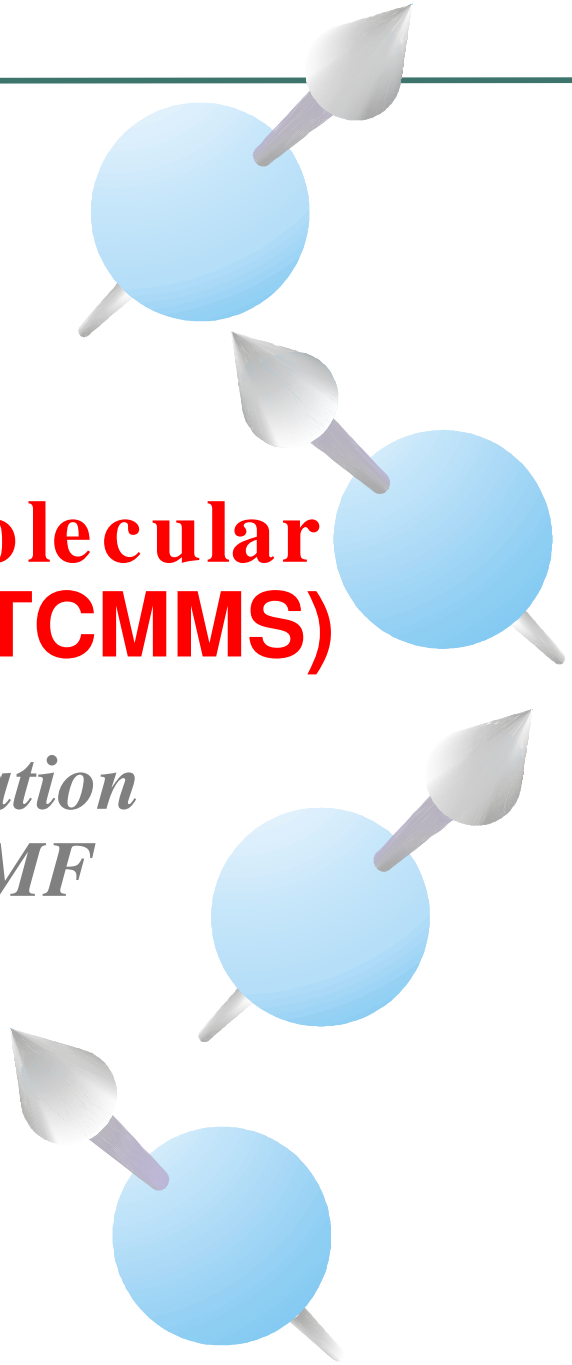
TCMMS
5-Year Plan

- Scientific Case
- Importance
- Proposal
- People Involved
- Cost Estimate
- Timetable



TRIUMF Centre for Molecular & Materials Science (TCMMS)

Proposal for Next Generation μSR Facilities at TRIUMF

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Scientific Case

Basic microscopic information on materials can be grouped into three major areas:

- **Structural**
- **Electronic**
- **Magnetic**

There is a constant critical need for scientific techniques that can measure these properties.

TRIUMF's μSR and β-NMR facilities can provide information on all three of these over a wide range of sample environments.

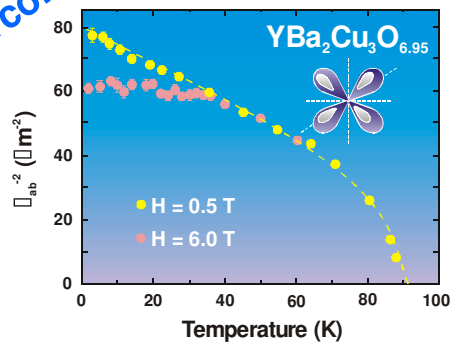
Many of the materials that are the subject of intense basic research eventually make the transition to practical applications. (*e.g.* high-T_c superconductor devices, magnetic materials with giant magnetoresistance in recording heads *etc*.…)

TCMMS

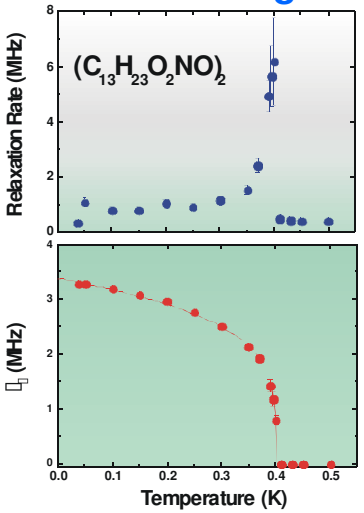
5-Year Plan

- Scientific Case
- Importance
- Proposal
- People Involved
- Cost Estimate
- Timetable

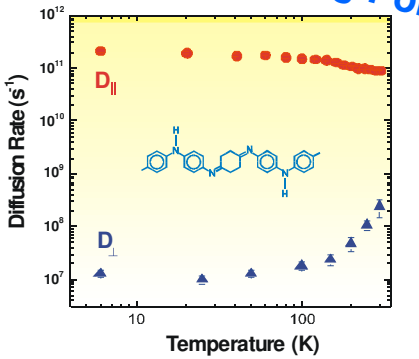
Superconductors



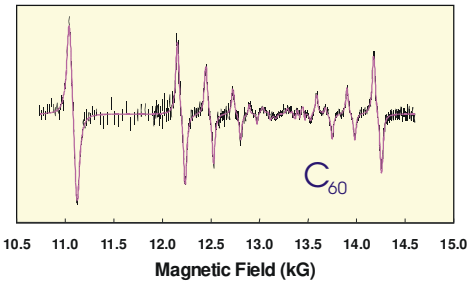
Molecular Magnets



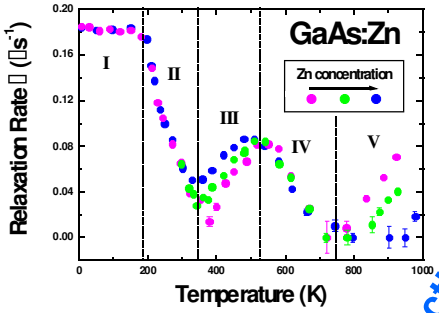
Conducting Polymers



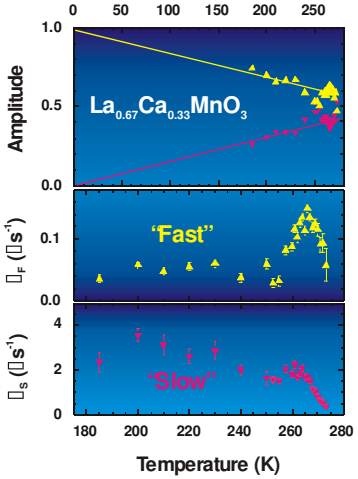
Free Radical Systems



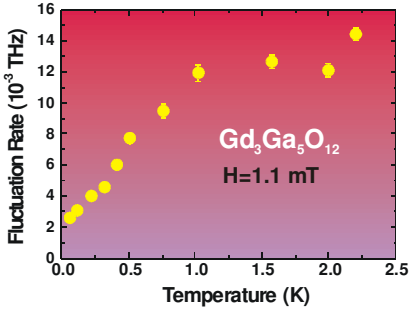
Semiconductors



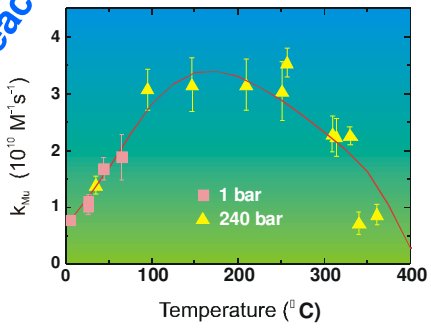
Magnetoresistance



Frustrated Systems



Chemical Reaction Kinetics



TCMMS
5-Year Plan

- Scientific Case
- Importance
- Proposal
- People Involved
- Cost Estimate
- Timetable

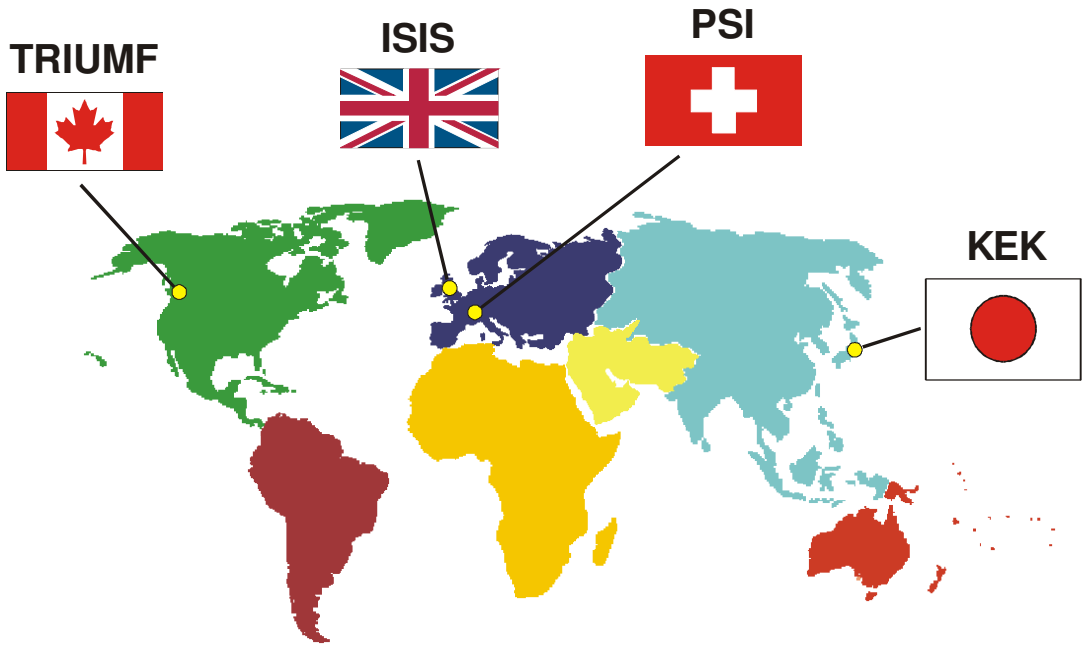
There is a great number of exciting new materials inaccessible to μSR because they are available only as small samples.

The combination of advanced μSR spectrometers and higher luminosity muon beam lines will open up new areas of research.

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Importance to the Scientific Community

TRIUMF provides the only source of muons appropriate for μSR in the Western hemisphere …

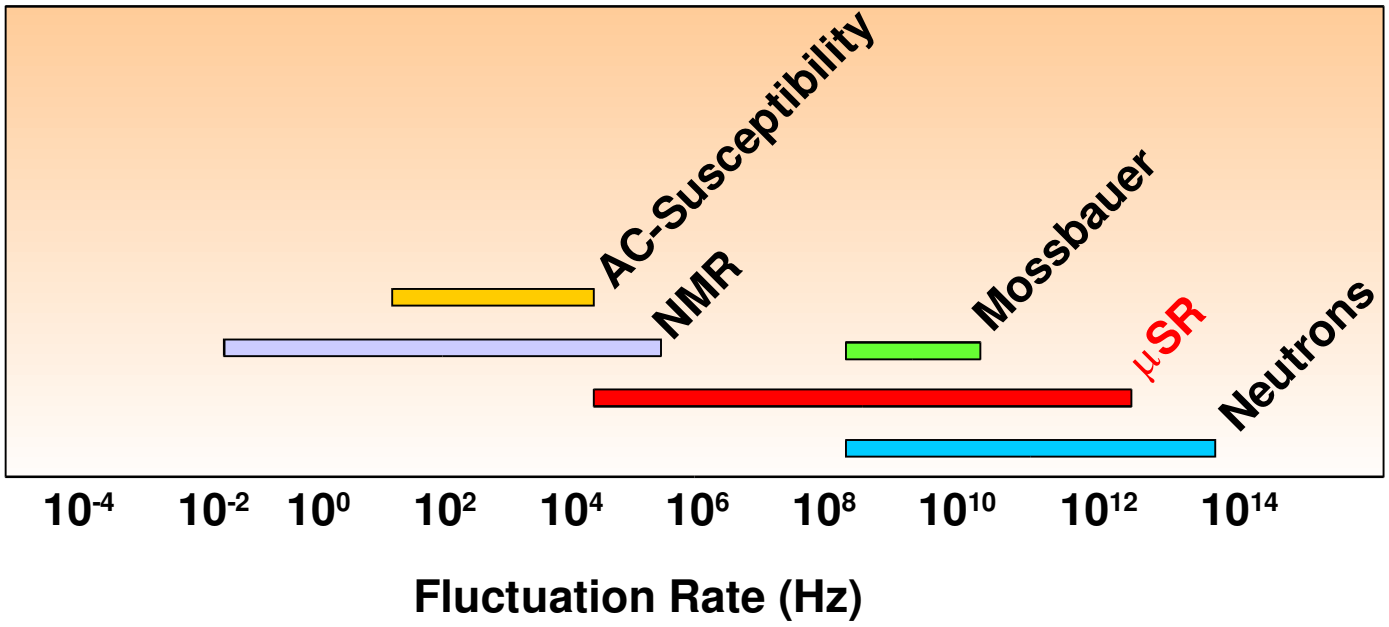


… and one of only two CW μSR facilities in the world.

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Muons are a special and indispensable probe of magnetism.

- **They are the most sensitive probe of local magnetism inside materials that is available to us.**
- **μSR can access a dynamical range that is not reachable by other widely used scientific techniques.**



Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Questions from Scientific Community:

"Experimental detection of this type of vortex by muon spin resonance and neutron scattering is proposed."
D. Arovas *et al.* Phys. Rev. Lett. 79, 2871 (1997).

"Muon spin resonance would be a way to look for interstitial fields…"
C. Varma, Phys. Rev. B 55, 14554 (1997).

Answers from μSR:

R.I. Miller *et al.,* Phys. Rev. Lett. 88, 137002 (2002)

J.E. Sonier *et al.,* Science 292, 1692 (2001); Phys. Rev. B, Oct. 1 issue (2002)

Without the TRIUMF μSR facility, many fundamental questions concerning the properties of materials would remain unanswered.

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Importance to TRIUMF

- Constant and long-term demand for existing TRIUMF infrastructure (*i.e.* cyclotron, Meson Hall).
- The TCMMS provides diversification of TRIUMF's mandate that is strongly supported by a very large materials science community in Canada and the United States.
- Guaranteed long-term flow of scientific output.

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Proposal

We are proposing a major expansion to service a broader scientific community and to bring TRIUMF's facilities in line with the maturity of the μSR technique.

- Broaden the **scope** of μSR applications by enabling new kinds of experiments.
- Make more effective and **efficient** use of μSR beam time.
- Maintain a **capability** in μSR techniques that is essential for materials science research in North America.
- Accommodate **more** experiments and fulfill the needs of recent faculty hires in Canada.

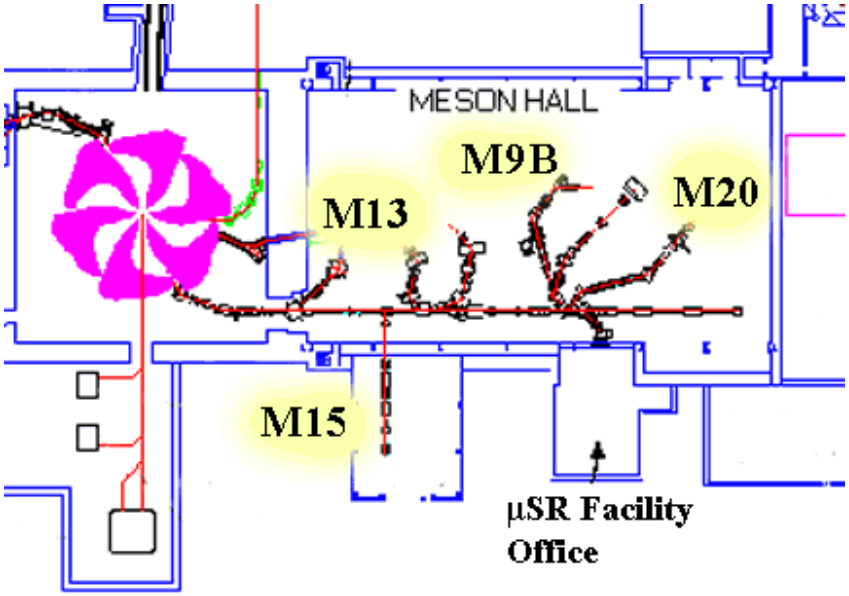
There is a **large** potential user base of non-μSR experts.

One Example: Neutron Scattering

Mark Lumsden (Oak Ridge National Laboratory)
1st μSR experiment Oct. 2001 on new $Cd_2Re_2O_7$ superconductor.
Paper to be published Sept. 30, 2002 in Physical Review Letters

TCMMS

5-Year Plan



M9B high momentum μ^+/μ^- (essential for chemistry & high-pressure)
M13 low rate surface μ^+, no spin rotator, dedicated to *TWIST*
M15 surface μ^+, dual spin-rotators, best luminosity (highest demand)
M20 surface μ^+, single spin-rotator, lower luminosity (high demand)

The TRIUMF μSR facility currently has 10 spectrometers but only 3 beam lines. Consequently the facility lacks the degree of automation necessary to establish the 'user-friendly environment' that is typical of the world's leading materials science research centers.

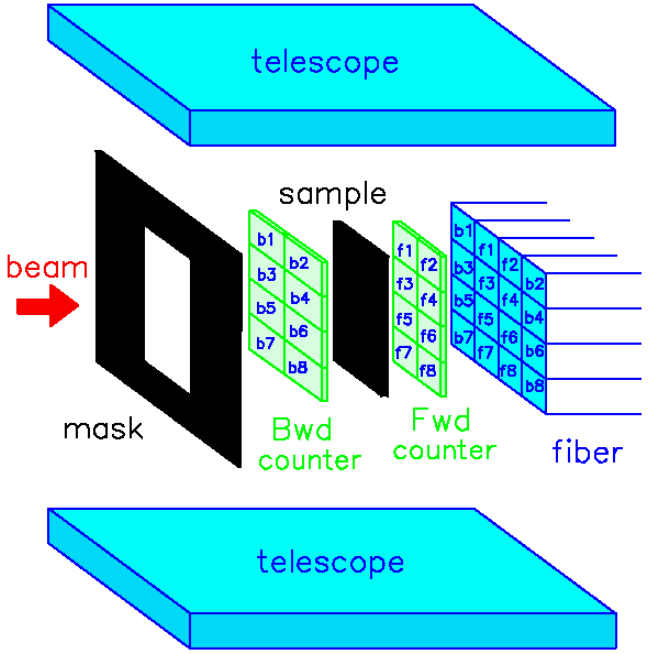
Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Build and commission MULTI spectrometer:

Conventional TD-μ⁺SR at a CW facility like TRIUMF is limited to a μ⁺ stopping rate of ≤ 10^5 s^{-1} because one must know which μ⁺ each e⁺ came from.

The **MULTI** spectrometer is effectively *mxn* independent TD-μ⁺SR experiments and therefore can use *mxn* times as many muons.

An additional advantage of the **MULTI** concept is its intrinsic low background capability for very small samples.



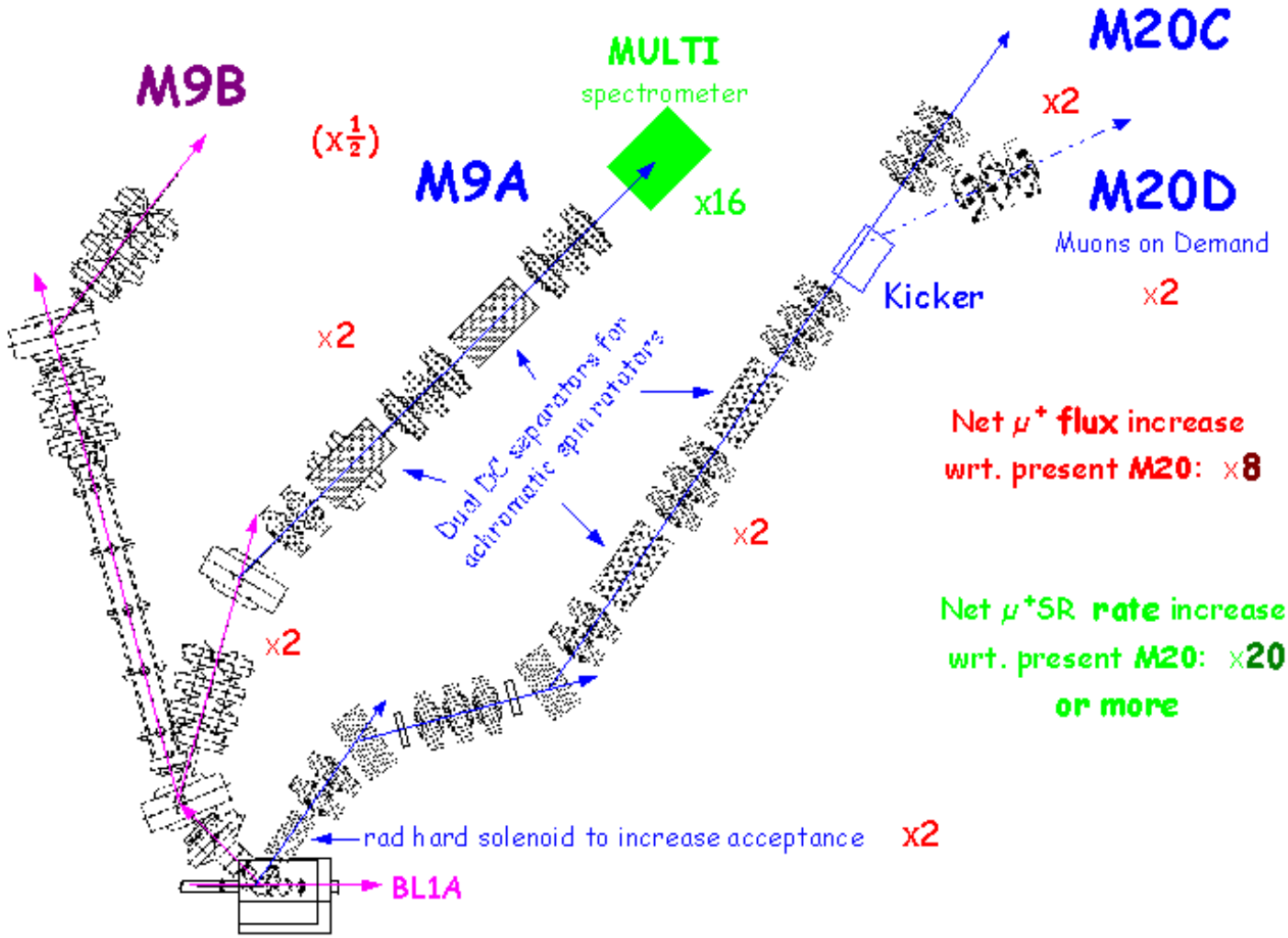
Successfully tested prototype is shown here; proposed new version has more (& smaller) pixels.

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

TCMMS

5-Year Plan

New M9A & M20



TCMMS
5-Year Plan

People Involved

Proposal

Jess Brewer (UBC)
Kim Chow (Alberta)
Don Fleming (UBC)
Rob Kiefl (UBC)
Syd Kreitzman (TRIUMF)
Graeme Luke (McMaster)
Andrew MacFarlane (UBC)
Paul Percival (SFU)
Jeff Sonier (SFU)

Design Study & Construction

- μSR Facility Personnel
- TRIUMF Technical Personnel

External Support

Robert Heffner (Los Alamos)
Tomo Uemura (Columbia)

TCMMS
5-Year Plan

Cost Estimate

M9A Upgrade with MULTI Spectrometer

Design Time

	Man Months	Total (Cdn)	Source of Funding
Beam Line Optics	2		
Spin Rotator Specifications	2		
HV Stacks Enclosures	2		
VAC System and Controls	2		
Safety and Shielding	1		
Beam Line Layout	1		
Management Engineer	4		
Design Technologist	8		
Total TRIUMF supplied technical design & engineers time	22@5K	110 K	TRIUMF
Data Acquisition and MULTI	1 Full Time Engineer	60 K	NSERC

Infrastructure Preparation

	Man Months	Total (Cdn)	Source of Funding
Decomissioning & Removal of TCP and Services	4		
Removal of RF Separator & Services	2		
Restructuring of M9A Counting Room	2		
Total Infrastructure Preparation	8@5 K	40 K	TRIUMF

Scientific Case
Importance
Proposal
People Involved
Cost Estimate
Timetable

Cost of Installation

	Total (Cdn)	Source of Funding
Capital Items in the Beam Line		
2 Spin Rotators + 4 HV stacks + power supplies	1500 K	TRIUMF
Other Beam Line Items		
Standard Components	50 K	
Cabling	10 K	
Vacuum & Control Systems	45 K	
	105 K	TRIUMF
Capital Items in the Spectrometer		
2 Cryostats	80 K	
SC Shielded 2 T Magnet with Axial & Horizontal Access engineers	450 K	
Fully Motorized Spectrometer Stand	40 K	
Cryogenic Controls	20 K	
Vacuum Stations	40 K	
	630 K	CFI
Capital Items in DAQ System		
VME Crate	6 K	
VME Modules	30 K	
Computers	6 K	
PMTs for Detectors	6 K	
MULTI-DAQ System	60 K	
	108 K	CFI
Ancillary Systems		
Scintillator Shop Detector Fabrication	40 K	
Beam Lines Group Installation	40 K	
Magnet Services	88 K	
Safety Systems & Installation	25 K	
	193 K	TRIUMF

TCMMS
5-Year Plan

M20 Upgrade

Design Time

	Man Months	Total (Cdn)	Source of Funding
Beam Line Optics	3		
Kicker/Septum Design	5		
Spin Rotator Specifications	2		
HV Stacks Enclosures	2		
VAC System and Controls	2		
Safety and Shielding	1		
Beam Line Layout	2		
Management Engineer	4		
Design Technologist	8		
Total TRIUMF supplied technical design & engineers time	30@5K	150 K	TRIUMF

Infrastructure Preparation

	Man Months	Total (Cdn)	Source of Funding
Removal of DC Separator & Services	2		
Restructuring of M20 Counting Room	2		
Total Infrastructure Preparation	4@5 K	20 K	TRIUMF

TCMMS
5-Year Plan

Cost of Installation

	Total (Cdn)	Source of Funding
Capital Items in the Beam Line		
2 Spin Rotators + 4 HV Stacks + Power Supplies	1500 K	
Electrostatic Kicker	300 K	
Septum Magnet + Power Supply	350 K	
2 Experimental Area Triplets + Power Supplies	380 K	
2 Rad Hard Quads + Power Supplies	500 K	
	3030 K	TRIUMF
Other Beam Line Items		
Standard Components	60 K	
Cabling	15 K	
Vacuum & Control Systems	55 K	
	130 K	TRIUMF
DAQ System		
Computers	6 K	
MULTI-DAQ System	60 K	
	66 K	CFI
Ancillary Systems		
Beam Lines Group Installation	50 K	
Magnet Services	154 K	
Safety Systems & Installation	25 K	
	229 K	TRIUMF

TCMMS 5-Year Plan

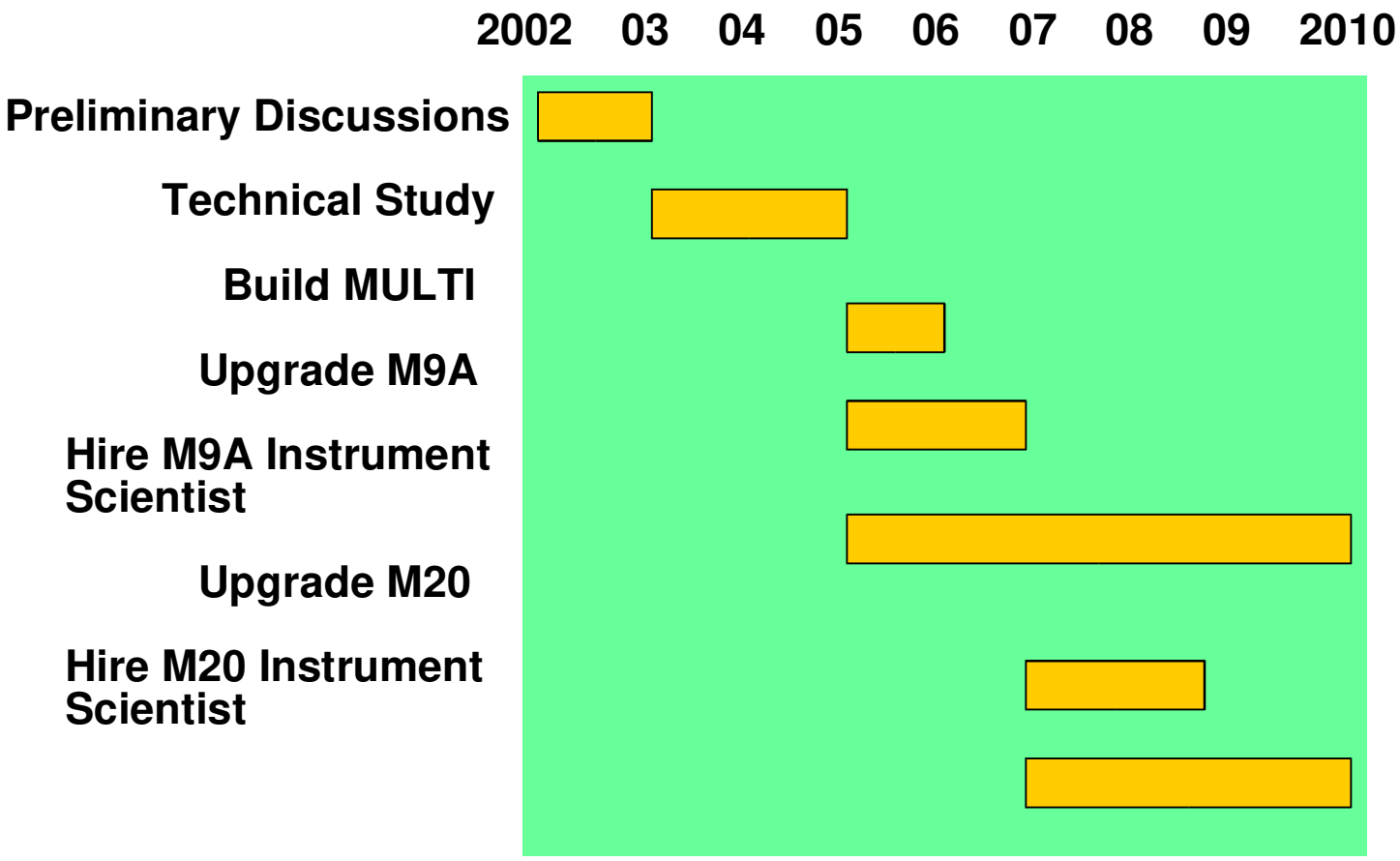
Total Cost

	Man Power	Spectrometer	DAQ	Beamline & Ancillaries	Total/Source
M9A & MULTI					
MFA	60				60
TRIUMF	230			1718	1948
CFI		630	108		738
Total/Category	290	630	108	1718	2746 K
M20					
TRIUMF	170			3389	3559
CFI			66		66
Total/Category					3625 K

Additional Costs:
Funding for M9A & M20 instrument scientists will be sought from μSR Facility NSERC grant.

Total Cost of Proposal: $6.37 M

Total Cost to TRIUMF: $5.51 M

TCMMS
5-Year Plan

Timetable