

Muon Spectroscopy User Meeting

Philip King

16 July 2018

Welcome!



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ISIS



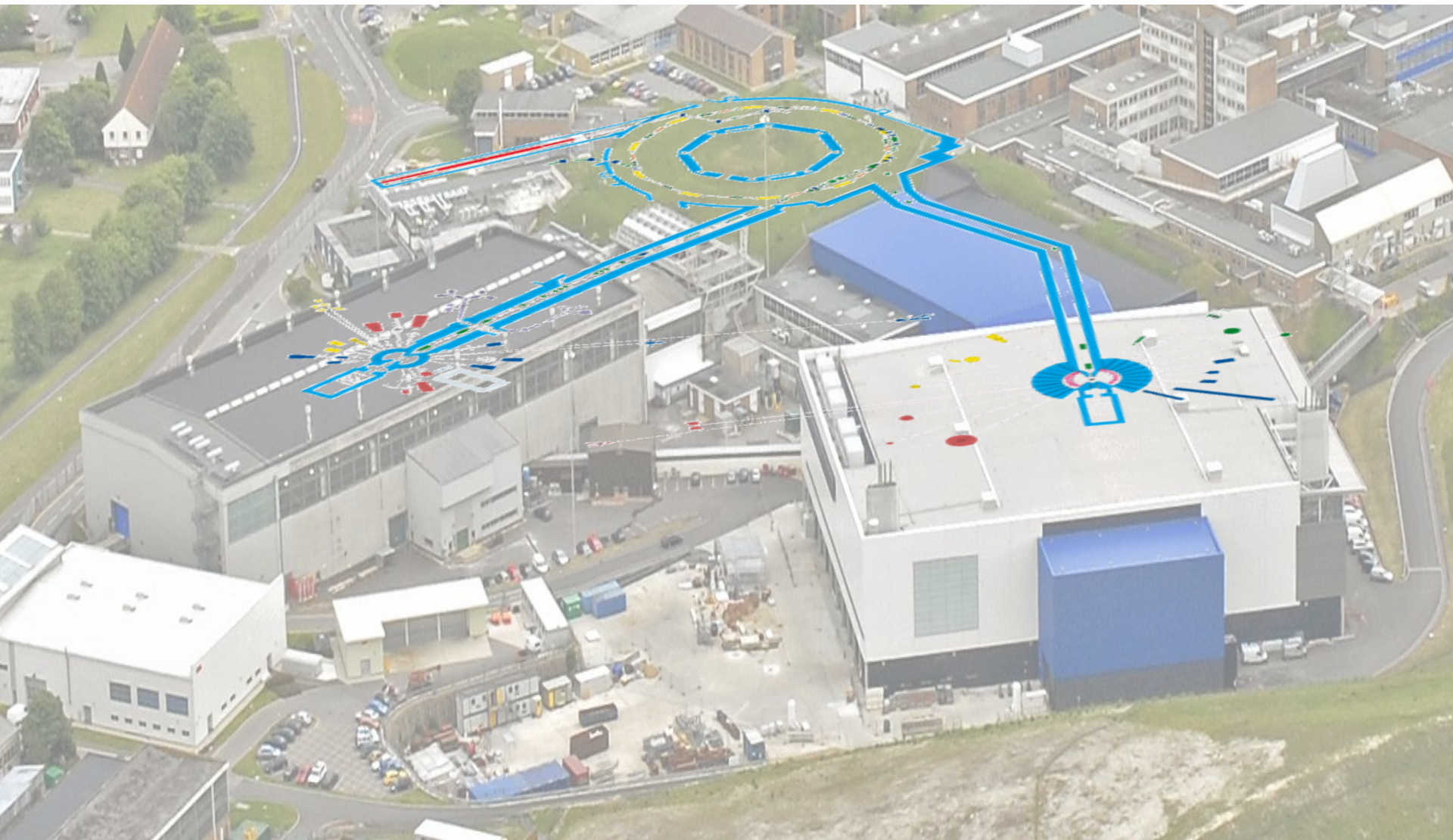
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STFC Rutherford Appleton Laboratory



*ISIS Pulsed Neutron and
Muon Source*

ISIS Pulsed Neutron and Muon Source



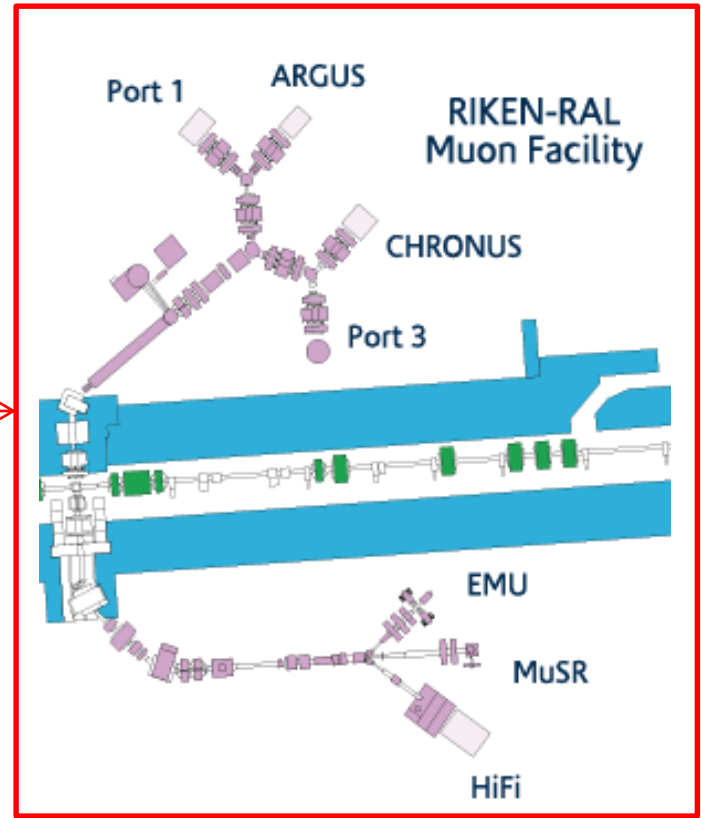
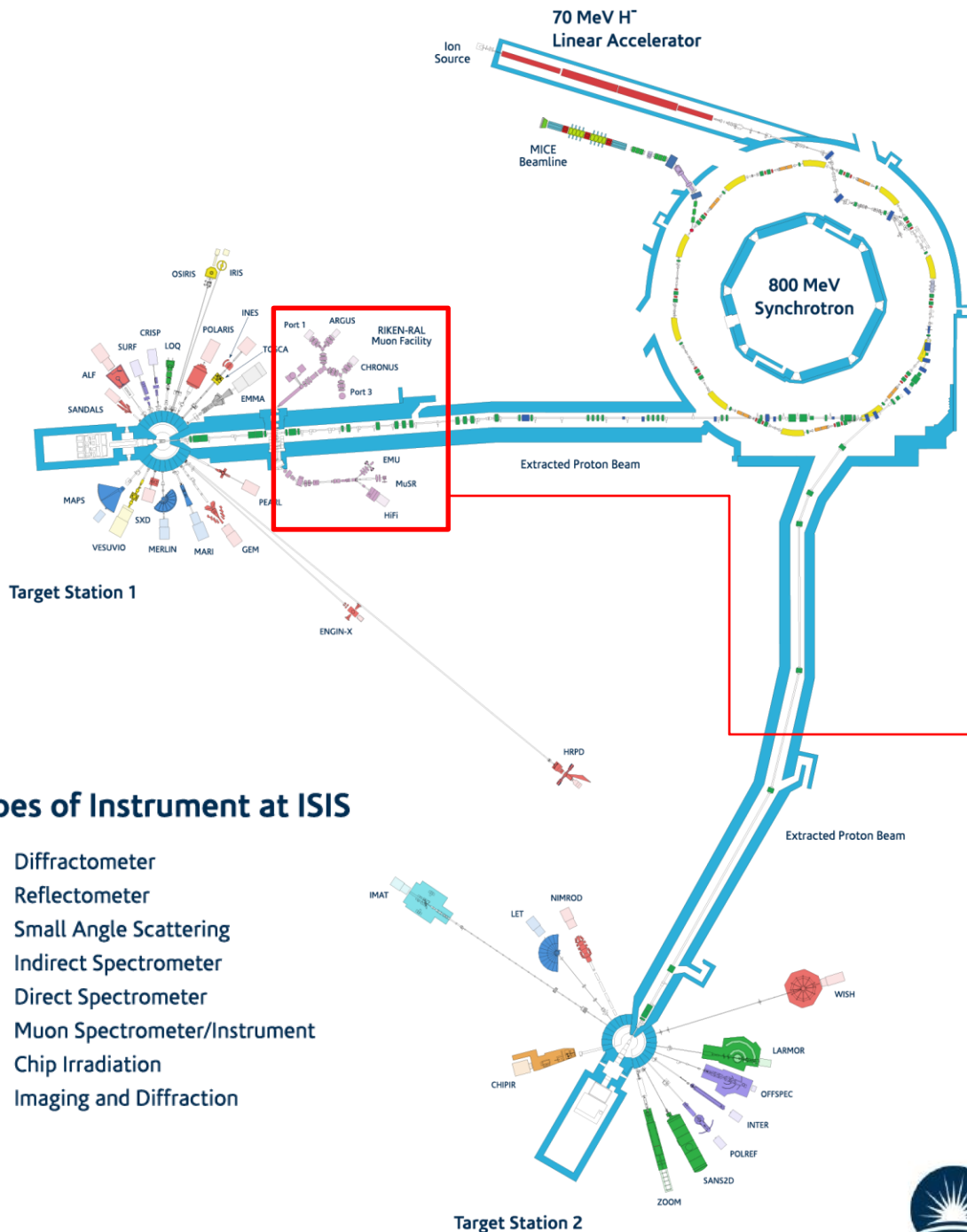
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Muons at ISIS



Types of Instrument at ISIS

- Diffractometer
- Reflectometer
- Small Angle Scattering
- Indirect Spectrometer
- Direct Spectrometer
- Muon Spectrometer/Instrument
- Chip Irradiation
- Imaging and Diffraction



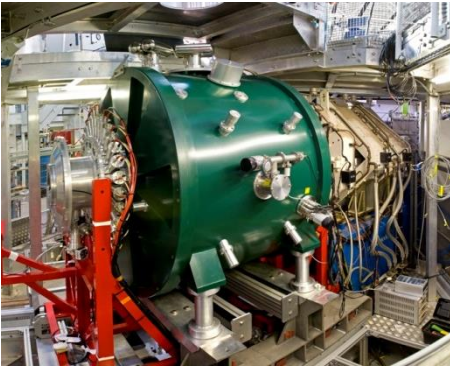
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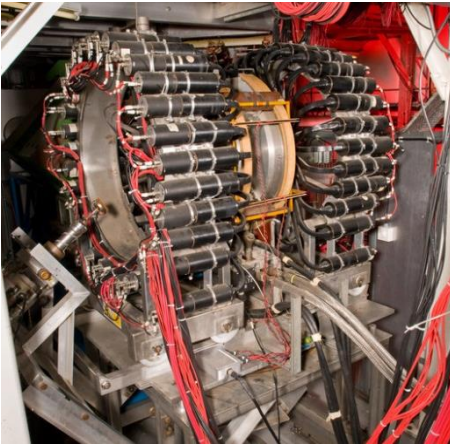


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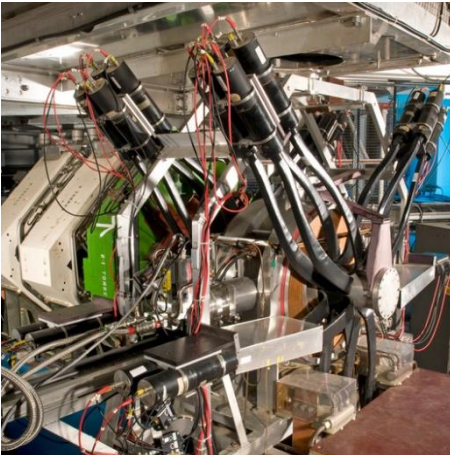
HiFi



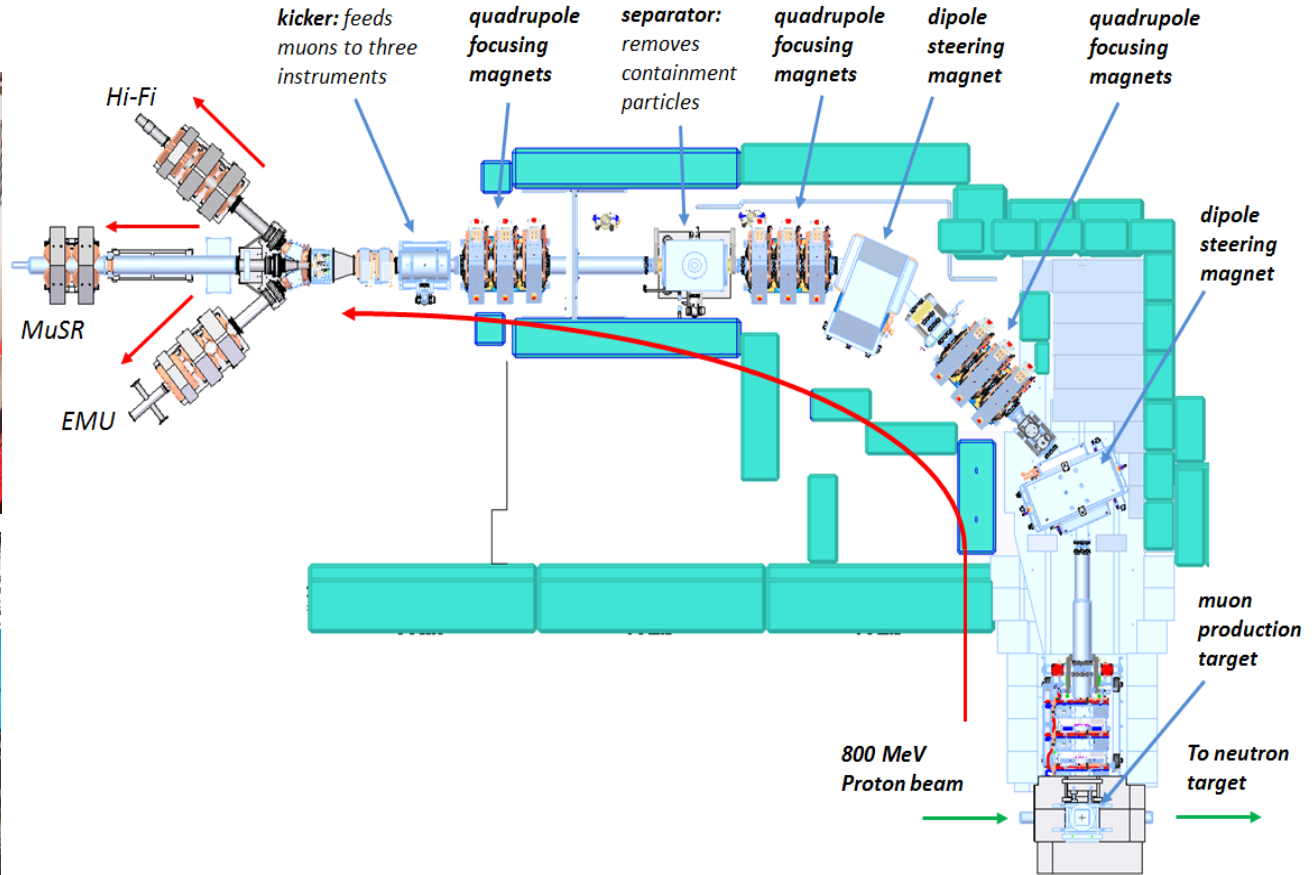
MuSR



EMU



South side muons



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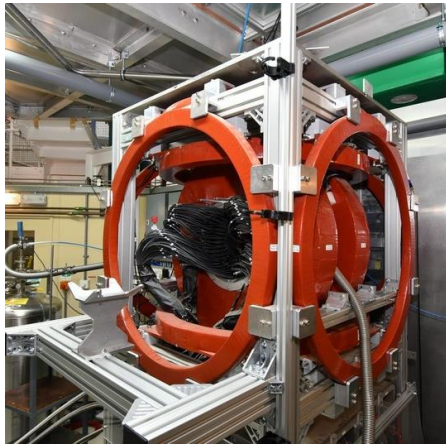
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North side muons – RIKEN-RAL Muon Facility

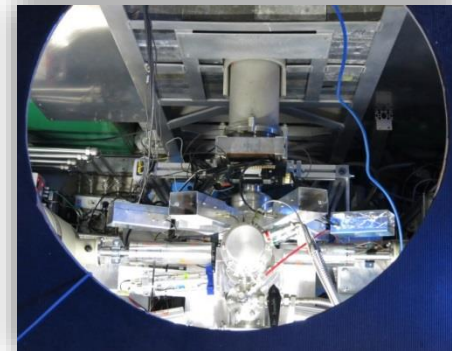
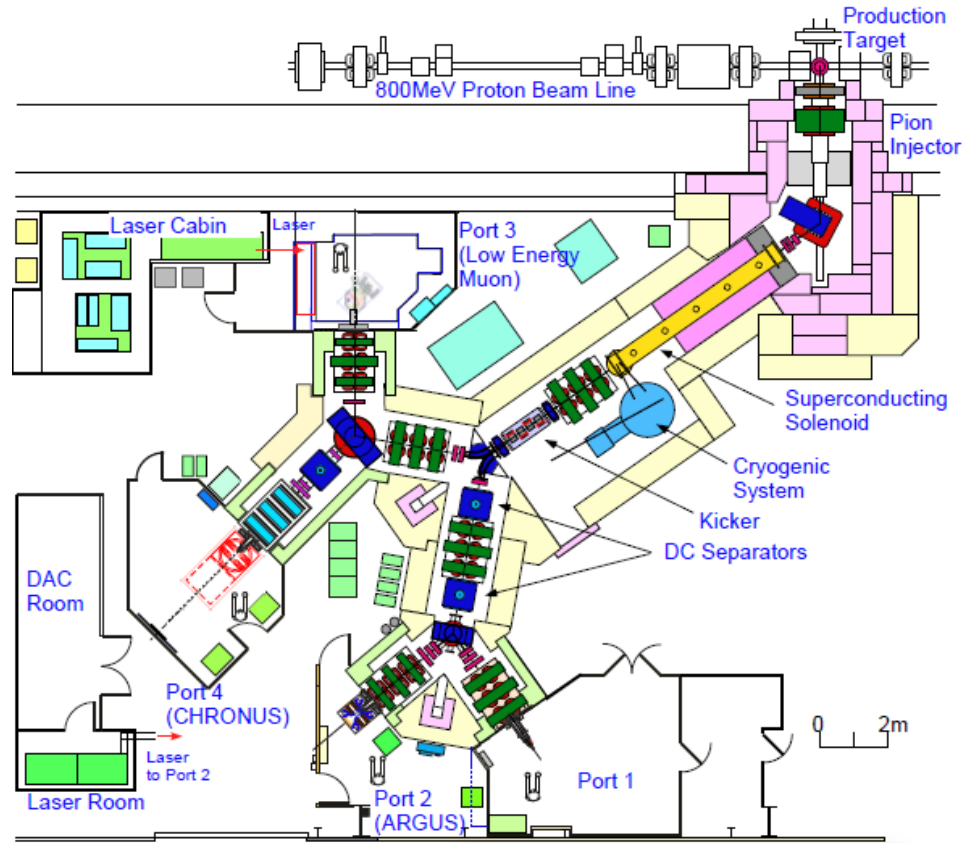
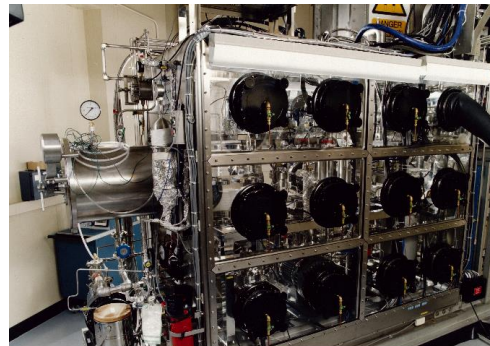
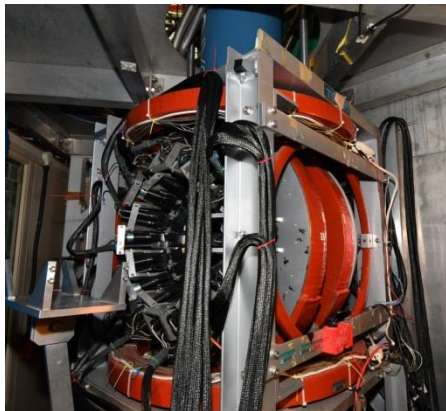
Port 3



CHRONUS



ARGUS



Port 1



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Magnetic and non-magnetic phases of a quantum spin liquid

F. L. Pratt¹, F. J. Blundell², T. Lancaster², S. Ohno³, K. Kawamura³, C. Balas⁴, Y. Shimizu⁴, K. Kanoda⁵, I. Watanabe⁶ & G. Saito⁶

VOLUME 89, NUMBER 14 PHYSICAL REVIEW LETTERS 30 SEPTEMBER 2002

Evidence for Weak Itinerant Long-Range Magnetic Correlations in UGe₂

A. Yaouanc¹, P. Dalmas de Réotier², P.C.M. Gubbens³, C.T. Kaiser³, A.A. Menovsky³, M. Mihalik³ and S.P. Cottrell⁴

VOLUME 88, NUMBER 7 PHYSICAL REVIEW LETTERS 18 FEBRUARY 2002

First-Order Transition in the Spin Dynamics of Geometrically Frustrated Yb₂Ti₂O₇

J.A. Hodges¹, P. Bonville¹, A. Forget¹, A. Yaouanc², P. Dalmas de Réotier², G. André³, M. Rams⁴, K. Królas⁴, C. Ritter⁵, P.C.M. Gubbens⁶, C.T. Kaiser⁶, P.J.C. King⁶ and C. Baines⁶

VOLUME 85, NUMBER 1 PHYSICAL REVIEW LETTERS 3 JULY 2000

Electron Localization in a Disordered Insulating Host

V.G. Stoeckh

Russian Research Centre "Kurchatov Institute," Kurchatov Square 46, Moscow 123182, Russia

PR L 107, 227003 (2011) PHYSICAL REVIEW LETTERS week ending 25 NOVEMBER 2011

Correlated Trends of Coexisting Magnetism and Superconductivity in Optimally Electron-Doped Oxypnictides

S. Samra^{1,6}, P. Carretta², P. Bonfi¹, G. Prando^{1,2}, G. Allodi³, R. De Renzi³, T. Shiroka^{4,5}, G. Lamura⁴, A. Martinelli⁵ and M. Pizzi⁶

NANO LETTERS

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Muons Probe Strong Hydrogen Interactions with Defective Graphene

Mauro Ricco^{1,5}, Daniele Pontieri², Marcello Marzani¹, Mohammad Choucat¹, John A. Stride^{6,5} and Oleg V. Yazyev^{3,4,5}

PR L 104, 057202 (2010) PHYSICAL REVIEW LETTERS week ending 5 FEBRUARY 2010

Ground State of the Easy-Axis Rare-Earth Kagome Lanthanide Pr₇G₃SiO₁₄

A. Zorko^{1,2}, F. Bert¹, P. Mendels¹, K. Marty¹ and P. Bordet¹

PR L 99, 017202 (2007) PHYSICAL REVIEW LETTERS week ending 4 JULY 2007

Chiral-Like Critical Behavior in the Antiferromagnet Cobalt Glycolate

F.L. Pratt¹, P.J. Baker¹, S.J. Blundell², T. Lancaster², M.A. Green³ and M. Kuzuno⁴

PR L 96, 247201 (2006) PHYSICAL REVIEW LETTERS week ending 23 JUNE 2006

Low-Temperature Spin Diffusion in a Highly Ideal S = 1/2 Heisenberg Antiferromagnetic Chain Studied by Muon Spin Relaxation

F.L. Pratt¹, S.J. Blundell², T. Lancaster², C. Baines³ and S. Takagi⁴

PR L 101, 097010 (2008) PHYSICAL REVIEW LETTERS week ending 29 AUGUST 2008

Coexistence of Magnetic Fluctuations and Superconductivity in the Pnictide High Temperature Superconductor SmFeAsO_{1-x}F_x Measured by Muon Spin Rotation

A.J. Drew¹, F.L. Pratt², T. Lancaster², S.J. Blundell², P.J. Baker¹, R.H. Liu³, G. Wu³, X.H. Chen⁴, I. Watanabe⁵, V.K. Malik³, A. Dubroka³, K.W. Kim¹, M. Rössle¹ and C. Bernhard⁶

Polymorphism control of superconductivity and magnetism in Cs₃C₆₀ close to the Mott transition

Alexey Y. Gasin¹, Yasuhiro Takabayashi¹, Peter Jeglič¹, Denis Aronov¹, Anton Potožnik¹, Peter J. Baker¹, Yasuo Ohno², Martin T. McDonnell³, Manolo D. Tzirakis¹, Alec McLennan¹, George R. Darling¹, Masaki Takata⁴, Matthew J. Rosseinsky⁵ and Komos Prassides⁶

VOLUME 88, NUMBER 13 PHYSICAL REVIEW LETTERS 1 APRIL 2002

Common Energy Scale for Magnetism and Superconductivity in Underdoped Cuprates: A Muon Spin Resonance Investigation of (Ca_{1-x}La_{1-x})₂(Ba_{1-75-x}La_{0.25+x})Cu₂O₇

Amit Kaniyel¹, Amit Keren², Yaakov Eckstein¹, Arkady Katzirich³, James S. Lord⁴ and Alex Amato⁵

VOLUME 79, NUMBER 8 PHYSICAL REVIEW LETTERS 25 AUGUST 1997

Investigation of Vortex Behavior in the Organic Superconductor κ -(BEDT-TTF)₂Cu(SCN)₂ Using Muon Spin Rotation

S.L. Lee¹, F.L. Pratt^{2,3}, S.J. Blundell², C.M. Aegerter¹, P.A. Pattenden², K.H. Chow², E.M. Forgan², T. Sasaki⁴, W. Hayes² and H. Keller²

PR L 100, 116601 (2008) PHYSICAL REVIEW LETTERS week ending 21 MARCH 2008

Intrinsic Mobility Limit for Anisotropic Electron Transport in Alq₃

A.J. Drew¹, F.L. Pratt², J. Hopper¹, L. Schulte¹, V. Malik-Kumar¹, N.A. Morley², P. Desai⁴, P. Shakya⁴, T. Krcmaric⁴, W.P. Gilpin⁴, K.W. Kim³, A. Dubroka³ and R. Scheurer^{5,6}

VOLUME 92, NUMBER 25 PHYSICAL REVIEW LETTERS week ending 25 JUNE 2004

Muon Spin Relaxation Measurements of Na_xCoO₂ · yH₂O

A. Kaniyel¹, A. Keren^{1,2}, L. Patlagan¹, K.B. Chaschka¹ and P. King²

PR L 98, 197203 (2007) PHYSICAL REVIEW LETTERS week ending 11 MAY 2007

Magnetism in Geometrically Frustrated Mn₂O₃ under Hydrostatic Pressure Studied with Muon Spin Relaxation

T. Lancaster^{1,6}, S.J. Blundell¹, D. Andrea^{2,3}, M. Janoschek^{3,4}, B. Roessli³, S.N. Gvasaliya⁴, K. Conder⁵, E. Pomjakushina^{4,5}, M.L. Brooks⁶, P.J. Baker⁶, D. Prabhakaran⁶, W. Hayes⁶ and F.L. Pratt⁶

PR L 99, 267601 (2007) PHYSICAL REVIEW LETTERS week ending 31 DECEMBER 2007

Muon-Fluorine Entangled States in Molecular Magnets

T. Lancaster^{1,6}, S.J. Blundell¹, P.J. Baker¹, M.L. Brooks¹, W. Hayes¹, F.L. Pratt², J.L. Manson³, M.M. Corneer⁴ and J.A. Schluter⁴

PR L 101, 136403 (2008) PHYSICAL REVIEW LETTERS week ending 26 SEPTEMBER 2008

Hydrogen Defect-Level Pinning in Semiconductors: The Muonium Equivalent

R.L. Licht^{1,4}, K.H. Chow² and S.E.J. Cox^{3,4}

PR L 107, 047208 (2011) PHYSICAL REVIEW LETTERS week ending 22 JULY 2011

Unconventional Magnetism in a Nitrogen-Containing Analog of Cupric Oxide

A. Zorko^{1,2}, P. Jeglič^{1,2}, A. Potožnik¹, D. Arčon^{1,3}, A. Balžytis², Z. Jagličič^{5,6}, X. Liu⁷, A.L. Tchougoureff^{5,8} and R. Droznikowski⁷

VOLUME 91, NUMBER 17 PHYSICAL REVIEW LETTERS 26 OCTOBER 1998

Thermal Fluctuations in the Magnetic Ground State of the Molecular Cluster Mn₁₂O₁₂ Acetate from μ SR and Proton NMR Relaxation

A. Lucifora¹, Z.H. Jiang², F. Beoa^{1,2}, P. Carretta² and D. Gatteschi³

VOLUME 89, NUMBER 14 PHYSICAL REVIEW LETTERS 30 SEPTEMBER 2002

Magnetic Correlations and the Anisotropic Kondo Effect in Ce_{1-x}La_xAl₃

E.A. Goremychkin¹, R. Osoviza¹, B.D. Rainford², T.A. Cozz^{3,4}, A.P. Marzi⁴, C.A. Scott² and P.J.C. King⁵

Coexistence of static magnetism and superconductivity in SmFeAsO_{1-x}F_x as revealed by muon spin rotation

A.J. Drew^{1,7}, Ch. Niedermayer⁸, P.J. Baker¹, F.L. Pratt¹, S.J. Blundell², T. Lancaster², R.H. Liu³, G. Wu³, X.H. Chen⁴, I. Watanabe⁵, V.K. Malik³, A. Dubroka³, M. Rössle³, K.W. Kim¹, C. Baines¹ and C. Bernhard⁶

1000+ publications

Measurement of the charge and current of magnetic monopoles in spin ice

S.T. Bramwell^{1*}, S.R. Giblin^{2*}, S. Calder¹, R. Aldus¹, D. Prabhakaran¹ & T. Fennel³

PR L 94, 097006 (2005) PHYSICAL REVIEW LETTERS week ending 11 MARCH 2005

Universal Scaling Relations in Molecular Superconductors

F.L. Pratt^{1,2} and S.J. Blundell^{2,3}

PRL 119, 226601 (2017) PHYSICAL REVIEW LETTERS week ending 1 DECEMBER 2017

Photoexcited Muon Spin Spectroscopy: A New Method for Measuring Excess Carrier Lifetime in Bulk Silicon

K. Yokoyama^{1,2*}, J.S. Lord¹, J. Miao^{3,4}, P. Mariani¹ and A.J. Drew^{1,2,3,5}

¹School of Physics and Astronomy, Queen Mary University of London, Mile End, London E1 4NS, United Kingdom

²ISIS, STFC Rutherford Appleton Laboratory, Didcot OX11 0QX, United Kingdom

³College of Physical Science and Technology, Sichuan University, Chengdu 610064, People's Republic of China

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PR L 98, 077204 (2007) PHYSICAL REVIEW LETTERS week ending 16 FEBRUARY 2007

Quantum Magnetism in the Paratacamite Family: Towards an Ideal Kagomé Lattice

P. Mendels¹, F. Bert¹, M.A. de Vries², A. Otariu¹, A. Harrison³, F. Dog², J.C. Trombe³, J.S. Lord⁴, A. Amato⁵ and C. Baines²

PR L 94, 136403 (2005) PHYSICAL REVIEW LETTERS week ending 8 APRIL 2005

Cascade of Bulk Magnetic Phase Transitions in Na_xCoO₂ as Studied by Muon Spin Rotation

P. Mendels¹, D. Boso¹, J. Bobert¹, G. Collin², D. Colson², N. Blanchard¹, H. Alloul¹, I. Mukhammedov¹, F. Bert¹, A. Amato⁴ and A.D. Hillier²

PR L 100, 257602 (2008) PHYSICAL REVIEW LETTERS week ending 27 JUNE 2008

Dynamics and Reactivity of Positively Charged Muonium in Heavily Doped Si:B and Comparisons with Hydrogen

A.J. Manson^{1,6}, Z. Salman^{7,3}, K.H. Chow^{1,3}, I. Fan¹, P.J.C. King³, B. Hitti⁴, J. Jiang¹ and S.P. Cottrell⁵

PR L 102, 117007 (2009) PHYSICAL REVIEW LETTERS week ending 20 MARCH 2009

Evidence for Time-Reversal Symmetry Breaking in the Noncentrosymmetric Superconductor LaNiC₂

A.D. Hillier¹, J. Quintanilla¹ and R. Cywinski²

PR L 104, 177202 (2010) PHYSICAL REVIEW LETTERS week ending 30 APRIL 2010

Valence Bond Glass on an fcc Lattice in the Double Perovskite Ba₂YMoO₆

M.A. de Vries^{1,2*}, A.C. McLaughlin³ and J.-W. G. Bos^{4,5}

PR L 103, 216601 (2009) PHYSICAL REVIEW LETTERS week ending 20 NOVEMBER 2009

Electric-Field-Enhanced Neutralization of Deep Centers in GaAs

VOLUME 92, NUMBER 25 PHYSICAL REVIEW LETTERS week ending 25 JUNE 2004

Muon Spin Relaxation Measurements of Na_xCoO₂ · yH₂O

A. Kaniyel¹, A. Keren^{1,2}, L. Patlagan¹, K.B. Chaschka¹ and P. King²

Three key themes of the meeting

- **RIKEN-RAL Muon Facility**
- **SuperMuSR**
- **Site Calculations**



RIKEN-RAL Muon Facility



Science & Technology Facilities Council

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RIKEN-RAL Muon Facility

AGREEMENT

between

The Science and Technology Facilities Council
of the United Kingdom

and

RIKEN
of Japan

concerning muon science
using the ISIS Facility
at the Rutherford Appleton Laboratory



Signed 

Brian Bowsher
Chief Executive
Science and Technology Facilities
Council

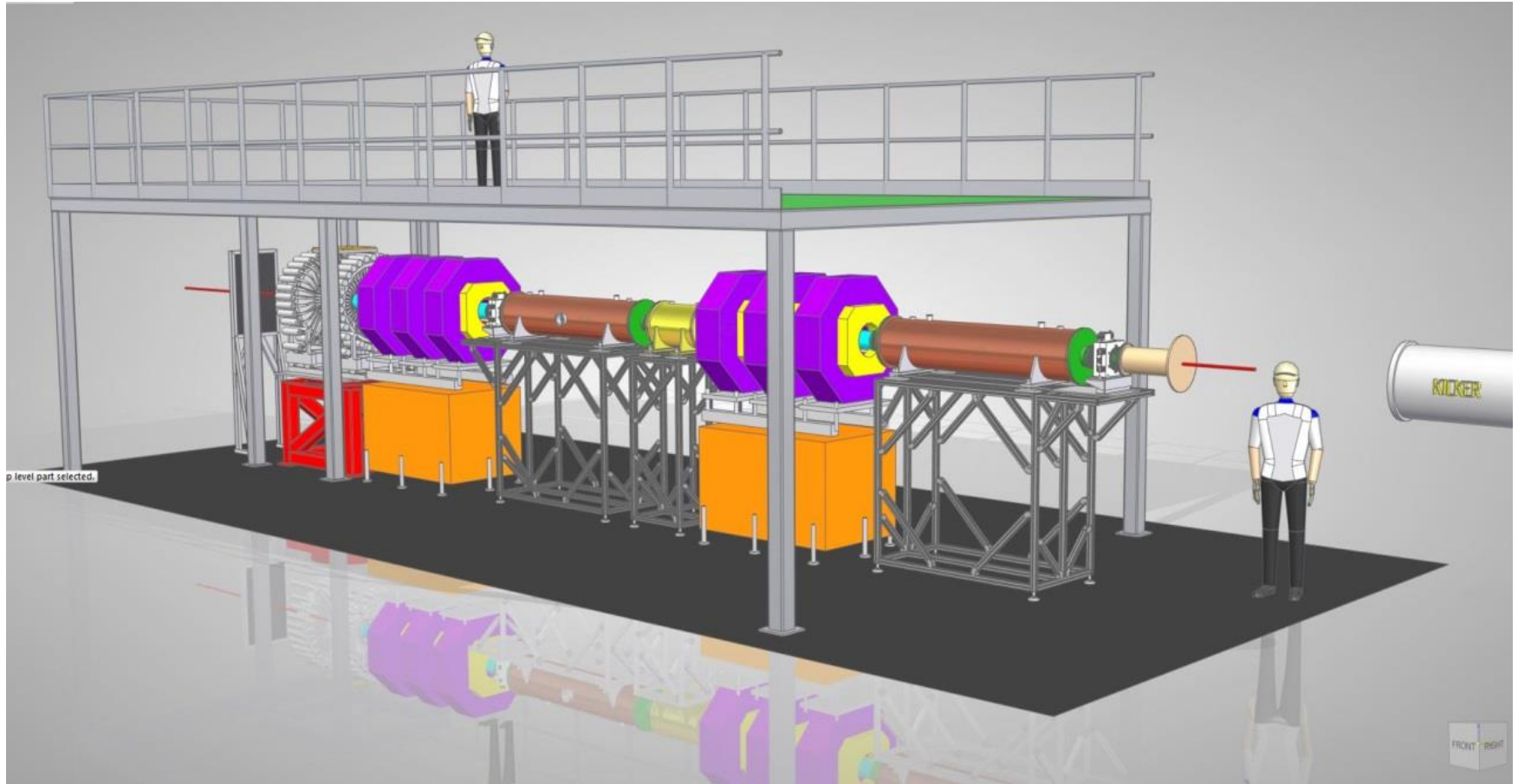
Date *30th March 2018*

Signed 

Hiroshi Matsumoto
President
RIKEN

Date *March 30, 2018*

SuperMuSR



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Site Calculations

A lot of activity in this area:

- Lancaster/Blundell/Pratt EPSRC grant
- de Renzi EU funding
- collaborative project with STFC Scientific Computing

Part of growing efforts which recognise the importance of modelling and simulation

- A variety of projects with STFC Scientific Computing
- Parallelisation of analysis and simulation codes for Excitations
- Ada Lovelace Centre – cross-facility centre for computational infrastructure and methods
- ‘Data analysis as a service’ – one-stop portal for data/modelling codes/compute resource
- AI/Machine Learning for facilities



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