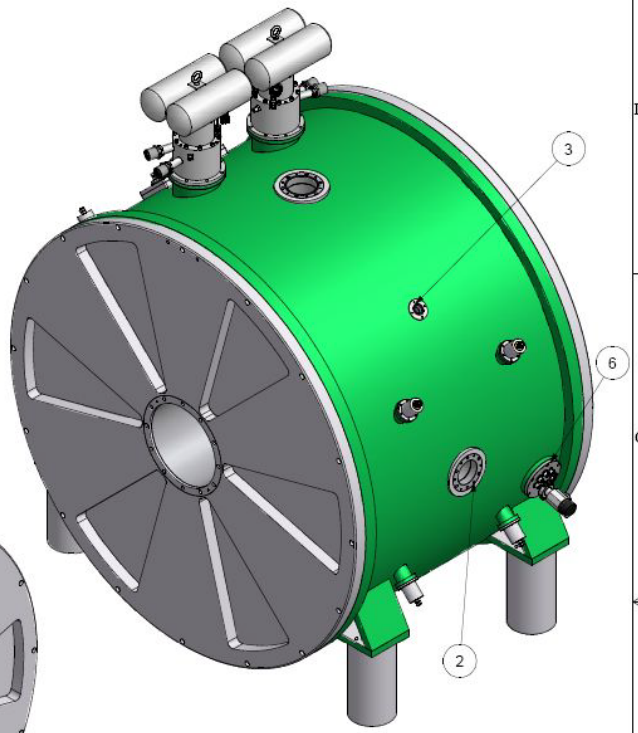
- 5 T main field, longitudinal, reversible
  - Stray field: 2 G at 3 m
  - Stability: 50ppm over 12 hours (persistent mode)
  - Ramp rate: 1T in 10 mins (full field in ~90 mins)
  - Homogeneity: 20 ppm over normal sample volume
  - Cool-down for system: ~7 days (cryogen-free)
- + 400 G auxiliary field (for field switching, e.g. ALC)
- + 2 x 100 G transverse fields
- Zero field ability

- Data rates at least 50 MeV/hr (64 detectors)
- Split pair to allow flexible SE access
- Temperature range: 30mK – 1500K
- 'fly-past' possible

3. Construction







Parts List	
ITEM	DESCRIPTION
1	PT415 Pulse tube cryocooler
2	87mm side access port
3	45 degree access port
4	Current terminal port
5	Radial tie rod adjustment
6	Instrumentation port

DRAWING No. DA2		CRYOGENIC LTD
SHEET 1 OF 1	FIRST DRAFT: 28/02/2007 THIS DRAFT: 01/03/2007	
STD. PART No.		MATERIAL SPECIFICATION / MASS 1359 kg
THIRD ANGLE PROJECTION		DRAFT SYSTEM DESIGN
DIMENSION MM	TOLERANCE (UNLESS STATED) X ±1 XX ±0.1	JOB / QUOTE NUMBER 2566
DRAWN BY: RM	REVIEWED BY:	QUANTITY 1

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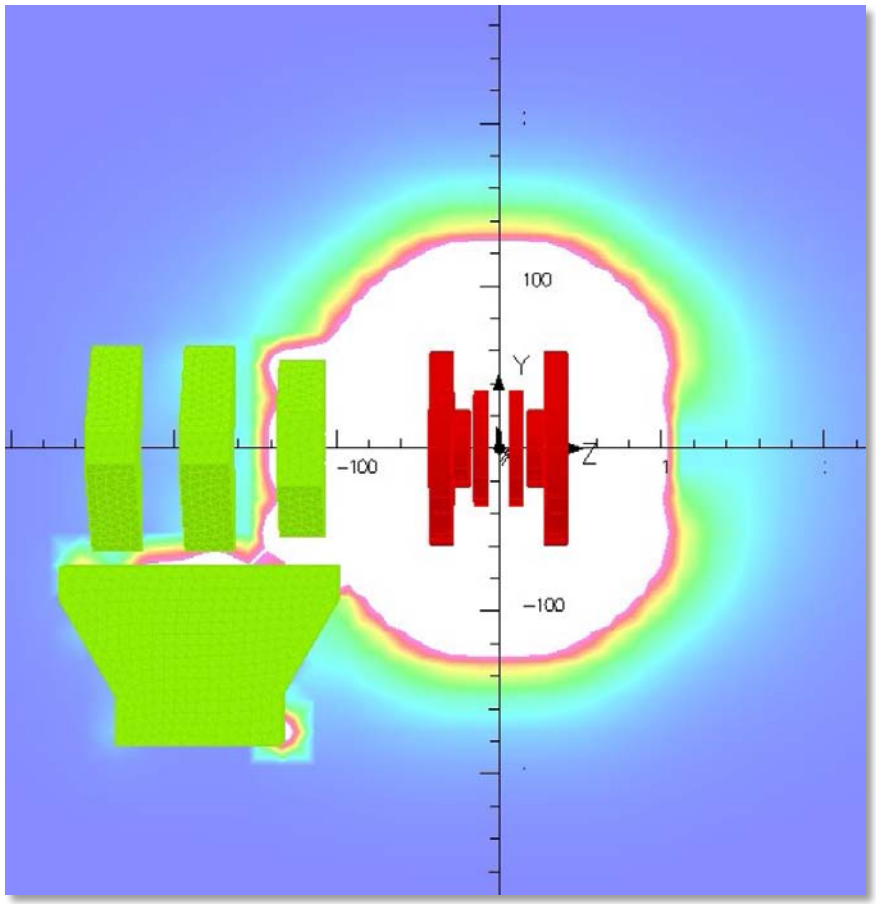
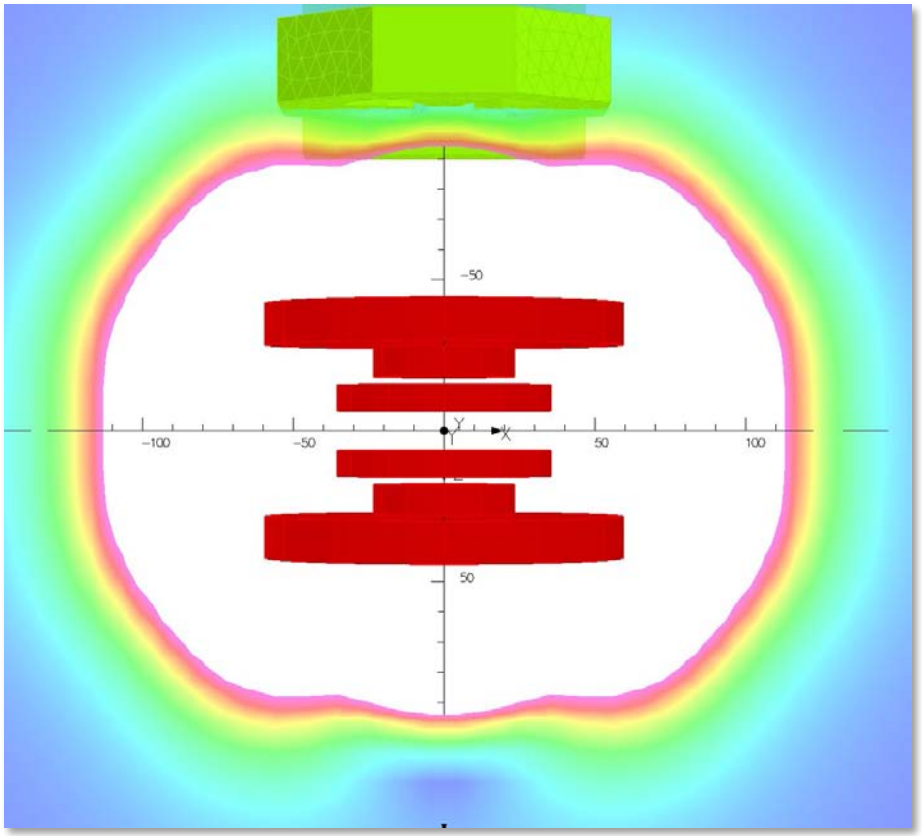
3. Construction





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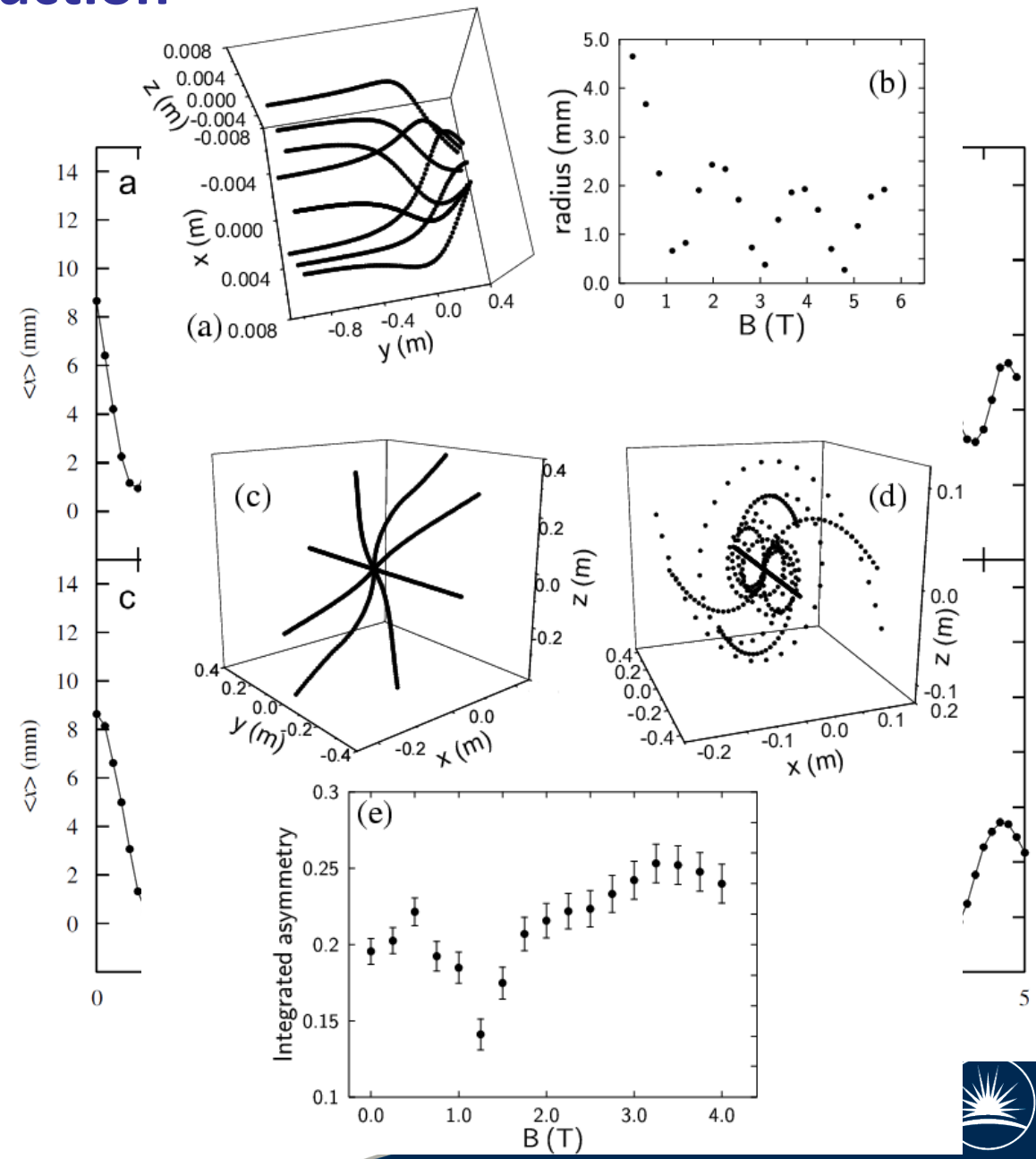

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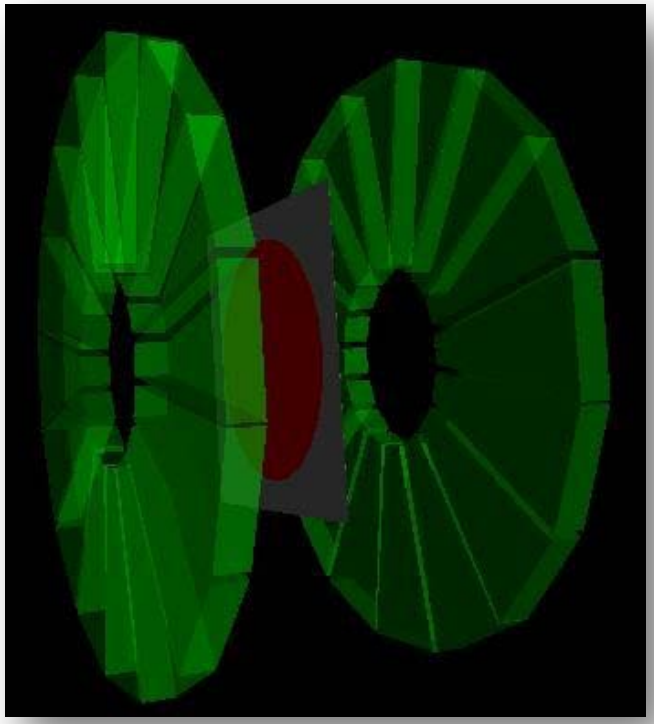
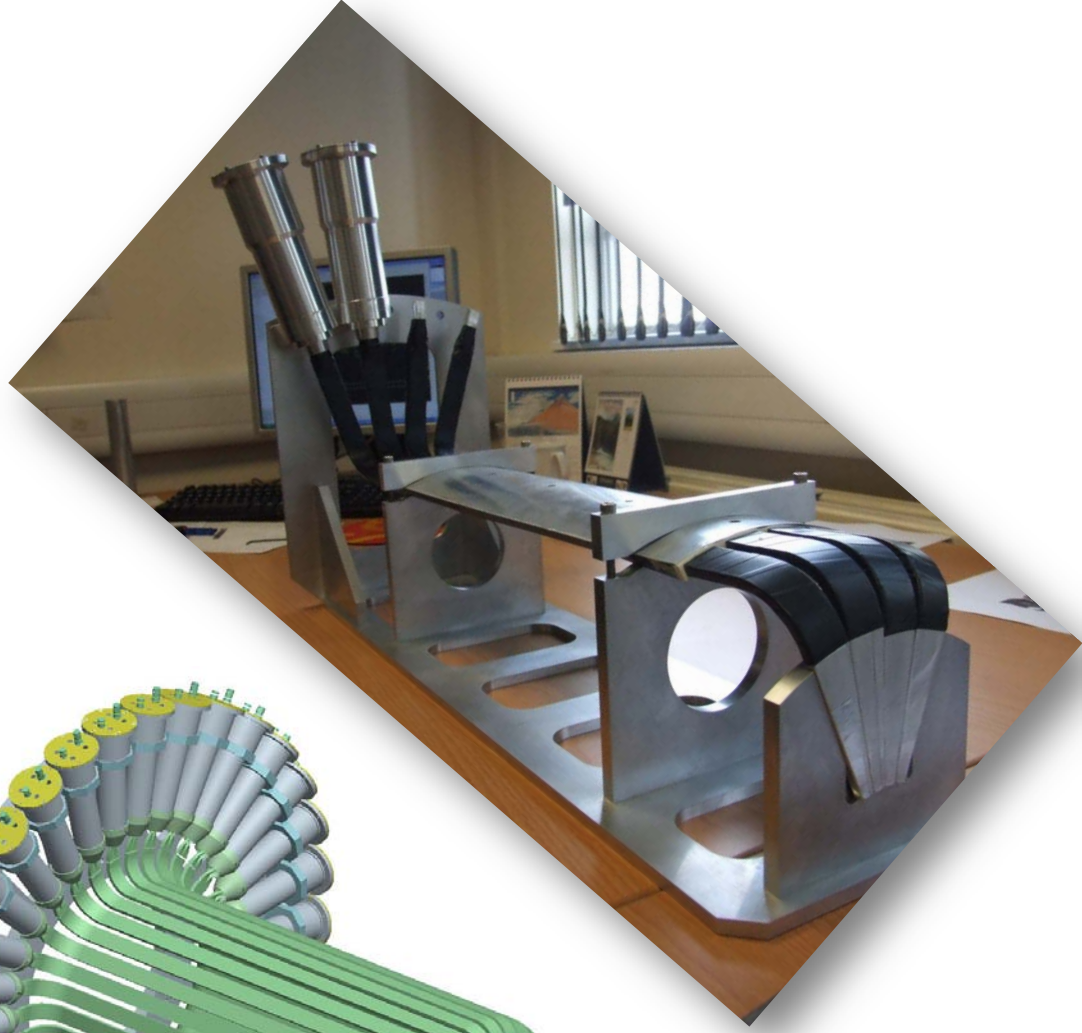
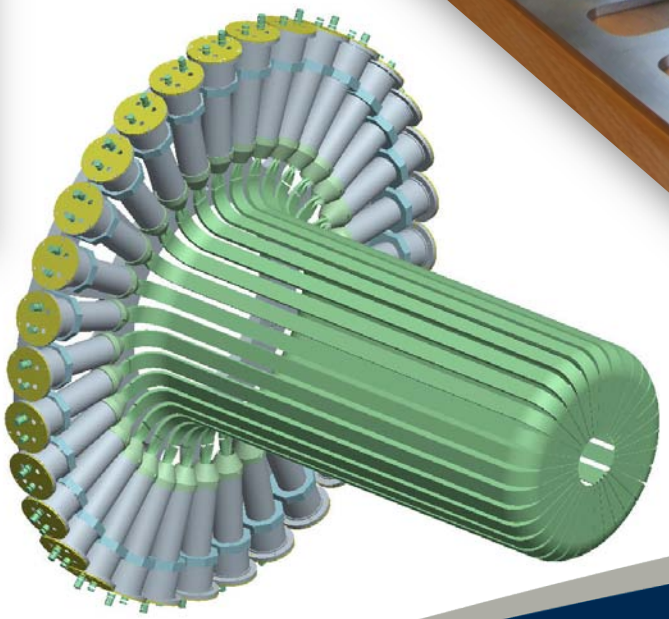
3. Construction







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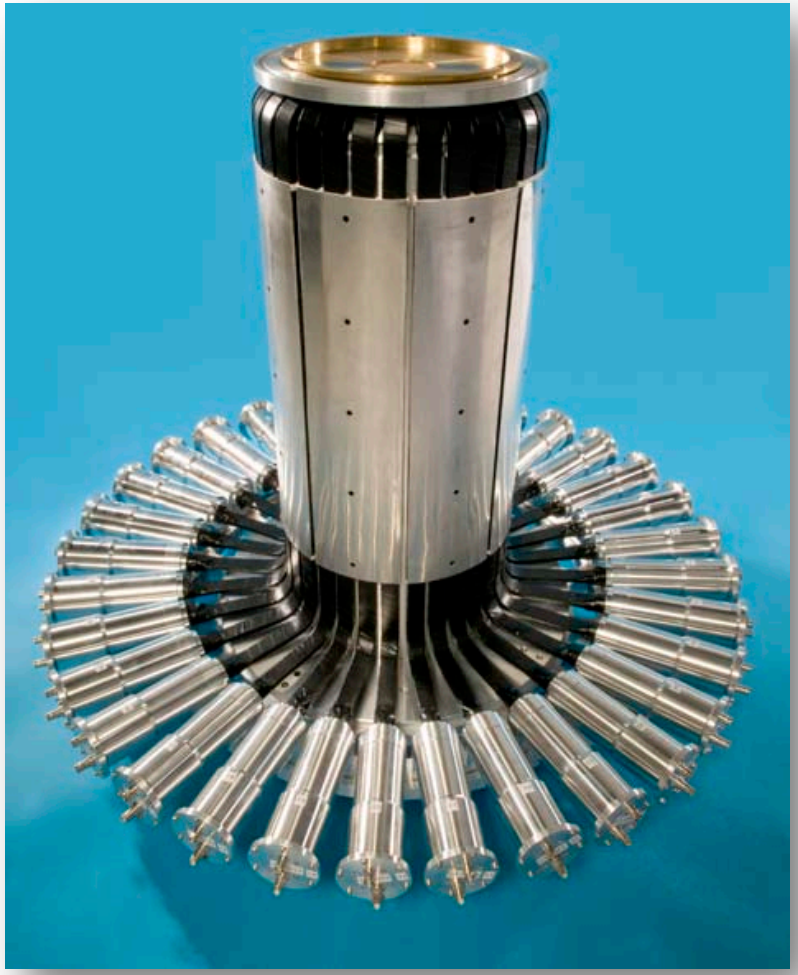

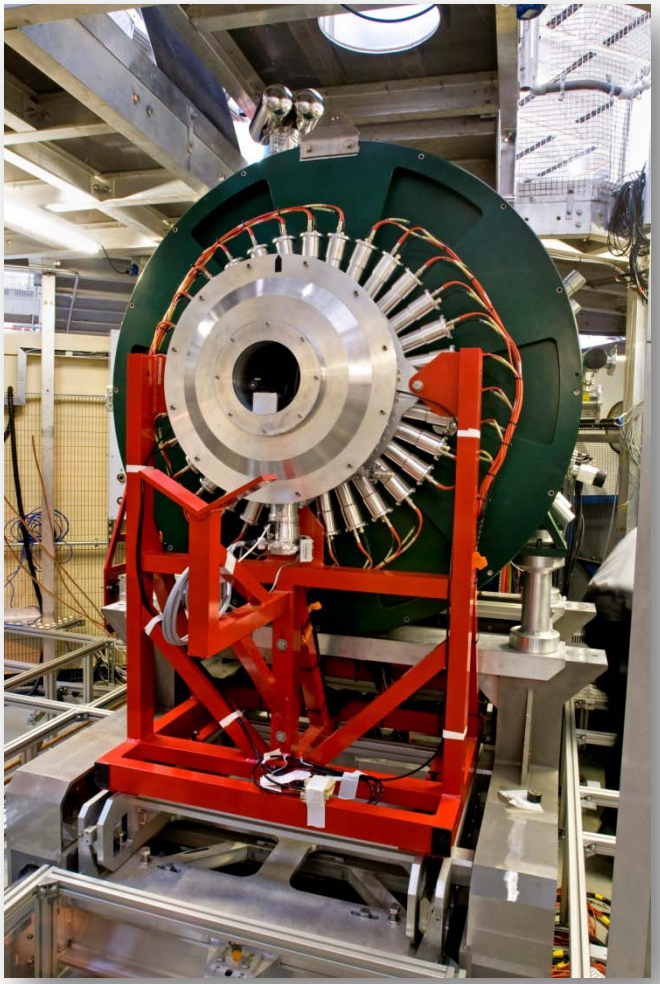

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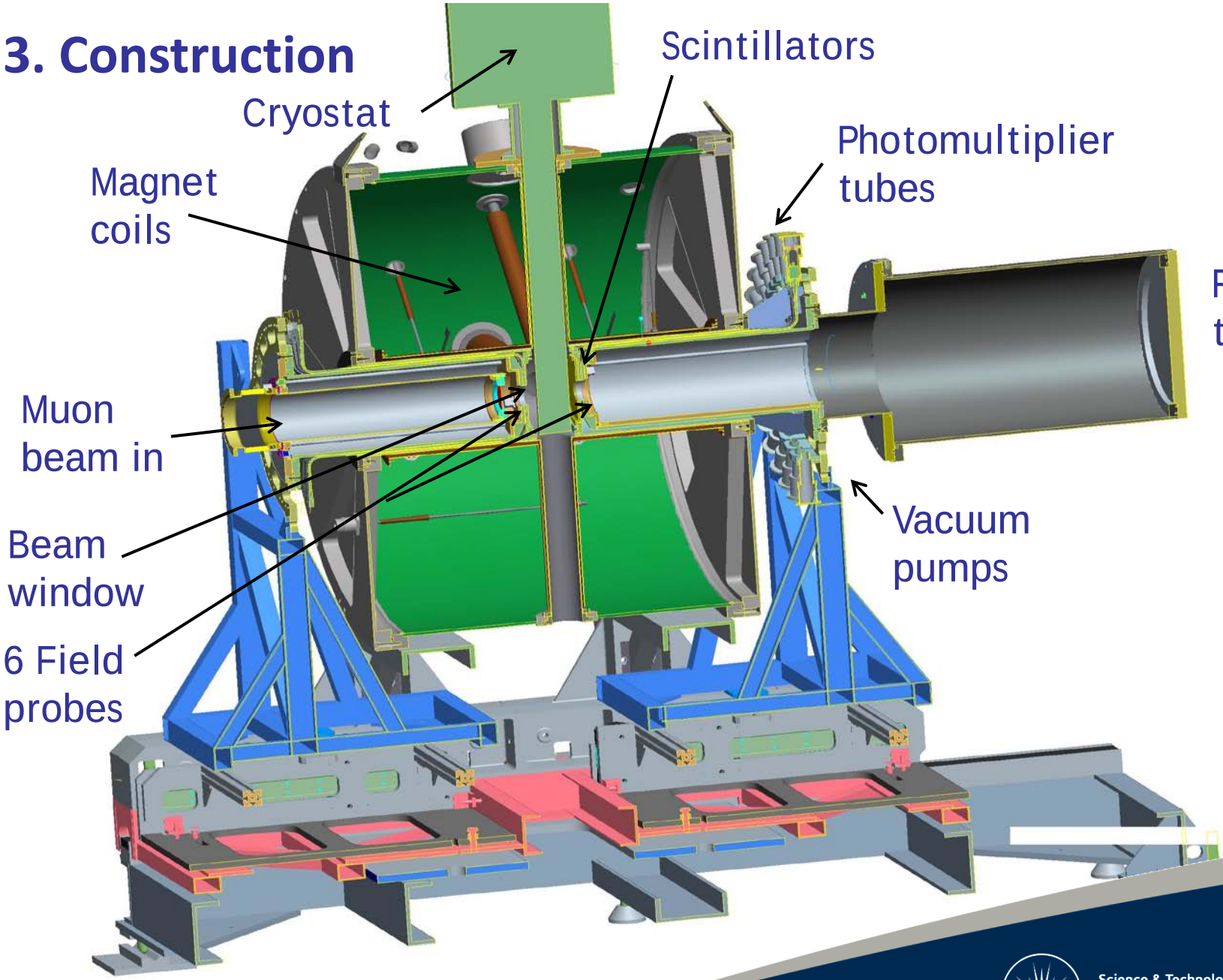

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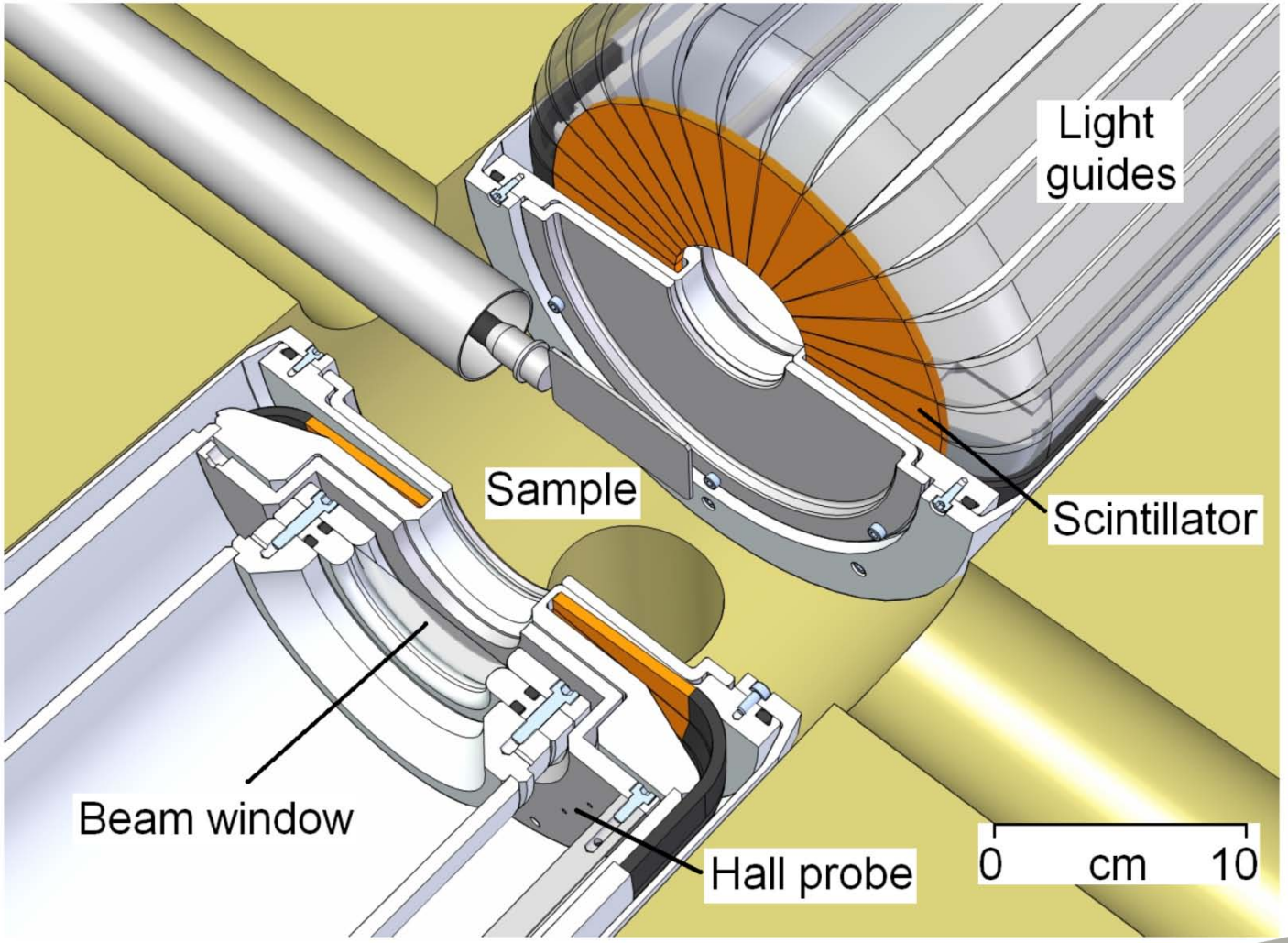
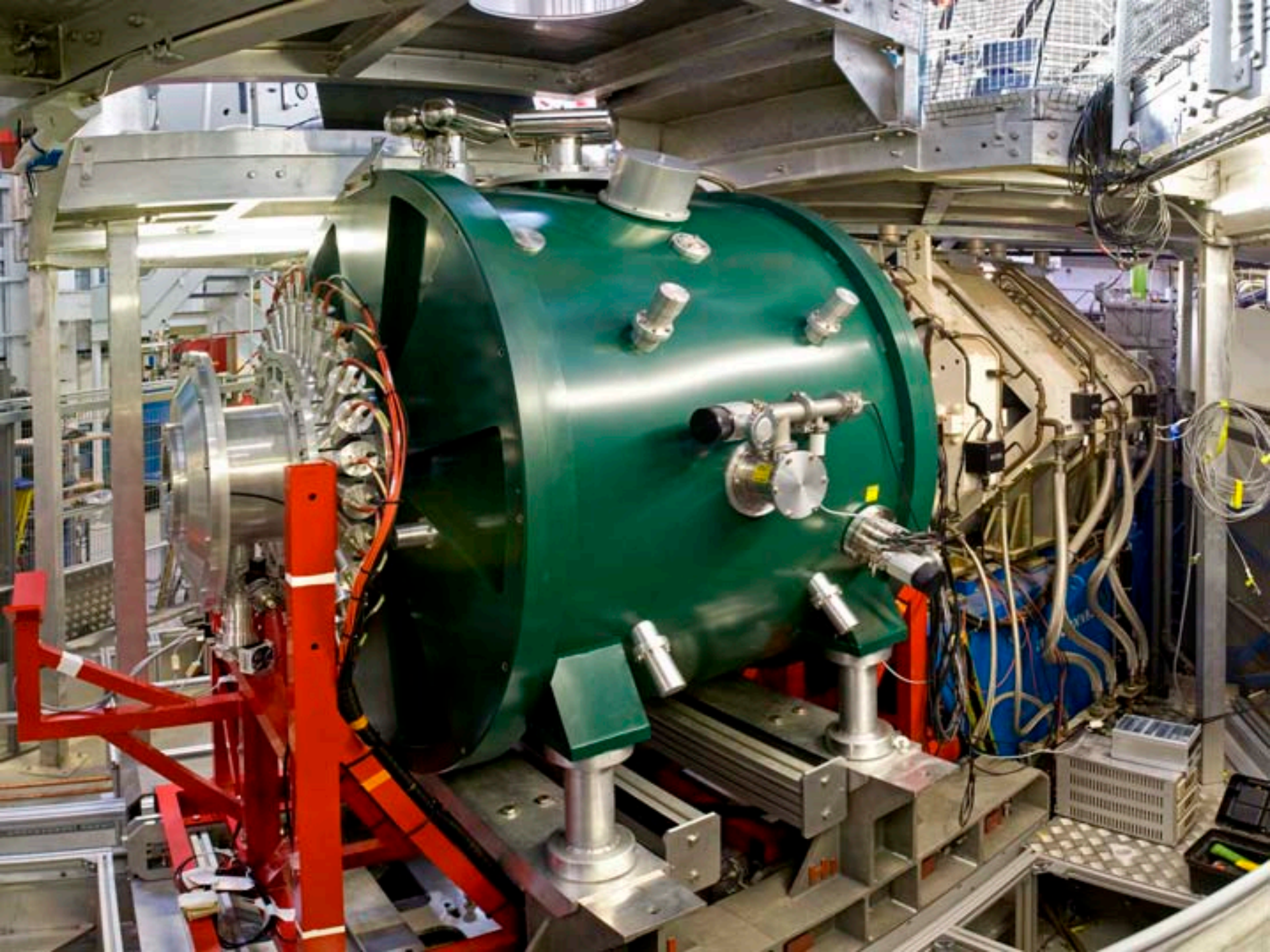


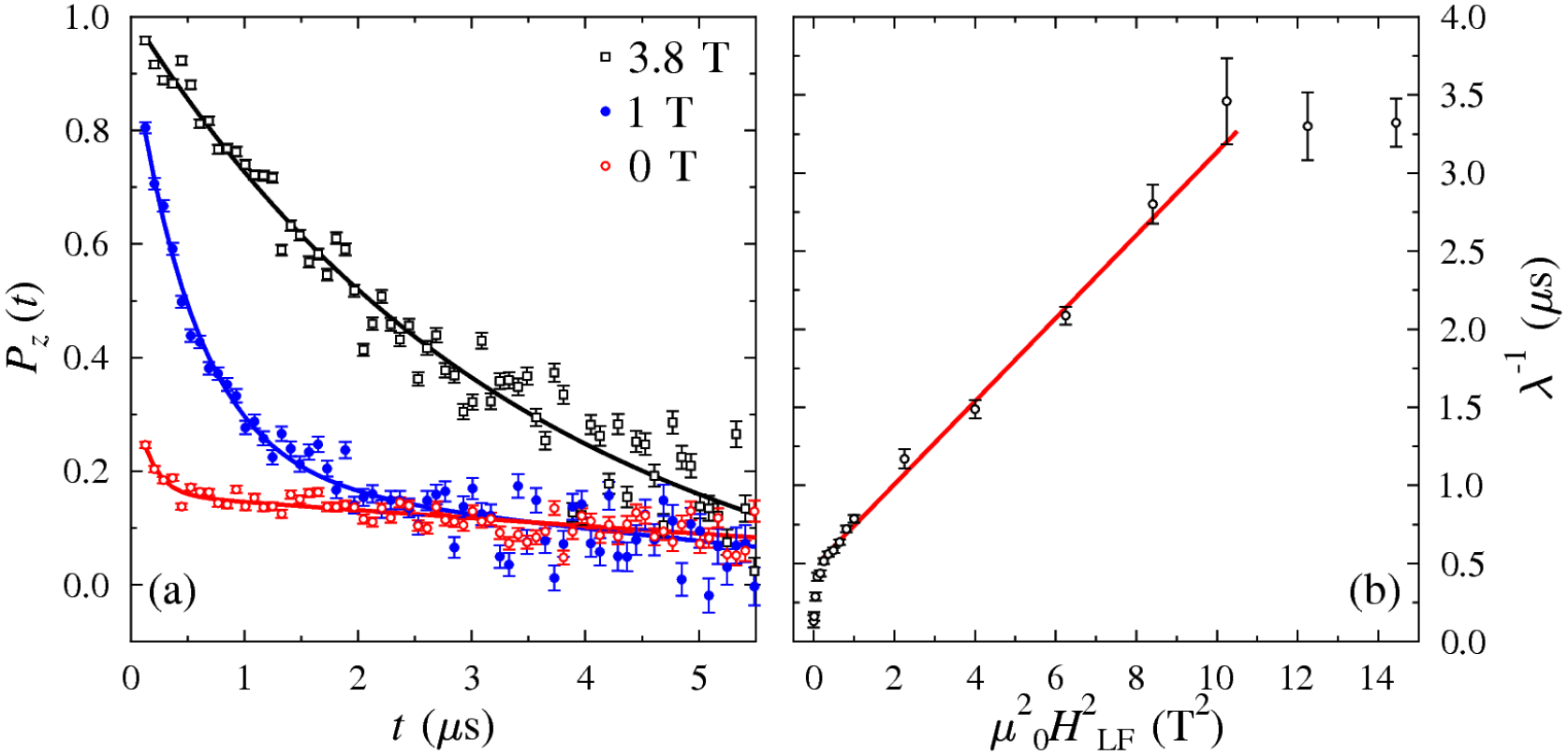


4. Science

First HiFi users: December 2009 - Alan Drew and co-workers, Iain McKenzie

4. Science

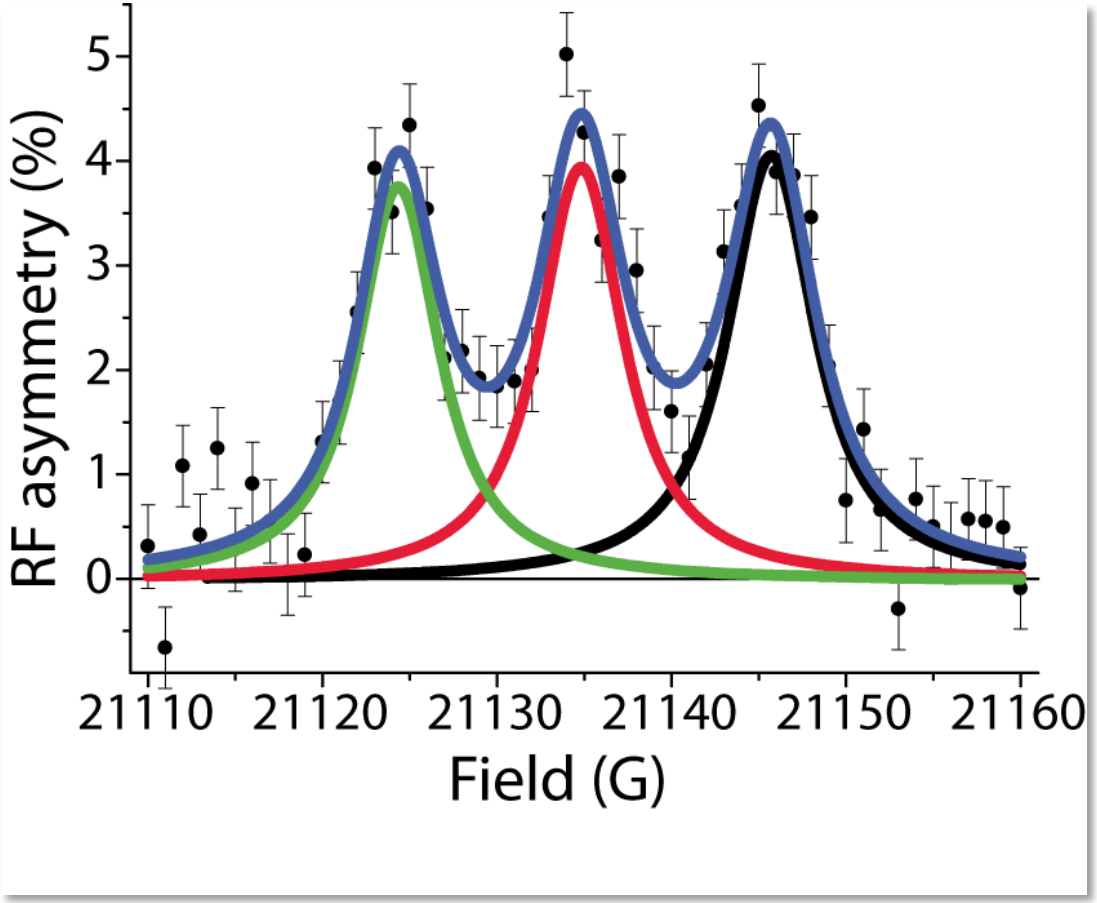
Magnetic decoupling of $Ca_3Co_2O_6$ (Baker et al.)



- Measurements at 15K.
- Magnetisation plateau between 0.5T and 3.5T
- Fitting of parameters reveals local field at the muon site and fluctuation timescale.

4. Science

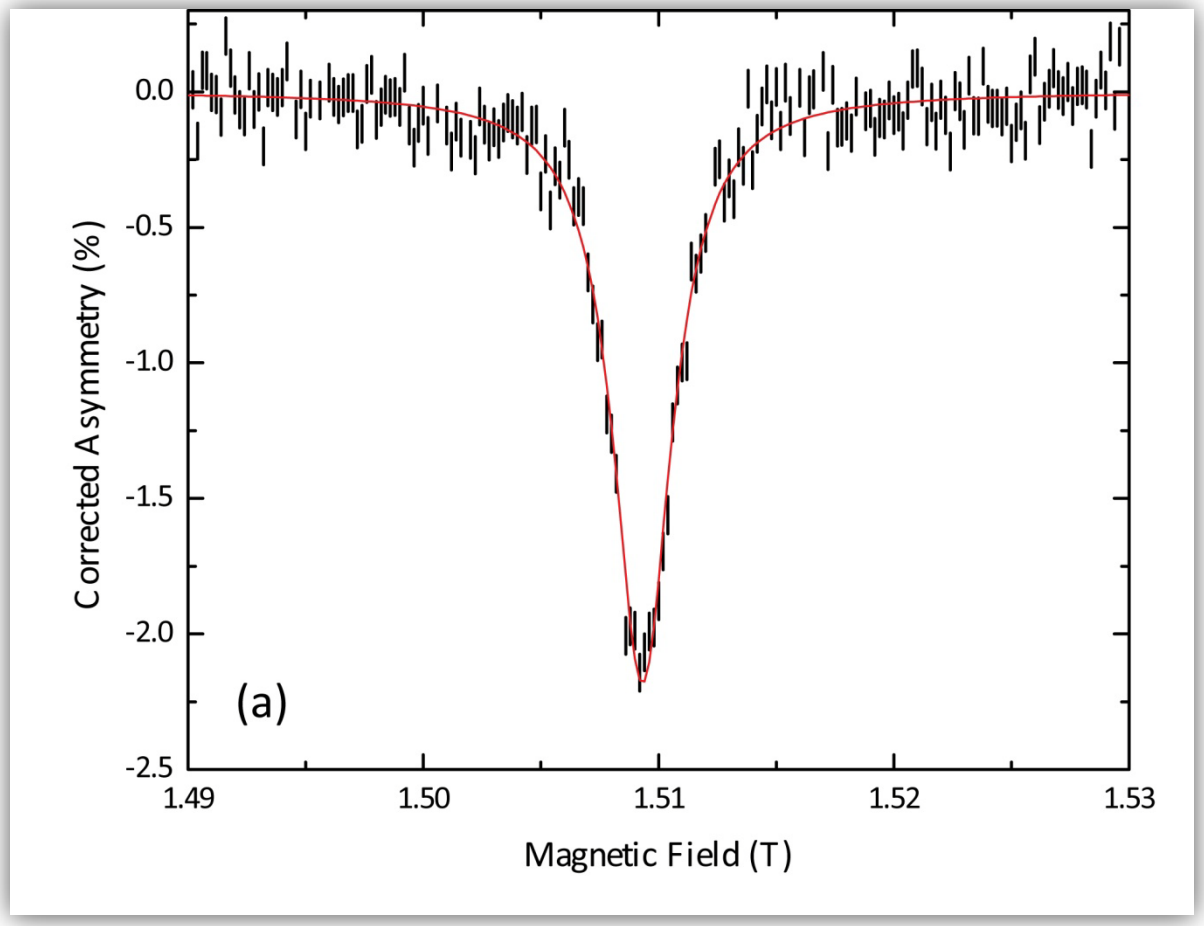
Shallow donor H states in CdTe explored by RF resonance (Gil, Vilao, Lord)



- Shallow donor muonium state in CdTe
- 5K, ~2.1T, fixed RF frequency
- Experiment to try to establish the nature of the muonium electron polarisation.

See HV Alberto O31

4. Science



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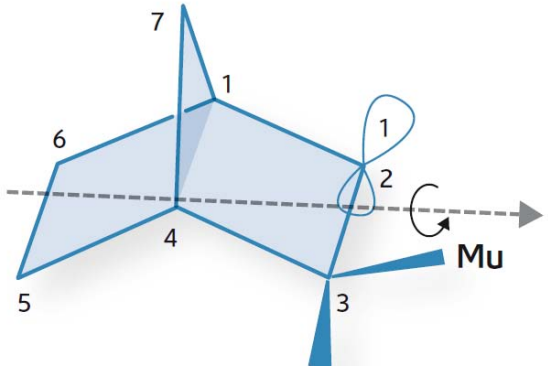
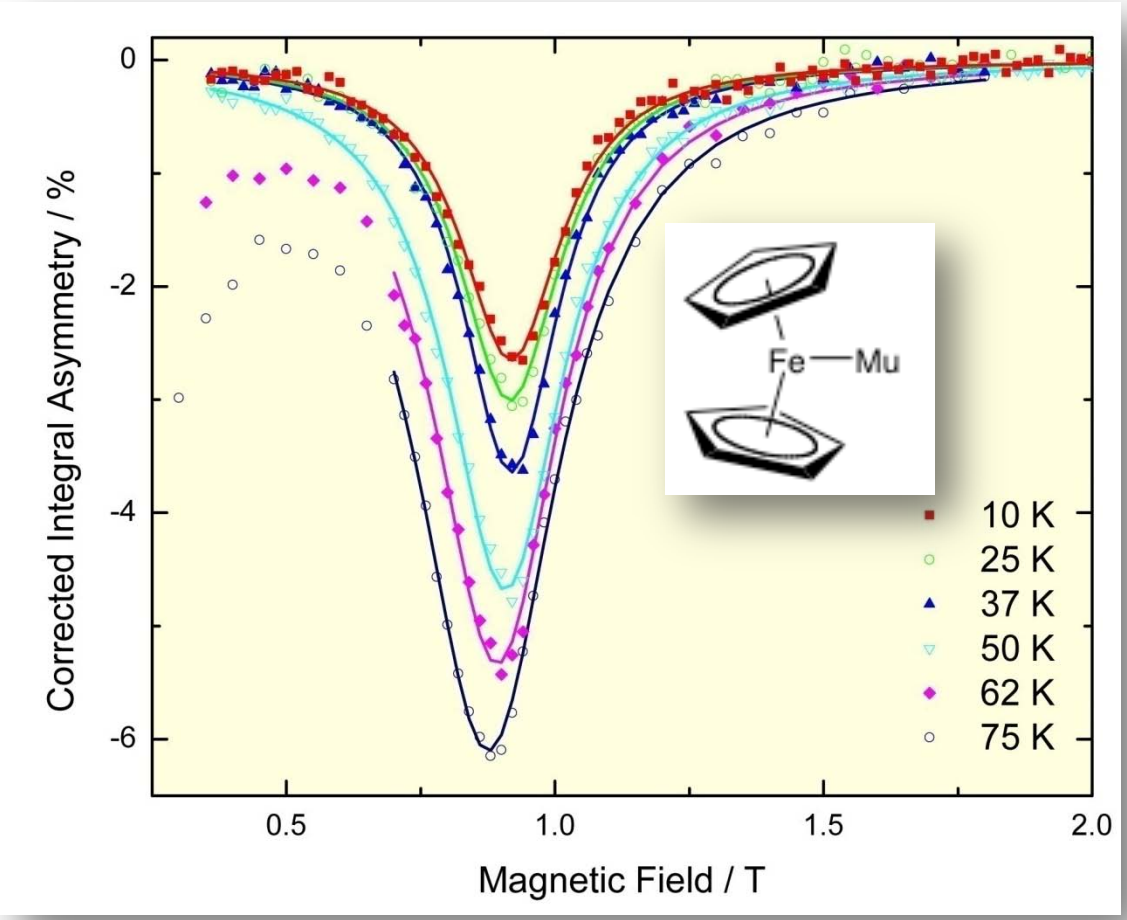
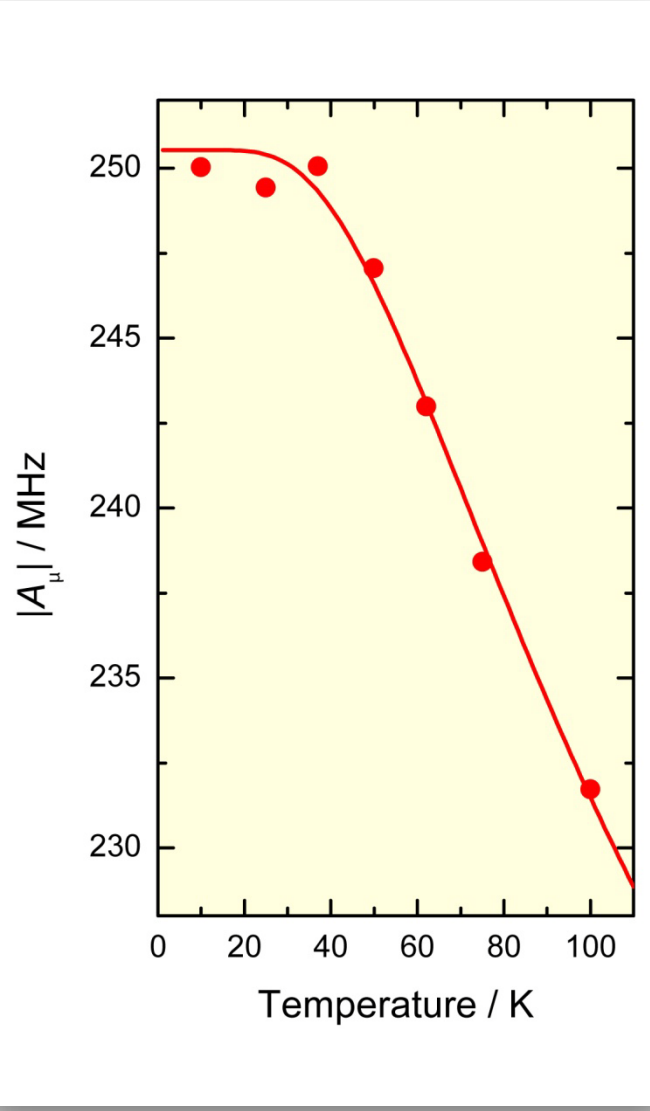


Resonance shape informs on molecular dynamics (rotations) in the plastic phase (McKenzie, Lord)

4. Science

Ferrocene dynamics explored by level crossing resonance (McKenzie et al.)





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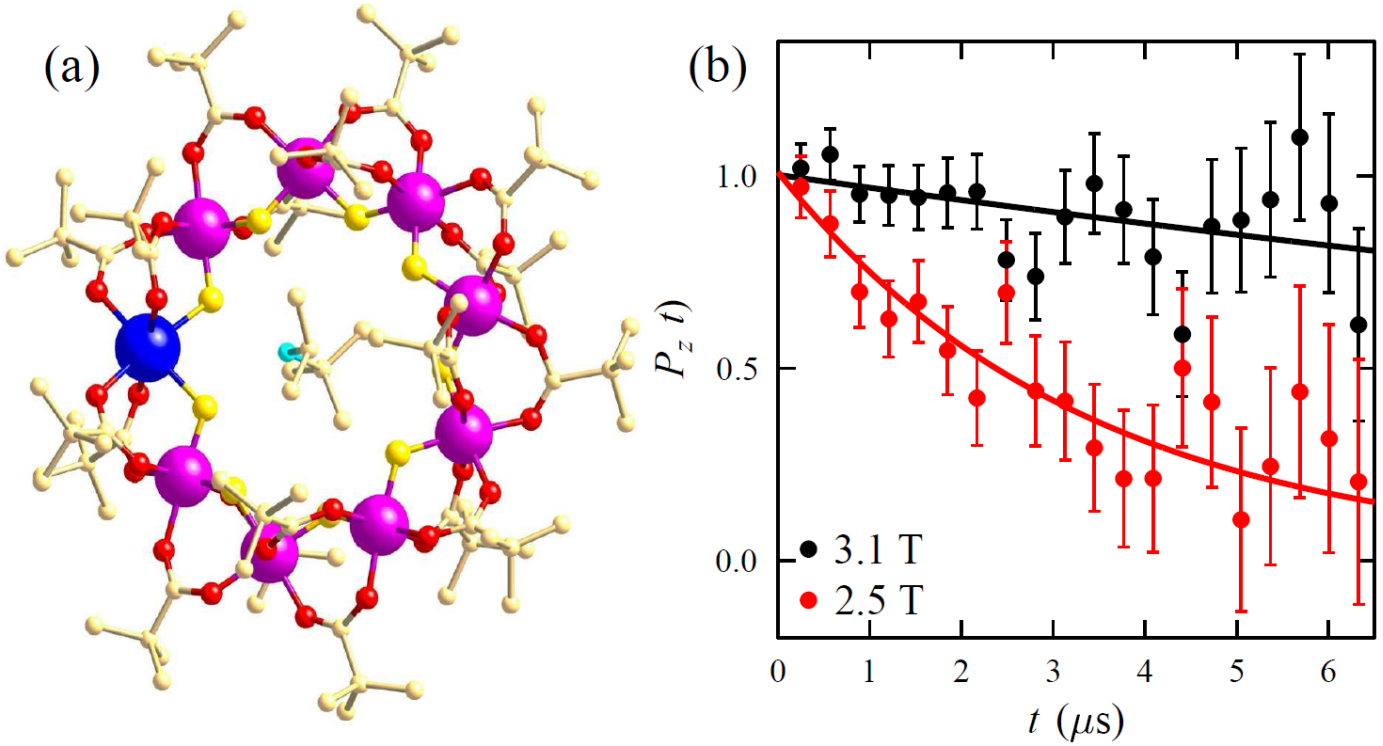
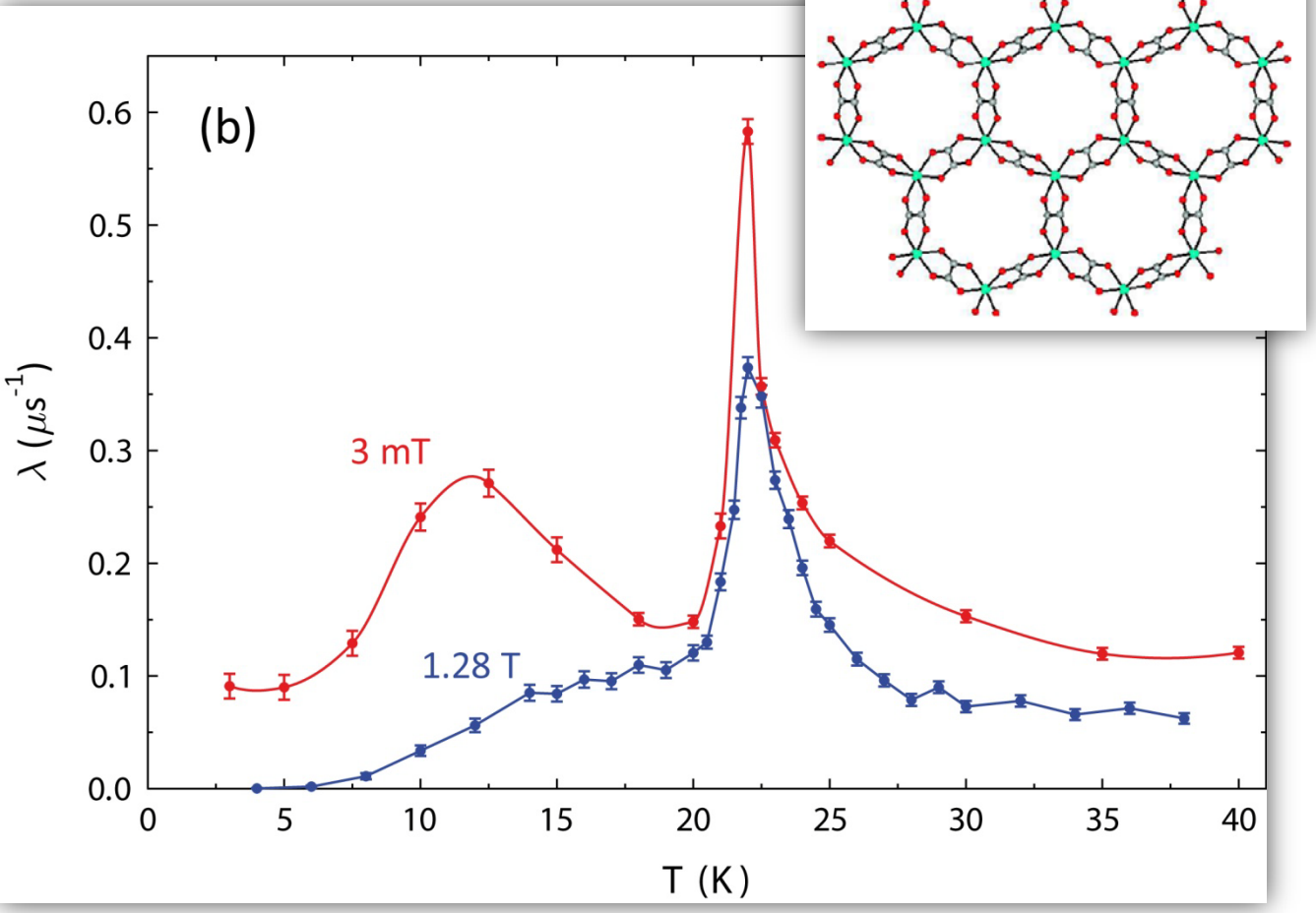
4. Science

Molecular nanomagnet spin transition observed by level crossing resonance (Lancaster et al.)



See Lancaster et al, O15, for more details.

4. Science



- Studies of organic magnetic systems based on oxalate-bridged transition metal ions
- New field-dependent magnetic transition in layered cobaltate compound below 22K (Pratt et al).

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4. Science

Leaflet on ‘level crossing resonance’ technique available from ISIS Muon Group web pages

www.isis.stfc.ac.uk/groups/muons

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Summary

- The HiFi project successfully created a muon spectrometer optimised for high field studies at a pulsed muon source
- 0T- 5T LF, 30mK – 1000K possible, data rates 50+ Mev/hr for time differential measurements
- Decoupling, level crossing resonance and RF studies have been demonstrated
- The instrument is now in regular use within the ISIS user programme
- Summary paper fully describing the new instrument and its capabilities has just been submitted to Rev Sci Inst

Acknowledgements

HiFi was constructed through an STFC Facility Development Grant (2005)

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All members of ISIS and Oxford Muon Groups (including Zaher Salman and Iain McKenzie), plus ISIS technical and design staff

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