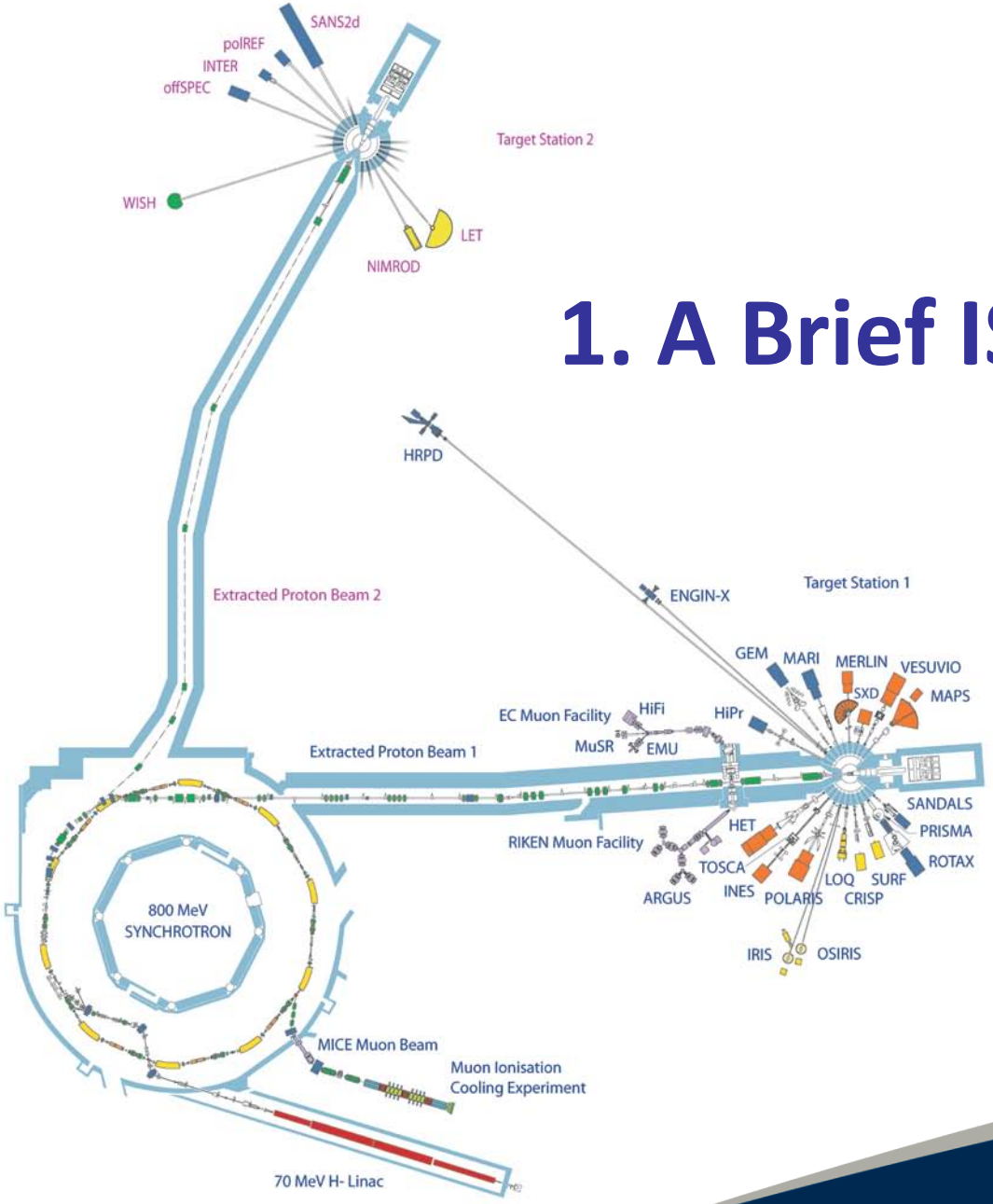
The ISIS Muon Facility

Philip King

1. *A brief ISIS Update*
2. *Recent developments at ISIS Muons*
   - *instruments*
   - *pulsed techniques*
   - *software*
   - *beamlines*
3. *Brief science examples*
4. *RIKEN-RAL Muon Facility*

1. A Brief ISIS Update



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The ISIS Pulsed Neutron and Muon Source

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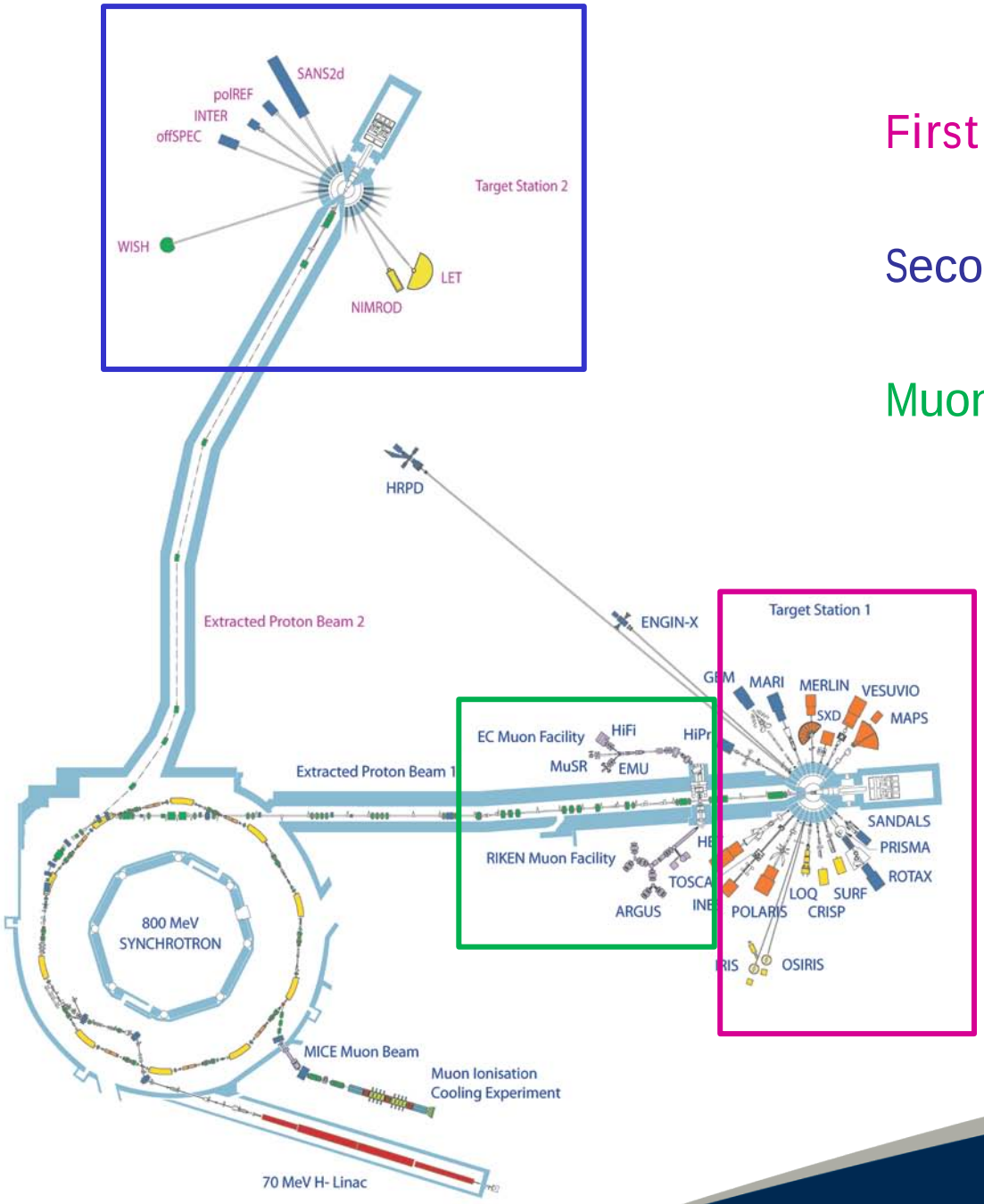

First target station

Second target station

Muons

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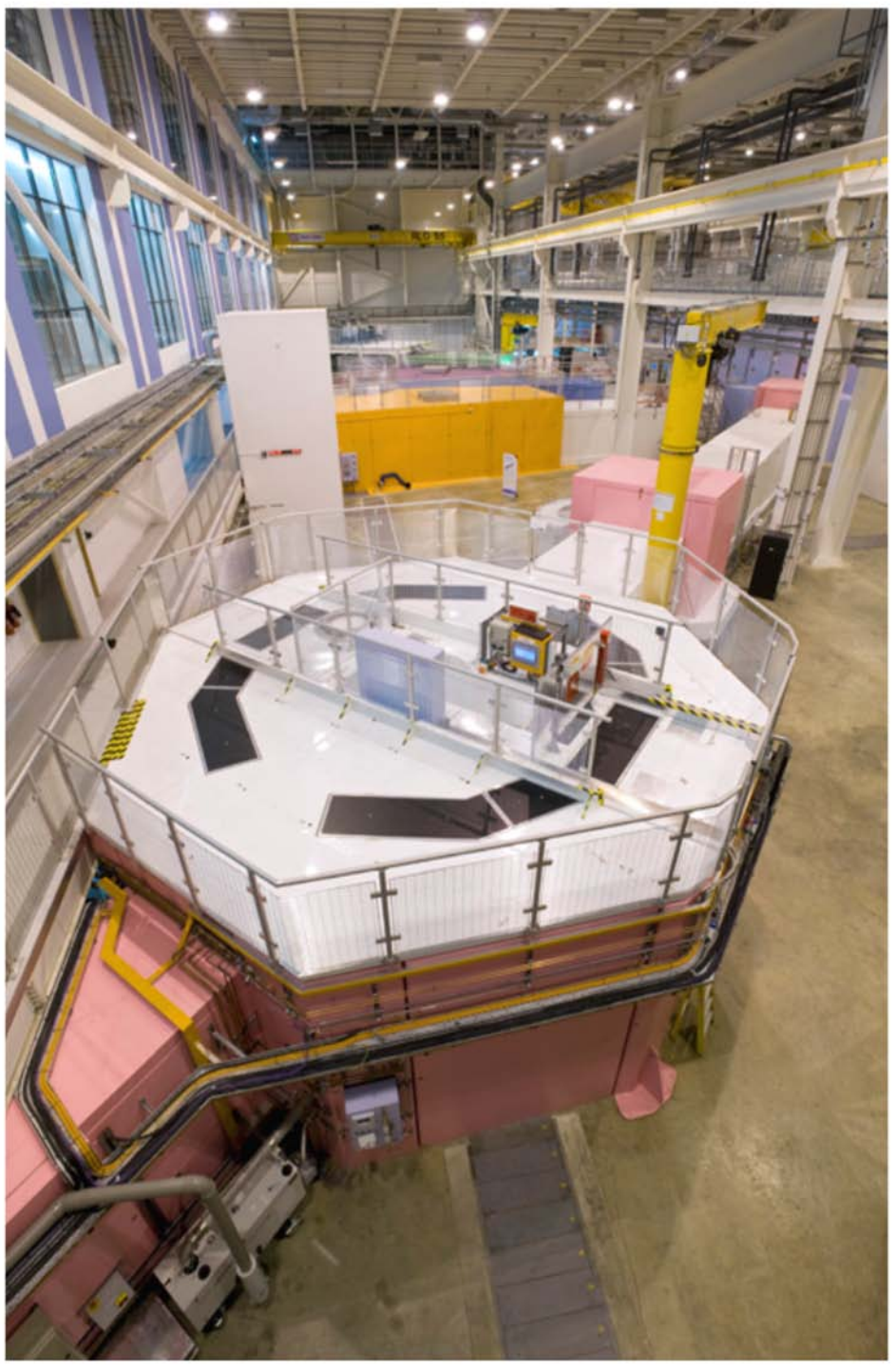
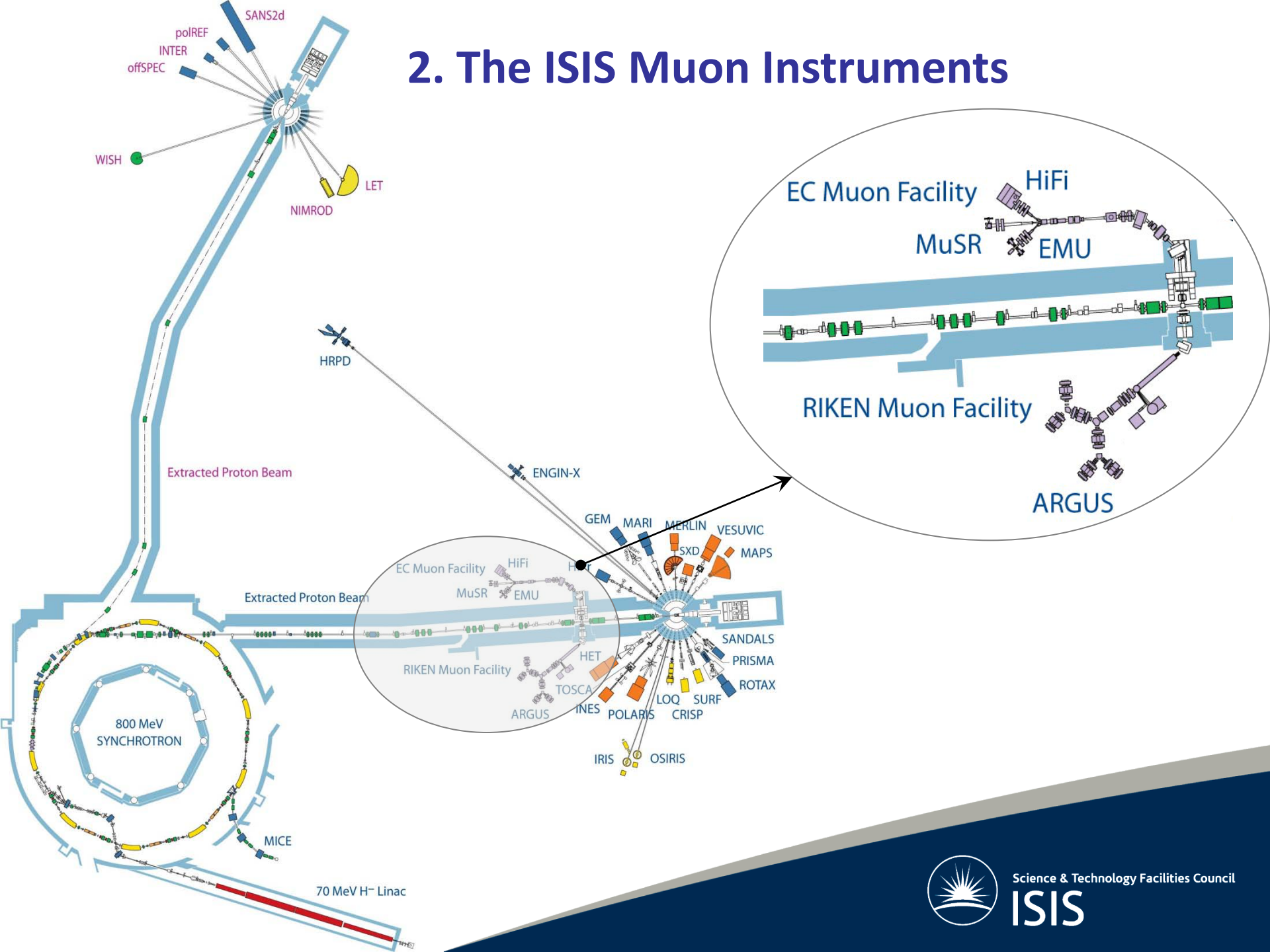
ISIS Second Target Station

ISIS Second Target Station



2. The ISIS Muon Instruments



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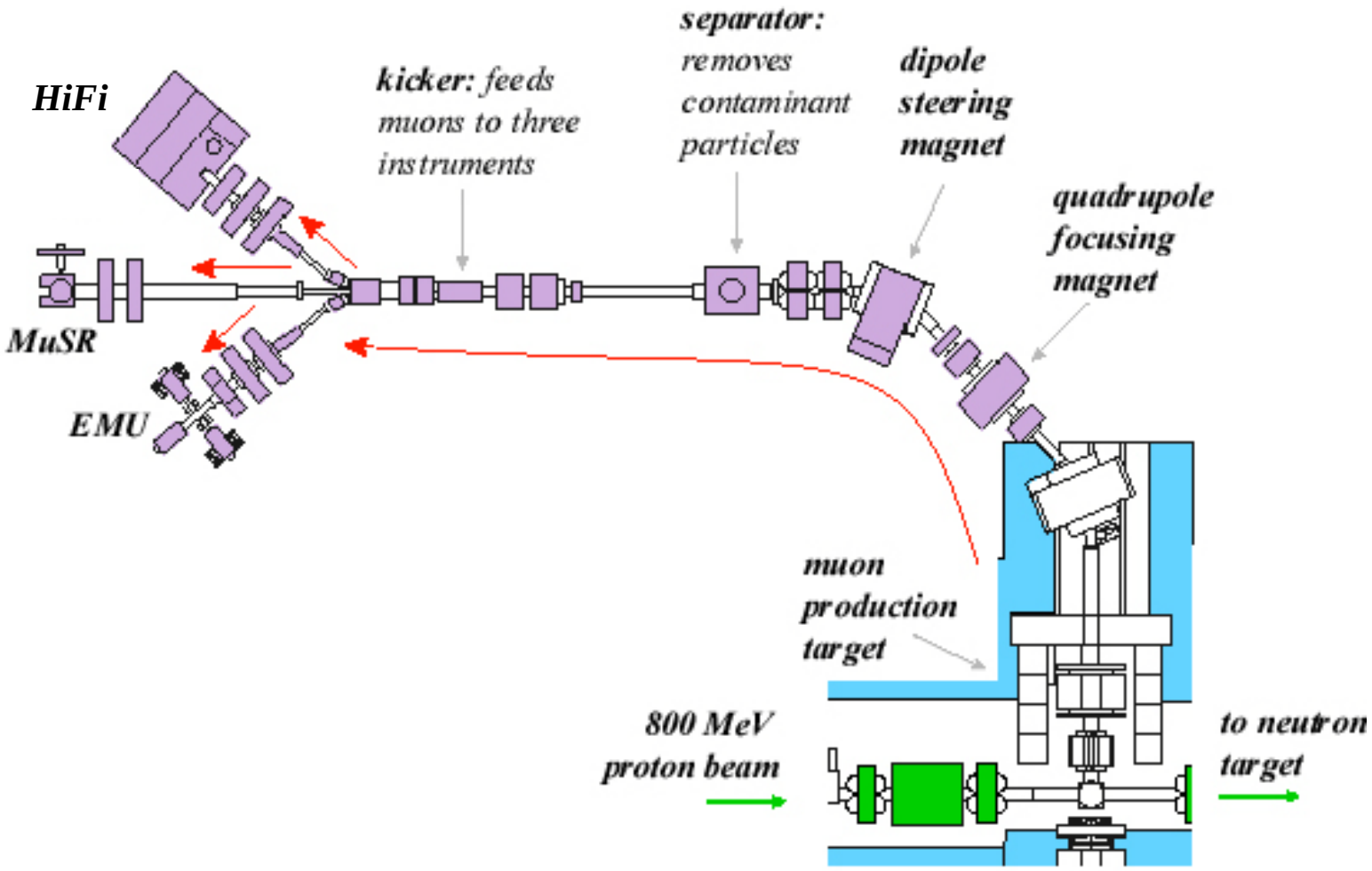
2. The ISIS Muon Instruments



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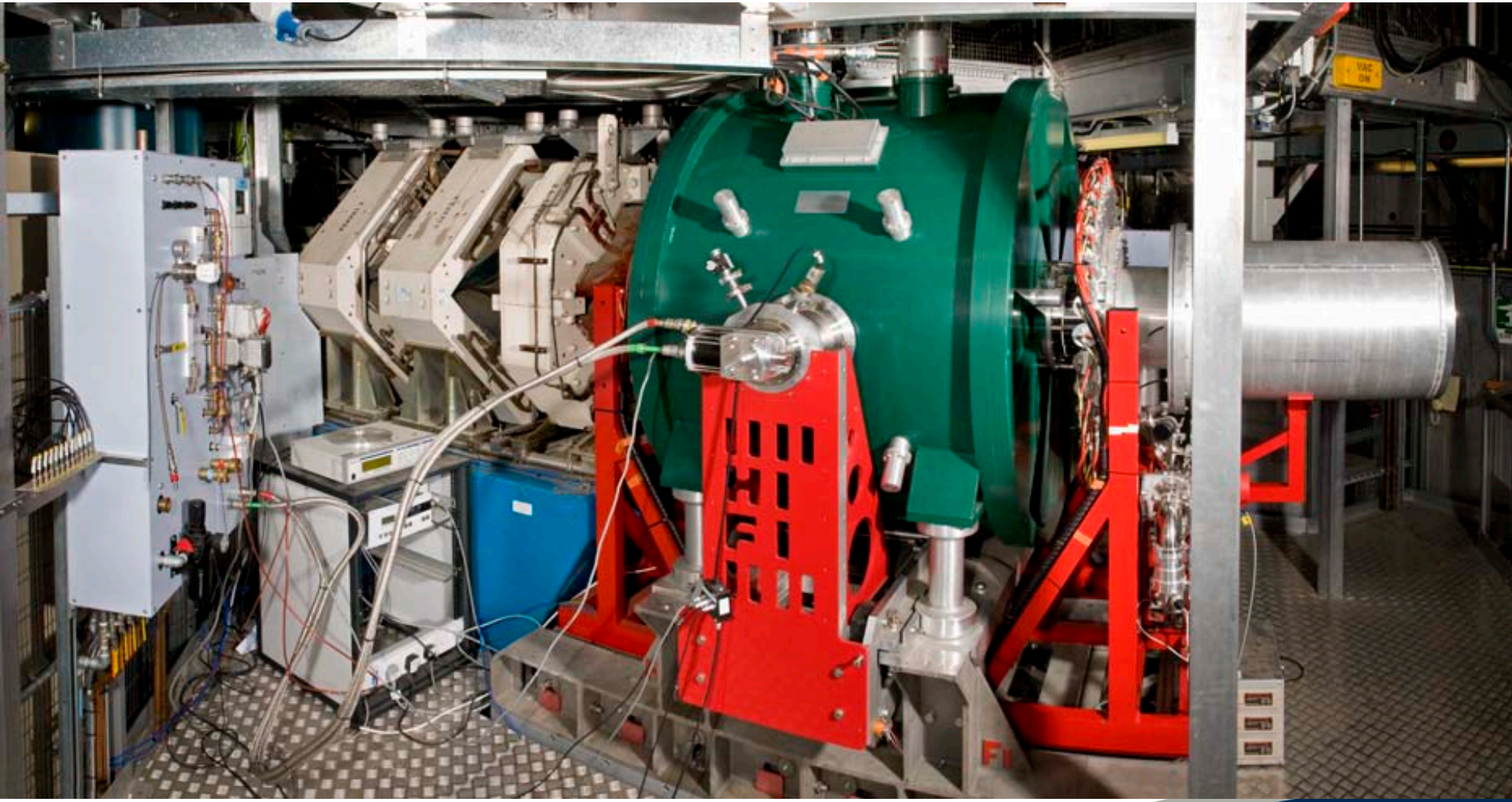
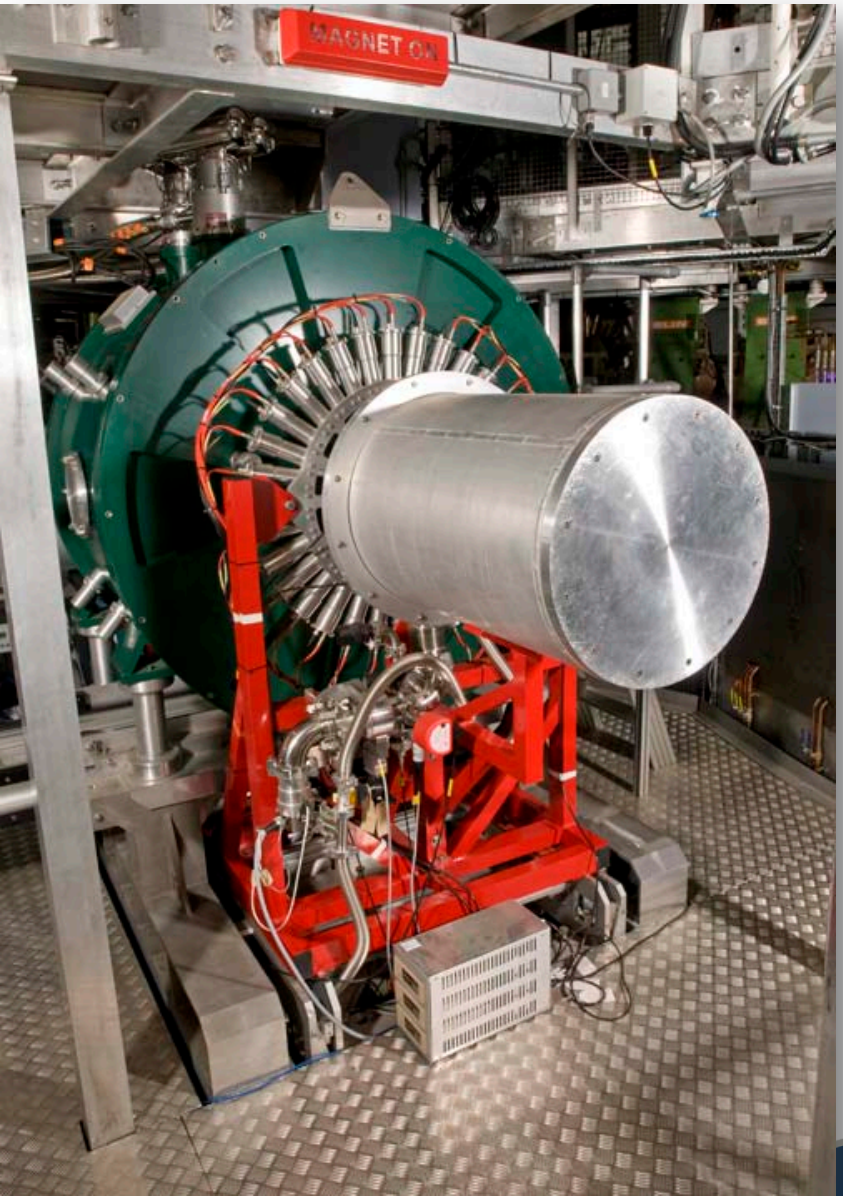
2. Recent developments: HIFI



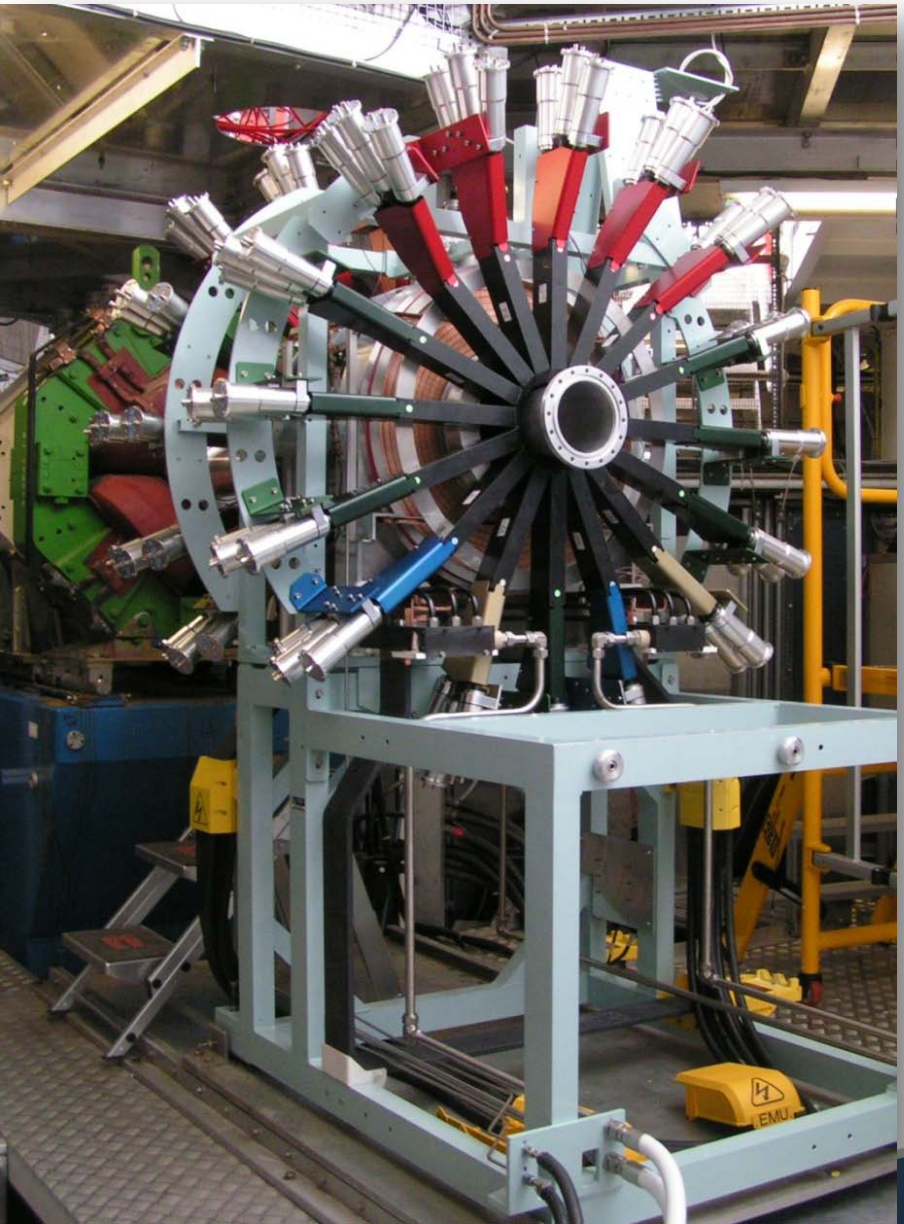
2. Recent developments: HIFI



- First muons in 2009
- 5 T longitudinal field
- 400 G longitudinal field for fast switching
- 100 G calibration fields
- Temperature range: 30mK – 1000K
- RF, E-fields
- liquids
- fly-past
- 64 detectors; 50 MeV/hr standard

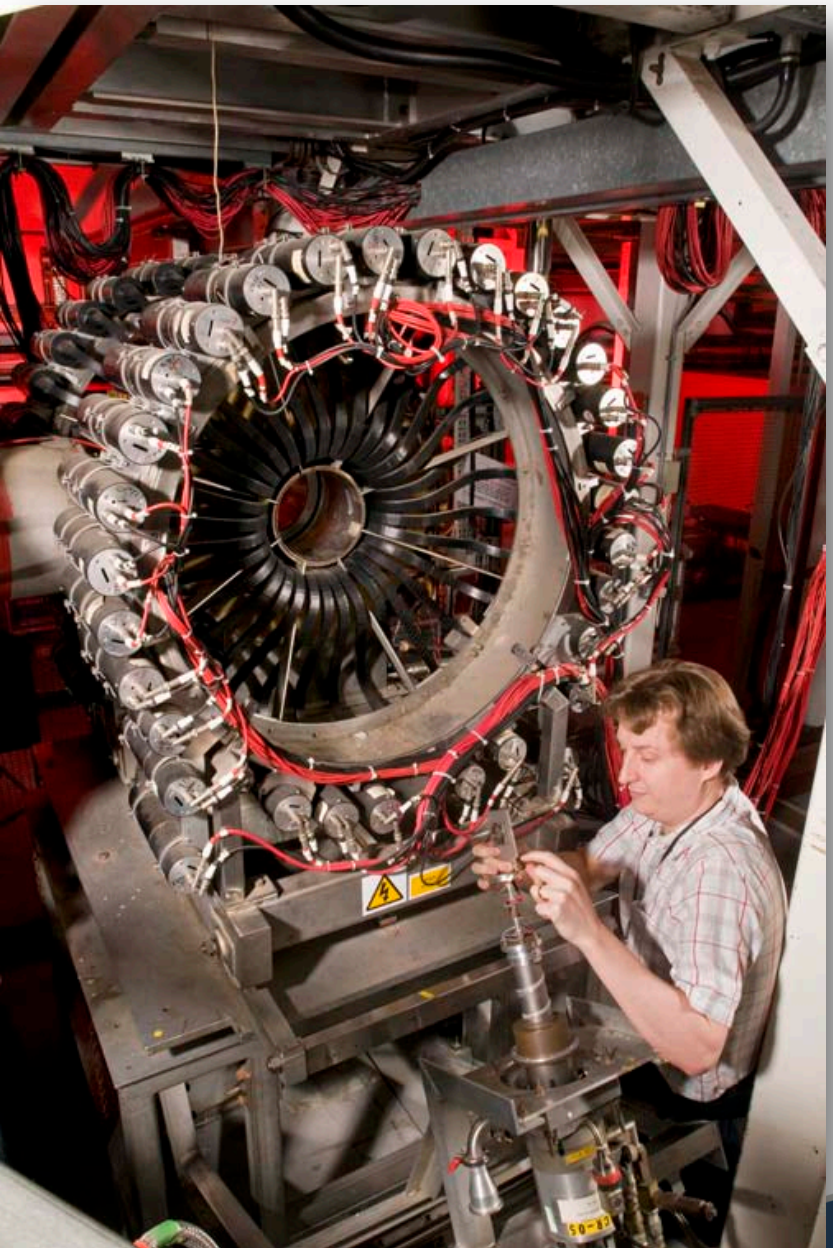
More on HiFi on Thursday morning

2. Recent developments: EMU



- New detectors, magnet, vacuum vessel and support frame in 2010
- 0.5 T LF; 100G TF
- 96 detectors; 60+ MeV/hr
- Temp range 300mk – 1500K – fridge also now possible.
- Optimised ‘fly-past’ for small samples

2. Recent developments: MuSR



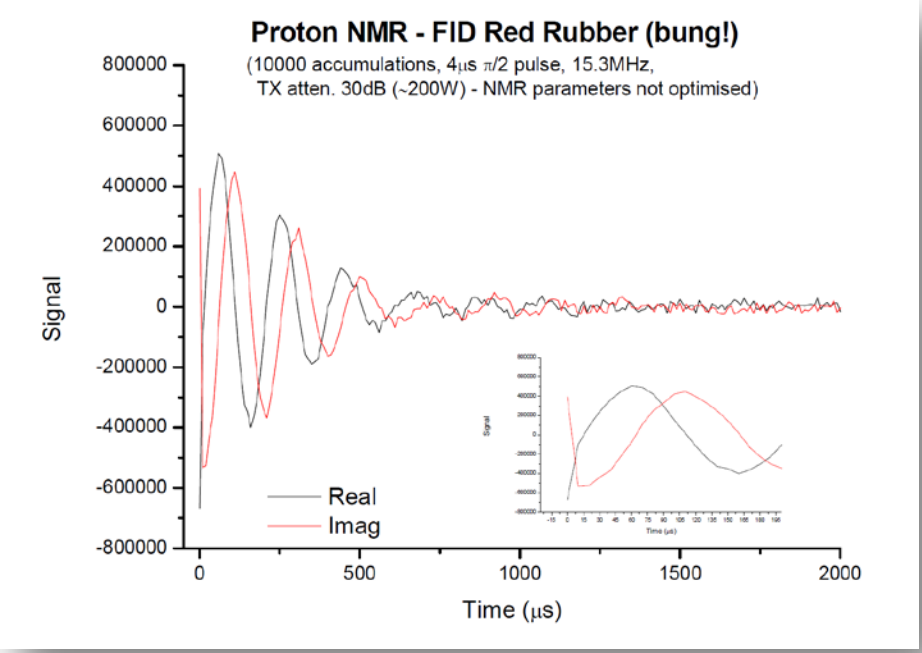
- Detector array replaced ~3 yrs ago
- 0.25 T field, rotatable – TF and LF
- 30 mK – 1000 K temp range
- suits magnetism and superconductivity studies in particular

2. Recent developments: pulsed techniques

Use of NMR methods

In-situ NMR:
To study samples under conditions identical to the μSR experiment

Off-beam NMR:
To test and characterise RF coils ready for experiments.



In-situ NMR signal from rubber

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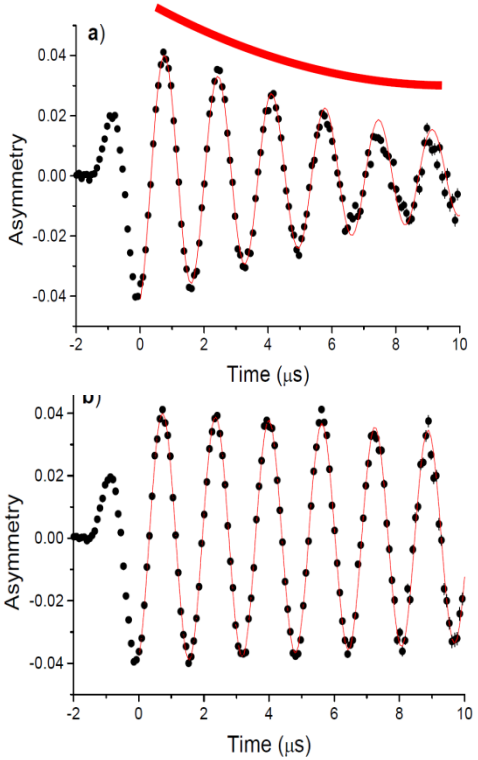
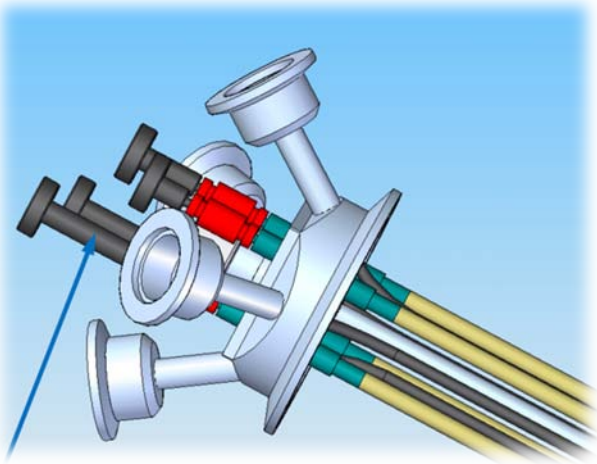
2. Recent developments: pulsed techniques

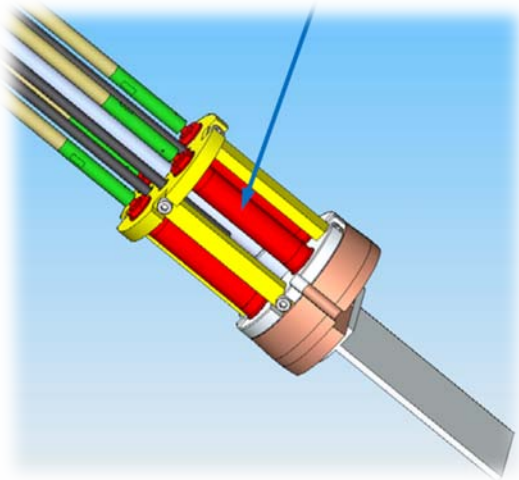
Development of an RF insert for HiFi

Will extend the range of nuclei available for RF decoupling

1.5-400K, RF power up to 1kW
Capacitors close to sample for wide tuning range





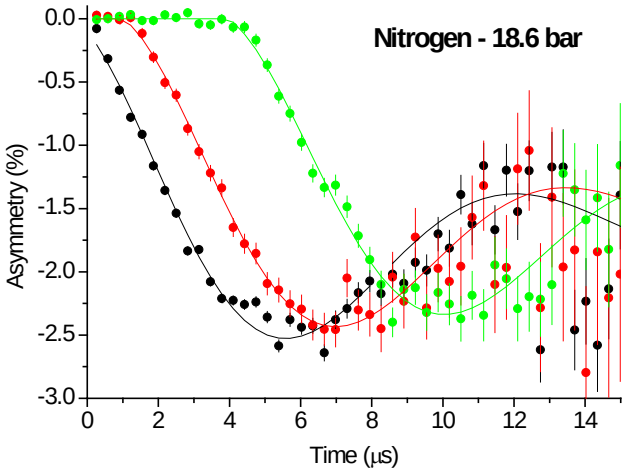


Non-magnetic capacitors for cryogenic operation. Four, for double resonance

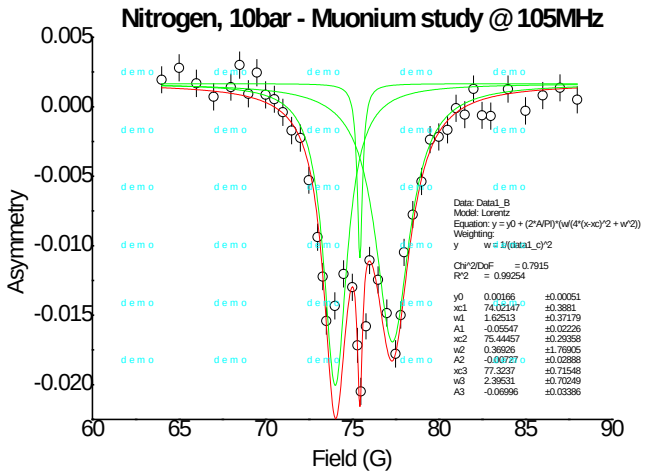
Remote RF tuning using external drive to capacitor

2. Recent developments: pulsed techniques

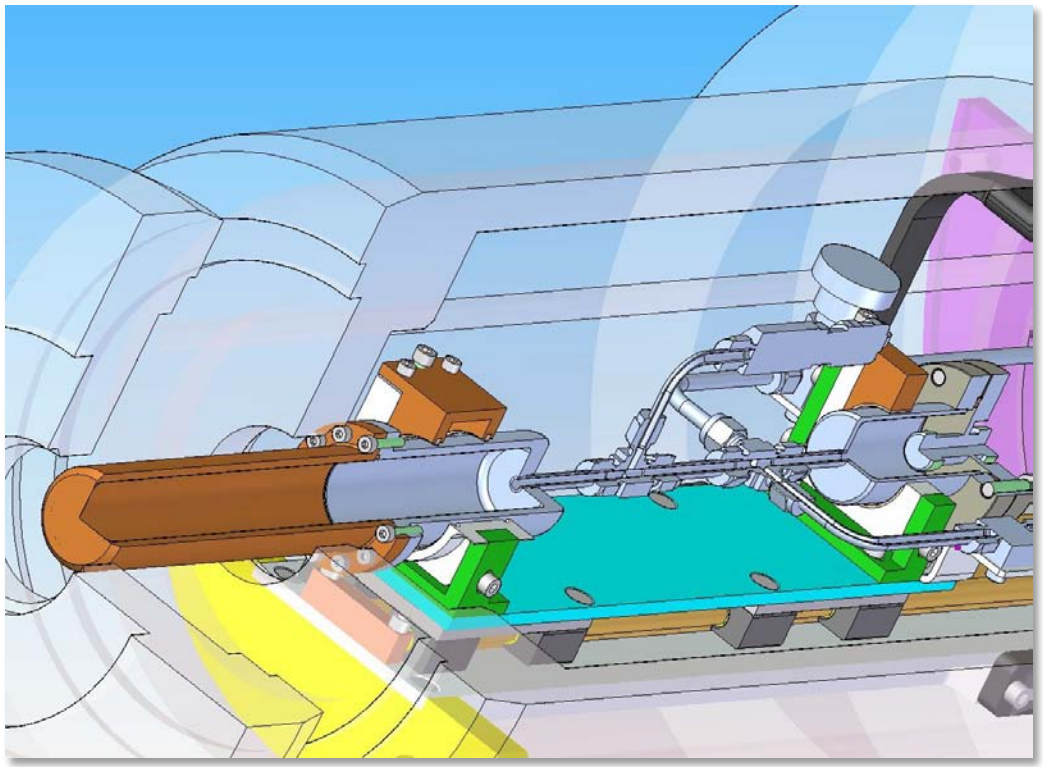
Development of Gas Cells for Muonium Chemistry
ALC and RFμSR measurements – a unique spectroscopic tool



Time delayed RFμSR: *kinetic studies*



Spectroscopy of paramagnetic species



See poster no. 3 by Cottrell et al

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2. Recent developments: pulsed techniques

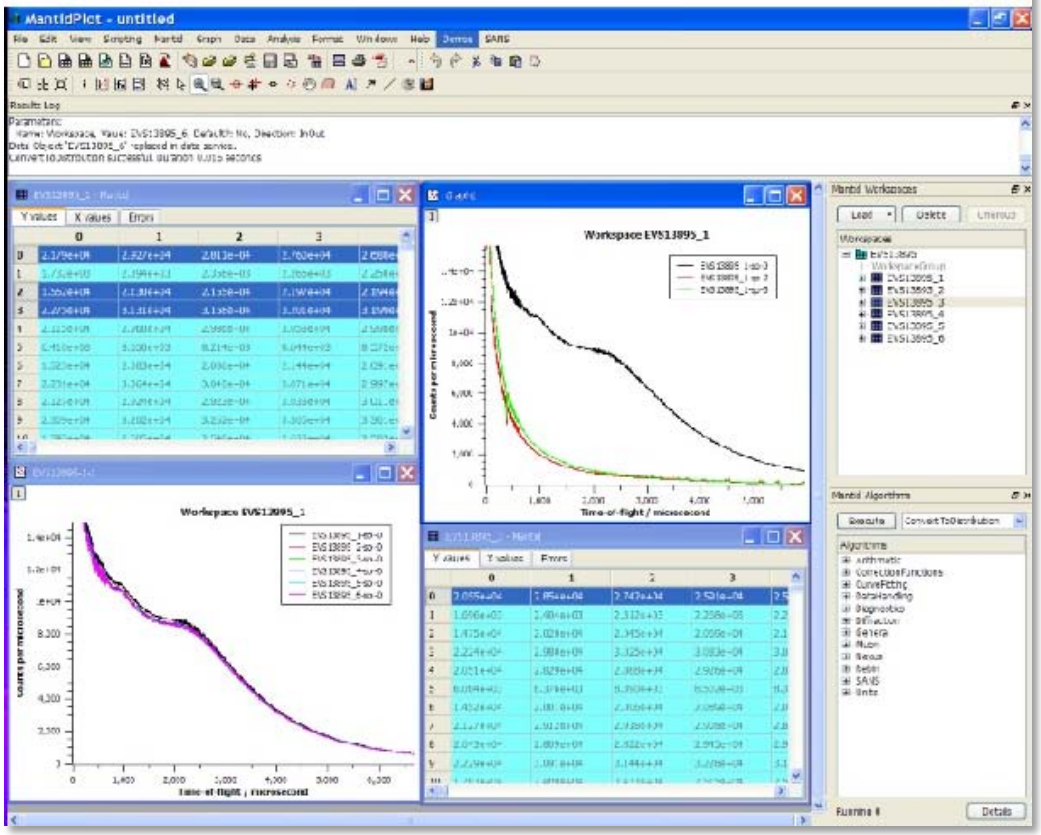
- RF equipment control now possible through scripting
- A wide variety of other pulsed techniques available
- ISIS ‘Period card’ within the DAE allows control of multiple pulsed stimuli
  - Up to 16 stimuli can be controlled at once
  - Very flexible definitions of period sequences possible
- Pulsed technique development supported through EC funding; collaborative with PSI

2. Recent developments: software

- **Muon users increasingly expect high levels of analysis support**
- **MANTID** – ISIS visualisation and analysis software
- Now widely used for ISIS neutrons; SNS neutrons; ILL neutrons exploring it; other neutron facilities in Europe interested
- Provision of a suite of routines in MANTID for muon data analysis

In general – lots of overlap at ISIS between technical aspects of neutrons and muons: s'ware, DAE, detectors, SE kit, user support, etc.

Publication quality 1D plots and matrix workspace views



See poster no. 68 by Cottrell et al

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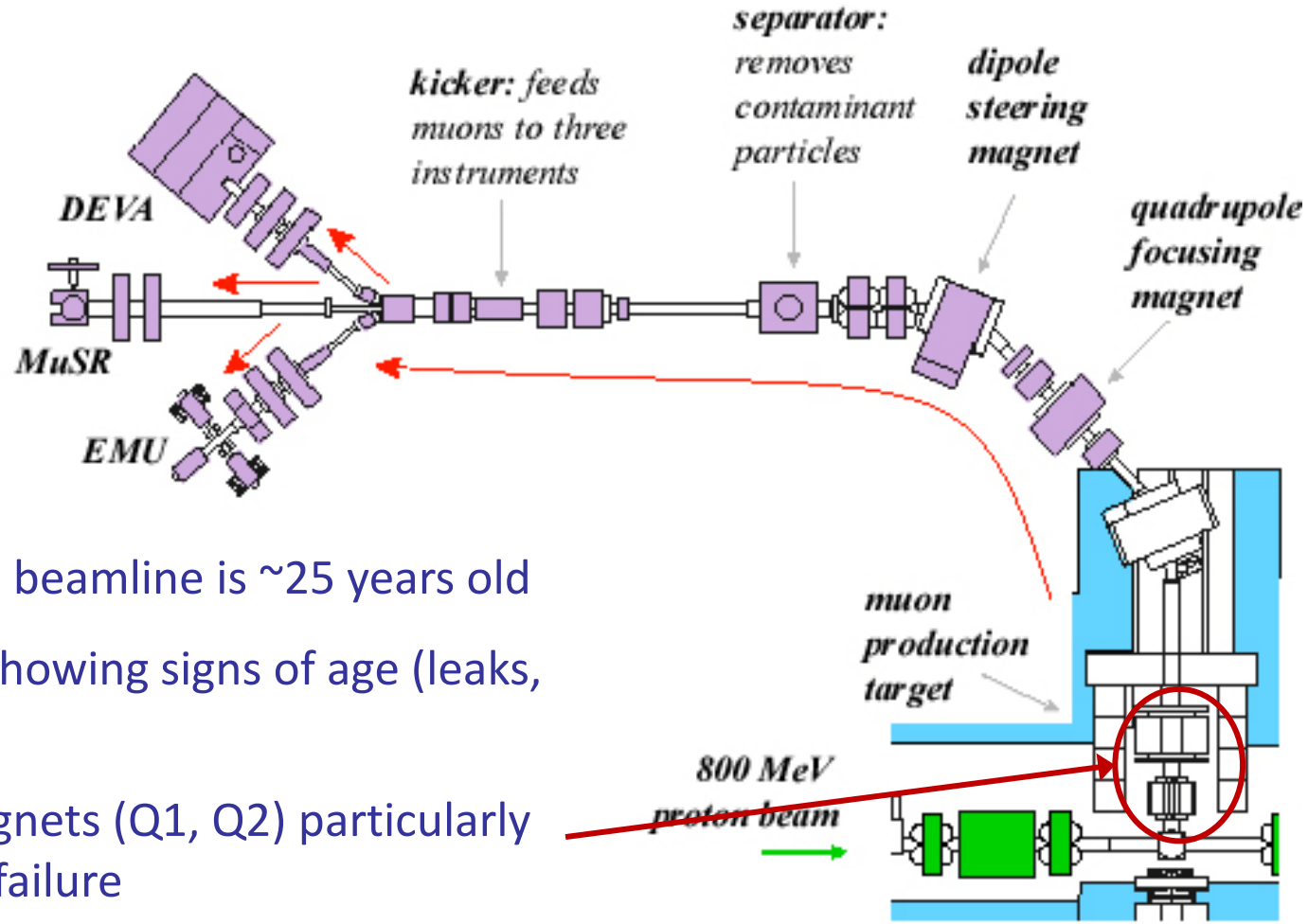
2. Ongoing developments: beamline refurbishment



- Primary muon beamline is ~25 years old
- Magnets are showing signs of age (leaks, shorts)
- Front-end magnets (Q1, Q2) particularly vulnerable to failure
- **3-year project to refurbish / replace all of the beamline magnets and other components**

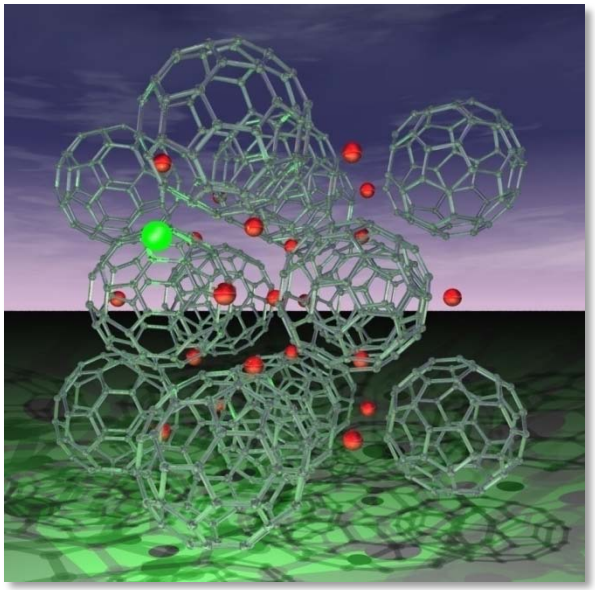
3. Science examples

Publications from ISIS Muons 2009 – present

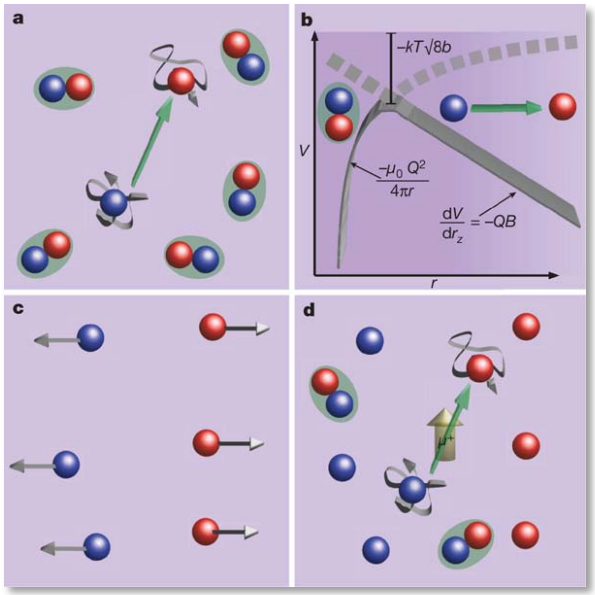
. . . include 5 PRL, 5 Nature family, 1 Science

- Baker et al, **Phys Rev Lett (2009)** *High-T_c materials*
- Bramwell, Giblin et al, **Nature (2009)** *Monopoles in spin ice*
- Drew et al, **Nature Materials (2009)** *Pnictide superconductors*
- Eschenko et al, **Phys Rev Lett (2009)** *H in GaAs*
- Hillier et al, **Phys Rev Lett (2009)** *Symmetry-breaking in superconductivity*
- Takabayashi, Prassides et al, **Science (2009)** *Superconductivity in fullerides*
- de Vries et al, **Phys Rev Lett (2010)** *Unconventional magnetism in perovskite structure*
- Ganin, Baker, Rosseinsky, Prassides et al, **Nature (2010)** *Fulleride superconductivity*
- Coronado et al, **Nature Chem (2010)** *Coexistence of superconductivity and magnetism*
- Parker et al, **Phys Rev Lett (2010)** *Magnetism and superconductivity in pnictides*
- Pratt et al, **Nature (2011)** *Quantum spin liquid*

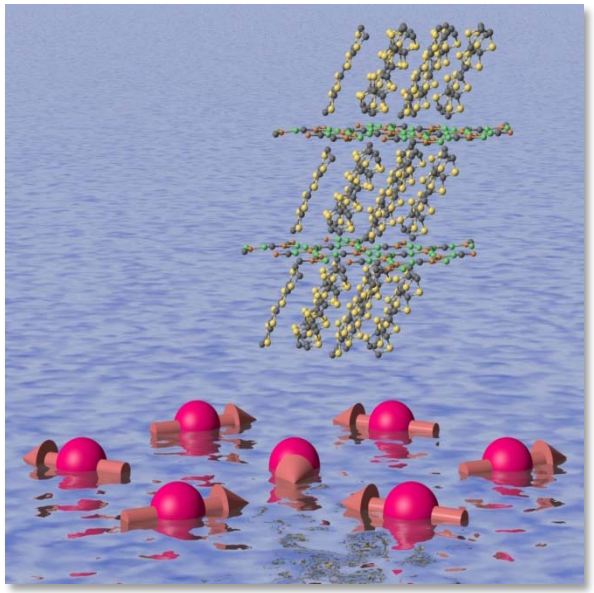
3. Science examples



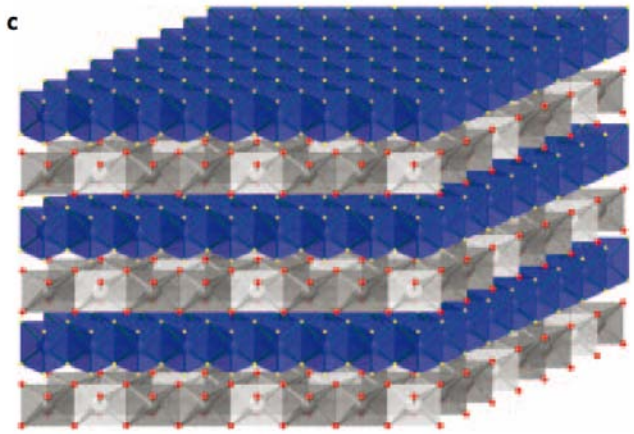
Ganin et al, Nature (2010)



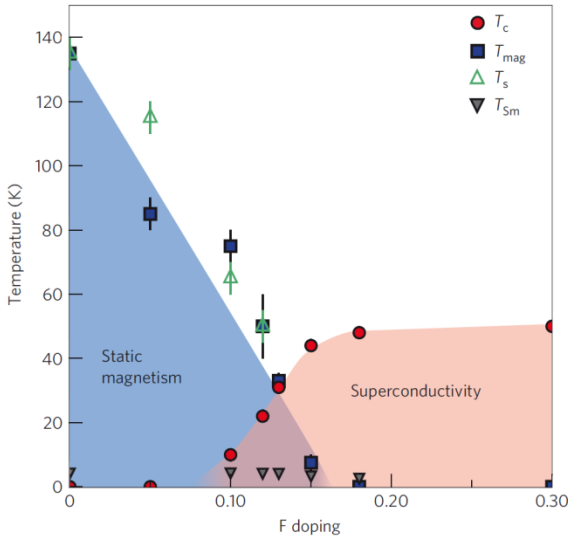
Bramwell, Giblin et al,
Nature (2009), Nature Physics (2011)



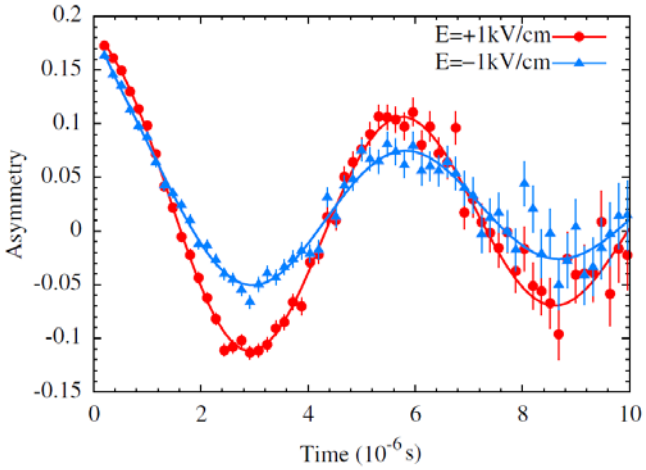
F Pratt, S Blundell, I Watanabe et al,
Nature (2011)



Coronado, Blundell, Baker et al
Nature Chemistry (2010)

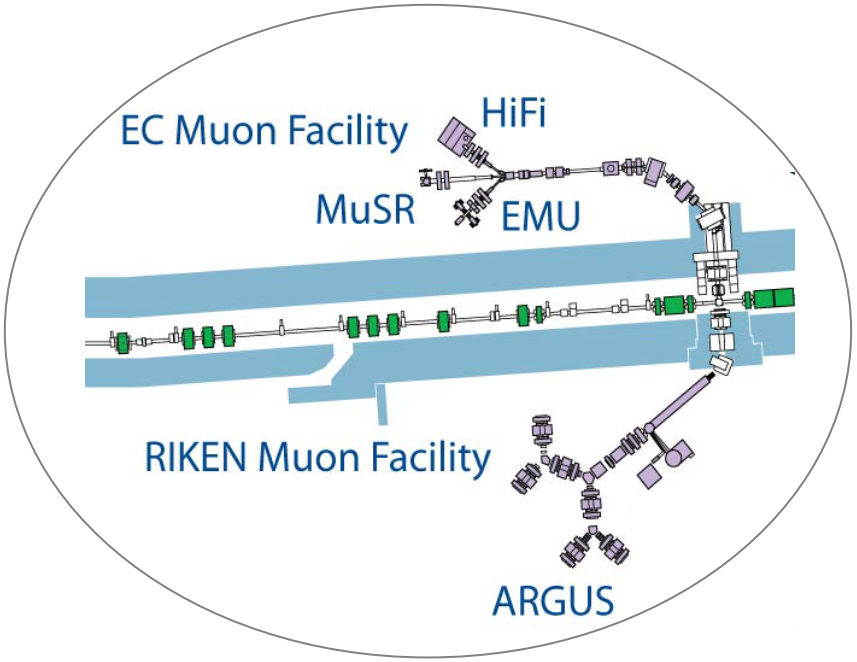


Drew et al, Nature Materials (2009)



Eshchenko, Storchak, Cottrell,
Morenzoni, PRL (2009)

4. The RIKEN-RAL Muon Facility



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4. The RIKEN-RAL Muon Facility: 2010

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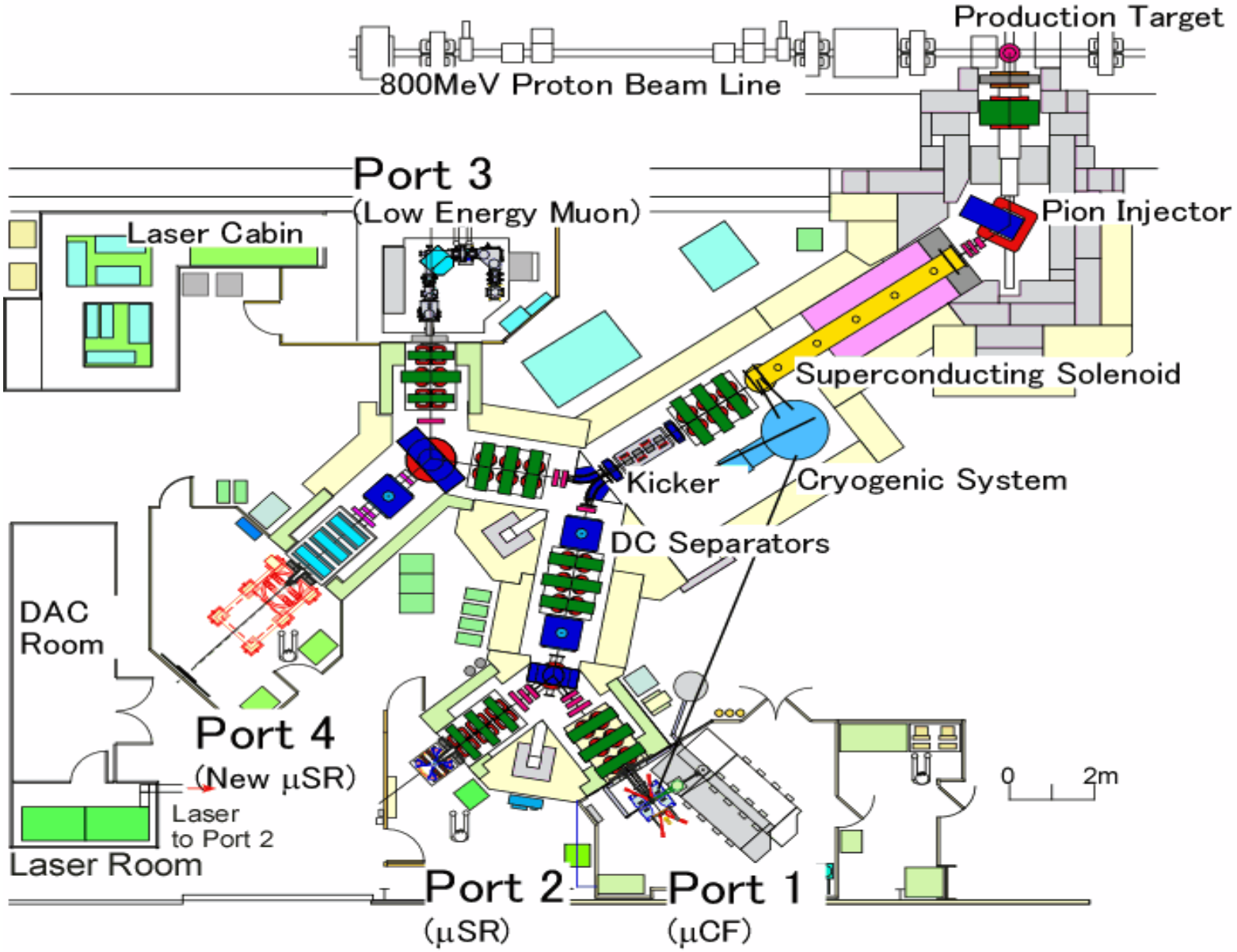
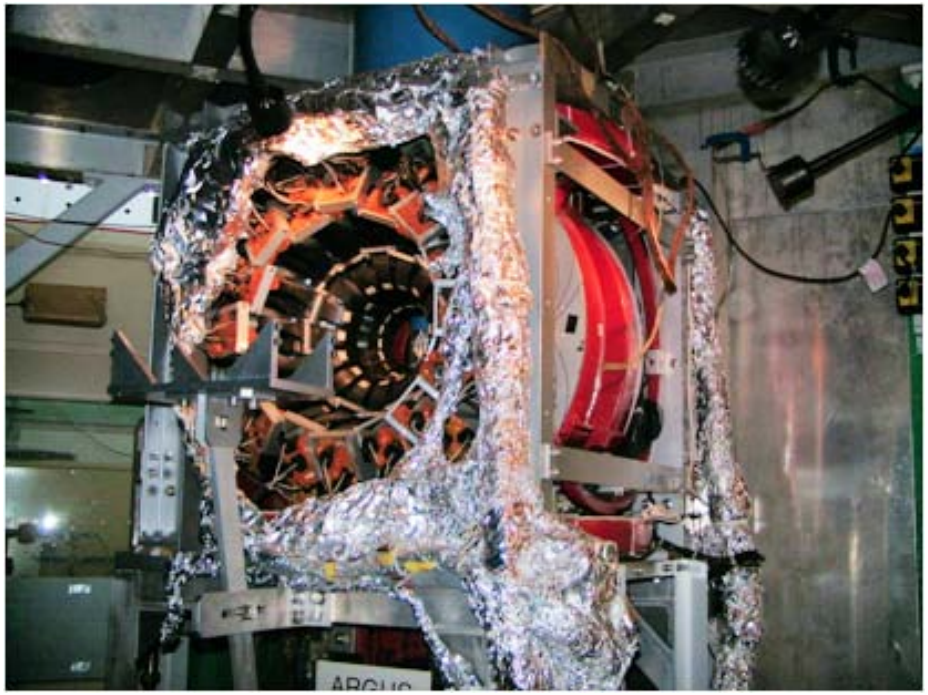
4. The RIKEN-RAL Muon Facility



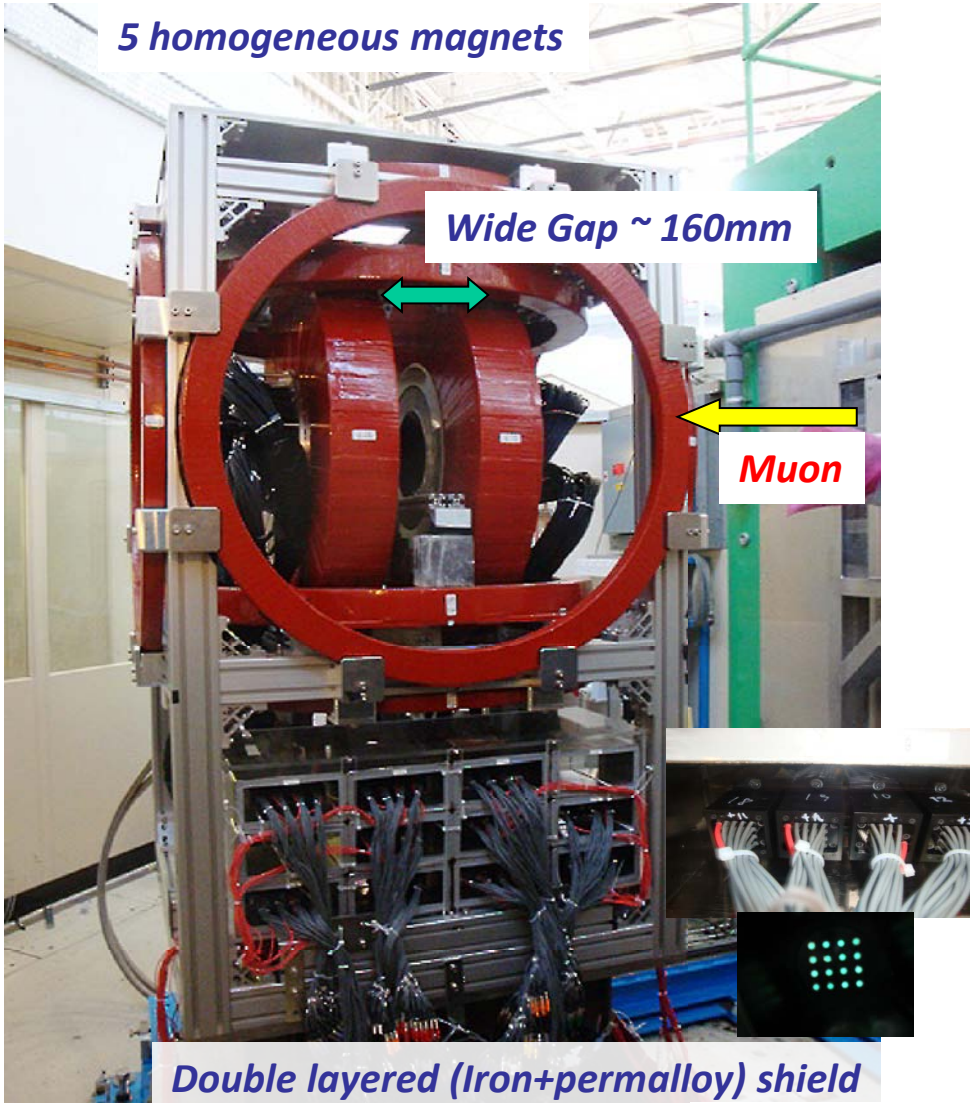
The RIKEN-RAL Muon Facility

4. The RIKEN-RAL Muon Facility: ARGUS



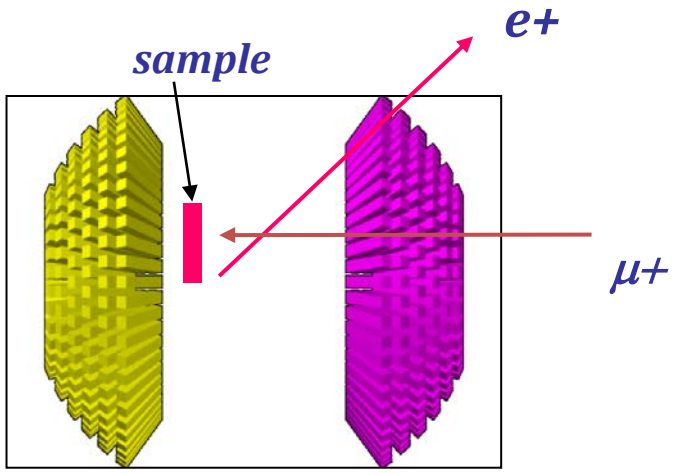
- General purpose μSR spectrometer
- 196 detectors; high data rate
- decay muons: pressure experiments up to 6kbar **(e.g. Telling et al., P84)**
- laser stimulation **(e.g. Torikai et al, O9)**

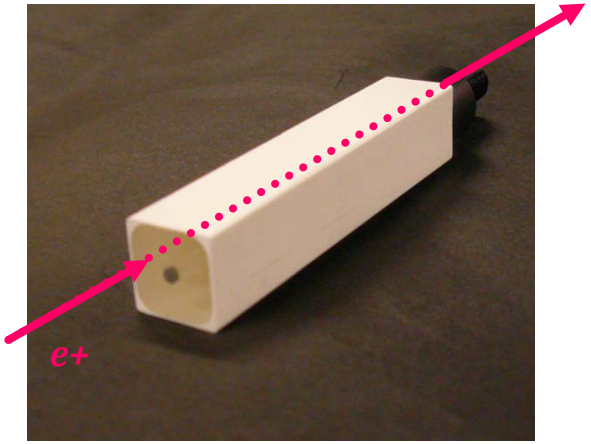
4. The RIKEN-RAL Muon Facility: CHRONUS



4. The RIKEN-RAL Muon Facility: CHRONUS

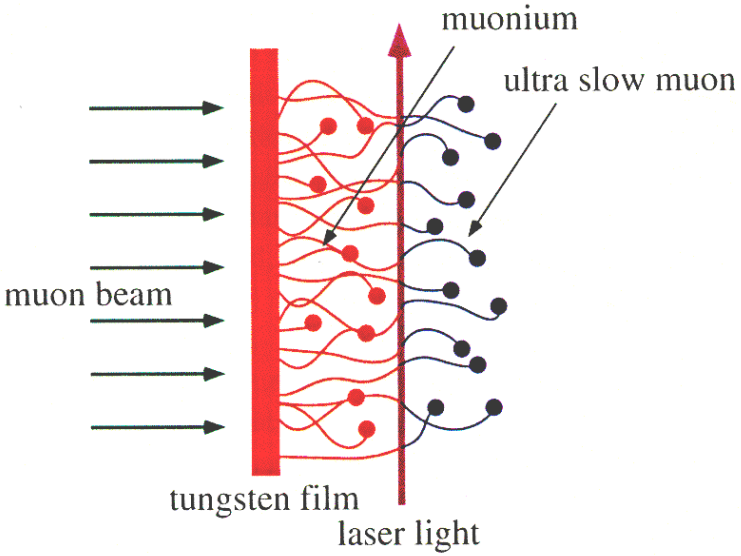
- New spectrometer
- Open access – μSR studies under extreme conditions
- LF 0.4T, TF 0.015T
- Compact, novel detector system:
  - specially designed scintillators
  - with wavelength-shifting fibre light guides
  - direction-sensitive counters
  - highly segmented (606 channels) for high data rates
  - 16 channel multi-anode photomultiplier tubes





Wavelength shifting fiber

4. The RIKEN-RAL Muon Facility: Low Energy Muons



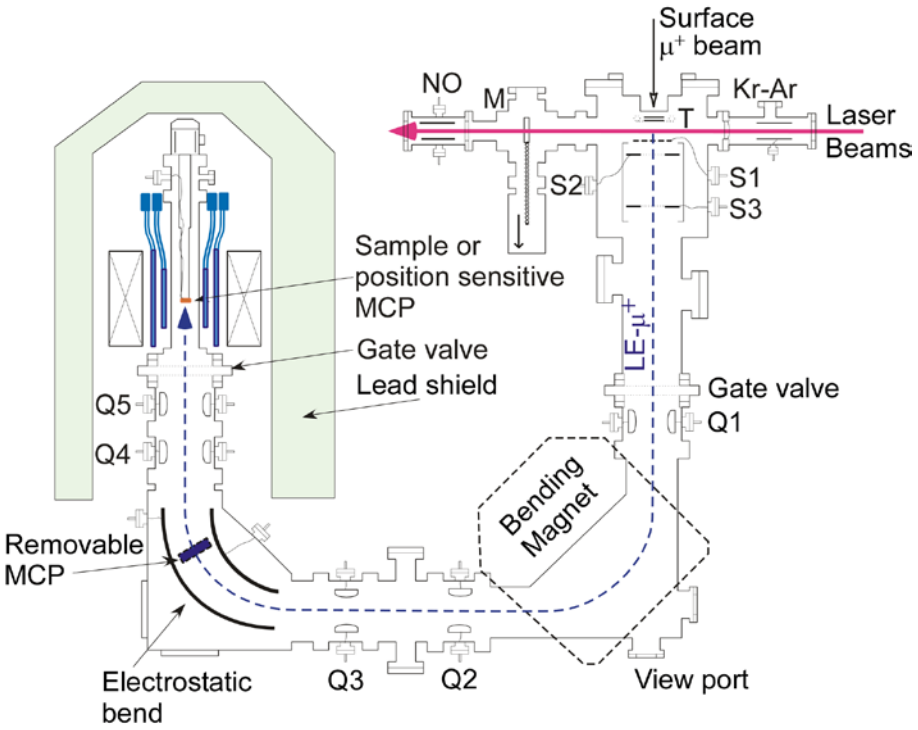
4. The RIKEN-RAL Muon Facility: Low Energy Muons

For:

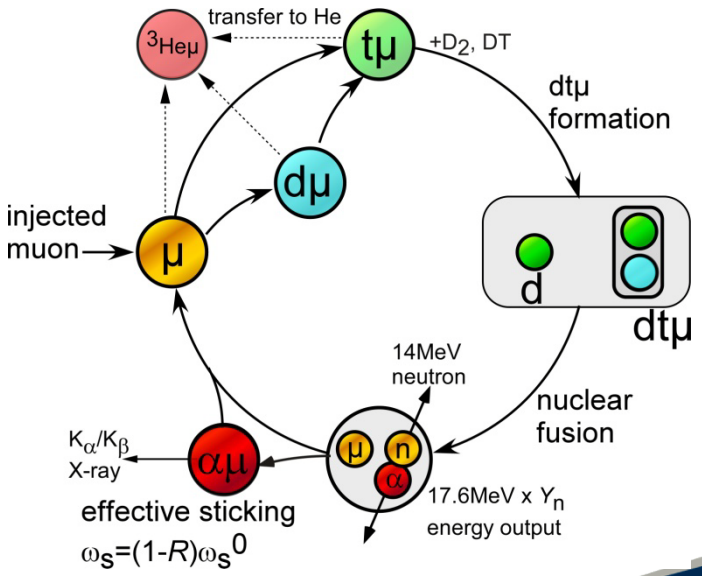
- μSR surface studies
- g-2 measurements

- short (10ns) muon pulse
- small spot size (10mm^2)
- good energy resolution
- good signal / noise

- 10-20 low energy muons /s
- plans to increase laser intensity – aim is 100x increase in low energy muon production



4. The RIKEN-RAL Muon Facility: muon catalysed fusion



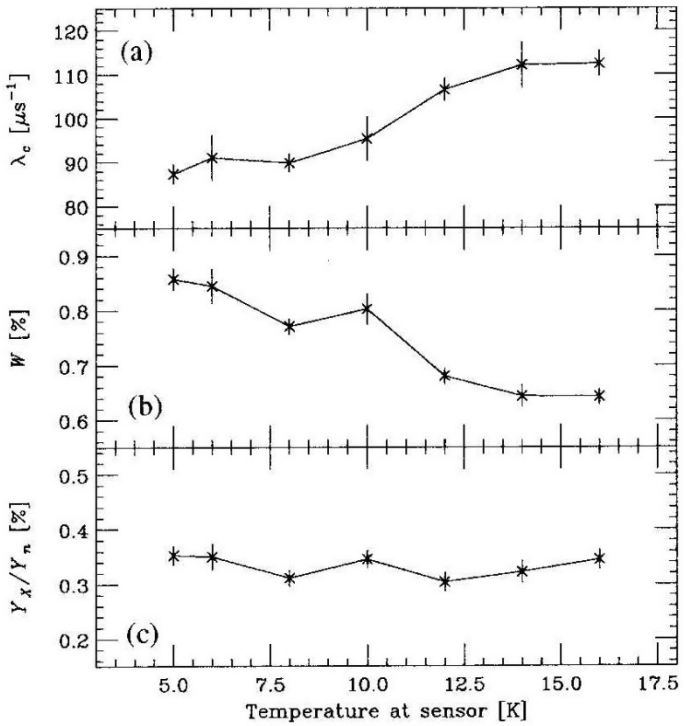


FIG. 2. Temperature dependence of (a) the muon cycling rate (λ_c), (b) the muon loss probability (W), and (c) the ratio of Y_X to Y_n at the tritium concentration of 0.4.

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ISIS Muon Facility

- ISIS proposal deadlines: 16 October, 16 April each year. ***See www.isis.stfc.ac.uk***
- UK users fully funded; some funding available for EC users and partner countries to cover T&S costs
- Full support for your experiment from ISIS muon group members (+ISIS technical staff):

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Sean Giblin


Steve Cottrell


Adrian Hillier


Sean Giblin
Francis Pratt


James Lord


Philip King


Steve Cox


Peter Baker

ISIS Muon Training School

- 1 week of lectures / tutorials / practical use of ISIS muon instruments
- Next course: early 2012
- Fully funded for UK and European attendees

See

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

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