RIKEN-RAL Update

K. Ishida (RIKEN)

About the RIKEN-RAL facility

Technical Developments Update
  MuSR
    High pressure, Laser, CRONUS
  Slow Muon Beam
About RIKEN-RAL

Congratulations to 25 years of MuSR at ISIS!

RIKEN is located at north-side of ISIS

Research
Port-2: Materials Science by uSR (ARGUS)
Port-4: Materials Science with mSR (CRONUS)
Port-3: Ultra-slow muon beam generation
Port-1: Muon catalyzed d-t fusion
RIKEN–RAL Muon Facility

Construction Stage (1994)

Recent

After beamline completion
About RIKEN-RAL

It is open to users through RIKEN PAC and ISIS Panel.

History
1990 The first RIKEN-RAL agreement between RIKEN and SERC
1991 Beginning of facility construction
1994 First muon beam
1995 Start of MuSR at ARGUS
2000 Second agreement between RIKEN and CCLRC
2010 The third agreement between RIKEN and STFC (for 7.5 years)

Staffs (2012):
P. King, M. Iwasaki, K. Ishida, I. Watanabe,
T. Matsuzaki, D. Tomono, K. Yokoyama,
I. Kawasaki, S. Okada, H. Guo, B. Adiperdana
ARGUS Spectrometer
Highly segmented detector (96+96)
High data rate (70 M/hr)
Magnetic field up to 0.4 T (LF) and 0.015 T (TF)
Various cryostats (dilution, 3He, He, Flow type)
Fly past setup (for small samples)

Many features common with ISIS Muons, but also has some unique features.

Choice of backward decay or surface muon
  high momentum muon for high pressure chamber

Other capabilities
  coupling with laser excitation
MuSR with Laser

Intense pulsed laser is a good match for pulsed muon

Nd:YAG by E. Torikai (Yamanashi) OPO by K. Shimomura (KEK)

**Nd:YAG** (1064 nm; 532 nm; 355 nm) + **OPO**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse repetition rate</td>
<td>25 Hz</td>
</tr>
<tr>
<td>Pulse duration (FWHM)</td>
<td>8 ns</td>
</tr>
<tr>
<td>Pulse energy @ 1064 nm</td>
<td>1400 mJ</td>
</tr>
<tr>
<td>Pulse energy @ 532 nm</td>
<td>600 mJ</td>
</tr>
<tr>
<td>Pulse energy @ 355 nm</td>
<td>350 mJ</td>
</tr>
<tr>
<td>OPO energy 420-700 nm (signal)</td>
<td>&lt;80 mJ</td>
</tr>
<tr>
<td>OPO energy 700-2600 nm (idler)</td>
<td>&lt;30 mJ</td>
</tr>
</tbody>
</table>

Wide tuning range of 400-2500 nm (photon energy of 0.5-3.1 eV)
Now upgrading to cover region down to 210nm
Laser for Chemistry: $\text{Mu} + H \rightarrow \text{MuH} + H$

Reaction rate $2 \times 10^7$ times faster

$\mu$H is used to study the reaction

H$_2$ gas cell (50 bar) with 532nm laser
Muon for Spintronics: Muon probing electron spin

Polarization photon is easily obtained
It can be used for polarization phenomena:
    good match for polarized muon also
Monitor of polarized conduction electron is one example.

Large laser ON/OFF, and left/right polarization effect
Gas Pressure

6.4 kbar, 1.5 K

120 MeV/c muon can penetrate 2 cm of copper walls
What High Pressure can do?

For example

pressure decreases the lattice constant (in soft materials ...)

-> Magnetic interaction between spins can be increased

Shift of frequency, new magnetic phase, ...

\[ \omega = \gamma \mu H_{\text{int}} \]

(DMe-DCNQI)$_2$Cu

![Graph showing the relationship between pressure and magnetic field intensity.](image)
High Pressure Development

Furthermore testing

Transport measurement ($\rho$ and hall effect) at HIFI 2.5K, 6.4kbar, 5T

High pressure SQUID ($\chi$ susceptibility) 3K, 5kbar, 7T
New MuSR Spectrometer: CHRONUS (Port4)

In order to meet high demands for MuSR opportunities at RIKEN-RAL

New face to MuSR Spectrometer (in RIKEN Port4)

ARGUS  CHRONUS

Detectors  96+96  303+303

Max Field  0.4 T  0.4 T

Higher data rate

Larger sample area

Waiting DAQ and Control be finalized
Ultra-slow muon project (Port3)

Ultra slow muon beam by laser ionization of thermal muonium

Ultra-slow muon beam can be used for surface/interface studies micro beam after acceleration
Ultra-slow muon for muon g-2

Acceleration of slow muon makes cold muon beam with small spread of size and momentum and can be stored in compact g-2 storage ring

(proposal submitted J-PARC PAC 2010, N. Saito)
Development for slow muon: Muonium emission target

We are searching for various porous materials as an alternative to hot W advantages: not heat, lower energy, ... Mu emission measurement from silica aerogel at TRIUMF
Development for slow muon: Slow Muon at RIKEN-RAL

Upgrade/modification of Port 3 since 2008
- Relocation of control rack
- New power supplies (stable and 10->20kV)
- Beamline simulation with Geant 4
- Beamline control with NI Lab View
- DAQ /PC replacement
- Laser of better stability (goal x10)

First beam since 2007 in April 2011
Resuming optimization work in 2012

Beam spot size
Development for slow mum: New Lyman-α Laser at RIKEN

(as a part of Grant-in-Aid for Muon Microscope 2011-2015, joint by institutes and universities)

Plan to achieve x100 Lyman-α power
1µJ -> 100 µJ, 4ns -> 1ns
first Lyman-α expected this month
RIKEN-RAL Muon Facility Developments

RIKEN-RAL has two spectrometer for $\mu$SR (ARGUS, CHRONUS)

Good optional features such as

Use of laser
Use of high pressure

also unique program using muons

slow muon beam development (for MuSR, muon g-2)